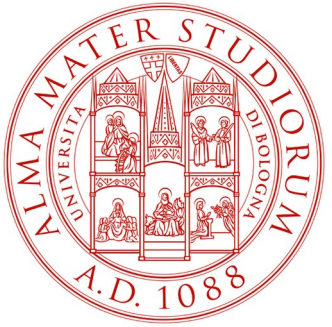


MSD clustering and η-correction

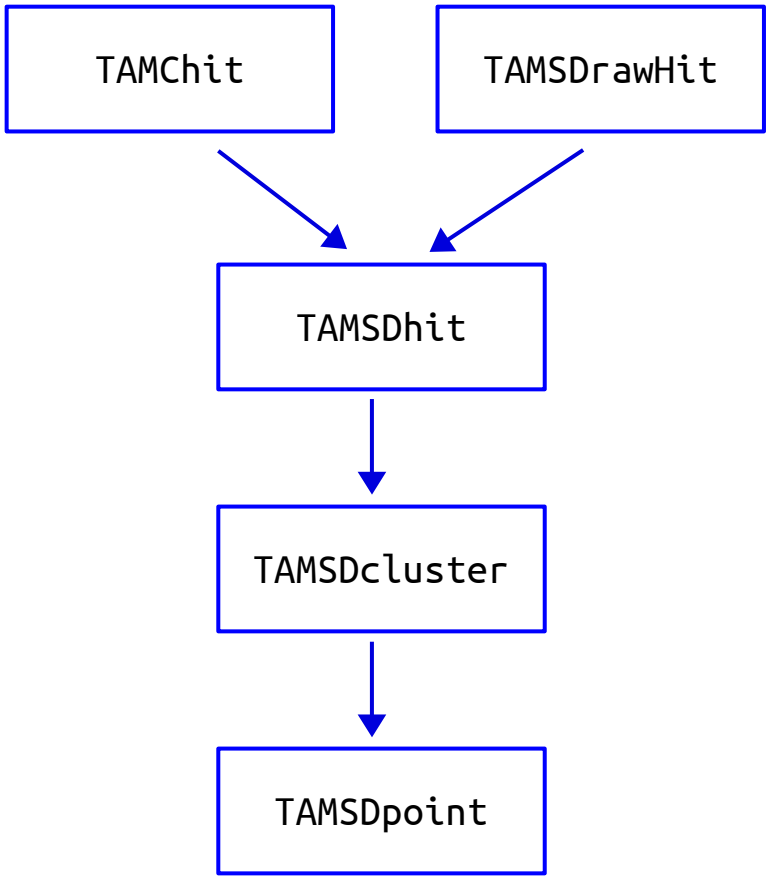
R. Zarrella, G. Silvestre (and A. Oliva)

FOOT XVI General Meeting 24-26/06/2024

The MSD workflow

Step-by-step review of the MSD data processing!

- **RawHit → Hit**
  - ➔ VA gain correction added
  - ➔ Correct flagging of noisy/dead strips
- **Hit → Cluster**
  - ➔ Clustering algorithm re-checked and updated
  - ➔ η-correction
- **MChit → Hit → Cluster**
  - ➔ Updated to match new containers

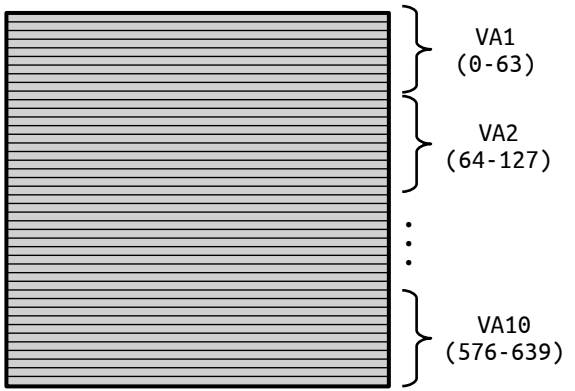


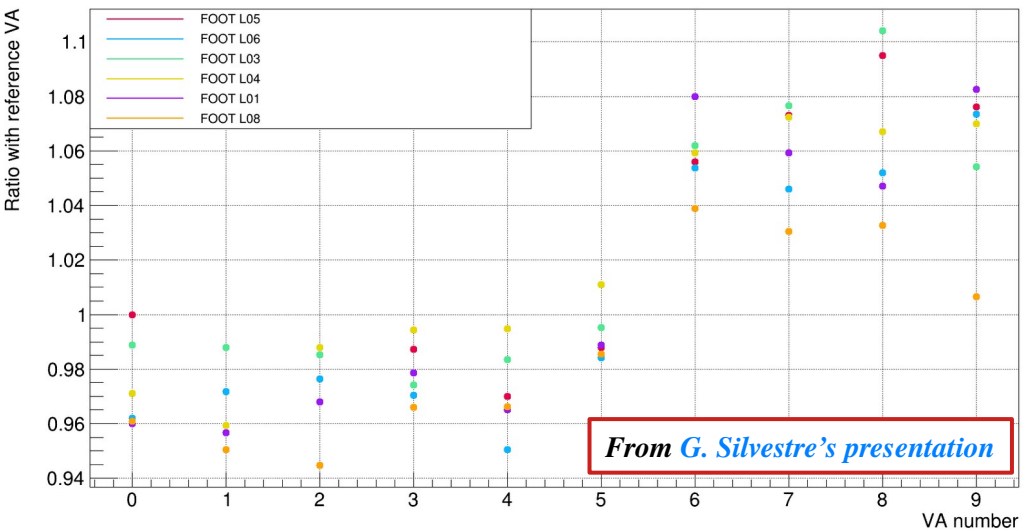
RawHit → Hit: VA gain correction

Strip-wise ADC correction

- 640 strips → 10 Voltage Amplifiers of 64 channels each
- Correct for gain difference
  - ➔ Fit Landau distribution for strip ΔE in each VA
  - ➔ Normalize MPVs
- **New calibration file in SHOE**
  - ➔ `shoe/Reconstruction/calib/*/TAMSD_VA_gain.cal`

Same for all campaigns!!





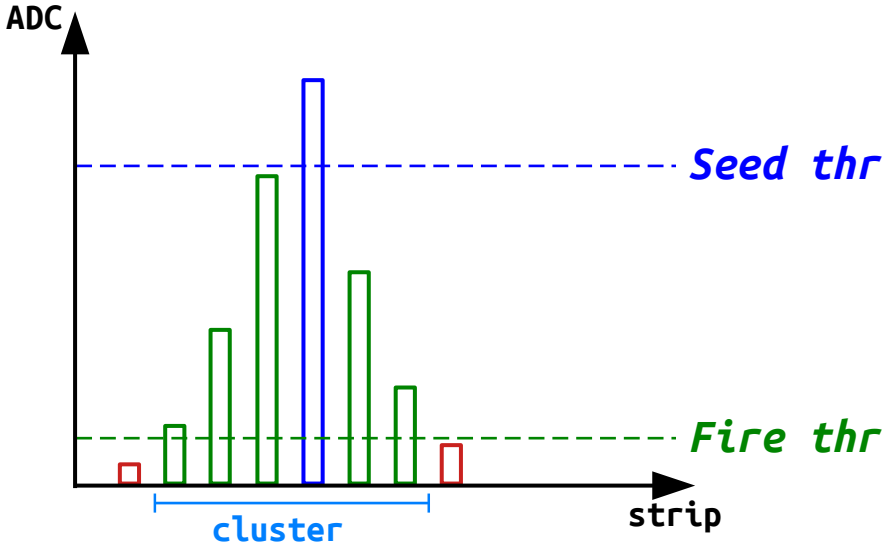
Hit → Cluster: Clustering algorithm

Double threshold algorithm

- "Fire" threshold → Strip is considered "on"
- "Seed" threshold → Enough signal for cluster!

1) Start from seed strip

2) Add left/right strips until above fire threshold



$$S_{clus,raw} = \sum_i S_i \qquad x_{clus} = \frac{\sum_i S_i \cdot x_i}{S_{clus,raw}}$$

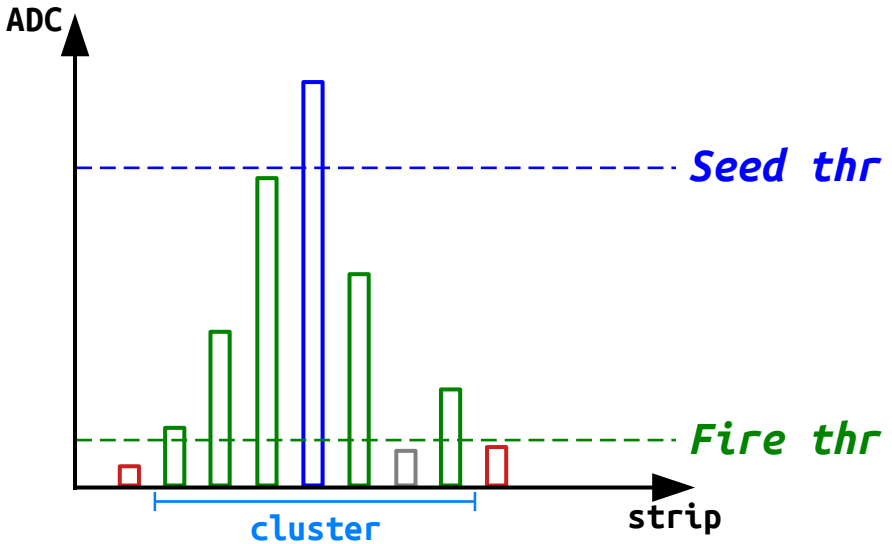
Hit → Cluster: Updated clustering algorithm

Double threshold algorithm

- "Fire" threshold → Strip is considered "on"
- "Seed" threshold → Enough signal for cluster!

1) Start from seed strip

2) Add left/right strips until above fire threshold **skipping noisy/dead strips**



Hit → Cluster: Updated clustering algorithm

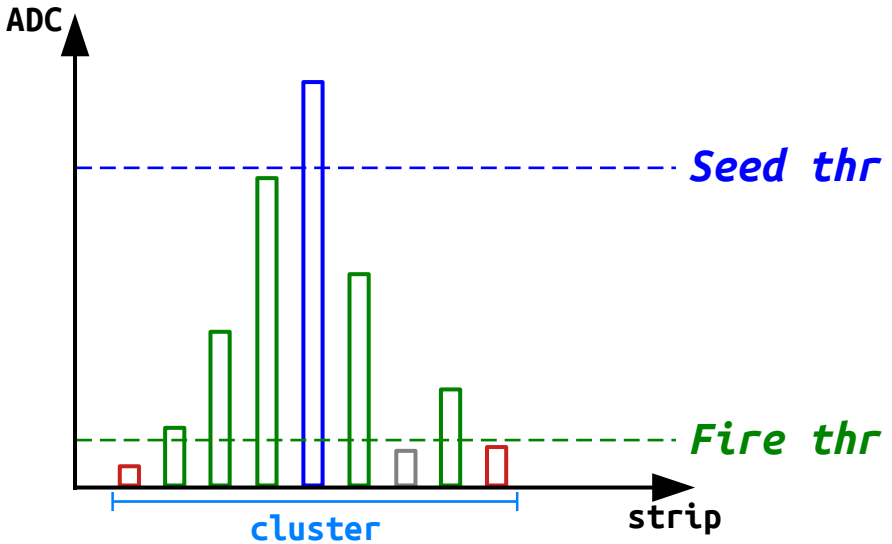
Double threshold algorithm

- "Fire" threshold → Strip is considered "on"
- "Seed" threshold → Enough signal for cluster!

1) Start from seed strip

2) Add left/right strips until above fire threshold **skipping noisy/dead strips**

3) **Add 1st two strips below fire threshold**



Hit → Cluster: Updated clustering algorithm

Double threshold algorithm

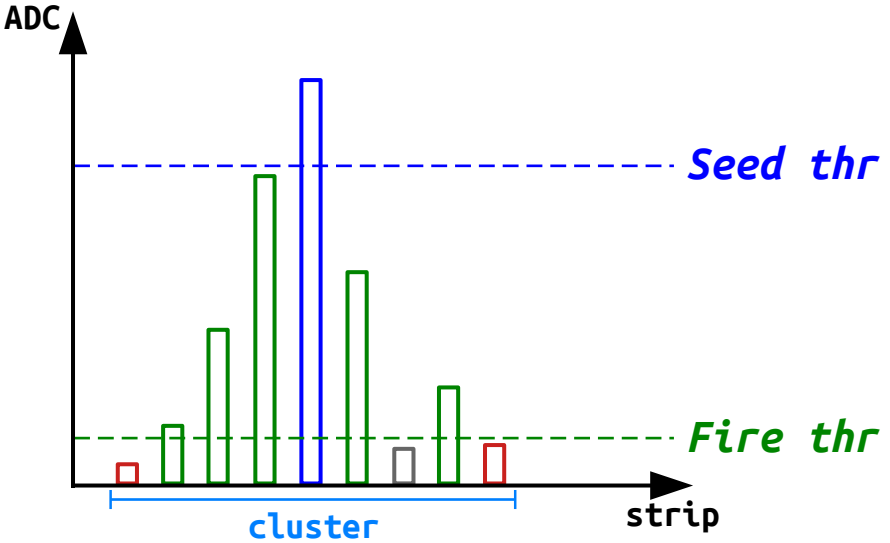
- "Fire" threshold → Strip is considered "on"
- "Seed" threshold → Enough signal for cluster!

1) Start from seed strip

2) Add left/right strips until above fire threshold **skipping noisy/dead strips**

3) **Add 1st two strips below fire threshold**

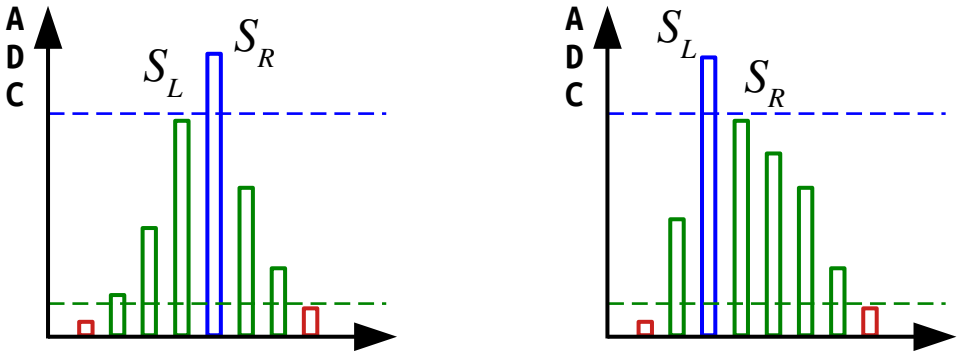
4) **Avoid noisy/dead strips for signal/position calculation**



$$S_{clus,raw} = \sum_{i}^{good} S_i \qquad x_{clus} = \frac{\sum_i^{good} S_i \cdot x_i}{S_{clus,raw}}$$

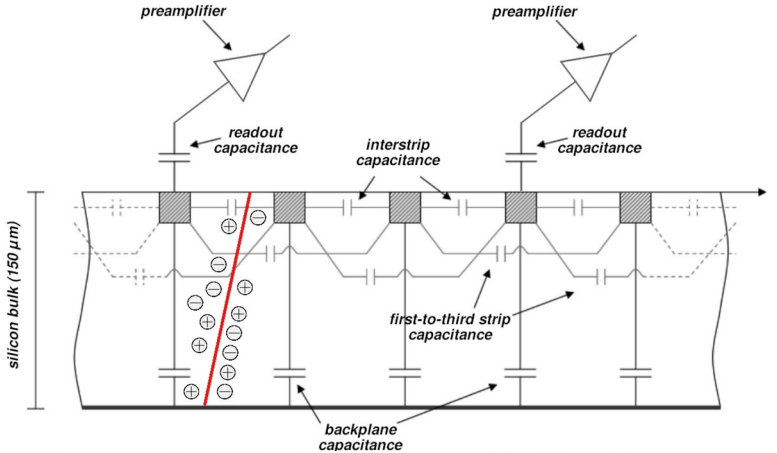
η parameter: refresh

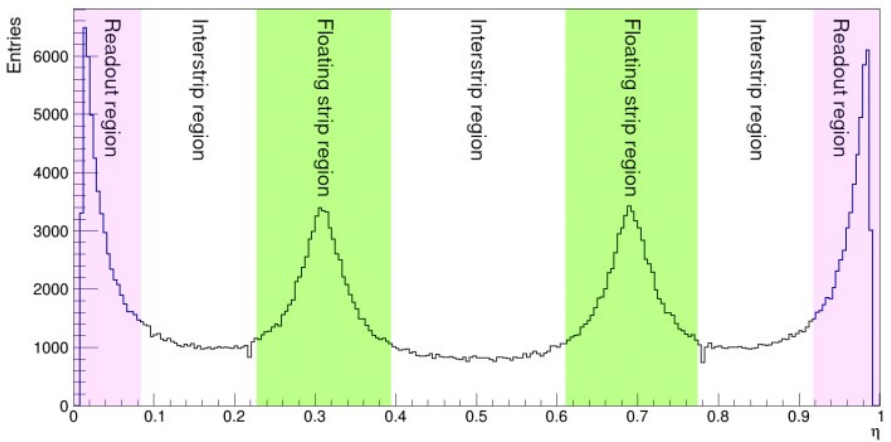
Floating strip configuration → charge collection depends on particle hit position!



$$\eta = \frac{S_L}{S_L + S_R}$$

$S_{L/R}$ = two highest strips in cluster





***η* = relative signal fraction of 2 highest strips**

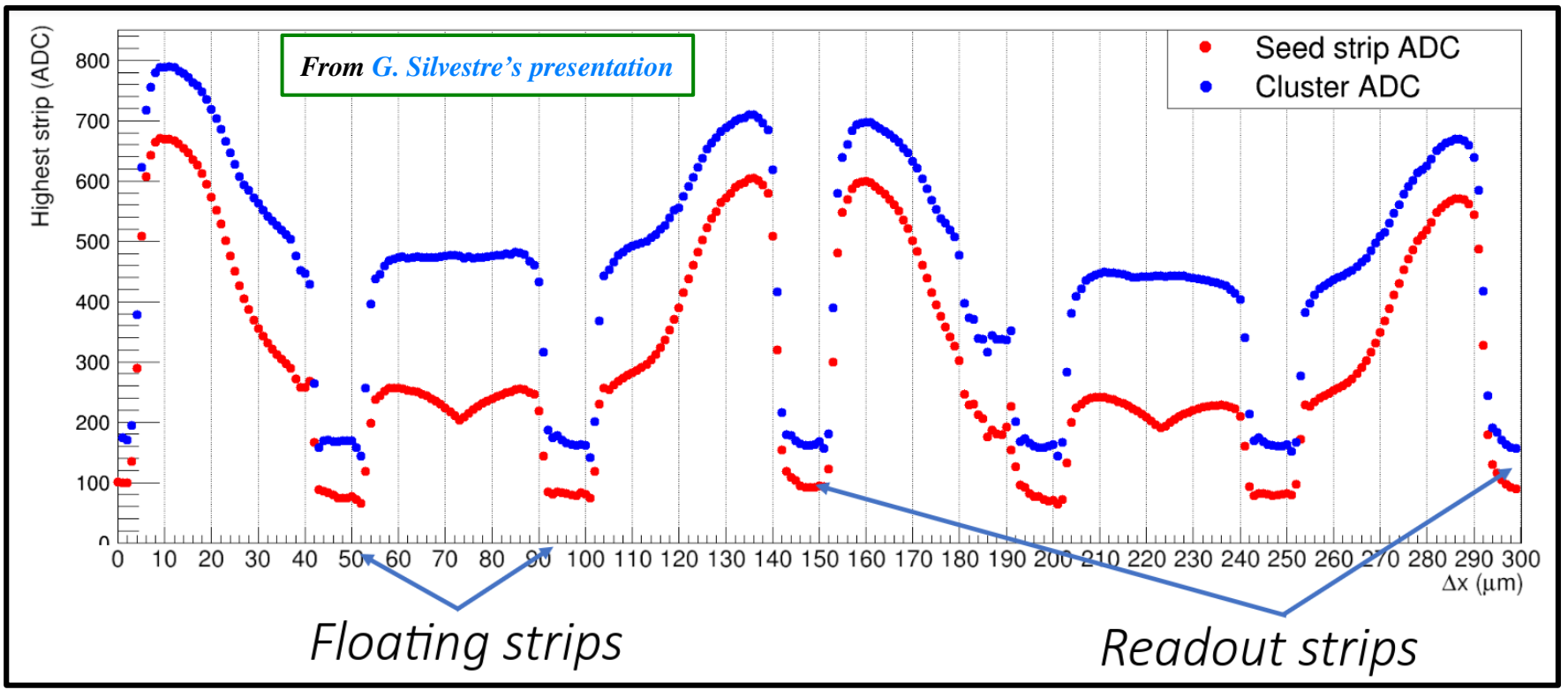
- Center of gravity in readout pitch units
- Peaks due to capacitive coupling
- Non-linear signal division btw strips

η parameter: refresh

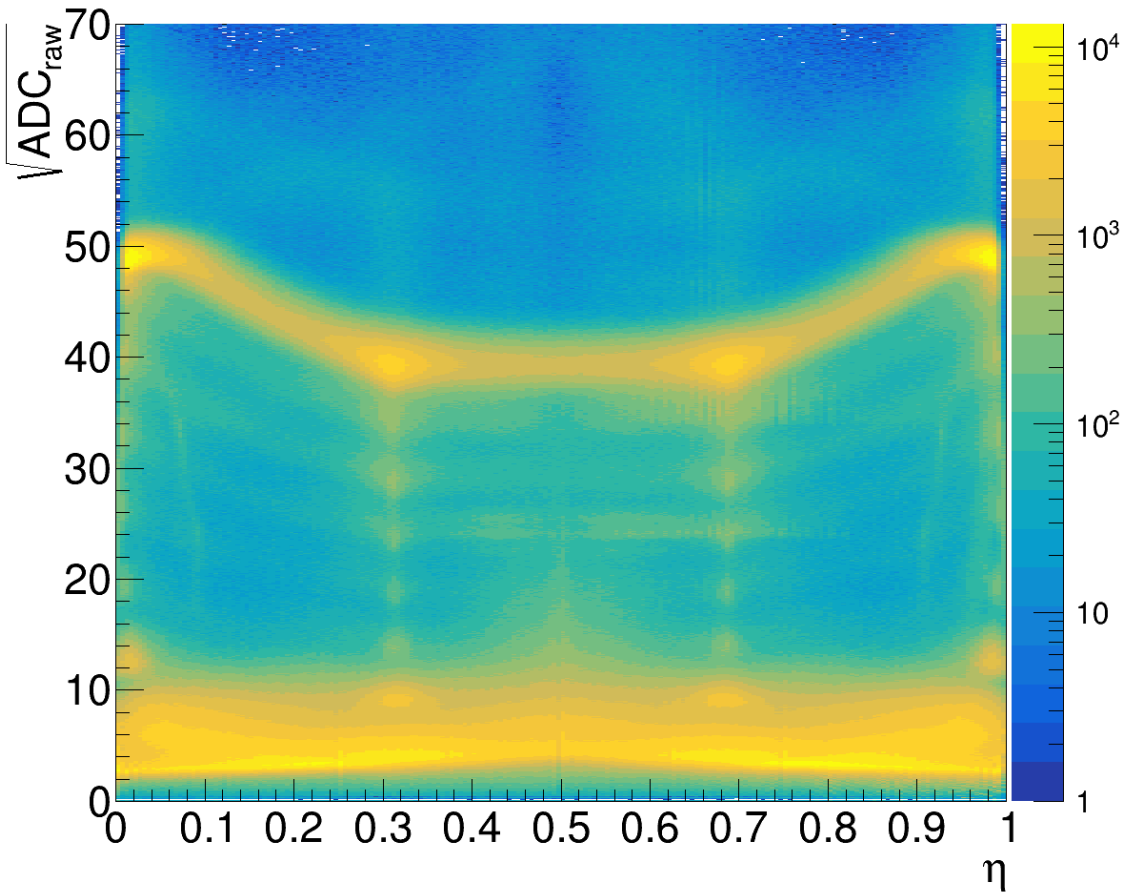
$$\eta = \frac{S_L}{S_L + S_R}$$

$S_{L/R}$ = two highest strips in cluster

Data taking w/ focused laser



η parameter: GSI2021 data



GSI2021 run 4303-4312

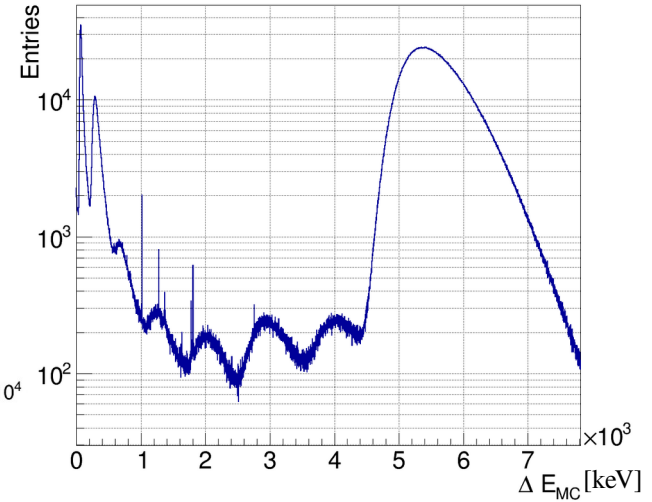
- ^{16}O @ 400 MeV/u
- Both MB and frag triggers
- Both C and PE targets

- $\sqrt{S_{raw}}$ ($\propto Z$) as a function of η
- Different Z populations noticeable
- No event selection
  → some background everywhere
- Many low signal clusters

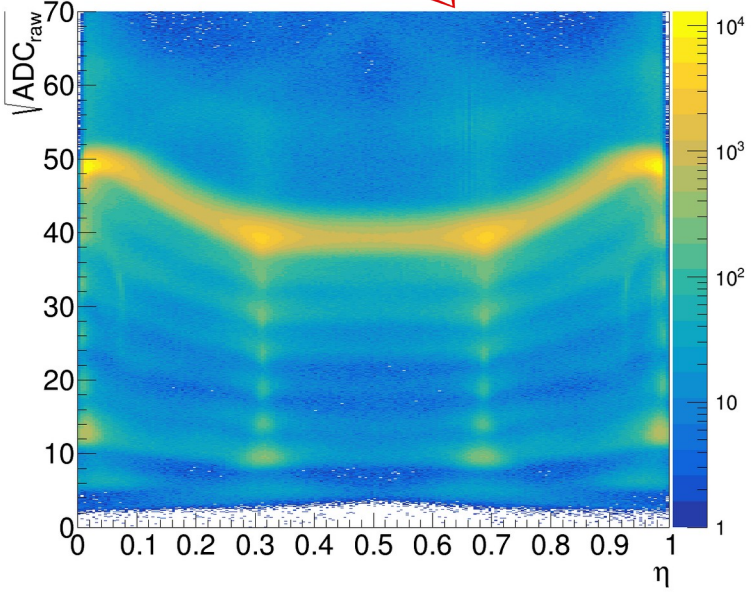
η correction: calibration strategy

Need to remove the η dependence

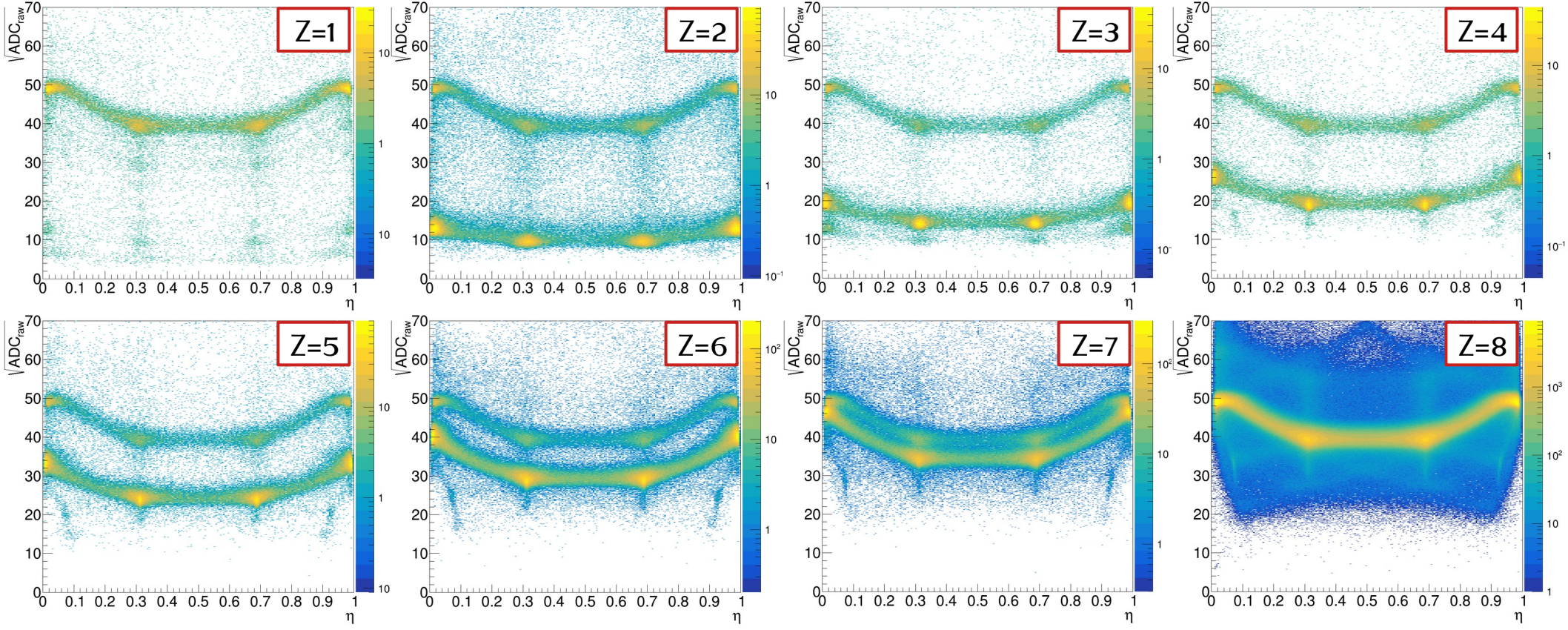
- Calculate expected ΔE for different Z in MC



1) Keep only 1 cluster/sensor/event (max signal)
2) Isolate η-signal for different Z
   → global track + TW
3) Fit $\sqrt{S}$ at different η values
4) Evaluate correction factor to recover MC ΔE
5) 2D-interpolation to obtain finer correction map



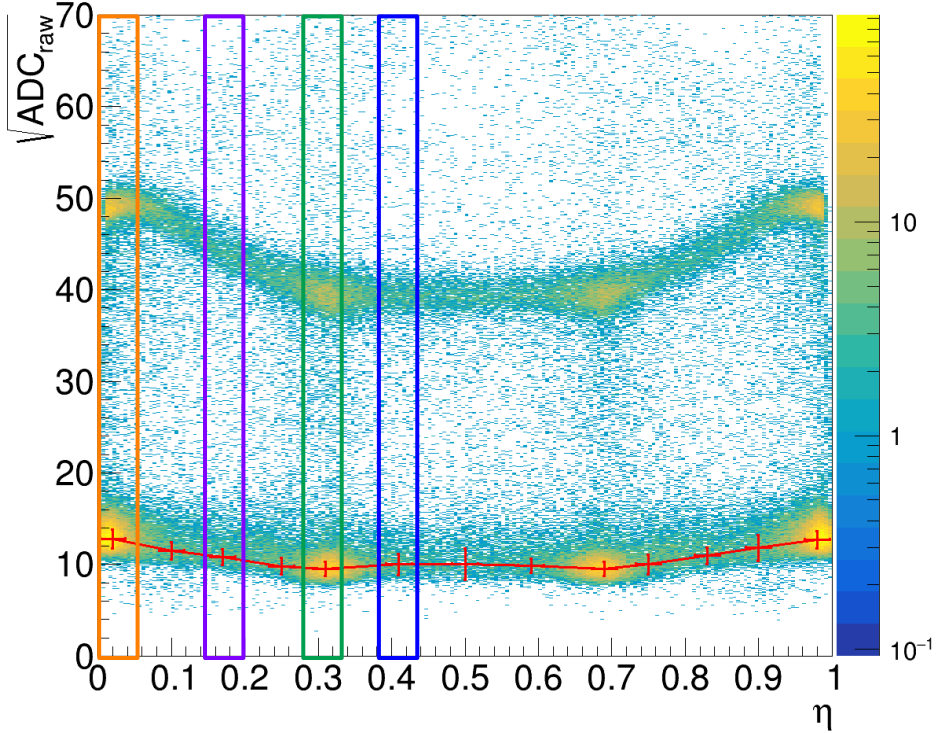
η correction: charge division



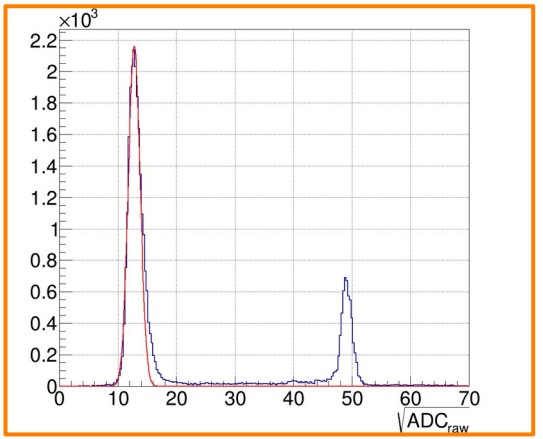
- **Charge identification + tracking coherent!!!!**
- Fragmentation in air/MSD visible

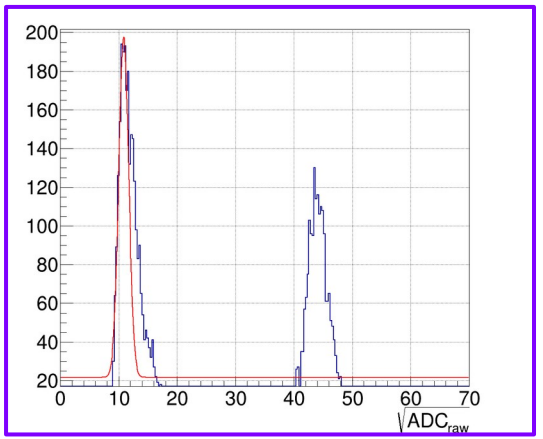
- Fit signal as function of η
- Low statistics for p w/ this selection → Use other sample

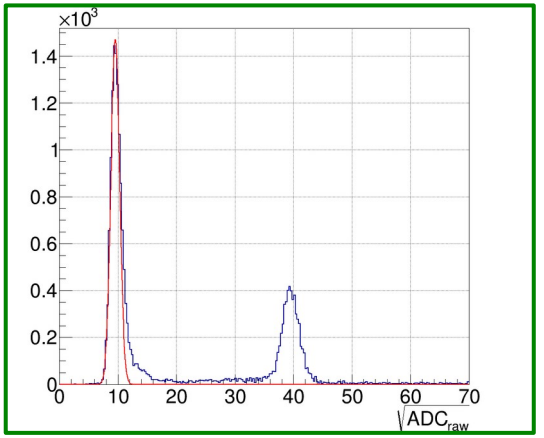
η correction: signal-η fit

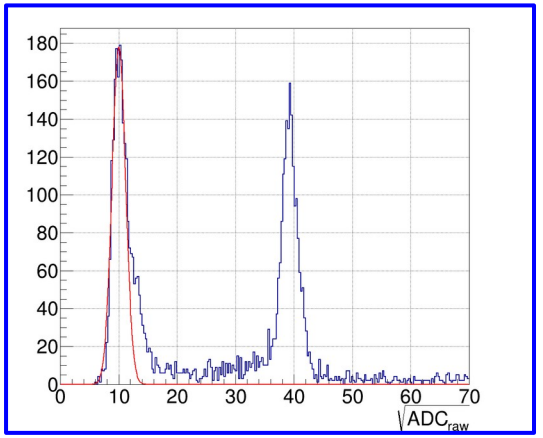


$$k(\eta, S_{raw}) = \frac{\sqrt{\Delta E_{MC}}}{\mu\left(\sqrt{S_{raw}(\eta)}\right)}$$

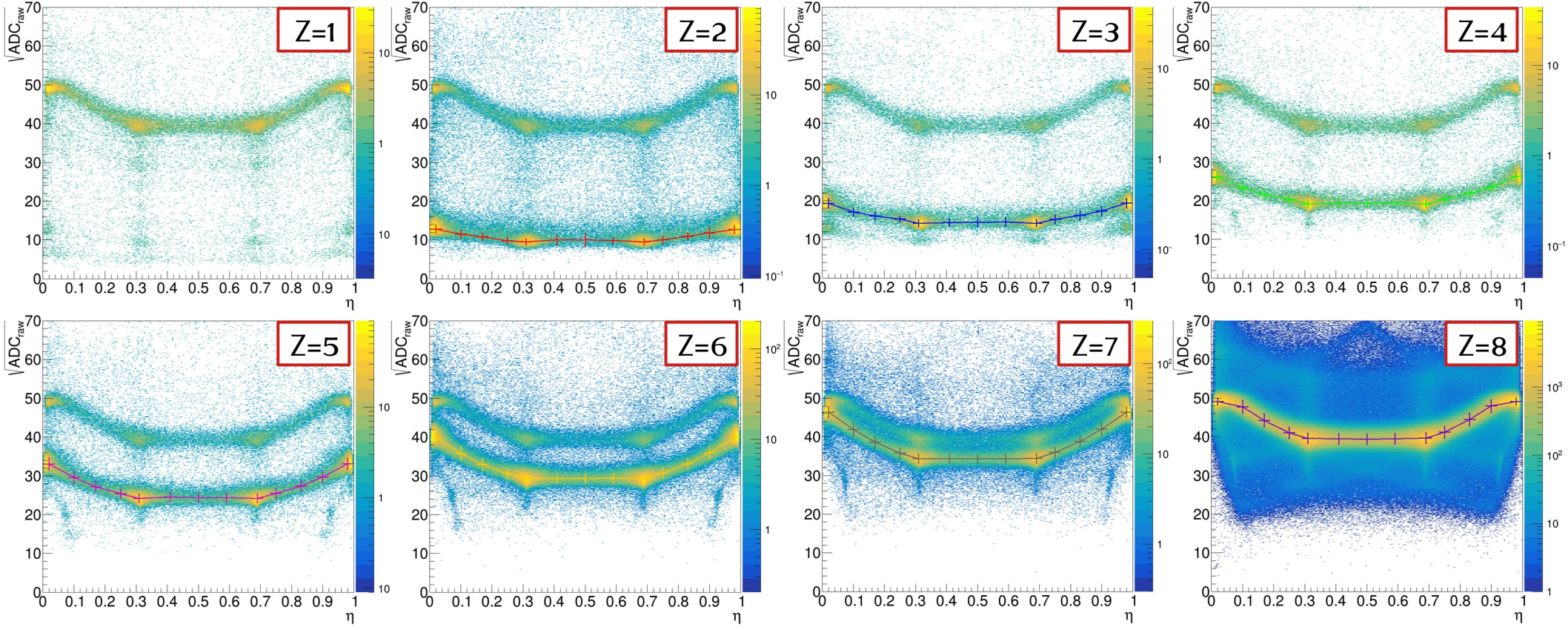








η correction: calibration

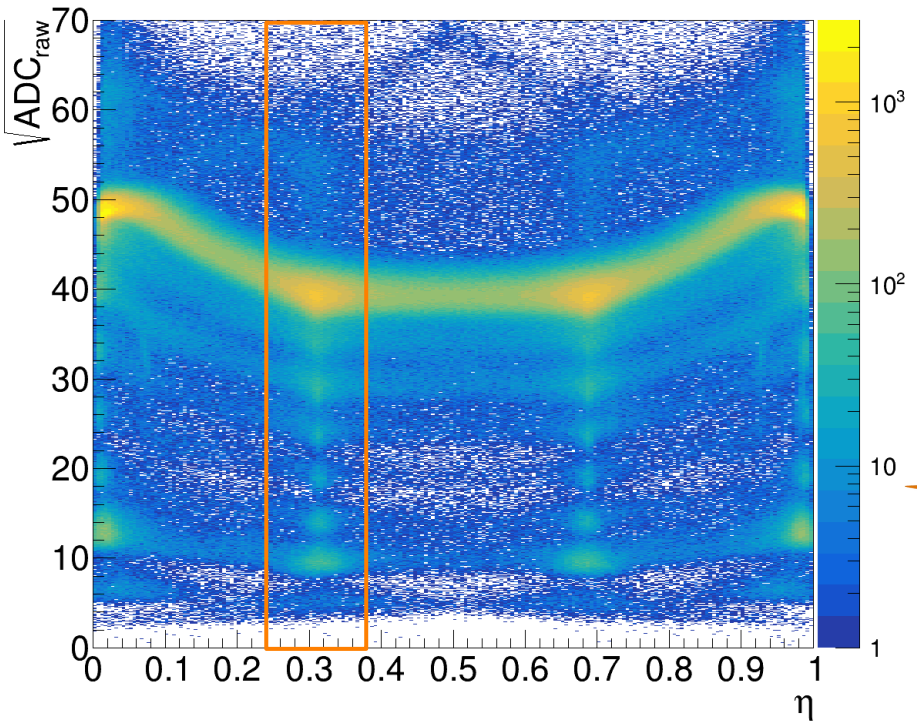


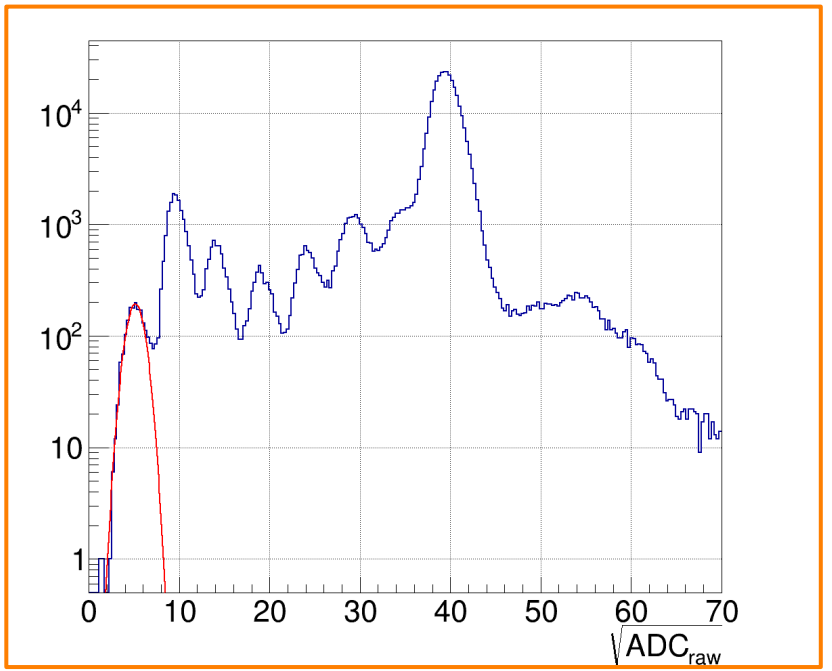
Fit works fine for all Z>1, but what about protons?

η correction: protons calibration

Look at only one sensor!

- Sensor response compatible btw each other
- Less low-signal background
- Start from He fits and rescale by a factor 2 → refit



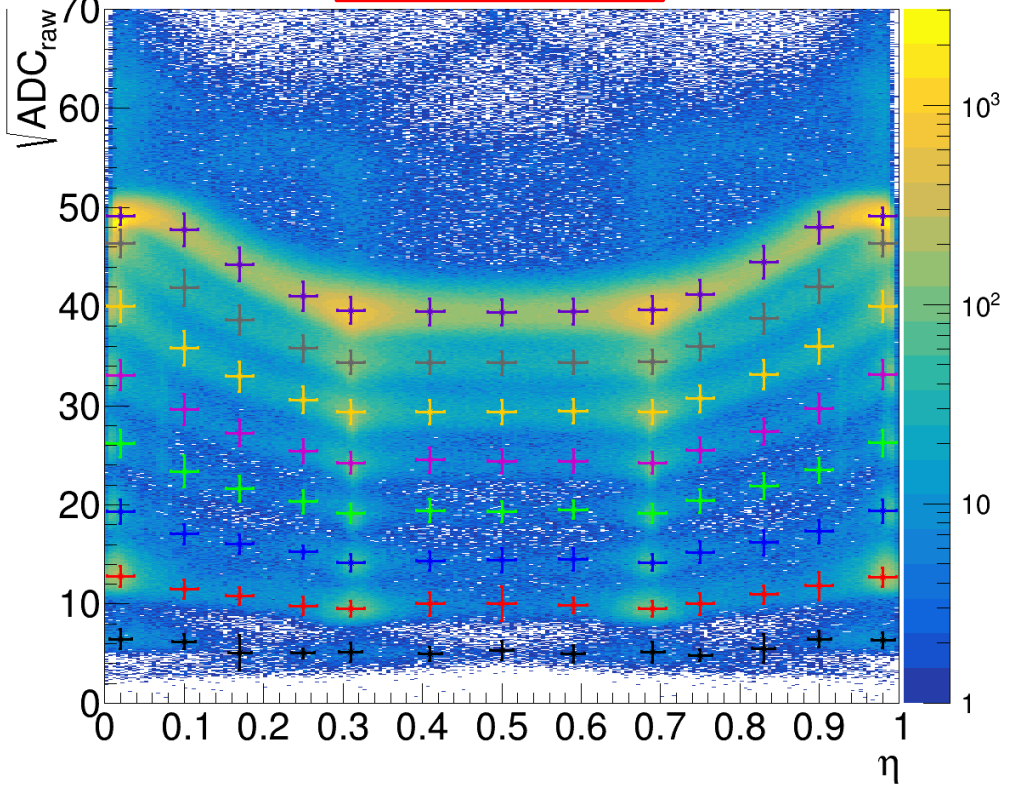


Recovered protons too!!

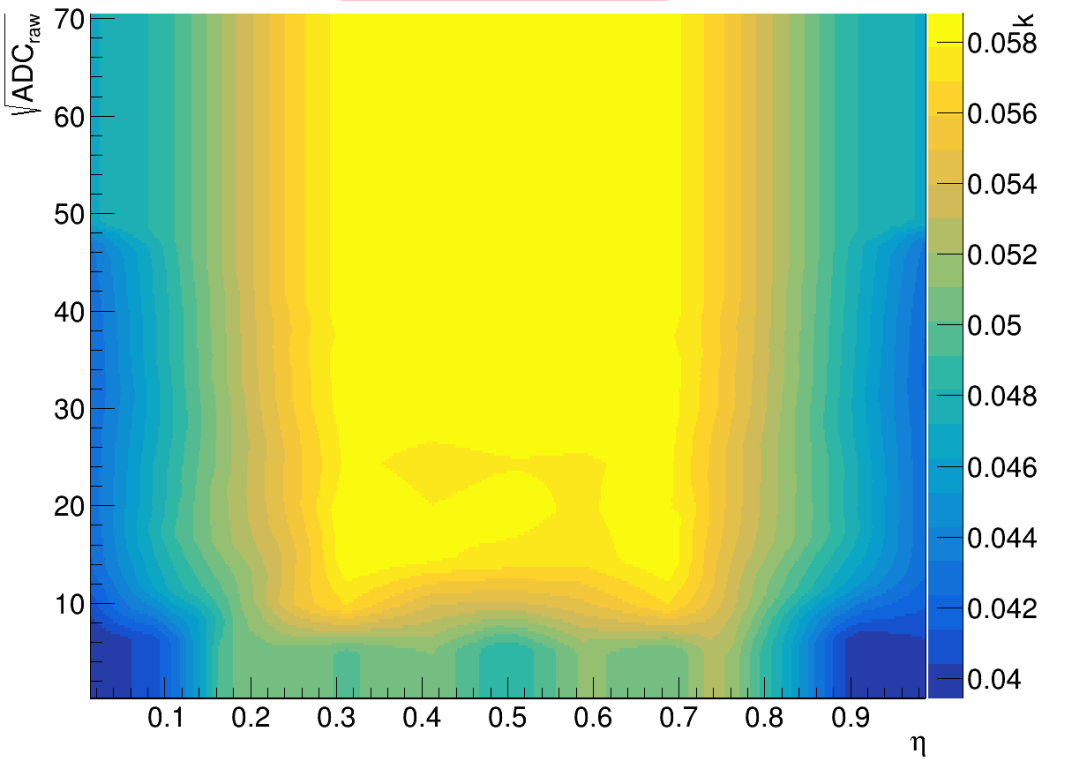
η correction: calibration map

Putting everything together → η-correction map!!

Full calibration



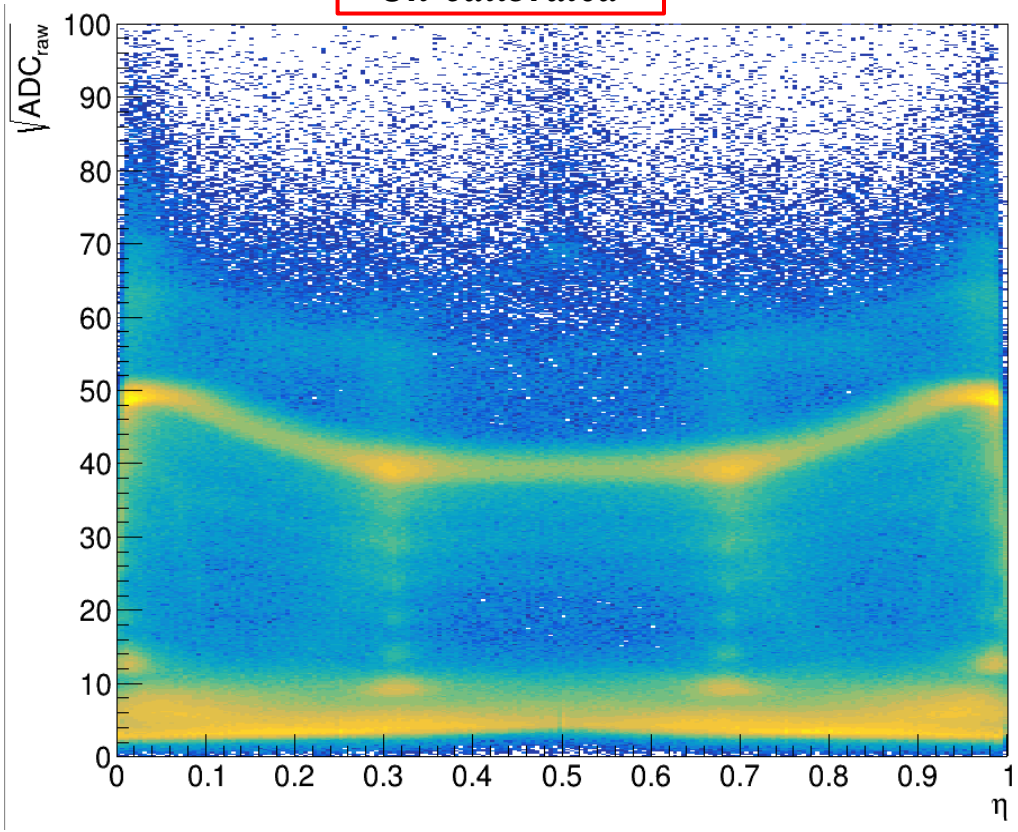
η-correction map



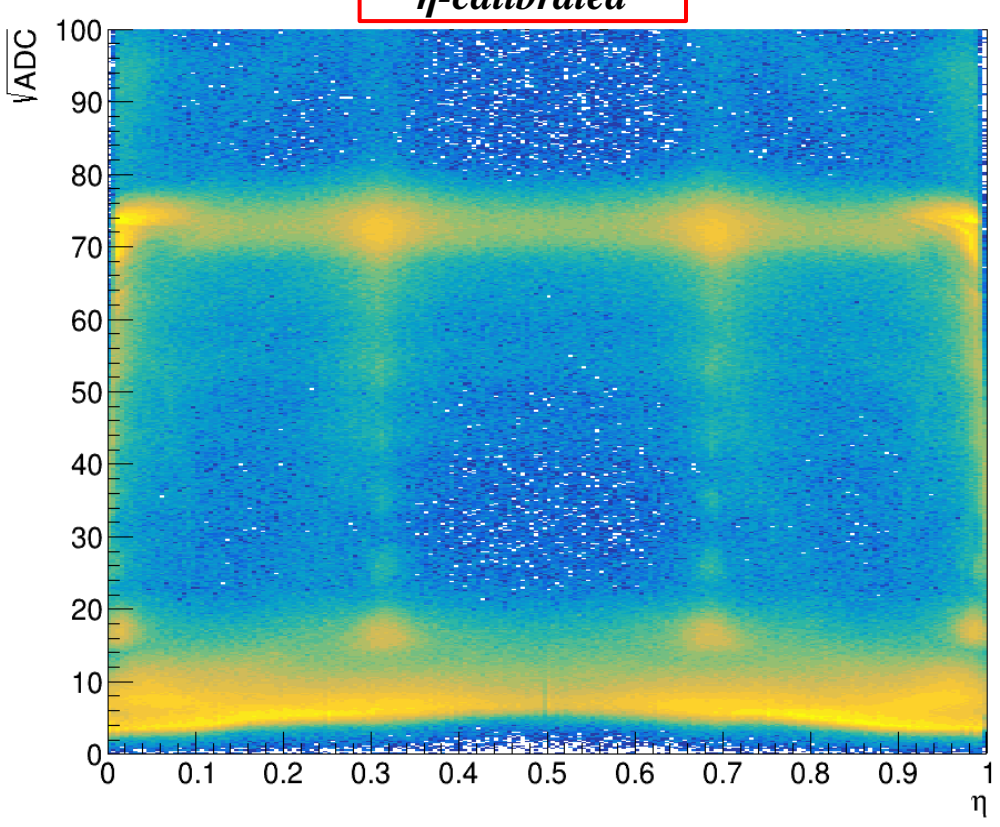
η correction: application to data!

Apply η-correction → Sensor response correctly flattened!!

Un-calibrated

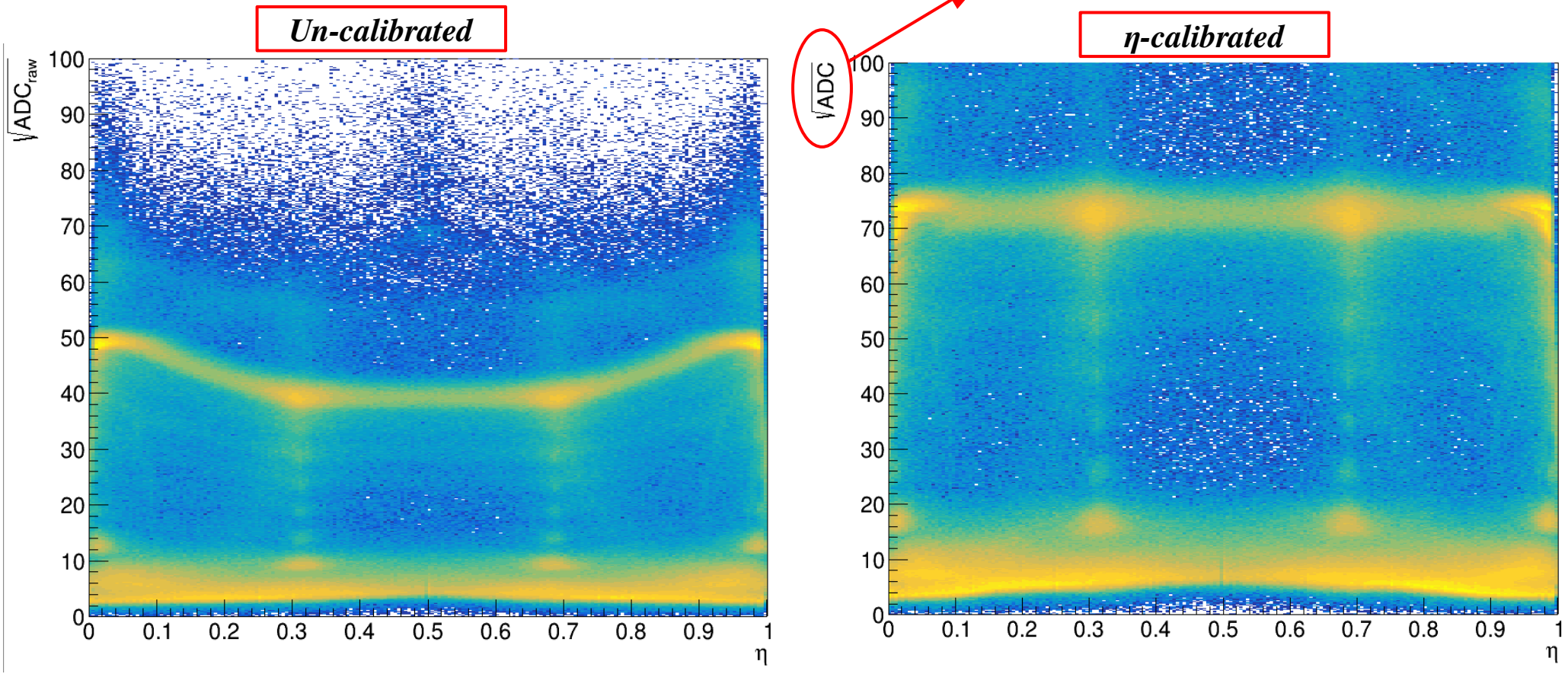


η-calibrated

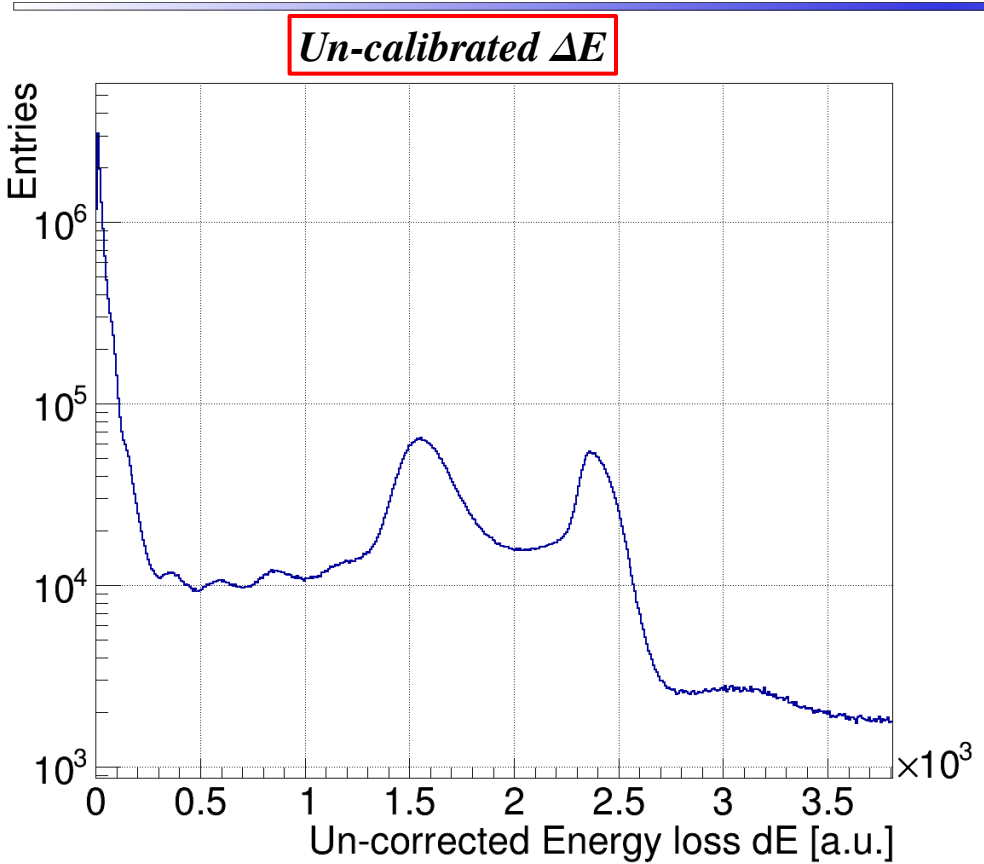


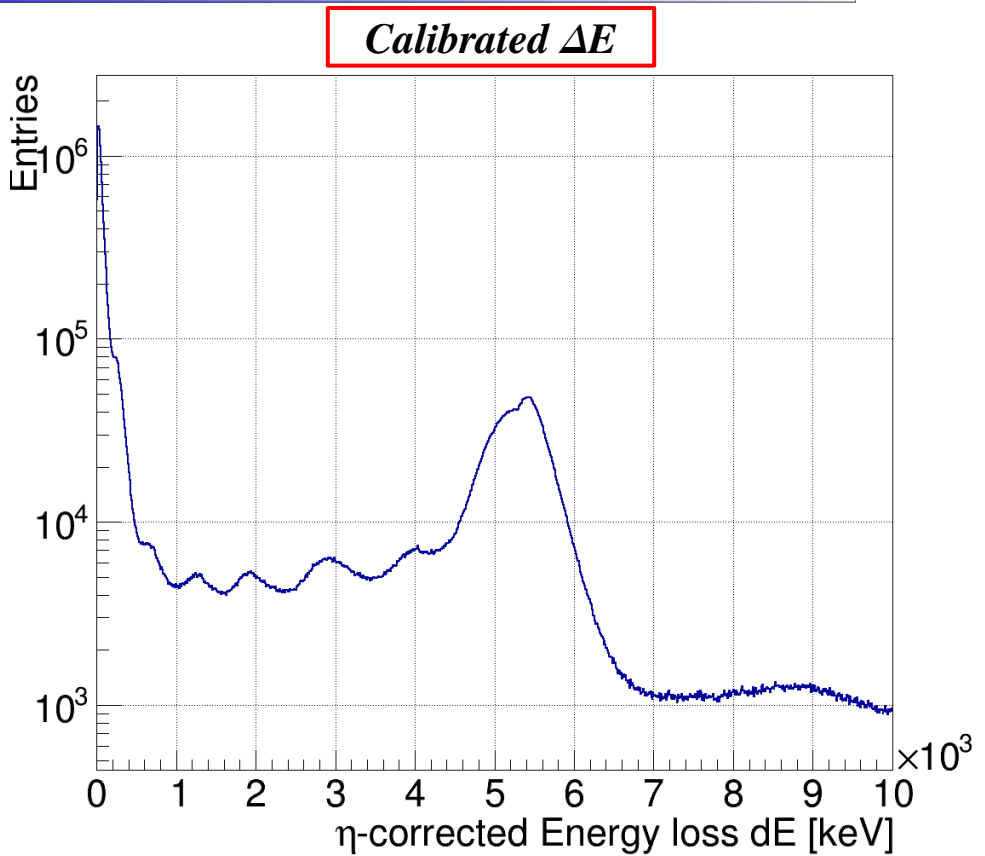
η correction: application to data!

Apply η-correction → Sensor response correctly flattened!! $\sqrt{\Delta E[keV]}$



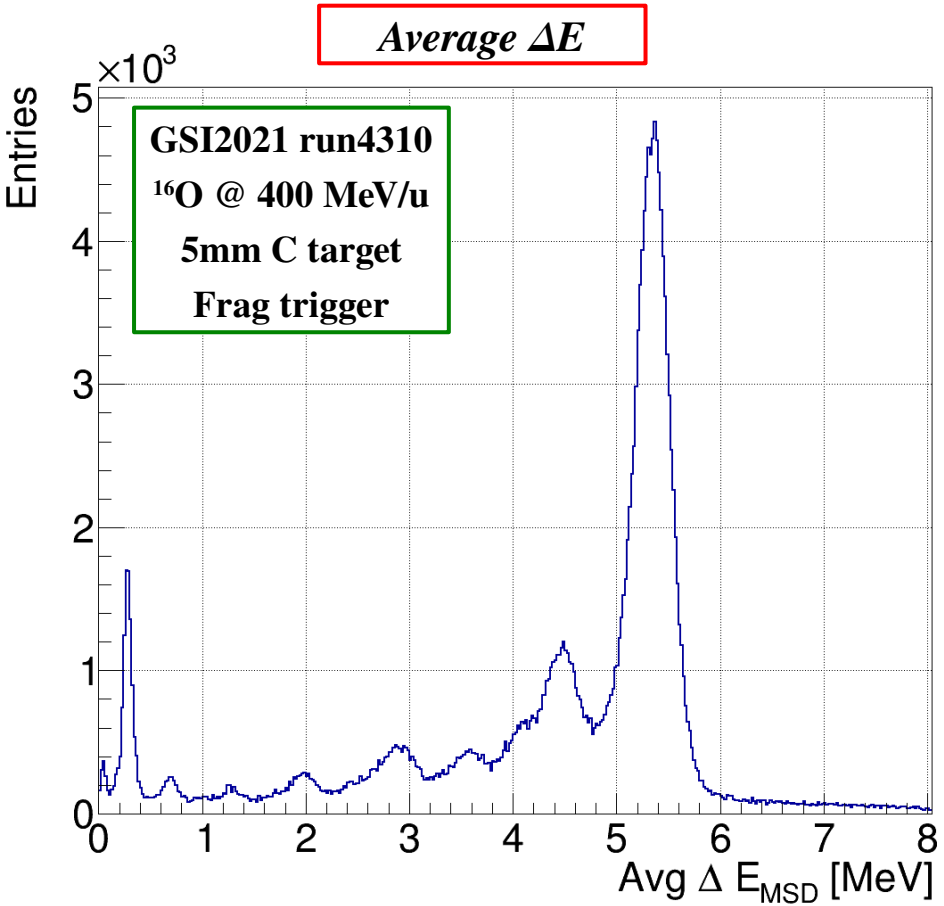
η correction: energy loss in one sensor





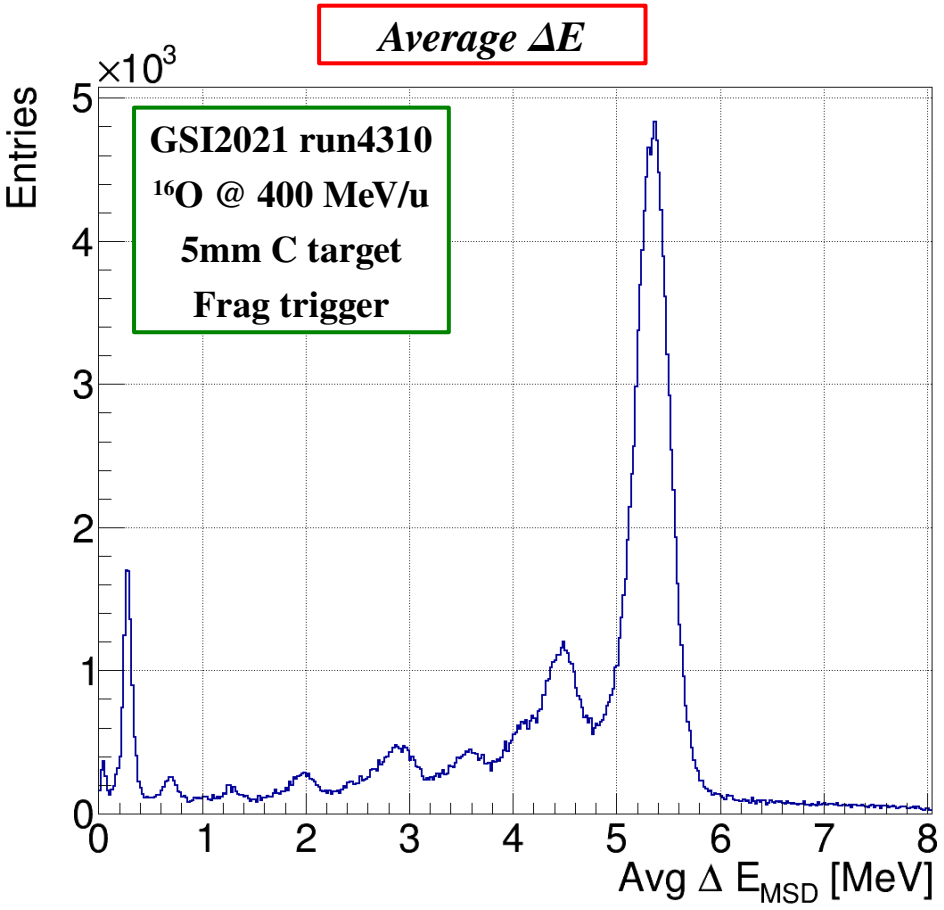
- Energy loss → double peak due to η removed
- Still some artifact from saturation (N-O)

η correction: multi-sensor energy loss



- Average energy loss between all sensors
- **Too many peaks!!**
- Mostly artifacts of noisy clusters/sensors

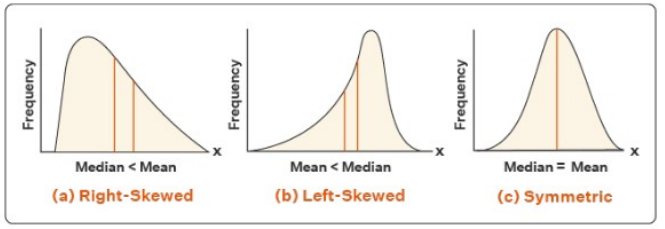
η correction: multi-sensor energy loss



- Average energy loss between all sensors
- **Too many peaks!!**
- Mostly artifacts of noisy clusters/sensors
- Switch to median???

Mean vs Median

- Choosing **mean** or **median** as the best expectation value of a distribution depends on the **outliers**

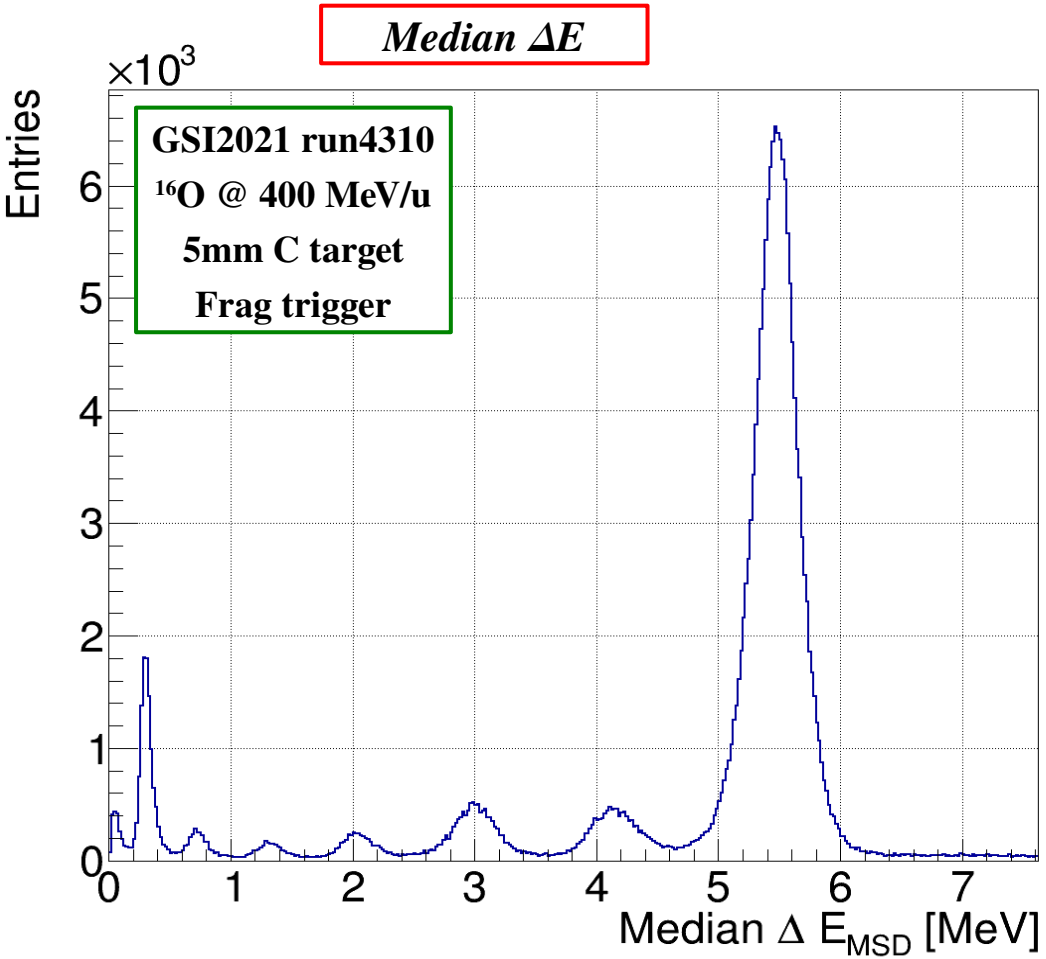


- **Median,** as the central value of a ordered set, is more robust in presence of outliers

Courtesy of G. Ubaldi

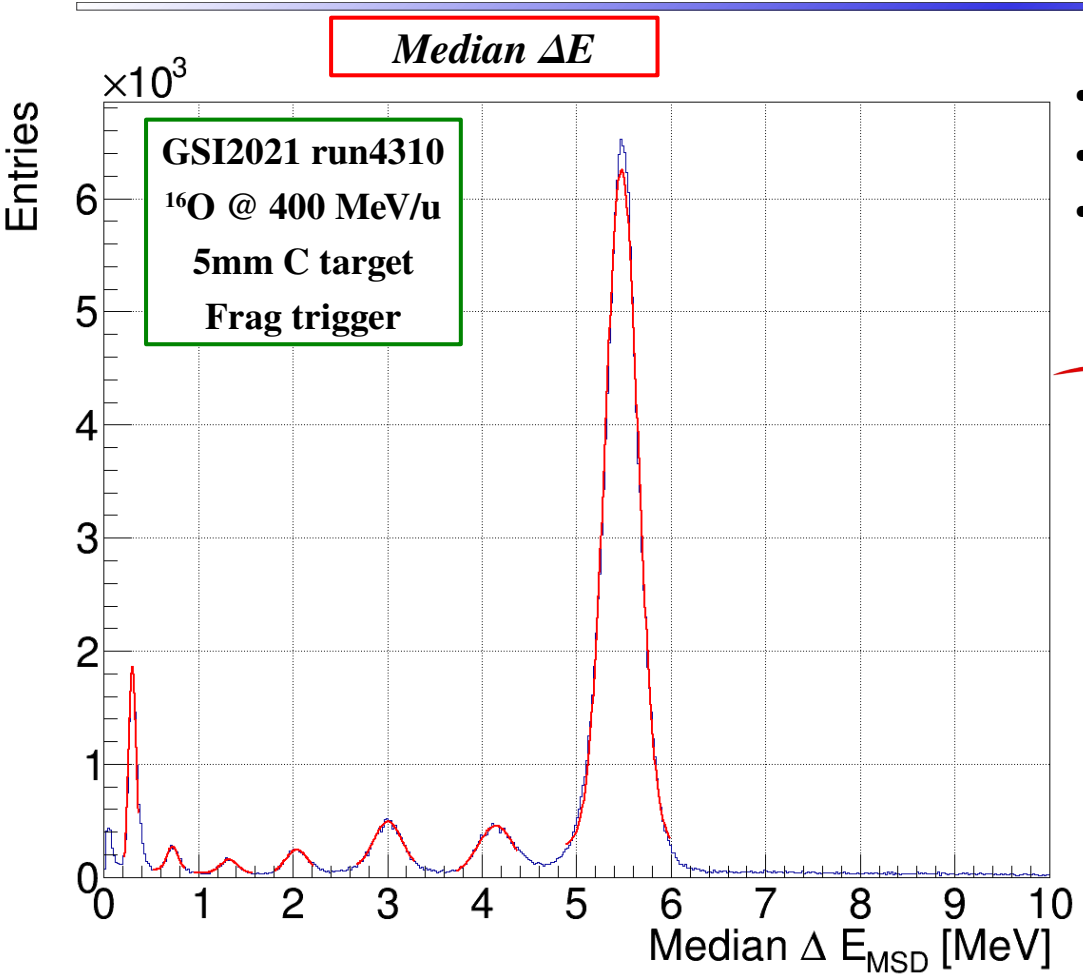
2

η correction: multi-sensor energy loss



- **Much better!!!**
- Get rid of artifacts
- Very good energy resolution!

η correction: multi-sensor energy loss



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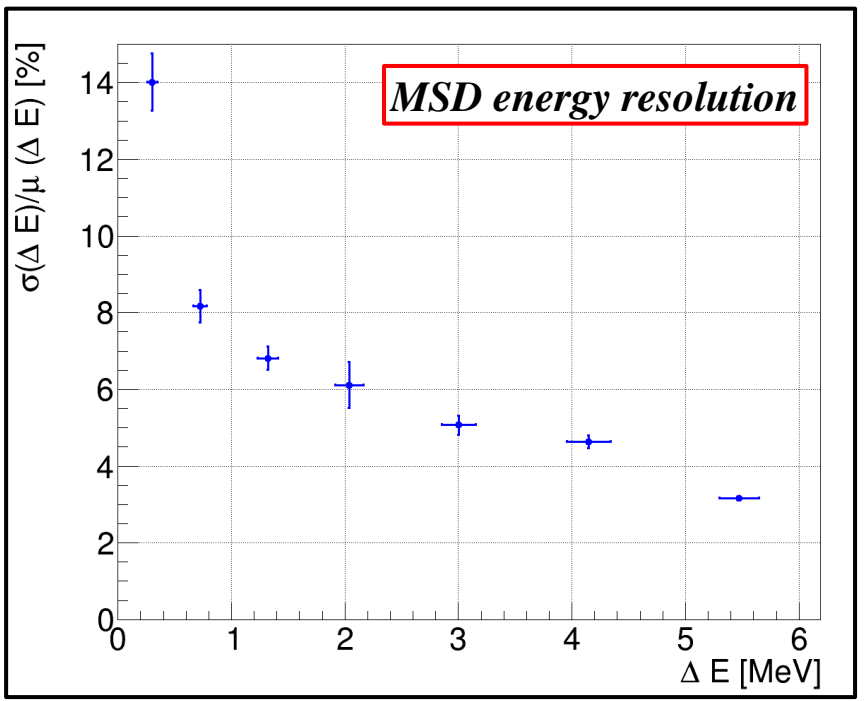
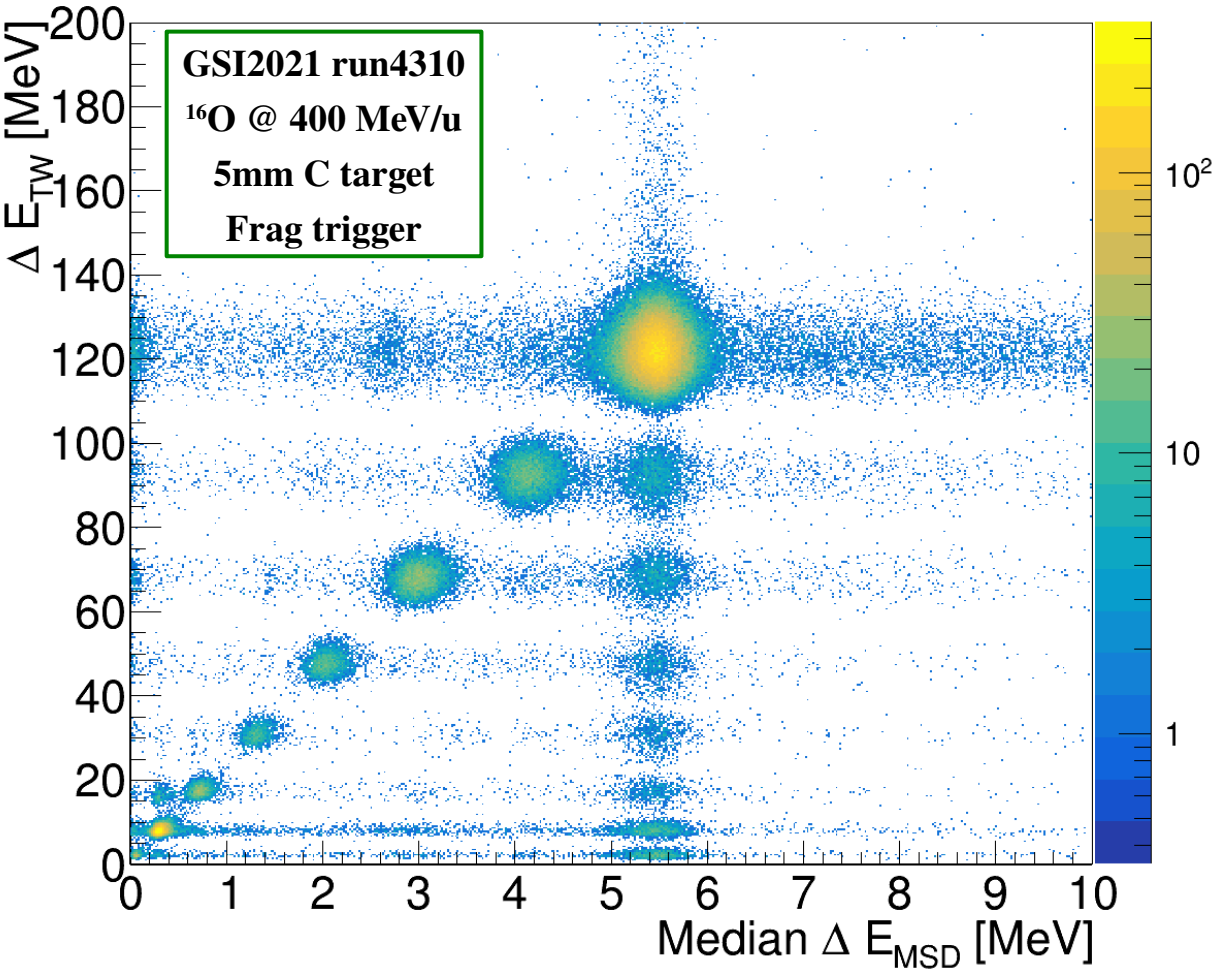
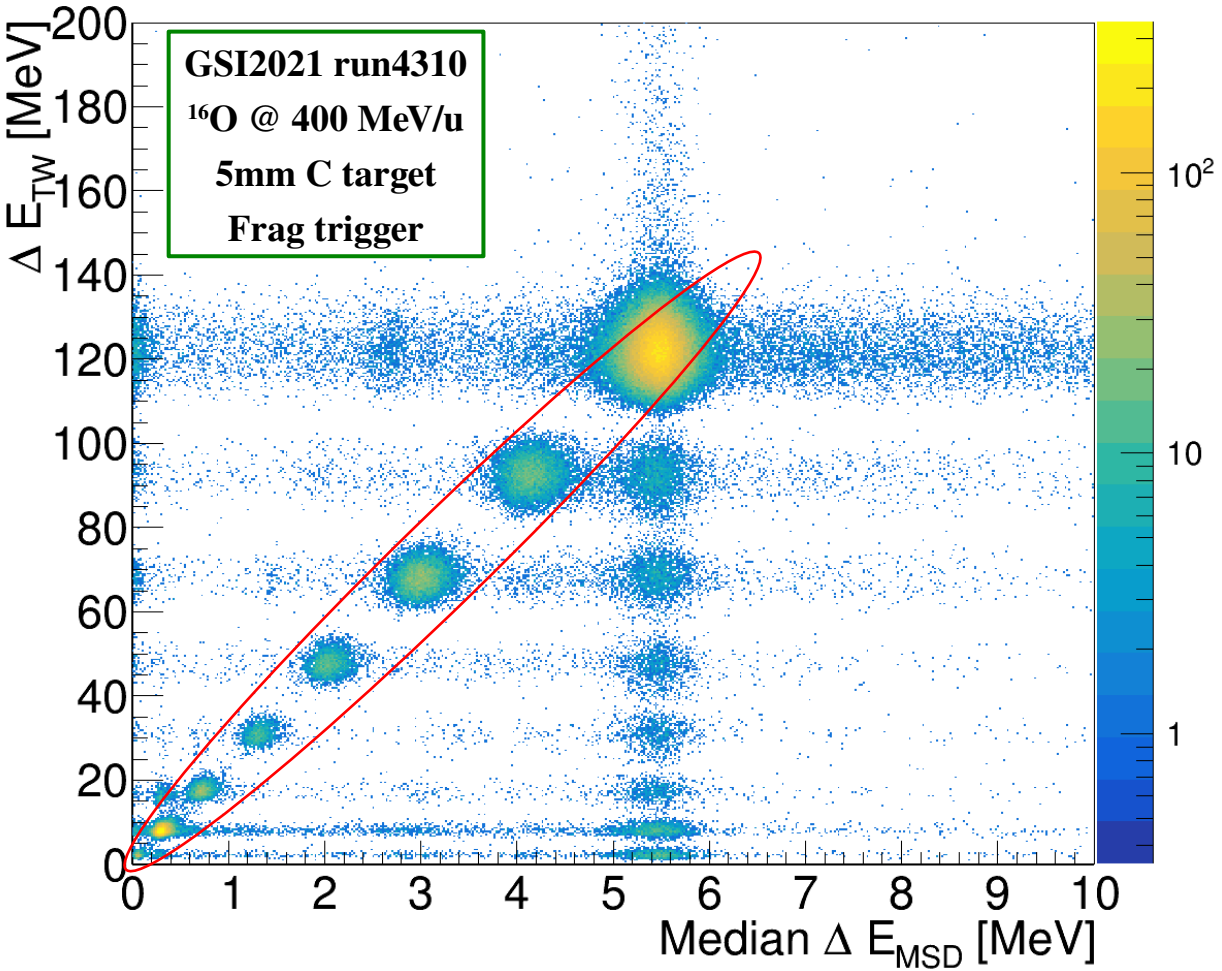


MSD-TW correlation



- **Very good MSD-TW correlation!**
- Possible to recognize many physics and reconstruction effects
  - Good correlation
  - Out-of-target fragmentation
  - 2-α pile-up
  - Noise artifacts
  - Event pile-up (?)

MSD-TW correlation



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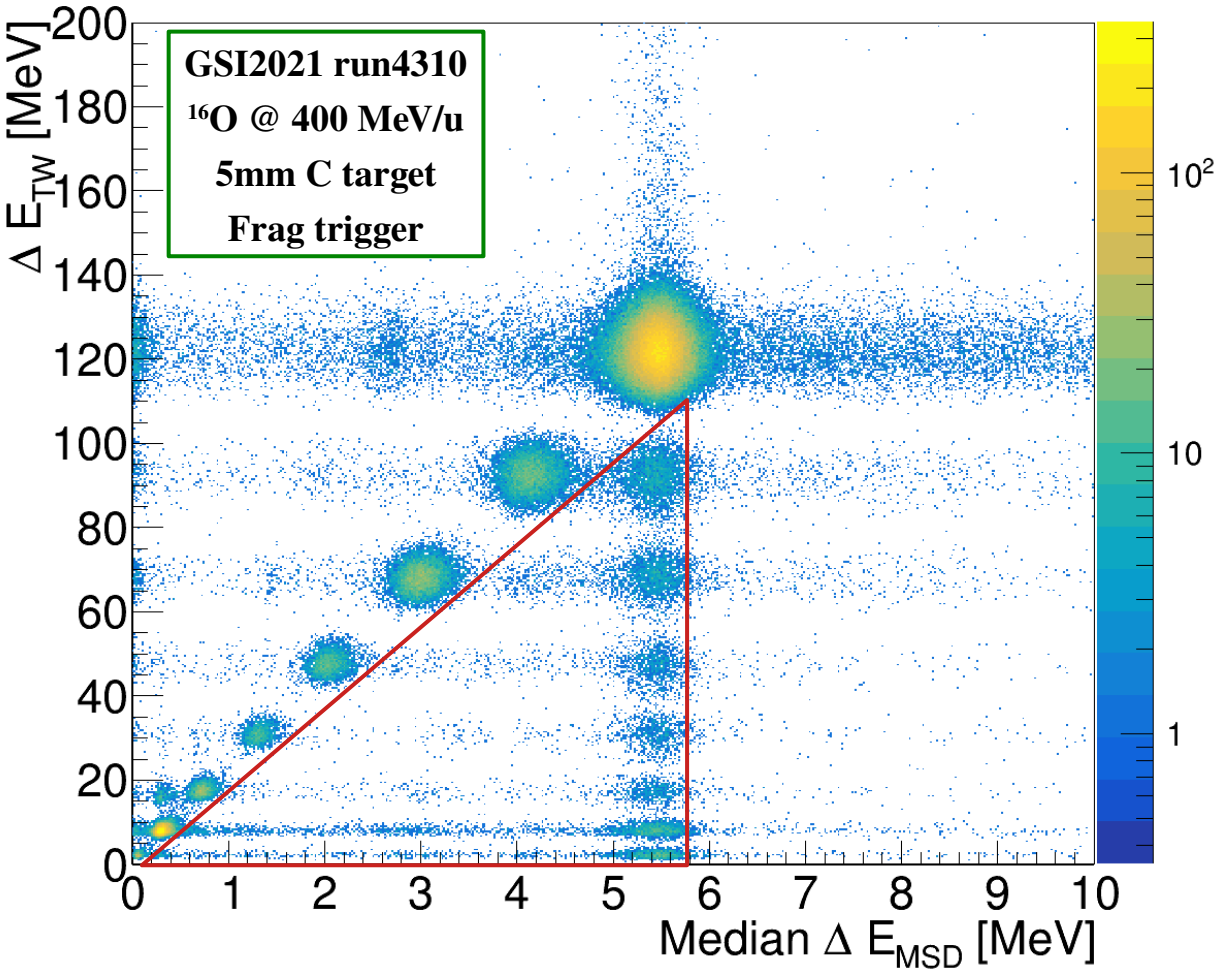
MSD-TW correlation



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  - **Out-of-target fragmentation**
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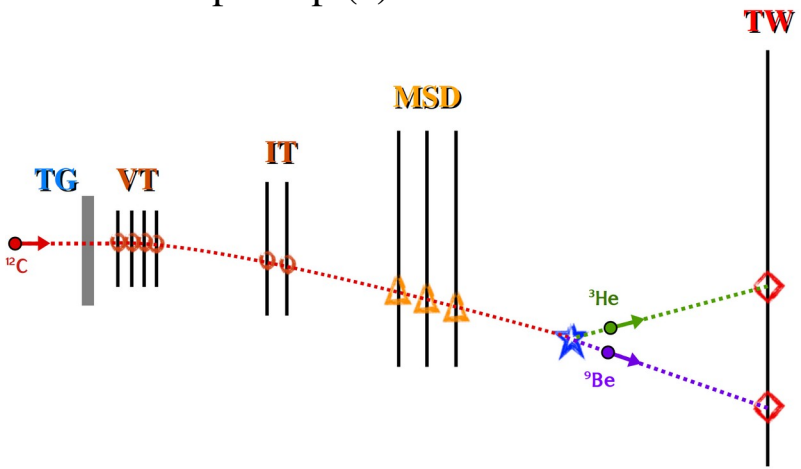
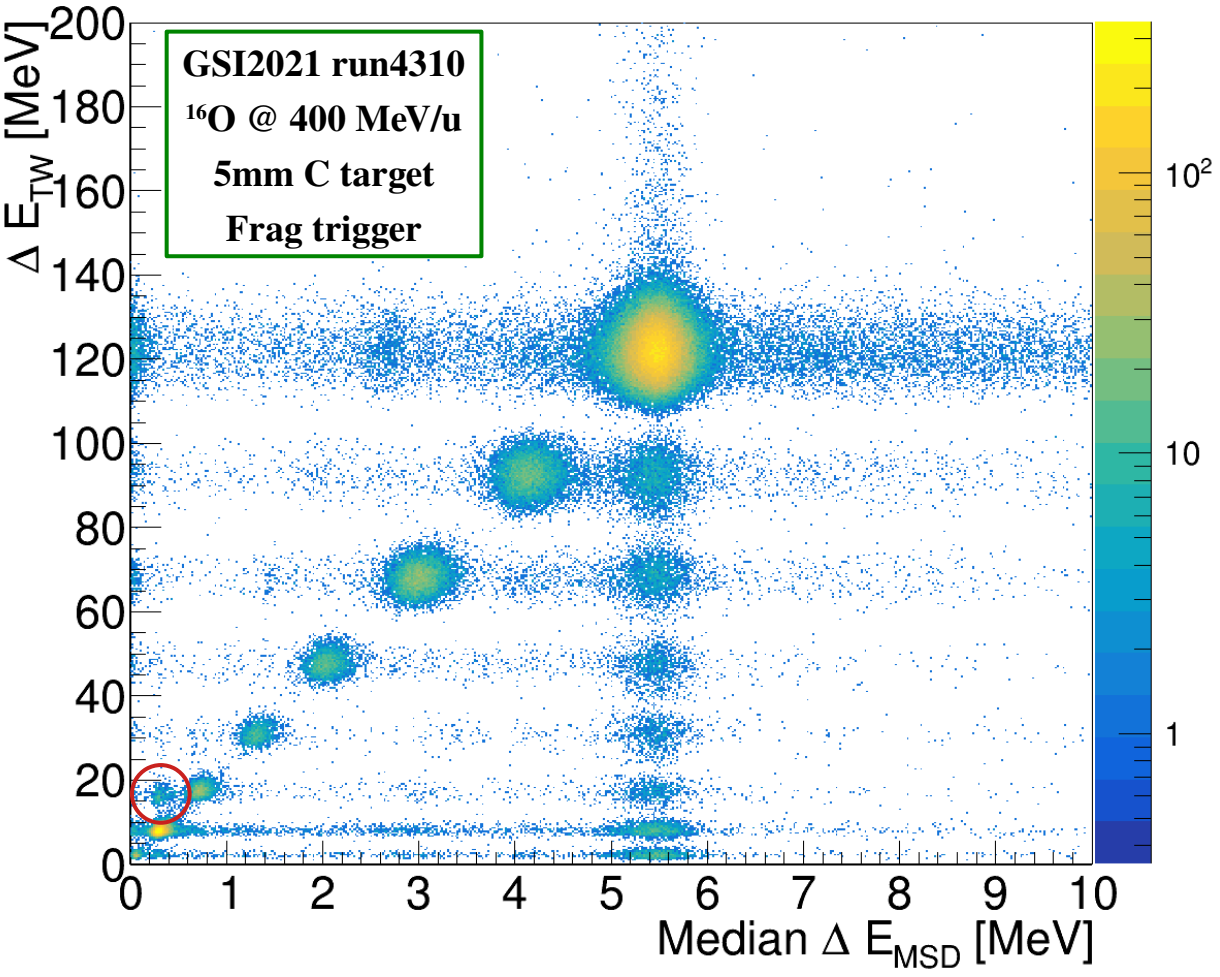
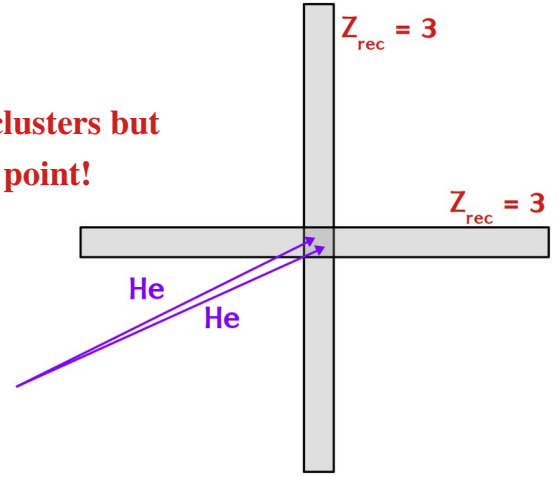


MSD-TW correlation

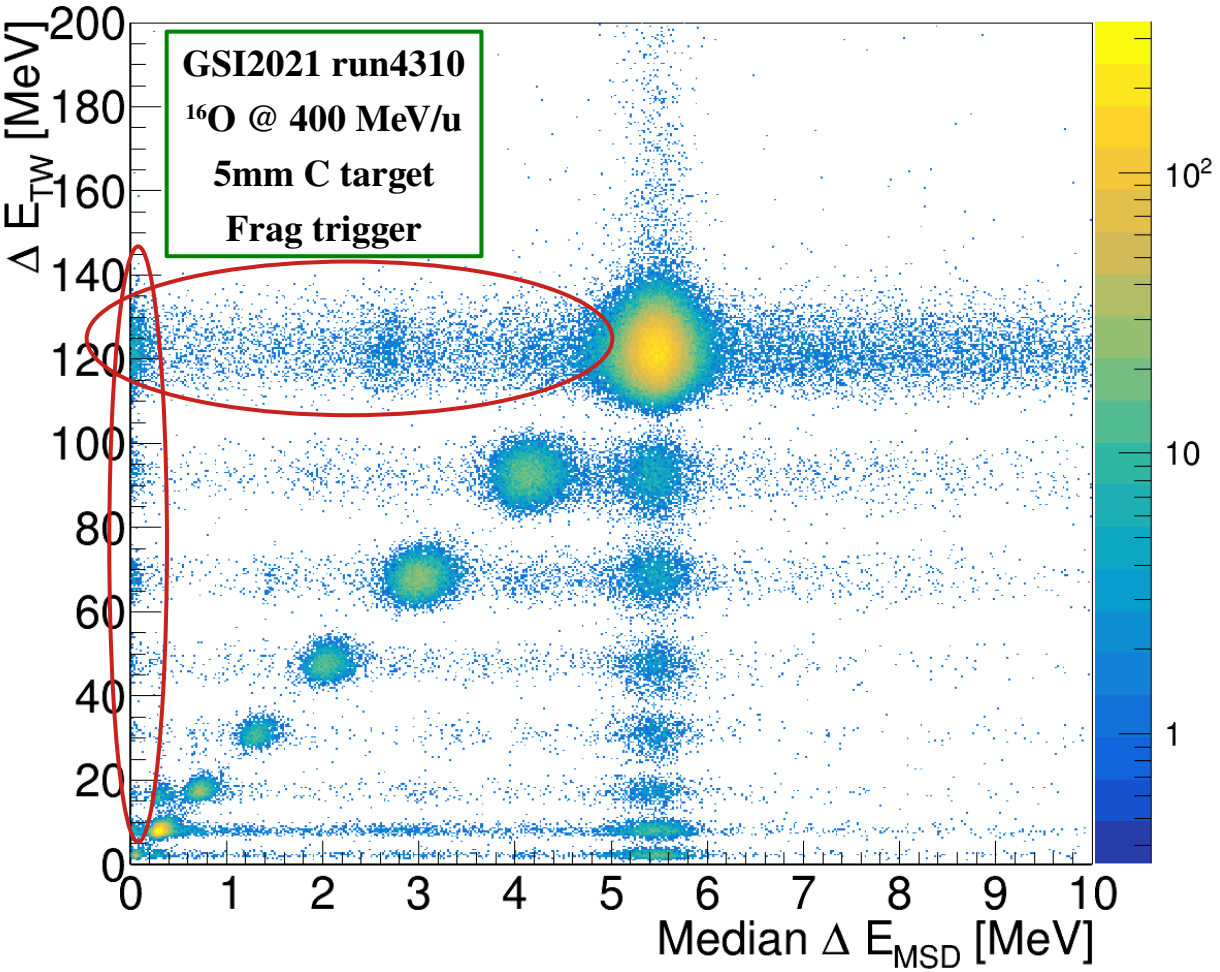


- **Very good MSD-TW correlation!**
- Possible to recognize many physics and reconstruction effects
  - Good correlation
  - Out-of-target fragmentation
  - **2-α pile-up**
  - Noise artifacts
  - Event pile-up (?)

2 MSD clusters but one TW point!



MSD-TW correlation

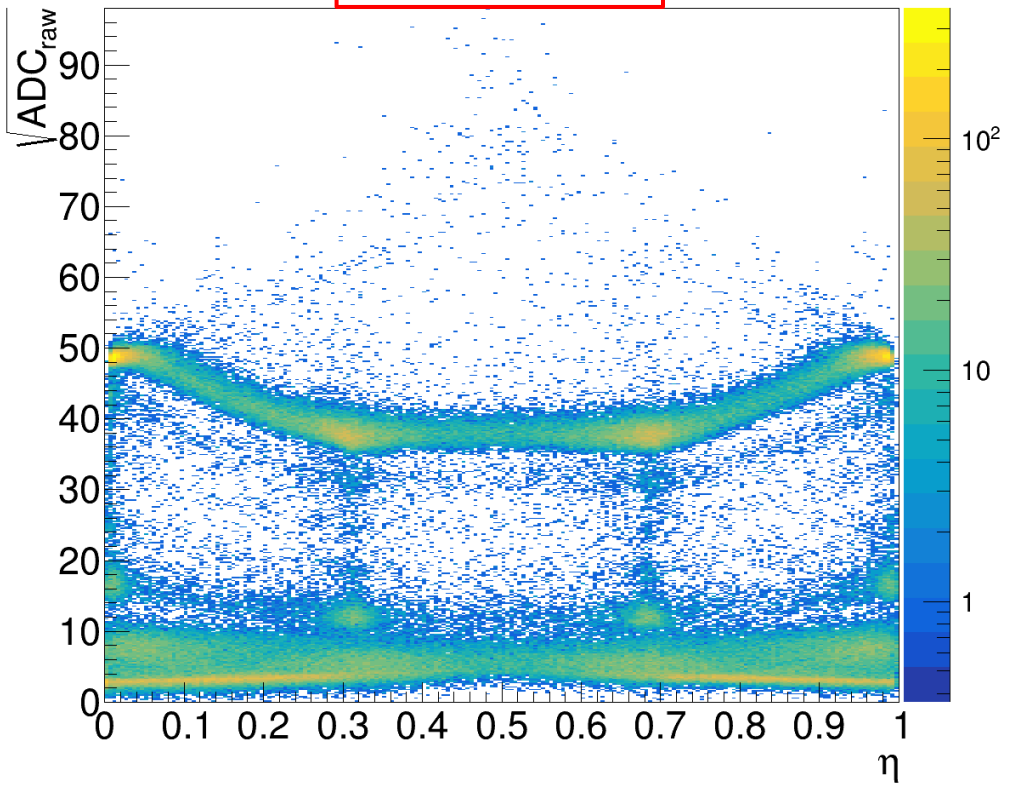


- **Very good MSD-TW correlation!**
- Possible to recognize many physics and reconstruction effects
  - Good correlation
  - Out-of-target fragmentation
  - 2-α pile-up
  - **Noise artifacts**
  - **Event pile-up (?)**

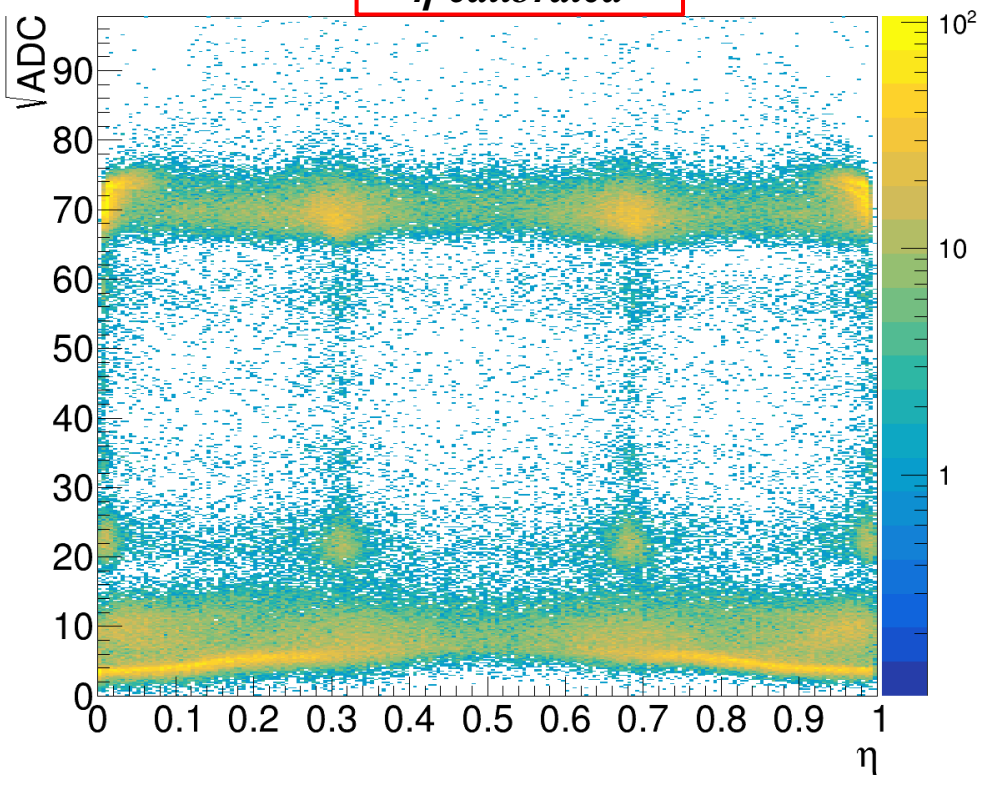
Bonus: η correction in CNAO2023

Apply η-correction → Same map works also for CNAO2023 (all sensors to be checked!)

Un-calibrated

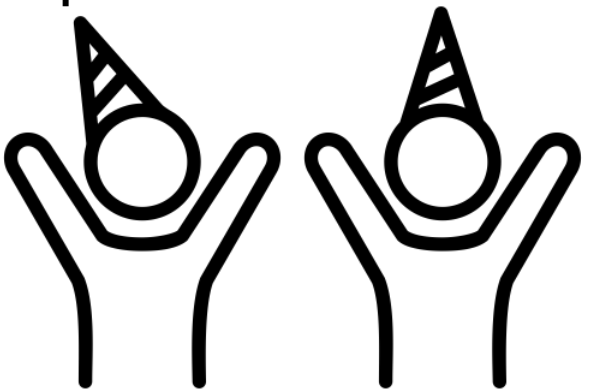


η-calibrated



Summary of software updates

- **Macro for η-correction map (`shoe/Reconstruction/macros/ComputeMsdEtaCorrection.C`)**
- **`TAMSDrawHit`**
  - `GetCharge()` → strip raw ADC readout
  - Fixed `IsSeed` and `IsFired` flags
  - Noisy/dead strip flagged correctly (from pedestal calibration files)
- **`TAMSDhit`**
  - `GetEnergyLoss()` → strip ADC with VA gain correction
- **`TAMSDcluster`**
  - Clustering algorithm updated!
  - η-correction now properly implemented $k(\eta, S_{raw})$
    - Map will be used imported in all campaigns
  - `GetEnergyLossNoEta()`→ Non-calibrated energy loss
  - `GetEnergyLoss()` → η-calibrated energy loss [MeV]
- **`TAMSDcalibrationMap`**
  - Loaded and applied 2D η-correction map (+ 2D interpolation of correction factors)

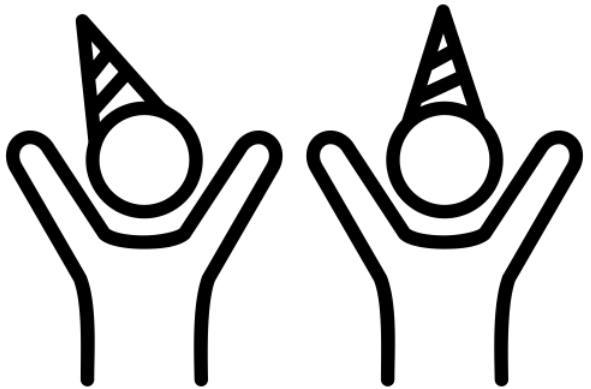


- **`TAMChit`**
  - Updated to match changes in data containers

Conclusions

MSD updates!

- Checked whole reconstruction chain from raw to cluster
- Updated clustering
- η-correction -> calibrated ΔE in MSD
- **Very good correlation w/ TW and glb tracks**
- **Very good energy resolution in MSD!**



- **Need to re-check all MSD pedestals and clustering thresholds!! (IMPORTANT)**
- No check performed on MSD tracking or MSDpoints!
- **Need for someone else to do this, so… volunteers are welcome!**

Many many thanks to Gianluigi and Alberto!!

(and to all my office mates for the patience… 😅)

Backup slides