SciFi alignment in 2023: updates

Giulia Tuci, for the SciFi alignment team
Heidelberg University
07.11.2023

Alignment in 2023: overview

- See [summary](#) @ SciFi General meeting

- Alignment: HalfModules (+ joint constraints) TxRz, starting from 2022 conditions
  Used 2022 constants for Mats

- Long tracks used for the alignment: asymmetric acceptance due to VELO open
  configuration introduces some challenges

- Known issues:
    - 1) No mat-contraction calibration
    - 2) Charge-dependent mass shift observed in HLT2-processed data: this
      presentation
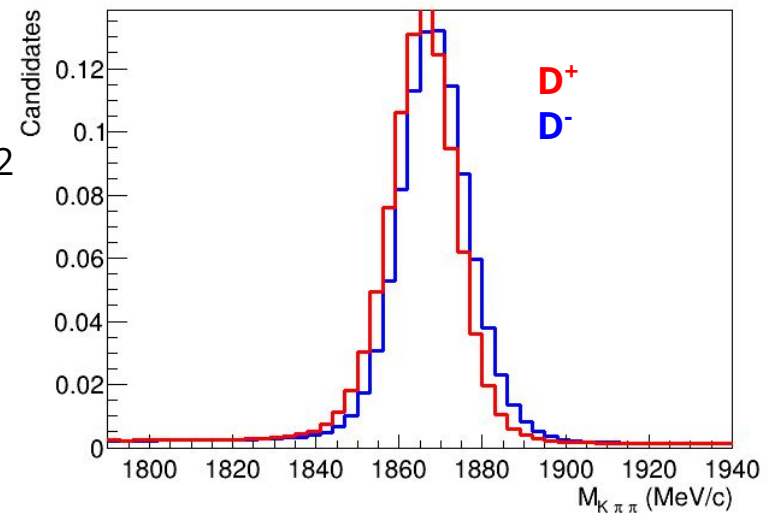
Mass peaks (v3 vs v6)

- Many thanks to Gregory Ciezarek for the plots!
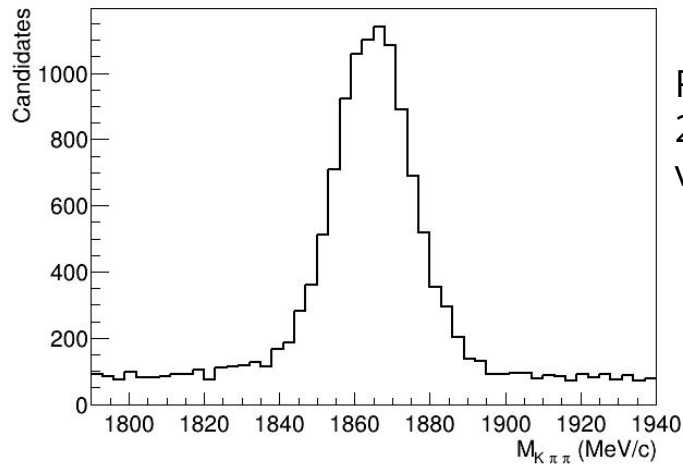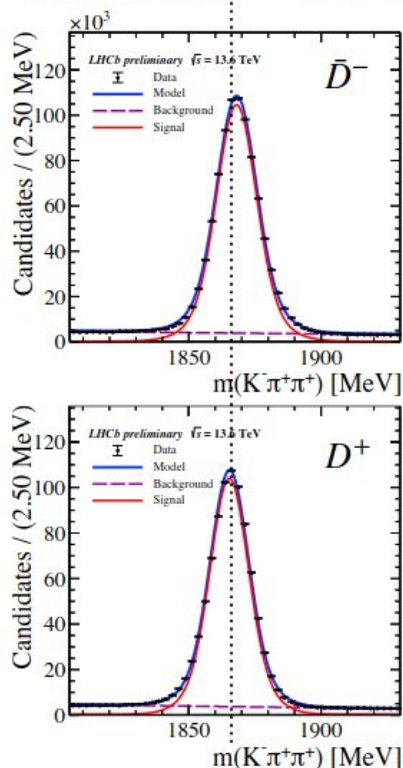

Runs
263810–263839
v3 alignment
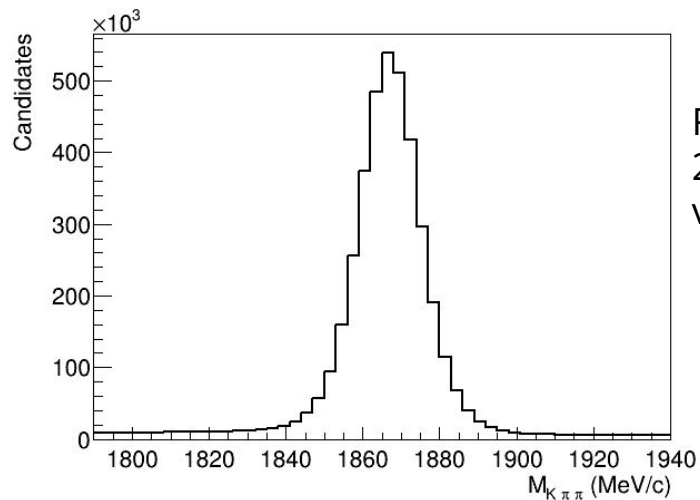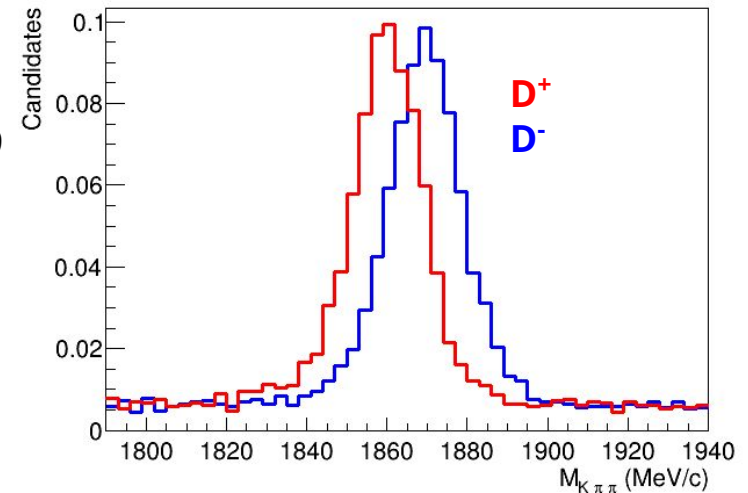
Runs
269370–269542
v6 alignment

Mass peaks (v9)

- We expected a further improvement with v9, but this is not the case
  - See Peilian's slides
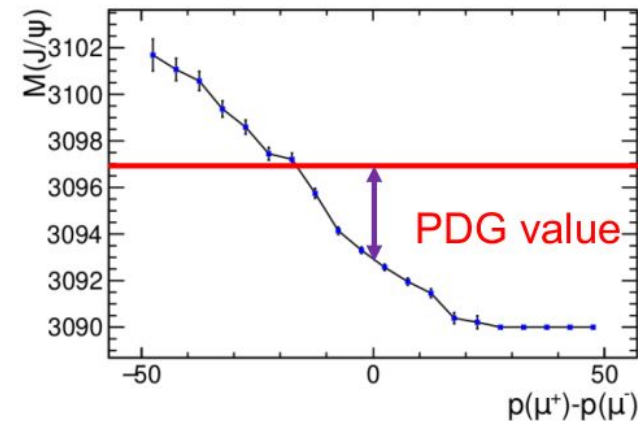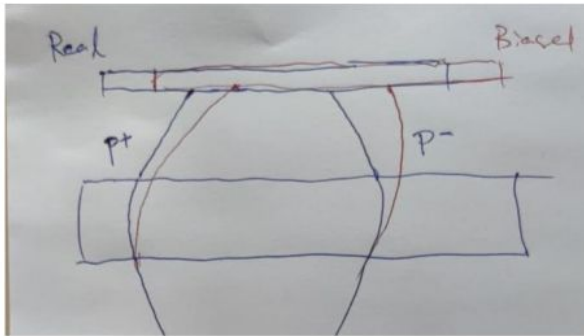

Mass fit to D^+ and D^- for commissioning 23 data

Data	D-	D+
Mass (MeV)	1868.28 +/- 0.01	1865.66 +/- 0.01
width (MeV)	8.22 +/- 0.12	8.56 +/- 0.15

- Significant shift between D^+ and $\bar{D}^-$ ~ 2.6 MeV

- mean mass in both D^+ and D^- shift w.r.t PDG mass:
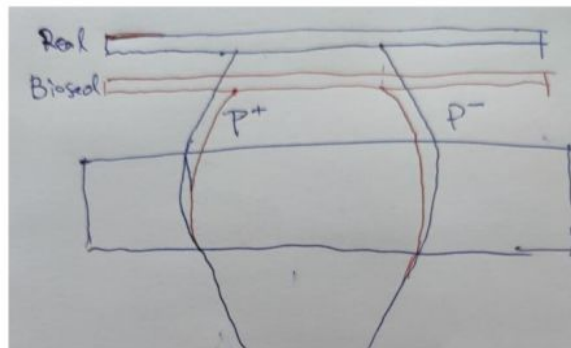$$M^{\mathrm{PDG}} = 1869.66 \pm 0.05 \text{ MeV}$$

Sources of mass shift

➢ Curvature bias lead to mass shift; 2 types of bias observed in 2023 data

1. Bias in T_x : $\delta m = (1 - cos\theta)(p_- - p_+)\delta p \sim C\delta r(p_- - p_+)$

2. Bias in T_z : $\delta m = (1 - cos\theta)(p_- + p_+)\delta p \sim C\delta z\, t_x(p_- + p_+)$

Plot and drawings kindly provided by Zehua Xu!

Details in backup

5

Issues discovered in the meanwhile

- <u>Banana-shape description</u>:
    - in the latest 2022 SciFi alignment version Rx was unintentionally set to 0 → no banana shape description.
    - A non-zero Rx has been introduced in 2023 alignment, but without changing Tz.
        - If the position in z was ~ correct for 2022 in the centre of the module, with Rx=0, then a shift is introduced

Side view
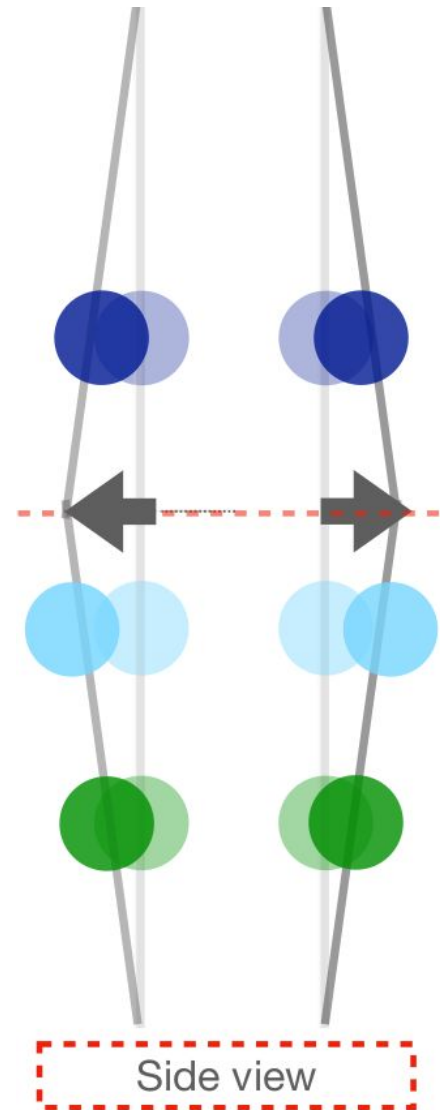
Issues discovered in the meanwhile (2)

- Particles selection
  - $D^0 \rightarrow$ Kpi candidates used to align the SciFi: use the D^0 mass constraint to prevent "weak modes" and improve alignment quality
  - Need a high purity sample...but selections too loose in online alignment configuration
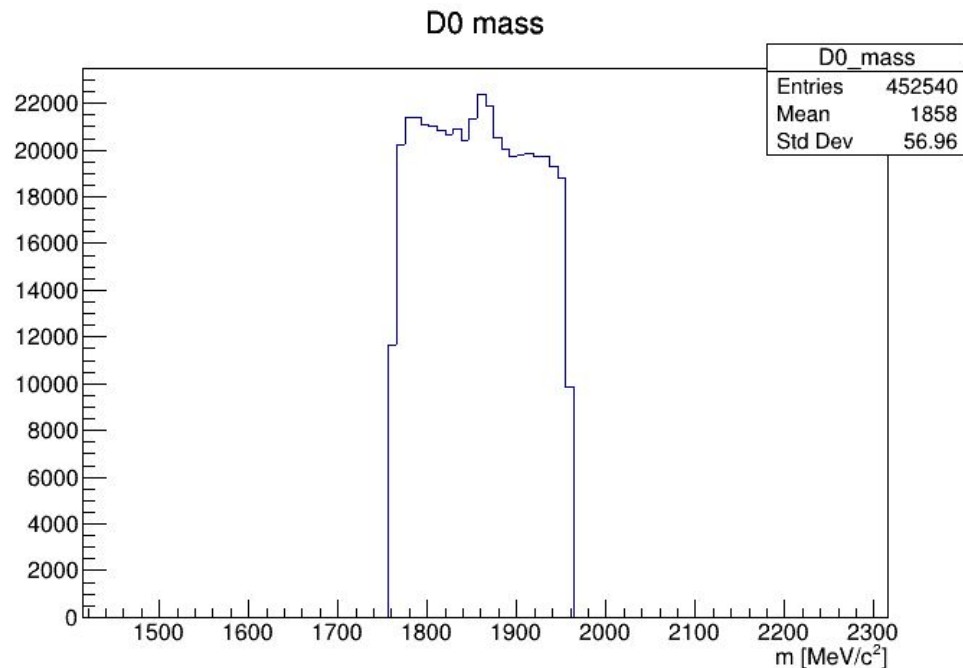
Issues discovered in the meanwhile (3)

- <u>Need to properly tune joints uncertainties</u>
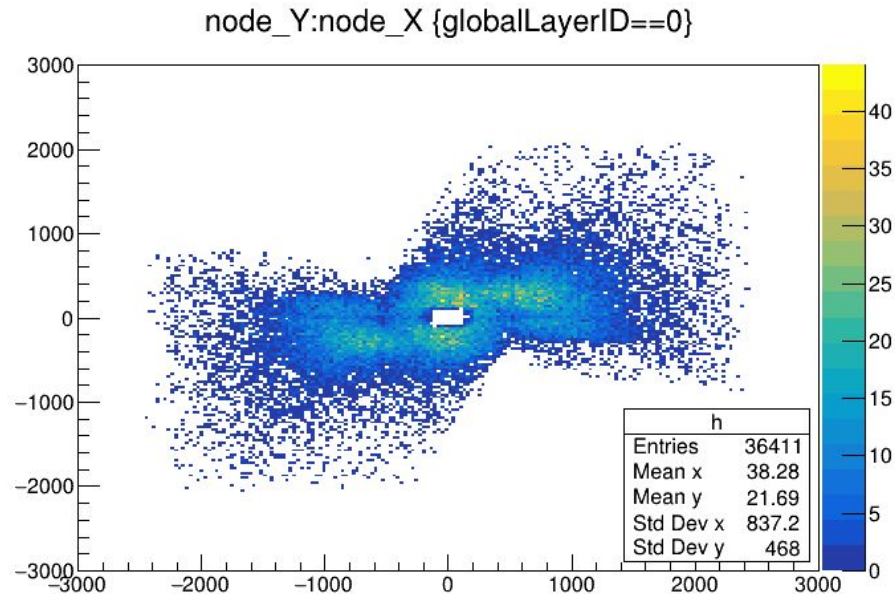 - Allowing "unwanted" configurations
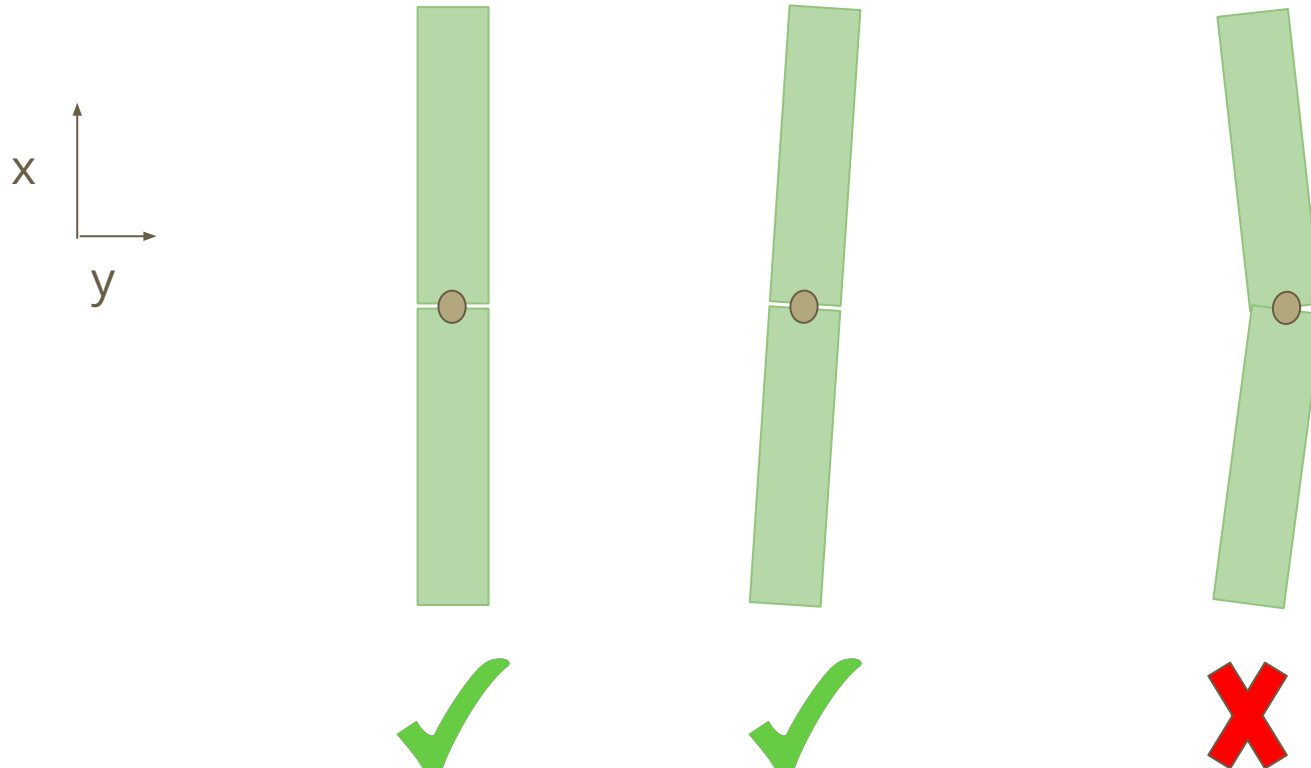
Issues discovered in the meanwhile (4)

- Does it really make sense to try to align HalfModules (not only for TxRz, but also for TzRx) in 2023 conditions?

Distribution of hits on track obtained on Velo Open MC

(Beam6800GeV-expected-2023-VeloOpen-MagUp-Nu1.4-25ns-Pythia8-sim-20230313-vc-mu100)

node_Y:node_X {globalLayerID==0}

| h	
Entries	36411
Mean x	38.28
Mean y	21.69
Std Dev x	837.2
Std Dev y	468

# Align Modules starting from design conditions

- Align Modules for TxRz starting from design position

- CFrames position fixed to the one obtained from the survey

- Mats in design position

- Remove particles (no D^0 mass constraint) from the alignment configuration

- Fix the position of the last layer

  - Run the alignment, then evaluate residual shift in x by looking at the mass variation as a function of the momentum asymmetry (slide 5)

  - Shift by hand last layer and run again the alignment

Status of alignment in 2023

Mass peaks

- Before (Modules TxRz, no particles)
  - μ(m(D+)) = 1865.5 +- 0.1 σ(m(D+)) = 7.5 +- 0.1
  - μ(m(D-)) = 1868.2 +- 0.1 σ(m(D-)) = 7.9 +- 0.1
- After (Modules TxRz, no particles, last layer shifted by -0.450mm)
  - μ(m(D+)) = 1866.6 +- 0.1 σ(m(D+)) = 7.5 +- 0.1
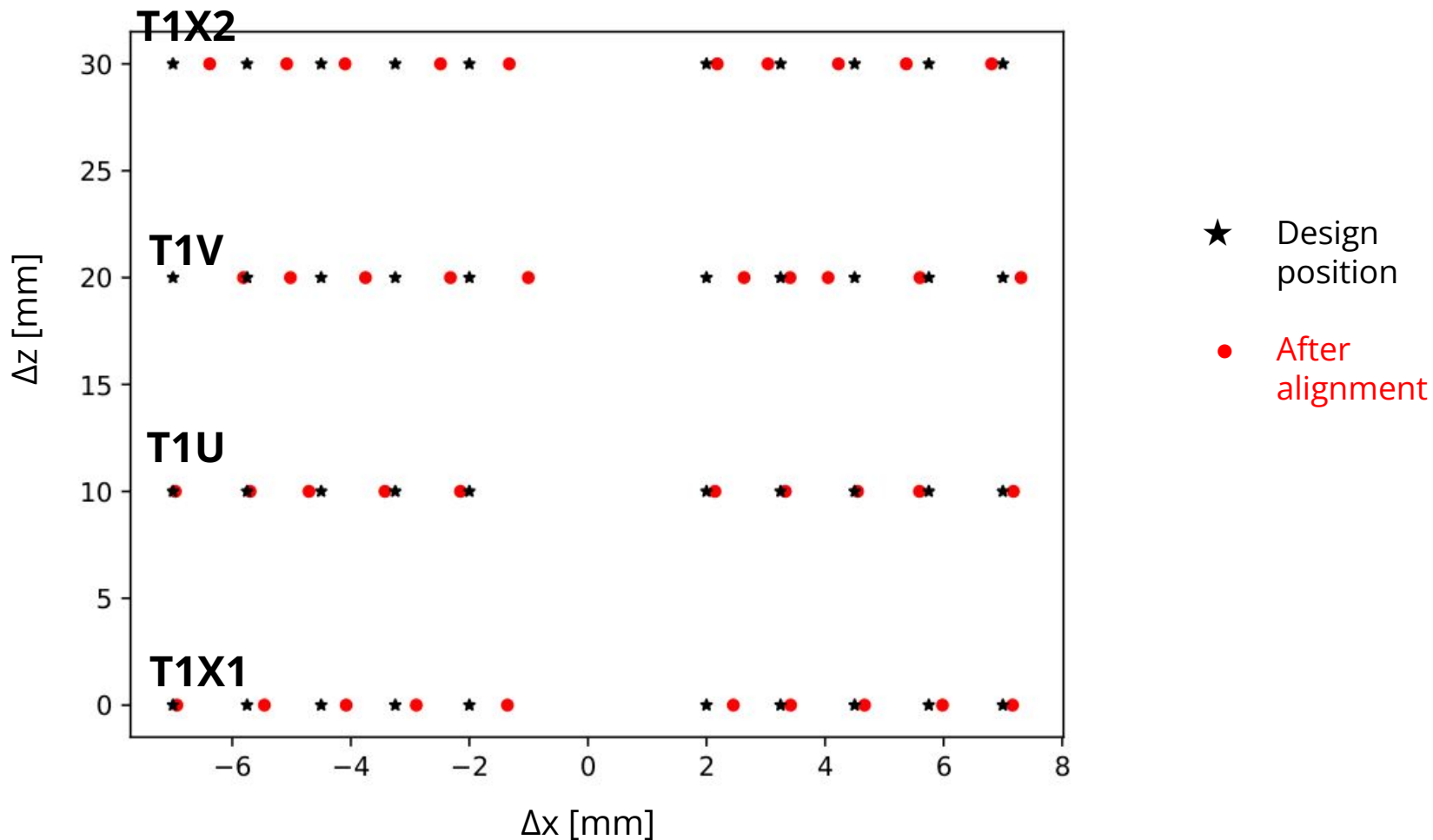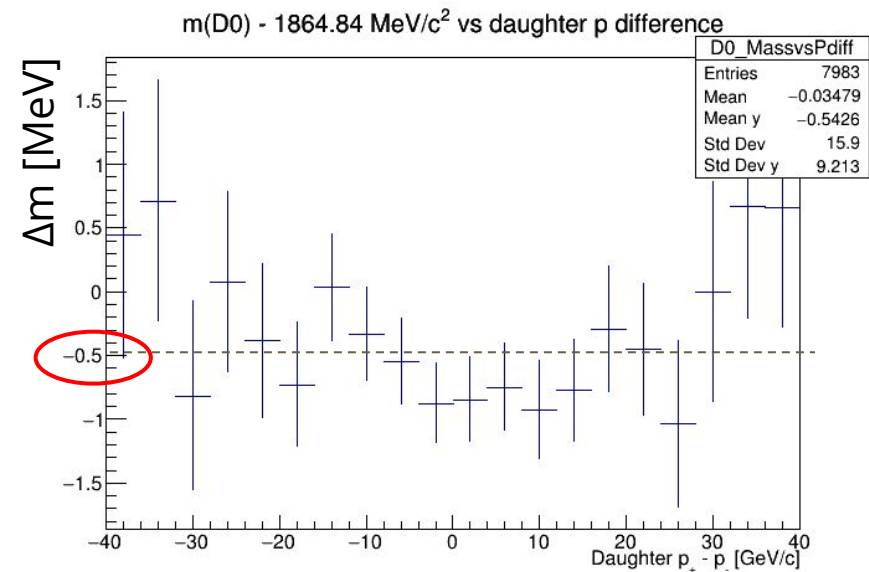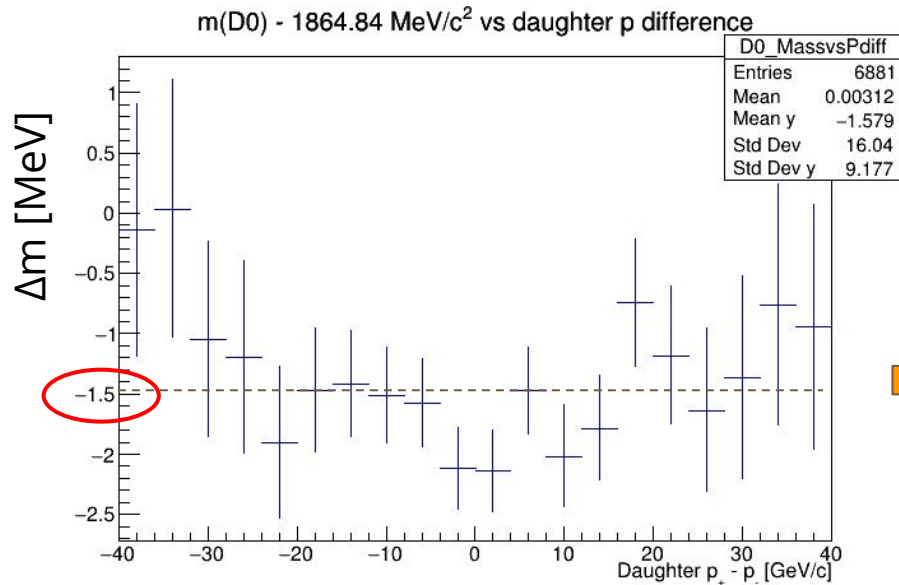 - μ(m(D-)) = 1866.9 +- 0.1 σ(m(D-)) = 7.6 +- 0.1
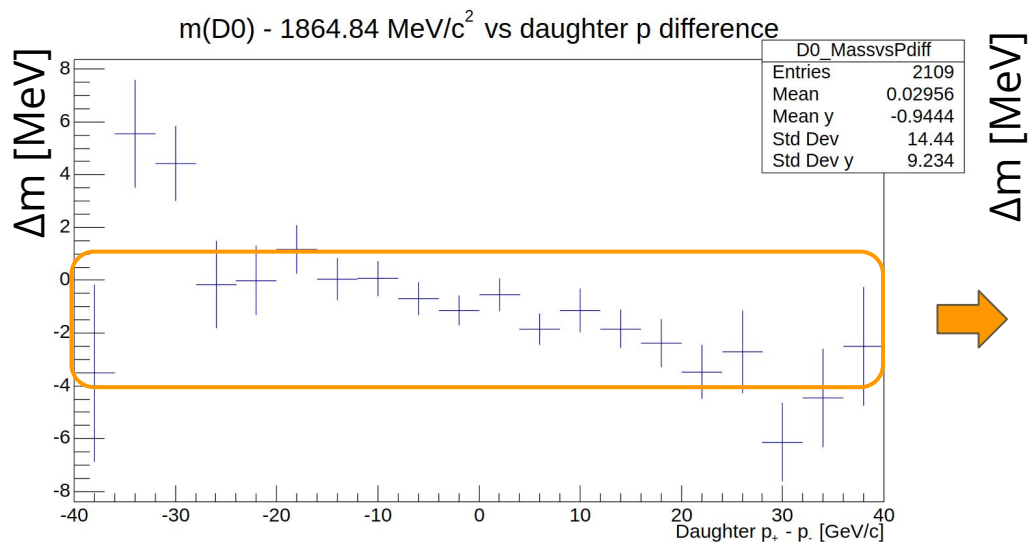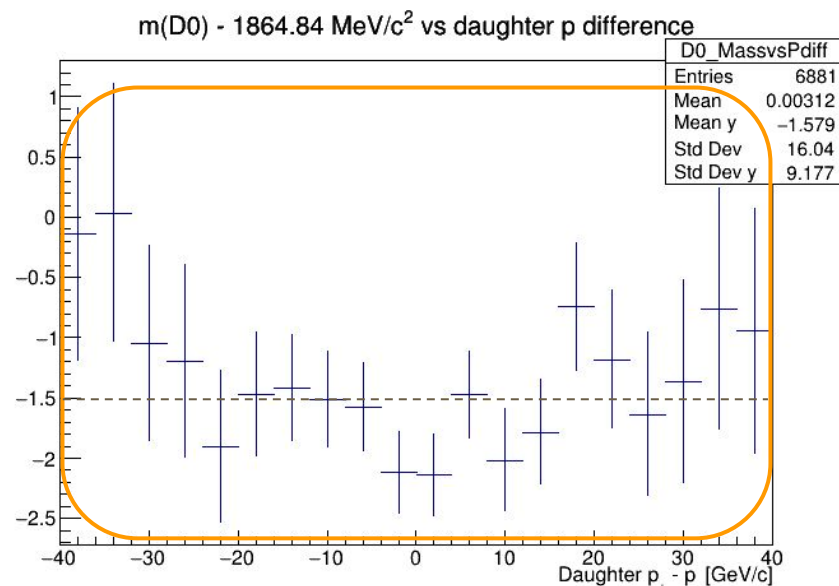
TxTz maps: where is the SciFi?
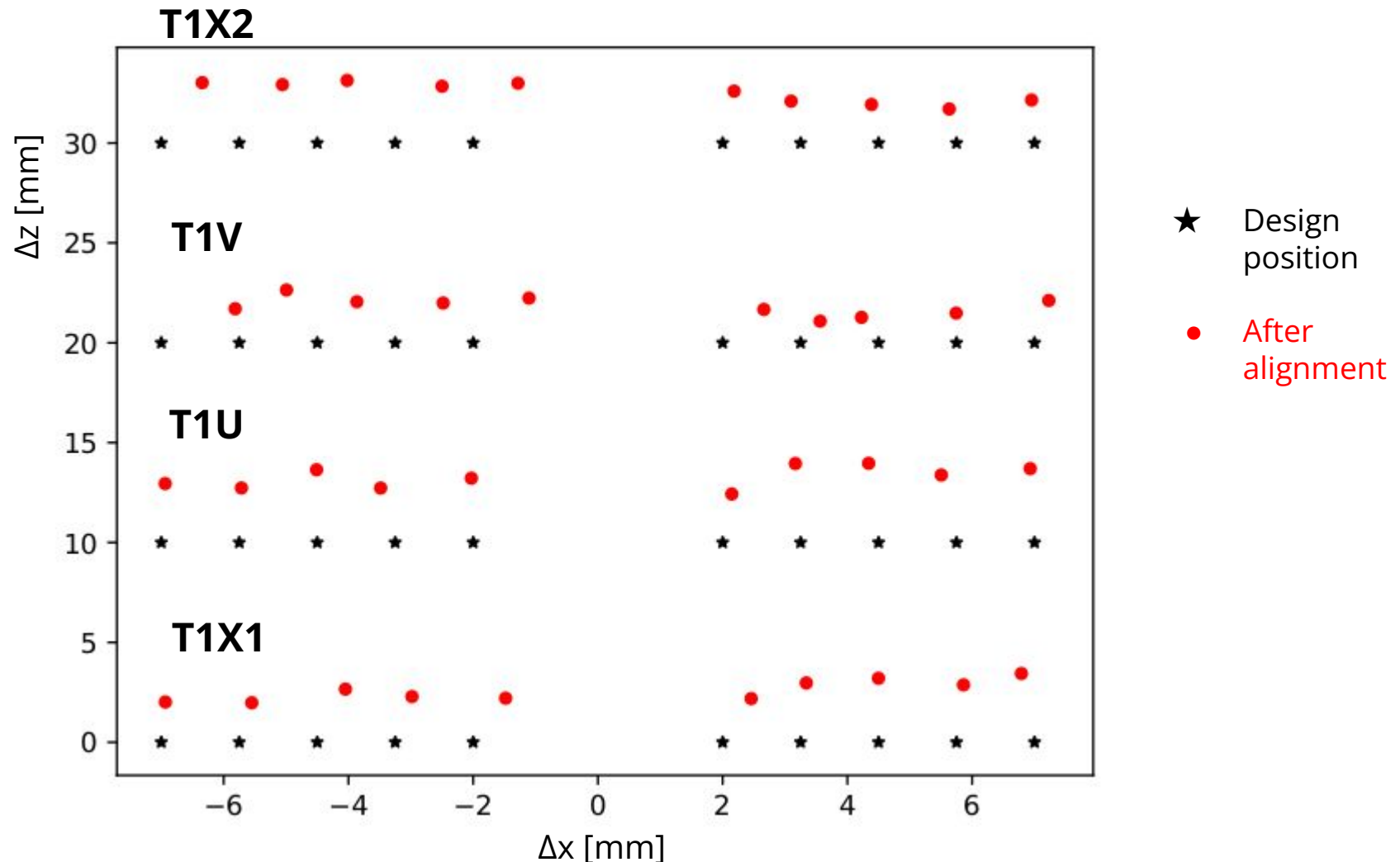## Movement of module centres relative to design position

- A 200 mum of shift between X-U V-X layers can be explained by a ~2 mm shift in y
  - 2 mm shift in y can be explained with a ~ 2/8000= 0.25mrad global rotation of the VELO

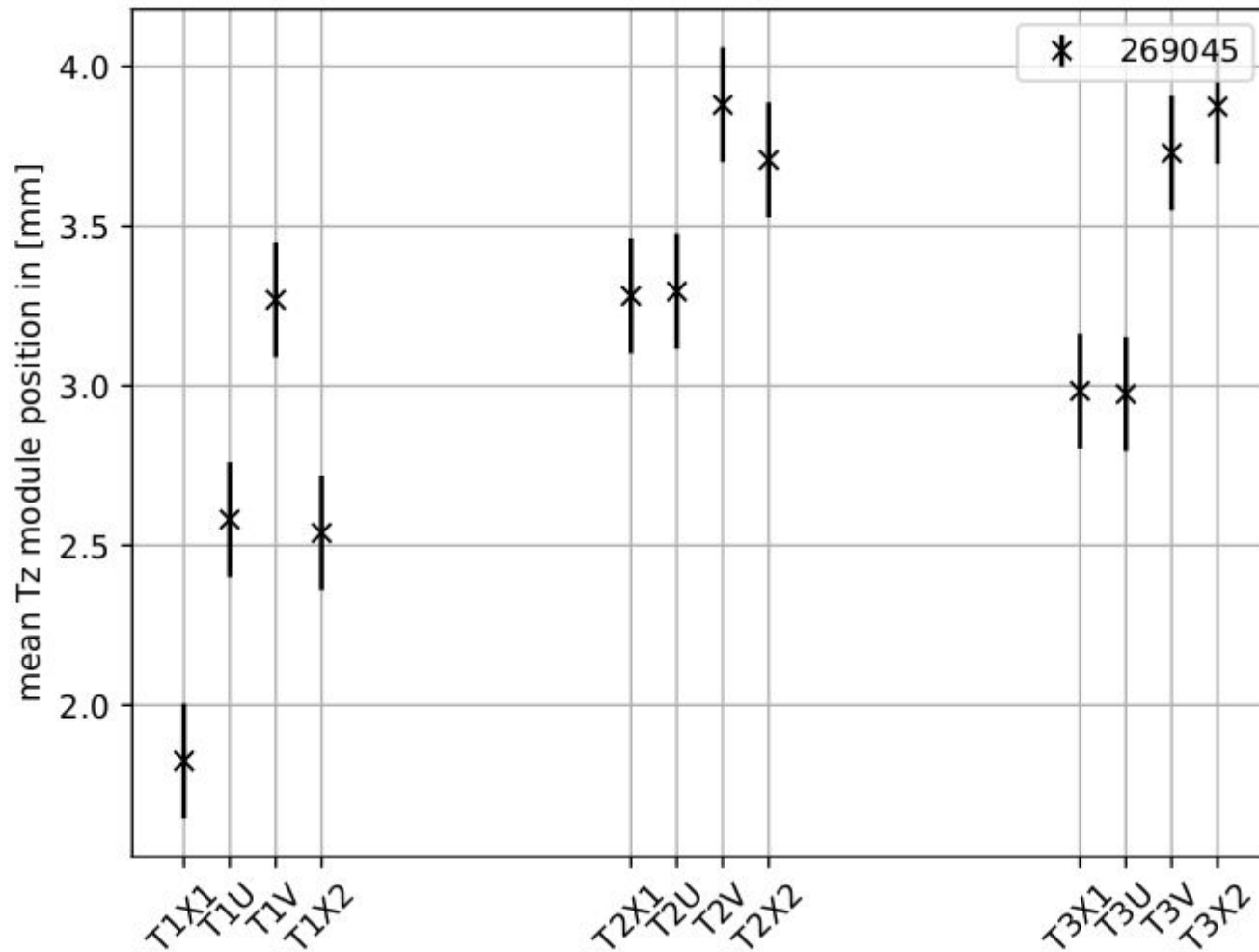# Add Tz to fix shift w.r.t PDG value

TxTz maps: where is the SciFi?
Movement of module centres relative to design position

Average movement of layers in z

Conclusions

- Cause of charge-dependent mass shift identified
  - D^0 mass constraint not effective: too loose selection used in HLT1
  - Currently trying to filter some post-HLT1 data with HLT2 selections to enrich the samples with D mesons and test again the mass constraint
  - Need to properly tune selections for 2024
- Investigating charge-independent shift w.r.t PDG value
  - Preliminary results seem to indicate the need of a global shift of about 3 mm w.r.t design position. Not in agreement with survey
- Observed patterns seem to point to a global rotation of the VELO: working on VELO+SciFi alignment
- To do: run the same configuration on 2022 data and compare results

Backup slides

Sources of mass shift

➢ Estimate the shift in T_x and T_z

➢ A particle reconstructed by 2 oppositely charged tracks :

$$m^2 = m_+^2 + m_-^2 + 2p_+ p_- (1 - cos\theta)$$

• If momentum has a small bias:

$$m = m + (p_+ \delta p_- + p_- \delta p_+)(1 - cos\theta)$$

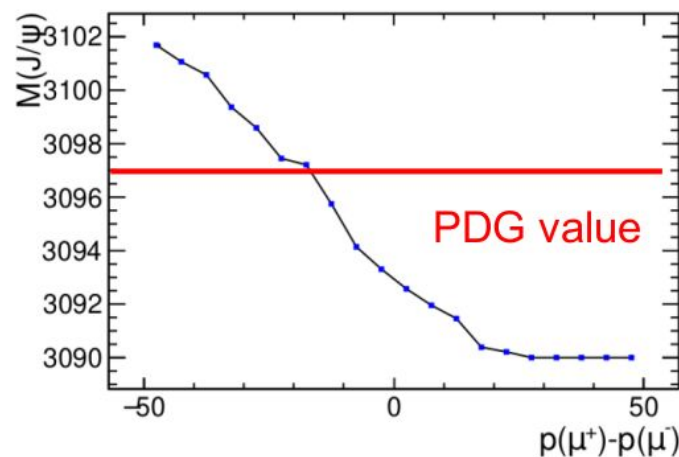Case 1 : There is bias in T_x, δp_+ and δp_- have opposite variation

$$\delta m = (1 - cos\theta)(p_- - p_+)\delta p \sim C\delta r(p_- - p_+)$$

Note: mass shift over $(p_- - p_+)$

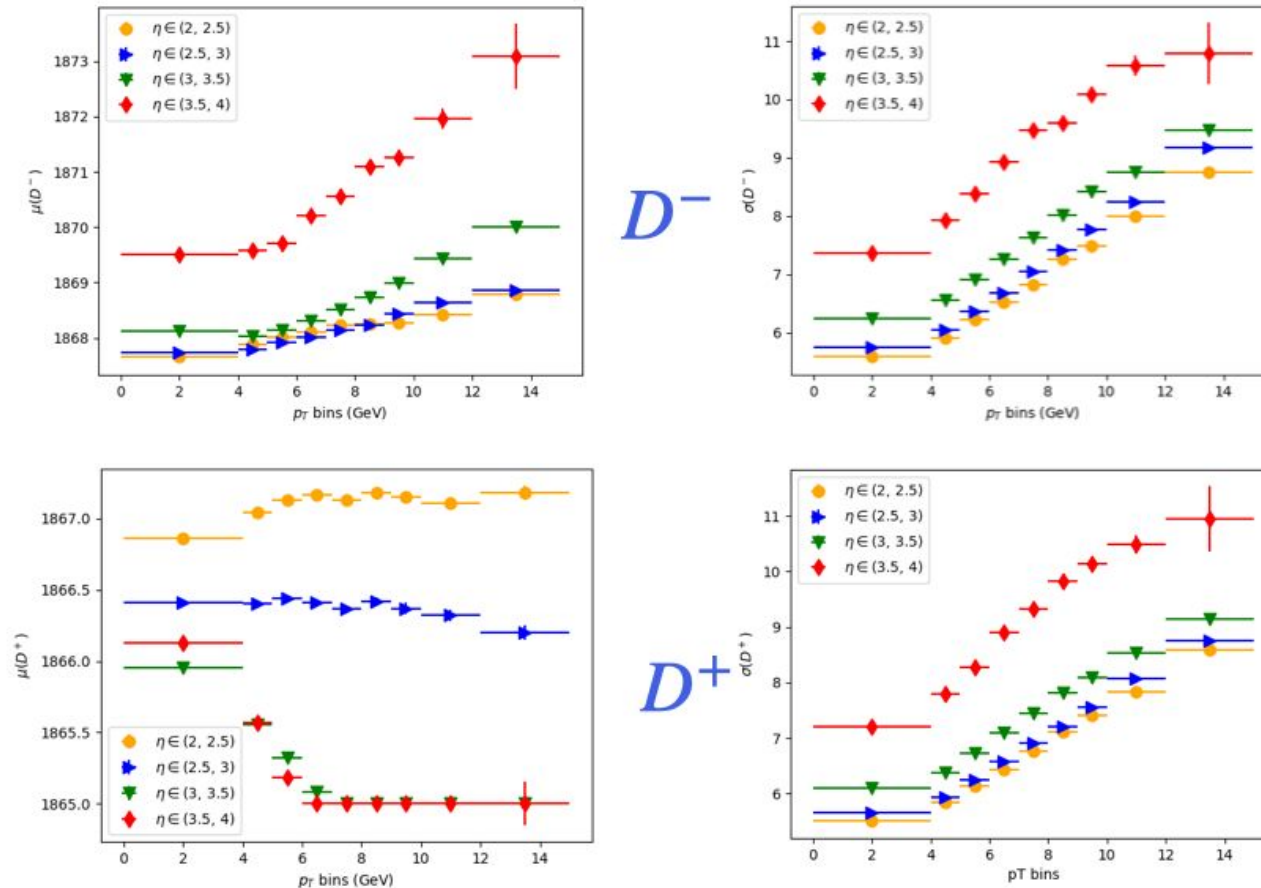Case 2 : There is bias in T_z, δp_+ and δp_- have same variation

$$\delta m = (1 - cos\theta)(p_- + p_+)\delta p \sim C\delta z \, t_x(p_- + p_+)$$

Note: mass shift to PDG value

Status of alignment in 2023
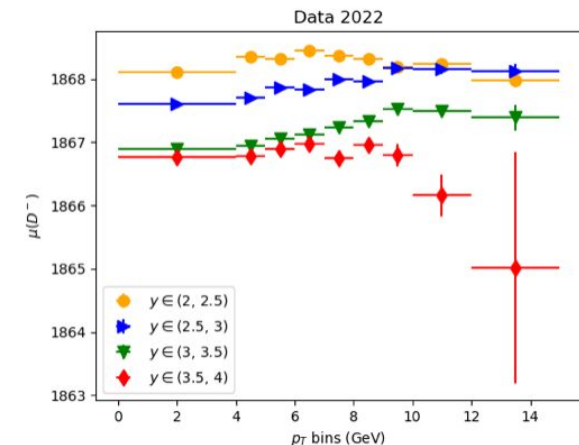
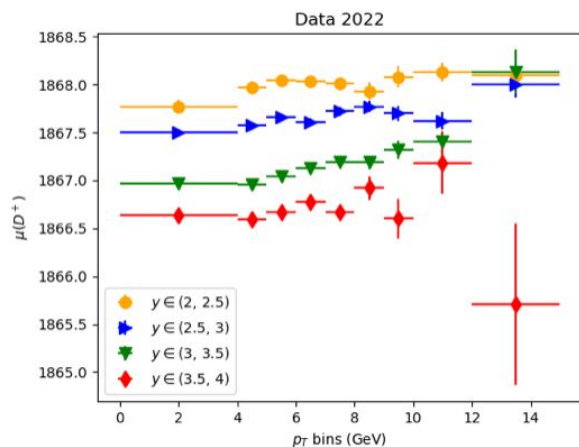# Studies on mass shift in 2023

mean and sigma from simultaneous mass fits

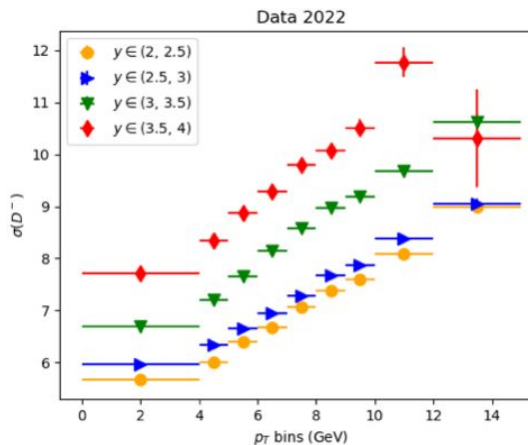To be understood!

Mean and sigma from simultaneous mass fits

AlignmentV10_2023_05_09_LHCP for 2022 data

D^-

D^+

G. Tuci   Status of alignment in 2023