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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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..).

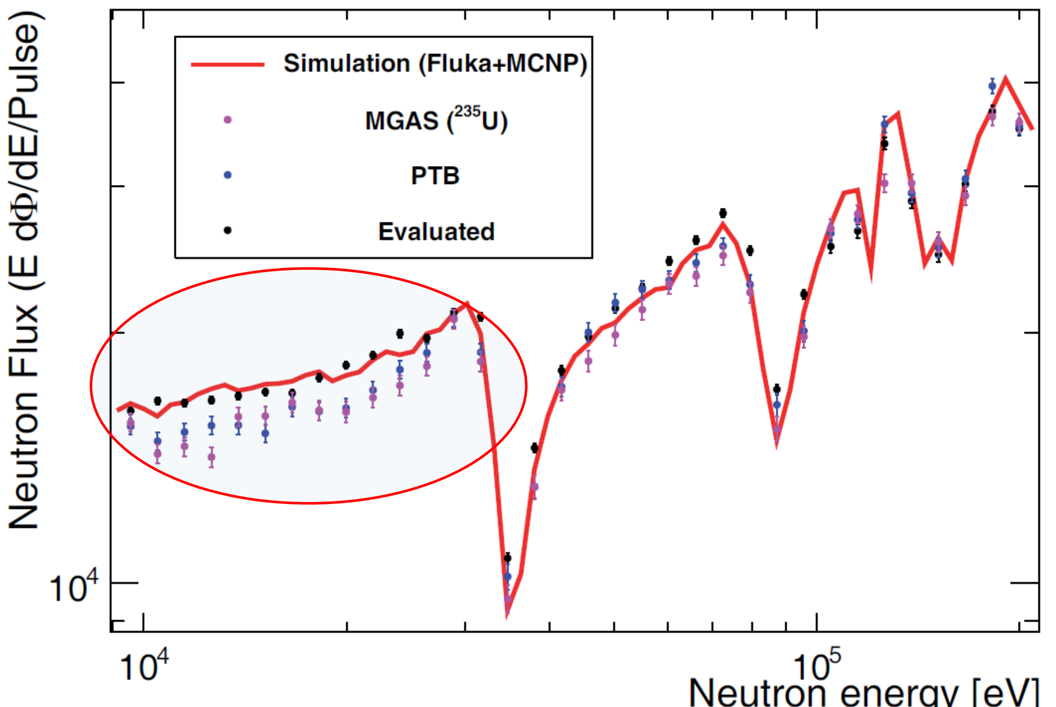
• **^{235}U(n,f) cross section** in the energy range proposed can have a significant impact on fast critical reactor and sub-critical ADS.

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.



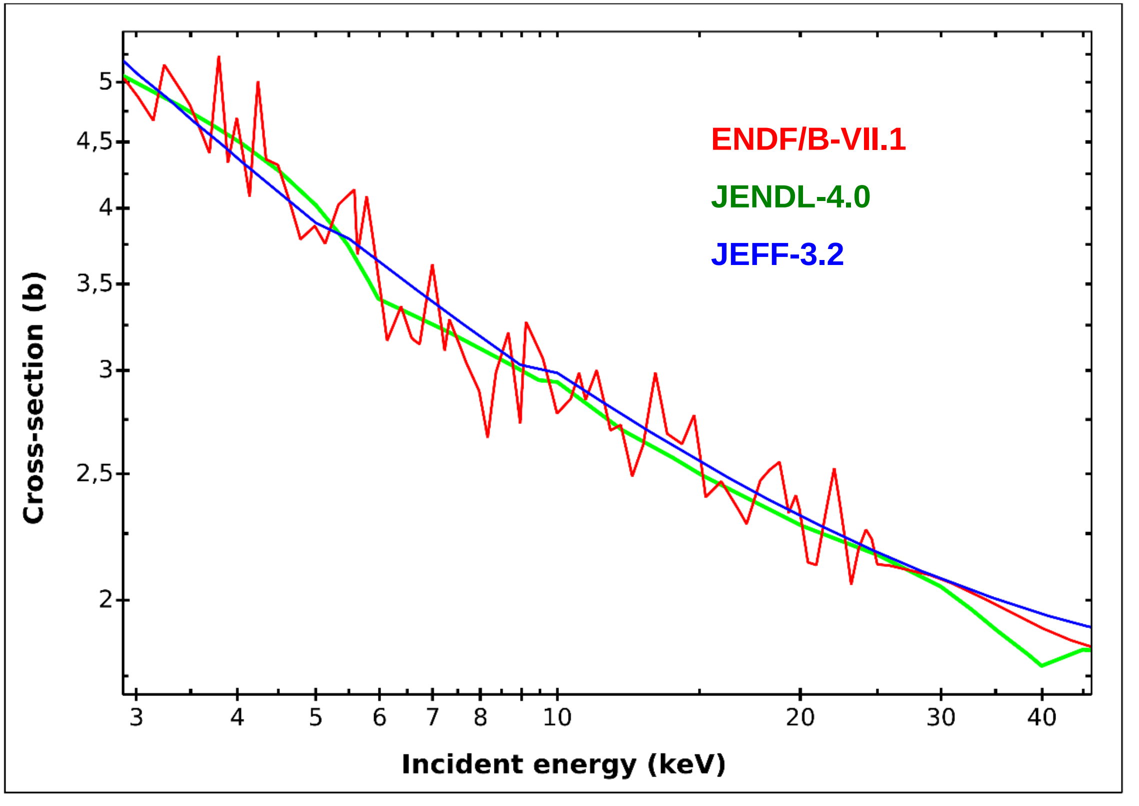
6-8% overestimation of the fission cross-section of ^{235}U in database**?**

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

*M. Barbagallo, et al. Eur. Phys. J. A (2013) 49:156

Motivations 2

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



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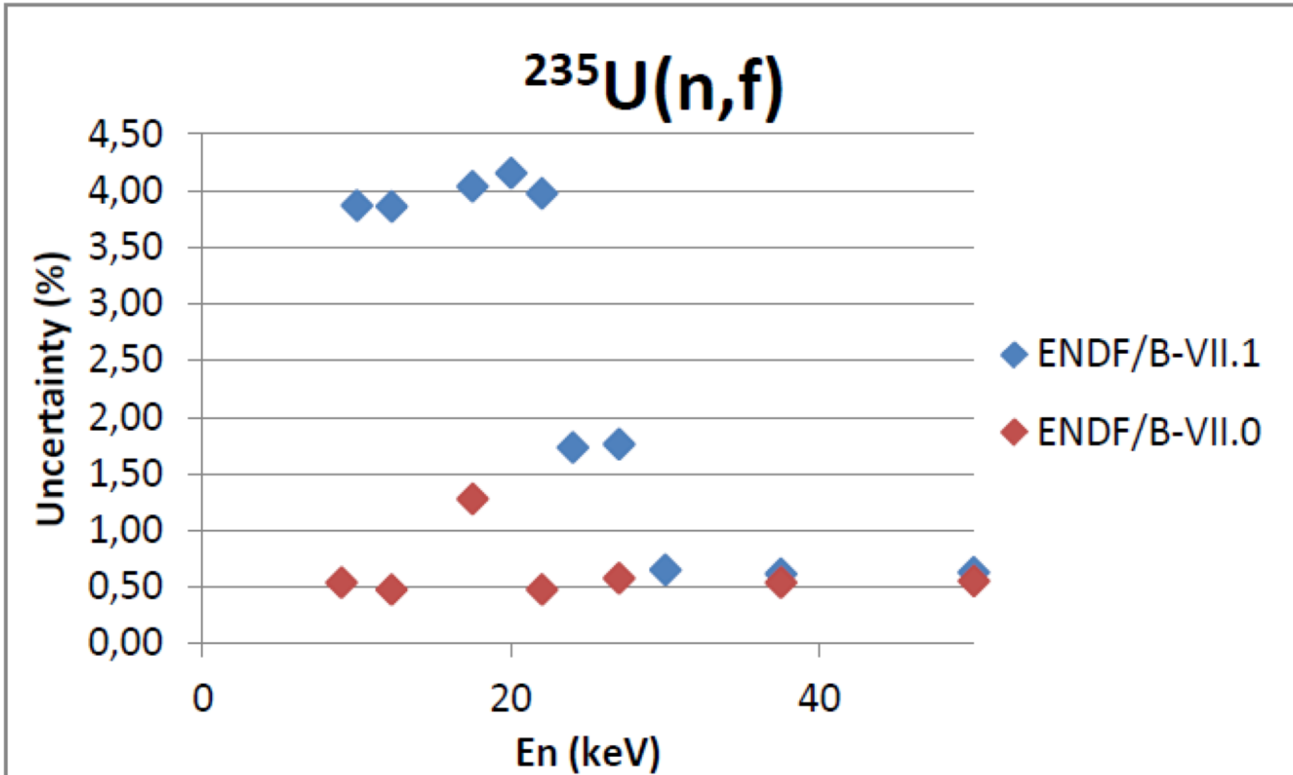
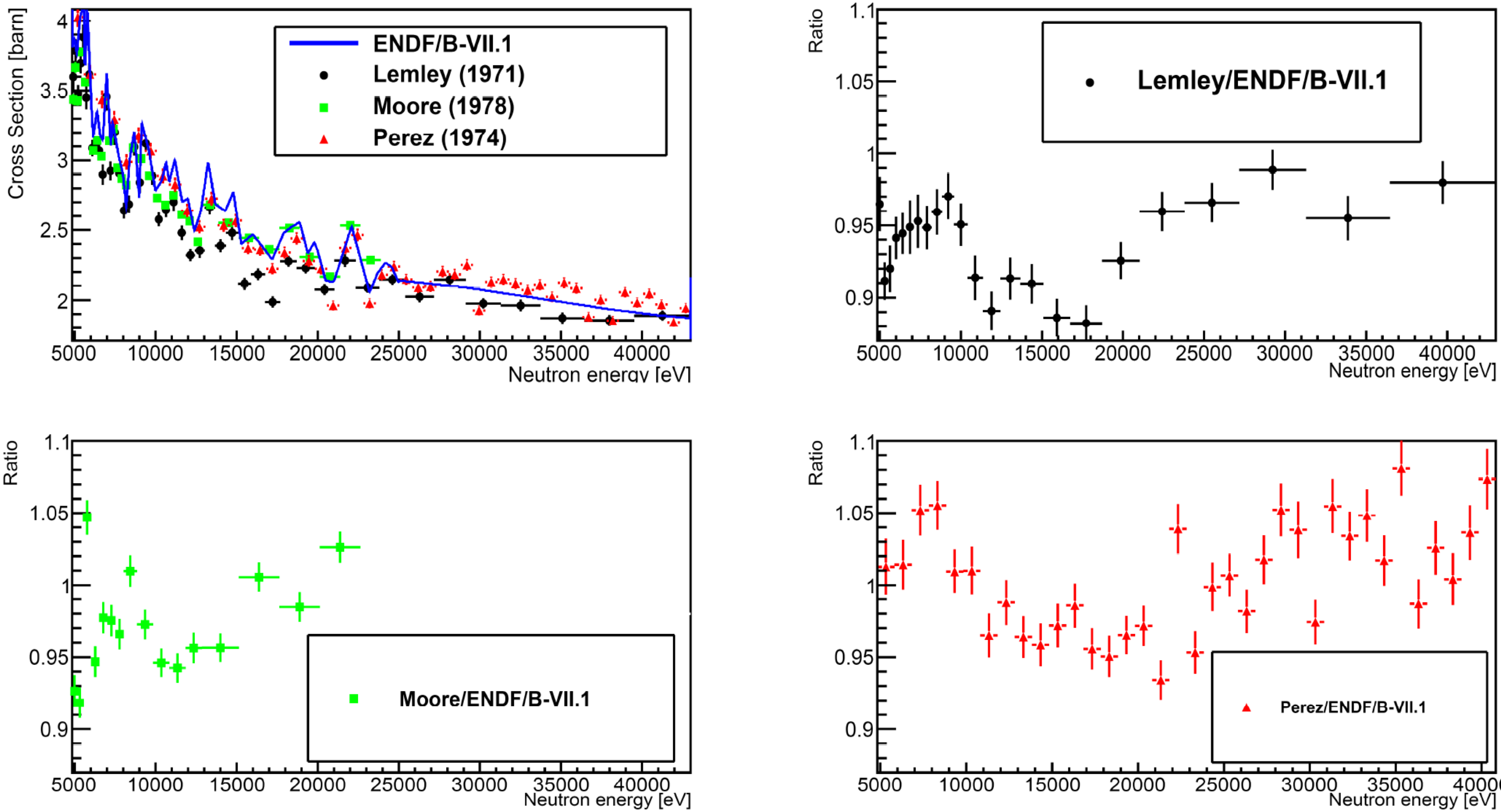


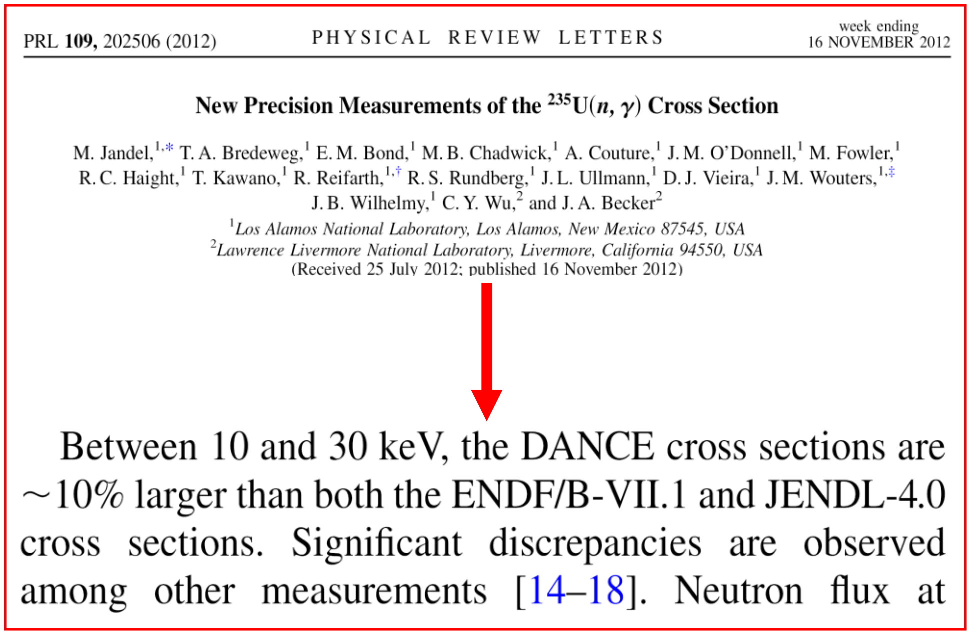
Only in this region, the uncertainties have been increased by a **factor 4** in the latest release of ENDF/B-VII data library.

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

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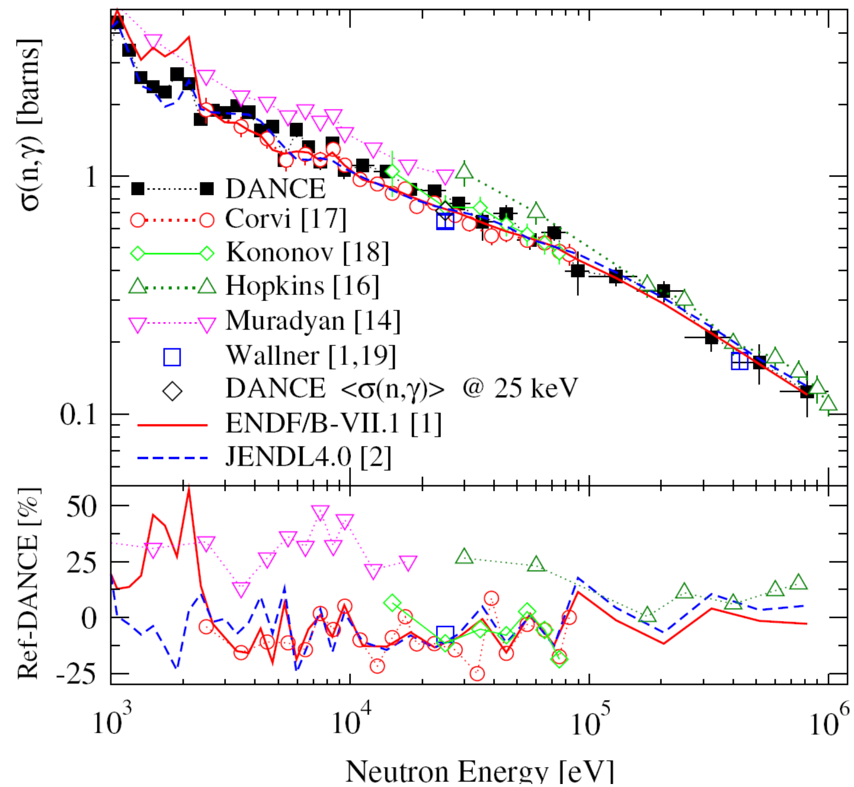
Between 10 and 30 keV, the DANCE cross sections are ~10% larger than both the ENDF/B-VII.1 and JENDL-4.0 cross sections. Significant discrepancies are observed among other measurements [14–18]. Neutron flux at



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.

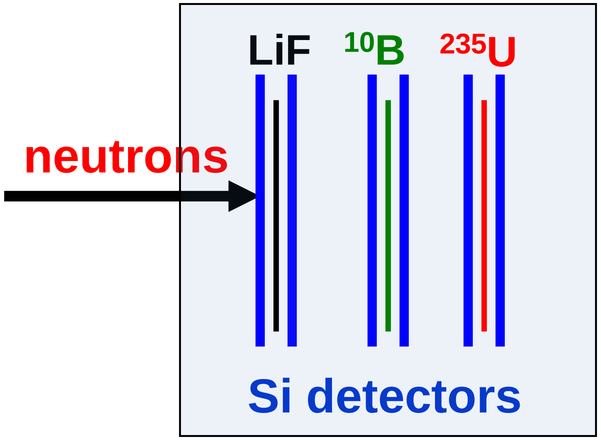
The measurement

We measured (Aug-Sept 2016) in **EAR1** the **^{235}U(n,f)** cross section together with the reference reactions **^{6}Li(n,t)** and **^{10}B(n,α).**

- Detection at forward and backward directions
- Energy resolution

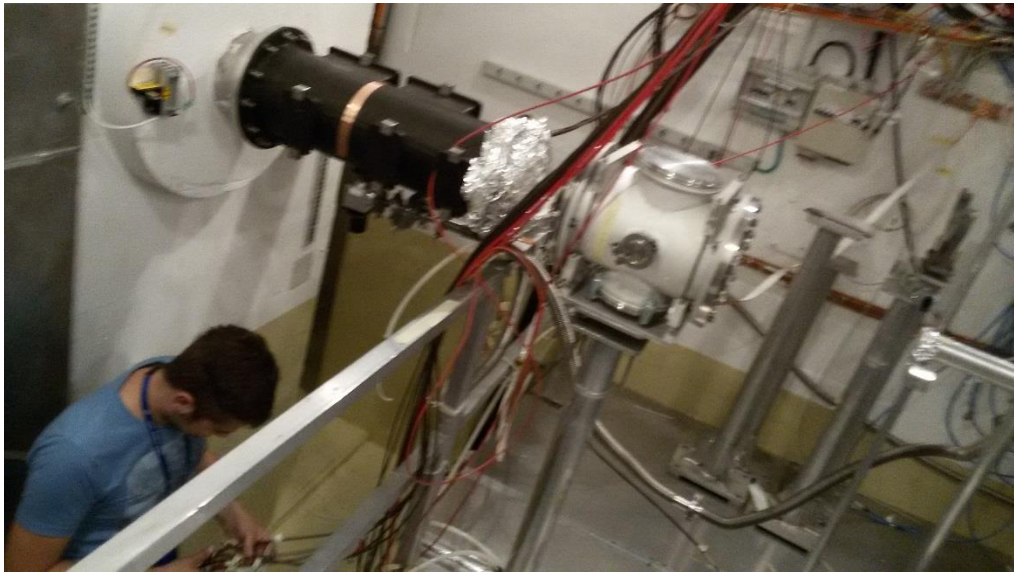
Silicon detectors stack *(5x5 cm^2 and 200 μm thickness)* **in the beam (capture collimator)**

EAR1@n_TOF



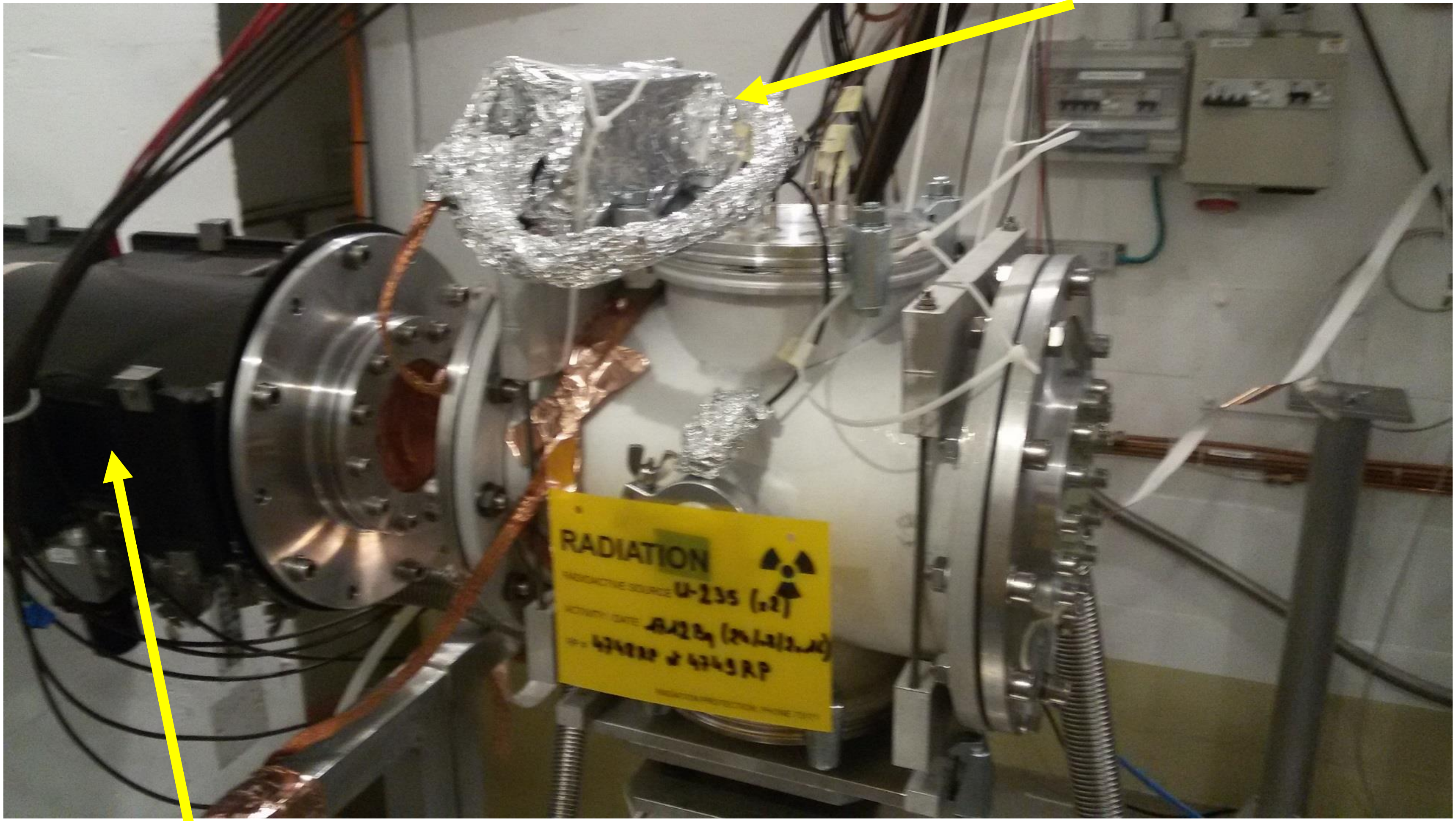
- 500 μg/cm^2 **^{6}LiF**, 50 μm Al backing (Laboratori Nazionali del Sud)
- 80 nm **$^{10}BC_4$**, 18 μm Al backing (ESS, Linkoping- Chewbacca)
- 275 μg/cm^2 **^{235}U**, 250 μm Al backing (Institute for Reference Materials and Measurement)

The setup



The setup

Lin/Log Mesytech preamp*

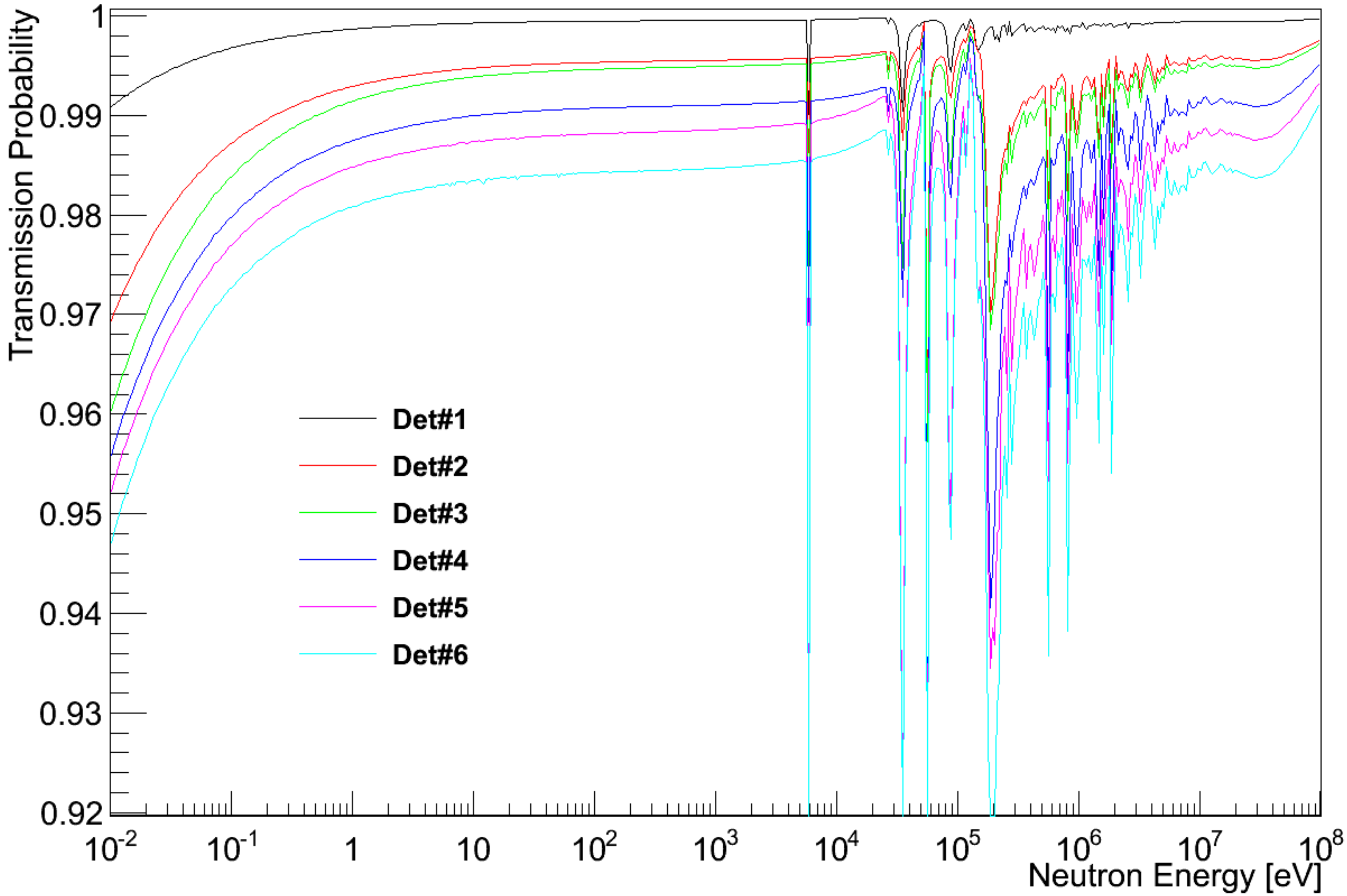


SiMon

*Same setup in different areas → ~ same response

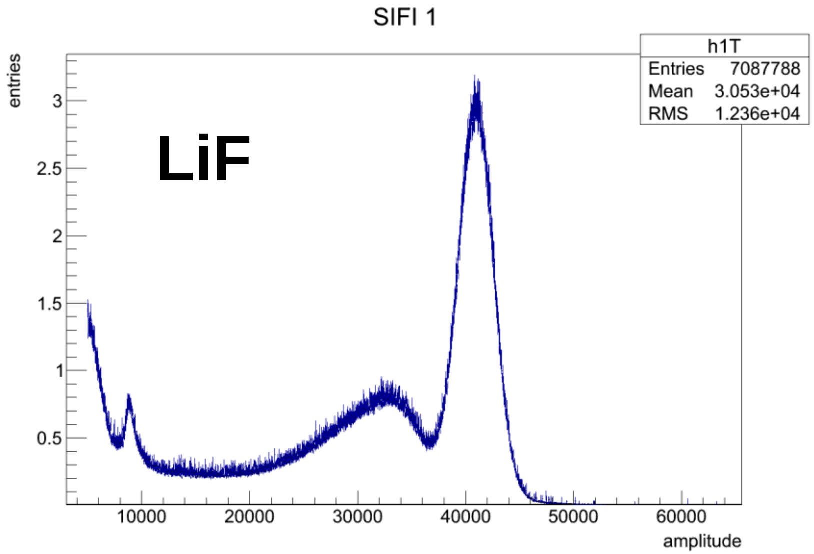
Preliminary Results

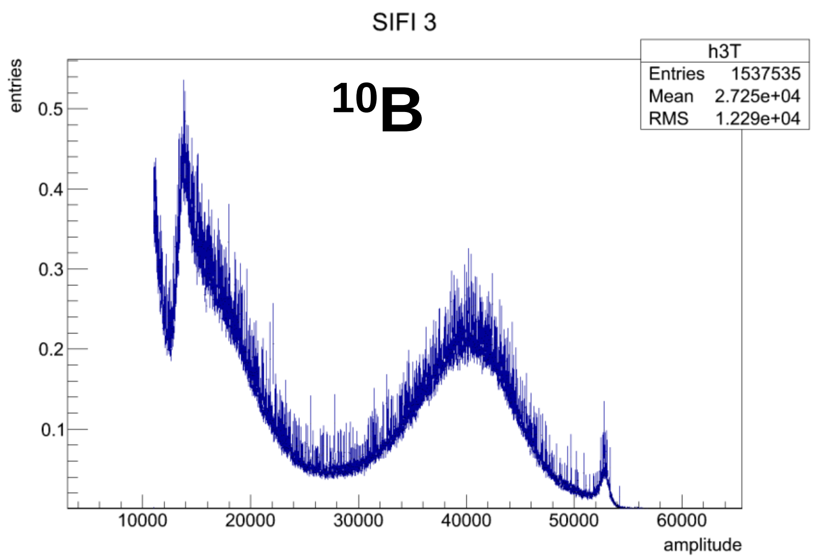
Calculated transmission factor

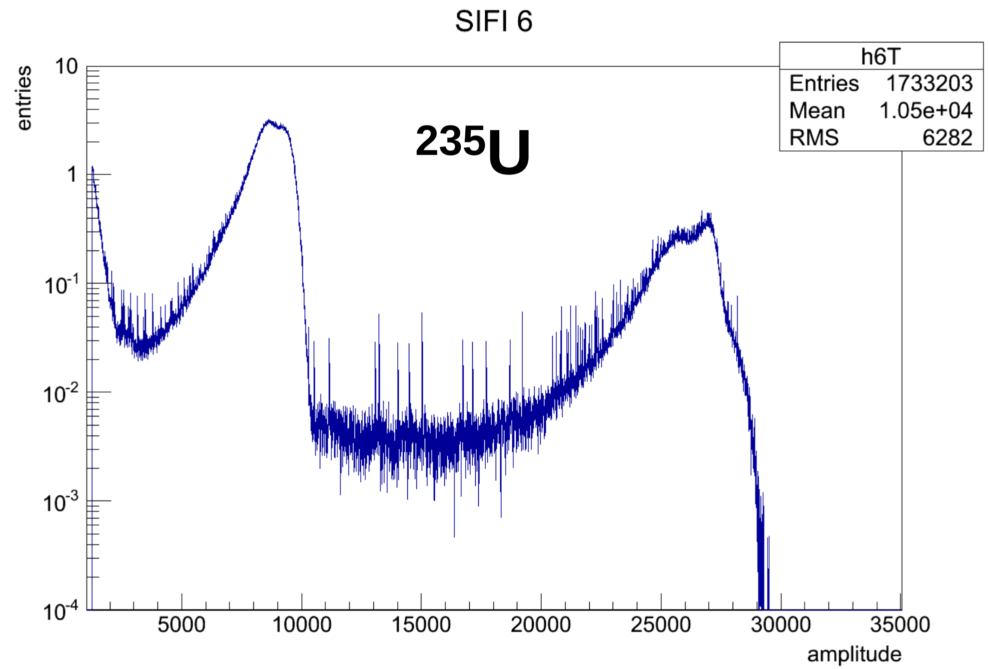


Preliminary Results

Amplitude spectra







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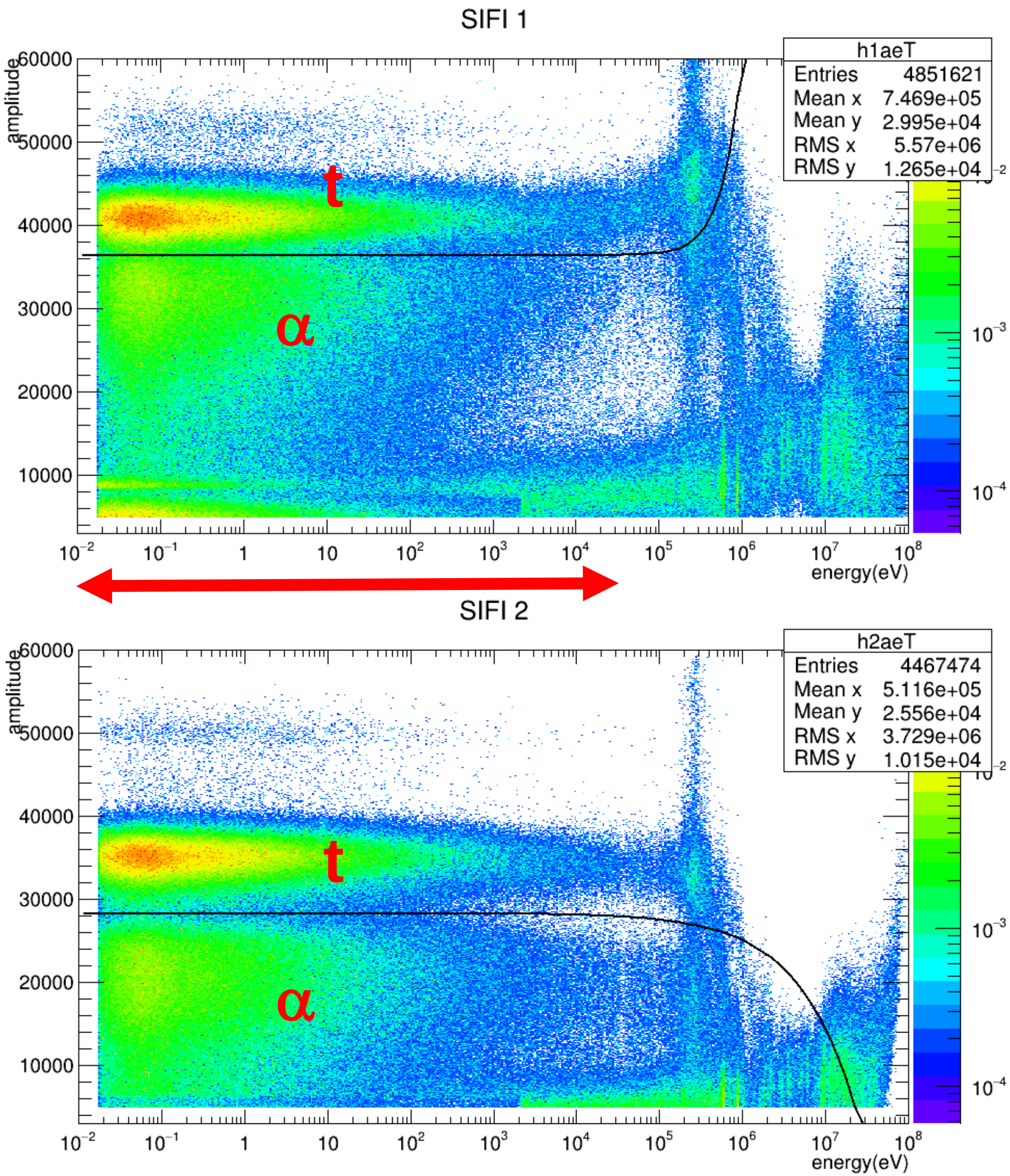
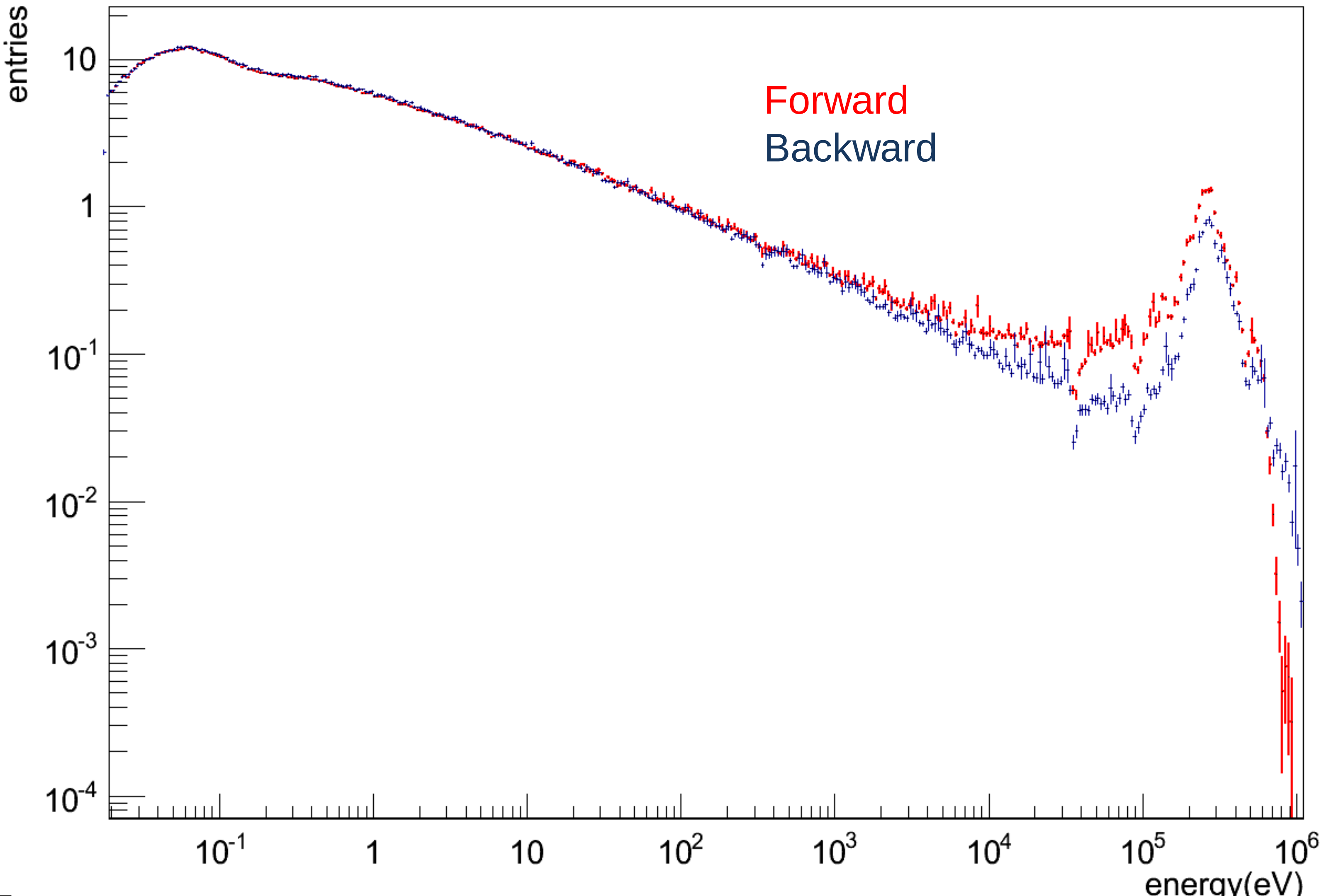


Forward direction

Back direction

Preliminary Results



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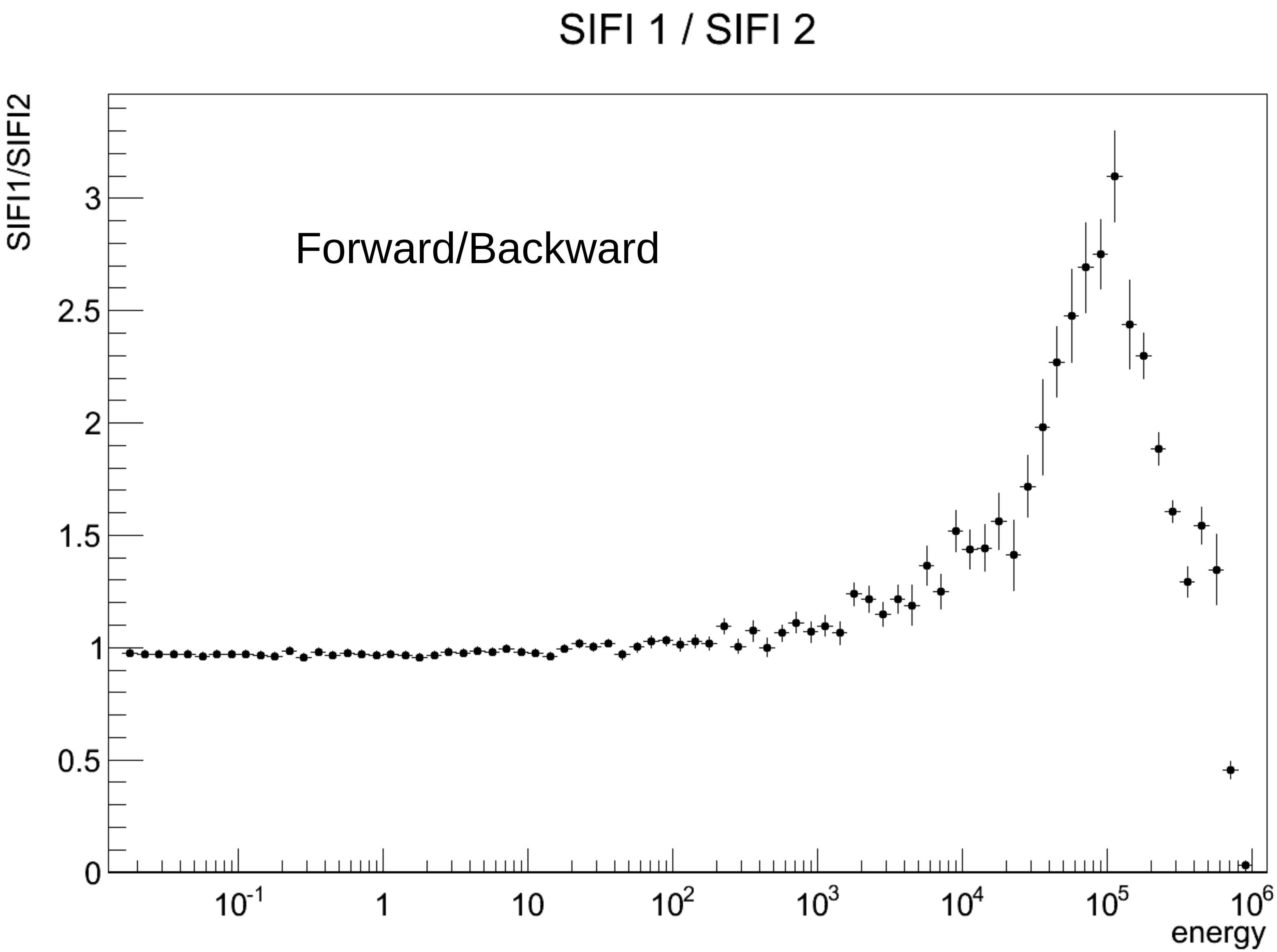

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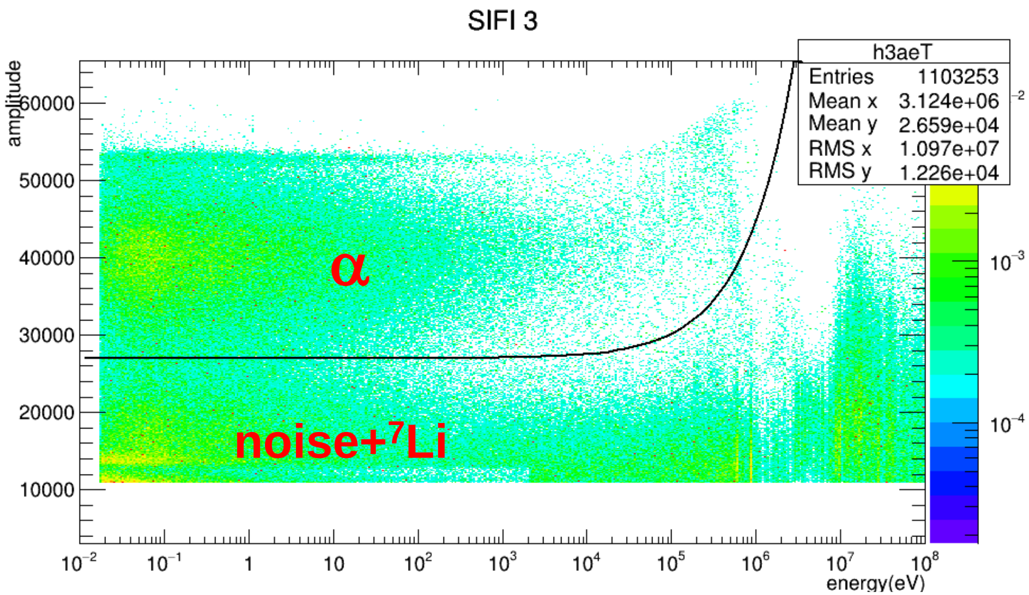
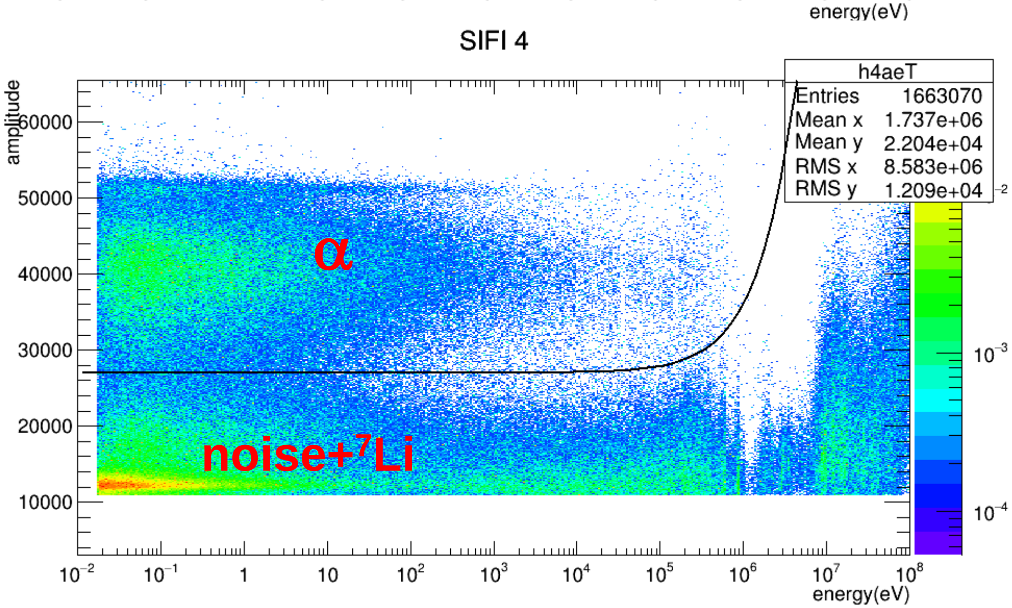
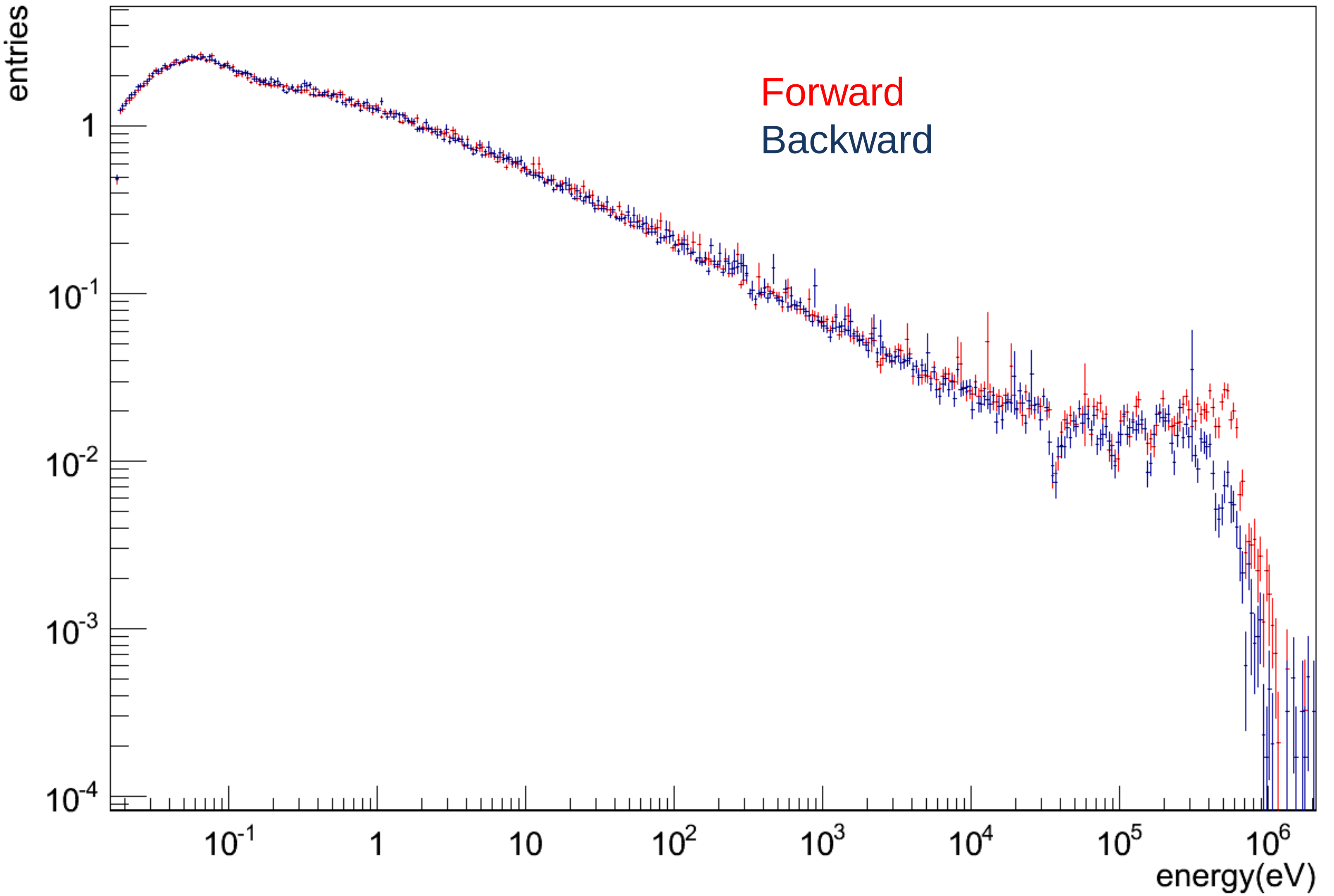


Forward direction



Back direction

Preliminary Results



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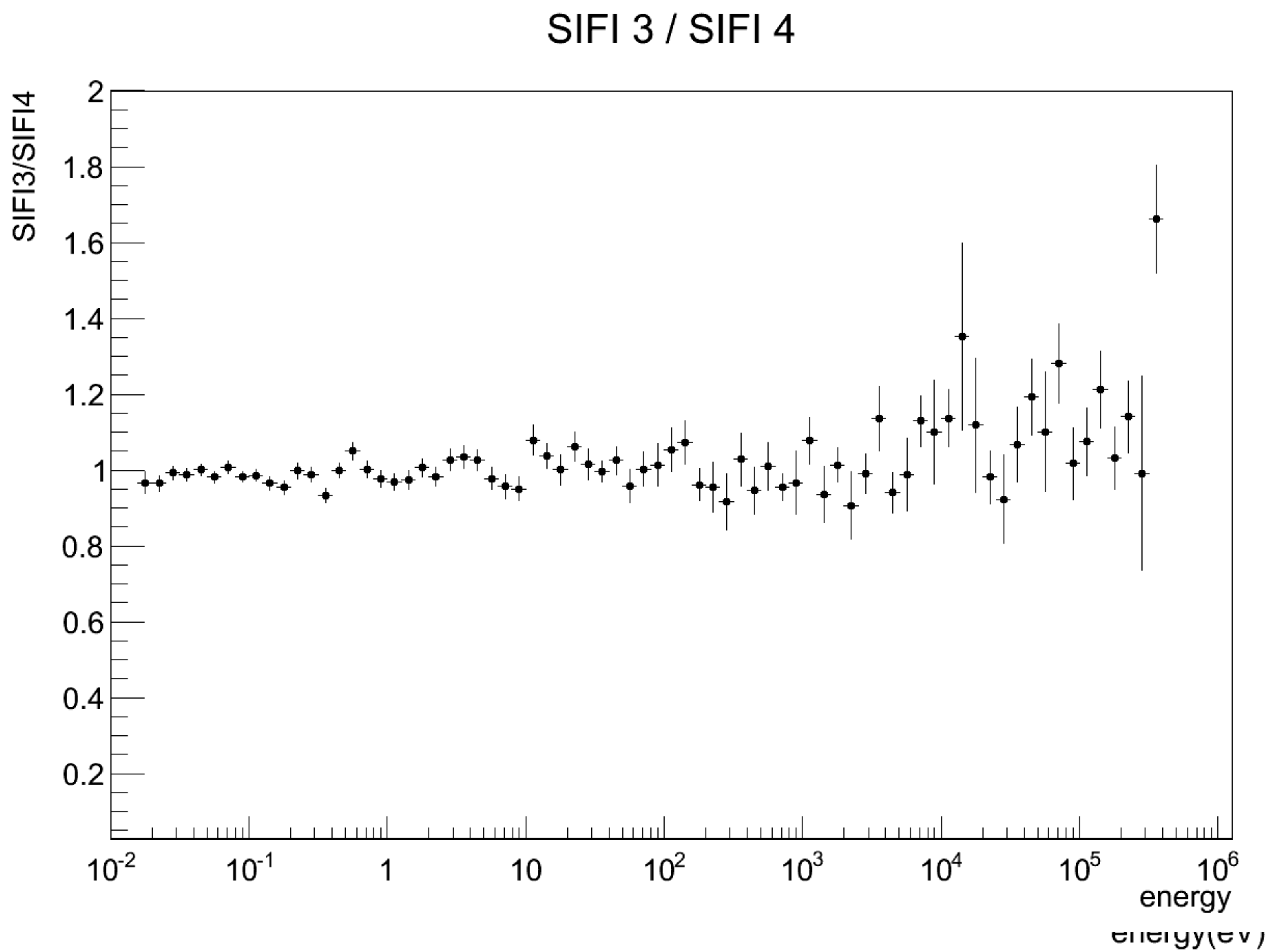

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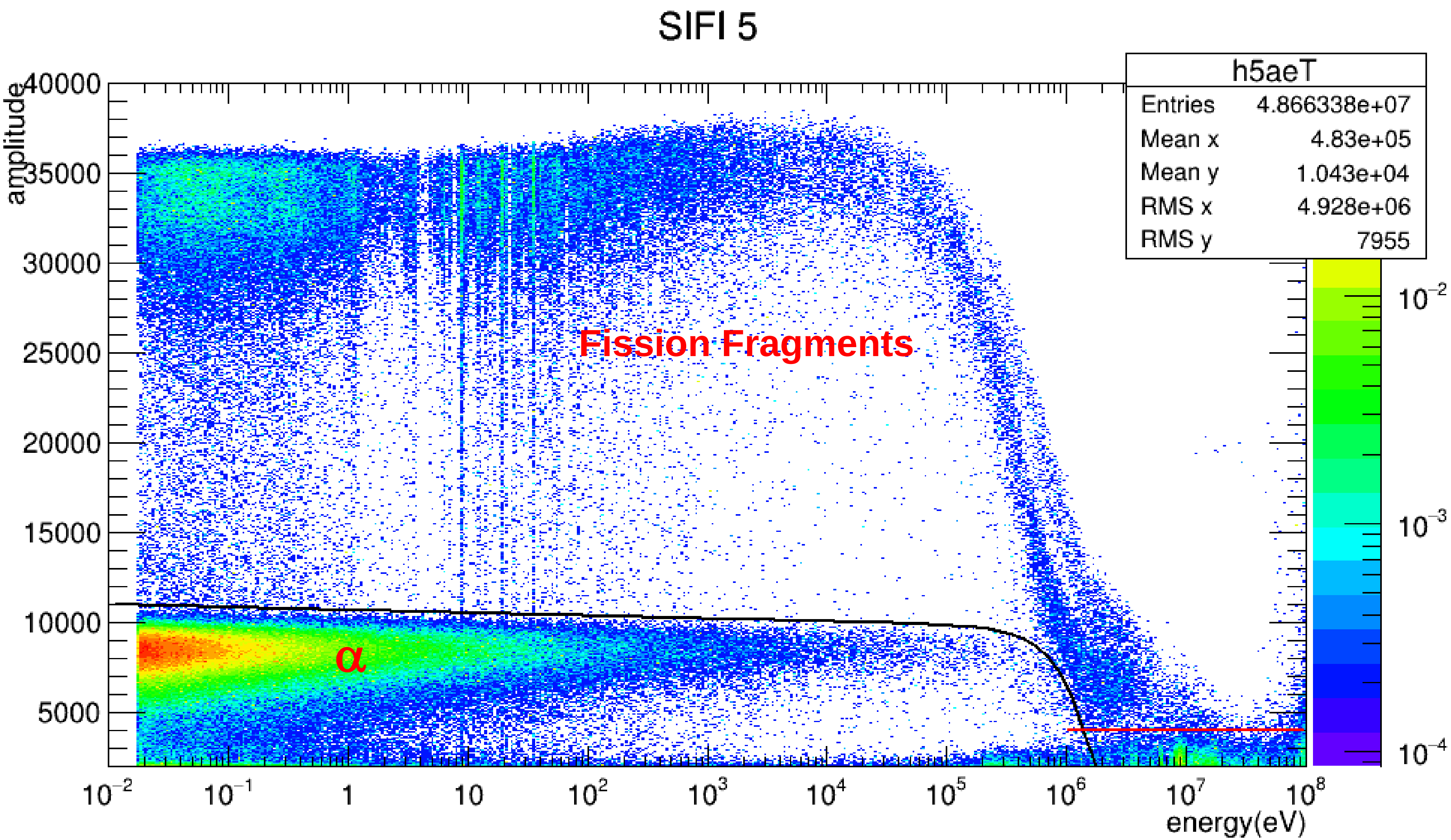

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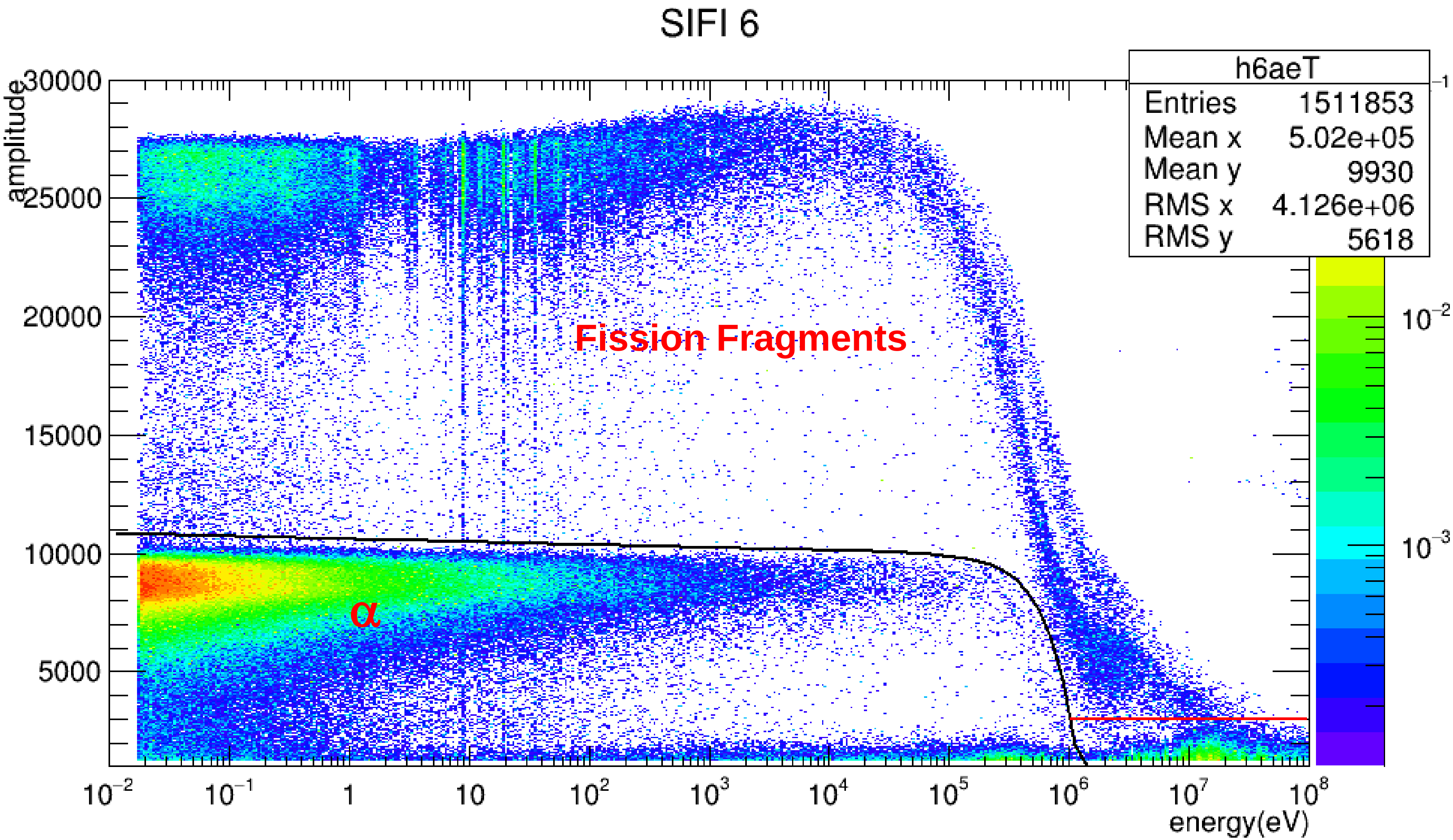

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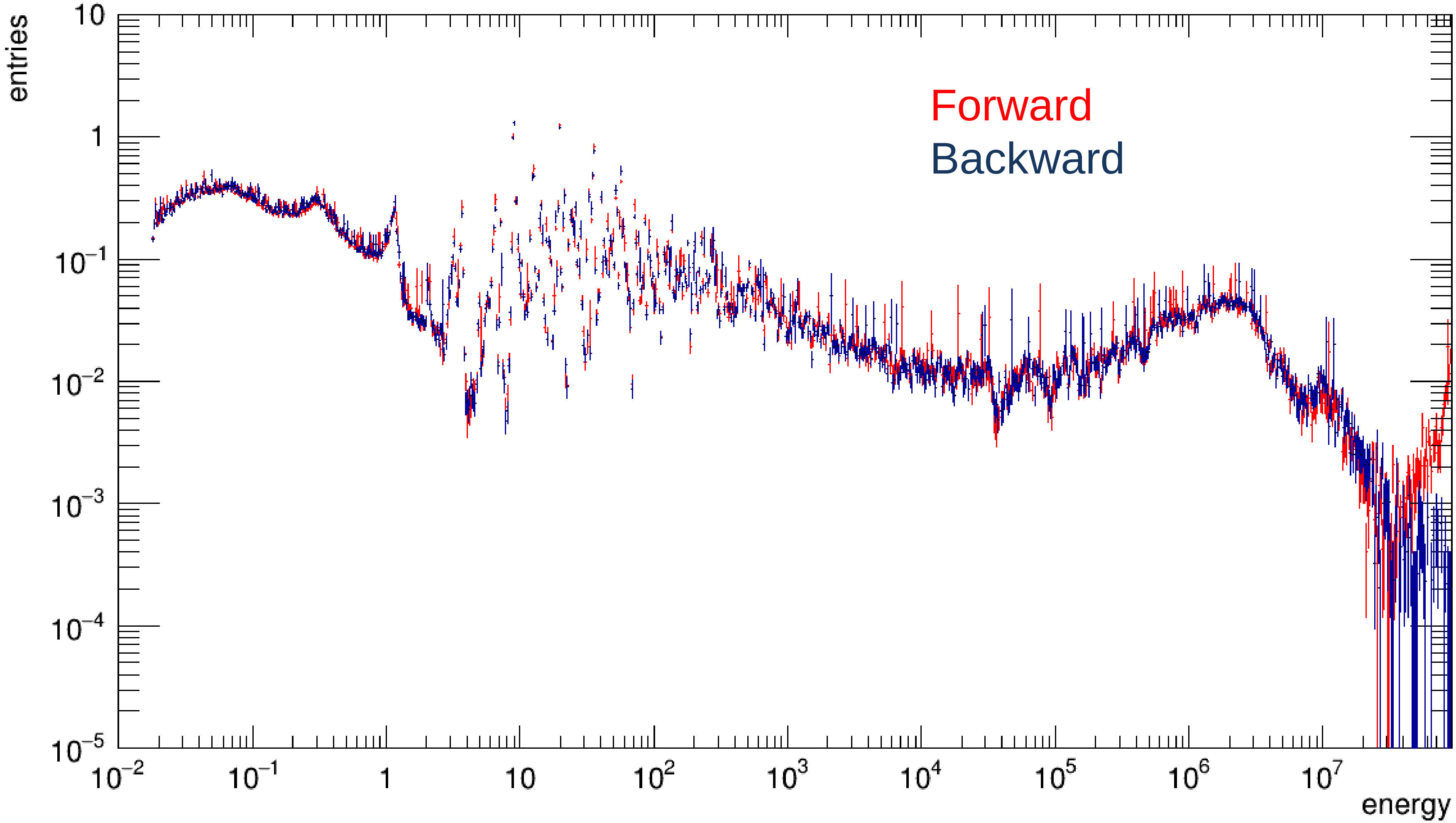

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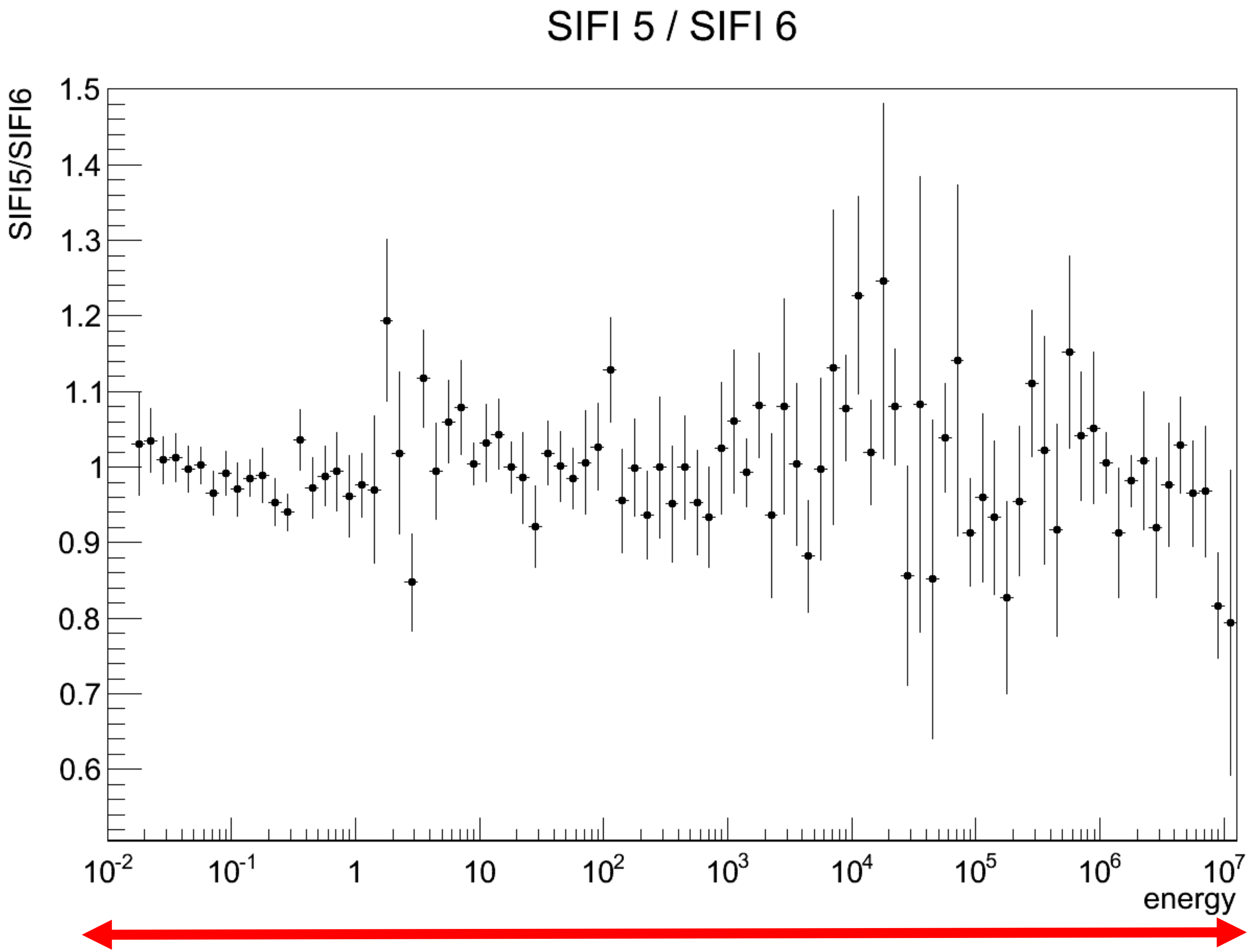
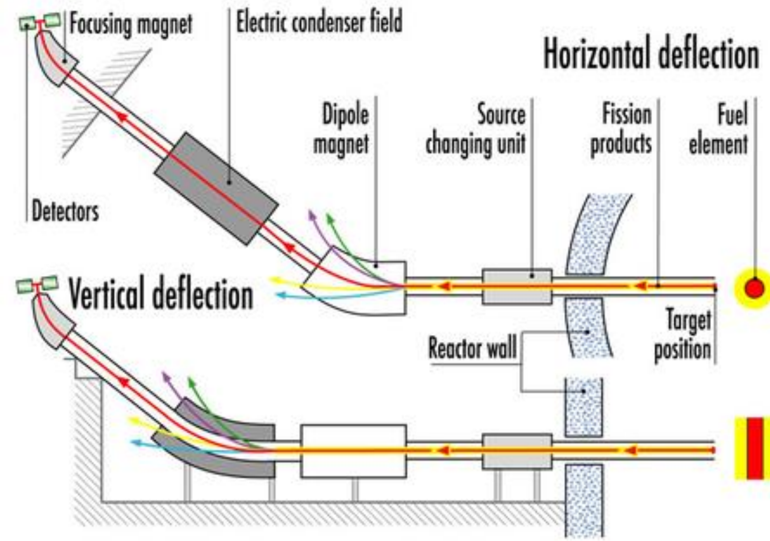


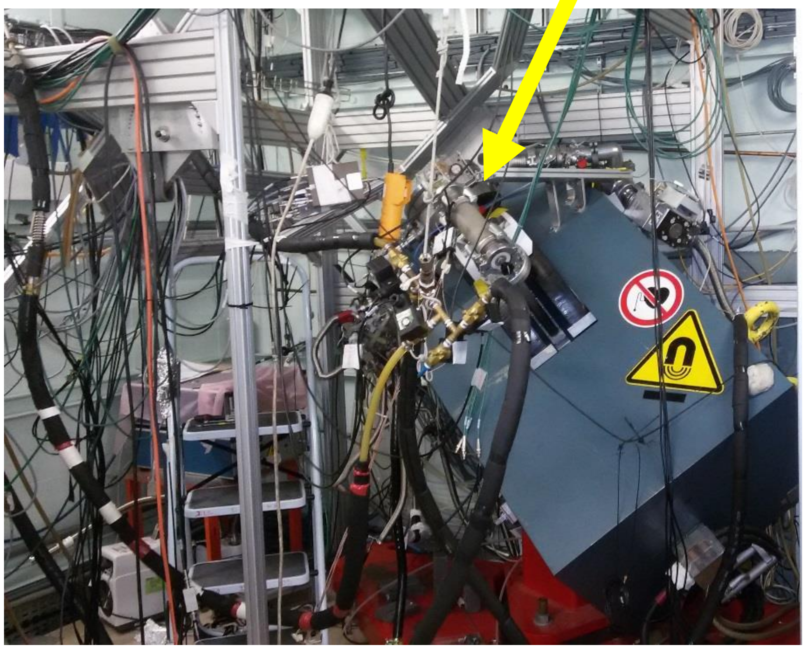
Ancillary measurement

Study of pulse height defect in the silicons

LOHENGRIN recoil mass spectrometer for fission products @ ILL-Grenoble



silicon



Features

flux at target position	$5.3 \cdot 10^{14}$ n cm^{-2} s^{-1}
solid angle W	$\leq 3.2\ 10^{-5}$ sr
total length of main path	23 m
mass dispersion for 1 % mass difference	3.24 cm
energy dispersion for 1 % energy difference	7.2 cm
mass resolution *A/dA* (FWHM)	400 for target size 0.8 x 7.5 cm^2 1500 for target size 0.16 x 4 cm^2
ionization chamber	
energy resolution	$E/\Delta E > 100$
nuclear charge resolution	$Z/\Delta Z \leq 36$

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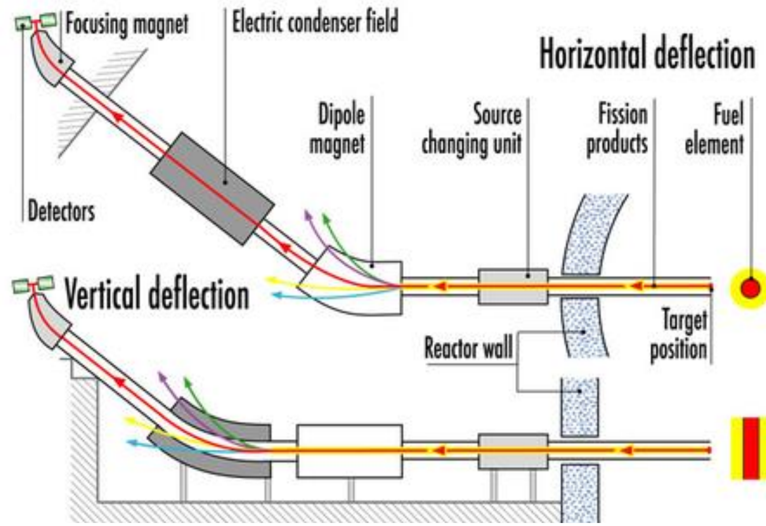
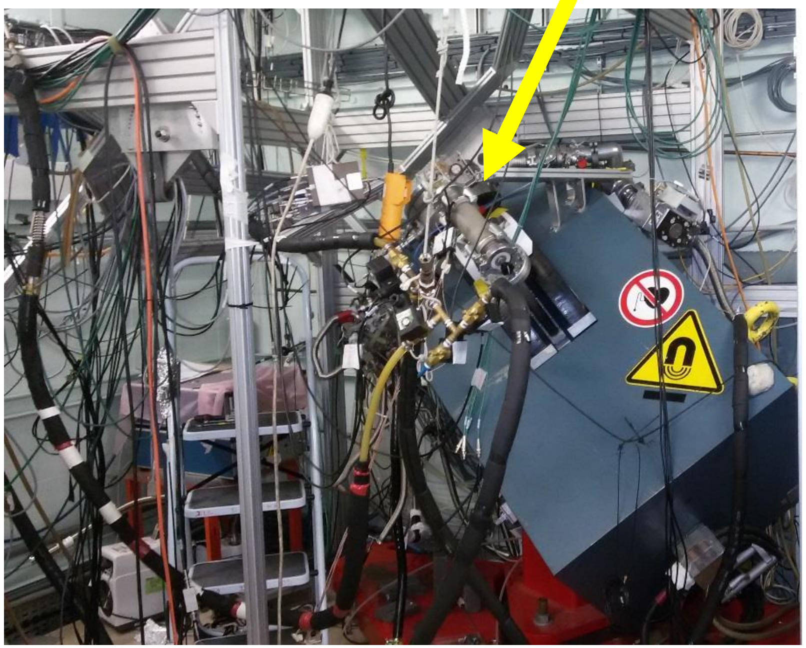
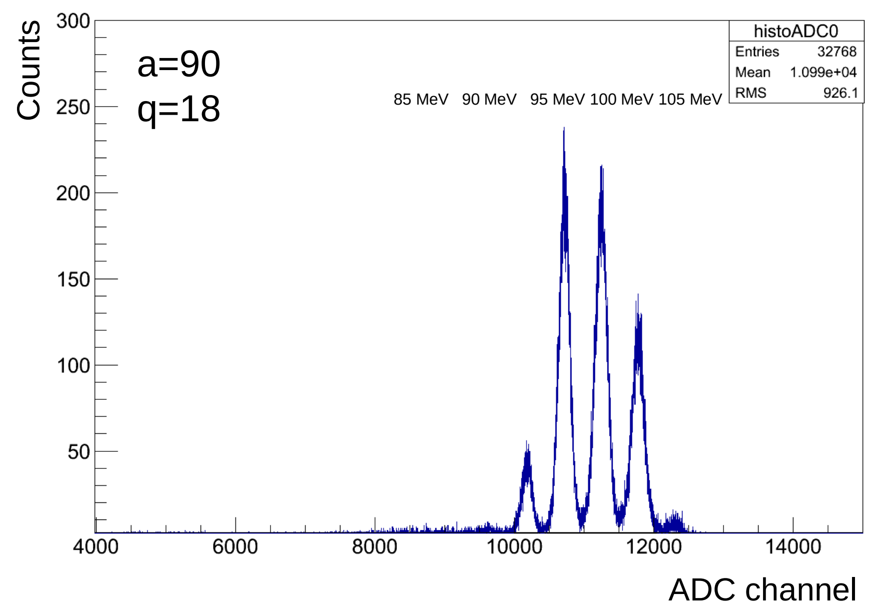


silicon





Next steps

- Refine Time of flight to Energy conversion
- Refine cuts applied
- Increase statistic
- Extract the ratios of the standards