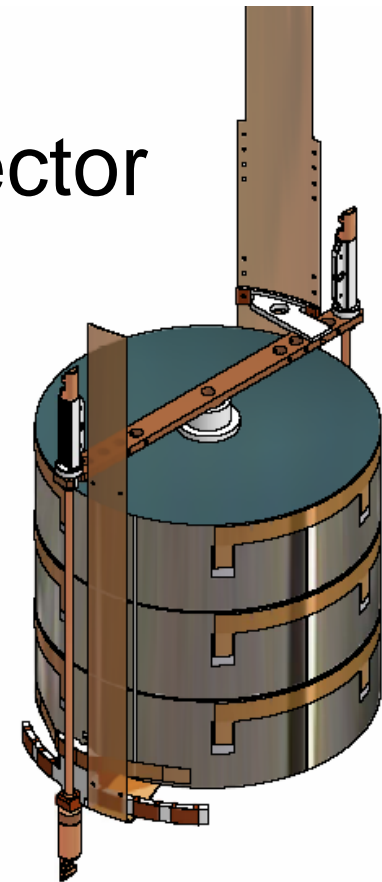


# Task Group 2

## 1. 18-fold Phase-II prototype detector

- Crystal Properties
- Segment anti-coincidence
- Pulse Shape Analysis (PSA)
- Neutron spectrum

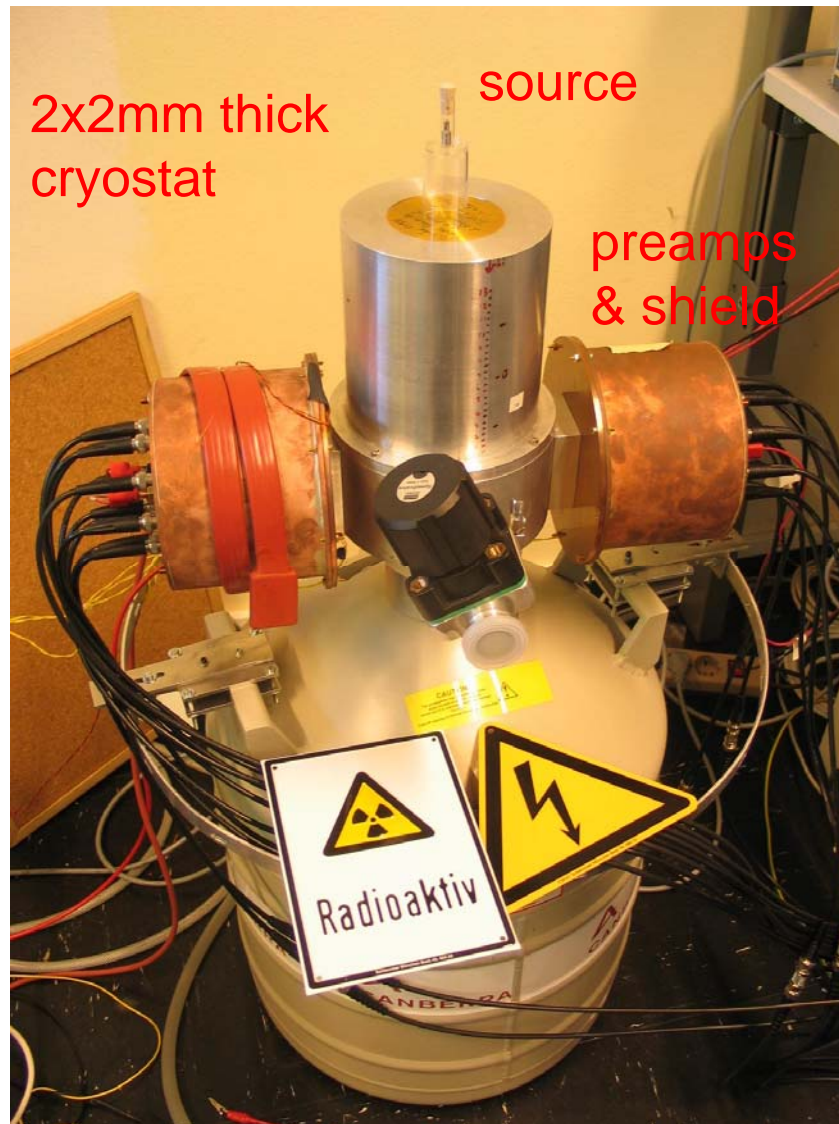
## 2. Outlook



I. Abt, K. Ackermann, A. Caldwell, M. Jelen, K. Kröninger  
J.Liu, X. Liu, B. Majorovits, S. Mayer, F. Stelzer, S. Vogt

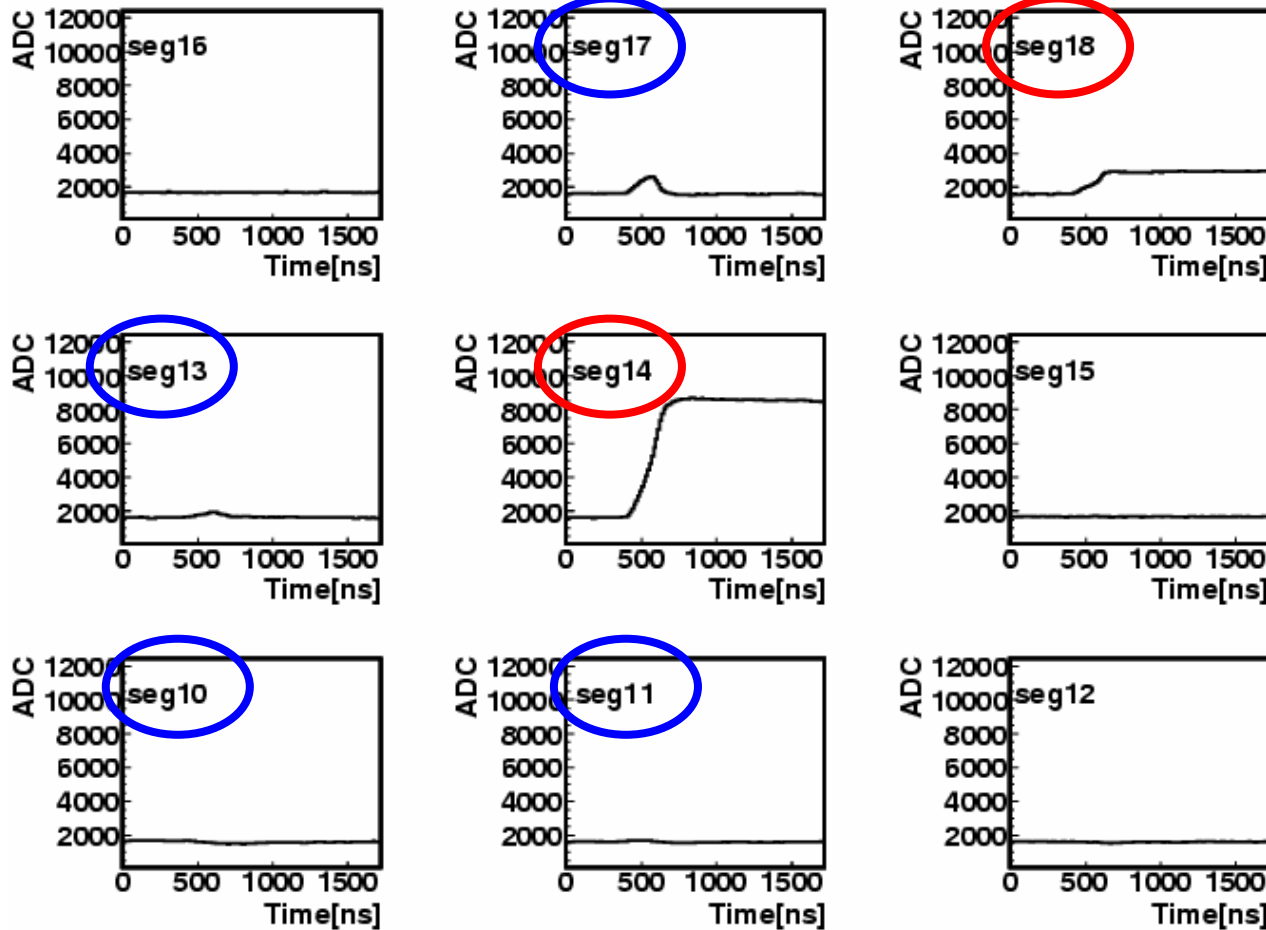
MPI für Physik, München, Germany

# 18-fold Phase II prototype detector

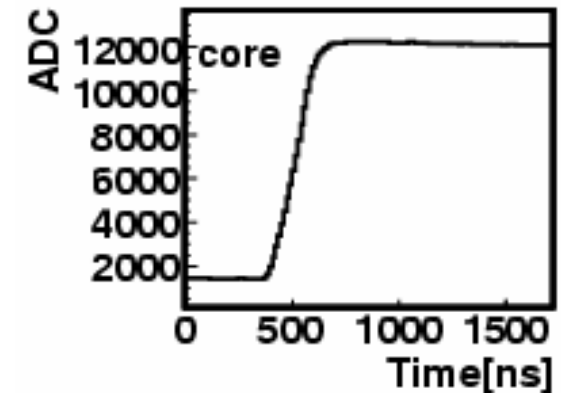


- n-type coaxial detector
- inner R 5mm,  
outer R 37.5mm  
height 69.8mm  
weight 1.63kg.
- 3-fold in z, 6-fold in  $\phi$ .
- FWHM core: 2.3keV (cold FET)  
segs: 2.5 - 4keV @1.3MeV
- data taking 2006 03 to 08
- ~100M events,  
gated Luminosity:  $10^{-4}$  pb $^{-1}$

# One (half) event-display



Segments 14 & 18:  
real energy deposit  
Segments 10,11,13,17:  
mirror charge

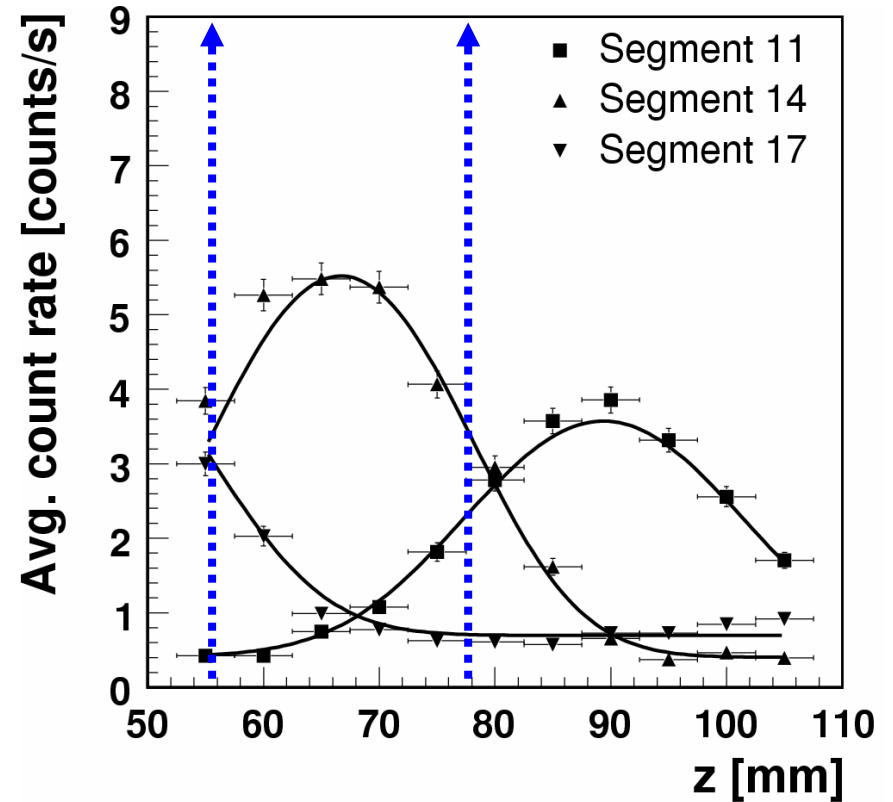
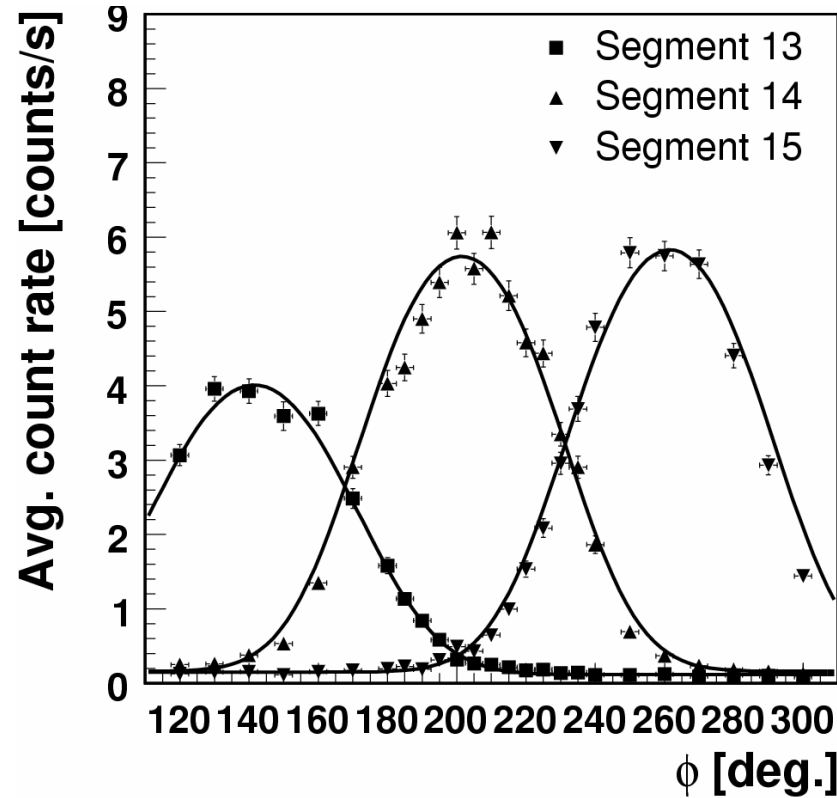


Core pulse

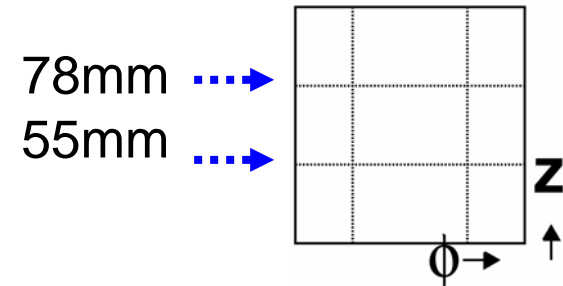
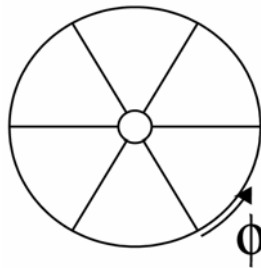
- Pixie4 DAQ, sampling rate 75MHz.

# Segment Position

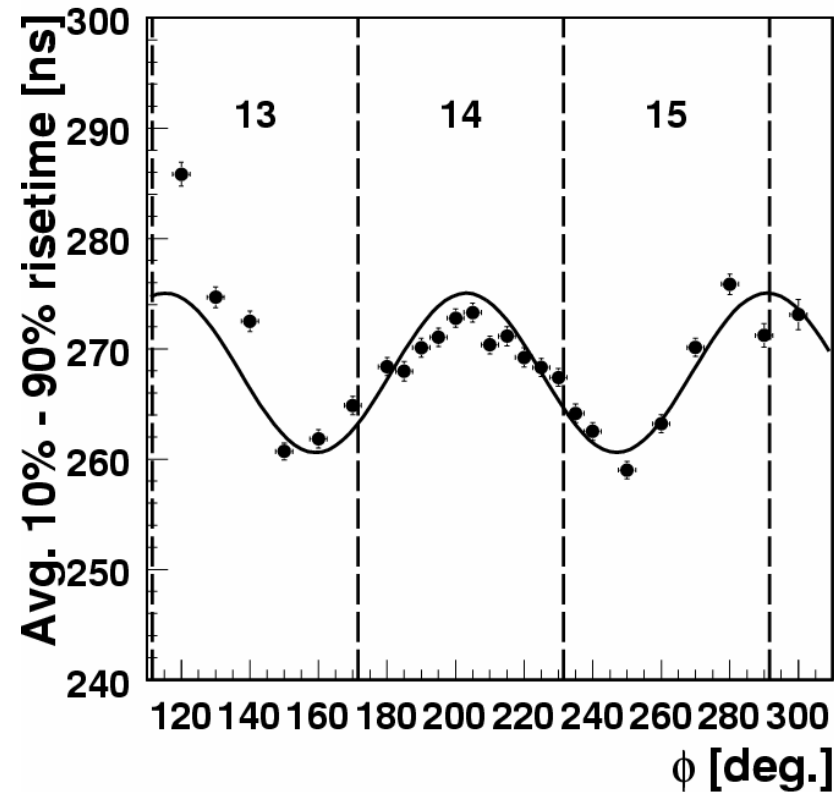
## Crystal Properties



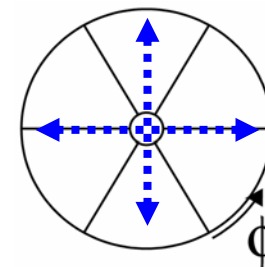
- $^{152}\text{Eu}$  122keV line
- Segment boundaries identified



# Pulse Rise Time

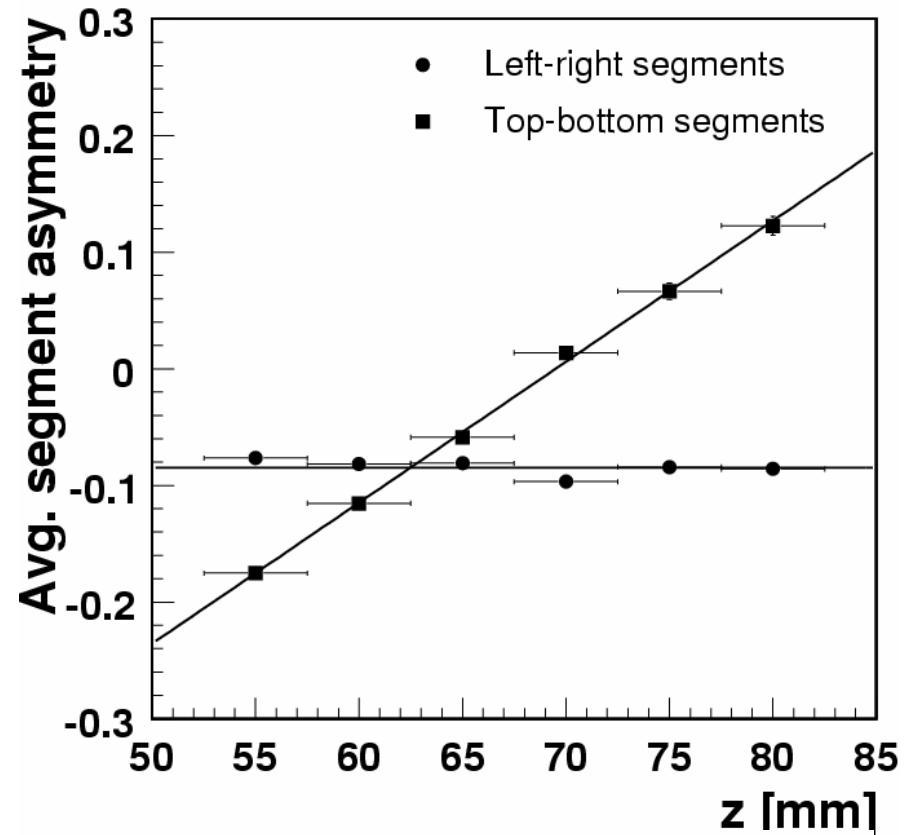
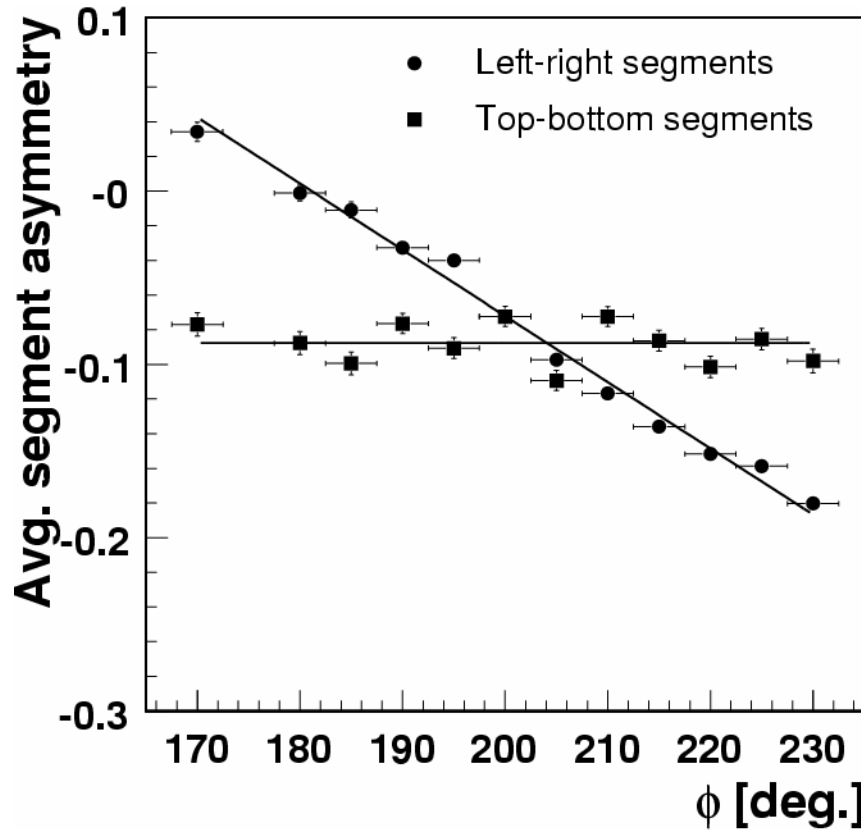


- $^{152}\text{Eu}$  122keV line
- Crystal axis effect on e/h drifting velocity

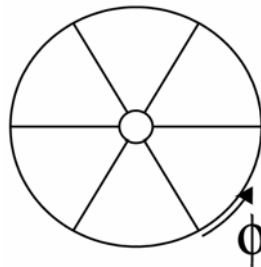


# Mirror charge asymmetry

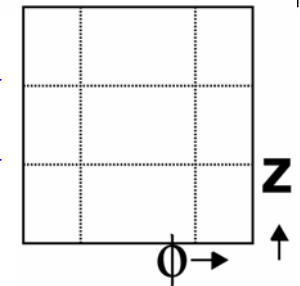
## Crystal Properties



■ Left-Right Asymmetry:  
 $\log_{10}(L/R)$

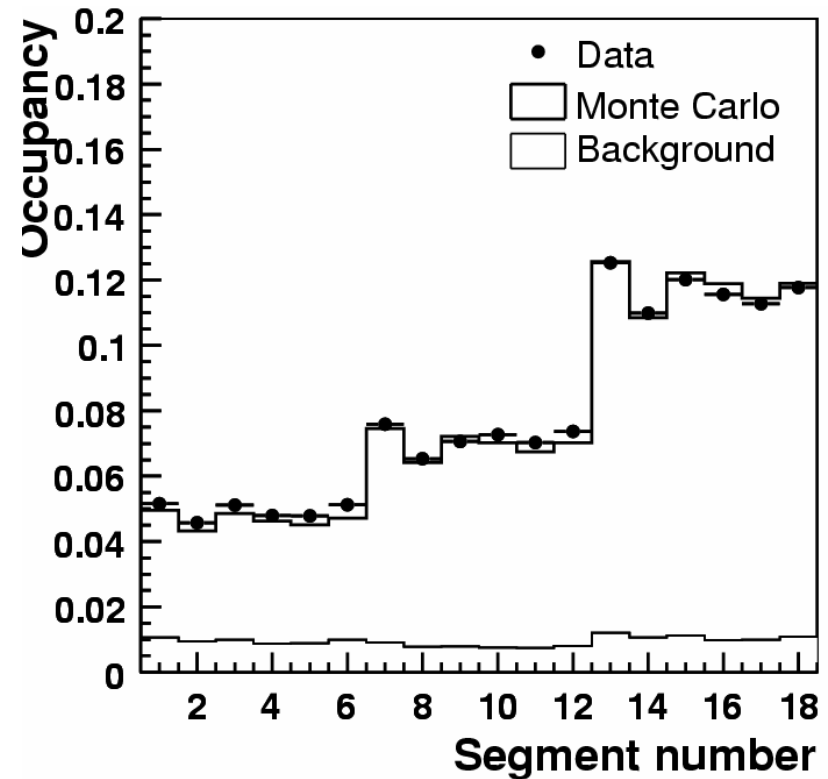
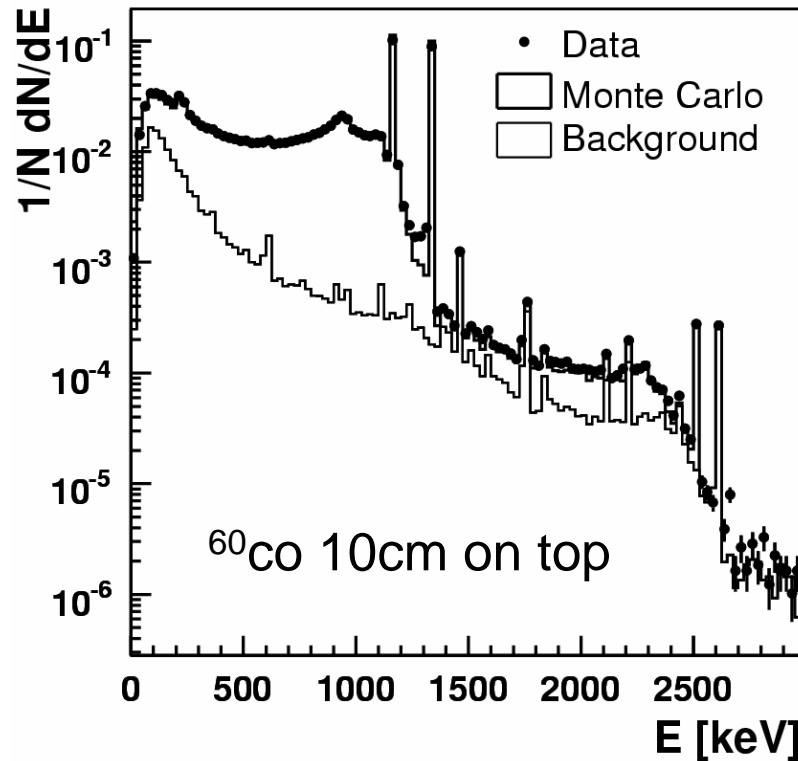


78mm  $\rightarrow$   
 55mm  $\rightarrow$



# Data-MC comparison

## Segment anti-coincidence



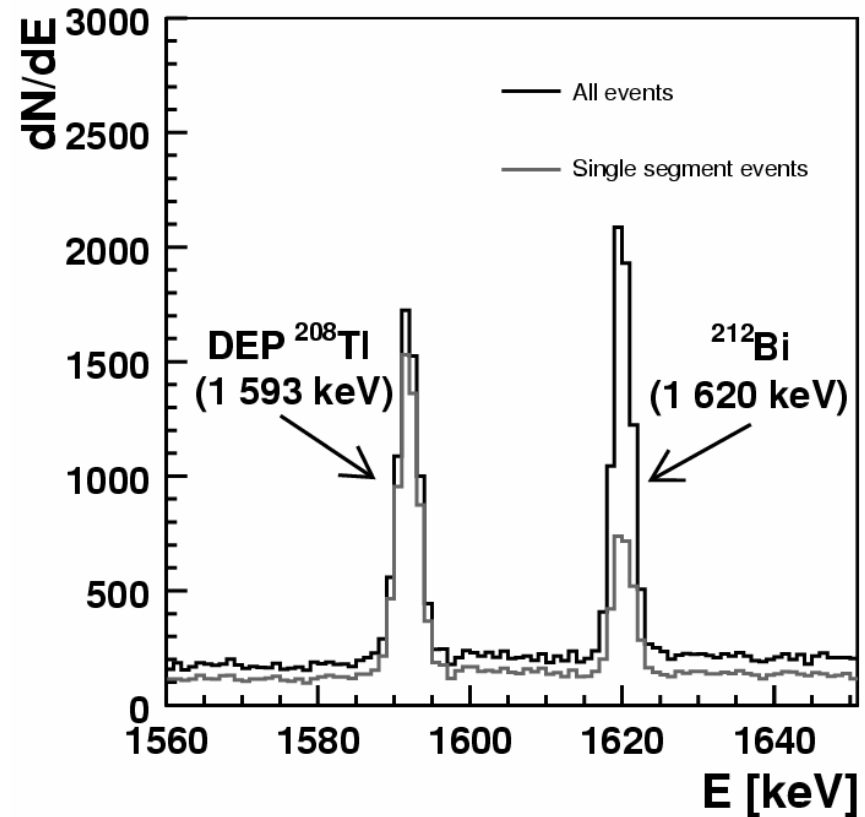
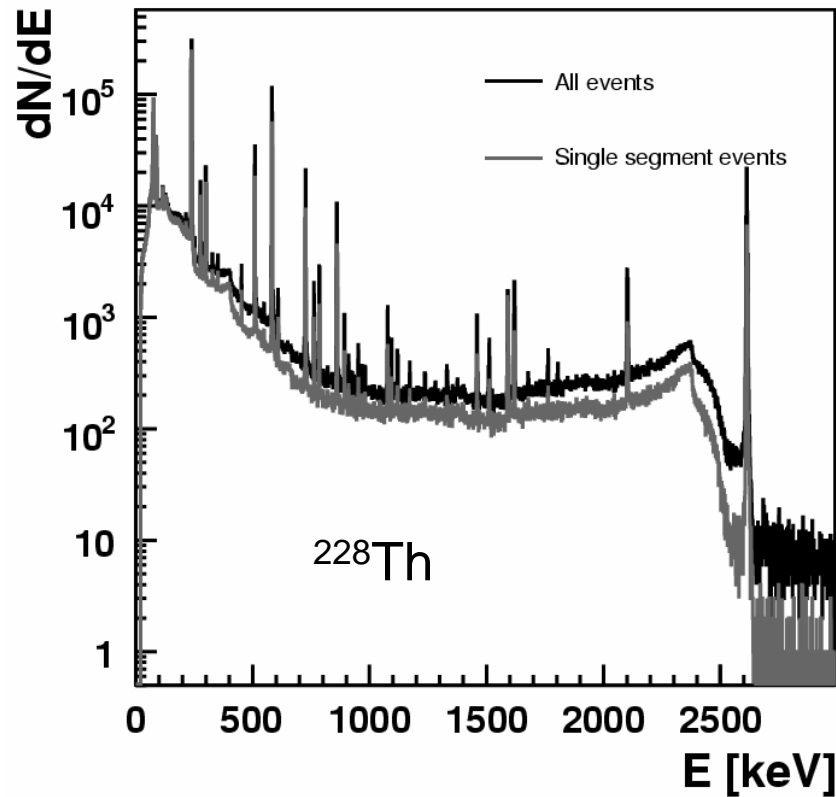
core & segments energy threshold 20keV

effective MC model:

- ✓ e/h drifting direction affected by crystal axis

# Single-segment events

## Segment anti-coincidence



- Double-Escape Peak (DEP) events: mostly Single-Site Events (SSE)
- Full photon energy peak events: mostly Multi-Site Events (MSE)



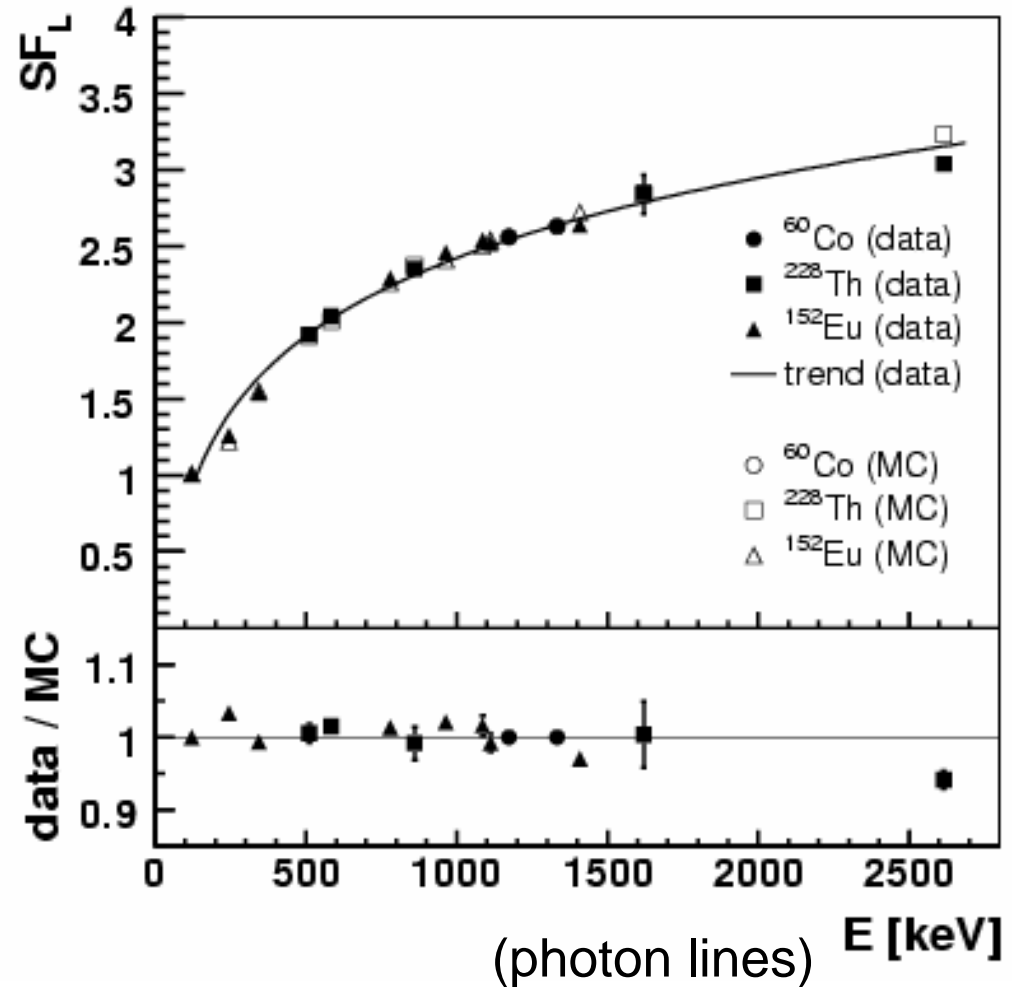
# Suppression Factor

## Segment anti-coincidence

SF: ratio of # events before and after single-segment cut

source	E (keV)	SF
$^{60}\text{Co}$	1333	$2.63 \pm 0.01$
$^{228}\text{Th}$	2615	$3.04 \pm 0.02$
$^{228}\text{Th}$	1593 (DEP)	$1.09 \pm 0.02$
$^{228}\text{Th}$	2039	$1.68 \pm 0.02$
$^{60}\text{Co}$	2039	$14.2 \pm 2.1$

- Data & MC agree within 5%
- Results independent of source position

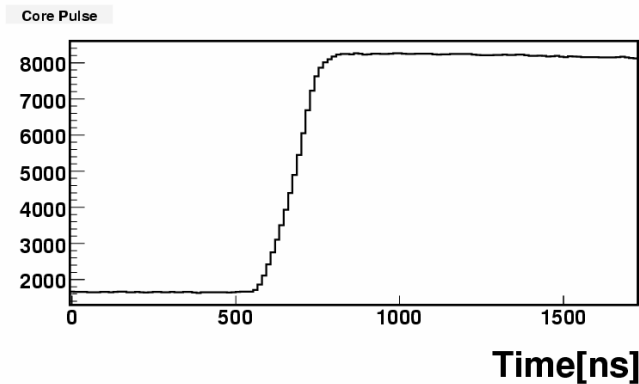


# Pulse shape analysis

PSA

Ecore = 1.593MeV

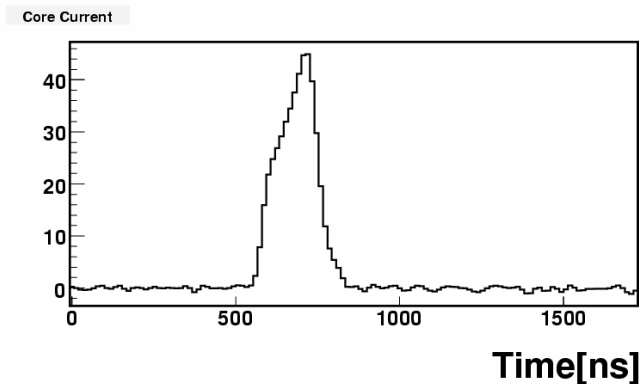
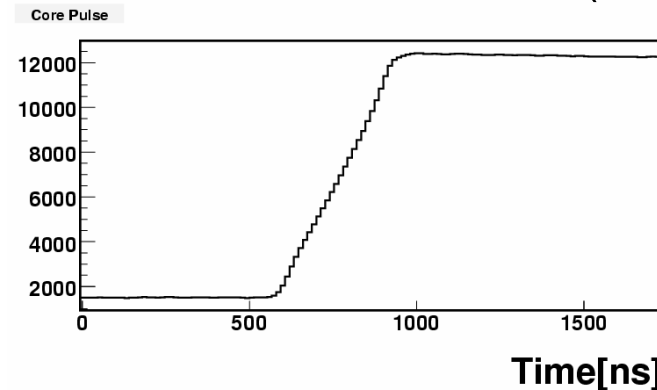
Single-Site Event candidate (SSE)



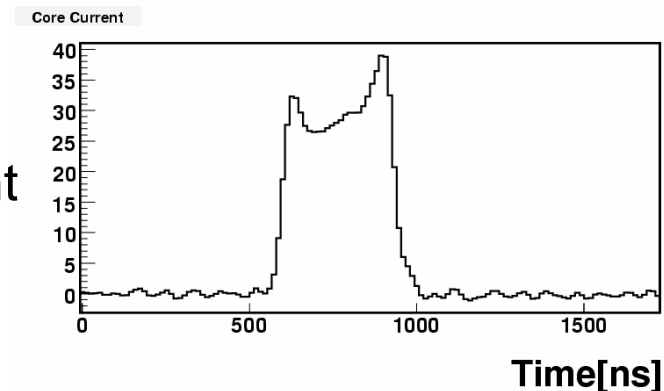
Core pulse

Ecore = 2.615MeV

Multi-Site Event candidate (MSE)



Core current

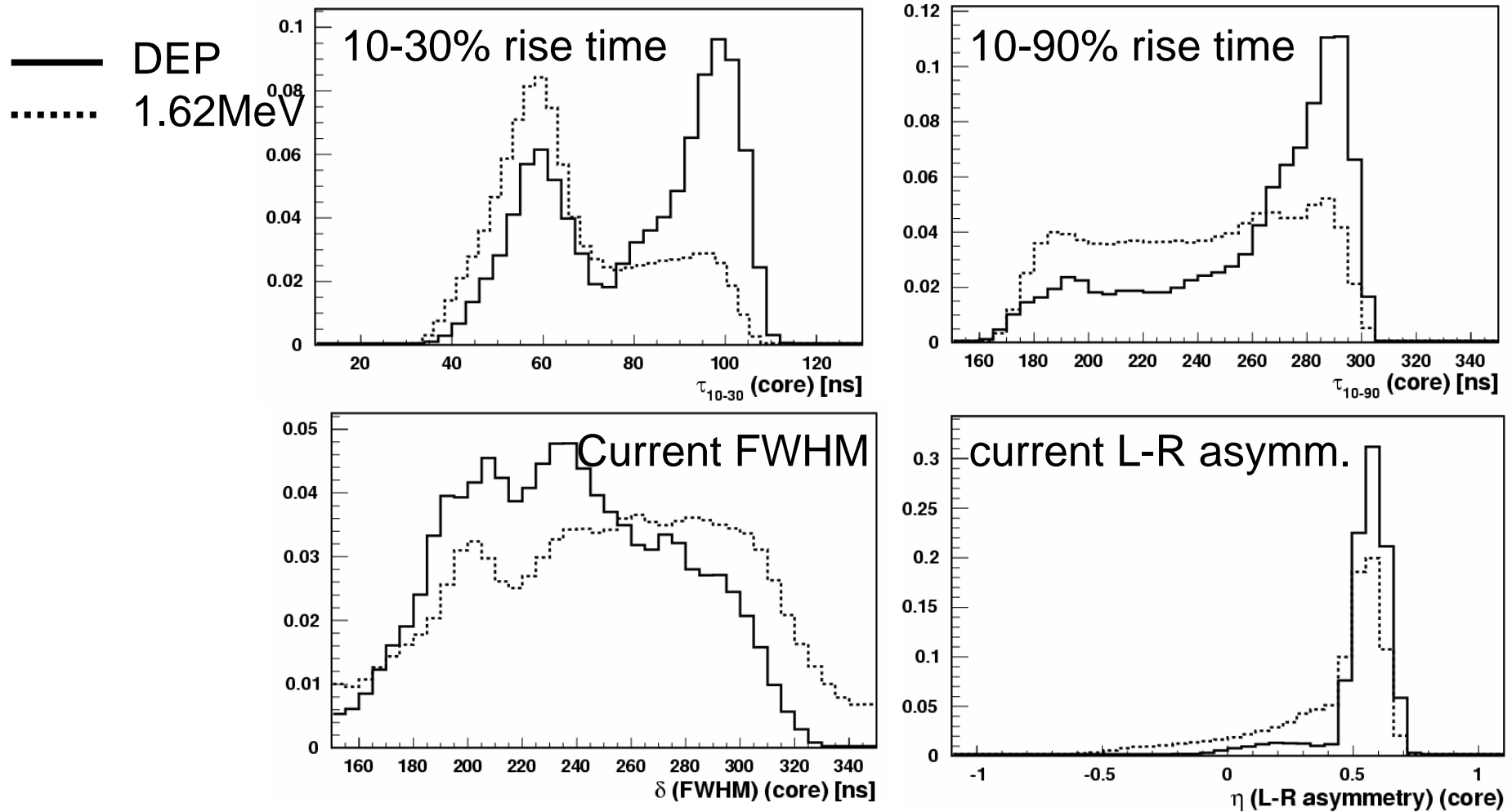


- Build SSE-dominant & MSE-dominant libraries
- Train PSA package
- Apply trained PSA to ROI (2.039MeV)

# DEP Pulse shape properties

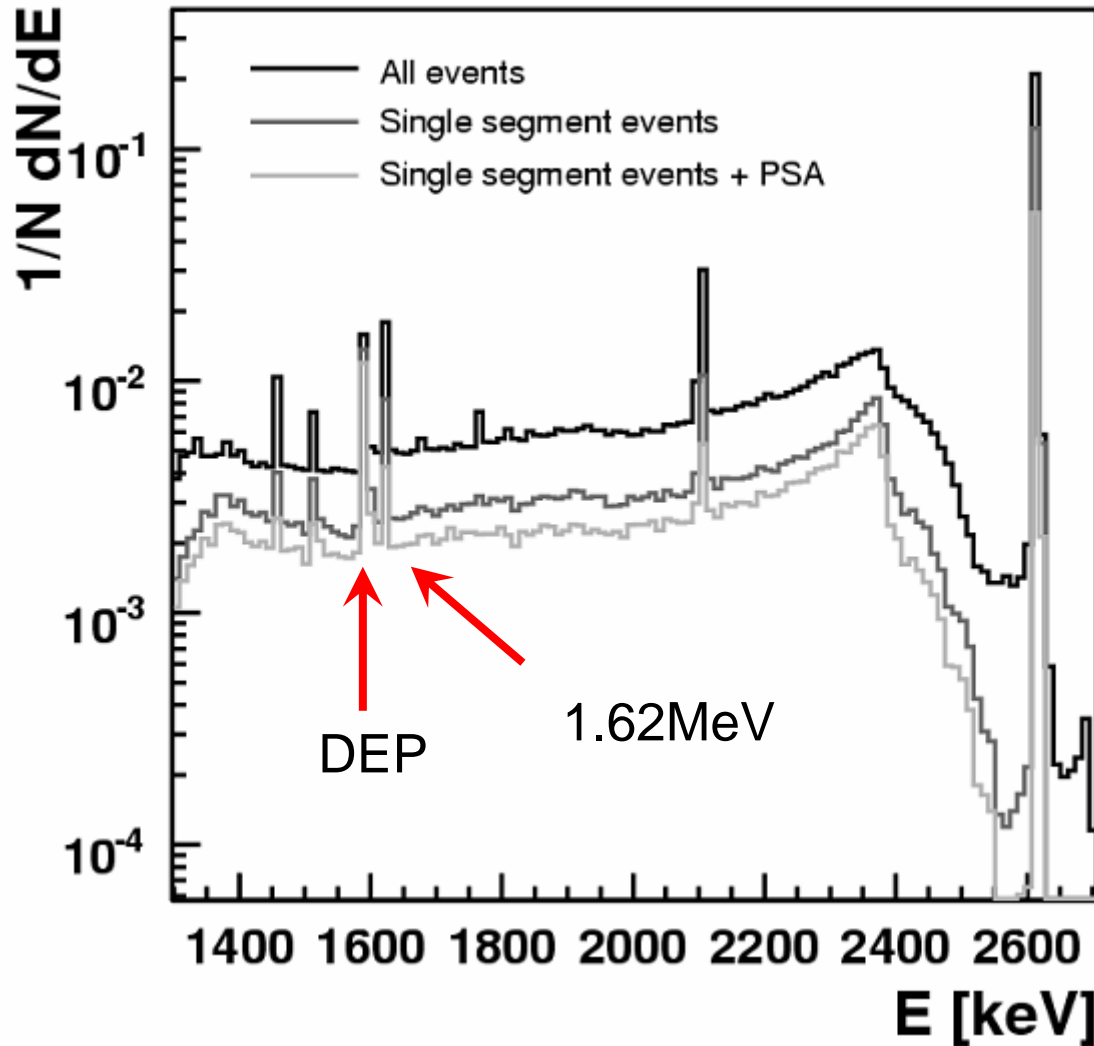
PSA with DEP

Select DEP events to build SSE library



# NN PSA on single-seg. events

PSA with DEP



Neural Networks (NN) trained with single-segment DEP events vs. 1.620MeV events

Energy	Apply NN
1620	45±2%
2615	39±2%
DEP (1592)	90 ±2%
2039	66±2%

Reduction factor on ROI:  
 1.68 (single-segment)  
 x1.33 (PSA) = 2.23

# Single compton-scattering

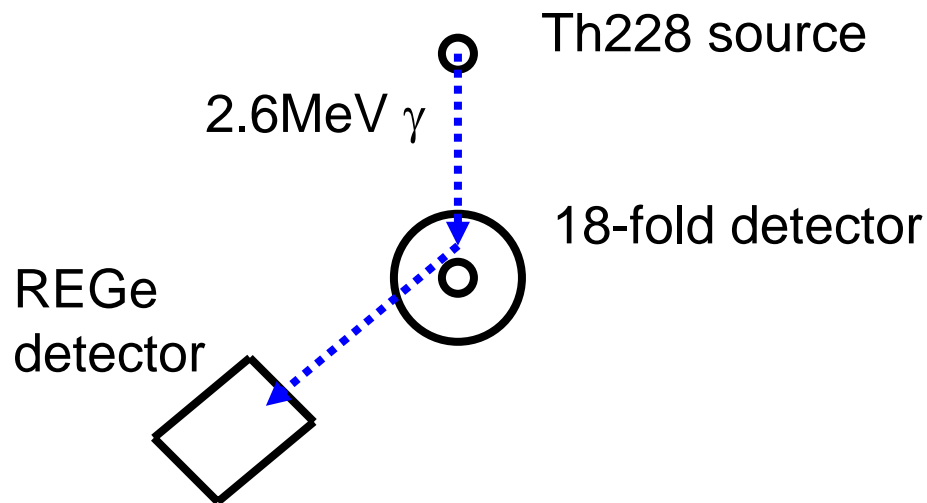
PSA with SCS

Single compton-scattering (SCS) events for SSE library:

$2.615\text{MeV } \gamma$  scatters at  $72^\circ \rightarrow 0.576\text{MeV } \gamma' + 2.039\text{MeV electron}$

use 2<sup>nd</sup> Ge detector:

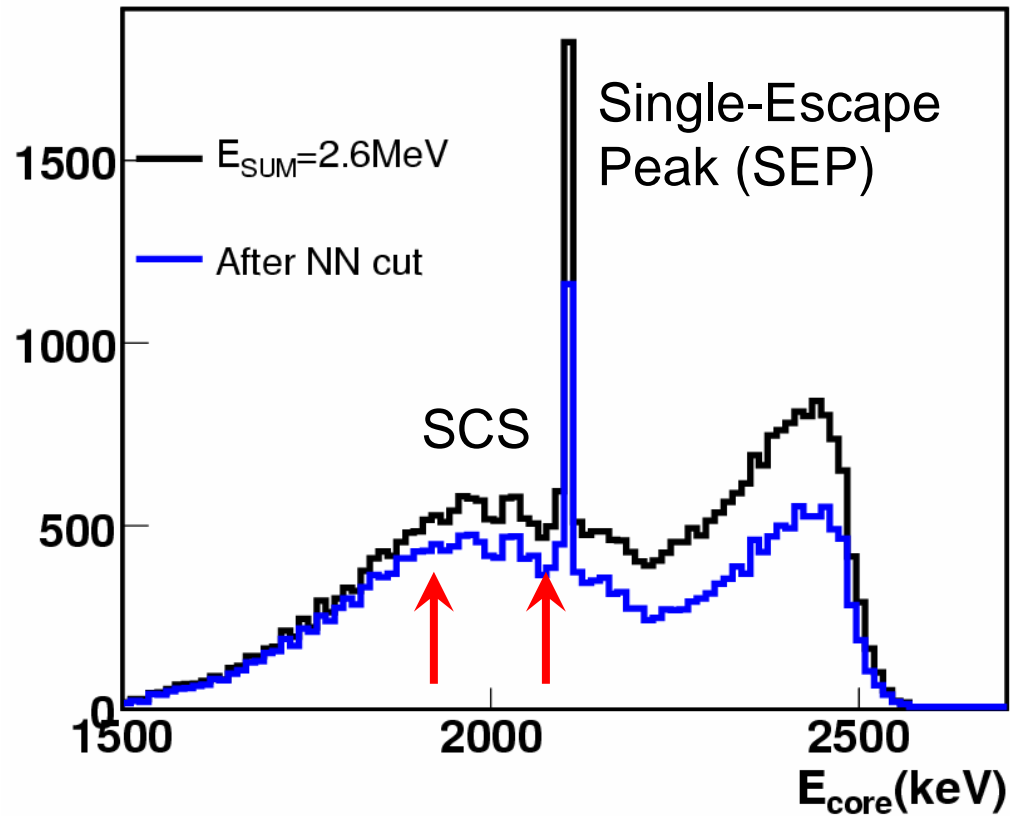
coincidence trigger & Sum=2.6MeV & Ecore at 2MeV



Canberra REGe detector

# Single compton-scattering

PSA with SCS

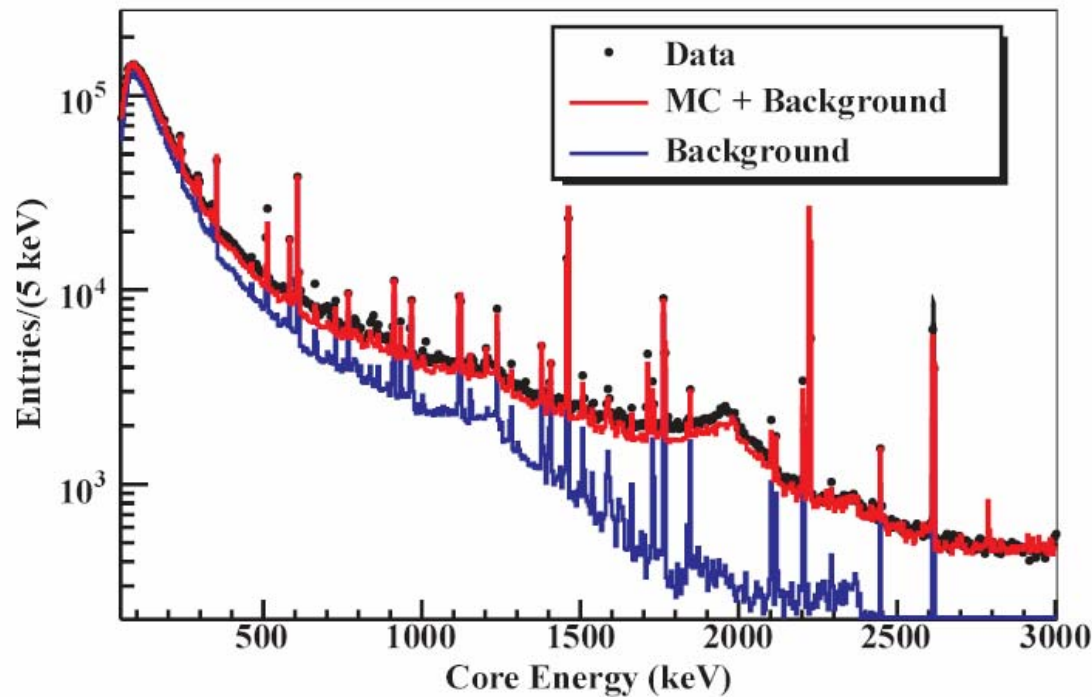


Energy	Apply NN
2615	62±1%
DEP (1592)	95 ±1%
SCS	89 ±2%
2039 (trigger core only)	76±2%

NN trained with SCS again 2.6MeV  
(No segment anti-coincidence cut yet)

# Neutron spectrum

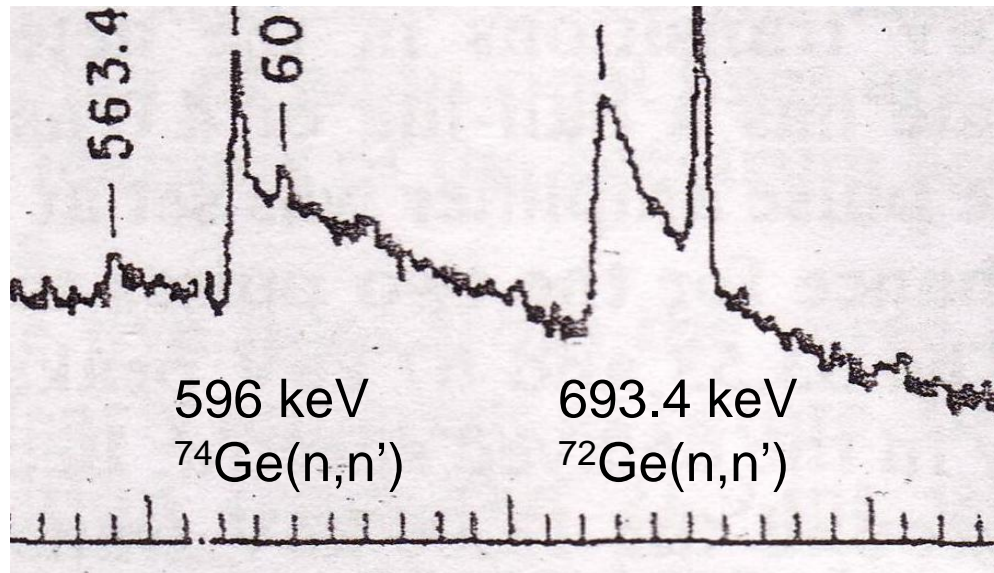
- Study neutron interaction & verify MaGe simulation
- AmBe neutron source with 1GBq Am
- 2 days exposure



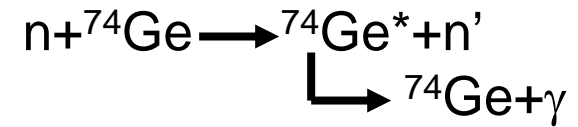
Energy [keV]	from
693, 834	$^{72}\text{Ge}(n,n')$
596	$^{74}\text{Ge}(n,n')$
563	$^{76}\text{Ge}(n,n')$
139	$^{75m}\text{Ge}$
198	$^{71m}\text{Ge}$
845,1014	$^{27}\text{Al}$
2223.5	n-cap. on H

# Using segmented detector

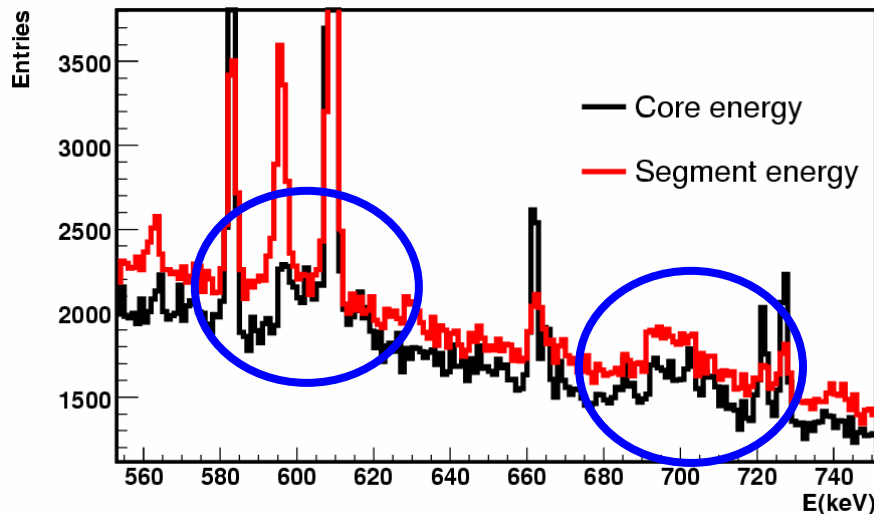
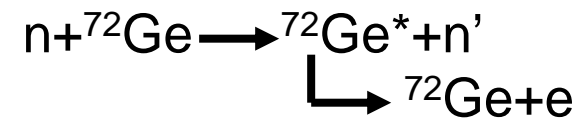
neutron spectrum



596keV line:



693.4keV line:

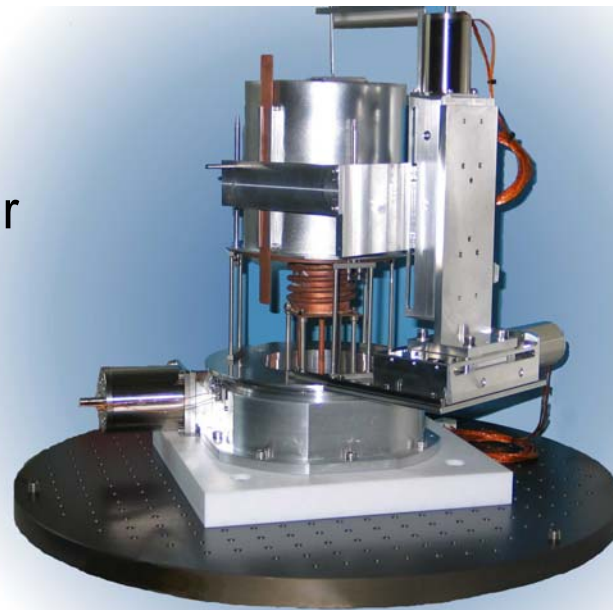


Unique power of  
segmented detector

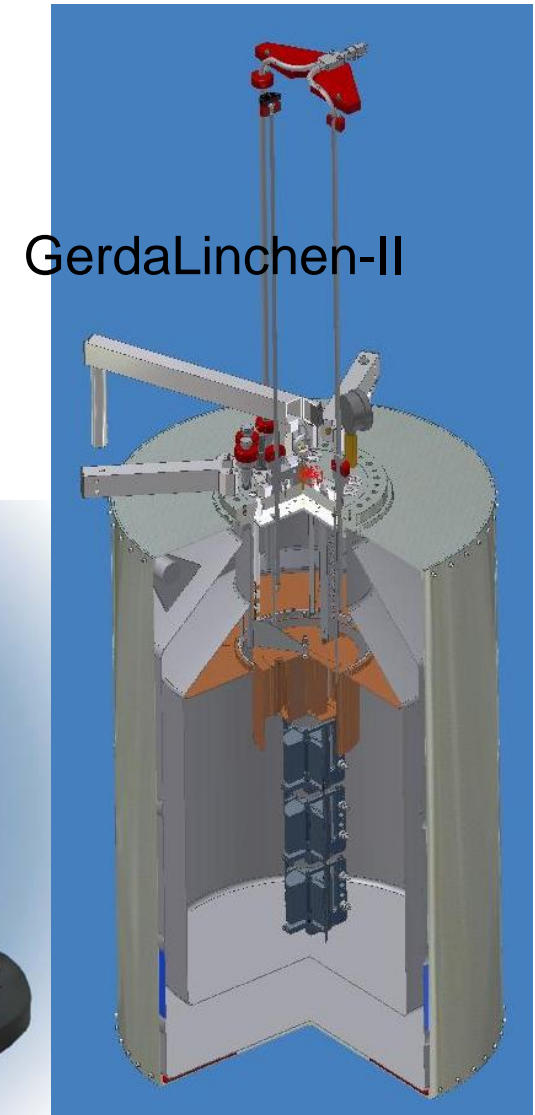


# Conclusion & outlook

- Many results from 18-fold n-type prototype detector papers to be published (→ K. Kroeninger's talk)
  - One 18-fold p-type detector arrives end of year.
  - One more 18-fold n-type detector ordered.
- 
- Teststand with detectors in LN<sub>2</sub>/LAr Feb. 2007.
  - Further measurement of IR-UV effect on crystal planned.
  - Design of teststand with detector & source in vacuum on going.



Galatea



GerdaLinchen-II

# Backup slides:

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# PSA vs. R90 DEP

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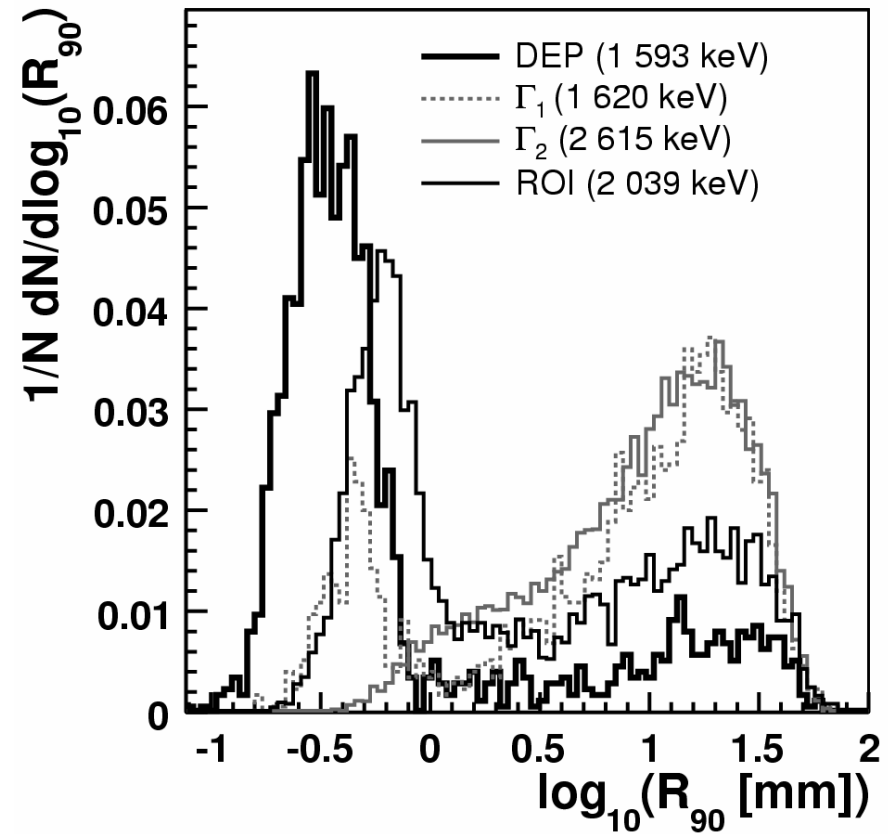
Fraction of SSE events ( $R_{90} < 2\text{mm}$ )

DEP: 88%, 1620: 45%

2615: 30%, 2039: 66%

$\varepsilon$ : efficiency of SSE identification  
 $98 \pm 2\%$

$\eta$ : efficiency of MSE identification  
 $107 \pm 10\%$



# PSA vs. R90 (SCS)

---

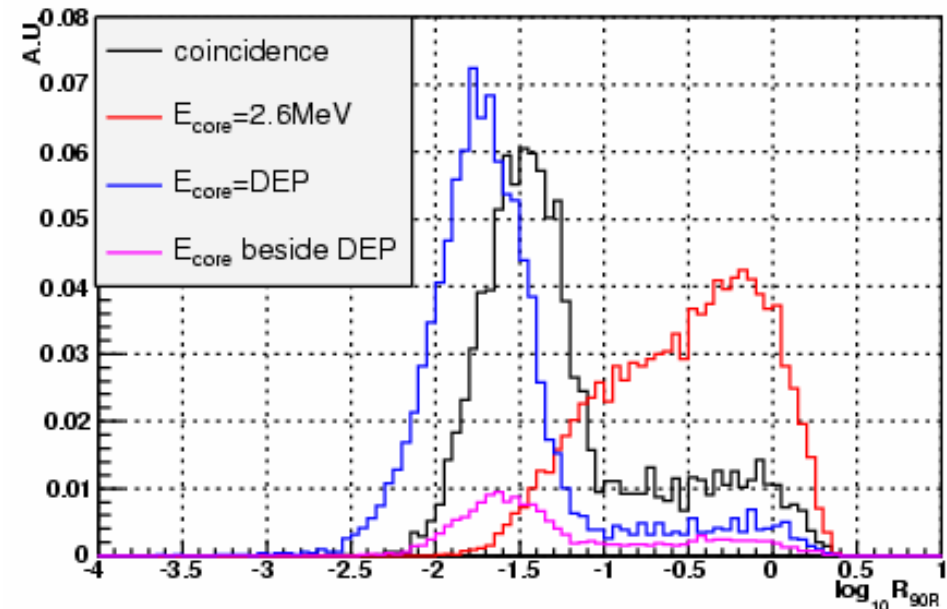
Fraction of SSE events ( $R_{90} < 2\text{mm}$ )

DEP: 95%, CSC: 80%

2615: 32%

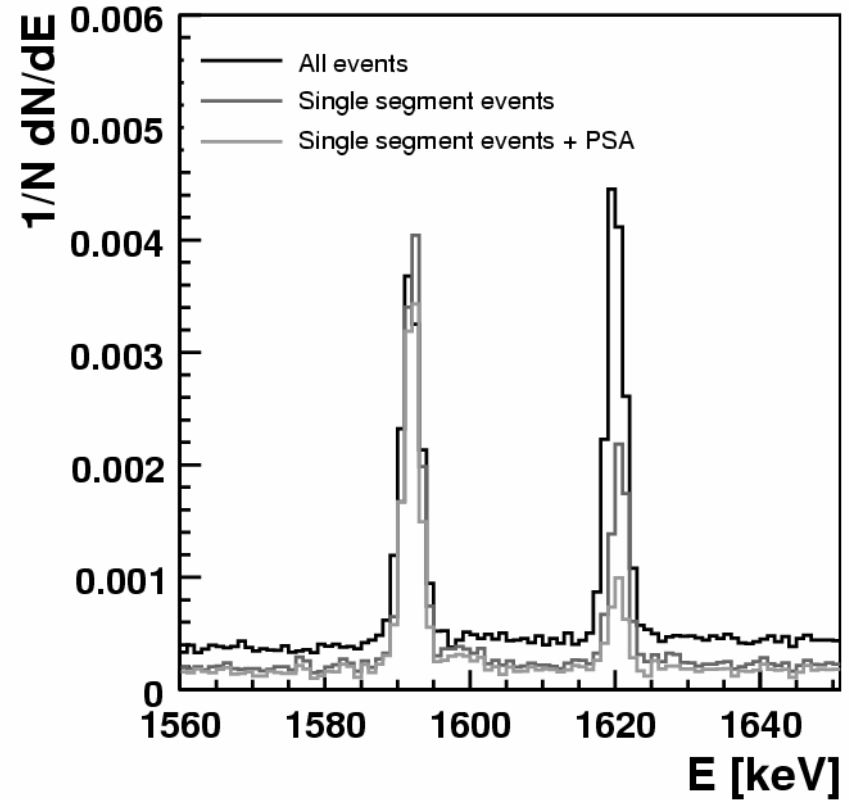
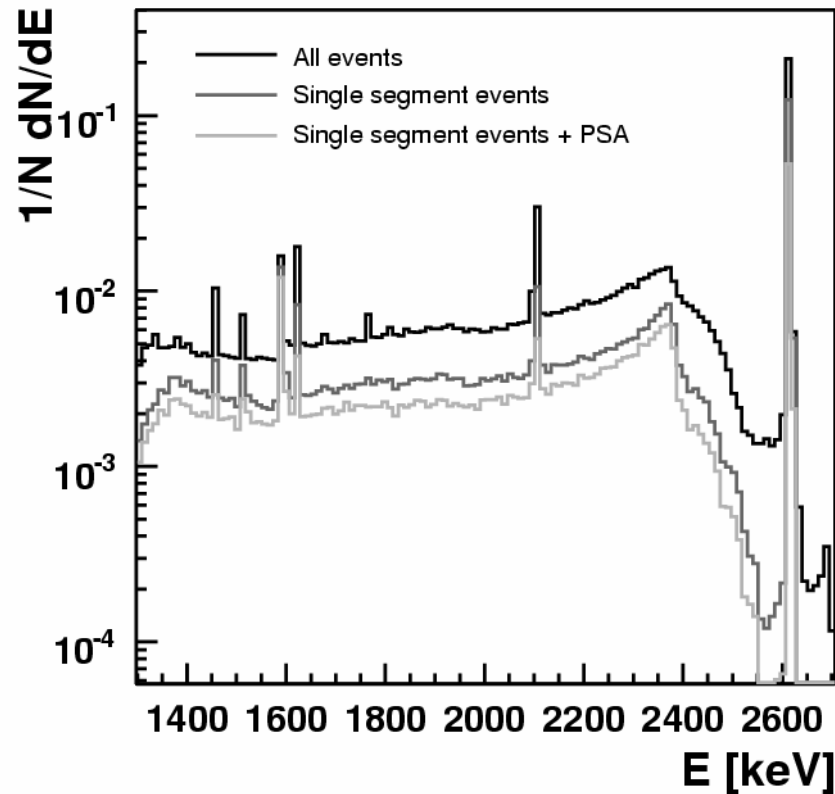
$\varepsilon$ : efficiency of SSE identification  
 $95 \pm 5\%$

$\eta$ : efficiency of MSE identification  
 $90 \pm 10\%$



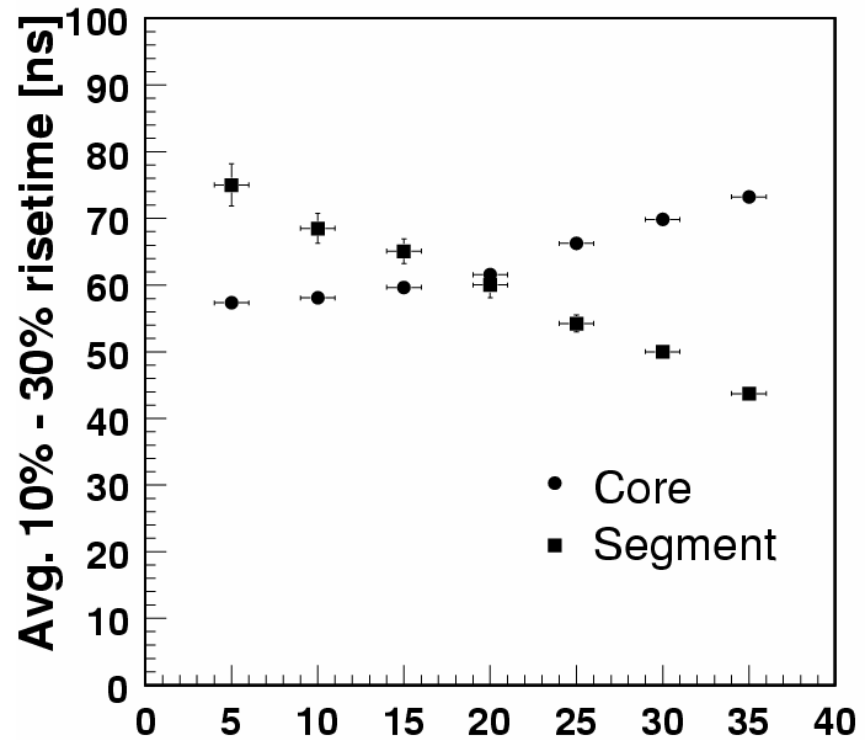
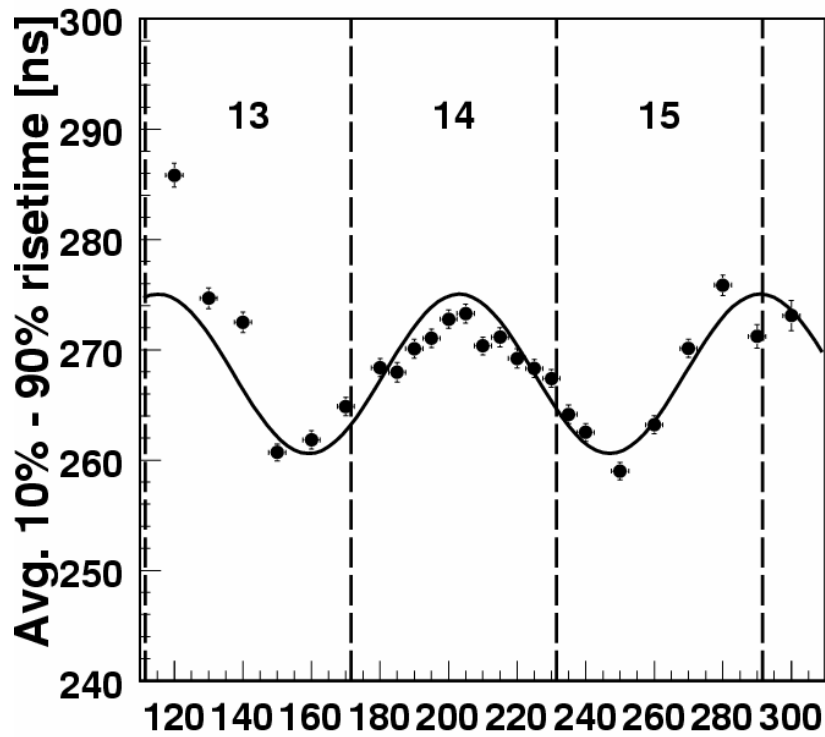
# PSA + segment anti-coincidence PSA with DEP

---

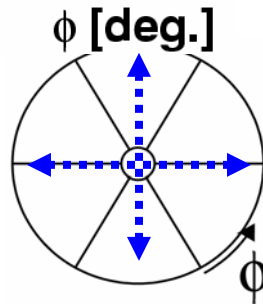


# Pulse Rise Time

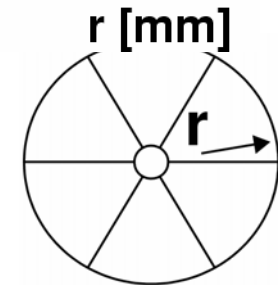
## Crystal Properties



- $^{152}\text{Eu}$  122keV line
- Crystal axis effect on e/h drifting velocity

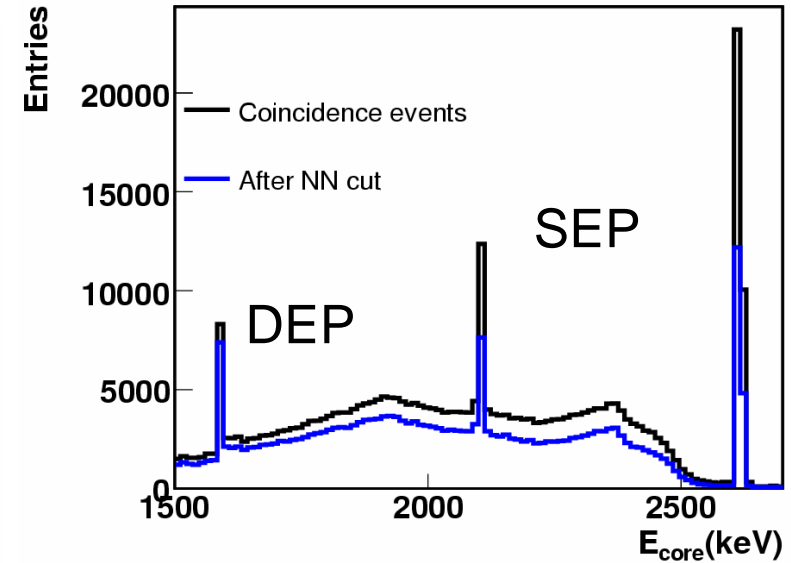
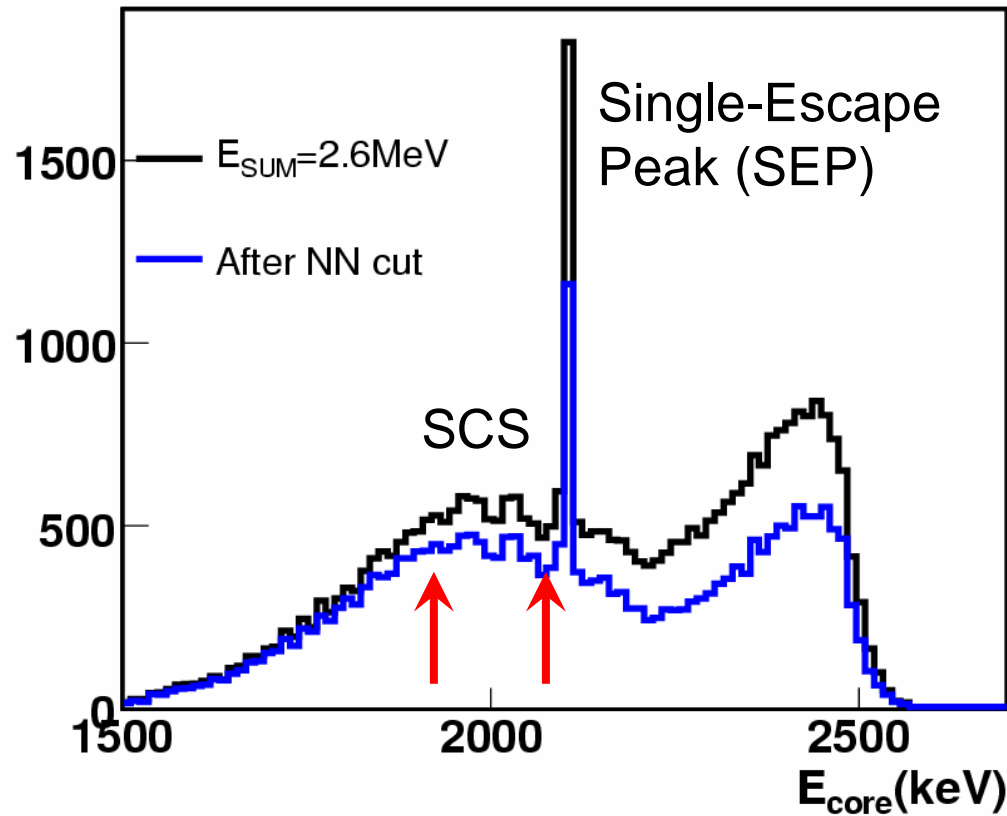


- Different pulse rising speed



# Single compton-scattering

PSA with SCS

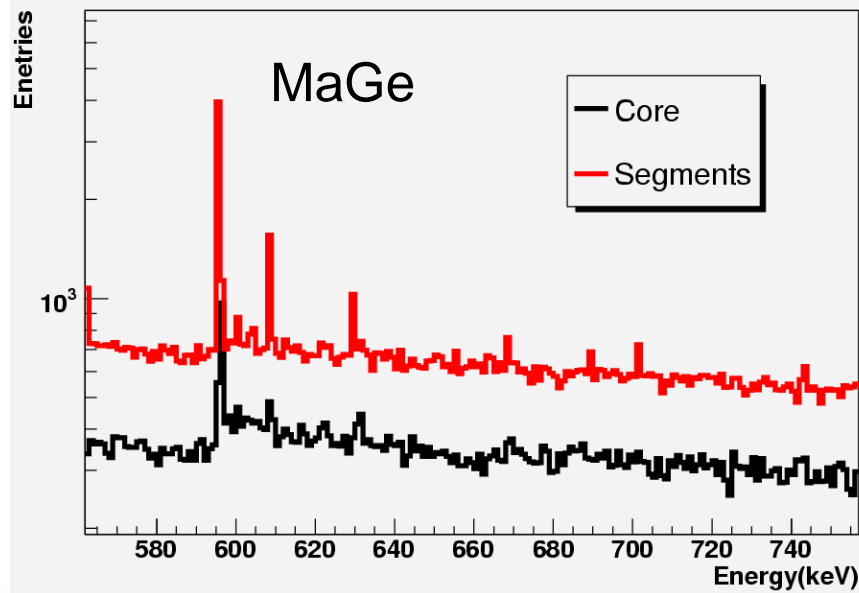


Energy	Apply NN
2615	$62 \pm 1\%$
DEP (1592)	$95 \pm 1\%$
SCS	$89 \pm 2\%$
2039 (trigger core only)	$76 \pm 2\%$

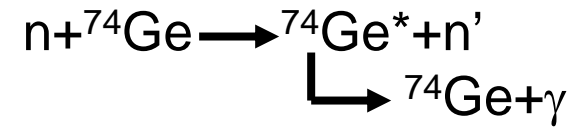
NN trained with SCS again 2.6MeV  
(No segment anti-coincidence cut yet)

# Using segmented detector

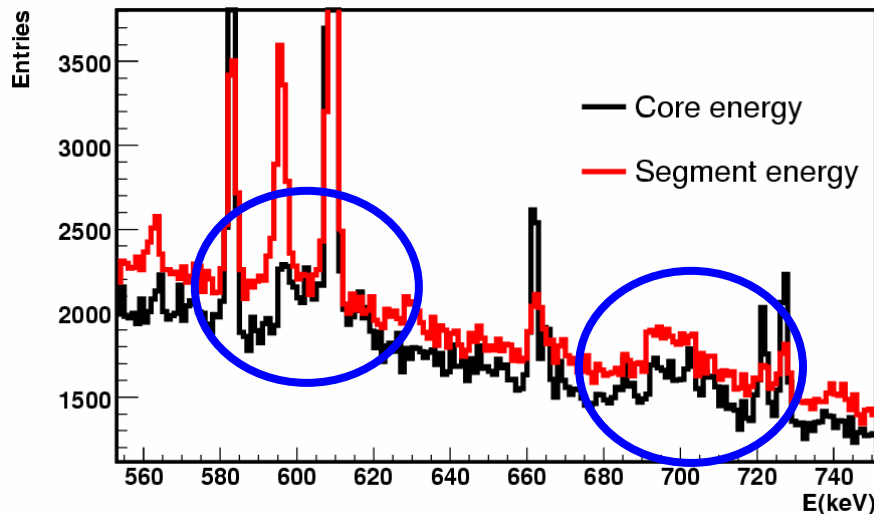
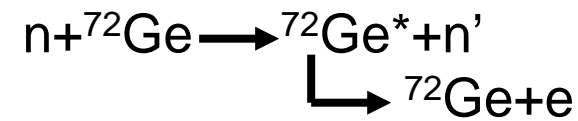
neutron spectrum



596keV line:



693.4keV line:



Unique power of  
segmented detector