Surface effects in Segmented Germanium Detectors

Lucia Garbini
Max-Planck-Institute for Physics

For the GeDet collaboration
Outline

- Introduction
  - physics goal and motivation

- Experimental set up
  - the detector prototype: SuperSiegfried
  - the test facility: GALATEA

- Top surface scanning
  - alphas in Germanium Detectors
  - first qualitative results

- Summary and Outlook
Physics goal and motivations:

**GOAL:**
characterization of detector response for alphas signals

**MOTIVATIONS:**

Alpha Background:
- Lead contamination on surfaces
- serious and often limiting
- $0
$ββ, Dark Matter searches

Study alpha events in a safe environment
- charge trapping
- detector's dead layer
Experimental setup:

Shoot alphas from $^{241}$Am on Super Siegfried (SuSie) inside GALATEA

SuperSiegfried:
- true coaxial n type HPGe detector
- 18 segments: 6 in $\varphi$, 3 in $z$
- 19th segment unsegmented in $\varphi$

GALATEA:
- vacuum chamber
  - low penetrating sources
- cryo tank to cool down the detector
- 3 motors to move 2 collimators in 3D
  - alpha source placed in the top one
- electronics inside
What do we expect in our detector?

**Alphas** = heavy charged particles
- they lose energy by dE/dx
- short path inside the detector
  - surface events
  - long pulses
- alphas from the $^{241}$Am
  - all with the same Energy $\sim$ 5 MeV
  - all the same penetration depth

The final result depends on the combination of:

1) geometrical effect
- different incident angle
  - different path inside the dead layer
  - different energy deposited inside the detector

2) stochastic effect
- charge trapping

![Diagram of detector with alphas and gammas]
Alphas in the energy spectrum

Alpha Scan: $r = 30$ mm $\phi = 262$

- Alpha Bump:
  - only in the 19th
  - different energy
Alphas in the pulses

- long pulse in the 19th seg
- mirror pulses
- mirror pulses + charge trapping
Top surface scanning

Scanning along the radius:
- fixed angle: varying the radius with steps of few mm
- check the different paths for the charge carriers
  - close to the surfaces

- point of interaction

→ electrons

→ holes

Scanning along the azimuthal angle:
- fixed radius: varying the angle with steps of few degrees
- check the effect of the Electric Field
  - change on the collection efficiency

- point of interaction

→ electrons

→ holes
Scanning points along the radius: core comparison

- no bumps at small radii
  → thick dead layer
- farther from the core
  → less energy recorded
Scanning point along the radius: Seg 19 comparison

- no bumps at small radii
  → thick dead layer
- closer to the outer surface
  → more energy recorded

Seg19 Spectra for different radius and $\varphi = 262^\circ$
Scanning points along azimuthal angle: core comparison

Core Spectra for different azimuthal angle and $r = 26$ mm

- closer to the metallization
  → less distorted E field
  → better charge collection
Scanning points along the azimuthal angle: seg19 comparison

Seg19 Spectra for different azimuthal angle and \( r = 26 \text{ mm} \)

- closer to the metallization
  → less distorted \( E \) field
  → better charge collection
Summary and Outlook:

Conclusions:

- alpha events are perfect candidates to study surface effects in Segmented Germanium Detectors

- operating SuperSiegfried in vacuum, as in GALATEA, allows us to use alpha sources to scan the detector

- difference of energy read by the core and the segment is a clear tracer of surface effects that can be used to reject these events as bkg events

What's next:

- extract informations about the effective dead layer from the energy spectra

- complete the characterization of the response to alpha particles

- try to define a parameter to reject alpha background based on the difference between the core energy and the segment energy
Backup slides
From a top surface scanning point:

**USING a source data set:**

- clear **structure** due to alphas
  - ratio plot
  - correlation plot
- **difficult to avoid the misidentification**
- **not only in the 19\(^{th}\) segment**
  - also in the segments underneath (→ mirror pulse)
- possible way to get rid of the alphas:
  - scan on the energy of the alphas
- **still MISSING** the automation
Zoom on the low energies:
- 59 keV gamma from the $^{241}\text{Am}$
- 57 keV $\alpha$ from $^{74}\text{W}$

Core comparison: $\phi = 272$

- different height different thickness of the dead layer
Data Analysis: alphas in the pulses

Seg19 comparison: phi = 272
Data Analysis: scanning points along the radius

Zoom on the low energies:
- 59 keV gamma from the $^{241}$Am
- 57 keV kα from $^{74}$W

Core comparison: $r = 26$ mm

Not uniform dead layer
Data Analysis: scanning points along the radius

Seg19 comparison: $r = 26$ mm

Counts

E / keV

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