Progress on alignment

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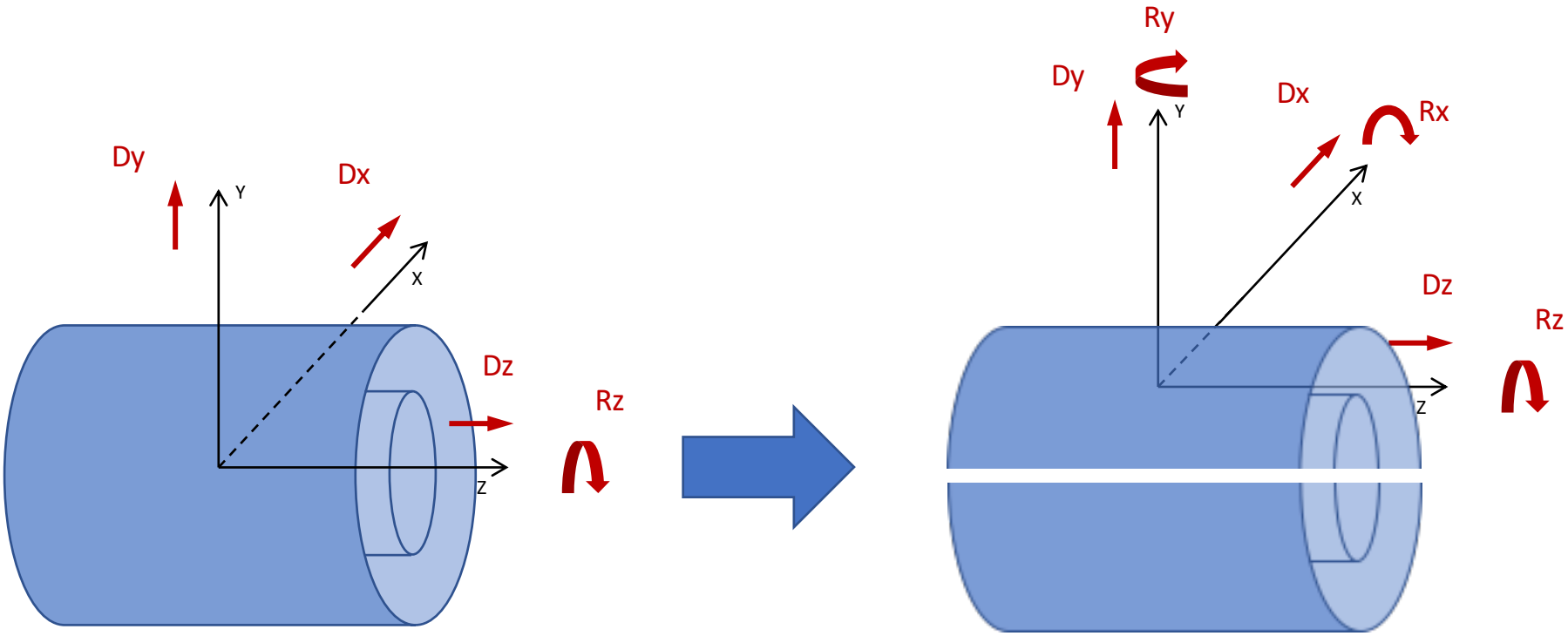
Cgem software meeting – Nov 12 2020

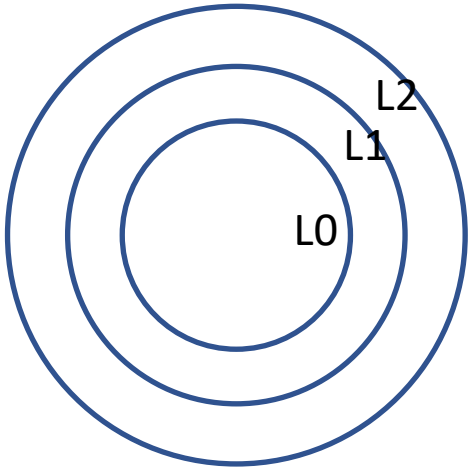
Alignment for Cgem

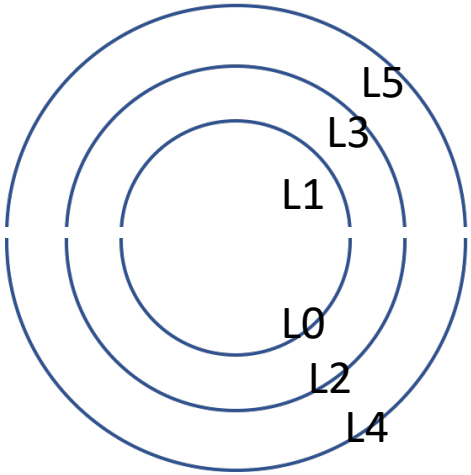
- Configuration of alignment algorithm for cosmic-ray data
  - **4** layers of Cgem, position of **inner 2 layer** is fixed as reference
  - For each layer, 6 alignment parameters: Dx, Dy, Dz, Rx, Ry ,Rz
  - Dy is also fixed because it is insensitive to cosmic-ray data



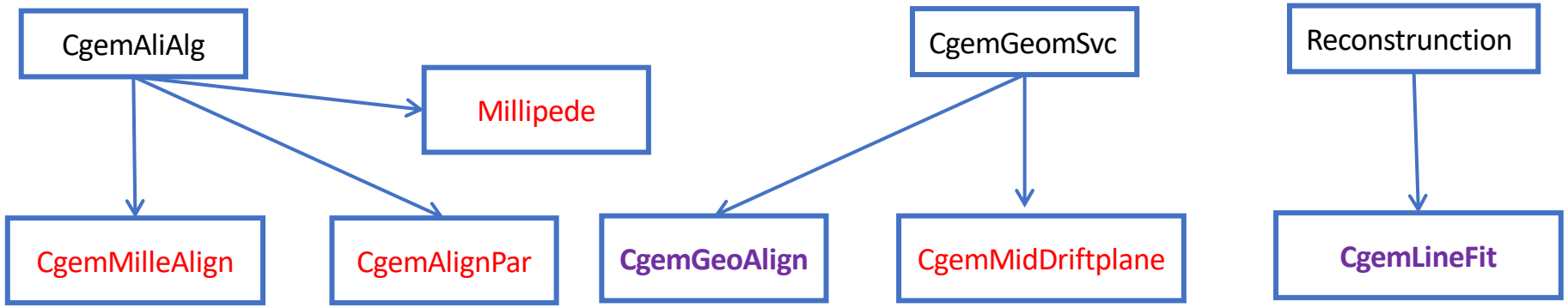
Algorithm modification

- We need re-define the layer index
  - From geometry layer → virtual layer

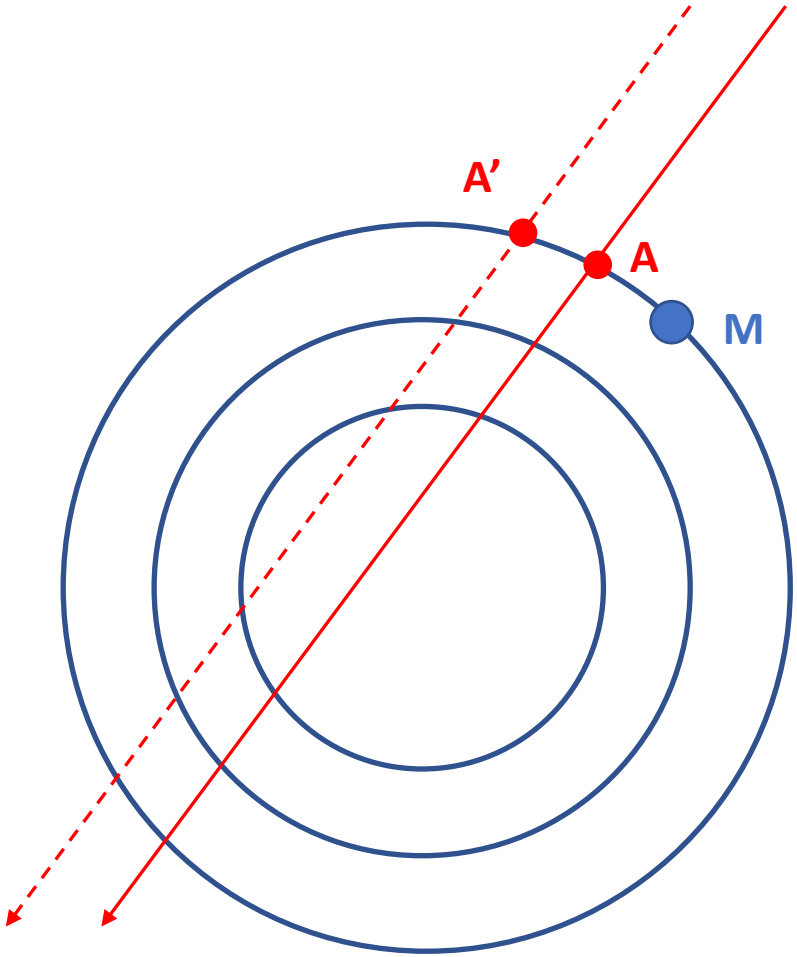




  - Only change the packages related to the alignment algorithm



Geometry server package



Key issue:

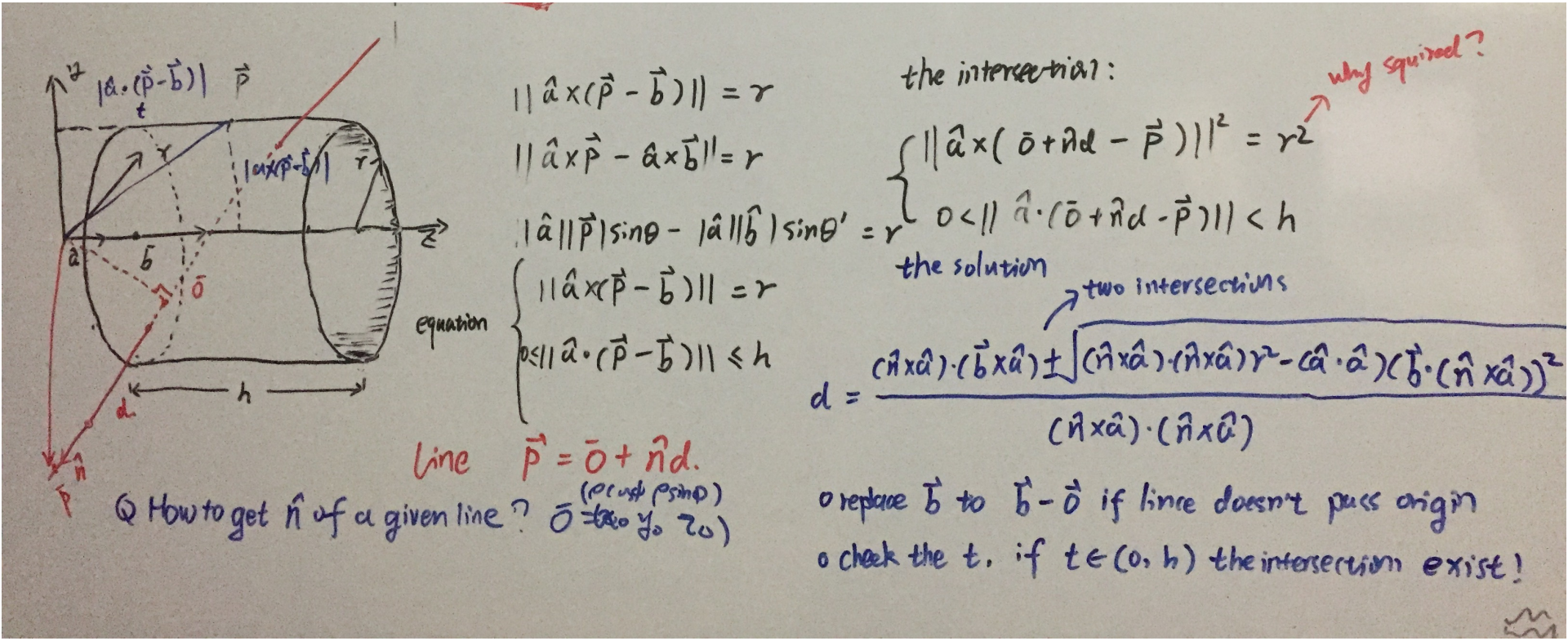
- How to calculate the new intersections **A'** if the detector is mis-aligned.

Current solution:

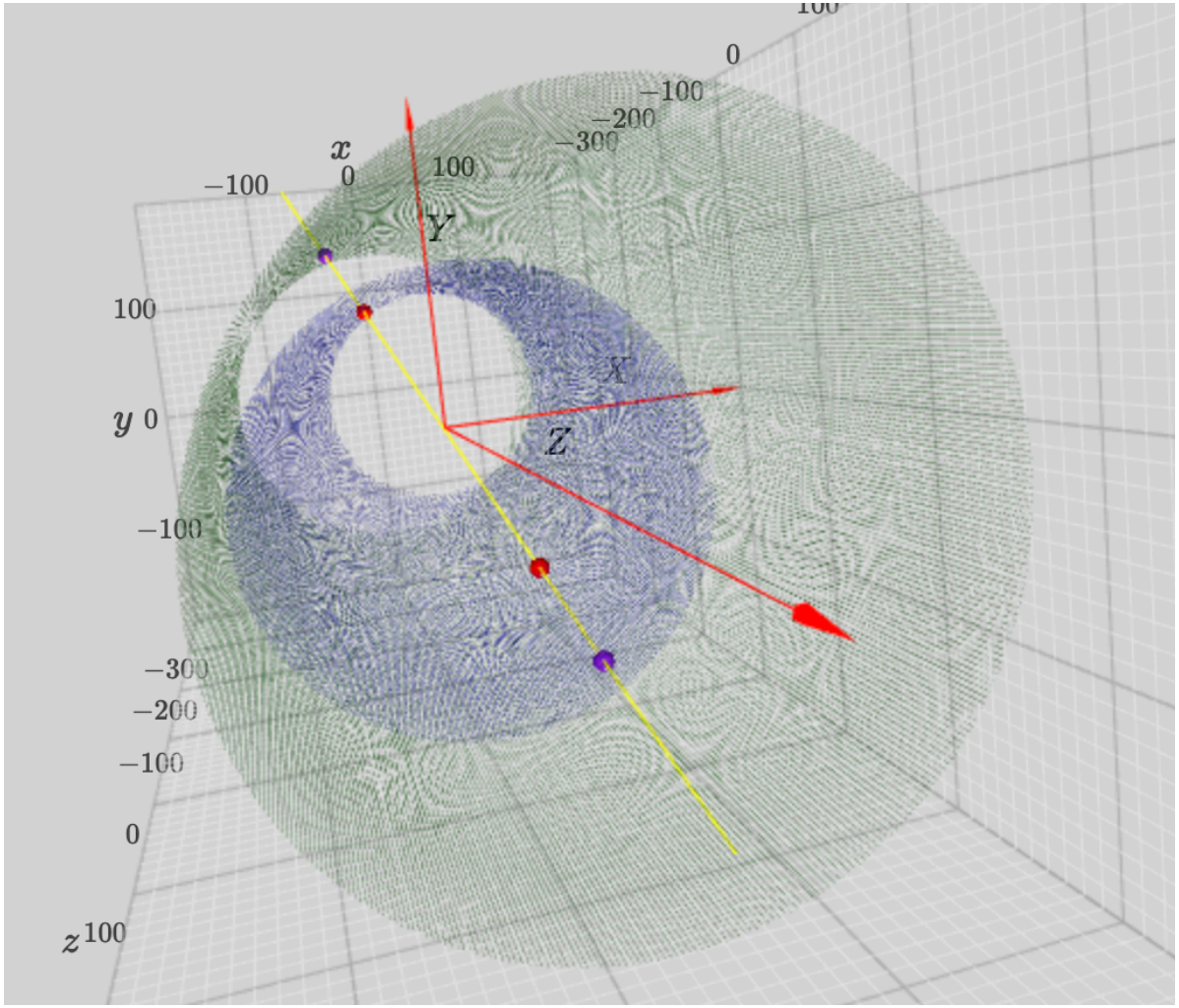
- We know the intersections of detector and a given line
- Changing the line parameters instead of changing the detector position
- Get the intersection with new line parameters

New algorithm

- Calculate the intersections between a given line and Cylinder with arbitrary orientation and position

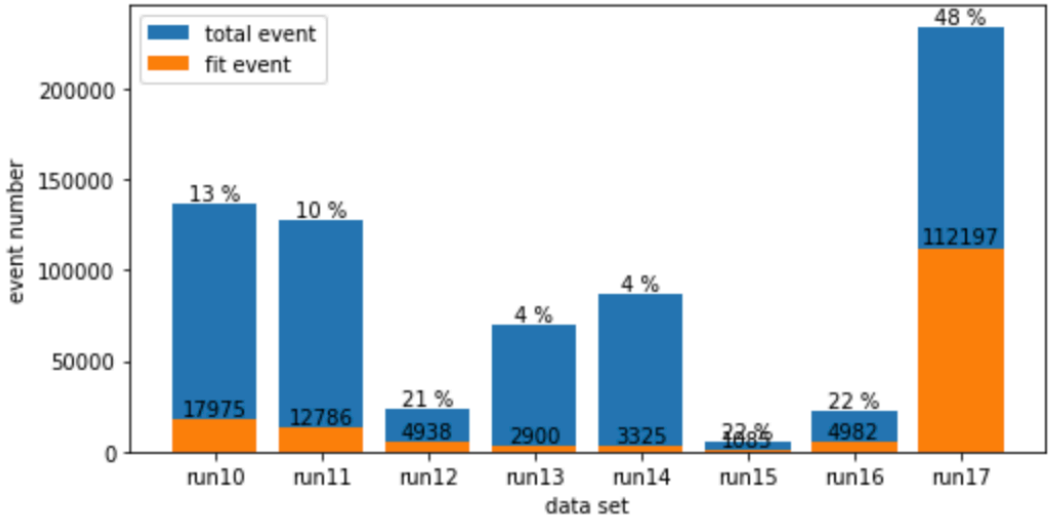


Algorithm validation

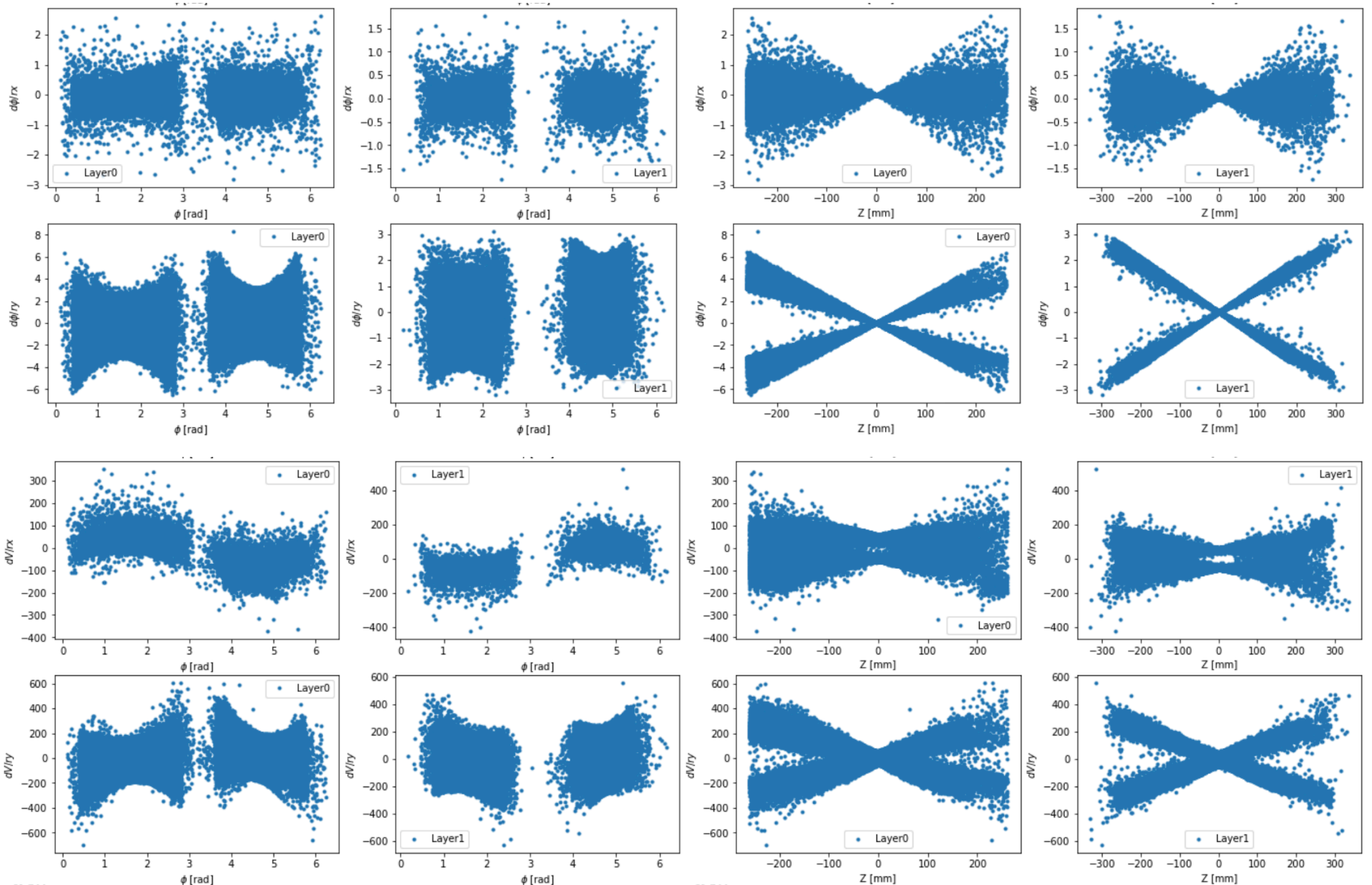


Data set and configuration

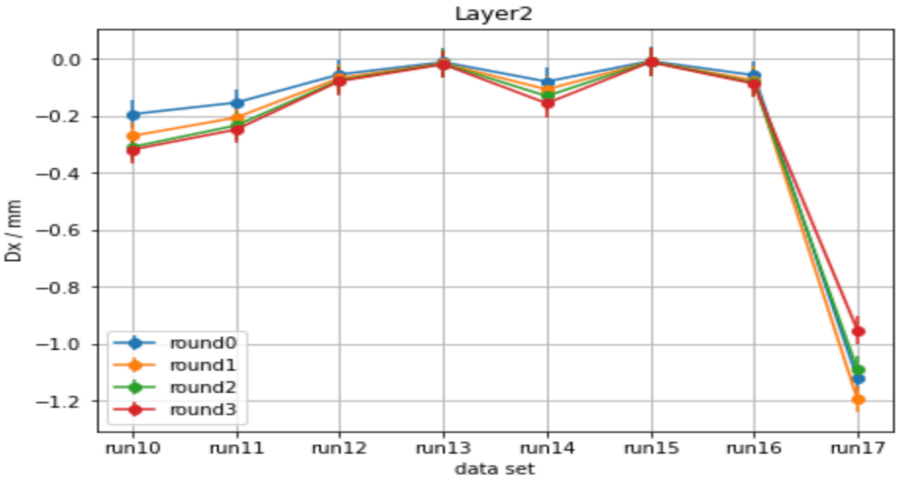
- Run over run10 – run17
  - CgemLineFit: Loop_maxQ, 3 clusters on each sheet
  - Chisq cut: <300 (wo alignment) <100 (w alignment)
  - Check the alignment parameter vs data sets
- Alignment procedure
  - Alignment parameters are obtained by iteration. The fit results from 1st round is used as the input for 2nd round fit
  - Initial parameters: Dx = 0, Dz = 0, Rx = 0, Ry = 0, Rz = 0
  - Iterate the procedure until parameters are converged

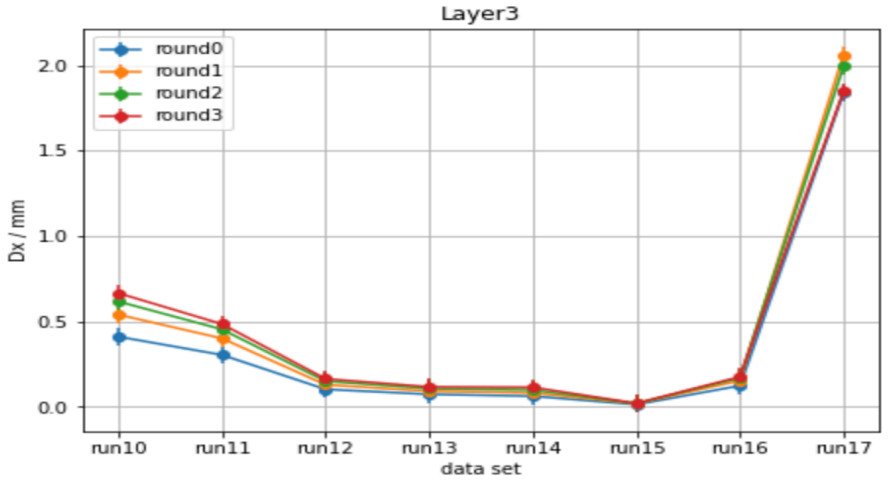


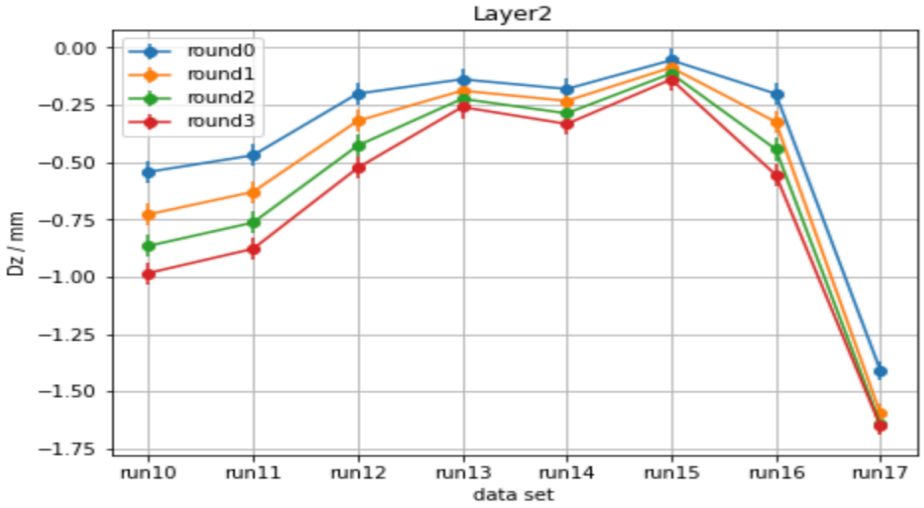
Derivatives $d\phi/dRx(dRy)$ vs ϕ and Z top 2, $dV/dRx(dRy)$ vs ϕ and Z bottom 2

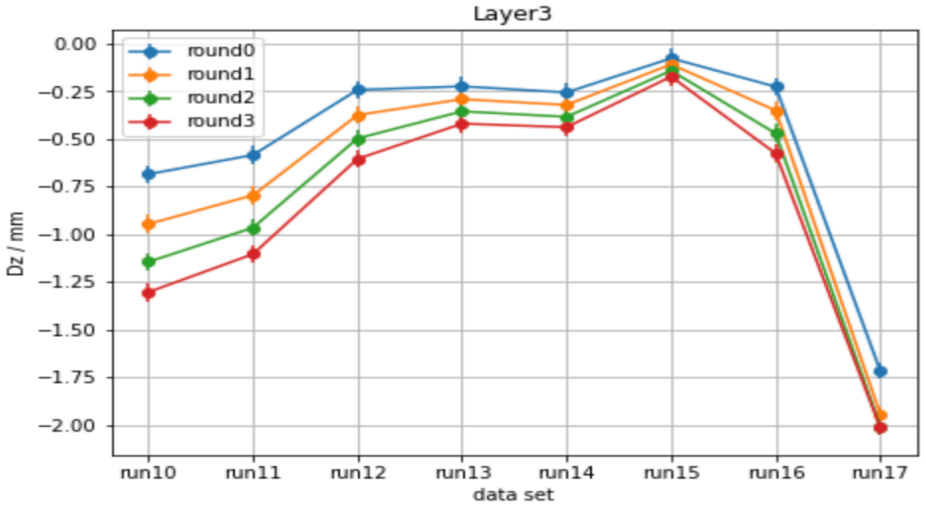


Fit results: Dx and Dz

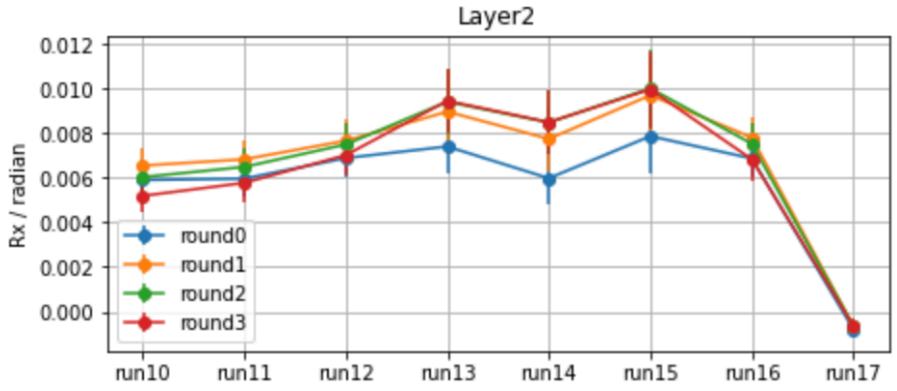


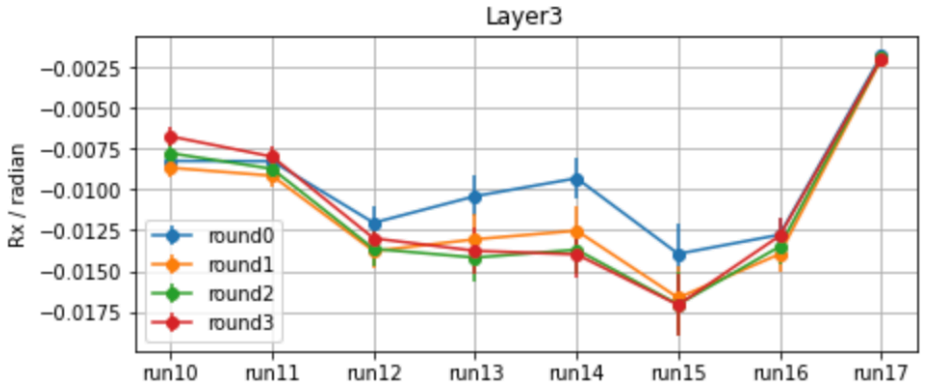


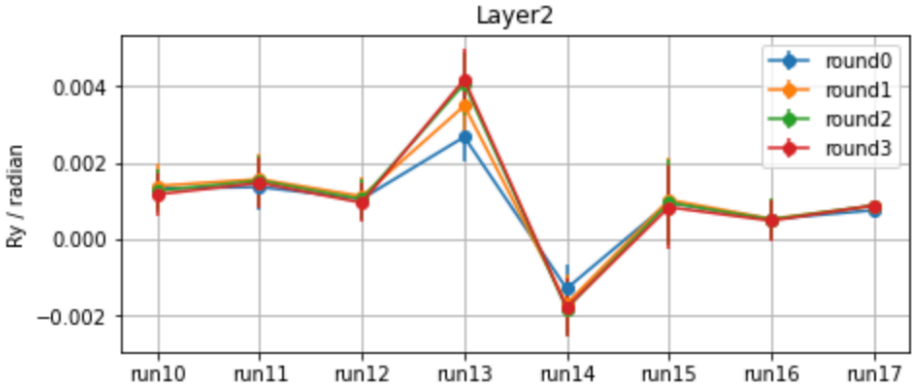


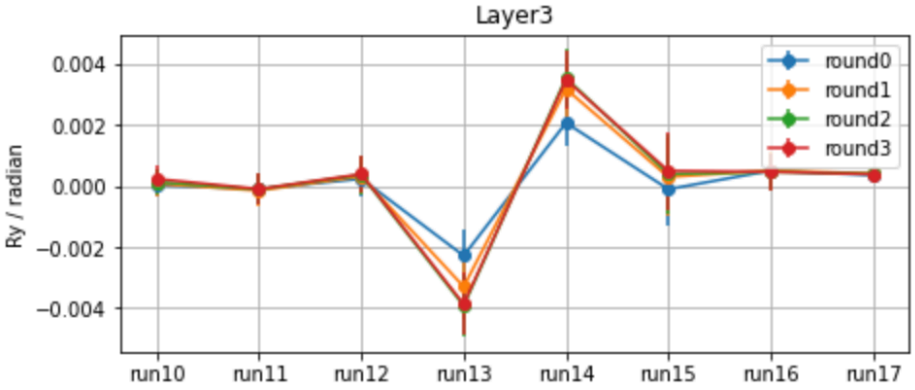


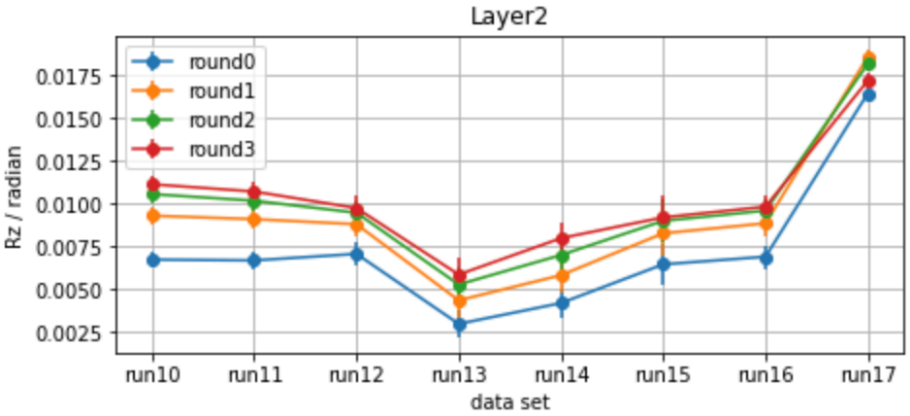
Fit results: Rx,Ry,Rz

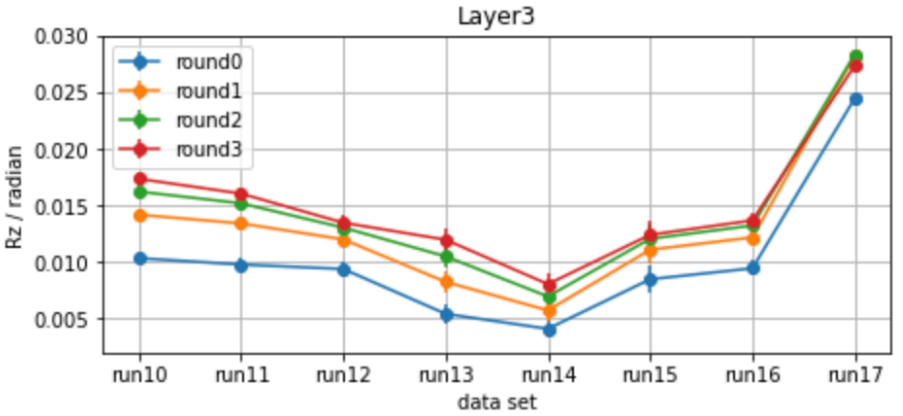












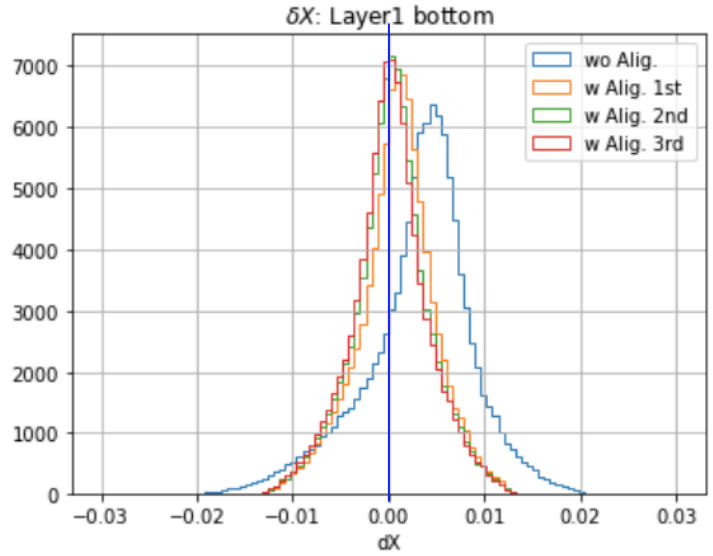
Fit results summary

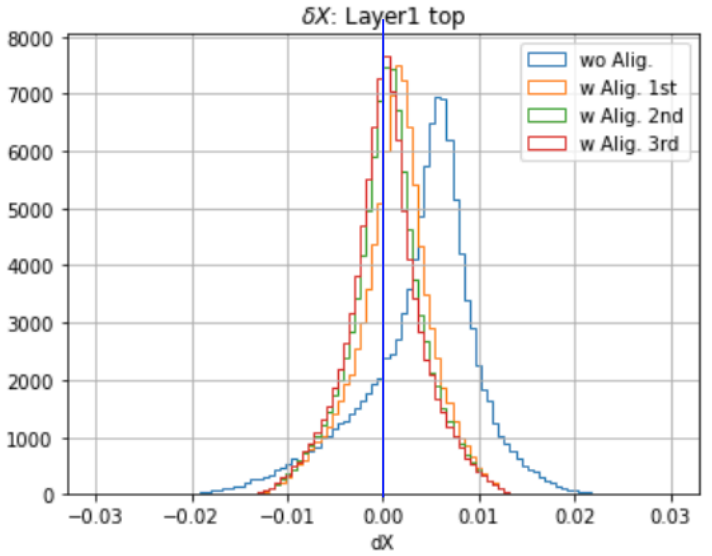
Run10	Dx (mm)	Dz (mm)	Rx (Rad.)	Ry (Rad.)	Rz (Rad.)
L2	-0.3176	-0.9835	0.0051	0.0011	0.0111
L3	0.6658	-1.3040	-0.0067	0.0002	0.0173

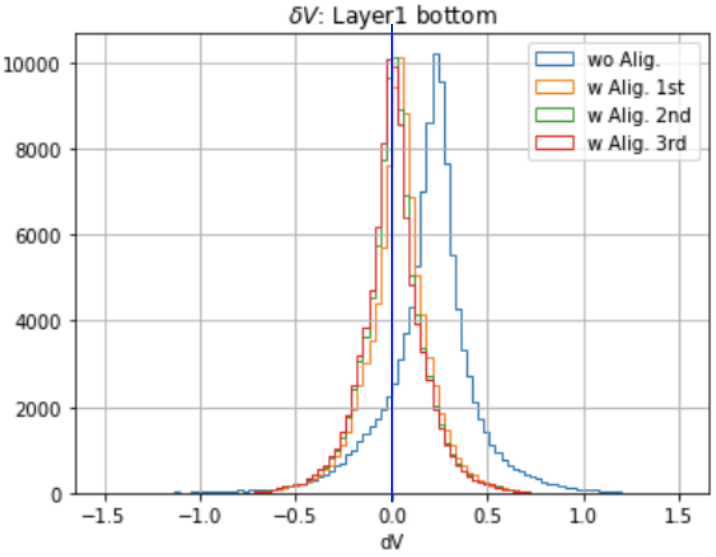
Run17	Dx (mm)	Dz (mm)	Rx (Rad.)	Ry (Rad.)	Rz (Rad.)
L2	-0.9514	-1.6501	-0.0006	0.0009	0.0171
L3	1.8454	-2.0144	-0.0019	0.0004	0.0273

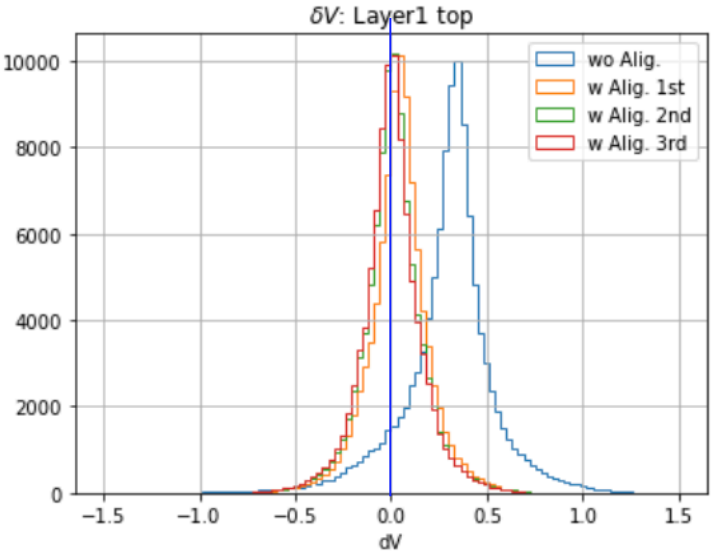
- The results from run17 are obviously different to other data-sets
- The mis-alignment effects on the top and bottom part could be different
- The signs of Dx from top and bottom part are opposite

Residual distribution – layer1-New

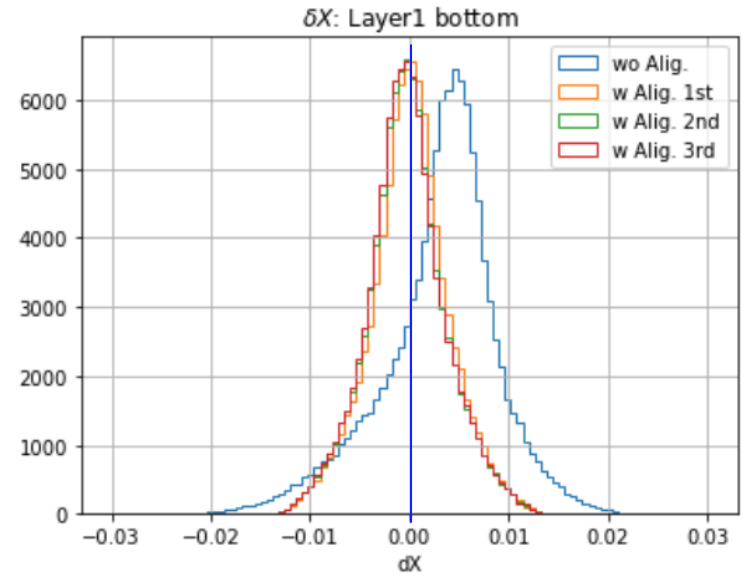


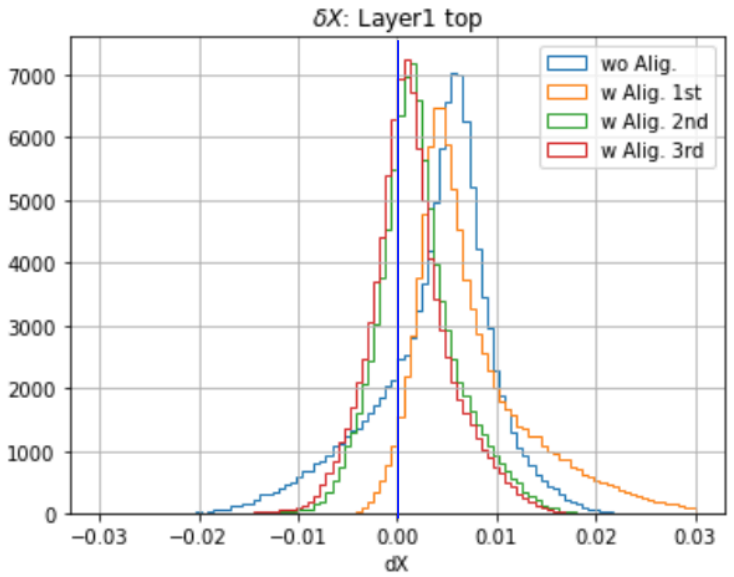


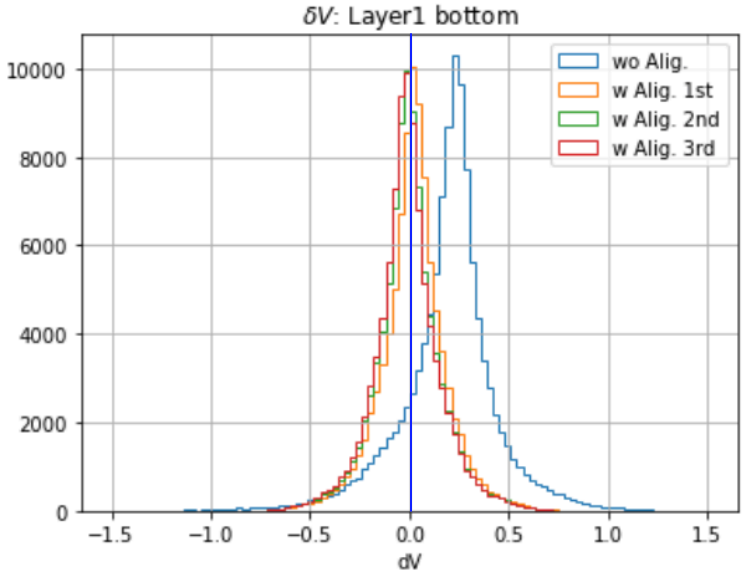


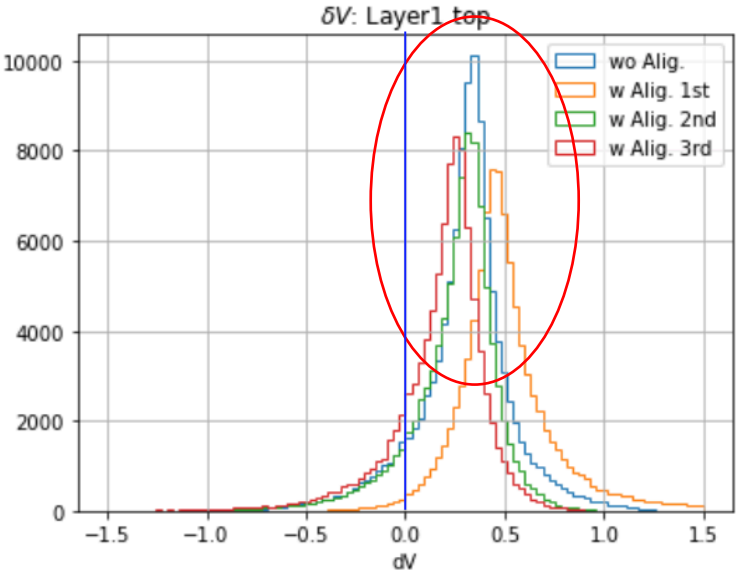


Residual distribution – layer1-Old

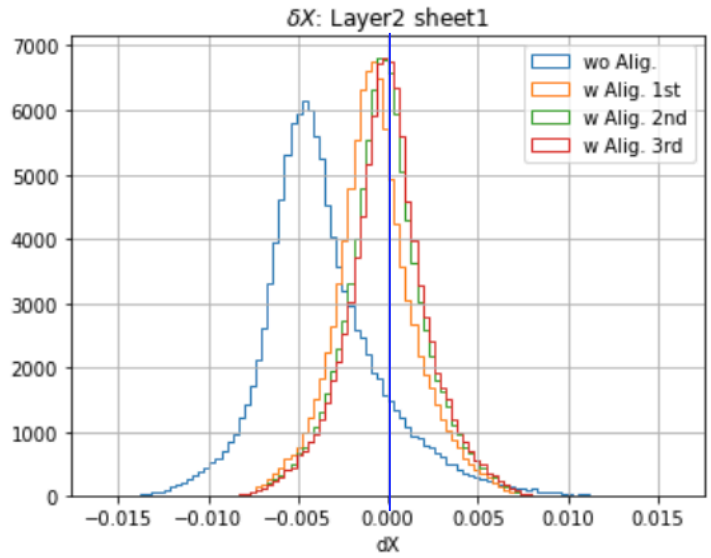


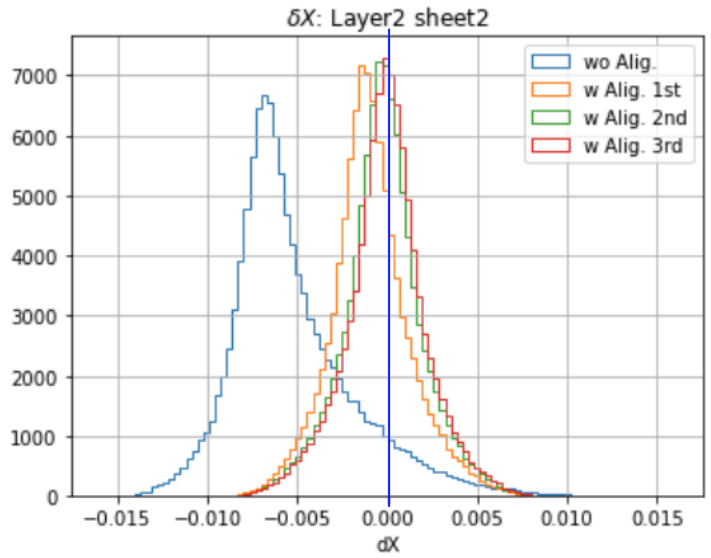


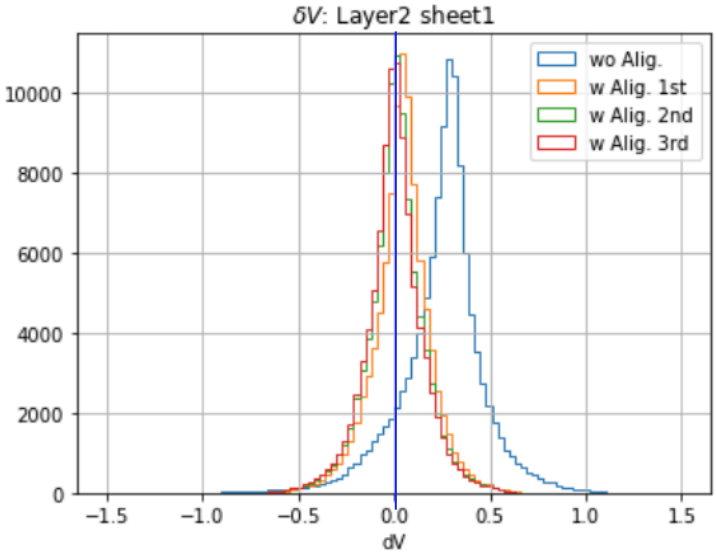


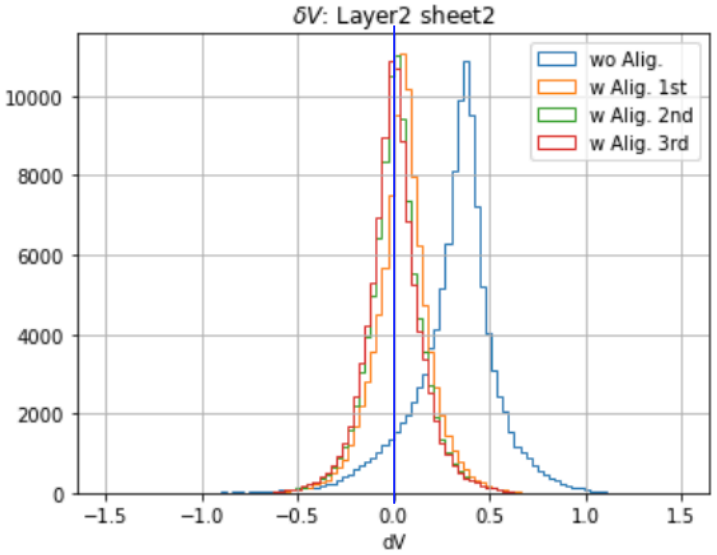


Residual distribution - layer2-New

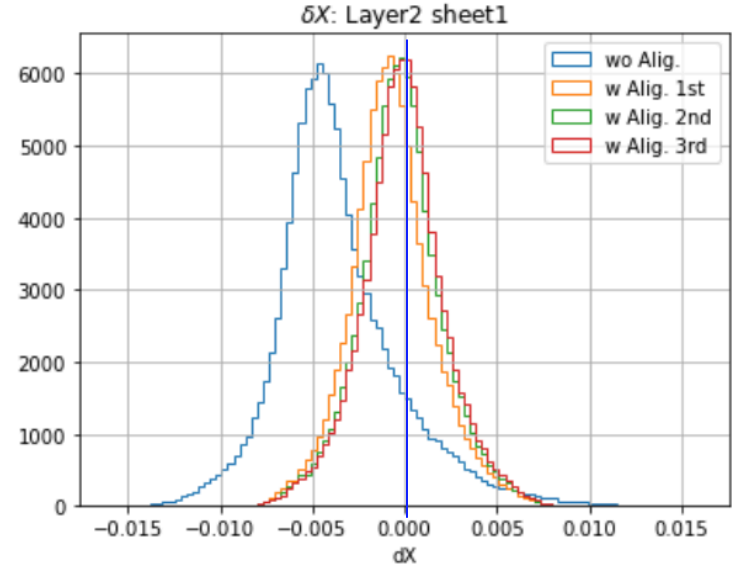


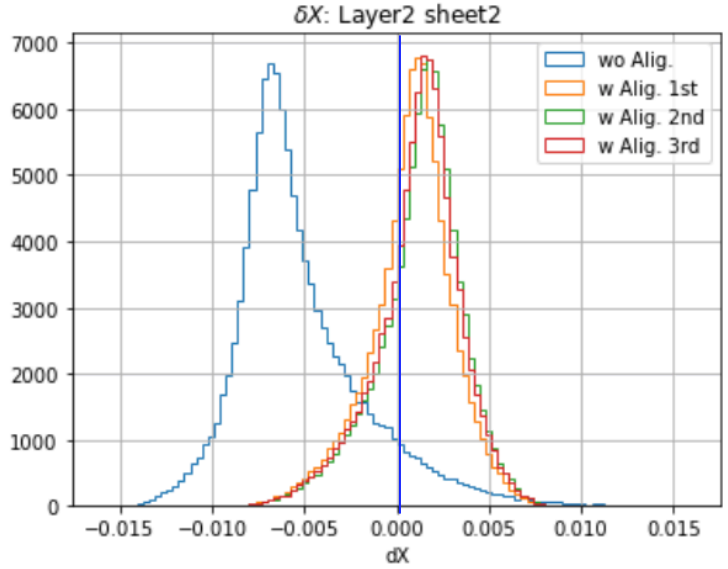


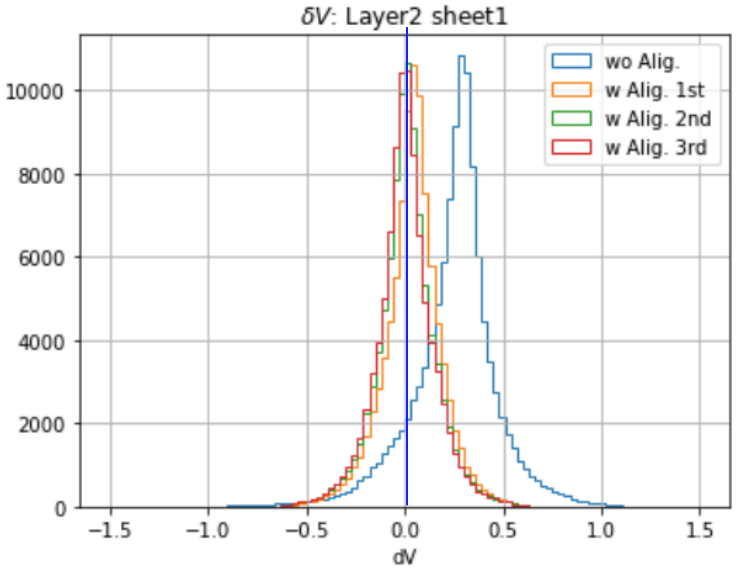


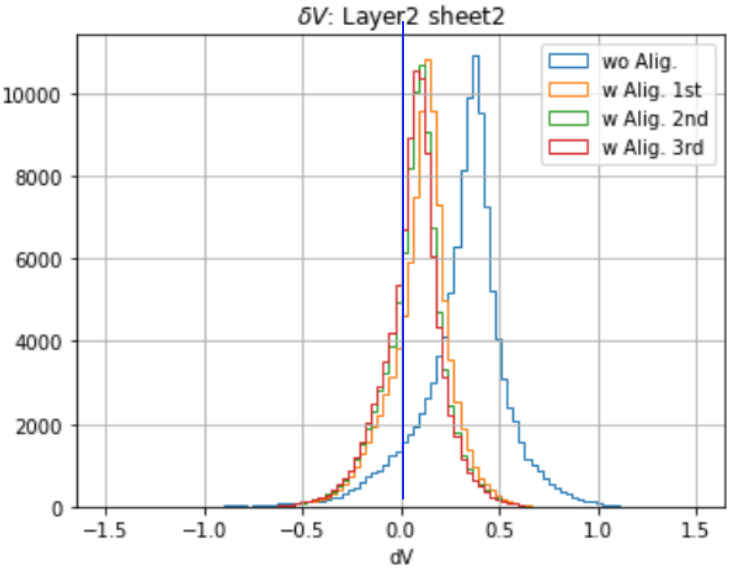


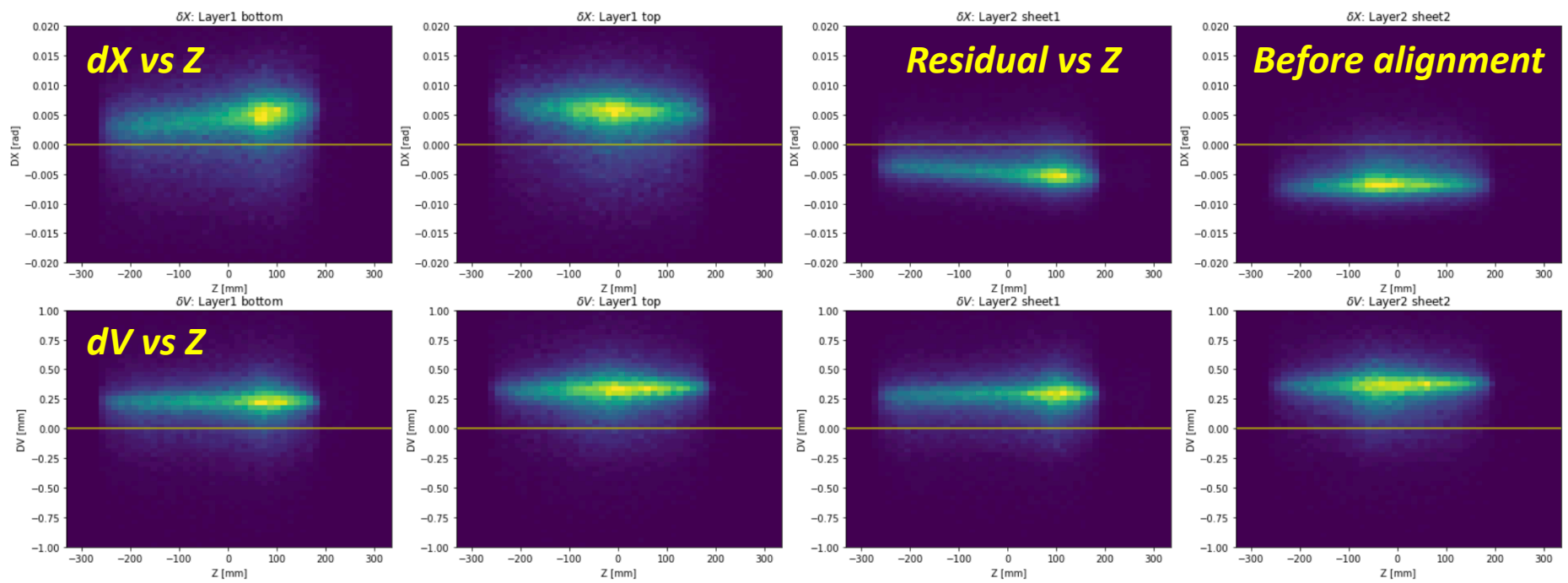
Residual distribution - layer2-Old

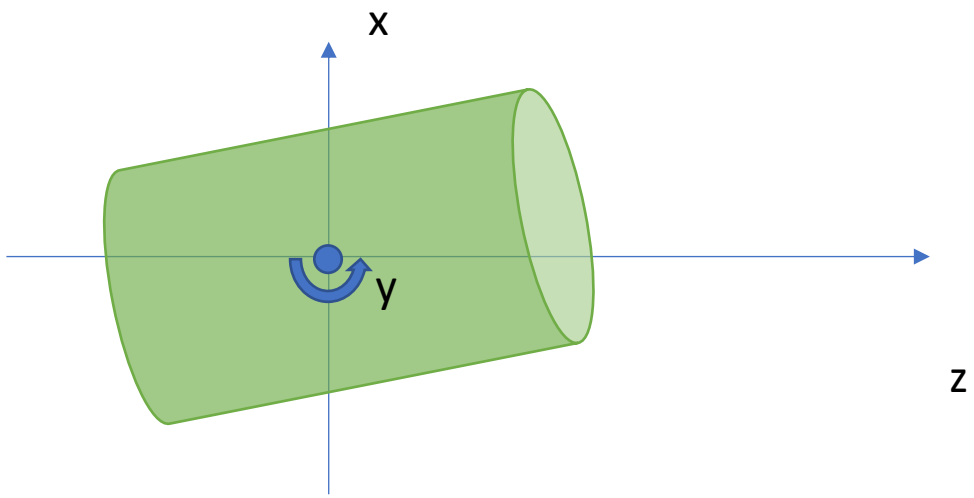


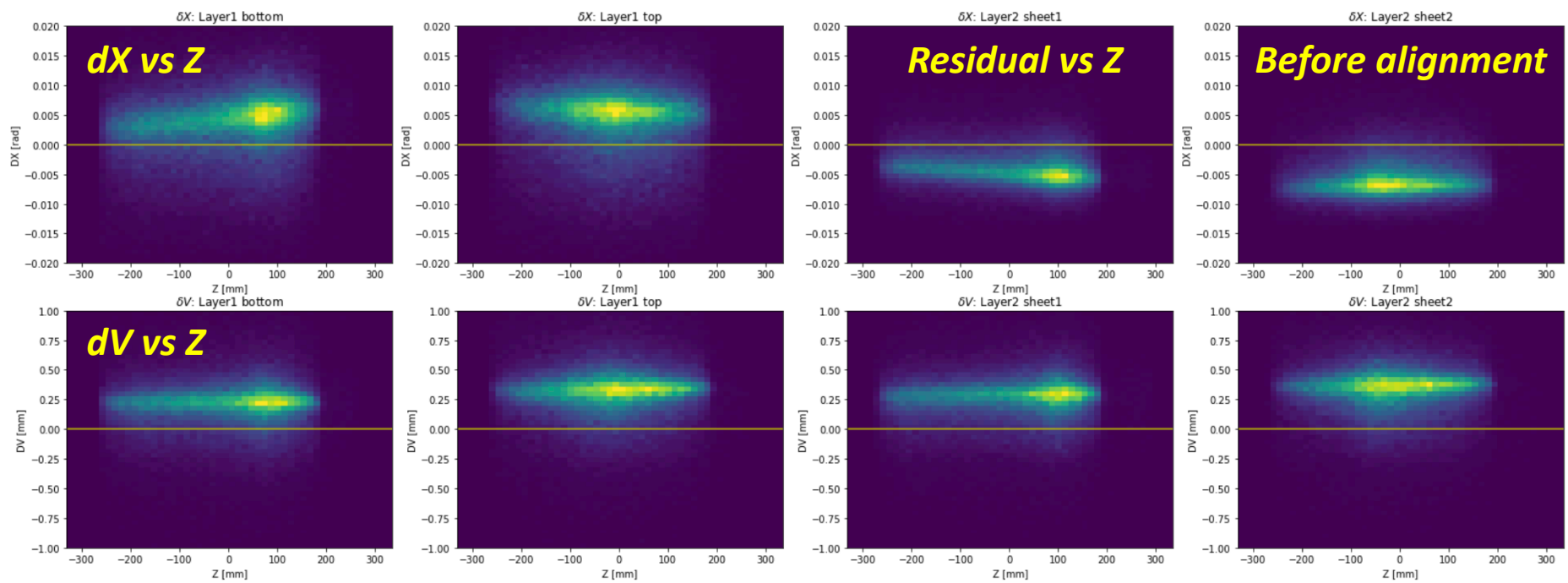


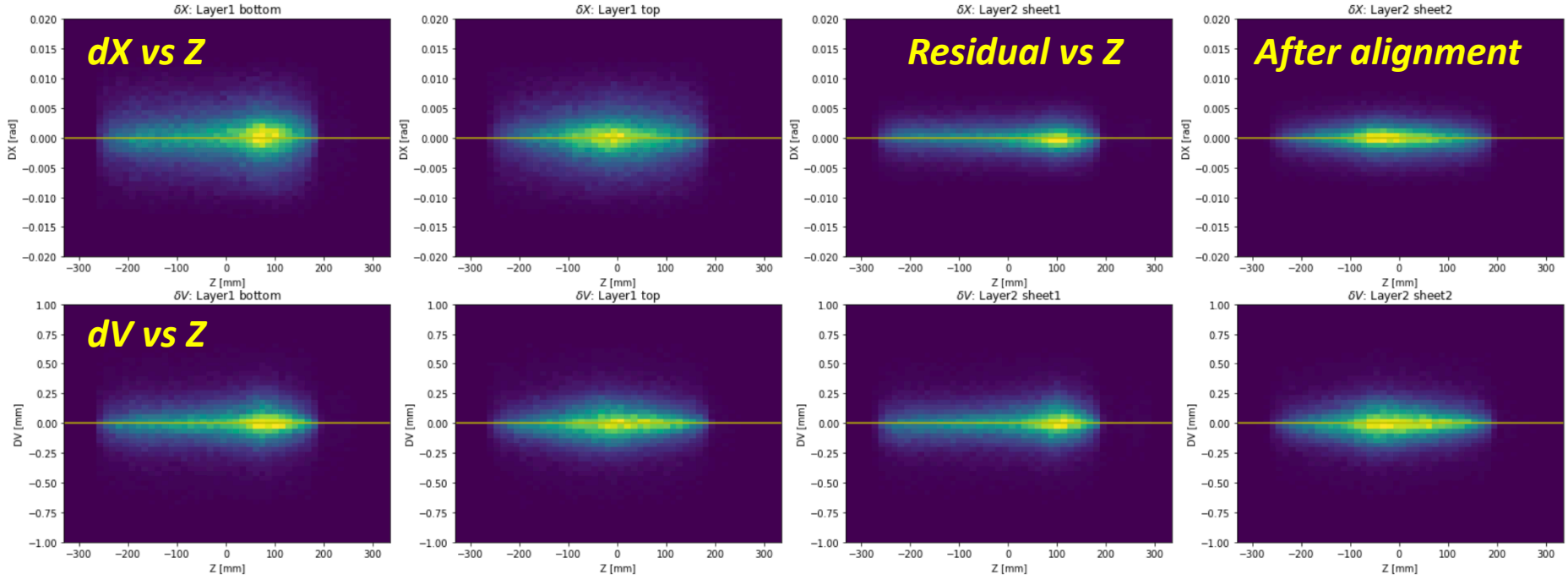


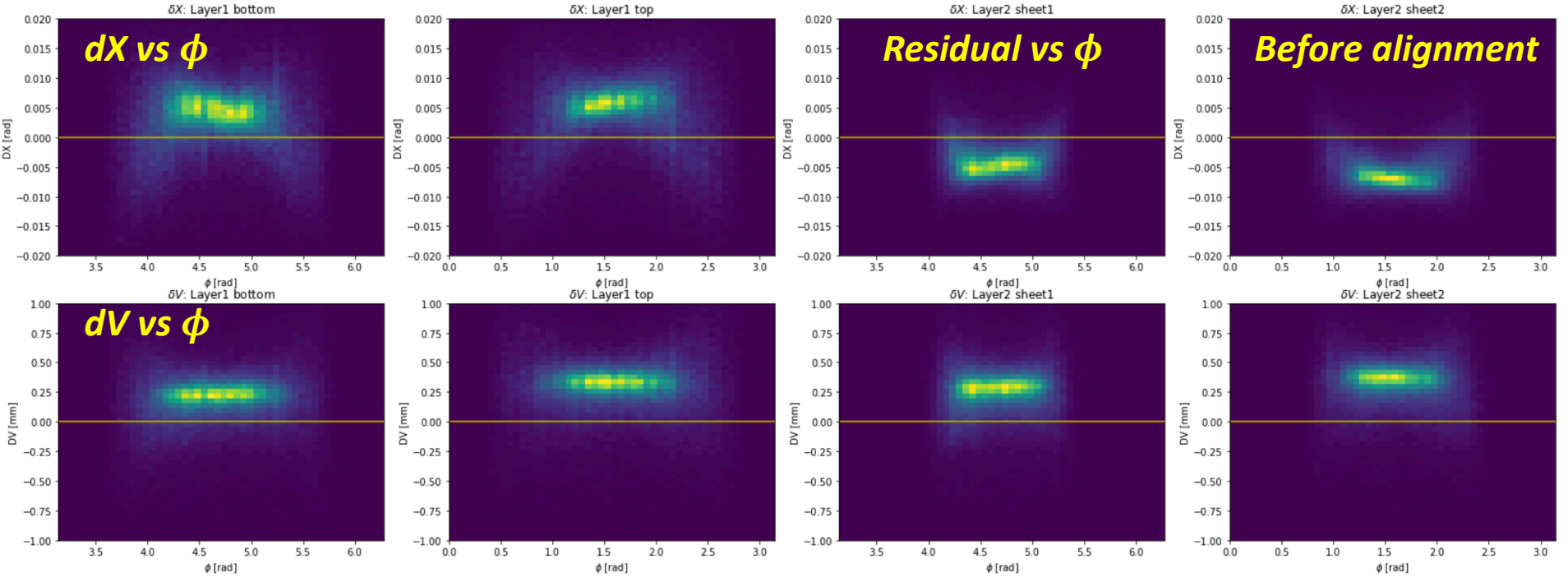


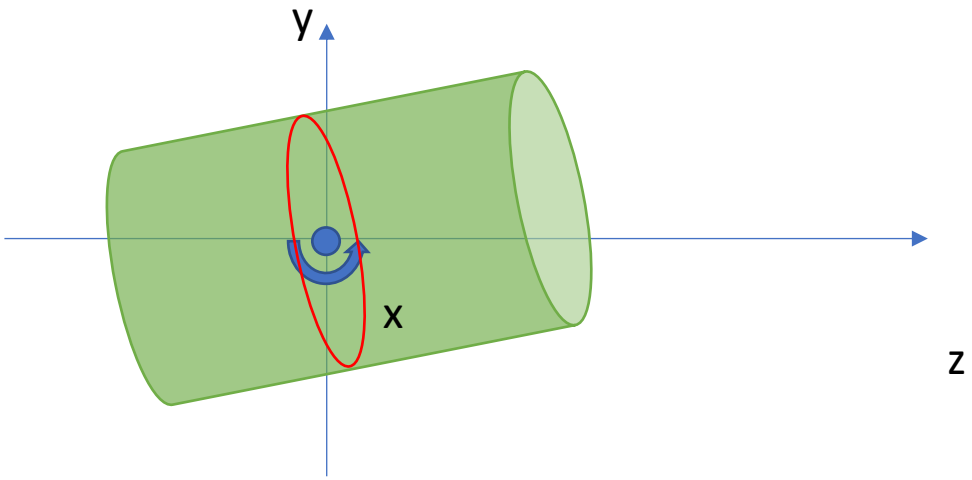

δX: Layer1 bottom
dX vs Z
δX: Layer1 top
δX: Layer2 sheet1
Residual vs Z
δX: Layer2 sheet2
Before alignment
δV: Layer1 bottom
dV vs Z
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
DX [rad]
DV [mm]
Z [mm]


x
y
z


δX: Layer1 bottom
dX vs Z
δX: Layer1 top
δX: Layer2 sheet1
Residual vs Z
δX: Layer2 sheet2
Before alignment
δV: Layer1 bottom
dV vs Z
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
DX [rad]
DV [mm]
Z [mm]


δX: Layer1 bottom
dX vs Z
δX: Layer1 top
δX: Layer2 sheet1
Residual vs Z
δX: Layer2 sheet2
After alignment
δV: Layer1 bottom
dV vs Z
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
DX [rad]
DV [mm]
Z [mm]


δX: Layer1 bottom
δX: Layer1 top
δX: Layer2 sheet1
δX: Layer2 sheet2
dX vs ϕ
Residual vs ϕ
Before alignment
δV: Layer1 bottom
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
dV vs ϕ
DX [rad]
DV [mm]
ϕ [rad]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x
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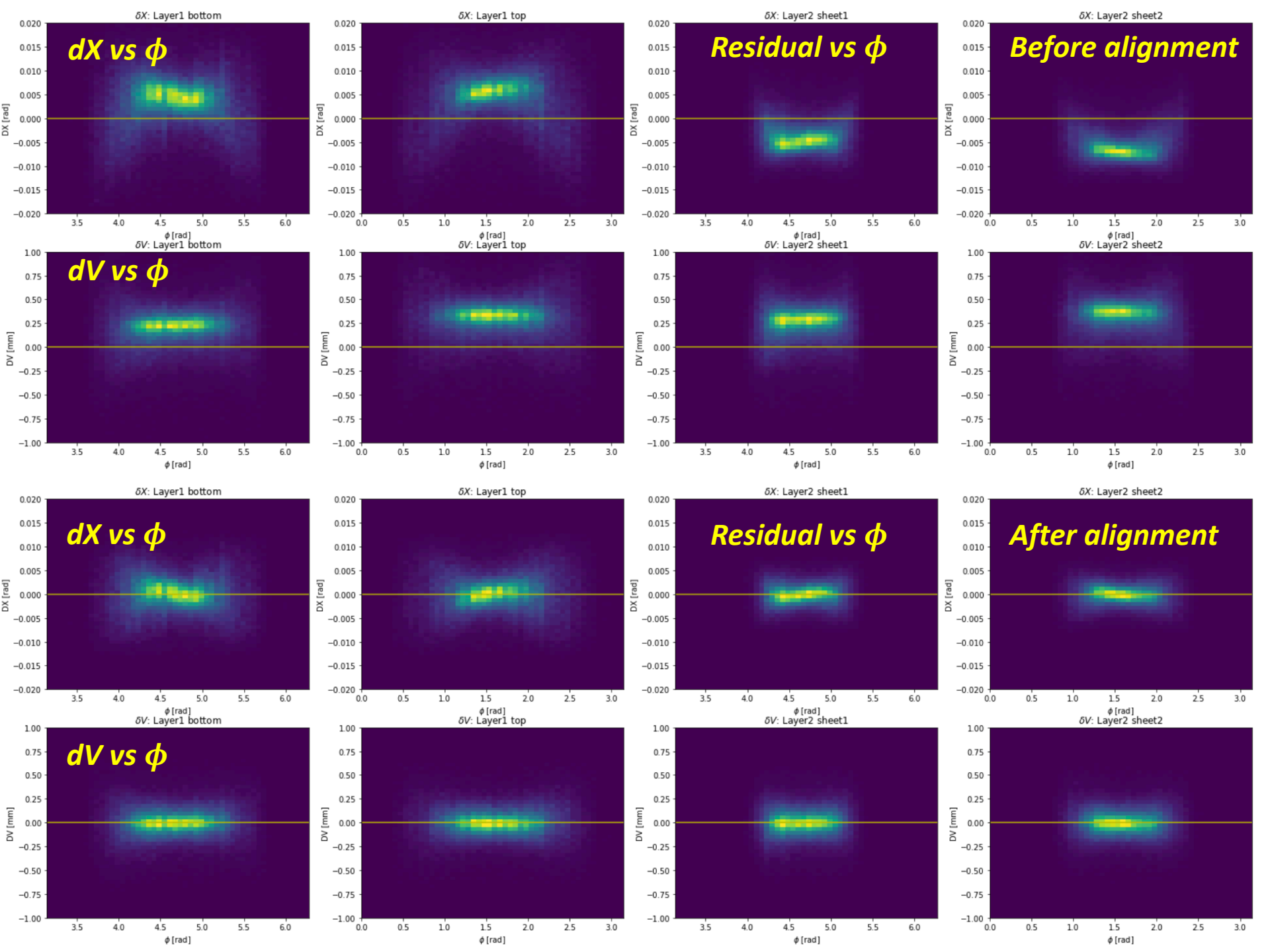
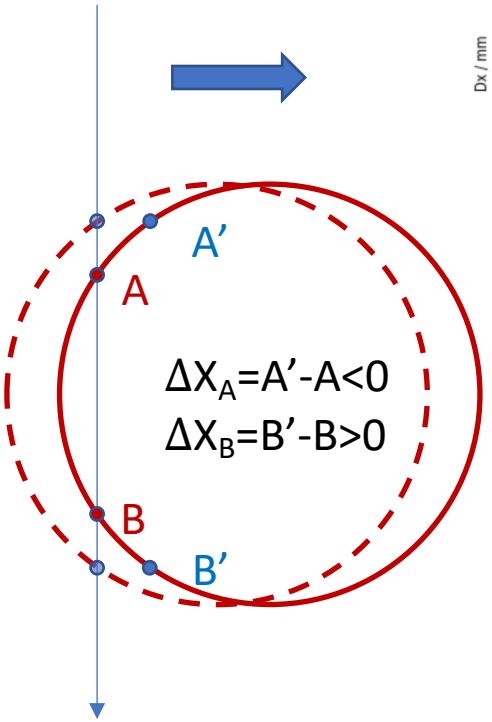
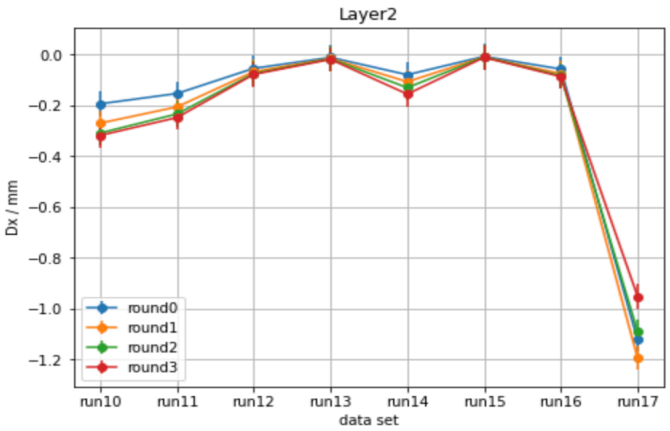
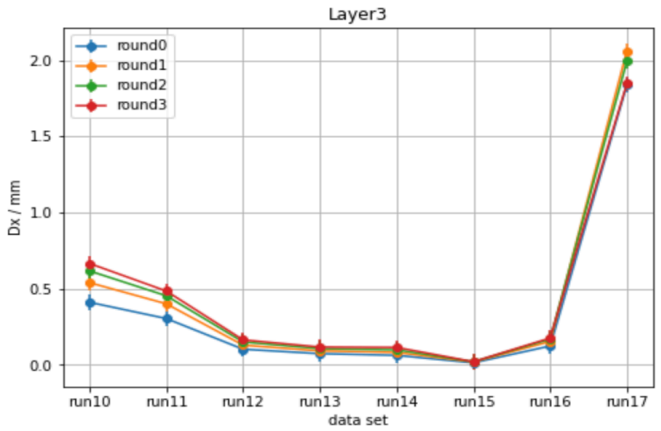

δX: Layer1 bottom
dX vs ϕ
δX: Layer1 top
δX: Layer2 sheet1
Residual vs ϕ
δX: Layer2 sheet2
Before alignment
δV: Layer1 bottom
dV vs ϕ
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
δX: Layer1 bottom
dX vs ϕ
δX: Layer1 top
δX: Layer2 sheet1
Residual vs ϕ
δX: Layer2 sheet2
After alignment
δV: Layer1 bottom
dV vs ϕ
δV: Layer1 top
δV: Layer2 sheet1
δV: Layer2 sheet2
DX [rad]
DV [mm]
ϕ [rad]

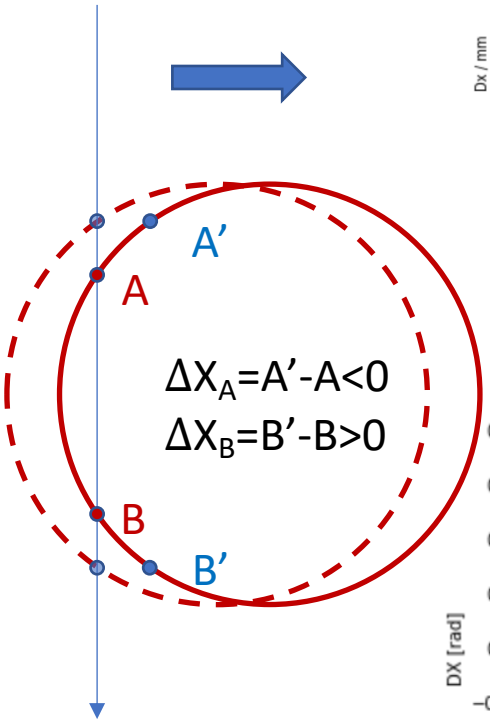
Issue of the alignment parameters

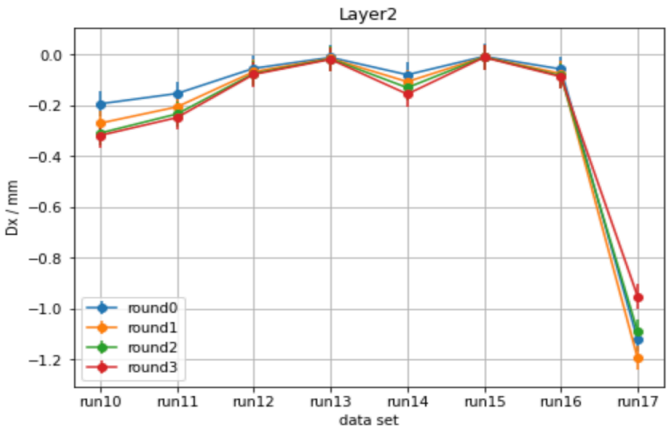


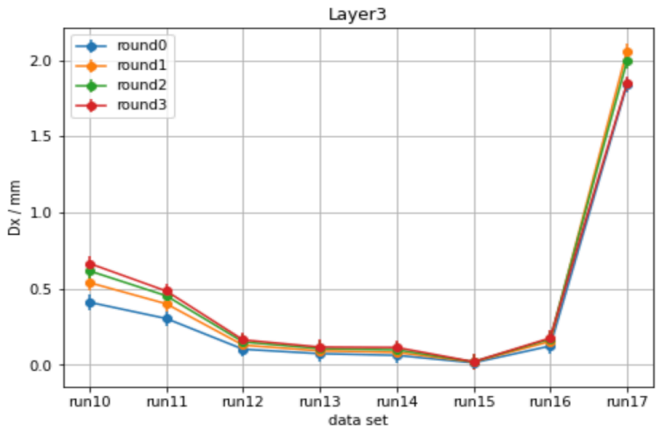


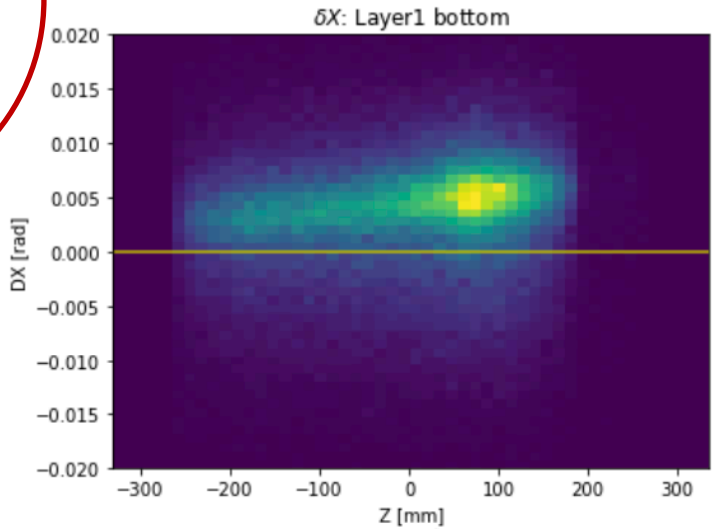


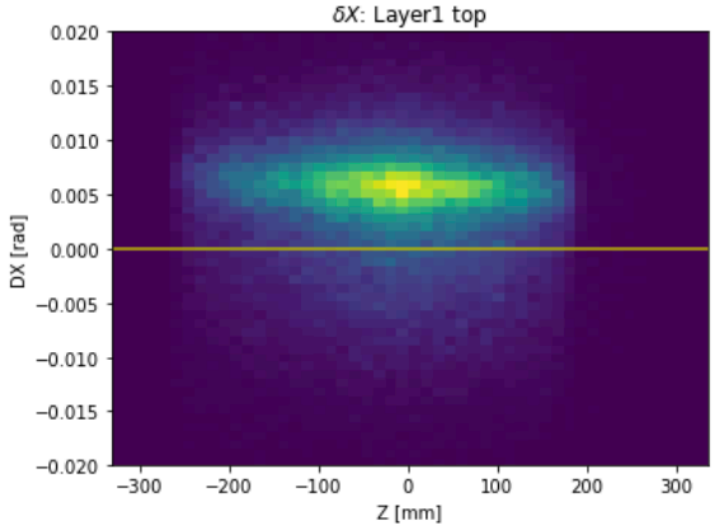
Issue of the alignment parameters





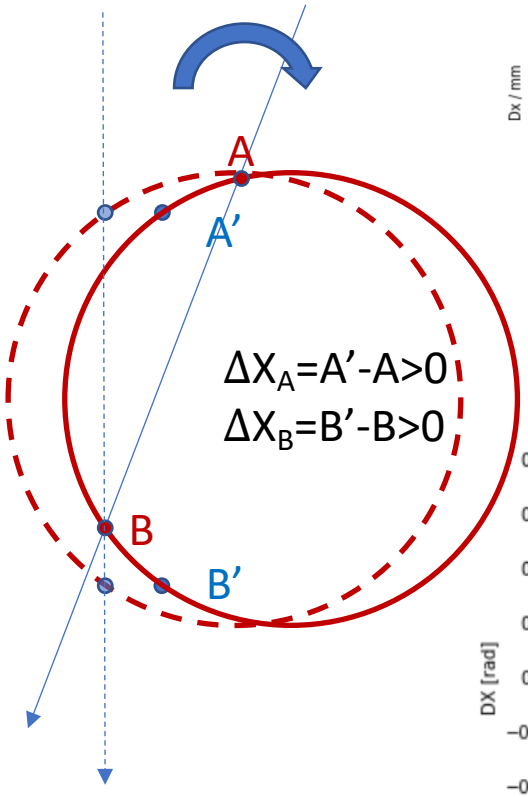


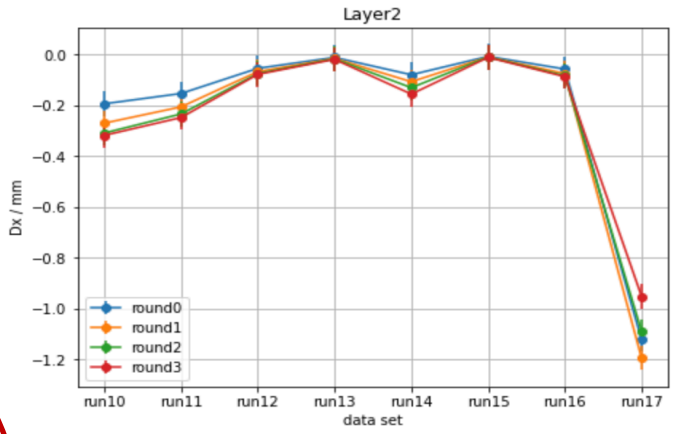


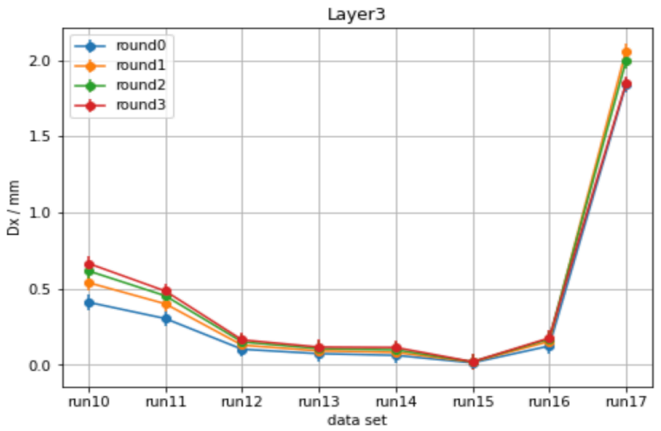


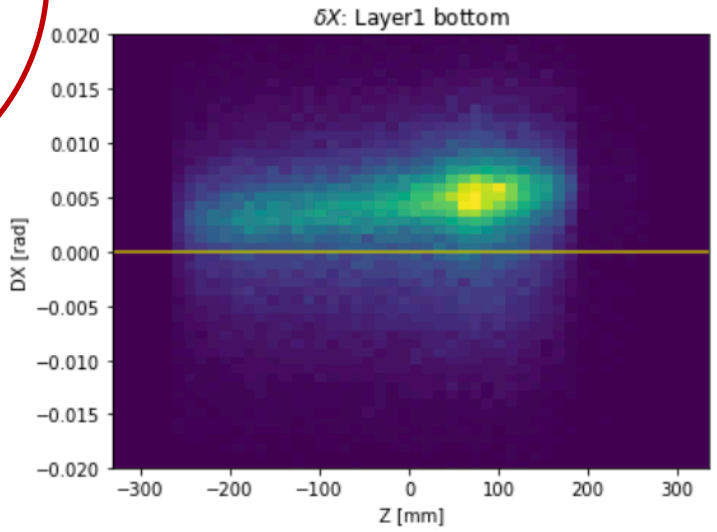
The residual distribution contradicts the shift along X axis

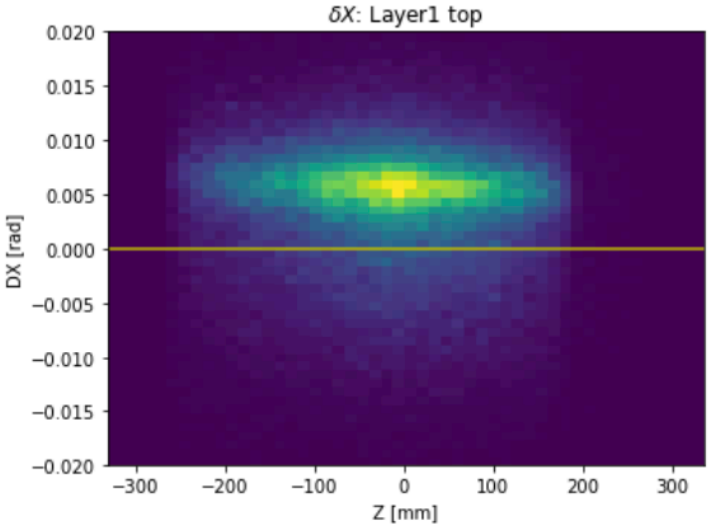
Issue of the alignment parameters











The residual distribution supports the rotation around Z axis

One assumption

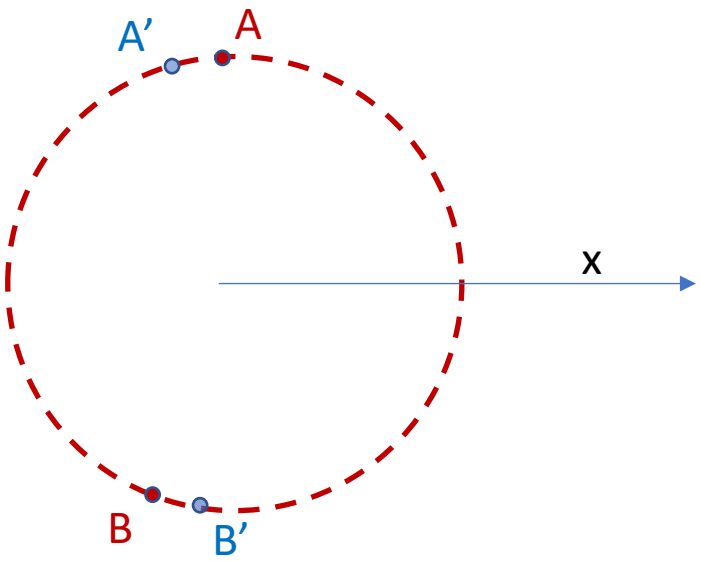
Alignment algorithm can't distinguish:

Hypo1: $Rz \neq 0$

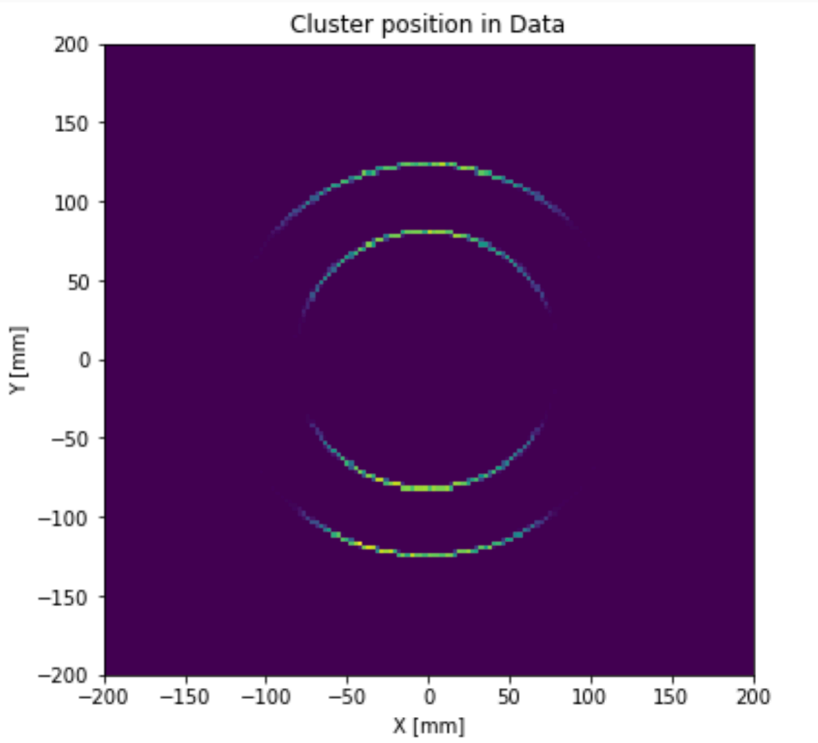
Hypo2: $Dx^{up} = -Dx^{down} \neq 0$

When most the tracks are vertical

$\Delta X_A = A' - A > 0$

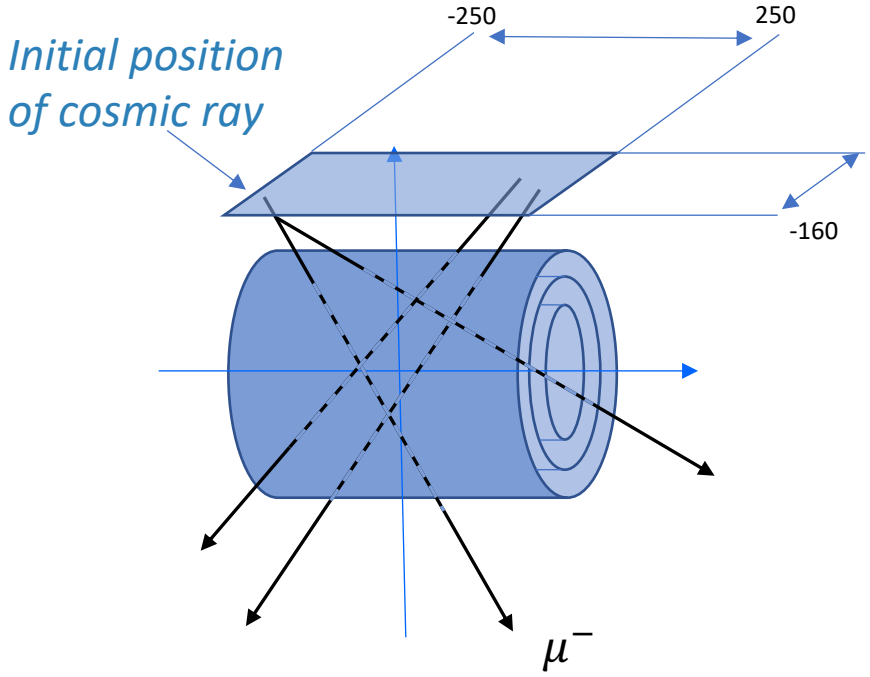


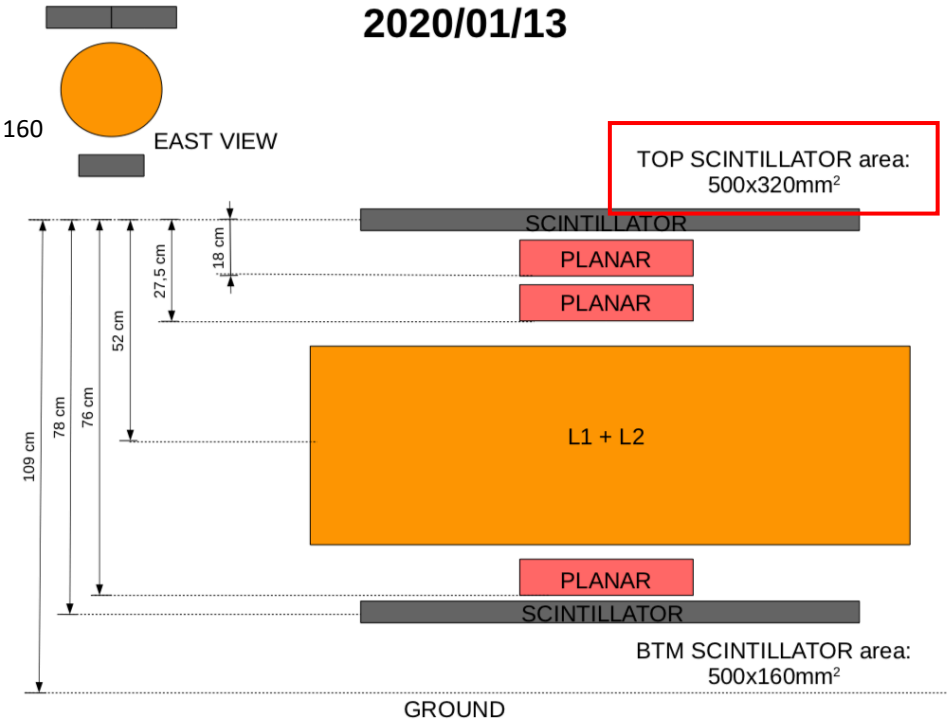
$\Delta X_B = B' - B > 0$



MC simulation

- 100,000 events for each different type of mis-alignment effect
- Generate MC with random **position & incident angles**
  - Initial position: Y = 520 mm X ∈ [-160, 160]mm Z ∈ [-250, 250]mm
  - Incident angle: $\theta \in [65°, 115°]$ $\phi \in [-151°, -29°]$
  - P ∈ [1.5, 4] GeV





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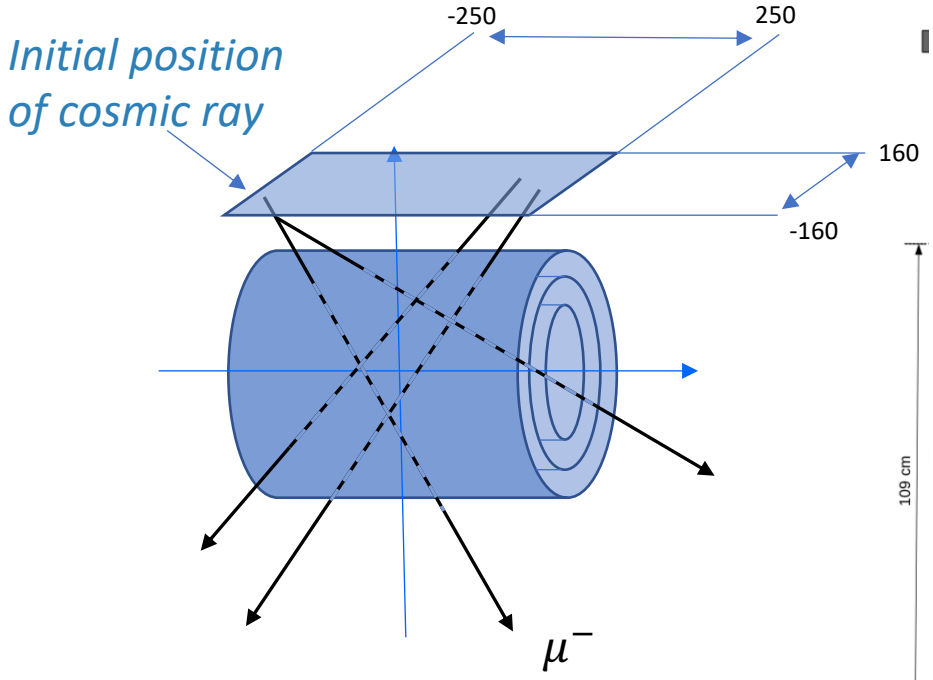
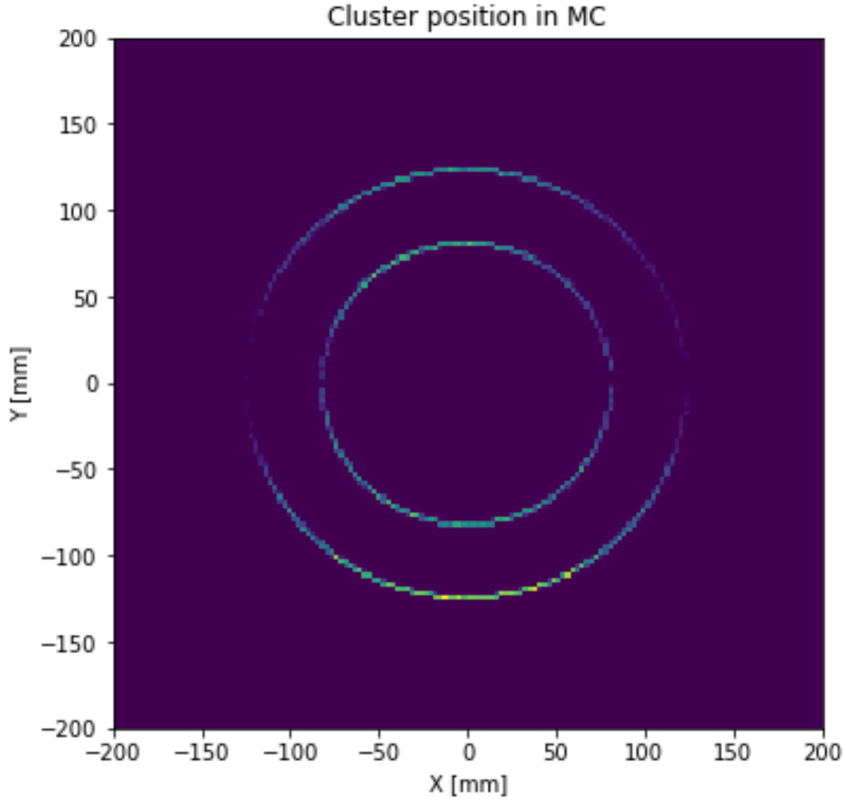
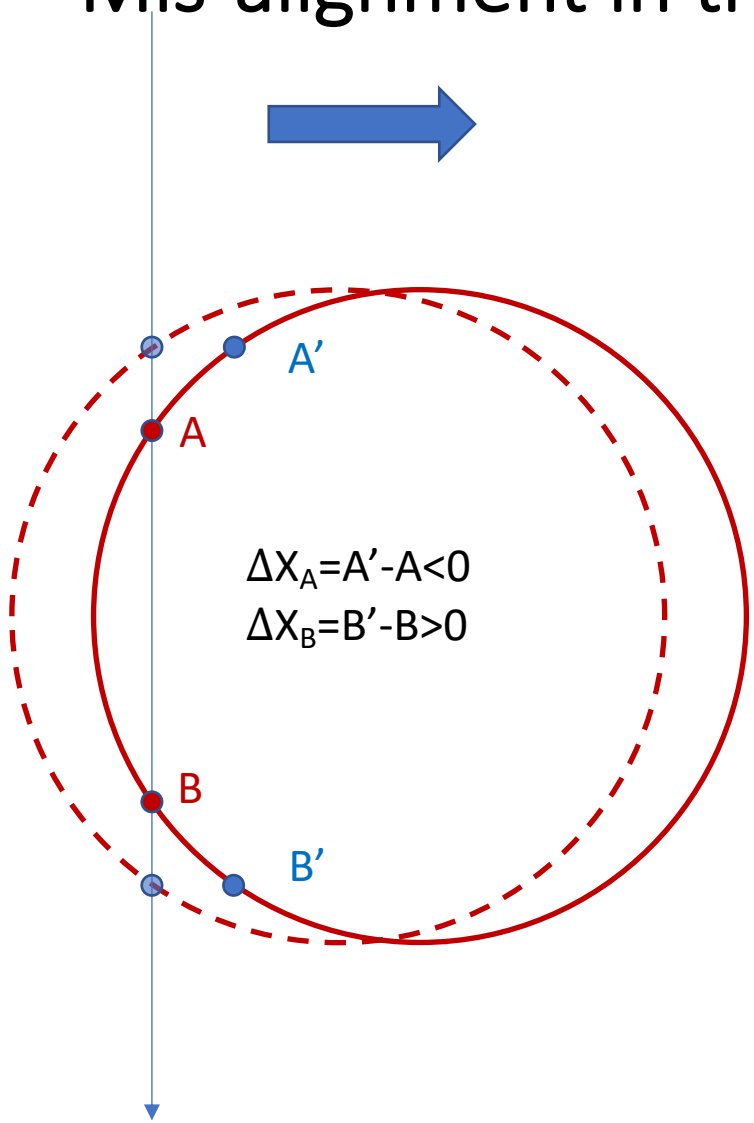
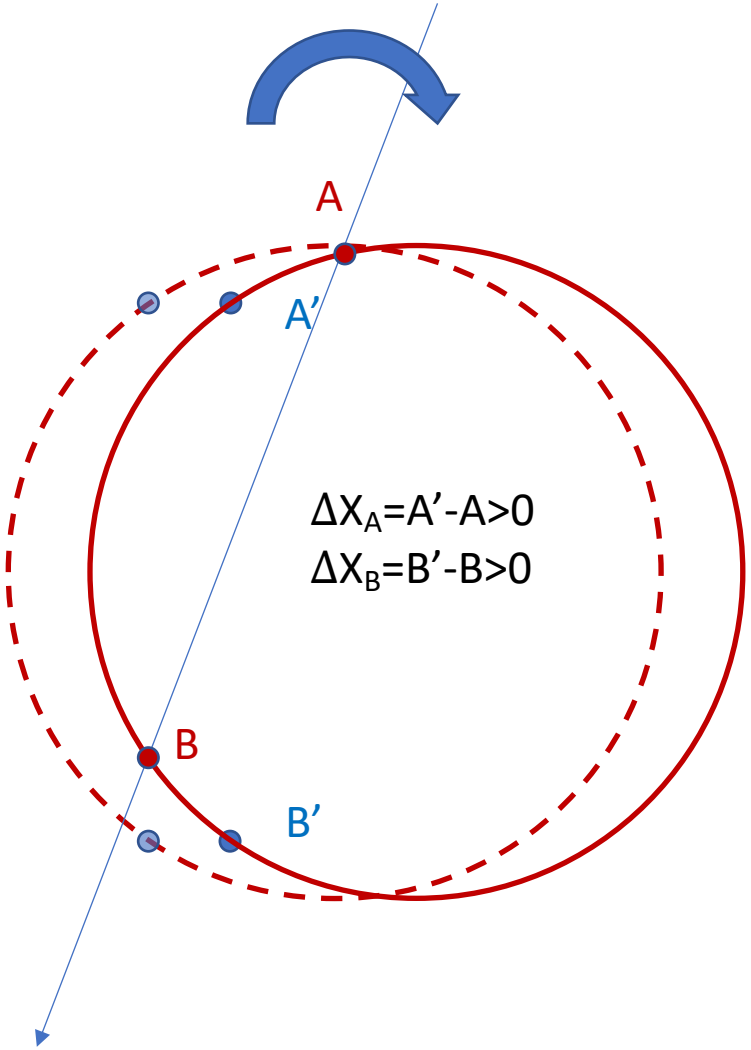




Mis-alignment in the MC samples



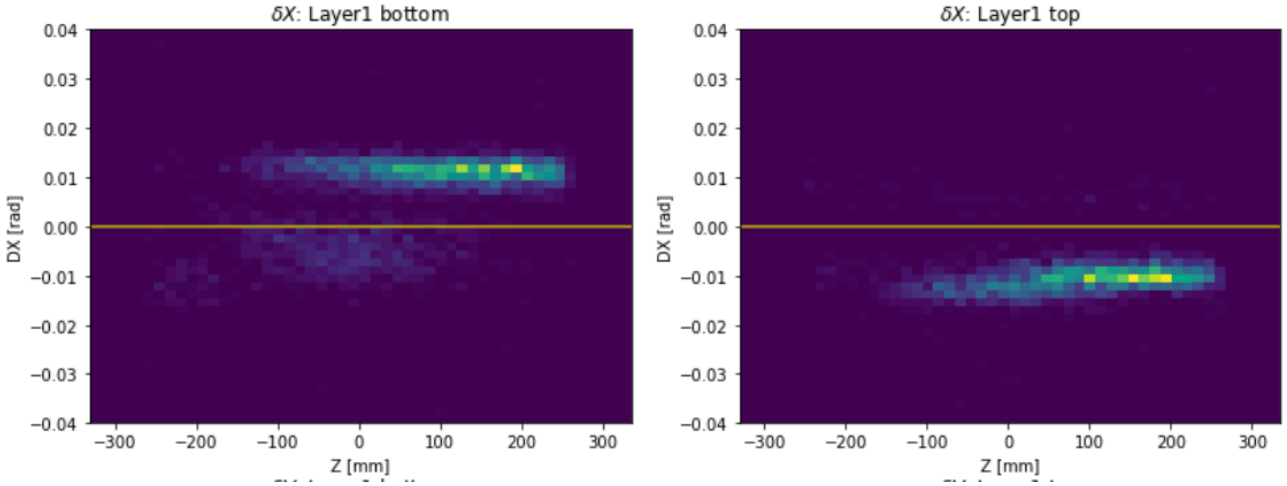
Sample1 Dx = 2mm



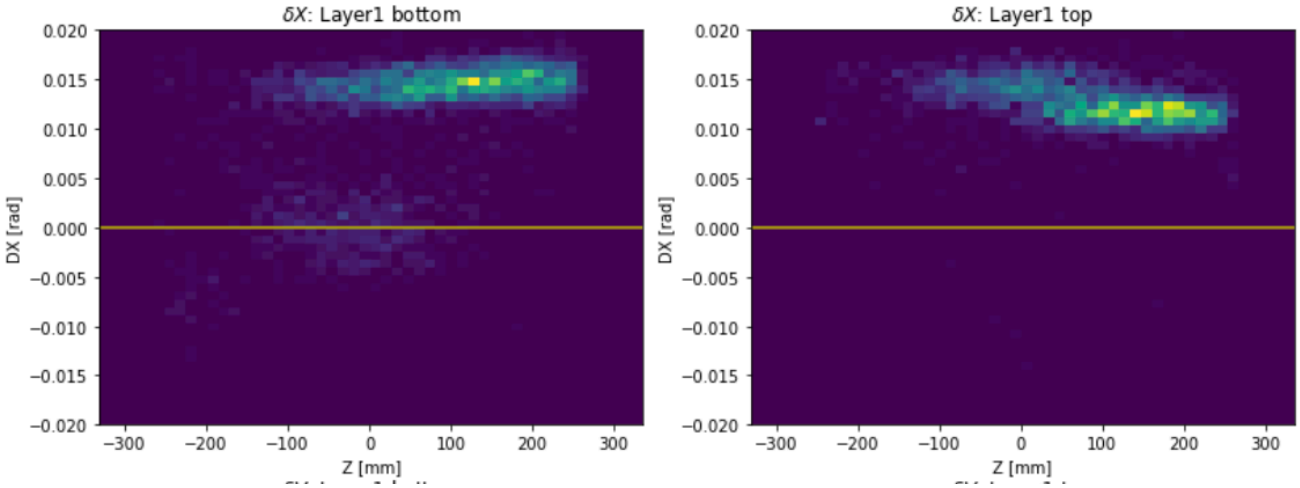
Sample2 Rz = 0.02rad

Residual distributions

Input Dx = 2 mm



Input rz = 0.02 rad



Fit Results (free all parameters)

Input Dx = 2 mm

Layer	DeltaX(mm)	DeltaY(mm)	DeltaZ(mm)	RX(rad)	RY(rad)	RZ(rad)
L0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L1	-0.0000000	-0.0000000	0.0000000	-0.0000000	0.0000000	0.0000000
L2	0.2201451	0.0000000	-0.1631478	0.0019563	0.0046912	0.0091267
L3	0.1684339	0.0000000	0.0320131	0.0000270	-0.0006295	-0.0151647
L4	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L5	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

Input rz = 0.02 rad

ayer	DeltaX(mm)	DeltaY(mm)	DeltaZ(mm)	RX(rad)	RY(rad)	RZ(rad)
L0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L1	0.0000000	0.0000000	0.0000000	-0.0000000	-0.0000000	0.0000000
L2	0.0925943	-0.0000000	-0.2183292	0.0026231	0.0058901	0.0129773
L3	-0.0480916	0.0000000	0.1223228	-0.0002877	-0.0009969	0.0184145
L4	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L5	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

~

Fit Results (constrain Dx and Rz to be same)

Input Dx = 2 mm

Layer	DeltaX(mm)	DeltaY(mm)	DeltaZ(mm)	RX(rad)	RY(rad)	RZ(rad)
L0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L1	0.0000000	-0.0000000	0.0000000	-0.0000000	-0.0000000	0.0000000
L2	1.4700961	-0.0000000	-0.0458378	0.0003253	0.0054992	-0.0027844
L3	1.4700961	0.0000000	-0.1237438	-0.0000281	0.0006285	-0.0027844
L4	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L5	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

Input rz = 0.02 rad

Layer	DeltaX(mm)	DeltaY(mm)	DeltaZ(mm)	RX(rad)	RY(rad)	RZ(rad)
L0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L1	0.0000000	0.0000000	0.0000000	-0.0000000	-0.0000000	-0.0000000
L2	-0.2951428	-0.0000000	-0.2348143	0.0029515	0.0056707	0.0163832
L3	-0.2951428	0.0000000	0.1604880	-0.0004396	-0.0010402	0.0163832
L4	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
L5	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

Summary

Progress

- More alignment parameters are taken into account
- The fitted alignment parameters can correct the residual distribution very well
- Current cosmic-ray data couldn’t disentangle the Dx and Rz properly because of the strong correlation

Next step

- More iteration
- Improve the fit procedure
- Separate run17 to several sub-samples