Analysis of the ^{237}Np(n,f) data with the FIC detector

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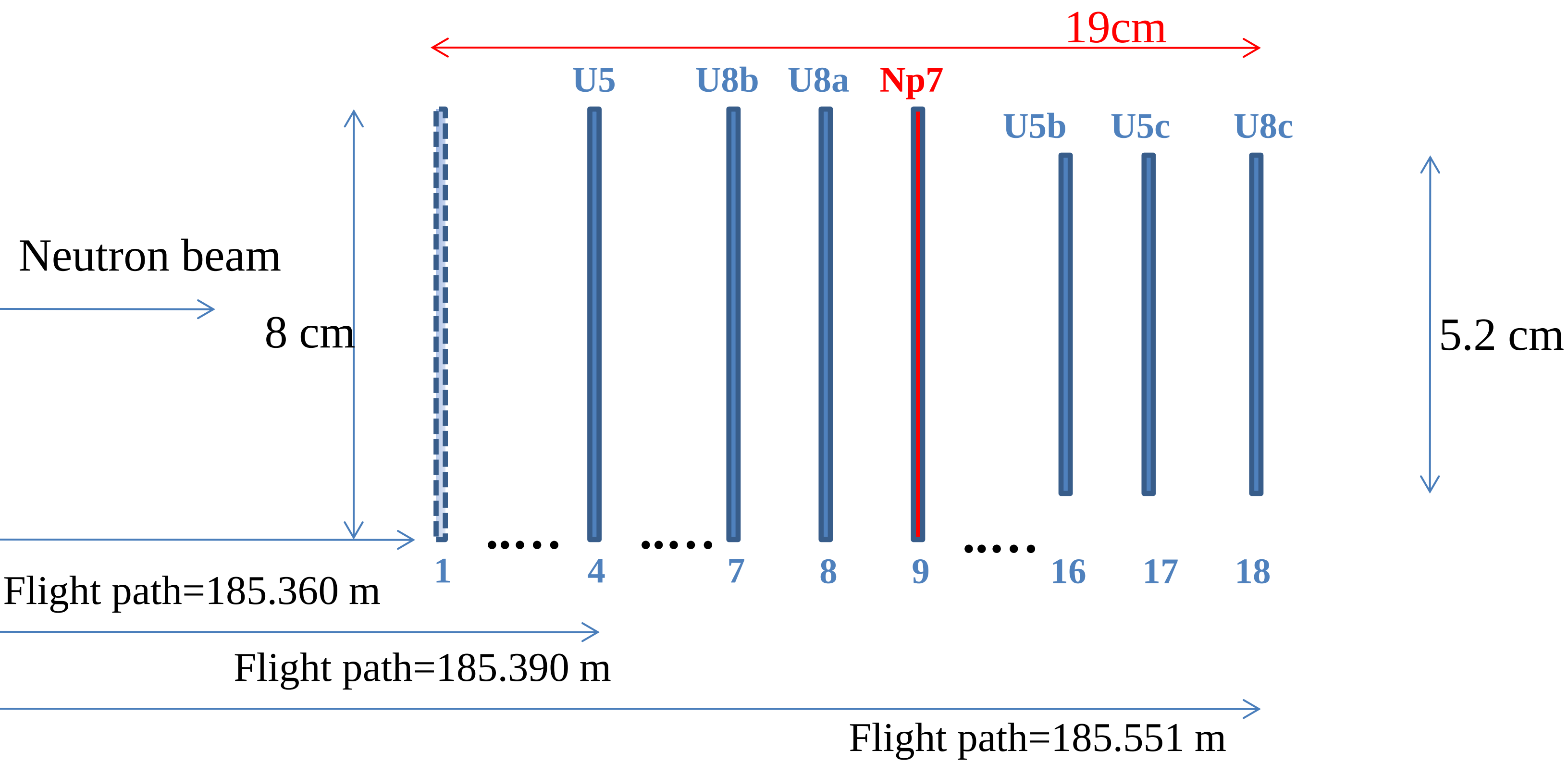
Outline

- Goal: analysis of the $^{237}Np(n,f)$ cross section data with FIC (n_TOF phase 1).
- Pulse shape analysis procedure.
- Problems faced- Solutions proposed.
- Results –To do’s.

FIC0 2003 – target assembly

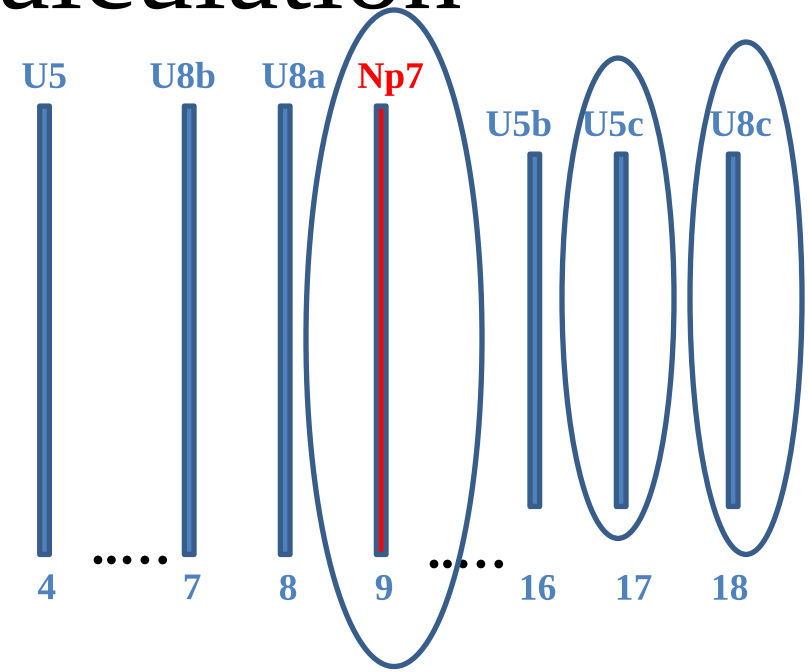
- Ar 90%, CF_4 10% at 720 mbar /sealed detector.
- d=2 cm.
- Sample diameters: 8 cm, 5.2 cm.



•Each detector signal was recorded at a FADC channel every 25 ns in a time window of 100µs.
•Reference for cs calculation: σ(U235(n,f)) up to E=2 MeV and σ(U238(n,f)) above.

Cross section calculation

$$\sigma_{Np_7(n,f)} = \frac{C_{Np7} Nt_{ref} nEvents_{ref} eff_{ref}}{C_{ref} Nt_{Np7} nEvents_{Np7} eff_{Np7}} \sigma_{ref}$$



C: number of accepted FF pulses.
Nt: number of target nuclei (for Np7, U5c, U8c values obtained from alpha measurements / RBS, for the rest nominal values taken)
nEvents: number of accepted events (normalization)
eff: "efficiency" factor for correction of self absorption of FF in the samples: FLUKA simulations.

The pulse shape analysis routines made by D. Karadimos were used.

Pulse Shape Analysis (*fic code*)

Undershooting and **rippling** of the baseline after the gamma flash.

- **<u>"Average event"</u>:** addition of all the events with **similar flash integral values** ($Y_{average}(t)$).
- **<u>Analysis of raw data:</u>**

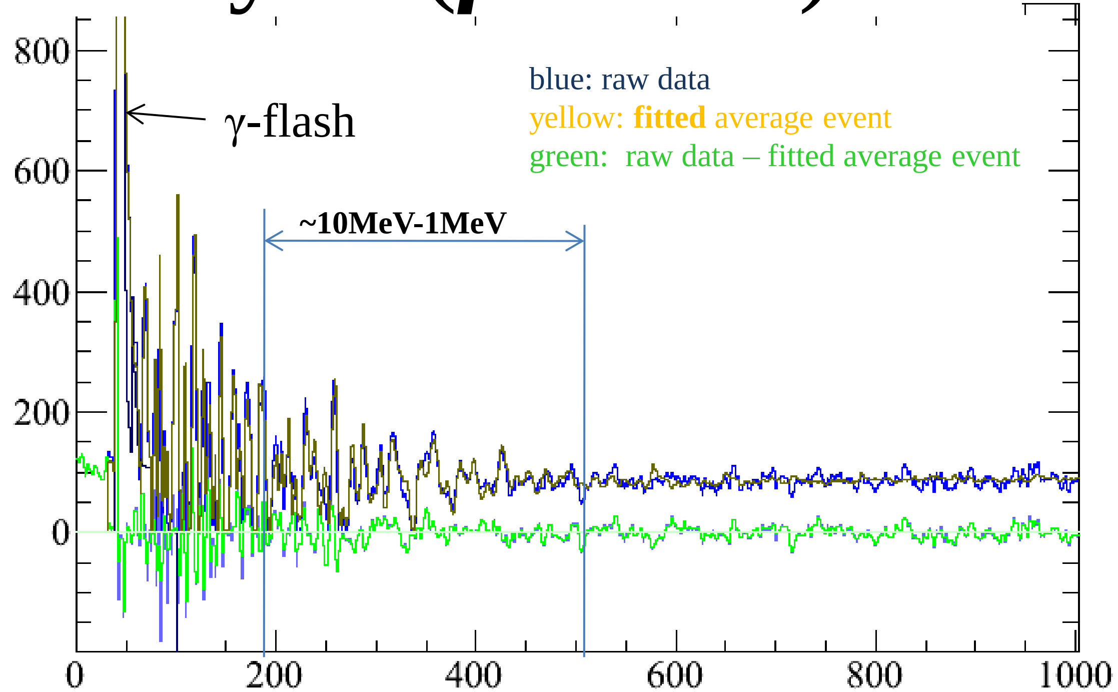
1. Selection of the proper "average event" and fit with linear function $Y(t)=Y_0+A\,Y_{average}(t)$ (yellow)
2. Subtraction of fitted average event from raw data / median filter 3. (green)
3. Pulse Shape Analysis:

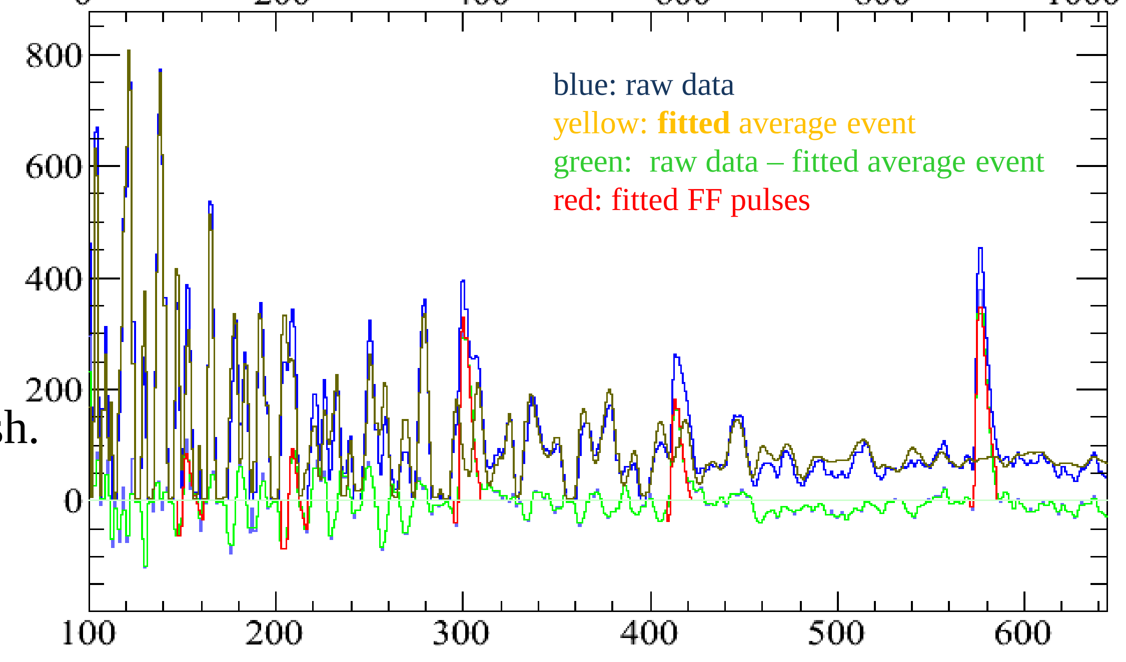
$$Y_{peak}(t) = Y_0 + A\left(1-e^{-\frac{t-t_0}{t_1}}\right)^p e^{-\frac{t-t_0}{t_2}}$$

(6 parameters: t_1=1.2/ t_2=4.3 / p=9.9)

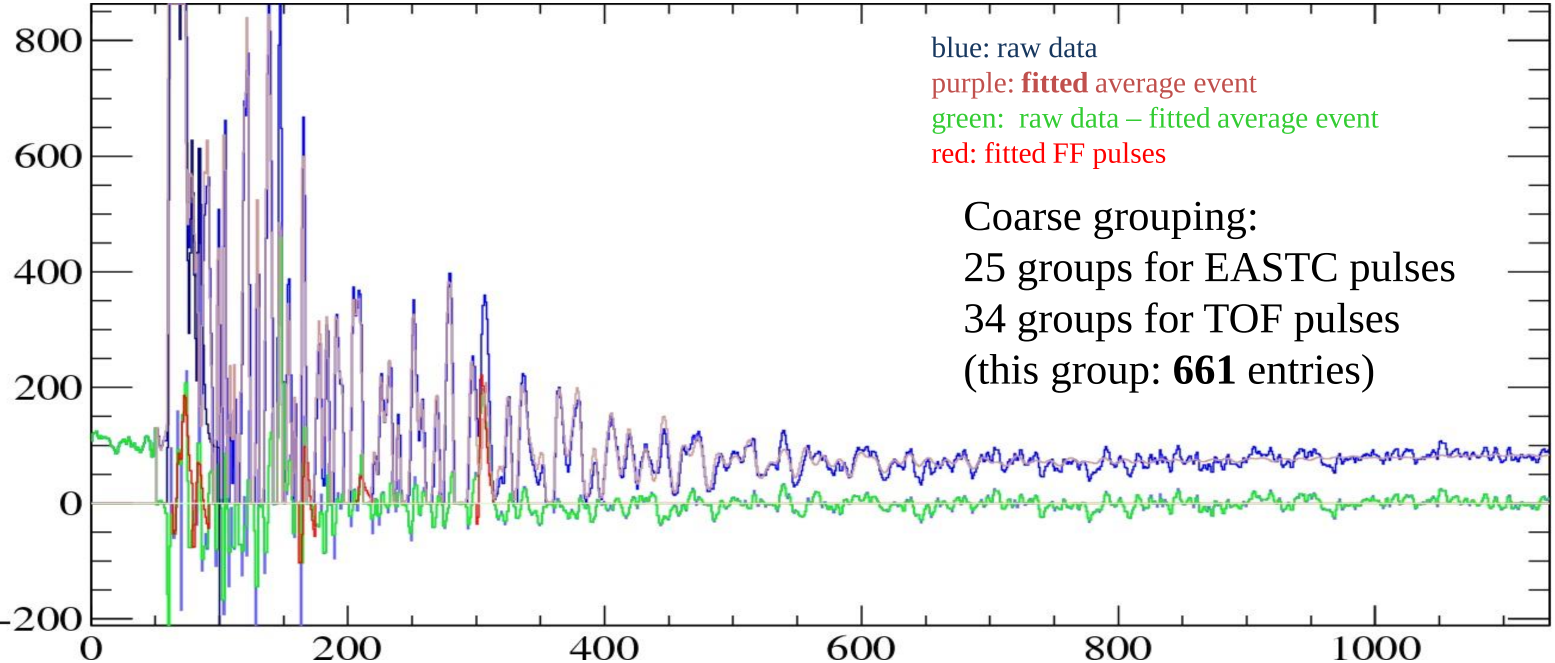
- Same function for fitting of gamma flash.

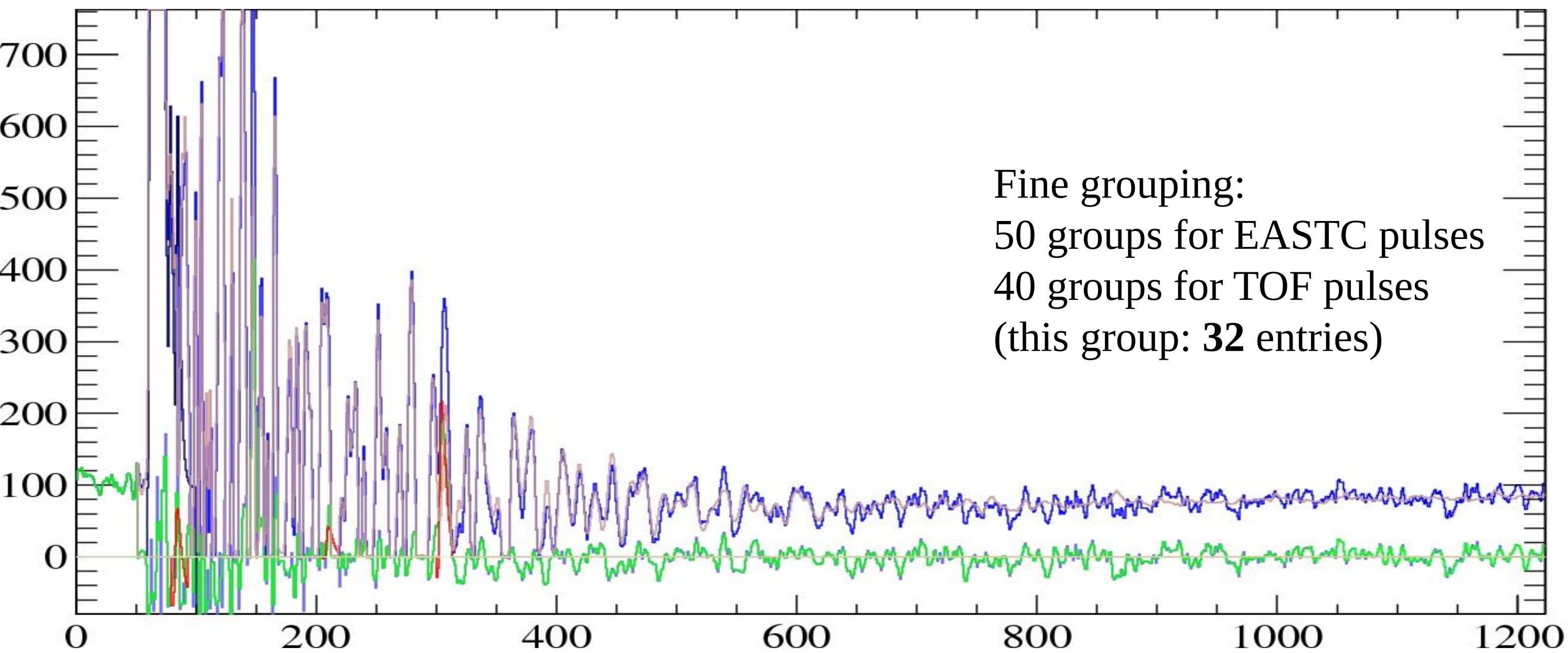
Time of Flight: centroid of the peak corrected for the distance covered in the Pb target and coolant/moderator layer.





Sensitivity on the grouping of events based on flash integral values (1)

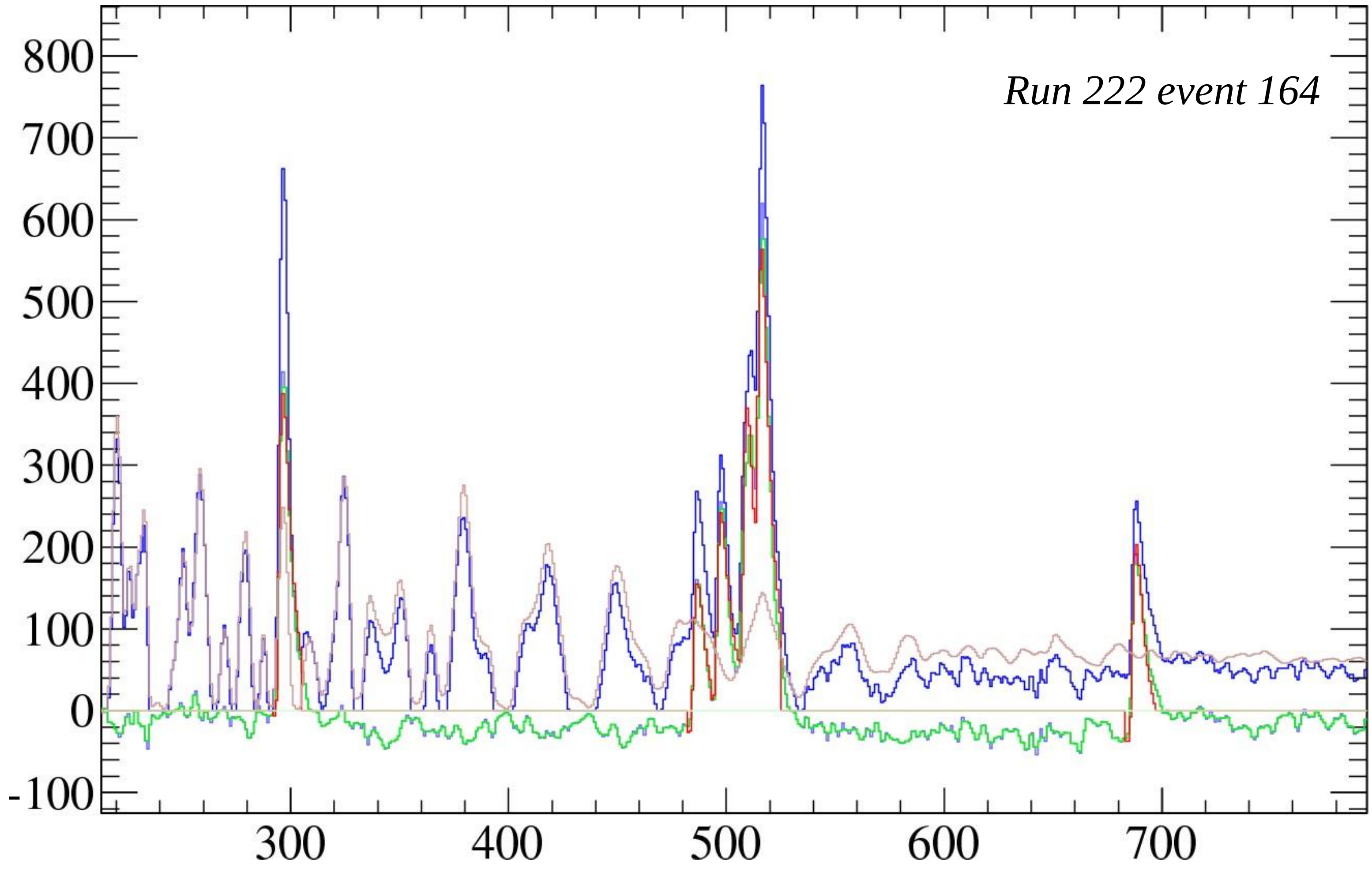




U5c sample
Low mass

not many FF signals per event

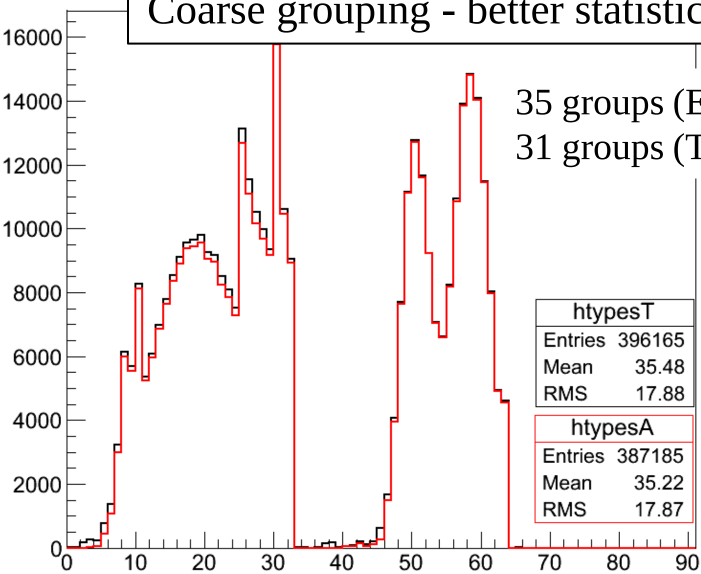
Sensitivity on the grouping of events based on flash integral values (2)
More difficult case: Np237



- Fitted “Average signal” slightly overestimates the raw data.
- Pulse shape analysis code succeeds to fit the FF pulses.

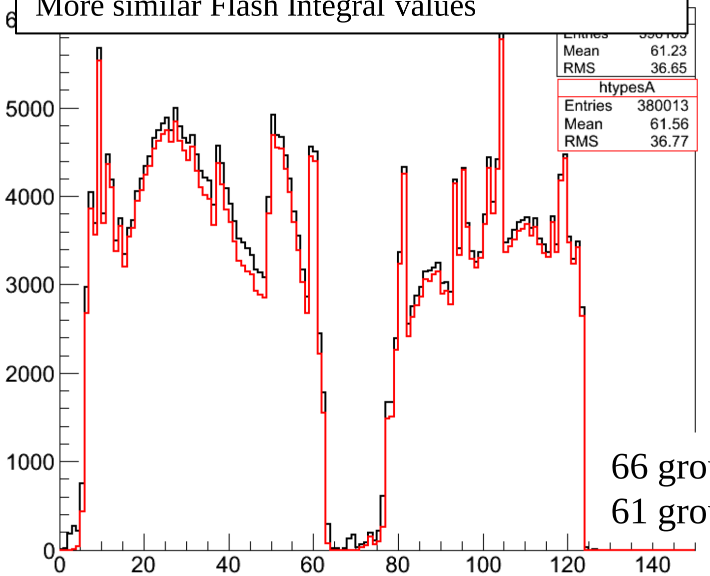
Sensitivity on the grouping of events based on flash integral values (3)

Coarse grouping - better statistics



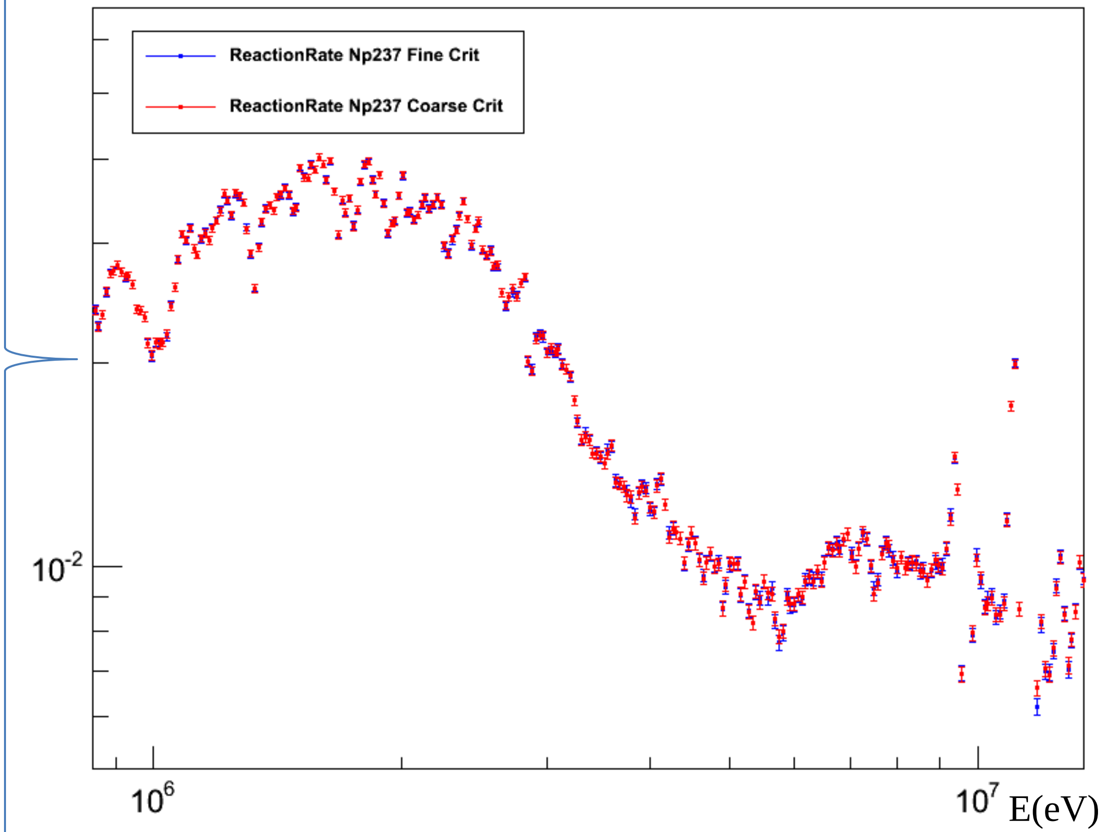
35 groups (EASTC)
31 groups (TOF)

Fine grouping- Worse statistics
More similar Flash Integral values



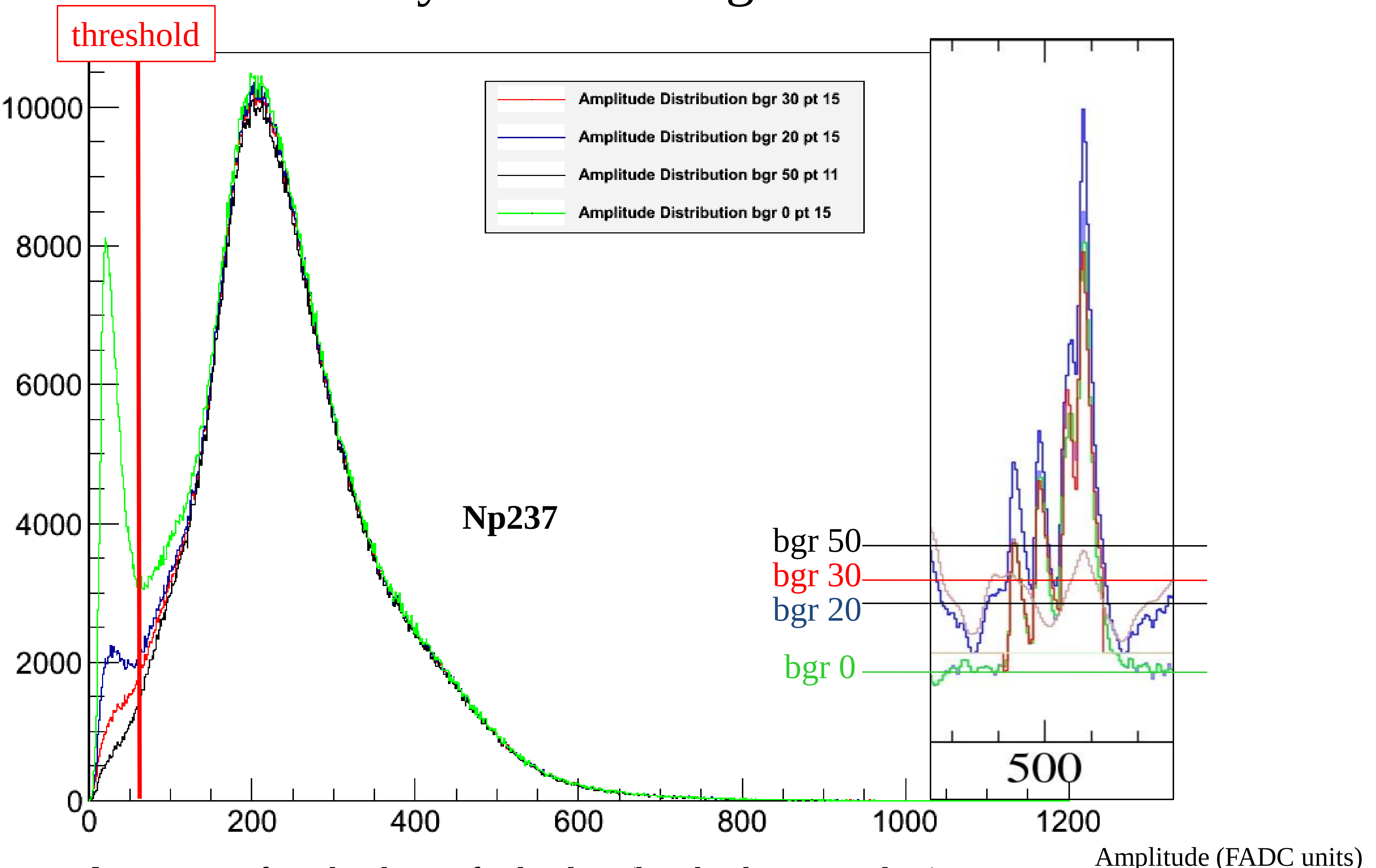
66 groups (EASTC)
61 groups (TOF)

Np237 sample-Comparison of Reaction Rate



Differences that don’t exceed 1.3% up to 10MeV

Sensitivity on the background level choice



- **bgr 30** was found to better fit the data (by checking raw data)
- Threshold applied: minimum of amplitude distribution with bgr 0.

Selection of events-pulses (***rootres*** *code*)

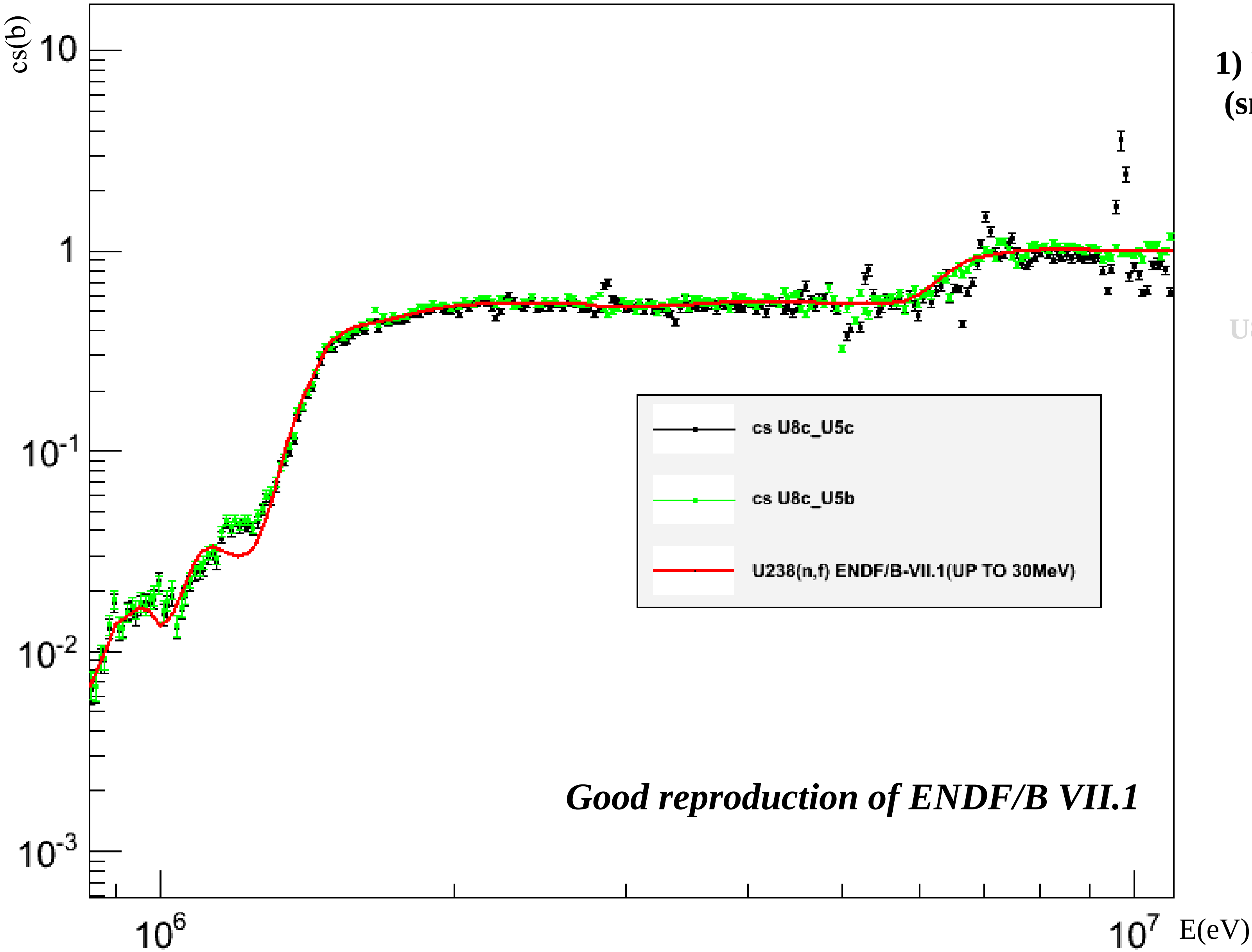
- Fitting parameters and errors from ***fic*** are stored in binary files.

  rootres creates the corresponding histograms in ROOT files for further selection.

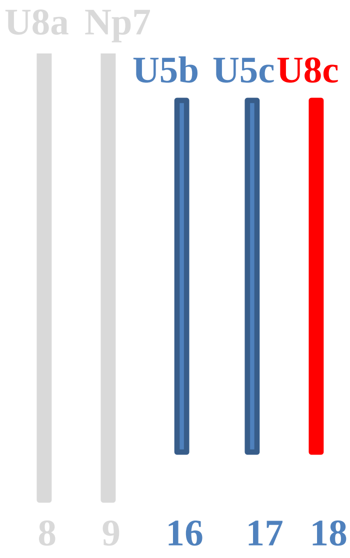
- Rejection of whole events with exclusion of **gamma flash** or **average signal** fitting parameters and FF pulses with exclusion of **peak** fitting parameters is possible.

- For each sample a separate analysis was performed in order to estimate the accepted limits of the fitting parameters and their errors.

$^{238}U(n,f)$ cross section calculation with $^{235}U(n,f)$ as reference

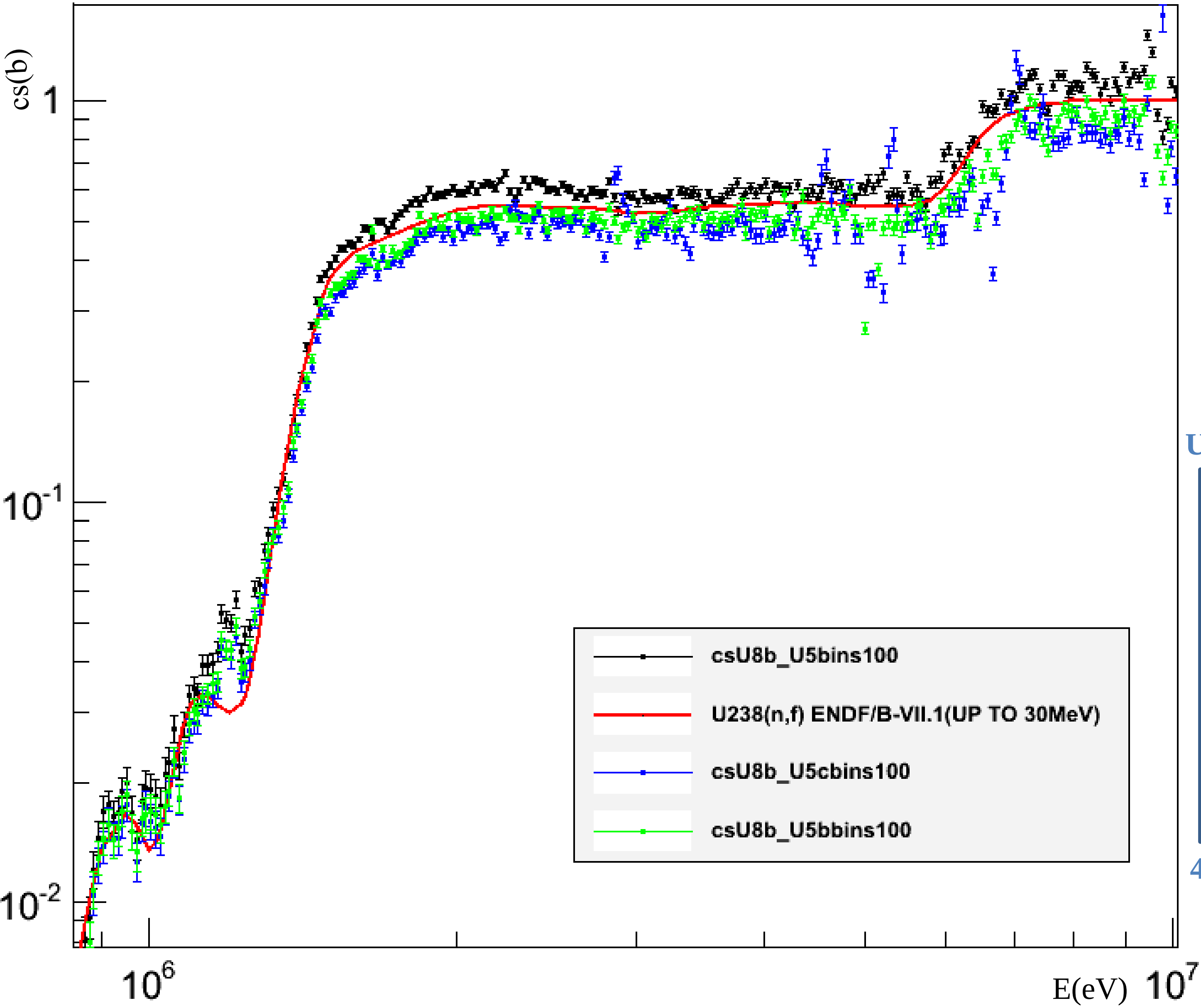


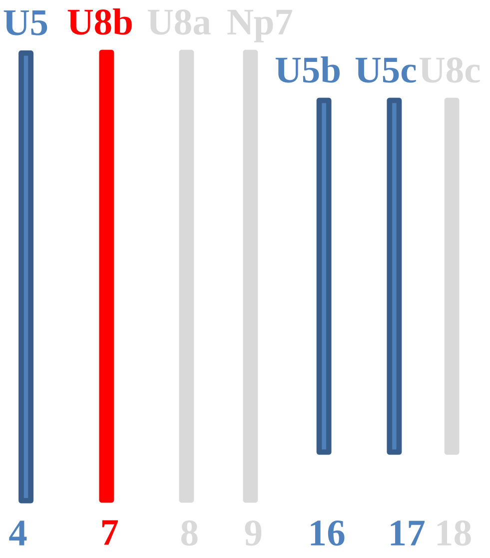
1) U8c as target (small targets)



Targets with same surface give reasonable results

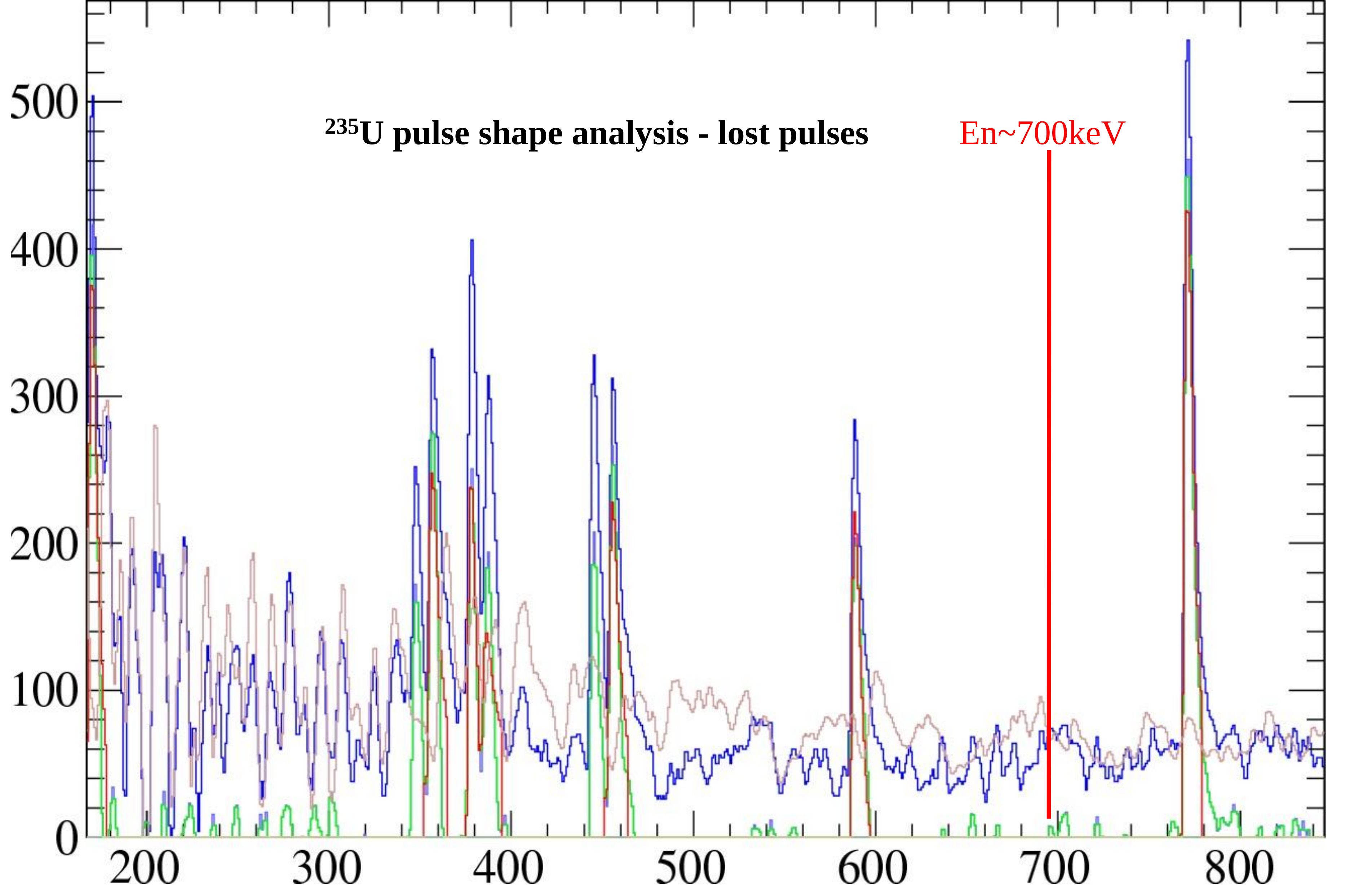
2) U8b as target





- Same results taking U8a as target.

1) U5 target pulse shape analysis is problematic due to big mass value+cross section=>High counting rate.
2) U8(big target) / U5c,U5b (small targets): systematically lower cs: **Neutron fluence losses due to different surfaces???**

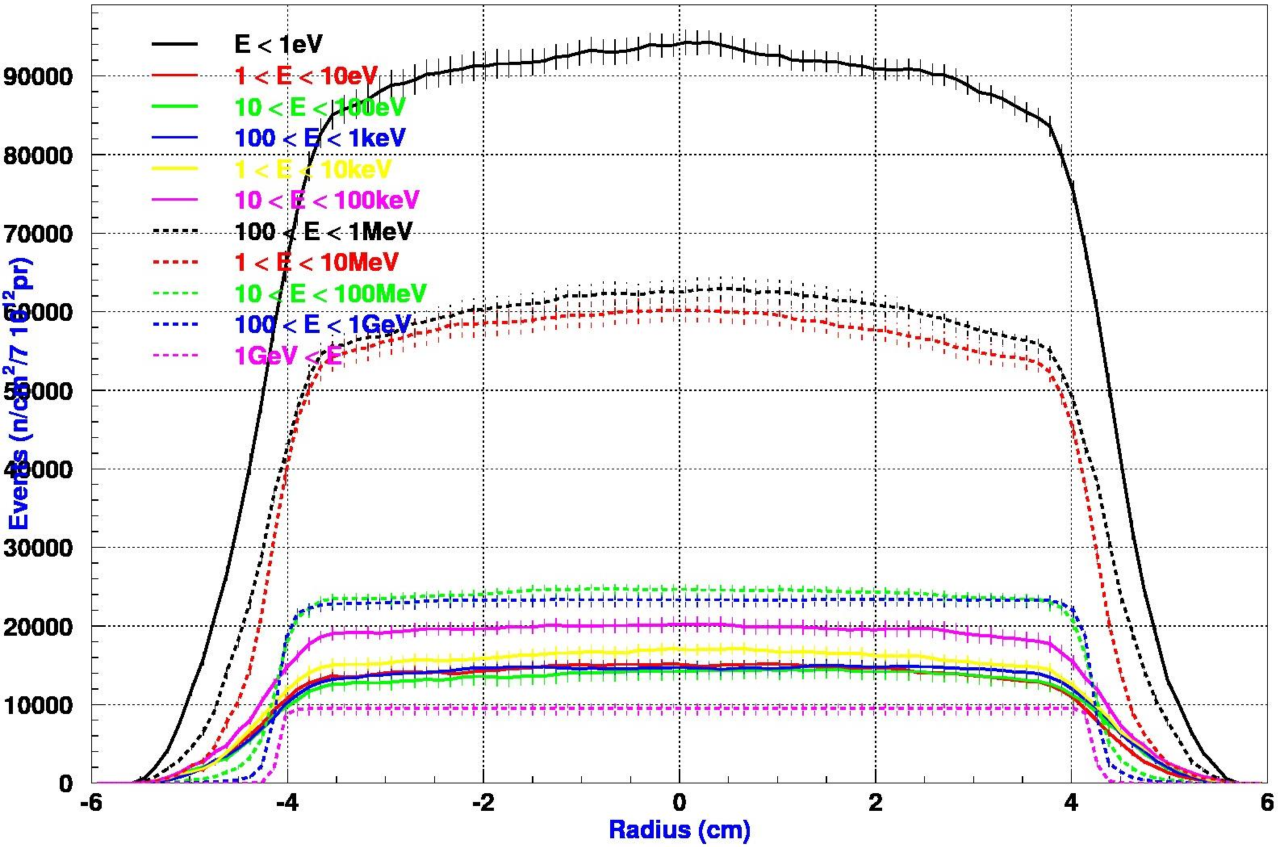


- Very massive target + high cross section value => average signal fails to reproduce raw data.
- Various efforts were made to improve the situation without great success.
- Need to use U5b or U5c as reference target => **U5b better statistics.**

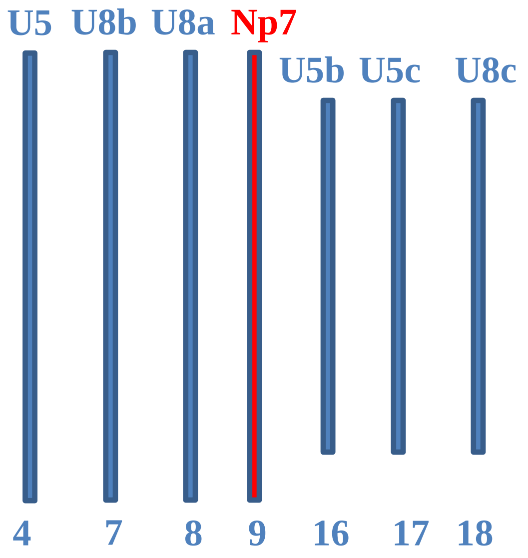
Investigation of correction factor due to different surfaces

- Smaller diameter (5.2cm) than Np237(8cm): Correction factor due to lower neutron fluence
- Estimation from:

1. Reaction rate ratio **(U8 big)/ (U8 small)**
2. Ratio cs ^{238}U(n,f): ENDF/ (cs ^{238}U(n,f) - **(big/small)**)

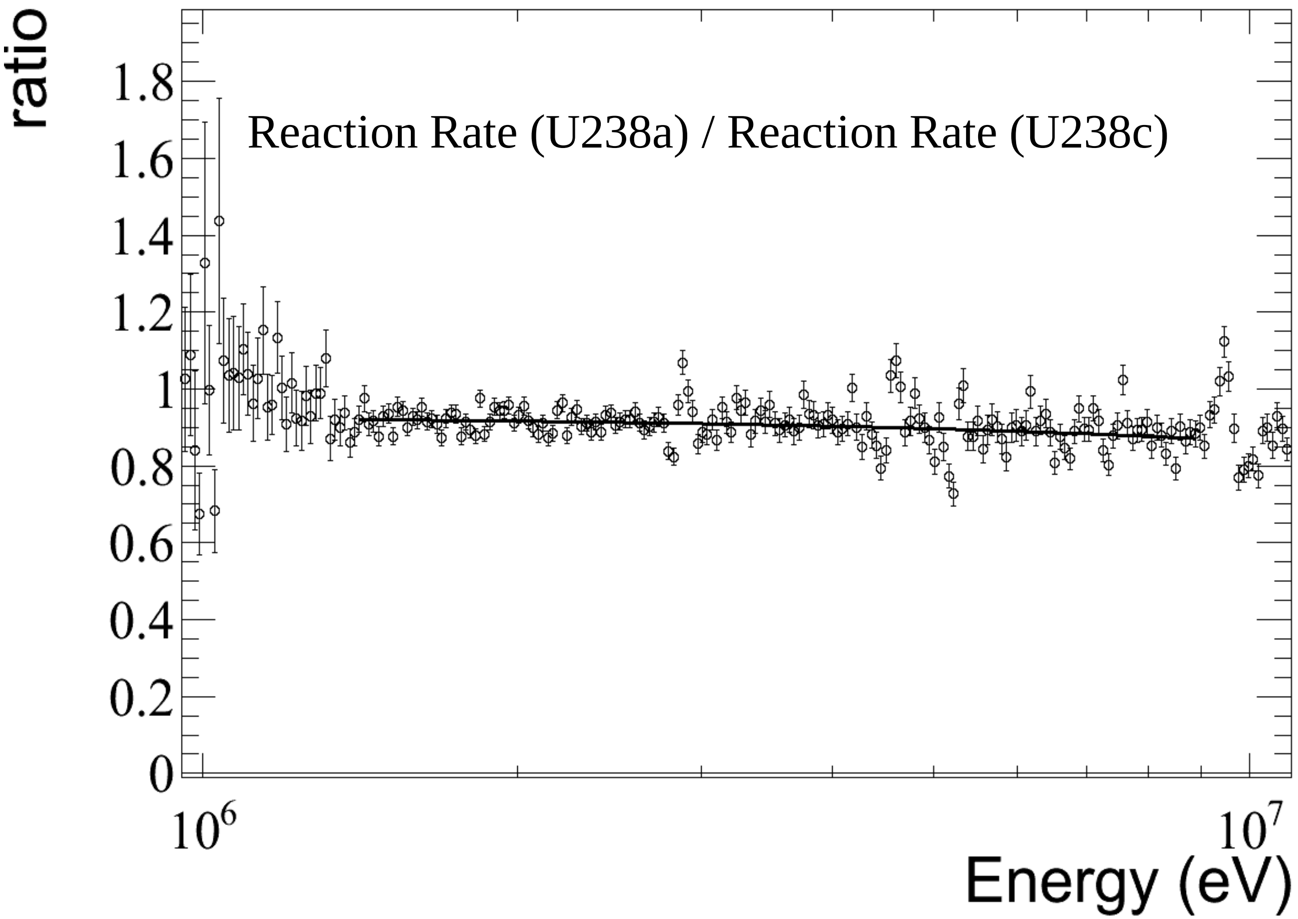


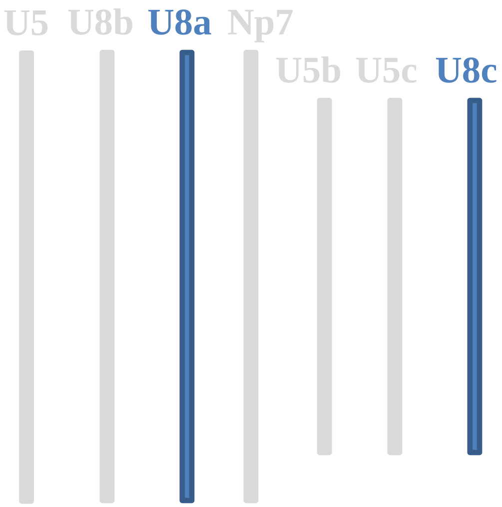
Mainly interested in the neutron energy region < 2MeV



Calculation of the neutron beam profile with calculator (V. Vlachoudis)

Reaction rate ratio fitting example



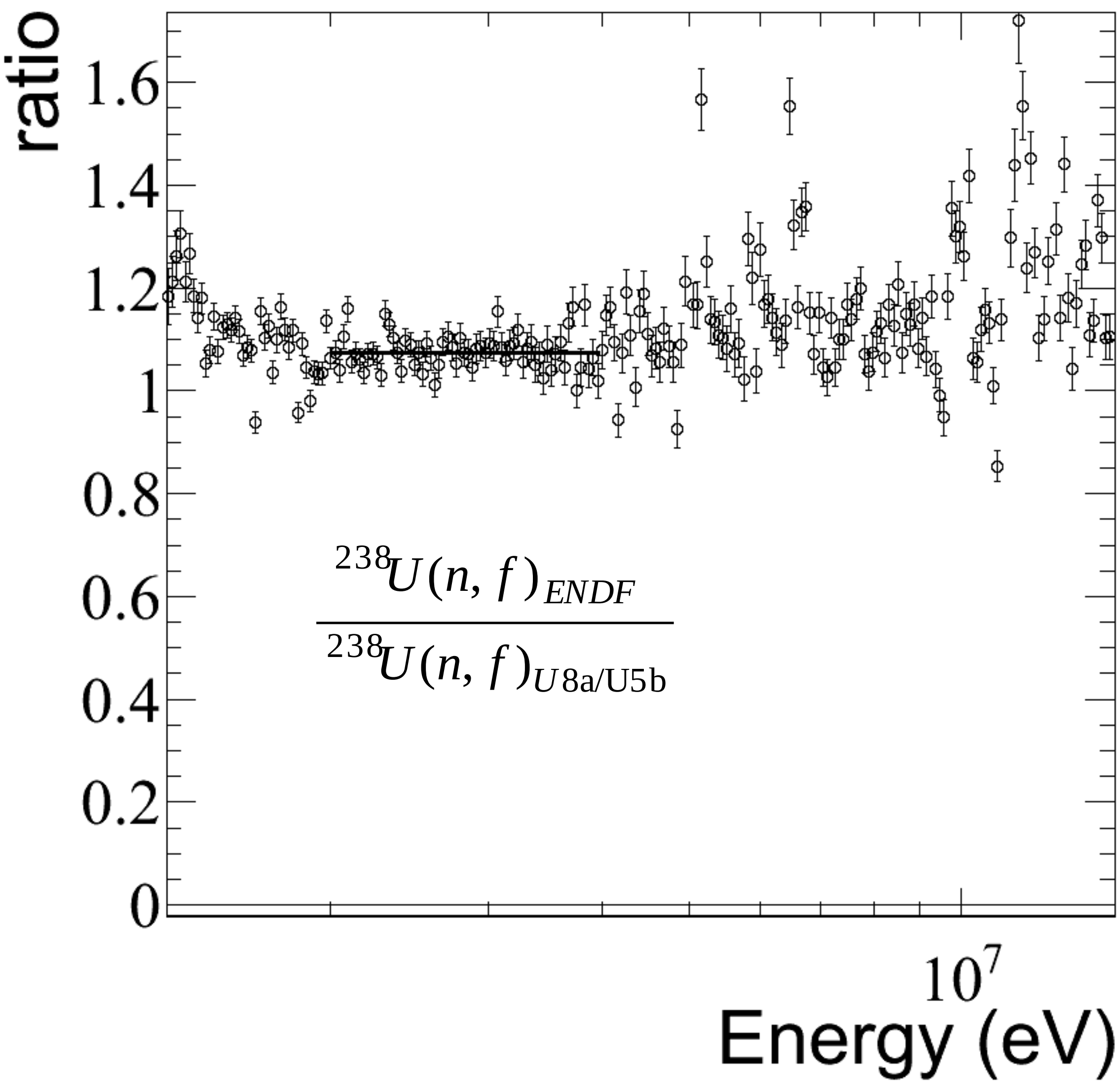


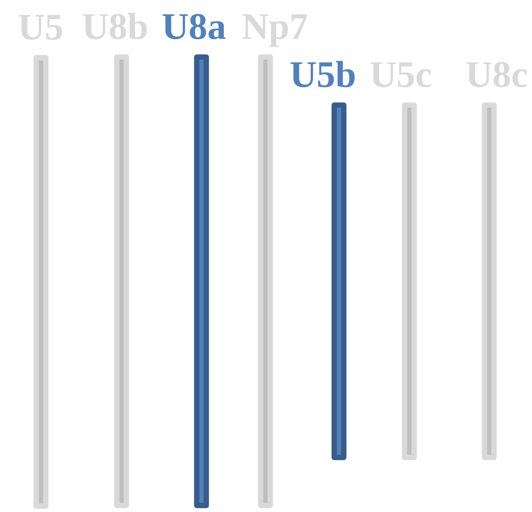
Linear fitting: y=a+b*E

1/a= **1.08**

b= -2.6e-9

Cross section ratio fitting example

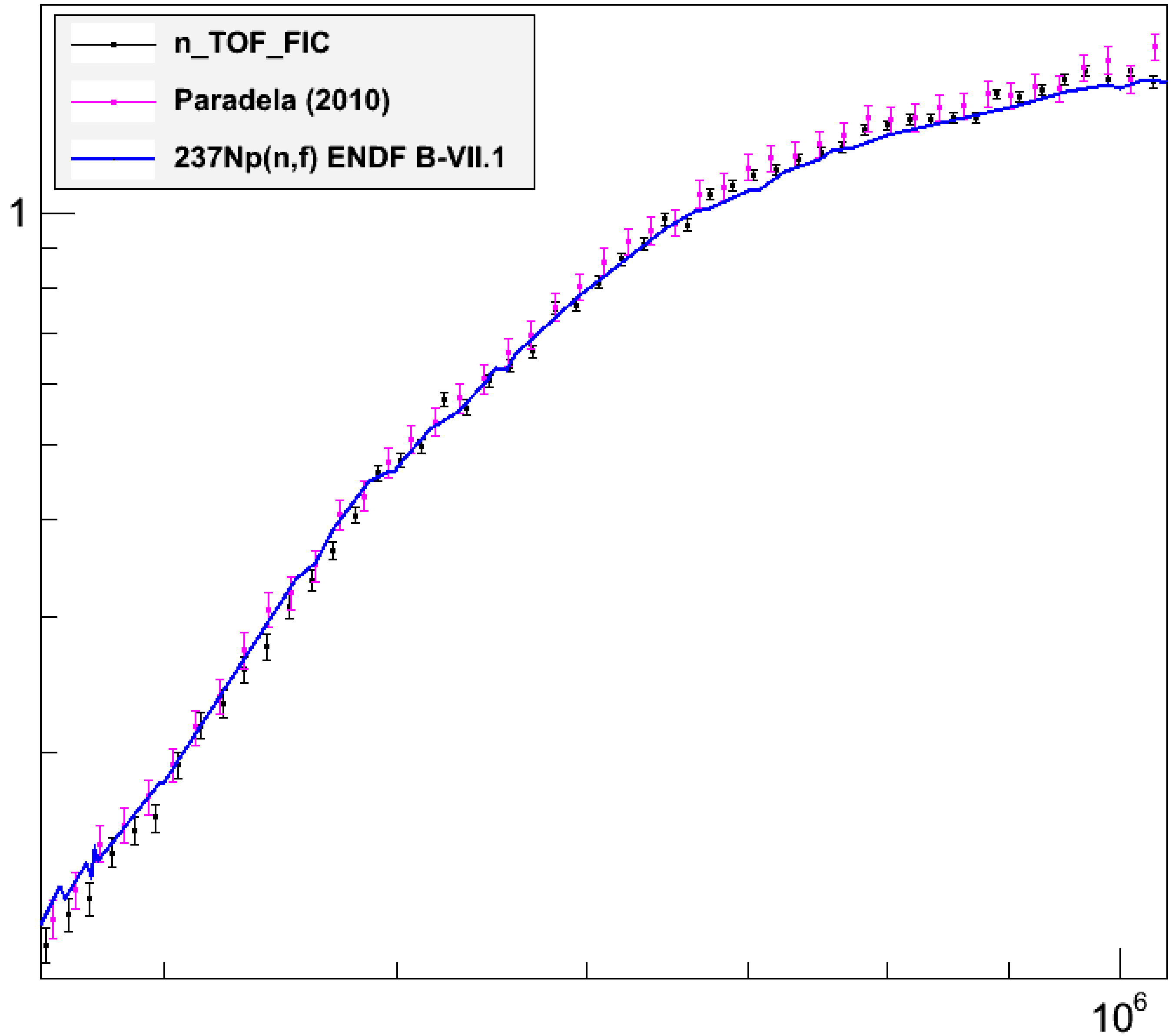




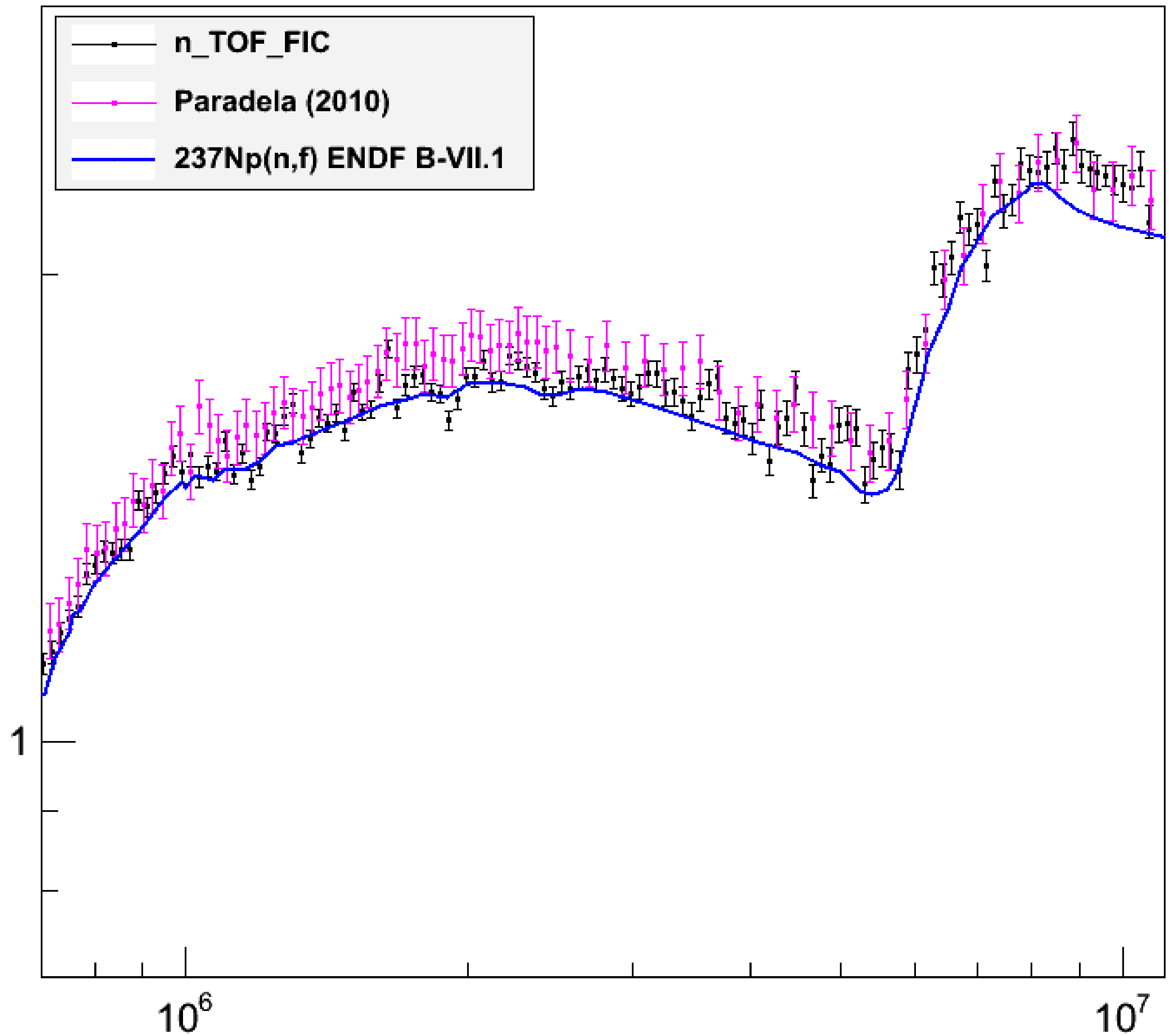
Mean value from all the fittings:
1.07±0.01

Correction factor for cross section Calculation $^{237}Np(n,f)$ with reference **U235b** (up to 2MeV).

Preliminary cross section results up to 1MeV



Preliminary cross section results 1-10MeV



To do's

- Estimation of subthreshold fission fragment signals (FLUKA simulation histograms convoluted with resolution function).
- Finalization of the analysis - Investigation of the systematic uncertainties.
- Theoretical investigation of ^{237}Np(n,f) cross section with statistical models (EMPIRE code).

……………………***Thank you***…………………….

European Union
European Social Fund

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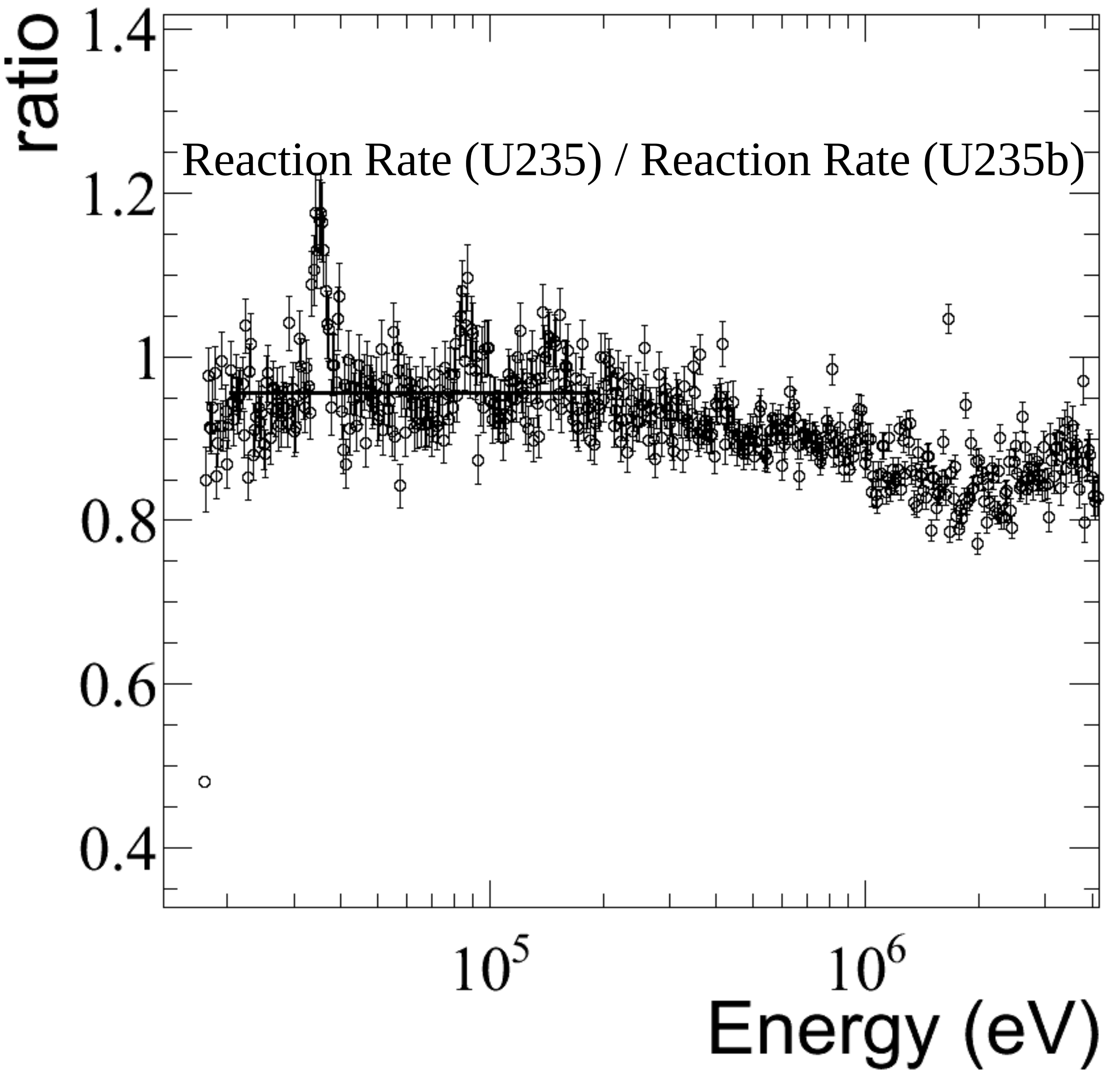
APPENDIX


ratio
1.4
1.2
1
0.8
0.6
0.4
Reaction Rate (U235) / Reaction Rate (U235b)
10^5
10^6
Energy (eV)

OFFSET: 0.95

Relative statistical error