

Transnational
Access to Large
Infrastructure
for a Safe
Management
of ActiNides



Pooled Facilities



www.talisman-project.eu

Safety issues are of fundamental importance for the acceptance and sustainable application of nuclear energy. A fundamental understanding of actinide properties and behaviour in fuel materials during the separation processes and once in geological repository is an imperative prerequisite to tackle all the related safety issues.

To meet the needs of the safe and sustainable management of nuclear energy, it is essential to maintain the highest level of expertise in actinide sciences in Europe and to prepare the next generation of scientists and engineers who will contribute to develop safe actinide management strategies.

Because actinides are radioactive elements, only a few academic and research organisations have the capabilities and licenses to work on these elements under safe conditions.

In the continuation of ACTINET-6 and ACTINET-13, TALISMAN will foster the networking between existing European infrastructures in actinide sciences and open their doors widely to any European scientists by offering and supporting transnational access to unique facilities.

It also enhances the efforts made to support education and training issues by continuing the ACTINET Summer School series and travel grant attributions for attending international conferences.

Thorsten Schäfer

WP Leader in charge of the networking between Pooled Facilities and Users within TALISMAN

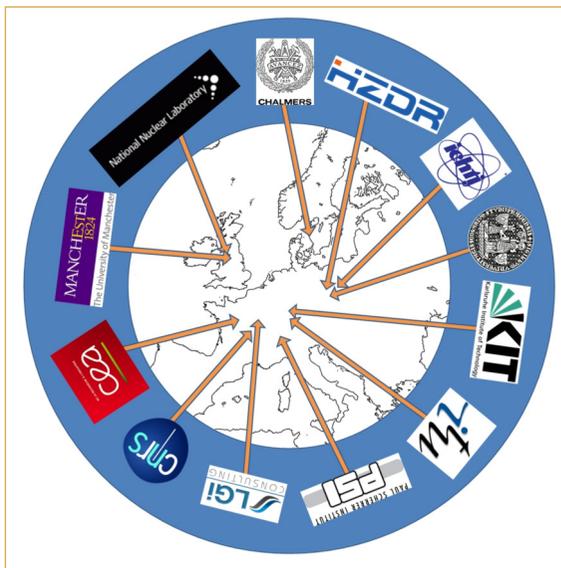
*Transnational Access to Large Infrastructures
for the Safe Management of Actinides*



TALISMAN: Transnational Access to Large Infrastructure for a Safe Management of Actinides

TALISMAN aims to reinforce networking and facilitating the use of existing European infrastructures in actinide sciences in order to keep a leading position in the field of nuclear energy.

To this end, the TALISMAN pooled facilities are accessible as a multi-site user facility for selected joint research activities. The pooled facilities offer includes:



- CEA, Commissariat à l'Énergie Atomique et aux énergies alternatives (*France*)
- CHALMERS, Chalmers Alpha and Fuel Laboratories (*Sweden*)
- EC-JRC-ITU, European Commission, Joint Research Centre, Institute for Transuranium Elements (*Germany*)
- HZDR-IRE, Institute of Resource Ecology, Helmholtz-Zentrum Dresden-Rossendorf (*Germany*)
- KIT-INE, Institute for Nuclear Waste Disposal, Karlsruhe Institute of Technology (*Germany*)
- Micro-XAS beamline at the Swiss Light Source, PSI, Paul-Scherrer-Institut (*Switzerland*)
- NNL, National Nuclear Laboratory (*United Kingdom*)

The pooled facilities are laboratories licensed and equipped with infrastructure and know-how for handling radioactive material at various levels of activity and under controlled conditions, with access to analytical techniques and characterisation methods.

TALISMAN pooled facilities are the sites of joint research projects proposed by European institutions and organisations. These research projects potentially address all the major fields of basic actinide sciences, keeping in mind the potential applications for the production of nuclear fission energy and the safety of nuclear waste disposal, and include:

- Actinide separation chemistry
- Actinides in the geological environment
- Actinide materials



More information
www.talisman-project.eu



The LN1 Laboratory within the ATALANTE facility in Marcoule is dedicated to molecular chemistry of all actinides in solution, solid state and at interfaces. It brings together selected techniques to obtain structural information, speciation and thermodynamic properties. Four gloveboxes are dedicated to classical chemical experiments, essential to synthesise and purify specific actinide compounds. Nine other gloveboxes are used for the preparation of samples before examination by the different techniques. The experimental results can be compared with theoretical approach of phenomena, with the help of experts in modelling in the team LILA.



CEA (Commissariat à l'Energie Atomique et aux énergies alternatives)
Marcoule, France

★ The chemistry gloveboxes and fume hoods are dedicated to:

- Purification and analysis of the actinides mother solutions
- Dissolution, dilution, solvent extraction, centrifugation, cristallisation...
- Classical analysis like pH measurements, UV-visible spectrometry, water measurements

An inert glovebox (argon) is under commissioning.

★ The analytical equipment, each connected to gloveboxes, is:

- Mass spectrometry (quadruple ion trap equipped with Electro spray Ionisation and Atmospheric Pressure Chemical Ionisation interface)
- FTIR spectrometry with 2 detector types for medium and far infrared and an ATR device
- Raman spectrometry equipped with optic fibres and 2 excitation lasers (633 and 532nm)
- Microcalorimetry (two titration microcalorimeters for inactive studies (Thermometrics and ITC) and one connected to a glovebox)
- Time resolved Induced laser Fluorescence Spectroscopy equipped with a pulsed Nd-Yag laser,
- 400MHz NMR spectrometry dedicated today to liquid samples
- Diffractometry 4 circles
- Alpha and gamma spectrometry



The work on any radionuclide is allowed with limits set by regulations and dose rates at the work bench. The laboratory is open to national and international researchers since 2009.

■ More information
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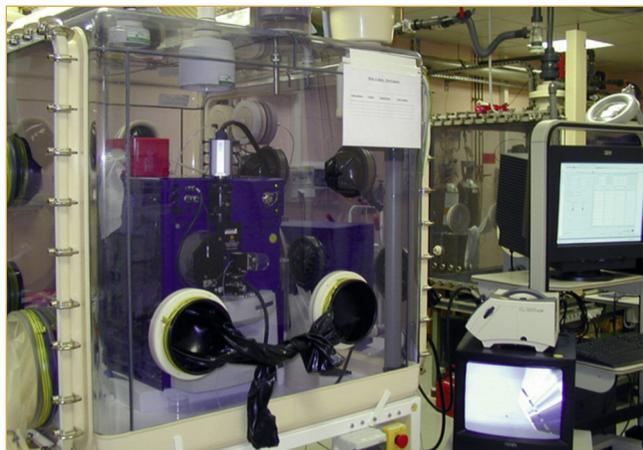


DPC Analytical Platform



CEA (Commissariat à l'Énergie Atomique et aux énergies alternatives)
Saclay, France

The Department of Physico-Chemistry (DPC) at the CEA Saclay Centre has a large panel of analytical tools for applied research related to the development of sustainable nuclear energy. Experimental studies are carried out in several fields among which isotopic and element measurements of radioactive samples (including dissolved used fuels), and speciation of actinides in solution. Therefore, the DPC comprises analytical and chemical laboratories and in particular a hot lab facility composed of gloveboxes and nuclearised instruments.



Within the TALISMAN network the DPC can propose the following techniques, all implemented in gloveboxes:

★ Instruments for isotopic and elementary analysis of radioactive solutions:

- Thermo-ionisation mass spectrometry (VG II and Sector 54)
- Multi-Collection ICP-MS (Isoprobe N) equipped with a reaction-collision cell
- ICP-MS (Thermo Scientific X7) coupled with HPLC
- Gloveboxes for preparation and separation on gravimetric columns

★ Instruments for elementary analysis of solids:

- Laser-induced breakdown spectroscopy (LIBS)

★ Instruments for speciation analysis of actinides in solution:

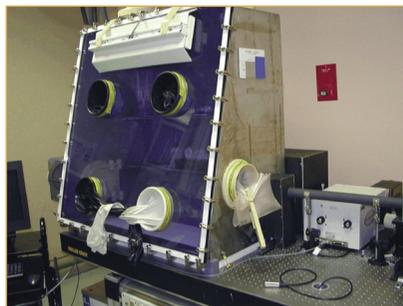
- Time-Resolved Laser-Induced Fluorescence Spectroscopy (TRLIFS) with tuneable excitation and a temperature-controlled sample cell (0-80°C)
- Nano-Electrospray Mass Spectrometry (nanoESI-MS) with a triple quadrupole for MS-MS

★ Part of the work at the DPC focuses on:

- Highly precise elementary, isotopic and radiochemical analysis on radioactive material
- Study of speciation (characterisation, coordination chemistry, measurement of basic thermodynamical and kinetic data...) of radionuclides and molecules in relevant media for nuclear fission energy
- Development and implementation of innovative techniques



ES-MS + HPLC Inactive laboratory



TRLIFS In glove box

More information
www.cea.fr

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Chalmers Alpha and Fuel Labs



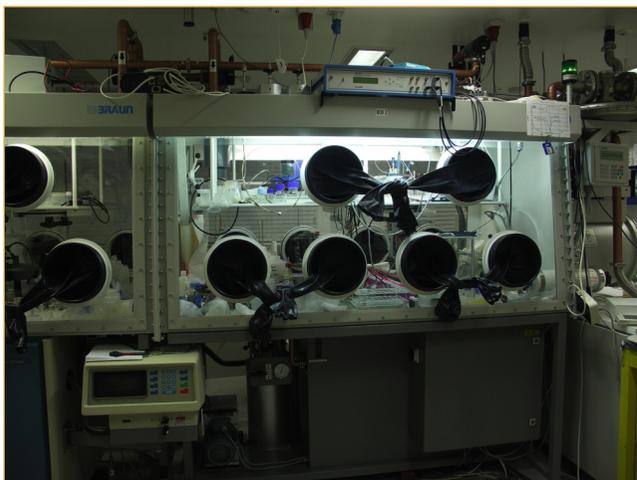
Nuclear Chemistry at Chalmers University of Technology is one of very few universities in the world that has fully equipped laboratories for work with gram amounts of alpha-emitting nuclides as well as gamma sources. A new nuclear fuel laboratory also allows the production of nuclear fuel pellets containing U, Pu and Am using the sol gel as well as a dry route.



CHALMERS

Chalmers University of
Technology, Gothenburg,
Sweden

- Work in this lab is limited to 100 g Pu and 10g of Am. All work with alpha emitters is performed in gloveboxes. The gamma laboratory is equipped with a hot cell that allows the work with up to 370 GBq of Co-60. This hot cell can be used e.g. for work with aged, used nuclear fuel.
- The analysis equipment includes HPGe, PIPS and LSC detectors for radiation measurements as well as centrifuges (AKUFVE) and mixer-settler systems for fast and accurate solvent extraction studies. The extraction equipment is available in plastic as well as metal versions to make studies of all types of extraction systems possible.
- There are also XRD, SEM, ICP-MS and ICP-OES that, unlike at most other laboratories, can be used for radioactive samples. A strong Co-60 irradiation source (18 kGy/h) for large volume samples is available as well as some weaker Cs-137 irradiation sources.
- Collaboration with Maxlab in Lund, Sweden, makes it possible to perform EXAFS studies on solid and liquid radioactive sources, including actinides.
- Thus it is possible to perform most types of thermodynamic investigations as well as small scale solvent extraction process tests. It is also possible to study radiolysis in a wide range of dose rates. Studies of alpha radiolysis with At-211 are also possible; this nuclide is short-lived and leaves a solution that can be treated as non-radioactive. Fabrication and investigation of novel nuclear fuels is possible as well as fabrication of dedicated fuels for e.g. fuel dissolution studies.



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ITU Laboratories & Hot-Cells



ITU (Institute for Transuranium elements), Joint Research Centre, Karlsruhe, Germany

The mission of ITU is to protect European citizens against risks associated with the handling and storage of highly radioactive elements. ITU's prime objectives are to serve as a reference centre for basic actinide research, to contribute to an effective safety and safeguards system for the nuclear fuel cycle, and to study technological and medical applications of transuranium elements.

To fulfill its various tasks, the Institute for Transuranium Elements, part of the Joint Research Centre from the European Commission, is provided with a large number of equipment and unique facilities. ITU's special facilities consist of 24 hot cells with capacities up to 1 Mio Curies and some 400 gloveboxes in 30 alpha laboratories. Within the scope of the ACTINET Project, the following facilities become accessible*. They are installed in alpha boxes or are specially equipped for handling actinide compounds. Some of them are also lead-shielded to receive samples with high gamma-activity.

★ Instruments for solid-state properties of actinide compounds:

- 237Np Mössbauer spectroscopy
- SQUID magnetometry
- Low temperature and room temperature transport properties at ambient and high pressure (diamond cells)
- High pressure X-ray diffractometry

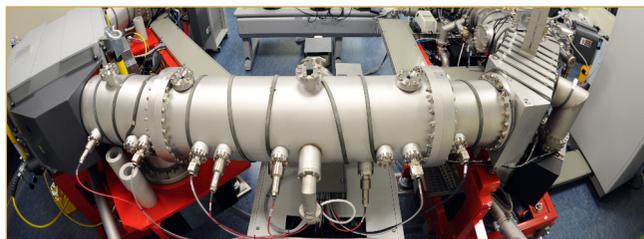
★ Instruments for the study of thermodynamics, thermophysics and radiation damage:

- Low- and high-temp calorimetry
- Knudsen cell with mass spectrometer and gas-inlet control
- Q-GAMES (quantitative Knudsen cell exhaust gas measurement device)
- Thermal diffusivity
- Thermal analysis for phase transitions and phase diagram measurements (laser heating, DSC)
- High-resolution electron microscopy (TEM/STEM/EDAX)
- High-temperature X-ray diffraction

★ Instruments for analytical or solid-liquid interface chemistry:

- Electron microprobe
- ICPMS
- SIMS
- XPS, UPS
- Scanning electron microscopy (SEM/EDAX) with micro-manipulator
- Analytical laboratory for traces and ultra-traces
- Autoclaves (up to 80 bar) for leaching experiment with oxygen and hydrogen activity sensors
- Controlled thin film deposition
- Quartz-nanobalance
- Electrochemistry cells
- Alpha spectrometry

* The use of some facilities within ACTINET may be restricted because they are also allocated to the Actinide User Laboratory, which is funded by other sources.



■ More information
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KIT-INE (Karlsruhe Institute of Technology - Institute for Nuclear Waste Disposal)
Karlsruhe, Germany

The Institute for Nuclear Waste Disposal (Institut für Nukleare Entsorgung - INE) belongs to the newly founded Karlsruhe Institute of Technology (KIT), a fusion between the Karlsruhe Research Center of the German Helmholtz Association and the University of Karlsruhe. INE research activities focus on the geochemical aspects of long-term safety of nuclear waste disposal. Sound expertise and state-of-the-art, advanced analytical techniques are available for actinide speciation and geochemistry, investigation of actinide migration, as well as research into partitioning and the vitrification of high level liquid waste.

KIT-INE has a number of facilities available as a pooled facility within the scope of the TALISMAN Project. The active laboratories at KIT-INE are licensed and equipped for working with radionuclides of all types including reactor fuels and alpha emitters. The INE-laboratories with their state-of-the-art equipment and instrumentation are located in one building complex. The INE-Beamline for actinide research is also available as a TALISMAN pooled facility for X-ray spectroscopy investigations and is located on the same KIT site, not far from the INE laboratories.

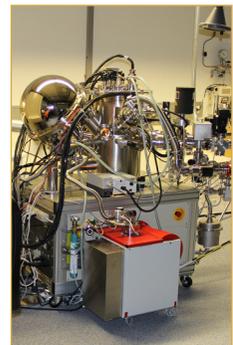
The following facilities and techniques are offered:

★ Actinide laboratories

- Hot cells (spent nuclear fuel experiments)
- Gloveboxes, partly with inert gas atmosphere (e.g. dedicated to migration experiments, speciation)
- Classical radio-analytical methods (α , β , γ -spectroscopy, autoradiography)
- ICP-OES, ICP-MS, high resolution ICP-MS coupled to glovebox, Laser-ablation, Ion chromatography, X-ray fluorescence, X-ray diffractometry
- Scanning electron microscopy, ESEM-EDX

★ Actinide speciation techniques

- Chemical speciation (e.g. Capillary electrophoresis-ICP-MS; Field flow fractionation-ICP-MS)
- Photoelectron spectroscopy, XPS, atomic force microscopy, AFM, Raman microscopy
- Laser spectroscopy
 - Time resolved laser fluorescence spectroscopy - TRLFS
 - Laser-induced breakdown detection -



LIBD partly combined with inert gas gloveboxes

- Multifunctional X-ray spectroscopy (XAFS) beamline for actinides (see separate description)
 - Experiments with activities up to 106 times the limit of exemption
 - Various detection schemes and sample environments
 - XAFS, GI-XAFS, PFY-XAFS, RIXS, micro(μ)-focused studies possible

■ **More information**
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INE Beamlines



KIT-INE (Karlsruhe Institute of Technology - Institute for Nuclear Waste Disposal) Karlsruhe, Germany

The INE-Beamline (INE-BL) at the synchrotron source ANKA located on the KIT North Campus, close to the INE controlled area labs, is dedicated to actinide speciation investigations related to geochemical aspects of nuclear waste disposal as well as applied and basic actinide research.

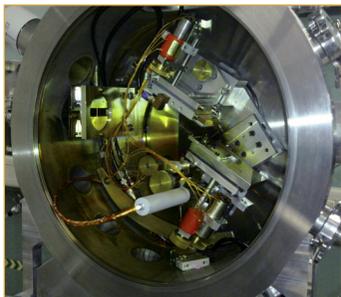
Investigations on non-fissile radioisotopes up to 10E+6 times the legal exemption limit and fissile radioisotopes (Pu-239, U-235) up to 200 mg, contained within two layers of protection, are possible at the INE-

- Compact Lemonnier-type double crystal monochromator (DCM) built at the University of Bonn, allowing fixed exit operation and fast crystal changes (presently available: Si(111), Si(311), Ge(422), InSb(111))
- Collimating and focusing mirrors for a sub-mm beam dimension at the sample position. Auxiliary μ -focusing with single bounce and polycapillary half-lenses available
- Sample positioners / goniometers and auxiliary slits for standard XAFS and surface sensitive GI-XAFS
- Johann spectrometer for high resolution emission measurements (PEX-XANES, RXS)
- Detectors available: fluorescence detectors (5 pixel high purity germanium, Vortex silicon drift detector) with digital detector read-out, image plates for μ -XRD, small area high resolution CCD, a calibrated PIN diode, ionisation chambers
- Various sample environments available, including liquid N₂ cryostat, spectro-electrochemical cell, inert gas containments
- Infrastructure for working with radioactive samples including sealed media feed-through chicanes, ventilation / filter system, hutch access through lock-room with hand/foot-contamination monitor

| Standard methods | monochromatic beam (2.1-25 keV) |
|---------------------|--|
| XAFS | characterization of bulk species |
| XAFS/XRD | correlate phases with pair distributions |
| XRF | determine concentration of species |
| Quick-EXAFS | study dynamic structural changes |
| Surface sensitive | grazing incidence techniques |
| GI-XAFS | characterization of surface sorbed species |
| GI-XRD* | identification of secondary phases on surfaces |
| X-ray reflectivity* | determination of surface layer thickness/roughness |
| Standing wave | characterize surface species structure |
| Spatial resolution | focused beam for "micro" or μ -technique |
| μ -XAFS | chemical state imaging |
| μ -XRF | elemental mapping |
| μ -XRD | identification and distribution mapping of phases |
| Energy resolution | wavelength dispersion of emission |
| HRXES | high resolution X-ray emission |
| RIXS | resonant inelastic X-ray scattering |
| Combined methods: | combined x-ray methods or other techniques |

*under development

Methods available at the INE-Beamline for actinide research at ANKA (KIT)



Double crystal monochromator

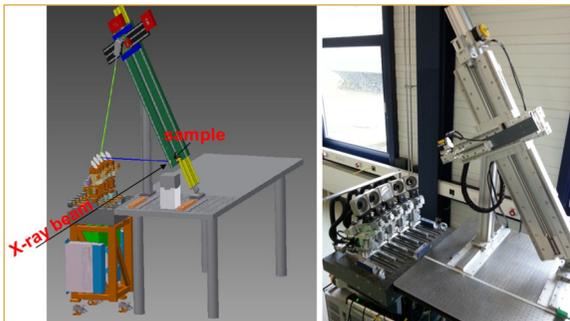
BL. A special protocol for working with radioactive samples at the INE-BL exists and is supervised by INE's own radiation protection officers.

The experimental instrumentation at the INE-BL has a modular design (see Table), with emphasis on X-ray spectroscopic investigations. The available energy range (~2.1-25 keV) covers key energy regions of

interest for investigations of actinides (L3 edges ~16 – 20 keV) and lanthanides as their homologues (L-edges ~5.5 – 11 keV).

★ Beamline specifics:

- Photon energies from the K-edge of P (2.1 keV) to the Pd K-edge (25 keV)



INE-Beamline: schematic set-up

More information <http://www.anka.kit.edu/english/981.php>

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HZDR Rossendorf Beamline



The HZDR Institute of Radiochemistry operates an X-ray absorption spectroscopy (XAS) station specifically designed for radiochemical experiments at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. The objective of this radiochemistry station is the identification, structural characterisation, and quantification of radionuclide species in a wide variety of matrices, ranging from alloys to liquids to environmental samples.

HZDR

HZDR - ROBL
(Helmholtz Zentrum Dresden
Rossendorf – Rossendorf
Beamline) located at ESRF,
Grenoble France

Due to the high brilliance of the ESRF and the beamline's solid-state fluorescence detector, a lower detection limit of tens of ppm is achieved up to the actinide L1-edges, making this beamline specifically suited to study radionuclides in aqueous and non-aqueous solutions, colloids, micro-organisms and plants, soils and sediments, and other dilute systems.

- Sample preparation, transport of the samples to the ESRF and back home, and the experiment itself has to meet specific guidelines reinforced by the ESRF Safety Group

★ Equipment

- Monochromator to cover XAS K-edges from vanadium to iodine, and L-edges from iodine to californium (see Table Optics)
- Ion chambers for transmission XAS
- 13-element Ge solid state detector (Canberra) with digital signal processing for fluorescence XAS with high energy resolution and high count rate
- Closed-cycle He cryostat (sample temperature 20 K) with large exit window for fluorescence detection
- Spectro-electrochemical cell for in-situ redox modifications
- Automatised sample stage for up to 8 samples
- Radiochemical safety system including a glovebox
- Permission to run actinides and other radionuclides (see non-exclusive list below) with an activity up to 185 MBq
- A range of certified sample holders for radionuclide samples

★ Access

- Up to 21 days of in-house beamtime are provided for collaborations between the HZDR and other partners within TALISMAN
- Each experiment must be discussed for technical feasibility and safety issues with the responsible beamline scientist before beam time can be scheduled



■ More information
[http://www.esrf.fr/
UsersAndScience/
Experiments/CRG/BM20/](http://www.esrf.fr/UsersAndScience/Experiments/CRG/BM20/)

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HZDR Laser Laboratory

HZDR

HZDR-IRE (Institute of Resource Ecology, Helmholtz-Zentrum Dresden-Rossendorf) Dresden, Germany.

The goal of radio-ecological research at the Institute of Resource Ecology (HZDR-IRE) is the protection of man and its environment from the hazards caused by radioactive heavy metals, notably the actinides (thorium, uranium, neptunium, plutonium, curium and americium) in the geo- and biosphere.

★ Applications of the research performed fall into three major categories:

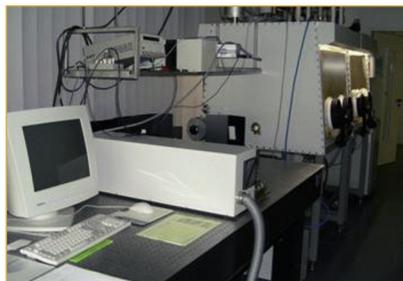
- Long-term safety assessment of nuclear waste disposal
- Determination of the environmental behaviour of radioactive contaminations due to accidents
- Development and validation of remediation measures to clean up the legacy of uranium mining

HZDR-IRE has the legal and technical framework to work with radionuclides up to 5×10^9 Bq per nuclide. HZDR-IRE pro-

vides a broad range of analytical methods; all of them installed in modern radiochemical laboratories with state-of-the-art equipment. S1-classified laboratories allow the handling of genetically modified organisms in a radiochemical laboratory.

★ Actinide laboratories:

- Actinide speciation by laser spectroscopy: Time-resolved laser-induced fluorescence spectroscopy – TRIFS (lifetimes > 20 ns: U(VI), Cm; lifetimes < 20 ns: U(IV), Am, Organics), Cryo-TRLFS (sample cooling: ≥ 4 K), tunable nanosecond and femtosecond laser systems (\rightleftharpoons excit.: 220–345 nm; 365–690 nm, 730–1,800 nm), detection range 300–1,500 nm, min. time resolution: picosecond range
- Vibrational spectroscopy – FT-IR, FT-Raman (in situ ATR technique for sorption and speciation studies; wavelength range: 4,000–10 cm^{-1})
- Confocal Laser Scanning Microscope (\rightleftharpoons excit.: 350–650 nm)
- UV-vis spectroscopy (long pass flow cell, max. path length: 2,500 mm)
- Standard and inert gas gloveboxes
- Classical radioanalytical methods (α -, β -, γ -spectroscopy / LSC)
- ICP-mass spectrometry coupled to a glovebox, ion chromatography, AAS
- (Micro-)Calorimetry, Isothermal titration calorimetry
- HPLC



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PSI MicroXAS Beamline



PAUL SCHERRER INSTITUT

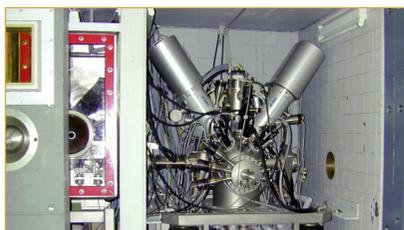


PSI (Paul Scherrer Institut)
Villigen, Switzerland

The Paul Scherrer Institute, with 1400 employees, is the largest research centre for natural and engineering sciences in Switzerland and a leading user laboratory. Its research activities focus on the main topics structure of matter, energy and environmental research as well as human health.

Based on the initiative and under the direction of the Laboratory for Waste Management (Department of Nuclear Energy and Safety, Paul Scherrer Institute), a high resolution hard X-ray microprobe station was built at the Swiss Light Source: the microXAS beamline. This analytical facility allows for the investigation of materials and matter by means of high intensity X-ray beams with a spatial resolution of approximately $1\mu\text{m}^2$.

The SIMS

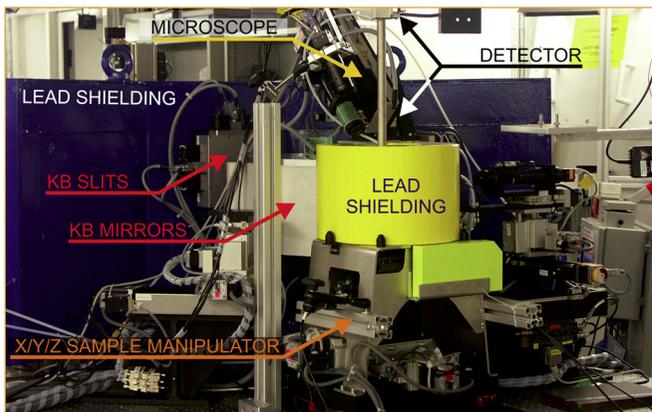


Without doubt, the capability to determine element-specific chemical properties such as local coordination environments or oxidation states by means of X-ray absorption spectroscopy is of fundamental importance. Using micro-focused X-ray beams, chemical speciation can be determined within single micro-domains simultaneously with local structural analysis. In particular the licence to investigate radioactive materials makes the microXAS beamline an exclusive X-ray microprobe facility.

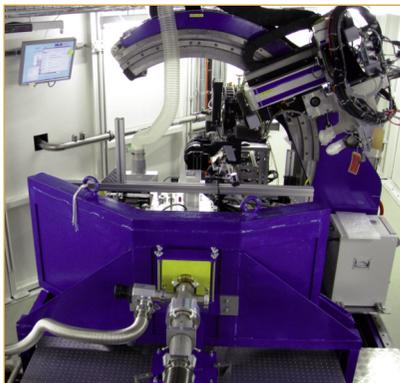
The microXAS beamline at the Swiss Light Source (SLS) is a microprobe facility optimised for X-ray absorption spectroscopy (XAS), X-ray fluorescence (XRF) and X-ray diffraction (XRD) experiments requiring high spatial resolution. It is designed for monochromatic and pink X-ray beams (~ 4 - 23 keV) with high flux and energy resolution combined with dynamic (sub-)micron focusing capabilities. The focal spot size can

be adjusted to the problem investigated ranging from a few mm^2 down to $1\mu\text{m}^2$. A minigap in-vacuum undulator (U19) provides high-brightness X-rays in the energy range of ~ 4 - 23 keV. This energy range covers most K- respectively L-edges of transition metals, lanthanides and actinides. Regarding beamline optics, a two-step focusing strategy is employed. By doing so, the following advantages result: maximised energy resolution, dynamic focusing and optimised acceptance.

Radioactive X-ray microprobe endstation



Radioactive x-ray microprobe endstation



■ Accommodation
The PSI Guesthouse provides on-site accommodation to visitors.

■ More information
<http://www.psi.ch/sls/microxas/micro-xas>

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NNL Central Laboratory



NNL (National Nuclear Laboratory) Sellafield, Seascale, United Kingdom

The National Nuclear Laboratory (NNL) is the United Kingdom's nuclear science and technology research organisation with a mission to support national programmes and deliver innovative solutions to customers. The NNL's flagship research facility, Central Laboratory, is located in Cumbria, North West England. It is designed to handle all types of radioactive material in a safe environment and is one of the most advanced facilities of its kind in the world.

The active laboratories contain a large number of fumehoods and currently eight gloveboxes. Four of these gloveboxes are

spectrometry to be carried out. Some of the gloveboxes also have feed lines that allow inactive chemicals to be pumped into them from the bench to feed equipment such as centrifugal contactors and mini mixer settlers. Classic solvent extraction and dissolution experiments are possible in an inerted atmosphere (nitrogen or argon) within the gloveboxes.

The laboratories contain analytical equipment to supplement the experimental work and development of analytical techniques is possible. The analytical techniques comprise:

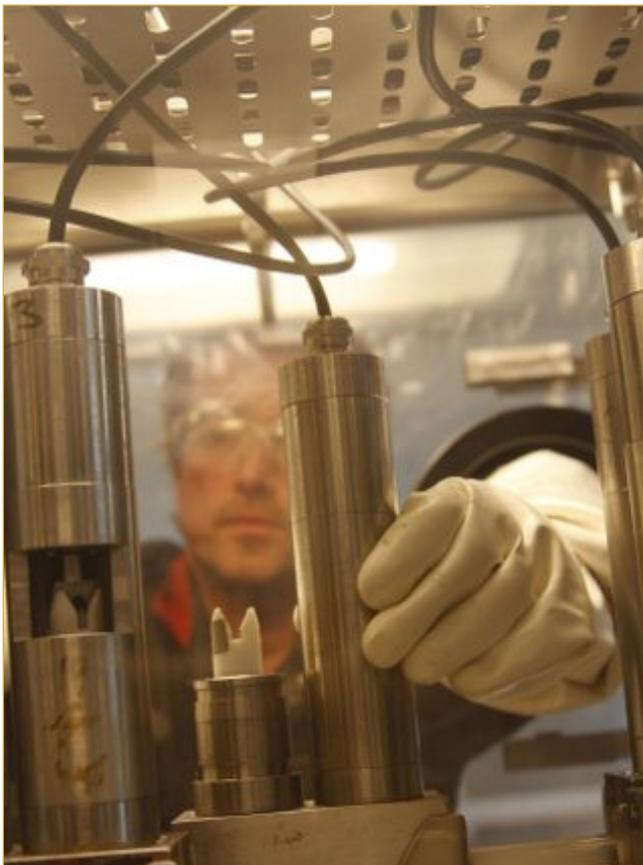
- Raman Spectrometry
- Time Resolved Laser Induced Fluorescence spectroscopy
- Gamma spectrometry
- Alpha spectrometry
- Liquid scintillation counting
- UV/vis/nIR spectrometry

Recent Research Council funding, via the University of Manchester, has procured some new analytical equipment including:

- Agilent Gas Chromatograph Mass Spectrometer 5975 C
- Agilent uv-Visible Infrared Spectrometry 8453
- Perkin Elmer NexION 300D ICPMS
- Bruker D8 Advance X-Ray Diffraction device

These world class facilities have already started opening up to national and international researchers and will continue to do so. Dedicated support and supervision is available from their very experienced scientists while their facility experts ensure work is conducted safely and within the confines of their safety case.

housed in the Ivan Owens Laboratory and are used for research into actinide chemistry, e.g. solvent extraction, ion exchange, redox kinetics, mass transfer etc. The gloveboxes are fitted with fibre optic bulkheads that allow UV/vis spectrometry and Raman



■ **More information**
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*Transnational Access to Large Infrastructures
for the Safe Management of ActiNides*

TALISMAN



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