Practical on Detector Efficiency

What you need to do:

The detection efficiency calibration of real germanium detector arrays!

- Fit gamma-ray photopeaks with GRSISort
- Edit and run the RootEffi script
- Submit screenshots of your fitted peaks, edited RootEffi script and efficiency curve ☺

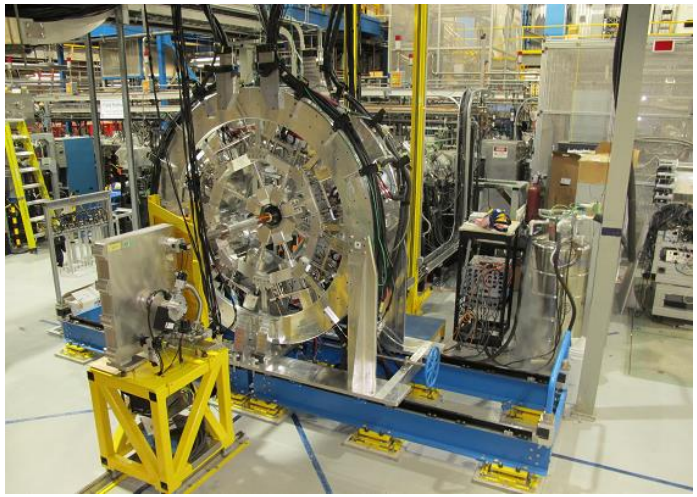
What you need to know:

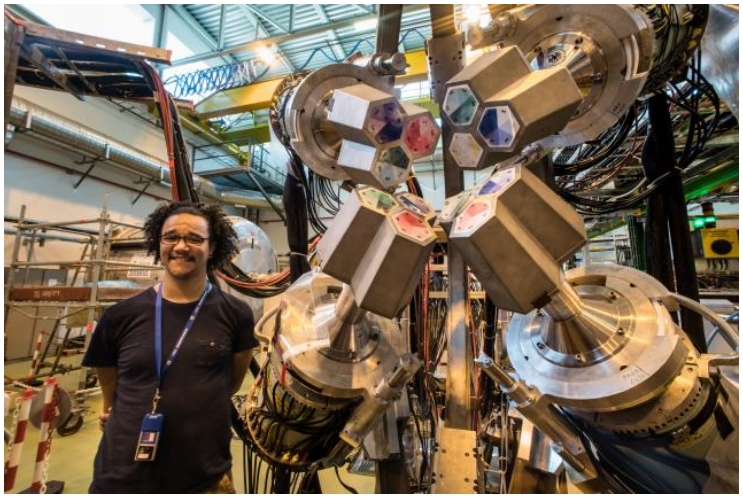
- How semiconductor detectors work
- How to find nuclear information
- How to fit peaks with GRSISort
- How to run a script in ROOT/GRSISort
- How to determine the detection efficiency

Germanium Detector Arrays

GRIFFIN, TRIUMF, Vancouver, Canada

64 crystals



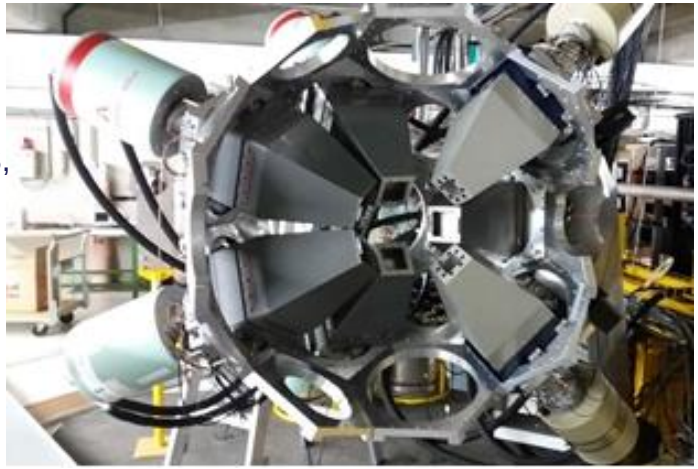


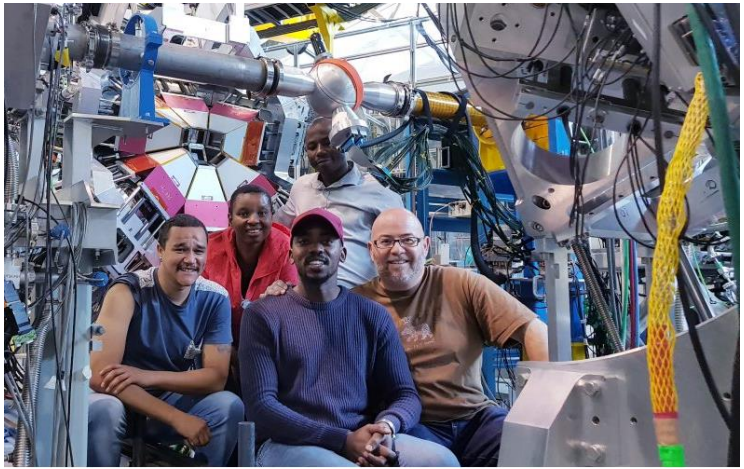
MINIBALL, CERN, Geneva, Switzerland

24 crystals

GAMKA, iThemba LABS, Cape Town, South Africa

52 crystals





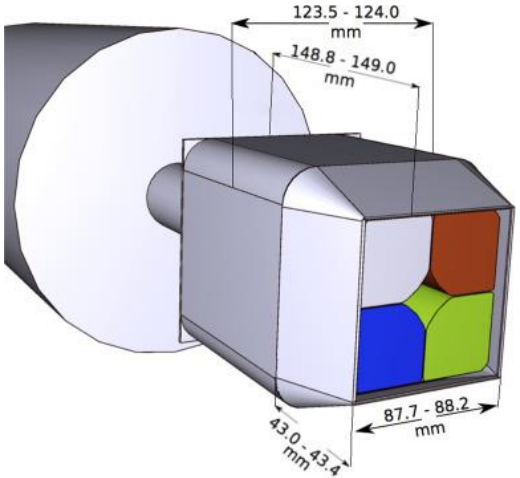
TIGRESS, TRIUMF, Vancouver, Canada

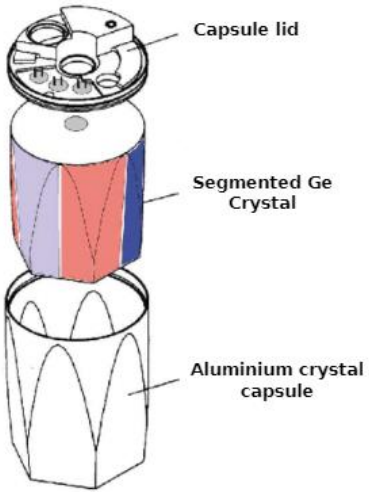
56 crystals

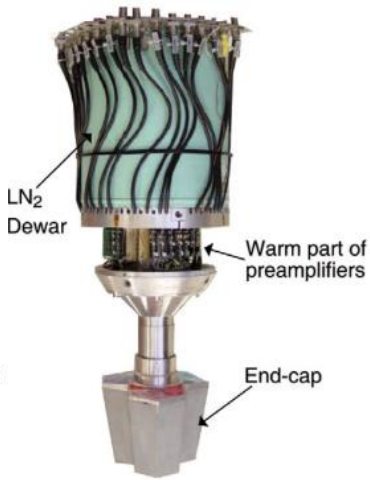
Configurations of Germanium Detectors

GRIFFIN,
TRIUMF,
Vancouver,
Canada

64 crystals
(16 clovers, not segmented)







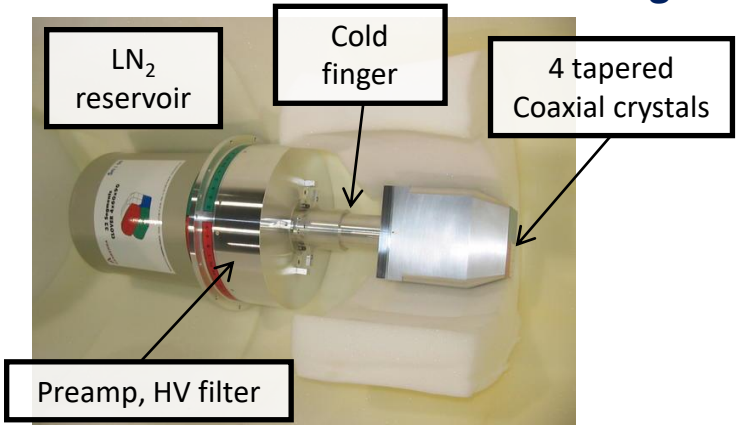
MINIBALL,
CERN,
Geneva,
Switzerland

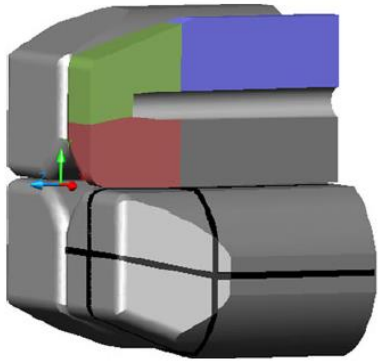
24 crystals
(8 triple clusters, 6-fold segmented)

Closed-end coaxial right cylinders ☺

GAMKA,
iThemba LABS,
Cape Town,
South Africa

52 crystals
(13 clovers, 4 segmented and 9 not segmented)

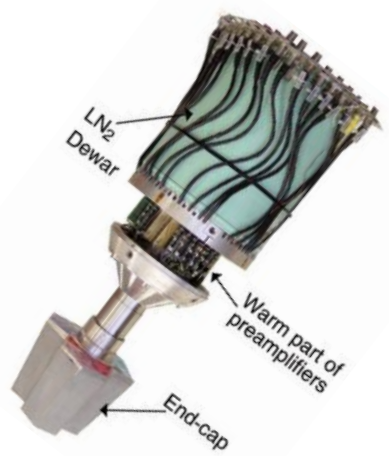




TIGRESS,
TRIUMF,
Vancouver,
Canada

56 crystals
(14 clovers, 8-fold segmented)

How to Determine the Detection Efficiency



$$\text{Absolute Efficiency } \epsilon_\gamma = \frac{\text{Number of } \gamma\text{-rays detected}}{\text{Number of } \gamma\text{-rays emitted}}$$

$$= \frac{N_{\gamma,detected}}{I_\gamma \cdot A \cdot t}$$

- $N_{\gamma,detected}$ ← Area of the photopeak
- t ← Data collection time
- A ← Activity of the source
- I_γ ← Absolute intensity of the gamma ray

$$\epsilon_\gamma(E) = 10^{p_0 + p_1 \log(E) + p_2 \log^2(E) + p_3/E^2}$$

z^AX

Gamma(γ)decay

$$\text{Relative Efficiency } \epsilon_\gamma = \frac{\frac{N_{\gamma1,detected}}{I_{\gamma1} \cdot A \cdot t}}{\frac{N_{\gamma2,detected}}{I_{\gamma2} \cdot A \cdot t}} = \frac{N_{\gamma1,detected}/I_{\gamma1}}{N_{\gamma2,detected}/I_{\gamma2}}$$

How to Find Nuclear Information

- Lund/LBNL Nuclear Data Search: http://nucleardata.nuclear.lu.se/toi/
- National Nuclear Data Center: https://www.nndc.bnl.gov/

The Lund/LBNL Nuclear Data Search

Version 2.0, February 1999

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ToRI

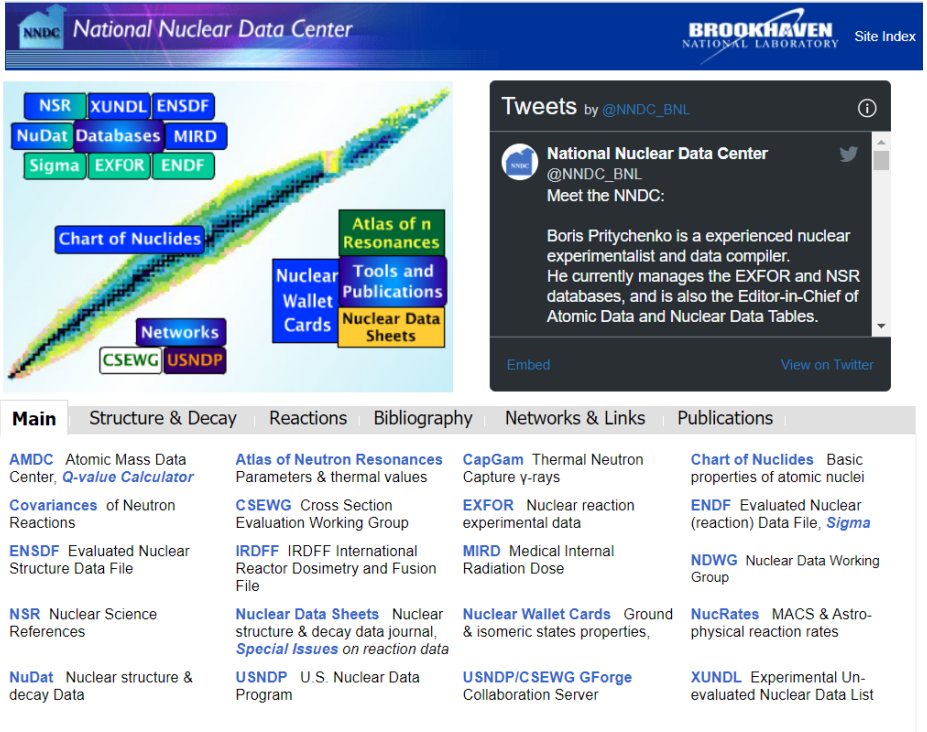
WWW Table of Radioactive Isotopes

Radiation search
Nuclide search
Atomic data (X-rays and Auger electrons, very preliminary!)
Periodic chart interface to the nuclides
Summary drawings for A=1-277 (PDF)
Nuclear charts (PDF, 333 kbyte)
Database status

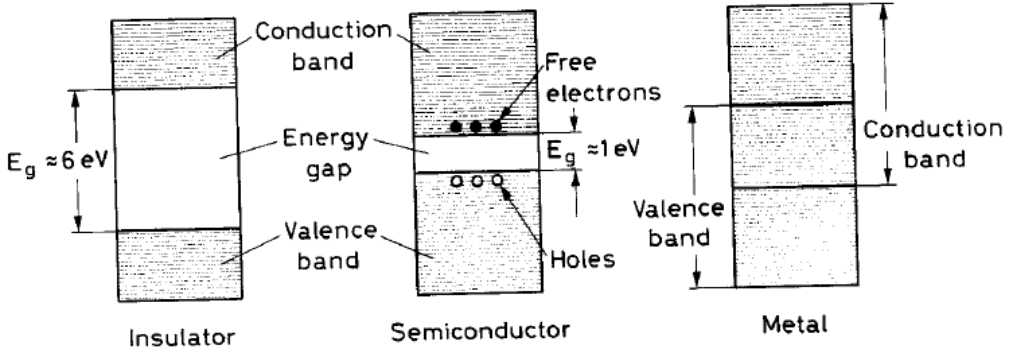
ToI

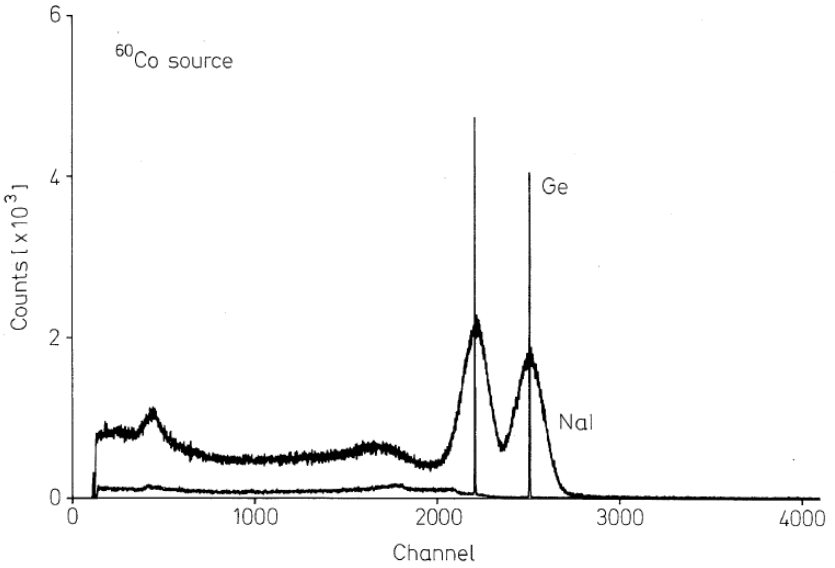
***Table of Isotopes* (ToI)**

About this service
ToI home page



Semiconductors vs. Scintillators

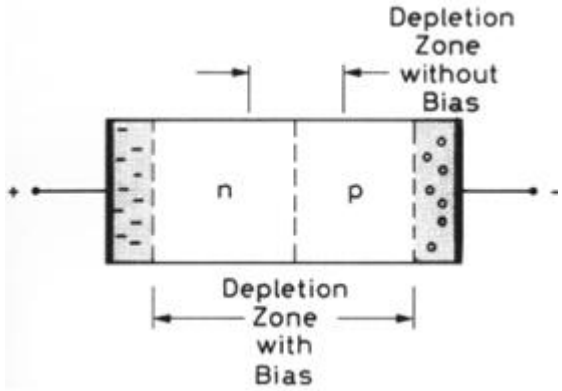


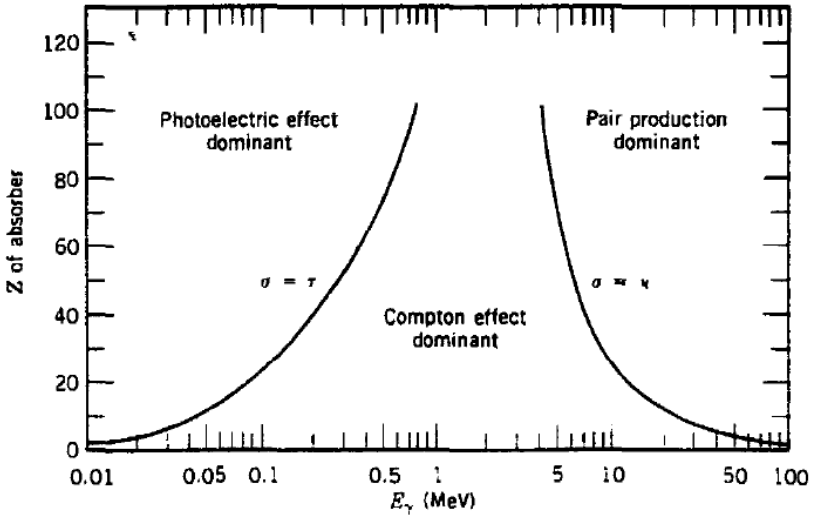


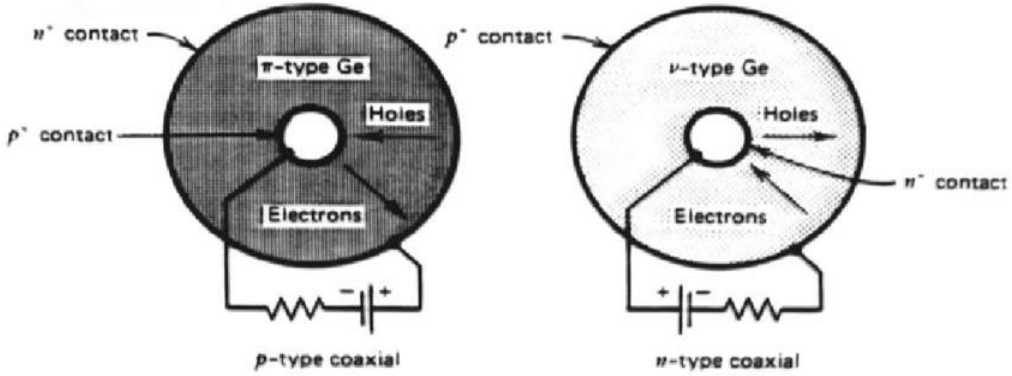
Material Property	NaI(Tl)	Germanium	Silicon
Type	Scintillator	Semiconductor	Semiconductor
Cooling	No	~ 95 K	No
Density (g/cm^2)	3.7	5.3	2.3
Band gap energy (eV)	20	2.9	3.8
Energy resolution at 1332 keV (keV)	13	1.9	

How Semiconductor Detectors Work

- An external field creates an area depleted of free charge carriers.
- Radiation interacts with the crystal and produces of electron-hole pairs.
- The electrons and holes drift towards electrodes and the electric pulse is amplified and processed.







K.S. Krane, *Introductory Nuclear Physics* (1988).
G.F. Knoll, *Radiation Detection and Measurement* (1989).
W.R. Leo, *Techniques for Nuclear and Particle Physics Experiments* (1994).