CNAO22 data analysis and first attempt of track reconstruction of CNAO2025 data

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CNAO2022

- Run considered:

  5468, 5460, 5470, 5471, 5472 (Majority trigger)

  5488, 5489, 5490, 5491, 5492, 5493, 5494, 5495, 5496 (Fragm. Trigger)

- Track Reconstruction, 1st attempt:

  - Kalman (GenFit) VTX, MSD, TW. Minimum 6 points/track required

  - BM-VT match enabled

  - also local MSD tracking activated (to be used later)

```
PedestalFlag:              0
TrackingFlag:              1
TrackingAlgo:              "Full"
PlanesForTrackMinimum:     3
SearchHitDistance:         0.03
Sensors:                   6
```

CNAO2022 Event Selection

2481758 total reconstructed events

- Pile-up rejection using: stNtuHit->GetHit(0)->GetPileUp()
- 1 BM track with 1 matched VTX vertex
- z coordinate of matched vertex within target with some tolerance: (-0.3 < z < 0.3 cm)
- At least 2 reconstructed global tracks with TW point (to get rid of primary contamination)

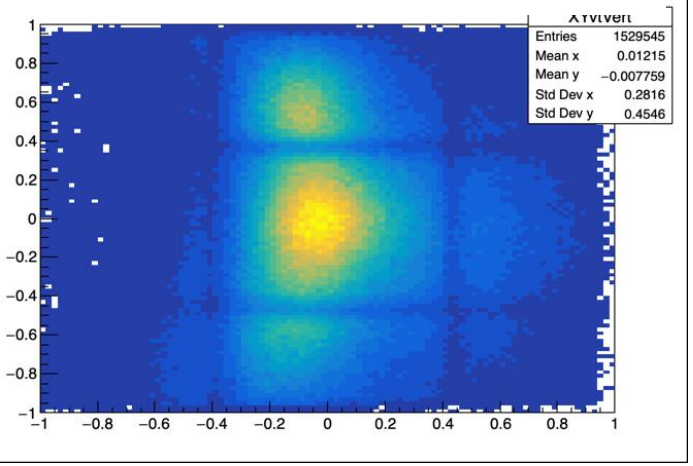
12716 total selected reconstructed events

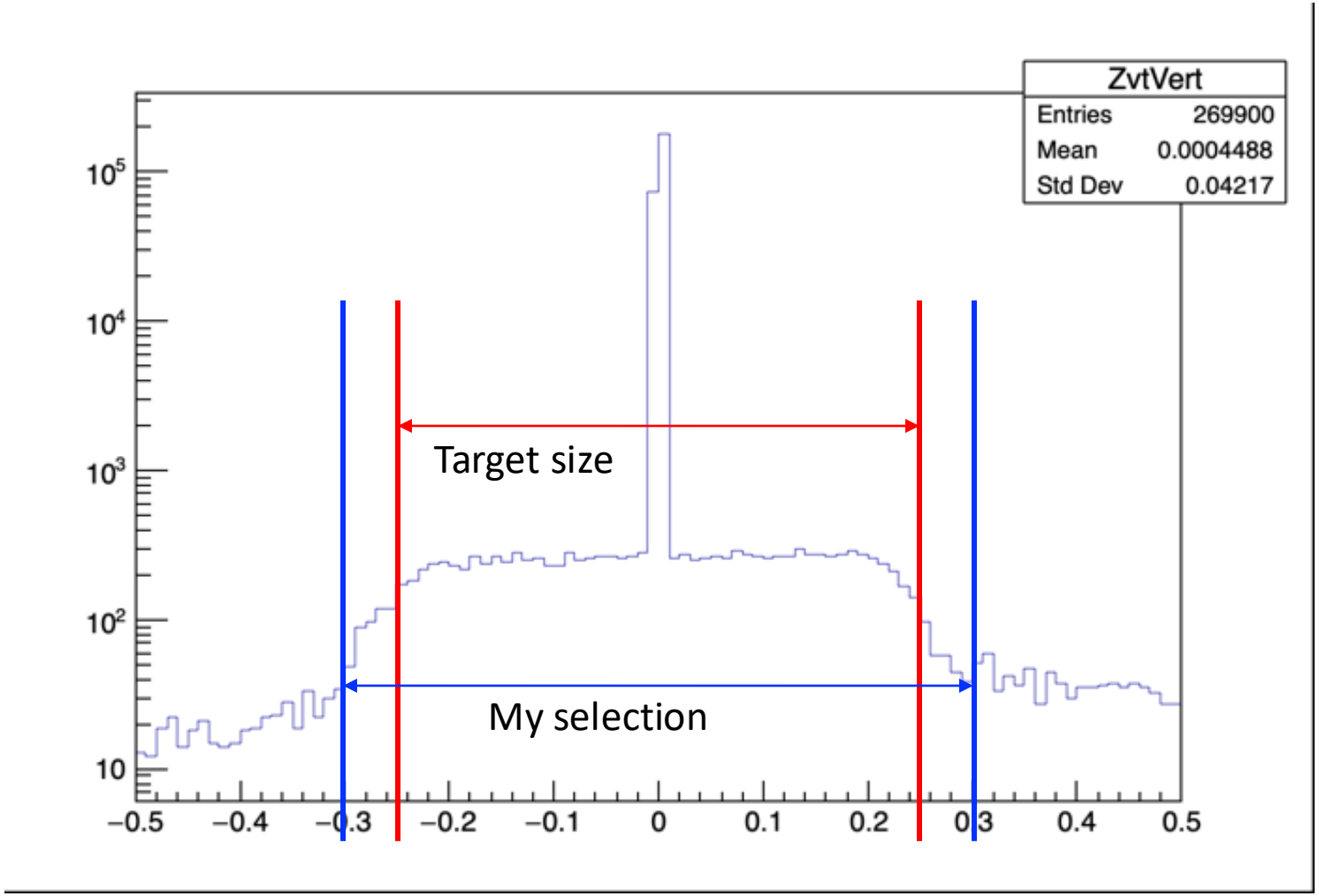
Track selection in selected events

- Npt VTX > 2 && Npt MSD > 2 — 32110 tracks
- TW point — 26839 tracks
- Chi2 < 2. — 10441 tracks
- X,Y at target position within a fiducial area of 2 x 2 cm^2 — 10428 tracks
- ToF< ToF for 50 MeV/u fragments — 10353 tracks

Z coordinate of Matched Vertex (all events)

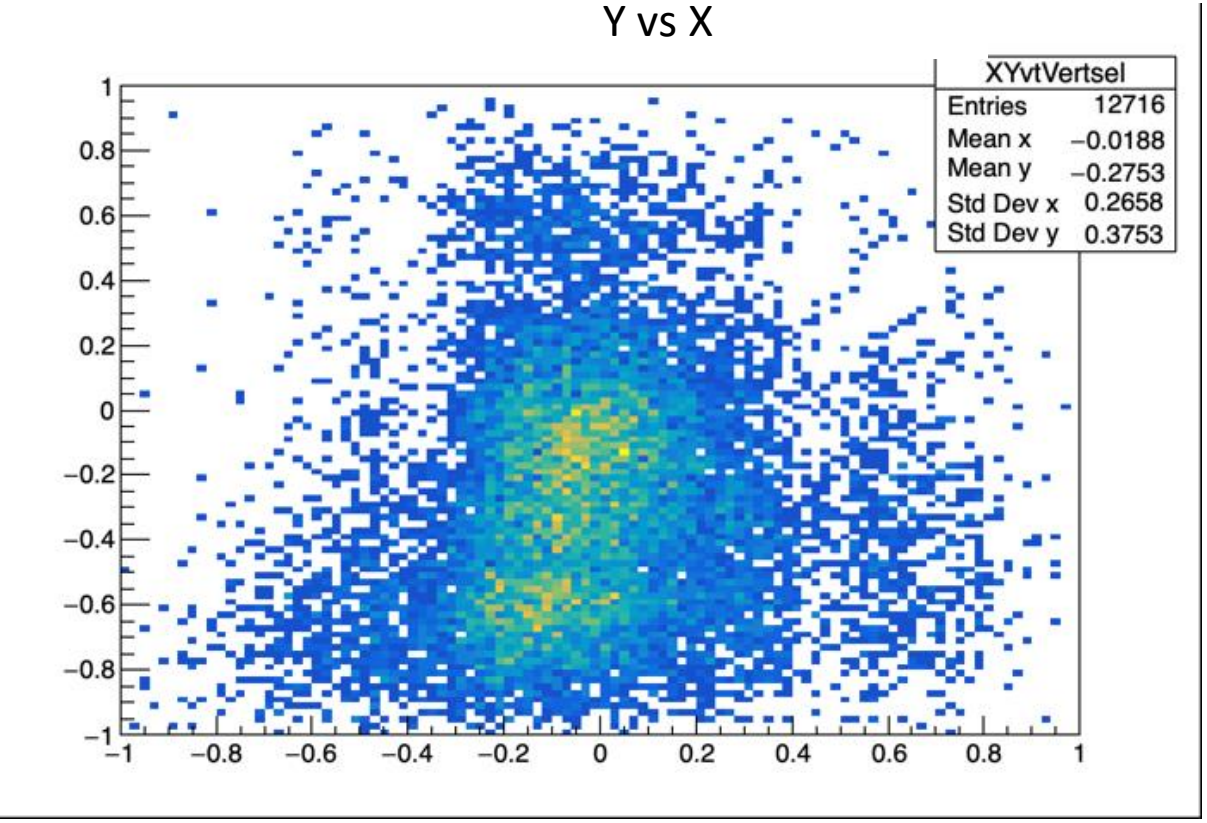
Y vs X



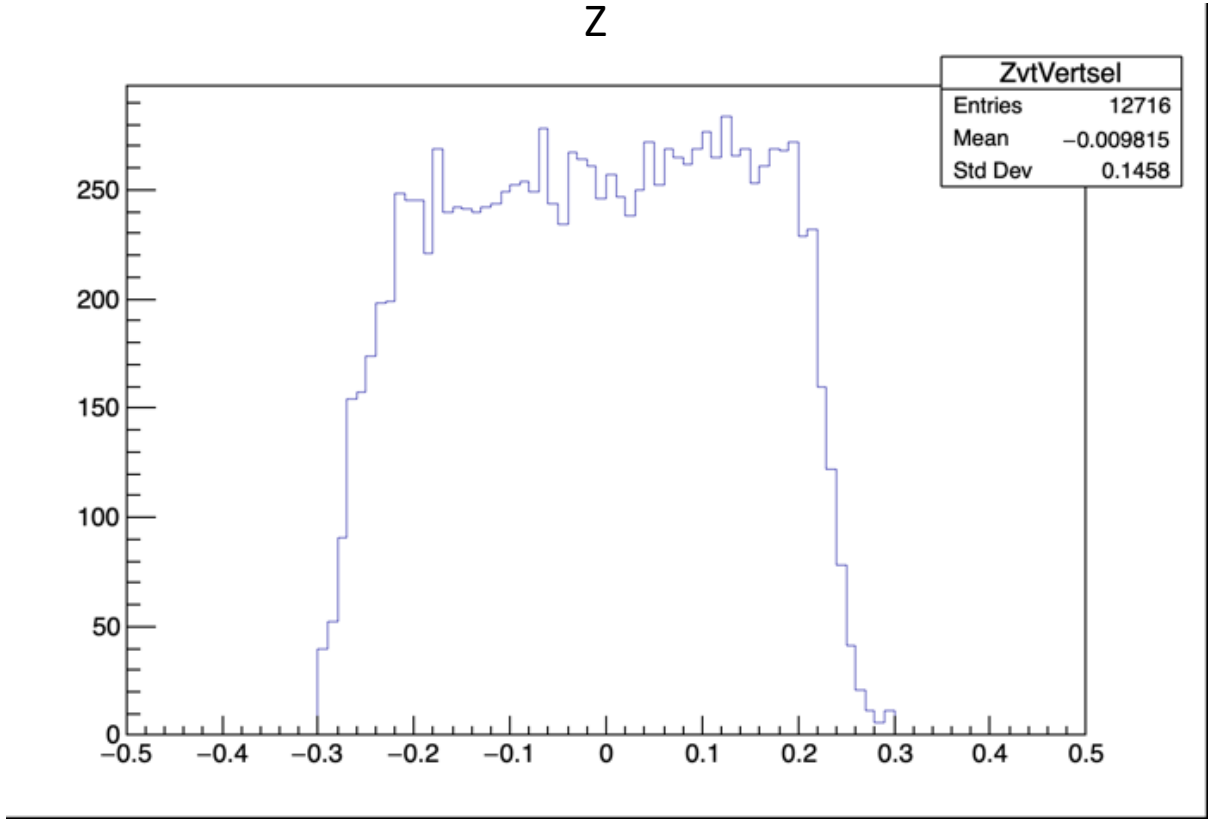


Vertex of selected events

Y vs X

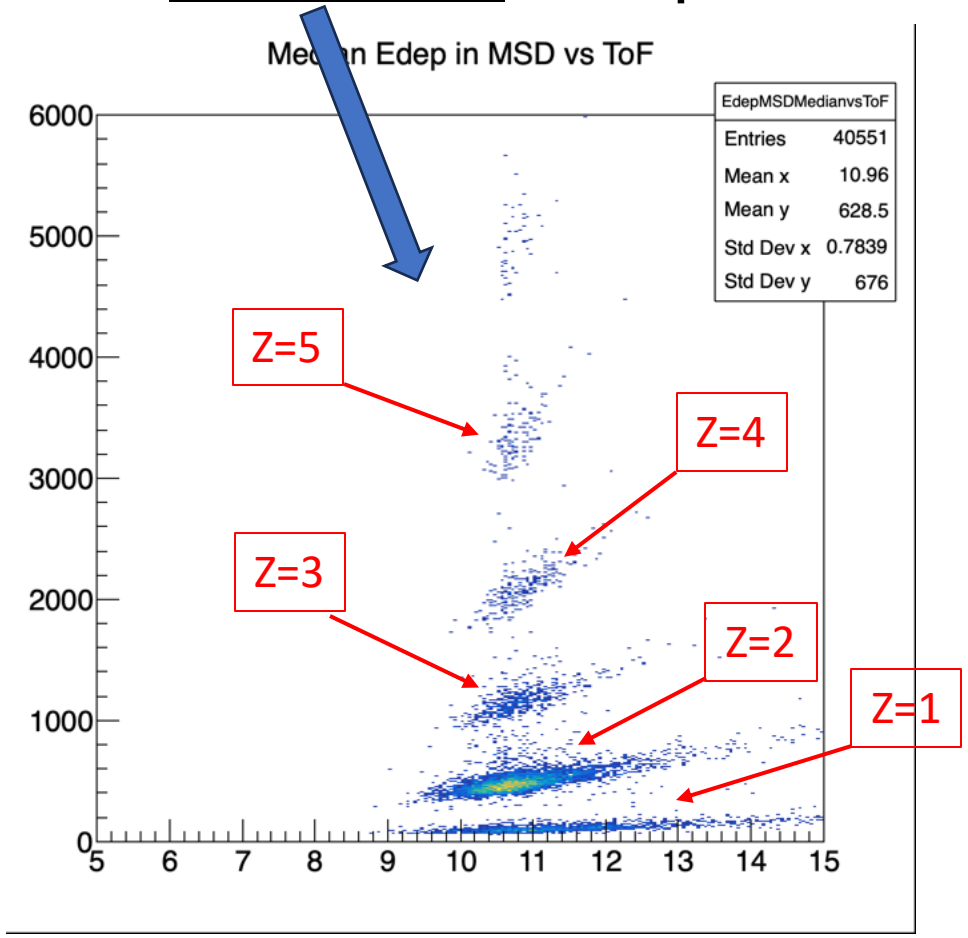


Z



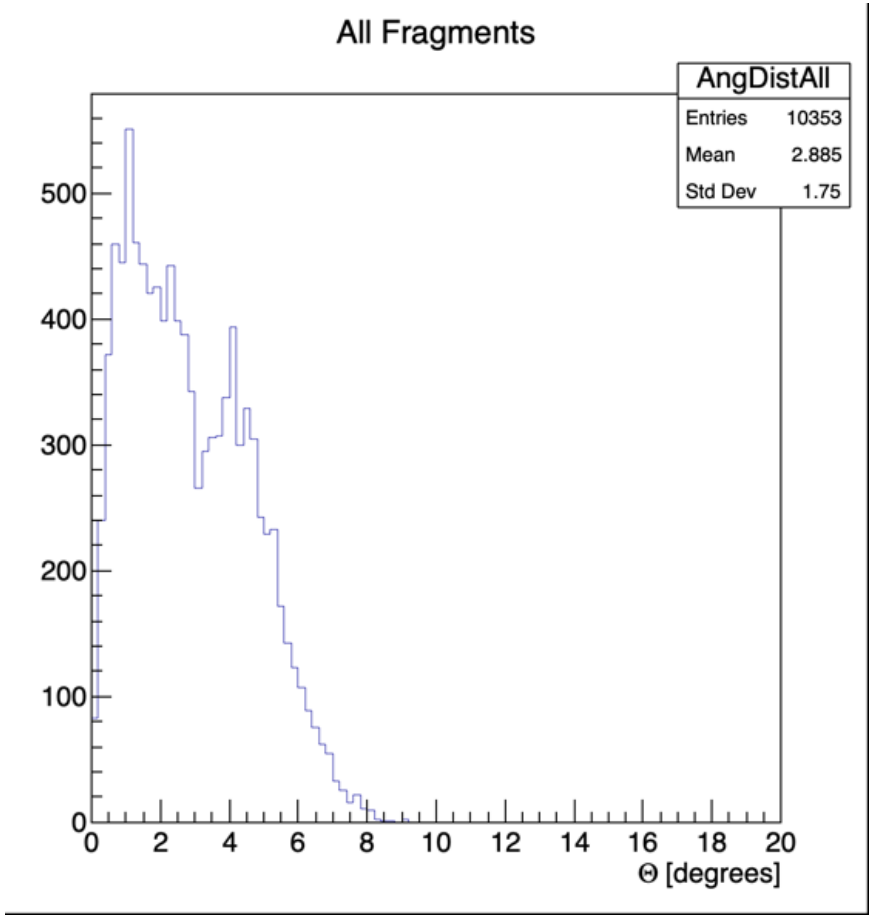
Z id

- To enhance Z-id reliability, the Charge identification matching between TW point and MSD Z-id is required



Angular distribution of selected tracks

- To be used as a qualitative evaluation of quality of results



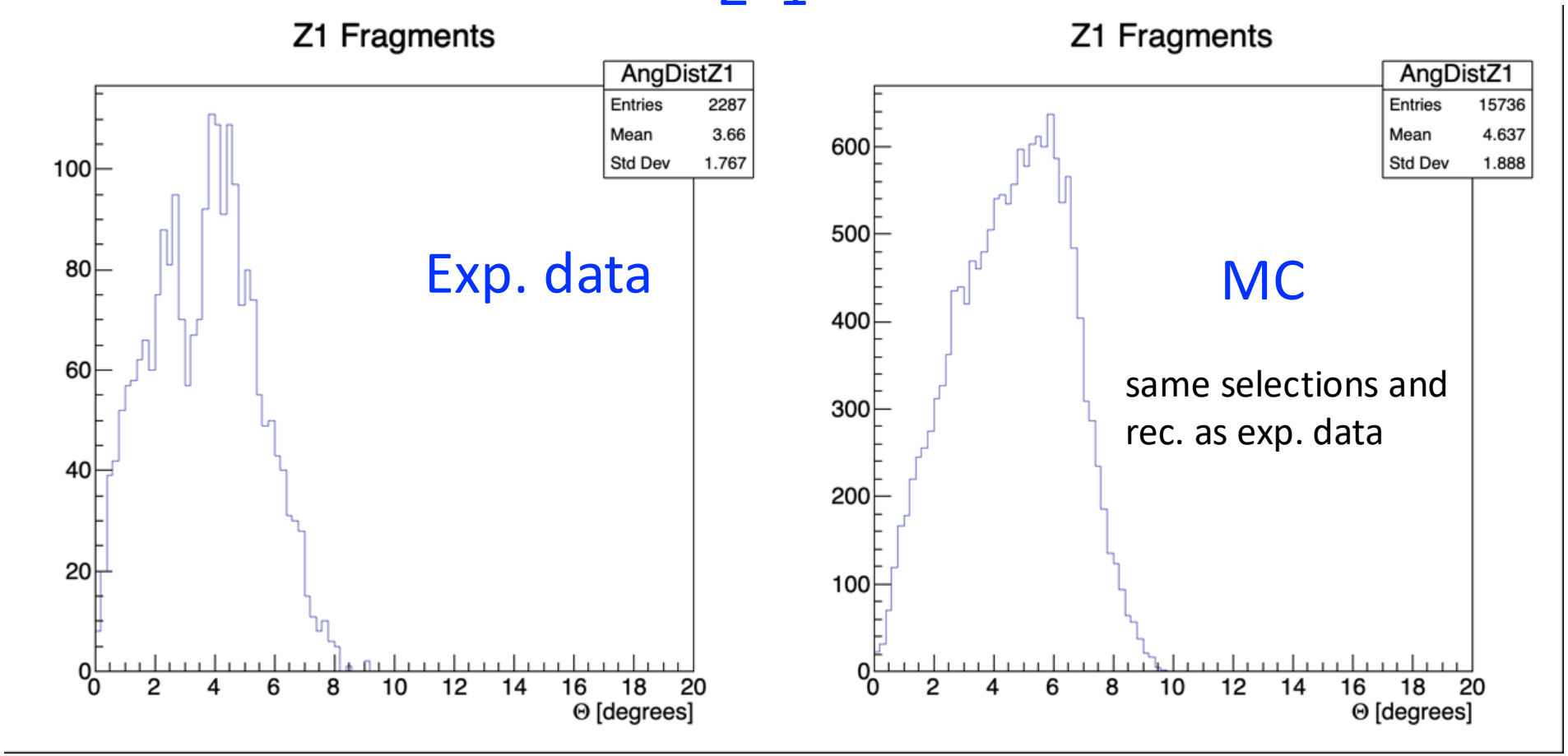
There is an evident anomaly

(No difference between Maj. and Fragm. Trigger runs)

Main anomalies are visible for Z=1 and Z=2

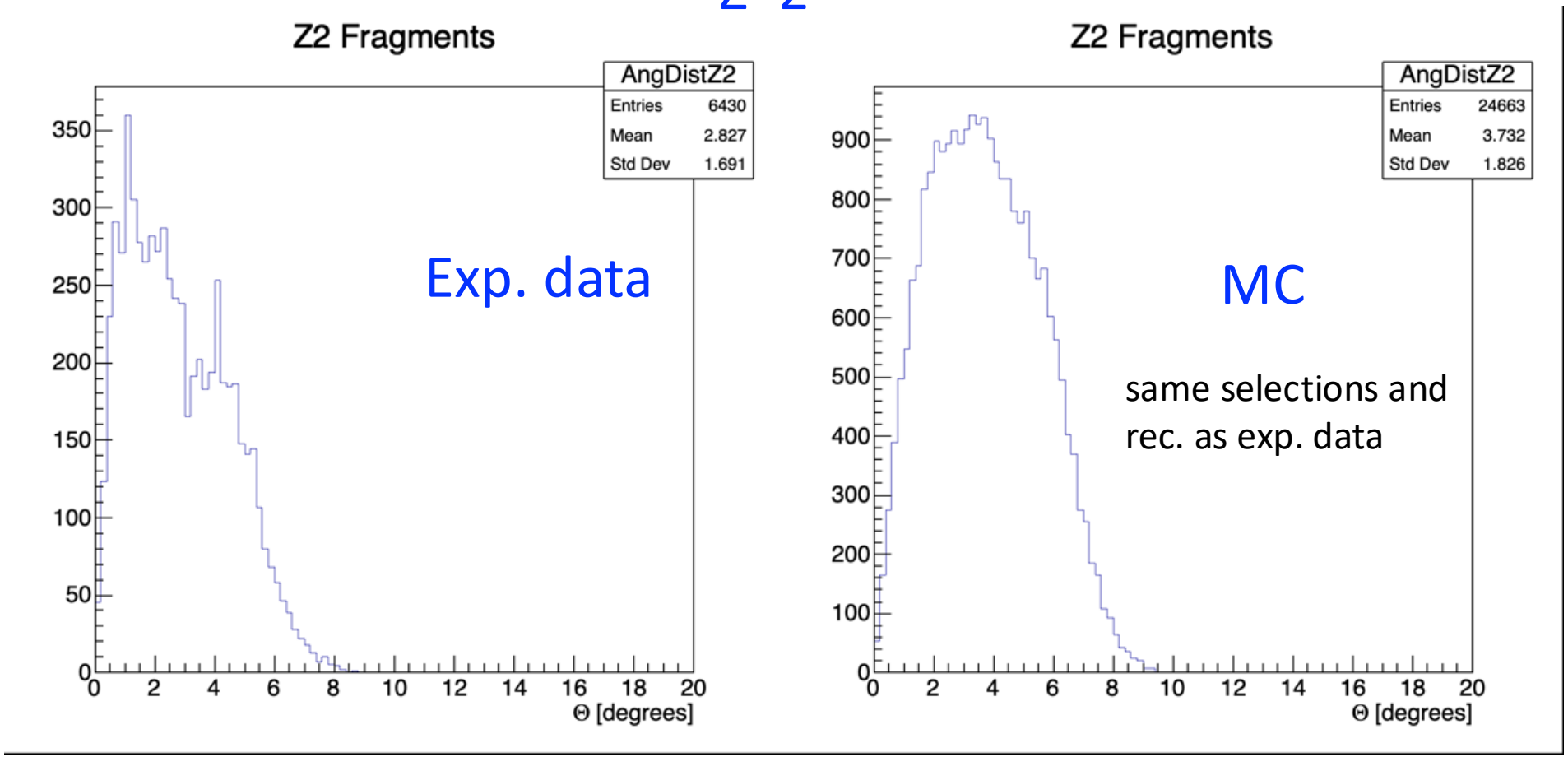
Angular distributions: Data vs MC

Z=1



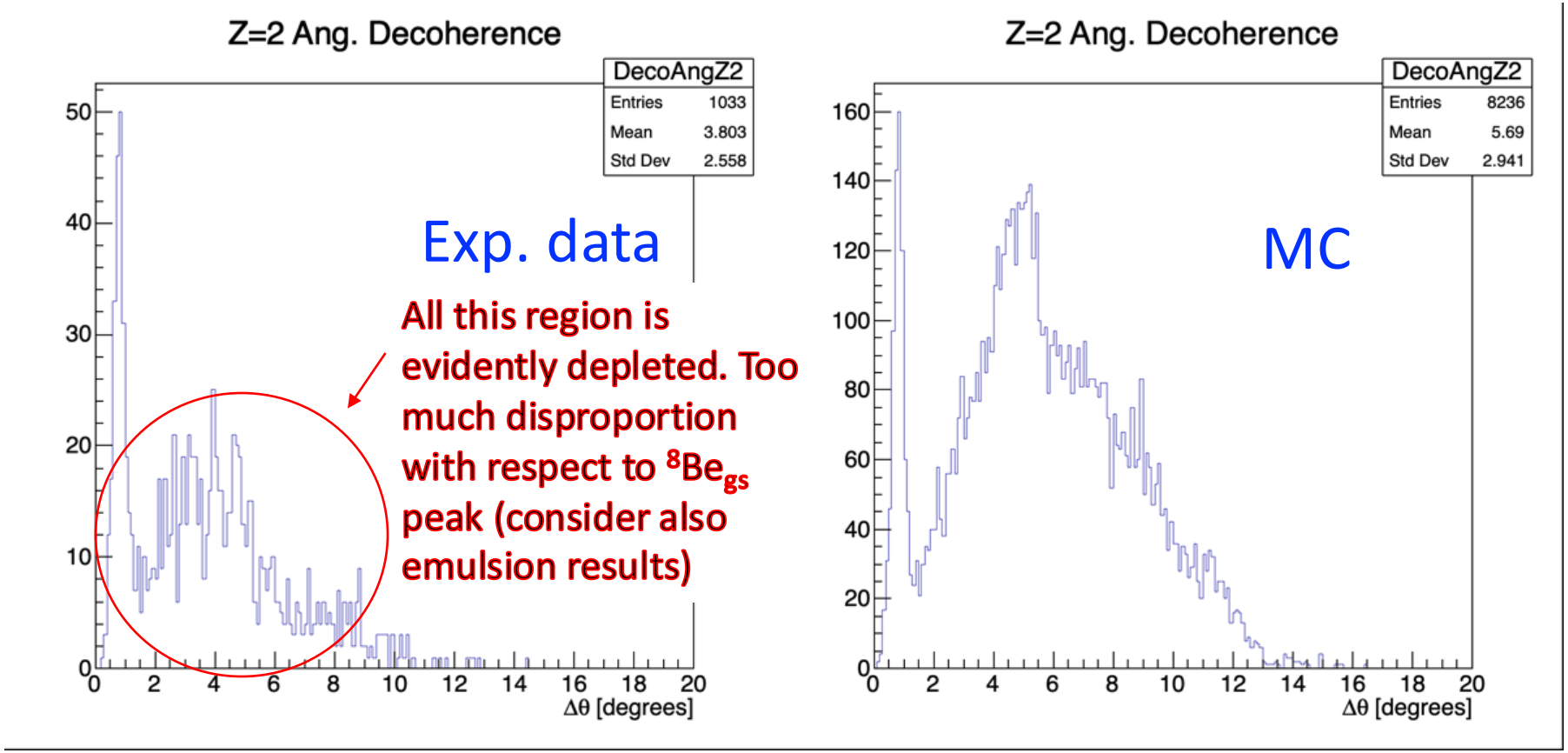
Angular distributions: Data vs MC

Z=2

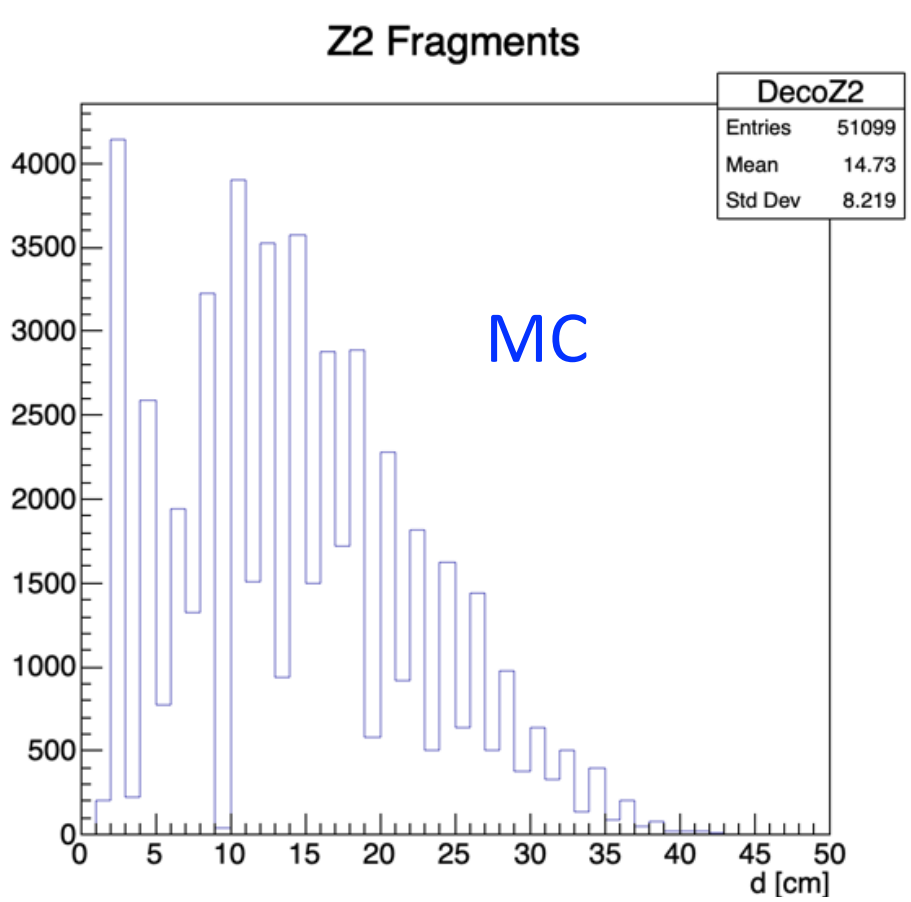


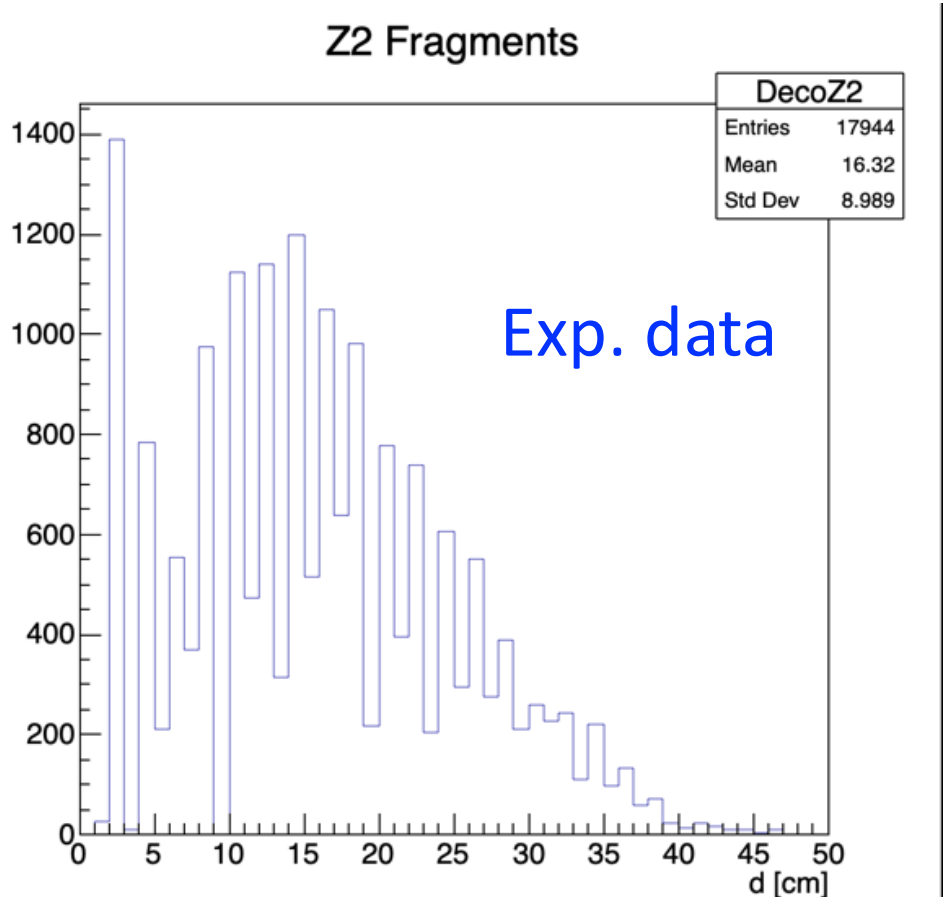
$\Delta\theta$ between Z=2 tracks

- The analysis of alpha clustering with ^{12}C projectiles can be used as a benchmarking physics process (well known process for this ion)



Same thing using just TW point position



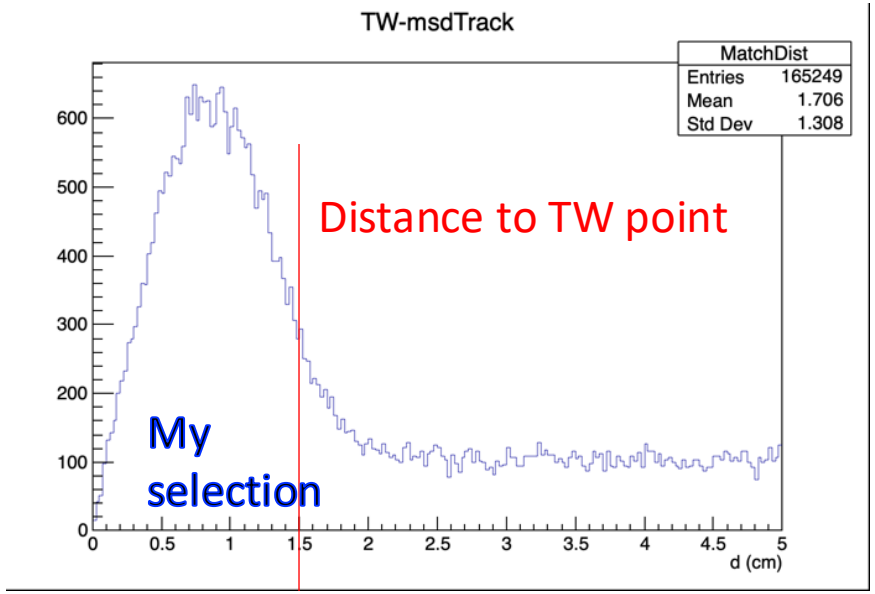


They are incredibly similar!!

➔ There must be a problem either in some part of hardware or in track reconstruction

Other attempts of track reconstruction

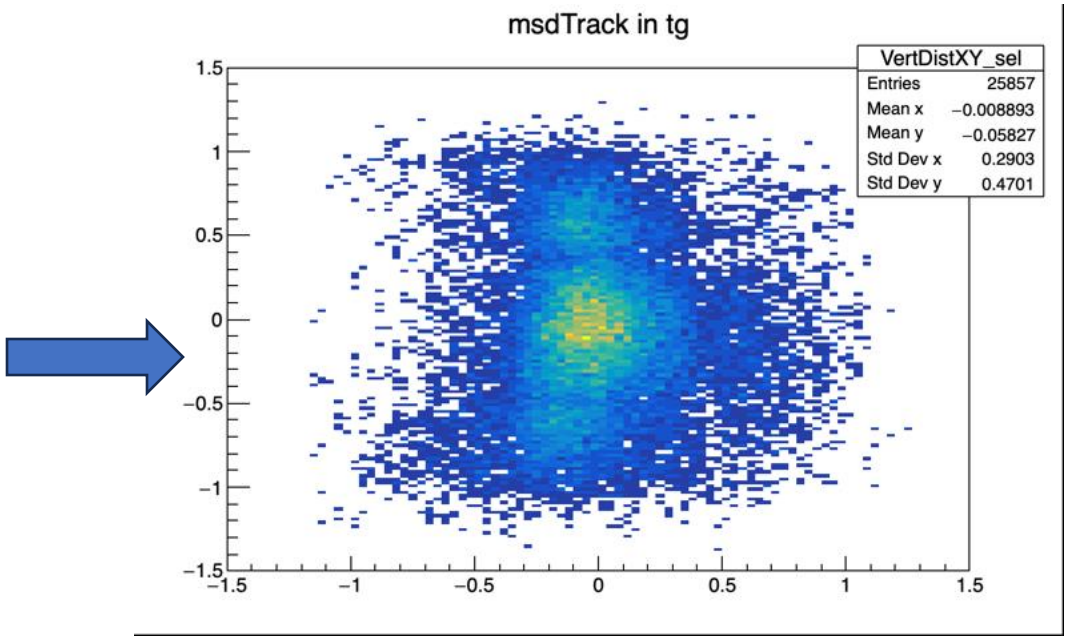
- Straigth line reconstruction does not solve the problem (while instead it was a solution for GSI2021 data)
- New attempt: use MSD tracks
  - Track selection: extrapolation to TW to search for a position matching with TW points



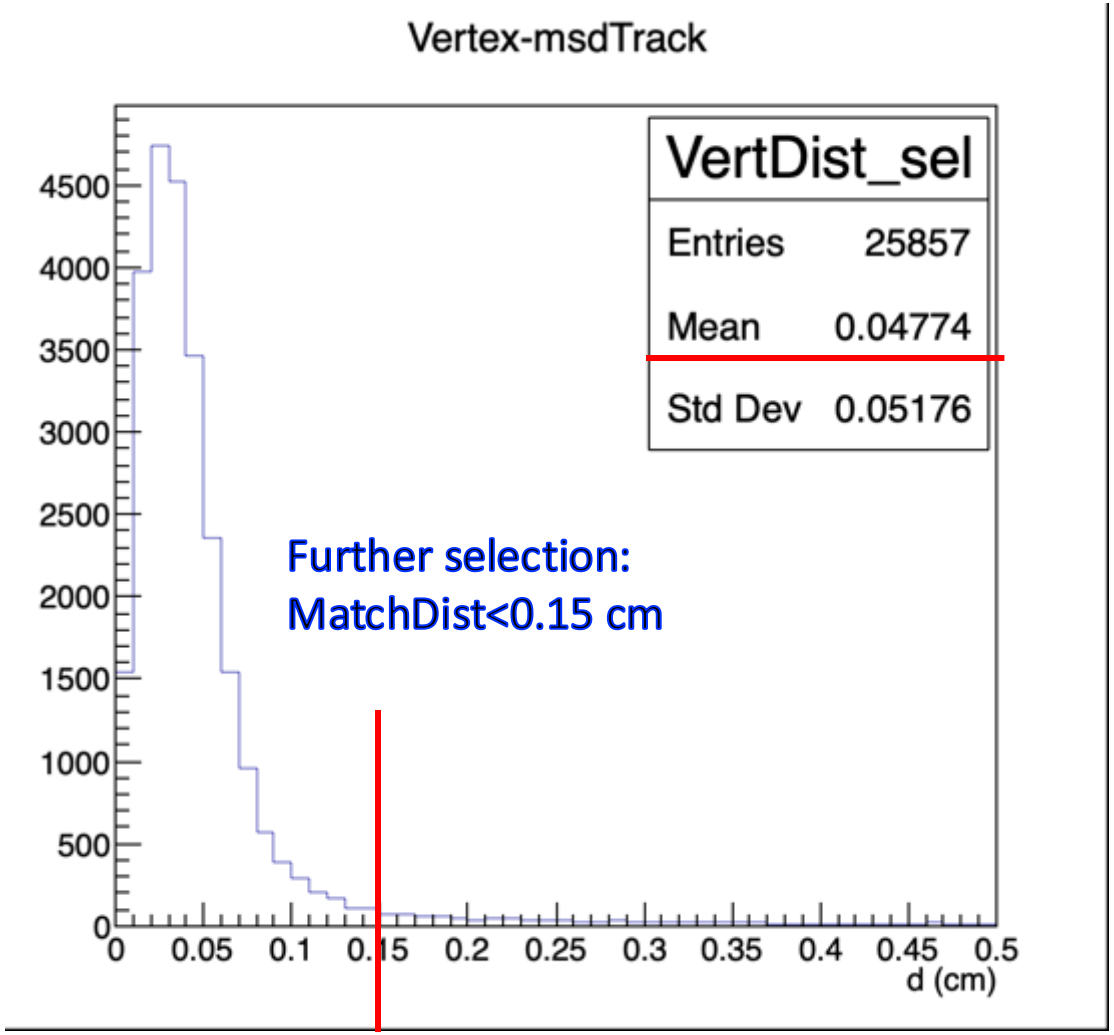
Event and Track Selection

- Pile-up rejection
- 1 BM track with 1 matched VTX vertex (*still considered reliable*)
- At least 2 reconstructed TW points and 2 MSD tracks (to get rid of primary contamination)

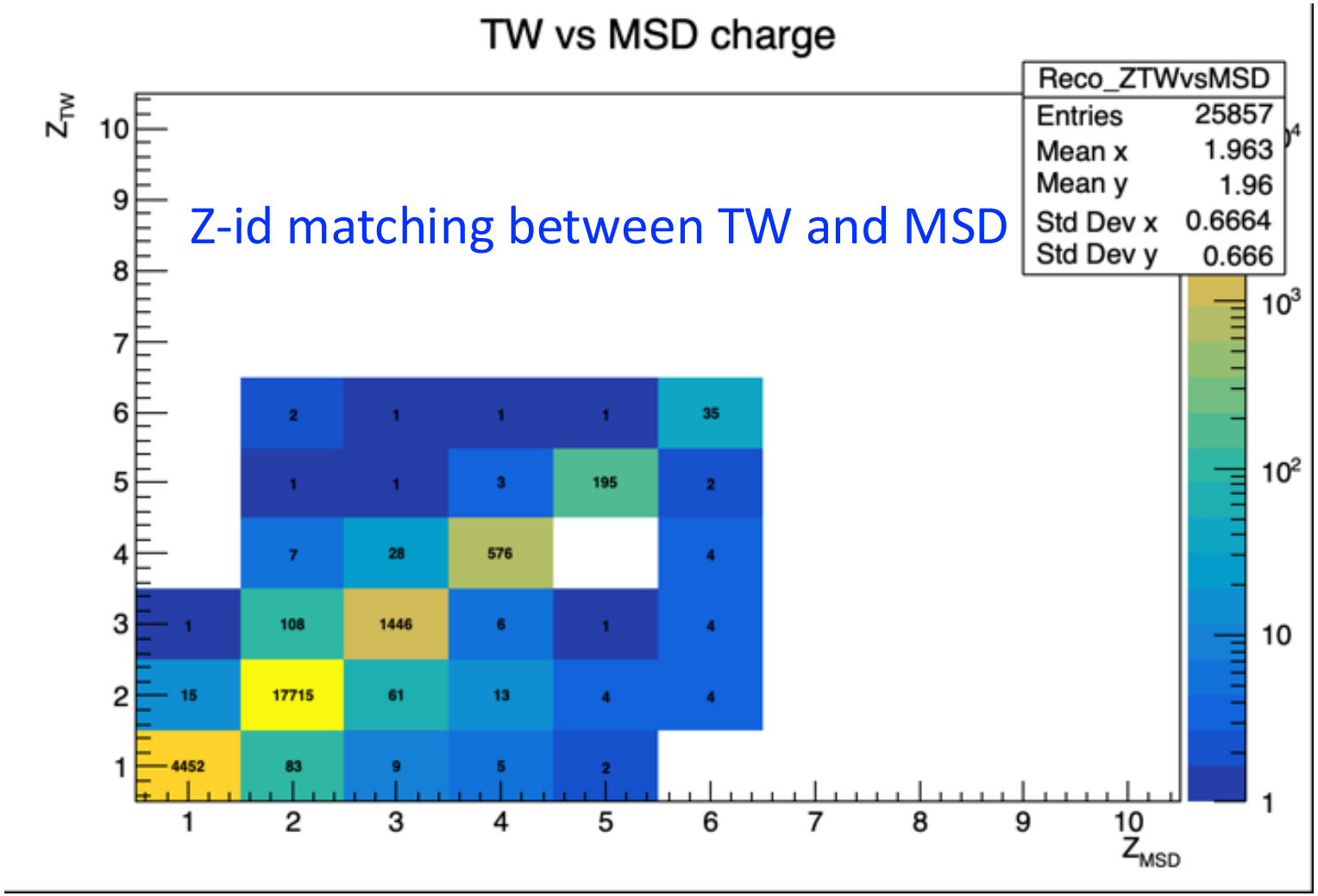
- MSD track matching with TW point
- A posteriori verification of distance of MSD track with respect to Matched Vertex



MSD track – Matched Vertex 2D-distance at $z = z_{MatchedVertex}$



Z-id goodness

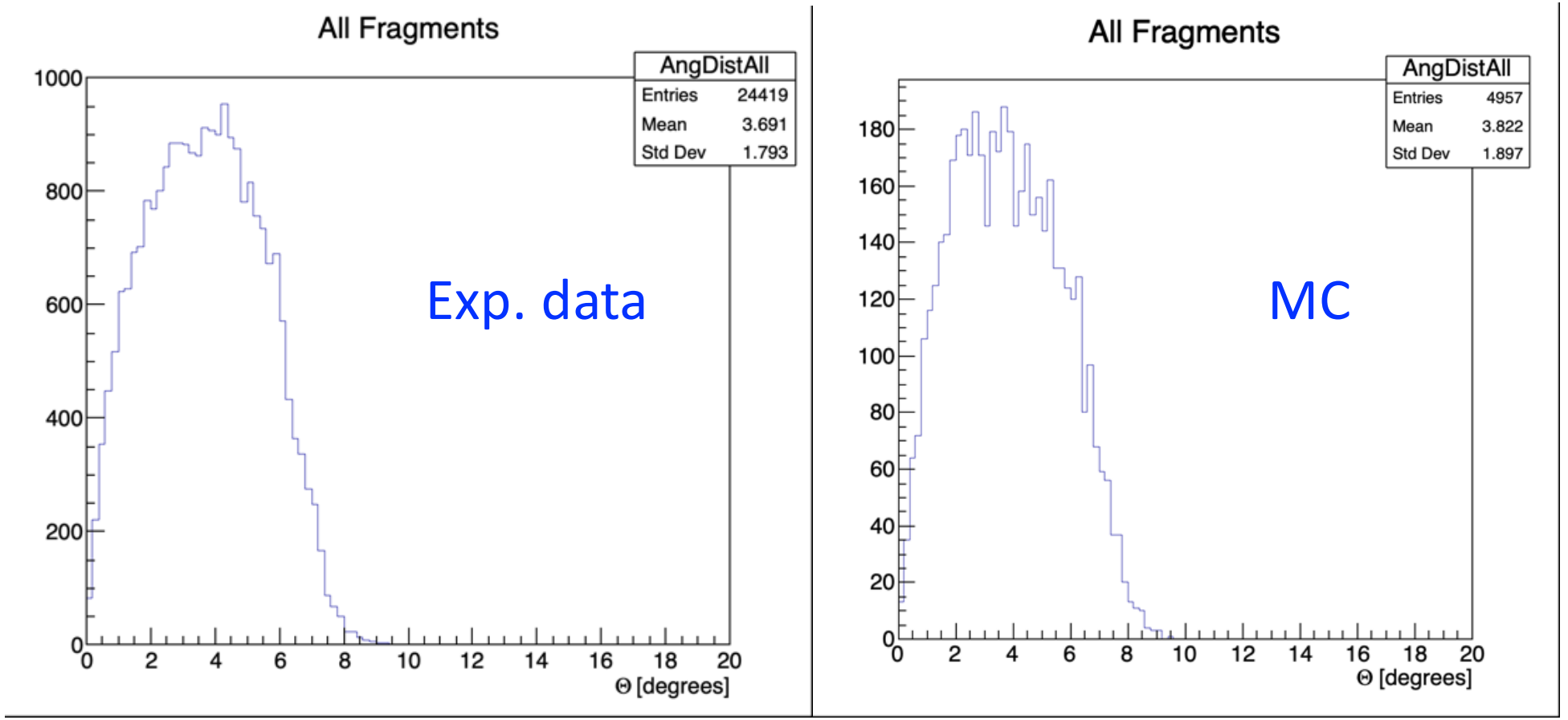


Final request:

$Z_{tw} = Z_{MSD}$

Angular Distribution

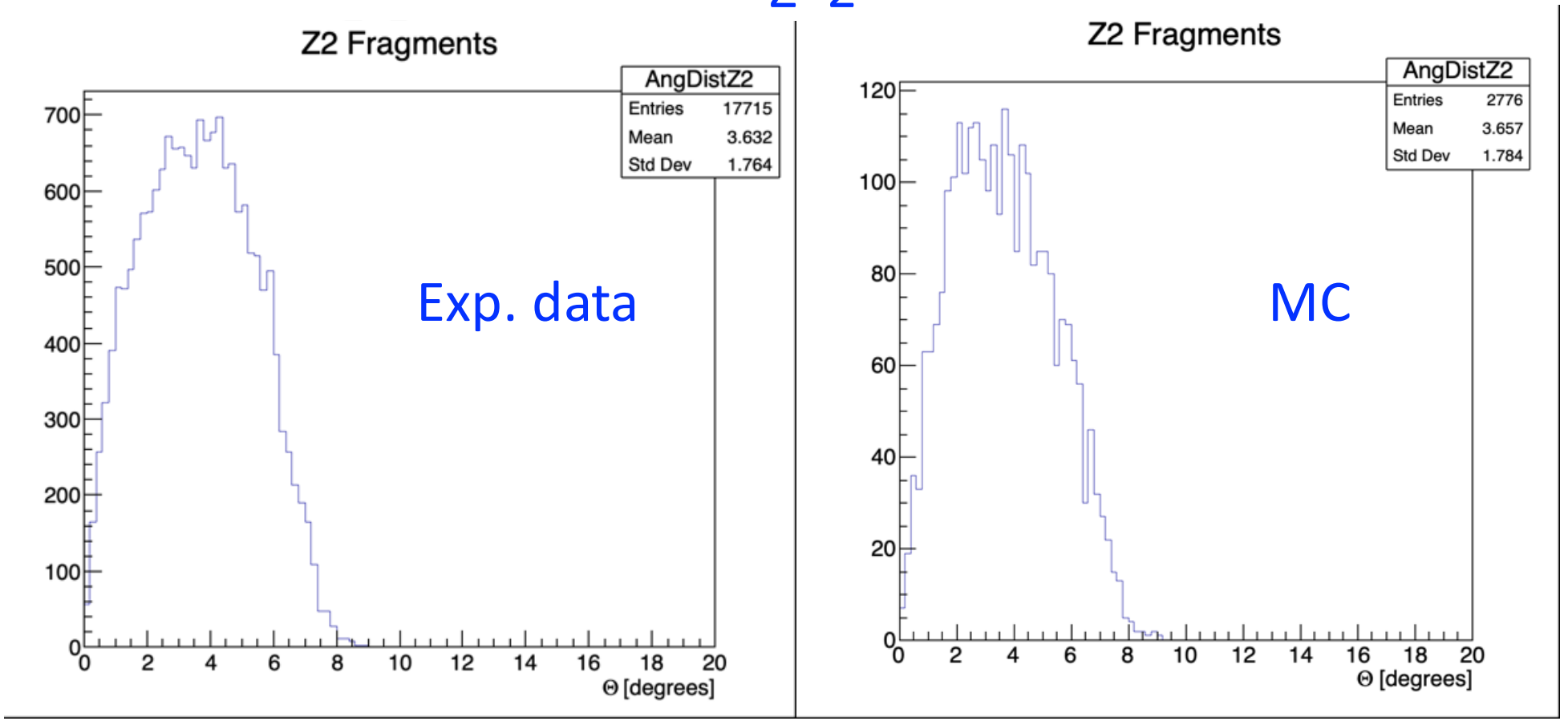
All Z



Now the result are much better

Angular Distribution Z=2

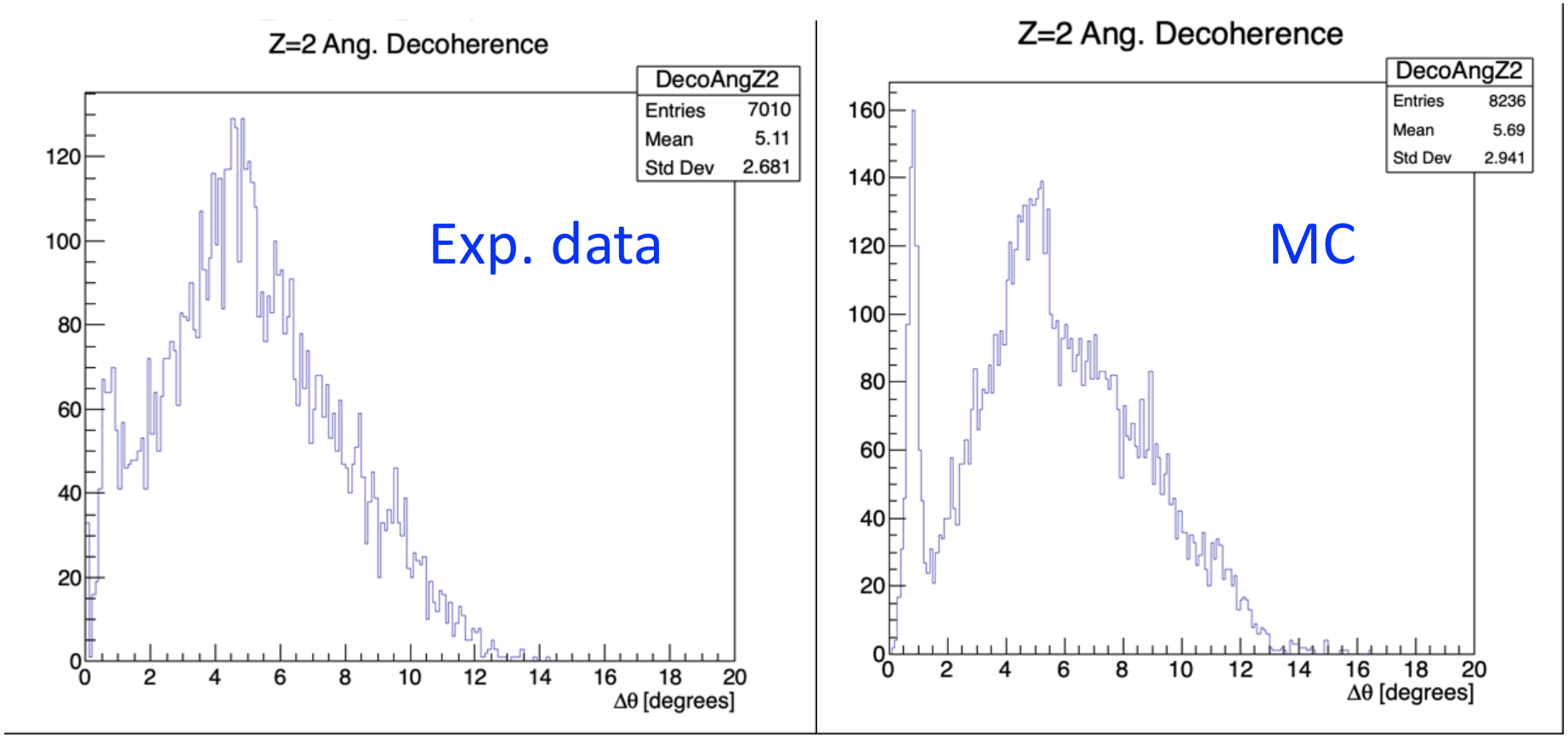
Z=2



Result are better

$\Delta\theta$ between Z=2 tracks

- The analysis of alpha clustering with ^{12}C projectiles can be used as a benchmarking physics process (well known process for this ion)



Results are improved, although now the $^{8}Be_{gs}$ peak might be too depleted

Preliminary conclusions for CNAO2022 data

- There could be problems either with VT or with global tracking for these data
- As for GSI2021, global tracking works ~perfectly on MC data, but not with experimental ones.
- In order to achieve more insight on the situation, the same analysis with MSD tracks should be repeated using VTX tracks
- All this procedure can be repeated on September CNAO2025 data

CNAO2025 data

- Analysis performed on run 7940 of CNAO2025 (second night, the run with the larger number of primaries)
- Shoe cnao2025datataking branch
- Both using Kalman-Genfit and MSD tracks matched with TW points, as for CNAO2022
- Reconstruction attempted two different times:
  1) After the first alignment using a preliminary geometry (CNAO2024)
  2) After the second alignment and with new geometry obtained from survey: ~5-10% gain in reconstructed tracks

Run 7940

Message ID: **90**	Entry time: **Mon Sep 8 00:07:32 2025**
Author:	Michi
Entry:	Run
Detector:	
Run Category:	Physics
Run Number:	7940
Number of Events:	318000
IsValid:	Yes
Beam:	C
Energy:	200
Target:	Graphite 5mm
MagneticField:	No
Trigger:	MB
BM HV:	1750
VTX thresholds:	7 sigma
IT thresholds:	10 sigma

Kalman-GenFit reconstruction

315013 events processed

Event Selection:

- No pile-up event
- 1 BM track with 1 matched VTX vertex
- z coordinate of matched vertex within target with some tolerance: (-0.3 < z < 0.3 cm)
- At least 2 reconstructed global tracks with TW point (to get rid of primary contamination)

Run 7940

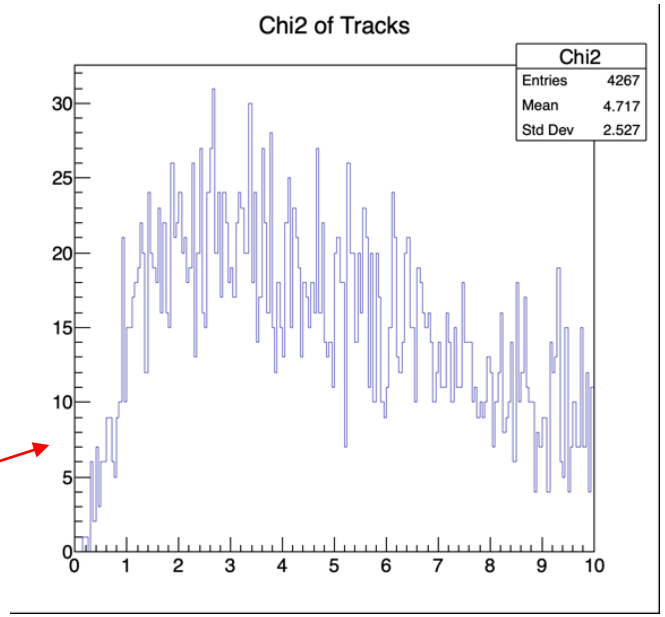
Kalman-GenFit reconstruction

Track Selection in Selected Events.

246503 reconstructed tracks

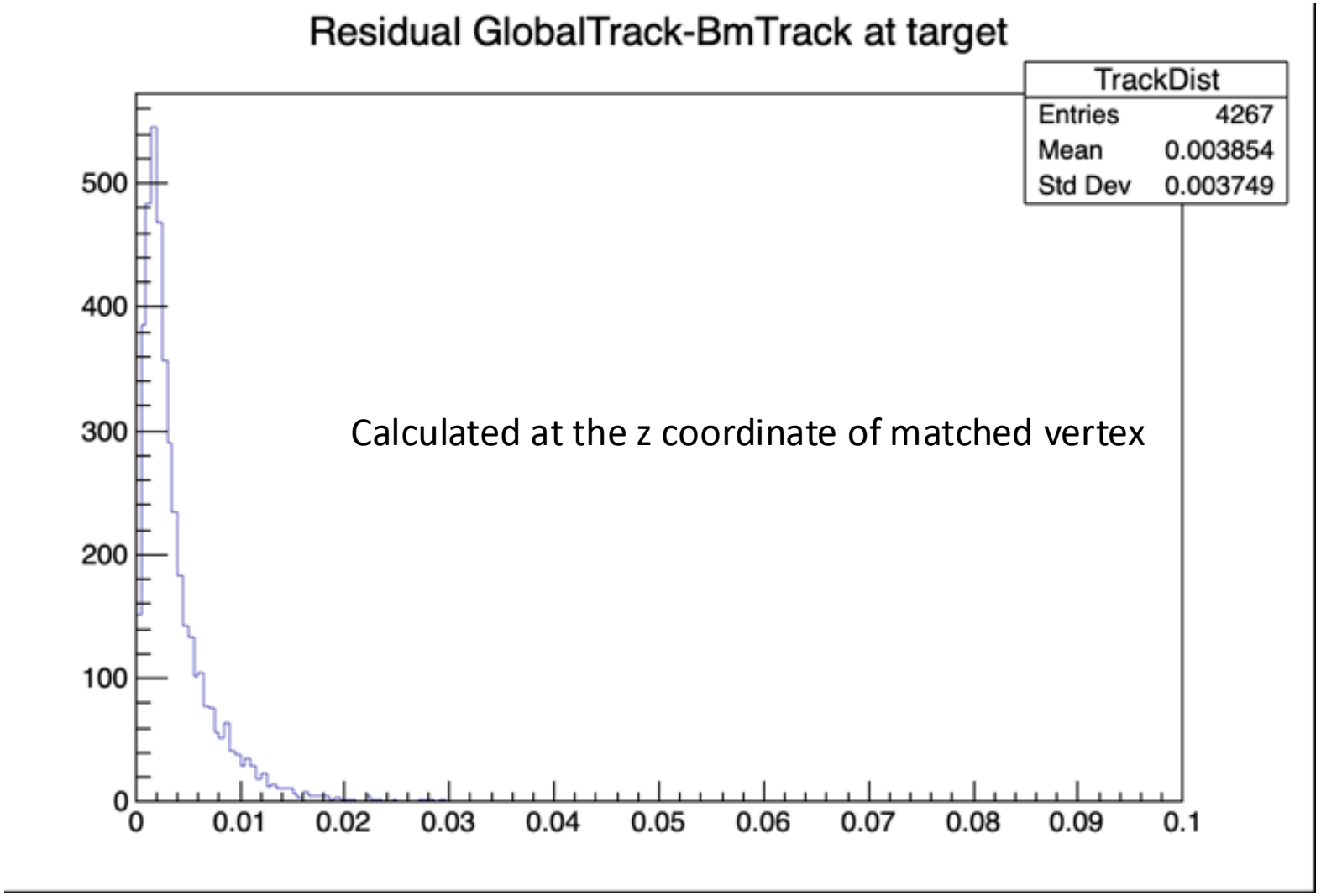
After selection of events with > 1 track:

- Npt VTX > 2 4267 tracks
- TW point 3828
- No Chi2 cut: it's orrible!



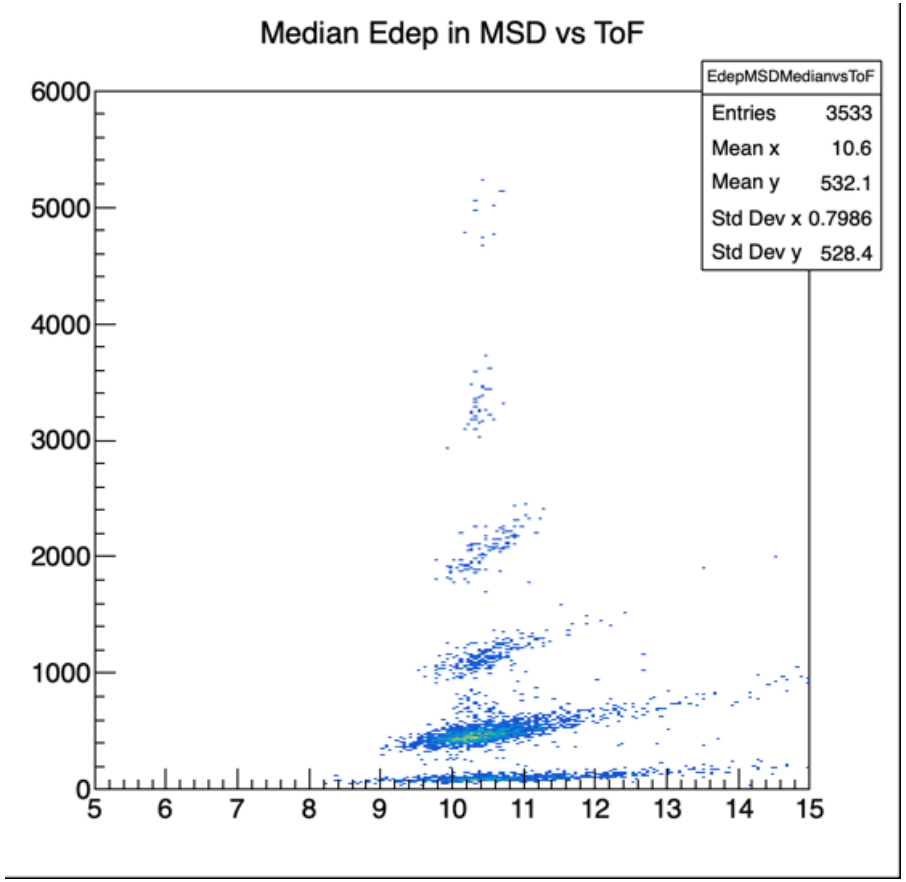
- X,Y at target position within a fiducial area of 2 x 2 cm^2: 3548
- ToF< ToF for 50 MeV/u fragments 3533

Transverse Distance between global track and matched vertex

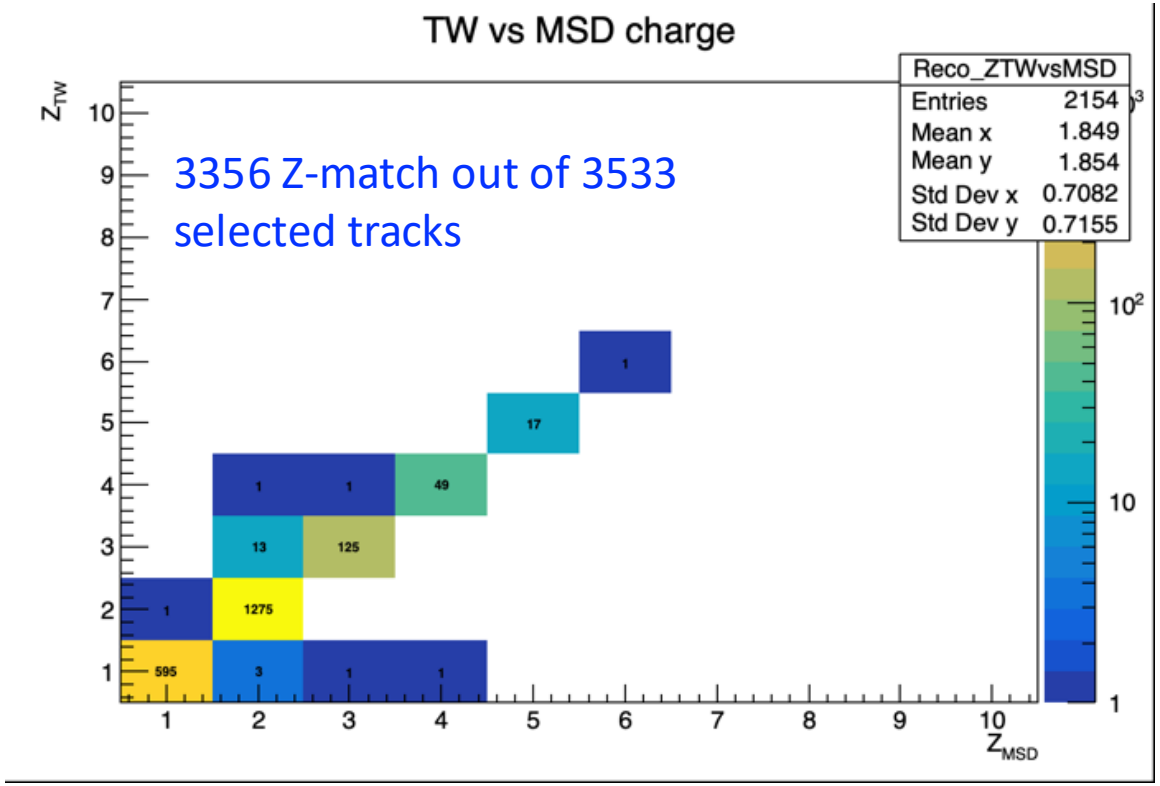


Z-id

MSD Z-id was used: it seems to work also for this run

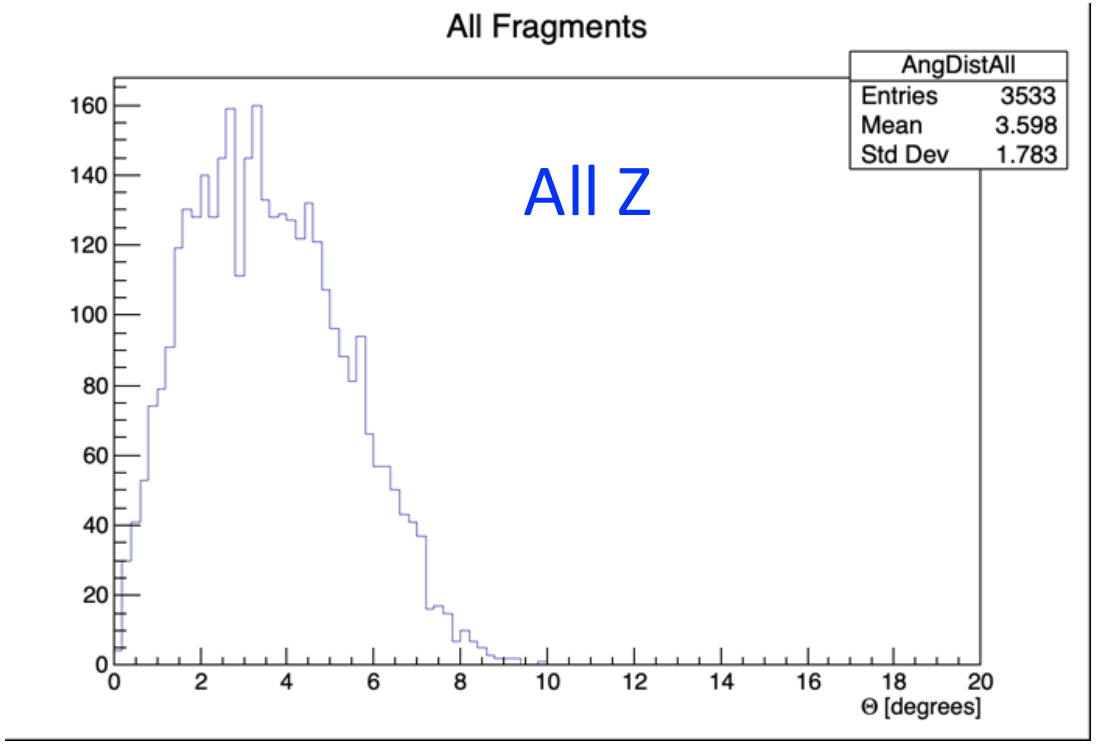


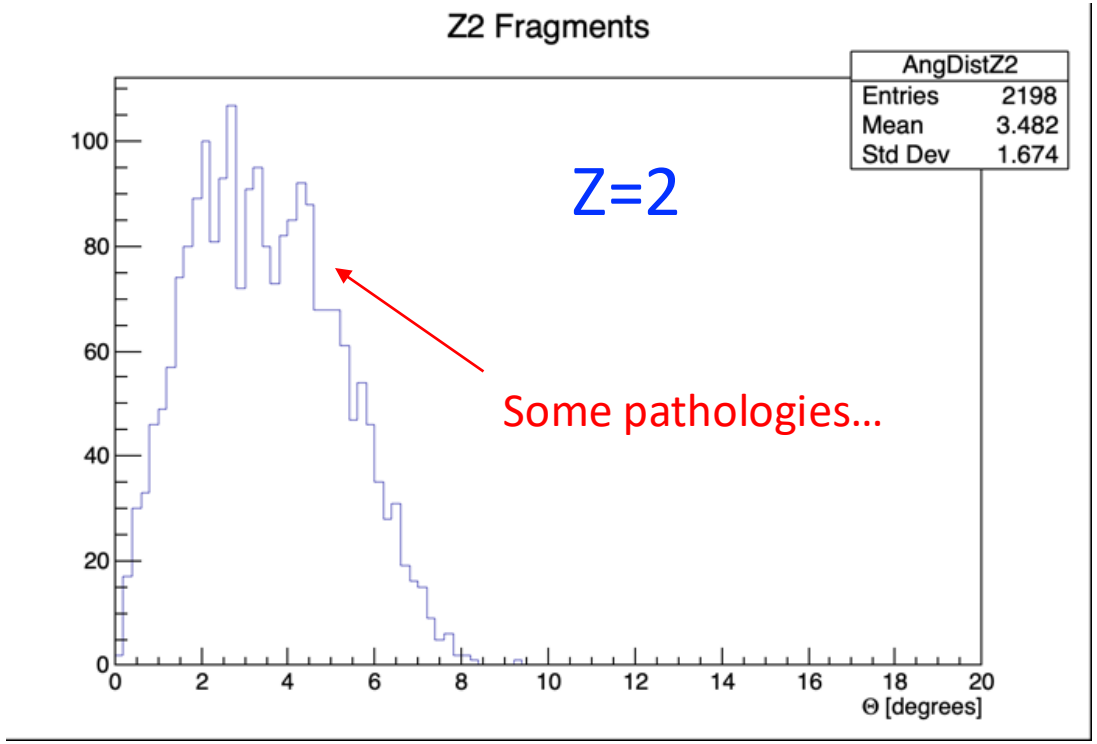
Z-id matching between TW and MSD



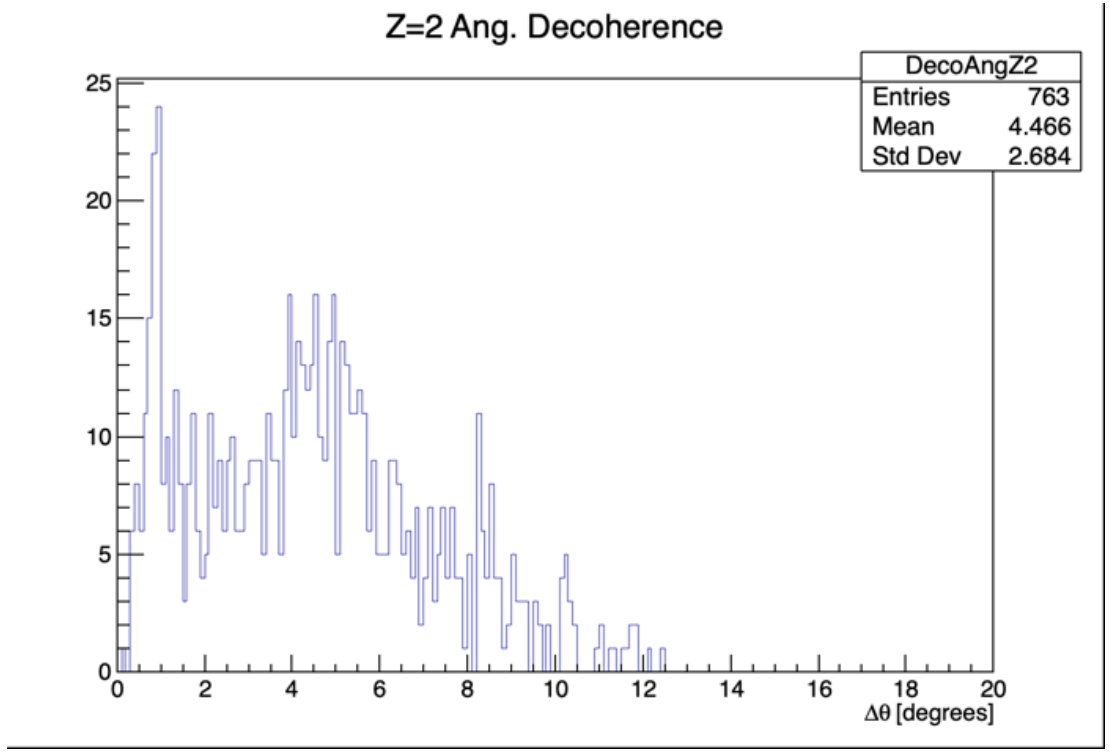
Run 7940 Angular Distributions. GenFIt

Exp. Data – GenFit





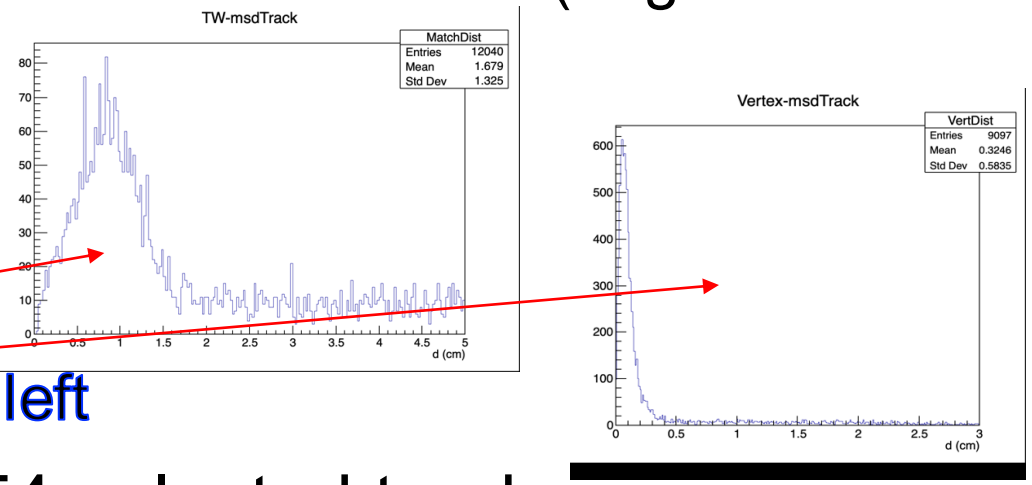
Run 7940: $\Delta\theta$ between Z=2 tracks. GenFIt



GenFit reconstruction: definitively pathological

Run 7940: analysis with MSD tracks

- Same procedure as for CNAO2022
- Event Selection:
  - Usual pile-up rejection
  - 1 BM track with 1 matched VTX vertex
  - At least 2 reconstructed TW points and 2 MSD tracks (to get rid of primary contamination)
- Track Selection:
  - Npt VTX > 2 && Npt MSD>2
  - TW point matching
  - Vertex matching

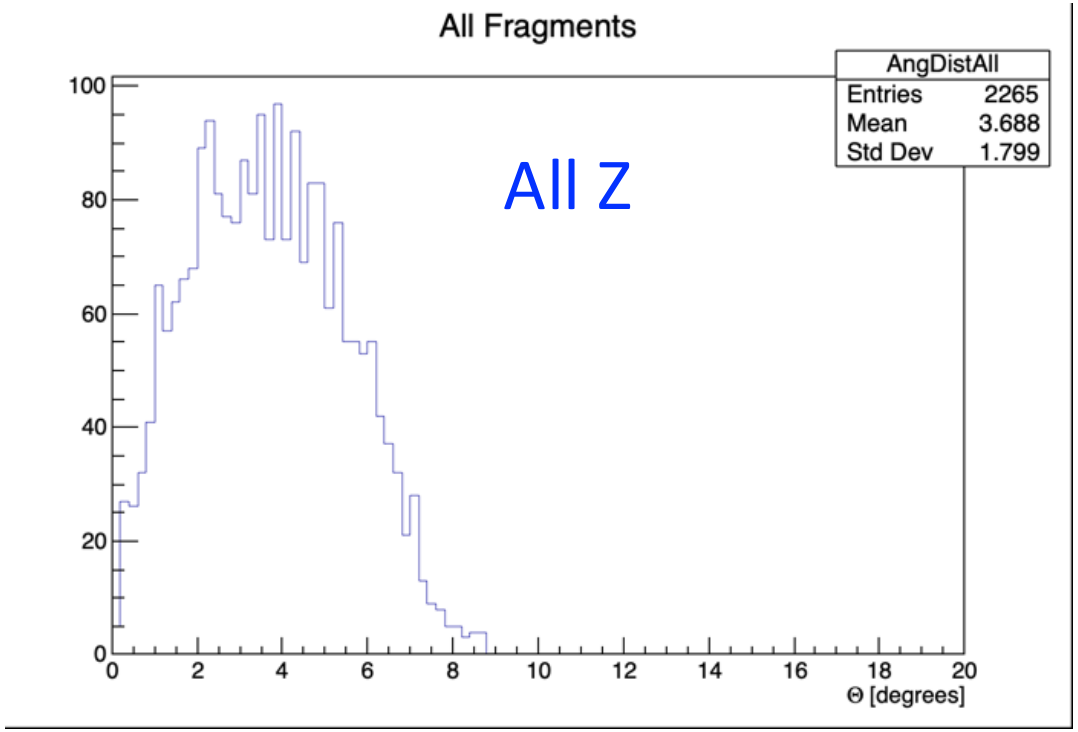


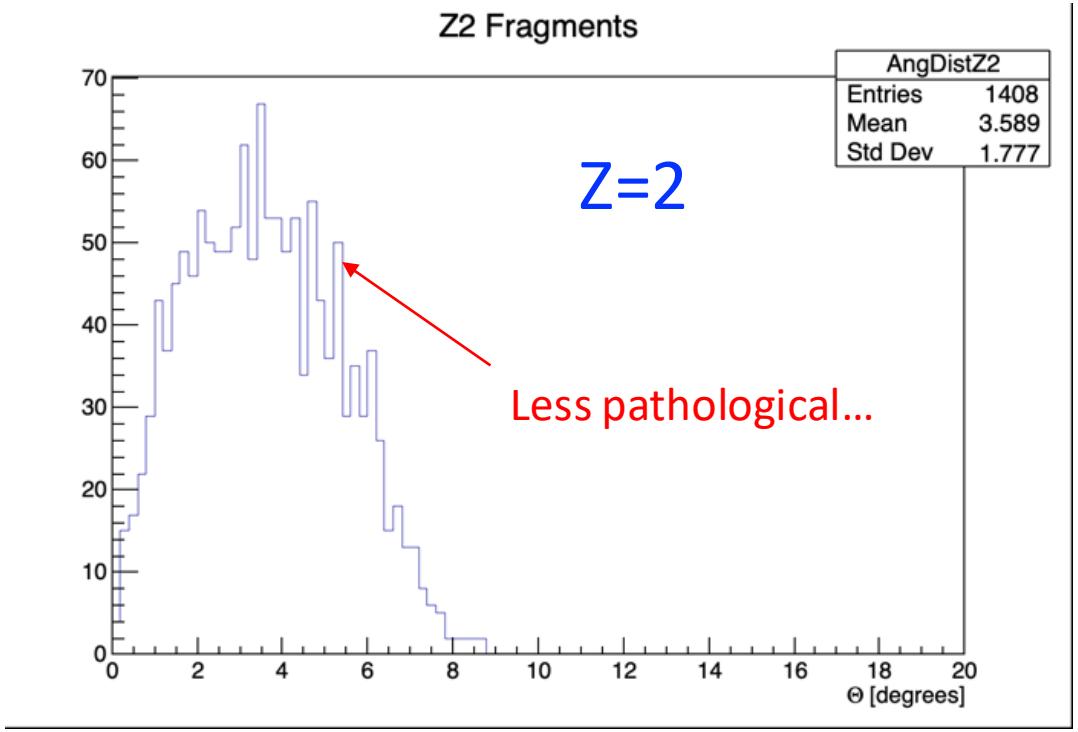
2354 tracks left

- Z-id: 2265 matches out of 2354 selected tracks

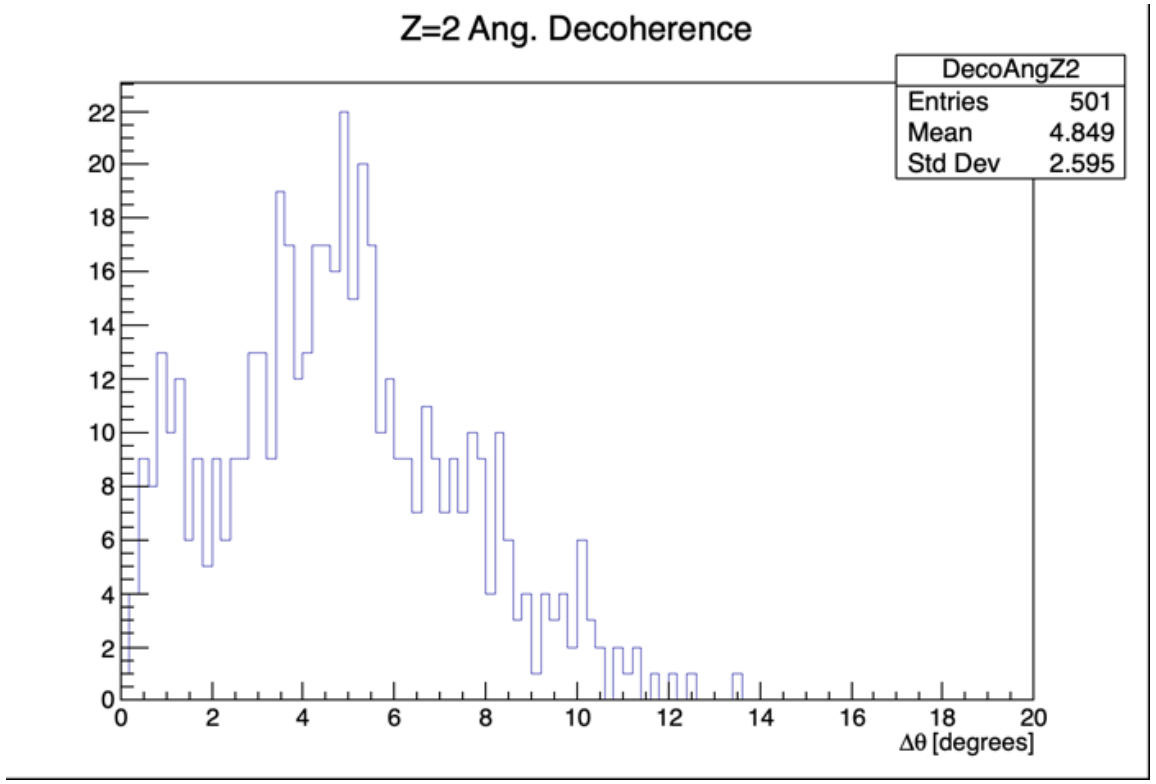
Run 7940 Angular Distributions. MSD tracks

Exp. Data – MSD tracks

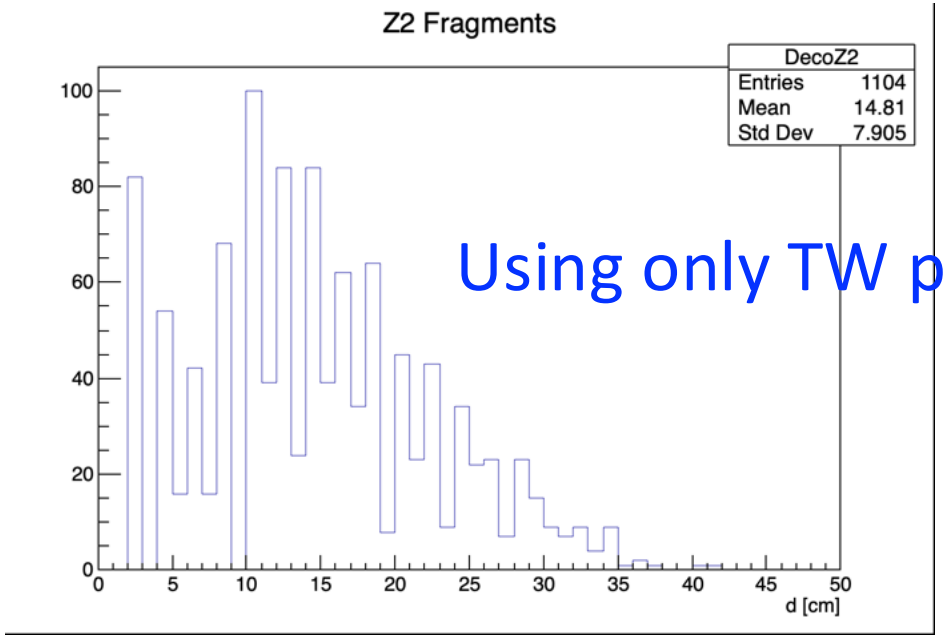




Run 7940: $\Delta\theta$ between Z=2 tracks. MSD tracks



MSD track analysis:
definitively less pathological



Using only TW point

Preliminary conclusions

- These CNAO2025 data seem intrinsically good
- Even after the damage due to high intensity proton spills, MSD tracking seems to work
- GenFit reconstruction seems to be have some problems (as in CNAO2022 and GSI2021 reconstructions)
- Given the good performance of VTX during this last data taking, this preliminary results seems to point to the existence of some software bug, not existing when MC data are concerned.