EuNPC 2018
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Measurement of $^{235}U(n,f)$ cross section between 10 and 30 keV

Presented by:
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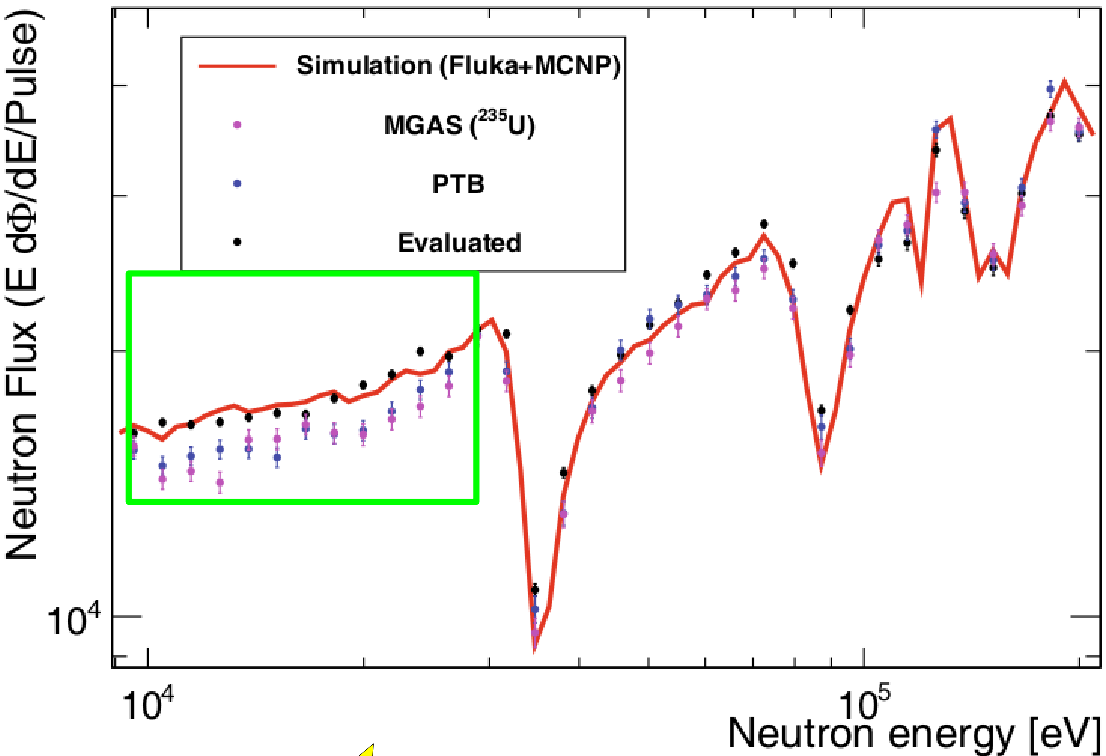
Motivations and physical interest



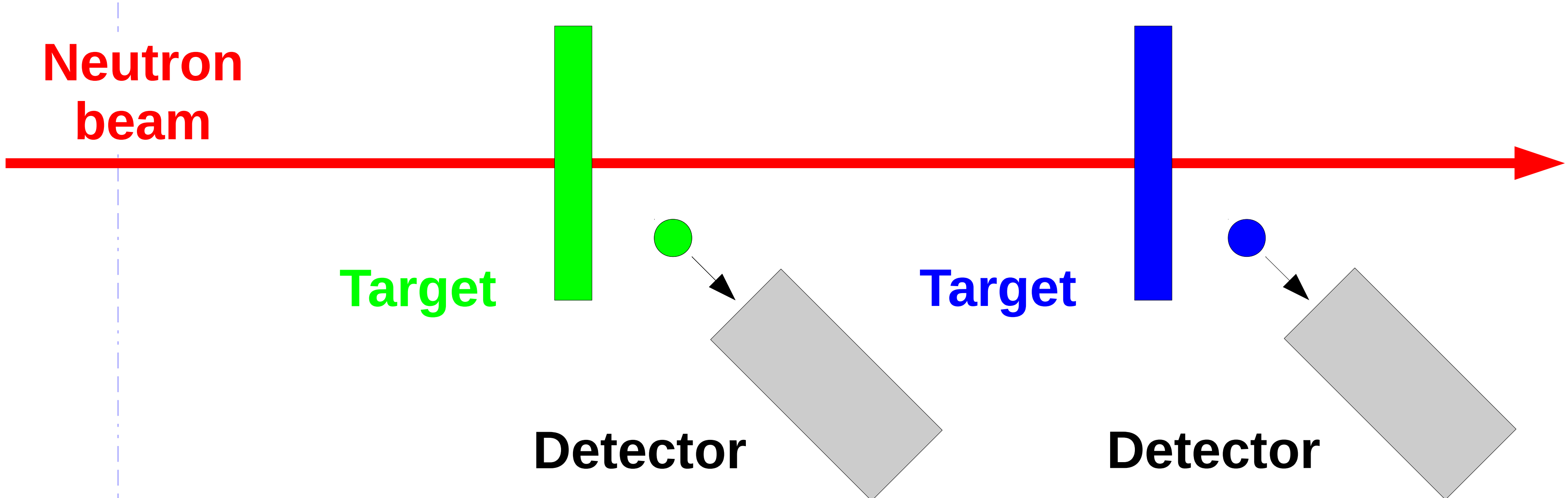
- Discrepancies (~8%) in the n_TOF neutron flux measure between detectors using fission and the ones using ^{6}Li(n,t) and ^{10}B(n,α)
- Discrepancies in the ^{235}U(n,γ) measure at DANCE (^{235}U(n,f) used as reference)

- **Increase the standard ^{235}U(n,f) accuracy** and extend its range (at present at thermal and between 150 keV and 200 MeV)
- Collect data for fission reactors of new generation

Neutron standards

Standard reaction used as reference

Measured reaction
X+n → products



Main used standards: H(n,p) $^{6}Li(n,t)^{4}He$

$^{10}B(n,\alpha)^{7}Li$ $^{197}Au(n,\gamma)$ **$^{235}U(n,f)$**

The new measurement

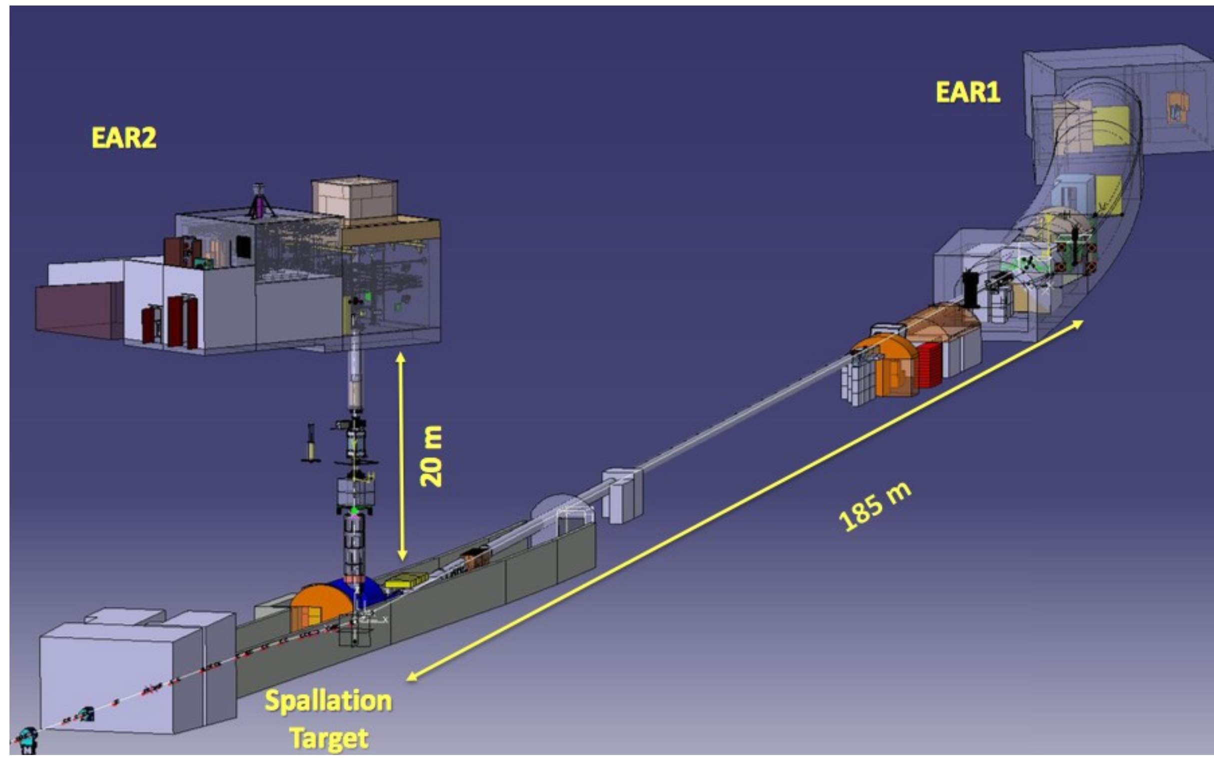
A new measurement of the $^{235}U(n,f)$ cross section has been made during the autumn 2016 using a custom experimental apparatus.

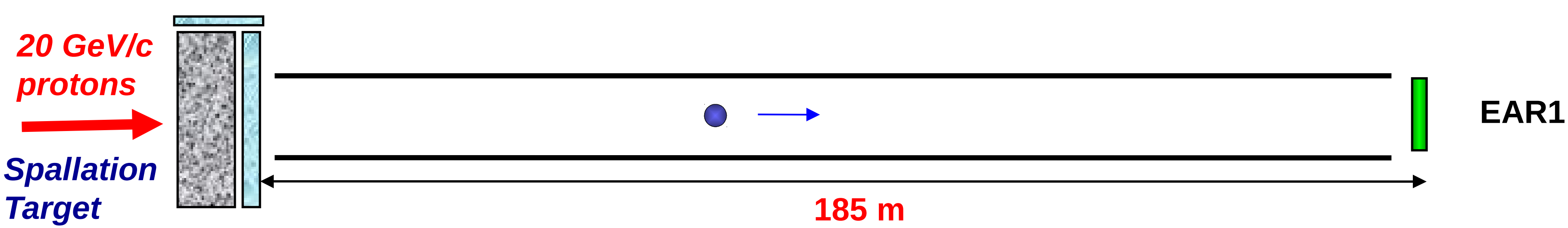
- The standards **$^{6}Li(n,t)$ and $^{10}B(n,\alpha)$** are used as references
- The measurement has been performed at the n_TOF facility
- Silicon detectors are used to measure the emitted products
- Silicons are placed **in beam** in order to maximize the geometrical efficiency, measuring products emitted **forward and backward**

n_TOF facility

neutron Time Of Flight

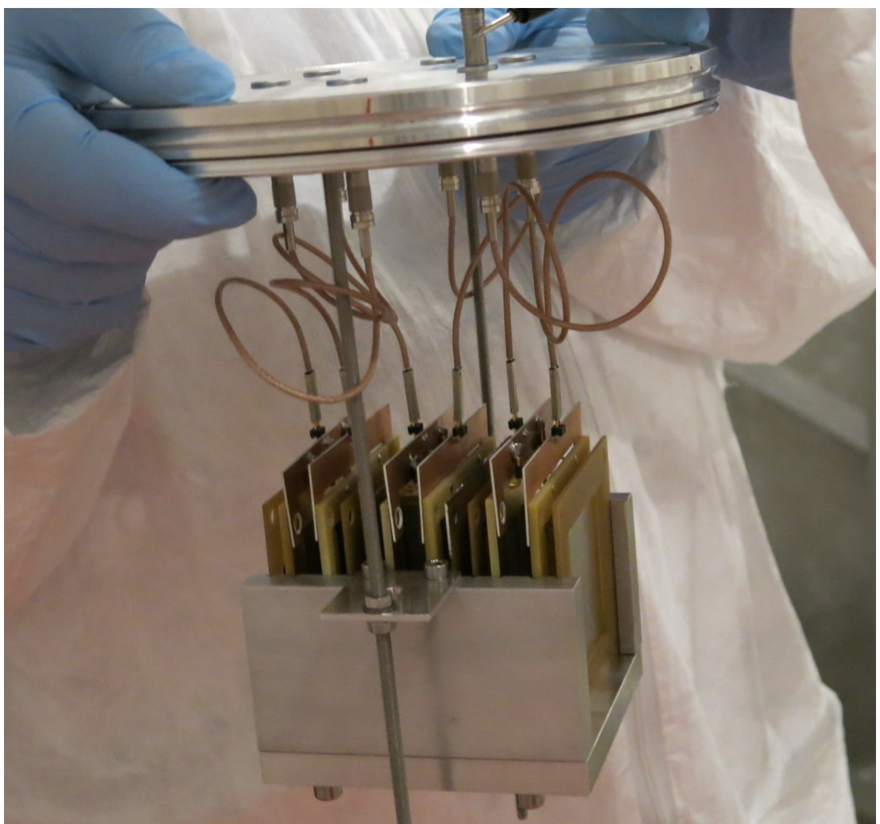
- Neutrons produced through a spallation process
- Extremely high instantaneous flux
- **High neutron energy resolution**
- **Wide neutron energy range** (from thermal to GeV)

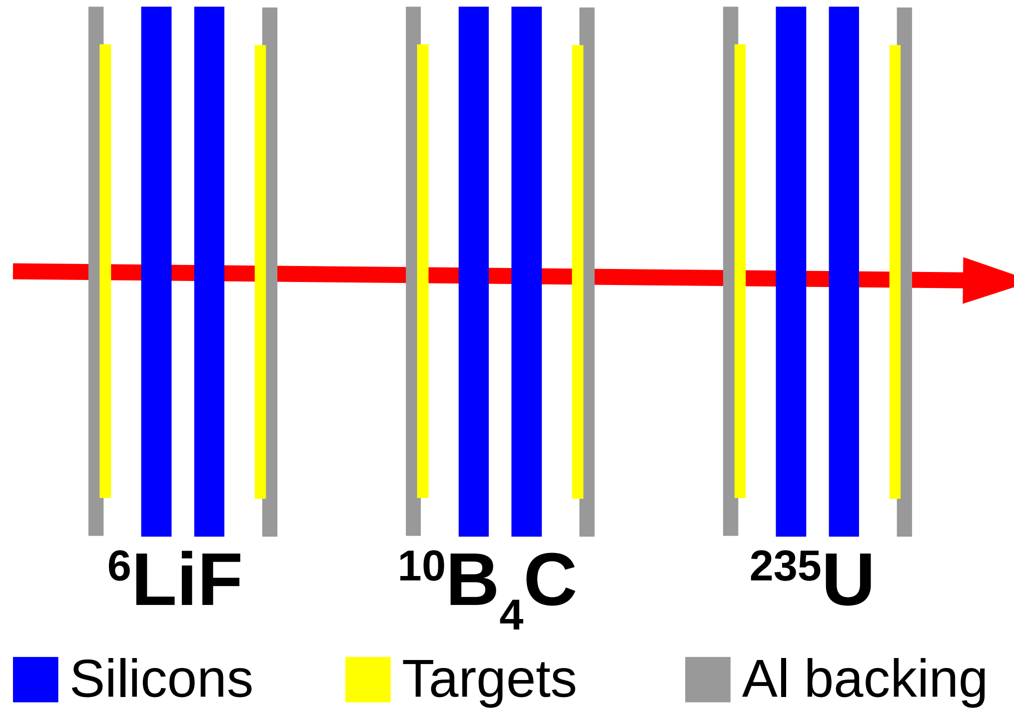




Setup

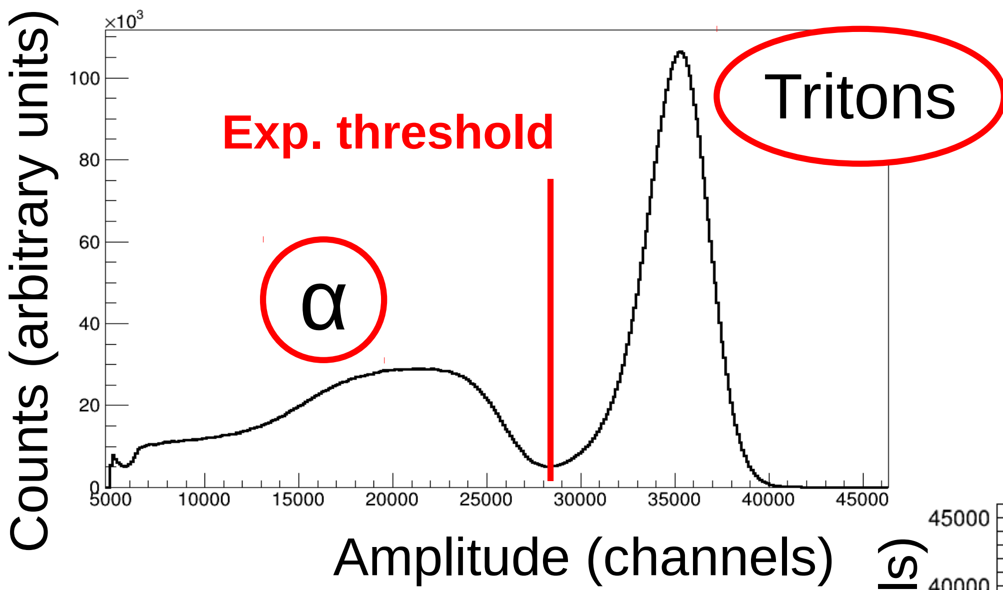
- Stack of 6 silicon detectors 5x5 cm^2 single pad 200 µm in beam





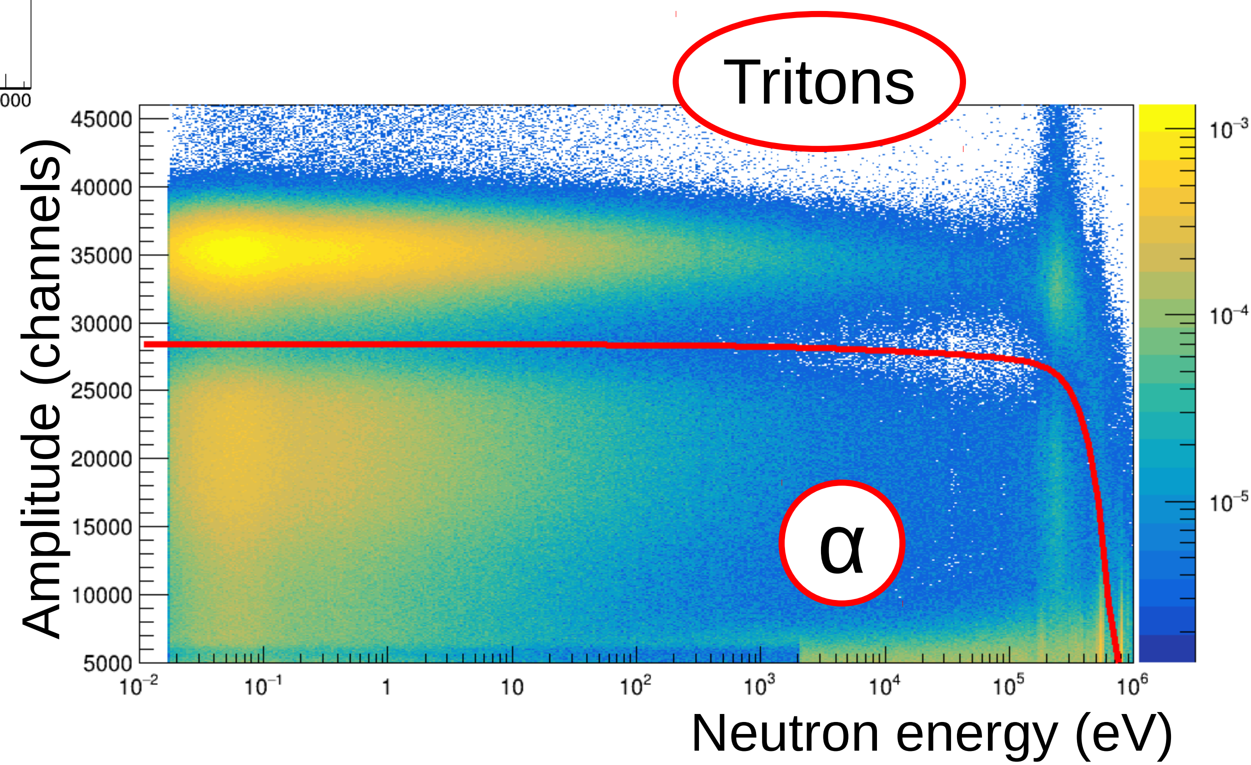
Target	Thickness (µm)	Al backing (µm)
^{6}LiF	1.9	50
$^{10}B_4C$	0.08	18
^{235}U	0.15	250

Events selection – $^{6}Li(n,t)^{4}He$

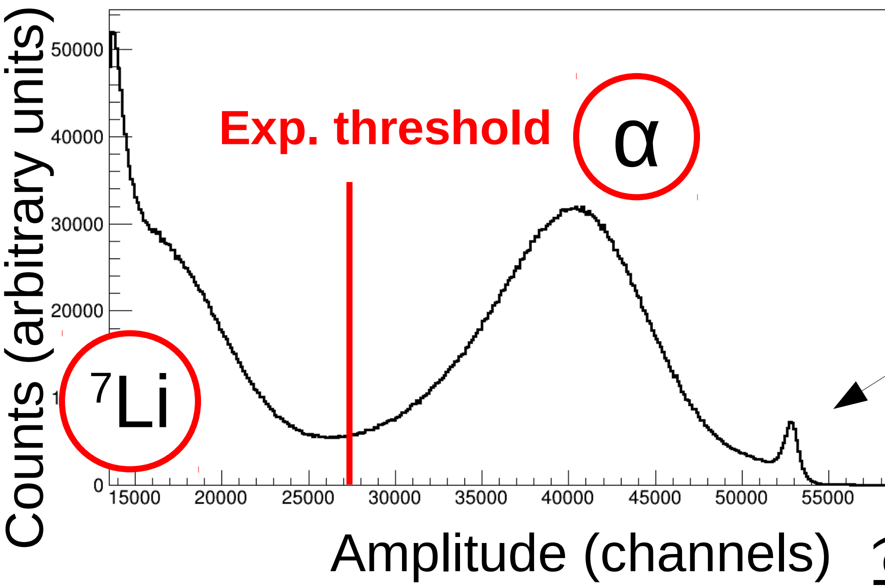


Reaction products are selected using the signal amplitude

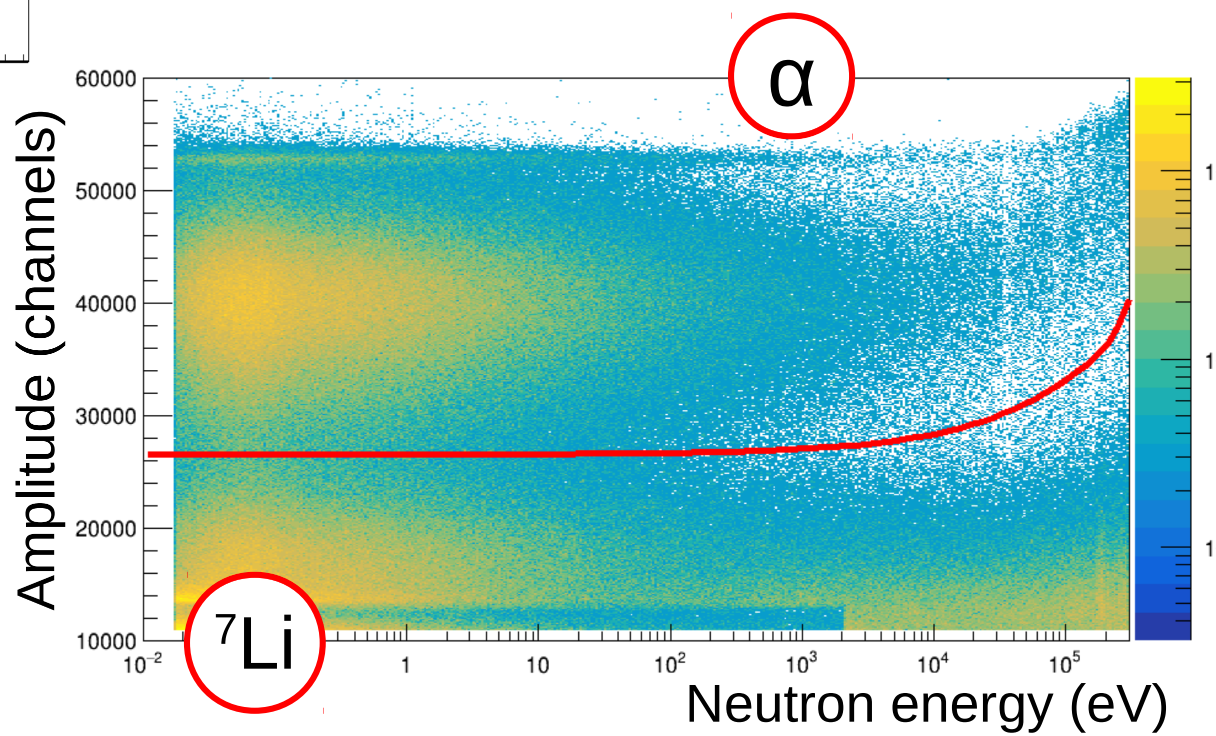
The threshold depends on the neutron energy



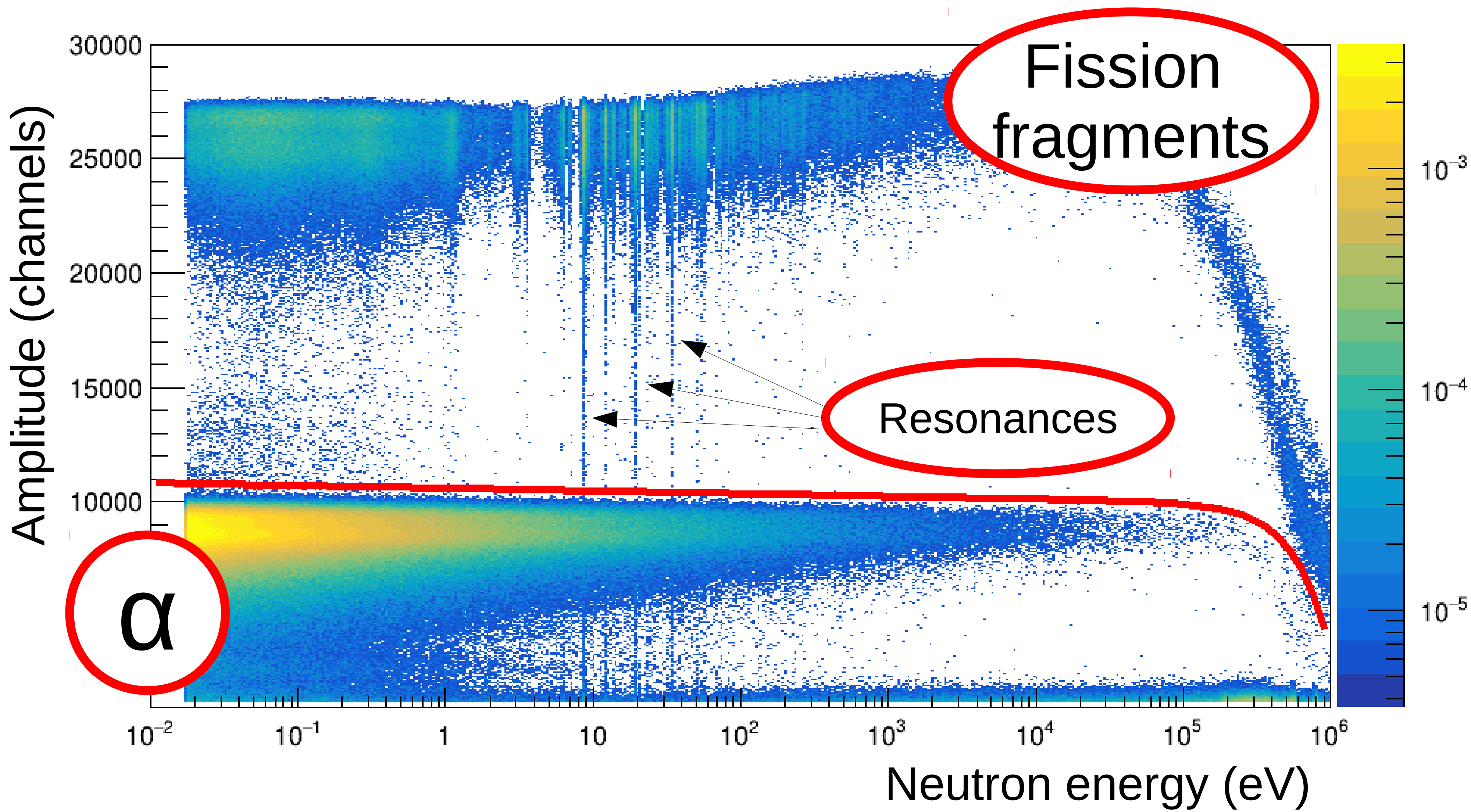
Events selection – $^{10}B(n,\alpha)^7Li$



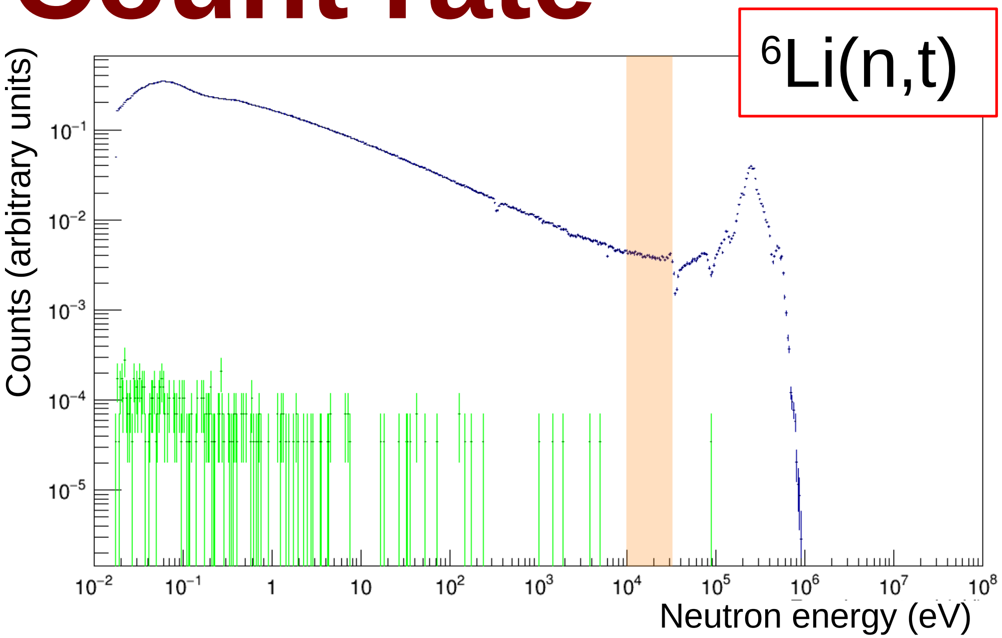
~6% of lithium produced is in the ground state with more kinetic energy available for the α

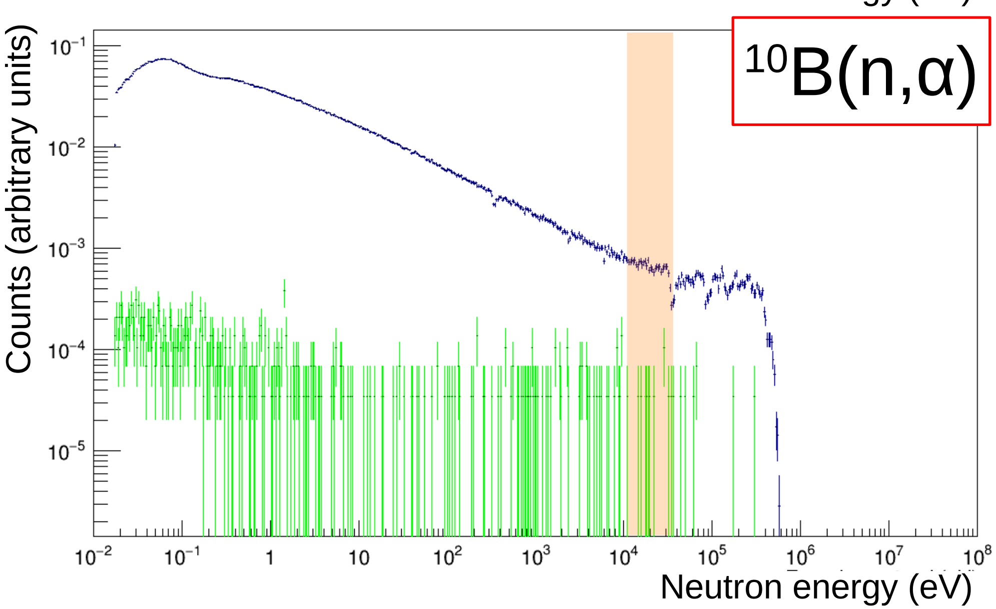


Events selection – $^{235}U(n,f)$

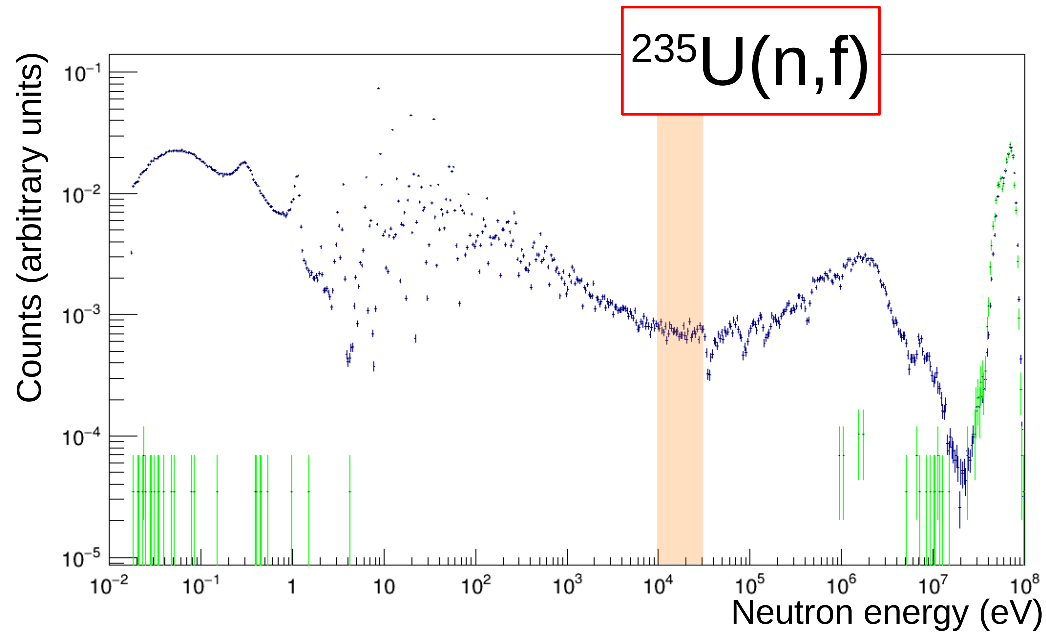


Count rate





Signals
Background

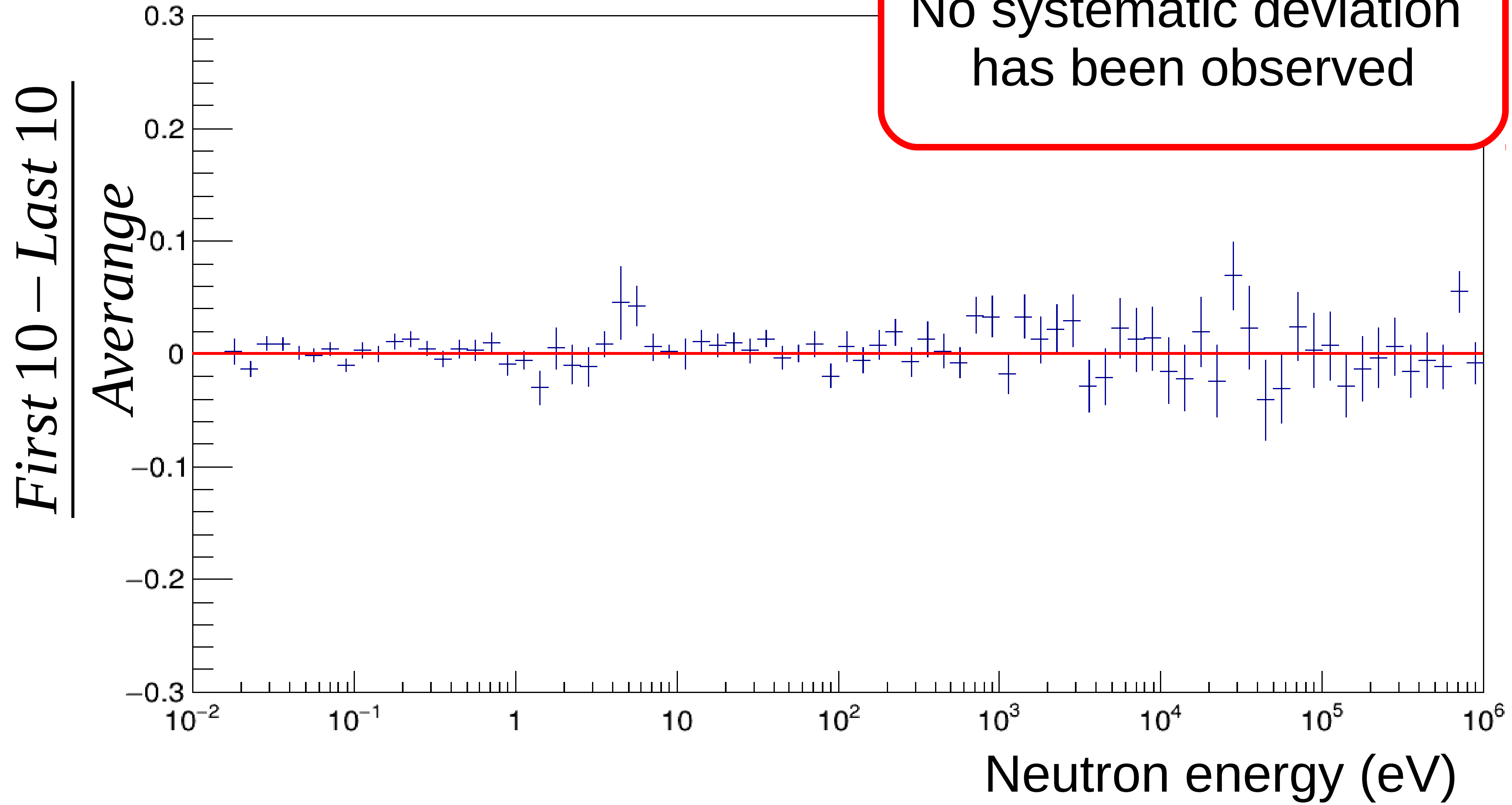


Good ratio
Signal / Background

Detectors stability

^{235}U(n,f)

No systematic deviation has been observed



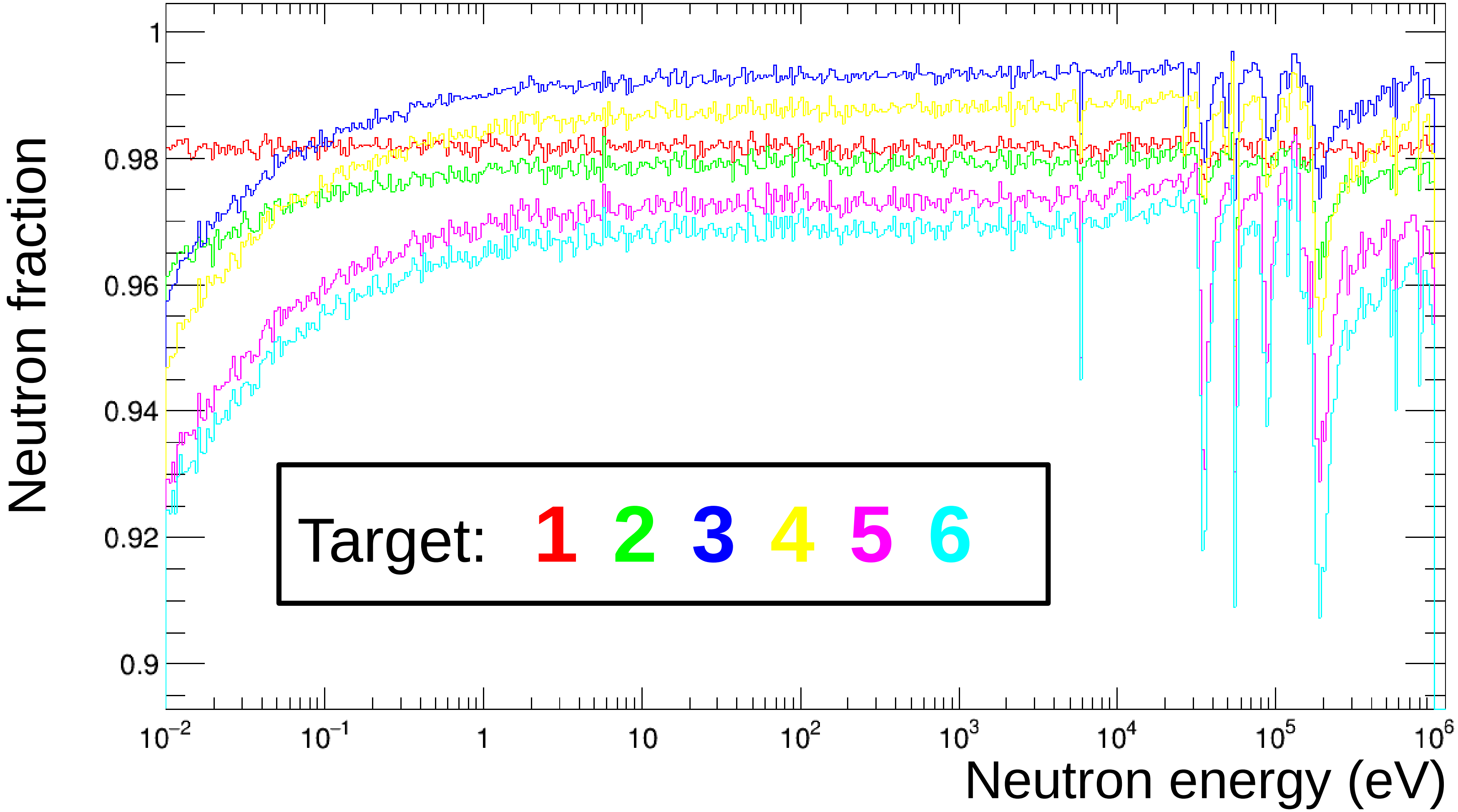
Data analysis

$$\sigma_{fission} = \frac{C_{fission} \cdot fAbs_{fission} \cdot \varepsilon_{std}}{C_{std} \cdot fAbs_{std}} \cdot N \cdot \sigma_{std}$$

$C_{fission}$ C_{std}	measured **count rates** after background subtraction
fAbs	coefficients representing the correction due to the **absorption** in dead layers, estimated with MC simulation
ε_{std}	**efficiency** of the detector measuring the standard reference, estimated with MC simulation
N	**normalization** coefficient, includes all the terms not depending on neutron energy (between 7.8 and 11 eV)
σ_{std}	standard cross section used as reference

Absorption correction - MC

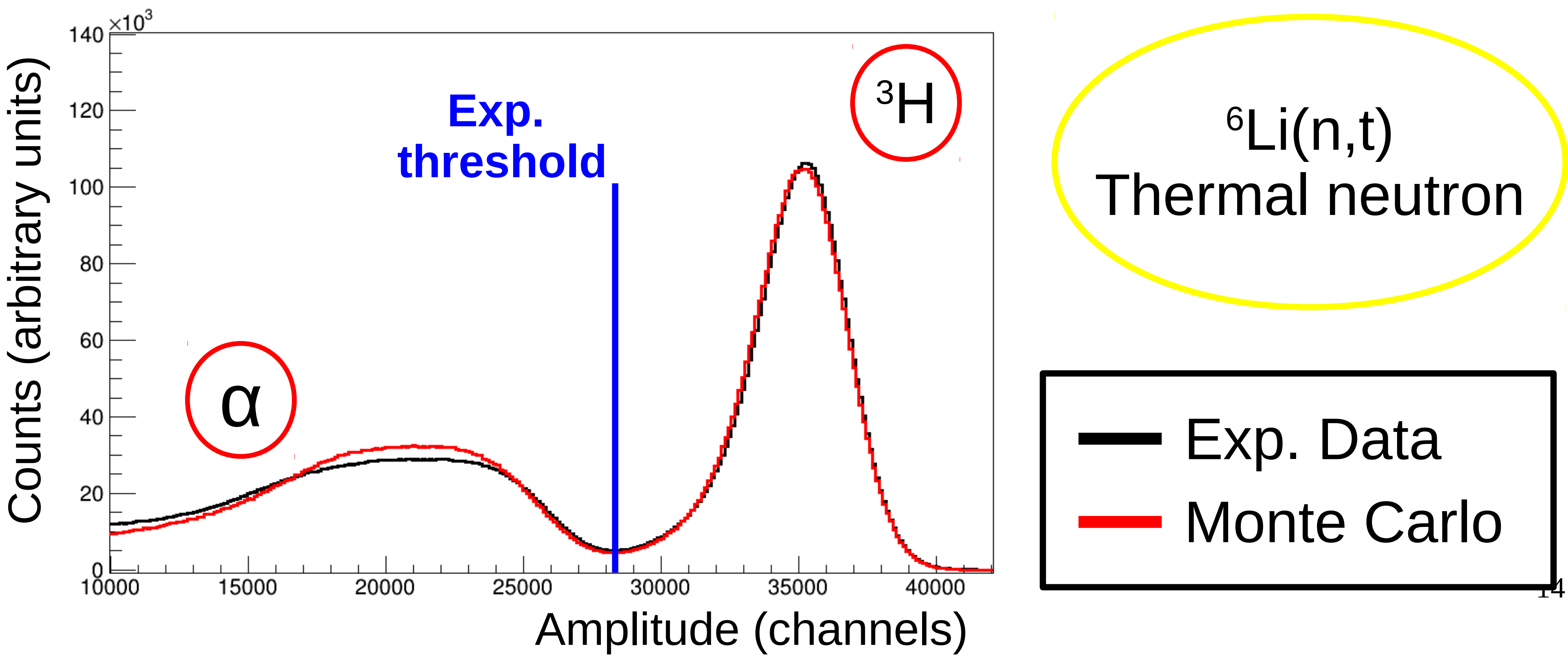
The **neutron fraction** hitting each target has been evaluated using Monte Carlo simulations, taking in account all the dead layers.



Efficiency – MC

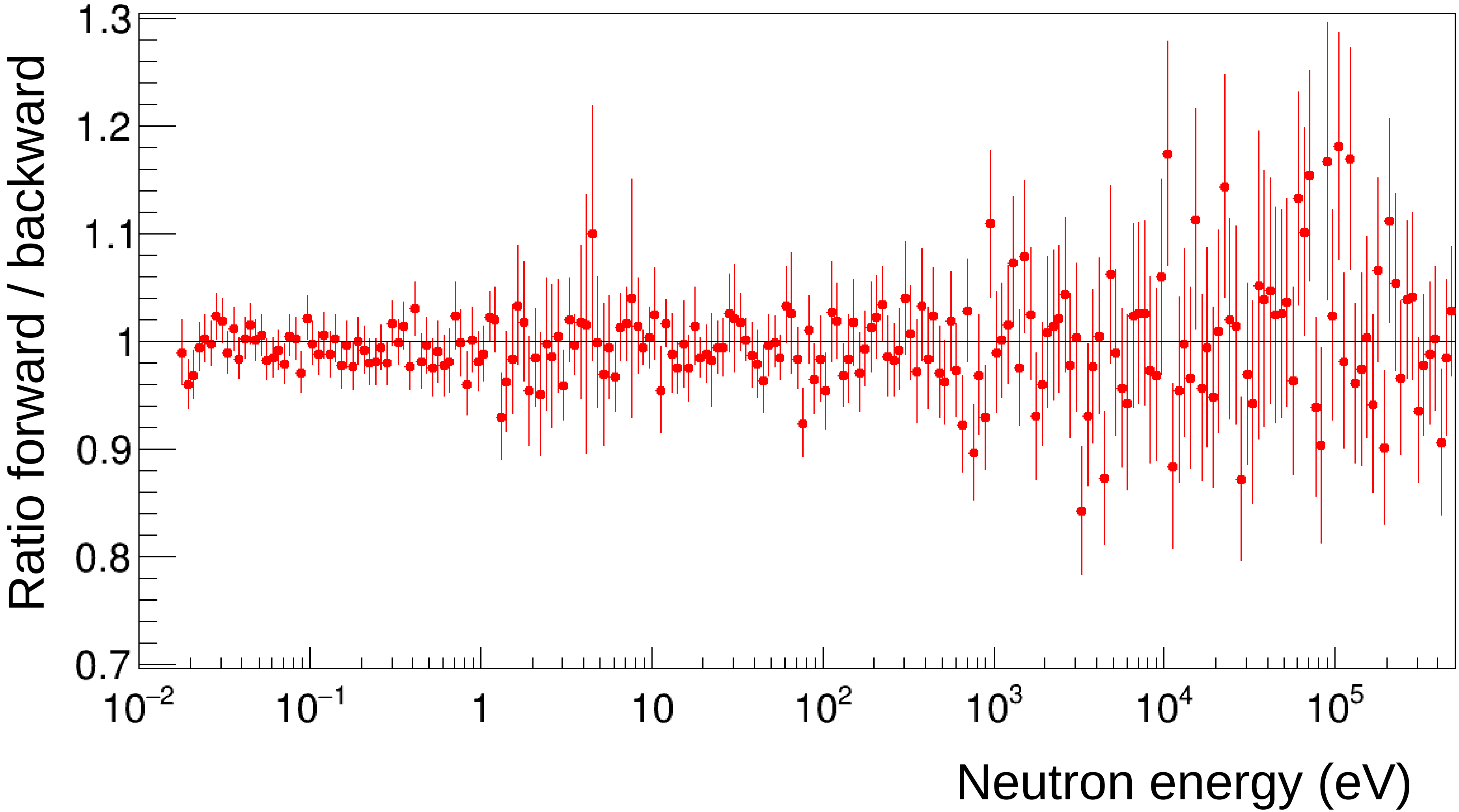
The combination of **detection** and **geometrical** efficiency has been calculated using MC for the reactions ^{6}Li(n,t) and ^{10}B(n,α) from thermal to 160 keV.

In this phase detectors has been calibrated and the experimental errors has been introduced.

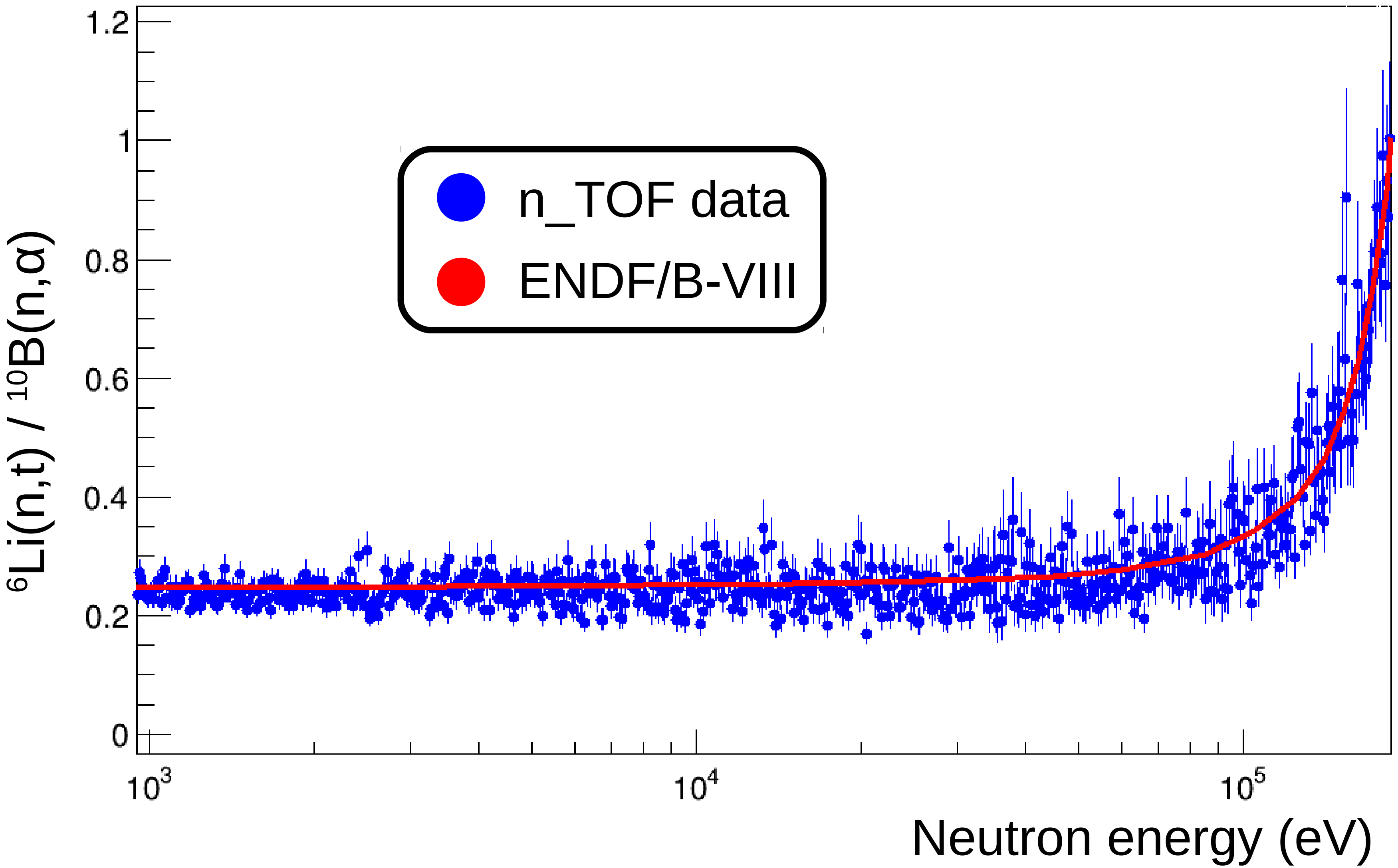


Ratio forward / backward

$^{235}U(n,f)$

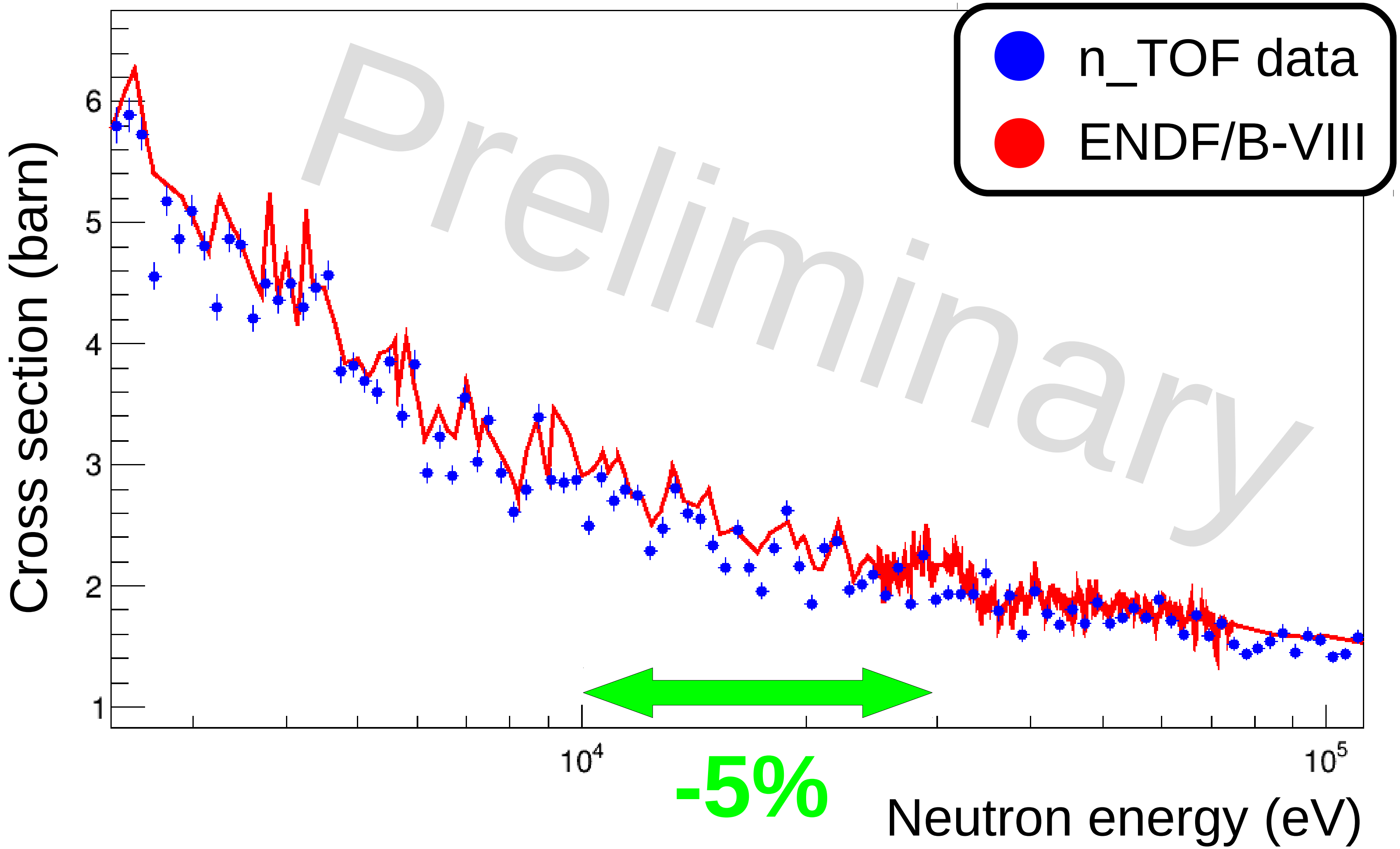


Ratio $^{6}Li(n,t)$ / $^{10}B(n,\alpha)$



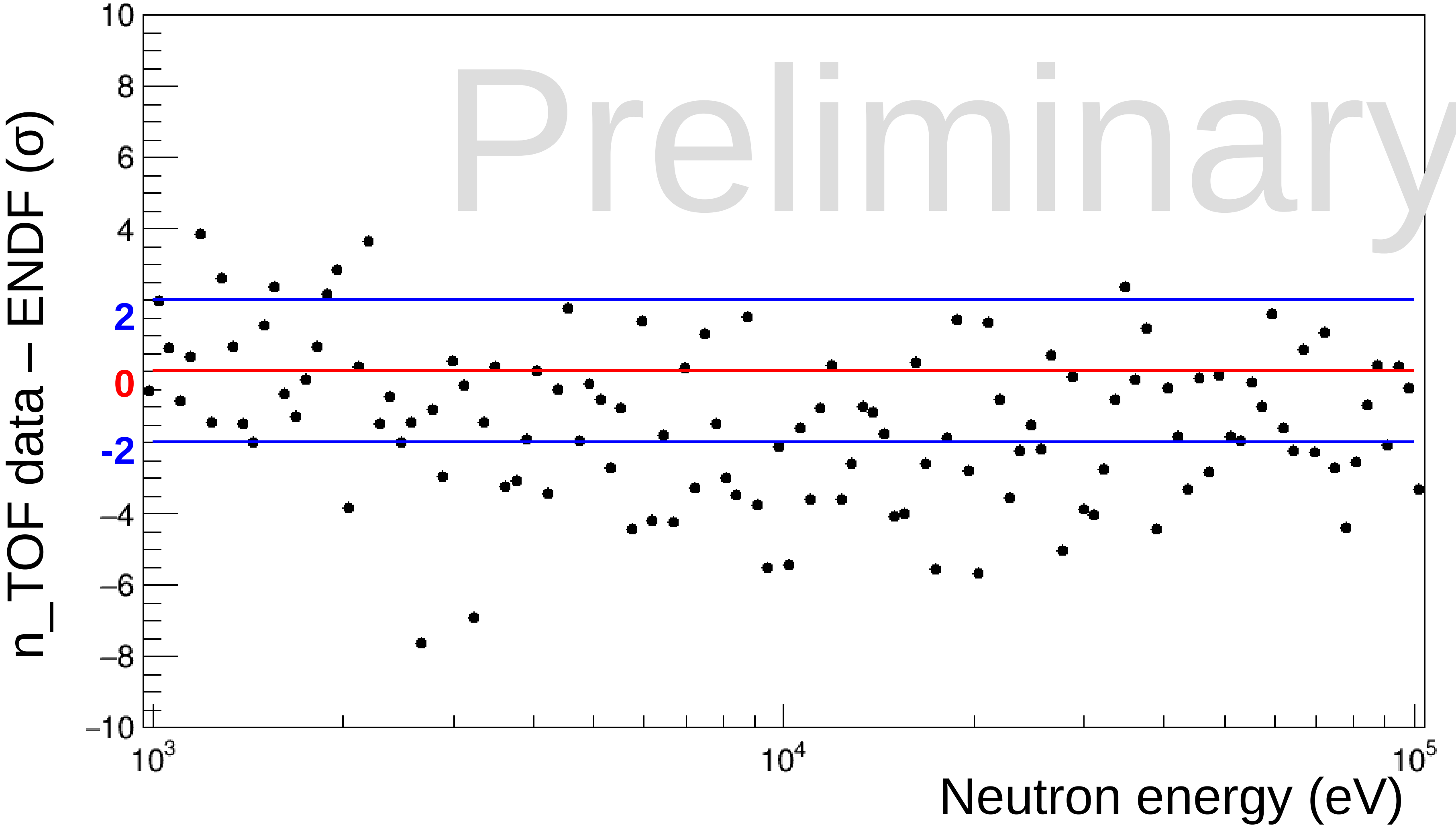
Cross section – $^{235}U(n,f)$

Combined data of $^{6}Li(n,t)$ and $^{10}B(n,\alpha)$ used as reference.



Deviation from ENDF

Differences between our data and ENDF in units of sigma (statistical only).



Conclusions

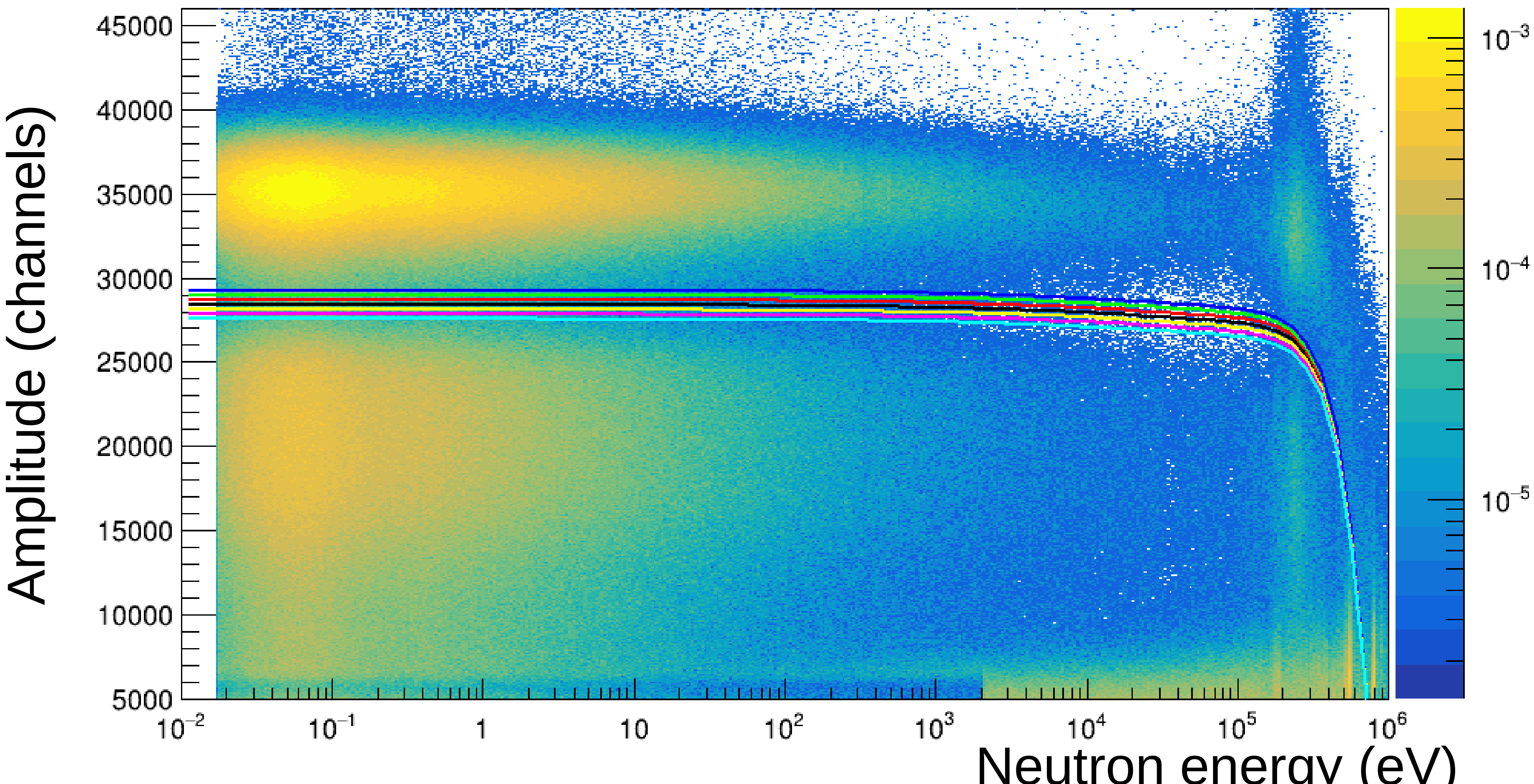
- An accurate measurement of the $^{235}U(n,f)$ cross section has been performed at n_TOF using $^{6}Li(n,t)$ and $^{10}B(n,\alpha)$ as reference.
- Preliminary data confirm an overestimation (around 5%) of the $^{235}U(n,f)$ in ENDF between 10 and 30 keV.
- New good quality data has been collected in the keV region, that will help to refine the evaluation of the structures of the uranium fission cross section.

Thank you

Experimental cuts systematic

^{6}Li(n,t) backward

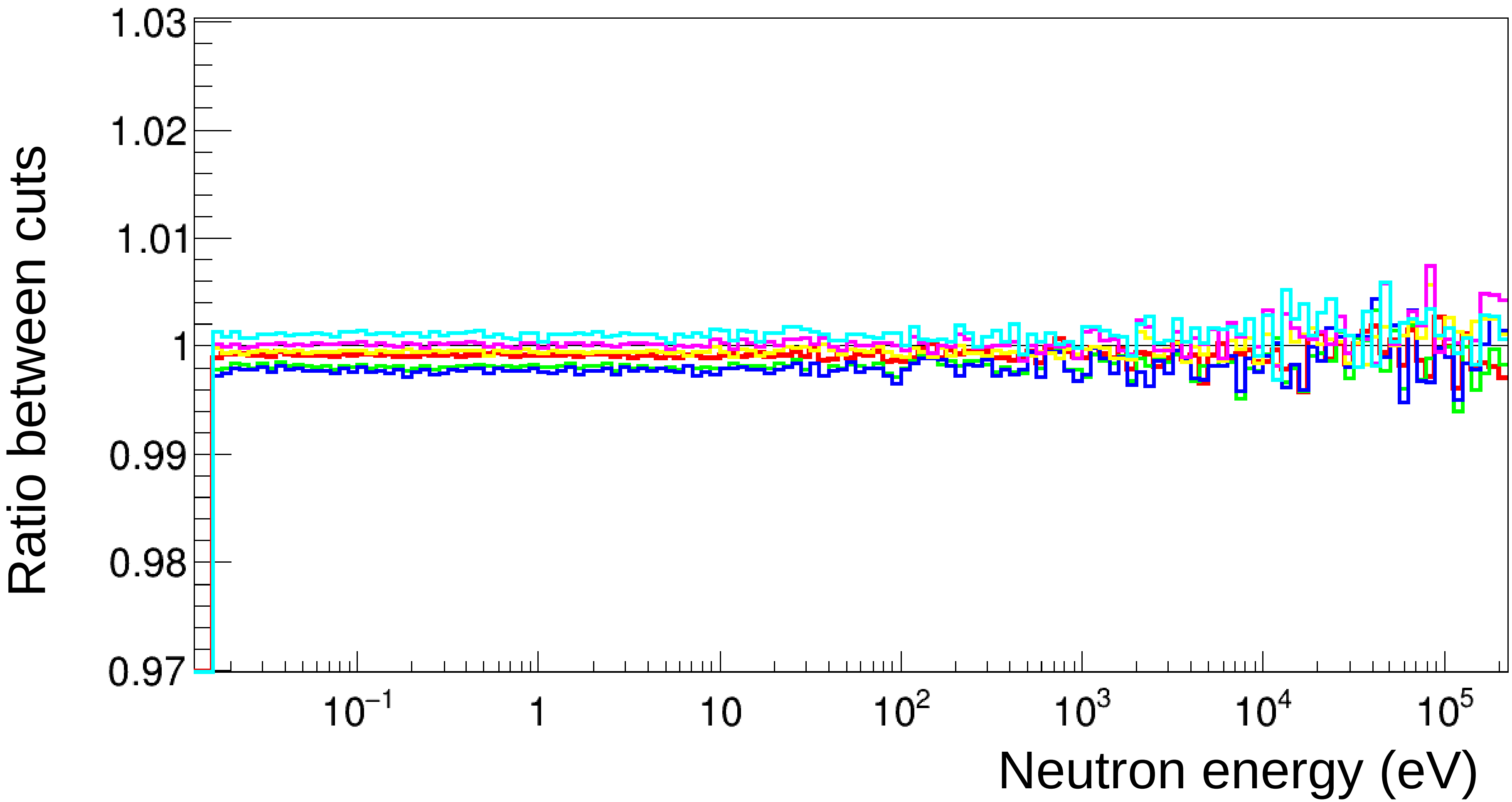
The sensitivity to the experimental cut has been evaluated with small variation of the threshold.



Experimental cuts systematic

$^{6}Li(n,t)$ backward

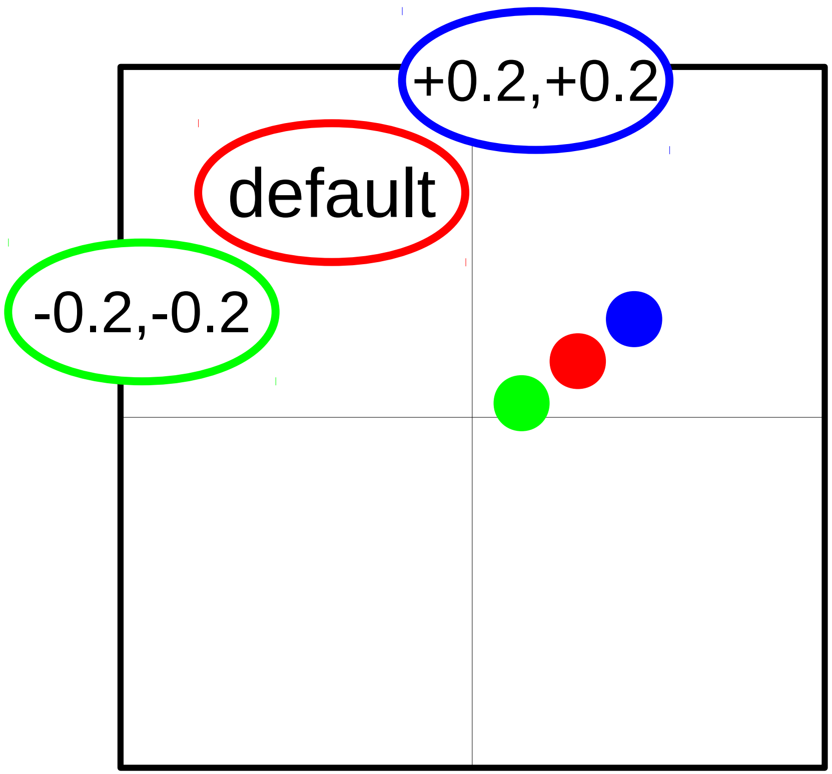
This source of systematic uncertainty has been proved to be negligible.

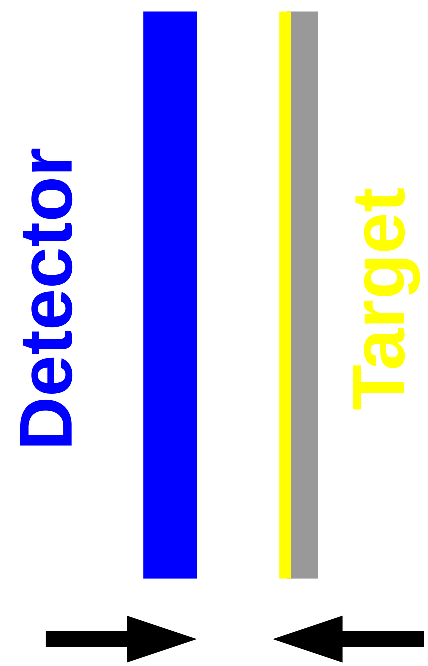


Efficiency systematic

The dependence of the efficiency by the geometrical setup has been evaluated with small changes in the simulations:

1) Moving the beam center on the XY plane





2) Reducing the distance between target and detector

Standard cross sections