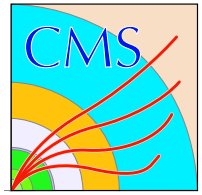
Testbeam Analysis



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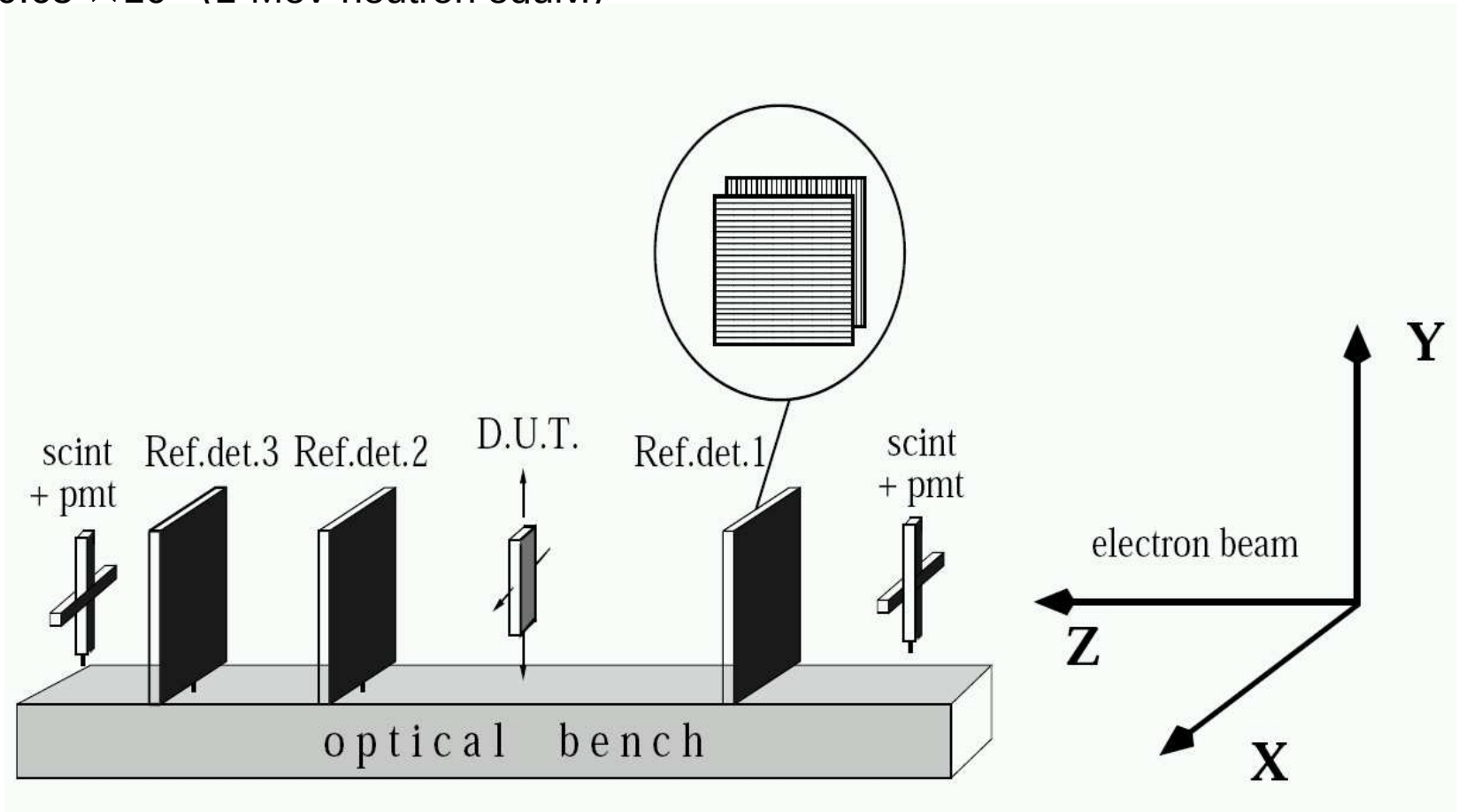
CMS Hamburg Meeting

31. Januar 2007

- Basic Setup
- Signal-to-Noise Analysis
- Resolution Studies

Basic Setup

- CMS Tracker Modules from different Parts of Tracker are tested
- Modules are subjected to different radiation doses: 0.1, 0.28, 0.29, 0.58 and 0.65 $\times 10^{14}$ (1 MeV neutron equiv.)



Desy 22 testbeam provides electron beam in energy range of 1– 6 GeV

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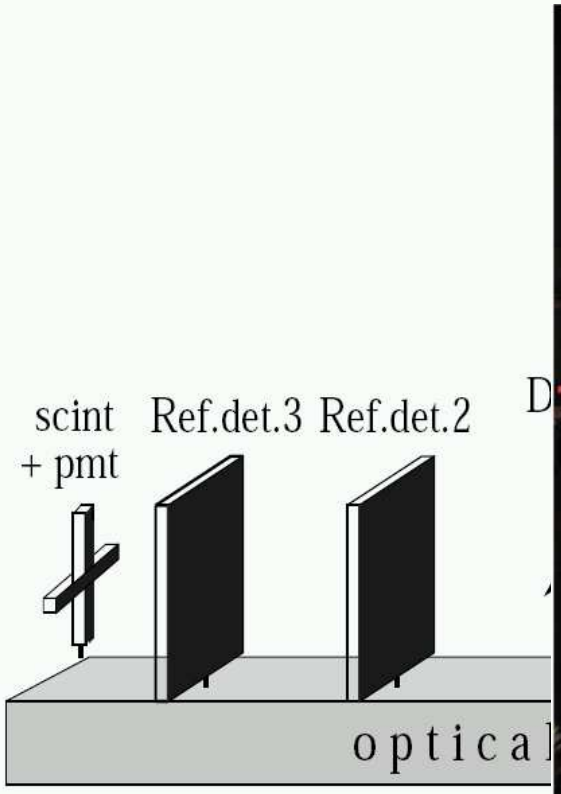

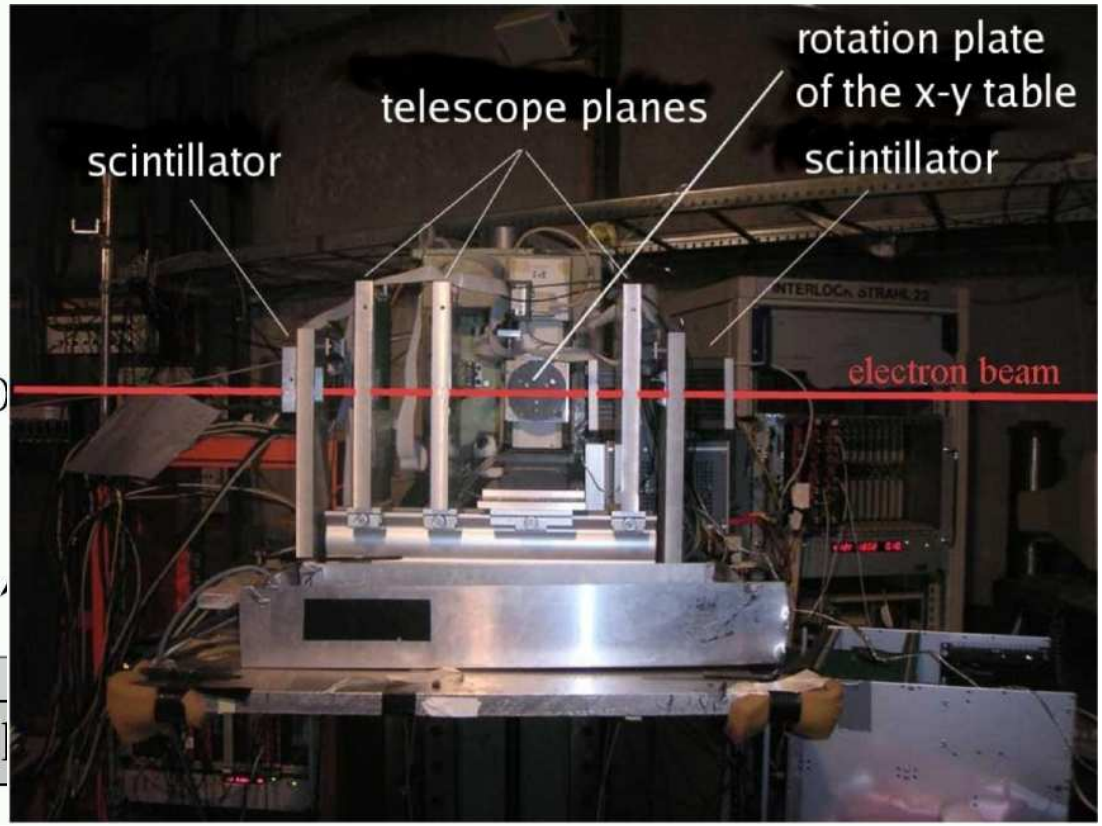

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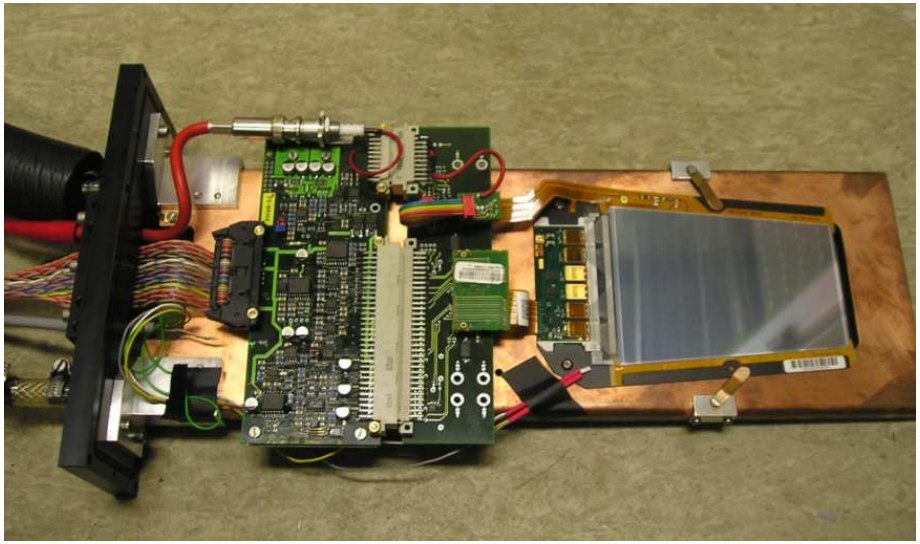
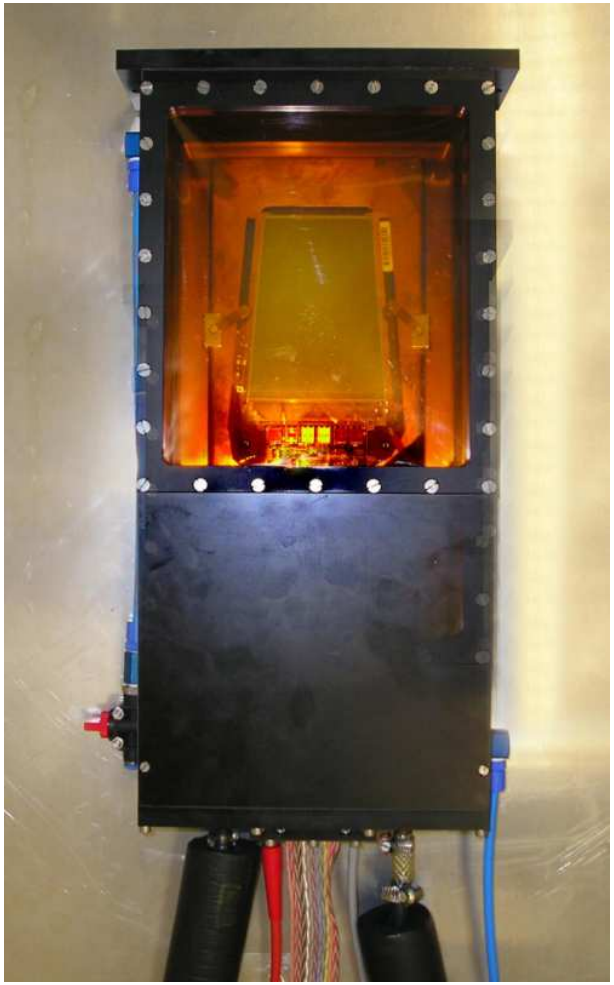
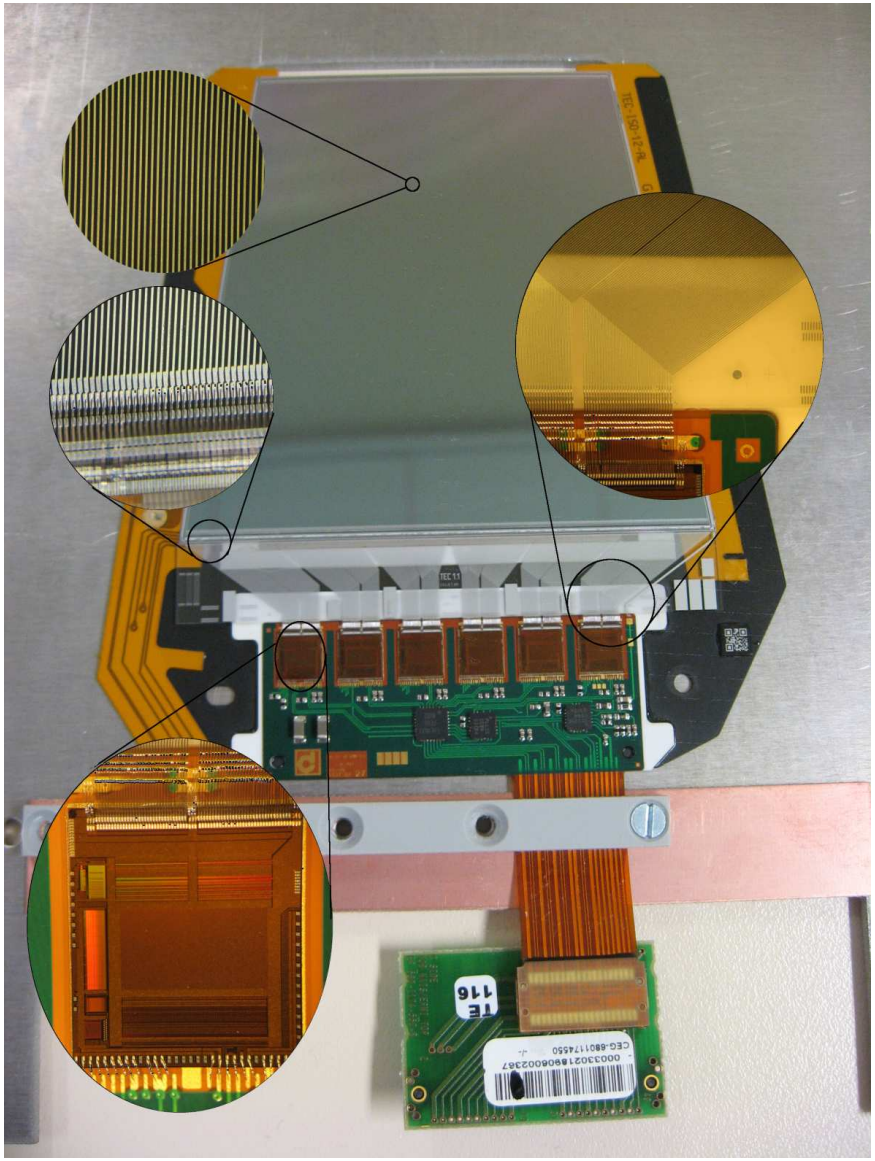
Basic Setup





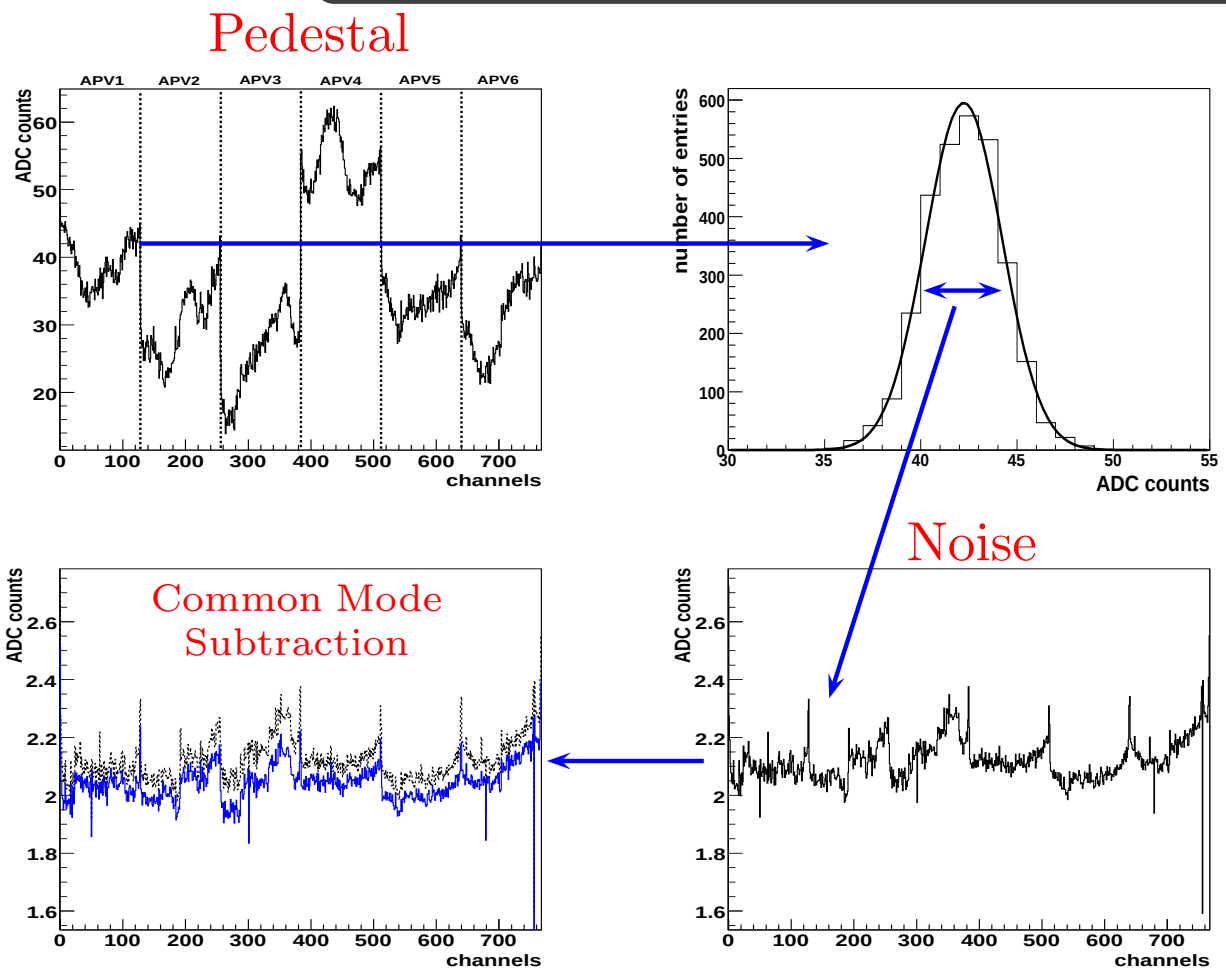
- Modules were kept in special box to simulate environmental conditions close to those within the tracker
- Box can be shifted and/or rotated
- Temperature can be varied

Reminder: CMS Silicon Sensors



- Strip pitch: between 80μm(first layer IB) and 205μm(last OB layer)
- Thickness: 320 μm (inner), 500 μm(outer layers)
- 512 - 768 Strips $\longrightarrow$ 4-6 APV readout chips
- 15 different geometries are used in the tracker

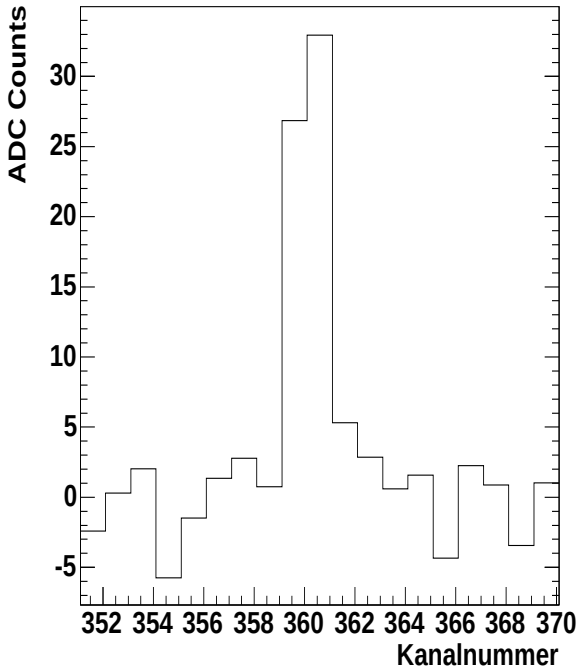
Data Analysis – Noise Determination



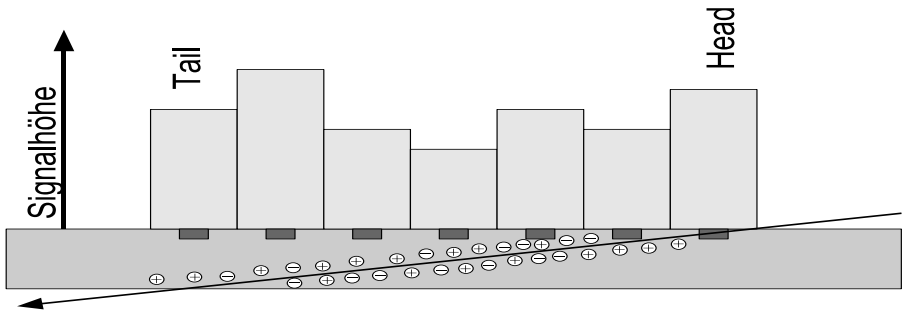
- Basic Analysis:
  - Find and Flag Noisy Channels
  - Pedestal and (Raw-)Noise determination
  - Common Mode Subtraction
- Next Step: Cluster Finding

Data Analysis – Cluster Finding

example cluster



- Clusters are being reconstructed with different algorithms
  - standard weighted algorithm (cuts on SNR of seed (4), neighbors (3) and cluster (5))
  - double centroid (center-of-gravity of seed with 2 neighbor strips is taken)
  - head-tail (first and last strip in cluster as well as average charge of strips is taken, suited for large clusters ⟶ at large incident angles)

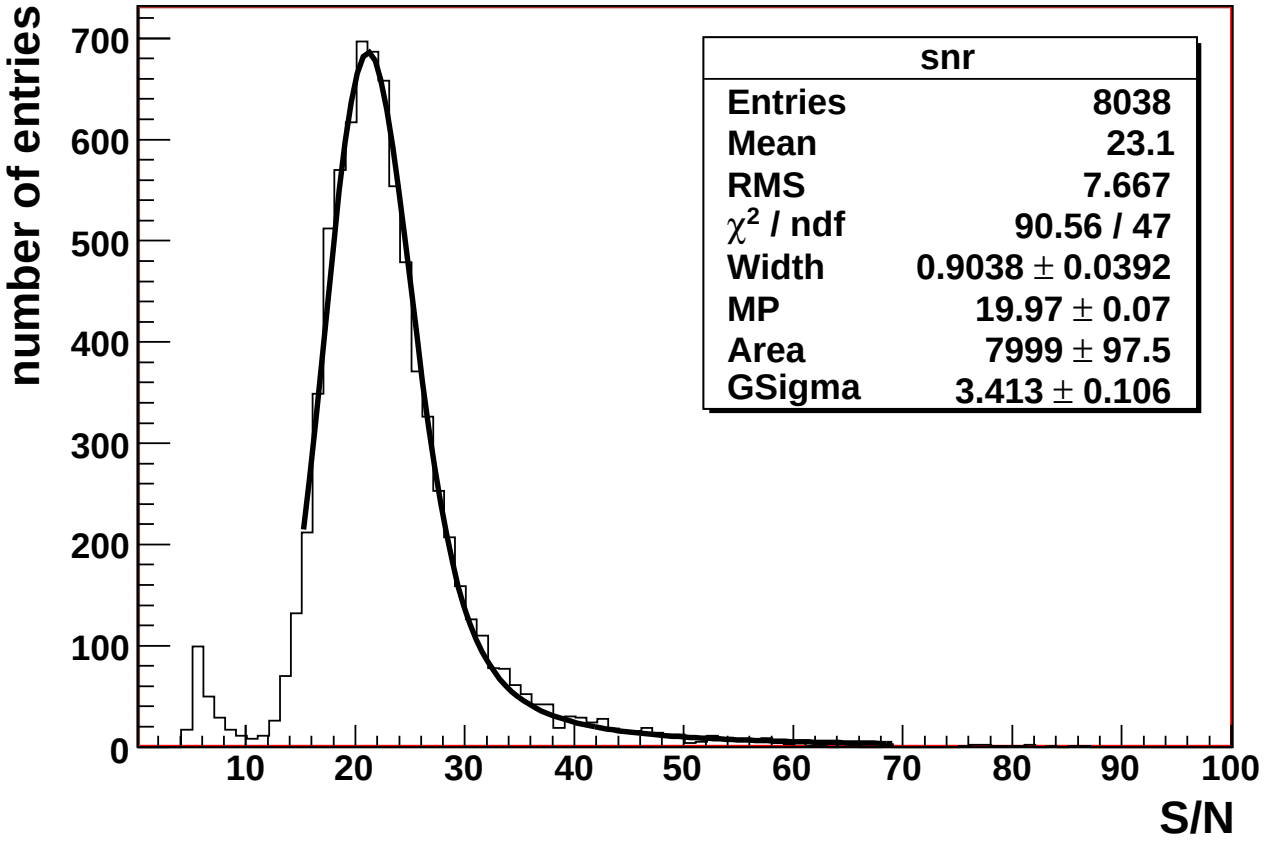


Data Analysis – Signal-to-Noise

- SNR distribution is fitted with convolution of gaus and landau

$\longrightarrow$

- MPV is taken as SNR value for respective run

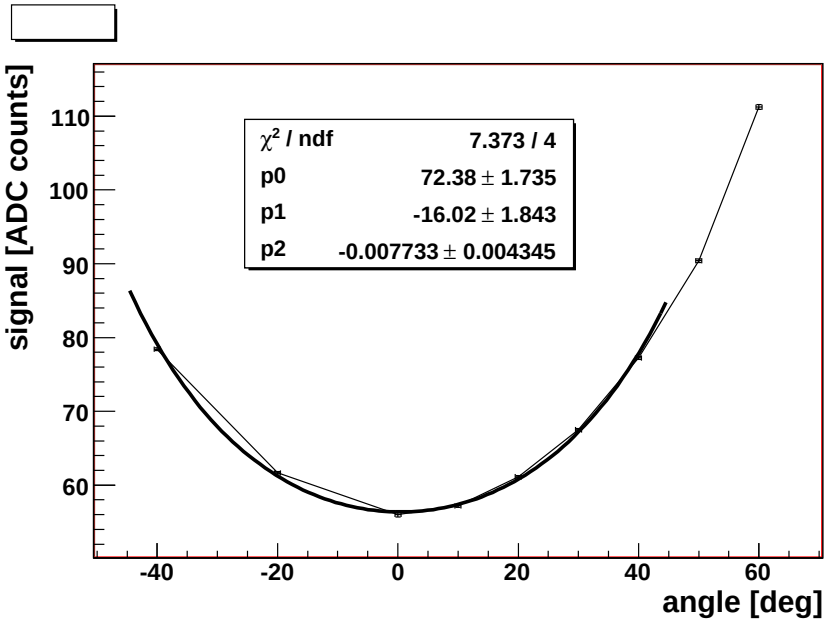


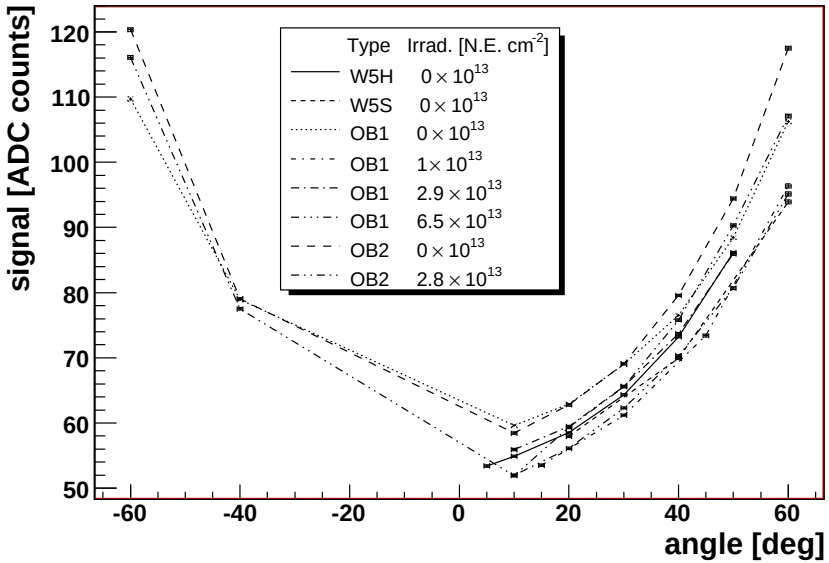
Signal-to-Noise Analysis

- High signal-to-noise is desired to have good identification of signal in all kinds of operation scenarios
- Signal-to-Noise ratio is analyzed w.r.t. several parameters
  - Inclination angle
  - Energy
  - Depletion voltage
  - Temperature
- SNR of more than 10 is aimed for even after long (10y) period of operation

Signal-to-Noise Analysis – Angular Scans

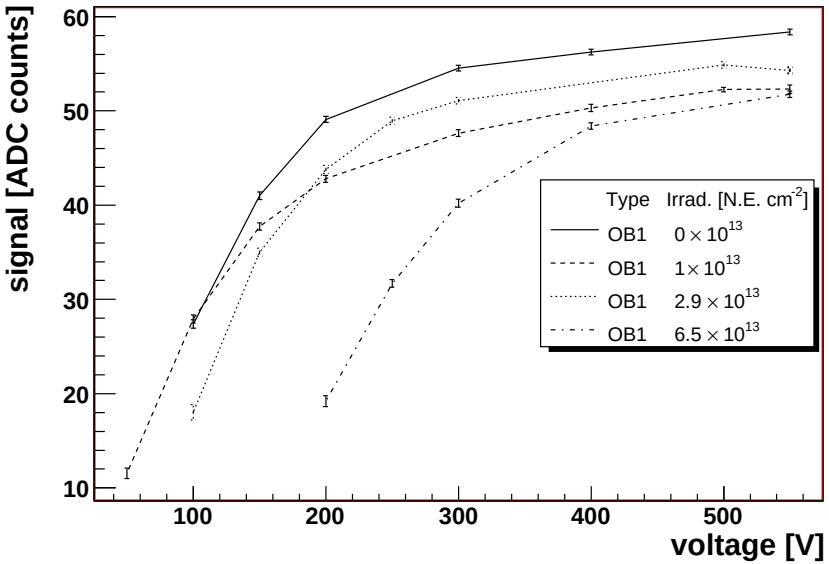
- SNR (below Signal) is expected to change since the path through the detector material evolves as $S = a + \frac{\mathrm{b}}{\cos(\alpha - c)}$

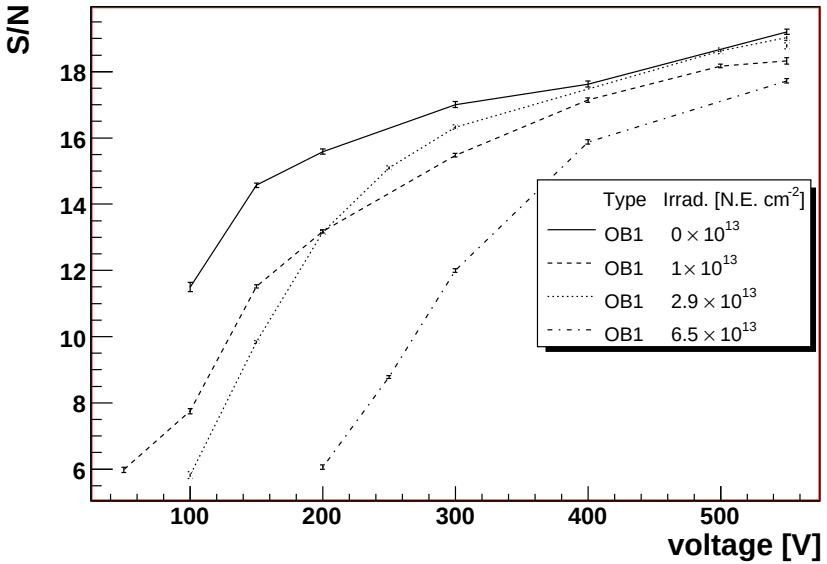




works good for angles which are not too large

Signal-to-Noise Analysis – Voltage Scans

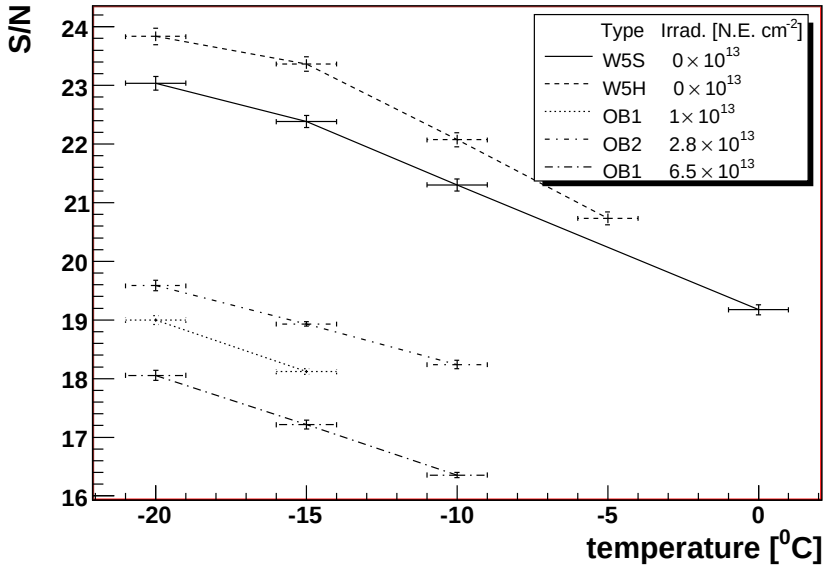




Signal increasing strongly below depletion voltage

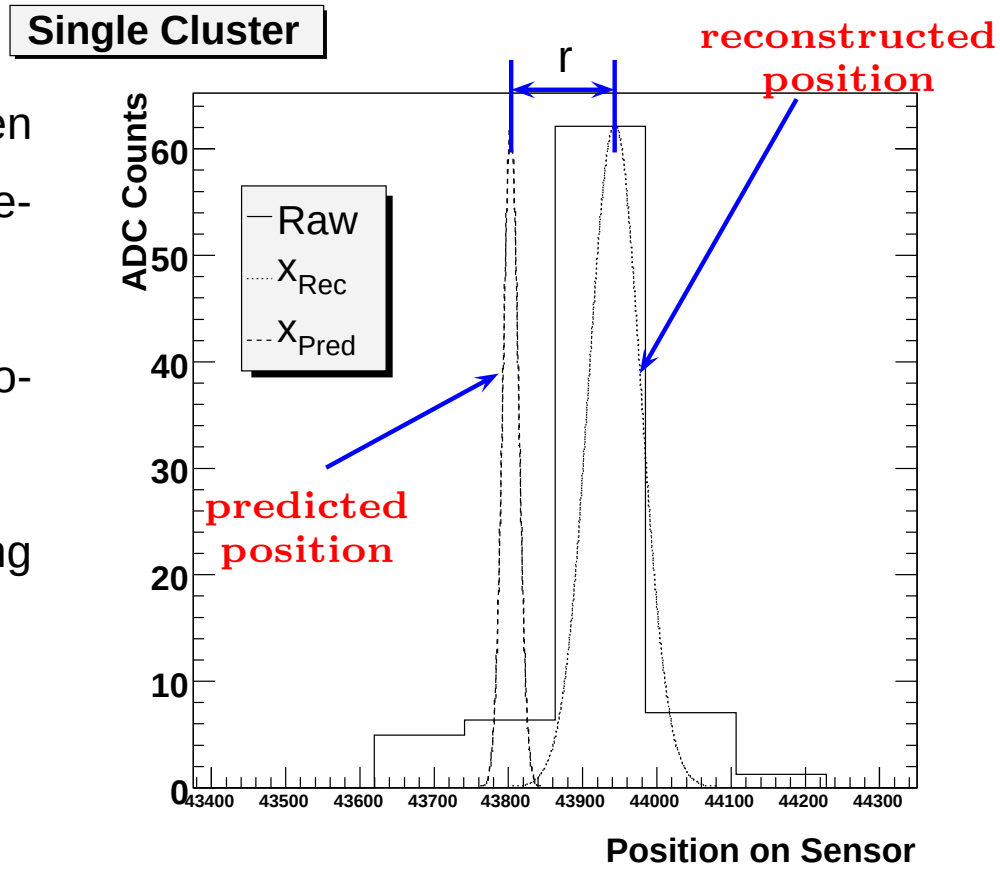
Signal-to-Noise Analysis – Temperature Scans

With increasing temperature, noise should increase⟶SNR should become worse



Resolution Studies

- Resolution is obtained by taking residual between prediction from the telescope and the position reconstructed on the module ($r = x_{\mathrm{pred}} - x_{\mathrm{rec}}$)
- Straight line fit is performed using all three telescope layers
- Due to relatively low energies, multiple scattering cannot be neglected



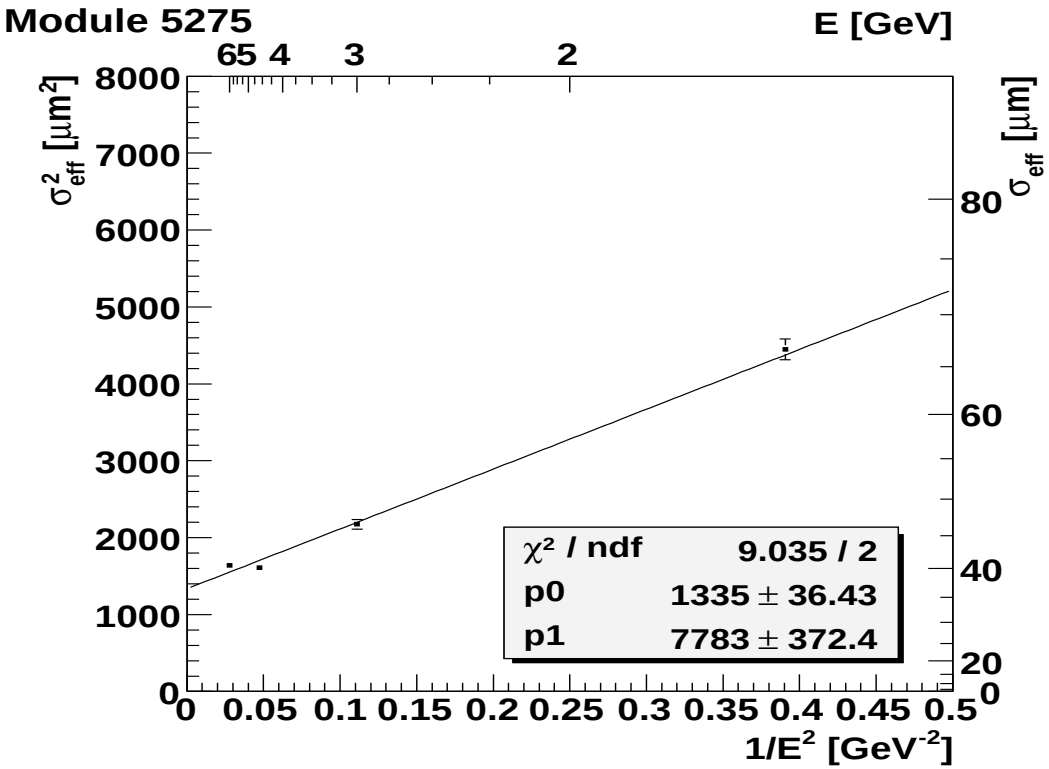
Resolution Studies II

- At low energy:

$$\sigma_{\text{Module,meas.}} = \sqrt{\sigma^2_{\text{Module,intr.}} + \sigma^2_{\text{Multiple Scattering}} + k_{\text{Geo}} \times \sigma^2_{\text{Telescope}}}$$

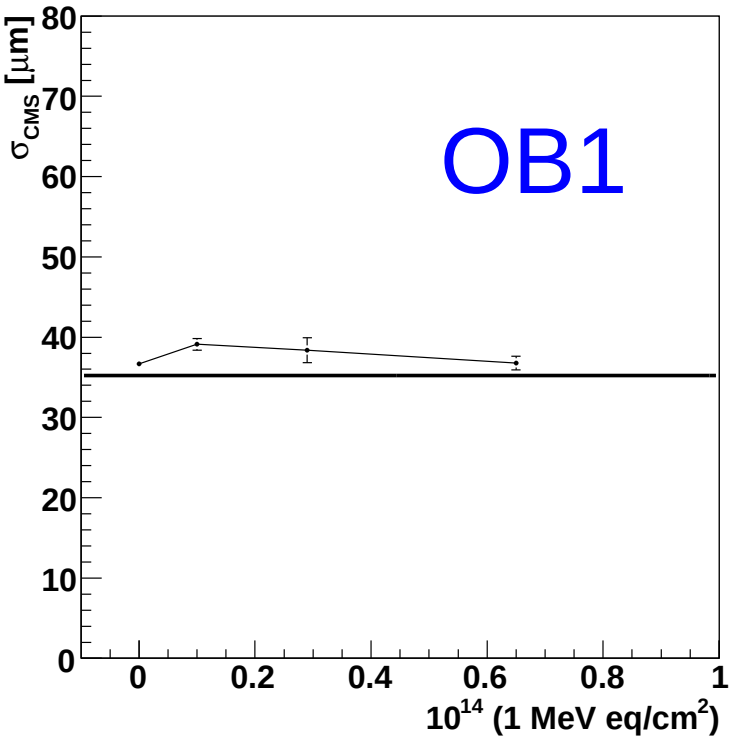
- extrapolation to infinite energies by fitting $\sigma^2\left(\frac{1}{E^2}\right)$ distribution

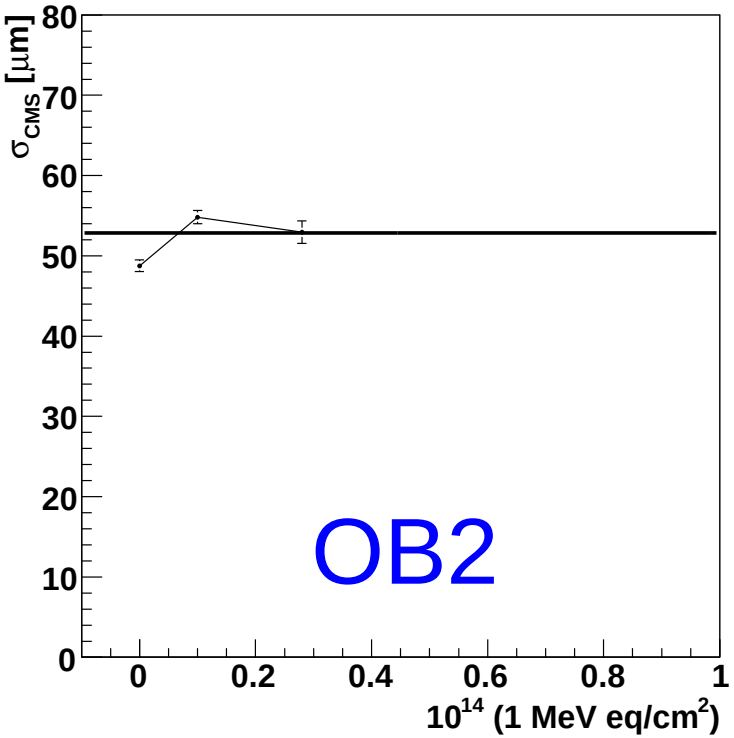
  - Intercept of fit is effective resolution of the module at infinite energies $\longrightarrow$no multiple scattering
  - k_{Geo} depedends only on geometry of setup
  - $\longrightarrow$Intrinsic resolution of Module under given conditions can be determined



Resolution Studies

Resolution as function of irradiation (0° incident angle)

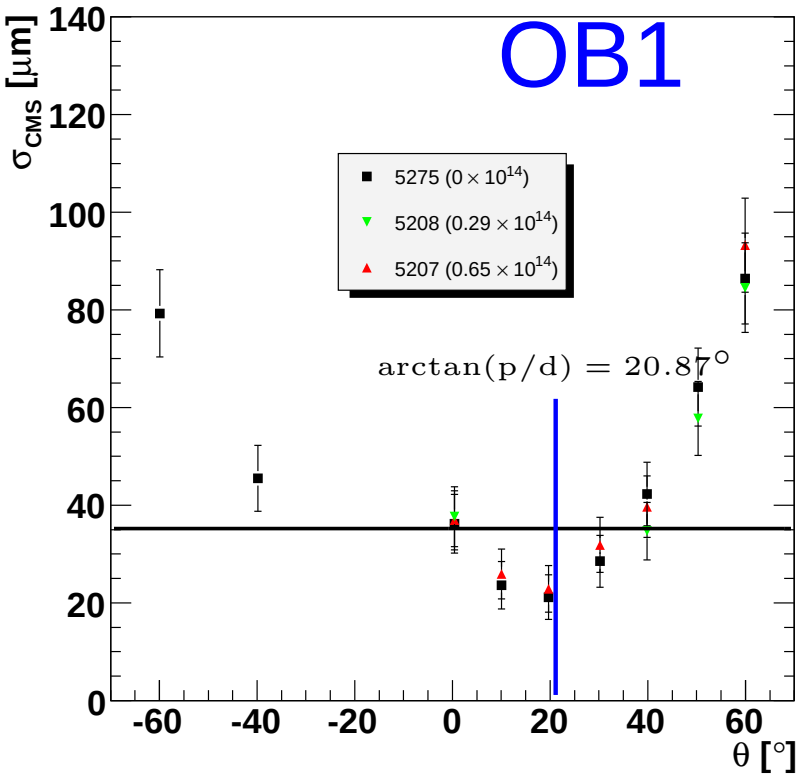




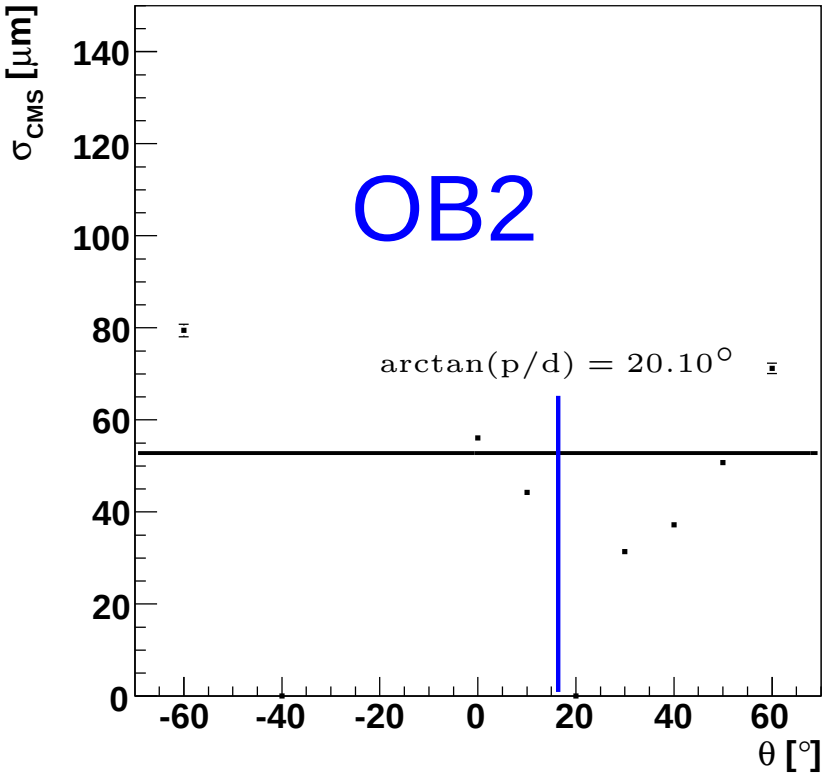
Slightly above expected digital resolution ⟶ under investigation

Resolution Studies – Angular Studies

Angular Scans: Due to benifical charge sharing, resolution should get better up to $\arctan \frac{p}{d} = 20.87°$ for OB1 ($20.1°$ for OB2)



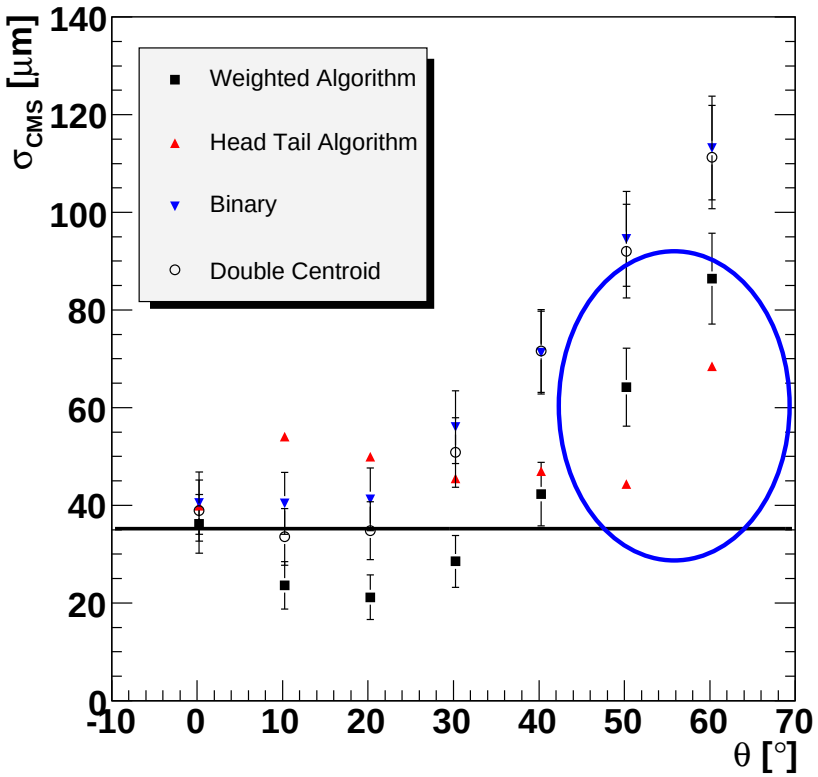
Outer Barrel ($p = 122\ \mu\text{m}$, $d = 320\ \mu\text{m}$)



Outer Barrel ($p = 183\ \mu\text{m}$, $d = 500\ \mu\text{m}$)

Resolution Studies – Cluster Algorithms

Resolution is investigated for different Cluster Algorithms



Simple weighted algorithm provides best results apart from large angles where head-tail algorithm performes best.

Summary ...

- Analysis of Testbeam Data mostly finished
- SNR ratios well behaved and well above desired level
- Resolution studies show expected behaviour of modules

... and Outlook

- Some unresolved issues (0° Resolution$\longrightarrow$comparison with simulations planned to investigate possible origins)
- Internal Note planned, draft in preparation