$^{64}Ni(n,\gamma)$ & $^{30}Si(n,\gamma)$

Motivations and Preliminary Results

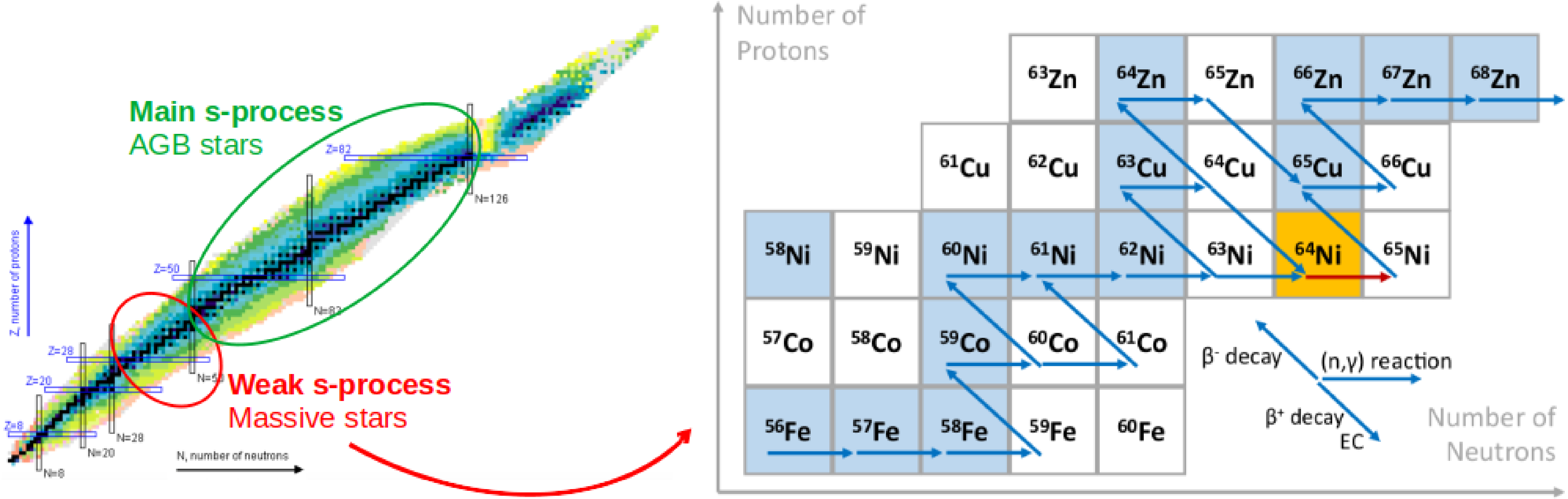
Michele Spelta

Outline

- Motivations
- State of the art
- Measurements
- Preliminary Results (ToF spectra)
- Ongoing analysis

^{64}Ni(n,γ): Motivations

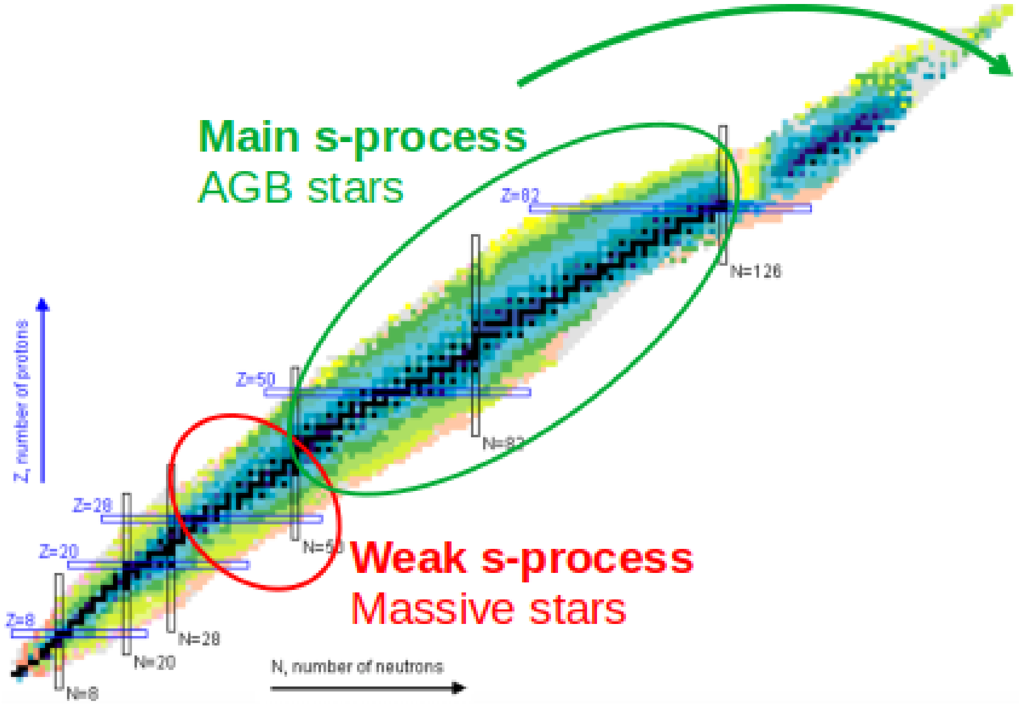
^{64}Ni is one of the **seeds of the s-process** and the knowledge of its capture cross section is essential to simulate the **weak s-process in massive stars**.

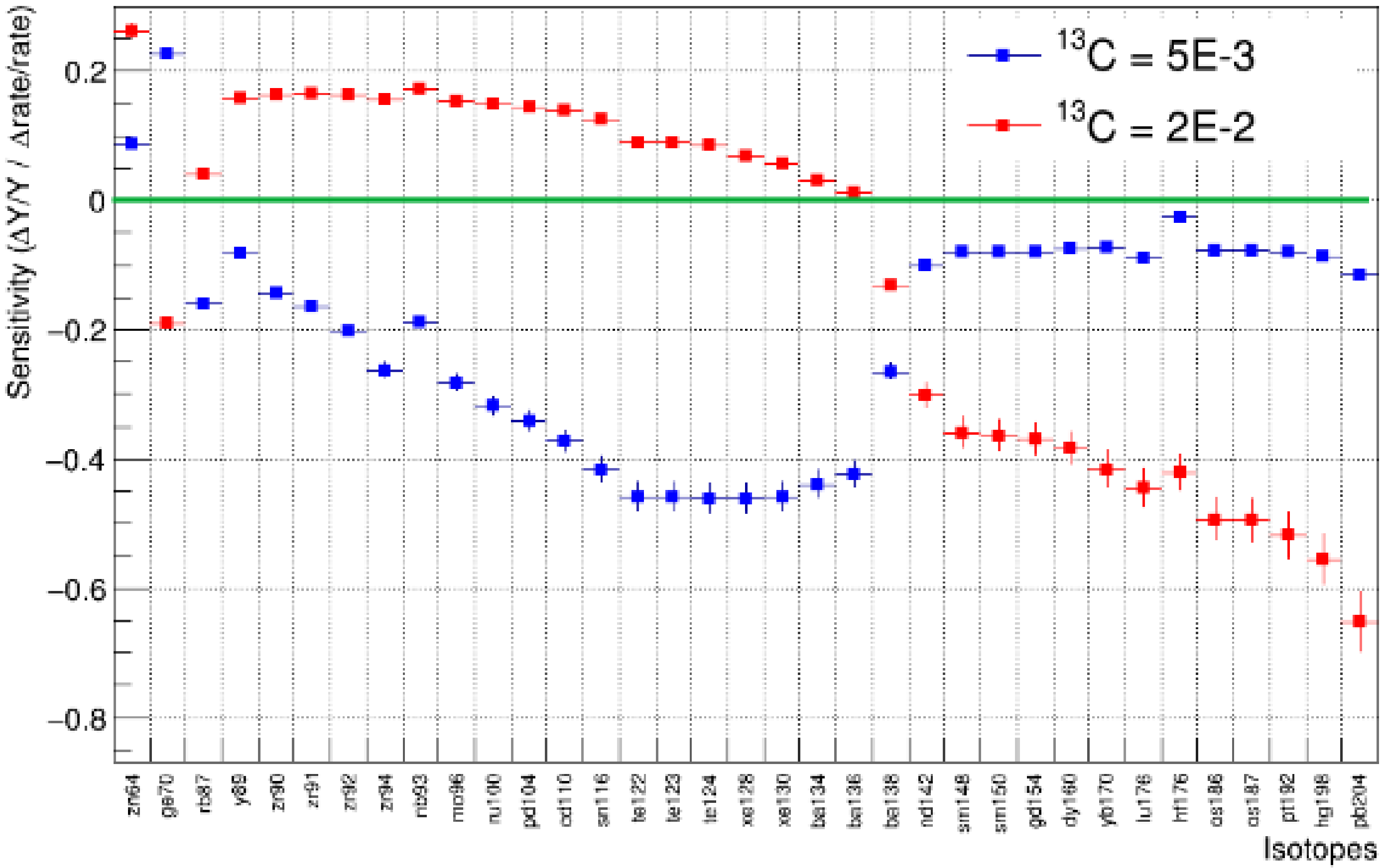


^{64}Ni(n,γ): Motivations

As a **"bottleneck"**, ^{64}Ni(n,ɣ) was also found to affect the isotopic abundances of many isotopes from the **main s-process in AGB stars**.

***Cescutti et al.**, MNRAS 478, 4101 – 4127 (2018)*

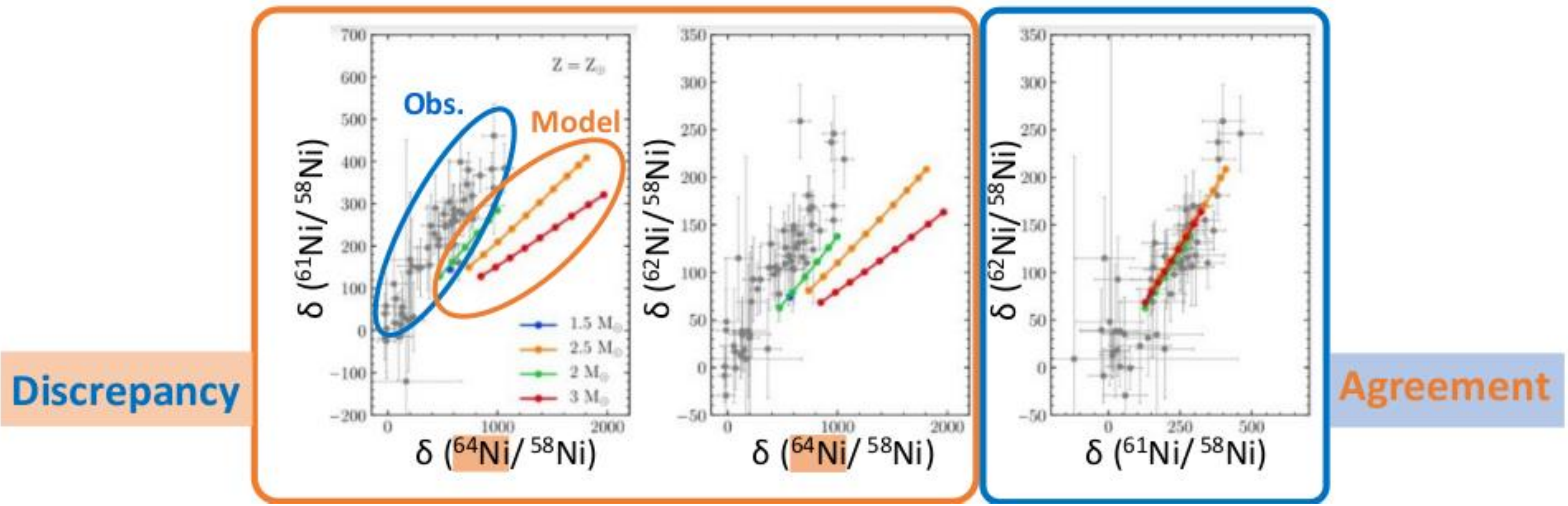




^{64}Ni(n,γ): Motivations

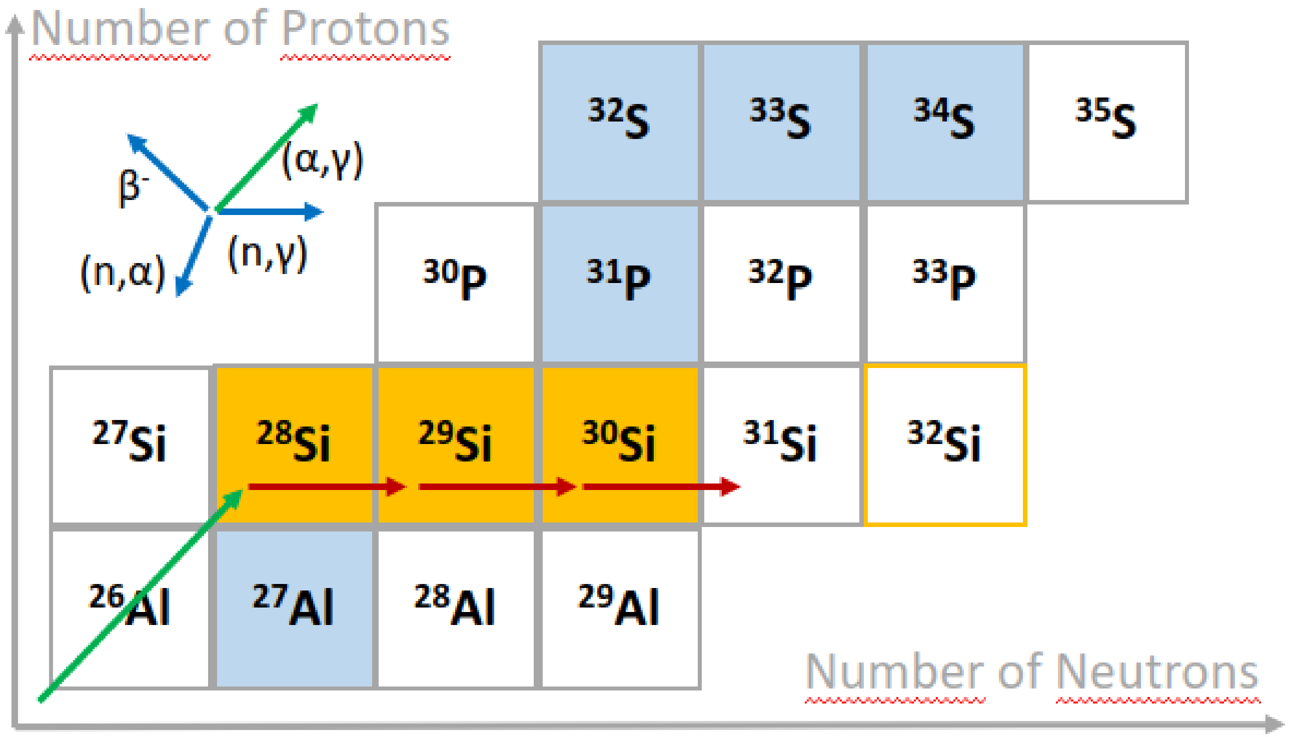
Discrepancy observed in SiC grains between measured isotopic ratios and predictions from magnetic-buoyancy induced mixing models in AGB stars.

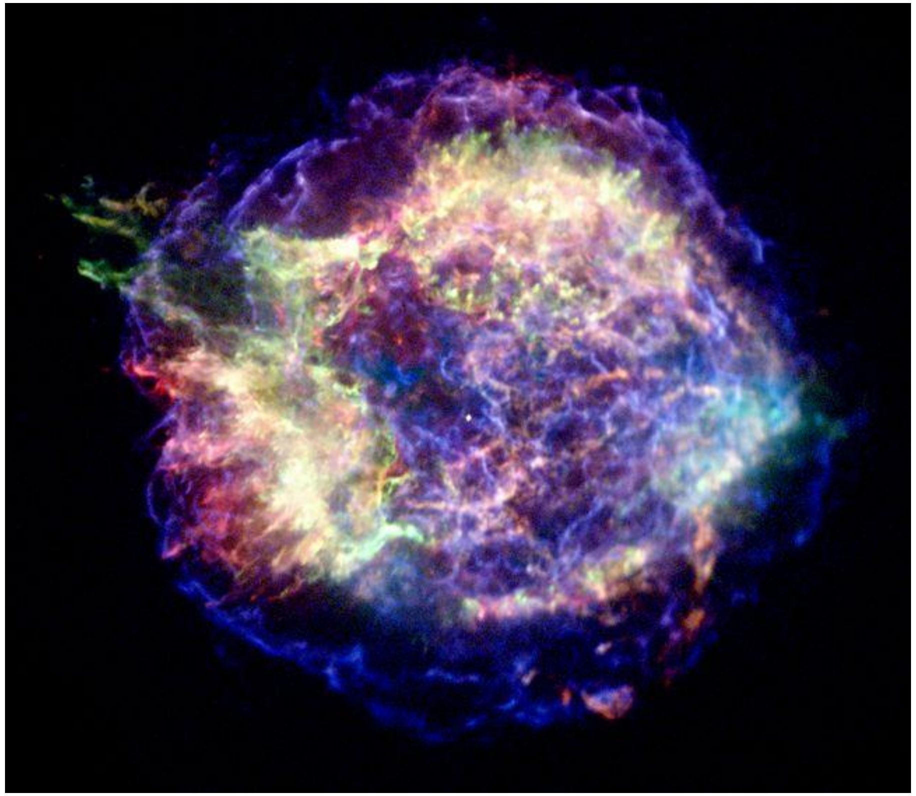
***D. Vescovi** et al., ApJ Lett., 897 (2020) 25*



^{30}Si(n,γ): Motivations

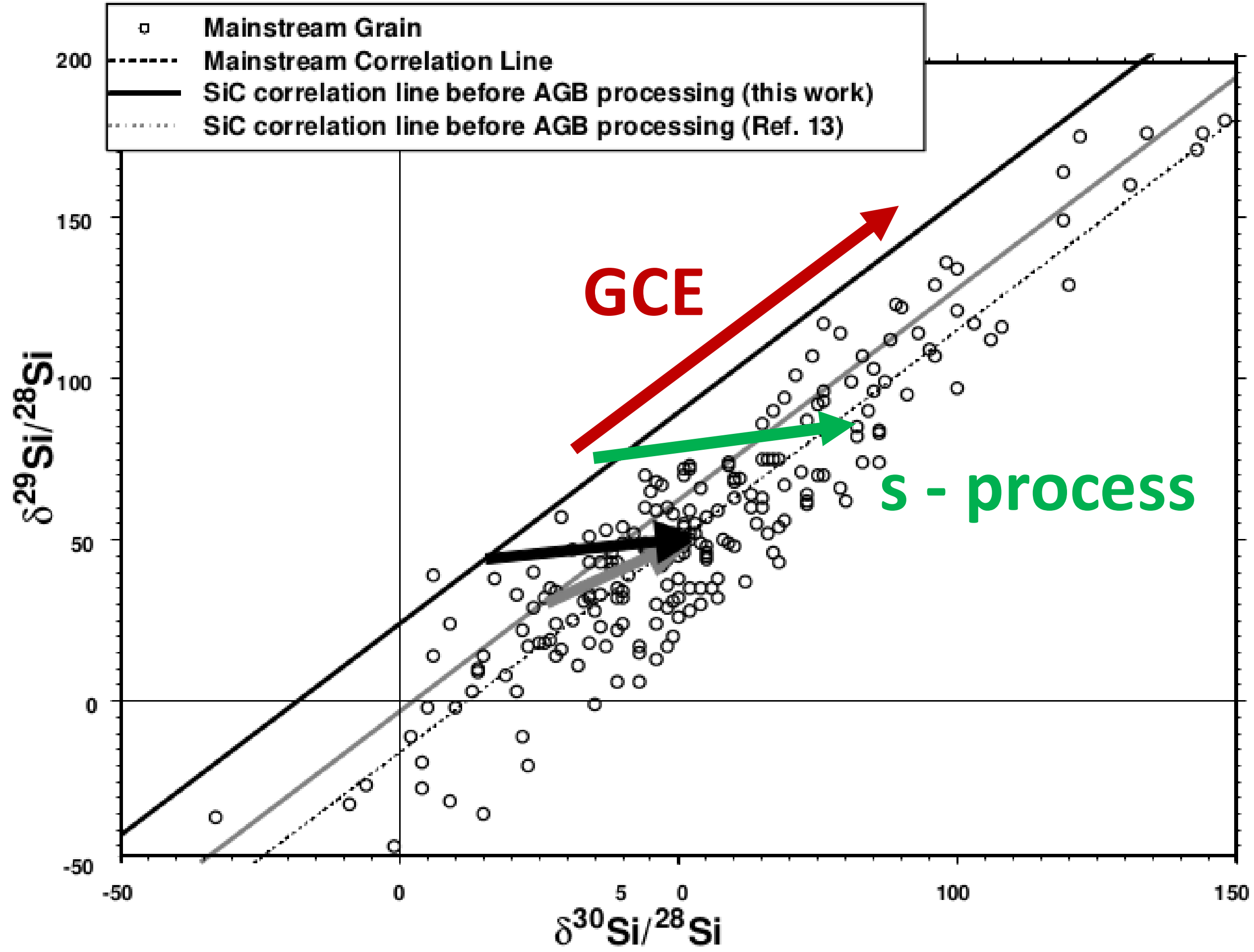
^{28}Si is mainly produced by α process, ^{29}Si and ^{30}Si are produced by **neutron capture reactions** mainly in the convective carbon shell of **massive stars** and released in **SN explosions**.





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

^{28}Si, ^{29}Si, $^{30}Si(n,\gamma)$ are important to explain the **isotopic ratios measured in SiC grains** (acc. < 5%)



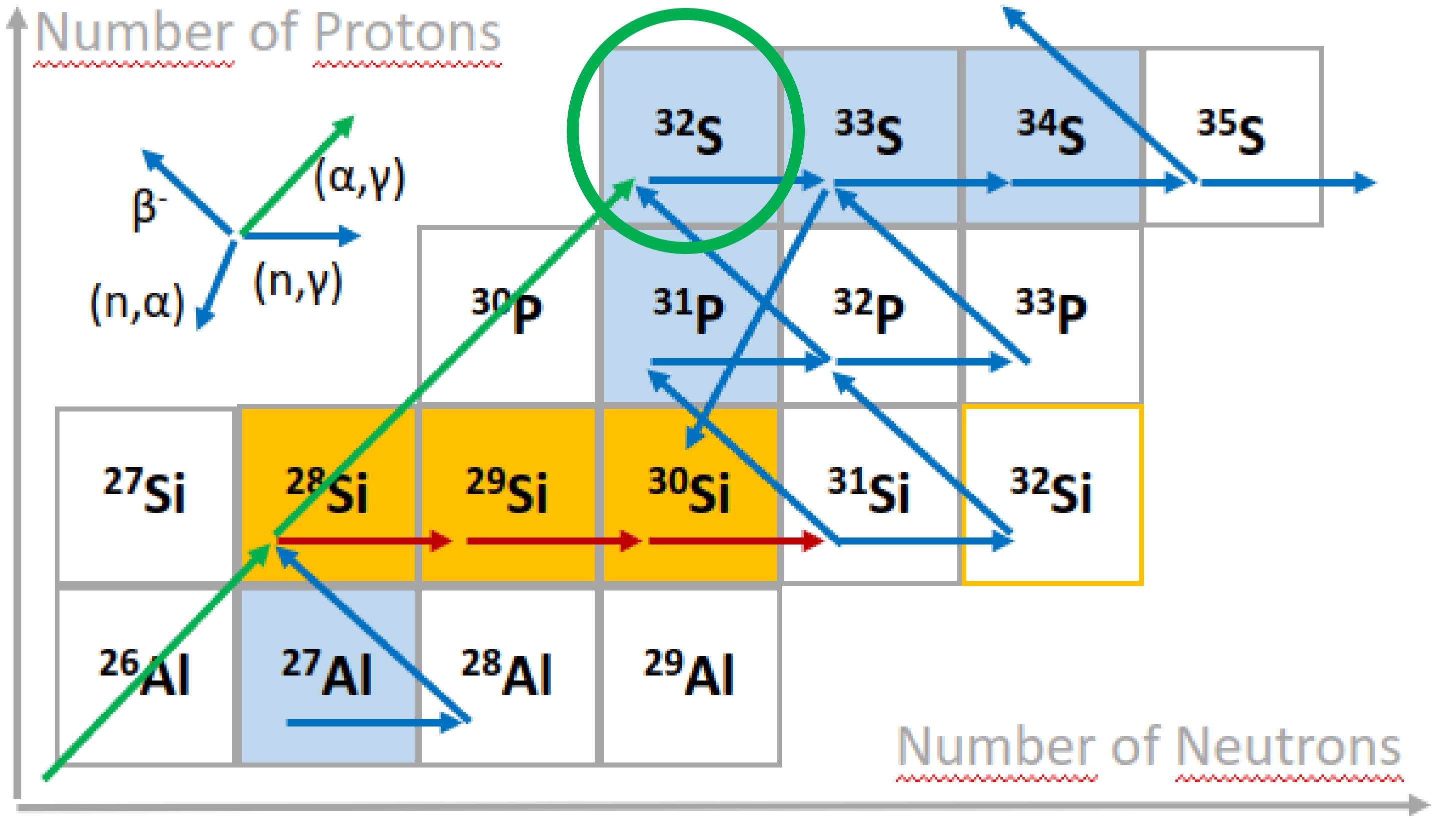
Mainstream SiC
from AGB

GCE vs s-process

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

^{30}Si(n,γ): Motivations

^{28}Si, ^{29}Si, ^{30}Si(n,ɣ) are important to explain the **isotopic ratios measured in SiC grains** (acc. < 5%)

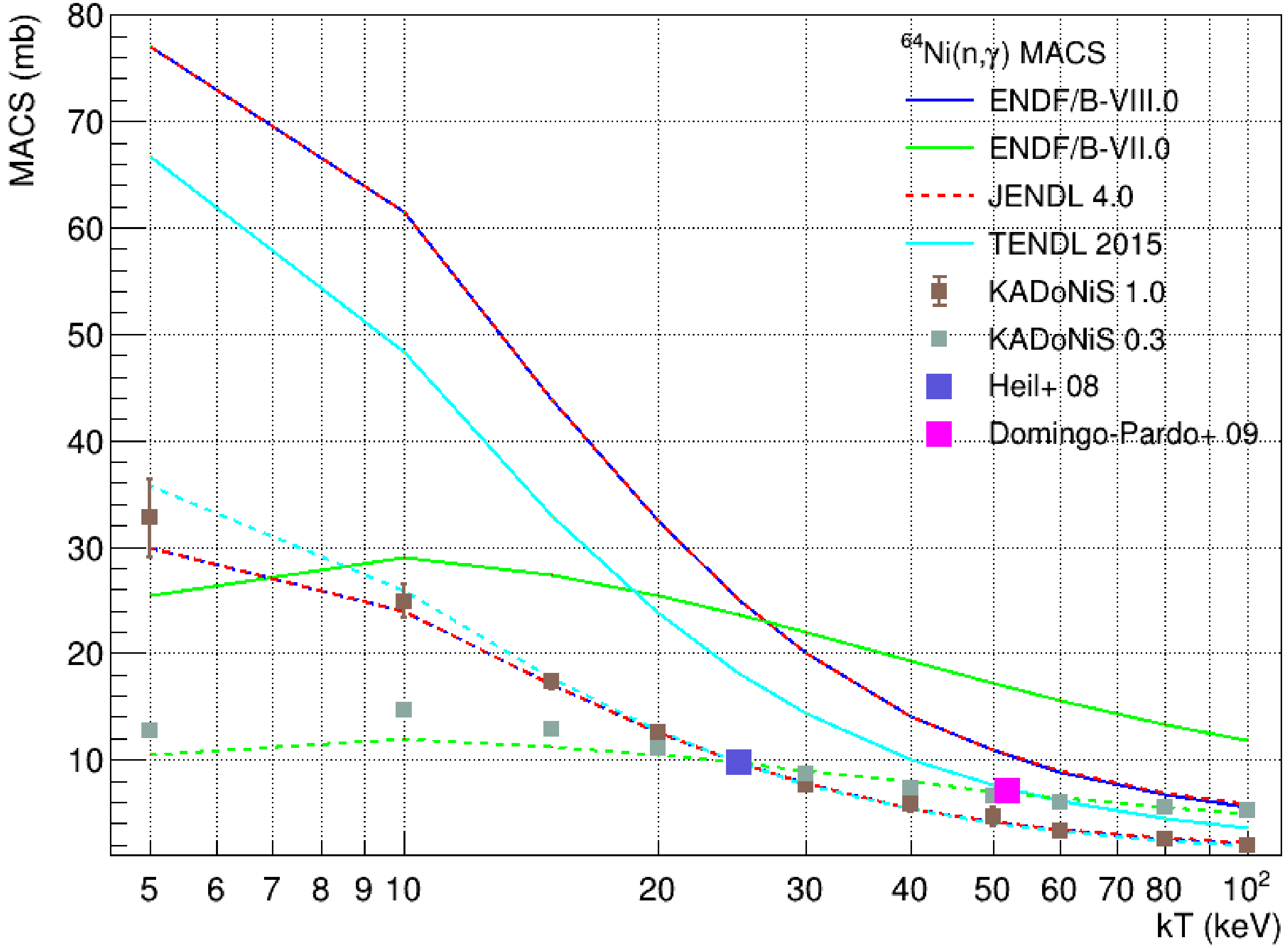


Type C SiC
from SN explosions

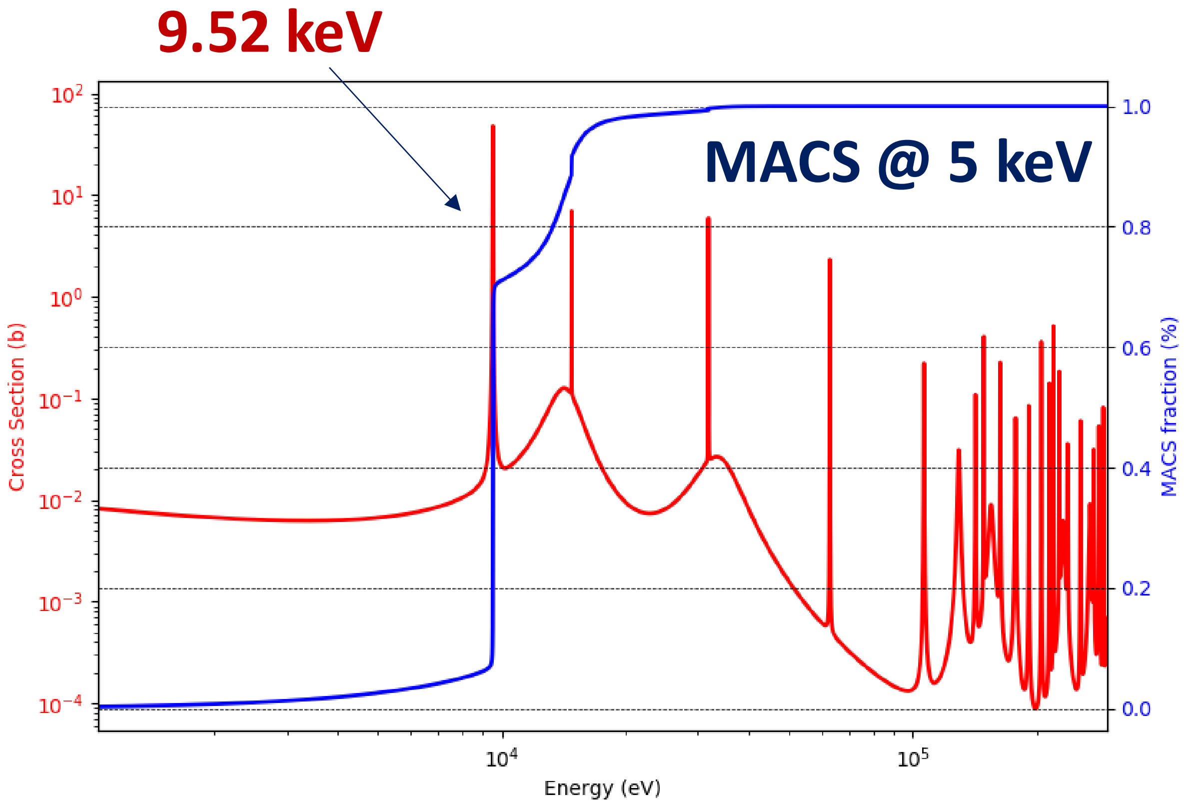
Constrain on neutron density in SN

^{64}Ni(n,γ): State of the art

Only **a few discrepant measurements available** in literature, leading to discrepant MACS



***Hockenbury et al.**, Phys. Rev. 178 (1969) 4*



^{30}Si(n,γ): State of the art

Only **a few discrepant measurements available** in literature, leading to discrepant MACS

▼ **Recommended MACS30** (Maxwellian Averaged Cross Section @ 30keV)

^{30}Si (n,γ)^{31}Si

Total MACS at 30keV: 1.82 ± 0.33 mb

Cross sections do not include stellar enhancement factors!

▶ History

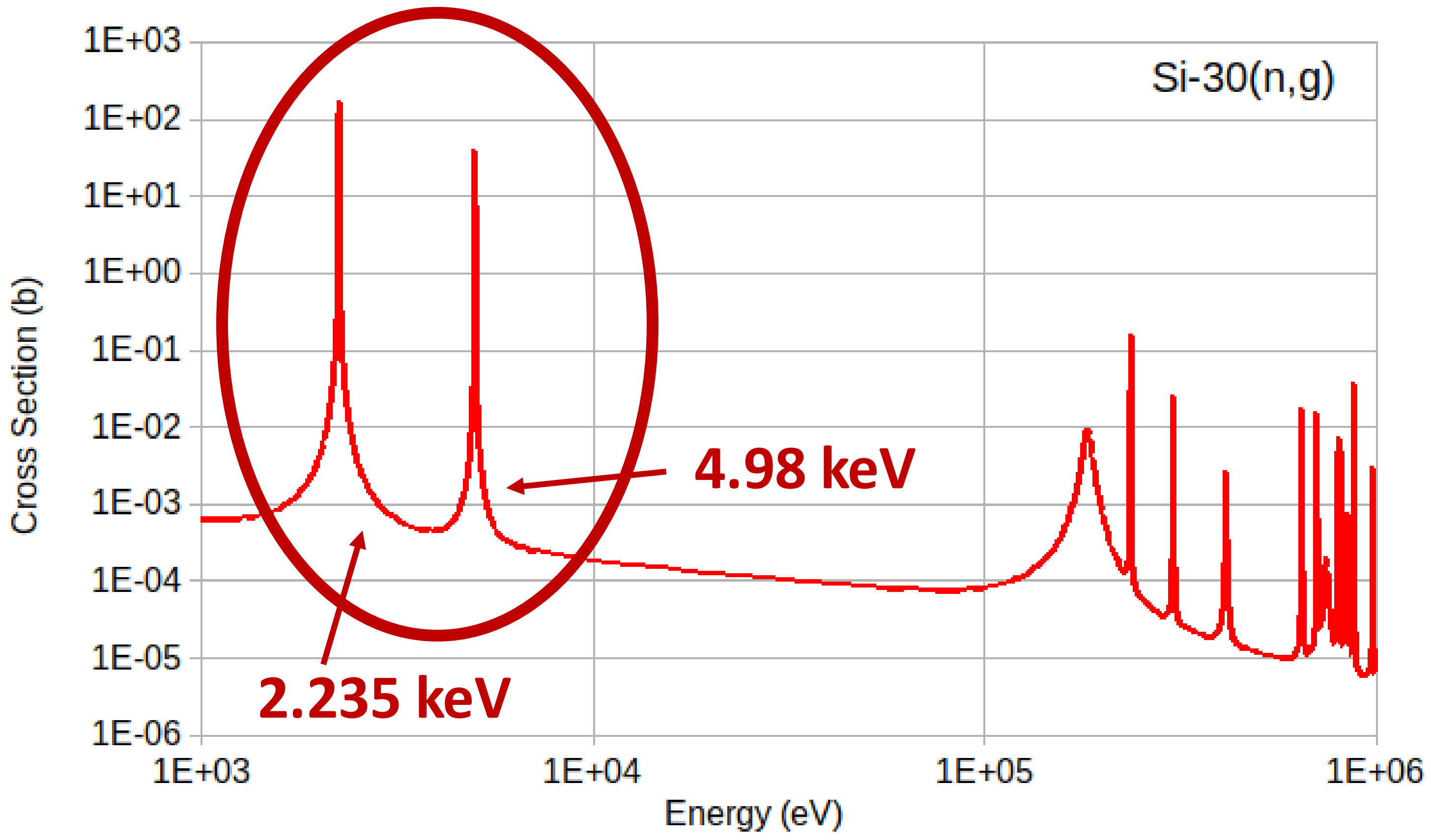
H. Beer et al., *Nucl. Phys. A 453, 062802 (2002)*

▶ Comment

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

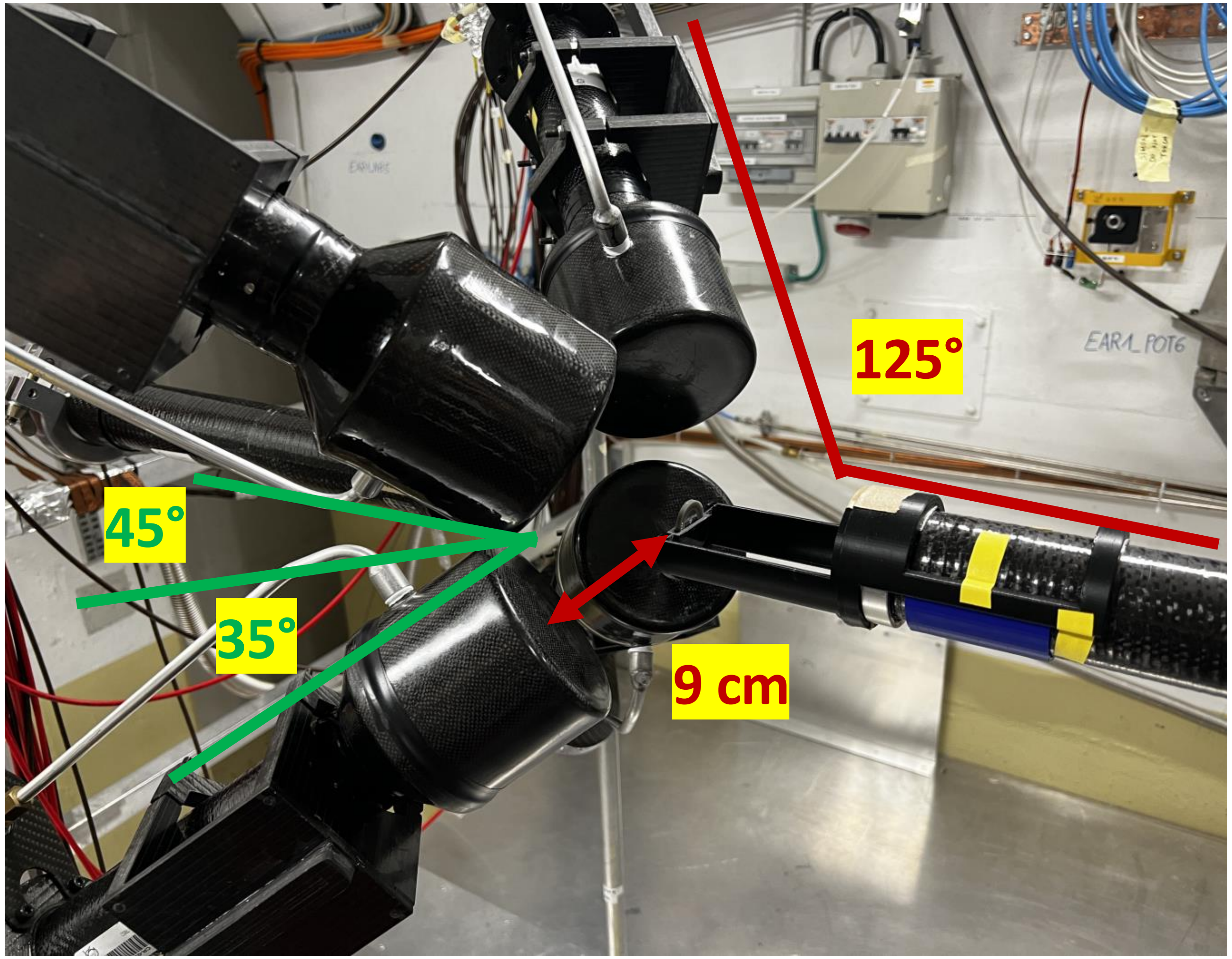
▼ List of all available values

original	renorm.	year	type	Comment
1.82 ± 0.33		2003	c	Linac, TOF, Au: Sat.; DC component is 0.48 (30) mb; no res. at
3.51 ± 0.15 kT= 25 keV	3.24 ± 0.14	2002,2015	c	VdG, Act., Au:RaK88 corrected by 632 mb/586 mb= 1.0785; DC
0.72 ± 0.07 kT= 52 keV		2002	c	VdG, Act., Au:RaK88
6.5 ± 0.6		1975	r	Linac, TOF, ^{6}Li, Au:Sat. Recalcul. including data of MDH81

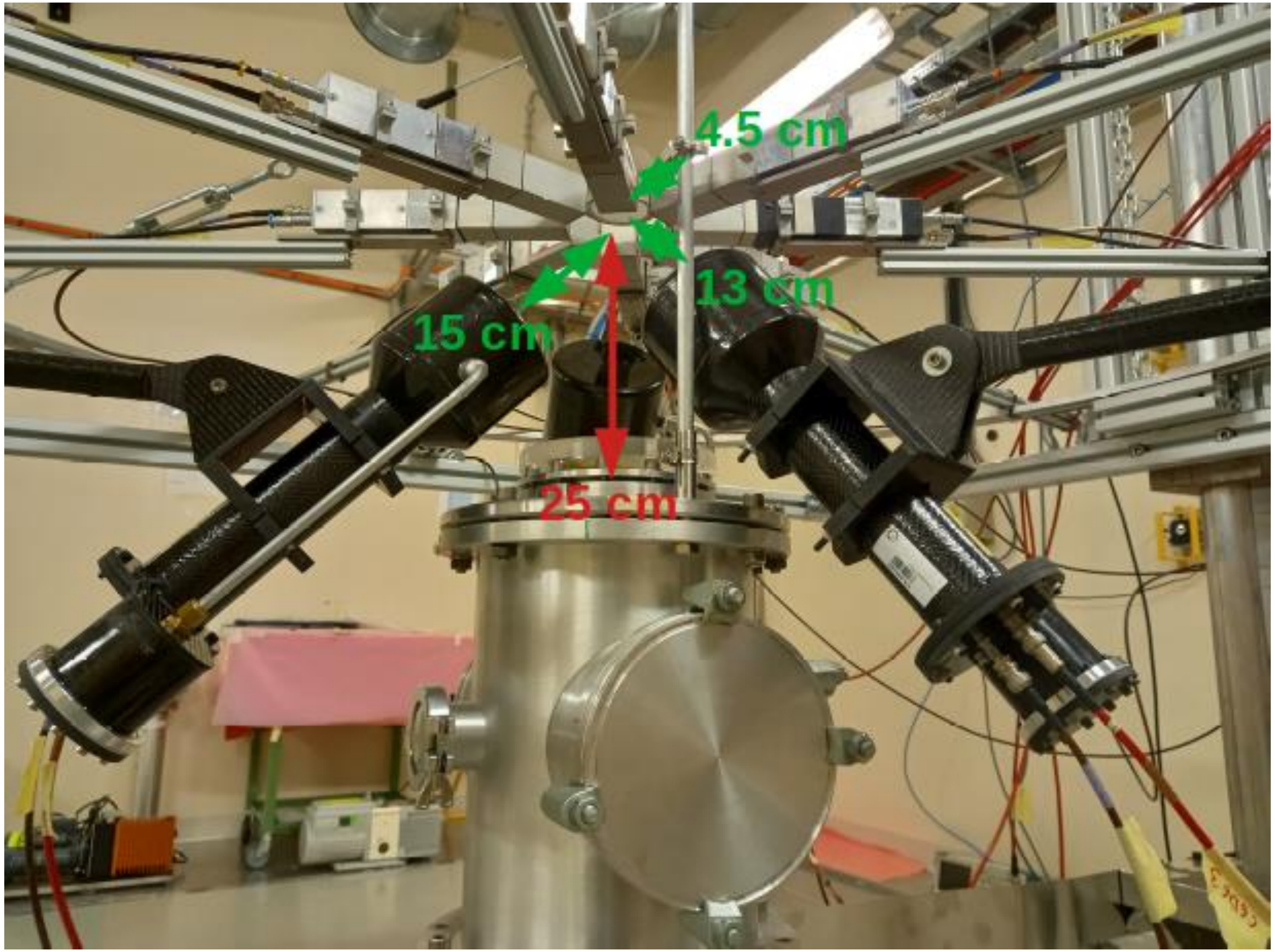


Measurement in EAR1

June – July: ^{30}**Si(n,ɣ)**, ^{nat}**Si(n,ɣ)** -> 3.81E+18 p



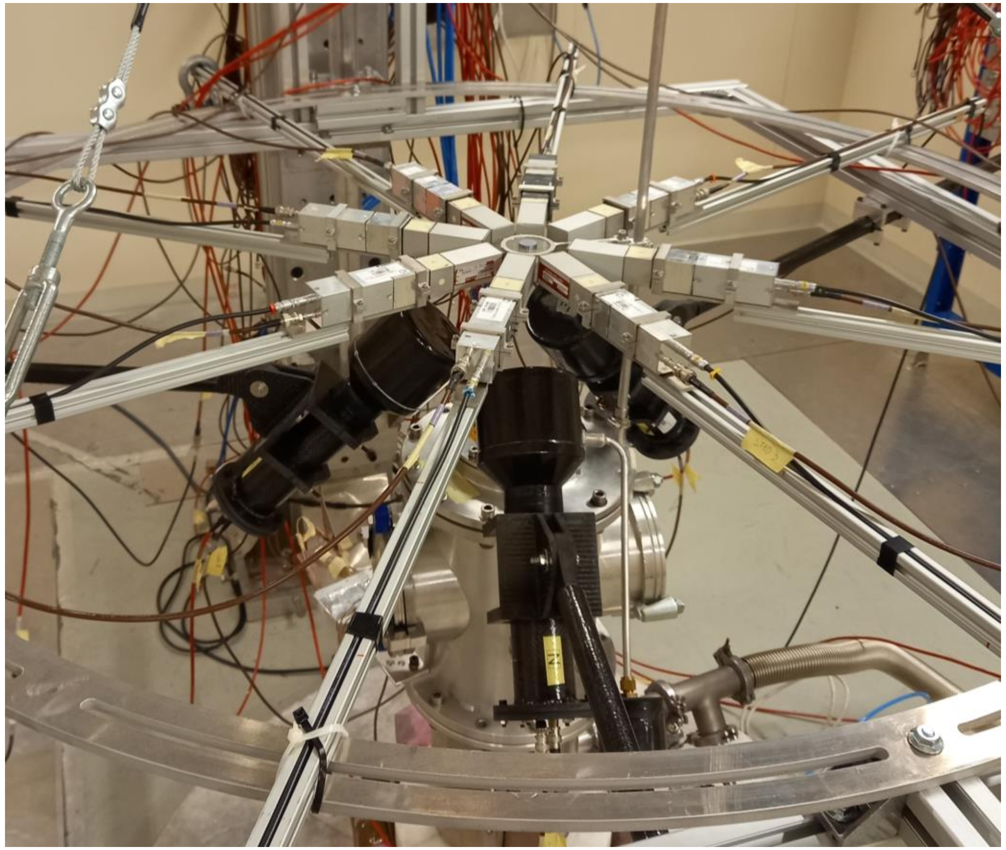
Measurement in EAR2



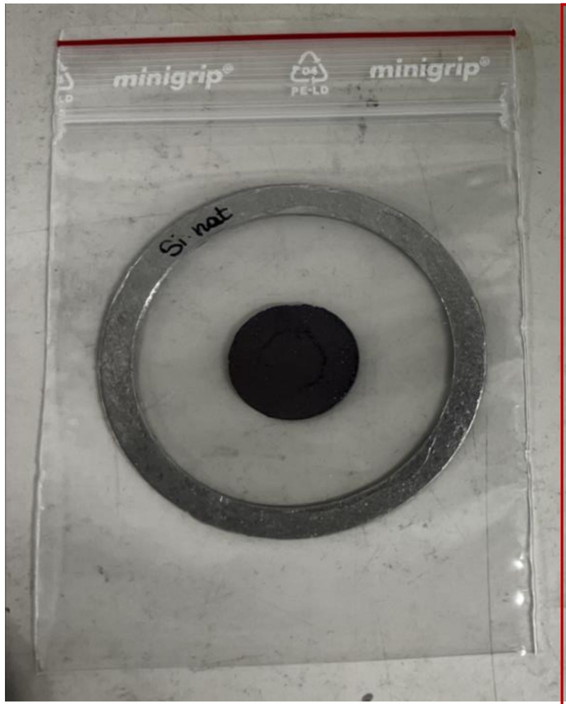
July-August

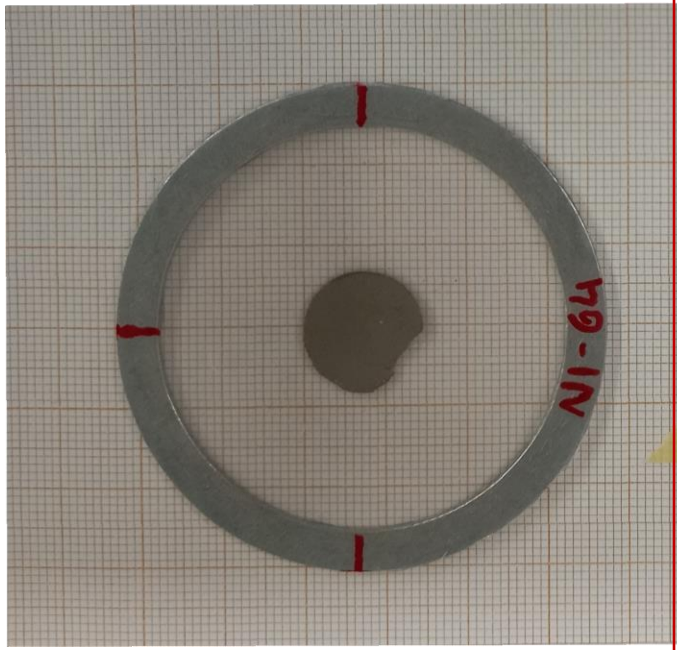
^{64}**Ni(n,ɣ)** -> 2.34E+18 p (**+56 %**)

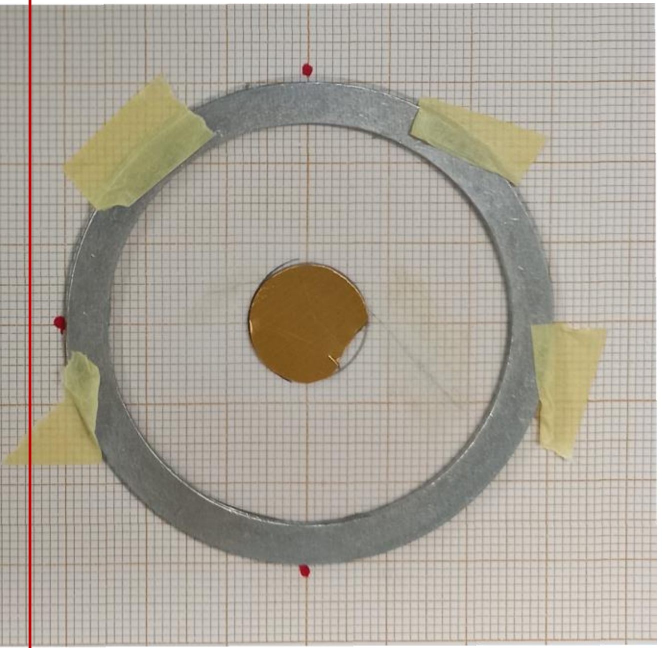
^{30}**Si(n,ɣ)**, ^{nat}**Si(n,ɣ)** -> 8.13E+17 p (**+11 %**)



Measurement







^{nat}Si

d = 20 mm
m = 2.932 g

^{30}Si >99 %

d = 22 mm
m_{pre} = 0.75 g
m_{post} = 0.99 g

^{64}Ni

d = 14.6 mm
m = 0.43 g

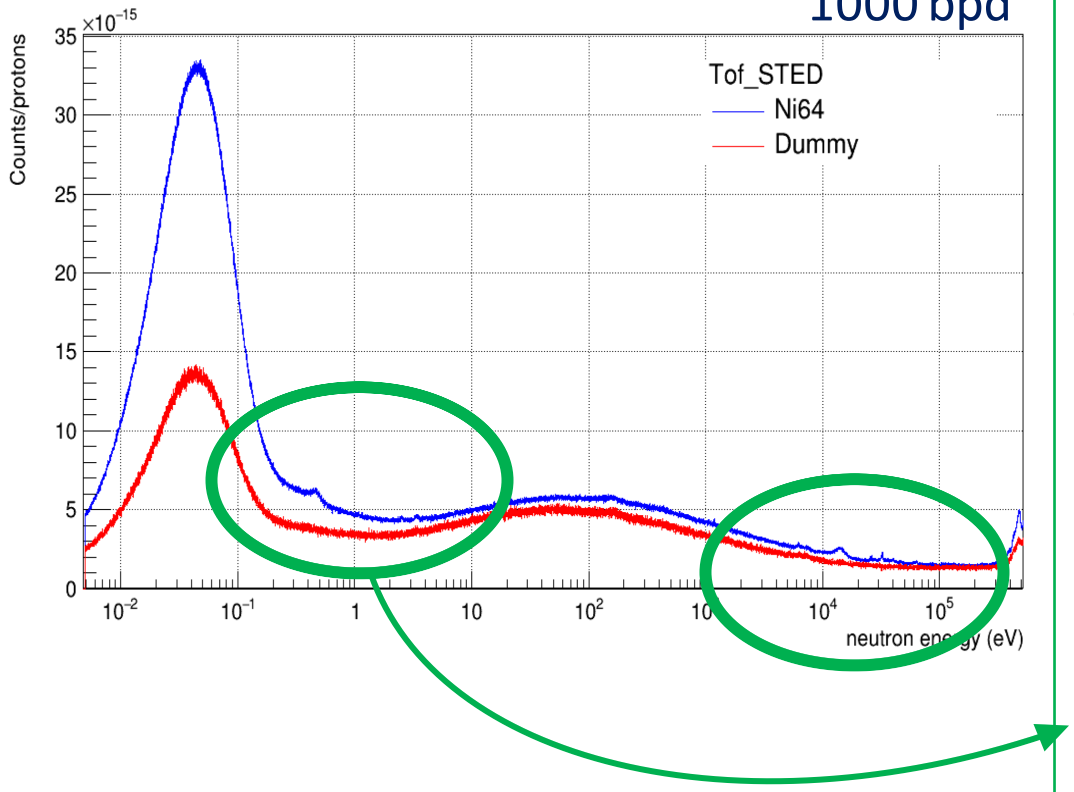
Au

R.Reifarth
D. Plonka
(*University Frankfurt*)

$^{64}Ni(n,\gamma)$: Preliminary Results

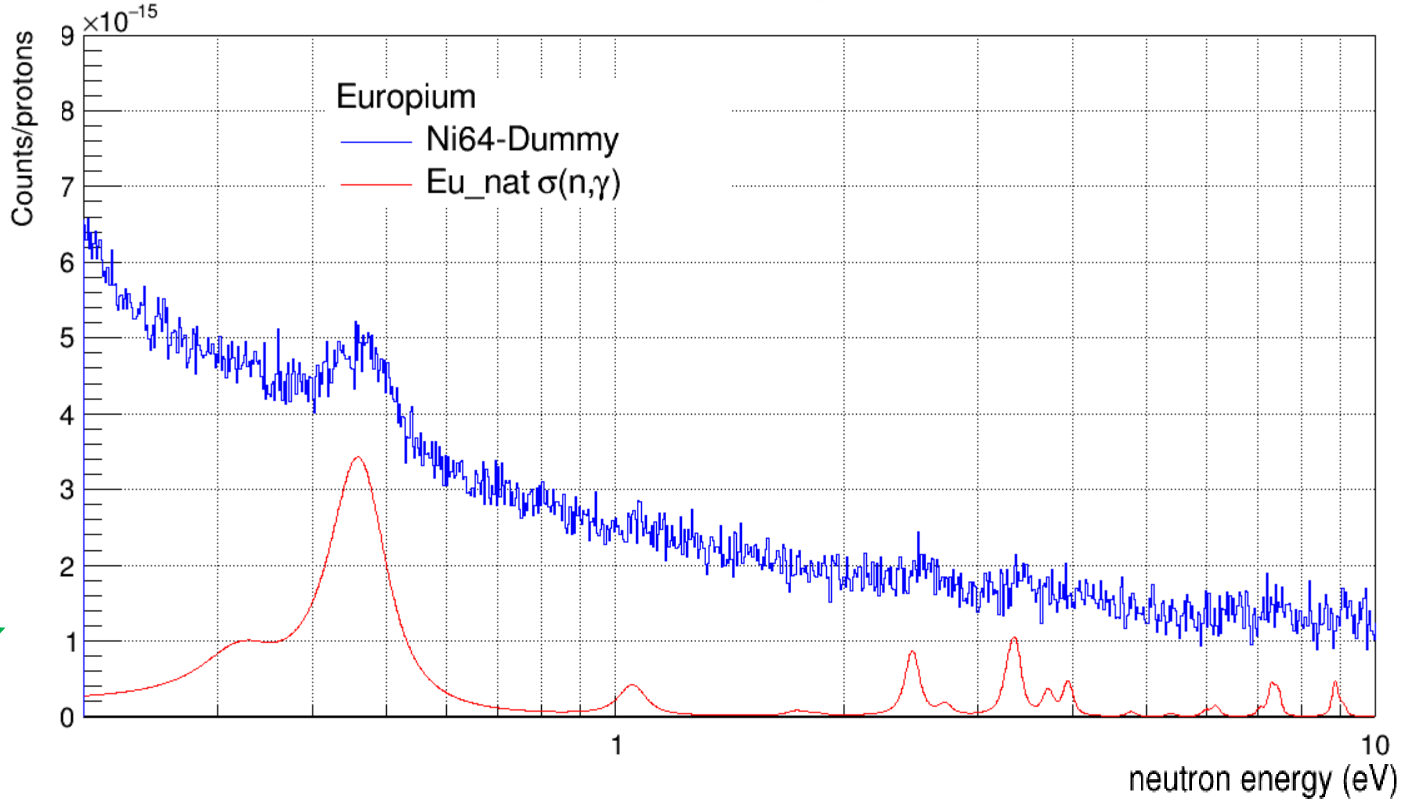
Preliminary ToF spectra from sTED

1000 bpd



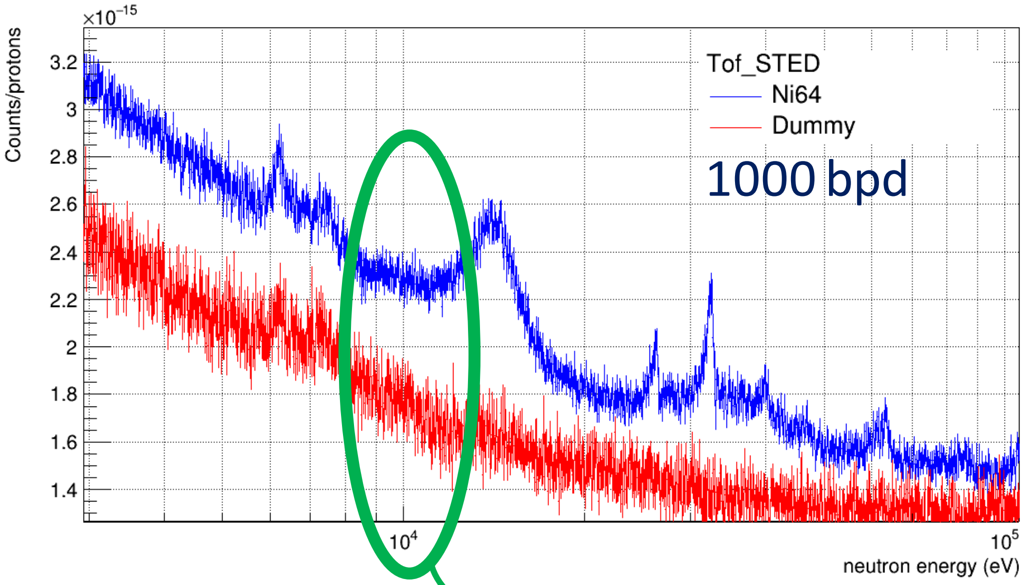
σ ≈ 5E+3 b @ 25 meV

Contamination of **Europium** (≈ 0.003 % -> 35 μg)

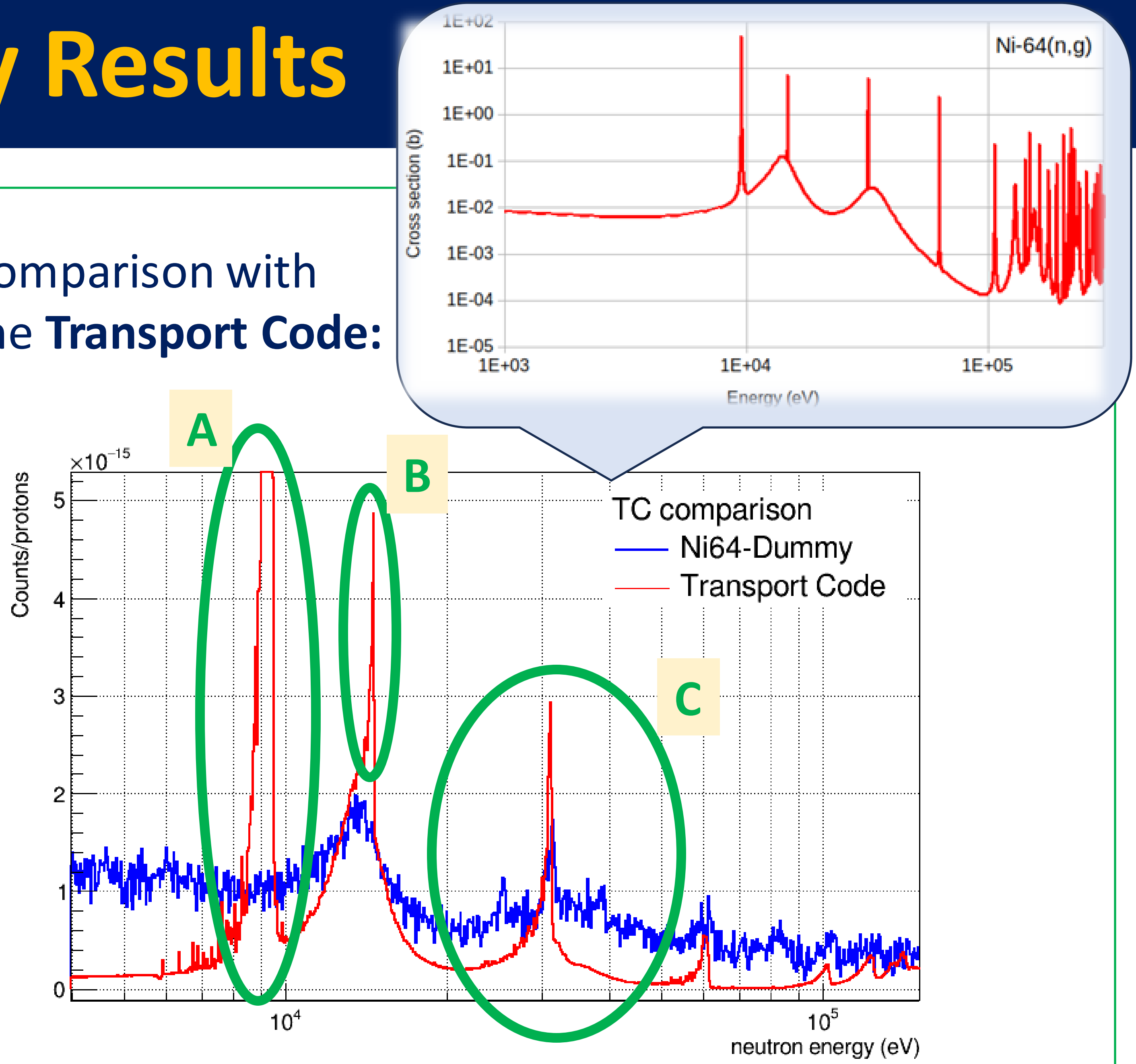


^{64}Ni(n,γ): Preliminary Results

Preliminary ToF spectra from sTED



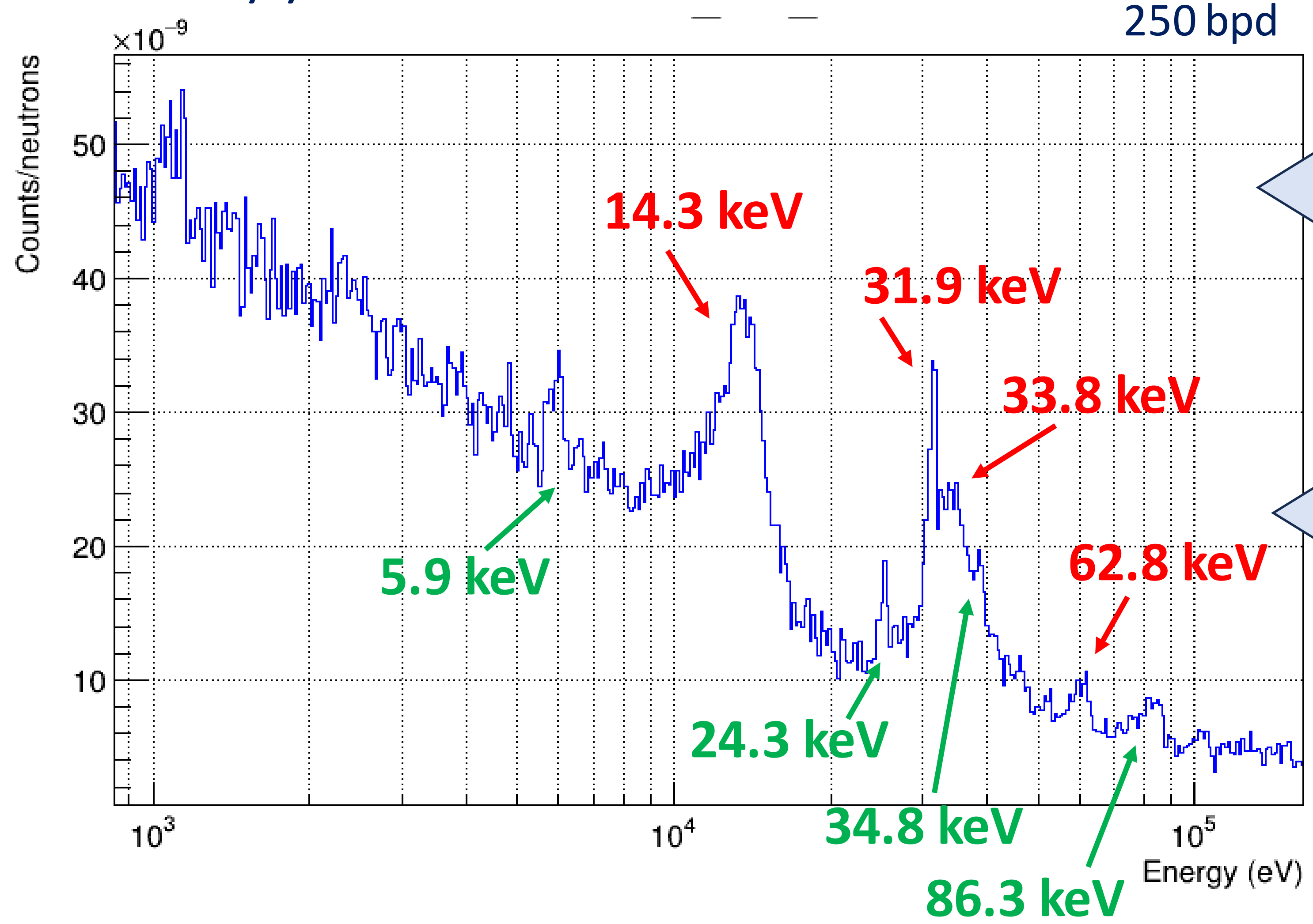
Comparison with the **Transport Code:**

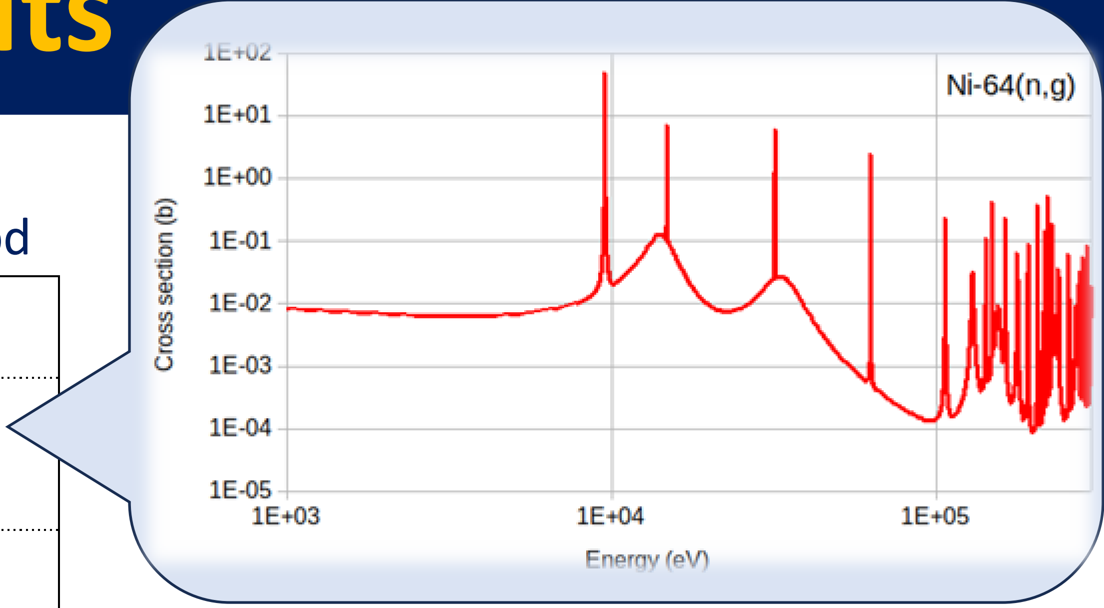


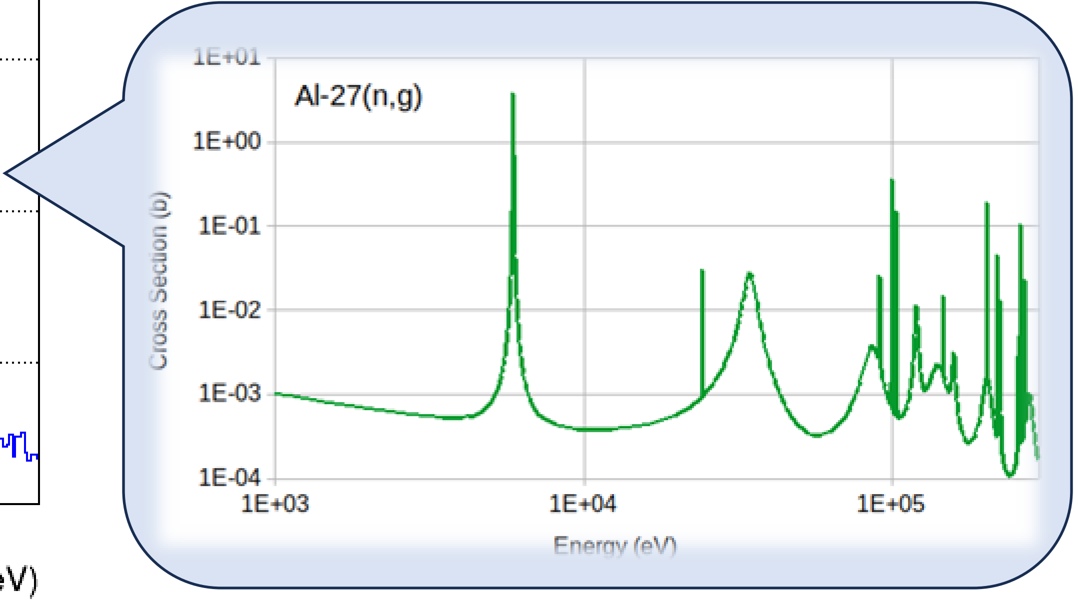
- **A.** No resonance at 9.52 keV
- **B.** P-resonance at 14.8 keV ?
- **C.** Interference of Al dip

$^{64}Ni(n,\gamma)$: Preliminary Results

Preliminary yield from sTED

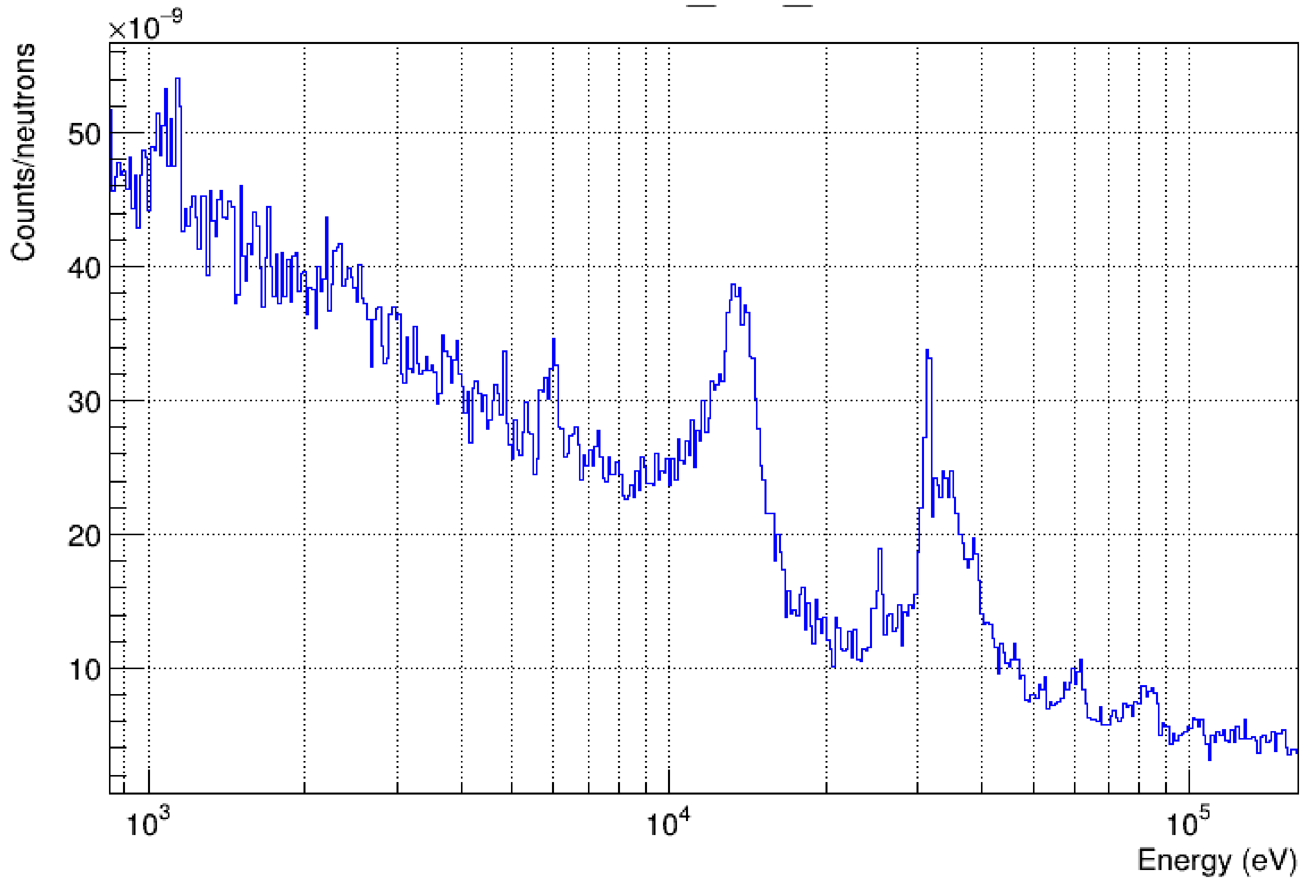


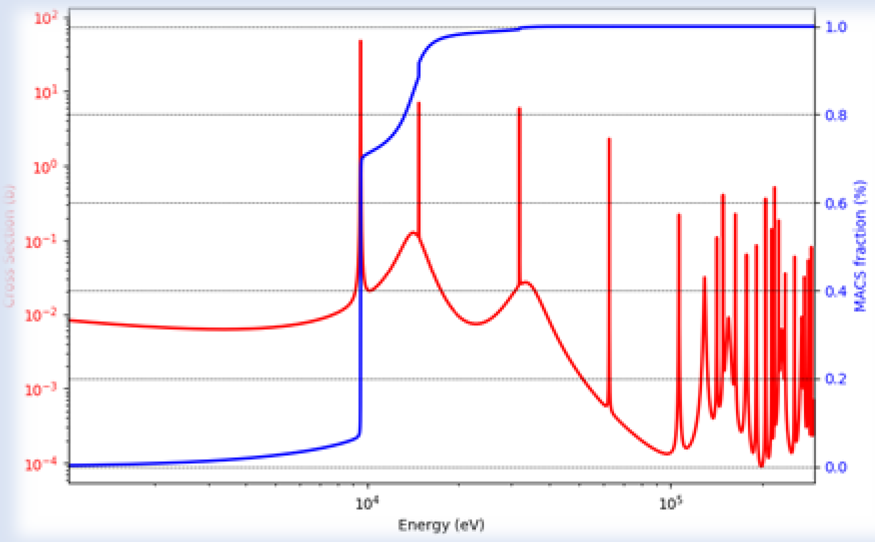


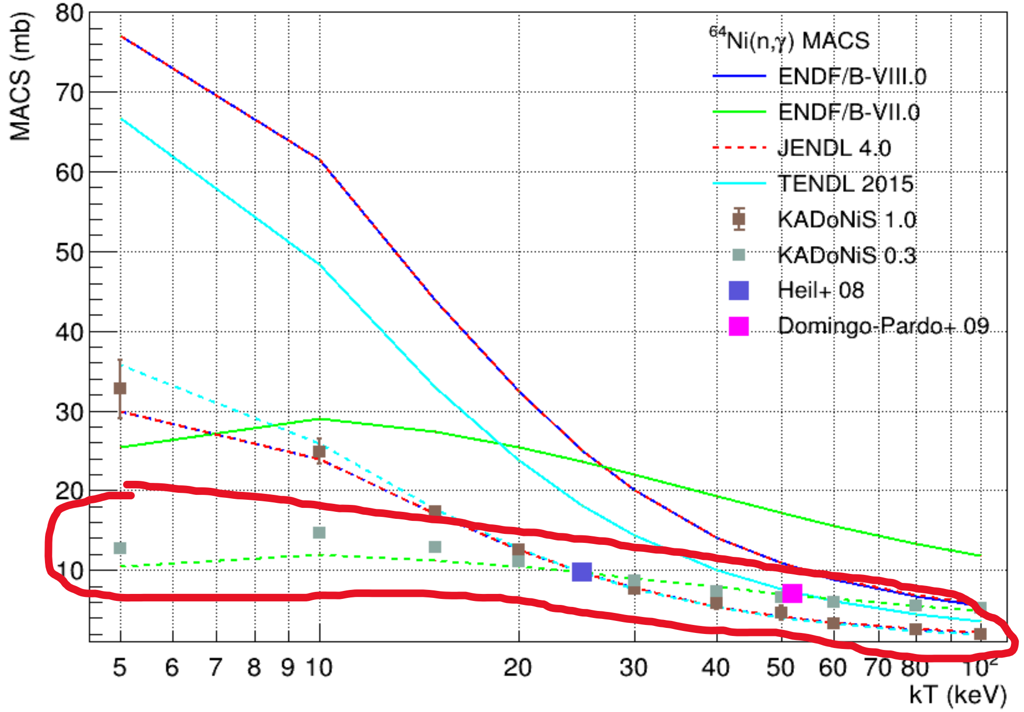


$^{64}Ni(n,\gamma)$: Preliminary Results

MACS from Kadonis 0.3 seems more in agreement with our data.

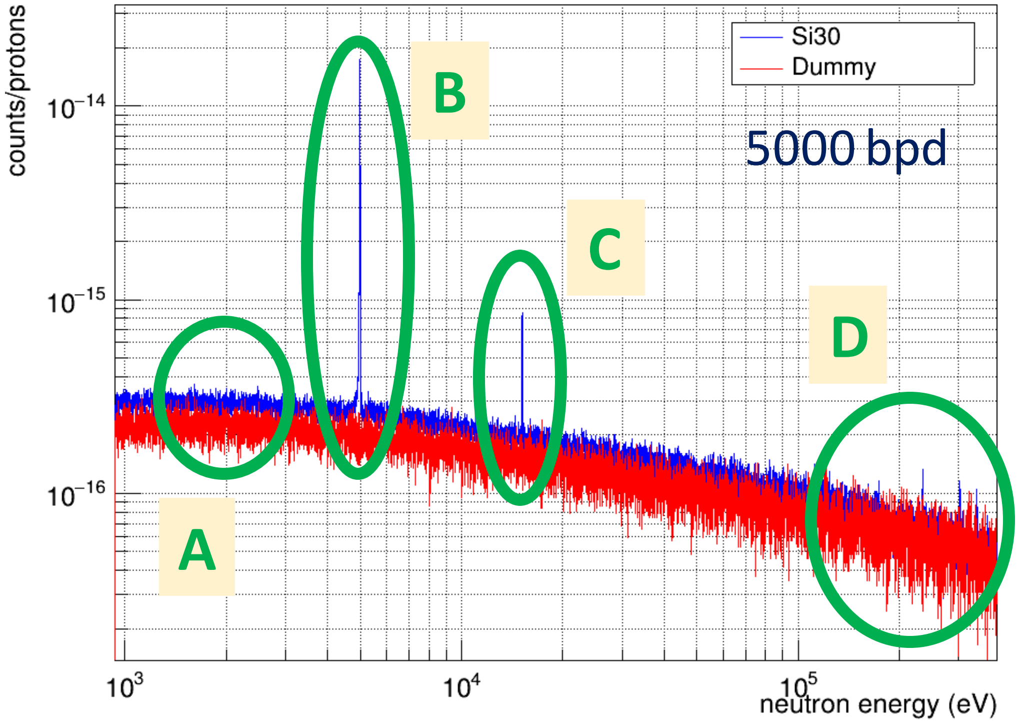




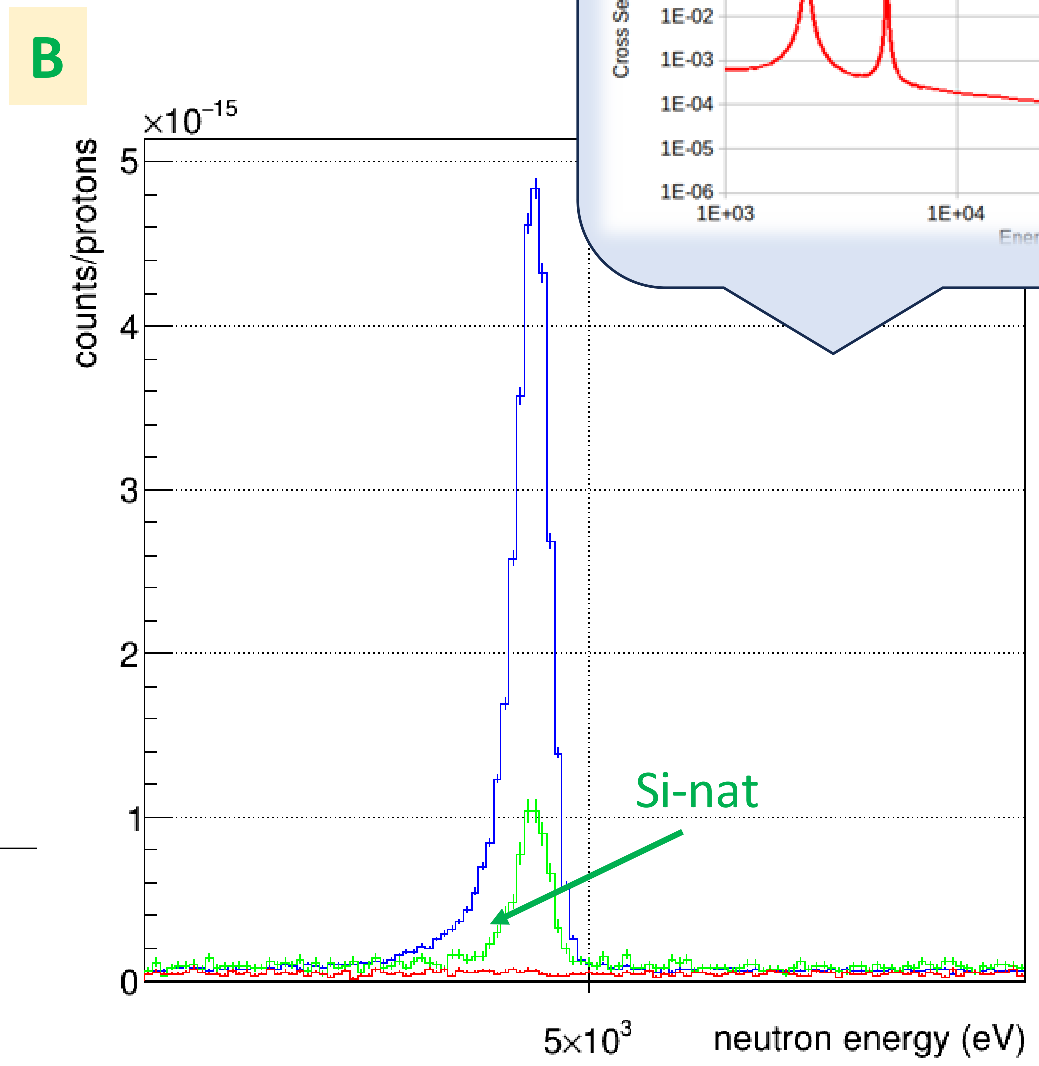


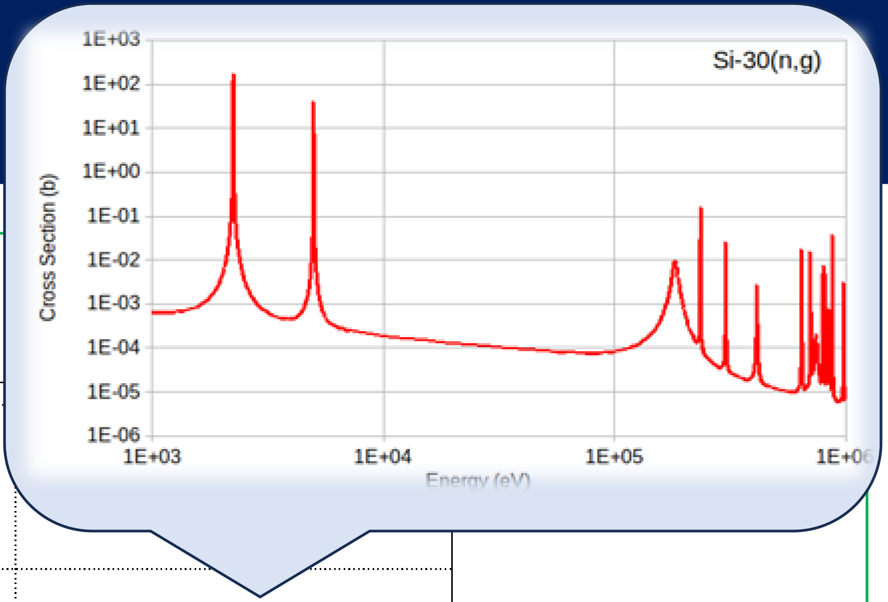
^{30}Si(n,γ): Preliminary Results

Preliminary ToF spectra

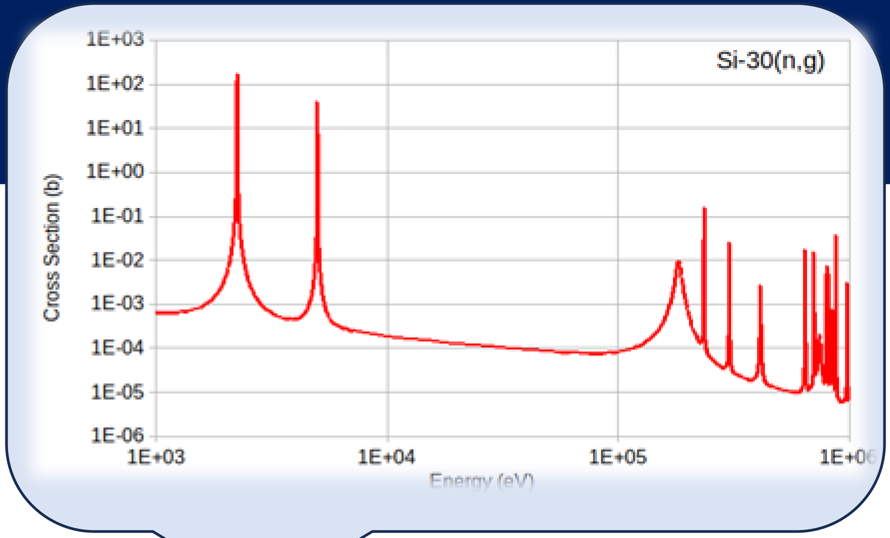


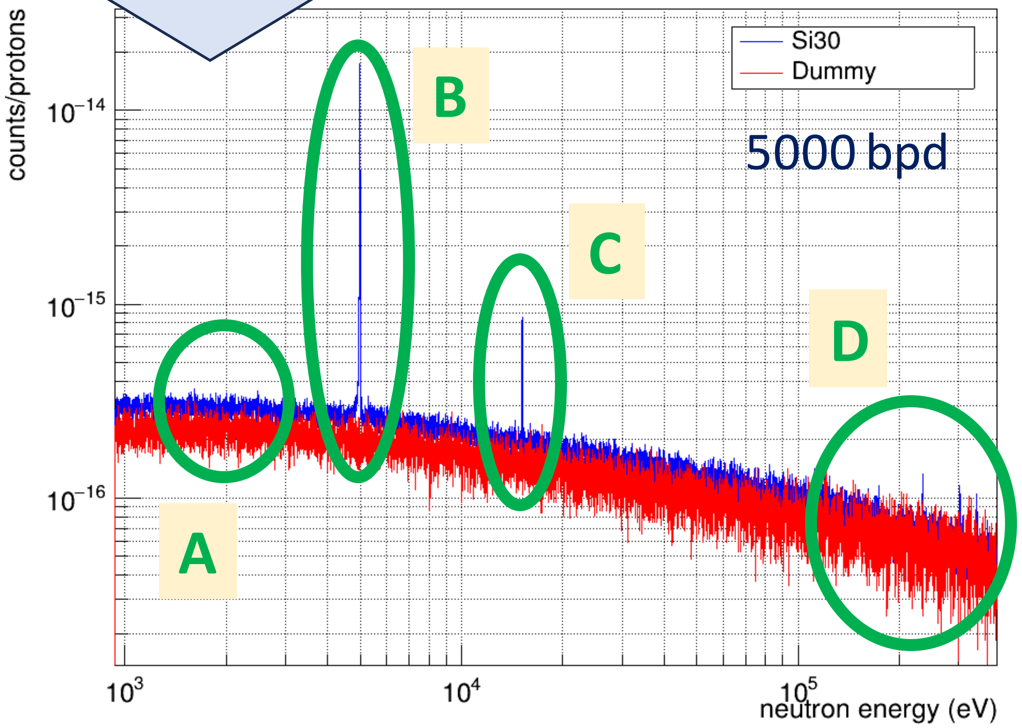
A. No resonance at 2.235 keV
B. Resonance at 4.98 keV





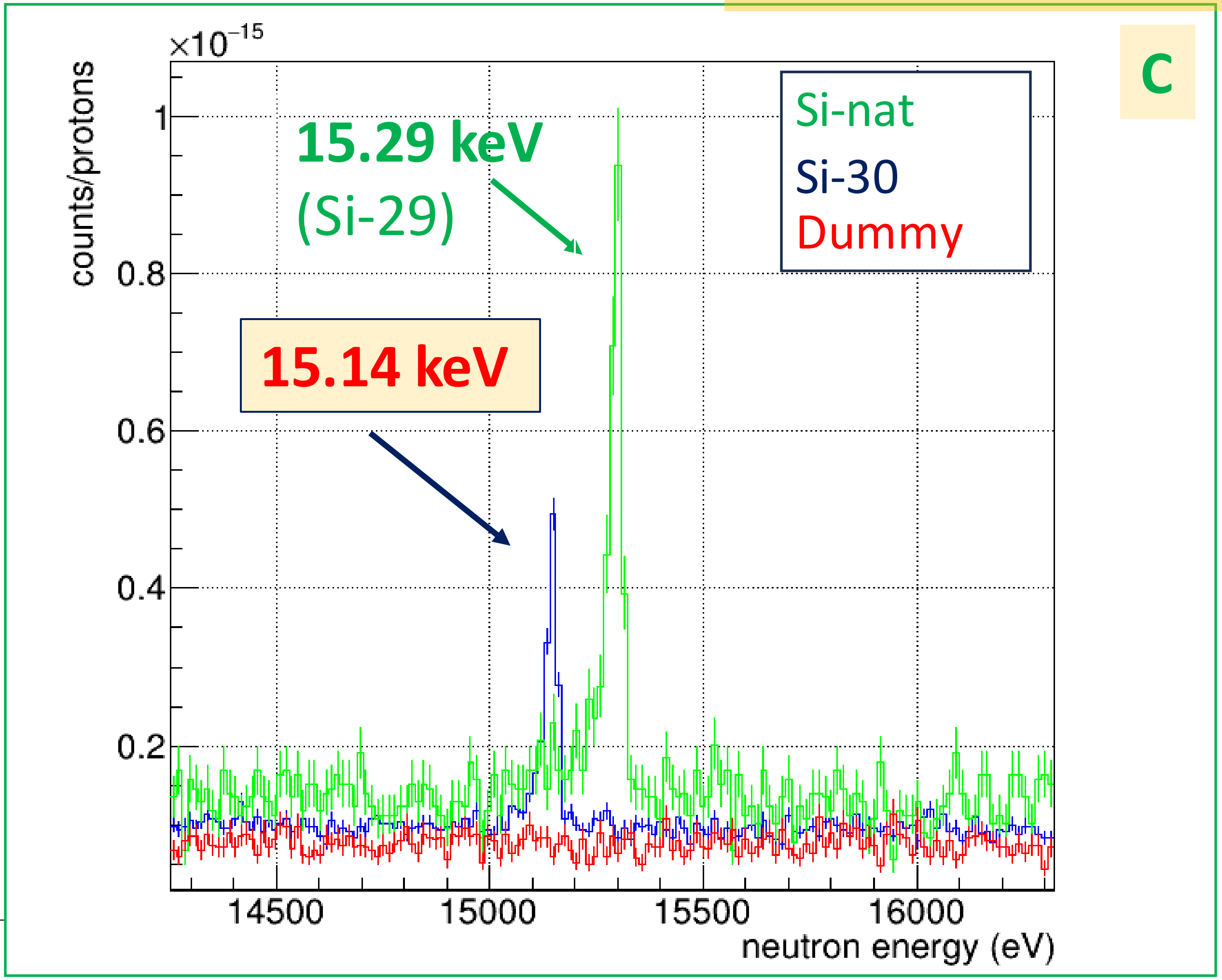
$^{30}Si(n,\gamma)$: Preliminary Results





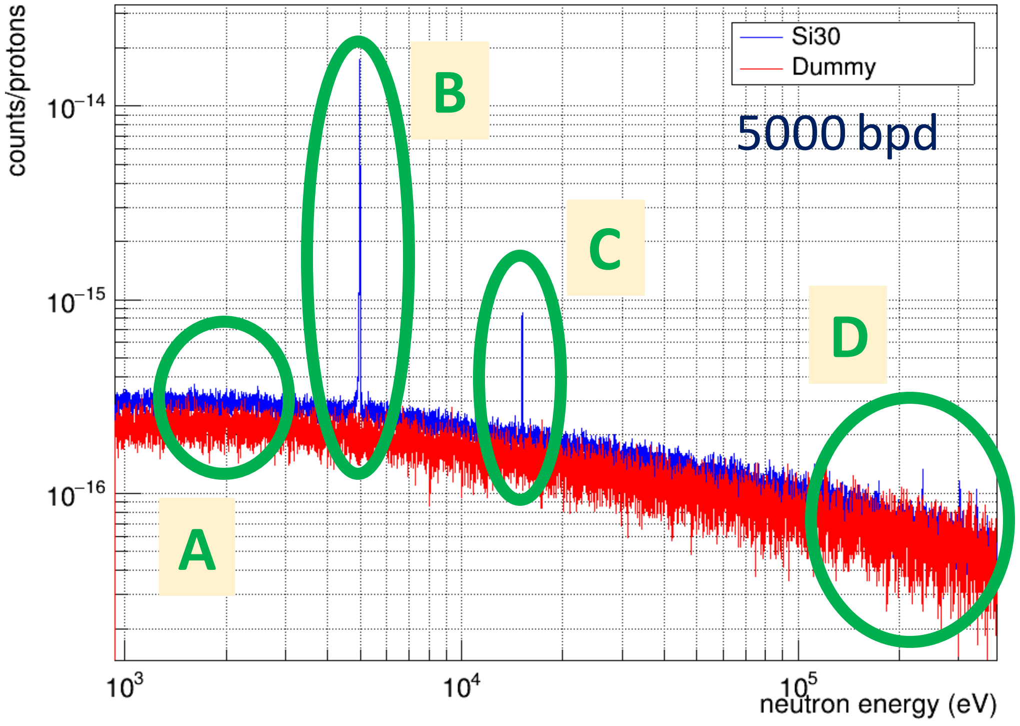
C. Resonance at 15.14 keV

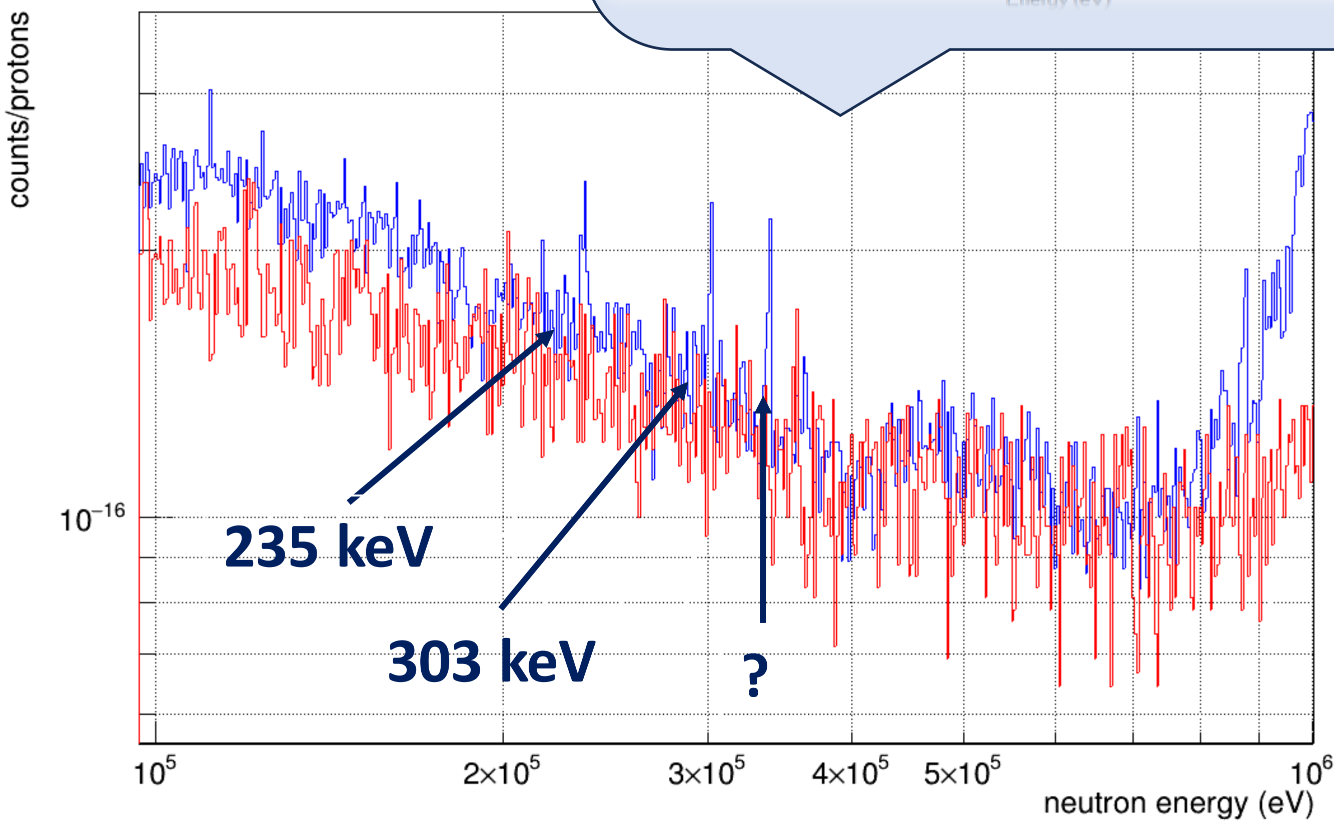
J. Boldeman et al., *Nucl. Phys. A252, 62 (1975)*

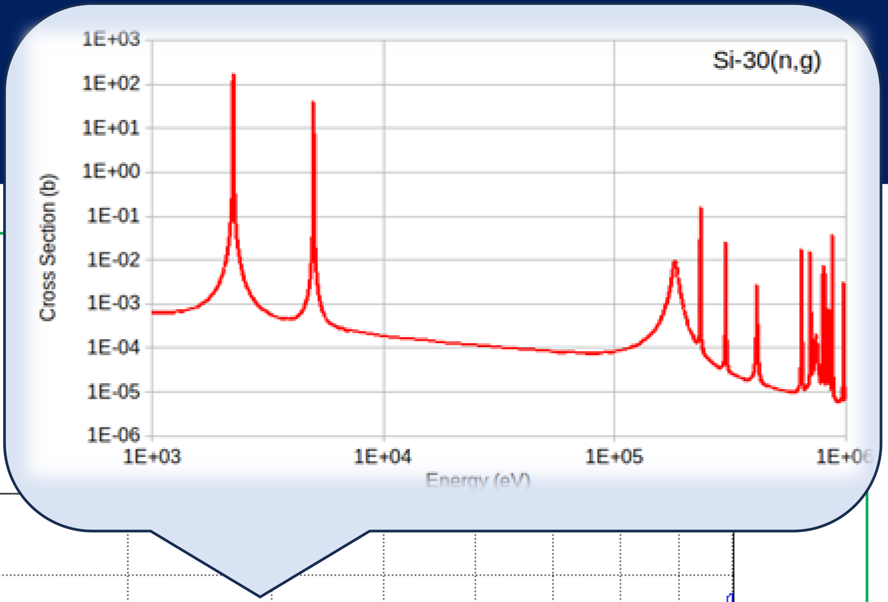


$^{30}Si(n,\gamma)$: Preliminary Results

Preliminary ToF spectra



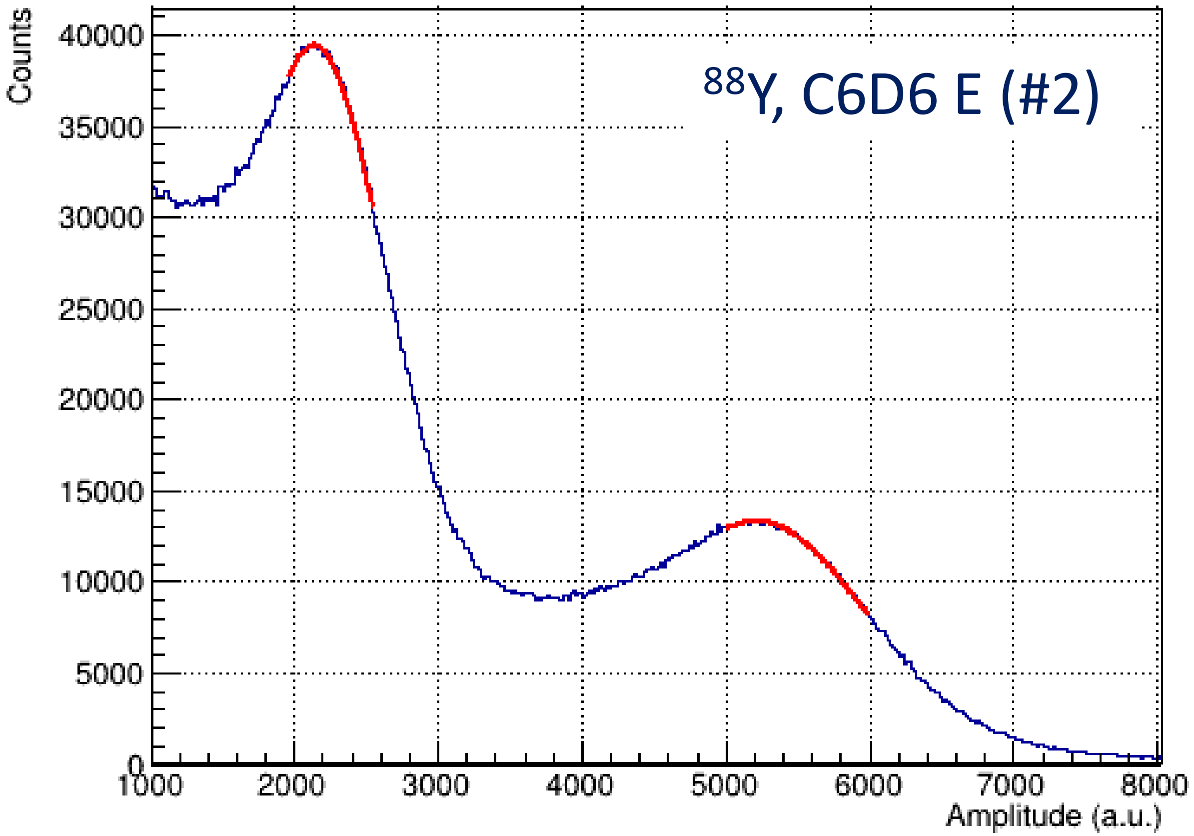


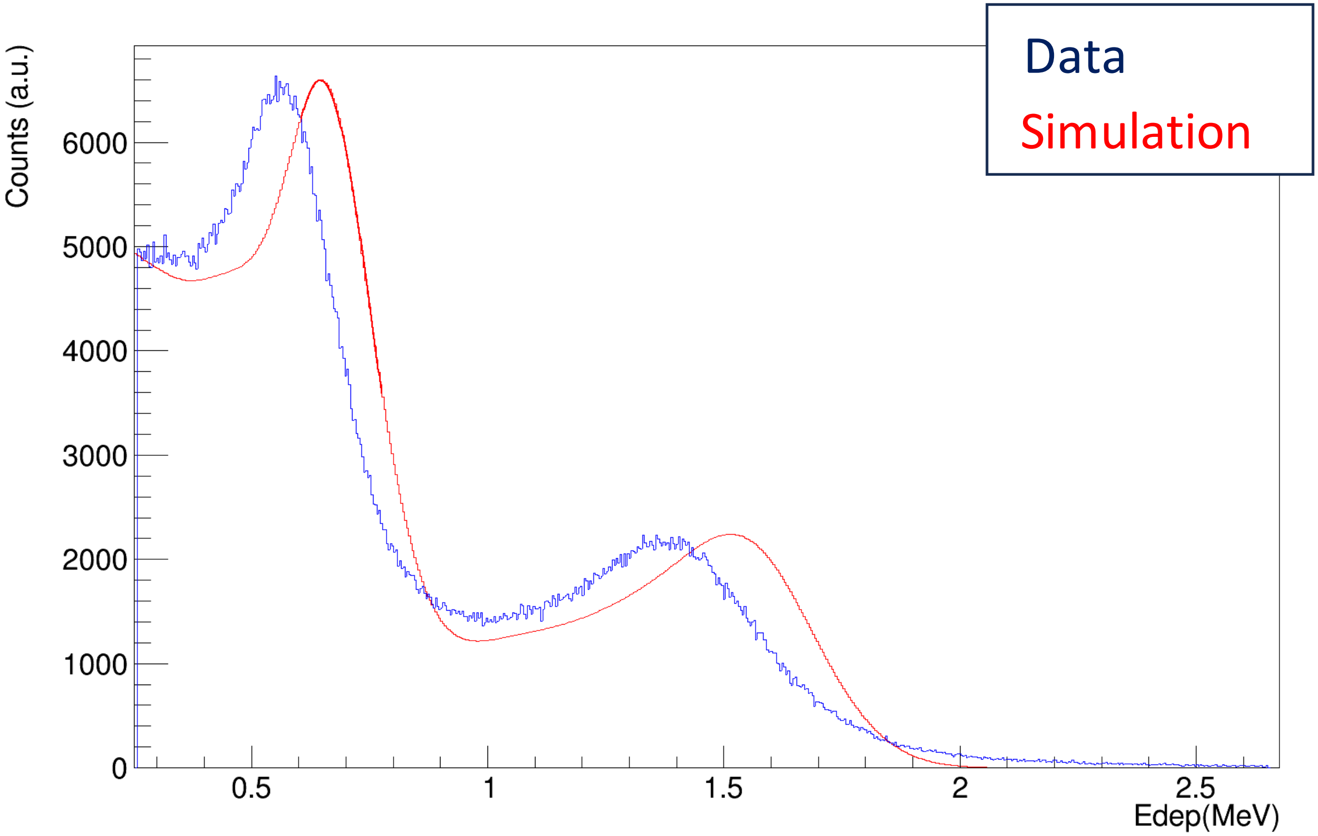


$^{30}Si(n,\gamma)$: Ongoing Analysis

The analysis is currently devoted to **detector calibration** with **G4 simulations**.

First guess with gaussian fitting of the Compton edge:

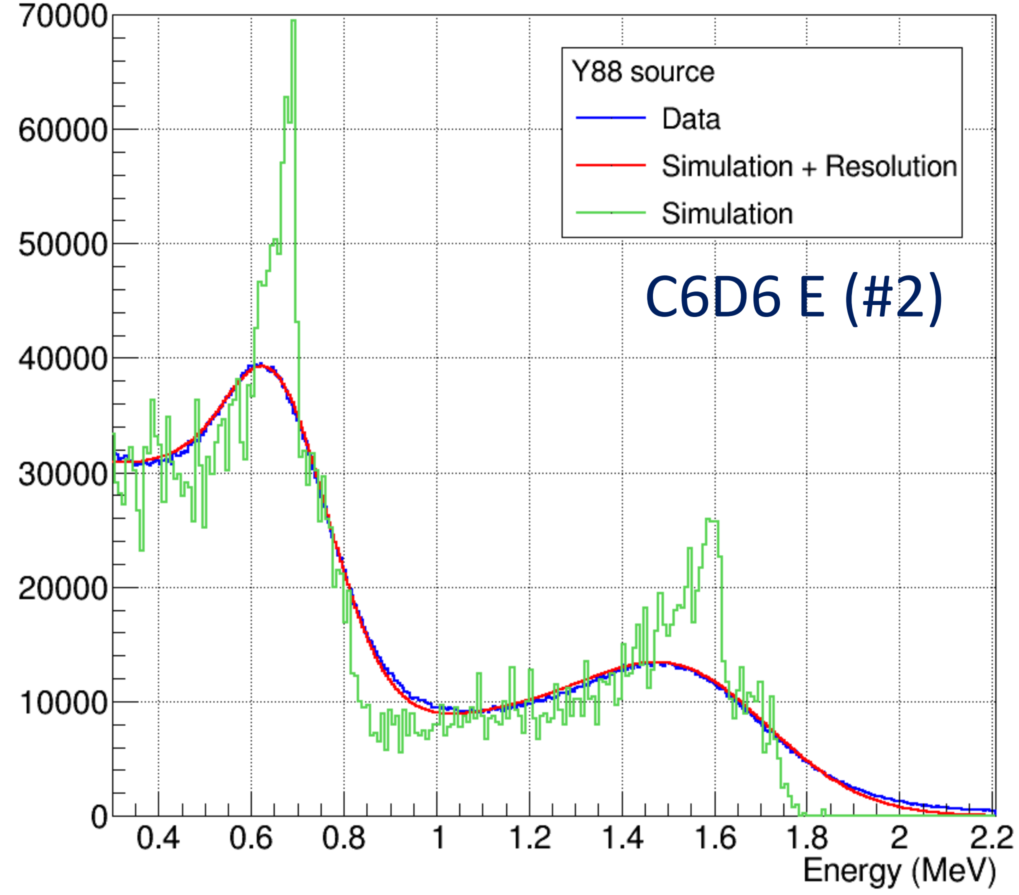


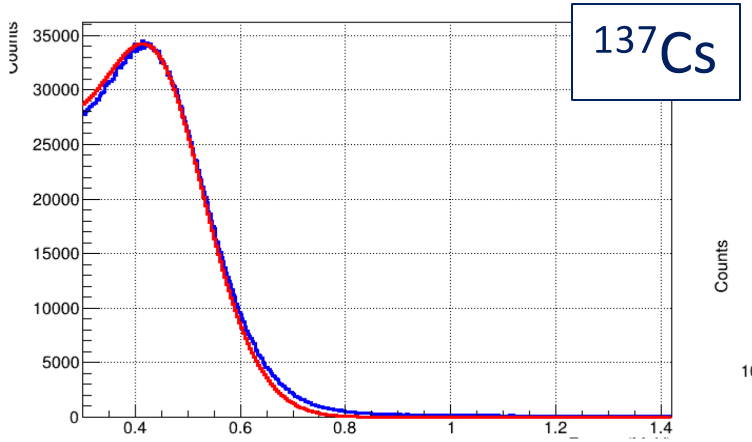


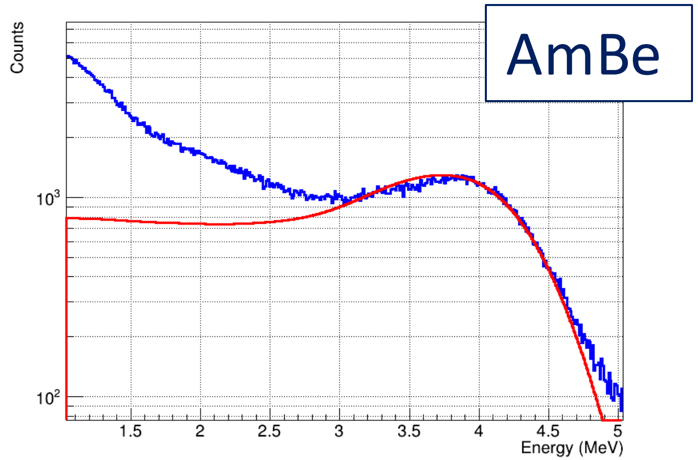
$^{30}Si(n,\gamma)$: Ongoing Analysis

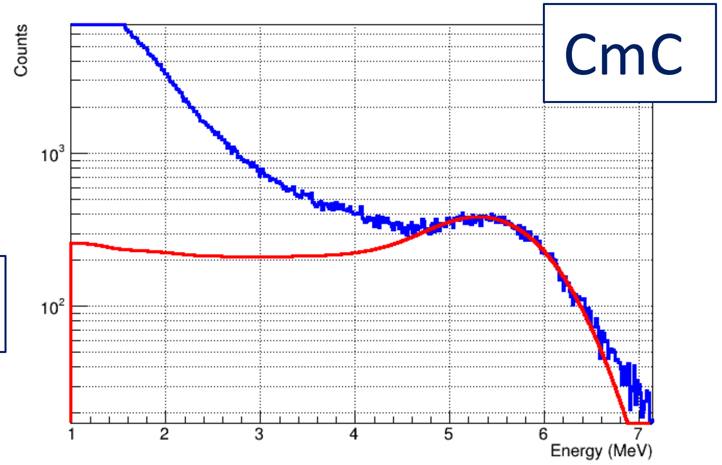
The analysis is currently devoted to **detector calibration** with **G4 simulations**.

Second guess with direct comparison with **resolution convoluted simulations**.





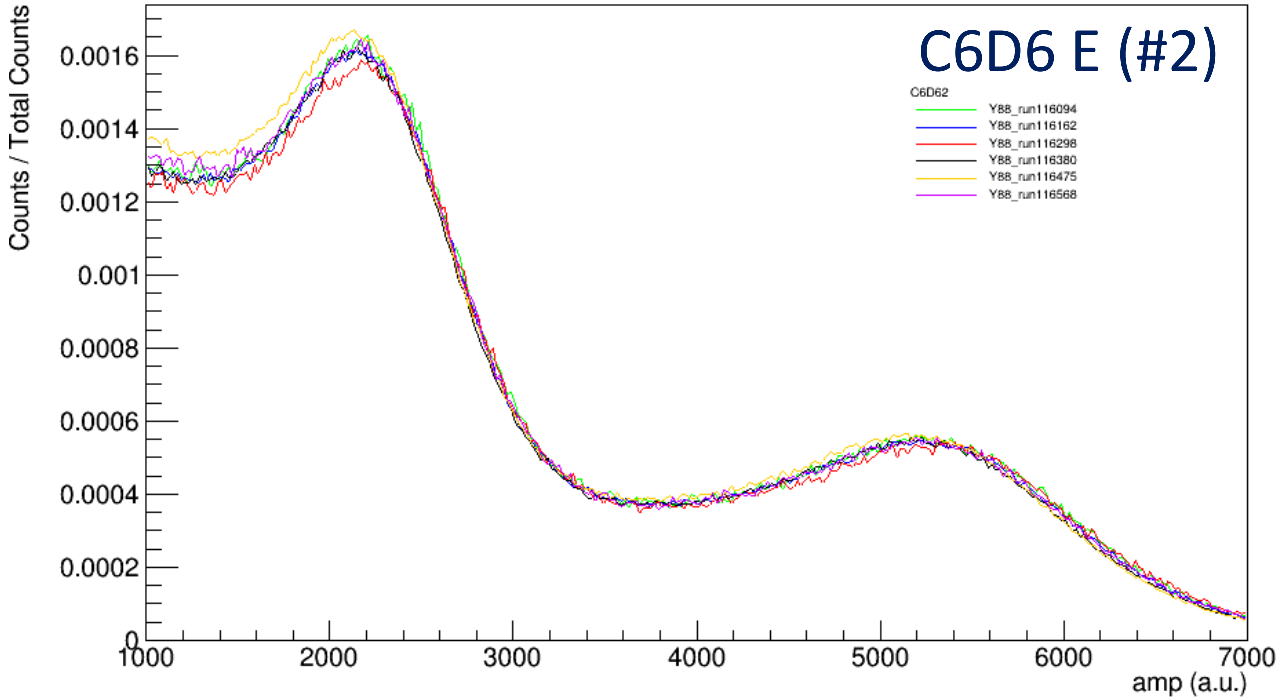




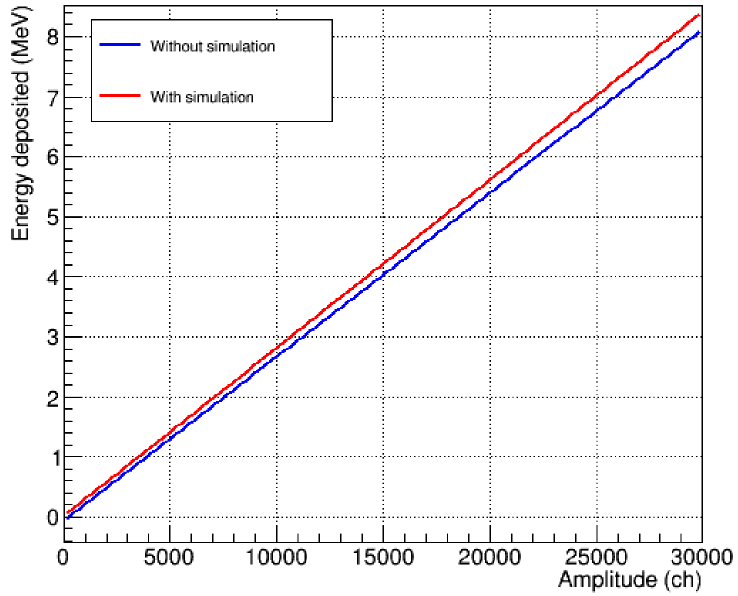
^{30}Si(n,γ): Ongoing Analysis

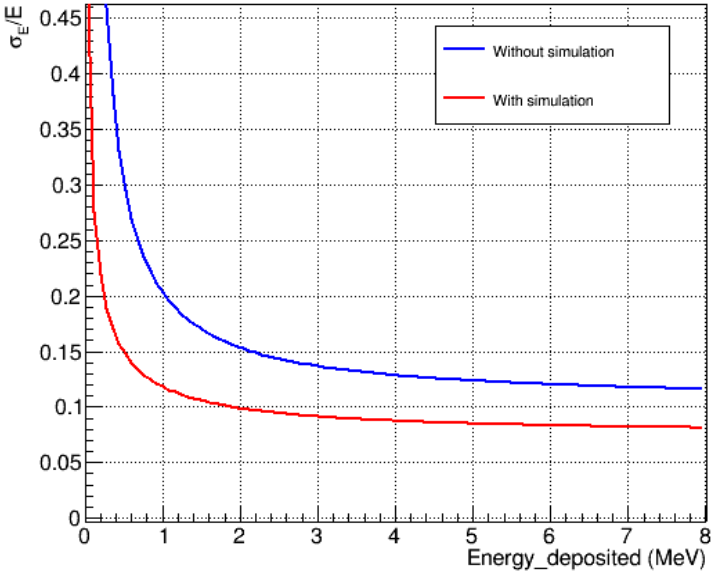
The analysis is currently devoted to **detector calibration** with **G4 simulations**.

Evaluation of the **uncertainty** on the calibration and **gain shift** during the measurement.



0.7 %





Summary

^{64}**Ni(n,γ)** and ^{30}**Si(n,γ)** are important measurement to accurately model **s-process** and explain the isotopic ratios measured in **SiC**.

^{64}Ni(n,γ)

- **Measurement EAR2**
- **Preliminary results**
- Detector calibrations
- WF
- Yield
- Resonance Fitting

^{30}Si(n,γ) ^{nat}Si(n,γ)

- **Measurement EAR1 & EAR2**
- **Preliminary results EAR1**
- **Detector calibrations EAR1**
- WF EAR1
- Yield EAR1
- Resonance Fitting EAR1
- Analysis EAR2 (thermal)
- Measurement of ^{30}Si, ^{29}Si(n,γ)

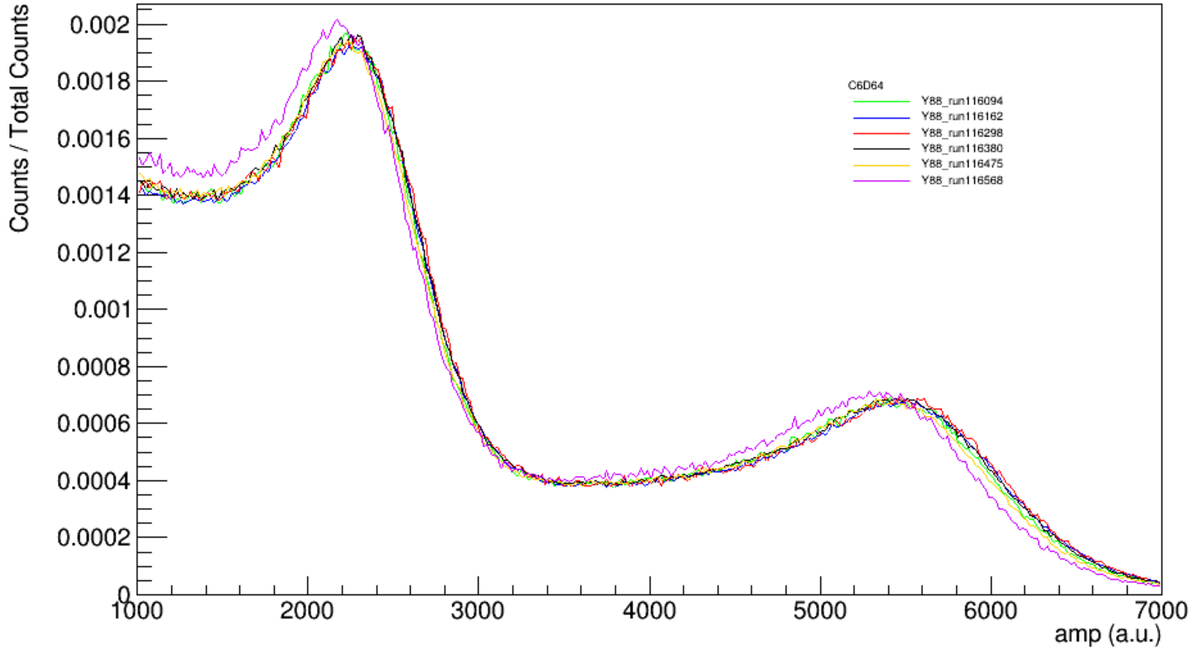
$^{64}Ni(n,\gamma)$ & $^{30}Si(n,\gamma)$

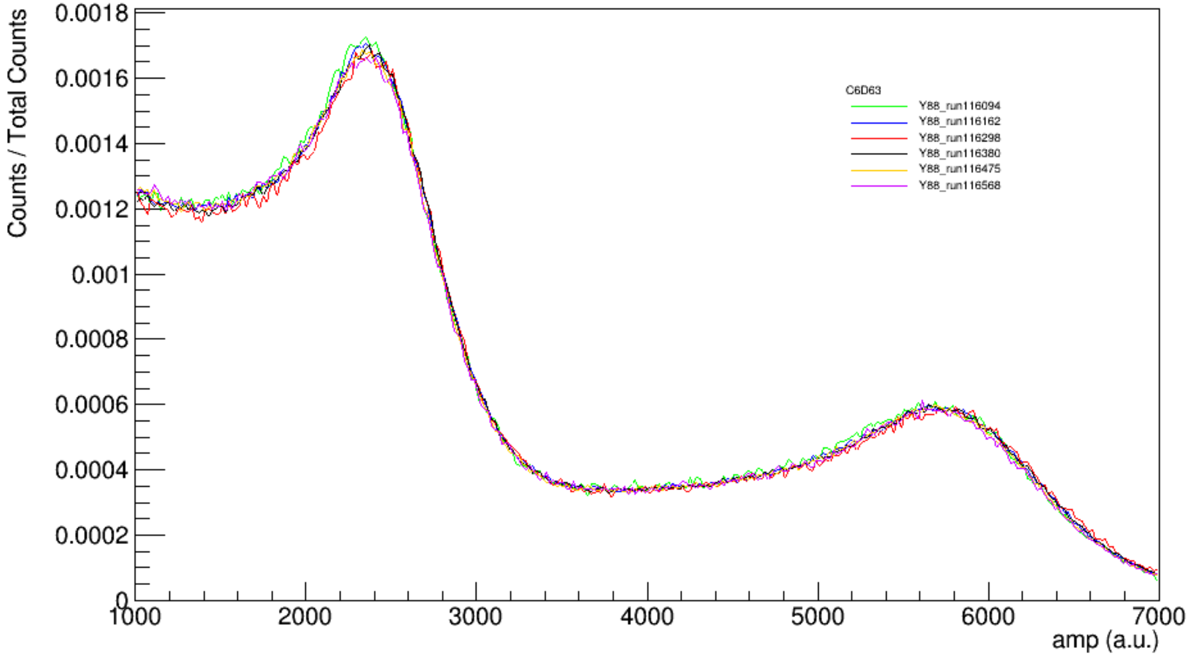
Motivations and Preliminary Results

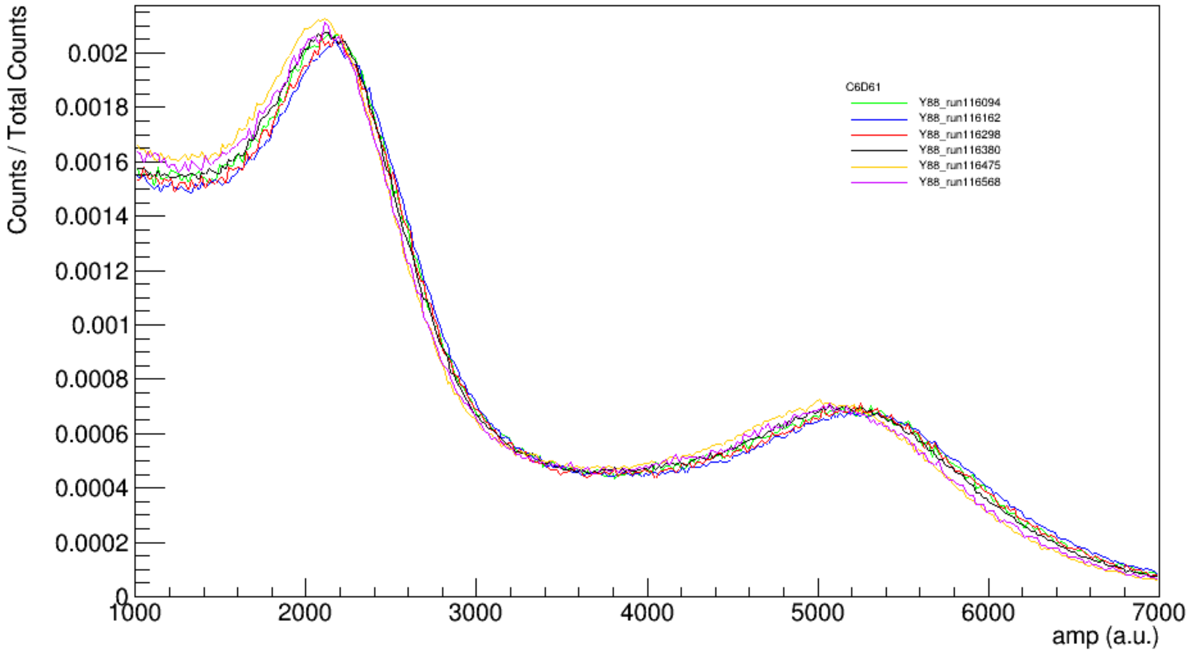
Michele Spelta

INFN TRIESTE
UNIVERSITÀ DEGLI STUDI DI TRIESTE
EURO-LABS EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCES

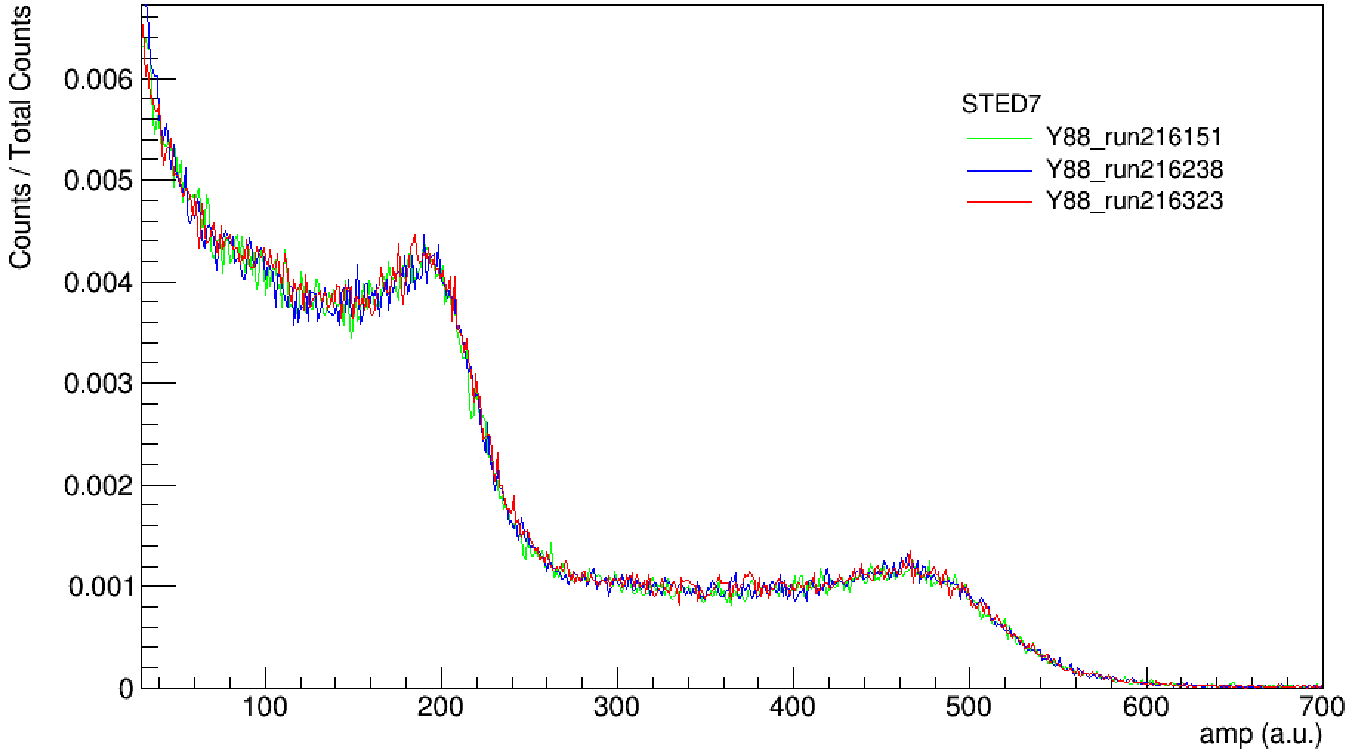
Gain shift C6D6 (Si-30)

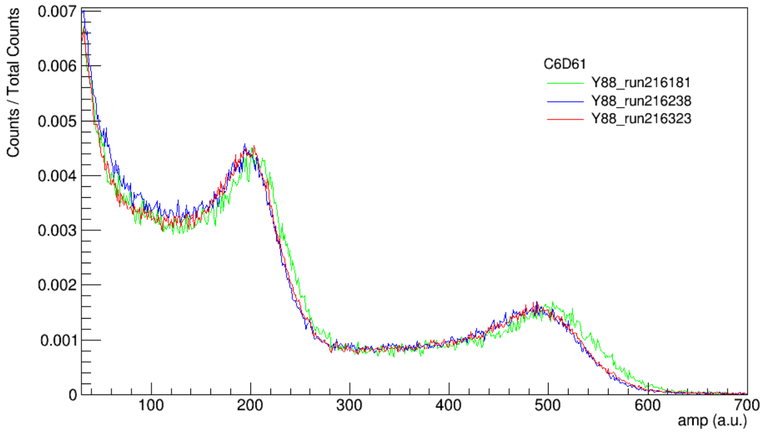


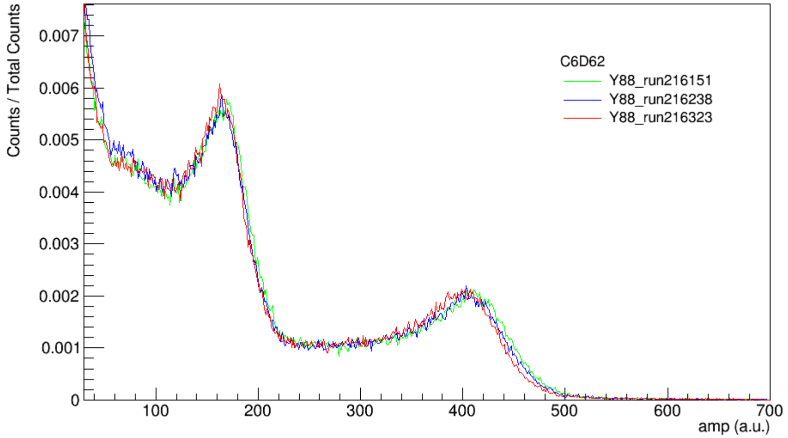


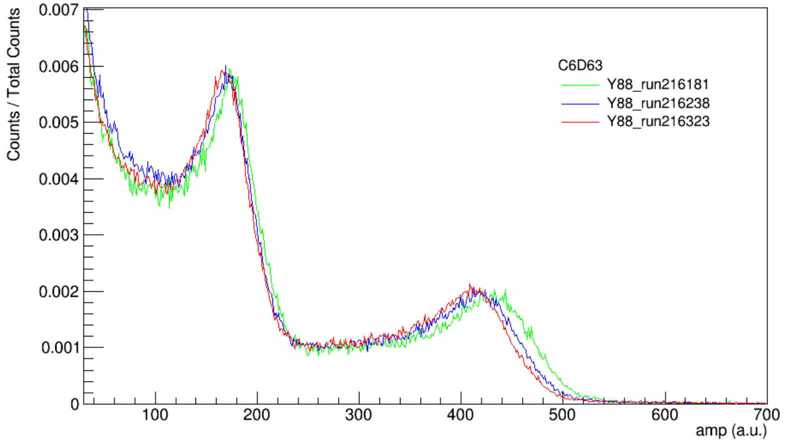


Gain shift STED - C6D6 (Ni-64)

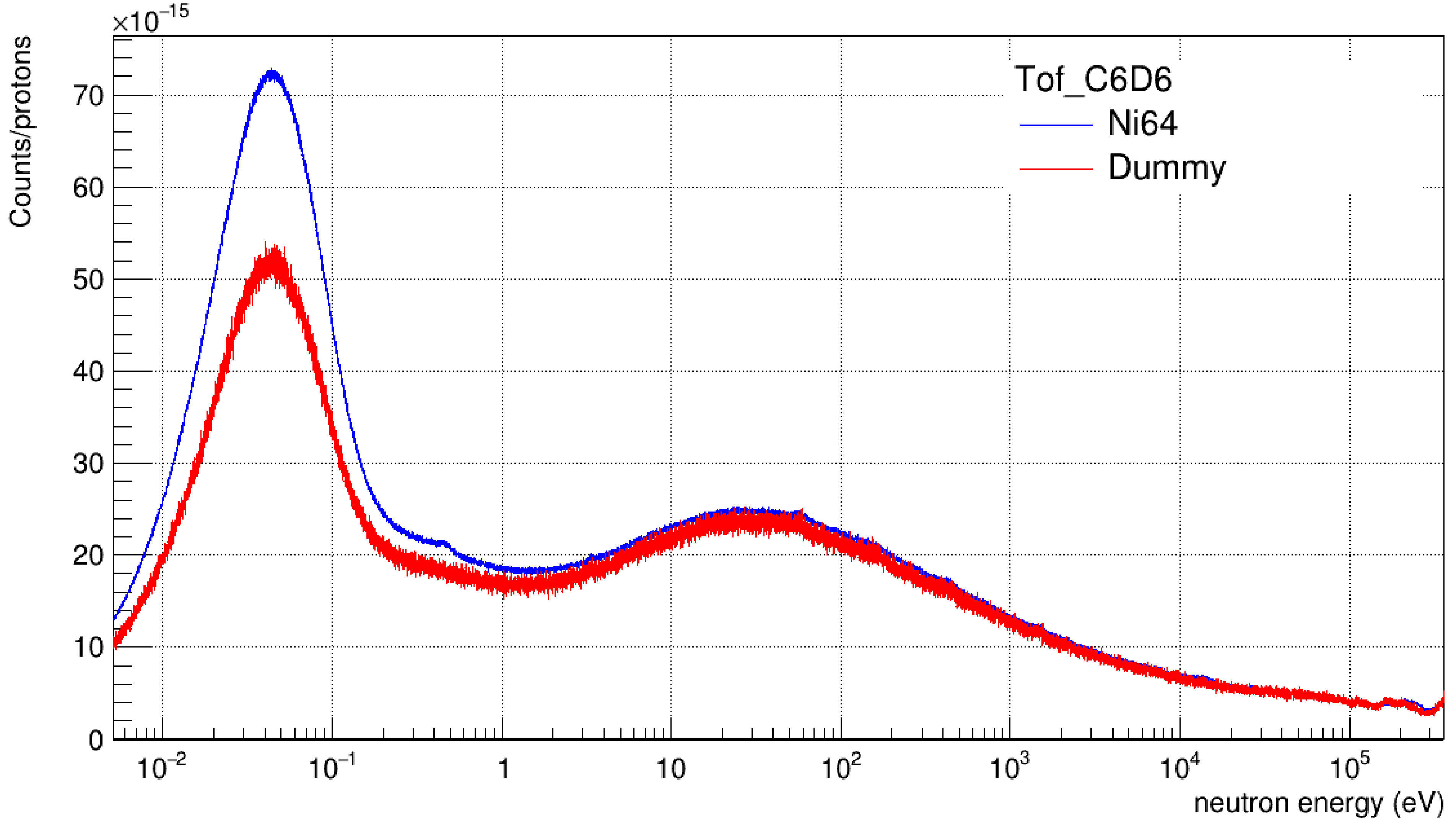








C6D6 (Ni-64)



×10^−15
Counts/protons
70
60
50
40
30
20
10
0
Tof_C6D6
Ni64
Dummy
10^−2
10^−1
1
10
10^2
10^3
10^4
10^5
neutron energy (eV)

Protons (Ni-64)

SCHEDULED PROTONS											
	Ni-64	Au brok	Au 15 mm	Au 14.7 mm	Au 20mm	C	Pb	Dummy *	Empty	Total	Scheduled
Measured	1,2542835E+18	2,2183168E+16	2,37388164E+16	6,545407E+15	1,044931E+16	1,186222E+17	1,2276547E+17	6,4889696E+17	1,33061E+17	2,3405457E+18	
Planned	1,00E+18	4,00E+16				1,00E+17	1,00E+17	2,00E+17	1,00E+17	1,54E+18	1,50E+18
% achieved	125,43%	157,29%				118,62%	122,77%	324,45%	133,06%	151,98%	156,04%

Protons (Si)

SCHEDULED PROTONS										
	Si-30	Au 20mm	Au 22mm	C	Au 20mm 2	Si-nat-2	Si-nat	Dummy *	Empty	
Measured	1,68248E+18	8,69058E+16	1,13142E+17	2,60039E+17	1,20725E+16	2,462243E+17	7,70477E+17	4,853125E+17	1,48816E+17	3,8054691E+18
Planned	--	--						--	--	
% achieved	--	--						--	--	

SCHEDULED PROTONS						
	Si-30	Au 22 mm	Au 20 mm	Dummy *	Si-nat	
Measured	2,69957E+17	1,1121E+16	1,5006E+16	3,22513E+17	1,94141E+17	8,12738E+17
Planned	--	--	--	--	--	7,33E+17
% achieved	--	--	--	--	--	110,83%