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Determination of isotopic ratio and elementary composition of irradiated Nuclear Fuel

G. Stadelmann

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DETERMINATION OF ISOTOPIC RATIO AND ELEMENTARY COMPOSITION OF IRRADIATED NUCLEAR FUEL

CEA Saclay

Laboratory of Nuclear, Isotopic and Elemental Analytical development

DEN / DANS / DPC / SEARS / LANIE



IAEA Presentation | Guillaume Stadelmann

OCTOBER 2015

I - LANIE laboratory

II - Nuclear Spent Fuel Analysis

III – Other things you should know about me

I – LANIE Laboratory

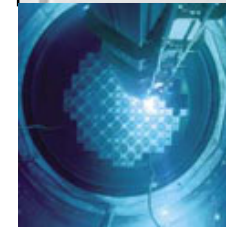
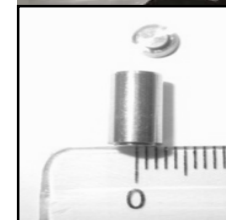
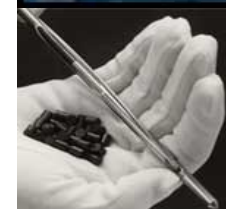
- Missions :
 - doing specific analyses for the support and development of nuclear energy
 - developing innovative technics and protocols of radionuclides chemical analysis
- 4 axes of research and applications
 - **High-accuracy isotopic and elemental analysis**
(by mass spectrometry)
 - Development of analytical microchips
 - Laser-Induced Breakdown Spectroscopy (LIBS)
 - RN speciation analysis
- The team: **18 permanent staff** (13 researchers, 4 technicians, 1 secretary) and about **2 post-doc researchers, 6 PhD students, and several undergraduate students**

High Accuracy Isotopic and Elemental Analyses

- Various samples :
 - Civil Nuclear spent fuel (2nd, 3rd and 4th generation)
 - Military fuel : Naval propulsion
 - Irradiated pure isotope : elemental transmutation
 - Dosimeters
 - Reprocessing samples
 - Nuclear waste
 - Safeguard (IAEA)
 - ...

- « Best Sellers » elements :
 - U, Pu, Minors Actinides, Lanthanide and Cs

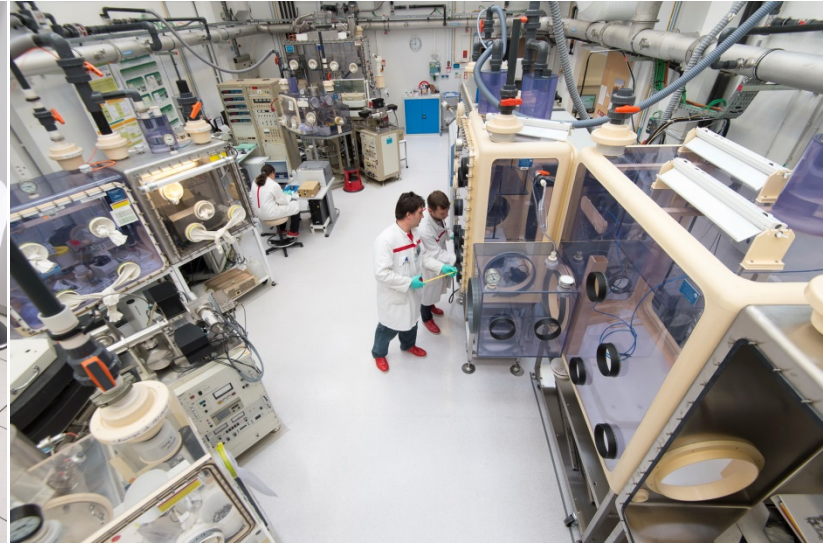
- « Specific demands » :
 - B, Li, Cf, Ho



Equipment and Laboratory

- 2 Laboratories :
 - “Cool Lab” : for analytical development and acid distillation
 - “Hot Lab Actineo” : Lab equipped with Glove Box for analysis of radioactive samples

- Instrumentation :
- Cool Lab
 - 1 Horiba-Jobin OES-ICP Activa
 - 1 Thermo Q-ICP-MS XSeriesII
 - 2 Thermo-Dione HPLC Ionic chromatography
- Actineo
 - 2 Thermo Q-ICP-MS XSeriesII and I
 - 1 Thermo MC-ICP-MS Neptune Plus
 - 1 VG Instrument MC-ICP-MS Isoprobe
 - 2 VG Instrument TIMS Isoprobe T and Sector54
 - 1 Thermo TIMS Triton
 - 4 Thermo-Dionex HPLC Ionic chromatography

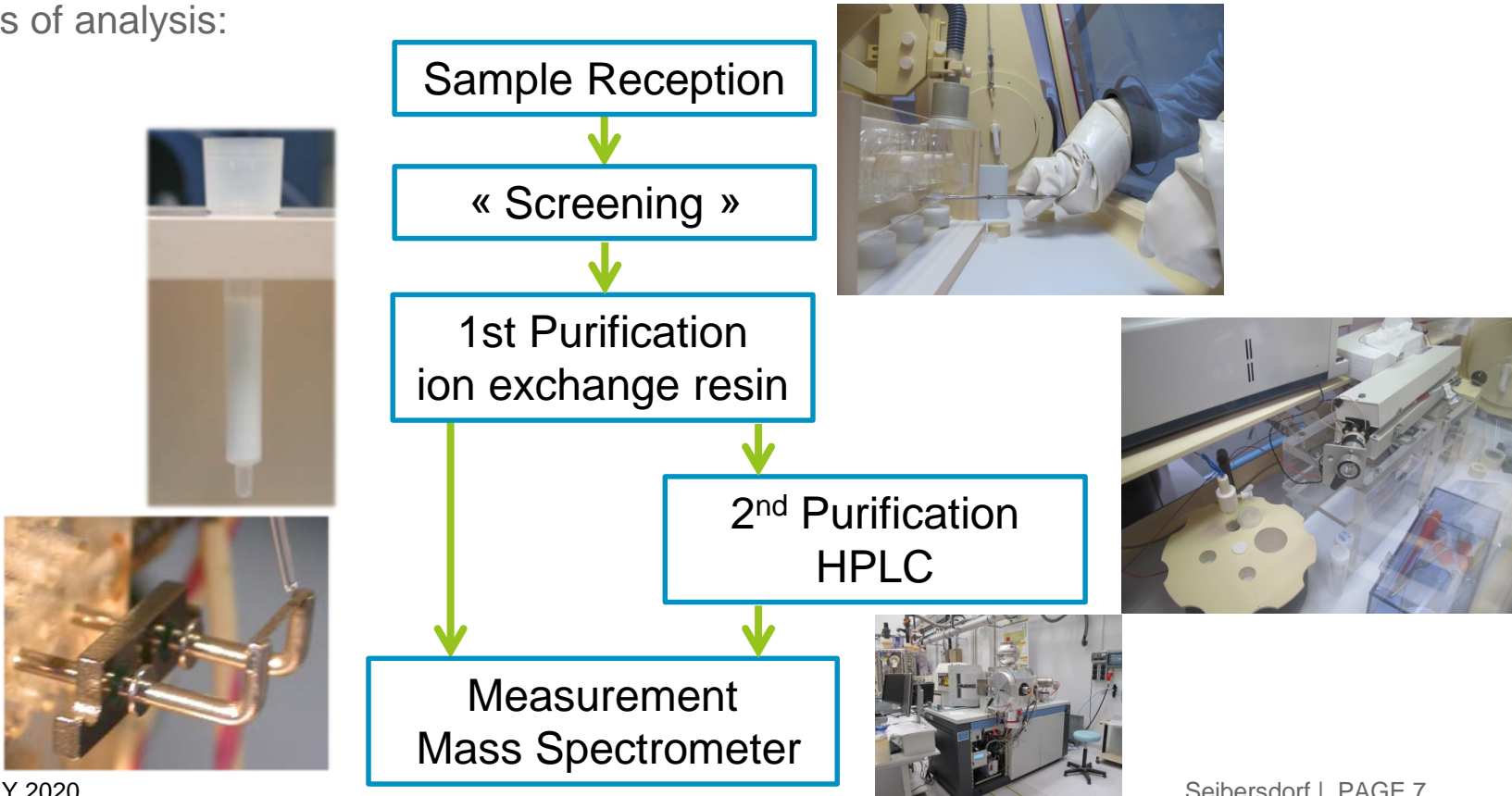


II – Nuclear spent fuel analysis

■ Objectives :

- Determination of fine isotopic ratio and elementary concentration (uncertainties < 1%)
- Elements of interest : U Pu Nd Cs Am Cm Eu Gd Sm Ce Np Pm

■ Process of analysis:

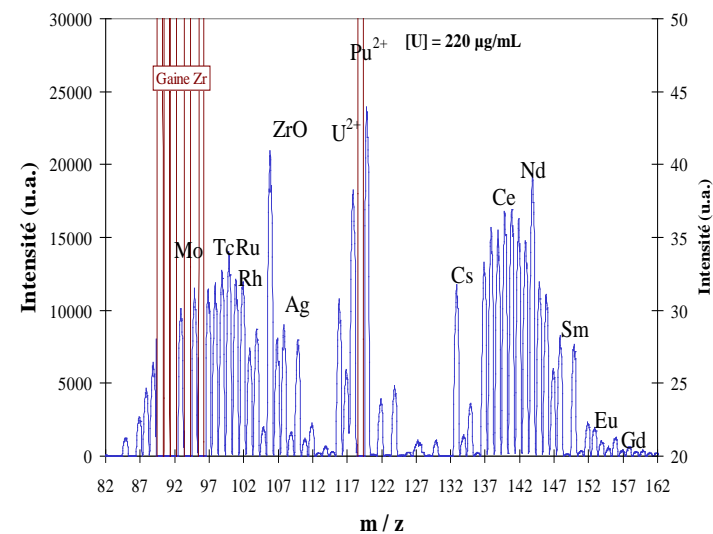
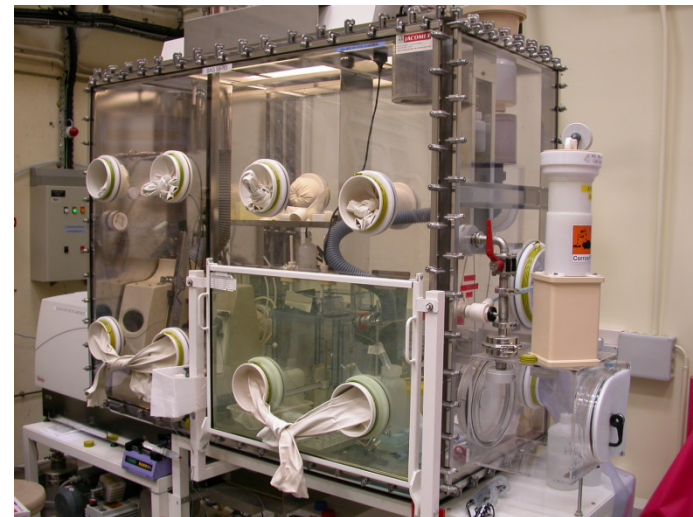


■ Sample reception

- Decontamination of Lead container
- Registration in the LIMS

■ « Screening »

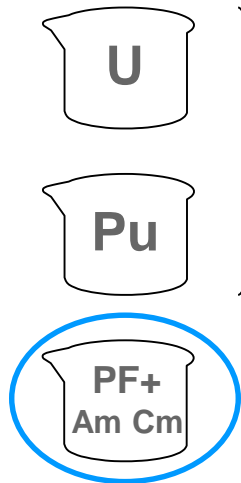
- Survey of the mass range from 4 to 250amu (check of no major pollution or contamination)
- Semi-quantification of elements of interest (preparation of the sampling volume and determination of critical element)



II – NUCLEAR SPENT FUEL ANALYSIS



1st separation
Ion exchange resin
(AG1-X10, AG1-X4)

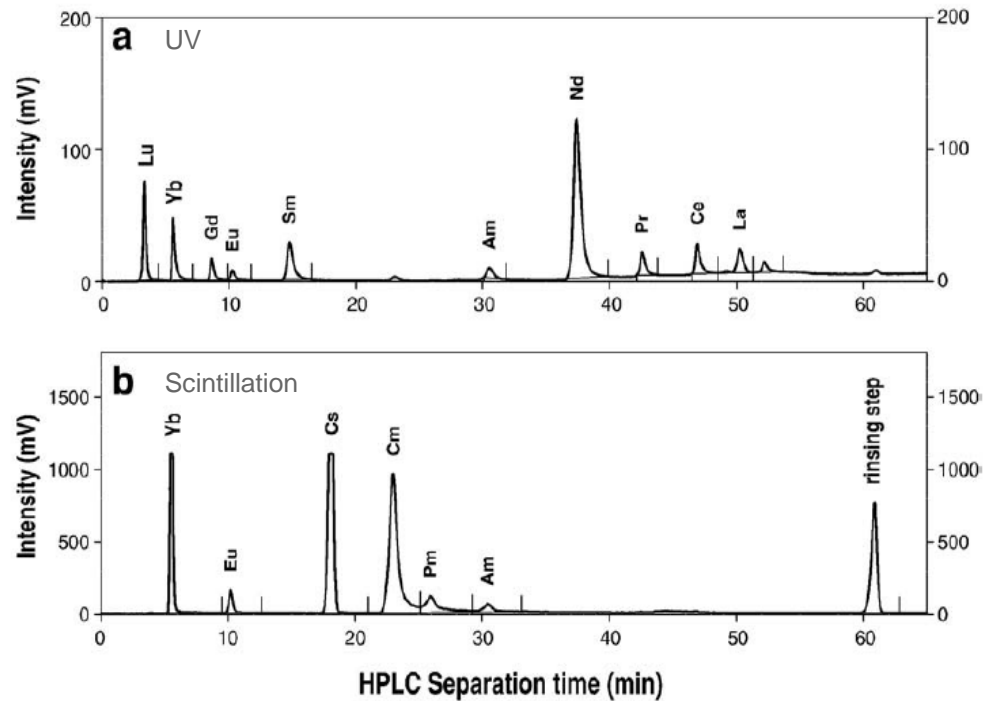
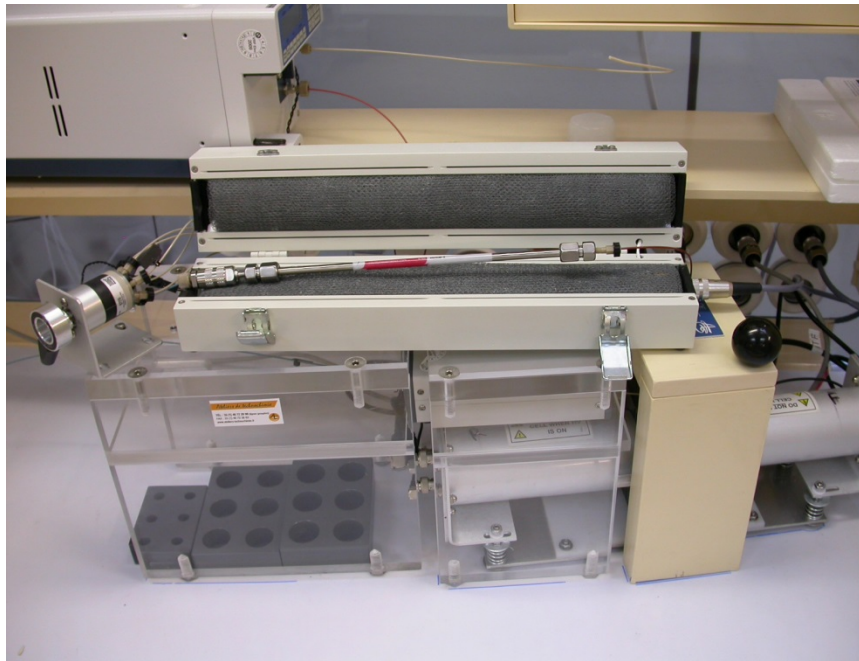


TIMS measurement



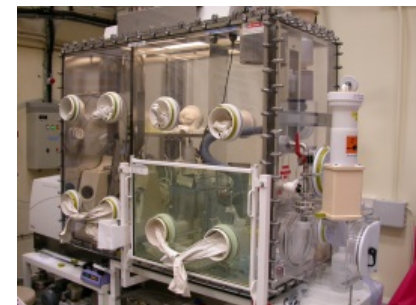
2nd Purification

2 Samples + 1 Blank /
Sample quantity based on the
critical element determined
previously

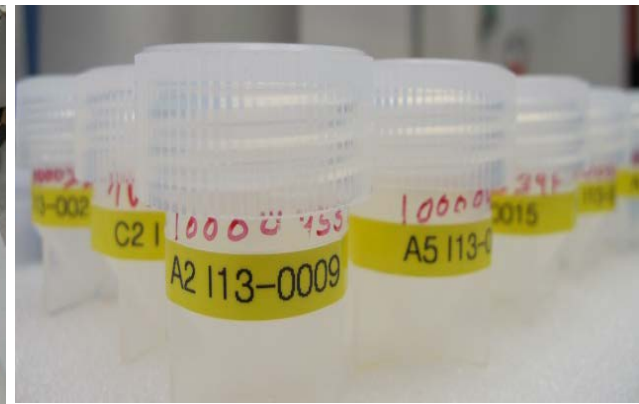


- Second separation by liquid chromatography
 - Strong Cation eXchange column (SCX)
 - Separation using a gradient in concentration of HMB (Hydroxy Methyl Butiric Acid)
 - Double detection : UV and liquid scintillator
 - Separation of every PF, minor actinides and Cs

- Pure elementary fraction measurement
- Targeting low uncertainties
 - ‰ for Isotopy and concentration (Isotopic Dilution)
 - % Concentration (with Q-ICP-MS)
- Measurement with TIMS
 - External Calibration (Sequential Method) for Isotopy
 - Total Evaporation for Isotopic dilution
- Measurement with MC-ICP-MS
 - Bracketing with CRM
- Measurement with Q-ICP-MS
 - External calibration with Matrix matching
 - Standard Addition



- From Nuclear spent fuel to Safeguard samples analyses
 - Qualification process began in 2013
 - Participation to Nuclear Material Round Robin (2013 and 2015)



- IAEA qualification obtained in February 2015 for U and Pu isotopic analysis

Some little things to help you know me a bit better

- Born in Colmar (Alsace- France)
- Studied chemistry and analytical chemistry
- Worked for car industry (Peugeot Citroen)
- Was a Scout leader
- Play Basketball with CEA sport association
- Like Food and Wine
- Very happy to join your team !



**THANK YOU FOR
YOUR ATTENTION**

Commissariat à l'énergie atomique et aux énergies alternatives
Centre de Saclay | 91191 Gif-sur-Yvette Cedex

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