

Jing Liu @ MaGe Meeting

# *MaGe Verification*

---

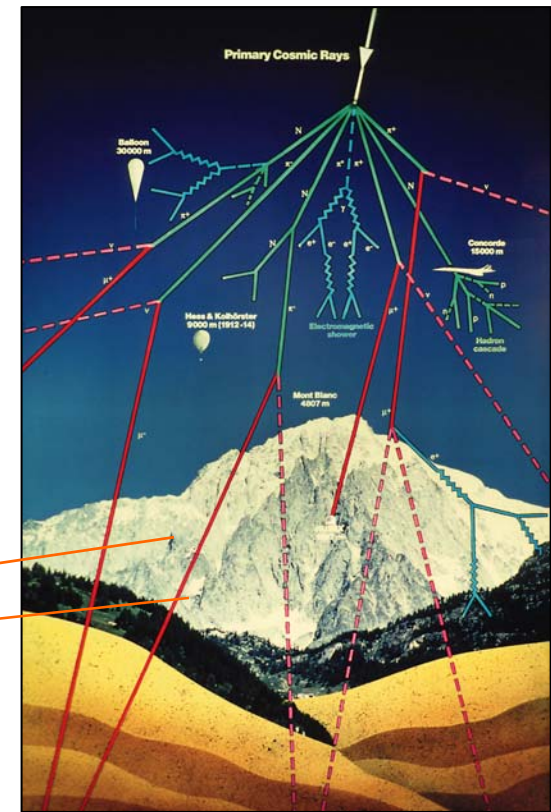
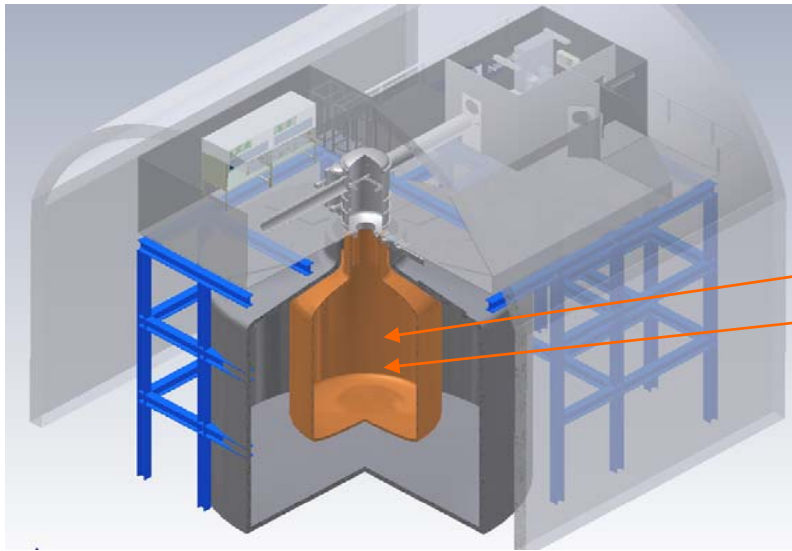
*Based on Neutron Interaction  
with Germanium Detector*

*Why we study neutron interaction  
with germanium detector*

---

# Neutrons Seen by Gerda Detectors

- Primordial neutrons produced in rock by  $(\alpha, n)$
- Neutrons produced by high energy cosmic ray muon spallation interaction

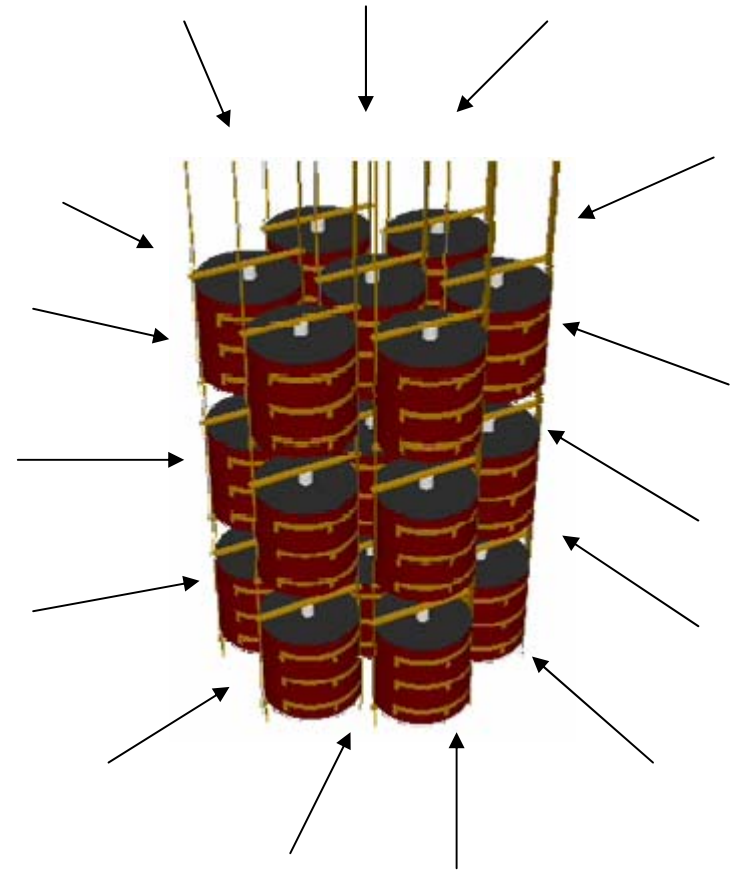
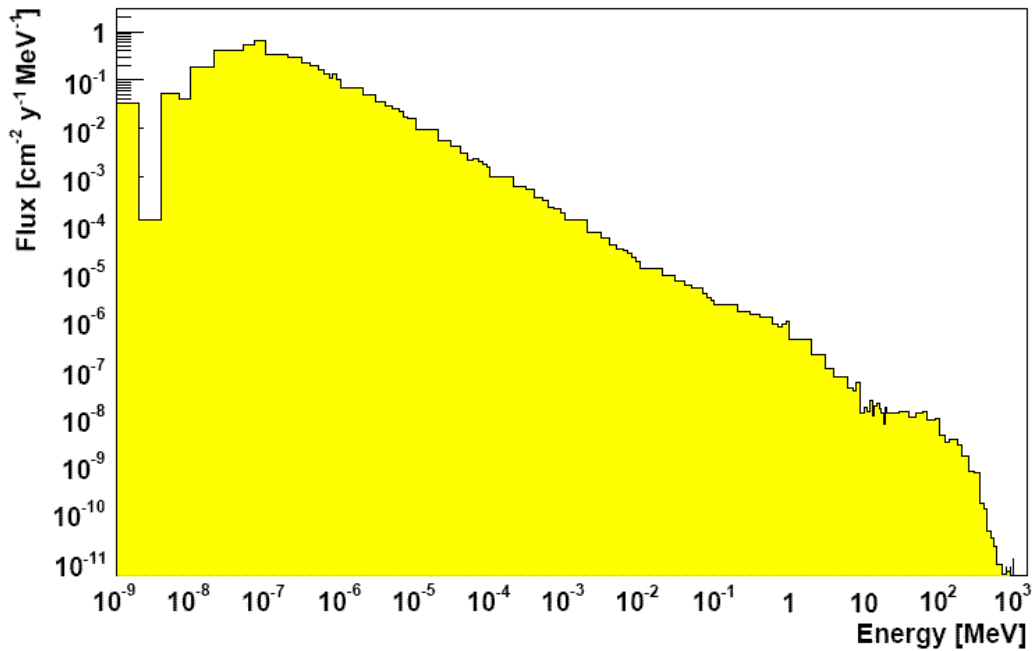


$(\alpha, n)$

$(\mu, n)$

# *Energy Distribution of Neutrons Arriving Detectors*

Daniel Kollar, GSTR-05-018



# Am-Be Neutron Source





# *Why I have to do it*

---



*Am-Be Source and*

---

*Neutron Interactions*

# Am-Be Source

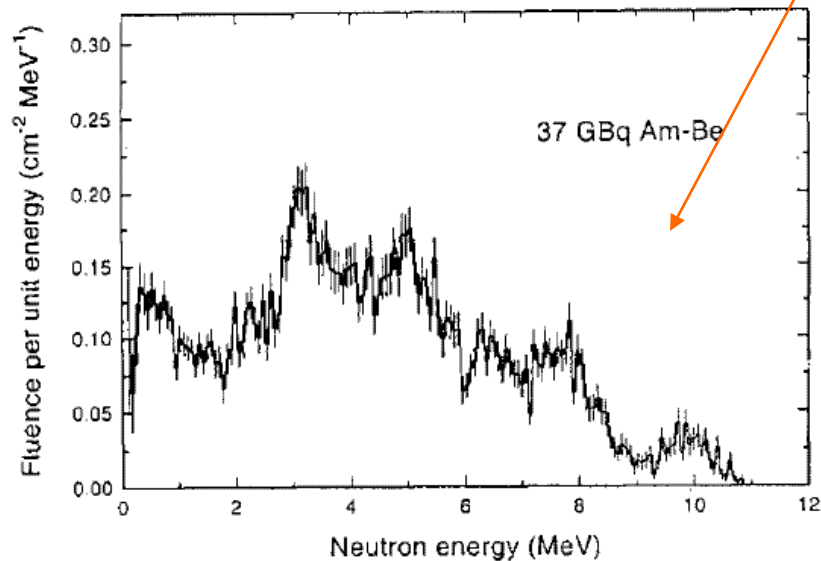
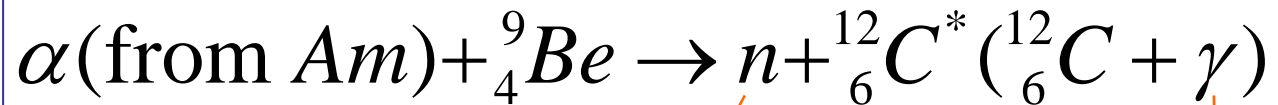
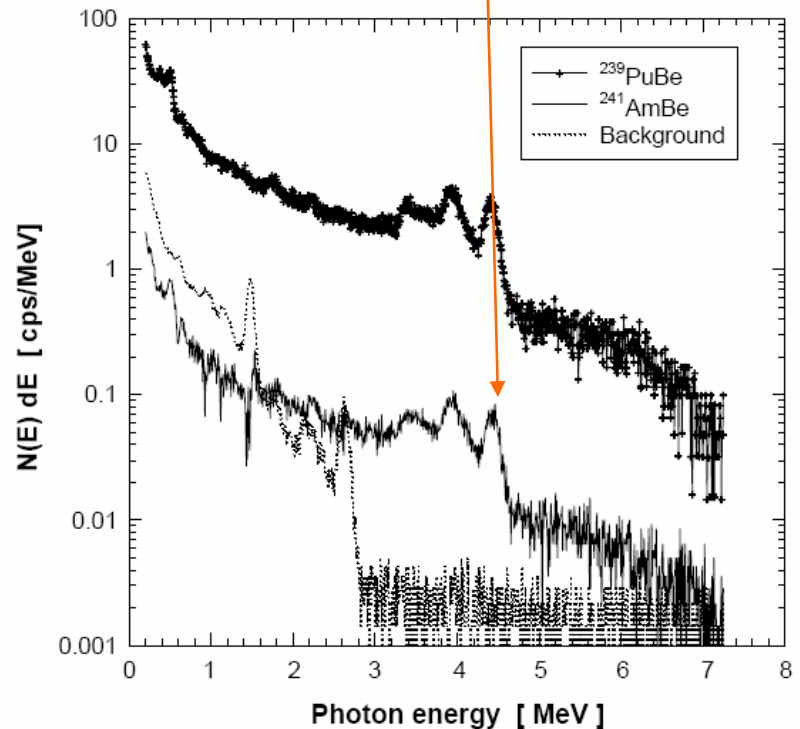


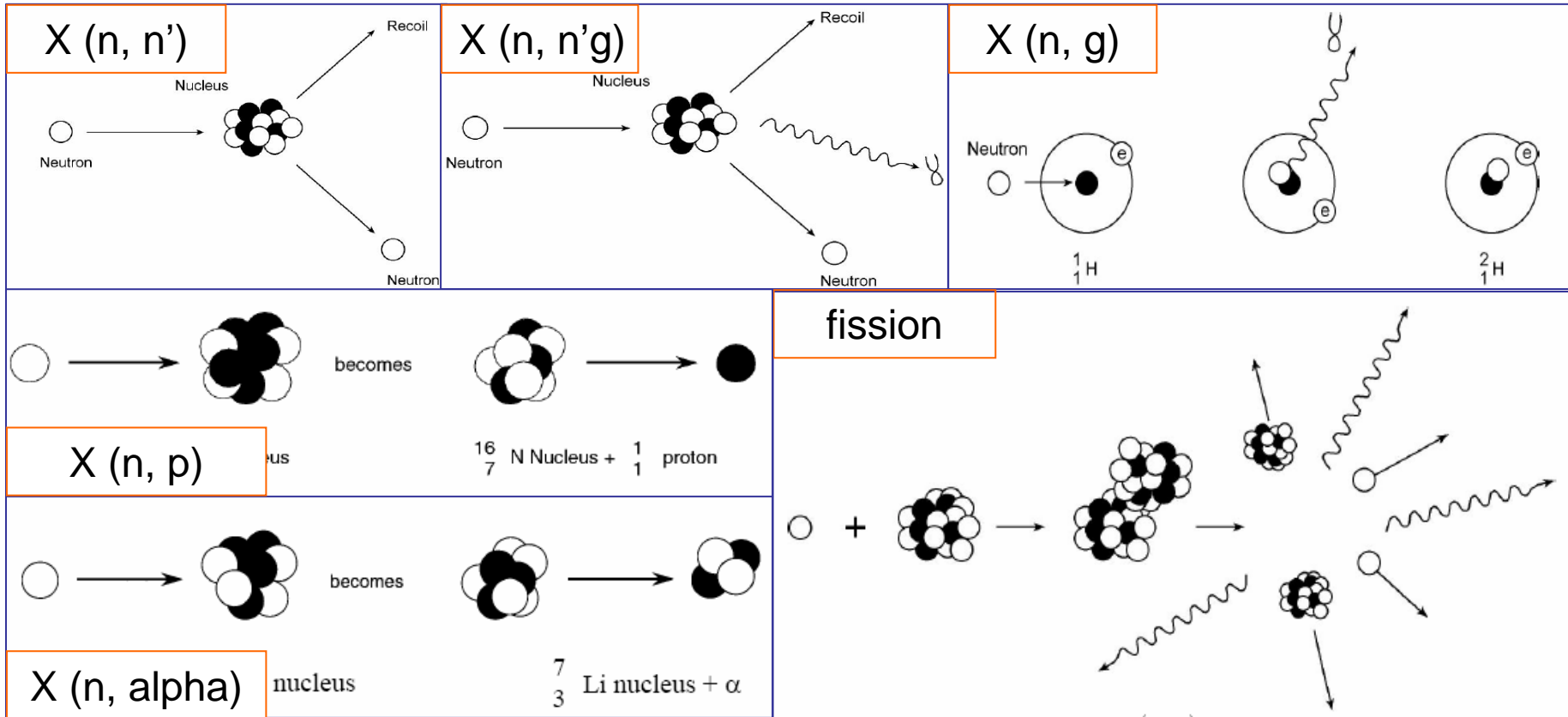
Fig. 5. Measured neutron energy spectrum from the 37 GBq Am-Be neutron source normalized to unit fluence, (uncertainties are due to counting statistics only).

H.R. Vega-Carrillo et al. / Applied Radiation and Isotopes 57 (2002) 167–170





# Neutron Interactions with Nucleus

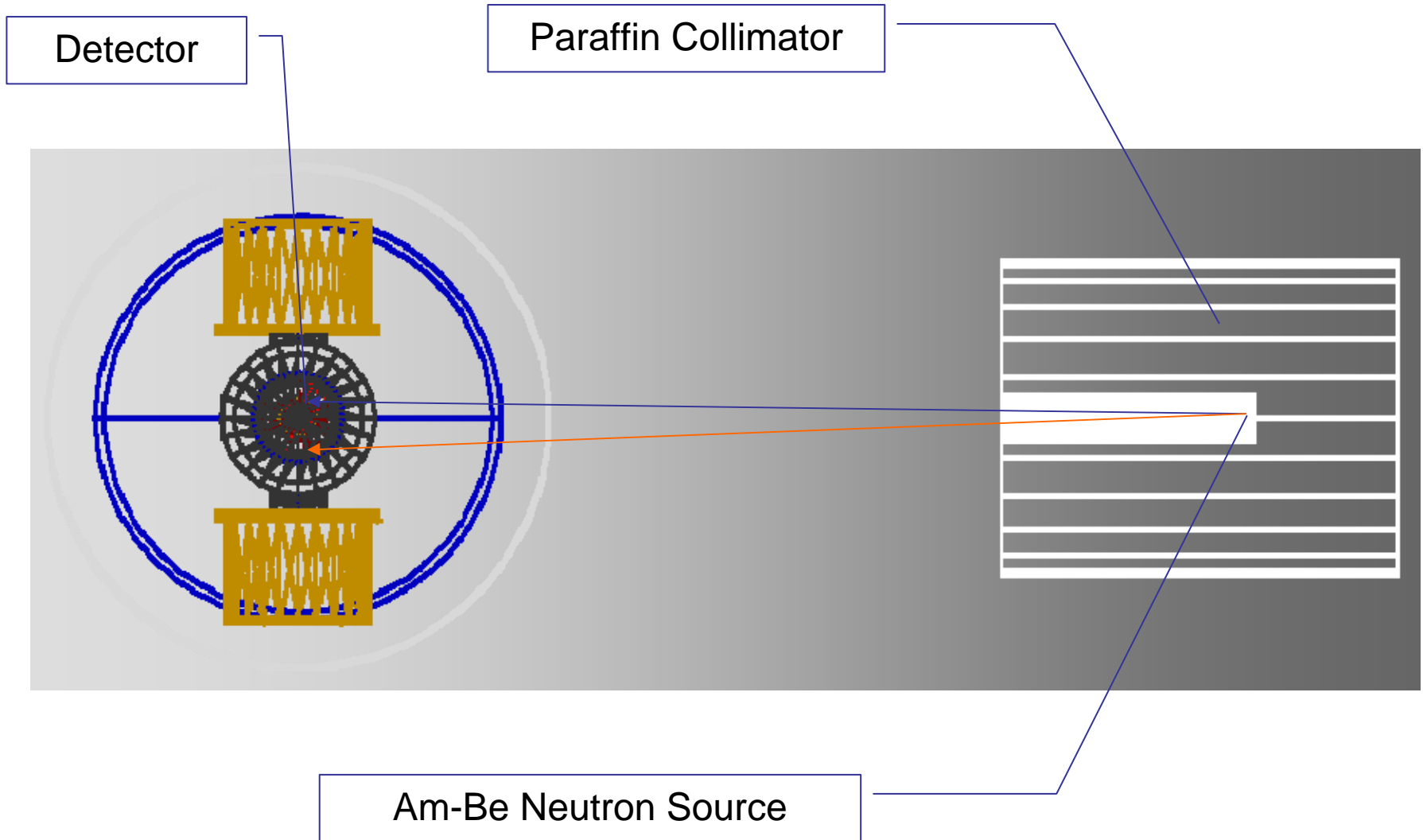


# *Experiment Setup*

---

# Munich Test Stand Setup

---



# *Majorana Test Stand Setup*

---



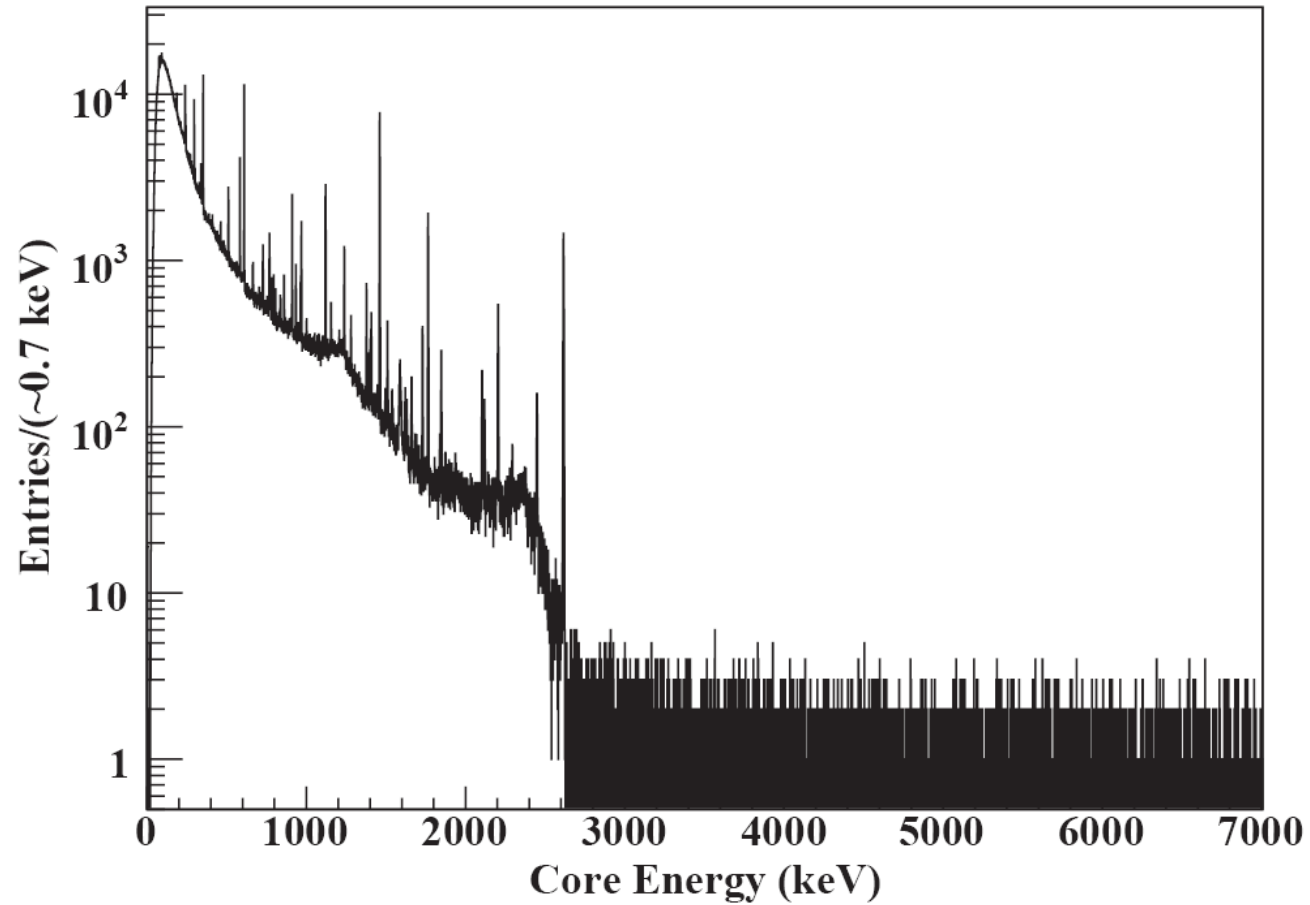
# *Energy Spectra*

---

*When neutron presented*

# *Background Spectrum*

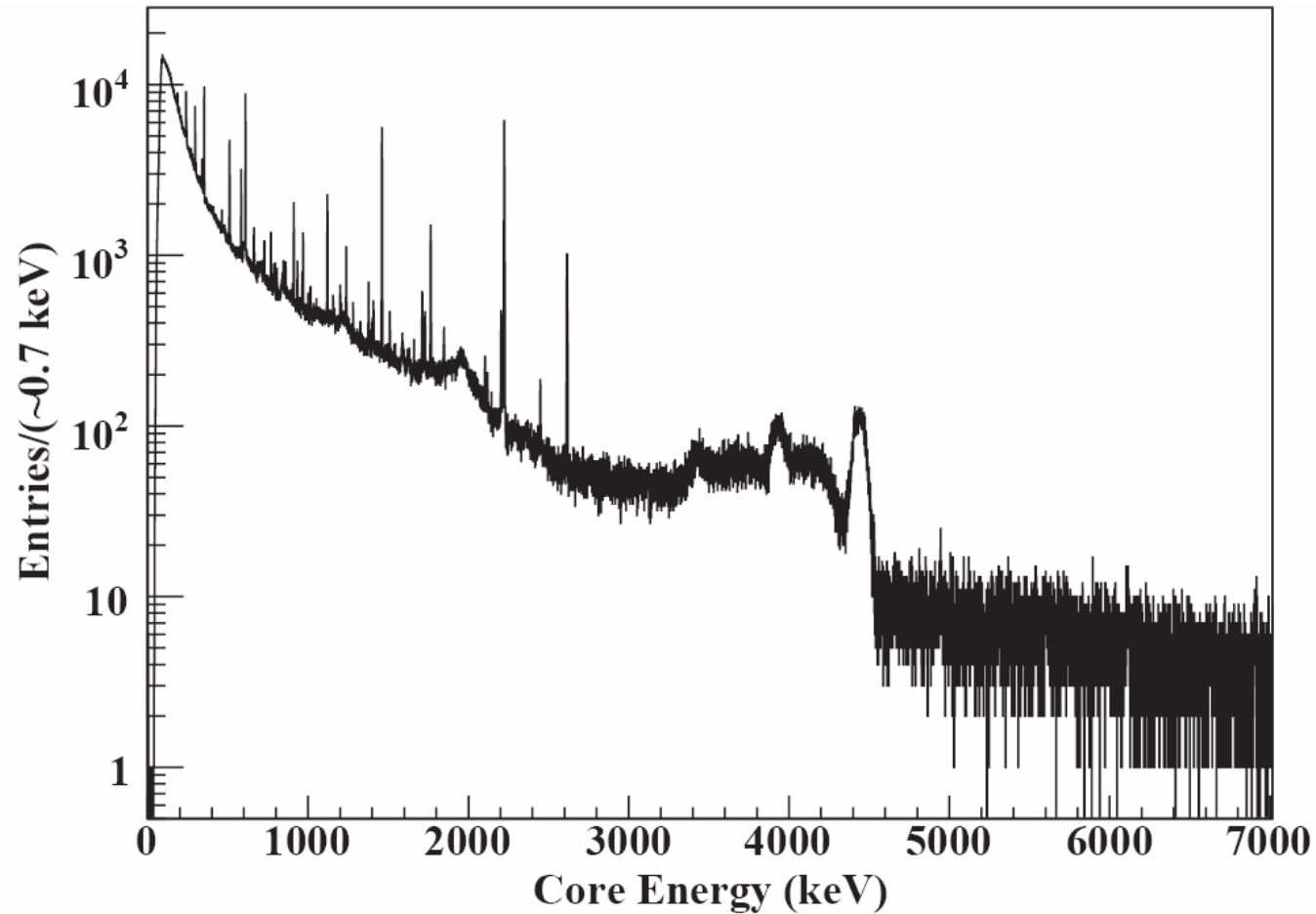
---





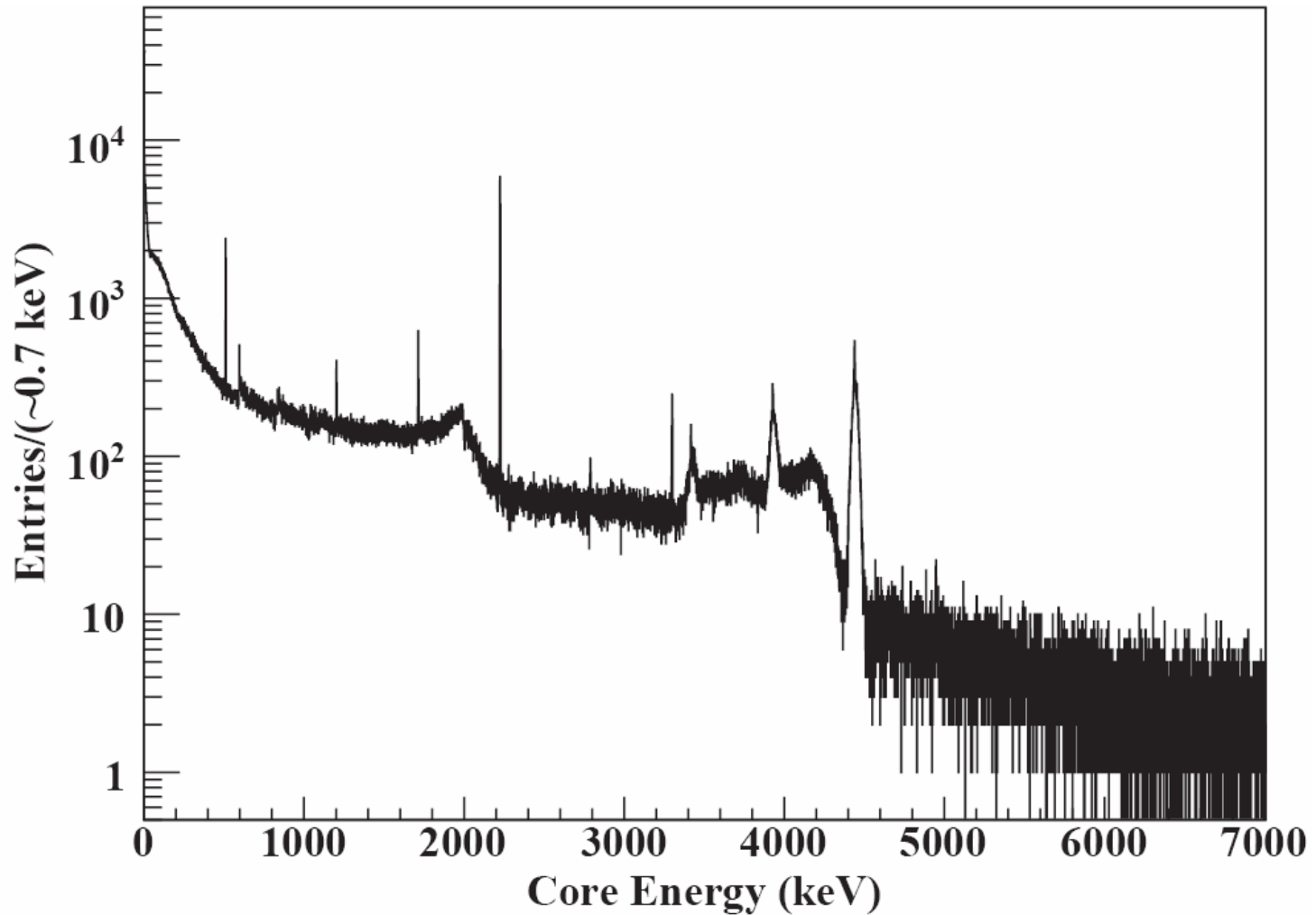
# *Spectrum with neutron presented*

---



# *Spectrum from Simulation*

---

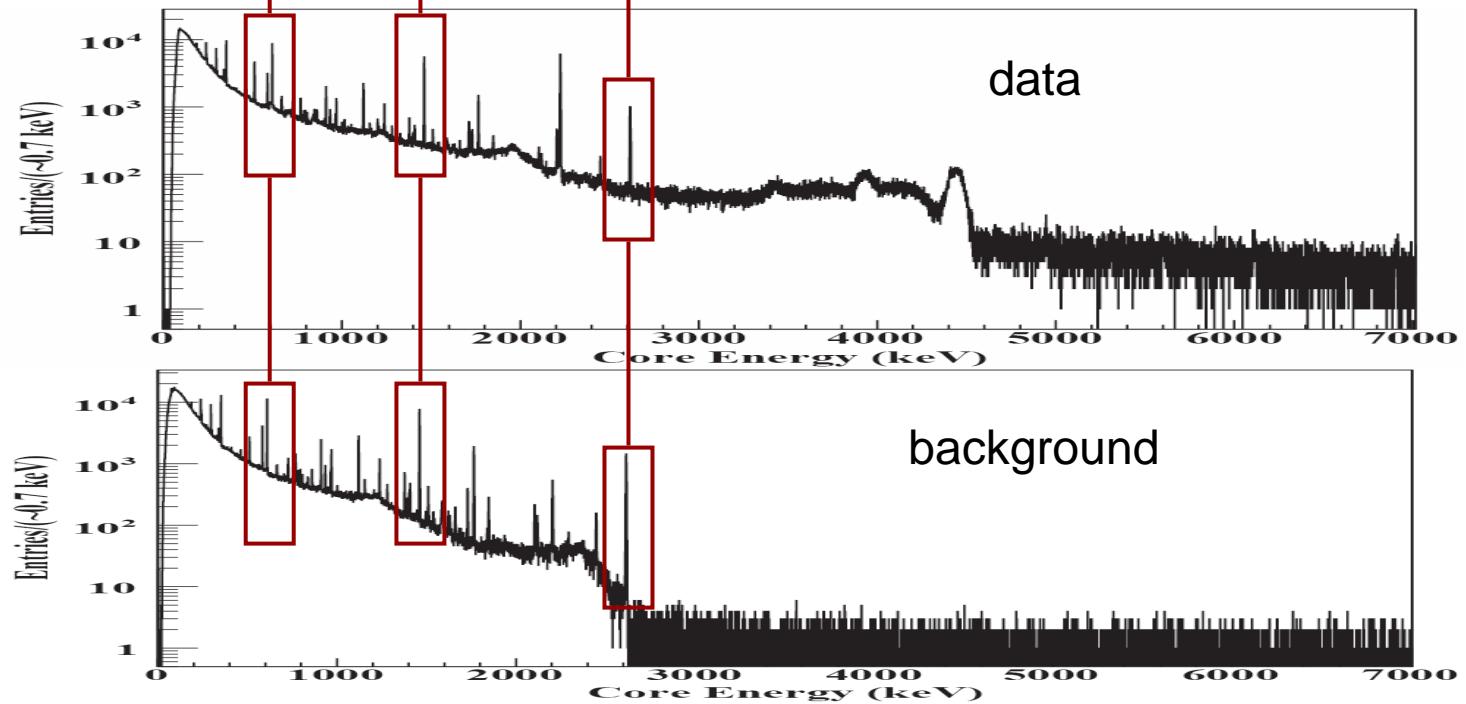


# Background Normalization

609 keV, Bi214 (U238)

1460 keV K40

2614 keV Tl208 (Th232)

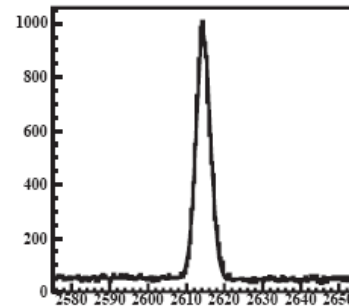
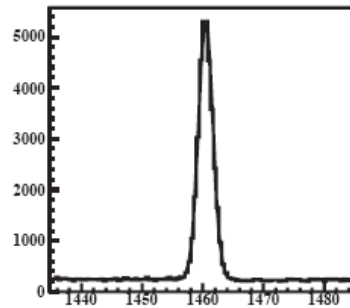
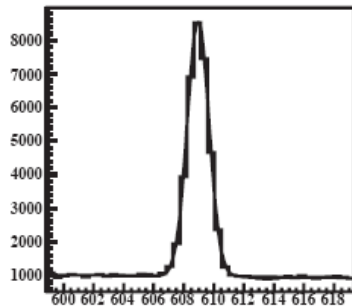


# Background Normalization

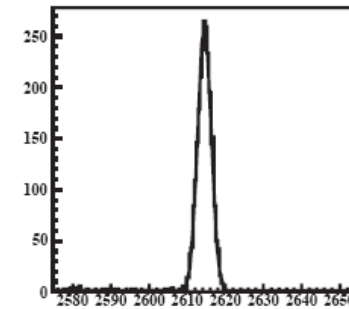
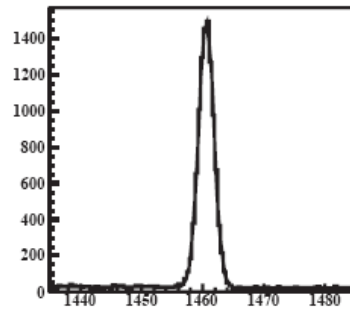
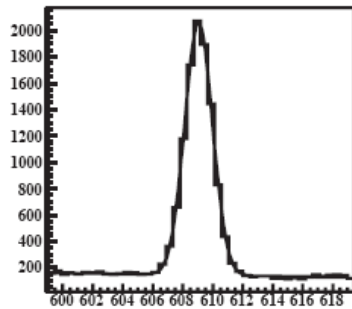
609 keV, Bi214

1460 keV K40

2614 keV Tl208

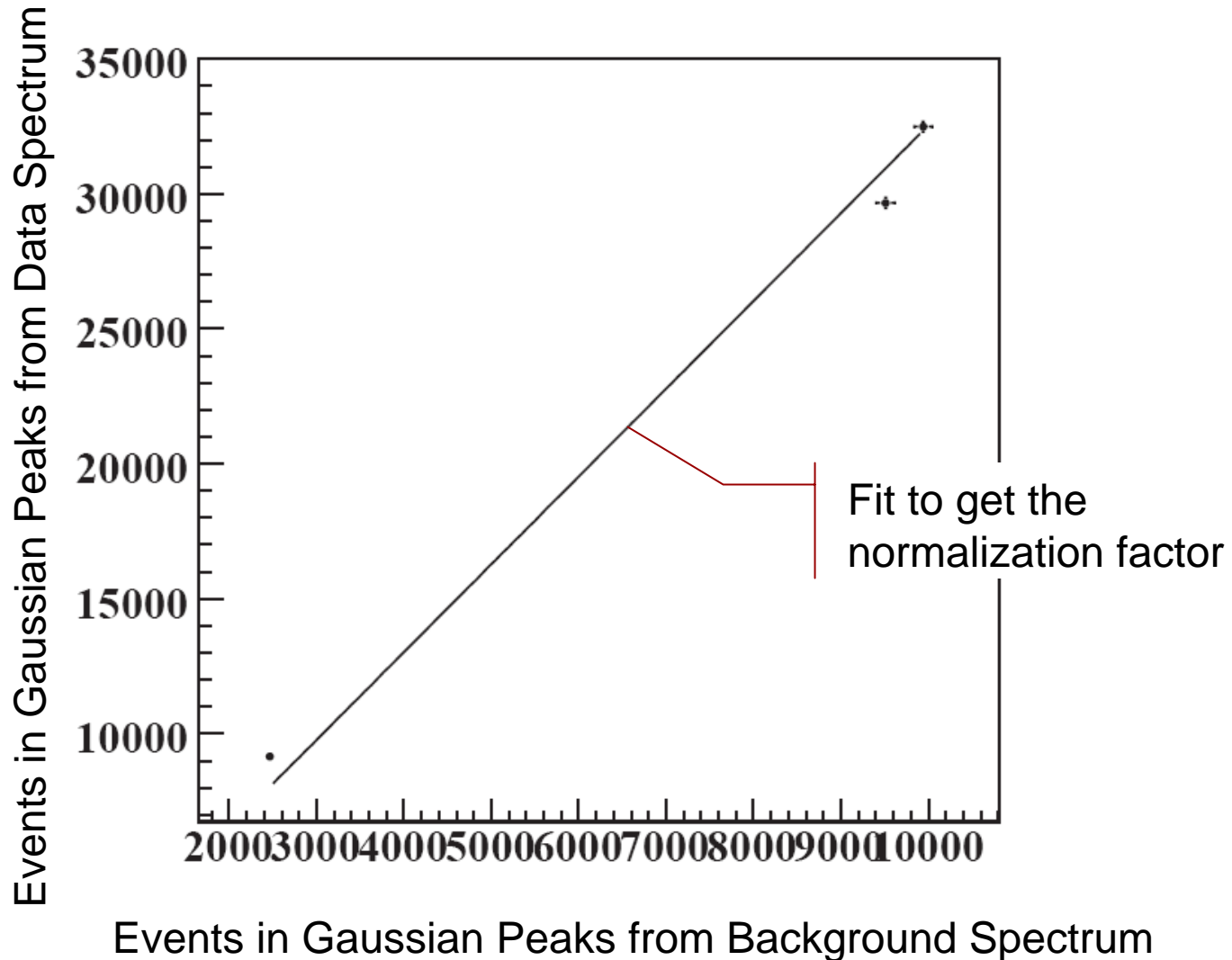


← data



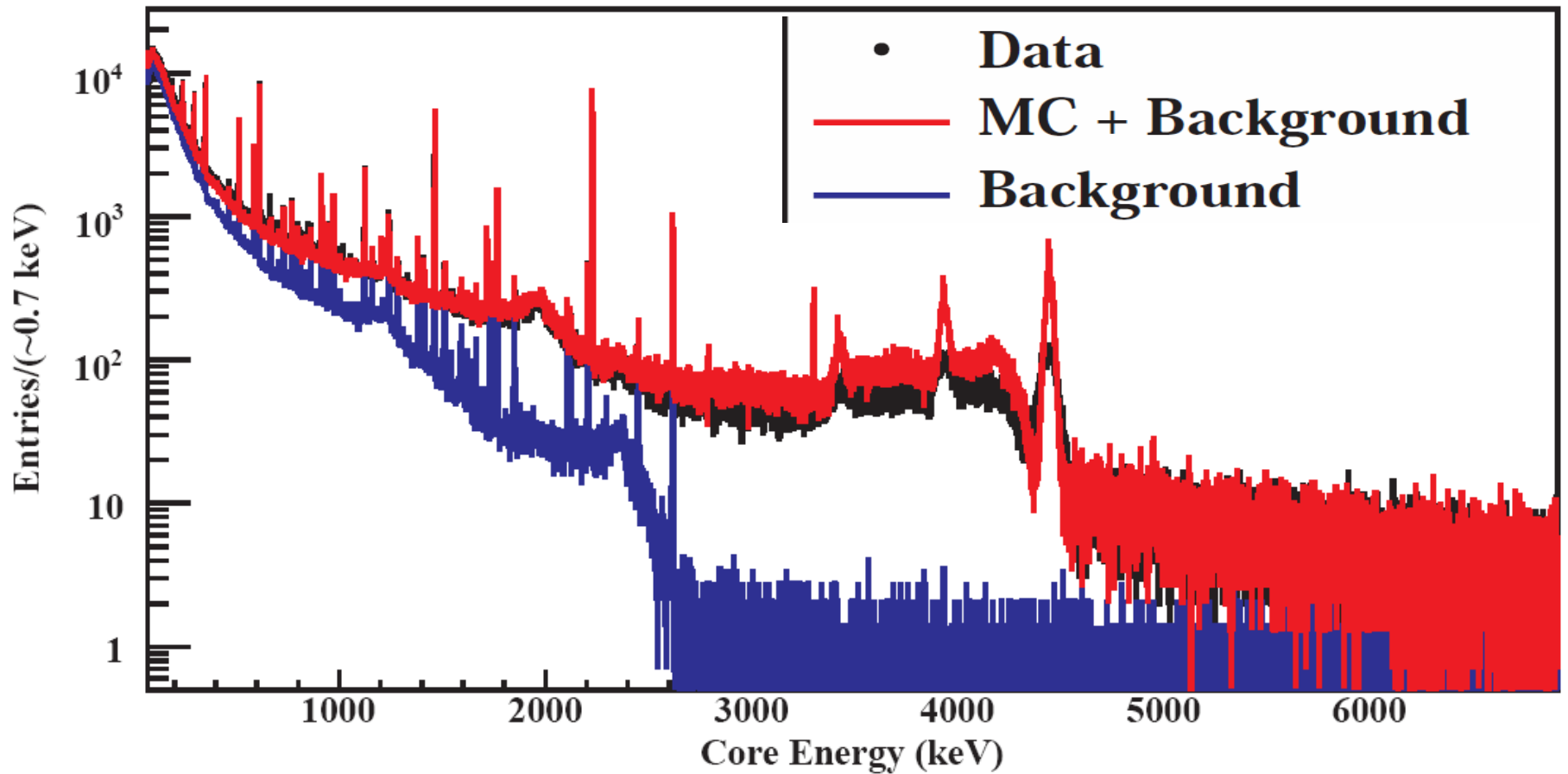
← background

# Background Normalization



# Simulation Normalization

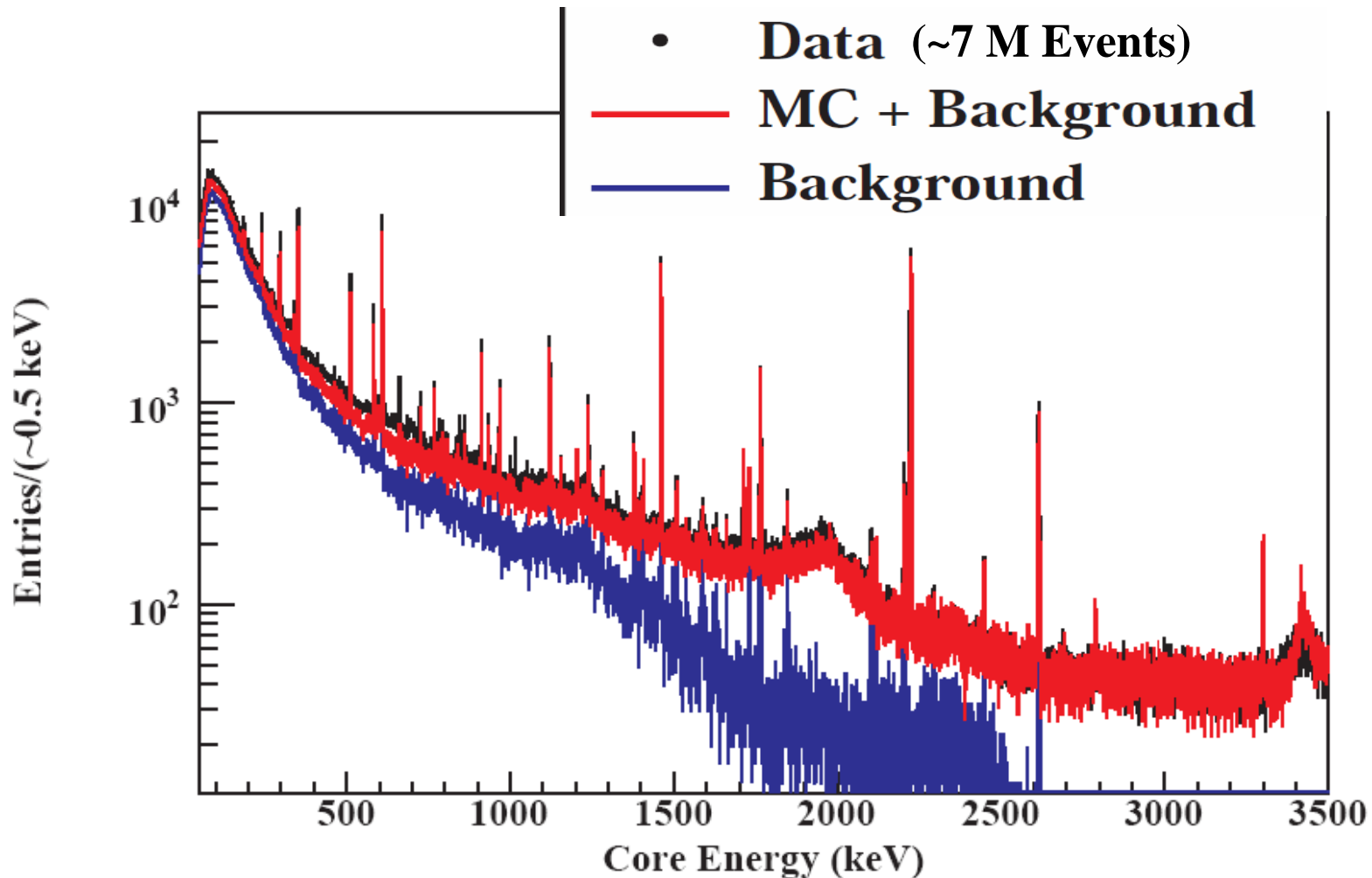
---





# Spectra Below 3.5 MeV

---



*Peaks from Neutron Interactions*

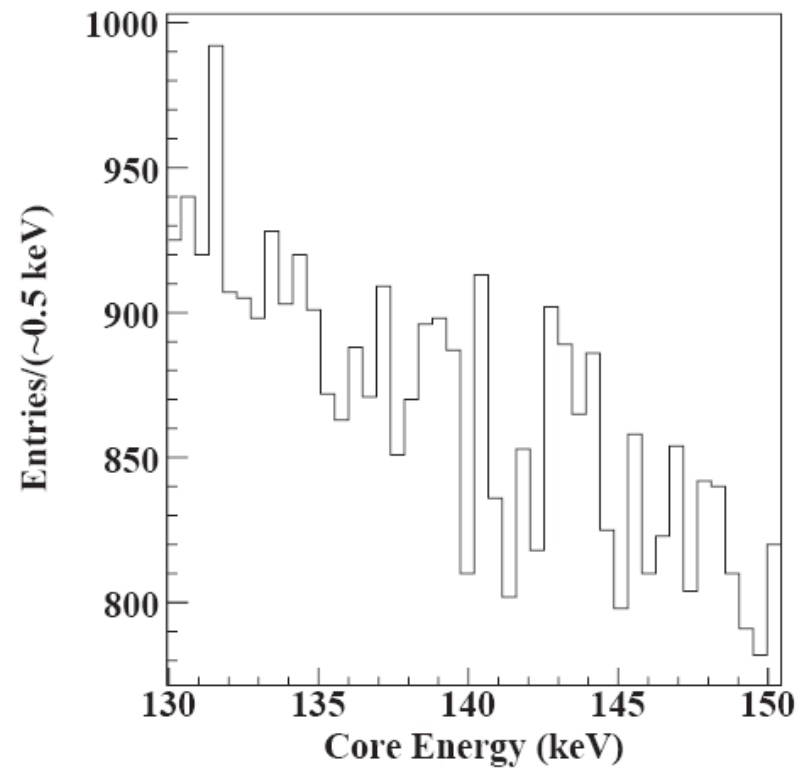
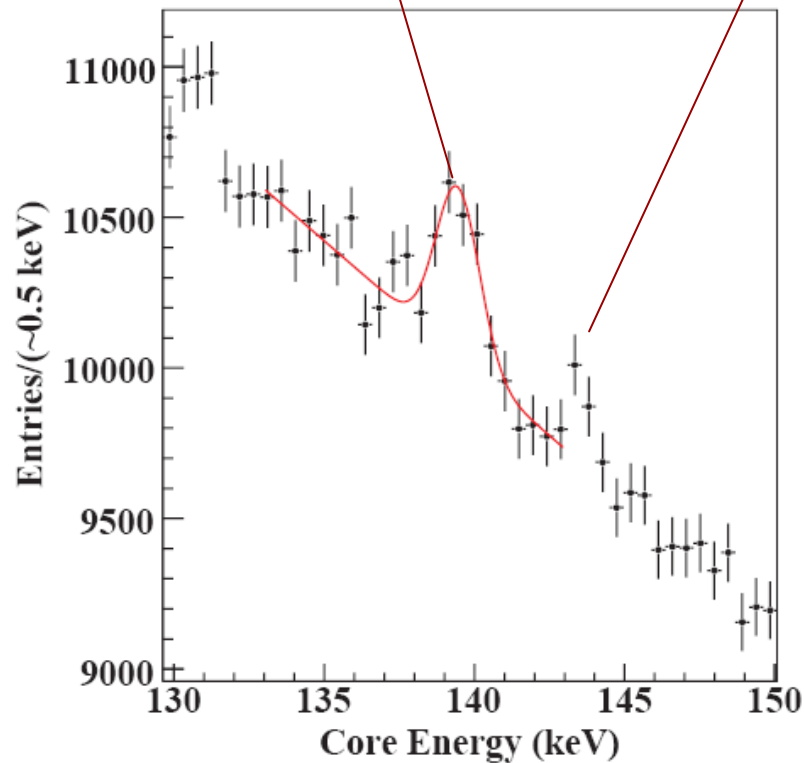
---

*with Germanium Isotopes*

# $n + {}^{74}\text{Ge} \rightarrow {}^{75\text{m}}\text{Ge}$ (139 keV gamma)

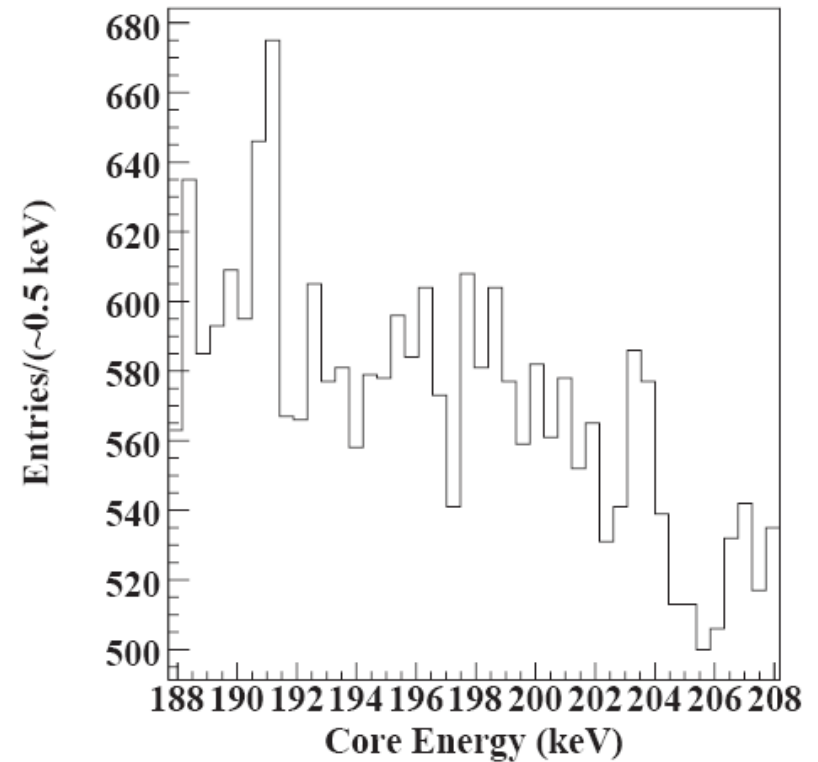
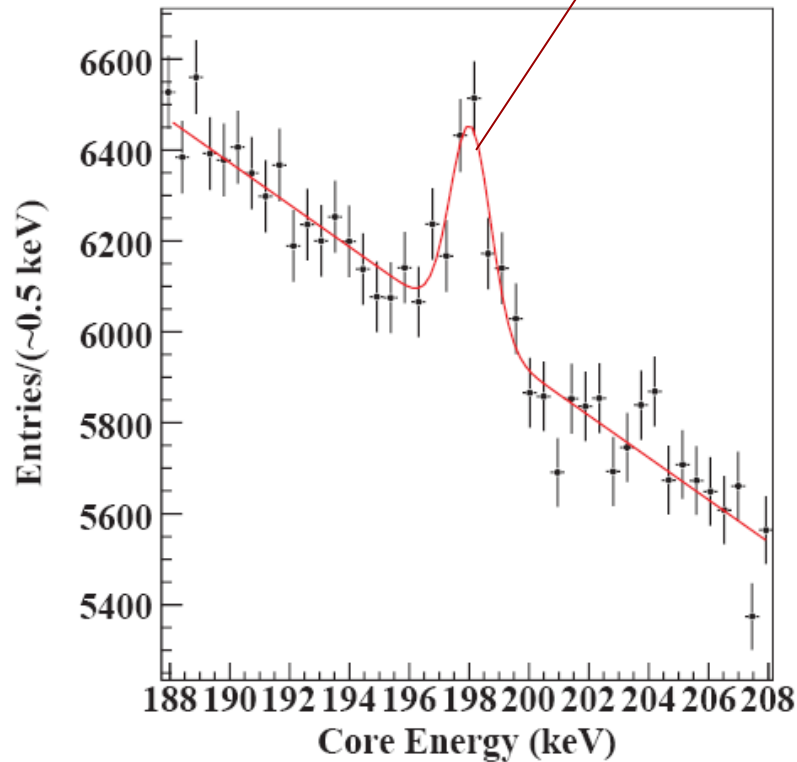
${}^{74}\text{Ge}(n,g)$

143 keV, U235



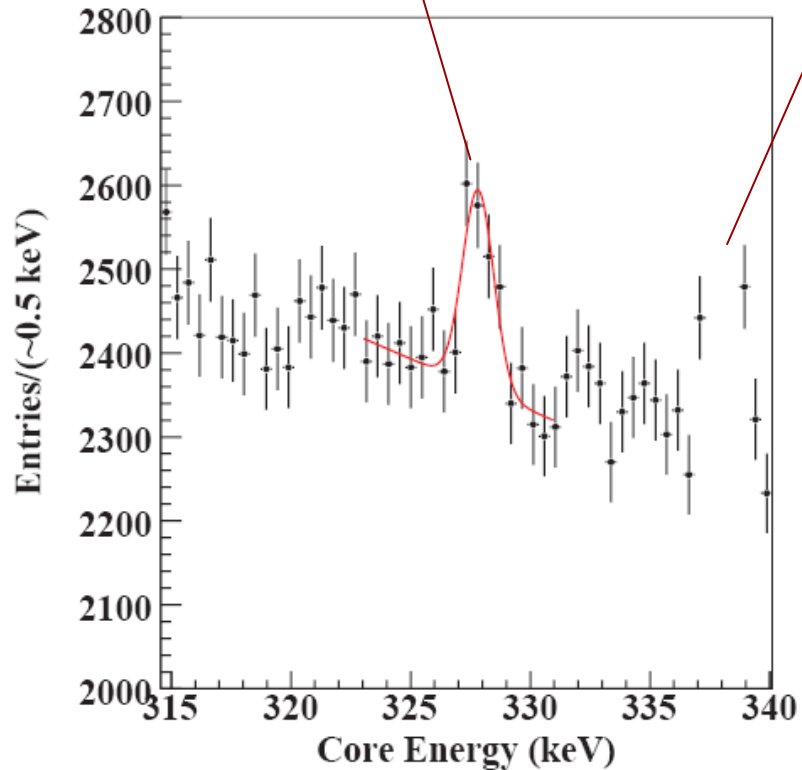
# $n+^{70}\text{Ge}\rightarrow^{71m}\text{Ge}$ (198 keV gamma)

$^{70}\text{Ge}(n,g)$

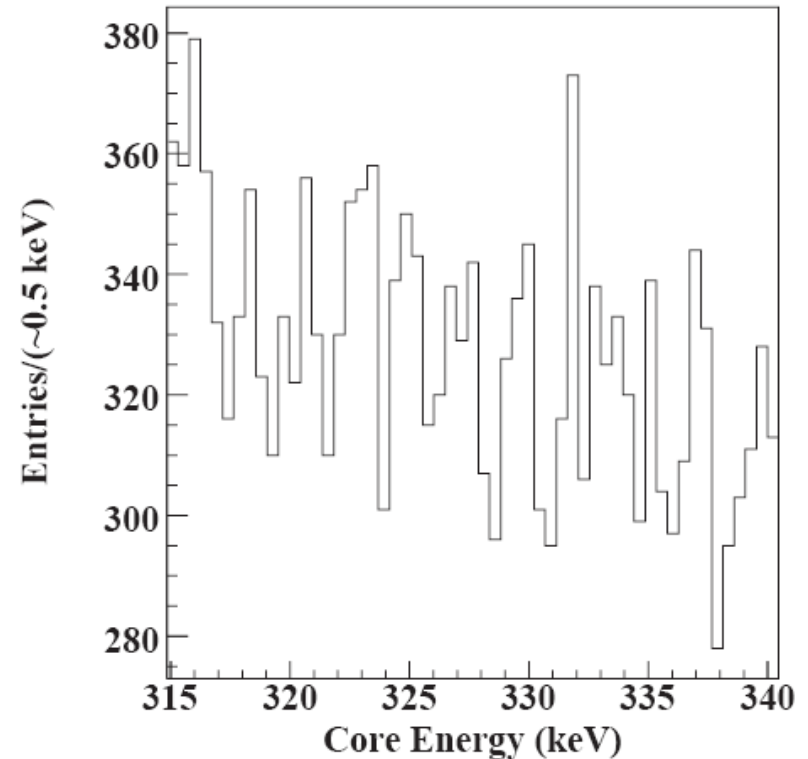


# $n+^{72}\text{Ge}\rightarrow^{73}\text{Ge}+326\text{ keV gamma}$

$^{72}\text{Ge}(n,g)$



338 keV, Ac228 (Th232)

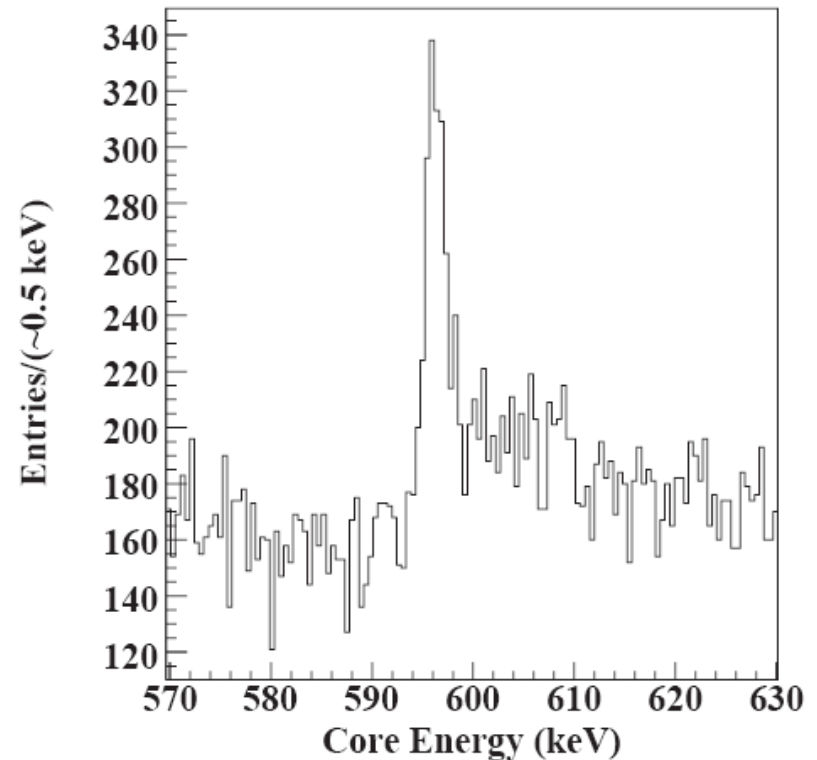
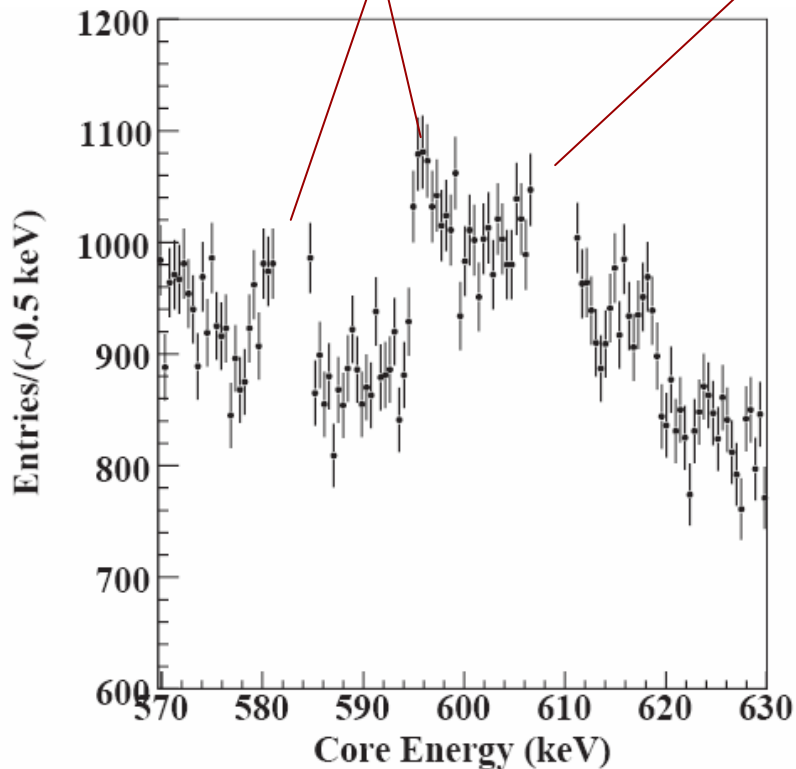


# $n+{}^{74}\text{Ge}\rightarrow{}^{74}\text{Ge}+n'+596\text{ keV gamma}$

${}^{74}\text{Ge}(n, n'g)$

583 keV TI208 (Th232)

609 keV, Bi214 (U238)





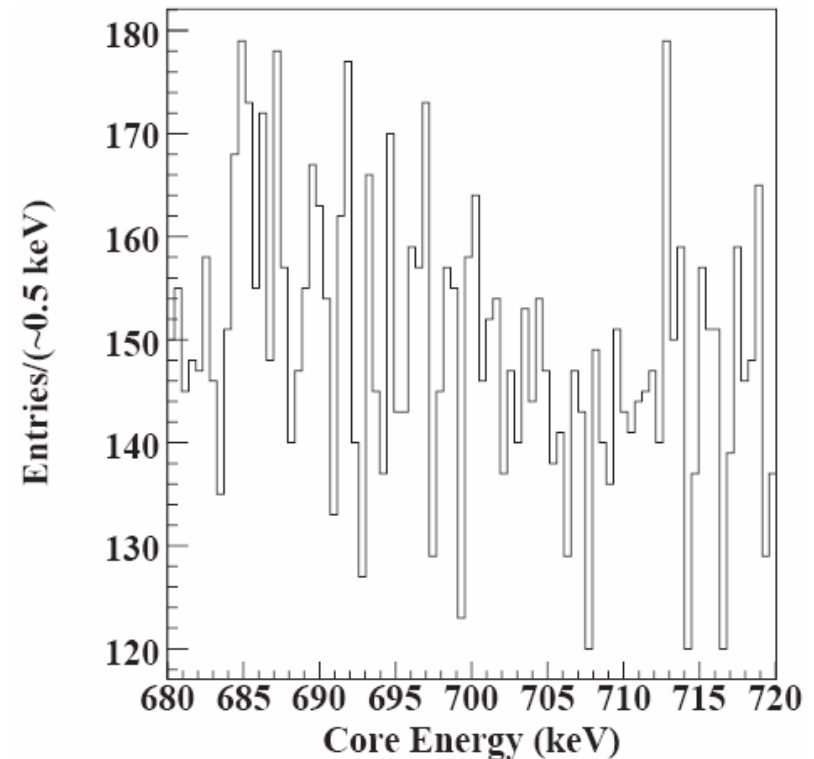
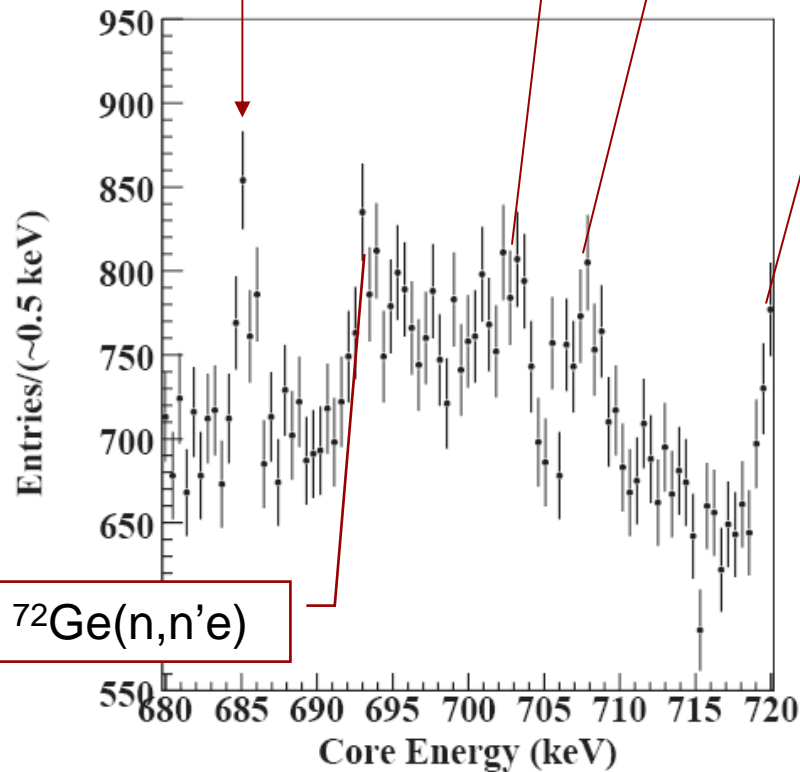


685 keV,  ${}^{63}\text{Cu}(n,n'g)$  ?

703 keV,  ${}^{120}\text{Sn}(n,n'g)$  ?

707 keV,  ${}^{70}\text{Ge}(n, g)$  ?

721 keV,  ${}^{120}\text{Sn}(n,n'g)$  ?



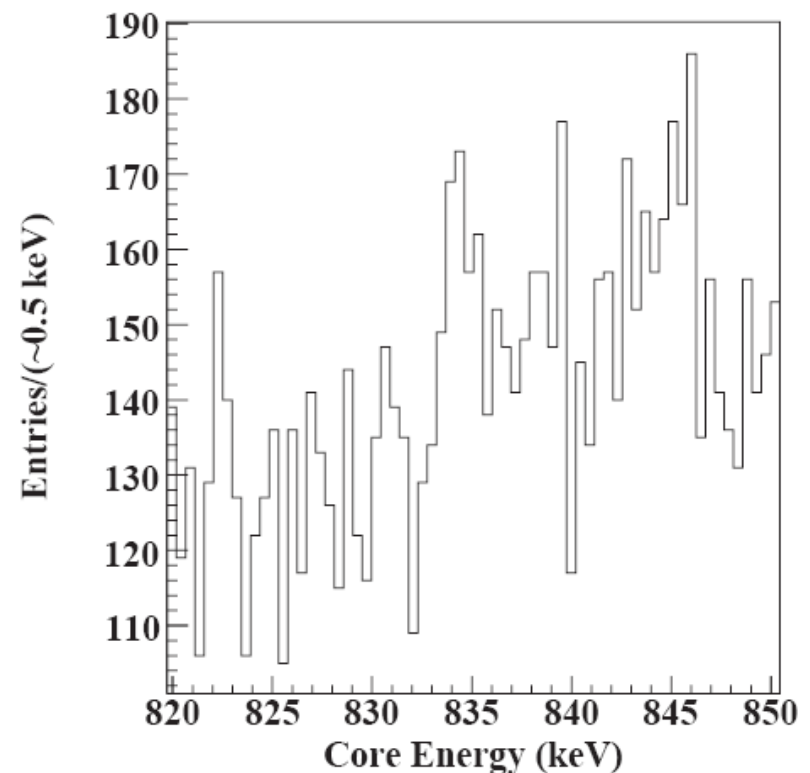
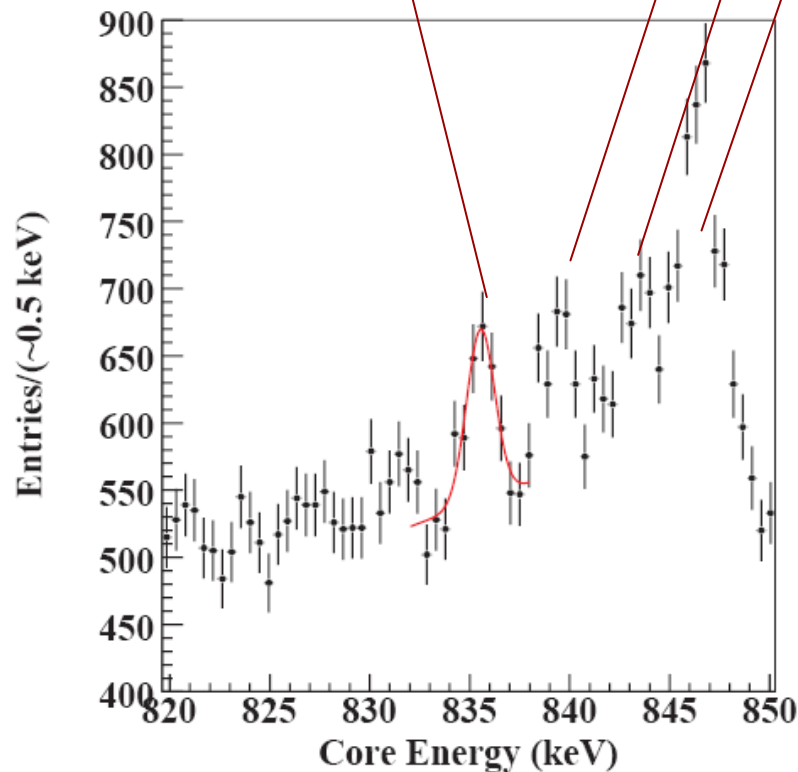
# $n+^{72}\text{Ge}\rightarrow^{72}\text{Ge}+n'+835\text{ keV gamma}$

$^{72}\text{Ge}(n,n'\text{g})$

840 keV, Ac228 (Th232)

843 keV,  $^{27}\text{Al}(n,n'\text{g})$

847 keV,  $^{56}\text{Fe}(n,n'\text{g})$



*Peaks from Neutron Interactions*

---

*with Environment Materials*

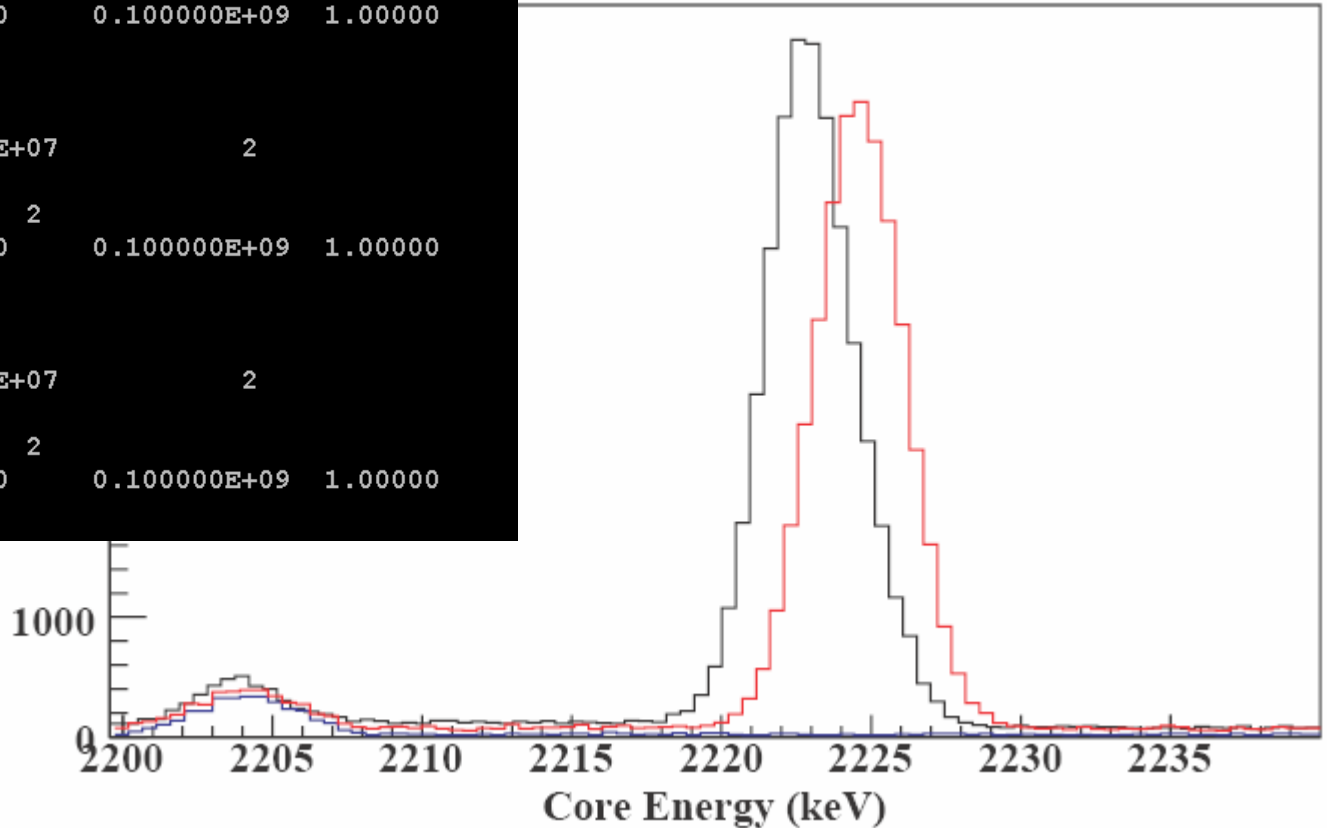


```

1 0.999170
1
2 0.222460E+07 2
1
2 2
0.100000E-04 1.00000 0.100000E+09 1.00000
1
1 0.999170
1
2 0.222460E+07 2
1
2 2
0.100000E-04 1.00000 0.100000E+09 1.00000
1
1 0.999170
1
2 0.222460E+07 2
1
2 2
0.100000E-04 1.00000 0.100000E+09 1.00000
1

```

0.222325E+07



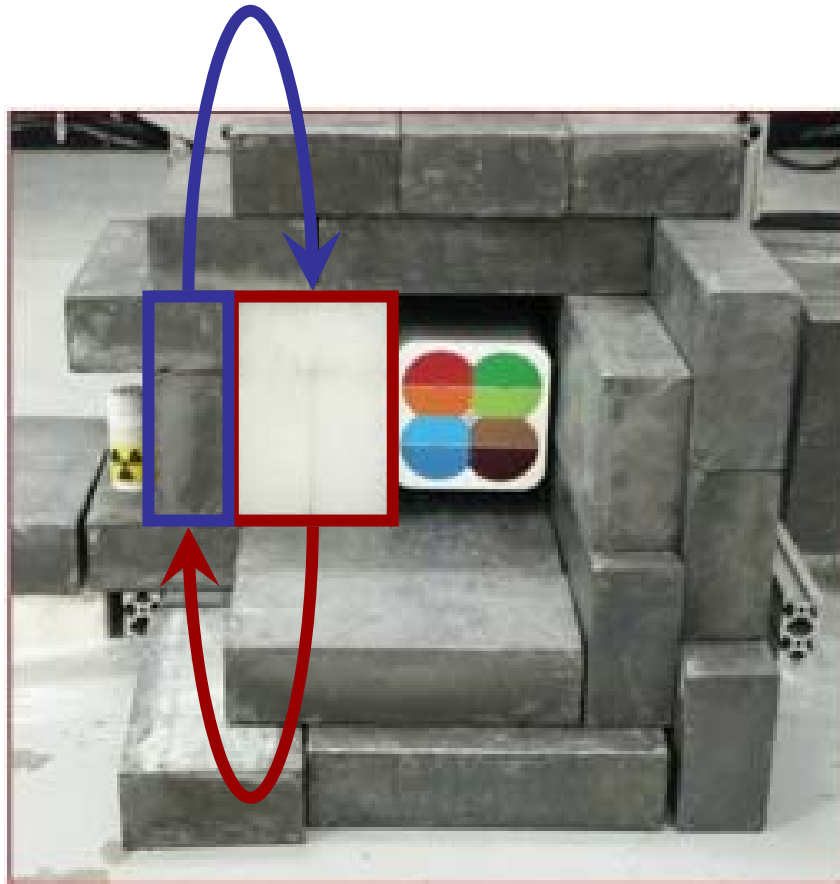
# *Summary of the Discrepancy*

---

- Compton Shoulder is higher in MC than in data
- 3.3 MeV gamma appears in MC not in data
  - Intense & energy of the gamma rays from Am-Be generator
  - Angular distribution of Am-Be generator
- Missing of the meta stable states in MC
  - They cannot be generated by Geant4
  - Work around going to be implemented in MaGe
- Missing of the internal conversion in MC
- Shift of 2.223 MeV gamma line and its escape peaks
  - Solved by modifying the Geant4 database file

# *New Design of the Experiment*

---





# *Conclusion*

---

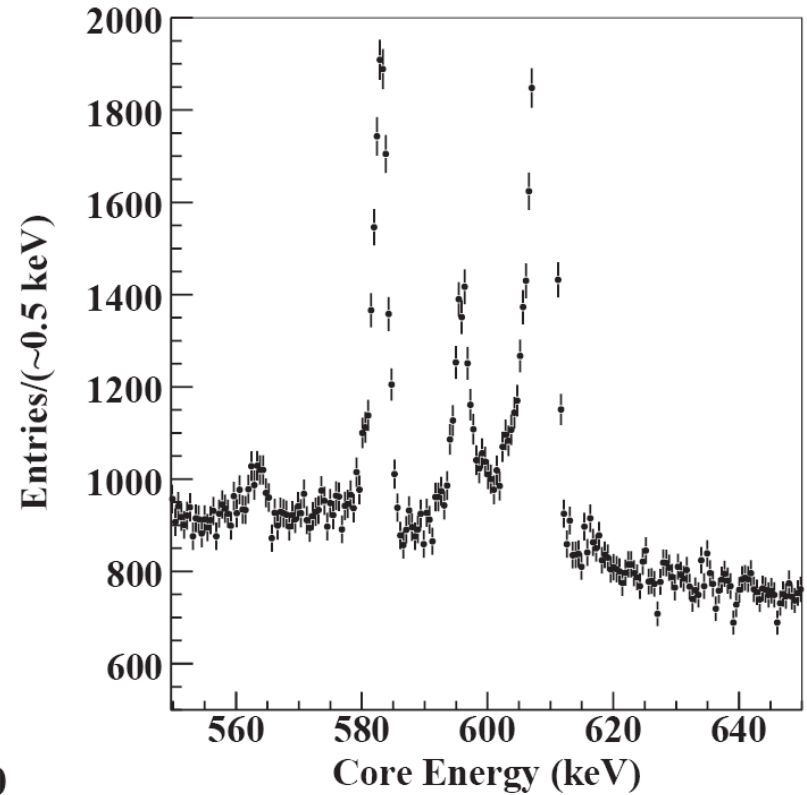
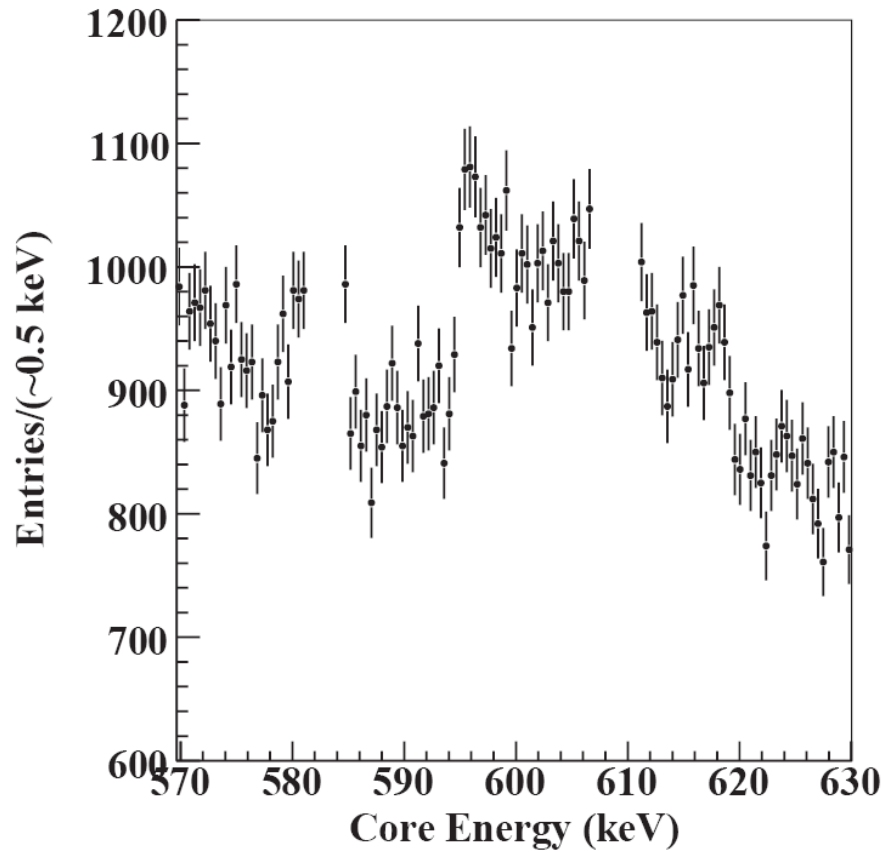
- Preliminary comparison already shows some discrepancy
- Some can be easily fixed, some cannot
- New setup and measurement are coming

*Further Identification of Peaks by  
Using Segmentation Information*

---

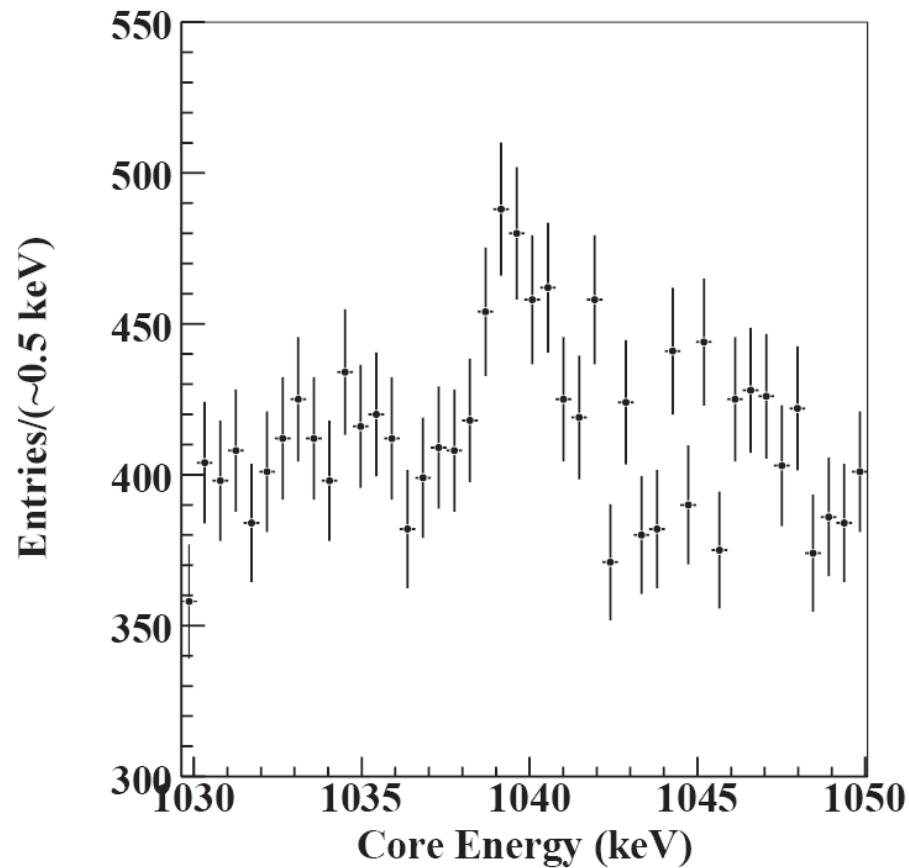
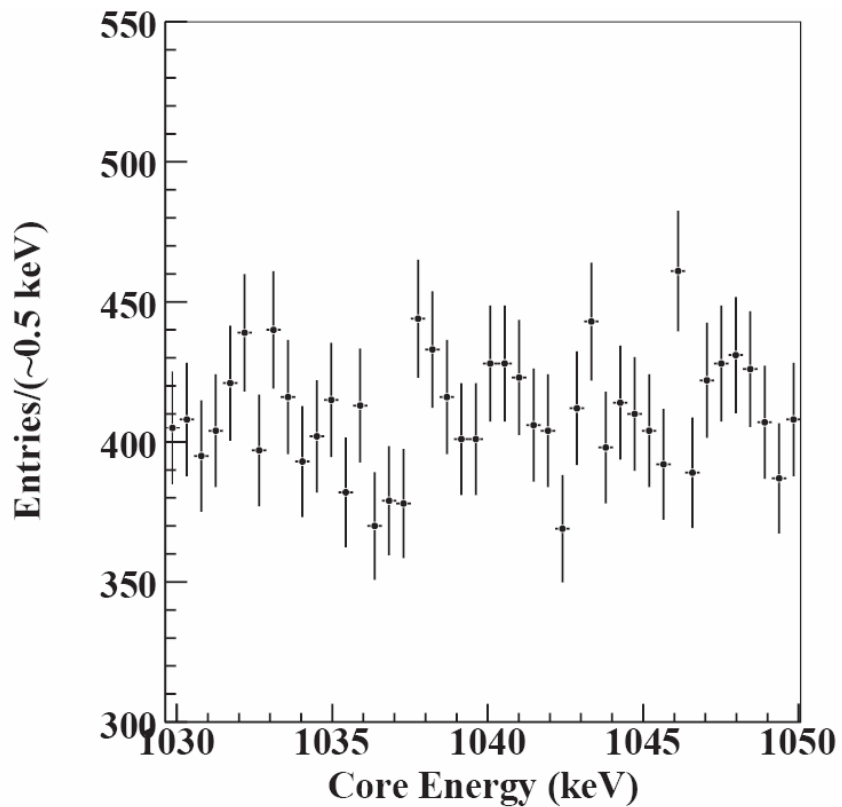
# $n + {}^{74}\text{Ge} \rightarrow {}^{74}\text{Ge} + n' + 596 \text{ keV gamma}$

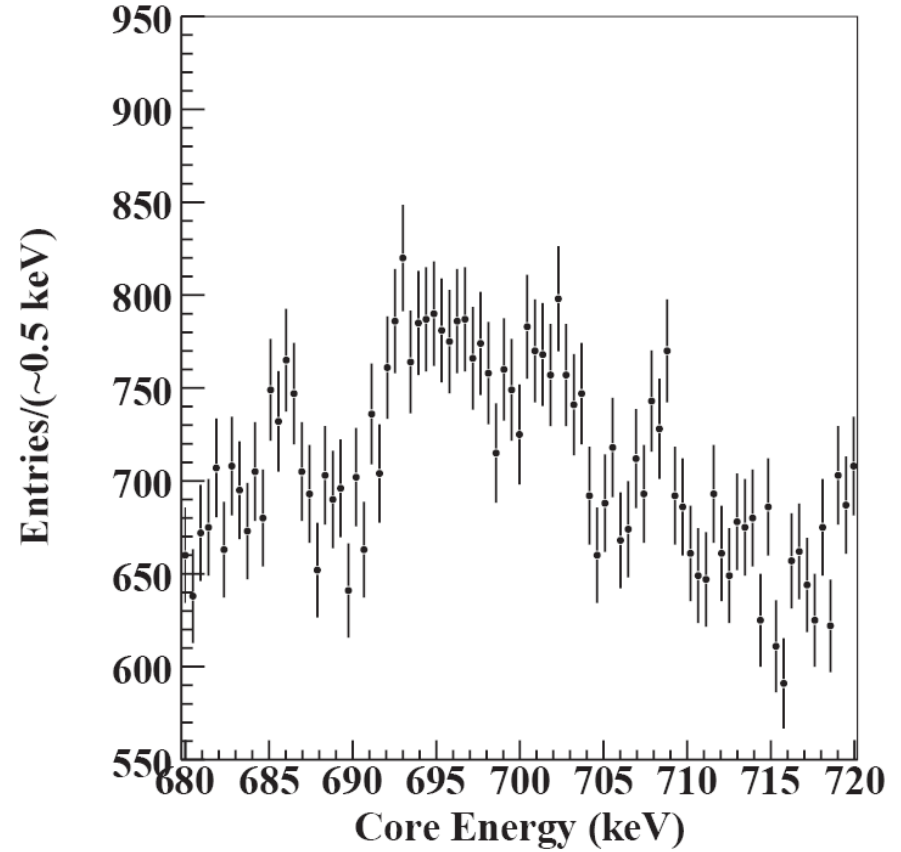
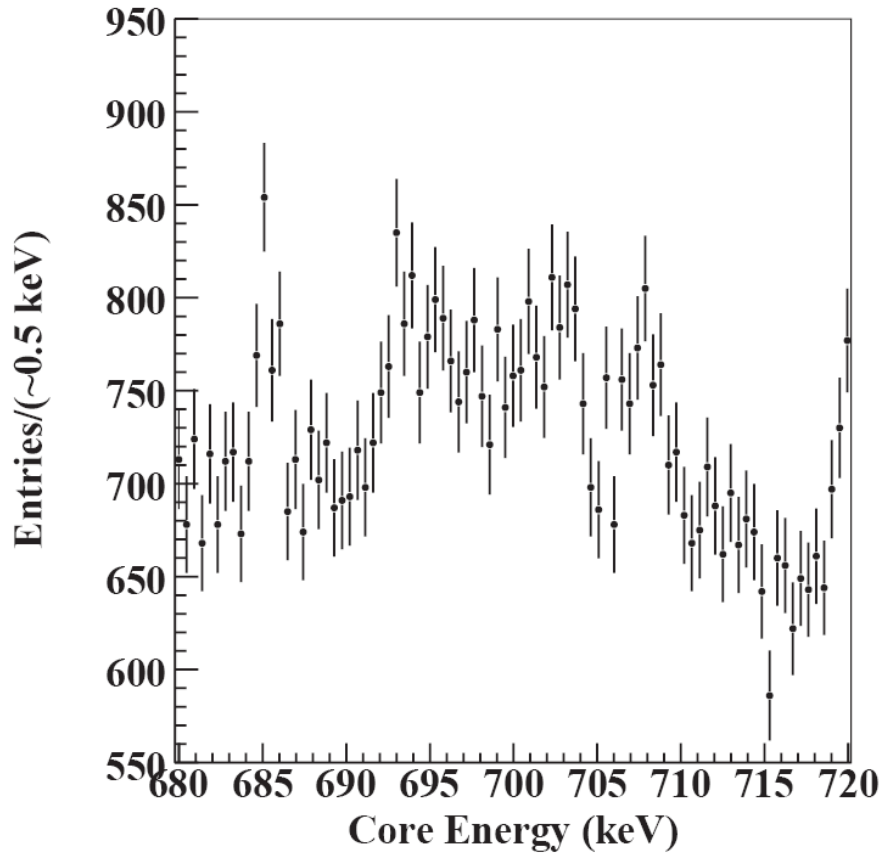
---



$n + {}^{70}\text{Ge} \rightarrow {}^{70}\text{Ge} + n' + 1039 \text{ keV gamma}$

---





70	69.924	2504(19)	20.84(87)%	72.64(1) h
72	71.922	0762(16)	27.54(34)%	
73	72.923	4594(16)	7.73(5)%	
74	73.921	1782(16)	36.28(73)%	
76	75.921	4027(16)	7.61(38)%	