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SciFi alignment

studies on alignment configuration and mass shifts

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on behalf of the SciFi alignment team

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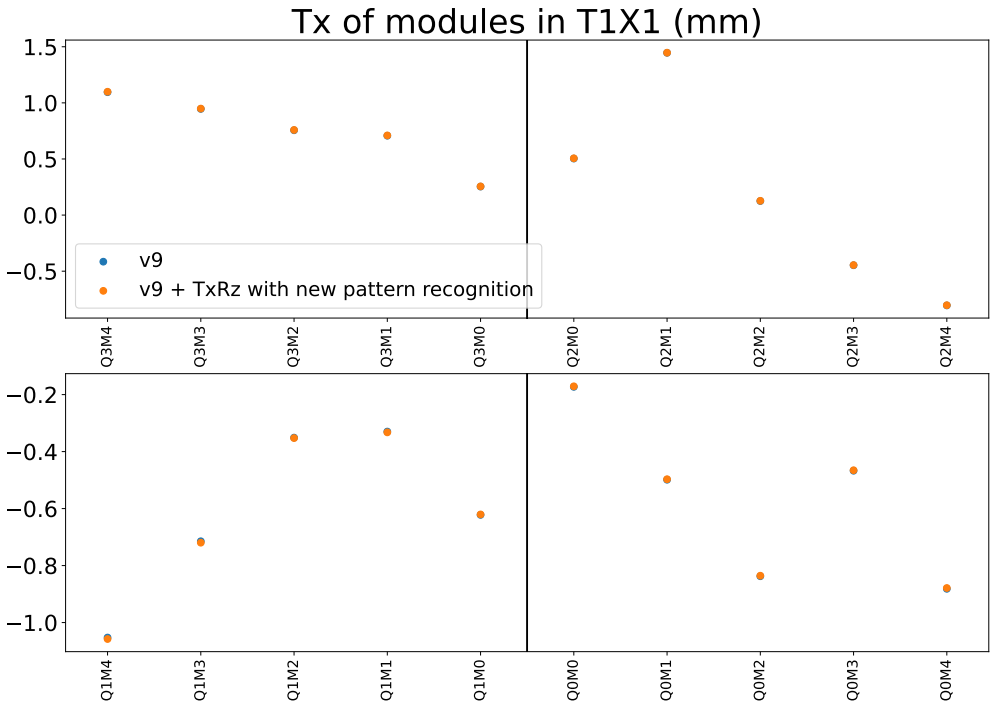
Updated pattern recongition in alignment: Rec!3565

- Alignment using 500k events from run 269045
- Aligning for HalfModules in Tx Rz + Back layer in stat. 3 fixed in Tx, Rz



- 10 % more tracks seen
- Procedure converges faster: one iteration less needed than before
- No impact on alignment constants (global coordinates shown)

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Rec!3565

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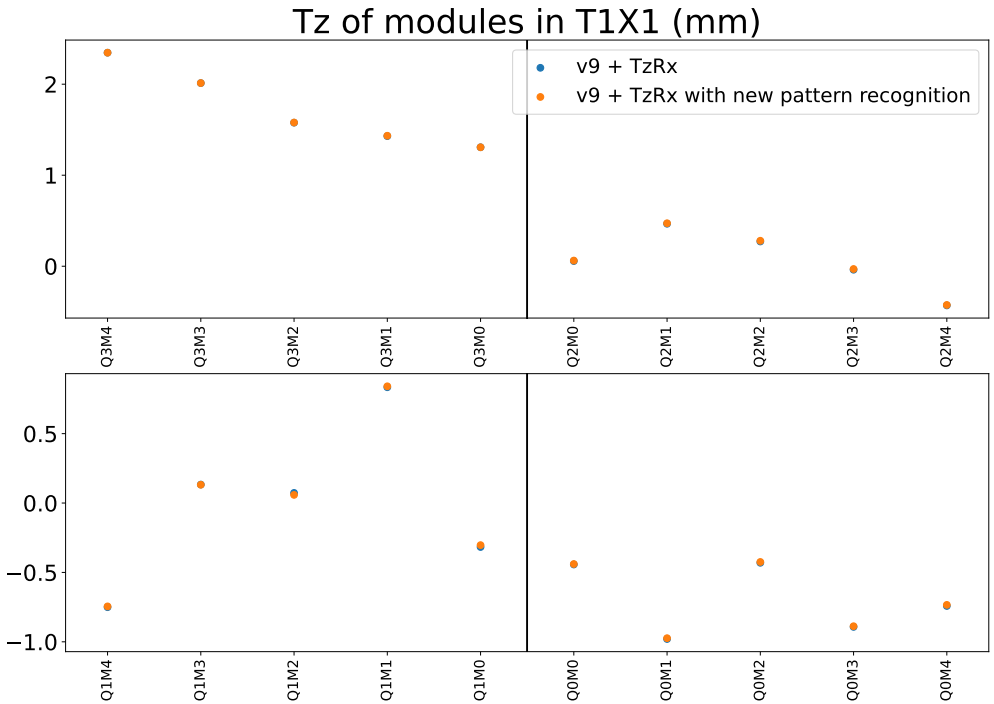
- Aligning for HalfModules in Tz Rx + Back layer in stat. 3 fixed in Tz, Rx



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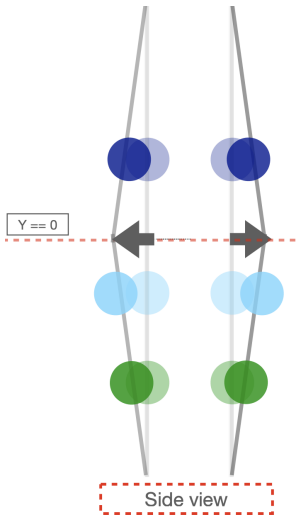
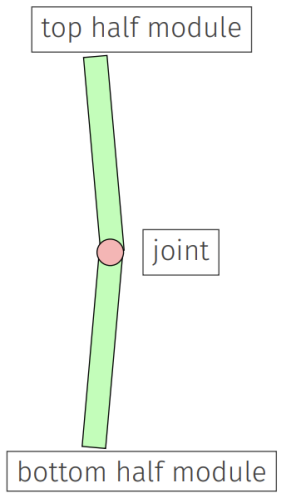
Alignment configurations: joint constraints

- SciFi modules are bending at the center (y = 0.0), inwards or outwards along the beam direction
- Half modules + joints reproduce the real shape



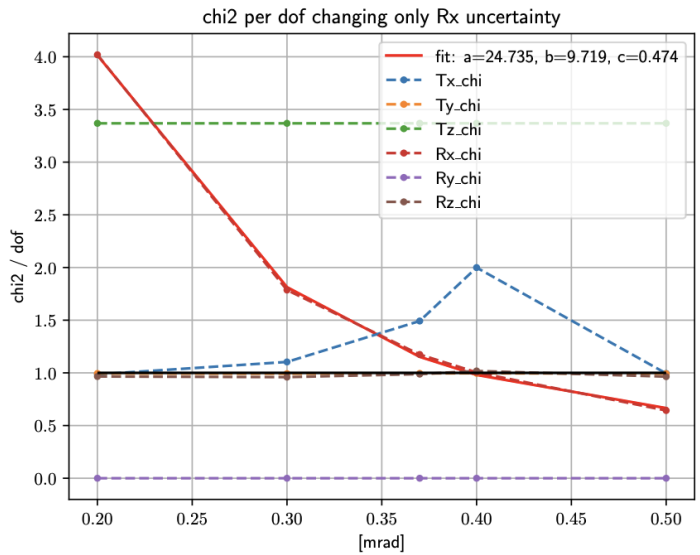


- Joints = survey constraint at the joint position
- Constraining two alignable elements:
  $\chi^2 = (p_A - p_B)^T V^{-1} (p_A - p_B)$
- No survey available for all degrees of freedom $\rightarrow$ tuning of survey constraint uncertainties needed to control their χ^2

Alignment configurations: joint constraints

- Look at the χ^2 contribution of all translations and rotations of joints
- Alignment scans for a range of uncertainties until $\chi^2/\text{dof} = 1$

Example: Tuning of Rx uncertainty

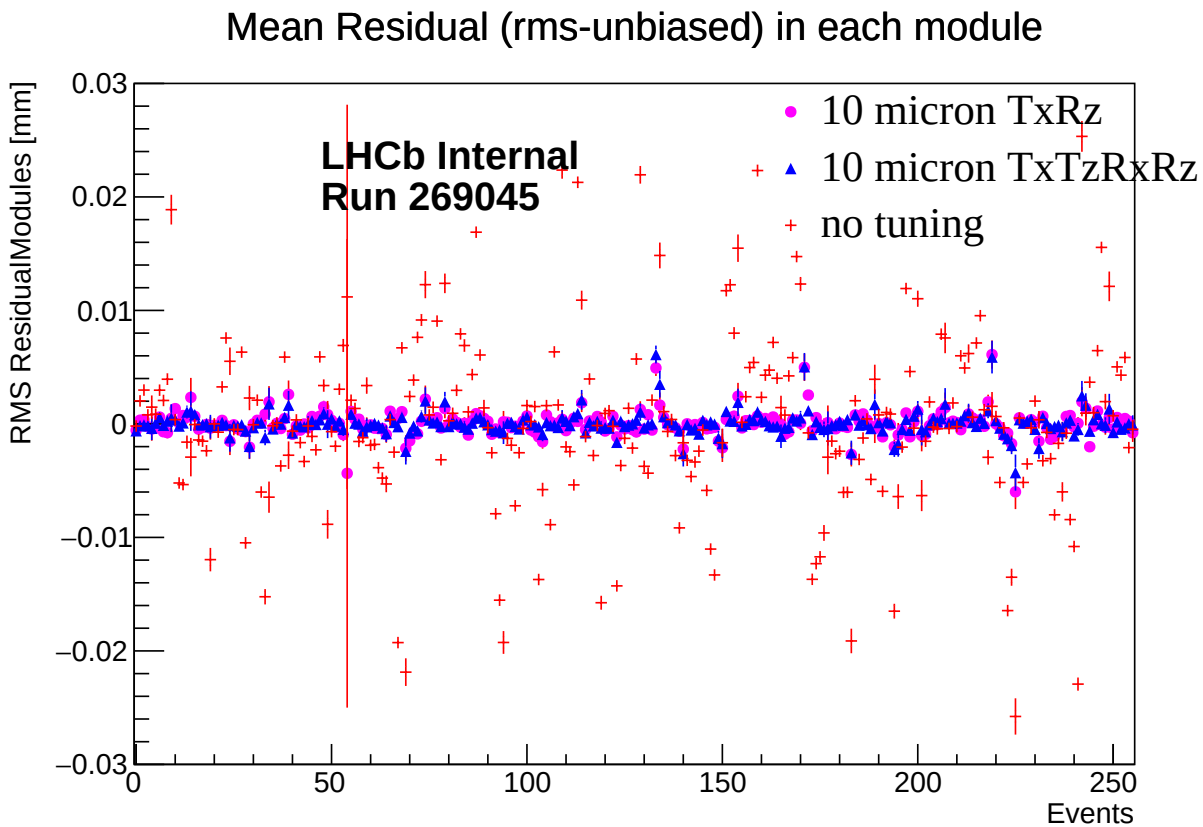


Parameter	uncertainty
Tx	10 μm
Ty	1.2 μm
Tz	1.9 μm
Rx	0.4 mrad
Ry	0.47 μrad
Rz	0.17 mrad

Rec !418

Obtained Rx uncertainty = 0.4 mrad
Stability checks of the modules shape from hardware $\rightarrow$ 0.35 mrad

Alignment configurations: joint constraints



- Improvements seen in residuals and tracking
- We will continue using the tuned uncertainties for the next data taking period

Curvature bias: $D^{\pm}$ mass

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

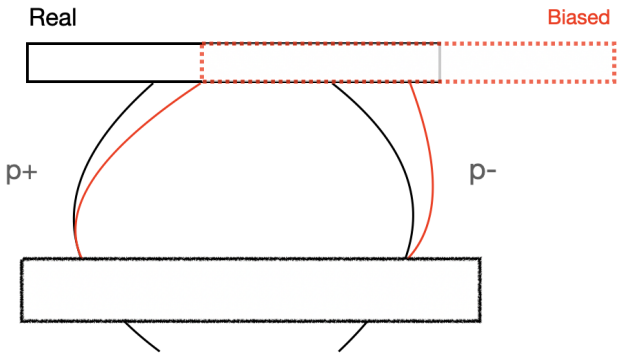
$$\delta m = (1 - cos\theta)(p_- - p_+)\delta p \sim C\delta r(p_- - p_+)$$

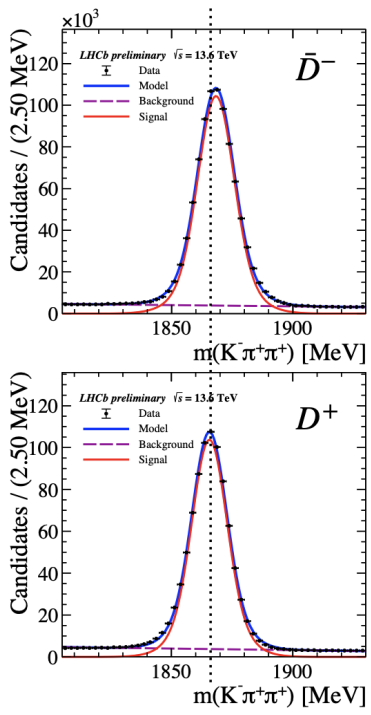
Note: mass shift over $(p_- - p_+)$

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





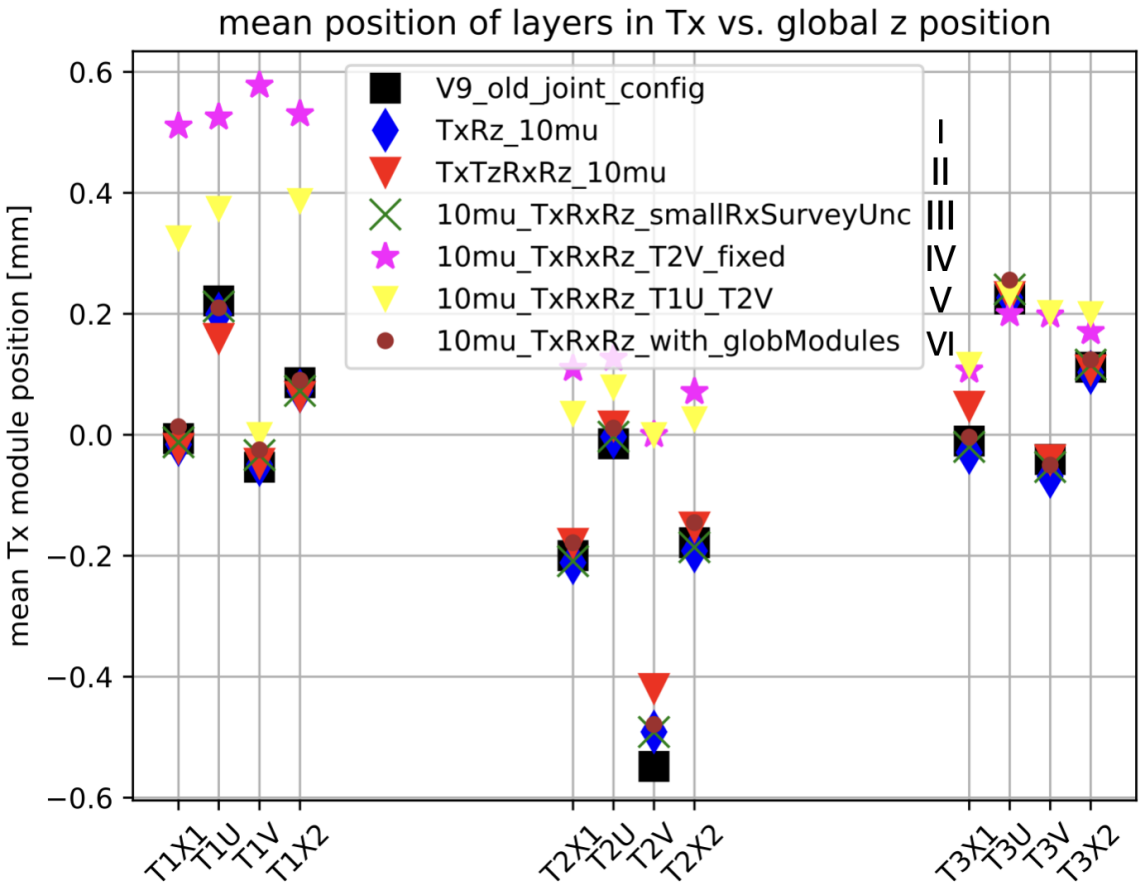
- Residual misalignment in Tx in one of the stations/layers in the SciFi
- Tz positions used from 2022: residual in z
- Interplay with rotations of joints of modules
- Mass constraint not working

Curvature bias: alignment configurations

- Several configurations checked
- All of them use the previously tuned joint uncertainties (slide 5)

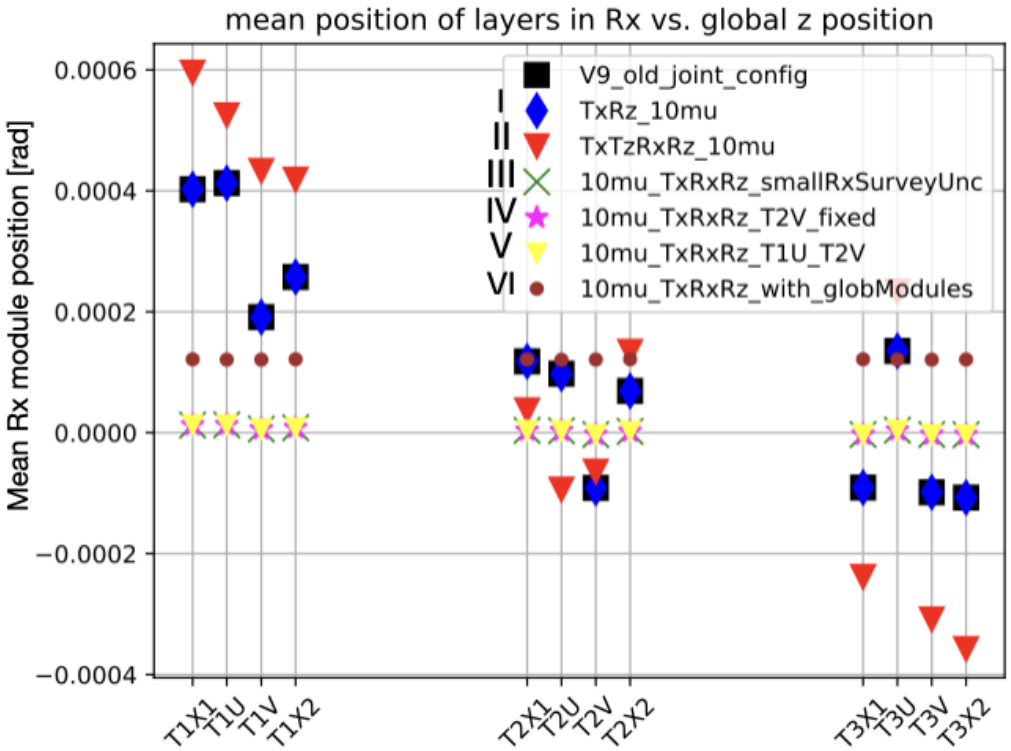
Configuration	I	II	III	IV	V	VI
Modules	TxRz	TxTzRxRz	TxRxRz	TxRxRz	TxRxRz	TxTzRxRz
Average constraint						
All modules	✗	✗	✗	✗	✗	✓
T2V+T1U	✗	✗	✗	✗	✓	✗
T2V layer av. pos.	✗	✗	✗	✓	✗	✗
Small Rx survey uncert.	✗	✗	✓	✓	✓	✓
Back layer in stat. 3	TxRz	TxTzRxRz	TxRxRz	TxRxRz	TxRxRz	TxTzRxRz
Modules joints	all dofs	all dofs	all dofs	all dofs	all dofs	all dofs
Survey	not used	not used	not used	not used	not used	not used

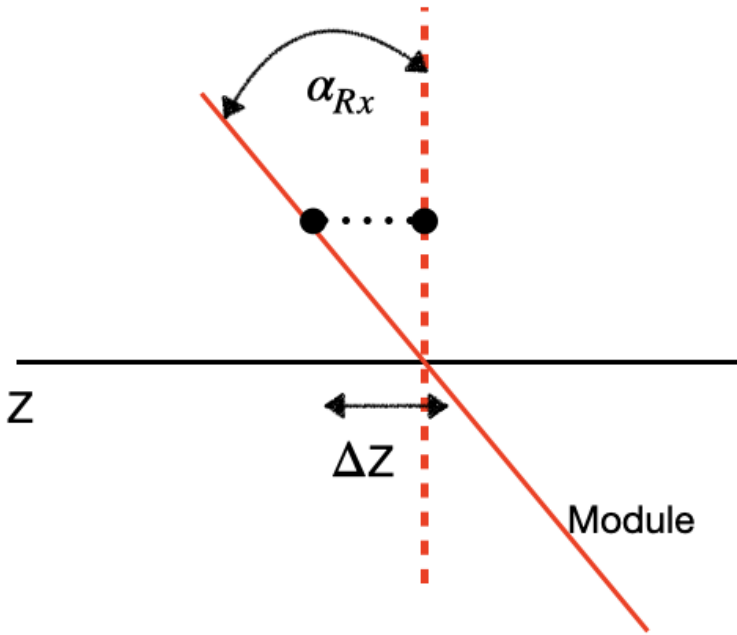
Curvature bias: alignment configurations Tx



- All layers in T2 have a shift in x compared with the other stations
- Configuration IV and V constrain layers in T1 and T2 that partly solve the discrepancy

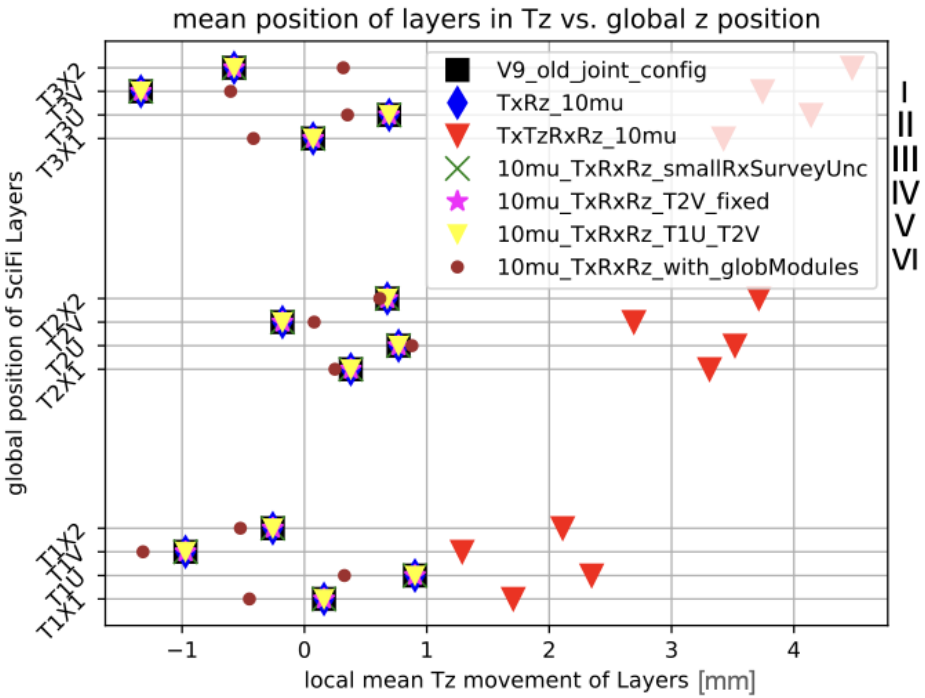
Curvature bias: alignment configurations Rx

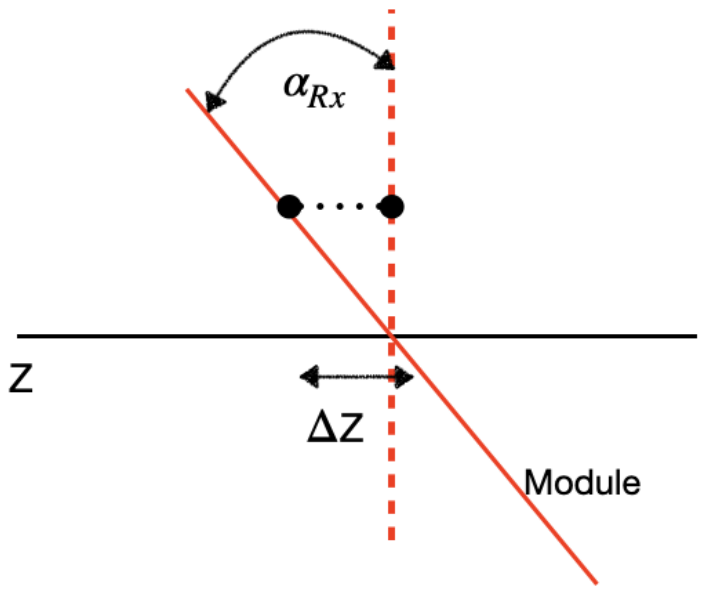




- In v9 Rx introducing rotation (for the modules bending)
- In II Tz and Rx are correlated, Rx movement translates to z positions
- In IV, V and VI 'removing' Rx with a small uncertainty

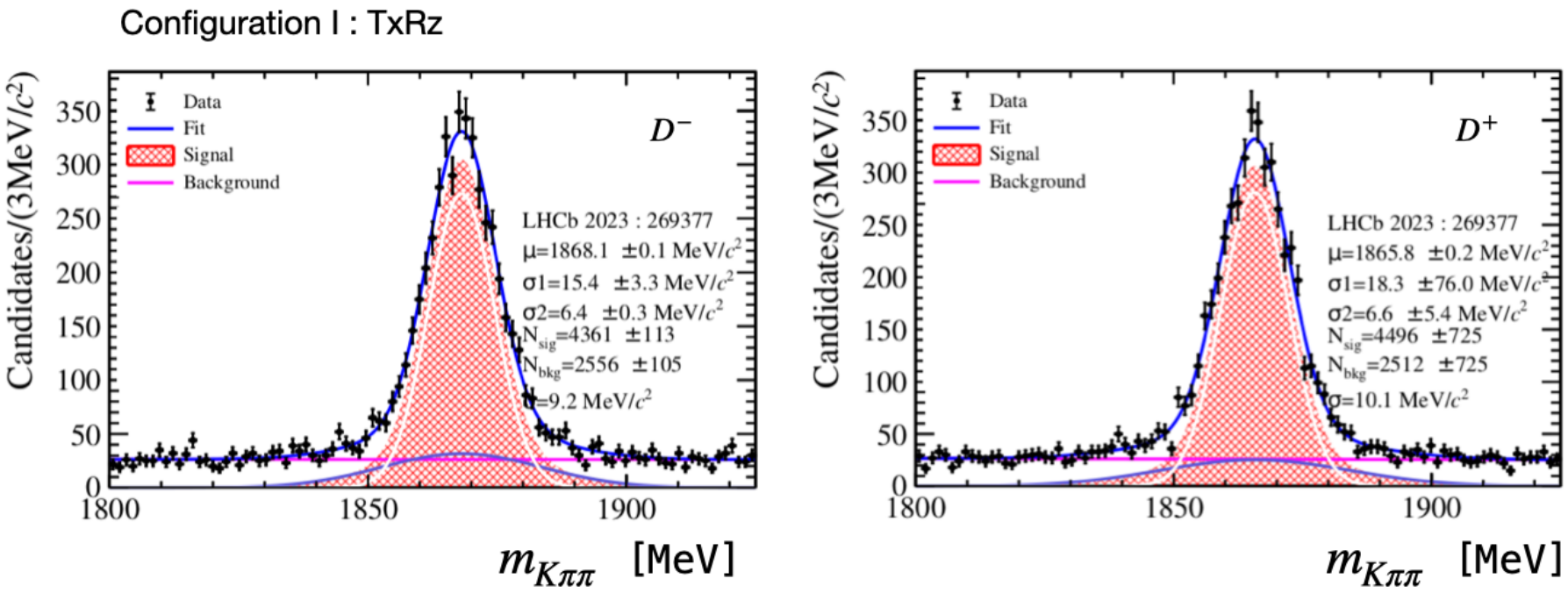
Curvature bias: alignment configurations Tz





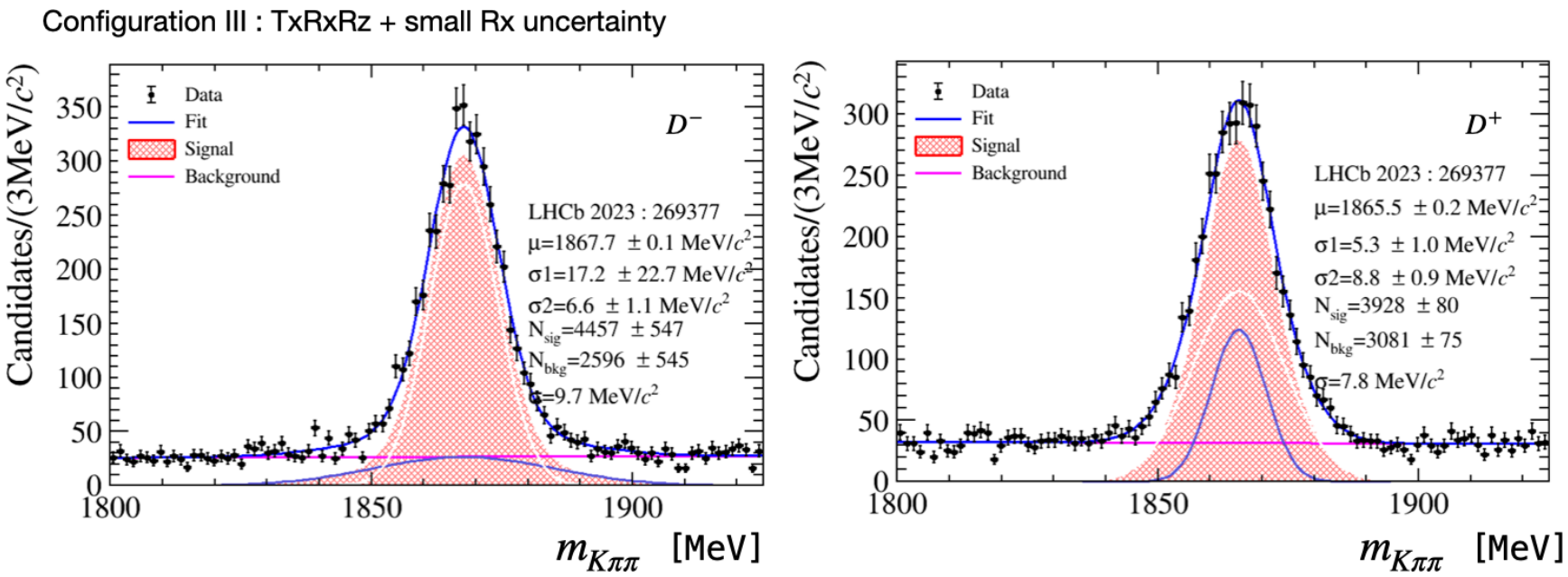
- Conf. II introduces large shifts: max 4 mm in z, all because Rx compensation
- To be able to disentangle between the both we put small survey uncertainty in Rx and then align for TxTzRxRz (VI)
- Not planning to include Rx and Tz in further data-taking

Curvature bias: $D^{\pm}$ mass fits



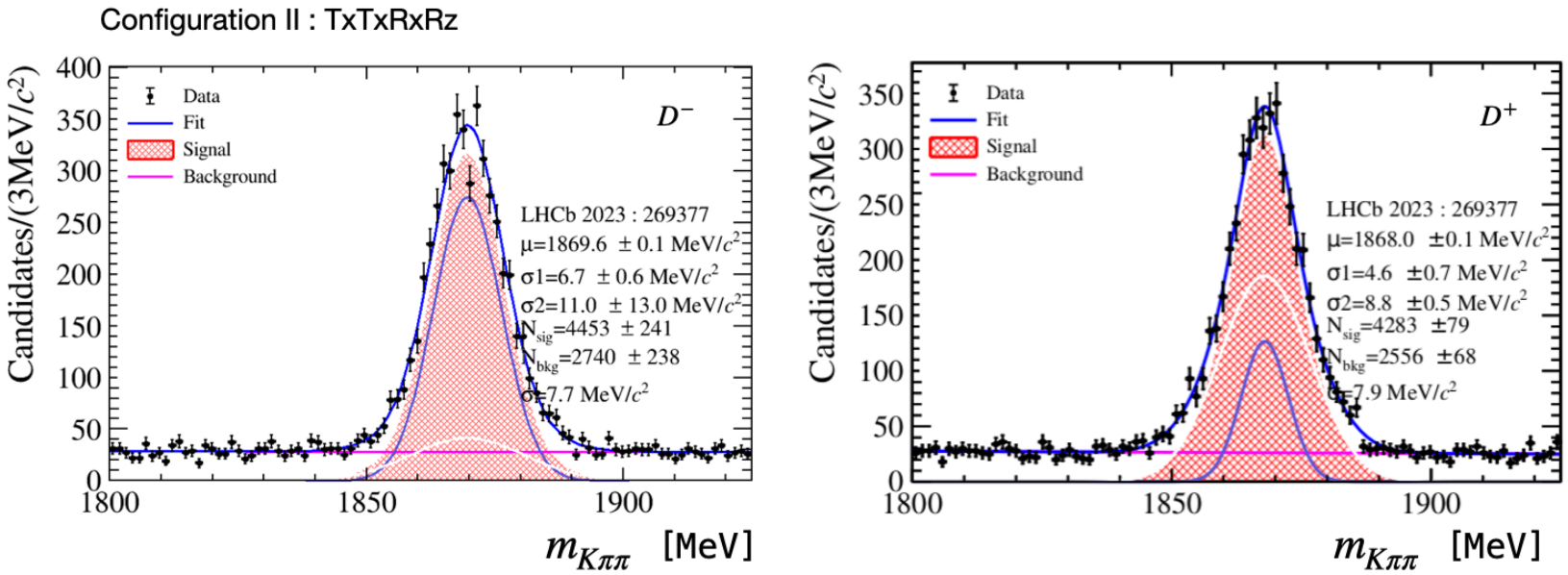
- Shift visible when adding the tuning of joints
- This is the same configuration as V9
- Already confirmed by analysts

Curvature bias: $D^{\pm}$ mass fits



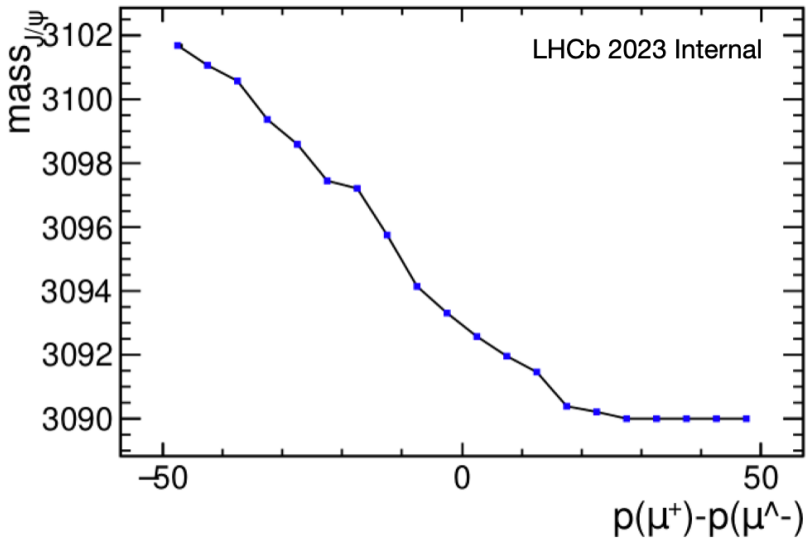
- Adding only Rx does not improve the $D^{\pm}$ shift

Curvature bias: $D^{\pm}$ mass fits

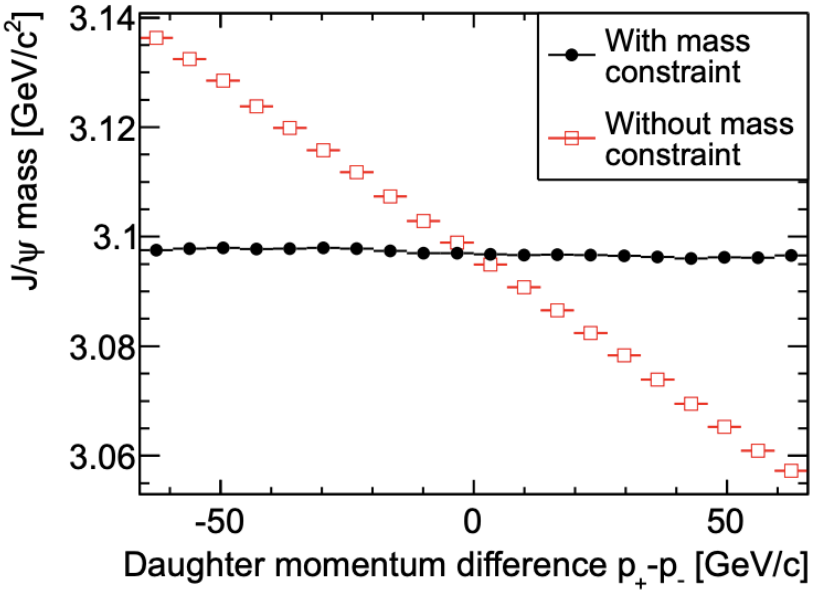


- Mass shift is vanishing when aligning for Rx and Tz together
- NOTE: Tz was already there from 2022 alignment
- This introduces shift in z not corresponding to survey
- To be checked if conf. VI solves the shift without large z movement

Curvature bias: J/Ψ mass



arXiv:1207.4756



- SciFi alignment events are collected using:
  RB 3 Tracker alignment
  'Hlt1(D2KPi|DiMuonHighMass|DisplacedDiMuon)Alignment'
- J/Ψ mass constraint not included (not working)
- Working on fixing this

Summary

- Curvature bias present: can come from bad alignment or from magnetic field description
- Aligning for Rx and Tz retrieve back the $D^{\pm}$ shift
- J/Ψ mass constraint to be added, currently only D^0 used
- Rotations in z to be checked in case they contribute to unphysical movements
- Other effects can come to play, suggestions are welcomed
- Plan to release a new version with all these fixes