$^{30}Si(n,\gamma)$ & $^{64}Ni(n,\gamma)$: Status of the Analysis

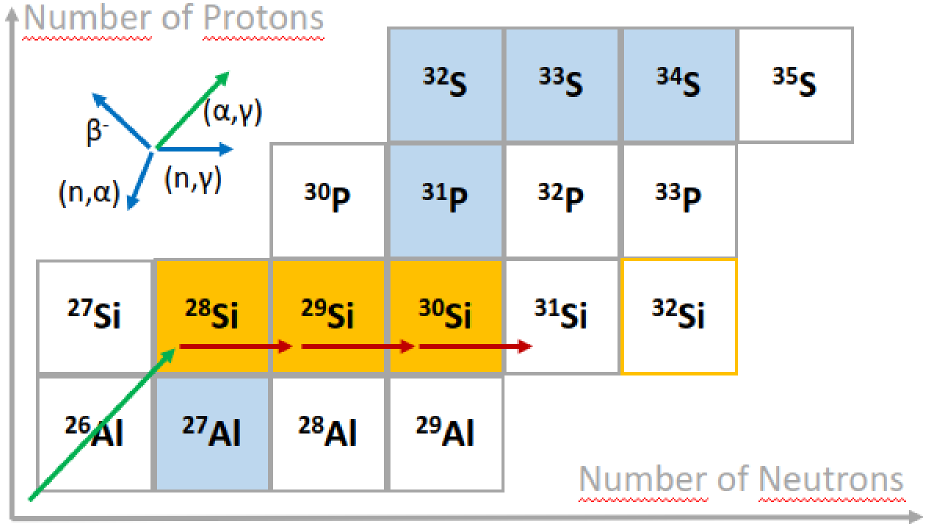
Michele Spelta

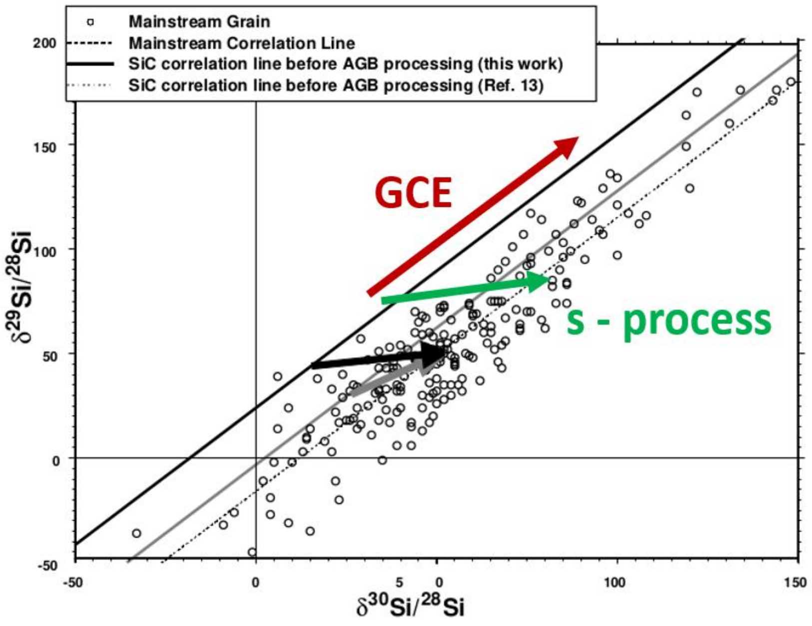
$^{30}Si(n,\gamma)$: Motivations

RECAP

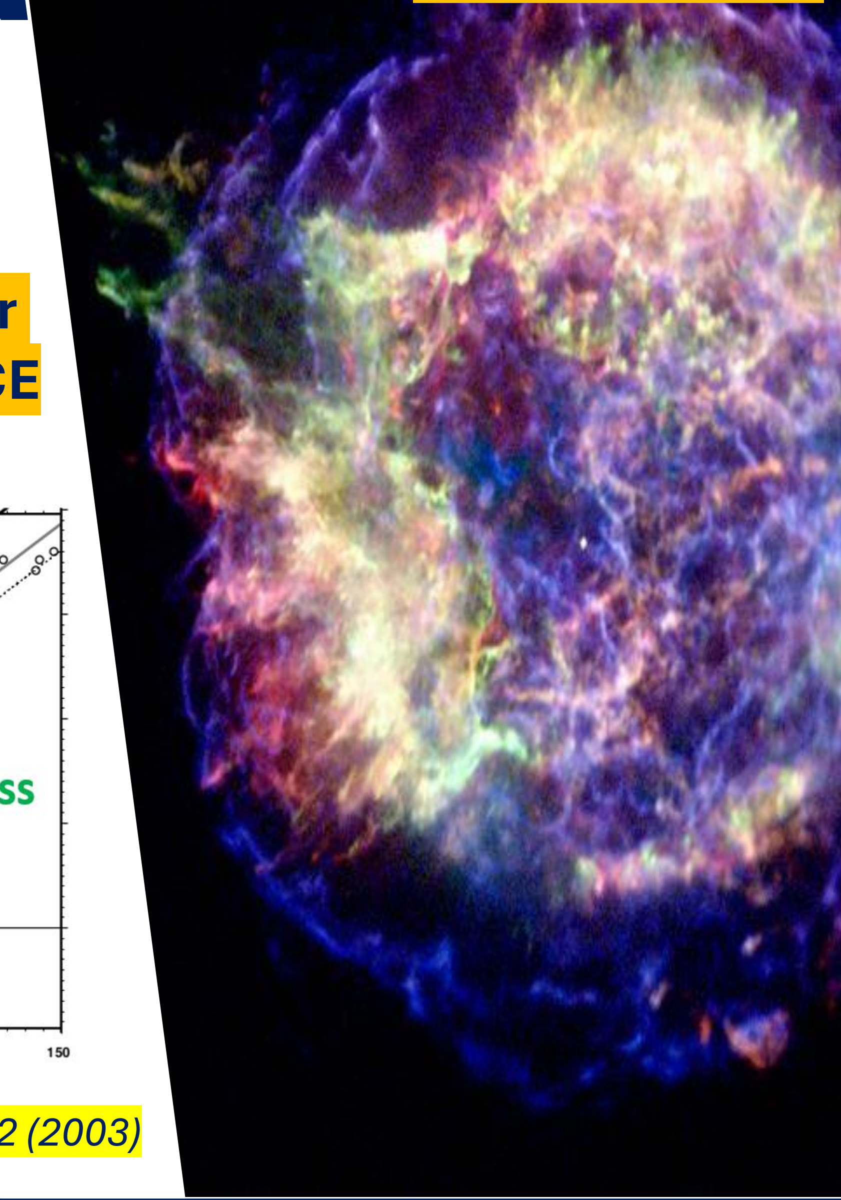
$^{30}Si(n, \gamma)$ cross section is important:

- to predict the abundance of Silicon isotopes produced in the convective carbon shell of **massive stars**
- to understand the Si isotopic abundances measured in **pre-solar SiC grains**, disentangling the contributions of **s-process** and **GCE**





K. Guber et al., *Phys. Rev. C 67, 062802 (2003)*



^{64}Ni(n,γ): Motivations

RECAP

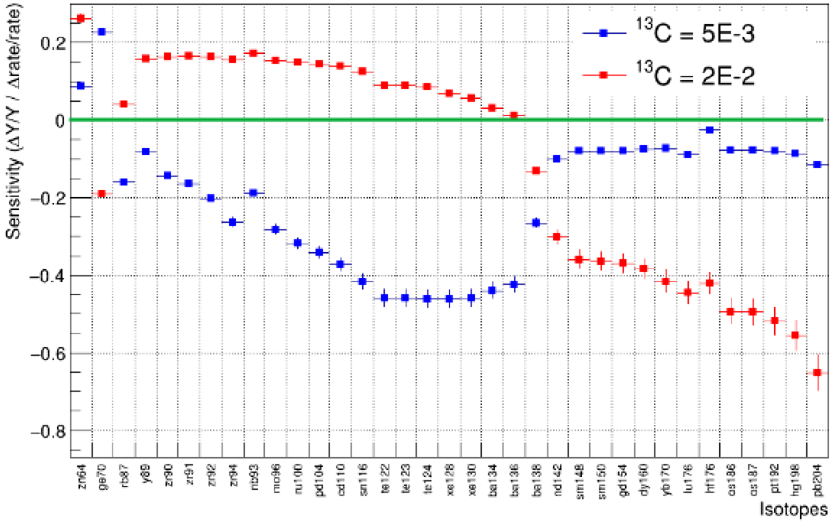
^{64}Ni(n, γ) cross section is important:

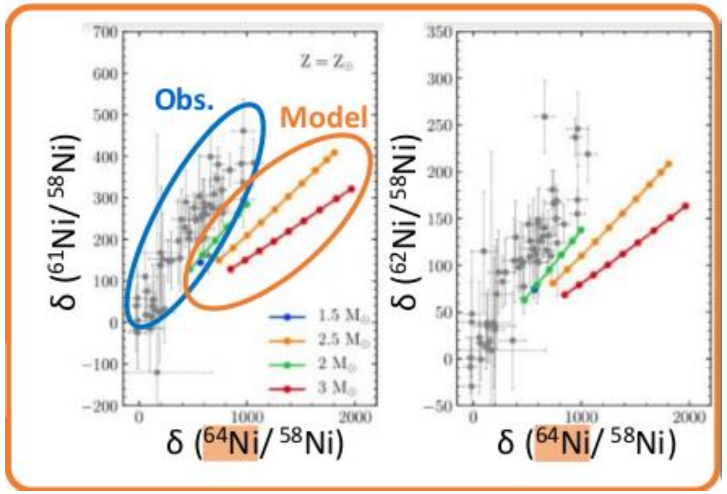
- because, as a **seed of the s-process**, it affects the abundances of many isotopes synthesized in the process

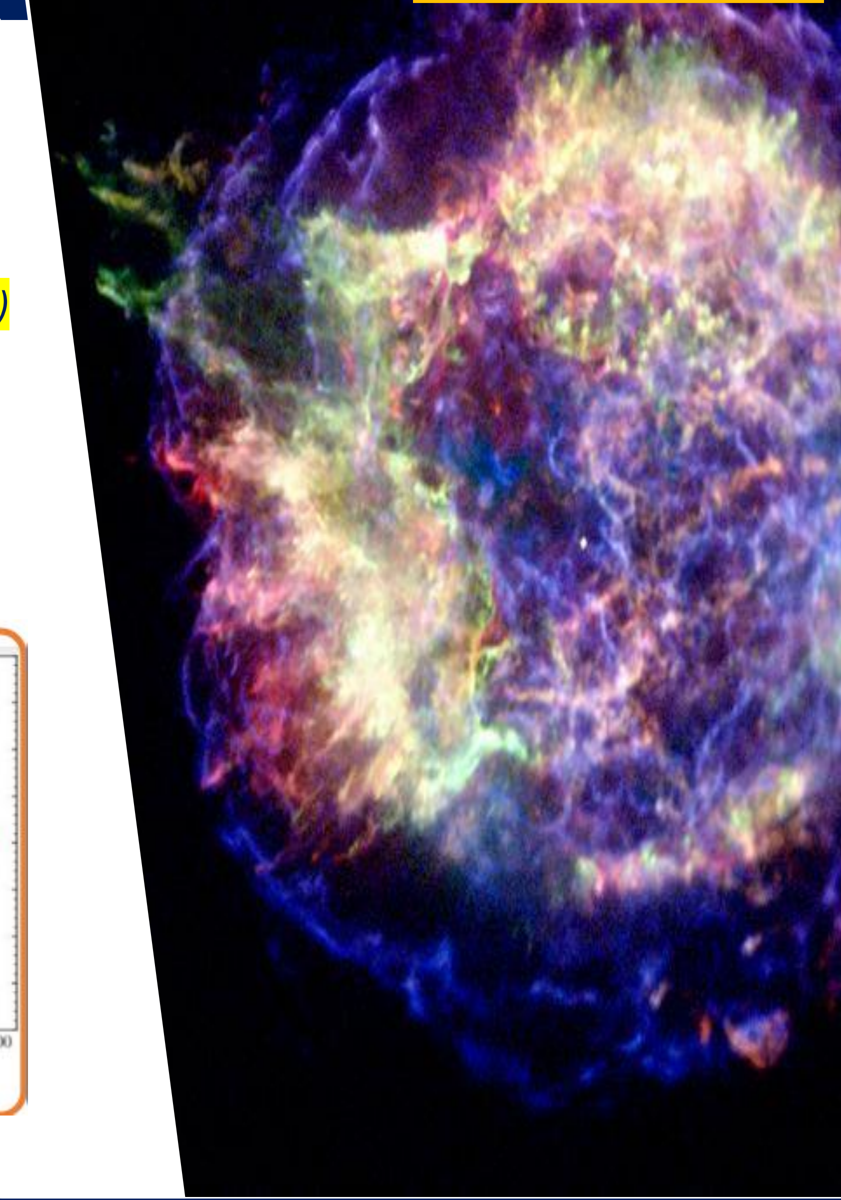
Cescutti et al., MNRAS 478, 4101 (2018)

- to possibly explain the **discrepancy observed in SiC grains** between measured and predicted ^{64}Ni isotopic abundances

Vescovi et al., ApJ Lett 897, 25 (2020)



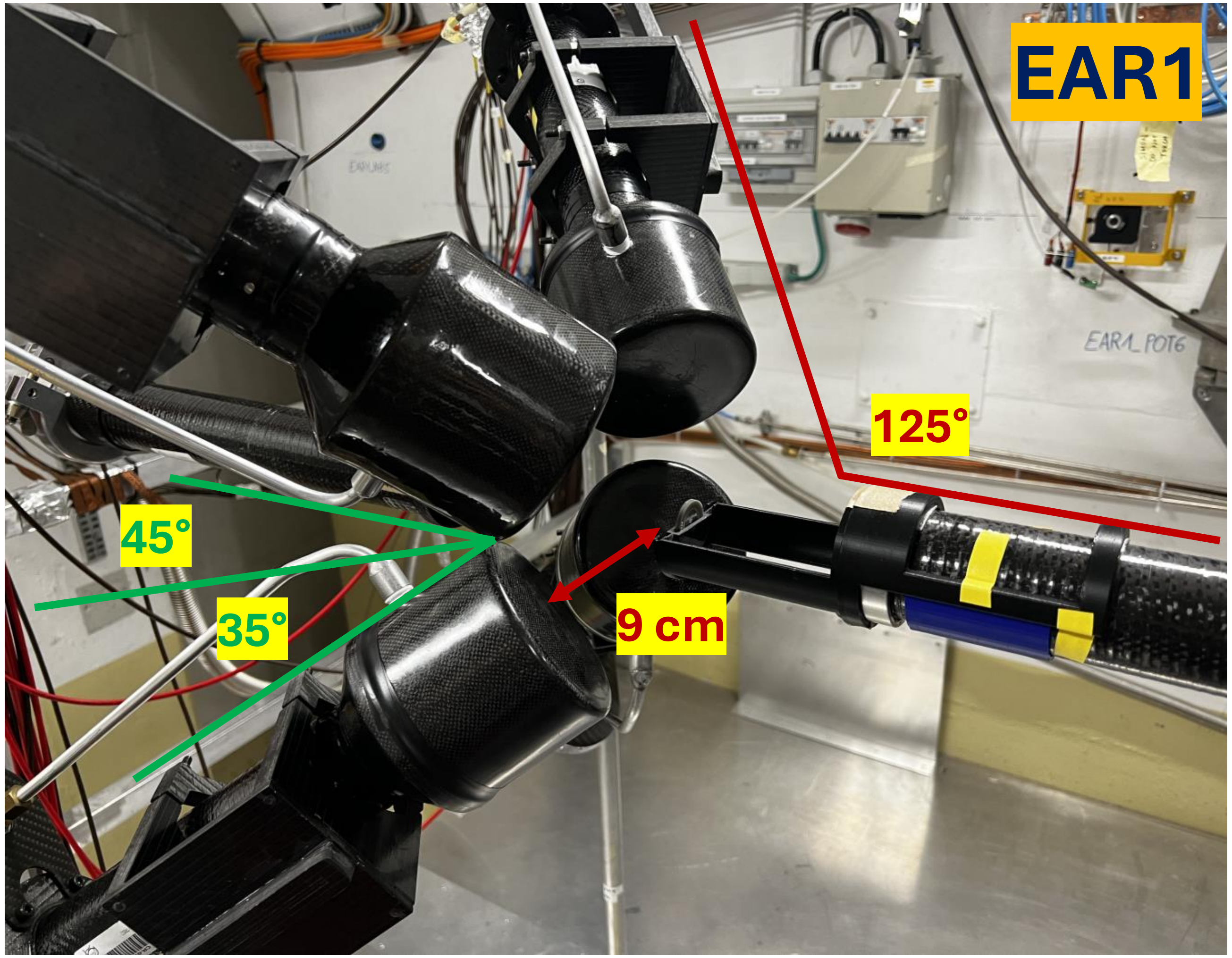


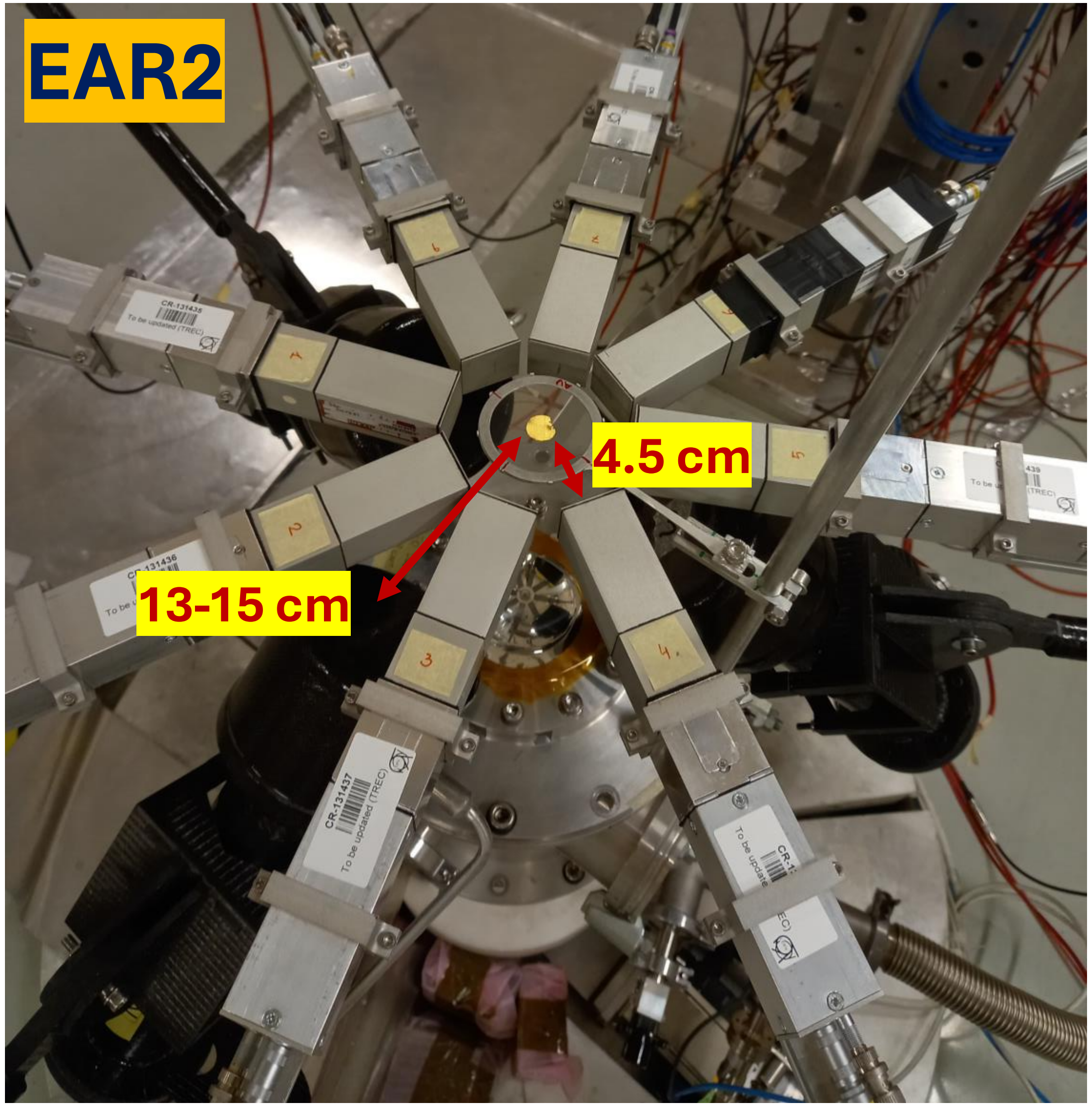


Setup

RECAP

^{30}Si(n, γ): EAR1 + EAR2; ^{64}Ni(n, γ): only EAR2

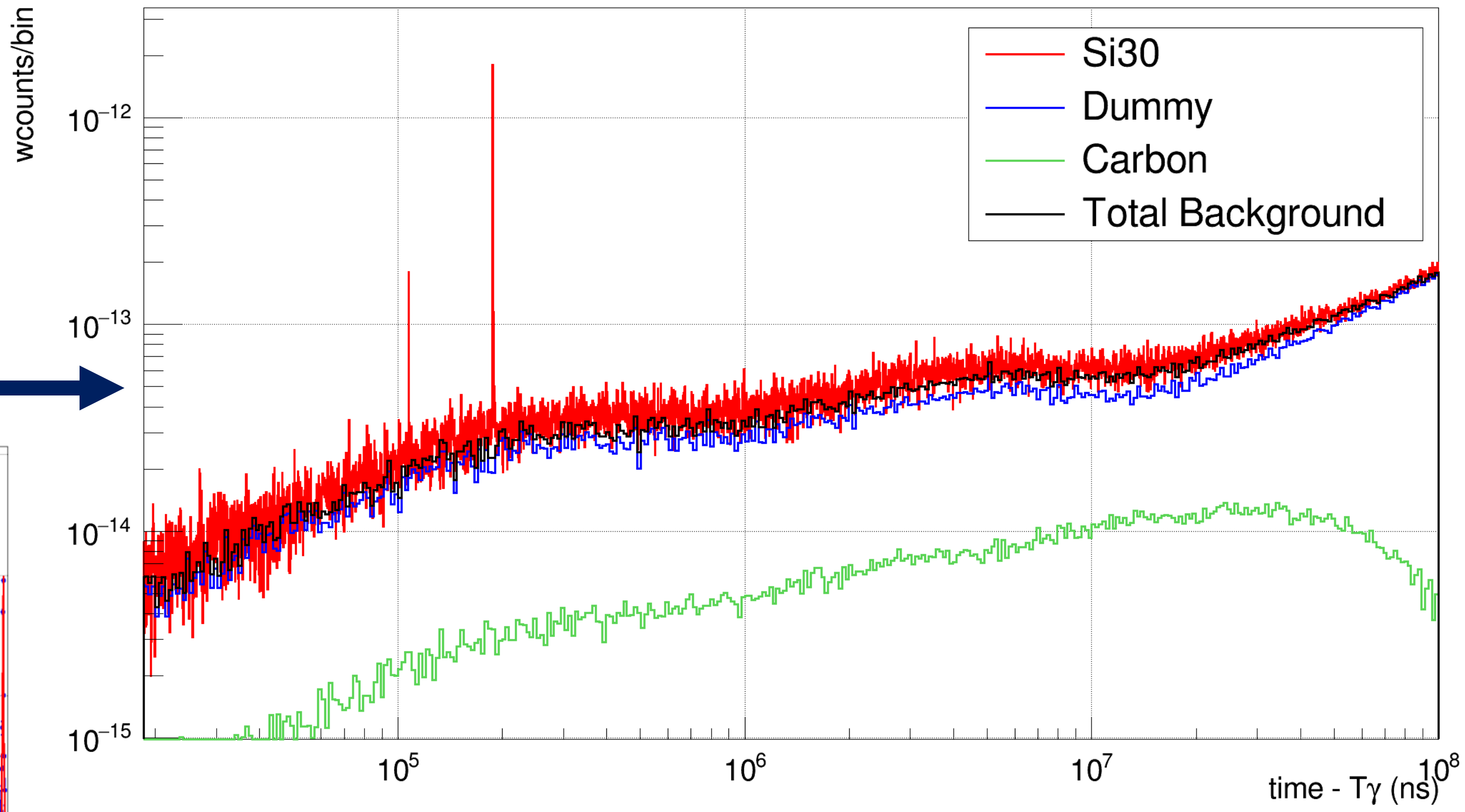


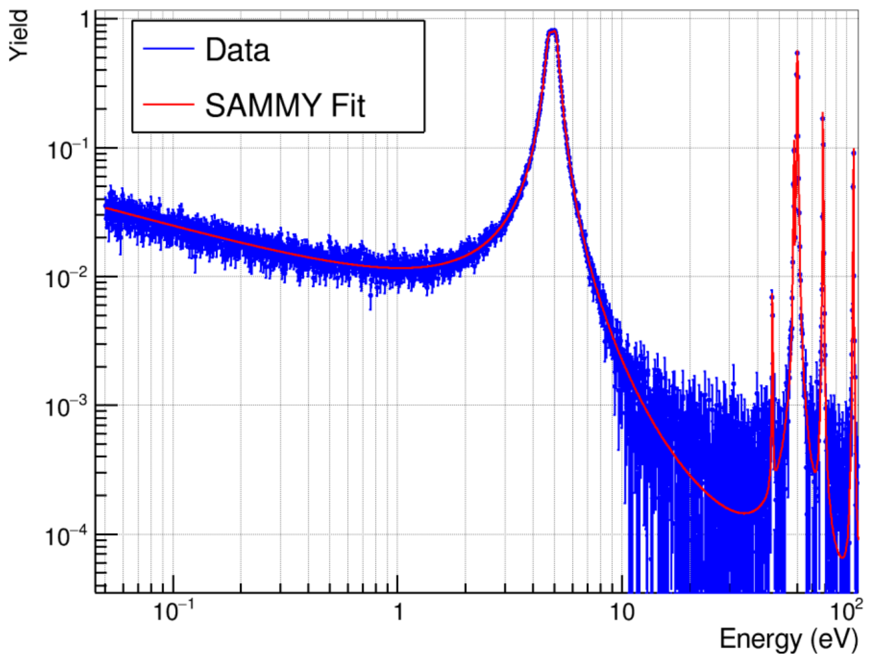


^{30}Si(n,γ) EAR1: Status

RECAP

1. Calibration
2. Weighting Functions
3. Study of rebounds
4. Gold (reference)
5. **Background Subtraction**



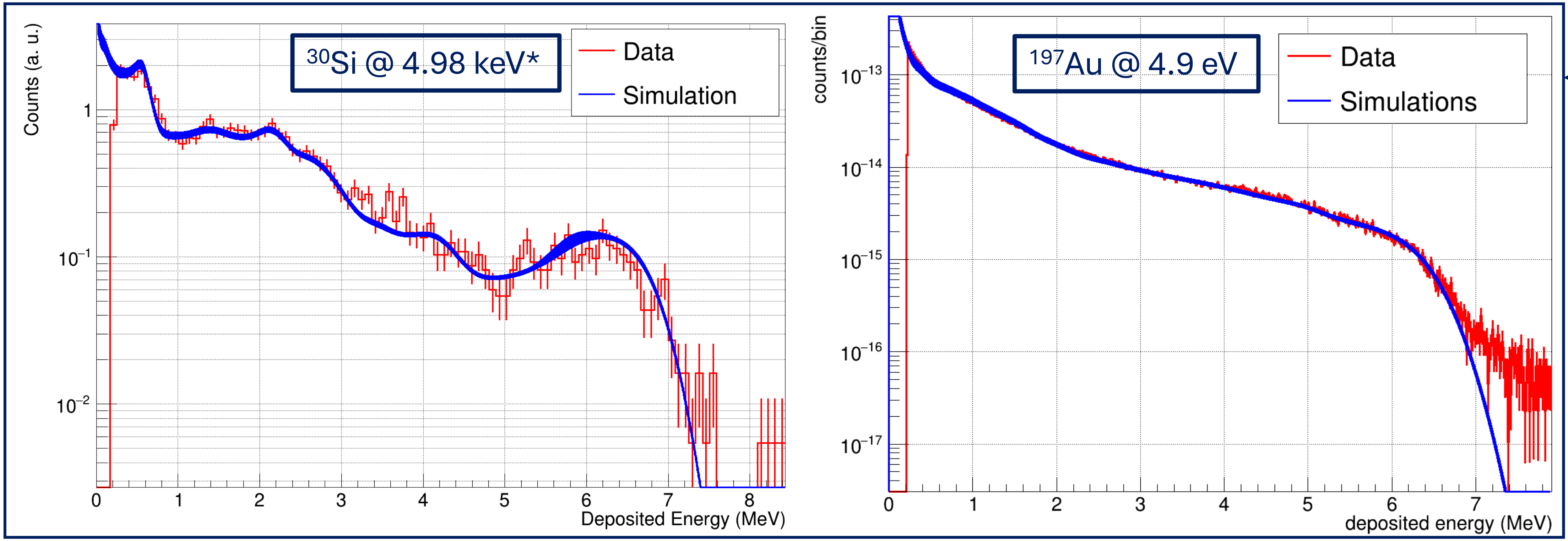


See previous collaboration meeting:
https://indico.cern.ch/event/1403789/

^{30}Si(n,γ) EAR1: Yield Corrections

^{30}Si and Gold de-excitation cascades have been simulated and tuned using **NUDEX** to correct for the **thresholds** and the **electron conversion** effects.

	C6D6 1	C6D6 2	C6D6 3	C6D6 4
Total w counts (Si30)	1.0052	1.0057	1.0040	1.0067
Total w counts (Au)	1.0503	1.0584	1.0446	1.0522
Correction ^{30}Si (Si/Au)	**0.957**	**0.950**	**0.961**	**0.957**

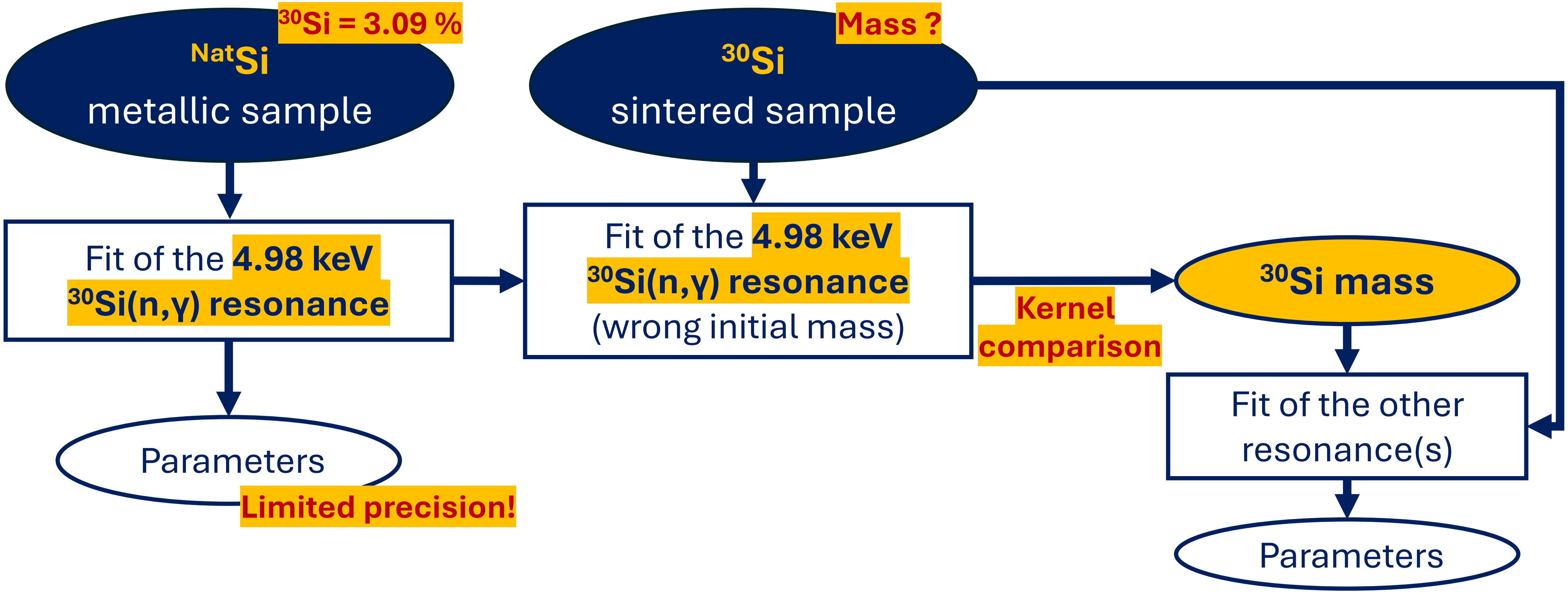


Ex: C6D6 4

*assumed for all resonances

^{30}Si(n,γ) EAR1: Mass Problem

The mass of ^{30}Si sample increased in the sintering procedure (oxidation), so a direct measurement of the actual mass of ^{30}Si in-beam is not available, but it has been estimated using a **^{Nat}Si metallic sample**:



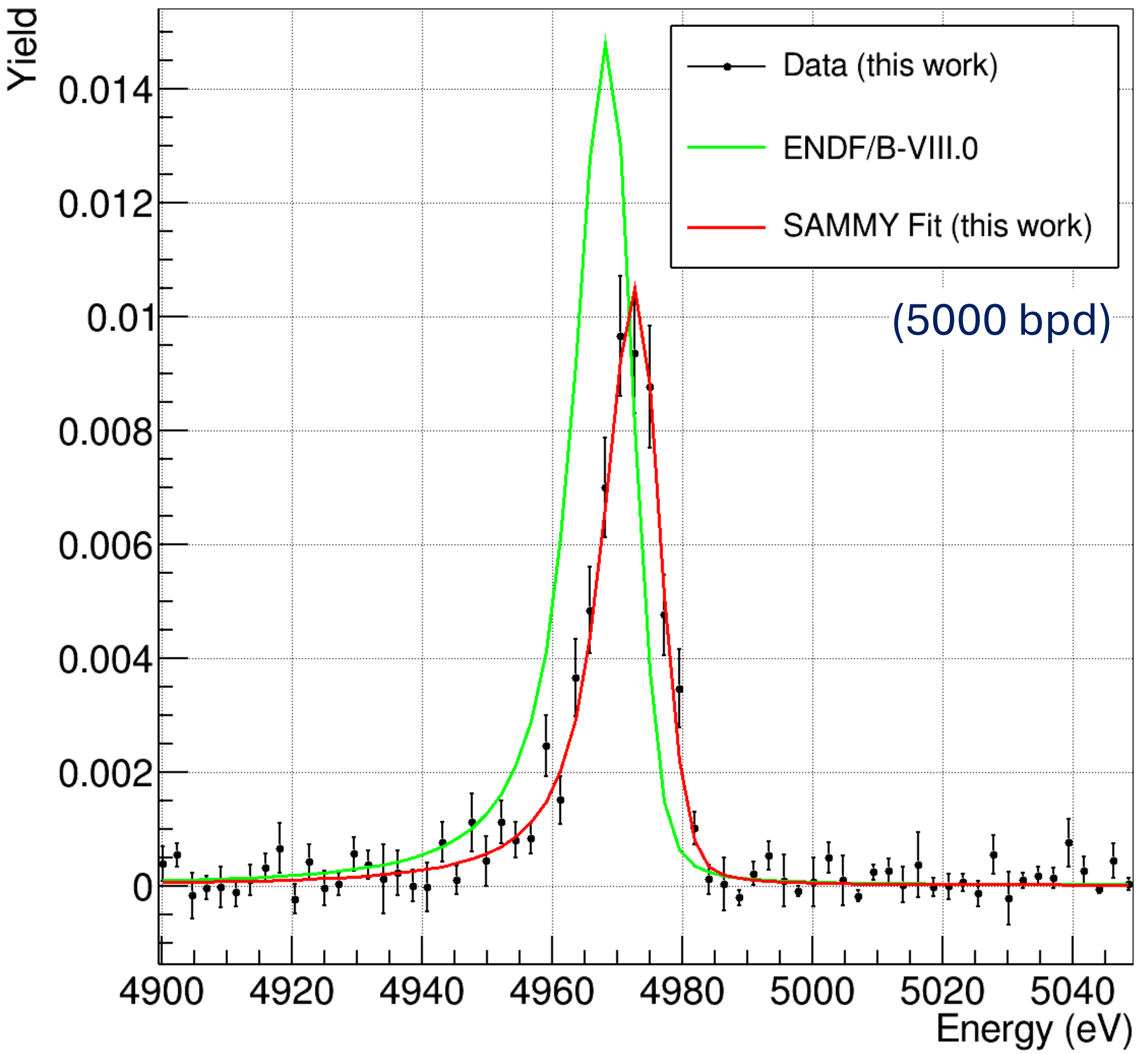
$^{30}Si(n,\gamma)$ EAR1: Resonance Fitting

SAMMY fit from the **^{Nat}Si sample**

J^{π}	½ -
E_R (eV)	4981.3 ± 0.3
Γ_n (meV)	1000 ± 500
Γ_γ (meV)	370 ± 60
$g\,\Gamma_n\Gamma_\gamma / \Gamma$ (meV)	**267 ± 14** *(5.2%)*

1300 ± 40 meV (Harvey 84)

Prev. Measurements	**$g\,\Gamma_n\Gamma_\gamma / \Gamma$ (meV)**
Guber et al. *Phys. Rev. C 67 (2003) 062802*	**190** *(- 29%)*
Beer et al. *Nucl. Phys. A 453 (2002) 062802*	**410** *(+ 54%)*
Boldeman et al. *Nucl. Phys. A252 (1975) 62*	**600 ± 60** *(+125%)*



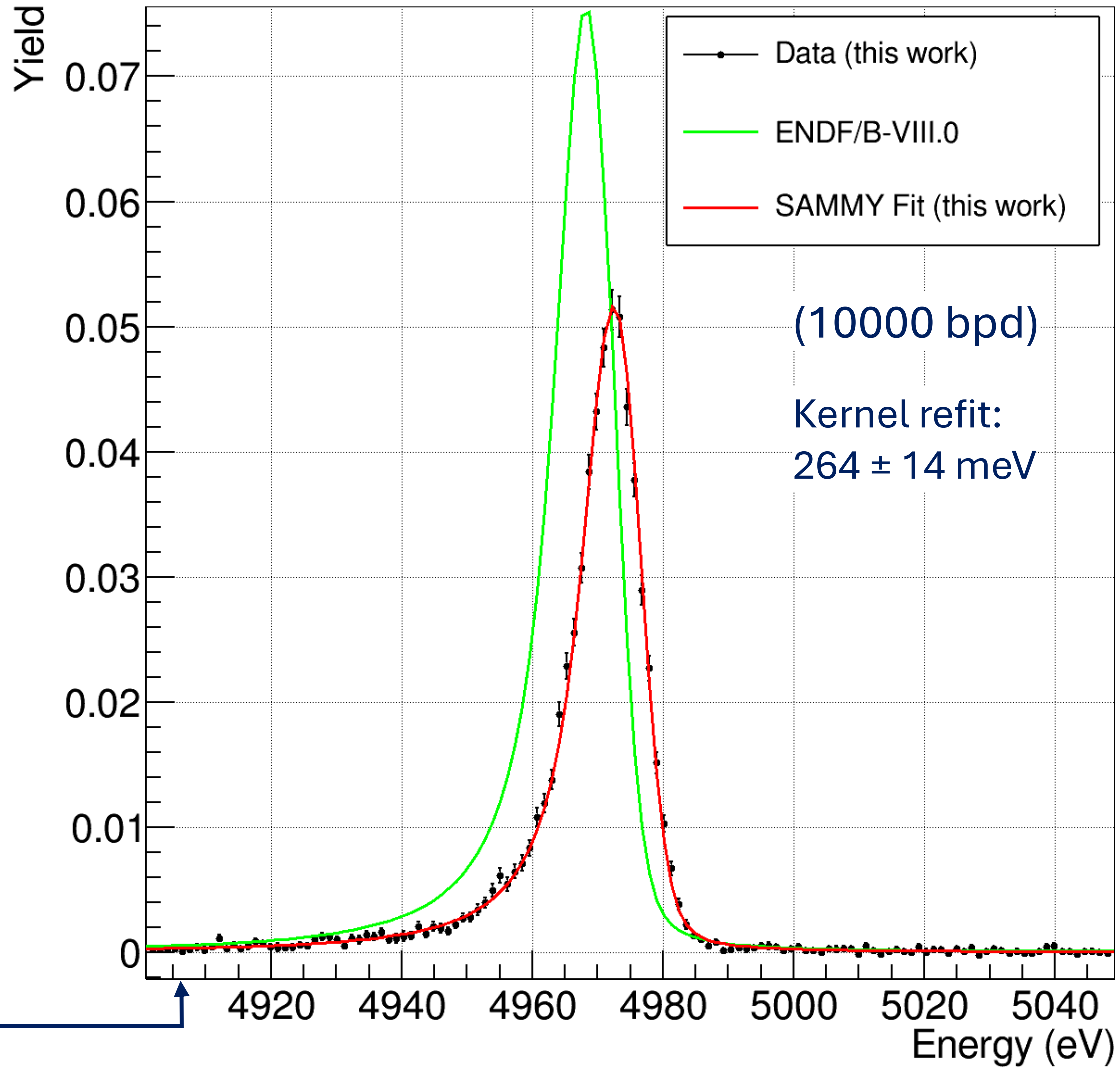
^{30}Si(n,γ) EAR1: Resonance Fitting

SAMMY fit from the **^{30}Si sample** to determine the actual ^{30}Si mass in-beam

	g $\Gamma_n\Gamma_\gamma / \Gamma$ (meV)
^{Nat}Si sample	267 ± 14 *(5.2%)*
^{30}Si sample*	247 ± 3 *(1.2%)*
Ratio	**0.92 ± 0.05 *(5.3%)***

	Mass (mg)
Pre-sintering*	750.34 ± 0.01
Sample (total)	992.5 ± 0.1 *(+32%)*
^{30}Si estimated	**690 ± 40 *(5.8%)*** *(-8%)*

In mass: 70% ^{30}Si, 30% Oxygen
In atoms: 55% ^{30}Si, 45% Oxygen



(10000 bpd)

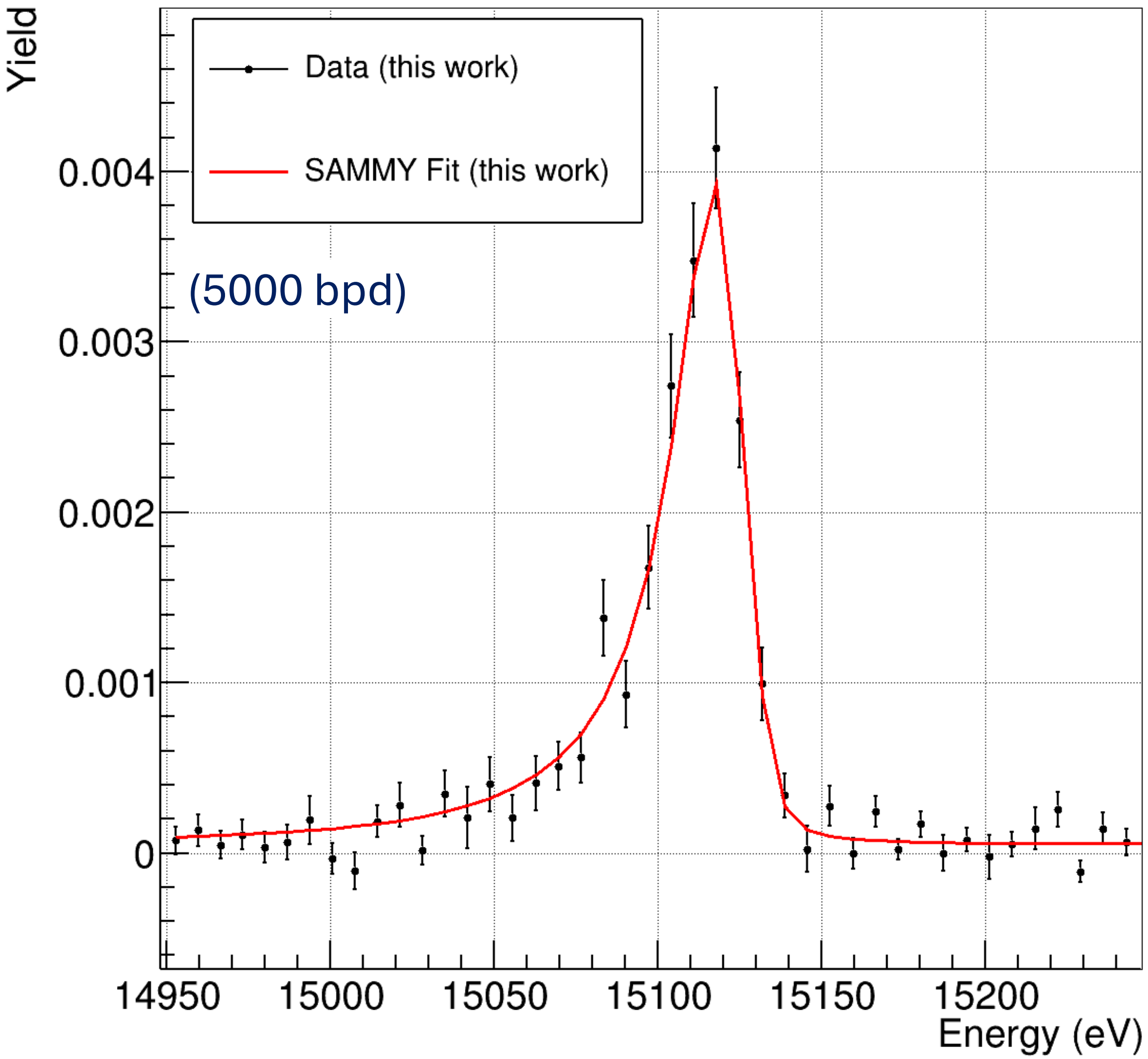
Kernel refit:
264 ± 14 meV

$^{30}Si(n,\gamma)$ EAR1: Resonance Fitting

Resonance at 15.14 keV **not present in evaluated data libraries**, but already observed in previous measurements

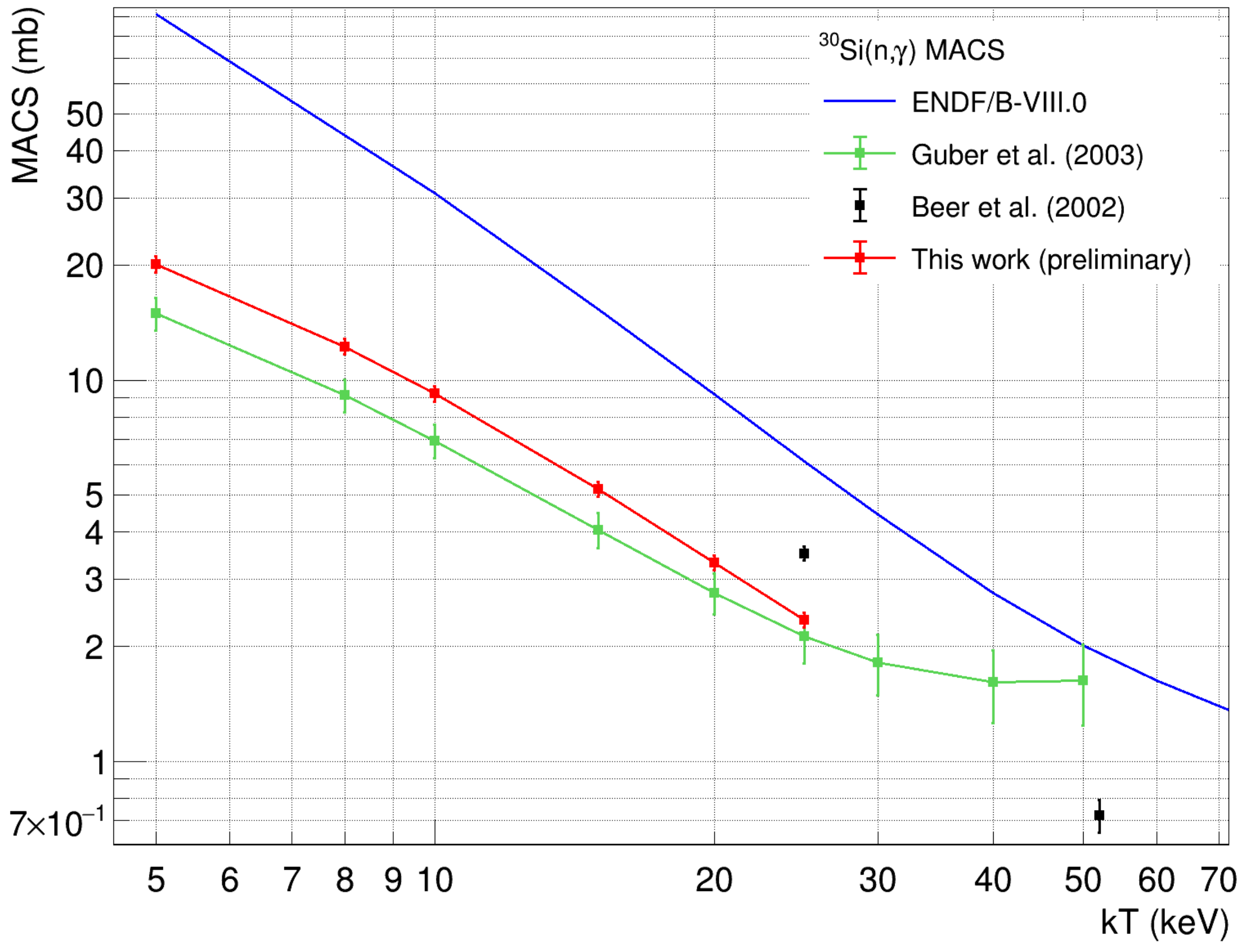
J^{π}	(½ ⁻)
E_R (eV)	15144.1 ± 0.6
Γ_n (meV)	3000 ± 1200
Γ_γ (meV)	153 ± 7
$g\,\Gamma_n\Gamma_\gamma/\Gamma$ (meV)	**146 ± 11** *(7.5%)*

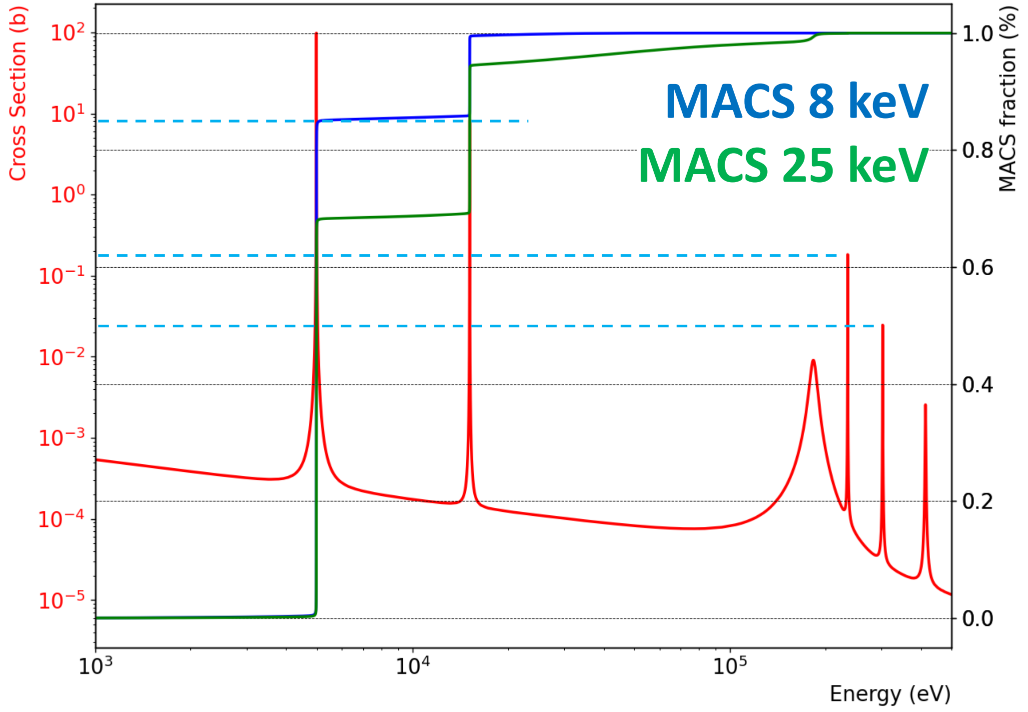
Prev. Measurements	$g\,\Gamma_n\Gamma_\gamma/\Gamma$ (meV)
Guber et al.	94 *(- 35%)*
Beer et al.	120 *(- 18%)*
Boldeman et al.	170 ± 20 *(+ 16%)*



$^{30}Si(n,\gamma)$ EAR1: Preliminary MACS

The first two resonances are the dominant contribution to the **MACS** up to 25 keV (**Direct capture*** contribution still missing, estimated at 0.3 – 0.45 mb by Beer / Guber)

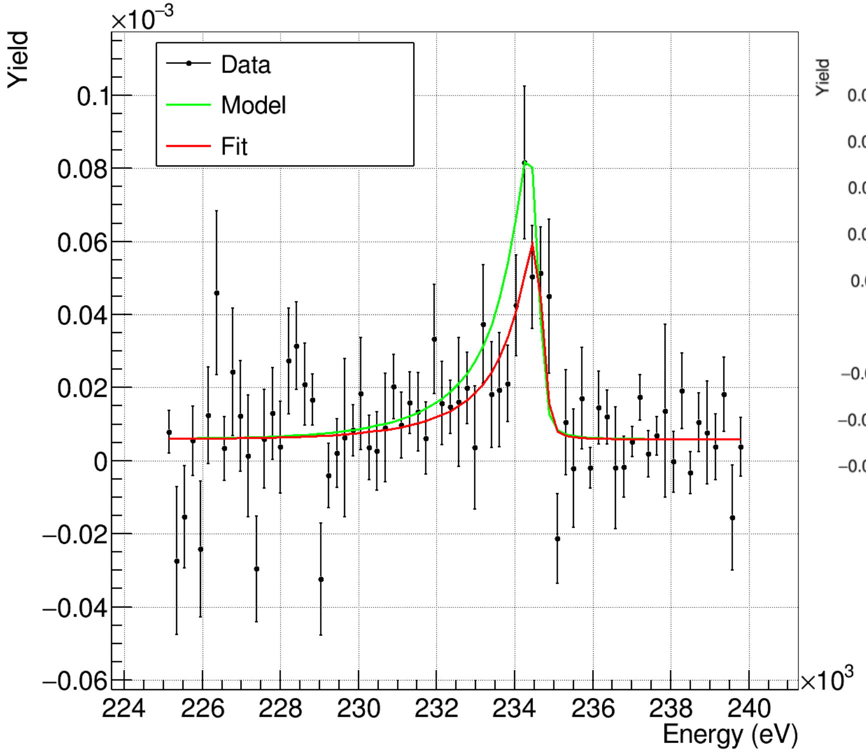




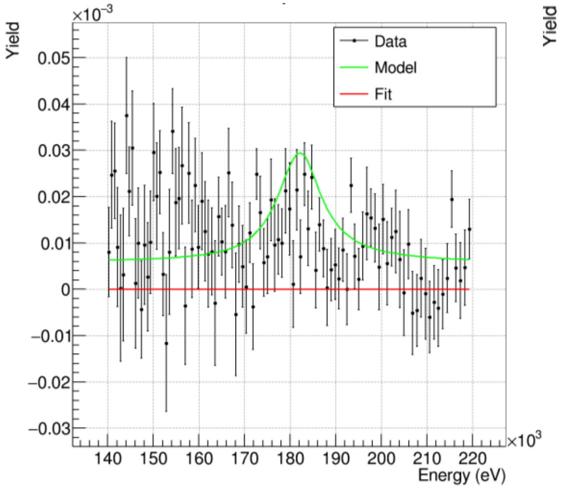
MACS @ 25 keV	This work	*Guber et al.*	*Beer et al.*
	2.35(10)**	2.1(3)	3.51(15)

$^{30}Si(n,\gamma)$ EAR1: High Energy Region

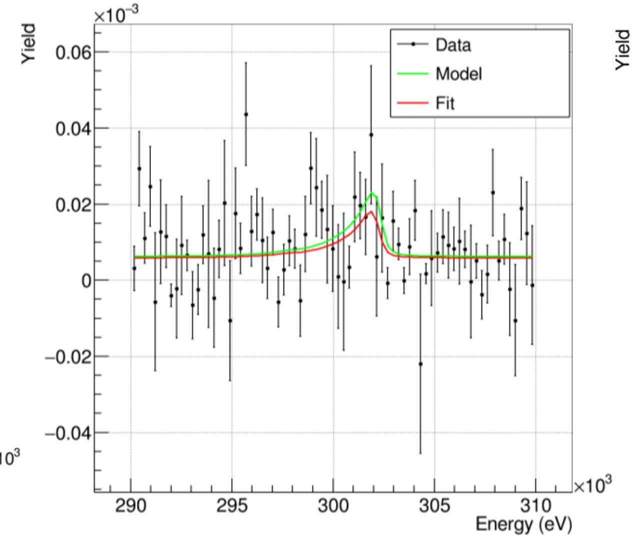
Resonances after 100 keV are smaller and suffer by large fluctuations and poor statistics.
For the moment, **just some fitting attempts** have been performed...



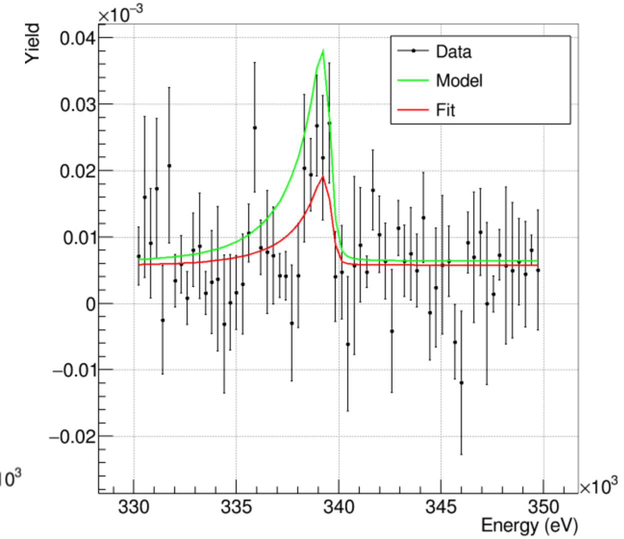
235 keV



180 keV
Never measured in capture, upper limit?



303 keV

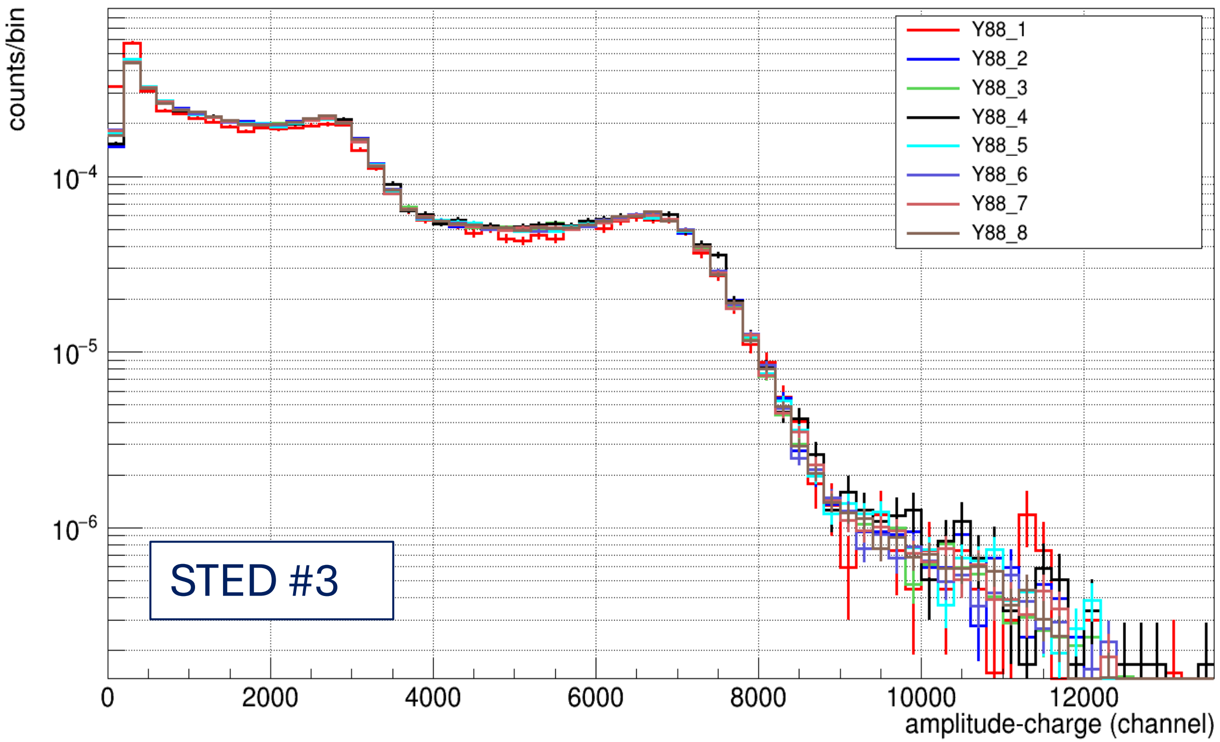


340 keV
Not reported in libraries

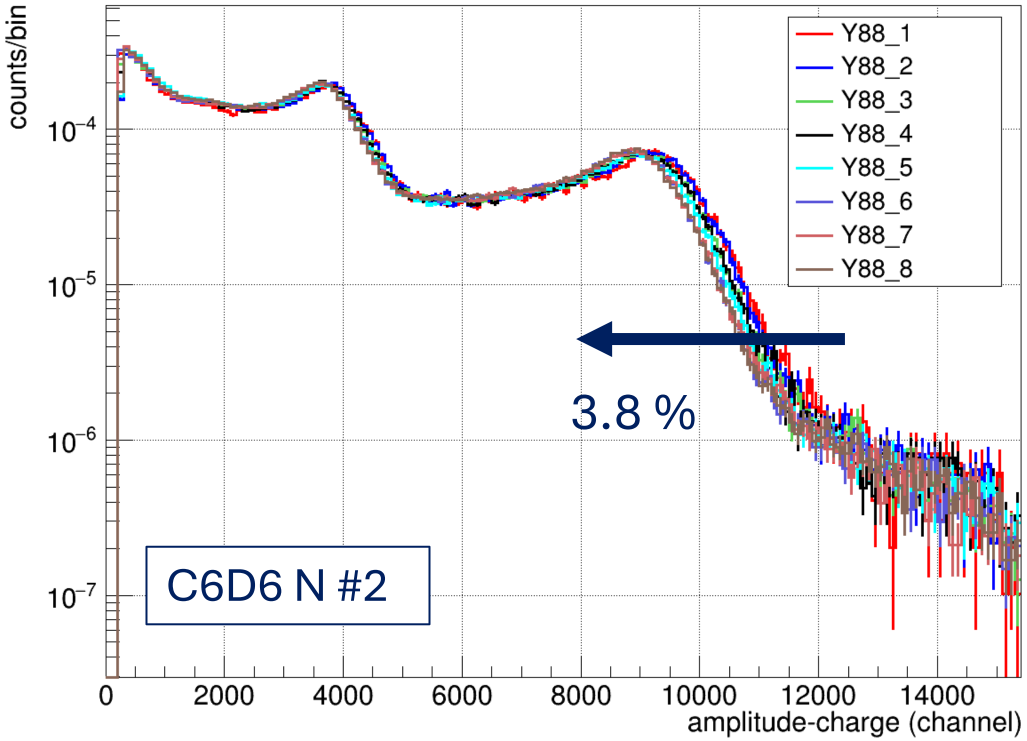
EAR2: Calibrations

Gain shift has been comparing different Y88 and Au runs:

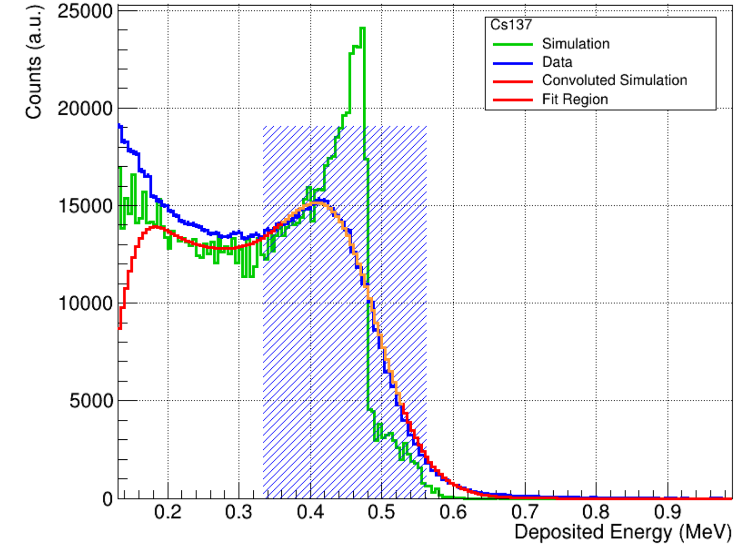
STED: Stable

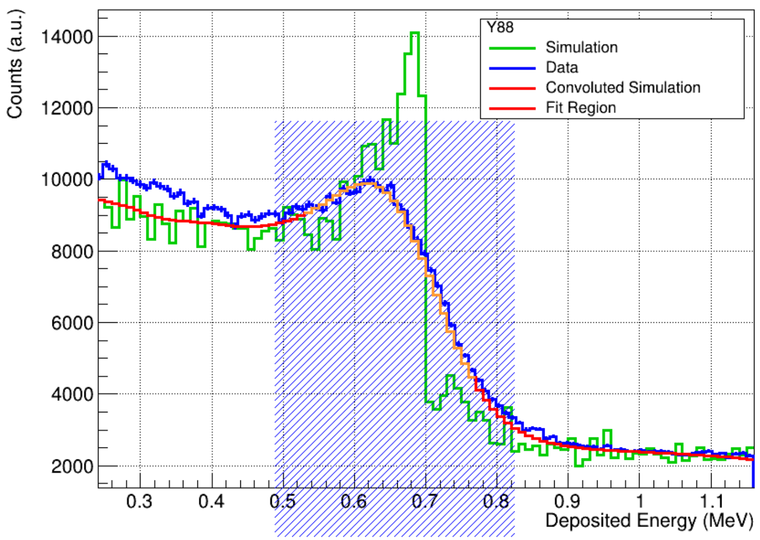


C6D6: Gain Shift

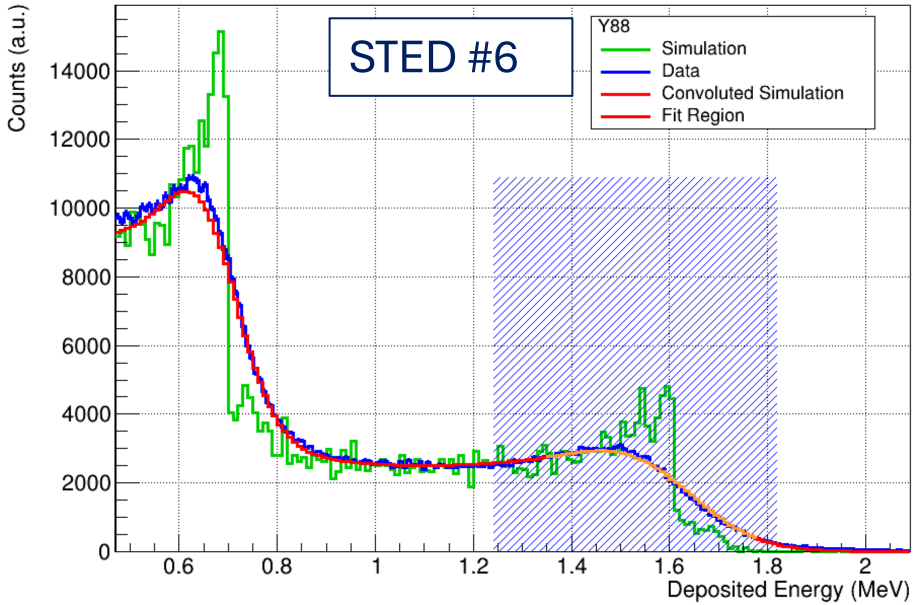


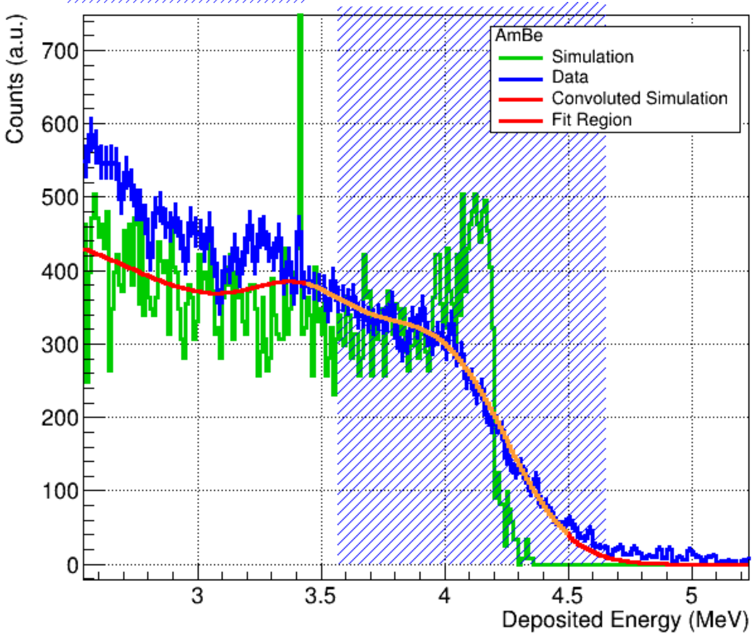
EAR2: Calibrations STED

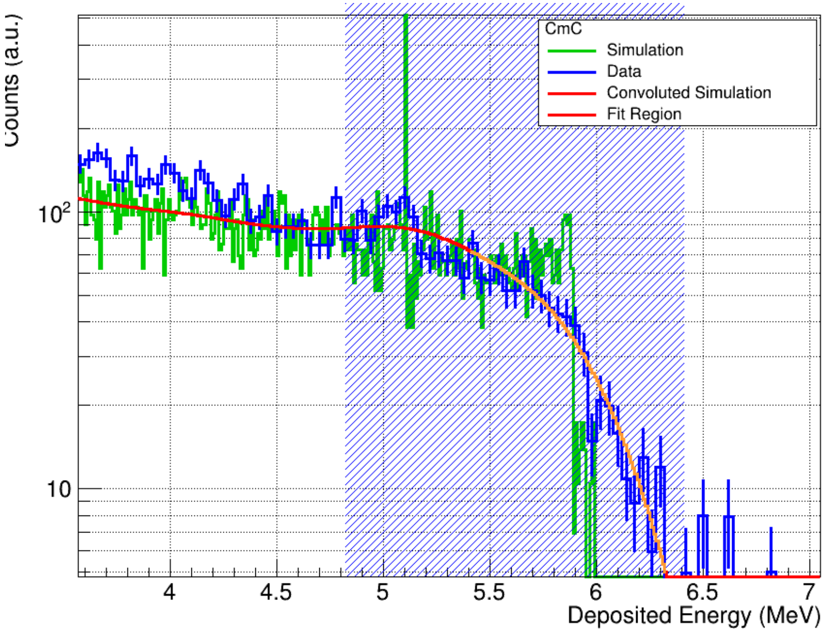




Calibration of the STED has been performed with a **direct comparison** between measured and simulated energy deposited spectra, tuning gain and resolution for each source:

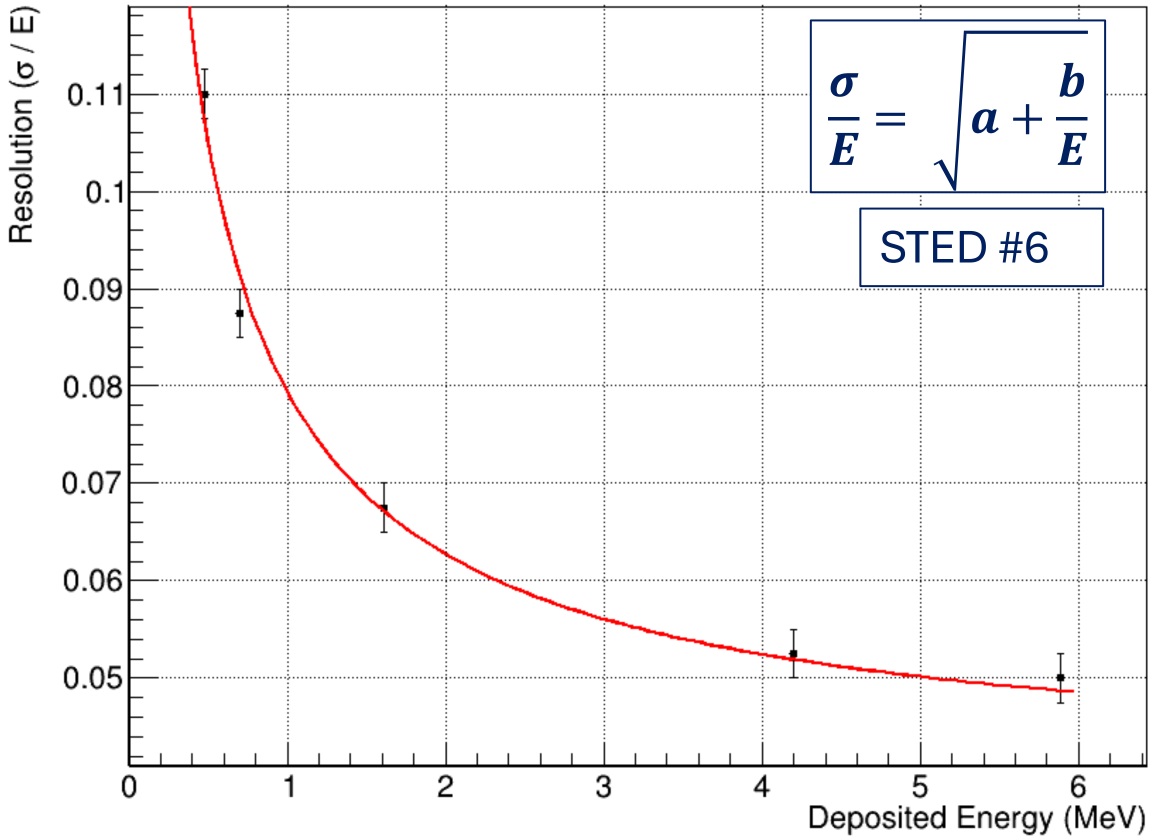


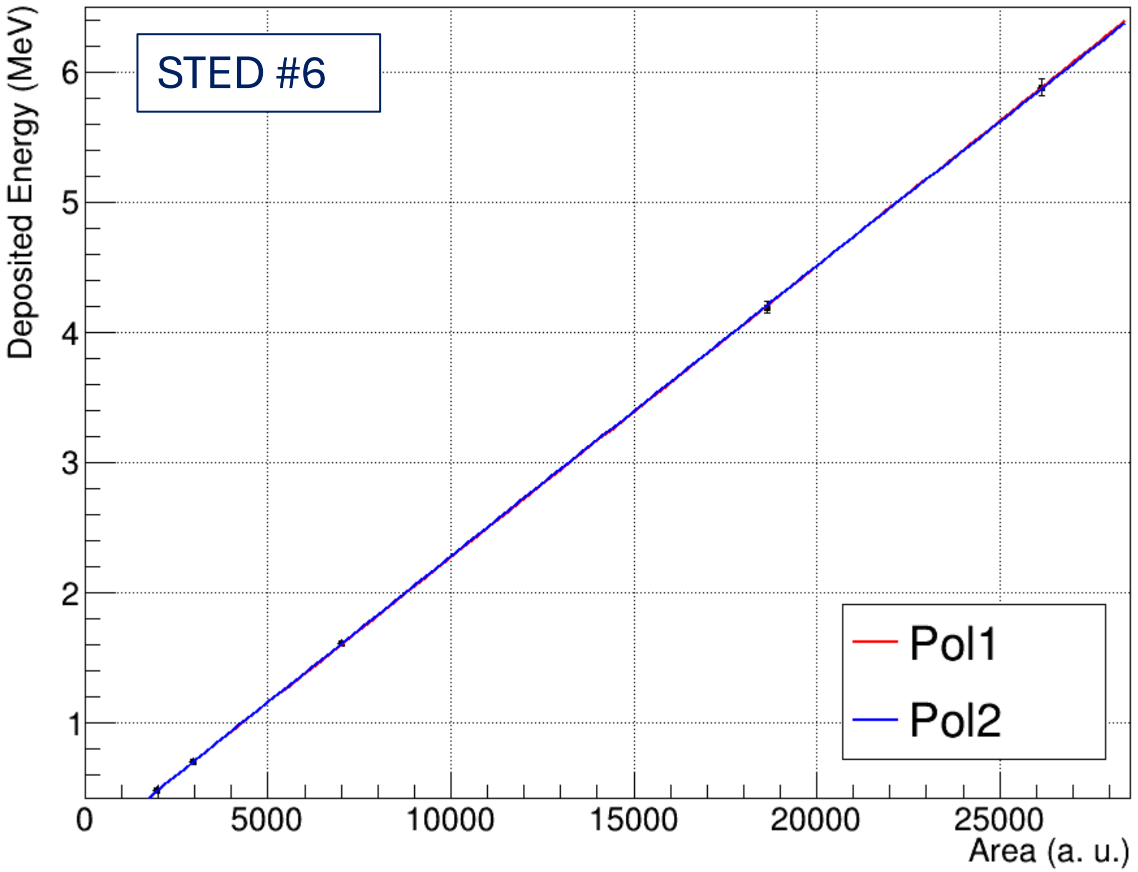




EAR2: Calibrations STED

Calibration and resolution functions have been computed fitting the results from different sources. The calibration of the STEDs are pretty linear.





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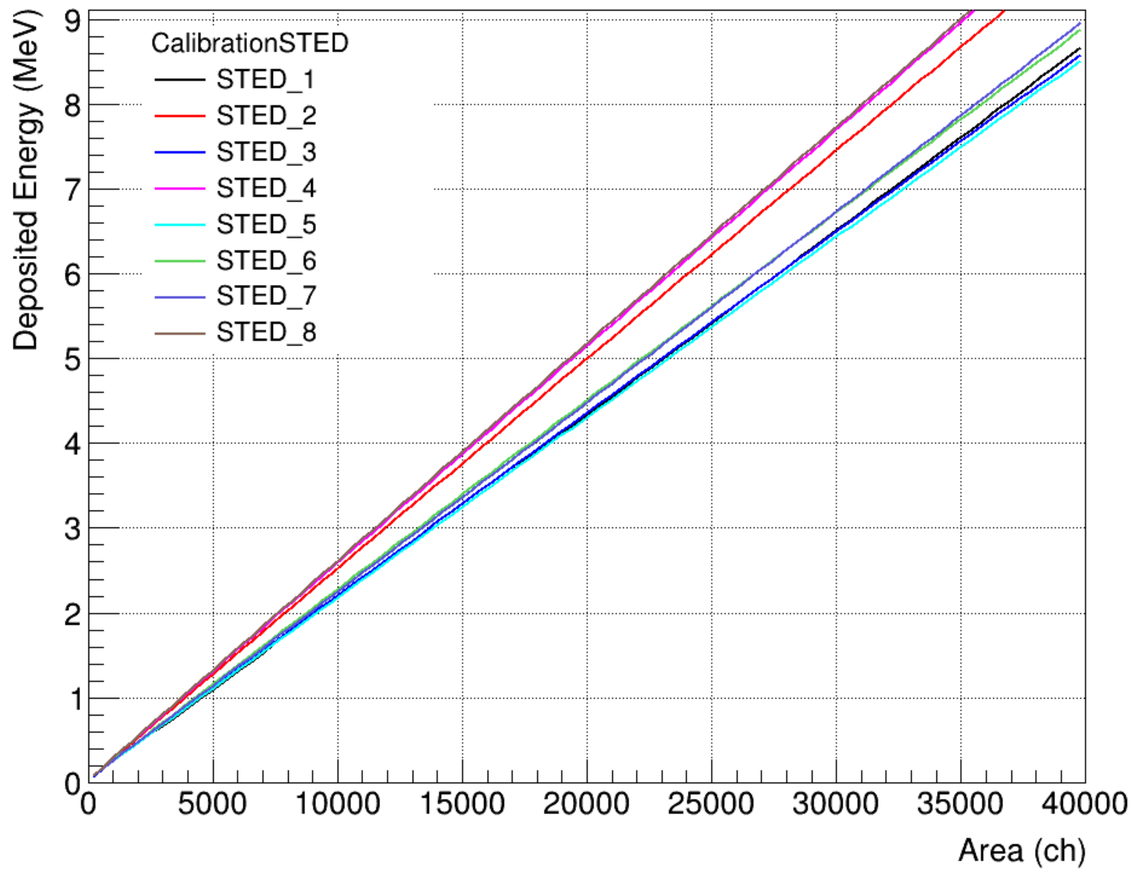
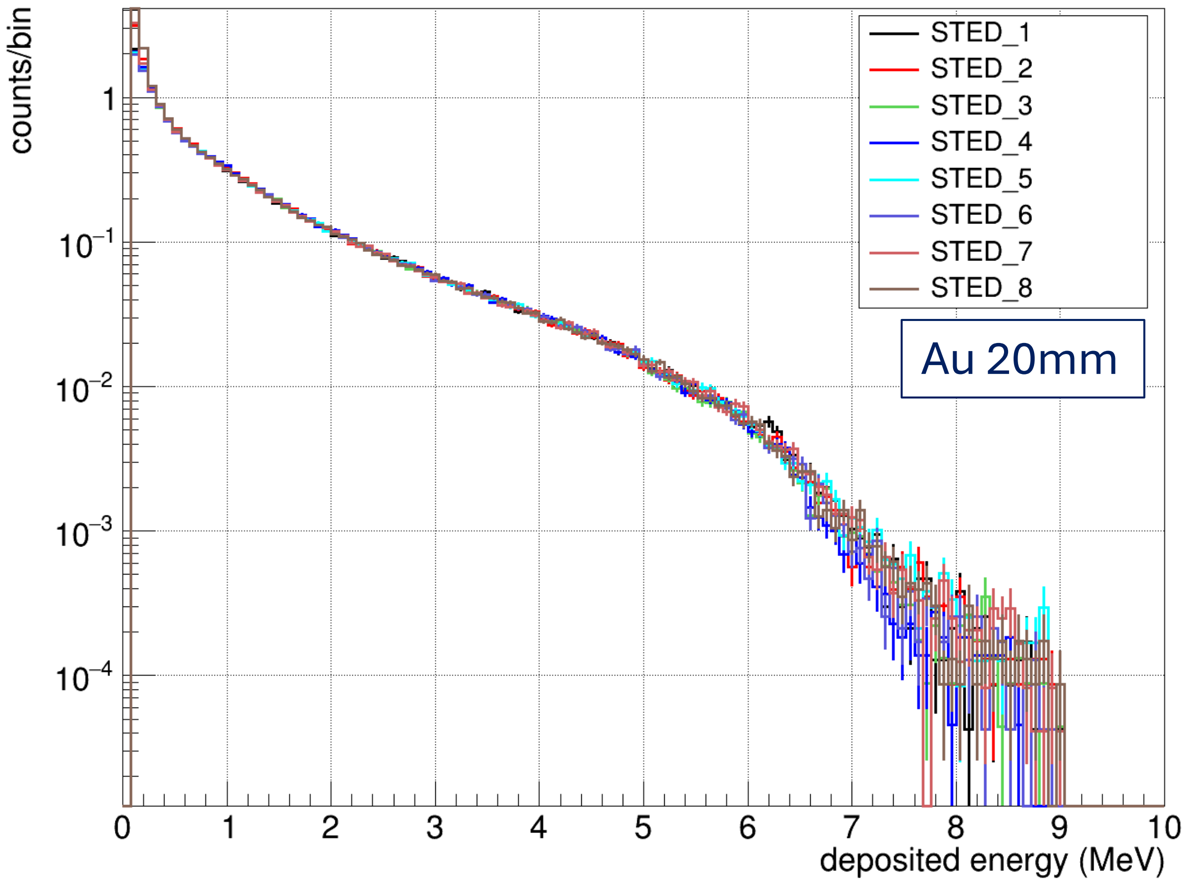
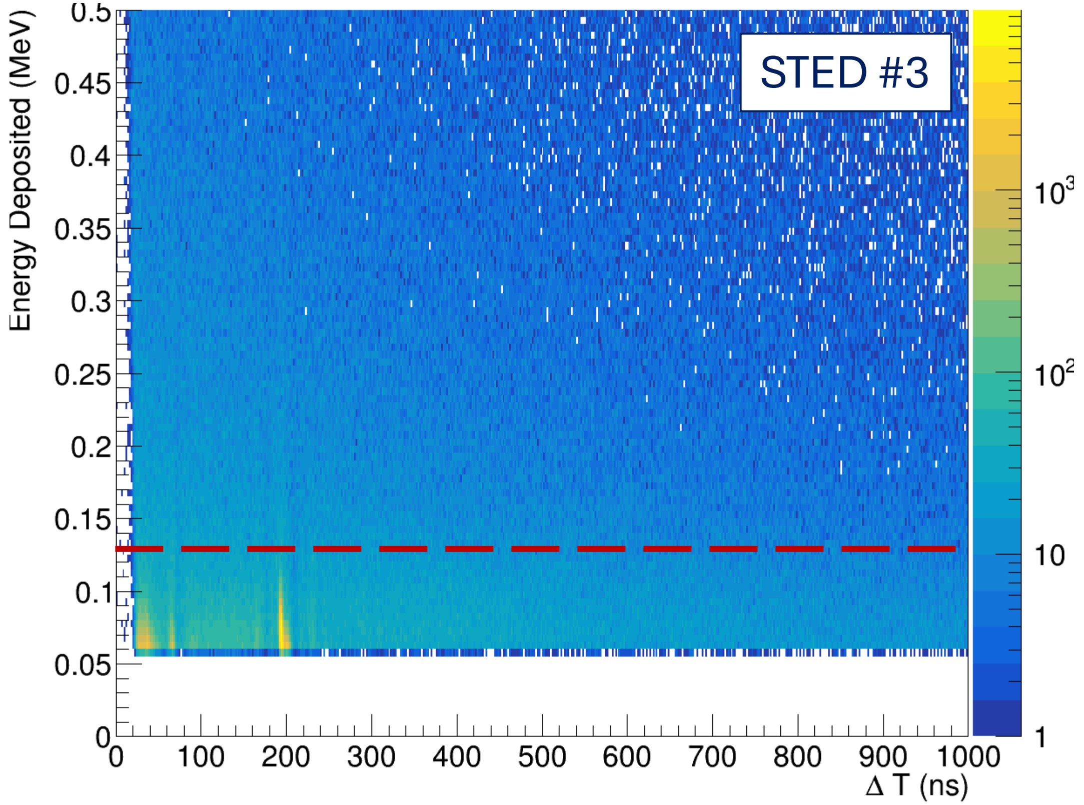
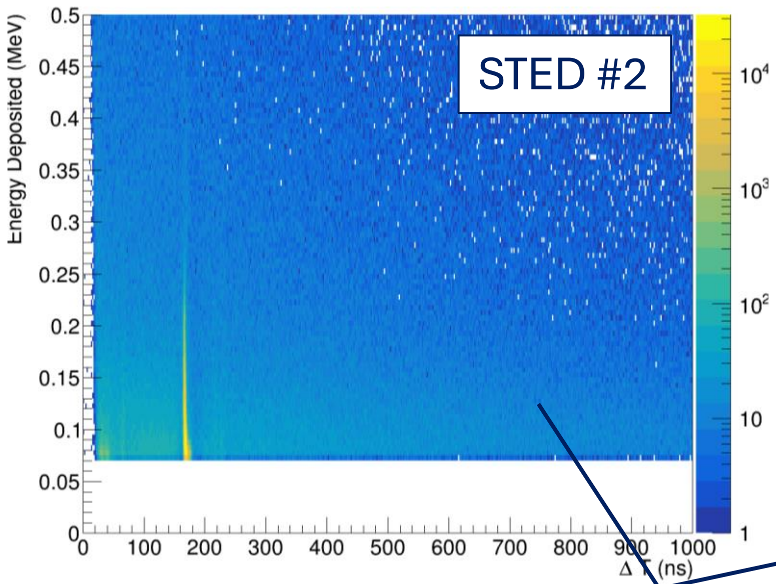


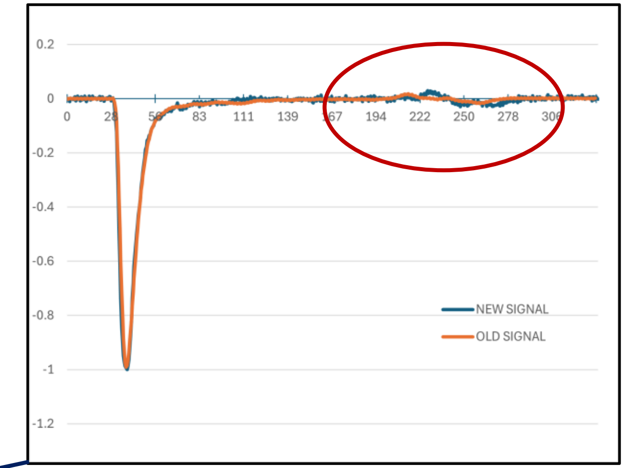


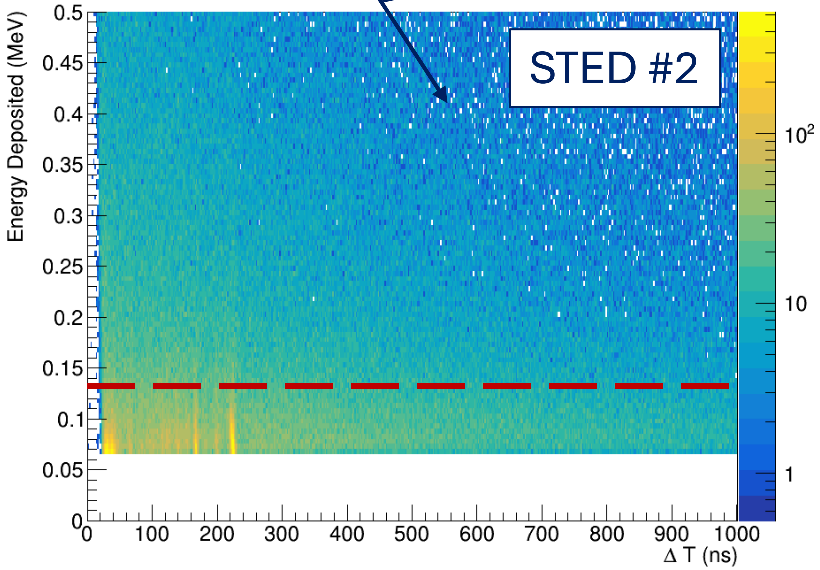
EAR2: Thresholds STED

STED rebounds have been fixed adjusting the **PSA**. Energy deposited thresholds can be set at **130 keV**.

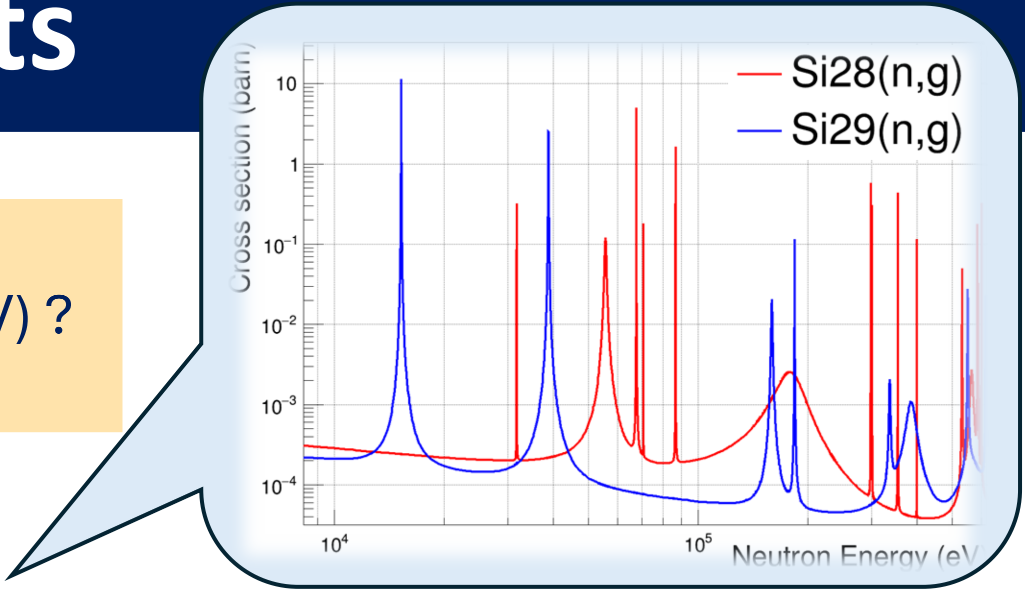




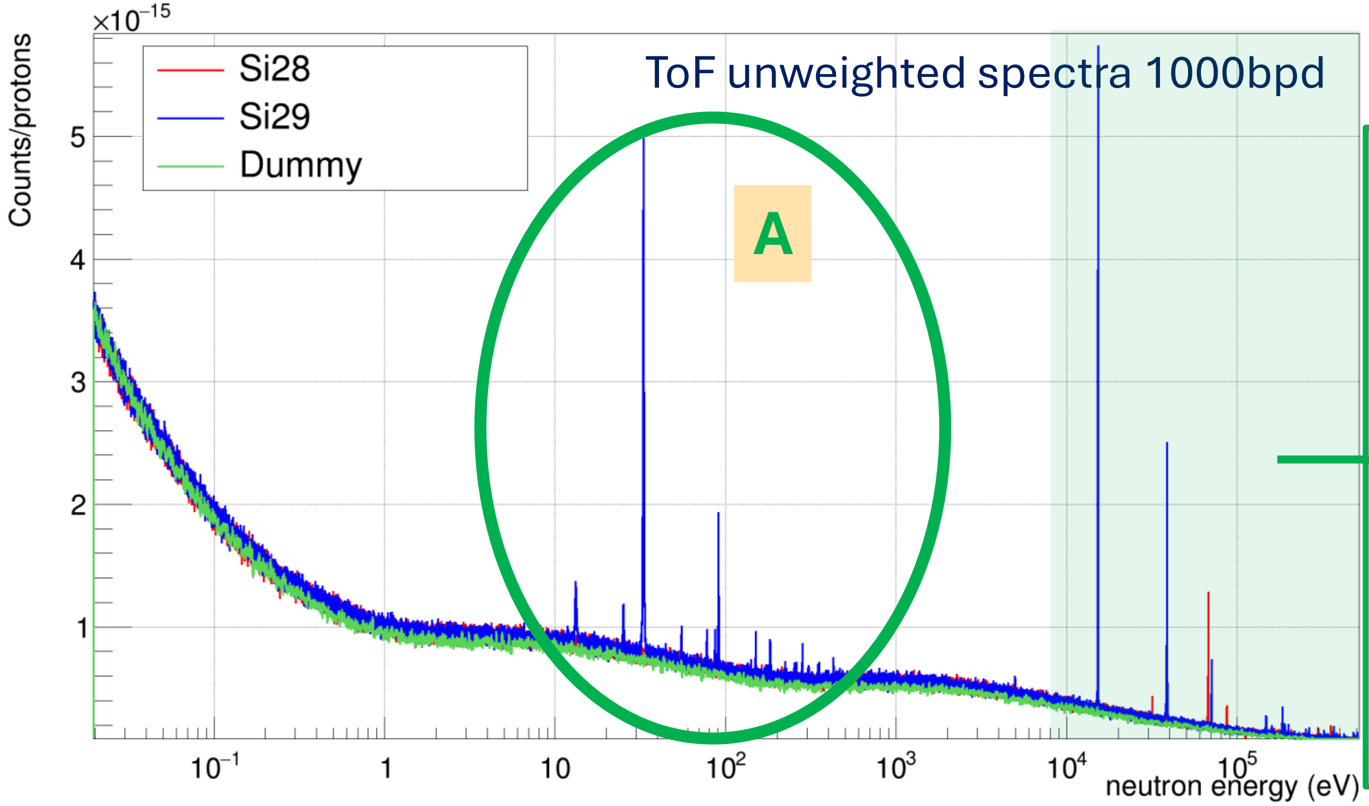


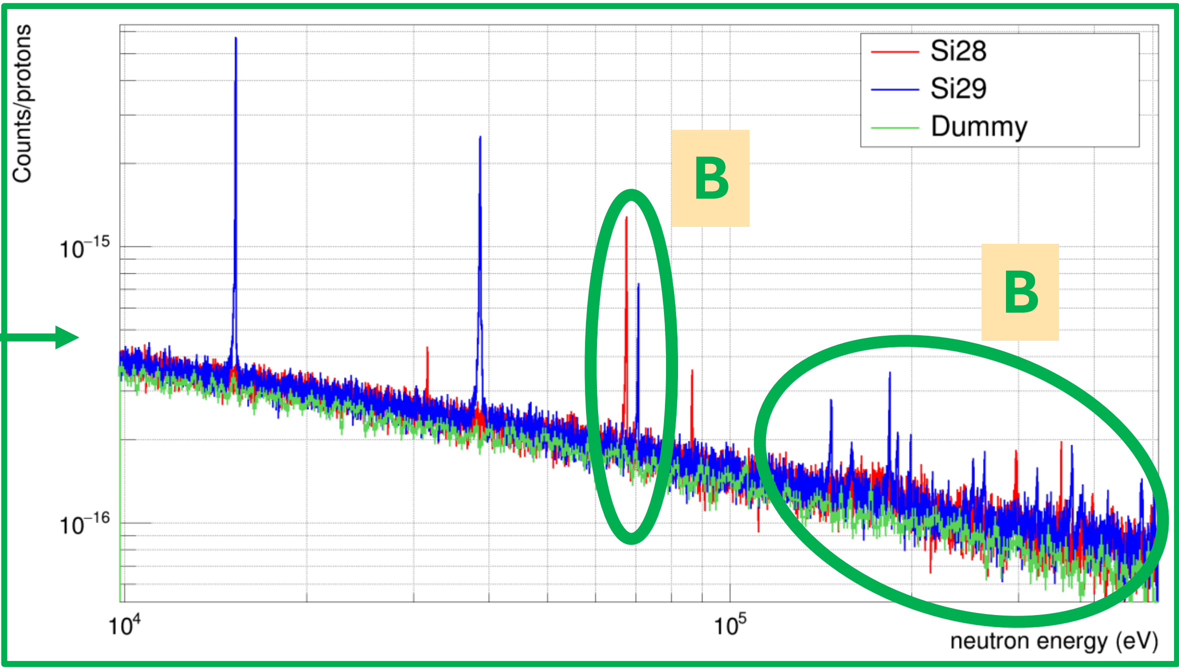


$^{28, 29}$Si(n,γ) Preliminary results



A. Contamination from **Pd** in Si29 sample ?
B. Some **"new" resonances for Si29** (≈ 70 keV, > 100 keV) ?
C. Some resonances not seen in **Si28**





Summary

^{30}Si(n,γ) EAR1

- *July 2023*
- Measurement
- Preliminary results EAR1
- Detector calibrations EAR1
- WF EAR1
- Yield EAR1
- *Sept 2024*
- Resonance Fitting EAR1
  High Energy (> 100 keV) resonances
- *June 2025*
- EAR2 (thermal)

^{64}Ni, ^{30}Si(n,γ) EAR2

- *August 2023*
- Measurements
- Preliminary results
- Detector calibrations
- WF — STED
- Yield
- *Spring 2025*
- Resonance Fitting
- *2025*
- Papers

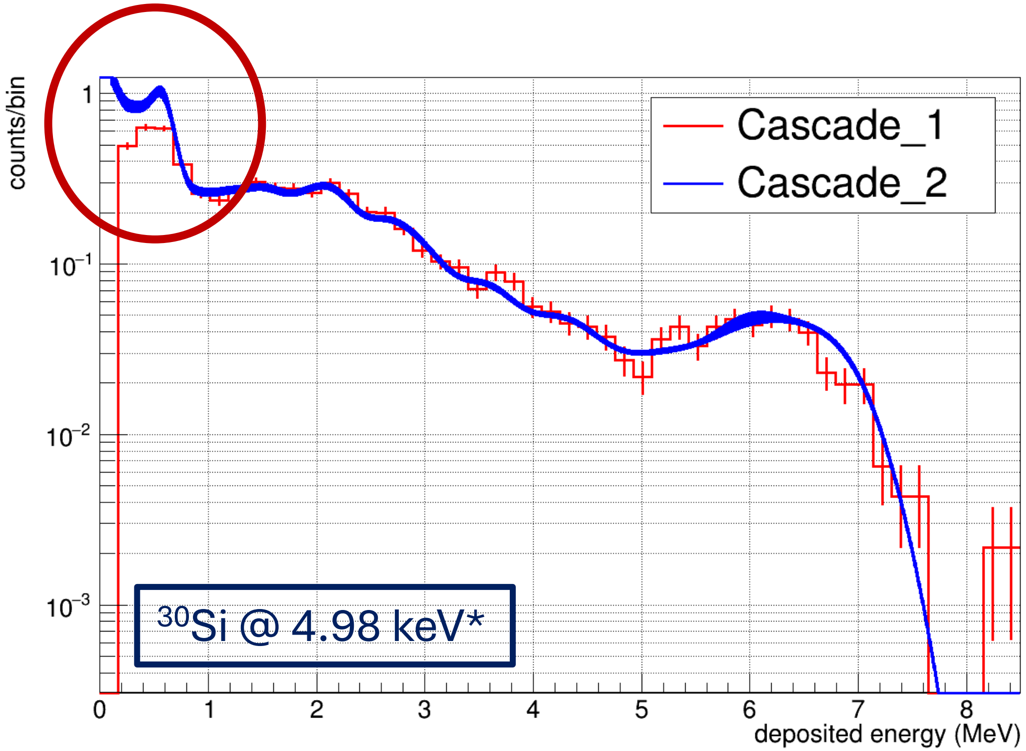
$^{30}Si(n,\gamma)$ & $^{64}Ni(n,\gamma)$: Status of the Analysis

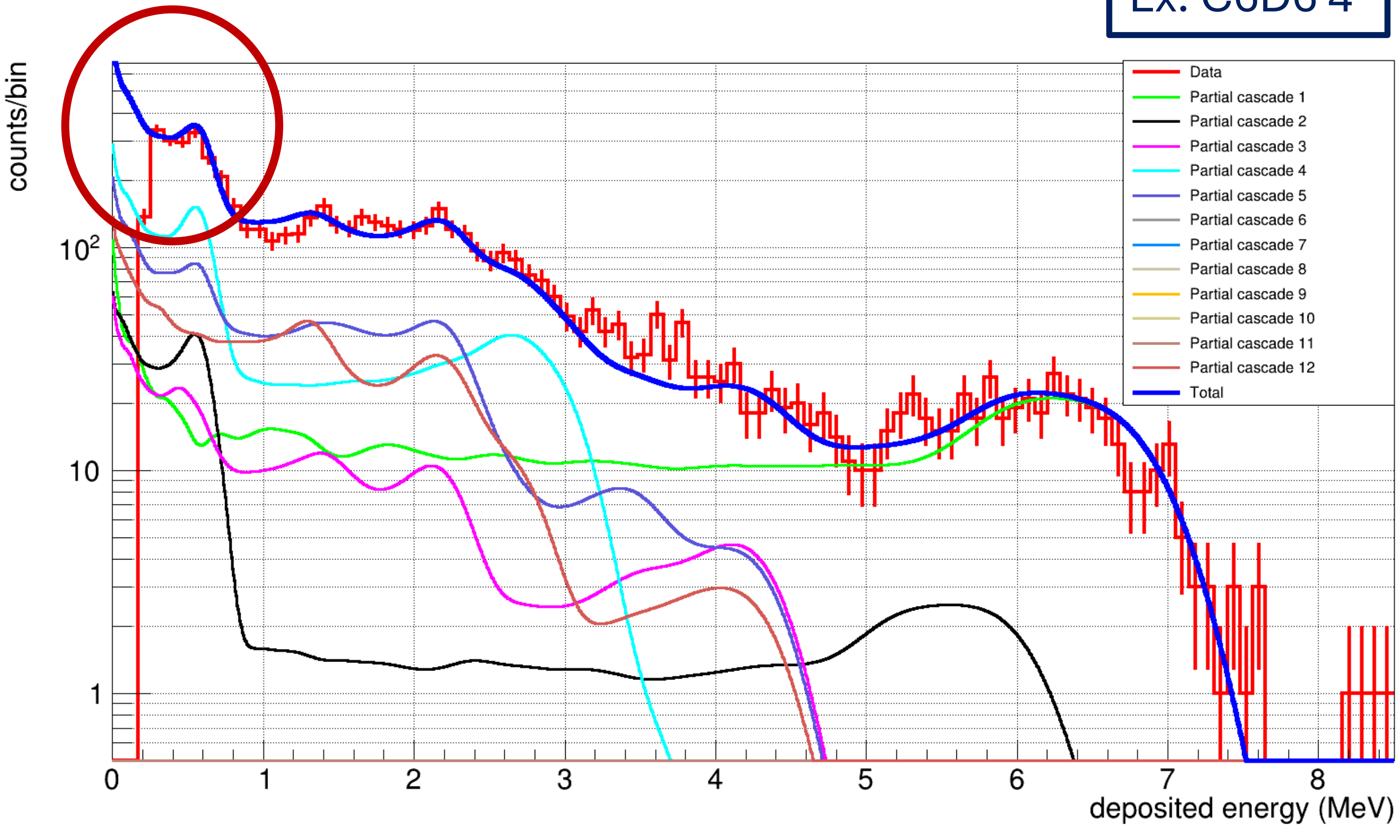
Michele Spelta

^{30}Si(n,γ) EAR1: Yield Corrections

^{31}Si de-excitation cascade for the 4.98 keV resonance has been tuned using **NUDEX** to correctly reproduce the measured spectrum (tuning of the primary transition probability)

Ex: C6D6 4

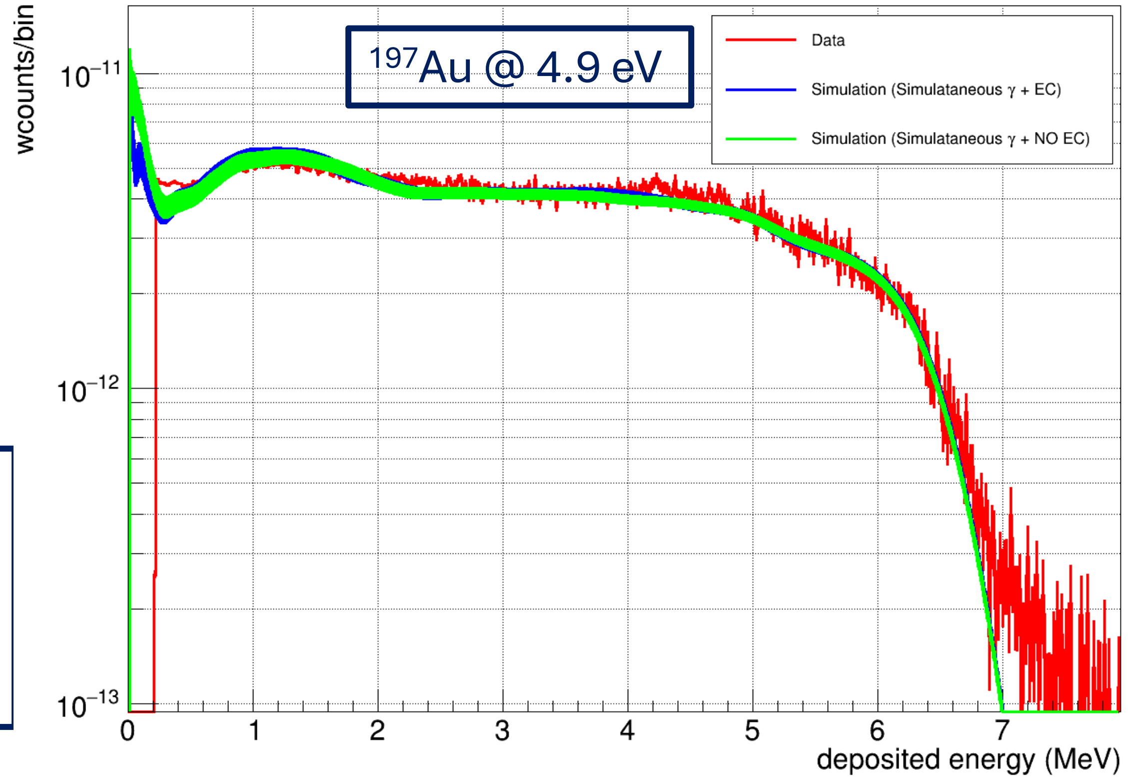




^{30}Si(n,γ) EAR1: Yield Corrections

Gold de-excitation cascade for the 4.9 eV resonance has been simulated using **NUDEX** to correct for the threshold and electron conversion.

Ex: C6D6 4



	C6D6 1	C6D6 2	C6D6 3	C6D6 4
Total w counts **no thrshold** (Au)	1.0396	1.0440	1.0364	1.0460
Total w counts **+ EC** (Au)	1.0103	1.0138	1.0079	1.0060
Total w counts no thr + EC (Au)	**1.0503**	**1.0584**	**1.0446**	**1.0522**

^{30}Si(n,γ) EAR1: High Energy Region

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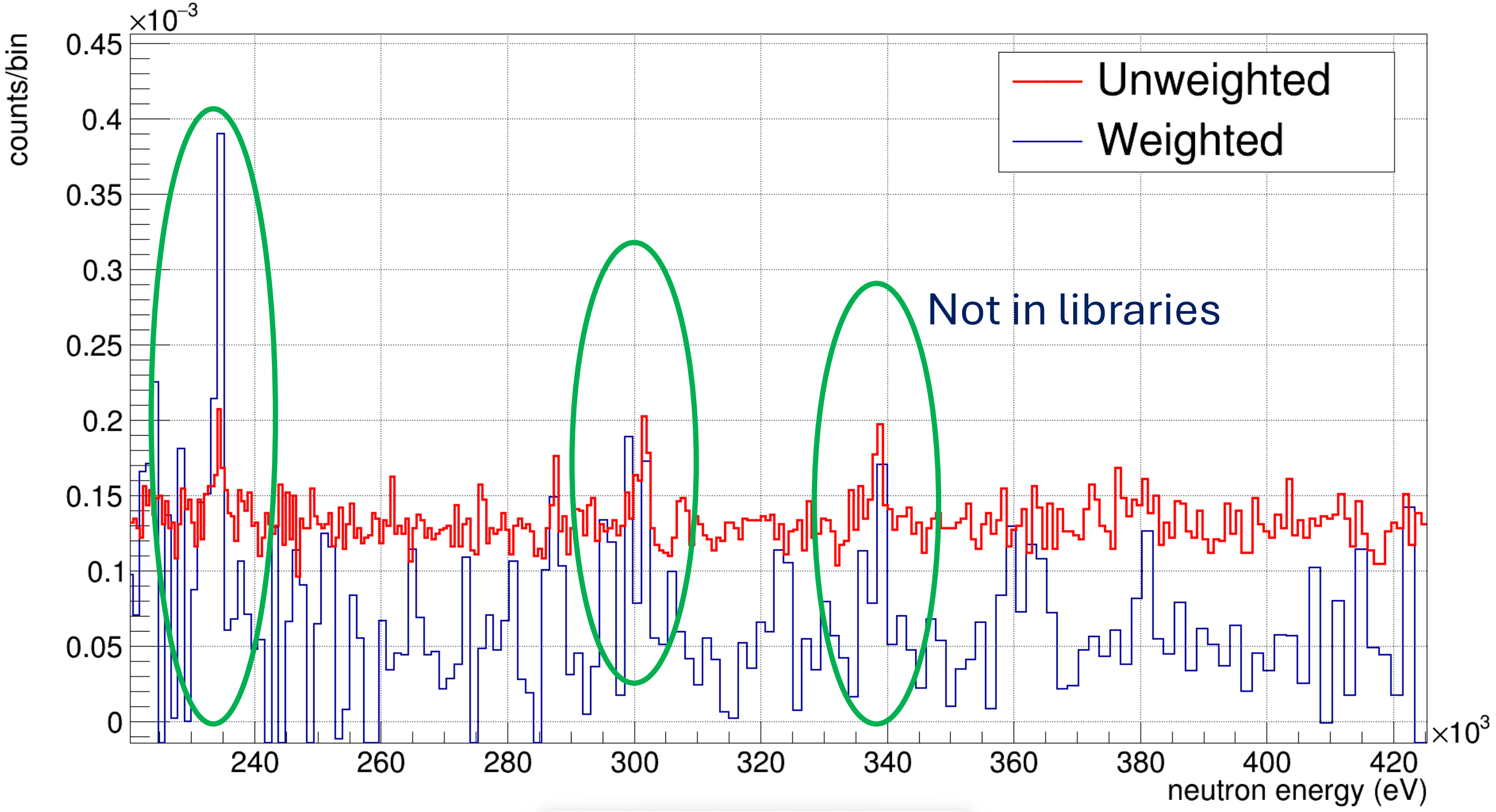

EAR2: Calibrations STED

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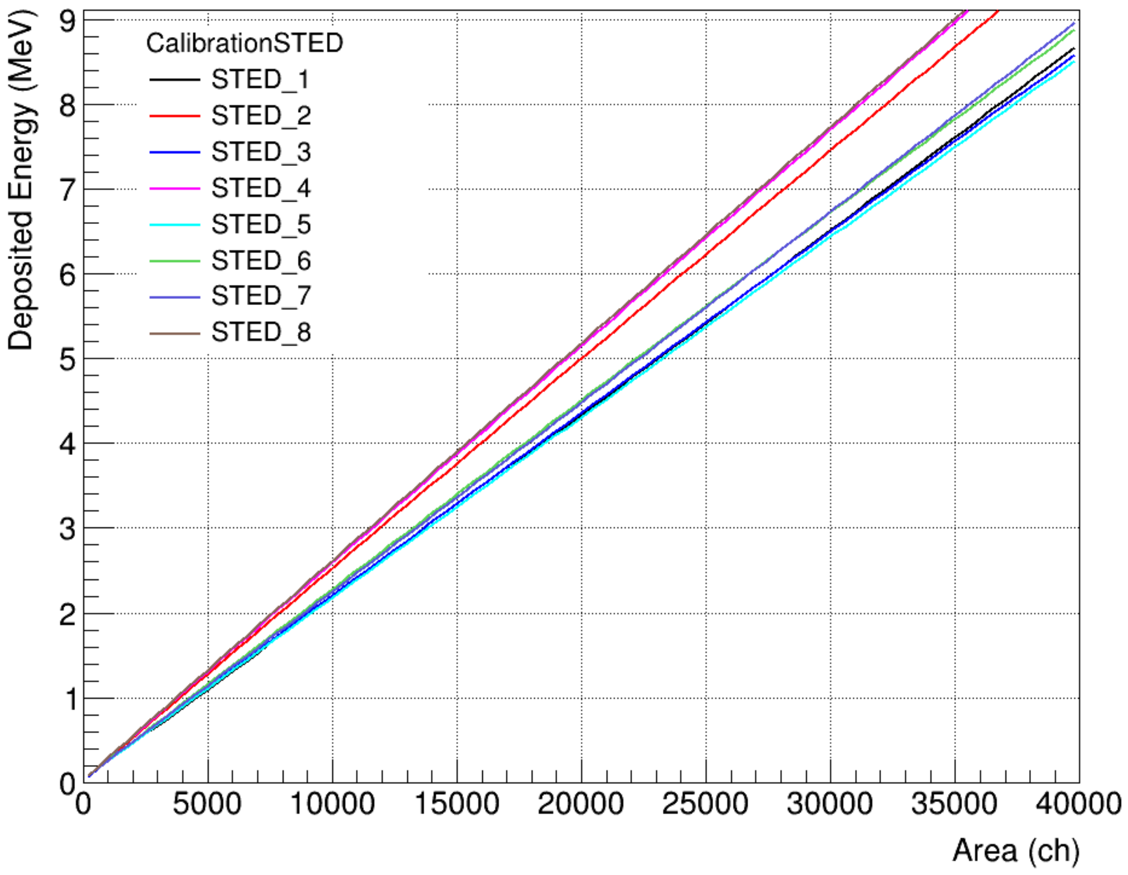
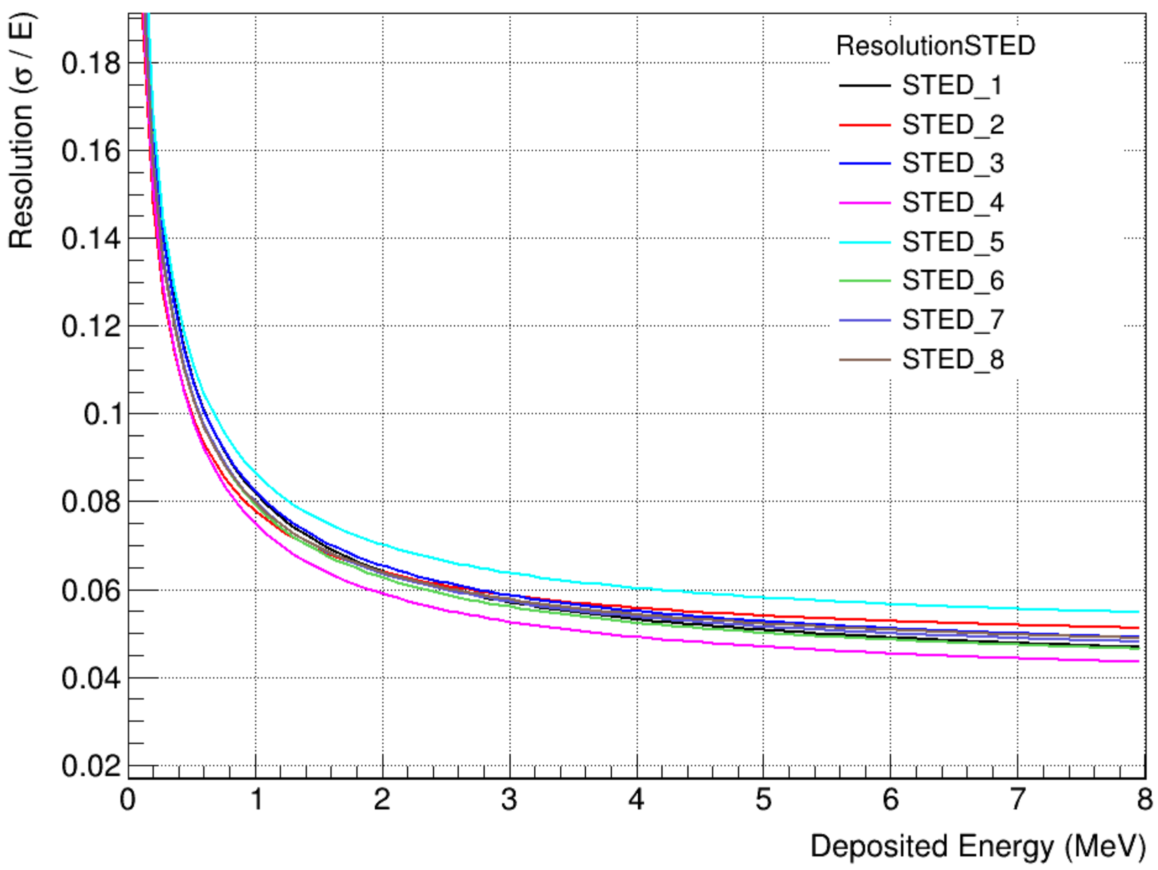
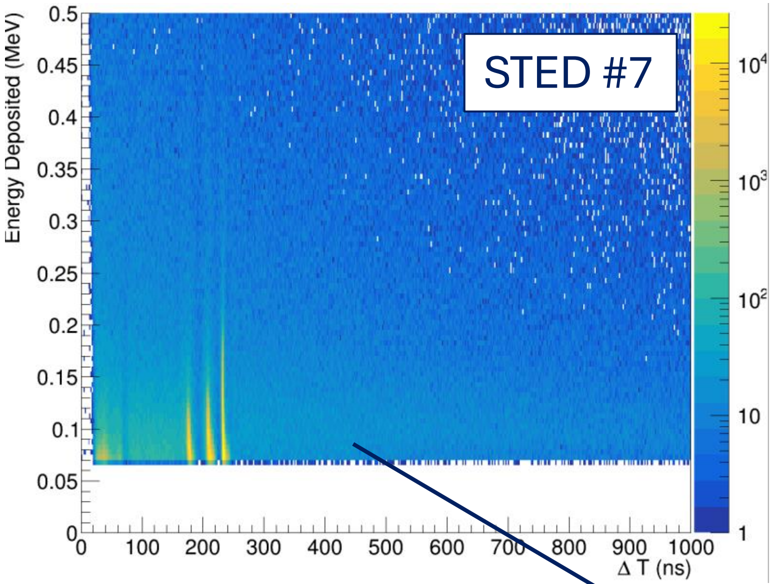




EAR2: Thresholds STED



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