

MOST2 offline tracking reconstruction and alignment

Shuqi Li, Hao Zeng, Gang Li, Linghui Wu, Zhijun Liang (IHEP)
Yiming Hu (NJU)

Tue, Sep29, 2022

Alignment

- straight line model: $x = X(z) + x_{res} = az + b + x_{res}; y = Y(z) + y_{res} = cz + d + y_{res}$
- considering misalignment:

local parameters (track parameters): a, b, c, d

global parameters (alignment parameters): $\Delta x, \Delta y, \Delta \gamma, \Delta z, \Delta \alpha, \Delta \beta$

$$X(\vec{p}^{local}, \vec{a}^{global}) = az + b - \Delta x + y\Delta y + a(\Delta z + x\Delta \beta + y\Delta \alpha)$$

$$Y(\vec{p}^{local}, \vec{a}^{global}) = cz + d - \Delta y - x\Delta \gamma + c(\Delta z + x\Delta \beta + y\Delta \alpha)$$

- minimize: $\chi^2 = \sum_{\text{data sets}} \left(\sum_{\text{events}} \left(\sum_{\text{tracks}} \left(\sum_{\text{hits}} w_i r_i^2 \right) \right) \right)$
global parameters that' we want to get

- solution:
$$\left(\begin{array}{c|ccc} C & \cdots & H_k & \cdots \\ \hline \vdots & \ddots & 0 & 0 \\ H_k^T & 0 & \Gamma_k & 0 \\ \vdots & 0 & 0 & \ddots \end{array} \right) \times \left(\begin{array}{c} \vec{a} \\ \vdots \\ \vec{p}_k \\ \vdots \end{array} \right) = \left(\begin{array}{c} \vec{b} \\ \vdots \\ \vec{\beta}_k \\ \vdots \end{array} \right)$$

global and local

Loop over all tracks

$$C_k = \sum_i w_{ki} \vec{d}_{ki}^{global} (\vec{d}_{ki}^{global})^T,$$

$$\vec{b}_k = \sum_i w_{ki} r_{ki} \vec{d}_{ki}^{global},$$

related to global

derivative vectors w.r.t the global parameters

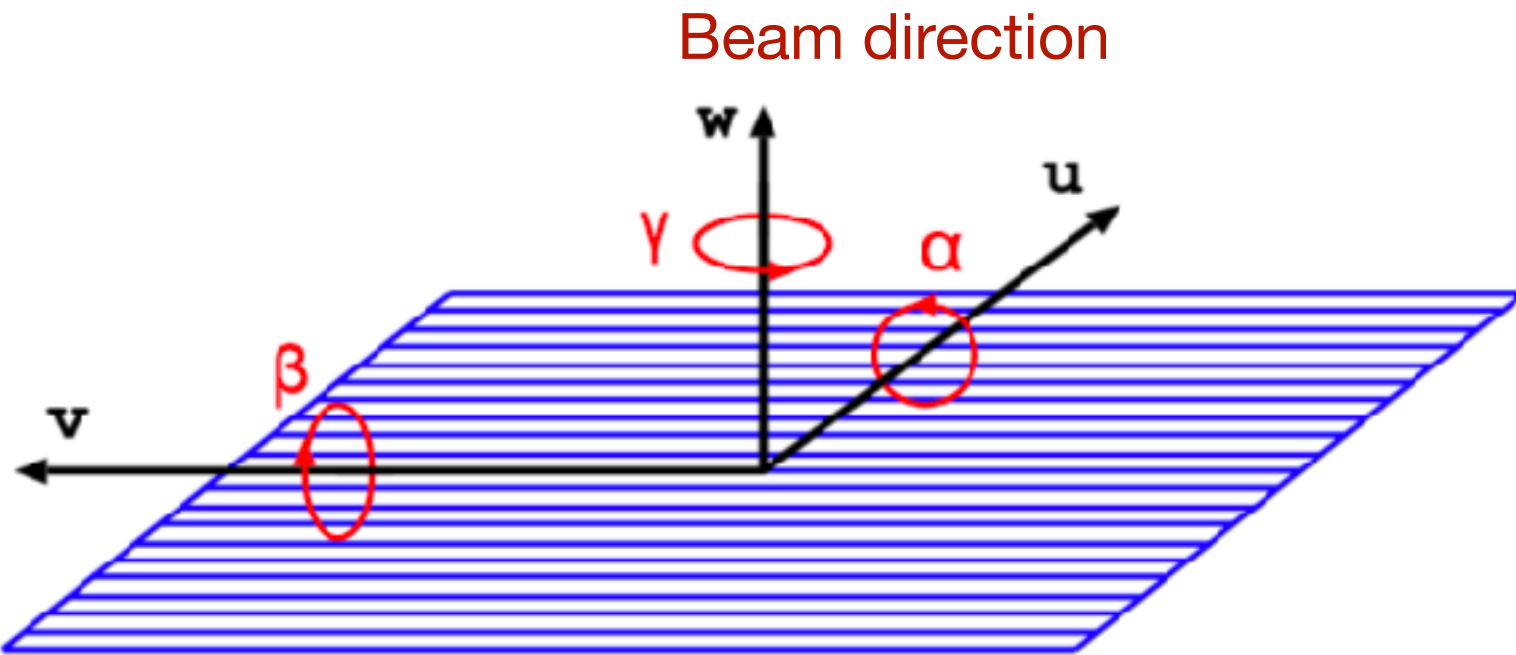
$$\vec{a} = C'^{-1} \vec{b}'$$

$$C' = \sum_k C_k - \sum_k H_k \Gamma_k^{-1} H_k^T,$$

$$\vec{b}' = \sum_k \vec{b}_k - \sum_k H_k \Gamma_k^{-1} \vec{\beta}_k.$$

Interface to Millepede

- using simulated data from G4
- interface to Millepede to solve the matrix, then get the corrected alignment parameters
- digitizing the simulation data, randomly change the ideal geometry



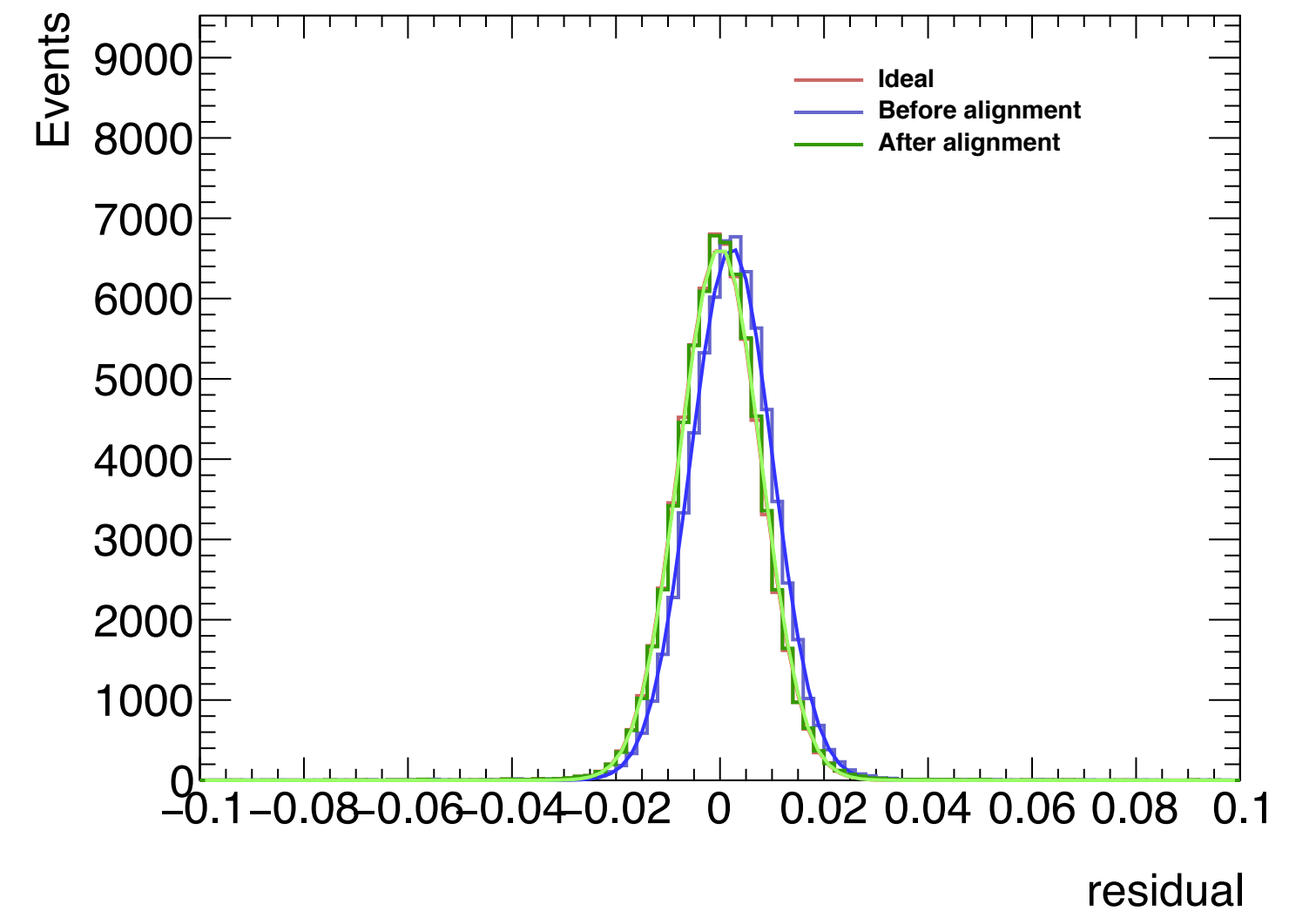
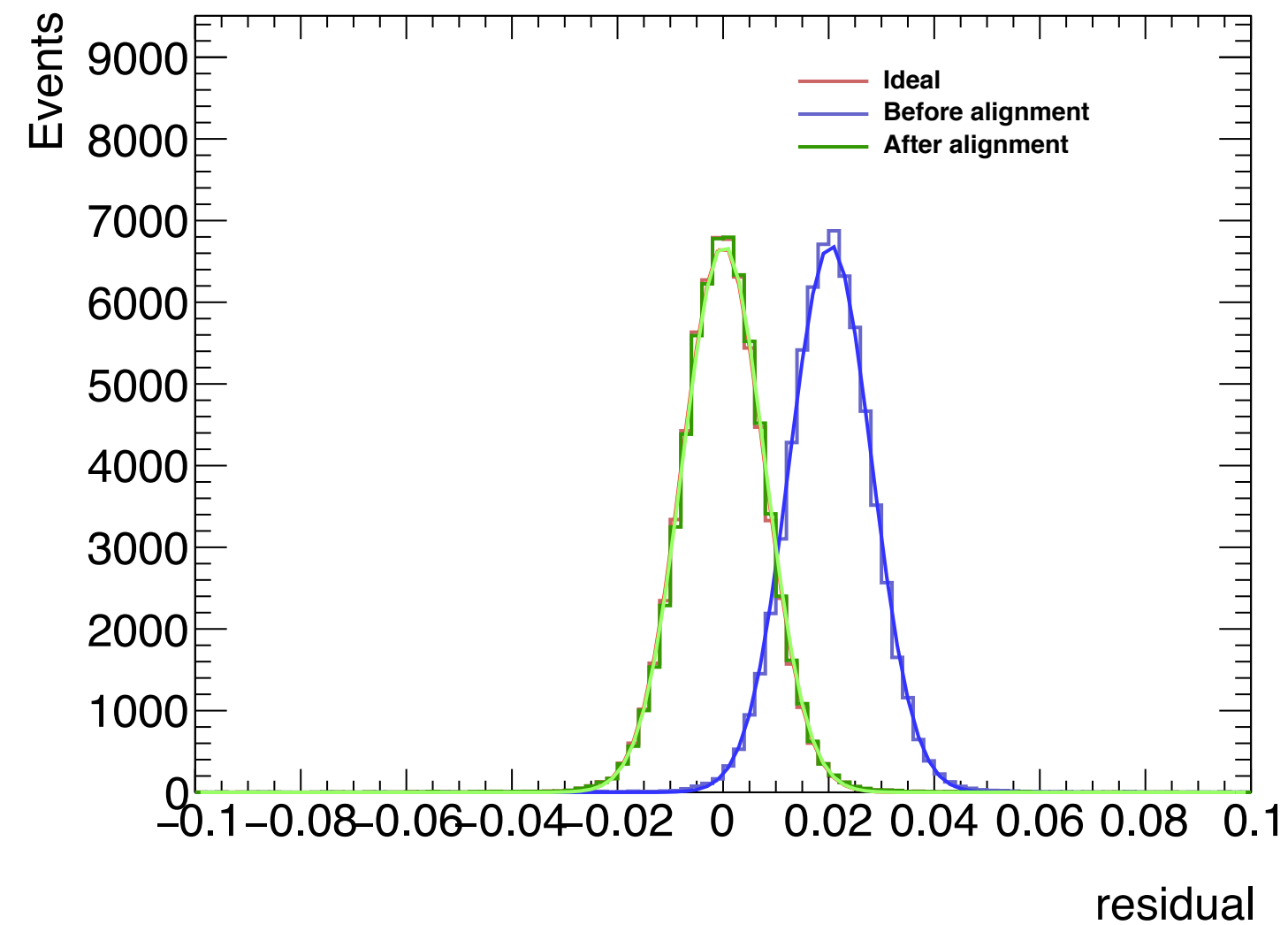
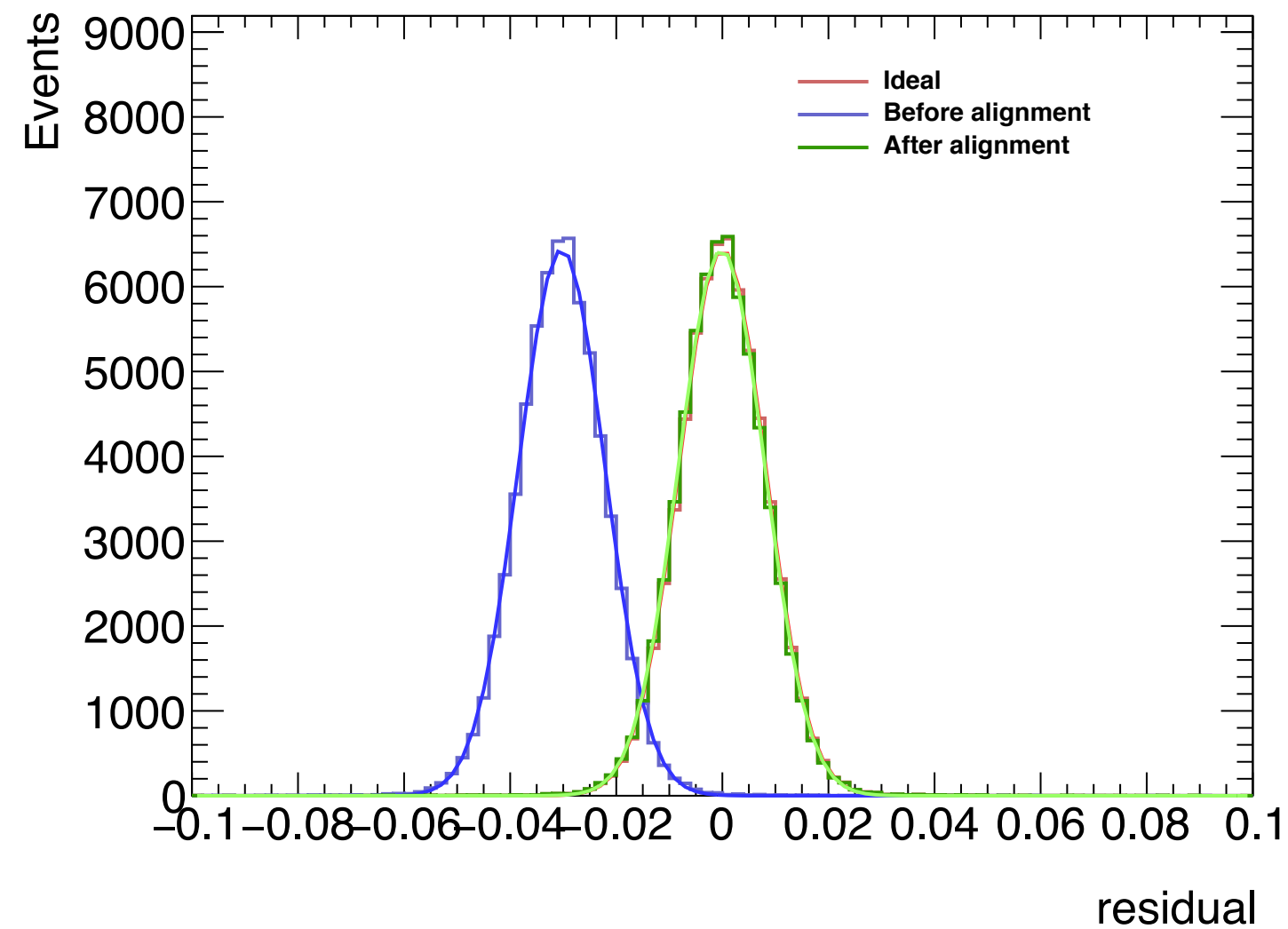
If add Δx , Δy , $\Delta \gamma$ only:

Unit: mm

Unit: rad

chipID	DeltaX setting	DeltaX fitted	DeltaY setting	DeltaY fitted	Deltay setting	Deltay fitted
1	0.07253	0.07250	-0.02467	-0.02448	0.00046	0.00268
2	0.02036	0.02024	0.02448	0.02448	0.00493	0.00159
3	-0.03740	-0.03747	0.02994	0.02992	-0.00189	-0.00265
4	-0.04566	-0.04552	-0.01967	-0.01993	0.01671	0.00941
5	-0.00856	-0.00853	0.04181	0.04175	-0.00823	-0.00259
6	-0.03031	-0.03015	-0.03201	-0.03207	0.00435	0.00572
7	0.01759	0.01763	-0.03591	-0.03587	0.00090	0.00178
8	-0.02344	-0.02362	-0.01411	-0.01378	-0.01306	-0.01160
9	-0.00738	-0.00738	0.03910	0.03913	-0.00168	-0.00220
10	0.02399	0.02401	-0.02652	-0.02655	0.00099	0.00023
11	-0.00952	-0.00955	0.00229	0.00221	-0.00016	0.00010
12	0.02780	0.02782	0.01526	0.01520	-0.00332	-0.00248

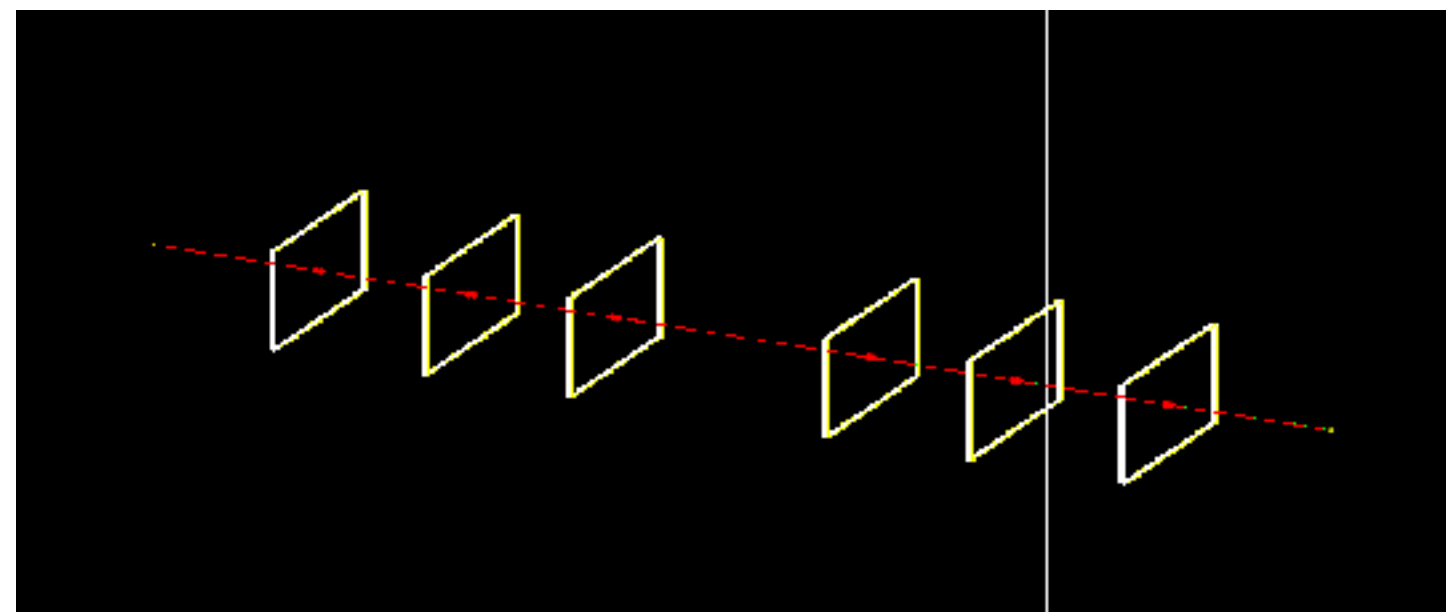
Residual Plots



- Residual plots Ideal/before alignment/ after alignment
- ~100,000 tracks
- All residual plots can be corrected well, although some mis-alignment parameters can't be corrected well

Next Plan

- using actual geometry simulation data
- constrains
- official Millepede2



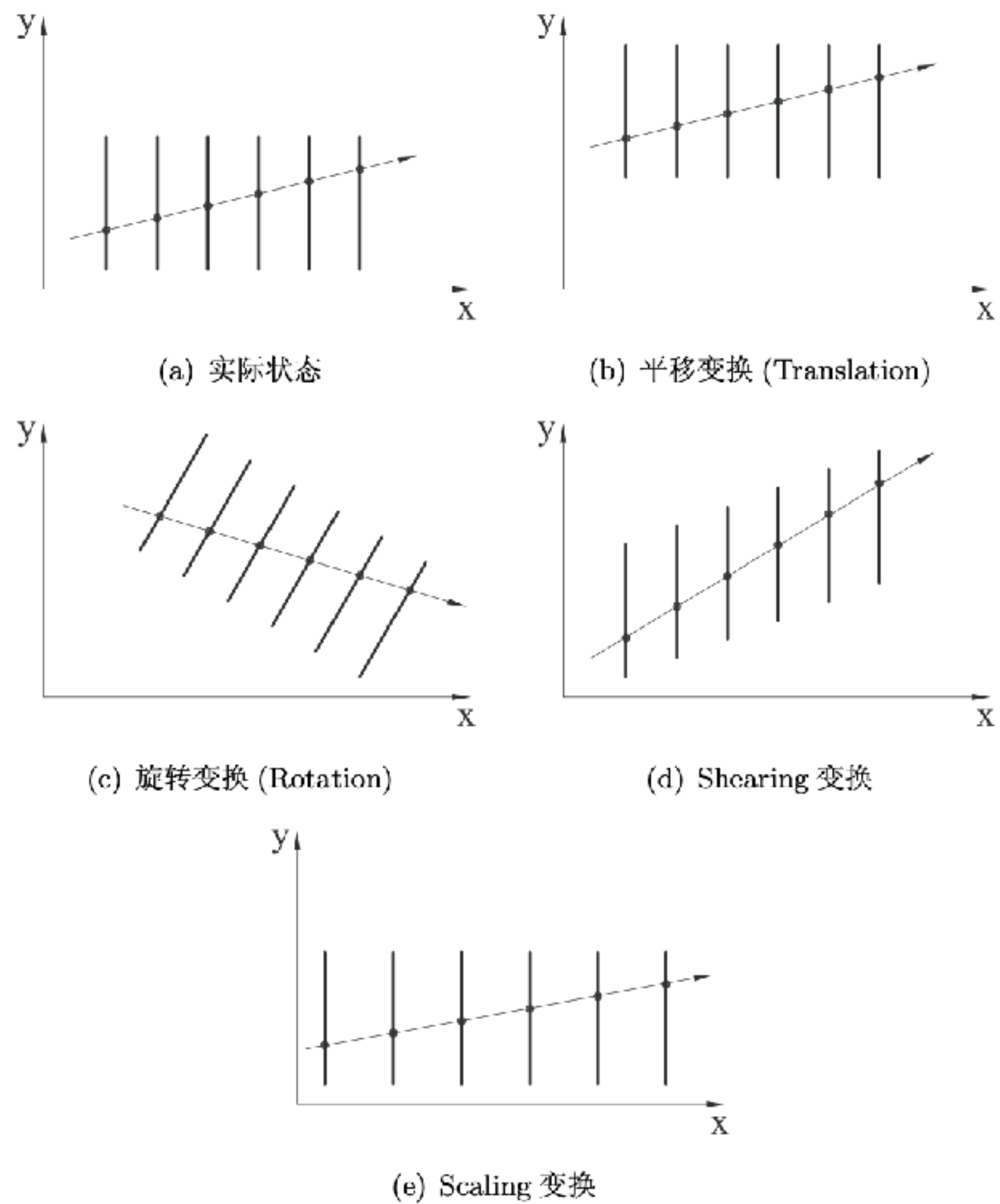
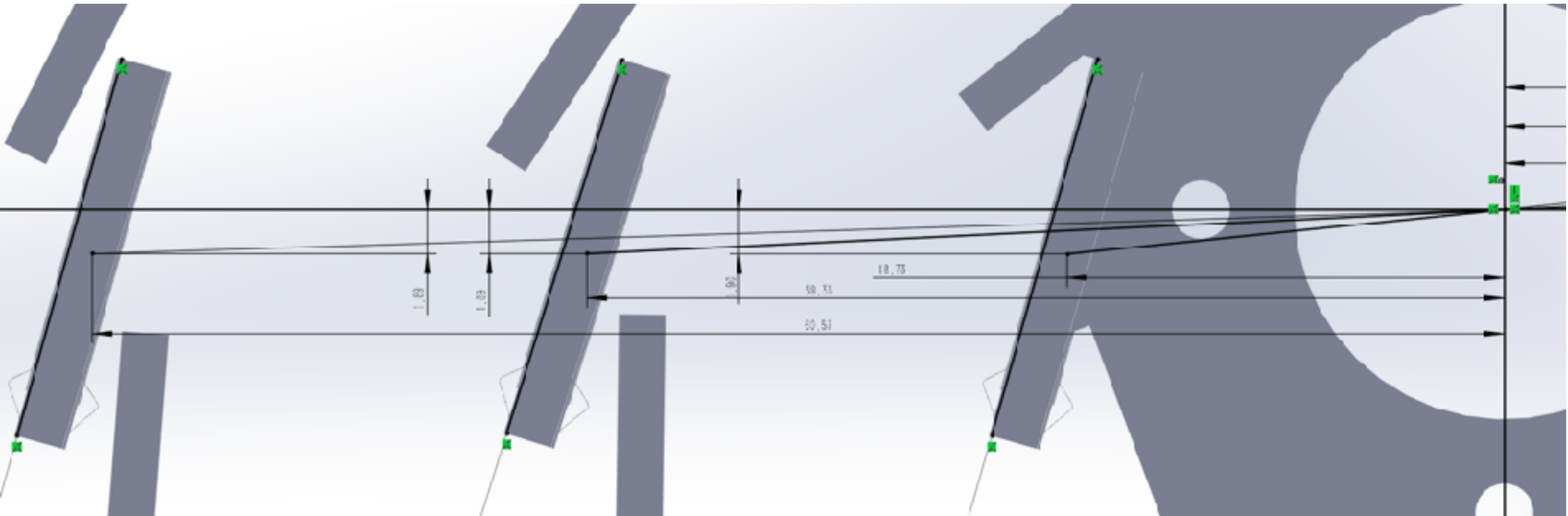
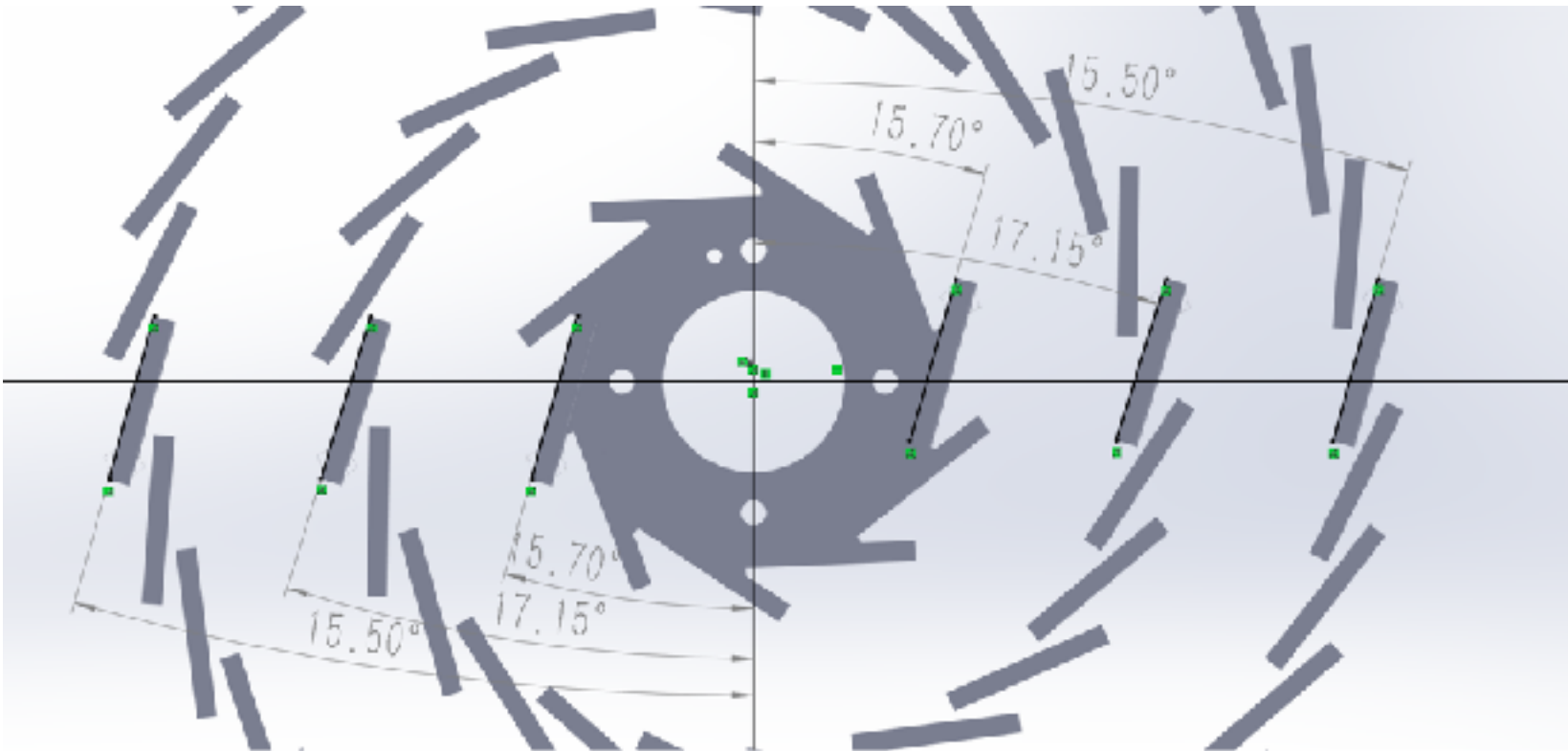


图 7.4: 径迹探测器校准中的4种线性变换效应

11 hits position fit, residual calculated from another hit

	material budget (X/X0 %)	chip0 sigma (um)	chip2 sigma (um)	chip4 sigma (um)	chip6 sigma (um)	chip8 sigma (um)	chip10 sigma (um)
50um	0.697	6.79/6.55	3.69/3.75	4.56/4.55	4.76/4.67	3.79/3.72	6.74/6.85
100um	0.804	7.12/6.95	3.82/3.84	4.91/4.85	4.99/4.99	3.86/3.79	6.91/7.32
150um	0.911	7.54/7.00	3.85/3.96	5.11/5.06	5.16/5.17	3.90/3.92	7.25/7.54



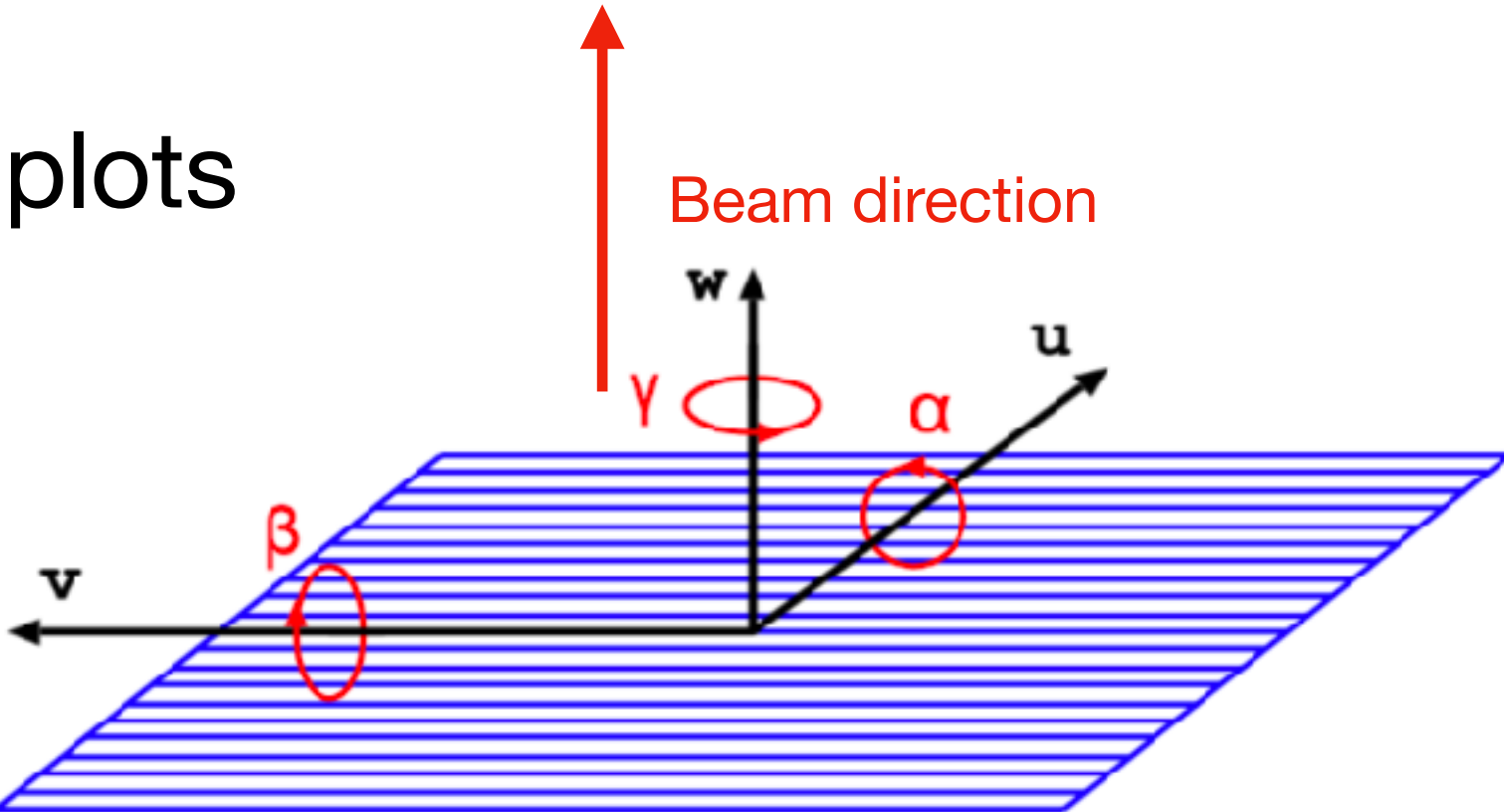
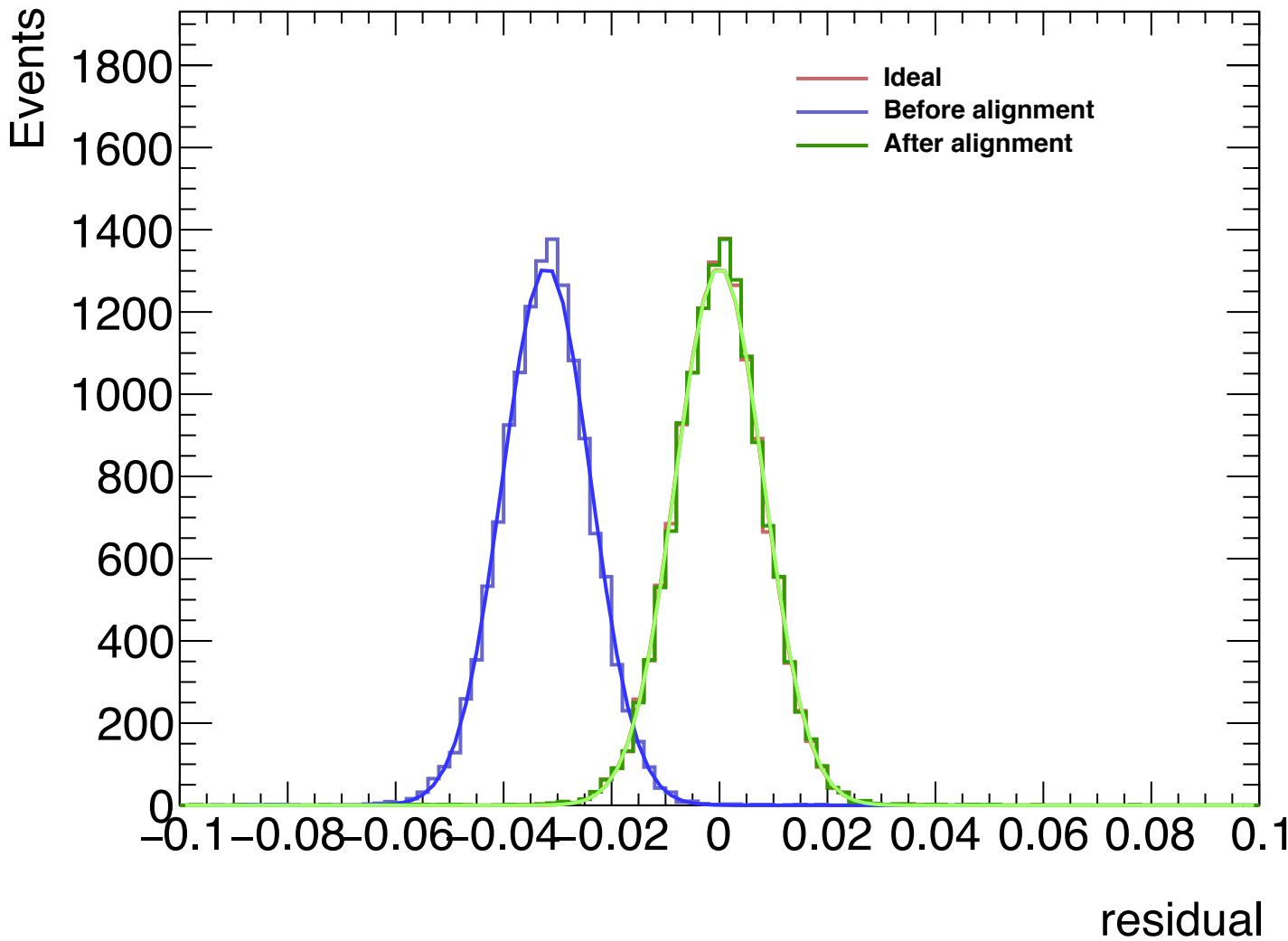
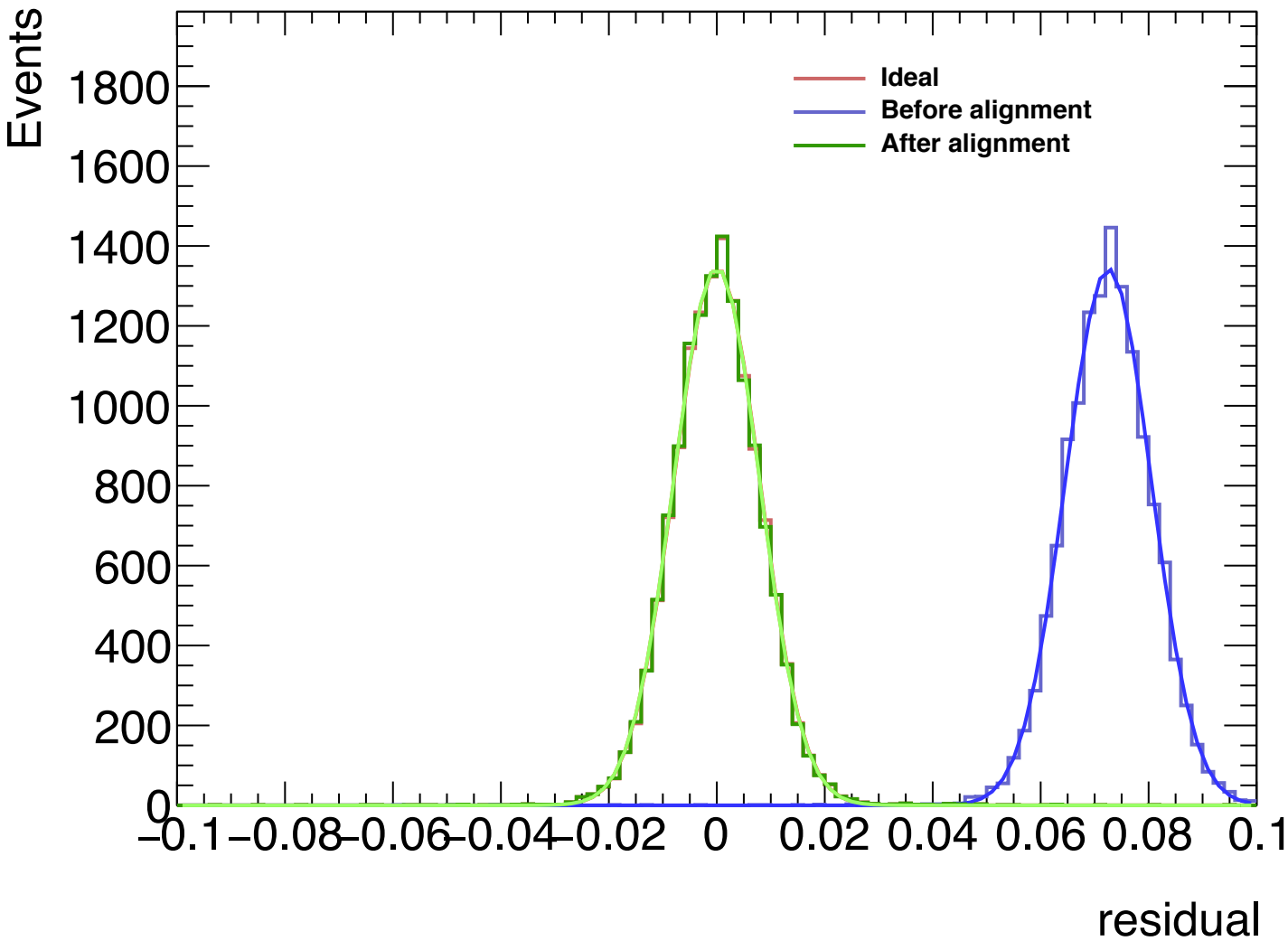
MOST2 offline tracking reconstruction and alignment

Shuqi Li, Hao Zeng, Gang Li, Linghui Wu, Zhijun Liang (IHEP)
Yiming Hu (NJU)

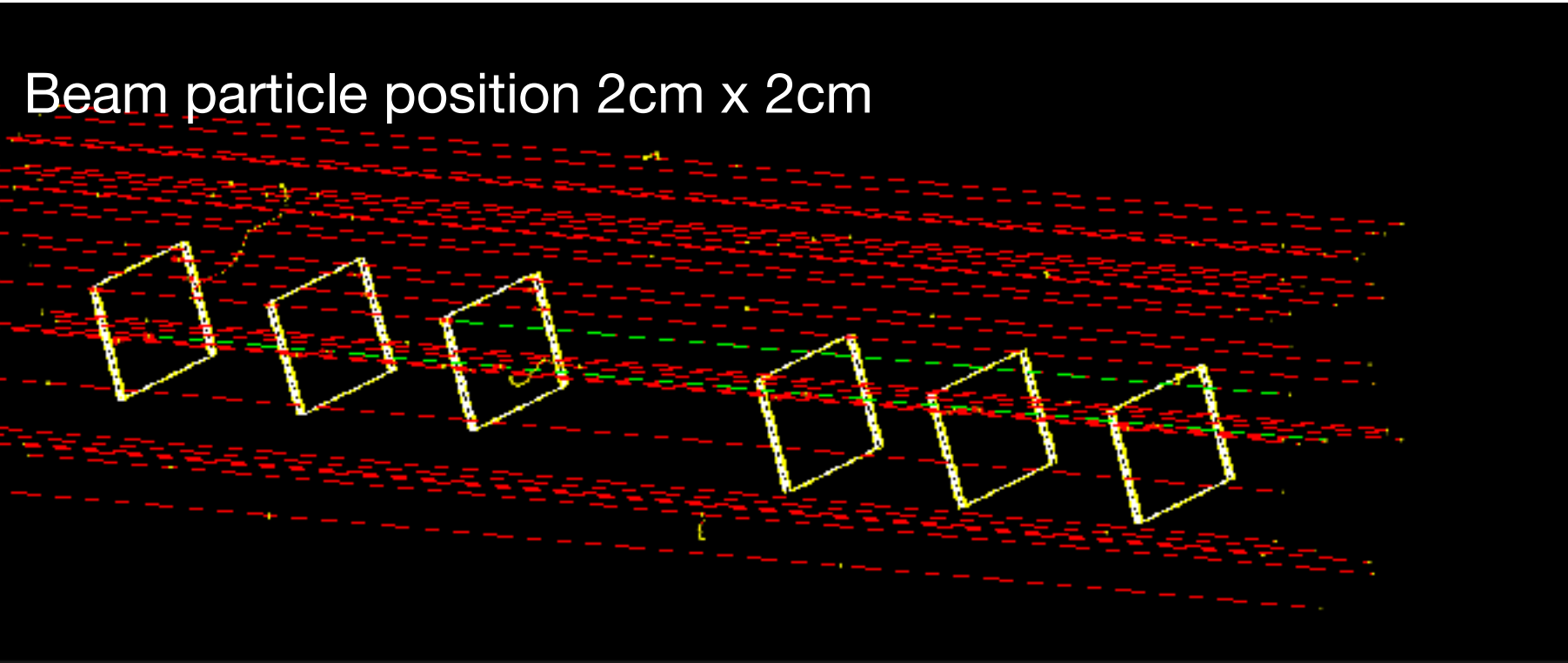
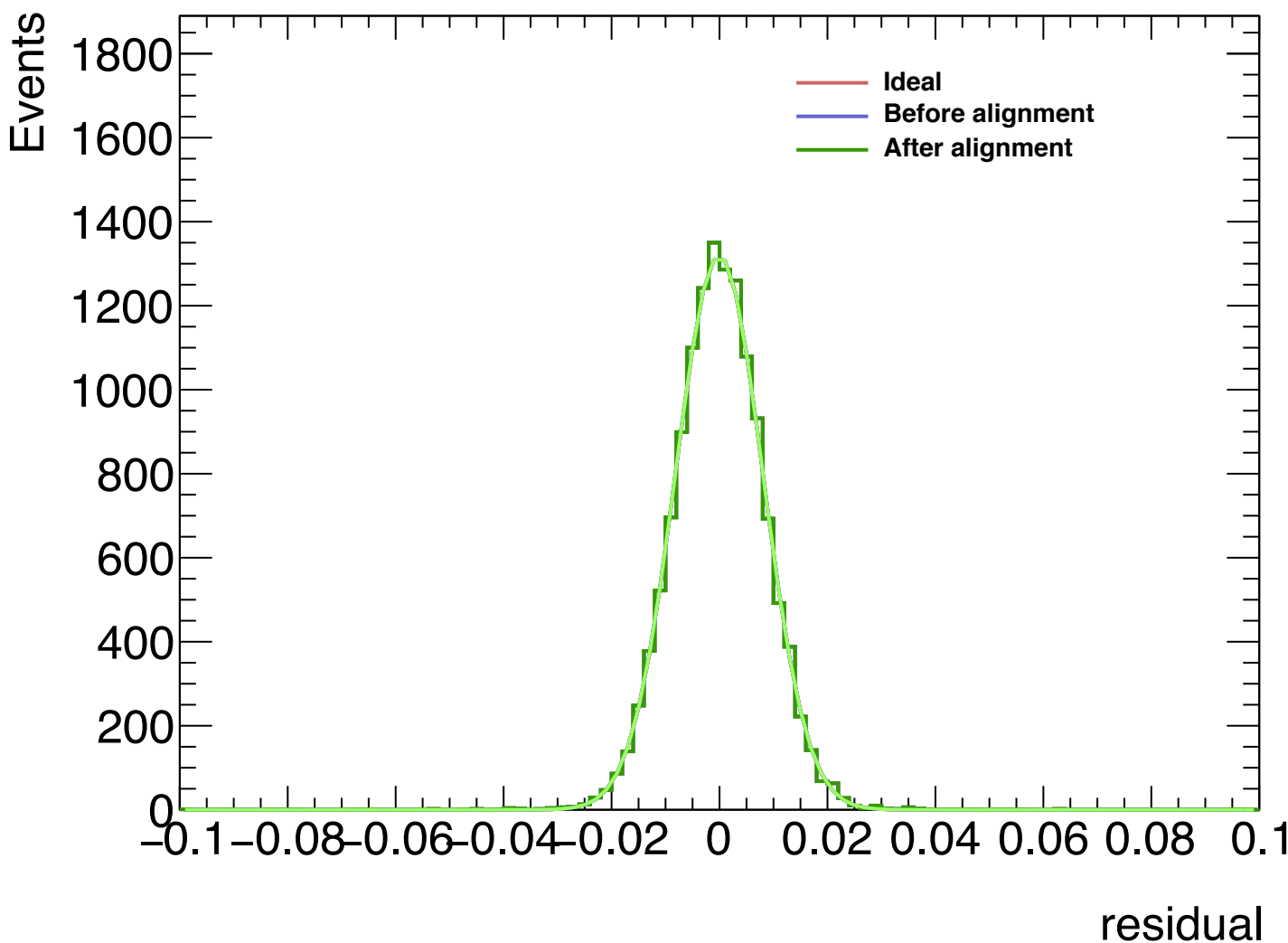
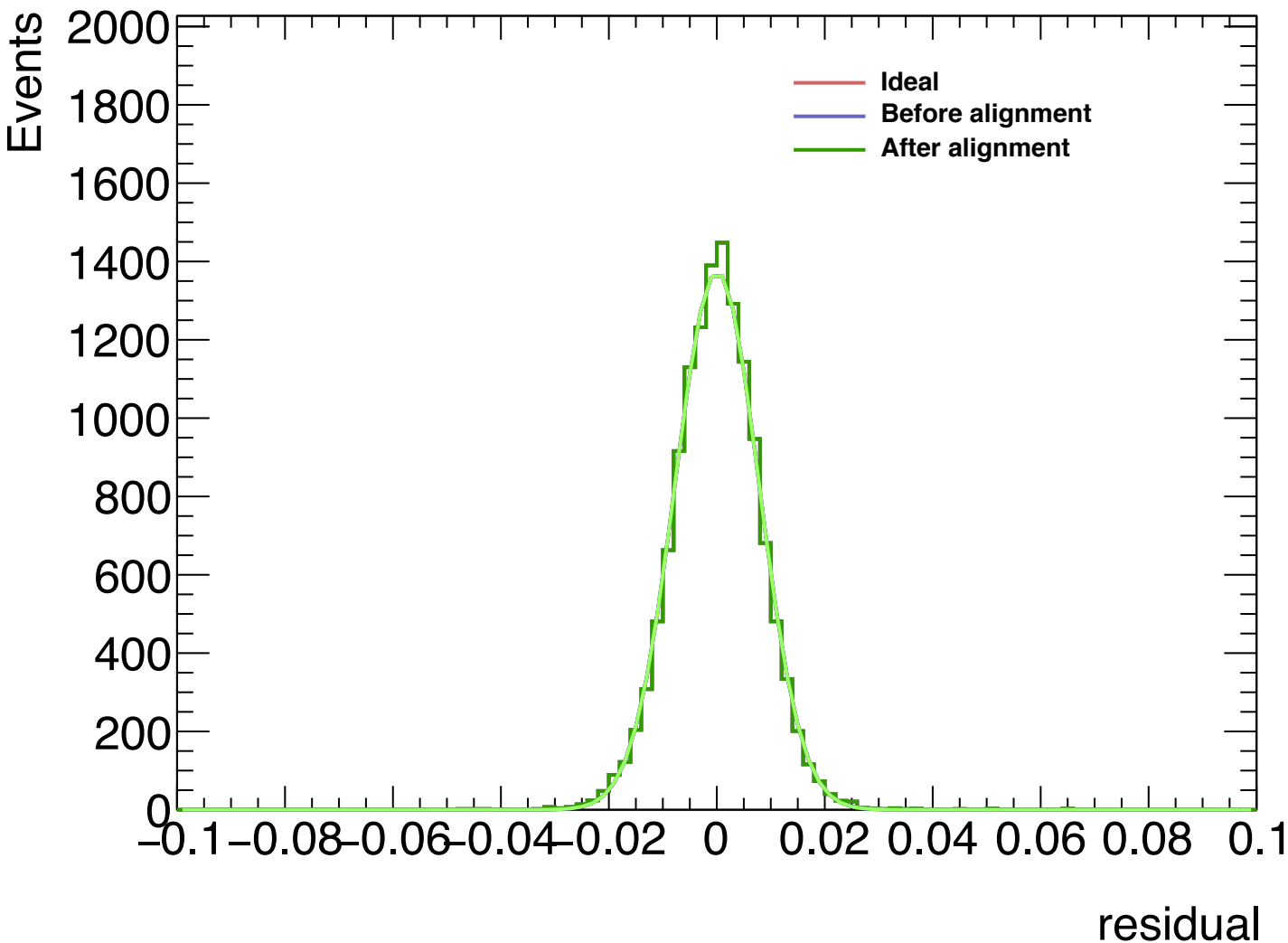
Tue, Oct13, 2022

Influence of alignment parameters on spatial resolution

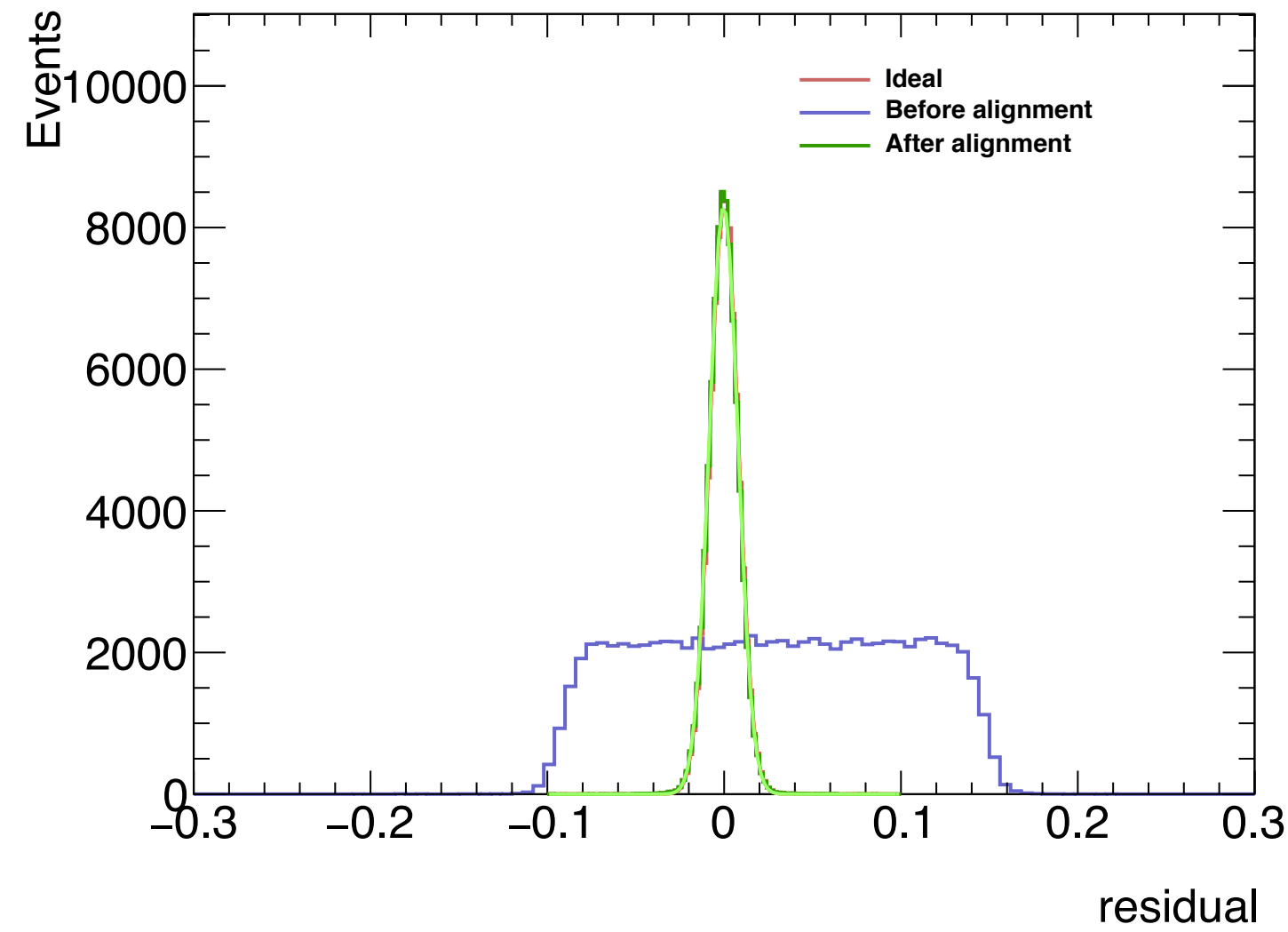
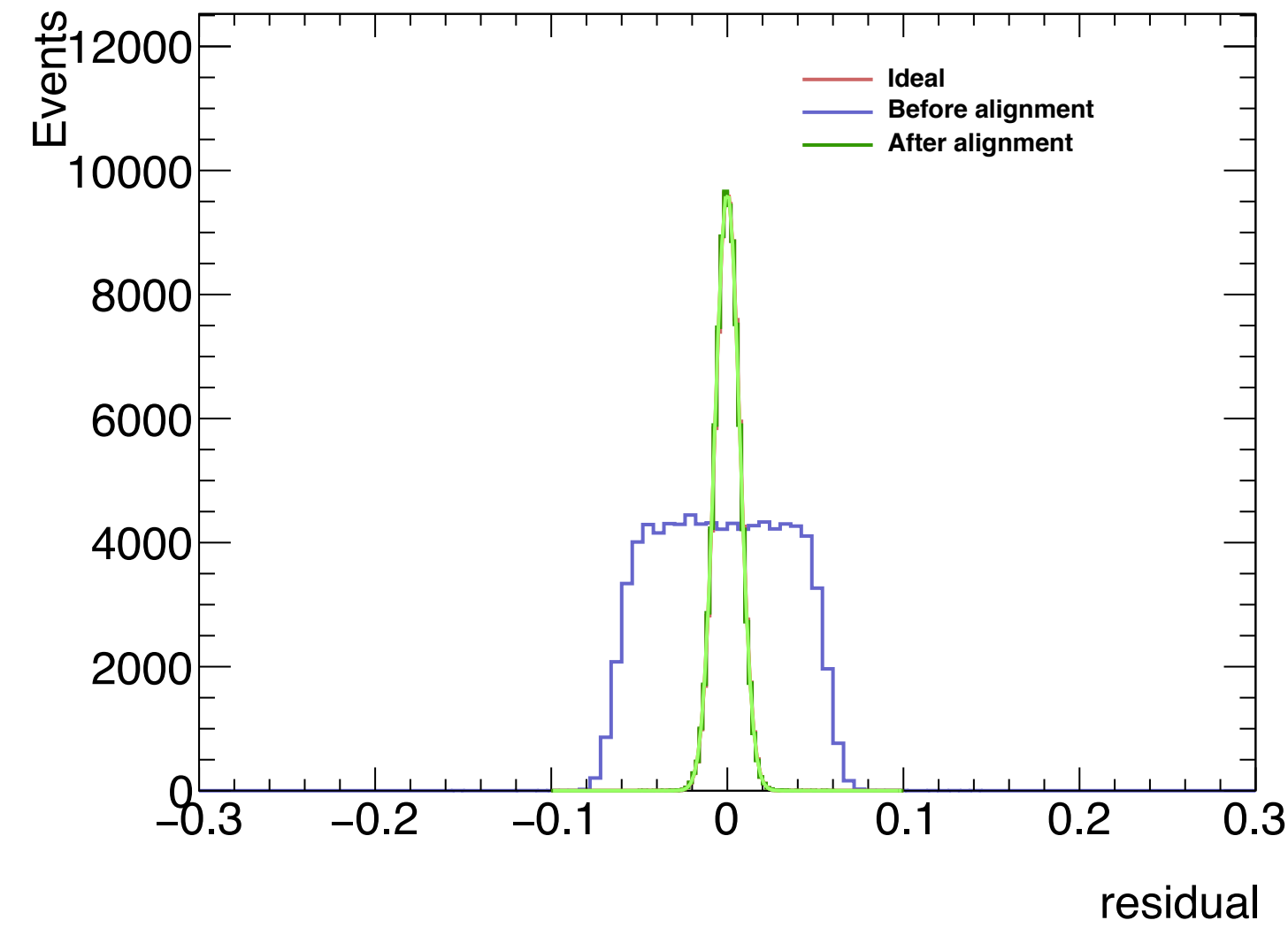
- Translation on X and Y only influence the mean value of residual plots



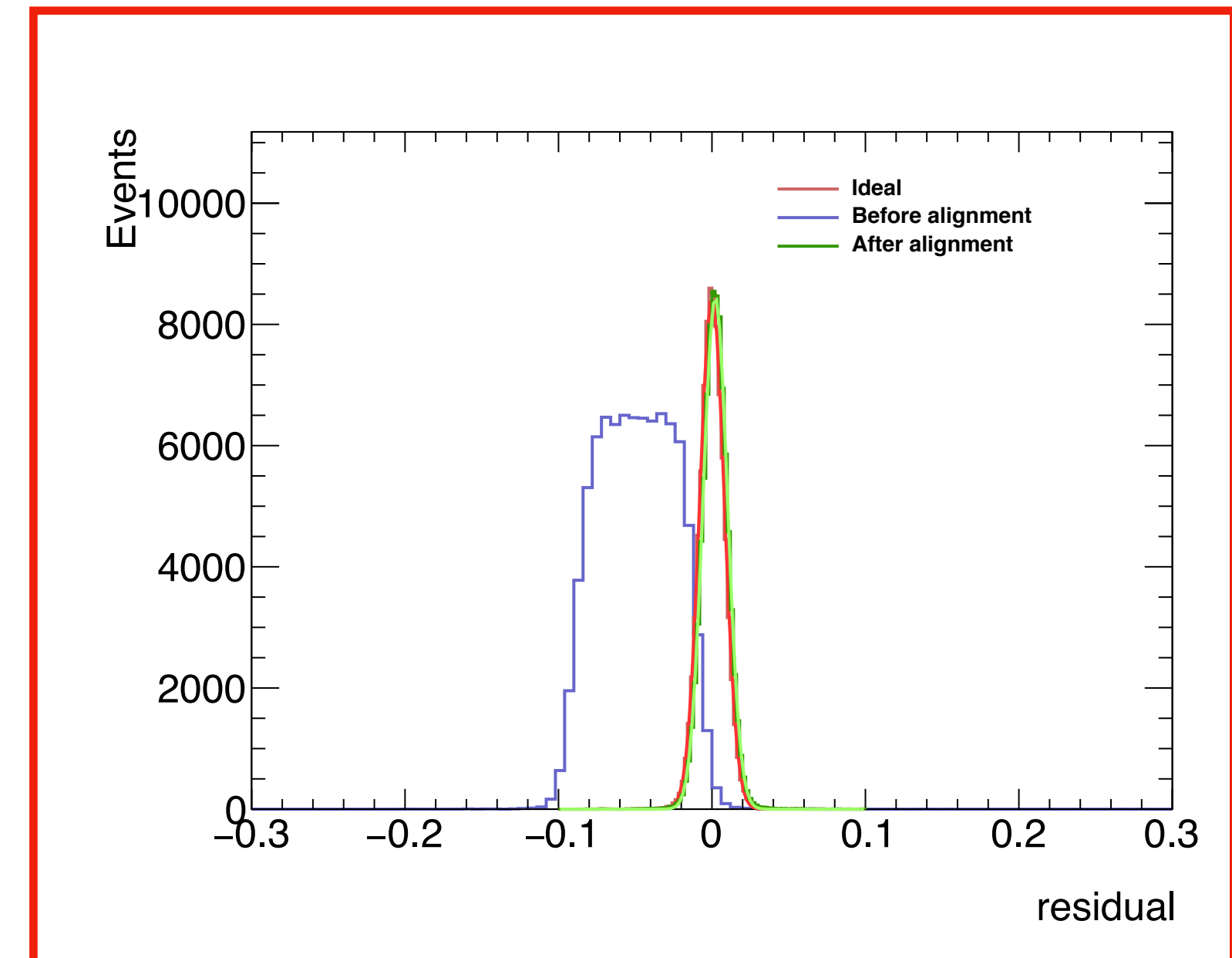
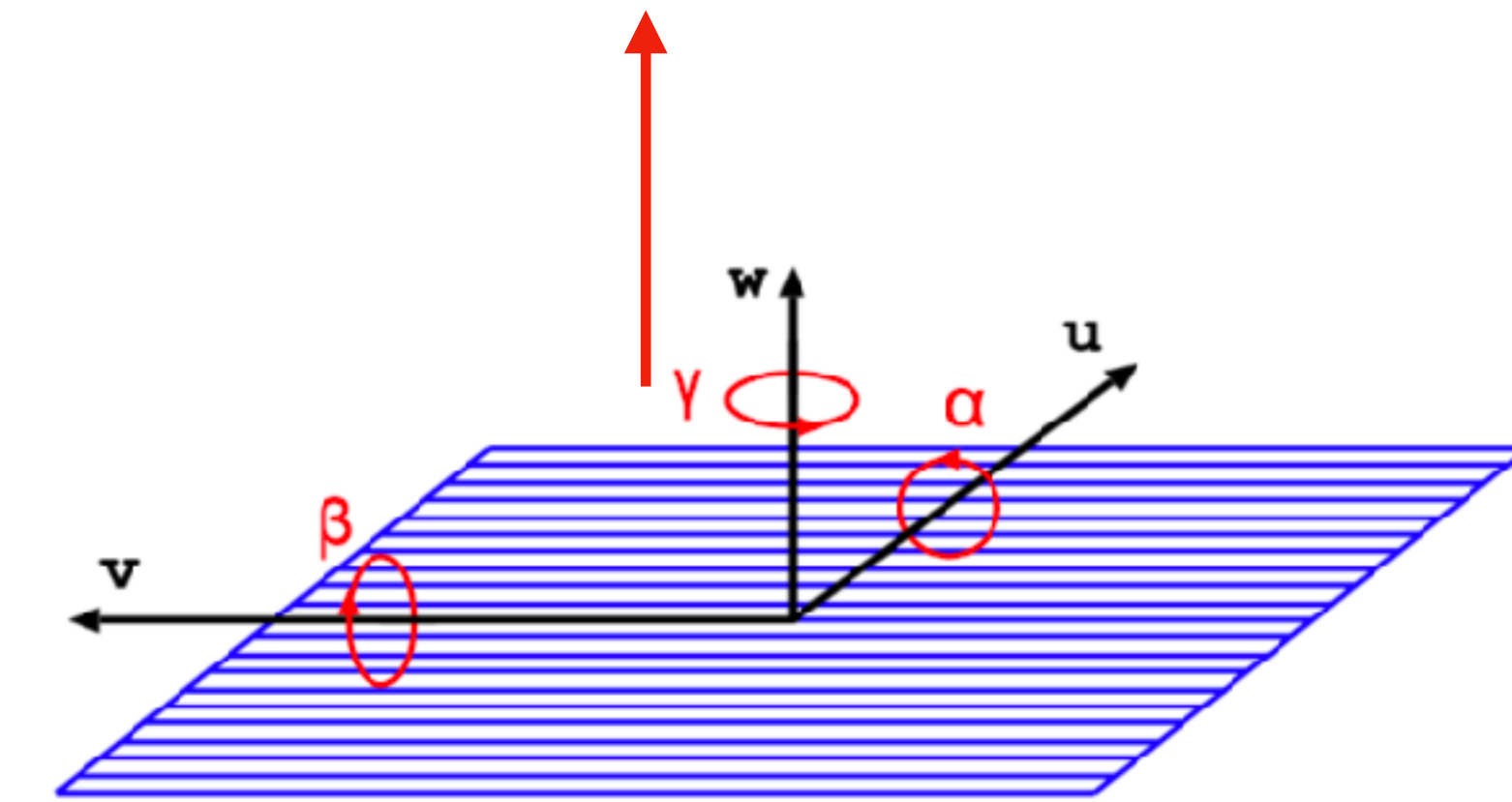
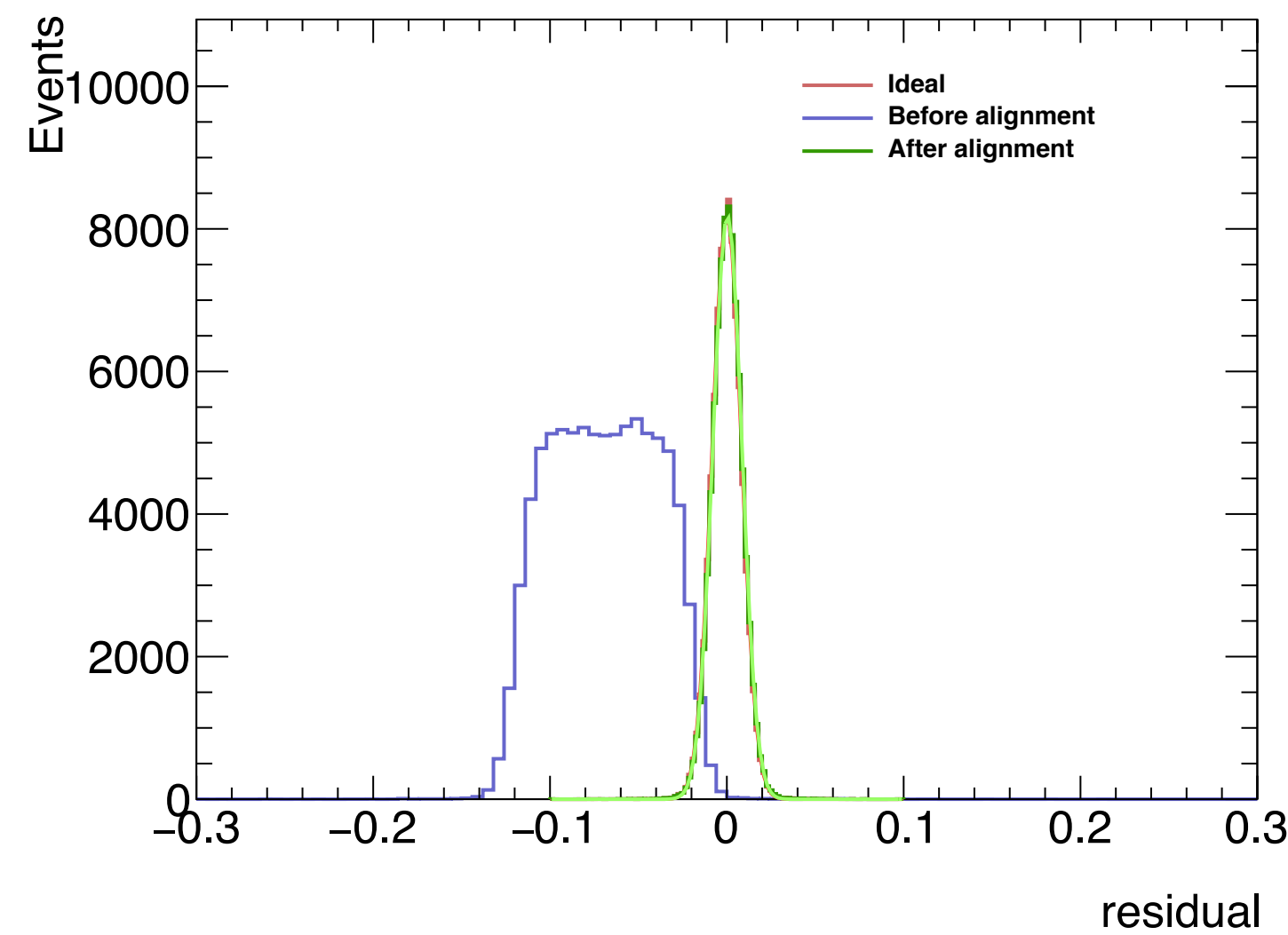
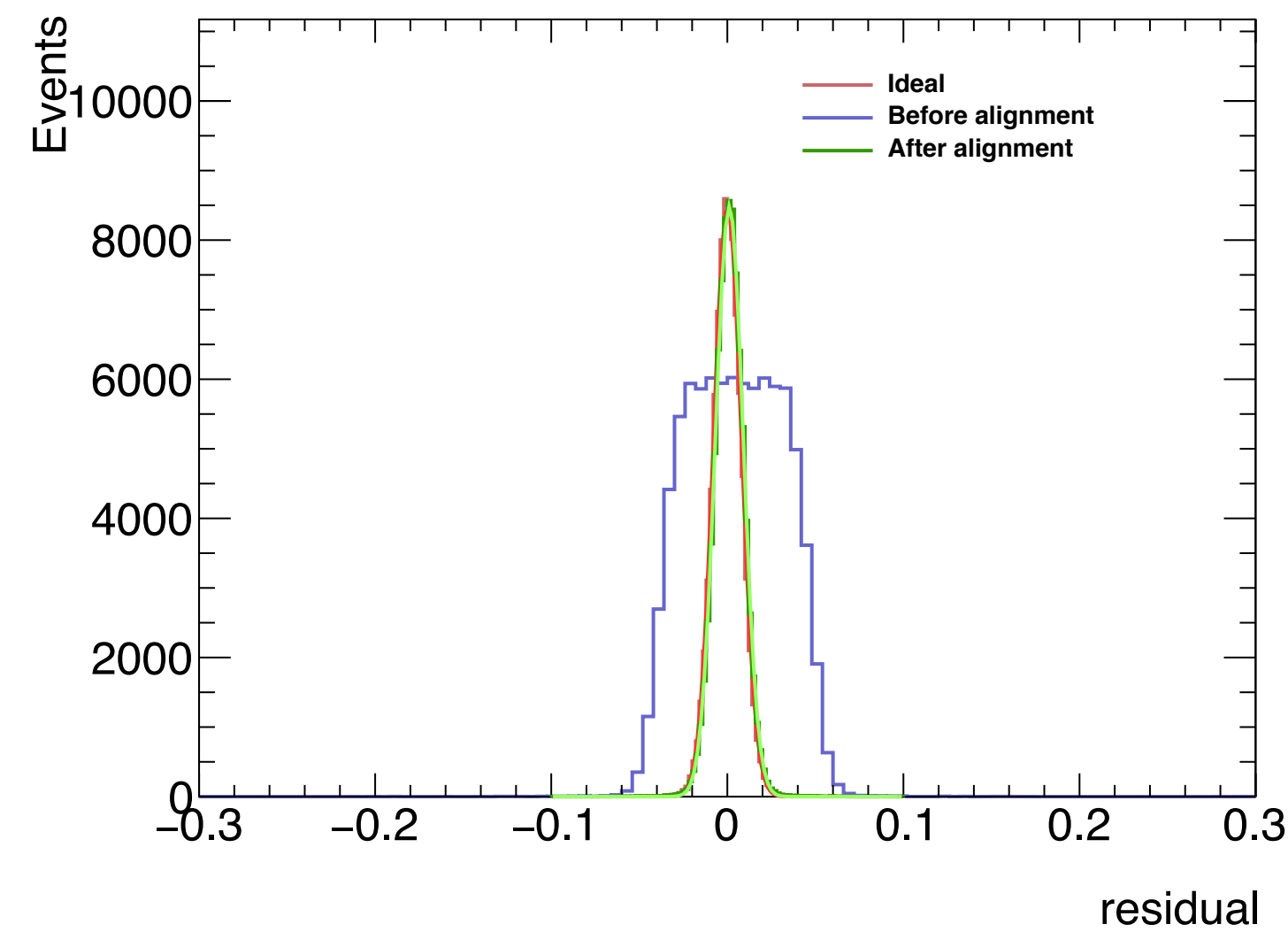
- Translation on Z and Rotation around X Y have little effect on residual plots



- Rotation around Z (beam direction) have great effect on spatial resolution



Increasing the translation error to 60 μm



- The horizontal assembly error is preferably within 60 microns
- The error of rotation around the beam direction is best controlled within 0.5 degrees

Summary

- I will don't consider Translation on Z and Rotation around XY alignment , only considering Translation on XY and Rotation around Z (beam direction) alignment
- I will perform 100 run Geant4 simulation and misalignment randomly, test the stability of alignment by residual plots.

MOST2 offline tracking reconstruction and alignment

Shuqi Li, Hao Zeng, Gang Li, Linghui Wu, Zhijun Liang (IHEP)
Yiming Hu (NJU)

Tue, Oct20, 2022

Alignment

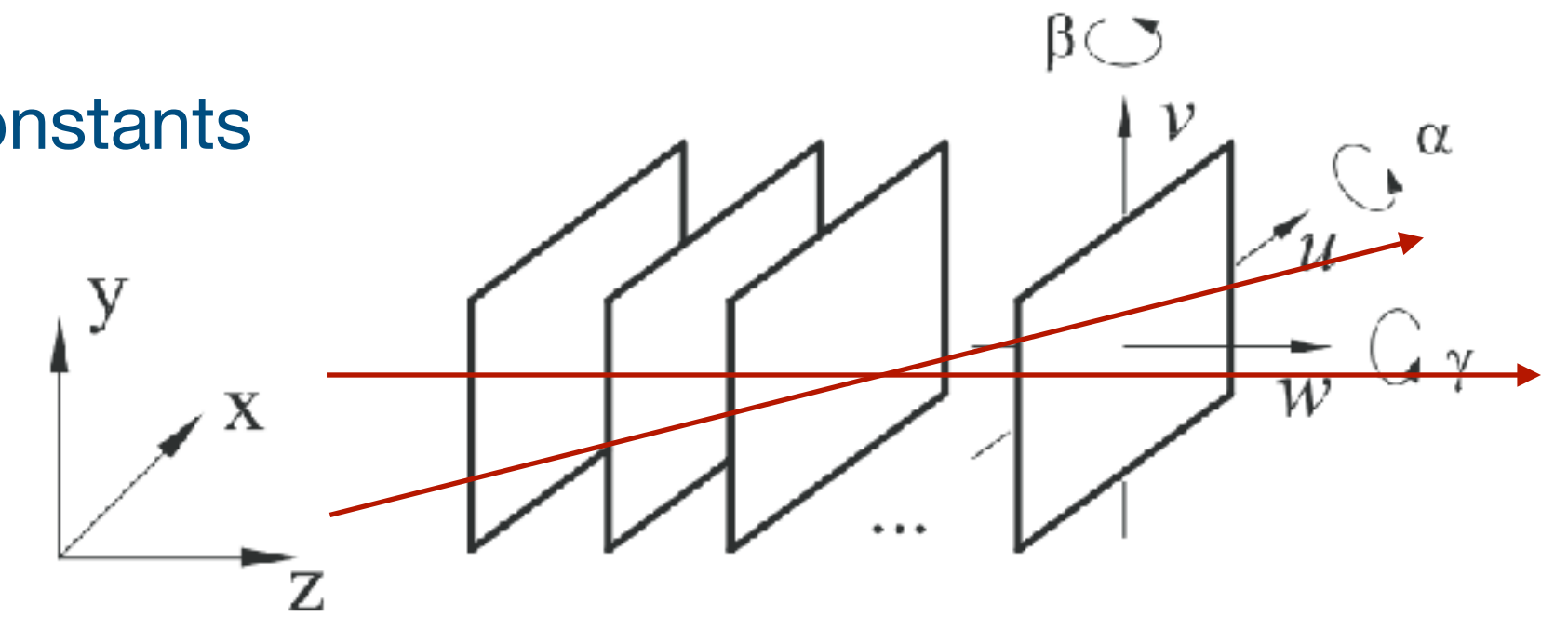
- straight line model: $x = X(z) + x_{res} = az + b + x_{res}; y = Y(z) + y_{res} = cz + d + y_{res}$
- considering misalignment

Building the linear relationship between the track parameters and the alignment constants

Simple situation (Discard the second-order miniature):

$$x_{corr}^{local} - x_{meas}^{local} = -\Delta u + y_{meas}^{local} \Delta \gamma + a(\Delta w + x_{meas}^{local} \Delta \beta + y_{meas}^{local} \Delta \alpha)$$

$$y_{corr}^{local} - y_{meas}^{local} = -\Delta v - x_{meas}^{local} \Delta \gamma + c(\Delta w + x_{meas}^{local} \Delta \beta + y_{meas}^{local} \Delta \alpha)$$



Actual situation (Discard the second-order miniature): $r_{corr} = \Delta RR(r^{global} - r_0) - \Delta r$

$$x_{corr}^{local} - x_{meas}^{local} = -\Delta u + y_{meas}^{local} \Delta \gamma + ah$$

$$y_{corr}^{local} - y_{meas}^{local} = -\Delta v + y_{meas}^{local} \Delta \gamma + ch$$

$$h = \frac{\Delta \beta x_{meas}^{local} + \Delta \alpha y_{meas}^{local} + \Delta w \cos \alpha - \Delta v \sin \alpha}{-a \Delta \beta - c(\Delta \alpha + \sin \alpha) - (\Delta \alpha \sin \alpha - \cos \alpha)}$$

- minimize: $\chi^2 = \sum_{\text{data sets}} \left(\sum_{\text{events}} \left(\sum_{\text{tracks}} \left(\sum_{\text{hits}} w_i r_i^2 \right) \right) \right)$

