Test beam studies for passive CMOS strip sensor

Marta Baselga, Leena Diehl, Ingrid-Maria Gregor, Tomasz Hemperek, Jan-Cedric Hönig, Sven Mädgefessel, Ulrich Parzefall, Arturo Rodriguez Rodriguez, **Surabhi Sharma**, Dennis Sperlich, Tianyang Wang, Liv Wiik-Fuchs

9th Beam Telescopes and Test Beam
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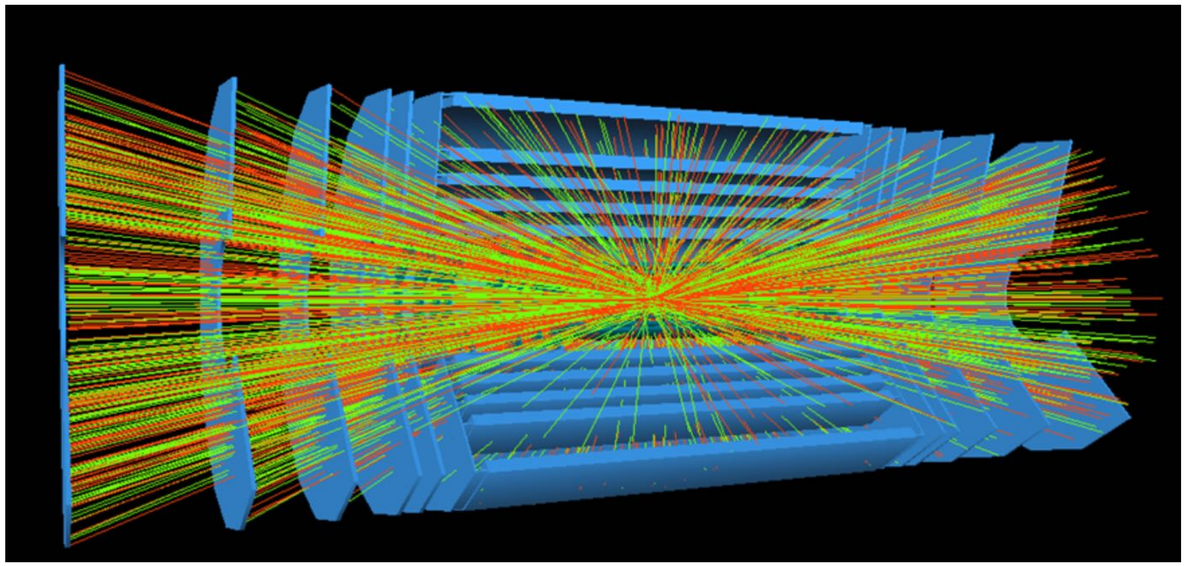
Outline

- Sensor Details
- Electrical measurement
- Goals and Setup for Test beam
- ALiBaVa setup
- Analysis Strategy
- ALiBaVa data reconstruction
- Telescope data reconstruction

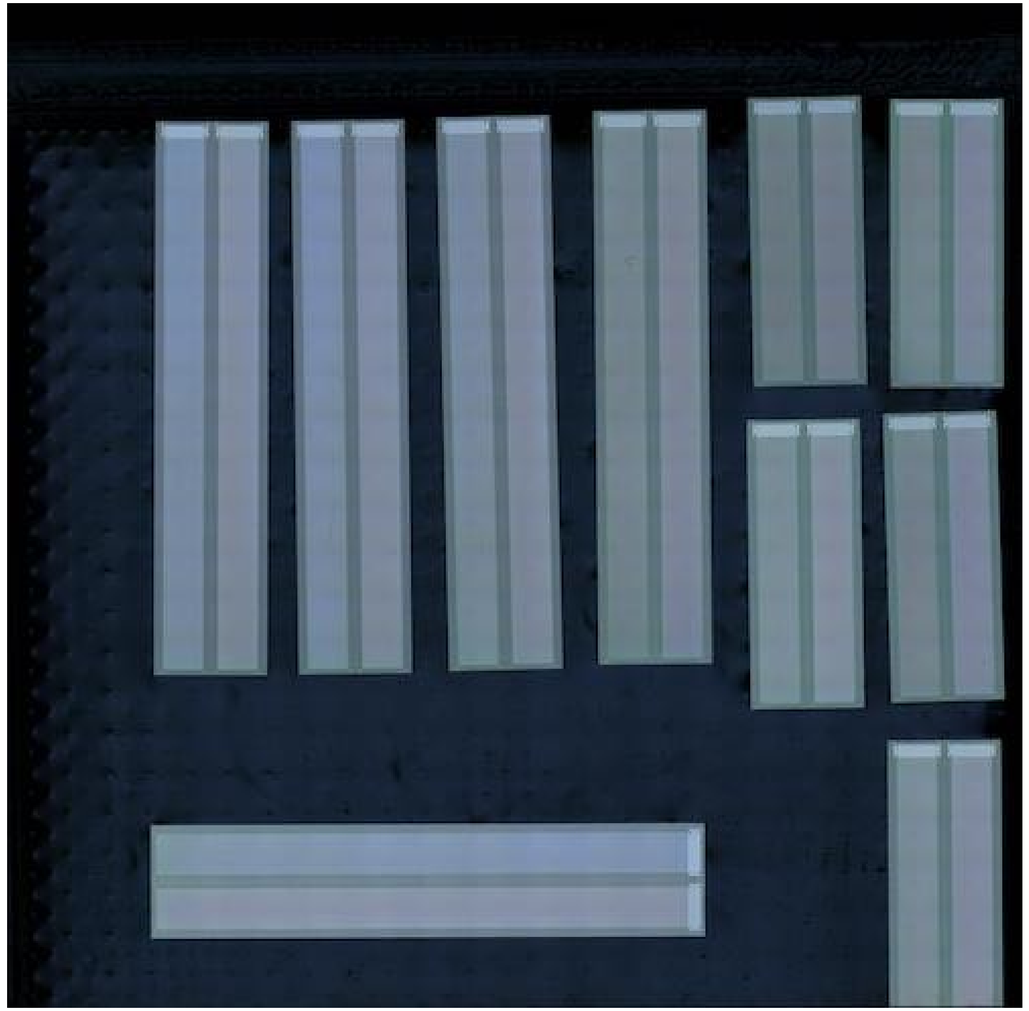
Motivation for passive CMOS

- **Requirements for future HEP detectors**
  - All silicon-based tracker
  - Possibly more radiation tolerant
  - Large surface
  - Cost effective-> Use of commercial CMOS production process



ATLAS detector in HL-LHC

Sensor structure



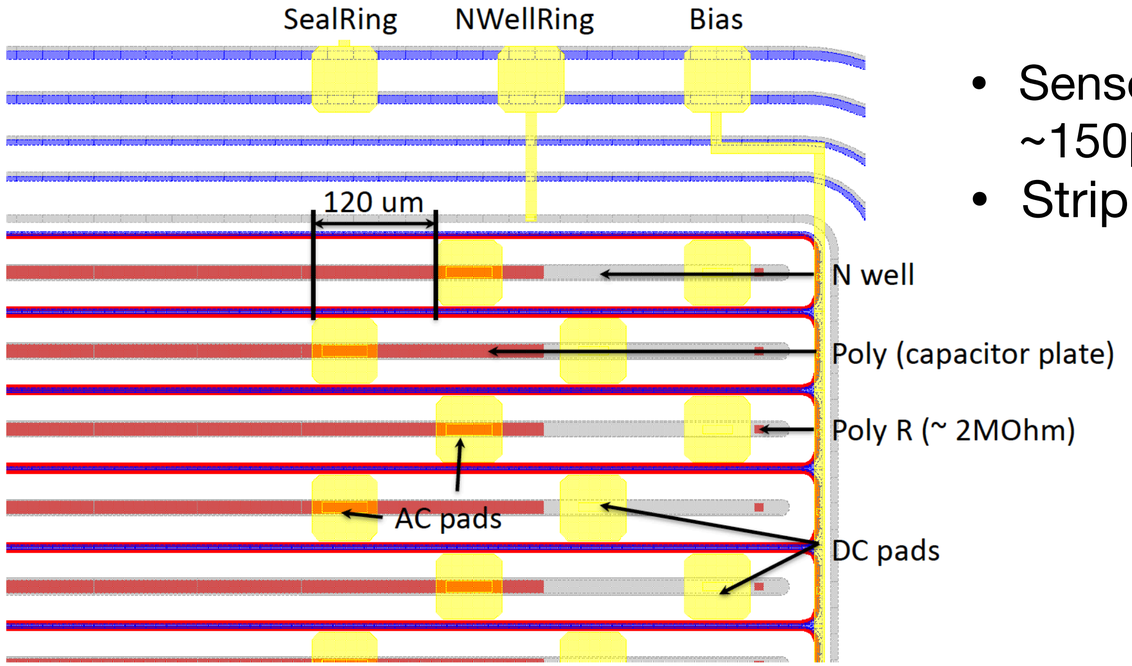
- First stitched strip sensor produced on 8” wafer by a commercial foundry

- **LFA150:**
  - L-Foundry 150 nm process (deep N-well/P-well)
  - Up to 7 metal layers
  - Resistivity of wafer: >2000 Ω·cm
  - Float-zone processing

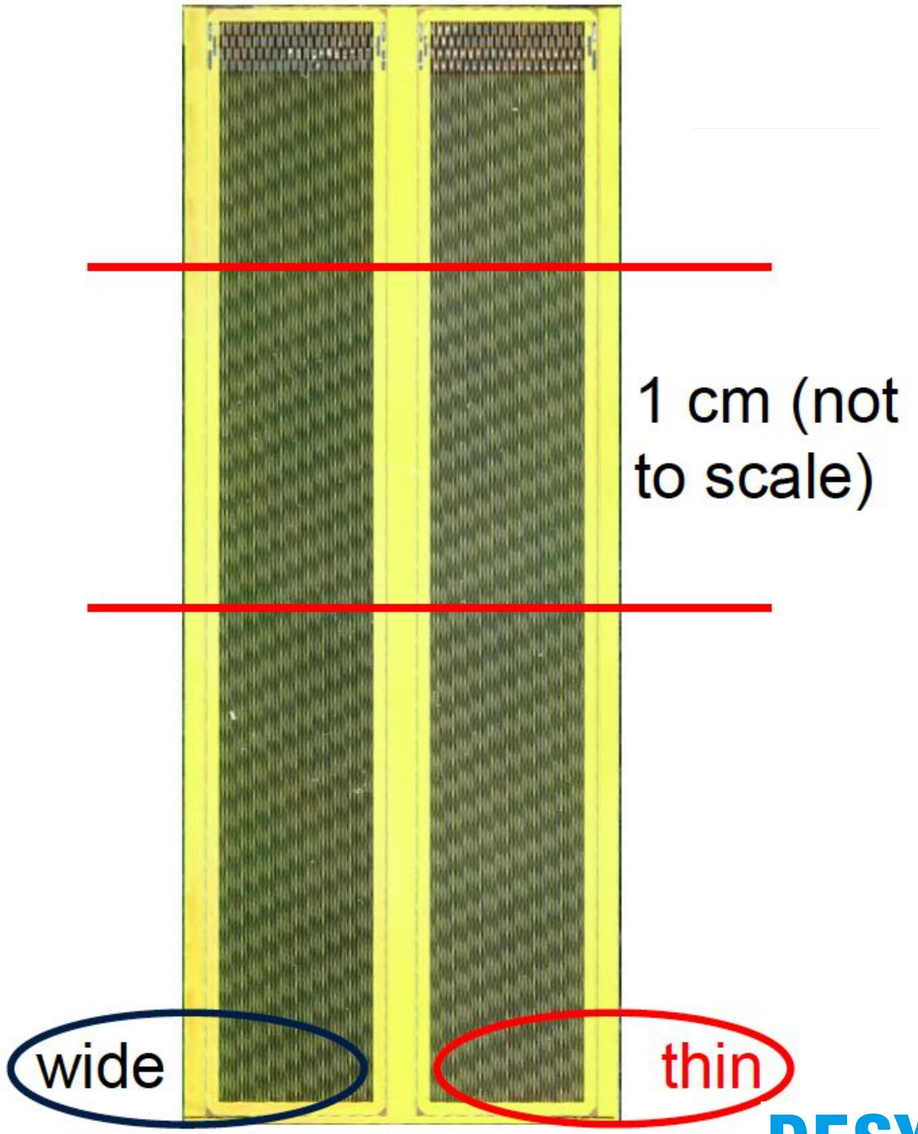
- Frontside process: Reticle stitching for large sensors

- The strip sensors has 2 different lengths : 2 cm and 4 cm

Sensor details



- Sensor thickness ~150µm
- Strip pitch =75.5 µm

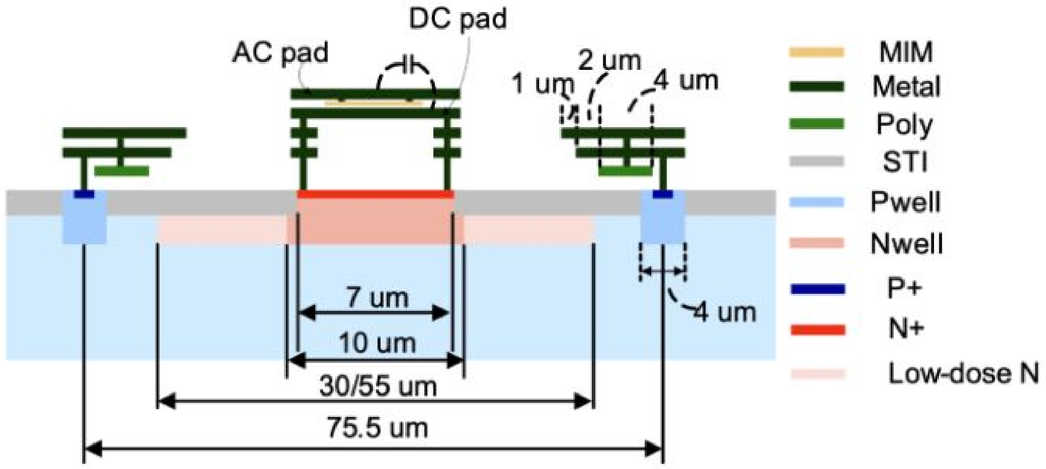


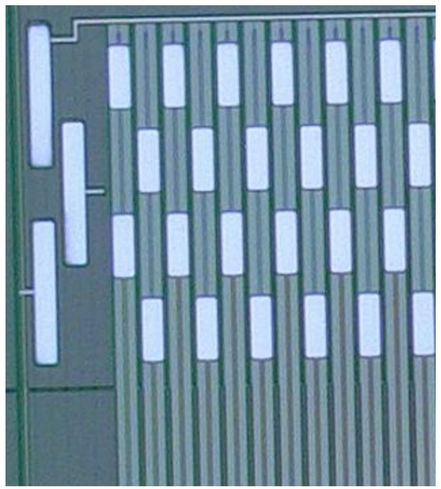
- Two different sensor flavours divided in left (wide) and right (thin) half of the sensor
- Each flavour has 40 strips
- Stitching reticles are ~1cm long

DESY.

Sensor design

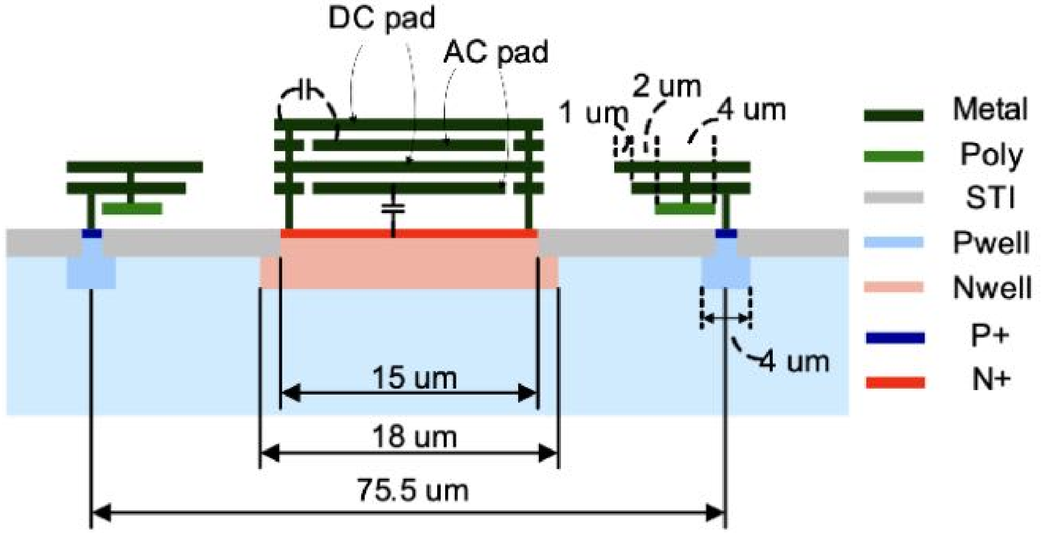
Wide implant

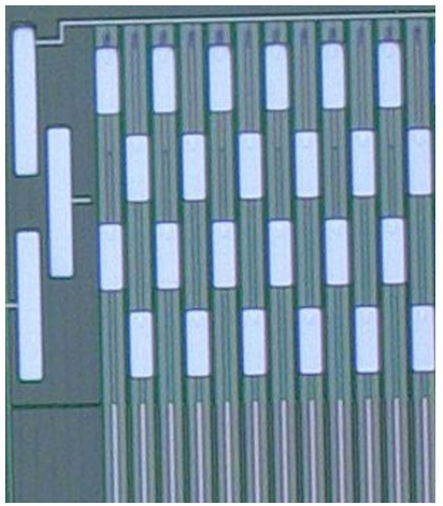




Wide implant has two different width for the low-dose N

Thin implant





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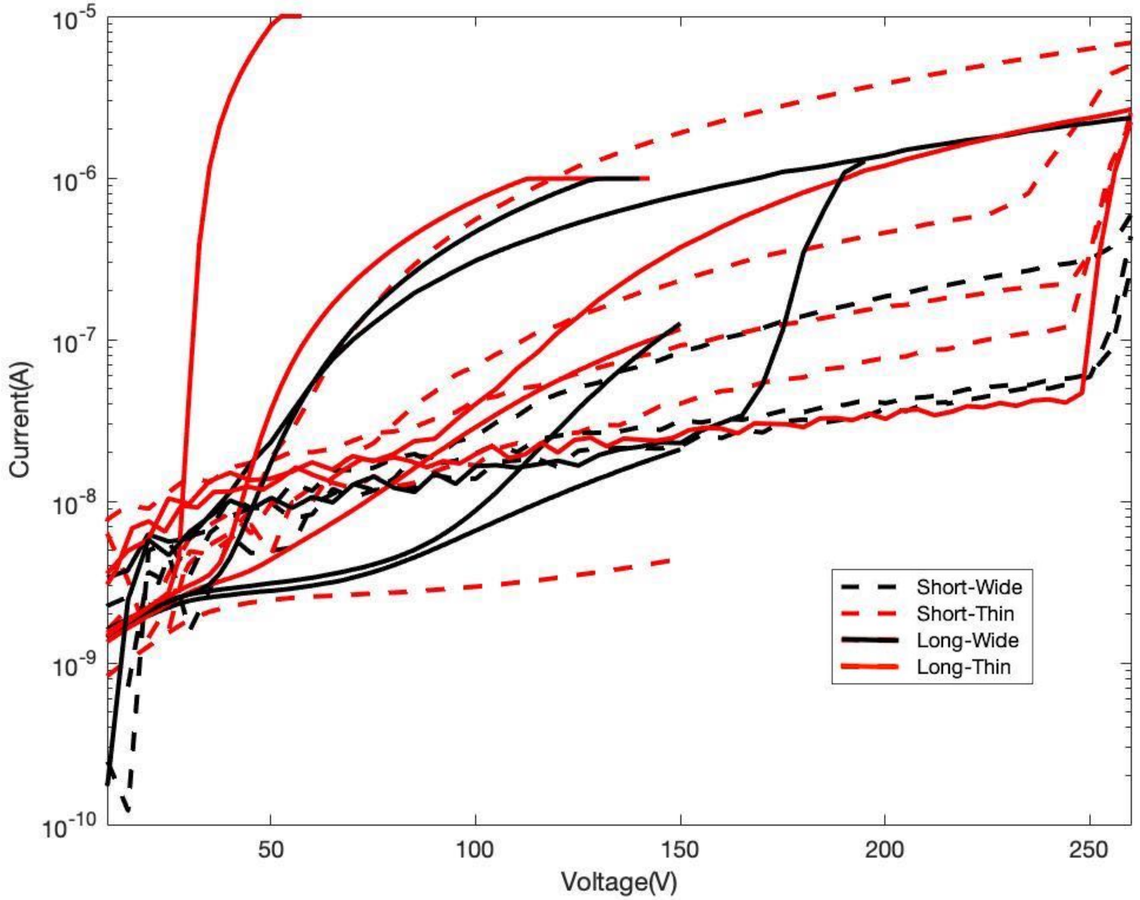
Electrical measurement

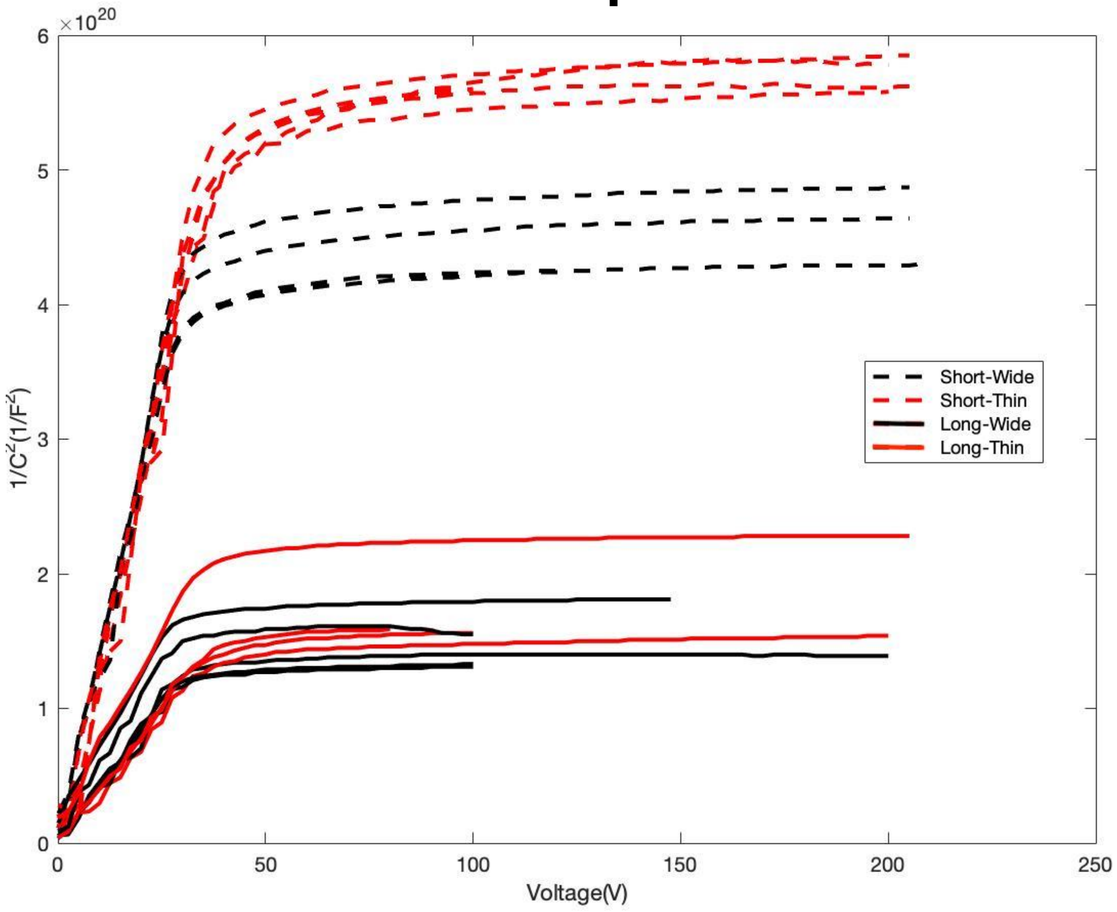
All measurements are performed at room temperature

IV plot



- For some of the sensor breakdown voltage is around 250V
- Some sensors show early breakdown -> bad backside process/implant (improved for next batch)

CV plot



- The depletion voltage is in the range of 30-40V
- Depletion voltage for wide sensor < Depletion voltage for thin sensor

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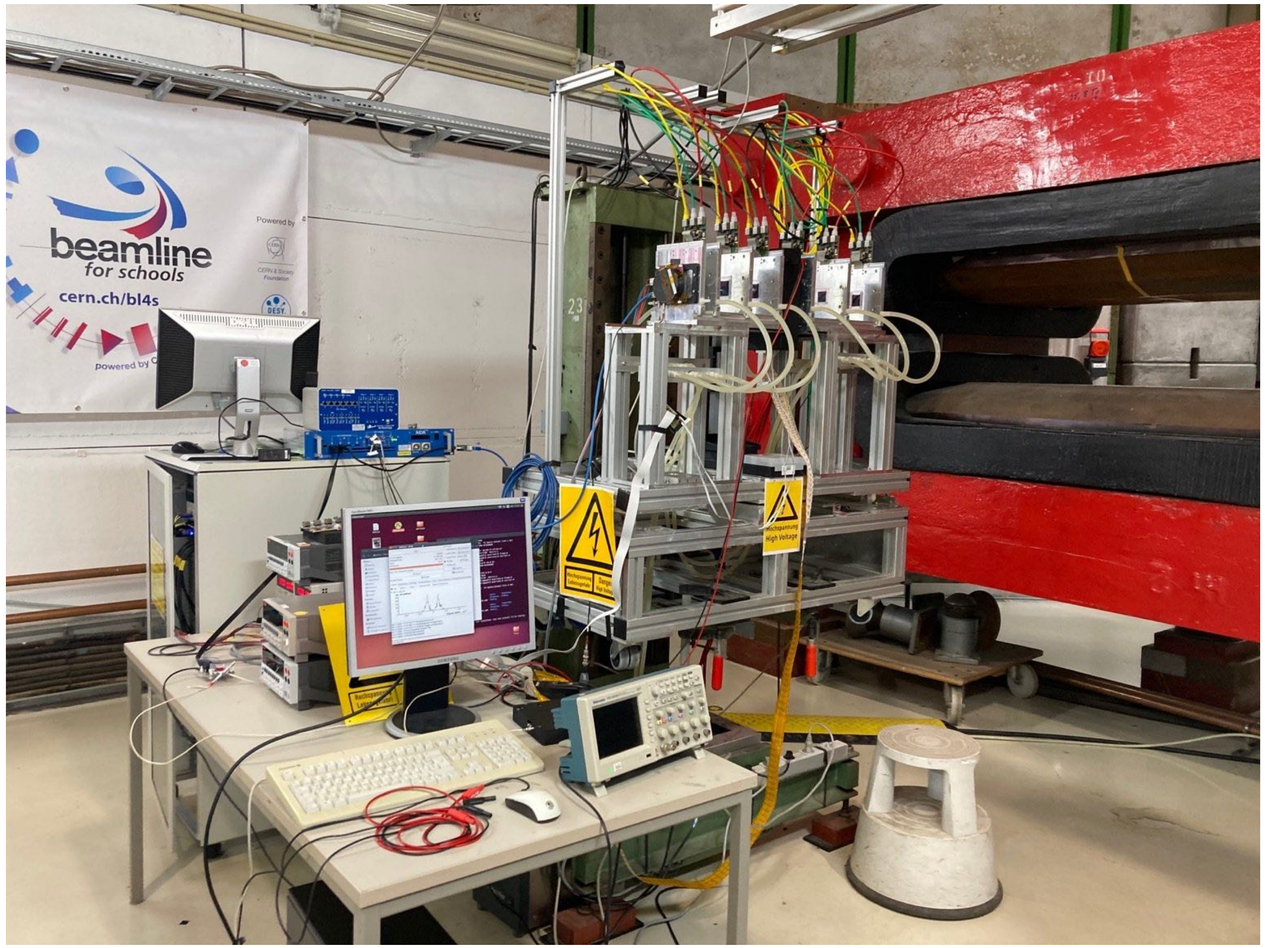
Goals for test beam

- Objectives
  - Sensor behaviour and signal formation with electrons
  - Study effects of stitching in the beam
  - Charge collection with different voltages

- Data taken at DESY II
  - Electron beam with beam energy 5 GeV
  - Using beam line 21 (DATURA telescope) with ALiBaVa system



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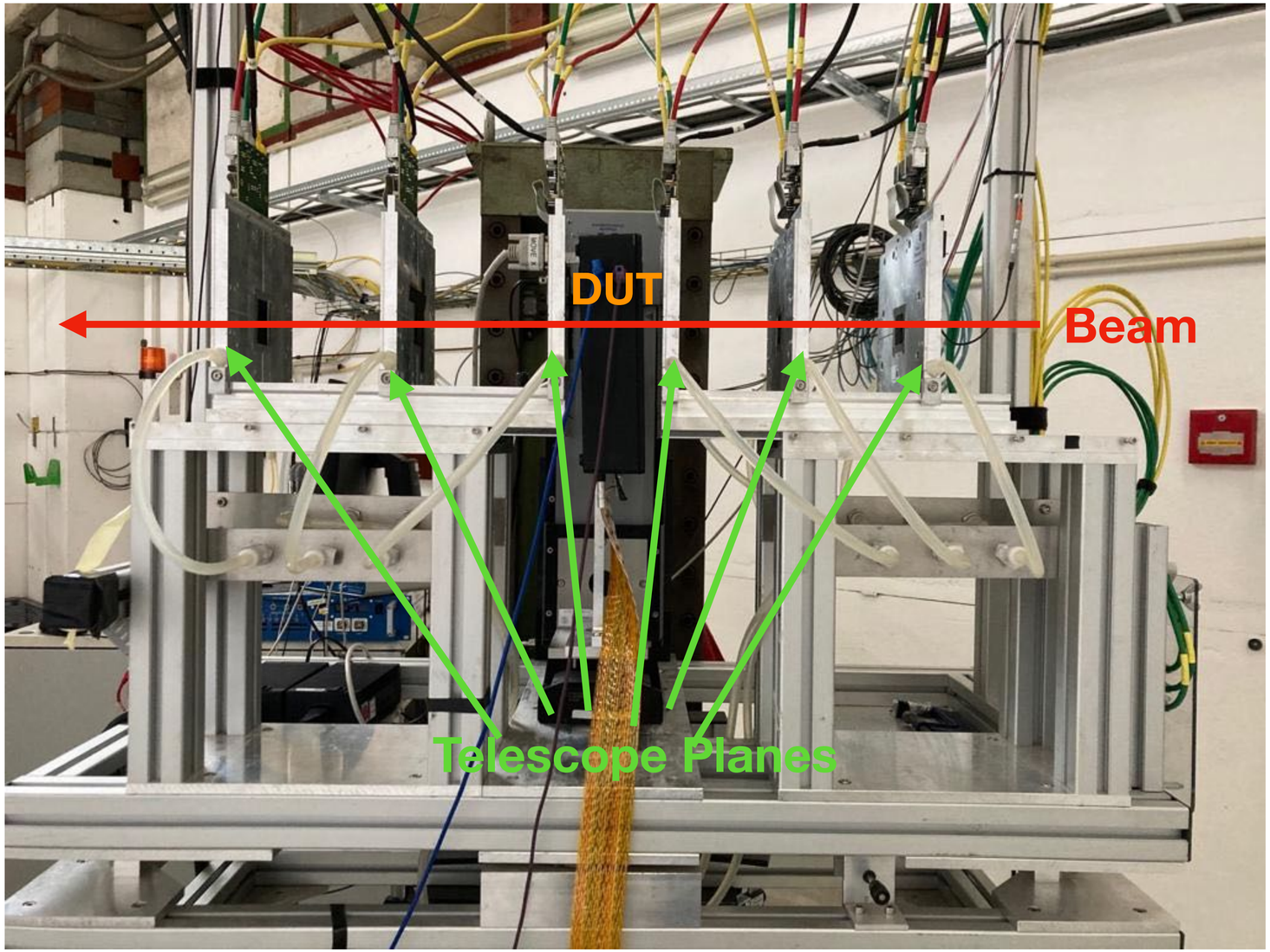
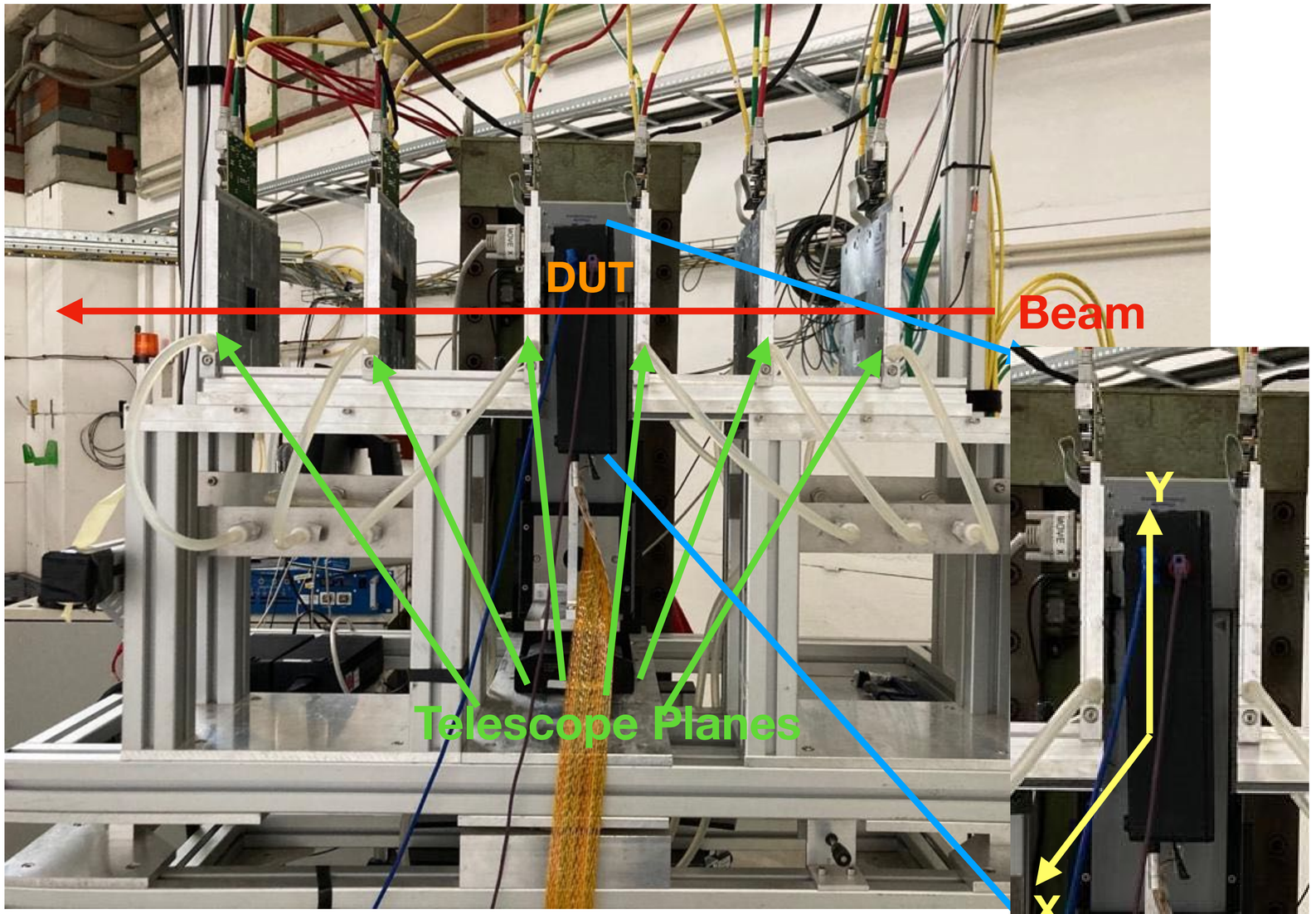
Setup for test beam



- Measurement for the long sensor is performed -> connected to the readout
- To study the effects of the stitching, sensor is scanned from top to bottom
- Temperature is monitored near the sensor

DESY.

Setup for test beam



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ALiBaVa setup

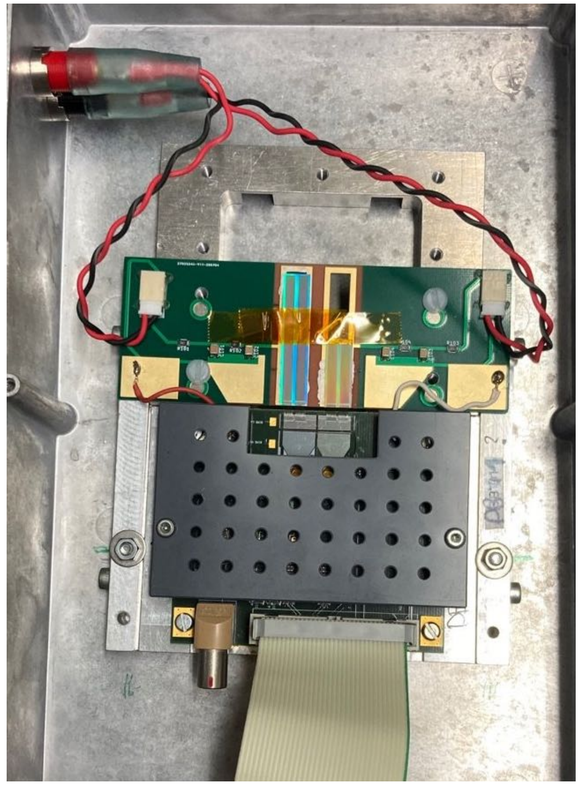
- ALiBaVa is the readout system for silicon strip sensors particularly to study the charge collection with source or laser measurement

- The system uses an analogue readout chip and has two main components: daughter board and mother board

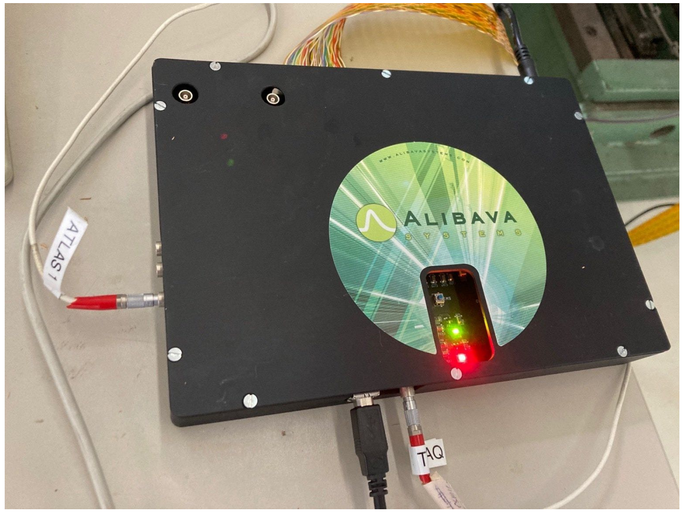
- Daughter board contains two beetle chip(used in LHCb) and is bonded to the silicon sensors under test

- Mother board process the analogue data that comes from daughter board

Sensor board with daughter board setup



Mother board



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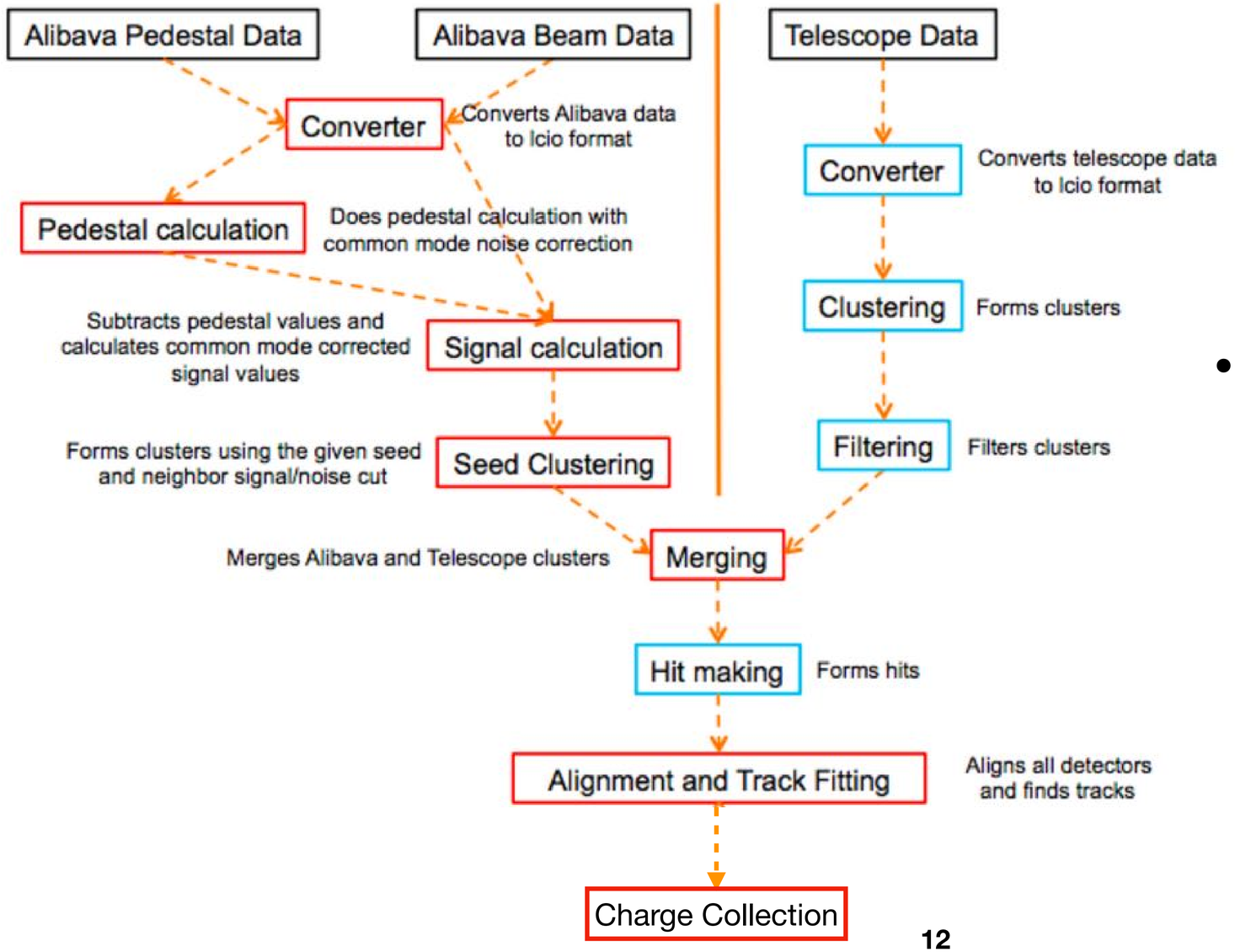
Analysis Strategy



- Using EUTelescope for analysis

Taken from Eda Yildrim thesis

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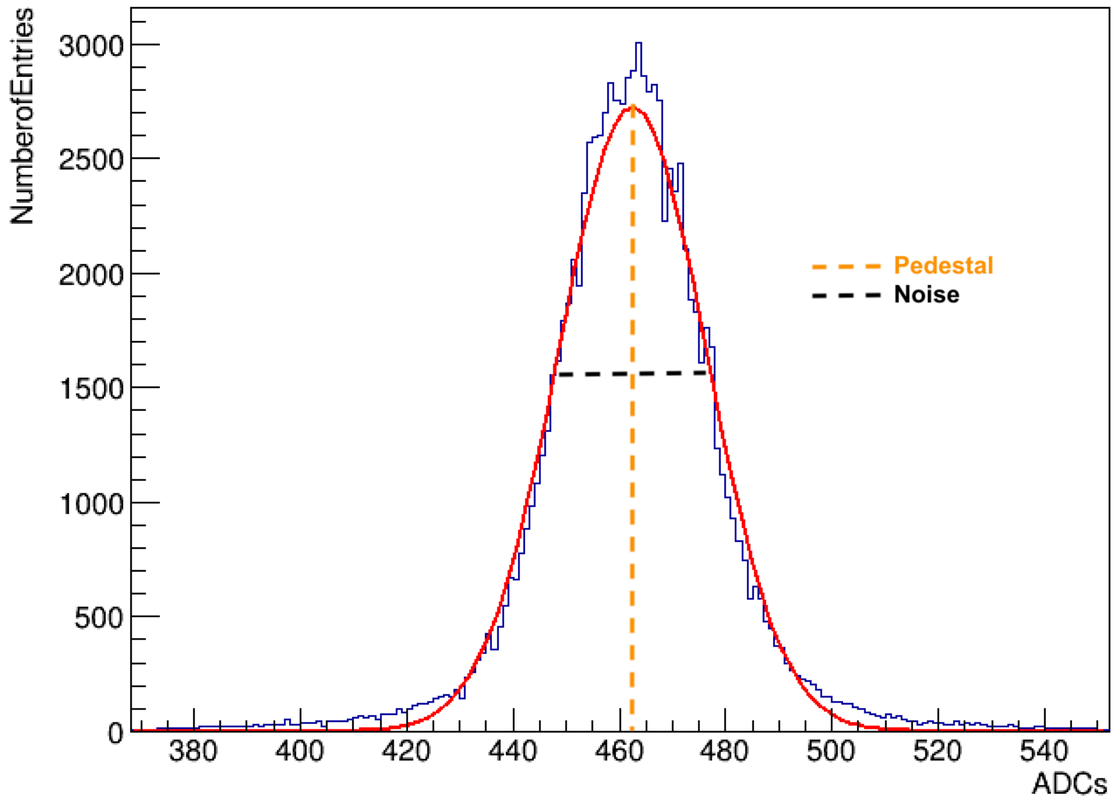
ALiBaVa data reconstruction

Pedestal Calculation

Pedestal and Noise Calculation

- Calculate base value and noise for each channel without any signal



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ALiBaVa data reconstruction

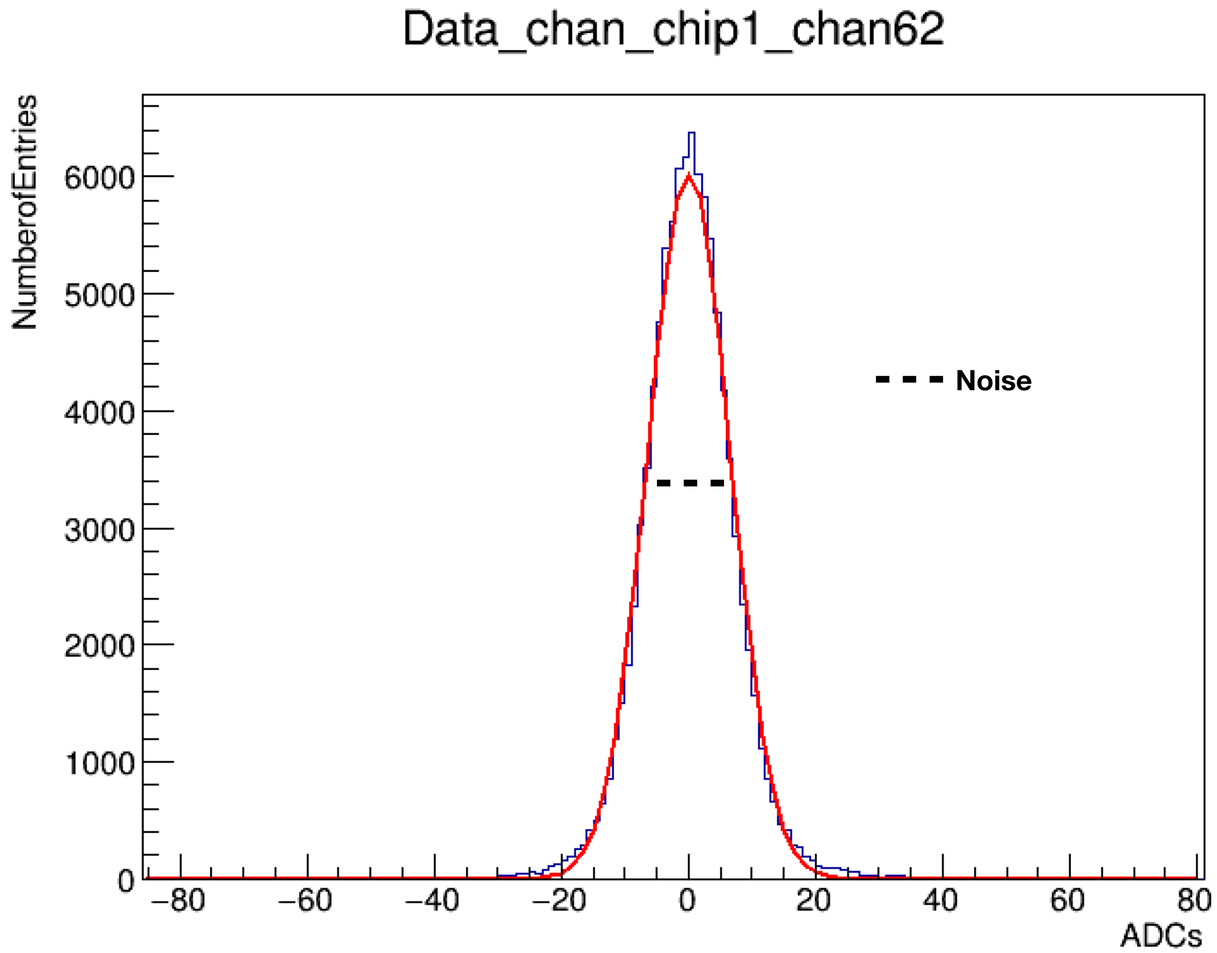
Signal Calculation

Pedestal and Noise Calculation

- Calculate base value and noise for each channel without any signal

Common Mode Correction

- Random shifts in voltage -> shifts in the channel base value
- Extra noise in the readout channel -> subtracted from the pedestal data



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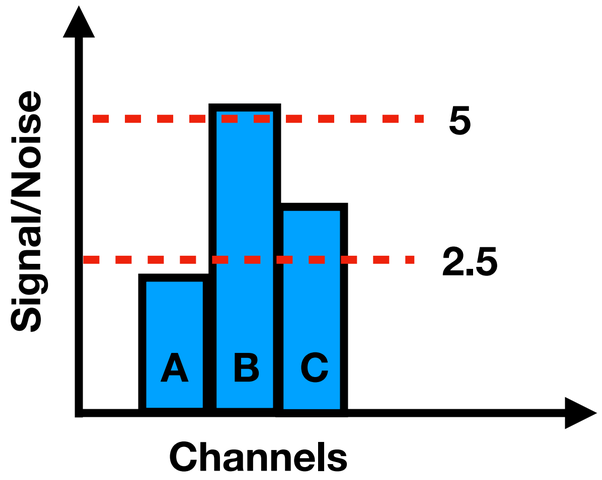
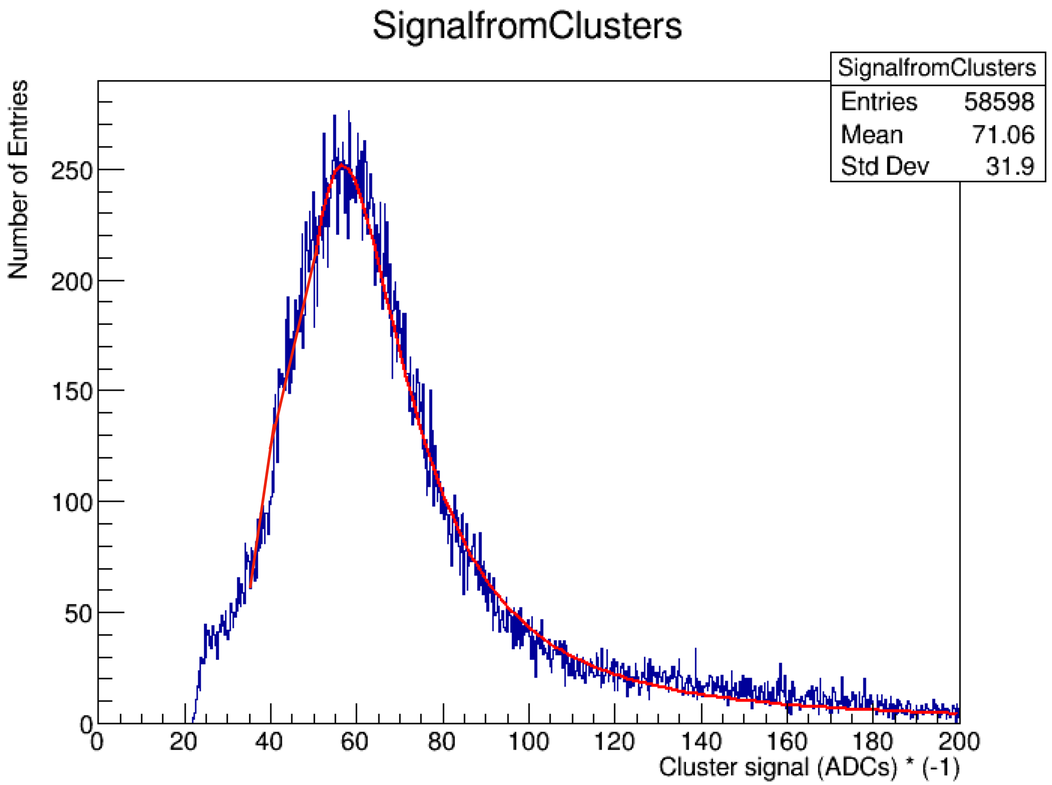
ALiBaVa data reconstruction

Seed Clustering

Clustering

- Seed : 5 x noise ; Neighbour: 2.5 x noise
- Neighbouring channels clustered with seed channel -> forms a cluster
- Maximum 5 channels in a cluster





DESY.

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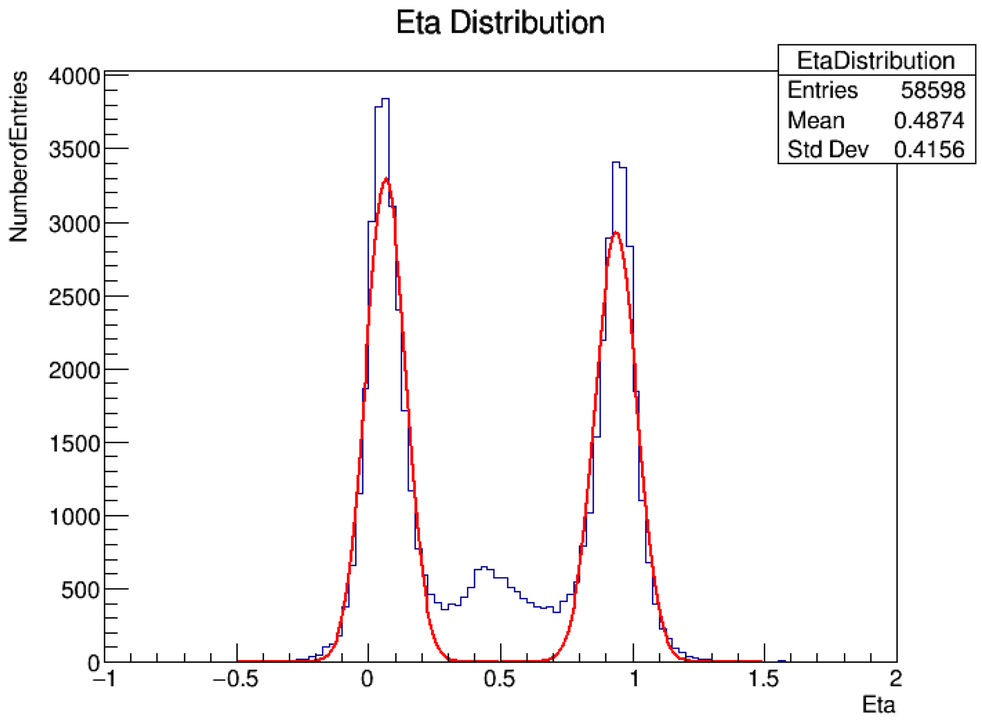
Asymmetric Eta-Distribution

- Eta distribution shows the measure of charge division
- Left channel -> increased charge -> cross talk effect



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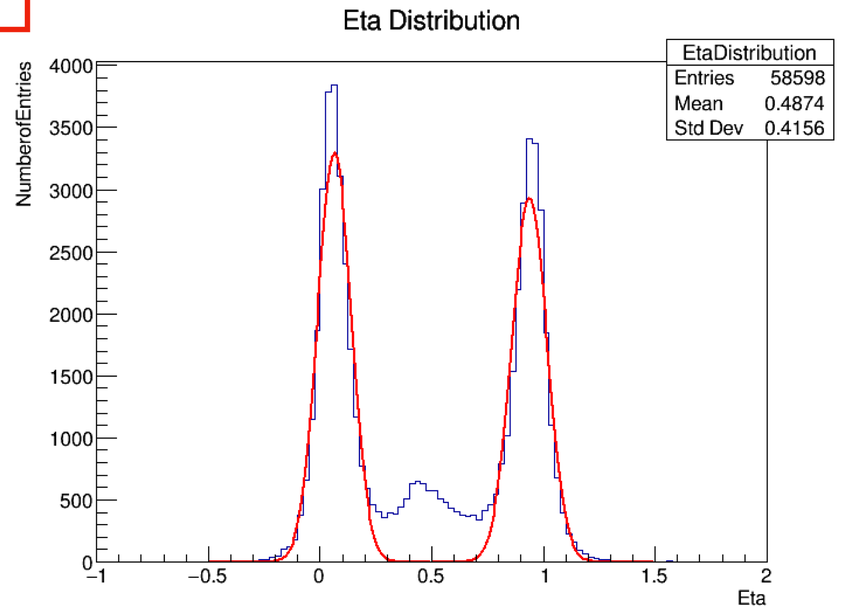
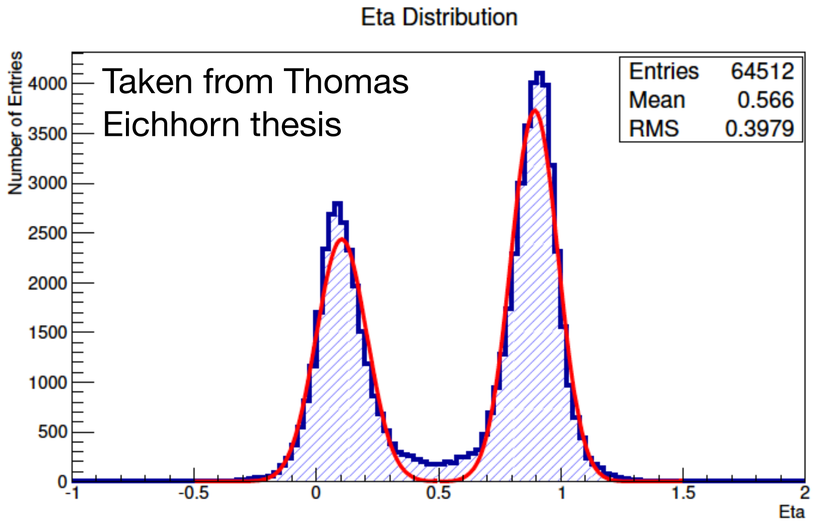
Plot should be like this -> Charge sharing can be seen in previous plot around eta = 0.5





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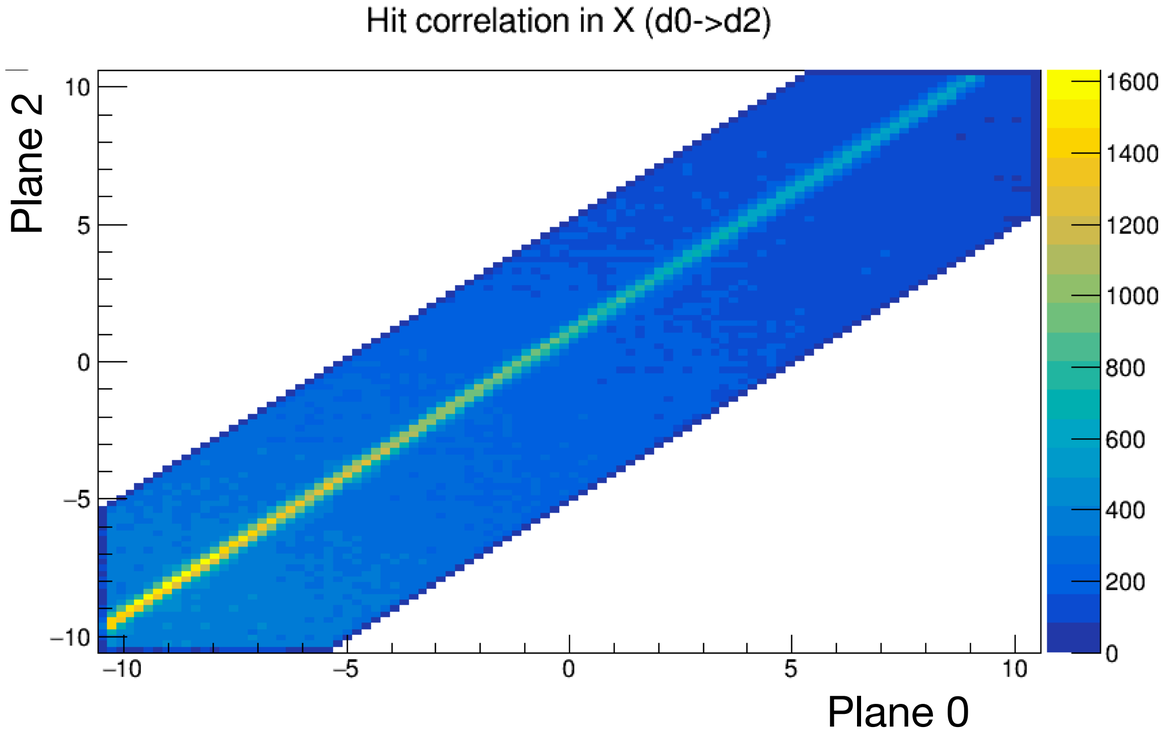
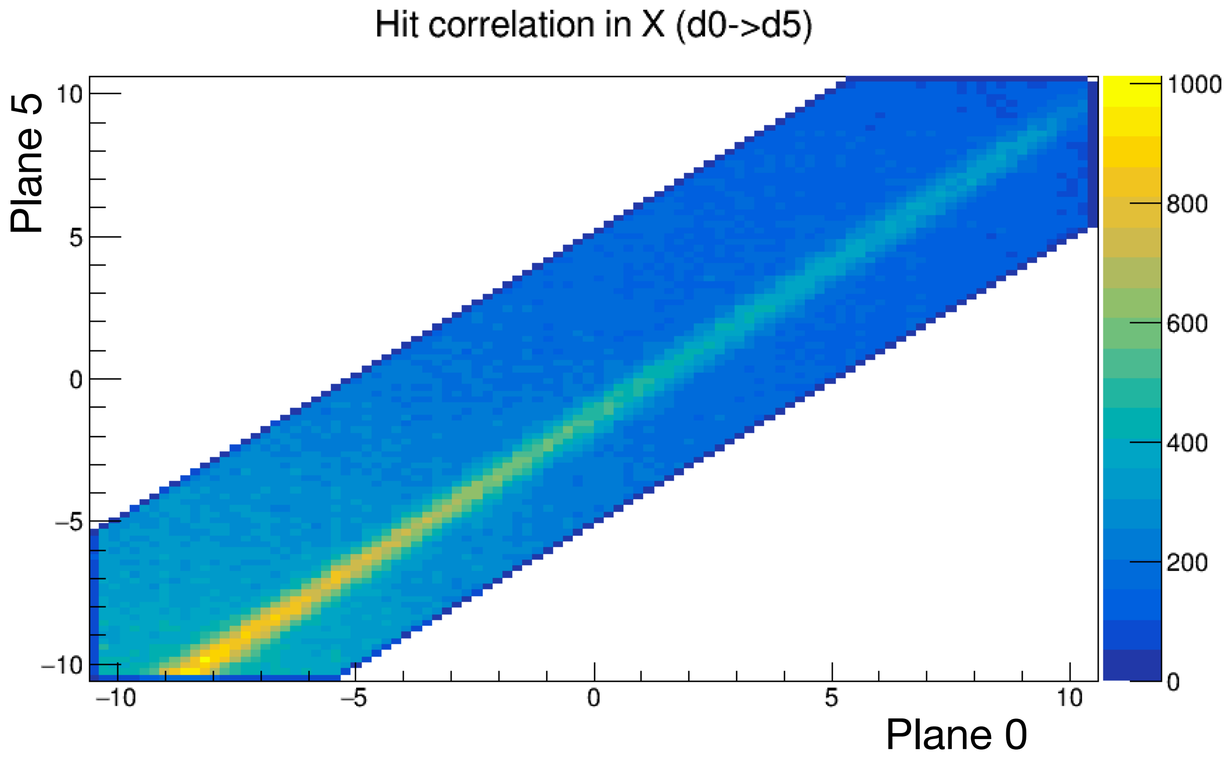
Telescope data reconstruction

Hitmaker

Without DUT





Correlation Plot

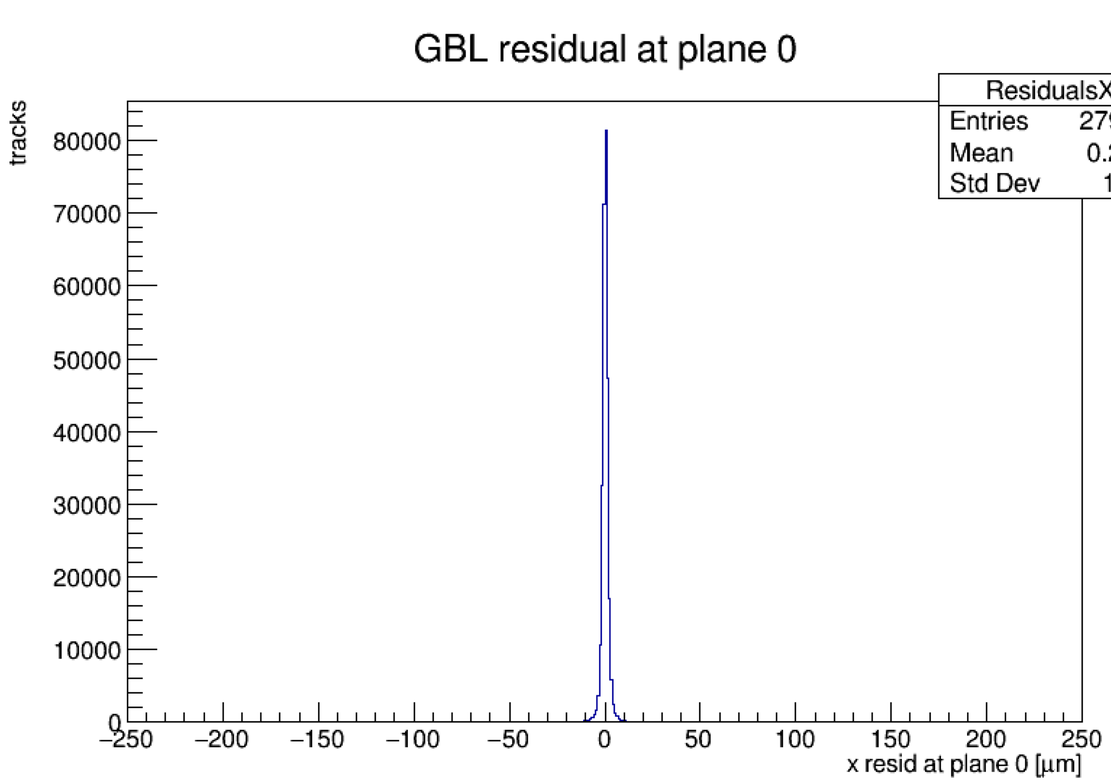
- Correlation between mimosa plane 1 and plane 3 is better than plane 1 and plane 6

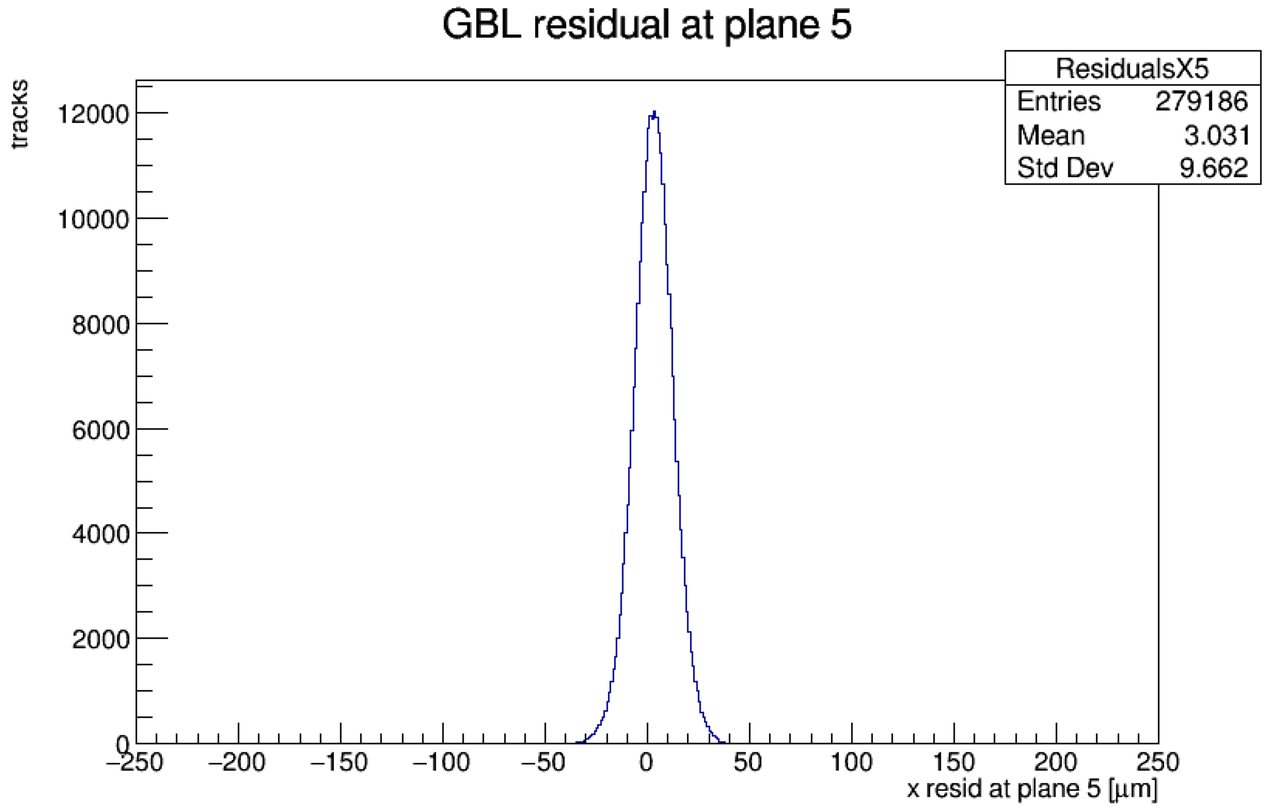
DESY.

Telescope data reconstruction

Alignment and Track Fitting

Without DUT





Residual Plot

- Residual -> distance between hit and fitted track extrapolation
- First iteration of residual values shows reasonable value

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Summary

- Performed first test beam measurement for passive CMOS strip sensor
- Working on the analysis with EUTelescope
- Initial reconstruction and analysis shows data taken is reasonable

Outlook

- Continuing the analysis further
- New test beam and irradiation studies is also being planned
- New batch of sensor with back-side metallisation that improves the initial electrical measurement

The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF)

Thank You for Attention

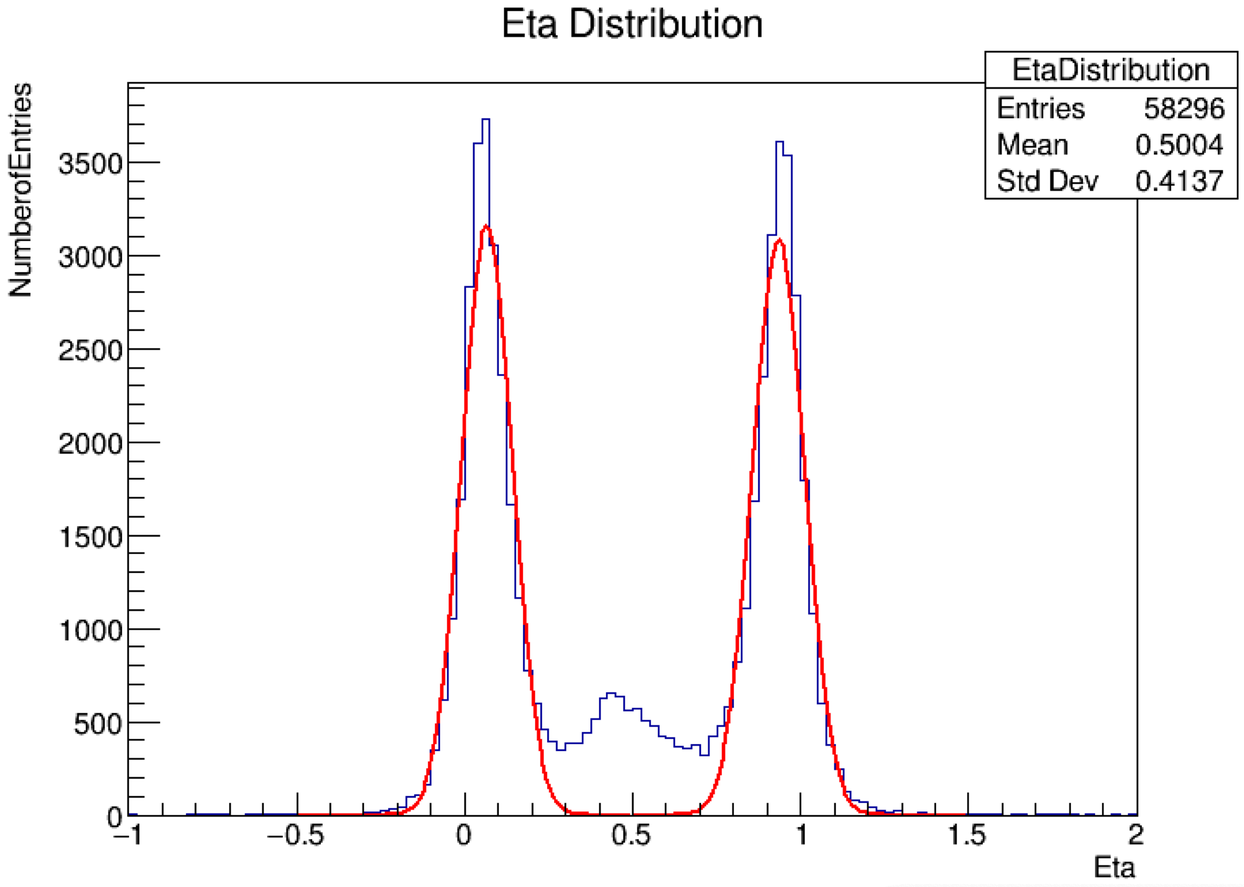
Backup

ALiBaVa data reconstruction

Seed Clustering

Finite Impulse Response(FIR) filter

- Calculate the cross talk coefficient for left or right channel -> till 2 channels on both sides
- Calculate the amount of cross talk signal
- Subtract it from the measured signal



DESY.