EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

FACULTY OF
SCIENCE

**Kepler Center of Astro and Particle Physics**

# Procurement, production and testing of BEGe detectors depleted in $^{76}$Ge

**28.03.2011, Florian Ritter, GERDA Collaboration**

# Outline

- what is GERDA?
- and what is a BEGe?
- why BEGe?
- test of BEGe
- conclusion

# what is GERDA?

## GERDA - The **GER**manium **D**etector **A**rray

- investigation of neutrinoless double beta decay ($0\nu\beta\beta$)
- use $^{76}$Ge crystals as source and detector
- start with crystals from Heidelberg-Moscow and IGEX
- new detector design (BEGe's)
- innovative shielding design
- low background, due to LNGS
- commissioning run ongoing

→ talk by Jozsef Janicsko Csathy, T104.2

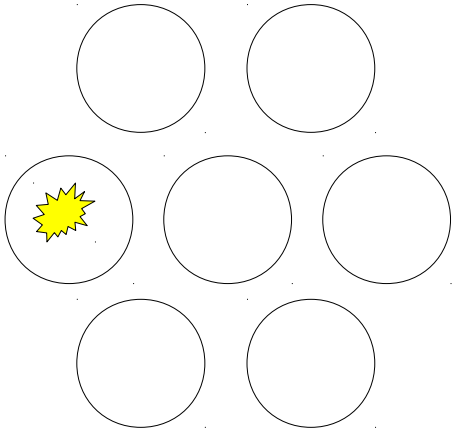
# different event types

signal

energy deposition of $Q_{\beta\beta}$ = 2039keV

within a small volume

Single Site Event

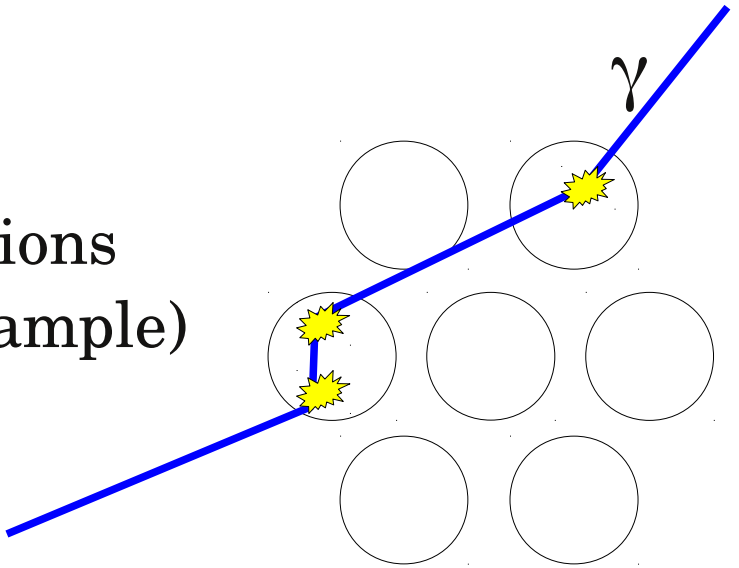


background

energy deposition on several locations

(due to compton scattering, for example)

Multi Site Event



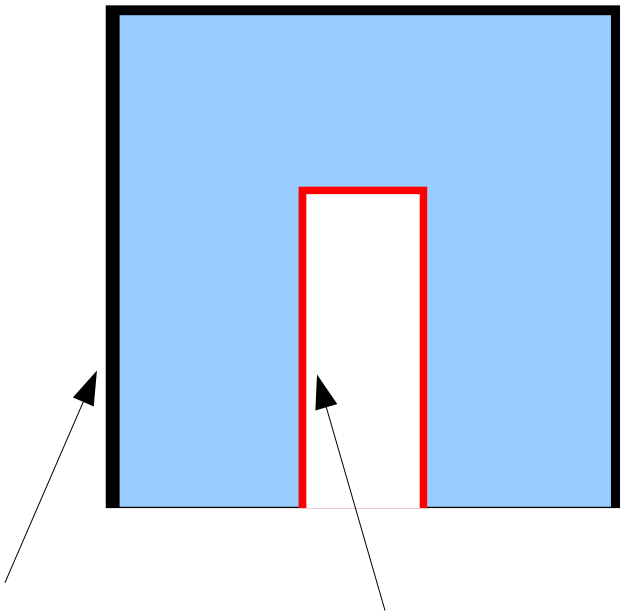
# BEGe?

GERDA – 0νββ is a single site event (SSE),
suppression of multi site events (MSE) neccessary!

- **standard** coaxial detector: HV and 1 contact, but no spatial resolution, Pusle Shape Discrimination possible
- **segmented** coaxial detector: HV + 1 contact per segment and spatial resolution
  → a lot of cables, potential background sources
- **BEGe**: only HV and 1 contact
  but: better PSD as standard coaxial detectors
  → less cables, less potential background sources

# what is a BEGe?

## standard coaxial Ge detector

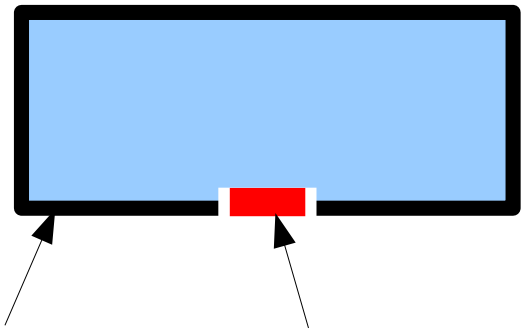


n+ contact  p+ contact (inner borehole)

diameter ≈ height (typ. 8cm)
m ≈ 2.5kg
energy threshold: ~10keV
energy resolution: 2keV@1.33MeV
pulse shape discrimination factor: 2-3

## BEGe detector

BEGe: **B**road **E**nergy **Ge**rmanium

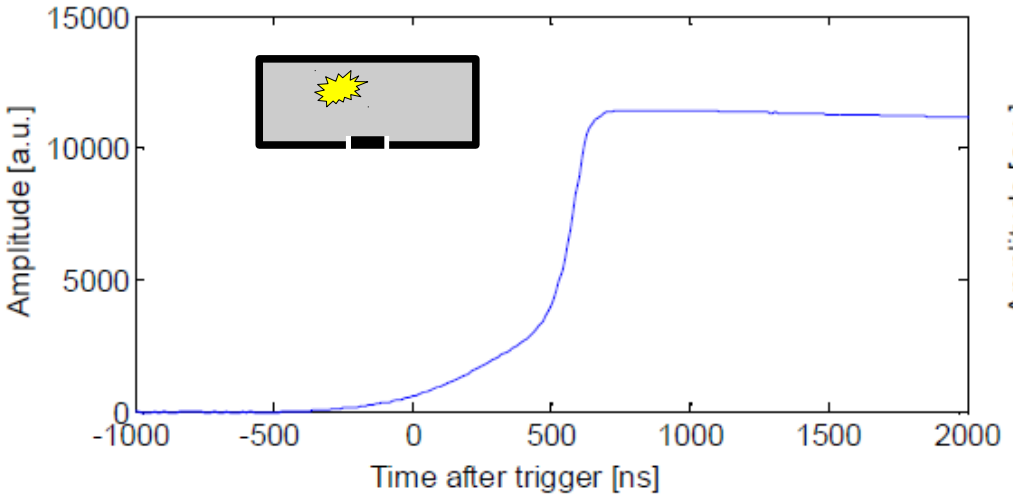


n+ contact  p+ contact (point contact)

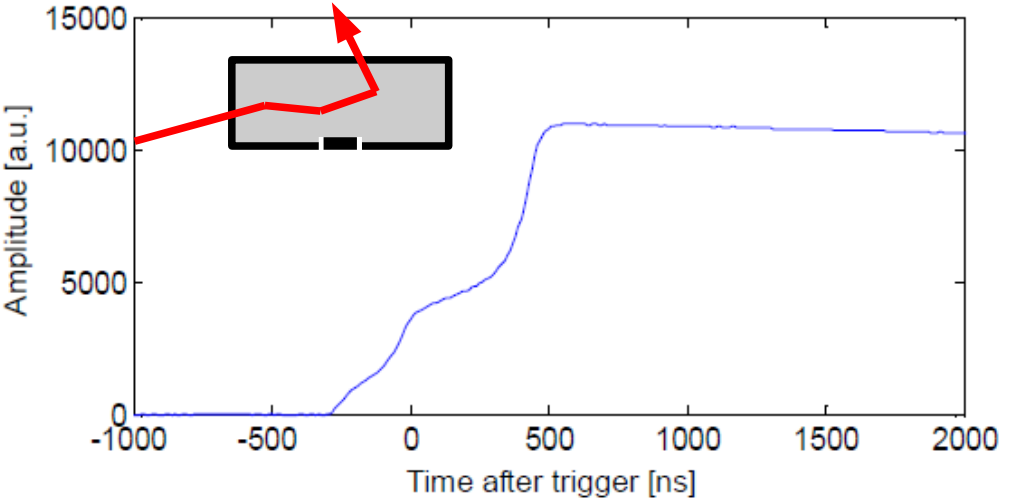
diameter ≈ 8cm
height ≈ 3cm
m ≈ 0.8kg
energy threshold: 3keV
energy resolution: 1.6keV@1.33MeV
pulse shape discrimination factor: >10

# why BEGe?

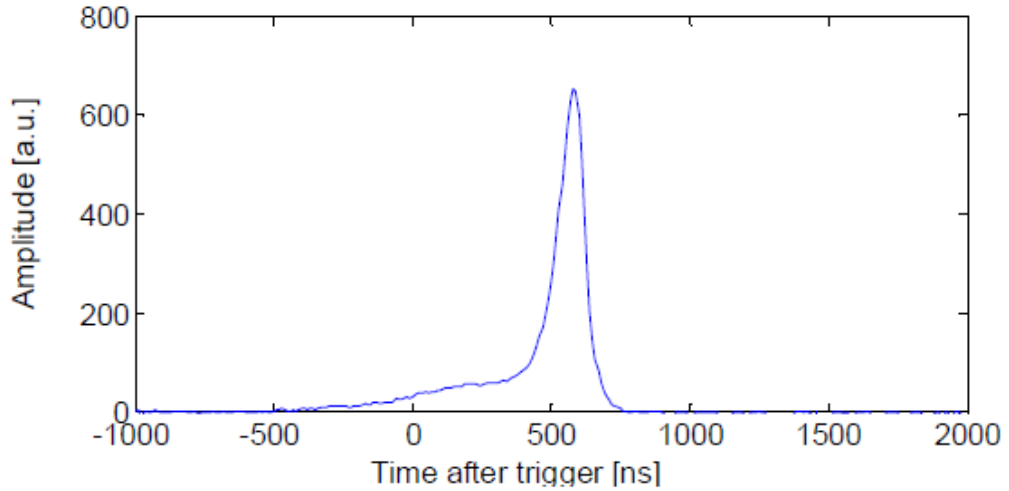
## single site event (SSE)

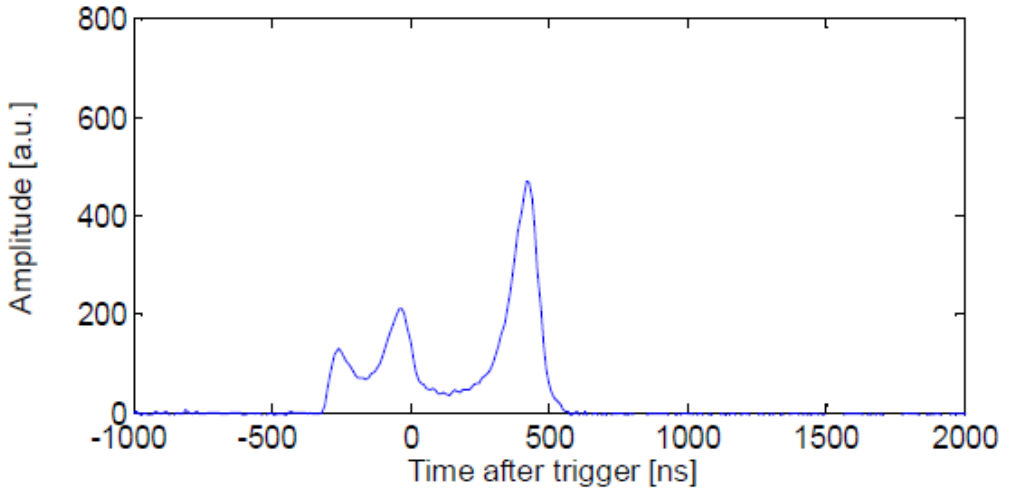



## multi site event (MSE)




Voltage pulses from preamplifier (detector **charge** pulse)



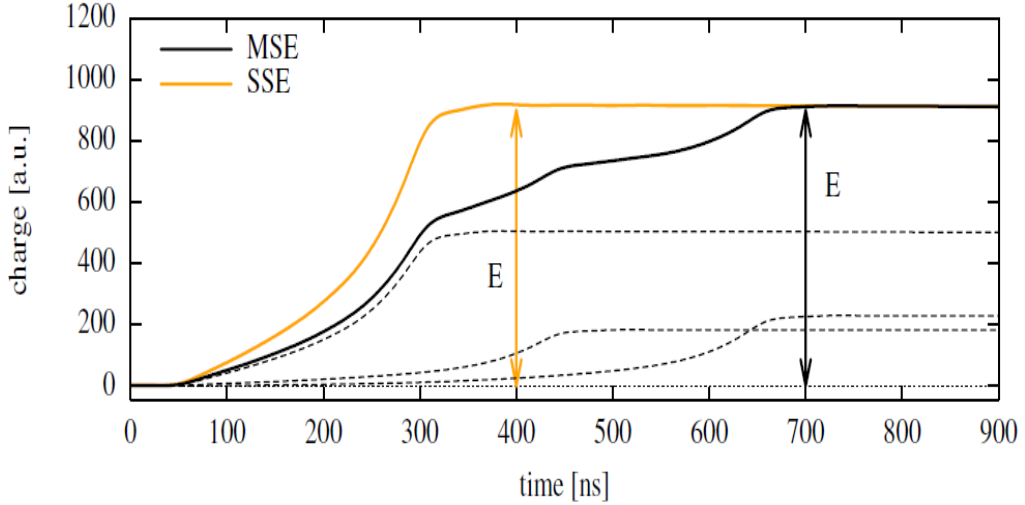




50ns smoothing, 10ns differentation (detector **current** pulse)

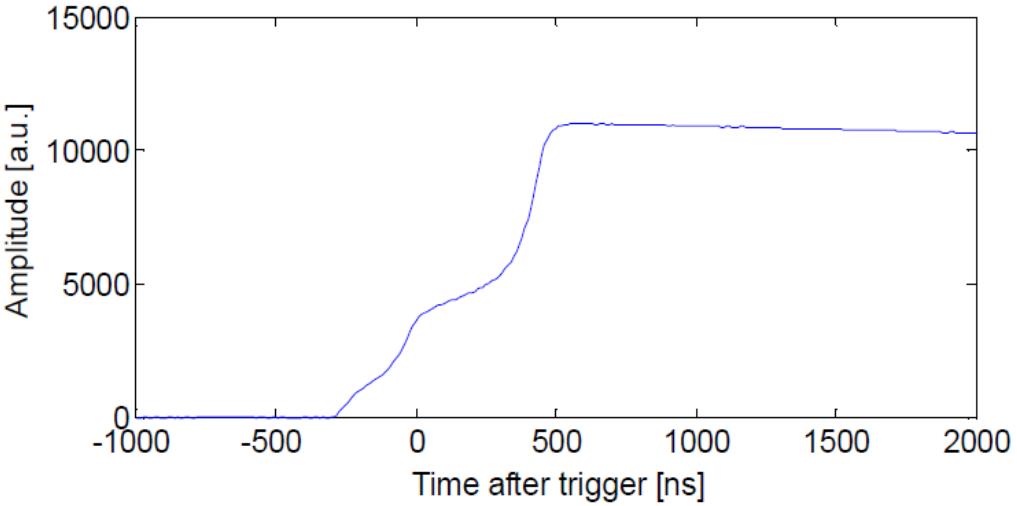
(phd thesis D. Budjas, 2009)

# why BEGe?

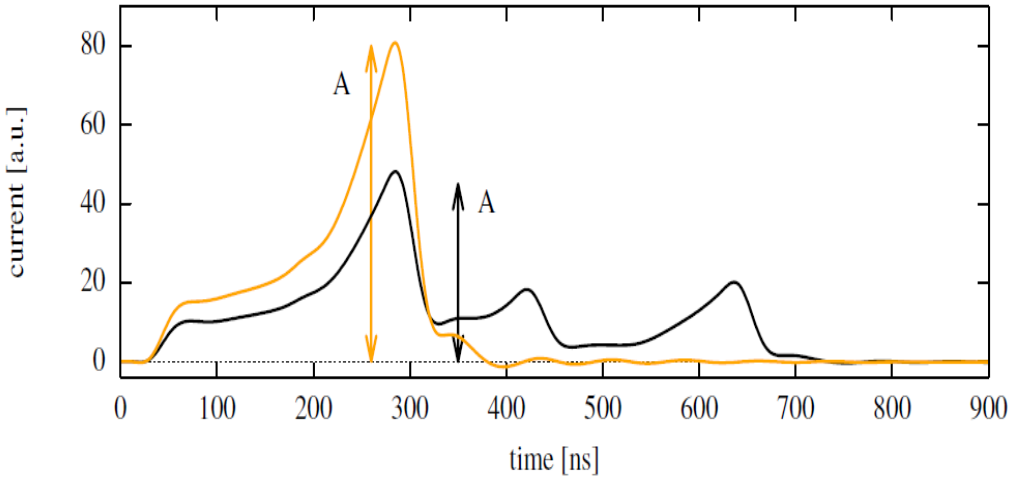
## simulations

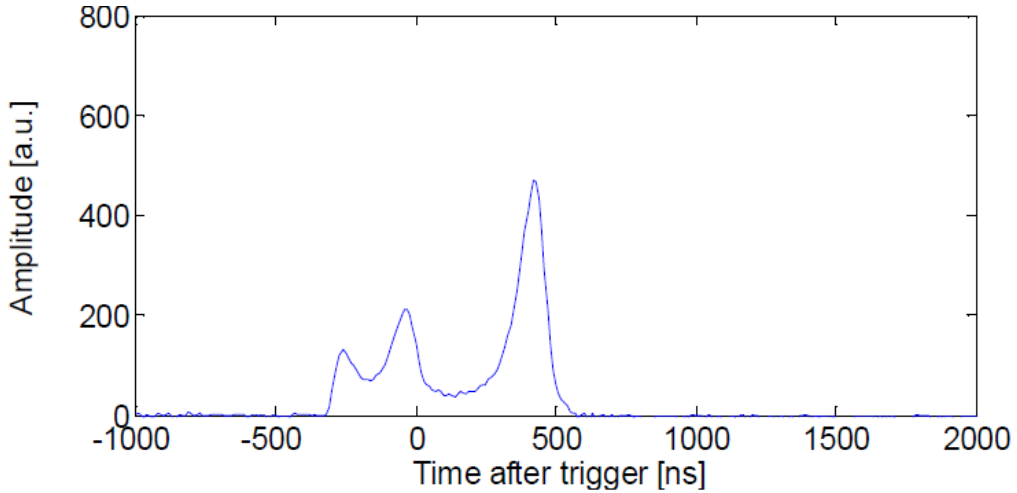



## data




voltage pulses from preamplifier (detector **charge** pulse)




after smoothing and differentation (detector **current** pulse)

(M. Agostini et al 2011 JINST 6 P03005)

(phd thesis D. Budjas, 2009)

# procurement and production

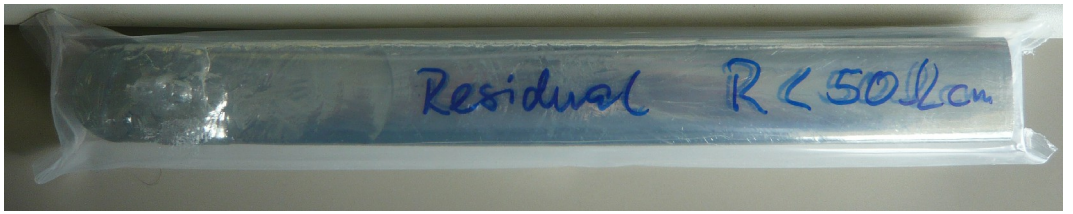

(depleted and enriched) $GeO_2$,

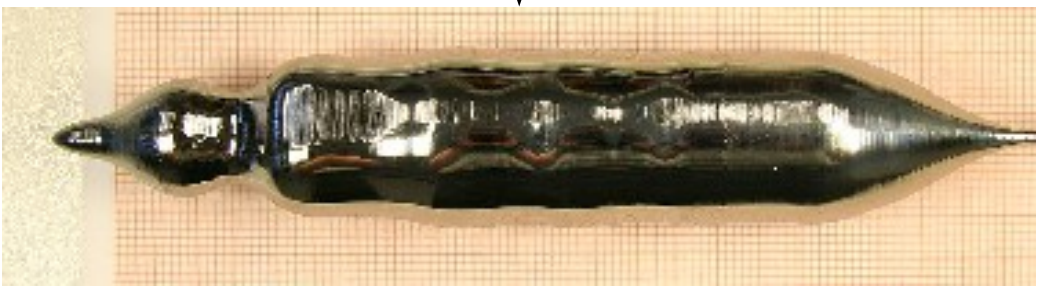
produced by ECP, Zelenogorsk, Russia

Isotopic analysis via

- Inductively Coupled Plasma Mass Spectroscopy (ICPMS)
- Neutron Activation Analysis (NAA)
- Prompt Gamma Activation Analysis (PGAA)

# procurement and production

Ge crystal, crystal pulling at Canberra, USA

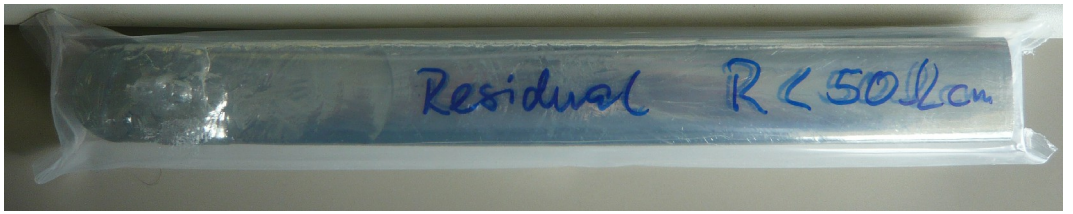
reduction from $GeO_2$ to metal,

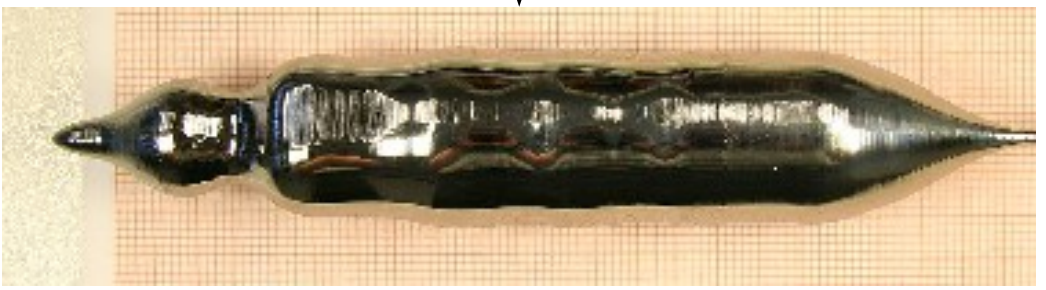
then production of crystal by zone refinement

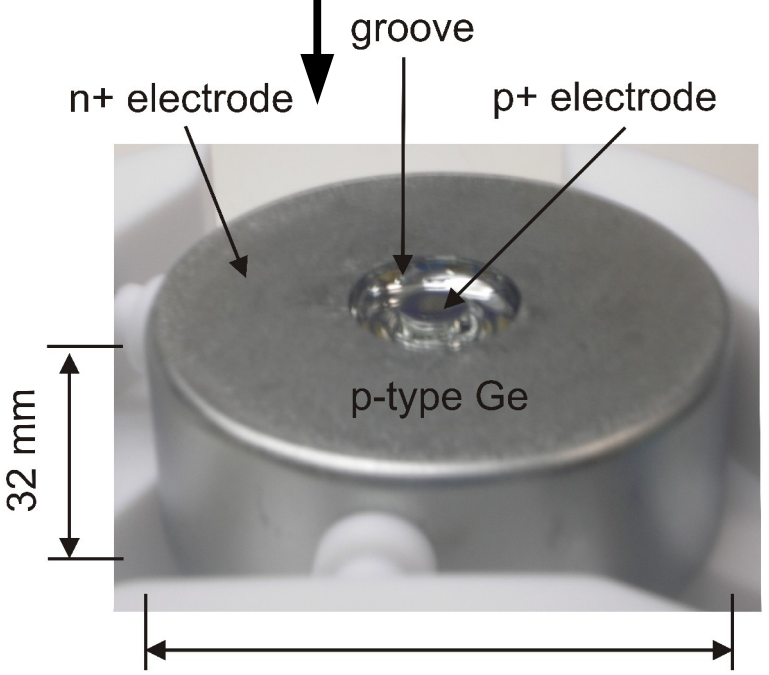
@ PPM Pure Metals GmbH, Langelsheim and

@ Canberra, Oak Ridge, USA

# procurement and production




diode fabrication & mounting
@ Canberra Belgium

# testing BEGes with a source

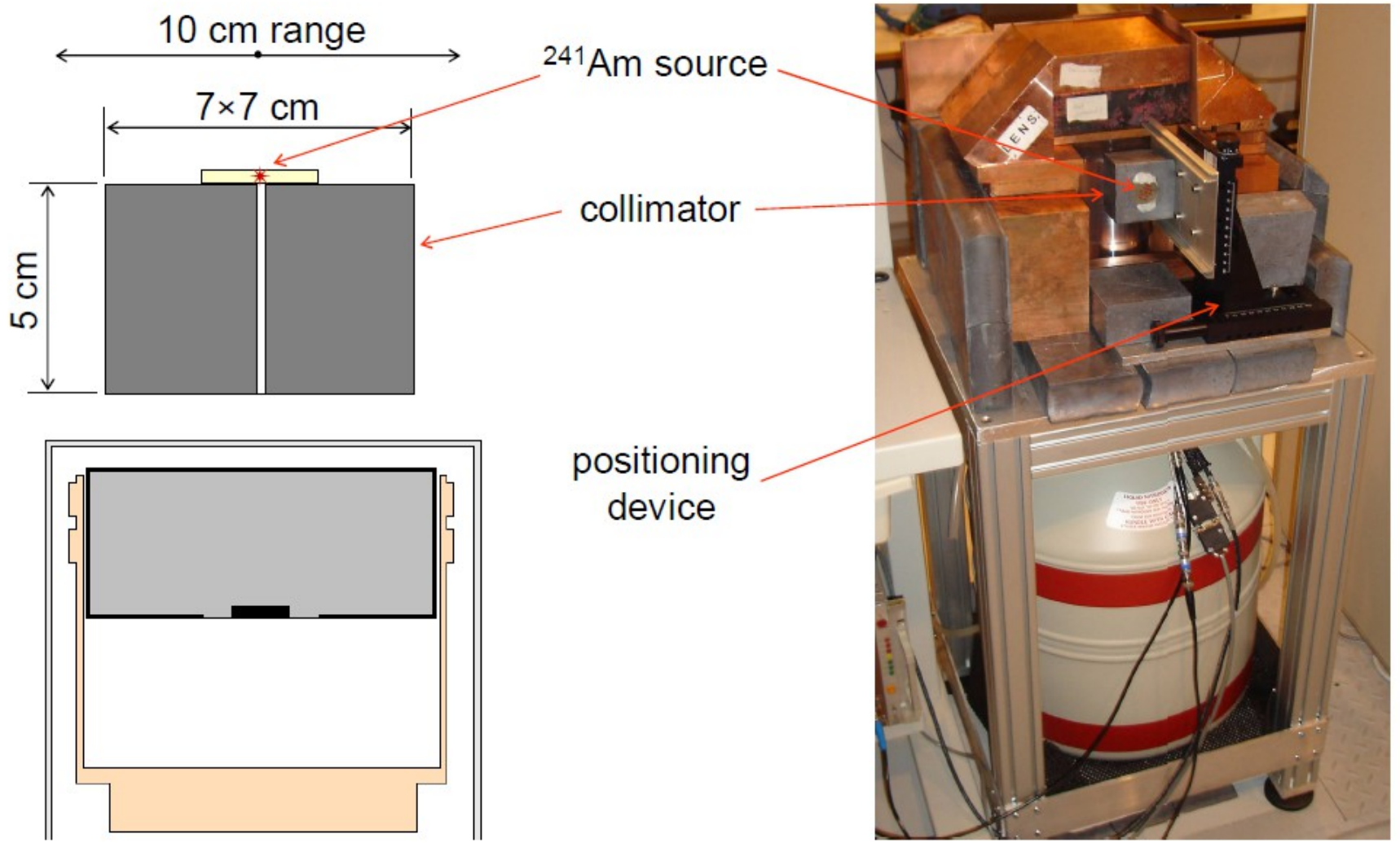
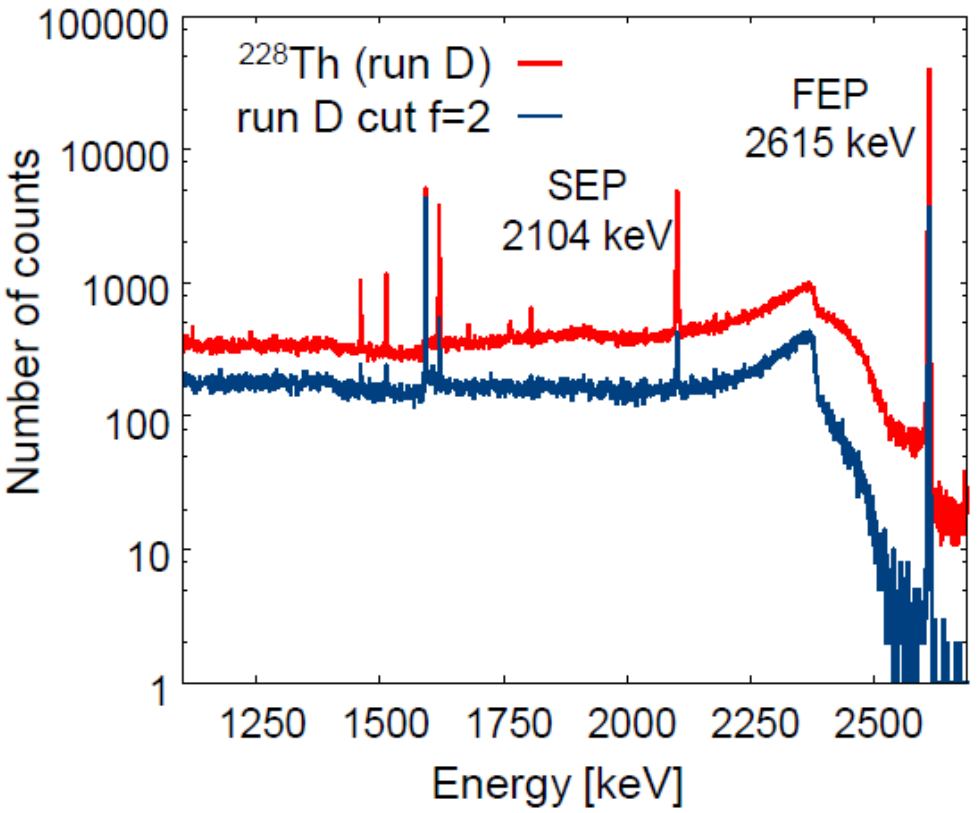
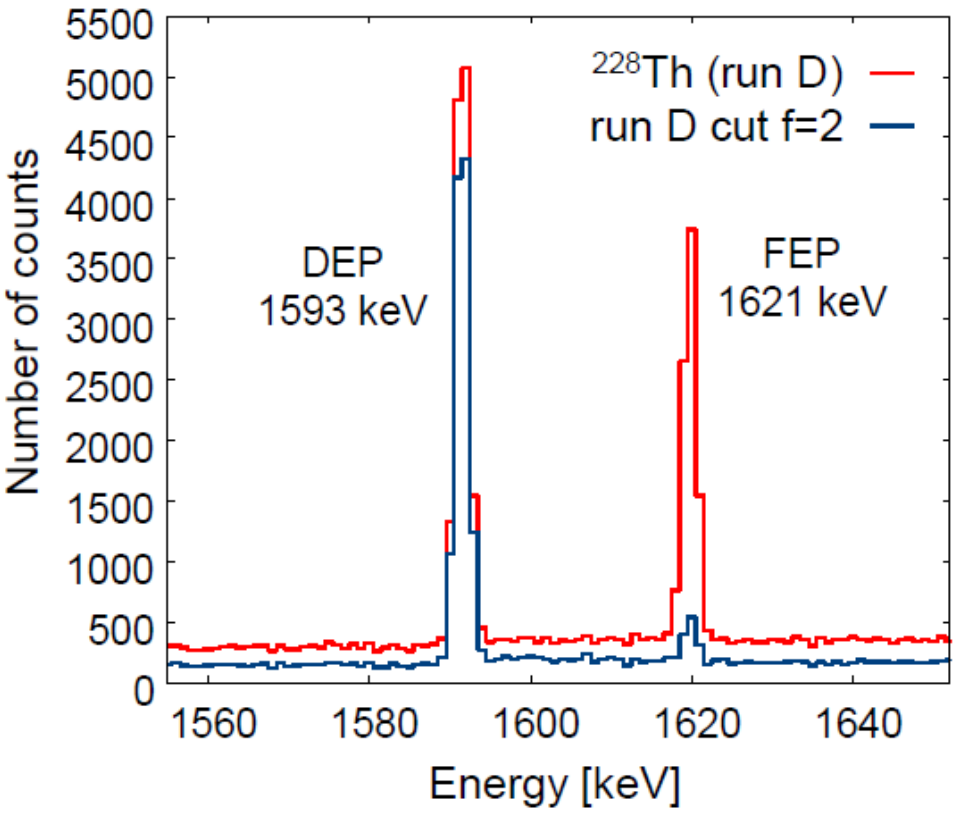



**Figure II-14** **Left:** The geometry of collimator scanning measurements with a $^{241}$Am source, configured for a top surface scan. The collimator with ∅1.5 mm hole is mounted on a precision positioning device allowing movement along the horizontal axis. **Right:** A photo of the collimator scanning setup configured for a side surface scan. A lead and copper shielding was built around the detector to reduce external background.

(phd thesis D. Budjas, 2009)

# testing BEGes with a source




(phd thesis D. Budjas, 2009)

red: $^{228}$Th measurement – no cuts

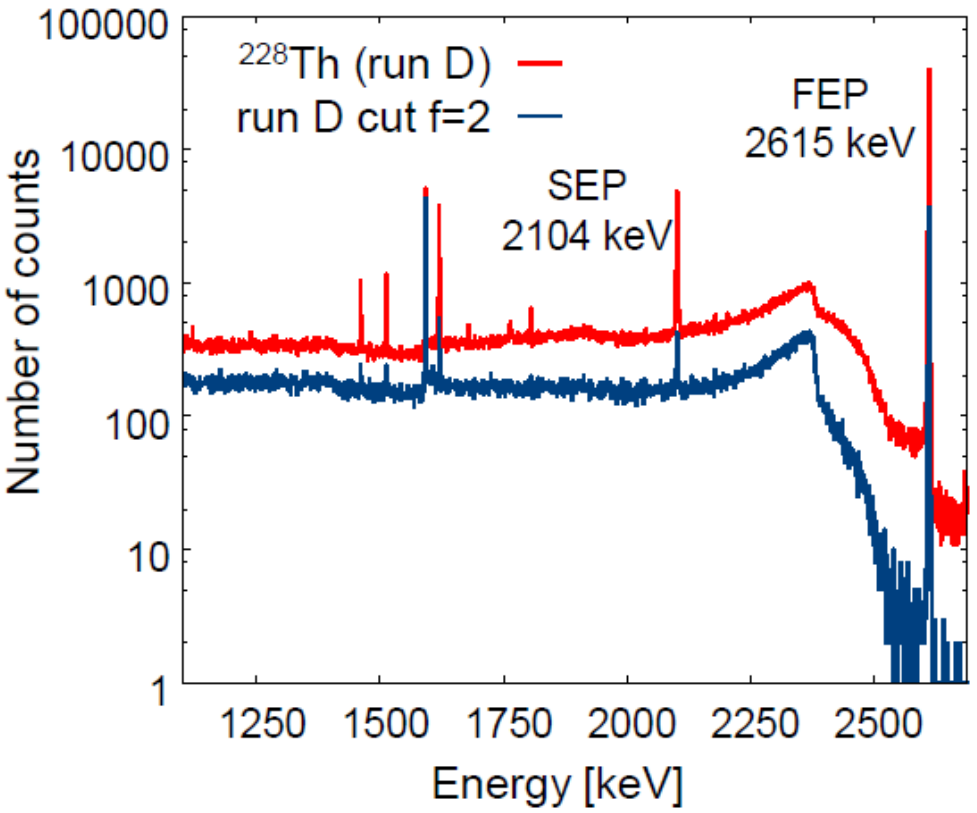
blue: spectrum after pulse shape discrimination

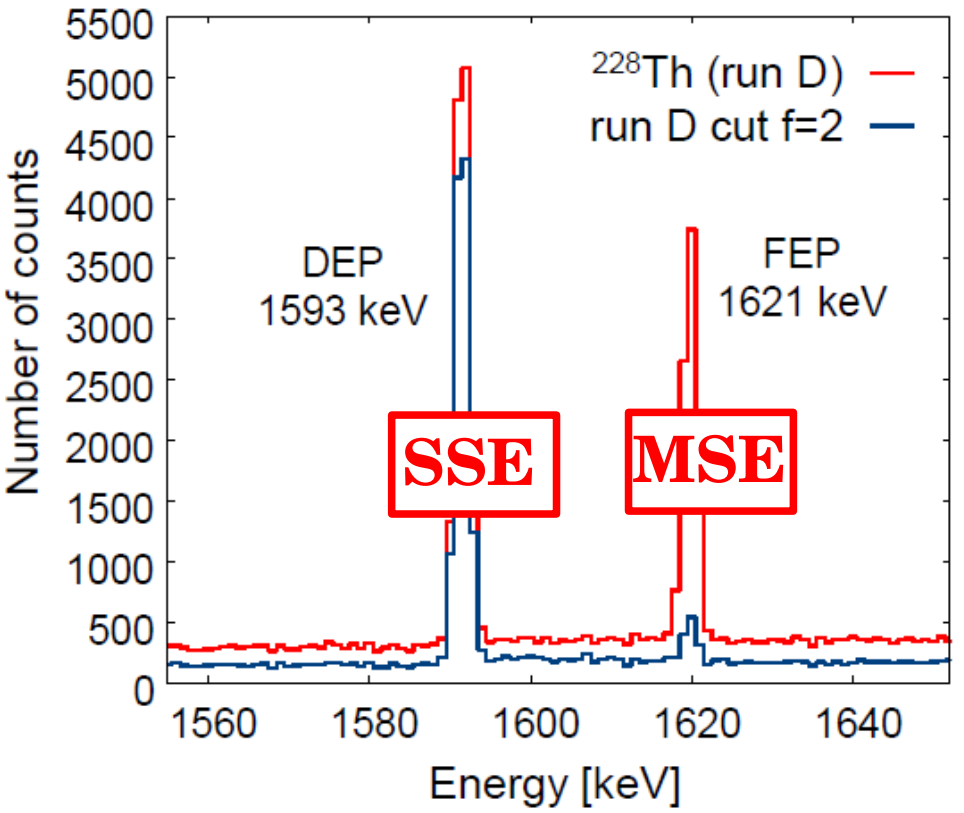
FEP: Full Energy Peak

SEP / DEP: Single Escape Peak / Double Escape Peak

($\gamma \rightarrow e^+e^-$, $e^+$ annihilates with $e^- \rightarrow$ 511keV-$\gamma$ escape the detector)

# testing BEGes with a source




(phd thesis D. Budjas, 2009)

red: $^{228}$Th measurement – no cuts

blue: spectrum after pulse shape discrimination

FEP: Full Energy Peak

SEP / DEP: Single Escape Peak / Double Escape Peak

($\gamma \rightarrow e^+e^-$, $e^+$ annihilates with $e^- \rightarrow$ 511keV-$\gamma$ escape the detector)

# conclusion

- full production chain is well understood
- several depleted Ge crystals have been grown
- depleted BEGe detectors are working well
- rejection of MSE proven with BEGes
- first enriched Ge crystals are grown
- first enriched BEGes to be produced

**stay tuned!**