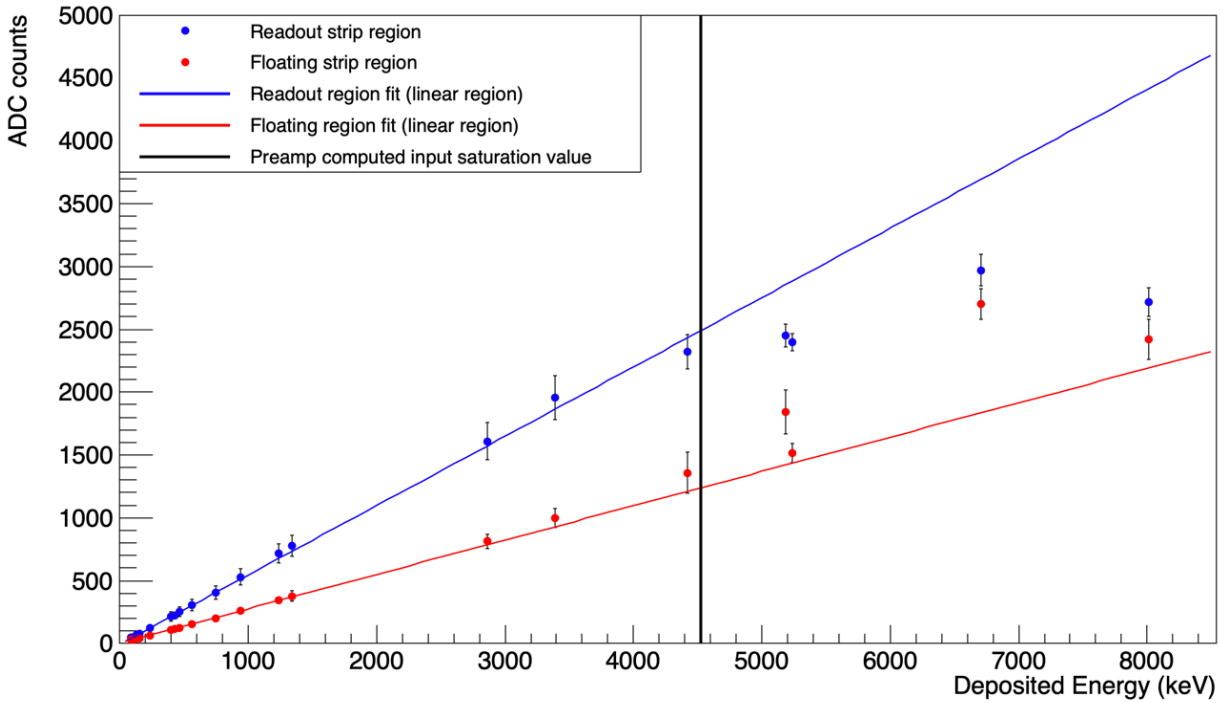
MSD status and calibration

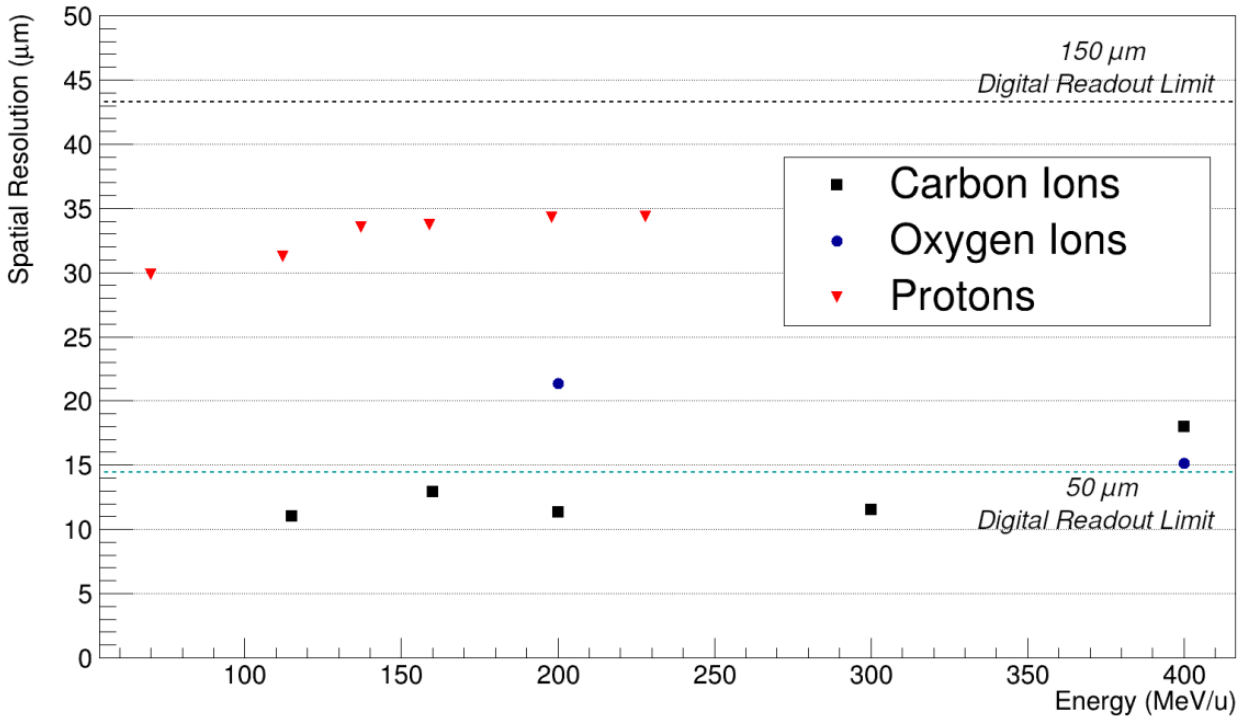
Gianluigi Silvestre

07/06/2023

Main results up to now



Response to wide range of deposited energy and identification of saturation regime



Spatial resolution for different particles

Next steps:

- Eta correction (see next slides) and work on software and charge/energy resolution: working with Matteo Franchini and his master student
- Better understanding of detection efficiency for low Z particles (i.e. protons): working with Roma group and Benedetto Di Ruzza / Leonello Servoli

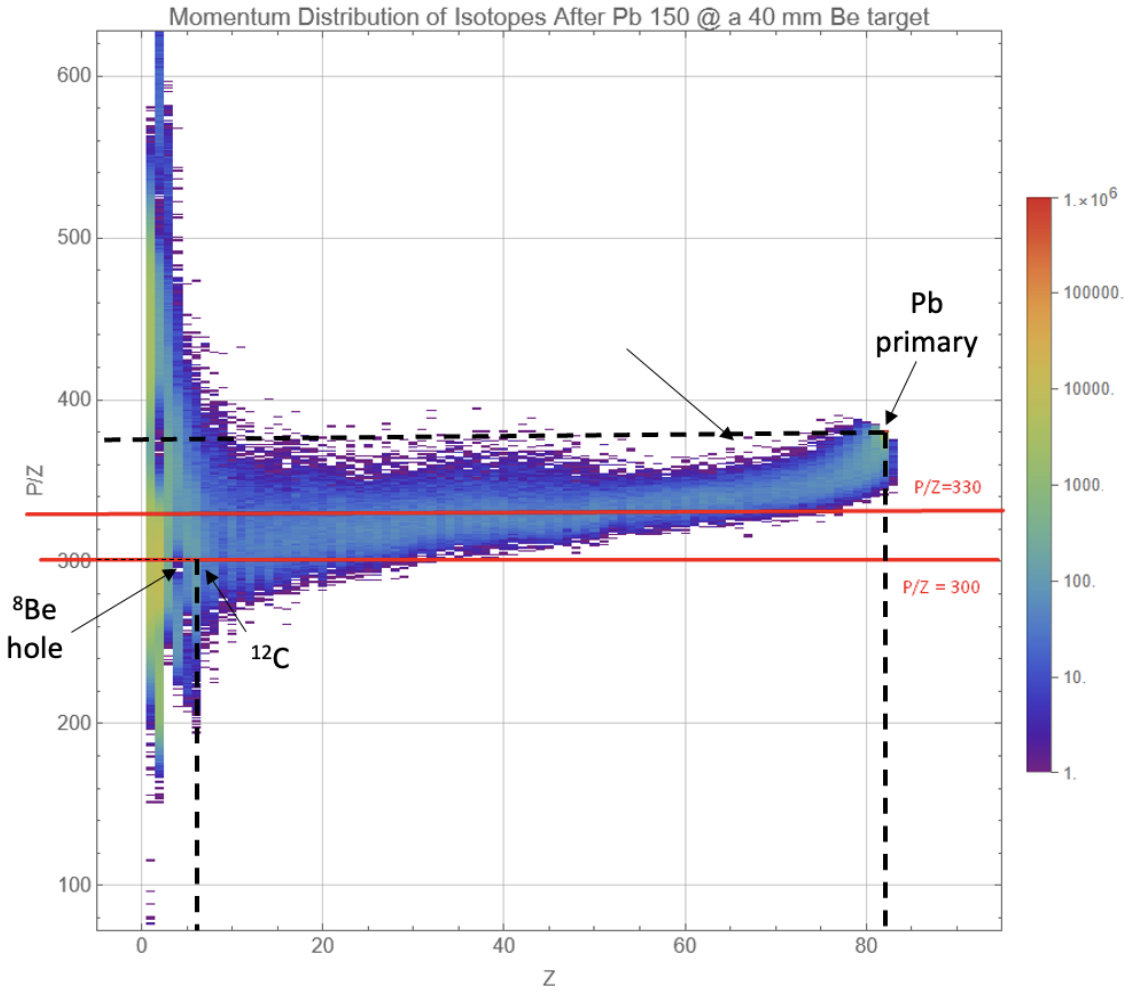
CERN Pb fragments test

Date	Location	Beam	Goal
November 2022	CERN SPS	Fragmented Pb	MSD performance and η calibration

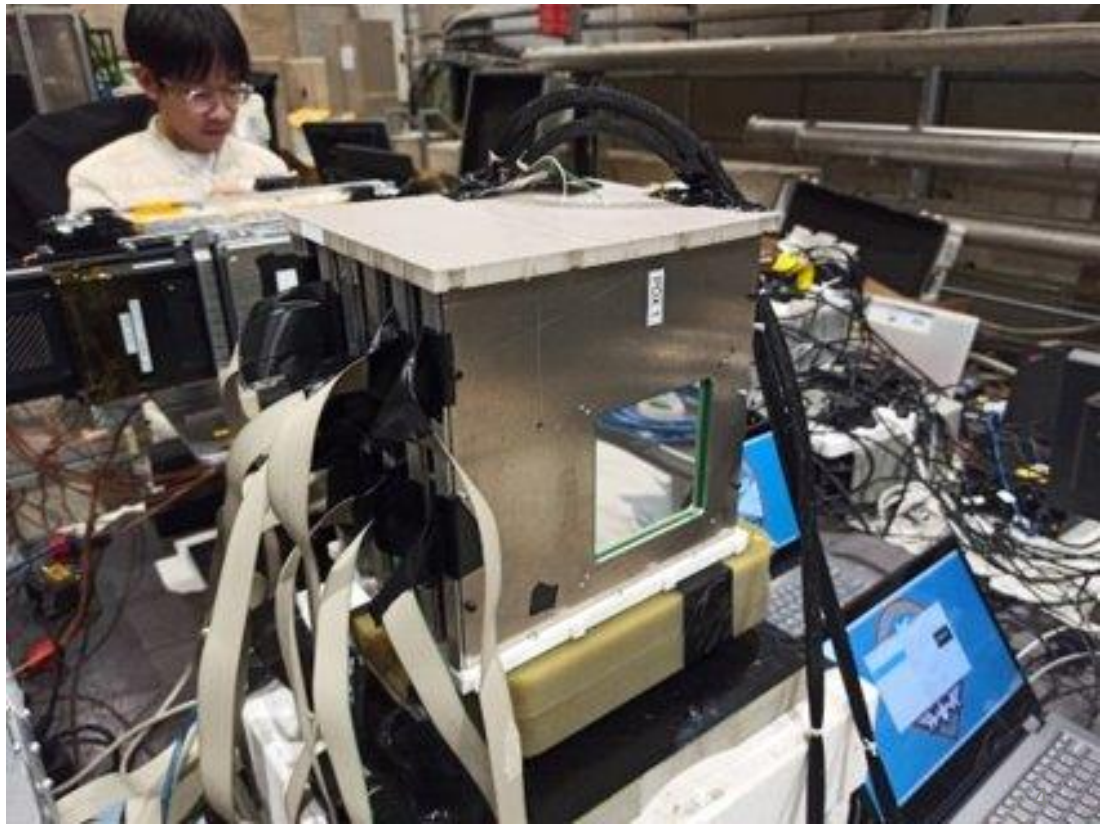
- Data taking with another experiment (HERD)
- Take two of 2021 data campaign (where we couldn't take useful data)
- Expanded tracker system (4 XY stations) but different DAQ system

- Goal: detector response/resolution to a wide range of ions and η calibration
  - Desiderata: fragmented ion beam with different Z covering a wide area with high statistics
  - A researcher from HERD worked on data analysis with our help (A. Oliva of INFN Bo from HERD SCD group)

CERN Pb fragments test



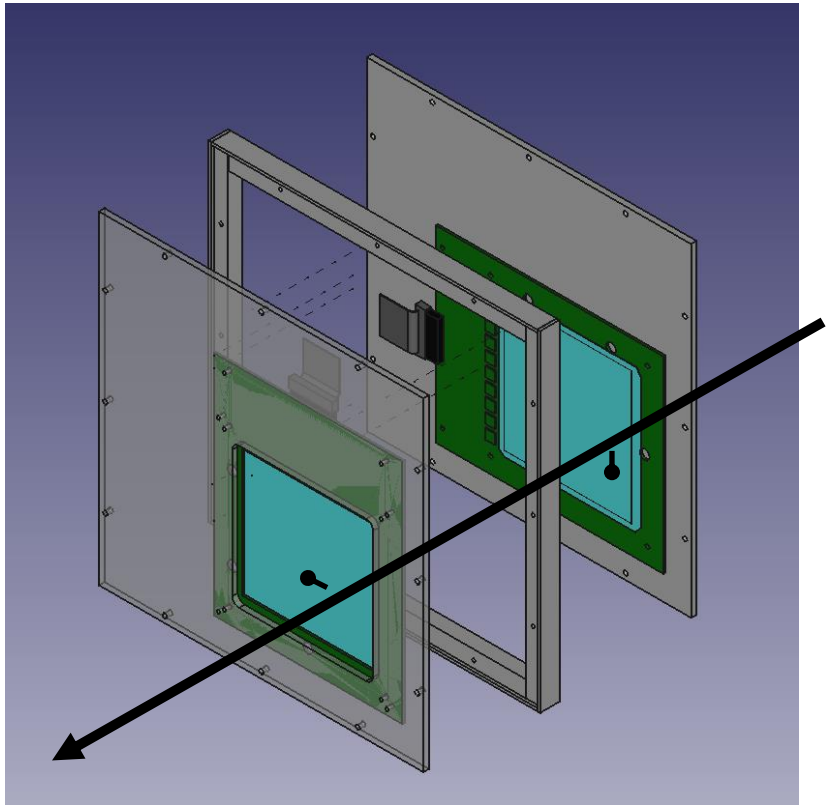
- Pb (150 A GeV/c or 379 GV/c) + Be (40 mm) target
- Fragments selected magnetically
- Rigidity interval of few % around 300 GV/c
- Approx A/Z=2.2
- Possible to get very high Z particles
- Tested 4 XY pairs of detectors

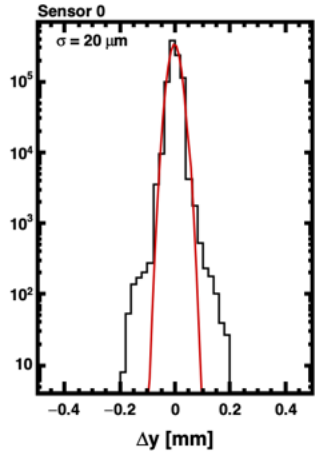


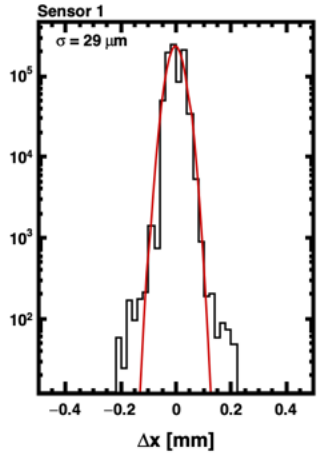
Alignment

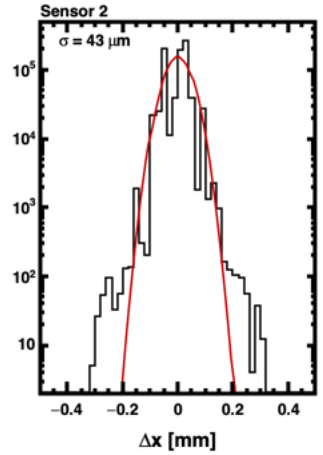
Courtesy of A. Oliva (HERD SCD Group)

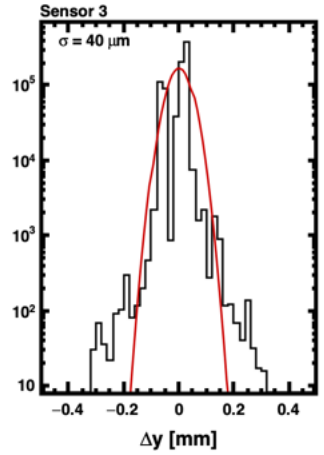
One track per event reconstructed with the largest cluster per each sensor.
Track is fitted with a straight line in XZ and YZ planes.
Quality on track fit χ^2 is required after the first alignment iteration.
Alignment is performed minimizing residuals of tracks along the two measurement coordinates,
First step is using median of residuals then with gaussian fit of residual (2 times).
Alignment parameters converge quickly, globally shifts are of the order of mm.

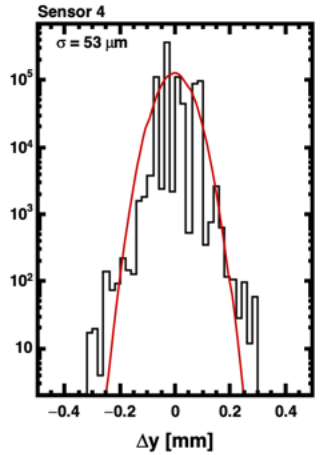


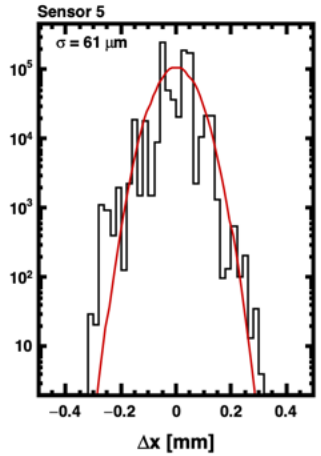


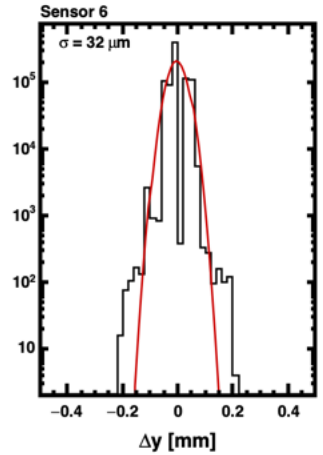


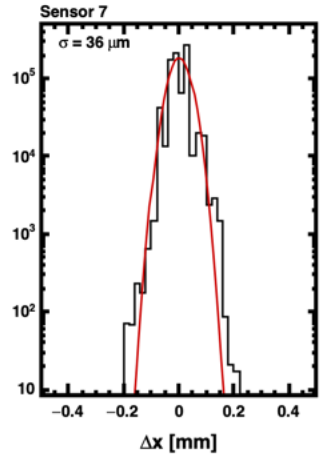






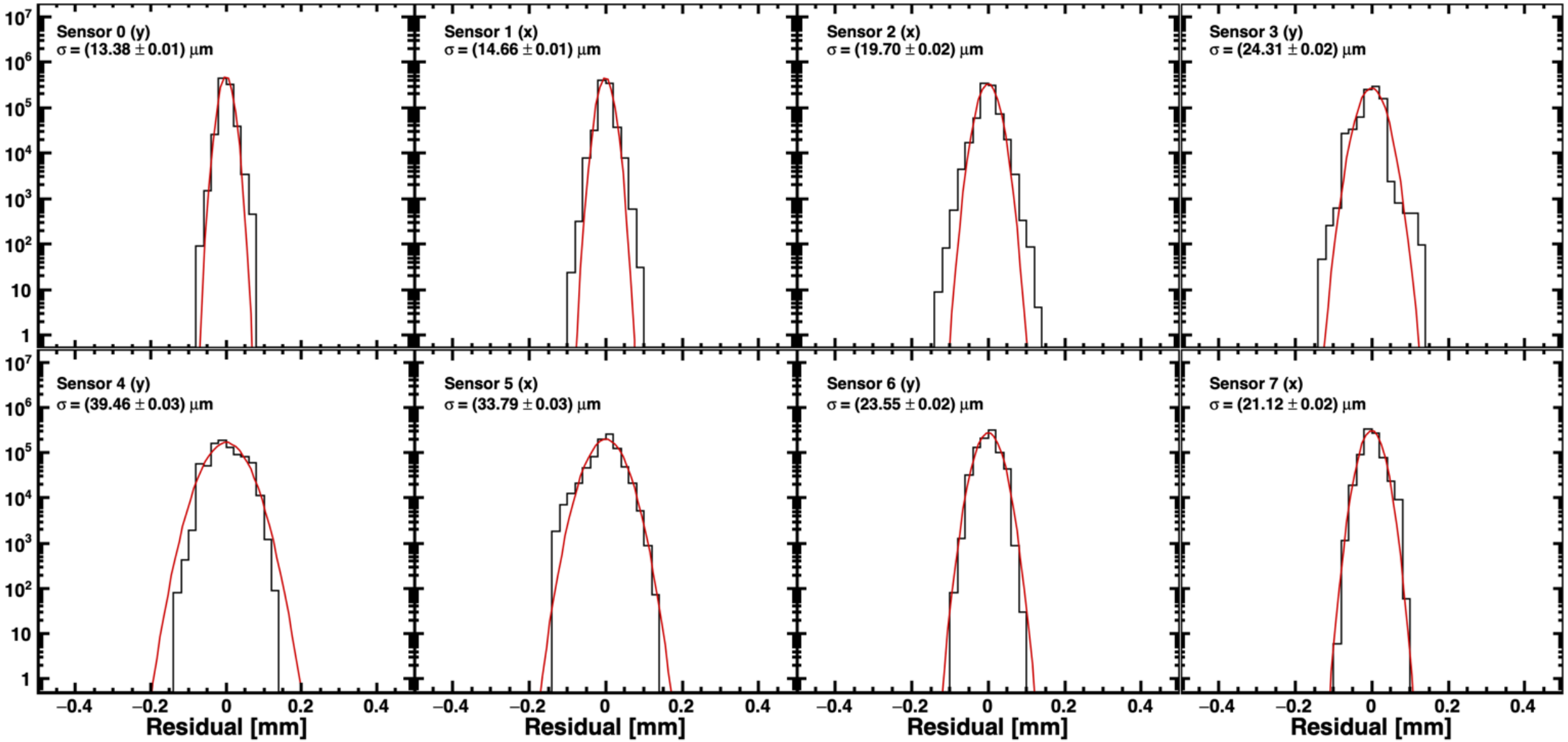






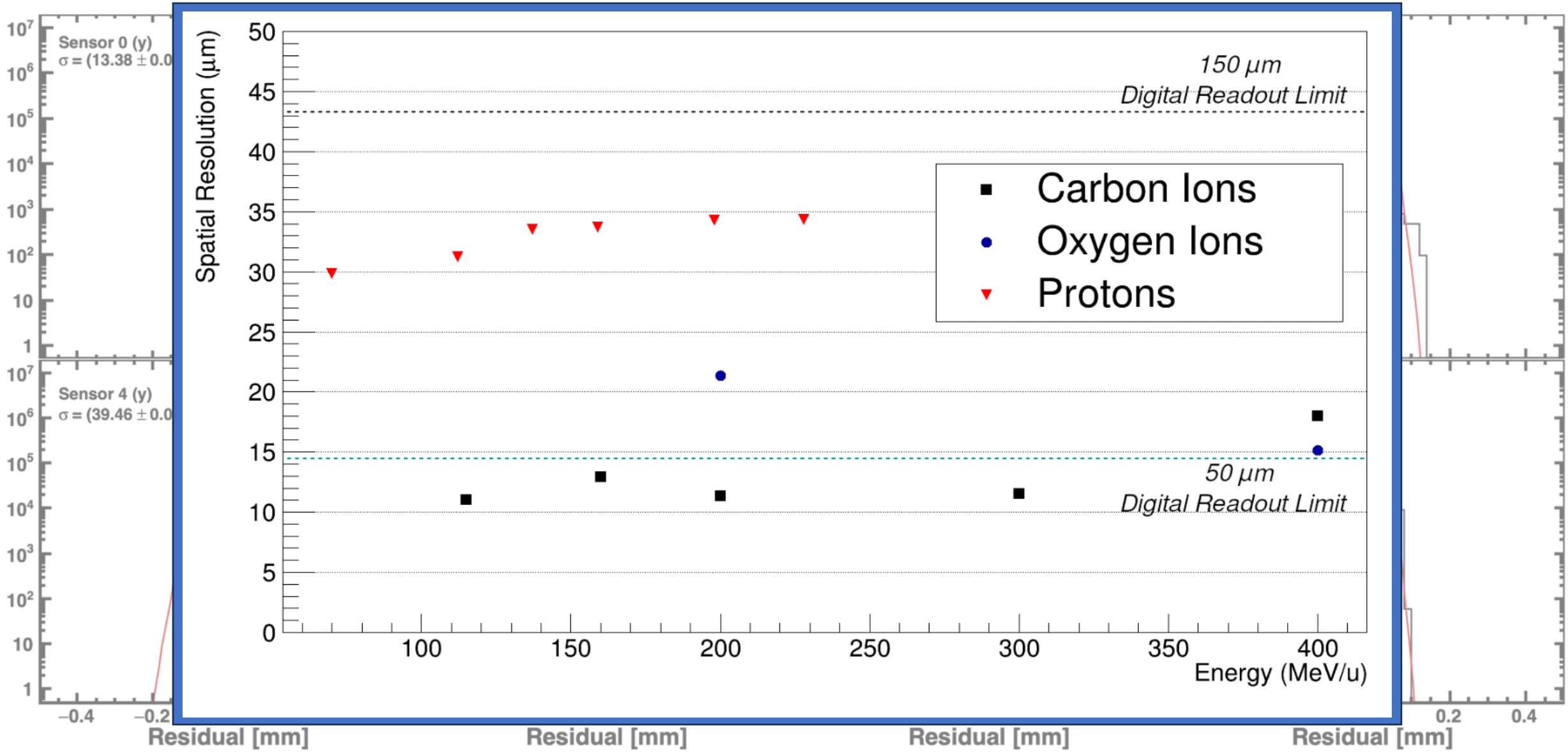
Residuals after alignment

Courtesy of A. Oliva (HERD SCD Group)



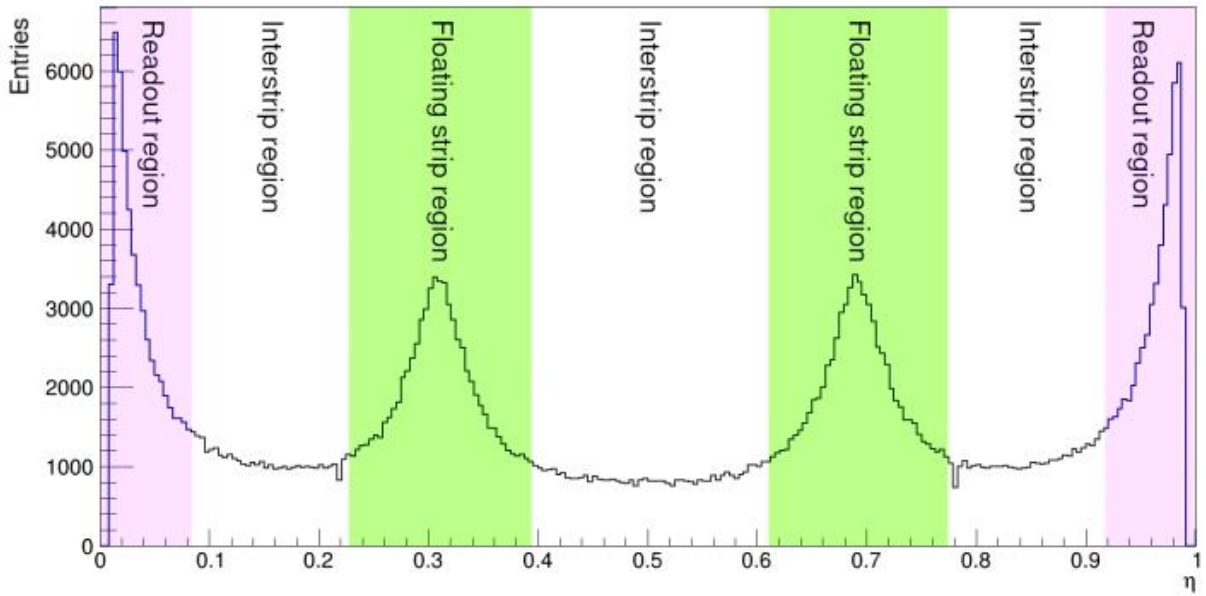
Residuals after alignment

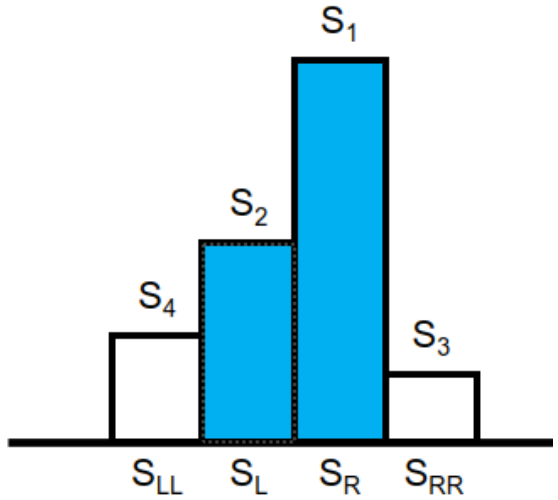
In agreement with values previously computed with FOOT campaigns data



The η parameter: refresh

- Eta parameter: relative signal fraction of the 2 highest strips in the cluster
  - Equivalent to center of gravity in units of the readout strip pitch
  - Capacitive coupling gives rise to the presence of peaks in the η distribution
  - Non linear charge division between strips
- Different regions corresponding to η intervals
- Expected resolution from η is 50/sqrt(12) ≈ 14 um (almost digital for implantation pitch)
- For saturation region the value tends to 150/sqrt(12) ≈ 43 um

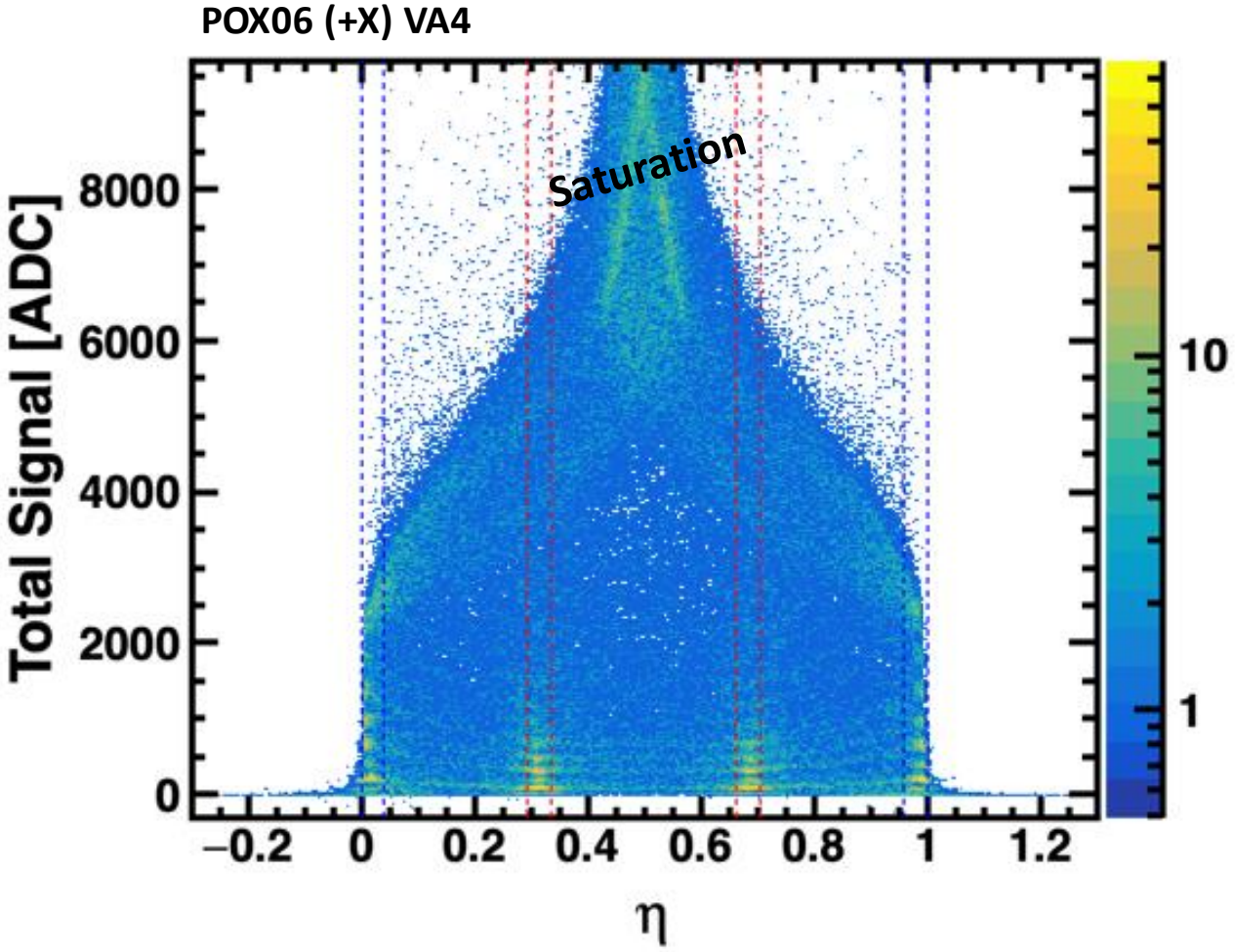


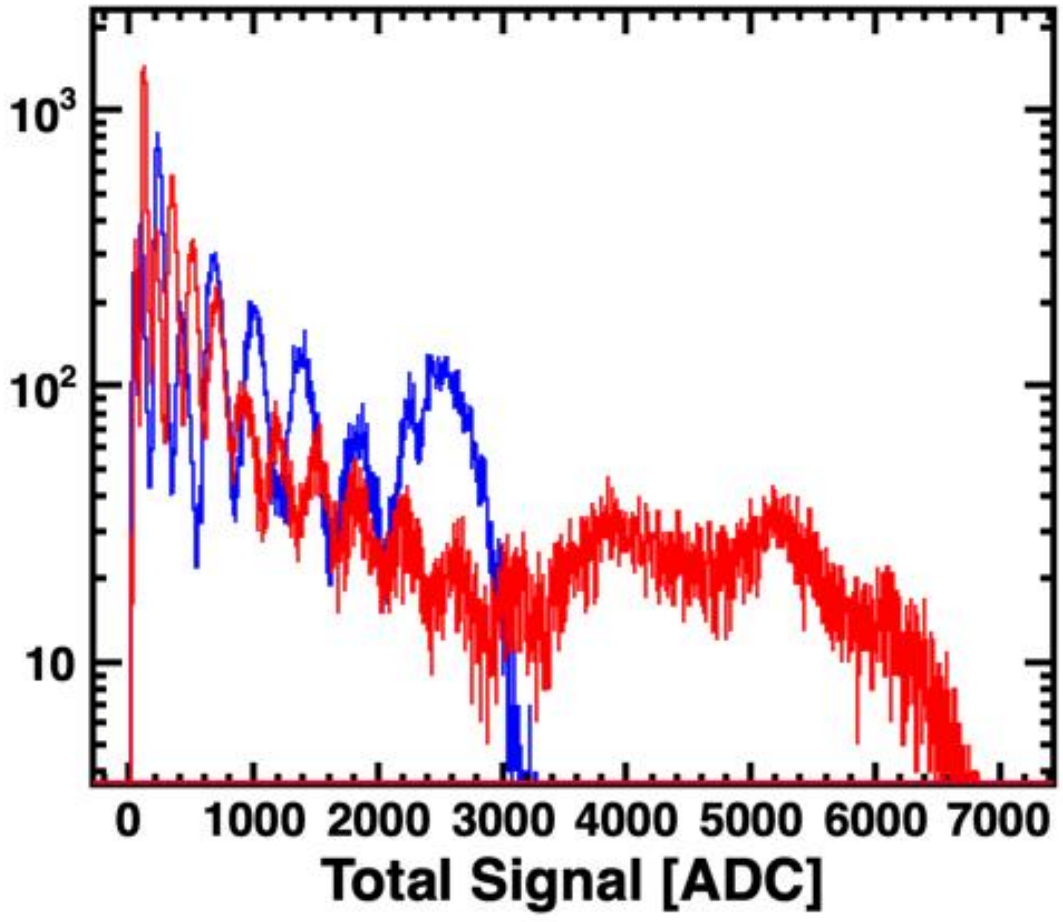


$\eta = S_R/(S_R + S_L)$: the center of gravity of the two highest readout strips (S_1 and S_2)

Total Signal vs η

Courtesy of A. Oliva (HERD SCD Group)



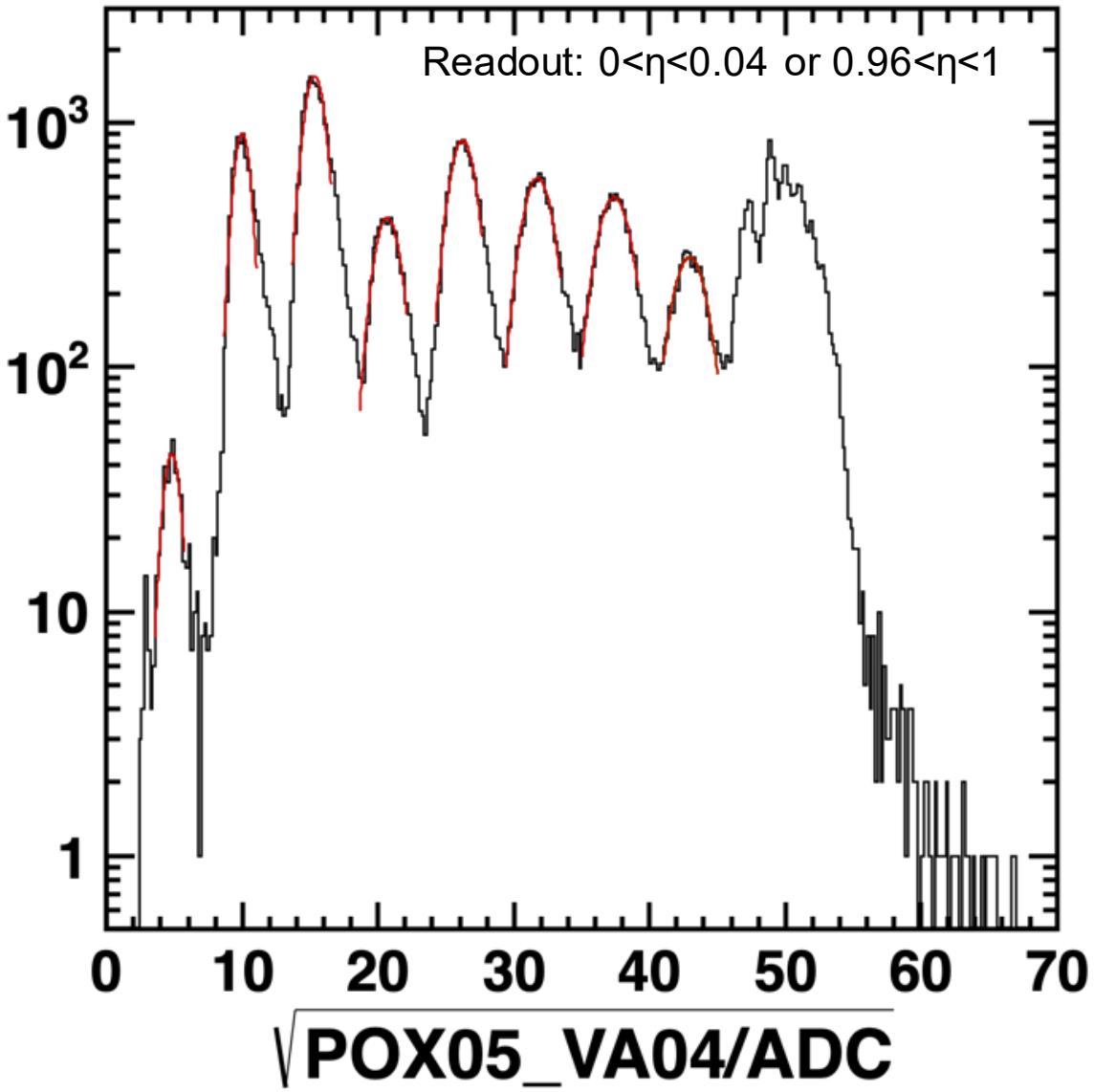


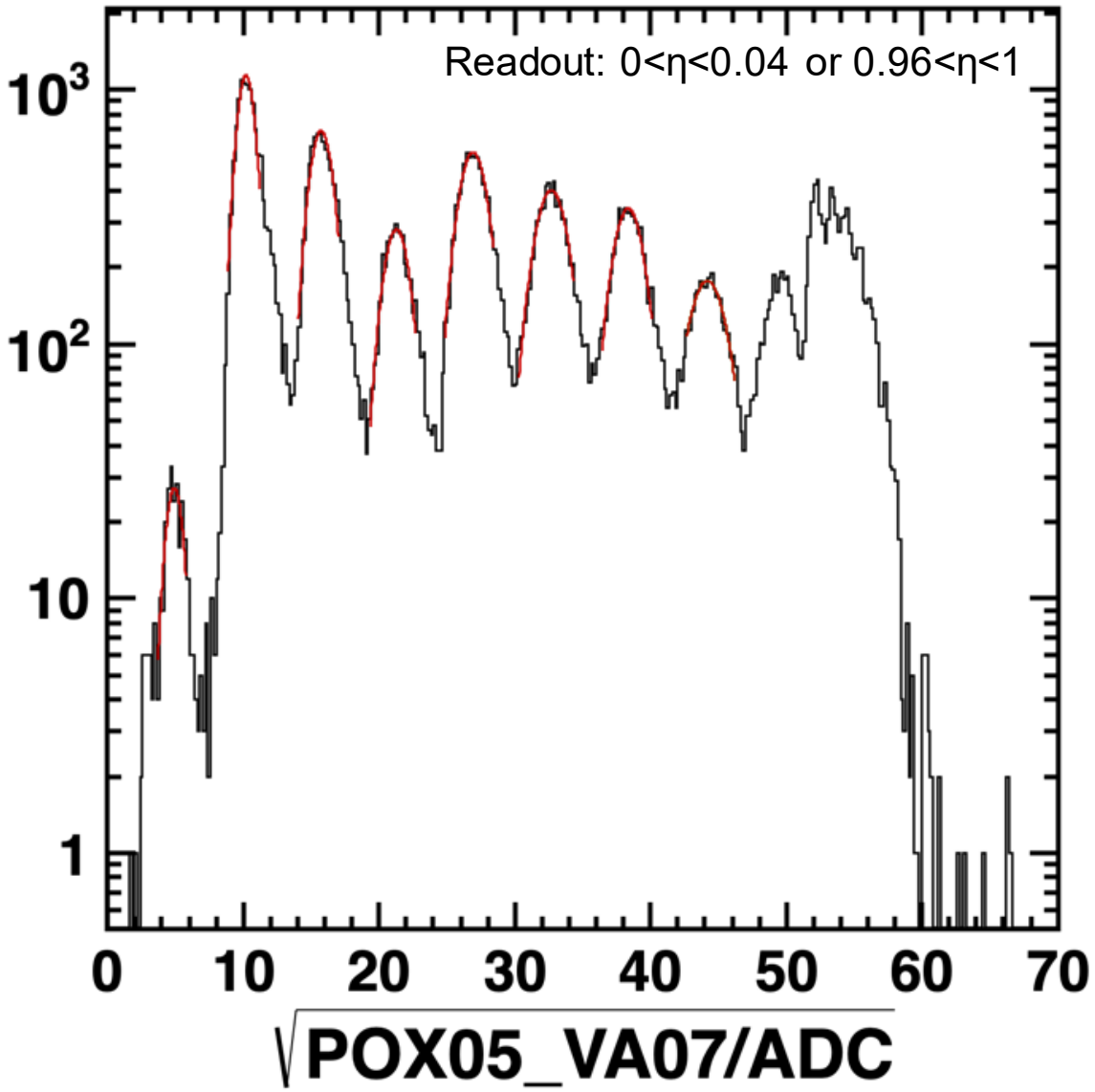
- The η-distribution shows 2 extra-peaks at about 1/3 and 2/3 as expected from the presence of 2 floating strips.
- Selecting two regions profiting of the η-symmetry: **readout**, **floating.**
- Basically, we can see up to 6 with **readout** region, and up to 14 with **floating** using total signal (as ~ expected).

Procedure for Gain Estimation

Courtesy of A. Oliva (HERD SCD Group)

Evaluate the peak position for each Z (from 1 to 8) and for each VA of every sensor selecting the readout region.
Compare the results with a chosen reference (POX06-VA04), and evaluate gain factors.





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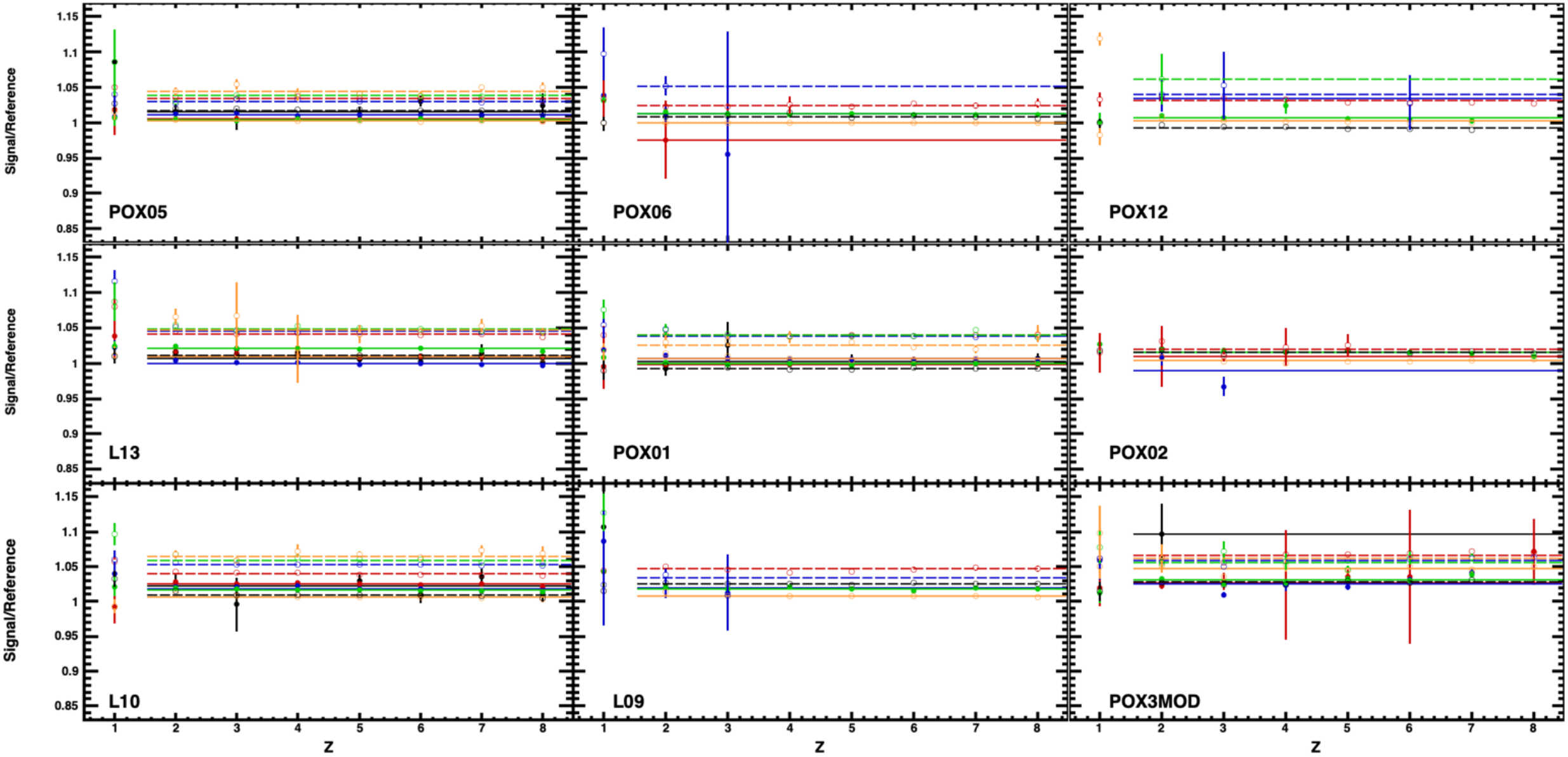
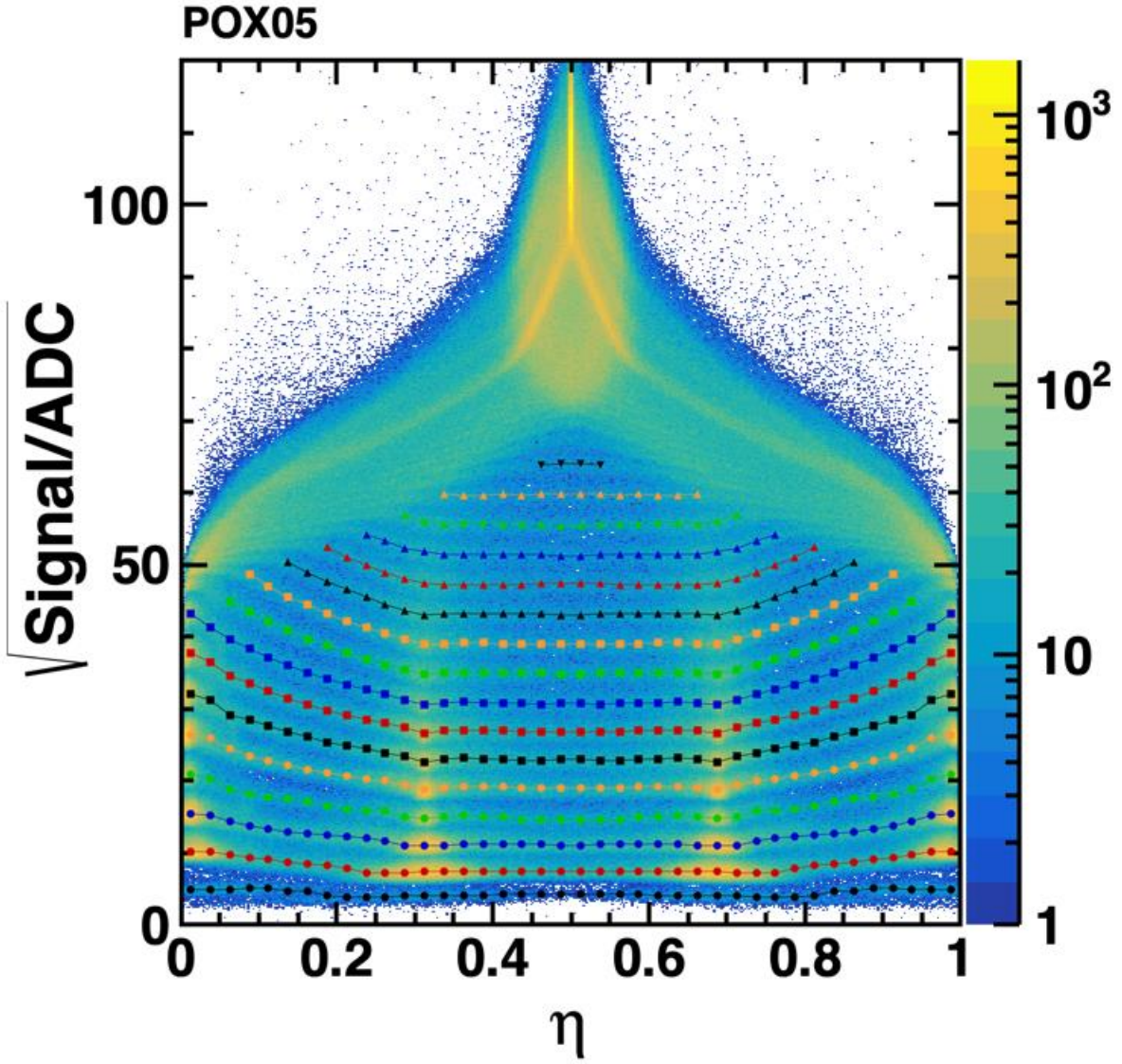
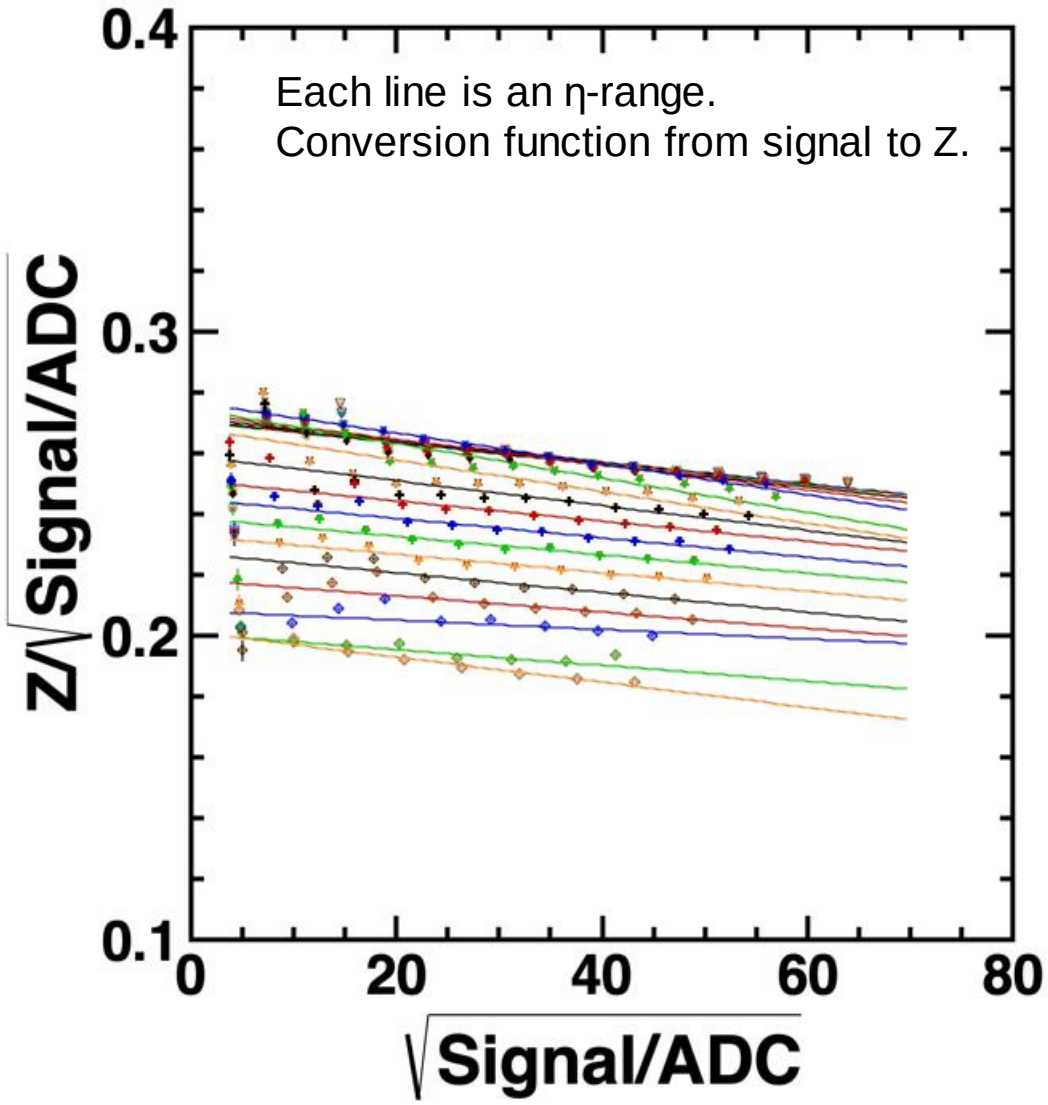


Total Signal vs η

Courtesy of A. Oliva (HERD SCD Group)

VAs of the same sensor are put together (after gain correction). For fitting a "η-folding" is applied.
Apply a handwritten peak finding procedure to characterize the signal variation with η (charge loss).





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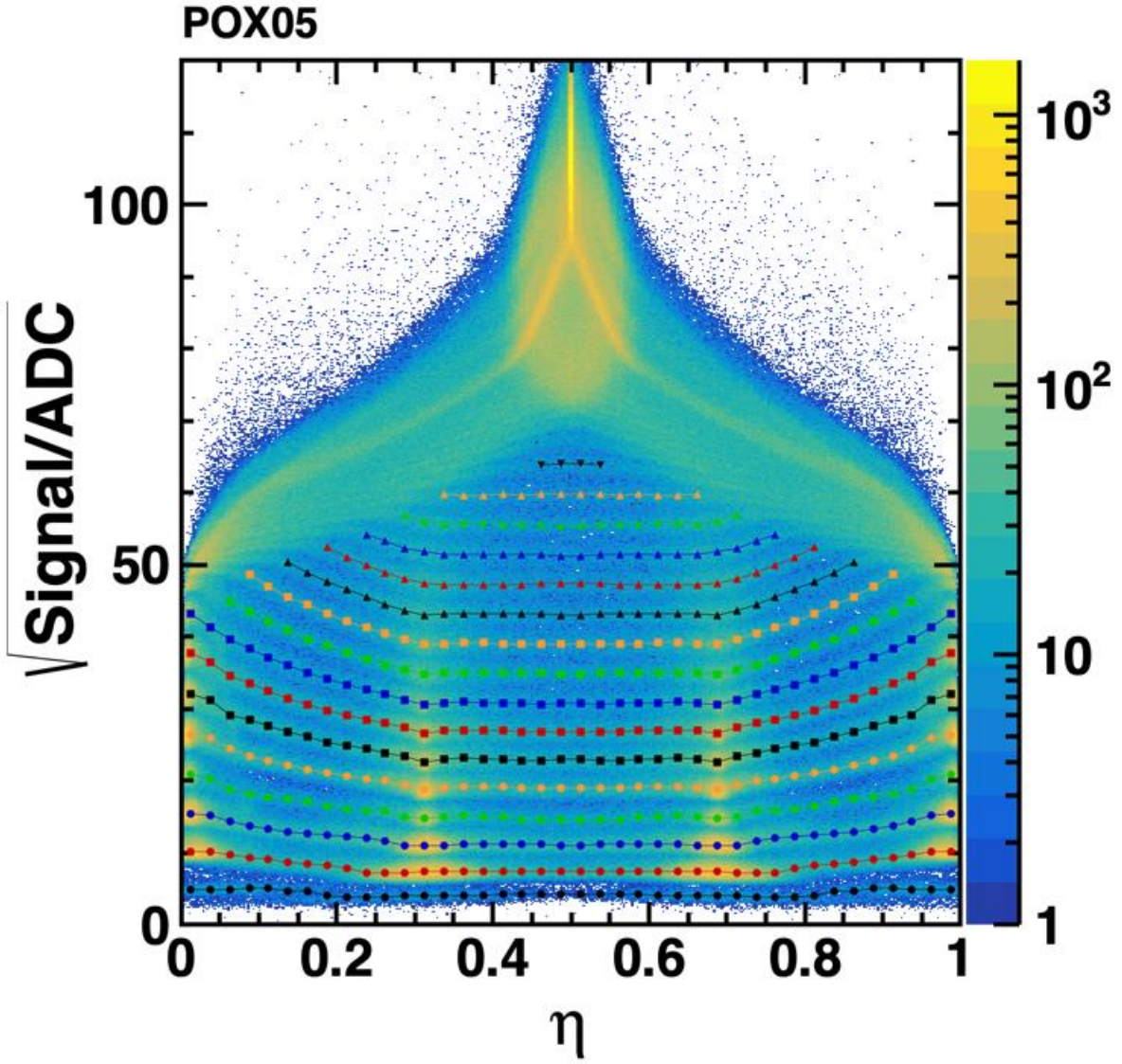
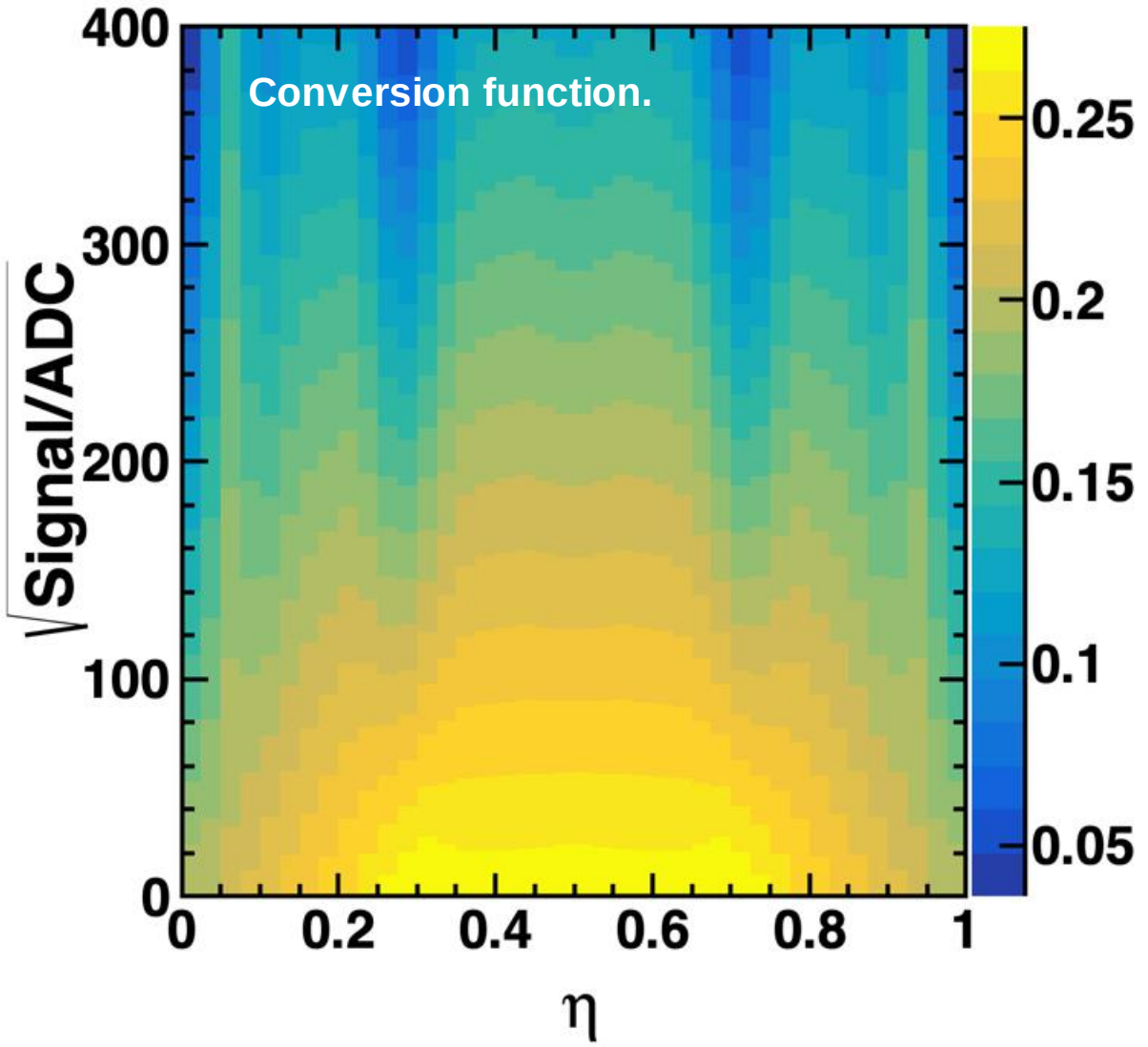
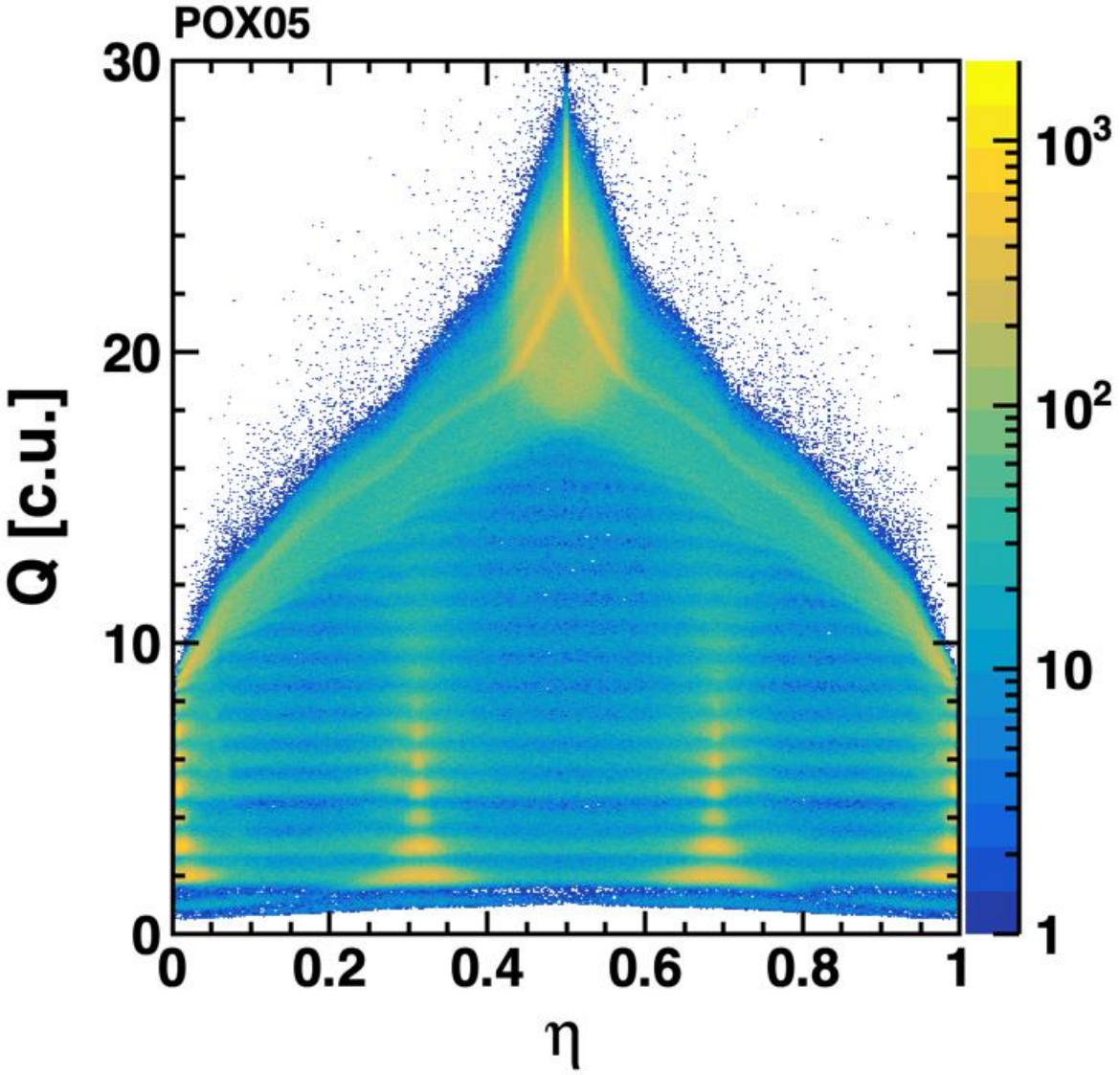


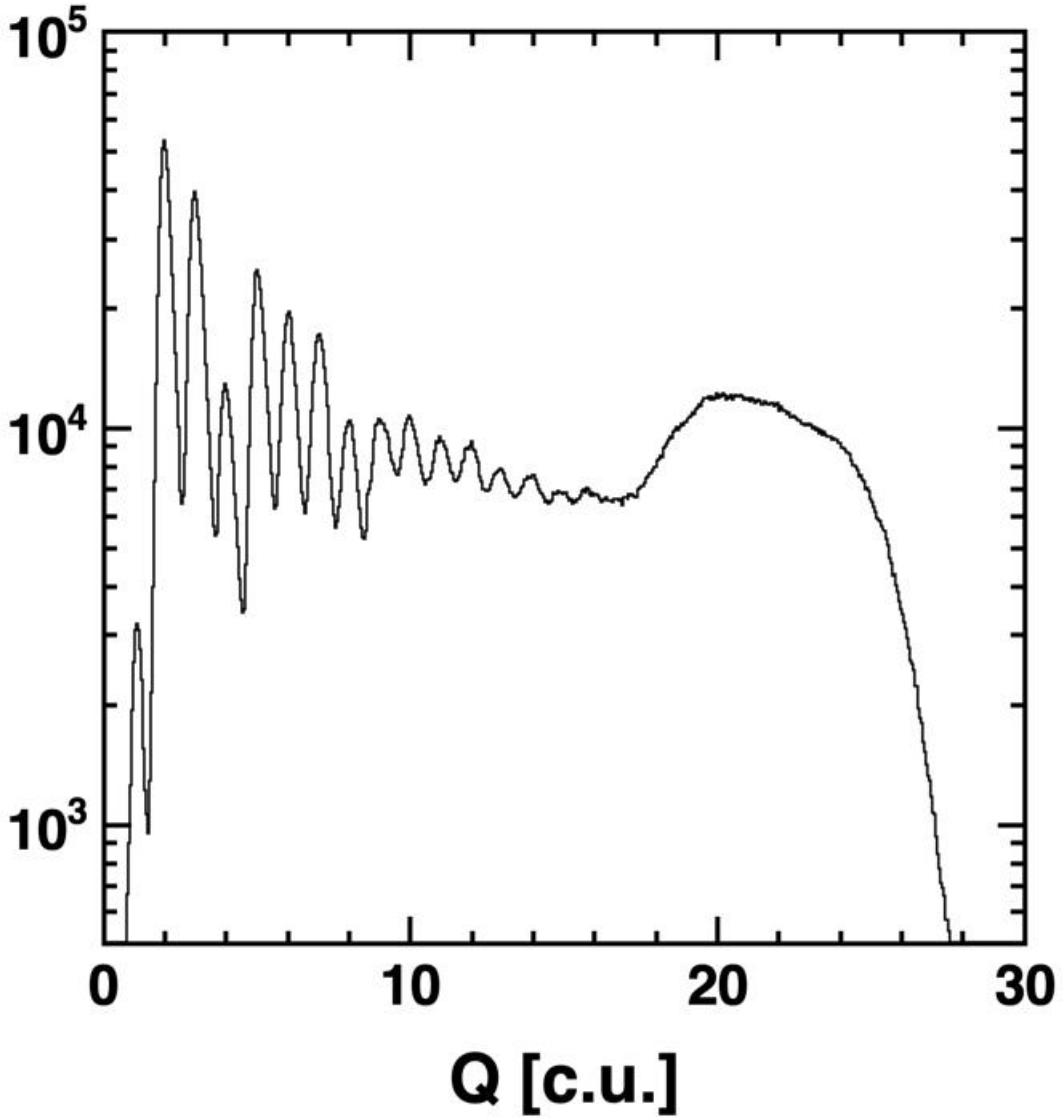


Single Sensor Charge

Courtesy of A. Oliva (HERD SCD Group)

After applying the conversion function.





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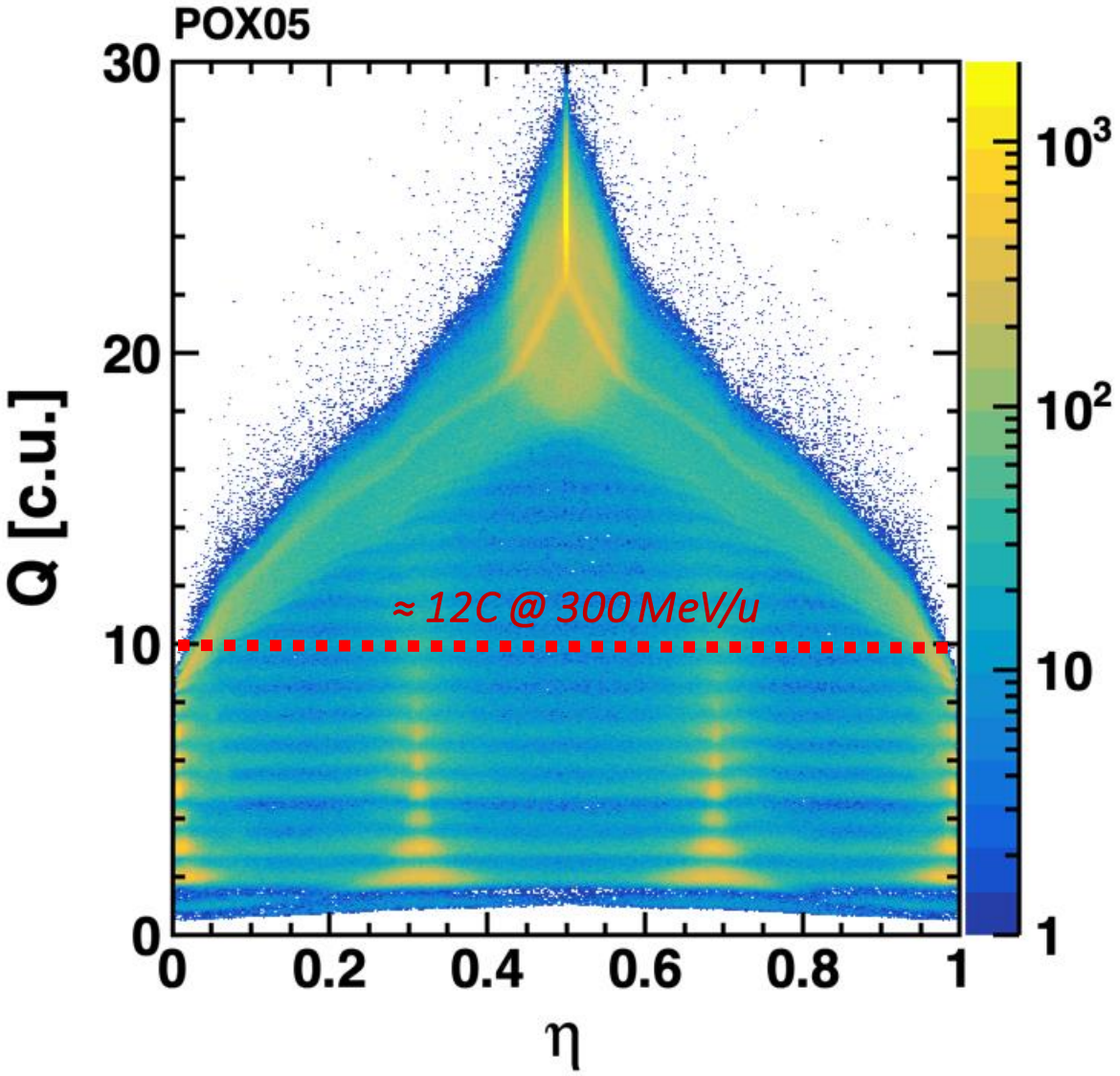
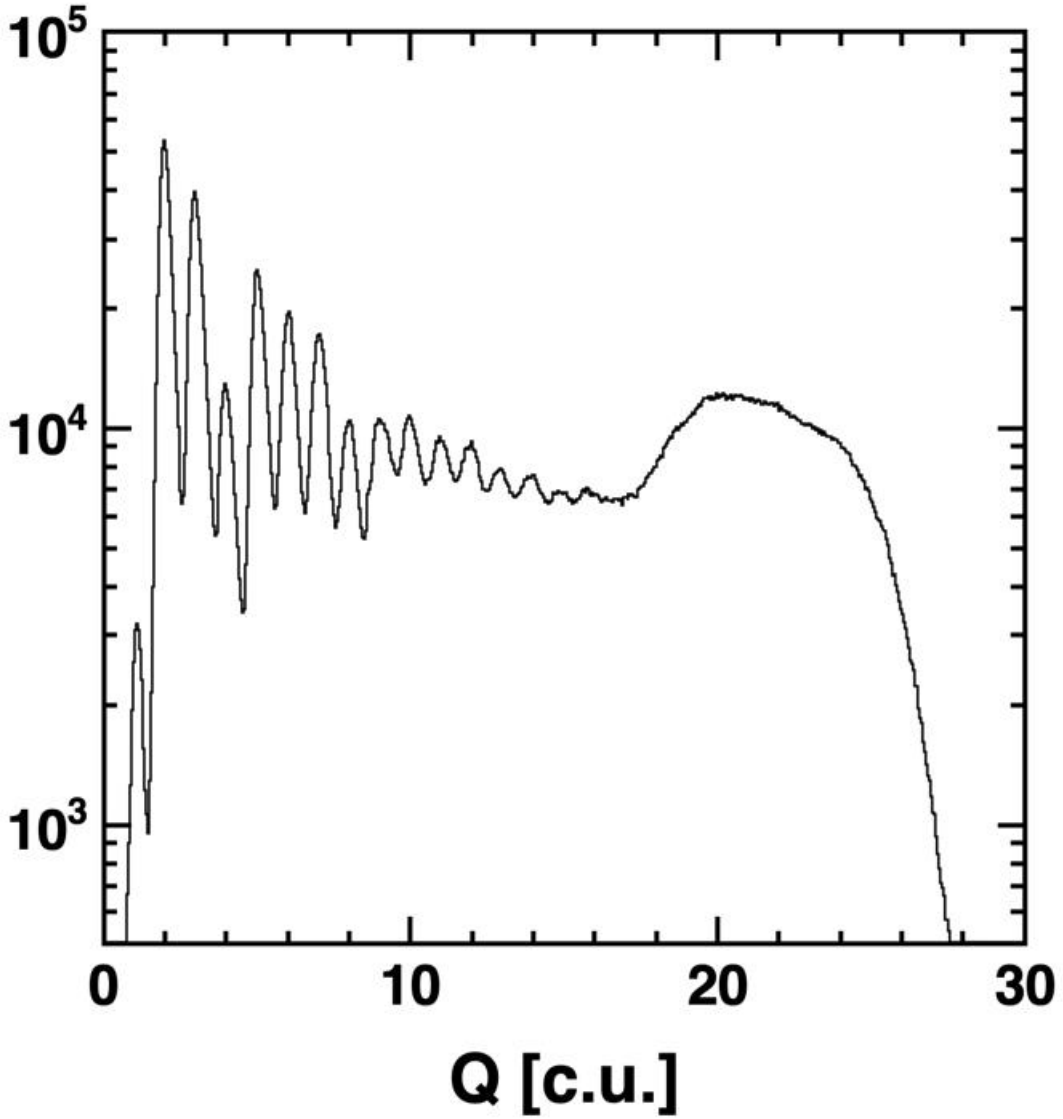
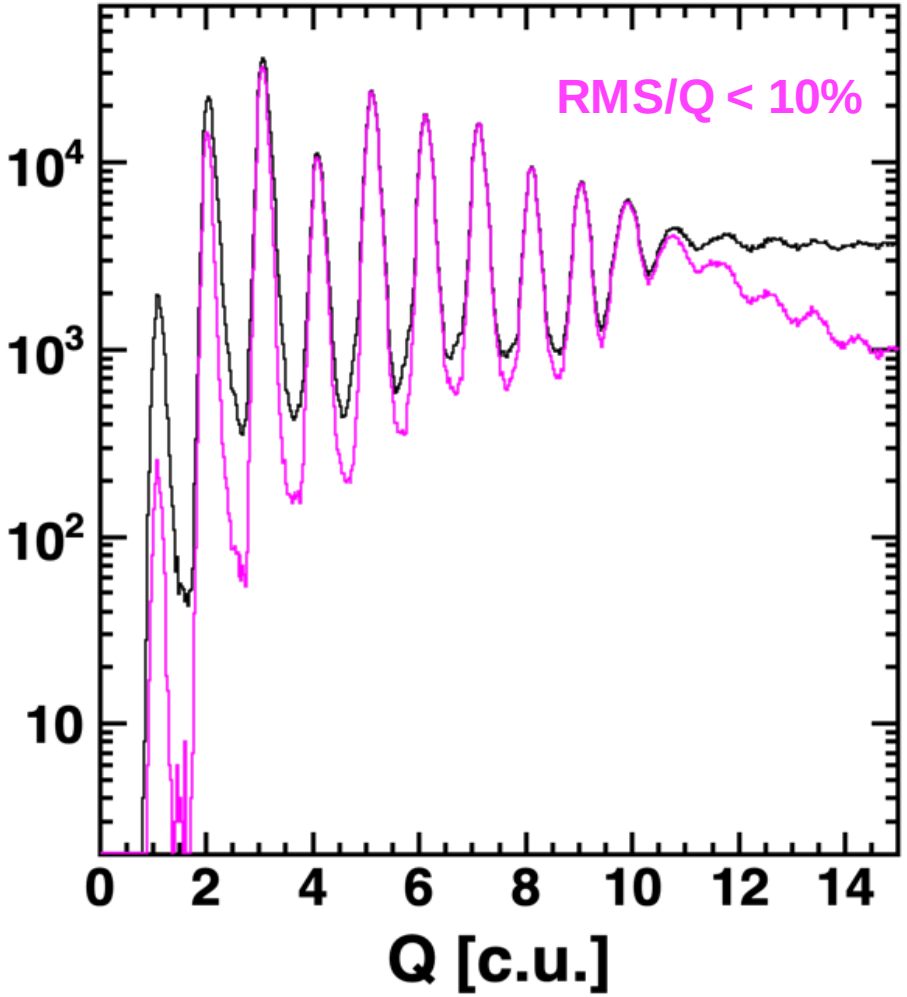


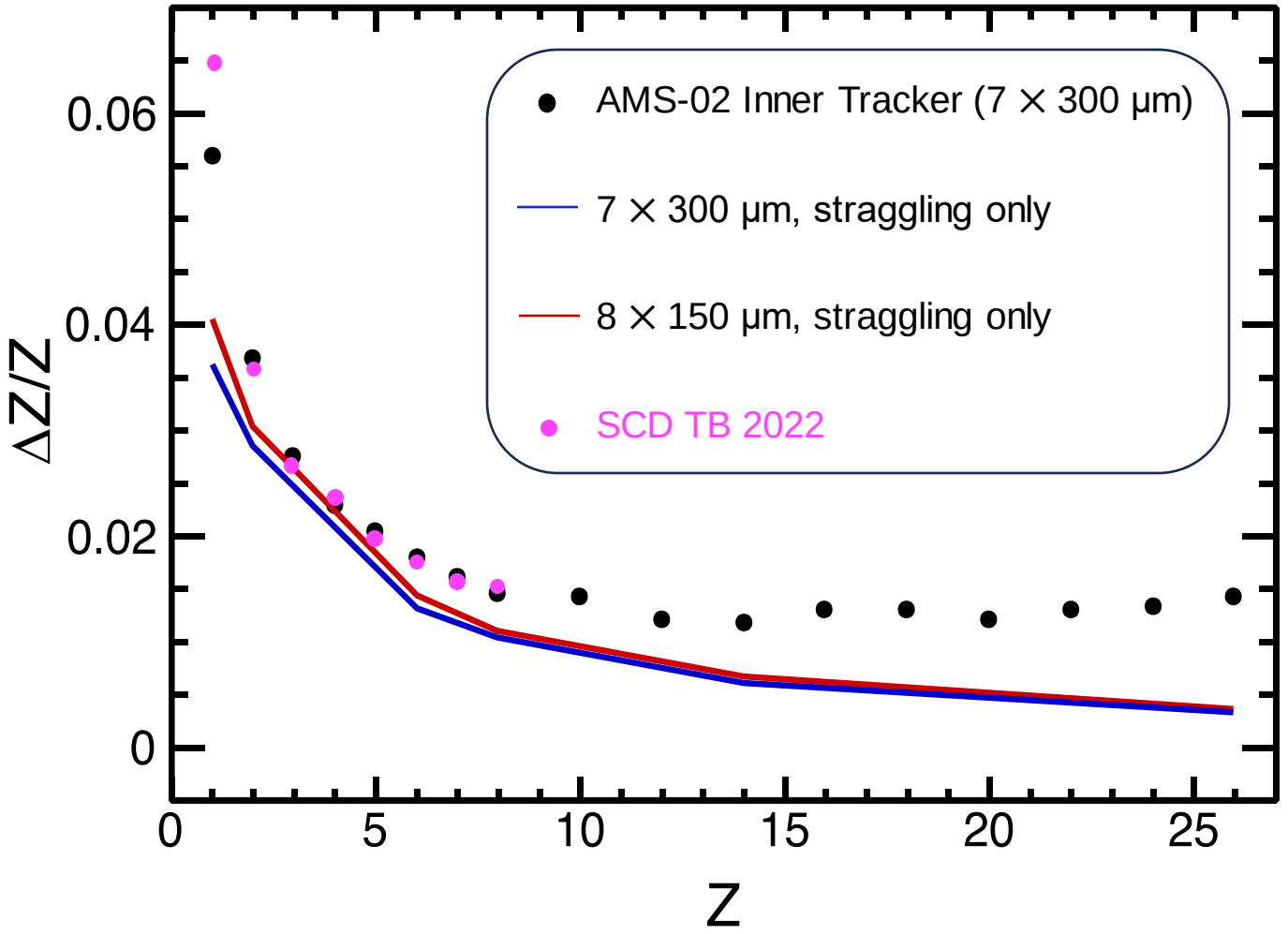


Track Charge Measurement

Courtesy of A. Oliva (HERD SCD Group)

Average of all sensors.



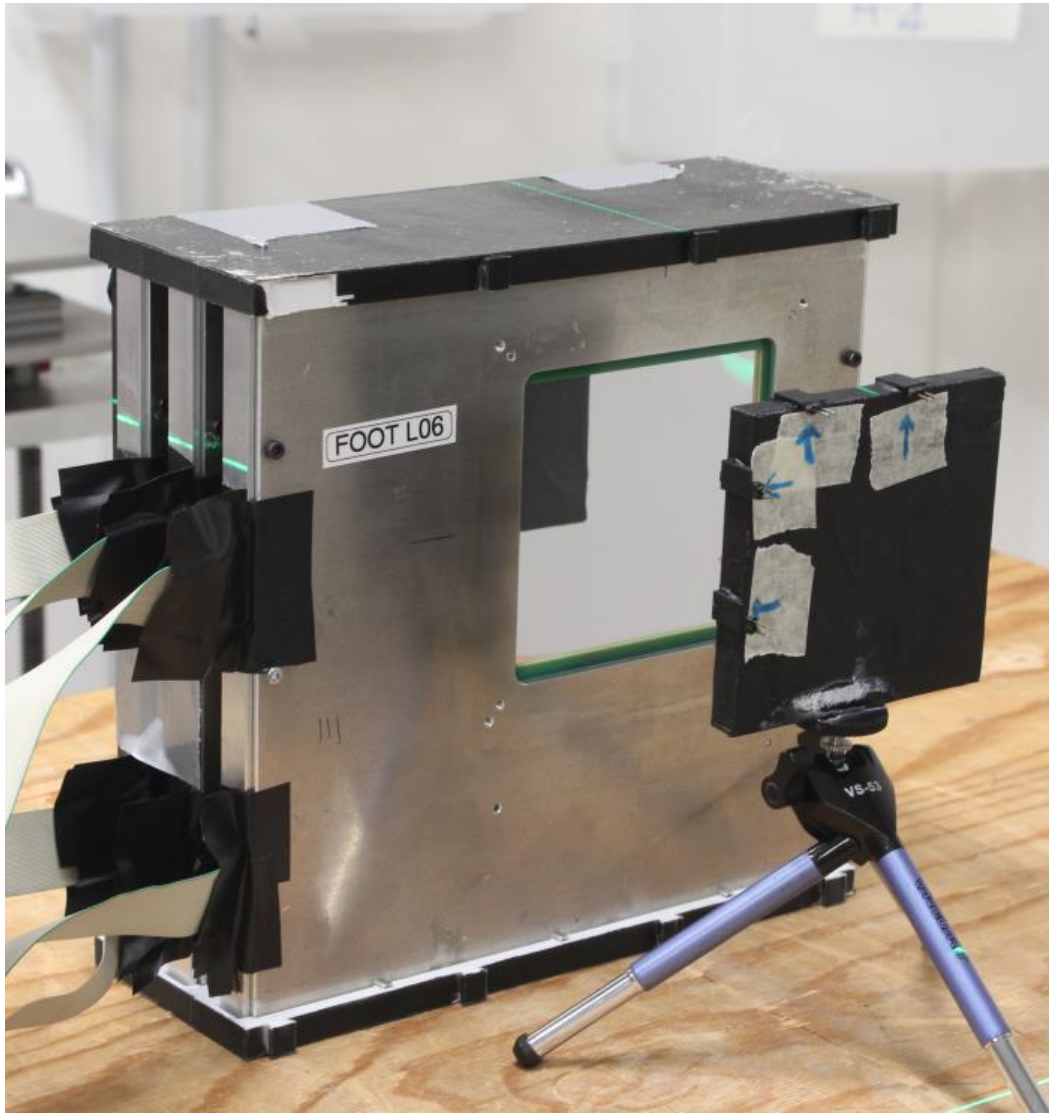


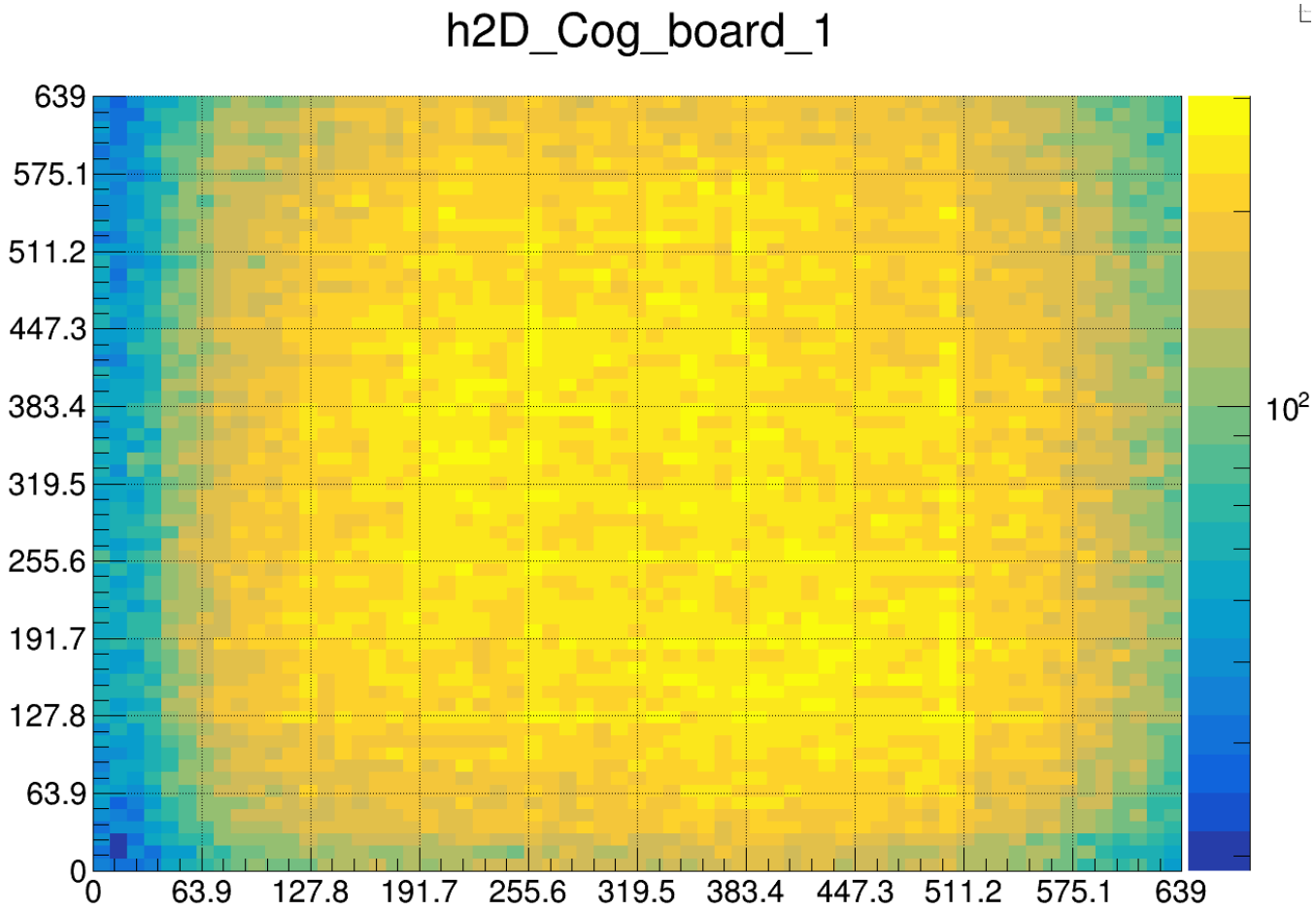
Bonus: CNAO 2023 data taking

Date	Location	Beam	Goal
April 2023	CNAO	Carbon	Analog readout gain calibration

- Parasitic data taking of AMS-L0 test
- Seized the opportunity to take data for FOOT MSD detectors
  - Beam sweep mode from XPR
  - First time almost all the sensor area is exposed to the beam
  - Calibrate the analog readout chips difference in gain

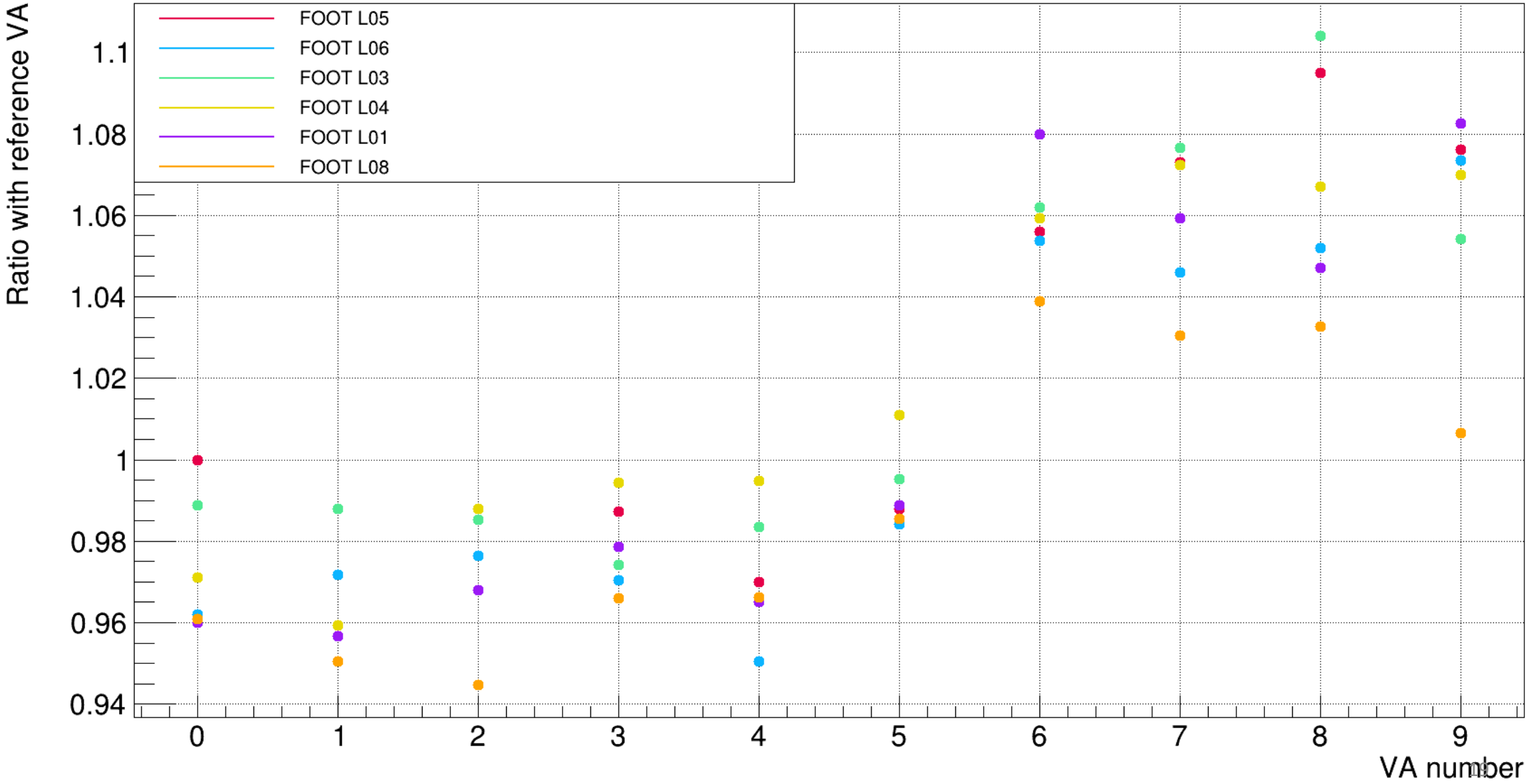
Bonus: CNAO 2023 data taking





Reconstructed cluster position for a test run @ 400MeV/u

Bonus: CNAO 2023 data taking



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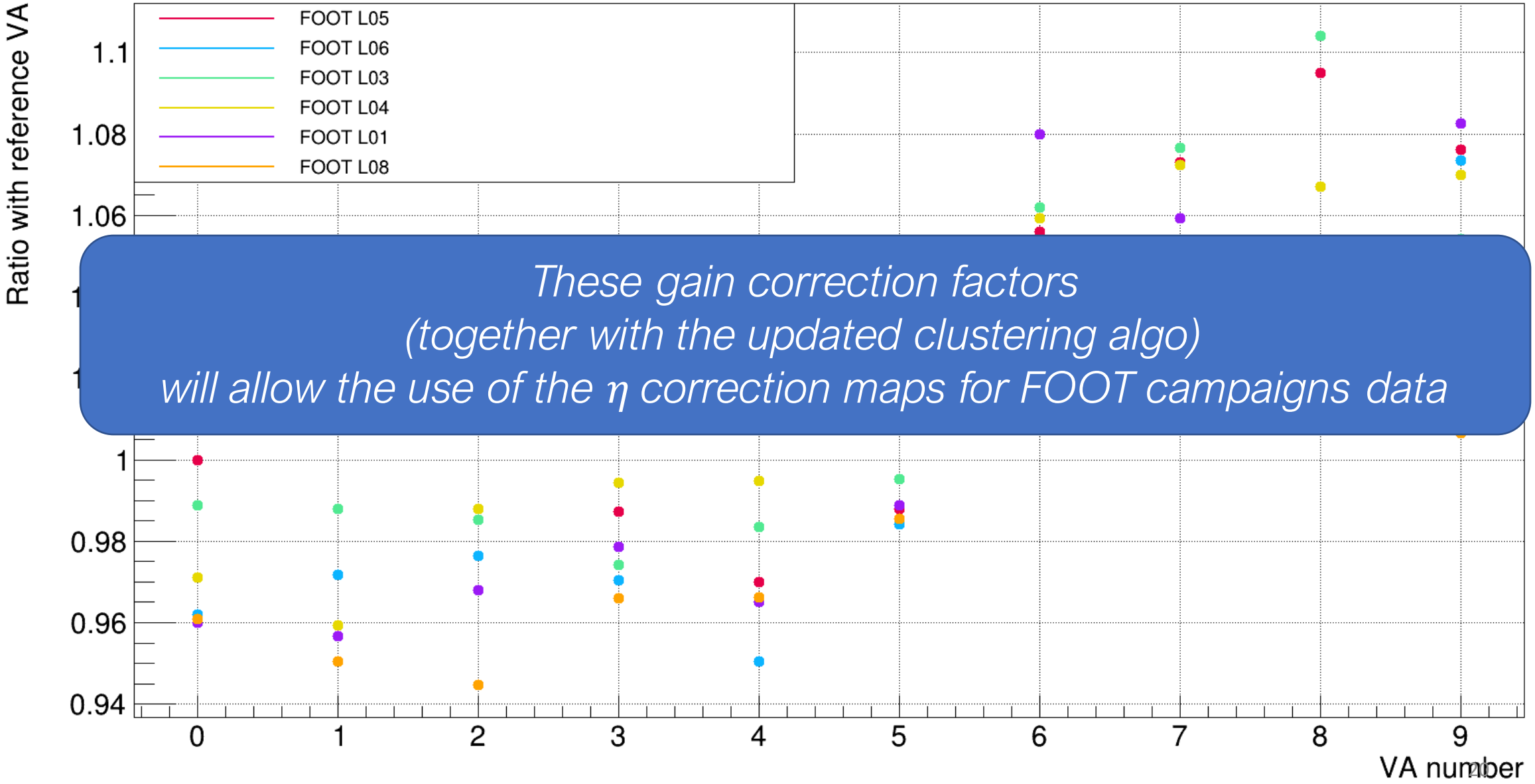

These gain correction factors
(together with the updated clustering algo)
will allow the use of the η correction maps for FOOT campaigns data

Conclusions

Work done since last GM update

1. Eta correction map and charge resolution estimation (thanks to A. Oliva)
2. Further confirmation of spatial resolution performance (A. Oliva)
3. Readout ASICs gain correction factors (G. Silvestre)

Work foreseen for the near future

1. Software implementation of improved clustering algorithm (see R. Zini et al presentation)
2. Software implementation of gain calibration factors and eta calibration map
3. Definition of the mechanics (D. Aisa and G. Silvestre)

Other works in progress

1. Detection efficiency for protons at HIT2022 (T. Minniti ?)
2. Detection efficiency for protons at TN2021 (B. Di Ruzza and L. Servoli)
3. Improved pedestals and noisy strip map (L. Salvi and G. Silvestre)

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Thanks for your attention