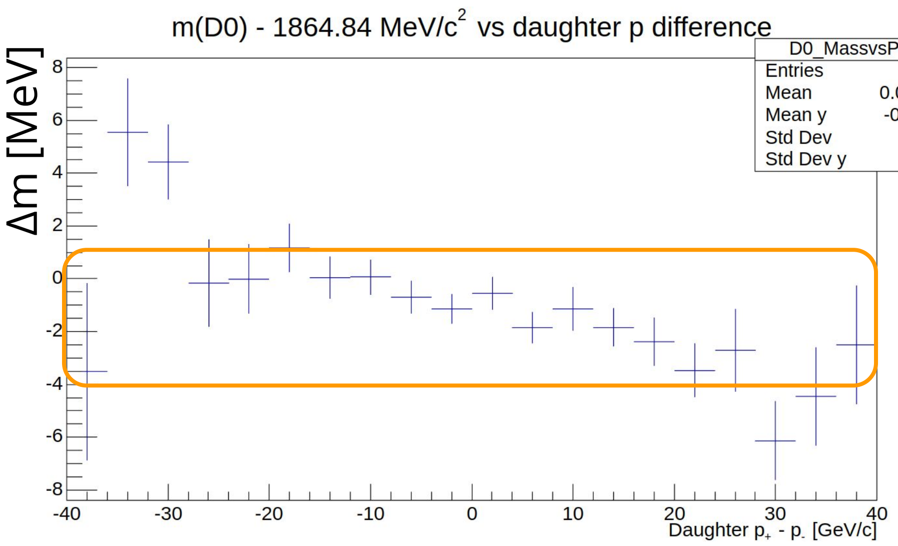
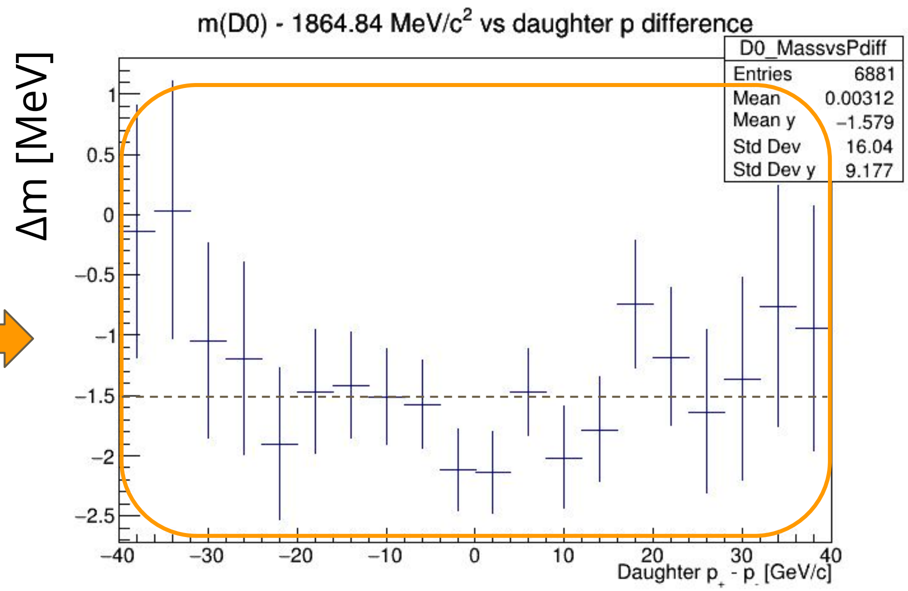
Align Modules starting from design conditions

- 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
  - Shift by hand last layer and run again the alignment

Mass peaks

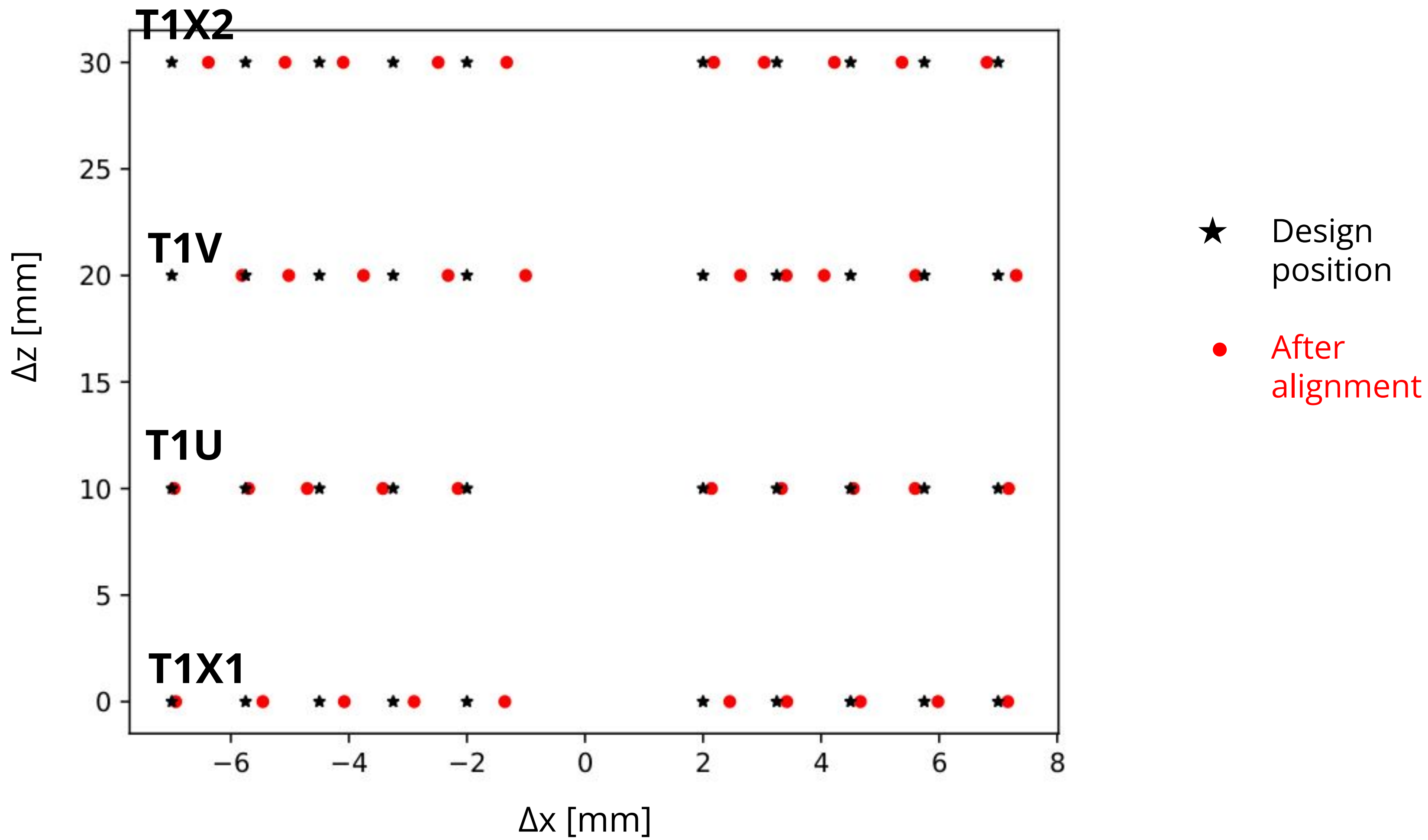
- Before (Modules TxRz, no particles)
  - μ(m(D+)) = 1865.5 +- 0.1 σ(m(D+)) = 7.5 +- 0.1
  - μ(m(D-)) = 1868.2 +- 0.1 σ(m(D-)) = 7.9 +- 0.1
- After (Modules TxRz, no particles, last layer shifted by -0.450mm)
  - μ(m(D+)) = 1866.6 +- 0.1 σ(m(D+)) = 7.5 +- 0.1
  - μ(m(D-)) = 1866.9 +- 0.1 σ(m(D-)) = 7.6 +- 0.1





TxTz maps: where is the SciFi?

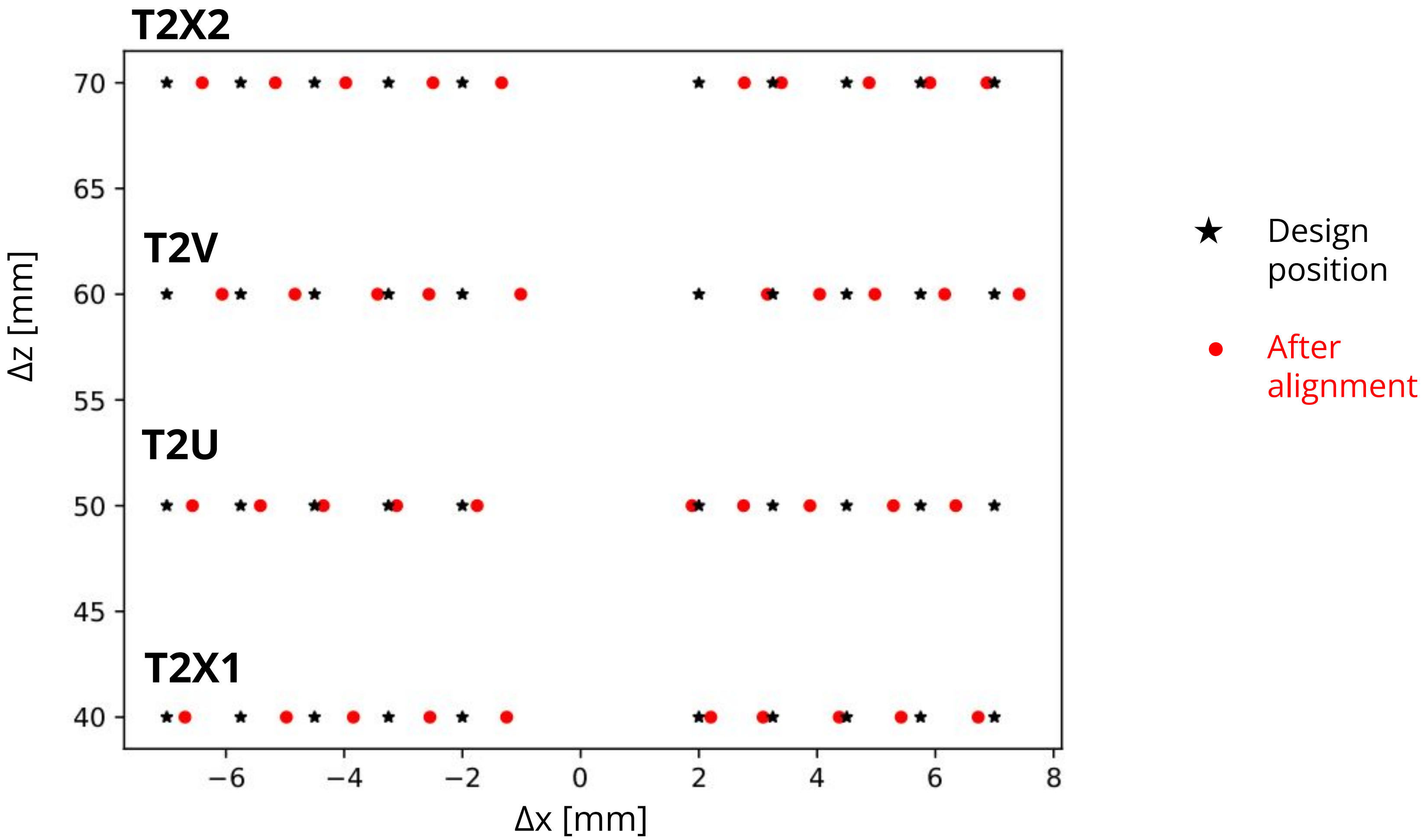
Movement of module centres relative to design position



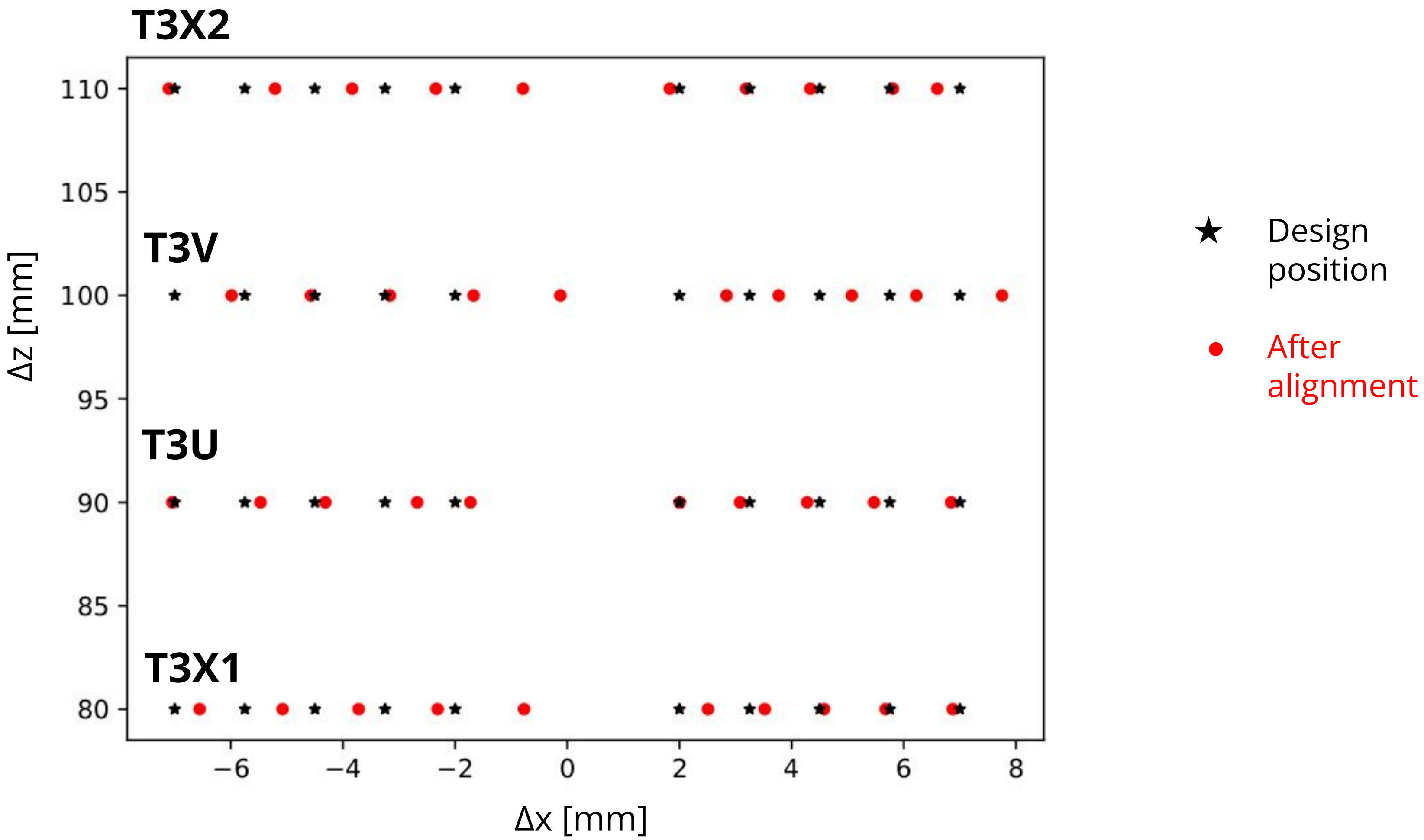
- A 200 mum of shift between X-U V-X layers can be explained by a ~2 mm shift in y
    - 2 mm shift in y can be explained with a ~ 2/8000= 0.25mrad global rotation of the VELO

TxTz maps: where is the SciFi?

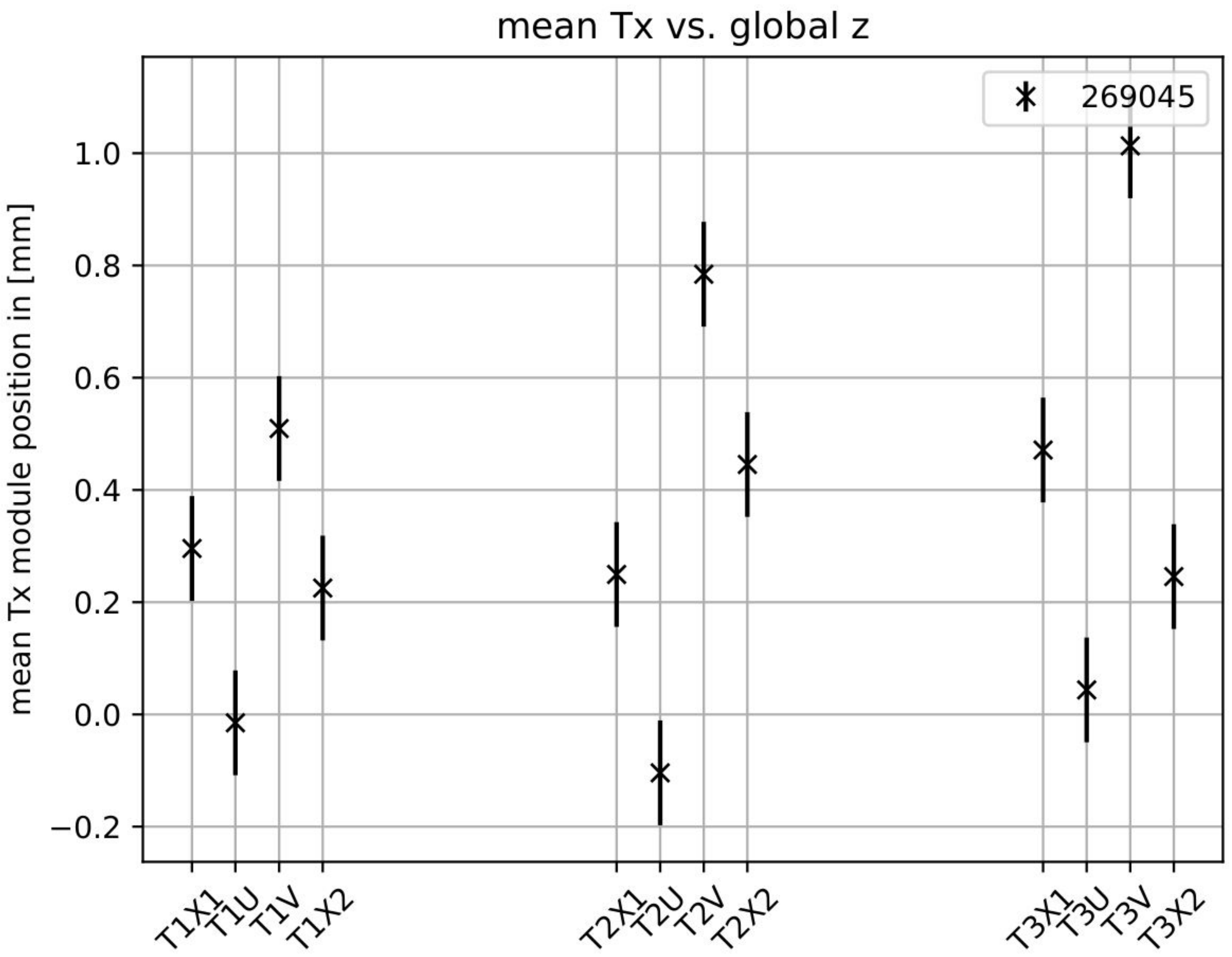
Movement of module centres relative to design position



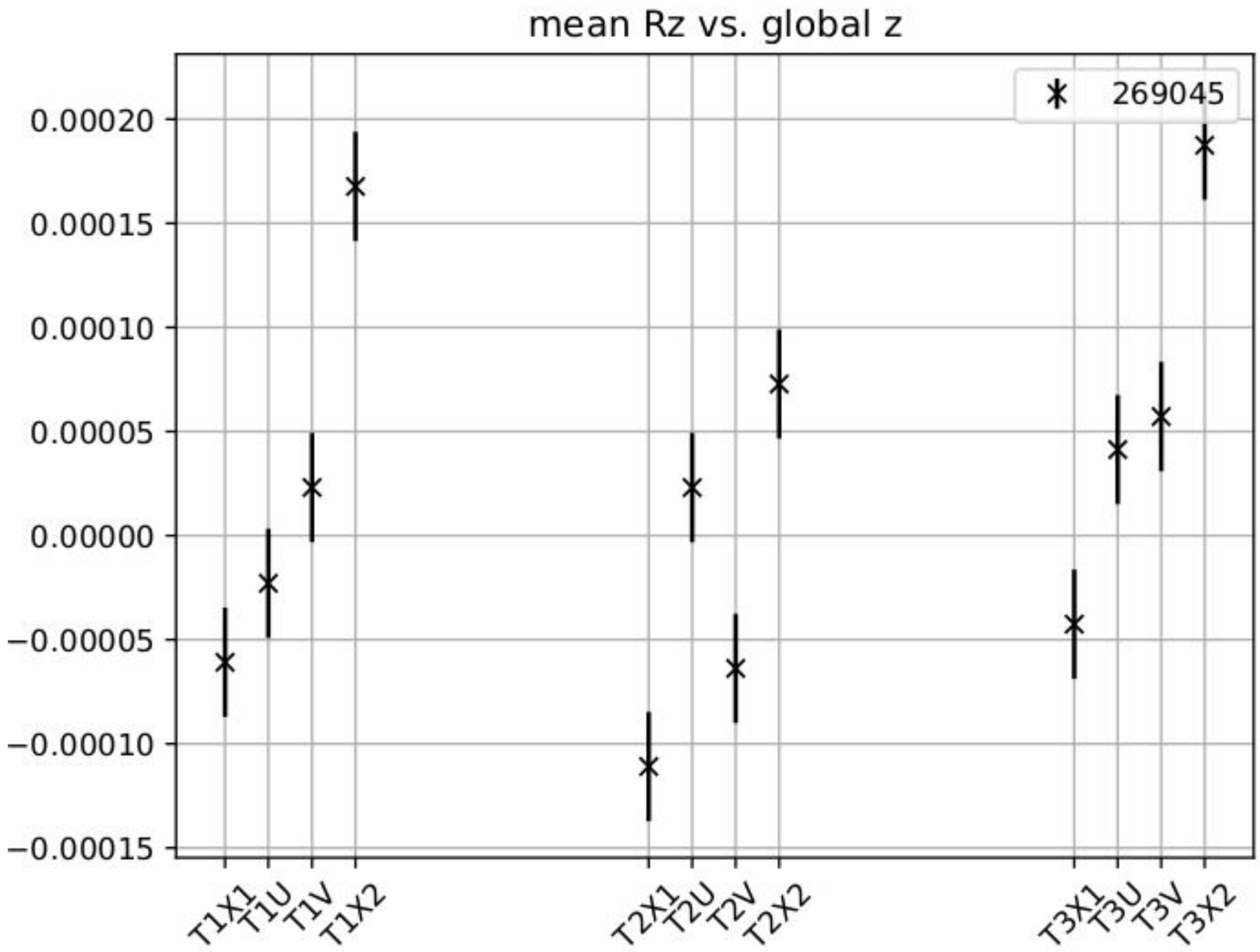
TxTz maps: where is the SciFi?
Movement of module centres relative to design position



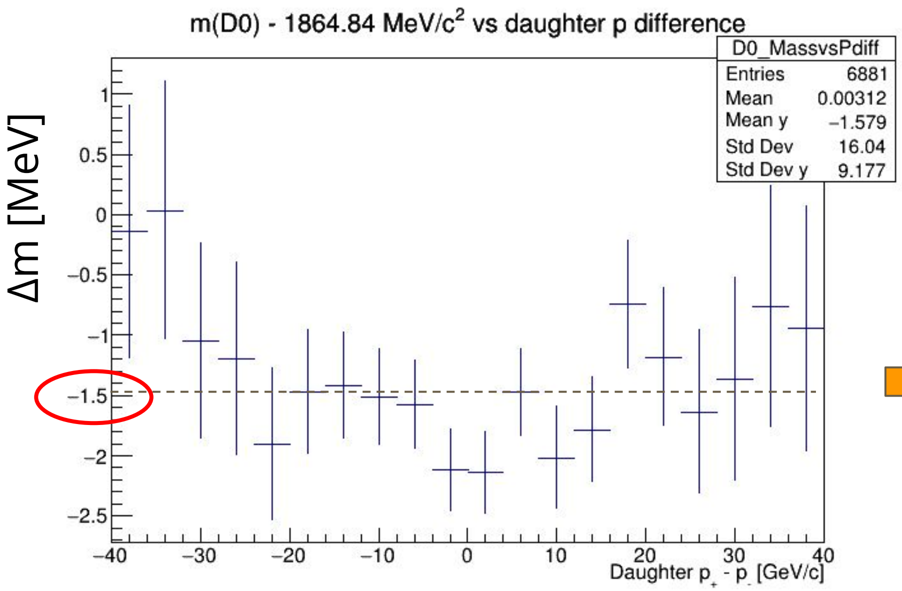
Average movement of layers

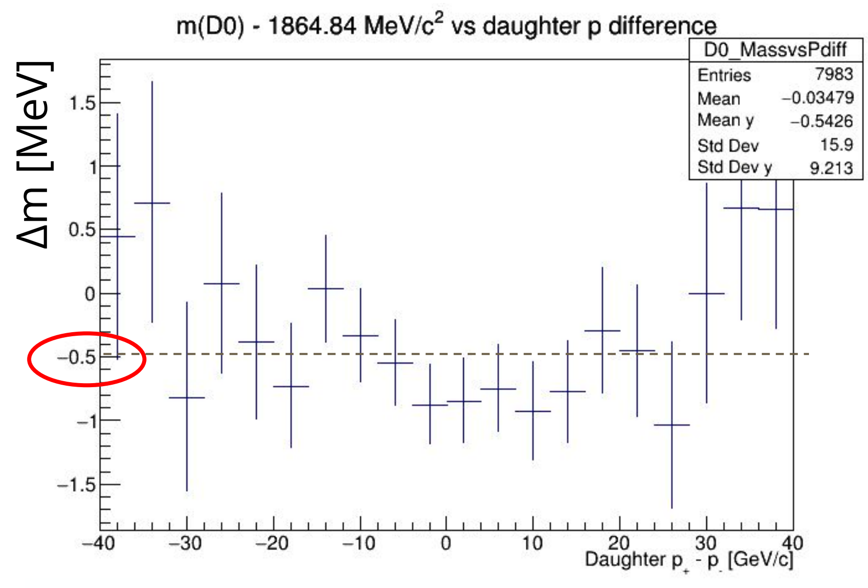


Average movement of layers

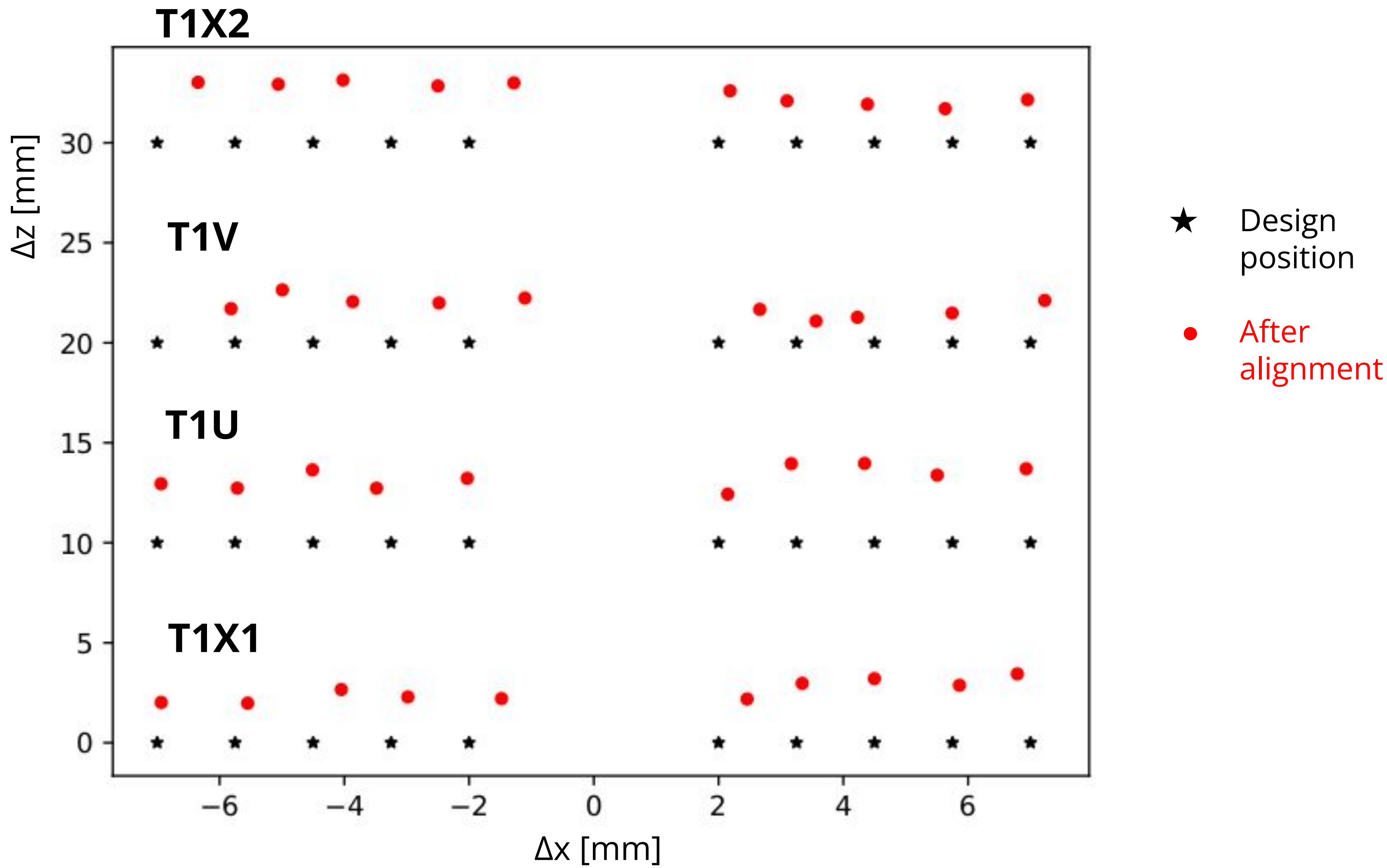


Add Tz to fix shift w.r.t PDG value

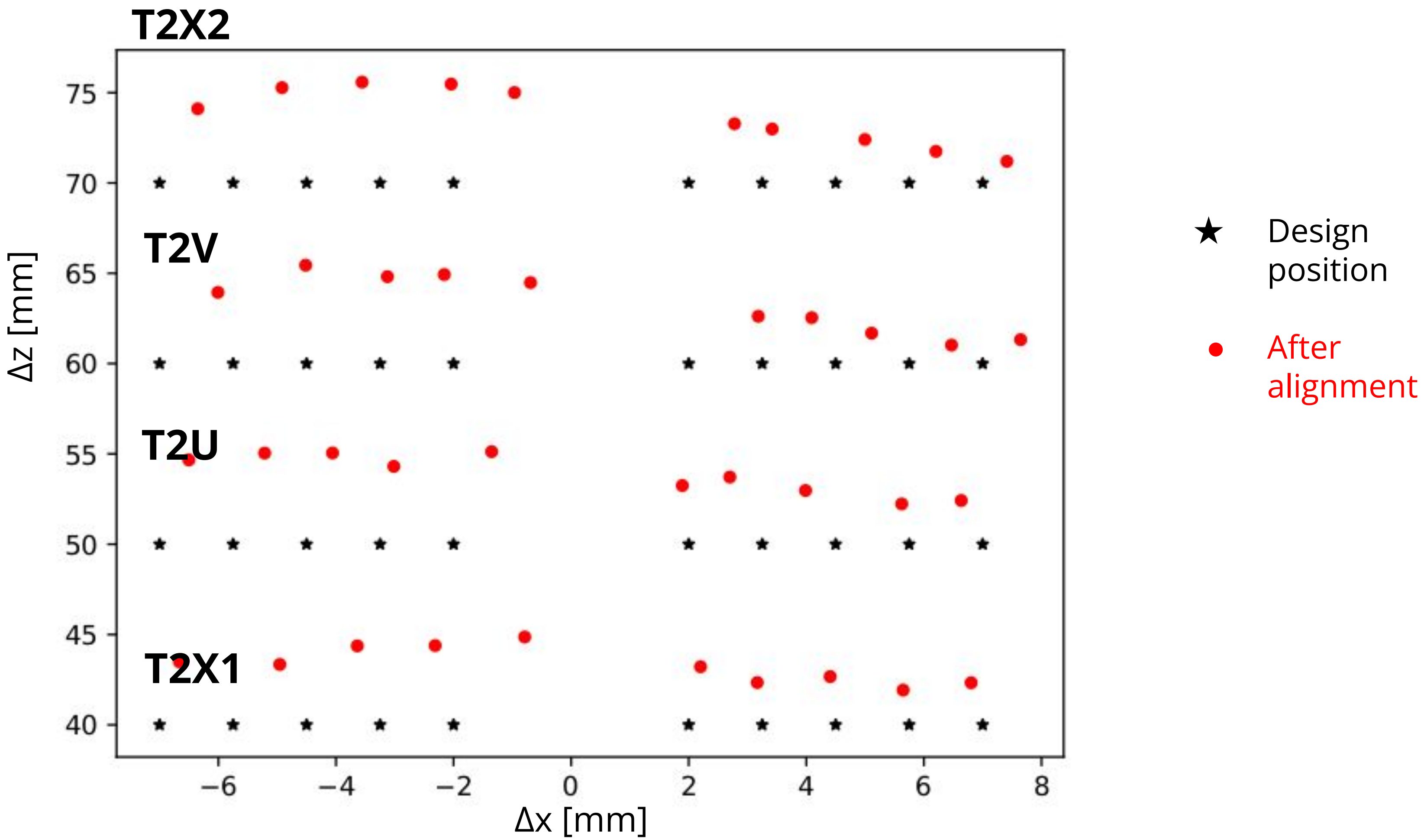




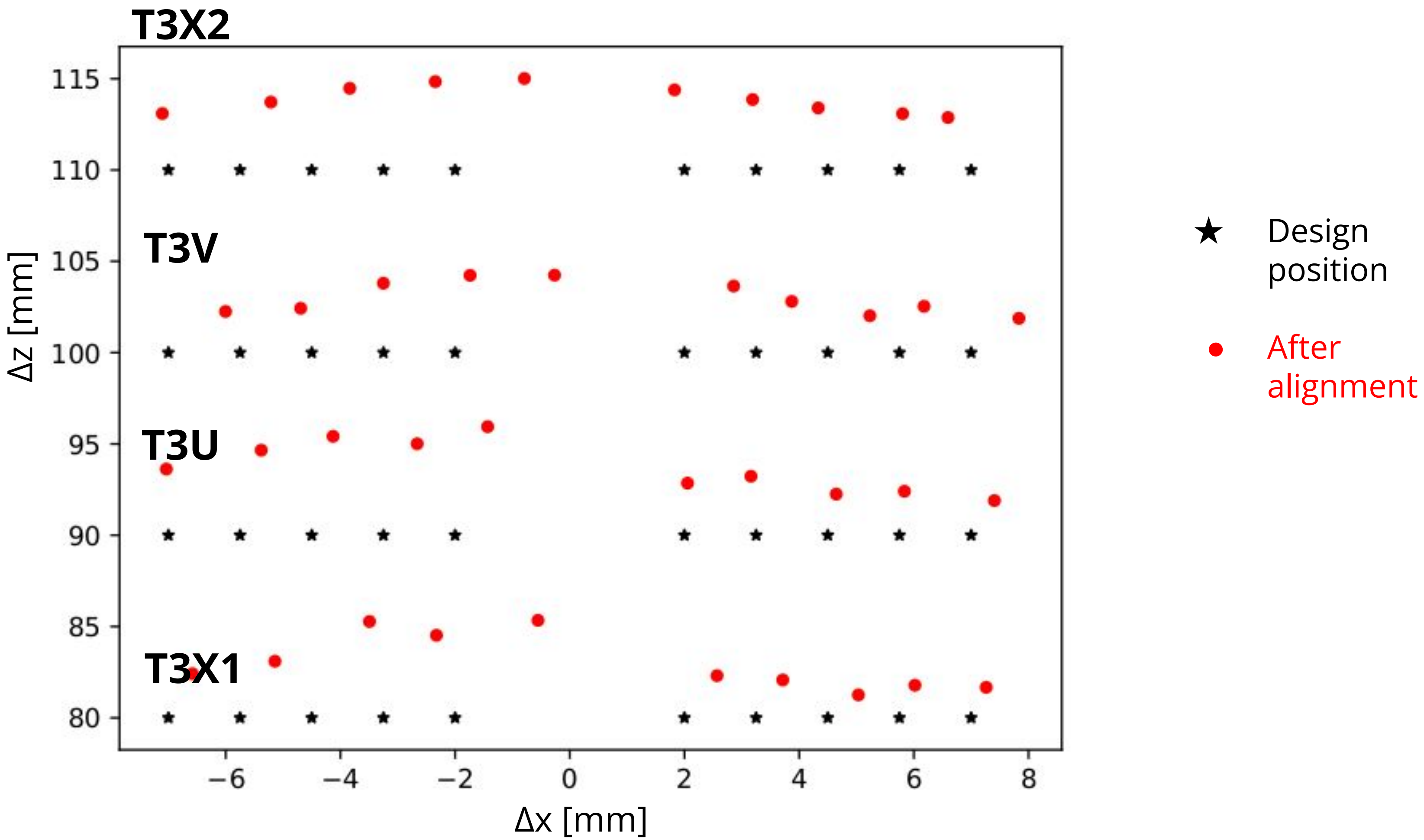
TxTz maps: where is the SciFi?
Movement of module centres relative to design position



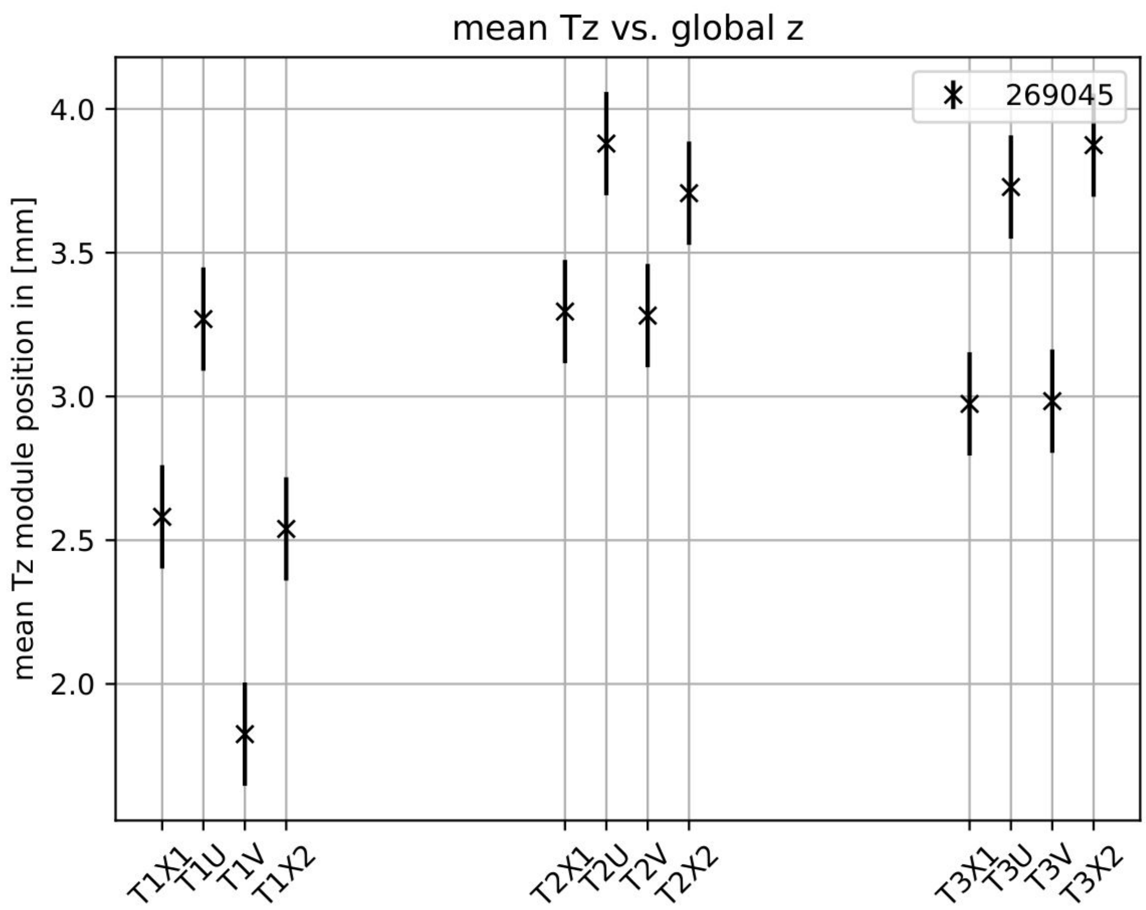
TxTz maps: where is the SciFi?
Movement of module centres relative to design position



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



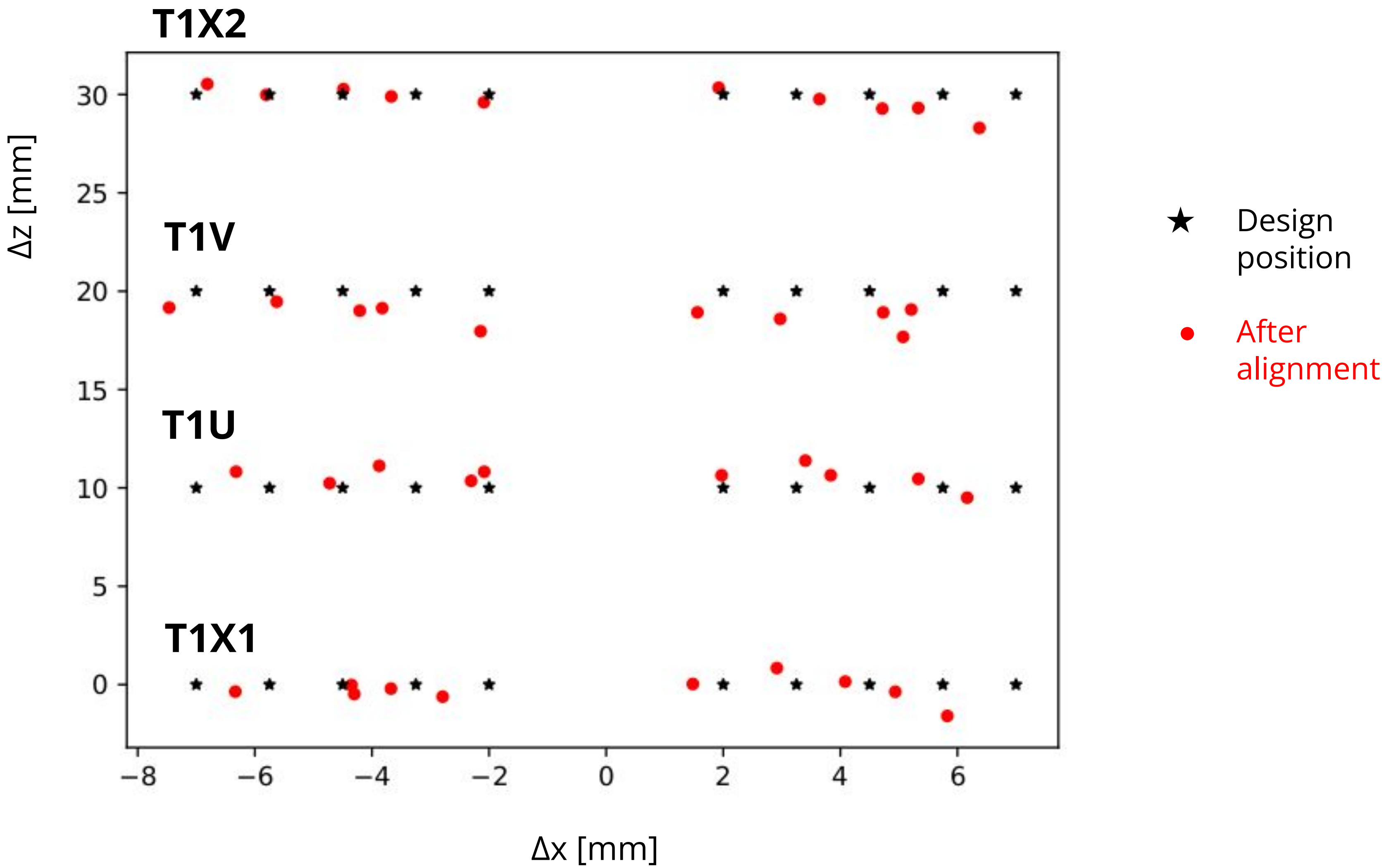
Average movement of layers in z



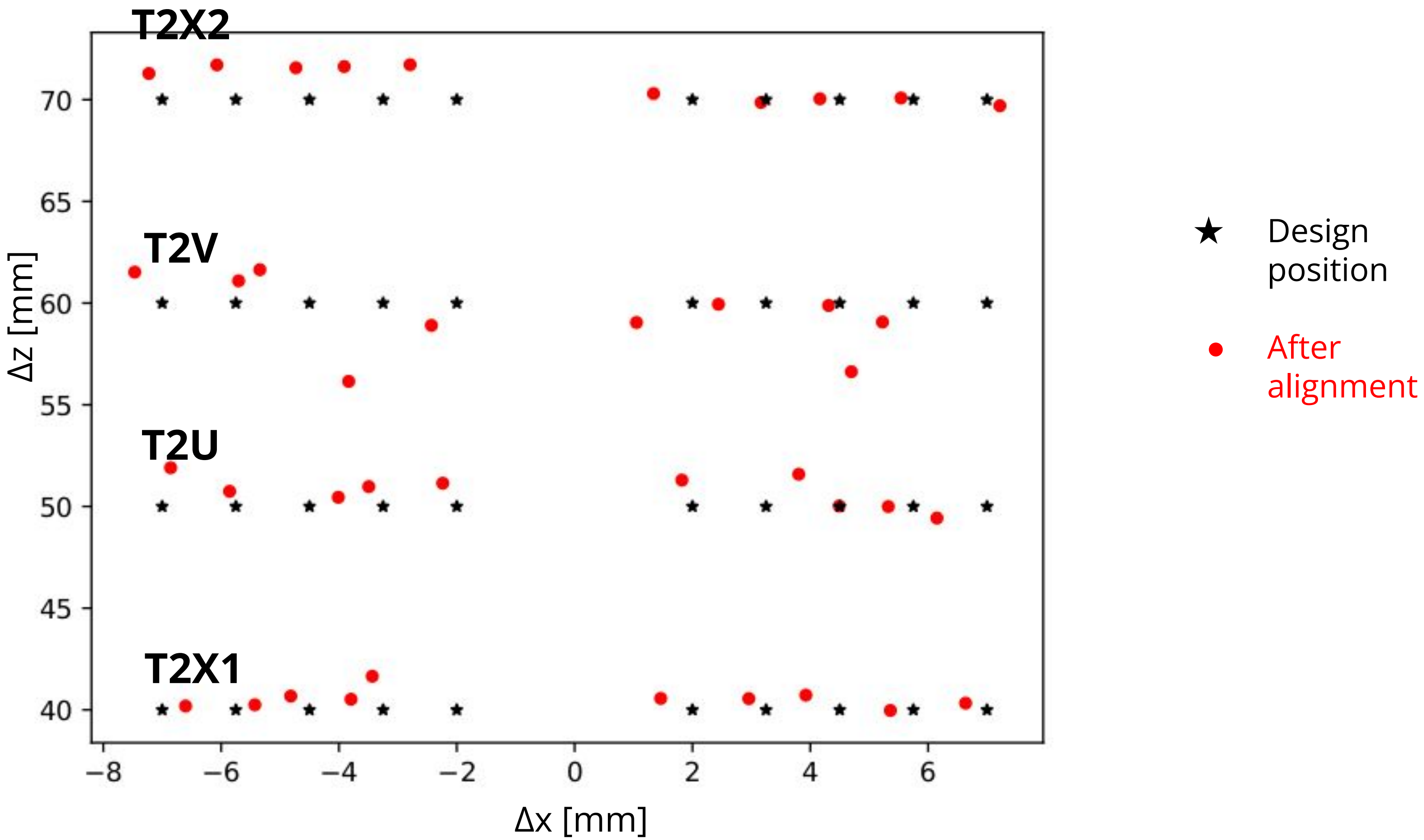
How was v9?

TxTz maps: where is the SciFi?

Movement of module centres relative to design position

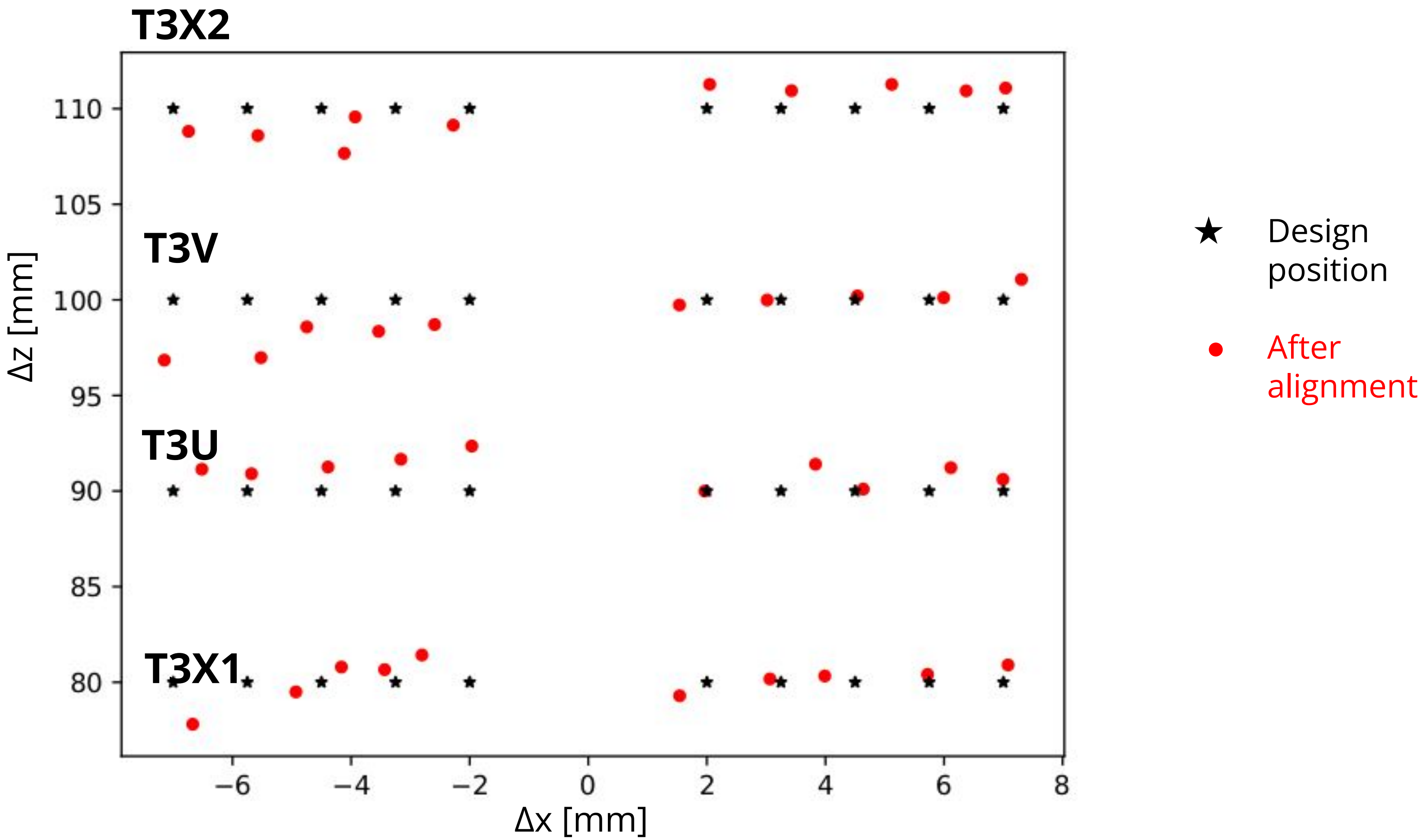


TxTz maps: where is the SciFi?
Movement of module centres relative to design position

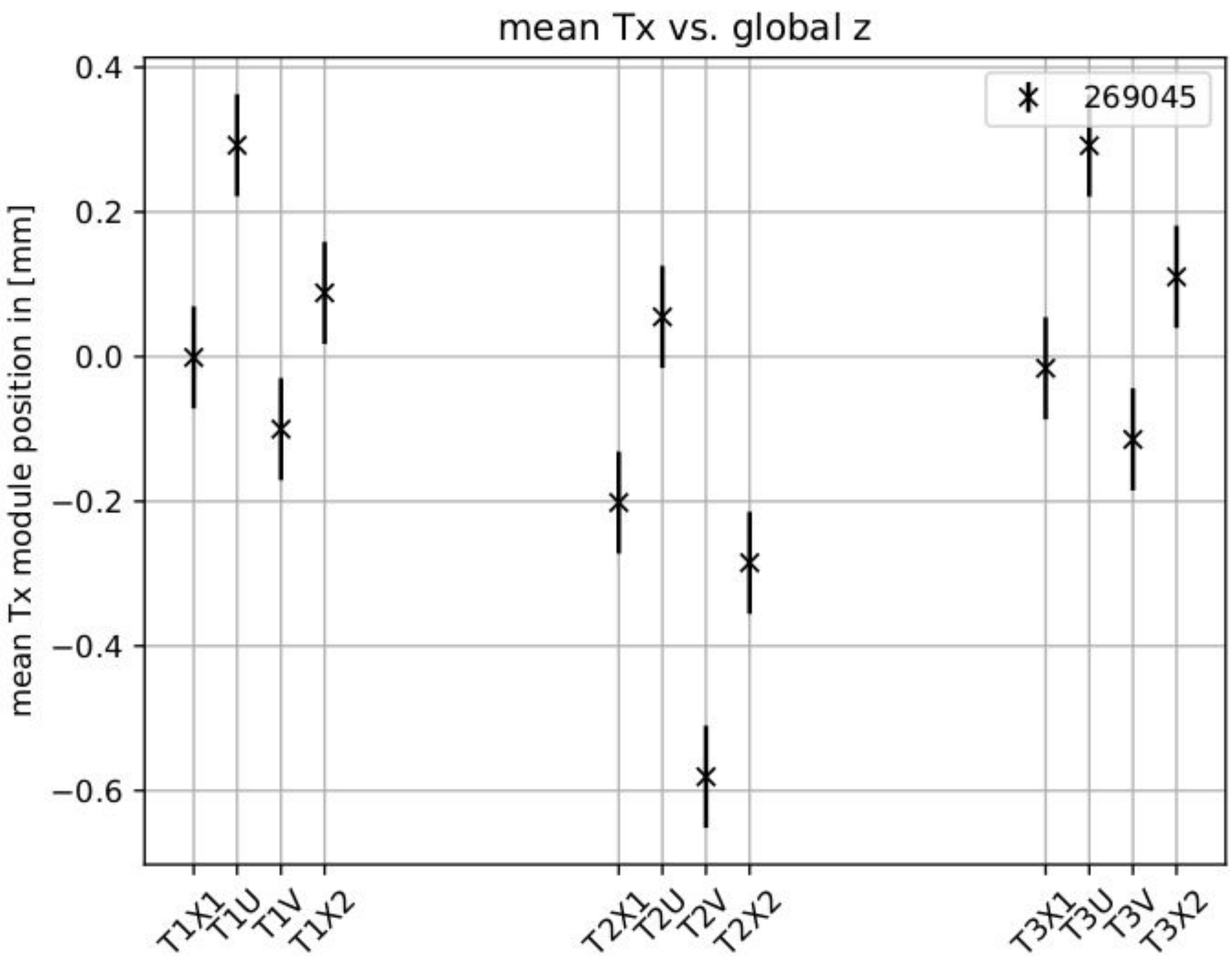


TxTz maps: where is the SciFi?

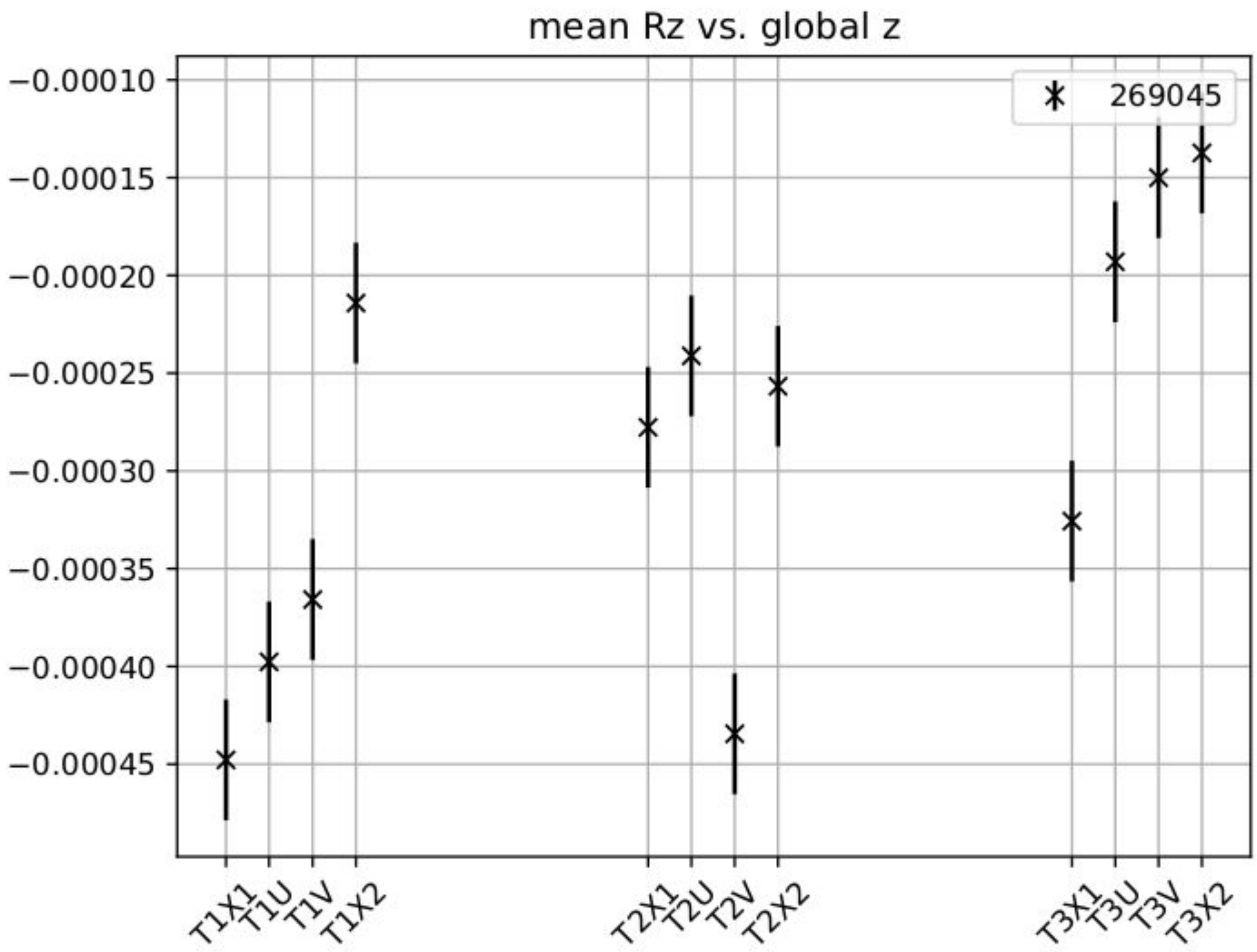
Movement of module centres relative to design position



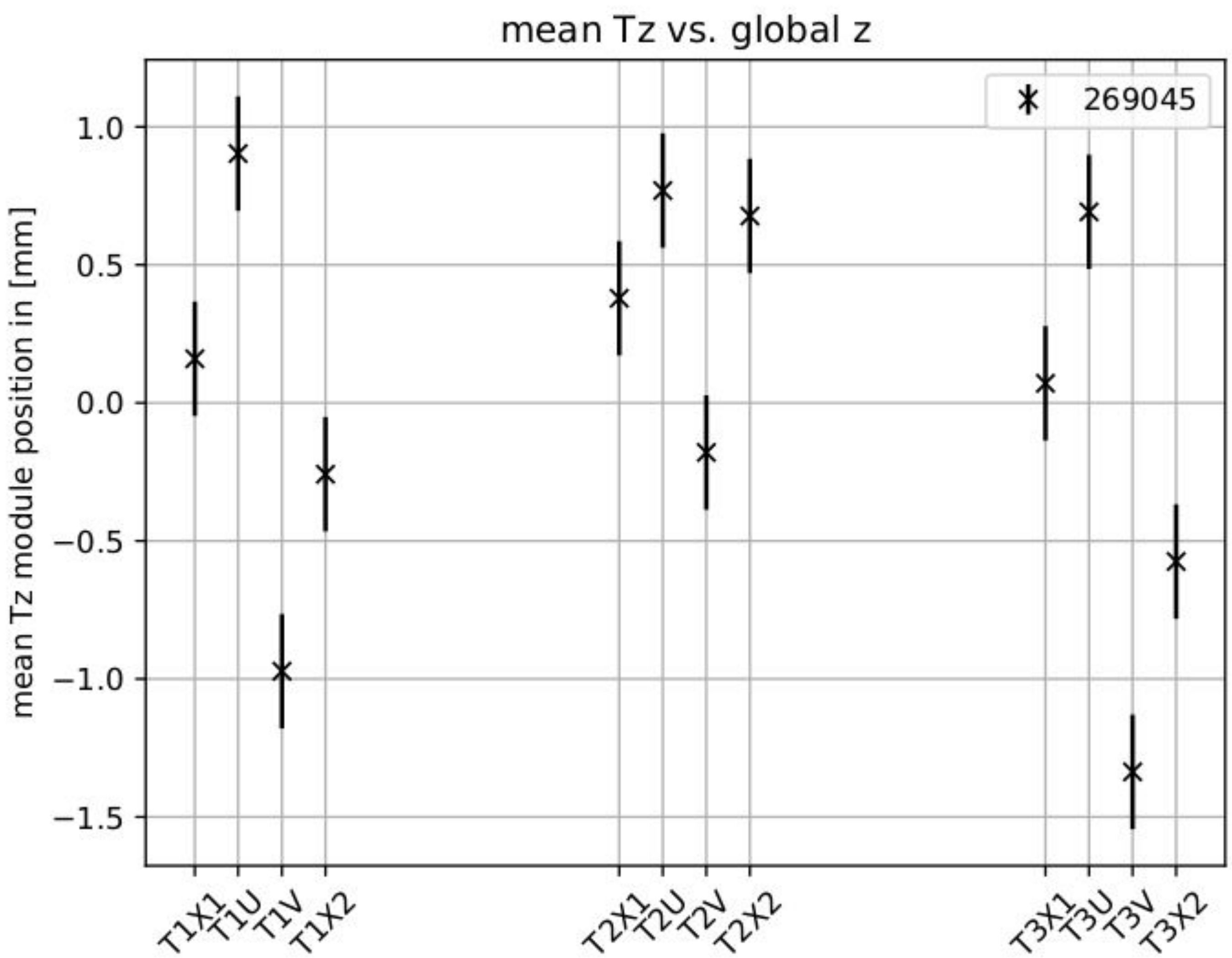
Average movement of layers



Average movement of layers



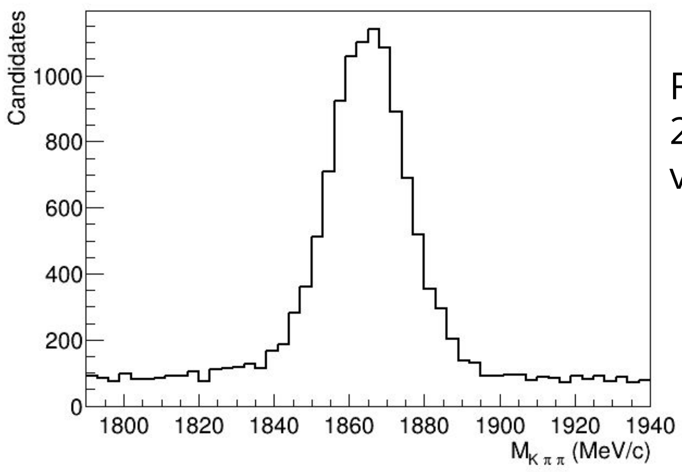
Average movement of layers



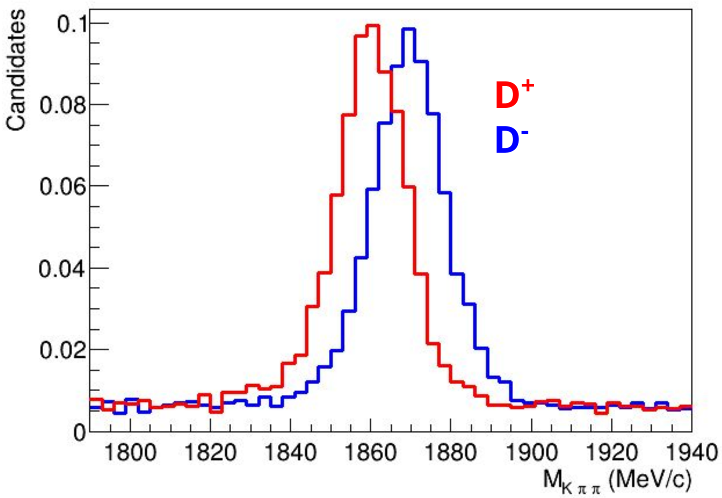
Backup slides

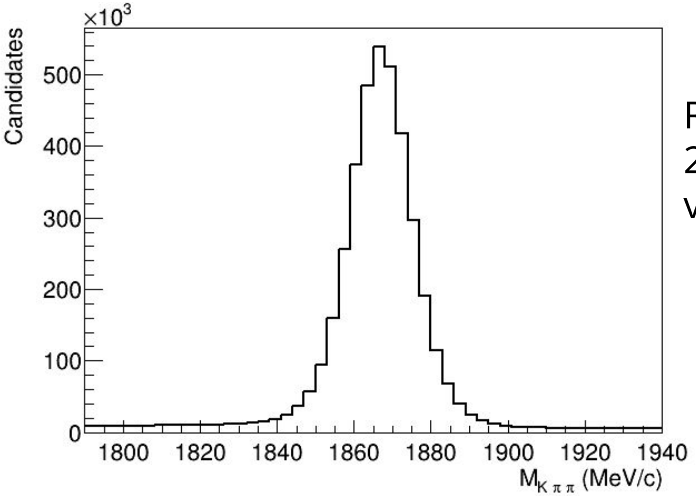
Mass peaks (v3 vs v6)

- Many thanks to Gregory Ciezarek for the plots!

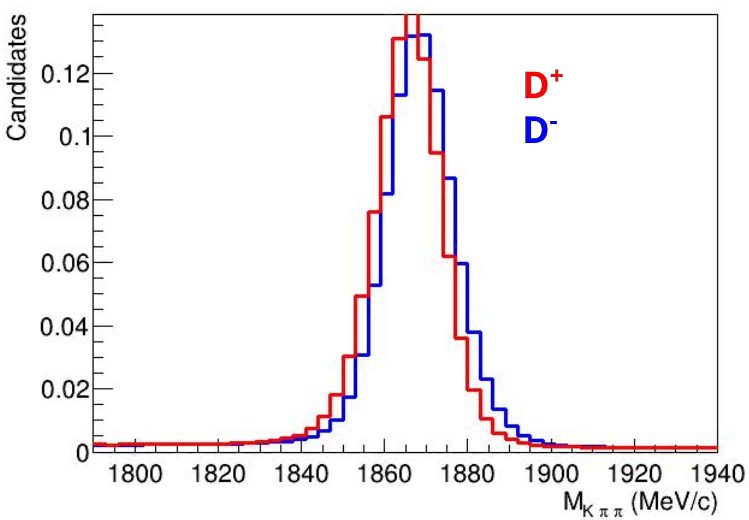


Runs
263810–263839
v3 alignment





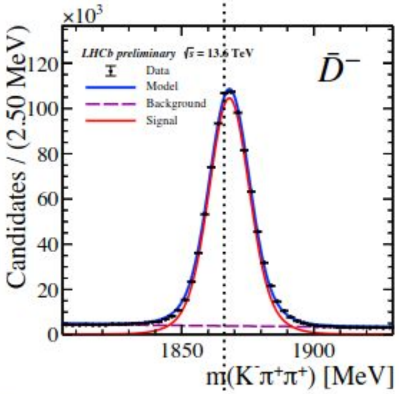
Runs
269370–269542
v6 alignment

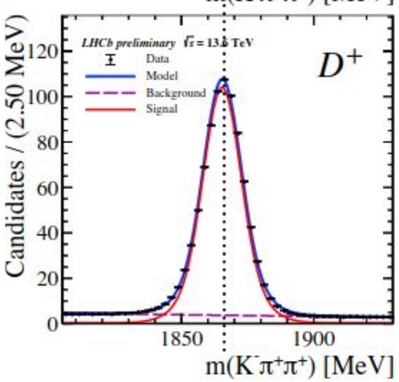


Mass peaks (v9)

- 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



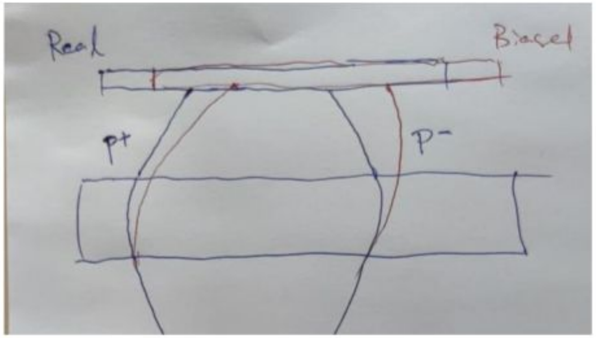


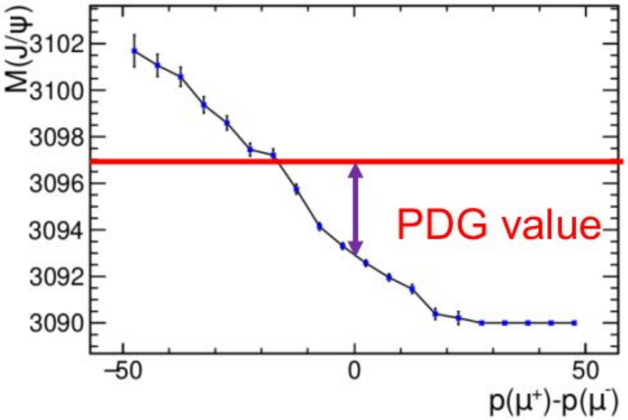
Data	D-	D+
Mass (MeV)	1868.28 +/- 0.01	1865.66 +/- 0.01
width (MeV)	8.22 +/- 0.12	8.56 +/- 0.15

- Significant shift between D^+ and $\bar{D}^-$ ~ 2.6 MeV
- mean mass in both D^+ and D^- shift w.r.t PDG mass: $M^{\mathrm{PDG}} = 1869.66 \pm 0.05$ MeV

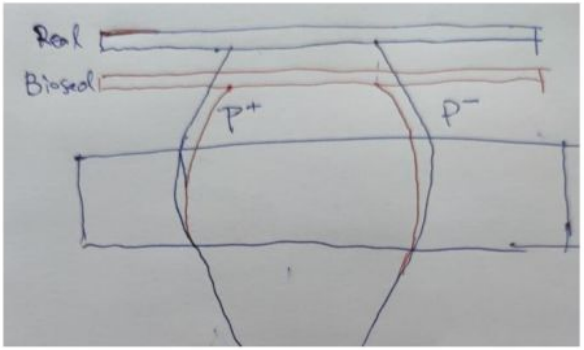
Sources of mass shift

- 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

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

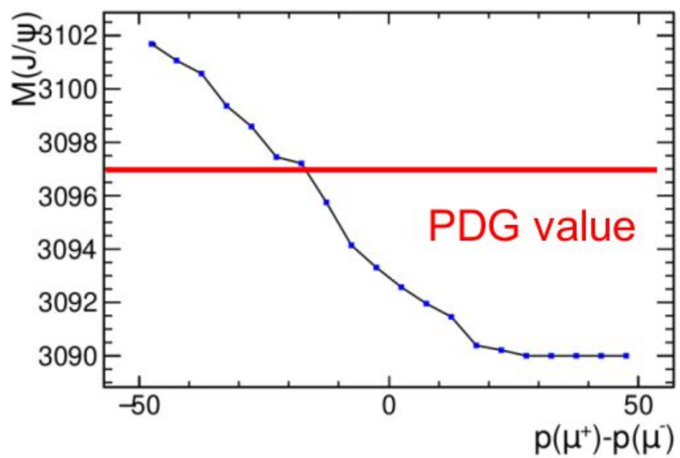
$$\delta m = (1 - cos\theta)(p_- - p_+)\delta p \sim C\delta r(p_- - p_+)$$

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

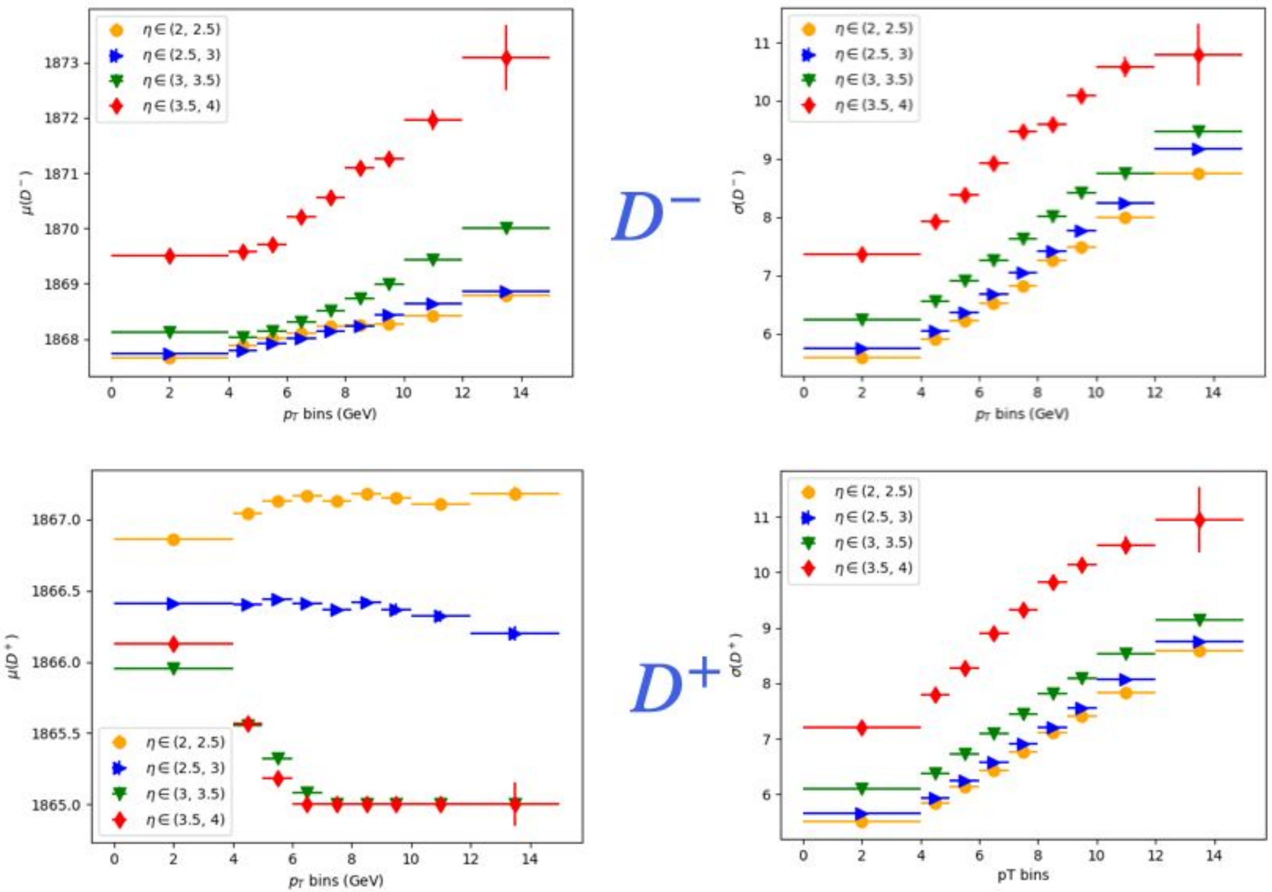


9/21/2023

12

Studies on mass shift in 2023

mean and sigma from simultaneous mass fits



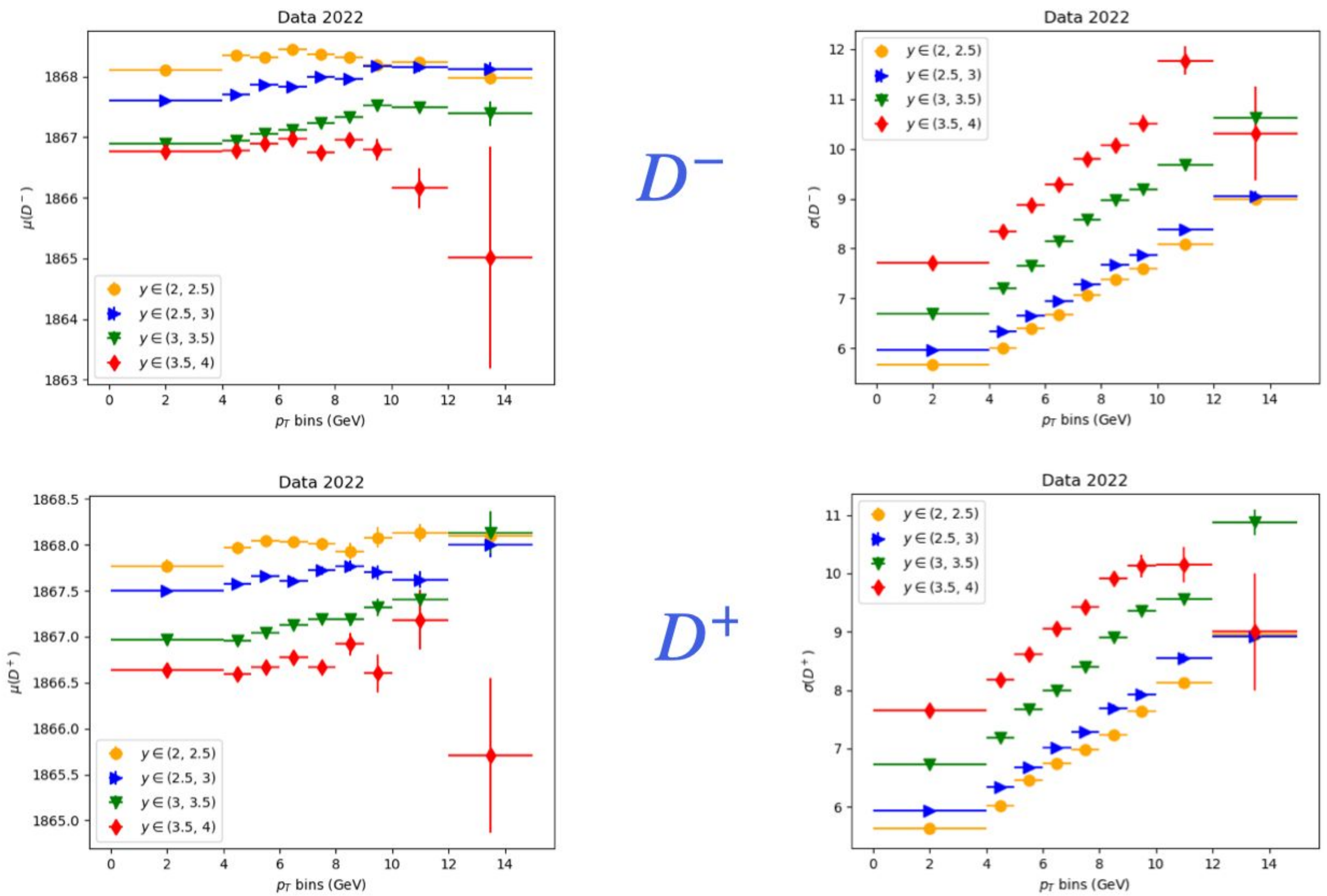
To be understood!

Peilian Li (CERN) 6

Studies on mass shift in 2022

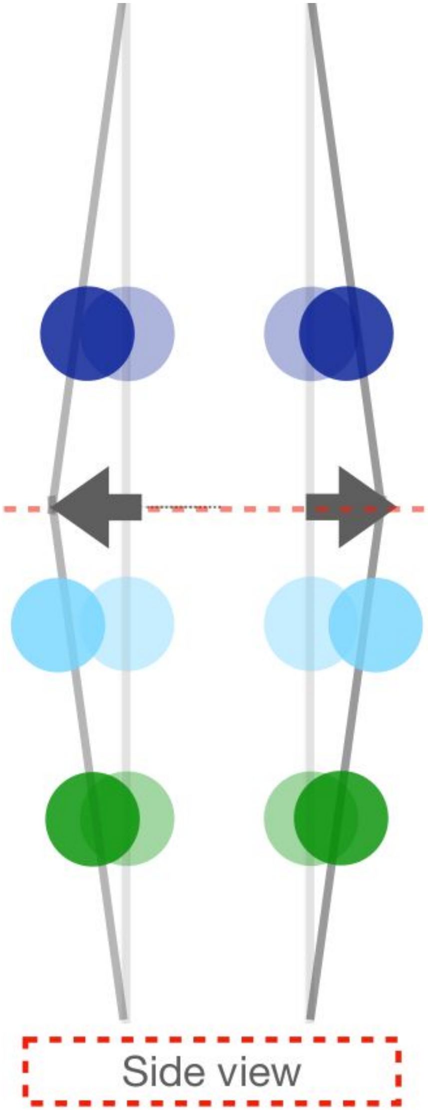
Mean and sigma from simultaneous mass fits

AlignmentV10_2023_05_09_LHCP for 2022 data



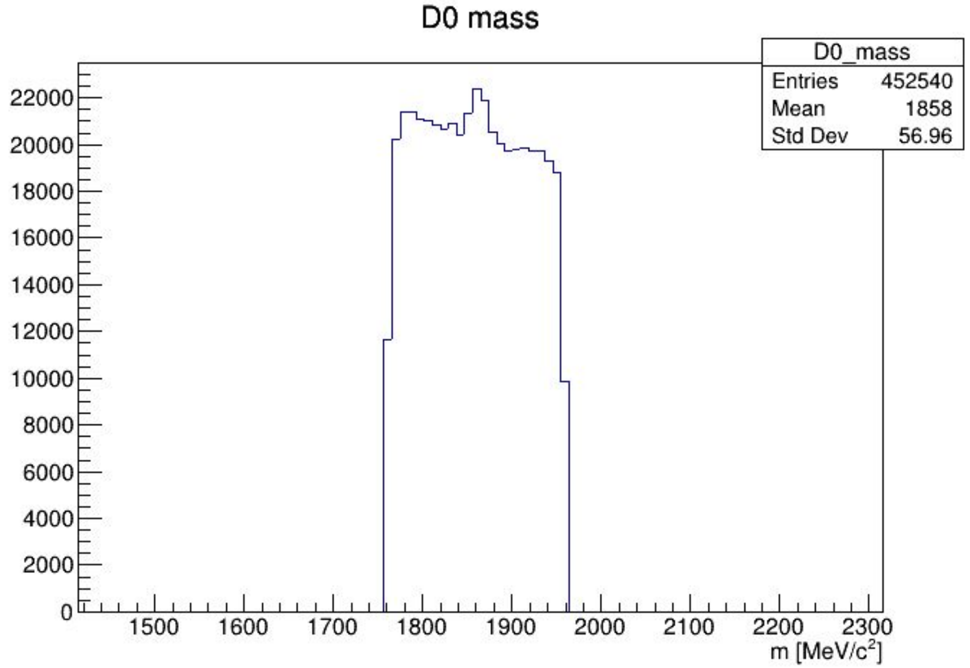
Issues discovered in the meanwhile

- Banana-shape description:
  - 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



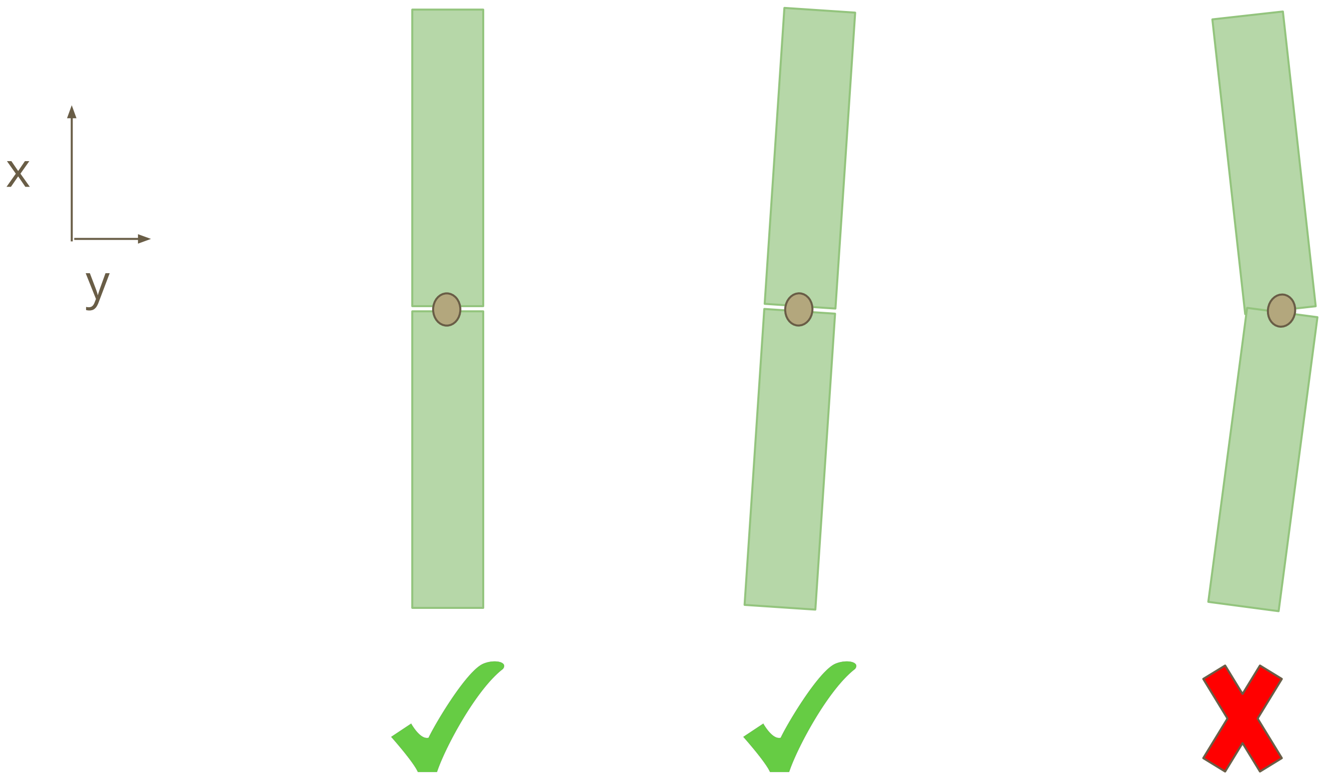
Issues discovered in the meanwhile (2)

- <u>Particles selection</u>
  - $D^0 \rightarrow$ 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)

- Need to properly tune joints uncertainties
  - 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)