MSD Status

Gianluigi Silvestre on behalf of the MSD Group at Perugia

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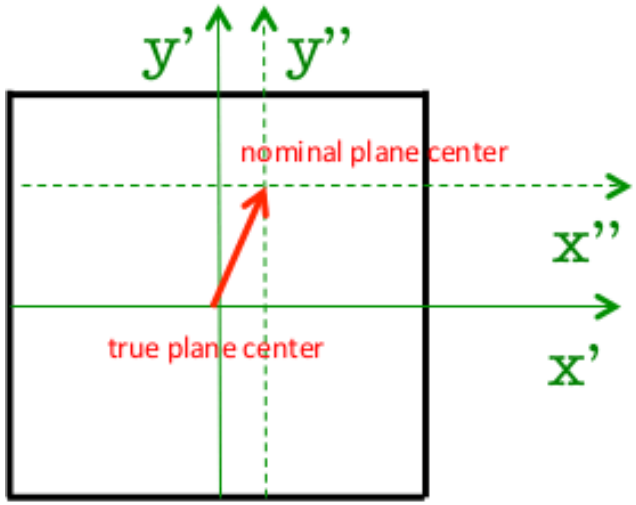
Summary

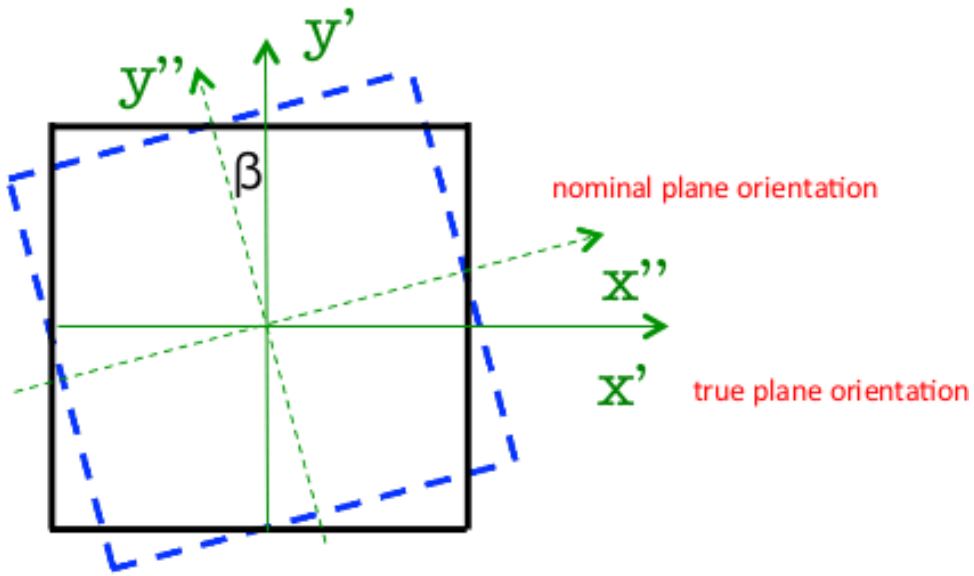
- Alignment
- Spatial resolution
- Noisy strips
- Efficiencies
- Response to charged particles

GSI 2021 Alignment

- Working on alignment with standalone code
  - Rigid shifts in the plane perpendicular to beam axis
  - Rotations around the beam axis
- Working on data selection: increase events with only 1 hit in each detector (reduce noise, use non alignment runs maybe …)
- Fixed some errors in the geometry (distances along the beam axis)
- Will need to then align MSD system with the rest of the detectors



$$x'' = x' - dx$$
$$y'' = y' - dy$$



$$x'' = \cos(\beta)\, x' - \sin(\beta)\, y'$$
$$y'' = \sin(\beta)\, x' + \cos(\beta)\, y'$$

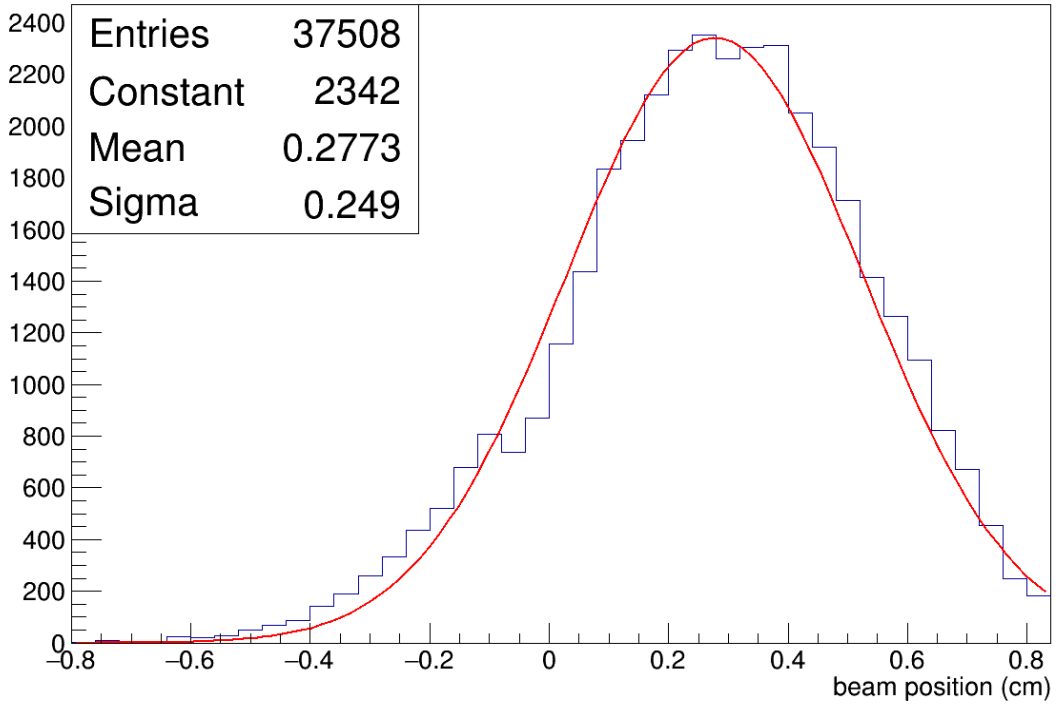
$$x'' - x' = dx = [\cos(\beta)-1]\, x' - \sin(\beta)\, y'$$
$$y'' - y' = dy = [\cos(\beta)-1]\, y' + \sin(\beta)\, x'$$

$D[dx, x'] = \cos(\beta)-1$ $D[dx, y'] = -\sin(\beta)$

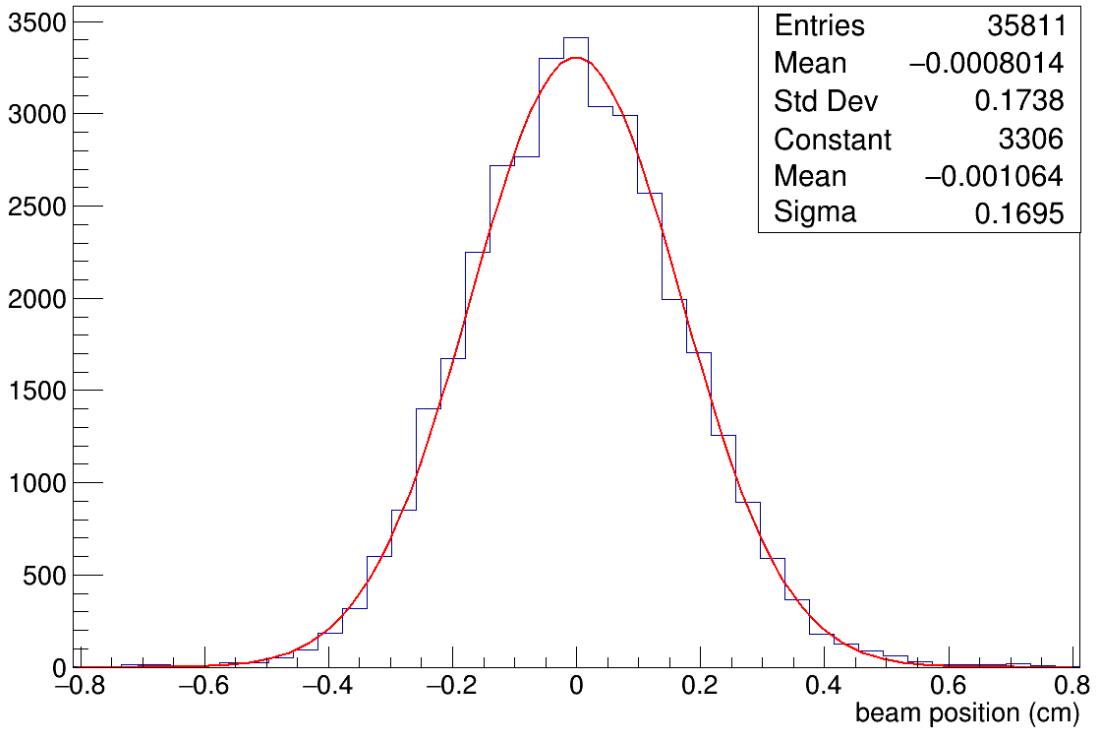
$D[dy, x'] = \sin(\beta)$ $D[dy, y'] = \cos(\beta)-1$

GSI 2021 Alignment

- Iterative procedure for the alignment
  - First step: reference detector alignment with the beam
  - Rigid shifts to centre the beam profile



Reference before alignment



Reference after alignment

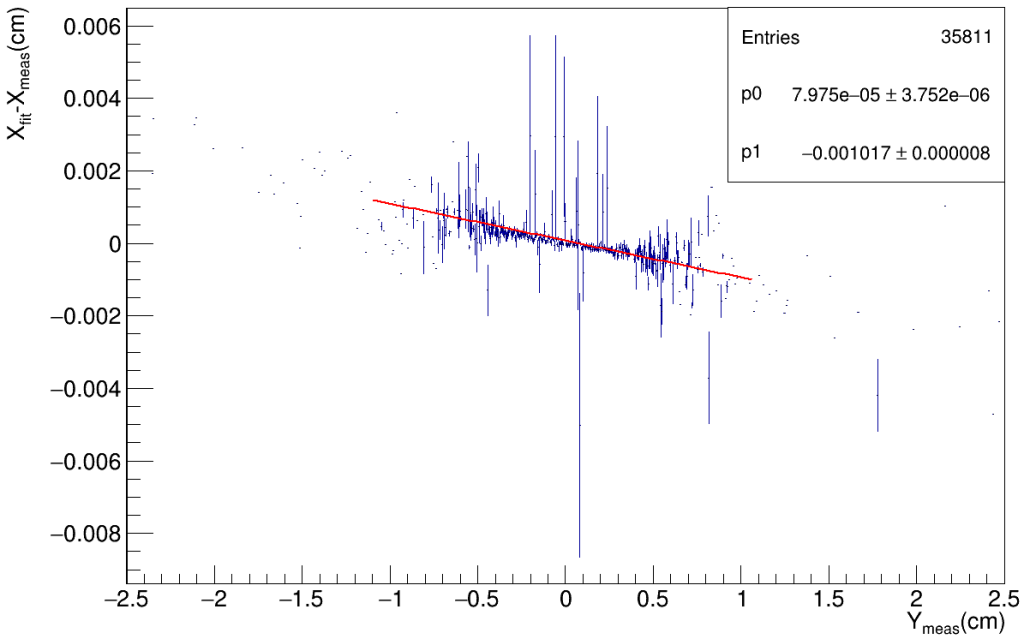
GSI 2021 Alignment

- Iterative procedure for the alignment
  - Rigid shifts and rotation computed at each step
  - Residual in X(Y) coordinate is dependent on Y(X) coordinate of impact in case of a rotation
  - Unbiased fit for residual calculations

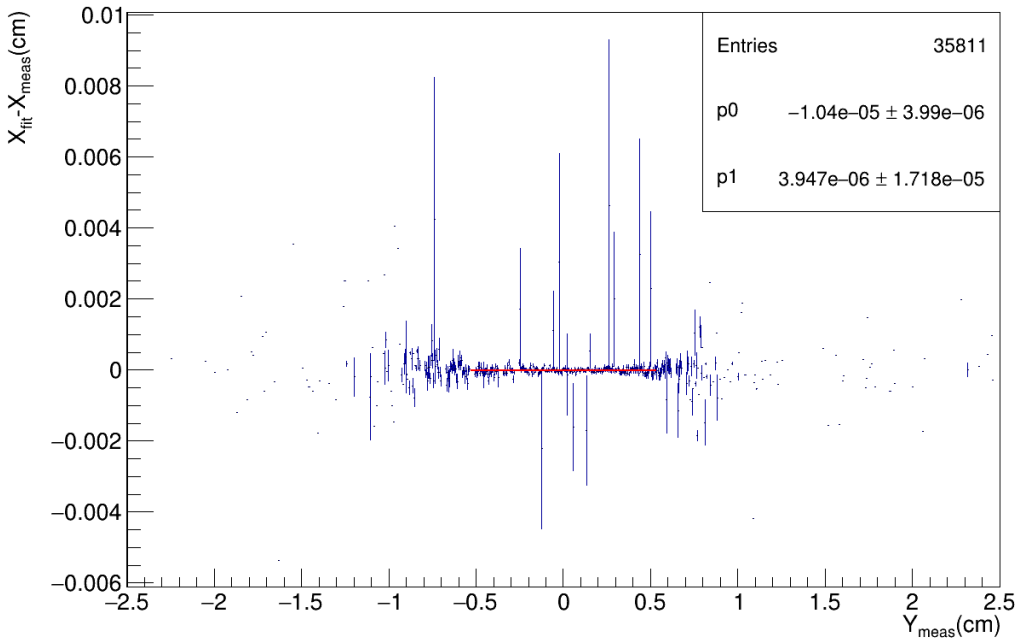
$D[dx, x'] = \cos(\beta)-1$ $D[dx, y'] = -\sin(\beta)$

$D[dy, x'] = \sin(\beta)$ $D[dy, y'] = \cos(\beta)-1$

h_rotation_Y_layer_0_iteration_0

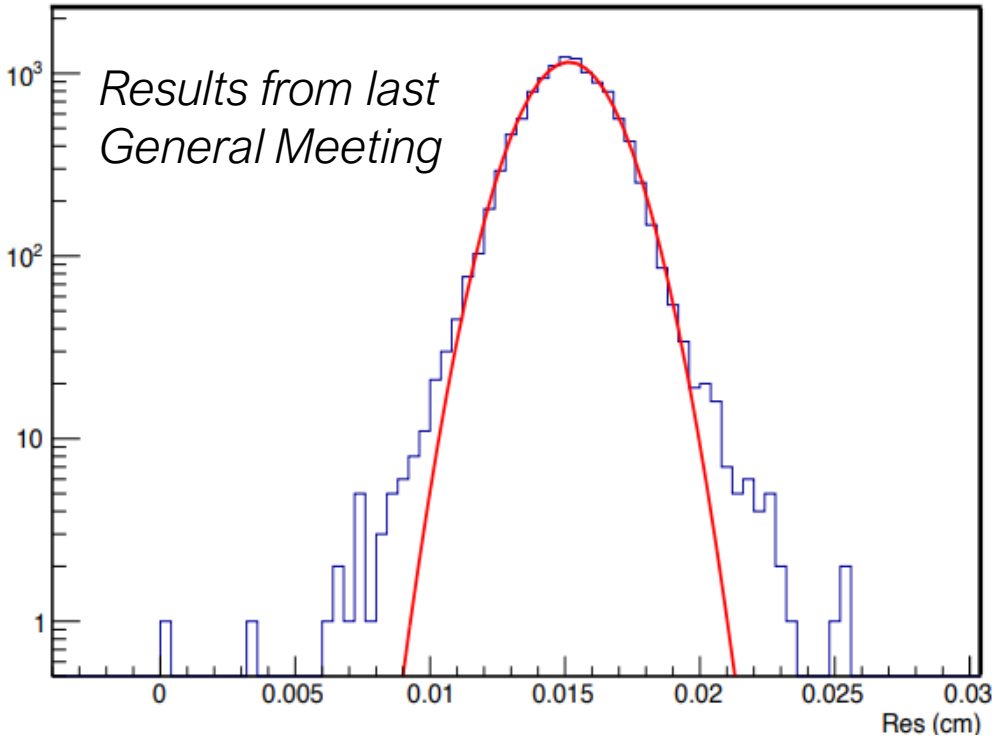


h_rotation_X_layer_0_iteration_499

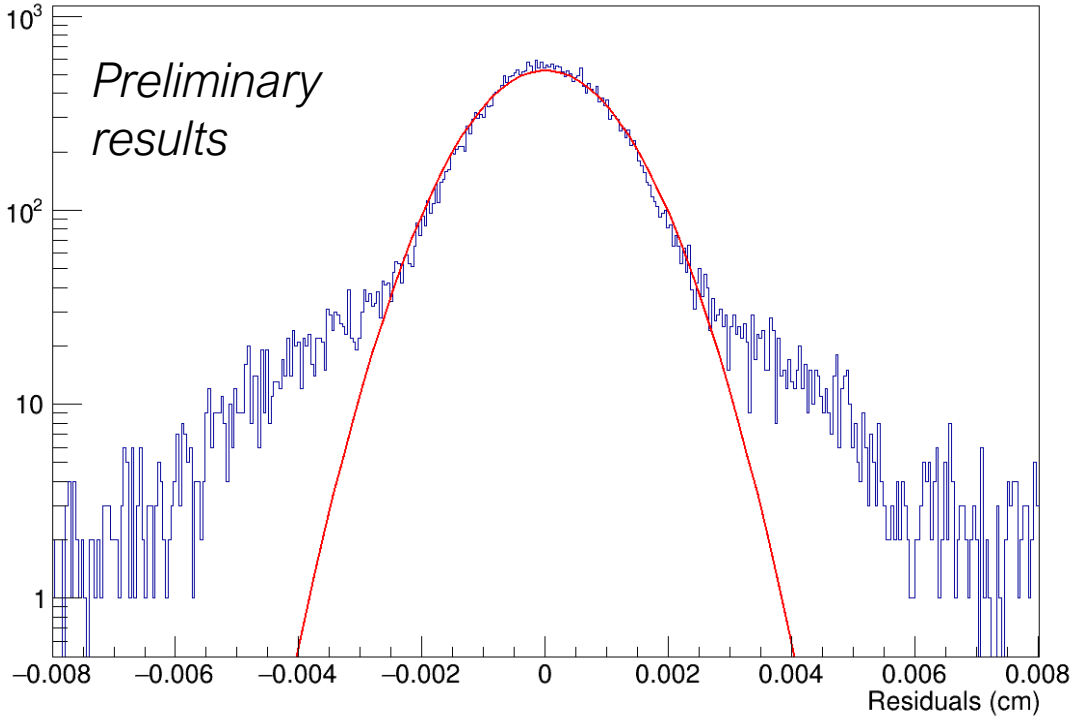


GSI 2021 Alignment

- Residuals are now correctly centered around 0
- Slight improvement in the estimated spatial resolution
- ToDo: study the resolution for all families of cluster widths



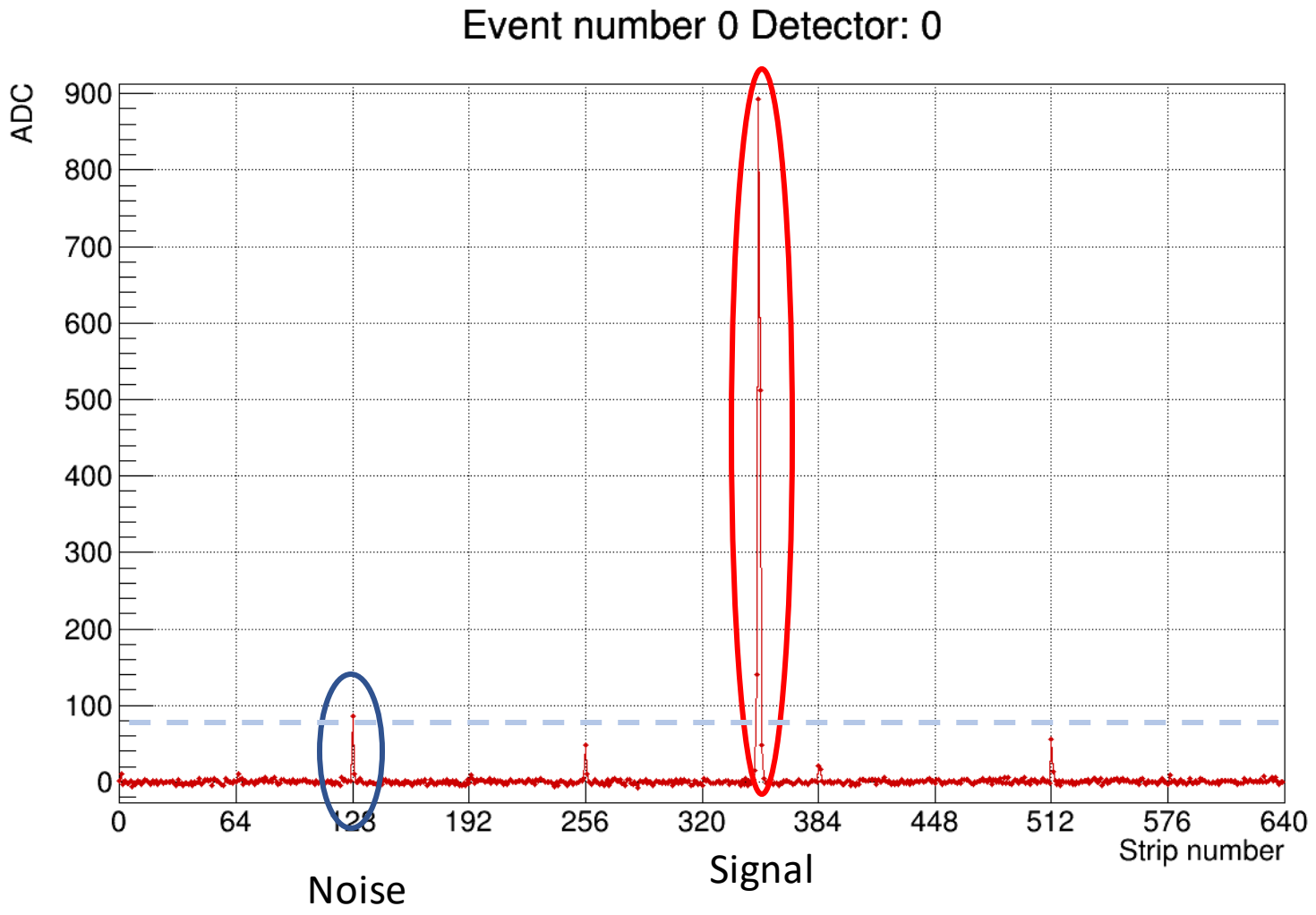
Resolution ≈ 15 μm



Resolution ≈ 12 μm

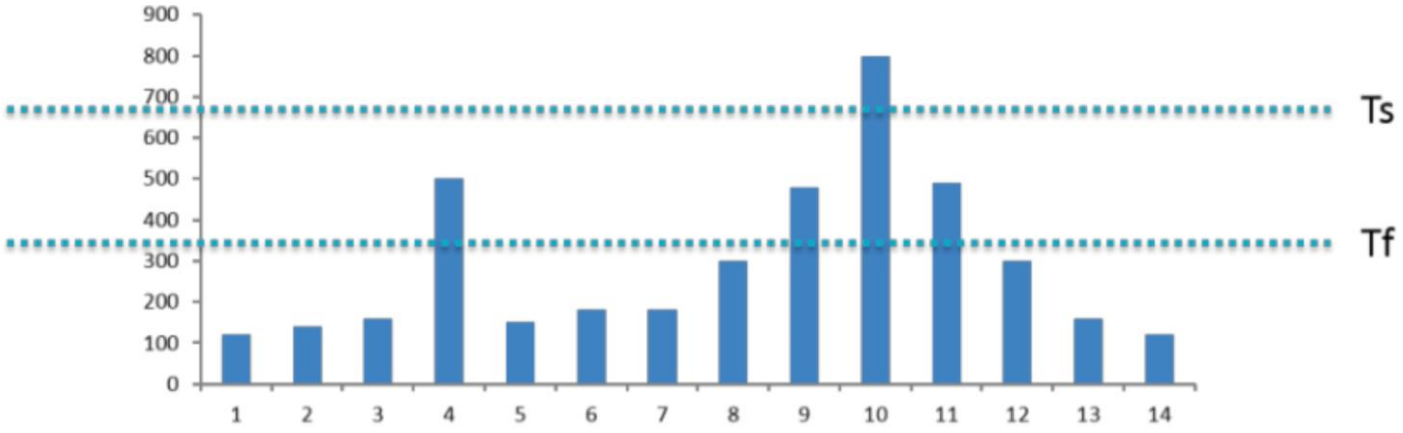
Noisy strips

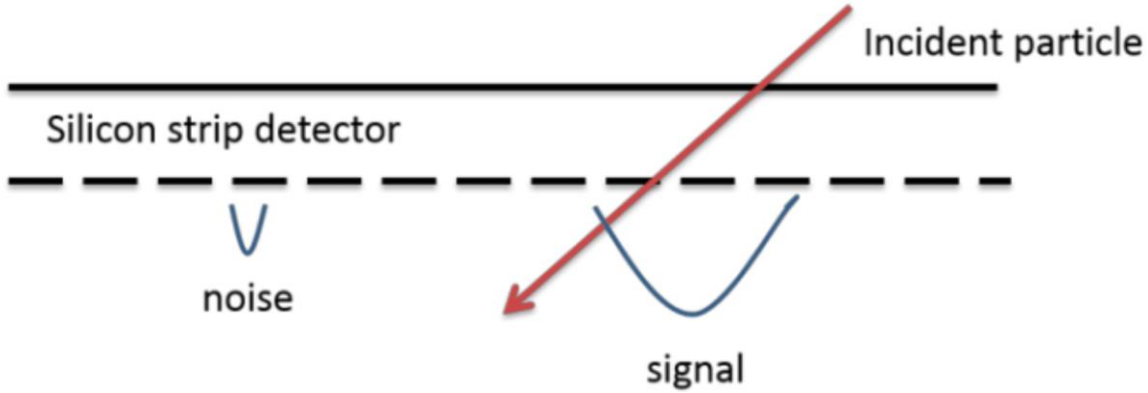
- First strip of each readout ASIC is noisy
  - Effect probably due to noise on the ASIC control signals
  - Signal is comparable to 5 MIPs, so much less than Oxygen primary
  - Calibration run is less noisy than data: effect of the beam needs to be studied
- One of the detectors has several noisy strips
- No big difference in cluster reconstruction with the dead strip map due to high cut threshold used (40 "sigmas", about 80-100 ADC depending on the channel)
- A new cluster algorithm might help



W.I.P.
New cluster reconstruction

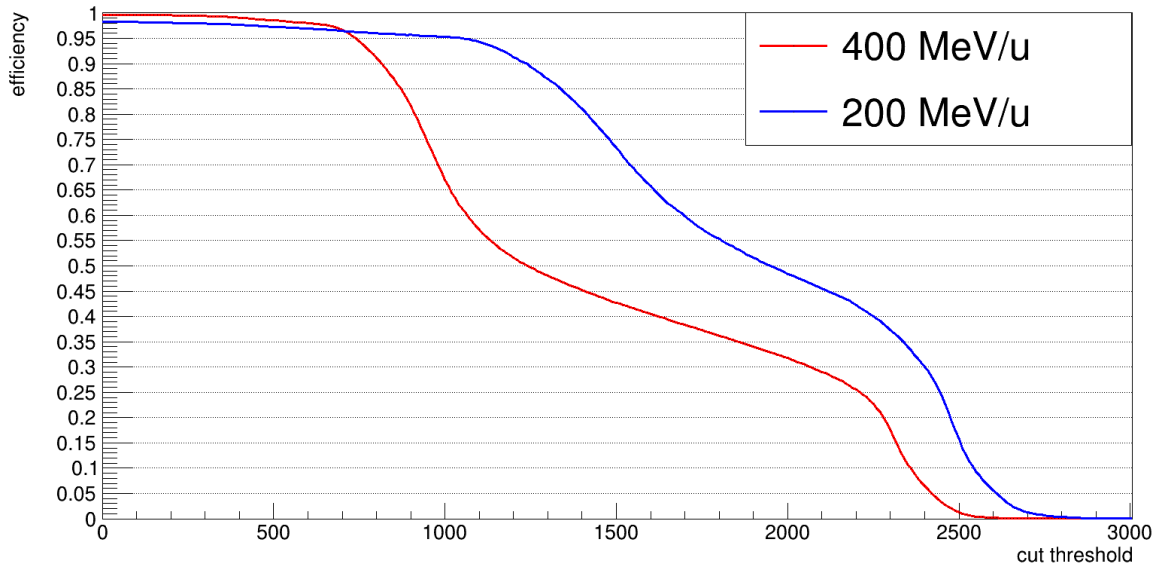
- Single threshold cluster reconstruction needs high cuts to avoid noise
- Implement a double threshold algorithm
- Possible to recover signals from strips now under threshold

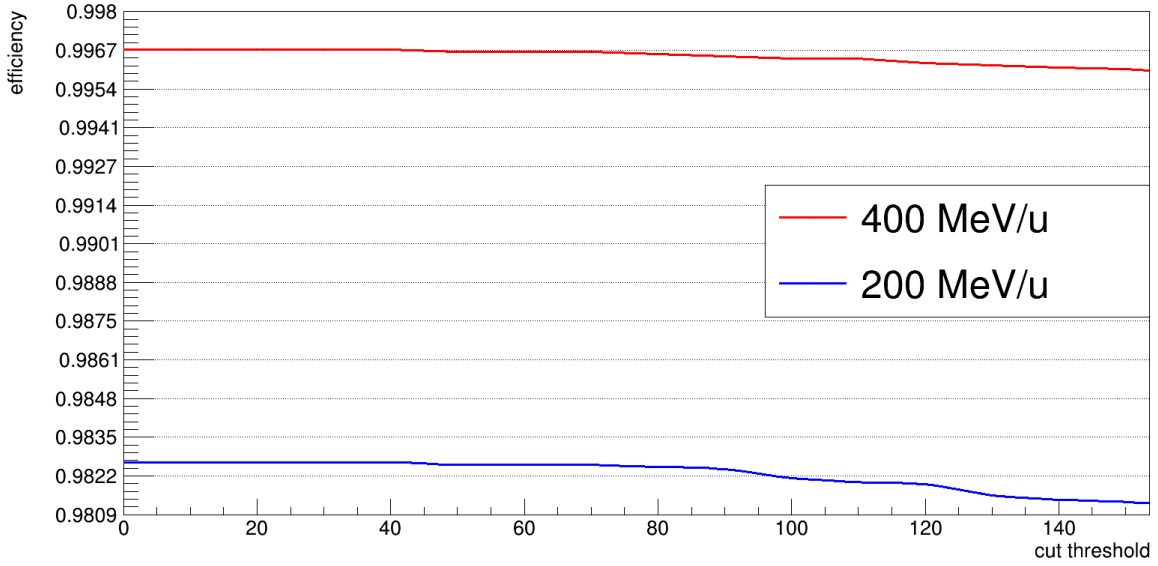




GSI 2021 Preliminary Efficiencies

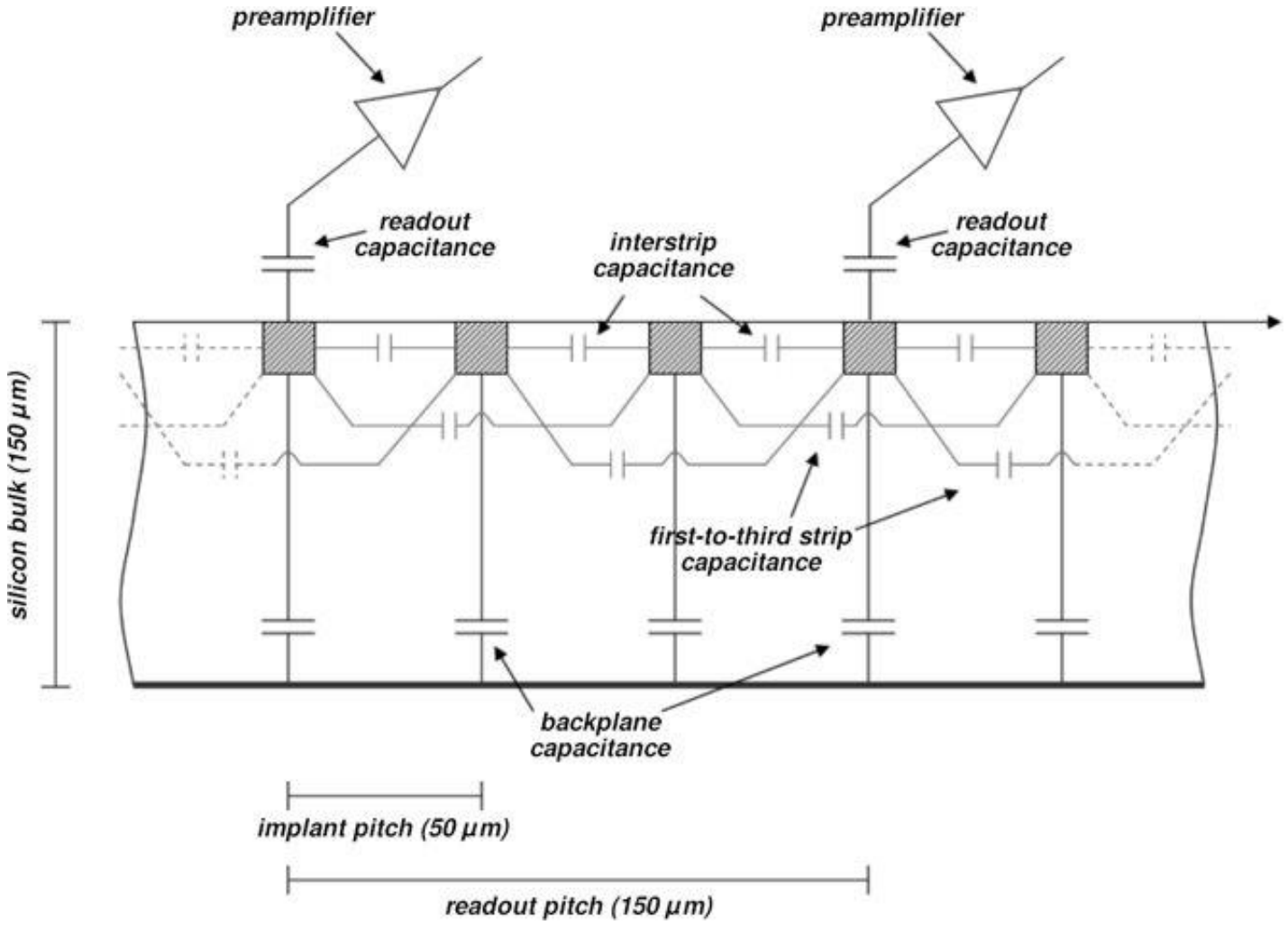
- Efficiencies estimation
  - High thresholds for cluster reconstructions on 1st and 3rd detectors
  - Cut at different thresholds on strips of the detector in the middle
  - With current cuts (around 100 ADC): >98% detection efficiency
  - To be studied: lower efficiency for 200 MeV/u data at low cuts





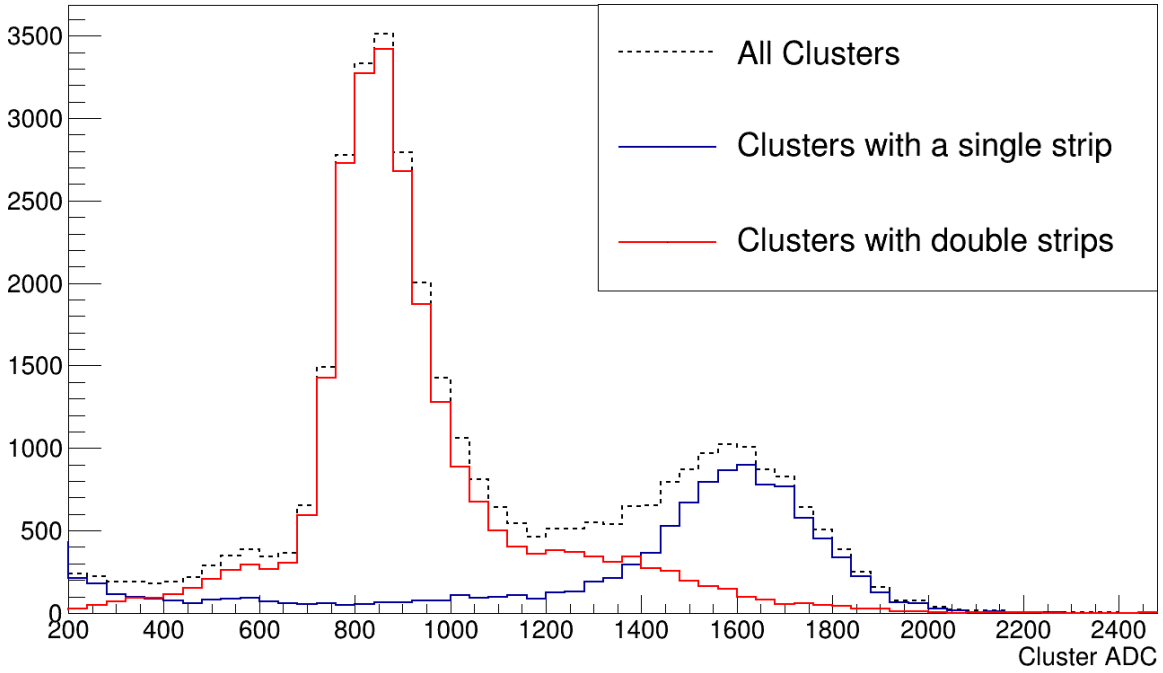
Reminder:
MSD readout strategy

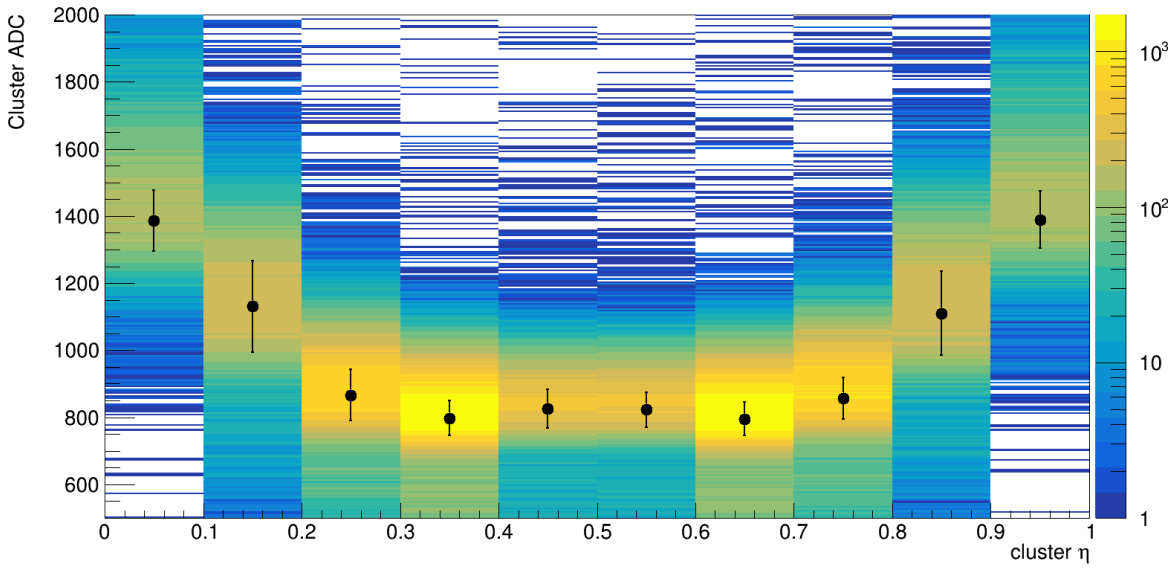
- AC-coupled silicon microstrip sensor read-out by ASIC chips
- Active area segmented in 1920 strips with a 50µm implantation pitch
- Readout pitch: 150µm, with 2 *"floating strips"*
- Total number of readout strips: 640
- Floating strips help with charge collection between readout strips
- Charge collection efficiency expected to be non linear between two readout strips



MSD signal

- Double peak structure for cluster ADC distribution
- Charge collection efficiency depends on the impact position with respect to readout strips
  - Higher signal peak mostly from single strip clusters
  - Lower peak mostly from larger clusters

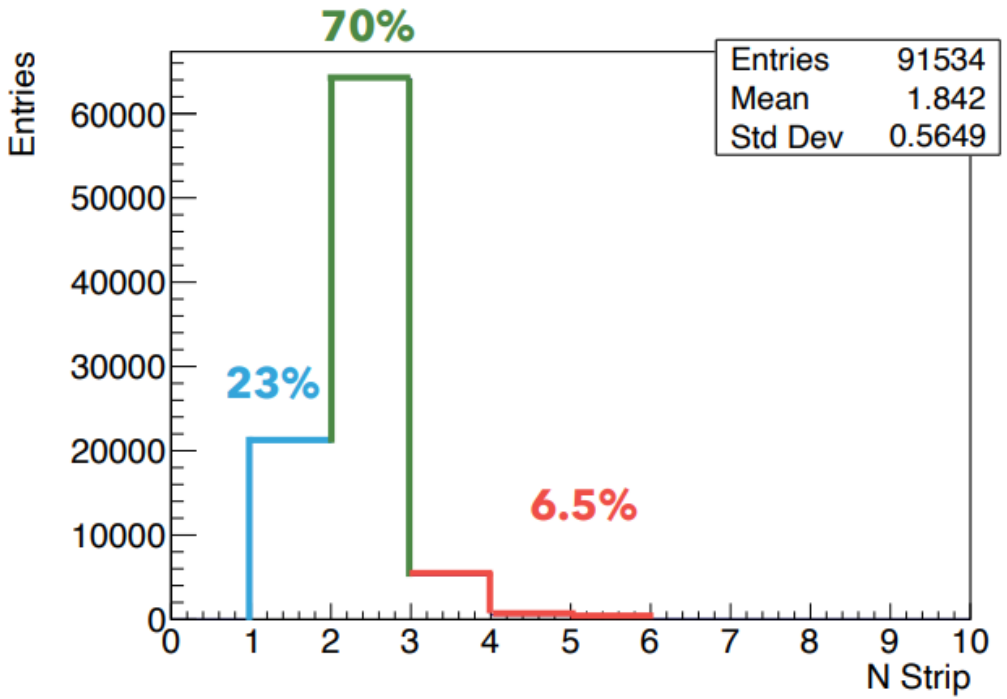




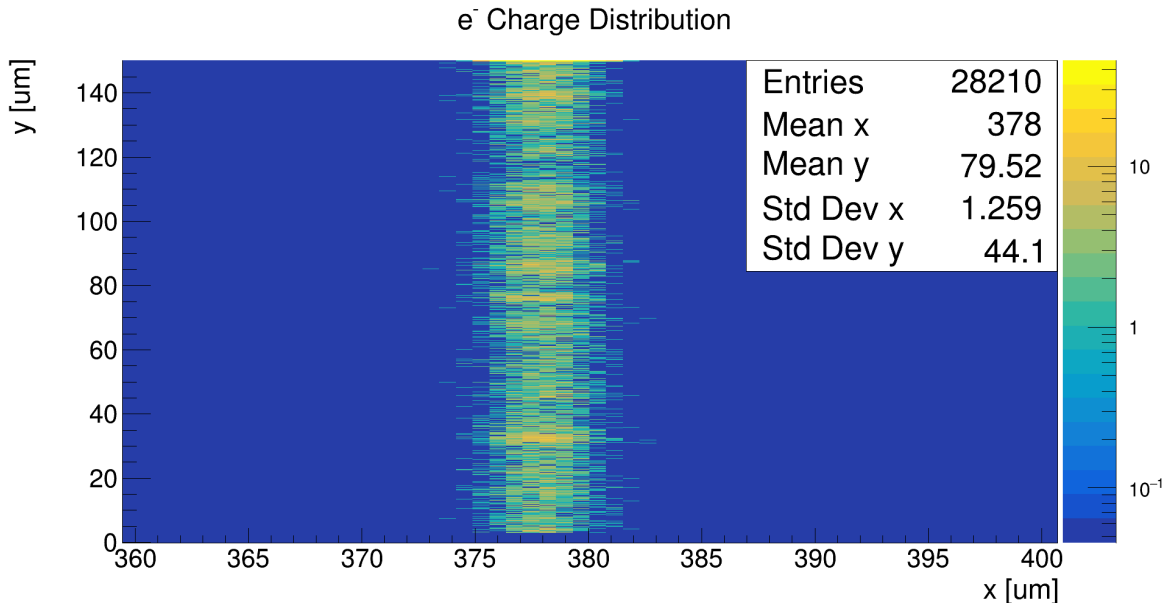
$$\eta = \frac{ADC_L}{ADC_L + ADC_R}$$

Cluster width

- Most of the clusters have 1 or 2 strips
  - Ionization charge is mostly deposited in a small region
    - Ionization charge is collected by either 1 strip (if deposited under a strip) or by 2 strips (if deposited between two readout strips)
    - δ electrons can give signal to strips further away (more evident with high Z charge like at GSI)



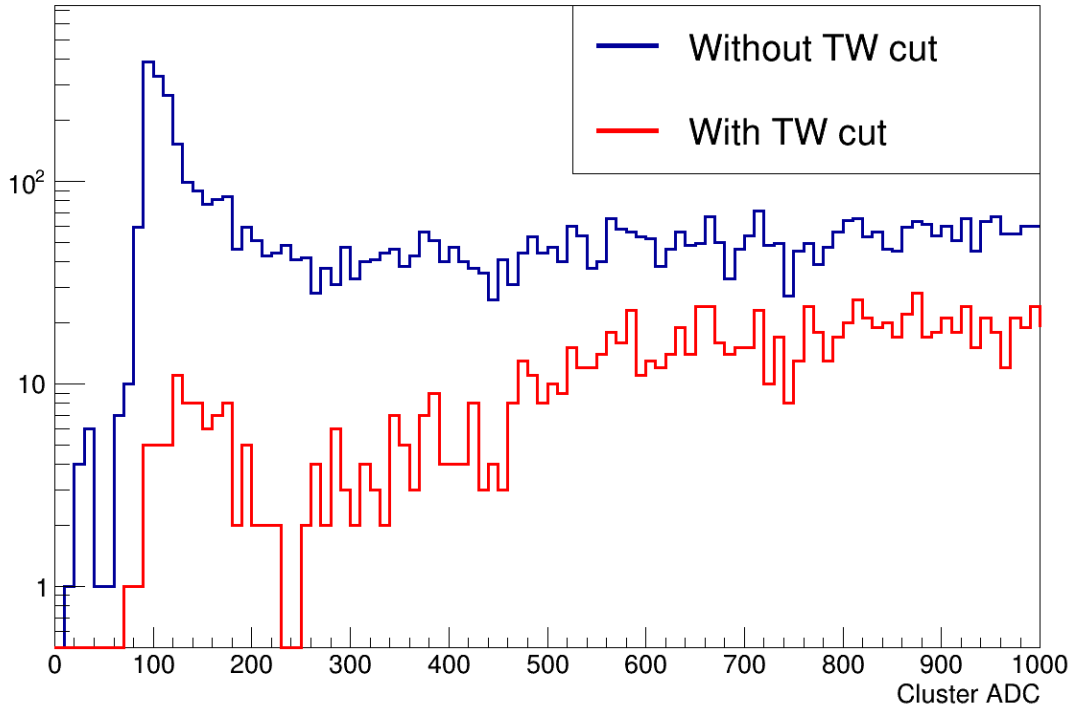
Number of strips per cluster for 400MeV/u Oxygen



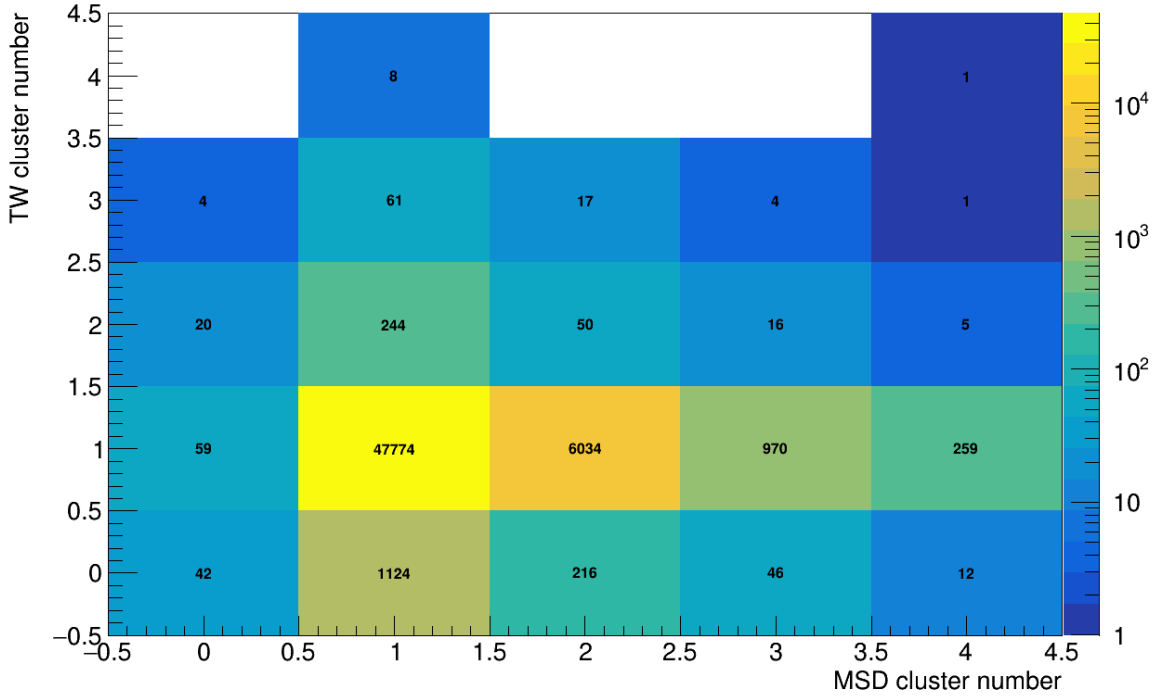
MIP ionization charge simulation

MSD signal

- Spurious noise strips mainly add to the single strip clusters
  - Using external reference (e.g. TW) distributions are "cleaner"



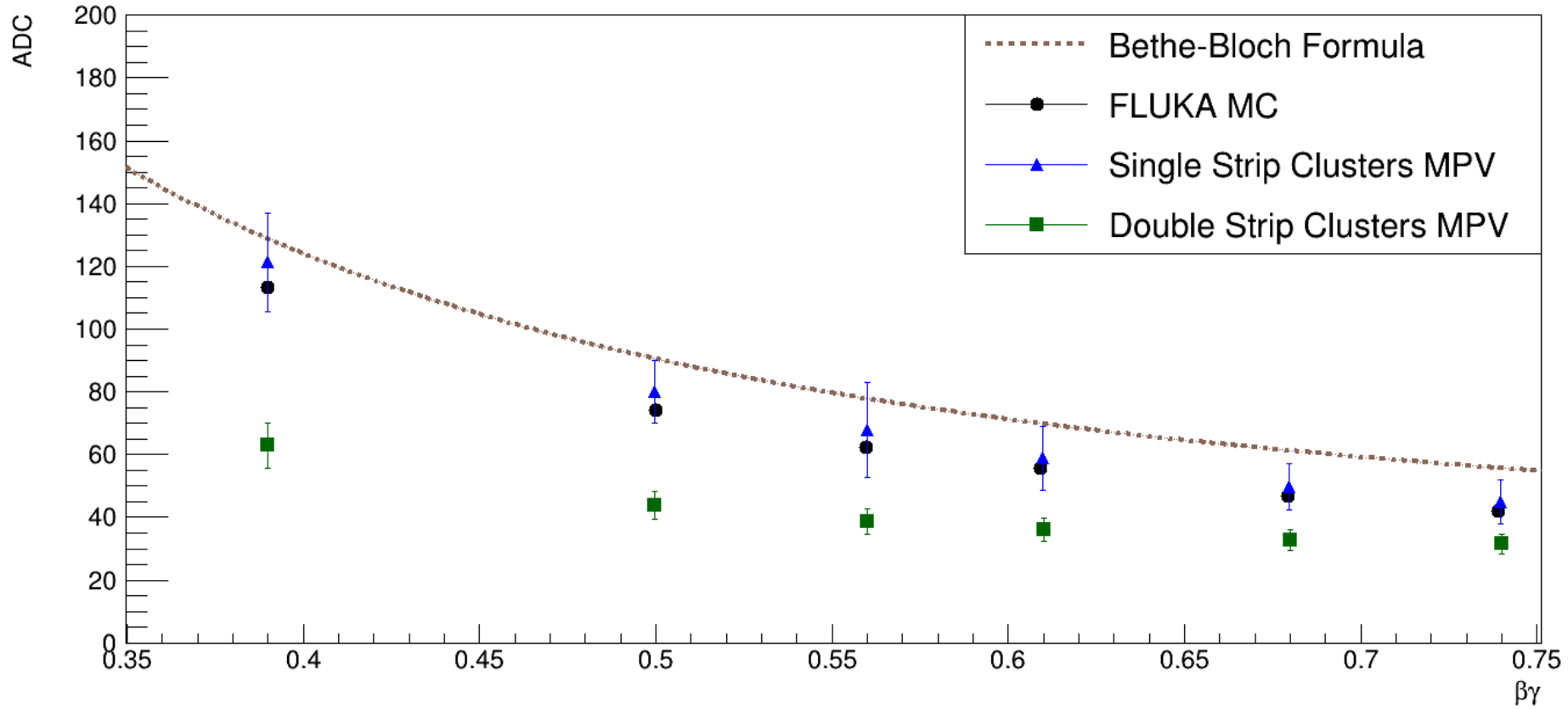
MSD cluster < 1000 ADC



Preliminary: response to charged particles

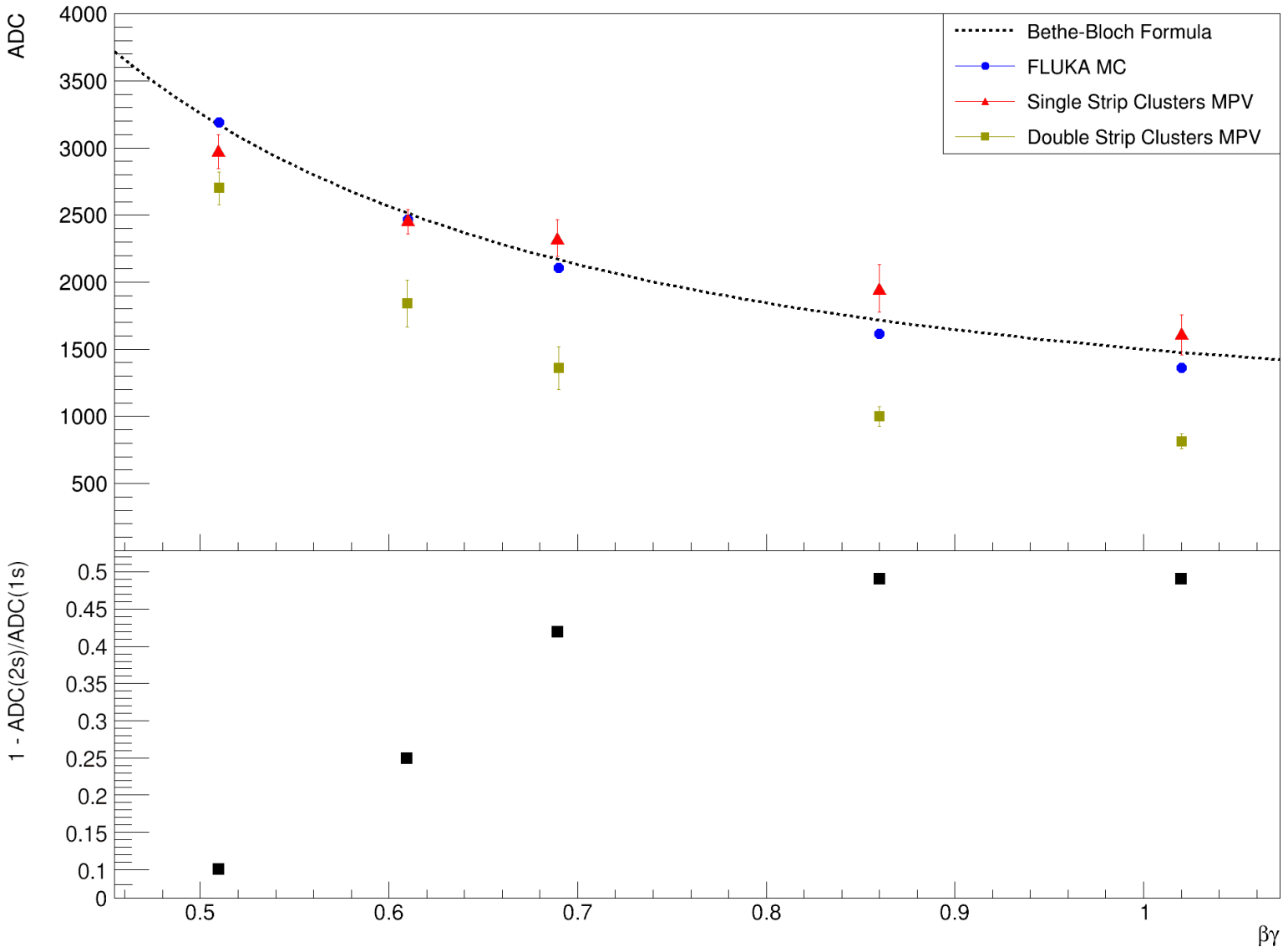
- Data from **Protons** at Trento Proton Therapy Facility
- Comparison with Bethe-Bloch formula
- Comparison with FLUKA MC

- Good agreement for single strip clusters, charge loss for double strips



Preliminary: response to charged particles

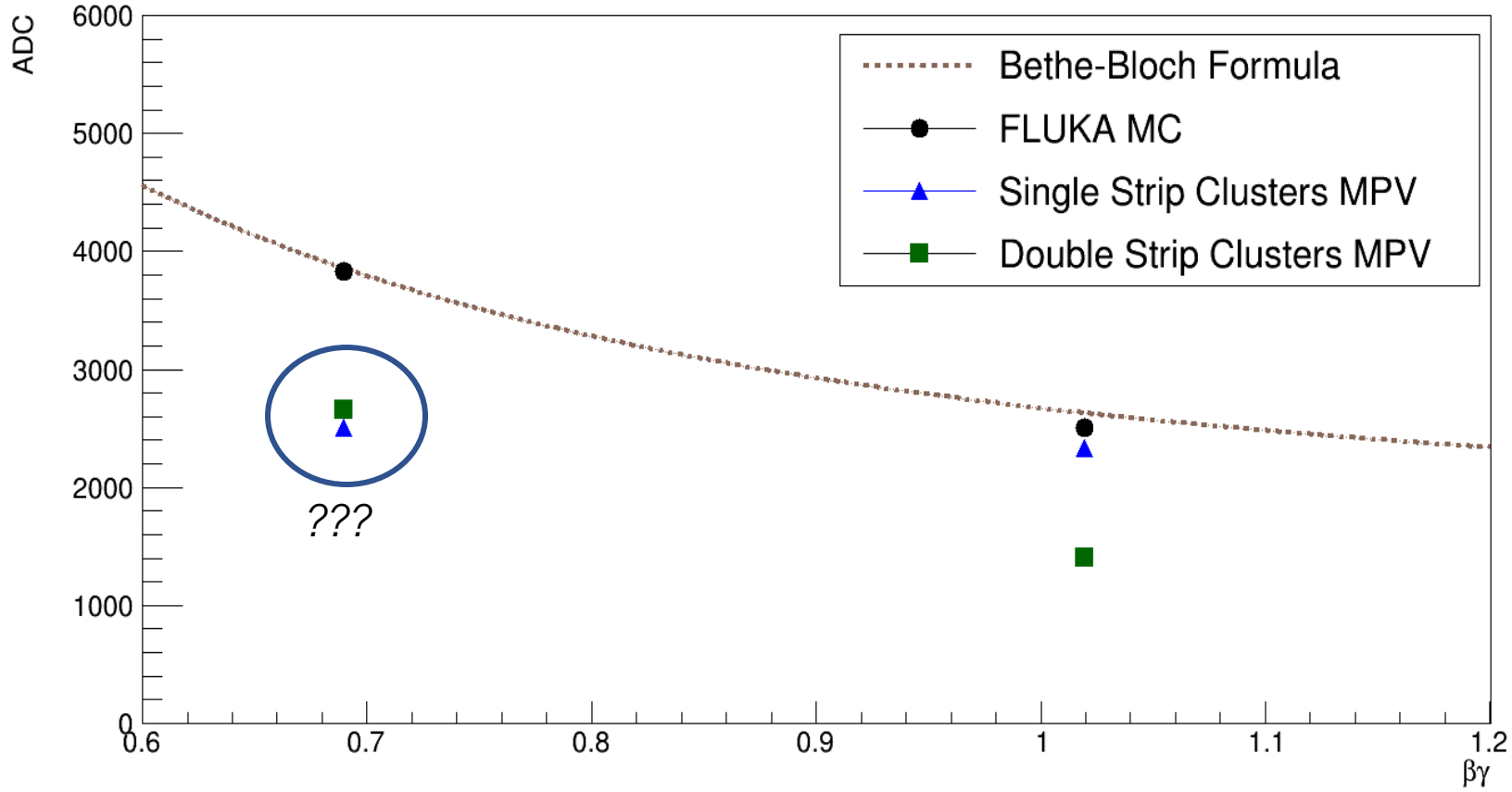
- Data from **Carbon** ions at CNAO
- Comparison with Bethe-Bloch formula
- Comparison with FLUKA MC
- Charge loss seems to depend on particle energy (under study)



Preliminary: response to charged particles

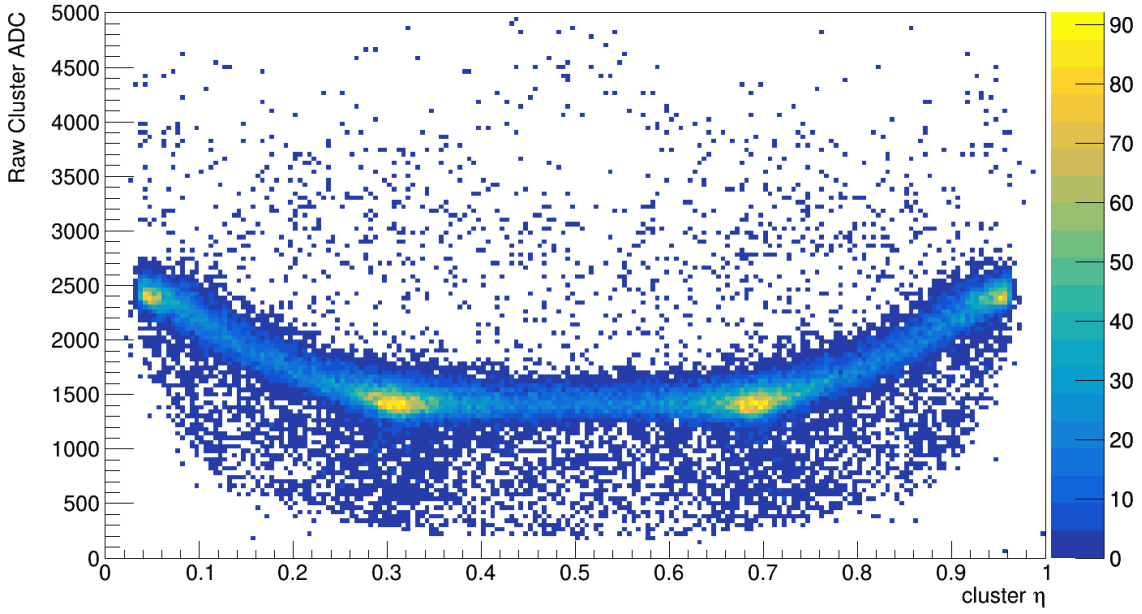
- Data from **Oxygen** ions at GSI
- Comparison with Bethe-Bloch formula
- Comparison with FLUKA MC

- Investigating strange behaviour at 200 MeV/u
  - Hypothesis 1: single strip saturation and/or non-linearity
  - Hypothesis 2: single strip clusters misidentification due to high threshold cuts

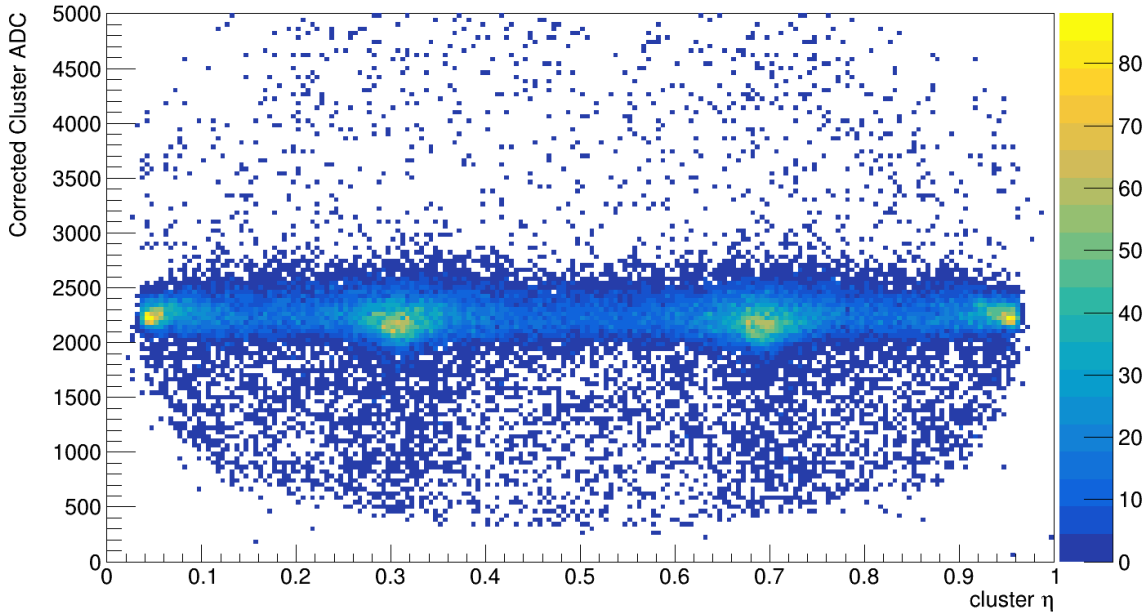


Preliminary eta correction

- First attempt at charge loss correction
  - Cluster ADC wrt impact position modelled with arbitrary function
  - First studies seems to show that the function depends on energy and Z of the particle



Before correction



After correction

ToDo

- Finalize alignment
- Spatial resolution for each family of clusters (wrt width, charge and energy)
  - Same for efficiency
- Model eta dependency of cluster signal for each Z and energy
- Eta function with external reference (to correct both cluster signal and reconstructed position)
- New double threshold clustering algorithm
- Working on Doxygen documentation of MSD libraries