Olga Kefallinou

Table of contents

01 Introduction

Type

HPGe detectors are semiconductor diodes

- *P-type*: doped with trivalent impurity (e.g. Boron)
- *N-type*: doped with pentavalent impurity (e.g. Phosphorus)

Why Germanium?

Except for its large crystals, due to germanium's higher atomic number and lower average energy necessary to create an electron-hole pair (2.9 keV) HPGe detectors are more efficient than silicon ones

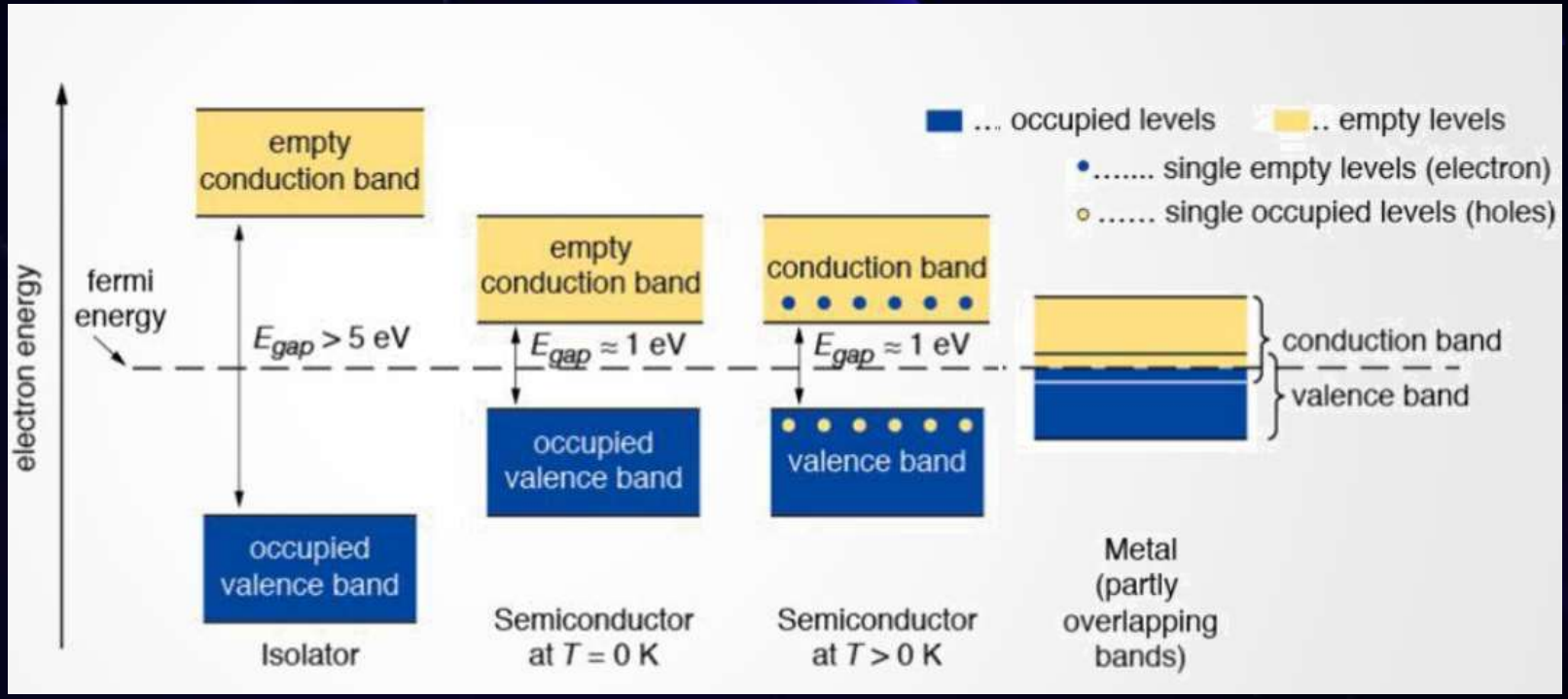
What does it detect?

HPGe detectors are sensetive to ioniziong radiation, particularly X-rays and γ-rays

HPGe detectors produce the highest resolution - 0.2% at 1 MeV- commonly available!

- ○ Gamma-ray tracking
- ● Nuclear security operations
- ○ Environmental monitoring
- ● Medical applications
- ○ Nuclear plant safety
- ● Radiometric assay

02 Working principle



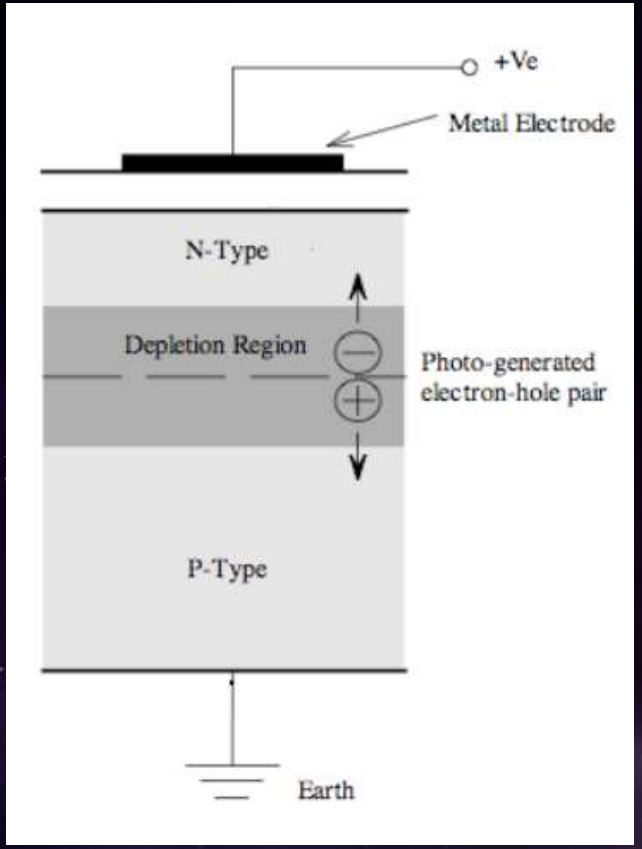
(a) *Isolator vs semiconductor vs metal.*
(b) *Source: [3]*

Ionizing radiation enters the germanium crystal and interacts with the semiconductor material

A HE photon passing through the detector ionizes the atoms of the semiconductor producing electron-hole pairs

Under the influence of an electric field, electrons and holes travel to the electrodes

The pulse that carries information about the photon's energy is measured in an outer circuit

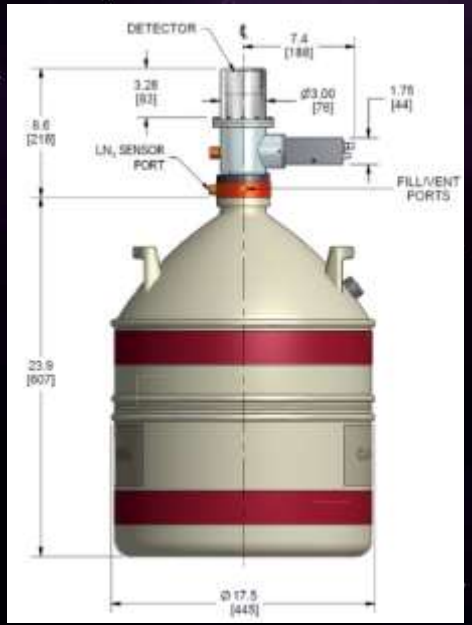


(a) Semiconductor setup.
(b) Source: [4]

03 Limitation

Cooling Requirement

HPGe detectors must be cooled to liquid nitrogen temperatures to reduce the thermal generation of charge carries



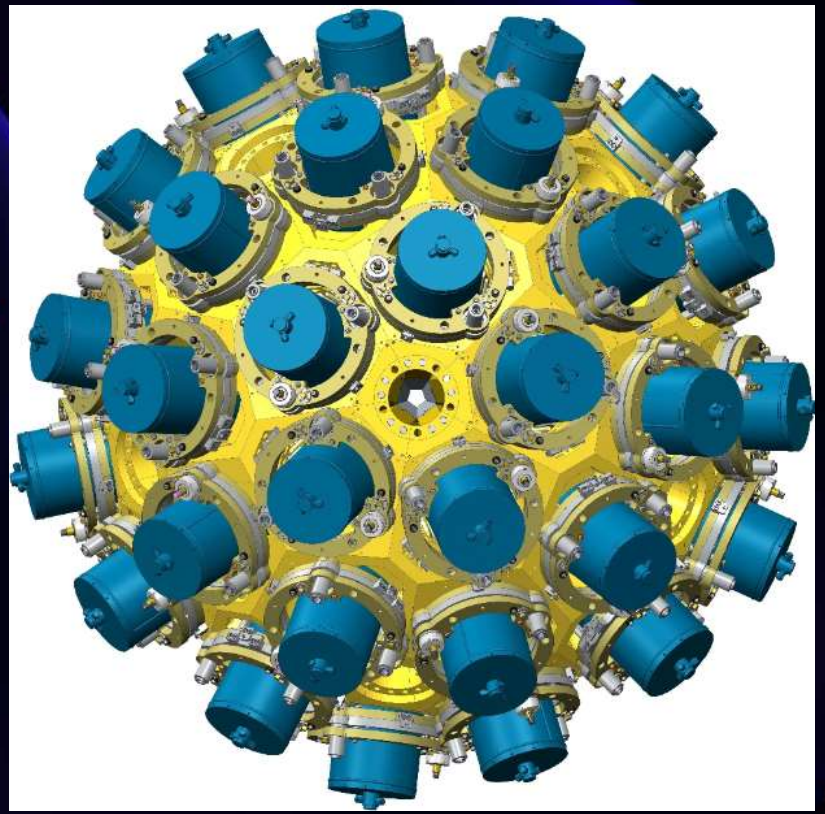
Liquid nitrogen cryostat
Source: [7]

04 Future prospects

AGATA (Advanced Gamma Tracking Array)

Aim: Developing and building a 4pi gamma-ray spectrometer of the next generation
Array of 180 large encapsulated HPGe
Based on gamma-ray tracking

40 research institutes in 13 European countries

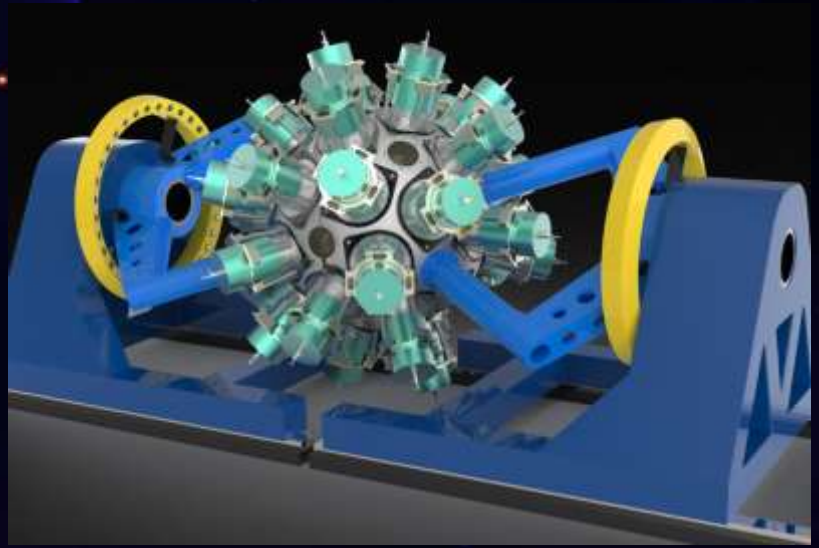


Artist's view of the 4π AGATA spectrometer showing the mechanical holding frame (yellow) and cryostat dewars (blue) of the HPGe detectors. The figure is from the AGATA Science White Book.

GRETA (Gamma-Ray Energy Tracking Array)

It’s claimed to be of order of 1000 times more powerful than the best present arrays
Shell of ~100 highly segmented large HPGe
Based on gamma-ray tracking

Facility for Rare Isotope Beams (FRIB) at Michigan State University



A rendering of GRETA, the Gamma-Ray Energy Tracking Array. (Credit: Berkeley Lab)

References

[1] Application of HPGe Detectors | Application of HPGe Detectors | nuclear-power.com
[2] HPGe Detector Application on Monitoring Enviromental Samples Around the Accelerator | wepor024.pdf (cern.ch)
[3] https://indico.cern.ch/event/975141/contributions/4157759/attachments/2165445/3654609/2020-Lecture-4-2-Semiconductor%20Detectors.pdf
[4] http://www.vikdhillon.staff.shef.ac.uk/teaching/phy217/detectors/phy217_det_structure.html
[5] Advantages and Disadvantages of HPGe Detectors | nuclear-power.com
[6] https://www.agata.org/about
[7] https://www.mirion.com/products/technologies/spectroscopy-scientific-analysis/gamma-spectroscopy/detectors/hpge-cryostats-coolers-options/flanged-cryostats-liquid-nitrogen-cryostat
[8] https://greta.lbl.gov/

Thank you for your attention!