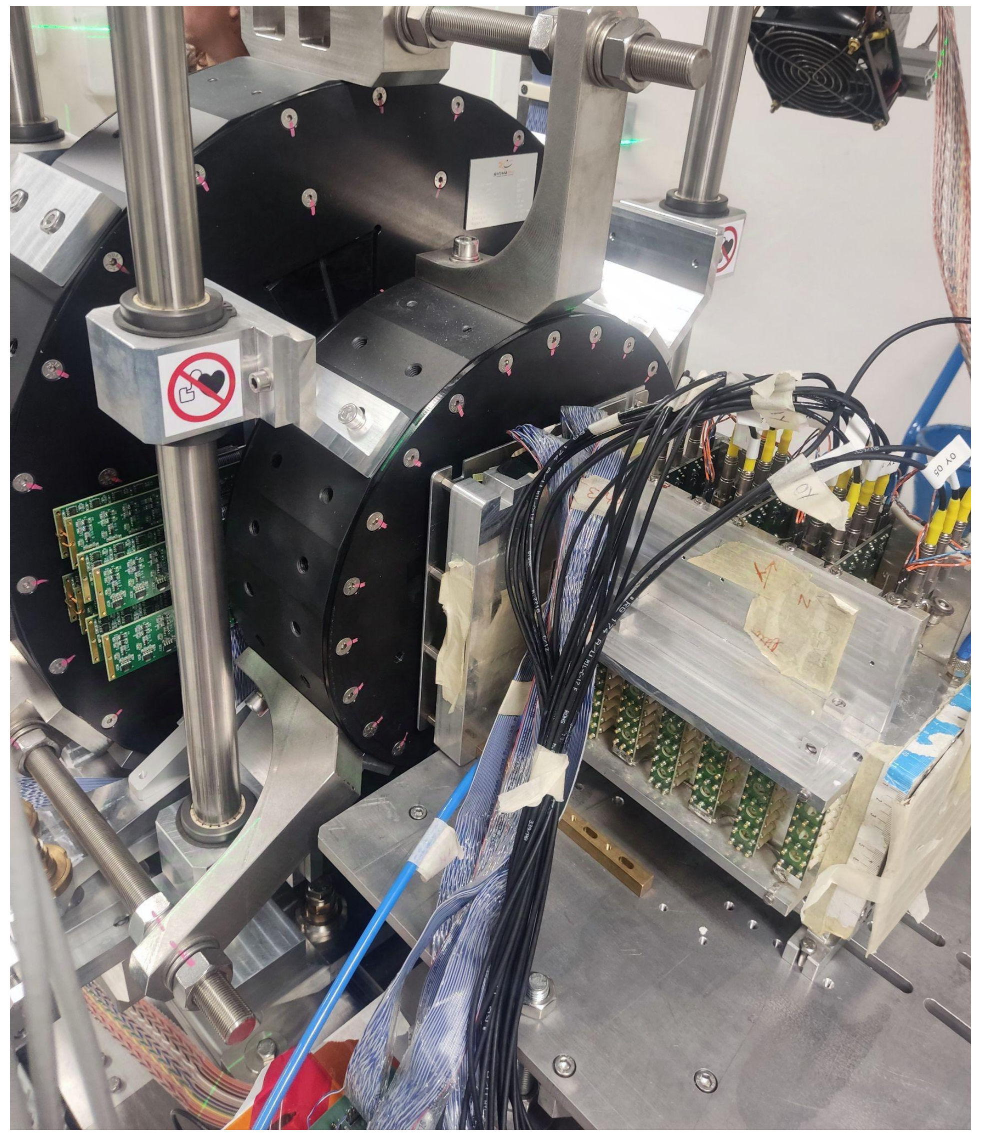
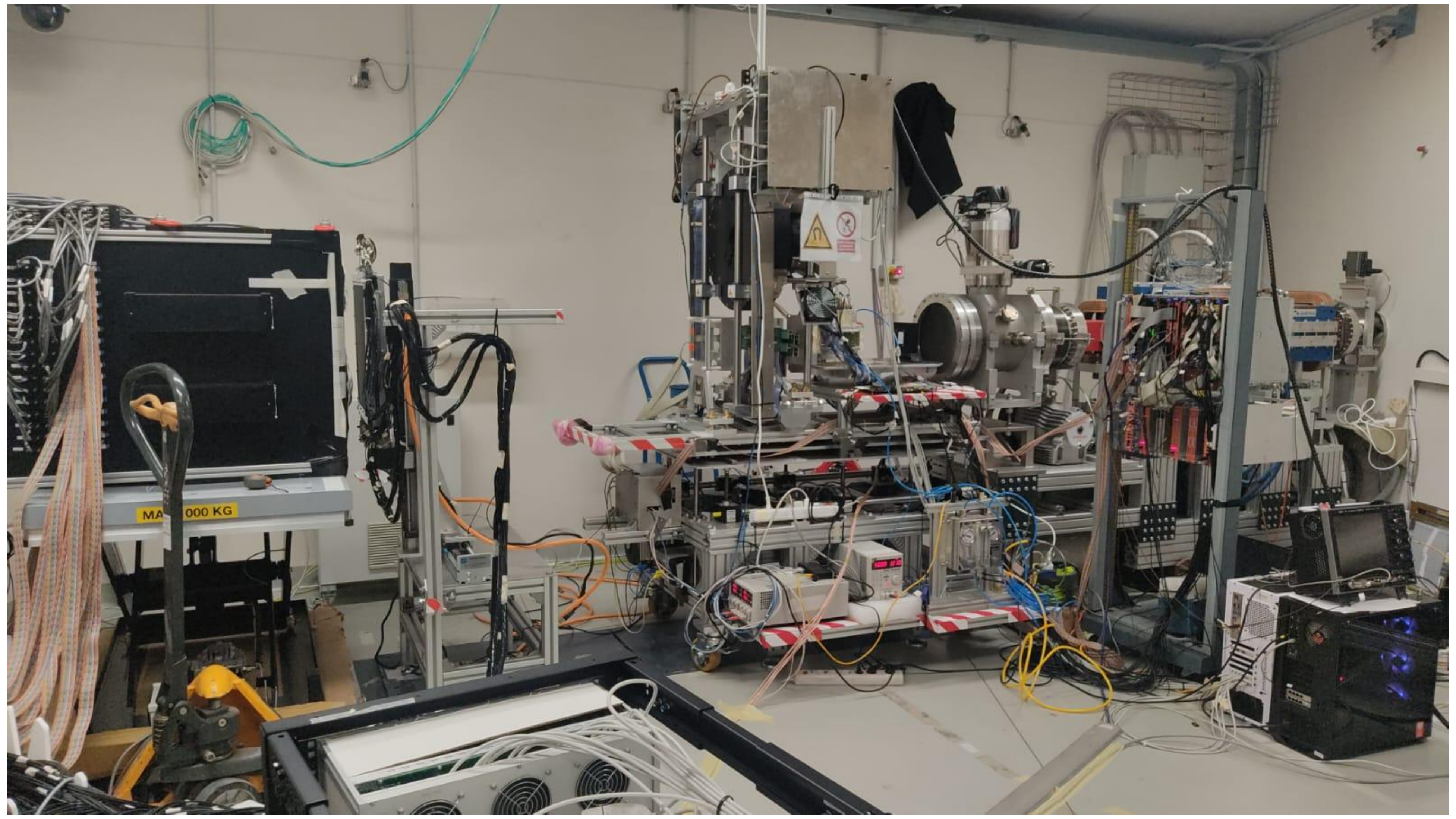
# VTX at CNAO2024

Chris, Luana, Marco
Thanks to: Giacomo U., Riccardo, Yun

# Threshold

CNAO2024:
- 9/11: Default
- 17/11 :  6 sigma
  - except run: 6964,6965: Default
- 18-11: logbook-threshold
- 19-11: logbook-threshold





# Quantity of interest

❖ **Tracking efficiency**

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  - search for a cluster near the intersection point
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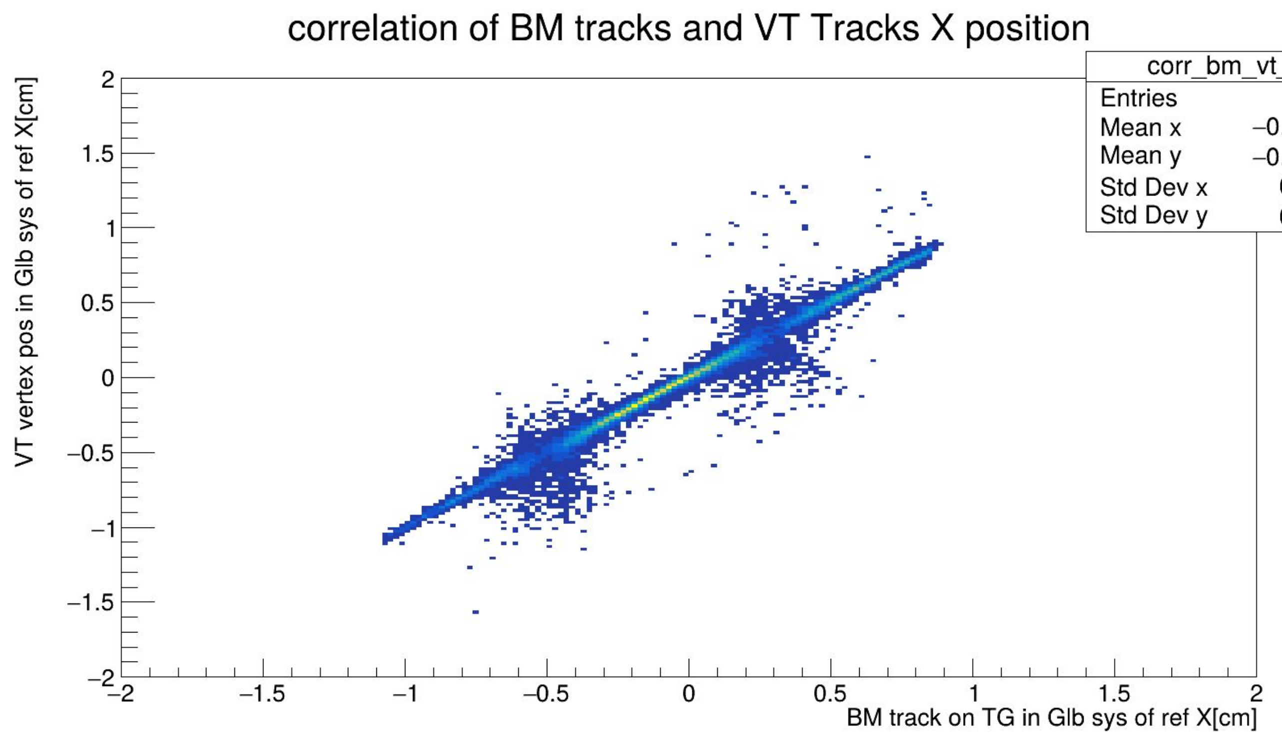
Dependence on:

- VTX interalignment
- VTX-BM alignement



# Quantity of interest

- **Noise (C and p runs):**

$$\frac{\#\text{cluster not tracked}}{\#\text{events with only 1 track in VTX}}$$

- **Noise (Pedestal runs):**

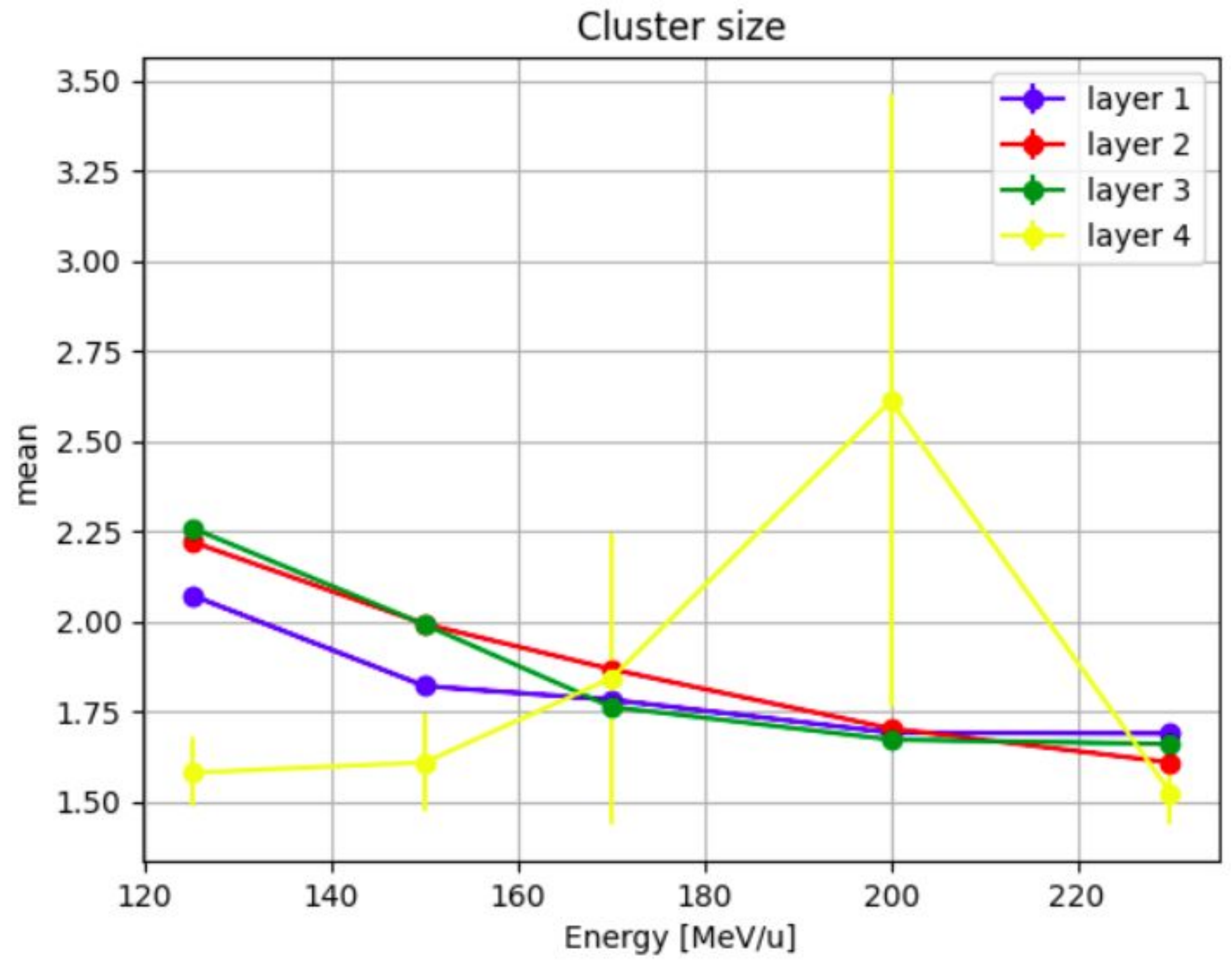
$$\frac{\#\text{active pixel}}{\#\text{events}}$$

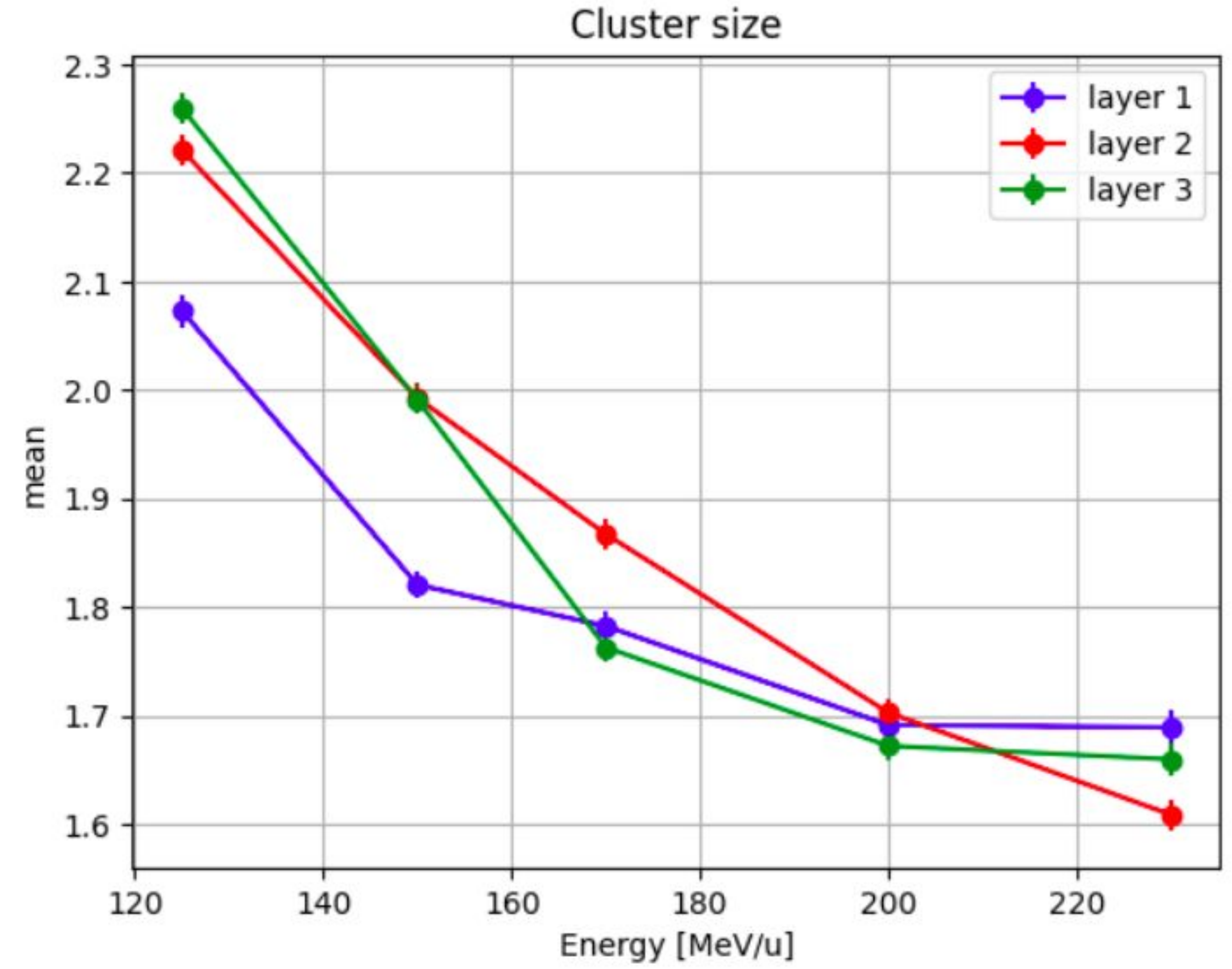
9/11/2024 Threshold -> Default

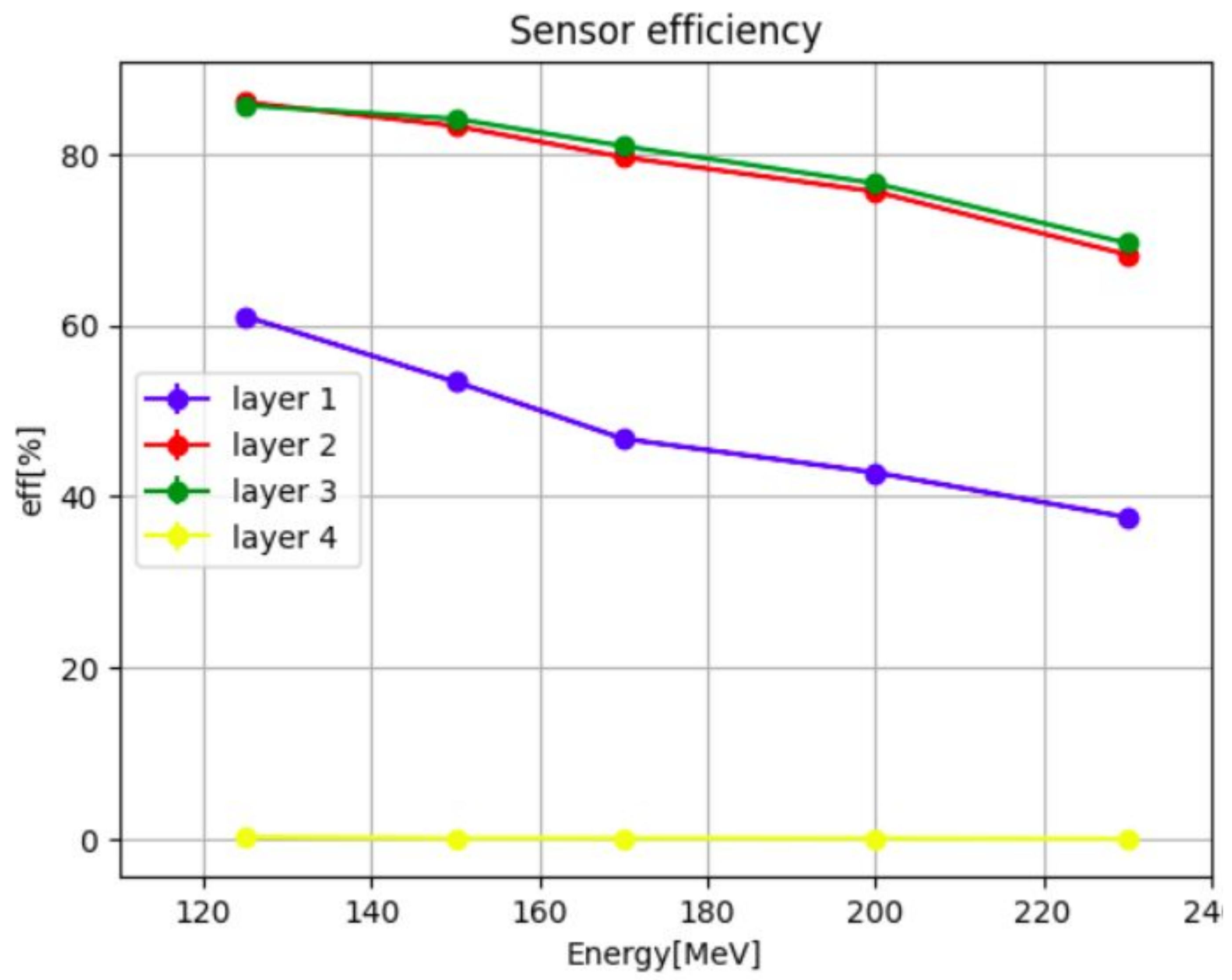
# Protons

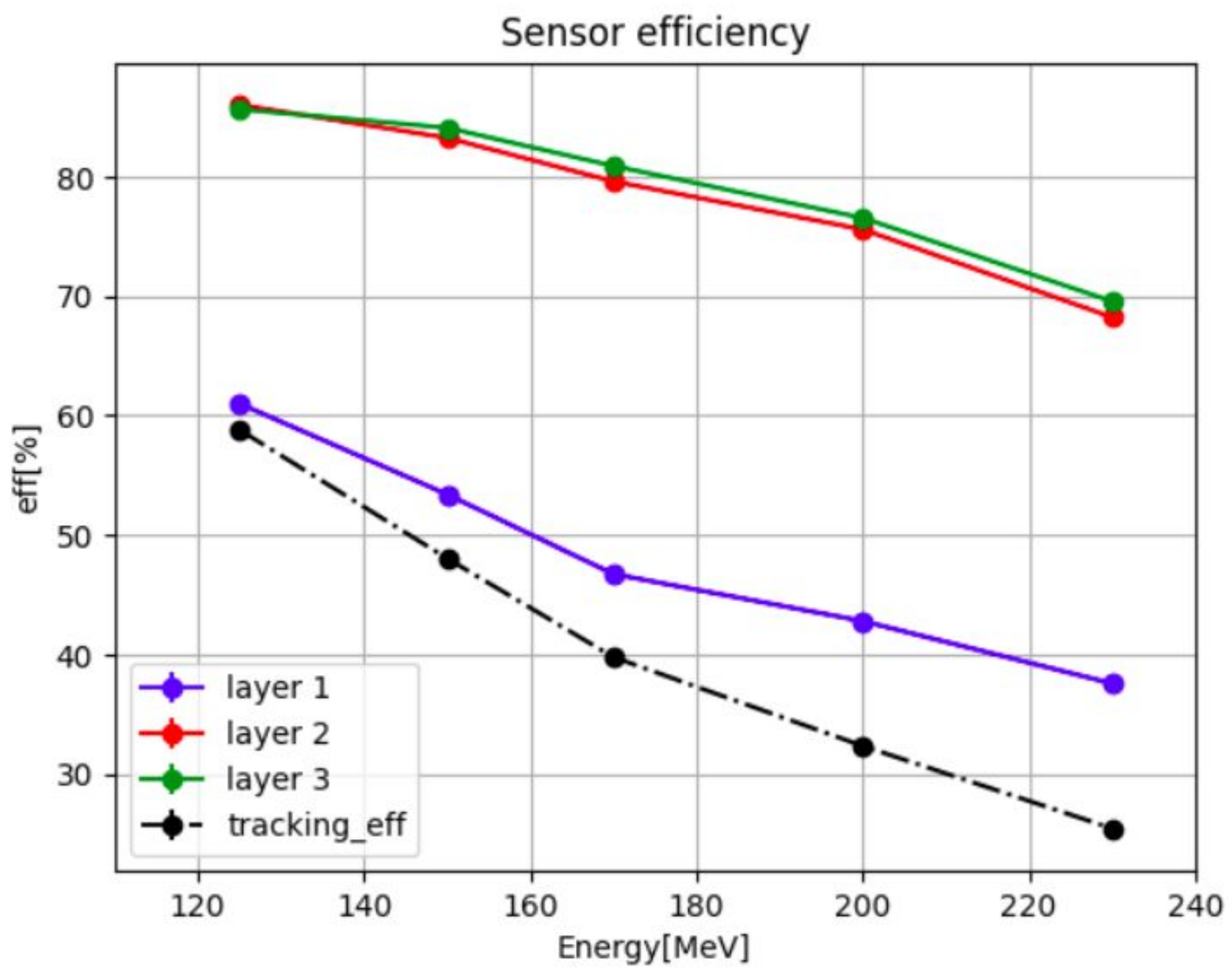
## Energy scan

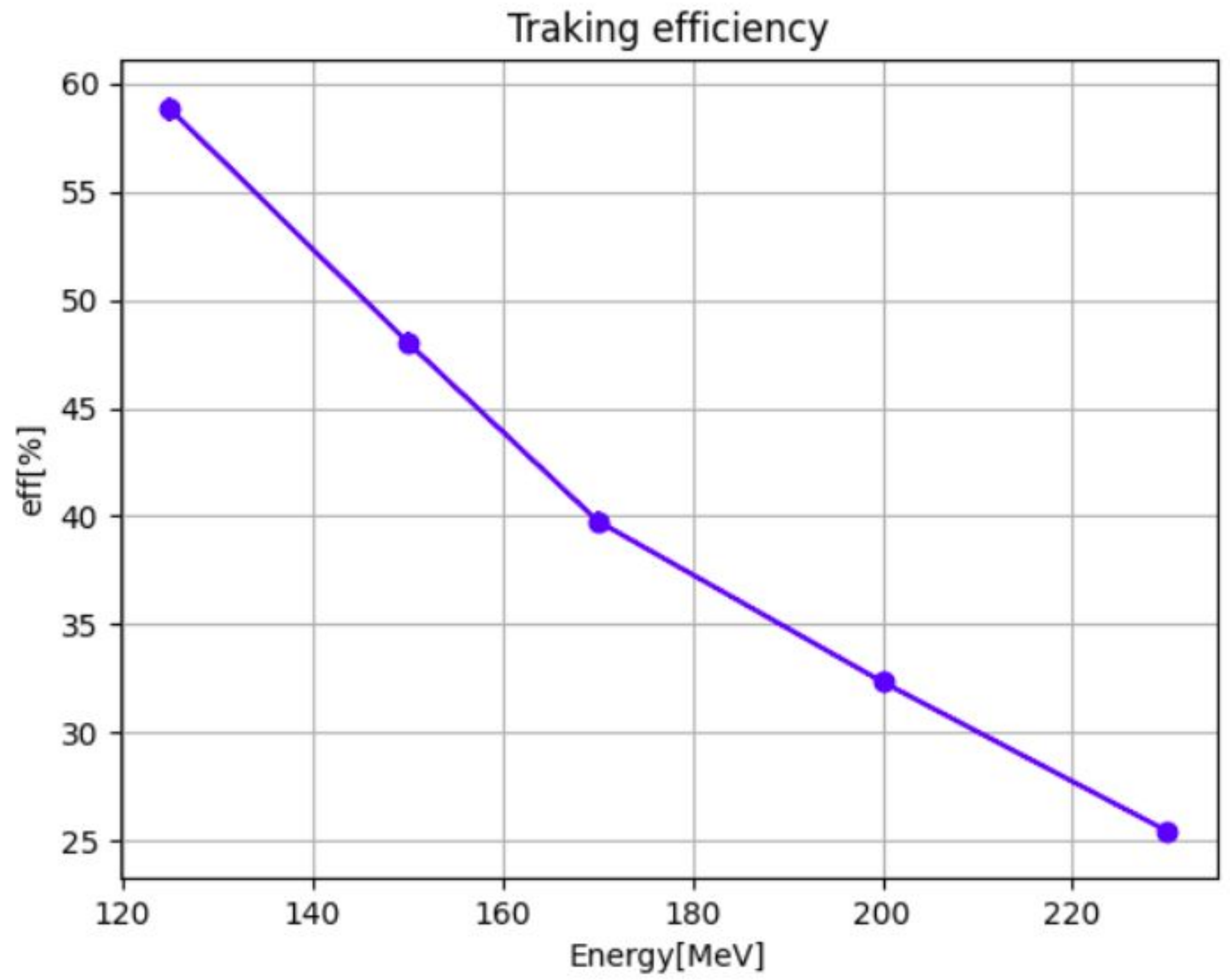
9/11/2024
run: 6749, 6764-6767



17/11/2024 Threshold -> 6σ

# Protons 230MeV

## Threshold of the 17/11

| - | 17/11 | 17/11 (default->6964) | 18/11 (6σ->7011) |
|---|---|---|---|
| Tracking efficiency | 89.81 ± 0.06 | 24.88± 0.32 | 91.95 ± 0.21 |
| Sensor 1 efficiency | 90.91 ± 0.05 | 36.49± 0.35 | 91.33 ± 0.22 |
| Sensor 2 efficiency | 90.76 ± 0.05 | 72.16 ± 0.33 | 91.13 ± 0.22 |
| Sensor 3 efficiency | 90.05 ± 0.05 | 72.42± 0.33 | 90.56 ± 0.23 |
| Sensor 4 efficiency | 1.23 ± 0.02 | 0.037± 0.014 | 86.27 ± 0.27 |
| Cluster size 1 | 4.45 ± 0.02 | 1.62 ± 0.01 | 4.39 ± 0.01 |
| Cluster size 2 | 4.59 ± 0.02 | 1.63 ± 0.01 | 4.49 ± 0.01 |
| Cluster size 3 | 4.67 ± 0.02 | 1.62 ± 0.01 | 4.54 ± 0.01 |
| Cluster size 4 | 3.74 ± 0.02 | 1.69 ± 0.17 | 2.49 ± 0.01 |

- run of 17/11 are compatible with run at <u>6σ</u> of the 18/11
  - difference on sensor 4 ➡ 18/11:: some noisy columns of the 4th sensor are masked, and a new power supply is used

- the last runs of the 17/11 (6964, 6965) are not compatible with previous ones, but are compatible with runs of the 9/11
  - run 6964 and 6965, taken after a power cycle of VTX ➡ <u>Default</u> configuration of threshold

# Default

- sensor 1

❖ **What threshold does Default correspond to?**

- **protons 230MeV**

| Threshold | cluster size | Sensor efficiency |
|---|---|---|
| *Default* | $1.68 \pm 0.01$ | $37.58 \pm 0.46$ |
| Max | $1.67 \pm 0.01$ | $76.99 \pm 0.33$ |

- **previous campaigns:**

| - | beam | threshold | cluster size | tracking eff |
|---|---|---|---|---|
| CNAO2023 | $p(200MeV)$ | - | $1.70 \pm 0.09$ | $41.40 \pm 4.34$ |
| CNAO2024 | $p(200MeV)$ | *Default* | $1.69 \pm 0.01$ | $32.35 \pm 0.41$ |
| CNAO2024 | $p(200MeV)$ | $6\sigma$ | $4.87 \pm 0.02$ | $86.70 \pm 0.23$ |

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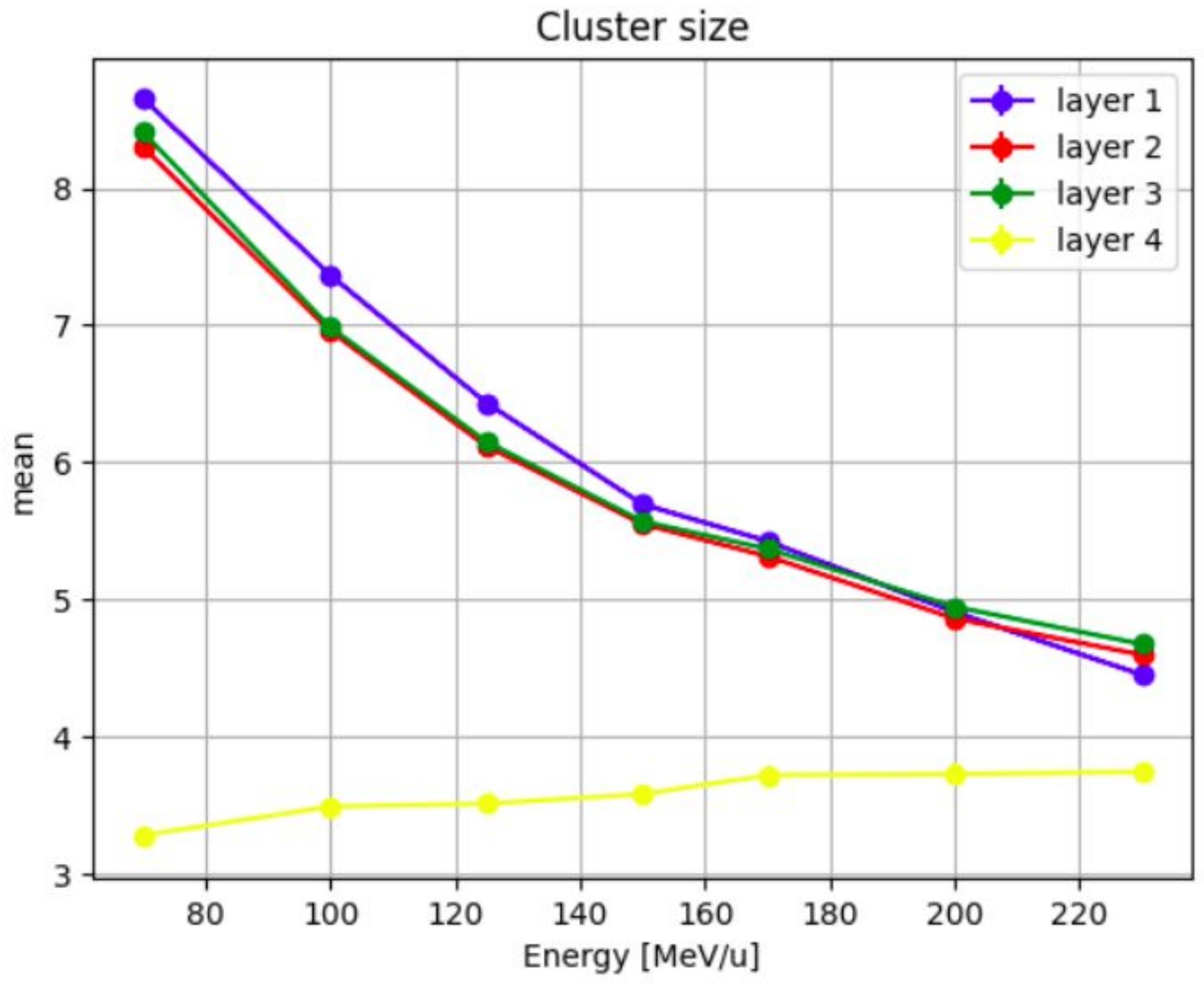
| CNAO2024 | $p(200MeV)$ | $6\sigma$ | $4.87 \pm 0.02$ | $86.70 \pm 0.23$ |

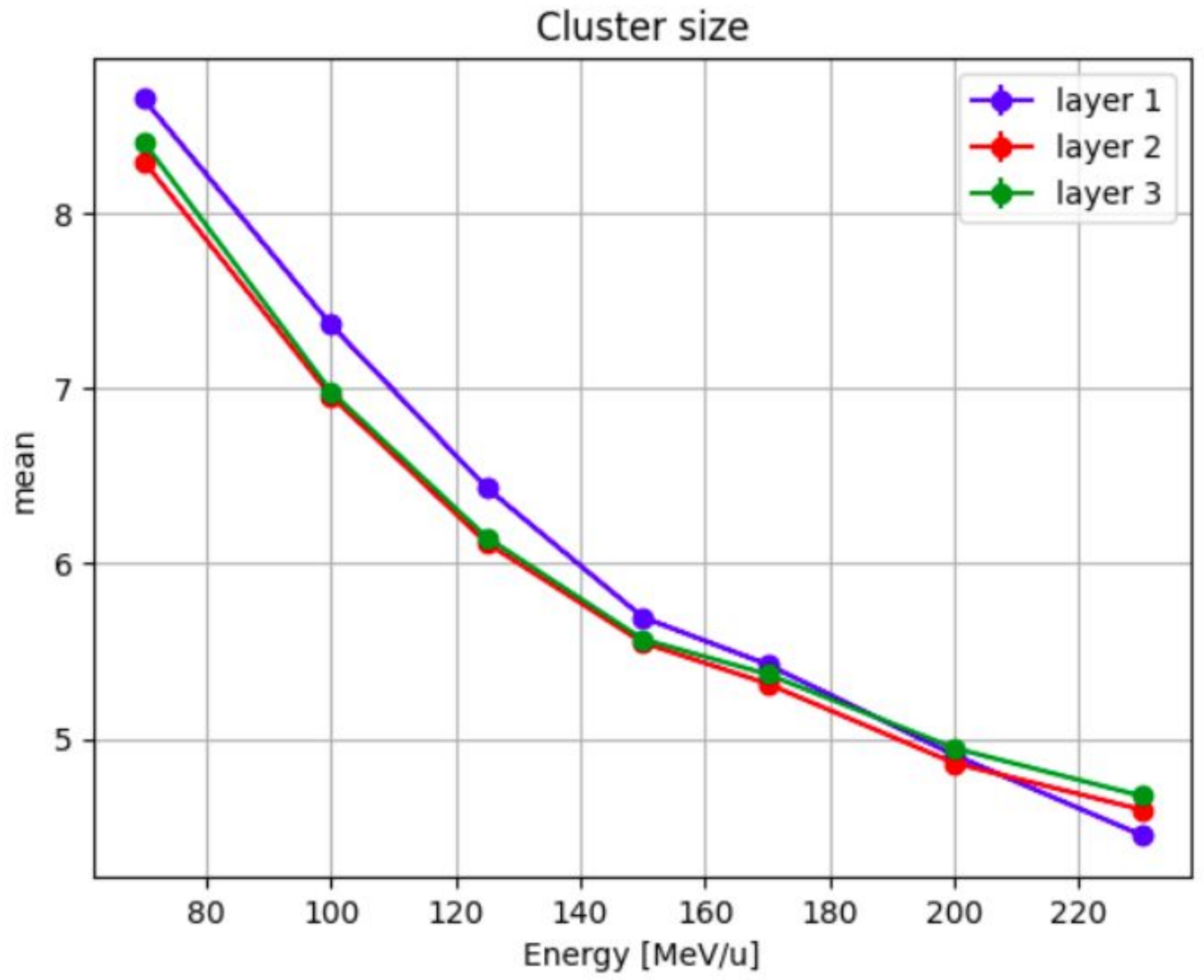
| - | beam | threshold | cluster size |
|---|---|---|---|
| GSI2021 | $^{16}O(400MeV/u)$ | - | $21.390 \pm 0.005$ |
| CNAO2022 | $^{12}C(200MeV/u)$ | - | $18.98 \pm 0.01$ |
| CNAO2023 | $^{12}C(200MeV/u)$ | - | $16.47 \pm 0.01$ |
| CNAO2024 | $^{12}C(200MeV/u)$ | *Defalut* | $16.43 \pm 0.02$ |
| CNAO2024 | $^{12}C(200MeV/u)$ | $6\sigma$ | $30.99 \pm 0.02$ |

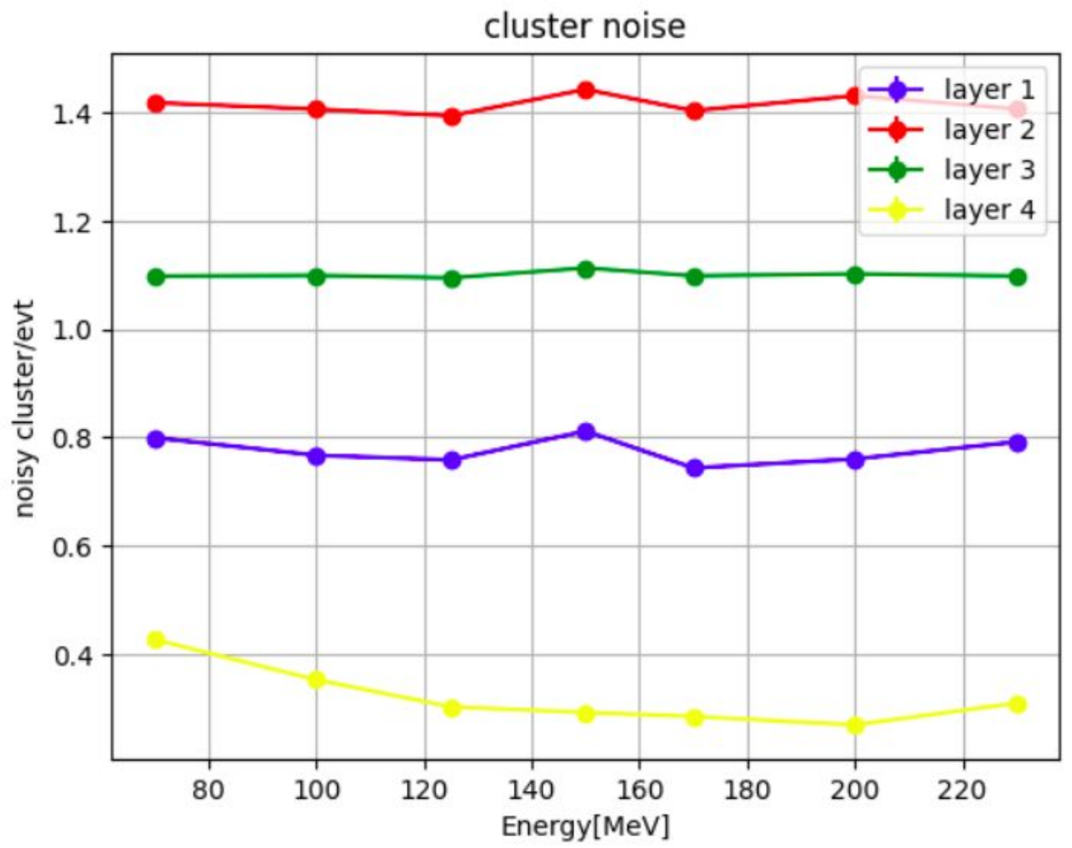
# 17/11/2024 Energy scan
# (Threshold = 6σ)

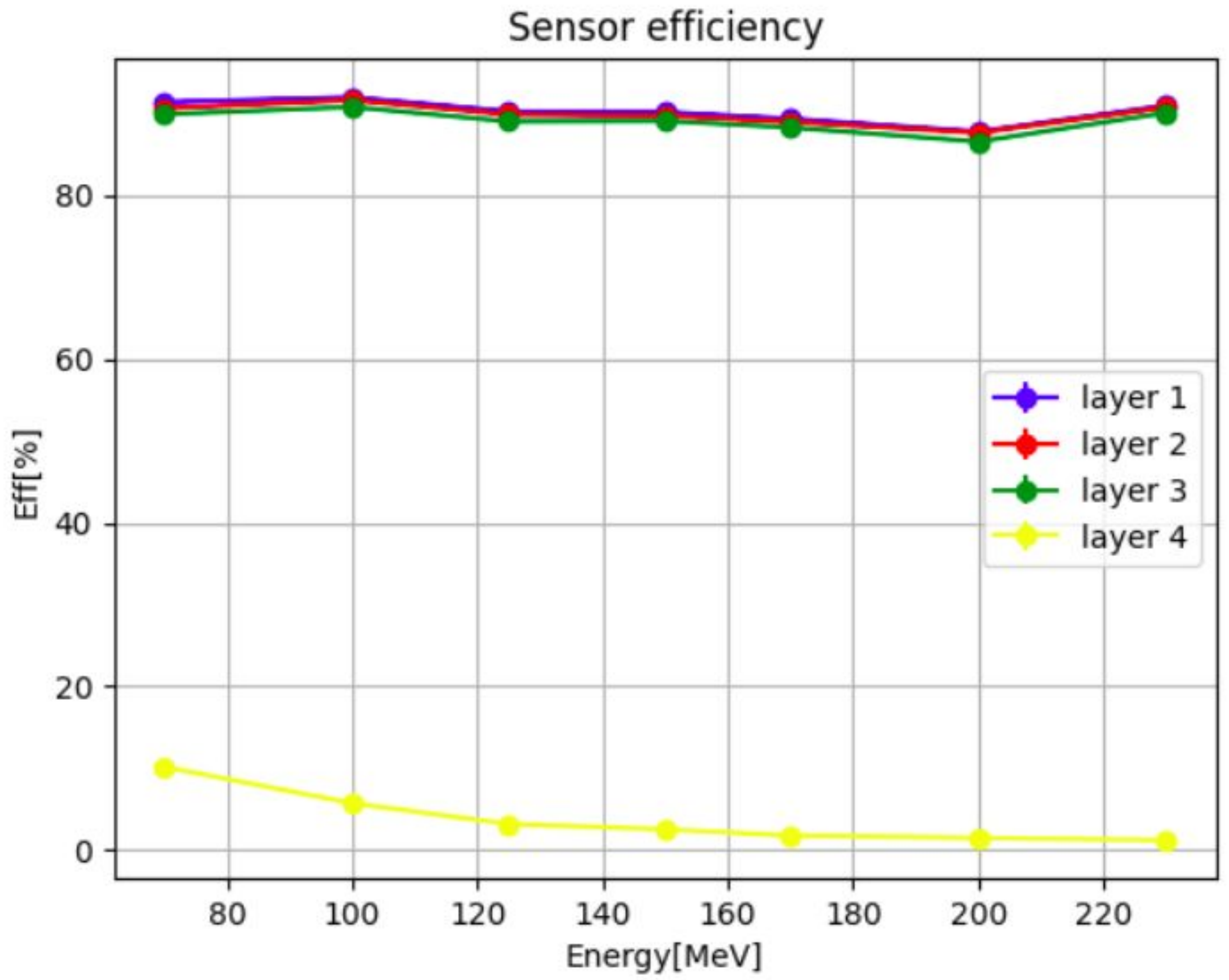
# Protons: Energy scan

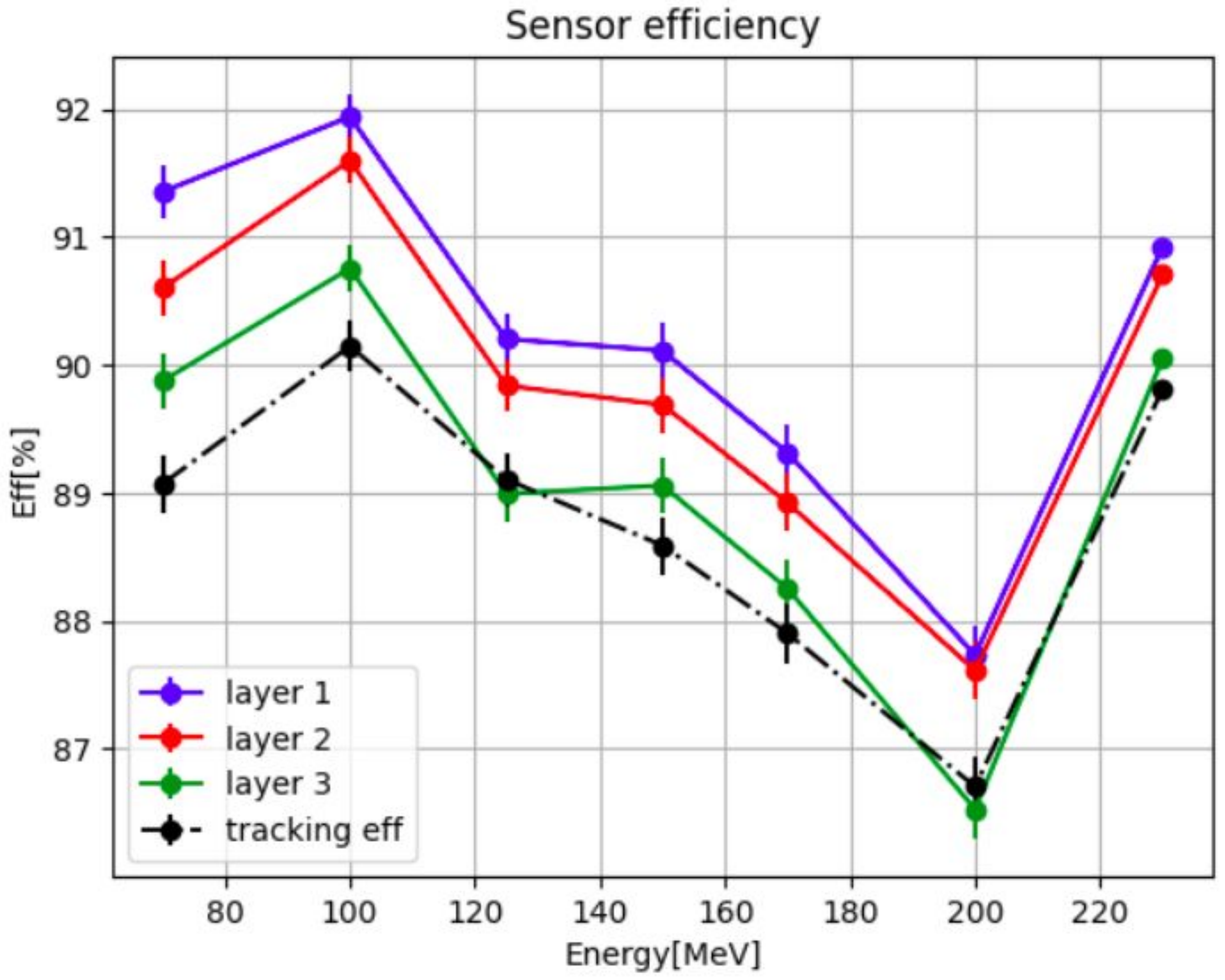
17/11/2024
run: 6946-6951

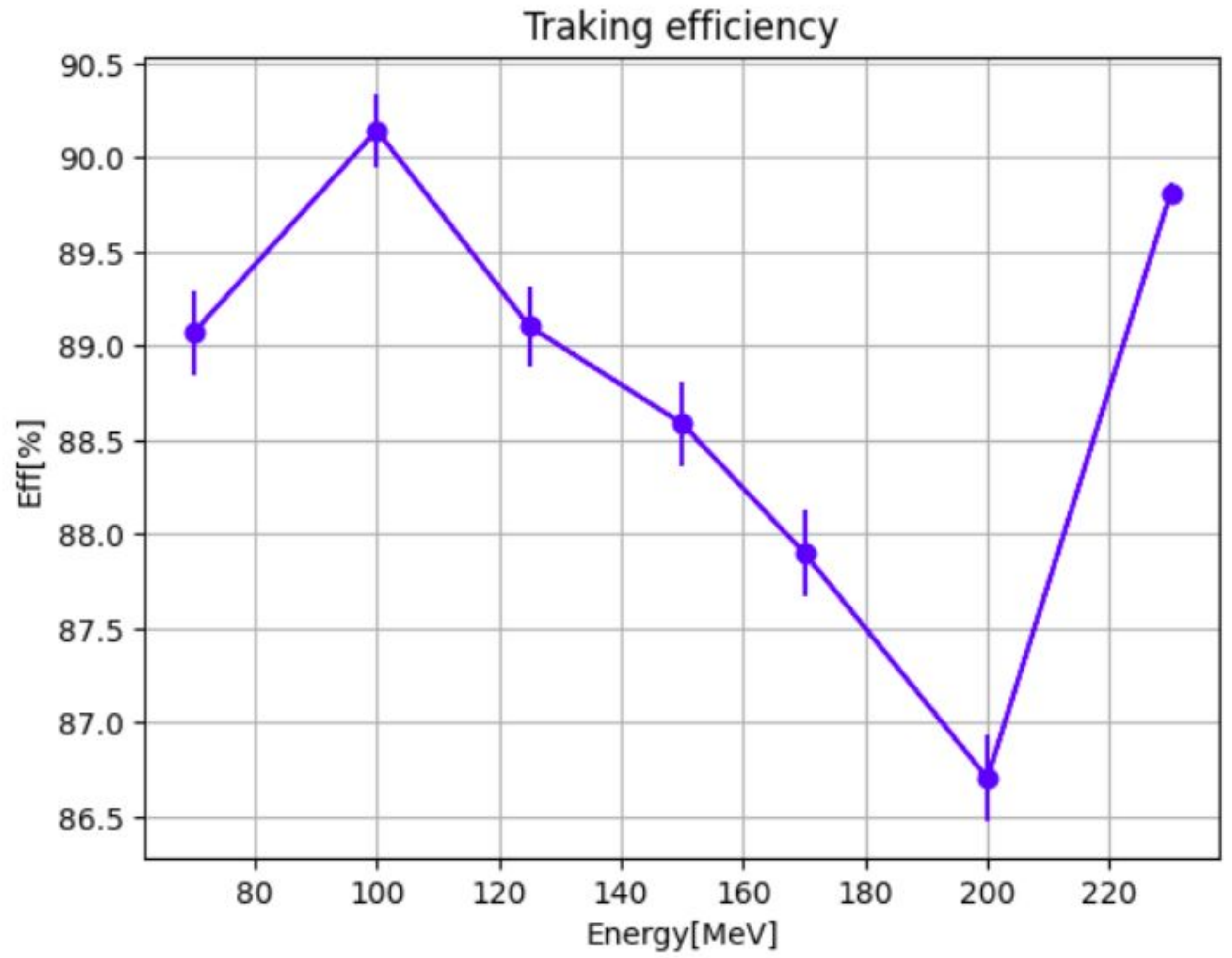


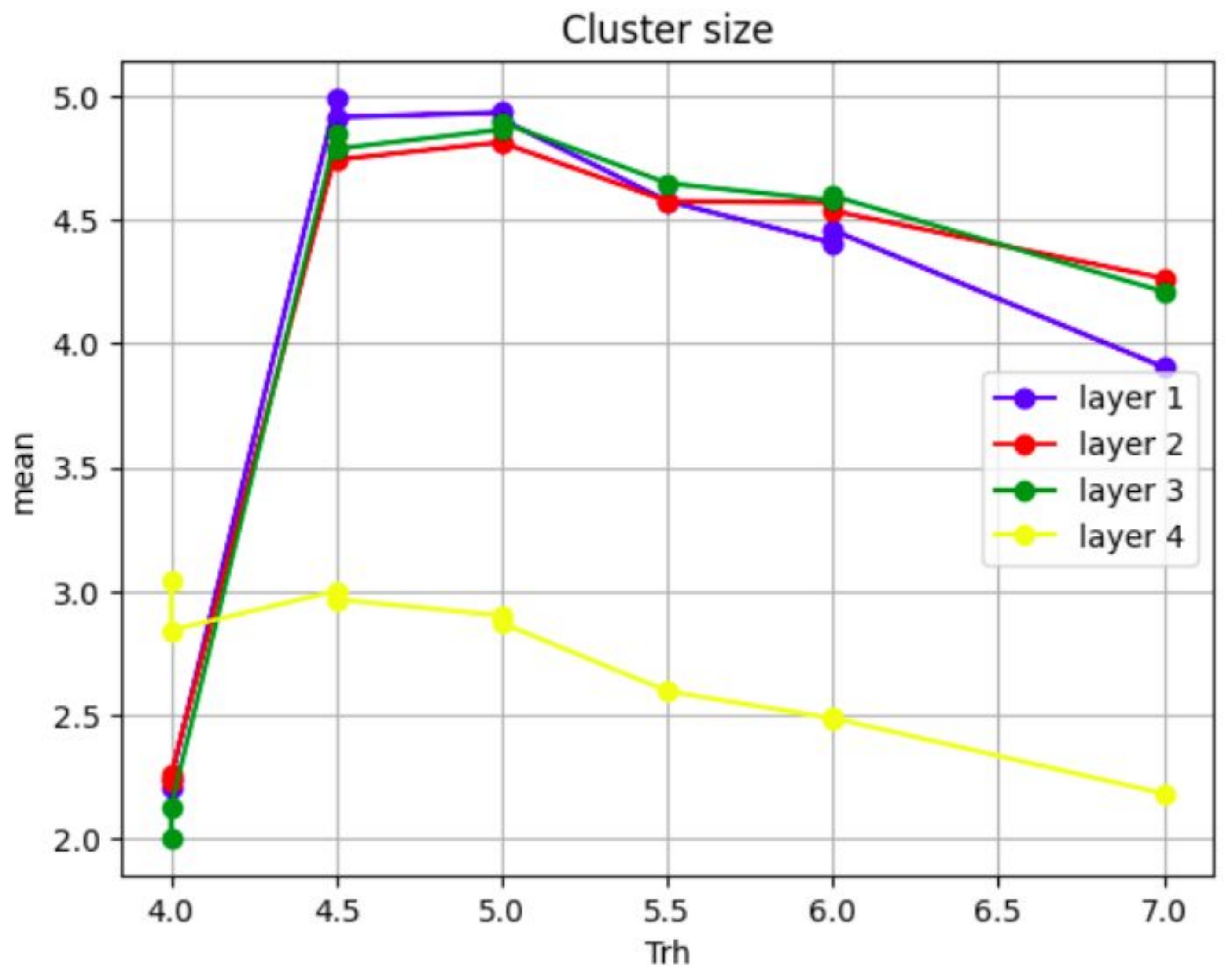



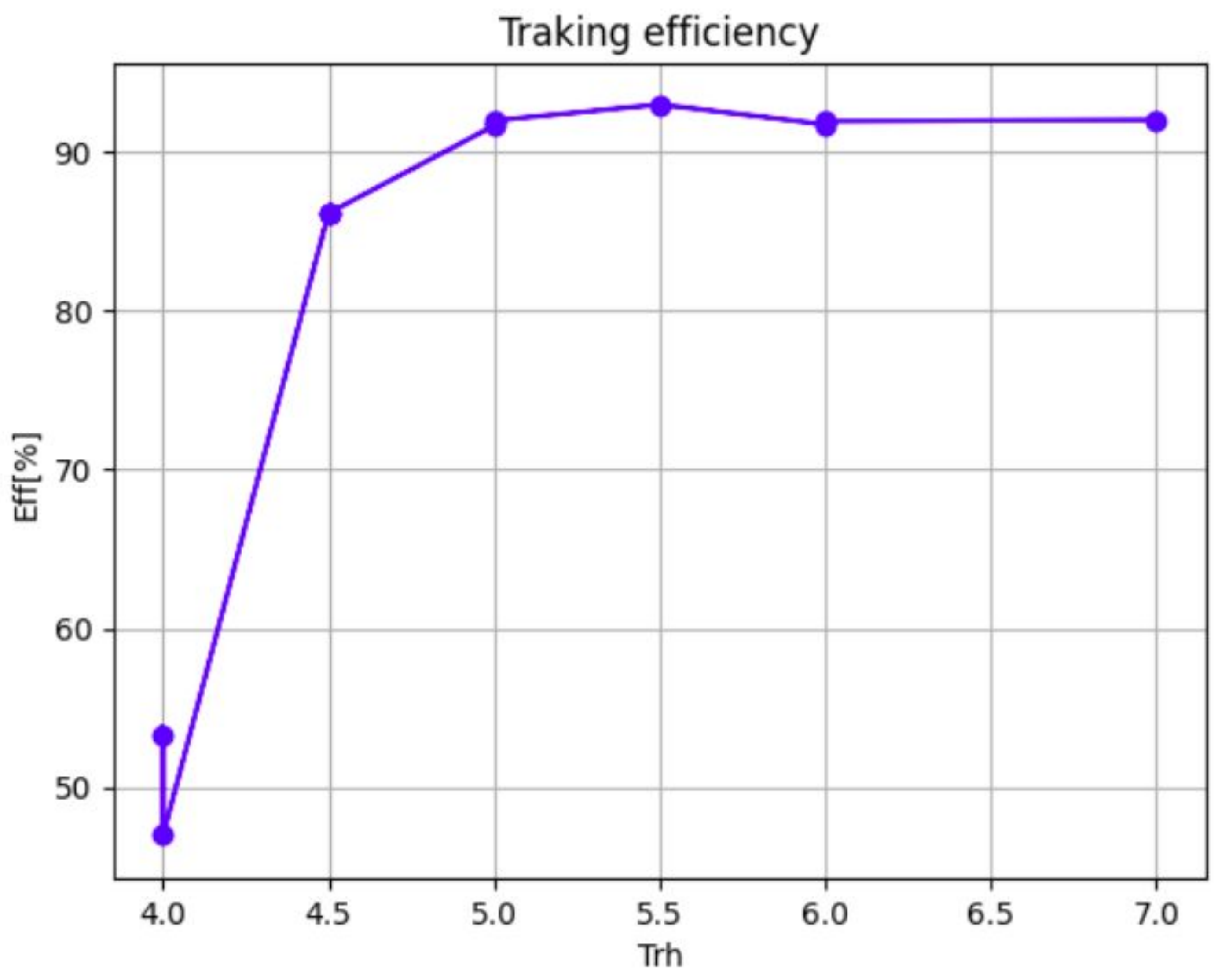
# 18/11/2024 Threshold scan

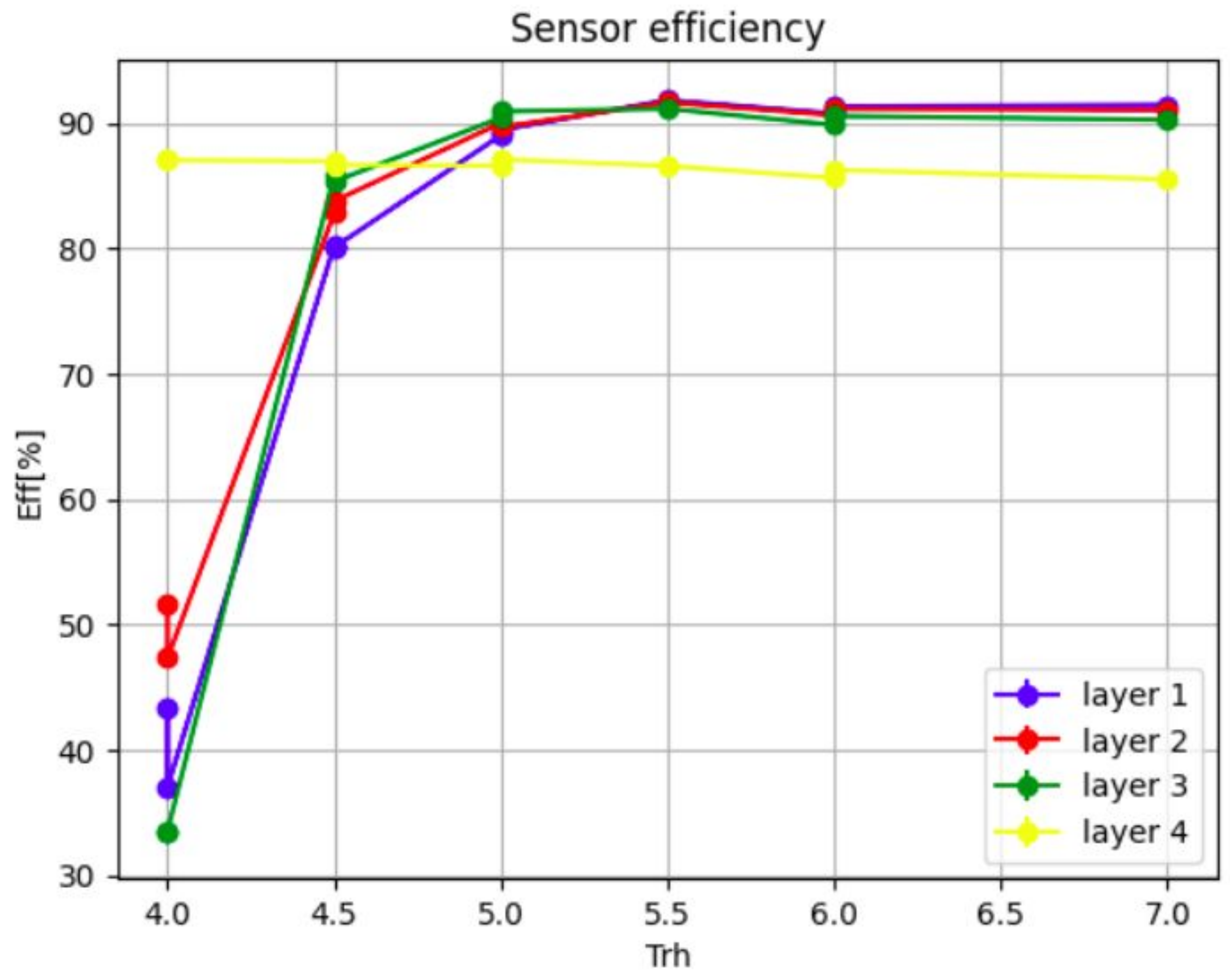
# 230MeV Protons

## Threshold scan

18/11/2024
run: 7005, 7007-7015, 7017, 7018



# 230MeV Protons

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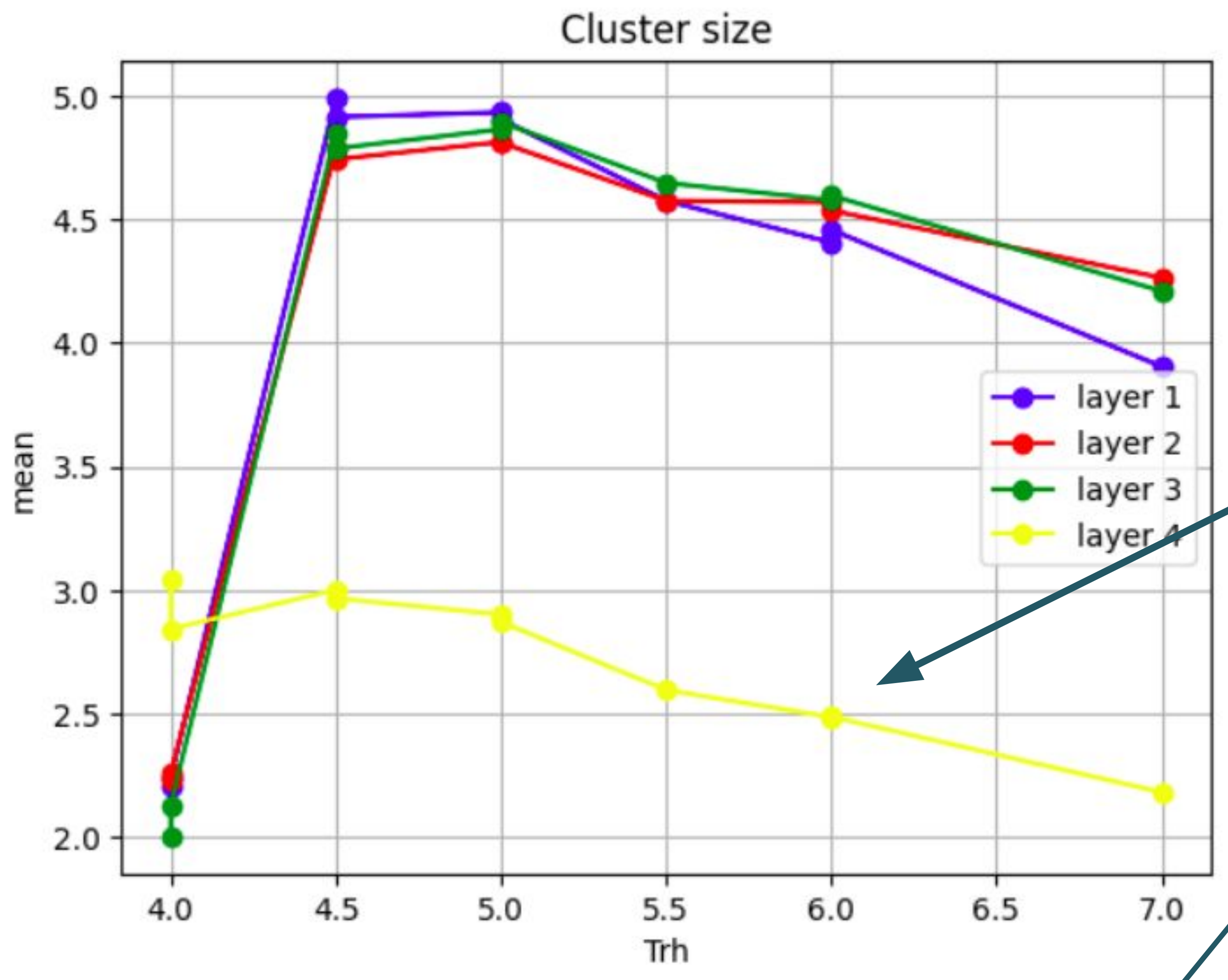
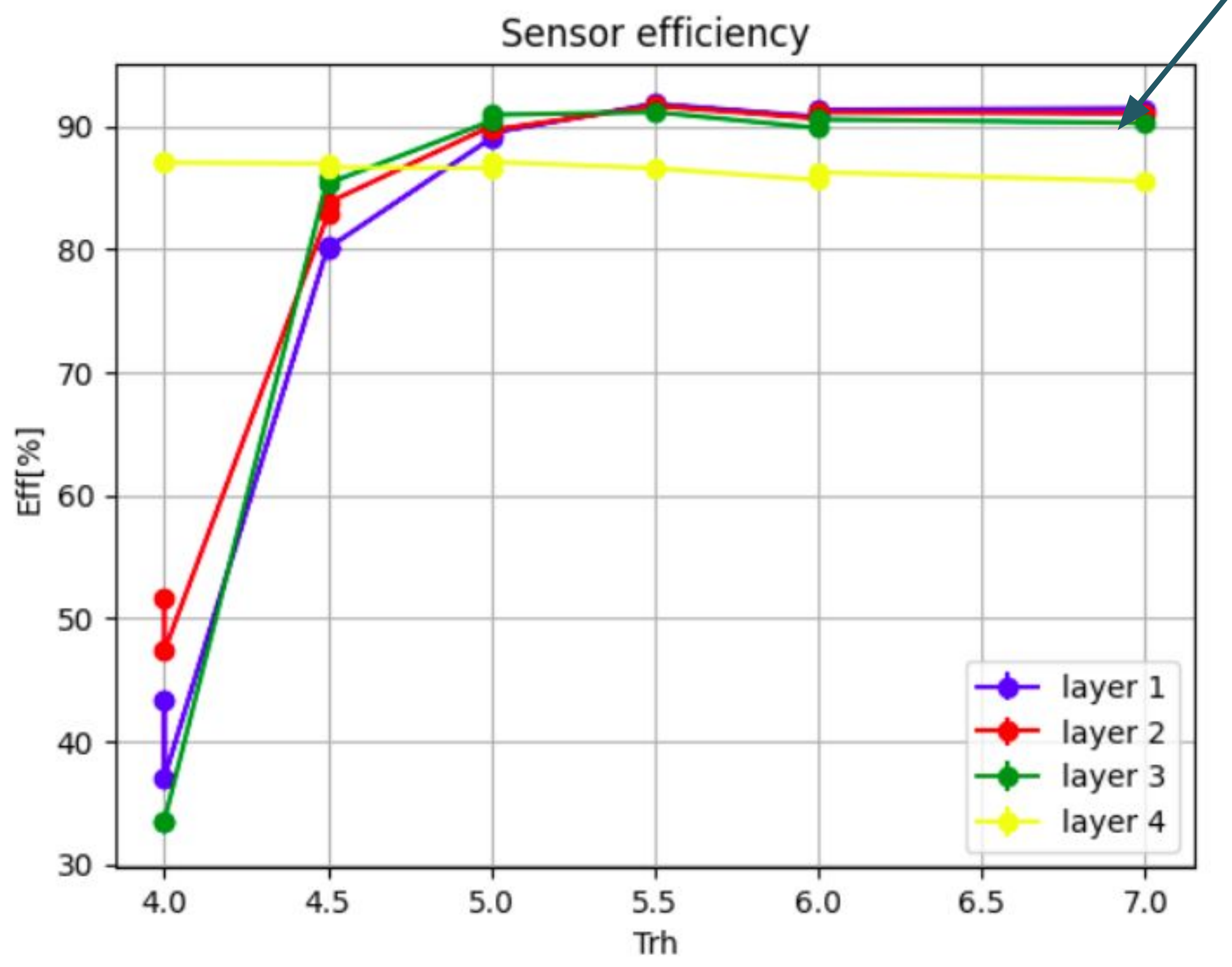


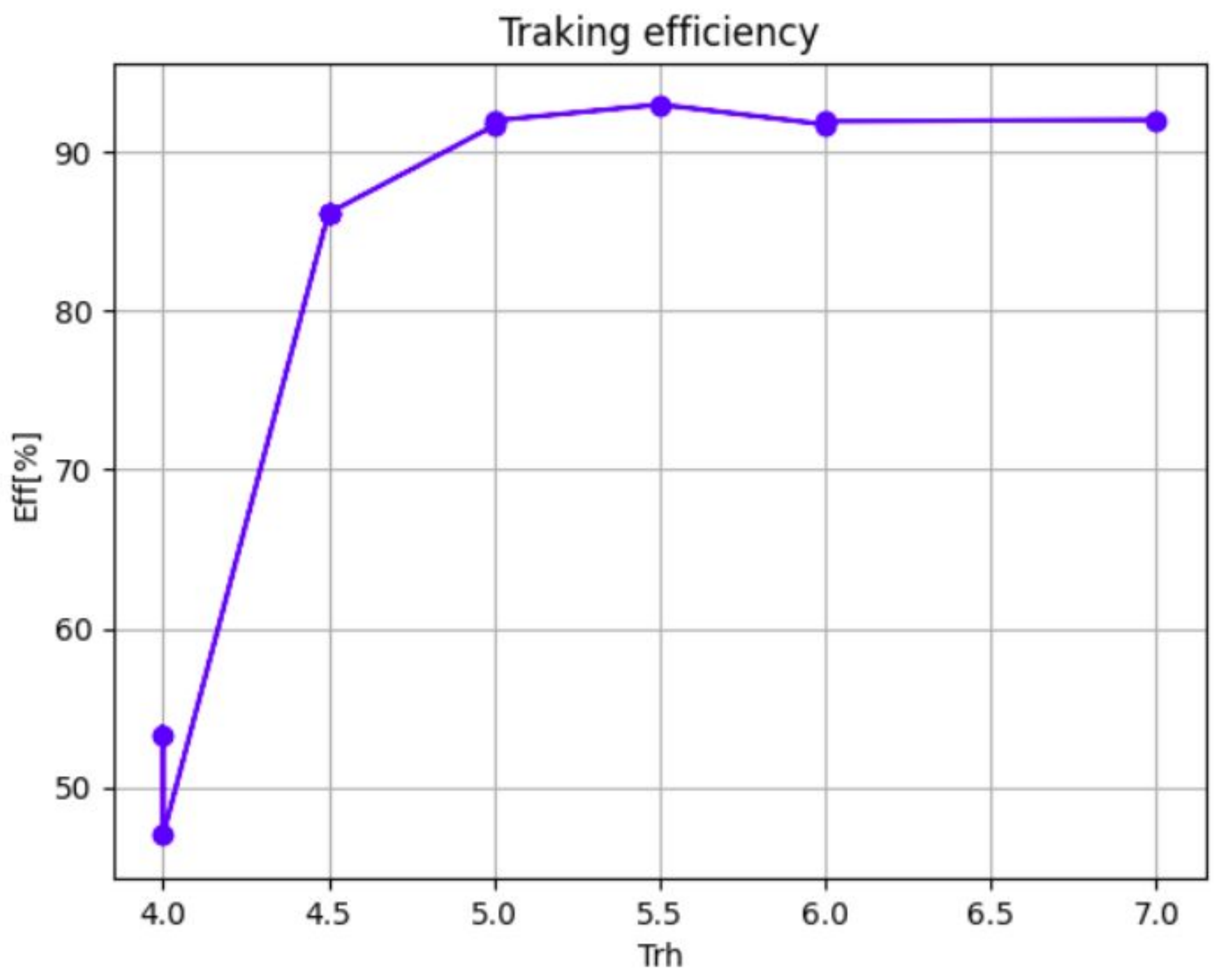

- Cluster size of sensor 4, on 17/11, at 6σ was at : <u>3.61+/- 0.54</u>

- Sensor 4 efficiency is improved




The only difference respect to the 17/11 are that some noisy columns of the 4th sensor are masked and the power supply is changed.

- What happened at 4σ?

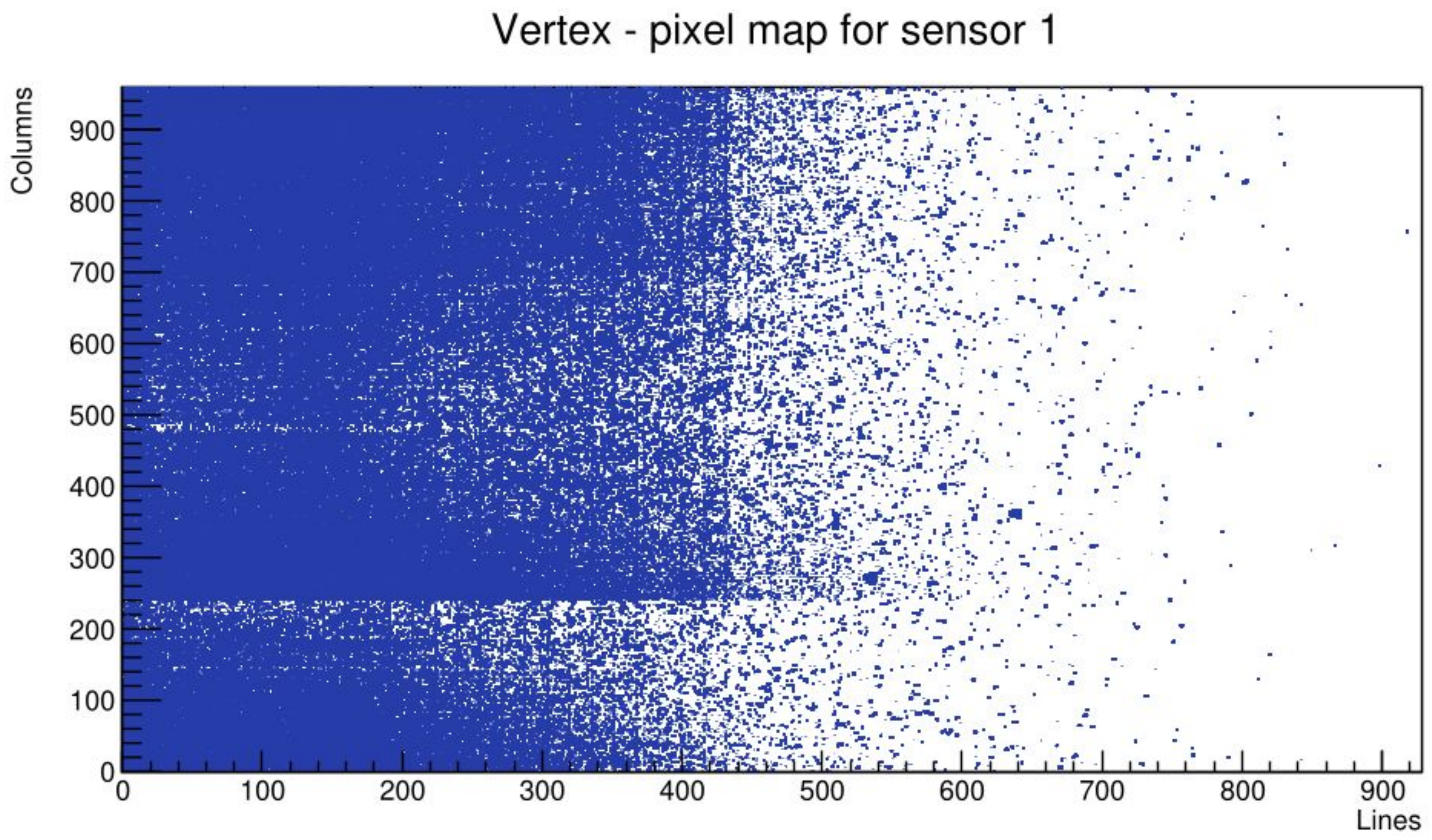


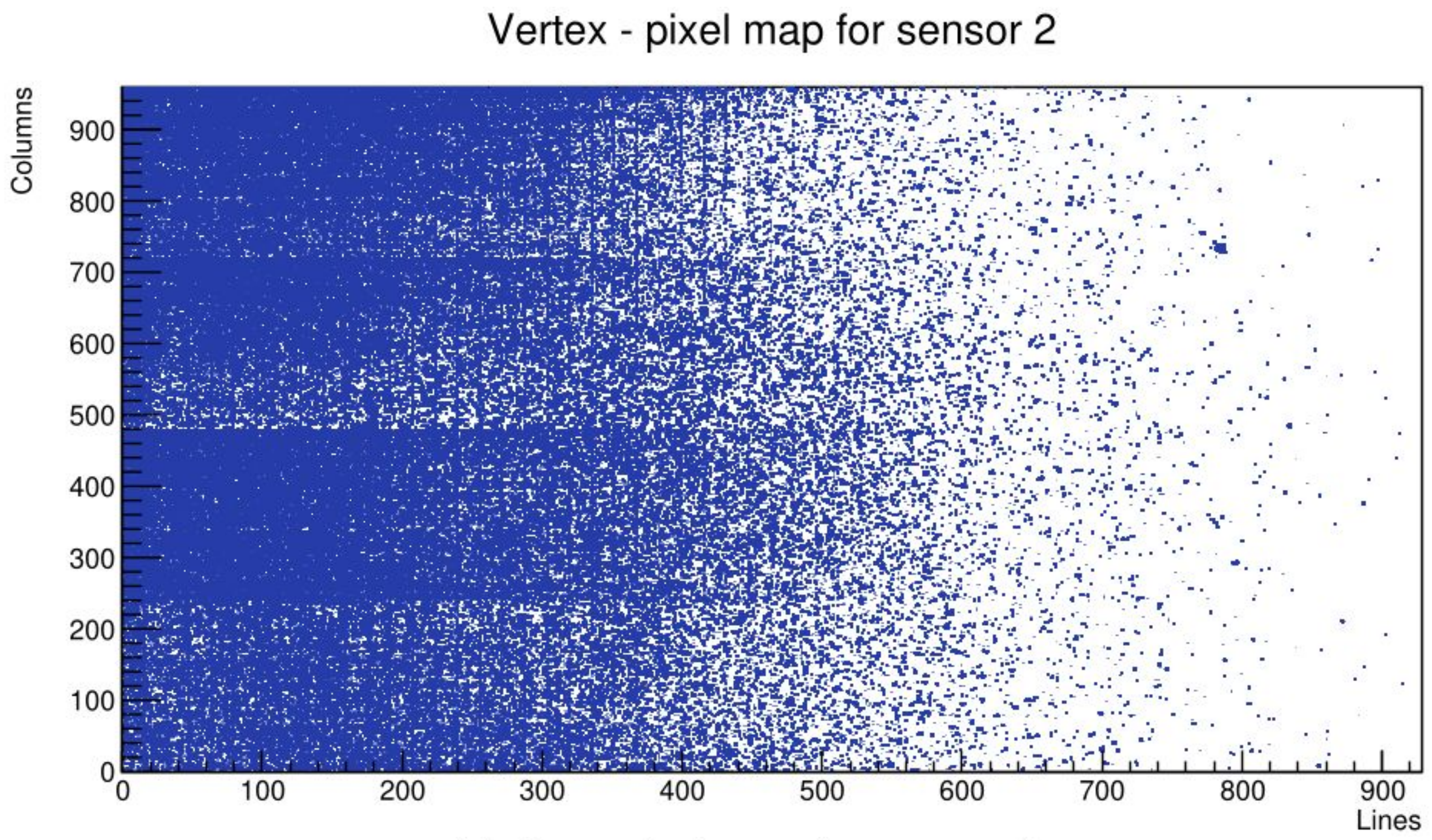
# 230MeV Protons

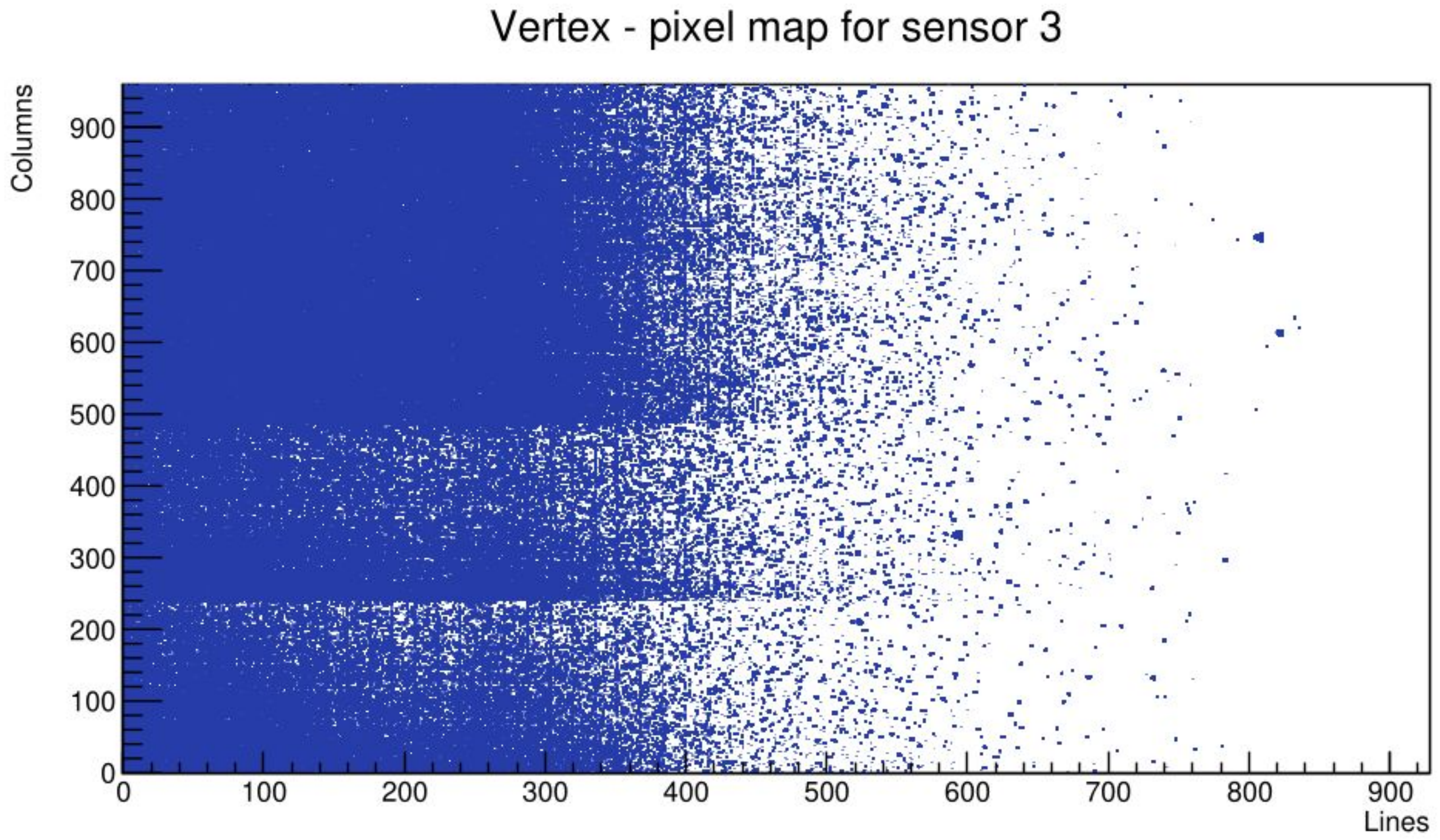
## Threshold study: 4σ

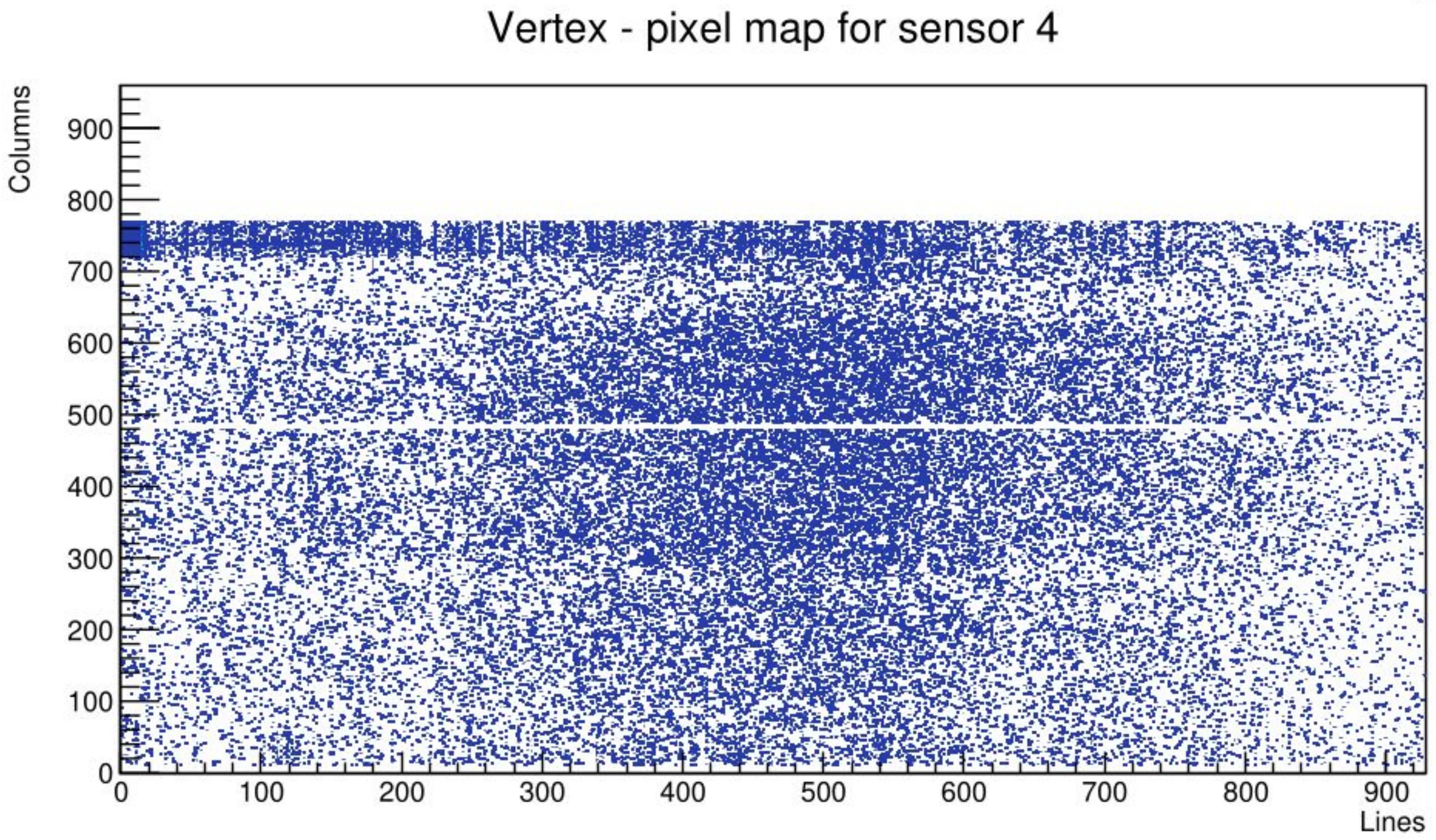
18/11/2024

run 7014 -> all layer at 4σ



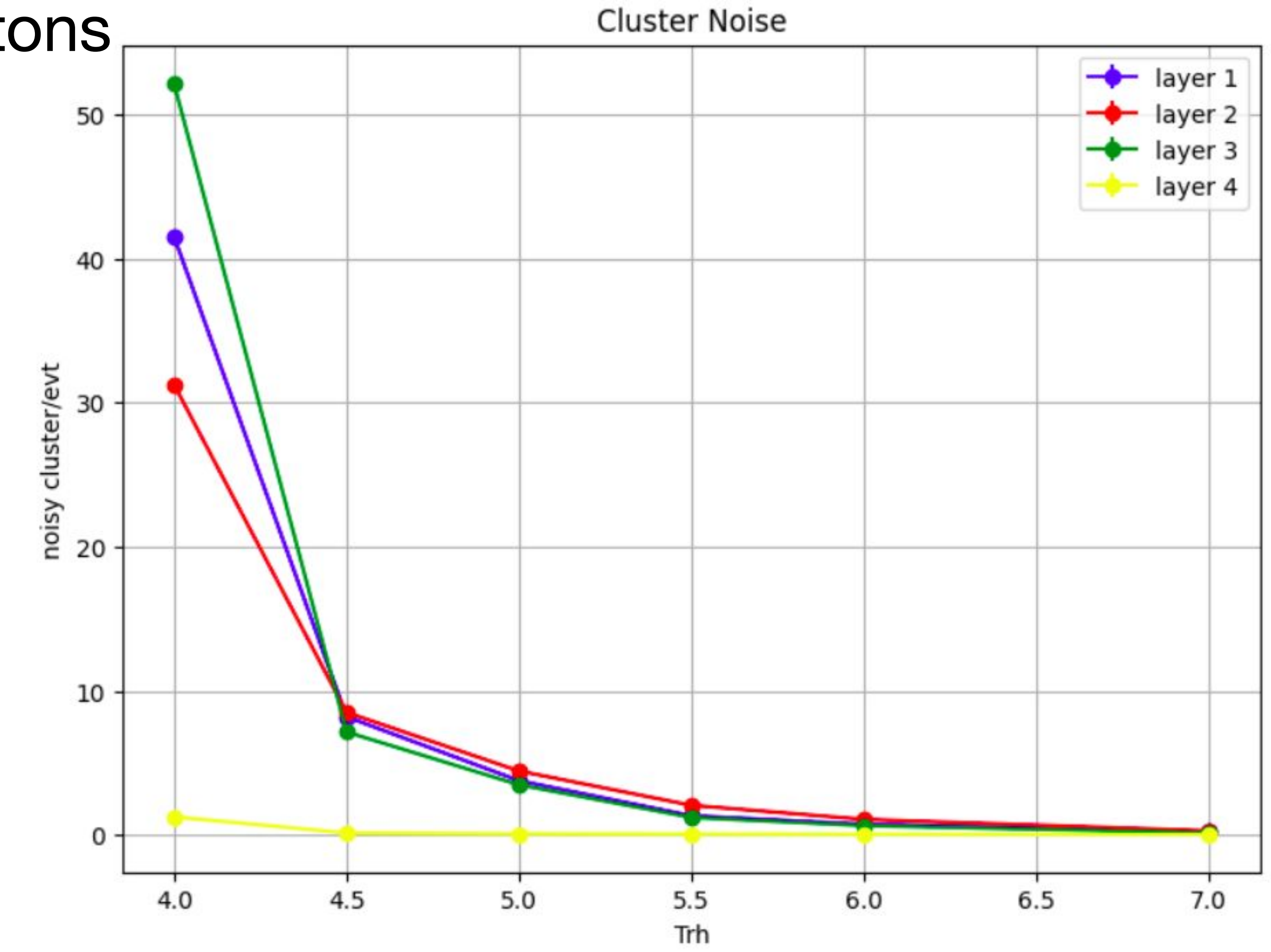



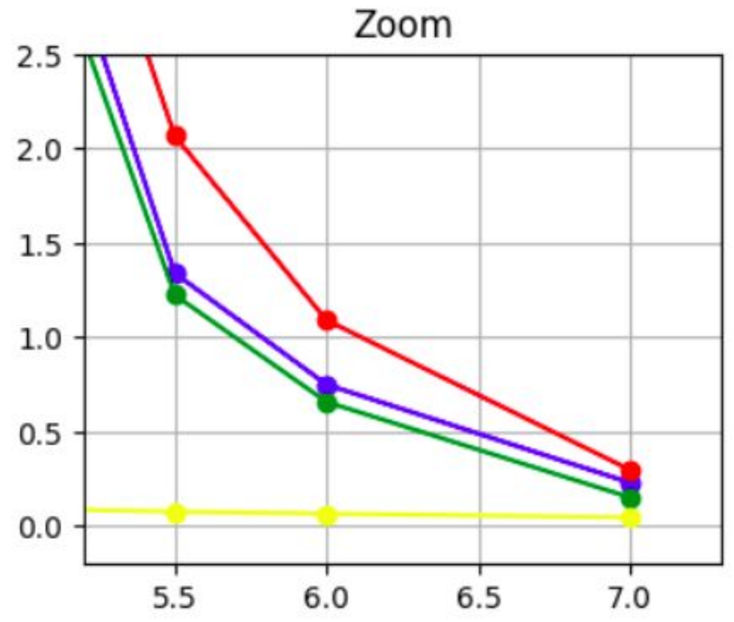

Only the sensor 4 can operate at 4σ !!!

# Noise

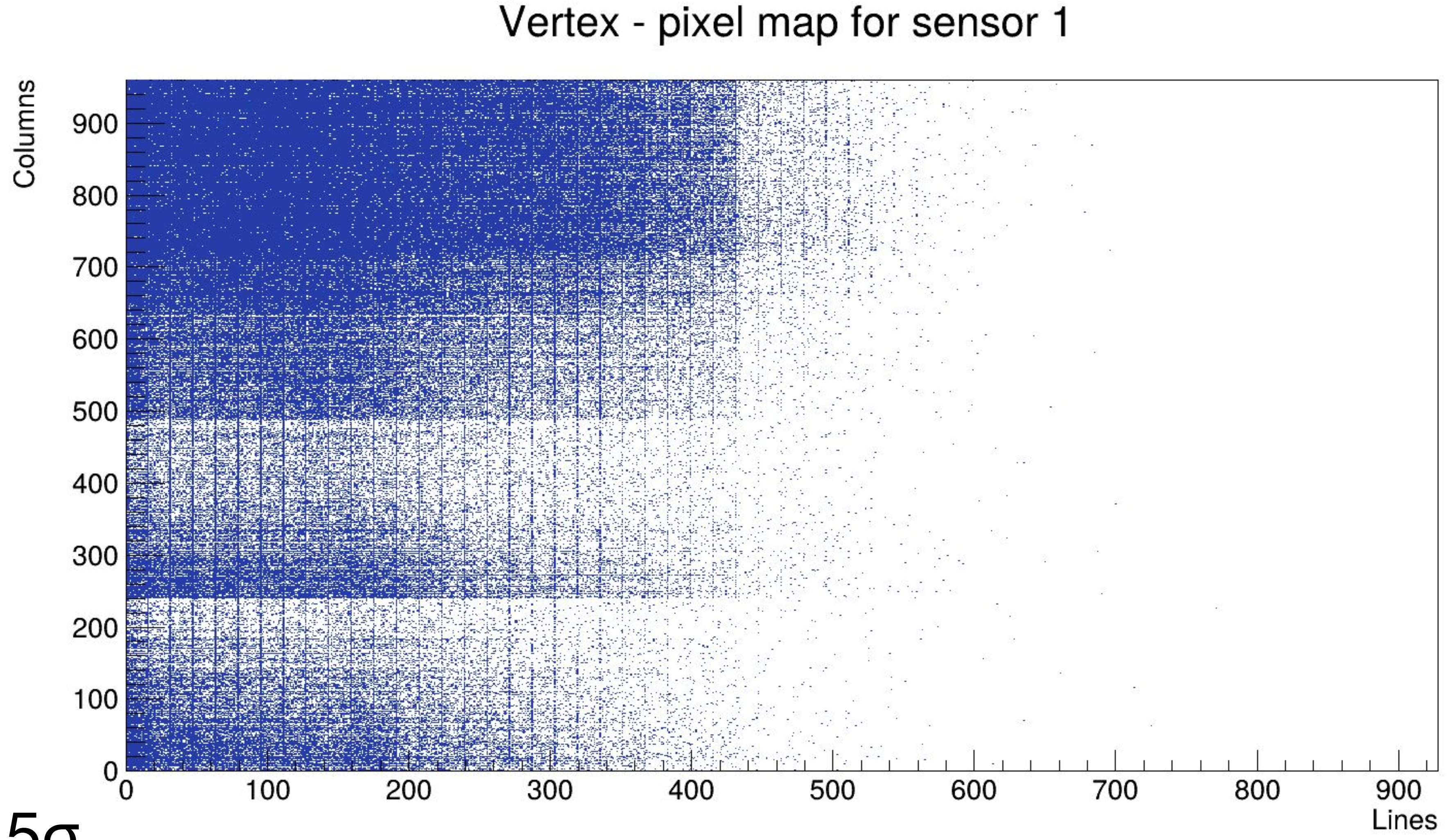
230MeV protons

Data:

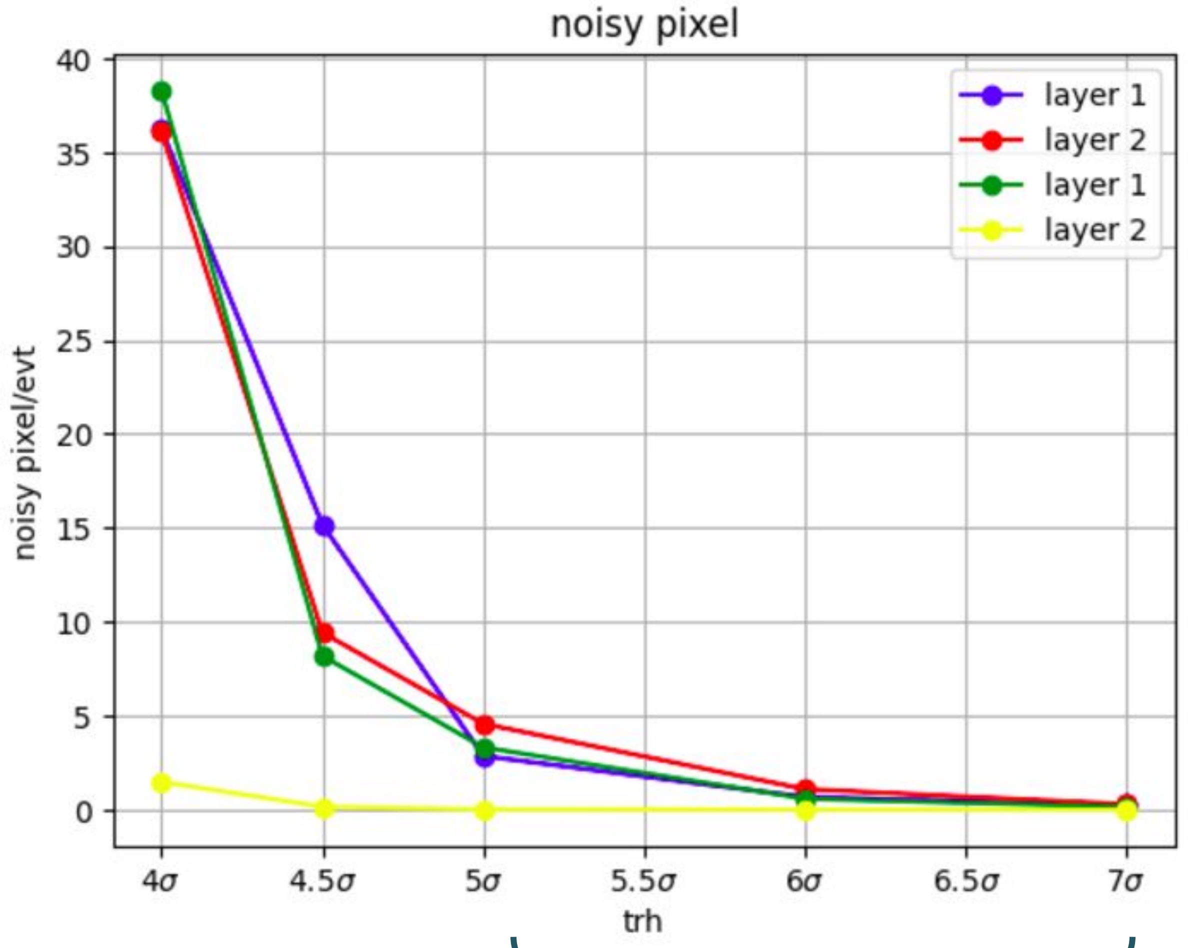


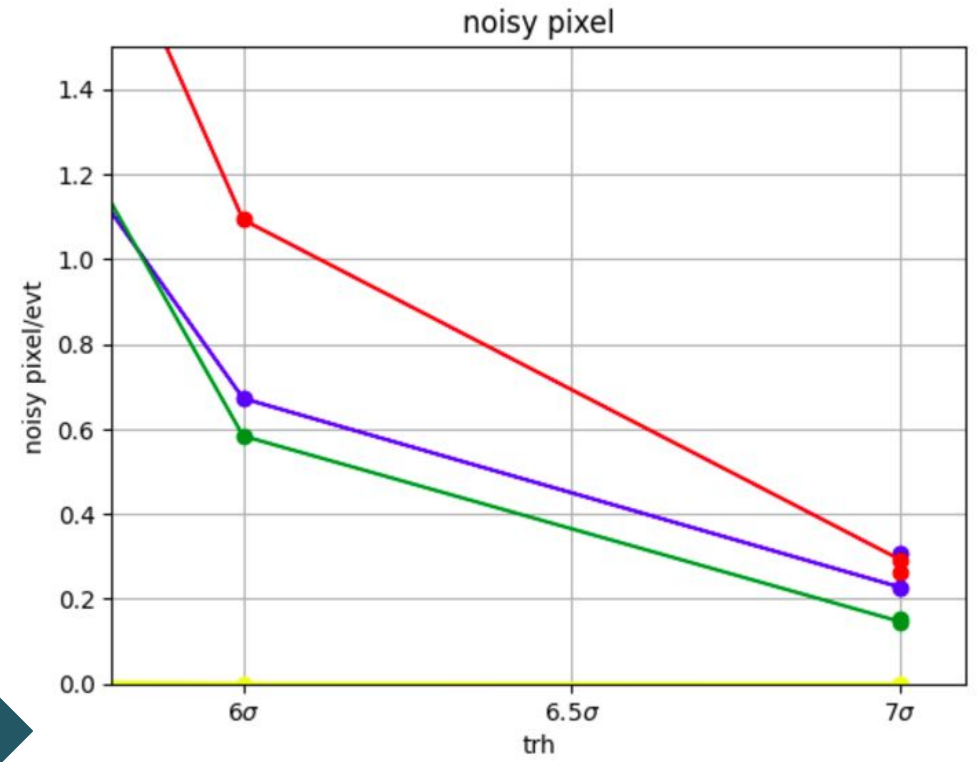




- 4σ

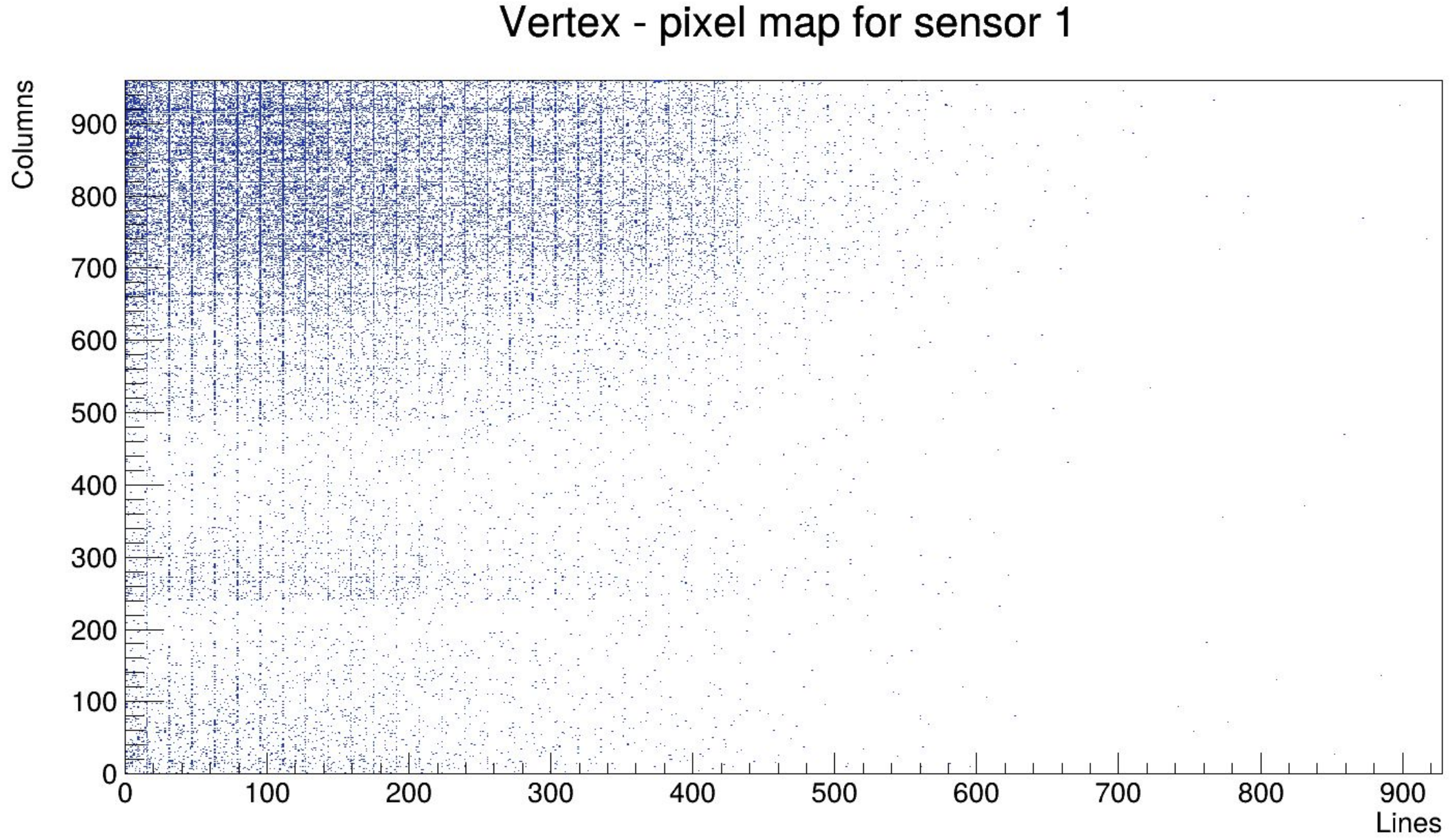



Pedestal :



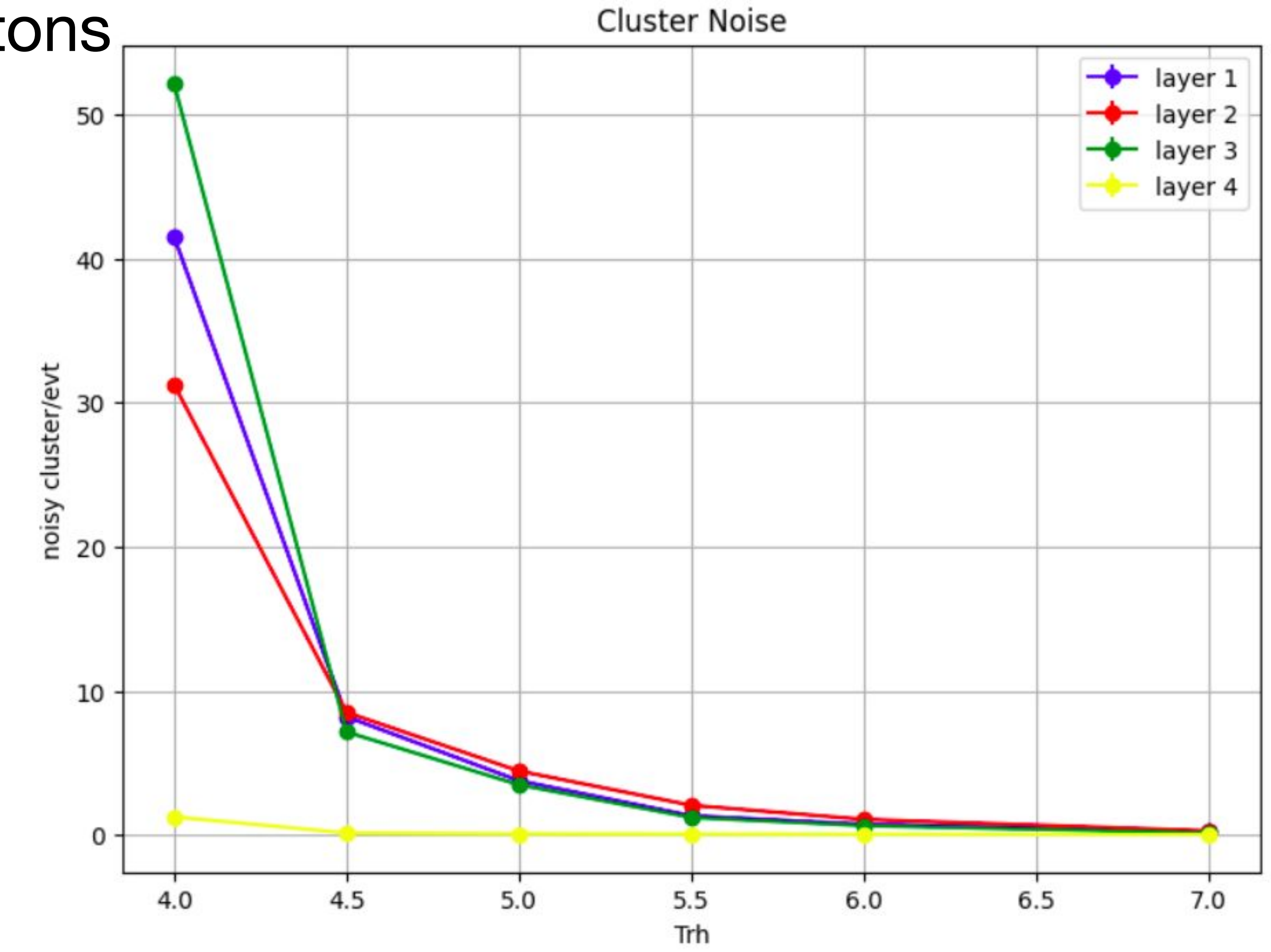

- 4.5σ

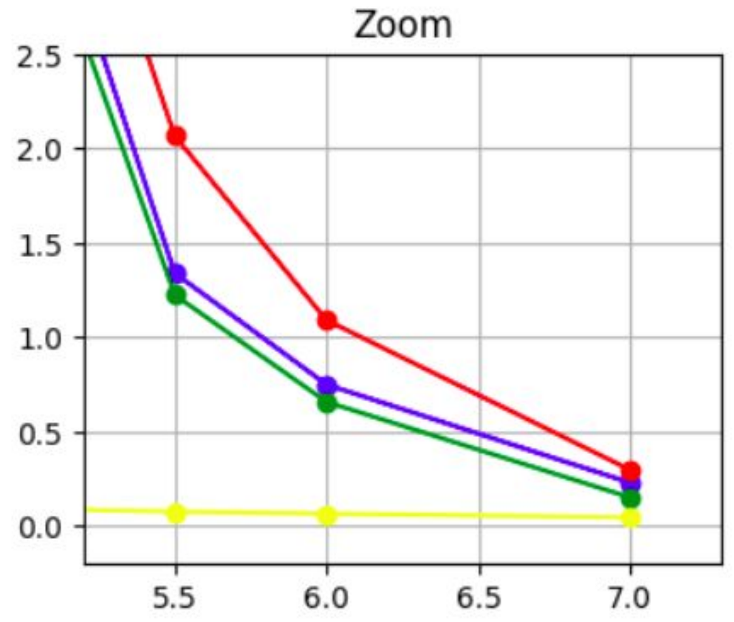


# Noise

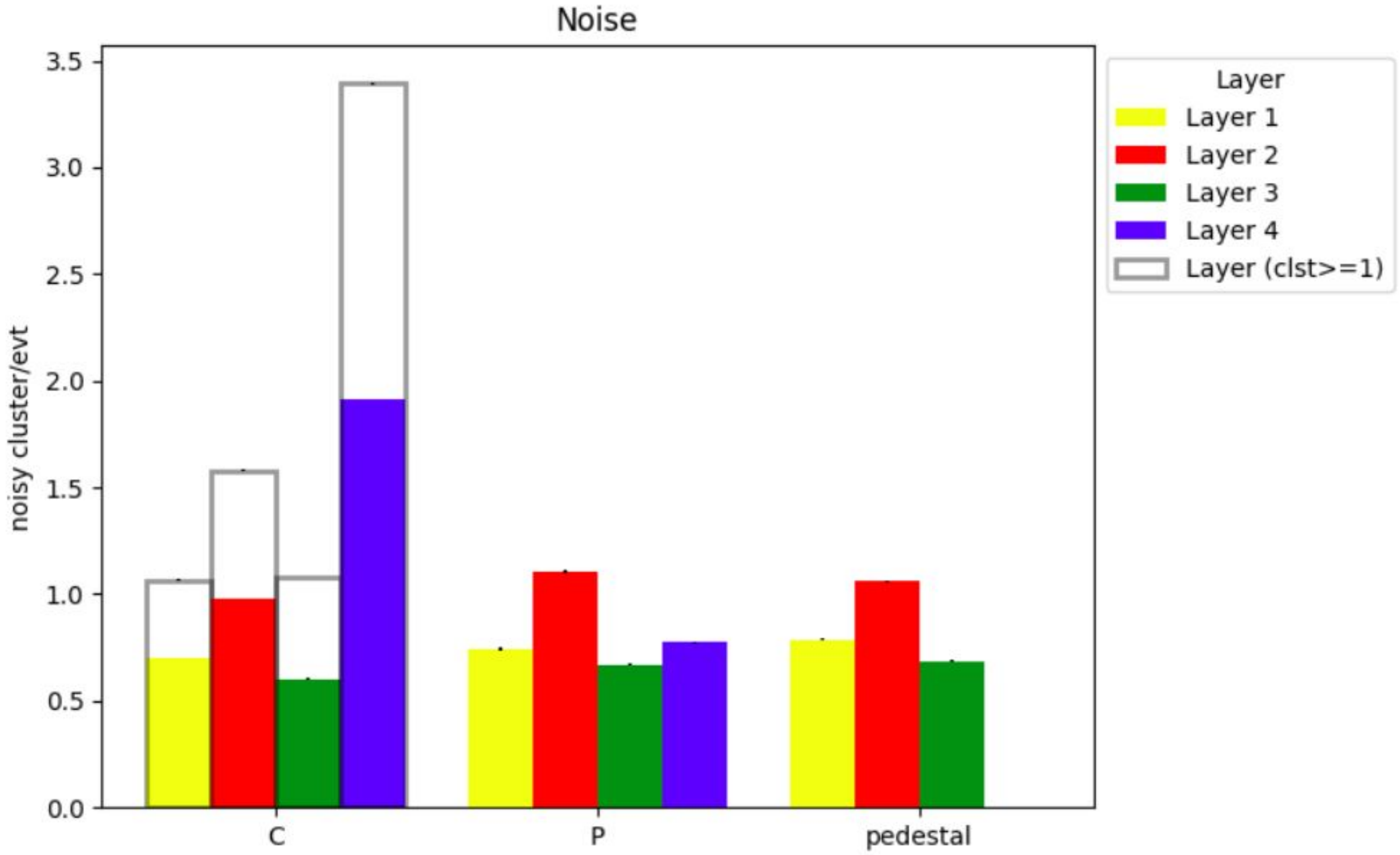
230MeV protons

## Data:

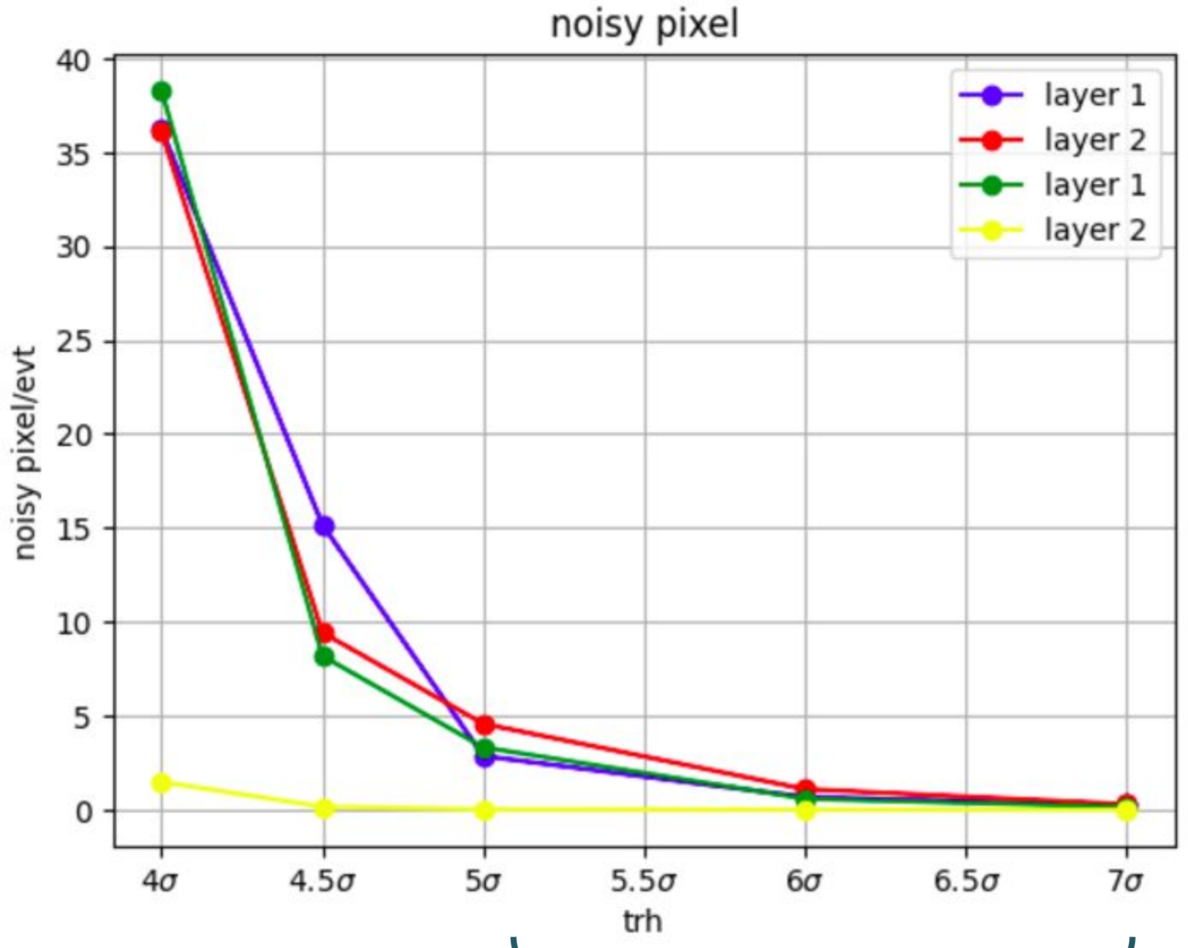


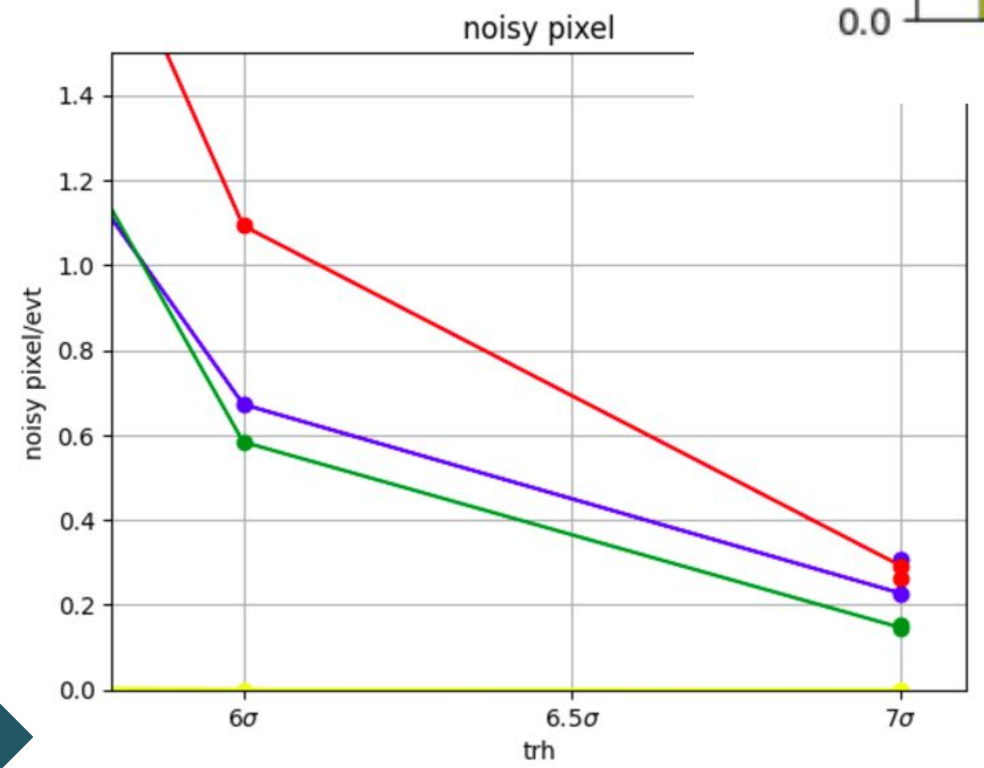




## Noise at 6σ:




## Pedestal :

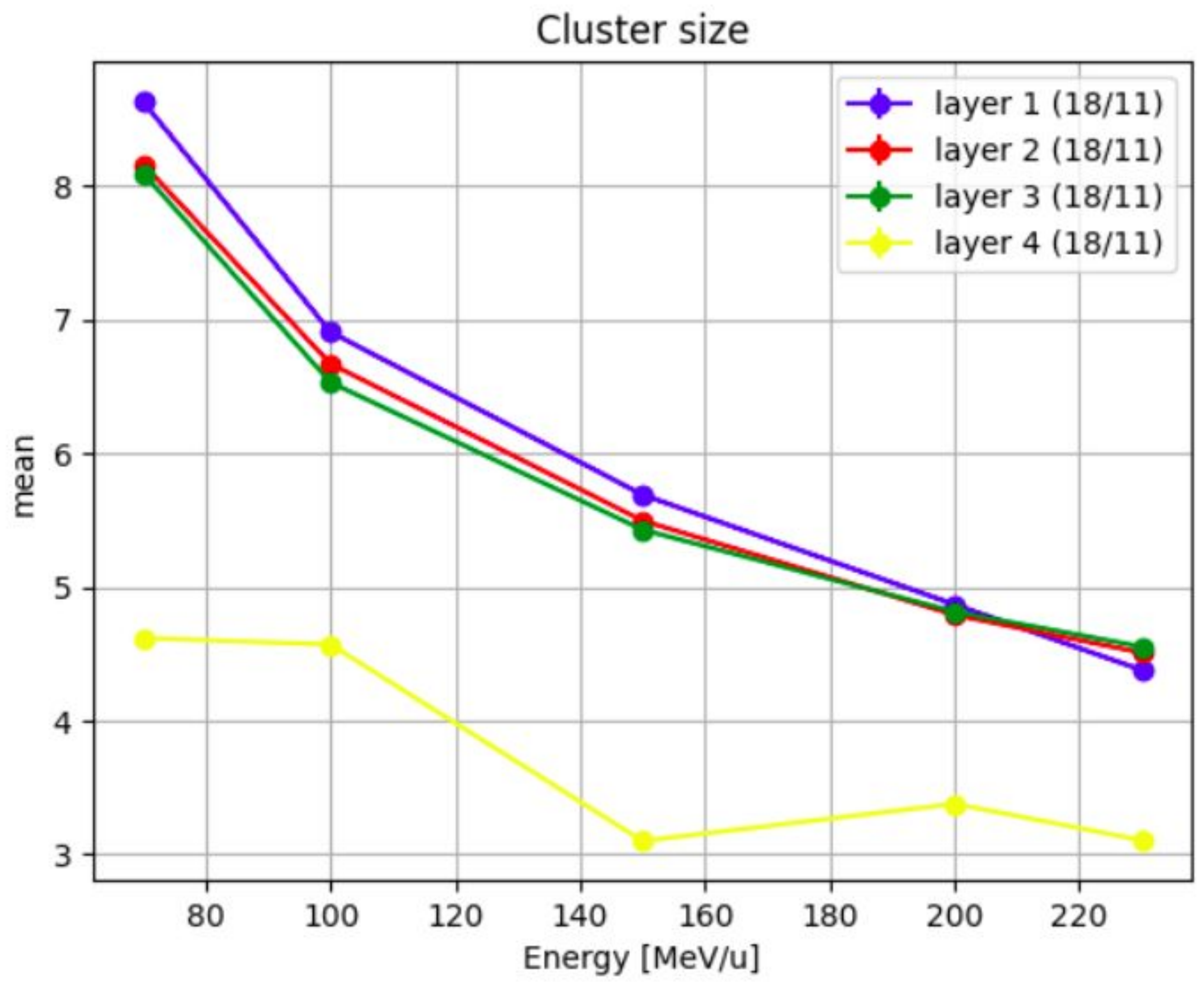


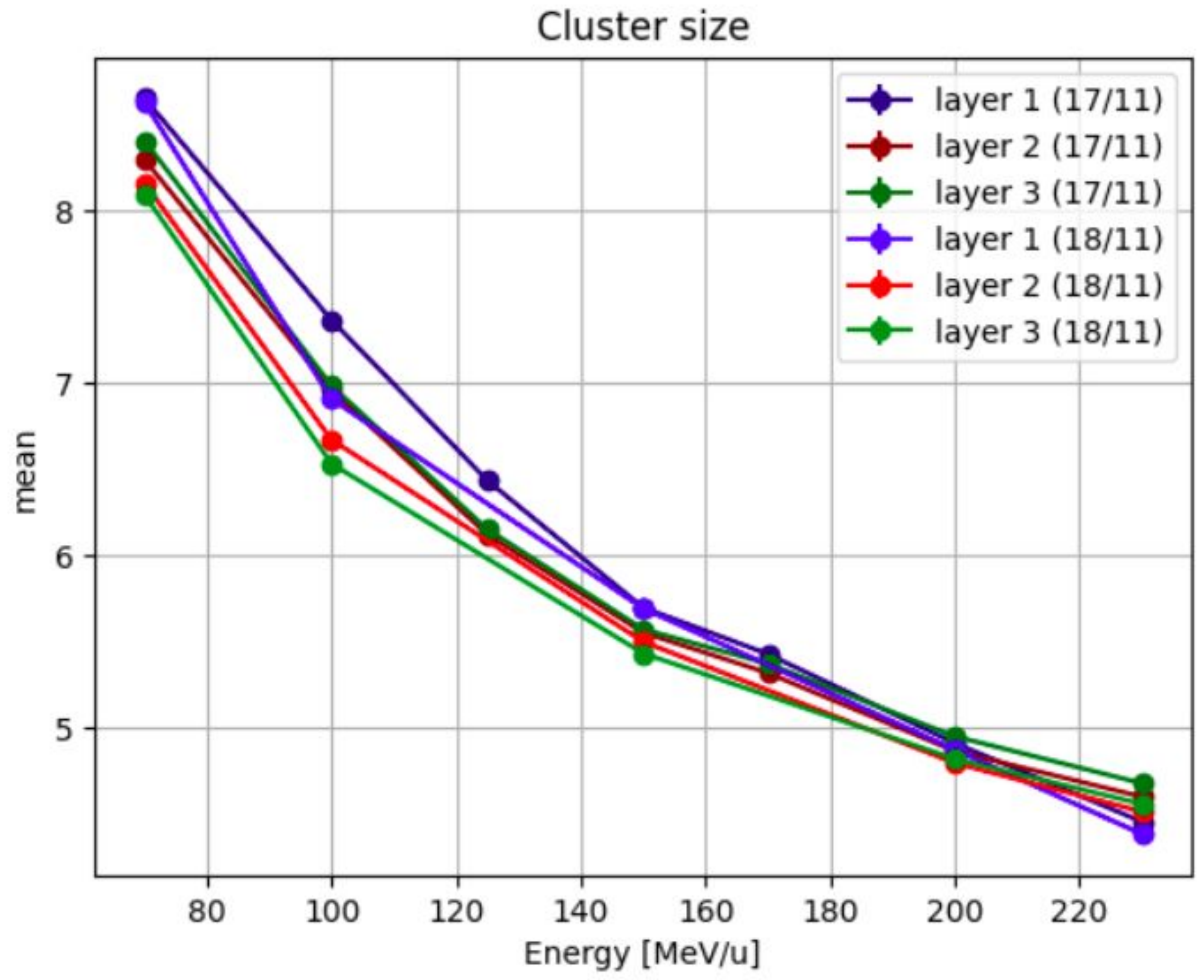
# 18/11/2024  Energy scan (6σ)

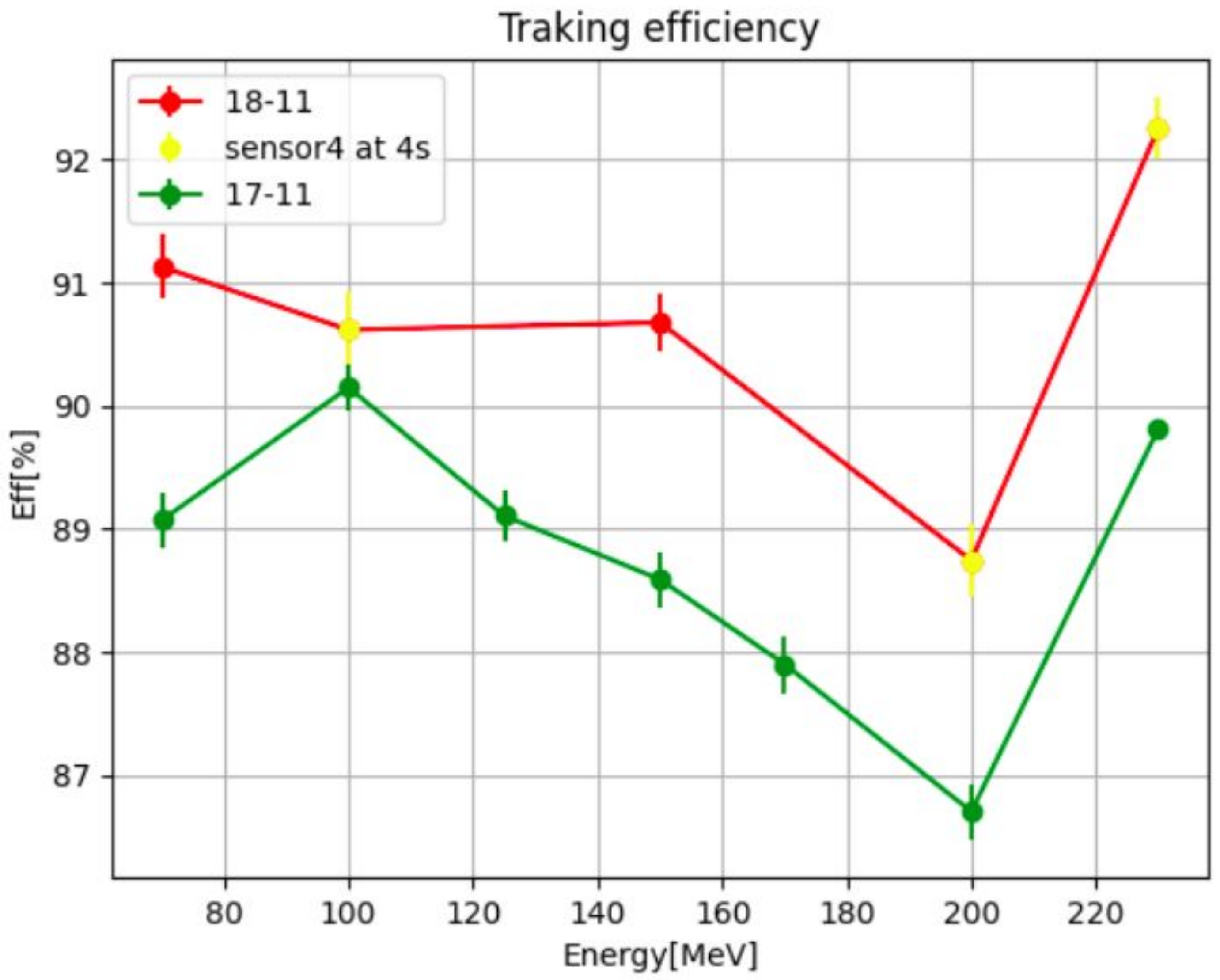
# Energy scan 18/11, and comparison with 17/11

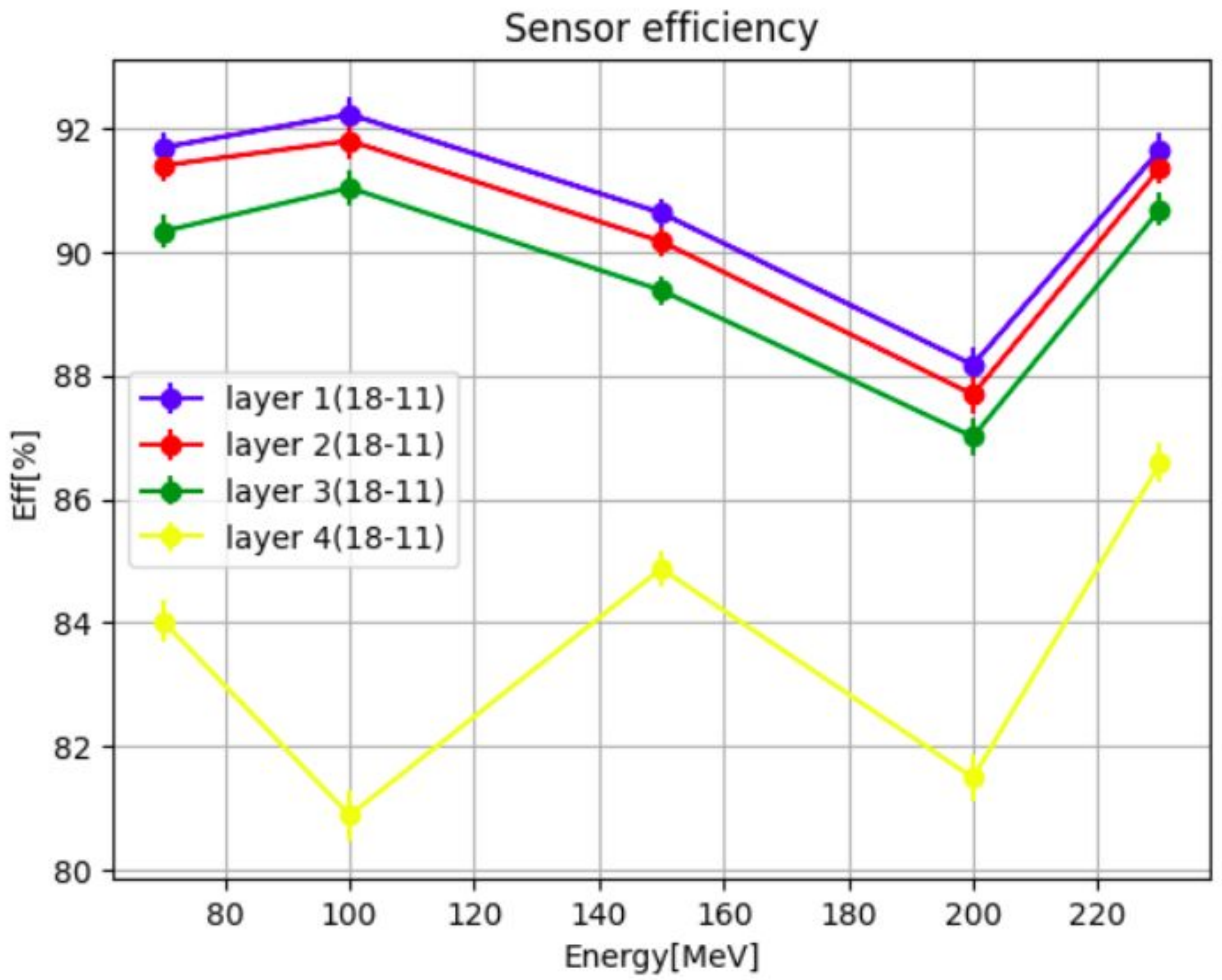
18/11/2024
run: 7019, 7021, 7022, 7024, 7025



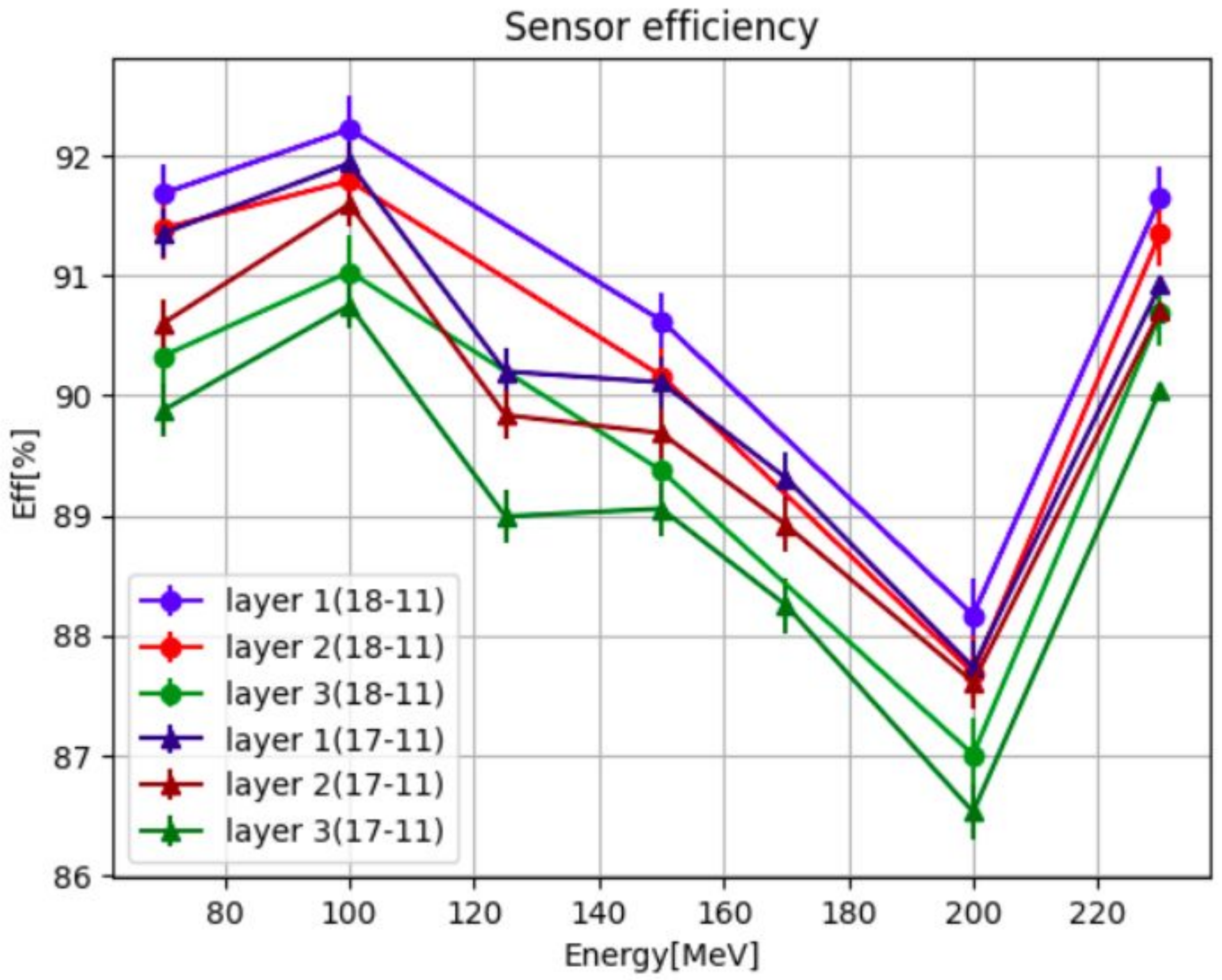

→




→



# Impact of threshold optimization on physics runs (C 200MeV/u)

❖ **Percentage of valid vertexes:**

$$\frac{\text{\#evt with a valid vtx, generated within the TG and matched with the BM}}{\text{\#evt with 1 BM track in the VTX acceptance}}$$

➢ **CNAO2023 ::** 1.371±0.029

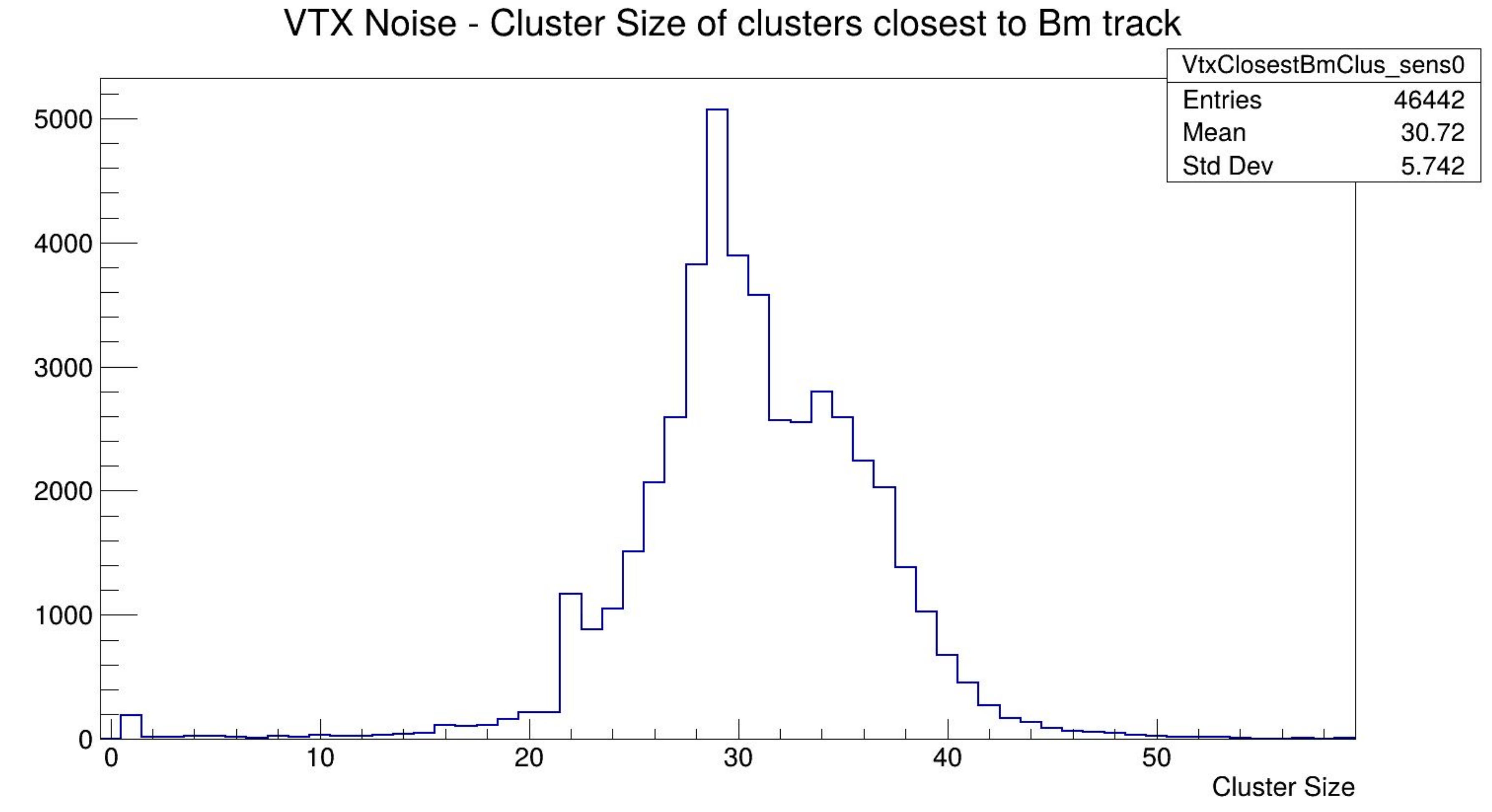
➢ **CNAO2024 ::** 1.810 ±0.037

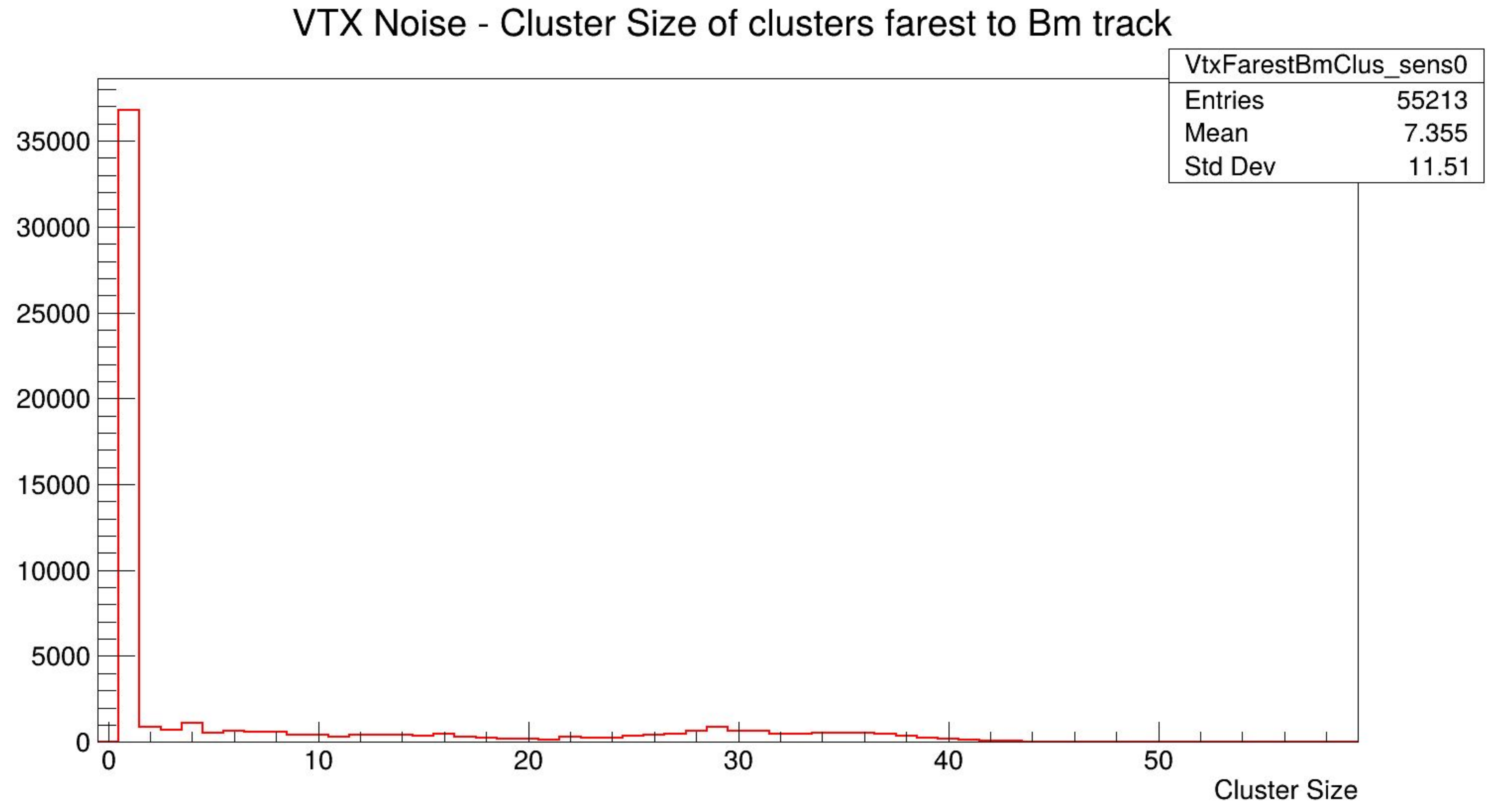
- same physics:
  - C 200MeV/u
- CNAO2024: Threshold optimization applied

It seems that optimizing the thresholds has increased the percentage of valid vertexes. This supports the hypothesis that, as expected, we are recovering fragmentation vertexes, (ex.: C->B+p).

Come fai..SBAI

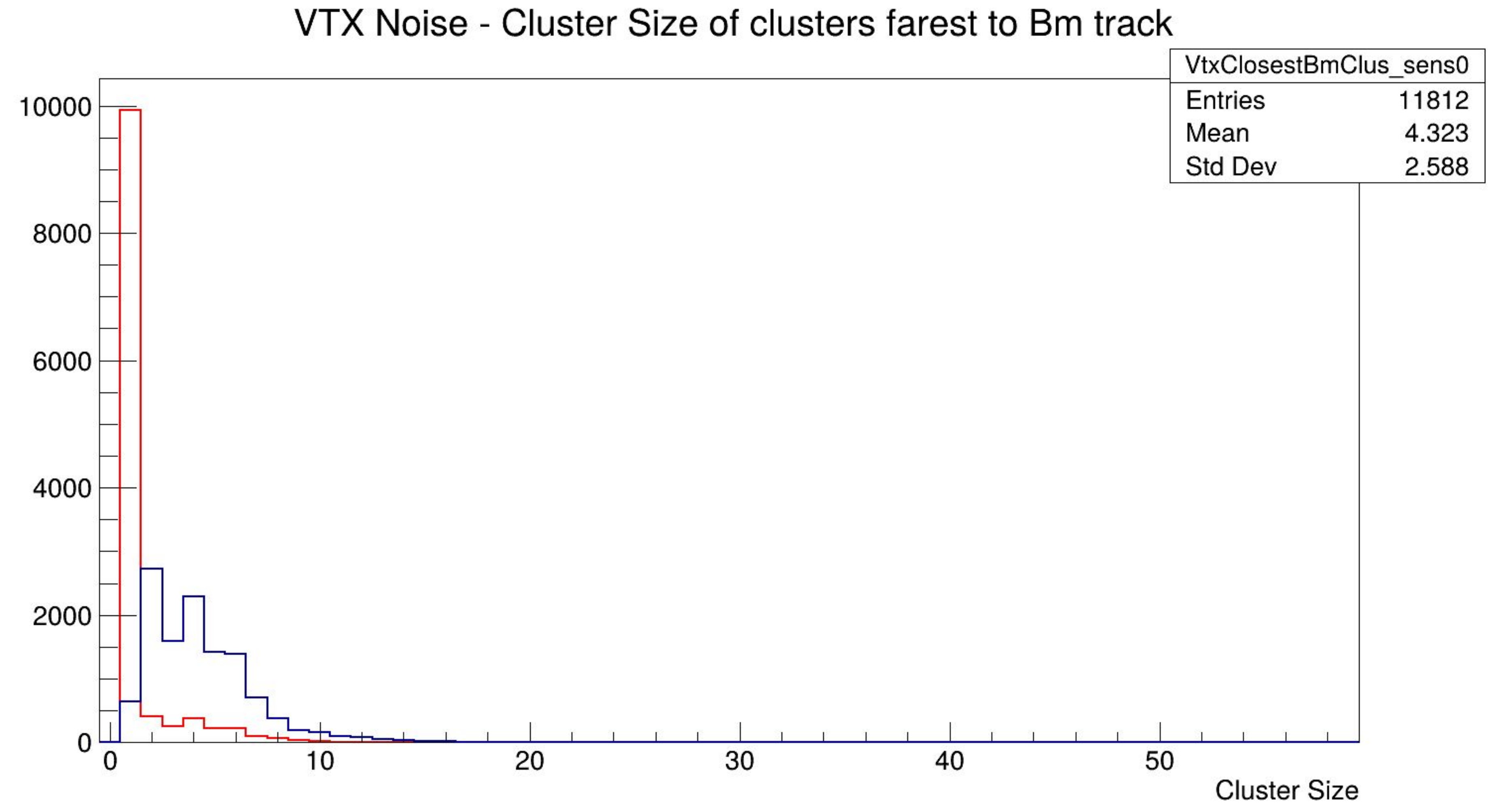
# Sensors efficiency -> Cluster size

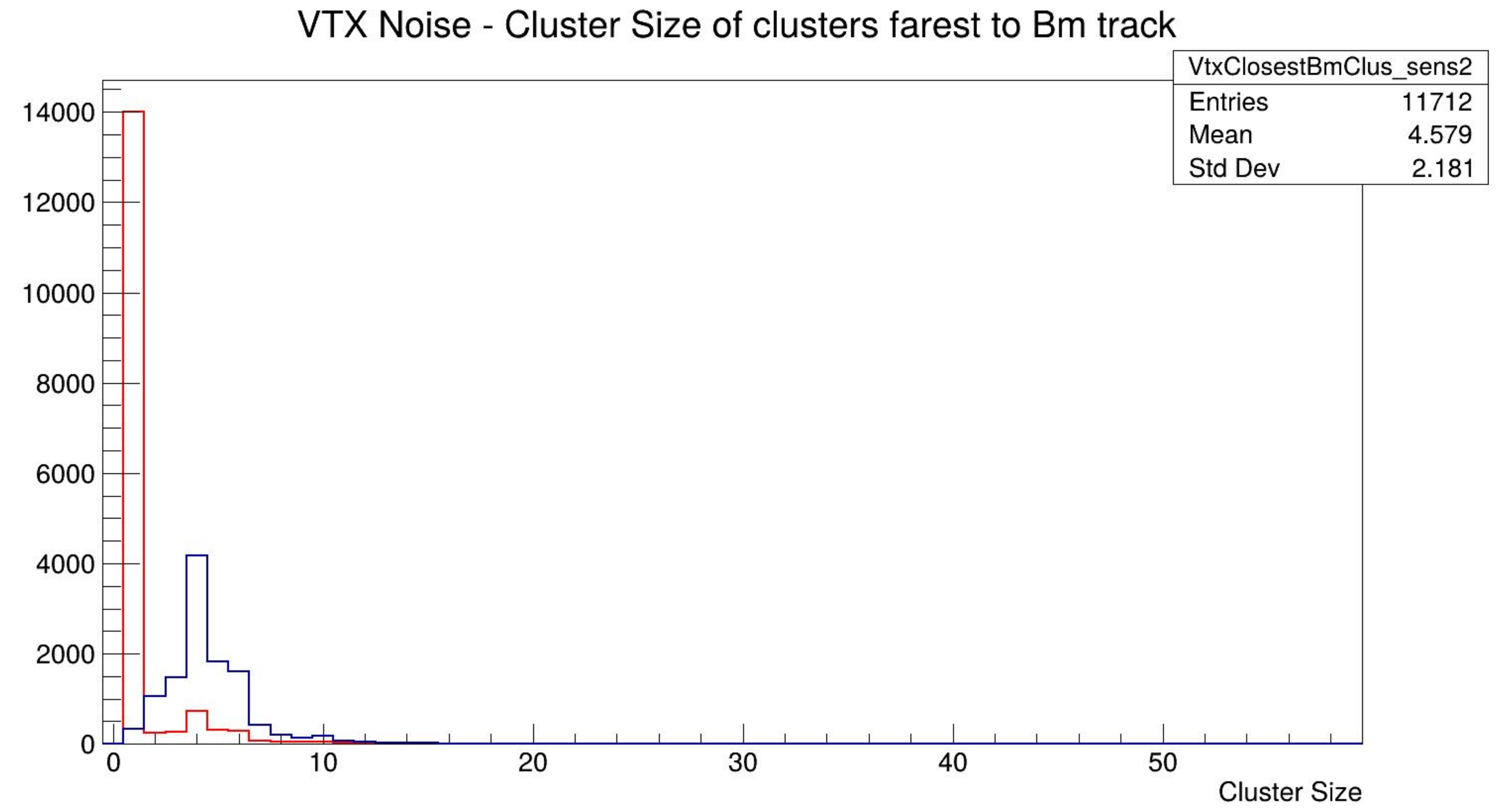



17/11/2024

C 200MeV/u, run: 6923

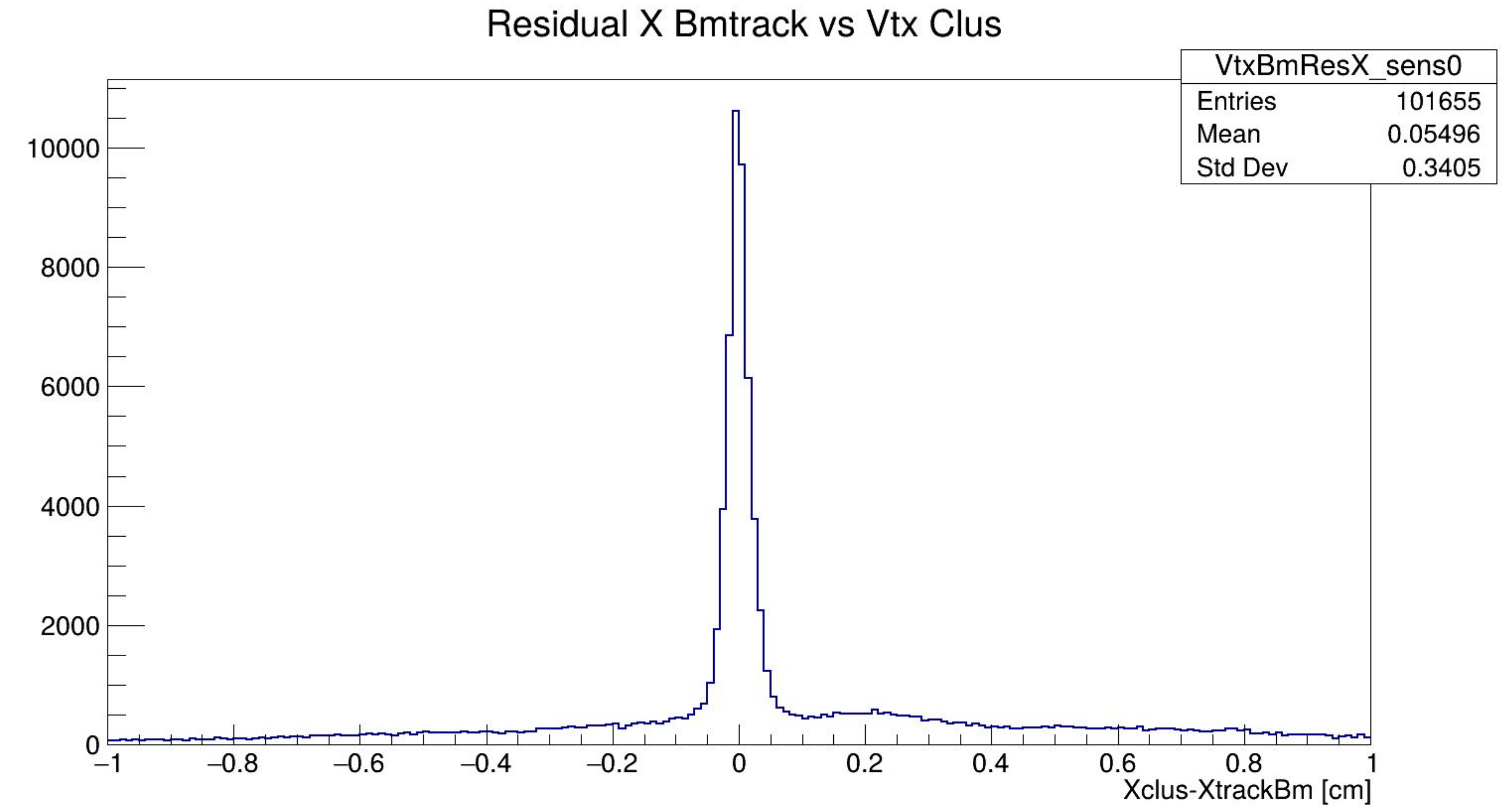


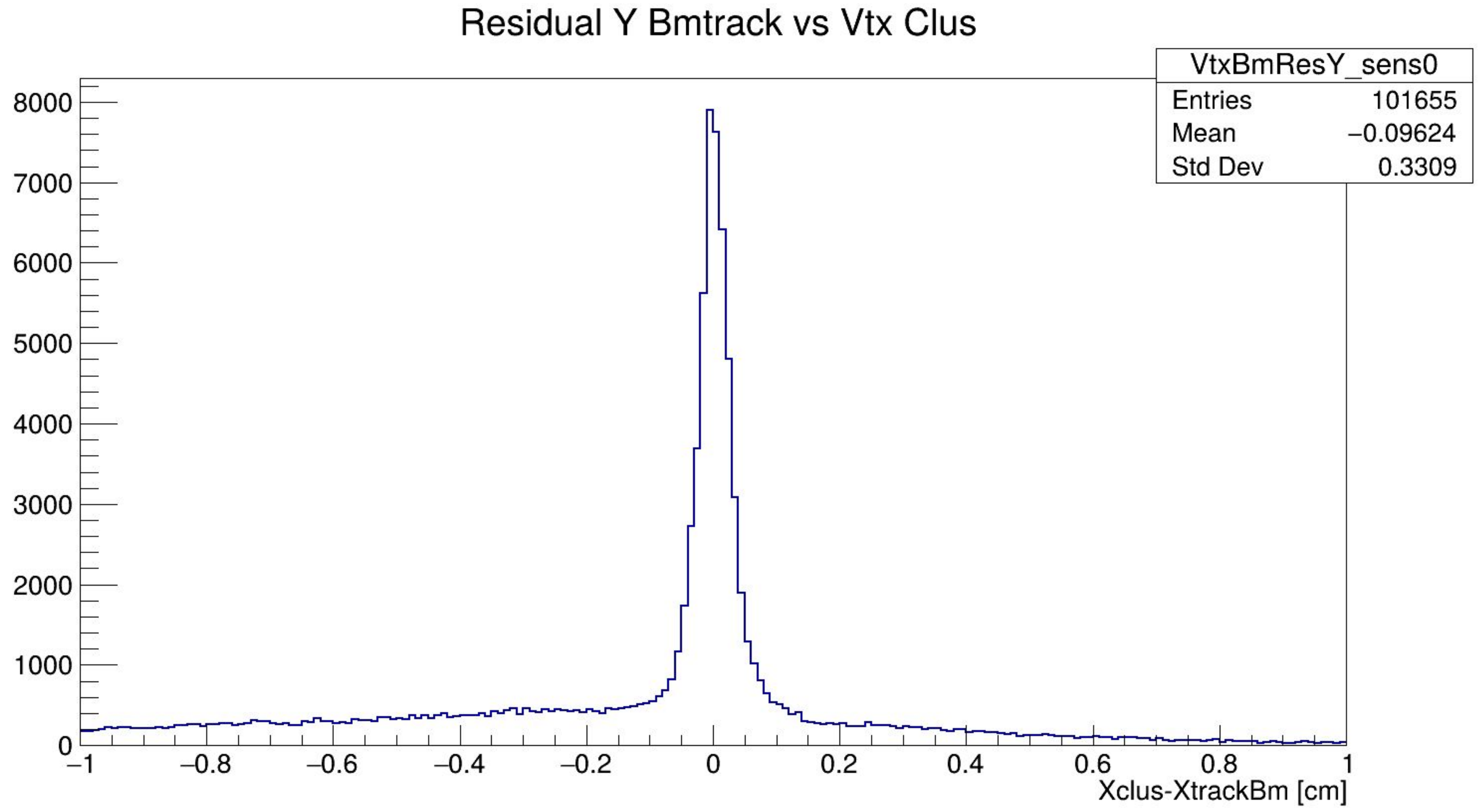




17/11/2024

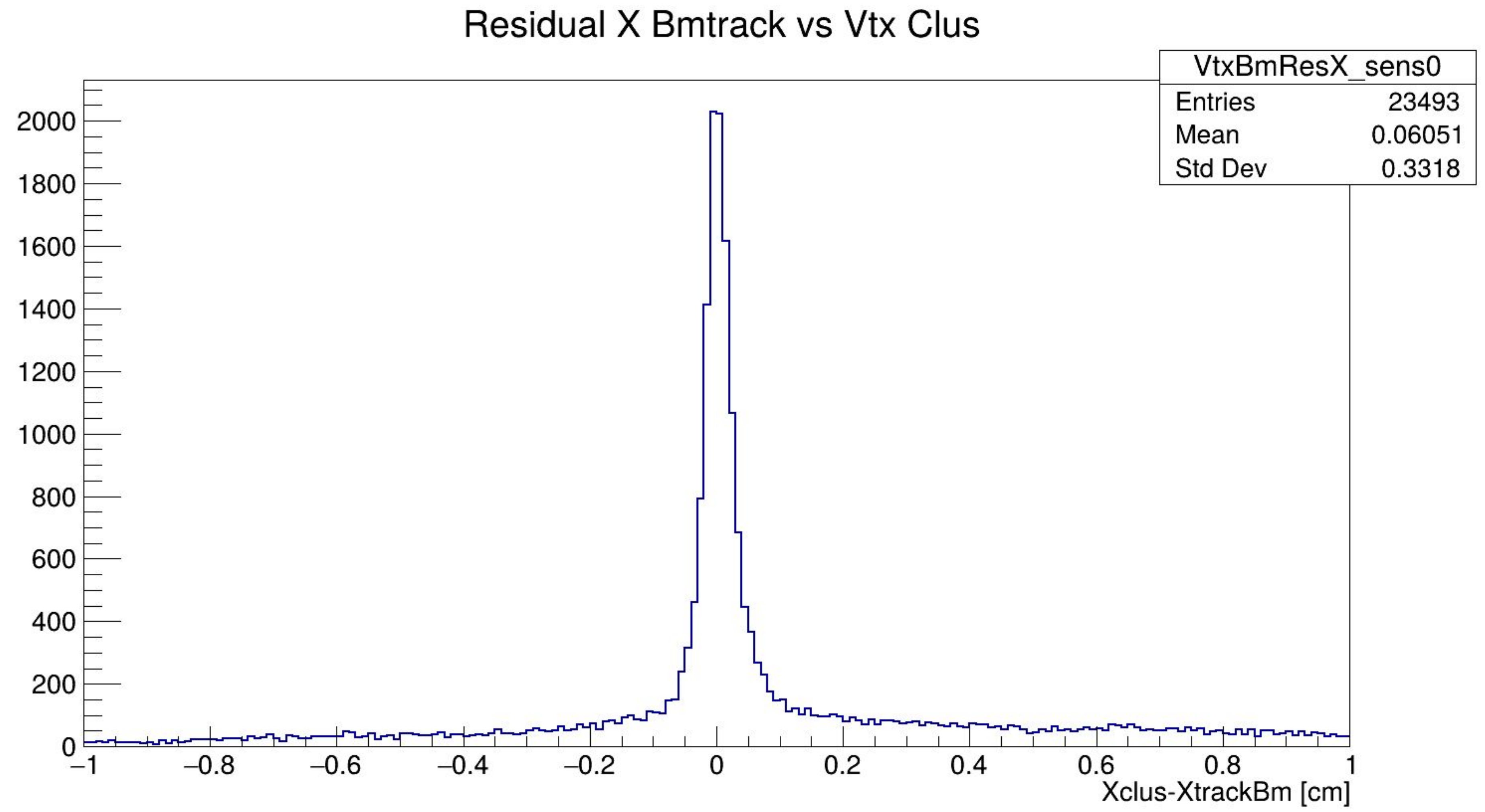
p 230MeV run: 6929

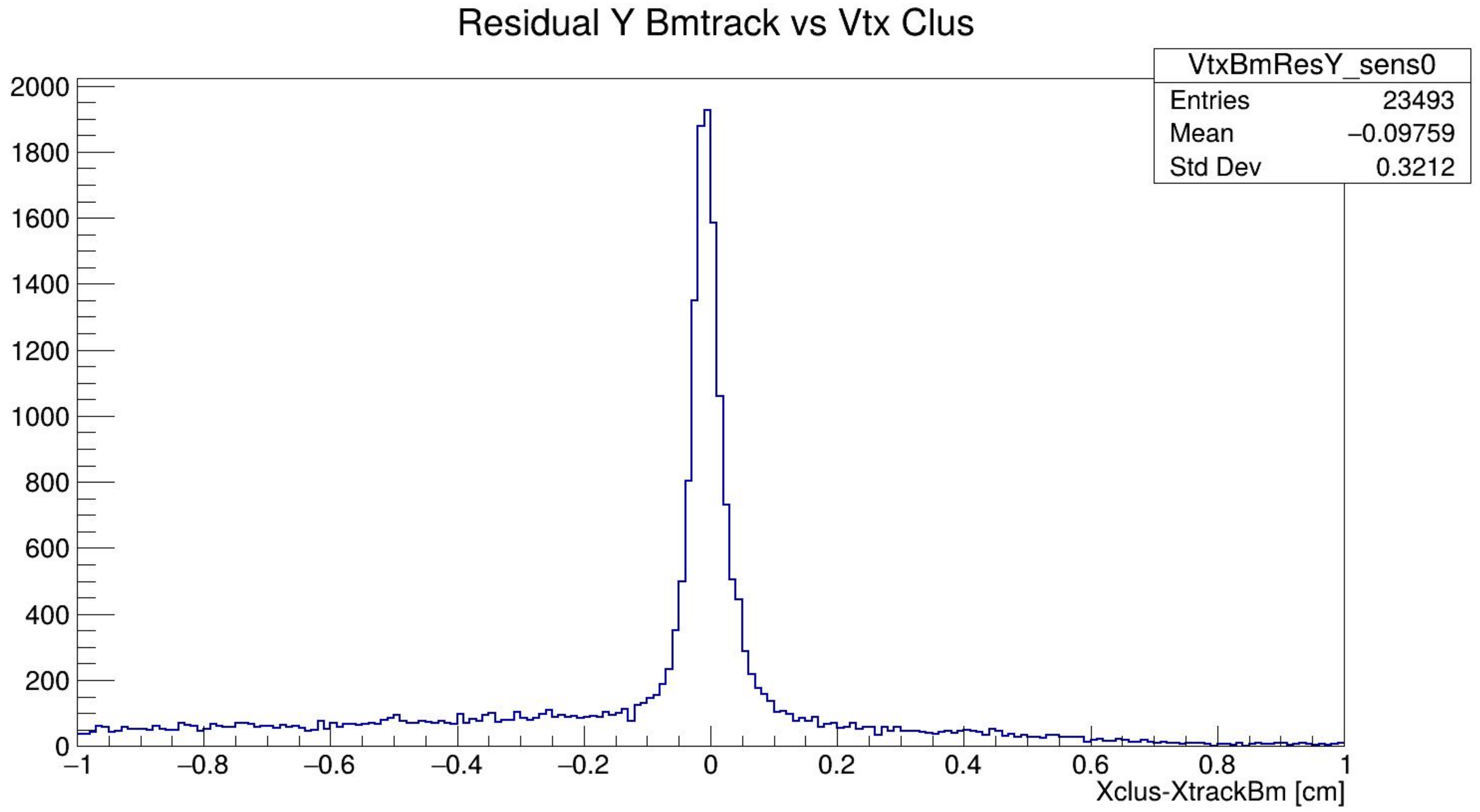
# Sensors efficiency -> Residual



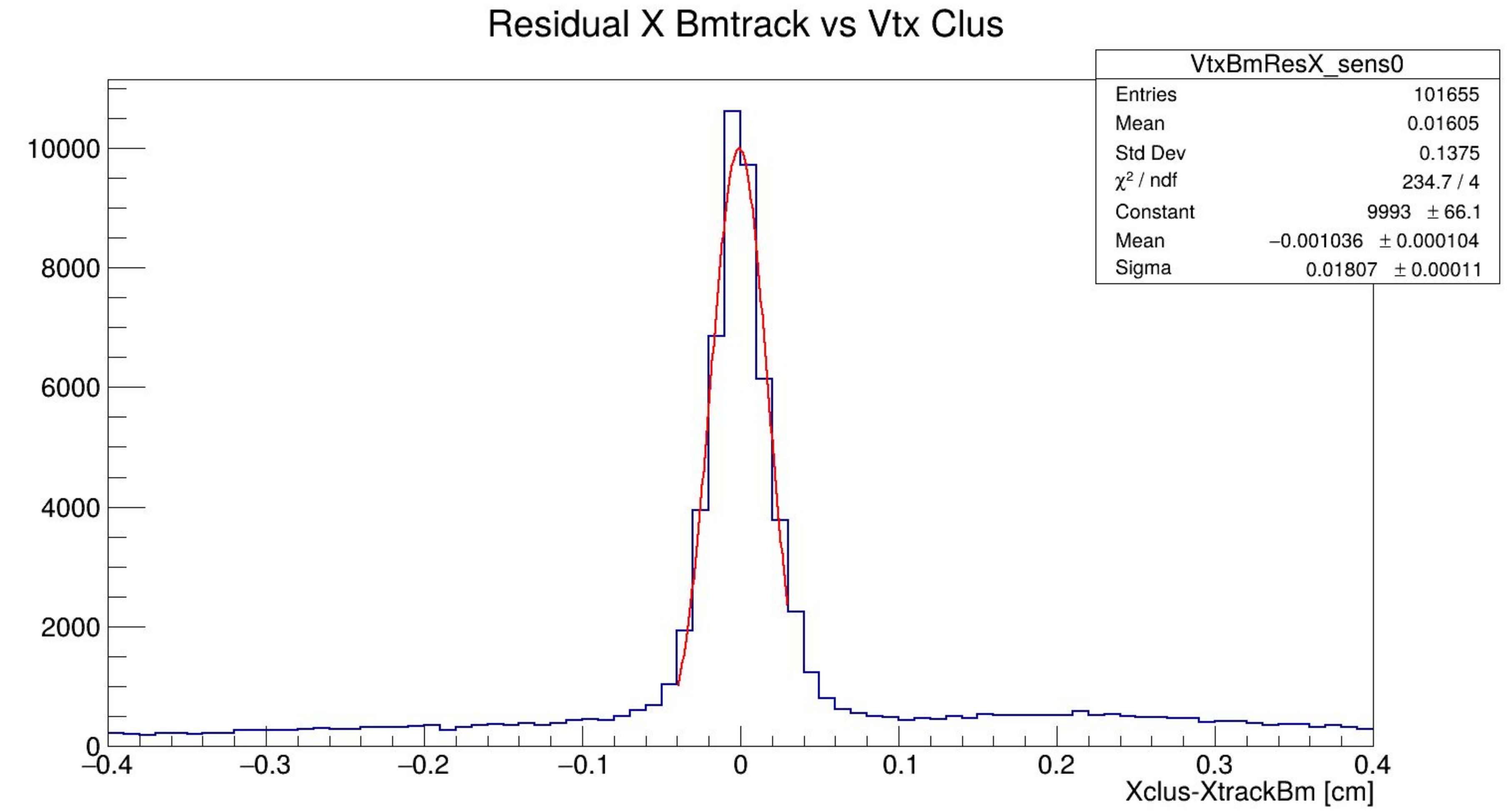

17/11/2024
C 200MeV/u run: 6923

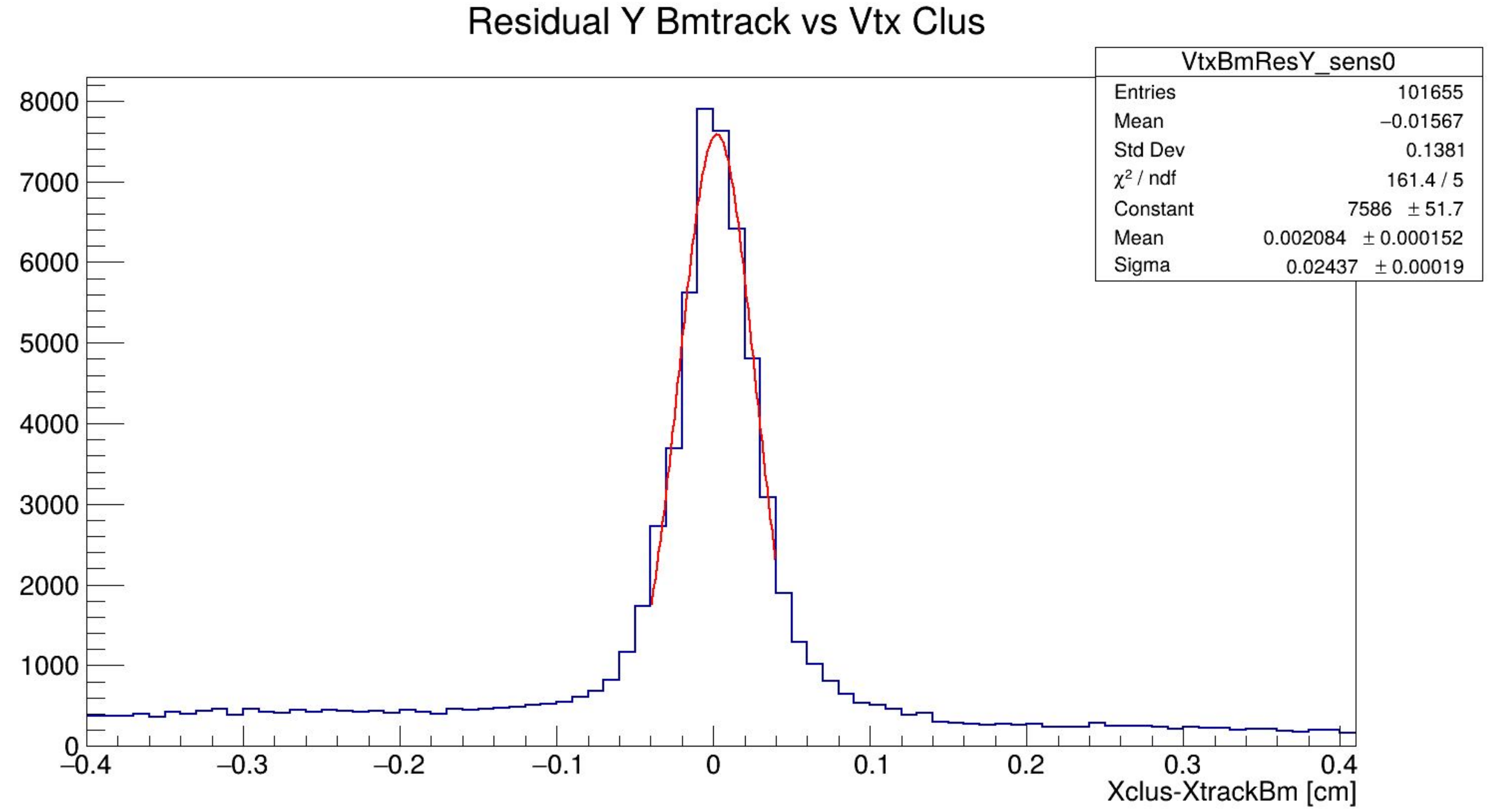


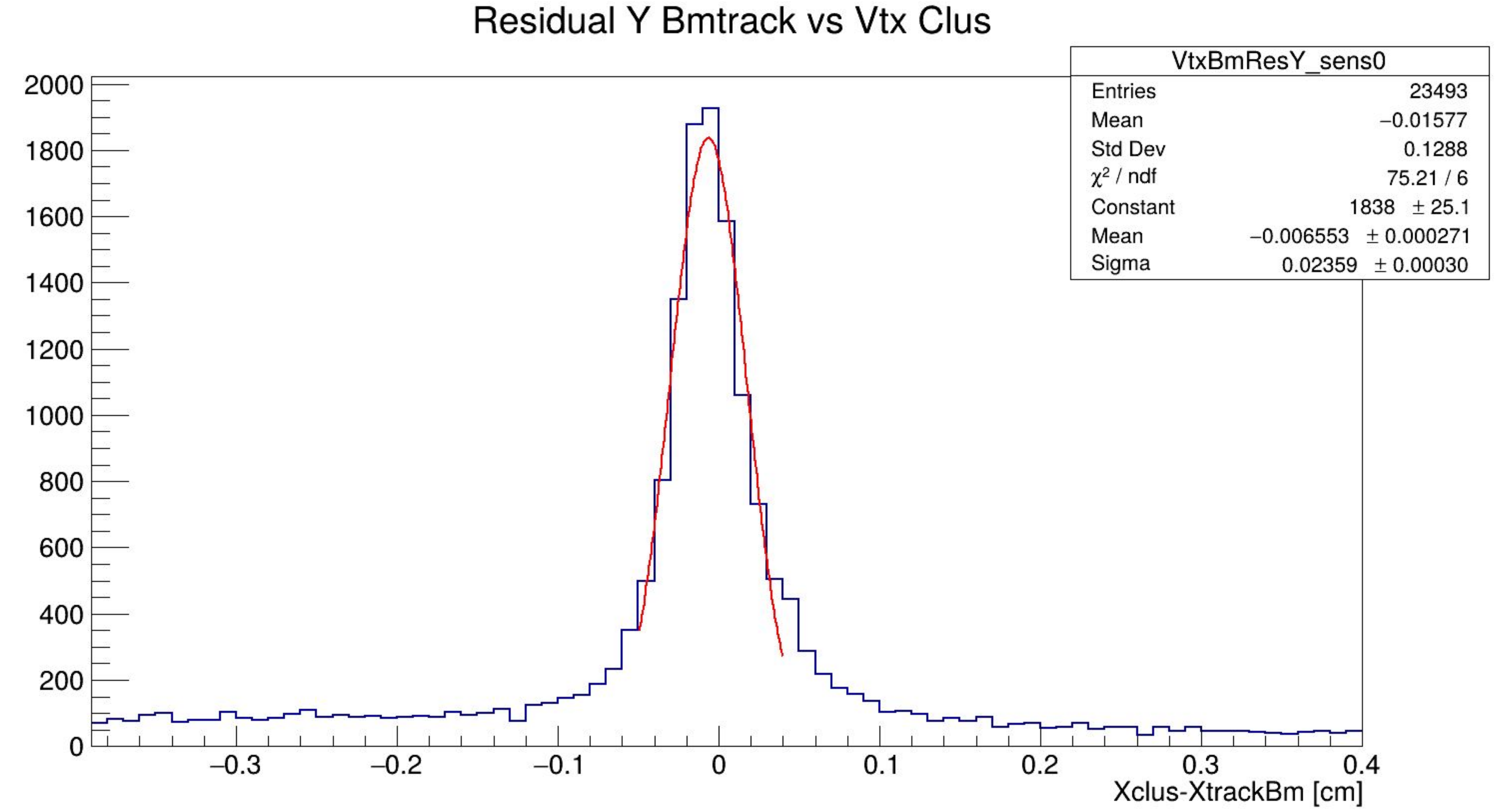

17/11/2024
p 230MeV run: 6929

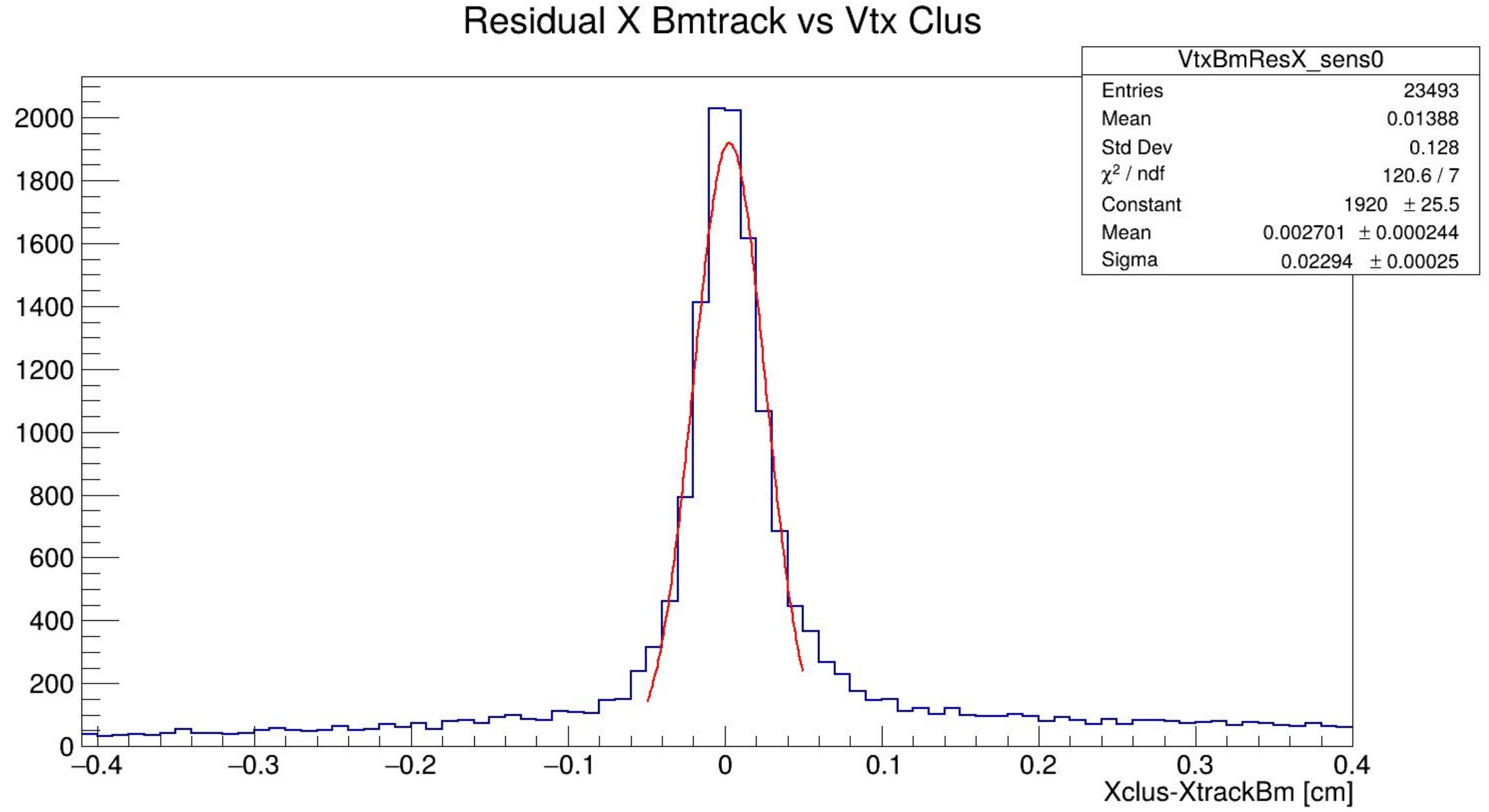
# Sensors efficiency -> Residual (6σ)



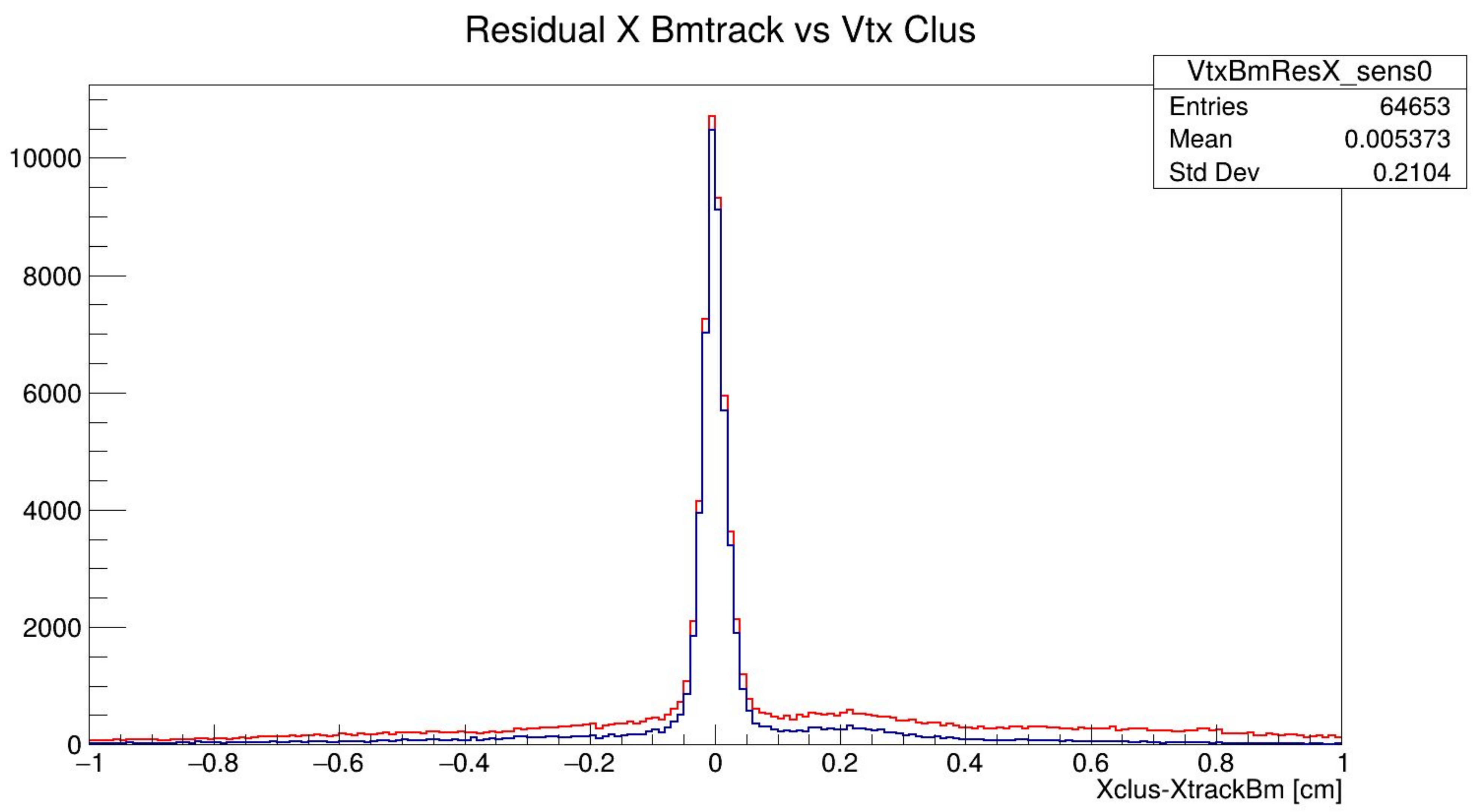

17/11/2024
C 200MeV/u run: 6923

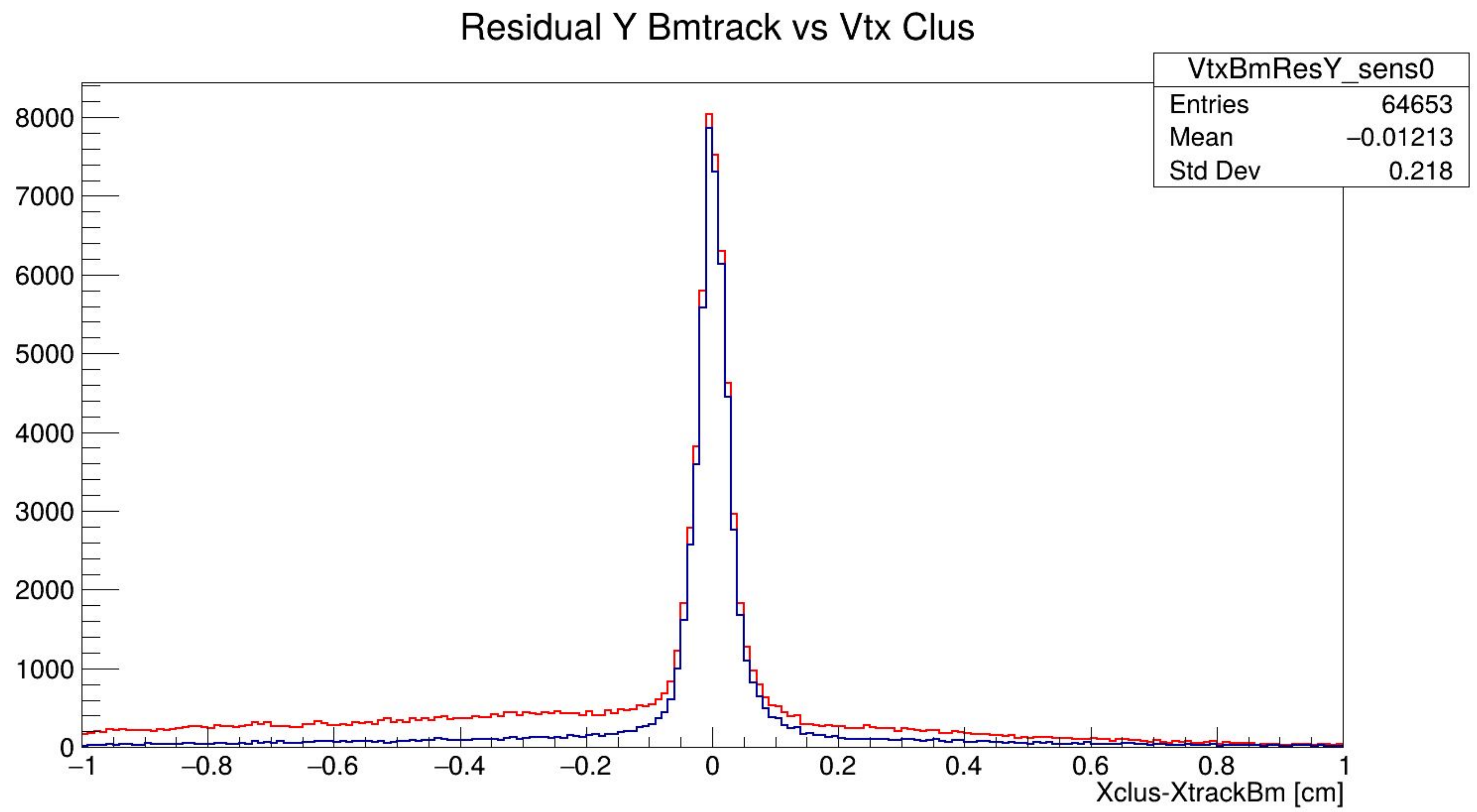



17/11/2024
p 230MeV run: 6929

# Sensors efficiency -> Residual




17/11/2024
C run: 6923

- Cluster size>=1
- Cluster size>=2

Asymmetry of residual:

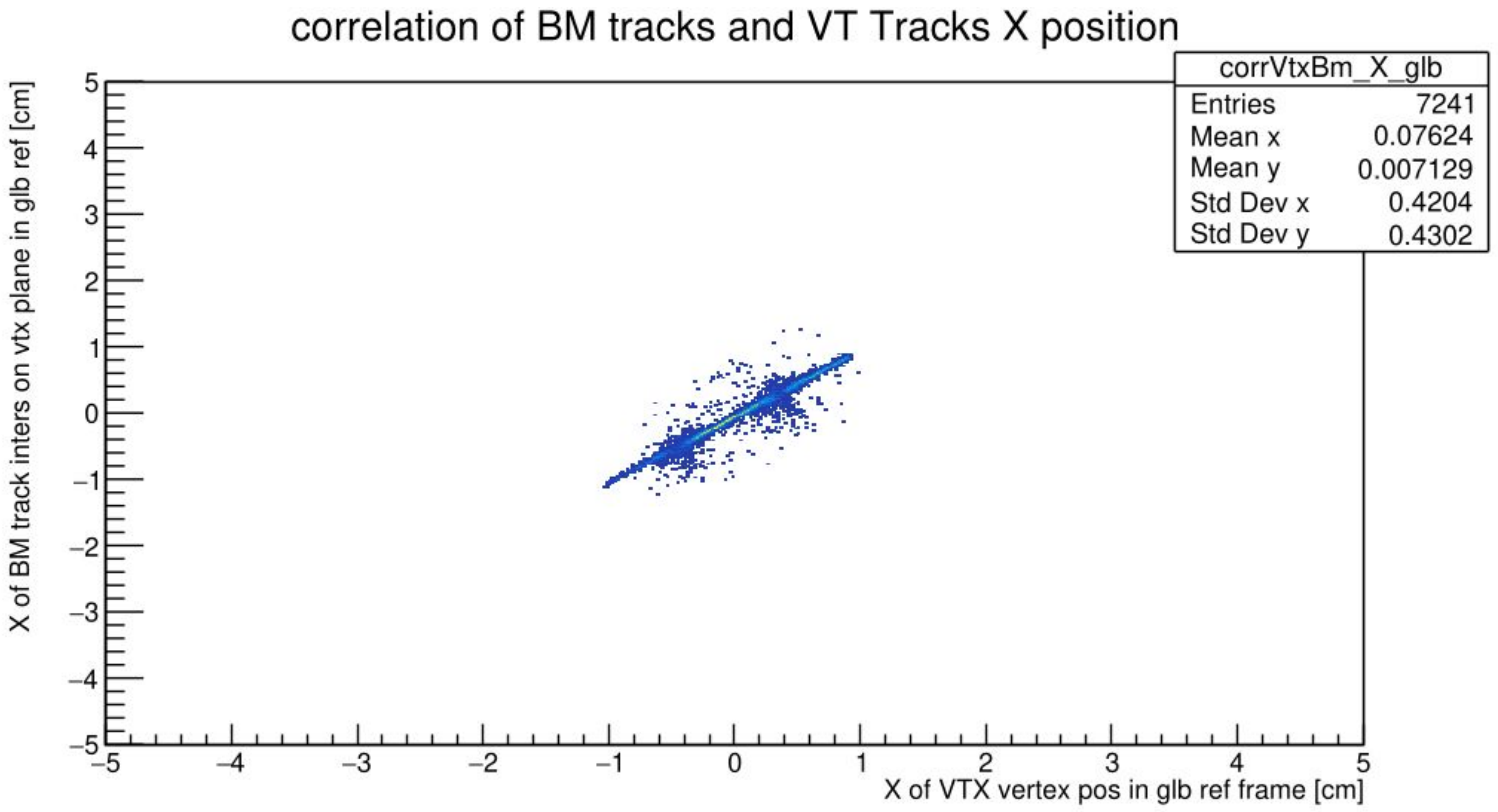
- present in all sensors
- present when eliminating noise at cluster size 1

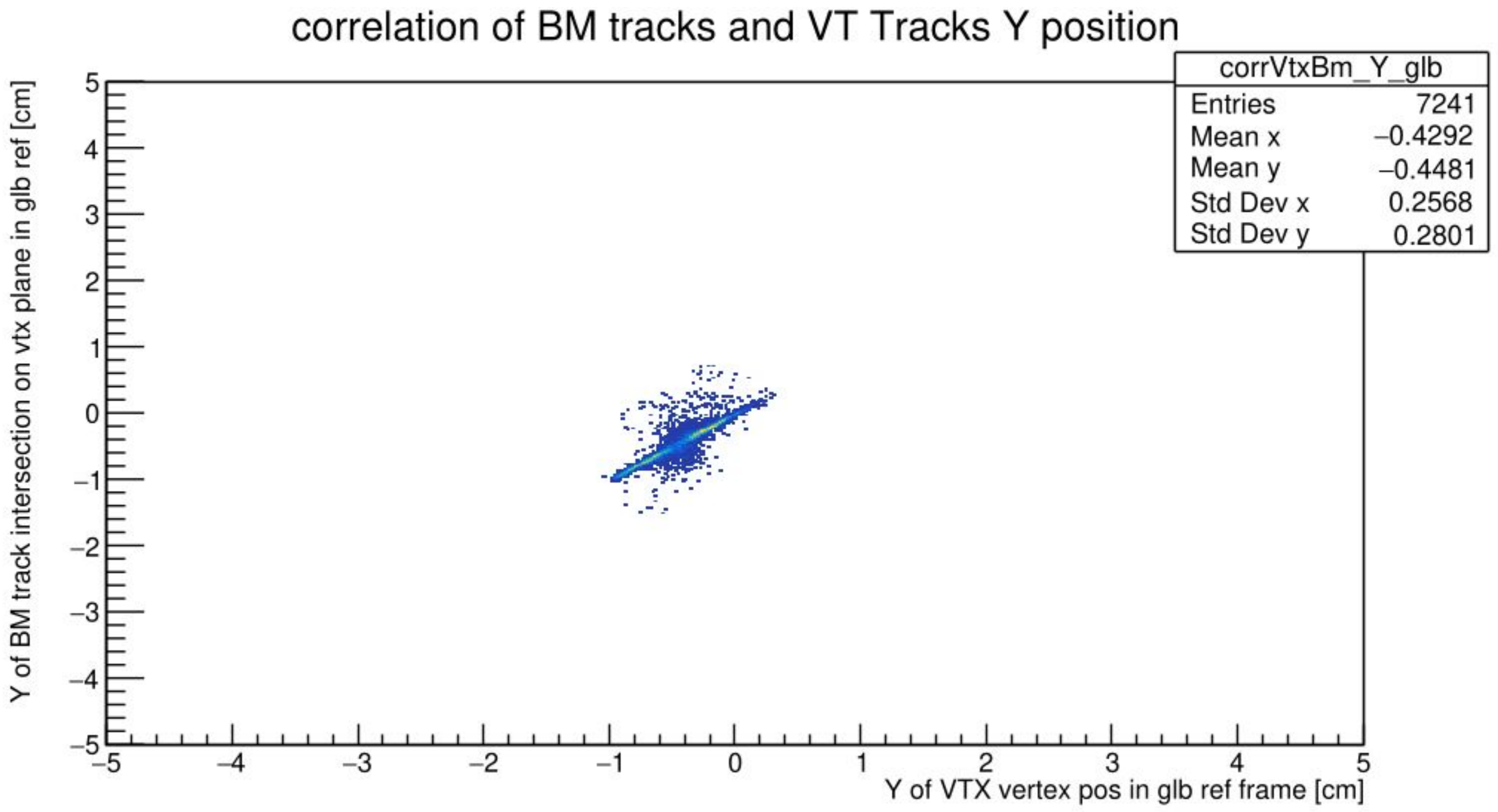
→ Do to the PileUp -> for a more precise analysis it is necessary to observe the (asymmetric) beam size for pileup events

# 230MeV Protons

## Threshold study: 4σ

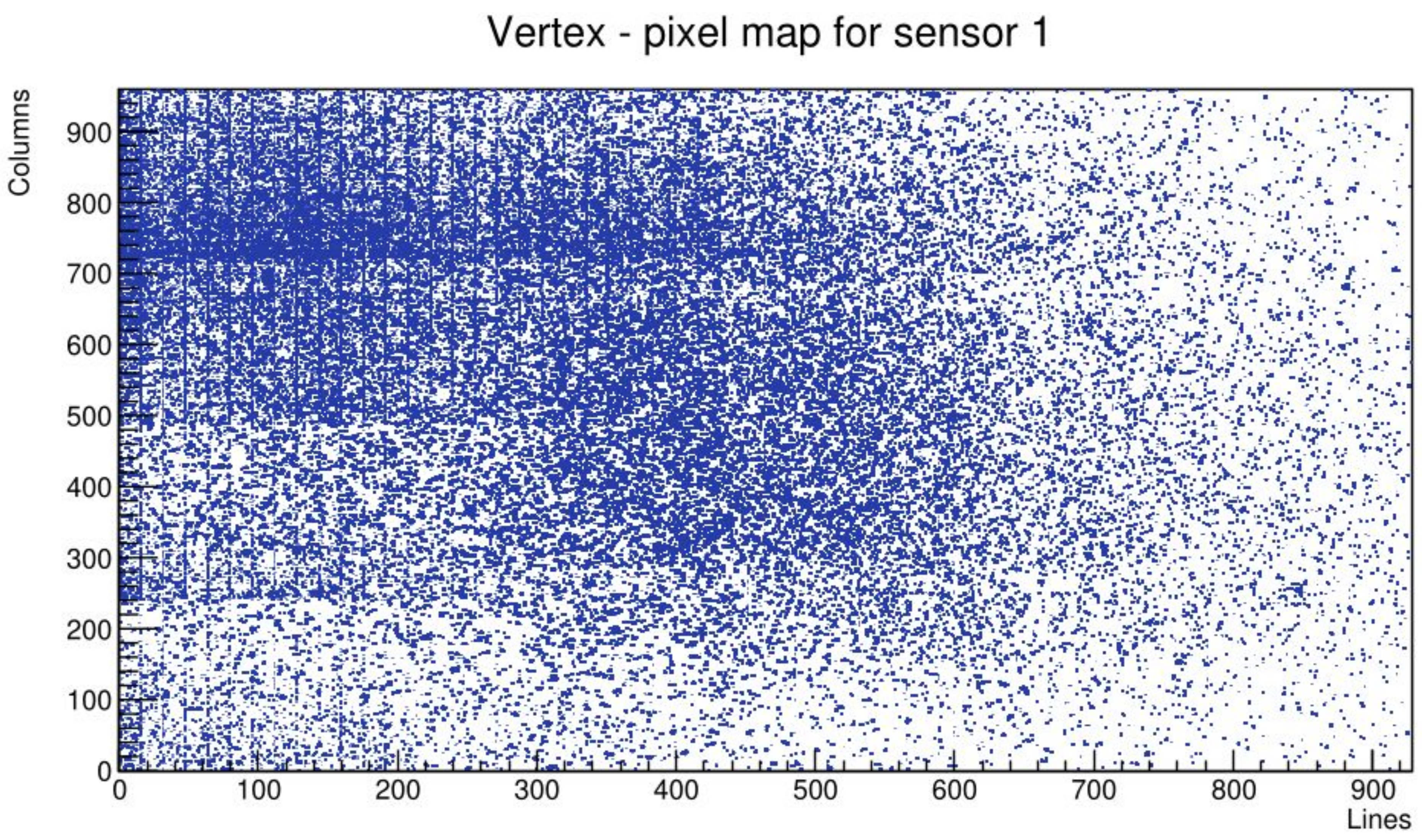
run 7014 -> all layer at 4σ

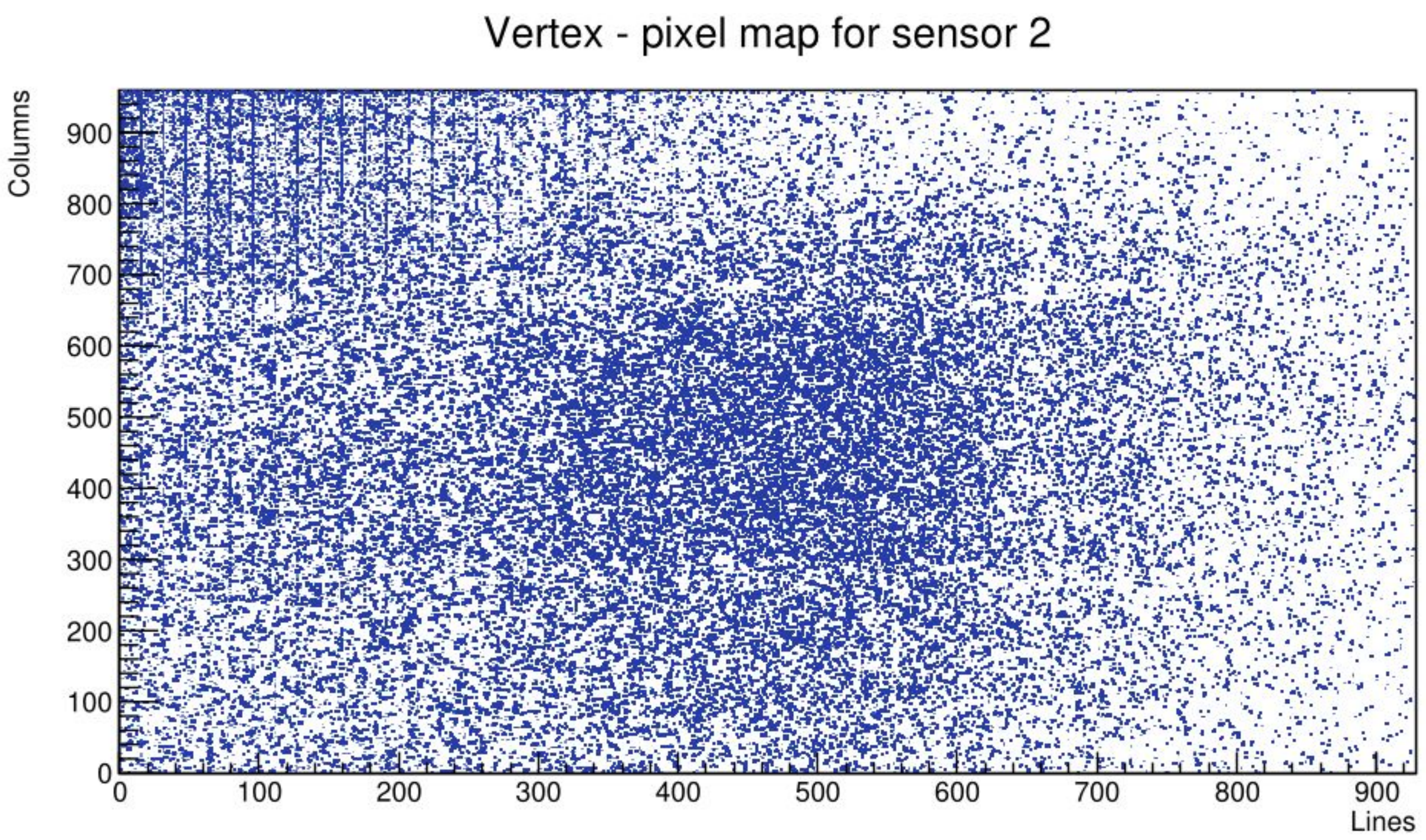


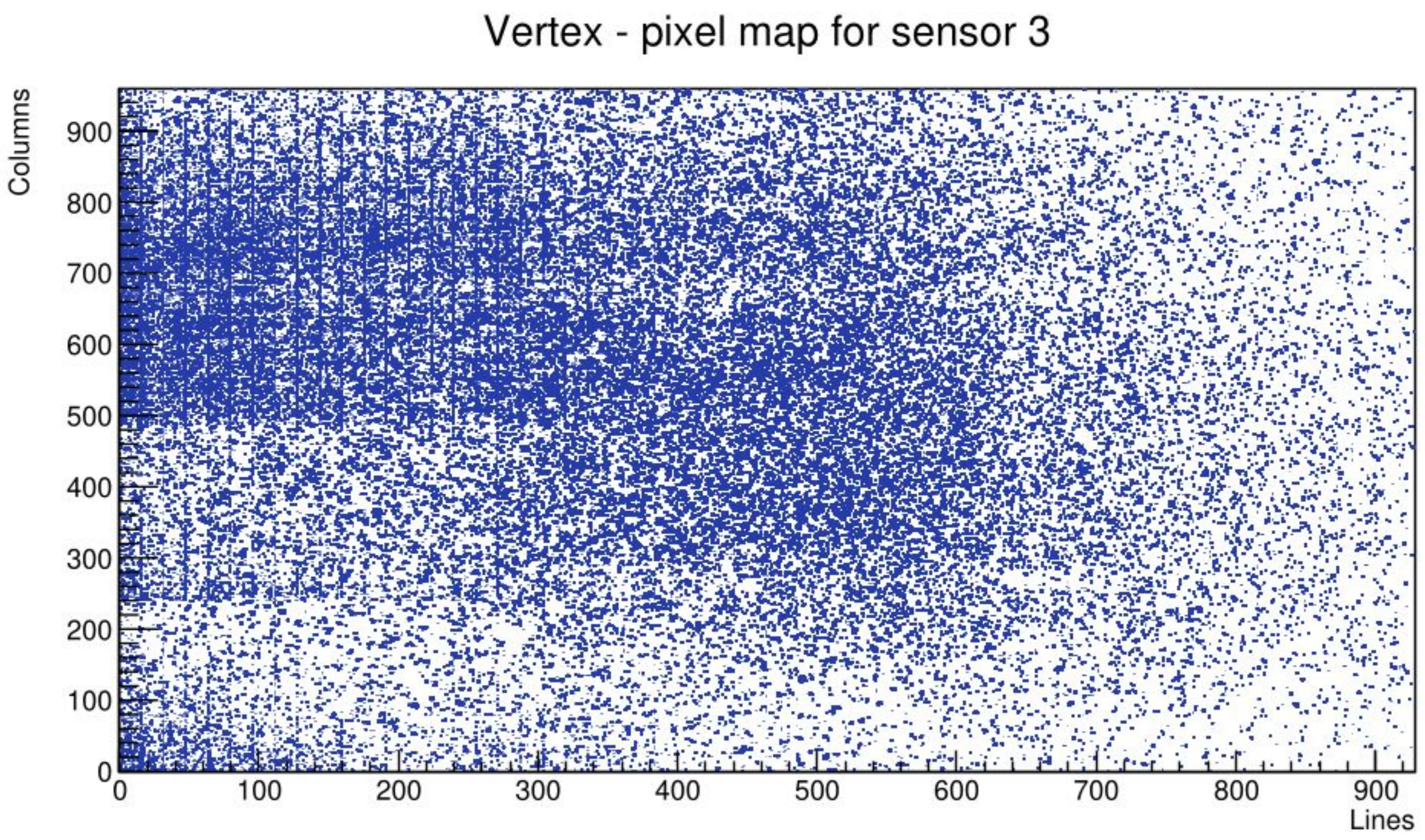



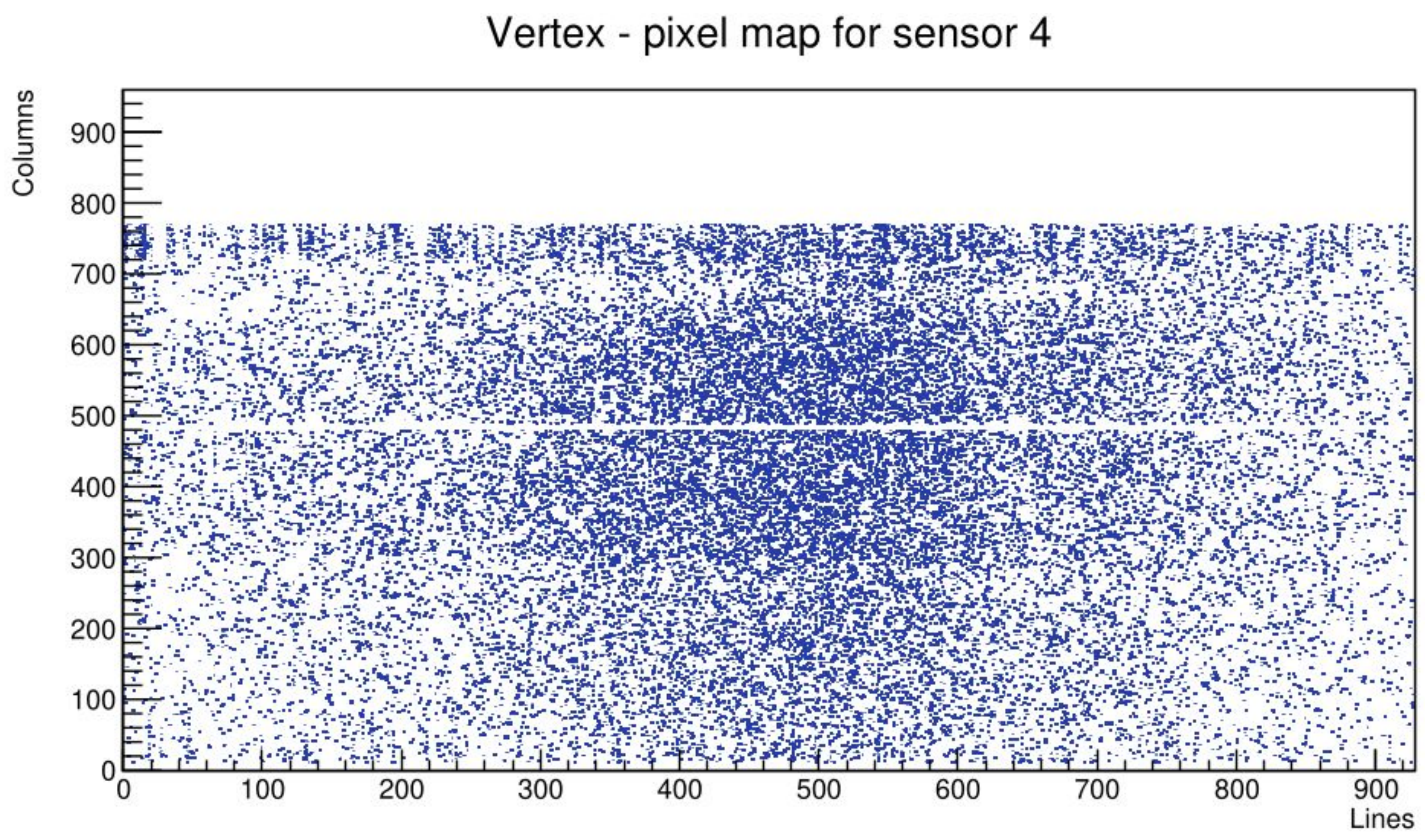
# 230MeV Protons

## Threshold study: 4.5σ



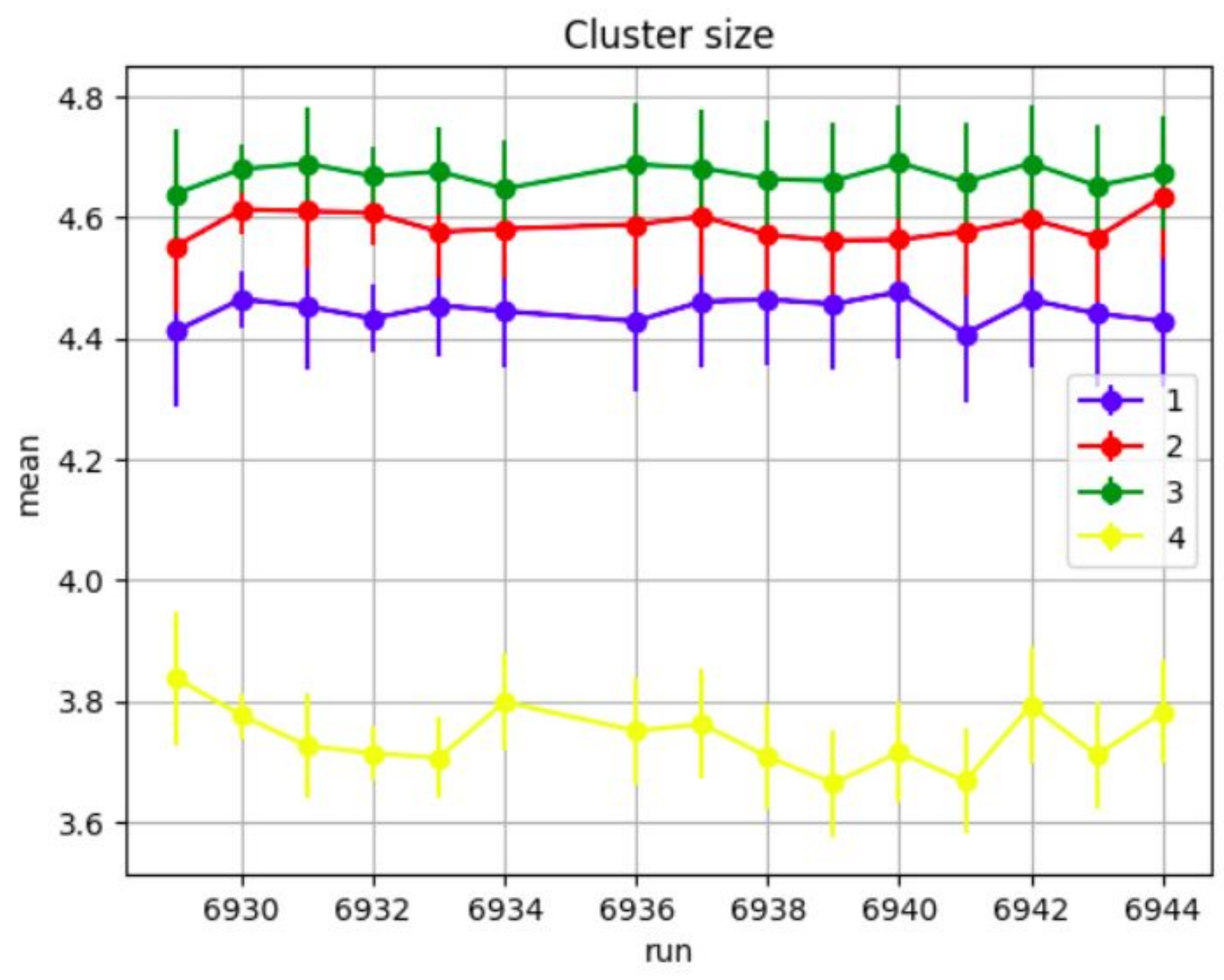



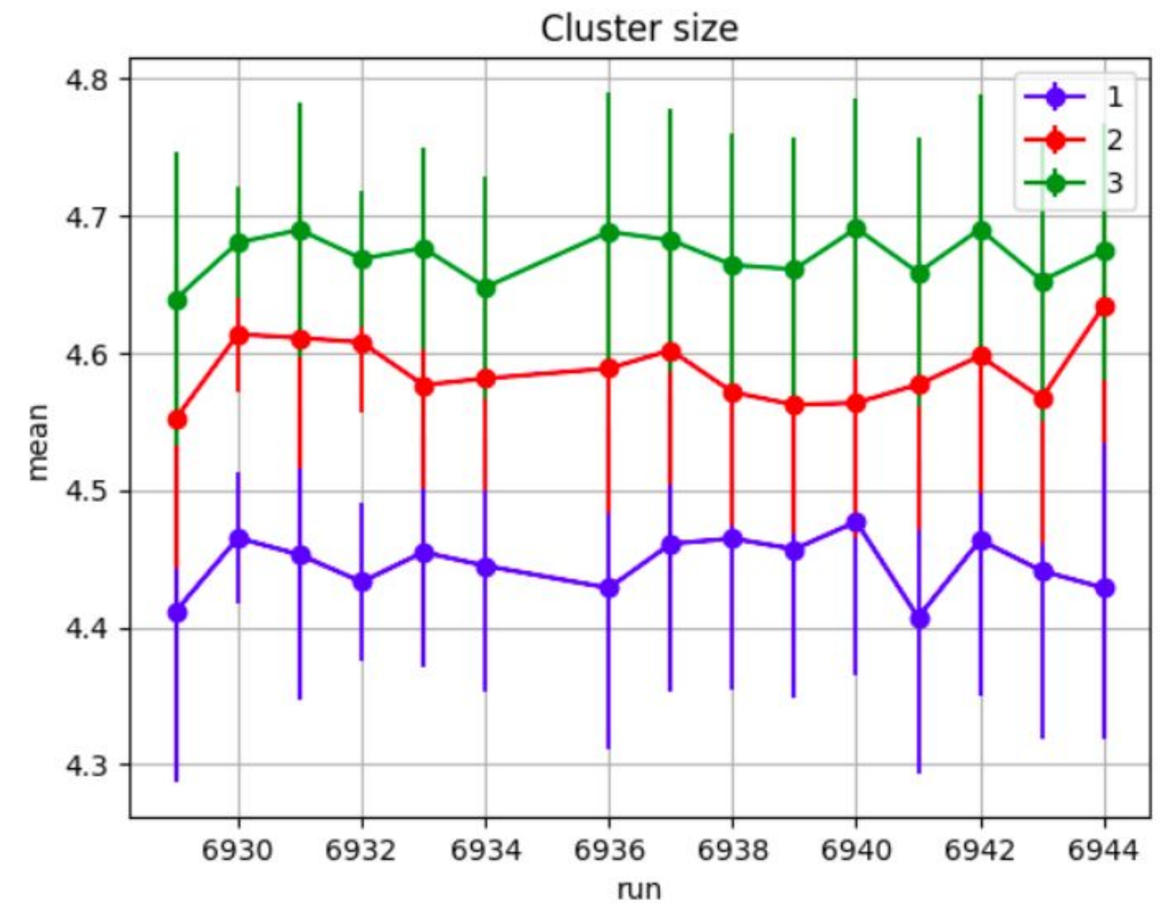

run 7017 -> all layer at 4.5σ

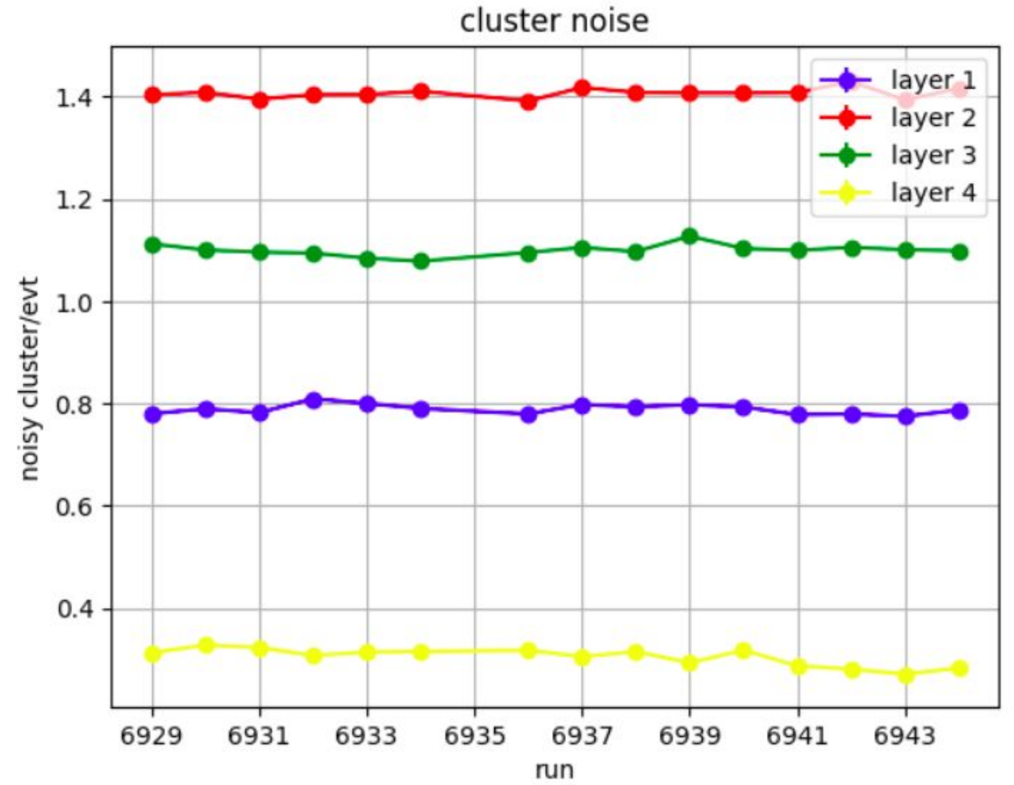
Even at 4.5 σ the first 3 sensors have some small features !!

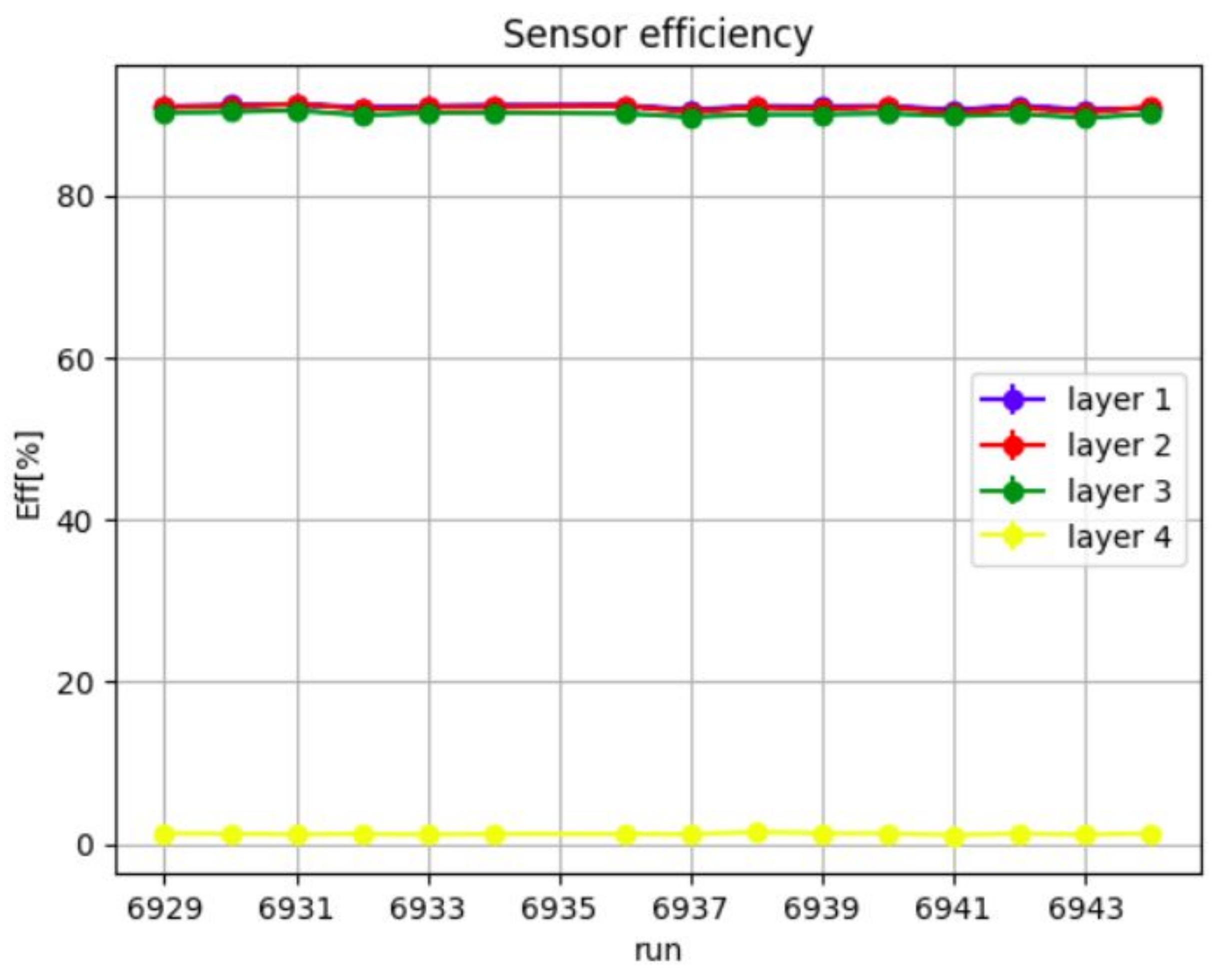
# Protons 230MeV

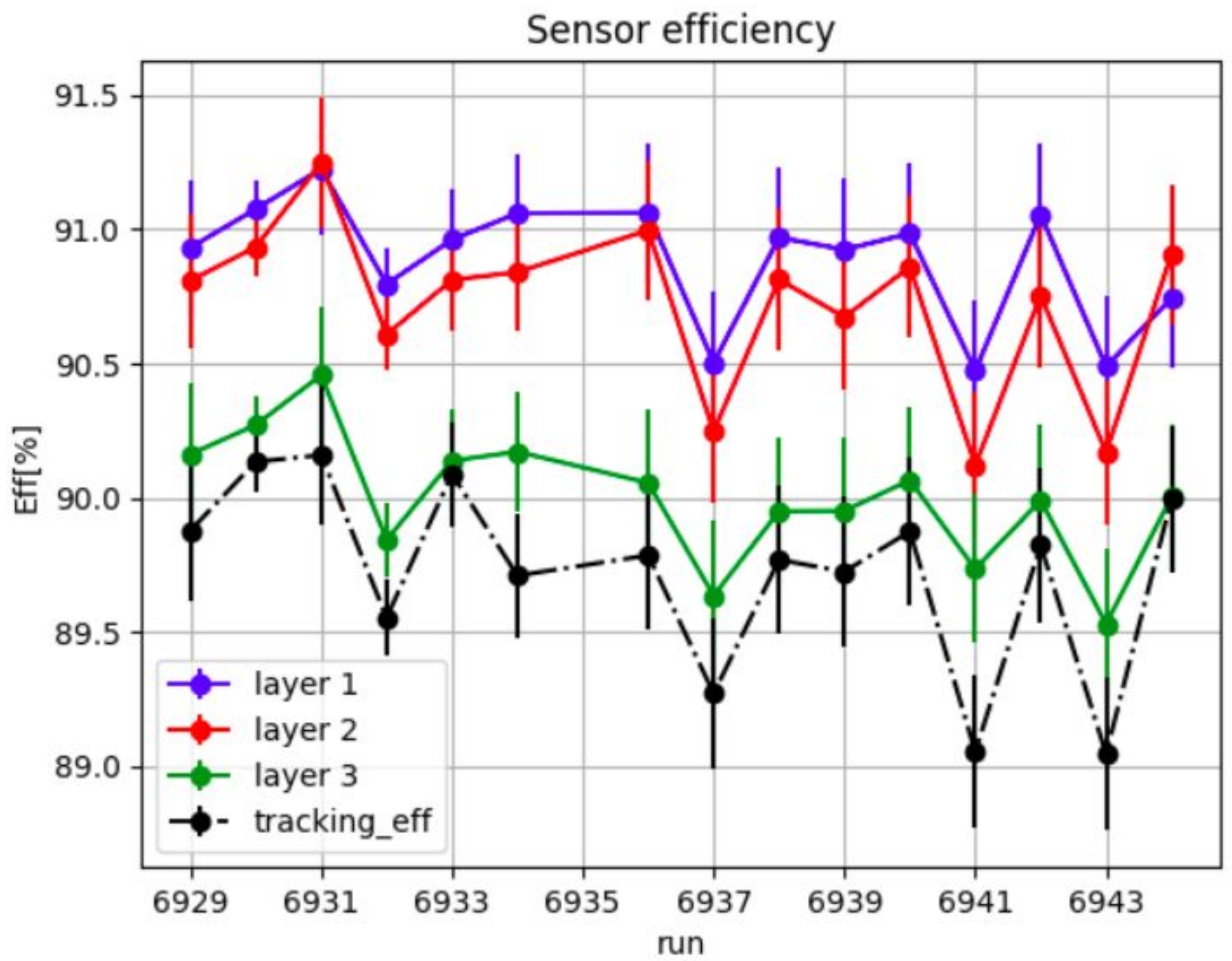
17/11/2024
run: 6929-6934, 6936-6944

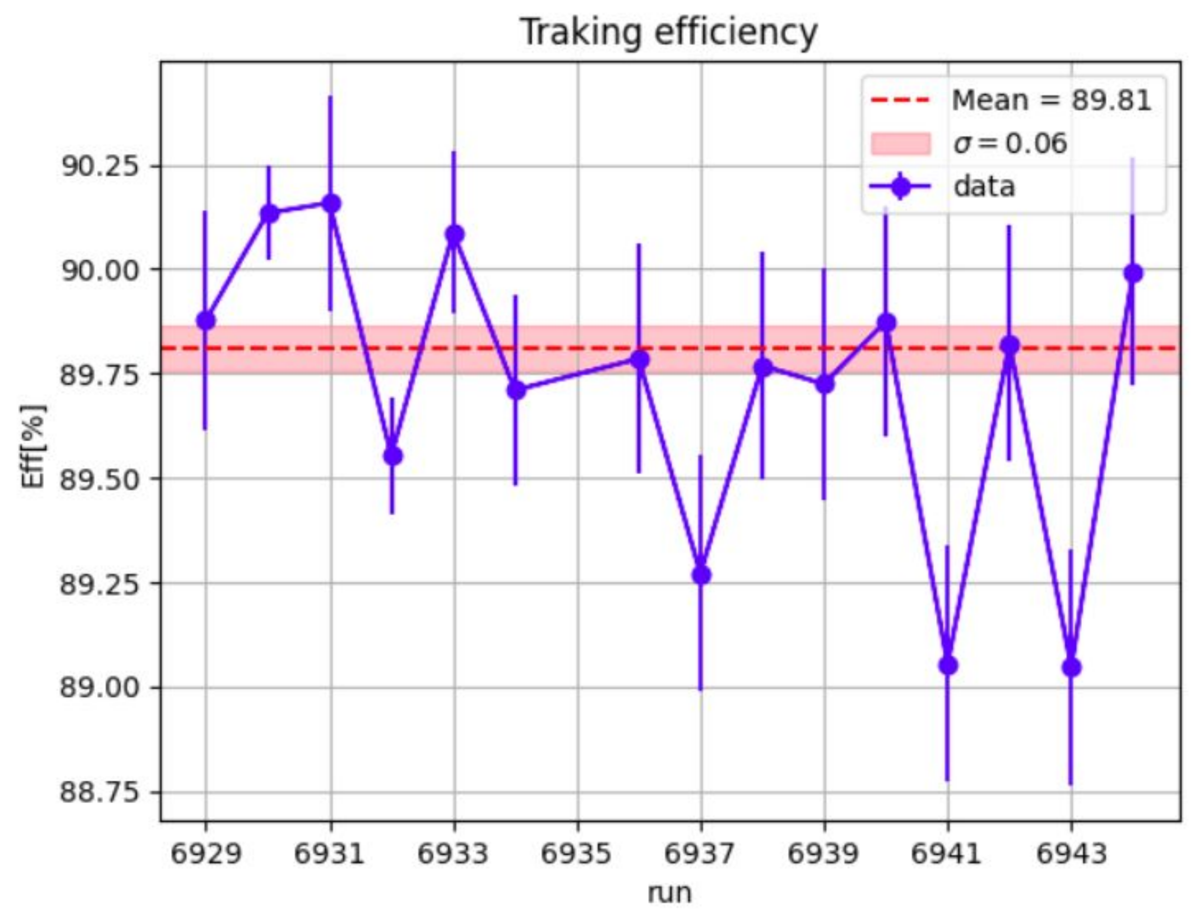


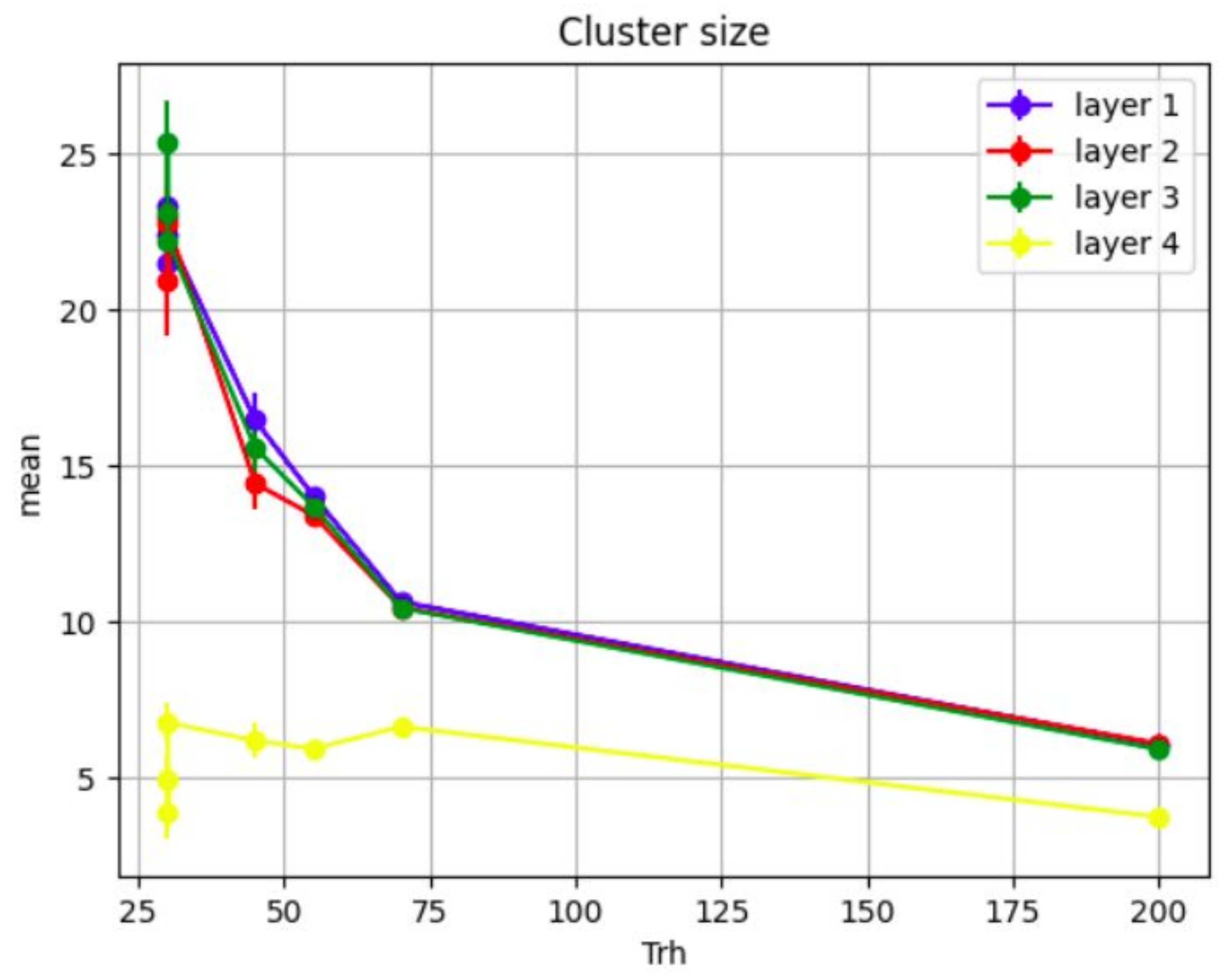



# Energy scan with emulsion

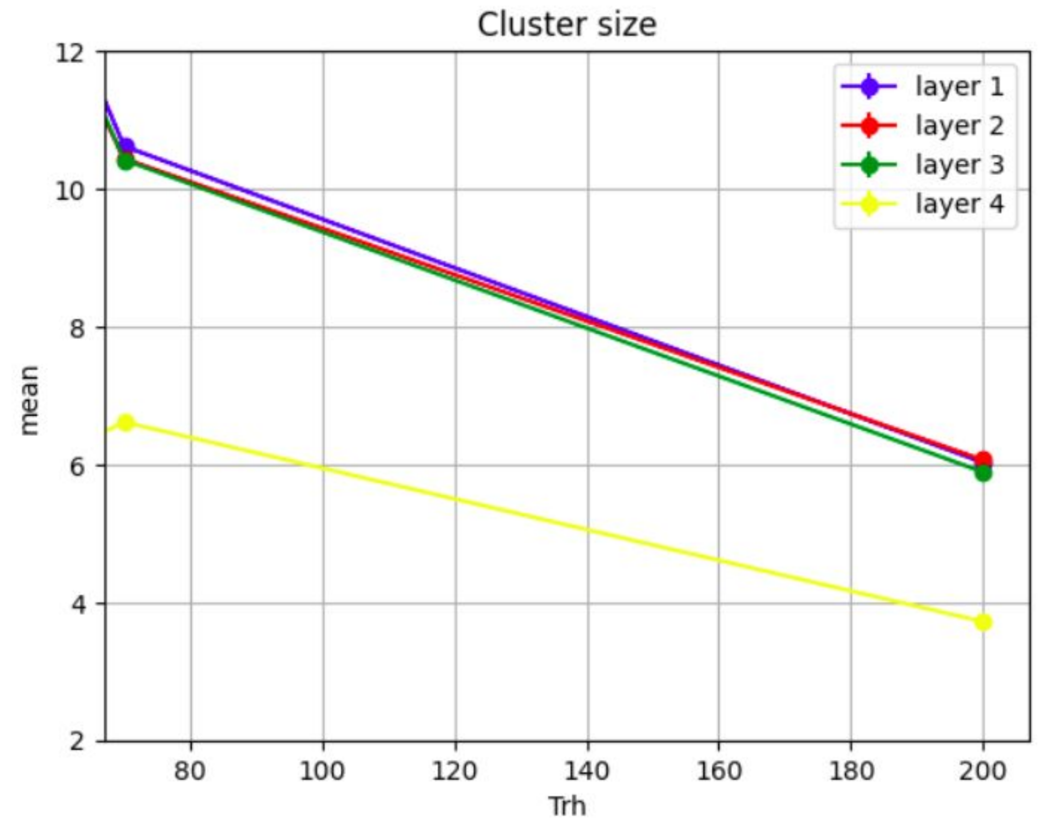
19/11/2024
run: 7053,7054, 7057, 7058,7060, 7061, 7062, 7063, 7064

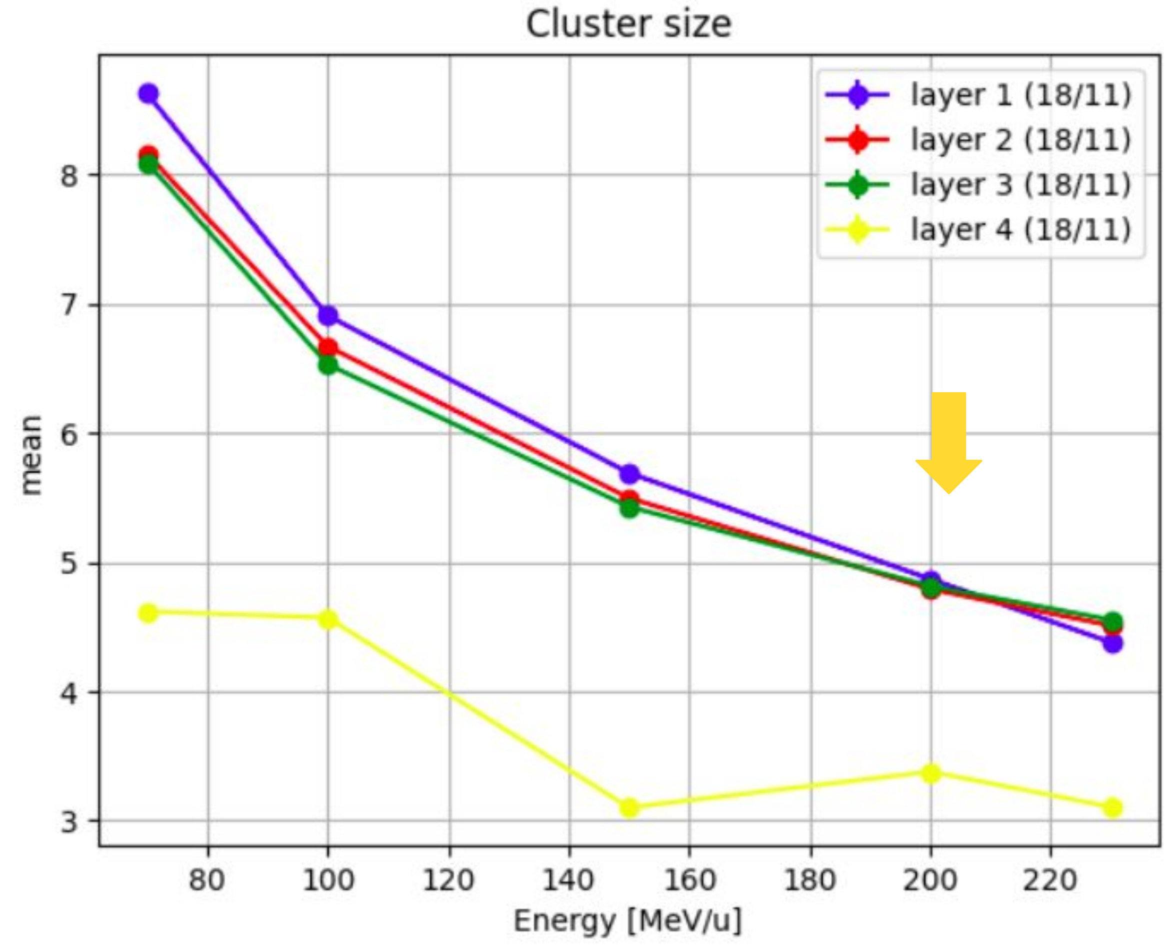
Look only the quantity VTX stand-alone: cluster size

- run at 15 MeV not usable → the VTX doesn't see anything
- run at 70 MeV and 200 MeV + emulsion not usable→ the thickness of the emulsions is greater, beam centering runs are used at that energy



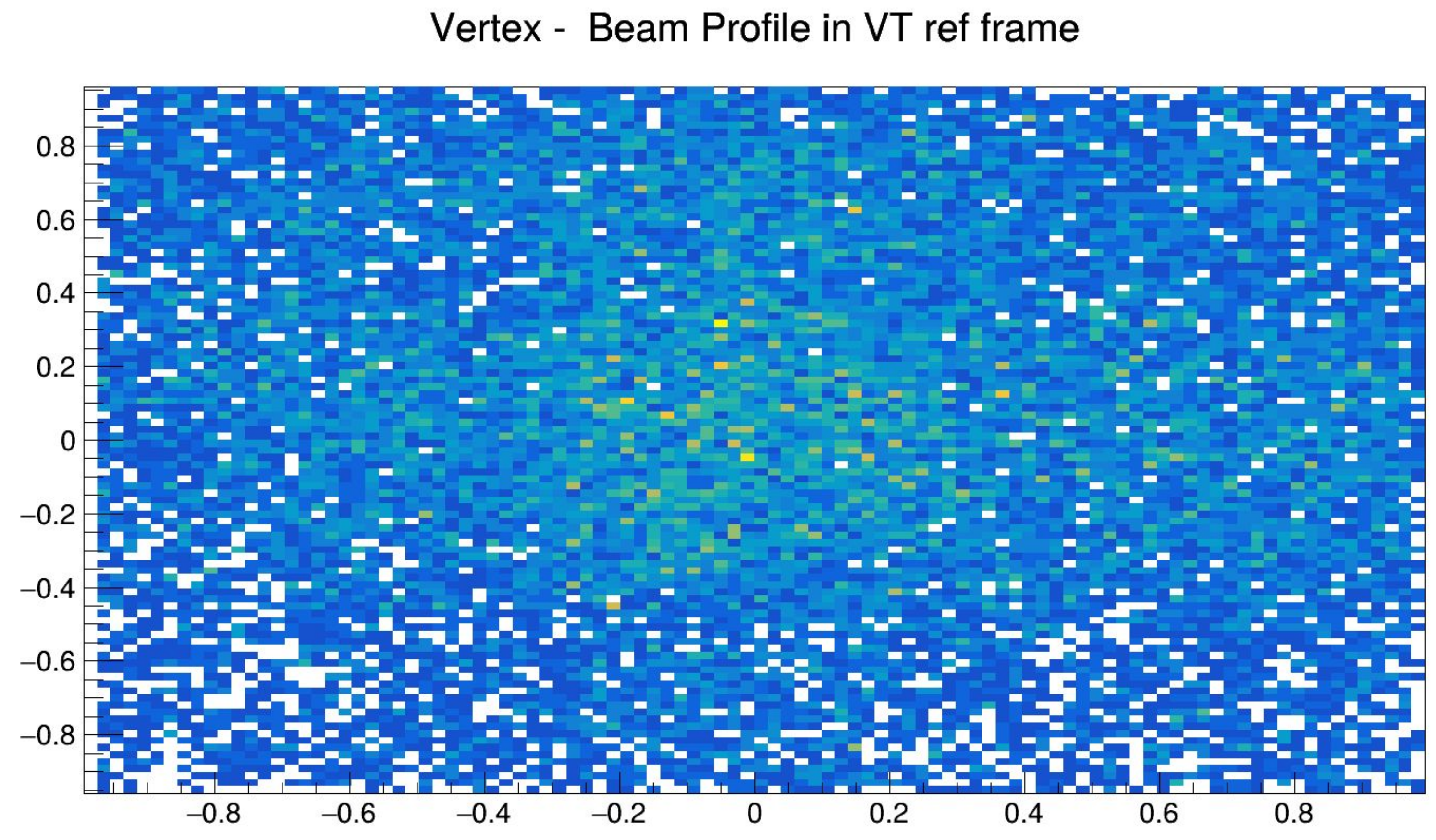

❑ 70 MeV and 200 MeV are compatible with previous scan



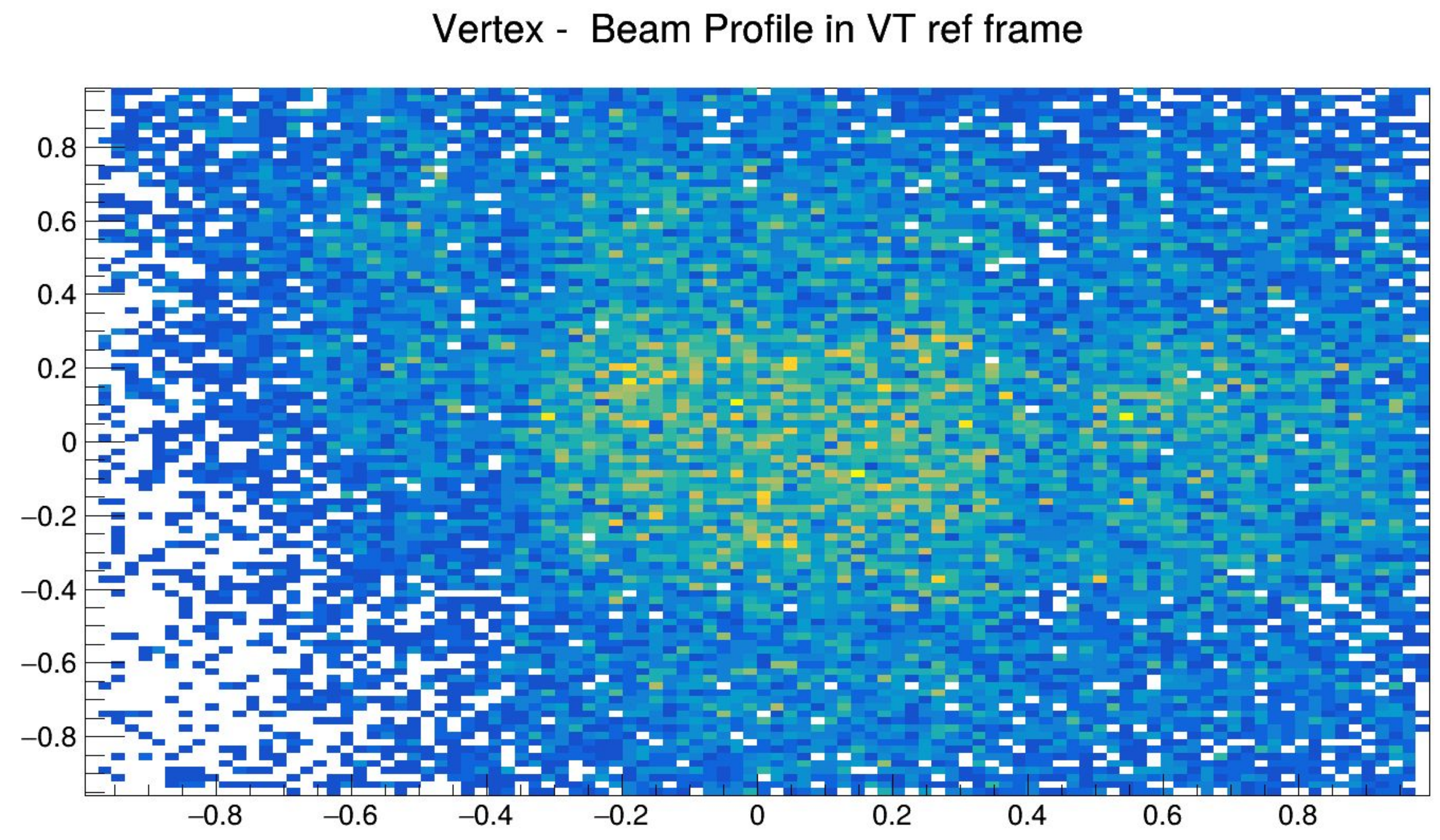



# Beam -> protons

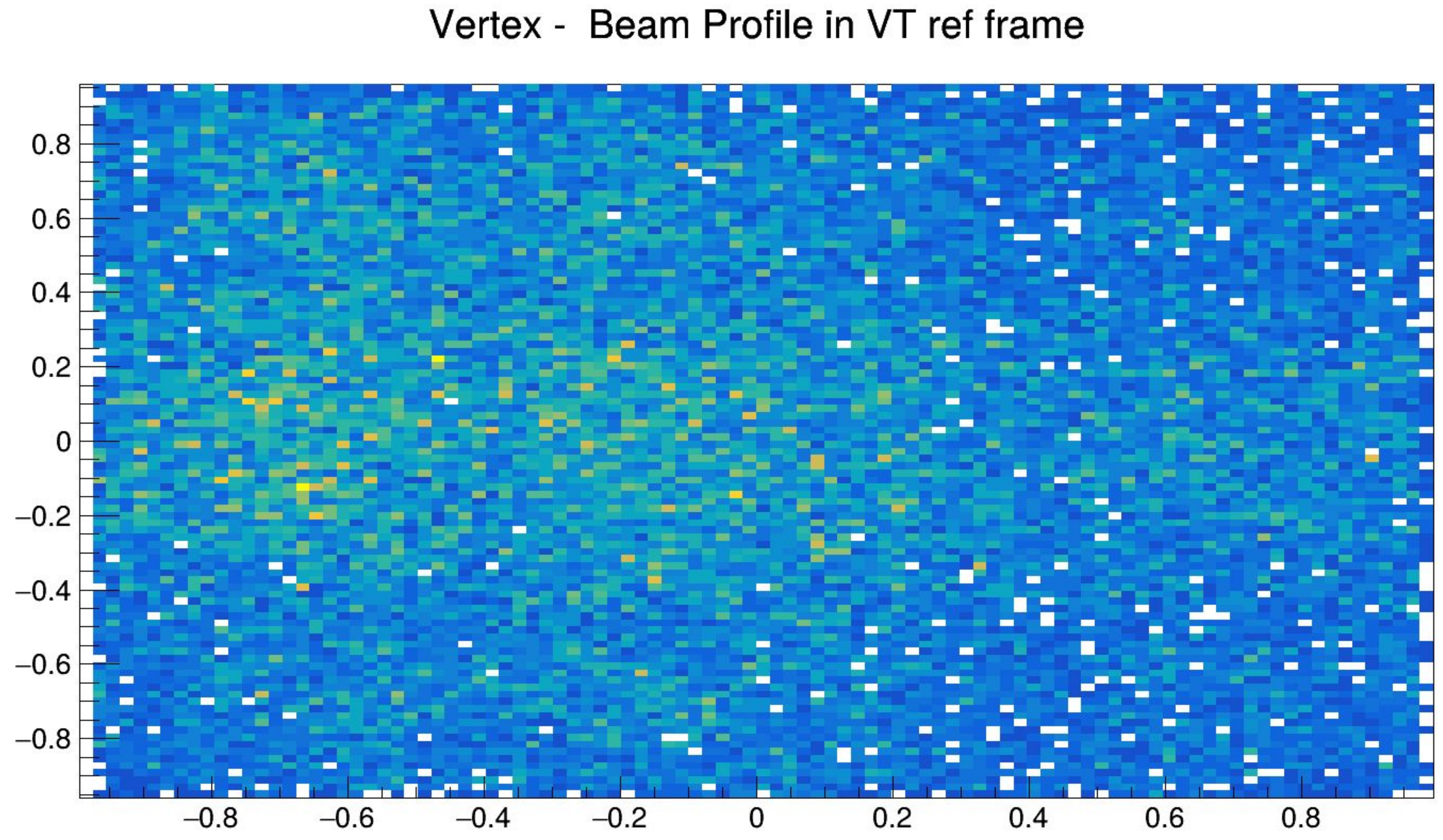
6946->70MeV



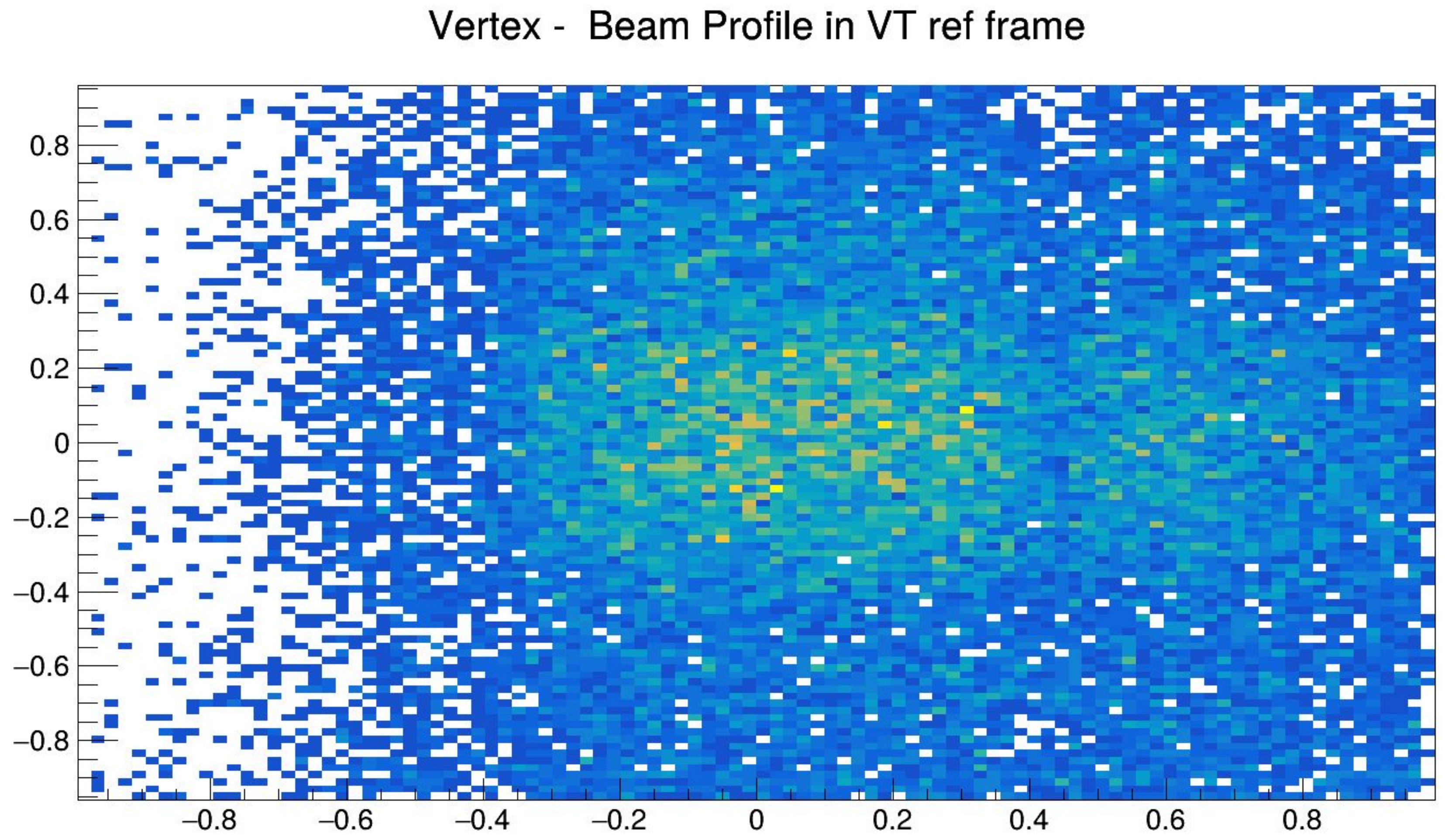

6947->150MeV




6948->100MeV

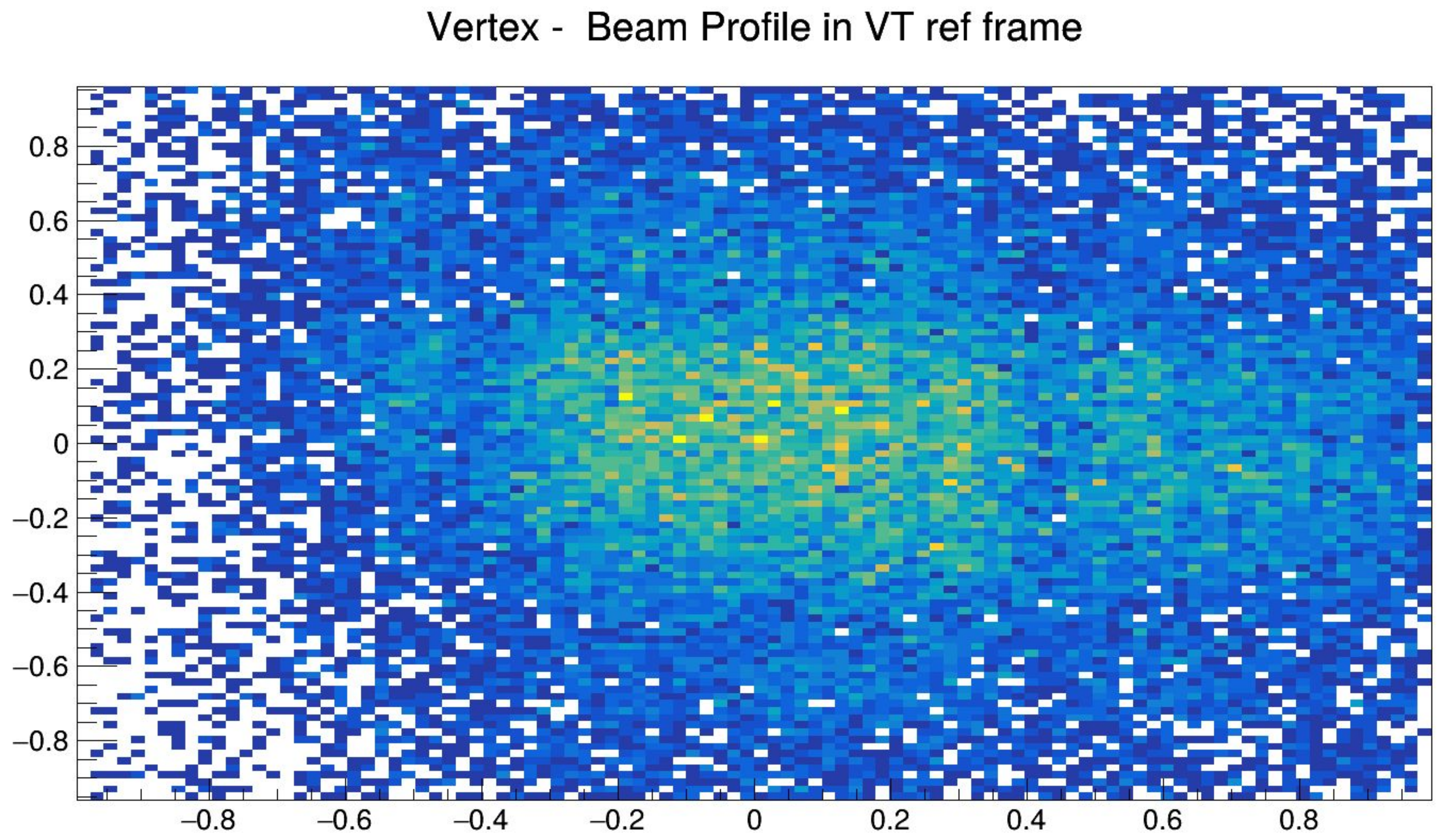



6949->170MeV

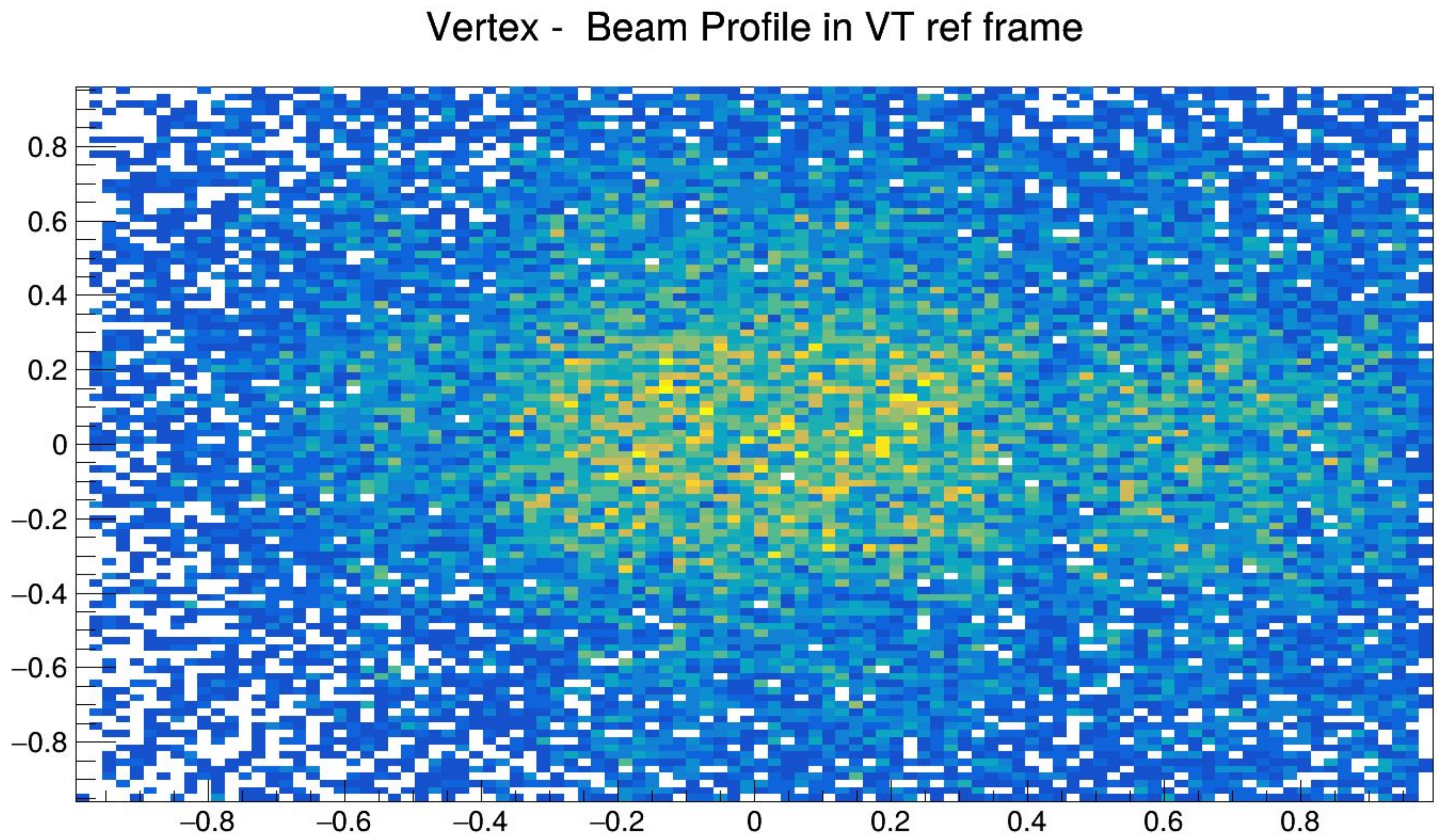


# Beam -> protons

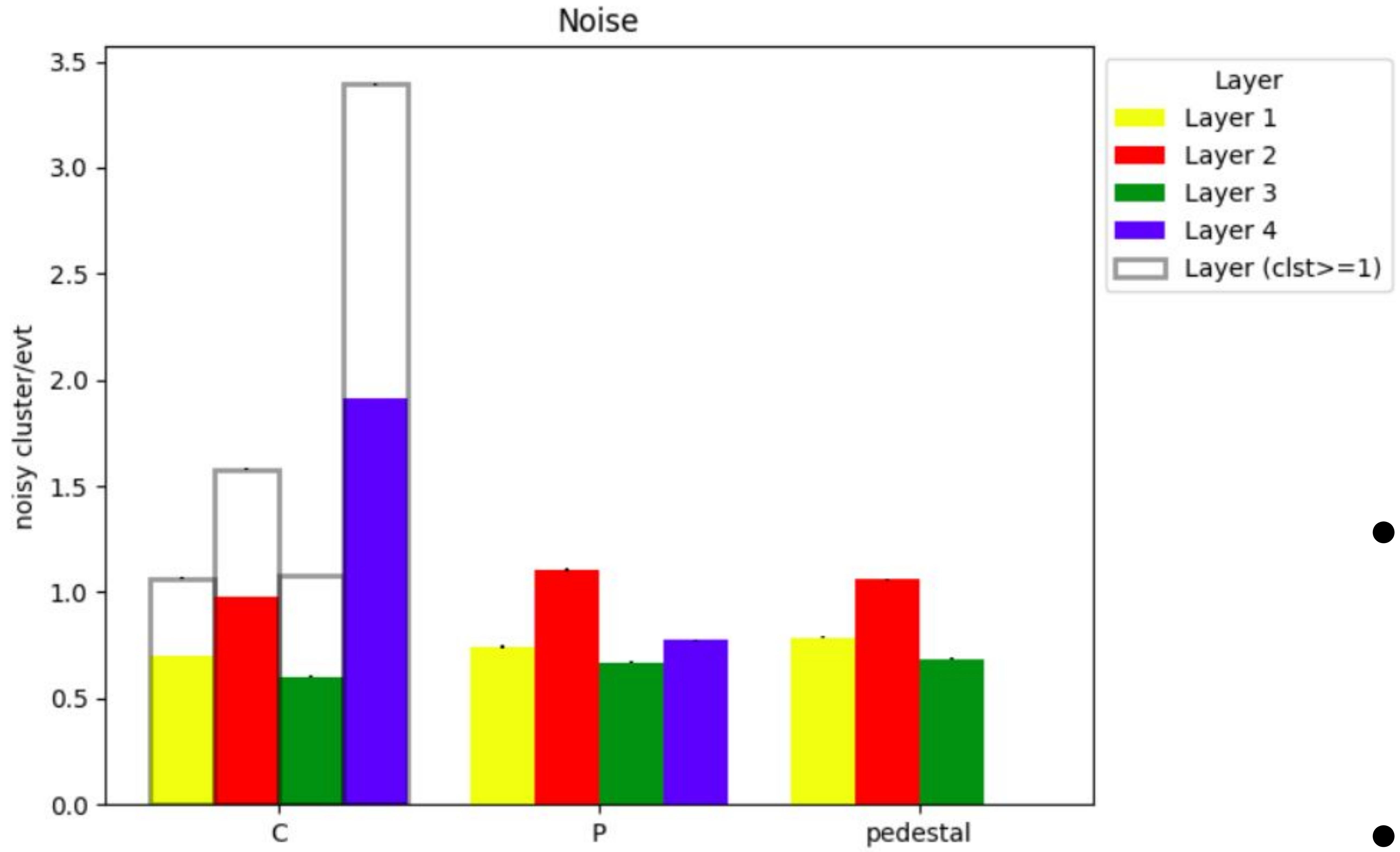
6950->200MeV




6951->230MeV



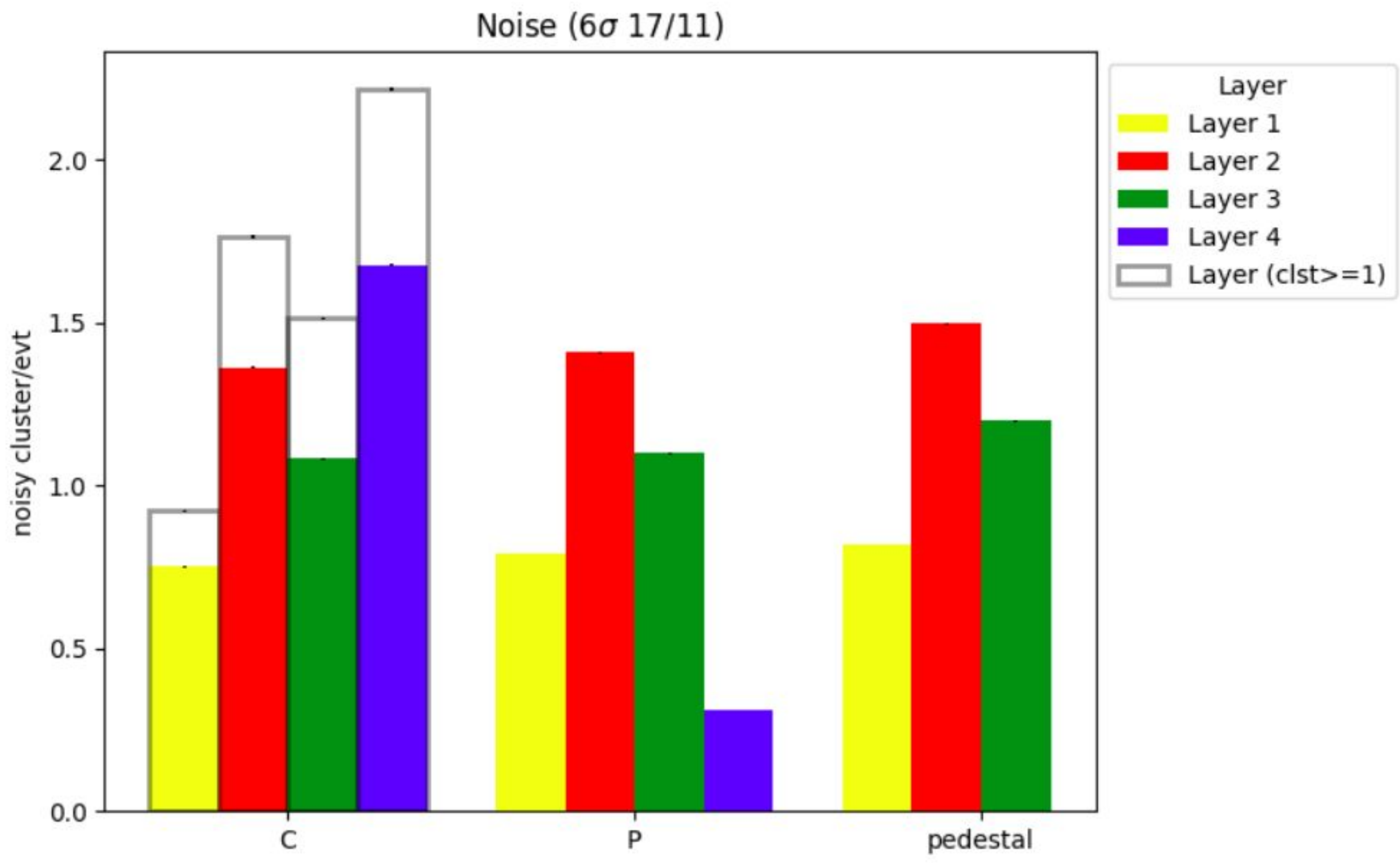
# Noise




18/11/2024
layer 1,2,3-> 6σ
layer 4->4σ
C 200MeV +TG: 7026, 7030
p(230MeV): 7019
pedestal: 7020

- For carbon, considering all not-tracked clusters includes clusters with a claster size >5, which are not electronic noise but real cluster, such as particles that scattered and re-entered a layer
- **The noise level is consistent across different configurations**
- Sensor 4 exhibits anomalous behavior,but it has also an unstable pedestal σ

# Noise (17/11/2024)



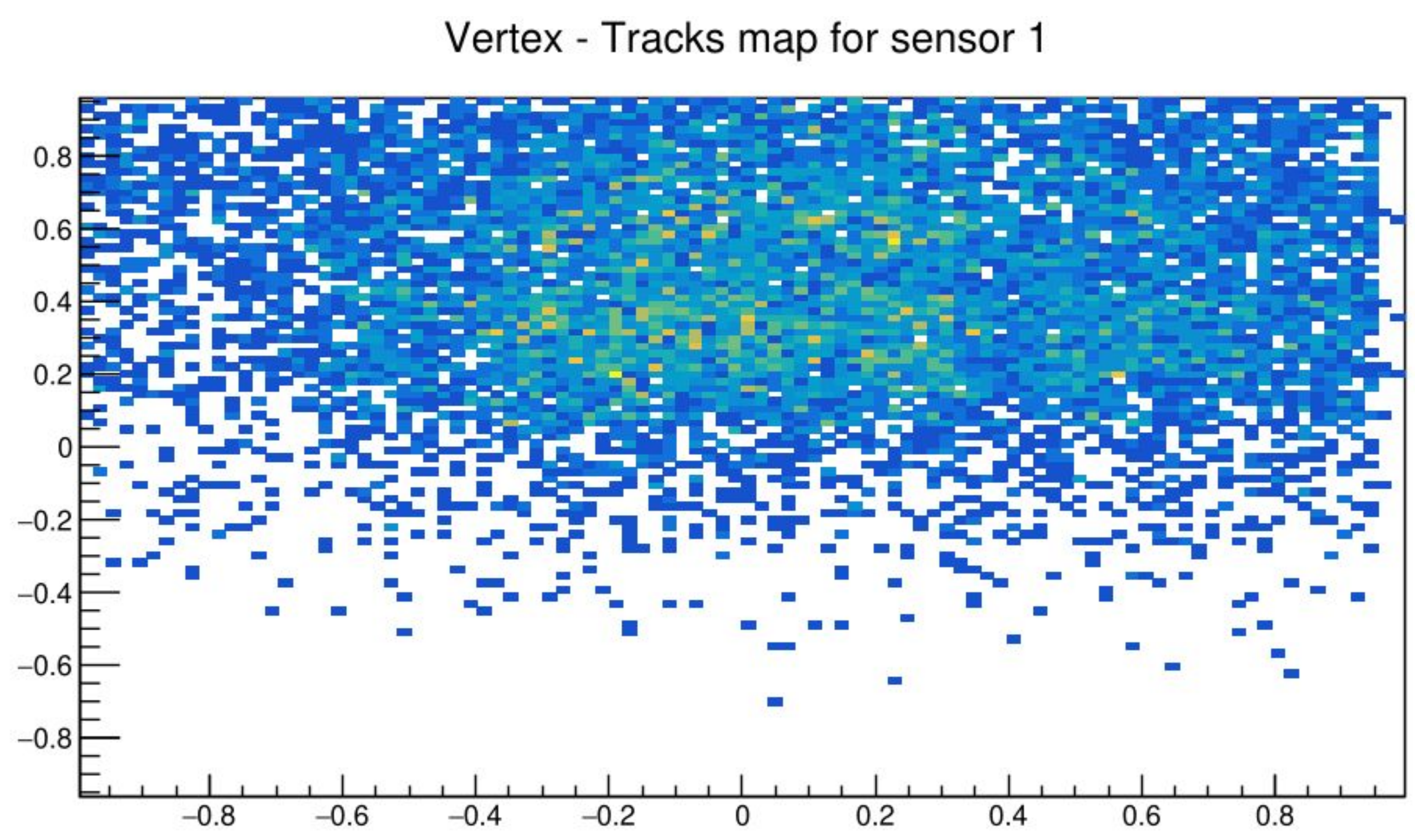

18/11/2024
layer 1,2,3,4-> 6σ
C 200MeV : 6923-6925,
p(230MeV): 6929-6934, 6936, -6944
pedestal: 6918, 6919, 6928, 6945, 6952

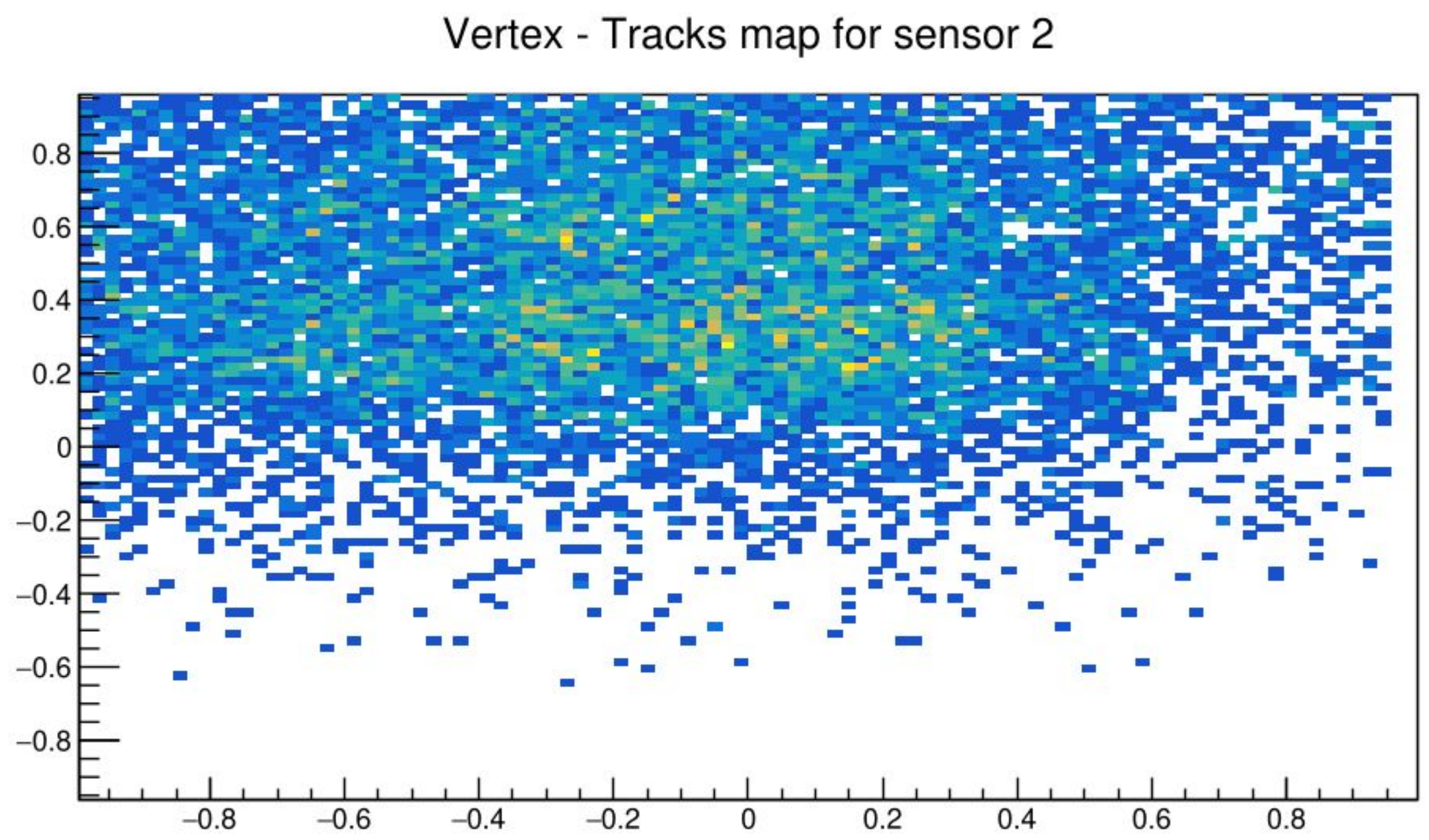
# Noise (9/11/2024)

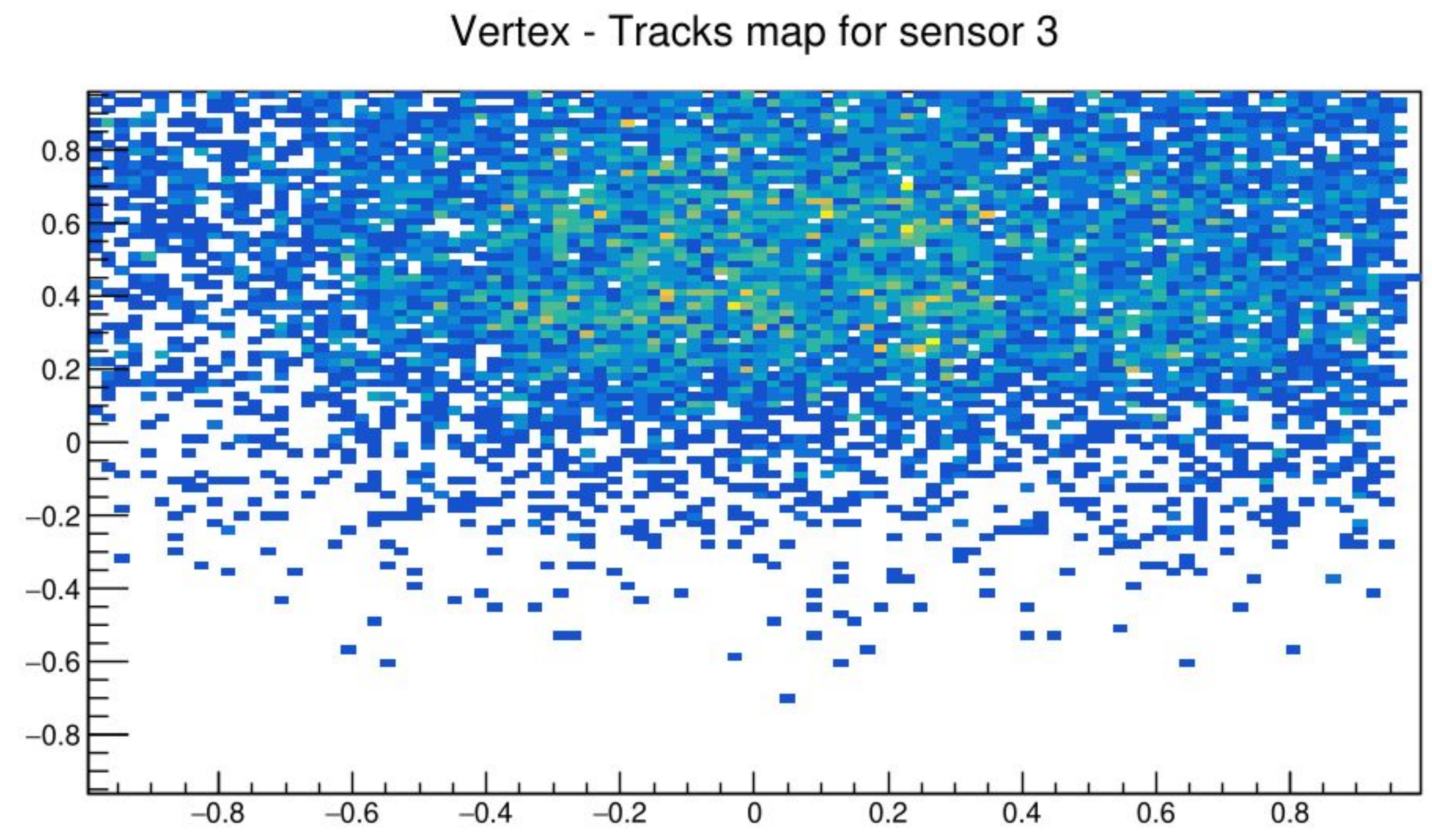

18/11/2024
layer 1,2,3,4-> Default
C 200MeV : 6747,6748,
p(230MeV): 6750-6753,6756
pedestal: 6755

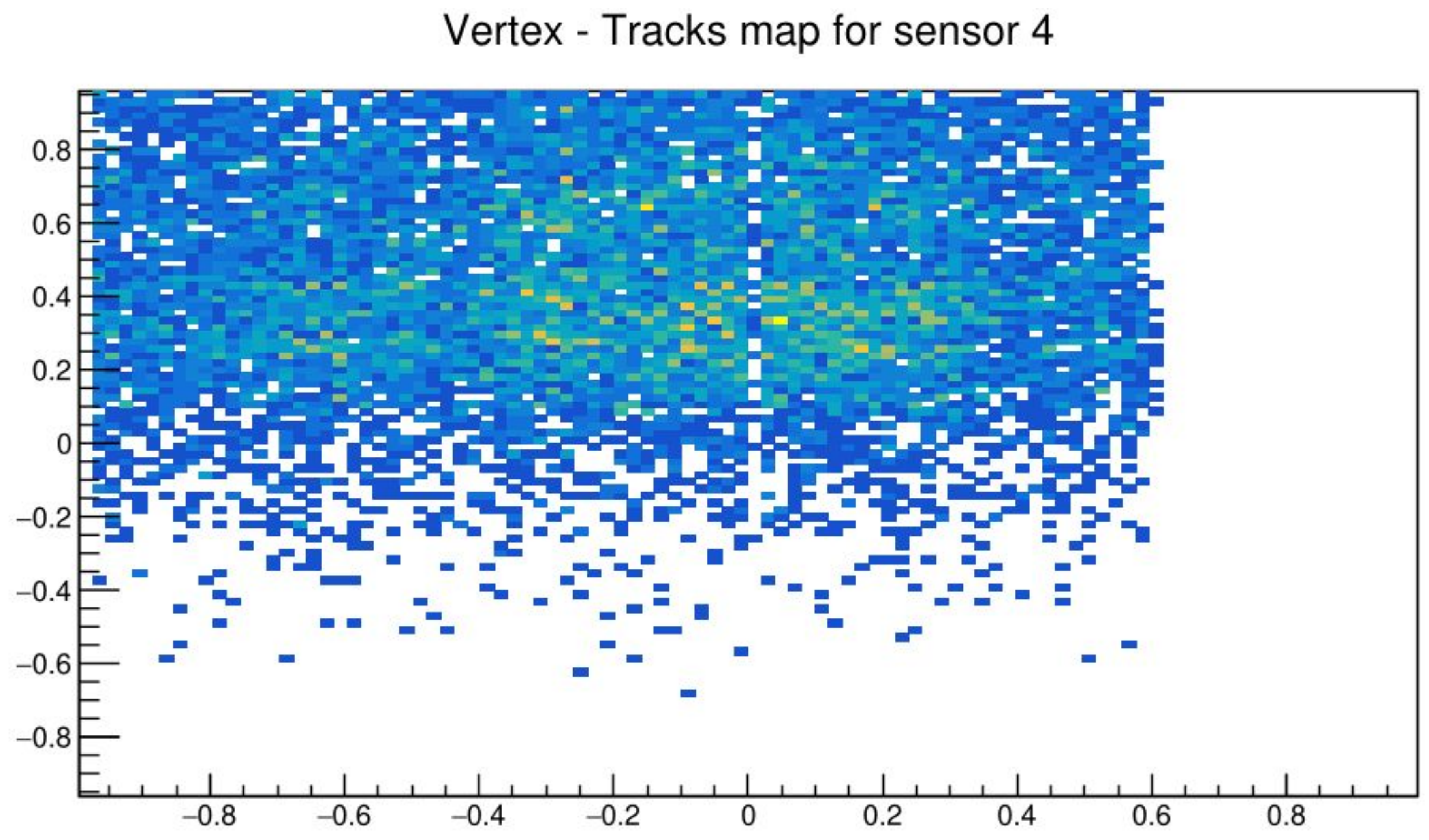
# 230MeV Protons

## Threshold study: 4σ




run 7014 -> all layer at 4σ

The track maps reveal the beam shape

↓

tracks can be reconstructed despite the noise.

This threshold is not viable as half of the detector is non-functional.

(some features also at 4.5σ and 5σ)

# MC previous campaigns

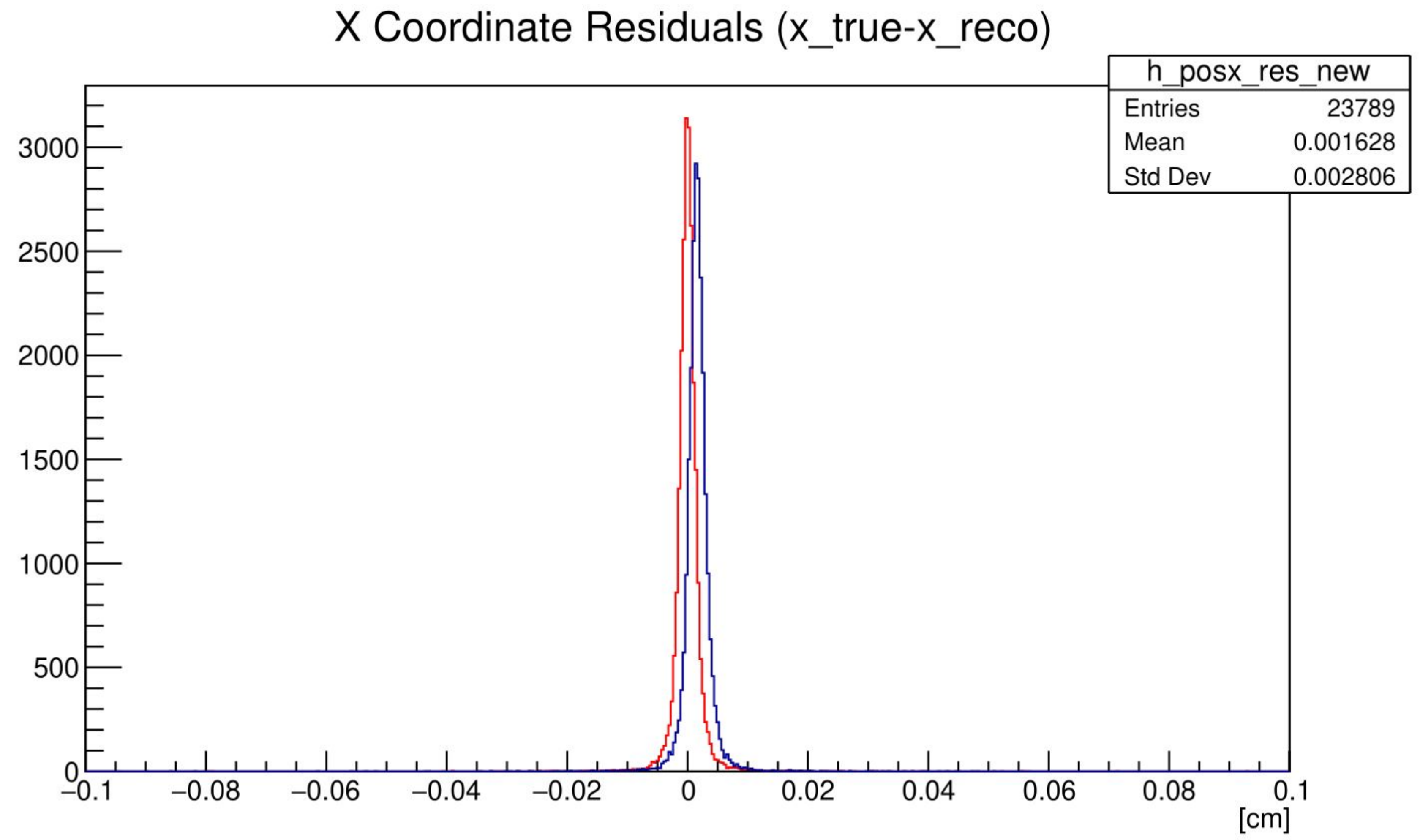
- **CNAO22PS_MC**

  p_vv= 2.897 ± 0.008

- **CNAO23PS_MC**

  p_vv(B)=2.78±0.02
  p_vv(฿)=2.79±0.02

- beam more centered at CNAO2022
- VTX at CNAO2023 is 0.52 cm further away




- **CNAO22PS_MC**

| - | mean $[cm]$ | $\sigma$ $[cm]$ |
|---|---|---|
| x | $(9.664 \pm 0.304) \times 10^{-6}$ | $(8.628 \pm 0.033) \times 10^{-4}$ |
| y | $(4.327 \pm 0.361) \times 10^{-5}$ | $(8.478 \pm 0.041) \times 10^{-4}$ |
| z | $(-1.401 \pm 0.025) \times 10^{-3}$ | $(5.192 \pm 0.036) \times 10^{-3}$ |

- **CNAO23PS_MC**

| - | mean $[cm]$ | $\sigma$ $[cm]$ |
|---|---|---|
| x | $(1.552 \pm 0.012) \times 10^{-3}$ | $(1.168 \pm 0.014) \times 10^{-3}$ |
| y | $(4.761 \pm 0.983) \times 10^{-5}$ | $(1.133 \pm 0.011) \times 10^{-3}$ |
| z | $(-2.332 \pm 0.103) \times 10^{-3}$ | $(8.674 \pm 0.144) \times 10^{-3}$ |