Review on Radiation Detection

Jędrek Iwanicki, HIL

What types of radiation you may expect to “see” during the workshop?

- α particles (calibration of particle detectors, target thickness measurements, nuclear reactions in ICARE)
- Heavy ions (ICARE experiments)
- γ rays (γ -γ coincidence measurement on EAGLE, timing measurement)
- X-rays (cyclotron RF voltage measurement)
- Neutrons (*unlikely* but we are prepared)

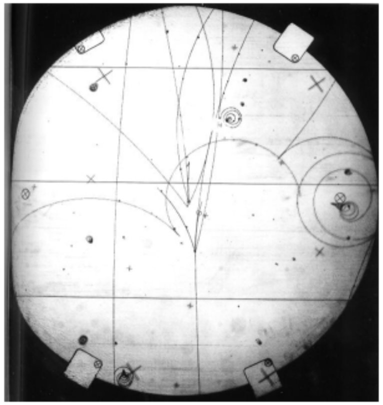
Principles of radiation detection

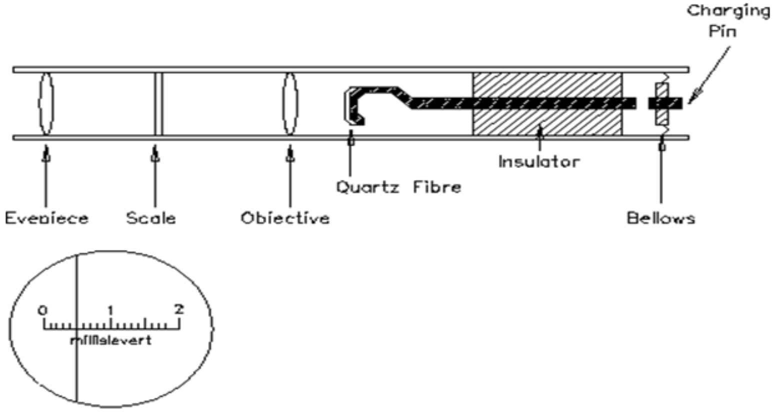
All types of radiation I am going to discuss are called *ionising radiation* – just because its energy is high enough to ionize an atom

- Ionization is the main phenomenon that makes radiation detection and measurement possible.
- Charged particles cause ionization of the matter along its path until they stop
- Neutral particles (photons included) need to interact with something that would emit charged particles, this badly affects efficiency.

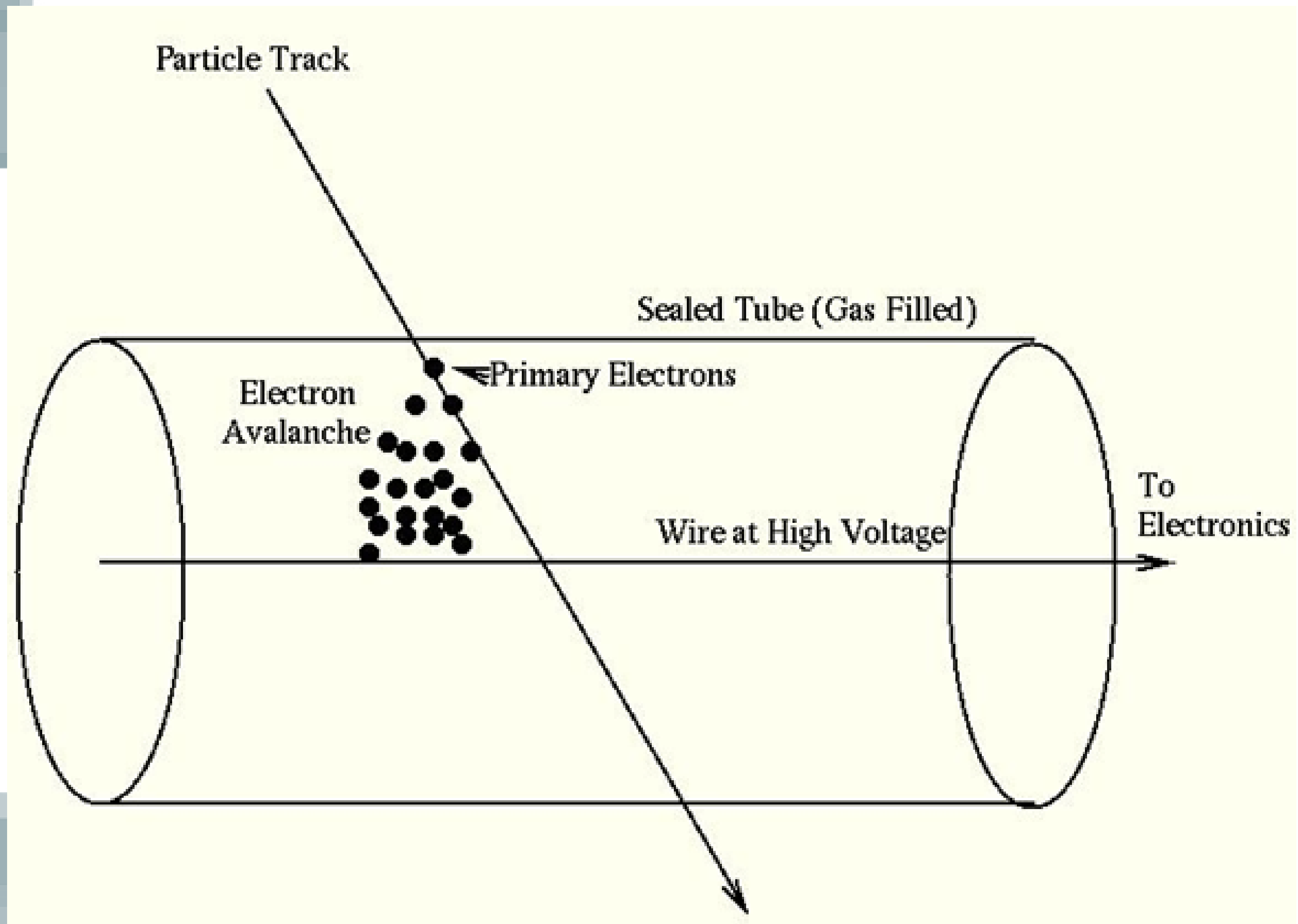
Obsolete detectors

- Electrometers
  - Curie electrometer
  - Some still used for radiation protection
- Photographic plate/film
  - Still used for radiation protection
- Cloud / bubble chamber

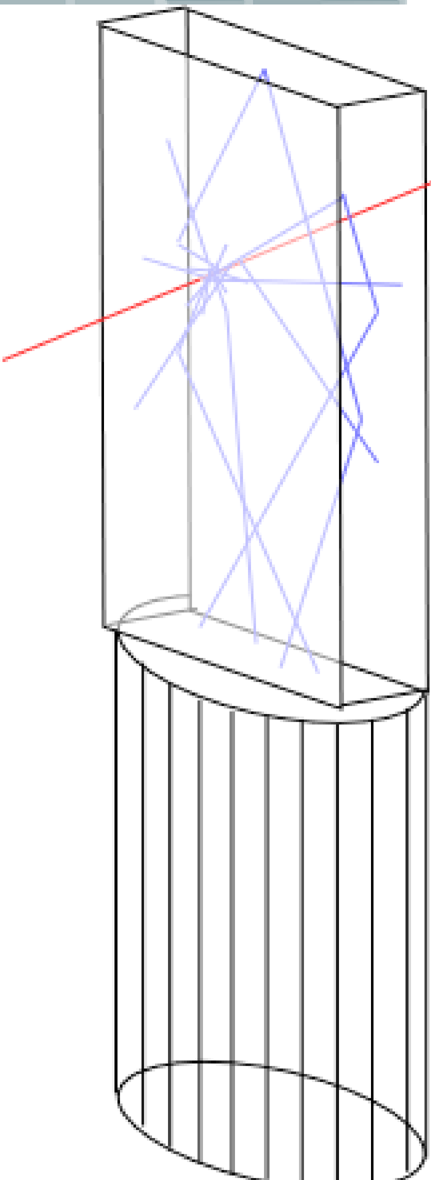




Gas detectors:
Geiger-Müller tube, proportional chamber

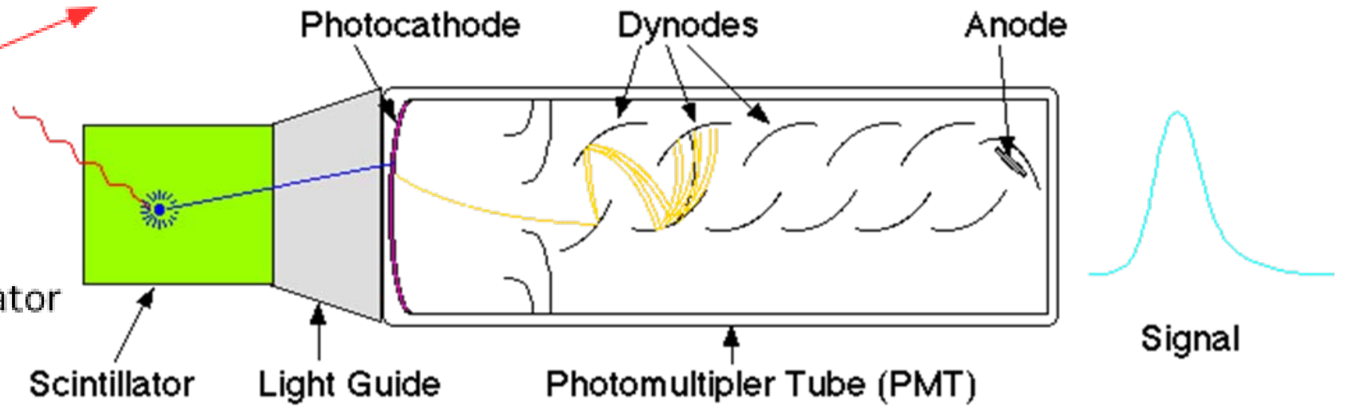


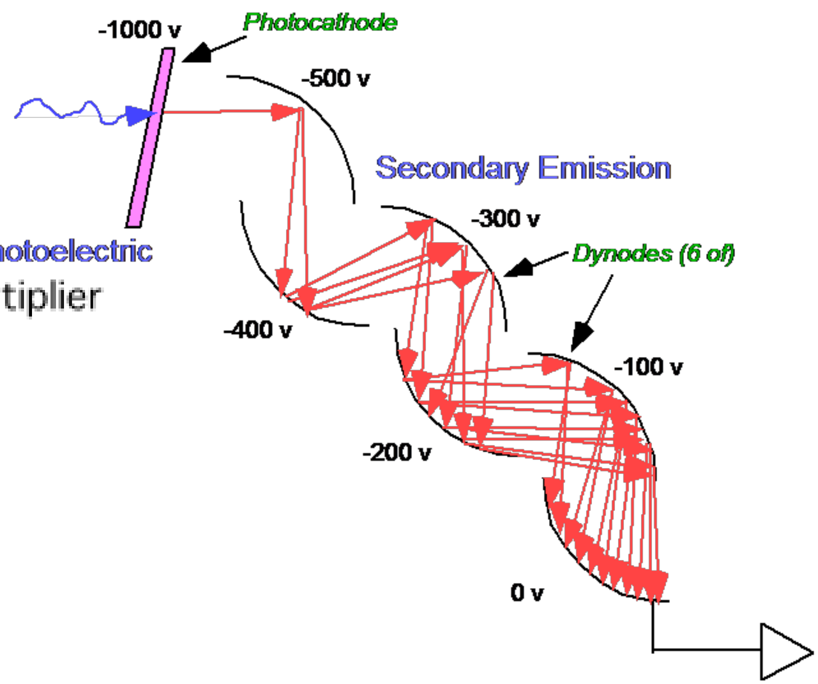
Scintillation detectors



Scintillator

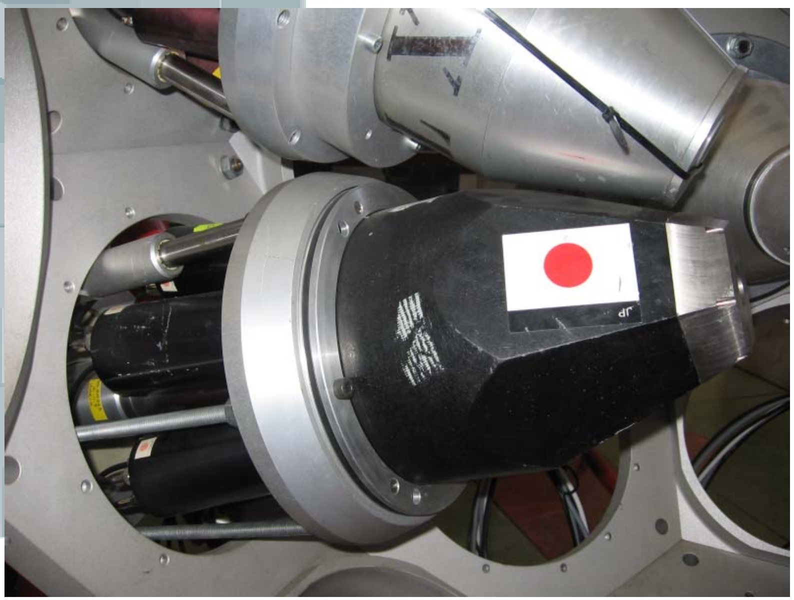
Photomultiplier Tube





Scintillation detectors

in EAGLE



Anti-Compton shields (BGO)

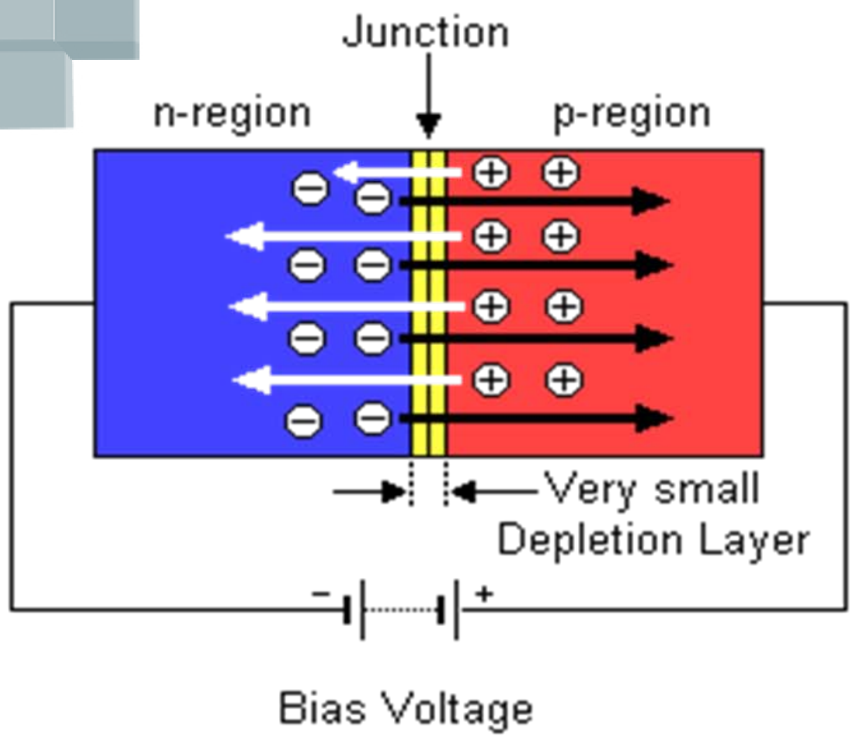
Elements of gamma multiplicity filter (BaF_2) *(not in use at the moment)*

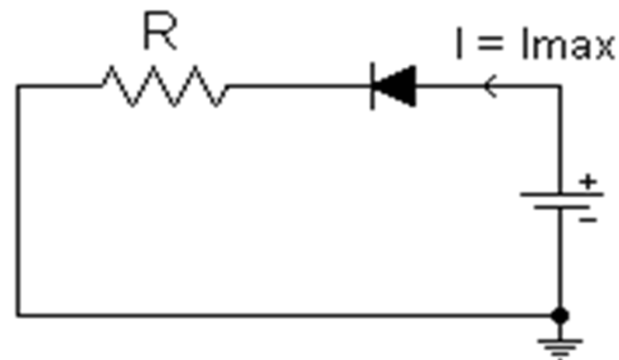
Scintillation detectors

Lanthanum Bromide

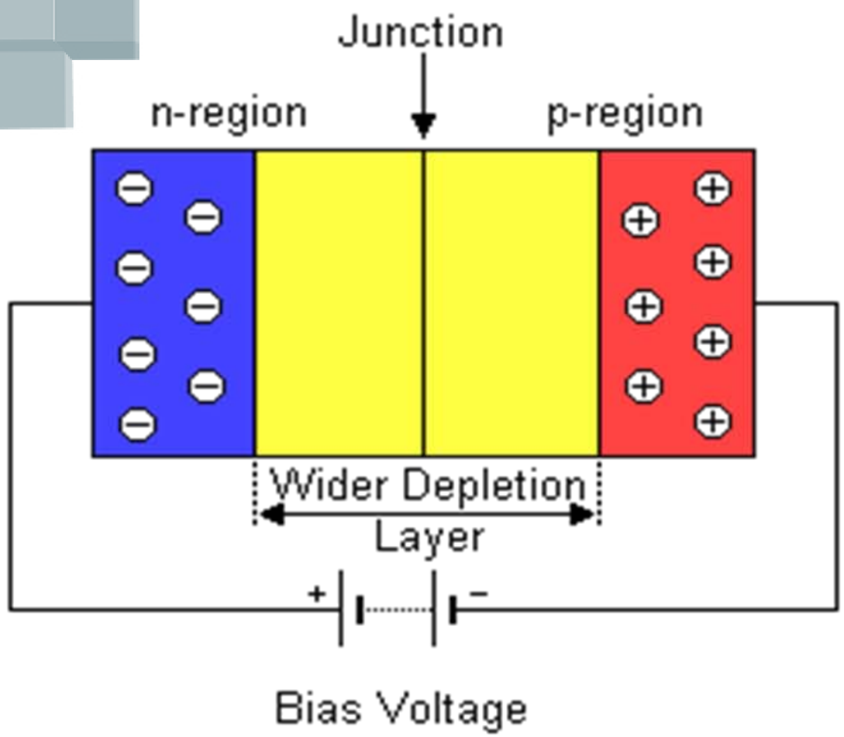
Caesium Iodide and plastic

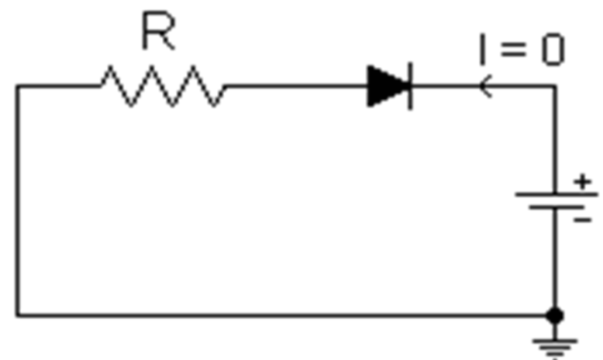
Semiconductor detector
– principle of operation



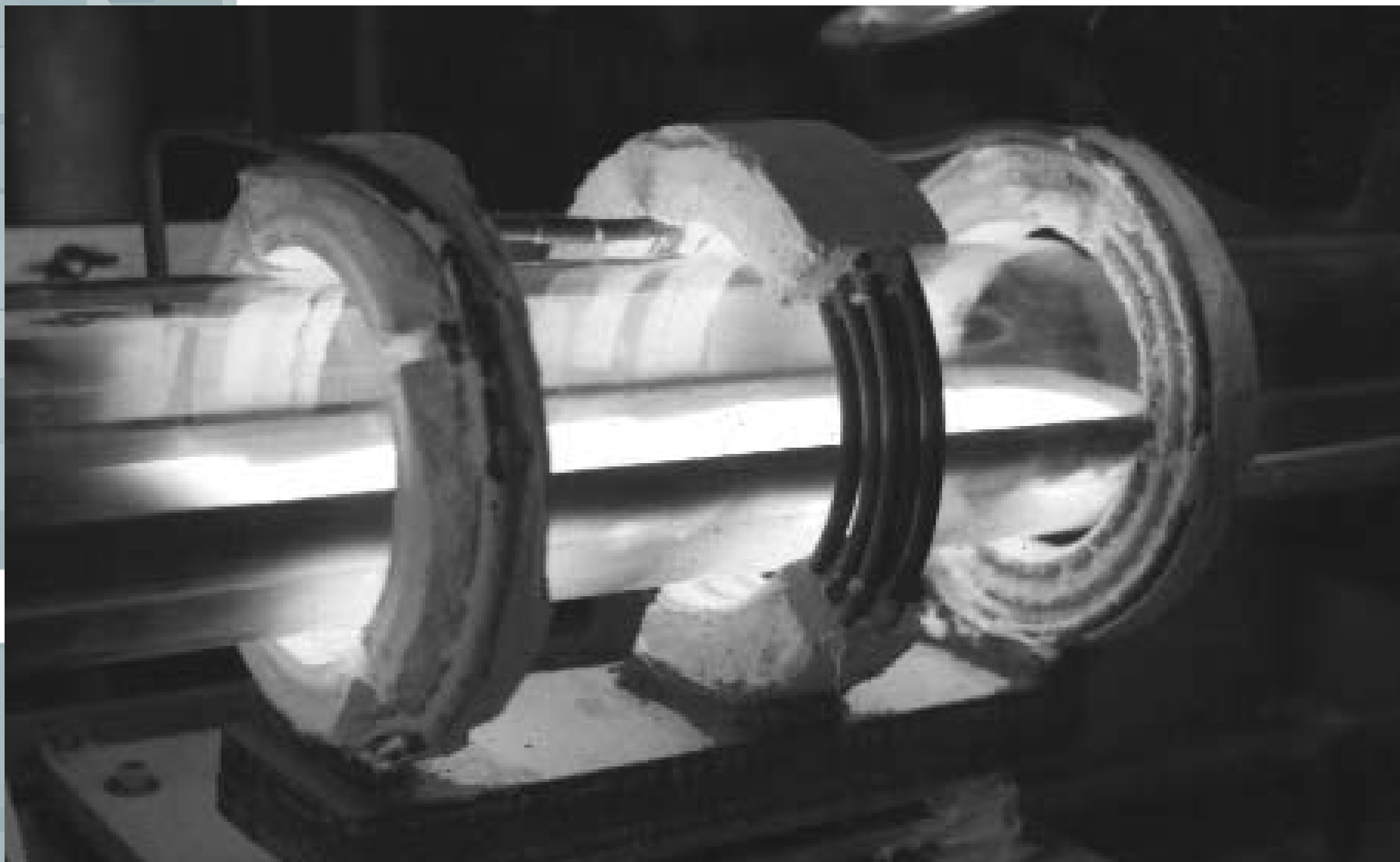


Semiconductor detector – principle of operation



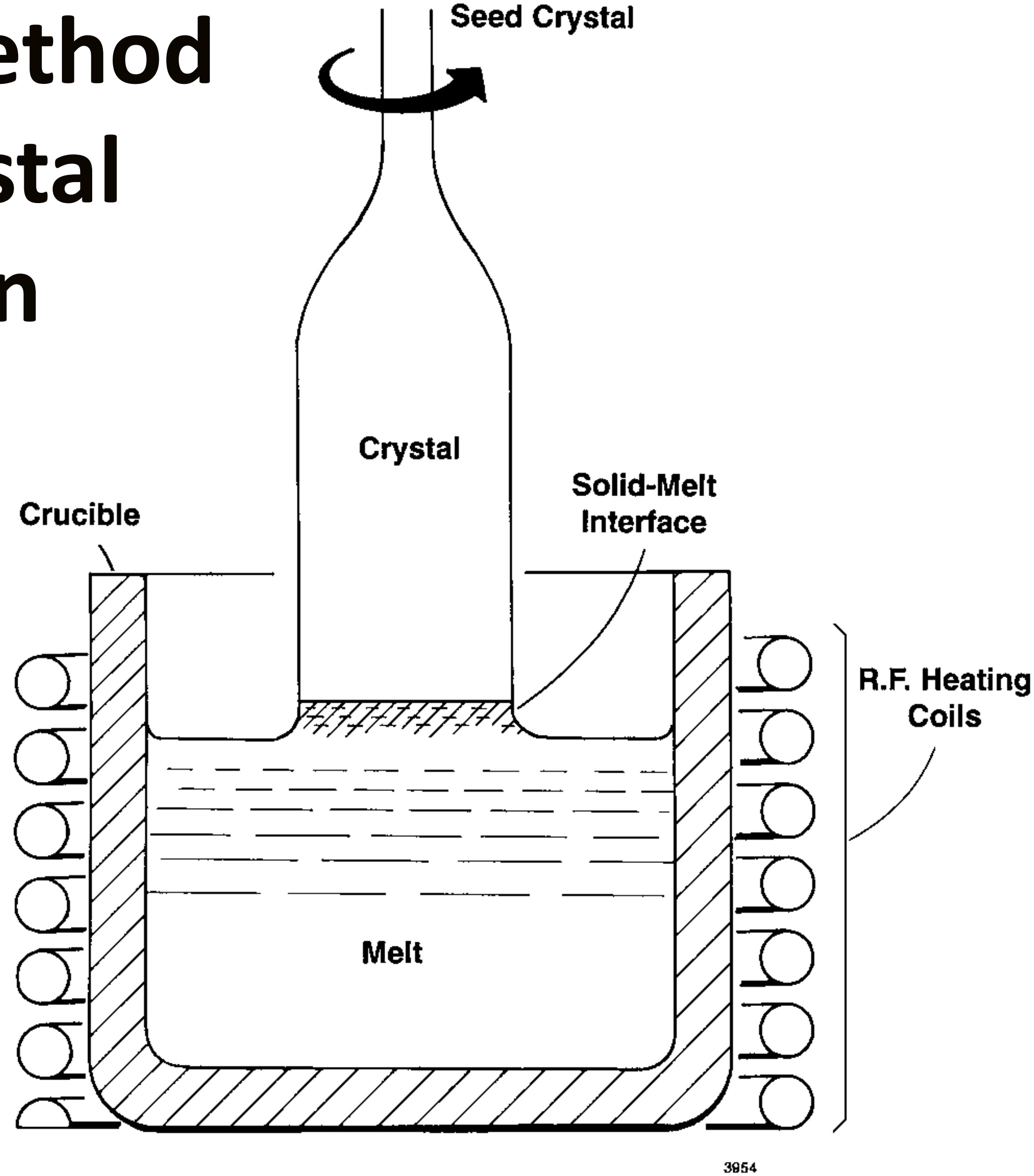


A 3-coil zone refiner

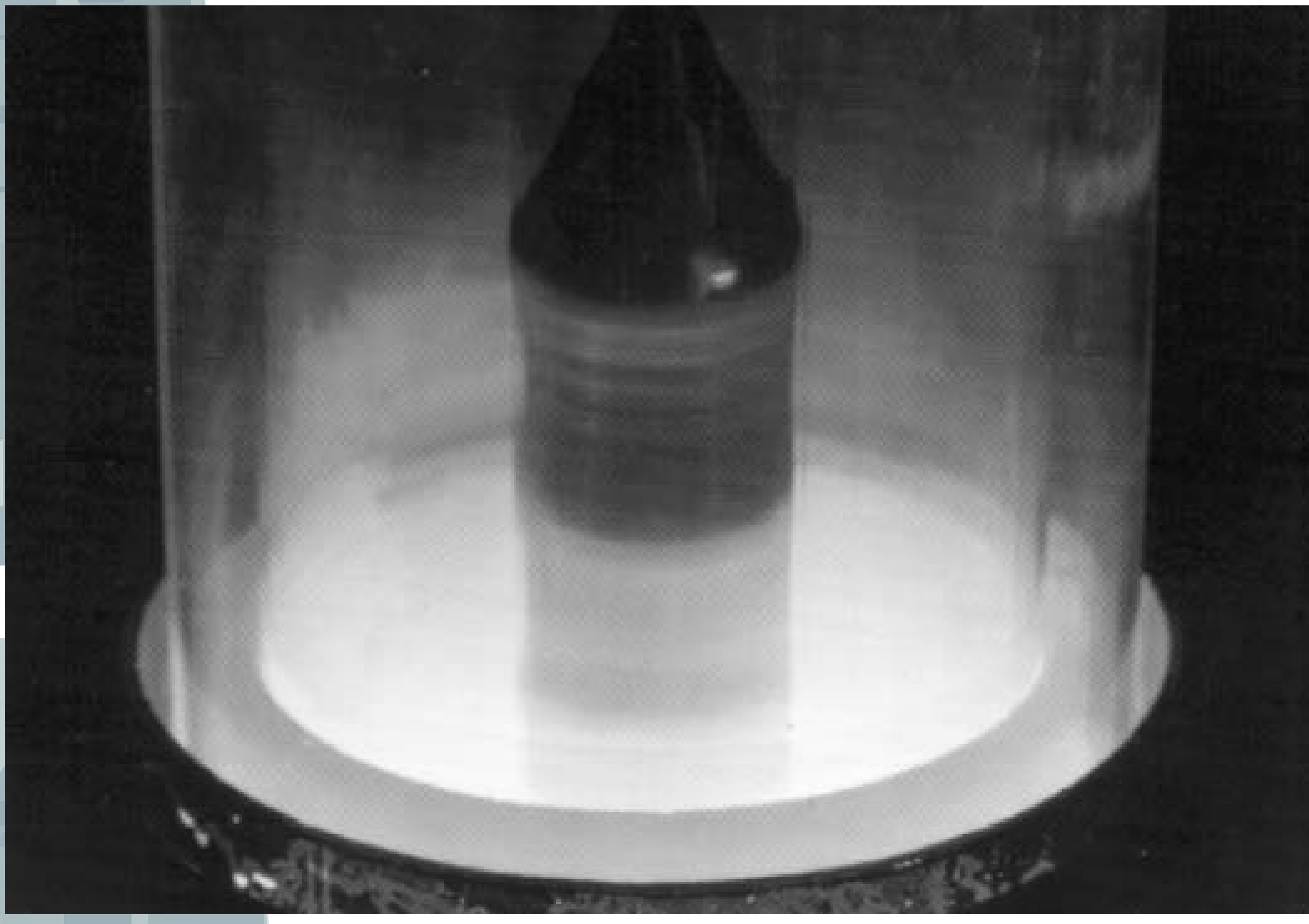


A zone-refined ingot

Czochralski method of monocrystal production



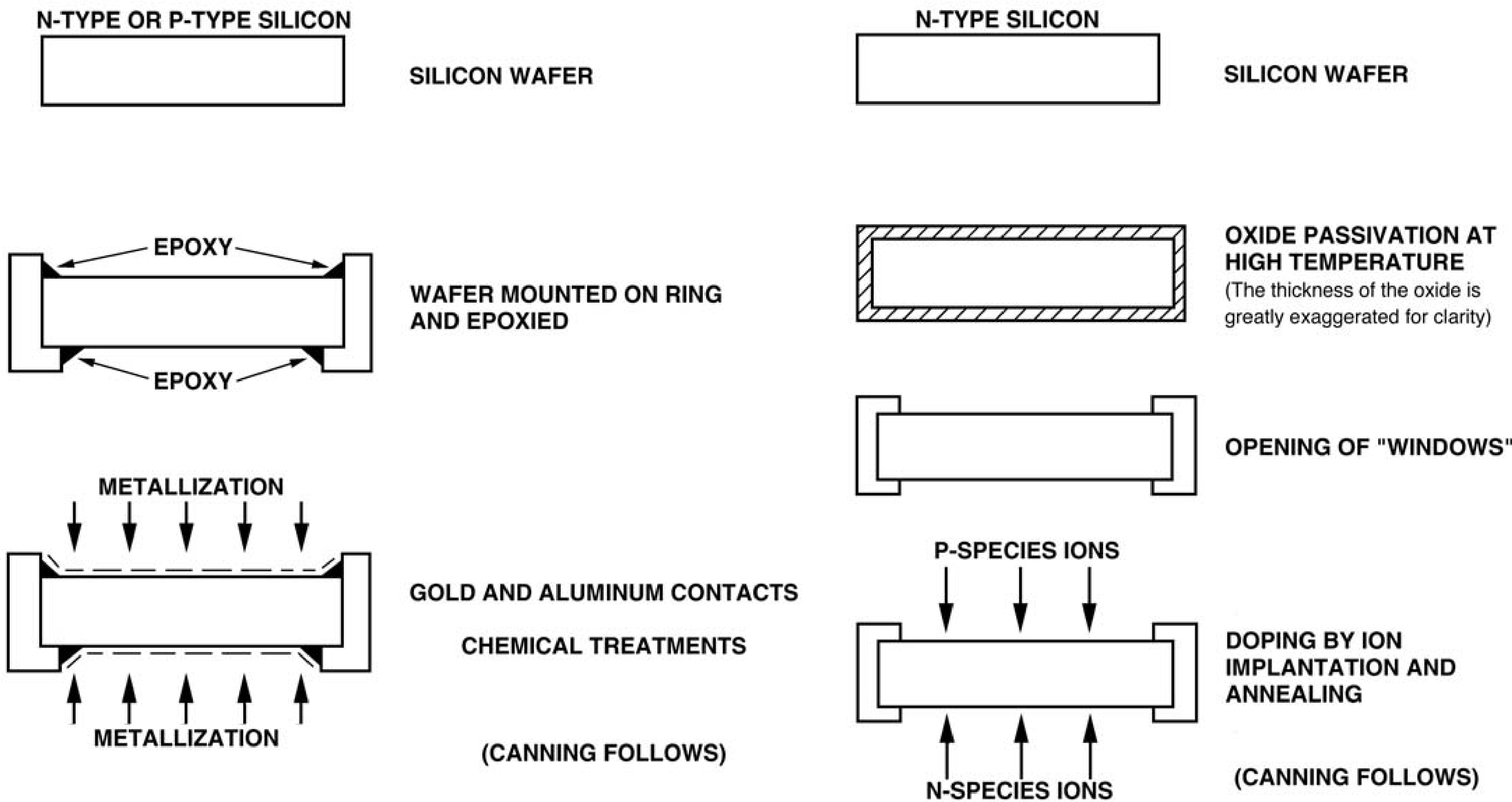
A crystal being grown



Grinding and slicing of a crystal

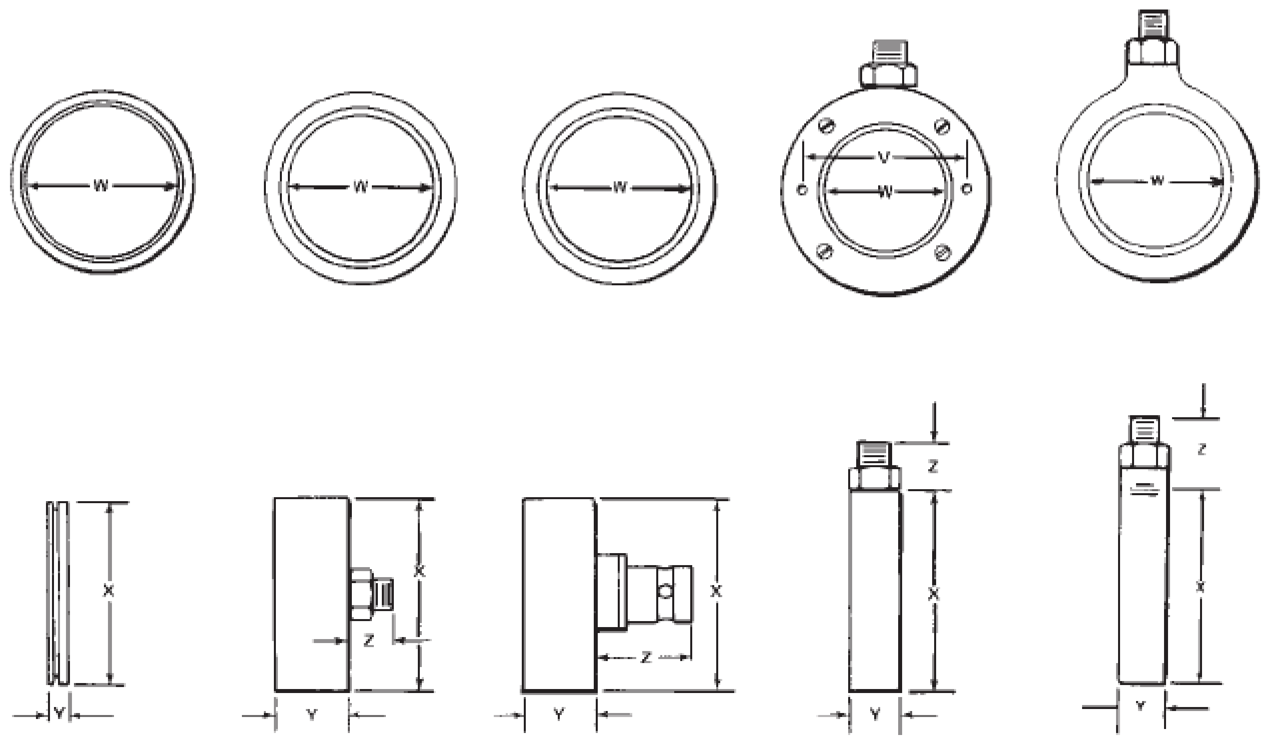
Charged Particle detector

how it is made?



- **Surface Barrier Si Detector**
- **Ion-Implanted Si Detector**

Charged Particle detector
form factors



Charged Particle detector

ICARE Si Detector

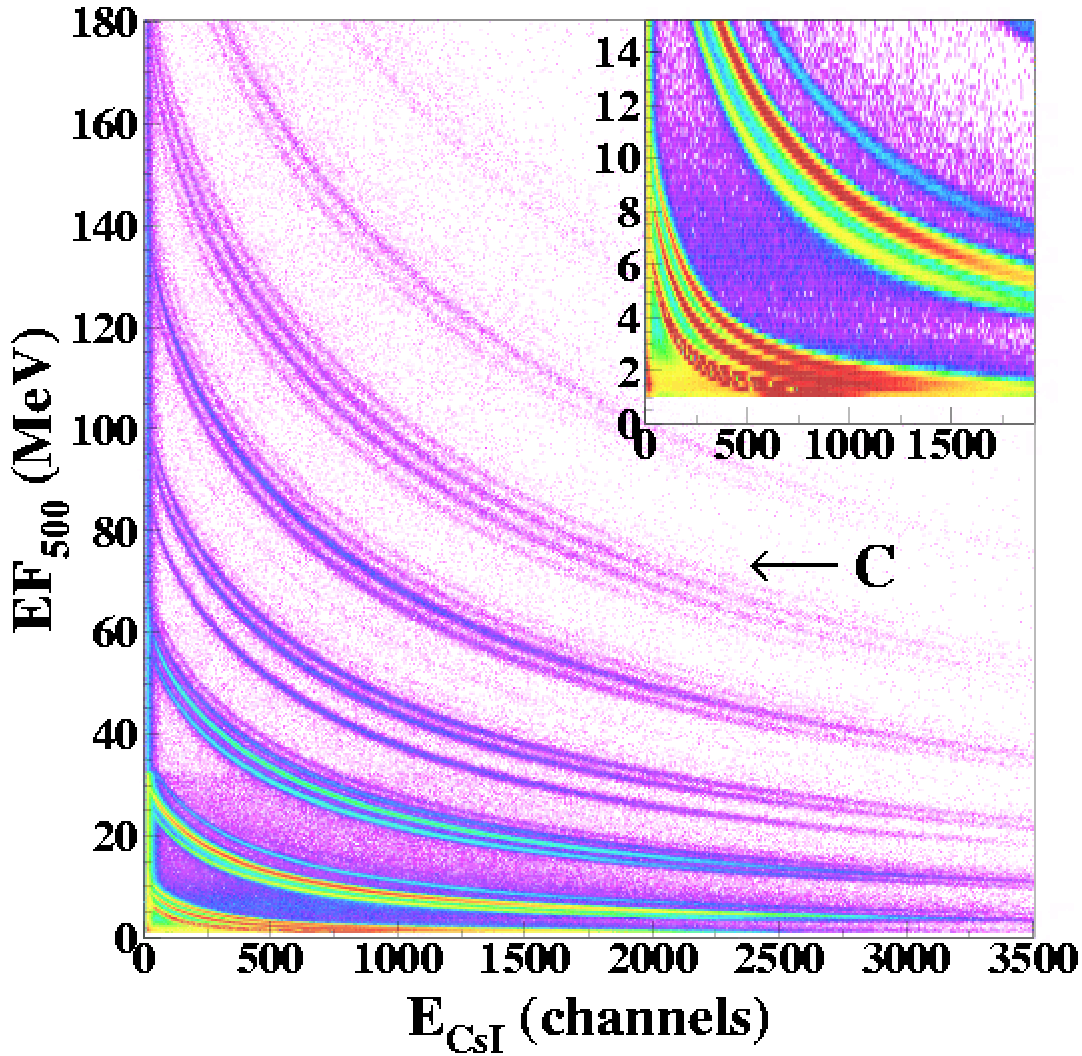
Particle detectors

- We will be using two types: silicon barrier detectors and gas detectors.
- ICARE uses gas/silicon combination as a particle identification E/ΔE telescope

ICARE telescope – disassembled

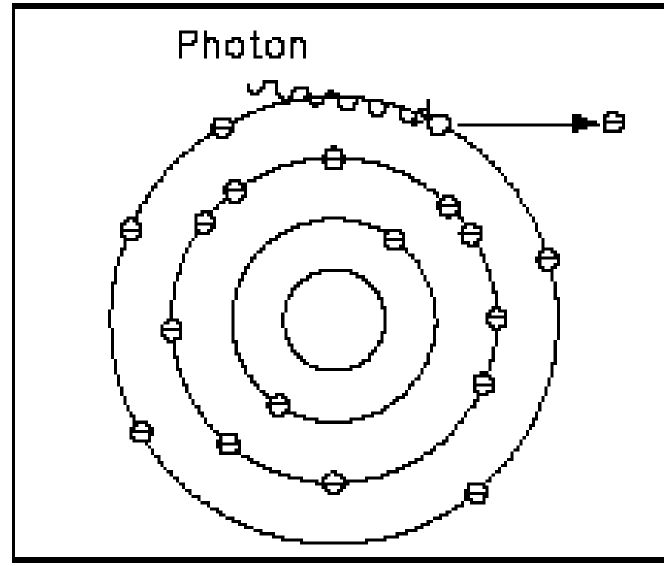
- Silicon part below
- Gas part put aside

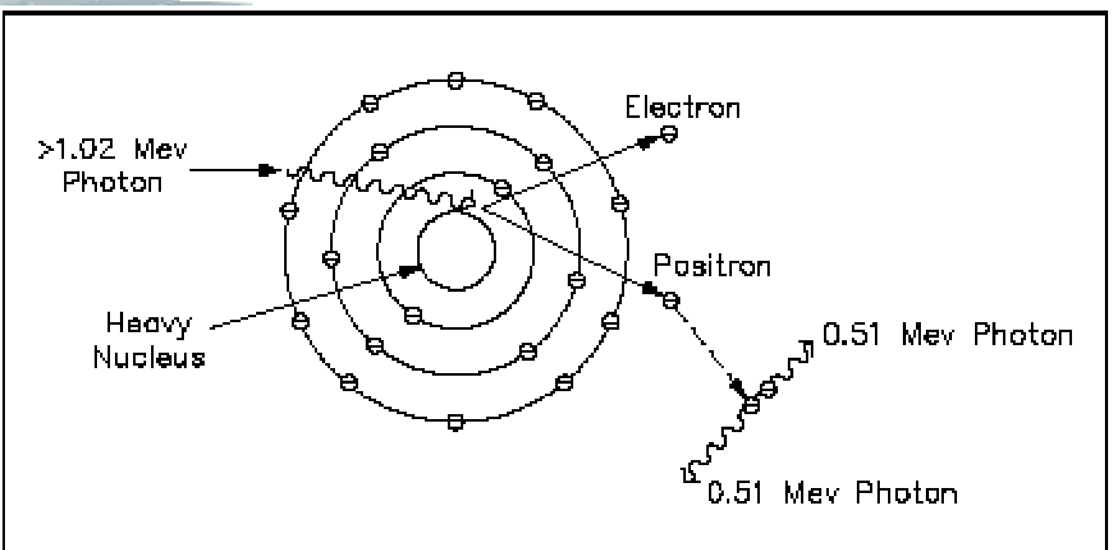
Charged particle identification:
E – ΔE telescope

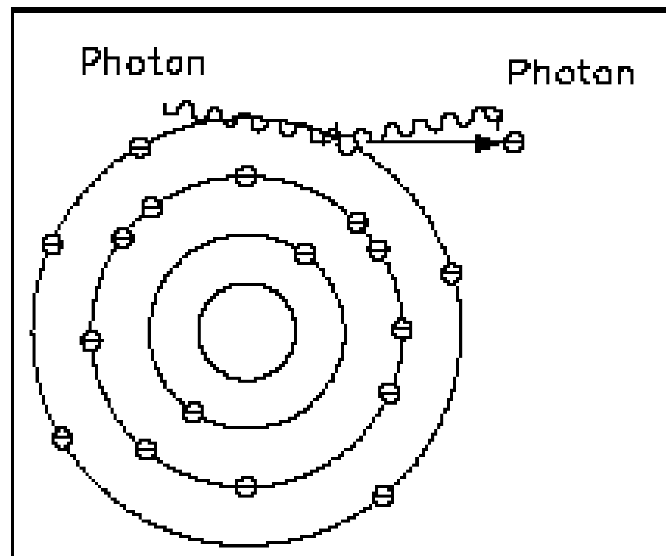


γ-ray interaction with matter

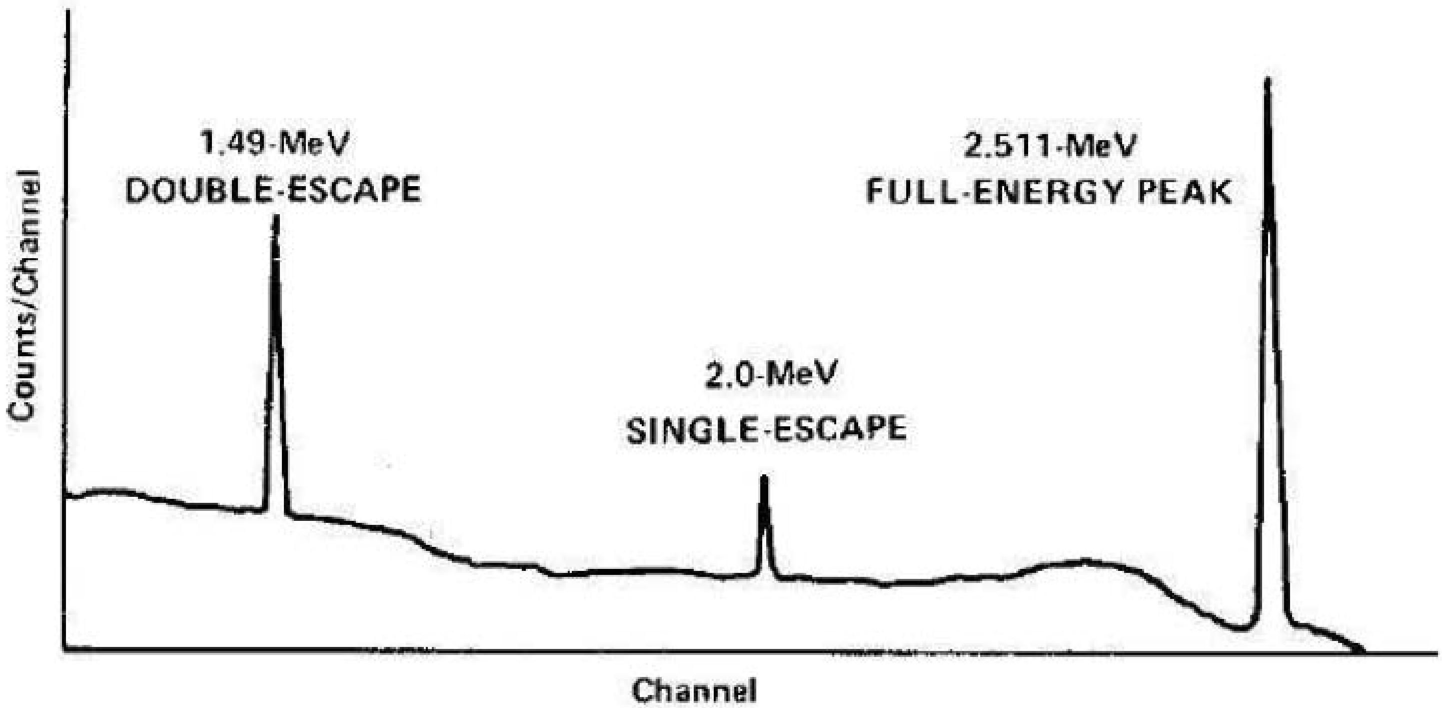
- Photoelectric effect
- Compton effect
- Pair creation

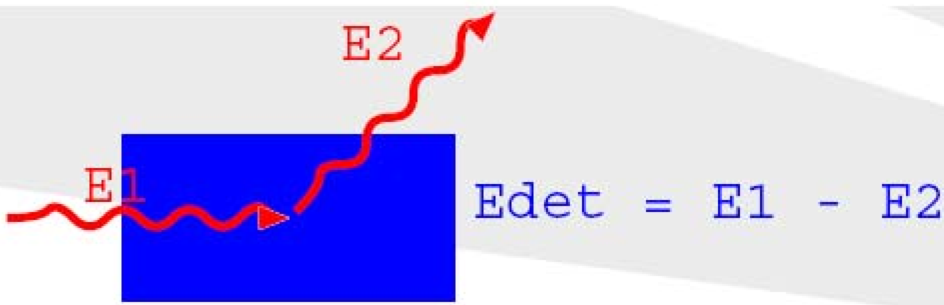




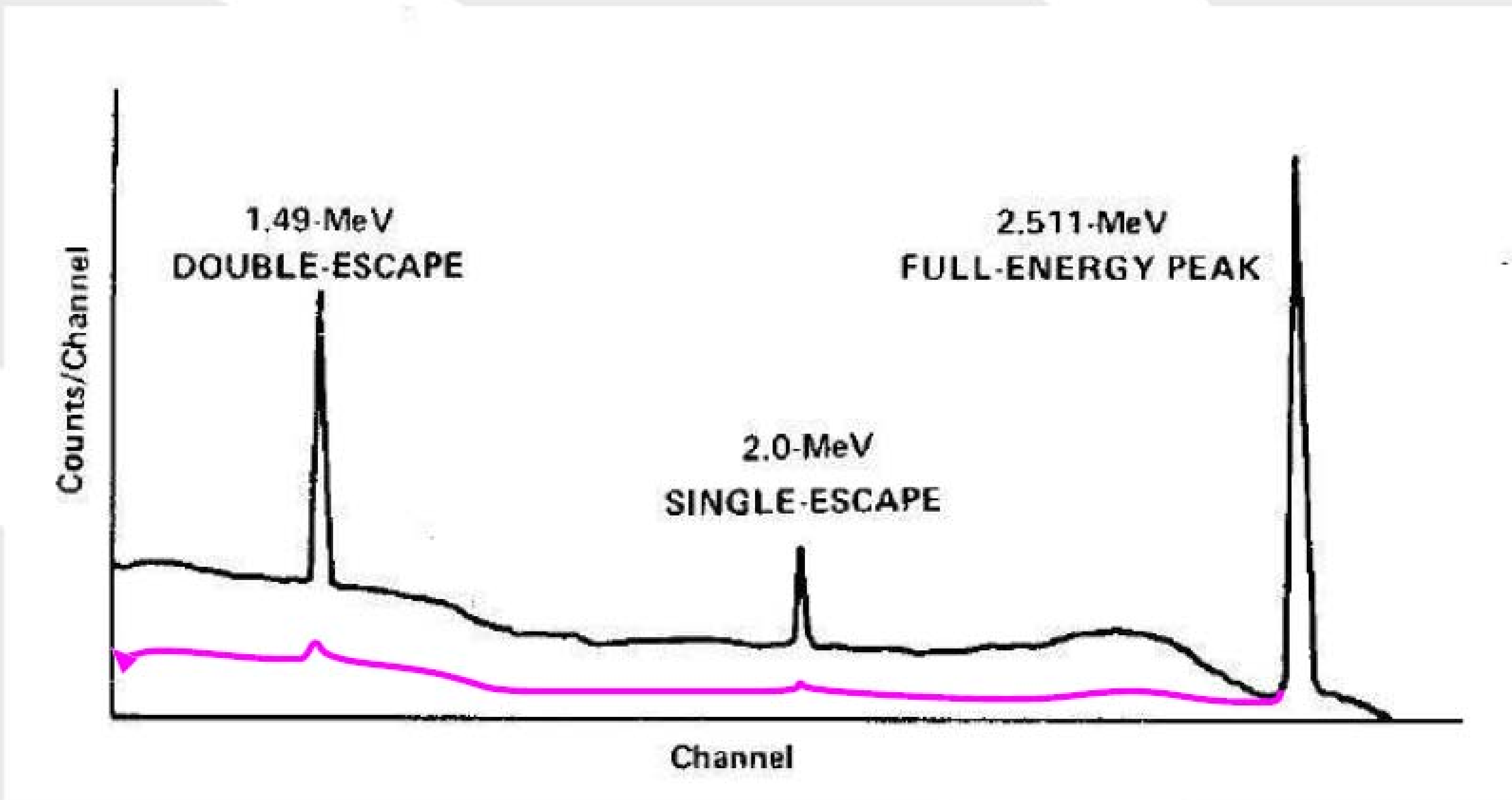


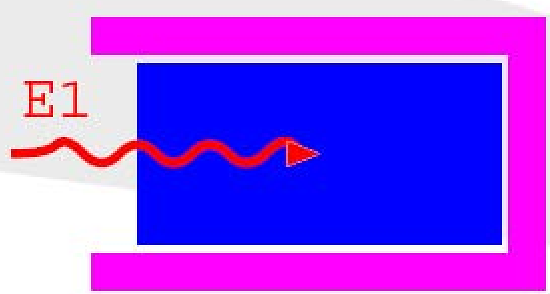
γ-ray energy spectrum
from a single crystal HPGE detector





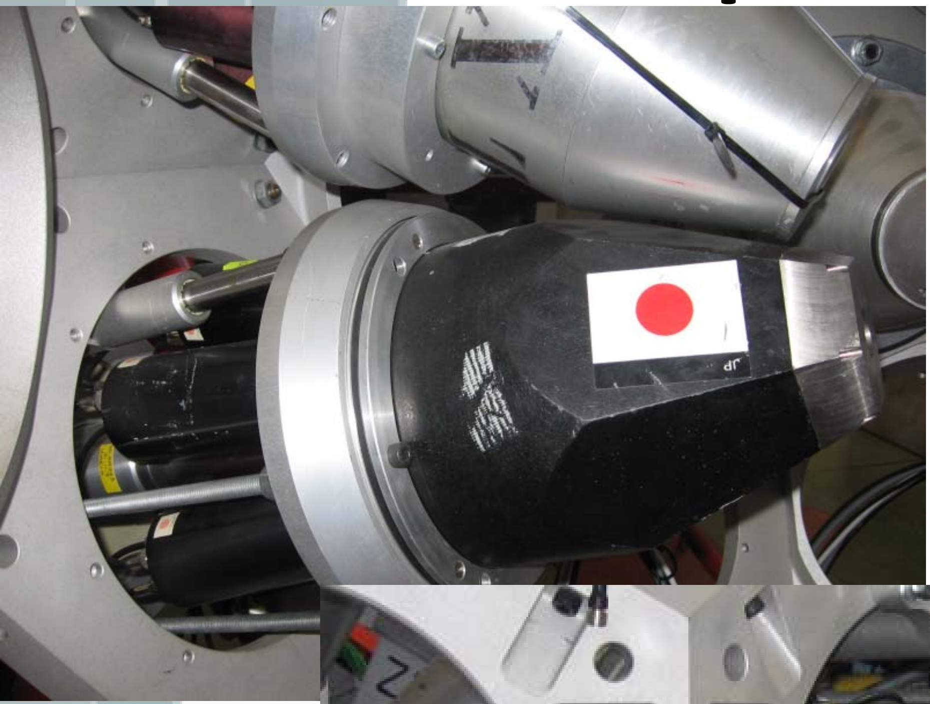
Anti-Compton shield



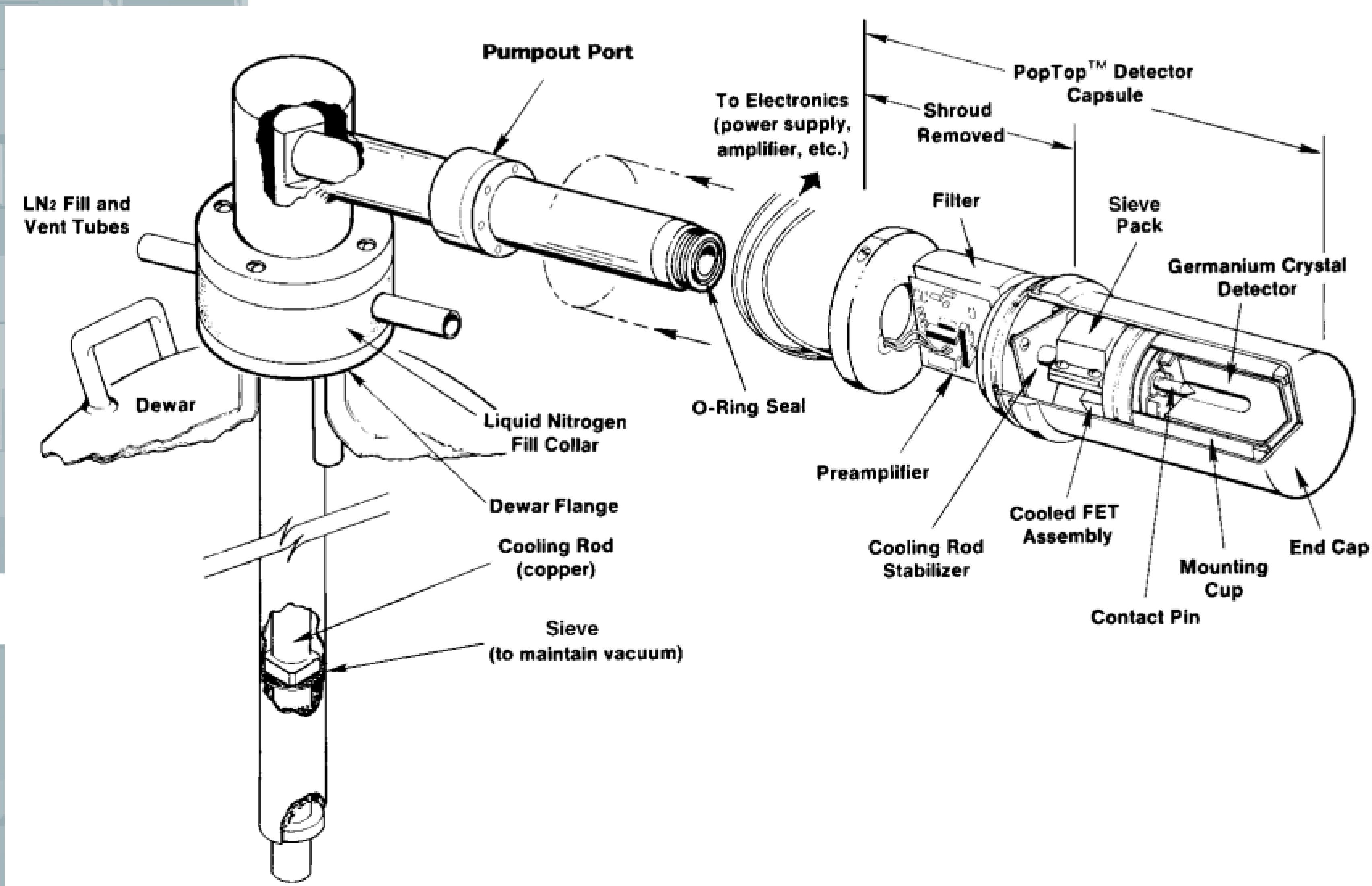


No anti-Compton shield

Anti-Compton shield (EAGLE)



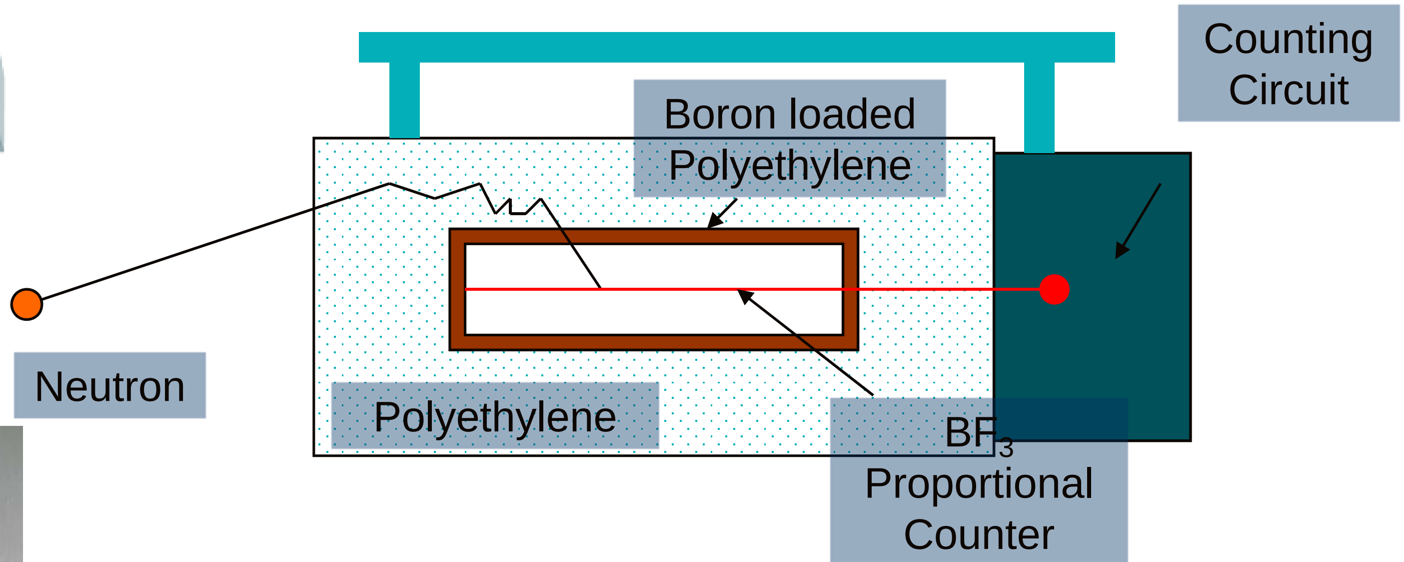
How a HPGe detector looks inside?



What you need to run it?

- Bias power supply
- Spectroscopy Amplifier
- Fast (timing) Amplifier

Neutron detector – (n,α) capture



← Radiation protection neutron detector (outside the HIL cyclotron vault)

Calibration of detectors
silicon detectors for charged particles

- Energy calibration – usually a good, linear response *(unless used for heavy, energetic particles)*
- Efficiency – one may safely assume they are 100% efficient

Calibration of detectors
scintillation detectors for charged particles

- Energy calibration – non-linear response
- Efficiency – 100% efficient

Calibration of detectors
HPGe detectors for gammas

- Energy calibration – linear response
- Efficiency – kind of complicated