^{241}Am: a difficult actinide for (n,γ) cross section measurement

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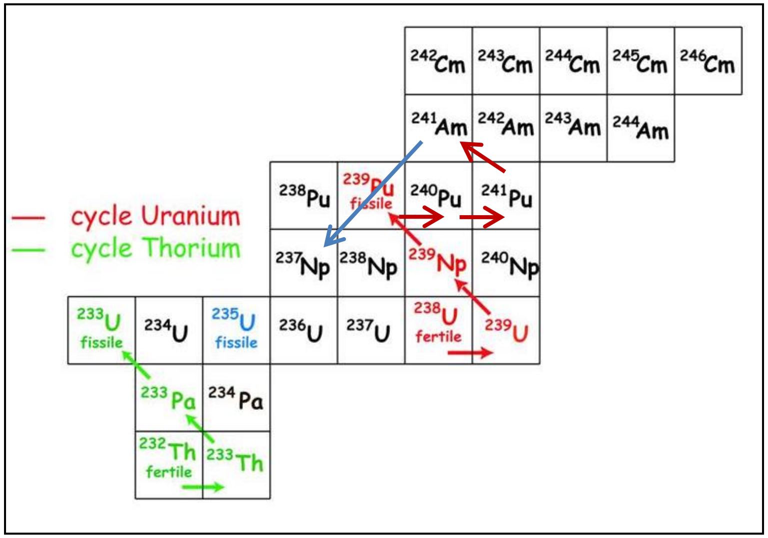
- Sample preparation for PGAA
- Irradiation and spectrum evaluation
- Thermal neutron capture cross sections
- Conclusions and future plans

^{241}Am: Importance in the nuclear fuel cycle



Production and decay of ^{241}Am in nuclear fuel

1 ton of nuclear fuel contains:

- **955.4 kg U**
- **8.5 kg Pu**

Minor actinides (MA):

- **0.5 kg ^{237}Np (t$_{1/2}$= 2.14 10^{6} y)**
- **0.6 kg $^{241+242}$Am (^{241}Am: t$_{1/2}$ = 432 y)**
- **0.02 kg Cm (^{245}Cm: t$_{1/2}$= 8500 y)**

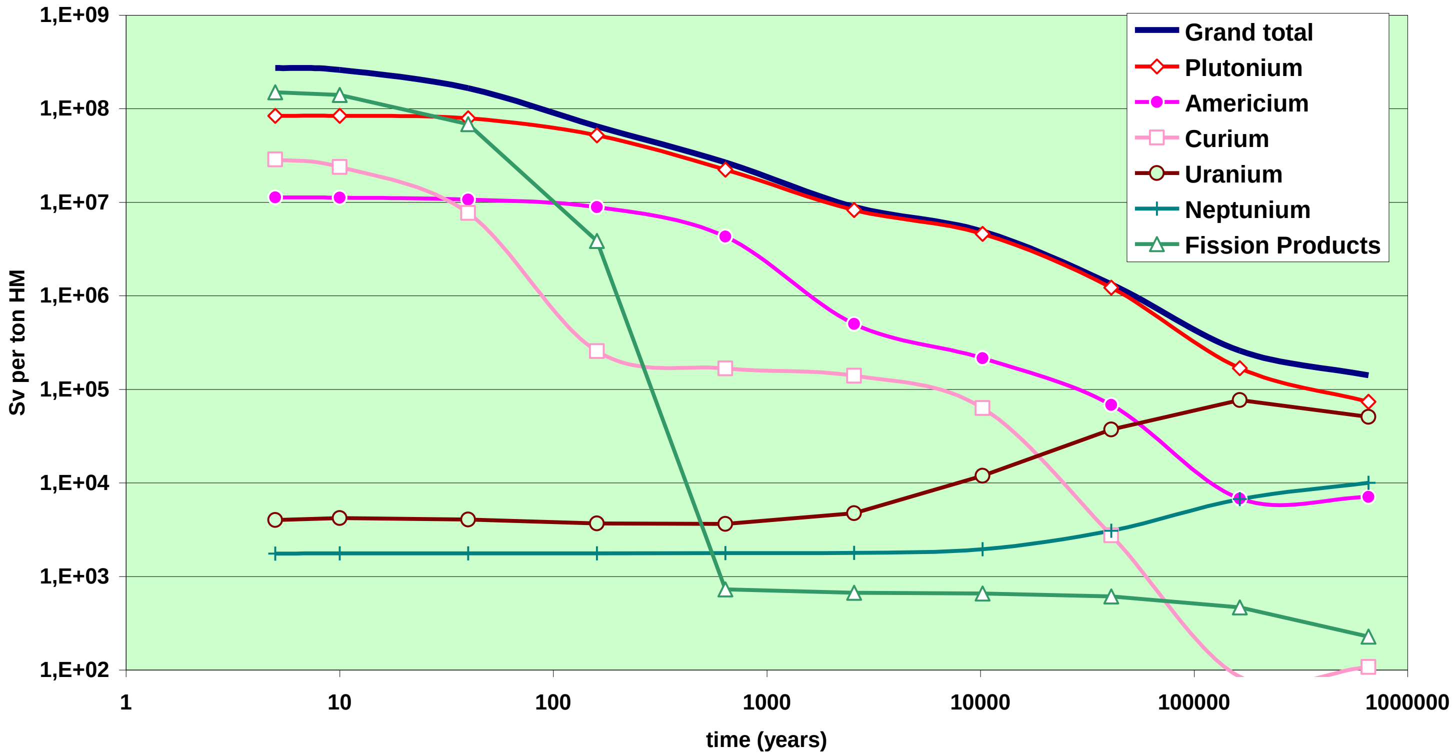
Long lived Fission Products:

- **0.2 kg ^{129}I (t$_{1/2}$ = 1.57 10^{7} y)**
- **0.8 kg ^{99}Tc (t$_{1/2}$ = 2.1 10^{5} y)**
- **0.7 kg ^{93}Zr (t$_{1/2}$ = 1.5 10^{6} y)**
- **0.3 kg ^{135}Cs (t$_{1/2}$ = 2.0 10^{6} y)**

Stable Isotopes:

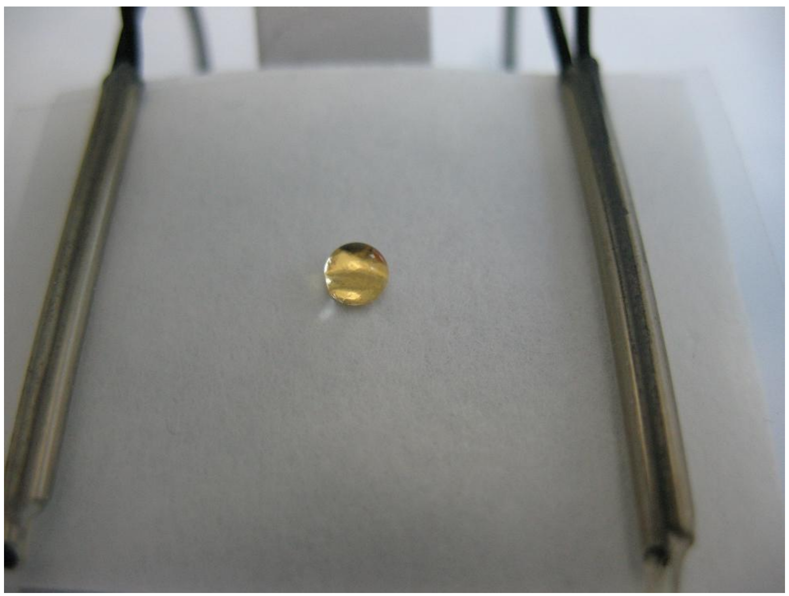
- **10.1 kg Lanthanides**
- **21.8 kg other stable Isotopes**

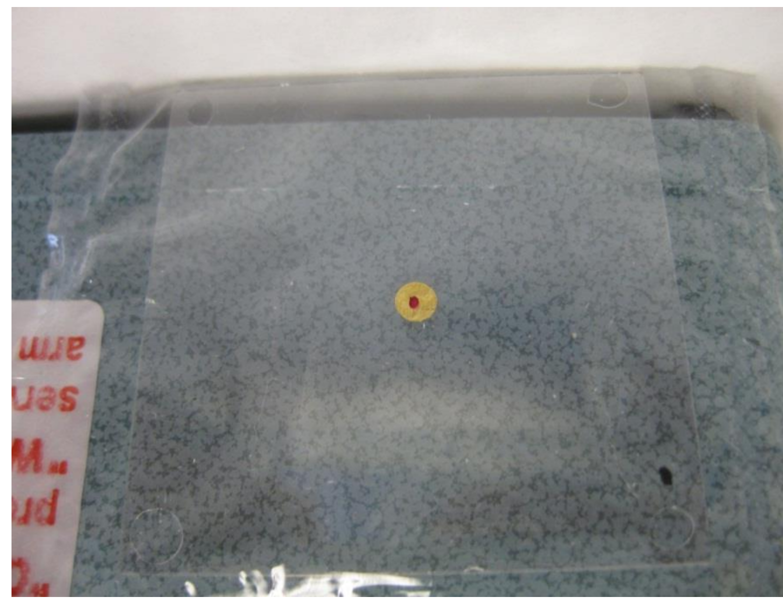
^{241}Am: Importance in the nuclear fuel cycle



Spent fuel toxicity, from: RED-Impact, Synthesis Report, Jülich, 2008

Sample preparation for PGAA



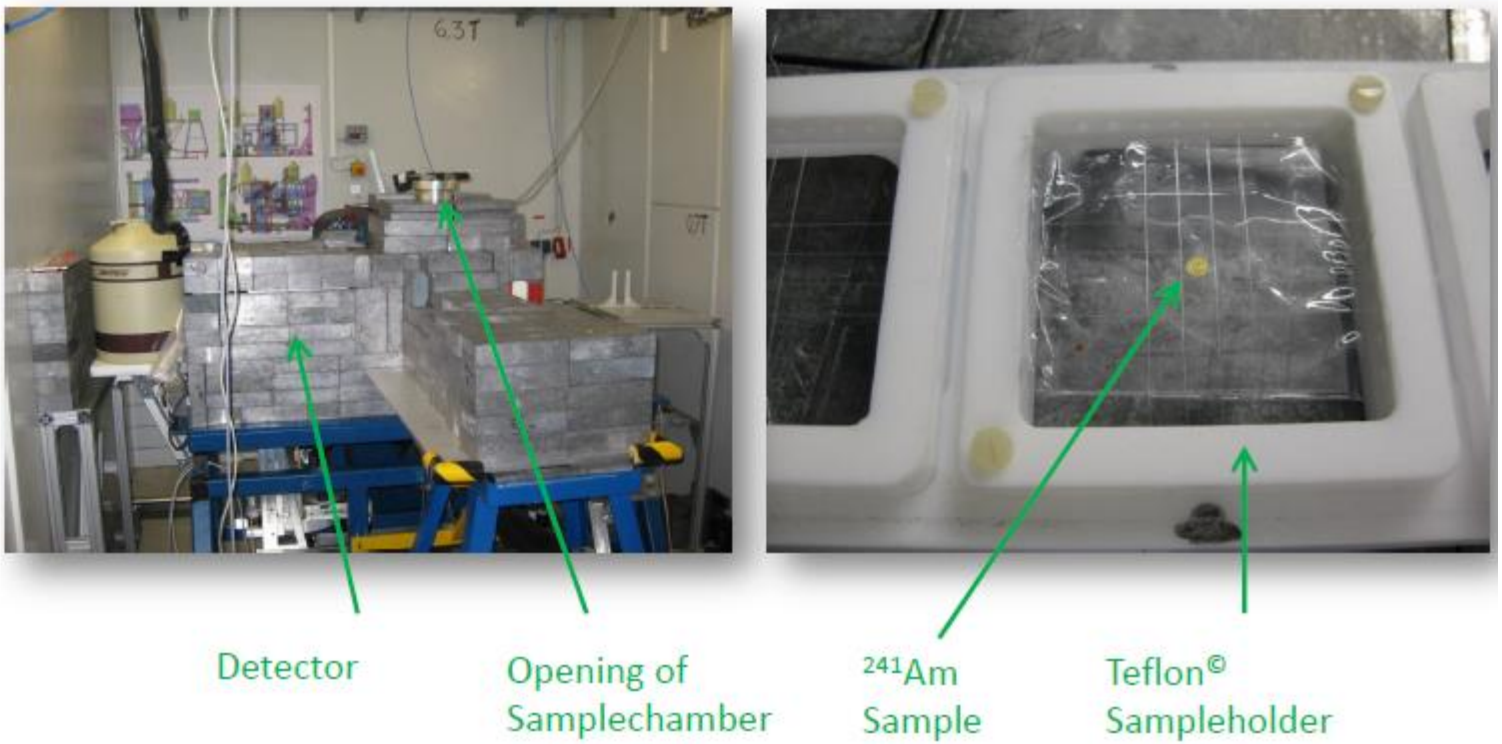


^{241}Am samples of 4-5 MBq have been prepared by PTB-Braunschweig

These samples were sealed in 0.2 mm quartz blades with epoxy and additionally sealed in Teflon© bags.

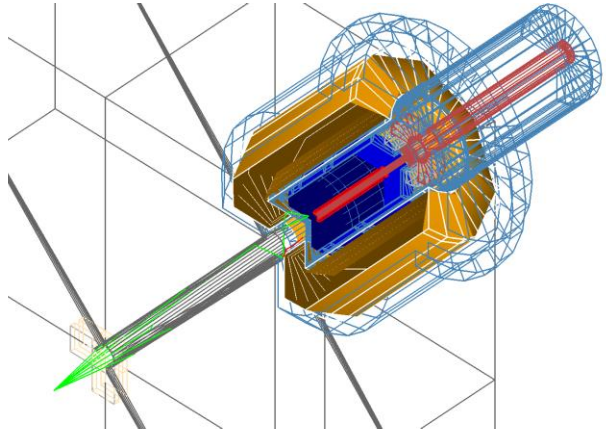
Sample preparation for PGAA

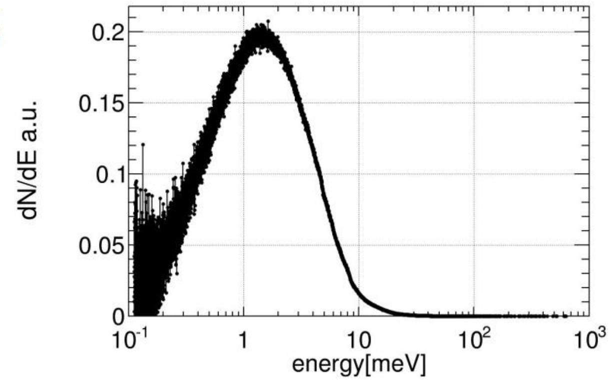
Samples are placed at an angle of 45° with the neutron beam in the sample chamber in front of the detector.



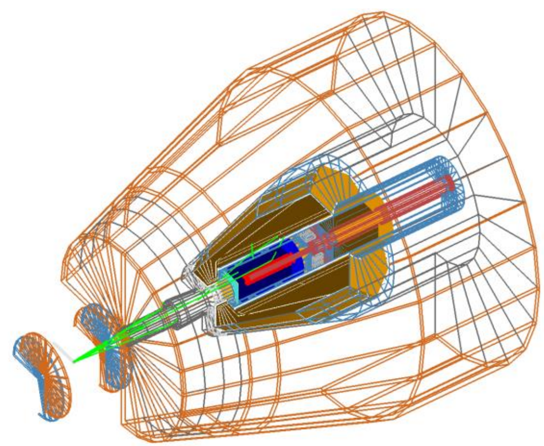
Measurement Facilities

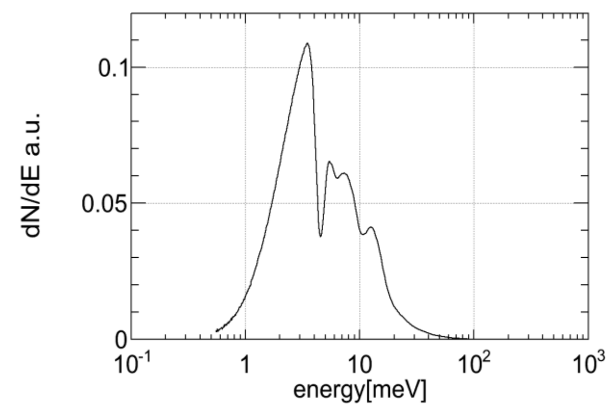
FRM II





Budapest





Experimental setup

GEANT4 simulation

N Energy spectrum

Spectrum evaluation

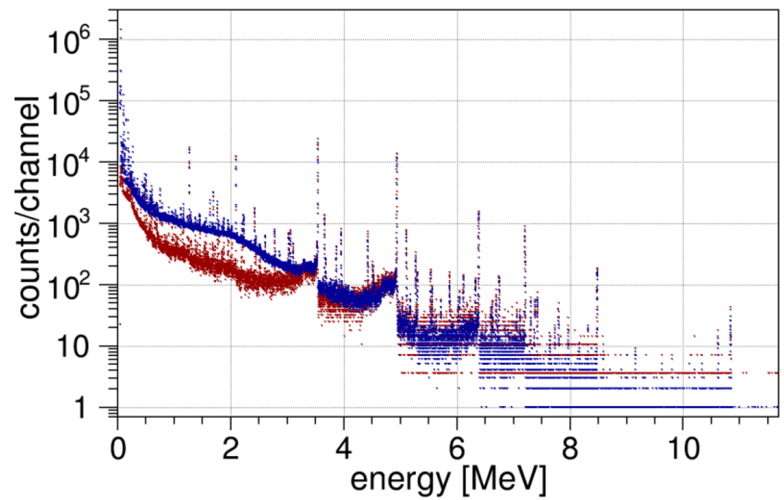
thermal equivalent neutron flux in the sample is: $\Phi_n = \frac{P_{411}}{N_{Au} \times \sigma_{411} \times t_{irr}}$,

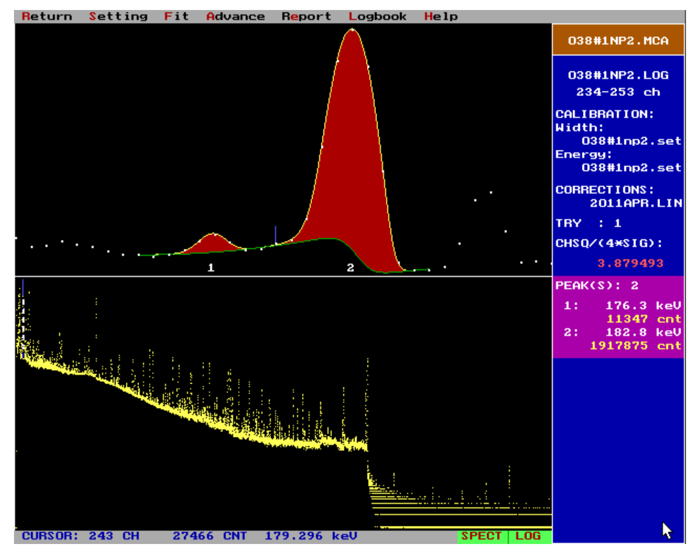
partial gamma ray production cross section is: $\sigma_\gamma = \frac{P_\gamma}{N \cdot \Phi_n \cdot t_{irr}}$,

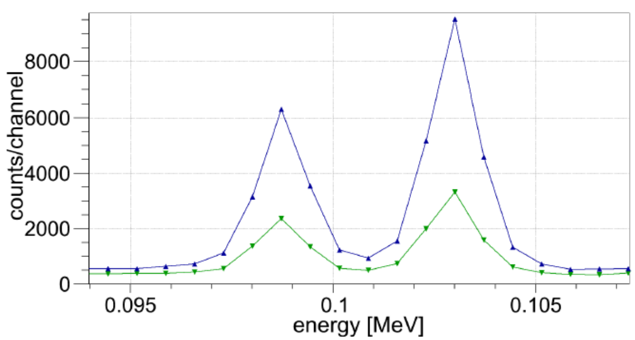
Monte Carlo simulations using the Geant4 code were carried out to account for self-shielding effects in the sample.

P is the corrected peak area, σ the corresponding partial gamma ray production cross section , N the number of atoms and t_{irr} the irradiation time.

gamma ray spectra were evaluated using Hypermet-PC







Thermal cross sections calculated using the ^{242}Pu X-Ray emission at 99 and 103 keV after ^{242g}Am decay to ^{242}Pu

Why ^{242}Pu x-rays?

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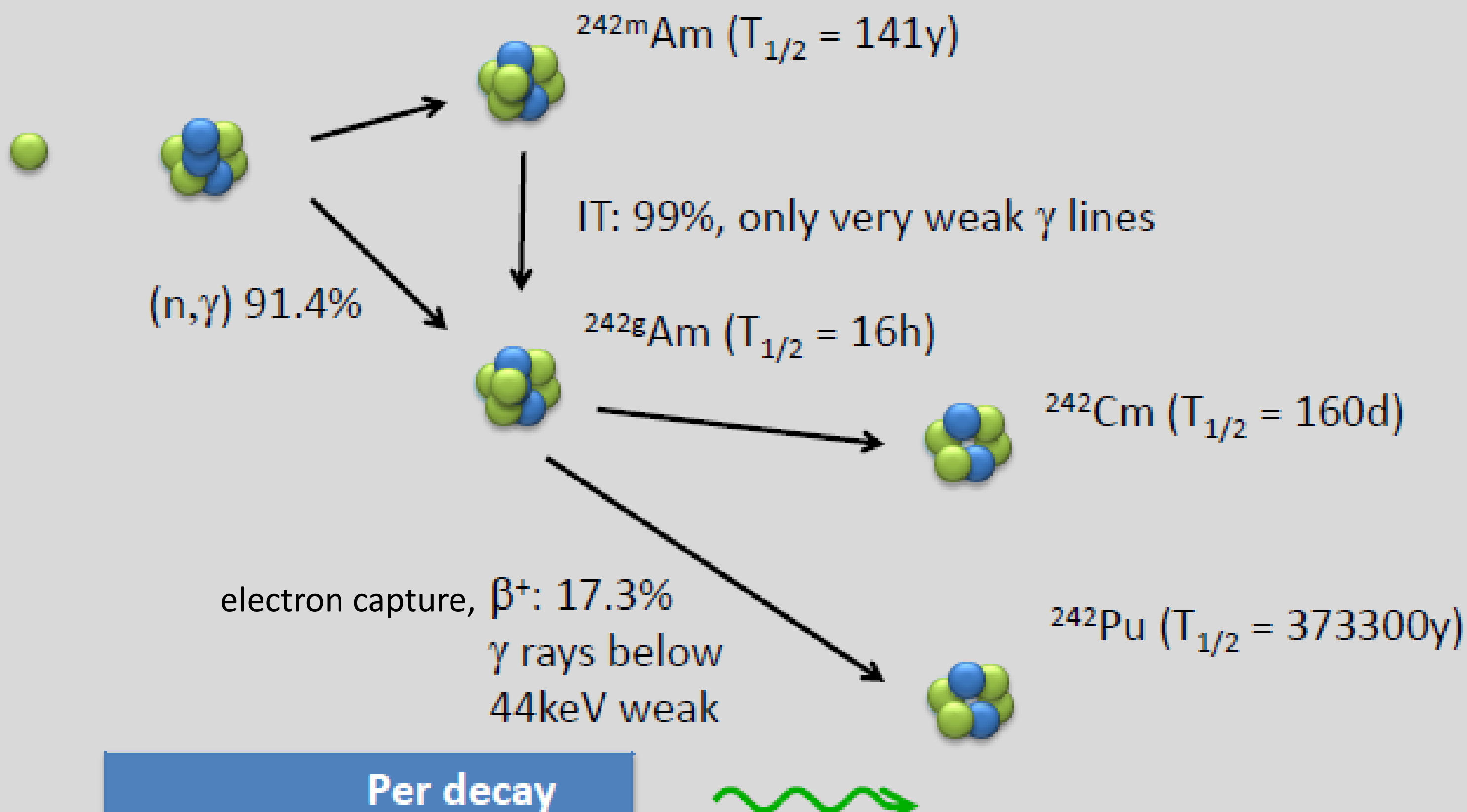
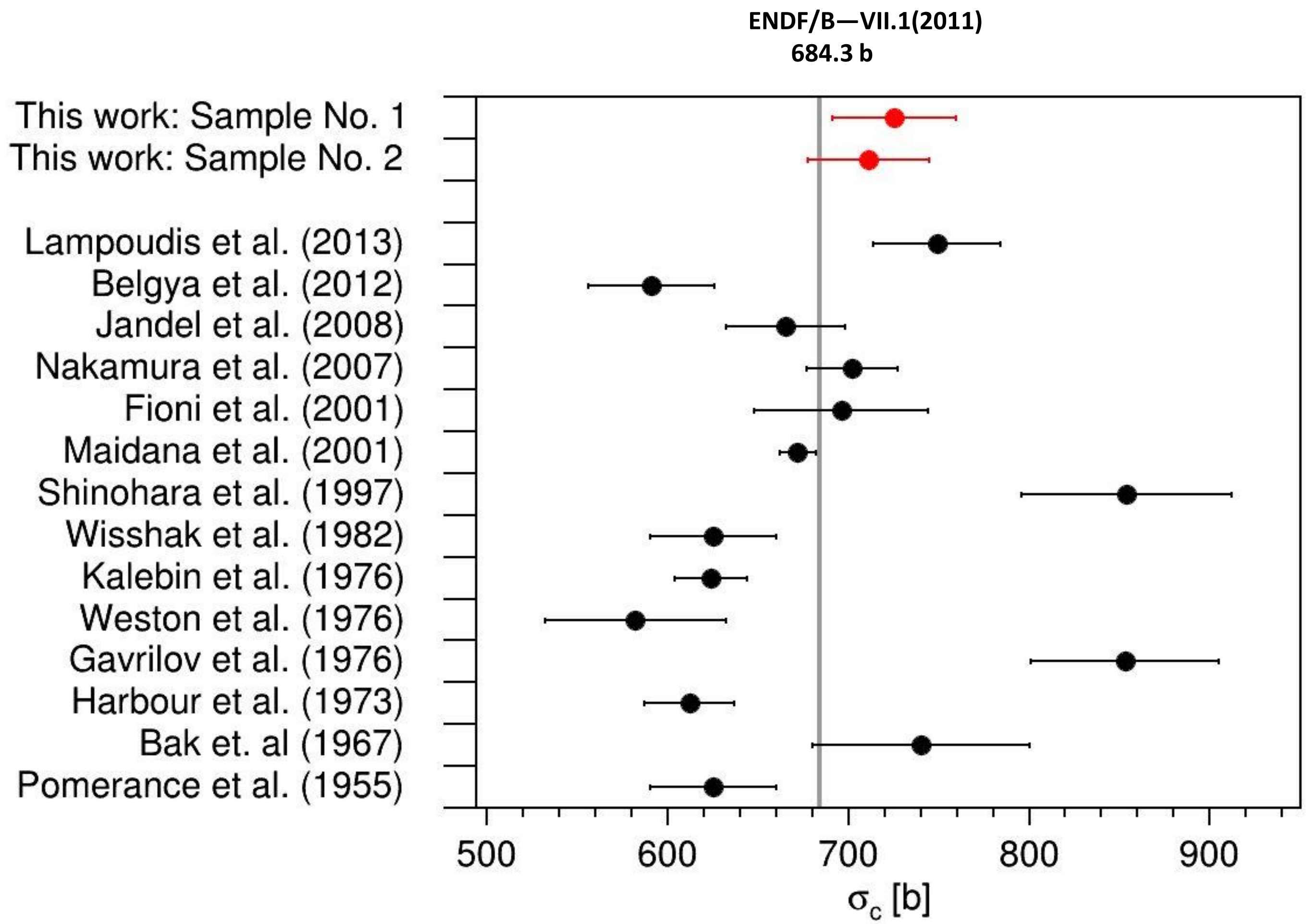


	Per decay
99 keV	0.0355 ± 0.0017
103 keV	0.056 ± 0.003

X-ray K_α after annihilation of e^+ and e^- in ^{242}Pu shell

Thermal neutron capture cross section of ^{241}Am



$^{241}Am(n,\gamma)^{242g,m}Am$

= 725,4 ± 34,4

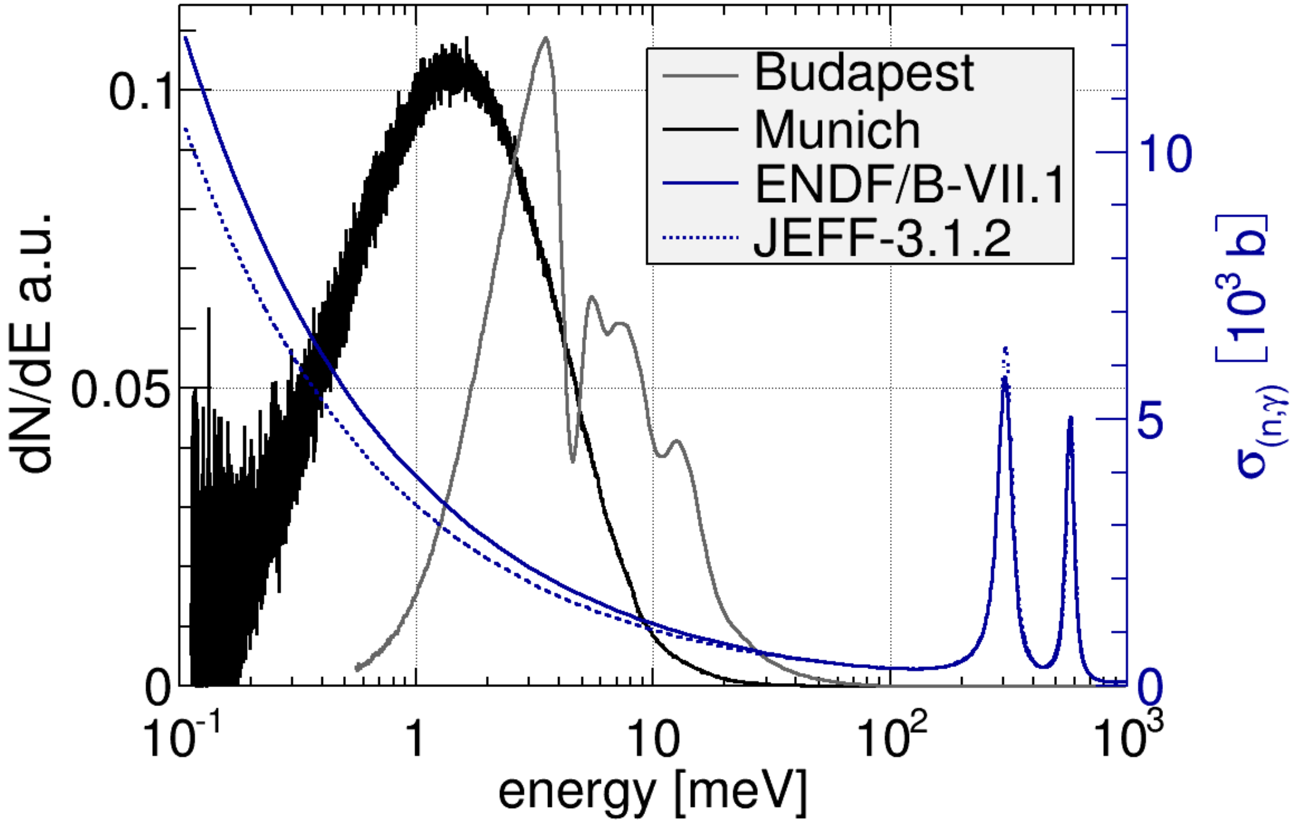
= 711.1 ± 33.9 b

$^{241}Am(n,\gamma)^{242g}Am$

= 663.0 ± 28.8

= 649.9 ± 28.2 b

Thermal neutron capture cross section of ^{241}Am



Problems in ^{241}Am cross section determination

- Preparation of samples is awkward due to self-radiation of ^{241}Am.
- Branching ration for ^{241g}Am and ^{241m}Am crucial for σ_0 ^{241}Am (Fioni, 2001: 0.914 ± 0.007)
- Evaluation based on x-rays from decay of ^{242}Am requires a LED.
- Low energy resonances influence thermal cross section determin.
- Uncertainty is dominated by emission probability of x-rays.
- Low abundance of prominent prompt gamma lines make σ_γ determination difficult.

We need stronger samples

Thank You!

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