PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut

Gavillet Didier

Division HOTLABOR (AHL) / The Hot Laboratory

Core competences and projects

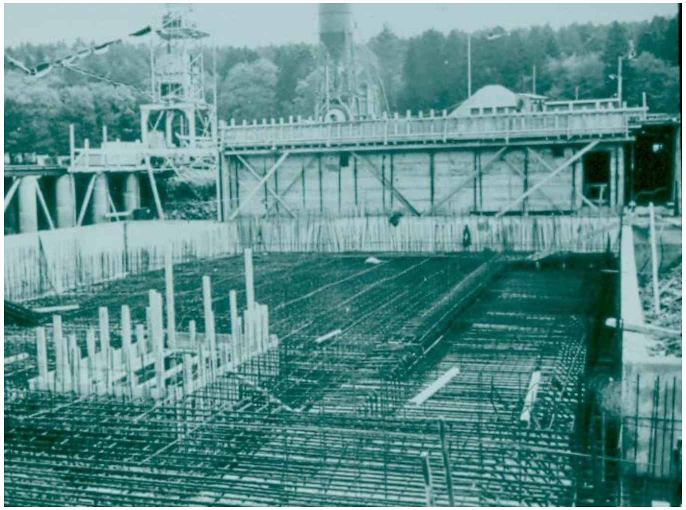
Outline of the presentation

- AHL / HOTLAB history and actual situation
- Mission / Strategy / Goals
- Core competences
- Highlights and Projects
- Conclusion

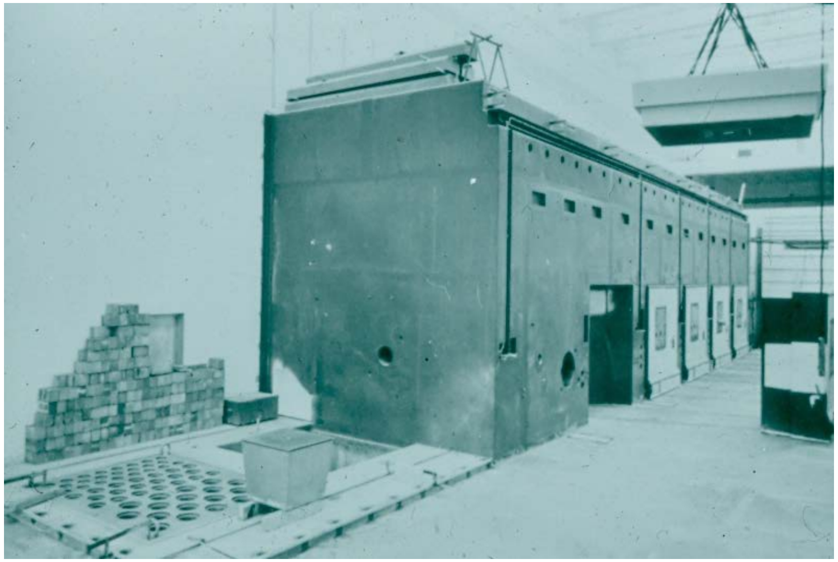
PSI Hot-Laboratory

History and Actual situation

HOTLABOR

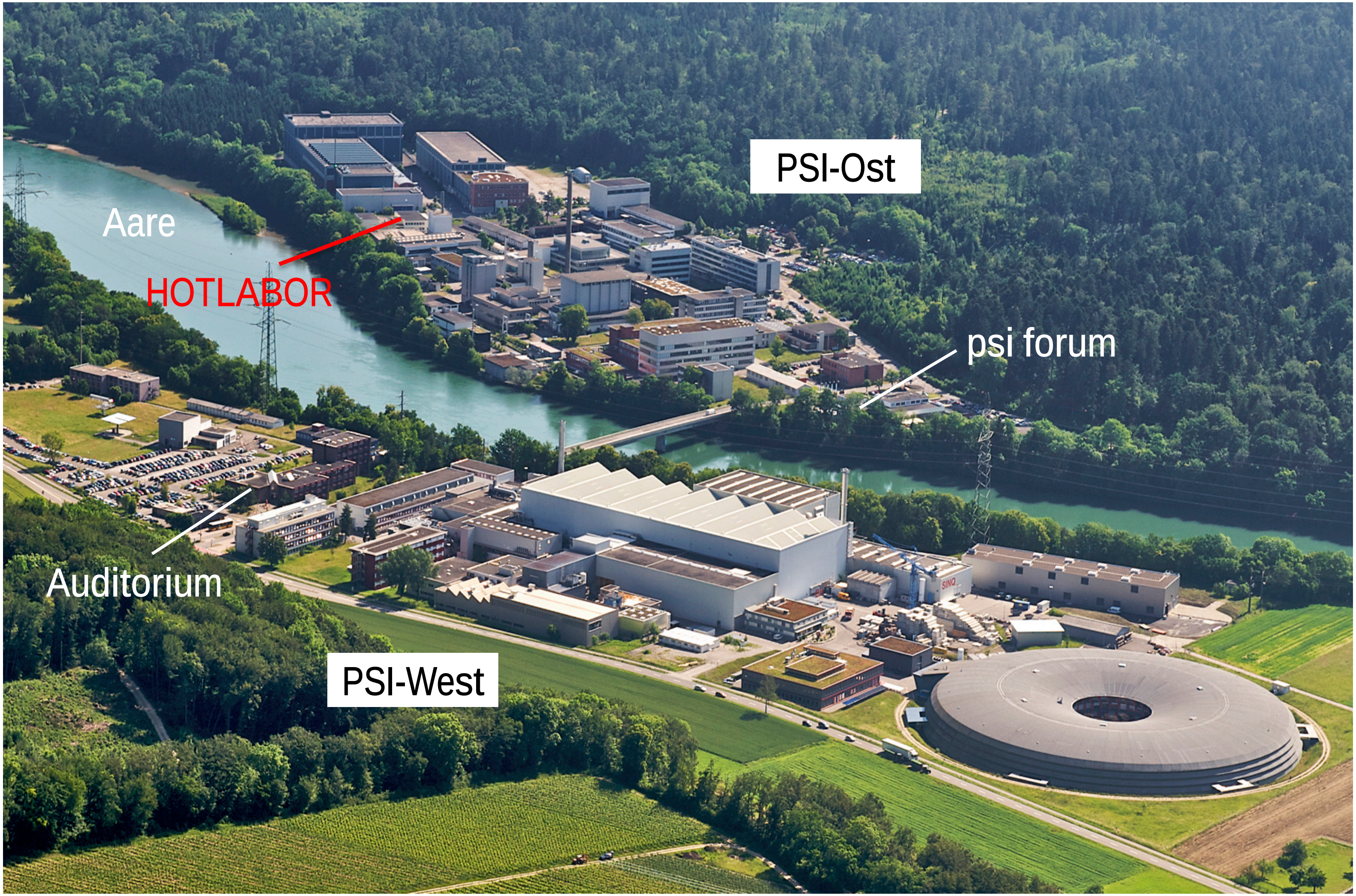


- The HOTLAB was
  - *designed in 1960*
  - *built between 1961 – 1963*
  - *inaugurated in October 1963*
  - *licensed in 1964 (unlimited)*
  - *till 1988: part of EIR*
  - *from 1988: part of PSI*



Hot-Cells

HOTLABOR



Legal Framework

- The renewal of the operational licence is on going
- The ENSI has completed the review of the safety report
- The process goes further with the Canton hearing and finally with the public hearing
- We expect a renewal of our license in about one year for now

Open problems / difficulties:

- Missing Earthquake-resistance proof → some refurbishment are needed
- Maximum inventory in the lab (limited due to the missing proof of the earthquake resistance)

Mission / Strategy / Goals

AHL Vision / Mission

- safe and efficient operation of the Hot laboratory
- Swiss competence centre for the handling and analysing highly radioactive materials including nuclear fuel
- contributes to the safe operation of the Swiss power plans
- supports PSI and external research groups for the handling, the preparation and the analysis of radioactive specimens
- develops and improves its analytical methods in the interest of the users of the lab

AHL operational goals

- AHL pursue a safe and efficient operation of the hot laboratory
- AHL develops and imposes a good safety culture in the facility.
- AHL pursue the renewal of the operational license with an attractive material capacity

AHL scientific goals

- keep and improve its competences and the needed infrastructure for the scientific investigation of LWR fuel pin
- keep and improve its competences and infrastructure for the scientific investigation of radioactive materials
- develop new preparation and analysis methods to better support all user of the laboratory

AHL scientific goals

- develop its capacity to produce very small specimens at specific location out of highly radioactive materials (FIB)
- keep the capacity to handle, treat and analyze small amount of fresh fuel (reference material; confiscate, Test material, …)

AHL strategic goals

- be the Swiss competence center for the analysis of radioactive materials
- conducts research work in collaboration with other users of the laboratory or as partner in international research projects in order to improve and acknowledge its core competences
- stay attractive for young technicians and scientists

Core competences

AHL core competences

- Operation of a nuclear facility
- Safety culture
- Handling, investigation and conditioning of highly radioactive materials
- Preparation and analytical investigation of radioactive materials (structure, chemical composition, material isotopic composition, failure mechanisms, …)
- Readiness and flexibility for immediate support to nuclear operators in Switzerland

Specificity of the Hot Laboratory

The hot laboratory is a building with the specific infrastructure for insuring the safety and security for the handling and analysis of radioactive materials

Specific Infrastructure

- Ventilation / under-pressure
- Water treatment / control
- Radioprotection
- Bookkeeping / Documentation
- Safety and Security

Operation of the hot laboratory

Operation

- Ventilators (Hot cells)
- Filter banks
- Water treatment
- Waste preconditionning

Was ist eine HOTLABOR

Special tools

- Hot Cell chain (cement)
- Lead or Steel cells
- Glove boxes
- Shielded analytic tools

Organisation

Organisation des PSI-HOTLABORs

PAUL SCHERRER INSTITUT PSI

Stand 04. November 2013

Abteilung HOTLABOR

4300 D. Gavillet [1]

Stv.: D. Kuster

Stab

4300 M. Streit [3]		W
	S. Jacobi	S
	A. Lagotzki [4]	T

AHL-Externe selbständige HL-Benutzer

HOTLABOR-Users

4402	Tonsorptions-Mechanismen LES	B. Baeyens
4404	Diffusionsprozesse LES	L. van Loon
4406	Zementsysteme LES	E. Wieland
4601	Fortgeschrittene Nukleare Materialien	M. Pouchon
4602	Nuklearbrennstoffe	J. Bertsch
	Ausserhalb AHL-QM	
2414	Radwaste Analytics	D. Schumann

Hotlabor-Betriebsgruppe

Operation

4301	Ch. Gerber [2]	GL
Stv.:	J. Kallfass	T
	R. Breitwieser	T
	M. Keller	T
	M. Kollofrath	T
	K. von Allmen	T
	J. Wichser	T
	R. Zumsteg	T
	N.N.	

Hotzellen-Experimente

Hot Cell

Analysis of fuel rods

4302	D. Kuster	GL
Stv.:	R. Schwarz	T
	V. Boutellier	T
	S. Hahl	T
	R. Zeh	T
	H. Schweikert	T
	A. Spahr	T
	H. Wiese	T

Analyse of radioactive materials including nuclear fuels

Oberflächen- und Festkörperanalytik

4303	M. Martin	GL
Stv.:	R. Brütsch	W
	A. Bullemer	T
	N. Mine	PoD
	S. Portier	W
	R. Restani	W
	A. Urech	T
	R. Grabherr	T

Isotopen- und Elementanalytik

4304	N.N.	GL
Stv.:	H.-P. Linder	T
	N. Kivel	W/PhD
	M. Krois	T
	S. Nichenko	PoD
	H. Potthast	W
	P. Reichel	T
	N. Shcherbina	W
	L. Veleva	PoD

Highlight and projects

Support for research Projects (MEGAPIE)

- Innovative processing / optimisation / safety and flexibility

Scientific Service for Power Plant

- PIE of fuel rod. From reception to overcanning

Radioactive Material analysis

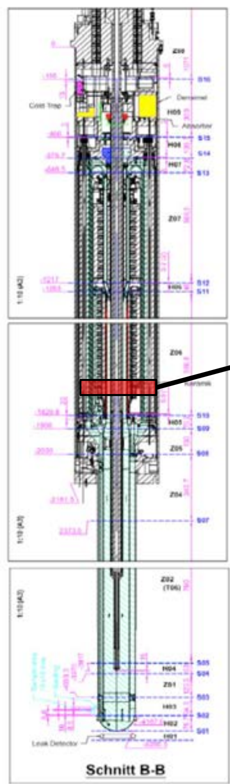
- Detailed analysis of radioactive materials
- Development of new tools

MEGAPIE

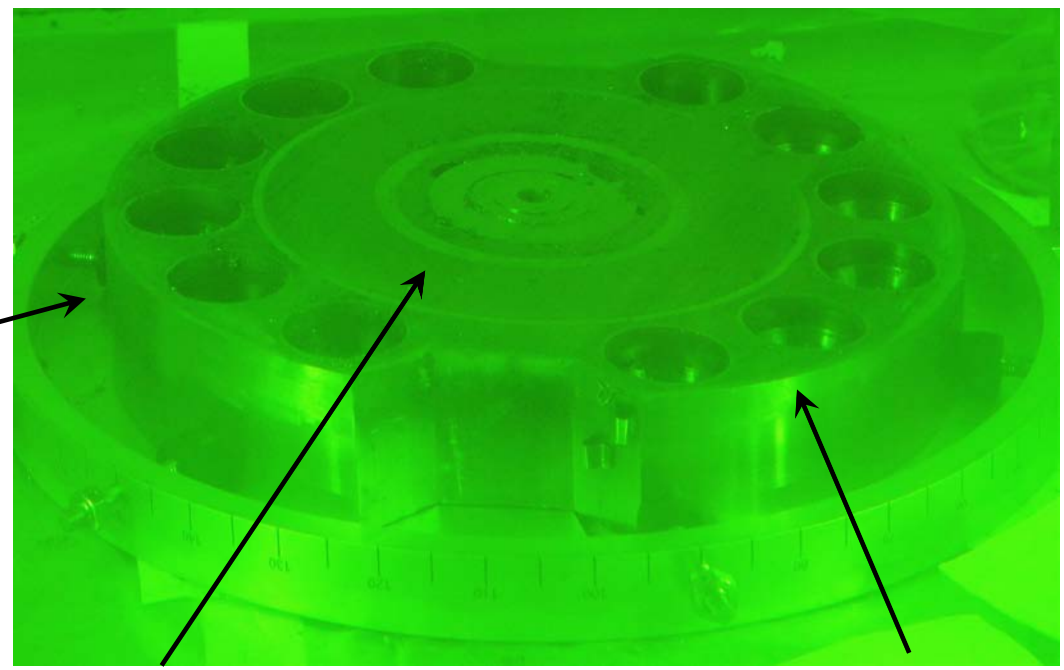
- Analysis and Specimen extraction in MEGAPIE Target
  (material behavior in liquid metal target)

Gamma mapping of the safety hull

Sectioning in ZWILAG



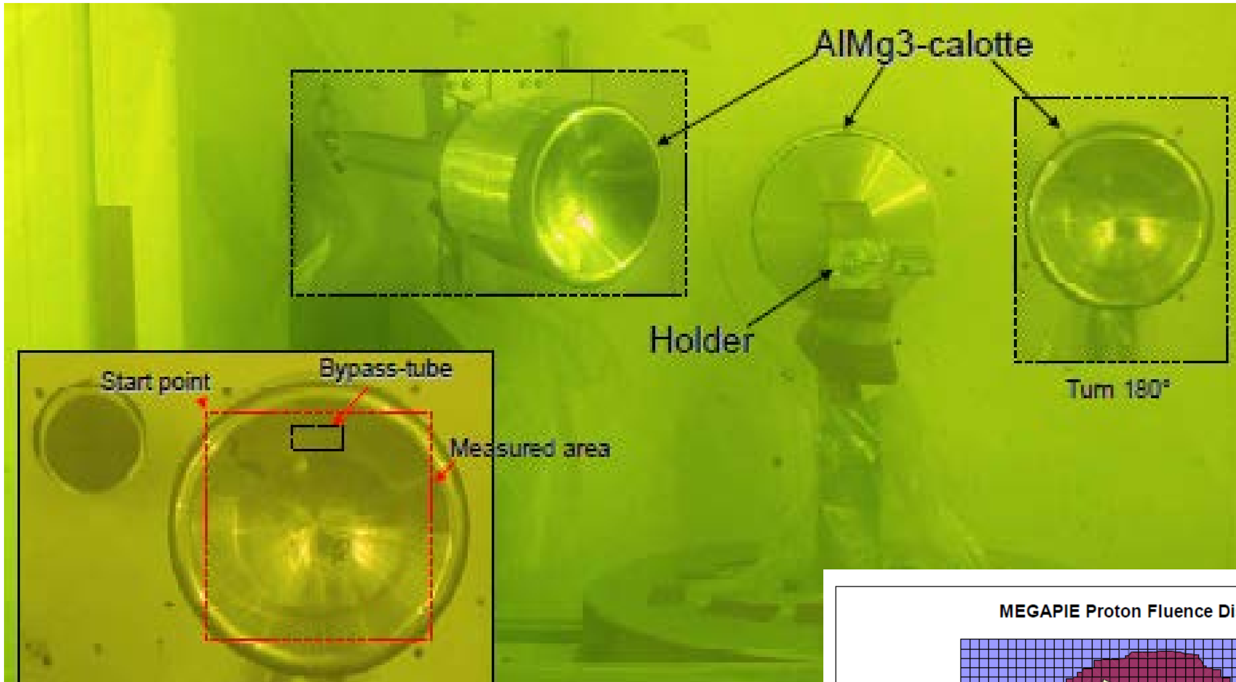
Specimen extraction in the hot laboratory at precise location

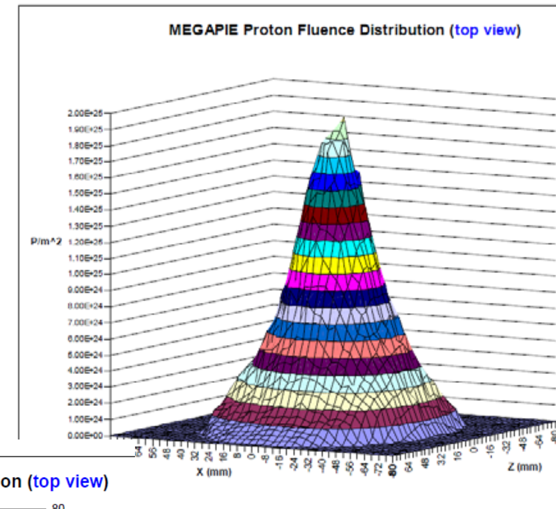


From LBE

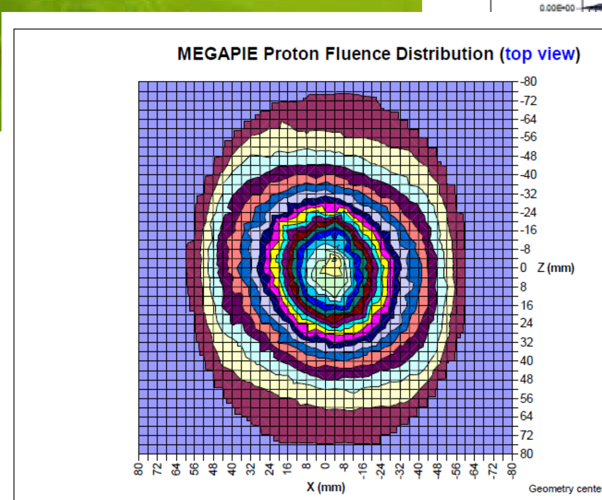
From steel

➢ Gamma-mapping of the MEGAPIE safety hull





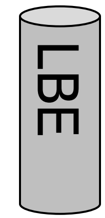
w of the proton fluence distribution.

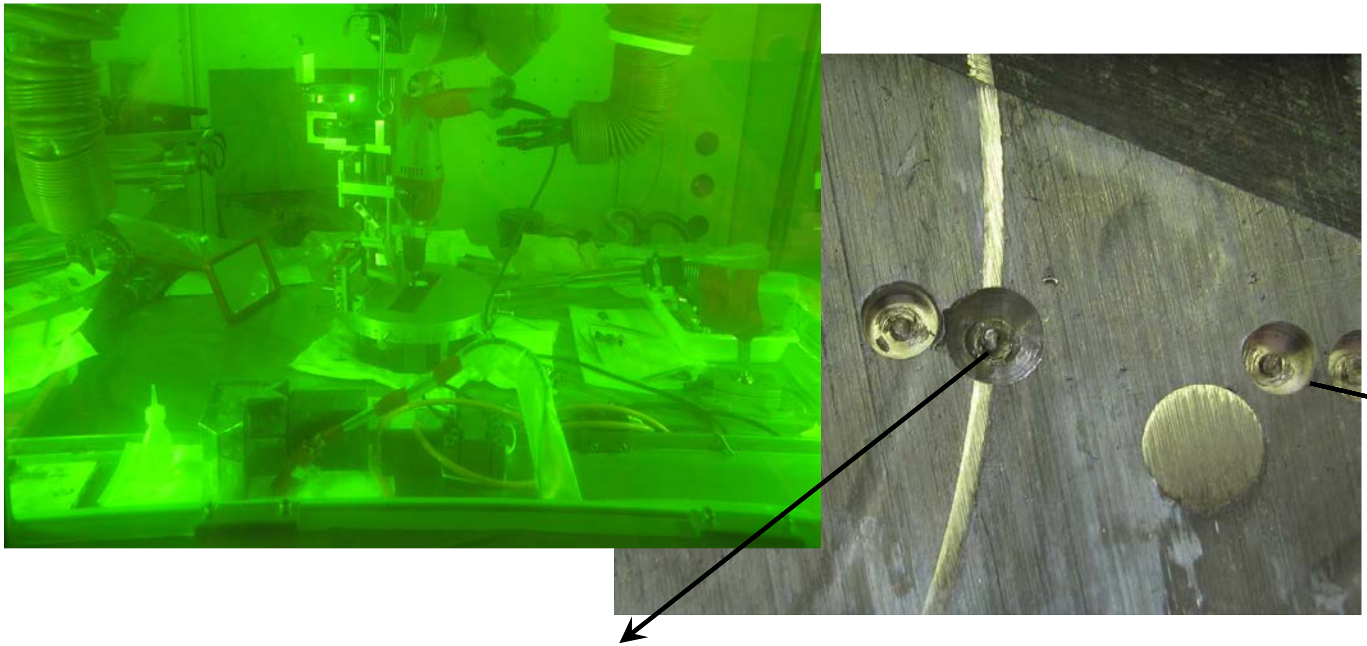


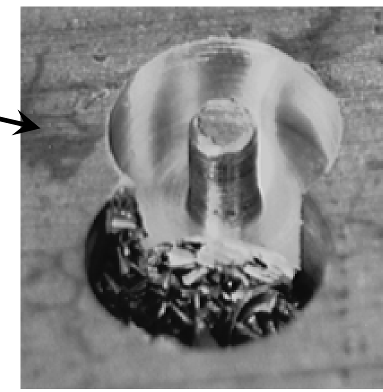
(1Sv/h in 1cm in center)

➢ Specimen extraction for LBE analysis

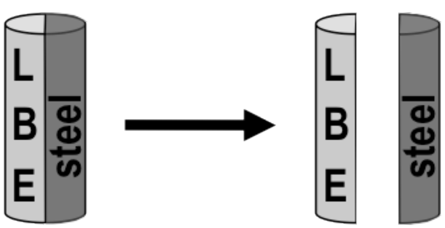
LBE specimen





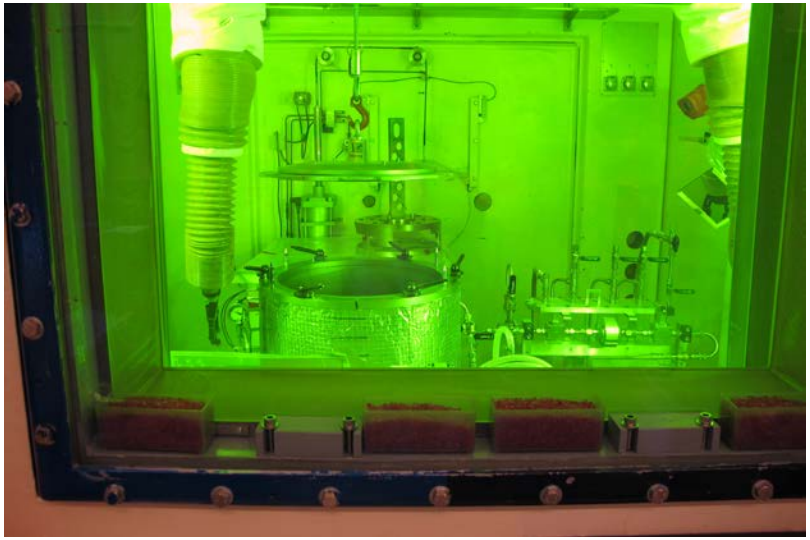


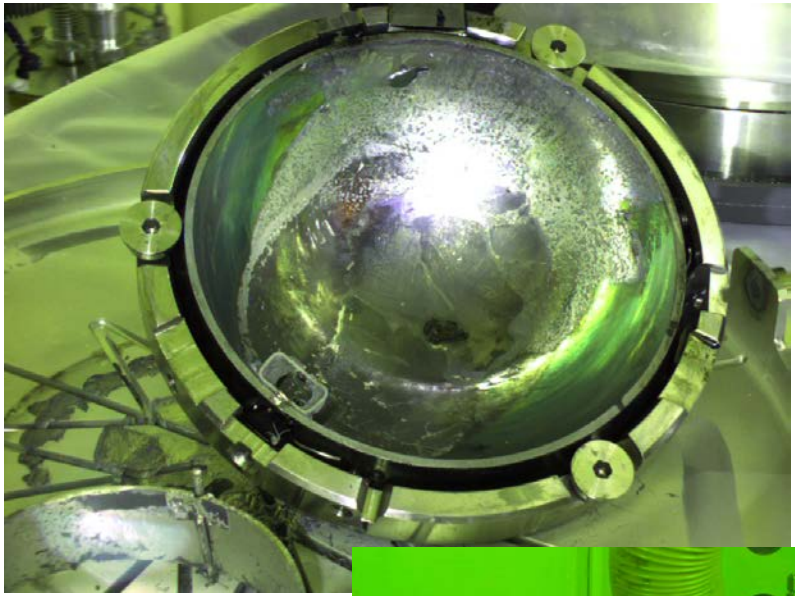
LBE specimen with steel

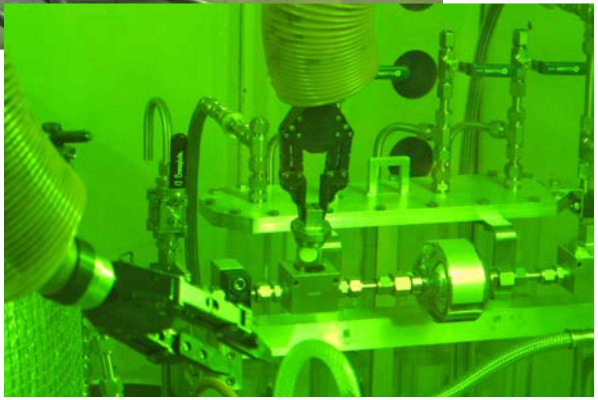


MEGAPIE

- LBE-removal out of MEGAPIE pieces (for structural material investigation)



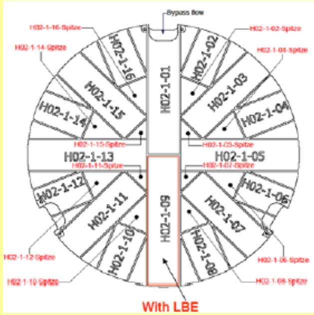




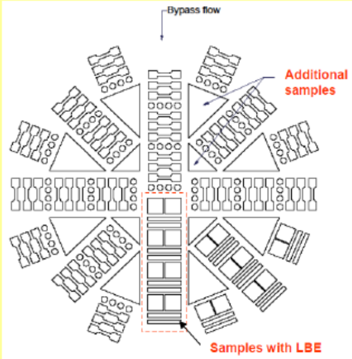
All LBE has been melted without large contamination of the cell

(this has proven the efficiency of the release protection measures)

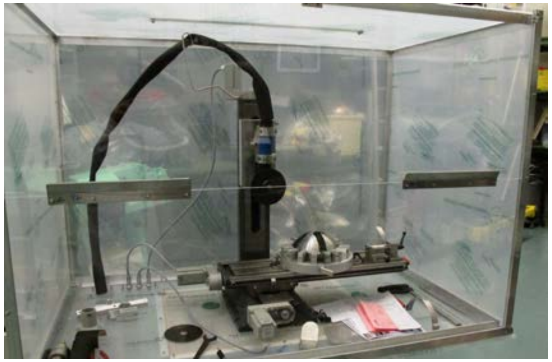
Tensile and TEM specimen preparation in steel



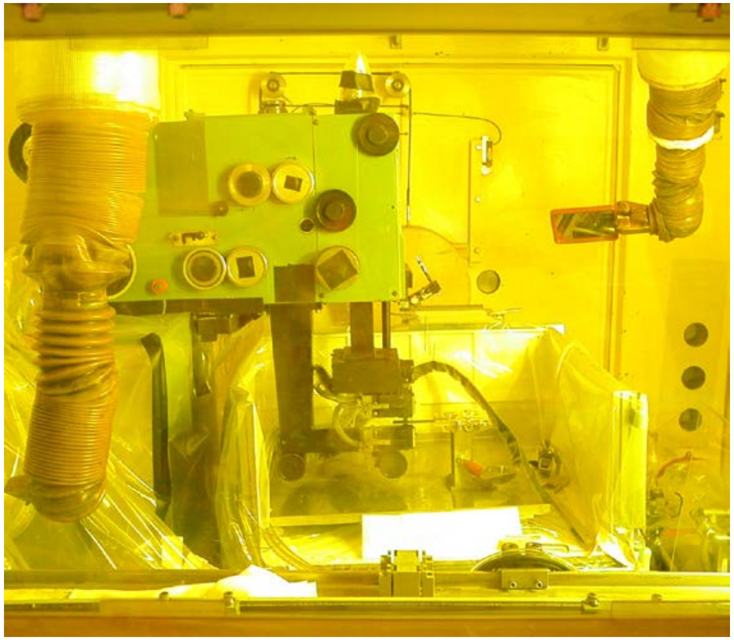
Plan for slicing the calotte into 16 large pieces



Samples to be extracted



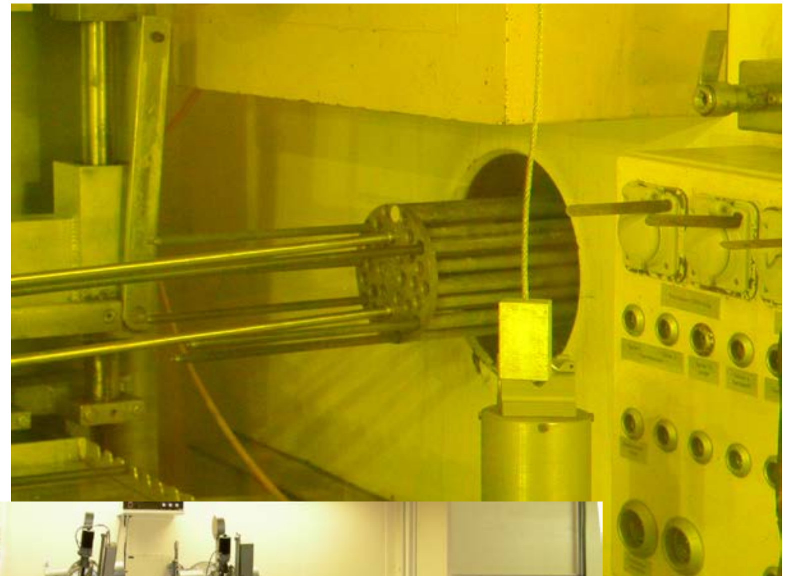
Development of the cutting tool and safety measures

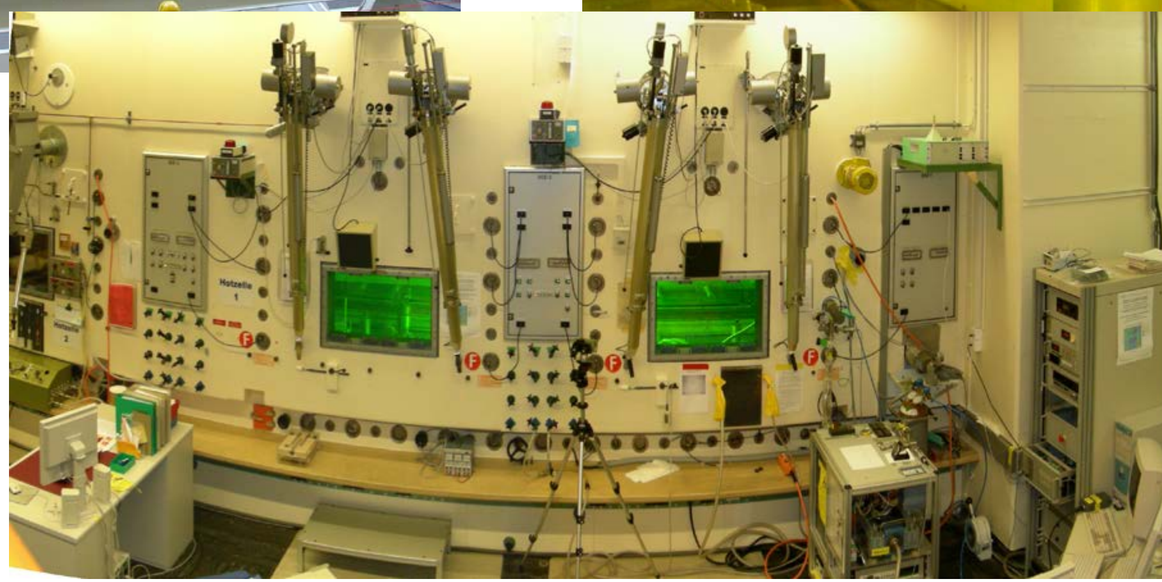


EDM Machine

Post Irradiation Analysis of fuel rods

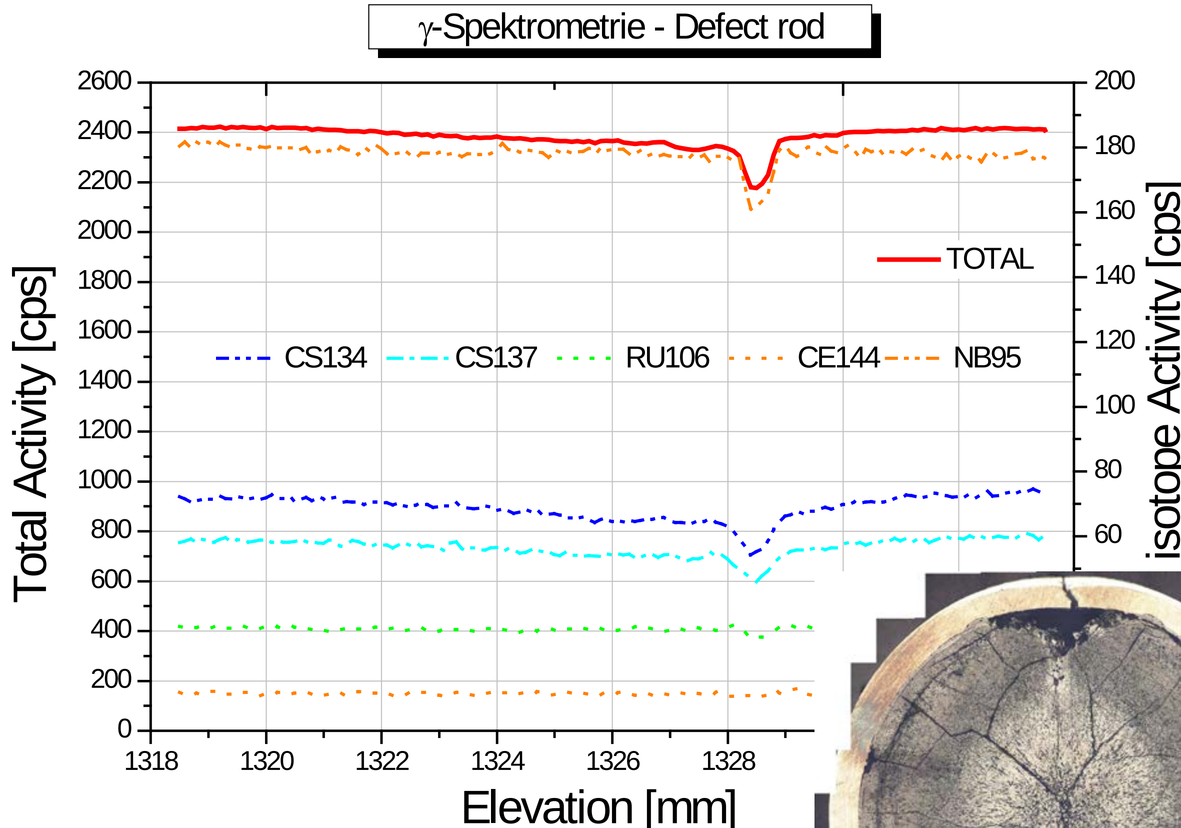
- Transfer of fuel rod in the concrete Cell





➢ Non Destructive Analyses

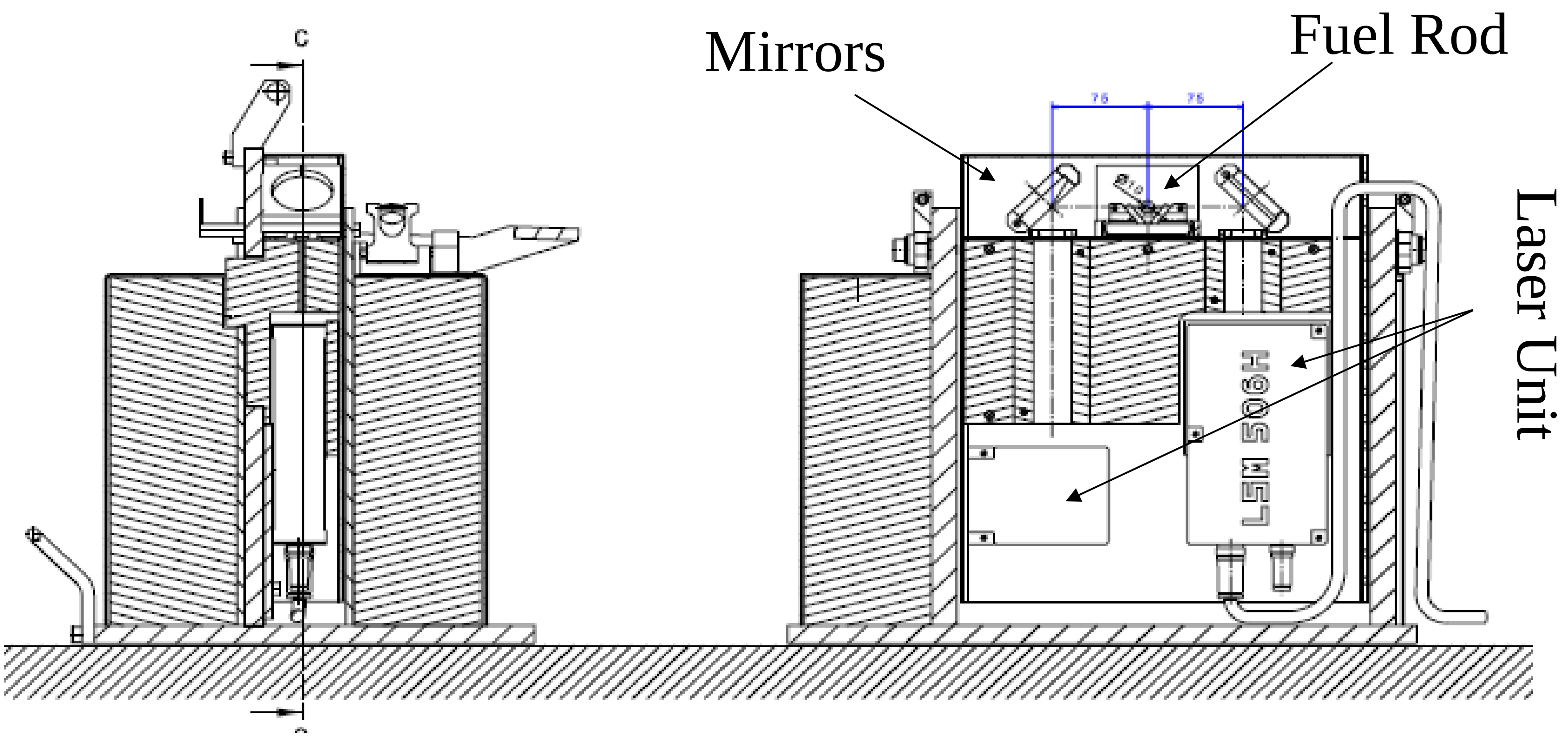
Visual inspection



gamma spectrometry (defect fuel rod)

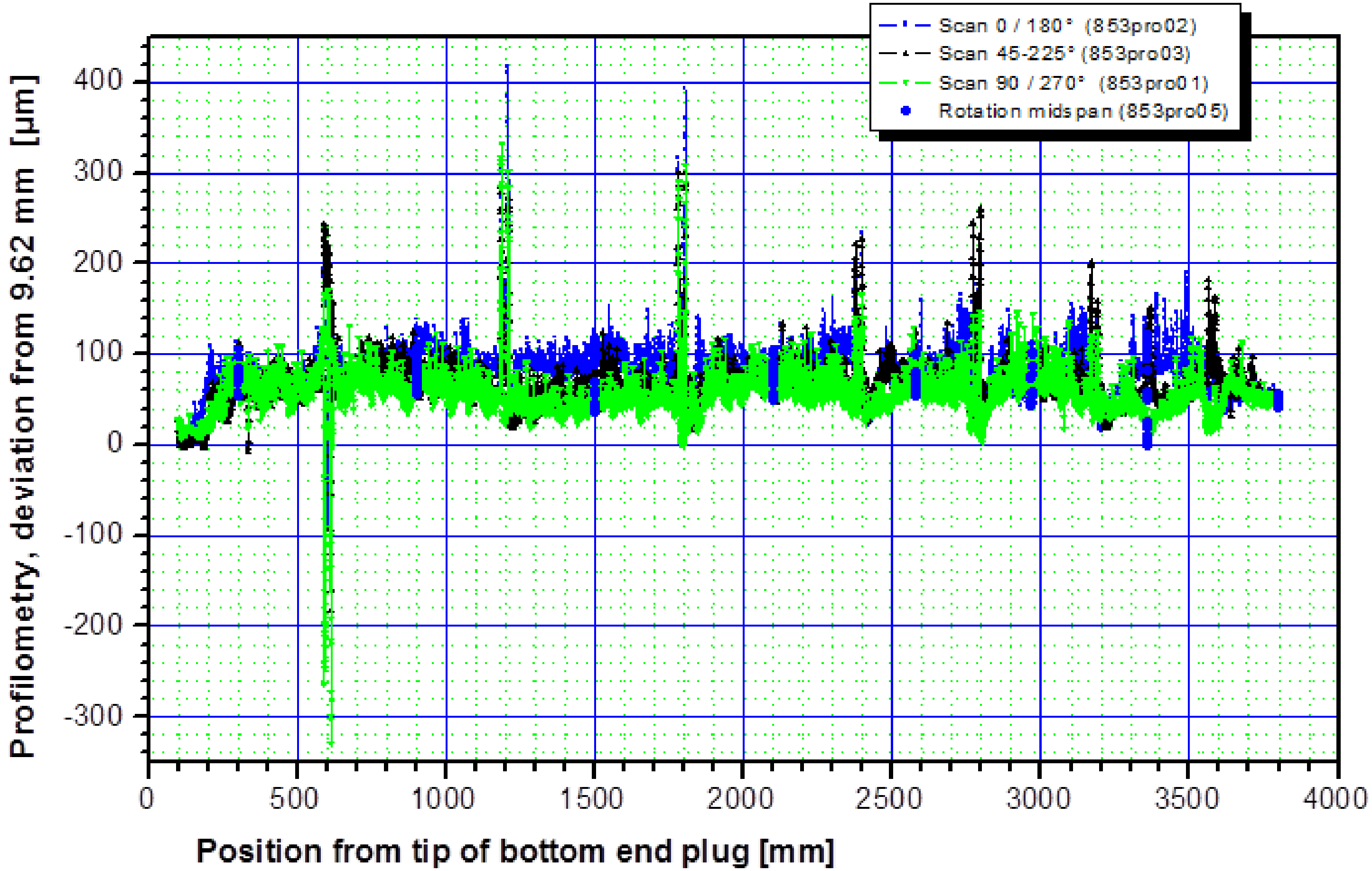
Post Irradiation Analysis of fuel rods

➢ Development of the needed tools



Post Irradiation Analysis of fuel rods

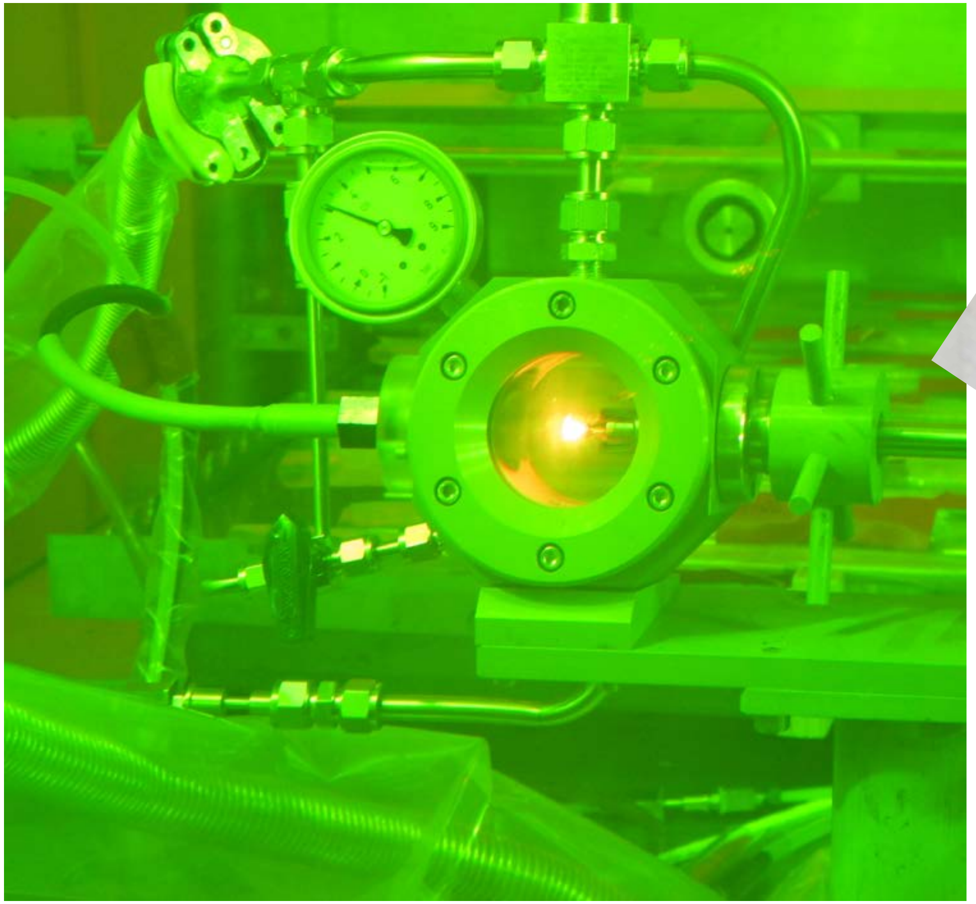
- Profilometry



Detection of possible anomaly in the clad / oxide layer

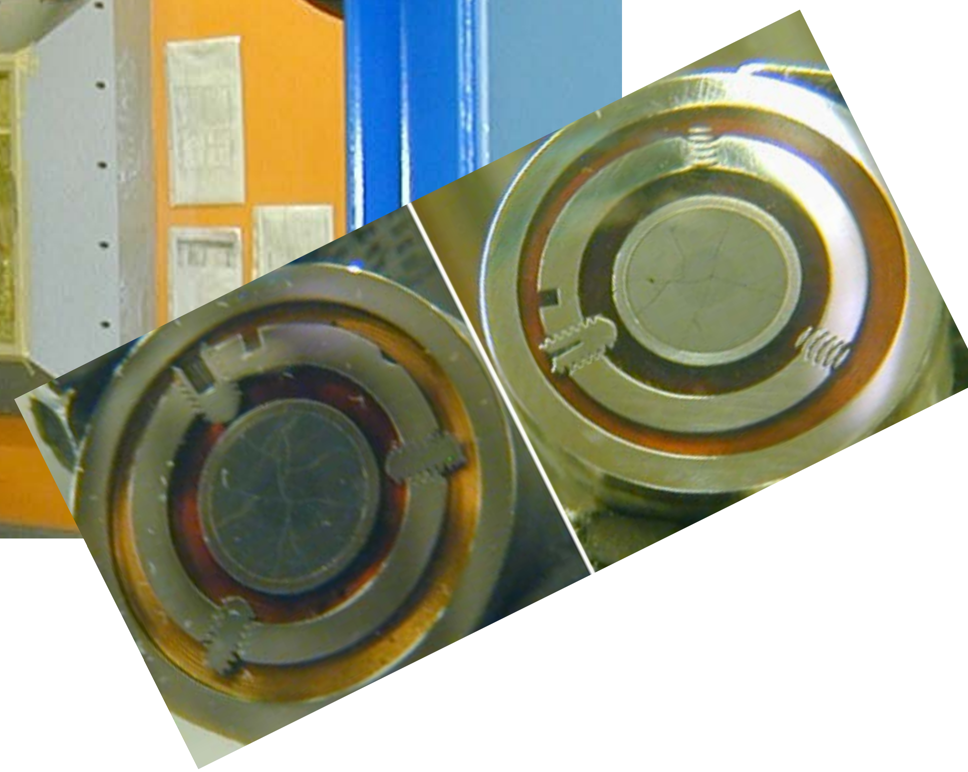
Post Irradiation Analysis of fuel rods

- over-canning of fuel segments



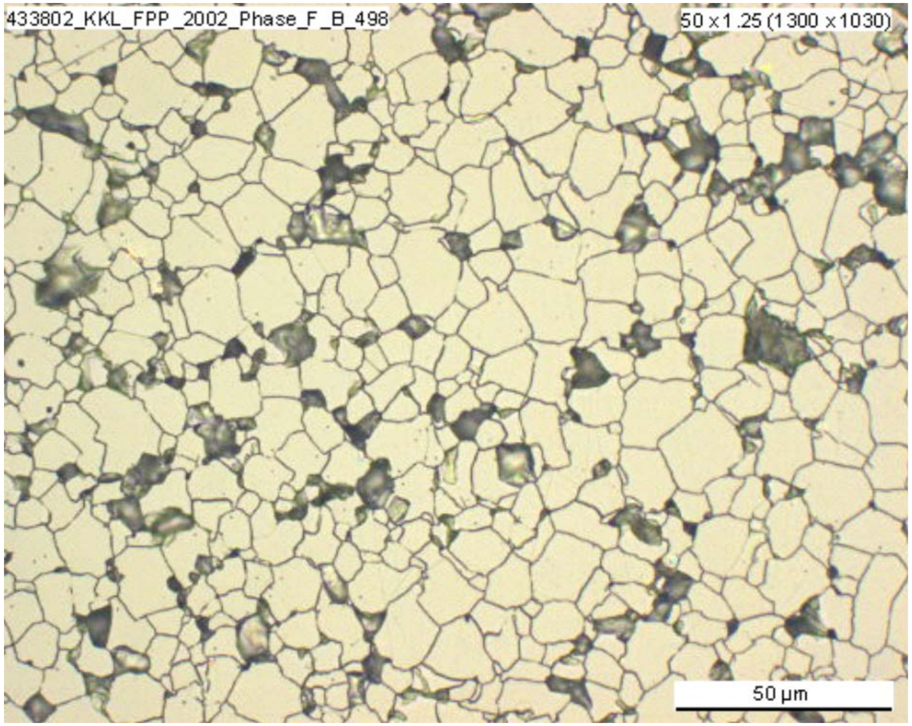
Over-canning fuel segments

Preparation of specimen for surface analyses

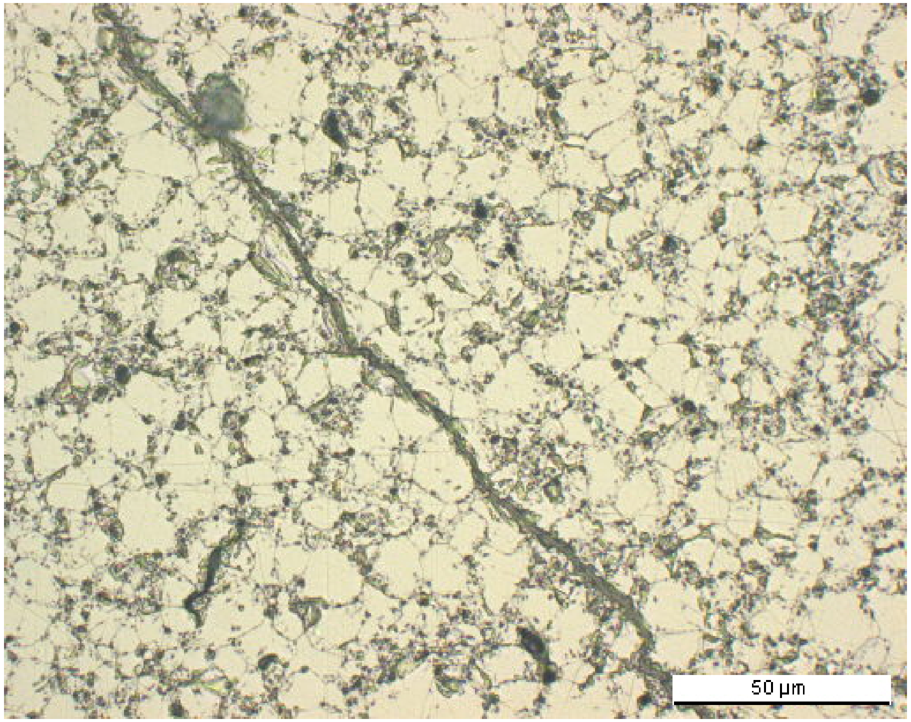


Optical microscopy

- Modification of the fuel morphology with burn-up in UO_2 (mid pellet radius, etched)



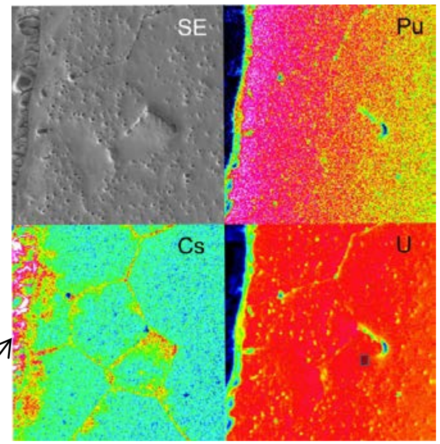
40 MWd/kgU

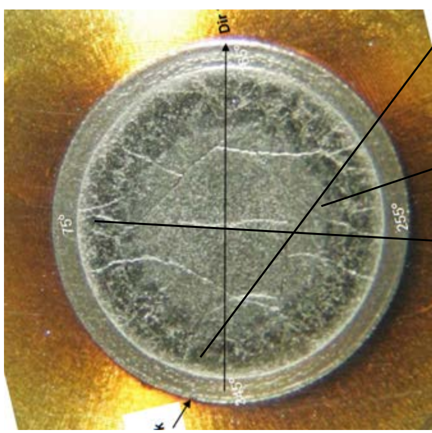


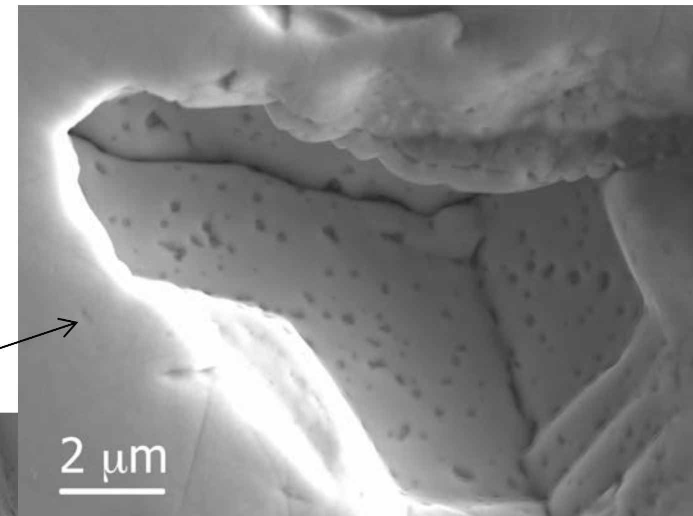
73 MWd/kgU

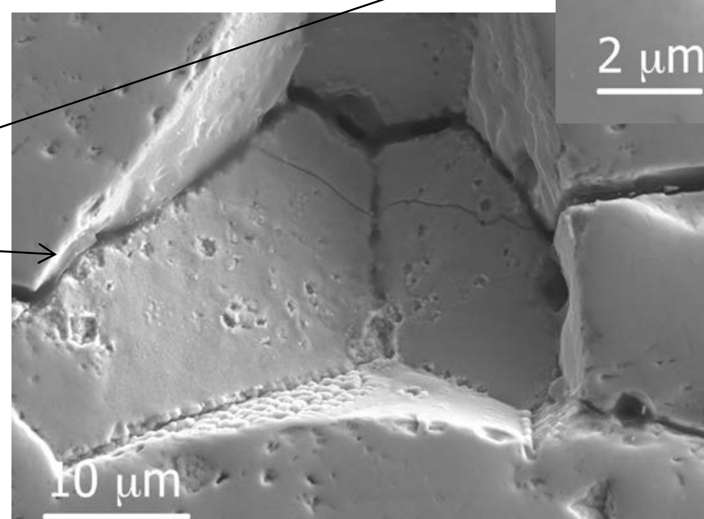
EPMA / Chemical analysis of the surface

- ➢ *Fuel structure and composition*





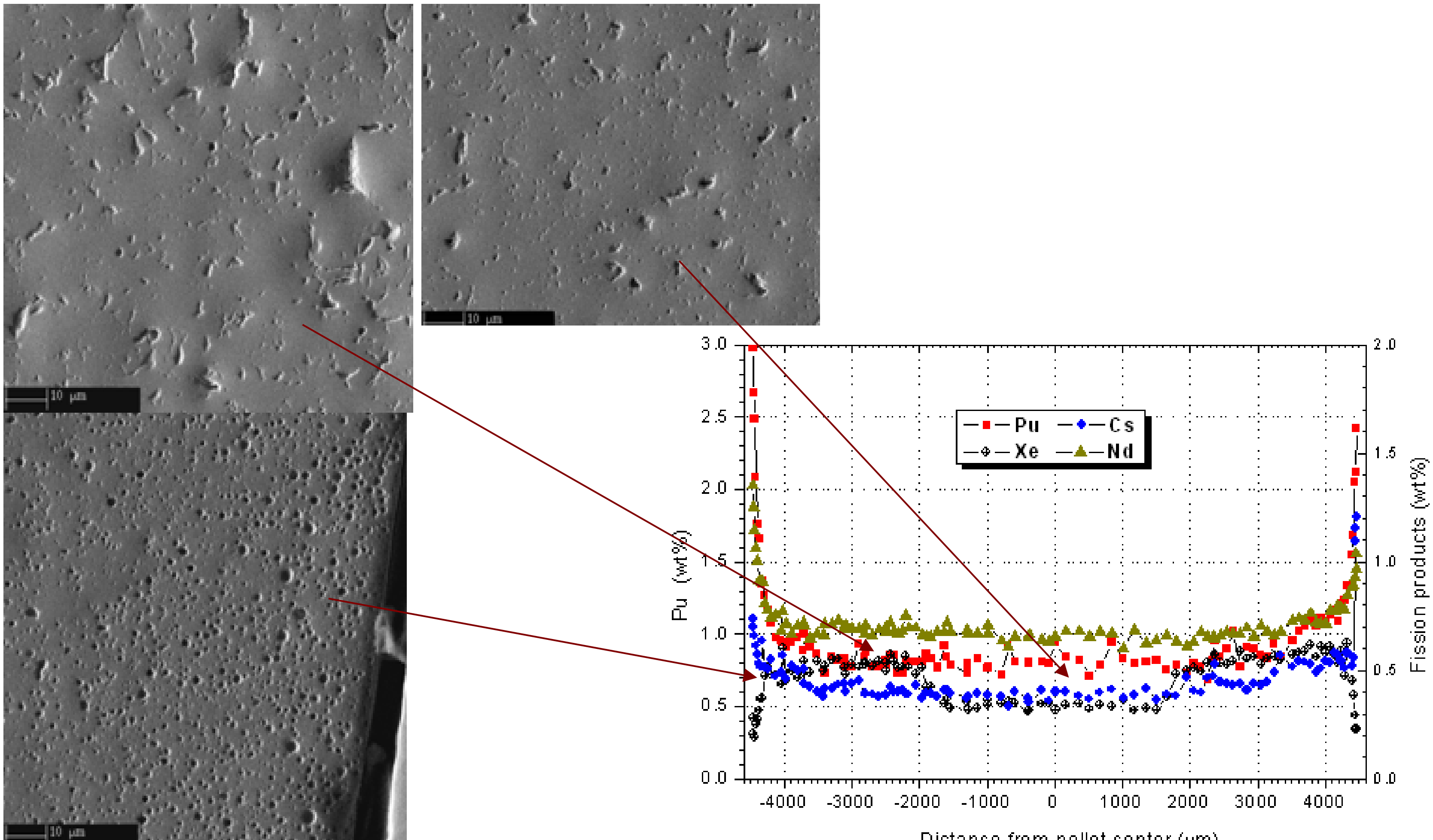




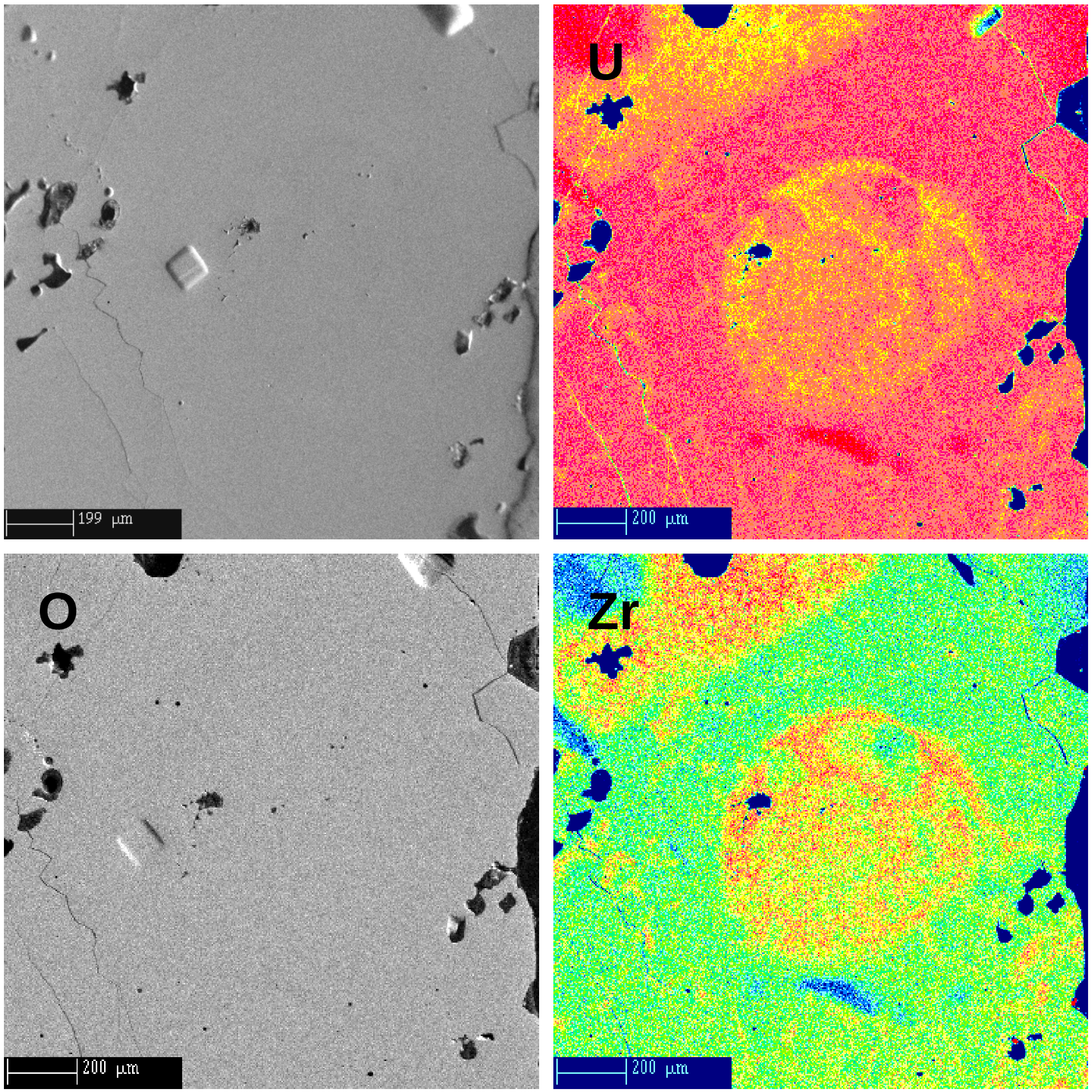
Detailed analysis of irradiated commercial fuel (element mapping, grain subdivision and FP precipitation

EPMA / Chemical analysis of the surface

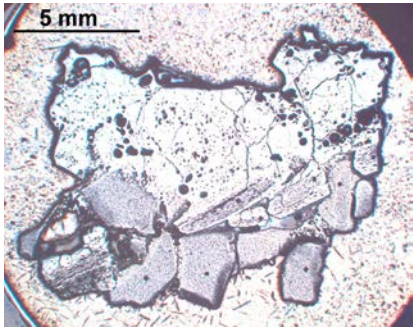
- *Fission product distribution in irradiated fuel*



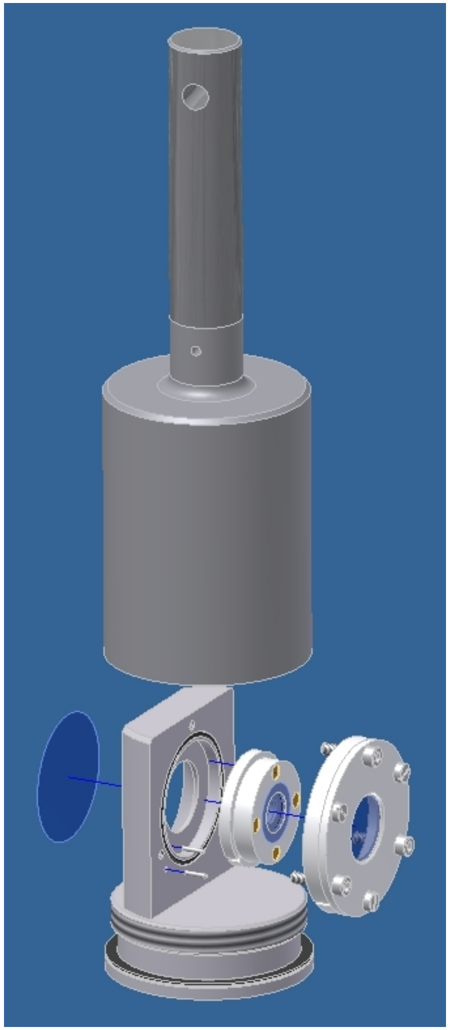
EPMA / Chemical analysis of the surface



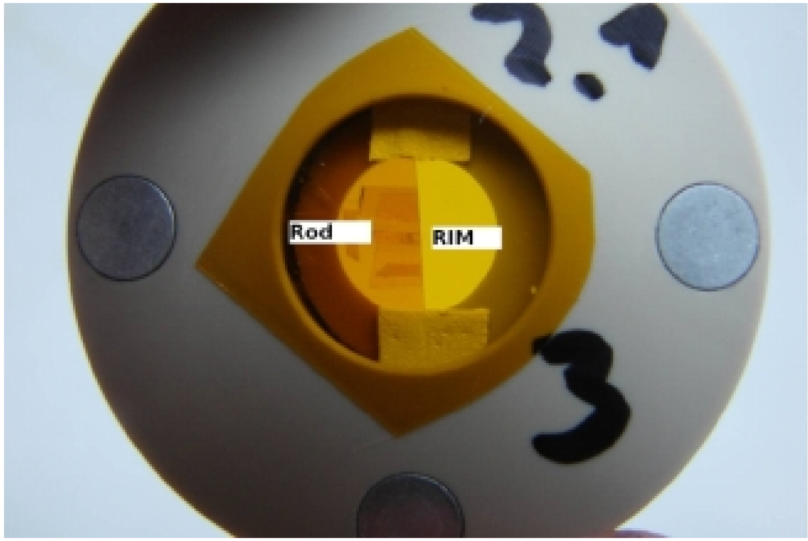
- Analysis of complex material (result of a severe accident test)
- "What you see is not always the reality"



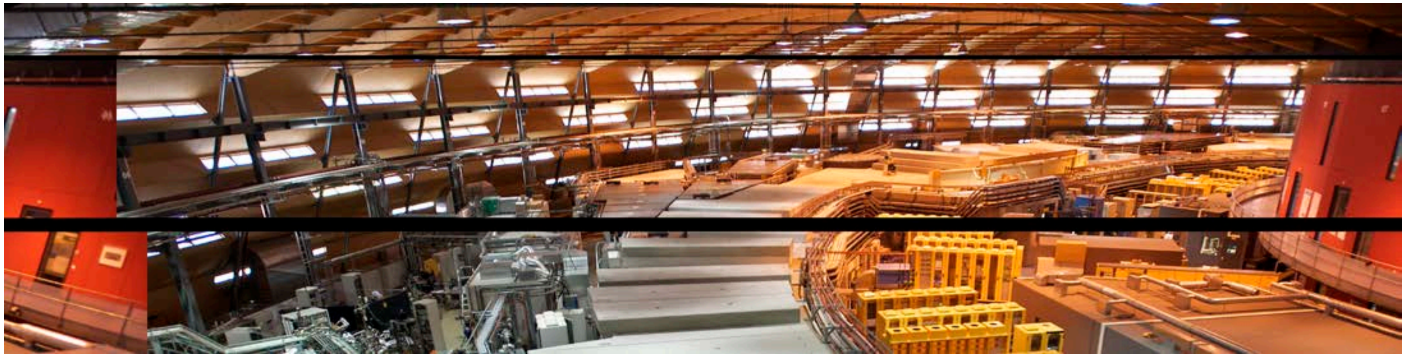
Specimen holder for XAS examination in SLS



Access to more specific information



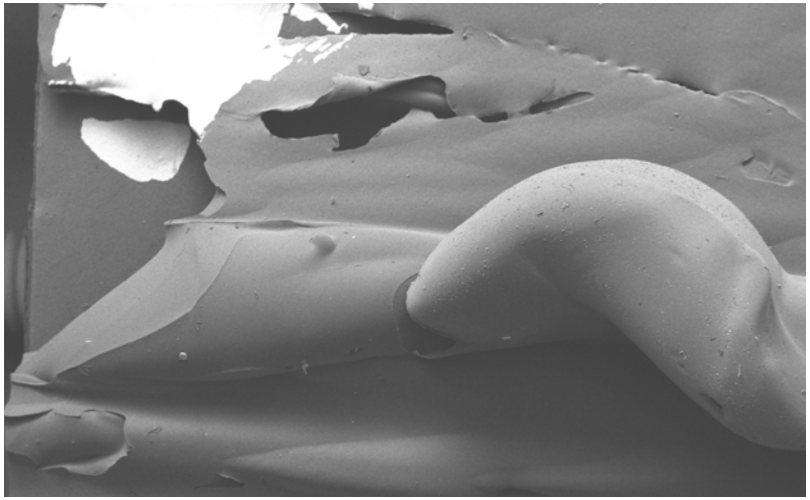
XAS: x-ray absorption spectroscopy in SLS / Collaboration with LNM

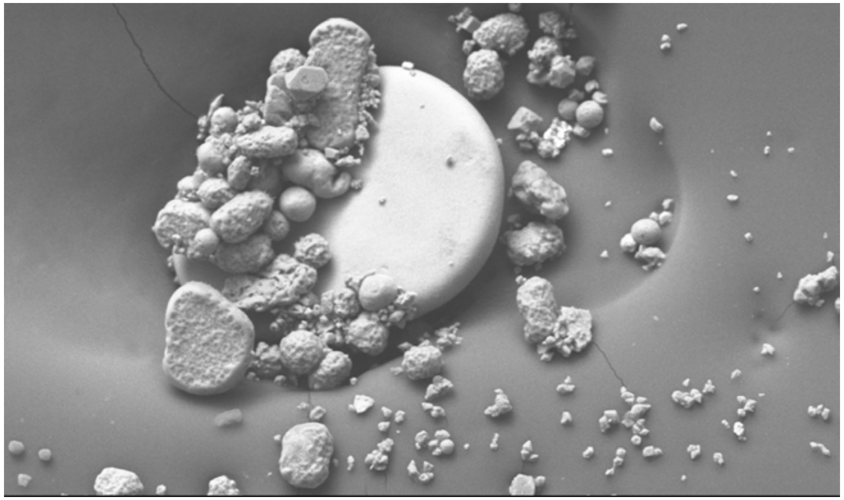


Radioactive material analysis

Analysis of «unexpected» radioactive material

- ➢ Determination of the analysis method
- ➢ Analysis and interpretation
- ➢ Usually request a fast response

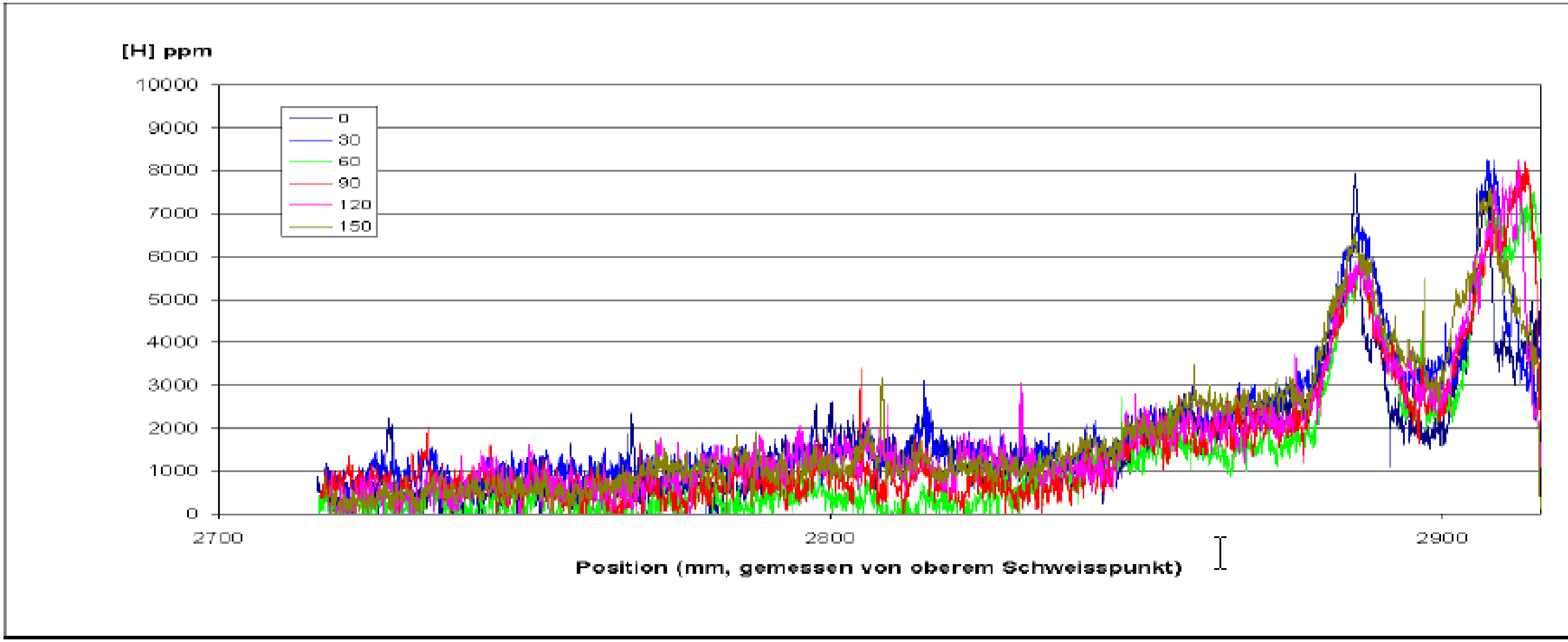




«Exotic» investigation of radioactive materials

- *using synergy in PSI*

(Analysis of a leaker in the HOTLAB and SINQ / H distribution in clad)



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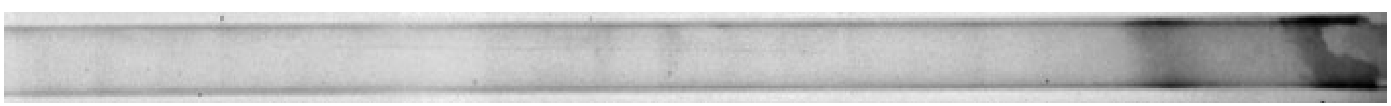
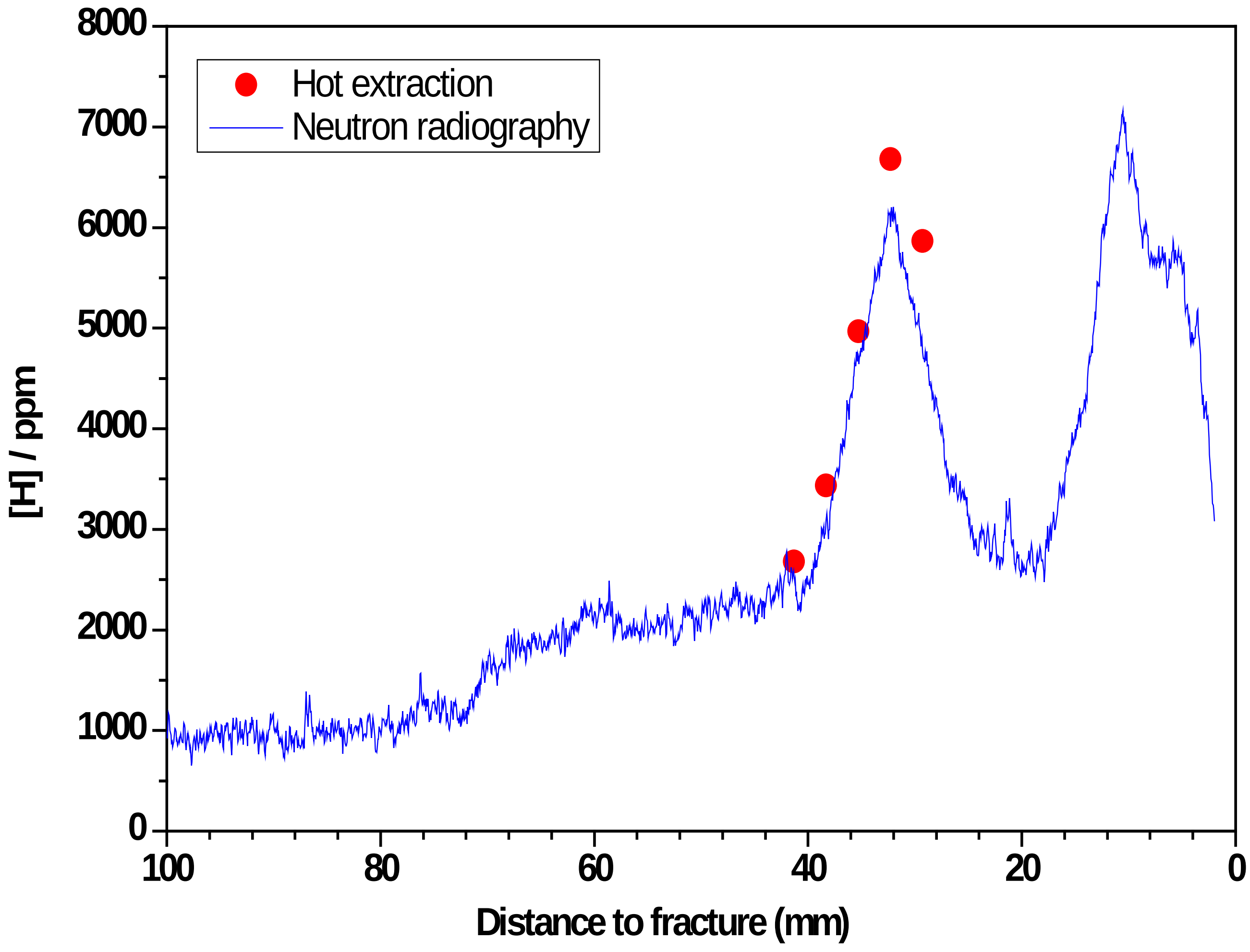


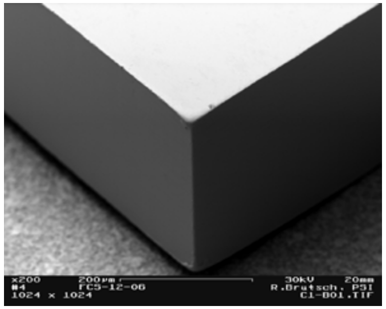
Radioactive material analysis

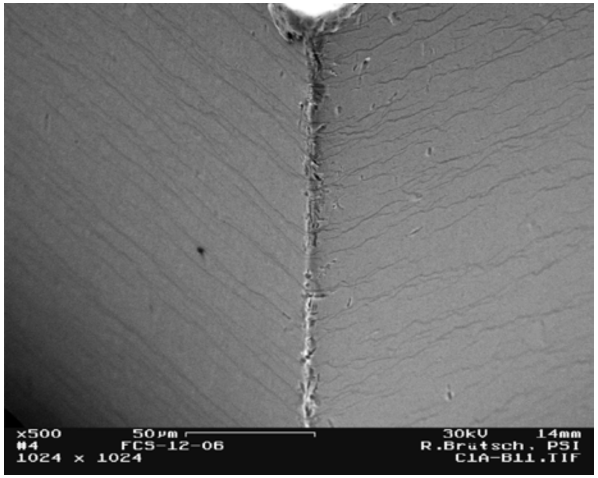
- Comparison local (HOTLAB) and global (SINQ) analyses

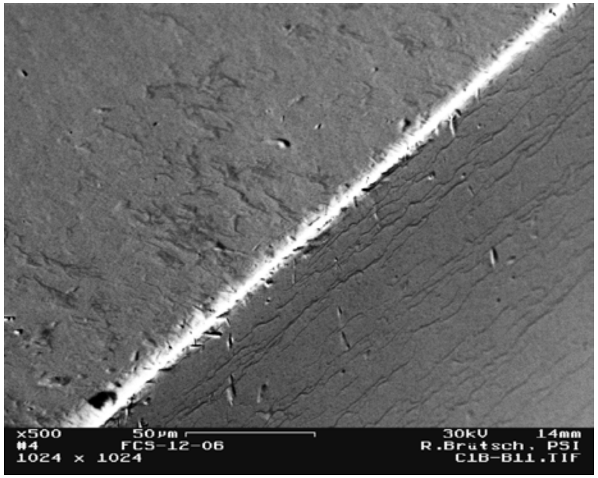


Development of new analysis method

- *Better understand and model the nuclear materials*







Investigation of the hydride structure in cladding

(innovative visualisation without etching and investigation methods)

Research work / development of new methods

- SIMS - Solving isobaric interferences between Pu and Am in $(Th, Pu)O_2$

System of 4 equations *and 4 unknowns*

$$I^{241} = I^{241}_{Pu} + I^{241}_{Am}$$

$$I^{257} = I^{257}_{PuO} + I^{257}_{AmO}$$

$$\frac{I^{239}_{Pu}}{I^{255}_{PuO}} = \frac{I^{241}_{Pu}}{I^{257}_{PuO}}$$

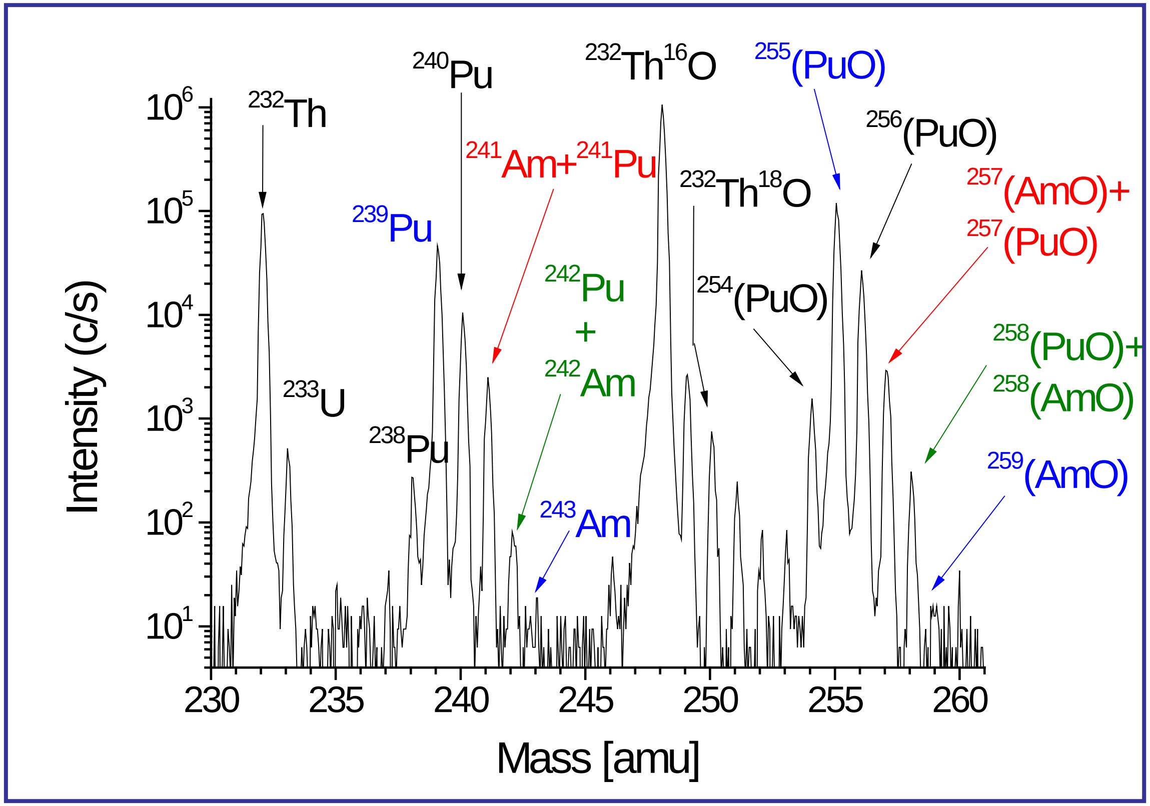
$$\frac{I^{243}_{Am}}{I^{259}_{AmO}} = \frac{I^{241}_{Am}}{I^{257}_{AmO}}$$

I^{241}_{Pu}

I^{241}_{Am}

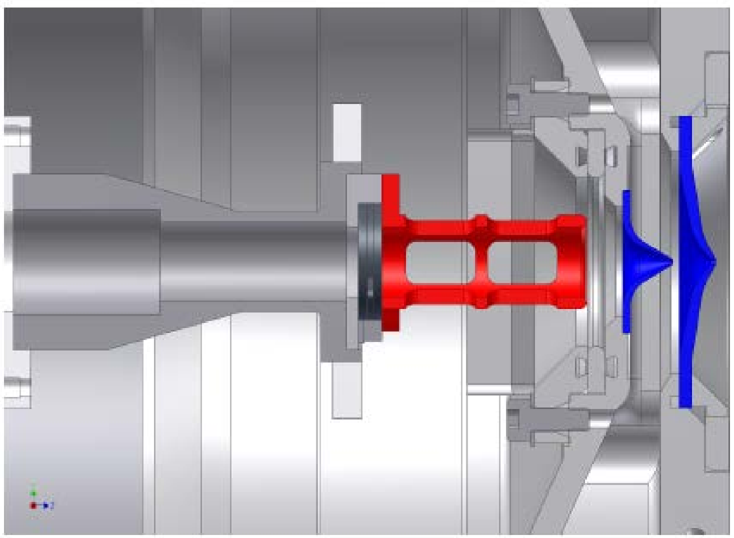
I^{257}_{PuO}

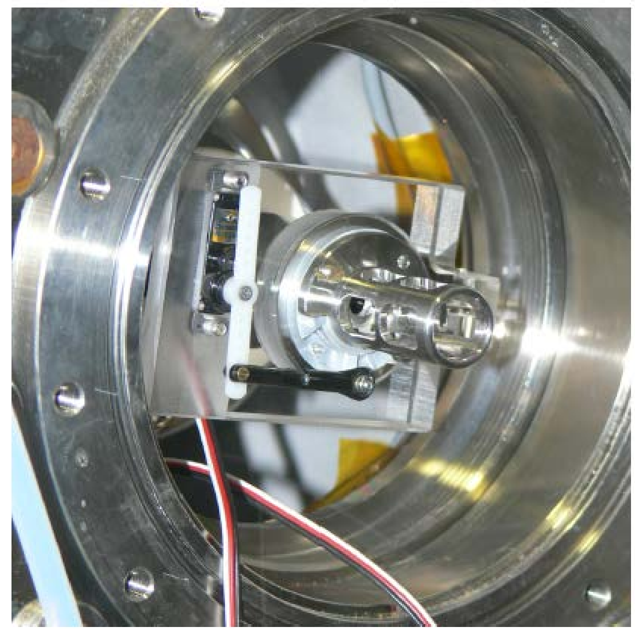
I^{257}_{AmO}



Research work / PhD in AHL

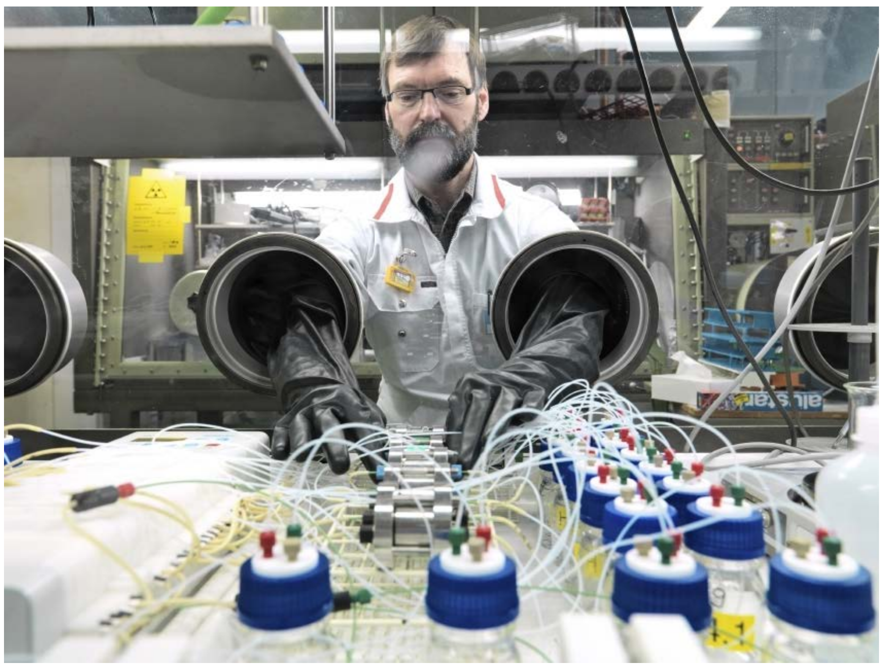
- Fundamental studies of the mass discrimination in multiple-collector inductively coupled plasma mass spectrometry
- Improvement of the instrumentation



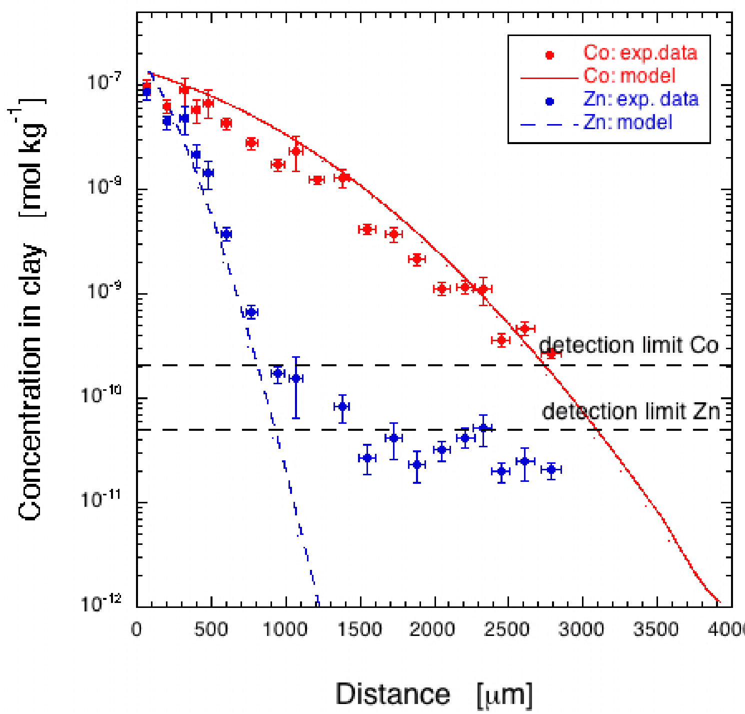


LES scientists are using the hot laboratory

- Investigation of transport und sorption mechanisms with radiioactive tracers / elements
- Critical research for waste repository



Diffusions measurement in glove box
(LES Info)



Conclusion

Conclusion

- Very good safety culture
- High flexibility and innovative thinking of the collaborators
- Standard PIE capabilities for fuel rods
- Good and mostly up to date analytical tools
- Good collaboration with the Swiss power plants / insure enough PIE work for the HOTLAB
- Good collaboration with research groups in PSI (LNM, LES, ...) and international partners (EU-projects, EPRI, WSE, Studsvik, AREVA)

Conclusion

- The stringent regulatory field reduce our reactivity and stresses our capacity
- The finance of AHL are sound but under pressure
- The funding needed to maintain and adapt the infrastructure to the new regulation and research demands is not insured on the long term
- AHL has been demonstrated its ability to conduct and perform complex projects safely and efficiently
- AHL has demonstrated its capacity to improve and further develop its specimen preparation and analysis methods to the interest of the Lab-users

Conclusion

The HOTLAB is a key facility for NES, the PSI and Switzerland

- We have to keep it up to date and insure the safety and needed capabilities for all its users
- Possible with the common financial effort from PSI, Swissnuclear, our project partners and the quality of our work

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