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Surface effects in Segmented Germanium Detectors

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For the GeDet collaboration

Outline

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- **Experimental set up**
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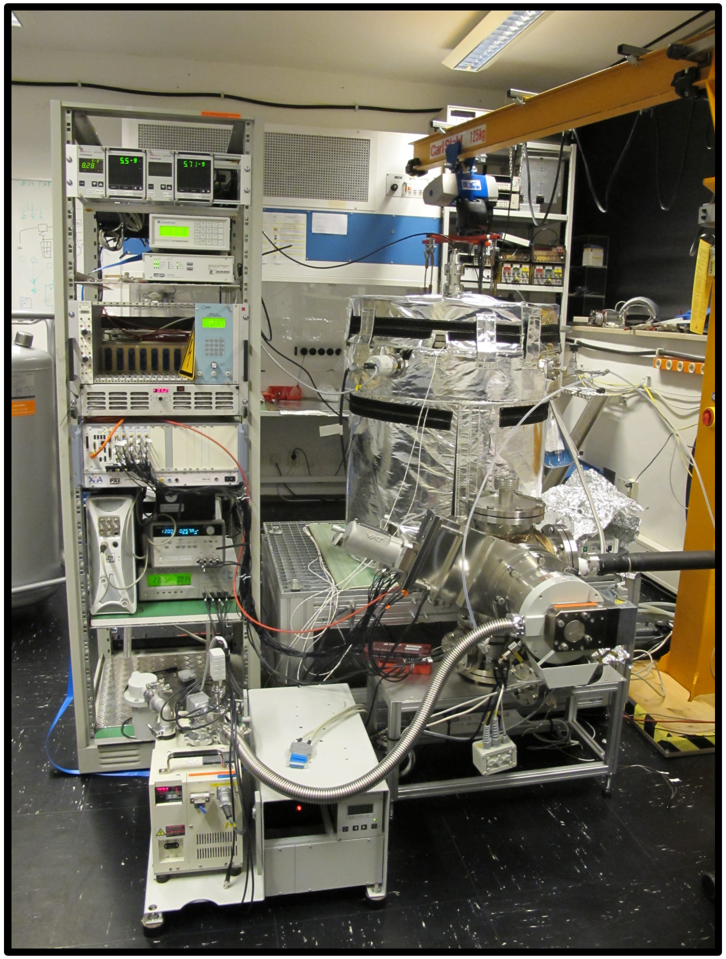
  - the test facility: **GALATEA**
- **Top surface scanning**
  - alphas in Germanium Detectors
  - first qualitative results
- **Summary and Outlook**



Physics goal and motivations:

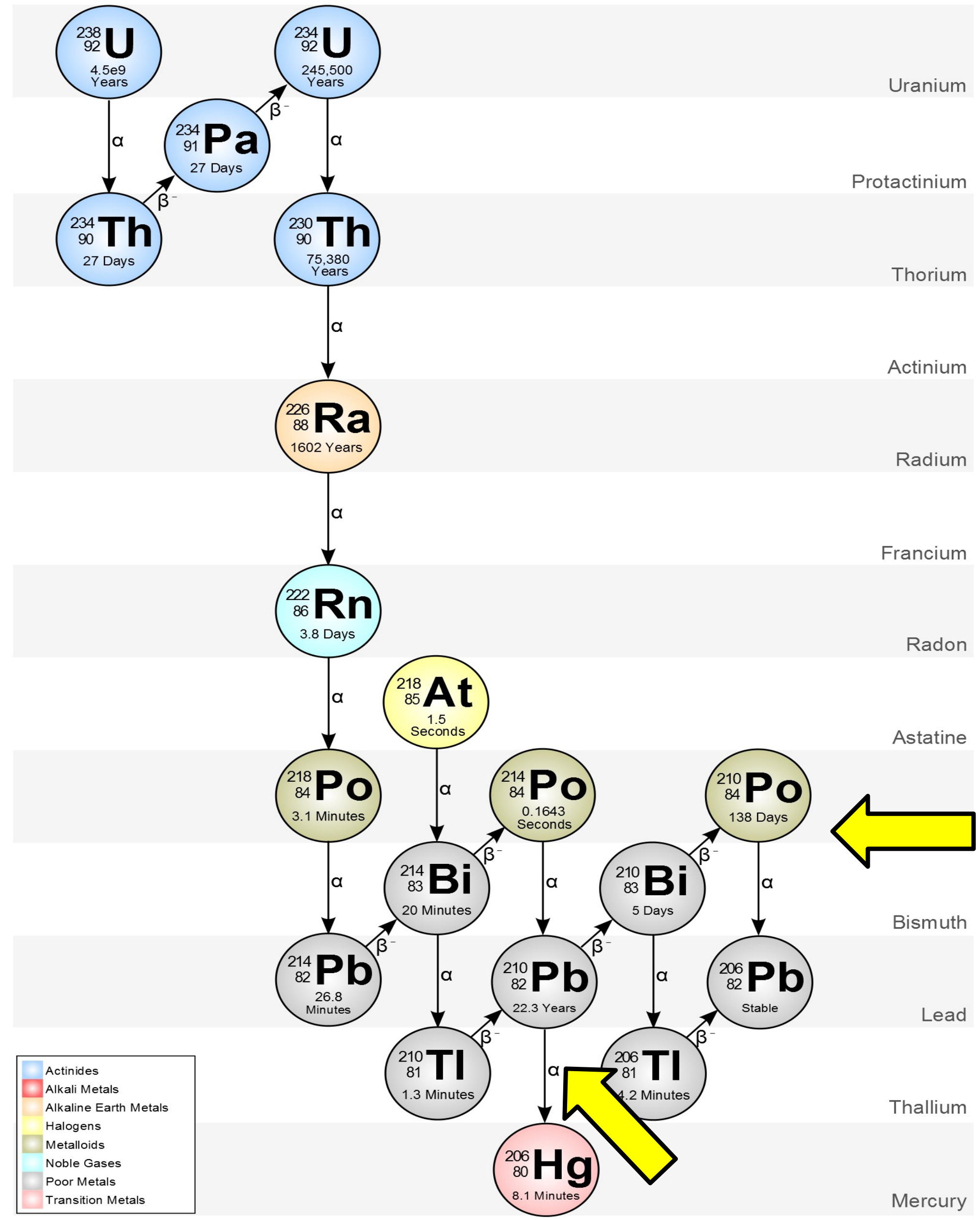
GOAL:

characterization of detector response
for **alphas signals**

MOTIVATIONS:

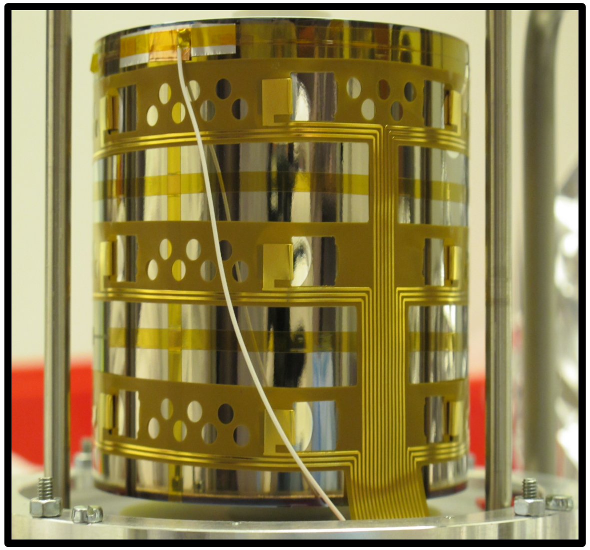
Alpha Background:
- Lead contamination on surfaces
- serious and often limiting
- 0νββ, Dark Matter searches

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



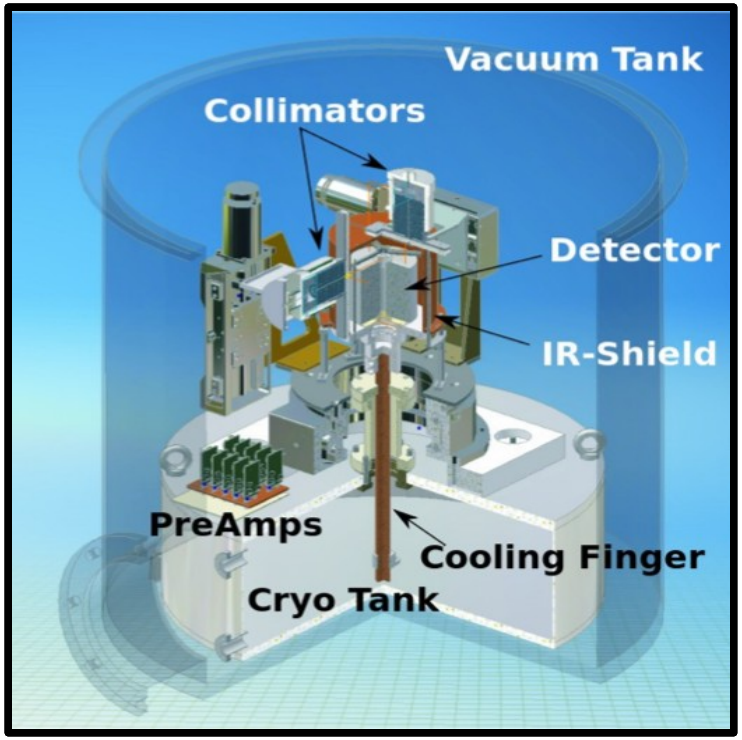
Experimental setup:

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



SuperSiegfried:

- true coaxial n type HPGe detector
- 18 segments: 6 in φ, 3 in z
- 19th segment unsegmented in φ



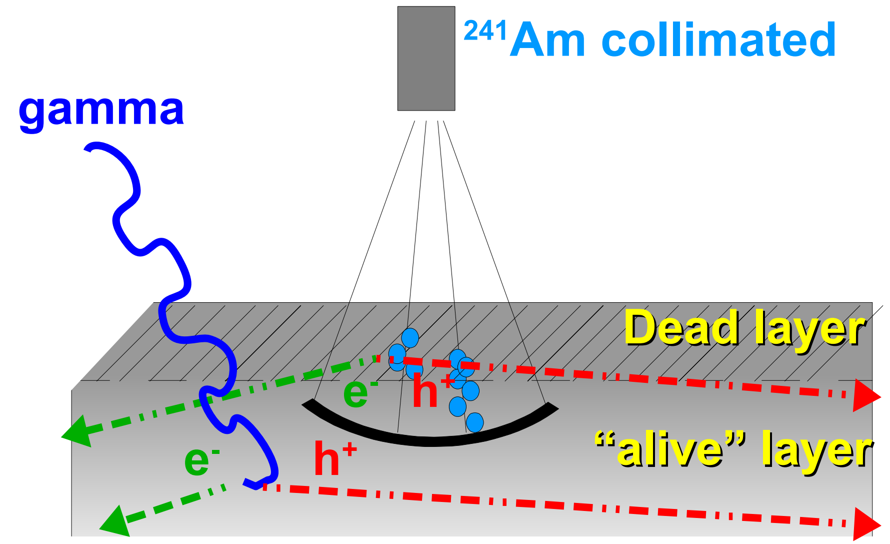
GALATEA:

- 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

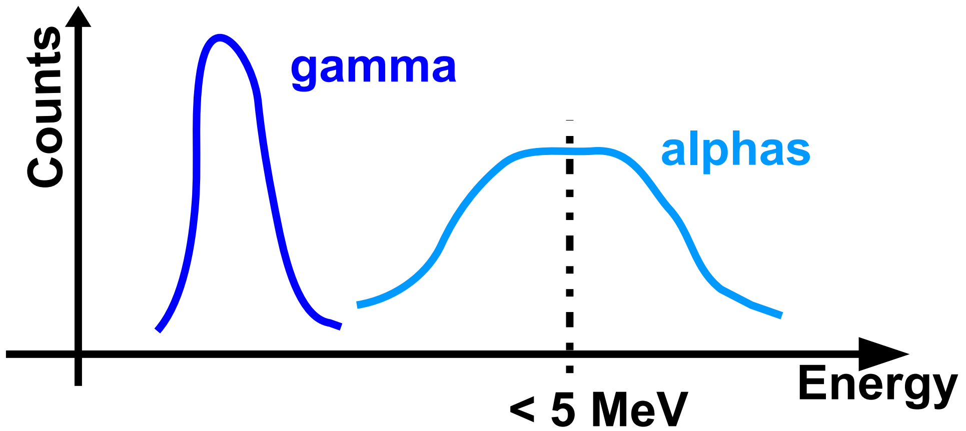
- **alphas from the ^{241}Am**
  - all with the same Energy ~ 5 MeV
  - all the same penetration depth



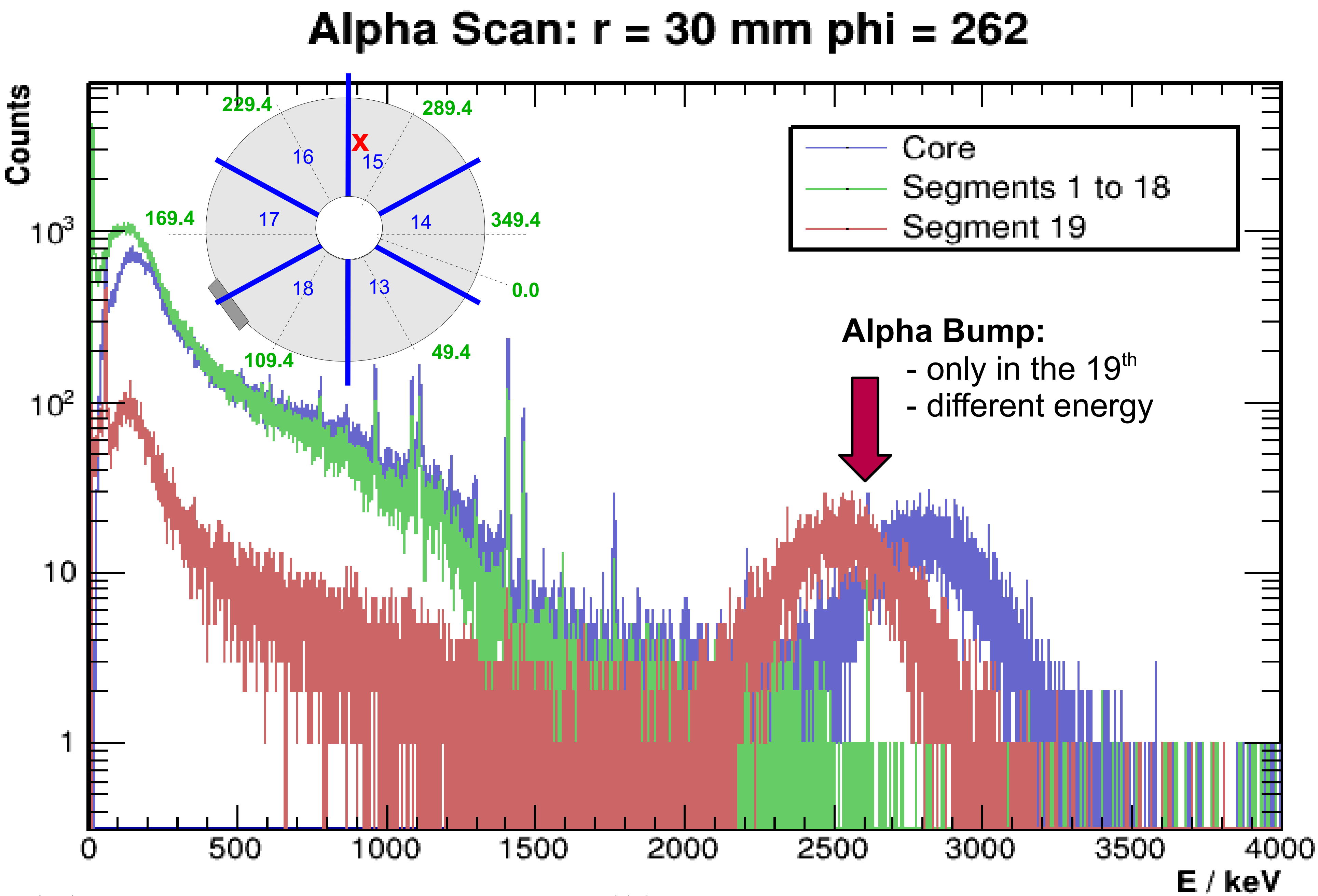
The final result depends on the combination of:

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

2) stochastic effect
- charge trapping

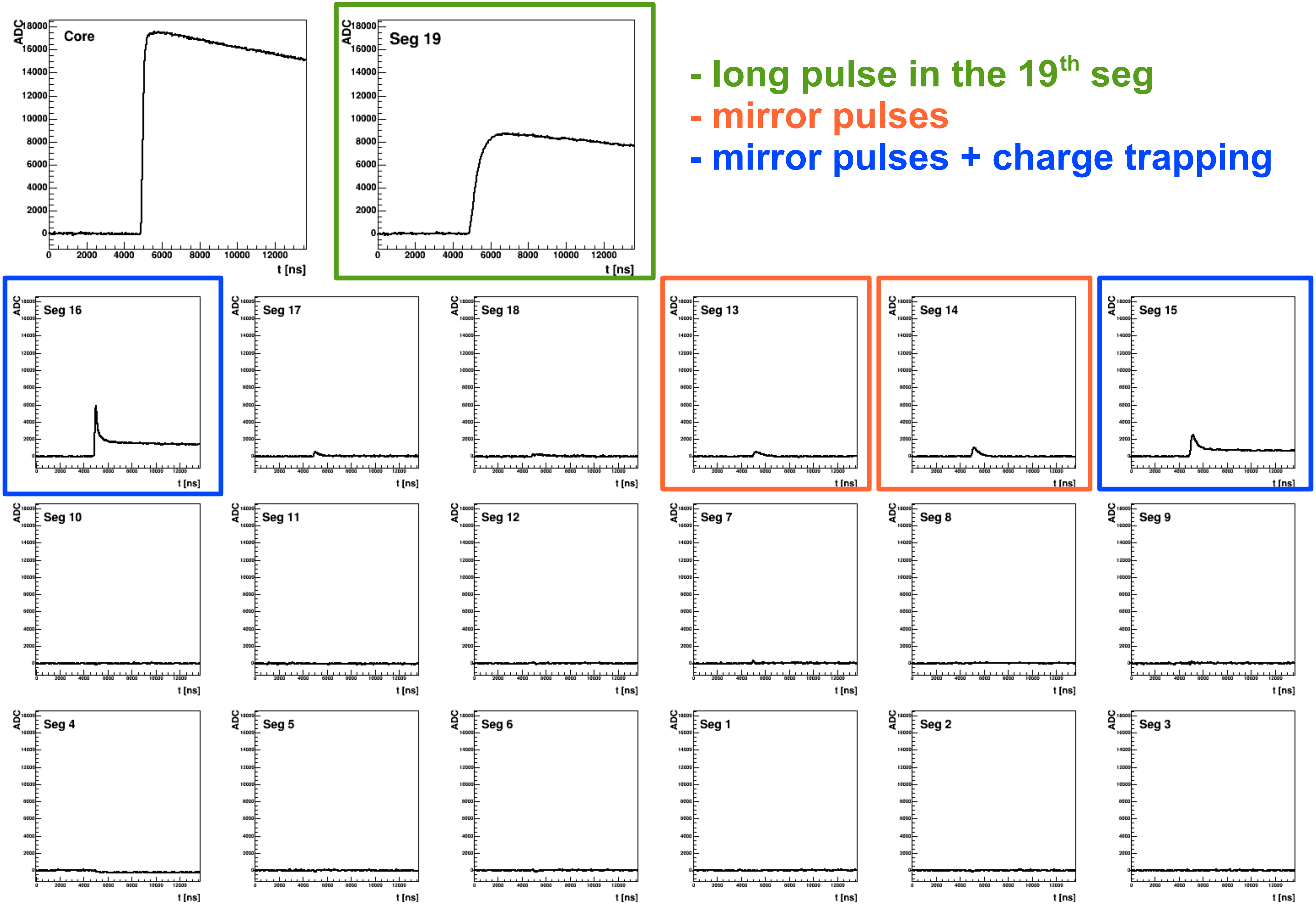


Alphas in the energy spectrum



Alphas in the pulses

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

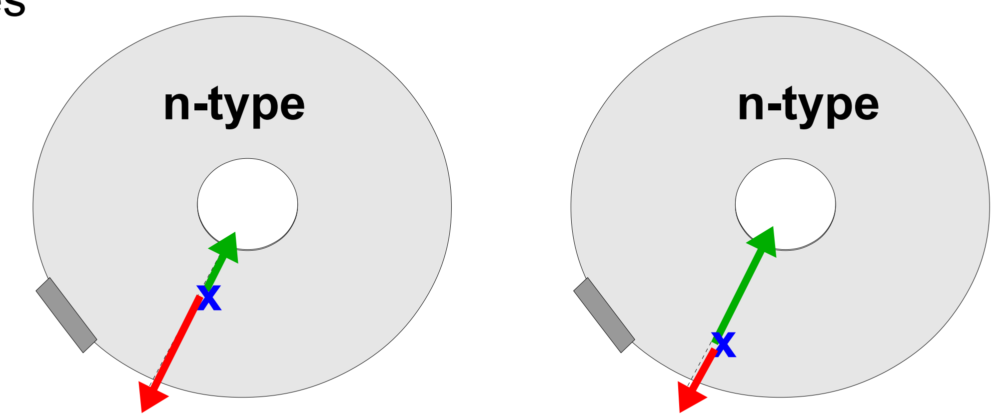


Top surface scanning

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

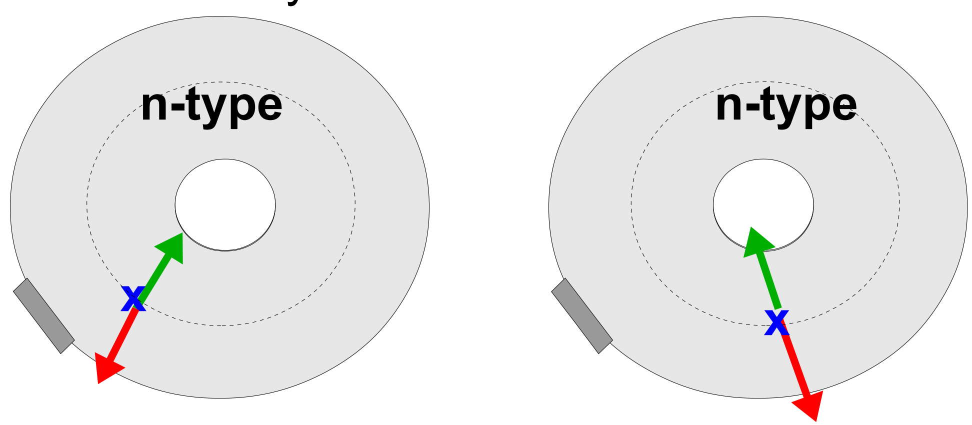
x point of interaction
→ electrons
→ holes



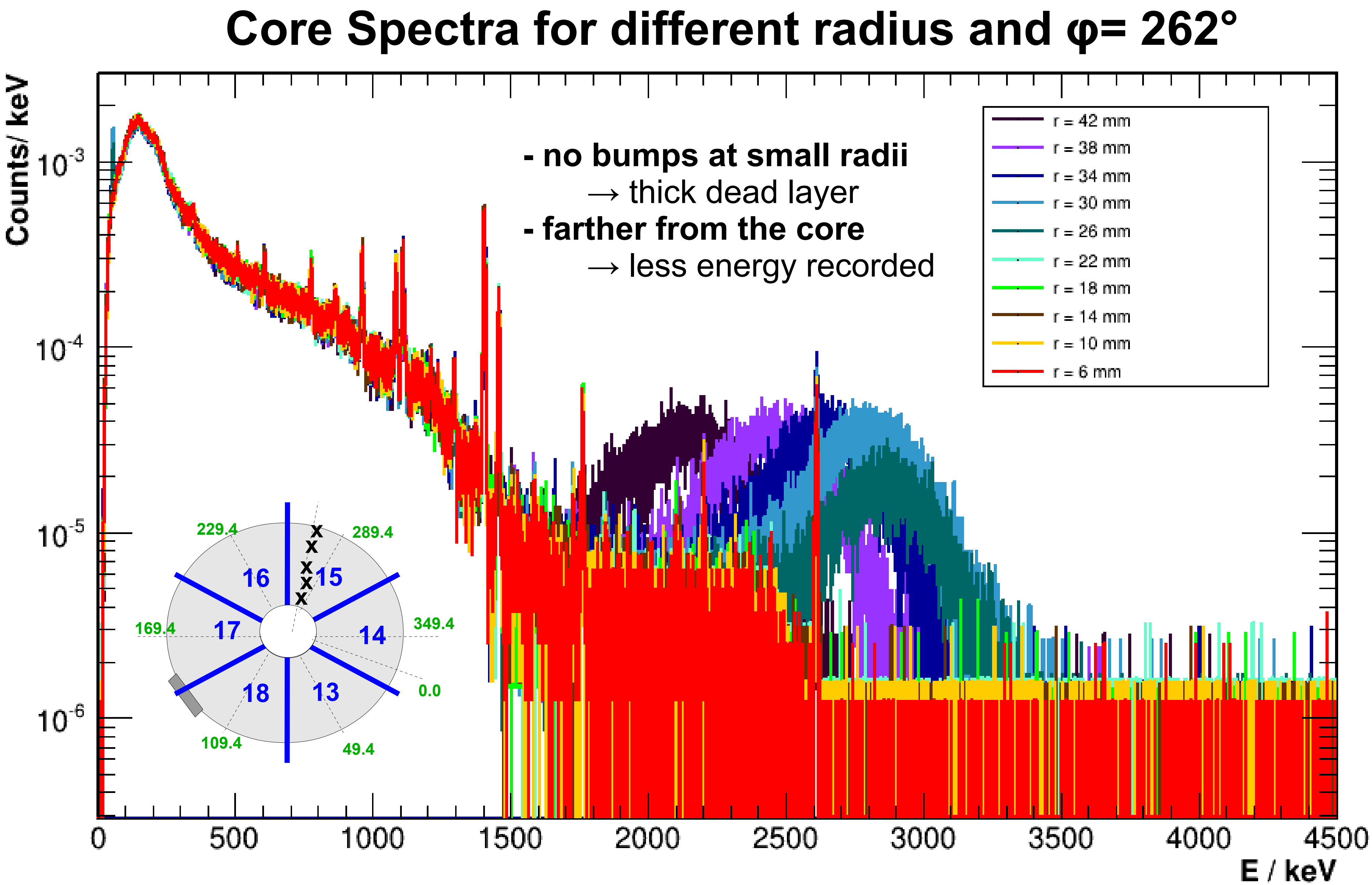
Scanning along the azimuthal angle:

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

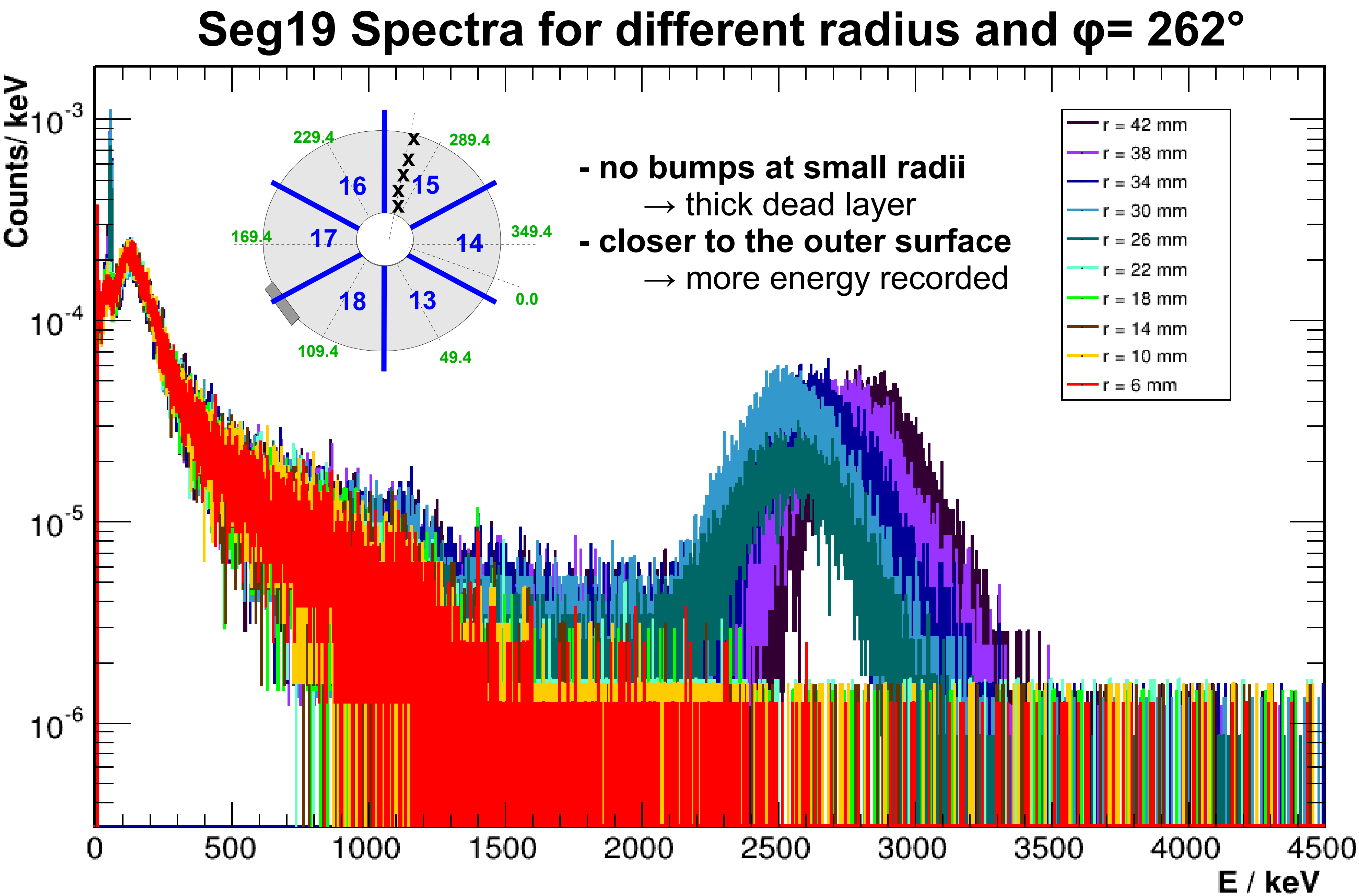
x point of interaction
→ electrons
→ holes



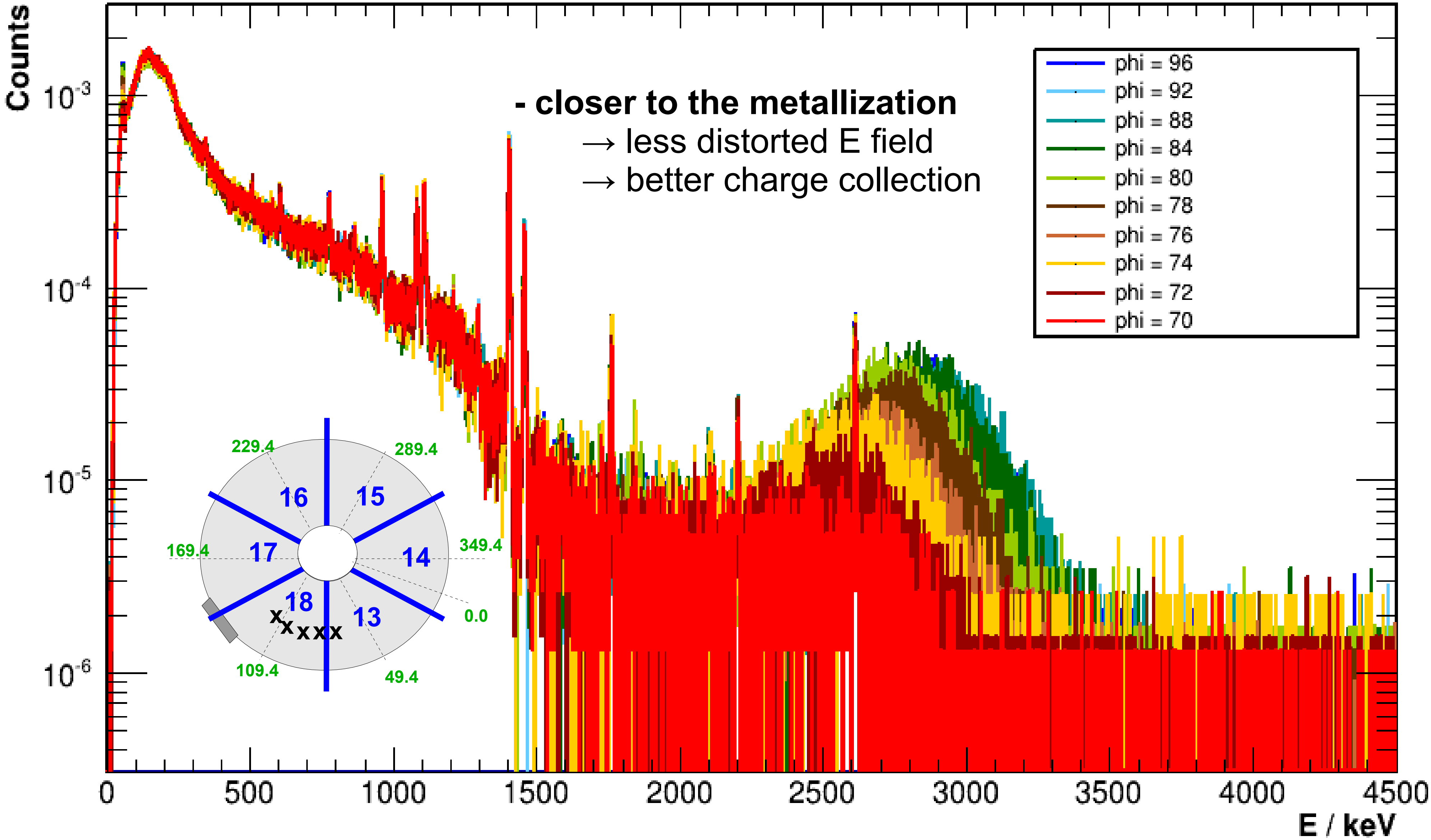
Scanning points along the radius: core comparison



Scanning point along the radius: Seg 19 comparison

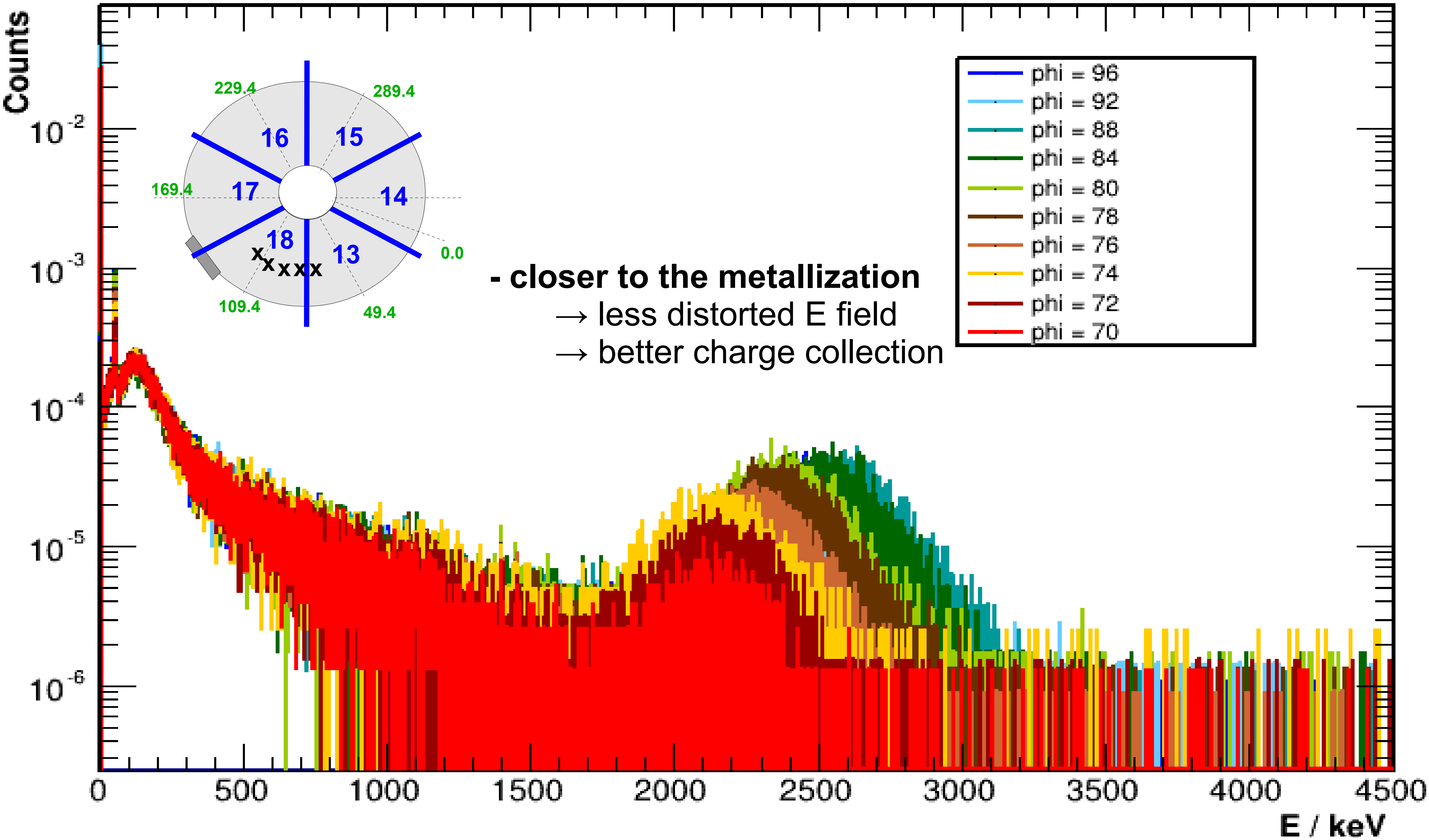


Core Spectra for different azimuthal angle and r = 26 mm



Scanning points along the azimuthal angle: seg19 comparison

Seg19 Spectra for different azimuthal angle and r = 26 mm



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

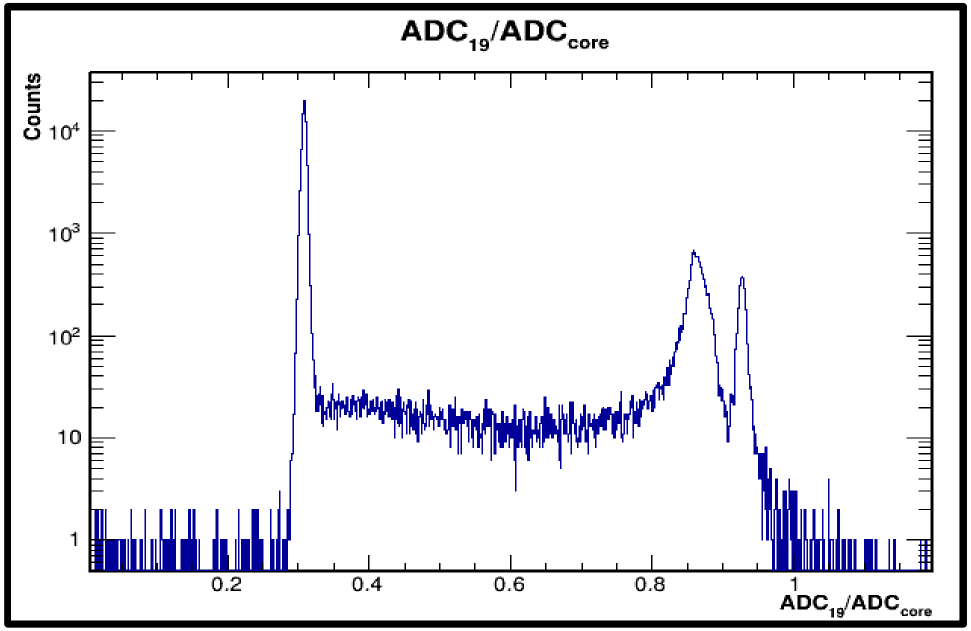
- complete the characterization of the response to alpha particles

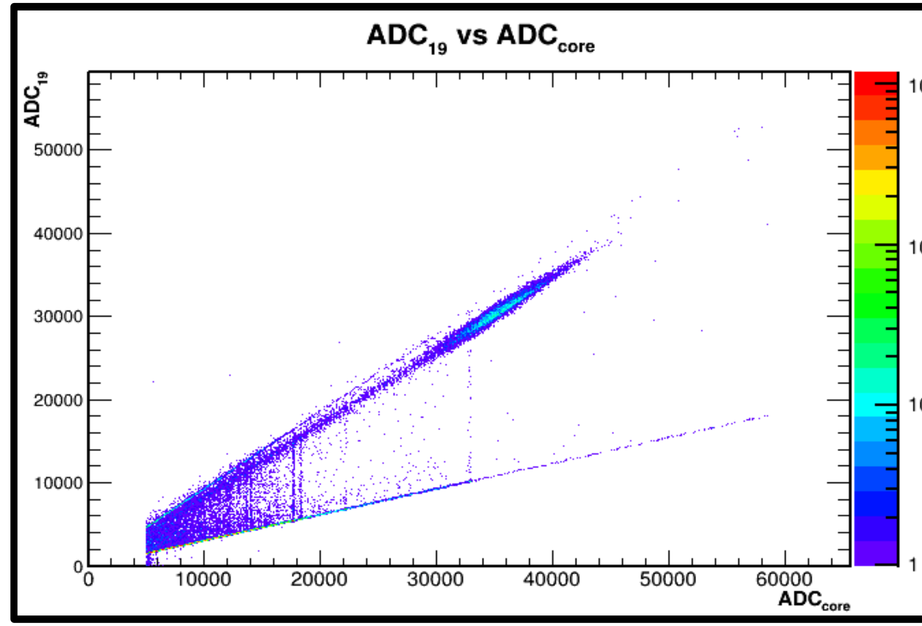
- try to define a parameter to reject alpha background based on the difference between the core energy and the segment energy

Backup slides

Calibration: need a strategy

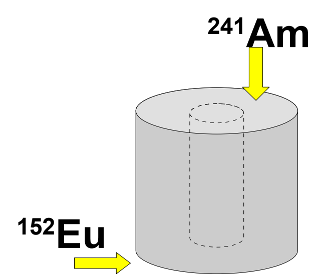
From a top surface scanning point:





USING a source data set:

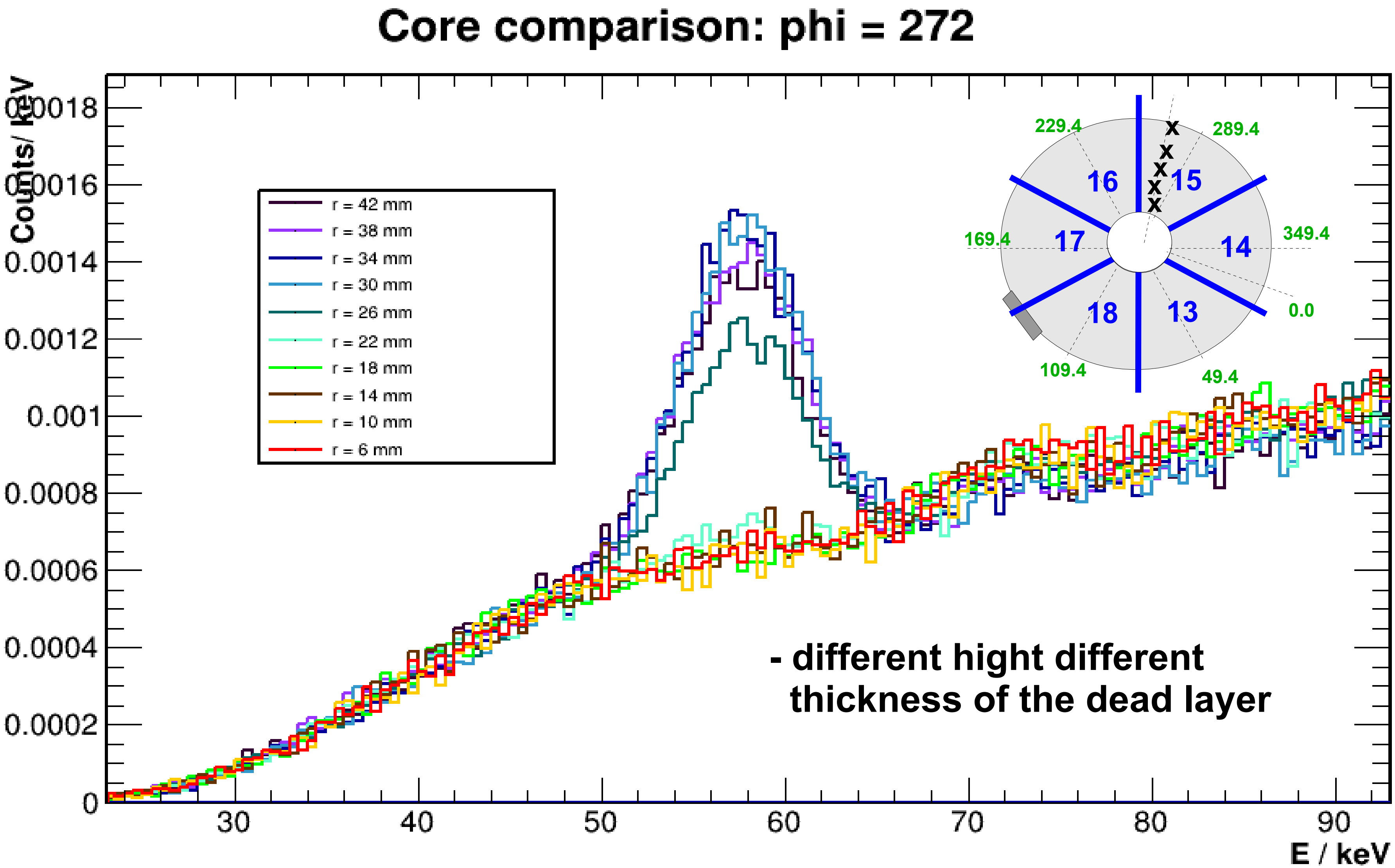
- clear **structure** due to alphas
  - ratio plot
  - correlation plot
- **difficult to avoid the misidentification**
- **not only in the 19th segment**
  - also in the segments underneath (→ mirror pulse)
- possible way to get rid of the alphas:
  - scan on the energy of the alphas
- **still MISSING the automation**



Data Analysis: alphas in the pulses

Zoom on the low energies:

- 59 keV gamma from the ^{241}Am
- 57 keV kα from ^{74}W



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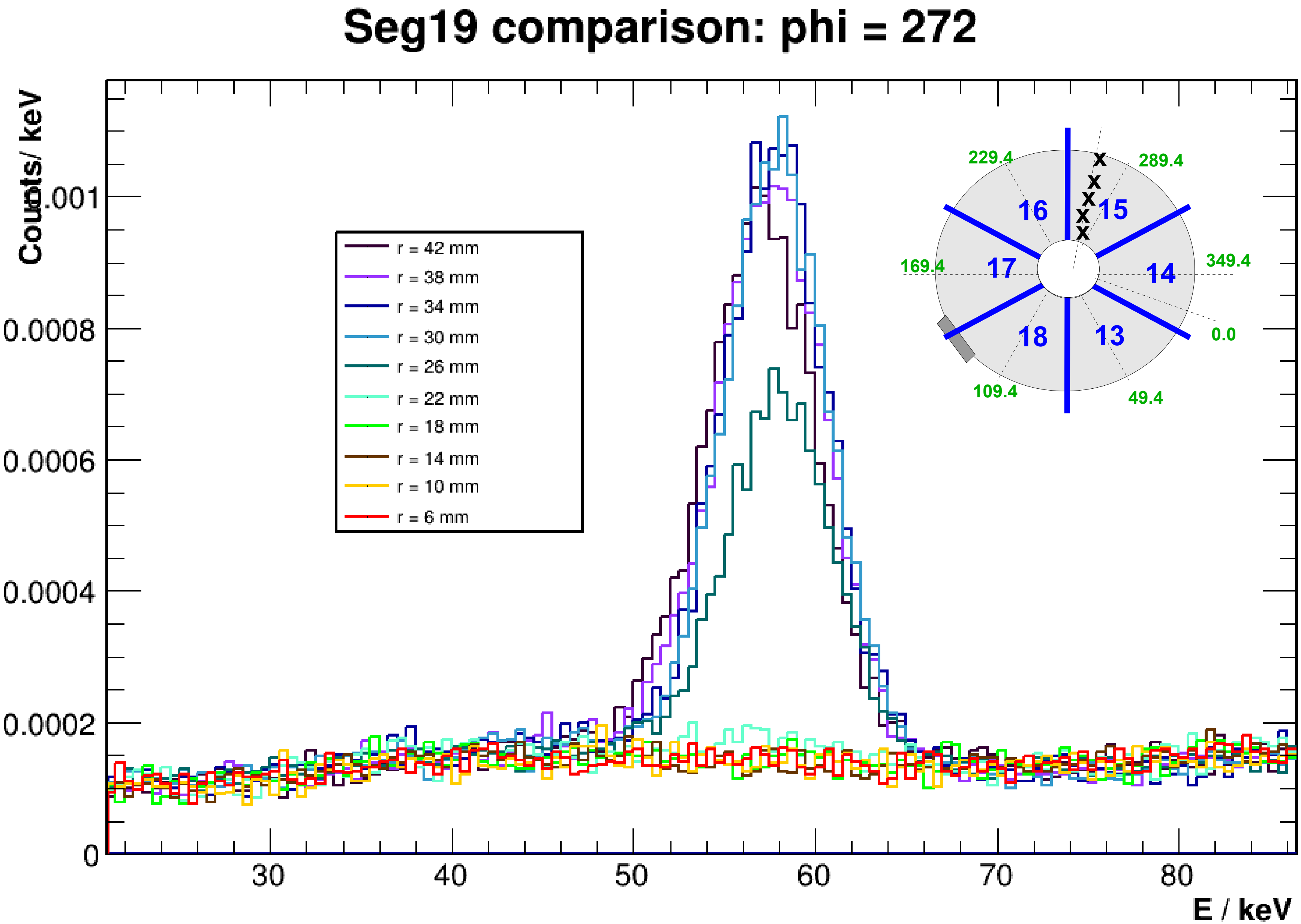

Data Analysis: scanning points along the radius

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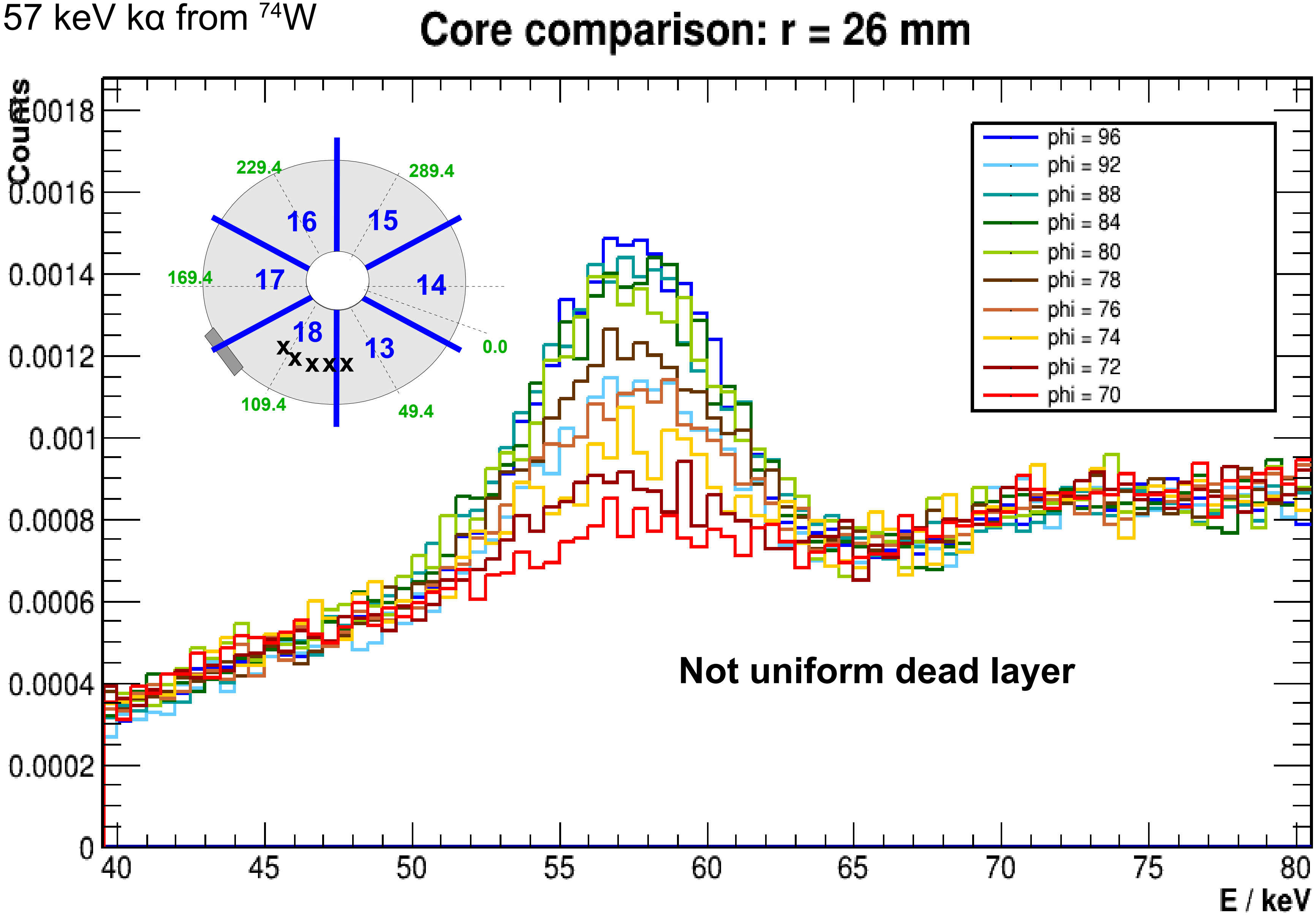

Data Analysis: scanning points along the radius