Experiments at JRC-Geel using MINERVE samples

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Subtask 5.3.1 Experiements at GELINA

The proposed experiments will consist in performing neutron transmission measurements at the JRC Geel GELINA facility using the same samples as those used in the CEA Cadarache MINERVE reactor as part of the past Burnup Credit program.

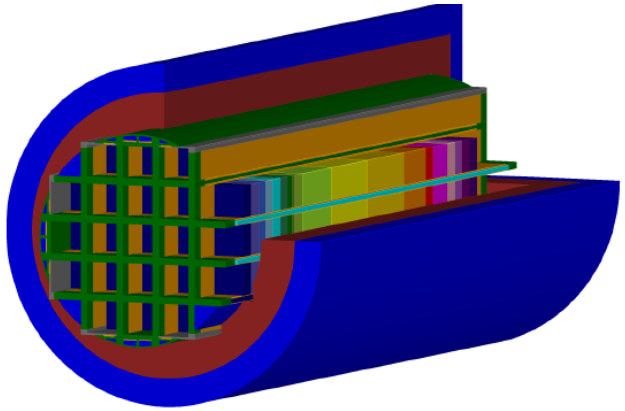
Preliminary studies show that such experiments should be feasible. Each sample is made of a UO2 matrix with a small admixture of a fission product: Sm, Nd, Cs, Mo, Ru, Eu, Gd, or Rh. The expected outcome will be a set of transmission data for each sample. These data will be first used to determine the amount of contaminants in the samples by Neutron Resonance Transmission Analysis (NRTA).

Burnup Credit definition

Burnup-Credit (BUC) : safety approach that accounts for the reduction of the spent fuel reactivity due to its burnup (reduction of net fissile content, actinides build-up, increase of **fission products** concentration)

Applications: spent fuel storage, transport cask

⇒ In this talk, we are interested by the contribution of the fission products

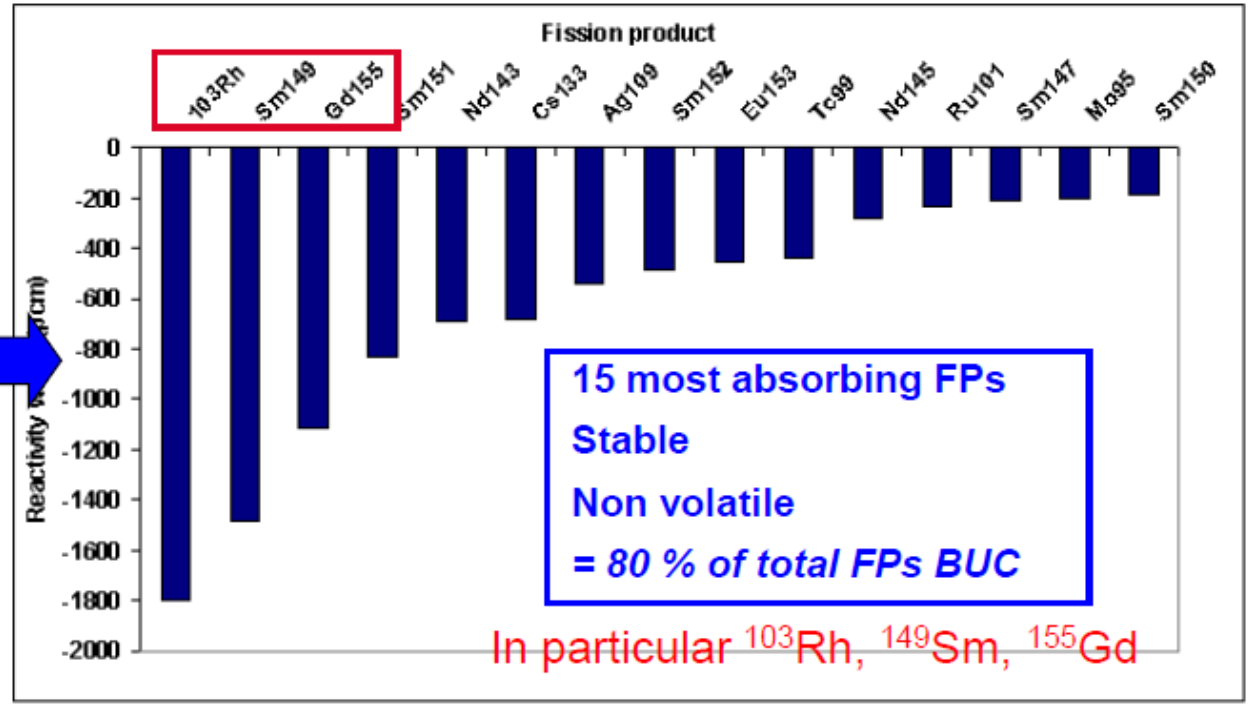


Fission product contribution

Fission product contribution in BUC calculations for UOX and MOX fuels (end of cycle)

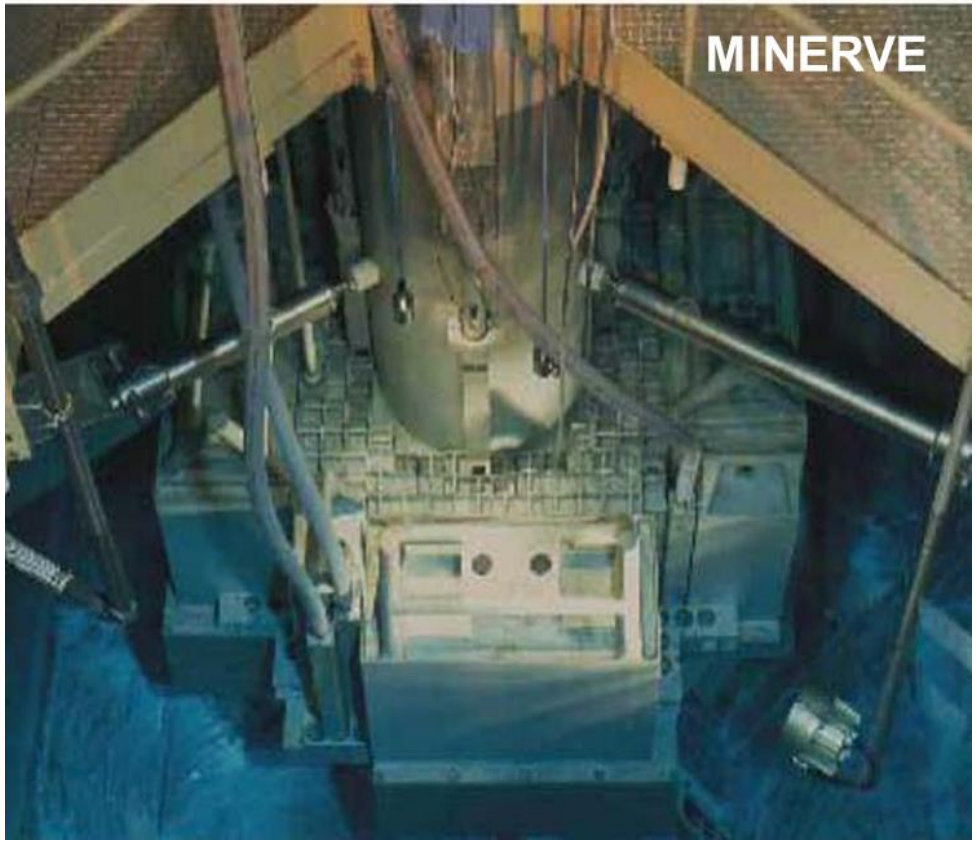
	PWR-UOx	PWR-MOx
Actinide BUC	19000 pcm	7550 pcm
15 FPs BUC	8400 pcm	8330 pcm
Total BUC	**27400 pcm**	**15880 pcm**

BU = 40 GWd/t_{HM} Cooling time 1 year

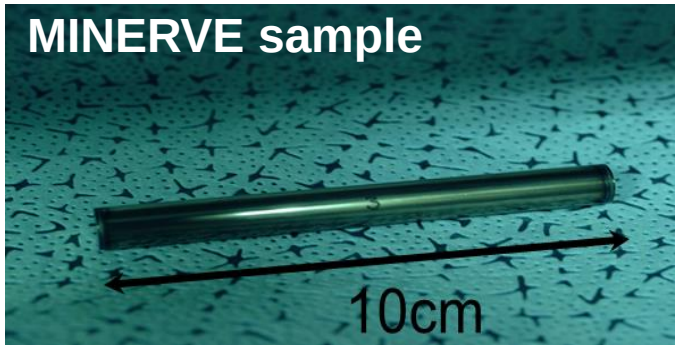


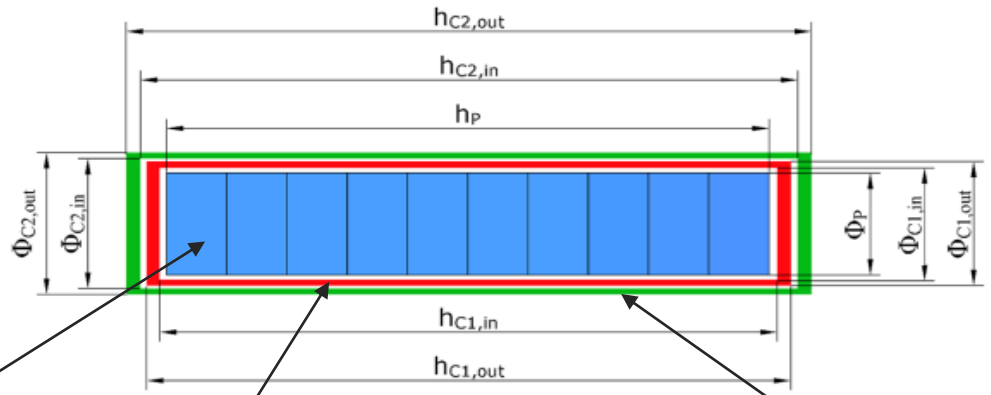
⇒ Calculation biases in BUC applications relies on integral measurements, such as reactivity worth measurements carried out in the **MINERVE reactor of CEA Cadarache**

MINERVE measurements for BUC applications



Reactivity worth measurements in the MINERVE reactor of CEA Cadarache using the so-called **MINERVE samples**





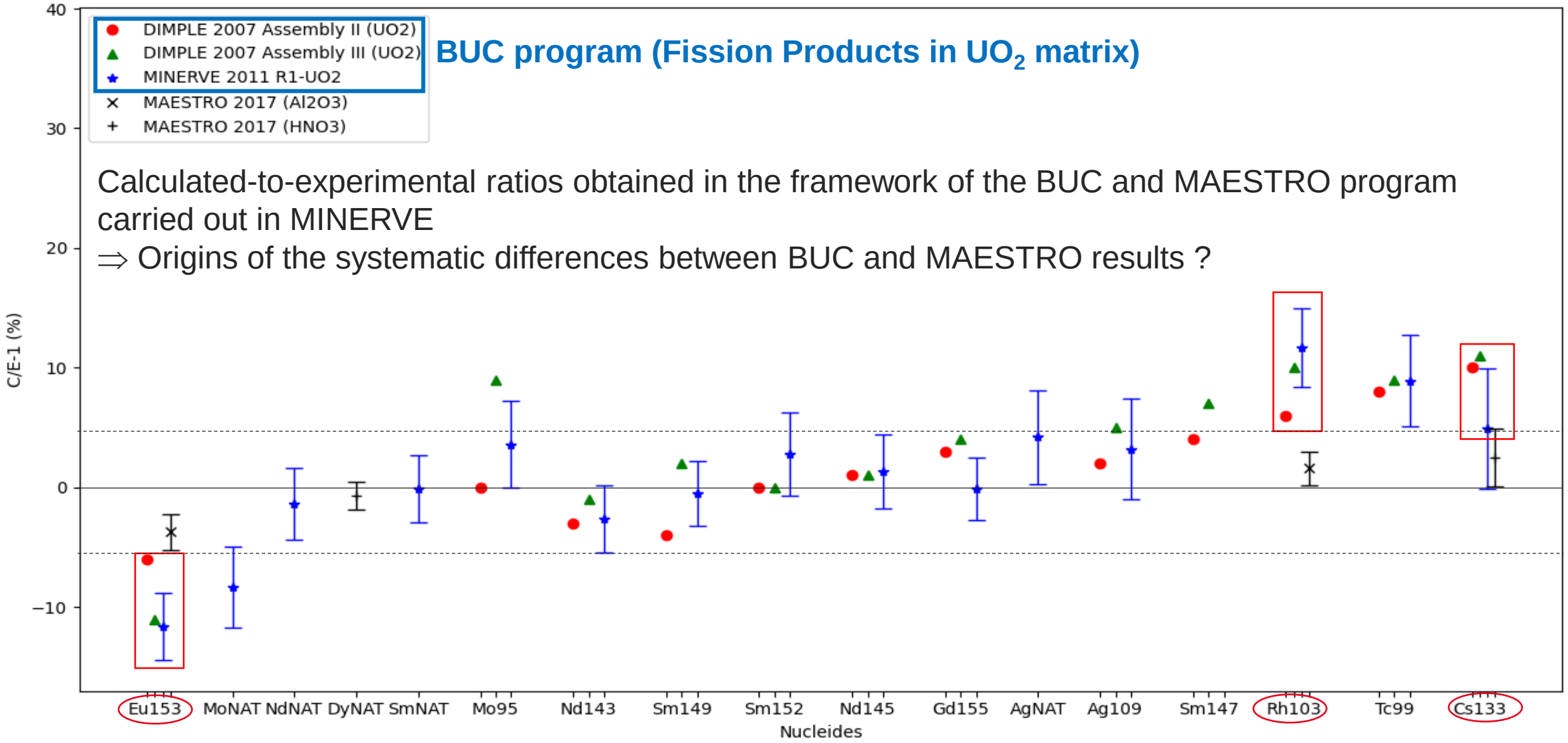
UO_2 pellet containing fission product

Zircaloy-4 cladding

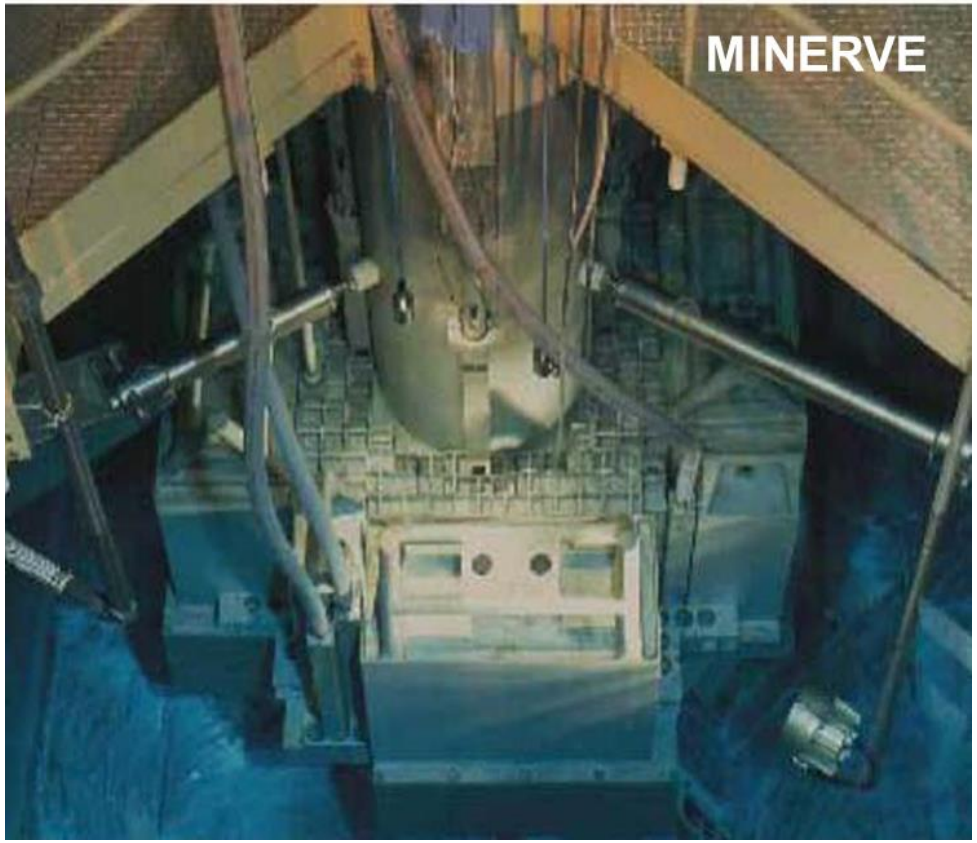
Zircaloy-4 cladding

MINERVE samples
cylindrical samples in which fission product are mixed to UO_2, Al_2O_3 or liquid.

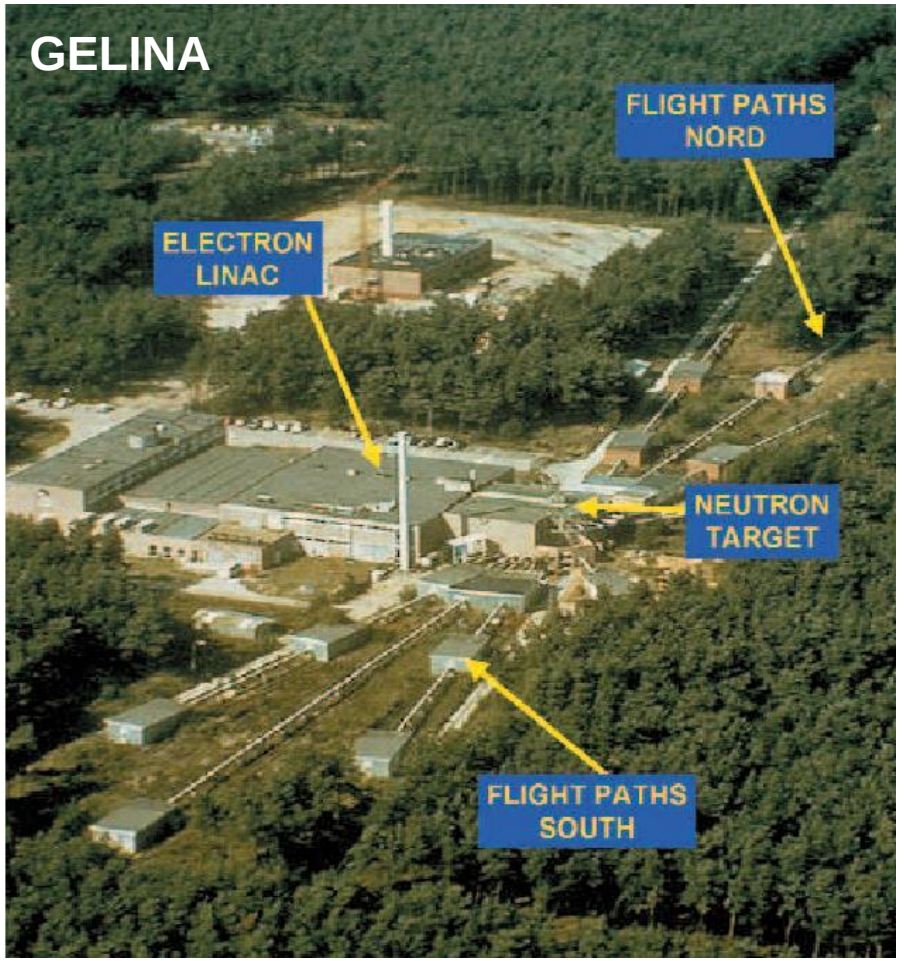
MINERVE results with JEFF-3.1.1



GELINA measurements for BUC applications



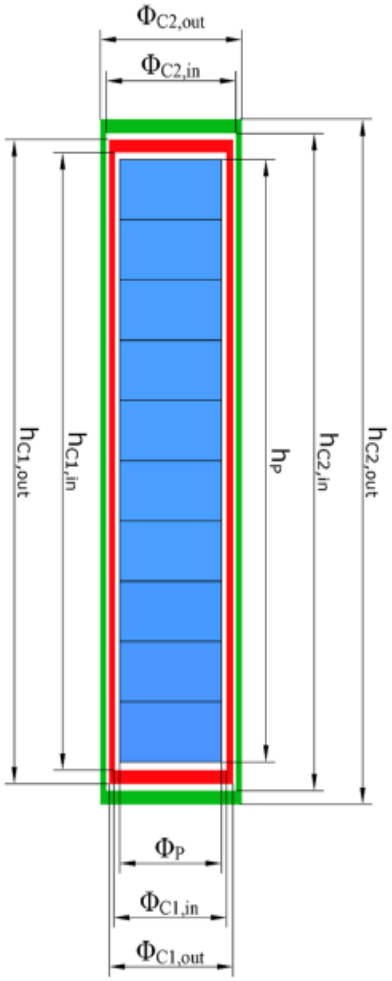
Reactivity worth measurements in the MINERVE reactor of CEA Cadarache using the so-called **MINERVE samples**

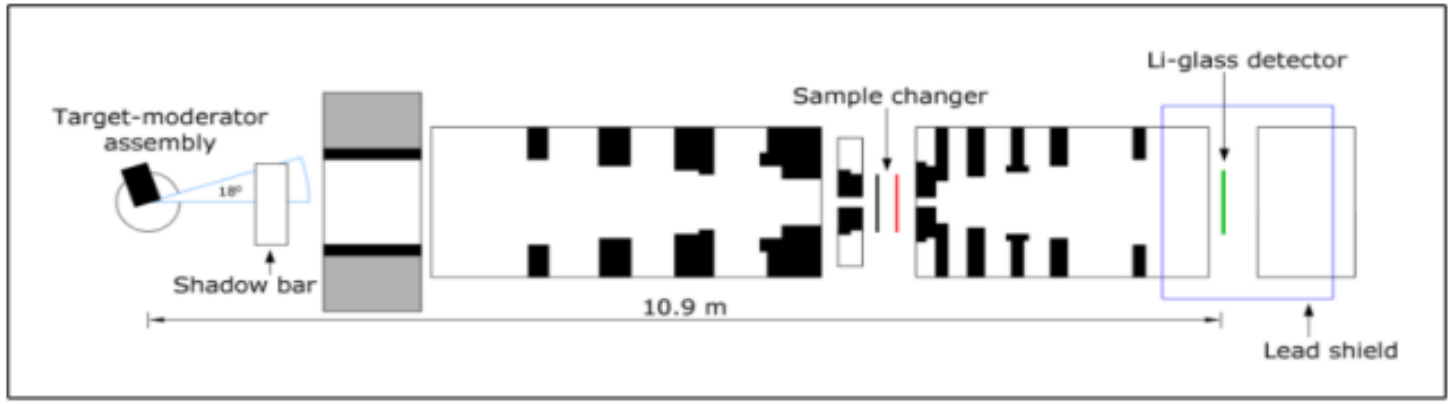


MINERVE samples can also be measured at the GELINA facility (JRC-Geel, Belgium) to verify integral results obtained with the MINERVE reactor

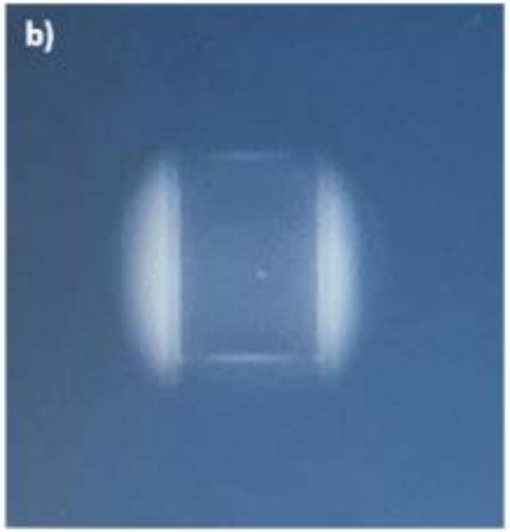
Principles of transmission measurement

Transmission measurements were performed at L=10.9 m from the neutron source (FP13)

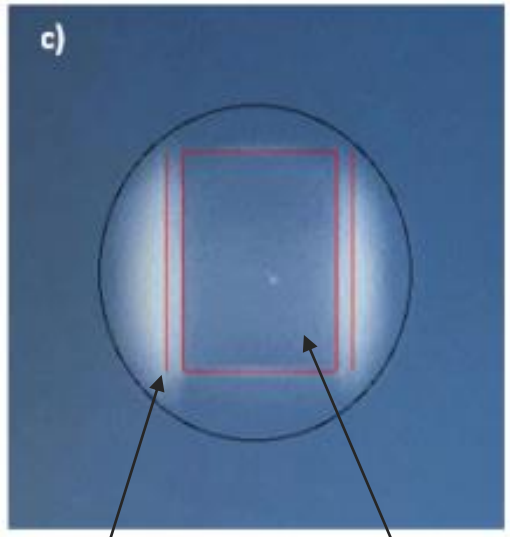




MINERVE sample placed vertically in the neutron beam



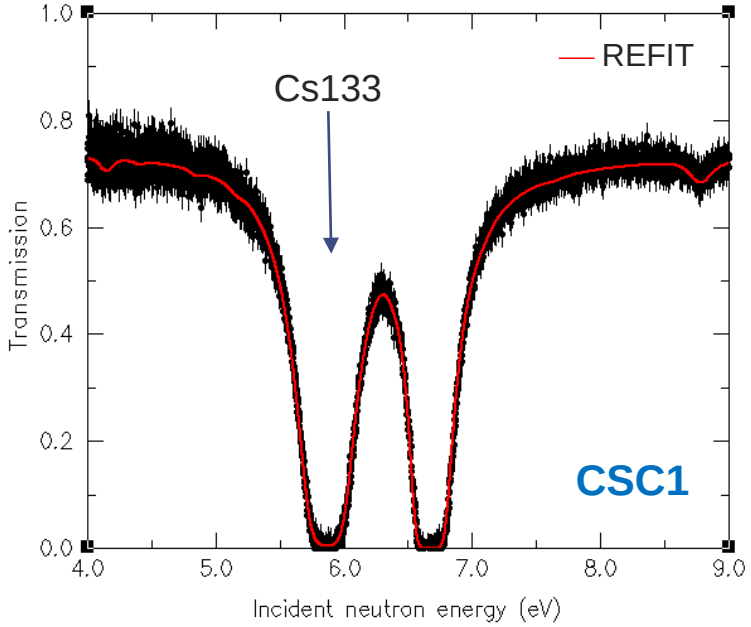
Picture of the MINERVE sample in the beam

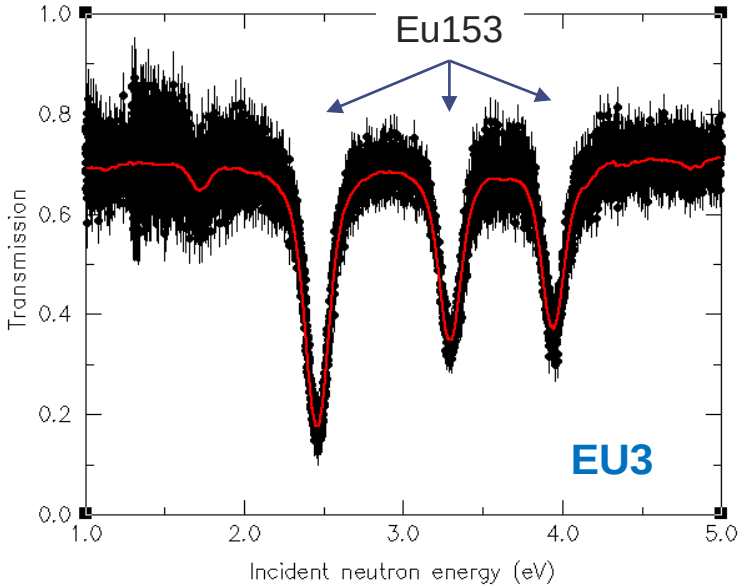


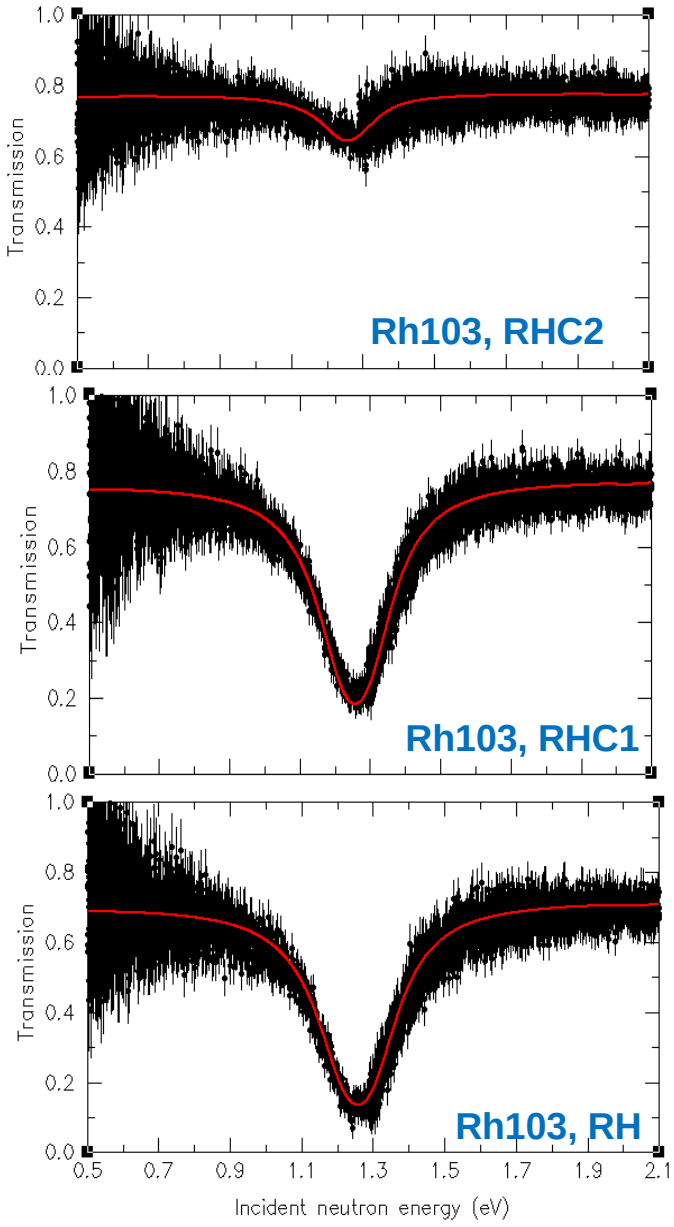
Zircaloy-4 cladding

UO_2 pellet containing fission product

Results (1/4)



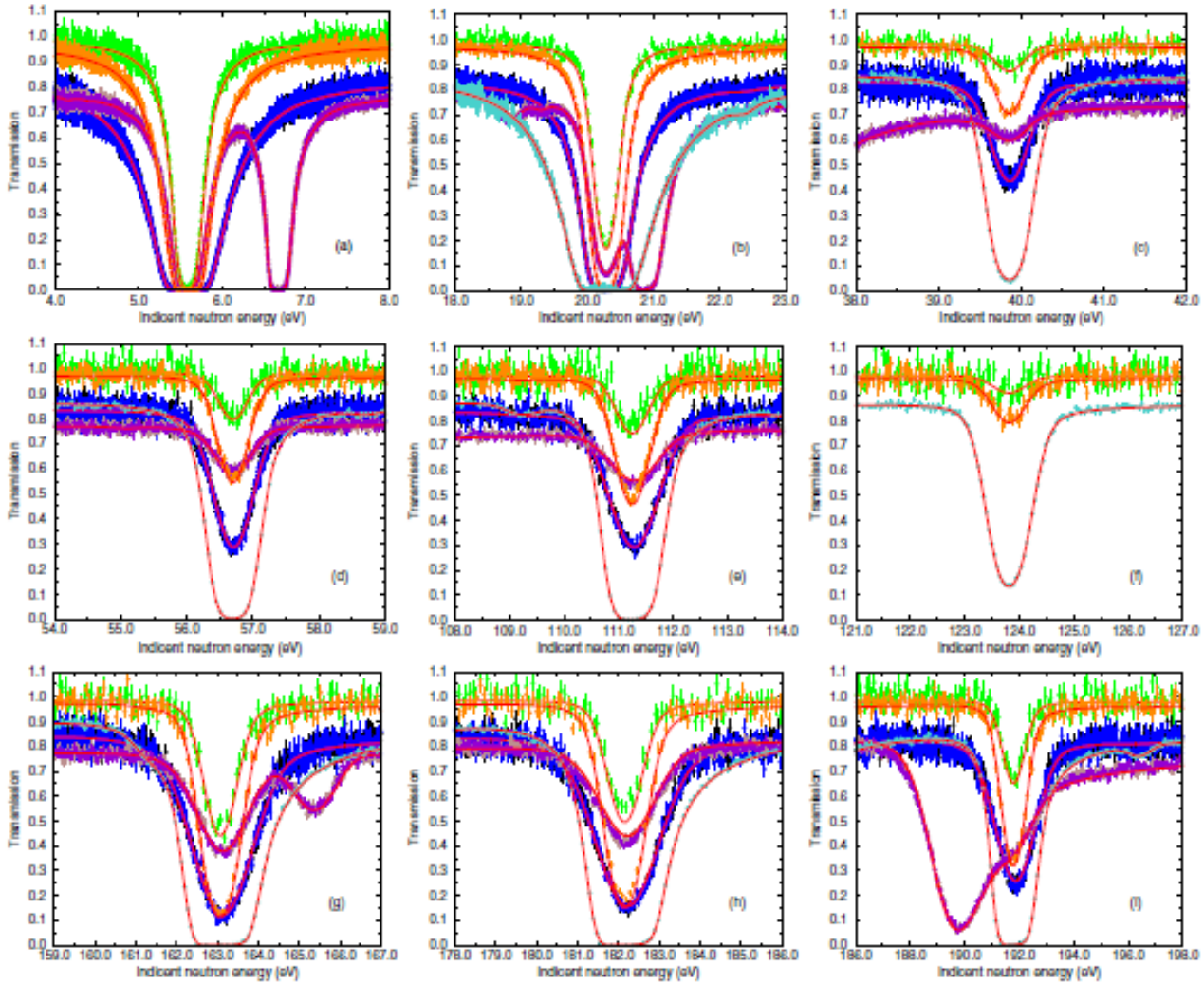




Good agreement between theoretical transmission (**in red**) and data (**in black**)

GELINA confimed MINERVE sample composition declared by the manufacturer

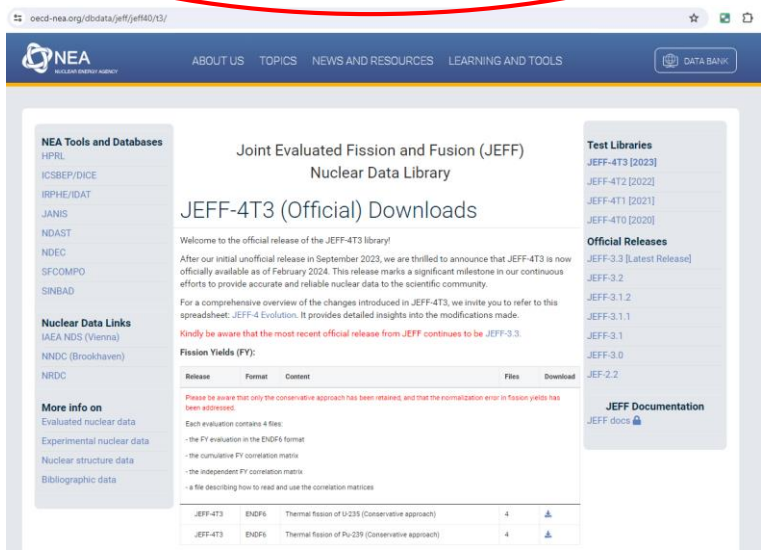
Results (2/4)



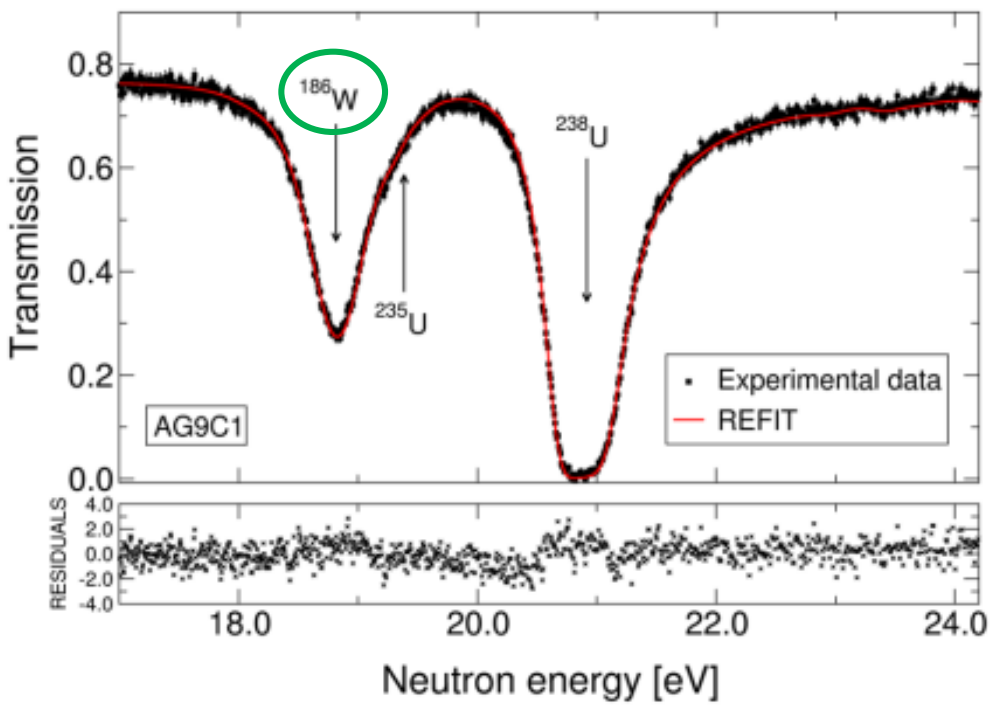
Tc99

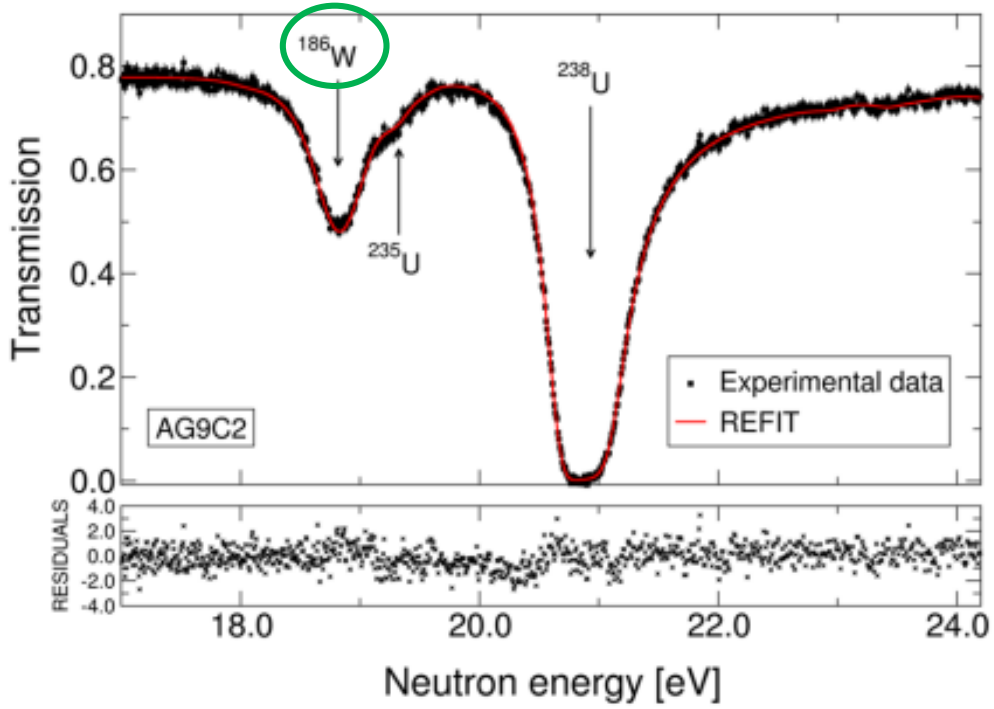
Simultaneous analysis of various transmission data measured at the GELINA facility

GELINA contributes to improve nuclear data for the JEFF library



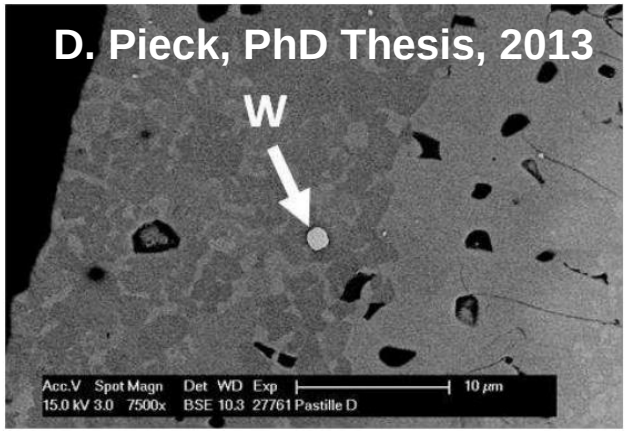
Results (3/4)





GELINA highlighted a tungstene contamination not reported by the manufacturer of the MINERVE samples

Erosion of **tungsten carbide balls** used for powder grinding



Results (4/4)

⇒ Volume number density of the tungsten isotopes in the MINERVE samples provided by GELINA

Sample	^{182}W (26.50 at%)	^{183}W (14.31 at%)	^{184}W (30.64 at%)	^{186}W (28.43 at%)
AG9C1	1.59×10^{-5}	8.56×10^{-6}	1.83×10^{-5}	1.70×10^{-5}
AG9C2	7.30×10^{-6}	3.94×10^{-6}	8.43×10^{-6}	7.82×10^{-6}
UNC	2.06×10^{-6}	1.11×10^{-6}	2.37×10^{-6}	2.20×10^{-6}
AAG	1.63×10^{-6}	8.80×10^{-7}	1.89×10^{-6}	1.75×10^{-6}

The densities are expressed in 10^{24} at/cm^3

⇒ Impact of tungsten on the calculated reactivity worth

MINERVE sample	Impact W on the calculated reactivity worth
AG9C1	+1.5 %
AG9C2	**+9,9 %**

Large impact of the tungsten contamination

GELINA suggests that the reactivity worth measured with the MINERVE sample AG9C2 is not trustable

Conclusions

30 MINERVE samples containing fission products available at JRC-Geel for transmission measurements

- Tc99, Ag109, Ag107, Rh103, Gd155, Eu153, Cs133, Gd_2O_3 completed

GELINA measurements confirm the composition provided by the manufacturer of the MINERVE samples …

- Differences between volume densities declared by the manufacturer and GELINA results close to 2%

… and highlighted a non-negligible tungsten contamination

- New interpretation of the pile oscilation measurements with the GELINA results in progress