Meeting nazionale n_TOF

Misura di n + ^{63,65}Cu. Analisi preliminare e prossime misure

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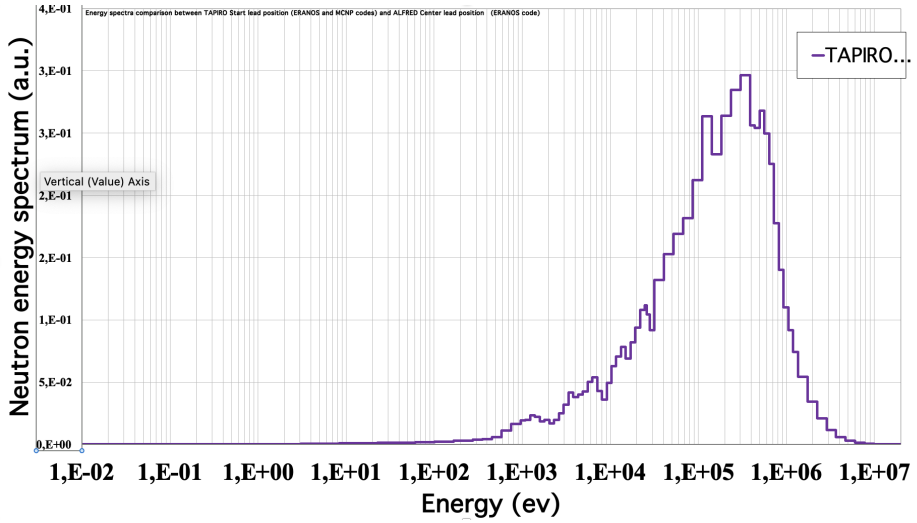
Why Copper?

Nuclear Technologies:

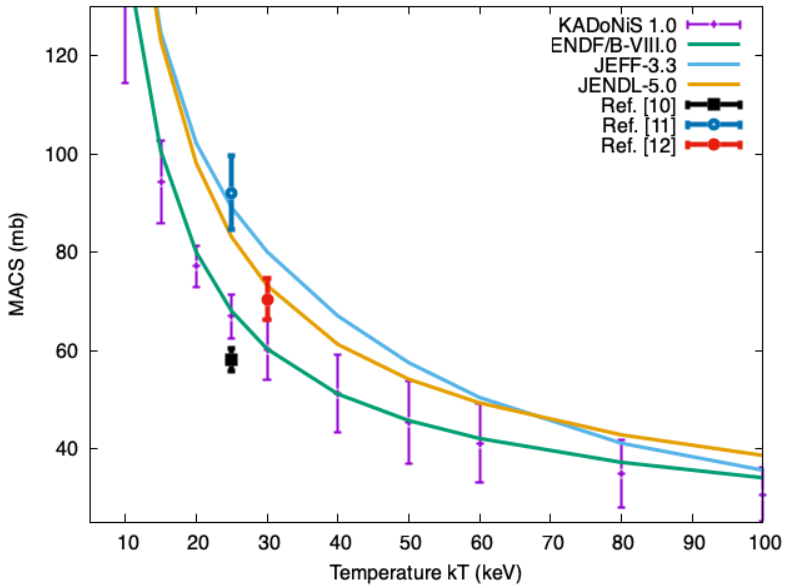
- Generation IV fast reactors
- Nuclear data and materials testing at the TAPIRO research reactor
- S&U studies revealed inadequacies in Cu data libraries

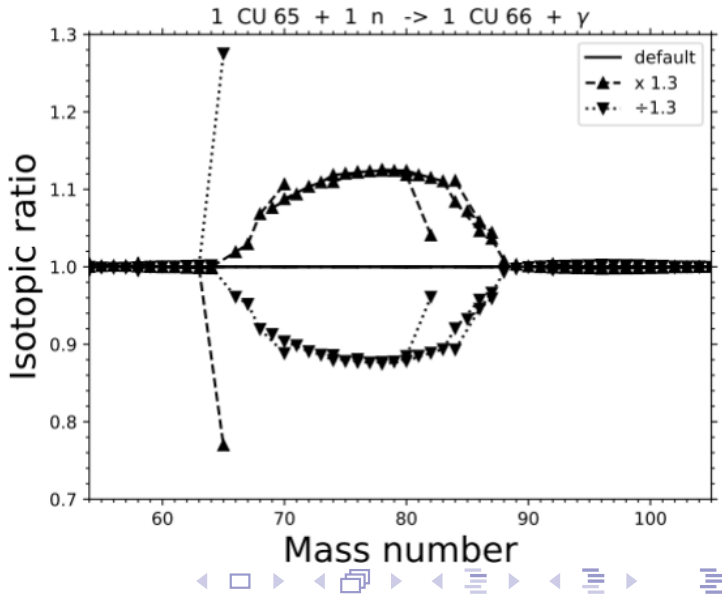


Why Copper?

Nuclear Astrophysics:

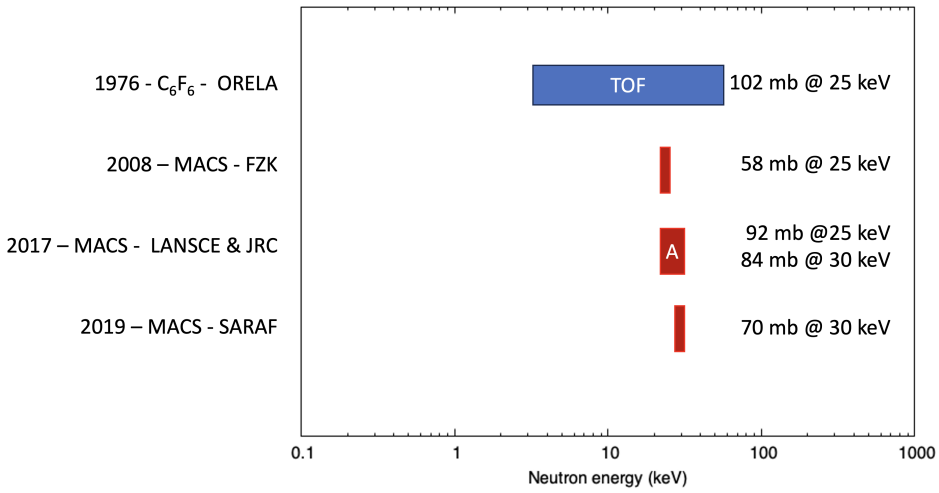
- Contributions of various Copper nucleosynthesis scenarios to be determined
- Accurate determination of Cu MACS will constrain the s-process contribution

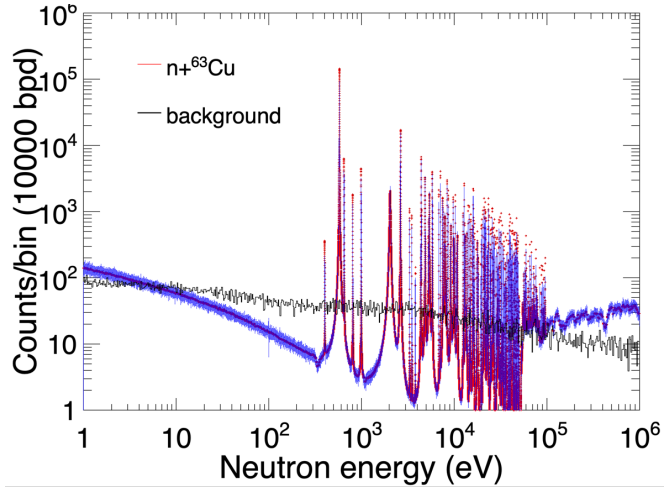




n + ^{63,65}Cu @ n_TOF EAR1: (n,γ)

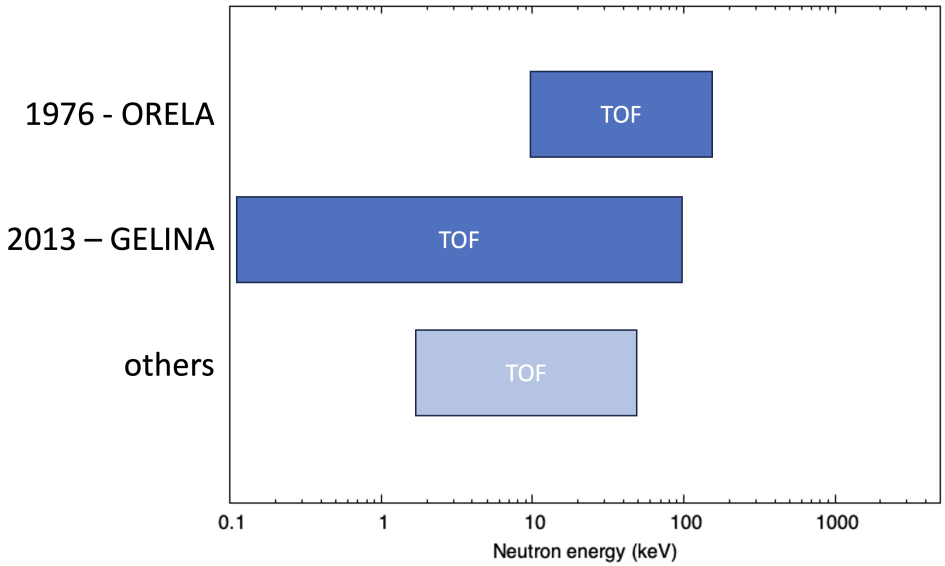
- 2024: ^{63}Cu(n,γ) and ^{65}Cu(n,γ)
- Measurements with C_6D_6 detectors
- Resonance parameter extraction in the energy range of interest $E_n < 400\,\text{keV}$

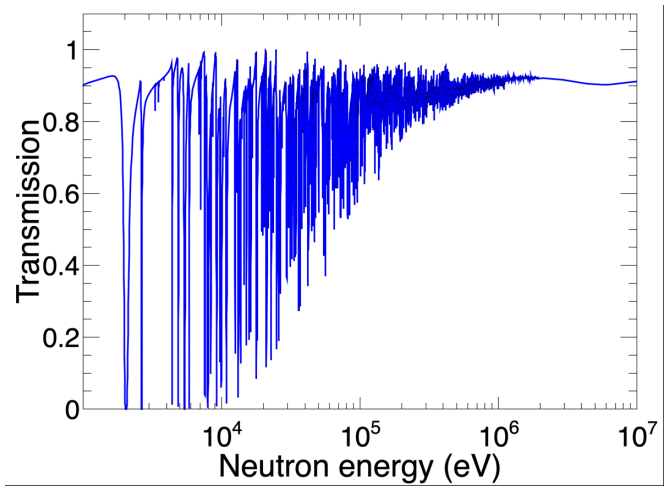




n + ^{63,65}Cu @ n_TOF EAR1: (n,tot)

- 2025: ^{63}Cu(n,tot) and ^{65}Cu(n,tot)
- Measurements with ^{235}U-loaded fission chamber
- Resonance parameter extraction in the energy range of interest $E_n < 5\,\mathrm{MeV}$
- Target: σ_{tot} uncertainty below 5% for $E_n > 100 keV$ with 100 bpd





n + ^{63,65}Cu @ n_TOF EAR1: angular measurements

- 2025: Tests for feasibility of elastic/inelastic angular distribution measurements

- Discussion on setup and detector R&D : this meeting!

Plan @ n_TOF: capture

Exp.	Sample	Protons	Comments
Capture	^{63}Cu	2.0×10^{18}	
Capture	^{65}Cu	2.0×10^{18}	
Capture	^{nat}Cu	0.3×10^{18}	EAR1 or EAR2
Capture	Empty-sample	0.2×10^{18}	background study
Capture	Pb	0.2×10^{18}	background study
Capture	C	0.2×10^{18}	background study
Capture	^{197}Au	0.1×10^{18}	normalization
Transmission	^{63}Cu	1.0×10^{18}	"Sample-in"
Transmission	^{65}Cu	1.0×10^{18}	"Sample-in"
Transmission	Empty-sample	1.0×10^{18}	"Sample-out"
		8.0×10^{18}	

Table 3: Summary of requested protons.

		PLAN		
		PROTONS (x10^17)		
	SHIFT	planned	Ongoing	%
Cu63	54	21.6	21.8	101
Au	5	2.0	1.7	85
Empty	7	2.8	2.9	103
Pb	3	1.2	1.1	89
C	3	1.2	1.1	95
AOB	6	2.4	6.6	274
TOTAL	78	31.2	35.2	112.8

Target:

- Observe resonances up to 50-200 keV
  - σ_γ uncertainty below 3-5%

Plan @ n_TOF: capture

Exp.	Sample	Protons	Comments
Capture	^{63}Cu	2.0×10^{18}	
Capture	^{65}Cu	2.0×10^{18}	
Capture	^{nat}Cu	0.3×10^{18}	EAR1 or EAR2
Capture	Empty-sample	0.2×10^{18}	background study
Capture	Pb	0.2×10^{18}	background study
Capture	C	0.2×10^{18}	background study
Capture	^{197}Au	0.1×10^{18}	normalization
Transmission	^{63}Cu	1.0×10^{18}	"Sample-in"
Transmission	^{65}Cu	1.0×10^{18}	"Sample-in"
Transmission	Empty-sample	1.0×10^{18}	"Sample-out"
		8.0×10^{18}	

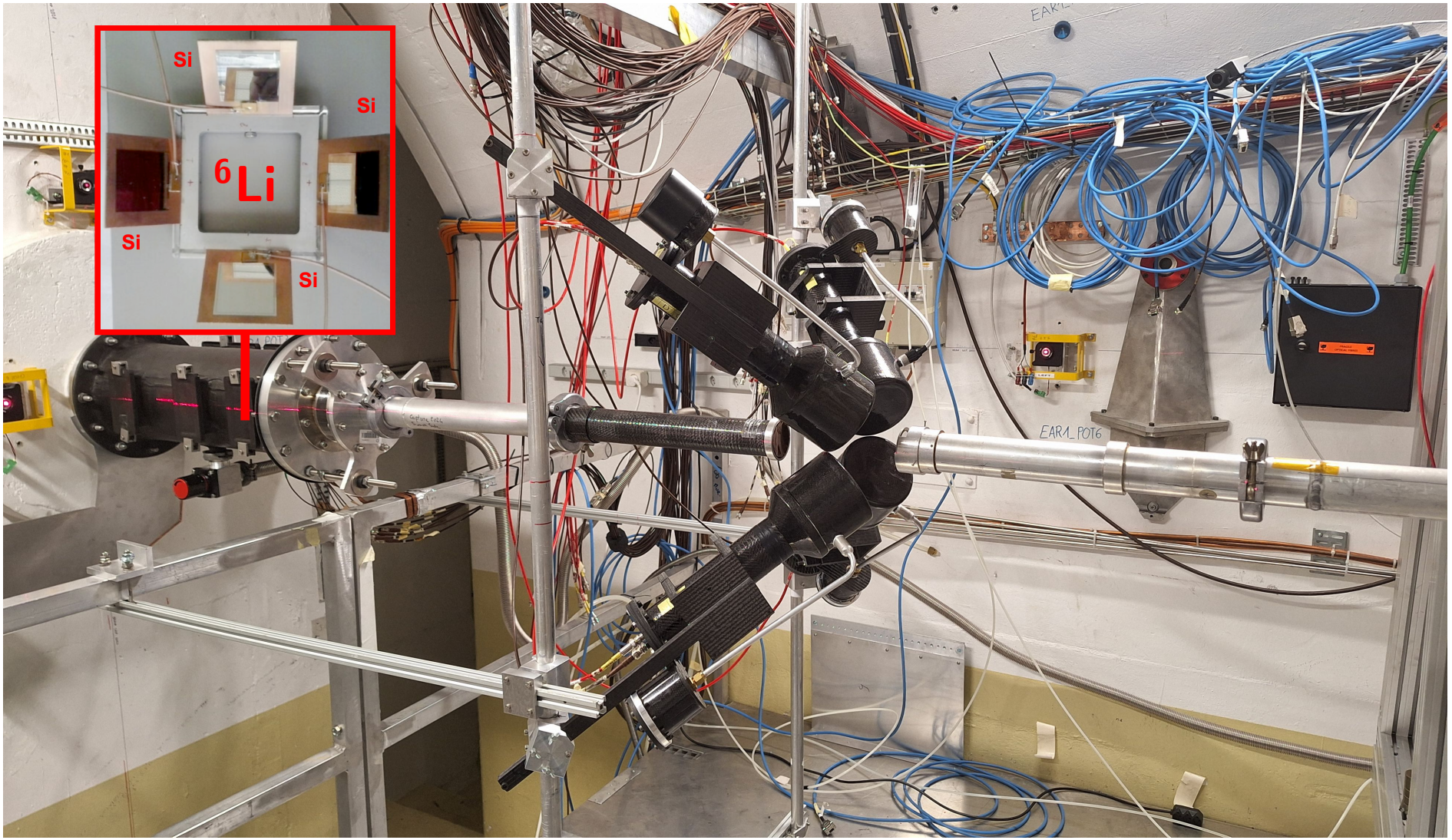
Table 3: Summary of requested protons.

	PLAN			
		PROTONS (x10^17)		
	SHIFT	planned	Ongoing	%
Cu65	50	18.3	17.3	94
Au	1	0.4	1.0	269
Empty	4	1.5	1.7	115
Pb	2	0.7	0.9	118
C	2	0.7	0.9	129
filters	8	2.9	4.0	136
TOTAL	67	24.6	25.7	104.8

Target:

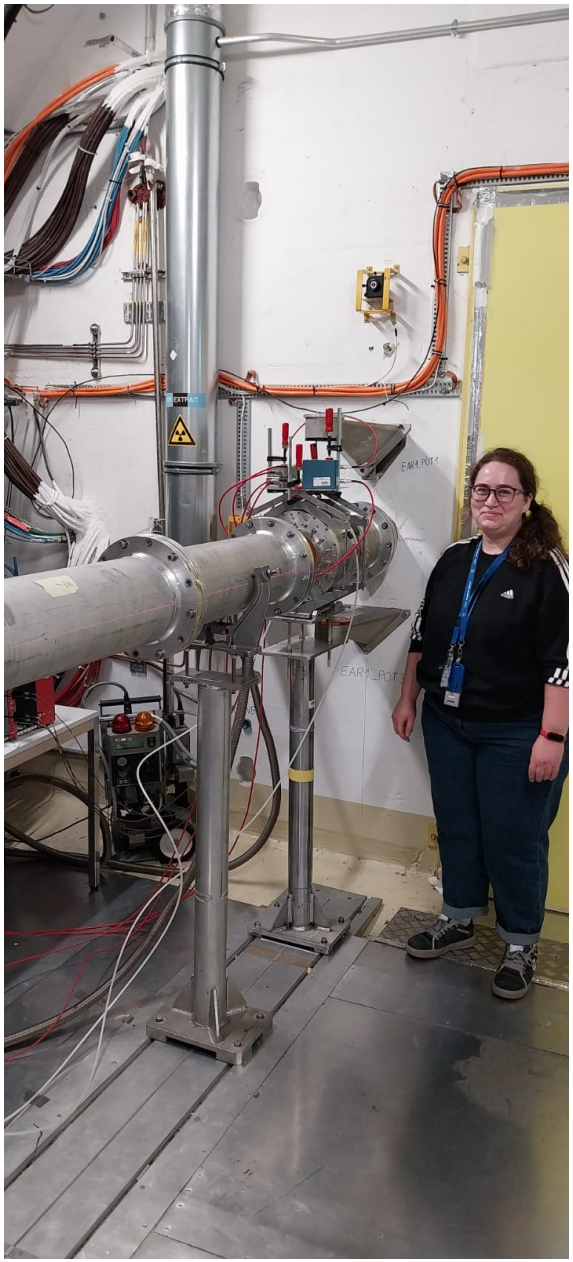
- Observe resonances up to 50-200 keV
  - σ_γ uncertainty below 3-5%

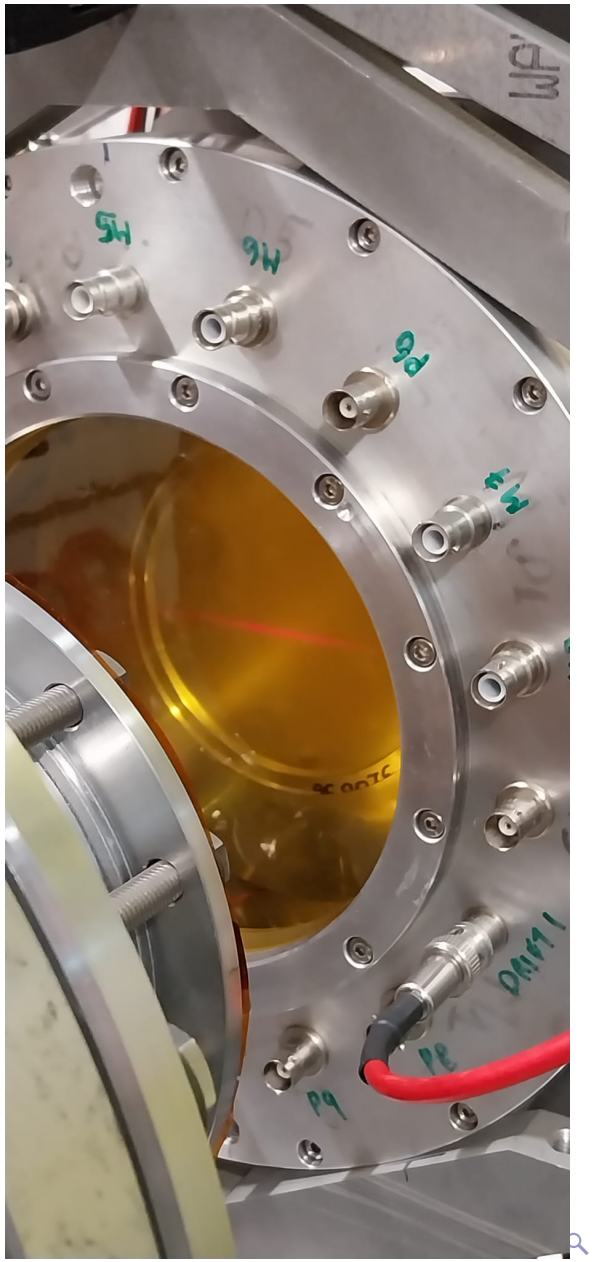
^{63}Cu capture campaign



^{65}Cu capture campaign: target & C_6D_6

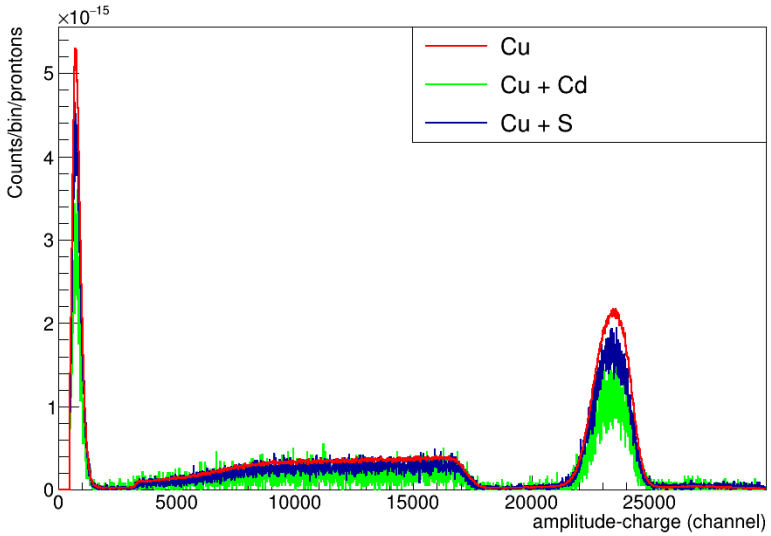
^{65}Cu capture campaign: MicroMegas

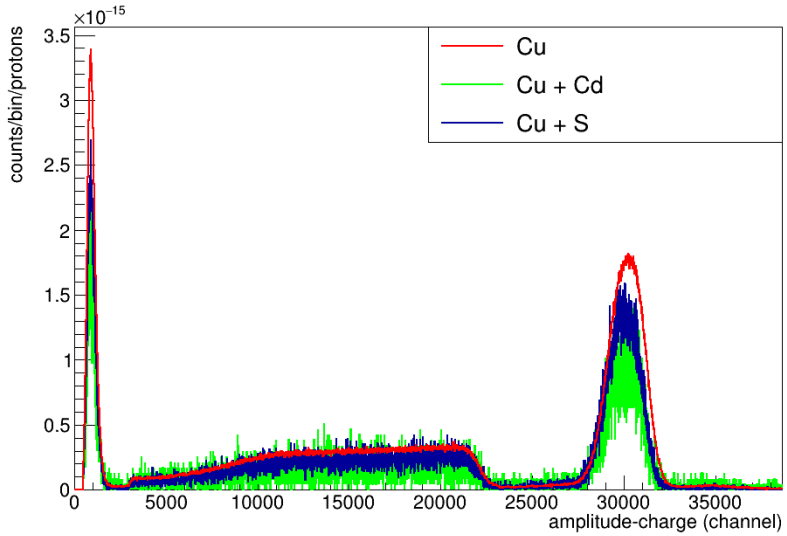


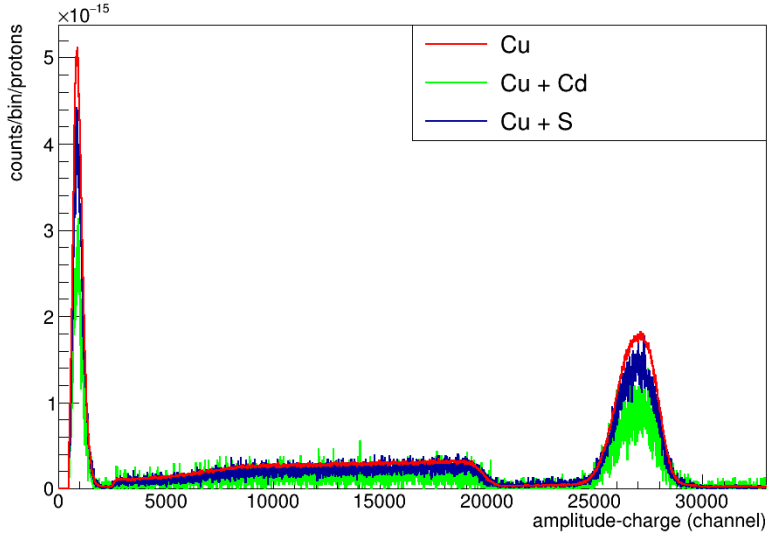


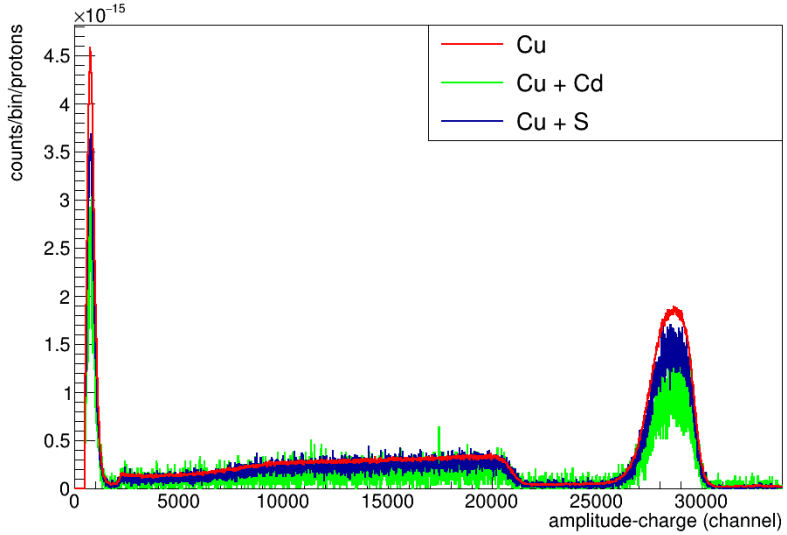
Preliminary analysis results: ^{63}Cu

SiMON amplitude spectra

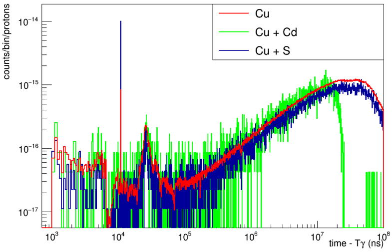


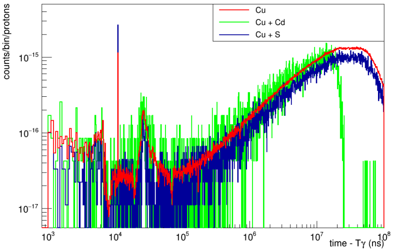


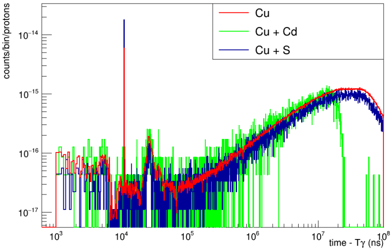


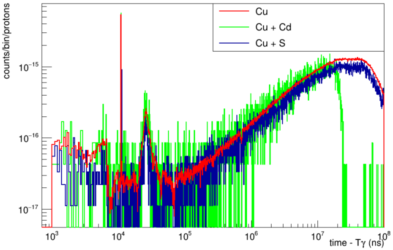


SiMON TOF spectra

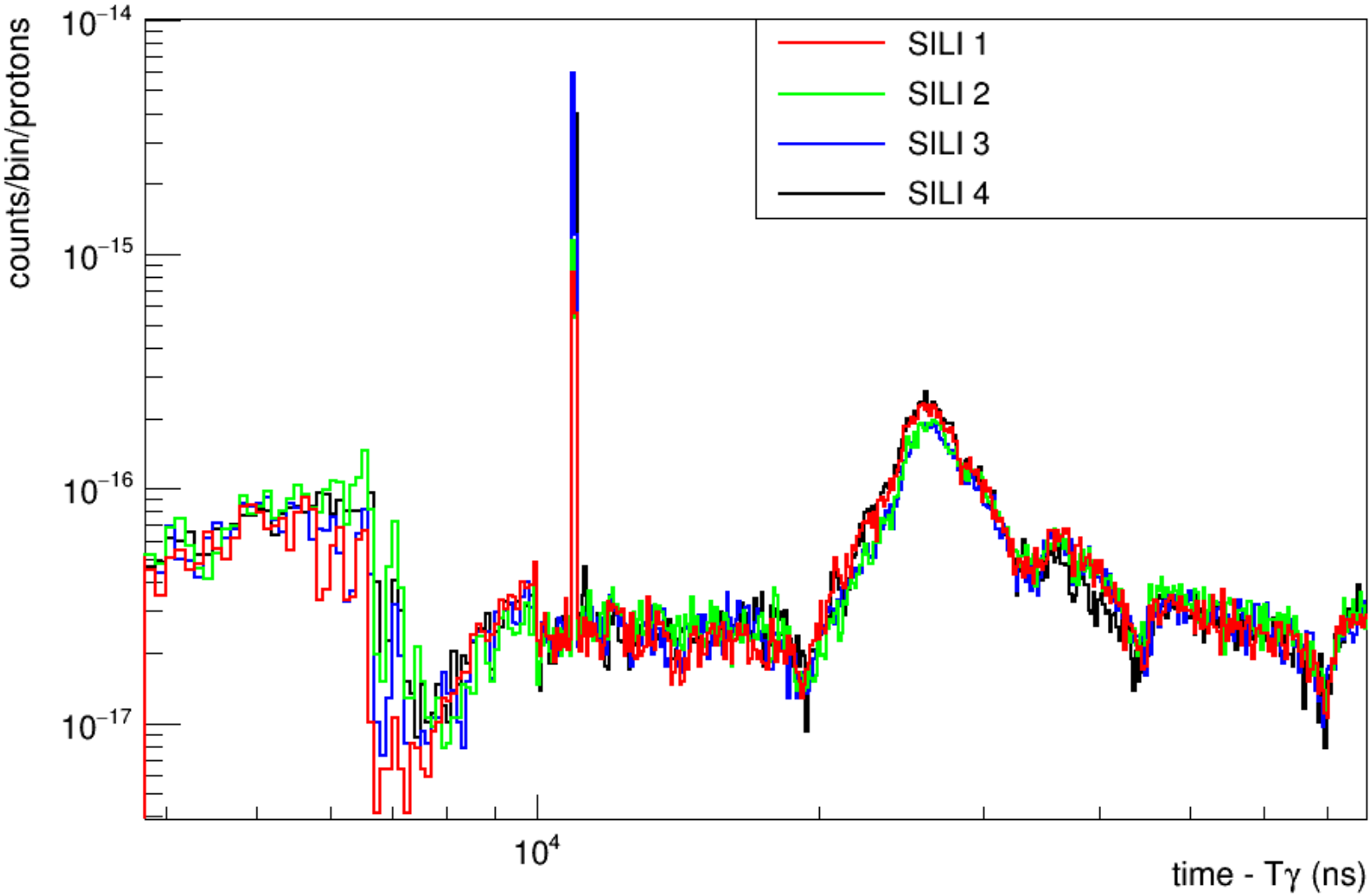




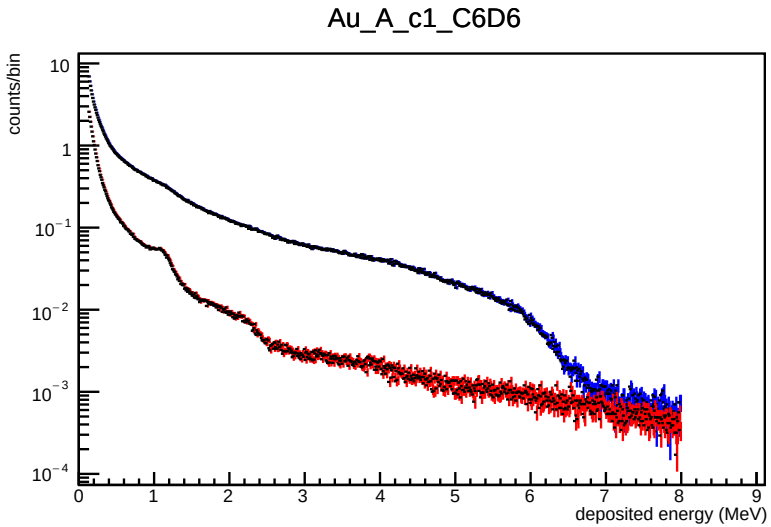


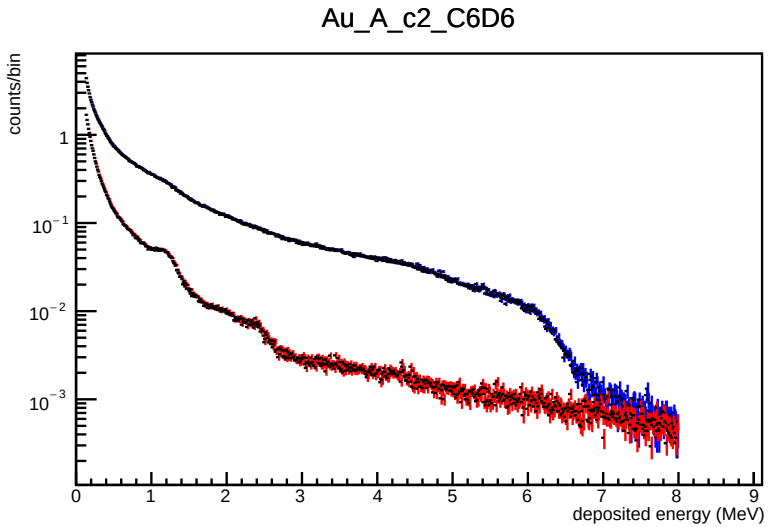


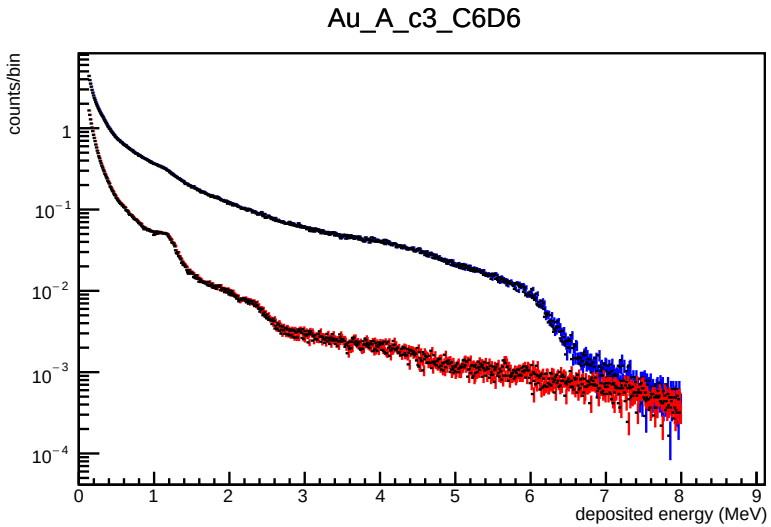
SiMON TOF spectra

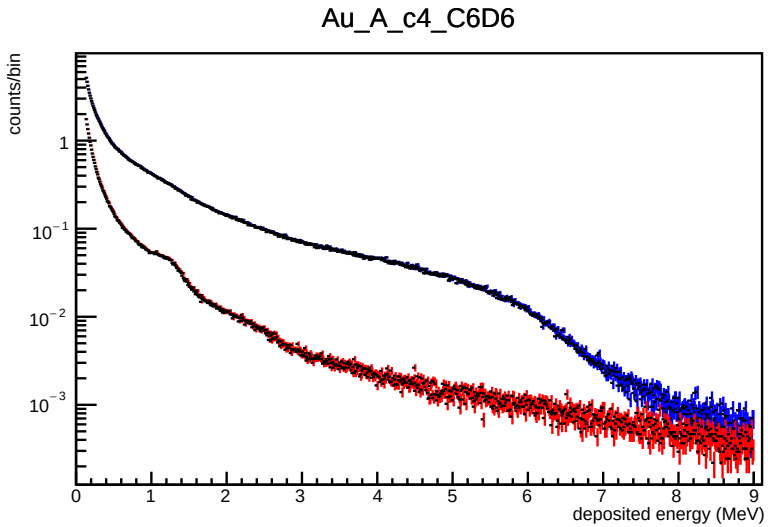


C_6D_6 amplitude spectra Au

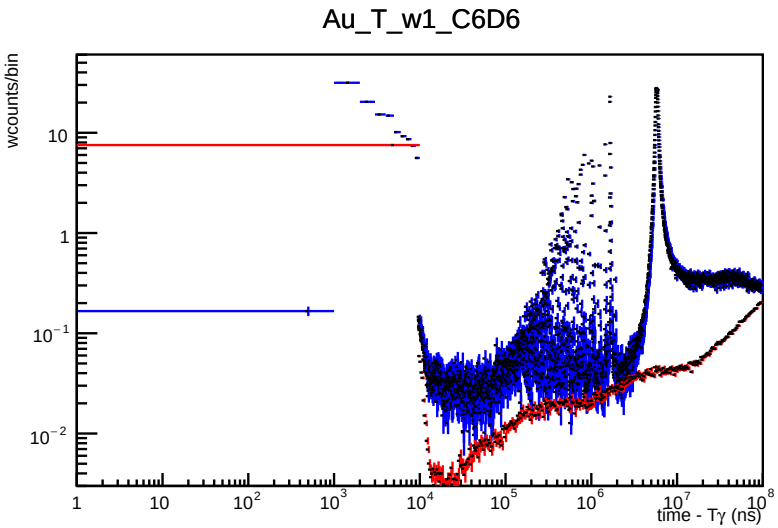


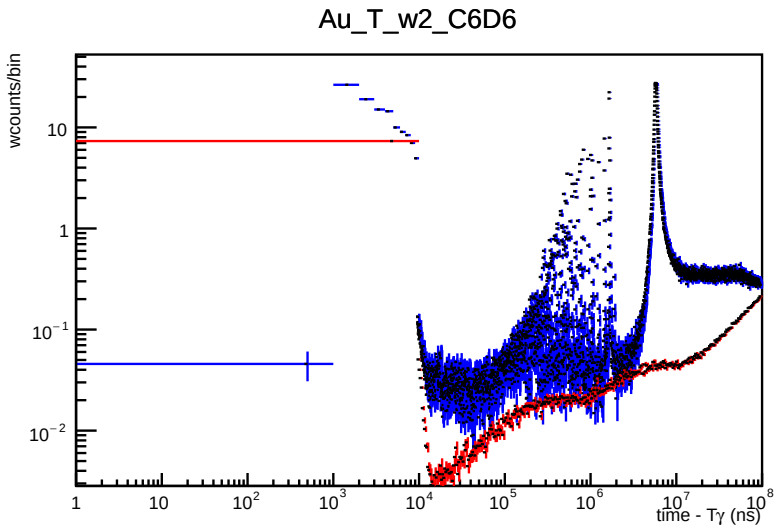


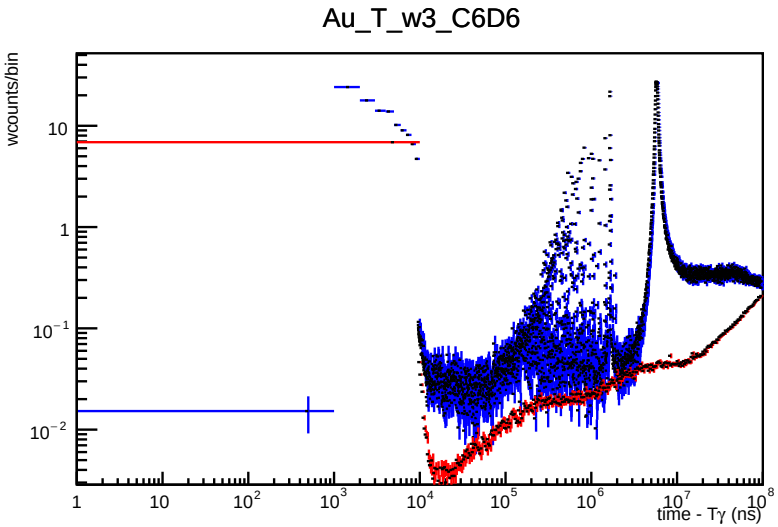


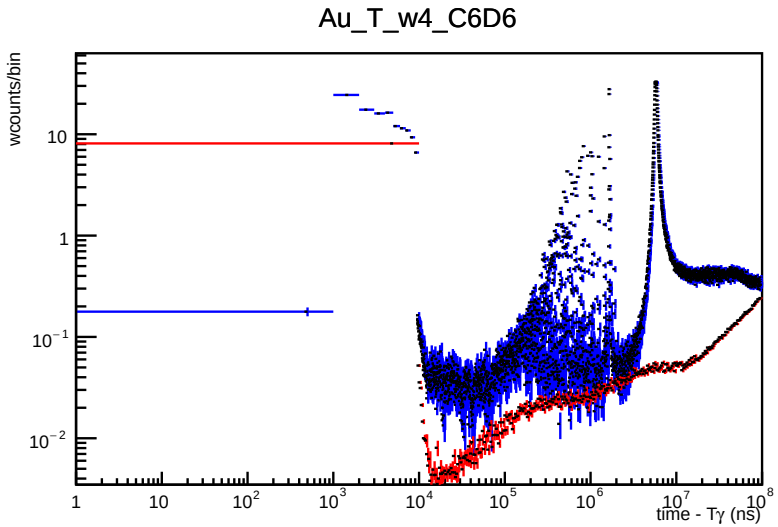


C_6D_6 TOF spectra Au

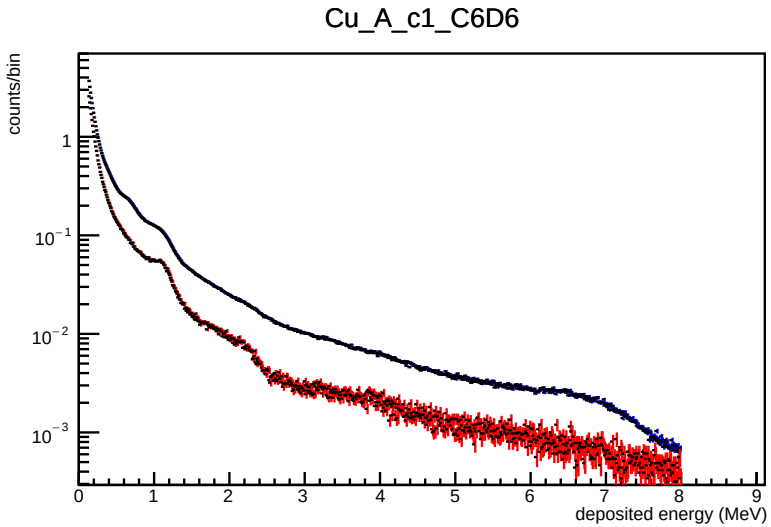


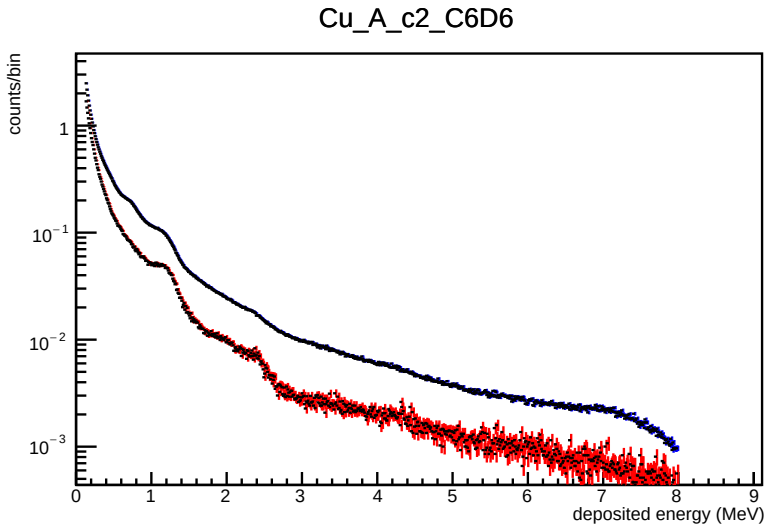


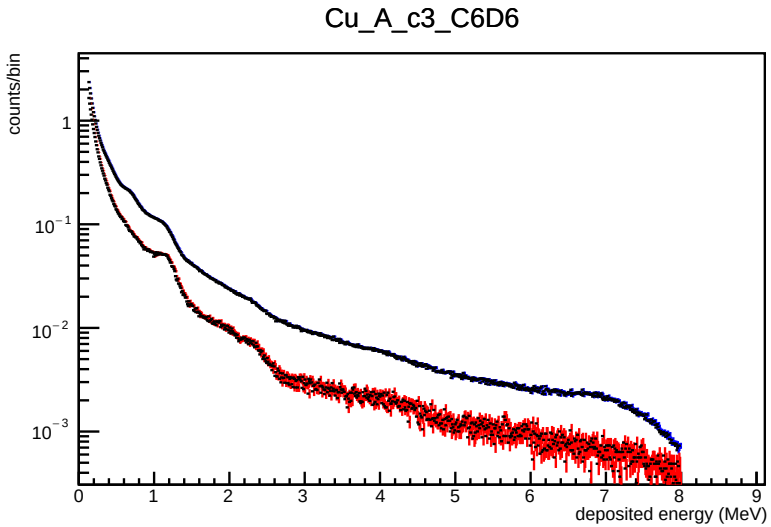


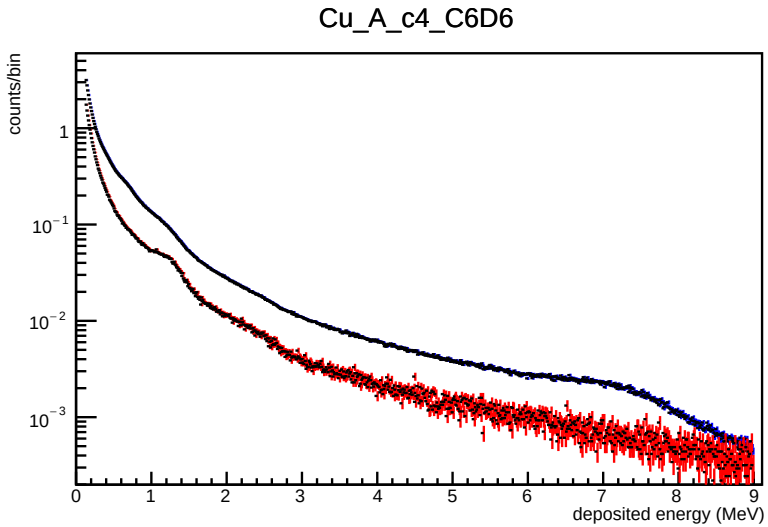


C_6D_6 amplitude spectra Cu

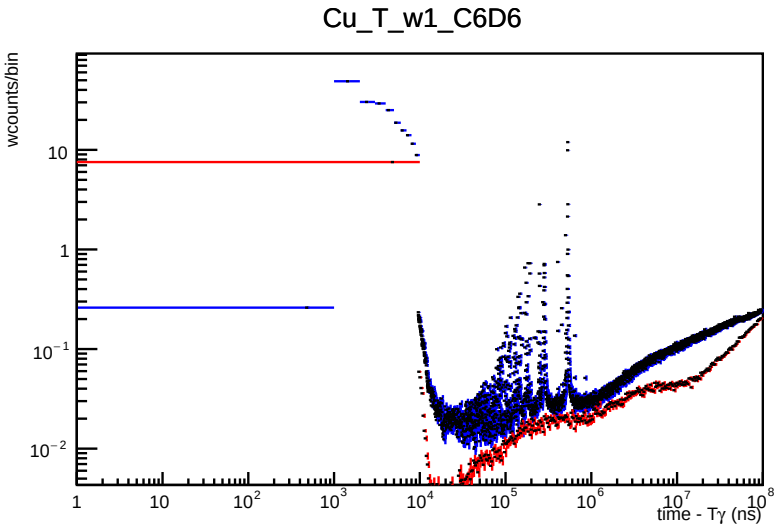


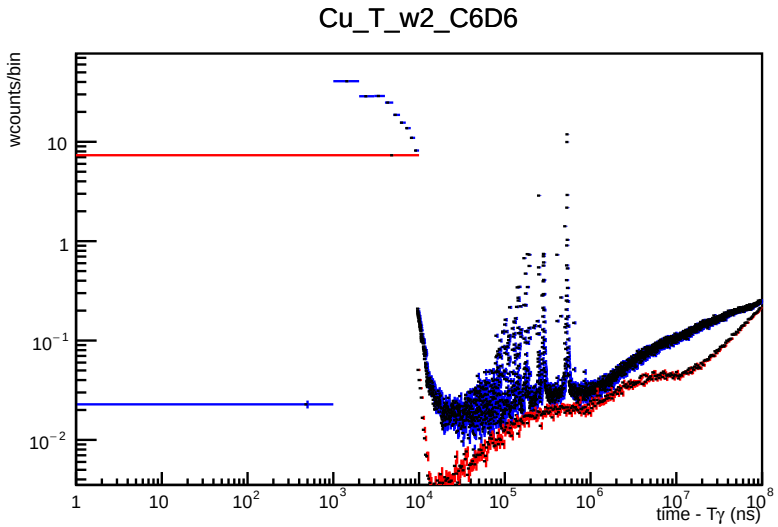


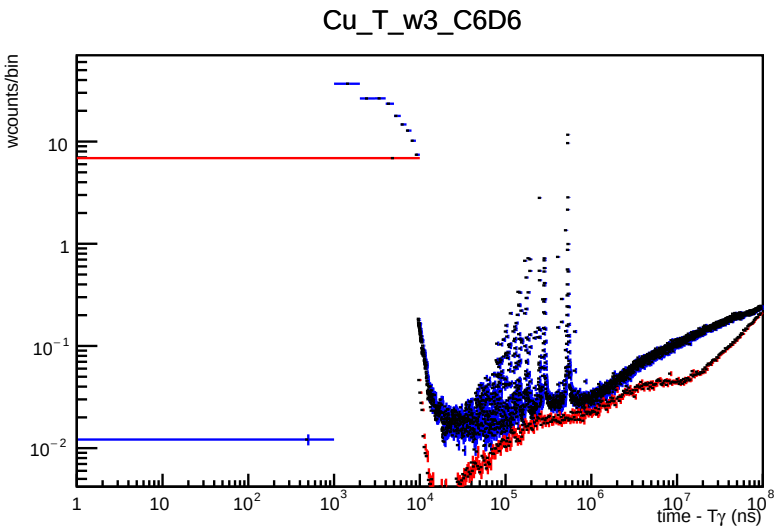


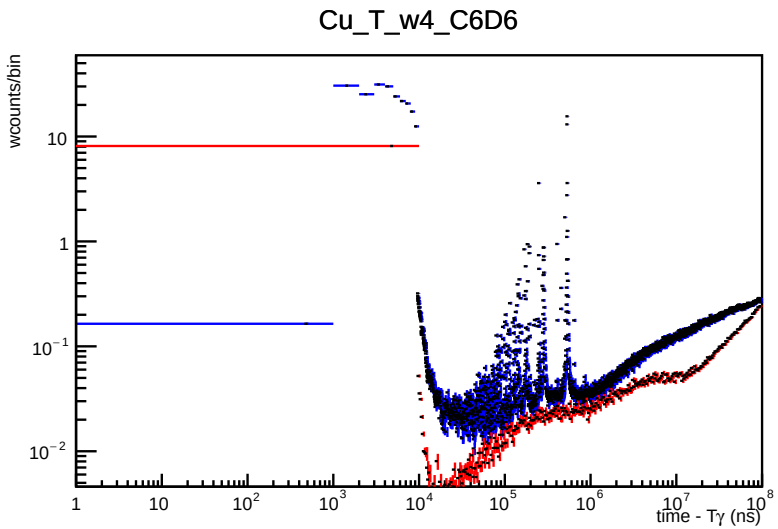


C_6D_6 TOF spectra Cu

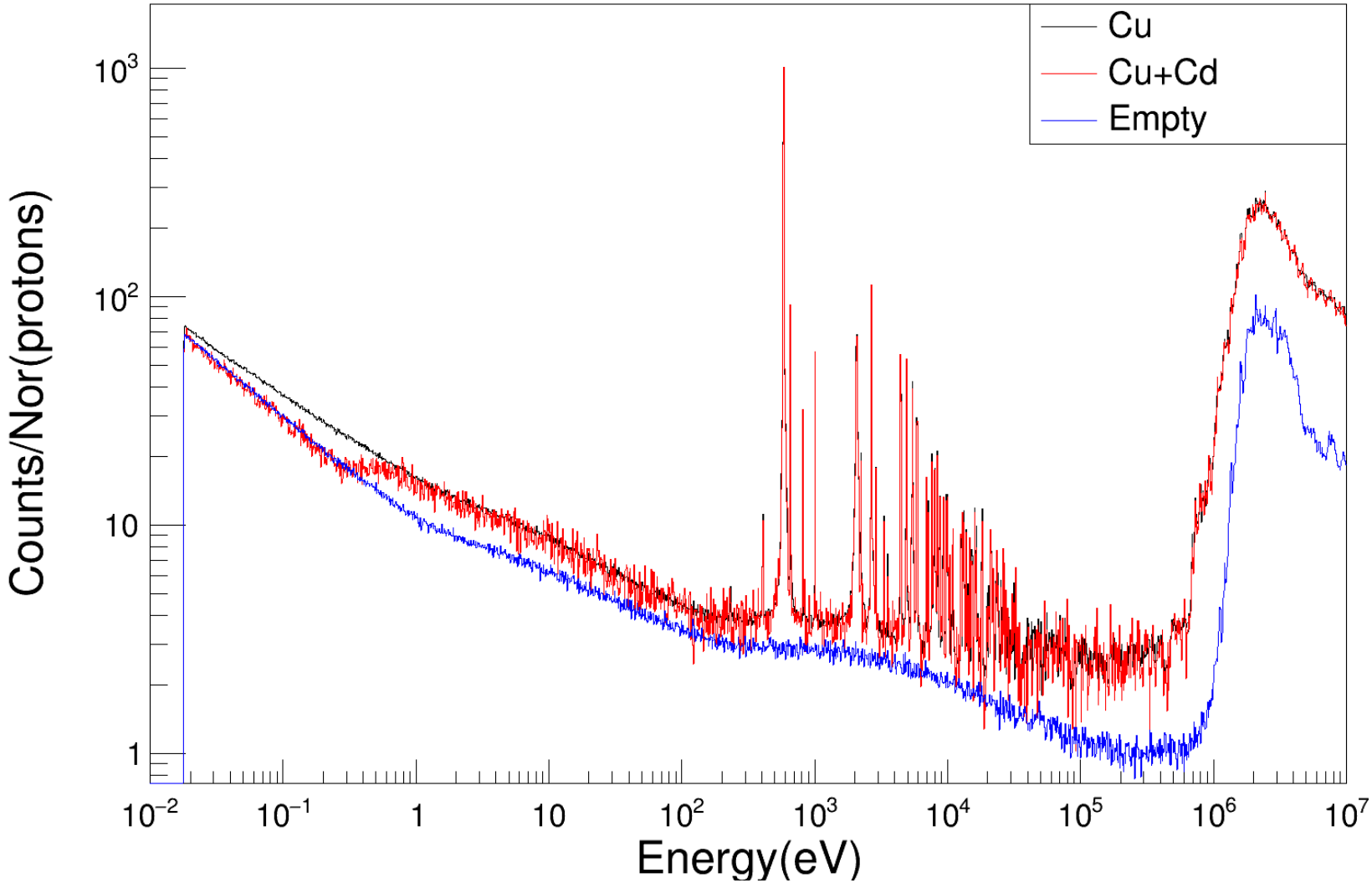




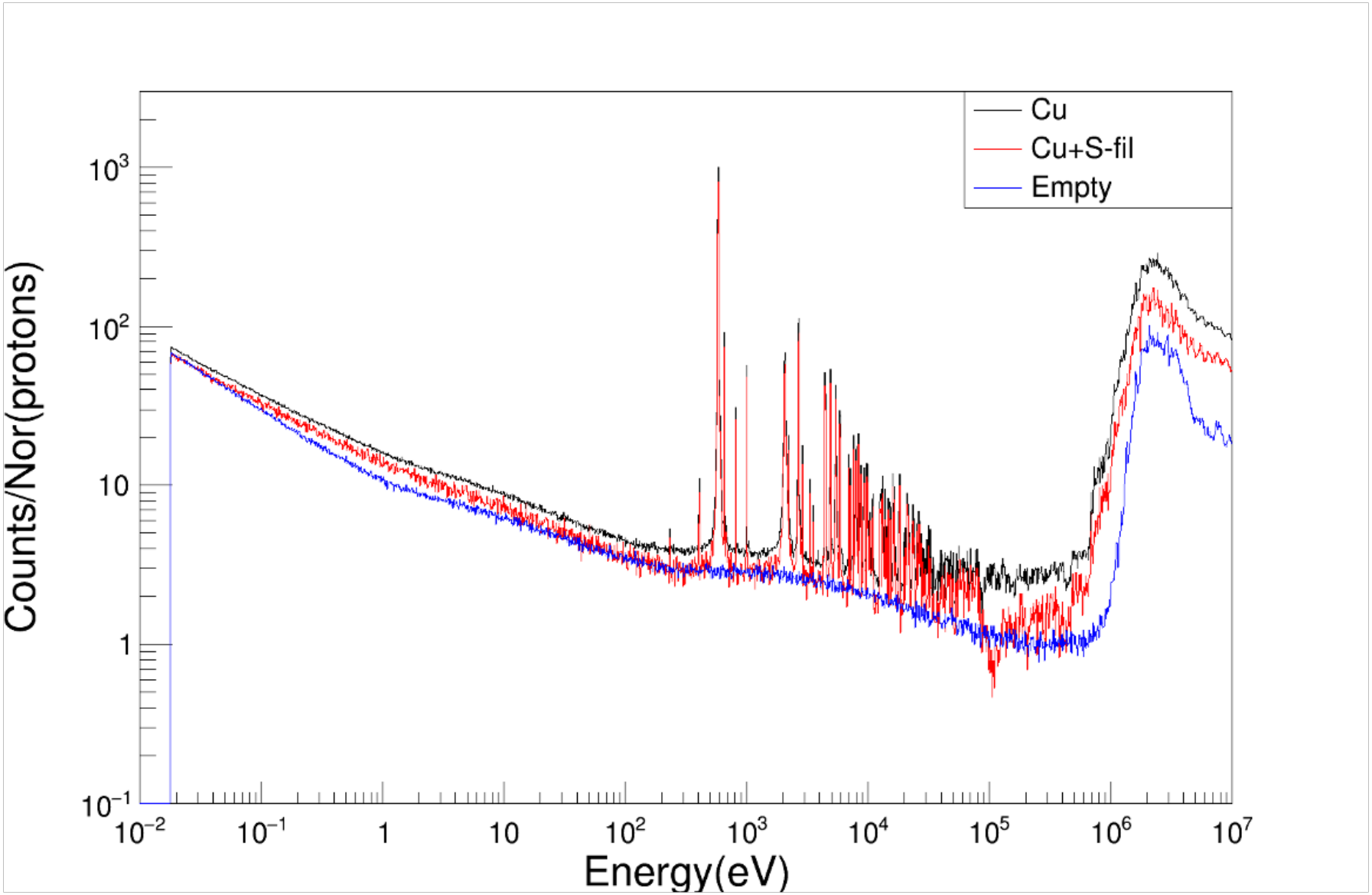




C_6D_6 counts normalized to neutron intensity



C_6D_6 counts normalized to neutron intensity



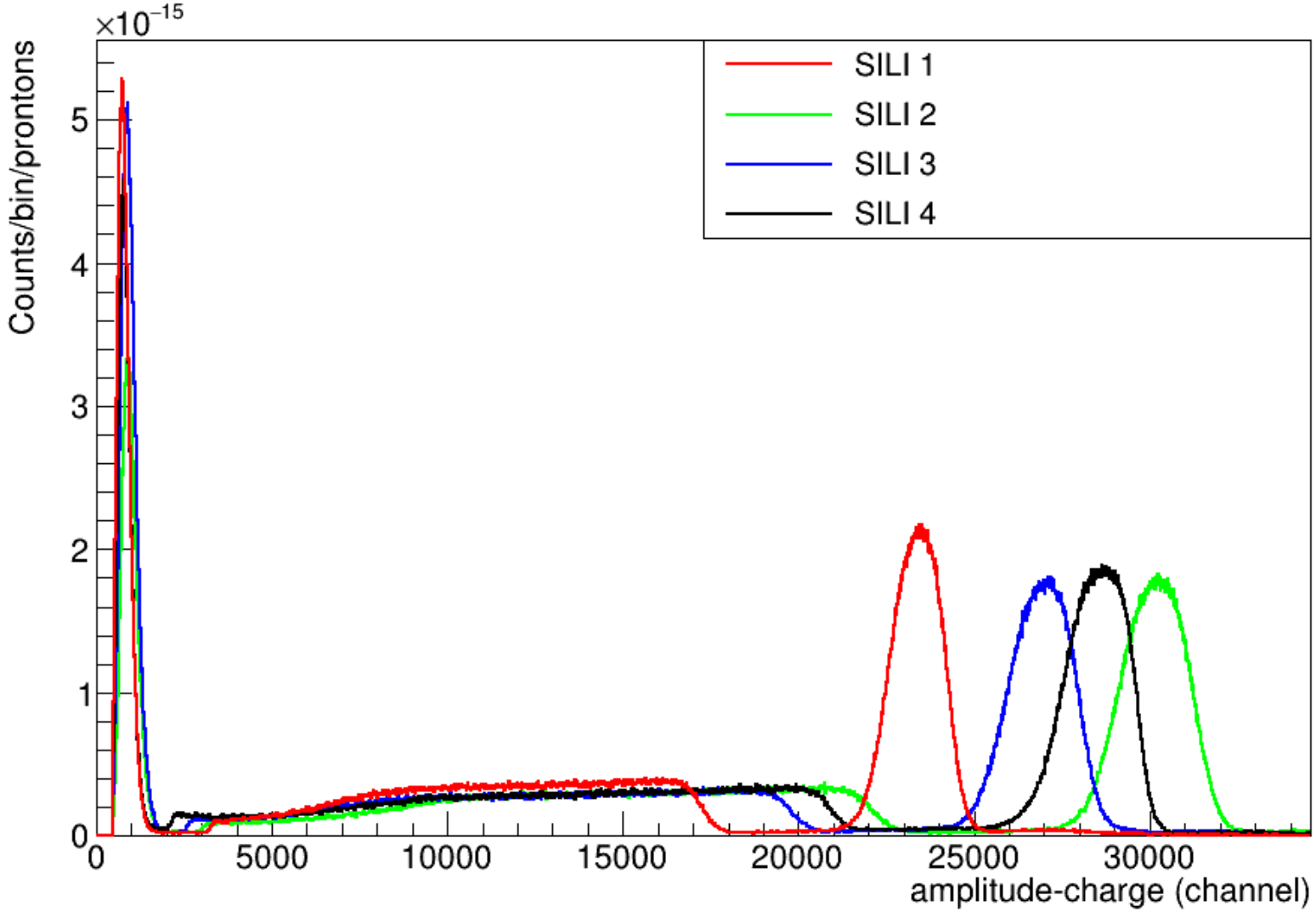
PhD RAMEN: to do next

- Check C_6D_6 gains calibrations
  - Produce MC WF for Cu
  - Study C_6D_6 background
    - Produce yields
      - RSA on Cu
- Systematic study on uncertainties
  - Transmission measurements
    - . . .

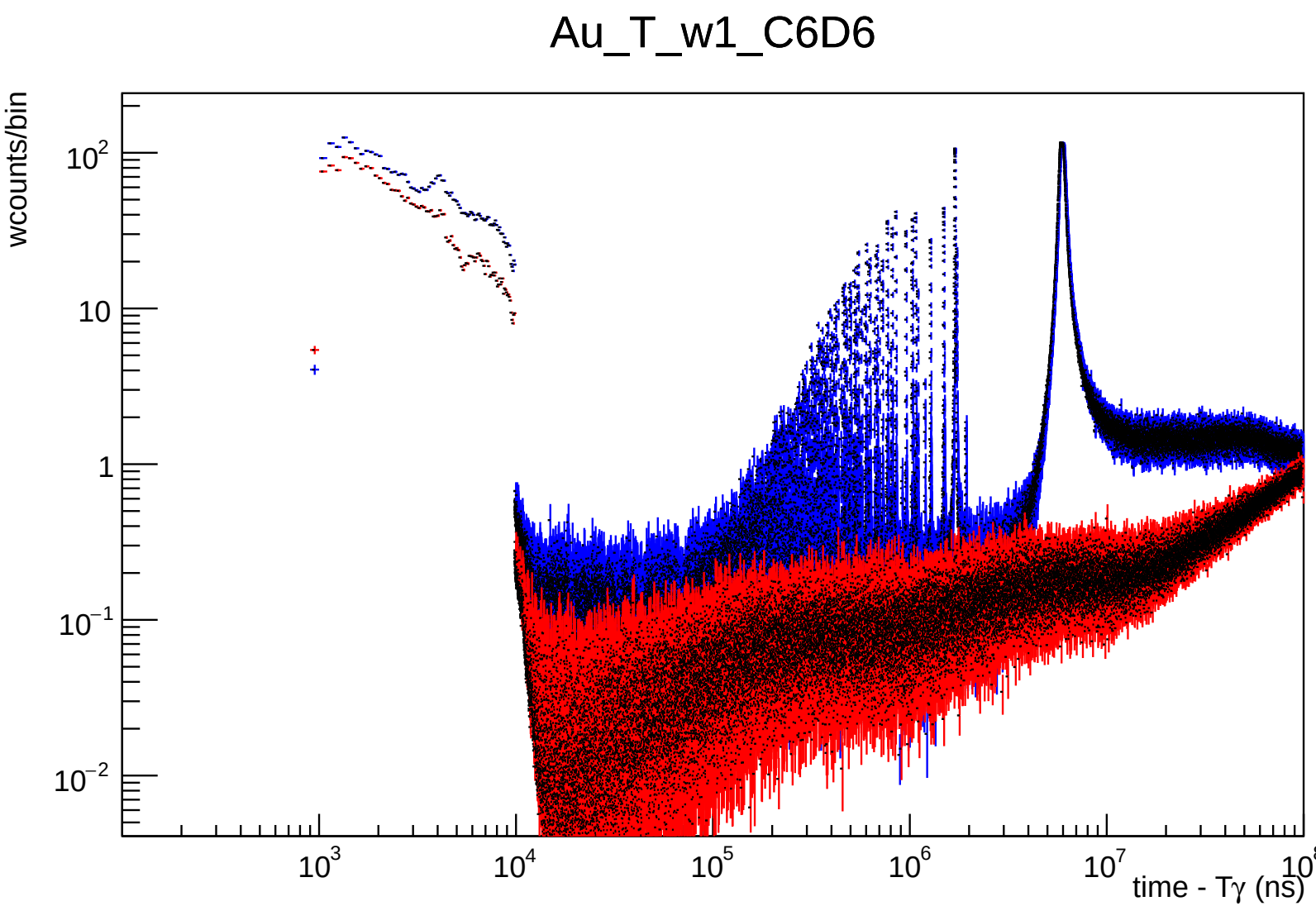
Thank You!

Backup slides

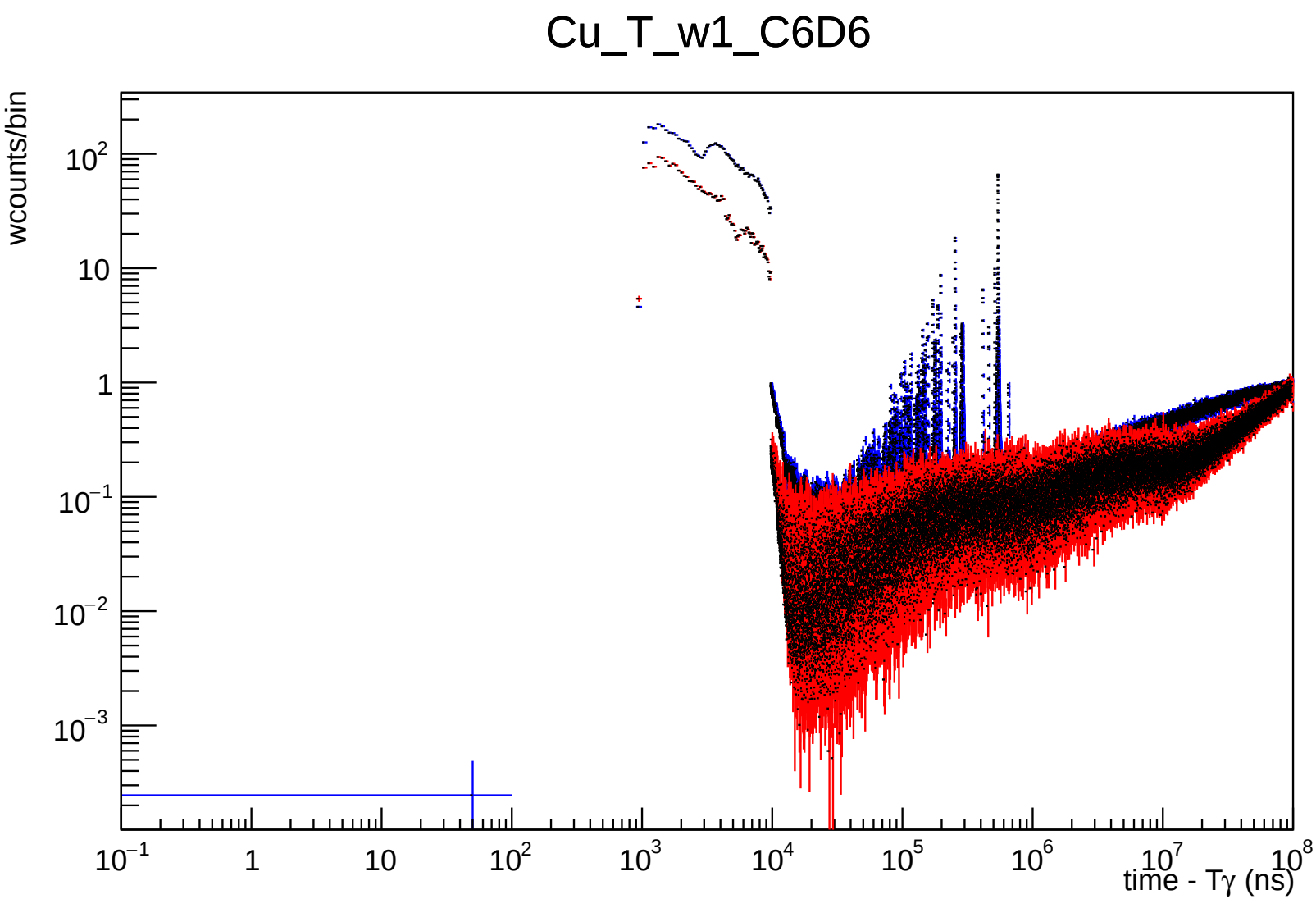
SiMON amplitude spectra



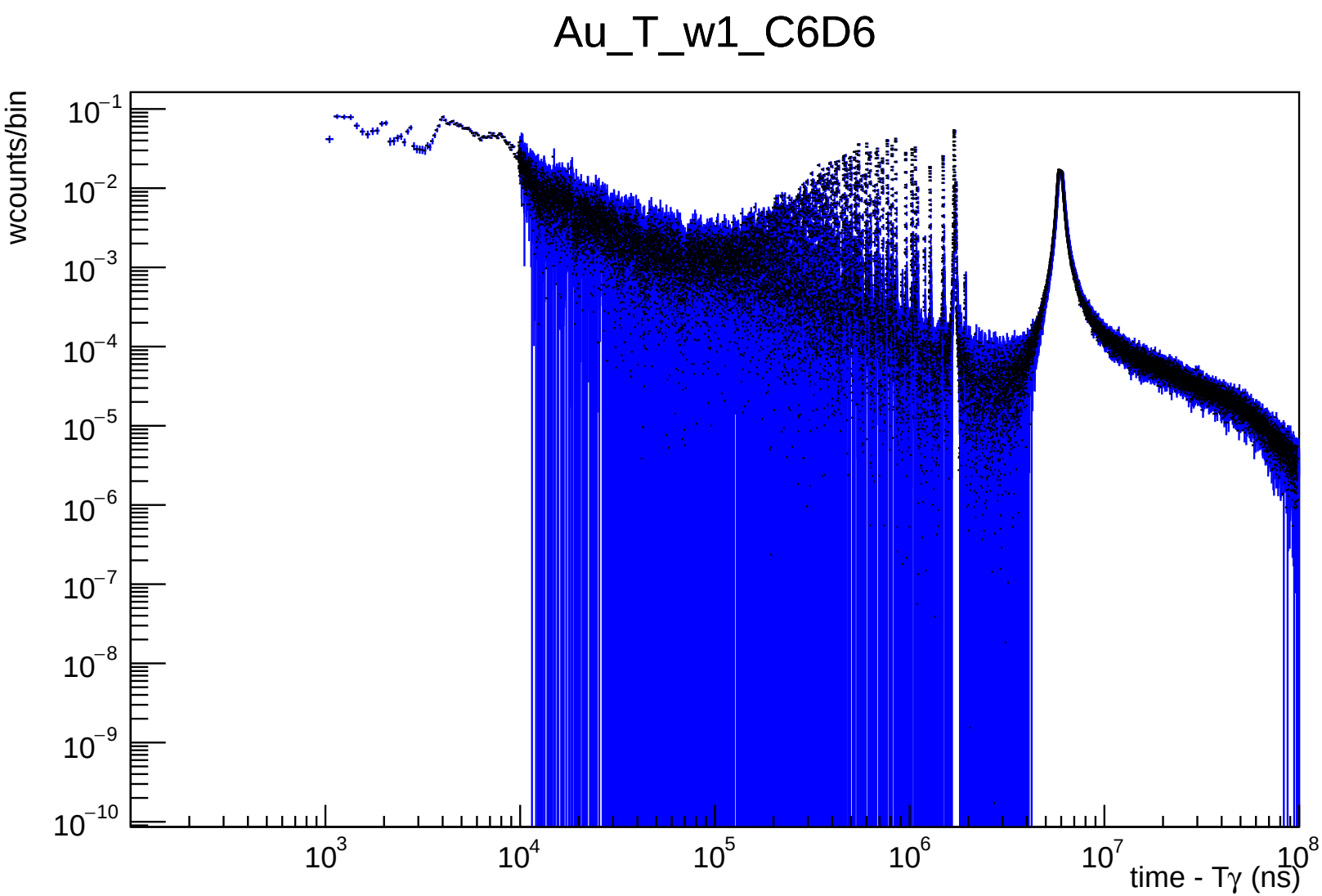
C_6D_6 TOF spectra Au



C_6D_6 TOF spectra Cu



C6D6


Au_T_w1_C6D6
wcounts/bin
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
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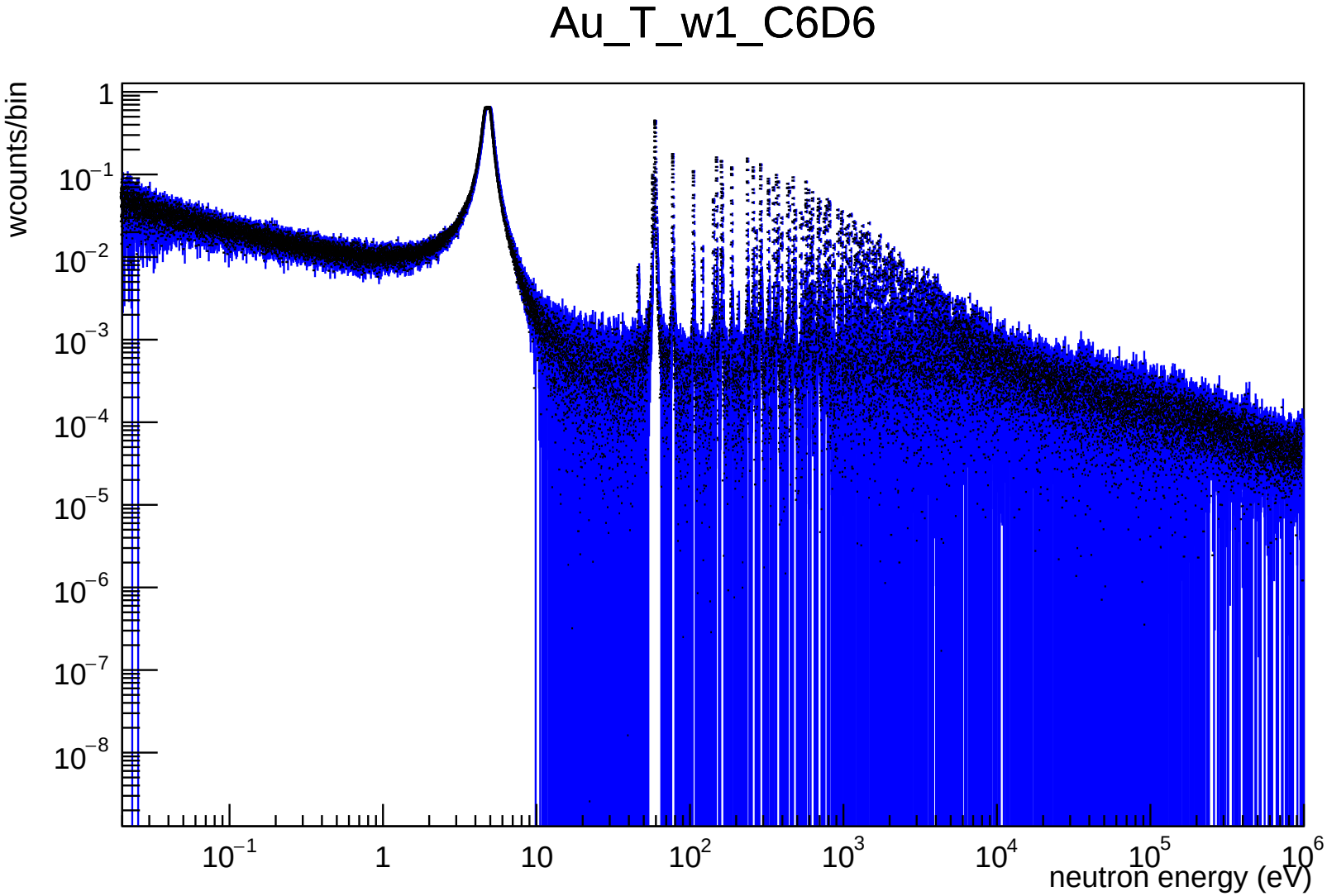
10^{5}
10^{6}
10^{7}
10^{8}
time - Tγ (ns)


Au_T_w1_C6D6
wcounts/bin
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10^{-1}
10^{-2}
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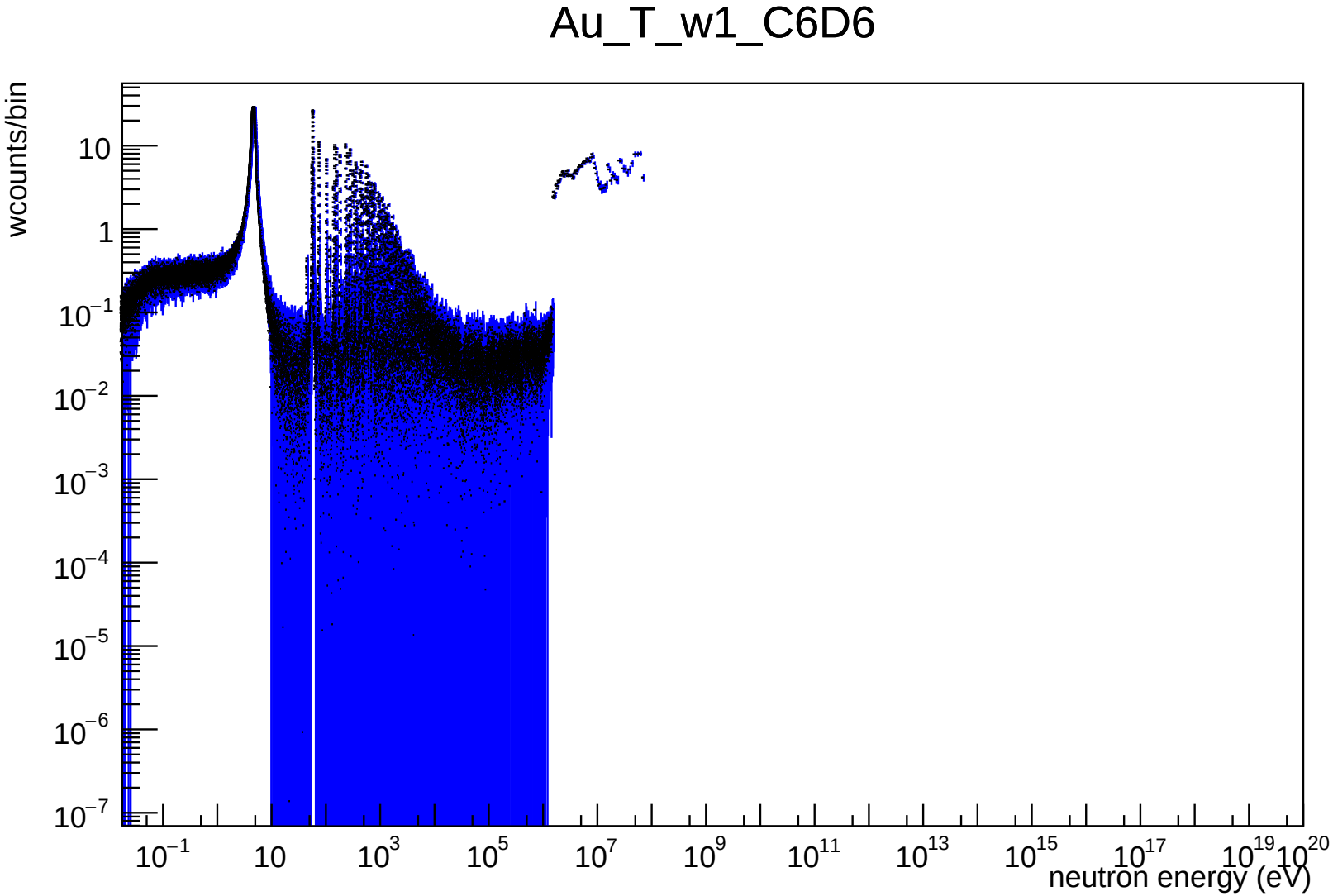
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-1}
1
10
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
neutron energy (eV)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wcounts/bin
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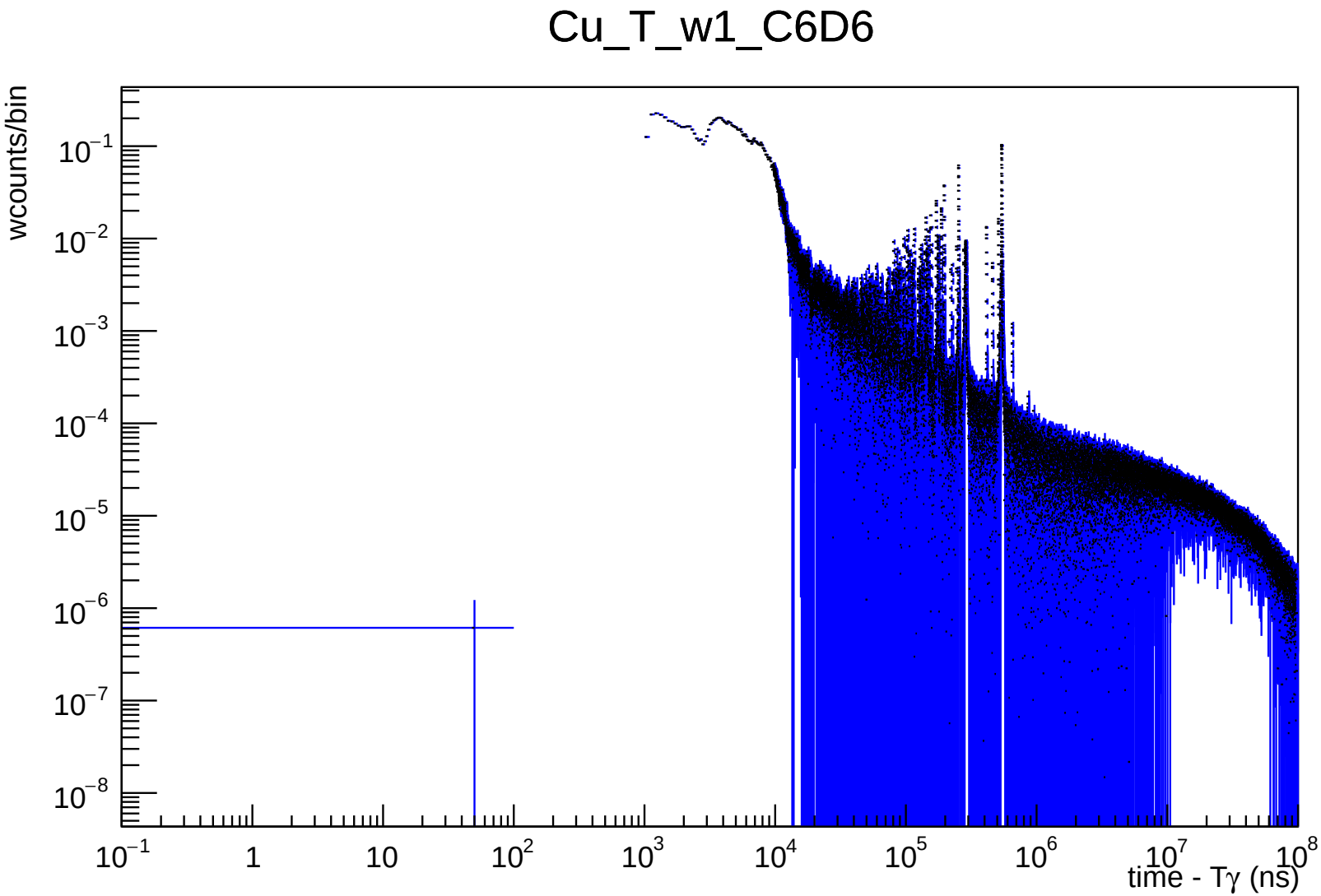
10^{20}
neutron energy (eV)


Cu_T_w1_C6D6
wcounts/bin
10^{-1}
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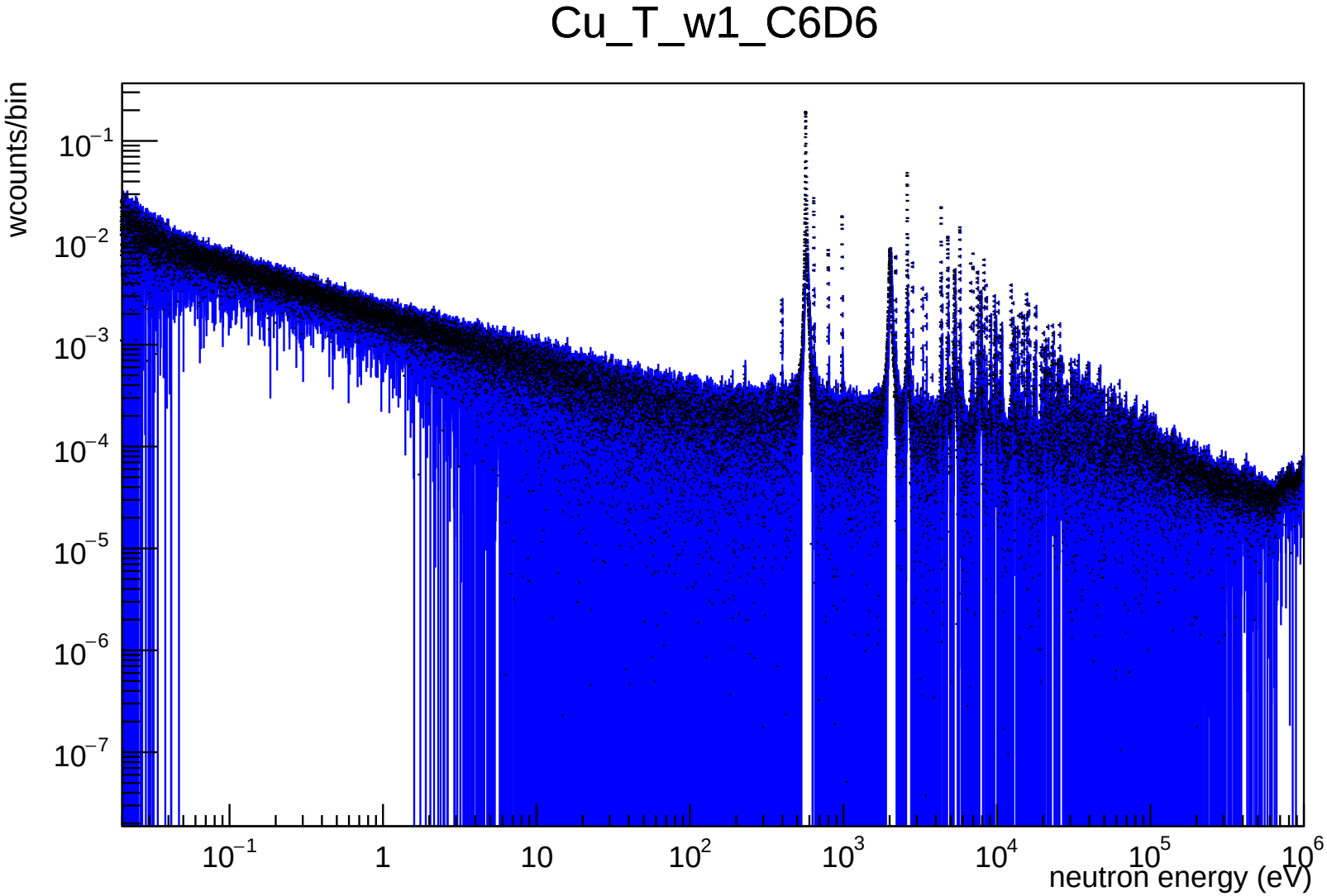
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-1}
1
10
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
time - Tγ (ns)


Cu_T_w1_C6D6
wcounts/bin
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10^{-4}
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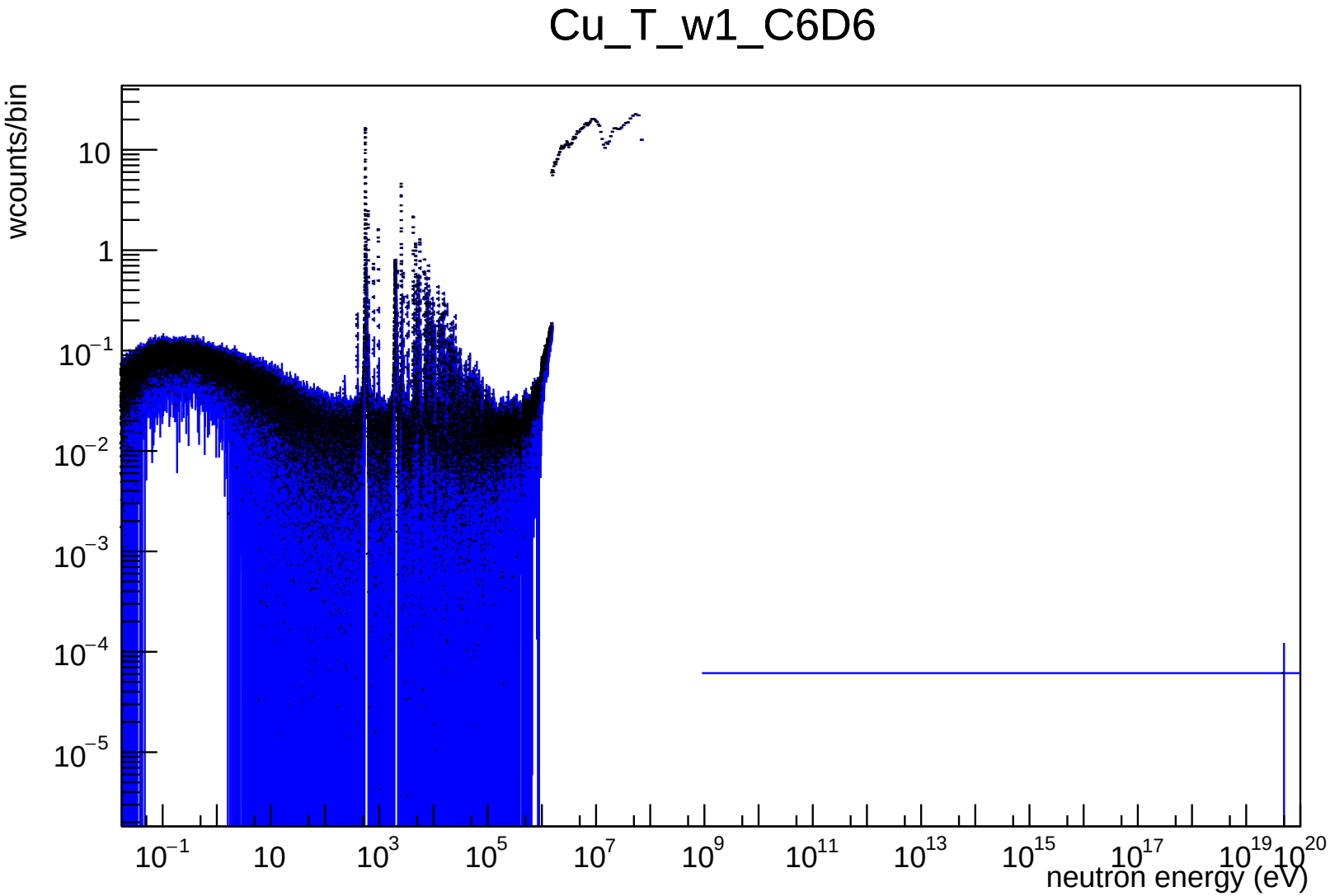
10^{-7}
10^{-1}
1
10
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
neutron energy (eV)


Cu_T_w1_C6D6
wcounts/bin
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
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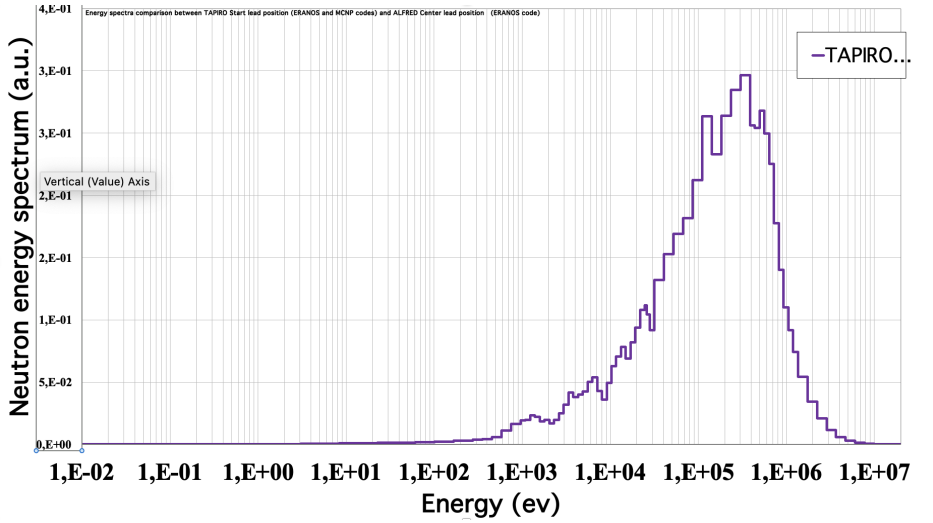
10^{3}
10^{5}
10^{7}
10^{9}
10^{11}
10^{13}
10^{15}
10^{17}
10^{19}
10^{20}
neutron energy (eV)

Why Copper?

Nuclear Technologies:

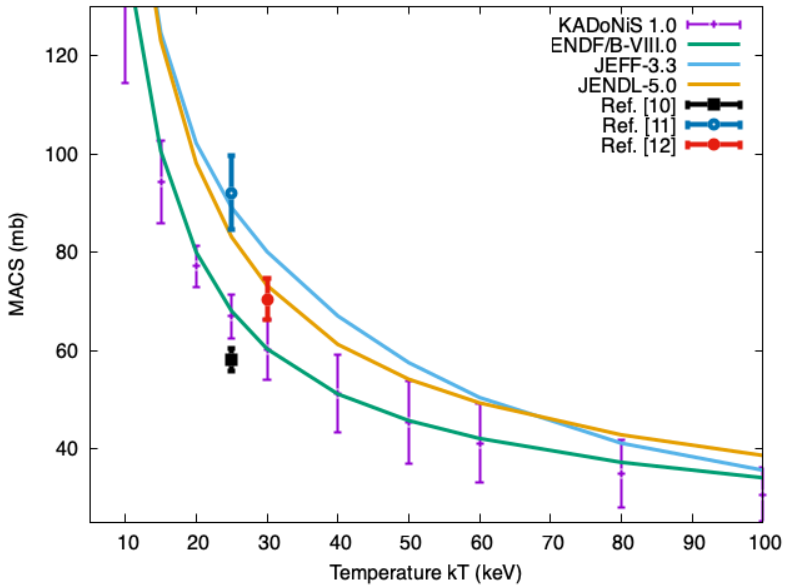
- TAPIRO research reactor plays a crucial role for testing nuclear data and materials for fast reactors
- S&U studies revealed inadequacies in major data libraries regarding Copper evaluations

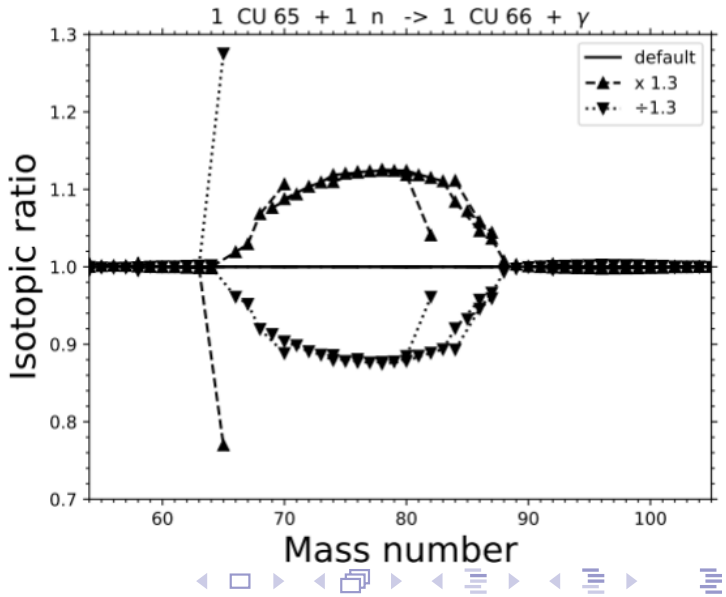


Why Copper?

Nuclear Astrophysics:

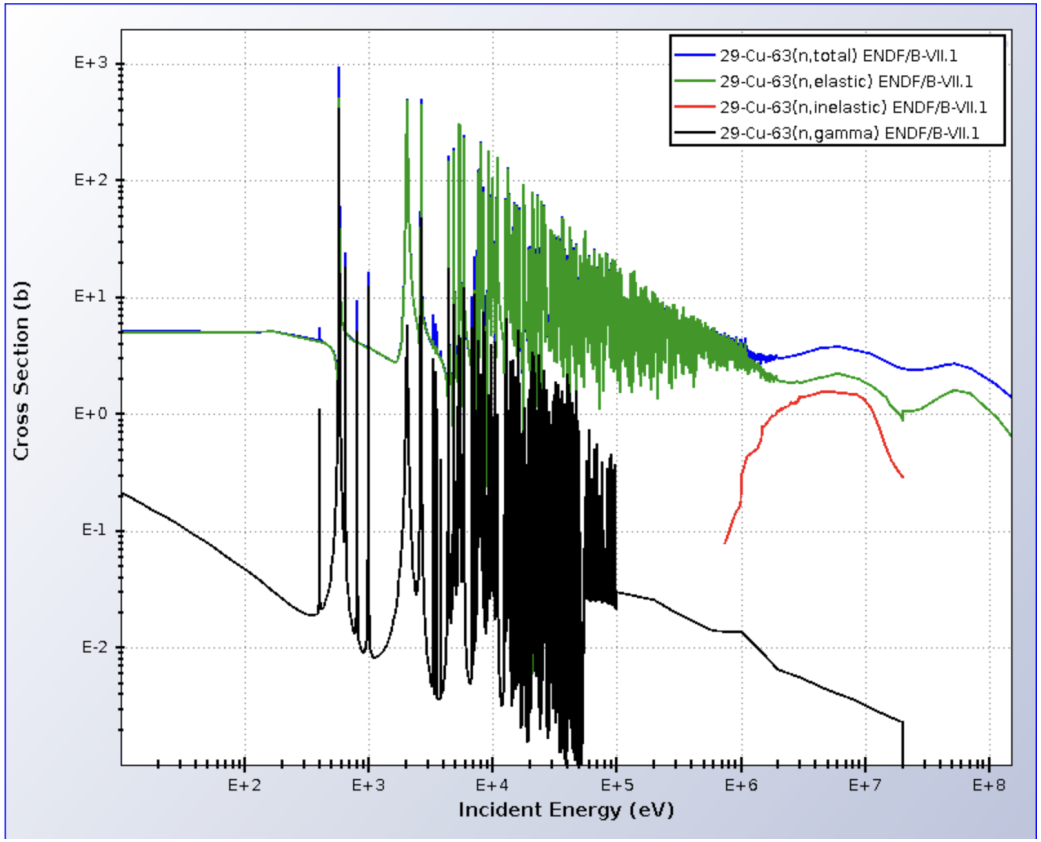
- The contributions of various nucleosynthesis scenarios (weak s-process in massive stars, main s-process in AGBs, SNe Ia and SNe II) need to be determined
- With accurate determination of Cu MACS, it will also be possible to improve the quantitative description of the s-process in massive stars





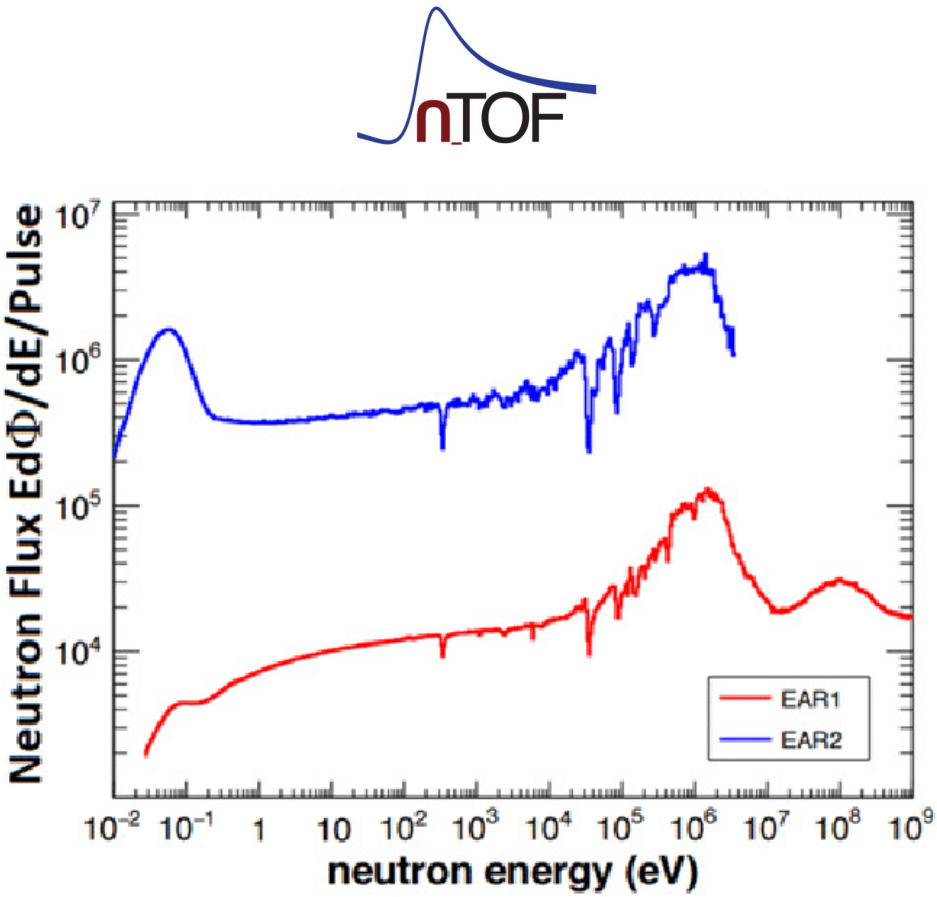
n + ^{63,65}Cu @ n_TOF EAR1: (n,n)

- A combined analysis of capture and transmission data will help deduce the $\sigma_e \simeq \sigma_{tot} - \sigma_\gamma$, with potential future studies on elastic angular distribution and the inelastic channel.



The n_TOF facility

- Wide energy range:
  $10\,\text{meV} < E_n < 1\,\text{GeV}$
- High current:
  7×10^{12} p/bunch $\rightarrow$
  $\sim 10^6$ n/pulse from spallation target
- Energy resolution:
  $\Delta E/E \sim 10^{-4}$@EAR1



PhD RAMEN project proposal

- Experimental data acquisition
- Tests for feasibility of elastic angular distribution measurements
- Analysis of the acquired data

MicroMegas