DPG 2007, Heidelberg

Identification of Neutron Interactions

with a Segmented Germanium Detector

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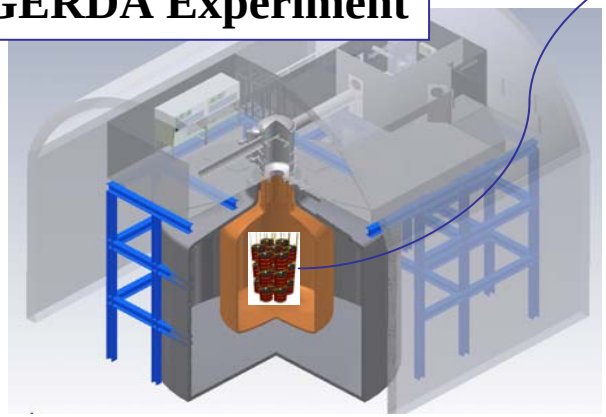
Why do we want to identify

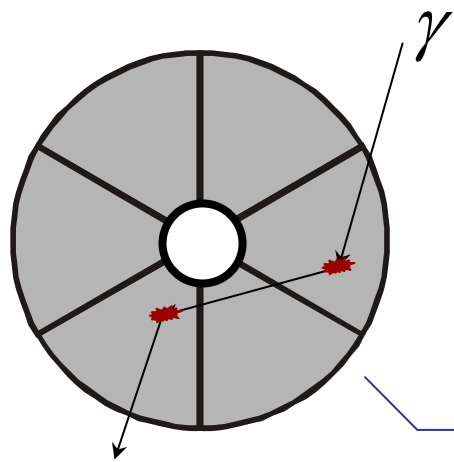
neutron interactions

GERDA Experiment

GERDA Experiment



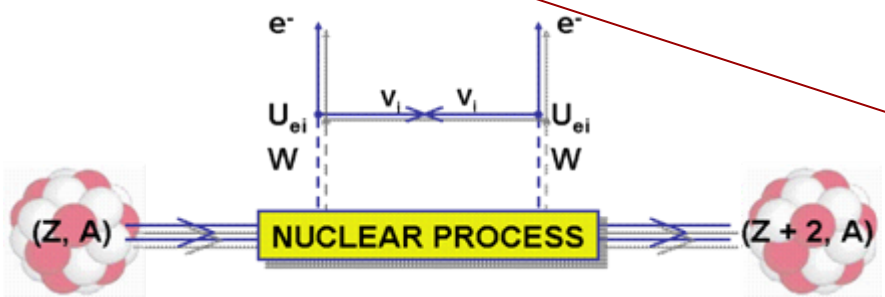
Segmented Ge detector



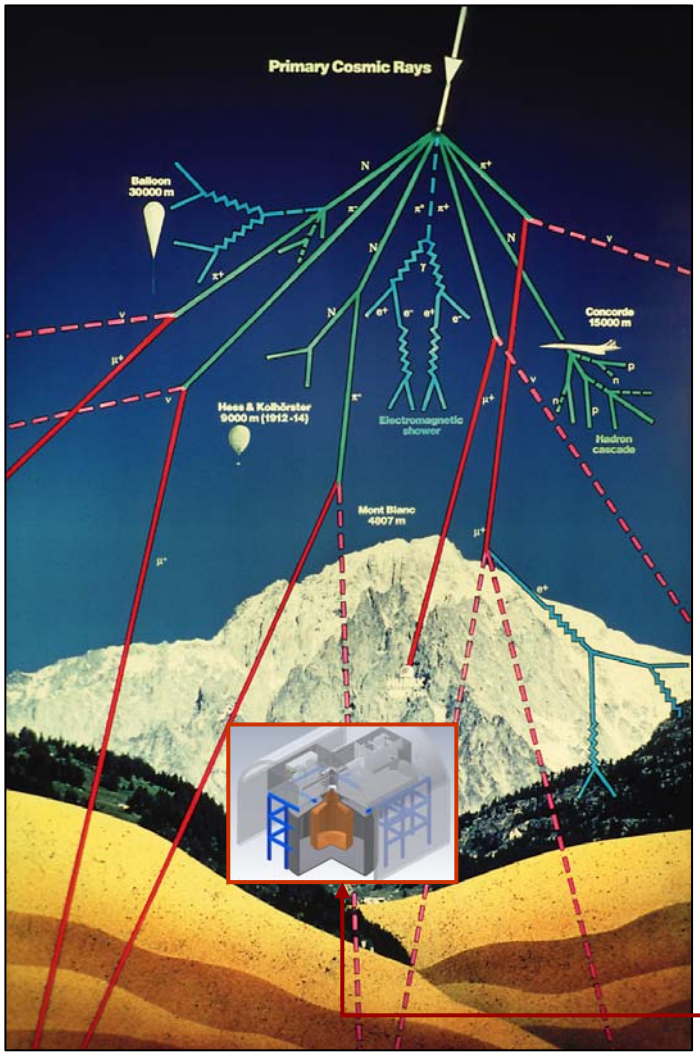
Background

Signal

$$^{76}Ge \rightarrow {}^{76}Se + 2e^{-} \; (0\nu\beta\beta\text{-decay})$$



Neutron Background



1

Neutrons produced by high energy cosmic ray muon spallation interaction (μ, n)

2

Primordial neutrons produced in rock by (α, n)

In order to decrease background, GERDA will be constructed underground

Things Interest us

?

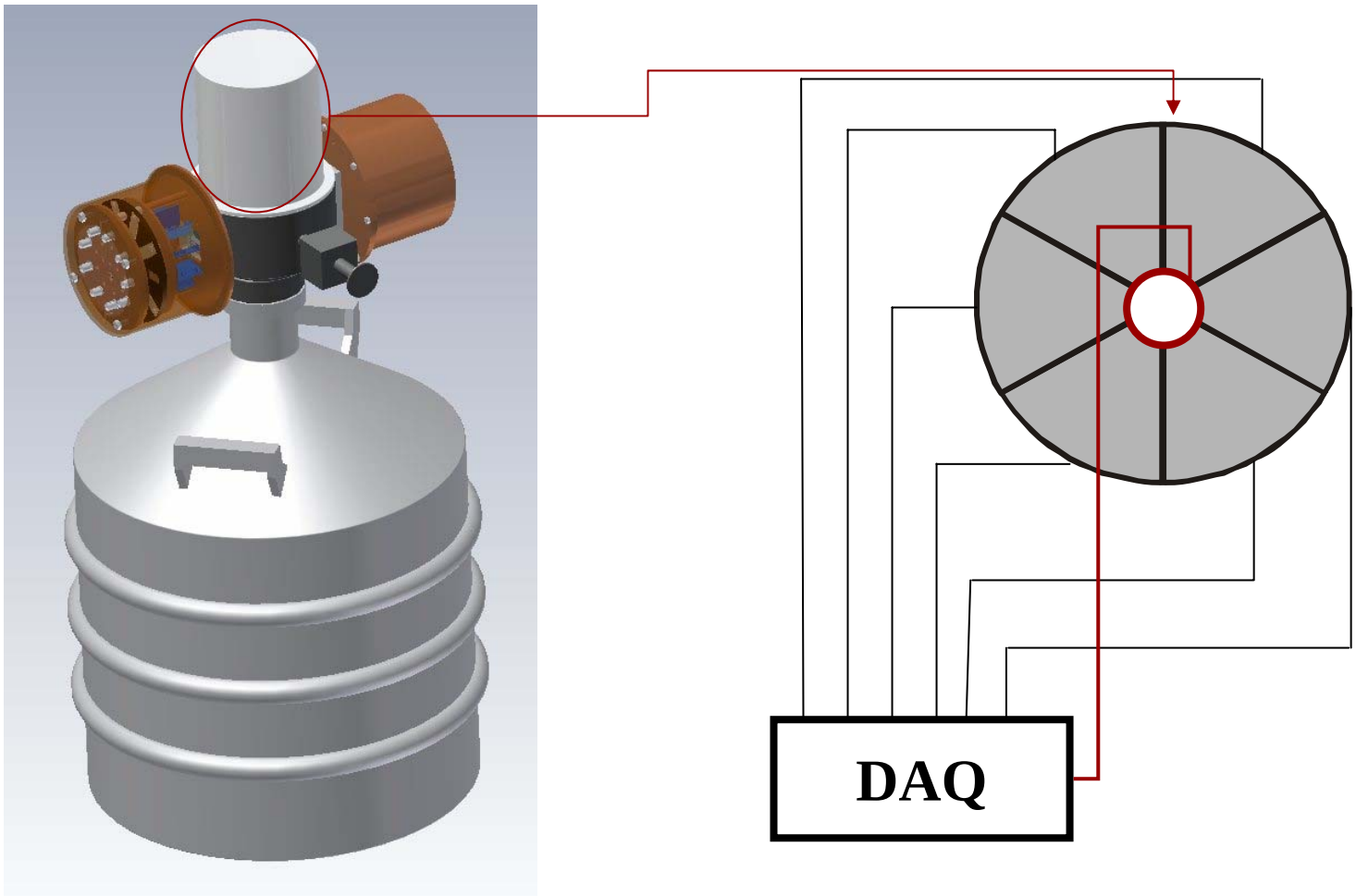
How does our detectors respond to the neutrons ?

?

Can the segmentation of the detector help us to identify neutron induced background ?

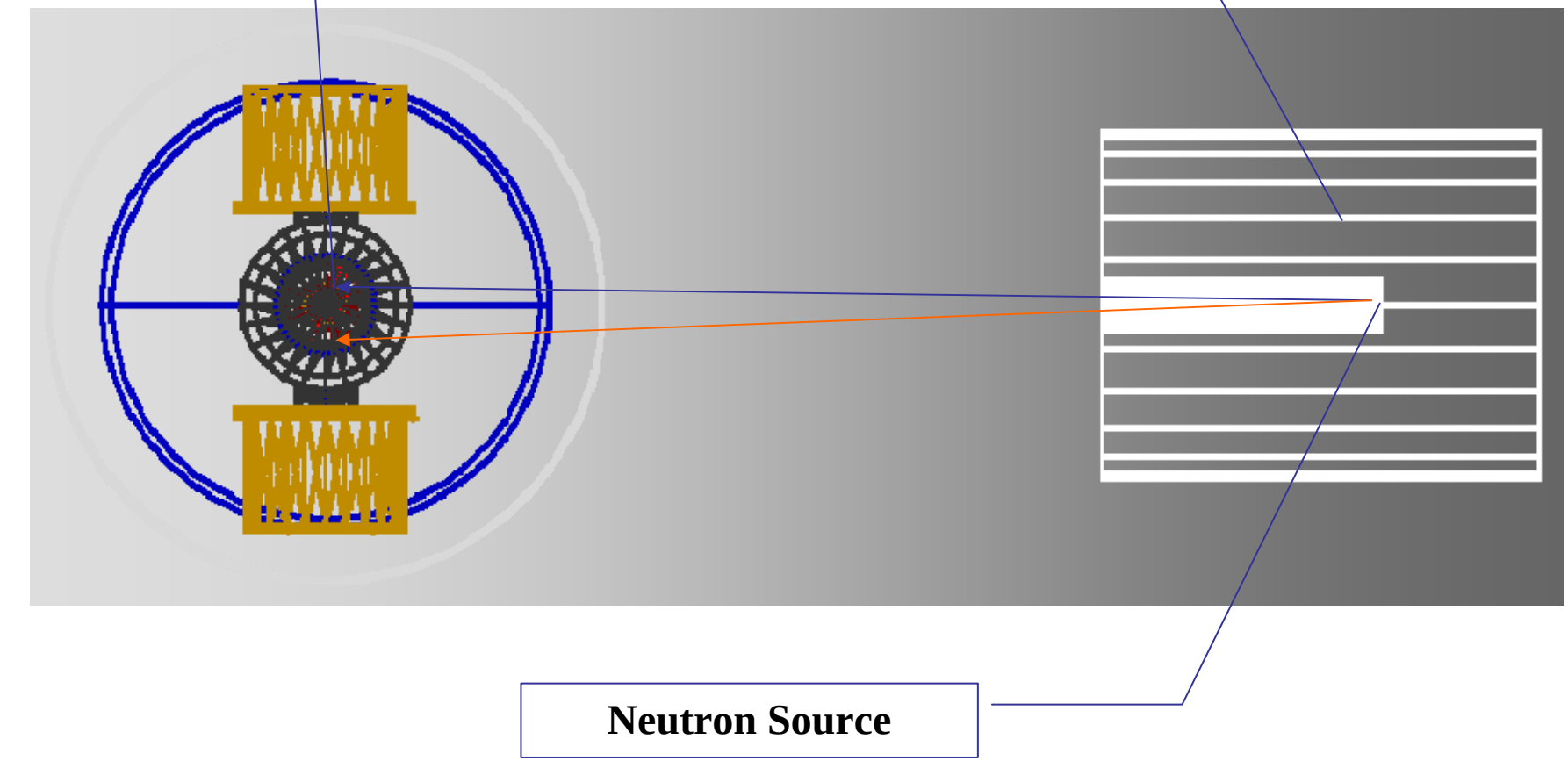
How do we do the measurement

18-fold Segmented Ge Detector

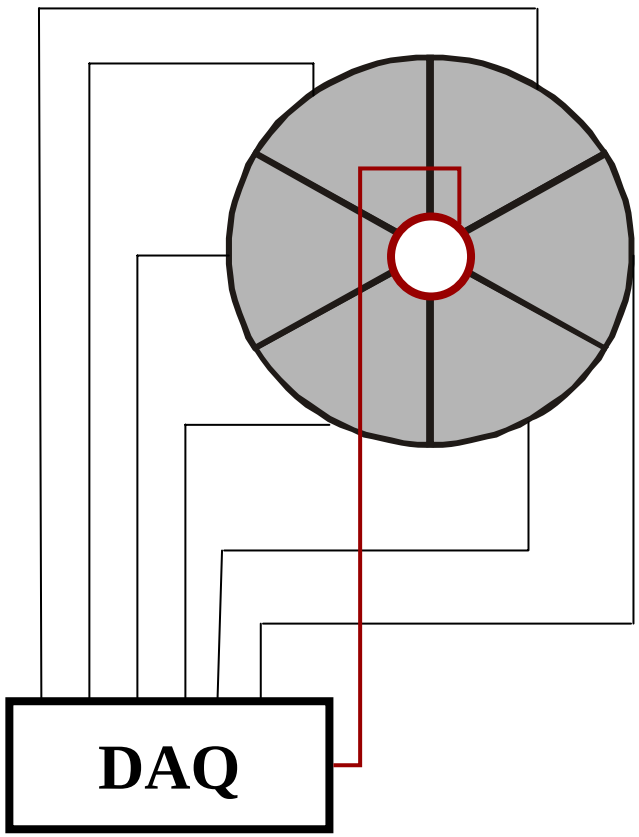


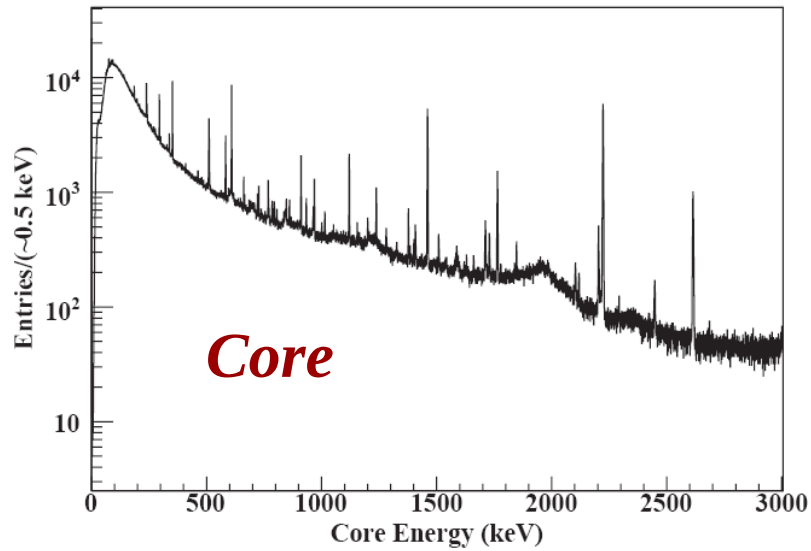
Experimental Setup

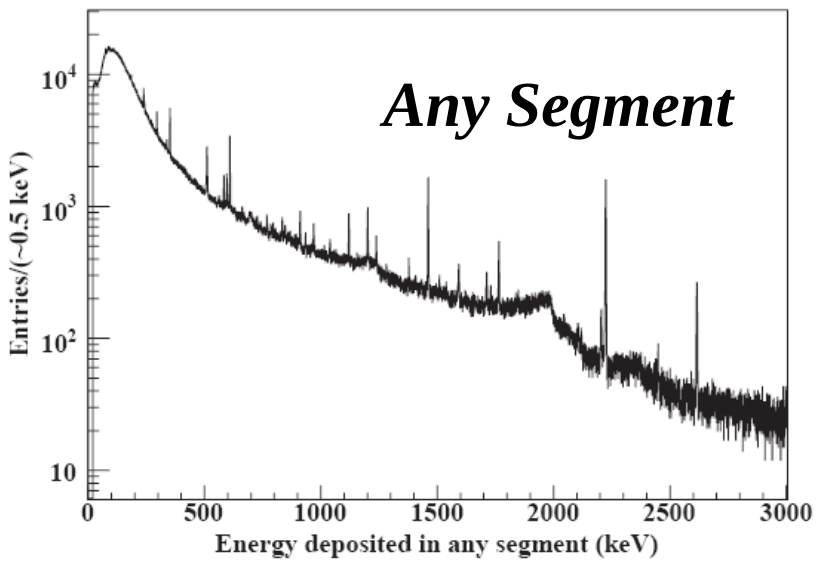
3 days, 7 M events



Core & Segments

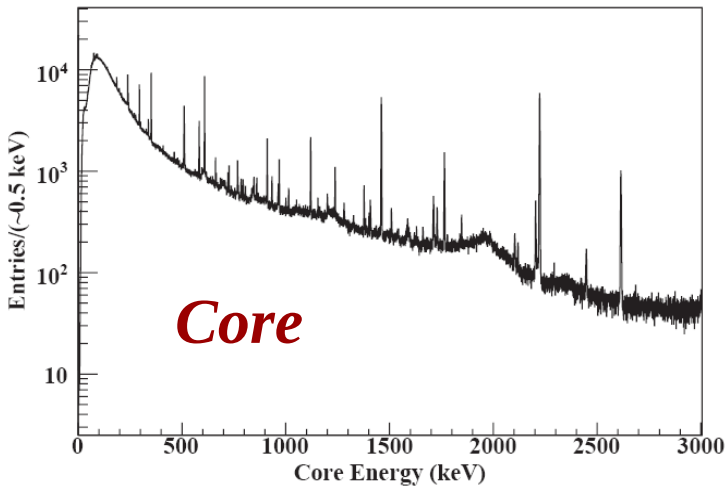


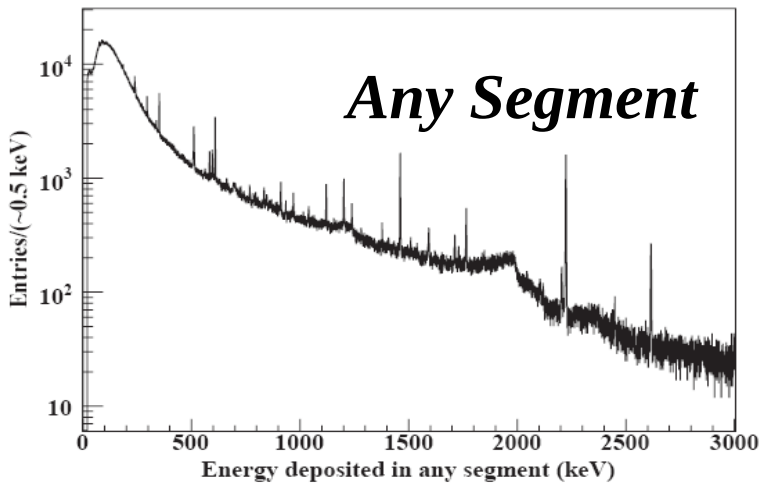




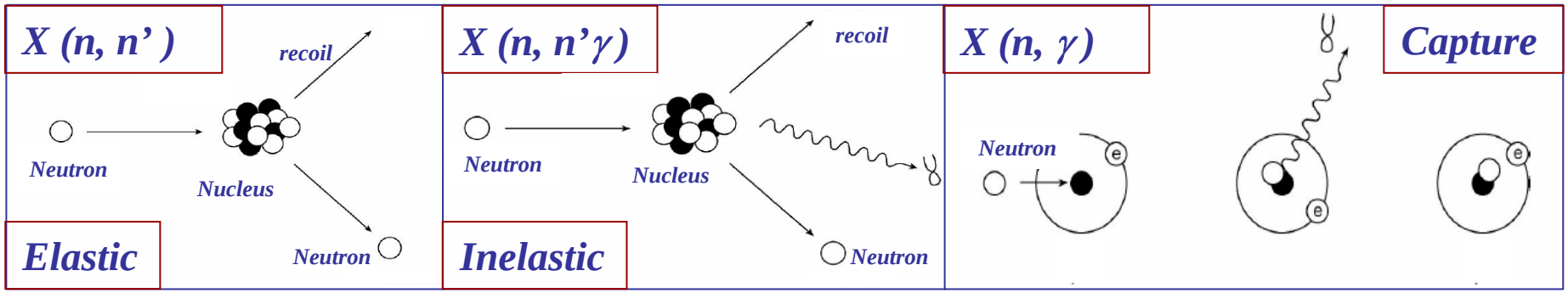
How to identify neutron interactions

by using segment information





Neutron Interactions with Nuclei



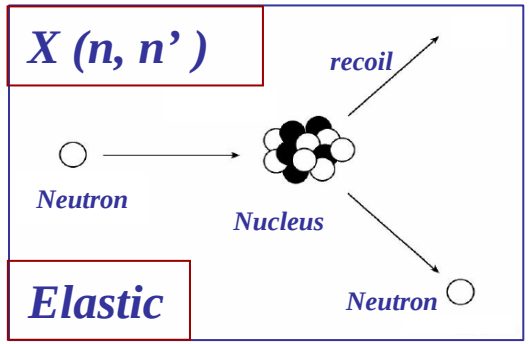
$$n + {}^{A}X \rightarrow {}^{A+1}X^{*}_{m}, \quad {}^{A+1}X^{*}_{m} \rightarrow {}^{A+1}X + \gamma$$

Meta-stable State

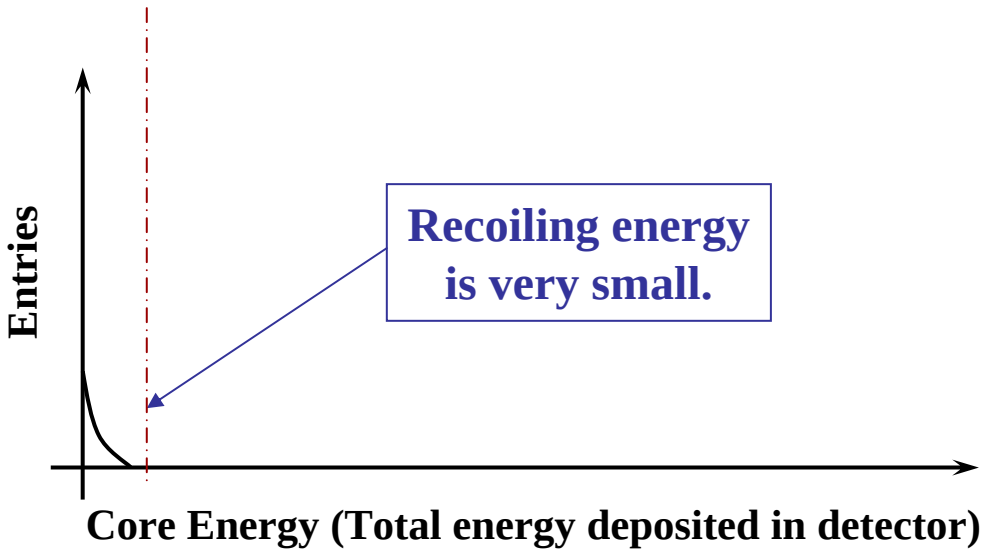
$$n + {}^{A}X \rightarrow {}^{A+1}X^{*}, \quad {}^{A+1}X^{*} \rightarrow {}^{A+1}X^{+} + e$$

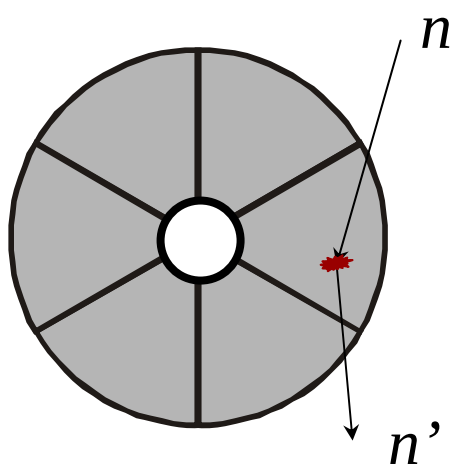
Internal Conversion

Elastic Scattering

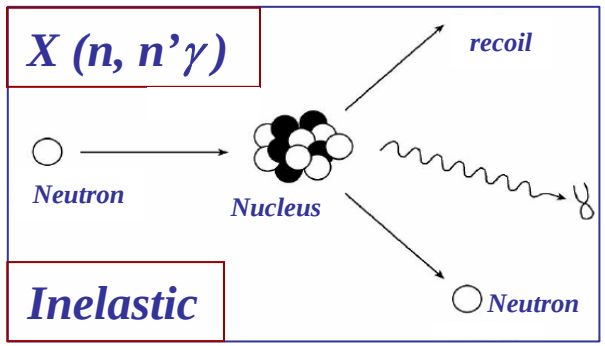


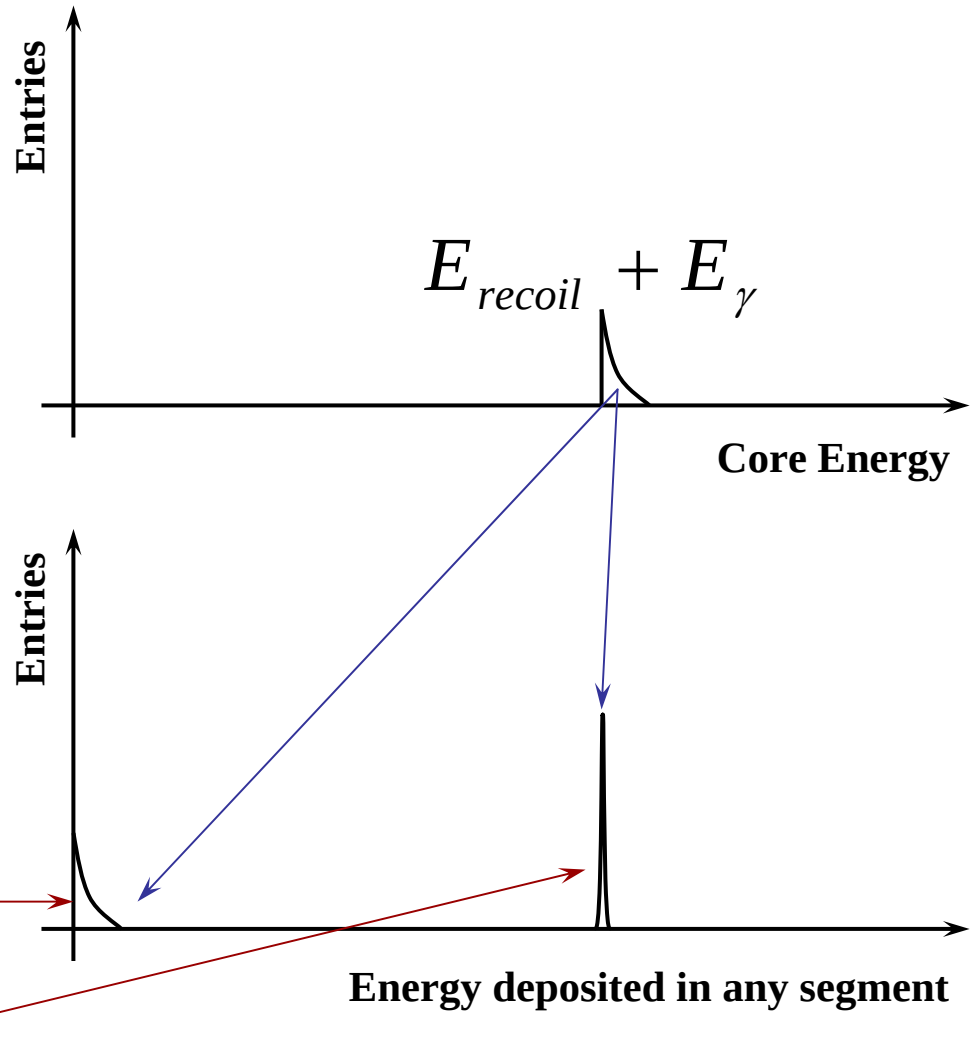
DAQ threshold

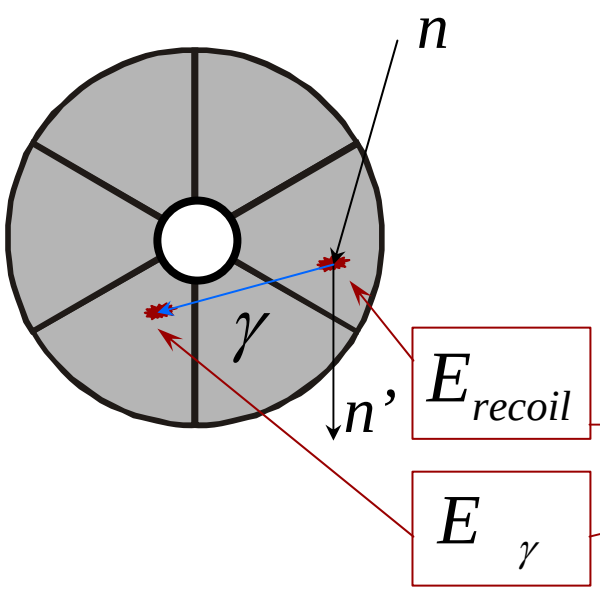




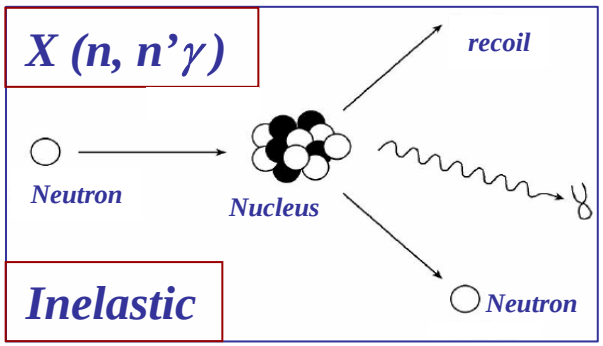
Simplest Inelastic Scattering

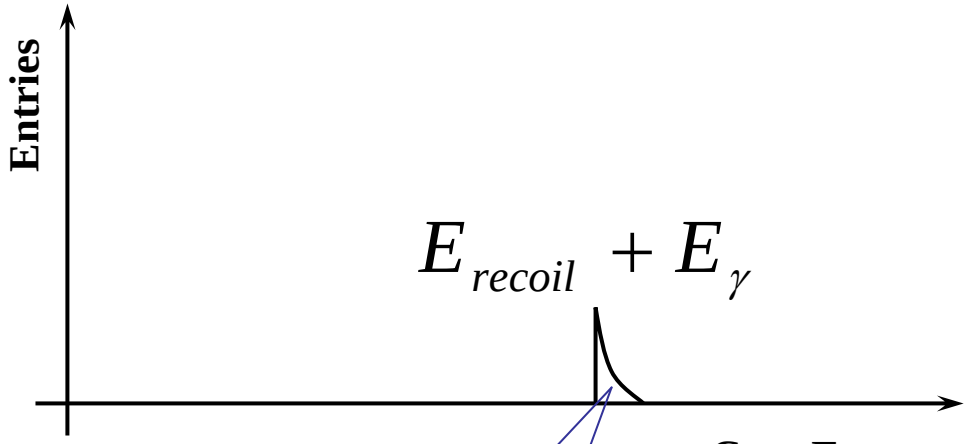


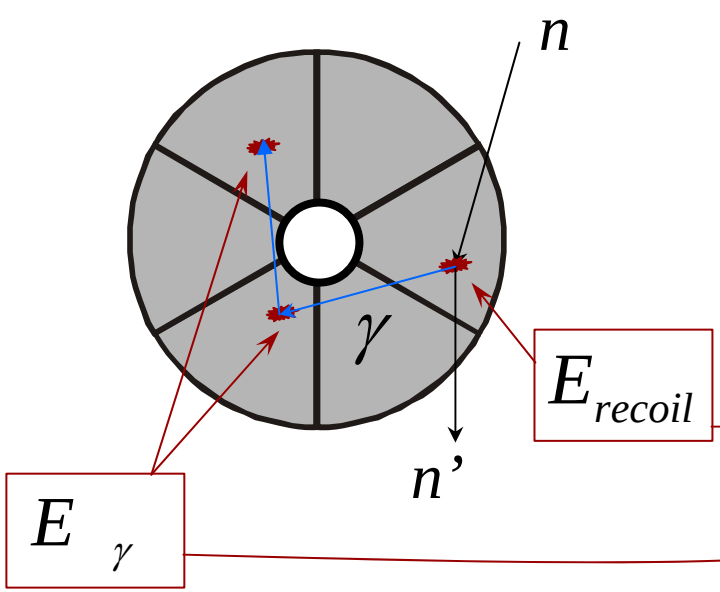


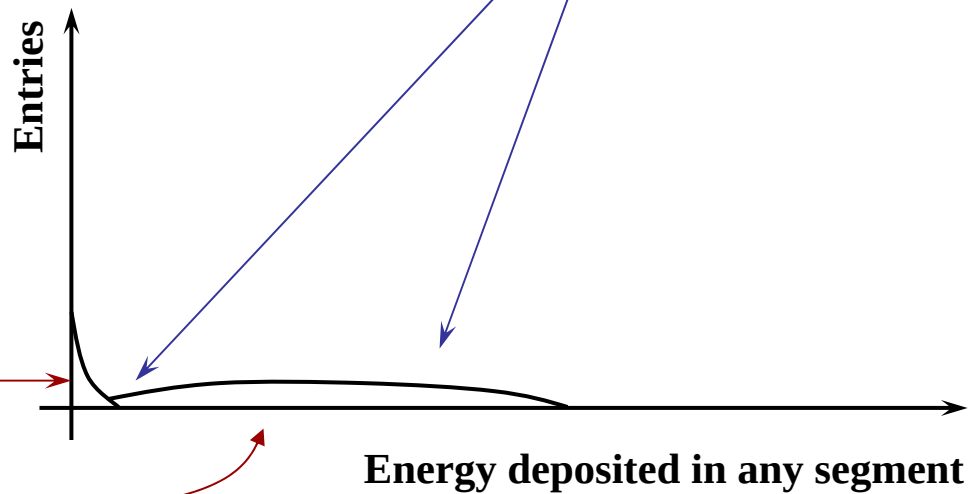


More Complex Inelastic Scattering

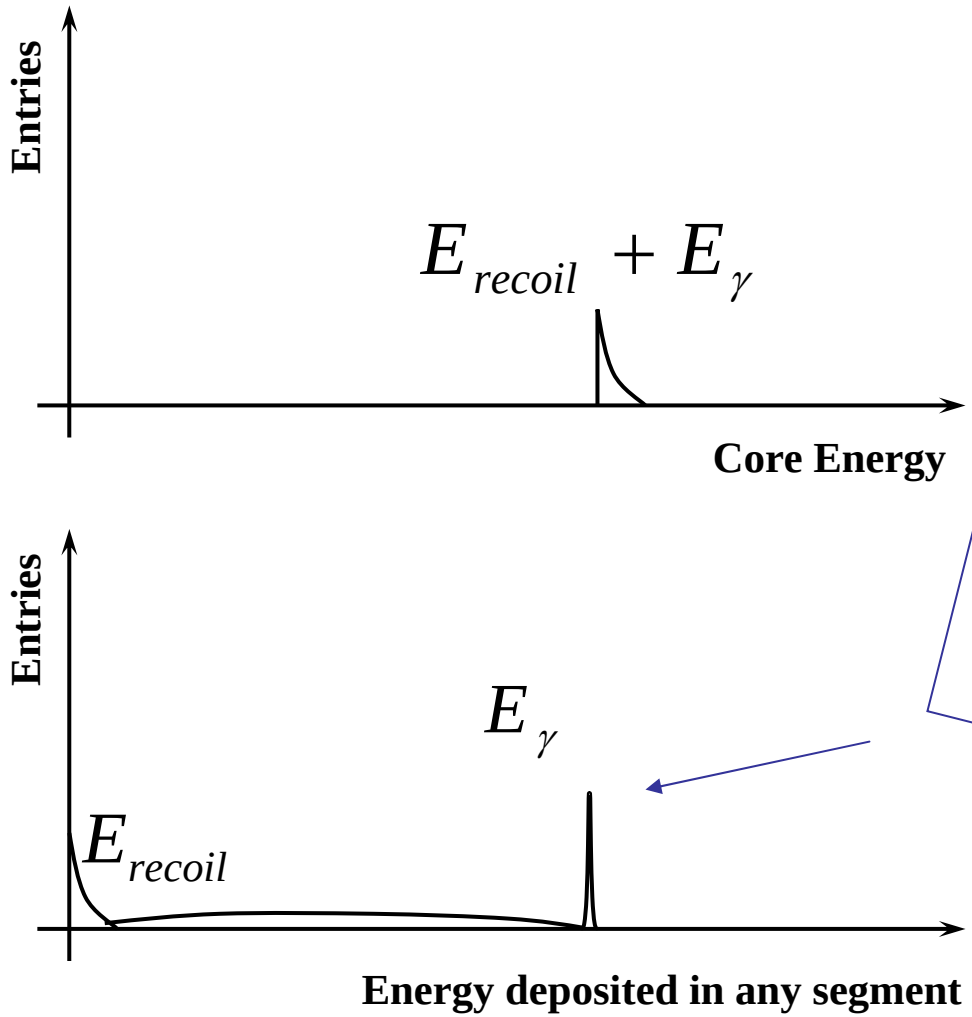








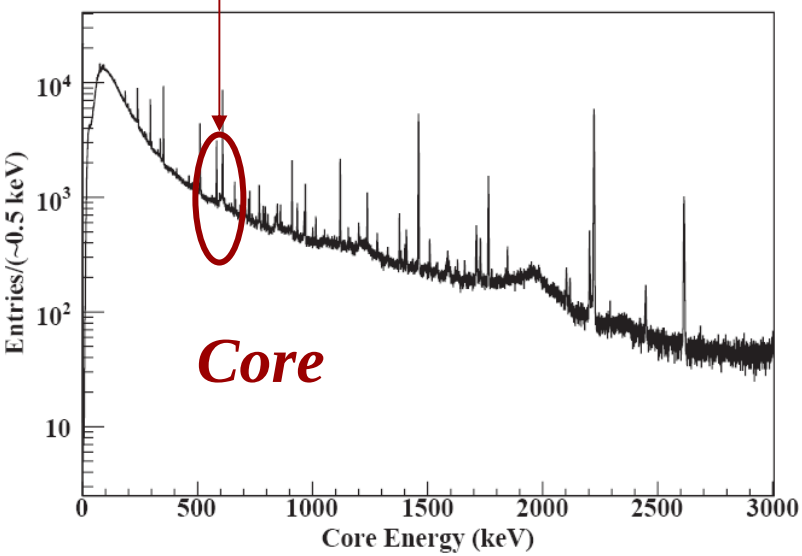
Inelastic Scattering in General

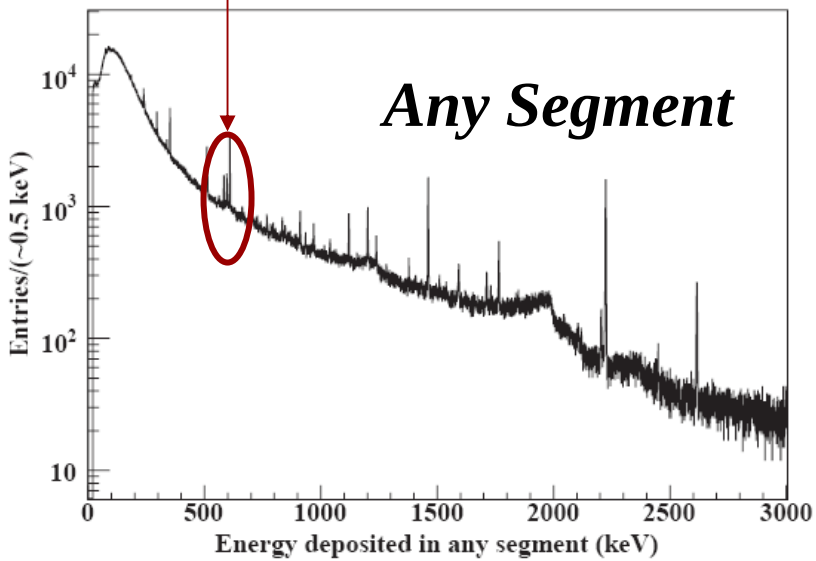


If the multi-scattering probability of the prompt photon is not so high, we can see the enhancement of the peak.

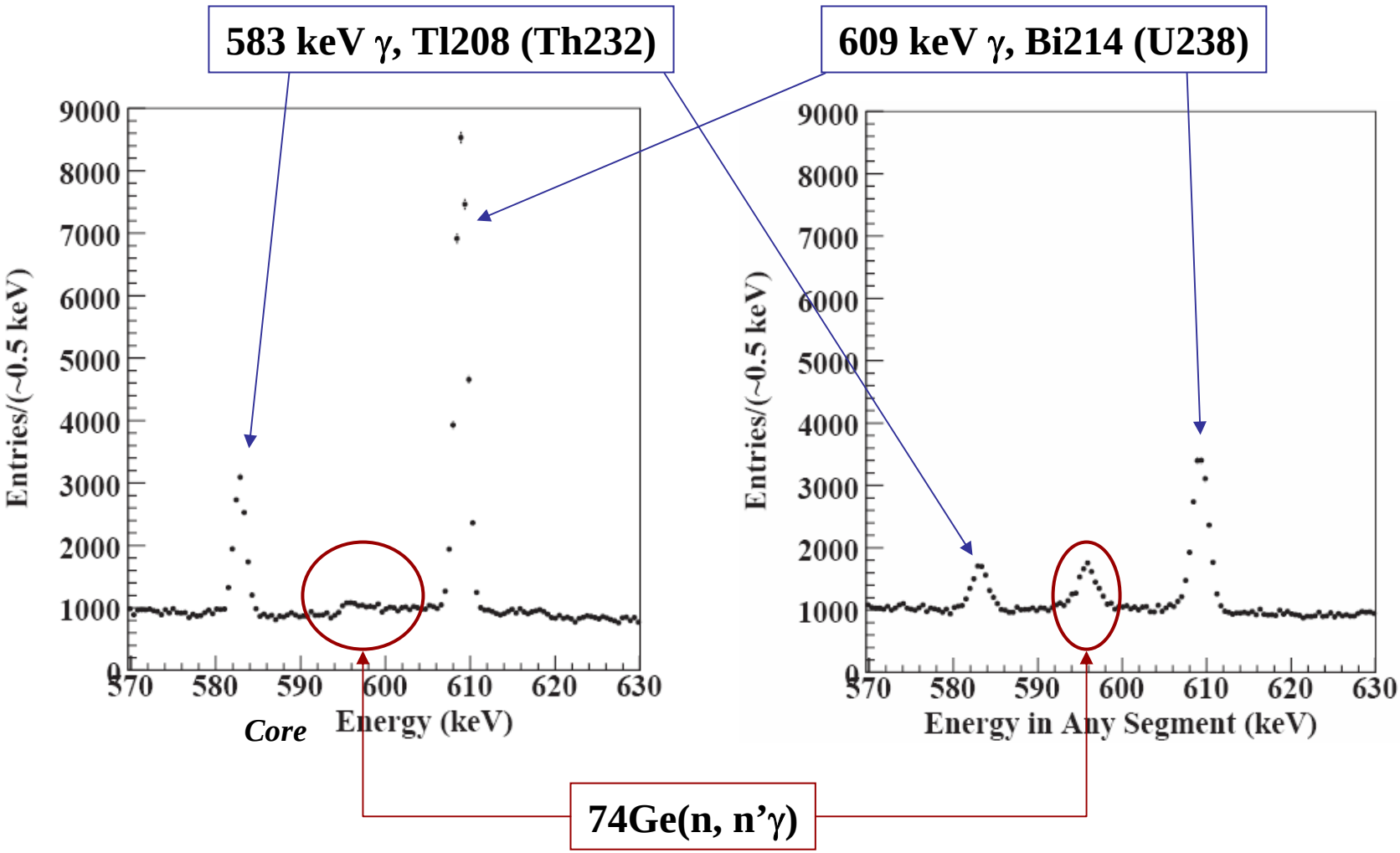
A Real Case of Inelastic Scattering

Zoom into (570, 630) keV

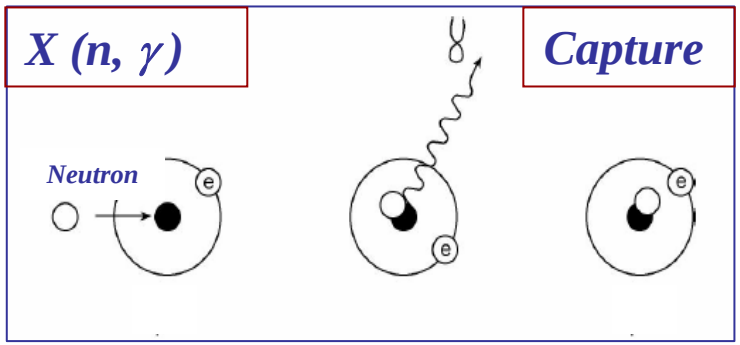


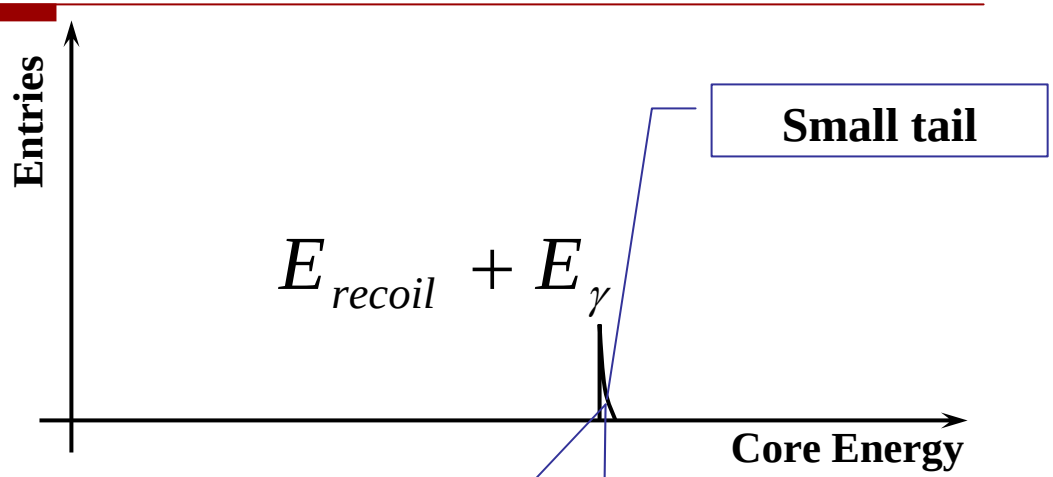


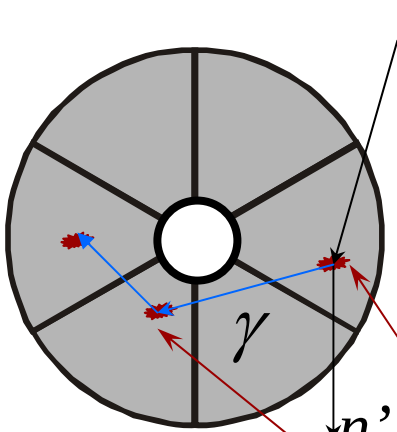
$n+^{74}Ge \rightarrow ^{74}Ge+n'+\gamma(596\ keV)$

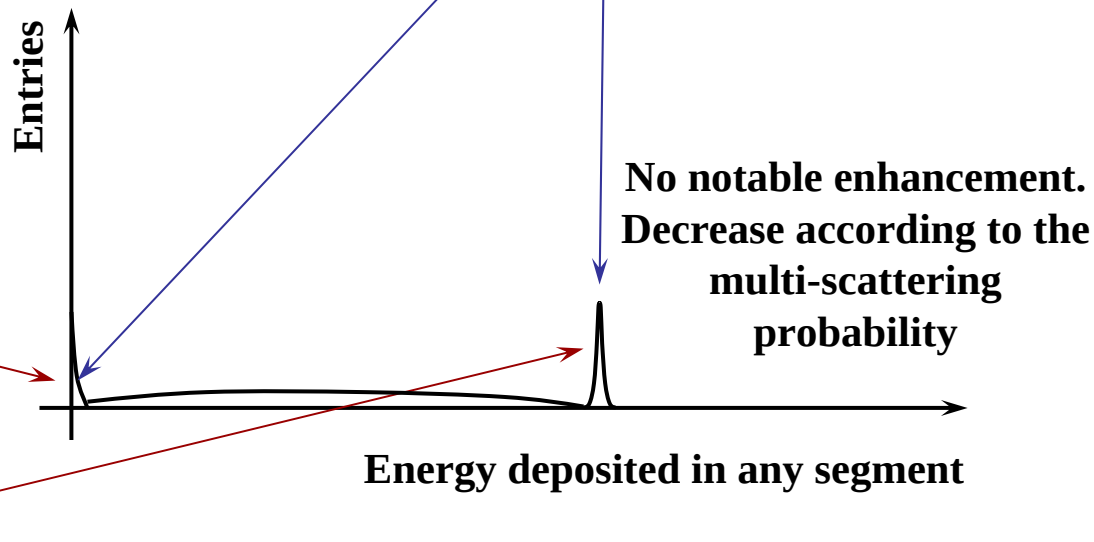


Thermal Capture

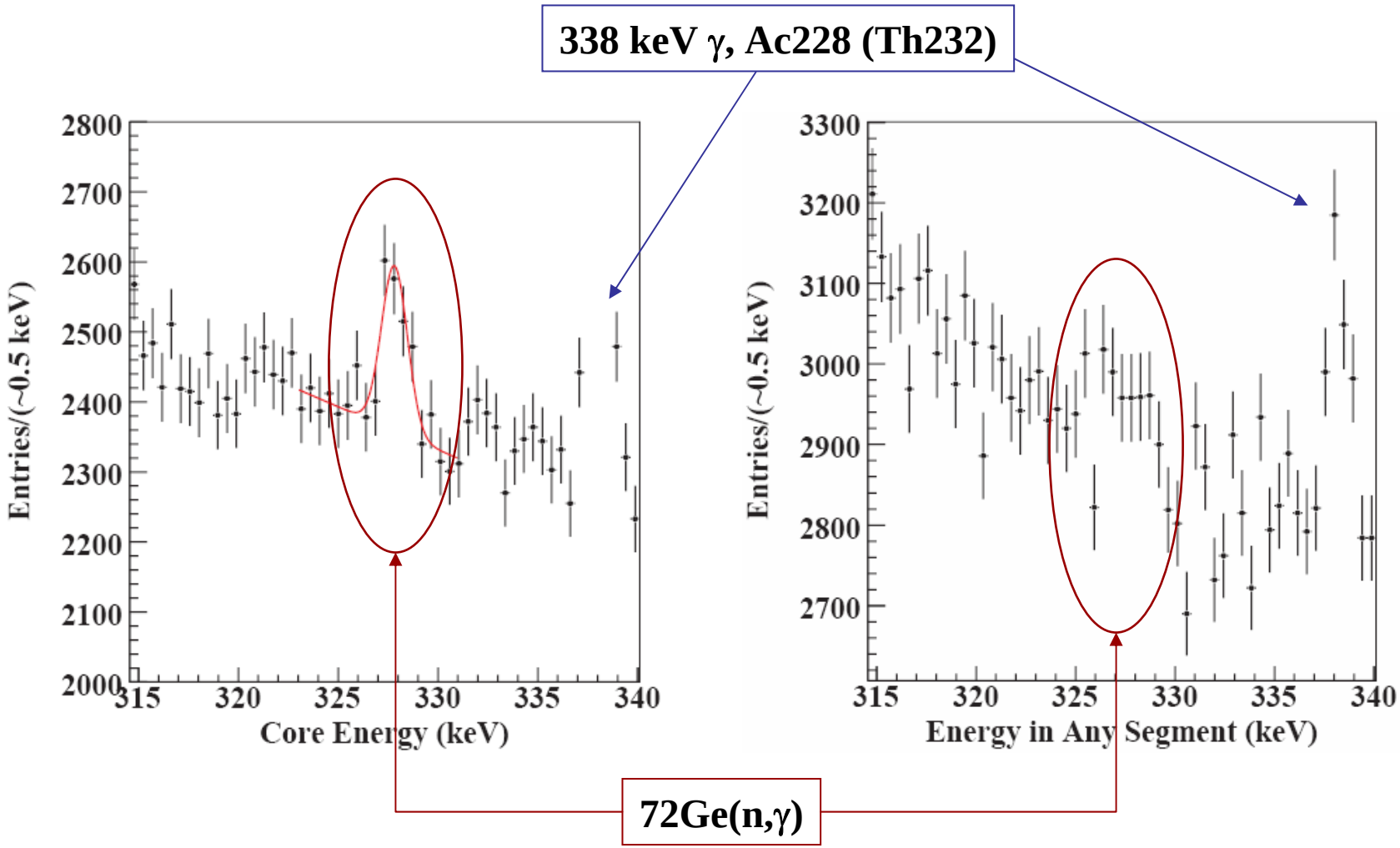




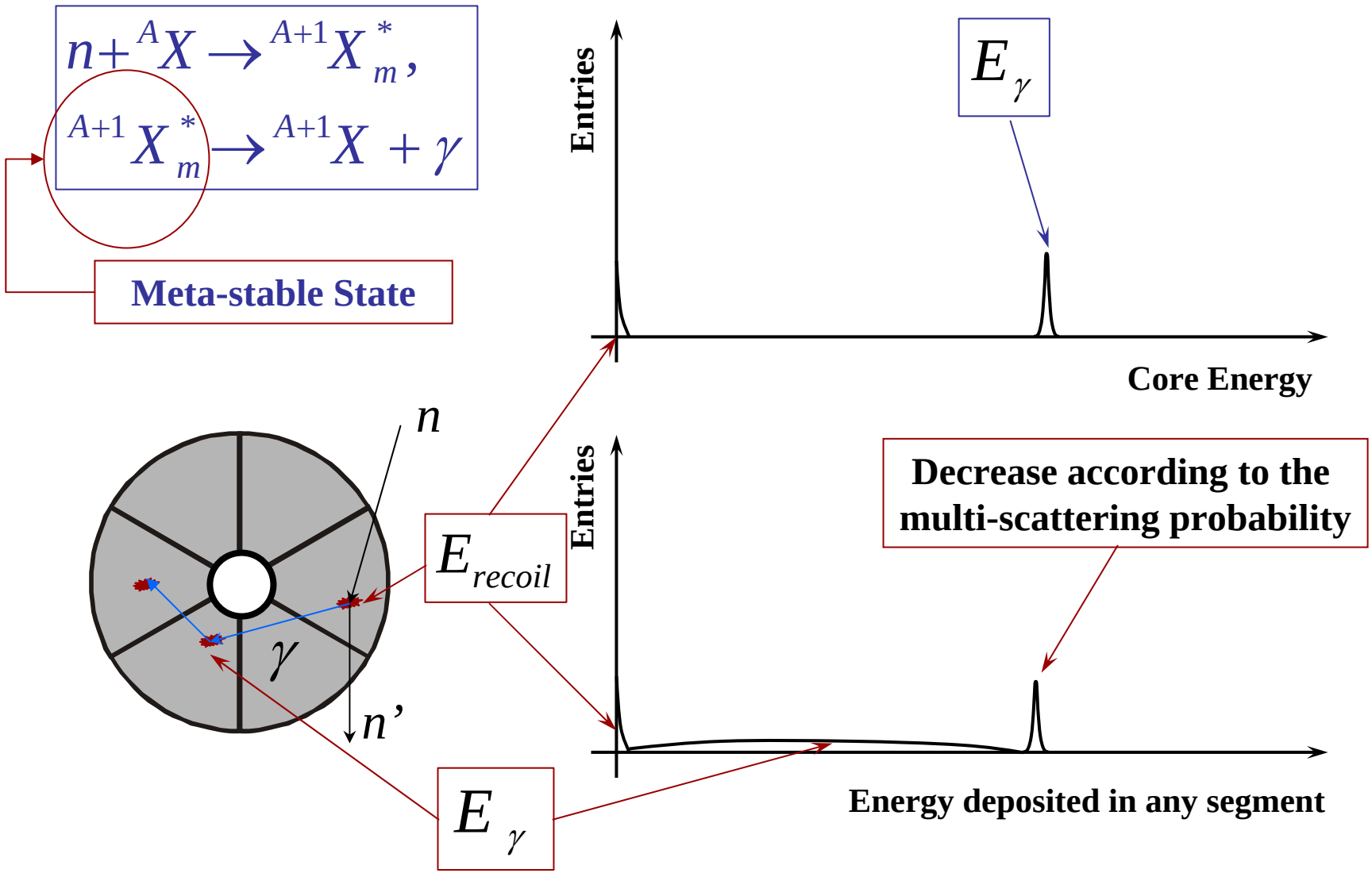




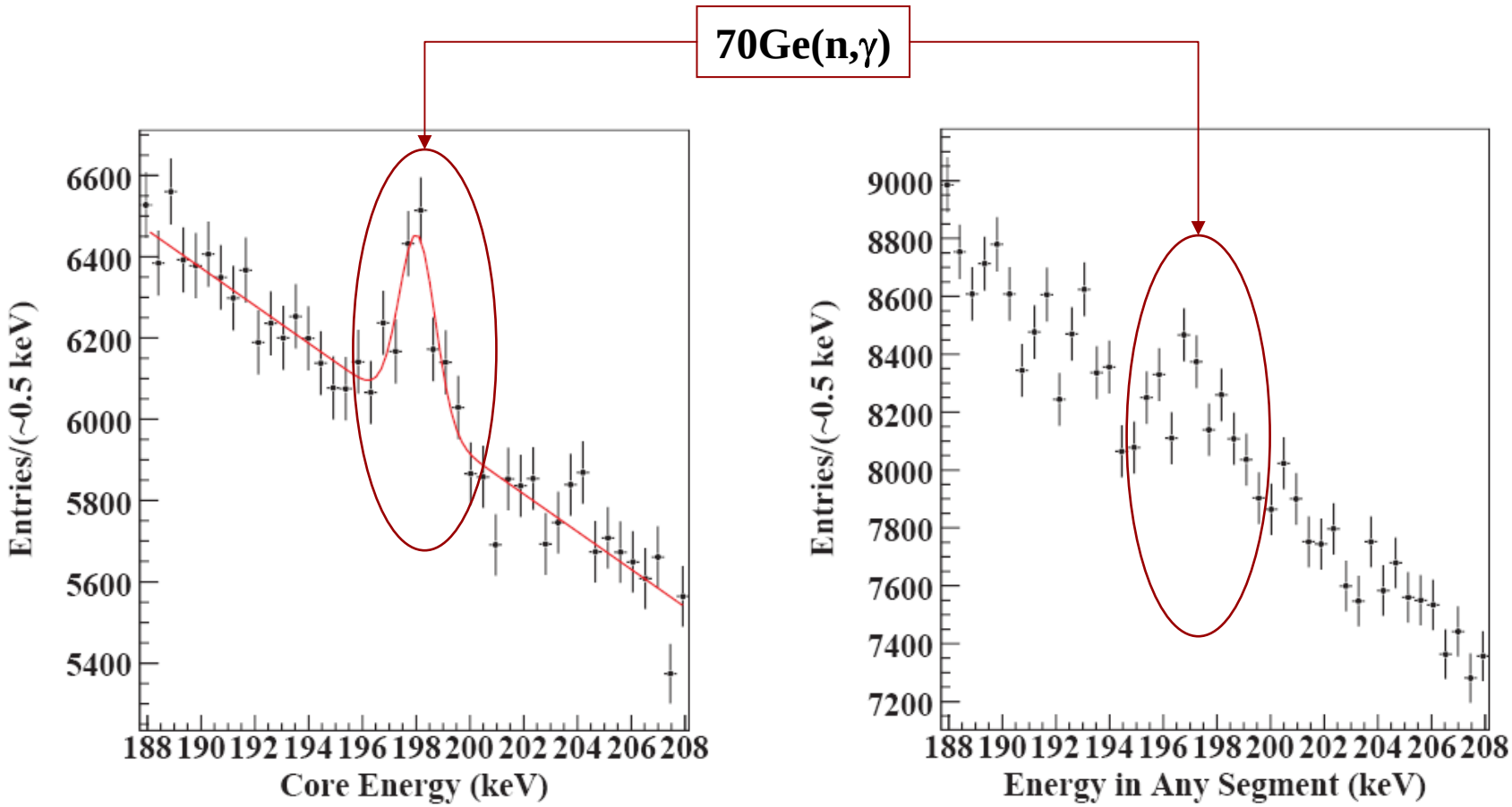
$n + {}^{72}Ge \rightarrow {}^{73}Ge + \gamma\,(326\ keV)$



Meta-stable State



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

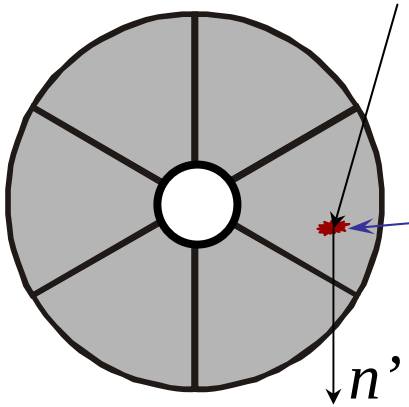


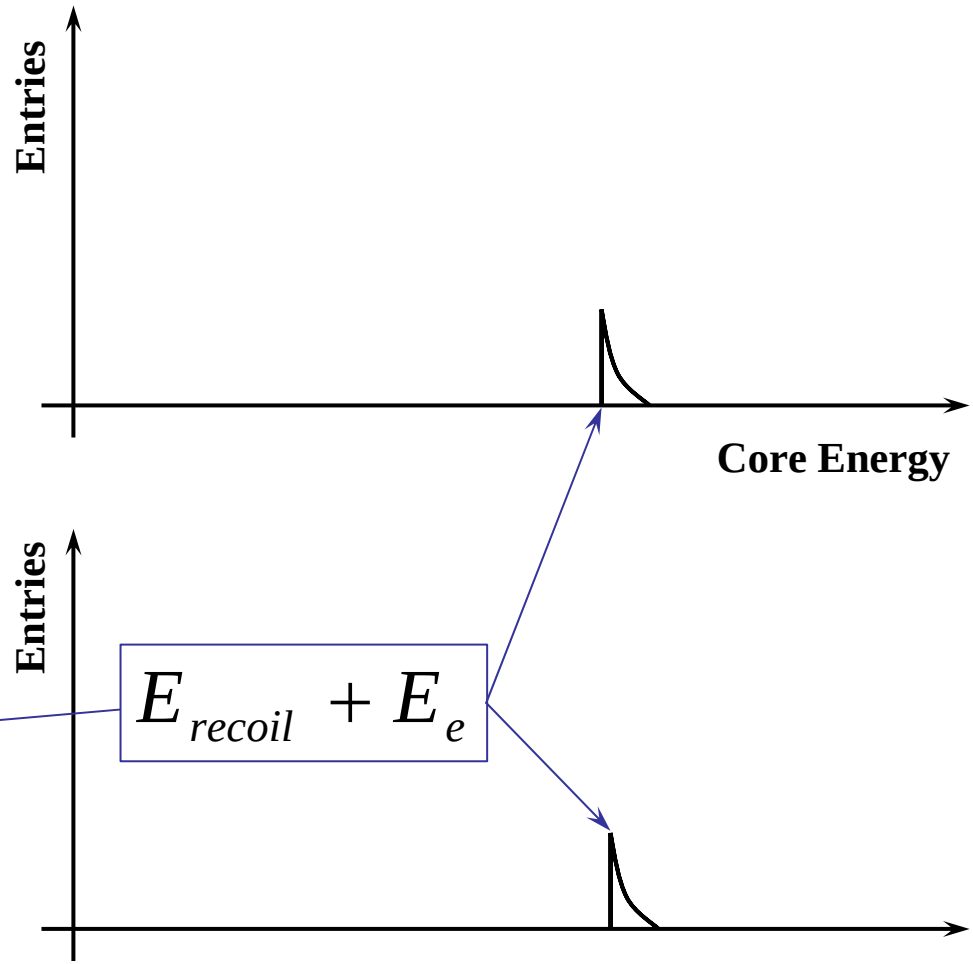
Internal Conversion

$$n + {}^{A}X \rightarrow {}^{A+1}X^{*},$$

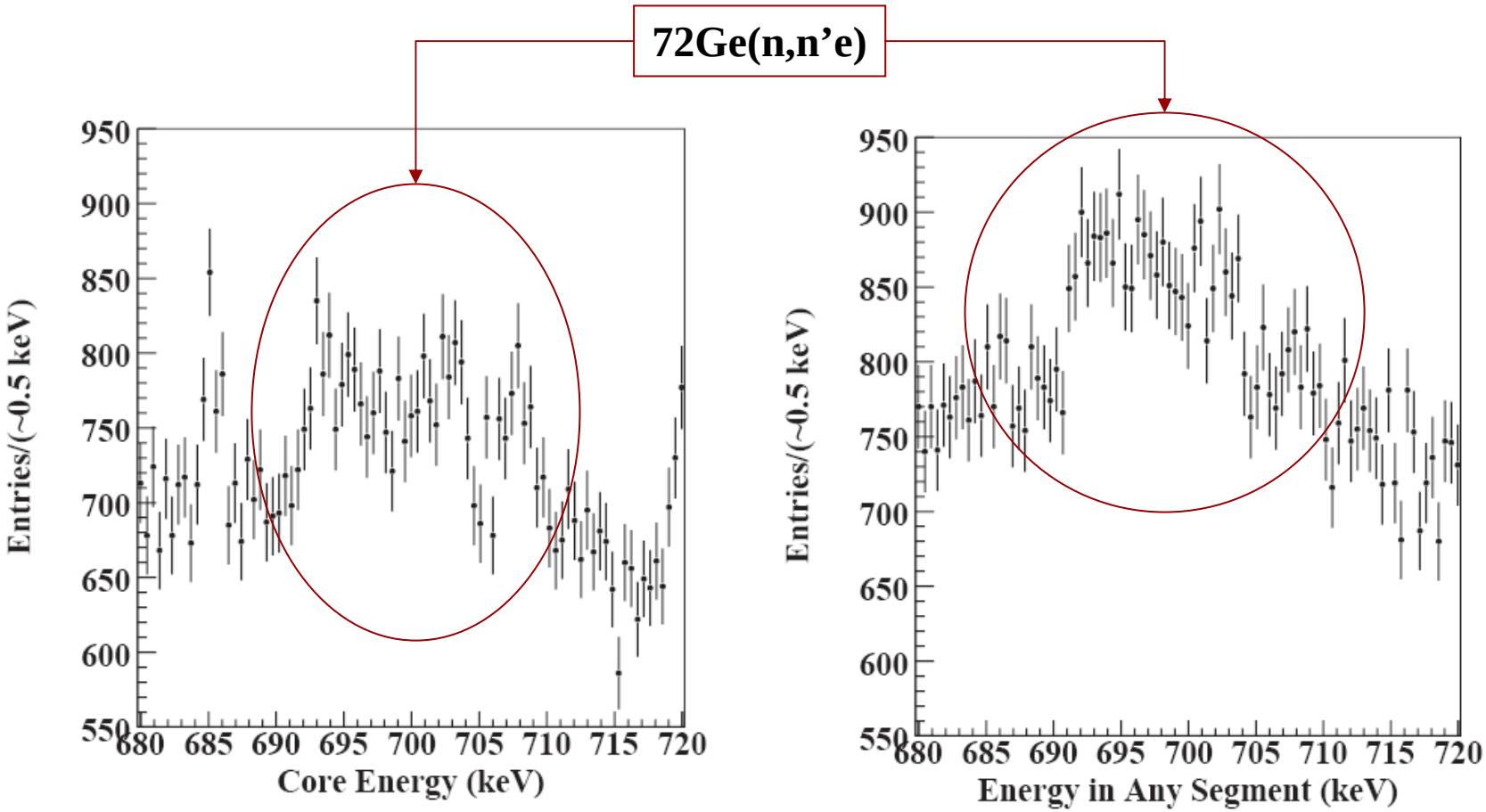
$${}^{A+1}X^{*} \rightarrow {}^{A+1}X^{+} + e$$

Internal Conversion



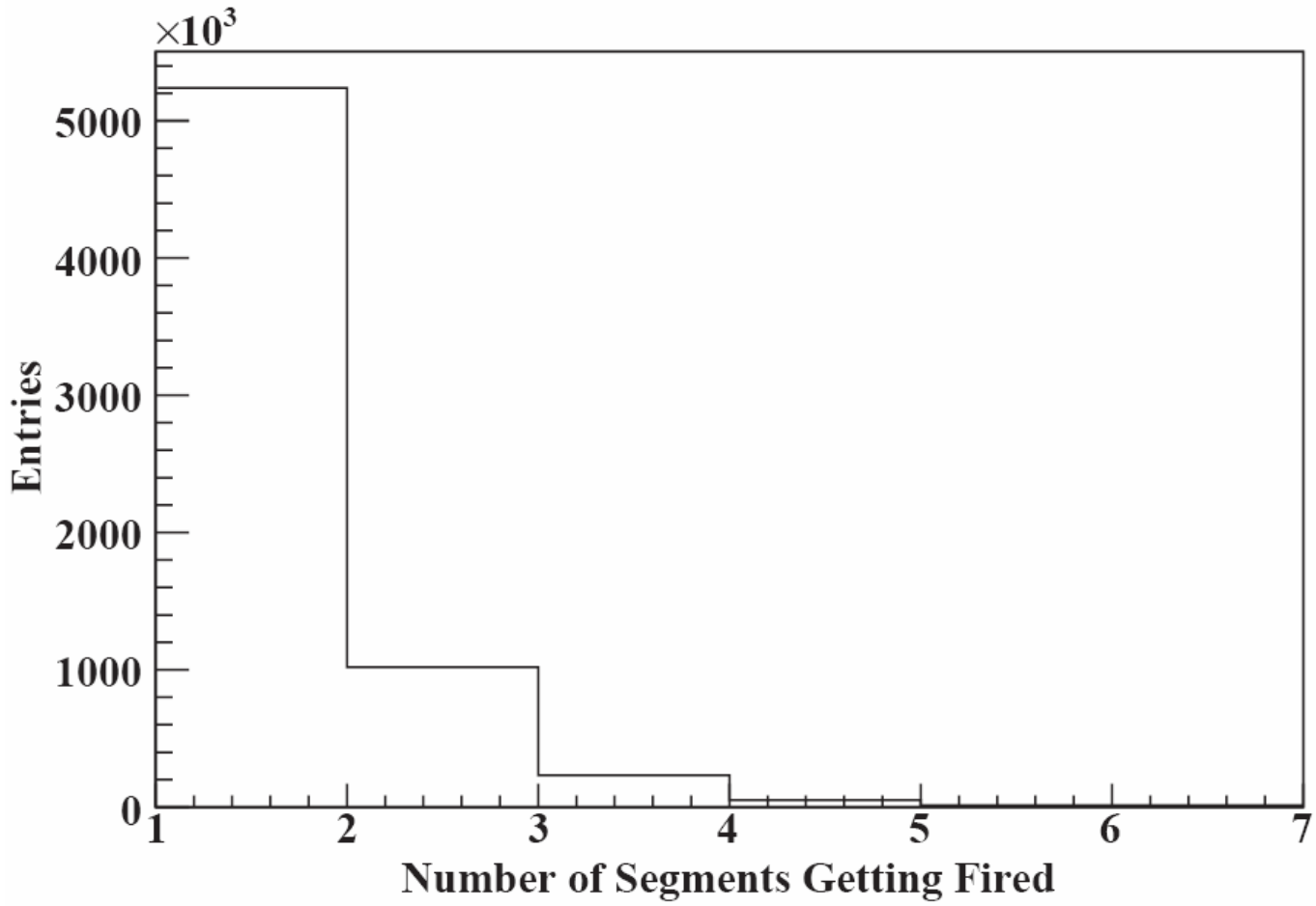


$n+^{72}Ge \rightarrow ^{72}Ge+n'+e(692\ keV)$



Conclusion

- GERDA searches for $0\nu\beta\beta$-decay
- Neutron interactions with Ge isotopes are a potential source of background for GERDA
- A segmented Ge detector was used to record neutron energy spectra
- Segment information can be used to identify neutron interactions with Ge isotopes


×10^3
5000
4000
3000
2000
1000
0
Entries
1
2
3
4
5
6
7
Number of Segments Getting Fired