MSD status: clustering and CNAO2025 updates

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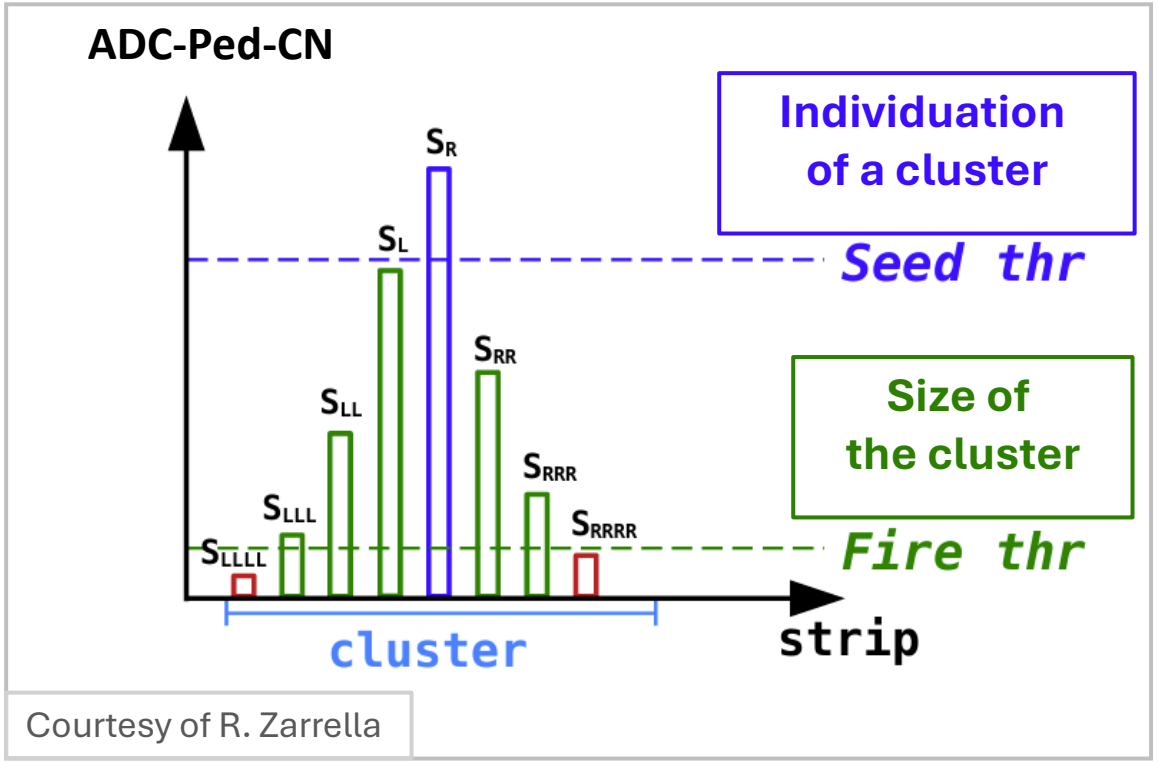
Clustering



Courtesy of R. Zarrella

N.B. At the moment we are using the SHOE algorithm to find clusters (the R. Zarrella's version) but we need to update it.

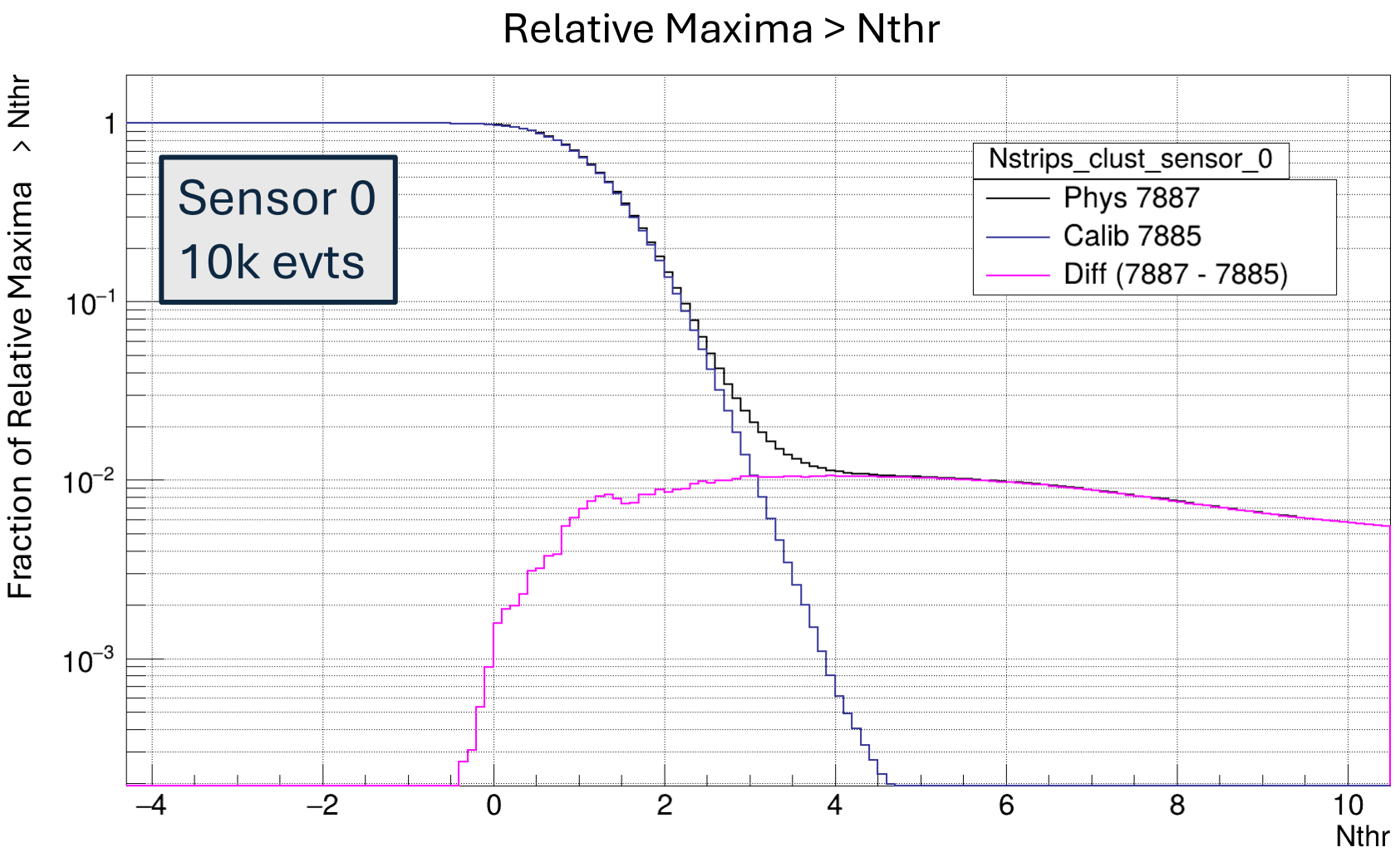
Hardware-based method to set Seed and Fired Thresholds:

- **Algorithm to find Relative Maxima**

1. Finding all relative maxima in a sensor (within 2 strips on left and right)
2. Sorting them by ADC value in descending order
3. Filtering out maxima that are too close to a higher one **(within strip_distance=3 for the moment)**

- **Cumulative histograms as function of a threshold**

Setting thresholds

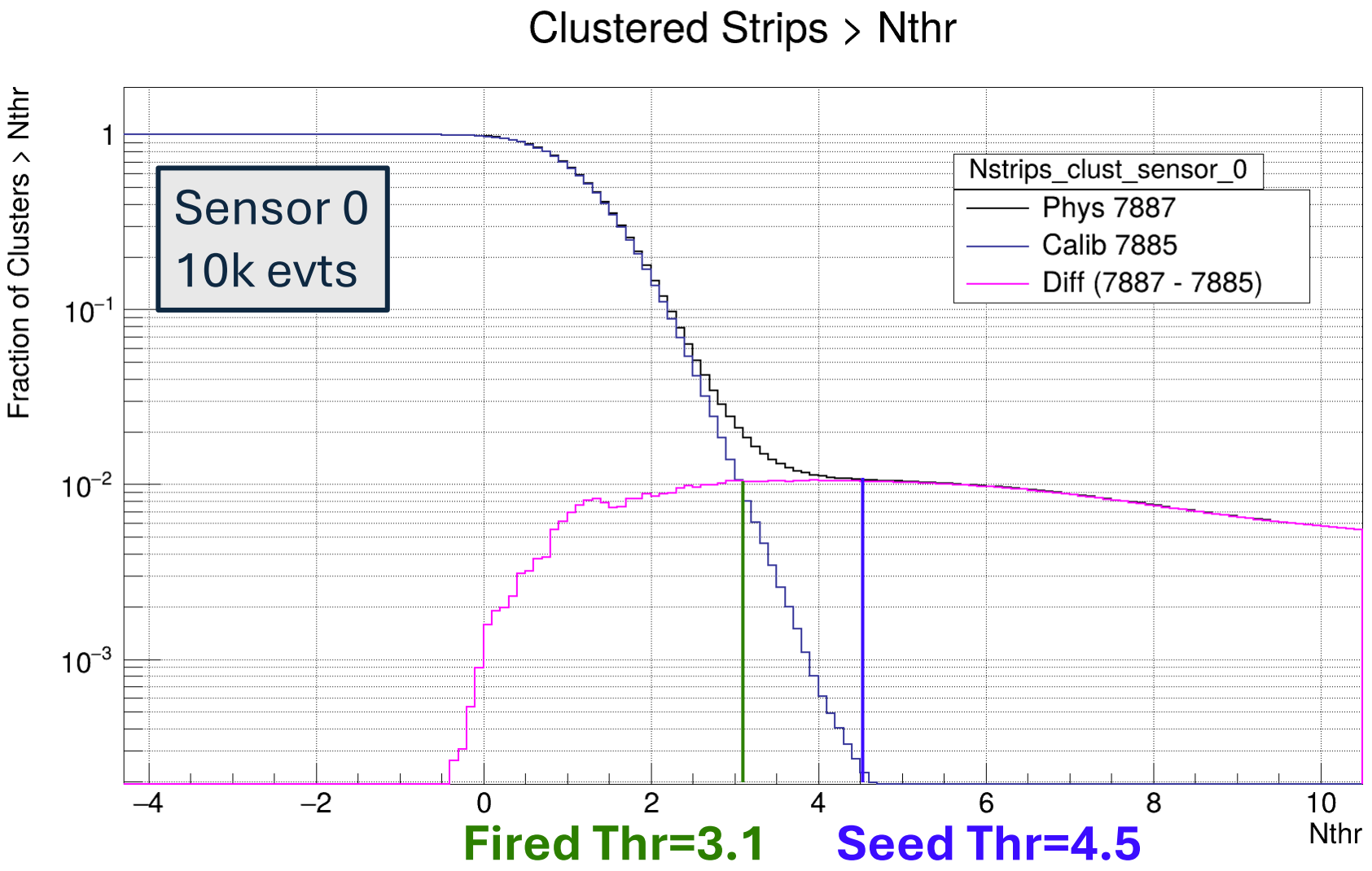


CumPhys: p@230MeV run 7887 CNAO2025

CumCalib: Pedestal run 7885 CNAO2025

CumDiff: CumPhys-CumCalib

Setting thresholds



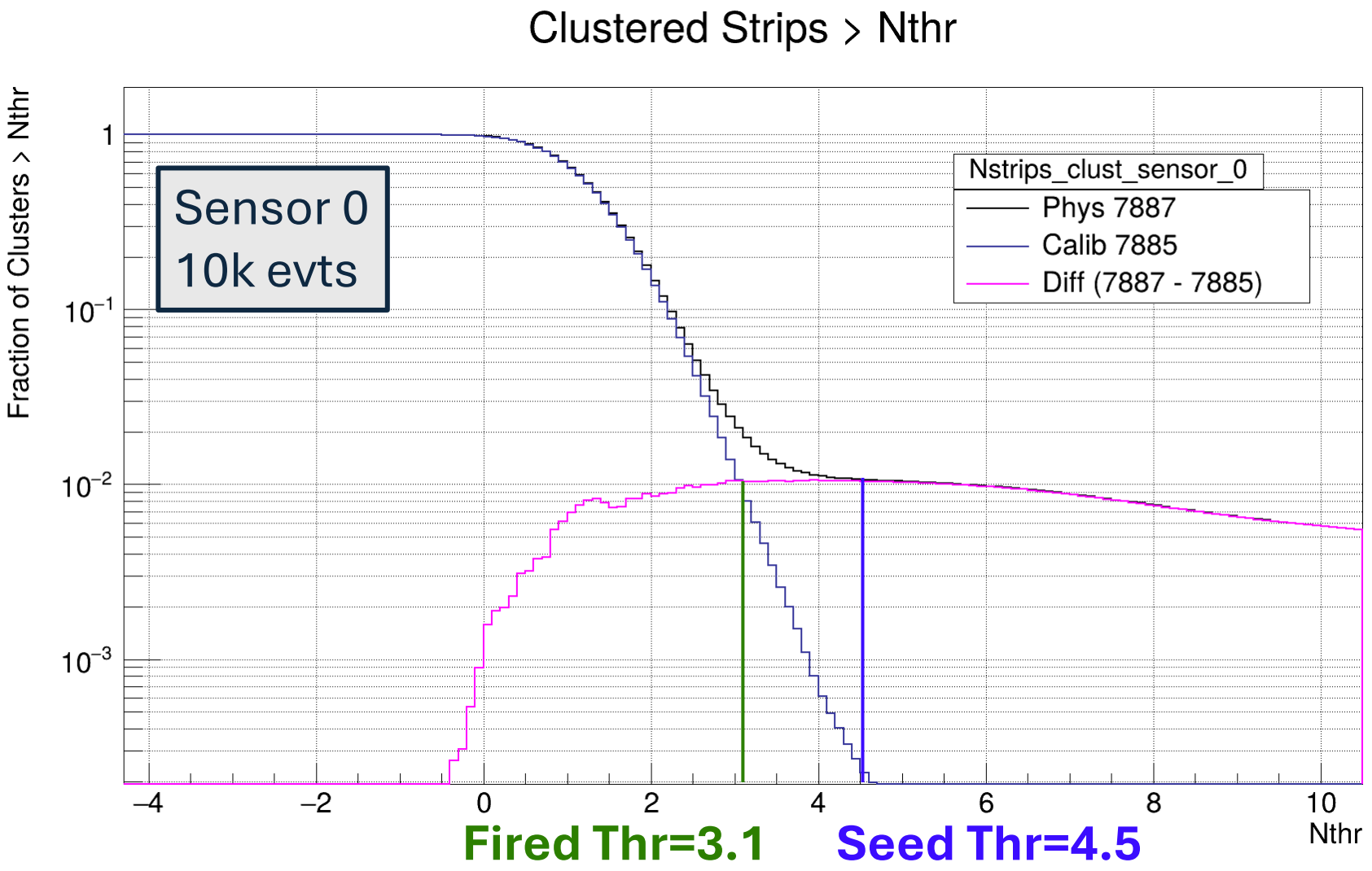
CumPhys: p@230MeV run 7887 CNAO2025

CumCalib: run 7885 CNAO2025

CumDiff: 7889-7885

- **Seed Thr:** intersection between Phys and Diff
- **Fired Thr:** intersecion between Calib and Diff

Setting thresholds



CumPhys: p@230MeV run 7887 CNAO2025

CumCalib: run 7885 CNAO2025

CumDiff: 7889-7885

Since expecting higher energy protons

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Starting point: Lowered Thrs

Seed Thr=4.0

Fired Thr = 2.5

Accidental beam on FOOT

Accidental beam on FOOT, 7th Sep 2025

- In the morning of 7th September 2025 few spills of protons were sent in the experimental area
  - 60 MeV protons
  - ~4x10^{10} particles
- To evaluate damage on MSD, let's compare a pedestal run of 6th of September and one from 7th

Courtesy of M. Barbanera

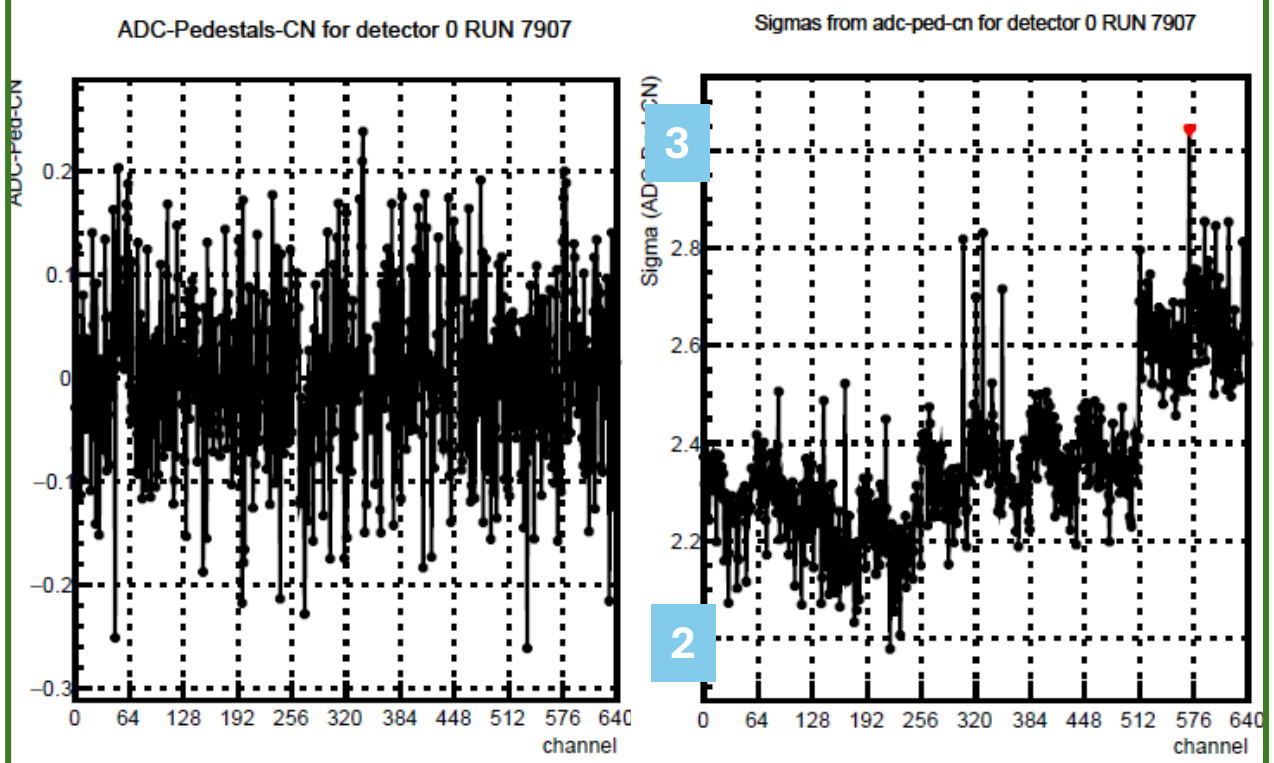
Unfortunately, during Night 2 we did not acquire protons ☹, but only Carbon on Carbon, so the comparison will be made using two runs of **C@200MeV on C (5mm) - No Magnetic field:**

- **Night 1 (before the accidental beam) – Run 7908 CNAO2025 (with Pedestal 7907)**
- **Night 2 (after the accidental beam) – Run 7940 CNAO2025 (with Pedestal 7929)**

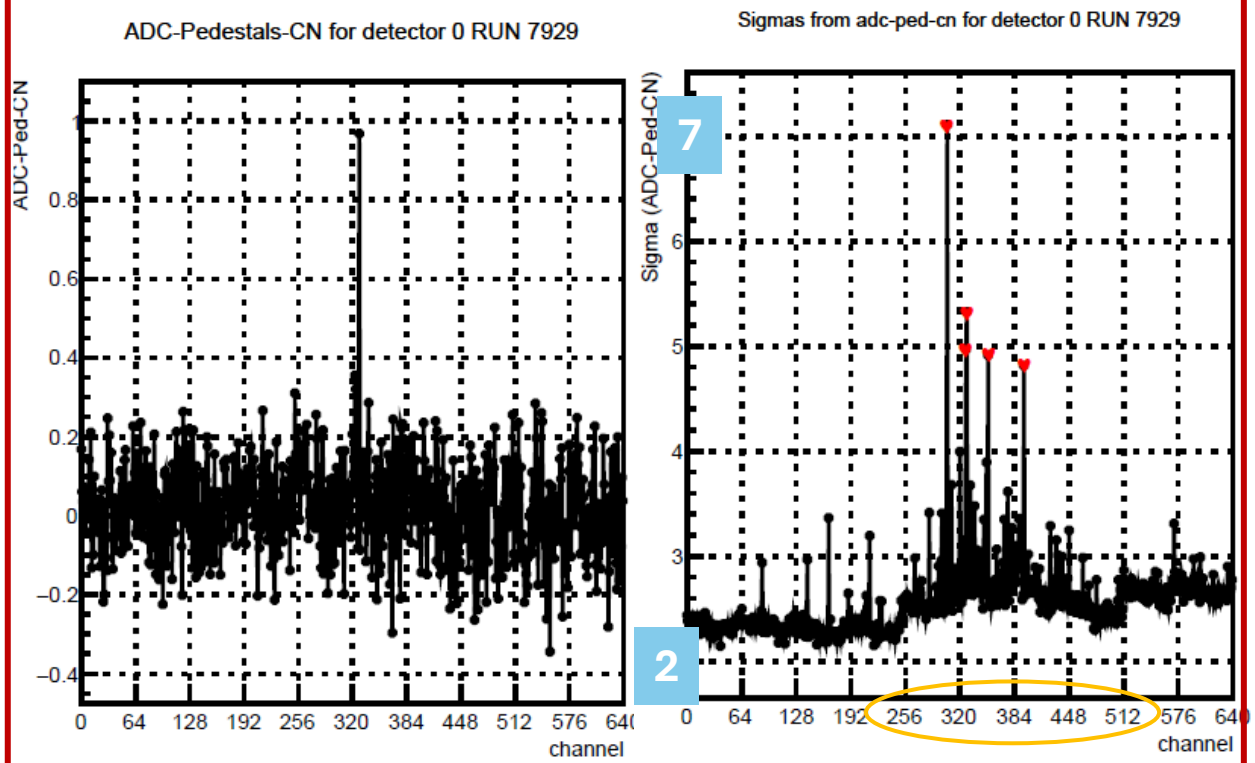
Comparison between Pedestals

Sensor 0
10k evts

Night 1



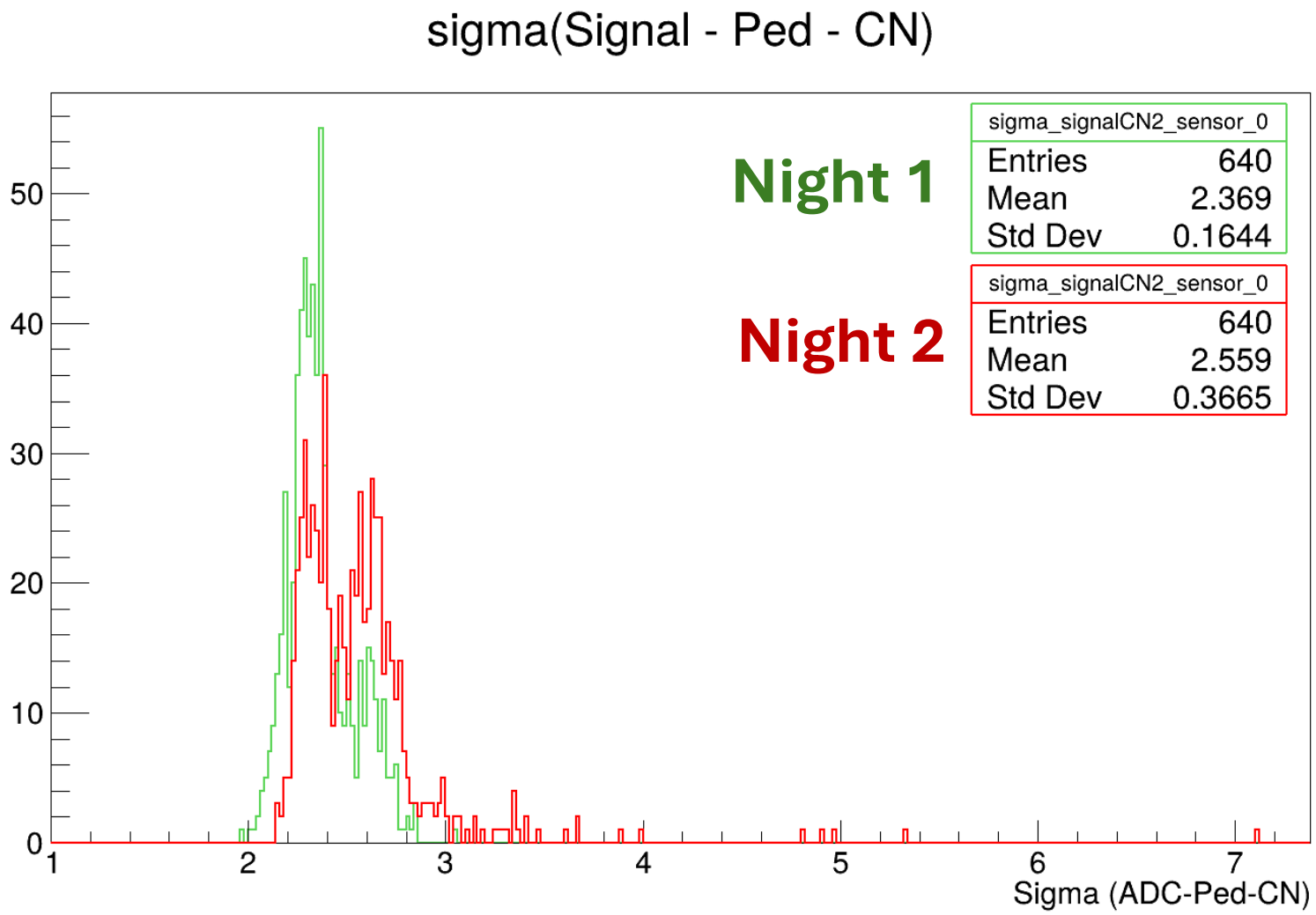
Night 2



- The pedestal is correctly subtracted
- The noise has increased in the beam region

Comparison between Pedestals

Sensor 0
10k evts




```
sen = 0 : NoiseThr = 3.30000
Sensore 0 -> Dead strips: 0 | Noisy strips: 1
```

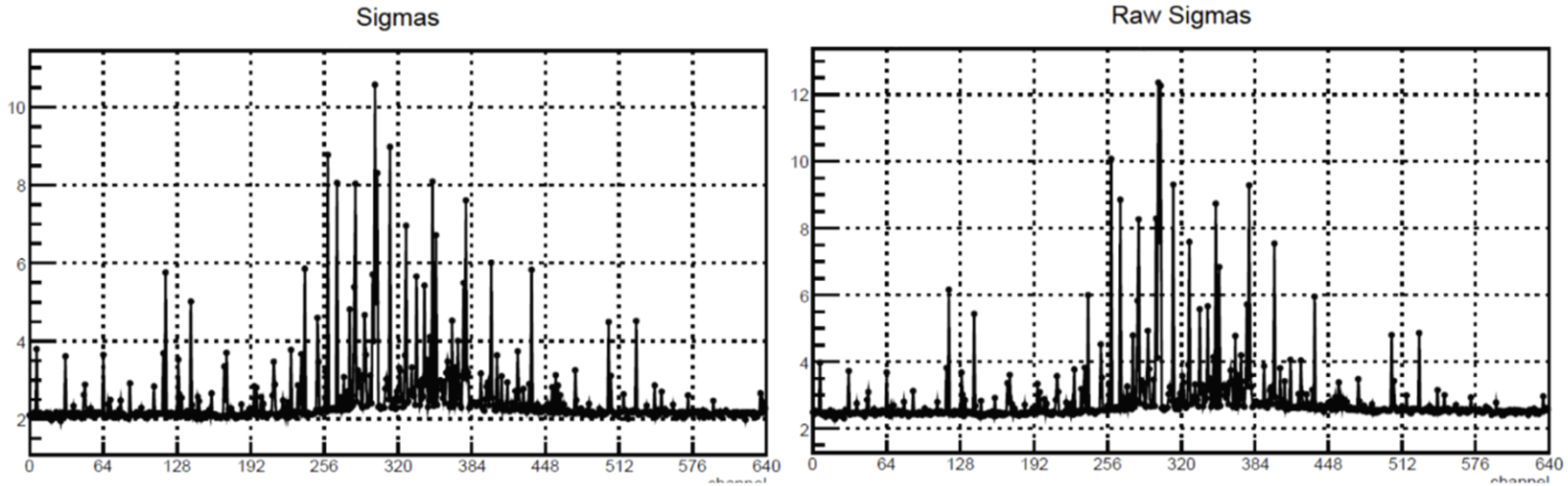
```
sen = 0 : NoiseThr = 4.10000
Sensore 0 -> Dead strips: 0 | Noisy strips: 5
```

MSD' Damage

Sensors' Damage

Courtesy of M. Barbanera

- Increase in sigma where the beam passed
  - From few ADCs to 10s of ADCs
  - How much does impact in SNR for protons?
- Possible bulk and/or oxide damage
  - Can alter the inter-strip capacitance with trapped charges
  - Need dedicated studies (and gain calibration with particles?)



Acquisition with Cosmic Rays in Perugia:

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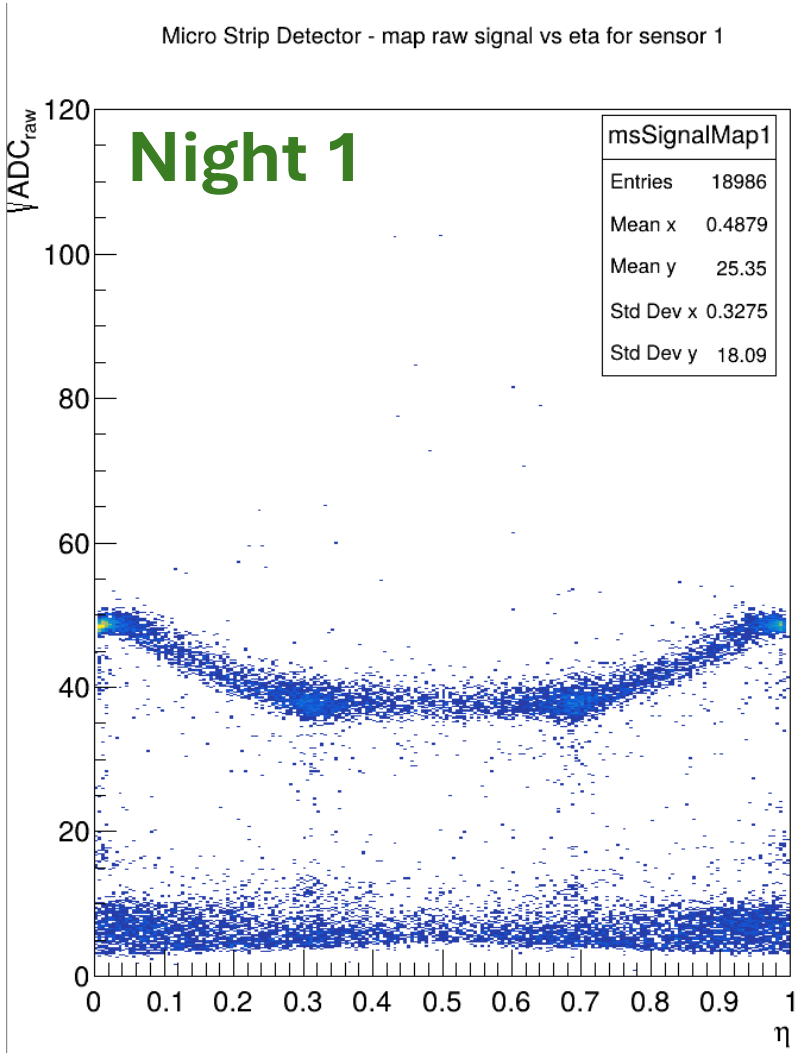
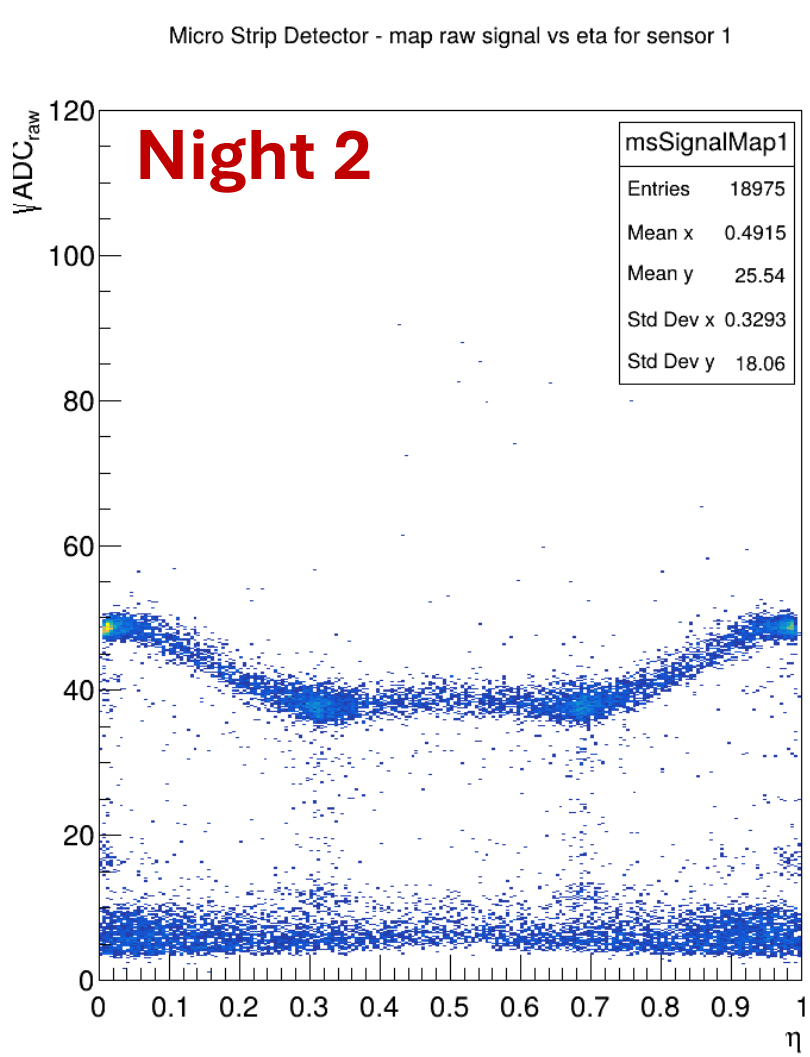
the effect observed during the Night 2 persists.

Comparison between Physics-C@200MeV/u onC

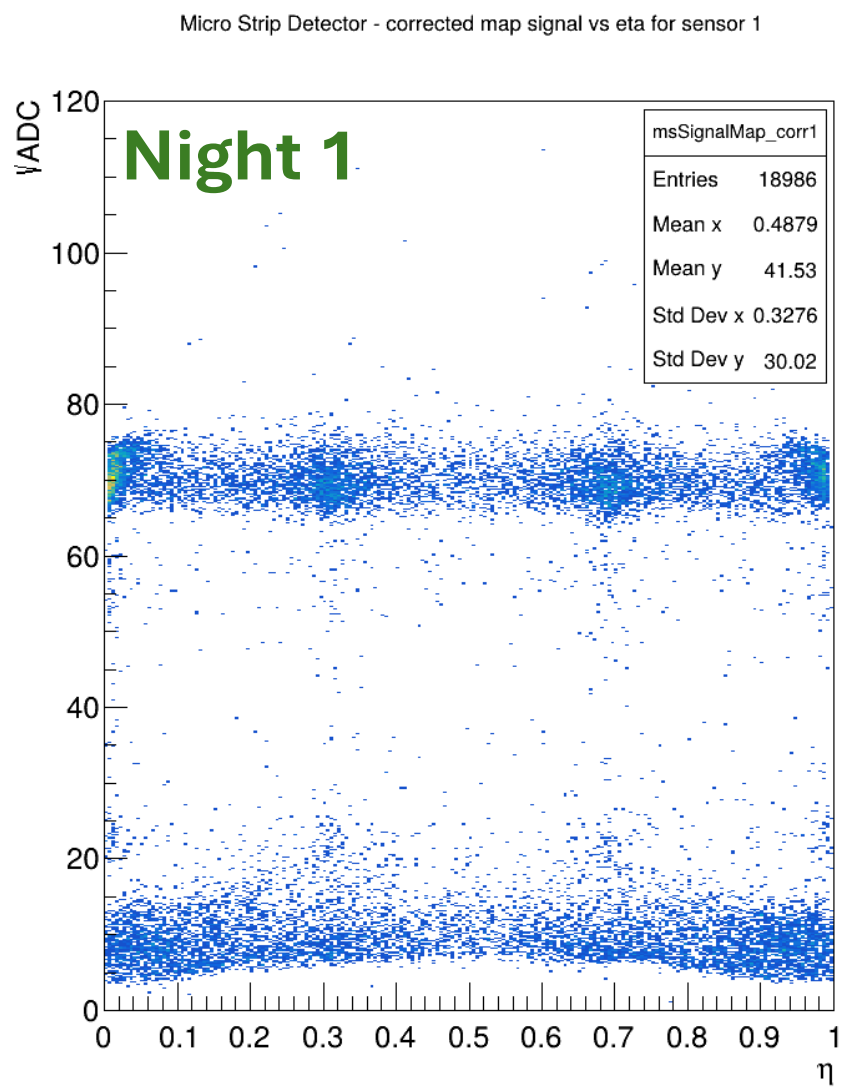
Without η Correction

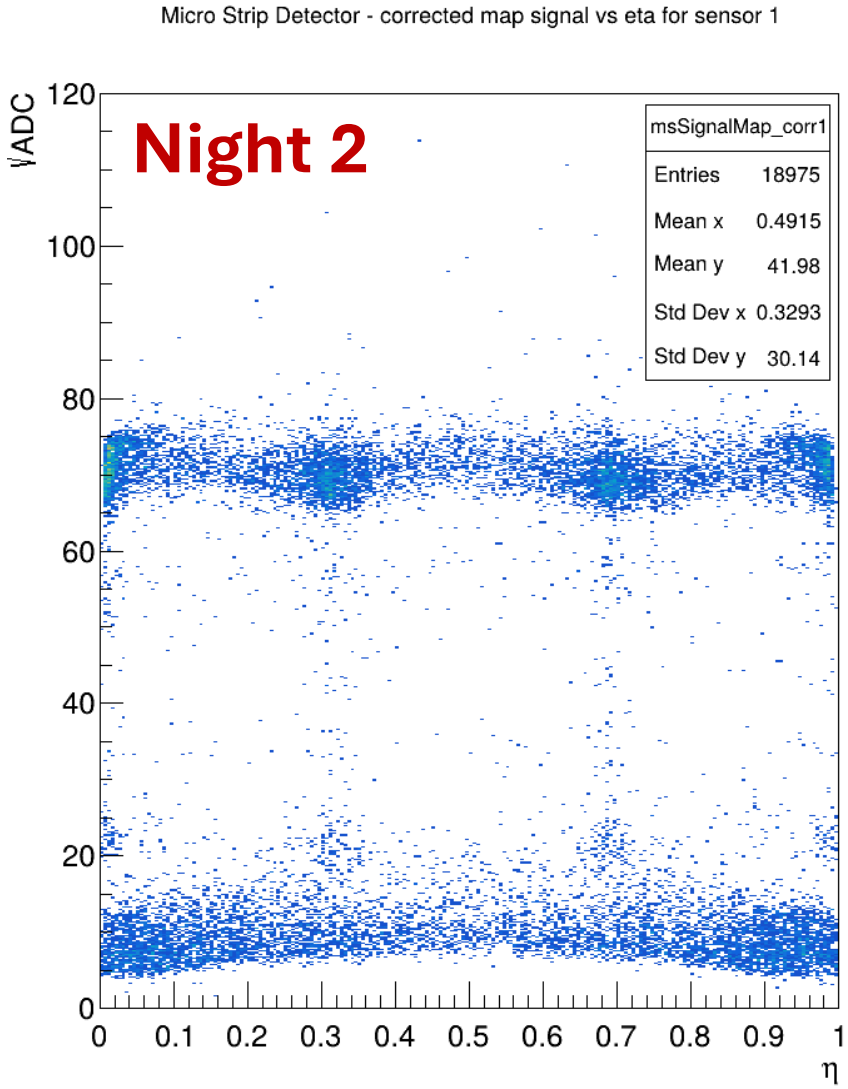




Comparison between Physics-C@200MeV/u onC

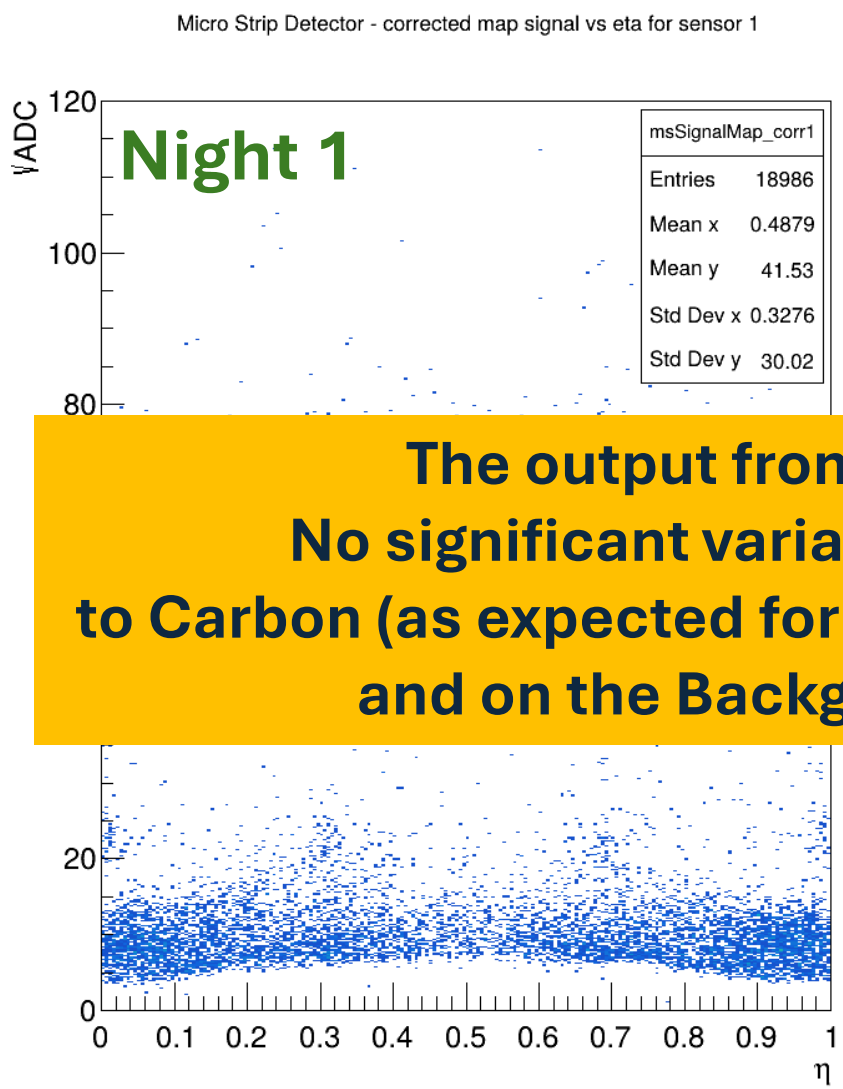
With η Correction

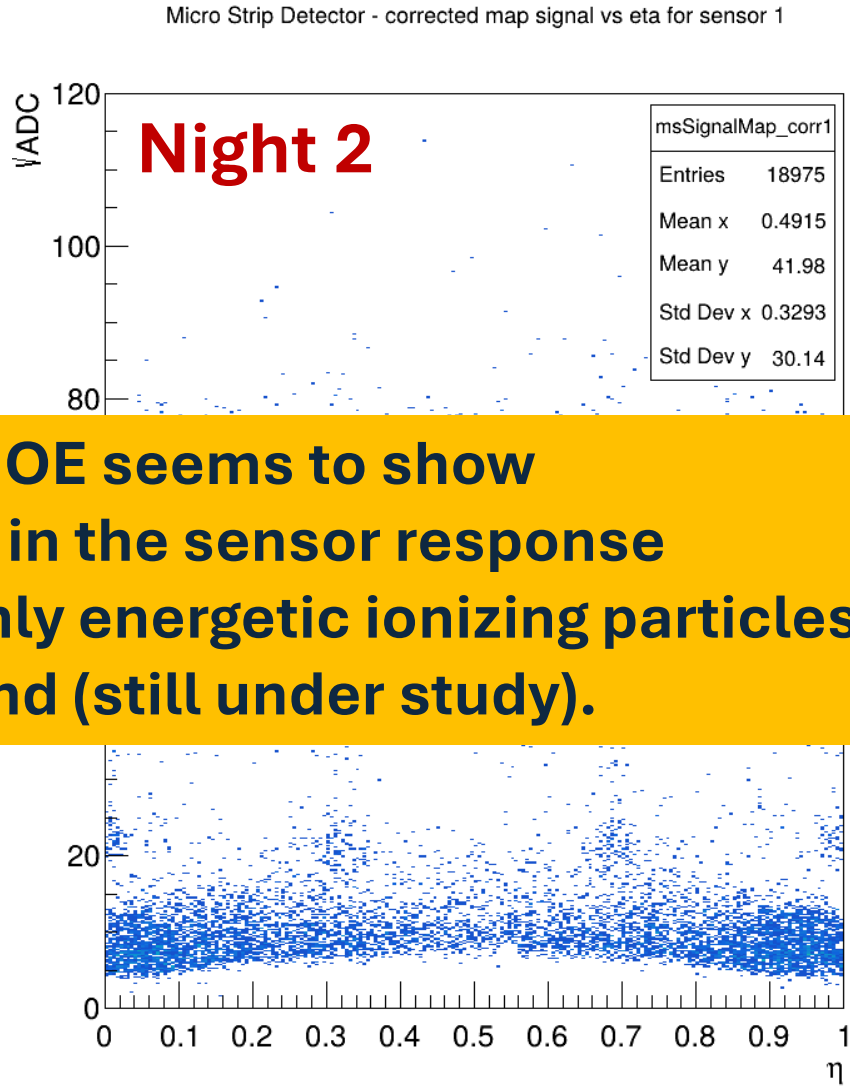




Comparison between Physics-C@200MeV/u onC

With η Correction



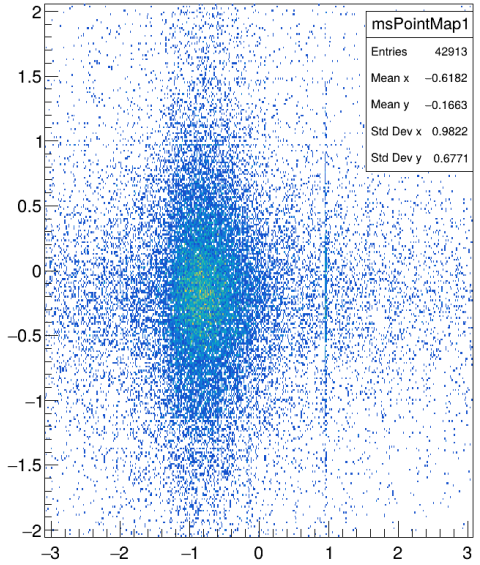


The output from SHOE seems to show
No significant variation in the sensor response
to Carbon (as expected for highly energetic ionizing particles)
and on the Background (still under study).

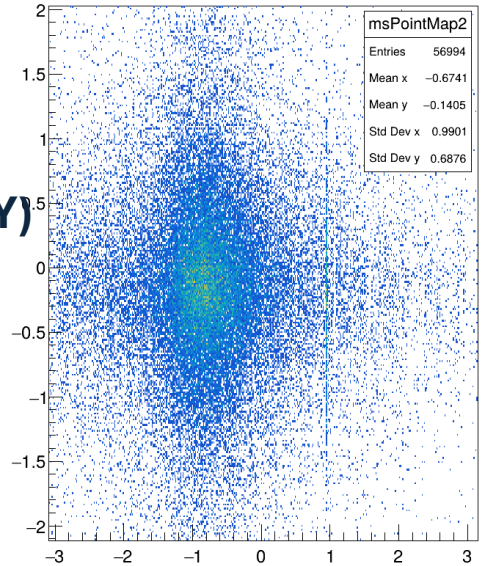
Beam Shape - C@200MeV/u on C

Night 1

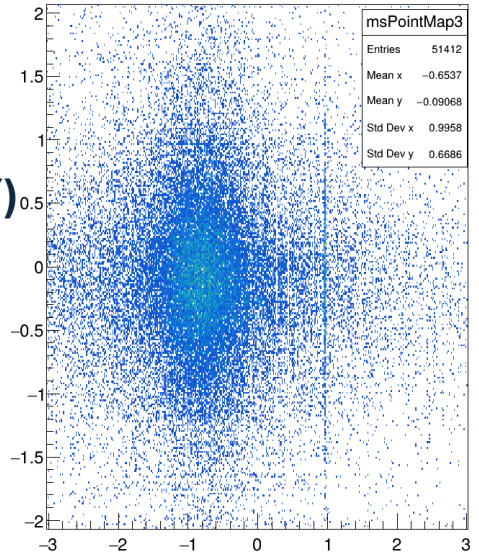
Plane 1 (X-Y)



Plane 2 (X-Y)

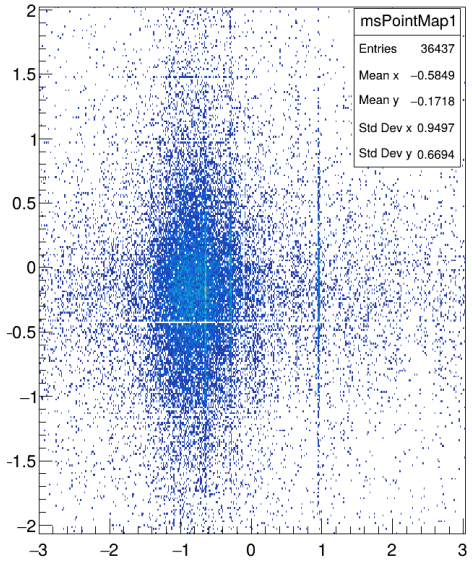


Plane 3 (X-Y)

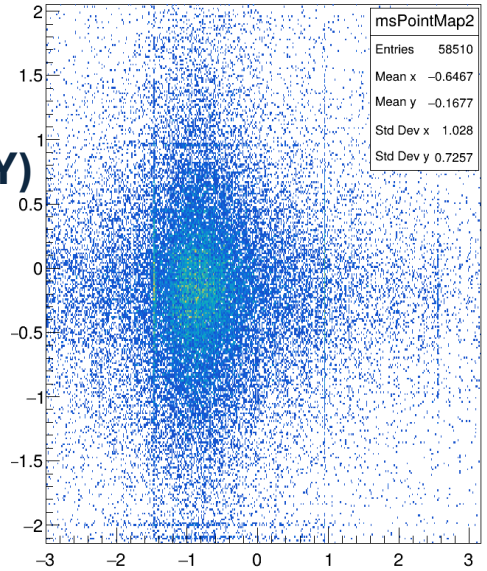


Night 2

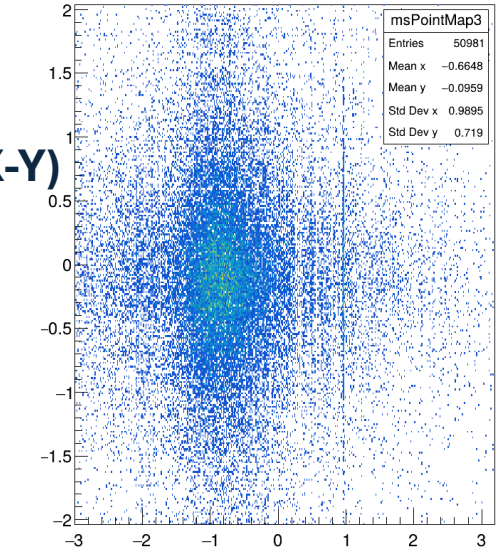
Plane 1 (X-Y)



Plane 2 (X-Y)

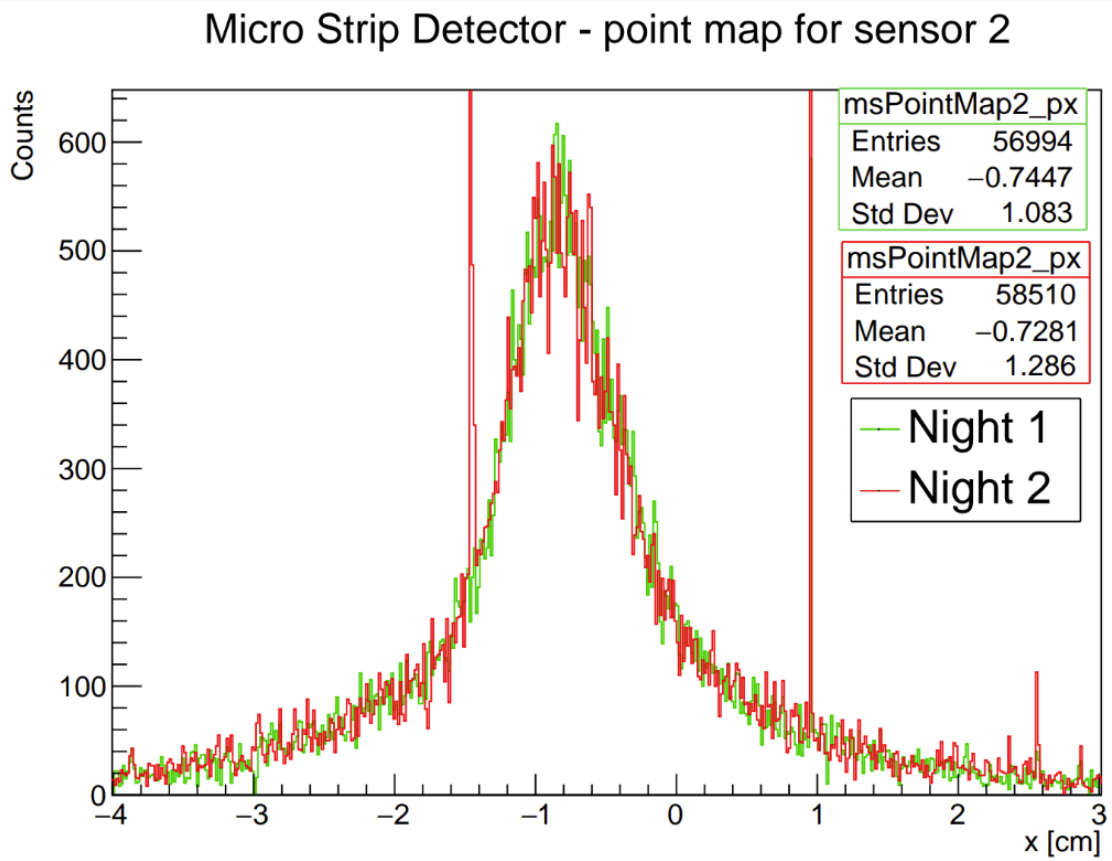


Plane 3 (X-Y)

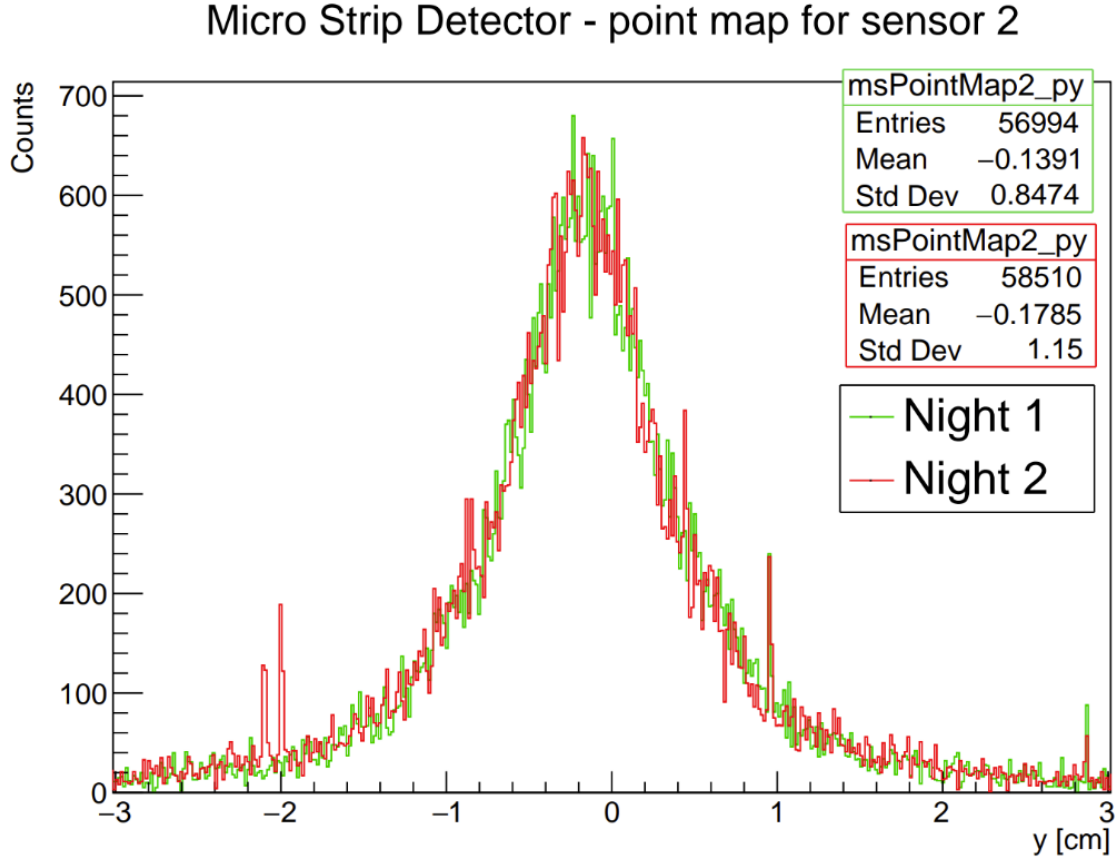


Beam Shape - C@200MeV/u on C

Plane 2 -X



Plane 2 -Y



Conclusion

- No evident changes in the in the shape of 2D histograms, the η Correction still works between Night 1 e 2, the interstrips capacitance has not changed and so we think that the **MSD Oxide has not been damaged**.

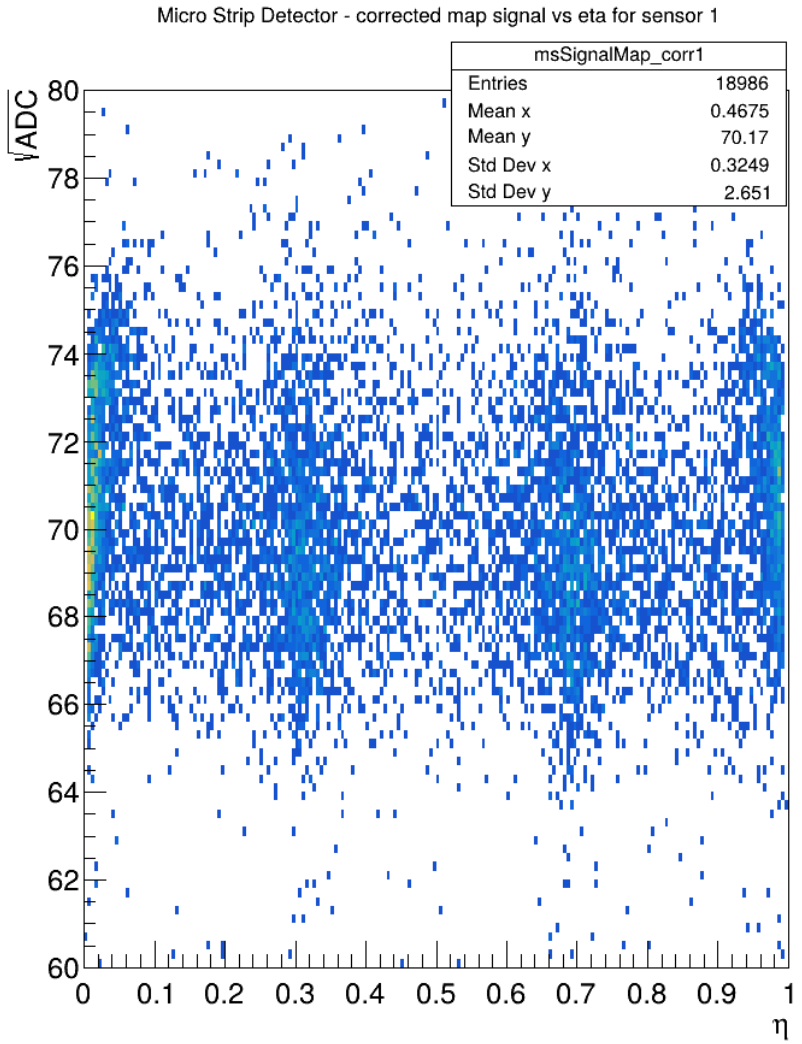
- Sistematic study on the **efficiency of each sensor** as a function of Seed and Fired thresholds.

- Optimization of **Clustering Algorithm** in SHOE.

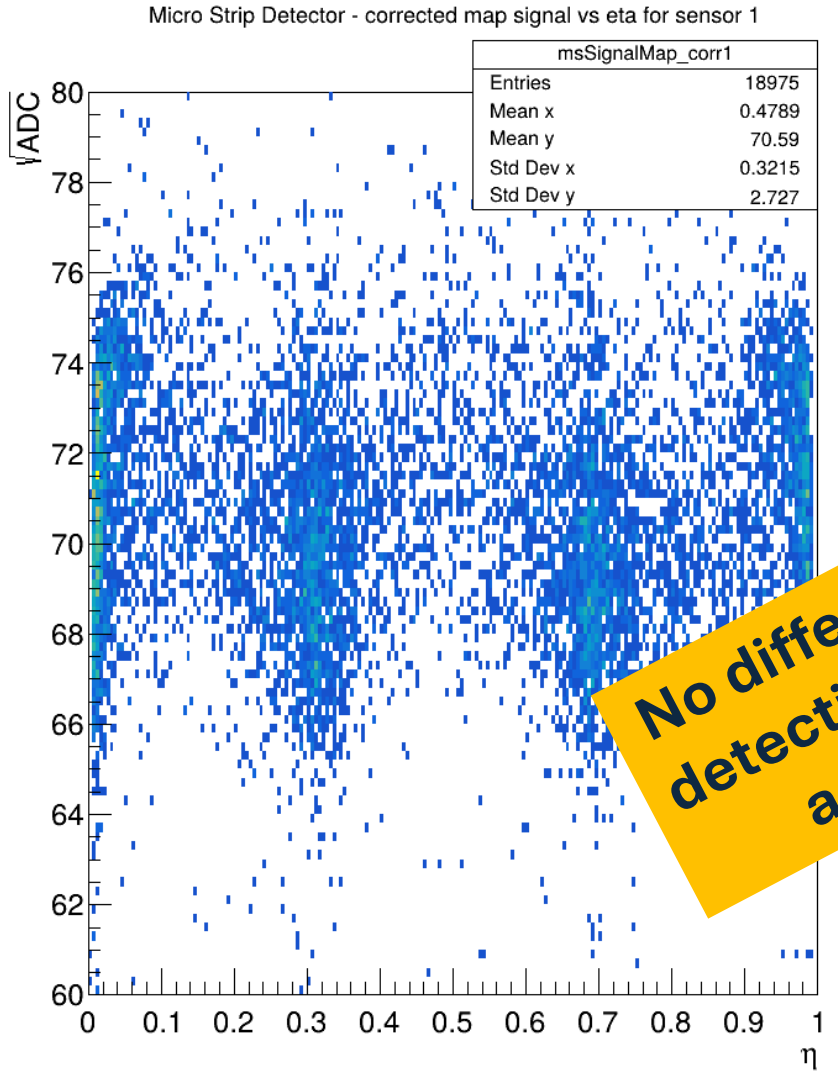
Comparison between Physics-C@200MeV/u onC

With η Correction: ZOOM on Carbon

Night 1



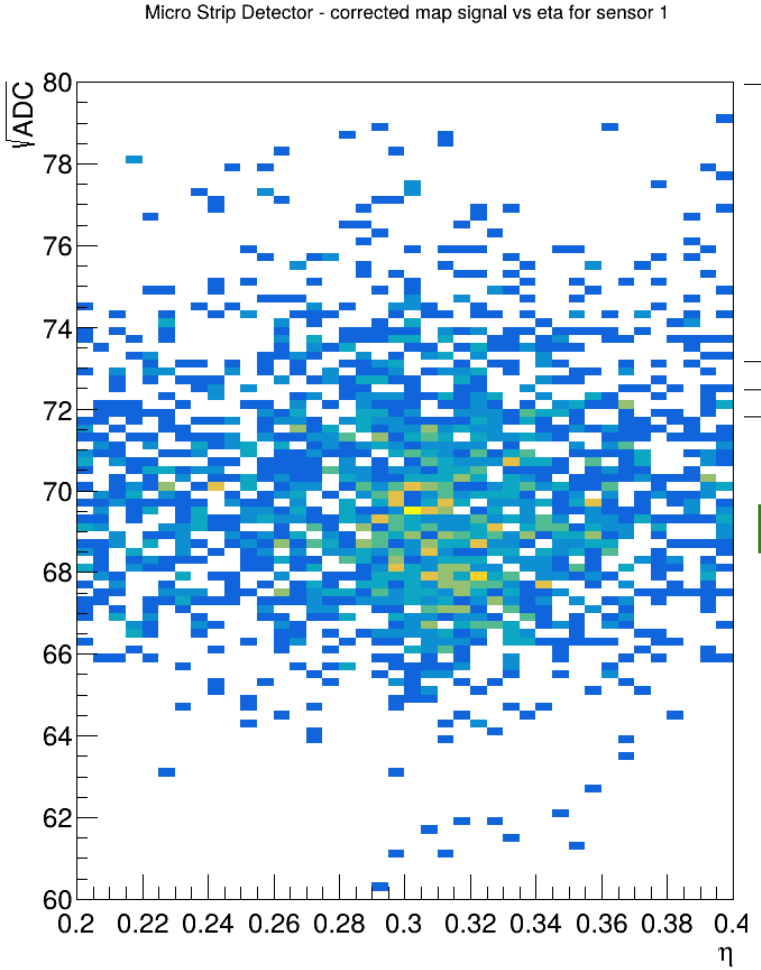
Night 2



No difference in the detection of Carbon, as expected.

Comparison between Physics-C@200MeV/u onC

With η Correction: ZOOM on Carbon and η



msSignalMap_corr1	
Entries	18986
Mean x	0.3041
Mean y	69.89
Std Dev x	0.04702
Std Dev y	2.634
Integral	2110
Skewness x	−0.19
Skewness y	0.3948
Kurtosis x	−0.4923
Kurtosis y	0.5658

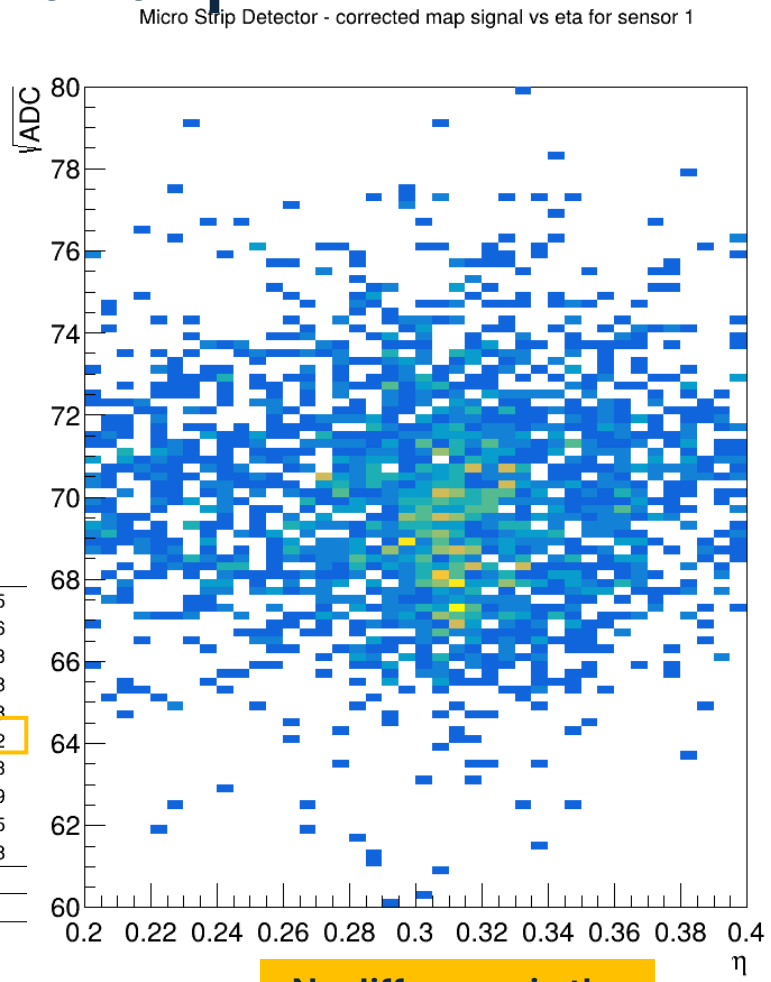
10	15	56
2408	2110	4743
2680	1577	5387

Night 1

Night 2

msSignalMap_corr1	
Entries	18975
Mean x	0.3046
Mean y	69.93
Std Dev x	0.04498
Std Dev y	2.598
Integral	2192
Skewness x	−0.2523
Skewness y	0.1879
Kurtosis x	−0.3565
Kurtosis y	0.498

7	17	49
2185	2192	4802
2929	1425	5369



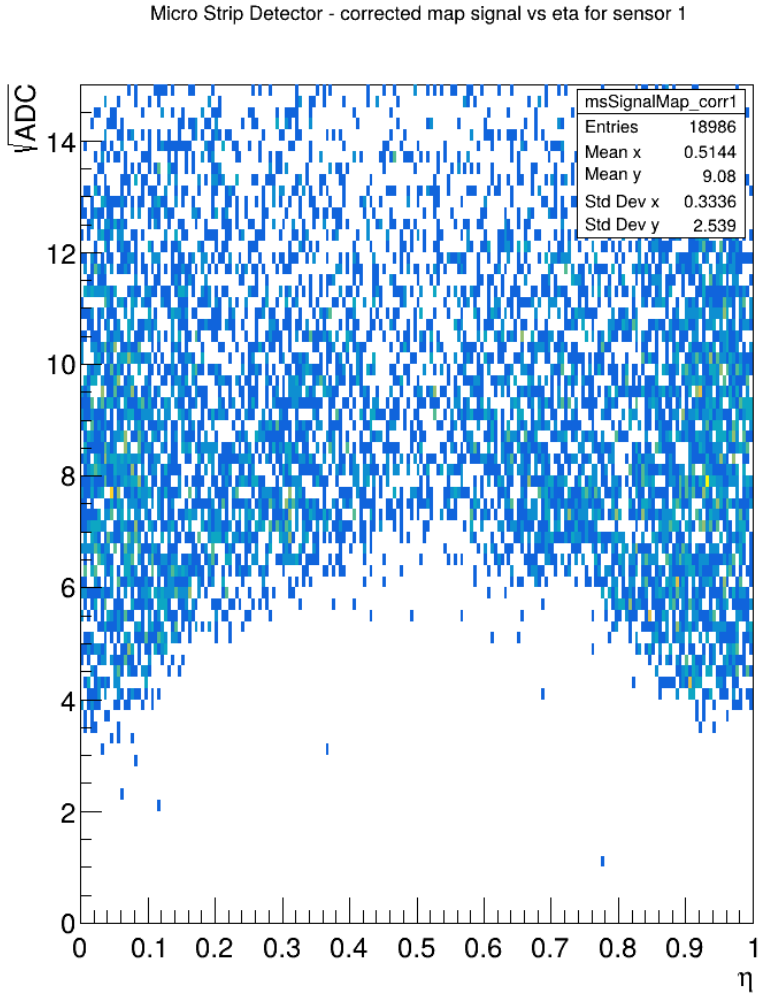
No significant changes in the integral, as expected.

No difference in the detection of Carbon, as expected.

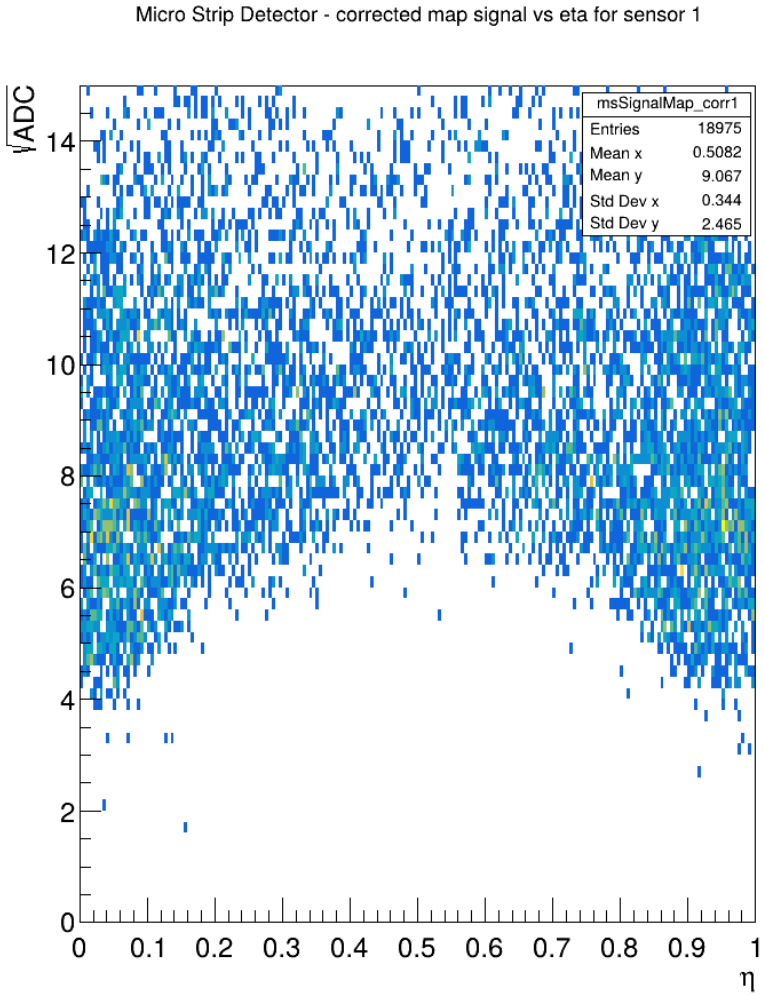
Comparison between Physics-C@200MeV/u onC

With η Correction: ZOOM on the Background

Night 1

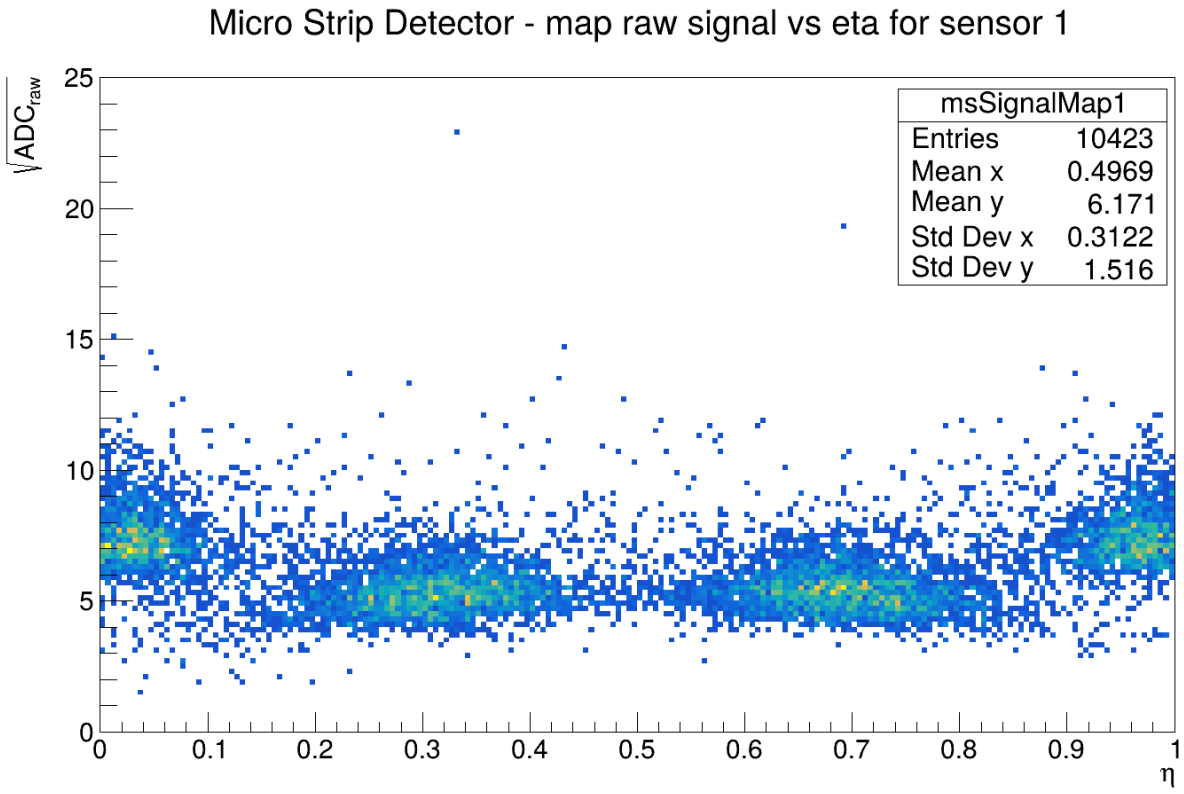


Night 2

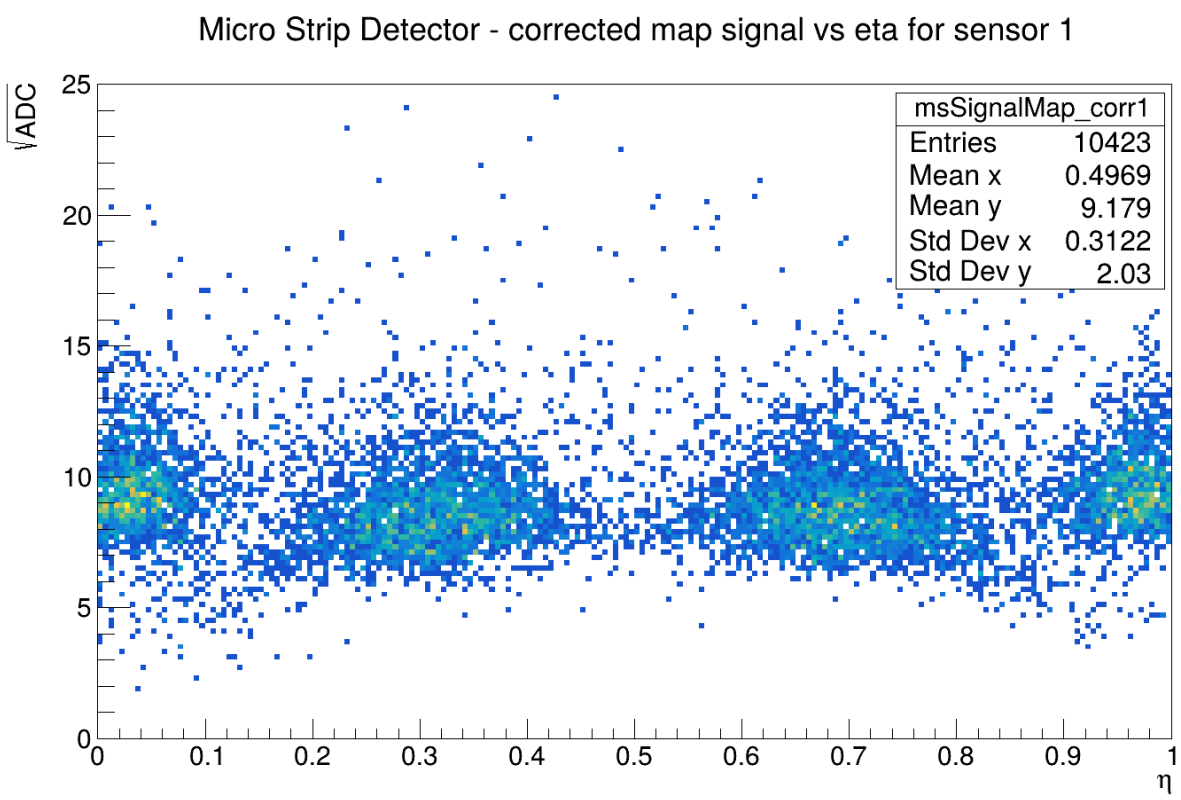


p@230MeV (run 7887 CNAO25)

Without η Correction



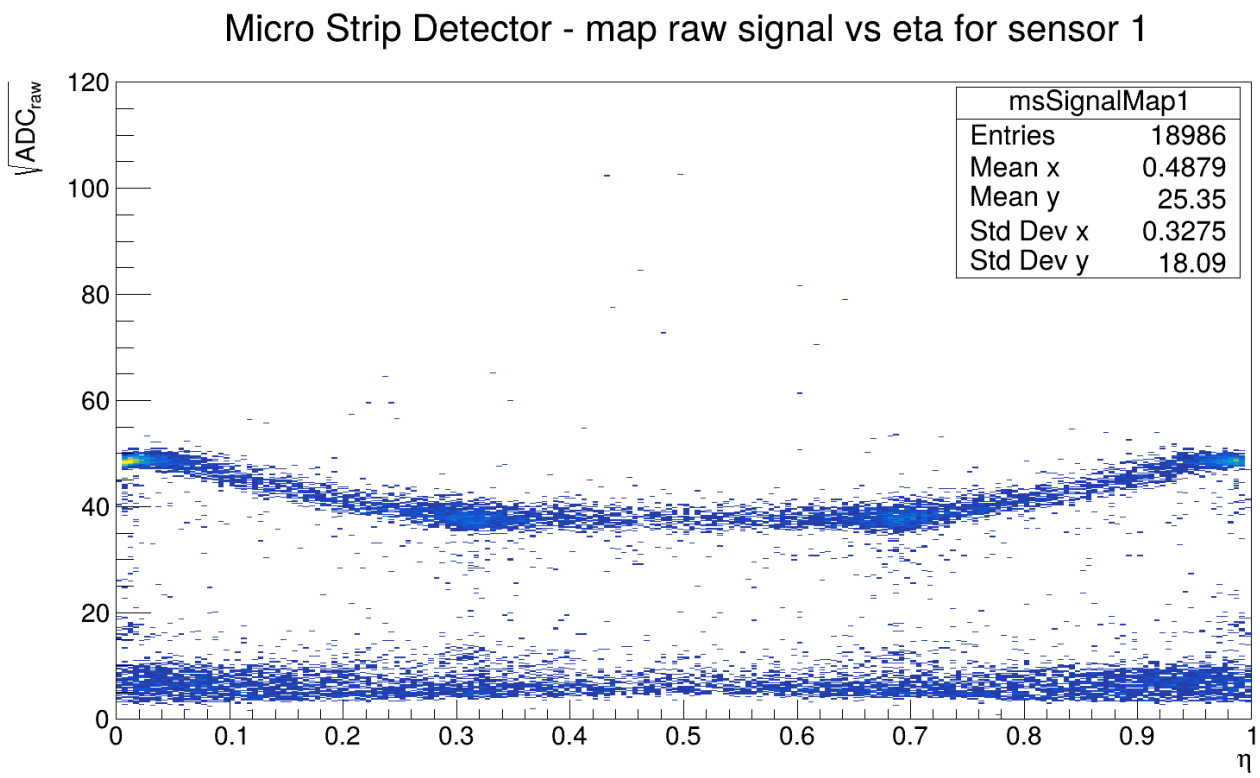
With η Correction



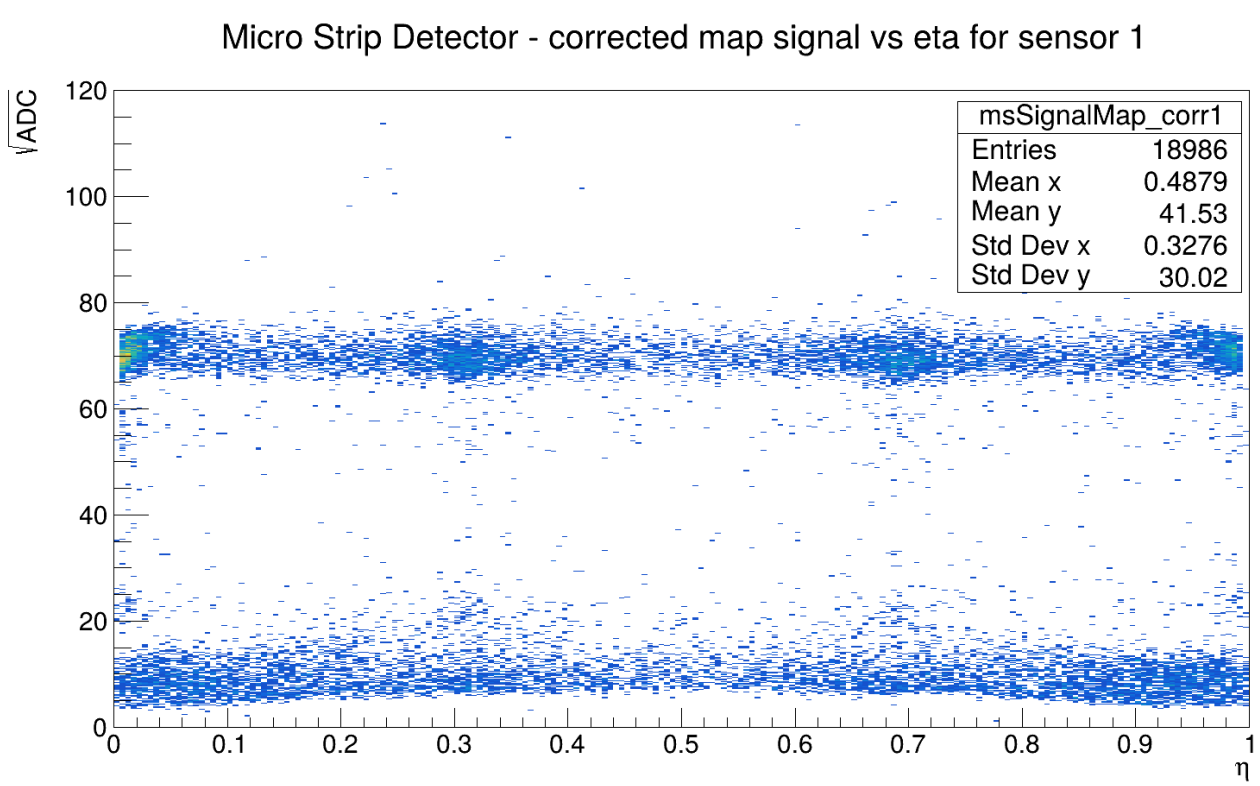
Che diciamo?

C@200MeV/u on C target (run7908 CNAO25)

Without η Correction



With η Correction



Che diciamo?