Munich Detector Test Stands

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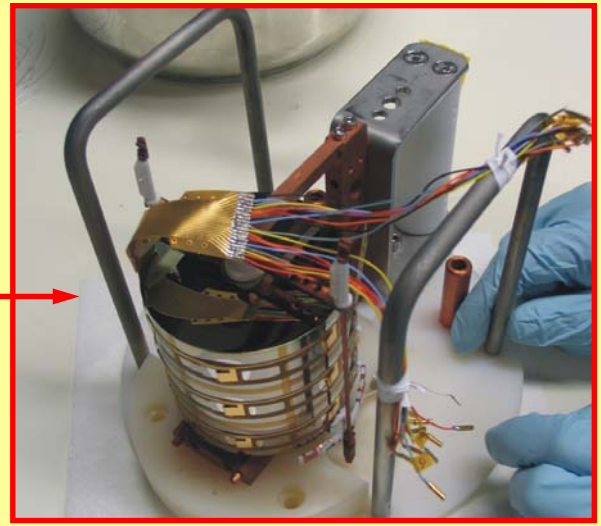
for

MPI für Physik, München

Two Test Stands

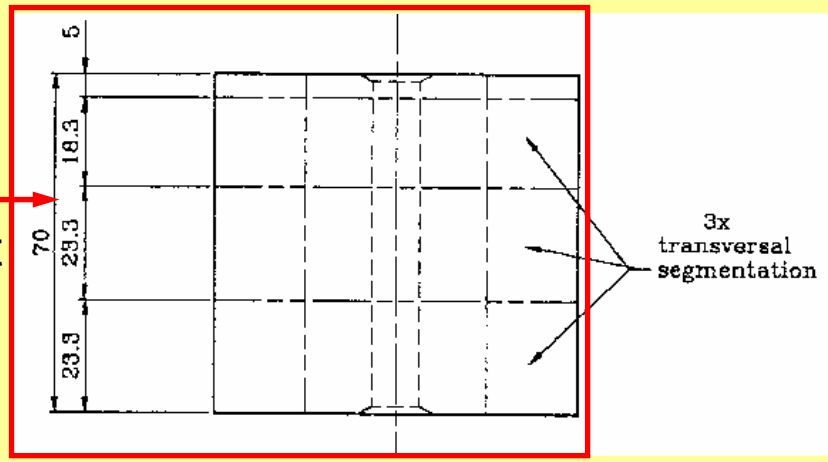
18-fold segmented detector

- History: “Siegfried 1” detector was operated in vacuum
- Last months: “Siegfried 2” detector was operated in LN
  → 1st time segmented Ge detector directly in Cryo Liquid

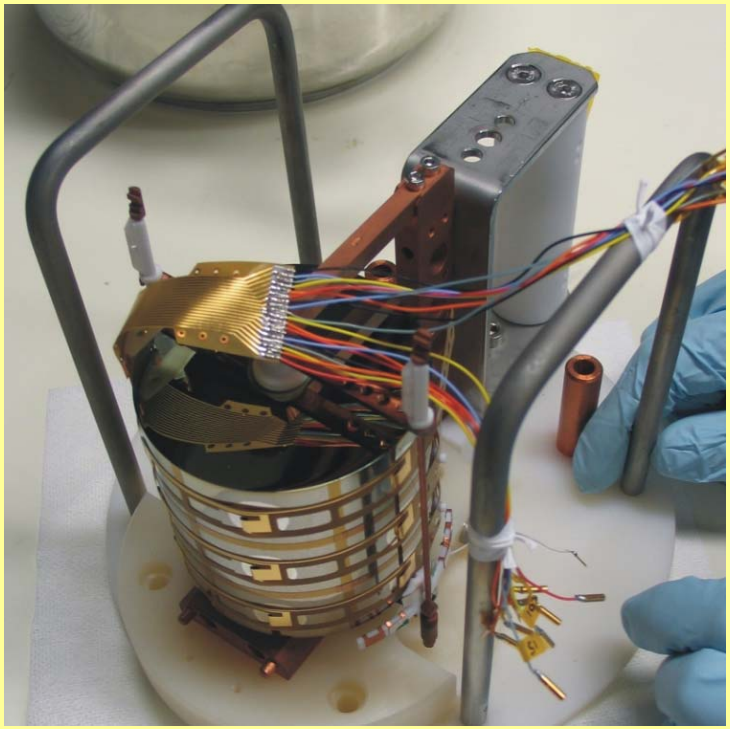


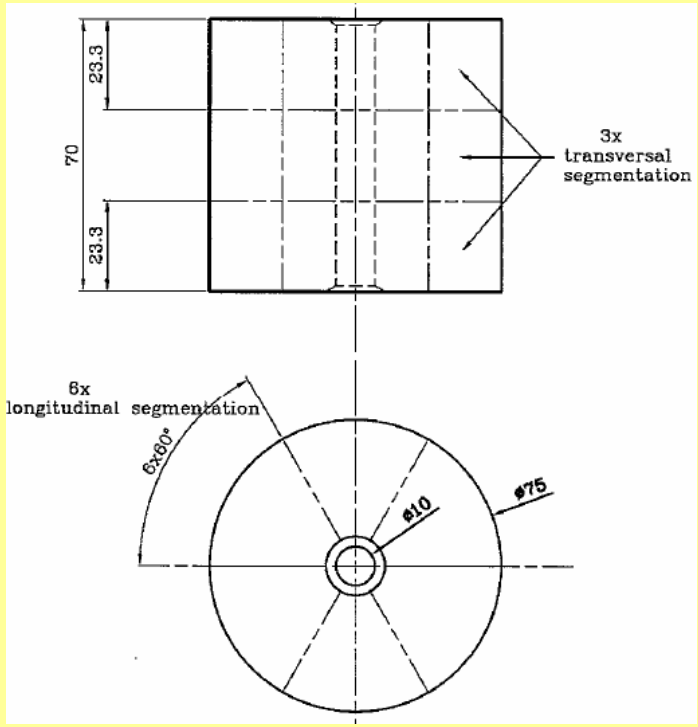
19-fold segmented detector

- “SuSi” (Super Siegfried) operated in conventional test cryostat similar to Siegfried 1



Geometry of 18-fold Segmented Detector



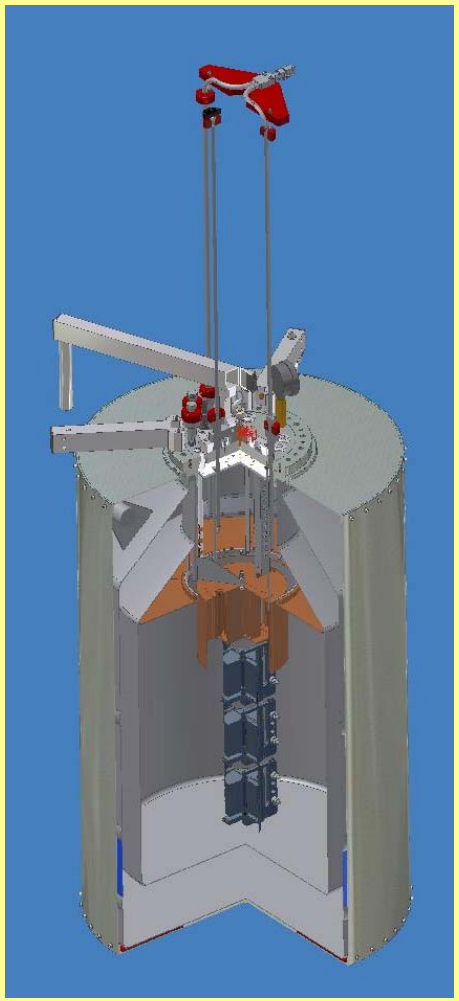


- Outer radius: 75mm
- Inner radius: 10mm

- Height: 70mm
- Weight: 1.58kg

Measurements with 18-fold Segmented Detector

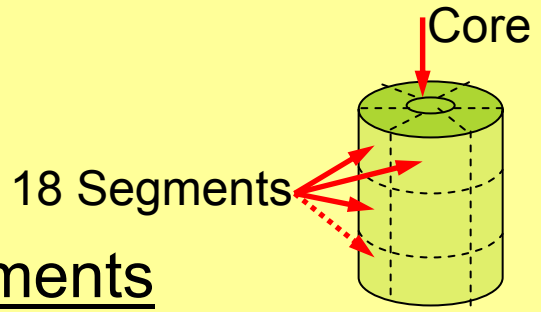
Test Stand



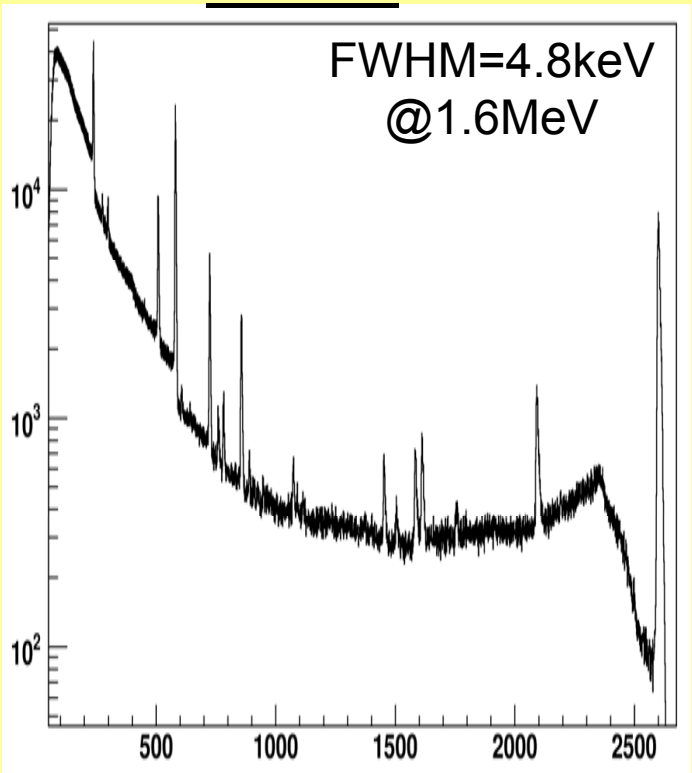
- Operate in Liquid Nitrogen
- Operating voltage: +2000V
- Sources can be inserted very close to detector w/o extra warm up / cool down of detector
- Positioning by rods from outside:
  - ΔΦ range: ~90°
  - Δz range: 'any' position directly beside det. in LN

Calibration Spectrum

- 1st time: operation of segmented n-type detector in LN (4month)
- Constant leakage current: < 6pA
- Calibration Spectrum Th-228,
  19 spectra are taken at the same time:

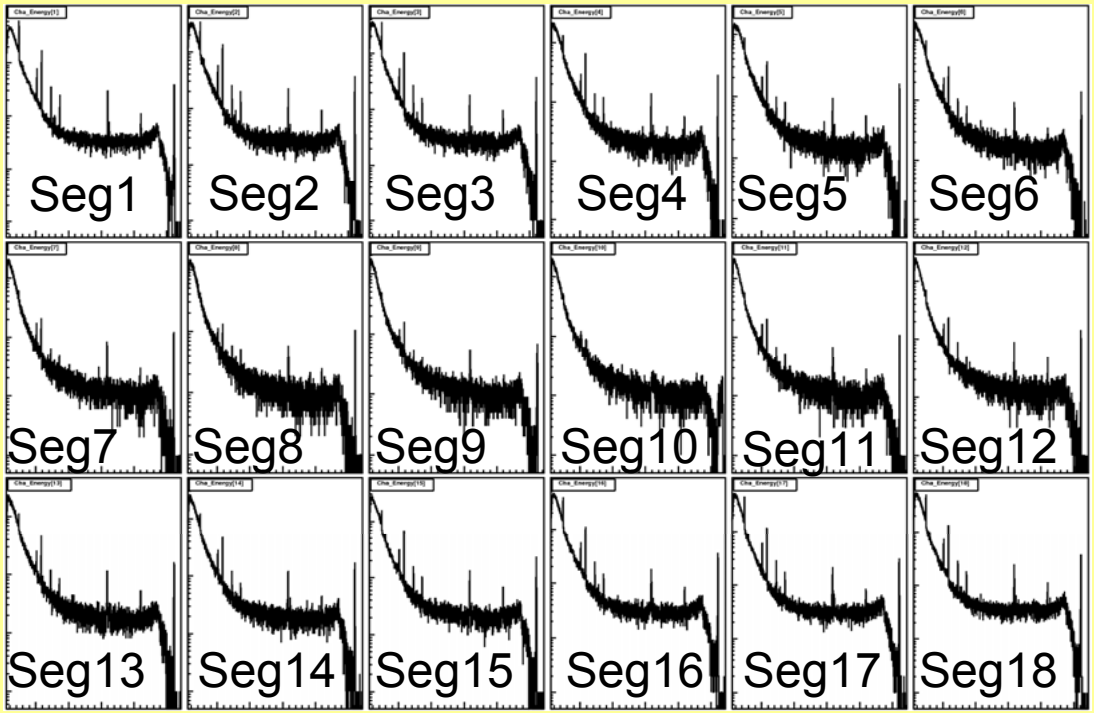


1 Core



Energy measured in core

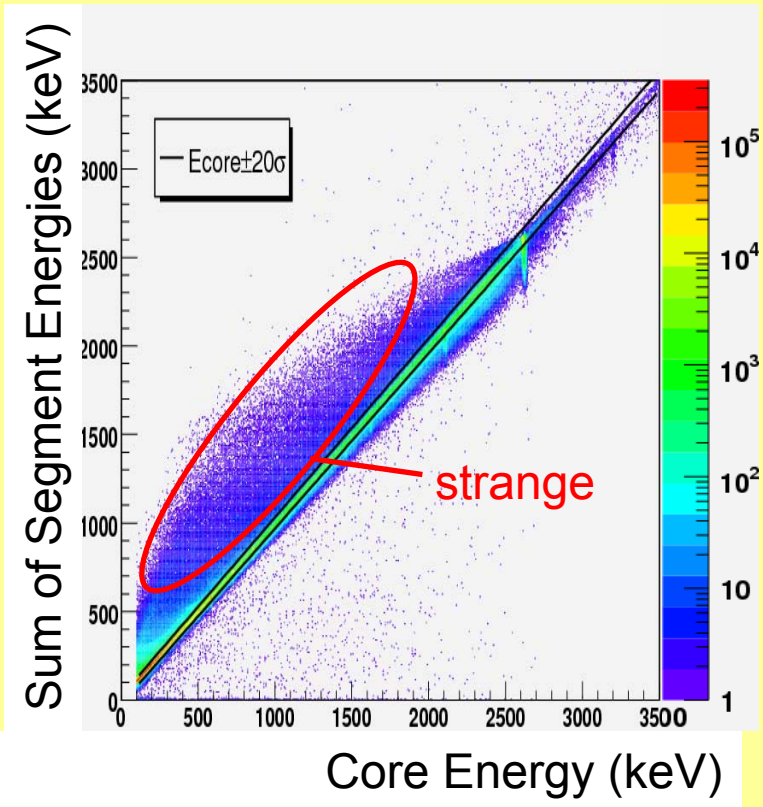
18 Segments

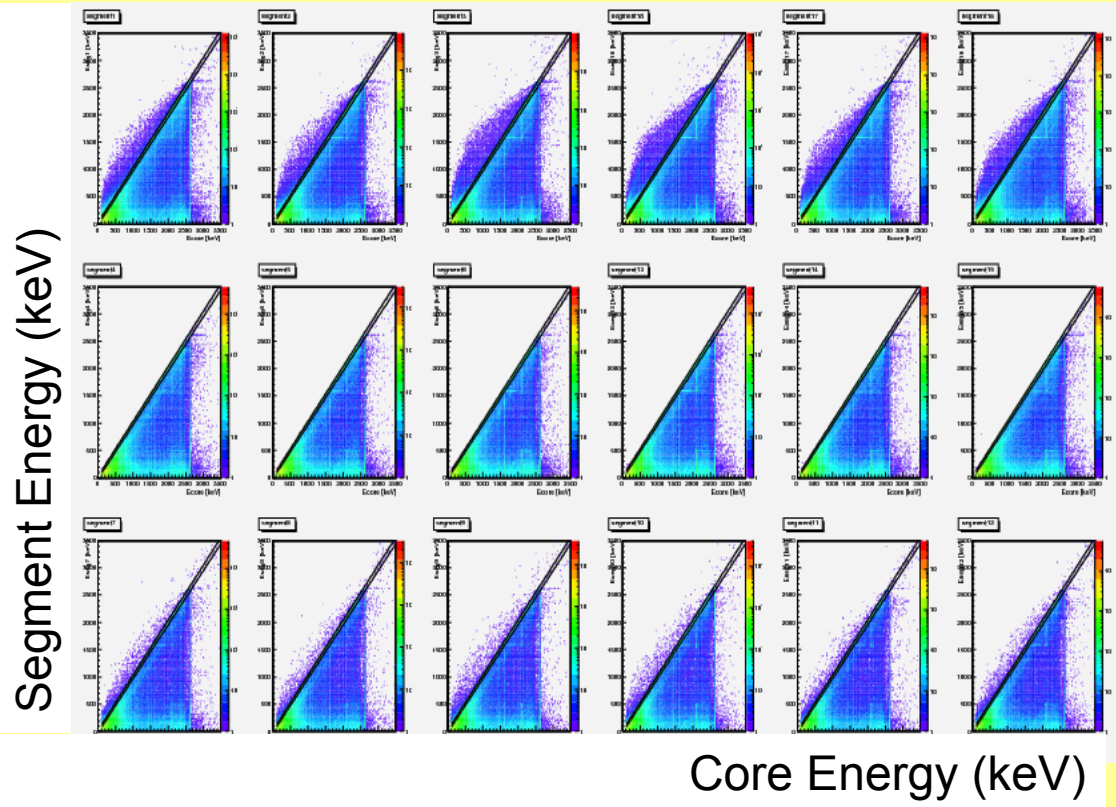


Energy measured in a single segment

Total Segment Energy > Core Energy

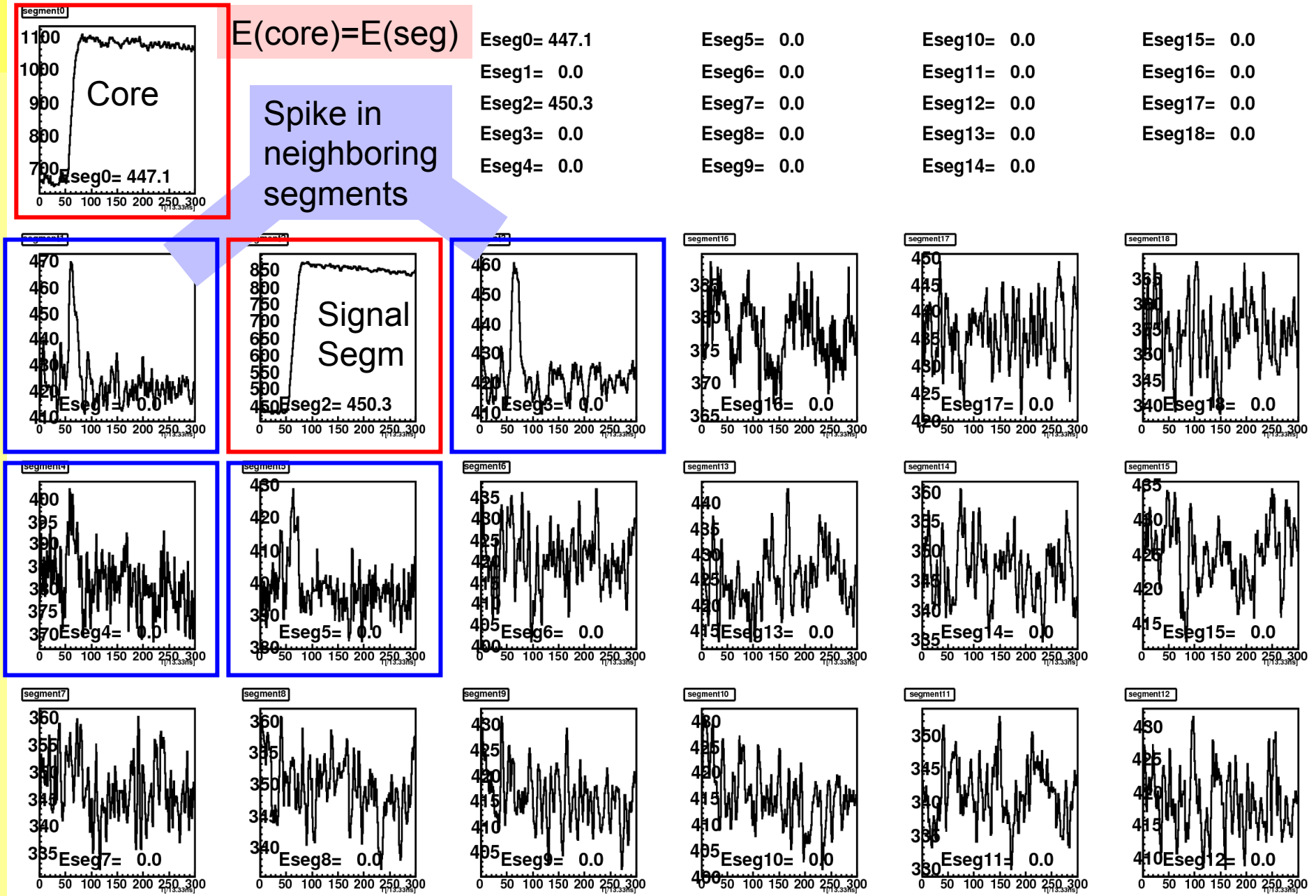
- Normally: Sum of segment energies ≈ Core energy (resolution)
- observed events with: Sum of segment energies >> Core energy



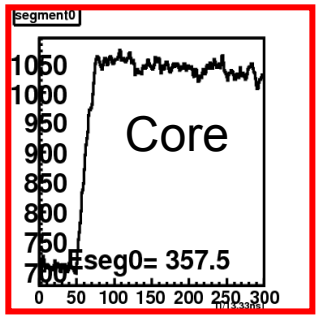


- Strange events show unexpected negative pulses
- Can be explained by trapped charges (see talks D.Lenz+J.Liu)
- Surface effect, no strange evt. in middle, only top/bottom

Pulses – Good Event

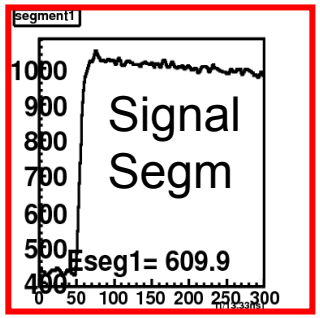


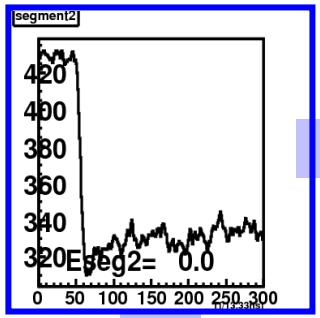
Pulses of Bad Events (E_totSeg>E_core)

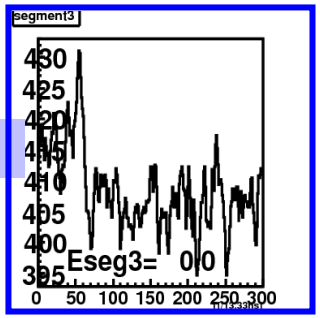


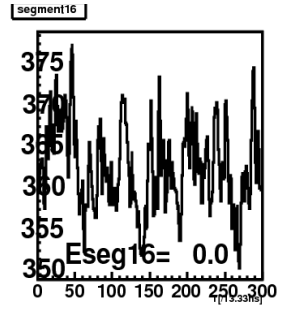
Eseg0= 357.5	Eseg5= 0.0	Eseg10= 0.0	Eseg15= 0.0
Eseg1= 609.9	Eseg6= 0.0	Eseg11= 0.0	Eseg16= 0.0

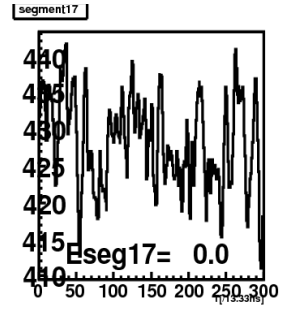
- Events with E(totSeg)>E(core) have negative segment pulses, But pulse should always be positive,
- From Simulation: trapped charges → negative pulses → $E_{totSeg} > E_{core}$

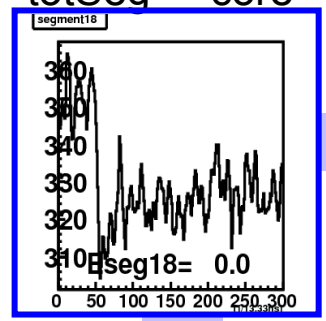


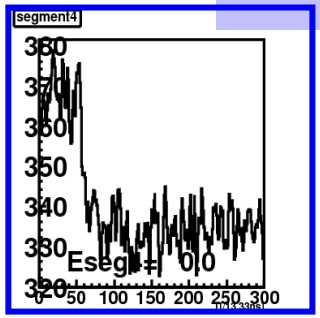


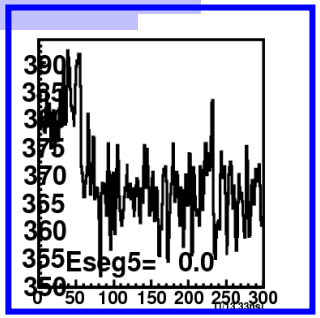


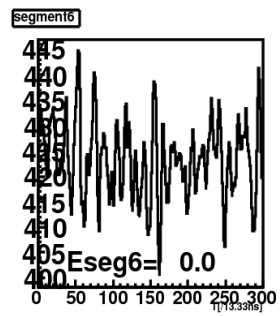


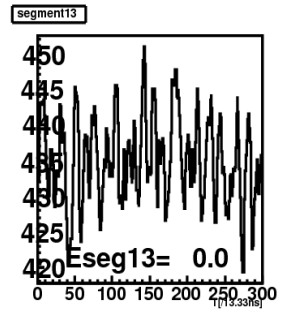


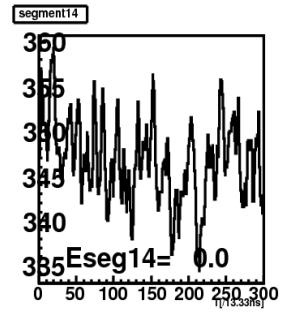


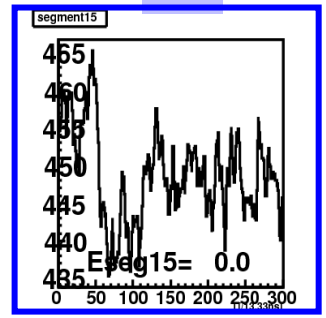


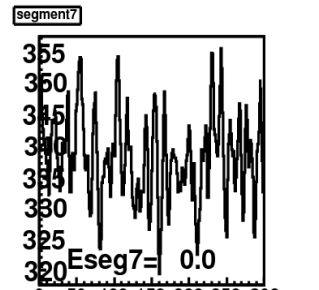


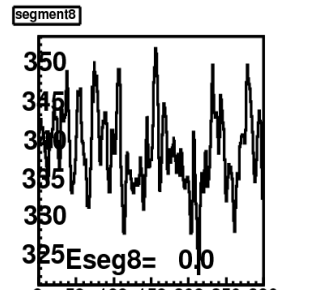


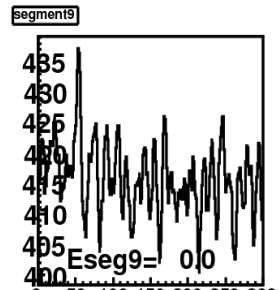


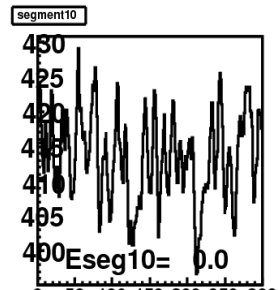


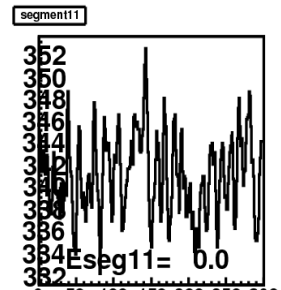


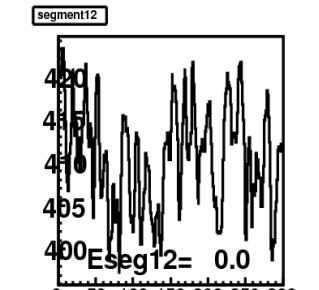






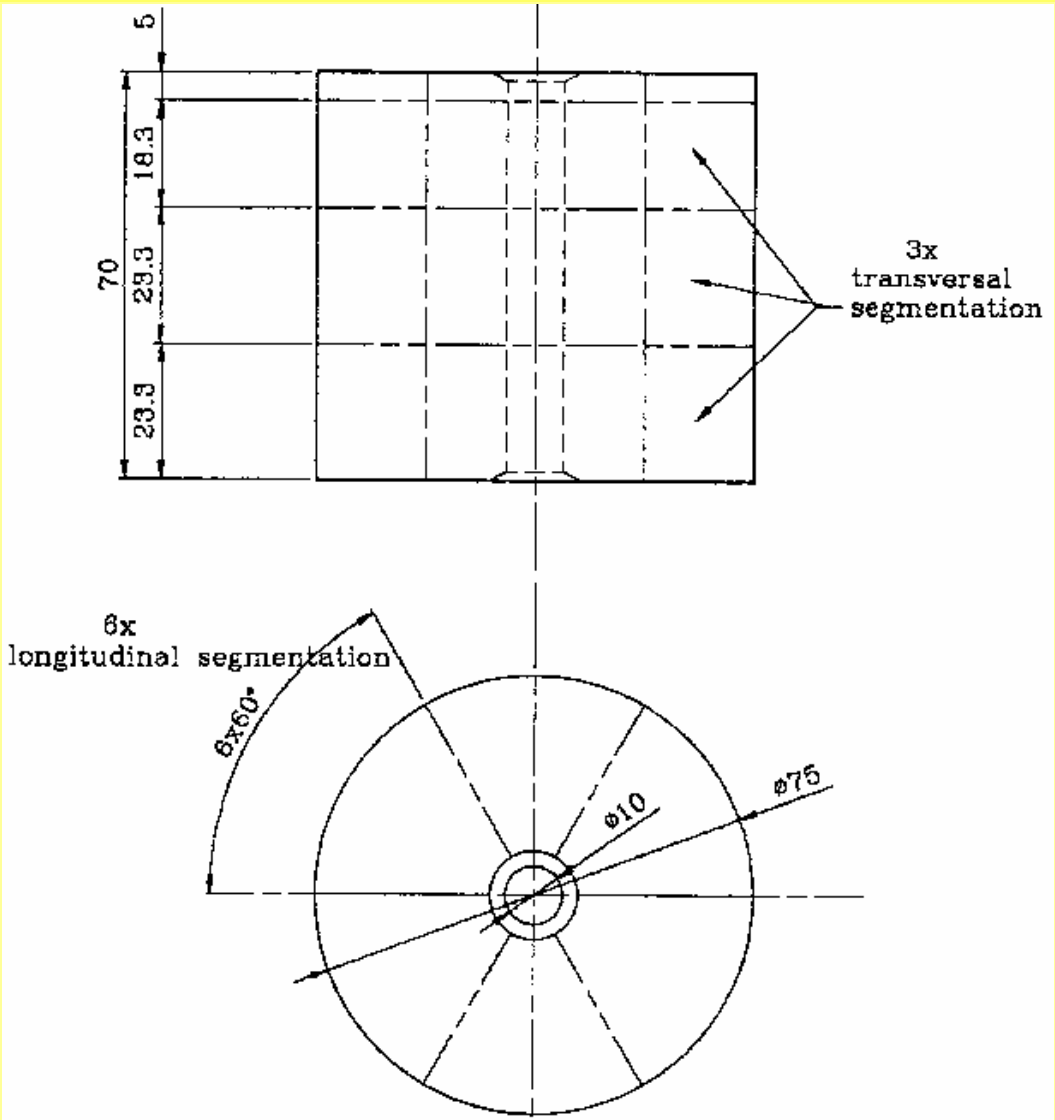






The 19-fold Segmented Detector

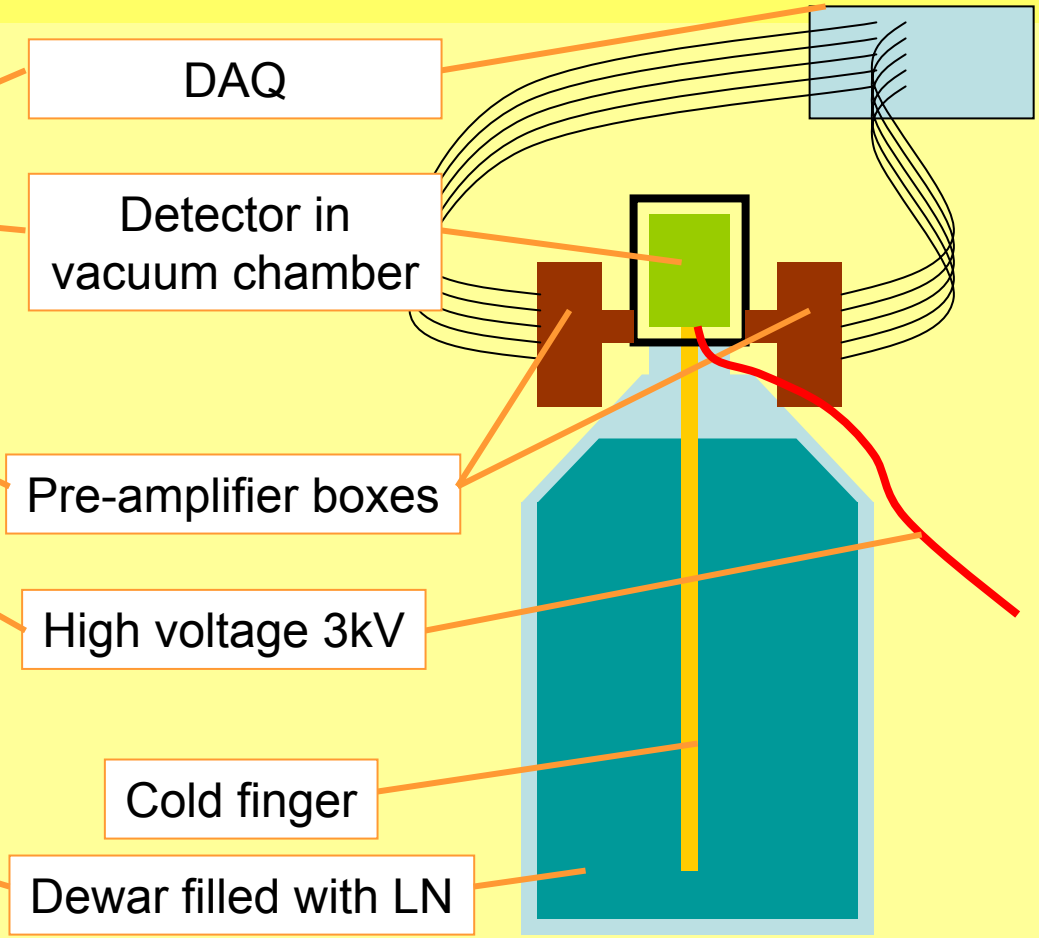
Geometry of 19-fold Segmented Detector



- Same size as 18-fold segmented detector
  - Outer radius: 75mm
  - Inner radius: 10mm
  - Height 70mm
  - Weight: 1.66kg

- 19th segment: 5mm thick
  - height of segments directly below 19th segment changes: 23.3mm→18.3mm
  - idea: study surface effects, Dead layer thickness, α sources

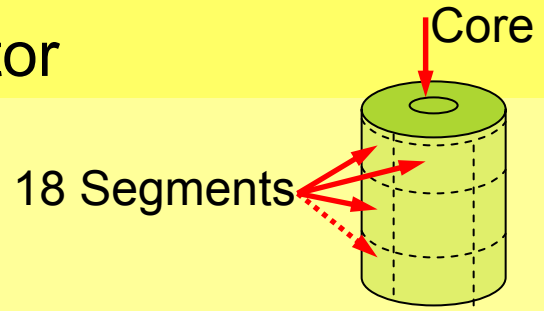
Measurements with 19-fold Segmented Detector



- Detector warmed up / cooled down several times
  ⇒ Stable operation
- Same experience as w/ 18-fold segmented detector

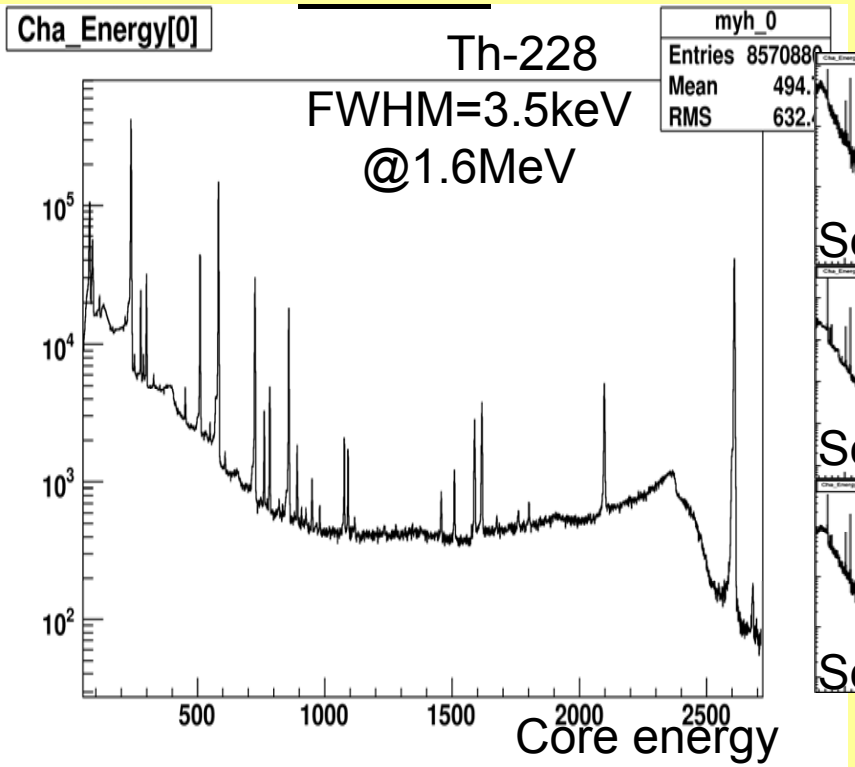
Leakage Current and Energy Resolution

of 19-fold Segmented Detector

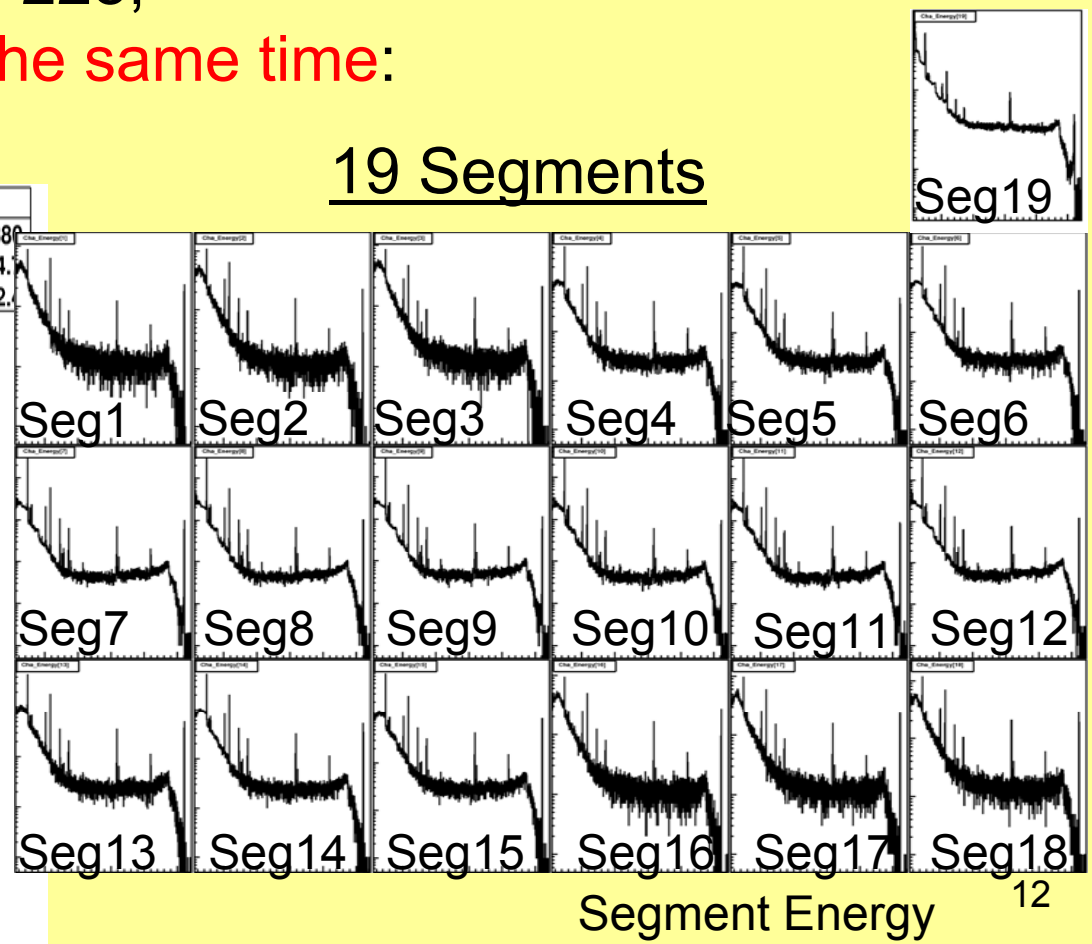


- Constant leakage current: < 20pA
- Calibration Spectrum Th-228,
  19 spectra are taken at the same time:

1 Core



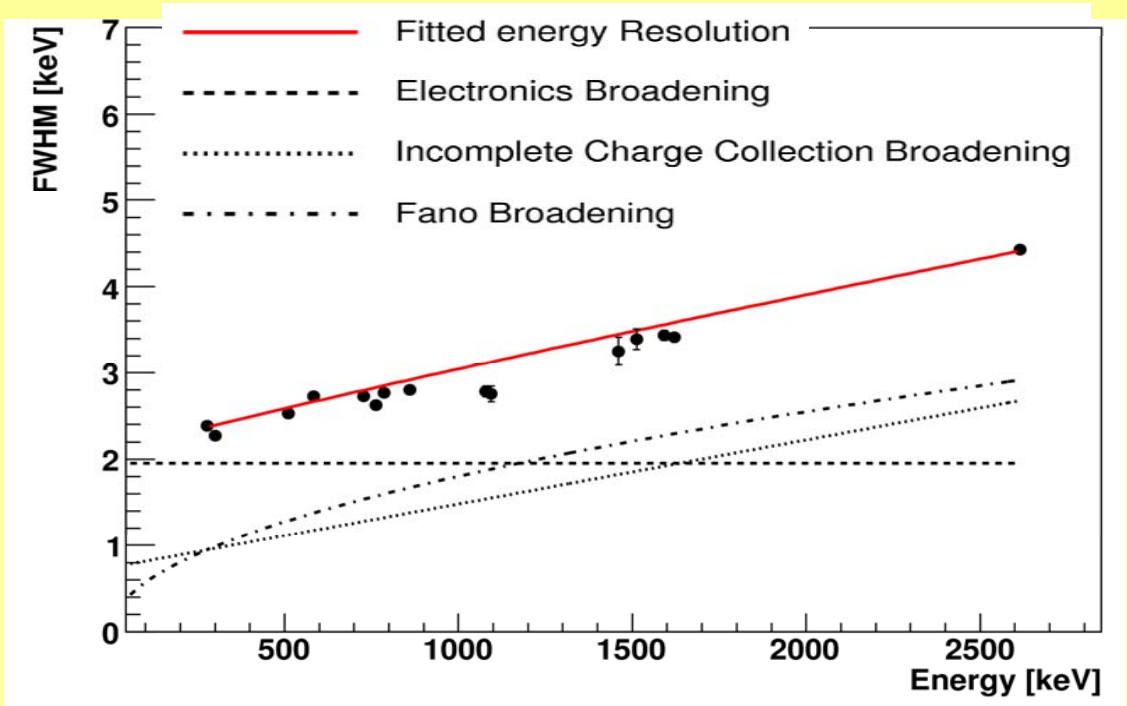
19 Segments



Energy Resolution of 19-fold Segmented Detector

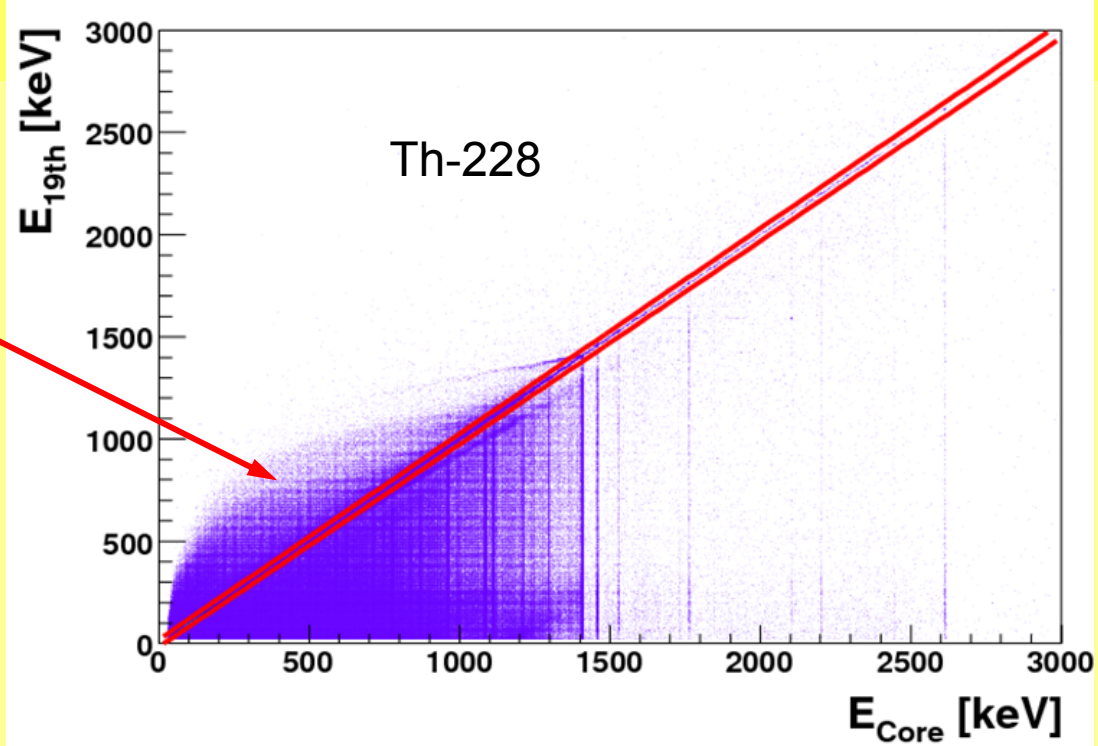
- Energy dependence:

- FWHM at 1332keV:
  - core: 2.7 keV
  - segments 1-18: 2.4-2.9 keV
  - 19th segment: 7.9 keV



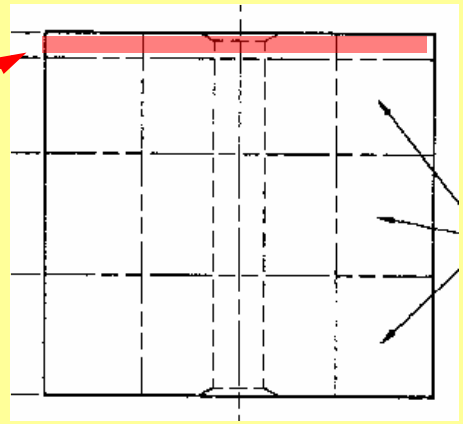
The 19th Segment

•Again: events with
E(seg19)>>E(core)



•Suspicion:
Dead-layer surface channeling effect
→ Electrons are trapped on their way towards core.
-Caused by non-ideal E field near top/bottom surface?
-Not completely metallized segments?

•Events with E(seg)>E(core)
appear only in the top segment 19



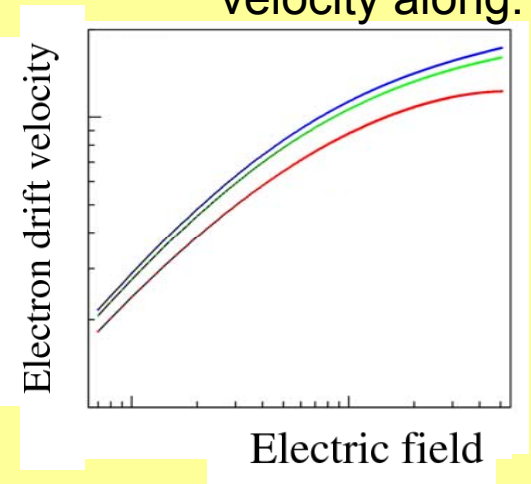
•Further investigation is on-going.
•19th segment helped a lot in understanding surface effects.

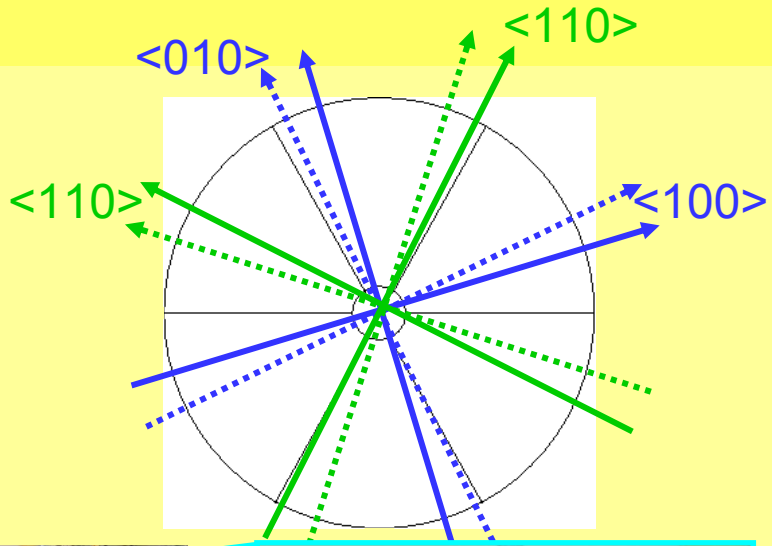
Crystal Axes of 19-fold Segmented Detector

How to determine crystal axis?

velocity along:

<100>
<110>
<111>





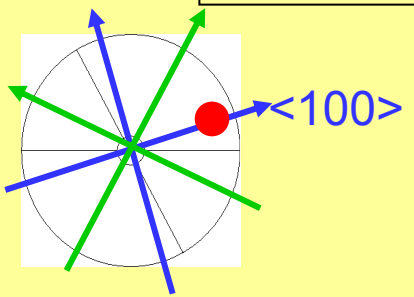
- E field well known (radial direction)

⇒Electrons drift towards core:

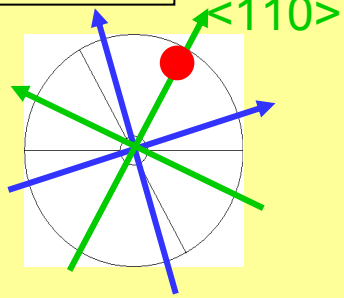
v[100] > v[110]

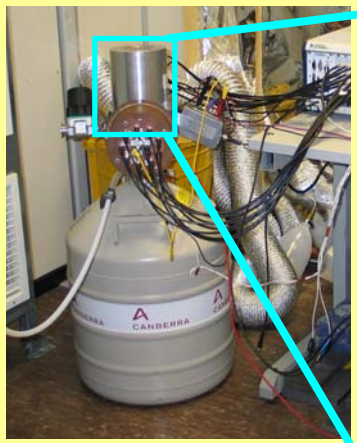
t_{rise}[100] < t_{rise}[110]

fast drift

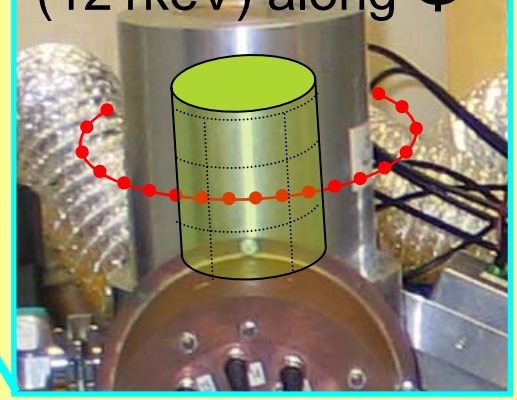


slow drift



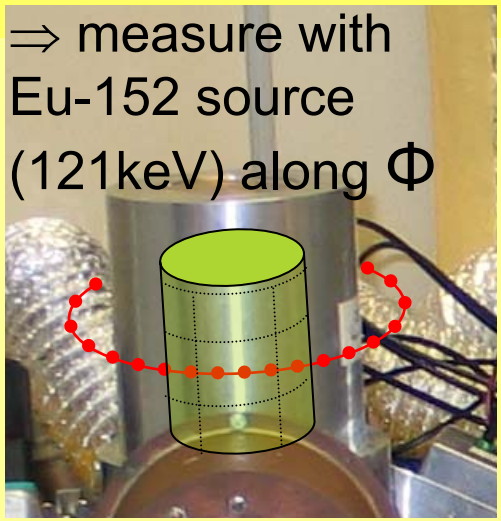


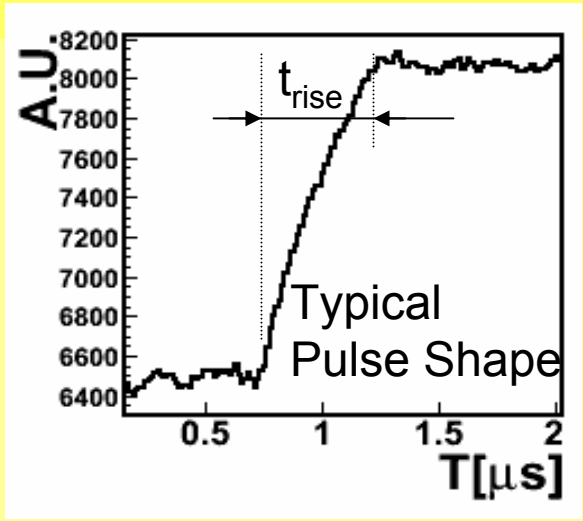
⇒ measure with Eu-152 source (121keV) along Φ

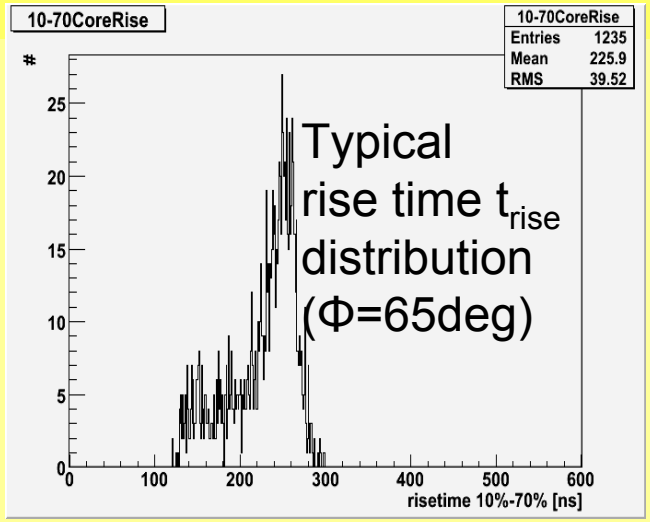


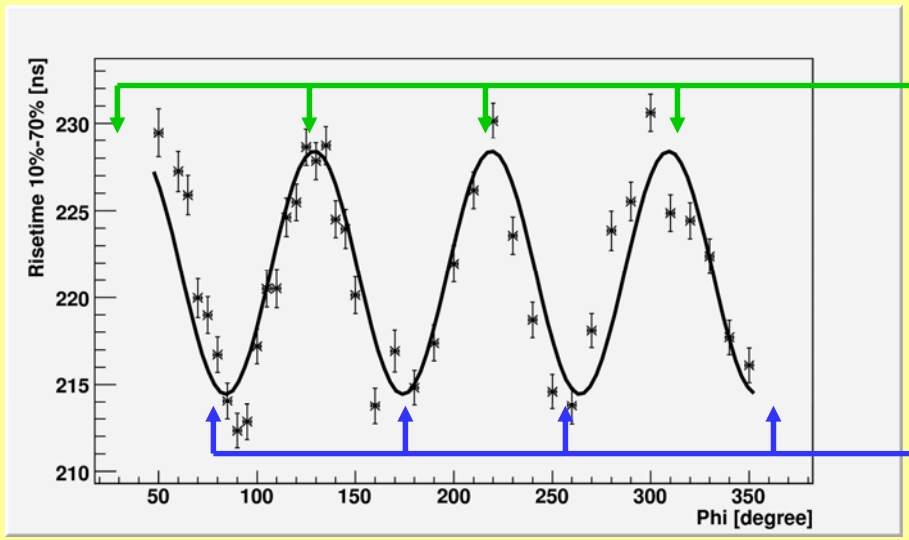
⇒ pulse rise time varies with Φ ⇒ look at pulse rise time as function of Φ

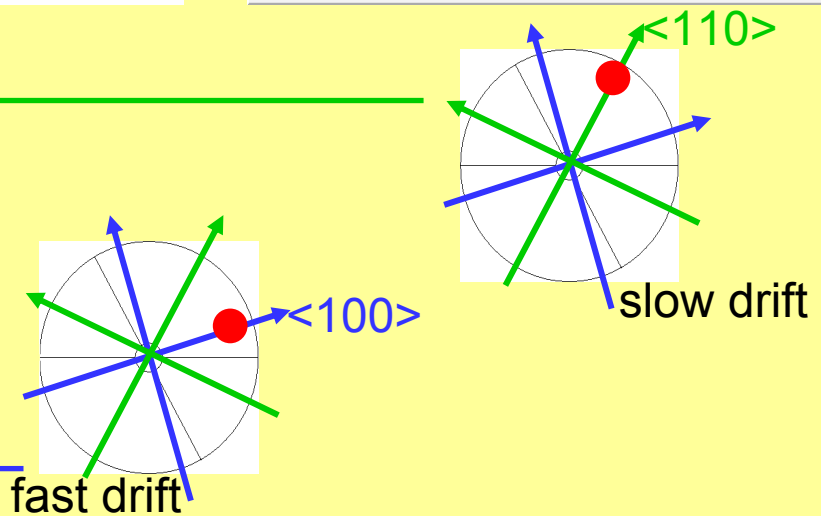
Crystal Axes of 19-fold Segmented Detector











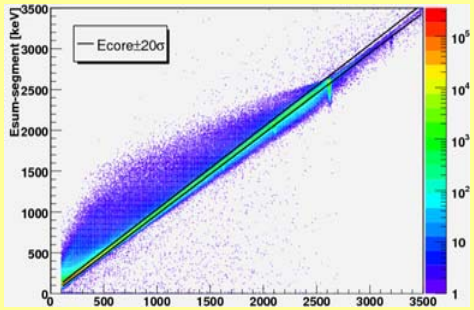
⇒Direction of crystal axes can be determined by Phi dependence of rise time distribution

Conclusion

•1st time: 18-fold segmented n-type detector operated directly in liquid nitrogen

•19-fold segmented detector:
- stable operation
- good for learning about surface effects

•Events with Sum of all segment energies >> Core Energy
- probably due to charge trapping at surface
- effects are reproduced in Pulse Shape Simulation
- seen in 19-fold and 18-fold segmented detectors



•Determination of crystal axis from Φ-dependence of pulse rise-times