High accuracy measurement of the ^{235}U(n,f) reaction cross-section in the 10-30 keV neutron energy range in EAR1@n_TOF

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Spokeperson: **M. Barbagallo**

Technical coordinator: **O. Aberle**

CERN INTC meeting, June 25th 2014

Why ^{235}U(n,f) @ 10-30 keV?

- **^{235}U(n,f) cross-section** is often *(i.e. nearly always)* used as a reference in cross-section measurements of **major and minor actinides.**

- **^{235}U(n,f)** based detectors are widely used to measure **neutron fluxes** (MACS..).

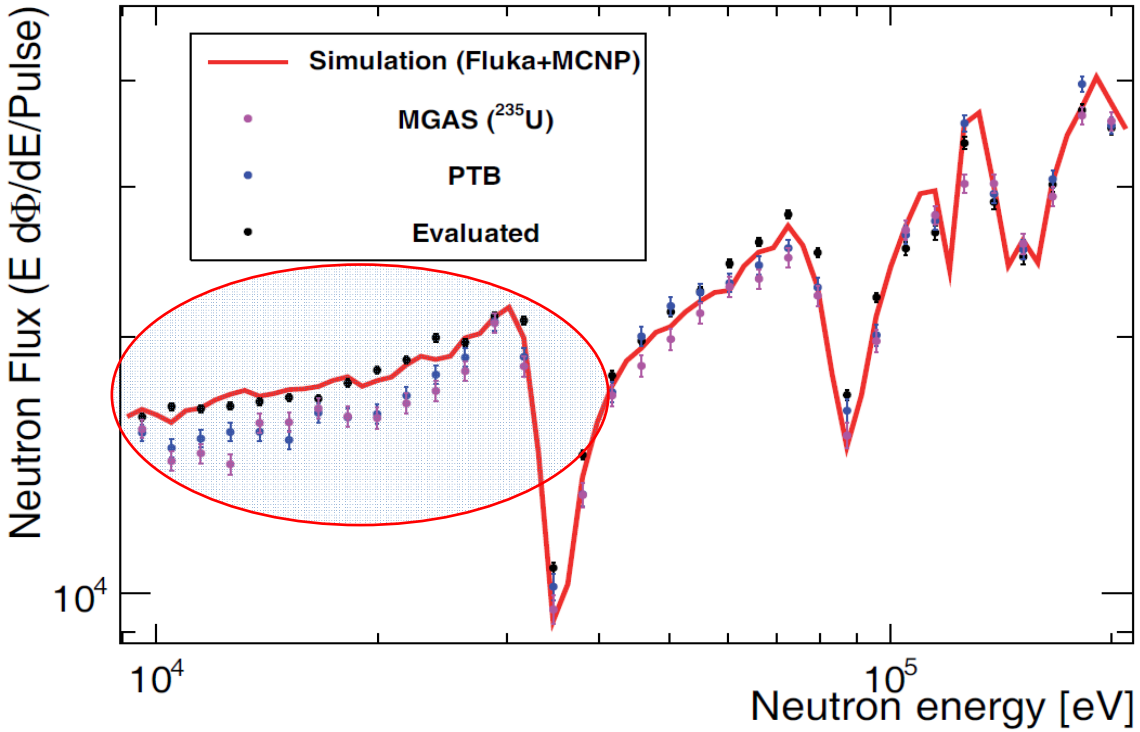
- **^{235}U(n,f) cross section** in the energy range proposed can have a significant impact on fast critical reactor and sub-critical ADS.

Motivations 1

The **n_TOF Phase-2 neutron flux** was accurately determined using **5 different detectors** and **3 different converting reactions.**

• The analysis of the neutron flux has revealed a discrepancy between results based on **^{235}U(n,f)** cross section and results based on **^{6}Li(n,t)α** and **^{10}B(n,α)^{7}Li,** **regardless of the detection system used (*).**

• Also the comparison with the simulations shows such a discrepancy in the range 10-30 keV.



6-8% overestimation of the fission cross-section of ^{235}U in database**?**

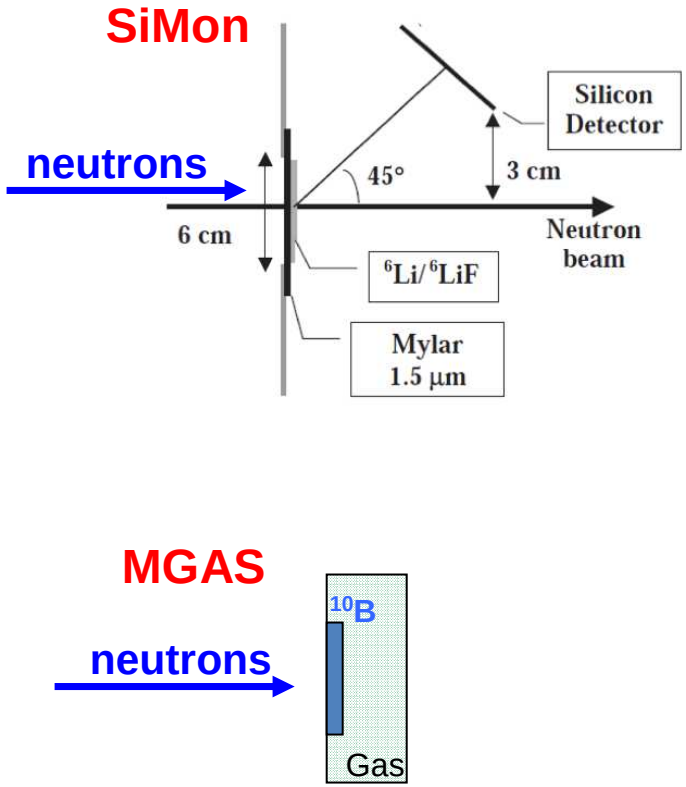
^{235}U(n,f) cross section not standard in that energy region, but declared known with <1% uncertainty (**)

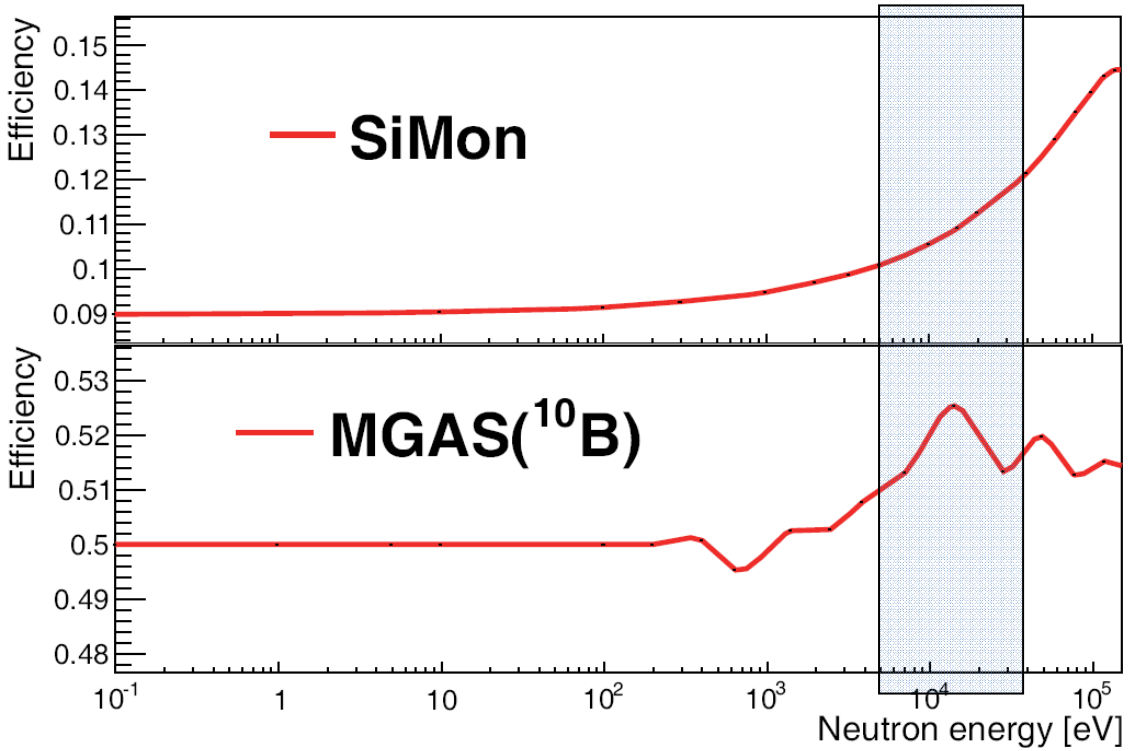
*M. Barbagallo, C. Guerrero, A. Tsinganis, D. Tarrio et al. Eur. Phys. J. A (2013) 49:156
**A.D. Carlson et al., Nucl. Data Sheet 119, 3215 (2009)

Motivations 1

In the energy range of interest the flux was determined combining the results from SiMon and MGAS(^{10}B) detectors.

The uncertainty in the **^{6}Li(n,t)** and **^{10}B(n,α)** **angular distributions** and on the particles selection prevents us from drawing a conclusion on this issue.





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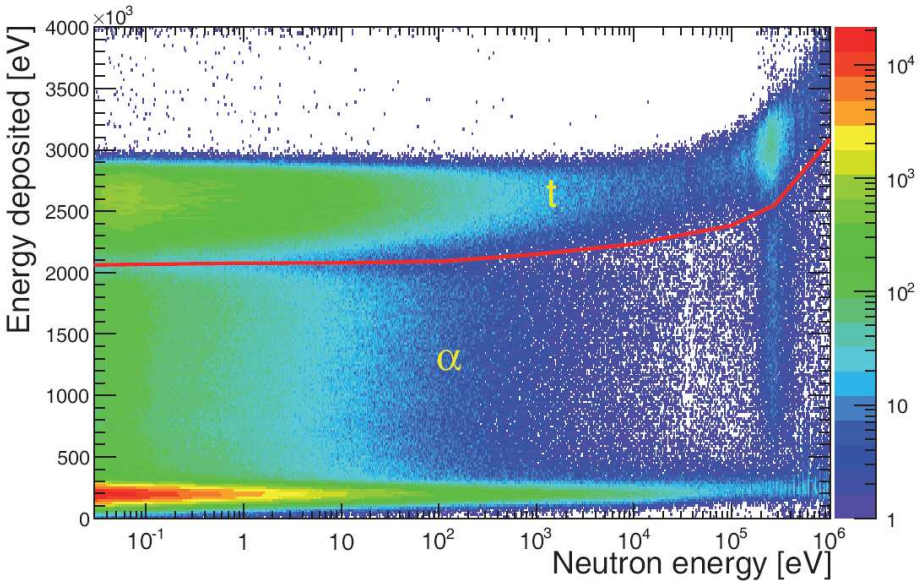
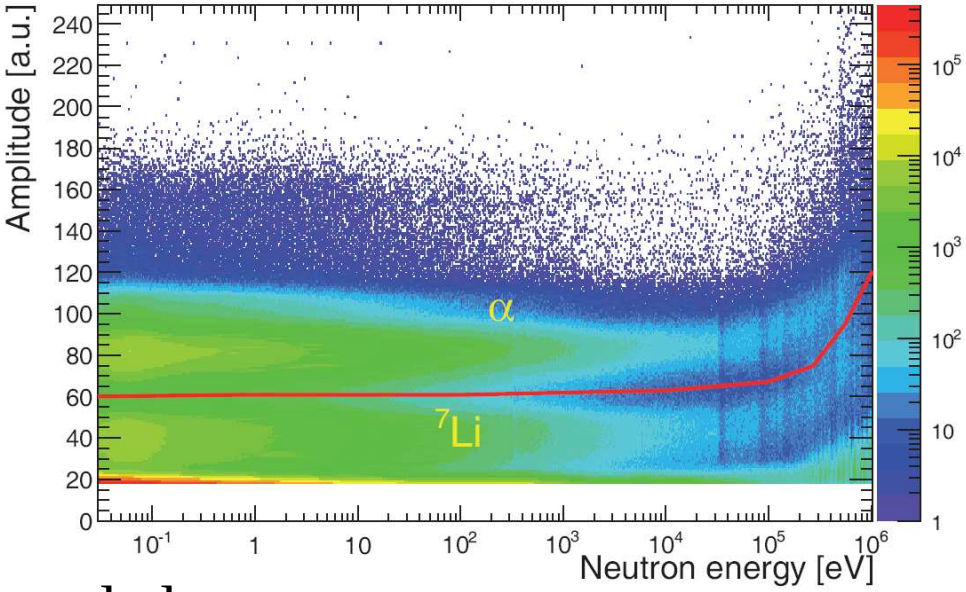


SiMon

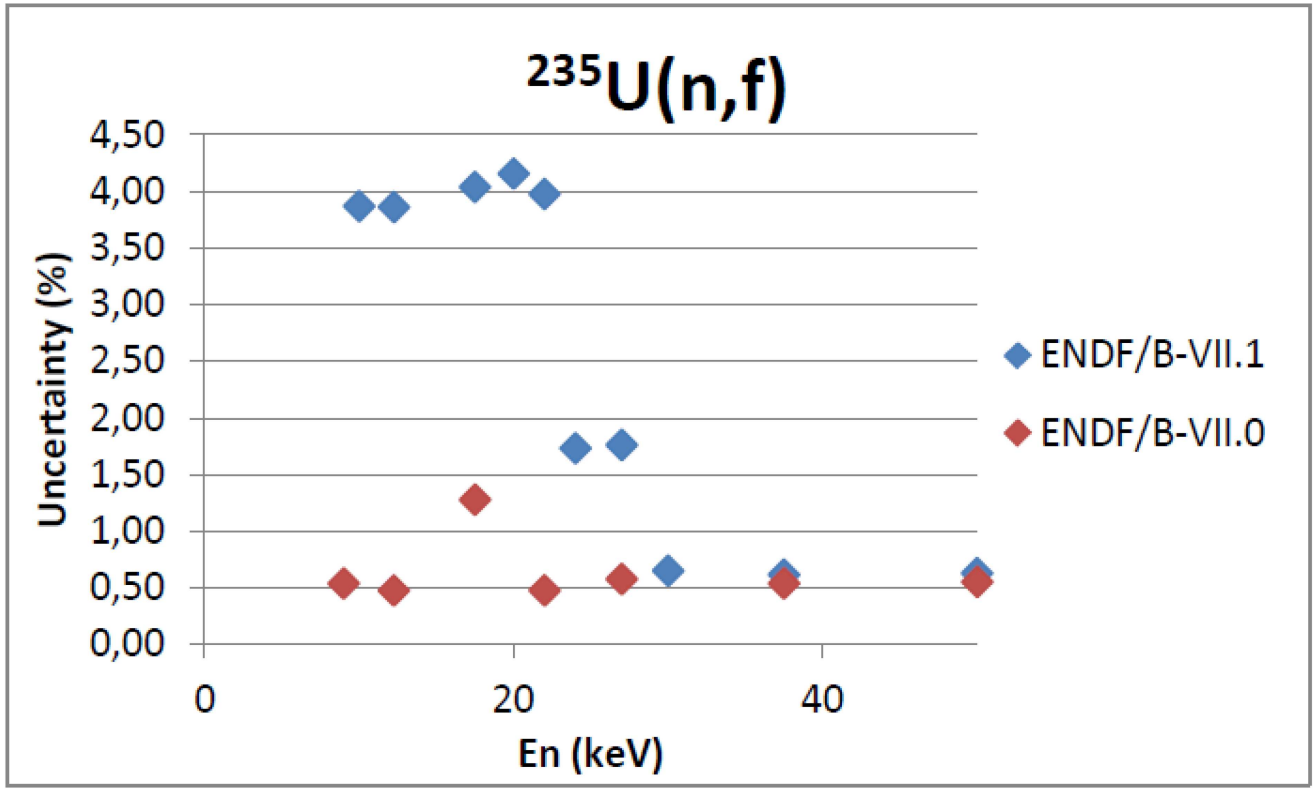
MGAS(^{10}B)

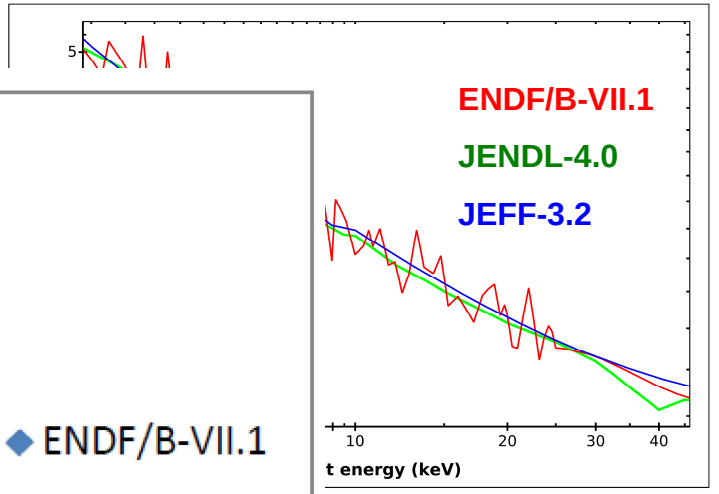


A more accurate measurement is needed.

Motivations 2

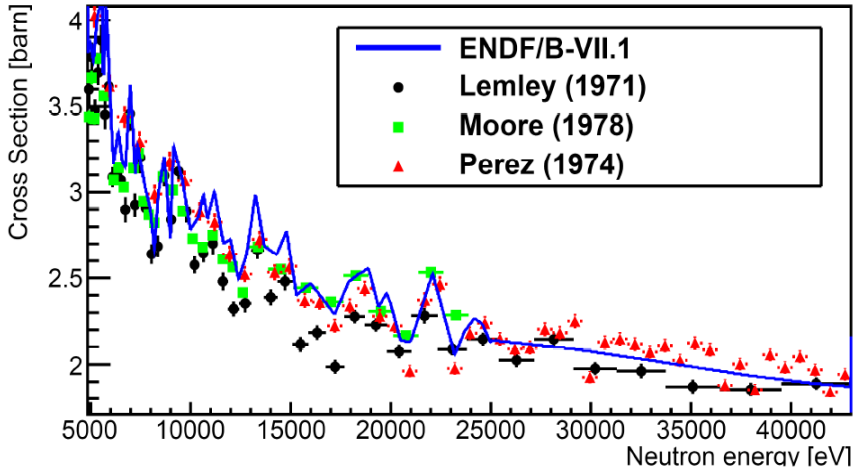
Evaluations in general are in agreement, although **"resonance-like" structures** are reported only in ENDF/B-VII.1 library.

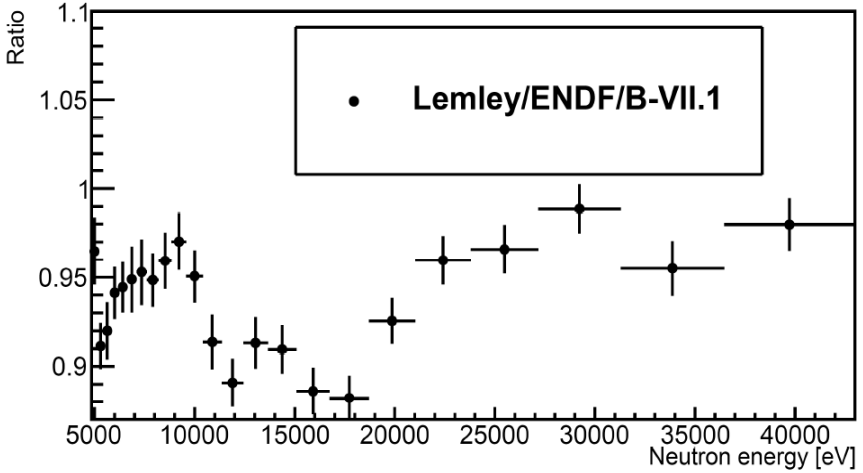


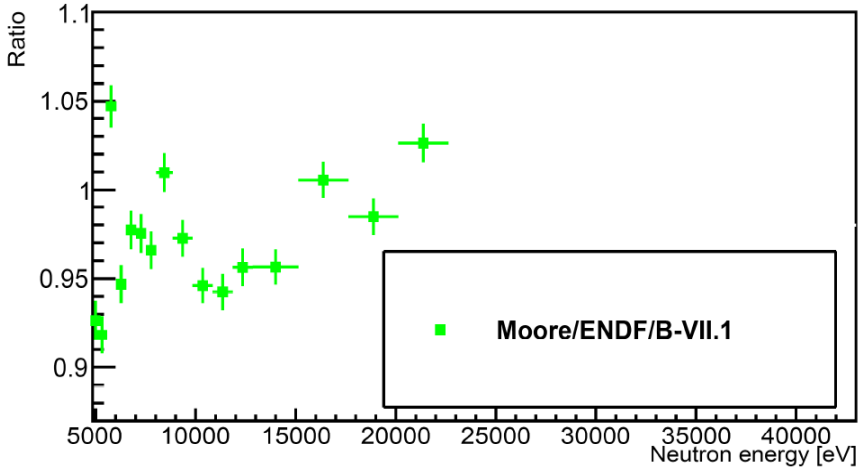


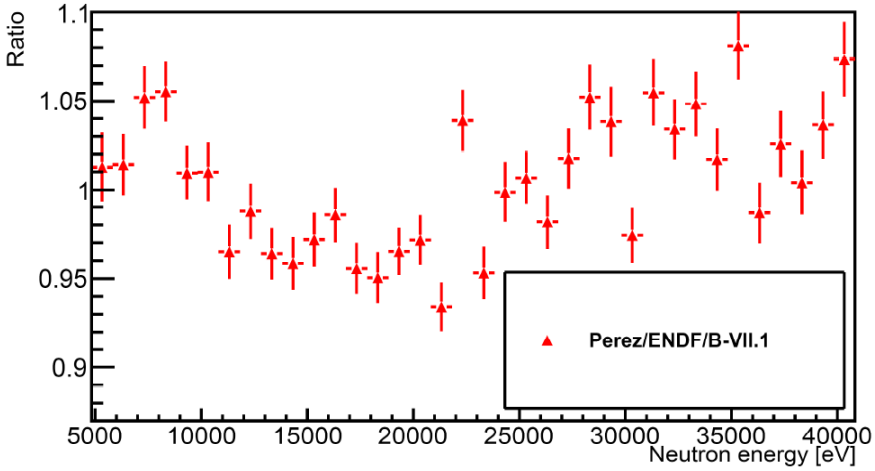
Only in this region, the uncertainties have been increased by a **factor 4** in the latest release of ENDF/B-VII data library.

Status of evaluations and experimental data









Motivations 3

^{235}U(n,γ) cross section was recently measured at Los Alamos **relative** to ^{235}U(n,f) using DANCE+PPAC

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New Precision Measurements of the ^{235}U(n, γ) Cross Section

M. Jandel,[1,*] T. A. Bredeweg,[1] E. M. Bond,[1] M. B. Chadwick,[1] A. Couture,[1] J. M. O'Donnell,[1] M. Fowler,[1] R. C. Haight,[1] T. Kawano,[1] R. Reifarth,[1,†] R. S. Rundberg,[1] J. L. Ullmann,[1] D. J. Vieira,[1] J. M. Wouters,[1,‡] J. B. Wilhelmy,[1] C. Y. Wu,[2] and J. A. Becker[2]

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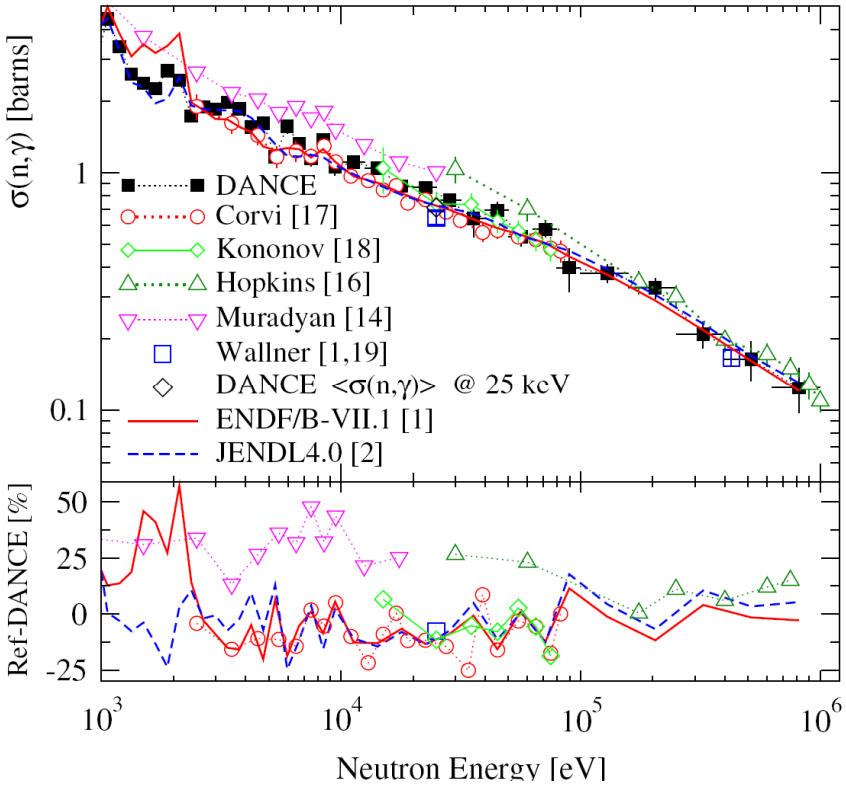
Between 10 and 30 keV, the DANCE cross sections are ~10% larger than both the ENDF/B-VII.1 and JENDL-4.0 cross sections. Significant discrepancies are observed among other measurements [14–18]. Neutron flux at

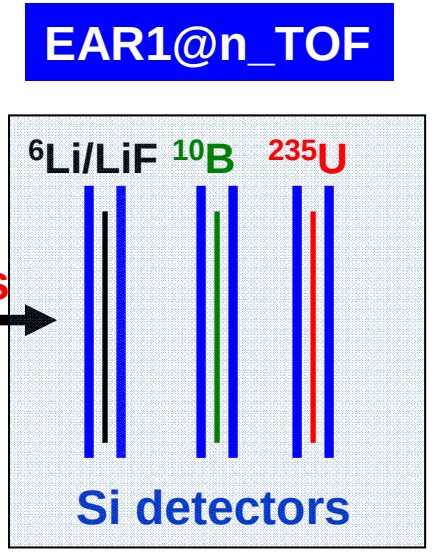


The 10% difference attributed to ^{235}U(n,γ) cross section could rather be explained by the overestimation of the **fission cross section**, consistent with our finding.

The measurement

We propose to measure in **EAR1** the **^{235}U(n,f)** cross section together with the reference reactions **^{6}Li(n,t)** and **^{10}B(n,α).**

Silicon detectors stack (*4x4 cm^2 and 200-300* μm *thickness)* **in the beam** **(capture collimator)**



- Detection at forward and backward directions
- Energy resolution
- No γ-flash issues in the energy range of interest

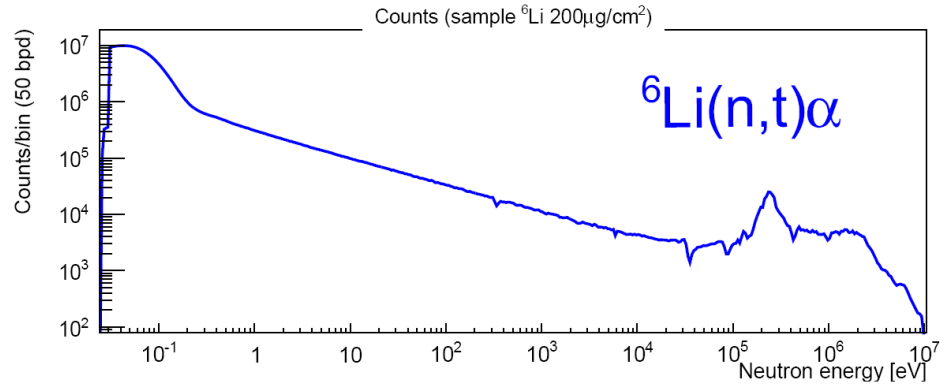
Detector test during the commissioning (Optimized MicroMegas)

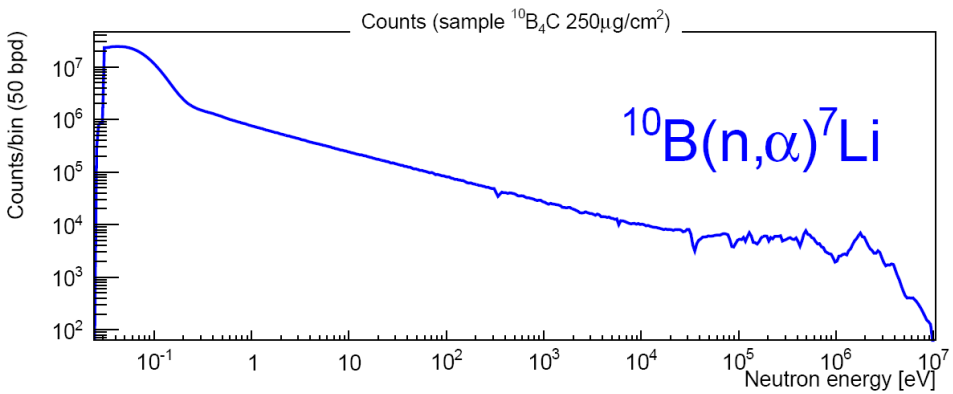
Samples:

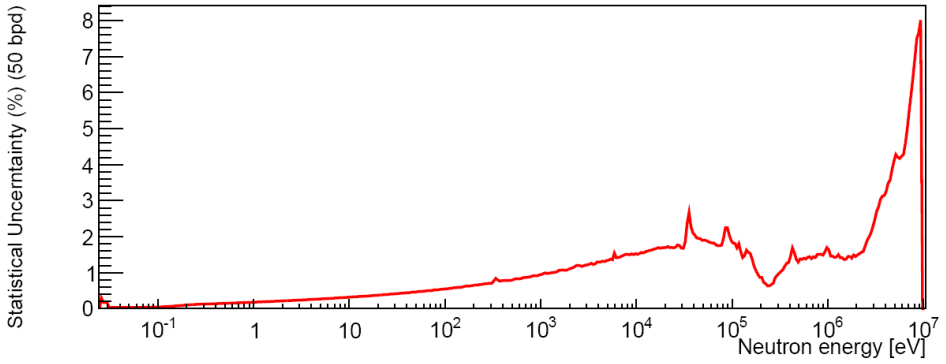
- 200-300 μg/cm^2 **^{6}Li** (C-Li-C or LiF) (LNS)
- 0.5 μm **$^{10}BC_4$** (possibly **directly** on the detector **or** on **both sides** of the **backing**) (CERN)
- 500 μg/cm^2 **^{235}U** (IRMM)

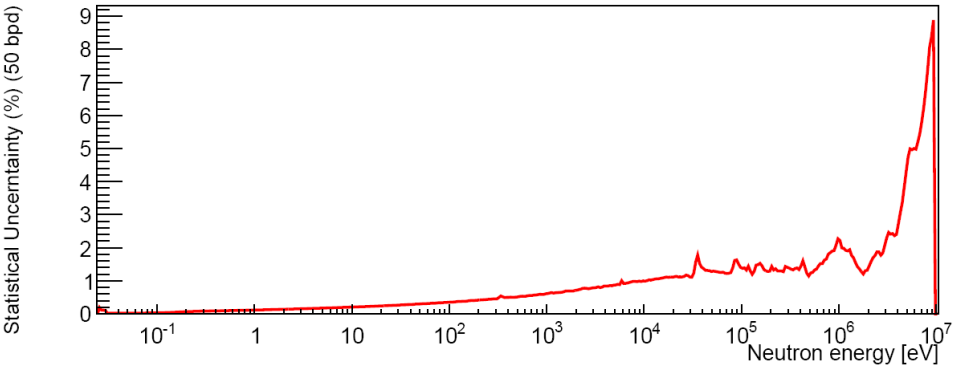
Protons request

In order to reach 1% accuracy in the energy range of interest and to observe resonance structures we ask for **1.5×10^{18} protons** on target









- 200 μg/cm^2 of ^{6}Li and 250 μg/cm^2 of ^{10}B^{4}C on 2 cm diameter circular area
- Efficiency 95%
- Flux= Flux@EAR1

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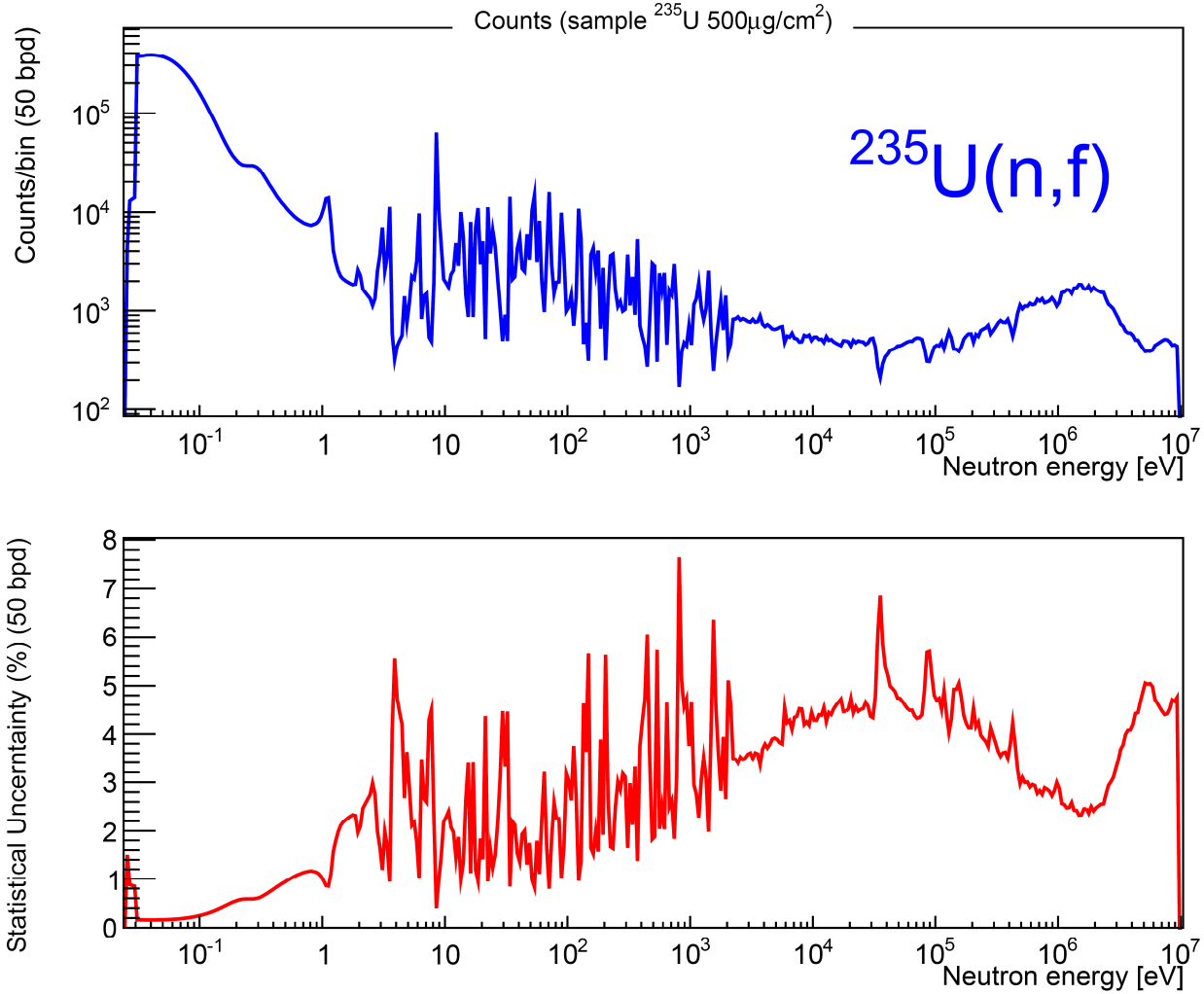

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- Flux= Flux@EAR1
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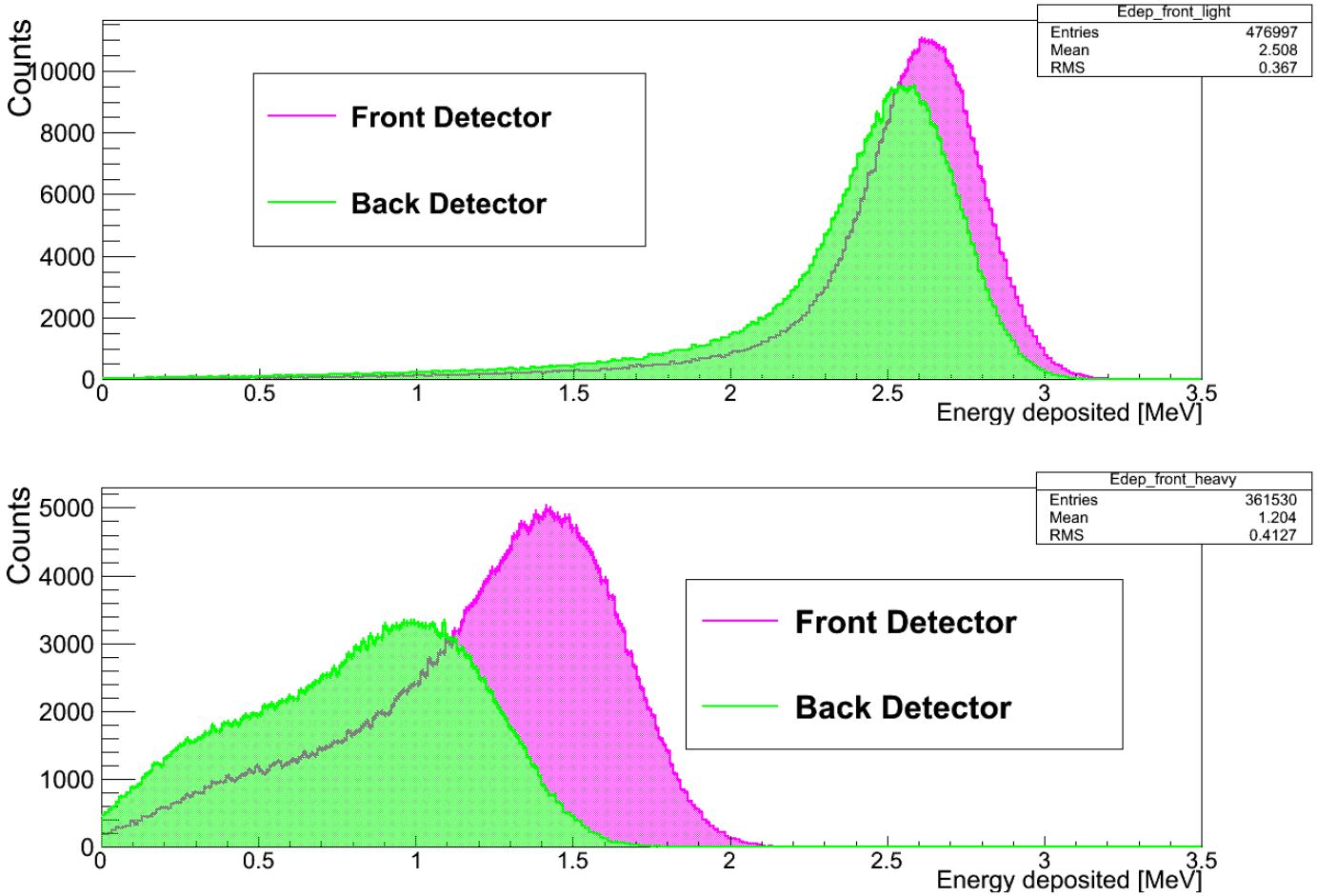
Thanks for your attention

Back up slides

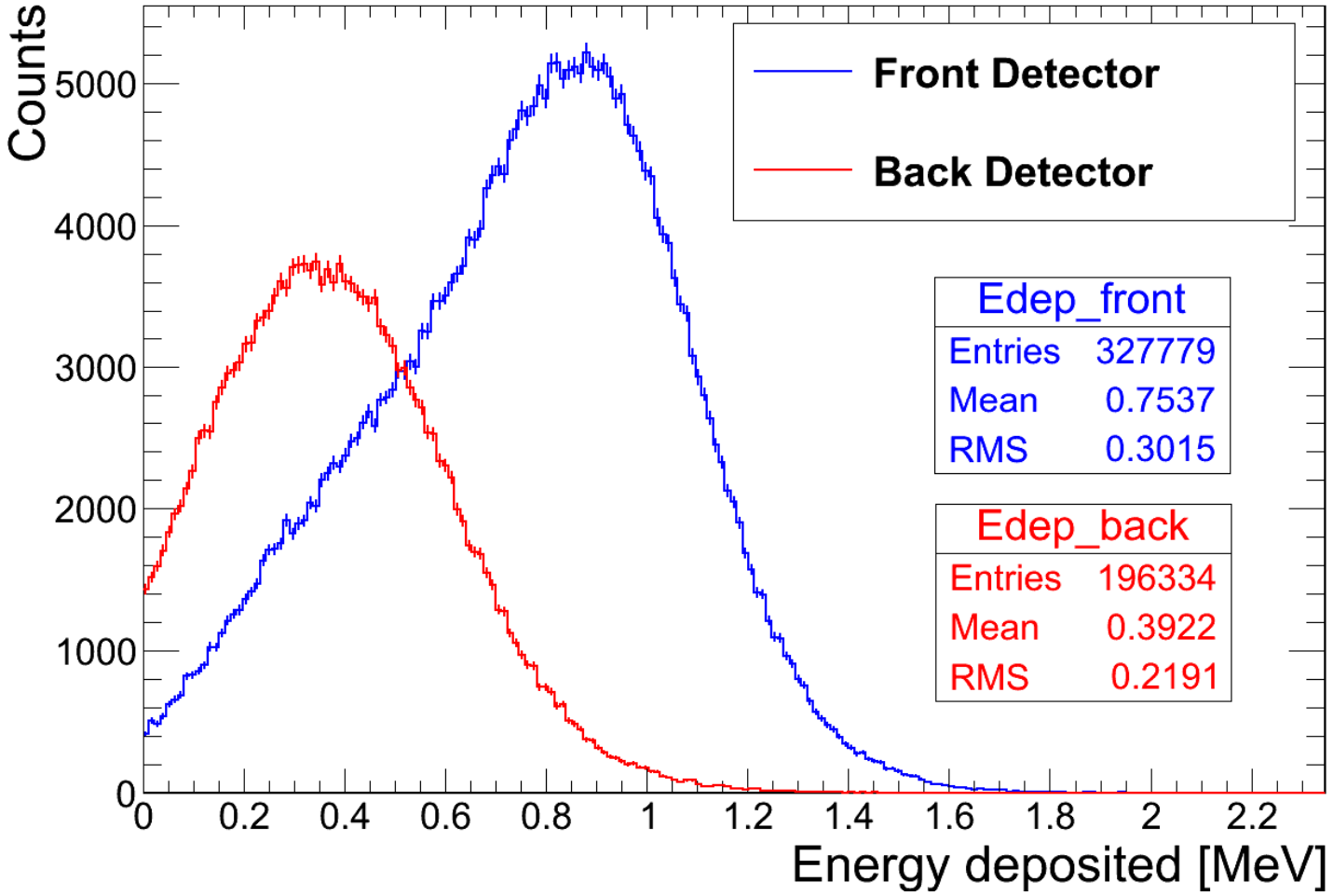
Expected energy deposition ^{6}Li



200 µg/cm^2 ^{6}Li in C sandwich deposited on 1.5 µm Mylar backing

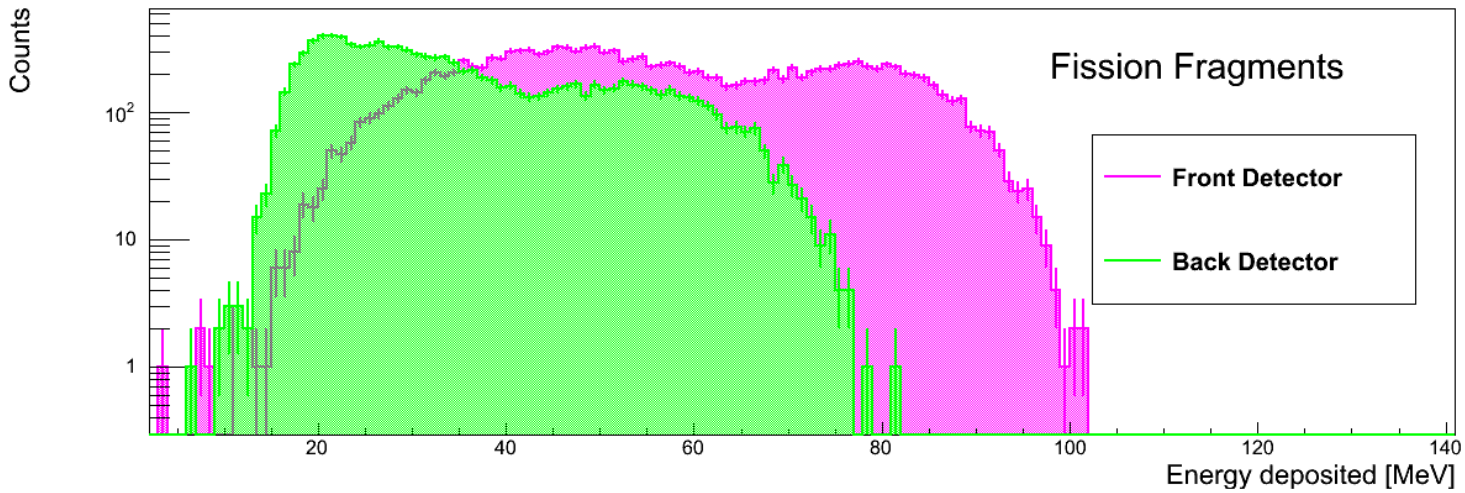
Expected energy deposition ^{10}B

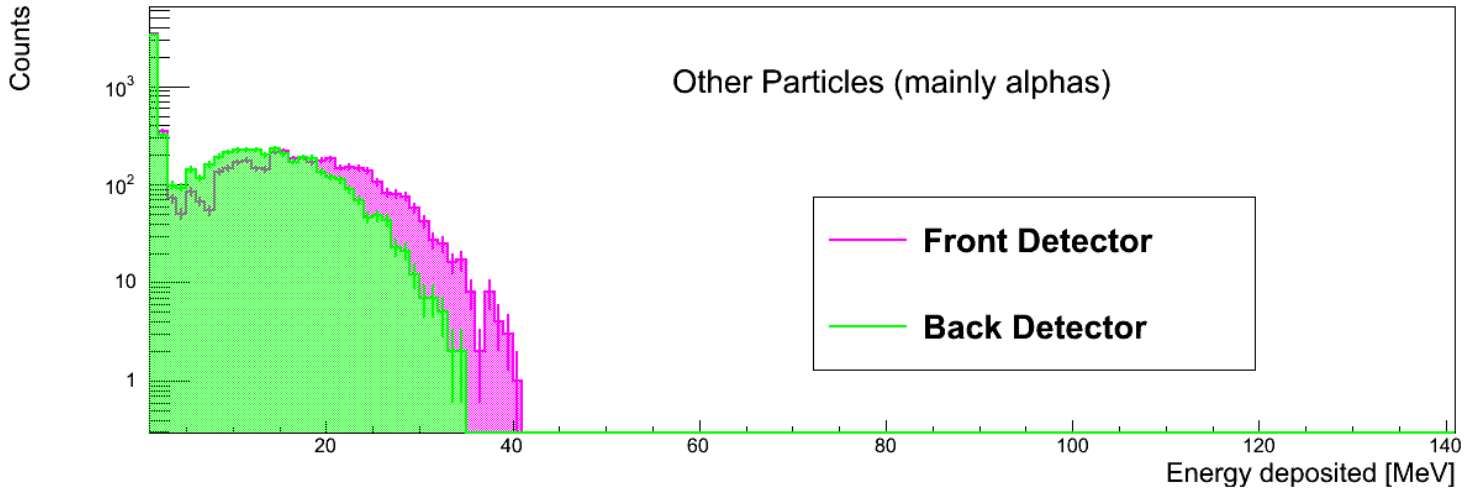
Alpha particles



125 µg/cm^2 $^{10}B_4C$ on 1.5 µm Mylar backing

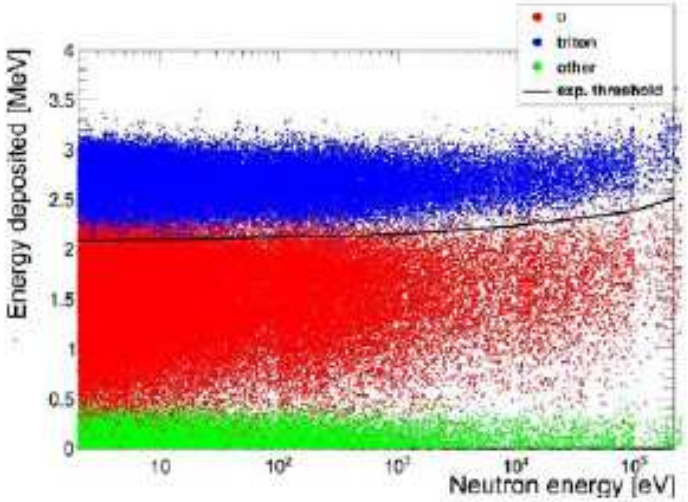
Expected energy deposition ^{235}U

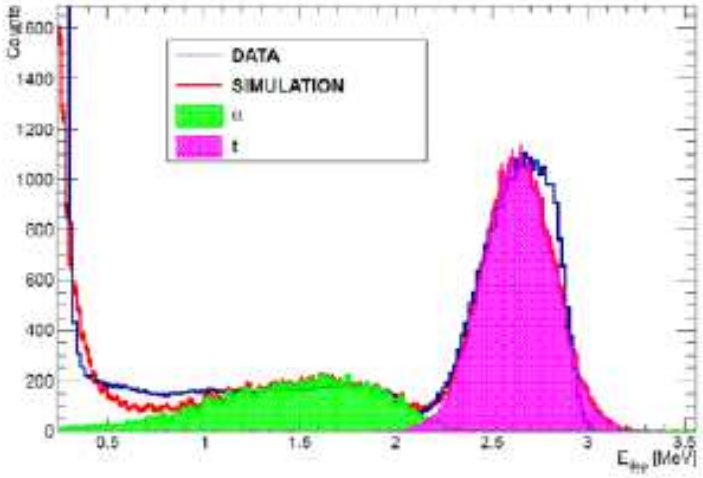


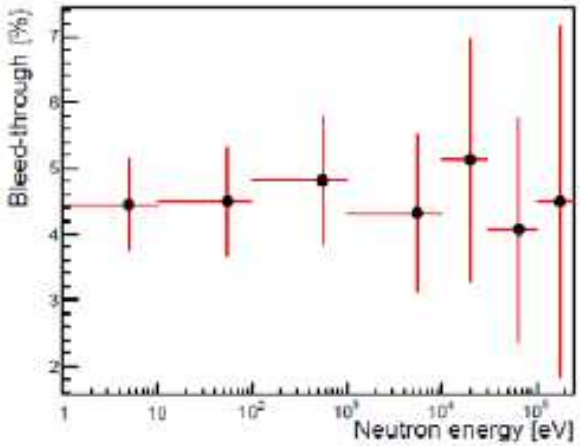


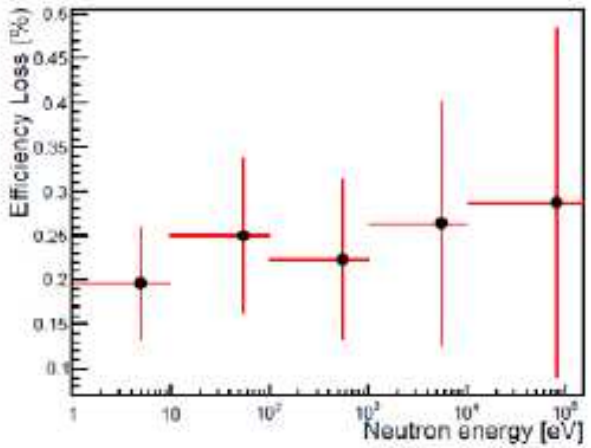
500 µg/cm^2 ^{235}U on 2 µm Al backing

Bleed-trough SiMon

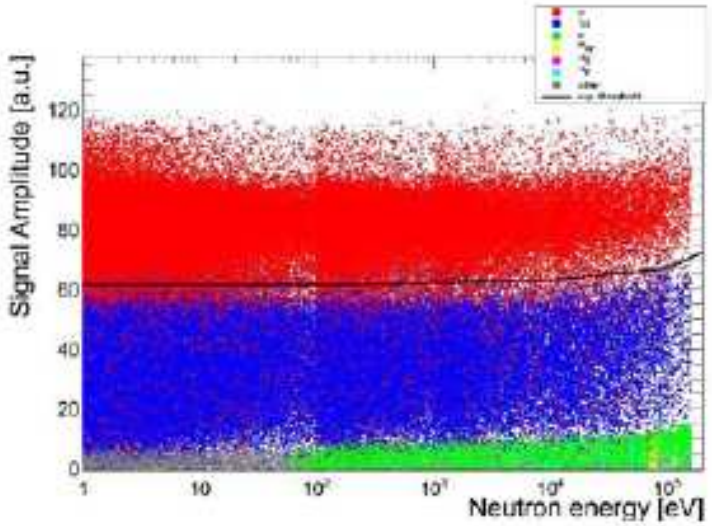


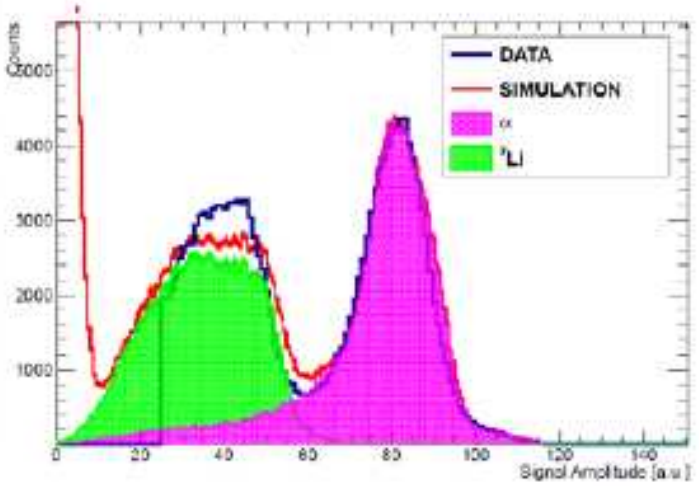


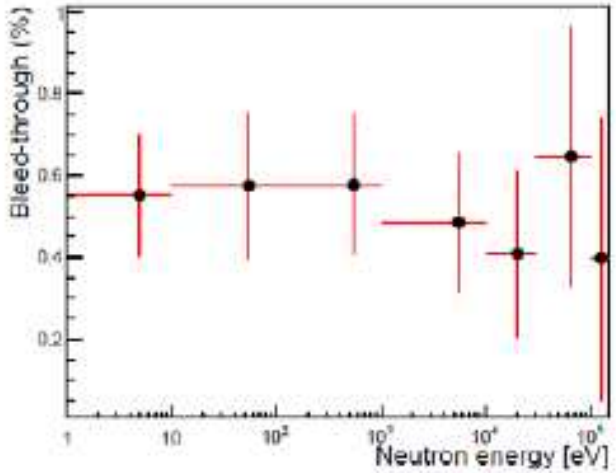


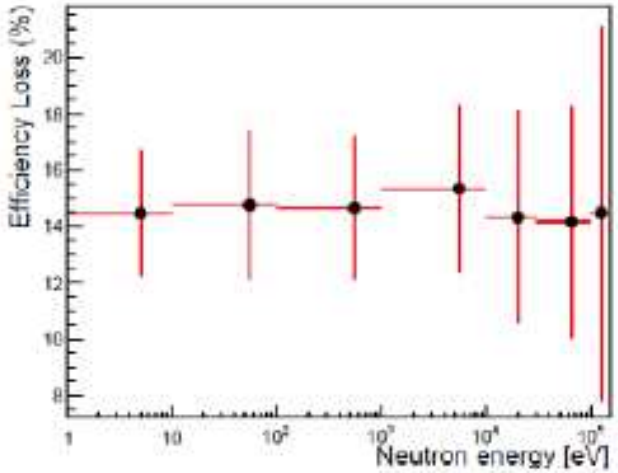


Bleed-trough MGAS

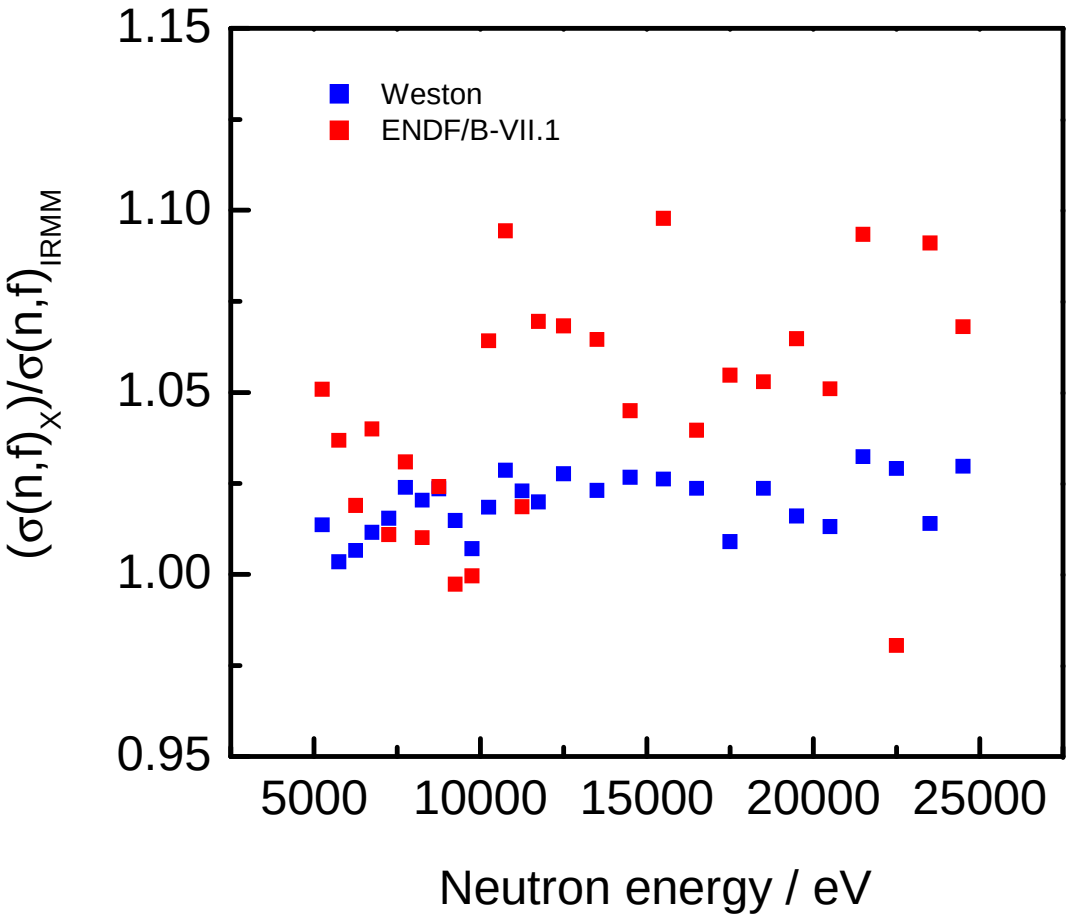






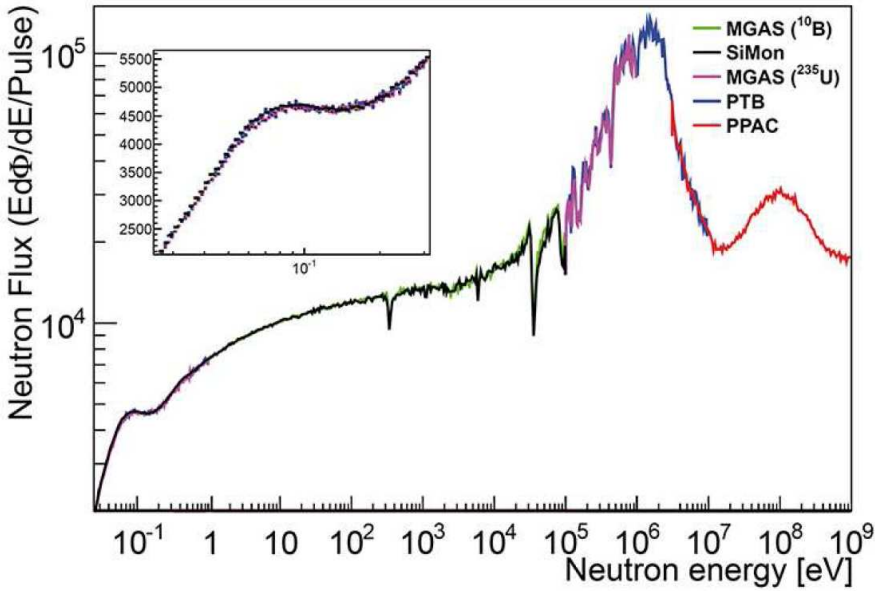


Status of evaluations and experimental data



Courtesy of P.Schillebeeckx, IRMM

Evaluated n_TOF Flux



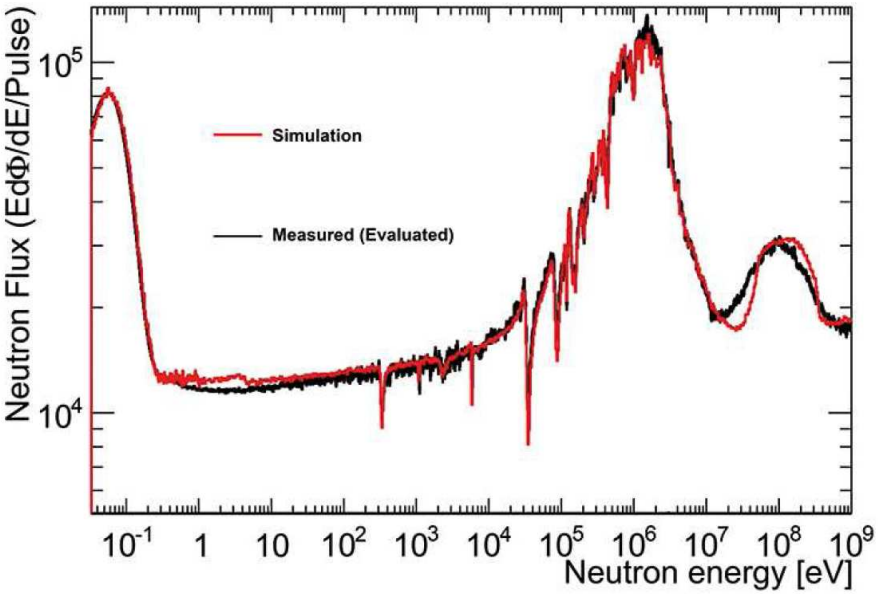


Table 4. Overall estimated systematic uncertainty.

Energy range	Uncertainty
0.025 eV–100 eV	1%
100 eV–10 keV	2%
10 keV–100 keV	4–5%
100 keV–10 MeV	∼ 2%
10 MeV–1 GeV	∼ 3%