

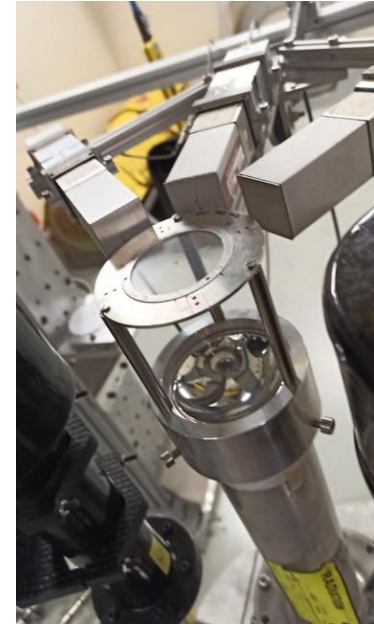
sTED detector

V. Alcayne, D. Cano-Ott, J. Garcia-Peréz, T. Martínez, E. Mendoza, J. Balibrea-Correa, A. Casanovas, C. Domingo-Pardo, F. García-Infantes, J. Lerendegui-Marco, Pavón-Rodríguez, A. Sánchez-Caballero, M. Bacak, ...

Part of the [SANDA EURATOM project \(WP1\)](#) and the [Spanish plan nacional: PGC2018-096717-B-C21, PID2021-123100NB-I00, and PDC2021-120828-I00](#)

Outline of the presentation

- Precise energy calibration.
- Deposited energy spectra of ^{197}Au
- Determination of the WF
- Comparison of the weighted yield with JEFF-3.3



Link to previous sTED presentations:






- [11-2021](#)
- [05-2022](#)



The isotopes measured with sTED are:

- ^{79}Se
- ^{94}Nb
- ^{160}Gd
- $^{94,95,96}\text{Mo}$
- ^{64}Ni (next year)

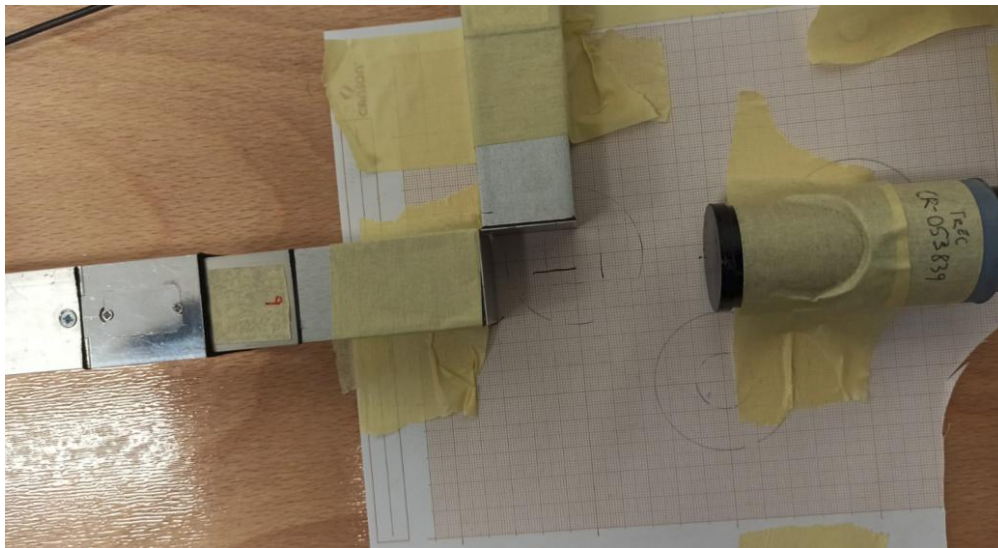
C₆D₆ detectors at n_TOF

Detector	Vol in litres	Available	Comments
 <p>BICRON</p>	0.621	4	The behavior of the 4 detectors is different. PMT: PHILLIPS, XP-4512B
 <p>L6D6</p> <p>International report</p>	1	8	<p>OLD (L6D6) PMT: 9829QSB (12 dyn. BeCu) VD Model E628BSN2</p>  <p>NEW (L6D6) PMT 9214QSB (12 dyn. SbCs) VD Model E238-12ASN2 PMT order: 6 by INFN-Legnaro</p> 
 <p>sTED</p>	0.049 (0.049*9 =0.441)	9	<p>PMT model R11265U (H11934) Photocathode: 26x26mm Borosilicate window Funding request for up to 36 detectors in the future</p>

Precise calibration in the n_TOF ELAB

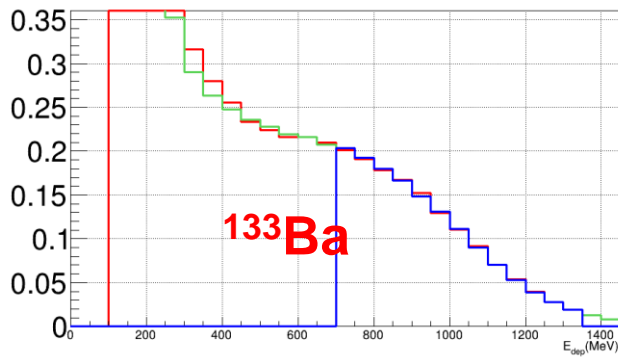
Dedicated campaign was performed in the ELAB to perform precise calibrations of the sTED at 1.6 cm from the calibration sources.

The calibration sources used are: Ba-133, Cs-137, Co-60, Bi-207, Y-88 and AmBe with a total of 8 points.

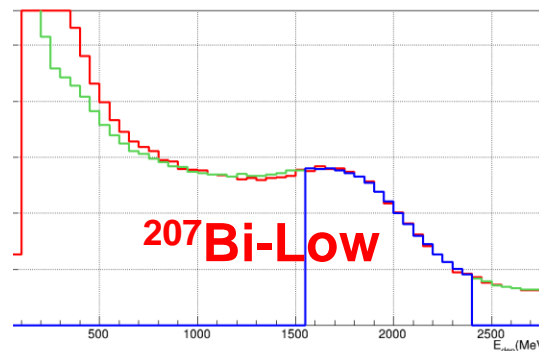


sTED energy calibration

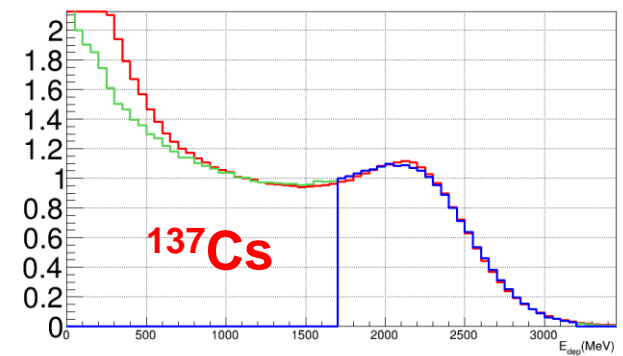
red:exp -- green:MC -- blue:fit region



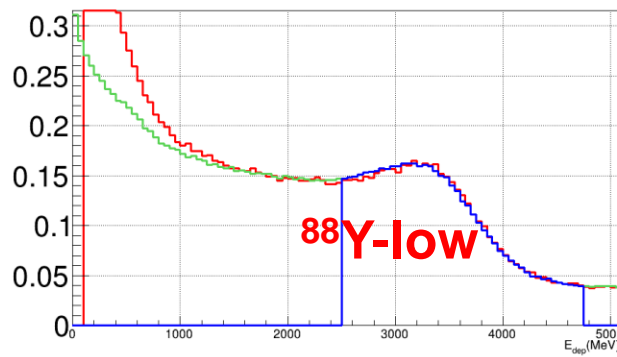
red:exp -- green:MC -- blue:fit region



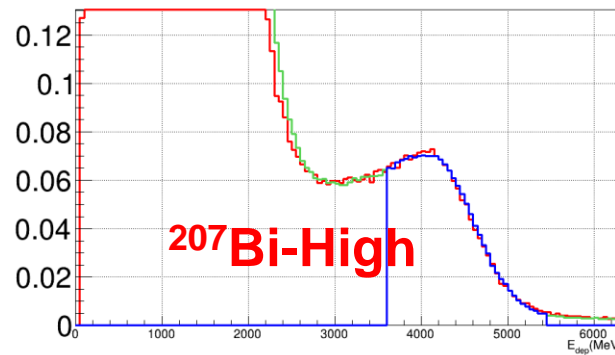
red:exp -- green:MC -- blue:fit region



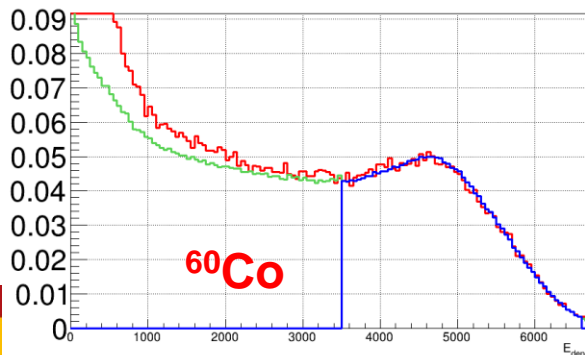
red:exp -- green:MC -- blue:fit region



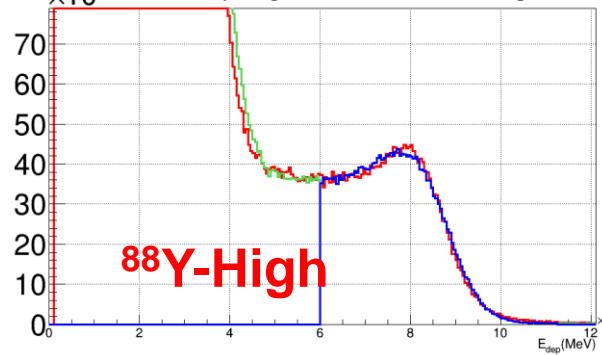
red:exp -- green:MC -- blue:fit region



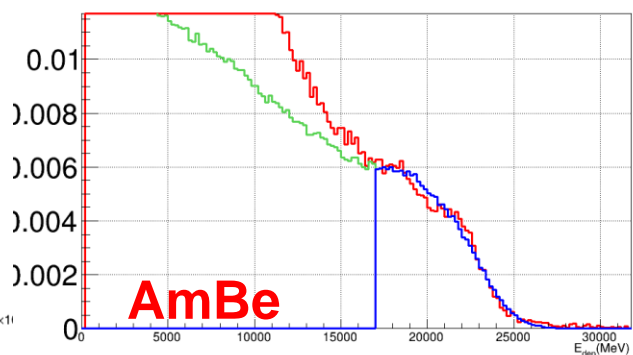
red:exp -- green:MC -- blue:fit region



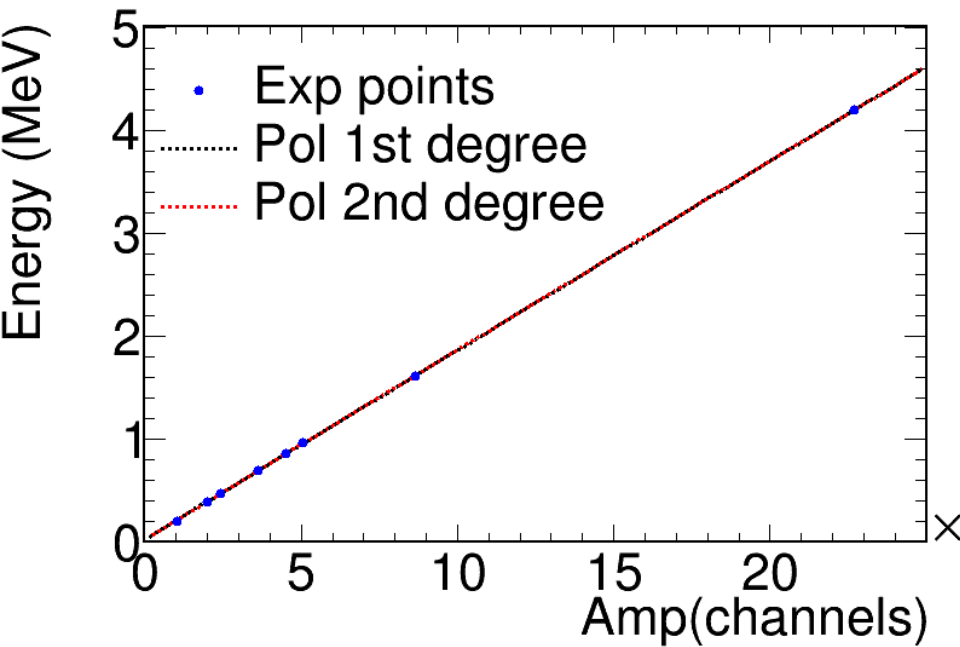
$\times 10^{-3}$ red:exp -- green:MC -- blue:fit region



red:exp -- green:MC -- blue:fit region



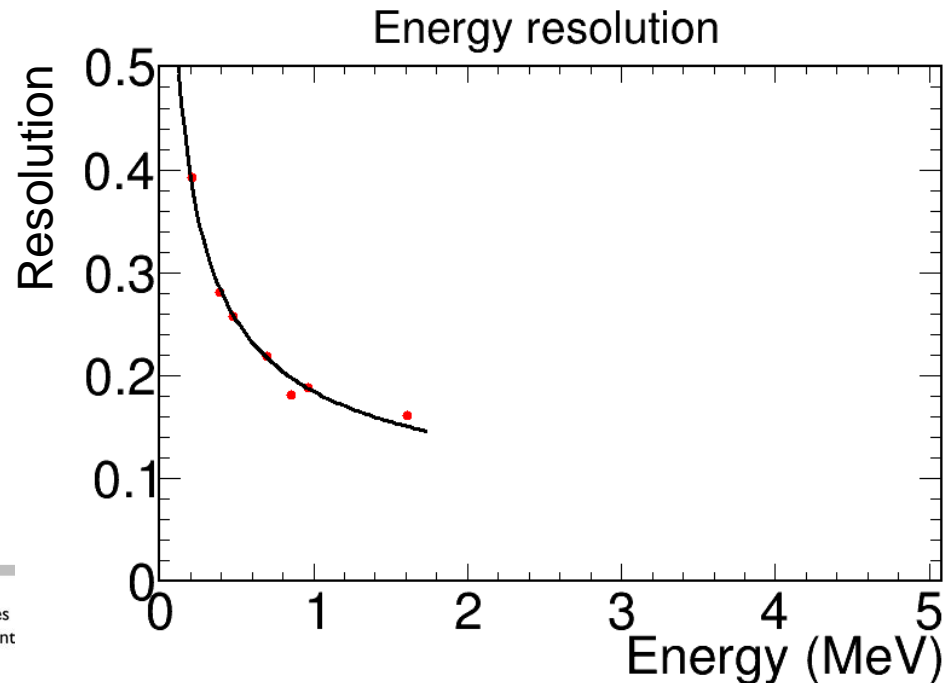
Energy calibration and resolution



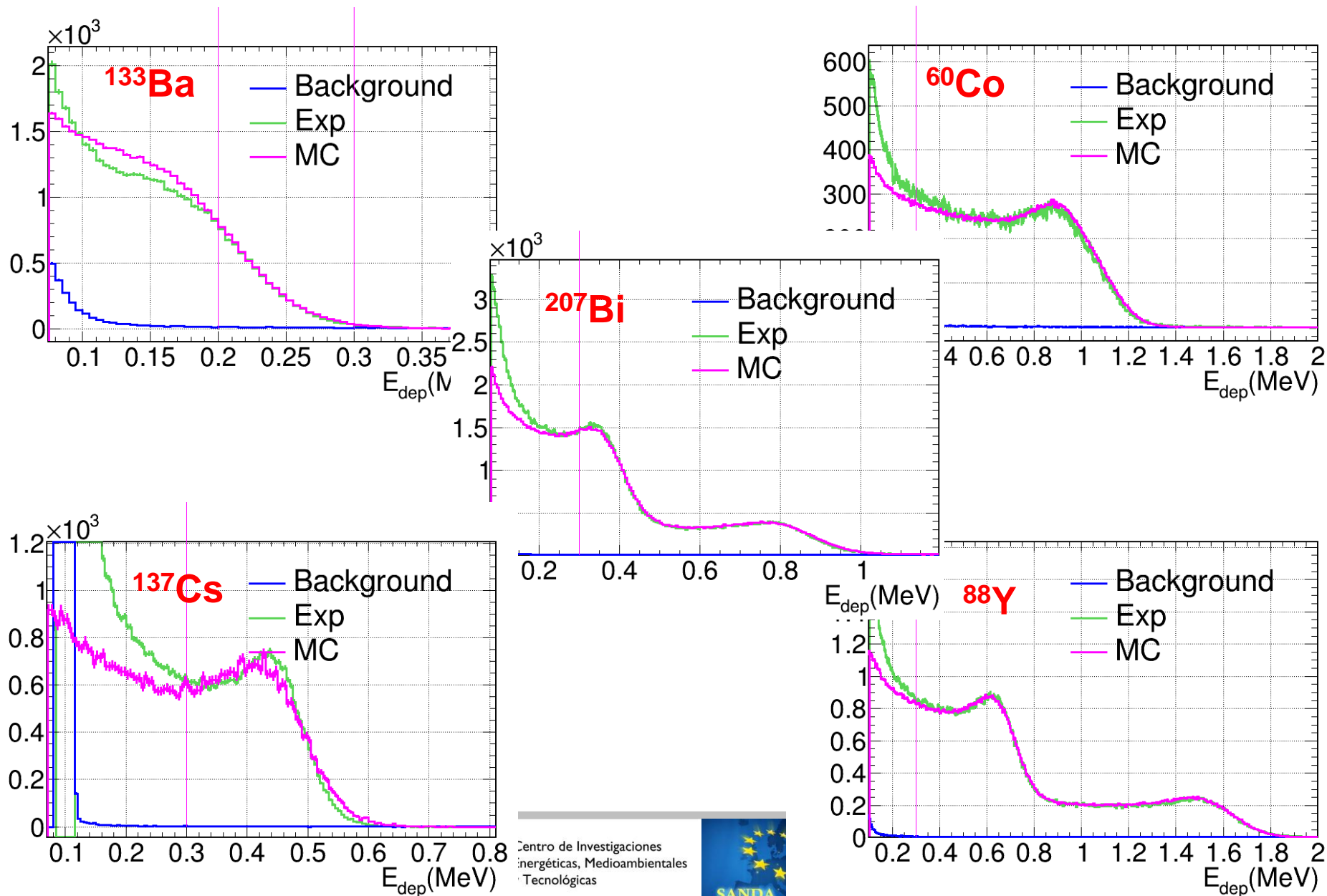
Fun (1st) = $0.0294595 + 0.000183572 \cdot \text{Amp}$
 Fun (2nd) = $0.026224 + 0.000184697 \cdot \text{Amp} - 4.59746e-11 \cdot \text{Amp} \cdot \text{Amp}$

$$\text{FWHM} = \sqrt{(\alpha \cdot E^2 + \beta \cdot E)}$$

$$\alpha = 0.00293063 \quad \beta = 0.00523148$$



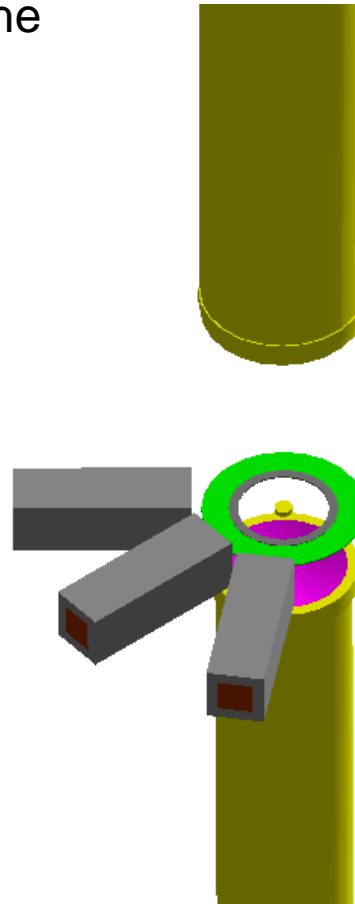
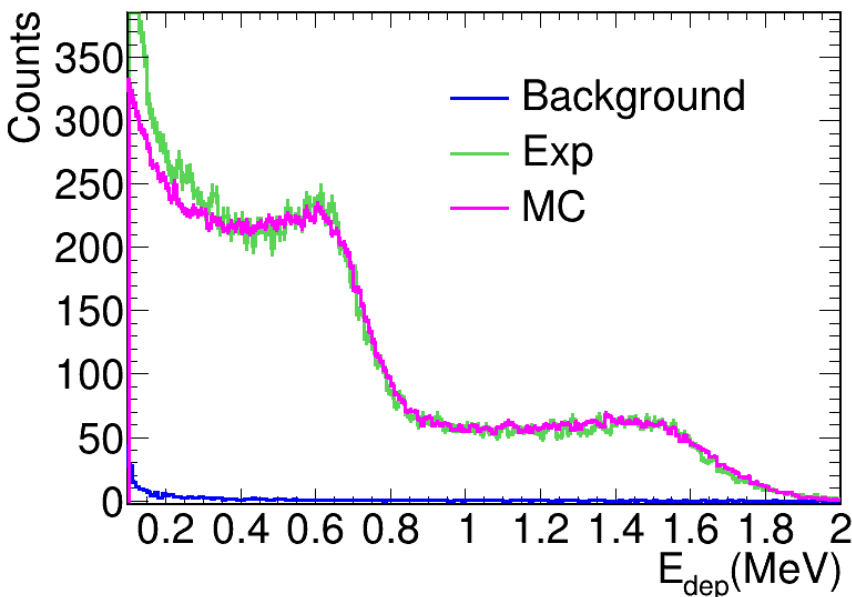
Comparison spectra calibrated with simulations



The sTED 10-2022 validation campaign

Three sTED detectors at ~ 5 cm were placed to obtain the final validation of the detectors:

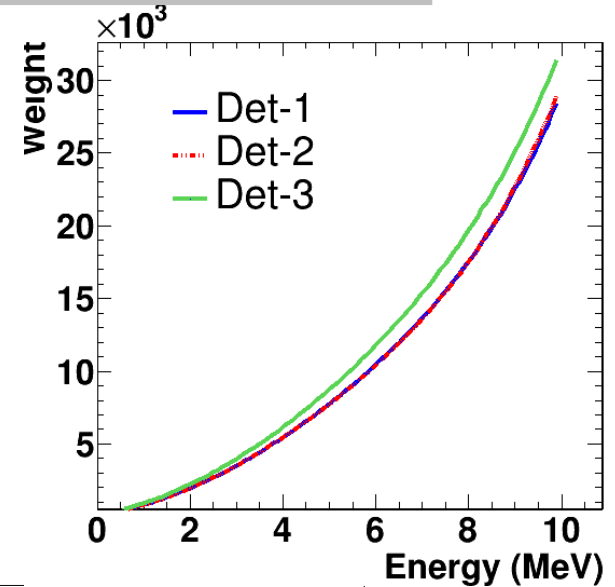
- Calibration
- WF
- ^{197}Au cascades
- Yield



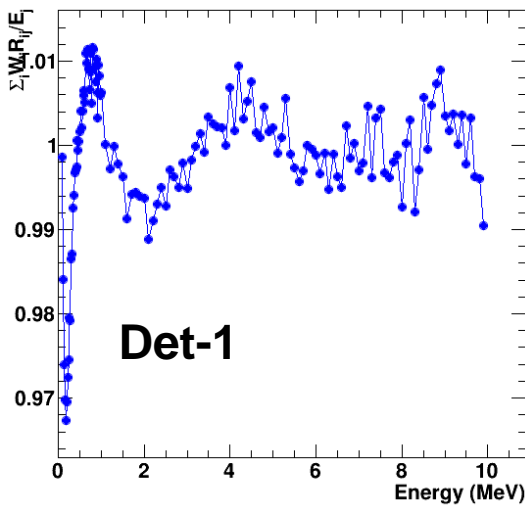
The WF determination

The WFs are determined with a 6th degree polynomial performing fits with ROOT.

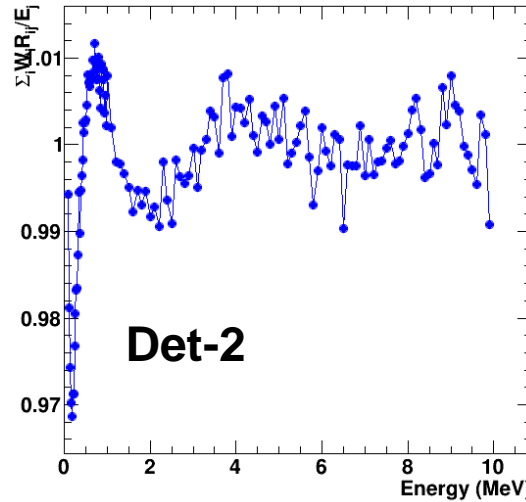
The RMS obtained is ~0.5% similar to the one obtained with BICRON or L6D6 detectors.



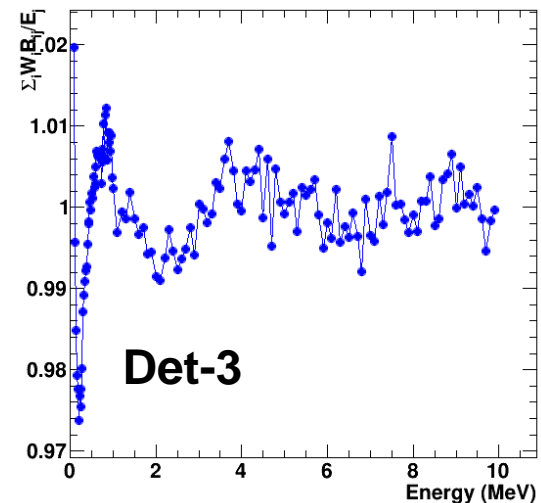
$\Sigma_i W_i R_{ij}/E_j$ RMS=0.857% RMSWeighted=0.583%



$\Sigma_i W_i R_{ij}/E_j$ RMS=0.836% RMSWeighted=0.563%

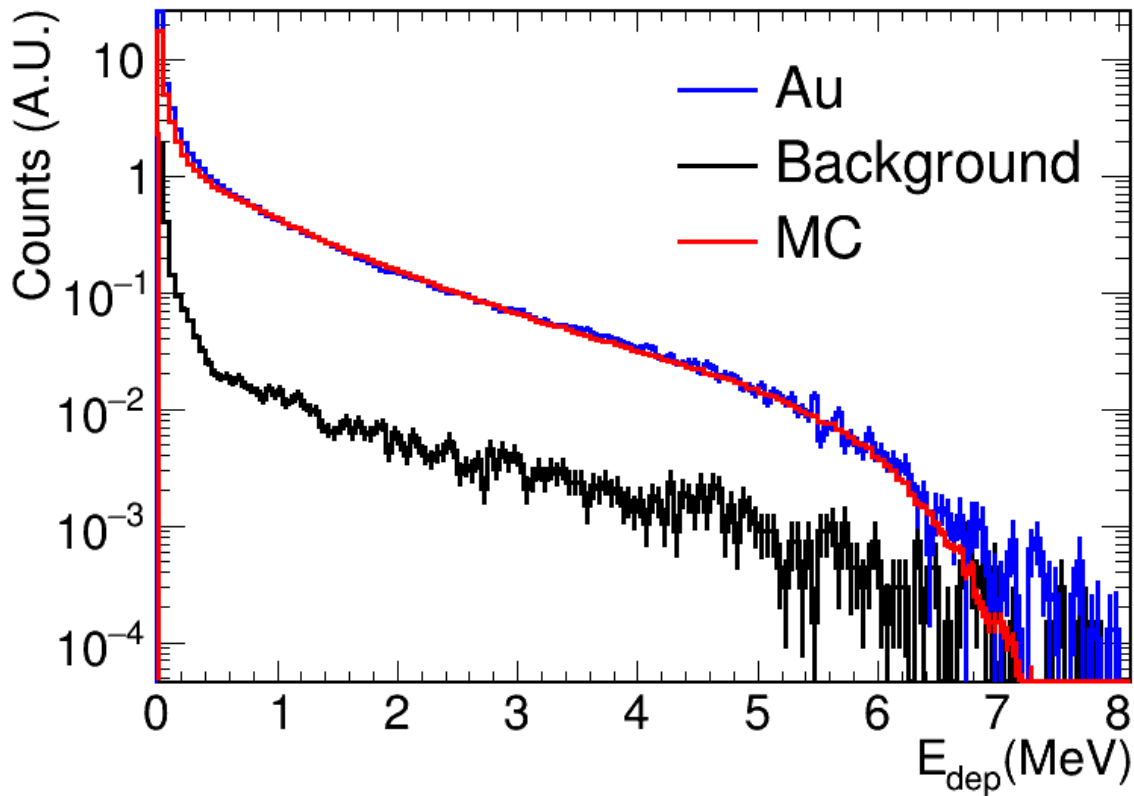


$\Sigma_i W_i R_{ij}/E_j$ RMS=0.736% RMSWeighted=0.534%



The ^{197}Au cascade

The ^{197}Au cascade used has been fitted with the TAC data by Carlos Guerrero. The cascade reproduce the deposited energy spectra.



Comparison of the experimental and evaluated data

The shape of the experimental yields have been compared for Au-197 with:

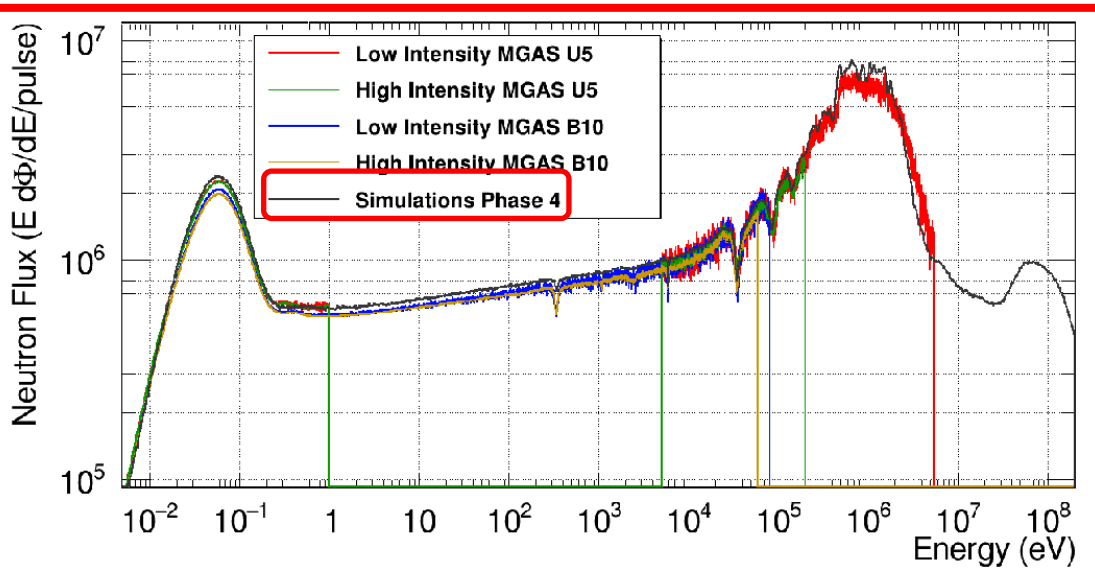
SAMMY → Using the RP of JEFF-3.3 only available until 3 keV. The multiple scattering is considered.

Convolution → The CS of ^{197}Au is convoluted with the RF. The multiple scattering corrections are not considered.

Flux and RF provided by **Jose Antonio Pavón-Rodríguez** :

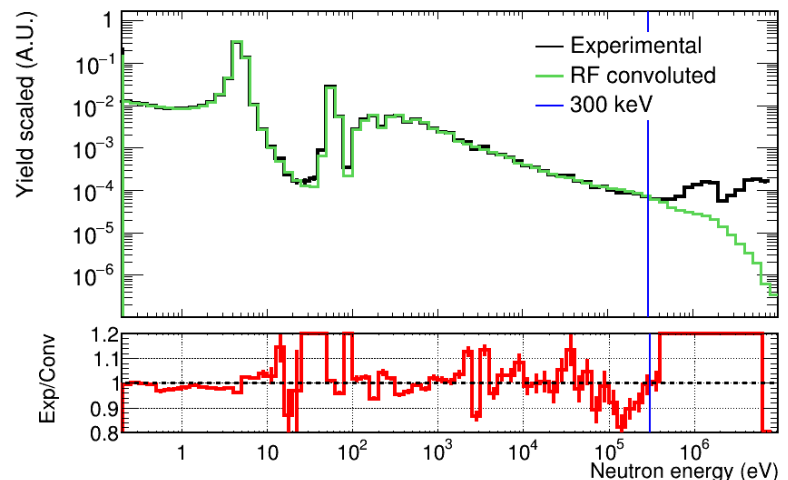
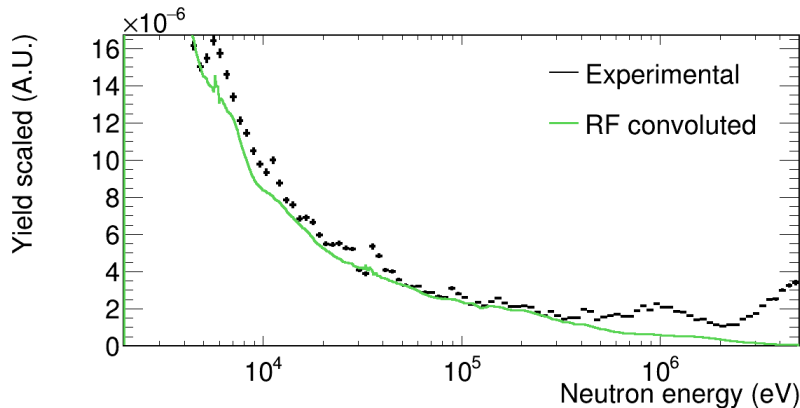
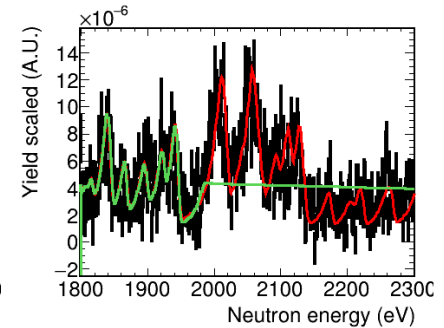
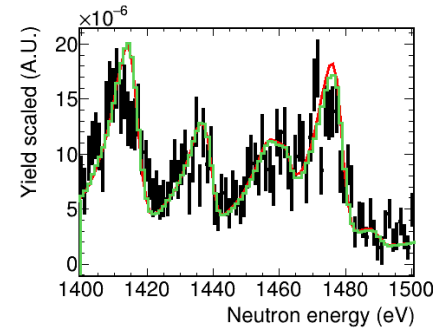
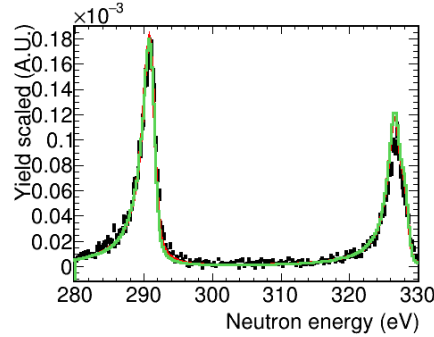
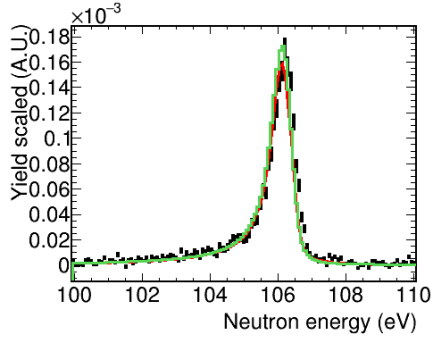
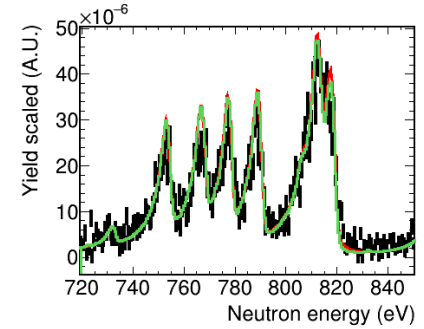
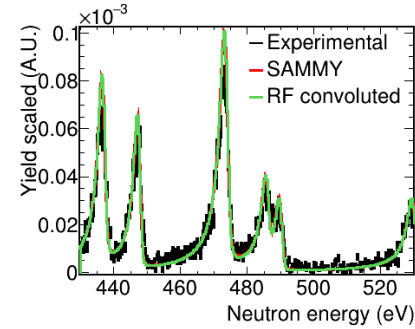
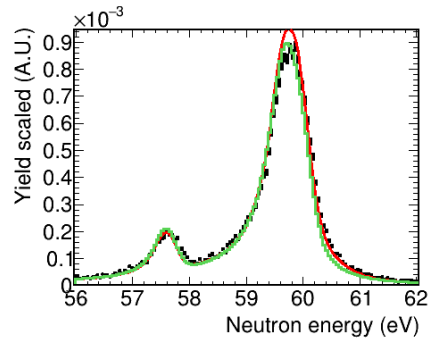
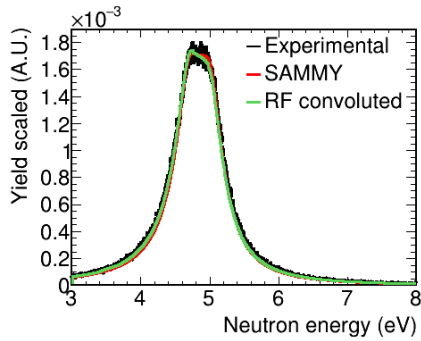
The RF is obtained with this config file

The flux used is “Simulation Phase 4”

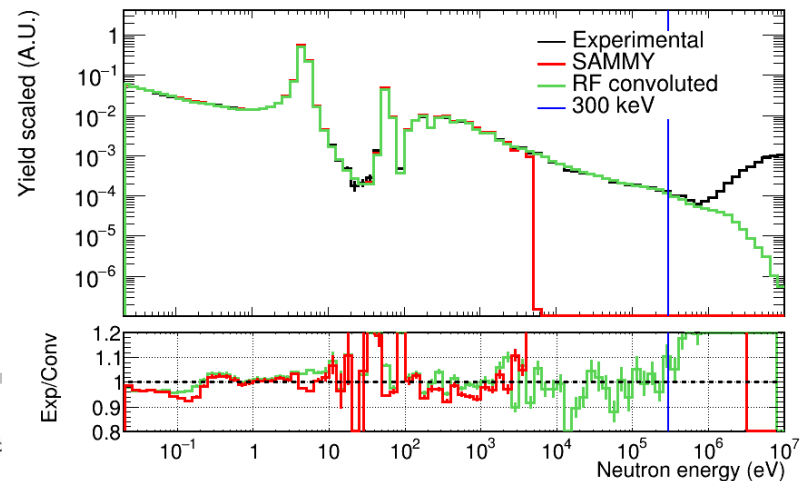
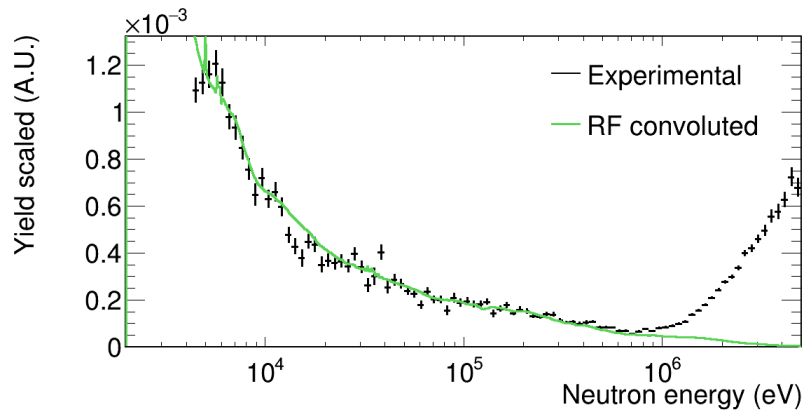
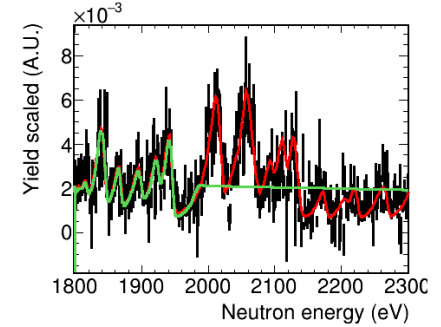
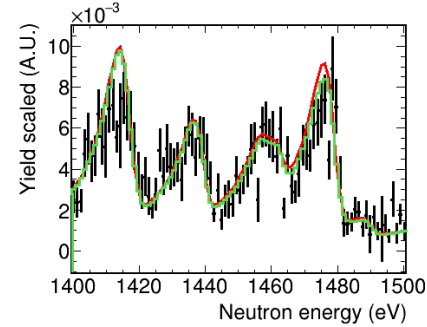
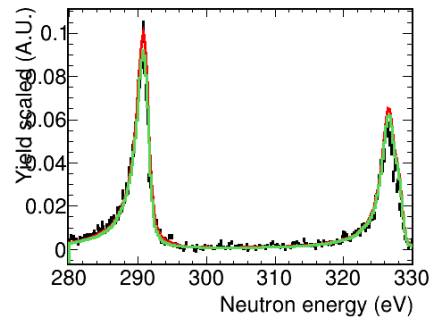
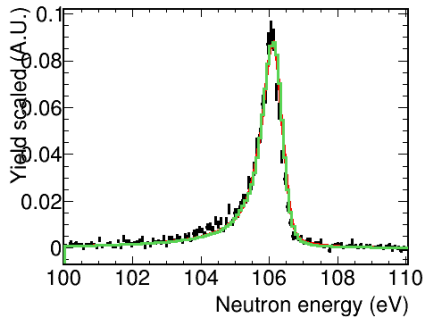
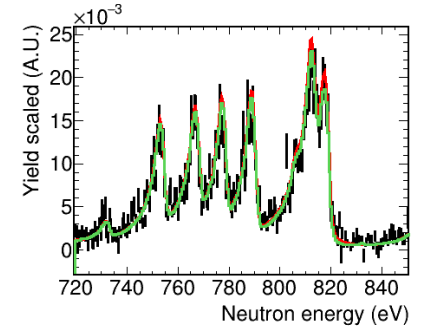
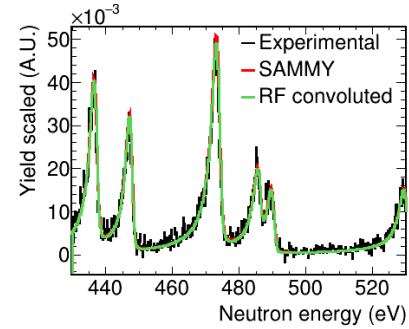
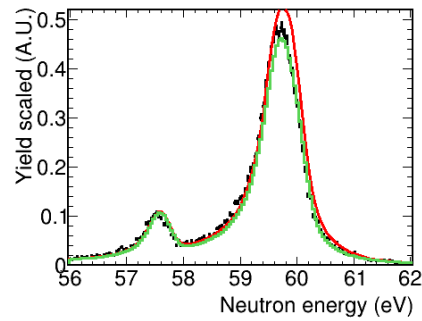
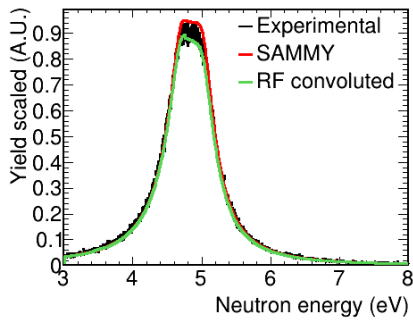


```
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beam_RMS,7e-09
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circle_x0,0.0
min_x,1.00E-03
radius_max,6.0
shape,Circular
min_y,-200
ear,EAR2
angle,2.5
radius_min,0.0
particle,Neutrons
bins_y,9000
step,0.05
collimation,ear2_july2021
is_yield,0
length,19.55
output_dir,/afs/cern.ch/work/j/jp
input_source,P4 FLUKA + MCNP
histogram_type,Lambda vs Energy
time_offset,0.0
max_x,1.00E+09
max_y,700
```

Au sample data 2021, without WF

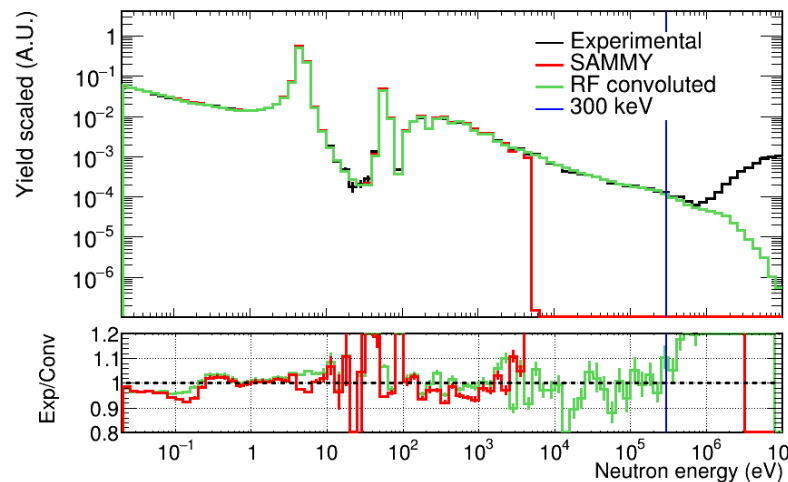
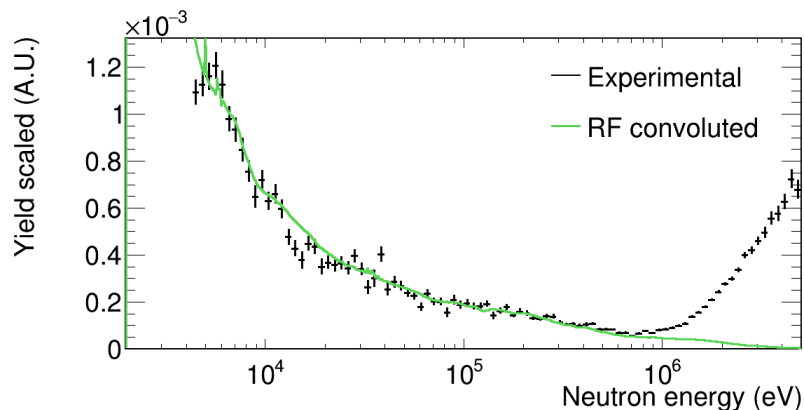
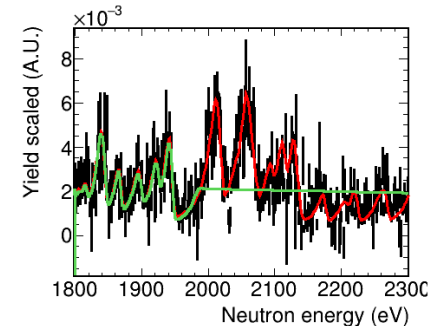
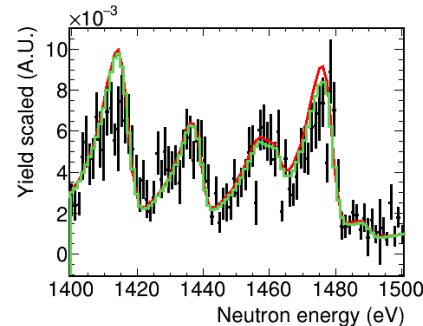
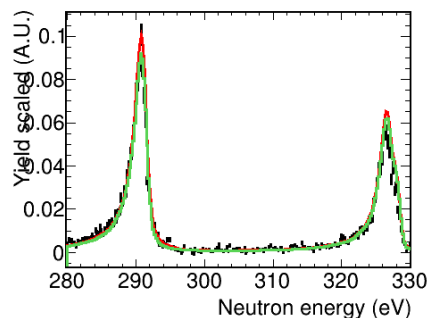
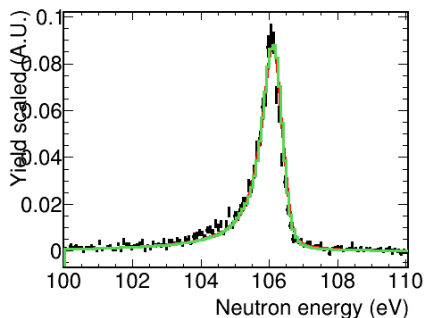
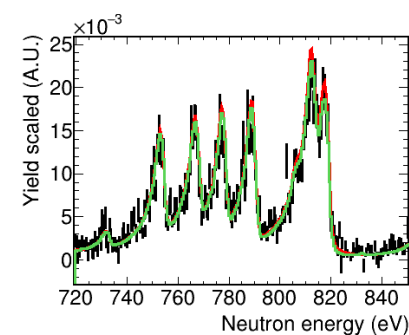
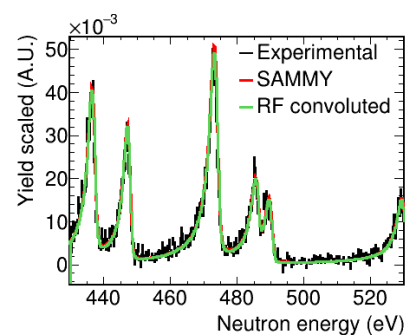
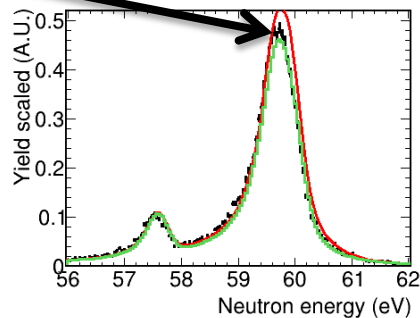
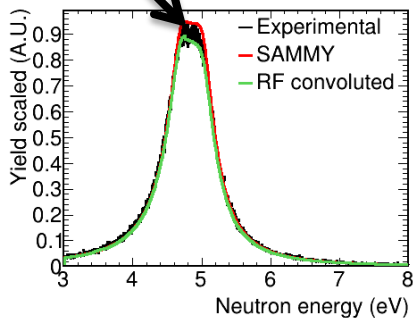


Au sample data 2022, with WF

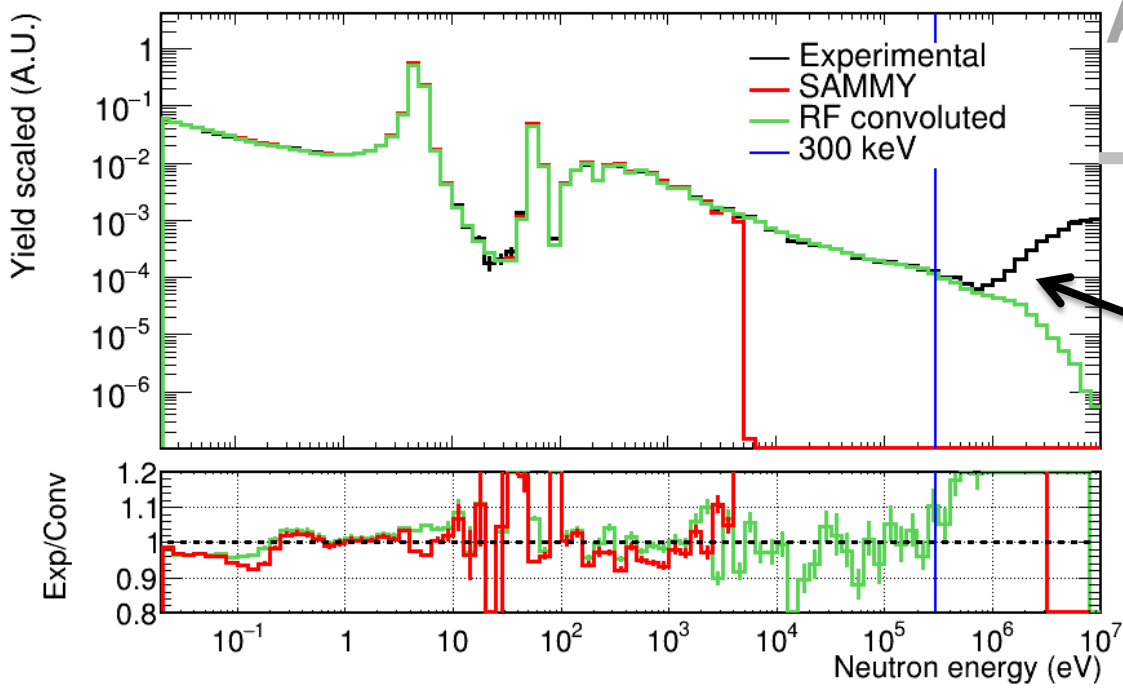


Pile-up

Au sample data 2022, with WF

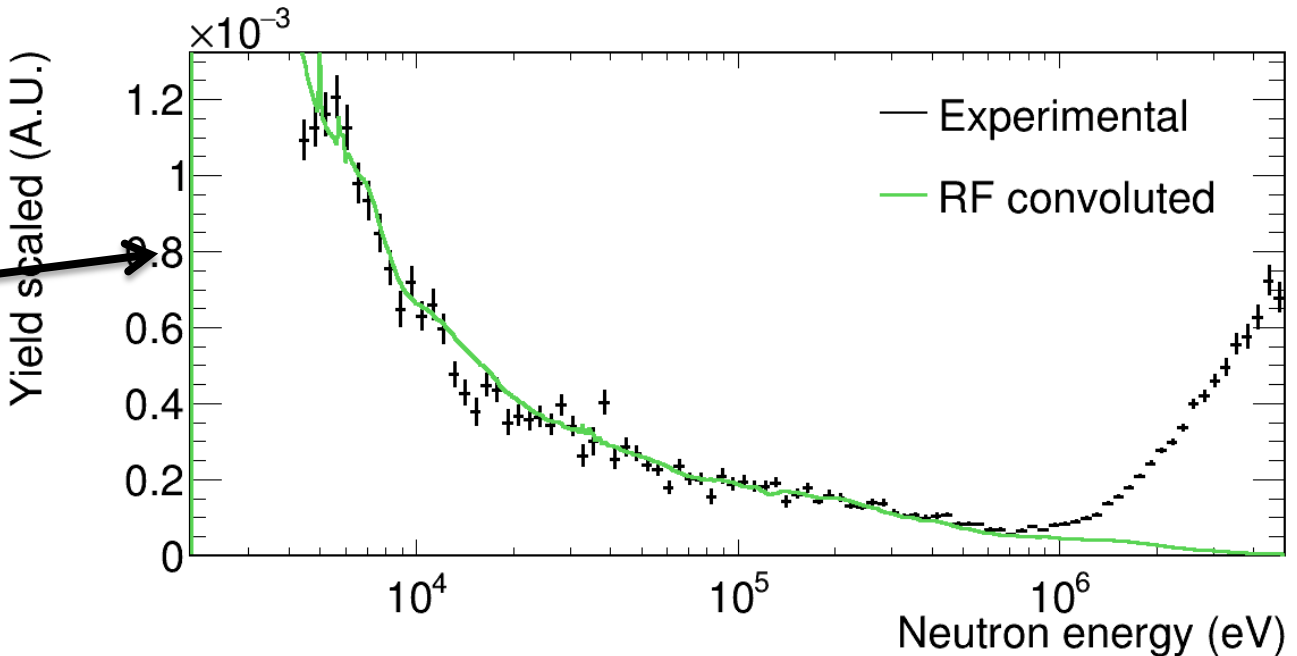


Au sample data 2022, with WF



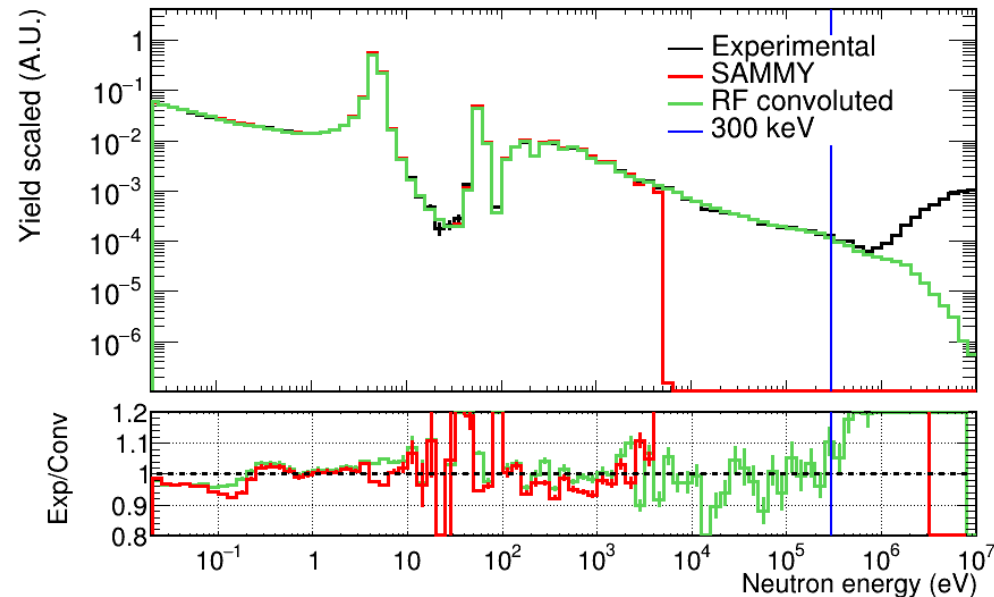
Good reproducibility form 0.02 to 3e5 eV.

Excellent results in the URR



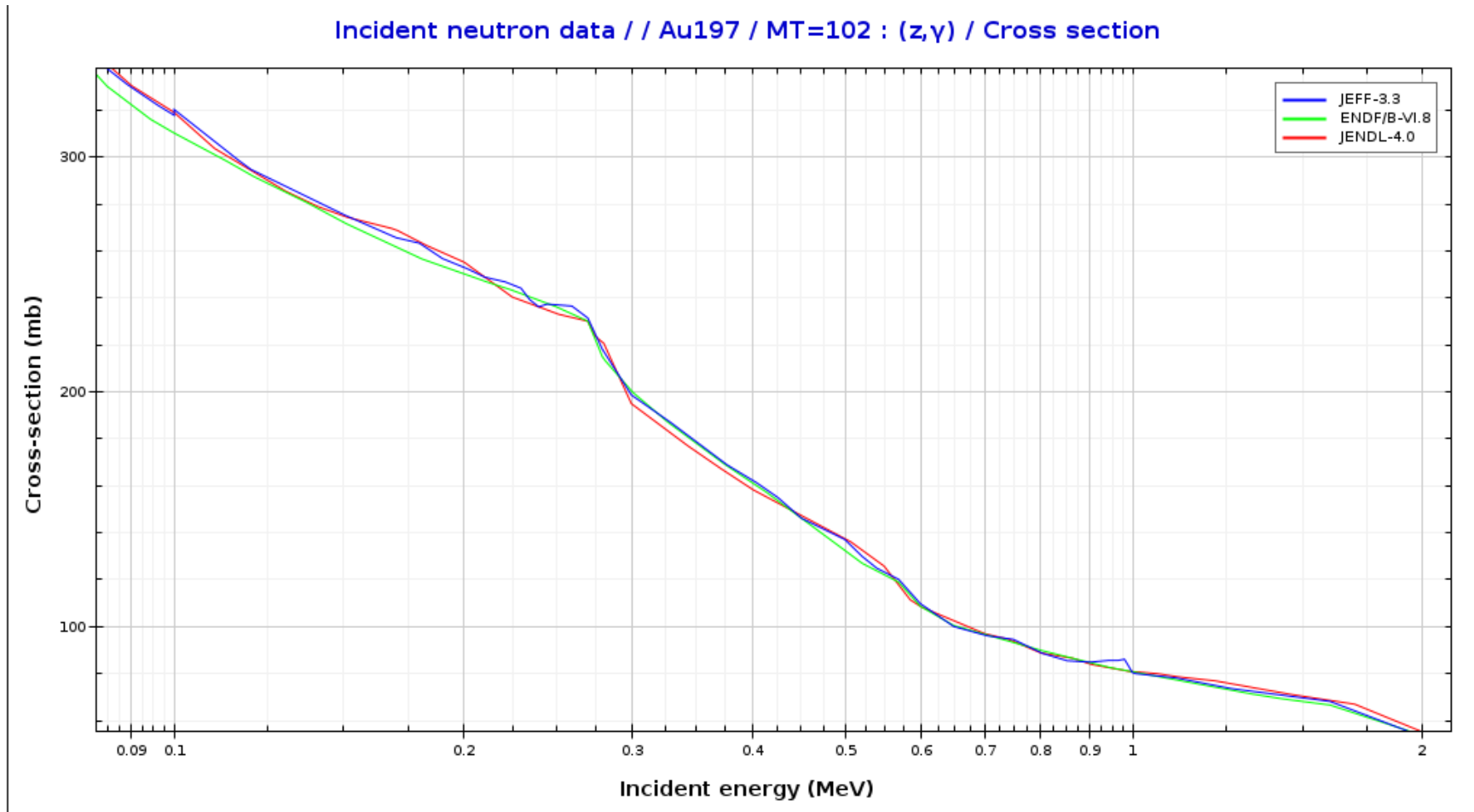
Conclusions

- The sTED detectors have been already used in several capture campaigns at EAR2.
- **Precise calibrations** has been performed with six γ -ray sources showing the linearity of the detector. The response of the detector has been precisely reproduced with Geant4 simulations.
- The **shape of the ^{197}Au cascades** has been reproduced with simulations.
- The precise Geant4 simulations has been used to **determine the WF** for the PHWT technique.
- The comparison of the experimental and evaluated capture yield for ^{197}Au shows that the detectors work properly (at least) **from 0.02 eV to 300 keV**.
- Above 300 keV, the discrepancies are probably due to the $(n,n'\gamma)$ reactions.



Extra slides

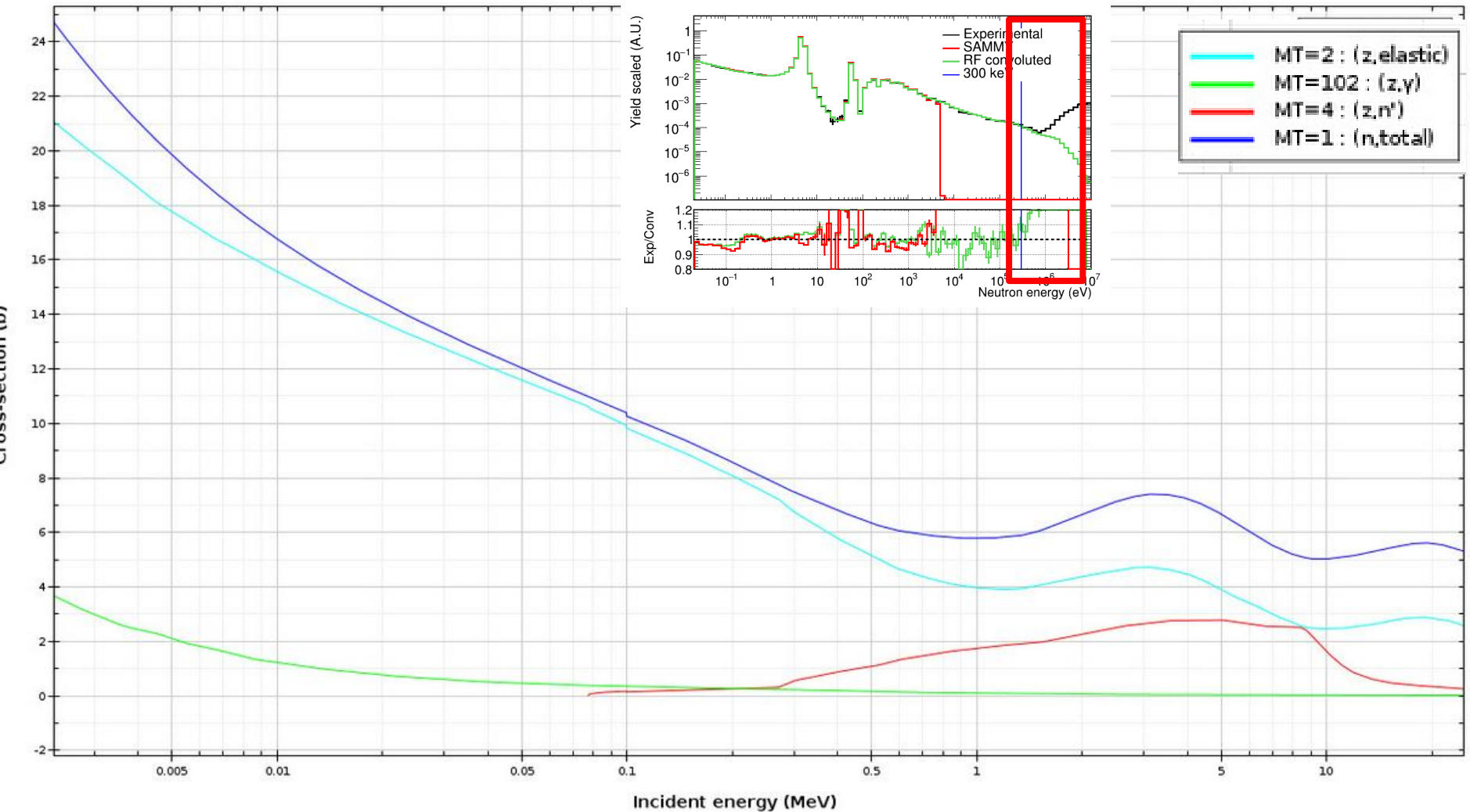
Compare Libraries



The inelastic channels (z,n')

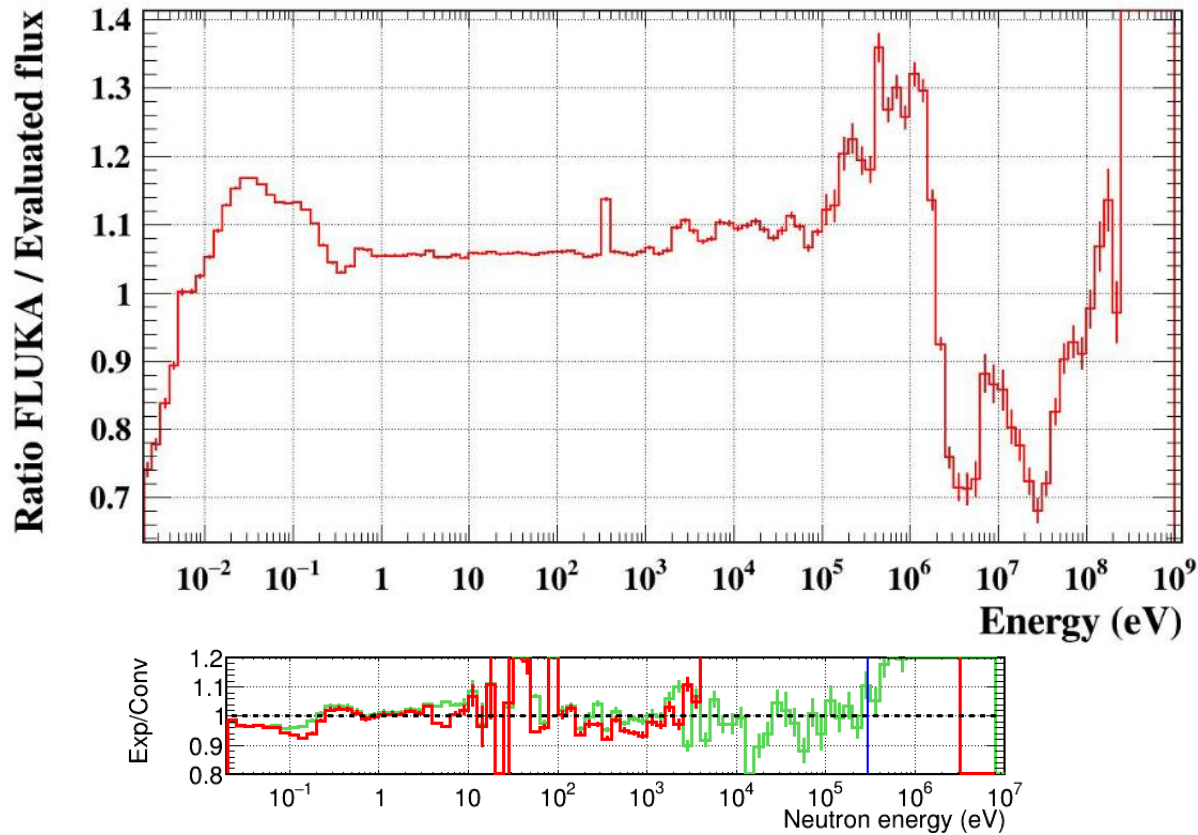
The differences at energies higher than 300 keV can be attributed to the inelastic reactions or to the elastic scattering. More work is in progress.

Incident neutron data / JEFF-3.3 / Au197 // Cross section



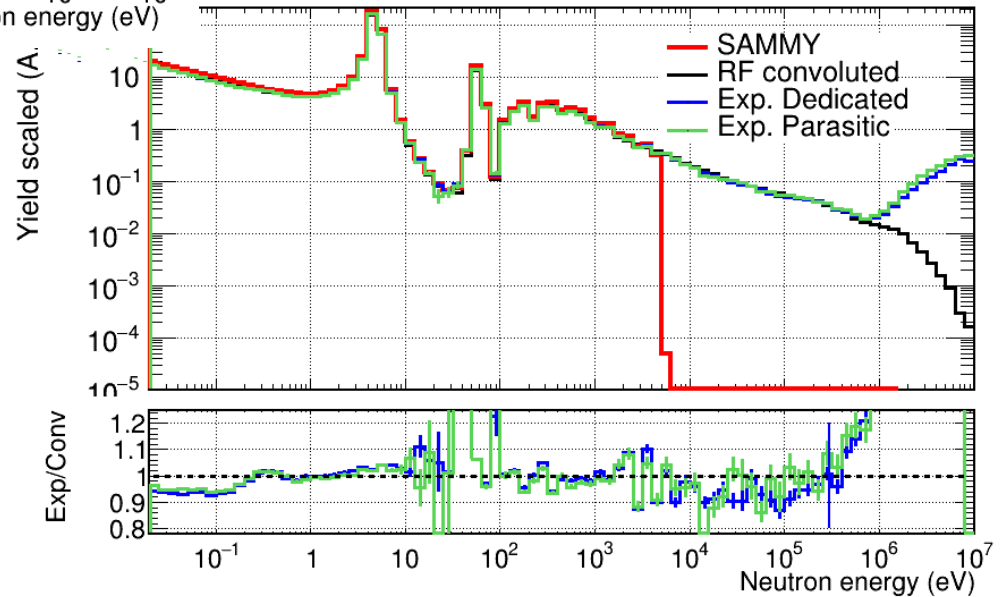
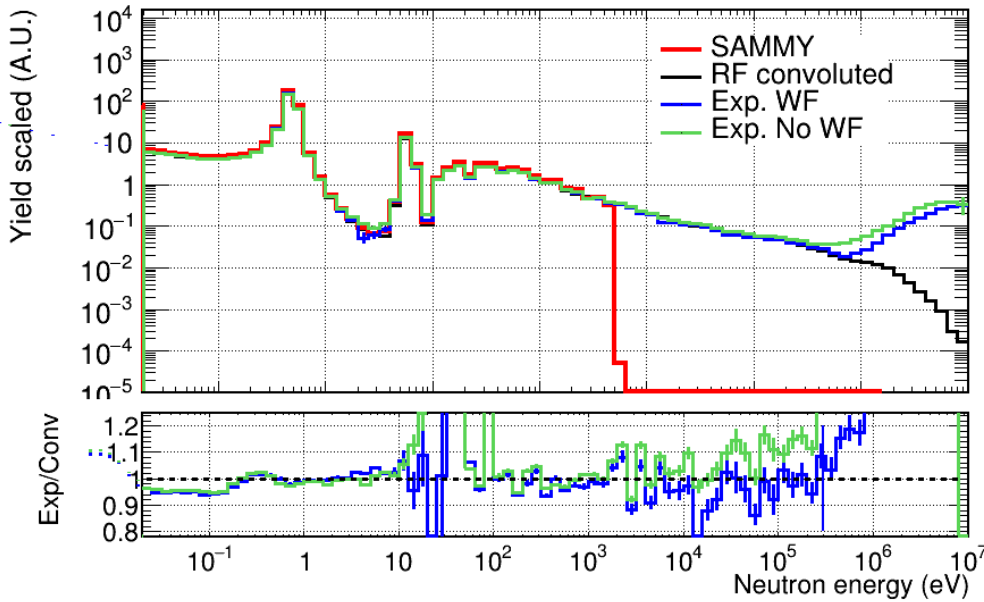
Compare differences in flux and yields

EAR2 evaluated flux and simulations



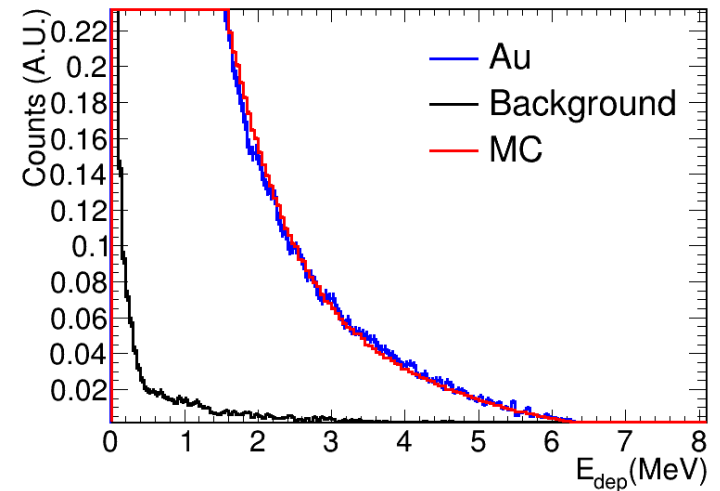
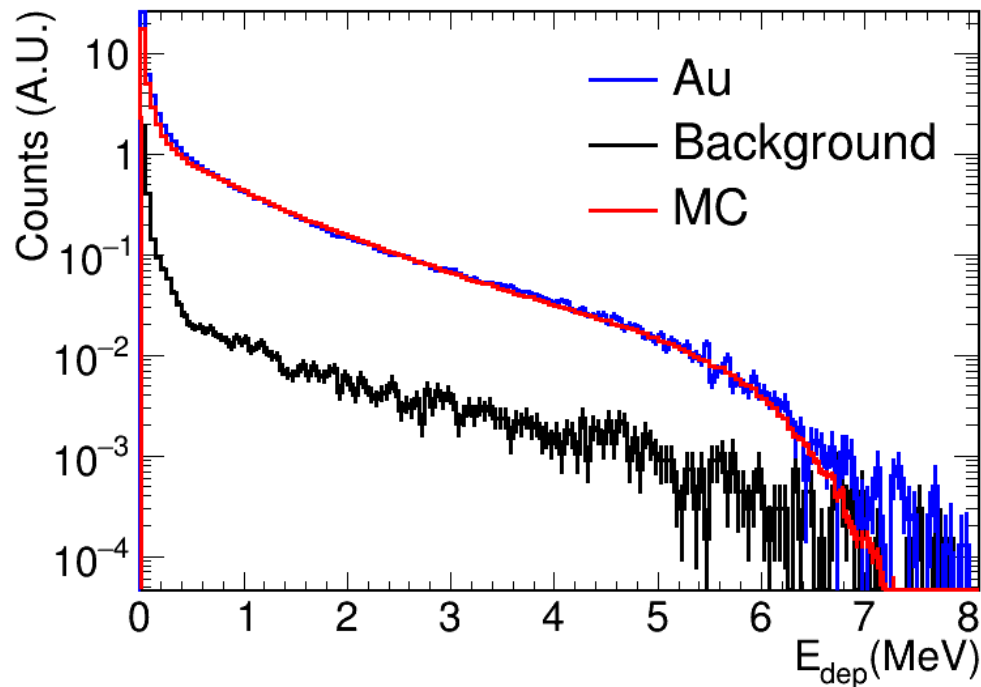
<https://indico.cern.ch/event/1168514/contributions/5152772/attachments/2565963/4424384/Flux%20Evaluation%20EAR2-3.pdf>

Compare WF/NoWF and 2/3

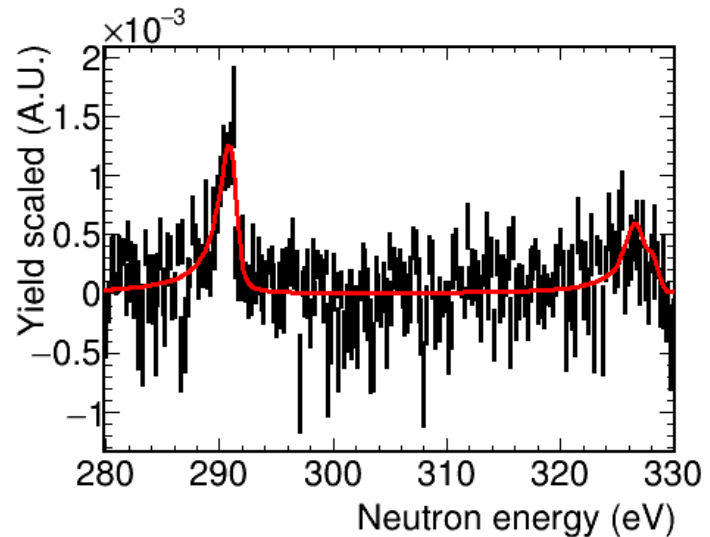
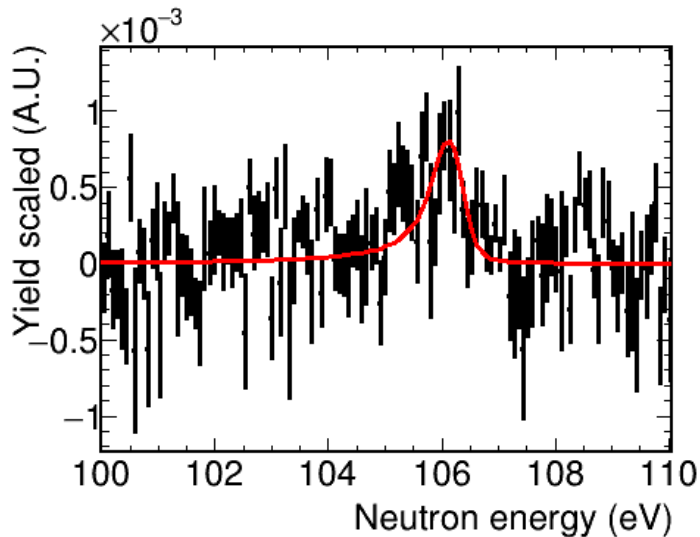
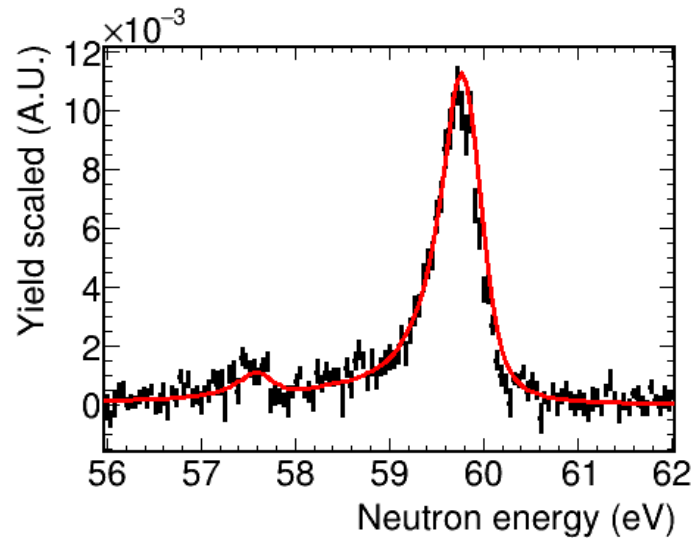
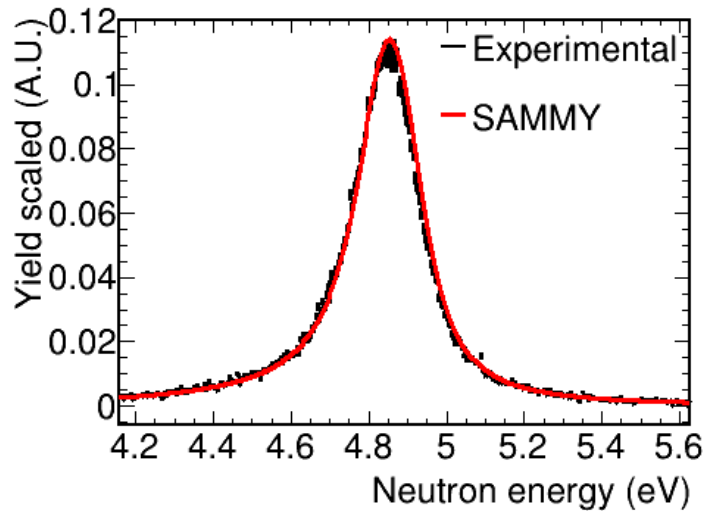


The ^{197}Au cascade

The ^{197}Au cascade used has been fitted with the TAC data by Carlos Guerrero. The cascade reproduce the deposited energy spectra.



Au (1 μ m 2cm) data 2022 with WF



Amplitude spectra as a function of the TOF with the gold samples

The following slides show the counting rates measured with the different detectors and the different gold samples, all of them with a threshold of 200 keV.

The measurements were performed with the following Au-197 samples:

- **Au01**: Au-197 covering the full beam, 0.2 mm thick. (extreme case)
- **Au02**: Au-197 covering the full beam, 0.1 mm thick.
- **Au03**: Au-197 with 2 cm diameter, 0.1 mm thick.
- **Au04**: Au-197 with 1,5 cm diameter, 0.075 mm thick.
- **Au05**: Au-197 with 0.5 cm diameter, 0.1 mm thick.



The detectors in place were:

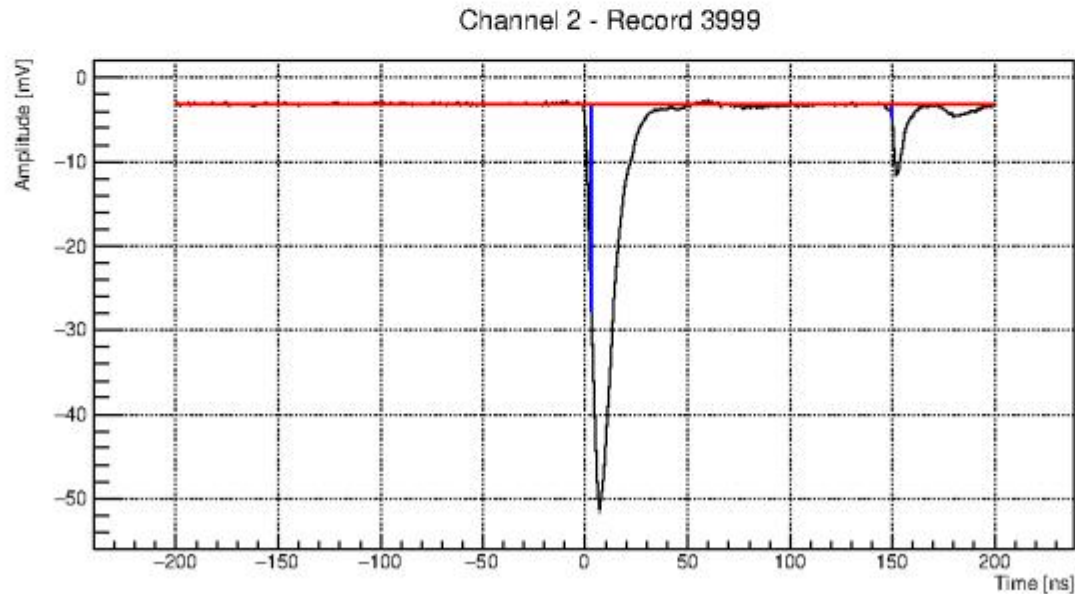
- **sTED**, located at 5 cm from the center of the beam (perpendicular). Just outside the beam halo.
- **B6D6** (BICRONS), located at 12 cm from the center of the beam.

Test with STED +R11265 (H11934)

PMT model R11265U
Photocathode: 26x26mm
Borosilicate window
SBA
HV= - 800V



Anode signal looks different to other PMT models. Smooth signal, lower noise and negligible ringing



Status of sTED in May 2022

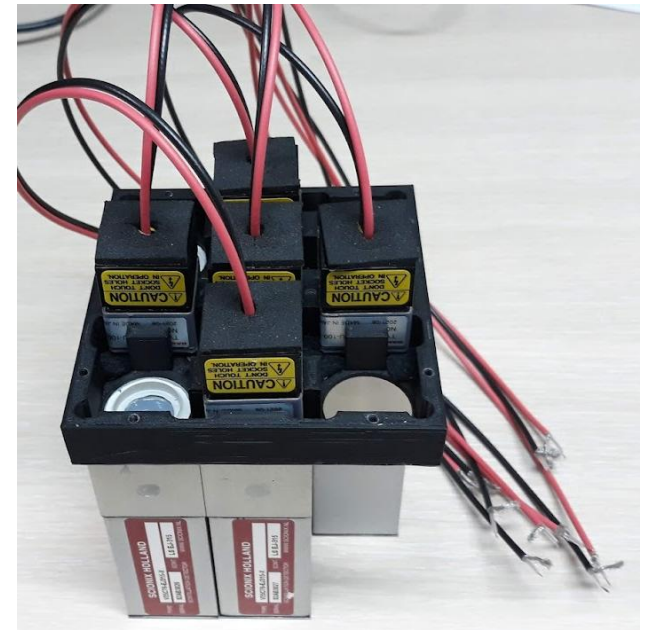
[sTED talk \(February 2019\)](#)

9 modules of the sTED detector are available at CIEMAT, forming a cluster. They are tested at the moment by T. Martinez.

The case for the detectors in the pictures is made with PLA (plastic for 3D printers). Another case made of aluminium, with lower neutron sensitivity, has been built.

Funding will be requested to **buy 3 more clusters (27 detectors)**, we are in the process of developing the project.

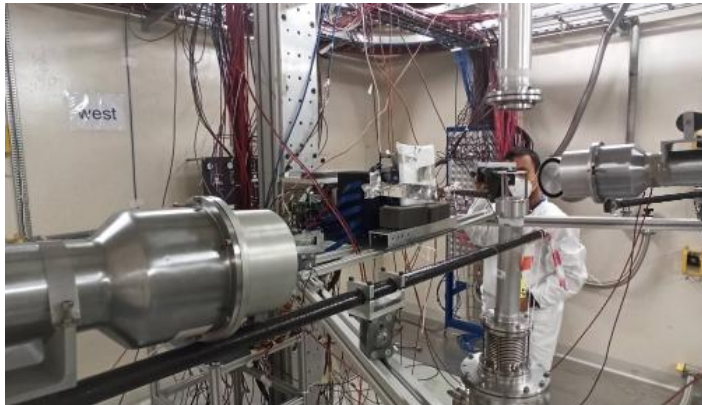
This detector has been test at CERN



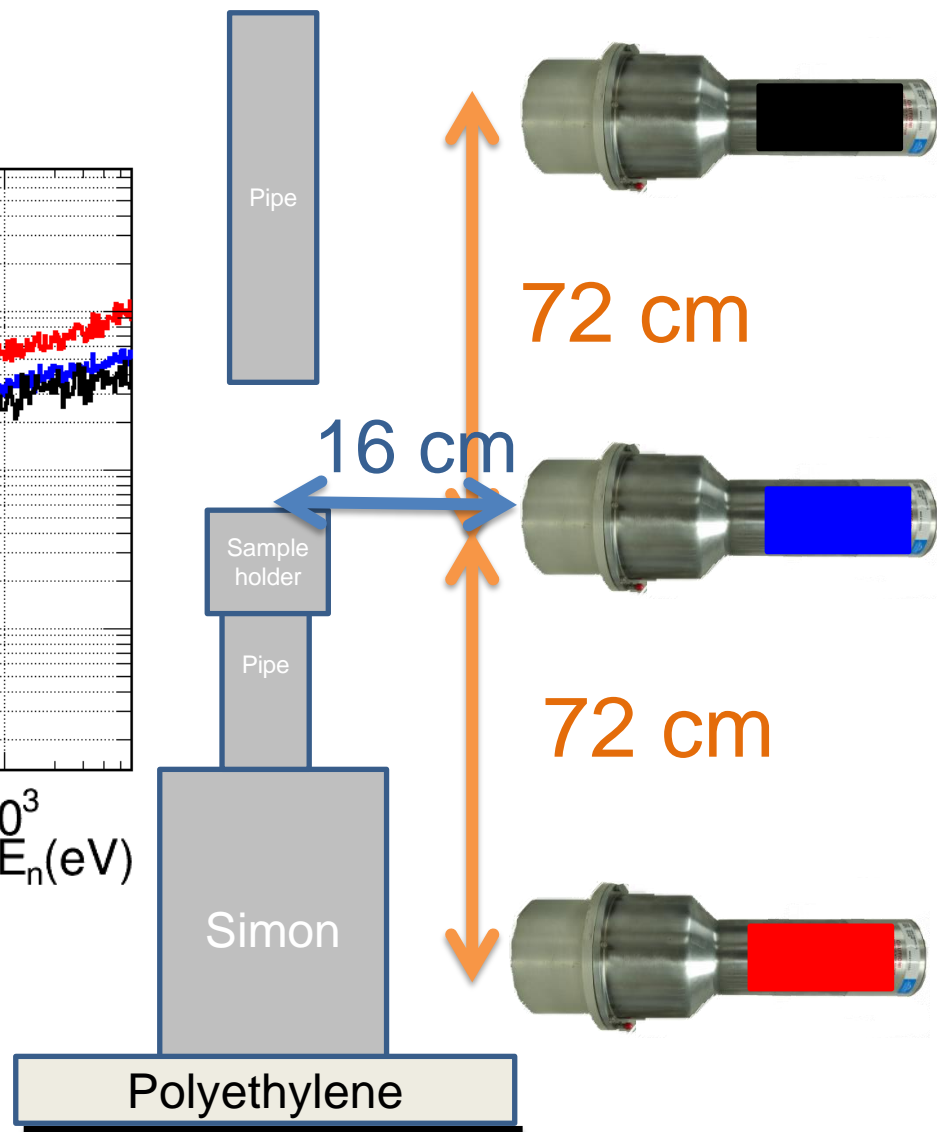
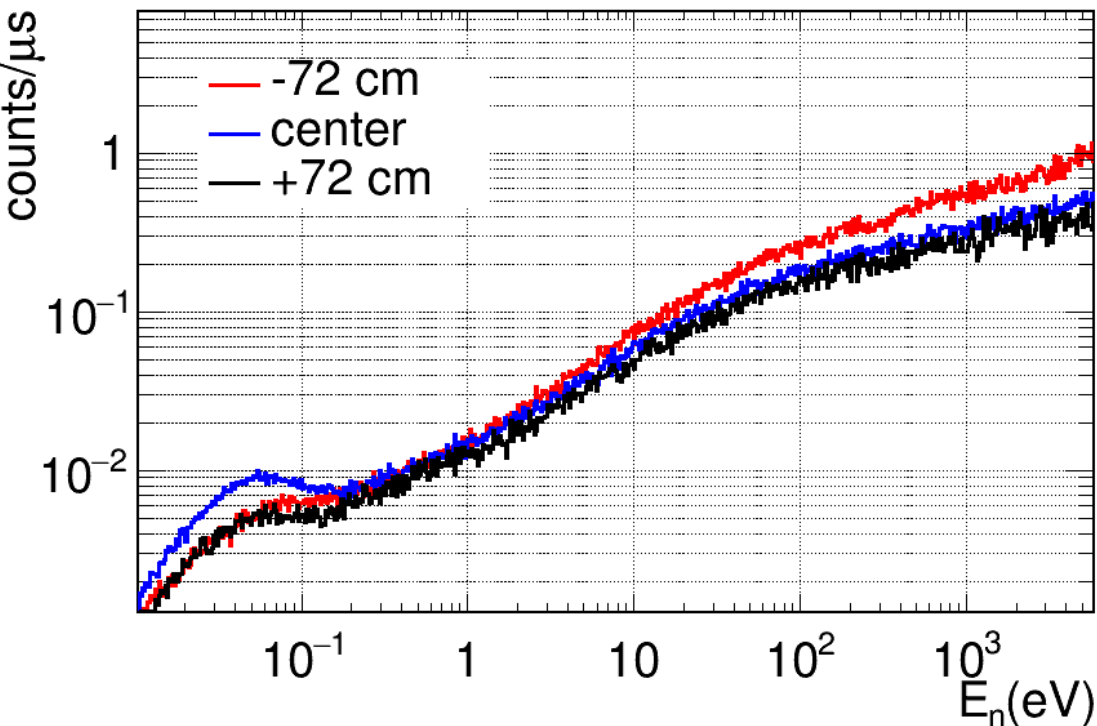
The background measurements at EAR2

The backgrounds were measured with the BICRON detectors located at different distances with nothing on beam:

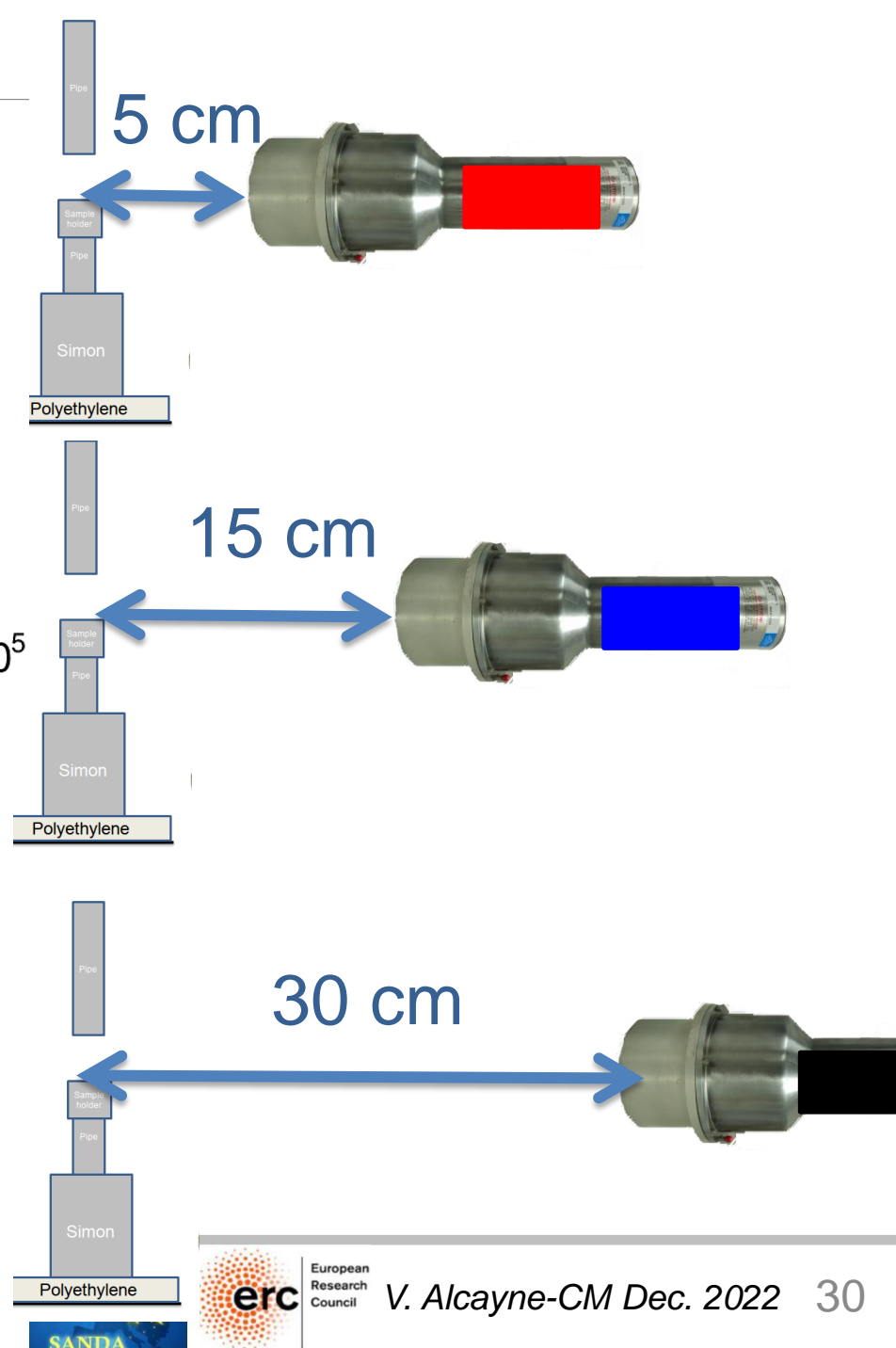
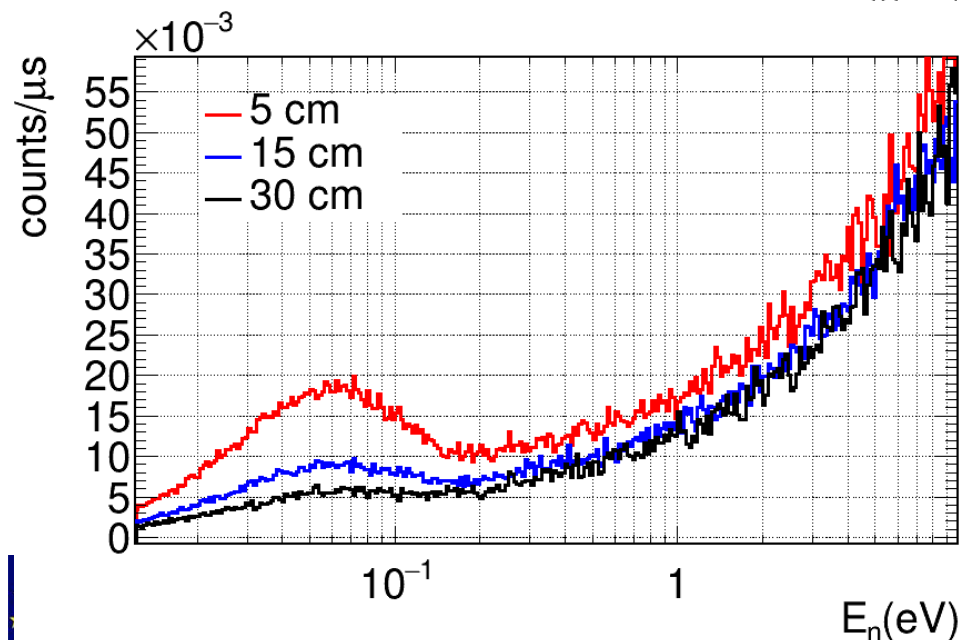
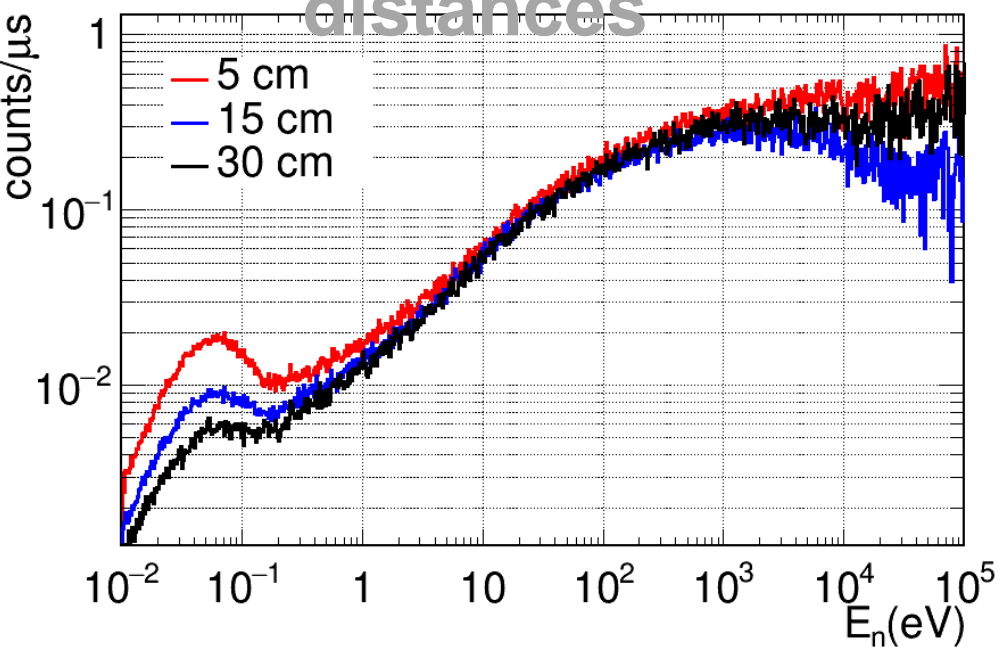
- Different heights
- Different distances from the beam
- Removing the polyethylene of the floor



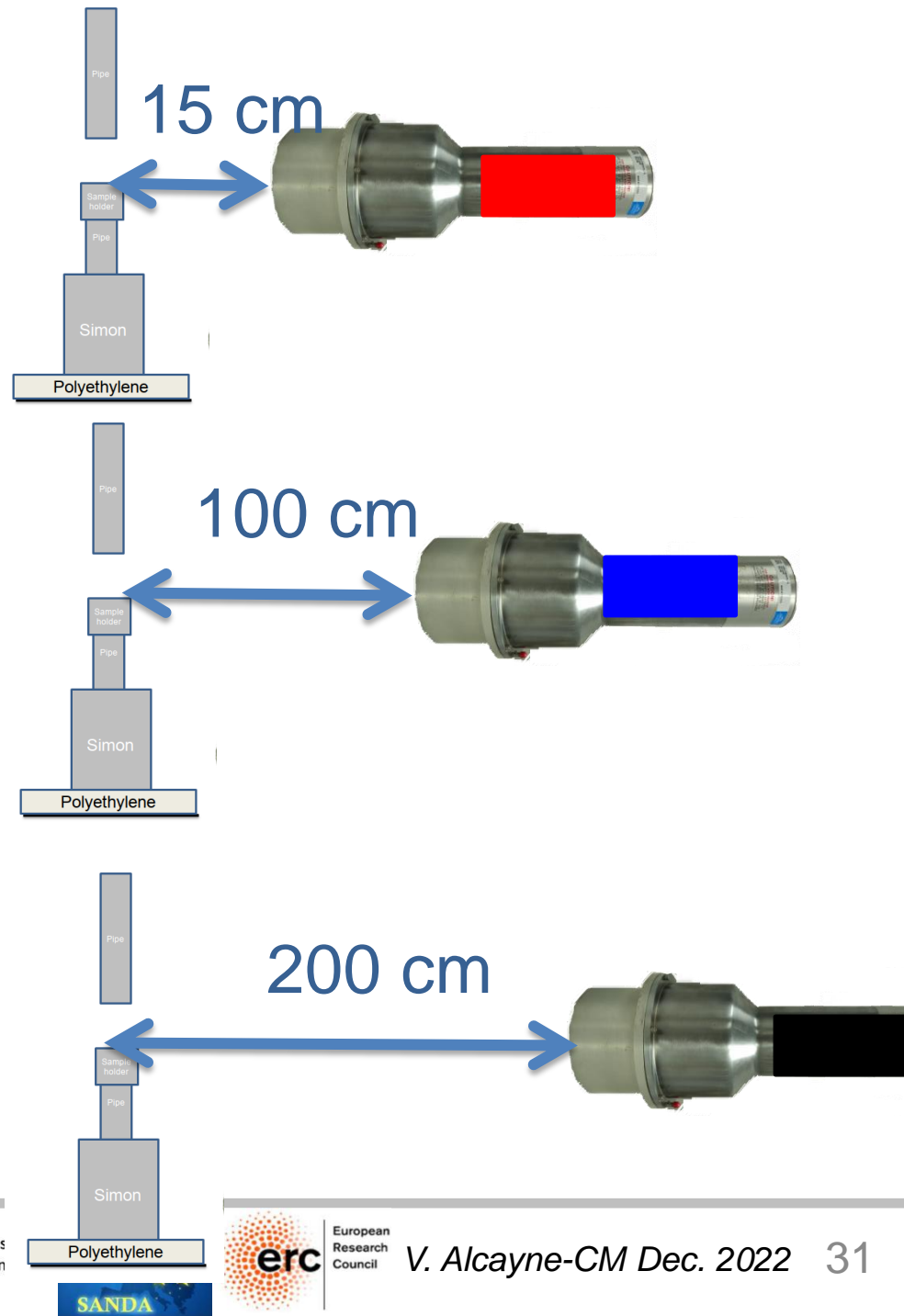
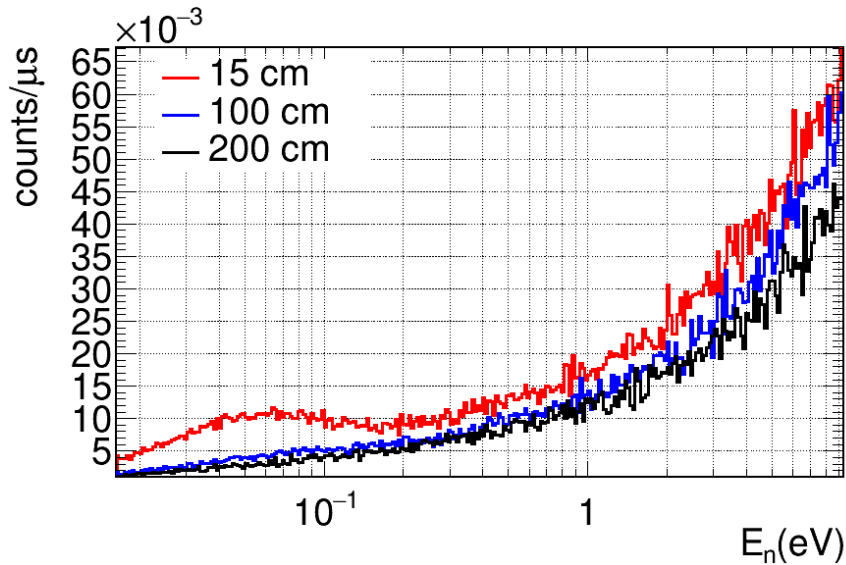
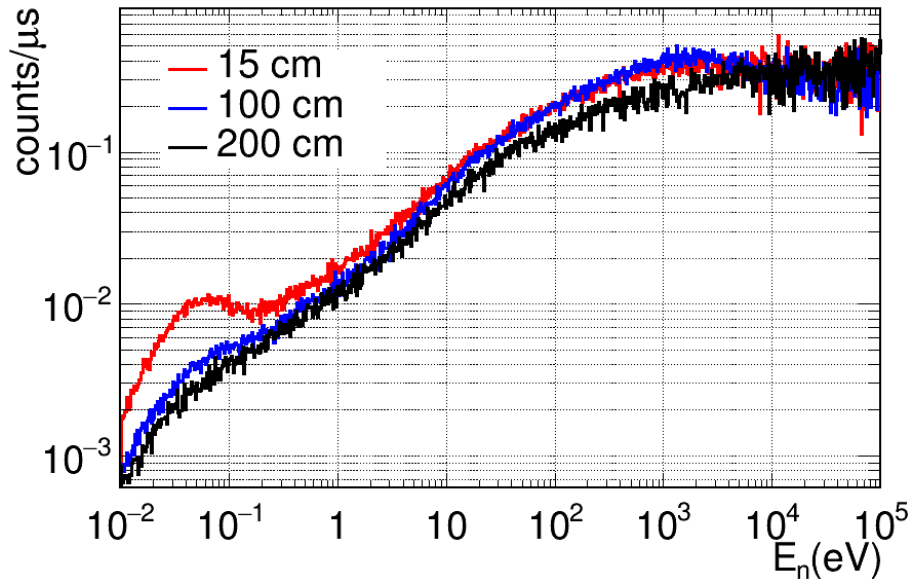
Background at different heights



Background at different distances



Background at different distances



Background without polyethylene

