

Meeting Nazionale n_TOF

Status of $^{63,65}\text{Cu}$ measurements and analysis



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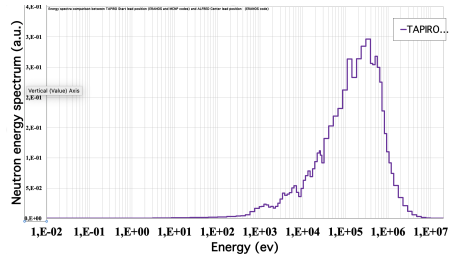
29 April 2025



Why Copper?

Nuclear Technologies:

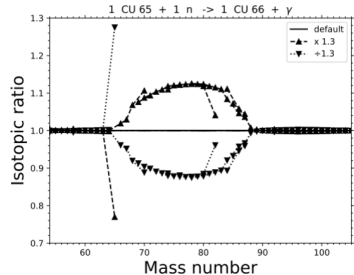
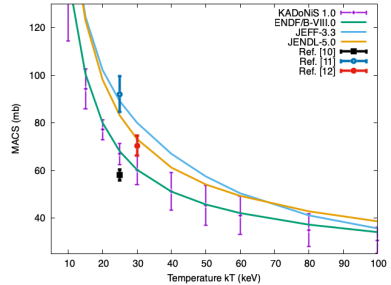
- Generation IV fast reactors
- Nuclear data and materials testing at the TAPIRO research reactor
- S&U studies revealed inadequacies in Cu data libraries



Why Copper?

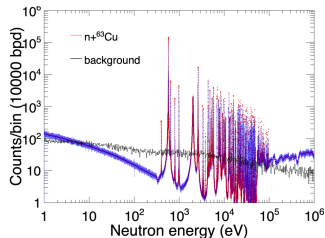
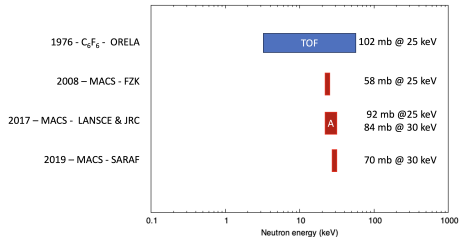
Nuclear Astrophysics:

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



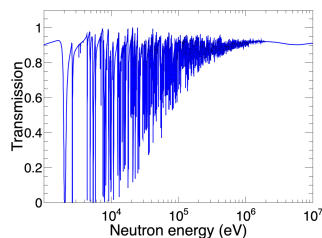
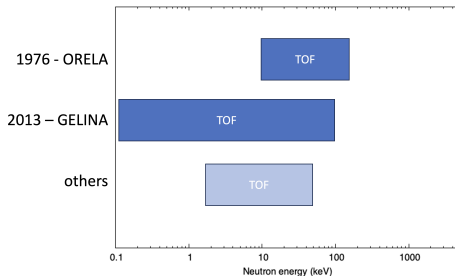
$n + {}^{63,65}\text{Cu}$ @ n_TOF EAR1: (n,γ)

- 2024: ${}^{63}\text{Cu}(n,\gamma)$ and ${}^{65}\text{Cu}(n,\gamma)$
- Measurements with C_6D_6 detectors
- Resonance parameter extraction in the energy range of interest $E_n < 400$ keV, σ_γ below 3-5%



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

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

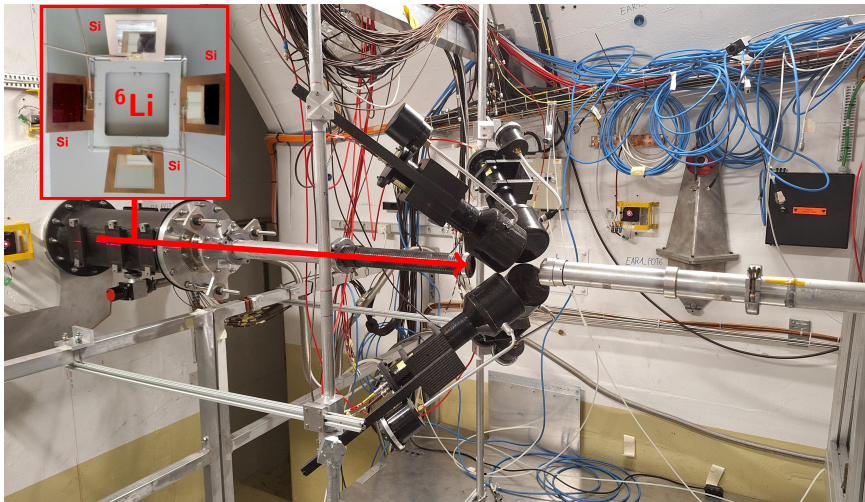


Measurements @ n_TOF: status

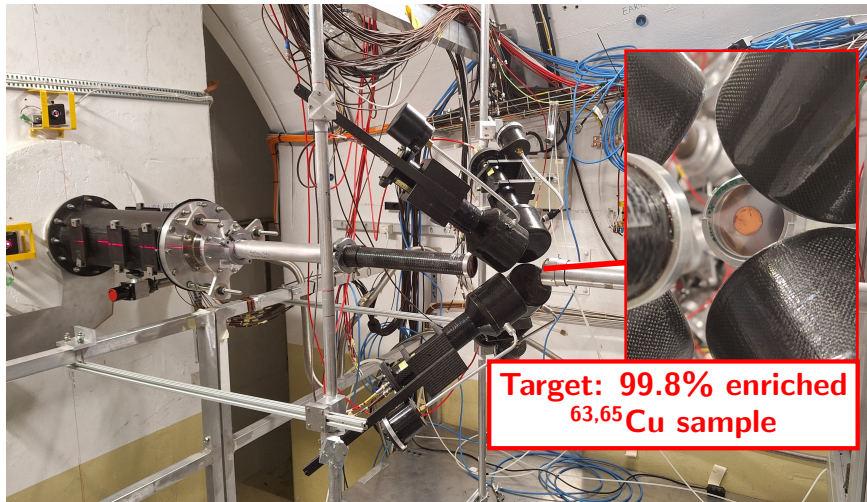
Experiment	Sample	Protons	Comments	
Capture	^{63}Cu	2.0×10^{18}		✓
Capture	^{65}Cu	2.0×10^{18}		✓
Capture	^{nat}Cu	0.3×10^{18}	EAR1 or EAR2	✓
Capture	Empty-sample	0.2×10^{18}	background study	✓
Capture	Pb	0.2×10^{18}	background study	✓
Capture	C	0.2×10^{18}	background study	✓
Capture	^{197}Au	0.1×10^{18}	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}		

Starting from May!

Measurements @ n_TOF: capture setup



Measurements @ n_TOF: capture setup

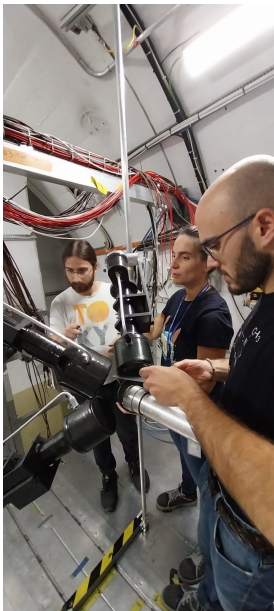


**Target: 99.8% enriched
 $^{63,65}\text{Cu}$ sample**

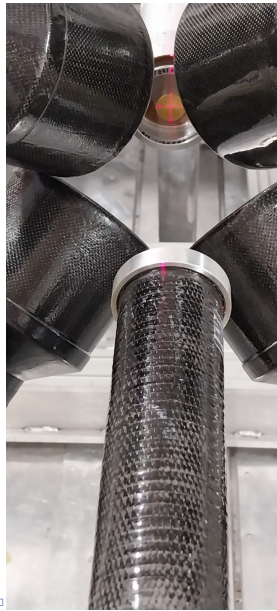
^{65}Cu capture campaign: target & C_6D_6



N. Pieretti



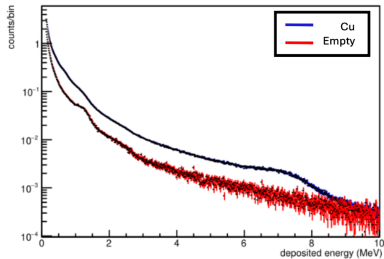
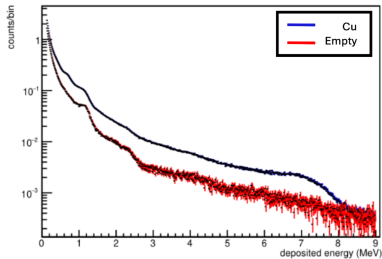
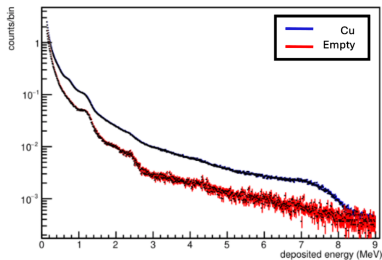
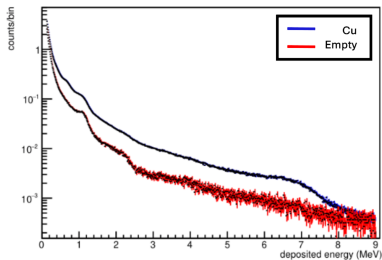
Meeting Nazionale n.TOF



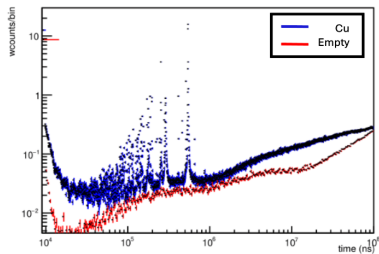
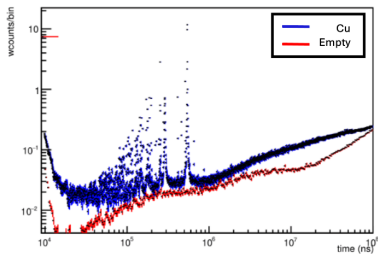
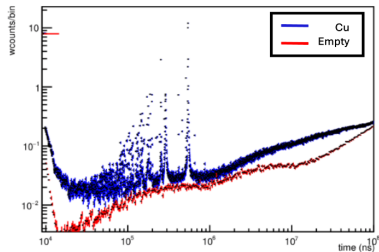
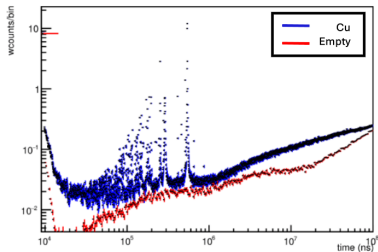
29 April 2025

Preliminary analysis results: ^{63}Cu

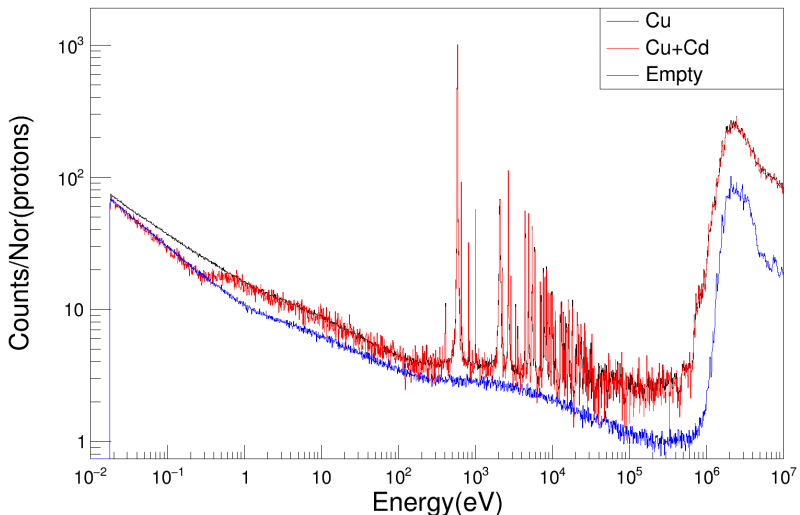
C₆D₆ amplitude spectra Cu



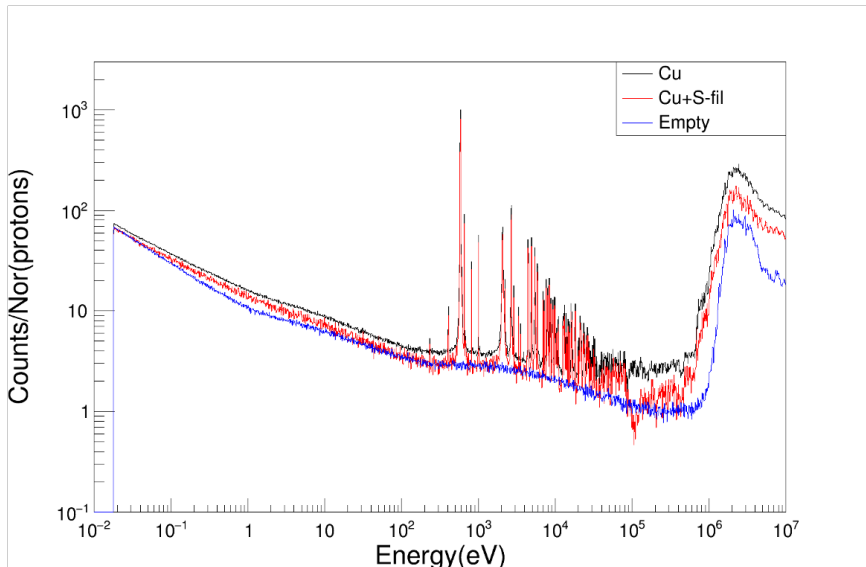
C_6D_6 TOF spectra Cu



C_6D_6 counts normalized to neutron intensity

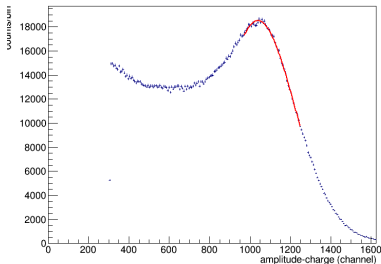


C_6D_6 counts normalized to neutron intensity

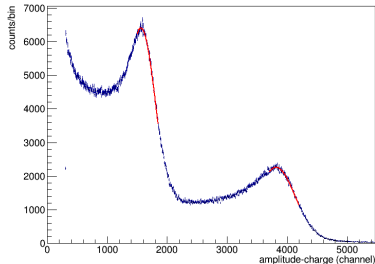


Calibration: peak fits from monoenergetic sources

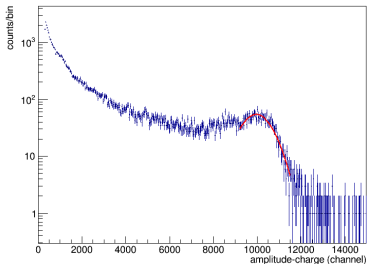
Cs_1_A_u2_C6D6



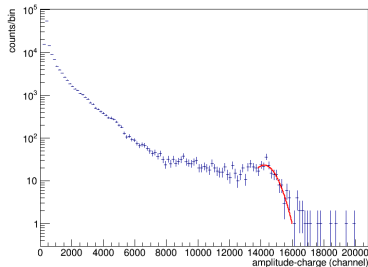
Y_1_A_u2_C6D6



AmBe_1_A_u2_C6D6

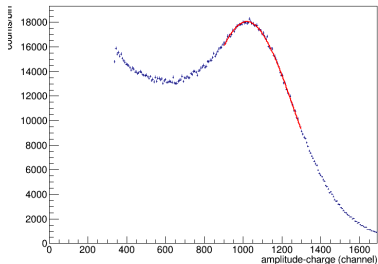


CmC_1_A_u2_C6D6

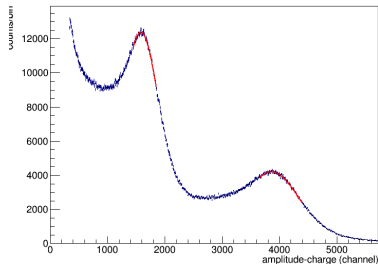


Calibration: peak fits from monoenergetic sources

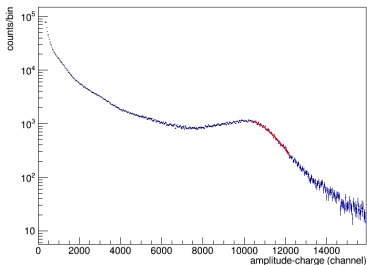
Cs_1_A_u4_C6D6



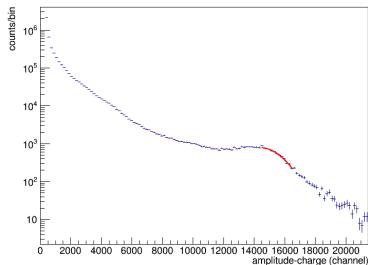
Y_1_A_u4_C6D6



AmBe_1_A_u4_C6D6

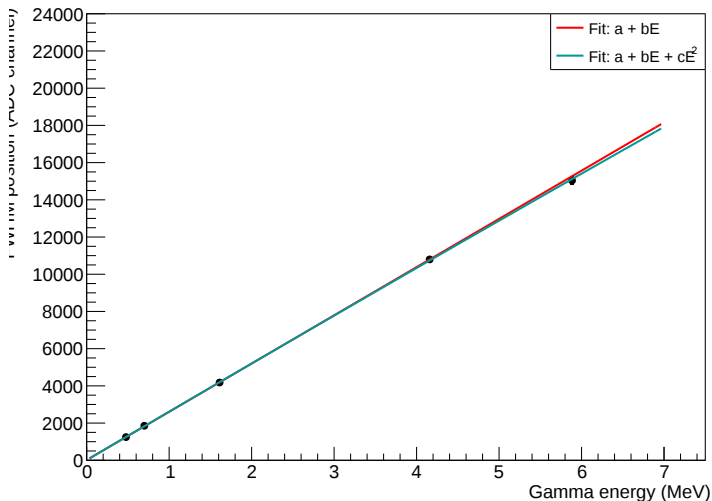


CmC_1_A_u4_C6D6



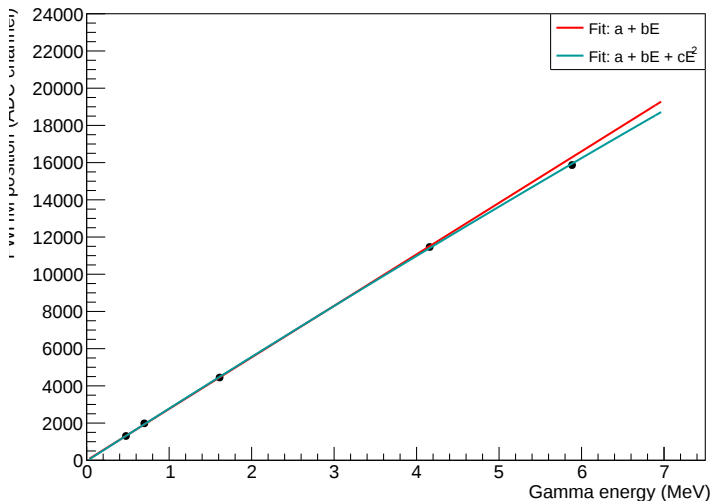
Calibration curves of C_6D_6 detectors

Calibration Curve (24/07 data) - Detector 2



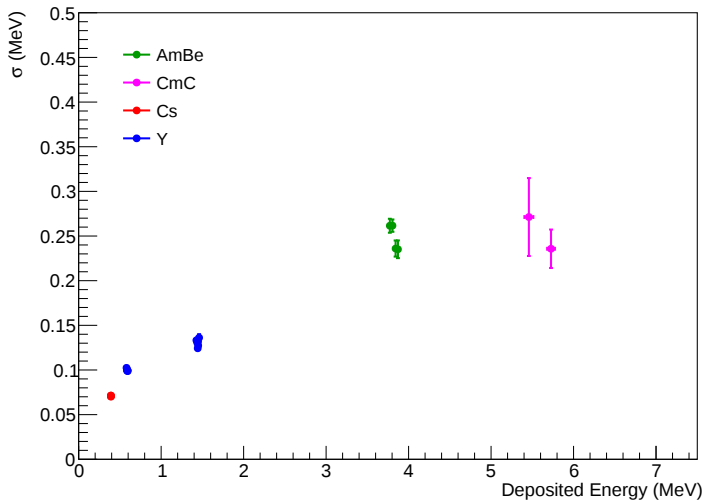
Calibration curves of C_6D_6 detectors

Calibration Curve (24/07 data) - Detector 4



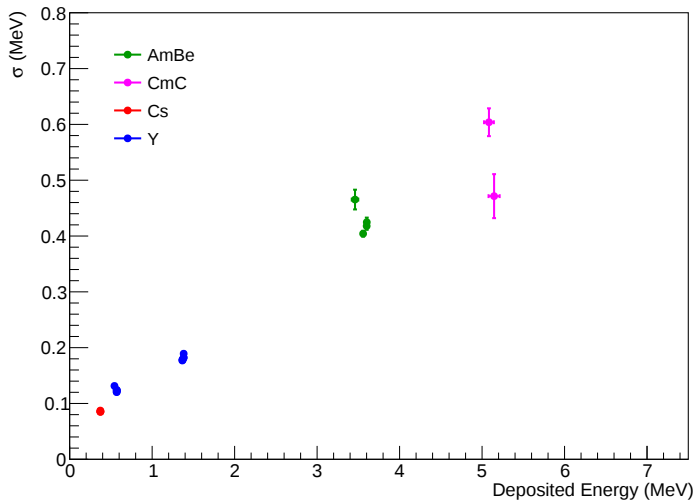
Resolution function of C_6D_6 detectors

Detector 2 - Resolution function



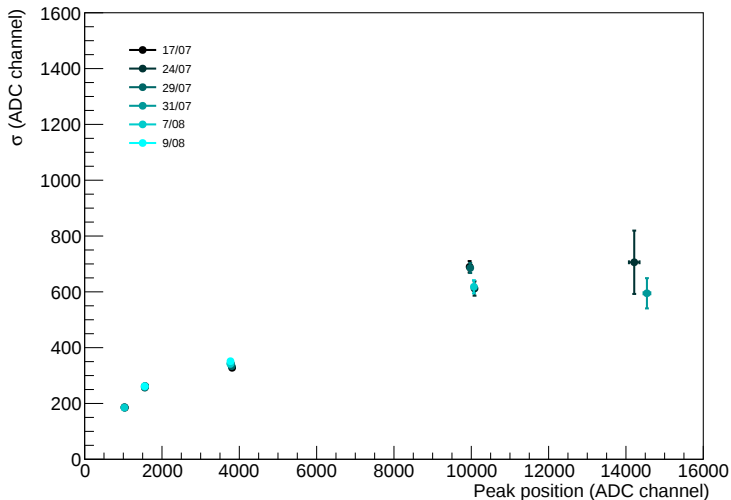
Resolution function of C_6D_6 detectors

Detector 4 - Resolution function



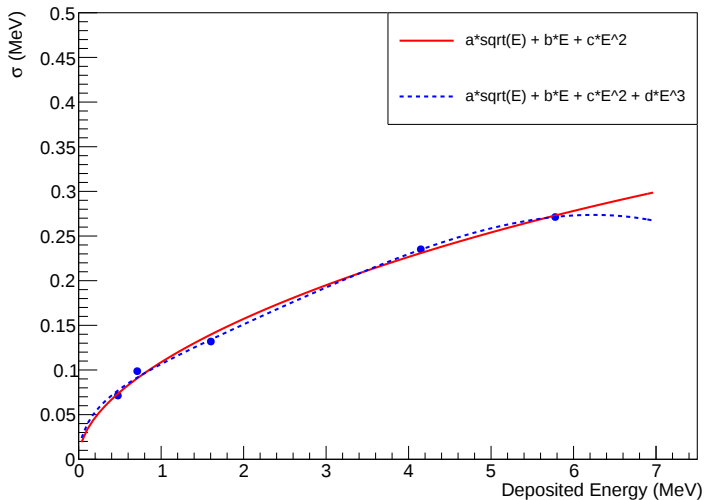
Response shift of C_6D_6 detectors

Detector 2 - Response shift



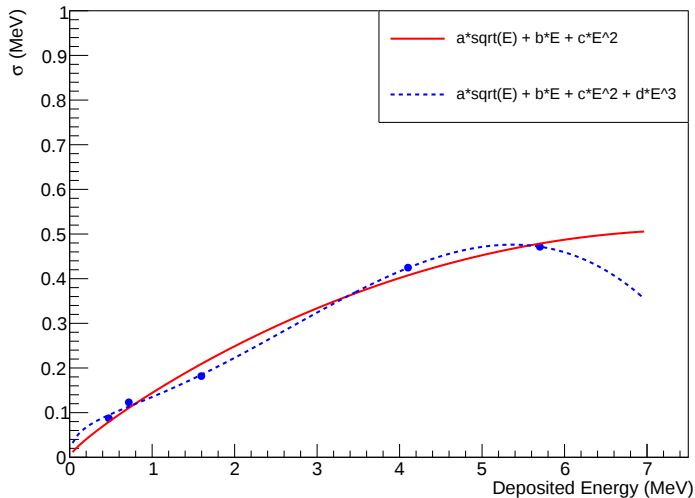
Resolution function of C_6D_6 detectors

Fitted sigma Function - Detector 2



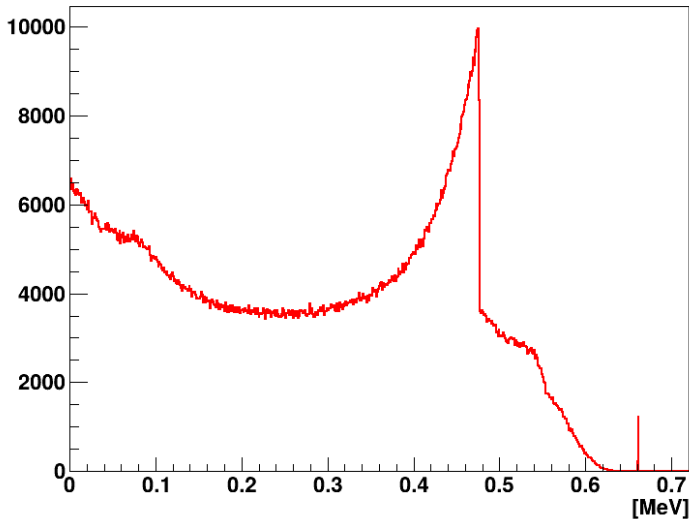
Resolution function of C_6D_6 detectors

Fitted sigma Function - Detector 4



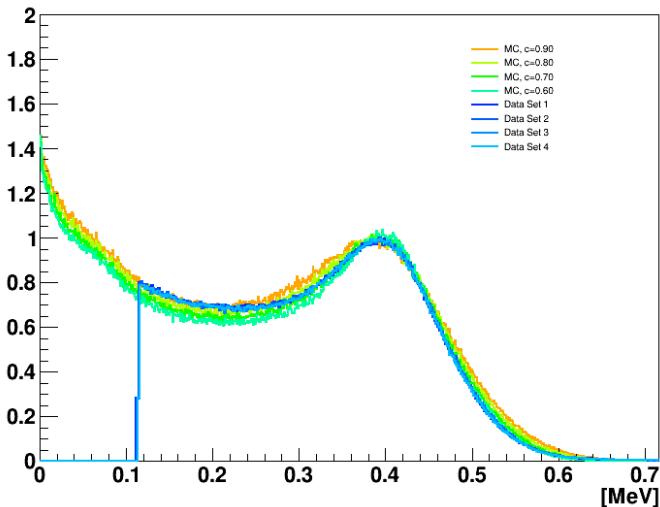
MC by P. C. Camprini

Deposited energy L6D6 2



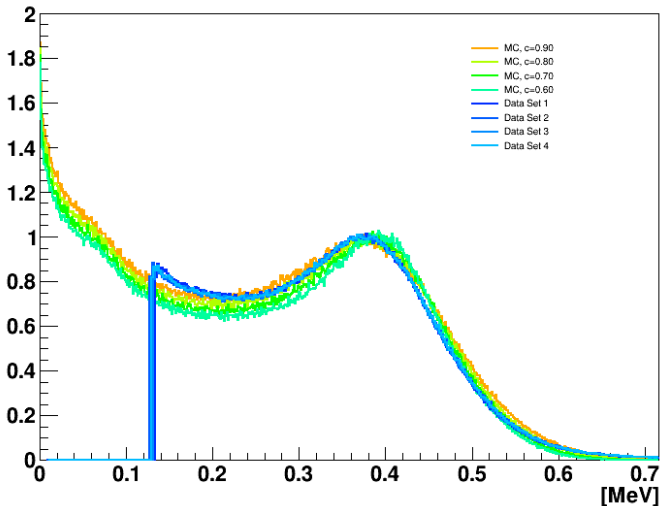
MC smearing and comparison

Deposited energy L6D6 2



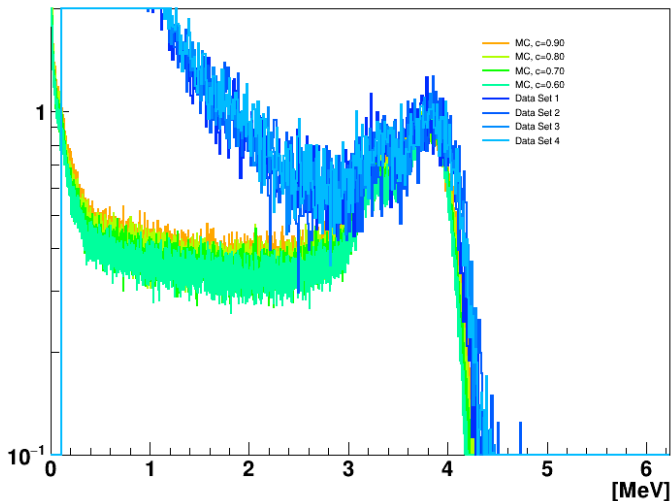
MC smearing and comparison

Deposited energy L6D6 4



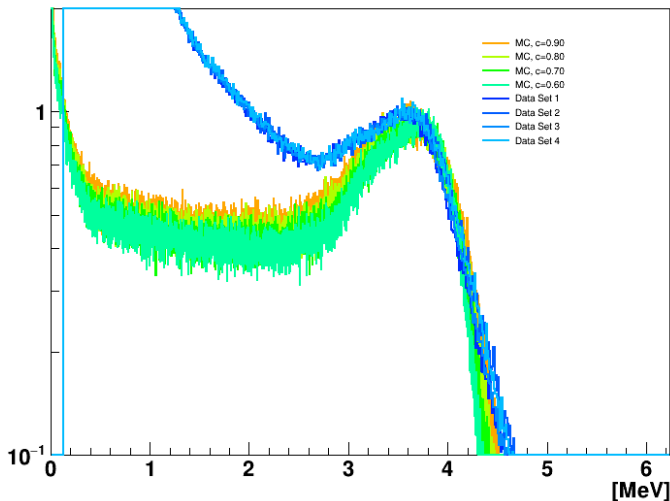
MC smearing and comparison

Deposited energy L6D6 2



MC smearing and comparison

Deposited energy L6D6 4



PhD RAMEN: to do list



- Produce MC WF for Cu - ongoing
 - Study C_6D_6 background
 - Produce yields
 - RSA on Cu
 - Systematic study on uncertainties
 - Transmission measurements
- Tests for feasibility of elastic/inelastic angular distribution measurements
 - . . .

Thank You!