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D6.4– Publishing the first version of a web-handbook based on the newsletters each featuring a different type of infrastructure and their access

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And special thanks to all the contributors to AIR²

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Abstract

This deliverable deals with a web-handbook made from the first ordered compilation of all the infrastructures that have been collected and whose visibility has been reinforced through the Bulletin AIR² (**A**ccess to **I**nfrastructures for **R**adiation protection **R**esearch). Its proposed and temporary structure is issued from three initial workgroups, which have proposed categories and subcategories in order to also build easily the database AIR²D² (**A**ccess to **I**nfrastructures for **R**adiation protection **R**esearch **D**ocumented **D**atabase) and their evolutions due to the collection of 3 years.
Infrastructures have been classified into three categories: (1) exposure platforms and contaminated sites, (2) databases, sample banks and cohorts, (3) analytical platforms, models and tools.
In order to build the subcategories, "Exposure Platforms" has been subdivided into (a) Low dose and low dose-rates, (b) Microbeams, (c) Particular radiation qualities: ions, neutrons, alpha…, (d) Internal contamination, (e) Observatory sites and (f) Metrology exposure platforms. The category "Databases, Sample banks, Cohorts" has been divided into "Databases", "Sample banks" and "Cohorts" and finally the category "Analytical platforms, Models & Tools" into "Analytical platforms" and "Models & Tools".

The document comprises four sections:
- First section: Introduction,
- Second section: The CONCERT's Infrastructure Web-handbook (extracted main parts of the web-handbook),
- Third section: Present status and perspectives,
- Fourth section (annex): preliminary version of the web-handbook with organized and compiled infrastructures' articles.

The first version of this web-handbook compiles the articles of 81 infrastructures with 31 exposure platforms and contaminated sites, 23 databases, sample banks and cohorts and 27 analytical platforms, models and tools.

The tables and all individual infrastructures' articles are compiled into the connected (with hyperlink) joined pdf file, which will permit to build a real web-handbook in which every researcher will easily identify suitable infrastructures related to their needs.
Observing that some infrastructures can be classified in more than one subcategories and that those subcategories may evolve in the future as new infrastructures are collected, this version is only a draft designed to show its feasibility. For the time being, the final host website has not been chosen.

<End of abstract>

Introduction

CONCERT, the European Joint Programme for the Integration of Radiation Protection Research, is operating as an umbrella structure based on the strategic research agendas already done in the fields of low dose risk research (MELODI), radioecology (ALLIANCE), nuclear emergency preparedness (NERIS), dosimetry (EURADOS) and medical radiation protection (EURAMED). CONCERT aims at attracting and pooling national research efforts with European ones in order to make better use of public R&D resources and to tackle common European challenges in Radiation Protection more effectively by joint research efforts in key areas.

Coming to CONCERT WP6- *Access to Infrastructures*, its major focus is to increase the visibility of high quality infrastructures available to perform cutting-edge research in any of the disciplines related to Radiation Protection, and to facilitate access to these facilities for researchers and students in the field. The term "infrastructures" comprises so-called large infrastructures such as exposure platforms, including those for animal and plant experiments (both laboratory and field facilities), epidemiological cohorts, sample banks, databases, analytical platforms such as biological dosimetry facilities and 'omics platforms and e-infrastructures including models and tools. The necessity to focus on infrastructures in Radiation Protection field has been highlighted by the HLEG (High Level Expert Group) in 2009. Since then, large EURATOM projects (DoReMi, OPERRA…) have included specific WPs and tasks dedicated to infrastructures. Surveys performed in former projects have revealed that the prevailing opinion is that most necessary infrastructures are already available although, not at the bench of each user. Indeed, besides the funding of experiments, the access to state of the art infrastructures is a major bottleneck. Therefore, WP6 started listing the infrastructures and provided a description of recommended criteria, both common ones (general information about the facility, its owner and the access rules) and technical ones, tailor-made for each infrastructure category. In order to best utilize existing resources, emphasis was put on promoting the visibility, using "mature" infrastructures to avoid unnecessary costs and duplication and aiming at sustainability.

To this end, two main tools have been developed by the WP6: the database **AIR²D²** (***A****ccess to* ***I****nfrastructures for* ***R****adiation protection* ***R****esearch* ***D****ocumented* ***D****atabase*) and CONCERT's monthly bulletin (10 issues/year), **AIR²** (***A****ccess to* ***I****nfrastructures for* ***R****adiation protection* ***R****esearch*). Since October 2015, AIR² serves for the dissemination of the information available on infrastructures related to Radiation Protection research and has now reached its 27th Issue with 81 infrastructures. The bulletin is housed on the CONCERT website:
http://www.concerth2020.eu/en/Concert_info/Access_Infrastructures.
AIR² consists of 5 pages: The 1st page includes the editorial of the WP6 leader (Dr Laure Sabatier, CEA) and the section "The floor to …", in which leaders of the CONCERT WPs and of the European platforms MELODI, EURADOS, ALLIANCE, NERIS, EURAMED, CONCERT grantees, POMs and national contact points related to infrastructures are invited to highlight their work through the infrastructure binocular. The next three pages are dedicated to presenting infrastructures: one infrastructure from the category "Exposure platforms" (page 2), one from the category "Databases, Sample banks, Cohorts" (page 3), and one from the category "Analytical platforms, Models & Tools" (page 4). These three pages are constituted in the same way, i.e. with a text featuring the infrastructure, written by its owner, two spaces for images/photographs/schemes, a photo of the author, two key references of work involving the infrastructure, and an ID card containing basic criteria to provide key information at a glance. Finally, page 5 resumes the list of infrastructures published to date, those to be featured in the next issue and a list of CONCERT courses and future events related to Radiation Protection research together with their respective hyperlinks. It was decided to use the colours of the CONCERT logo for the bulletin, with one colour per page: "Exposure platforms"=**green**, "Databases, Sample banks, Cohorts"=**orange**, "Analytical platforms, Models & Tools"= **yellow**.

The third tool developed as instrument of visibility to facilitate the future set-up of projects in the Radiation Protection field is a web-handbook, presented below in its first version. It is issued directly from the efforts made to create and to keep alive AIR² and AIR²D². All the pages featuring infrastructures (pages 2, 3 and 4 of the AIR² bulletin) are assembled; differently listing all the published infrastructures. For the final version, it has been decided to include 120 infrastructures of the 3 aforementioned categories, each of which will be divided into new subtopics, e.g. Exposure Platforms will be subdivided into (a) Low dose and low dose-rates, (b) Microbeams, (c) Particular radiation qualities: ions, neutrons, alpha…, (d) Internal contamination, (e) Observatory sites and (f) Metrology exposure platforms ; the category "Databases, Sample banks, Cohorts" will be divided into "Databases", "Sample banks" and "Cohorts" and similarly the category "Analytical platforms, Models & Tools" into "Analytical platforms" and "Models & Tools".

The present document comprises this introduction, a short chapter entitled “The CONCERT’s Infrastructure Web-handbook”, where the principal parts extracted from the web-handbook are shown: definitions, a categories and subcategories table, the three cross tables corresponding to the three categories “Exposure platforms”, “Databases, Sample banks, Cohorts” and “Analytical platforms, Models & Tools” including the 11 subcategories with a first classification of the 81 infrastructures published till May 2018 in the 27 issues of AIR². It also includes a “Present status and perspectives” chapter as conclusion of this deliverable considering the future infrastructures (39) to be introduced, the possible improvements and potential evolutions. Among them, the idea is to complete the web-handbook with various introductions dedicated to each category and subcategory in order to describe the current landscape and its strengths and weaknesses. Finally, a connected (with hyperlinks) pdf file constitutes the very first draft version of 81 infrastructures for a potential web-handbook. This is only a provision of the D6.6 deliverable (M60), proposed for improvement and in order to identify volunteers to contribute to the introductions of each chapter and subchapter of the final version. The present status of this very preliminary version of the web-handbook is provided in the annex.

The CONCERT's Infrastructure Web-handbook

The very first version of this web-handbook comprises:

- The Acknowledgements,
- A general introduction
- How to use this web-handbook
- Definitions
- A table of categories and subcategories
- Three cross tables corresponding to each chapter with hyperlinks and containing labels/tags for each infrastructure
- An index

CONCERT's Infrastructure Web-handbook structure		
Chapter	**Category**	**Subcategory**
1	Exposure platforms	(a) Low doses and low dose rates (b) Microbeams (c) Particular radiation qualities: ions, neutrons, alpha… (d) Internal contamination (e) Observatory sites (f) Metrology exposure platforms
2	Databases, Sample banks, Cohorts	(a) Databases (b) Sample banks (c) Cohorts
3	Analytical platforms, Models & Tools	(a) Analytical platforms (b) Models & Tools

Table 1: Attribution of labels for categories and subcategories

Definitions

Exposure platform:
A facility where organisms, samples or instruments may be irradiated under controlled conditions in which dosimetric characteristics are well known and under quality control and SI traceability.

Low dose and low dose rates:
An ionising radiation dose of <100 mGy and a dose rate of <0.1 mGy/min averaged over 1 h (corresponding to 6 mGy/h) (UNSCEAR 2012).

Microbeam:
A small collimated beam, with micrometer or sub-micrometer dimensions. Together with integrated imaging techniques, they allow precisely localized radiation damages.

Internal contamination facility:
Facility where animals (or plants) are exposed to radiation *via* ingestion, inhalation or by wounds. Organisms are kept under controlled conditions.

Observatory site:
Natural site contaminated by radionuclides (NORM or anthropogenic) *via* industrial activities or accidental releases.

Metrology exposure platforms:
Metrology is defined by the International Bureau of Weights and Measures (BIPM) as "the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology". They are facilities dedicated to well define and quantified radiation beams or radioactive sources to irradiate, to test and/or calibrate measurement devices aiming to ensure that the produced results and their uncertainties during research projects are confident and reliable and traceable to SI system.

Databases:
Organised collections of data.

Sample Banks:
Collection of biological samples (e.g. humans, animals, or plant samples…) and inert samples with a relation to radiation topics (e.g. nuclear workers, irradiation during childhood with low doses, irradiation during a radiological accident…) and generally associated/connected to databases.

Cohorts:
Grouping of information and/or data about one particular population in radiation research area (e.g. nuclear workers, irradiation during childhood with low doses, irradiation during a radiological accident…). Generally applied for epidemiological and or health studies. Can be linked to a Sample bank.

Analytical platform:
Depending on the endpoints, dedicated analytical platform should be selected to investigate irradiated or potentially irradiated samples in order to define the received dose or to study biological alteration in the sample due to the irradiation (e.g. expression of proteins or genes, post-translational modification of proteins, activation/inactivation of regulatory and other biological pathways, DNA damage and repair 'omics platforms).

Models & Tools:
Predictive or analytical software or process, as well as biological model (such as animal or plant model).

Cross Tables

Chapter 1: Exposure platforms		
Subcategories	**Infrastructure**	**Other categories**
(a) Low doses and low dose rates	FIGARO	(d)
	PULEX-Cosmic Silence	(c)
	Silesian Centre for Environmental Radioactivity (SCRS-GIG)	(c) (d)
	LIBIS	
	Microtron Laboratory	
	Low dose rate facility at Stockholm University	
	MICADO'LAB Experimental Platform	
(b) Microbeams	SNAKE	
(c) Particular radiation qualities: ions, neutrons, alpha…	Radon Exposure Chamber	(a) (d)
	Biological Irradiation Facility (BIO)	(a)
	CIRIL	
	Mixed alpha and X-ray exposure facility	
	Alpha particles irradiator	
	Changing dose rate exposure facility	
	Proton IRRADiation facility (IRRAD)	(f)
(d) Internal contamination	B3, Animal Contamination Facility	(c)
	Facility radionuclides availability, transfer and migration	
	Nanoparticle Inhalation Facility	
(e) Observatory sites	The Chernobyl Exclusion Zone	
	Forest observatory site in Yamakiya	
	Belgian NORM Observatory Site	
(f) Metrology exposure platforms	Laboratory for retrospective Radon and Thoron dosimetry	(c)
	Calibration Laboratory at KIT	
	MELAF	(c)
	Radiation Metrology Laboratory (DOS)	
	Laboratory for Dosimetry Standards (NDS)	
	CALibration LABoratory(CALLAB)	
	Radon Calibration Laboratory of BfS	
	Calibration and Dosimetry Laboratory (INTE-UPC)	
	The Nuclear Metrology Group (NMG)	
	UNIPI neutron irradiation facility	(c)

Table 2: Exposure Platform cross table with tags for each infrastructure

Chapter 2 : Databases, Sample banks, Cohorts		
Subcategories	**Infrastructure**	**Other categories**
(a) Databases	FREDERICA	
	STORE	
	Wildlife Transfer Database	
	RES³T	
	JANUS Animal Radiobiology Archive	
	MARiS – MARine Information System	
(b) Sample banks	Biobank of Eastern Finland	
	Chernobyl Tissue Bank	
	Belgian Soil Collection	
	The Bank of Biological Materials of SBRC	
(c) Cohorts	The Wismut Cohort and Biobank	(b)
	French Haemangioma Cohort and Biobank	(b)
	3-Generation exposure study	(b)
	Portuguese Tinea Capitis Cohort	(b)
	French longitudinal study of children (Elfe)	(b)
	INWORKS Cohort	
	EPI-CT scan cohort	
	Chernobyl clean-up workers from Latvia	
	ESTCHERN Cohort	(b)
	German airline crew cohort	
	The Techa River Cohort (TRC)	(b)
	Greek interventional cardiologists cohort	
	The German Thorotrast Cohort Study	

Table 3: Databases, Sample banks, Cohorts cross table with tags for each infrastructure

Chapter 3 : Analytical platforms, Models & Tools	
Subcategories	**Infrastructure**
(a) Analytical platforms	RENEB The Genomic Medicine and Bioinformatics Core Facility MetaboHUB ProFI Radiobiology and immunology platform (CTU-FBME) France Génomique The SCK•CEN Genomics platform CATI HZDR–Radioanalytical Laboratories Advanced Technologies Network (ATeN) Center BfS In Vivo Measurement Facilities ECORITME Consolidated Radioisotope Facility (CORiF) Centre for Omic Sciences (COS) The iGE3 Genomics Platform VIB Proteomics Core
(b) Models & Tools	Dose Estimate, CABAS and NETA LDRadStatsNet ERICA Tool CROM-8 The Analytical Platform of the PREPARE project Symbiose INFRAFRONTIER The CERES Platform The Severe Nuclear Accident Program (SNAP) The BIANCA code OEDIPE

Table 4: Analytical platforms, Models & Tools cross table with tags for each infrastructure

Infrastructure	Exposure platforms						Databases, Sample banks Cohorts			Analytical platforms Models & Tools	
	Low doses and low dose rates	Microbeams	Particular radiation qualities: ions, neutrons,	Internal contamination	Observatory sites	Metrology exposure platforms	Databases	Sample banks	Cohorts	Analytical platforms	Models & Tools
FIGARO	■			▪							
PULEX-Cosmic Silence	■		▪								
Silesian Centre for Environmental Radioactivity (SCRS-GIG)	■		▪	▪							
LIBIS	■										
Microtron Laboratory	■										
Low dose rate facility at Stockholm University	■										
MICADO'LAB Experimental Platform	■										
SNAKE		■									
Radon Exposure Chamber	▪		■	▪							
Biological Irradiation Facility (BIO)	▪		■								
CIRIL			■								
Mixed alpha and X-ray exposure facility			■								
Alpha particles irradiator			■								
Changing dose rate exposure facility			■								
Proton IRRADiation facility (IRRAD)			■			▪					
B3, Animal Contamination Facility			▪	■							
Facility radionuclides availability, transfer and migration				■							
Nanoparticle Inhalation Facility				■							
The Chernobyl Exclusion Zone					■						
Forest observatory site in Yamakiya					■						
Belgian NORM Observatory Site					■						
Laboratory for retrospective Radon and Thoron dosimetry			▪			■					
Calibration Laboratory at KIT						■					
MELAF			▪			■					
Radiation Metrology Laboratory (DOS)						■					
Laboratory for Dosimetry Standards (NDS)						■					
CALibration LABoratory(CALLAB)						■					
Radon Calibration Laboratory of BfS						■					
Calibration and Dosimetry Laboratory (INTE-UPC)						■					
The Nuclear Metrology Group (NMG)						■					
UNIPI neutron irradiation facility						■					

Infrastructure	Exposure platforms						Databases, Sample banks Cohorts			Analytical platforms Models & Tools	
	Low doses and low dose rates	Microbeams	Particular radiation qualities: ions, neutrons, alpha…	Internal contamination	Observatory sites	Metrology exposure platforms	Databases	Sample banks	Cohorts	Analytical platforms	Models & Tools
FREDERICA											
STORE											
RES³T											
Wildlife Transfer Database											
JANUS Animal Radiobiology Archive											
MARiS – MARine Information System											
Biobank of Eastern Finland											
Chernobyl Tissue Bank											
Belgian Soil Collection											
The Bank of Biological Materials of SBRC											
The Wismut Cohort and Biobank											
French Haemangioma Cohort and Biobank											
3-Generation exposure study											
Portuguese Tinea Capitis Cohort											
French longitudinal study of children (Elfe)											
INWORKS Cohort											
EPI-CT scan cohort											
Chernobyl clean-up workers from Latvia											
ESTCHERN Cohort											
German airline crew cohort											
The Techa River Cohort (TRC)											
Greek interventional cardiologists cohort											
The German Thorotrast Cohort Study											

Infrastructure	Exposure platforms						Databases, Sample banks Cohorts			Analytical platforms Models & Tools	
	Low doses and low dose rates	Microbeams	Particular radiation qualities: ions, neutrons, alpha…	Internal contamination	Observatory sites	Metrology exposure platforms	Databases	Sample banks	Cohorts	Analytical platforms	Models & Tools
RENEB											
The Genomic Medicine and Bioinformatics Core Facility											
MetaboHUB											
ProFI											
Radiobiology and immunology platform (CTU-FBME)											
France Génomique											
The SCK•CEN Genomics platform											
CATI											
HZDR–Radioanalytical Laboratories											
Advanced Technologies Network (ATeN) Center											
BfS In Vivo Measurement Facilities											
ECORITME											
Consolidated Radioisotope Facility (CORiF)											
Centre for Omic Sciences (COS)											
The iGE3 Genomics Platform											
VIB Proteomics Core											
Dose Estimate, CABAS and NETA											
LDRadStatsNet											
ERICA Tool											
The Analytical Platform of the PREPARE project											
CROM-8											
Symbiose											
INFRAFRONTIER											
The CERES Platform											
The Severe Nuclear Accident Program (SNAP)											
The BIANCA code											
OEDIPE											

Present status and perspectives

In the present deliverable, 81 infrastructures, published till May 2018 in the first 27 Issues of AIR² are presented. This first version of the web handbook (final version to be delivered at M60) consists of 3 main chapters, representing the 3 categories that AIR² readers are already familiar with: "Exposure platforms", "Databases, Sample banks, Cohorts", "Analytical platforms, Models & Tools". Each chapter has been divided into subcategories aiming to facilitate researchers and students in the field of Radiation Protection research finding information about potential infrastructures they need. First level of information with detailed technical characteristics, access conditions and a contact are provided about "well known" but also for "newly-developed" infrastructures. They have been described going beyond CONCERT partners and even including non EURATOM countries in order to more accurately draw the radiation protection infrastructure landscape.

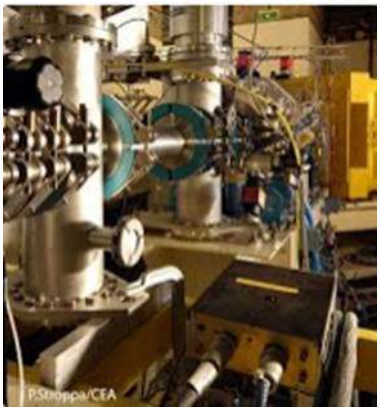
As is becoming clear through this preliminary version of the web-handbook and will continue to clarify with future AIR² issues, Europe has many high quality infrastructures to support Radiation Protection research. It will nevertheless be important to identify gaps and remain responsive to new requirements that may emerge with scientific and technological developments. Some categories of infrastructures are quite straightforward, while others, such as "Databases, Sample Banks and Cohorts", are more complex. Exposure platforms are the cornerstone of most radiation protection research activities, indeed we present featuring 31 of them in comparison to only 23 "Databases, Sample banks, Cohorts". Some less visible infrastructures are also the most fragile. Frequently created during a European project to answer to a particular need, they fall dormant afterwards through lack of sustainable funding, when they could have been so useful for future research if kept active and updated. AIR² will focus its efforts in keeping them under the spotlight. Similarly, efforts will be focused to enlarge the scope to other subcategories such as, for example, infrastructures for image-guided small animal radiotherapy, microbeams, internal contamination facilities, observatory sites, sample banks and so on.

Most of the infrastructures needed for Radiation Protection research exist across Europe (and sometimes outside). CONCERT promotes the visibility of those infrastructures and recommends their use. One of the roles of CONCERT is to ensure the availability of and facilitate access to operational "state-of-the-art" research infrastructures required to support the research efforts of radiation protection researchers. The priority is done in order to promote the use of mature infrastructures and avoid unnecessary duplication. The open approach of CONCERT involves the use of infrastructures which fulfil recommended criteria. They are integrated on the voluntary basis into a searchable available database AIR²D² (http://www.concert-infrastructures.eu/home) that can be updated to include new candidates. At the time being, the best way to achieve the sustainability of these infrastructures is to use them for research projects. The web-handbook answers also to enforce their visibility and increase their funding potential through European projects. The web-handbook may be seen as the funding preliminary act of a dedicated virtual open network to support Radiation Protection research.

As this preliminary version of the web-handbook is essentially based on AIR², it is a result of an "ongoing" work and we can easily imagine an extended version including hyperlinks with the AIR²D² Database and why not, directly other links using tools already available through Internet.

The web-handbook in its version of 2020 will be also a great tool to analyse the infrastructure landscape, its strengths and weaknesses and to supervise its evolution. It will help to keep the potential to carry out suitable and required research in the radiation protection field. Many introductions of the chapters will be written in this spirit.

The help of the entire Radiation Protection Research community is required to cover all the radiation protection relative present and future topics of research: low dose, radioecology, dosimetry, emergency situations, medical use, social sciences, etc…. Even if the first final version of the web-handbook will include 120 infrastructures, at the time being nobody knows which would exactly be the last 39 ones issued from our 13 remaining issues of AIR². And surely, this the 120 collected infrastructures are among the top listed ones, however it is not an exhaustive description of the entire landscape of the potentially available infrastructures in Europe. Shortly, this is not a "closed" web-handbook and we will hopefully open it and revise it on a continuous basis.



Exposure platforms

Databases, Sample banks, Cohorts

Analytical platforms, Models, &Tools

EUROPEAN JOINT PROGRAMME FOR THE INTEGRATION OF RADIATION PROTECTION RESEARCH
CONCERT
HORIZON 2020
This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

The first version of CONCERT's Infrastrtucture Webhandbook is out and we are both proud and happy for it!

This webhandbook would not have been possible without the collaboration and monthly contributions of exceptional researchers and infrastructure owners in the field of Radiation Protection Research to our newsletter, AIR^2. All credit goes to them: Deborah Oughton, Antonella Tabocchini, Malgorzata Wysocka, Alessandro Campa, David Chvatil, Siamak Haghdoost, Christelle Adam, Guenther Dollinger, Claudia Fournier, Andreas Maier, Balázs Zábori, Florent Durantel, Yannick Saintigny, Andrzej Wojcik, Giuseppe Esposito, Federico Ravotti, Nina Griffiths, Nathalie Vanhoudt, Rachel Smith, Nick Beresford, Hirofumi Tsukada, Dobromir Pressyanov, Lukas Exner, Andreas Schüller, Reetta Nylund, Matjaž Mihelič, Pierre Carbonez, Elisabeth Foerster, Mercè Ginjaume, Nigel Hawkes, Riccardo Ciolini, Almudena Real, Bernd Grosche, Vinzenz Brendler, Gayle Woloschak, Paul J. Morris, Sisko Salomaa, Arto Mannermaa, Gerry Thomas, Ravil Takhauov, Michaela Kreuzer, Monika Frenzel, Kazbek Apsalikov, Paula Boaventura, Marie-Aline Charles, Ausrele Kesminiene, Jelena Reste, Kaja Rahu, Hajo Zeeb, Lyudmila Krestinina, Eleftheria Carinou, Mandy Birschwilks, Ulrike Kulka, Laszlo Nagy, Christophe Junot, Jérôme Garin, Anna Fiserova, Pierre Le Ber, Rafi Benotmane, Jean-François Mangin, Harald Foerstendorf, Andreas C. Scheinost, Maurizio Marrale, Udo Gerstmann, Christelle Adam, William Blake, Alex Taylor, Nuria Canela, Mylène Docquier, Francis Impens, Liz Ainsbury, Justin Brown, Juan Carlos Mora, Wolfgang Raskob, Marc-André Gonze, Christophe Mourlon, Martin Hrabě de Angelis, Marguerite Monfort, Jerzy Bartnicki, Heiko Klein, Francesca Ballarini, Mario Carante, Aurélie Desbrée.

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The numbers speak for themselves: 27 Issues, 81 infrastructures, more than 20 countries and institutes represented and 1000 monthly readers of AIR^2! Thank you all!

General Introduction

CONCERT, the European Joint Programme for the Integration of Radiation Protection Research, is operating as an umbrella structure based on the strategic research agendas already done in the fields of low dose risk research (MELODI), radioecology (ALLIANCE), nuclear emergency preparedness (NERIS), dosimetry (EURADOS) and medical radiation protection (EURAMED). CONCERT aims at attracting and pooling national research efforts with European ones in order to make better use of public R&D resources and to tackle common European challenges in Radiation Protection more effectively by joint research efforts in key areas.

Coming to CONCERT WP6- *Access to Infrastructures*, its major focus is to increase the visibility of high quality infrastructures available to perform cutting-edge research in any of the disciplines related to Radiation Protection, and to facilitate access to these facilities for researchers and students in the field. The term "infrastructures" comprises so-called large infrastructures such as exposure platforms, including those for animal and plant experiments (both laboratory and field facilities), epidemiological cohorts, sample banks, databases, analytical platforms such as biological dosimetry facilities and 'omics platforms and e-infrastructures including models and tools. The necessity to focus on infrastructures in Radiation Protection field has been highlighted by the HLEG (High Level Expert Group) in 2009. Since then, large EURATOM projects (DoReMi, OPERRA…) have included specific WPs and tasks dedicated to infrastructures. Surveys performed in former projects have revealed that the prevailing opinion is that most necessary infrastructures are already available although, not at the bench of each user. Indeed, besides the funding of experiments, the access to state of the art infrastructures is a major bottleneck. Therefore, WP6 started listing the infrastructures and provided a description of recommended criteria, both common ones (general information about the facility, its owner and the access rules) and technical ones, tailor-made for each infrastructure category. In order to best utilize existing resources, emphasis was put on promoting the visibility, using "mature" infrastructures to avoid unnecessary costs and duplication and aiming at sustainability.

To this end, two main tools have been developed by the WP6: the database **AIR²D²** (***A**ccess to **I**nfrastructures for **R**adiation protection **R**esearch **D**ocumented **D**atabase*) and CONCERT's monthly bulletin (10 issues/year), **AIR²** (***A**ccess to **I**nfrastructures for **R**adiation protection **R**esearch*). Since October 2015, AIR² serves for the dissemination of the information available on infrastructures related to Radiation Protection research and has now reached its 27th Issue with 81 infrastructures. The bulletin is housed on the CONCERT website: http://www.concerth2020.eu/en/Concert_info/Access_Infrastructures.

The third tool developed as instrument of visibility to facilitate future set-up of projects in the Radiation Protection field is a web-handbook presented below in its first version. It is issued directly from the efforts done to create and to make live AIR² and AIR²D². All the pages featuring infrastructures (pages 2, 3 and 4 of the AIR² bulletin) are assembled differently listing all the published infrastructures. For the final version, it was decided to include 120 infrastructures of the 3 aforementioned categories (as chapters), each of which is divided into subcategories, e.g. Exposure Platforms subdivided into (a) Low dose and low dose-rates, (b) Microbeams, (c) Particular radiation qualities: ions, neutrons, alpha…, (d) Internal contamination, (e) Observatory sites and (f) Metrology exposure platforms ; the category "Databases, Sample banks, Cohorts" divided into "Databases", "Sample banks" and "Cohorts" and similarly the category "Analytical platforms, Models & Tools" into "Analytical platforms" and "Models & Tools".

The first version comprises the three categories divided 11 subcategories with a first classification of the 81 tagged infrastructures published till May 2018 in the 27 issues of AIR². For 2020, the complete version will include 39 infrastructures more, with possible technical improvements as links to AIR²D² database for example and other potential evolutions focused on a first analysis of this landscape. Among them, the idea is to complete the web-handbook with various introductions dedicated to each category and subcategory in order to describe each dedicated landscape and its strengths and weaknesses.

How to use this webhandbook

The present webhandbook consists of the following parts:

- Detailed **"Definitions"**, explaining which infrastructures correspond to each category and subcategory. Namely, the terms *Exposure platform*, *Low dose and low dose rates*, *Microbeam*, *Internal contamination facility*, *Observatory site*, *Metrology exposure platforms*, *Databases*, *Sample Banks*, *Cohorts*, *Analytical platform* and *Models & Tools* are clearly defined.

- 1 **blue context table** providing an overview of the chapters to follow. Hyperlinks to all the main chapters and subchapters are provided in order to facilitate the reader.

- 1 **green context table** for the 1st Chapter, Exposure platforms, including the subcategories of (a) Low doses and low dose rates, (b) Microbeams, (c) Particular radiation qualities: ions, neutrons, alpha…, (d) Internal contamination, (e) Observatory sites and (f) Metrology exposure platforms. All the 31 infrastructures presented till May 2018 in the 27 issues of AIR^2 are attributed to their corresponding categories and hyperlinks that redirect the reader to the respective article are provided.

- 1 **orange context table** for the 2nd Chapter, Databases, Sample banks, Cohorts, including the subcategories of (a) Databases, (b) Sample banks, (c) Cohorts. All the 23 infrastructures presented till May 2018 in the 27 issues of AIR^2 are attributed to their corresponding categories and hyperlinks that redirect the reader to the respective article are provided.

- 1 **yellow context table** for the 3nd Chapter, Analytical platforms, Models & Tools including the subcategories of (a) (a) Analytical platforms (b) Models & Tools. All the 27 infrastructures presented till May 2018 in the 27 issues of AIR^2 are attributed to their corresponding categories and hyperlinks that redirect the reader to the respective article are provided.

- The 3 main Chapters: **Exposure platforms**, **Databases, Sample banks, Cohorts** and **Analytical platforms, Models & Tools** in the form of AIR^2 individual articles. The infrastructures are presented in respect to the order of appearance of the main subcategory that they belong (see the 3 context tables).

In order to facilitate the navigation of the reader and provide more information, hyperlinks are provided throughout the webhandbook. Just click the underlined words! Enjoy reading.

Definitions

Exposure platform:
A facility where organisms, samples or instruments may be irradiated under controlled conditions in which dosimetric characteristics are well known and under quality control and SI traceability.

Low dose and low dose rates:
An ionising radiation dose of <100 mGy and a dose rate of <0.1 mGy/min averaged over 1 h (corresponding to 6 mGy/h) (UNSCEAR 2012).

Microbeam:
A small collimated beam, with micrometer or sub-micrometer dimensions. Together with integrated imaging techniques, they allow precisely localized radiation damages.

Internal contamination facility:
Facility where animals (or plants) are exposed to radiation *via* ingestion, inhalation or by wounds. Organisms are kept under controlled conditions.

Observatory site:
Natural site contaminated by radionuclides (NORM or anthropogenic) *via* industrial activities or accidental releases.

Metrology exposure platforms:
Metrology is defined by the International Bureau of Weights and Measures (BIPM) as "the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology". They are facilities dedicated to well define and quantified radiation beams or radioactive sources to irradiate, to test and/or calibrate measurement devices aiming to ensure that the produced results and their uncertainties during research projects are confident and reliable and traceable to SI system.

Databases:
Organised collections of data.

Sample Banks:
Collection of biological samples (e.g. humans, animals, or plant samples…) and inert samples with a relation to radiation topics (e.g. nuclear workers, irradiation during childhood with low doses, irradiation during a radiological accident…) and generally associated/connected to databases.

Cohorts:
Grouping of information and/or data about one particular population in radiation research area (e.g. nuclear workers, irradiation during childhood with low doses, irradiation during a radiological accident…). Generally applied for epidemiological and or health studies. Can be linked to a Sample bank.

Analytical platform:
Depending on the endpoints, dedicated analytical platform should be selected to investigate irradiated or potentially irradiated samples in order to define the received dose or to study biological alteration in the sample due to the irradiation (e.g. expression of proteins or genes, post-translational modification of proteins, activation/inactivation of regulatory and other biological pathways, DNA damage and repair ‘omics platforms).

Models & Tools:
Predictive or analytical software or process, as well as biological model (such as animal or plant model).

CONCERT's Infrastructure Webhandbook structure

Chapter	Categories	Subcategories	Page
1	Exposure platforms	(a) Low doses and low dose rates	8-14
		(b) Microbeams	16
		(c) Particular radiation qualities: ions, neutrons, alpha…	18-24
		(d) Internal contamination	26-28
		(e) Observatory sites	30-32
		(f) Metrology exposure platforms	34-43
2	Databases, Sample banks, Cohorts	(a) Databases	46-51
		(b) Sample banks	53-56
		(c) Cohorts	58-70
3	Analytical platforms, Models & Tools	(a) Analytical platforms	73-88
		(b) Models & Tools	90-11

Chapter 1 : Exposure platforms

Subcategories	Infrastructure	Other categories	Page
(a) Low doses and low dose rates	FIGARO	(d)	8
	PULEX-Cosmic Silence	(c)	9
	Silesian Centre for Environmental Radioactivity (SCRS-GIG)	(c) (d)	10
	LIBIS		11
	Microtron Laboratory		12
	Low dose rate facility at Stockholm University		13
	MICADO'LAB Experimental Platform		14
(b) Microbeams	SNAKE		16
(c) Particular radiation qualities: ions, neutrons, alpha…	Radon Exposure Chamber	(a) (d)	18
	Biological Irradiation Facility (BIO)	(a)	19
	CIRIL		20
	Mixed alpha and X-ray exposure facility		21
	Alpha particles irradiator		22
	Changing dose rate exposure facility		23
	Proton IRRADiation facility (IRRAD)	(f)	24
(d) Internal contamination	B3, Animal Contamination Facility	(c)	26
	Facility radionuclides availability, transfer and migration		27
	Nanoparticle Inhalation Facility		28
(e) Observatory sites	The Chernobyl Exclusion Zone		30
	Forest observatory site in Yamakiya		31
	Belgian NORM Observatory Site		32
(f) Metrology exposure platforms	Laboratory for retrospective Radon and Thoron dosimetry	(c)	34
	Calibration Laboratory at KIT		35
	MELAF	(c)	36
	Radiation Metrology Laboratory (DOS)		37
	Laboratory for Dosimetry Standards (NDS)		38
	CALibration LABoratory(CALLAB)		39
	Radon Calibration Laboratory of BfS		40
	Calibration and Dosimetry Laboratory (INTE-UPC)		41
	The Nuclear Metrology Group (NMG)		42
	UNIPI neutron irradiation facility	(c)	43

Subcategory (a) : Low doses and low dose rates		
Infrastructure	Other categories	Page
FIGARO	(d)	8
PULEX-Cosmic Silence	(c)	9
Silesian Centre for Environmental Radioactivity (SCRS-GIG)	(c) (d)	10
LIBIS		11
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Low dose rate facility at Stockholm University		13
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FIGARO

Low Dose Irradiation Facility at the Centre for Environmental Radioactivity

The Norwegian University of Life Sciences (NMBU) has had a gamma irradiation facility on campus since 1952. In 2003 a facility for low-dose exposure ecotoxicological experiments was opened and used for a variety of chronic and sub-chronic exposure studies (e.g., fish, mussels, earthworms, plants). With the support of DoReMi, the facility underwent extensive upgrades in 2012 in order to meet the requirements for small rodent chronic exposure experiments. The present facility, FIGARO, at the Centre of Environmental Radioactivity (CERAD), is equipped with a climate control system (temperature, light, humidity), and is fully approved as an animal research facility, including the use of GMO rodent and other plant and animal models.

Photo: NMBU/S. Dahl

Deborah Oughton

(www.scanbur-technology.com) and Innovive racks. As an example, irradiation of up to 150 mice can be carried out at 2 mGy/hr with an additional 80-160 controls, and larger numbers can be accommodated at lower dose rates. DoReMi has supported two collaborative projects involving long-term irradiation of mice (up to 3 months). The OSTINATO project investigated the impact of chronic irradiation on the onset of Parkinson disease in a predisposed mice model and CLOGIGAT studied gut cancer incidence in APCmin/+mice. These projects involved the successful transport, irradiation and return of more than 1000 mice to respectively Germany and the UK.

Photo, left to right: NMBU/G. Bjørneby and D.A. Brede

Left to right: The 12 Ci Co-60 gamma source; Mice irradiation using the ScanClime system

CERAD continues to carry out a number of studies using other organisms, focusing on both mechanistic and ecotoxicological investigations. In addition to mice, 2014-2105 saw experiments on zebrafish, nematodes (c elegans), salmon, algae, daphnia, earthworms and various plant species.

CERAD/FIGARO is open for collaboration, and we welcome suggestions for projects with CONCERT partners.

FIGARO is primarily designed as an external gamma irradiation facility, although it is also authorised for radionuclide internal exposure (including alpha emitters), as well as other chemical stressors (e.g., metals, organics, nanoparticles) and UV exposure. The irradiation source is 12 Ci Co-60 which provides a continuous dose rate field from 3 Gy/hr (at source) down to 400 µGy/hr and allows simultaneous, chronic exposure of samples over the whole dose-rate field. A temperature and pH controlled flow-through system is available for aquatic organism exposures. The climate control specifications for the experimental hall are:

- Temperature: 4 - 37 °C (+/- 1 °C)
- Light : ca. 50 - 300 lux with automatic dimmer (10 min)
- Humidity: 45 - 65% (ScanClime)
- Ventilation: 300 m3/h

The capacity for small rodent irradiation depends on the dose rate and the animal cage system. FIGARO has access to both ScanClime

Photo: NMBU/D. Oughton

Figaro Irradiation Hall during a uranium fish experiment

ID Card:

Exposure type:
External (internal possible)

Source:
Co-60

Dose rate:
3 Gy - 400 uGy/hr

Irradiation type:
Gamma

Irradiated organism type:
Cells, animals (small rodents, fish, amphibians, invertebrates) plants. GMO

Address:
Centre For Environmental Radioactivity (CERAD), Norwegian University of Life Sciences, PO Box 5003, 1432 Aas, Norway

Access:
Joint research collaborations only, ongoing applications

Supporting lab:
Biomolecular and biochemistry laboratories, cell culture, and dissection.

Internet link:
www.nmbu.no/cerad

Contact:
Deborah Oughton, Deborah.oughton@nmbu.no, +47 64965544/40
Ole Christain Lind Ole.christian.lind@nmbu.no. +47 64965545/40

Related to:
ALLIANCE/MELODI

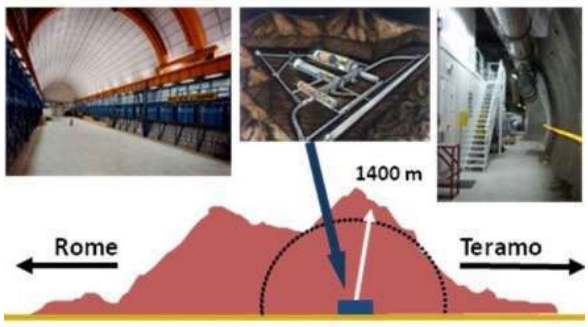
DOSE-DEPENDENT HEPATIC TRANSCRIPTIONAL RESPONSES IN ATLANTIC SALMON (SALMO SALAR) EXPOSED TO SUBLETHAL DOSES OF GAMMA RADIATION. Song et al., 2014. Aquat Toxicol 156:52-64

GENOTOXIC EFFECTS OF CHRONIC LOW DOSE RATE GAMMA IRRADIATION IN MICE DEVELOPING GASTROINTESTINAL TUMORS. Graupner et al., 2015, ICRR Kyoto, Japan.

PULEX-COSMIC SILENCE

Extremely low radiation background facilities at INFN-LNGS

The Gran Sasso National Laboratory (LNGS) in Italy is one of the four national laboratories of the INFN (National Institute for Nuclear Physics). It is the largest underground laboratory in the world devoted to neutrino and astroparticle physics. Located between L'Aquila and Teramo, approx 120 km from Rome, the underground structures are situated on one side of the 10 km long highway tunnel which crosses the Gran Sasso massif. The underground complex consists of three huge experimental halls and bypass tunnels. The halls are equipped with all technical and safety equipment and plants necessary for the experimental activities and to ensure proper working conditions for the people involved.



Picture: modified from Eur. Phys. J. Plus (2012) 127: 37

The INFN-LNGS underground laboratory

The PULEX cell culture facility is located in one of the bypass tunnels. The facility was set up to perform in vitro experiments in extremely low radiation background in the context of a close collaboration between INFN, Istituto Superiore di Sanità (ISS) and Centro Fermi. In this environment, the natural coverage of 1400 m thick rock provides a reduction factor of one million in the cosmic ray flux, and the neutron flux is a thousand times less than on the surface. In the PULEX facility, the Radon concentration is kept at a very low level by an efficient ventilation system that pumps air from the outside. Moreover, the cell culture laboratory hosts two CO2 incubators, one of which is shielded with 5 cm of Fe to further reduce the gamma component of the radiation spectrum.

Since the pioneering work on yeasts carried out by Satta and co-workers in the late 90's, several experiments have been performed using rodent and human cell cultures grown in parallel in the PULEX facility and in external laboratories, with the aim of investigating if modulation of the radiation environment can modify the biochemistry of biological systems and their response to genotoxic agents. Interestingly, the overall results obtained using different in vitro models have shown that cells cultured in a strongly reduced radiation environment are less tolerant to radiation-induced DNA damage and less efficient in scavenging reactive oxygen species than cells grown in the external reference environments.

Photo: M. Sabatini/ISS

Antonella Tabocchini

At present, an animal house facility is under construction next to the PULEX cell culture laboratory. This new facility, named COSMIC SILENCE, will be provided with temperature and light control systems, as well as an independent ventilation system. Once it is ready, the first planned experiments will be done with Drosophila melanogaster. In the future, after authorization, it will be possible to perform experiments with mice. To this end, the facility has been designed to host a 60-cage mouse rack.

On a smaller scale, the PULEX-COSMIC SILENCE facilities nicely complement the FIGARO facility allowing radiobiological investigation in a radiation environment below the average background level. The PULEX facilities are open to collaboration, including use of other organisms, and any suggestions for projects with CONCERT partners are very welcome.

Inside and outside the PULEX cell culture facility underground the LNGS

Photo: M.A. Tabocchini/ISS

ID Card:

Exposure type:
External (extremely low radiation background)

Source:
Environmental radiation with negligible contribution by directly ionizing cosmic rays and neutrons

Dose rate:
~ 4 nGy/h (with Fe shielding)
~ 40 nGy/h (w/o shielding)

Irradiation type:
gamma (cosmic & terrestrial), alpha (radon)

Irradiated organism type:
Presently cells and small animals, e.g. insects, worms. Mice in the future, after authorization.

Address:
Laboratori Nazionali del Gran Sasso
Via G. Acitelli, 22
67100 Assergi L'Aquila, Italy

Access:
Joint research collaboration and scientific committee approval

Supporting lab:
external cell culture lab, (bio) chemistry lab

Internet link:
https://www.lngs.infn.it/en

Contact:
Maria Antonella Tabocchini : antonella.tabocchini@iss.it, +39 0649903020
Marco Balata: marco.balata@lngs.infn.it +39 0862437292

Related to:
MELODI, ALLIANCE

LOW ENVIRONMENTAL RADIATION BACKGROUND IMPAIRS BIOLOGICAL DEFENCE OF THE YEAST SACCHAROMYCES CEREVISIAE TO CHEMICAL RADIOMIMETIC AGENTS. Satta et al., 1995. Mutat Res 347:129-133

LOW-RADIATION ENVIRONMENT AFFECTS THE DEVELOPMENT OF PROTECTION MECHANISMS IN V79 CELLS. Fratini et al., 2015. Radiat Environ Biophys 54:183–19

Silesian Centre for Environmental Radioactivity (SCRS-GIG)

A multipurpose irradiation facility for all types of radiation

Radiation research at the Central Mining Institute (GIG) began in the early 1970s with the discovery of enhanced natural radioactivity in coal mines. The rapid development of scientific and technical capabilities and the wider understanding of radiation protection which followed, led to the creation of the Silesian Centre for Environmental Radioactivity (SCRS-GIG); the facility moved to new premises in 2012. Furthermore, the experience gathered in complex NORM investigation allowed the SCRS-GIG team to assist the emerging Polish nuclear industry to solve problems related to environmental radioactivity.

Photo: S. Jarosławska-Sobór/GIG

Optical calibration bench for controlled exposure to gamma and X radiation using IM6/M-2 irradiator (Cs-137: source activity: 100 Ci, 1 Ci and 10 mCi) and/or XCS-320-ST/X-RAY CAL Vacuum tube (320kV)

In order to maintain the provision of high quality radiation monitoring, a complex system of irradiation facilities has been developed. A radon chamber of 17 m^3, allowing control of climatic parameters, is used for exposure to alpha radiation in the atmosphere with controlled radon concentration. As radon progeny-forming aerosols are crucial in this case, it is possible to generate and measure polydisperse/monodisperse aerosols in the air, in the size range of nm to µm, using instrumentation from TSI (USA).

Using a Gamma irradiator IM6/M-2 with Cs-137 sources (air kerma rate varies from 1.5 µGy/h to 187 mGy/h) or with an X-Ray machine of the type XCS-320-ST/X-RAY CAL (320 kV), equipped with a set of filters in order to modify the X-Ray beam according to ISO rules an object can be irradiated at different distances, ranging from 300 to 4000 mm, changeable every 1 mm. Maximal air kerma rate is ca. 40 Gy/h.

Photo: A. Jastrząb-Neigbor

Malgorzata Wysocka

Besides exposure to a straight radiation beam, two stands are used for panoramic irradiation at given distances (1m, 0.7m and 0.3m) using an IN1/P neutron irradiator with Am-241/Be source, 1 Ci activity (flux density: $6.6x10^{-5}$ $Nxs^{-1}xBq^{-1}$ for neutron energy 0.025 eV - 12 MeV; dose rate at a distance of 1m: ca. 30 uSv/h) or with an IM1/P gamma irradiator with a Cs-137 0.05 Ci source (available air kerma rate: 150 - 1700 µGy/h). As high penetrating radiation is not the only source of risk, an installation with an IB1/P beta irradiator (Sr-90, 0.05 Ci) is also in use. The radiation beam is collimated and the distance can be changed up to 1m from the source. The dose rate varies from 50 to 3100 mSv/h.

All these installations are located in an air-conditioned, shielded room in the underground part of SCRS-GIG's new headquarters, and are currently used for calibration of a wide variety of radiometric devices under different ambient conditions.

As all these activities need to be coupled with relevant measurement possibilities, a wide variety of radon and radon progeny, and dose and exposure measurement techniques has been developed and implemented. Additional support is provided by a well equiped low-background, high resolution gamma spectrometry laboratory, an alpha spectrometry laboratory or LSC laboratory with two QUANTULUS counters.

All the installations can be easily adapted, upon request, to expose living organisms to different kinds of radiation.

Radon chamber (17m^3)

Photo: B. Michalik/GIG

ID Card:

Exposure type:
Internal (inhalation), external

Sources:
Radon & radon progeny, X-ray tube, Cs-137, Am-241/Be, Sr-90

Dose rate:
Gamma (collimated beam): 0.001 – 187 mGy/h
Gamma (panoramic): 150 - 1700 µGy/h
X-ray (collimated beam): up to 40 Gy/h
Neutron (panoramic): ca 30 uSv/h
Beta (collimated beam): 50-3000 mSv/h
Radon: activity concentration in air up to ca 10 kBq/m^3

Irradiation type:
Alpha - ambient atmosphere (3D), Gamma - beam & panoramic, Neutron - panoramic, Beta- beam

Irradiated organism type:
Possible, not exposed yet : Cell cultures, animals (small rodent size), vegetation (pot size).

Address:
Główny Instytut Górnictwa
PLac Gwarków 1, 40-166 Katowice, POLAND

Access:
selection committee (bilateral/ multilateral collaboration, access frequency limited

Supporting lab:
alpha, gamma spectrometry, LSC, TLD dosimetry, X-ray & gamma secondary reference standards

Internet link:
www.radiometria.gig.eu

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Related to:
ALLIANCE

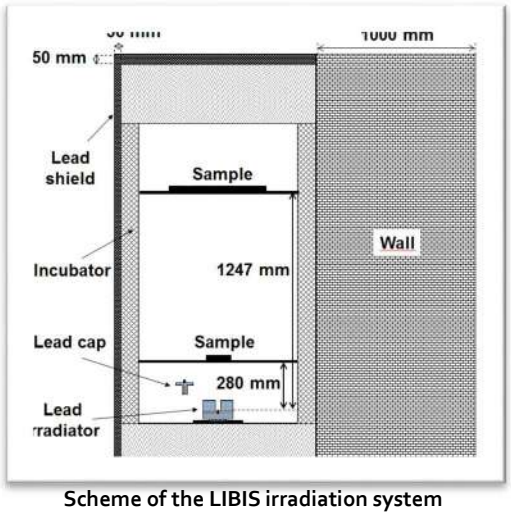
MEASUREMENTS OF LOW DOSES WITH PANASONIC DOSIMETERS. ALGORITHM AND TESTS. Skubacz K., 2015. Radiat. Meas. 75. 9-14.
APPLICATION OF THE BOHM CHAMBER FOR REFERENCE BETA DOSE MEASUREMENTS AND THE CALIBRATION OF PERSONAL DOSIMETERS. Skubacz K. 2016. Nukleonika (MS 2/15).61(1), 61-67, DOI: 10.1515/nuka-2016-0001

LIBIS

Low dose rate gamma irradiation facility for cell cultures

The Italian National Institute of Health (Istituto Superiore di Sanità, ISS) has a long- standing tradition in radiation research, dating back to the days of its foundation in the 1930's. In 1993, ISS acquired a Gammacell® 40 Exactor (Nordion International Inc.) for acute irradiation of biological samples, with gamma rays from a Cs-137 source, at a dose rate of about 1 Gy/min.

The support of DoReMi made it possible to build a facility for low dose rate and chronic gamma irradiation of cell cultures: LIBIS (**L**ow dose/dose rate gamma **I**rradiation facility for in vitro **BI**ological **S**ystems). This recently completed facility, designed and built at ISS, was explicitly conceived to accommodate a very wide range of low dose rates. It allows samples to be irradiated with Cs-137 gamma rays, from 20 mGy/h down to 2 mGy/h, and the rate can be varied in a practically continuous way within this range. The irradiations are performed inside a CO_2 cell culture incubator, allowing the physiological conditions to be maintained even in experiments lasting many weeks. The incubator is shielded by lead shields (on two sides and on the top) and by very thick brick walls (on the other two sides).



Drawer: Institute: G. Esposito/ISS

Scheme of the LIBIS irradiation system

The main components of the facility are its three lead irradiators, each of which houses a Cs-137 source; the activities of the three sources are in the ratio 1:20:500, with the activity of the strongest source being about 18 GBq. To conduct an experiment, one of the irradiators is placed at the bottom of the incubator, and the sample can be placed at a distance from the source varying from 28 cm to about 125 cm (see illustration). All experiments are performed in completely safe operating conditions, in line with radiation protection criteria. The facility has been designed to ensure that the irradiation areas for samples placed at various distances will provide a high dose rate uniformity over the sample. It is also possible to irradiate several samples at the same time with different dose rates. Accurate measurements can be performed before and during an experiment to ensure precise dosimetry.

Photo: B. Caccia/ISS

Alessandro Campa

Given the dose rates involved, the LIBIS facility allows the biological effects on cell cultures to be studied under low and very low dose rate low LET radiation. The facility offers added value through its ability to enable comparisons to be made with the effects of acute irradiations, using the Gammacell® 40, which is housed in the same room of LIBIS, and with the effects of low dose rate high LET irradiation, using the alpha irradiator available within the same department. Thus, the relevance of radiation quality in low dose rate exposures can be studied.

LIBIS is open to collaboration with all interested research groups. Suggestions and proposals for projects are most welcome. Access to the infrastructure for joint research collaboration is free of charge under written agreement. The department also offers access to cell culture, biochemistry and molecular biology laboratories.

The LIBIS facility: the lead shields surrounding the incubator

Photo: G. Esposito/ISS

ID Card:

Exposure type:
External

Source:
Cs-137

Dose rate:
2 µGy/h - 20 mGy/h

Irradiation type:
Gamma

Irradiated organism type:
Cells

Address:
Istituto Superiore di Sanità
Viale Regina Elena, 299
00161 Roma, Italy

Access:
Joint research collaboration

Supporting lab:
Cell culture, biochemistry and molecular biology labs

Internet link:
Under construction

Contact:
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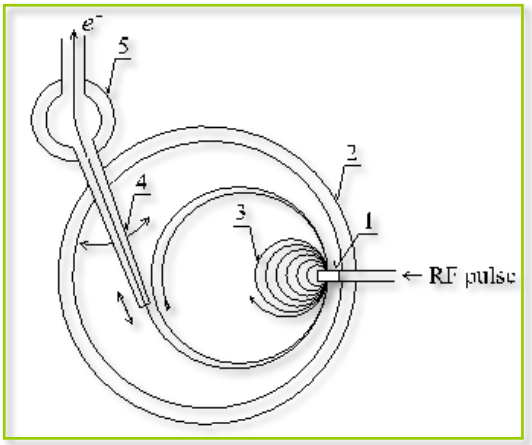
Related to:
DOREMI, MELODI, EURADOS

FACILITY FOR GAMMA IRRADIATIONS OF CULTURED CELLS AT LOW DOSE RATES: DESIGN, PHYSICAL CHARACTERISTICS AND FUNCTIONING. G. Esposito, et al. Applied Radiation and Isotopes, 115, 227-234 .

Microtron Laboratory

Microtron for biomedical, environmental and PAA procedures

The MT 25 Microtron in Prague is a cyclic electron accelerator with a Kapitza type resonator. The particles are accelerated by an RF electric field of constant frequency in a constant uniform magnetic field. In the vacuum chamber, the electrons follow circular paths with a common tangent point. The accelerating cavity, which is excited by the RF field, is located at this point. The Microtron MT 25 serves as a source of relativistic electrons (primary electron beam), secondary photon beams (bremsstrahlung) and neutrons from nuclear reactions.



The microtron scheme

Examples of accelerator applications:

Radiation resistance testing and studies in well controlled and monitored conditions are possible for electron and photon beams and for neutrons. Photon beams are frequently used for photon activation analysis of geological, biological, environmental and other samples. This method allows non-destructive determination of a large number of elements. The laboratory is equipped with a coaxial HPGe detector and multichannel analyser. The microtron laboratory was recently installed with a fully automatic pneumatic post for fast transport of samples between irradiation positions and a HPGe detector. This system expands the possibilities of photon activation analysis, as it enables determination of samples with short half-life. Some photo-nuclear reactions can produce a number of radionuclides. For example, it is possible to install a pilot apparatus for ^{123}I production. ^{124}Xe is irradiated under pressure; this radioisotope is generated for radiopharmaceutical production in an external workplace. The single workstation is equipped with a contrivance for the generation of highly homogeneous gamma and electron fields which determine with exactitude the values of dose rate (gamma fields – max. 10 Gy/min, electron fields – several hundred Gy/min, field size is 10x10cm^2). The calibrated ionisation chambers for gamma and electrons are made available (with relevant measure lines and a precision calibrated electrometer). The microtron laboratory is equipped with accurate, integral, electron current measurement from 10^9 to 10^{16} electrons/cm^2 for nuclear physics purposes.

Photo: Chvatil/NPI

David Chvatil

Radiation colouring of plastic materials, glasses and crystals produced by bremsstrahlung, and the modifications of their optical, electrical and mechanical attributes can be studied and tested. Both electron and photon beams are suitable for sterilisation. In the case of the electron beam, the sterilisation dose is reached within a few minutes (depending on the sample size). The beams with energy of up to 10 MeV are used for irradiation of biological, food and similar sample types. Crosslinking improves some properties of the polymers. Irradiation creates free radicals which will often produce various chemical reactions. The free radicals can recombine forming crosslinks. Radiation crosslinking can be performed using electron or photon beams. Electron beams are also used to produce the NV centres in nanodiamonds.

Vacuum chamber of the accelerator

Photo: Chvatil/NPI

ID Card:

Exposure type:
External

Source:
Electron accelerator Microtron MT25

Dose rate:
0.01 Gy – 10 kGy / min

Irradiation type:
Electron and gamma beam, neutron

Irradiated organism type:
Cells, animals (fish, rodents etc.) vegetal…

Address:
Nuclear Physics Institute of the CAS, p.r.i., Řež 130, 25068 Řež, Czech Republic

Access:
Free

Supporting lab:
SPF animal facility for experiments and breeding of small rodents, cell culture and immunology laboratory, microscopy

Internet link:
http://accs.ujf.cas.cz/mt25

Contact:
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anna.fiserova@fbmi.cvut.cz
+420 724127666
David Chvatil,
chvatil@ujf.cas.cz,
+420 222323657

Related to:
MELODI, ALLIANCE

A MATHEMATICAL MODEL OF THE MT 25 MICROTRON. *Journal of Instrumentation*. (2011),Krist, P. et al: T10005/1-T10005/13. ISSN 1748-0221
INNOVATIONS AT THE MT 25 MICROTRON AIMED AT APPLICATIONS IN PHOTON ACTIVATION ANALYSIS. *Journal of Radioanalytical and Nuclear Chemistry*. (2015), Krist, P. - et al s. 183-188. ISSN 0236-5731

Low dose rate facility at Stockholm University

Low dose rate exposure facilities for cells and animals

Stockholm University was founded in 1878. Today, it has 70,000 students, 1,800 doctoral students and a staff of 5,000 who are active within science, the humanities, social sciences and law. The first Chair of Radiobiology was appointed in 1962, at a time when the work focused on genetics and plant breeding. In 1972, Radiation Biology moved to the Wallenberg Laboratory at the new campus in Frescati, and in 1985 to the Arrhenius Science Laboratories.

In the 1970's, low dose radiation facilities were constructed for field experiments, mainly for plant genetics and genotoxicology. At that time there was already a strong focus on DNA damage, and several new methods were invented to measure DNA strandbreaks as well as chromosomal damage in plants and eukaryotic cells.

In the last two decades, the interest of the research groups has gradually moved towards risk estimates of low doses and dose rates, and to exploration of new technologies such as omics to study the cellular responses to doses in the mGy range. Thus new radiation exposure facilities were needed in the department and, with the help of skilled technicians and an excellent workshop, several new facilities were constructed, as described below.

At present two radiation facilities with caesium sources are available for chronic exposure of cells in culture, with dose rates ranging from 1 mGy/h up to 50 mGy/h, and dose rate can be decreased by lead shielding to a few µGy/h (picture 1) [1, 2].

A new radiation facility for animal exposure was constructed in 2015 and is equipped with a caesium source. This facility is constructed for exposure of mice to low doses and low dose rates. The dose rates range from 1 mGy/h up to 70 mGy/h and dose rate can be decreased by lead shielding to a few µGy/h. Mice can be exposed chronically and exposure time should not exceed 4 weeks. The animals are hosted in standard cages with space for up to 5 mice per cage. The facility can accommodate four cages placed one on top of the other, providing a gradient of dose rates (picture 2). After exposure, the mice can be kept in the animal facility for extended periods depending on the choice of endpoints.

Photo: Siamak Haghdoost (SU)

Siamak Haghdoost

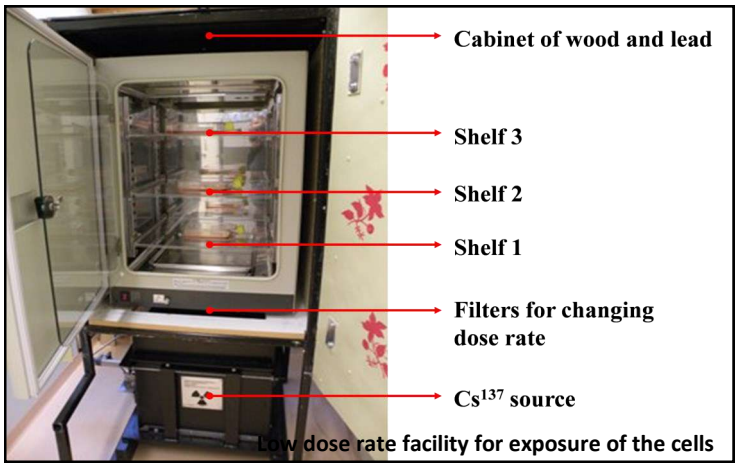

Photo: Siamak Haghdoost (SU)

Low dose rate facility for exposure of the cells

The construction has been approved by the Swedish Radiation Safety Authority (SSM) and complies with the ethical rules for animal experiments. The primary objective is to provide scientists in the field of radiation protection research with access to a low dose and dose rate exposure facility for short term exposure of mice.

The animal exposure facility is located in the Stockholm University animal facility, and includes animal care, animal exposure and post irradiation handling, for example, preparation of organs/samples at different times post irradiation. This radiation facility is primarily constructed for the study of biomarkers in response to low doses and dose rates and for studies of the mechanisms behind cellular/organ responses. It may also be used for pilot studies where only a small number of animals are needed.

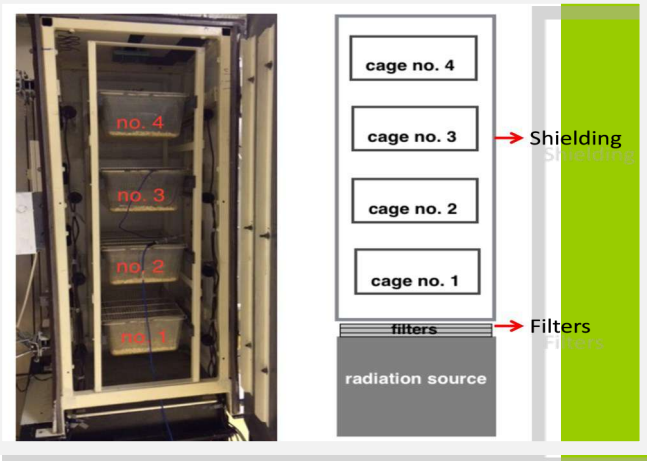

Photo: Siamak Haghdoost (SU)

Low dose rate facility for animal exposure

ID Card:

Exposure type:
Low dose rates external gamma radiation

Source:
Cesium 137

Dose rates

Cell culture facility:
From 1 to 50 mGy/h with lead shielding

Animal facility:
From 1 up to 70 mGy/h with lead shielding
Housing capacity: 4 cages and 5 mice per cage

Preferred type of organism for irradiation:
Mouse

Exposure time:
Up to 4 weeks

Address:
Centre for Radiation Protection Research
Department of Molecular Bioscience, Wenner-Gren Institute
Stockholm University
10691 Stockholm
Sweden

Access:
Joint research collaboration and upon ethical approval by the ethical committee

Contact:
Siamak Haghdoost
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tel:+46(0)8164064
Andrzej Wojcik
Andrzej.Wojcik@su.se
tel:+46(0)8161217

Related to:
MELODI, EURADOS

THE NUCLEOTIDE POOL, ATARGET FOR LOW-DOSE GAMMA-RAY-INDUCED OXIDATIVE STRESS,T. Sangsuwan, S. Haghdoost, Radiation Research, 170 (2008), 776-783

QUANTITATIVE PROTEOMIC ANALYSIS REVEALS INDUCTION OF PREMATURE SENESCENCE IN HUMAN UMBILICAL VEIN ENDOTHELIAL CELLS EXPOSED TO CHRONIC LOW-DOSE RATE GAMMA RADIATION. Yentrapalli, O. Azimzadeh, Z. Barjaktarovic, H. Sarioglu, A. Wojcik, M. Harms-Ringdahl, M.J. Atkinson, S. Haghdoost, S. Tapio, Proteomics, 13 (2013) 1096-1107

MICADO'LAB Experimental Platform

Effects on ecosystems of chronic exposure to gamma radiation

On 22 May 2017, the French Institute for Radiological Protection and Nuclear Safety (IRSN) inaugurated its new irradiation platform. MICADO'Lab (Moyen d'Irradiation Chronique pour l'Acquisition de relations DOse effet en Laboratoire) is an external gamma irradiation platform designed to study the effects on ecosystems of chronic exposure to ionising radiation.

MICADO'Lab is designed to cover the reference values for the ecosystem's protection and the band of dose rates (see graph) that could potentially result in deleterious effects in individuals from the different types of Reference Animals and Plants (Derived Consideration Reference Levels, DCRLs). The MICADO'Lab platform, set up on the Cadarache site (Bouches du Rhône, France), consists of an air-conditioned irradiation hall measuring 4 m in width, 35 m in length and 5 m in height, which is able to accommodate experimental equipment for the exposure of different biological models (cell cultures, plants and animals). Four ^{137}Cs sources are used to irradiate the organisms at dose rates ranging from 5 µGy/h to 100 mGy/h. The irradiation period of between a few hours and several weeks means that chronic exposure of one or more generations can be carried out.

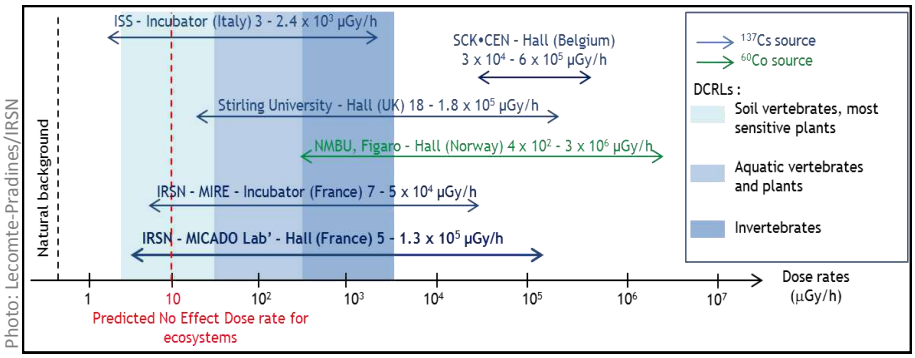


Photo: Lecomte-Pradines/IRSN

Comparison of MICADO'Lab and other European facilities
(reference value for ecosystem protection and DCRLs are indicated)

MICADO'Lab is open for scientific collaboration, especially on research conducted within the framework of European projects. This irradiation platform offers unique exposure conditions that complement the conditions offered by other European facilities, particularly in terms of the radiation energy and the range of dose rates that can be applied.

The research for which the facility is being used aims to:

- understand the mechanistic links between the effects observed at different biological levels (from molecules to individuals), in particular to identify early markers of toxicity (biomarkers),
- characterise and compare the radiosensitivity of species,
- evaluate the transgenerational effects (heritability, reversibility, adaptation),
- characterise the effects on the structure and function of ecosystems.

These studies are conducted on model organisms that are widely used in ecotoxicology (e.g. the zebrafish *Danio rerio*, the nematode *Caenorhabditis elegans* and the daphnid *Daphnia magna*) distinguished by their life cycle and radiosensitivity (see additional graph 1). Breeding facilities are available for such vertebrate and invertebrate species. Growth-chambers are also available for the research on plants and experiments with contaminated soils.

Photo: C. Adam-Guillermin/IRSN

Dr Christelle Adam

MICADO'Lab is part of a wider IRSN platform dedicated to the ECOtoxicology of Ionising Radiation & Trace Metals (ECORITME), allowed to host experiments using a wide spectrum of radionuclides. The effects of ionising radiations are measured experimentally from molecular level to individual level. Establishing the links between the different biological levels relies on the use of modelling tools (see analytical platform ECORITME page 4). The platform offers:

- analytical support consisting of physiology, cellular and molecular biology, biochemistry, microscopy and dosimetry laboratories, which are essential for characterizing radiation-induced effects at different biological levels;
- modeling support for performing and improving predictive ecological risk assessments for chronic exposure to low doses of ionising radiation and/or metals, in isolation or in mixtures (speciation-bioavailability relationships, dose-effects relationships, mixture exposure and effects models, PBPK models, individual to population extrapolation, ecological risk).

MICADO'Lab control room and view of the irradiation hall

Photo: Francesco Acerbis/IRSN

Gagnaire B et al. (2015) External gamma irradiation-induced effects in early-life stages of Danio rerio. Aquat Toxicol 169:69
Parisot F et al (2015) DNA alterations and effects on growth and reproduction in Daphnia magna during chronic exposure to gamma radiation over three successive generations. Aquat Toxicol 163: 27-36

IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

ID Card:

Exposure type: External

Source: ^{137}Cs (4x111 GBq)

Dose rate: 5 µGy/h to 100 mGy/h

Irradiation type: gamma

Irradiated organism type: model organisms in ecotoxicology (nematode, daphnid, zebrafish, plants…)

Address:
IRSN/PRP-ENV/SERIS
Bât. 159 – Cadarache, B.P. 3
13115 Saint Paul Lez Durance
France

Access: Joint research collaborations only

Supporting lab: cellular biology laboratory, breeding facilities, analysis platform (physiology, cellular and molecular biology, biochemistry, microscopy), dosimetry

Internet link:
http://www.irsn.fr/FR/Larecherche/outils-scientifiques/installations-moyens-experimentaux/Micado-Lab/

Contact: micado-lab@irsn.fr

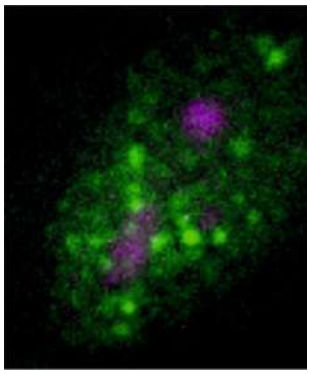
Related to: ALLIANCE, MELODI

Subcategory (b) Microbeams		
Infrastructure	Other categories	Page
SNAKE		16

SNAKE

Munich Ion Microbeam Irradiation Facility

The ion microprobe SNAKE (Superconducting Nanoprobe for Applied nuclear (German: Kern) physics Experiments) is installed at the 14 MV Tandem Accelerator in Garching near Munich and can be used for material analysis as well as for radiation biology research. The sub-micrometer beam size allows the targeted irradiation of single defined cells but also of more complex samples with single or counted ions, making it a suitable tool for low and high dose research. SNAKE provides protons and heavier ions with a wide energy range and thus LET range (2-2000 keV/µm), as follows:



Photo, C. Siebenwirth/UnibwM

Targeted irradiation (green cross) of a nucleolus (purple) in a cell nucleus

- protons: 4 – 28 MeV
- d, He, B, C, O: 2 – 10 MeV/nucl
- heavier ions: 0.2 – 4 MeV/nucl

By scanning the ion microbeam to irradiate one spot after another with a predefined pattern without targeting, it is possible to irradiate several cm² of cell cultures, tissues and small animals. The maximum ion range is obtained with protons, allowing irradiation of samples of up to 5 mm thick, such as 3D tissues, mouse ears or tumours. The heavier ions are more suitable for the exposure of single cell layers due to their lower range.

The live cell imaging setup with temperature control was designed for the irradiation of living cells with online monitoring. It can be used for targeted irradiation of single cells or even cellular substructures like mitochondria or nucleoli with a targeting accuracy <2 µm. Furthermore, it enables kinetic and dynamic studies of cell reactions, such as the (sequential) recruitment of several repair factors after DNA double-strand break induction.

Photo: UnibwM

Guenther Dollinger

At SNAKE, LET dependent studies using low and high LET particles can be used for intercomparison studies, in particular to investigate various endpoints of cell reactions after irradiation, especially at low doses.

Using the chopper-buncher system installed at the tandem accelerator, it is possible to form a short pulsed proton beam of about 1 ns duration at the target station of SNAKE. Using the focusing system of SNAKE, up to 20 Gy can be delivered in a single proton pulse to a beam spot of about 100 µm. This can be used to investigate ultra-high dose rate effects when irradiating from low to high doses.

The Facility offers access to the SNAKE microbeam, including all possible irradiation modes as described above, to potential users. Especially low-dose effects, also in the framework of bystander research, can be studied. In addition, for radiobiological experiments at SNAKE, access is provided to the biolab, including the cell cultures that have been developed, cell containers and irradiation and/or biological protocols. The user support staff are experienced in developing new irradiation as well as biological protocols as required, and in implementing and performing these protocols in collaboration with the external users.

SNAKE irradiation facility

Photo: T. Naeser/MAP

ID Card:

Exposure type:
External

Source:
14 MV Tandem Accelerator

Dose rate:
Single ion irradiation up to 10^9 Gy/s

Irradiation type:
Ions (protons, Li, C, …)
LET: 2-2000 keV/µm
Range < 5mm
Horizontal beam
Microbeam < 1 µm
Targeting accuracy < 2 µm

Irradiated organism type:
Cells, tissue, small animals

Address:
Maier-Leibnitz-Laboratorium (MLL),
85748 Garching, Germany

Access:
Joint research collaborations only, 3-6 beam times/yr

Supporting lab:
Cell culture

Internet link:
https://www.unibw.de/lrt2/forschung/snake

Contact:
Günther Dollinger,
guenther.dollinger@unibw.de

+49 8960043505

Related to:
MELODI, EURADOS, ALLIANCE

MICROIRRADIATION OF CELLS WITH ENERGETIC HEAVY IONS. Hauptner et al. 2004, Radiat Environ Biophys 42:237-245
LIVE CELL IMAGING AT THE MUNICH ION MICROBEAM SNAKE – A STATUS REPORT. Drexler et al. 2015, Radiat Oncol. 18;10:42

Subcategory (c) Particular radiation qualities: ions, neutrons, alpha…

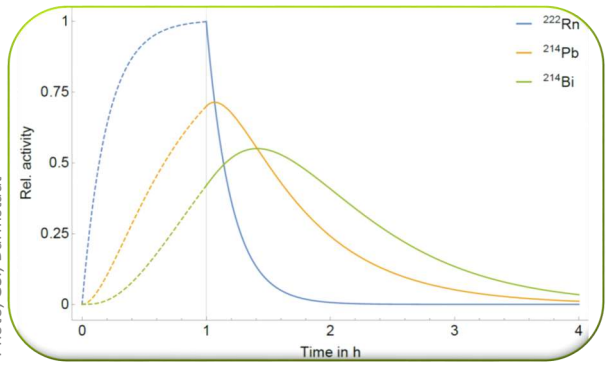
Infrastructure	Other categories	Page
Radon Exposure Chamber	(a) (d)	18
Biological Irradiation Facility (BIO)	(a)	19
CIRIL		20
Mixed alpha and X-ray exposure facility		21
Alpha particles irradiator		22
Changing dose rate exposure facility		23
Proton IRRADiation facility (IRRAD)	(f)	24

Radon Exposure Chamber

Investigating anti-inflammatory effects of ionizing radiation

Radon is used in the treatment of chronic inflammatory diseases such as rheumatoid arthritis or ankylosing spondylitis. Patients are subjected to radon baths or inhalation therapies in radon galleries. Within the GREWIS project, eight scientific groups at GSI, TU Darmstadt and the Universities of Frankfurt and Erlangen are currently investigating the underlying physical and biochemical mechanisms and the genetic effects potentially linked to low dose radon exposure.

At GSI, a radon chamber was constructed to mimick stable radon gallery conditions and up to 15 times higher radon concentrations. The complete chamber is positioned in a radiologically controlled area. In adjacent biological laboratories, experiments can be performed with cell cultures and small animals such as mice. The exposure chamber has a volume of 50 litres allowing the exposure of up to 15 mice or 24 petri dishes (diameter: 5.5 cm). During experiments, the samples are exposed to radon-222 and its short lived daughters. The gas accumulates in a radium-226 source and is flushed into the experiment chamber. By varying the accumulation time, it is possible to adjust the radon concentration. The dose depends on the activity-concentration and the exposure time and is usually in the µGy range. During the experiments, the system operates as a closed circuit. Before removing the samples from the chamber, it is flushed with air to dilute and wash out the radon, which is collected in an activated coal filter.



Photo, GSI, Darmstadt

Relative activity of the primary Rn-222 and the daughter nuclei Pb-214 and Bi-214 over time taking radioactive decay and diffusion into account

The chamber is mounted in a heated water bath with an integrated thermostat, which enables the temperature to be controlled with high accuracy and stability. In addition, the relative humidity is controlled using a carrier gas mixed with vaporized sterile water to avoid biological contamination. For cell culture experiments, additional CO_2 regulation can be used which is deactivated for animal experiments. A summary of the different parameters and their limiting values is illustrated in the table below.

Photo: G. Otto/GSI, Darmstadt

A. Maier, G. Kraft, C. Fournier

After an intense test phase, the radon chamber was used to expose mice in therapy-like conditions, and biological tissue up to the highest possible concentration. In the mice experiments, the local exposure of radon was detected using a marker for DNA damage (double strand breaks) in various tissues. Tissue samples such as fat, bone and tendon from commercially available pork meat were used for the first measurements. These revealed that primary radon diffuses out of the tissue within a few minutes after exposure and that the residual radioactivity originates from the daughter nuclei. The amount of the primary radon in the tissue sample could be calculated from the measurement of the gamma activity of lead and bismuth using a sensitive intrinsic Ge detector. A new mobile detector system has been established that will enable in situ measurements to be performed at the radon therapy locations.

Parameter	Range
Activity concentration	0-620 kBq/m³
Temperature	20-37°C
Relative humidity	0-100%
CO_2-concentration	0-20% (only during cell experiments)

Radon exposure chamber

Photo: E. Thoennes/GSI, Darmstadt

ID Card:

Exposure type:
External (cell culture)
External/Internal (mice)

Source:
Radon-222

Dose rate:
To be determined according to the radon activity concentration, the biological half-life and the duration of the exposure

Irradiation type:
Alpha (5.5 MeV, 6.0 MeV, 7.7 MeV)

Irradiated organism type:
Cells, animals (e.g. mice)

Address:
GSI Helmholtzcenter for Heavy Ion Research, Planckstraße 1, 64291 Darmstadt, Germany

Access:
Registration for cell experiments; animal experiments need to be licensed by local authorities

Supporting lab:
Biochemistry lab, cell culture lab, microscopy, FACS

Internet link:
www.gsi.de/en/work/research/biophysics.htm

Contact:
Claudia Fournier, c.fournier@gsi.de, +49 6159 71 2106
Andreas Maier, a.maier@gsi.de, +49 6159 71 2585

Related to:
MELODI, EURADOS, ALLIANCE

EXPERIMENTAL SETUP FOR RADON EXPOSURE AND FIRST DIFFUSION STUDIES USING GAMMA SPECTROSCOPY. A. Maier et al., Nucl. Instr. Meth. Phys. B 2015, 326: 187-193

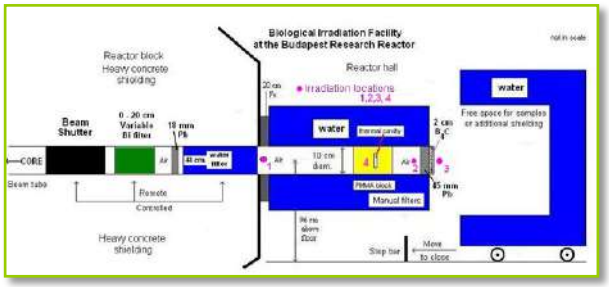
RADON EXPOSURE SETUP FOR CELLS AND SMALL ANIMALS. A. Maier et al. GSI Scientific Report 2013, p. 247

BIOLOGICAL IRRADIATION FACILITY (BIO)

Providing a reliable platform for biological irradiation studies

The Biological Irradiation Facility operates within the Budapest Neutron Centre (BNC) to provide a reliable platform for biological irradiation studies. The physical properties of the facility are described below.

The channel lock consists of 3 segments made of steel and heavy concrete and turnable around an eccentric axis to open and close the channel. There is a remotely controlled internal filter holder, at a distance of 262 cm from the core, which has six windows with the following characteristics: four Bi disks of 5, 10, 15 and 20 cm, one Pb disk of 20 cm thickness, and the 6th window is an open hole. At the orifice of the beam tube, two cylindrical tanks constructed from alumina serve respectively as a water shutter and as its emergency water storage. The water can be pumped up from and released into a larger buffer tank located outside the reactor shielding block using pressurised air. The construction materials inside the beam tube work as internal, non-removable filters with total thickness of 18 mm Pb and 15 mm Al.



Source: www.bnc.hu

Figure 1: Schematic view of the Biological Irradiation Facility

The irradiation cavity is situated outside the shielding block of the reactor at a distance of 1400 mm, thus its surface-to-reactor core distance is 3100 mm including the exchangeable core window (65 mm), made either of beryllium (serving as the fast neutron reflector also) or aluminium. The use of the aluminium window results in a hard neutron spectrum. Between the shielding surface of the reactor and the cavity, there is a borated water shielded collimator with a useful diameter of 10 cm. It is possible to use this collimator as a holder for external filters of about 800 mm length. At present, filters made of plexiglass, polyethylene, iron, aluminium and lead are available to decrease the gamma and neutron intensity or to modify the neutron spectrum and the neutron-to-gamma ratio. There are two changeable filter disks of boron-carbide which work as thermal and epithermal absorbers. The collimator is movable on a rail. The samples to be irradiated can be rotated to achieve a uniform, homogeneous irradiation. Cadmium or boron-carbide filters are used, if required, for decreasing the thermal neutron contribution.

Balázs Zábori

Three levels of the dosimetry system were developed: real time, active beam monitors; passive activation, track-etched and TL detectors, and computer codes for spectrum and dose calculations. Each exposure is individually planned and continuously monitored during the procedure. Some typical dose and flux values are presented in Table 1 and a schematic view of the system is presented in Figure 1.

The irradiation facility is suitable for studying the effects of the neutron and gamma radiation and high dose rate on seeds, cells, electronic devices, etc.

Quantity	Energy range	Min	Max
Neutron dose rate (mGy/s)	E > 0.5 eV	0.023	14
Gamma dose rate (μGy/s)	-	1.5	2570
Fast neutron flux ($cm^{-2}s^{-1}$)	E > 100 keV	2×10E+6	2×10E+9
Intermediate neutron flux ($cm^{-2}s^{-1}$)	100 keV > E > 0.5 eV	8×10E+3	2×10E+6
Thermal neutron flux ($cm^{-2}s^{-1}$)	E < 0.5 eV	5×10E+4	3×10E+8

Table 1:Presently existing minimum and maximum dose and flux values.

The hall of the research reactor

Source: www.bnc.hu

BNC Budapest Neutron Centre

ID Card:

Exposure type:
External

Source:
Research reactor

Neutron dose rate:
0.023 – 14 mGy/s

Gamma dose rate:
1.5 – 2570 μGy/s

Irradiation type:
Neutron, gamma

Possible targets:
Seeds, cells, small animals, electronic devices etc.

Address:
H-1121, Budapest, Konkoly-Thege M. út 29-33.
Hungary

Access:
Joint ongoing research collaboration or made available with charge for access costs

Supporting lab:
Radiation protection laboratories, cell culture lab in the near future

Internet link:
http://www.bnc.hu/?q=node/8

Contact:
Balázs Zábori,
zabori.balazs@energia.mta.hu

Related to:
ALLIANCE, EURADOS, MELODI

REALISTIC NEUTRON SPECTRA FOR RADIATION PROTECTION AND OTHER APPLICATIONS AT AERI, BUDAPEST. Pálfalvi J.K., et al. 2002. Nucl. Instrum. Methods A 476, 452-456.
RADIATION DAMAGE IN VIDEO DIAGNOSTIC DEVICES FOR WENDELSTEIN 7-X. Náfrádi, et al. 2008. 4 p. (Europhysics conference abstracts; Vol 32D P 5.079.)

CIRIL

Centre for Interdisciplinary Research with Heavy Ions

The heavy ions accelerated at the GANIL facility (Caen, France) interest not only nuclear, atomic or solid state physics but are also a valuable tool for various studies in radiobiology. The GANIL accelerator can provide various beams, from carbon to uranium, at maximum energies ranging from 95 MeV/A for light ions down to 24 MeV/A for uranium. GANIL cyclotrons supply a wide range of energy, which can be extended further by beam degraders. For the last 20 years, the CIMAP laboratory has managed the CIRIL platform lab user facility for Interdisciplinary research at GANIL, which was reinforced 15 years ago by the radiation-biology laboratory LARIA. The biology platform operated by LARIA includes a comprehensive tissue culture room, a molecular biology laboratory and a proteomics laboratory, allowing hosted teams to perform various canonical assays in the radiation biology field. Furthermore, the platform can be adapted for special requirements. The automatic biological sample holder designed at CIMAP can be used with 12.5 and 25 cm^2 flasks, tubes (0.5 ; 1.5 ; 2 and 15 ml), lab-tek™ chamber slide, 8 cm^2 culture dishes and 96-well plates (36 wells irradiated). Fields of interest for platform users are either radiation protection of space travelers (healthy tissues) or cancer treatment (tumours and surrounding healthy tissues). The CIRIL staff consists of the scientific coordinators, the technical coordinators of the four beam lines devoted to interdisciplinary research, the CIMAP technical staff, the physicists of AMA and MADIR, and the radiation-biologists of the LARIA groups who serve as local contacts or beamline scientists for external users.

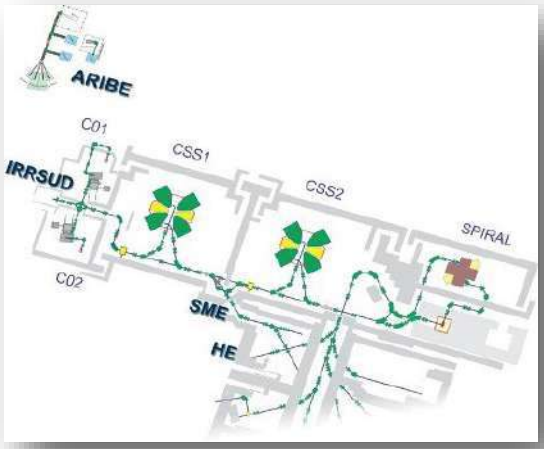


Photo: GANIL

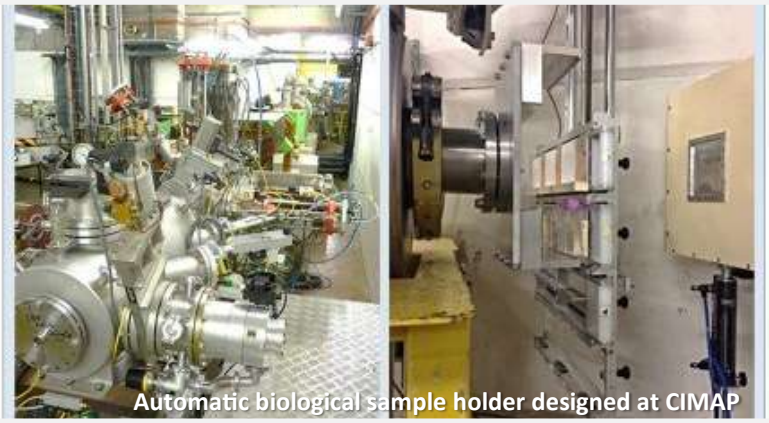
The 4 beamlines for the interdisciplinary researches corresponding to 4 exits at different locations on the ion accelator. ARIBE is located outside the GANIL INB, whereas IRRSUD, SME and HE are inside the INB on the GANIL facility.

Photo: F. Chevalier, LARIA-IRCM

F. Durantel - Y. Saintigny

Most biology ion exposures are currently performed in the D1 experimental area through the high energy (HE) beam line IRABAT and soon through the medium energy (SME) beam line IRASME. Thanks to the CIMAP expertise in ion irradiation, specific on-line instrumentation has been developed, such as the multi-sample irradiation holder (remotely controlled), beam control software and low dose on-line dosimetry. Most importantly, for each experiment, a team of physicists participates in the beam tuning and dosimetry. This activity has been the initial step to larger local projects linked to the development of hadron-therapy in France (Archade). Most irradiation for biological experiments is done at low dose/fluence (<10 Gy, 10^5-10^7 particles/cm^2). Moreover, studies are focused on ion distribution in adherent cells or 3D models. Providing accurate dosimetry is thus a crucial point for these kinds of experiments.

All the interdisciplinary experiments performed at GANIL have to be evaluated by an international and independent scientific committee (iPAC), even those proposed by CIMAP researchers. Each year, more than 25 UT (25 x 8 hours) of beam time are allocated to the radiation-biology programme by iPAC.



Automatic biological sample holder designed at CIMAP

Photo: F. Chevalier, LARIA-IRCM

ID Card:

Exposure type:
External exposition

Source:
Cyclotrons

Dose rate:
0.5 to 5 Gy/min

Irradiation type:
Accelerated ions beam (^{12}C to ^{206}Pb). Horizontal

Irradiated organism type:
Cells (2D and 3D models)

Address:
GANIL – CIMAP, Bd Henri Becquerel, 14070 Caen, France

Access:
Selection committee (iPAC)

Supporting lab:
Radiation biology platform with cell culture lab, biomolecular and biochemistry lab.

Internet link:
http://cimap.ensicaen.fr/spip.php?rubrique138

Contact:
Florent Durantel, durantel@ganil.fr; ciril@ganil.fr

Yannick Saintigny, saintigny@ganil.fr

Related to:
MELODI, ALLIANCE, EURADOS

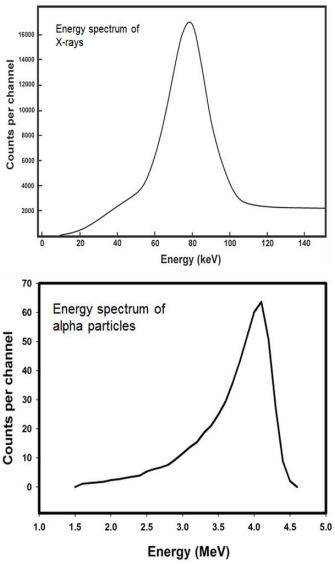
DOSIMETRY FOR RADIOBIOLOGY EXPERIMENTS AT GANIL. Durantel et al. NIM A. 2016.

ACTIVATION OF THE NUCLEAR FACTOR KB PATHWAY BY HEAVY ION BEAMS OF DIFFERENT LINEAR ENERGY TRANSFER. Hellweg et al. Int. J. Radiat. Biol., vol. 87, no. 9, pp. 954–963, Sep. 2011.

Mixed alpha and X-ray exposure facility

Simultaneous exposure of cells to high and low LET radiation

People are often simultaneously exposed to a mixed field of low and high linear energy transfer (LET) radiation. The most common scenario occurs in areas with high natural background radiation, where both the levels of gamma radiation and indoor radon are elevated. Another situation occurs during aeroplane and space flights where cosmic high LET radiation interacts with shielding material to produce gamma radiation. Finally, radiotherapy patients treated with intensity-modulated radiation therapy, fast neutron therapy and boron neutron capture therapy are exposed to mixed beams of neutrons and photons.



An important question related to the health effects of exposure to mixed beams is whether the risk can be calculated by simply adding the effects of the low and high LET dose components or whether the different radiations act in a synergistic manner. The available experimental data do not allow a definite conclusion to be drawn. Indeed, both additivity and synergism have been reported. The reason for this discrepancy is not understood but one factor could be that cells are exposed sequentially, rather than simultaneously, to the two types of radiation. Simultaneous irradiation is the desirable scenario but requires a dedicated irradiation facility. At Stockholm University, a facility has been constructed where cells can be simultaneously exposed to 241Am alpha particles and X-rays at 37 °C.

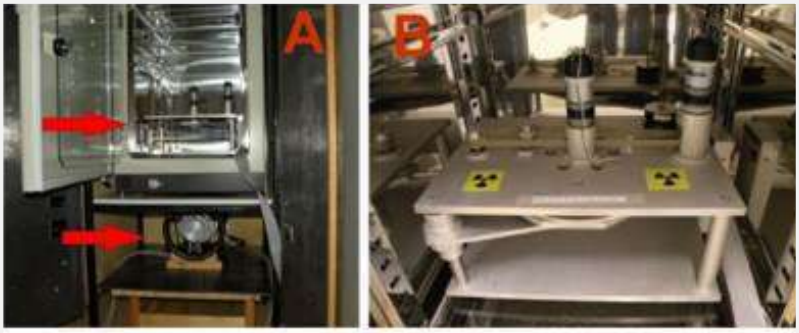
Photo: A. Wojcik/SU

Andrzej Wojcik

The facility consists of an alpha irradiator, custom-constructed in the Institute of Nuclear Chemistry and Technology, Warsaw, Poland, an X-ray tube (YXLON SMART 200, Yxlon International, Hamburg, Germany) and a 164 l cell incubator. The alpha irradiator is positioned inside and the X-ray tube under the incubator. The whole setup is placed in a lead container so that it can be safely operated in a laboratory room.

The source of alpha radiation is 241Am (Eckert and Ziegler, Berlin, Germany) with a total activity of 50 MBq. The source is attached to a steel disc that in turn is glued to a circular turn-table, with the active side (ca 15 cm in diameter) facing downwards. Below the source is an aluminium shelf on which cells on polyamide discs can be positioned for exposure and covered by a Mylar foil. The shelf can be moved vertically by a remote-controlled step-engine. The X-ray tube is operated at 190 kV, 4.0 mA without any additional filtering.

The facility works as intended, allowing exposure of cells to alpha particles, X-rays and a combination of both in a temperature-controlled environment. It allows to further characterise the response of cells, both adherent and in suspension, to mixed beams of high and low LET, thus providing the opportunity to generate much needed data on the effect of mixed beams of ionizing radiation.



A: Incubator with the alpha irradiator (top arrow) and the X-ray tube underneath (bottom arrow). B: Close-up picture of the alpha irradiator

Photo: A. Wojcik/SU

ID Card:

Exposure type:
External

Source:
Am-241, X-ray machine

Dose rate:
Alpha: 0.26 Gy per minute
X-rays: 0.06 Gy per minute

Irradiation type:
Alphas and photons, vertical beams

Irradiated organism type:
Adherent cells

Address:
Stockholm university

Access:
Free, decision by source owner

Supporting lab:
Biomolecular and cell culture lab

Contact:
Andrzej Wojcik
andrzej.wojcik@su.se
tel: 0046762122744

Related to:
MELODI, EURADOS

CHARACTERISATION OF A SETUP FOR MIXED BEAM EXPOSURES OF CELLS TO 241AM ALPHA PARTICLES AND X-RAYS. Staaf E, et al. Radiat Prot Dosimetry. 2012 Sep;151(3):570-9.

COMPLEX ABERRATIONS IN LYMPHOCYTES EXPOSED TO MIXED BEAMS OF 241AM ALPHA PARTICLES AND X-RAYS. Staaf E, et al. Mutation Research 756: 95-100, 2013.

Alpha particles irradiator

Irradiator for studies with cultured cells at low dose rate

The alpha-particle irradiator was designed and constructed at the Istituto Superiore di Sanità (ISS) in Rome, for the exposure of cultured cells in physiological conditions, to dose rates ranging from a hundred of microGy/h to few tens of Gy/h. It consists of a stainless steel cylindrical chamber, 240 mm in diameter and 197 mm high, that can be equipped alternatively with Cm-244 or Am-241 sources of different activities. The bottom and top of the cylinder are closed by flanges of the same stainless steel. The chamber, flushed with helium gas at a pressure kept slightly above the external pressure, is inserted into a cell culture incubator where temperature and CO2 concentration are strictly controlled. The top flange has a hole where a specially designed petri dish 56 mm in diameter, with a thin Mylar^{R} bottom, can be inserted to irradiate the cells growing as a monolayer on the Mylar^{R} foil. The residual range of alpha particles at the cell entrance is enough to irradiate the cells in a nearly track-segment mode.

Spectrometric and dosimetric characterisation of the irradiator was carried out by means of an ion-implanted silicon charged-particle detector, CR39 detectors, and Monte Carlo simulations. For both sources, the uniformity of the alpha particles dose on the sample was better than ±7 %; this uniformity is obtained by an appropriate compromise between the source-to-sample distance and the sample area. The values of the LET incident on the cell sample can be varied in the range (90 – 130) keV/micron approximately. The dose rate can be varied by changing the source-to sample distance or by placing a collimator in proximity of the source.

The facility is especially suitable for bystander experiments. Adaptors have been designed in order to reproduce the geometry of commercial cell culture companion plates. A co-culture system can be used to investigate effects induced by factors released into the culture medium from directly targeted cells on cells, growing on inserts, placed at a distance that is well beyond the range of the alpha particles. Partial irradiation of the sample can also be performed by shielding part of the irradiation dishes. For both the Cm-244 and Am-241 sources, the photon dose to directly irradiated and bystander cells is negligible.

This alpha irradiator facility represents a useful resource to study a variety of biological effects induced by low dose rate alpha particles. These studies can provide data of interest for radiation protection and therapy due to the role of alpha particles in background radiation exposure (which is largely due to inhalation of radon and its progeny) and in nuclear medicine therapies with alpha emitters. The facility is open for collaboration, and any suggestions for projects with CONCERT partners are very welcome.

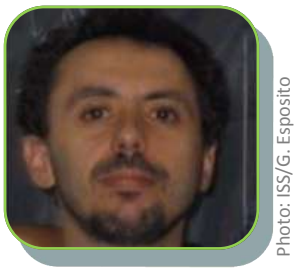


Photo: ISS/G. Esposito

Dr Giuseppe Esposito

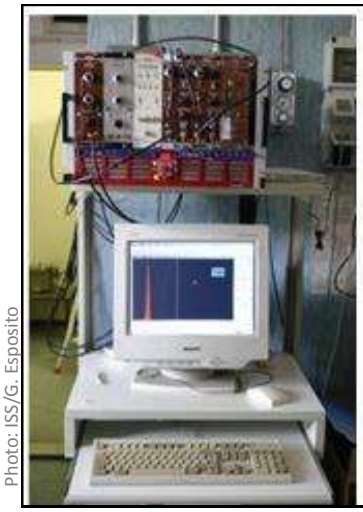
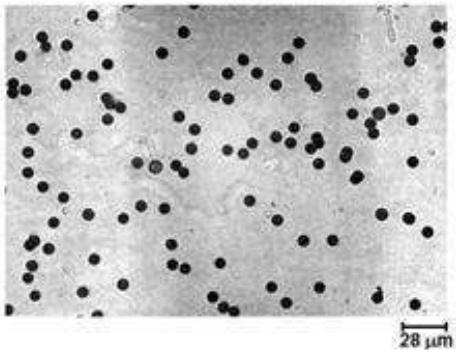


Photo: ISS/G. Esposito

← **Electronic chain implemented by (NIM)-modules for the energy spectrum measurement**



↑ **Etched tracks in a CR39 detector**

Photo: ISS/G. Esposito

Alpha particles irradiator at the Istituto Superiore di Sanità

Esposito G. et al., 2006, A ^{244}Cm Irradiator for protracted exposure of culture mammalian cells with alpha particles, Health Physics, 90, p66-73

Esposito G. et al., 2009, An alpha particle irradiator for biological research and its implementation for bystander effect studies, Radiation Research, 172, p632-642

ID Card:

Exposure type:
External

Source:
Am 241 or Cm 244

Dose rate:
~130 µGy/h to 20 Gy/h

Irradiation type:
Alpha particles

Irradiated organism type:
Cells

Address:
Istituto Superiore di Sanità
Viale Regina Elena, 299
00161 Roma, Italy

Access:
joint research collaboration

Supporting lab:
Cell culture, biochemistry and molecular biology labs

Internet link:
Under construction

Contact:
Giuseppe Esposito,
giuseppe.esposito@iss.infn.it
+39 0649902006
Maria Antonella Tabocchini,
antonella.tabocchini@iss.it
+39 0649903020

Related to:
MELODI, EURADOS

Changing dose rate exposure facility

Exposure of cells to continuously changing photon dose rate

Exposure scenarios where the dose rate is continually changing are very common. A good example is aircraft flight where the dose rate of cosmic radiation can change 16-fold during take-off and landing. Moreover, there are many accidental exposure scenarios where either the sources or the exposed subjects are in motion with respect to one another. Despite the fact that many exposures involve changing dose rates, the vast majority of research studying the effects of ionising radiation is performed exposing samples at constant dose rates. It is possible that the technical limits of the irradiation equipment used may prevent other types of exposure scenarios. However, effects from such exposures may be highly relevant for the assessment of radiation risk. Thus, it is surprising that research on the biological effects of changing dose rates has, until recently, been neglected.

Photo: Andrzej Wojcik (SU)

The facility inside an incubator

The presistaltic pump is not visible. The X-ray tube is positioned below the incubator and the whole setup is enclosed in a lead cabinet for safe use

To study the effects of changing dose rates, we have constructed a facility where three samples can be simultaneously irradiated with X-rays either at an increasing, a decreasing, or a constant dose rate. The facility fits inside a 37°C incubator that can be positioned above an X-ray tube or a gamma source. Cells in tubes, flasks or Petri dishes can be simultaneously exposed to an increasing, a decreasing and a constant dose rate in the range of 2.2 to 37 mGy per minute.

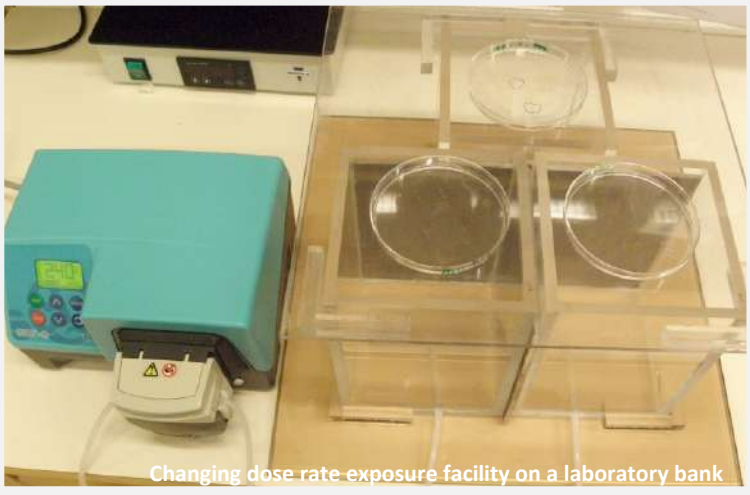
The facility is composed of three identical Plexiglas tanks, separated by 4 mm lead plates to absorb scattered radiation. Tanks 1 and 2 are interconnected by a silicone tube via a peristaltic pump. Cell samples can be positioned on top of the tanks. The facility fits inside a 164 l cell incubator modified so that there are no wires or electronic components in its bottom plate. An X-ray tube is placed under the incubator and the distance from the X-ray source to the bottom of the facility is ~ 30 cm. The beam angle, as given by the manufacturer, is 40º x 55º.

Photo: Andrzej Wojcik (SU)

Andrzej Wojcik

During exposure, the pump transfers the shielding medium, an aqueous solution of barium chloride, from one tank (increasing dose-rate, IDR) into the other (decreasing dose-rate, DDR), resulting in an exponential, 14-fold dose-rate change during the exposure. Tank 3 (average dose-rate, ADR) contains a volume of barium chloride resulting in the same dose-rate on top of the tank as the average dose-rate on top of tanks 1 and 2. The exposure is monitored with an ionisation chamber positioned on the tank that is acting as the IDR tank, and terminated when the starting conditions have been reversed on top of tanks 1 and 2. Consequently, the same total dose will have been delivered on top of all three tanks when the exposure is terminated.

The facility makes it possible to characterise the cellular response to changing dose rates. The design and low building cost of the device permit users to customise and build a device to suit their particular needs, encouraging other research groups to contribute to the understanding of the effects of changing dose rates.



Changing dose rate exposure facility on a laboratory bank

Photo: Andrzej Wojcik (SU)

Petri dishes are placed on top of tanks between which a barium chloride solution is pumbed with the help of a peristaltic pump (green). A third tank (visible behind the two front tanks) is permanently filled with a volume of barium chloride that yields the average dose rate. Consequently, cells on all three tanks receive the same dose

A NEW DEVICE TO EXPOSE CELLS TO CHANGING DOSE RATES OF IONISING RADIATION, Brehwens K et al. Radiation Protection Dosimetry, 148 (2003), 366-371

MICRONUCLEUS FREQUENCIES AND CLONOGENIC CELL SURVIVAL IN TK6 CELLS EXPOSED TO CHANGING DOSE RATES UNDER CONTROLLED TEMPERATURE CONDITIONS, Brehwens K et al. International Journal of Radiation Biology, 90 (2014), 241-247

Stockholm University

ID Card:

Exposure type:
External

Source:
Xray machine

Dose rate:
2.2 to 37 mGy per minute

Irradiation type:
photons, vertical beam

Irradiated organism type:
Cells in culture

Address:
Stockholm University

Access:
free, decision by source owner

Supporting lab:
Biomolecular and cell culture lab

Internet link:

Contact:
Andrzej Wojcik
Andrzej.wojcick@su.se
tel:+46(0)8161217

Related to:
MELODI, EURADOS, RENEB

Proton IRRADiation facility (IRRAD)

A 24 GeV/c p^+ beam for the qualification of HEP components

The proton **IRRAD**iation Facility (IRRAD), located in the East Area of the Proton Synchrotron (PS) accelerator at CERN, is mainly used to qualify components for High Energy Physics experiments. This includes both low-Z samples such as thin silicon devices and particle-detector test structures, and high-Z samples such as the dense materials used in the construction of calorimeter devices. Moreover, at IRRAD it is also possible to perform tests on electronic components/systems, radiation monitoring devices and dosimeters in passive mode with reduced power requirements, and with an active readout.

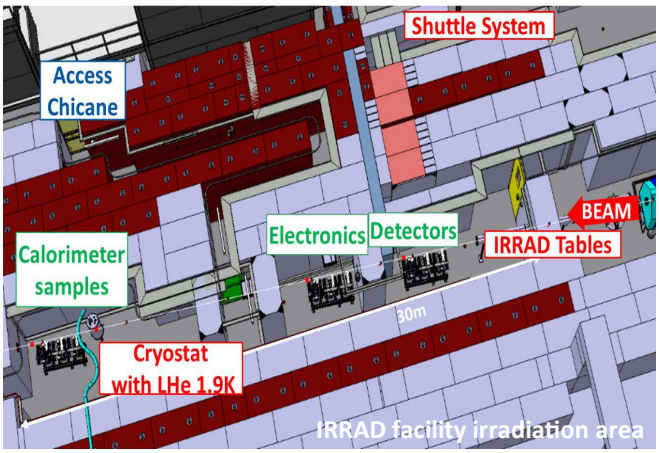


Photo: IRRAD team/CERN

The PS accelerator supplies IRRAD with a 24 GeV/c proton beam of variable size ranging from 12×12 mm^2 to 20×20 mm^2 in spills of ~400 ms duration, every 10 s on average. Other beam sizes are available to users upon request. IRRAD is equipped with remotely controlled tables to precisely position the samples in the proton beam. The volume available for irradiation may reach up to 20×20×50 cm^3. In addition, a remotely controlled conveyer (*IRRAD1 shuttle*) is available for the irradiation of small and passive samples, with maximum overall dimensions of 5×5×15 cm^3; this shuttle can be moved from the outside area to the irradiation position without the need to stop the beam and disable human access inside the area.

The IRRAD1 shuttle travels across the radiation shielding blocks for a distance of ~10 m through a conduit of 400×400 mm^2, designed to minimise direct radiation streaming. For both types of systems, dedicated user interfaces allow users to remotely control them in an easy and user-friendly manner, and to monitor the sample positions and the environmental conditions of IRRAD in real time. All this information is displayed on dedicated webpages accessible to the users.

Furthermore, at IRRAD it is also possible to perform irradiations at low temperature (down to -25°C). Two cooling systems located outside the irradiation area provide chilled fluid to the specially designed cold boxes positioned on two IRRAD tables. In addition, a cryostat filled with liquid Helium (LHe) allows special irradiations to be performed with samples exposed at cryogenic temperatures down to 1.9 K.

Photo: CERN EP/EN department

IRRAD facility team

With regard to dosimetry, pure Aluminum foils are used to measure the total proton fluence delivered to a sample with a precision of ±7%. This is achieved by performing γ-spectrometry measurements of the irradiated foil samples to evaluate the ^{24}Na and ^{22}Na activities. Other types of dosimetric technologies are also available at IRRAD (Alanine, RPLs, GaF films, etc.) depending on user requirements.

To guarantee precise beam steering along the beamline, a dedicated instrument, the Beam Profile Monitor, is used. This provides a real time image of the Gaussian beam profile in a webpage display. The same type of detector is used to align the IRRAD tables with regard to the beam trajectory and to provide users with detailed information on the beam delivered to their samples.

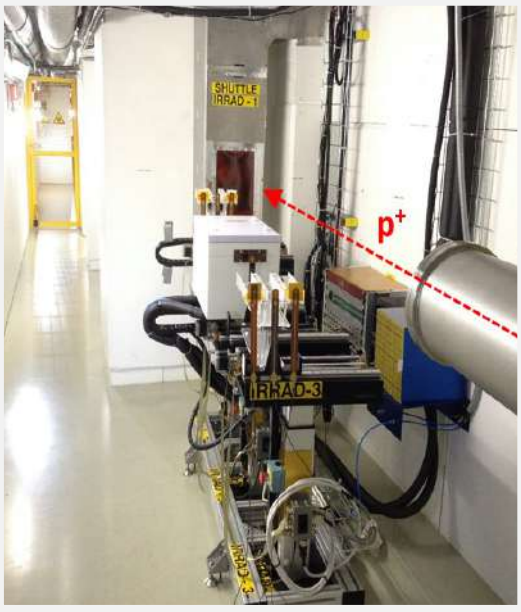


Photo: IRRAD team/CERN

IRRAD tables (foreground). IRRAD1 shuttle conduit (background).

ID Card:

Exposure type:
External

Source:
CERN Proton Synchrotron Accelerator

Dose rate:
~5×10^{11} p/spill
(~5×10^{15} p/cm^2/week corresponding to ~ 1.5 MGy/week in Si on 10×10 mm^2)

Irradiation type:
Proton

Irradiated organism type:
N/A

Address:
CERN
CH-1211
Geneva 23
Switzerland

Access:
Prior agreement/research collaboration services

Supporting lab:
N/A

Internet link:
https://ps-irrad.web.cern.ch

Contact:
Federico Ravotti
+41 22 76 74280
irrad.ps@cern.ch
Federico.Ravotti@cern.ch

Related to:
AIDA-2020
EURADOS

IRRAD: The New 24GeV/c Proton Irradiation Facility at CERN, Gkotse B., Glaser M., Moll M., Ravotti F. (2015), In Proc. AccApp'15 , Washington, DC, 182-187

The Beam Profile Monitoring System for the IRRAD Proton Facility at the CERN PS East Area, Gkotse B., Glaser M., Matli E., Ravotti F., Gan K. K., Kagan H., Smith S., Warner J. (2015), In Proc. AccApp'15, Washington, DC, 479-484

Subcategory (d) Internal contamination		
Infrastructure	Other categories	Page
B3, Animal Contamination Facility	(c)	26
Facility radionuclides availability, transfer and migration		27
Nanoparticle Inhalation Facility		28

B3, Animal Contamination Facility

Actinide behavior following lung or wound contamination

The RadioToxicology Laboratory (LRT) was created in 1961. Since then, numerous experiments have been carried out using a variety of radionuclides. The main focus of activity is on actinides.

The LRT houses a radiologically-controlled zone with a dedicated animal house facility where inhalation and other methods of internal contamination using alpha emitter actinides

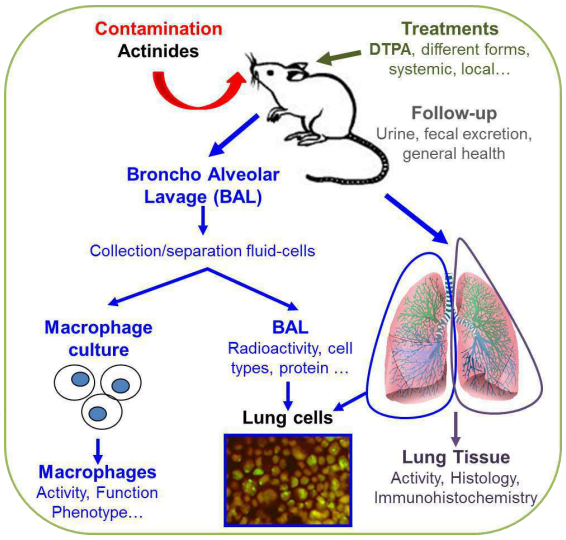


Diagram: CEA/N. Griffiths

Road map for studies after inhalation of actinides

(Plutonium Pu, Americium Am, MOX: Mixed OXide of Uranium U, Pu) are performed. The use of actinides is tightly controlled and requires effective confinement during experimental procedures. The inhalation system to expose animals is within a modified glove box. During inhalation, the animals are conscious and restrained in cardboard tubes with a perforated cover at the head end to allow breathing. This type of exposure is termed "nose-only", and up to 30 rats can be exposed at any one time.

The aerosols created for contamination may be collected and characterized in terms of particle size (cascade impactor). This experimental technique allows simulation of a realistic contamination scenario involving radioactive elements, most likely in an insoluble form, which could be released into the atmosphere (see example of a road map for an actinide inhalation study in figure).

In addition to inhalation studies and lung pathologies with MOX, Pu or Neptunium, the following subjects have been addressed: Pu-induced osteosarcomas, development of a wound model for actinide contamination and evaluation of different decorporation regimens. Tissue samples, mainly paraffin embedded and collected over the decades, have recently been classified, and form the basis of the in-house "Experimental Radiotoxicology Biobank". This bioresource incorporates different tissues, contaminants and routes of contamination.

Photo: P Herpin

Nina Griffiths

LRT also carries out *in vitro* experiments to improve the estimation of dose distribution in human lung epithelial cell monolayers after contamination with alpha emitting radionuclides. Numerical models of cell monolayers can be derived from confocal images. γH2AX foci are markers of radiation-induced DNA damage. This work aims to facilitate assessment of the heterogeneity of dose distribution from alpha particle emitters in cells.

Lastly, LRT performs research *in silico* and is currently developing a unique numerical toolkit to facilitate storage and analysis of the numerous experimental data acquired in the laboratory under various conditions. This toolkit is designed to contribute to a better understanding of actinide biokinetics with particular emphasis on contamination conditions such as the route of intake or the physicochemical form.

Inhalation system for rats

Photo: CEA/DAM/CADAM

ID Card:

Exposure type:
Internal contamination

Source:
Actinides

Dose rate:
To be determined as a function of the radionuclide, radioactive and biological half-life, the administered activity, the duration of the experiment and the potential use of decorporation/ decontamination procedures.

Irradiation type:
Alpha (5000 keV)

Irradiated organism type:
rats, cells

Address:
CEA of Bruyères-le-Châtel,
Domaine du Grand Rué,
BP12 Bruyères-le-Châtel,
91297 ARPAJON cedex , France.

Access:
Use of the facility requires specific authorization for people and projects in addition to authorization for animal experiments

Supporting lab:
Radiochemistry, biochemistry, cell culture, microscopy

Internet link:
http://ircm.cea.fr/dsv/ircm/Pages/Equipes/LRT.aspx

Contacts:
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+33 (0)1 69 26 57 12

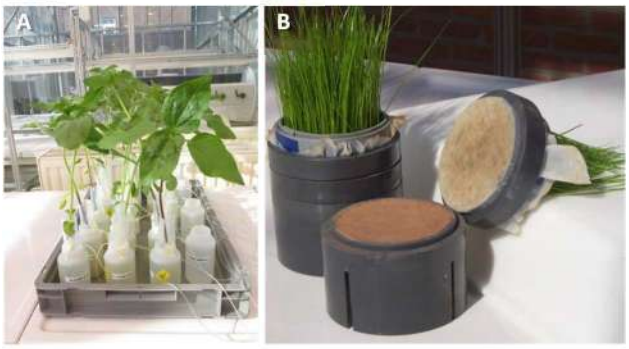
Related to:
EURADOS, MELODI, STORE

PREFERENTIAL DECORPORATION OF AMERICIUM BY PULMONARY ADMINISTRATION OF DTPA DRY POWDER AFTER INHALATION OF AGED PUO(2) CONTAINING AMERICIUM IN RATS. O. Grémy et al., Radiat Res. 2010; 174(5):637-44.
INTERNAL CONTAMINATION BY ACTINIDES AFTER WOUNDING: A ROBUST RODENT MODEL FOR ASSESSMENT OF LOCAL AND DISTANT ACTINIDE RETENTION. NM. Griffiths et al., Health Phys. 2012; 103(2):187-94.

Facility radionuclides availability, transfer and migration

Understanding the behaviour of radionuclides in the biosphere

At the Biosphere Impact Studies group (BIS) of the Belgian Nuclear Research Centre (SCK•CEN), mechanisms and processes are studied to better understand and predict radionuclide behaviour in the terrestrial, freshwater and marine environment by using dedicated laboratory set-ups, greenhouse experiments and field studies, as well as developing modelling tools calibrated and validated with the data sets thus developed. To perform this research, an infrastructure is available for conducting lab experiments to study radionuclide availability, transfer and migration in the environment.



Photos: SCK•CEN

Fytoremediation experiment with sunflower (A) - Rhizoplan system (B)

The facility is located in a controlled area, making it possible to work with open radioactive sources. A large range of radionuclides can be used, e.g. ^{134}Cs, ^{137}Cs, ^{60}Co, ^{90}Sr, ^{238}U, ^{232}Th, ^{241}Am. The permitted activities are dependent on the dose rate, shielding possibilities, radioactive waste limits, etc., and need to be discussed and approved by the physical control unit of SCK•CEN before starting the experiments.

The facility offers the possibility to contaminate soil, sediment and water and simulate atmospheric deposition. Plants (and other organisms) can be grown on/in these contaminated substrates to study their uptake of radionuclides (figure A). Many plant species have already been used in the labs, e.g. ryegrass, sunflower, clover, maize, pine trees and rice, plus other organisms such as mycorrhizas.

Specific experimental set-ups have been developed at BIS, for example:

- In order to screen the radionuclide uptake potential of plants for a large array of soils, a rhizoplan system was developed in which only a small amount of soil is used, and the roots, shoots and soil can be harvested separately (figure B).
- To be able to differentiate between root uptake and stem uptake of radiocaesium by rice, a hydroponic system was developed in which rice stems are in contact with ^{134}Cs while rice roots are in contact with ^{137}Cs (figure C).

Photo: Patrick Liebens

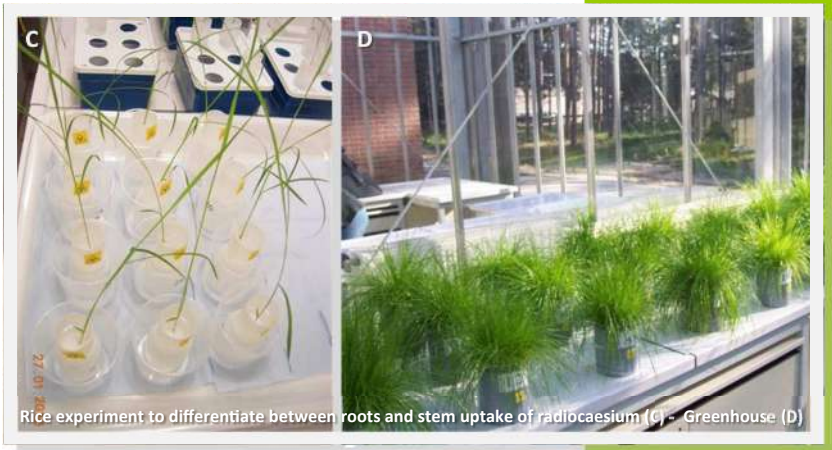
Nathalie Vanhoudt

The facility is equipped with a greenhouse consisting of four compartments (each 20 m²) in which the environmental conditions can be separately regulated with heaters, screens, natural ventilation and lights (figure D). To ensure more controlled environmental conditions, two large climate chambers (8 m² and 3 m²) are available in which the temperature and light conditions can be programmed and controlled. Also, one fully controlled climate chamber of 1 m² is available if, in addition to light and temperature, humidity also needs to be regulated.

In addition to the indoor lab experiments, lysimeters are available with different soil types to perform outdoor experiments.

The facility is supported by fully equipped labs for soil sampling and characterisation, element analyses (ICP-MS, IC, etc.) and radioactivity measurements (low level alpha, beta, gamma). In addition, a collection of Belgian, Japanese and European soils is available.

The facility is open for collaboration, and proposals for projects with CONCERT partners are welcome.



Rice experiment to differentiate between roots and stem uptake of radiocaesium (C) - Greenhouse (D)

Photo: SCK•CEN

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

ID Card:

Exposure type:
Internal exposure (through uptake of radionuclides from contaminated soil/sediment/water)

Source:
Large range of radionuclides (^{134}Cs, ^{137}Cs, ^{238}U, ^{232}Th, ^{90}Sr, etc.)

Dose rate:
Radionuclide-dependent (according to radiation type, shielding possibilities, radioactive waste limits, etc.)

Irradiation type:
Alpha, beta, gamma

Irradiated organism type:
Exposure of plants and mycorrhiza via contaminated soil, sediment or water

Address:
Belgian Nuclear Research Centre (SCK•CEN), Boeretang 200, 2400 Mol, Belgium

Access:
Joint research collaboration and subject to internal approval

Supporting lab:
Labs for soil characterisation and (radio) analytical chemistry

Contact:
Nathalie Vanhoudt, nathalie.vanhoudt@sckcen.be, +32 14 33 21 12

Related to:
ALLIANCE

CAN WE PREDICT URANIUM BIOAVAILABILITY BASED ON SOIL PARAMETERS? PART 1: EFFECT OF SOIL PARAMETERS ON SOIL SOLUTION URANIUM CONCENTRATION. H. Vandenhove et al., Environ. Pollut. 2007; 145(2):587-95.

PREDICTING RADIOCAESIUM SORPTION CHARACTERISTICS WITH SOIL CHEMICAL PROPERTIES FOR JAPANESE SOILS. S. Uematsu et al., Sci.Total Environ. 2015; 524-525:148-56.

Nanoparticle Inhalation Facility

PHE Centre for Radiation, Chemical and Environmental Hazards

The Centre for Radiation, Chemical and Environmental Hazards (CRCE) has had an inhalation exposure facility for many decades. The facility was originally developed to undertake inhalation studies using aerosols of relevance to the nuclear industry. In 2008 the facility was extensively re-furbished to enable it to undertake studies to explore the toxicity of inhaled nanomaterials.

Photo: PHE

Rachel Smith

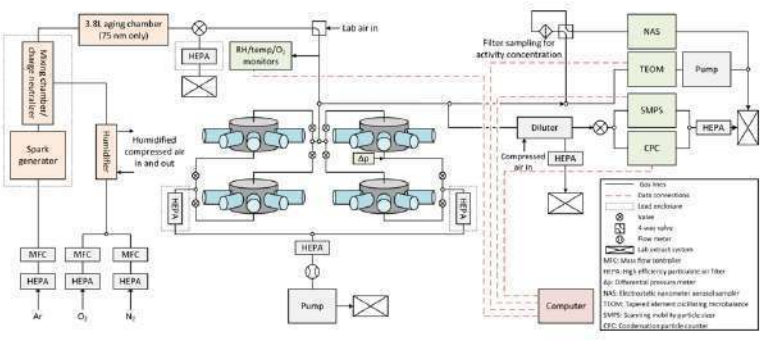
The facility is flexible and has a range of aerosol production, delivery and characterisation options. Aerosols can be generated from carbon or metallic electrodes using a spark generator, and carbon nanotube aerosols can be produced using a 'NIOSH style' acoustic aerosol generator. Aerosols can be generated from materials in dispersions using various atomisers and nebulisers. Aerosols can be delivered to a range of small rodents, both nose-only and whole-body, and to cell cultures using a CultexTM system. We have an extensive range of aerosol characterisation equipment to cover aerosols from nano to micron sized. On-line equipment to measure aerosol particle size distributions includes: TSI Aerodynamic Particle Sizer (APS), TSI Scanning Mobility Particle Sizer (SMPS) with standard and nano-DMA, and nano-MOUDI cascade impactor. Aerosol mass concentrations are measured using filter based gravimetric methods and on-line using a Tapered Element Oscillating Microbalance (TEOM). Aerosol particles can also be sampled onto EM grids using a number of options including an electrostatic precipitator, for post-exposure analysis. The temperature, humidity and oxygen content of the aerosol delievered is also monitored continuously during exposures.

Photo: PHE

Nose-only aerosol delivery system

The facility currently focuses primarily on inhalation toxicity studies using non-radioactive nano-sized aerosols, however, it is possible to use radioactive aerosols in the facility. For example, a recent study to explore the deposition, clearance and translocation of nano-sized aerosol particles following inhalation was performed using nano-sized iridium-192 aerosol particles produced using an iridium-192 electrode in one of the aerosol spark generators. This study made use of radioactive counting and analysis equipment from the significant range available at CRCE.

CRCE is open for collaboration and welcomes suggestions for projects with partners.



Example of inhalation system set-up illustrating aerosol production

Photo: PHE

ID Card:

Exposure type:
Internal, Inhalation

Source:
Various options

Dose rate:
Variable

Irradiation type:
All

Irradiated organism type:
Cells, small rodents

Address:
Centre for Radiation, Chemical and Environmental Hazards
Harwell Science Campus,
Didcot,
Oxfordshire OX11 0RQ
UK

Access:
Joint research collaborations

Supporting lab:
Radioactive counting, radiochemical analysis, cell culture, dissection

Internet link:
NA

Contact:
Rachel Smith,
Rachel.Smith@phe.gov.uk
+44 (0)1235 825191

Related to:

SIZE DEPENDENT DEPOSITION OF INHALED NANOPARTICLES IN THE RAT RESPIRATORY TRACT USING A NEW NOSE-ONLY EXPOSURE SYSTEM. Buckley A, et al. (2016). J Aerosol Science and Technology

Subcategory (e) Observatory sites		
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THE CHERNOBYL EXCLUSION ZONE

A radioecological observatory
A focus for joint, long-term, radioecological research

Radioecological Observatories are radioactively (and chemically) contaminated field sites that will provide a focus for joint, long-term, radioecological research. The Chernobyl Exclusion Zone (CEZ) Observatory is one of four proposed by the EC funded STAR and COMET projects.

Site overview

The Chernobyl Exclusion Zone contains the most radioactively contaminated sites in the world. The area is highly heterogeneously contaminated by a number of radionuclides including ^{137}Cs, ^{90}Sr, ^{241}Am and Pu-isotopes. The Ukrainian area of the CEZ (approximately 2600 km^2) contains forests, abandoned farmlands, wetlands, flowing and standing waters, deserted villages and urban areas. The Belarusian CEZ (approximately 2160 km^2) consists mainly of forests, swamps, marshes and peat-bogs.

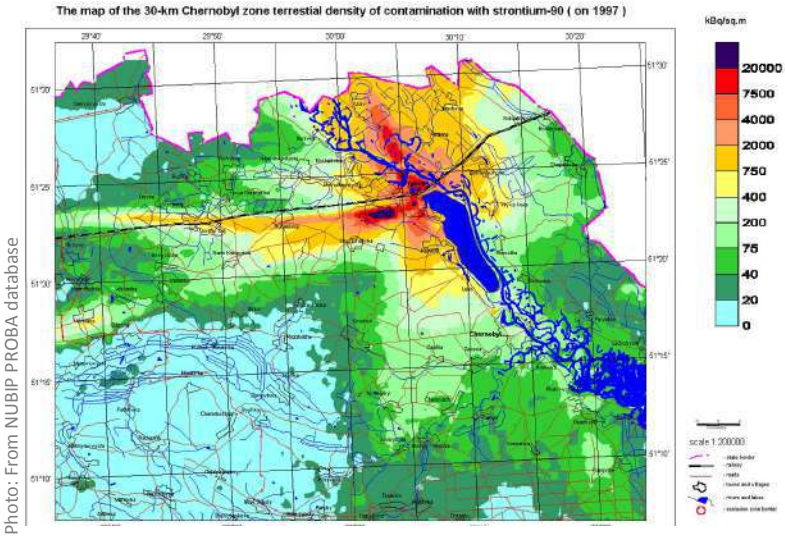


Photo: From NUBIP PROBA database

Sr-90 in the Ukrainian CEZ

(http://www.radioecology-exchange.org/content/nubip)

The site is species rich with >400 species of vertebrates, including 67 ichthyoids, 11 amphibians, 7 reptilians, 251 birds and 73 mammals; many are Red Book species. The climate is temperate-continental with the growing period beginning around mid-April and ending in late October.

Why is the CEZ a Radioecological Observatory?

The CEZ has many features making it an important radioecological site:

- Contamination levels are such that the behaviour/transfer/mobility of a number of radionuclides can be studied (^{137}Cs, ^{90}Sr, ^{241}Am, Pu-isotopes, U-isotopes, ^{129}I, ^{14}C and ^{99}Tc)
- The presence of 'hot particles' means that their behaviour in the environment can be studied
- Dose rates remain sufficiently high that we may expect to observe effects on wildlife in some areas
- Published results on radiation effects from the CEZ are contentious with a lack of agreement on interpretation amongst scientists (see http://dx.doi.org/10.1002/ieam.238)

Photo: N Bersford/CEH

Pr Nick Beresford

- A wide range of species and habitats are present.

ALLIANCE activities in the CEZ

COMET partners have collaborated to conducted studies on radionuclide transfer to wildlife and agricultural products, and also radiation effects to a range of wildlife species (frogs, earthworms and plants). Datasets from the CEZ presenting spatial data on radionuclide deposition, soil properties, land use and radionuclide activity concentrations in wildlife are currently being prepared for submission to openly accessible data centres. COMET also ran a field studies course for international students in the CEZ.

On-going and future ALLIANCE activities include: jointly supervised PhD on radiation effects in birds and collaboration in RED FIRE, a study looking at the effects of radiation on the Red Forest as it recovers from a largescale fire in the summer of 2016.

Chernobyl NPP complex (June 2015)

Photo: Nick Bersford/NERC-CEH

ID Card:

Type of ecosystem contaminated:
Terrestrial and freshwater (and urban)

Compartment of environment contaminated:
All sample types

Contamination source:
Radionuclides released by the Chernobyl accident (including Cs-137, Sr-90, Am-241, Pu-isotopes, U-isotopes, I-129, C-14, Tc-99) including in the form of 'hot particles'

Radioactivity or dosimetric characteristics:
Activity concentrations and dose rates

Total contaminated area:
>4700 km^2

Species exposed/present in the site:
Area is species rich, e.g. 400 species of vertebrate animals, including: 67 ichthyoids, 11 amphibians, 7 reptilians, 251 birds and 73 mammals

Authorized related data/samples:
http://www.radioecology-exchange.org/content/chernobyl-exclusion-zone

Presence of an associated contamination:
No significant evidence for this

Supporting lab:
Basic laboratory facility are available in the Chernobyl Exclusion Zone

Access:
Require permission - achieved through a local collaborator. Work will require pre-planning to ensure permissions etc. are in place

Internet link:
http://www.radioecology-exchange.org/content/chernobyl-exclusion-zone

Other links
http://www.radioecology-exchange.org/content/radioecological-observatories)
http://www.ceh.ac.uk/news-and-media/blogs/understanding-ecological-impact-major-fire-chernobyl-red-forest)
https://resy5.iket.kit.edu/CONFIDENCE/

Contact:
Pr Nick Beresford
nab@ceh.ac.uk

Related to:
ALLIANCE

CHERNOBYL CATASTROPHE AND CONSEQUENCES, Smith J. T. , Beresford, N.A. (2005) Springer Praxis Books, Praxis Publishing Ltd, Chichester, UK, ISBN: 9783540238669, https://link.springer.com/book/10.1007%2F3-540-28079-0

THIRTY YEARS AFTER THE CHERNOBYL ACCIDENT: WHAT DO WE KNOW ABOUT THE EFFECTS OF RADIATION ON THE ENVIRONMENT?, Barnett C., Welch S,. (2016) COMET Workshop report, http://bit.ly/2p2BPVH

Forest observatory site in Yamakiya

Fukushima observatory sites contaminated by radiocaesium

Fukushima University has established forest observatory sites in Yamakiya, Tsushima and Okuma (Fukushima). The Yamakiya forest observatory site (37º35'20.5"N, 140º42'37.1"E) is located 35 km north-west of the TEPCO* Fukushima Daiichi Nuclear Power Station and has been operational since it was established in 2014.

Photo: H. Tsukada/IER

Forest observatory site in Yamakiya, Fukushima

The site is a cedar-dominant community of approximately 7 ha, with an elevation difference of approximately 100 m. Average temperature is 12.7°C (-9.3-37.1°C) and annual precipitation is 1220 mm ·y^{-1}.

The major soil type is Andosols and it supports a planted Japanese Sugi cedar stand. The ^{137}Cs inventory is 670 ± 400 kBq·m^{-2} (n=6) and ^{137}Cs activity concentration in surface soil (humus + depth of 0-10 cm) is 19 ± 8.3 Bq·g^{-1}. The distributions of ^{137}Cs in exchangeable, bound-to-organic matter and residual fractions in the 0-5 cm soil layer collected in 2015 were 5%, 4% and 91% respectively, with most of the ^{137}Cs in the strongly bound fraction.

No other contamination by heavy metals was observed in the area. Aggregated Transfer Factor (TF) for ^{137}Cs, defined as the concentration of ^{137}Cs in animals (Bq·kg^{-1} FW) divided by soil ^{137}Cs levels (Bq·m^{-2}), has been determined. Tags in earthworm, frog, newt, bee, mouse and boar were 0.0022, 0.0014, 0.00049, 0.00016, 0.012 and 0.0019 respectively.

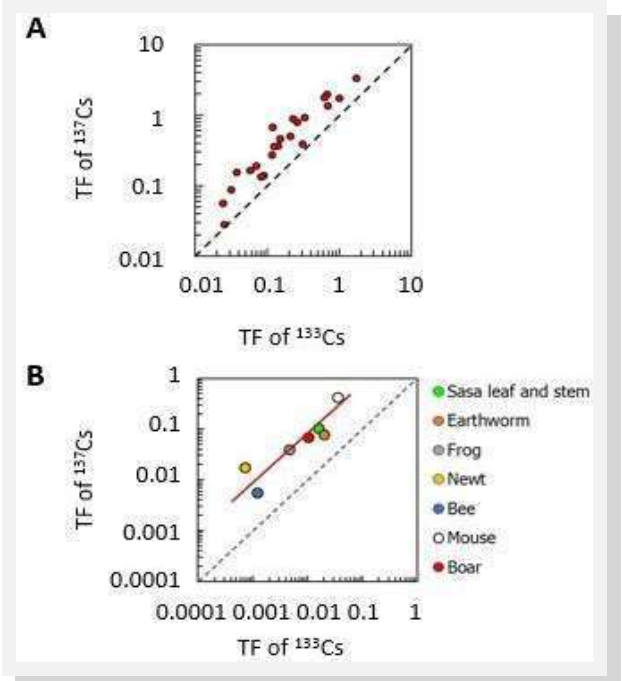
The mean ^{137}Cs radioactivity concentration in the Montane brown frog collected at the Yamakiya observatory site in 2016 was 1.12 ± 0.81 (n=20) Bq·g^{-1} FW. The range of radioactivity concentration (0.08 - 3.2 Bq·g^{-1} FW) was two orders of magnitude, even in the limited area. The external radiation dose in the frog from radiocaesium ($^{134+137}$Cs) calculated using the ERICA tool was 4.2 µGy·h^{-1}. The internal radiation dose in the frog was 0.2 µGy·h^{-1}, which was 5% of the external dose.

Photo: H. Tsukada/IER

Dr Hirofumi Tsukada

Previously reported TF from substrate to mushroom of ^{137}Cs is well correlated with that of stable ^{133}Cs. This suggests that the transfer of ^{133}Cs from substrate to mushroom is utilised as a natural analogue of radiocaesium. The transfer factors, defined as the concentration of ^{137}Cs in plant and animals divided by that in surface soil, were well correlated with the transfer factor of ^{133}Cs. This indicates that the behaviour of ^{133}Cs can be regarded as a useful analogue for predicting long-term changes of radiocaesium in the forest environment.

*Tokyo Electric Power Company



A) Comparsion of transfer factor of stable ^{133}Cs and ^{137}Cs in mushroom in 1992.

B) Comparsion of transfer factor of stable ^{133}Cs and ^{137}Cs in plants and animals collected in Yamakiya, Fukushima.

Radiocesium distribution and fluxes in the typical *Cryptomeria japonica* forest at the late stage after the accident at Fukushima Dai-Ichi Nuclear Power Plant, Yoschenko V., Takase T., Konoplev A., Nanba K., Onda Y., Kivva S., Zheleznyak M., Sato N., Keitoku K. (2017), J Environ Radioact, 166, 45-55

Transfer of radiocaesium and stable caesium from substrata to mushrooms in a pine forest in Rokkasho-mura, Aomori, Japan, Tsukada H., Shibata H., Sugiyama H. (1998), J Environ Radioact, 39, 149-160

ID Card:

Type of ecosystem contaminated:
Semi-natural forest environment

Compartment of environment contaminated:
Soil, water, sediments, plants, animals

Contamination source:
Radiocaesium, radioiodine and other radionuclides from TEPCO's FDNPS accident

Radioactivity or dosimetric characteristics:
Radiocaesium is the major source of contamination, and Pu, ^{90}Sr et al. are also deposited in the surrounding areas of the FDNPS

Total contaminated area:
953 km^2 (>20 mSv·y^{-1}, 7% of Fukushima Prefecture)

Species exposed/present in the site:
Japanese cedar, pine and broad-leaf trees, bamboo, fern, sasa plant, earthworm, frog, newt, mouse, wild boar, etc.

Authorized related data/ samples:
COMET report, publications

Supporting lab:
Institute of Environmental Radioactivity (IER) at Fukushima University supports sampling, pretreatment and analyses

Access:
Permission from IER is required

Address:
Yamakiya, Kawamata, Fukushima Prefecture

Contact:
Pr. Dr Hirofumi Tsukada
hirot@ipc.fukushima-u.ac.jp
+81 24 503 3013

Related to:
ALLIANCE

Belgian NORM Observatory Site

Opportunities for joint, long-term radioecological research

To ensure joint, long-term radioecological research, four observatory sites have been proposed by the EU-projects STAR and COMET. Among these is the Belgian NORM observatory site, a calcium difluoride sludge heap from the phosphate industry, partly covered with vegetation such as trees, grasses and shrubs. Levels of ^{226}Ra contamination of between 2000 and 6000 Bq kg^{-1} can be found in the soil and sludge in combination with contaminants such as As, Cd, Cr, Pb and Zn. Although remediation measures are planned, approximately 7 ha of the site are available for the next 10 to 15 years to perform long-term radioecological research in a NORM-contaminated terrestrial ecosystem.

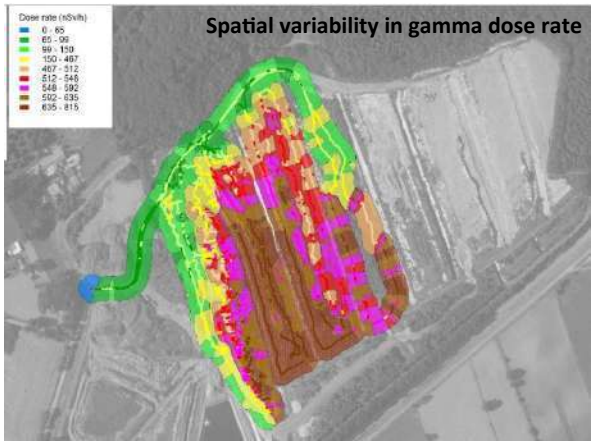


Photo: SCK•CEN

Since the site is private domain, by agreement with the site owner, permission to access and work there has to be obtained *via* SCK•CEN (nathalie.vanhoudt@sckcen.be) and is subject to signature of a working agreement.

In the COMET project, a working group has been created for the site in order to define common goals and establish joint research actions. Several research institutes have shown an interest, and common research activities have begun.

For example, a monitoring campaign was carried out to map the gamma dose rate at the site. Subsequently, the spatial variability in contaminant concentrations was evaluated by radiological and chemical characterisation of 9 superficial soil samples. Additionally, a sampling campaign was undertaken to determine the radionuclide distribution between soil (at different depths), tree roots, needles, bark, grasses, moss, etc. A leaching experiment was performed for U- and Th-isotopes and ^{210}Po to evaluate the mobility of radionuclides in the soil. Further investigations will deepen the knowledge of the processes that determine radionuclide mobility and bioavailability in soil and sludge.

Future plans for collaborative studies at this site include:

Photo: Patrick Liebens

Dr Nathalie Vanhoudt

- Understanding and modelling the long-term influence of vegetation on radionuclide dispersion in forest ecosystems. As part of the TERRITORIES project (EU-CONCERT funded project), a pine forest plot is being instrumented at the site, with equipment to follow the cycling of naturally occurring radionuclides and other elements in the trees, integrated with monitoring of the energy and water cycles. It is also planned to monitor the radionuclide content in seasonal samples of soil, sludge, tree roots, bark, wood, branches, tree needles and litterfall.
- Additional sampling campaigns will be set up to further characterise the site in order to gain more in-depth knowledge of the processes that determine radionuclide mobility and bioavailability in soil and sludge, and to compare radionuclide behaviour at different NORM sites.
- The resulting site-specific data will be used to improve and/or validate radiological models and to assess their transferability to different environments.
- The data and knowledge gathered will be shared between the partners to ensure efficiency, continuity and sustainability in radioecological research.

Photo: Nathalie Vanhoudt/SCK•CEN

ID Card:

Type of ecosystem contaminated:
Terrestrial - forest

Compartment of environment contaminated:
Soil, sludge, vegetation

Contamination source:
Naturally occurring radionuclides present in the sludge (including ^{238}U, ^{226}Ra, ^{210}Pb and ^{210}Po)

Radioactivity or dosimetric characteristics:
Activity concentrations: e.g. 4-6 Bq g^{-1} ^{238}U and 2-6 Bq g^{-1} ^{226}Ra
Dose rates: up to 800 nSv h^{-1}

Total contaminated area:
Approximately 7 ha

Species exposed/present in the site:
Trees, shrubs, herbs, grasses, insects, etc.

Presence of an associated contamination:
Co-contaminants such as As, Cd, Cr, Pb and Zn

Supporting lab:
No laboratory infrastructure available on site. Subject to agreement, SCK•CEN laboratories can be made available

Access:
Permission to access and work at the site has to be obtained *via* SCK•CEN (nathalie.vanhoudt@sckcen.be) and is subject to signature of a working agreement

Internet link:
http://www.radioecology-exchange.org/content/belgian-norm-site

Contact:
Dr Nathalie Vanhoudt
nathalie.vanhoudt@sckcen.be
+32 14 33 21 12

Related to:
ALLIANCE
NERIS

Concentrations and distributions of Al, Ca, Cl, K, Mg and Mn in a Scots pine forest in Belgium, Gielen S., Vives i Batlle J., Vincke C., Van Hees M., Vandenhove H. (2016), Ecological Modelling 324, 1-10
Modelling water and ^{36}Cl cycling in a Belgian pine forest, Vives i Batlle J., Vandenhove H., Gielen S. (2014), 3rd Int. Conf. Radioecol. & Env. Radioact. (ICRER), Paper OP-035

Subcategory (f) Metrology exposure platforms		
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Calibration and Dosimetry Laboratory (INTE-UPC)		41
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Laboratory for retrospective Radon and Thoron dosimetry

Advancing retrospective radon and thoron dosimetry

The infrastructure for retrospective radon and thoron dosimetry at Sofia University in Bulgaria was completed in 2015 in the framework of the DoReMi project. Its main purpose is to provide low dose retrospective dosimetry for epidemiological studies in which radon/thoron is the primary risk agent or a confounder. However, it can be used for other types of research involving radon/thoron exposure, detector response studies, radon/thoron measurement in buildings and in the environment, etc.

The infrastructure comprises two basic units:
1) Radon (Rn-222) and Thoron (Rn-220) Exposure Facility (RTEF);
2) Laboratory for Electro-Chemical Etching of track-etch detectors (LECE). The emphasised method for retrospective measurements employs CDs/DVDs stored indoors as track-etch detectors.

Photo: D. Dimitrov, Sofia University

Dobromir Pressyanov

Photo,

The RTEF and the research team (from left: S. Georgiev, K. Mitev, I. Dimitrova, D. Pressyanov)

The RTEF is designed for exposures at a wide range of activity concentrations and temperatures. It has the unique capability to support not only static but also dynamic reference exposure conditions in which radon and thoron concentrations and/or the temperature follow pre-programmed time functions. Mixed as well as pure radon and thoron atmospheres can be created with programmable levels/ratios.The RTEF is illustrated in the diagramme and photo, and its capabilities are summarised in the ID card. The activity concentration in the system is controlled by setting the flow regime and the flow rate of air through the sources of radon and thoron. The pump flow rate is controlled by a computer with dedicated hardware and software. The reference activity of radon and thoron in the system is measured by calibrated monitors (AlphaGUARD or RAD7). The temperature inside the exposure vessel is maintained by a specifically designed thermostat that can support programmable static or dynamic temperature regimes.

The RTEF is suitable for:
- Experiments at different (static or dynamic) reference radon and/or thoron concentrations for exposure times ranging from less than an hour to several months (e.g. for calibration of radon and thoron detectors, study of the detector's response and cross-talk between the radon and thoron signals in a mixed atmosphere, exposure of cell cultures, studies of radon sorption and desorption in biological substrates and other materials);
- Exposures under dynamic activity concentration and temperature reproducing the conditions in the real environment.

The LECE is oriented mostly to etching alpha tracks created by radon/thoron and their progeny in CDs/DVDs or other solid state nuclear track detectors. Various etching regimes at HV (effective) within 100 – 4000 V and a frequency of 6 kHz are possible. High precision is achieved by individual *a posteriori* calibration of each disk by additional exposure in the RTEF after the disk is collected. The infrastructure at Sofia University has sufficient capacity to manage the workload of large-scale epidemiological studies or other measurement campaigns

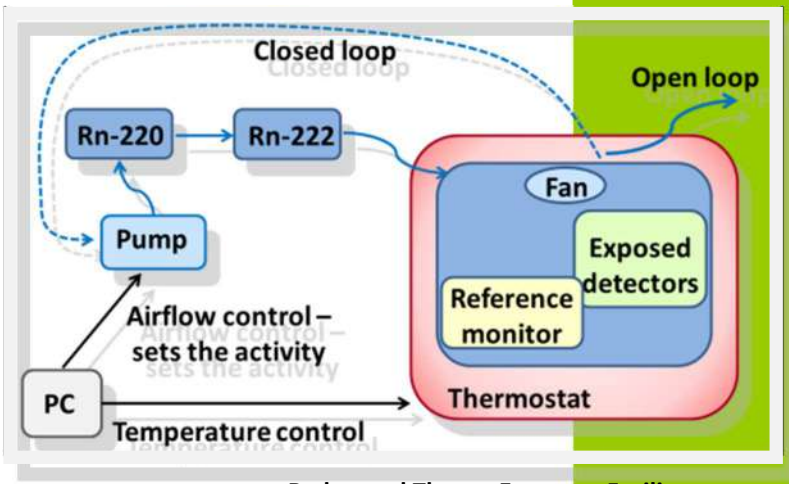


Photo: Faculty of Physics, Sofia University

Radon and Thoron Exposure Facility

ID Card:

Exposure type:
Exposure to staic or dynamic radon/thoron activity concentrations with time-dependent temperature regime

Source:
^{222}Rn and ^{220}Rn

Dose rate:
^{222}Rn: 1-2000 kBq/m^3
^{220}Rn:2-1800kBq/m^3

Temperature range:
-15°C to +60°C

Irradiation type:
alpha particles (5.5, 6.0,6.1,6.3,6.8,7.7,8.8 MeV)

Possible targets:
^{222}Rn and ^{220}Rn detectors cells

Address:
5 James Bourchier Blvd, Sofia 1164, Bulgaria

Access:
Available upon request and task specification

Supporting lab:
Laboratory of Dosimetry and Radiation Protection, Faculty of Physics, Sofia University "St Kliment Ohridski", Sofia, Bulgaria

Internet link:
http://doremi-noe.net/irradiation_facilities

Contact:
Dobromir Pressyanov
pressyan@phys.uni-sofia.bg
+359 2 8161 268

Related to: DOREMI

LABORATORY FACILITYTO CREATE REFERENCE RADON+THORONATMOSPHERE UNDER DYNAMIC EXPOSURE CONDITIONS D. Pressyanov, K. Mitev, S. Georgiev, I. Dimitrova, J. Kolev., J. Environ. Radioact., 166 (2017), 181-187

OPTIMIZATION OF ETCHING CONDITIONS OF CDs/DVDs USED AS DETECTORS FOR Rn 222 D.Pressyanov, K. Mitev, S. Georgiev, I. Dimitrova,. Radiat. Meas. 83 (2015), 36-40

CALIBRATION LABORATORY AT KIT

Accreditation for irradiations according to ISO 17025

The Irradiation Facility at Karlsruhe Institute of Technology provides photon, electron and neutron irrradiations in the dose range from 50 µGy up to 5 Gy. Dose rates vary from 2 µGy/h up to 80 mGy/h (air KERMA rate for photons). All doses can be converted to the appropriate operational quantities (e.g. Hp (3) or H*(10)) in Sieverts.

For photon irradiations, the facility uses 6 sources of Cs-137 at different activity levels ranging from 1E+7 Bq up to 1E+13 Bq, and two X -Ray tubes (soft X-rays with voltages up to 60 kV, hard X-rays up to 320 kV, currents up to 20 mA), in combination with different filters. The irradiation workbench, 8 metres in length, allows maximum field sizes of up to 100 cm x 100 cm (95% isodose). Mounting frames for different kinds of samples are available. Figure 1 shows the placement before irradiation of a 10 L ionisation chamber for low dose rate, located within the facility.

A Beta Secondary Standard (BSS2) with sources of Pm-147, Kr-85 and Sr-90/Y-90 (activities in the E+08 Bq range) is available for electron irradiation.

In 2009, the facilities for photon and electron irradiation were awarded an accreditation to the ISO/IEC 17025:2005 standard.

Neutron irradiations in air are performed using either a Cf-252 source (E+06 Bq, E=2.13 MeV, 11,3 neutrons/cm^2*s) or an Am-Be-Source (E+11 Bq, E=4.16 MeV, 225 neutrons/cm^2*s). The hall in which these irradiations are performed is constructed from wood materials to reduce backscatter. Application for accreditation of these irradiations is also planned in the near future.

Photo: Lukas Exner (KIT)

Lukas Exner

A solid state dosimetry laboratory using TLD and track-etch detectors is available, close to the facility. The irradiation facility was originally designed for the irradiation and calibration of active and passive dosemeters, but in addition has always been used for research and development. For example, both laboratories recently developed a dosemeter for monitoring doses to the eye lens in the appropriate quantity Hp(3). This new dosimeter has been used in a study on eye lens doses in the workplaces and took part in several intercomparison exercises.

Access to the facilities is available via research collaborations or service contracts for irradiations.

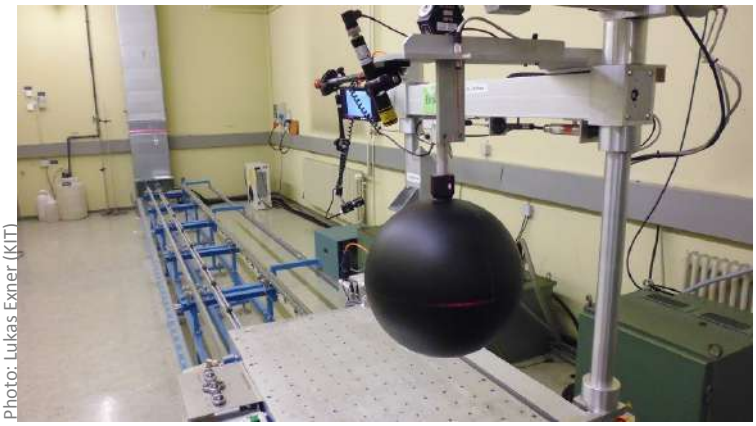


Photo: Lukas Exner (KIT)

The positioning of a 10L ionisation chamber for low dose rate before irradiation with photons. A moveable arm is used to move the chamber into the correct position, a Laser system is used to monitor the correct placement

Photo: Florian Arend (KIT)

A CAD-drawing of the photon irradiation set-up. The field generated by one of the ^{137}Cs sources is displayed. The X-Ray tubes with the different filter options mounted on the two wheels have been moved into the parking position

Behrens et al., 2016, Intercomparison of eye lens dosemeters, Radiation Protection Dosimetry (http://rpd.oxfordjournals.org/content/early/2016/03/22/rpd.ncw051.full, Radiat Prot Dosimetry (2016) doi: 10.1093/rpd/ncw051)

Burgkhardt B. et al., 2002, Experience in long-term neutron dose equivalent measurements using etched track detectors with (n, alpha) converters in moderator, Radiation Protection Dosimetry, 101, p579-584

ID Card:

Exposure type: *external*
Source:
Photons : Cs-137, X-Ray tubes
Electrons: Beta Secondary Standard BSS2
Neutrons: Cf-252, Am-Be
Dose rate:
2 µGy/h – 80 mGy/h (air Kerma)
Irradiation type:
Photons, Electrons, Neutrons
Irradiated organism type:
Samples and Measurement Devices

Address:
Karlsruhe Institute of Technology
Sicherheit und Umwelt
Kalibrierlabor
Hermann-von-Helmholtz-Platz 1,
76344 Eggenstein-Leopoldshafen

Access:
joint research collaborations, service contracts

Supporting lab:
solid state dosimetry laboratory

Internet link:
www.sum.kit.edu

Contact:
Lukas Exner
lukas.exner@kit.edu,
Phone: +49 721 608 26320
Christian Naber
christian.naber@kit.edu,
Phone: +49 721 608 22644

Related to:
MELODI, EURADOS

MELAF

Facility for high energy photon and electron radiation

The German National Metrology Institute (PTB-Physikalisch-Technische-Bundesanstalt) operates the Metrological Electron Accelerator Facility (MELAF) for service and research in the field of dosimetry for external beam radiotherapy. A custom-designed research electron linear accelerator (LINAC) and two commercially available medical LINACs, together with a Co-60 irradiation facility, offer excellent experimental conditions for investigations requiring high-energy photon and electron radiation. The PTB makes available its metrologically well-characterised radiation fields to external researchers from, for example, the field of radiobiology or medical radiation protection research.

Photo: A. Schüller/PTB

Dr Andreas Schüller

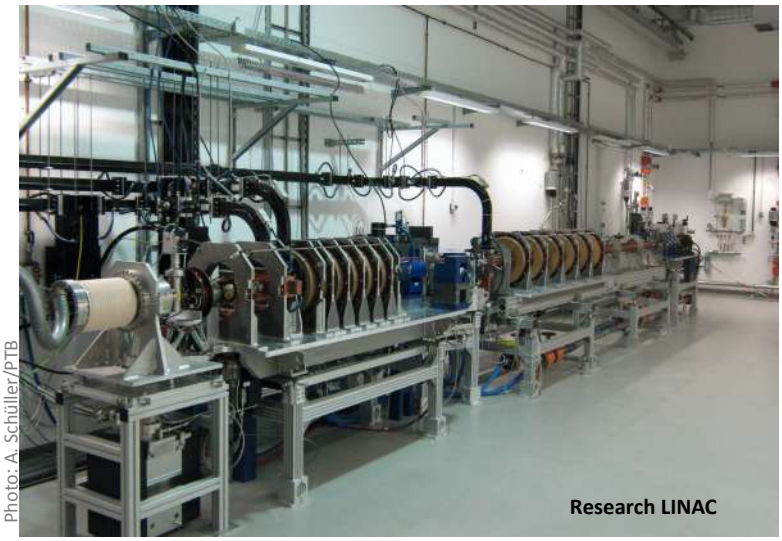


Photo: A. Schüller/PTB

Research LINAC

The MELAF is located in a dedicated building with four irradiation rooms. Two irradiation rooms are equipped with medical LINACs of the type *Elekta Precise Treatment System*. In total, 9 electron beam qualities (nominal energy 4 MeV to 22 MeV) and 6 photon beam qualities (nominal accelerating voltage 4 MV to 25 MV) can be generated. The LINACs provide a pulsed beam (6 Hz to 400 Hz, 3 µs pulse duration) and are equipped with a multileaf collimator which allows irregularly shaped fields of up to 40 cm x 40 cm at 1 m distance. Typical dose rates are 0.1 Gy/min to 5 Gy/min.

The research LINAC consists of a low-energy section (0.5 MeV to 10 MeV) and a high-energy section (6 MeV to 50 MeV). At both sections the electron beam can be deflected into the dedicated beam line in its respective irradiation room. The properties of the beam, e.g. the spectral electron fluence or the beam current, are measured as absolute values with small uncertainties. Thus, radiation effects can be studied as a function of these quantities. The research LINAC provides a pulsed beam (1 Hz to 100 Hz, 2.5 µs duration), and the energy can be varied continuously. At the end of each beam line, the electrons either pass through an exit window for electron irradiations or impinge on a bremsstrahlung target for the generation of high-energy photons. Dose rates are up to several Gy/s.

The MELAF is also equipped with an irradiation facility for Co-60 gamma radiation (129 TBq as at May 2017). It generates a radiation field with a field size of 10 cm x 10 cm at a distance of 1 m from the source. Typical dose rates range from 3 Gy/min to 0.03 Gy/min depending on distance from the source (0.5 m to 5 m).

Ionisation chambers with calibrations traceable to the PTB primary standards are available for dose measurements at the highest accuracy level. An alanine/ESR dosimetry system is available for the determination of the total dose in relatively small volumes (alanine probe: ø=4.8 mm, h=3 mm).

Furthermore, the PTB provides an S1 laboratory for cell culture and microbiological preparations with approval to work on genetically modified cells.

Access to the facility is available upon request. The PTB is willing to support external investigators, offering its expertise in the field of dosimetry and on all issues related to the MELAF.

One of the two medical LINACs

Photo: A. Schüller/PTB

K. Derikum, A Dedicated Irradiation Facility for Radiotherapy Dosimetry, IFMBE Proceedings (2009) p53-55

H. Zutz, **O. Hupe**, Ambient dose and dose rate measurements in the vicinity of Elekta Precise accelerators for radiation therapy, Radiation Protection Dosimetry (2014), 162, 4, p431-437

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

ID Card:

Exposure type:
external

Source:
Electron linear accelerator
Co 60

Dose rate:
0.01 Gy/min –100 Gy/min

Irradiation type:
electron and photon beam (vertical and horizontal)
Gamma (horizontal)

Irradiated organism type:
Cell cultures, blood, insects, Plants, measurement devices

Address:
Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

Access:
free, available upon request

Supporting lab:
for cell culture (S1) and microbiological preparations,
for reference dosimetry

Internet link:
www.ptb.de/MELAF

Contact:
Andreas Schüller
andreas.schueller@ptb.de
Tel.: +49 531 592-6209

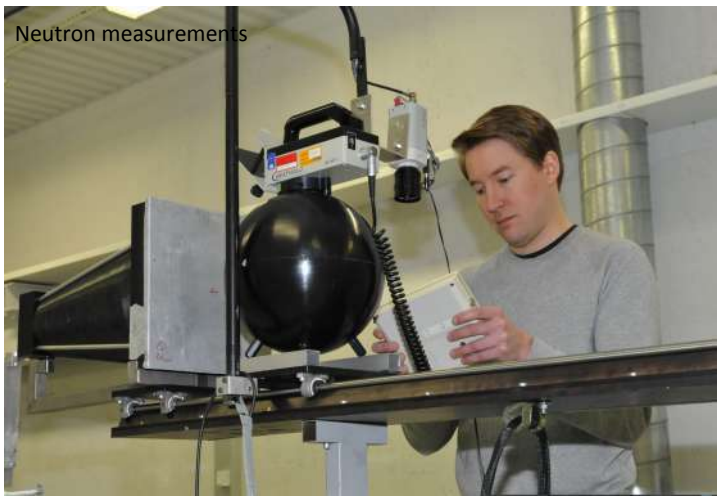
Related to: EURADOS

RADIATION METROLOGY LABORATORY

Facilities with wide range of radiation sources at STUK

The Finnish national standard for ionising radiation is maintained by the Radiation metrology laboratory (DOS) at the Radiation and Nuclear Safety Authority (STUK) in Helsinki. In addition, DOS provides a wide range of irradiation and calibration facilities.

The facilities at STUK include equipment for calibration, testing and irradiation of active and passive targets such as electronic components, with the following radiation qualities:



Neutron measurements

Photo: Teuvo Parviainen/STUK

- Gamma-ray sources: 4 x ^{137}Cs and 5 x ^{60}Co
- ^{241}Am photon source
- Two X-ray devices with voltage span from 10 kV to 320 kV
- Beta-active point sources (^{90}Sr, ^{85}Kr, ^{147}Pm)
- Neutron sources (AmBe, ^{252}Cf)
- Planar sources (^{90}Sr, ^{36}Cl, ^{60}Co, ^{14}C, ^{241}Am, ^{239}Pu, ^{137}Cs).

The air Kerma rate available is from 700 nGy/h to 40 Gy/h. In addition, a medical X-ray imaging facility with digital radiography is at hand. The calibration and irradiation premises include three separate irradiation halls for radiotherapy, radiation protection and X-ray calibrations and a common control room to operate irradiation instruments. Typically, either measurement devices or passive targets are irradiated. There is no facility available for maintenance of living biological materials.

Quality assurance and quality control at the national laboratory are maintained in accordance with the international Mutual Recognition Arrangement CIPM MRA (Comité International des Poids et Mesures). The quality systems of the laboratories recognised by the CIPM MRA arrangement meet the requirements of the ISO 17025 standard. The approval decision to join CIPM MRA is by self-declaration. In order to earn recognition by other laboratories, it is necessary to deliver annual reports to the EURAMET association and participate in regular intercomparison measurements and external audits.

Photo: Tosikuva Oy/Jarkko Översti

Dr Reetta Nylund

STUK is a member of the IAEA/WHO SSDL laboratory network and the European Association of National Metrology Institutes (EURAMET) and has contributed to a vast number of EURAMET- operated research projects in the field of dosimetry and metrology. The research conducted in the laboratory has generally been related to the use of radiation, such as in dosimetry, occupational and clinical radiation exposure, X-ray imaging and measuring methodologies. Several equipment manufacturers use the services of the laboratory as an integral part of their R&D process. In addition, STUK has agreements with Finnish universities for research cooperation involving the use of STUK's irradiation facilities. Access to the STUK facilities is by prior agreement either in the context of collaborative research projects or for irradiation and calibration services.

GBX200 ^{60}Co irradiation unit with a water phantom

Photo: Teuvo Parviainen/STUK

ID Card:

Exposure type:
External

Source:
see text

Dose rate:
700 nGy/h to 40 Gy/h

Irradiation type:
gamma, X-ray, alpha, beta, neutron

Irradiated organism type:
not available

Address:
Radiation and Nuclear Safety Authority (STUK)
Laippatie 4, 00880 Helsinki, Finland

Access:
Prior agreement/research collaboration service

Supporting lab:
No

Internet link:
www.stuk.fi

Contact:
Reetta Nylund
+358401520941
Reetta.nylund@stuk.fi

Related to:
EURADOS, MELODI, EURAMED

Hourdakis C.J., et al, (2016) Comparison of pencil-type ionization chamber calibration results and methods between dosimetry laboratories, Physica Medica,32(1):42-51.

Csete I., et al, (2010) Report on EUROMET.RI(I)-K1 and EUROMET.RI(I)-K4 (EUROMET project no. 813): Comparison of air kerma and absorbed dose to water measurements of ^{60}Co radiation beams for radiotherapy, Metrologia, Vol 47,Technical supplement 06012

Laboratory for Dosimetry Standards (NDS)

HQ metrological support for ionising radiation measurements

The Laboratory for Dosimetry Standards was established at Jozef Stefan Institute in 1992. In 2008 it was appointed by Metrology Institute of the Republic of Slovenia (MIRS) as Designated institute (DI) and holder of Slovenian national standard for ionising radiation (air kerma, Ka, and dose equivalent, H). NDS is accredited according to the ISO/IEC 17025:2005 standard by Slovenian Accreditation. With calibration of dose / dose rate meters and surface contamination monitors we provide dissemination of metrology traceability on national and international level. We are actively engaged in the work of Technical Committee for Ionising Radiation (TC-IR) at the international organisation EURAMET. In 2015 best Calibration and Measurement Capabilities (CMC) of the NDS were approved and reported by BIPM.

Photo: JSI

M.Sc. Matjaž Mihelič

For calibrations in gamma radiation beams, the NDS uses collimated photon beams produced with ^{137}Cs and ^{60}Co sources and a set of lead attenuators with attenuation range of 16.000 (^{137}Cs), installed in a revolver type homemade irradiator. Additional variation of the dose rates at the irradiated object can be achieved with distance changes in the range from 1 to 100. This is also true for ^{241}Am source which does not have attenuators. The shape of the field is 30 x 30 cm for ^{137}Cs and ^{60}Co sources and 30 cm in diameter for ^{241}Am source, all at 1 m distance. The shape of X-ray fields are circular 18 cm (N, RQR, RQA qualities) and 10 cm (RQR-M, RQA-M qualities) in diameter at 1 m distance. Dose rate can be varied in orders of magnitude with anode current and distance. The irradiated object is put into the central beam of selected source with the aid of several lasers. Relative shifts are made with remotely controlled 3 dimensional coordinate system.

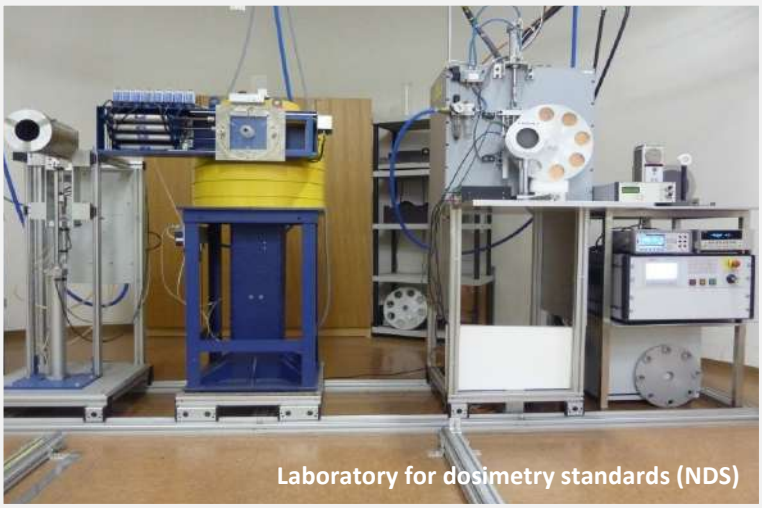
Photo: JSI

Dissemination of metrology traceability on national and international level; ionisation chambers from top to bottom: 1. LS-01 ensures the traceability for ^{137}Cs, ^{60}Co, ^{241}Am sources, and X-ray narrow spectra; 2. TW 34060 ensures traceability for RQR and RQA radiation qualities; 3. RC 06 M ensures traceability for RQR-M in RQA-M radiation qualities

Our lab can irradiate arbitrary samples within the above mentioned dimensions. The irradiation time is controlled by means of electronic timer. The ambient parameters are measured with traceable sensors of temperature, pressure and humidity.

Background irradiation is regularly measured and kept within narrow margins.

The reference quantity for the beam calibrations is the air kerma, determined with secondary standard ionization chambers traceable to the primary standards of the Hungarian Trade Licensing Office (MKEH) and International Atomic Energy Agency (IAEA, Austria).



Laboratory for dosimetry standards (NDS)

Photo: JSI

Calibration and measurement capabilities of NDS, confirmed with BIPM supplementary intercomparisons are published in BIPM KCDB database

Štuhec, M., Zorko, B., Vekić, B., Miljanić, S., Basić, B., Ban, R. (2007) Harmonization of individual dosimetry quality control within metrology system of a small country, Radiation Protection Dosimetry, Vol. 125, 1-4, p117-120

ID Card:

Exposure type: external

Sources: ^{60}Co, ^{137}Cs, ^{241}Am, X-ray: 10-160 keV (ISO 4037 narrow spectra N, IEC 61267 diagnostic spectra: RQR, RQA), X-ray: 2-60 keV (IEC 61267 mammographic spectra: RQR-M, RQA-M)

Irradiation type: Gamma, X-ray

Dose rate range: 0- 0.1 Gy.min^{-1}

Dose range: 0- 1 Gy

Energy, Energy range: 2- 1250 keV

Possible duration of exposure: 100 h

Dose rate modulation options: manual: 10^4

Space available to install the objects to be irradiated: 7 m

Main use of the facility: calibration, irradiation

Dosimetric quantity used: Air kerma, ambient dose equivalent H*(10), personal dose equivalent Hp(10), personal dose equivalent Hp(0,07), surface emission rate: α,β

Address:
Jozef Stefan Institute
Jamova cesta 39
1000 Ljubljana, Slovenia

Access: by prior arrangement with head of the laboratory

Internet link: http://ol.ijs.si/?module=1&lan=1&id=13&mid=7_11_13

Contacts:
Matjaž Mihelič
matjaz.mihelic@ijs.si
+38614773651
Benjamin Zorko
benjamin.zorko@ijs.si
+38614773416

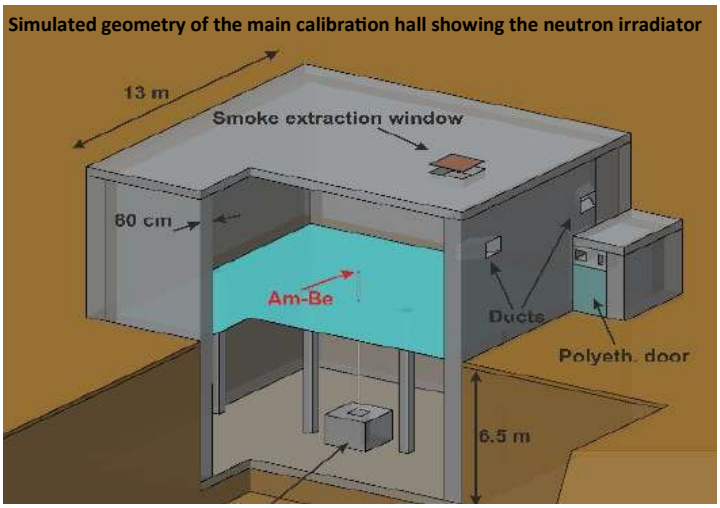
Related to: MELODI, EURADOS

CALibration LABoratory(CALLAB)

CERN Radiation Protection Calibration Facility

The CERN radiation protection CALibration LABoratory (CALLAB), in service since 2015, is a new state-of-the-art calibration facility designed according to the requirements of the ISO 17025 standard. Its design, safety and shielding calculations have been the subject of the Ph.D thesis of Dr F. Pozzi. CALLAB consists of two irradiation rooms (named CC60 and main calibration hall), office space, storage and control rooms.

The CC60 room houses a Co-60 source (nominal activity of 11.8 TBq in August 2014). For large systems of around 1 m^3, the Total Ionizing Dose (TID) delivered ranges from 1 to 10 kGy whereas for smaller samples it can reach up to 100 kGy within days or weeks depending on the position.



Simulated geometry of the main calibration hall showing the neutron irradiator

Photo: F. Pozzi/CERN

The CC60 room is expected to be upgraded with a 100 TBq Co-60 source for higher air kerma rate testing. Typical uncertainties on the air kerma values are around 5%.

The CC60 room is used for the qualification of the electronic components against TID effects. The irradiation room size permits coverage of the two windows of low air kerma rate (0.36 to 3.60 Gy/hr) and standard air kerma rate (36 to 360 Gy/hr) as defined by the European Space Agency (ESA) standard .

The main calibration hall is a 13x13x13 m^3 concrete vault, half of which is underground to take advantage from the natural shielding provided by the earth. It houses:

- four Am-Be sources, providing H*(10) rate between tens of nSv/h and 700 µSv/h;
- five Cs-137 sources and one Co-60 source providing H* (10) rate between tens of nSv/h and 200 mSv/h;
- two beta sources : 1.85 GBq of Sr-90 and 4 GBq of Kr-85;
- one X-ray generator with a peak voltage of 320 kV.

Photo: Pierre Carbonez/CERN

Pierre Carbonez

Typical uncertainties on the reference values are below 5%. All the irradiators and their calibration benches are remotely operated from the control room. Simultaneous neutron/photon irradiations are possible in a shared bench to investigate the response of detectors in mixed radiation fields. The layout of the calibration hall is specifically designed to minimise neutron scattering. CALLAB is currently undergoing the ISO 17025 accreditation process.

Every year, about 9000 semi-passive photon dosimeters (DIS-1), 1500 operational photon dosimeters (DMC 2000/3000), 800 portable radiation monitoring devices and ionisation chambers are calibrated at CALLAB. The laboratory is also used to test and evaluate prototype detectors and new commercial products. The investigation of Single Event Effects (SEEs) induced by neutrons is also possible by attaching the instrumentation to the holder of the Am-Be source.

Dr Pozzi installing a REM counter on the Neutron Calibration bench

Photo: Pierre Carbonez/CERN

ID Card:

Exposure type:
External

Source:
Am-Be (x 4) : 100 MBq – 888 GBq
Cs-137(x 5) : 300 MBq – 3 TBq
Co-60 (x 2) : 5 GBq and 10 TBq
Sr-90 : 1.85 GBq
Kr-85 : 4 GBq
X-ray generator 320 kV

Dose rate:
tens of nSv/h to Sv/h

Irradiation type:
gamma, neutron, beta, X-rays, mixed gamma + neutron

Irradiated organism type:
None

Address:
CERN
route de Meyrin
1211 Geneva 23
Switzerland

Access:
Subject to acceptance by the facility manager

Supporting lab:
CERN Dosimetry Service

Internet link:
https://hse.cern/content/rp/calibration-services

Contact:
Pierre Carbonez
Pierre.Carbonez@cern.ch

Related to:
EURADOS

CERN irradiation facilities, Pozzi F., Alia R.G., Brugger M., Carbonez P., Danzeca S., Gkotse B., Jaekel M. R., Ravotti F., Silari M., Tali M. (2017), Radiat. Prot. Dosimetry, doi: 10.1093/rpd/ncx187

New radiation protection calibration facility at CERN, Brugger M., Carbonez P., Pozzi F., Silari M., Tali M. (2014), Radiat. Prot. Dosimetry 161, 181-184

Radon Calibration Laboratory of BfS

Controlled Rn-222, Rn-220, climate and aerosol parameters

Radon measurements in the area of radiation protection and research should be reliable. In order to meet this objective, the Federal Office for Radiation Protection (BfS) operates a laboratory for exposure to Rn-222 (radon) and Rn-220 (thoron) and their progenies, under defined climate conditions. Its infrastructure is dedicated to calibration exposures of measurement instruments, testing of metrological properties (type test), development of measurement methods and further research in the field of radon metrology.

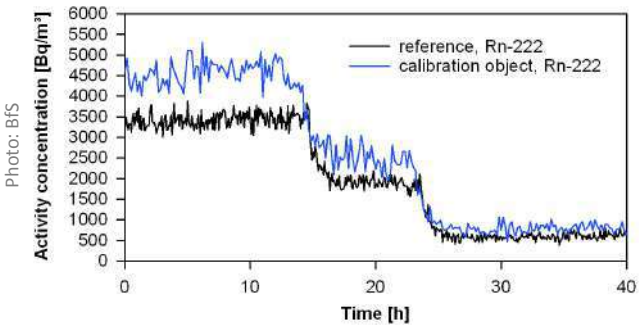


Photo: BfS

Rn-222 activity concentration within the chamber during exposure at different constant Rn-222 levels, measured by a calibration object and the laboratory's reference standards.

The measurands (Rn-222 and Rn-220) of activity concentration in air (CRn, CTn) and the potential alpha energy concentration of the short-lived Rn -222 progenies (PAEC), as well as the environmental parameters, are all traced back to national standards. The laboratory has been accredited since 1999 as a calibration laboratory for the measurands CRn and PAEC according to the norm EN ISO/IEC 17025. International comparisons of passive radon measuring instruments have been carried out since 2003. In addition to offering exposure and calibration services, the laboratory welcomes research collaborations with metrological or scientific institutions.

The radon atmospheres are generated either in several stainless steel containers with volumes of 0.4 m³, or in walk-in chambers with an inner volume of 11m³ and 30m³ (PAEC chamber). Rn-222 activity concentrations of between 50 Bq/m³ and 100 kBq/m³ are adjusted by injections of Rn-222 gas obtained from an Ra-226 source. To compensate for Rn-222 losses due to radioactive decay, the containers are permanently connected to Ra-226 flow-through sources via flow dividers or computer-controlled piston pumps. Atmospheres containing Rn-220 are created by a Th-228 source. The air inside the containers is continuously mixed by fans installed internally, which allow the activity concentrations to be kept sufficiently homogenous and constant in time during the exposures.

Photo: F. Schneider / BfS

Calibration laboratory group

The activity concentrations are continuously measured by scintillation cells and/or with a commercially available instrument. Temperature and humidity are monitored within all calibration containers; in the case of the walk-in chambers, temperature can be adjusted from -2°C to 40°C, and relative humidity from 10% to 90%. Ambient air pressure is also monitored.

The aerosol concentration, aerosol size distribution and air velocity all have a significant influence on the radon decay product atmosphere. Therefore, the PAEC chamber is equipped with:

- an aerosol generator to create aerosols with desired particle concentration (range 200-50,000 per cm³) and desired size distribution,
- a scanning mobility particle sizer spectrometer to measure the aerosol particle concentration and size distribution, and
- fans with adjustable tilt and power.

Thus, the equilibrium factor in the PAEC chamber can be adjusted between 0.1 and 0.9, and the unattached fraction of the radon progenies between 1% and 60%. The PAEC itself reaches values of between 0.3 and 640 µJ/m³. In addition, an air filter system and different alpha and gamma spectrometers are also available.

Laboratory with stainless-steel containers, measurement and dosing system

Photo: MD/ BfS

Bundesamt für Strahlenschutz

ID Card:

Exposure type:
External

Source:
^{222}Rn, ^{220}Rn and their short-living progenies

Dose rate:
^{222}Rn activity concentration
0.5 – 100 kBq/m³

PAEC 0.3 – 640 µJ/m³

Irradiation type:
Alpha radiation (5.3 MeV, 6.0 MeV, 6.8 MeV, 7.7 MeV, 8.8 MeV)

Irradiated organism type:
non-biological materials

Address:
Federal Office for Radiation Protection (BfS)
Koepenicker Allee 120-130,
10318 Berlin, Germany

Access:
Site access by prior appointment only

Internet link:
http://www.bfs.de/EN/topics/ion/service/radon-measurement/calibration-laboratory/calibration-laboratory_node.html

Contacts:
E. Foerster
Dr M. Dubslaff
cal-radon@bfs.de

Related to: MELODI, EURADOS

Performance tests for instruments measuring radon activity concentration, Beck T.R., Buchroeder H., Schmidt V. (2009), Applied Radiation and Isotopes 67 (5), 876-880

The measurement accuracy of passive radon instruments, Beck T.R., Foerster E., Buchroeder H., Schmidt V., Doering J. (2013), Radiation Protection Dosimetry, 158 (1), 59-6

Calibration and Dosimetry Laboratory (INTE-UPC)

Radiation Protection and Medical Radiation Physics

The Calibration and Dosimetry Laboratory (in Spanish, LCD) of the Institute of Energy Techniques (INTE) at the Polytechnic University of Catalonia (UPC) is a secondary standard metrology laboratory for ionising radiation, accredited by the Spanish accreditation body (ENAC). The LCD obtained its first formal recognition in 1987 with the award of the EN 45001 standard, followed in 2009 by the ISO/IEC 17025.

Photo: INTE-UPC

Dr Mercè Ginjaume

Photo: INTE-UPC

UPC Photon calibration facility

The main equipment of the Laboratory includes the following: a photon irradiator with six ^{137}Cs and one ^{60}Co sources; an HS320 Rich Seifert X-ray generator of high stability with a maximum high voltage of 320 kV; a MAMMOMAT Siemens low-energy X-ray generator with Mo anode to produce mammography qualities; an Amersham-Buchler BSS-1 beta secondary standard irradiator with two sources of ^{90}Sr, and several 10 cm x 10 cm alpha-beta sources designed for calibrating portable surface contamination monitors.

Measurement traceability for photon radiation is ensured through the calibration of several ionisation chambers to the National Metrology Institute of Germany (PTB) and through the calibration of the beta secondary standard to the National Institute of Standards in the United States (NIST).

The LCD offers a calibration service for users of ionising radiation, mainly in Spain. The most common services include: calibration of environmental and radiation protection instruments; surface contamination monitors; kVp meters and dosimeters for X-ray quality control, and the irradiation of personal dosimeters both passive and active. LCD also collaborates with the Spanish Nuclear Safety Council (CSN, Spanish regulator), to organise periodic intercomparisons of Spanish-approved personal dosimetry services.

As a university laboratory, LCD organises training sessions for graduate and post-graduate students on topics related to the field of radiation protection. LCD is part of the Biomedical Engineering Research Centre (CREB) of the UPC. The LCD team is currently participating in several national and international research projects and is also actively involved in several activities of the European Radiation Dosimetry Group (EURADOS).

The main research projects undertaken at LCD include the FP7 project ORAMED (2008 -2011), various projects financed by the CSN (e.g. *Development of Methodologies for Estimating the Dose to the Eye Lens in Interventional Radiology* (2012-2015)), and the Horizon 2020 project, MEDIRAD (2017-2021). The research activities of the Laboratory are linked to the INTE's Dosimetry and Medical Radiation Physics research programme. Further details regarding projects, publications and theses involving the facilities, are available via the website.

Photo: INTE-UPC

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Institut de Tècniques Energètiques

ID Card:

Exposure type:
External

Source:
ISO 4037-1 Narrow X-Ray series, ^{137}Cs, ^{60}Co, IEC 61267 diagnostic (RQR) and mammography (RQR-M) radiation qualities, ISO 6980-1 ^{90}Sr-^{90}Y, wide area reference sources (^{90}Sr-^{90}Y, ^{60}Co, ^{14}C, ^{241}Am, ^{36}Cl)

Dose rate:
^{137}Cs (1 µGy/h - 54 mGy/h), ^{60}Co (11 µGy/h - 0.45 mGy/h), X-ray (narrow series) (0.1-200 mGy/h), X-ray (diagnostic) (0.1-10 Gy/h), ^{90}Sr-^{90}Y (4 mGy/h; 0.5 Gy/h)

Irradiation type:
gamma, X-ray, beta

Irradiated organism type:
None

Address:
Polytechnic University of Catalonia
Institute of Energy Technologies
Calibration and Dosimetry Laboratory
Diagonal, 647
08028 Barcelona (Spain)

Access:
Joint research collaborations, service contracts

Supporting lab:
Thermoluminescent Dosimetry Laboratory (TLD), Computer cluster

Internet link:
https://inte.upc.edu/en

Contact:
Mercè Ginjaume
+34 93 405 44 57
merce.ginjaume@upc.edu
+34 93 401 18 72
calibracion.laboratorio@upc.edu

Related to:
EURADOS, MELODI

First EURADOS intercomparison exercice of eye lens dosemeters for medical applications, Clairand I., Ginjaume M., Vanhavere F., Carinou E., Daures J., Denoziere M., Silva E.H., Roig M., Principi S., Van Rycheghem L. (2016), Radiat. Prot. Dosimetry 170 (1-4), 21-26

A practical approach to perform the isotropy test for extremity dosemeters, Gultresa J., Llansana J., Roig M., Ginjaume M. (2016), Radiat. Prot. Dosimetry 170 (1-4), 95-99

The Nuclear Metrology Group (NMG)

Neutron measurement and irradiation facility

NPL is the UK's National Measurement Institute and is a centre of excellence in developing and applying the highest quality measurement standards available. The Nuclear Metrology Group (NMG) represents one of NPL's many activities, and has world-class facilities for producing a wide range of well-characterised neutron fields. NMG can also determine the neutron output of radionuclide sources to high precision by measuring the activation of manganese in a manganese sulphate bath. These facilities are used for type testing and calibrating neutron-sensitive instruments, characterising neutron sources, and for research aimed at improving neutron standards and neutron measuring instruments. Much of the work is for radiation protection.

Photo: NPL

Dr Nigel Hawkes

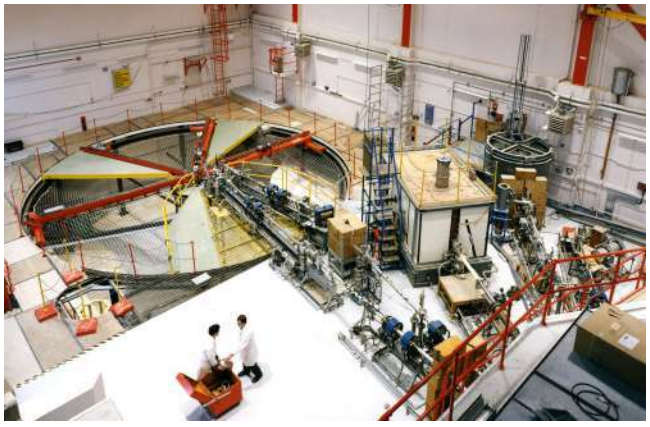


Photo: NPL

Main experimental area, measuring 18 x 18 x 26 m. From bottom right towards top left, the photo shows the accelerator beam lines, the thermal pile, and the low-scatter area.

In the main experimental area, protons or deuterons from a 3.5 MV Van de Graaff accelerator can be directed onto a suitable target to produce monoenergetic neutrons at energies from under 100 keV to 16.5 MeV (although not all energies within this range are available). The target is at the centre of a low-scatter area, at least 6 m away from the floor or any massive structures, in order to minimise room scatter. The neutron fluence is measured using carefully calibrated long counters.

To produce thermal neutrons, deuterons from the same accelerator are directed instead into the thermal pile, which consists essentially of two high-output neutron-producing targets inside a large graphite moderator. The highest fluence rates are available near the centre of the moderator via a 12 cm diameter access hole, while wider artefacts can be irradiated in a vertical thermal beam that emerges from the top of the pile.

The low-scatter area is also used for irradiations with radionuclide sources, of which the group has several of various types, including ^{241}Am/Be and ^{252}Cf. A D_2O-moderated ^{252}Cf field is also available. A pneumatic transfer system is used to bring the strongest of the sources from the shielded store to the irradiation position.

In addition to its irradiation facilities, the NMG has several neutron instruments, including Bonner sphere spectrometer sets and tissue equivalent proportional counters. These are used for neutron research, usually dosimetry-related, or for making off-site measurements at a customer's own premises. NMG also has considerable expertise in neutron-related calculations, including Monte Carlo modelling and the unfolding of neutron energy spectra from pulse height spectra. Currently the group is planning a new facility to produce an intense neutron field for radiation hardness testing.

Some examples of the type of work undertaken by the group are:

- Irradiating personal dose meters to precisely known doses for an intercomparison exercise;
- Contributing to the design of novel neutron instruments through Monte Carlo modelling and experimental measurements;
- Characterising the angular distribution of the output of a neutron source or generator, relative to its symmetry axis;
- Measuring neutron dose rates close to radiotherapy facilities.

Photo: NPL

The Manganese Bath facility for measuring the neutron output of radionuclide sources by the activation of manganese sulphate solution.

Progress in providing neutron standards at the UK National Physical Laboratory, Hawkes N. P., Bennett A., Cheema S. S., Horwood N. A., Jones L. N., Kolkowski P., Roberts N. J., Taylor G. C. and Thomas D. J. (2007), Nuclear Instruments and Methods in Physics Research Section A, 580, 183–185

Recent developments in radionuclide neutron source emission rate measurements at the National Physical Laboratory, Roberts N. J. and Jones L. N. (2010), Applied Radiation & Isotopes, 68, 626-630

NPL National Physical Laboratory

ID Card:

Exposure type:
External

Source:
Am/Be, Am/B, Am/F, Am/Li, ^{252}Cf, D_2O-moderated ^{252}Cf; ^{60}Co, ^{137}Cs;
Monoenergetic neutrons 70 keV to 16.5 MeV;
Thermal pile.
Measurement of neutron source emission rate via Mn bath.

Dose rate:
Depending on source and energy, 1 to several thousand µSv/h at 1 m
Thermal pile: max neutron fluence rate $3x10^7$ cm^{-2} s^{-1}.

Irradiation type:
Neutron with gamma present, gamma

Irradiated organism type:
None

Address:
National Physical Laboratory
Hampton Road
Teddington,
Middx. TW11 0LW
United Kingdom

Access:
See contacts below

Internet link:
http://www.npl.co.uk/science-technology/neutron-metrology/

Contact:
David Thomas
david.thomas@npl.co.uk

Nigel Hawkes
nigel.hawkes@npl.co.uk

neutron_enquiries@npl.co.uk

+44 20 8943 8637

Related to:
EURADOS

UNIPI neutron irradiation facility

Neutron irradiation room with AmBe and gamma sources

The University of Pisa's neutron irradiation facility (UNIPI-AmBe) has been in operation since 2010, and consists of an irradiation room for fast neutrons and gamma exposures designed to minimise neutron scattering. The facility, which is part of the Nuclear Measurement Laboratory of the University of Pisa, has been performing nuclear measurements for over 50 years.

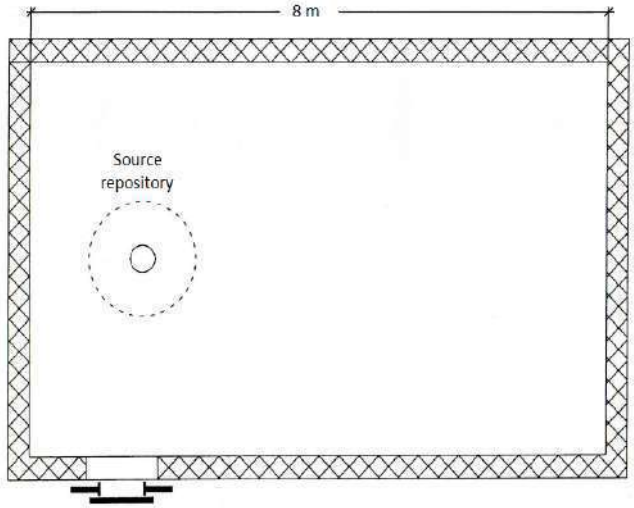


Photo: R. Ciolini/Pisa University

Top view of the neutron/gamma irradiation facility

It consists of an open space (5 m x 8 m x 2.5 m) with concrete walls, no windows and only one access door. Located in a 2 m deep ground repository, it houses two radionuclide AmBe neutron sources with a total nominal activity of 14.2 GBq, and a ^{60}Co source with a nominal activity of 1.1 GBq. The reference neutron dose rate H*(10) is 9.4 µSv/h at 1 m neutron source distance. Moreover, a ^{60}Co calibrated source (dose rate 0.53 mSv/h at 1 m free in air) is available in the source repository, to be used for personal gamma dosimetry calibration or together with neutron sources to investigate the response of the detectors to mixed radiation fields. A broad range of neutron and gamma dose rates can be obtained by varying the distance between the source and the irradiated device.

An air conditioning system maintains the room temperature at a constant value during the exposures. The radioactive sources are extracted from the storage box and positioned inside the room, at a specified distance from the device/detector to be irradiated. At the end of the irradiation, they are stored again in the repository. There are no particular restrictions on the items to be irradiated; only size limitations due to the dimensions of the room and the entrance door. The duration of each exposure is normally within an interval of 0–24 h, but longer time intervals are possible. The facility is protected by a controlled access security system. All irradiation procedures and instrument calibrations are performed according to the facility's ISO 9001 standard certification.

Photo: R. Ciolini/Pisa University

Dr Riccardo Ciolini

The UNIPI-AmBe facility includes ancillary equipment such as a Bonner sphere spectrometer system, 30 cm x 30 cm x 15 cm ISO phantoms, supports for objects to be irradiated, and Rem counters and gamma dose rate meters for environmental gamma/neutron monitoring. The facility is mainly used for nuclear measurement research, instrument calibration (dose/dose rate meters) and radiation protection measurements, but also performs teaching activities (Nuclear and Biomedical Engineering Master's degree courses). In addition to offering exposure and calibration services, the facility welcomes research collaborations with metrological or scientific institutions.

Photo: R. Ciolini/Pisa University

View of the irradiation room

UNIVERSITÀ DI PISA

ID Card:

Exposure type:
External

Source:
AmBe and ^{60}Co

Dose rate:
9.4 µSv/h at 1 m (neutron) and 0.53 mSv/h at 1 m (gamma)

Irradiation type:
Neutron, gamma

Irradiated organism type:
None

Address:
Bruno Guerrini Laboratory

Department of Civil and Industrial Engineering (DICI)

University of Pisa

Via di Torretta
I-56122 San Piero a Grado
Pisa, Italy

Access:
Subject to prior agreement with the management staff

Supporting lab:
Nuclear Measurement Laboratory

Department of Civil and Industrial Engineering (DICI)

University of Pisa

Largo Lucio Lazzarino 2

I-56126 Pisa, Italy

Internet link:
www.dici.unipi.it

Contact:
Riccardo Ciolini
+39 050 2218026
r.ciolini@ing.unipi.it

Related to:
EURADOS

Track size distributions in CR-39 neutron dosimeters treated with carbon dioxide, d'Errico F., de Vasconcelos D. A. A., Ciolini R., Hulber E. (2017), Radiation Measurements, 106, 607-611

Application of a Bonner sphere spectrometer for the determination of the angular neutron energy spectrum of an accelerator-based BNCT facility, Mirzajani N., Ciolini R., Di Fulvio A., Esposito J., d'Errico F. (2014), Applied Radiation & Isotopes, 88, 216-220

Chapter 2 : Databases, Sample banks, Cohorts

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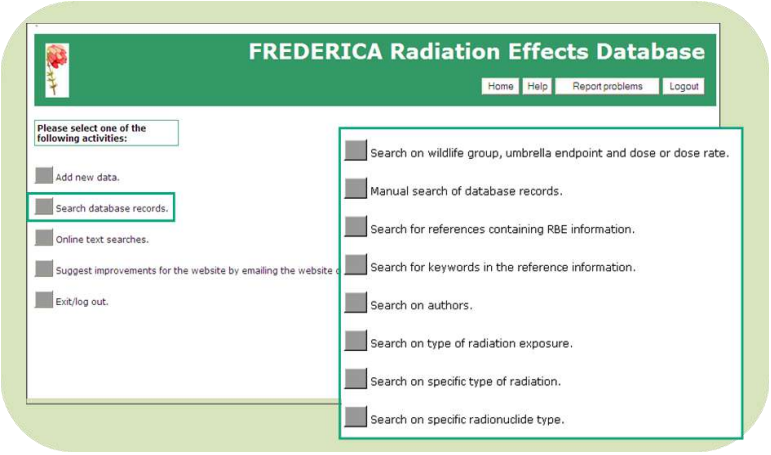
FREDERICA

A unique database on the effects of ionising radiation in non-human biota

Knowledge of ionising radiation-induced effects on diverse organisms is crucial to assess the radiological impact on the environment. The FREDERICA radiation effects database was developed to provide an online compilation of the known effects of ionising radiation on non-human species. The database was produced under the EC funded project ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) and is available online (see link in ID Card).

FREDERICA contains some 30,000 data entries from 1,231 references. The data entries correspond to pairs of points (exposure level, biological effect) along with information on the conditions in which these data were obtained (tested species, life stage, exposure regime, effect endpoint, etc.). The data are organised into wildlife groups (amphibians, aquatic invertebrates, aquatic plants, bacteria, birds, crustaceans, fish, fungi, insects, mammals, molluscs, mosses/lichens, reptiles, soil fauna, terrestrial plants and zooplankton). While the biological effects reported in the database are at an individual level, the endpoints considered include those relevant to possible responses at the population level (e.g. reproductive capacity, mortality, morbidity and mutations) [1].



Search capabilities of the FREDERICA database

Each reference in FREDERICA was reviewed for the information that is available to the reader in relation to dosimetry, experimental design and statistics. The information provided was scored to reflect the presence or absence of these key data. This provides a measure of the quality of the information in each reference so that if further work is needed (e.g. to refine risk assessment criteria) those papers which contain most, if not all, of the likely information can be easily found.

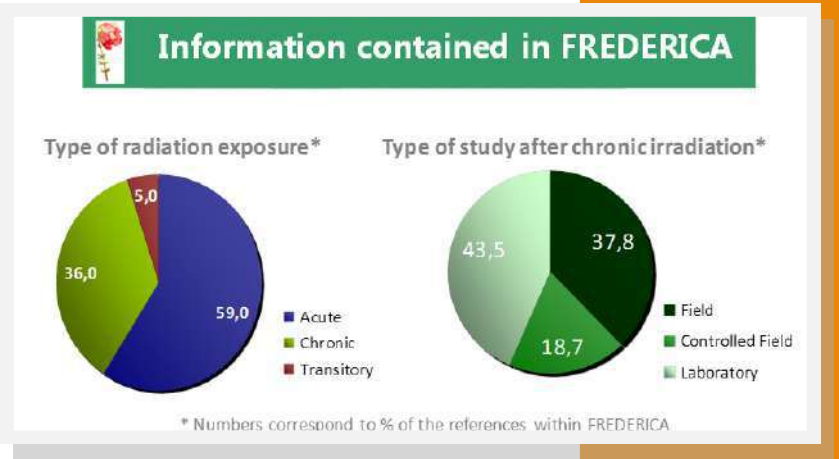
Within the information compiled in FREDERICA, 64% of the data sets have been obtained after acute and transitory exposure to radiation (59 and 5%, respectively), whereas 36% of the data sets have been obtained after chronic irradiation. Chronic irradiation studies are considered to be more relevant to environmental radiological protection [2]. Considering chronic exposure data, fish, mammals and terrestrial plants are the wildlife groups most widely reported, representing 70.5% of the FREDERICA data for chronic irradiation. The information is scarce for bacteria, crustaceans, fungi, moss and lichen, and zooplankton, since only one or two references have been found for these groups. There is no information on the effects of chronic irradiation for amphibians, aquatic plants or reptiles [1].

Almudena Real

FREDERICA offers several search capabilities (see Figure above), for which outputs can be exported as an Excel or text file.

The FREDERICA database has been used in many applications, such as:

- Helping define biological effect levels.
- Inclusion as part of the ICRP Reference Animals and Plants (RAPs) review.
- Inclusion as part of the UNSCEAR review on biological Endpoints.
- Integration into the ERICA Tool to perform environmental risk assessments.



FREDERICA Radiation Effects Database

ID Card:

Database topic:
Ionising radiation-induced effects

Information available type:
Exposure-biological effect, species, life stage, irradiation regime. Searchable

Data type:
Peer reviewed articles

Link with a biobank:
No

Exportable:
Yes

Species:
Non-human animals and plants

Internet link:
http://www.frederica-online.org/mainpage.asp

Access:
Free (user needs to register)

Contact:
Almudena Real: almudena.real@ciemat.es;
+34 913 466 750
David Copplestone: david.copplestone@stir.ac.uk;
+44 01786 467852

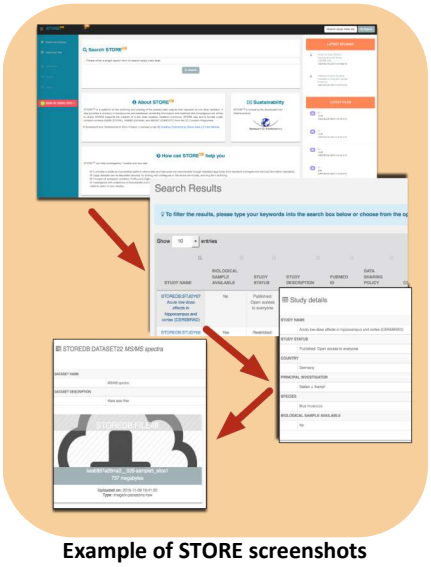
Related to: ALLIANCE

[1] THE DEVELOPMENT AND PURPOSE OF THE FREDERICA RADIATION EFFECTS DATABASE. D. Copplestone, et al. Journal of Environmental Radioactivity 99: 1456-1463 (2008).
[2] ISSUES AND PRACTICES IN THE USE OF EFFECTS DATA FROM FREDERICA IN THE ERICA INTEGRATED APPROACH. J. Garnier-Laplace, et al. Journal of Environmental Radioactivity 99: 1474–1483 (2008).

STORE

An infrastructure for sharing of data and resources

Sharing primary data to enable accountability, reproducibility and re-use has become a concern for the whole of the scientific community in recent years. Funding agencies and journals alike now insist that the products of publicly-funded science are made freely available. The European Commission has been in the forefront of open data policies, and the sharing of data and biomaterial from publicly-funded radiation protection related science will be required by Horizon 2020. Open data adds great value to the original investment and yields substantial scientific rewards [1].



Picture: P. Schofield/UCam

Example of STORE screenshots

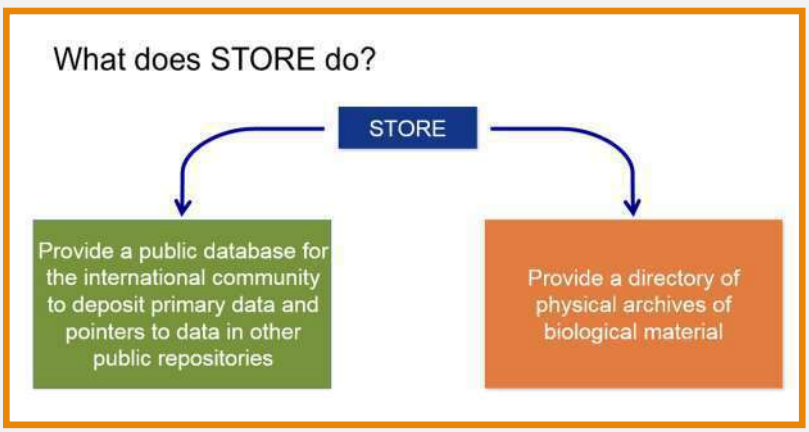
Based on experience from the ERA database [2], the STORE consortium created a platform to provide an infrastructure for the storage and dissemination of data from radiobiological research. When STORE became part of DoReMi, it was broadened to fit the needs of radiation epidemiology and it took on the additional role of acting as a directory of bioresources. With the start of CONCERT, it became clear that the needs of other platforms or consortia should also be considered, e.g. ALLIANCE and RENEB. CONCERT's Subtask 6.2.1 will develop STORE according to this new user need, and a contract between BfS and the University of Cambridge, the developer of STORE (UCam, Paul Schofield), has been signed within the framework of CONCERT.

STORE is a platform for resource sharing which enables users to locate data or bioresources, such as physical samples (tissue samples, FFPE blocks, slides, etc.), using structured metadata and standard vocabularies. Users, identified by their ORCID IDs, can upload primary data of any format, accession IDs for data in other databases, and details of physical samples. Data is assigned an accession number and will be given a DOI which will enable it to be cited in publications. Uploading is project-based and users retain control and ownership of their data. The BfS provides long term sustainability and data security so that users can be assured of longevity and security. Data may be stably archived for future use, cited in support of publications, or shared between collaborators. The database has additional applications for standardisation, validation, education and radiological emergency resilience.

Photo: R. Kanzliwius/BfS

Bernd Grosche

STORE is available at http://www.storedb.org. The resource is open and free to individual investigators, journals and funding agencies. It establishes the basis for long-term use and exchanges between scientists from different countries and from various fields; in addition, its flexibility and agility allows it to act as a sharing and archival infrastructure for the whole radioprotection research community. Links to other relevant databases have already been established (e.g. CTB, ERA, Janus) and further links will follow (e.g. FREDERICA). STORE will be federated with the European Commission's re3data initiative, Biosharing, and will be compliant with Nature Scientific Data's criteria for recognised repositories. Questions and suggestions are welcome at store@bfs.de.



Picture: P. Schofield/UCam, & B. Grosche/BfS

ID Card:

Database topic:
Primary data from low dose radiation studies, materials and bioresources.

Description:
STORE is a platform for the archiving and sharing of the primary data outputs from research on low dose radiation. In addition it provides a directory of bioresources and external databases containing relevant information and materials that investigators are willing to share.

Data ownership:
Ownership of Data remains with the originator, but the database is under the direction of BfS and UCam.

Data type:
Any kind of data, no format requirements

Access:
Free to deposit and recover data. Sign up via ORCID ID. Data can be selectively released by the originator or made totally open.

Exportable:
Data can be exported

Species:
Humans, animals, plants (to come)

Internet link:
http://rbstore.eu; http://storedb.org

Contact:
store@bfs.de
At BfS:
Bernd Grosche, bgrosche@bfs.de
Ulrike Kulka ,ukulka@bfs.de
Mandy Birschwilks, mbirschwilks@bfs.de
At UCam:
Paul Schofield ,pns12@cam.ac.uk
Michael Gruenberger (technical support), mg287@cam.ac.uk

Related to:
CONCERT, MELODI, ALLIANCE, RENEB

[1] **ARCHIVING LESSONS FROM RADIOBIOLOGY.** Schofield PN, Tapio S, Grosche B. Nature 2010; 468:634-634
[2] **THE EUROPEAN RADIOBIOLOGICAL ARCHIVES: ONLINE ACCESS TO DATA FROM RADIOBIOLOGICAL EXPERIMENTS.** Birschwilks M, et al. Radiat Res 2011; 175:526-531.

Wildlife Transfer Database

Database collating concentration ratios for wildlife

A key element of most systems for assessing the impact of radionuclides on the environment is a means to estimate the transfer of radionuclides to organisms. To facilitate this, an international wildlife transfer database (WTD) was developed

to provide an online (http://www.wildlifetransferdatabase.org/), searchable compilation of transfer parameters in the form of equilibrium-based whole-organism to media concentration ratios (CRwo-media). The database was subsequently used to produce IAEA (TRS-479) and ICRP (ICRP-114) publications and also to populate version 1.2 of the ERICA Tool (http://www.erica-tool.com/).

The original version of the WTD, as described by Copplestone et al. (2013) contained information from 523 references. There were more than 50,000 lines of data representing 86,979 CRwo-media values for 1438 species and 71 elements. Subsequently, about 17,000 additional CRwo-media values have been added to December 2013 (Brown et al., 2016). These new inputs include: data for representative species of the ICRPs Reference Animals and Plants from a UK forest; monitoring data from Finland and Japanese estuaries; Canadian wildlife data; Pu data from US weapons testing programme sites; data for wild plants and invertebrates from north western USA. The number of elements included, as of December 2013, had increased to 80.

Photo: R. Fawkes(University of Salford

Nick Beresford

Currently the database is being used to: develop the update of IAEA SRS-19; by the ICRP in the development of its environmental protection framework; and to develop novel transfer models by the TREE project (http://www.ceh.ac.uk/tree).

The wildlife transfer database is being maintained and is open for all interested parties to add appropriate data. Periodically updated summary tables are provided on the database website. A help file for completing the database is available from: https://wiki.ceh.ac.uk/x/-QHbBg. Anybody wanting to add large amounts of data should contact Nick Beresford or David Copplestone to discuss how this can be most efficiently done.

Sampling earthworms (http://www.ceh.ac.uk/tree)

Photo: C. Barnett/NERC-CEH

ID Card:

Database topic:
Radioecology

Information available type:
Wholebody radionuclide concentration ratios

Data type:
Database

Link with a biobank:
no

Exportable:
Summary tables only

Species:
All wildlife (plants and animals)

Internet link:
http://www.wildlifetransferdatabase.org/

Access:
Free – to add data and view/export summaries

Contact:
Nick Beresford
nab@ceh.ac.uk

David Copplestone
david.copplestone@stir.ac.uk

Related to:
ALLIANCE

AN INTERNATIONAL DATABASE OF RADIONUCLIDE CONCENTRATION RATIOS FOR WILDLIFE: DEVELOPMENT AND USES. Copplestone, D. et al. 2013. J. Environ. Radioact. 126, 288-298.
A NEW VERSION OF THE ERICA TOOL TO FACILITATE IMPACT ASSESSMENTS OF RADIOACTIVITY ON WILD PLANTS AND ANIMALS. Brown, J.E., et al. 2016. J. Environ. Radioact. 153, 141-148.

RES³T

Mineral-specific sorption data (for mechanistic models)

RES³T, the Rossendorf Expert System for Surface and Sorption Thermodynamics, is a digitised thermodynamic sorption database which is implemented as a relational database. It is mineral-specific and can therefore also be used for additive models of more complex solid phases such as rocks or soils. Its purpose is to support reactive transport modelling for contaminants through the geosphere and ecosphere. RES³T allows the parameterisation of mechanistic sorption models, offering added value in the form of explanations and scientific support for measured data, and increasing confidence levels especially for Kd values measured under complex site-specific conditions. Predictive uses can provide approximations for parameter spaces that are difficult or too time-consuming for experiments. Combined with sensitivity and uncertainty analyses, it can probe the influence of variability and uncertainties in geochemistry on Kd. It may also improve experimental set-up. In addition, it can provide scoping calculations and estimate the possible effect of "what-if" scenarios on Kd.

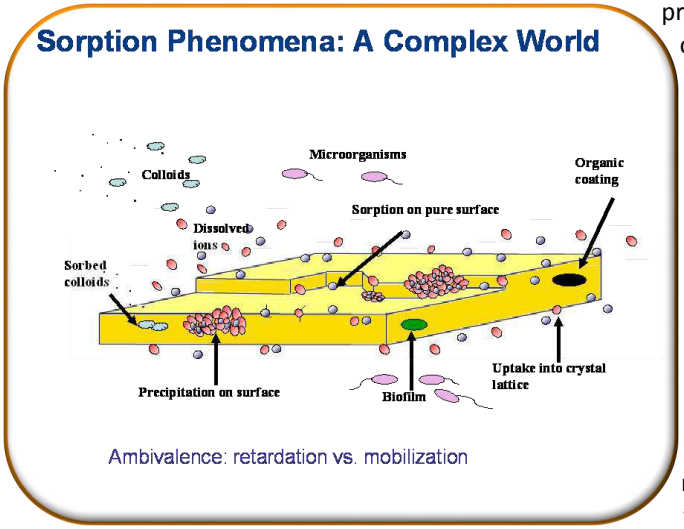


Photo: V. Brendler / HZDR

The universum of processes affecting the transport of contaminants through the ecosphere

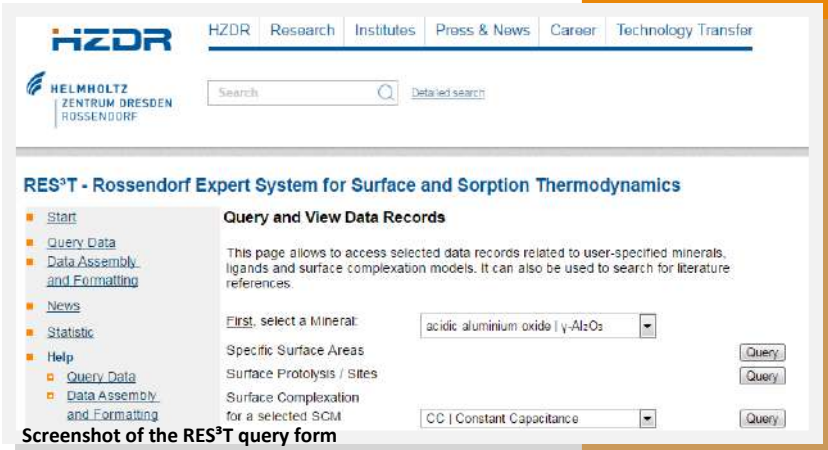
An integrated user interface helps to access selected mineral and sorption data, to extract internally consistent data sets for sorption modelling, and to export them into formats suitable for other modelling software. Data records comprise mineral properties, specific surface area values, characteristics of surface binding sites and their protolysis, sorption ligand information and surface complexation reactions. The database contains originally published values only, i.e. for many surface reactions, different competing constants are provided (no recommended values), thus the user has to decide which values to actually use. The surface complexation models which are most extensively covered include the Constant Capacitance, the Diffuse Double Layer, the Triple Layer, the Non-electrostatic and the CD-MUSIC approaches. The two surface protolysis steps are supported. The selection of minerals via the RES³T interface allows comprehensive modelling of retardation in most of the relevant soil and rock types, thus delivering source terms for a broad variety of transfer coefficients. The focus for dissolved contaminants and ligands is currently set to radionuclide, heavy metals and arsenic, but in principle any dissolved moiety that is able to sorb onto surfaces can be included.

Photo: J. Grämer / HZDR

Vinzenz Brendler

An extensive bibliography is also included, providing links not only to the above-listed data items, but also to background information on surface complexation model theories, surface species evidence by independent spectroscopic and quantum chemical approaches, and sorption experiment techniques. Access to the database is free and requires no registration. However, the developers are grateful for any critical feedback to further improve functionality and extend the range of application areas.

This project was funded by the German Federal Ministry of Economics and Labour (BMWA) under contract No. PtWt+E 02E9471.



Screenshot of the RES³T query form

Photo: V. Brendler / HZDR

RES³T-ROSSENDORF EXPERT SYSTEM FOR SURFACE AND SORPTION THERMODYNAMICS. V. Brendler, et al. Journal of Contaminant Hydrology, 61 (2003), 281-291.
GUIDELINES FOR THERMODYNAMIC SORPTION MODELLING IN THE CONTEXT OF RADIOACTIVE WASTE DISPOSAL. Payne T.E., et al. Environmental Modelling & Software, 42 (2013), 143-156.

ID Card:

Database topic:
Geochemistry, Radioecology

Information available type:
Mineral-specific sorption data (for mechanistic models)

Data type:
Thermodynamic sorption data, mineral characteristics, bibliography

Link with a biobank:
Not available

Exportable:
ASCII, CSV, MS Excel

Species:
138 Ligands onto 135 minerals (as of April 2016)

Internet link:
www.hzdr.de/res3t

Access:
Free, but usage shall be cited

Contact:
Vinzenz Brendler
V.Brendler@hzdr.de
+49 351 260 2430

Related to:

JANUS Animal Radiobiology Archive

Irradiated animal data and tissue archive

Created by Dave Paunesku for the Woloschak Lab at Northwestern University and financed by NASA and the US Depatment of Energy, a collection of data and tissue samples from materials made at different US National Laboratories during animal studies done between 1950's and 1990's is accessible. The Janus experiments, carried out at Argonne National Laboratory from 1972 to 1989 and supported by grants from the US Department of Energy, investigated the effects of neutron and gamma radiation on mouse tissues primarily from B6CF1 mice.

photographer T. Paunesku

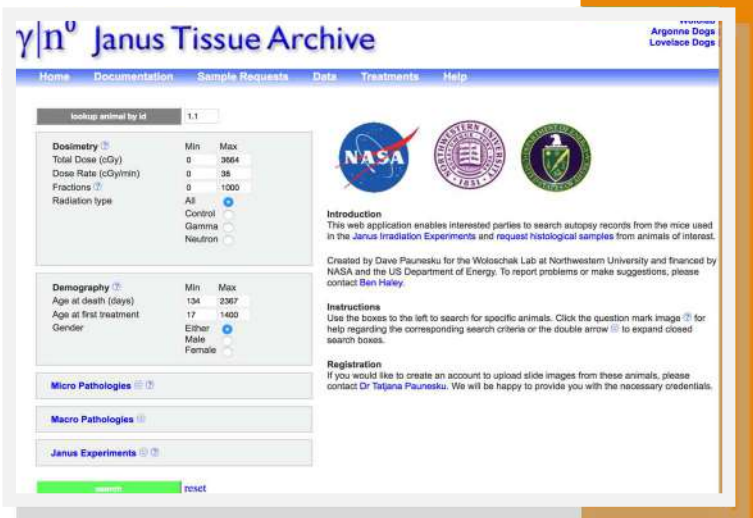
Pr Gayle Woloschak

Historic ANL photo

Janus irradiator configuration surrounded with animal cages

Data and paraffin embedded tissues from thousands of mice and dogs exposed to ionizing radiation are available for research. These materials were collected over several decades of DOE funded research. Studies using these materials and information include computational research (see e.g. reference 1) as well as use of tissues for PCRs, immunohistochemistry, X-ray fluorescence microscopy (e.g. reference 2) etc. All of these resources are available for collaborative research with CONCERT projects and may be of interest for several reasons: (a) archival materials include tissues from many thousands of animals exposed to low dose rates or low doses of radiation; (b) data about radiation exposures of these animals is comprehensive, including details about irradiations (age of first exposure, dose, dose rate, delivery protocol etc.) as well as animals (gender, species, strain, age at first and final exposure, age at death, health status etc.). Much of the recent work was made public not only through publication but also through open source sharing.

For example, both data [https://github.com/benjaminhaley/janus/blob/master/data/external5.rds] and scripts [https://github.com/benjaminhaley/janus/blob/master/scripts/exp/ddref.Rmd] used for work published in reference 1 are available on github. Therefore, materials available in Janus Animal Radiobiology Archive may also be used for training/educational purposes.



THE INCREASE IN ANIMAL MORTALITY RISK FOLLOWING EXPOSURETO SPARELY IONIZING RADIATION IS NOT LINEAR QUADRATIC WITH DOSE
Haley BM, Paunesku T, Grdina DJ, Woloschak GE. PLoS One. 2015 Dec 9;10(12)
PAST AND FUTURE WORK ON RADIOBIOLOGY MEGA-STUDIES: ACASE STUDY AT ARGONNE NATIONAL LABORATORY
Haley BM, Wang Q, Wanzer B, Vogt S, Finney L, Yang PL, Paunesku T, Woloschak G. Health Phys. 2011 Jun;100(6):613-21.

ID Card:

Database topic:
Radiobiology

Information available type:
Exposure dose, age of exposure, gender, species, dose rate, time of death, necropsy report (gross and micro pathology), searchable

Data type:
animal lifespan, diseases at time of death

Link with a biobank:
yes (paraffin tissues only)

Exportable:
yes

Species:
mice,dogs

Internet link:
http://janus.northwestern.edu/janus2/index.php

http://janus.northwestern.edu/janus2/dog_tissues/

http://janus.northwestern.edu/lovelace/

Access:
free

Contact:
Tatjana Paunesku
t.paunesku@gmail.com

Benjamin Haley
Benjami.haley@gmail.com

MARiS – MARine Information System

Measurements of radioactivity in the marine environment

On behalf of its Member States, the IAEA Environment Laboratories are responsible for the data curation and development of the Marine Information System (MARiS), an online database of levels of radionuclides in the marine environment. MARiS makes available data and information on radionuclides for scientists, policy-makers and interested members of the public to have a better understanding of radioactivity levels in the world's oceans.

Photo: V. Shi/Xiamen University

Paul J. Morris

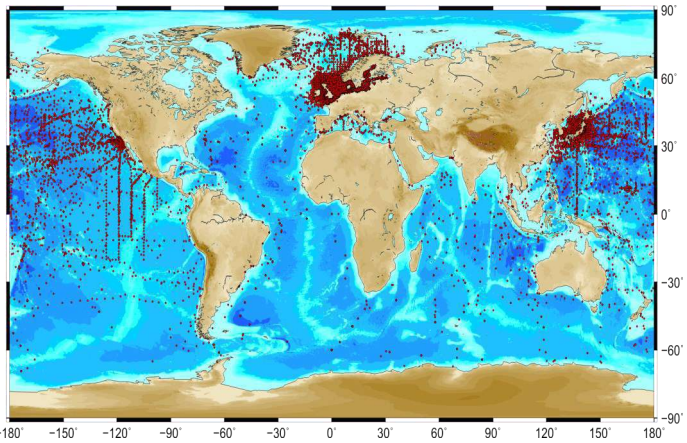


Photo: P. Morris/IAEA

The global distribution of measurements of radionuclides in seawater contained in MARiS

Seawater, sediments and biota in the ocean are naturally radioactive. In addition, the ocean contains a comparatively small amount of radioactivity resulting from anthropogenic activity (i.e. human-caused). The major sources of anthropogenic radionuclides include fallout from nuclear weapons testing, and both routine and accidental releases from nuclear facilities. These radionuclides end up in the marine environment through direct discharges, atmospheric deposition, or run-off from land. The majority of naturally-occurring radionuclides originate from the rocks and sediments that make up the Earth's crust and ocean floor, while others are produced by the interaction of cosmic rays with the higher atmosphere. Access to data on marine radioactivity is essential for understanding natural marine processes and humans' impact on the seas and oceans.

The MARiS database currently contains over 176,000 marine radioactivity data, representing more than 60 different radionuclides or radionuclide ratios in seawater, biota, seabed sediments, and suspended matter. Data contained in the MARiS database is extracted from a larger in-house database called GLOMARD, the Global Marine Radioactivity Database, which serves as the master database for data curation and validation prior to inclusion in MARiS. Marine radioactivity measurements have been collected, managed and curated at the Environment Laboratories in Monaco since the early 1990s. Data originates from published scientific papers, reports, and databases created within institutes or scientific programmes in Member States. Data included in MARiS has either already been published or has been submitted directly from a data provider with permission to include the data in MARiS. MARiS website users can search for data using various criteria, for example geographical region, type of sample, radionuclide, date or depth.

Data in MARiS can be used by Member States to assess distributions and trends of radionuclides; validate dispersion models, provide data constraints for radiological assessment models; and investigate marine processes (e.g. water-mass transport, carbon cycling, sedimentation rates), some of which influence pollution and climate. In addition to scientists and policy-makers, MARiS can be used by the public to access reliable information about radioactivity in the marine environment.

If you have data that you would like to contribute to MARiS you are invited to email the contact in the ID Card.

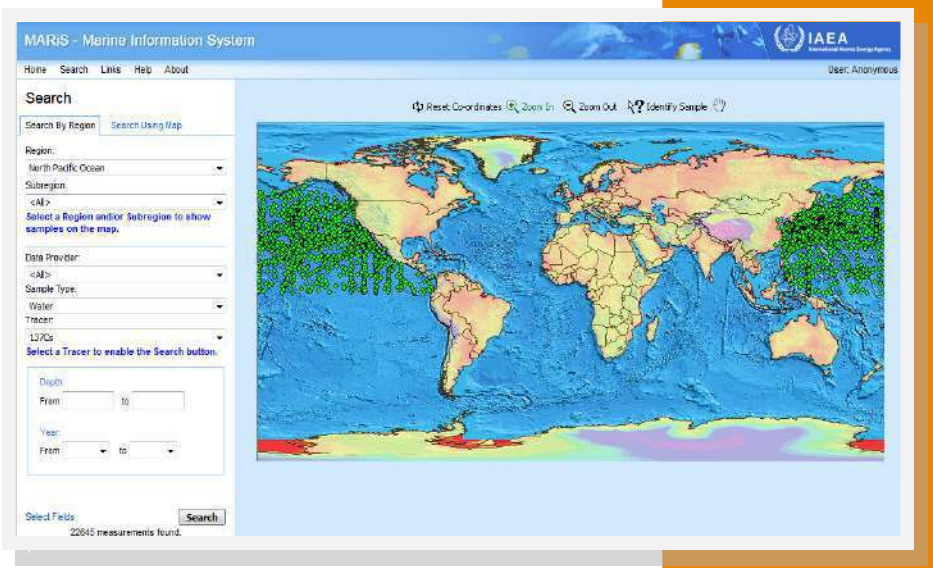


Photo: P. Morris/IAEA

Screenshot of the MARiS query form and auto-updating map when searching for measurements of, for example, Cs-137 in seawater in the North Pacific

ID Card:

Database topic:
Marine radioactivity

Information available type:
Measured activities of radionuclides in marine samples with associated metadata

Data type:
Reported values from publications, data reports, other databases, and direct submission from data-originators

Link with a biobank:
No

Exportable:
Preview table is exportable to a downloadable CSV file

Species:
Marine samples: seawater, sediment, biota, suspended matter

Internet link:
https://maris.iaea.org/

Access:
Open access with a request to acknowledge the source of the data

Contact:
MARIS.Contact-Point@iaea.org

Related to:
ALLIANCE

Global marine radioactivity database (GLOMARD), IAEA (2000), TECDOC-1146

MARiS homepage contains links to various presentations

Subcategory (b) : Sample banks		
Infrastructure	Other categories	Page
Biobank of Eastern Finland		53
Chernobyl Tissue Bank		54
Belgian Soil Collection		55
The Bank of Biological Materials of SBRC		56

BIOBANK OF EASTERN FINLAND

Potential for development of personalised medicine

The Biobank of Eastern Finland was established by the Hospital Districts of Eastern Finland and the University of Eastern Finland in 2015, in Kuopio. It is a hospital-integrated biobank with a catchment area population of over 800,000. The biobank aims at collecting samples from each new consenting patient entering a hospital in Eastern Finland ("Capture all newcomers" principle).

Existing pathology archives contain 250,000 samples from 100,000 persons. Population based diagnostic samples are connected with clinically relevant information from hospital records, including demographics, treatment, long-term follow-up and genomic data, if available. The advanced Finnish Biobank Act enables the donors to be re-contacted for collection of additional information. Digitalisation of FFPE-tumour material as well as tissue microarrays are ongoing. To ensure high quality samples and data, the Biobank of Eastern Finland implements the OECD Quality Guidelines.

Photo: Alias, Markus Aspergen

Digital pathology service

The population in Eastern Finland is highly homogenous due to the founder effect, geographic and historical barriers and low migration. The combination of the biobank sample material and related genomic and clinical information creates a valuable framework for research towards innovations in personalised medicine.

The specific benefits for Finnish biobank research include the availability of individual social security numbers, old church records dating back to the 17th century used to track people, national health care registries and hospital electronic health records. The data is continually integrated to provide tools for clients with innovative research initiatives. Special emphasis is set on the acceptance and support of the public for the biobank's goals and functions; the Finns, in general, are willing to provide personal information for medical research, which ensures a representative sample of the population.

Sisko Salomaa

Arto Mannermaa

Photo: UEF

The Finnish Biobank Act came into force in September 2013. The purpose of this new act is to promote medical research and innovation and also to protect donor rights and privacy. The key aspects of the legislation are broad consent for upcoming research and the enabling of secondary use of stored samples and related data.

The biobank can assign samples and related data for the sole purpose of high-level health sciences research and product development. Scientists who are planning a research project and would like to use the biobank's materials are invited to contact the biobank for further information for their research design.

The Biobank of Eastern Finland collaborates with the University of Eastern Finland (Department of Environmental and Biological Sciences) in the OPERRA project. The aim is to set up guidance and procedures for the biobanking of samples from patients exposed to medical radiation, and to provide high quality dosimetric information.

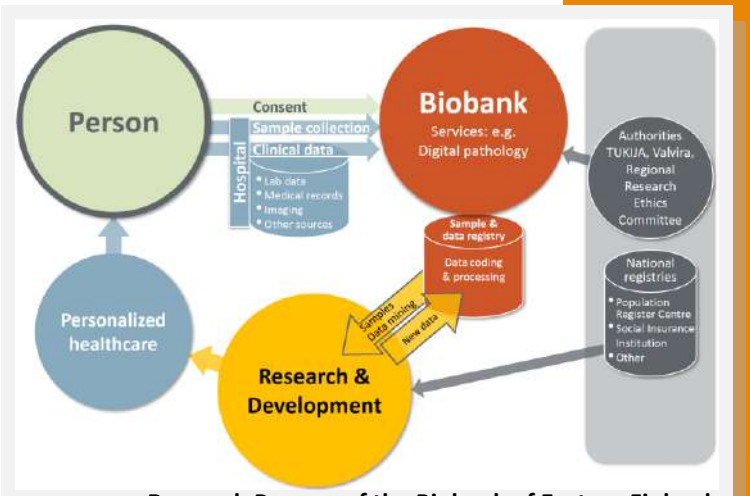


Photo: UEF

Research Process of the Biobank of Eastern Finland

ID Card:

Sample bank topic:
Clinical Biobank

Type of samples:
Human tissue samples and related clinical data from a population isolate in Eastern Finland

Sample type:
Blood, Serum, Plasma, Tissue (FFPE/frozen), DNA

Sample storage condition:
FFPE at room temperature; tissue samples, plasma and serum at liquid nitrogen vapor phase

Condition of use:
For medical research and R&D purposes

Access:
Researchers interested in the biobank material should contact biobank and send a proposal to biobank SAB

Internet link:
www.easternfinlandbiobank.fi

Contact:
Arto Mannermaa
Arto.mannermaa@uef.fi

Related to:
BBMRI,UEF, KUH

MELODI, EURADOS, EURAMED

CHERNOBYL TISSUE BANK

Providing quality assured and annotated human biosamples

The Chernobyl Tissue Bank (CTB) was established in 1998 to collect, store and distribute biological samples from patients born on or after 26th April 1967, and resident in the regions of Ukraine and Russia contaminated by fallout from the Chernobyl accident and who developed thyroid cancer. The project is supported financially by the National Cancer Institute of the USA and the Sasakawa Memorial Foundation of Japan, and has the political support of the Governments of Ukraine and Russia. Patients attending thyroid clinics in the Institute of Endocrinology in Kiev, Ukraine and the Medical Radiological Research Centre in Obninsk, Russia are asked to consent to the use of samples left over from their operation for suspected thyroid cancer for research. The study cohort includes any patient with a pre-operative diagnosis of suspected thyroid cancer, who was resident in the most heavily contaminated regions of Ukraine and Russia at the time of the accident and aged under 19 at the time of the accident (i.e. born on or after 26th April 1967).

Photo: Imperial College

Pr Gerry Thomas

The current collection comprises 4500 cases of thyroid cancer and adenoma. 3094 of the 4500 cases are from the exposed areas of Ukraine and Russia, whereas 1406 cases come from the unexposed areas of Ukraine and Russia. There are also 758 post Chernobyl cases (born after 1st December 1986) from Ukraine and Russia: 475 cases are from the exposed areas and a further 283 are from unexposed areas. A thyroid dose is estimated for each case once the pathology consensus diagnosis is agreed. The collection includes samples from the Ukraine-American cohort.

Photo, A Galpine, Imperial College, London

CTB laboratory in IEM, Kiev, Ukraine

A sample of blood for extraction of DNA, serum and samples of both frozen (where the tumour is large enough) and formalin fixed paraffin embedded (FFPE) tumour and normal thyroid tissue are provided by each patient. The pathology of every case submitted to the CTB is reviewed by an international panel of pathologists. Molecular biology quality assurance (QA) is carried out on each sample prior to release to researchers. In order to maximise the use of the resource, nucleic acids are extracted from the same frozen tissue block, aliquotted and are distributed to multiple researchers. Individual sections from FFPE blocks from individual cases are also issued to multiple researchers. Researchers apply for material through an online portal (https://cisbic.bioinformatics.ic.ac.uk/ctb/html_ctb_public/). Applications are reviewed by an independent external review panel, thus ensuring that the material is used appropriately in first class scientific research. Researchers agree to provide data from their studies back to the project in order that these can be integrated into future studies. So far, 2828 aliquots of RNA and 2377 aliquots of DNA extracted from tissue, 428 aliquots of DNA from blood, 375 vials of whole blood, 9107 sections from FFPE blocks, and 1137 tissue blocks have been released to researchers in 11 different countries for 39 separate projects.

Thomas GA, Unger K, Krznaric, K, Galpine A, Bethel JA, Tomlinson C, Woodbridge M, Butcher S (2012) **The Chernobyl Tissue Bank — A Repository for Biomaterial and Data Used in Integrative and Systems Biology Modeling the Human Response to Radiation**, Genes 3(2), 278-290

Thomas GA (2012) **The Chernobyl Tissue Bank: integrating research on radiation-induced thyroid Cancer**. J Radiol Prot;32:N77-80

ID Card:

Organism type of sample:
Human

Storage condition:
Depends on type of sample
See website for details

Sample type:
Frozen tissue, DNA and RNA extracted from frozen tissue, blodd samples, DNA extracted from blodd, serum, sections from FFPE tissue

Condition of use:
Available to any bona fide researchers in any country

Address:
Coordinating Centre: CTB secretariat, Department of Surgery and Cancer, Imperial College London, Room 11L04, Charing Cross Hospital, Fulham Palace Road, London W68RF

Internet link:
www.chernobyltissuebank.com

Access:
Application via CTB portal (see website for details), all applications considered by an External Review Panel.
Reviewed via email
No deadlines for application.
full details on website

Contact:
Pr GA Thomas
Gerry.thomas@imperial.ac.uk

BELGIAN SOIL COLLECTION

Uncontaminated Belgian soils to use in experiments

A collection of 20 uncontaminated Belgian soils (figure 1) is available at the Biosphere Impact Studies group of the Belgian Nuclear Research Centre (SCK•CEN). These soils can be contaminated with specific radionuclides (e.g. ^{137}Cs, ^{238}U, ^{232}Th, etc.) and used in dedicated lab experiments to study mechanisms and processes to improve the understanding of radionuclide behaviour in the terrestrial environment.

Photo: SCK•CEN

Dr Nathalie Vanhoudt

distribution coefficients to be calculated and relationships with soil characteristics to be evaluated. In addition, in order to evaluate radionuclide uptake by plants and to calculate transfer factors, soil-to-plant transfer studies were performed using several plant species such as ryegrass, clover, maize, etc. (figure 2). Furthermore, some of these soils were used to compare sequential extraction procedures for uranium fractionation in soil.

As highlighted in the September 2016 issue of AIR², SCK•CEN makes available facilities in which these soils can be used for the study of radionuclide availability, transfer and migration.

Photo: SCK•CEN

Figure1: Visible differences in colour as present in the Belgian soil collection

The soils were gathered from 20 locations spread over different geological parts of Belgium with the majority coming from Flanders. After removing the vegetation root mat, the soils were collected by sampling the upper 10 cm soil layer. The soils were air-dried, sieved (2 mm) and several soil characteristics were analysed such as texture, total organic matter (OM), cation exchange capacity (CEC), CaCO3, bulk density and field capacity.

In the past, subsamples of these soils were contaminated with ^{238}U, ^{226}Ra, ^{232}Th and ^{99}Tc to evaluate the possibility of linking the mobility and bioavailability of these radionuclides with soil characteristics. Following an incubation period of several weeks, soil characteristics such as pH, exchangeable cations, available P, amorphous Fe, etc., were analysed. Subsequent analysis of the radionuclide concentrations in the extracted soil solutions allowed solid-liquid

The facilities are supported by laboratories which are fully-equipped for soil-sampling and characterisation, element analysis and radioactivity measurements.

Photo: SCK•CEN

Figure 2: Plant uptake experiments in the greenhouse using contaminated soil

Vandenhove H., Van Hees M., Wouters K., Wannijn J., (2007), Can we predict uranium bioavailability based on soil parameters? Part 1: Effect of soil parameters on soil solution uranium concentration, Environmental Pollution, 145, p587-595

Vandenhove H., Van Hees M., (2007), Predicting radium availability and uptake from soil properties,. Chemosphere, 69, p664-674

ID Card:

Organism type of Sample:
Belgian Soil Collection

Storage Conditions:
Room temperature
Dry conditions

Sample type:
Uncontaminated soil
Upper 10 cm soil layer

Access Conditions:
Joint research collaboration
Subject to internal approval

Internet link:
No

Address:
Belgian Nuclear Research Centre (SCK•CEN)
Boeretang 200
2400 Mol, Belgium

Contact:
Nathalie Vanhoudt
nathalie.vanhoudt@sckcen.be
+32 14 33 21 12

Related to: ALLIANCE

The Bank of Biological Materials of SBRC

A 20,000 sample collection of individuals exposed to long term ionising radiation at various doses

The Bank of Biological Materials (BBM) was created in Seversk (Russia) in 2002 by the Seversk Biophysical Research Center of the Russian Federal Medical and Biological Agency (SBRC). The aim of the BBM is to collect samples from employees of the Siberian Group of Chemical Enterprises (SGCE), the world's largest nuclear industrial complex, and from the residents of Seversk, an industrial town located in immediate proximity to the SGCE.

Photo: SBRC

Low-temperature refrigerators "Sanyo MDF-U32V" for deep freezing and storage of biological samples

The BBM collection is subdivided into four categories: 1) Healthy employees of SGCE, 2) Healthy Seversk residents, 3) Patients with malignant tumours (MT) (SGCE employees and Seversk residents), and 4) Patients with acute myocardial infarctions (AMI) (SGCE employees and Seversk residents).

The collection currently comprises 20,000 samples from more than 10,000 donors. Sample types include whole blood, blood DNA, tissue samples (normal and tumour tissue) and cytogenetic suspensions. These four categories contain the following bioresources:

1) "Healthy employees of SGCE" category includes biological materials from 1,678 donors (1,139 men and 539 women) with no previous diagnosis of MT or AMI (Table 1). 197 employees of the SGCE have had no previous exposure to ionising radiation, 742 employees have been exposed only to external γ-radiation and 739 employees have been exposed to combined (external and internal) irradiation.

2) "Healthy Seversk residents" category contains biological materials from individuals with no previous diagnosis of MT or AMI, and no previous exposure to ionising irradiation. As of 2018, this category contains biomaterial from 1,734 donors (258 men and 1,476 women).

Photo: SBRC

Dr Ravil Takhauov

3) "MT patients" category contains whole blood samples from 982 MT patients (473 men and 509 women) of which 501 patients (319 men and 182 women) were employees of the SGCE and 481 (154 men and 327 women) were residents of Seversk who had never worked at the SGCE (Table 2). The "MT patients" category also includes tumour and normal tissue samples in FFPE blocks collected from 2,331 patients.

4) "AMI patients" category contains biological samples from 573 patients with AMI (394 men and 179 women). Out of a total of 573 patients, 386 (307 men and 79 women) were employees of the SGCE and 187 (87 men and 100 women) were residents of Seversk (Table 2).

A database (Unified Electronic Database or UED) was set up at SGCE in 2014 to provide information on donors and their biological material. This database contains information such as sex, age, donor's life status, presence/absence of radiation exposure, irradiation dose and diagnosis.

Together the BBM and UED constitute a unique resource of human biological materials and data for conducting studies on the molecular basis of individual radiosensitivity, and on the genetic mechanisms involved in the pathogenesis of common diseases following long-term exposure to low-dose ionising radiation, as well as other research studies involving radiation and medical genetics.

Table 1. Structure of the BBM category "Healthy employees of SGCE"

Healthy employees of SGCE	Unexposed to irradiation	External irradiation	Combined irradiation
Number	197	742	739
Average age (M±SE), years	59.73±1.07	56.20±0.40	55.36±0.41
Average duration of work (M±SE), years	29.93±1.58	28.75±0.66	27.09±0.76
External dose (M±SE), mSv	–	117.49±7.23	69.29±4.26

Table 2. Structure of the BBM categories "MT patients" and "AMI patients"

Parameter	Seversk residents	Employees of SGCE		
		Unexposed to irradiation	External irradiation	Combined irradiation
"MT patients"				
Number	481	254	147	100
Average age (M±SE), years	61.43±0.60	64.48±0.66	64.41±0.67	64.91±0.85
Average duration of work (M±SE), years	–	29.00±2.33	34.70±2.32	35.31±2.28
External dose (M±SE), mSv	–	–	169.67±18.63	113.46±14.04
"AMI patients"				
Number	187	147	125	114
Average age (M±SE), years	69.30±1.61	61.61±0.89	64.74±0.89	65.16±1.05
Average duration of work (M±SE), years	–	35.07±1.28	38.05±1.08	38.70±1.01
External dose (M±SE), mSv	–	–	135.02±19.73	120.22±14.86

The bank of biological samples representing individuals exposed to long-term ionizing radiation at various doses, Takhauov R. M., Karpov A. B., Albach E. N., Khalyuzova M. V., Freidin M. B., Litviakov N. V. et al. (2015), Biopreservation and Biobanking, 13 (2), 72–78

Different patterns of allelic imbalance in sporadic tumors and tumors associated with long-term exposure to gamma-radiation, Litviakov N. V., Freidin M.B., Sazonov A. E., Khalyuzova M. V., Buldakov M. A. et al. (2015), Mutation Research/Genetic Toxicology and Environmental Mutagenesis, 794, 8–16

ID Card:

Sample bank:
Collection of 20,000 biological samples (blood, tissue, blood DNA, cytogenetic suspensions) from more than 10,000 donors. Donors comprise: 1,734 Seversk residents, 1,678 healthy SGCE employees, 982 patients with cancer at different sites (Seversk residents and SGCE employees) and 573 patients with acute myocardial infarction (Seversk residents and SGCE employees).

Organism type of sample:
Human blood, total DNA, tissue samples

Storage condition:
–20°C, –80°C

Address:
Seversk Biophysical Research Center (SBRC)
87, Kommunistichesky avenue, Seversk, Tomsk Region, 636070, Russia

Access:
The database is owned by SBRC. Access to coded (anonymised) data is subject to permission from SBRC's Commission of Experts.

Internet link:
www.sbrc.ru

Contact:
Andrey B. Karpov
mail@sbrc.ru
sbnc@fmbamail.ru
+7 3823 99 40 01

Related to:
EURADOS, MELODI, EURAMED

Subcategory (c) : Cohorts

Infrastructure	Other categories	Page
The Wismut Cohort and Biobank	(b)	58
French Haemangioma Cohort and Biobank	(b)	59
3-Generation exposure study	(b)	60
Portuguese Tinea Capitis Cohort	(b)	61
French longitudinal study of children (Elfe)	(b)	62
INWORKS Cohort		63
EPI-CT scan cohort		64
Chernobyl clean-up workers from Latvia		65
ESTCHERN Cohort	(b)	66
German airline crew cohort		67
The Techa River Cohort (TRC)	(b)	68
Greek interventional cardiologists cohort		69
The German Thorotrast Cohort Study		70

The Wismut Cohort and Biobank

A cohort of nearly 60,000 uranium miners with extensive exposure data

The German uranium miner cohort offers a unique basis for the assessment of health effects associated with inhalation of radon and its progeny and uranium dust, but also effects associated with exposure to low dose external gamma radiation. The cohort includes 58,982 male workers employed between 1946 and 1989 at the East German uranium mining company "Wismut" [1]. Individual information on exposure to radon, long-lived radionuclides and external gamma radiation is available for all cohort members. In addition, absorbed doses to various organs have been calculated with support from the European Commission (Alpha-risk project).

Cumulative exposure to	Mean	Median	Max
Radon progeny [WLM]	280	33	3224
External gamma radiation [mSv]	47	16	909
Long-lived radionuclides [kBqh/m³]	4.1	1.0	132.2

Distribution of radiation exposures among exposed miners (n=50,700)

Strengths of the cohort are the large size, long follow-up period (mean 37 years), large number of total deaths (25,438), wide range of radiation exposures, and availability of information on silica, fine dust and arsenic dust; some information is also available for smoking. Individual data from the cohort are accessible to the scientific community (http://www.bfs.de/EN/bfs/science-research/projects/wismut/wismut-cohort-proposals.html). These data allow investigation of the exposure-response relationship for cancer and non-cancer mortality, different radiation qualities (alpha-radiation, gamma radiation) and low dose or dose rate range. A European pooling of the uranium miner cohort studies (Czech, French and German miners) was performed in the EU alpha-risk project and a worldwide pooling of uranium miner cohorts from Canada, the United States and Europe is currently in preparation.

In addition to the cohort data, a biobank at the BfS contains biological samples from former Wismut employees, which overlap to some extent with the cohort. The biobank consists of three sets of biomaterial: 1) Biomaterial collected from 2009–2012 from miners alive at that time (n=442); 2) Biomaterial from miners who died from lung cancer (biomaterial obtained from the pathological archive) (n=400); 3) Biomaterial from children whose fathers died from lung cancer before the age of 50 (n=81). The biomaterial (lymphocytes, plasma, DNA, RNA, fixed lymphocytes) from the first and third sets was obtained from blood and is of high quality [2], and is stored at -20°C, -80°C or in liquid nitrogen depending on the material. DNA and RNA for the second set are obtained from formalin-fixed paraffin-embedded tumour and normal lung tissue of lower quality.

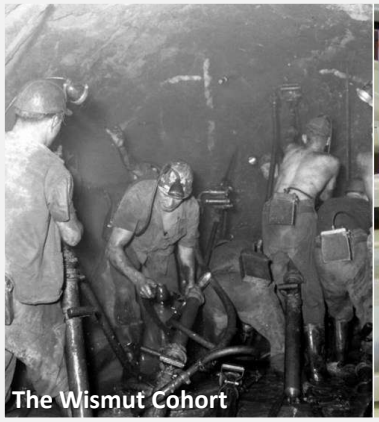
Michaela Kreuzer

For the miners whose material is in the biobank, the same exposure data are available as for the Wismut cohort. Additionally, information on smoking is partly available as are epidemiological and medical data and data for the material from the pathological archive tumour subtype.

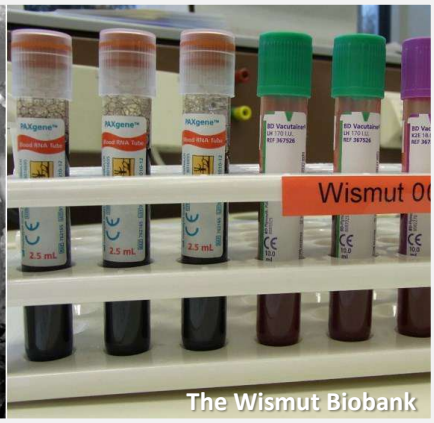
The biobank has already been used:

- To investigate leukemia specific markers
- To detect chronic radiation exposure using miRNA expression and whole genome expression arrays as well as mFISH analysis

Access to the Wismut biobank is restricted to approved proposals. Experimental data will be archived via STORE.



The Wismut Cohort



The Wismut Biobank

Photo left to right: Wismut GmbH, BfS/S. Hornhardt

Bundesamt für Strahlenschutz

ID Card:

Data base topic:
Male Uranium miners

Data owner:
BfS

Description:
Cohort study with individual data on exposure to radon, external gamma radiation and long-lived radionuclides

Biobank available:
GUMB - The German Uranium Miners Biobank

Sample type:
Blood: DNA, RNA, lymphocytes (cultured as well as fixed), plasma
Tumour tissue: DNA, RNA
Normal tissue: DNA, RNA

Sample storage condition:
-80°C (DNA, RNA, plasma) or liquid nitrogen (lymphocytes/plasma)

Access:
External scientists interested in the cohort data or biobank material may send a proposal to the BfS

Contact:
For cohort data:
Michaela Kreuzer:
mkreuzer@bfs.de,
+49 30 18333 2250
For biobank material:
Maria Gomolka:
mgomolka@bfs.de
+49 30 18333 2211

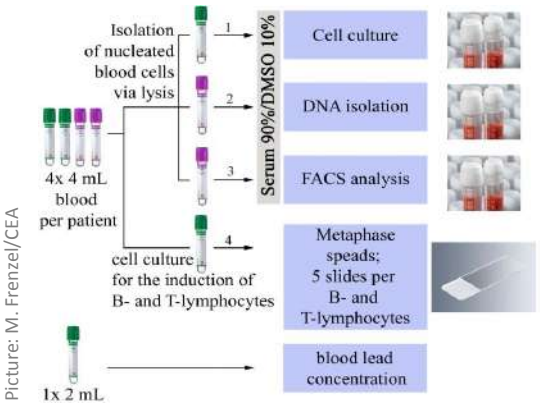
Related to:
Research: MELODI, EURADOS

[1] COHORT PROFILE: THE GERMAN URANIUM MINERS COHORT STUDY (WISMUT COHORT), 1946 – 2003. M. Kreuzer, et al. Int J Epidemiol 2010; 39:980-7.
[2] ASSESSMENT OF mRNA AND microRNA STABILIZATION IN PERIPHERAL HUMAN BLOOD FOR MULTICENTER STUDIES AND BIOBANKS. DG. Weber, et al. Biomark Insights. 2010;5:95-102.

French Haemangioma Cohort and Biobank

Cohort for low-dose study long-term after radiation therapy

The risk of exposure to low doses of ionising radiation below 100 mSv is still controversial and highly discussed since especially its effect on the appearance of long-term pathologies might be larger than assumed. There is evidence that exposure to low doses increases for example the cancer risk but this effect is less pronounced and concurs with other confounding factors such as smoking. Actually, most model calculations are based on in vitro experiments.



Picture: M. Frenzel/CEA

Scheme of the FHC blood biobank

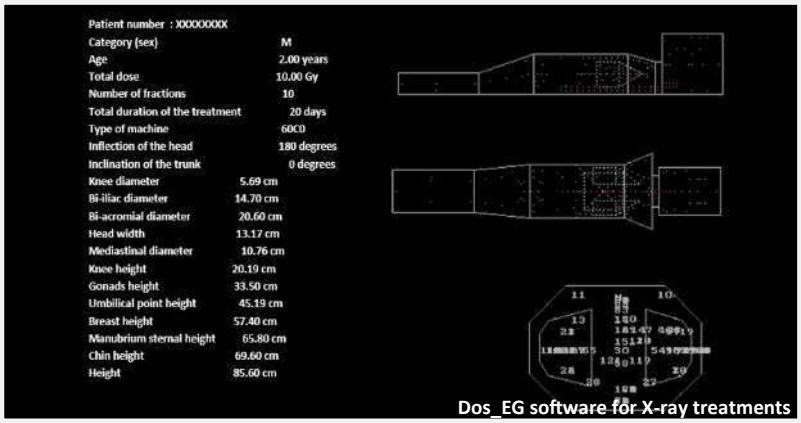
In France, children presenting with a skin haemangioma during early childhood were treated with radiotherapy from 1940-1973. Epidemiological analyses of this cohort have demonstrated a 3-fold higher risk of developing cancer (especially skin, breast and thyroid cancer). The French haemangioma cohort (FHC) is exceptional as it fulfils all necessary characteristics for low dose studies. It allows joint epidemiological and biological analyses to be performed for direct radiation risk assessment and the study of radiation-induced pathologies, due to accurate dosimetry calculations (i.e. the dose received at all major organs, taking into account the size of the baby/child during treatment) thanks to access to radiotherapy medical records. The FHC is very homogeneous, representing a normal healthy population characterised only by a haemangioma. It contains not only patients who received radiotherapy from different sources (^{226}Ra, X-rays, ^{32}P, ^{90}Y or ^{90}Sr) but also untreated individuals or those who received cryotherapy and serve as internal controls. A long-term post-irradiation follow-up exists.

A biobank for the FHC blood samples was set up through collaborations between INSERM (U1018, Florent de Vathaire) and the CEA (Radiation and Oncology Laboratory, Laure Sabatier) during the EU project, EpiRadBio. Only donors who received radiotherapy before the age of 3 years were selected, together with respective non-exposed controls. This biobank contains cytogenetic slides of metaphase spreads for T- and B-lymphocytes as well as isolated nucleated blood cells frozen in liquid nitrogen under conditions (10% DMSO in serum) to allow future cell culture experiments and DNA and FACS analyses to be undertaken. Supplementary information on confounding factors is available for every donor thanks to a questionnaire. This includes body weight and size, type of work, smoking and consumption of alcohol, (for women) number of pregnancies, appearance of cancer/benign tumour, radiological procedures during lifetime, chronic diseases, phototype and skin type. Additionally, the blood lead concentration at the time of blood donation has been determined. All this information is essential to distinguish the effect of radiation treatment from that of other factors which might influence cancer development.

Photo: Hartmuth Schröder

Monika Frenzel

The FHC allows in vivo studies and the identification of biomarkers to develop efficient models for long-term risk estimation for pathologies induced by low doses of ionising radiation, even a long time after exposure.



Dos_EG software for X-ray treatments

Picture: F. De Vathaire/INSERM

ID Card:

Cohort type:
French haemangioma cohort (humans, French citizens), 8335 subjects (5744 treated with radiotherapy), Brachytherapy (^{226}Ra, ^{32}P, ^{90}Y, ^{90}Sr) and X-ray (local treatment for skin haemangioma)

Age:
- at exposure: Starting from early childhood, mostly treated before the age of 15 years (7800 subjects, of whom 5473 received radiotherapy)
- currently: 42-75 years old

Biobank available:
Yes, 369 subjects (231 women, 138 men) of whom 70 non-exposed and 299 exposed subjects (under the age of 3 years; 261 donors <100 mSv, 38 donors 100 mSv; mean bone marrow dose)

Sample type:
Frozen nucleated blood cells (for cell culture, DNA/FACS analysis), cytogenetic slides with metaphase spreads of T- and B-lymphocytes

Sample storage conditions:
-20°C, liquid nitrogen

Conditions of use:
External use possible (via a selection committee)

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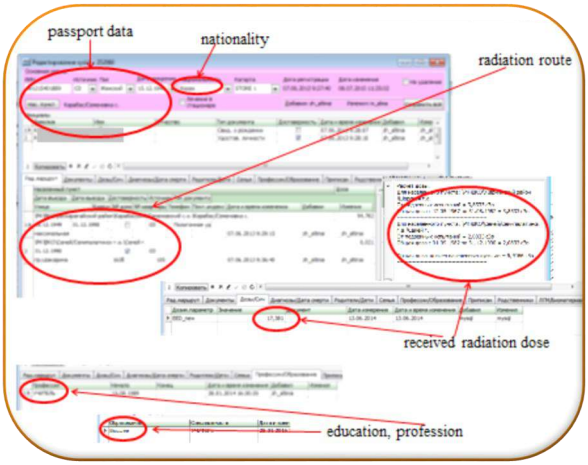
Related to:
MELODI, EURADOS, CARPEM

RADIOTHERAPY AS A RISK FACTOR FOR MALIGNANT MELANOMA FOLLOWING CHILDHOOD SKIN HEMANGIOMA. Haddy N et al. Melanoma Res. 2012, 1, 77-85.
ASSESSING CANCER RISKS OF LOW-DOSE RADIATION. Mullenders L. et al. Nature Reviews Cancer. 2009, 9, 596-604.

3-Generation exposure study

Data and biomaterial for studying transgenerational effects

The Semipalatinsk nuclear test site (STS) is located approximately 150 km west of the city of Semipalatinsk (now called Semey), and was a major site for nuclear weapons-testing by the former Soviet Union. It was here that the Soviet Union conducted their first nuclear test on 29 August 1949. Later, 465 nuclear explosions were carried out between 1949 and 1989, including 118 atmospheric events (88 air events and 30 surface events) from 1949-1962. The last event was conducted at the STS on 19 October 1989. The total yield of atmospheric events conducted at STS is reported to be 6.58 megatons of TNT equivalent, which corresponds to approximately 66% of the total estimated Soviet bomb yield.



Photo, Research Institute for Radiation Medicine and Ecology Semey, Kazakhstan State Scientific Automated Medical Register

Infrastructure of the State Scientific Automated Medical Register

The 118 atmospheric events conducted between 1949 and 1962 were the primary source of radioactive contamination of the environment and of the radiation exposure to the public. The most damaging tests, in terms of exposure, were those conducted on 29 August 1949, 24 September 1951, 12 August and 24 August 1956 [1].

The Research Institute for Radiation Medicine and Ecology in Semey, Kazakhstan, runs a registry of the population living around STS. It is the successor of the 1957-founded medical institution Dispensary No. 4 of the USSR Ministry of Health whose activities included studies on the health effects of radiation exposure to those residing adjacent to the STS.

Today, the Institute does follow-ups of those affected by nuclear bomb testing and their offspring. An important tool for this task is the State Scientific Automated Medical Register, which allows long-term individual follow-up and the study of radiation-related effects using incidence and mortality data. As of November 2015, the Register held information on 316,640 subjects (209,030 alive; 107,610 deceased) [2].

Photo: salon Saur

Kazbek Apsalikov

In 2014, the Institute started collecting information on 8,400 persons from the Register, setting up the basis for a three-generation study. The following data are abstracted:

a) registration data: individual's ID, sex, nationality, date and place of birth; b) medical information (where applicable): diagnoses names and dates, congenital malformations, cause of death; c) dosimetry data: radiation route, radiation dose (based on doses assigned by Kazakh legislation, which can differ from the doses estimated by other methods); d) information on lifestyle factors: smoking, alcohol; availability of biological samples: blood, DNA, tumour and normal tissues.

This information is included in the STORE database (AIR², #3). Of the 8,400 individuals registered, 2,380 were affected by the test, 2,937 belong to the F1 generation and 3,083 to the F2 generation. Overall, the following information is available: 11,327 medical diagnosis for incident cases, 1,199 causes of death, 1,937 smoking information, 2,982 drinking information, 215 blood samples, 79 DNA, 14 cancer and 14 healthy tissue samples, and for 145 information on chromosomal aberrations.

The database for the three-generation study can be extended.

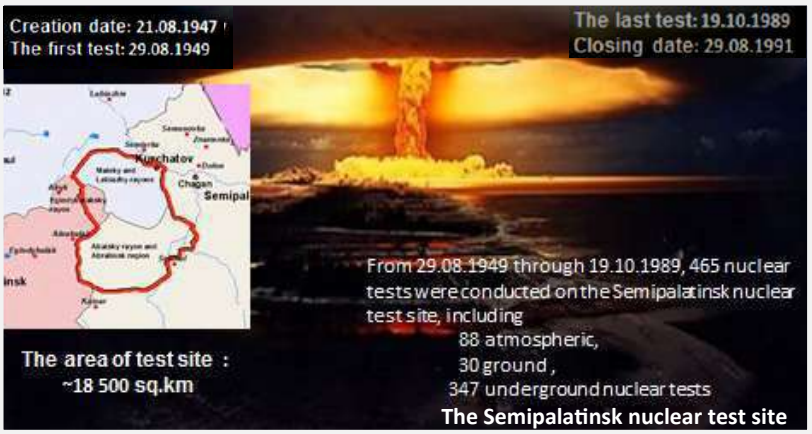


Photo: Research Institute for Radiation Medicine and Ecology Semey, Kazakhstan

ID Card:

Database topic:
Epidemiology

Information available type:
Vital status, incidence data, congenital malformation, partly biosamples, radiation dose

Data type:
Cohort

Link with a biobank:
Yes

Exportable:
Yes (MS Excel)

Species:
Human

Access:
Information through STORE, access after agreement

Contact:
Prof. Kazbek N. Apsalikov, Director of the Scientific Research Institute of Radiation Medicine and Ecology
k.n.apsalikov@mail.ru

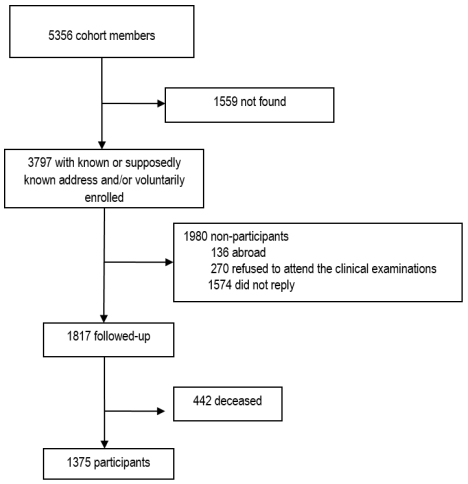
Related to:
MELODI

[1] **THE LEGACIES OF SOVIET NUCLEAR TESTING IN KAZAKHSTAN: FALLOUT, PUBLIC HEALTH AND SOCIETAL ISSUES. SOCIAL AND ETHICAL ASPECTS OF RADIATION RISK MANAGEMENT.** Bauer, et al (2013). Elsevier Science, 239-258.
[2] Statistical Report "**ANALYSIS OF THE CURRENT STATUS OF THE STATE SCIENTIFIC AUTOMATED MEDICAL REGISTER OF THE POPULATION AFFECTED BY THE SEMIPALATINSK TEST SITE.**" 2015. Research Institute of Radiation Medicine and Ecology, Semey.

Portuguese Tinea Capitis Cohort

Evaluation of long term effects of childhood LDR exposure

Before the introduction of Griseofulvin in 1959, the best approach to treat tinea capitis infection was X-ray scalp epilation combined with topical antimycotic ointments. The irradiation procedure used was the five point Keinbock–Adamson technique which consisted of applying a radiation dose of 5-6Gy to the scalp. Doses at other organs, such as thyroid and carotids, were in the low dose range.



Flowchart depicting participants and non-participants from the cohort

The original registry comprised 5356 cases, irradiated in the former DCHSP (North of Portugal), for which information is available on the dose applied, age at irradiation and treatment date (between 1950 and 1962) [1,2]. From this original registry, 1375 individuals were clinically observed from 2006-2011 – see flowchart above (Figure).

Clinical observation was directed mainly to the head and neck regions, and a summarized clinical history was obtained; for 70% of the individuals, a thyroid scan report was obtained. Blood and oral mucosa cells were collected, and DNA was extracted from total blood. For 400 of the 1375 cases, blood lymphocytes were also collected. DNA was extracted from formalin-fixed paraffin-embedded thyroid tumours and basal cell carcinomas, and also from adjacent normal tissue.

Since September 2012, these individuals have been observed a second time, in the context of carotid atherosclerotic disease, and a non-irradiated control group, mainly composed of the spouses (90%), is also being constituted. A total of 398 irradiated and 253 non-irradiated individuals have been observed. The following tests are performed: 1) Clinical examination directed to cardiovascular disease (including anthropomorphic data, blood pressure measurements, smoking load information); 2) B-mode ultrasound imaging of carotid arteries for carotid plaques assessment, intima media thickness and stenosis evaluation; 3) Several biochemical measurements (including homocysteine, hsCRP, lipoprotein A). Blood is collected for: 1) DNA extraction; 2) Lymphocyte isolation; 3) Plasma storage.

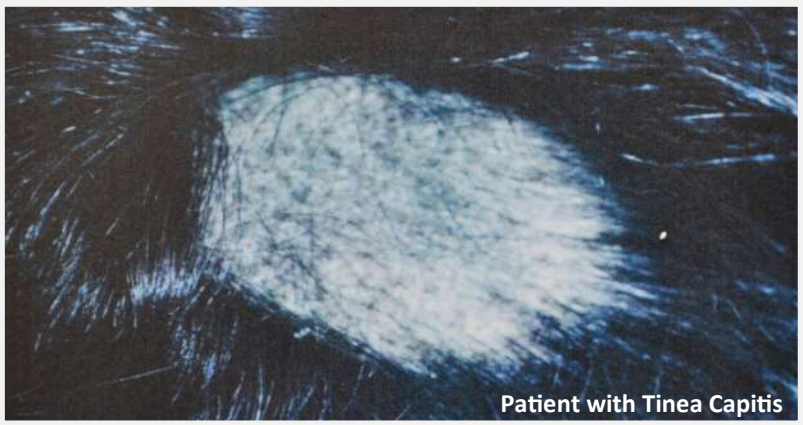
Photo: M. Gomes

Paula Boaventura

The strengths of this cohort are the long latency period between radiation exposure and evaluation of late effects (40 to 60 years), radiation exposure in childhood when individuals are more radiosensitive, information on the doses applied, and availability of biological samples for a considerable number of individuals from the original cohort. For about 400 individuals in the cohort, detailed information on their health status has been obtained (e.g. diabetes, hypertension, metabolic syndrome, presence/absence of carotid plaques), as well as DNA from two clinical observations. As an age-matched non-irradiated control group has also been collected, case control studies can be performed allowing the establishment of subgroups according to health status and radiation exposure.

The cohort and biobank have already been used for the study of genetic alterations in thyroid tumours and basal cell carcinomas, and to evaluate head and neck tumour prevalence.

Access to the cohort is restricted to approved proposals.



Patient with Tinea Capitis

Photo: Prof. Aureliano da Fonseca

1. **HEAD AND NECK LESIONS IN A COHORT IRRADIATED IN CHILDHOOD FOR TINEA CAPITIS TREATMENT.** Boaventura P, et al. Lancet Infect Dis. 2011;11(3):163-4.
2. **THYROID AND PARATHYROID TUMOURS IN PATIENTS SUBMITTED TO X-RAY SCALP EPILATION DURING THE TINEA CAPITIS ERADICATION CAMPAIGN IN THE NORTH OF PORTUGAL (1950-1963).** Boaventura P, et al. Virchows Arch. 2014;465(4):445-52.

ID Card:

Cohort type:
Tinea capitis, former scalp-irradiated patients: 1375 individuals. Scalp-irradiated according to the five point Keinbock–Adamson technique (325-400R in each point).

Age:
- at exposure: 7.2±3.0 (1-23)
- at moment of first clinical observation: 58.6±4.5 (47-75)

Sample type:
Total blood DNA, oral mucosa cells, lymphocytes, plasma, serum, tumour and normal tissue DNA (thyroid and basal cell carcinoma), stored at -20°C

Sample storage conditions:
Blood DNA stored a 4°C; oral mucosa cells stored at -80°C; lymphocytes stored at -80°C; tumour tissue DNA stored at -20°C; plasma and serum stored at -80°C

Conditions of use:
External researchers interested in the cohort data or biobank material should send a proposal to Ipatimup/Cancer Biology

Contact:
Paula Boaventura
mboaventura@ipatimup.pt;
R. Júlio Amaral de Carvalho, 45, 4200-135 Porto, Portugal

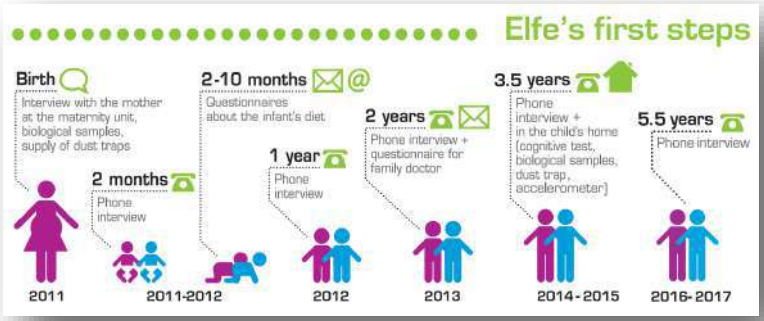
Related to:
MELODI

French longitudinal study of children (Elfe)

18,000 children followed from birth to adulthood

The conditions in which children live and grow are changing fast. Research is therefore needed to find out more about how children's environment in their early years affects their development, their health and even their socialisation. A cohort follow-up study is the best means of closely monitoring children's trajectories. This involves recruiting a large sample of children and tracking them throughout their development.

It was for precisely this reason that Elfe was set up, taking into account questions submitted by 15 themed groups representing more than 150 researchers, as well as concerns expressed by various public bodies. Launched in metropolitan France in April 2011, this resolutely multidisciplinary study recruited more than 18,000 children born that year.



The bulk of the data has so far been collected via surveys of the children's parents (telephone interviews at the 2-month, 1-year, 2-year and 3.5-year milestones or postal/Internet questionnaires). The children were directly studied for the first time when they reached the age of 3.5 years, on the occasion of a home visit during the 2014-2015 wave.

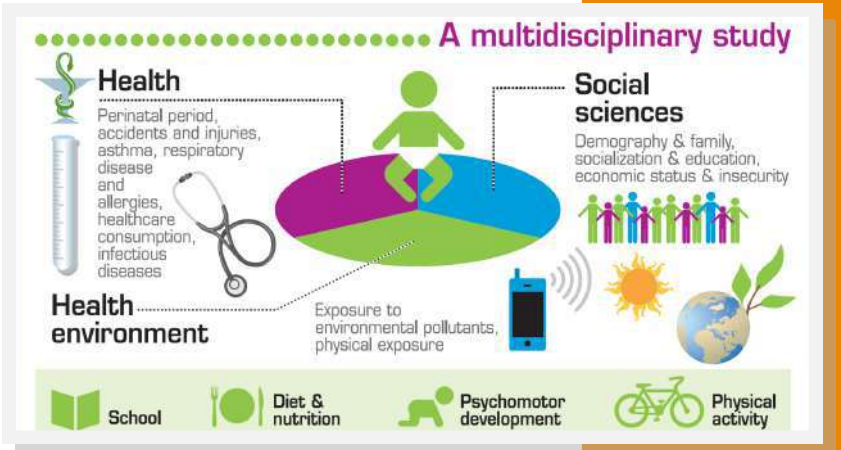
Alongside the cohort, we have set up a biobank containing samples from a subgroup of Elfe families. These were collected in the maternity units where the children were born (mother's urine, venous blood, hair and breast milk, cord blood, newborn's meconium/stool), and again during the survey at 3.5 years (child's hair, urine and stool).

The research carried out by the Elfe teams can be placed under three main headings: health, social sciences and the environment. In the latter, the emphasis is on measuring exposure to various chemical substances or physical agents and studying their impact on children's health and development. Regarding physical agents, for example, the radon study undertaken by a team from the French Institute for Public Health Surveillance (InVS) seeks to identify variations in childhood exposure to radon in the home. A further aim is to assess the public health risks for the dose levels that are observed, and revisit current hypotheses on the dose-response relationship. The medical radiation study, meanwhile, led by researchers from the French Institute for Radiological Protection and Nuclear Safety (IRSN), is intended to provide a detailed and exhaustive picture of children's exposure to diagnostic medical imaging with or without ionizing radiation (IR). It will then be possible to establish dosimetric estimates of IR exposure, based on standardised measurements or literature findings. A second objective will be to join international consortiums collecting the same sort of data, in order to assess the risk of cancer and other pathologies potentially associated with this exposure.

Source: Guenet/Inserm

Marie-Aline Charles

Since 2013, Elfe data have been available to researchers actively involved in the study - mainly in the design of its questionnaires, and a year ago, access was extended to the whole of the scientific community, under certain conditions.



ID Card:

Cohort type:
18,000 French children born in 2011

Age:
Birth to adulthood

Biobank available:
Yes

Sample type:
Maternal urine, blood, milk and hair at birth
Cord blood and meconium/ stools of newborns + hair, urine and stools of children aged 3,5 years

Sample storage conditions:
Hairs : room temperature
Urine, milk, stools : - 80°C
Products derived from blood (total blood, serum, plasma) : liquid nitrogen

Conditions of use:
External use possible subject to conditions

Access:
Access to data and/or biological samples subject to conditions

Internet link:
http://www.elfe-france.fr/
https://pandora.vjf.inserm.fr/public/

Contact:
marie-aline.charles@inserm.fr

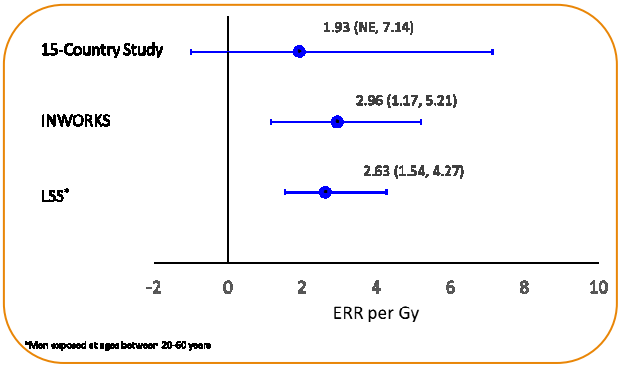
Related to:
MELODI

CONSTRUCTING A COHORT: EXPERIENCE WITH THE FRENCH ELFE PROJECT. Pirus C. et al. Population 2010, 65(4), 637-670.
QPCR STANDARD OPERATING PROCEDURE FOR MEASURING MICROORGANISMS IN DWELLINGS IN THE ELFE STUDY. Scherer E, et al. Sc Tot Environ 2014; 466-467:716-24.

INWORKS Cohort

Multinational cohort study of nuclear workers

The International Nuclear Workers Study (INWORKS) is a collaborative study of cancer risk among radiation workers in the nuclear industry. It is built upon the previous '15-Country Study' using the same core protocol and takes advantage of updated follow-up and exposure data from the three most informative cohorts involved in that study. The INWORKS study comprises 308,297 workers employed by the Atomic Energy Commission (CEA), AREVA Nuclear Cycle and the National Electricity Company (EDF) in France; the Departments of Energy and Defense in the USA; and, in the UK, by nuclear industry employers included in the National Registry for Radiation Workers (NRRW).



Comparison of INWORKS leukaemia findings with other studies

Workers from the nuclear industry represent a unique population in which to study the health effects of ionising radiation; they are mostly exposed to radiation at low levels over the course of their working life. Moreover, all workers included in INWORKS have records that provide individual quantitative radiation dose estimates. Workers in INWORKS were mainly exposed to external radiation, usually gamma-rays, and doses were measured regularly with personal dosimeters. For all participating cohorts, records of individual recorded doses have been kept since the very beginning of the industry in the 1940's. Recorded external penetrating radiation dose estimates are converted to absorbed organ doses expressed in gray (Gy) using the appropriate conversion factor. The mean individual cumulative colon and red bone marrow dose estimates over the period from 1945 to 2005 were 21mGy and 16mGy, respectively.

Over a mean follow-up duration of 27 years, the total number of observed deaths was 66,632, including 17,957 deaths due to solid cancers, 1,791 deaths due to haematological cancers and 27,848 deaths due to cardiovascular diseases.

Photo: R. Dray/IARC

Ausrele Kesminiene

INWORKS demonstrated a significant association between cumulative red bone marrow dose and the risk of all leukaemias, excluding chronic lymphocytic leukaemia (CLL) (n=531 deaths), with an Excess Relative Risk (ERR) of 2.96 per Gy, 90% Confidence Interval (CI)= [1.17 ; 5.21], and between cumulative colon dose and the risk of solid cancers, with an ERR of 0.47 per Gy, 90% CI = [0.18 ; 0.79]. Estimated dose-risk relationships are very close to those derived from the cohort of Japanese A-bomb survivors. Sensitivity analyses demonstrated the stability of the observed relationships. When restricting to low doses (below 100 mGy for solid cancer and below 300 mGy for non-CLL leukaemia), the dose-risk relationships demonstrated reduced precision; the estimated ERR per Gy were not significantly different from zero, but remained consistent with those obtained over the whole dose range.

INWORKS has assembled some of the strongest evidence to strengthen the scientific basis for the protection of adults from low dose, low dose rate exposures to ionising radiation.

Photo: R. Dray/IARC

International Agency for Research on Cancer
World Health Organization

ID Card:

Database type:
Individual data on humans exposed to protracted low-doses of ionising radiation

Cohort type:
International cohort comprising 308,297 workers from the nuclear industry in France, the UK and USA

Age/follow-up:
- age at exposure: from 20 to 60 years
- mean age at end of current follow-up: 58 years
- mean duration of follow-up: 27 years, total of 8.2 million person-years

Data available:
Vital status, causes of death for cancer and non- cancer diseases, individual organ doses due to external radiation, socio-economic status

Biobank available:
No

Access:
The data are maintained at IARC for an agreed period of time; for ethical reasons and due to agreements with data contributors, it is not possible to send the data outside of IARC.

Internet link:
http://www.iarc.fr/

Contact:
Ausrele Kesminiene, International Agency for Research on Cancer (IARC), Lyon, France
kesminienea@iarc.fr

Related to:
MELODI, CARPEM

IONISING RADIATION AND RISK OF DEATH FROM LEUKAEMIA AND LYMPHOMA IN RADIATION-MONITORED WORKERS (INWORKS): AN INTERNATIONAL COHORT STUDY. Leuraud K et al. Lancet Haematol 2015;2:e276-81
RISK OF CANCER FROM OCCUPATIONAL EXPOSURE TO IONISING RADIATION: RETROSPECTIVE COHORT STUDY OF WORKERS IN FRANCE, THE UNITED KINGDOM, AND THE UNITED STATES (INWORKS). Richardson DB et al. BMJ 2015;351:h5359

EPI-CT scan cohort

A multinational cohort of children who have undergone a computed tomography

EPI-CT is designed as a multinational cohort study of children and young adults who have undergone at least one computed tomography (CT) scan before the age of 22 years. It comprises three main parts: 1) an epidemiological cohort study assessing cancer effects of radiation exposure from CT; 2) a dosimetry system to evaluate individual doses and related uncertainty, and supporting dose reduction and optimisation strategies; 3) a pilot study to evaluate the feasibility of applying different biomarkers of hypersensitivity in young patients exposed to low doses from CT.

Photo: IARC

Dr Ausrele Kesminiene

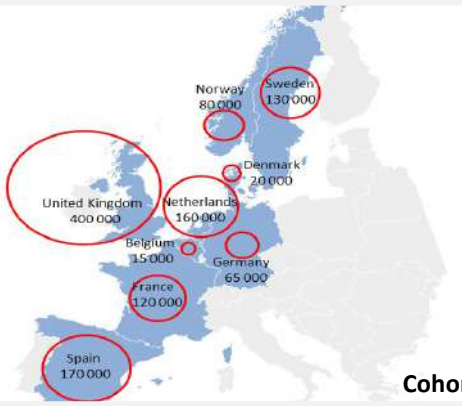
The study is built upon and has expanded existing cohorts in France, Germany and the UK, and has led to the setting up of similar cohorts in Belgium, Denmark, the Netherlands, Norway, Spain and Sweden, based on a common protocol. Coordinated by the International Agency for Research on Cancer (IARC), the study has recruited over 1,000,000 patients.

National cohorts have been assembled retrospectively and prospectively from radiology department records. Cohort members have been followed passively through linkage with cancer, mortality and other registries (including hospital discharge databases), to determine the cancer incidence and vital status of study participants.

Dosimetric data for the distant past is extremely limited, and only sparse information could be obtained for dose reconstruction. For recent years, detailed dosimetric data has been extracted from the Picture Archiving Communication System (PACS) with the use of dedicated PerMoS software. NCI-CT software, which uses Monte-Carlo (MC) simulation methods, is used to calculate organ doses for the ICRP reference phantoms. Dose reconstruction strategy, including uncertainty analysis, is based on a two-dimensional MC (2DMC) simulation approach, which provides alternative realisations of sets of doses for each organ of interest resulting from more than 2,000,000 CT examinations. The impact of various sources of bias on estimates of cancer risk is being characterised in countries where this information is available. Simulation studies are being conducted to investigate the impact of bias on the risk estimates from the entire study.

The biological pilot study has demonstrated that chromosomal aberration and DNA double-strand break induction rates were higher following CT irradiation of blood samples from newborns and young children compared to adults; these differences were also visible in the γ-H2AX-foci assay. *In vitro* assessment of the γ-H2AX-foci assay demonstrated that it is technically feasible to apply this assay in a multicentre prospective CT study.

As the largest and the most statistically powerful study of paediatric CT scans undertaken to date, the EPI-CT study provides direct epidemiological evidence on the potential cancer risk from exposure to low doses of ionising radiation, and may help to limit the radiation dose delivered to children.



Cohort repartition

ID Card:

Database type:
Individual data on humans exposed to protracted low-doses of ionising radiation

Cohort type:
International cohort comprising 1,163,571 patients from BE, DK, FR, DE, NL, NO, ES, SE and GB, who have undergone CT examination.

Age/follow-up:
- age at exposure: from 0 to 22 years
- mean age at the first examination: 10 years,
-mean age at the end of current follow-up: 20 years
- follow-up period varies by country and ranges from 1973 to 2015

Data available:
-Individual organ doses due to external X-ray irradiation, including uncertainty analysis;
- cancer incidence;
-vital status (except in Germany and partially in FR;
-socioeconomic status available in BE, FR, NL, ES and GB
-cancer predisposing syndromes available in FR, NL and NO.

Link with a biobank:
no

Internet link:
http://epi-ct.iarc.fr/

Access:
The data are maintained by each individual country; national principal investigators should be contacted.

Contact:
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kesminienea@iarc.fr

Related to:
MELODI, EURAMED

ASSESSING ORGAN DOSES FROM PAEDIATRIC CT SCANS – A NOVEL APPROACH FOR AN EPIDEMIOLOGY STUDY (THE EPI-CT STUDY)
Thierry-Chef I, Dabin J, Friberg EG, Hermen J, Istad TS, Jahnen A, Krille L, Lee C, Maccia C, Nordenskjöld A, Olerud HM, Rani K, Rehel JL, Simon SL, Struelens L, Kesminiene A. Int J Environ Res Public Health. 2013 Feb 18;10(2):717-28

EPI-CT: DESIGN, CHALLENGES AND EPIDEMIOLOGICAL METHODS OF AN INTERNATIONAL STUDY ON CANCER RISK AFTER PAEDIATRIC CT
Bosch de Basea M, Pearce M S, Kesminiene A, Bernier MO, Dabin J, Engels H, Hauptmann M, Krille L, Meulepas JM, Struelens L, Baatout S, Kaijser M, Maccia C, Jahnen A, Thierry-Chef I, Blettner M, Johansen C, Kjaerheim K, Nordenskjöld A, Olerud H, Salotti J A, Andersen T V, Vrijheid M, Cardis E. Radiol Prot 2015 Jul 30; 35(3):611-628

LATVIAN STATE REGISTER OF PERSONS EXPOSED TO RADIATION DUE TO THE CHERNOBYL NUCLEAR POWER PLANT ACCIDENT

Cohort of Chernobyl accident clean-up workers from Latvia

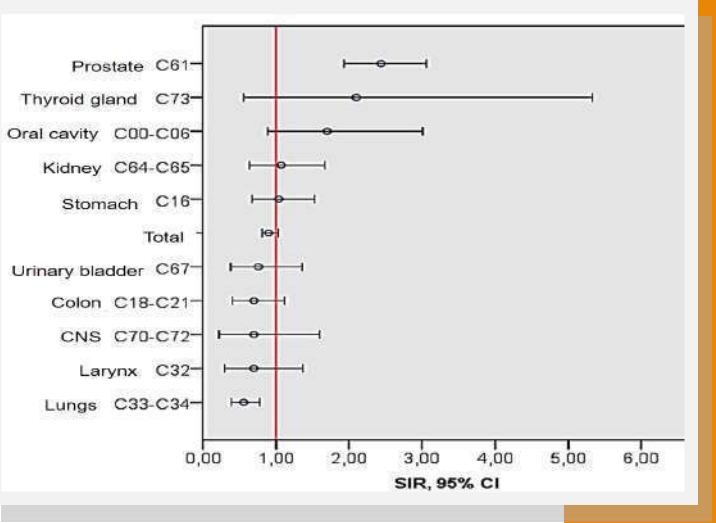
More than 6,000 Latvian inhabitants were among the Soviet people sent to Chernobyl to clean up the site of the nuclear power plant (CNPP) following the accident in 1986. At that time, most were healthy young males (military personnel and civilians of reproductive age). They stayed in Chernobyl for 1-6 months between 1986 and 1991, performing decontamination, transportation and construction tasks. During their stay, they were exposed to external radiation and radionuclides which were deposited into their bodies. Among the non-radiation factors, the most significant were the psycho-emotional stress, the physical overload and the effects of heavy metals and other chemicals. Contrary to Ukraine, Belarus and Russia, the territory of Latvia showed no significant increase in background radiation after the CNPP accident, thus since their return from Chernobyl, the clean-up workers have been living in an area relatively non-contaminated by radiation. Information on the health status of the CNPP accident clean-up workers has been gathered regularly in Latvia from 1987 to the present day, i.e. for about 30 years. Since 1994, this information has been recorded in the Latvian State Register of Persons Exposed to Radiation due to the CNPP Accident. On 1st January 2016, the register contained data from 5,043 persons registered as clean-up workers (who were within the 30 km zone of the CNPP), 1,795 persons who suffered effects of the accident, including 153 persons evacuated from Chernobyl and 1,642 children of clean-up workers born after the accident. The CNPP clean-up workers received regular medical follow-up throughout this time period at a single medical centre. This provided the opportunity to gather information on their health status from a single source. The data base contains individual data on regular medical check-ups and changes in health, as well as data on the cause of death, work tasks performed in Chernobyl and documented exposure doses (evaluable for 57% of clean-up workers). Mean exposure was estimated at about 130 mSv (min 0.1 mSv, max 500 mSv) but doses recorded in the "Military Passport" may not always be accurate. The register is maintained by specialists from the Centre of Occupational and Radiation Medicine (Pauls Stradins Clinical University Hospital). The research is carried out in collaboration with scientists from the Institute of Occupational Safety and Environmental Health (Riga Stradins University). Latvian scientists have conducted many studies based on the information collected, including studies in collaboration with scientists from other countries. Clinical observations and physiological, immunological and epidemiological studies of the Latvian CNPP workers cohort show that these individuals have a higher incidence of wide-ranging disease than the non-exposed general Latvian population. These findings create a need for further research to determine the reasons and mechanisms for the progression of health disorders in this cohort.

Photo: J Reste/RSU IOSEH

Monument in Riga dedicated to the victims of Chernobyl accident (annual memorial event on April 26th)

Photo: J Reste/RSU IOSEH

Dr Jelena Reste



Comparison of oncologic morbidity between CNPP workers and general Latvian male population

ID Card:

Database type:
Individual data on humans exposed to low-doses of ionizing radiation in nuclear power plant accident clean-up works

Cohort type:
6000 males, who were protractedly exposed to ionizing radiation during recovery works in Chernobyl in 1986-1991 (external irradiation and internal deposition of long-living radionuclides)

Age/follow-up:
- age at exposure: 32±7 years
- current age: 61±7 years
mean duration of follow-up: 29 years
follow-up period: from 1986 till now

Biobank available:
no, but feasible on demand

Data available:
individual data on working tasks performed in Chernobyl, health condition in dynamics during follow-up period, results of regular medical check-ups, causes of death for cancer and non-cancer diseases

Access:
Joint research collaboration. The data are maintained by Latvian State Register; the permission for use should be received; the processing of data may be done without personal sensitive information only; it is not possible to send the database outside

Internet link:
http://www.rsu.lv/eng/science-and-research/research-organisation/structure/institutes-and-laboratories/institute-for-occupational-safety-and-environmental-health

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jelena.reste@rsu.lv

Related to:
MELODI

INVESTIGATIONS ON HEALTH CONDITIONS OF CHERNOBYL NUCLEAR POWER PLANT ACCIDENT RECOVERY WORKERS FROM LATVIA IN LATE PERIOD AFTER DISASTER. Reste J. et al (2016), Proc Latv Acad Sci B Nat Exact Appl Science,70(5), 257-265
CLINICAL ASPECTS OF THE HEALTH DISTURBANCES IN CHERNOBYL NUCLEAR POWER PLANT ACCIDENT CLEAN-UP WORKERS 5LIQUIDATOR FROM LATVIA, Eglite M. et al, Inflammopharmacology (2009), 163–169

ESTCHERN COHORT

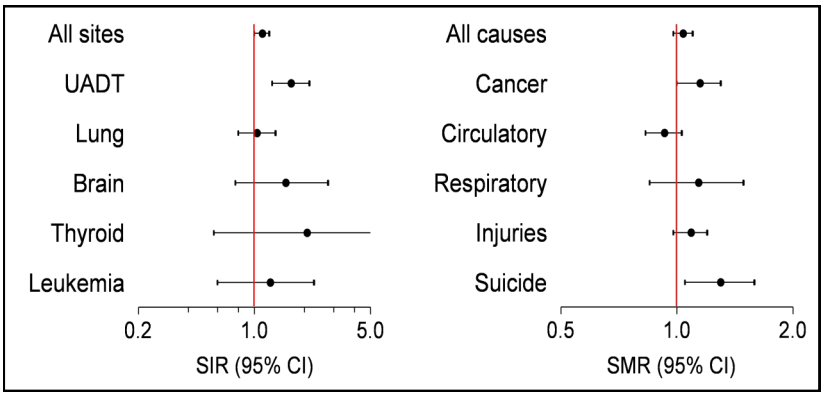
Cohort Study of Chernobyl clean-up workers from Estonia

The Estonian cohort study of Chernobyl clean-up workers was set up in 1992 at the Institute of Experimental and Clinical Medicine (now the National Institute for Health Development), in collaboration with US and Finnish colleagues and with major funding from the National Cancer Institute (USA). The aim of the study was to contribute to the knowledge on the long-term health effects of the Chernobyl accident. The cohort consists of 4,831 men from Estonia who worked in the Chernobyl area between 1986 and 1991. Initial information gathered for each individual includes name, date of birth, place of residence, date of arrival in and departure from Chernobyl, and documented whole-body radiation dose. Follow-up of the cohort members through the national population registry, to get unique personal identification numbers and update their vital status, is almost complete (0.4% of subjects untraced). By 31 December 2014, 108,331 person-years at risk (mean 22.5) had accumulated. Two-thirds of the men were sent to the contaminated area in 1986; their mean age was 31 years, mean duration of the service 102 days, and documented mean radiation dose 99 mGy.

Several sub-studies were carried out: 1) A self-administered questionnaire (1992–1995, 3,888 responses) was a major source of information on service in Chernobyl, health behaviour and socio-demographic characteristics, 2) Biodosimetry (1992–1996, blood samples from 3,197 men) which incorporated the GPA locus mutation assay and FISH chromosomal translocation analyses confirmed the low mean dose of 100–110 mGy, 3) Thyroid screening (1995, 1,984 screenees) did not reveal higher prevalence of thyroid nodules or thyroid cancers in the cohort, 4) Minisatellite mutation frequency among post-Chernobyl offspring (1999, 147 families) was slightly (not significantly) increased compared to their pre-Chernobyl siblings, 5) Follow-up for cancer incidence through the cancer registry (1986–2012, 369 cases) showed borderline overall cancer risk; there were 10 leukaemias *vs* 8.03 expected, and 4 thyroid cancers *vs* 1.93 expected; significant excess was evident for UADT* cancer, 6) Mortality in the cohort (1986–2014, 1,176 deaths) was similar to that expected; the risk of suicide among clean-up workers has been persistently 30 % higher than in the male population (94 suicides *vs* 72.15 expected), 7) Non-cancer morbidity analysis (2004–2012, 3,680 clean-up workers *vs* 7,631 unexposed men) revealed an elevated risk for diseases of the thyroid gland (not related to year of arrival) and ischaemic heart disease; clean-up workers experienced an excess of alcohol-induced conditions and external causes of morbidity, and 8) A mental health questionnaire (2010, 614 clean-up workers *vs* 706 unexposed men) demonstrated the increased risk of suicide ideation, depressive disorders and alcohol dependence in the cohort.

No clear evidence of adverse health effects of radiation exposure among clean-up workers has been observed, however small risks may have been undetectable.

*Upper AeroDigestive Tract



Cancer incidence and mortality in the cohort of Chernobyl clean-up workers in comparison with the Estonian male population

Photo: K.Rahu (selfie)

Dr Kaja Rahu

Thyroid screening of Chernobyl clean-up workers in Tallinn, 27 March 1995

Photo: M.Rahu/NIHD

ID Card:

Cohort type:
Chernobyl clean-up workers from Estonia; individual records of 4,831 men exposed to low-dose ionising radiation after the Chernobyl accident

Age/follow-up:
Age at exposure: 18–68 years; follow-up for site-specific cancer incidence and cause-specific mortality

Biobank available: Yes

Sample type:
Primary lymphocytes (from 3,197 clean-up workers)

Sample storage conditions:
-80°C, liquid nitrogen

Conditions of use:
External use possible

Access:
Subject to permission from the Scientific Resource Committee

Internet link:
http://www.tai.ee

Contact:
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Tel. +372 659 3943

Related to: MELODI

Rahu K, Rahu M, Tekkel M, Veidebaum T, Hakulinen T, Auvinen A et al. (2015) Chernobyl cleanup workers from Estonia: cohort description and related epidemiological research. J Radiol Prot;35:R35–R45.
Rahu K, Auvinen A, Hakulinen T, Tekkel M, Inskip PD, Bromet EJ et al. (2013) Chernobyl cleanup workers from Estonia: follow-up for cancer incidence and mortality. J Radiol Prot 2013;33:395–411.

German airline crew cohort

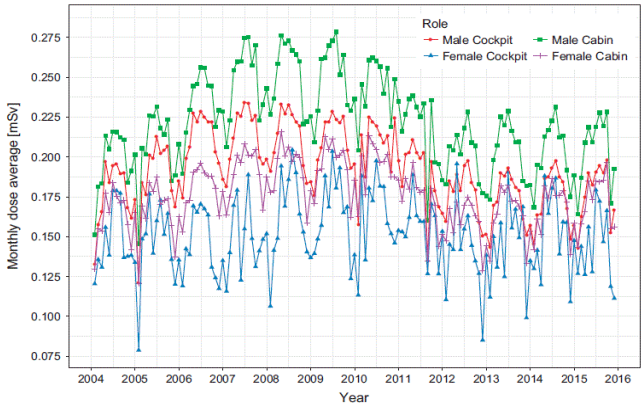
The use of radiation registry data in the 3rd follow-up study

Commercial airline crews are one of the occupational groups with the highest exposure to natural radiation of cosmic origin. Several national airline personnel cohorts in Europe and North America were established in the 1990s with the aim of investigating the occupational health risks of cockpit and cabin crew, and in particular to identify radiation-associated cancer. As one of the largest national studies (n= 26,846), the German cohort study is currently concluding its third follow-up investigation with an additional 10 years of observation, up to the end of 2014, and with an overall follow-up time of up to 55 years (1960-2014).

Photo: BIPS

Pr Hajo Zeeb

et al., 2017). In this third follow-up period, exposure data from 26,805 cohort members was available, compared to n=5,995 in the previous analyses. SMR and RR analyses are currently underway and results will be submitted for publication in international peer-reviewed journals in the first part of 2018.



Mean monthly effective aircrew dose from 2004 to 2015, stratified by sex and role.
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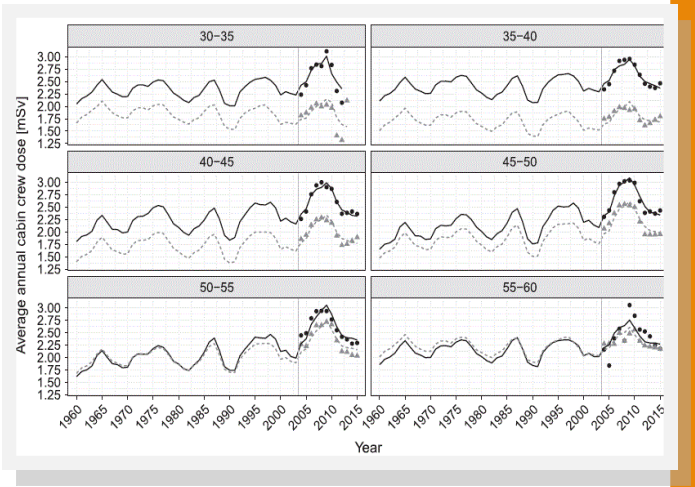
To our knowledge this is the first mortality follow-up study using SSR registry data in Germany. The data availability further enables convenient and quality assured exposure assessment via data-linkage for (possible) future follow-up studies of this cohort and/or the set-up of a new generation of aircrew cohorts, as working conditions have changed since the initial cohort started in terms of flight frequencies, ranges and routes, thus resulting in higher lifetime radiation doses compared to those individuals who started in the pre-jet era. Also, follow-up work will be more convenient as unique registry identifiers are used, which will ensure cohort retention and nearly complete exposure assessment. Furthermore, SSR data may also be used to ascertain vital status if SSR data availability exceeds the cohort time-inclusion criteria, which also leads to cost reduction.

In the previous follow-up studies, exposure assessment was based on dose reconstructions using a job-exposure matrix approach based on company flight records, to estimate individual radiation doses for the cockpit personnel only. Cabin crew were not included as detailed flight records were not available. Following regulatory changes in 2003, aircrews in Germany are now systematically monitored, and individual monthly effective doses have been documented by the Federal Radiation Registry (SSR) since mid-2003 (complete data availability: start of 2004).

Thus, in this follow-up study, the newly available exposure data are now included for cockpit and cabin cohort members, for exposures during the period from 2004 to 2014. In addition, the estimated radiation exposure of the cabin crew for the years from 1960 to 2003 has been modelled as a function of age, sex, job category, solar activity and male pilots' dose, to provide the opportunity to conduct dose-response analyses for the full cohort (Wollschlaeger



Predicted (lines) and observed (points) average annual effective cabin crew dose plotted from 1960 to 2015, stratified by sex and 5-year age groups.
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ID Card:

Cohort type:
German airline cockpit and cabin crew with 26,805 individual occupational exposure records

Age/follow-up:
Age at exposure: 18-62 years; mortality follow-up for radiation-related cancers and other disease outcomes

Biobank available:
No

Access:
To be discussed with the research team

Internet link:
https://www.bips-institut.de/en/home.html

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Related to:
MELODI

Estimated radiation exposure of German commercial airline cabin crew in the years 1960-2003 modeled using dose registry data for 2004-2015, Wollschlaeger D., Hammer G. P., Schafft T., Dreger S., Blettner M., Zeeb H. (2017), J Expo Sci Environ Epidemiol., doi: 10.1038/jes.2017.21.
Mortality from cancer and other causes in commercial airline crews: a joint analysis of cohorts from 10 countries, Hammer G. P., Auvinnen A. et al. (2013), Occup. Environ. Med. 71, 313-322

The Techa River Cohort (TRC)

Cohort study of general population exposed on the Techa River

The Techa River Cohort (TRC) includes individuals born before 1950 and who lived in any of the 41 villages situated along the Techa River (Russia) between 1950 and 1960. The TRC members were affected by external γ-radiation from contaminated river sediments and flood plain soil, and by internal exposure to radionuclides, including ^{89}Sr, ^{90}Sr and ^{137}Cs, due to consumption of local water, milk and food products which were contaminated following the release of radioactive waste into the Techa River by the Mayak Radiochemical Plant between 1949 and 1956.

Table 1. Demographic characteristics of TRC

Parameters	n	%
Sex		
Male	12,558	42%
Female	17,172	58%
Ethnicity		
Tatars & Bashkirs	5,950	20%
Slavs	23,780	80%
Age at January 1, 1950		
<1	1,032	3%
1-14	8,824	30%
15-59	17,279	58%
60 & older	2,595	9%
Total TRC	29,730	100%

Table 2. Vital status of TRC members

Vital status as of 31/12/2007	People
Alive in catchment area	5,684
Dead	17,307
% known cause of death	91%
Lost of follow-up	6,739
Including: migrants	4,696
persons with unknown status	2,043
Total TRC	29,730

The first specialised medical examinations of the residents of the Techa riverside villages took place in 1951. From 1955 to present, the residents of these villages have been followed up by the physicians of the Clinic of the Urals Research Centre for Radiation Medicine (URCRM), under the Federal Medical-Biological Agency.

A Registry of exposed persons and a medical dosimetry database were created at the URCRM in the 1970s. Between the late 1960s and the 1980s, URCRM researchers conducted an extensive review of official documents including tax records, vital statistics, medical records and population surveys, to identify potential cohort members. The demographic characteristics are shown in Table 1. Follow-up of vital status (Table 2), and of cancer incidence and mortality of TRC members, covers a period of more than 50 years and is based on the addresses provided by the bureau of information, the death certificates from the statistical offices of Chelyabinsk and Kurgan oblasts and cancer notification forms from the Chelyabinsk oblast oncology dispensary. The start date of the follow-up and the catchment areas used in the studies were dependent on data access.

Individualised organ doses for TRC members over the whole follow-up period were calculated by the URCRM dosimetry team using specially developed software (Techa River Dosimetry System-TRDS). The results presented are based on TRDS-2009, a software version which incorporates recent advances in radionuclide intake reconstruction, external exposure assessment and reduction in the uncertainty of dose estimates. Development work is in progress to further improve TRDS.

Photo: Krestinina L./URCRM

Dr Lyudmila Krestinina

The TRC is a unique resource for estimating cancer risks following chronic exposure to low-medium doses in the general population. It is one of the few human populations affected by protracted strontium exposure, a radionuclide which concentrates in the bone and is thus of great relevance for leukaemia studies. Studies of cancer incidence and mortality in this cohort have been undertaken in Russian-American projects (NCI: 1995-2013; DOE under JCCRER: 1996-2018) and in a European project (SOUL: 2006-2009). Results of radiation effects studied in the TRC show significant excess relative risk for all leukaemias, and also for leukaemias excluding chronic lymphatic leukaemia (CLL), as well as for solid cancer mortality in the TRC and for solid cancer incidence in the Chelyabinsk subcohort of the TRC. The study of non-cancer effects in the TRC (SOUL project) also showed significant risk for all diseases of the circulatory system and for ischaemic heart disease (Table 3).

Table 3. Dose response in Techa River Cohort

Parameters	Solid cancer			Leukemia		Cardio-vascular diseases (CVD)	
	Mortality[1]	Incidence[2]		Incidence[3]		Mortality[4]	
People	29,730	Techa River Incidence cohort 17,435		28,223		29,735	
Follow-up period	1950-2007	1956-2007		1953-2007		1950-2003	
Cases, n	2,303	1,933		99	72	7,595	3,194
Person-years	927,743	472,788		847,877		901,563	
Lag period, years	5	5	5	2		15	
ERR/Gy	0.61	0.87	Smoking adjusted 0.77	All leukemias 1.1	Leukemias Non-CLL 2.2	All CVD 0.36	Ischemic heart diseases 0.56
95% CI	0.04-1.3	0.2-1.6	0.13-1.5	0.4-2.4	0.8-5.4	0.02-0.74	0.01-1.19
P	0.03	0.008	0.02	<0.001	<0.001	0.04	<0.05
Model	linear	linear		linear			
Excess cases	50 (2.2%)	69 (3.6%)	61 (3.1%)	29 (30%)	34 (47%)	73 (1%)	49 (1.5%)

1- Schonfeld et al., 2013, Radiat Res (179); 2- Davis et al., 2015, Radiat Res (184);
3-Krestinina et al., 2013, BJC (109); 4-Krestinina et al., 2013, Radiat Environ Biophys (52)

ID Card:

Cohort type:
Approx. 30,000 persons from the general population, born before 1.1.1950 and resident in the Techa Riverside villages during 1950-1960, environmentally exposed to protracted low- and medium doses (<1 Gy) to soft tissues and to low-high doses to red bone marrow (<7 Gy).

Age/follow-up:
- at exposure: 0-90> years
- current age(2017): 67-90> years
- mean age of those alive at the end of 2014: 74.7 years

Mortality follow-up: 1950-2014.
Cancer incidence: 1956-2014

Biobank available:
Yes

Sample type:
Cells, DNA, fixed slides

Sample storage condition:
(-80°C, liquid nitrogen…)

Access:
The database is owned by URCRM. Access to coded (impersonalized) data is subject to permission from URCRM Commission of Experts.

Internet link:
www.urcrm.ru

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Related to:
MELODI

Leukaemia incidence in the Techa River Cohort: 1953–2007, Krestinina L. Y., Davis F. G., Schonfeld S., Preston D. L., Degteva M., Epifanova S. et al. (2013), British Journal of Cancer, 109, 2886–2893
Solid cancer mortality in the Techa River Cohort (1950–2007), Schonfeld S. J., Krestinina L. Y., Epifanova S., Degteva M. O., Akleyev A. V., Preston D. L. (2013), Radiation Research, 179, 183–189

Greek interventional cardiologists cohort

Estimation of eye lens doses in Greek cardiologists

The Greek Atomic Energy Commission is the national regulatory authority for radiation safety, and is responsible for maintaining the National Dose Registry (NDR) for workers occupationally exposed to ionising radiation.

Eye lens doses seem to be of great concern, especially for staff working in interventional cardiology, due to a decrease in the eye lens dose limit for occupational exposure, as set out in the latest European Basic Safety Standards Directive 2013/59/EURATOM. For this reason, efforts have been made in the present cohort to retrospectively estimate the eye lens doses in interventional cardiologists, based mainly on the whole body dose data kept in the NDR since 1989.

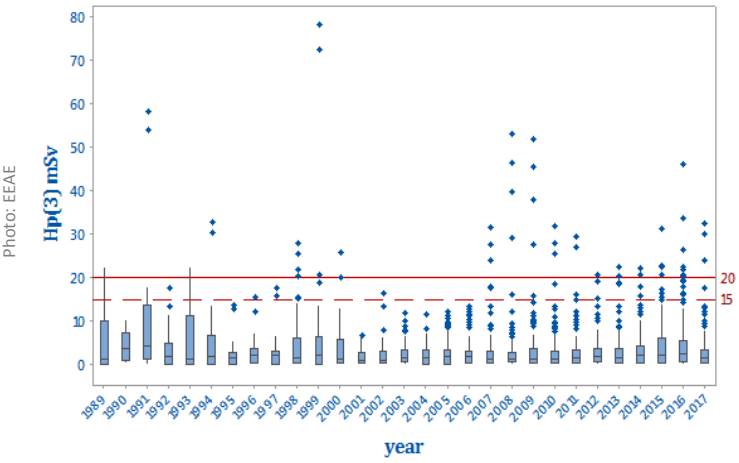

Photo: EEAE

Box plots showing the evolution of the annual Hp(3) in mSv.

A short questionnaire has also been used to collect data on the type and number of procedures, the X-ray system configuration and the use of protective measures during the respective exposure periods. All the relevant data for active interventional cardiologists in the cohort have been extracted from the NDR. Of the 530 cardiologists contacted, 150 completed the questionnaire. The eye lens dose was estimated using the second approach developed in the EURALOC project (OPERRA). For each cardiologist, the distribution of the possible cumulative eye lens doses was estimated individually and separately for each eye. The above graph shows the evolution of the annual Hp(3) dose for the cohort since 1989. From the questionnaires and the estimated eye lens dose values, it can be concluded that:

- The use of personal protective equipment is increasing. More specifically, an increase in the use of protective shields was noted in the 1990s. The use of lead glasses is also increasing; however 30% of the cardiologists are still not using lead glasses.

Photo: EEAE

Dr Eleftheria Carinou

- Whole body doses seem to have increased over the last 15 years (from 5.3 mSv to 10.6 mSv). The estimated eye lens dose values indicate that the new annual eye lens dose limit has been exceeded in some cases.
- The maximum cumulative eye lens dose is estimated at 700 mSv.

The present approach used for estimation of the eye lens doses has the advantage that is based on individual measurements (i.e. whole body doses) for each cardiologist; however, there are also serious disadvantages, mostly related to the constant use of the personal dose meter in the past, and to its position on the worker's body.

Moreover, the findings in the present cohort underline the importance of keeping an NDR, which has proved to be a powerful tool for the retrospective estimation of eye lens doses in interventional cardiologists.

The research leading to these results has received funding from the European Atomic Energy Community's Seventh Framework Programme under grant agreement n° 604984.

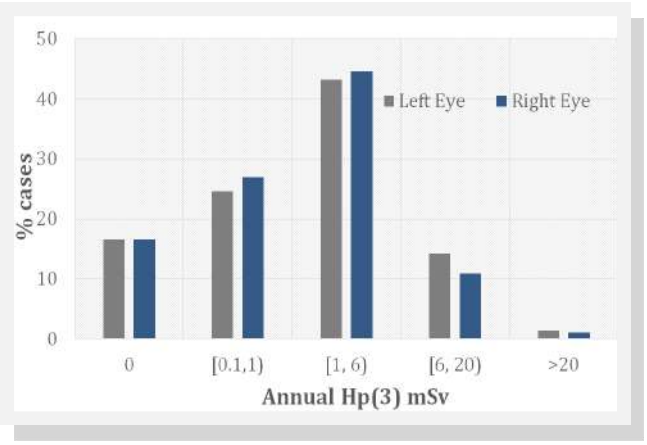

Photo: EEAE

Distribution of the estimated annual Hp(3) for both eyes.

Eye lens radiation exposure in greek interventional cardiology personnel, Thrapsanioti Z., Askounis P., Datseris I., Diamanti R. A., Papathanasiou M., Carinou E. (2017), Radiation Protection Dosimetry, 175 (3), 344–356

The influence of operator position, height and body orientation on eye lens dose in interventional radiology and cardiology: Monte Carlo simulations versus realistic clinical measurements, Principi S., Farah J., Ferrari P., Carinou E., Clairand I., Ginjaume M. (2016), Physica Medica, 32 (9), 1111–1117

EEAE ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΑΤΟΜΙΚΗΣ ΕΝΕΡΓΕΙΑΣ GREEK ATOMIC ENERGY COMMISSION

ID Card:

Cohort type:
Interventional cardiologists
530 contacted; 150 replied

Age/follow-up:
Age at exposure: 30-67 years old
Data extracted from the National Dose Registry database starting from 1989

Biobank available:
N/A

Access:
Contact E. Carinou for possible external use of the cohort data

Internet link:
https://eeae.gr/en/

Contact:
Dr Eleftheria Carinou
Eleftheria.carinou@eeae.gr
+30 2106506718

Related to:
EURADOS, MELODI

The German Thorotrast Cohort Study

Cohort study on internal exposure to alpha radiation

Thorotrast was the trade name of the radioactive radiographic contrast agent containing 25% colloidal solution of thorium dioxide, widely used in the period 1930 - 1950 in Germany and other countries. The main application of Thorotrast was as an intravascular injection for cerebral angiography. Thorotrast is retained by the reticuloendothelial system, with a biological half-life of several hundred years. Thus, patients suffer lifetime exposure to internal alpha radiation. The potential risks of Thorotrast were recognised several years after the first application, on the appearance of sarcoma. It was banned in 1949 -1950.

Photo: https://media.springernature.com/lw785/springer-static/image/art%3A10.1007%2Fs00117-016-0186-7/MediaObjects/117_2016_186_Fig1_HTML.gif

Original 12 ml vial from the company Heyden (right) and a vial for animal experiments from a U.S. company (left)

Thorotrast patients have been followed-up in epidemiological surveys. Five cohort studies were carried out with patients from Japan, Portugal, Denmark, the USA and Germany. The largest of these was the German Thorotrast Study that started in 1968 with a follow-up until 31 December 2004.

The aim of this study was to determine the long-term health consequences of the incorporated colloidal thorium dioxide and the resulting radiation exposure through epidemiological surveys as well as clinical, radiological and biophysical examination of the patients. The study comprised 2,326 Thorotrast patients and 1,890 patients from a matched control group. The 899 Thorotrast patients and 662 controls who were alive at the start of the study in 1968 were followed-up through clinical examinations on a biannual basis.

At the end of 2004, only 9 of the 2,326 exposed individuals and 151 of the 1,890 controls were still alive. For all deceased individuals, causes of death were collected in various ways and coded according to ICD-10. When the exposed group was compared with the control group, based on post-mortem examinations and pathology, high relative risks were observed for liver cancer, leukaemia, myelodysplastic syndromes (MDS) and carcinoma of the extrahepatic bile ducts. SMR analyses were conducted based on national rates. They showed a strong life-shortening effect, with increased mortality being observed in particular for liver cancer, but also for bone cancer and malignancies of the haematopoietic system, but not for lung cancer.

Photo: BfS

Dr Mandy Birschwilks

Leukaemias appeared 5 yr after injection and continued to increase subsequently, while liver cancers did not appear until almost 20 yr after injection and then increased very rapidly. Dose-effect relationships were calculated for various endpoints showing different shapes of dose-response. A 2016 paper (DOI 10.1007/s00411-016-0651-8) describes the cohort, important results on dosimetry, medical examinations and chromosomal aberrations, and also asks some open questions. The data from the German Thorotrast Study are available to any interested researchers through the STORE database (http://storedb.org). Information on individual patients, including X-ray films, is available from the German Cancer Research Center, Heidelberg.

German Thorotrast Study – patients' vital status (at end of follow-up Dec. 2004)

	Thorotrast patients				Comparison group			
Vital status	male	female	sum	%	male	female	sum	%
alive	6	3	9	0.4%	99	52	151	8.0%
deceased	1,709	604	2,313	99.4%	1,305	428	1,733	91.7%
lost to follow-up	2	2	4	0.2%	-	-	6	0.3%
sum	1,717	609	**2,326**	100.0%	1,408	484	**1,890**	100.0%
	73.8%	26.2%			74.4%	25.6%		

(Based on Becker et al. 2008, numbers for lost to follow-up by sex are not available in the comparison group)

ID Card:

Cohort type:
Thorotrast®, Germany
Thorotrast Study: 2,326 Thorotrast patients and 1,890 patients from a matched control group.

Biobank available:
N/A

Conditions of use:
Researchers interested in the cohort data should send a proposal describing the envisaged study design or type of analysis.

Access:
Will be granted after approval through the STORE website.

Internet link:
http://storedb.org

Contact:
Dr Mandy Birschwilks
store@bfs.de
mbirschwilks@bfs.de

Related to:
MELODI, EURAMED

The German Thorotrast Cohort Study: a review and how to get access to the data, Grosche B., Birschwilks M., Wesch H., Kaul A., van Kaick G. (2016), Radiat Environ Biophys, 55 (3), 281–289
The German thorotrast study: recent results and assessment of risks, van Kaick G., Dalheimer A., Hornik S., Kaul A., Liebermann D., Lührs H., Spiethoff A., Wegener K., Wesch H. (1999), Radiat Res, 152 (6), S64–S71

Chapter 3 : Analytical platforms, Models & Tools

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Subcategory (a) : Analytical platforms

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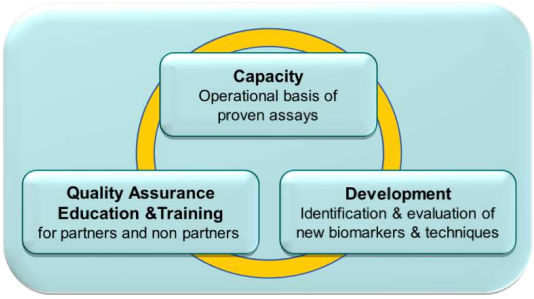
RENEB

A network for emergency preparedness and scientific research

RENEB is a European Biodosimetry Network, able to perform large scale rapid biodosimetric dose estimation. Specialized to handle a large number of samples, RENEB contributes to radiological emergency preparedness and large scale research projects. The network infrastructure is based on reliable assays and techniques combined with high performance standards. To enhance the effectiveness of the network, RENEB is linked to global emergency preparedness and response systems as well as to the European radiation research area.



The network was initiated in January 2012 with 23 partners from 16 European countries with the support of the EC (EURATOM FP7, GA 295513). At this time the focus was on emergency preparedness with the aim to significantly increase dose reconstruction capacities in case of large-scale radiological scenarios. Individual dose estimation based on biological samples and/or inert personalized devices has been optimized to support the rapid categorization of many victims according to the received dose. Communication and cross-border collaboration was standardized and cooperation with national and international emergency and preparedness organizations such as IAEA and WHO were initiated.

The value of RENEB to support topics also outside emergency preparedness is now evident. With established strategies to guarantee consistent performance between the partner laboratories, the network has the ability and capacity to contribute to large scale research projects with the analysis of exposure biomarkers. This includes studies on the effects of low doses, group related radiation sensitivity, contribution to non-cancer diseases, and epidemiological studies where sampling and handling of bioprobes is included. RENEB also drives the development and evaluation of new exposure markers with special view to their applicability for addressing acute or protracted exposures as well as exposures dating back years or decades.

As such, RENEB as an analysis platform is of special interest for the Emergency Preparedness Platform NERIS by adding preparedness in the field of individual dose estimation. Moreover it benefits MELODI and EURADOS by providing capacity for radiation research and specialized biomarker development. Concerning the latter, the radioecological Platform ALLIANCE will also profit from RENEB. Last but not least, RENEB provides intercomparisons, specialized courses and seminars open also to laboratories outside the network, thus being of relevance for E&T in the CONCERT-EJP.

Photo: ISS/A. Campa

Ulrike Kulka

RENEB was never meant to be a "time limited or closed club" and strategies were developed to identify "candidates" and integrate them as solid partners. Currently, RENEB comprises 22 partners and 7 candidates from 17 European countries. 16 have already signed a MoU, and thus form the nucleus of a unique growing infrastructure, combining high quality standards in the application and validation of biomarkers and maintenance and advancement of scientific and technical competence.

RENEB Consortium: BfS* Germany, BIR Germany, CEA France, ENEA Italy, HMGU Germany, ICHTJ Poland, INSP* Romania, IRSN France, ISS Italy, IST* Portugal, LAFE* Spain, NCRRP* Bulgaria, NCSRD Greece, OKK-OSSKI Hungary, NRPA* Norway, PHE* United Kingdom, SERMAS* Spain, STUK Finland, ,SU-CRPR* Sweden, UAB* Spain, UGent* Belgium, UNITUS* Italy

RENEB candidate: AMVRC* Italy, DIT* Irland, FZ Jülich Germany, INFN Italy, RPC* Lithuania, SCK•CEN* Belgium, US Spain

**MoU signed*

Photo: ISS/A. Campa

ID Card:

Analytical platform type:
biodosimetry, markers of exposure, retrospective dosimetry on biological and inert samples

Main techniques proposed:
panel of cytogenetic assays, gene expression assay, gamma H2AX assay, EPR/OSL dosimetry

Capacity:
emergency situation: up to 1000 samples per week, depending on assay;
research: up to 500 samples per week for several weeks, depending on assay;

Delay to start:
Emergency situation: immediately, no delay;
Research: dependent on the project

Intercomparison exercise options:
possible for all network assays and techniques

Training options:
possible for all network assays and techniques

Access:
Emergency situation: regulated by national authorities;
Research: selection by members

Internet link:
http://reneb.eu

Contact:
Ulrike Kulka
reneb@bfs.de
+49 30 18333 2210

Related to:
Emergency preparedness: NERIS,
Research: EURADOS, MELODI,

REALISING THE EUROPEAN NETWORK OF BIODOSIMETRY: RENEB—STATUS QUO. U. Kulka, et al. Radiat Prot Dosimetry. 2015 Apr;164(1-2):42-5.
THE FIRST GAMMA-H2AX BIODOSIMETRY INTERCOMPARISON EXERCISE OF THE DEVELOPING EUROPEAN BIODOSIMETRY NETWORK RENEB. S. Barnard, et al.Radiat Prot Dosimetry. 2015 Apr;164(3):265-70.

The Genomic Medicine and Bioinformatics Core Facility

Hungarian Genomics Research Network

The Genomic Medicine and Bioinformatics Core Facility (http://genomics.med.unideb.hu) was established in the year 2000 to provide access to cutting edge genomics technologies and foster collaborations between basic science and clinical research groups, as well as small and large pharma companies in the area of clinical genomics. The Centre now has 20 staff members working in the areas of biobanking, gene expression profiling, epigenetics, next generation sequencing and bioinformatics. The Centre is a national leader in the field of genomics. It is a designated key national infrastructure, coordinator of the Hungarian Genomics Research Network, and leader of the National Genomics Technology Platform (http://www.genomika.net/gntp/home.html).

Photo: UD/Sandor Nagy

Standardized epigenetics workflow based on robotics

The main research infrastructure comprises:

- Next Generation Sequencing (Illumina HiScan) (Exome Sequencing, RNA-Seq, ChIP-Seq, RNA-Seq)
- Microarray Technologies (Affymetrix and Illumina Arrays, gene expression, genotyping and cytogenetics)
- Biobanking system, sample processing using robotics (Qiagen), lN_2 storage and -70°C storage for over 20,000 samples
- Pipetting robots for sample preparation and processing (Tecan, IPStar)
- UNIX server for data analysis and storage

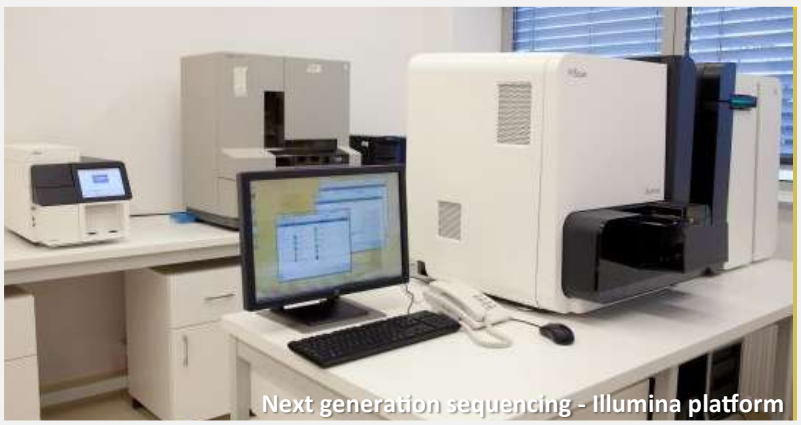
The Centre's long-standing technology and twinning partner in the MOLMEDREX project is the Gene Core at EMBL, Heidelberg. This partnership consists of regular bidirectional visits and transfer of know-how from GeneCore (EMBL). In addition, the Centre has been involved as an external partner (access user) in the European Sequencing and Genotyping Infrastructure Project (ESGI: http://www.esgi-infrastructure.eu/) and was invited to undertake continued collaboration on the project.

Photo: UD/Sandor Nagy

Laszlo Nagy

To date, the Centre has successfully completed projects for pharma and biotech companies such as Pfizer Global Research (EUR 340 K), Richter Hungary (Schizo Biobank EUR 2,900 K) and Csertex (EUR 1,000 K). Besides the pharma contacts, the Centre has provided services to dozens of Hungarian research groups, as well as groups from Poland, Romania, Lithuania, Taiwan, Greece, etc.

The Genomic Medicine and Bioinformatics Core Facility is located in the "In Vitro Diagnostic Building", together with the Laboratory of Medicine, the Molecular Diagnostic Laboratory and Microbiology Institutes. The Molecular Diagnostic Laboratory performs DNA analysis for monogenic disorders using sequencing, targeted mutation analysis, MLPA, trinucleotide repeat analysis, next-generation sequencing on the Roche Junior sequencer and clinical exome sequencing. It is one of the largest genetic centres in Hungary, performing 6,000 genetic tests annually including prenatal analysis. This close connection with the clinical units also ensures access to clinical samples.



Next generation sequencing - Illumina platform

Photo: UD/Sandor Nagy

ID Card:

Analytical platform type:
Genomics

Main techniques proposed:
Next Generation Sequencing (RNA-seq, DNA-seq, ChIP-seq) microarray (gene expression, SNP, CNV), clinical sample collection and processing (biobanking)

Delay to start:
None

Duration of experiment:
Technique-dependent

Training proposed:
See details on website

Address:
University of Debrecen, Medical and Health Science Center
Debrecen Clinical Genomic Center
4032 Debrecen, Hungary, Nagyerdei krt. 98. Pf. 6.

Access:
Genomics and biobanking core facility

Internet link:
http://genomics.med.unideb.hu

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Laszlo Nagy:
nagyl@med.unideb.hu
+36-52-411-717 (ext. 50015)

Related to:
MELODI, ALLIANCE, CARPEM

PRMT1 AND PRMT8 REGULATE RETINOIC ACID-DEPENDENT NEURONAL DIFFERENTIATION WITH IMPLICATIONS TO NEUROPATHOLOGY. Z. Simandi Z et al., Stem Cells. 2015 Mar;33(3):726-41.
THE ACTIVE ENHANCER NETWORK OPERATED BY LIGANDED RXR SUPPORTS ANGIOGENIC ACTIVITY IN MACROPHAGES. B. Daniel, et al. Genes Dev. 2014 Jul 15;28(14):1562-77.

MetaboHUB

French National Infrastructure for Metabolomics and Fluxomics

MetaboHUB is the French national facility in metabolomics and fluxomics selected in 2012 in the framework of the programme "Investissement d'Avenir" for a 7 years funding. It proposes advanced research services in metabolomics and fluxomics to provide opportunities for integration into other European infrastructures. The MetaboHUB infrastructure offers tools and services to academic research teams and industrial partners in the fields of nutrition and health, agriculture and biotechnology.

Photo: L. Lizet/INRA

Metabolomics relies on NMR and MS based technologies coupled with data mining tools

The objectives of the MetaboHUB infrastructure are fourfold: (i) to identify metabolites in human biofluids, as well as in plants, microorganisms and animal cell extracts, through the implementation, curation and maintainance of centralised, open spectral repositories for metabolite annotations, (ii) to provide high-throughput, quantitative technologies for biochemical phenotyping of large sets of samples and for systems biology, (iii) to develop large-scale flux profiling and subcellular fluxomics, and (iv) to attract a new generation of scientists and users by promoting metabolomics through education and training.

The MetaboHUB infrastructure will be developed in two interlinked phases: a construction phase and an operational phase. The construction phase (the first four years) is dedicated to harmonising, implementing and upgrading the four existing platforms with common metabolomics and fluxomics tools and methods, in order to build a world-class research centre and database in the field of metabolomics. To this end, the work plan is organised into 6 work packages (WP): Multi-site implementation of analytical chemistry for metabolite detection, quantification and identification (WP1); Fluxomics (WP2); Shared bioinformatics tools for data management and mining (WP3); Quality management (WP4); Coordination of services, governance and access to infrastructure (WP5), and Communication, training and technology transfer (WP6). The operational phase will be dedicated to handling the rise in the day-to-day activity of this national infrastructure which will operate as a world-class research centre in metabolomics, open to both academic and private partners. Activities and services will include providing spectral databases, centralised data repositories, standardised analytical methods for metabolomics, reagents for absolute quantification of metabolites, data mining tools and platforms capable of analysing large numbers of samples from large-scale projects.

Photo: S. Leblois/CEA

Christophe Junot

The French MetaboHUB project includes the four main French metabolomics platforms accredited with the national IBiSA quality standard. These are: the Bordeaux Metabolomics Platform (BMP, INRA and University of Bordeaux), the MetaboHUB-Paris Platform (Paris area - CEA and Pierre et Marie Curie University), the MetaToul Platform (Toulouse, Paul Sabatier University, INSA, INRA, CNRS and INSERM) and the Metabolism Exploration Platform (PFEM at Clermont-Ferrand, INRA and Blaise Pascal University). These four partners develop shared tools and expertise for basic and applied research projects.

Bordeaux, November 2013

Photo: INRA

ID Card:

Analytical platform type:
Nuclear Magnetic Resonance (NMR), Mass Spectrometry (MS), Statistical analyses and data mining, bioinformatics

Main techniques proposed:
- Targeted metabolite analyses
- Metabolite identification
- Non targeted metabolomics
- Non targeted lipidomics
- ^{13}C fluxomics
- Metabolic network analysis

Capacity:
Dependent on the application. MetaboHUB is able to handle cohorts of a few hundreds of samples for untargeted and targeted metabolomic studies.

Delay to start:
Dependent on the project.

Duration of experiment:
Dependent on the project.

Intercomparison exercise proposed:
Not available for the moment. Analyses of reference material such as NIST plasma are envisaged.

Training proposed:
Specific trainings on MS, NMR and data mining tools can be proposed by MetaboHUB platforms.

Address:
MetaboHUB, INRA center of Bordeaux
71 avenue Edouard Bourleaux
33140 Villenave d'Ornon, France

Access:
Projects can be submitted to the executive management board at any time.

Internet link:
www.metabohub.fr/

Contact:
contact@metabohub.fr

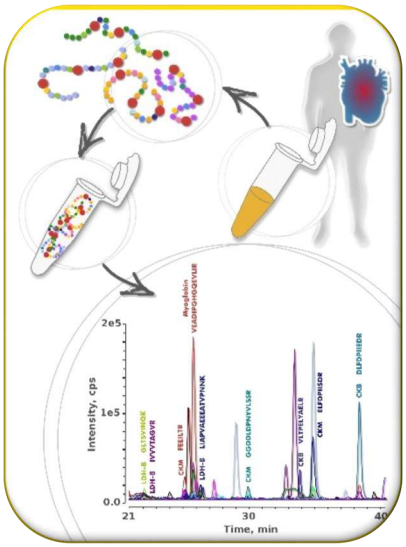
Related to:
MELODI, ALLIANCE, CARPEM, RENEB

ANALYSIS OF THE HUMAN ADULT URINARY METABOLOME VARIATIONS WITH AGE, BODY MASS INDEX, AND GENDER BY IMPLEMENTING A COMPREHENSIVE WORKFLOW FOR UNIVARIATE AND OPLS STATISTICAL ANALYSES. Thévenot EA et al., J Proteome Res. 2015;14(8):3322-35.
COORDINATION OF STANDARDS IN METABOLOMICS (COSMOS): FACILITATING INTEGRATED METABOLOMICS DATA ACCESS. Salek RM et al., Metabolomics. 2015;11 (6):1587-1597.

ProFI

French National Infrastructure for Proteomics

Initially devoted to protein identification, proteomics today aims to provide in-depth characterization of proteomes for functional proteomics and clinical applications. This leads to new challenges, including how to quantitatively determine variations within the proteome as a result of various stimuli or different cellular states, how to detect low abundance proteins important for biology or health, how to identify protein complexes and study their dynamics, and how to analyse post-translational modifications that play a key role in protein function. Within this highly challenging context, France has created ProFI, the French national proteomics facility. ProFI was selected for funding in 2012 through the government program, "Investments for the Future", and awarded 7 years' funding (€15m). ProFI is a joint infrastructure which regroups the three best known French proteomics platforms: the Laboratory for Exploration of the Dynamics of Proteomes (CEA, INSERM and Grenoble Alps University), the Laboratory for Bioorganic Mass Spectrometry (CNRS and Strasbourg University) and the Proteomics and Mass Spectrometry of Biomolecules research group (CNRS and Toulouse Paul Sabatier University). The objectives of ProFI are two-fold: (1) to undertake R&D activities in quantitative proteomics and bioinformatics; (2) to make the services of ProFI widely available both to the scientific community and industrial sector by setting up a highly technical environment compatible with the production and processing of high quality data at very high throughput, within the context of ISO 9001 quality assurance certification.



Picture: V. Brun/CEA

Biomarkers detection and quantification using multiplex SRM Mass Spectrometry

Photo: E. Begouen/INSERM

Jérôme Garin

Using a proteomics approach to study biological or clinical problems requires access both to the protein repertory of the samples involved in the study and to the information on the abundance of these proteins and their post-translational modifications. To carry out quantitative proteomics analysis, ProFI platforms use two complementary strategies: large-scale proteomics studies without preconceptions ("shotgun" proteomics using Orbitrap mass spectrometers) and targeted quantitative studies on a few proteins of interest ("Selected Reaction Monitoring" multiplex analyses). Both the nature of the biological material and the type of questions asked will determine which of these strategies to use.

Increasing the power of computing and bioinformatics in the proteomics field is one of the main aims of the infrastructure. ProFI has developed a fully shared computing environment between Grenoble, Toulouse and Strasbourg, with the aim of facilitating data exchange and constituting a shared platform for the development of new software. ProFI has made this software environment available to the whole scientific community via its web site. Regular training sessions are offered to allow staff from academic and industrial proteomics platforms to familiarize themselves with this new environment. In this way, the resources allocated to ProFI benefit a wide community.

Proteomics lab in Grenoble

Photo: P. Latron/INSERM

ID Card:

Analytical platform type:
-Mass spectrometry
-Nano and micro liquid chromatography
-Bioinformatics

Main techniques proposed:
-Shotgun proteomics
-Targeted proteomics
-Identification of post translational modifications

Capacity:
Hundreds of samples a month

Delay to start:
Dependent on the project

Duration of experiment:
Dependent on the project. For small projects, results can be obtained in less than a month

Intercomparison exercise proposed:
Standard protein mixtures and ProFI MS data obtained on those samples are available

Training proposed:
Specific training courses are proposed (see website)

Address:
CEA Grenoble, Bat42,
17 rue des Martyrs,
38054 Grenoble Cedex, France

Access:
Projects can be submitted via the website

Internet link:
http://www.profiproteomics.fr

Contact:
Jérôme GARIN,
jerome.garin@cea.fr

Related to:
MELODI, ALLIANCE, CARPEM, NERIS

BENCHMARKING QUANTITATIVE LABEL-FREE LC–MS DATA PROCESSING WORKFLOWS USING A COMPLEX SPIKED PROTEOMIC STANDARD DATASET. Claire RAMUS et al. Journal of Proteomics (2015) 132: 51-62

MASS SPECTROMETRY-BASED WORKFLOW FOR ACCURATE QUANTIFICATION OF ESCHERICHIA COLI ENZYMES: HOW PROTEOMICS CAN PLAY A KEY ROLE IN METABOLIC ENGINEERING. Mathieu TRAUCHESSEC et al. Mol. Cell Proteomics (2014) 13, 954–9

Radiobiology and immunology platform (CTU-FBME)

Analytical platform for immunology and radiobiology

The immunological laboratory of CTU FBME, located in Prague, disposes of SPF animal facility for small rodents breeding and in vivo experiments, and of the tissue culture laboratory. Experimental animals are housed in different levels of barrier protection including GMO Class I and Class II (Optimice racks with IVC cages).

We can analyze radiation induced changes, i.e. the health condition of animals, the phenotype

Photo: CTU FBME

SPF animal facility

and functional analyses of immune cells; proliferation or cytotoxicity evaluated on established cell lines, biological samples and primary cultures employing Core facility for cytometry FACS (LSRII), confocal microscopy (Olympus FV-1000), ELISA reader (Tecan Infinite), and evaluation of gut microflora (MALDI, Bruker). We can offer various experimental mouse models for cancer, inflammation or autoimmunity as well as newly generated mouse strains with different sensitivity to radiation. We can also provide frozen sections of biological material for further analyses.

In cooperation with small enterprise (APIGENEX Ltd.) we are developing safe radioprotectants (nor-muramyl lipoglycopeptides derived from bacterial cell wall peptidoglycans) for restoration of hematopoiesis, and thus prevention of leukopenia evoked by radiotherapy. APIGENEX Ltd. company is focused to research and development for foreign companies (e.g. Novo Nordisk, Pfizer, GSK, Schering Plough) in the development of innovative pharmaceuticals.

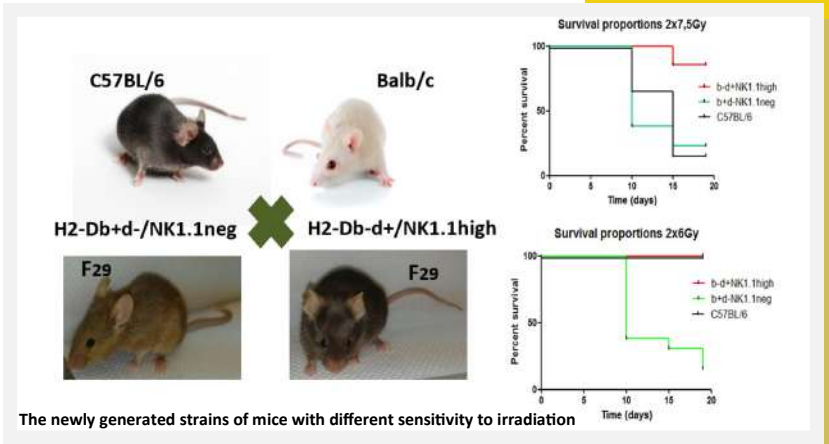
Photo: Fiser/CTU FBME

Anna Fiserova

The irradiation of mice will be performed using Microtron MT-25 (NPI ASCR v.v.i.) that will serve as a source of relativistic electrons (primary electron beam), secondary photon beams (bremsstrahlung), and neutrons from nuclear reactions. The accelerator applications involve radiation resistance testing studies in well controlled and monitored conditions, whole body or local irradiation of animals using collimator. Advanced neutron and photon activation analysis (PAA) will be applicable for determination of large number of elements in biological samples. Further we have access to ^{60}Co-irradiator for low doses irradiation.

Moreover, we have close collaboration with clinical departments employing radiodiagnostics or radiotherapy of patients (CT, X rays, ^{60}Co, ^{137}Cs, and proton therapy). Taken together, we can perform clinical, immulogical, and immunopharmacological examination of small rodents and humans. For obtained data processing we have specialist for bioinformatics.

We are open for collaboration with other infrastructures, preferentially focused to genomics, and CONCERT partners for common research.



The newly generated strains of mice with different sensitivity to irradiation

Picture: CTU FBME

ID Card:

Analytical platform type:
Imunology and radiobiology

Main techniques proposed:
Flow cytometry, confocal microscopy, immunological assays (ELISA, proliferation, cytokine synthesis), functional tests of cytotoxicity, antibody formation, microbiom

Delay to start:
None

Duration of experiment:
Design of experiment and assay-dependent

Training proposed:
Work with small rodents, isolation of biological material (organs, cells), cell culture, FACS analysis, ELISA

Address:
Immunological Laboratory of FBME CTU is located at National Institute of Public Health, Šrobárova 48, 10042 Prague 10, Czech Republic

Access:
National Institute of Public Health, Centre of Toxicology and Health Safety, NRL for Welfare of Laboratory Animals, Building 31

Internet link:
Under construction

Contact:
Anna Fiserova
anna.fiserova@fbmi.cvut.cz
+420 724127666

Related to:
MELODI, DoReMi, CONCERT

THE EVOLUTION OF RECTAL AND URINARY TOXICITY AND IMMUNE RESPONSE IN PROSTATE CANCER PATIENTS TREATED WITH TWO 3DCRT TECHNIQUES. Vránová J, et al. 2011. *Radiat Oncol*; 6:87.
COLLAGEN-INDUCED ARTHRITIS: SEVERITY AND IMMUNE RESPONSE ATTENUATION USING MULTIVALENT N-ACETYL GLUCOSAMINE. Richter J, et al. 2014. Clin. Exp. Immunol ;177:121-33.

France Génomique

French National Infrastructure for Genomics

Over the last 20 years, Life Sciences has hugely benefited from the spectacular developments in genome sequencing technologies which have rendered data acquisition faster, easier and cheaper. This has resulted in research discoveries and progress in all fields (biology, medicine, agronomy, biodiversity, etc.) that were beyond reach only a few years ago.

The sequencing of the human genome (3 billion bases) was officially completed in 2003 after more than 10 years of work. Today, the complete resequencing of an individual can be done within days, at a cost of only a few hundred euros. Given these developments, which are radically transforming our approach to the life sciences, it was deemed essential for French research to remain independent and competitive in the genomics field in order to retain ownership of its results. This led to the creation of France Génomique.

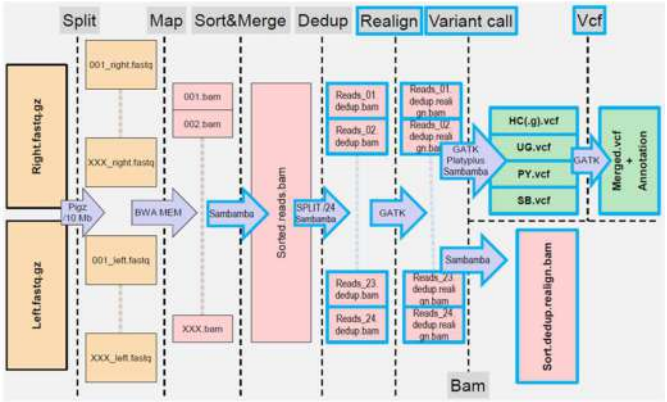


Photo: V. Meyer / IG

The VarScope 2.0 pipeline for whole-genome analysis

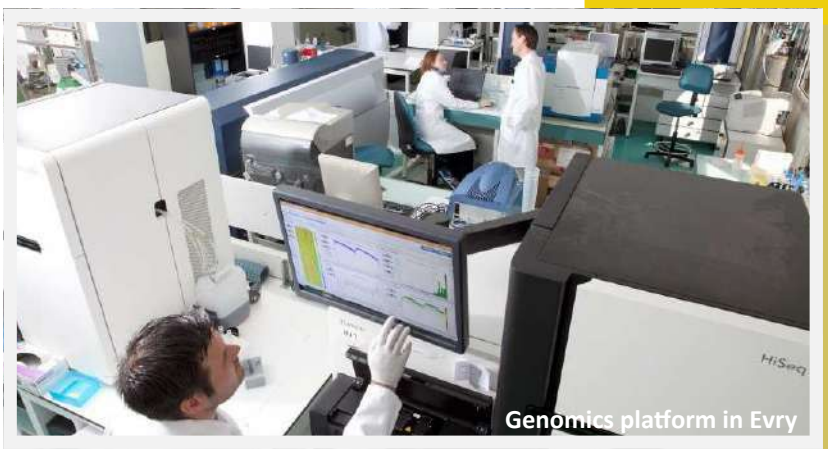
Created in 2011 through grant support from the French government programme "Investments for the Future", France Génomique (FG) is a national genomics infrastructure born out of the desire to maintain France at the highest level of competitiveness and performance, at the cutting edge of the field of genomics production and data analysis, thus reinforcing France's visibility in the international genomics landscape. The FG infrastructure brings together the majority of the French sequencing and bioinformatics platforms: CEA (coordinator), INRA, CNRS, Inserm, INRIA, Pasteur Institute, Curie Institute, ENS Paris and IGBMC Strasbourg.

The FG infrastructure offers: (1) an integrated structure and governance, providing greater visibility and higher functionality to the network in general and to each of its platforms, (2) access to a network facility of sequencing and/or bioinformatics platforms that have been operational for many years and have each developed complementary expertise, (3) the opportunity to undertake ambitious projects with strong visibility, through submission to the FG "large projects" call for proposals and selection on the basis of scientific excellence by external scientific review committees, (4) a critical mass to generate innovation collectively through continual survey, evaluation and development of new sequencing and bioinformatics methodologies and technologies, (5) access to competitively priced genomics services and associated bioinformatics with state-of-the-art, permanently upgraded data production, storage and processing systems and (6) access to a high performance computing centre and to data storage systems at the CEA/TGCC, equipped with large scalable capacity that is adapted to the exponential growth of the data being generated.

Photo: P Le Ber / CEA

Pierre Le Ber

An essential mission of FG is to disseminate its expertise, knowledge and know-how within the FG community but also more importantly to the wider French life sciences community: regular training sessions and workshops are organised by the FG platforms to allow students and researchers to improve their skills in this highly strategic field.



Genomics platform in Evry

Photo: F. Rhodes

ID Card:

Analytical platform type:
- Genomics
- Bioinformatics

Main techniques proposed:
- Next-Generation Sequencing (NGS): genome (de novo / resequencing), transcriptome, epigenome …
- 3rd generation sequencing (long reads, single molecule)
- Genotyping
- High-throughput data processing

Capacity:
100+ Terabases/month

Waiting time:
Depends on the project (sample availability)

Duration of experiment:
Depends on project size and complexity

Training proposed:
Various general or specific training courses (wet lab techniques and/or data processing and analysis)

Address:
CEA/Institut de Génomique, 2 rue Gaston Crémieux, 91057 Evry Cedex, France

Access:
Although international projects are accepted, the project PI has to be from a French laboratory. Projects can be submitted continuously via the Web portal or directly to the platforms. Very large projects can be submitted via the "large scale projects" call for proposals (every 18 months).

Internet link:
www.france-genomique.org

Contact:
Pierre Le Ber
contact@france-genomique.org

Related to:
MELODI, ALLIANCE, CARPEM

EUKARYOTIC PLANKTON DIVERSITY IN THE SUNLIT OCEAN. De Vargas C, et al., Science (2015) 348 (6237): 1261605.
CHARACTERISATION OF MUTATIONS OF THE PHOSPHOINOSITIDE-3-KINASE REGULATORY SUBUNIT, PIK3R2, IN PERISYLVIAN POLYMICROGYRIA: A NEXT-GENERATION SEQUENCING STUDY. Mirzaa GM et al., Lancet Neurol (2015) 14 (12): 1182-1195.

The SCK•CEN Genomics platform

Exploring the genomic changes induced by radiation

Since the discovery of the DNA (Deoxyribonucleic acid) double helix in the 1950's, several techniques were developed to study this mysterious molecule and to illustrate its role in the cell and in life. The human genome consists of (44 + XX/XY) chromosomes, made out of supercoiled and compacted stretches of DNA. These DNA sequences contain coding and non-coding areas. The coding genes are regulated at different levels to fine-tune their expression into effector proteins.

Photo: R. Benotmane/SCK•CEN

Quality control of RNA samples

Since the 1950's, genetics has been the discipline that studies the structure and function of single genes while genomics, which emerged in the new millennium after the full sequencing of the human genome, addresses the functioning of all genes and their interactions. Thus genomics seeks to understand the influence of genes on the development and growth of organisms, as well as in cancer and other diseases. The term "omics" has come to refer generally to the study of large, comprehensive biological data sets.

The Genomics Platform at SCK•CEN was established in 2003, based on microarray technology to study global gene expression. Initially, the platform was equipped with a DNA spotting robot (MicroGrid, UK) producing homemade spotted glass slide arrays. The genomics platform was later upgraded through acquisition of Affymetrix technology (Santa Clara, USA), for which precast arrays are commercially available. The Affymetrix GeneChip arrays cover quite a large variety of sequenced and well-annotated genomes from different species for transcriptomics (gene expression and alternative splicing). In addition, other applications can now also be performed, including microRNA quantification and chromatin immunoprecipitation (ChIP) for epigenetic studies, as well as genotyping (SNP, CNV) and tiling. This upgrade has provided a wider genomic vision and more in-depth knowledge with which to uncover the hidden layers of the genome in different biological systems.

Photo: R. Benotmane/SCK•CEN

Rafi Benotmane

When considering an experiment with replicates and different conditions and time points, translating these data into a biological hypothesis becomes challenging. Data analysis is therefore a critical step in genome-wide analysis involving statistics and bioinformatics. Advanced statistical methods help to reduce the complexity of the data to reveal highly significant changes between two conditions (treated *vs.* untreated). On the other hand, bioinformatics is a new discipline that emerged in parallel with genomic studies, and which provides biological meaning to the numerical variations. It involves data mining to identify gene interactions and regulatory networks leading to pathway inference. The Genomics Platform at the Radiobiology Unit of the Belgian Nuclear Research Centre has been involved in several EU-funded projects for more than a decade. The long-term expertise gathered has led to high quality, reproducible data, and to the development of dedicated bioinformatics pipelines for optimal data analysis.

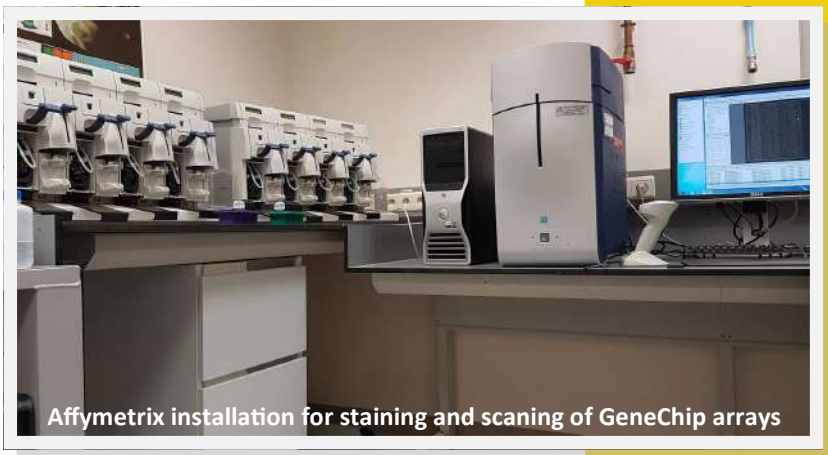


Photo: R. Benotmane/SCK•CEN

Affymetrix installation for staining and scaning of GeneChip arrays

ID Card:

Analytical platform type:
Microarray platform for transcriptomic, microRNA, LncRNA, methylation and tiling analyses

Main techniques proposed:
Gene expression quantification using microarray technology

Capacity:
50 to 100 array per week

Delay to start:
at least a month in front

Intercomparison exercise options:
Several quality controls are run by Affymetrix (the array provider) and many other controls are assessed in house

Training options:
possible

Access:
Selection (no more than 4 persons at once)

Internet link:
www.sckcen.be

Contact:
Rafi Benotmane
abenotma@sckcen.be

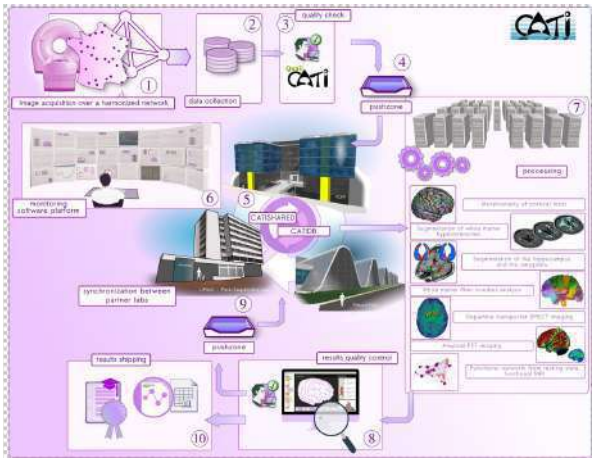
Related to:
MELODI and many other EU radiation research projects

IDENTIFICATION OF NOVEL RADIATION INDUCED p53 DEPENDENT TRANSCRIPTS EXTENSIVELY REGULATED DURING MOUSE BRAIN DEVELOPMENT
Quintens R, Verreet T, Janssen A, Neefs M, Leysen L, Michaux A, Verslegers M, Samari N, Pani G, Verheyde J, Baatout S, Benotmane MA. . Biol Open. 2015 Feb 13;4(3):331-44
TRANSCRIPTOMIC AND PROTEOMIC ANALYSIS OF MOUSE RADIATION INDUCED ACUTE MYELOID LEUKAEMIA (AML)
Badie C, Blachowicz A, Barjaktarovic Z, Finnon R, Michaux A, Sarioglu H, Brown N, Manning G, Benotmane MA, Tapio S, Polanska J, Bouffler SD. .Oncotarget. 2016 May 26. doi: 10.18632/oncotarget.9626. PubMed PMID: 27250028

CATI

A large infrastructure for the neuroimaging of cohorts

CATI was born from the collaborative efforts of a consortium of neuroimaging research laboratories with complementary expertise: NeuroSpin (the French high-field MR imaging centre of the CEA) and four teams located at the Pitié-Salpêtrière Hospital: ARAMIS and CENIR (the neuroimaging analysis research team and the neuroimaging platform of the Brain and Spine Institute), the Institute for Memory and Alzheimer's disease (IM2A) and LIB (an Inserm/UPMC unit focusing on functional imaging research). These teams, who had been collaborating for several years, were granted EUR 9 million in 2011 by the French Alzheimer's disease initiative to create CATI, a national platform which aims to support multicentre neuroimaging studies. Services offered by CATI include the standardisation of MRI and PET/SPECT data acquisitions, the transfer of data to a centralised database, monitoring, quality control and image analysis. Initially designed to address the specific needs of Alzheimer's disease, the platform is now open to academic research projects and therapeutic trials targeting any neuropsychiatric disorder. The CATI infrastructure stretches across France, collecting additional know-how from all the French groups and organisations involved in neuroimaging, in order to offer the best tools for scientific projects.



Picture:G. Operto, Neurospin, CEA

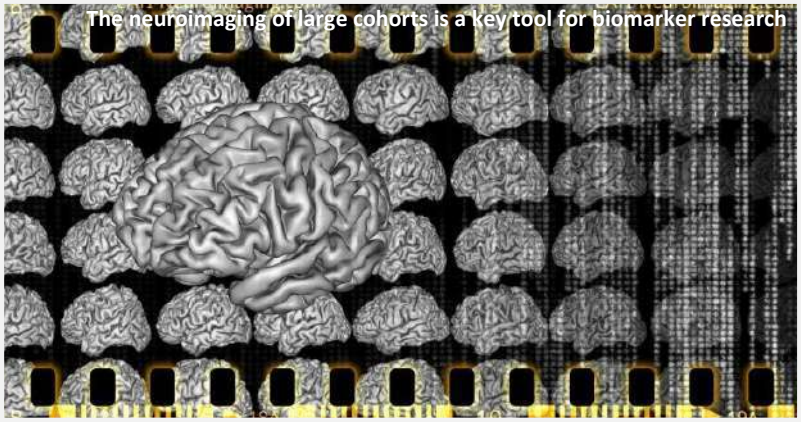
CATI is a large infrastructure which seamlessly integrates a large network of imaging facilities and a very rich portfolio of image analysis pipelines.

In agreement with the French societies of Neuroradiology, Radiology and Nuclear Medicine, CATI currently harmonises imaging acquisitions across more than 40 French sites and this network can be expanded according to demand. In addition, 20 European sites will join the network starting from 2015. Although data accessibility policy is specifically chosen by the PI of each study, CATI aims to facilitate data sharing across studies and to promote this as much as possible. The platform is currently responsible for the imaging protocols of more than 30 large French multicentre studies, including several therapeutic trials and the Memento cohort of the French Alzheimer initiative. Three European projects have also been using the platform since 2015. In the context of Memento, which images 2300 subjects with isolated memory complaints or mild cognitive impairment, CATI has close links with the French network of memory centres.

Photo: private source

Jean-François Mangin

CATI embeds a team of MRI and PET physicists, engineers and researchers in charge of standardising acquisitions and monitoring MRI and PET scanners within the CATI network. The Keosys Company deals with the secure transfer of imaging data to the CATI central database through a web service that is accessible from imaging acquisition sites. A team of research assistants performs quality control of the incoming raw datasets. For data analysis, CATI provides broad expertise in image processing and statistical meta-analysis tools, which are operated by engineers and technicians. CATI can provide assistance at any stage of a study and can perform additional imaging harmonisation or dedicated algorithmic R&D for new facilities upon request.



The neuroimaging of large cohorts is a key tool for biomarker research

Photo: JF Mangin, Neurospin, CEA

ID Card:

Analytical platform type:
Neuroimaging

Main techniques proposed:
MRI (T1, T2, T2*, resting state, fMRI, ASL, diffusion, Melanine), PET (FDG, amyloid), SPECT (DATSCAN)

Capacity:
Up to several thousand patients per project

Waiting time:
A few months if using existing network facilities; 6 months if new facilities have to be harmonized

Duration of experiment:
Usually several years

Address:
Neurospin, CEA, 91191 Gif sur Yvette, France

Access:
Academic research projects and therapeutic trials – service fees apply

Internet link:
http://CATI-neuroimaging.com

Contact:
jfmangin@cea.fr

Related to:
MELODI, EURAMED

CATI: A LARGE DISTRIBUTED INFRASTRUCTURE FOR THE NEUROIMAGING OF COHORTS. Grégory Operto et al., Neuroinformatics, 2016.
OPTIMIZATION OF BRAIN PET IMAGING FOR A MULTICENTRE TRIAL: THE FRENCH CATI EXPERIENCE. Marie-Odile Habert et al., EJNMMI Phys, 2016.

HZDR-Radioanalytical Laboratories

Valuable tools for the spectroscopy of radioactive samples

The reliable protection of people and the environment from the hazards caused by radionuclides requires a detailed knowledge of their migration and transfer behaviour in the environment. Hence, a molecular understanding of the chemical reactions of the contaminants in the geosphere and biosphere is indispensable. Comprehensive molecular information can be obtained by a multi-method approach and – in case of radioactive samples – where the spectroscopic techniques are located in an appropriate infrastructure.

Photo, O. Killig/HZDR

Rossendorf Beamline (ROBL) at the ESRF in Grenoble

The Institute of Resource Ecology of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR-IRE) provides experimental and technical equipment for officially licensed work with radionuclides up to a limit of 5×10^9 Bq. The institute uses a broad range of analytical methods, all of which are performed in modern radiochemical laboratories with state-of-the-art equipment. Additionally, some of the laboratories are S1-classified, allowing the handling of genetically modified organisms in a radiation protection area.

The radioanalytical laboratories at HZDR focus mainly on sophisticated spectroscopic techniques in combination with conventional radioanalytical methods. The main research infrastructure comprises:

- Laser spectroscopy: Time-resolved laser fluorescence spectroscopy (TRLFS) with tunable nanosecond and femtosecond laser systems (excitation wavelength: 220 –1,800 nm, detection range: 300–1,500 nm, maximum time resolution in the picosecond range); Cryo-TRLFS (sample cooling: ≥ 4 K), Confocal Laser Scanning Microscopy (excitation wavelength: 350–650 nm); Laser-Induced Photoacoustic Spectroscopy (LPAS)
- NMR spectroscopy – liquid/solid state (400/600 MHz)
- Vibrational spectroscopy – FT-IR (in situ ATR technique, mid/far-IR), FT-Raman
- UV-vis-NIR spectroscopy (conventional and long pass flow cell, maximum path length: 2,500 mm)
- X-ray diffraction for single crystals and powder samples
- Standard and inert gas glove boxes suitable for work with radionuclides, in particular alpha-emitting nuclides, as well as with Schlenk lines for chemical synthesis
- Classical radioanalytical methods (α-, β-, γ-spectroscopy) and elemental analysis (ICP-MS, AAS, IC)
- Methods for characterisation of colloids
- (Micro-)Calorimetry, Isothermal titration calorimetry
- State-of-the-art microbiological and biochemical methods including conventional separation techniques (HPLC, CE)

Furthermore, the IRE runs the Rossendorf Beamline (ROBL) at the European Synchrotron Radiation Facility (ESRF) in Grenoble (France). ROBL is the first research facility at a public synchrotron to be dedicated to radionuclide work. The brilliant X-ray flux of the ESRF is used to perform:

- X-ray absorption spectroscopy: EXAFS and (high-resolution) XANES
- X-ray emission spectroscopy (XES) and resonant inelastic X-ray scattering (RIXS)
- Powder and single crystal diffraction
- Surface diffraction (CTR) and resonant anomalous X-ray reflectivity (RAXR)

Photo: private

H. Foerstendorf (left)

A.C. Scheinost (right)

Photo: O. Killig/HZDR

Radiochemical experiments in glovebox

Günther, A., Raff, J., Merroun, M. L., Roßberg, A., Kothe, E., Bernhard, G., 2014. Interaction of U(VI) with Schizophyllum commune studied by microscopic and spectroscopic methods. Biometals 27, 775-785.

Kvashnina, K. O., Scheinost, A. C., 2016. A Johann-type X-ray emission spectrometer at the Rossendorf beamline. Journal of Synchrotron Radiation 23, 836-841.

ID Card:

Purpose:

Spectroscopic and radioanalytical studies of actinides and fission products in biological and geological environmentally relevant systems

Access:

HZDR Radioanalytical Laboratory: Applications are available under surveillance of experienced staff scientists of HZDR. Technical equipment is provided for radionuclide activities up to $5x10^9$ Bq.

ROBL: Beamtime is offered upon scientific merit of the submitted proposal, which is evaluated by review panels of HZDR or ESRF.

Housed on:

Helmholtz-Zentrum Dresden-Rossendorf, Institute of Resource Ecology, Dresden, Germany

Rossendorf Beamline (ROBL) at ESRF, Grenoble, France

Address:

Helmholtz-Zentrum Dresden Rossendorf, Institute of Resource Ecology
Bautzner Landstraße 400
01328 Dresden, Germany

Internet link:

www.hzdr.de/FWO

Contact:

HZDR: Harald Foerstendorf
foersten@hzdr.de
+49 351 260 3664

ROBL: Andreas C. Scheinost
scheinost@esrf.fr;
+33 476 88 2462

Related to: ALLIANCE

Advanced Technologies Network (ATeN) Center

A large research infrastructures for advanced biotechnologies

The Advanced Technologies Network (ATeN) Center, directed by Prof. Maurizio Leone, is a centre of excellence of the University of Palermo (Sicily) which provides cutting-edge research, development and service activities for technological transfer to the public and private sectors. The Center consists of three macro-areas (Cellular and Molecular Biotechnology, In vivo Analysis, Biocompatible Materials and Systems) in which scientists with different backgrounds (e.g. biotechnology, biology, chemistry, physics, engineering, medicine, bioinformatics) work together to produce the technological know-how needed to achieve highly competitive scientific results. Due to its sophisticated structure and equipment (25 laboratories housed in 2500 m² with approx. 100 instrumentation facilities), ATeN is among the few centres in the world able to provide a production chain ranging from the synthesis of materials to in vivo tests.

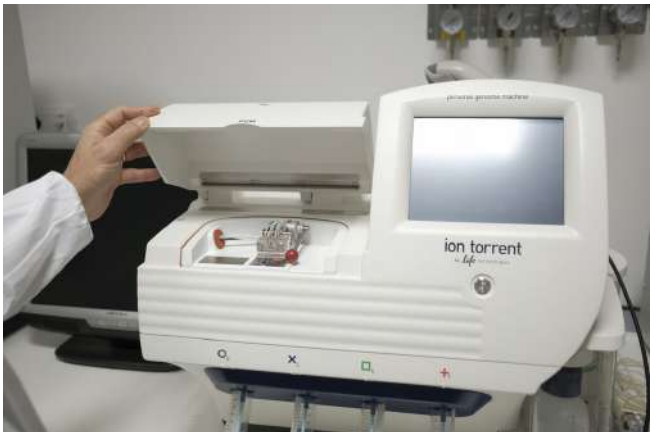


Photo: Agenzia CMC Studio

Ion PGM™ System for Next-Generation Sequencing

The macro-area of Cellular and Molecular Biotechnologies deals with the production and propagation of stem cells and primary cell cultures, large-scale analysis of DNA, RNA and proteins. The laboratory of genomics and proteomics provides molecular analysis at advanced technological level. The laboratory works in different advanced sectors through the analysis of large families of genes, proteins, enzymes and metabolites. These sectors include: development and technological improvement of drugs including proteins, vaccines and monoclonal antibodies, which are largely obtained from targeted application of genetic modification techniques and personalised medicine; characterisation, through the analysis of genetic and protein profiles and of molecular pathways, experimental cellular and animal models of disease; identification of specific response markers of cells and tissues to exposure to ionising radiation and/or molecules with biological activity and potential pharmacological activity; validation of products for molecular diagnostics; development of services for advanced diagnostics and for drug discovery; development of bioinformatics products (acquisition, storage, distribution, analysis and interpretation of the data mainly for molecular biology, genetics and biochemistry).

Photo: Agenzia CMC Studio

Maurizio Marrale

The In Vivo Analysis macro-area, with two enclosures containing small animals and zebrafish, carries out analyses on the effects of ionising radiation and the testing of drugs, biomaterials, biomarkers and radiopharmaceuticals, as well as functional analyses for the production of primary cultures from transgenic organisms and 3D imaging.

Multiple bioimaging techniques are available to explore the biological structure and function of molecules in live cells and in tissues by means of 3D and 4D measurements.

Confocal and multiphoton microscopy, atomic force microscopy, together with advanced spectroscopy techniques (e.g. Raman, EPR, NMR) can be applied to analyse biological, physical and chemical phenomena in order to characterise the material properties.

Photo: Agenzia CMC Studio

Laboratory of Pulsed Electron Paramagnetic Resonance

CHAB mediterranean center for human health advanced biotechnologies

ID Card:

Analytical platform type:
Biological dosimetry and physical retrospective dosimetry, exposure markers, proteomics, genome sequencing, transcriptome sequencing, transcriptomics, metabolomics, exosomes, small molecules

Main techniques proposed:
Panel of cytogenetic assays, gene expression assay, protein markers, EPR/TL dosimetry, gamma spectrometry, microscopy

Capacity:
20 measurements per week

Waiting time:
None

Duration of experiment:
Dependent on experiment and assay

Address:
Viale delle Scienze Edificio 18 I-91128 Palermo (Italy)

Access:
Free

Internet link:
http://www.chab.center/home-en

Contact:
Maurizio Marrale
maurizio.marrale@unipa.it
+39 091 23899073

Related to:
MELODI, EURADOS, RENEB

MONITORING FEW MOLECULAR BINDING EVENTS IN SCALABLE CONFINED AQUEOUS COMPARTMENTS BY RASTER IMAGE CORRELATION SPECTROSCOPY (CADRICS). G. Arrabito, F. Cavaleri, V. Montalbano, V. Vetri, M. Leone, B. Pignataro, Lab on a Chip, 16 (2016), 4666-4676

PRELIMINARY APPLICATION OF THERMOLUMINESCENCE AND SINGLE ALIQUOT REGENERATION METHOD FOR DOSE RECONSTRUCTION IN SODA LIME GLASS. M. Marrale, A. Longo, A. Bartolotta, M. D'oca, and M. Brai, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 297 (2013), 58-63

BfS IN VIVO MEASUREMENT FACILITIES

Whole and partial body counting and Quality Assurance

Incorporated gamma-emitting radionuclides can be determined in humans using gamma ray spectrometry to measure the radiation that leaves the body. Since this test is performed on living persons, this type of measurement is called in vivo method. Radionuclides that are (more or less) distributed throughout the body, for example Cs-137 and K-40, are determined by whole-body counters. Nuclides that tend to concentrate in specific organs, especially nuclides such as iodine isotopes in the thyroid or inhaled small plutonium dioxide particles in the lung, are determined by partial body counters.

Photo: O Meisenberg/BfS

Available phantoms including a brick phantom and skull, neck and torso phantoms

The counting efficiency of an in vivo counter is normally determined using a calibration phantom. This phantom is similar in size and shape and has similar attenuation characteristics to those of the body of the real person to be screened, and also contains radioactive sources. For whole-body counting, brick phantoms are often used. In vivo counting is a routine method used for monitoring employees who have been potentially exposed to internal radiation. Special applications include, for example, follow-up studies of exceptional incorporation cases or the monitoring of special population groups.

The BfS operates two incorporation monitoring laboratories at its sites in Berlin/Karlshorst and Oberschleißheim/ Neuherberg (near Munich). Each facility permanently operates a stretcher type whole-body counter (WBC), performing about 500 to 700 measurements per year each. The persons monitored come from research and nuclear power reactors, radionuclide production companies and nuclear waste final repositories. In addition, a reference group of unexposed persons from the population is also monitored. Standard counting time is 20 minutes. The WBC in Neuherberg is equipped with four stationary HPGe detectors, and the WBC in Berlin is equipped with two detectors which are used in a scanning mode. In addition, each facility keeps a partial-body counter in readiness. These counters are kept 'ready-to-use' for emergency preparedness and special measurements.

Photo: U Gerstmann/BfS

Dr Udo Gerstmann

In accordance with the German Radiation Protection Ordinance, the BfS offers in vivo intercomparison analysis for the incorporation monitoring laboratories in Germany. These laboratories have to identify and quantify radionuclides in phantoms. Currently, brick, thyroid, skull and torso phantoms are available. For emergency preparedness, the BfS has begun to produce more radioactive sources with a broader variety of radionuclides. In 2017, the production of special components for phantoms using 3D printing was launched.

Photo: O Meisenberg, S Helbig/BfS

The three main in-vivo measurement facilities: whole- and partial-body counter in Neuherberg and scanning whole-body counter in Berlin

Bundesamt für Strahlenschutz

ID Card:

Analytical platform type:
Internal Dosimetry

Main techniques proposed:
Whole body counting and organ counting (e.g. thyroid, lung, liver, bone…)

Source:
Large range of radionuclides with gamma ray emission (Cs-134/137, I-131, Ba-133, Am-241, Eu-152…)

Intercomparison exercise proposed:
Annual in vivo intercomparison offered

Address:
Bundesamt für Strahlenschutz,
Ingolstädter Landstrasse 1,
85764 Neuherberg, Germany

Bundesamt für Strahlenschutz,
Köpenicker Allee 120-130,
10318 Berlin, Germany

Internet link:
http://www.bfs.de/EN/topics/ion/service/incorporation/incorporation_node.html

Contact:
Udo Gerstmann
ugertsmann@bfs.de
+49 89 18333-2430

Related to:
MELODI, EURADOS

A PUZZLING CASE OF CONTAMINATION WITH Am-241, A. Giussani, P. Nogueira, N. El Faramawy, W. Buchholz, U. C. Gerstmann, M. Hartmann, O. Meisenberg, D. Noßke und W. Rühm, J. Radiol. Prot., 36, (2016), 391-404
RETROSPECTIVE ESTIMATION OF EXPOSURE TO SHORT LIVED Rn-222 PROGENY BY MEASUREMENT OF Pb-210 IN THE SKULL, R. Scheler, K. Dettmann, J. Brose, Radiat. Prot. Dosim., 79, (1998), 129-132

ECORITME

ECOtoxicology of Ionising Radiation and Trace Metals

The **ECORITME** platform is specialized in the field of "**ECO**toxicology of **M**etals and **I**onising **R**adiation". It combines analytical tools, modeling developments and advanced statistics. **ECORITME** offers all the required skills for performing and improving predictive ecological risk assessment for chronic exposure to low doses of ionising radiation. It is also designed for studying complex toxicant exposure (from the external media to the molecular targets including dynamic transformations, biokinetics, and interactions in mixtures) through the development of advanced and innovative in vitro models and analytical methods.

Photo: C. Adam-Guillermin/IRSN

Dr Christelle Adam

ECORITME allows the controlled exposure of experimental units from micro- to large-scales, to external gamma irradiation and/or internal contamination with alpha- or beta-radionuclides alone or in combination with metals or organic compounds. It offers the possibility to use various biological models such as unicellular algae, plants, invertebrates (e.g. the waterflea *Daphnia magna*, the nematode Caenorhabditis elegans) or fish (e.g. the zebrafish *Danio rerio*, including fish cells such as ZF4). A phytotron and growth-chambers complement the platform for the research on plants and experiments with contaminated soils. **ECORITME** includes 1200 m^2 of laboratory space (plus 1600 m^2 of associated technical zones and radioactive waste/effluent treatment areas). The laboratories are authorized to host experiments using a wide spectrum of radionuclides (82 radioisotopes including ^{3}H, ^{14}C, ^{137}Cs, isotopes of Pu, Am, U…) in compliance with the current regulations.

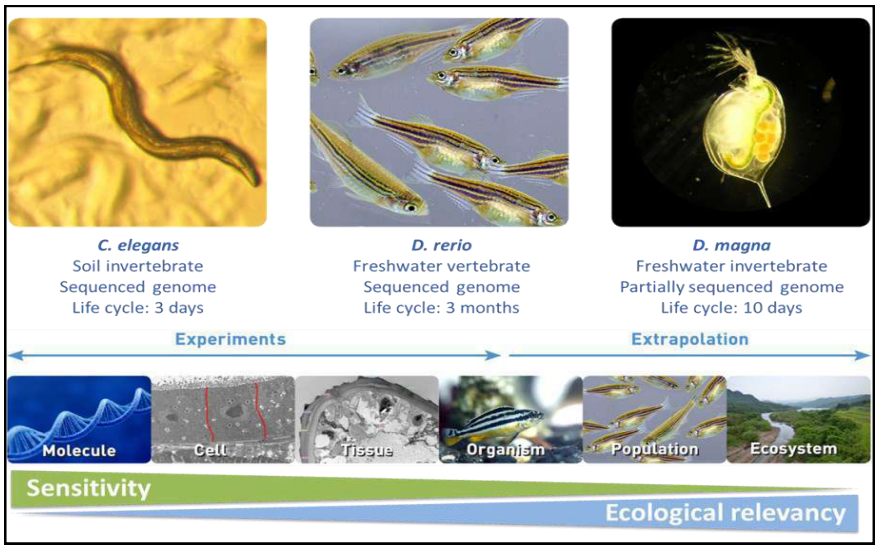


Photo: IRSN

Main biological models used in the ECORITME platform and various levels of biological organisation at which effects are measured, combining sensitive and ecologically relevant responses

ECORITME offers supports as follows: (i) Modeling skills and tools for : speciation and bioavailability (Biotic Ligand Model), dosimetry (**EDEN** model), dose-effects, mixture exposure and effects, individual to population effect extrapolation, biostatistics for field data, bioinformatics and system biology, ecological risk; (ii) An integrated technical platform (analytical equipment, organism husbandry, and exposure laboratories). This platform allows experiments to be performed under controlled conditions for various biological models with or without the use of radioactive tracers and/or ionising radiation, and/or any chemical elements such as metals; (iii) A unique tool with **MICADO'Lab** equipment (see Exposure platform page 2). An innovative field of application of this equipment is to that is allows perfect control of the delivered energy. Thus enabling manipulation of the red-ox status of any biological object.

Photo: IRSN

Devices used to detect low concentrations of metals and their chemical forms (top), and Transmission Electronic Microscope used for histological and microlocalisation analyses (bottom)

ID Card:

Analytical platform type:

Use of biochemistry, immunochemistry, microscopy, transcriptomics, proteomics to characterize biological responses:

- DNA damages
- Oxidizing stress,
- Neurotoxicity,
- Immunotoxicity…

Quantification of trace and major elements, radionuclides and their speciation in environmental and biological matrices

Main techniques proposed:

- Coulter-Counters,
- Flow cytometer,
- Epifluorescence microscope,
- Apotome,
- Transmission Electronic Microscope with EDAX probe for elementary analysis,
- Confocal microscope (ZOOM plateau),
- Ultramicrotome,
- Cryomicrotome,
- PCR, Rt-qPCR,
- 2D-electrophoresis,
- Incubators for cell culture or organisms maintenance,
- ICP-MS, ICP-OES,
- HPLC,
- Gamma spectrometry,
- Liquid scintillation,
- SLRT…

Access:

Analytical tools available for joint research collaborations only

Internet link:

http://www.irsn.fr/EN/Research/Research-organisation/Research-units/environment-unit/LECO/

Contact:

christelle.adam-guillermin@irsn.fr

Related to: ALLIANCE, MELODI

Alonzo F., Hertel-Aas T., Réal A., Lance E., Garcia-Sanchez L., Bradshaw C., Vives i Batlle J., Oughton D. H., Garnier-Laplace J. (2016). Population modelling to compare chronic external gamma radiotoxicity between individual and population endpoints in four taxonomic groups. Journal of Environmental Radioactivity 152: 46-59

Armant O., Kewin Gombeau, Sophia Murat El Houdigui, Magali Floriani, Virginie Camilleri, Isabelle Cavalie, and Christelle Adam-Guillermin (2017). Zebrafish exposure to environmentally relevant concentration of depleted uranium impairs progeny development at the molecular and histological levels. PLoS One 12(5): e0177932.

Consolidated Radioisotope Facility (CORiF)

Environmental radioactivity and X-ray fluorescence analysis

Environmental radiation, often termed "background radiation", has been present everywhere in our surroundings since the formation of the earth and originates from naturally occurring or man-made radiation sources. High concentrations of both natural and synthetic radioisotopes have been detected in soils, in the sea and in river slit, especially in close proximity to contaminated sites. Thus, environmental monitoring of radioactivity levels is essential for radiation protection.

Photo: Plymouth University

Pr William Blake Dr Alex Taylor

Photo: Plymouth University

EG&G Ortec Well (GWL-170-15-S) HPGe Gamma spectrometry system and PANalytical Axios Max WD XRF system

The ISO 9001-2008-certified Plymouth University Consolidated Radio-isotope Facility (CoRiF) is a dedicated laboratory for the manipulation and analysis of natural and enhanced radioactive materials. CoRiF has a licence to hold and dispose of alpha, beta and gamma radionuclides, which are used to support a wide range of research or consultancy services to external academic, public and private sector clients. Data quality is assured through regular participation in external proficiency tests.

Measurement of gamma-emitting radioisotopes is undertaken using three EG&G Ortec gamma spectrometry systems, all of which are suitable for low-level ^{210}Pb determination. The detector geometries allow a wide range of sample types to be analysed: 1 x planar (GEM), 1 x coaxial (GMX) and 1 x well detector (GWL), with typical in-house applications including contaminated land assessment, sediment-contaminant source fingerprinting and sediment and peat geochronology.

X-ray fluorescence spectrometry provides complementary major and minor element geochemical analyses using a wavelength dispersive X-ray fluorescence (WD XRF) spectrometer (PANalytical Axios Max) with facility to prepare and run soil and sediment samples as fused beads (using PANalytical Eagon 2 fusion system), pressed pellets and loose powders.

Alpha and beta emitting radioisotopes are analysed using two Beckman Coulter automated Liquid Scintillation 6500 Counters with facility to prepare and analyse environmental samples and solids and liquids relating to high activity radio-tracer studies (which can be undertaken in-house as required).

Services offered by CoRiF include investigations of contaminated land and aquatic ecosystems, geochemical tracer studies using radiochemicals, investigation of eco- and geno-toxic effects of radionuclides, sediment and peat geochronology, sediment and contaminant source apportionment (fingerprinting), soil erosion and sediment budget evaluation, and complementary research involving non-radiometric analyses.

In relation to environmental forensics, CoRiF is currently involved in the EU Horizon 2020 funded project IMIXSED, in which researchers are applying fallout radionuclide and wavelength dispersive X-ray fluorescence tools to track eroded sediment through a degraded river basin in East Africa.

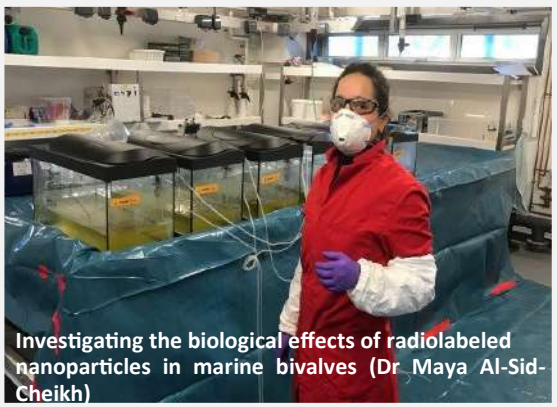


Photo: Plymouth University

Investigating the biological effects of radiolabeled nanoparticles in marine bivalves (Dr Maya Al-Sid-Cheikh)

SUCCEED WITH PLYMOUTH UNIVERSITY

ID Card:

Analytical platform type:
Dedicated laboratory for the manipulation and analysis of natural and enhanced radioactive materials and applications of radioactivity in material analysis

Main techniques proposed:
Gamma spectrometry, Wavelength dispersive X-ray fluorescence (WD XRF), Liquid scintillation counting, Laser particle sizing, Inductively coupled plasma mass spectrometry & optical emission spectrometry (ICP MS & ICP OES)

Capacity:
Hundreds samples per month

Delay to start:
Depends on technique-please enquire

Duration of experiment:
Dependent on the techniques applied

Address:
Consolidated Radio-isotope Facility, Plymouth University, Plymouth University, Plymouth PL4 8AA, United Kingdom

Access:
The analytical facility is accessible to joint research collaborators and scientists of the public or private sector after selection.

Internet link:
https://www.plymouth.ac.uk/schools/school-of-geography-earth-and-environmental-sciences/consolidated-radio-isotope-facility

Contact:
Professor Will Blake:
william.blake@plymouth.ac.uk
Dr Alex Taylor
alex.taylor@plymouth.ac.uk
+44 1752 585969

Related to:
ALLIANCE

Bioaccessibility of U, Th and Pb in solid wastes and soils from an abandoned uranium mine, Foulkes M., Millward G., Henderson S., Blake W. (2017), J Environ Radioact, 173:85–96
Mobilization of Technetium from Reduced Sediments under Seawater Inundation and Intrusion Scenarios, Eagling J., Worsfold P.J., Blake W., Keith-Roach M.J. (2012), Environ Sci Technol 46:11798–11803

Centre for Omic Sciences (COS)

A unit for metabolomics, proteomics, genomics and transcriptomics

EURECAT is the major Technology Centre of Catalonia, Spain. EURECAT provides the industrial and business sectors with differential technology and advanced expertise; it offers solutions to their innovation needs and boosts their competitiveness in a fast-paced environment. The range of services offered by the centre is primarily focused on key strategic sectors of the Catalan economy: Food, Health, Energy and Resources, Industrial Systems, Design-based Industries, Industries related to Sustainable Mobility and the Cultural Industries.

Photo: EURECAT

Dr Nuria Canela

Non targeted metabolomics unit

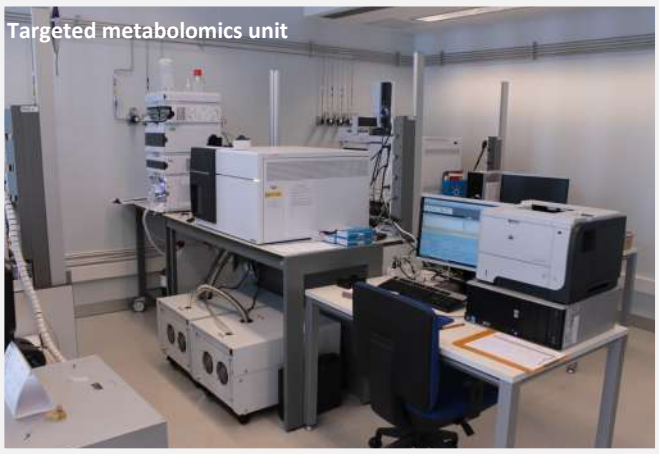
Photo: COS

The centre serves over a thousand businesses, participates in over 200 national and international R&D&I high level strategic projects, holds 73 international patents and owns 9 technology-based companies. It comprises eight centres in Catalonia and one in Latin America (Brazil).

EURECAT has 3 main technology divisions: digital, industrial and biotechnologies. Its biotechnologies division manages the Centre for Omic Sciences (COS). COS is a joint Unit comprising the University Rovira i Virgili (URV) and EURECAT. COS hosts a large, well-equipped analytical facility for high throughput omic studies which focuses on metabolomics but also includes proteomics, transcriptomics, genomics, imaging and research facilities for organisms and cells, based on an initial equipment investment of more than 10 million euros.

EURECAT-COS is a singular facility, unique in Spain, due to its equipment set-up and its approach to biochemical problems. COS provides support services to both companies and academia. These services are underpinned by state-of-the-art technologies, comprising a microarray platform, a next generation sequencing platform, 9 high-end mass spectrometers including MS-Imaging systems, 2 NMR instruments, an SPR protein interaction analysis system and various robots and high throughput technologies, as well as computing infrastructures and other analytical tools. Moreover, the biotechnologies infrastructure has acquired new facilities to develop in silico, in vitro and in vivo research studies and human intervention studies to validate the efficacy and non-toxicity of new bioactive compounds and extracts.

The vision of COS is to become a hub facility for omic sciences based on a metabolomics approach, and to become a European reference centre for omic science research and services applied to the field of food and nutrition. The facility is unique because its approach to biological problems begins with metabolomics in order to generate new hypotheses for molecular mechanisms that can then be validated using the other omics (proteomics, transcriptomics and interactomics) and in vivo models. Additionally, the integrated information from the different omics provides a novel means of investigating biomarkers and understanding biological processes related to the consumption of healthy foods.



Targeted metabolomics unit

Photo: COS

ID Card:

Analytical platform type:
Scientific operator in the world of omic technologies fully equipped with cutting-edge metabolomics, proteomics, transcriptomic, and genomic tools. We offer scientific advice and support from experimental design prior to omic assessment complete with facilities with in-vitro and in-vivo models and a Human Nutrition Unit available to our clients.

Main techniques proposed:
DNA sequencing & fragment analysis (Sagner DNA Sequencing), Next generation sequencing (Ion Torrent PGM), Microarray analysis, Automated real-time PCR analysis, Targeted proteomic profiling (SRM assays), MALDI tissue imaging, Luminex bead array and others.

Capacity:
Hundreds samples per month

Address:
Centre for Omic Sciences
Avda. Universitat no 1
43204-Reus, Spain

Access:
For access demands please contact:
info@omicscentre.com

Internet link:
http://omicscentre.com

Contact:
Àurea Rodríguez
aurea.rodriguez@ctns.cat

Related to:
MELODI, ALLIANCE

Hydroxytyrosol and its complex forms (secoiridoids) modulate aorta and heart proteome in healthy rats: Potential cardio-protective effects, Catalán Ú., Rubió L., López de Las Hazas M. C., Herrero P., Nadal P., Canela N., Pedret A., Motilva M. J., Solà R. (2016), Mol Nutr Food Res 60(10), 2114-2129
Analytical methods in sphingolipidomics: Quantitative and profiling approaches in food analysis, Canela N., Herrero P., Mariné S., Nadal P., Ras M. R., Rodríguez M. Á., Arola L. (2016), J Chromatogr A 1428, 16-38

The iGE3 Genomics Platform

Cutting-edge Genomic Technologies to support research

The iGE3 (**i**nstitute of **G**enetics and **G**enomics of **G**eneva) genomics platform of the University of Geneva provides access to a wide array of state of the art technologies ranging from high-throughput genomics to very targeted analysis. Established in 2002 as the "Frontiers-in-Genetics" genomics platform of the Swiss National Centers of Competence in Research (NCCR), its services were initially restricted to the research groups of the NCCR consortium. It rapidly became a reference laboratory in the genomics field and access was extended to all laboratories, including the private sector. In 2012, the platform joined the newly created interdisciplinary iGE3 consortium.

Photo: Brice Petit/Brice Petit Photography

Dr Mylène Docquier

years ago) the nCounter analysis system (nanoString Technologies); iGE3 is the third site in Europe to offer this technology. The nCounter allows digital counting of individual molecules using molecular barcodes with very high dynamic range, reproducibility and specificity, and with no enzymatic reaction.

Photo: Brice Petit / Brice Petit Photography

Next Generation Sequencing using Illumina HiSeq 4000

The main activity of the iGE3 genomics facility is Next Generation Sequencing (NGS). Illumina HiSeq 4000, 2500 and MiSeq sequencers allow sequencing of whole genomes, exomes and transcriptomes as well as more targeted sequencing (of enriched regions). The laboratory has also implemented a single-cell NGS approach using the Fluidigm C1 prep station, which enables high parallel (800 single cells at a time) transcriptome analysis or targeted DNA sequencing. The applications of this high throughput single-cell technology include cell classification (Telley L. et al. 2016, data illustrated in the Figure below), tissue heterogeneity studies and CRISPR-Cas9 screening.

The platform is also equipped with Illumina and Affymetrix microarray technologies for Single Nucleotide Polymorphism (SNP) analysis (Genome-wide association studies and cytogenetics), DNA copy number profiling, DNA methylation status and expression profiling, including miRNA.

For projects requiring expression analysis of smaller gene sets, or specific metabolic pathway genes, the platform offers (since 8

For targeted expression analysis, the facility proposes the widely used real-time PCR technology. In response to growing interest in digital PCR, the platform has also implemented the QuantStudio3D digital PCR system (Thermo Fisher Scientific) for rare variant detection, absolute quantification, biomarker analysis and viral or bacterial detection.

All data generated by the platform can be further analysed by the bioinformatics team. Particular attention is given to understanding the projects and needs of each individual user in order to optimise the analysis pipeline, and new tools are developed as needed. For users who want to analyse their data themselves, guidelines and informatics tools are available.

The provision of proximity services is another of the strengths of the iGE3 platform. Every project and experimental design is directly discussed with the users. Additionally, in order to adapt platform capacity to match demand, continuous efforts are made to optimise protocols and develop and implement new technologies.

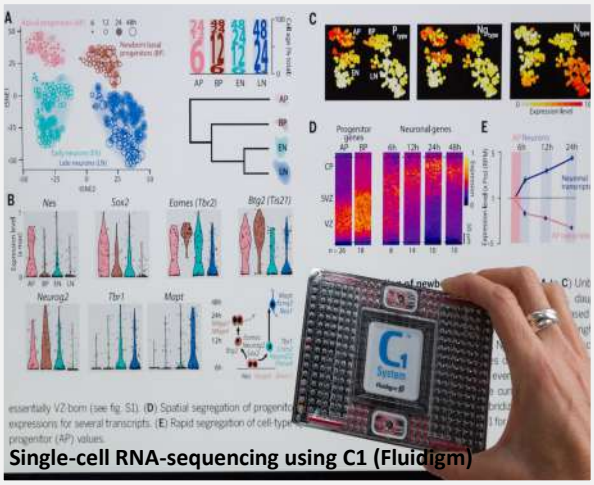


Photo: Brice Petit / Brice Petit Photography

Single-cell RNA-sequencing using C1 (Fluidigm)

ID Card:

Analytical platform type:
Genomics

Main techniques proposed:
-Next Generation Sequencing (RNA, DNA, exome-seq…)
-Microarrays (SNP, CNV, methylation, expression)
-nCounter (nanoString)
-q- and d-PCR

Capacity:
Several hundred NGS libraries and arrays per week

Delay to start:
None

Duration of experiment:
Depends on the request (maximum 1.5 months including the analysis)

Intercomparison exercise proposed:
Illumina Phix quality
Affymetrix spikes

Training proposed:
On request

Address:
University of Geneva
CMU 6 - laboratory A06.2707
Rue Michel Servet, 1
CH-1211 Geneva 4
Switzerland

Access:
Free

Internet link:
https://ige3.genomics.unige.ch

Contact:
Mylène Docquier
mylene.docquier@unige.ch
+41 22 379 50 31

Related to:
MELODI

Metagenomics analysis of red blood cell and fresh-frozen plasma units, Lau P., Cordey S., Brito F., Tirefort D., Petty T. J., Turin L., Guichebaron A., Docquier M. et al. (2017), Transfusion, 57 (7) , 1787-1800
Sequential transcriptional waves direct the differentiation of newborn neurons in the mouse neocortex, Telley L., Govindan S., Prados J., Stevant I., Nef S., Dermitzakis E., Dayer A., Jabaudon D. (2016), Science, 351 (6280), 1443-1446

VIB Proteomics Core

State-of-the-art proteomics service facility in Belgium

The VIB Proteomics Core (PRC), located at the VIB-UGent Center for Medical Biotechnology in Ghent, Belgium, provides contemporary mass spectrometry (MS)-based proteomics services to academic and non-academic users. The PRC started in 2005 as a spin-off service unit of the proteomics laboratory of Prof. Dr Kris Gevaert. Today, it has evolved from a research-oriented facility to a service-oriented platform and has become a reference centre for proteome research in Belgium and beyond.

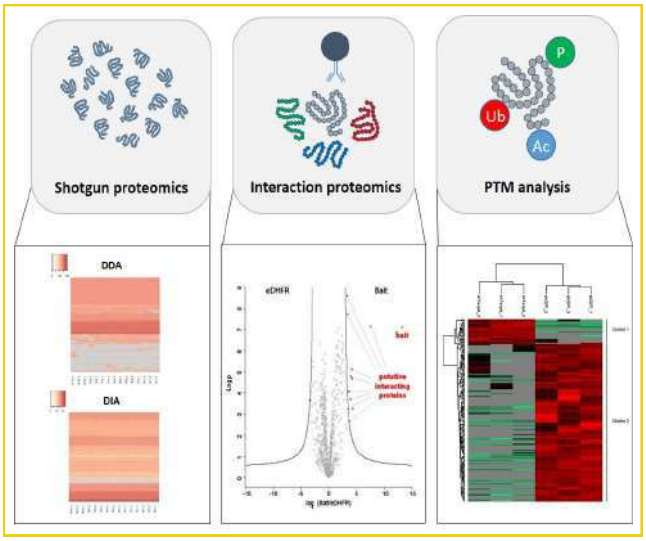


Photo: Teresa Maia/VIB

Main analysis types at the VIB Proteomics Core

Six state-of-the-art orbitrap mass spectrometers coupled with nano-LC chromatography systems are available to perform LC-MS/MS analyses at the PRC. These instruments run 24/7 and can process several hundred samples/month. In addition, the PRC has a triple quadrupole mass spectrometer for targeted proteomics, as well as a MALDI-TOF MS/MS instrument.

As part of its routine services portfolio, the PRC offers three main types of proteomics applications in modern life sciences: 1) Shotgun analysis which generates comprehensive proteomic profiles that reveal differences in protein levels associated with a particular cellular state or experimental condition; 2) Affinity purification mass spectrometry (AP-MS) experiments which allow the characterisation of protein complexes and the discovery of novel protein interactions; 3) Mapping of common protein post-translational modifications such as acetylation, phosphorylation and ubiquitination, for which the PRC has extensive experience.

In addition to these routine applications, customised services are provided including the identification of proteolytic processing sites, the development of targeted proteomics assays (e.g. by SRM/PRM) and mass determination of intact proteins. Samples can be isotopically labelled (e.g. by SILAC or TMT labelling) for optimal quantitation accuracy or sample multiplexing, in addition to the standard label-free workflows.

Photo: VIB

Dr Francis Impens

Significant advances in the development of LC-MS/MS instrumentation and data analysis software over recent years have set the stage for clinical proteomics. In order to keep pace with these developments and to take an active role in biomarker discovery, the PRC recently implemented a novel analysis pipeline based on Data Independent Acquisition (DIA). This pipeline ensures improved detectability and quantitation of proteins, and is ideally suited for high-throughput screening of patient samples.

The PRC is operated by an experienced, international team composed of MS engineers, biochemists and data analysts, and applies constant monitoring procedures including daily MS quality control and continuous benchmarking of implemented protocols. Thus the facility is able to deliver high quality services at all times, encompassing every step of a proteomics experiment. Users are guided from sample collection to data analysis, and receive assistance from the PRC team to formulate biological conclusions that are easy to interpret for the non-proteomics expert.

Photo: Delphi Van Haver/VIB

ID Card:

Analytical platform type:
Proteomics

Main techniques proposed:
- Mass spectrometry-based proteomics (LC-MS/MS)
- Shotgun proteomics by DDA & DIA
- Analysis of common post-translational modifications (e.g. phosphorylation, ubiquitination, acetylation)
- Characterisation of protein complexes and interaction partners (e.g. AP-MS, Bio-ID)
- Targeted proteomics by SRM & PRM

Capacity:
Hundreds of samples per month

Delay to start:
Dependent on the scale of the project, typically 1 to 2 weeks

Duration of experiment:
Dependent on the scale of the project, typically 5 to 6 weeks

Intercomparison exercise proposed:
Daily quality control *via* QCloud (https://qcloud.crg.eu)

Training proposed:
On request

Address:
VIB Proteomics Core
Albert Baertsoenkaai 3 - 9000 Gent, Belgium

Access:
For academic and non-academic users

Internet link:
https://corefacilities.vib.be/pec

Contact:
Dr Francis Impens
francis.impens@vib-ugent.be
+32 9 264 93 60

Related to:
VIB, Core for Life, EU-LIFE, UGent-CRIG

Quality control in mass spectrometry-based proteomics, Bittremieux W., Tabb D. L., Impens F., Staes A., Timmerman E., Martens L., Laukens K. (2017), Mass Spectrometry Reviews, doi:10.1002/mas.21544
Phase separation of C9orf72 dipeptide repeats perturbs stress granule dynamics, Boeynaems S., Bogaert E., Kovacs D., Konijnenberg A., Timmerman E., Volkov A., Guharoy M., De Decker M., Jaspers T., Ryan V. H., Janke A. M., Baatsen P., Vercruysse T., Kolaitis R. M. et al. (2017), Mol Cell, 65 (6), 1044-1055

Subcategory (b) : Models & Tools

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Dose Estimate, CABAS and NETA

Statistical and software tools for cytogenetic biodosimetry

Cytogenetic methods of biological dosimetry are crucial for triage of individuals following suspected radiation overexposure and also to support large scale research projects where biological markers of exposure and effect are required (see issue 1 – RENEB). The biological and statistical methods for dose estimation in radiation cytogenetics are now extremely well defined. To facilitate dosimetry, calibration data are collected and fitted under

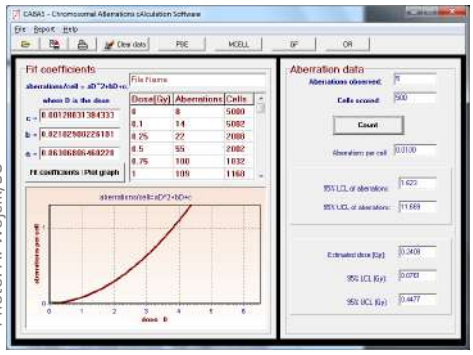


Photo: A. Wojcik/SU

The interface of CABAS

Poisson assumptions to a linear or linear quadratic model and the coefficients are then used to calculate doses. Full details of this classical procedure can be found in the International Atomic Energy Agency manual (http://www-pub.iaea.org/MTCD/publications/PDF/EPR-Biodosimetry%202011_web.pdf).

Statistical methods for analysis of cytogenetic data can be complex – for instance iteratively reweighted or maximum likelihood methods to fit calibration curves - however good statistical analysis is crucial to ensure that accurate dose and uncertainty estimates are produced. Thus in recent years there has been a lot of work on developing computational tools to support implementation of the IAEA statistical analysis methods. In particular, Dose Estimate and CABAS allow users to fit calibration curves and estimate whole or partial body doses in acute or protracted scenarios. Both tools contain graphic user interfaces for ease of use, come with full instructions, and have been extensively tested. Dose Estimate can be obtained by emailing liz.ainsbury@phe.gov.uk and CABAS from http://www.ujk.edu.pl/ibiol/cabas/. In addition, there are a large number of inhouse tools developed at the various biodosimetry laboratories in Europe, for instance GLIM (UAB), MLREG (BfS), BIODOSEUAB and DOSGEN (CPHR).

Photo: left to right:K. Rothkamm/ Hamburg University; A.Wojcik/SU

Liz Ainsbury - Andrzej Wojcik

Limitations in the traditional methods, for instance departure from Poisson distribution in partial body exposures, have led to development of new analysis methods based on alternative models to Poisson. NETA allows users to test whether data are Poisson or Neyman A distributed, for example: http://www.ujk.edu.pl/ibiol/neta/. Bayesian analysis is a very attractive solution to characterise cytogenetic doses, as the results are given in terms of probability distributions which intrinsically include uncertainty information. CytoBayesJ (liz.ainsbury@phe.gov.uk) and the R software radir (https://cran.r-project.org/web/packages/radir/index.html) are simple tools for this purpose.

Software tools have also been developed to assist in triage categorisation – including the Multibiodose EU FP7 project software (http://www.multibiodose.eu/software.html) and outside the EU, BAT and FRAT (https://www.usuhs.edu/afrri/biodosimetrytools).

Finally, in addition to defined tools, the retrospective dosimetry community has a number of biostatisticians devoted to analysing data and developing statistical analysis methods and tools. These experts are very happy to collaborate going forward – contact the authors or through RENEB (reneb@bfs.de).

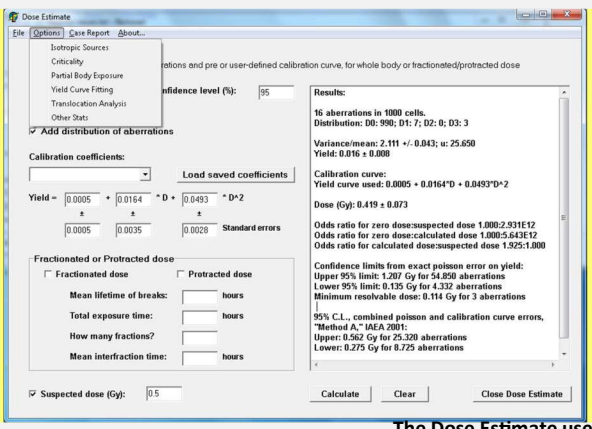


Photo: L.Ainsbury/PHE

The Dose Estimate user interface

ID Card:

Purpose:
Cytogenetic radiation dose and uncertainty assessment

Capacity:
N/A - freeware

Use:
Graphic user interface providing simple tools to fit calibration curves and estimate cytogenetic radiation doses

Housed by:
Dose Estimate: PHE;
CABAS: SU and JKU

Training proposed on the software:
Full instructions and example data are provided, but adhoc training can be given if needed

Access:
Dose estimate: Free, by emailing liz.ainsbury@phe.gov.uk;
CABAS: Free to download from: http://www.ujk.edu.pl/ibiol/cabas/ or by emailing andrzej.wojcik@su.se

Contact:
Dose Estimate: liz.ainsbury@phe.gov.uk, 0044 1235 825105;
CABAS: Andrzej.wojcik@su.se, 00468161217

Related to:
MELODI, EURADOS, CARPEM,

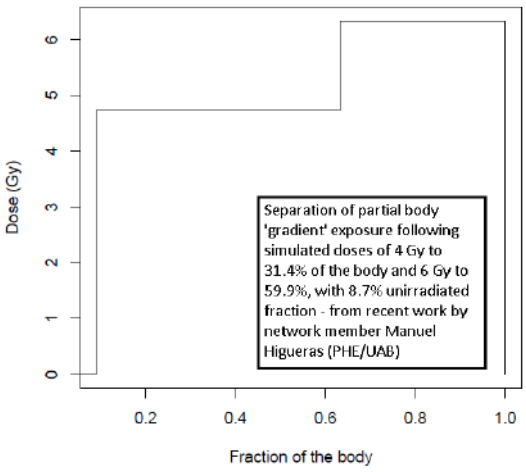
CABAS - A FREELY AVAILABLE PC PROGRAM FOR FITTING CALIBRATION CURVES IN CHROMOSOME ABERRATION DOSIMETRY. Deperas, J., et al. Radiat. Prot. Dosim. 2007 124:115-23.

DOSE ESTIMATION SOFTWARE FOR RADIATION BIODOSIMETRY. Ainsbury EA, Lloyd DC. Health Phys. 2010 98(2):290-5.

LDRadStatsNet

Network of statisticians interested in low dose IR research

Uncertainties, both quantitative and conceptual in nature, have been identified as key to addressing the remaining research questions in EU low dose radiation research. Sophisticated techniques are in use across the different disciplines, however, there seems to be little commonality and, furthermore, the proportion of individuals with formal mathematical and statistical training compared to the other scientific disciplines appears relatively low. In order to address this, DoReMi collaborators from PHE and CREAL, together with colleagues from Universitat Autonoma de Barcelona (UAB) and Durham University (DU), organized a workshop to bring together researchers from the low dose radiation fields and invited expert mathematicians and statisticians with an interest in applied uncertainty analysis. The meeting was funded by EU FP7 DoReMi and the Centre de Recerca Matemàtica (CRM) which is a consortium between the UAB and several institutions and was held at CREAL, Barcelona, in September 2015.



DoReMi low dose radiation experts outlined the key research questions and the associated problems, together with the solutions that are currently being applied in DoReMi and the other EU low dose radiation research consortia, under the general headings of radiation biology, modelling and epidemiology research. The invited external statistical experts then outlined their own current research – the idea being to stimulate exchange of ideas. Focused discussions then took place to attempt to identify areas in which standard or indeed novel statistical methods can be applied to solve EU low dose radiation research questions going forward under MELODI and CONCERT.

The conclusions from the meeting were broad, but can be summarised as follows:

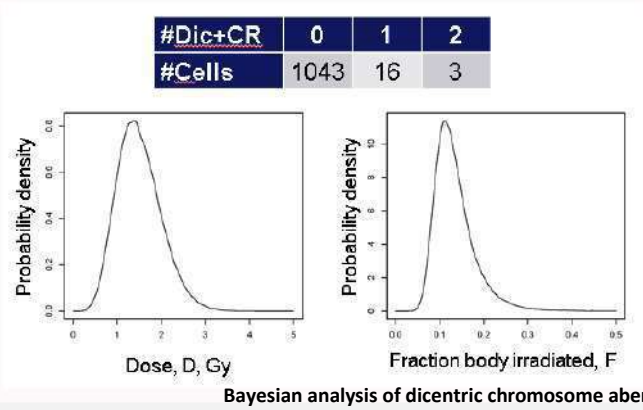
Photo: K. Rothkamm/PHE

Liz Ainsbury

1) It will be very important to consider and account for uncertainty in order to solve the remaining low dose research questions, identified in the relevant strategic research agendas. Statisticians must work closely with scientists from the other disciplines, indeed communication in interdisciplinary research can be supported by statistical expertise, e.g. in communication of what information is needed / what is available.

2) Training courses and workshops will clearly play a role in ensuring adequate statistical support for radiation research going forward, but the focus should be on opening a dialogue between scientists from different fields and at different stages of their careers, rather than on the purely instructive format of traditional training courses. A CONCERT funded course will take place in July - details here.

3) The meeting attendees all supported creating an informal network of scientists interested in the formal analysis of uncertainties in radiation research questions - resulting in the birth of 'LDRadStatsNet'. Individuals interested in joining the informal network or in drawing on the expertise of network members should contact Liz Ainsbury (liz.ainsbury@phe.gov.uk) for futher information in the first instance.



Bayesian analysis of dicentric chromosome aberrations

Graph: calibration data from Vinnikov et al., 2013

ID Card:

Purpose:
To support statistical analysis in EU low dose radiation research projects

Capacity:
Project dependent

Use:
Statistical analysis, statistical modelling, epidemiological analysis, etc…

Housed at:
Administered by PHE, UK

Training proposed:
Adhoc as required

Access:
Contact Liz Ainsbury in the first instance

Internet link:
Further details available at: http://www.doremi-noe.net/meetings_and_events.html#LDRadStats

Contact:
Liz Ainsbury, liz.ainsbury@phe.gov.uk

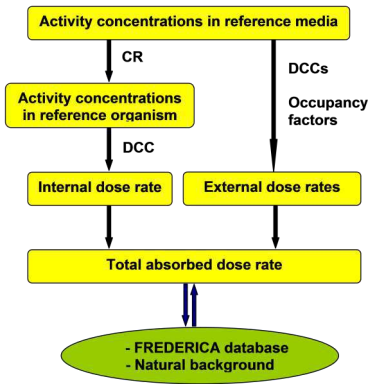
Related to:
EURADOS, RENEB and many other EU radiation research projects

RADIR PACKAGE: AN R IMPLEMENTATION FOR CYTOGENETIC BIODOSIMETRY DOSE ESTIMATION. Moriña D, et al. J Radiol Prot. 2015;35(3):557-69.
ZERO-INFLATED REGRESSION MODELS FOR RADIATION-INDUCED CHROMOSOME ABERRATION DATA: A COMPARATIVE STUDY. Oliveira M, et al. Biom J. 2016 58(2):259-79 .

ERICA Tool

The ERICA Tool supports adept environmental risk assessment

A key component of the ERICA Integrated Approach was the quantification of environmental risk involving, as an initial step, the combination of data on environmental transfer and dosimetry to provide a measure of wildlife exposure. These values, in the form of dose rates or corresponding activity concentrations for screening purposes, could then be compared with benchmarks, derived from exposure levels at which detrimental effects are known to occur, for the estimation of risk. In view of the large data sets underpinning the assessment approach and the potential to introduce errors when performing numerous calculations by hand, a supporting computer-based tool, the ERICA Tool, was developed as described in Brown et al. (2008). The Tool gives the option to cover a comprehensive list of radioisotopes and organism types, and has particular emphasis on the assessment of planned routine discharges of radionuclides and existing exposure situations.



Source: NRPA

Components within the assessment part of the ERICA Tool

The ERICA Tool adopts a tiered structure. There are two generic screening tiers and a third site-specific tier. The first Tier is very simple, based around Environmental Media Concentration Limits, EMCLs, defined as the activity concentration of a given radionuclide in media (soil, sediment water) that will result in a dose-rate to the most exposed reference organism equal to the screening dose-rate. This Tier requires minimal input from the assessor. The second Tier, although still a screening tier, is used to calculate dose rates explicitly and requires more detailed input from the assessor allowing for scrutiny and editing of default parameters in the process. A key procedural element of Tier 2 involves the application of Uncertainty Factors, UFs. Such factors reflect knowledge concerning probability distribution functions and provide a way of incorporating conservatism into the assessment by allowing the consideration of high percentile values in underlying parameters. Tier 3 allows a fully probabilistic analysis to be undertaken.

Photo: Justin Brown/NRPA

Justin Brown

The ERICA Tool has been further evaluated in numerous studies and has been widely applied by the scientific community. Examples include: consideration of potential environmental impacts from deep geological disposal facilities in various European countries; scoping analyses in line with newly introduced environmental regulations; in quantifying environmental impacts from operating and planned nuclear power stations and assessments of the impact of near-surface radioactive waste repositories in Europe and Australia.

Training in the use of the Tool has been relatively comprehensive (see: https://wiki.ceh.ac.uk/x/dIPJBg) with a bespoke 'Questions & Answers' webpage having been developed (see: https://wiki.ceh.ac.uk/x/r48ZBw). The software is freely available for download (http://www.erica-tool.com and http://www.erica-tool.eu/) with the newest version of the software described in Brown et al. (2016).

Web-page at http://www.erica-tool.com

Source: NRPA

ID Card:

Purpose:
Environmental risk assessment

Information available type:
Radionuclide transfer, eco-dosimetry and biological effects for wildlife (summarised from published literature)

Use:
Individuals can download and use the software themselves for screening assessments, but may need a specialist for site specific analyses

Training proposed on the software:
Training in the use of the Tool has been relatively comprehensive (see: https://wiki.ceh.ac.uk/x/dIPJBg) and is ongoing – see website for details

Access:
Free

Internet link:
http://www.erica-tool.com and http://www.erica-tool.eu/

Contact:
Justin Brown
Justin.brown@nrpa.no;
+47 67162500

Nicholas Beresford
nab@ceh.ac.uk
+44 1524 595856

Related to:
Alliance

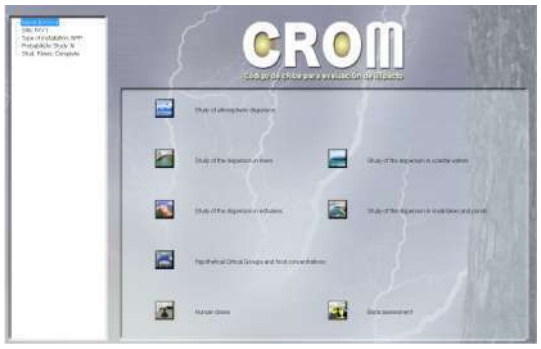
The ERICA Tool. Brown, J.E., et al. (2008). J. Environ Radioact, 99, pp.1371-1383.

A new version of the ERICA Tool to facilitate impact assessments of radioactivity on wild plants and animals. Brown J.E., et al. (2016). J. Environ Radioact, 153, pp. 141-148.

CROM-8

A code to integrate dose assessments for humans and biota

CROM code was initially designed as a computational tool to implement the more complex models described in the Safety Report Series No 19 (SRS-19) of the International Atomic Energy Agency (IAEA), but has evolved to include new capabilities. The SRS-19, published in 2001, compiles the generic models for the transport of radionuclides in the environment (produced as a discharge in an installation) and all their associated parameters.



Picture: CIEMAT

Figure 1 : Main screen of CROM8

In 2007, CROM 6, a stable version, quality controlled by the IAEA, was distributed by the Agency worldwide as the basis for the calculation of these models. This was followed by CROM 7, created to propagate the uncertainties of the measurements and parameters through the models, and then almost immediately by a new version, CROM 8, to include the protection of the biota, in accordance with the requirements of the IAEA and the EU. All these versions are freely available at ftp://ftp.ciemat.es/pub/CROM.

CROM 8 (Figure 1), a tool for integrated assessment of effective doses for humans and absorbed doses for biota, was developed on the basis that both approaches require contamination levels of environmental media, such as air, freshwater, soil, etc, as inputs. Therefore, the use of common models to derive these concentrations from the discharges produced in a nuclear, radioactive or even a NORM installation, would allow simultaneous calculations to be performed. CROM 8 includes default data for 162 radionuclides for humans and 63 for biota. Two sets of Reference Animals and Plants are also available: one from ICRP and accepted by the IAEA, and another from ERICA. The code does not include the screening levels (tiers) specified in the SRS-19 for humans nor those in the ERICA-Tool for biota. The code does allow assessments to be performed in rivers, lakes and marine environments and in contaminated atmosphere and soils.

Photo: JC Mora/CIEMAT

Juan Carlos Mora

The CROM tool was developed by the CIEMAT and the Polytechnic University of Madrid and co-sponsored by CIEMAT, ENRESA, IAEA and STAR.

Simultaneous to the development of CROM 8, parallel development began on the Open Platform CROM (OP-CROM), with the aim of creating a flexible tool that would allow implementation of any model, including the SRS-19 models, and which could be run on different computer platforms (operating systems and computer architecture). Another aim of OP-CROM was to enable all data and parameters to be input or generated as separate text files, rather than use an established database as is the case in the CROM family. Further, the tool would be freely distributed and would follow the open software philosophy, allowing others to contribute to its development.

In fact, OP-CROM has exceeded these aims (Figure 2), and plans exist to: generate new modules with advanced models; develop modules allowing dynamic calculations; include additional default parameters, or additional graphical user interfaces to allow the results to be presented in maps integrated into other tools such as Google Earth.

Figure 2: One of the multiple possibilities of OP-CROM

Picture: CIEMAT

ID Card:

Purpose:
Dose estimation in humans and biota.

Capacity:
N/A (freeware)

Use:
Integrated assessment of effective doses for humans and absorbed doses for biota.

Housed at:
CIEMAT

Software Training: Manuals available in English and Spanish. CIEMAT provides training upon request.

Address:
CIEMAT, Av Complutense 40, Madrid 28040, Spain

Access:
Free

Internet link: ftp://ftp.ciemat.es/pub/CROM

Contact:
Juan-Carlos Mora
jc.mora@ciemat.es
+34 91 346 6751

Related to:
ALLIANCE

CROM. Intellectual Property Registry No M-000481/2006. Registration Entry 16/2011/3841. 12 of May of 2011. (2011)
GENERIC MODEL FOR COMBINED TIER-1 ASSESSMENTS FOR HUMANS AND WILDLIFE. Juan C. Mora, et al. STAR (Contract Number: Fission-2010-3.5.1-269672) DELIVERABLE (D-N°3.1) (2015)

The Analytical Platform of the PREPARE project

Web based information exchange for emergency management

The European project PREPARE (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe) is aimed at closing gaps that have been identified in nuclear and radiological preparedness following the first evaluation of the Fukushima disaster. Among other measures, a so-called Analytical Platform (AP) has been developed to explore the scientific and operational means of improving information collection, information exchange and the evaluation of such types of disasters.

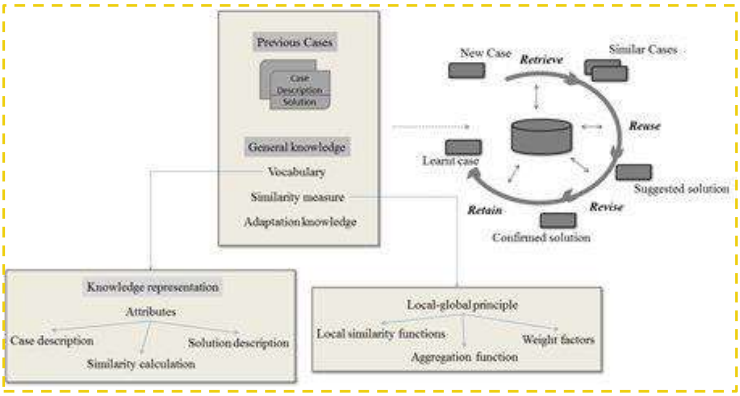


Photo: KIT

Knowledge database and CBR cycle

The AP provides a framework to allow discussion between experts and to disseminate congruent information on the current situation to the public. The AP is composed of three types of tools. Module 1 supports the expert-to-expert interactions in analysing an ongoing incident. Components include:

- A knowledge database and case-based reasoning (CBR) functionalities with machine-learning algorithms to find solutions for events that are not part of the existing knowledge database.
- A multi-criteria analysis tool for evaluating the effects of potential sets of measures to be taken.
- A means of communication to allow experts to analyse an on-going event (virtual meeting room).

The toolbox is completed by a web-crawling facility, which allows the collection and processing of information from all possible sources, and an "Ask the expert" tool to communicate information to the public about assessments.

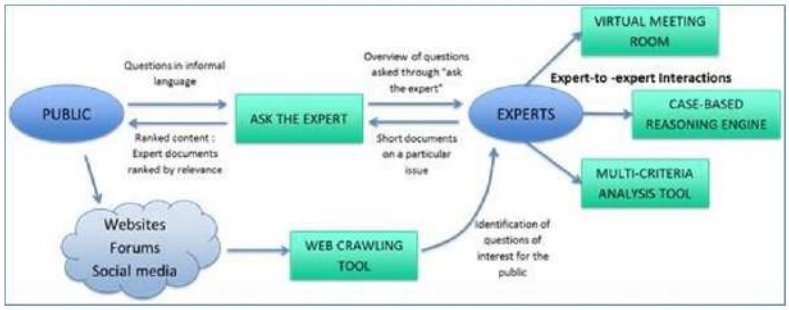
The AP is designed to be installed centrally and access is provided via a web browser from any mobile or stationary computer. The AP was designed to be applicable in all phases of an emergency. The knowledge database contains more than 100 scenarios and historical cases for early phase countermeasures, and several dozen for the late phase. These can be used as a starting point for the evaluation of an on-going event. Internal communication is supported by the virtual meeting room that allows experts to communicate on particular topics. This communication is secure and only visible to those who have been assigned to this task. The forum and web-crawling facilities serve to support communications with the public.

Photo: KIT

Wolfgang Raskob

Application areas of the AP include situations where information is sparse and uncertain, for example, if the accident has happened in a neighbouring country. Training of decision-makers and other experts is also a possible field of application, as the AP contains lots of information for many different scenarios and provides vast knowledge not only on historical consequences but also on particular events from the scenario database.

Now that the Analytical Platform has been developed, the next step is to explore its application and usability. To facilitate this, an "Information, participation and communication" working group has been established under NERIS (http://www.eu-neris.net/). Among other tasks, the group intends to establish adequate rules of conduct and the basis for maintenance of the platform.



Interactions with the public and the experts through the PREPARE AP tools

Photo: KIT

ID Card:

Purpose:
Information collection and exchange to analyse an ongoing nuclear emergency

Capacity:
No limitation

Use:
Installed centrally and accessed via web browser. Possible to install it locally for training

Housed at:
Virtual installation (Virtual Box)

Address:
If applicable

Access:
Installed centrally at KIT, user can request access. Access is free

Internet link:
Will be provided after registration

Contact:
Wolfgang Raskob,
Karlsruhe Institute of Technology (KIT), Germany
Tel: +49 721 608 22480
Wolfgang.Raskob@kit.edu

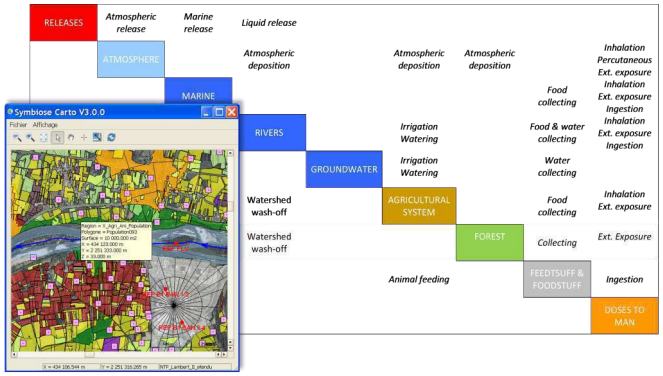
Related to:
NERIS

PREPARE: INNOVATIVE INTEGRATED TOOLS AND PLATFORMS FOR RADIOLOGICAL EMERGENCY PREPAREDNESS AND POST-ACCIDENT RESPONSE IN EUROPE. Raskob et al. Radiation Protection Dosimetry, 164(2015), pp.170-174
STRUCTURING AND REUSING KNOWLEDGE FROM HISTORICAL EVENTS FOR SUPPORTING NUCLEAR EMERGENCY AND REMEDIATION MANAGEMENT. Moehrle, S. et al. Eng. Appl. Artif. Intel. (2015)

Symbiose

A Modeling Platform for Environmental Radiological Assessment

SYMBIOSE is a simulation platform that aims at modelling the fate and dispersion of radioactive substances in environmental systems, and assessing their impact on humans and biota, accounting for uncertainty and variability. This platform can be used in a wide range of situations for assessing risks induced by radioactive releases from nuclear facilities under normal operational, accidental, or decommissioning conditions. As shown in Figure 1, environmental models in SYMBIOSE address atmospheric, terrestrial, freshwater and marine systems, as well as the main transfer processes at their interfaces.



SYMBIOSE: matrix featuring the environmental systems (diagonal boxes) and the interactions between them (off-diagonal boxes), which depict exchanges of mass, energy or information; example of landscape around an NPP for spatial predictions

The modelled exposure pathways for humans are external irradiation (plume shine and ground shine) and internal contamination (inhalation, percutaneous transfer for tritium, ingestion).

SYMBIOSE deals with several hundreds of radionuclides, derived from up to 70 chemical elements including chlorine, hydrogen and carbon, for which specific non-equilibrium approaches have been proposed. Outputs such as concentrations, activities, stocks and fluxes of pollutants or (a)biotic mass obey mainly to mass conservation equations (ODE & PDE ordinary and partial differential equations). When the previous approach is not possible, empirical parameterisations such as transfer factors or transfer functions are adopted. Spatial predictions are produced for a given sub-system on a specific spatial frame (i.e. collection of points, polylines or polygones). The specification of these frames, along with the spatial interactions between the frames, defines a landscape model.

SYMBIOSE has been developed in the context of an R&D project led by IRSN and co-funded by Electricité de France (EDF). Each of the co-owners (IRSN and EDF) are able to provide SYMBIOSE to licensees for specific purposes. The industrial version is regularly upgraded to take account of user feedback. The most recent version, SYMBIOSE V2.3, was released in early 2017. As shown in Figure 2, the SYMBIOSE platform, which runs under Windows/Linux OS, in French/English language, features a highly flexible and modular architecture. This consists of four major components:

Photo: M.A. Gonze, C. Mourlon,IRSN

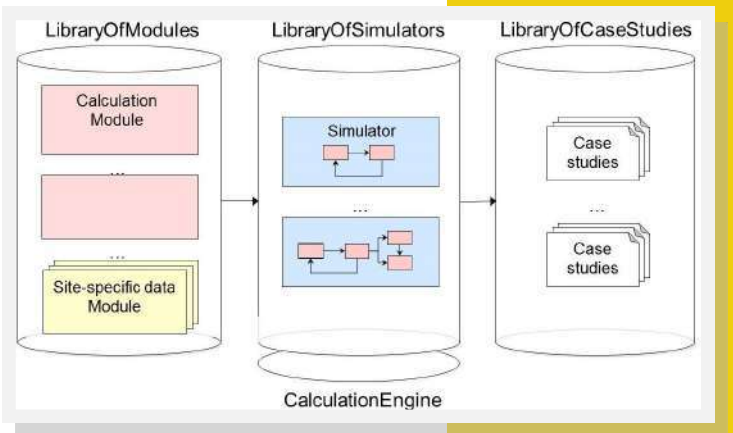
M.A. Gonze, C. Mourlon

-A library of modules, a module being an autonomous/reusable piece of software that models an environmental sub-system and encapsulates related parameters (generic/site-specific and deterministic/probabilistic values),

-A library of simulators, a simulator being a fit-for-purpose code that addresses a specific environmental problem, built by instantiating and connecting pre-existing modules through a graphical user interface,

-A library of case studies for the various existing simulators, and

-The application itself for managing modules and simulators or performing simulations through the use of a powerful calculation engine capable of dealing with complex space and time dynamics.



Simplified scheme displaying the architecture of SYMBIOSE platform

Simon-Cornu M. et al., 2015, Evaluating variability and uncertainty in radiological impact assessment using SYMBIOSE, Journal of Environmental Radioactivity, 139, p91-102

Gonze M. A. et al., 2016, Modeling the dynamics of ambient dose rates induced by radiocaesium in the Fukushima terrestrial environment, Journal of Environmental Radioactivity, 161, p22-34

ID Card:

Purpose:
A Modeling and Simulation Platform for Environmental Radiological Impact Assessments

Use:
Restricted to co-owners (IRSN and EDF) and licensees; some skills and initial training needed.

Training proposed on the software:
One or two sessions per year for co-owners (IRSN and EDF) or licensees

Access:
Licenses for specific needs (possibly free for certain uses)

Internet link:
https://gforge.irsn.fr/gf/project/symbiose/

Contact:
symbiose@irsn.fr

Related to:
ALLIANCE

INFRAFRONTIER

High quality resources for biomedical research

INFRAFRONTIER is the European Research Infrastructure for the developement, phenotyping, archiving and distribution of model mammalian genomes. It is a pan-European **non-profit** endeavour by more than 25 public research centres and private companies from 14 European countries and Canada, and the European Molecular Biology Laboratory. In INFRAFRONTIER these partners join forces to **advance the understanding of human health and disease.**

The INFRAFRONTIER Research Infrastructure offers **open access to unique scientific platforms, resources and services**, and to the extensive expertise of the INFRAFRONTIER partners:

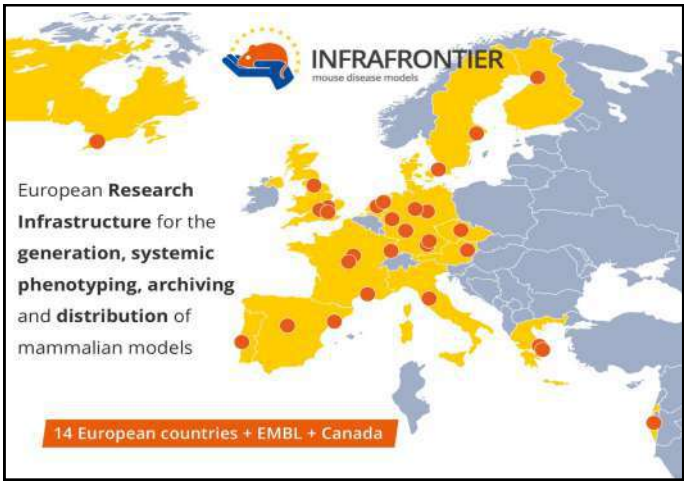


Photo: INFRAFRONTIER/Helmholtz Zentrum München

- Scientifically valuable mutant mouse strains are archived by the **European Mouse Mutant Archive (EMMA)** and distributed to interested researchers around the globe.
- Rodent **model generation** (mouse and rat) is offered using gene targeting in embryonic ES-cells or CRISPR/Cas9 technologies
- **Systemic phenotyping** of mutant mice offers a whole-organism view on gene function and pleiotropic effects. In-depth phenotyping (e.g. immuno-phenotyping, metabolic phenotyping) provides further insights.
- **Germ-free (axenic) mice** reveal the contribution of the gut microflora to phenotype-genotype interactions.
- The GEMM-ESC archive at the Netherlands Cancer Institute offers a rapid target gene validation in **complex cancer mouse models**.
- **Training** courses teach the state-of-the-art in the generation, cryopreservation and phenotyping of mouse models under strict animal welfare standards and promote the 3R -principles.

The INFRAFRONTIER Research Infrastructure has a **global user community**. All resources and services can be accessed at INFRAFRONTIER's central web portal www.infrafrontier.eu. In 2016, biomedical researchers requested more than 600 mouse strains from the European Mouse Mutant Archive (EMMA).

Photo: INFRAFRONTIER/Helmholtz Zentrum München

Dr Martin Hrabě de Angelis

The INFRAFRONTIER Partners share a **common European spirit and goal**: Advancing the understanding of human health and disease using mammalian models. They actively work together to provide high-quality platforms, resources and services for the biomedical research community, and to disseminate and share knowledge and expertise. This pan-European effort is coordinated by the **INFRAFRONTIER GmbH**, located in Munich, Germany, which guides the development of:

- **common standards and procedures** to ensure highest quality and reliability
- **common technology development** to further improve the INFRAFRONTIER resources and services
- **common outreach activities** to spread the word about INFRAFRONTIER
- **common training activities** to disseminate knowledge to current users and the next generation of biomedical researchers.

INFRAFRONTIER fully embraces the **3R principles: Replacement** - Supporting methods which avoid or replace the use of mice in research; **Reduction** - Using methods which minimise the number of mice used per experiment; **Refinement** - Applying methods which minimise suffering and improve animal welfare. By providing centralised access to high-quality resources, it adds the **INFRAFRONTIER Rs: Reproducibility, Reliability and Responsibility**.

Photo: INFRAFRONTIER/Helmholtz Zentrum München

INFRAFRONTIER
mouse disease models

ID Card:

Resources and Services:

- Rodent model development (mouse and rat)
- Systemic phenotypic and specialised phenotyping
- Archiving and distribution of mutant mouse strains
- Axenic (germ-free) mice
- Cancer mouse models
- Training and consulting

Central coordination:
INFRAFRONTIER GmbH,
Ingolstaedter Landstrasse 1,
85764 Neuherberg
Germany

Internet link:
www.infrafrontier.eu

Contact:
info@infrafrontier.eu

Related to:
MELODI, EURAMED

ESFRI European Strategy Forum on Research Infrastructures

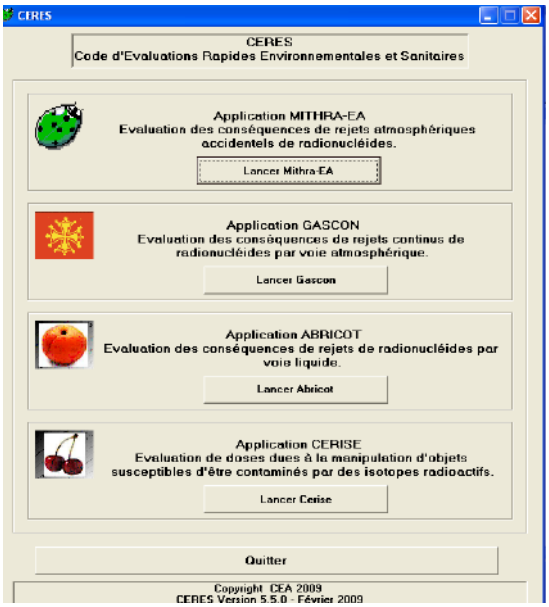
INFRAFRONTIER Consortium. 2015. "INFRAFRONTIER–Providing Mutant Mouse Resources as Research Tools for the International Scientific Community." Nucleic Acids Research 43, p1171–D1175. doi:10.1093/nar/gku1193

Raess, Michael, Ana Ambrosio de Castro, Valérie Gailus-Durner, Sabine Fessele, Martin Hrabě de Angelis, and the INFRAFRONTIER Consortium. 2016. "INFRAFRONTIER: A European Resource for Studying the Functional Basis of Human Disease.", Mammalian Genome 27 (7), p445–50, doi:10.1007/s00335-016-9642-y

THE CERES® PLATFORM

A rapid environmental and sanitary assessment code

The Radioanalysis, Chemistry, Environment Division of the French Alternative Energies and Atomic Energy Commission (CEA) is in charge of the development of methods and tools to estimate the impact of accidental or routine pollutant releases (radionuclides or chemicals) on human health and the environment. It has developed the CERES® tool (Code d'Evaluations Rapides Environnementales et Sanitaires) of Environmental sanitation) to ensure that all impact evaluations of CEA installations releases are carried out in the same way. The CERES® platform houses a database containing the characteristics of approximatively 800 isotopes or pollutants (dose coefficients, transfer coefficients from soil to plants, from plants to animals…) and can be used either in emergency situations or for safety files.



Main interface of CERES® platform

Currently, CERES® focuses on the integration of chemical reactions during atmospheric transfer, the development of heavy gas models and the use of topography in accidental situations.

For accidental atmospheric releases, atmospheric transport modelling is performed using the Gaussian puff model, MITHRA. Different standard deviation equations are used such as Doury's formula (default option), function of travel time. The activity emitted from a facility into the environment is evaluated using the ERASTEM system which is a box model, that takes into account transfers between different compartments of the installation. For routine atmospheric emissions, dispersion calculations are performed using the GASCON model, which is based on the Gaussian puff model described above. In this case, the release over time rate is constant and the different meteorological data acquired near the sites over a period of one or more years is based on observations. For normal releases in rivers, the ABRICOT model which assumes immediate dilution, is used.

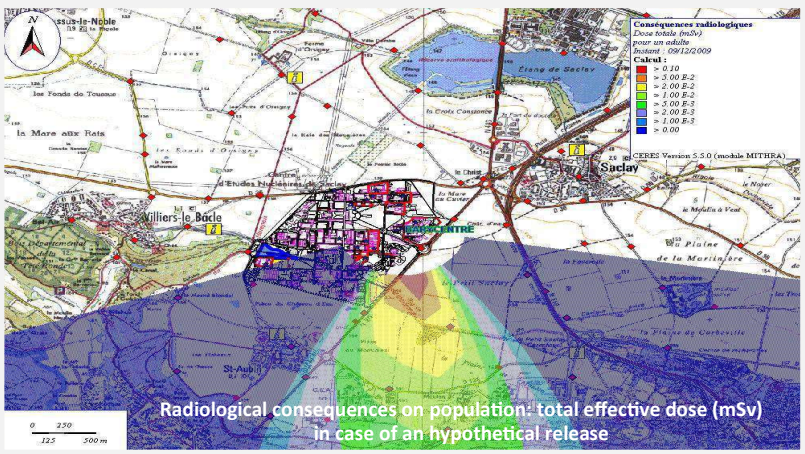
Dr Marguerite Monfort

Impact evaluations are performed in population groups whose characteristics are made available in a "site" dependent database containing stacks, measurement points, dietary habits, etc. The consequences in terms of effective dose or dose to the thyroid in accidental situation only, are estimated for the following pathways:

- immersion in the plume, which leads to internal exposure by inhalation and external exposure by irradiation following atmospheric release,
- presence on the deposits, which leads to external radiation exposure,
- inhalation of resuspended deposits in the case of liquid releases,
- ingestion of water or fish following liquid releases,
- consumption of plants, whose activity comes from the deposits of aerosols and rainfall or from ground transfers *via* root uptake,
- consumption of contaminated animal products.

In the case of tritium emissions, the modes of exposure differ in that immersion in the plume leads to internal exposure by inhalation and passage through the skin. Tritium is a low energy pure β emitter and does not cause external exposure via radiation deposits. Contamination can also occur through inhalation or ingestion *via* the food chain.

For accidental releases, the intervention levels for radiological emergencies defined by decree are highlighted if reached. The external exposure dose coefficients are derived from the Federal Guidance Report n°12, while the internal ones are either from the decree of September 1, 2003 or from ICRP publications: transfer coefficients in food chain are those proposed by international literature - TRS 472, AIEA, 2010.



Radiological consequences on population: total effective dose (mSv) in case of an hypothetical release

ID Card:

Purpose:
Dose assessment on population

Use:
need a specialist

Housed on:
CEA

Training proposed on the code:
Yes

Delay to start:
No

Access:
On demand (not free)

Internet link:
www.dase-cea.fr

Contact:
Marguerite Monfort
Marguerite.monfort@cea.fr
33 1 69 26 46 19

Address:
CEA DAM Ile de France
Bruyères le Châtel
91297 Arpajon
France

Related to:
MELODI, EURADOS, NERIS

Eckerman K. F., Ryman J. C., (1993) External exposure to radionuclides in air, water and soil. Federal Guidance Report 12-EPA 402-R-93-081

ICRP Publication 72 (1995) Age-dependant doses to members of the public from intake of radionuclides-Part 5 Compilation of Ingestion and Inhalation Dose Coefficients

The Severe Nuclear Accident Program (SNAP)

A Norwegian model for nuclear emergency

The Norwegian Meteorological Institute (MET) is responsible for modelling atmospheric dispersion of radioactive debris in the event of a nuclear emergency related to a nuclear accident or detonation. An additional task of the MET in a nuclear emergency is to identify unknown sources of radiation indicated by elevated levels of measurement. The basic tool used by the MET for such events is the Severe Nuclear Accident Program (SNAP).

Photo: Jan Terje Rausand/MET

Dr Jerzy Bartnicki **Dr Heiko Klein**

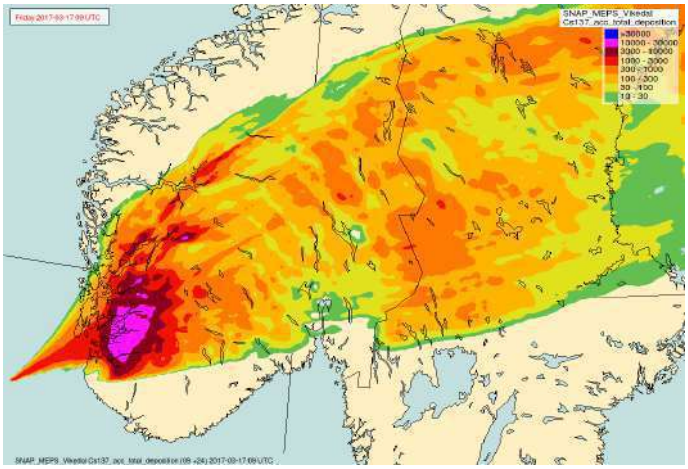


Photo: H. Klein /MET

SNAP dispersion results from a hypothetical accident on a floating nuclear powerplant transported along the Norwegian coast.

The SNAP model was developed at the MET in 1994 as a Lagrangian particle model. The present version is fully operational at the MET and takes into account atmospheric transport and deposition of gases, noble gases and particles of different size and density emitted during nuclear accidents or explosions. SNAP can also be run remotely by experts from the Norwegian Radiation Protection Authority (NRPA) where the Norwegian Crisis Committee is located.

In the event of a nuclear accident, the source term for the model runs is usually provided by NRPA. This source term includes the magnitude of release which is time dependant, the elevation, time profile of release and the nuclides released. In the case of a nuclear explosion, the source term depends on the explosive yield. In this type of event, radioactivity is transported mainly as particles of different sizes. A large variation of the particle size in the initial cloud is represented by 10 discrete classes with a characteristic particle radius ranging from 2 µm to 200 µm. All meteorological input is available on-line at the MET from different operational Numerical Weather Prediction (NWP) models, e.g. from the ECMWF forecast or from the regional Norwegian/ Swedish MetCoOp Ensemble Prediction System (MEPS).

The SNAP model can be run in different domains, ranging from the local domain with a resolution of 2.5 km to the hemispheric domain with spatial resolution of approximately 10 km. Once released into the air, radioactive gases and particles are subject to advection, turbulent diffusion and deposition (dry and wet). In the model calculations, the advection process is immediately followed by the diffusion process. A random walk approach is used to parameterise horizontal and vertical diffusion. When large and dense particles are released, gravitational settling is more effective than vertical diffusion and this process is taken into account. The effectiveness of dry deposition is mainly a function of atmospheric stability which is calculated based on the Local Richardson Number. Wet deposition is a function of precipitation intensity and type, as well as particle size.

The SNAP model has been used both for simulations of historical events (e.g. nuclear detonations in Novaya Zemlya, Chernobyl Accident) and real time simulations (e.g. Fukushima accident). It was tested in the ETEX experiment and showed good agreement with observations (ETEX 1). It has also been used for tracing unknown sources of radioactivity (e.g. recent ^{106}Ru case). SNAP is the dispersion model currently used by the MET in the CONFIDENCE project and also in CERAD CoE.

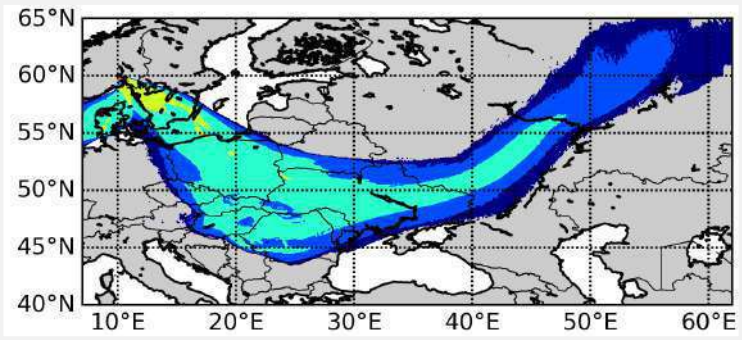


Photo: H. Klein/MET

Inverse SNAP dispersion calculations (-156h) of ^{106}Ru measurements in Oslo on 2/10/2017.

Norwegian Meteorological Institute | CERAD

ID Card:

Purpose:
Atmospheric dispersion of radioactivity

Use:
Needs a specialist

Housed at:
Norwegian Meteorological Institute (MET)

Training proposed on the software:
None

Address:
Norwegian Meteorological Institute,
Henrik Mohns Plass 1
0313 Oslo, Norway

Access:
Open source

Internet link:
https://github.com/metno/snap

Contacts:
Heiko Klein
heiko.klein@met.no

Jerzy Bartnicki
Jerzy.bartnicki@met.no

Related to:
NERIS

Atmospheric transport of radioactive debris to Norway in case of a hypothetical accident related to the recovery of the Russian submarine K-27, Bartnicki J., Amundsen I., Brown J., Hosseini A., Hov Ø., Haakenstad H., Klein H., Lind O. C., Salbu B., Szacinski Wendel C. C., Ytre-Eide M. A. (2016), Journal of Environmental Radioactivity, 151, 404-416.
Operational SNAP model for remote applications from NRPA, Bartnicki J., Haakenstad H. and Hov Ø. (2011), Met.no report No. 12/2011. Norwegian Meteorological Institute, Oslo, Norway

The BIANCA code

BIophysical ANalysis of Cell death and chromosome Aberrations

BIANCA (BIophysical ANalysis of Cell death and chromosome Aberrations) is a biophysical model/MC code that simulates cell death and chromosome aberrations by different radiation types, including those of interest for radiation protection (e.g. alpha particles) and cancer hadron therapy (protons and C-ions). The model/code is developed and maintained at the University of Pavia (UniPv) and the National Institute of Nuclear Physics (INFN) in Pavia, Italy.

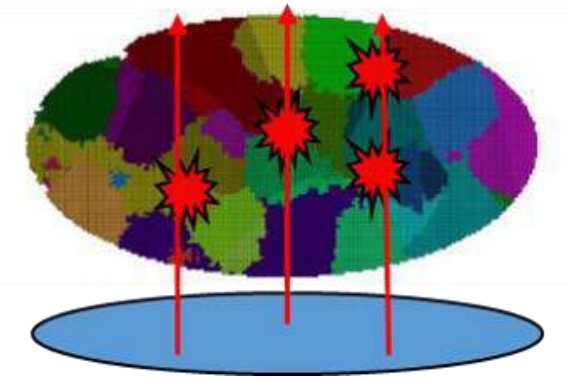


Photo: F. Ballarini and M. Carante/UniPv and INFN

Simulation of light-ion irradiation of a cell nucleus by the BIANCA code

The model, which ascribes a pivotal role to DNA cluster damage, is based on the following assumptions:

- Ionising radiation can induce DNA "Cluster Lesions" (CLs), where a CL is defined as critical DNA damage that produces two independent chromosome fragments.
- Distance-dependent mis-rejoining (or un-rejoining) of chromosome fragments produces chromosome aberrations.
- Certain aberrations (dicentrics, rings and large deletions) lead to cell death.

The CL yield, which mainly depends on radiation quality but is also modulated by the cell features, is adjusted by comparisons with experimental data. The fragment un-rejoining probability (or the characteristic distance of the fragment mis-rejoining probability, depending on the model version) is the second, and last, adjustable parameter.

The genomes (number of chromosomes and chromosome sizes) of human, hamster and rat cells have been implemented, and others can be added. The cell nucleus can be modelled either by a cylinder (for cell monolayers) or by a sphere (for cell suspensions), and the nucleus size can be chosen by the user. Each interphase chromosome-arm domain is described explicitly by the union of 0.1-µm-size voxels.

Photo: UniPv and INFN

Prof. F. Ballarini **Dr M. Carante**

The model has been recently applied to V79 cells (which are widely used in radiobiology, also to characterise hadron therapy beams) and AG01522 cells exposed to protons, He-ions and C-ions over a wide range of LET values. The good agreement between simulations and data allowed the creation of a database of particle- and LET-dependent CL yields; by fitting these yields, cell death and chromosome aberrations can be predicted also at LET values where experimental data are not available.

In view of hadron therapy applications, this allows an almost continuous set of α and β cell-survival parameters to be produced, which can be read by a radiation transport code and/or a TPS. In parallel, to elucidate the DNA damage repair mechanisms, the dependence of the fragment (mis-) rejoining probability on the (initial) fragment distance was investigated in human lymphocytes and fibroblasts. An exponential function of the form $\exp(-r/r_0)$, which is consistent with chromatin free -end diffusion, was found to better describe proximity effects with respect to both a step function and a Gaussian function. Furthermore, the results supported the use of the F-ratio (dicentrics to centric rings) and/or the G-ratio (interstitial deletions to centric rings) as "fingerprints" of low-dose, high-LET exposure, which can have applications for radiation protection.

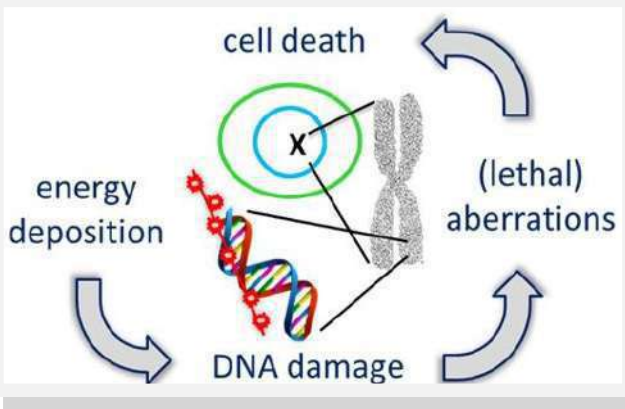


Photo: F. Ballarini and M. Carante/UniPv and INFN

Scheme of the main steps included in the BIANCA model

Chromosome aberrations and cell death by ionizing radiation: Evolution of a biophysical model, Ballarini F., Carante M. P. (2016), Radiation Physics and Chemistry, 128, 18-25

Proximity effects in chromosome aberration induction by low-LET ionizing radiation, Tello Cajiao J. J., Carante M. P., Bernal Rodriguez M. A., Ballarini F. (2017), DNA Repair, 58, 38-46

ID Card:

Purpose:
Calculation of cell death and chromosome damage probabilities

Use:
Use of the BIANCA code needs some initial skills and further training

Housed at:
- University of Pavia (UniPv)
- National Institute of Nuclear Physics (INFN)

Training proposed on the software:
N/A

Address:
University of Pavia, Physics Department
via Bassi 6, I-27100 Pavia, Italy

INFN-Section of Pavia
via Bassi 6, I-27100 Pavia, Italy

Access:
Currently the code is not freely available. Researchers interested in BIANCA should contact F. Ballarini and M. Carante.

Internet link:
http://fisica.unipv.it/ricerca/RicAppl/ENG/EN_SFB_Radio_computazionale.htm

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Related to:
MELODI

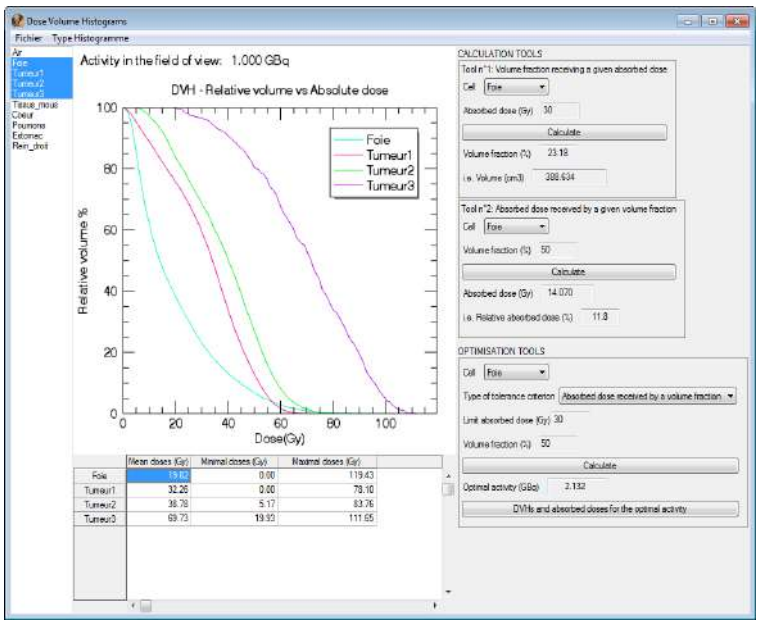
OEDIPE

A software tool for personalised dosimetry in nuclear medicine

Nuclear medicine is currently a rapidly evolving sector, particularly due to the discovery of new tumour-specific biomarkers and the availability of previously unconsidered radionuclides. Therapeutic procedures are of particular interest in this context, and one of the challenges is how to determine the individual activity to be administered to each patient. Currently, the administered activity is still largely standard, and sometimes tailored to patient weight or body surface area, although the European Directive 2013/59/Euratom emphasises that individual dose planning should be performed.

Photo: Céline Lelache/IRSN

Dr Aurélie Desbrée



Dose-volume histograms for regions of interest and treatment planning optimisation tools

Since biological effects, both in terms of response and toxicity, are primarily dependent on dose rather than administered activity, it is crucial to determine the personalised absorbed doses delivered to healthy tissues.

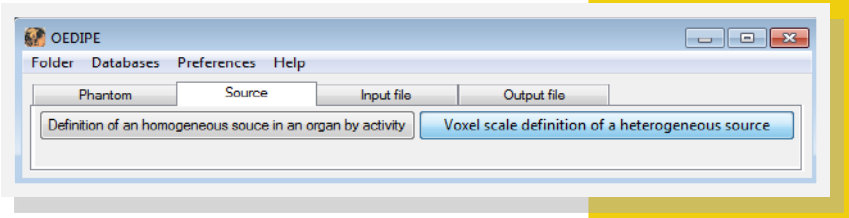
Only these estimations can ensure that healthy tissue irradiation will not lead to unacceptable toxicity, and can optimise treatment planning by calculating the maximal activity that can be safely administered to each patient. This activity is determined according to tolerance criteria for organs at risk, either for mean absorbed doses, dose-volume fractions or maximal absorbed doses.

The OEDIPE software offers a user-friendly graphical interface to carry out dosimetry, and a treatment planning tool for clinical applications of nuclear medicine. This tool has been developed to drive nuclear medicine treatment planning towards the refinements proposed in external dosimetry. OEDIPE creates an input file that must be run with the MCNPX Monte Carlo code, and it provides tools to process the results.

Mean absorbed doses to the regions of interest, isodose curves and dose-volume histograms can be obtained from data describing the patient's anatomy, based on CT or MRI images, and activity distribution data, based on PET or SPECT images. The distribution of Biological Effective Dose (BED) at the organ or voxel level can also be derived from the heterogeneous absorbed dose distribution. For treatment planning optimisation, tools have been implemented to provide the maximal injectable activity that can be administered to the patient according to tolerance criteria for organs at risk, expressed in terms of mean absorbed doses or dose-volume fractions.

Moreover, it is possible to calculate the maximal injectable activity for fractionated protocols, based on a BED tolerance criterion and depending on the number of fractions, the activity administered at each fraction, and the time delays between fractions.

In particular, this tool has been applied to selective internal radiation therapy (SIRT) in collaboration with the George Pompidou European Hospital in Paris. Therapy consists of injecting microspheres labelled with ^{90}Y into the lesions *via* the hepatic artery to treat unresectable hepatic cancers. This has allowed a 3D personalised dosimetry evaluation to be performed, based on patient-specific data and Monte Carlo calculations, and evaluated retrospectively on clinical data.



Main interface of the OEDIPE software

ID Card:

Purpose:
Dose assessment in nuclear medicine

Use:
Need some skills in the field

Housed at:
Administered by IRSN, France

Training proposed on the software:
N/A

Address:
IRSN
31 avenue de la Division Leclerc
92260 Fontenay-aux-Roses
France

Access:
On demand/through collaboration

Internet link:
http://www.irsn.fr/EN/Research/Scientific-tools/Computer-codes/Pages/OEDIPE-Personalised-dosimetric-evaluation-tool-3443.aspx

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Related to:
MELODI
EURADOS

OEDIPE, a software for personalized Monte Carlo dosimetry and treatment planning optimization in nuclear medicine: absorbed dose and biologically effective dose considerations, Petitguillaume A. et al. (2014), Radioprotection, 49 (4), 275-281
Three-dimensional personalized Monte Carlo dosimetry in ^{90}Y resin microspheres therapy of hepatic metastases: nontumoral liver and lungs radiation protection considerations and treatment planning optimization, Petitguillaume A. et al. (2014), J. Nucl. Med., 55, 405-413

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