MOST2 offline tracking reconstruction and alignment

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

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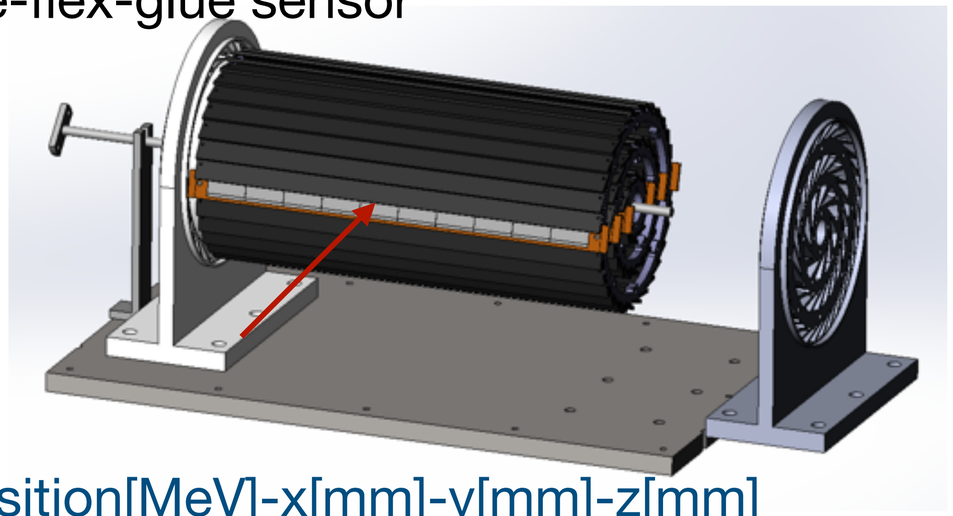
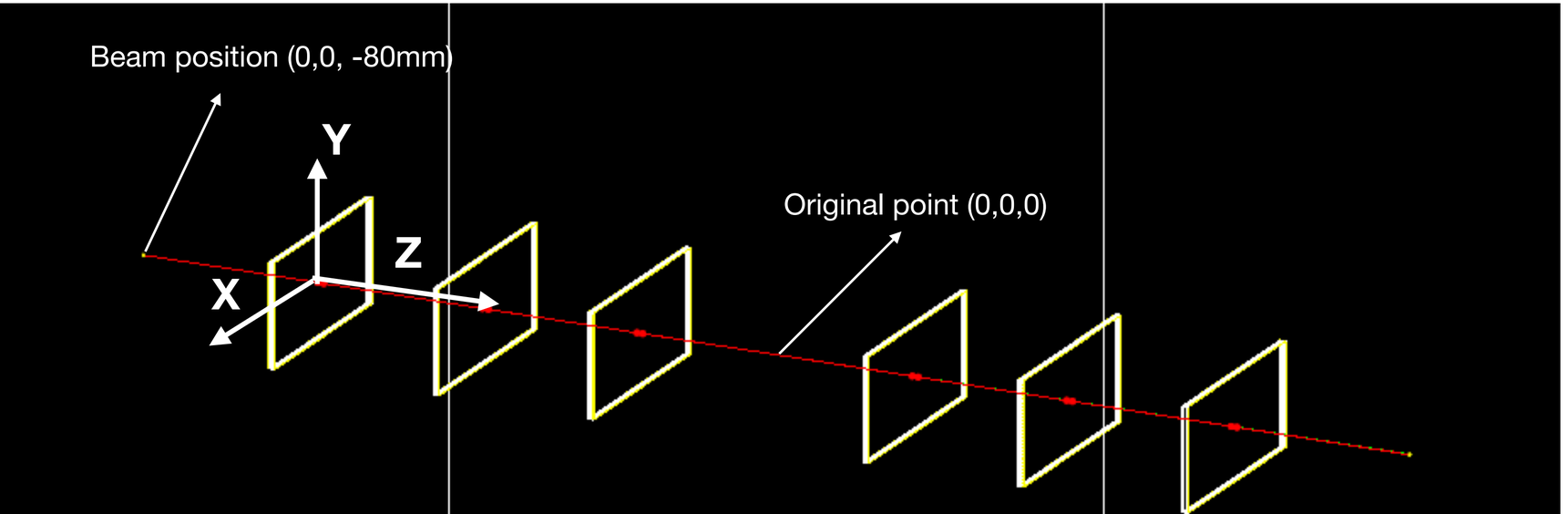
Simulation setup

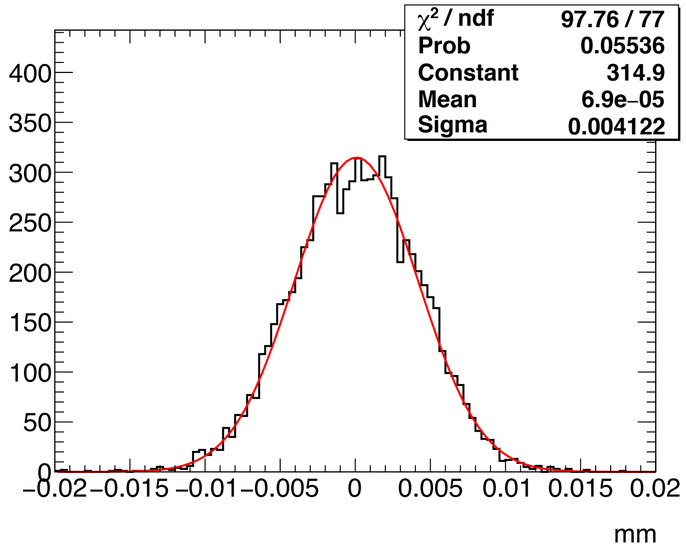
- Electron Beam: 5GeV
- 低能电磁过程
- module structure：sensor-glue-flex-glue- carbon fiber- glue-flex-glue sensor
- module components thickness:
  - sensor(G4_Si): 50um/100um/150um;
  - glue(Epoxy): 60um;
  - flex(Kapton+Al): 74um+26.8um;
  - support(carbon fiber): 250um
- information saved in ROOT File:
  - EventID-TrackID-PlaneID (where the hit at)-Energy deposition[MeV]-x[mm]-y[mm]-z[mm]



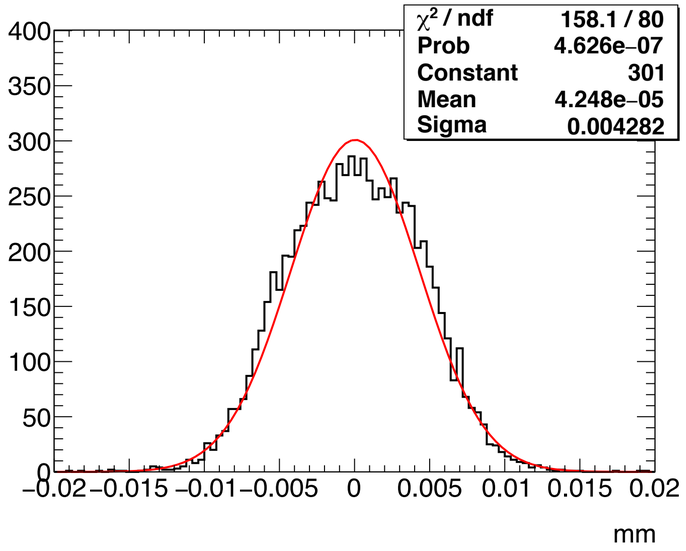


Fitting

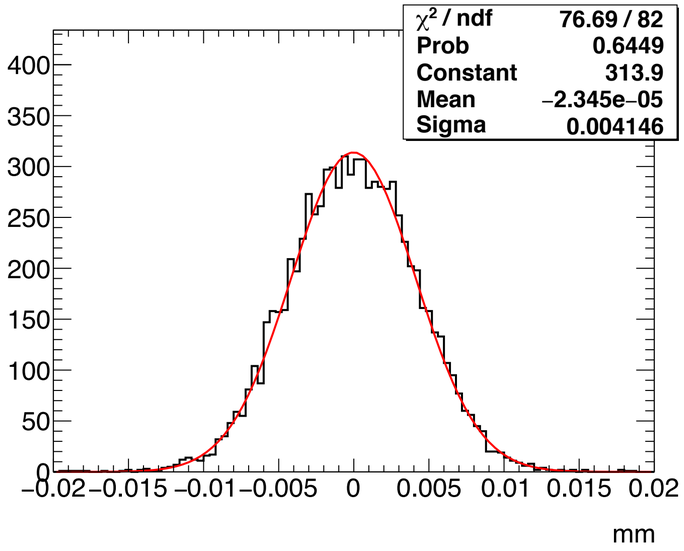
- f(x)=a1*z+b1+x; f(y)=a2*z+b2+y
- Residual for every sensor plane on x, y direction
- Considering detector smearing, sigma = 7um



plane0 x residual



plane6 x residual



plane11 x residual

Simulation for different chip thickness

	material budget (X/X0 %)	chip0 sigma (um)	chip2 sigma (um)	chip4 sigma (um)	chip6 sigma (um)	chip8 sigma (um)	chip10 sigma (um)
50um	0.44	4.12	3.62	4.24	4.28	3.66	4.11
100um	0.57	4.58	3.70	4.66	4.60	3.74	4.61
150um	0.69	4.88	3.85	4.77	4.83	3.88	4.75

- module structure：sensor-glue-flex-glue- carbon fiber- glue-flex-glue sensor
- module components thickness:
  - sensor(G4_Si): 50um/100um/150um;
  - glue(Epoxy): 60um;
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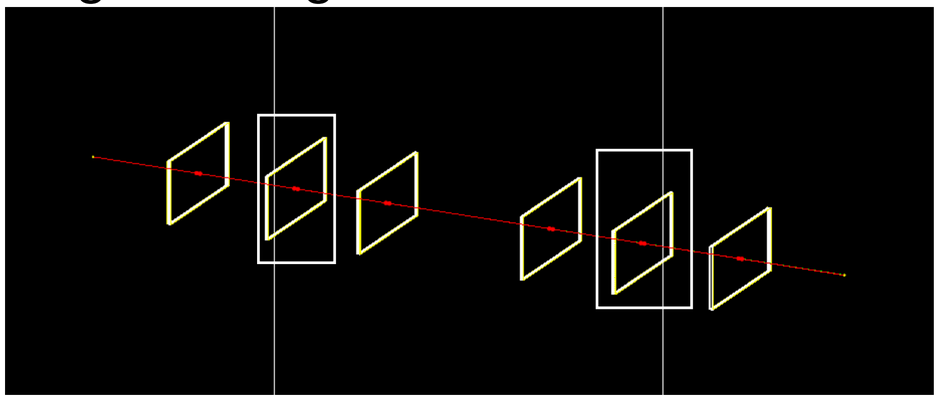


12 hits position fit

	material budget (X/X0 %)	chip0 sigma (um)	chip2 sigma (um)	chip4 sigma (um)	chip6 sigma (um)	chip8 sigma (um)	chip10 sigma (um)
50um	0.44	4.30/4.28	3.02/3.01	3.07/3.12	3.15/3.11	3.03/3.03	4.25/4.39
100um	0.57	4.77/4.73	3.19/3.18	3.58/3.54	3.54/3.59	3.14/3.16	4.74/4.85
150um	0.69	5.06/4.90	3.21/3.22	3.82/3.78	3.80/3.80	3.23/3.17	4.93/5.04

11 hits position fit, residual calculated from another hit

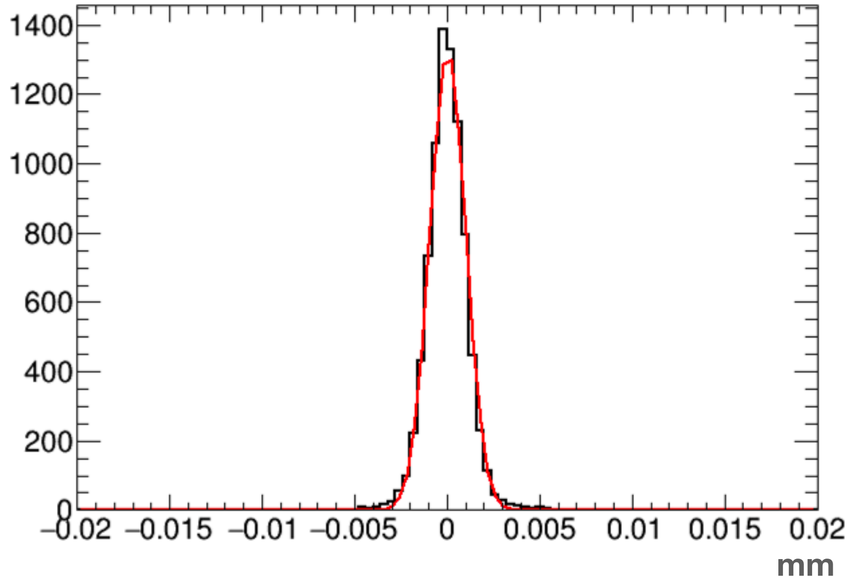
	material budget (X/X0 %)	chip0 sigma (um)	chip2 sigma (um)	chip4 sigma (um)	chip6 sigma (um)	chip8 sigma (um)	chip10 sigma (um)
50um	0.44	5.20/5.12	3.32/3.26	3.33/3.35	3.38/3.35	3.32/3.36	5.10/5.33
100um	0.57	5.90/5.72	3.50/3.49	3.92/3.85	3.86/3.88	3.47/3.44	5.84/6.00
150um	0.69	6.30/6.07	3.54/3.61	4.14/4.10	4.13/4.15	3.58/3.53	6.08/6.28

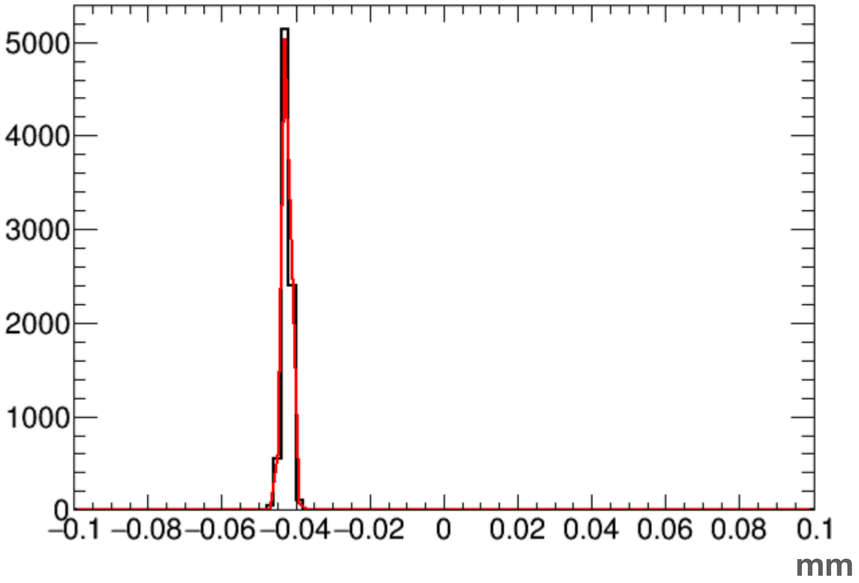
Backup

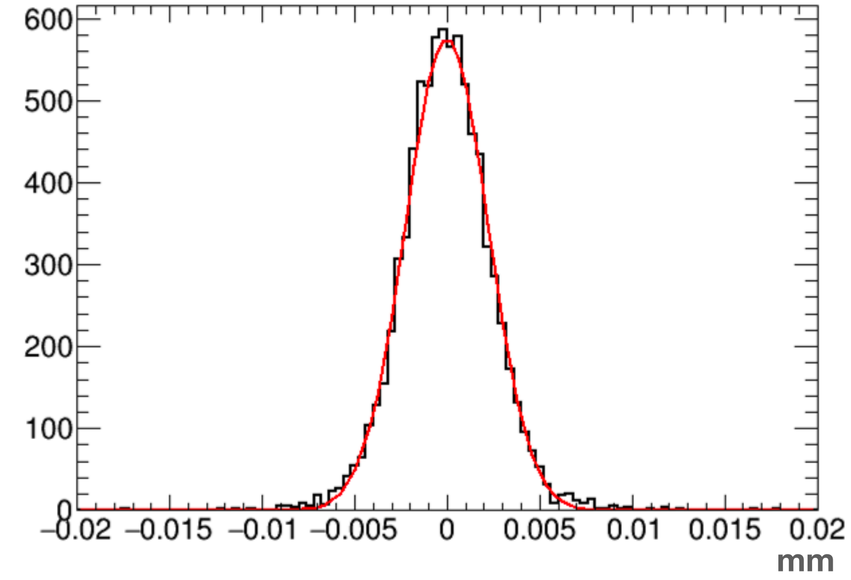
	Helium gas coolant	Paraffin coolant	CDR
beam pipe	0.00558	0.00707	0.00203
IT Module: Flex cable	0.00312	0.00312	0.00312
IT Module: Glue sensor	0.00037	0.00037	0.00037
IT Module: Glue support	0.00037	0.00037	0.00037
IT Module: Ladder support	0.00643	0.00643	0.00643
IT Module: Sensor	0.00444	0.00444	0.00444
total	0.02031	0.02180	0.01676

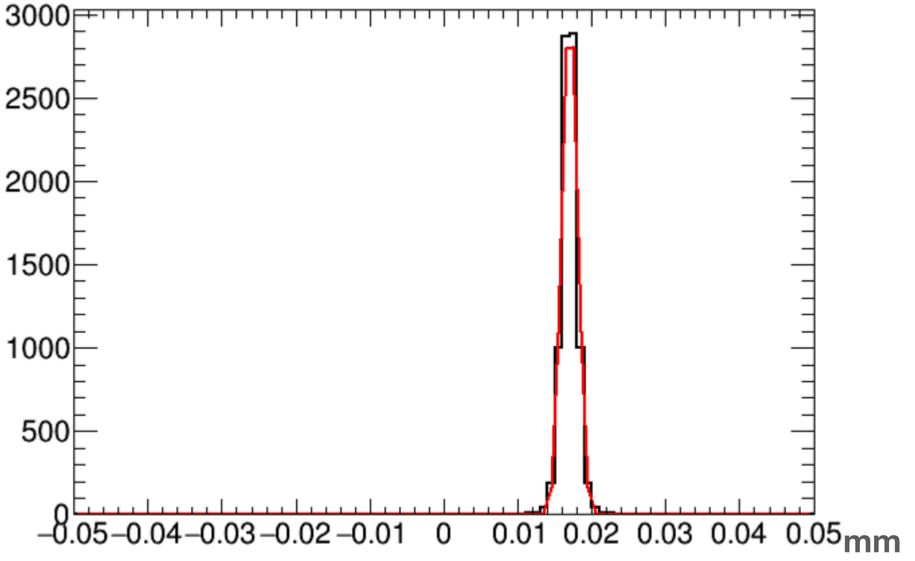
Table 15: Beam pipe and vertex detector material budget of each component for different design: CDR, Helium gas coolant design and paraffin coolant design.

- translation along x -0.05mm for plane3
- translation along y +0.02 mm for plane8
- Residual plots









Rotation matrix R, translation matrix Δr $\quad R = \begin{pmatrix} 1 & \Delta\gamma & \Delta\beta \\ -\Delta\gamma & 1 & \Delta\alpha \\ -\Delta\beta & -\Delta\alpha & 1 \end{pmatrix} \quad \Delta r = \begin{pmatrix} \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$

From the local to global frame $\quad \vec{r}_{hit}^{\,local} = R \cdot (\vec{r}_{hit}^{\,global} - (\vec{r}_{0}^{\,global} + \Delta r))$

If perfect aligned: $\quad \vec{r}_{hit}^{\,local} = \vec{r}_{hit}^{\,global} - \vec{r}_{0}^{\,global} = \vec{r}_{hit}^{\,global} - \begin{pmatrix} 0 \\ 0 \\ z^{global} \end{pmatrix}$ (3) $\quad \vec{r}_{0}^{\,global} = \begin{pmatrix} 0 \\ 0 \\ z^{global} \end{pmatrix}$

If misaligned:

$$\vec{r}_{hit}^{\,local,new} = R(\vec{r}_{hit}^{\,global,new} - (\vec{r}_{0}^{\,global} + \Delta r)) \quad (1)$$

considering straight line model：

$$x^{global} = az^{global} + b;\ y^{global} = cz^{global} + d;\ \Delta x^{global} = a\Delta z^{global};\ \Delta y^{global} = c\Delta z^{global}$$

$$\therefore \vec{r}_{hit}^{\,global,new} = \vec{r}_{hit}^{\,global} + h \cdot \begin{pmatrix} a \\ c \\ 1 \end{pmatrix};\ h = \Delta z^{global} \quad (2)$$

from equation (1) (2) (3)

$$\therefore \vec{r}_{hit}^{\,local,new} = R(\vec{r}_{hit}^{\,global,new} - (\vec{r}_{0}^{\,global} + \Delta r)) = R(\vec{r}_{hit}^{\,global} + h \cdot \begin{pmatrix} a \\ c \\ 1 \end{pmatrix} - (\vec{r}_{0}^{\,global} + \Delta r)) = R(\vec{r}_{hit}^{\,local} + h \cdot \begin{pmatrix} a \\ c \\ 1 \end{pmatrix} - \Delta r) \quad (4)$$

$$\therefore \vec{r}_{hit}^{local,new} = R(\vec{r}_{hit}^{global,new} - (\vec{r}_0^{global} + \Delta r)) = R(\vec{r}_{hit}^{global} + h \cdot \begin{pmatrix} a \\ c \\ 1 \end{pmatrix} - (\vec{r}_0^{global} + \Delta r)) = R(\vec{r}_{hit}^{local} + h \cdot \begin{pmatrix} a \\ c \\ 1 \end{pmatrix} - \Delta r) \quad (4)$$

Simplifying: $R \cdot \Delta r \approx \begin{pmatrix} \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$

$$\therefore \vec{r}_{hit}^{local,new} = \begin{pmatrix} 1 & \Delta\gamma & \Delta\beta \\ -\Delta\gamma & 1 & \Delta\alpha \\ -\Delta\beta & -\Delta\alpha & 1 \end{pmatrix} \begin{pmatrix} x^{global} + ah \\ y^{global} + ch \\ z^{global} + h - z^{global} \end{pmatrix} - \begin{pmatrix} \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$$

$\vec{r}_{hit}^{local,new}$ z component should be equal to 0

$$\therefore -\Delta\beta(x^{local} + ah) - \Delta\alpha(y^{local} + ch) + h - \Delta z = 0$$

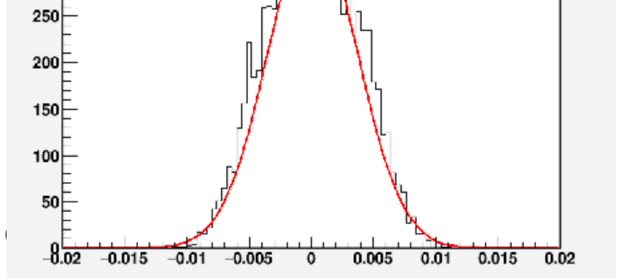
$$\therefore h = \frac{\Delta z + \Delta\beta x^{local} + \Delta\alpha y^{local}}{1 - a\Delta\beta - b\Delta\alpha} \approx \Delta z + \Delta\beta \cdot x^{local} + \Delta\alpha \cdot y^{local} \quad (5)$$

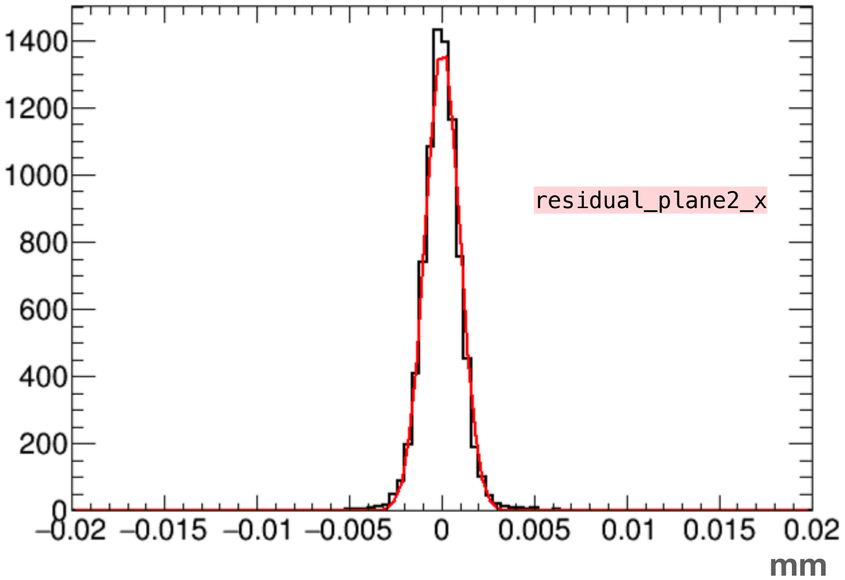
最小二乘直线拟合 **斜率**

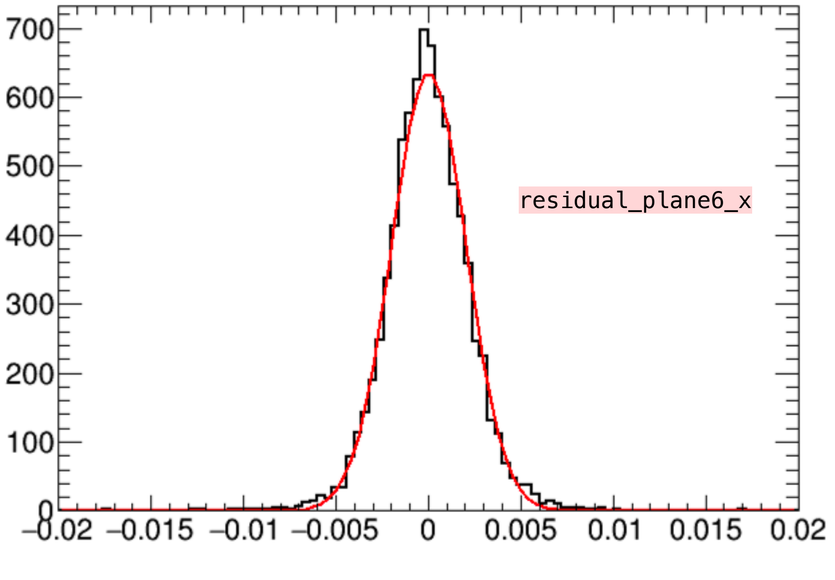
$$\begin{cases} x_{hit}^{new} = x_{hit} - \Delta_x + y_{hit} \cdot \Delta_\gamma + a \cdot (\Delta_z + x_{hit} \cdot \Delta_\beta + y_{hit} \cdot \Delta_\alpha) \\ y_{hit}^{new} = y_{hit} - \Delta_y - x_{hit} \cdot \Delta_\gamma + c \cdot (\Delta_z + x_{hit} \cdot \Delta_\beta + y_{hit} \cdot \Delta_\alpha) \end{cases}$$

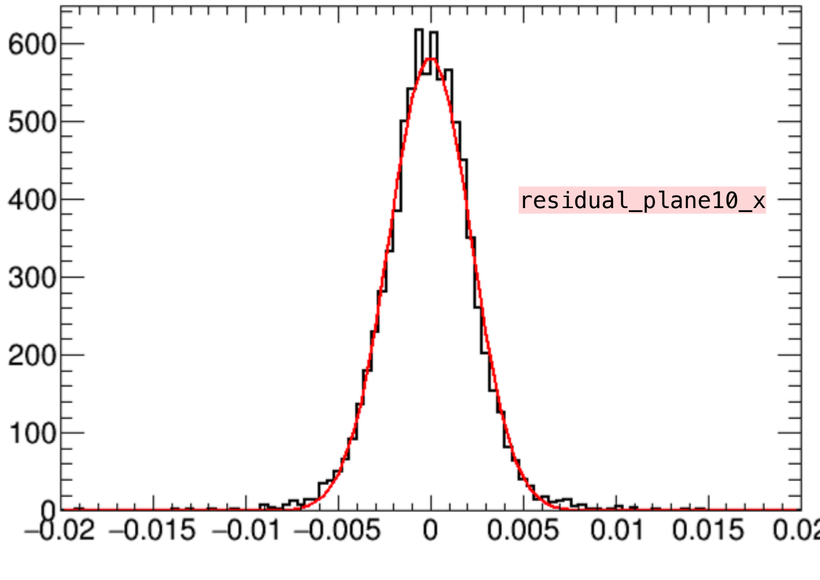
Fitting

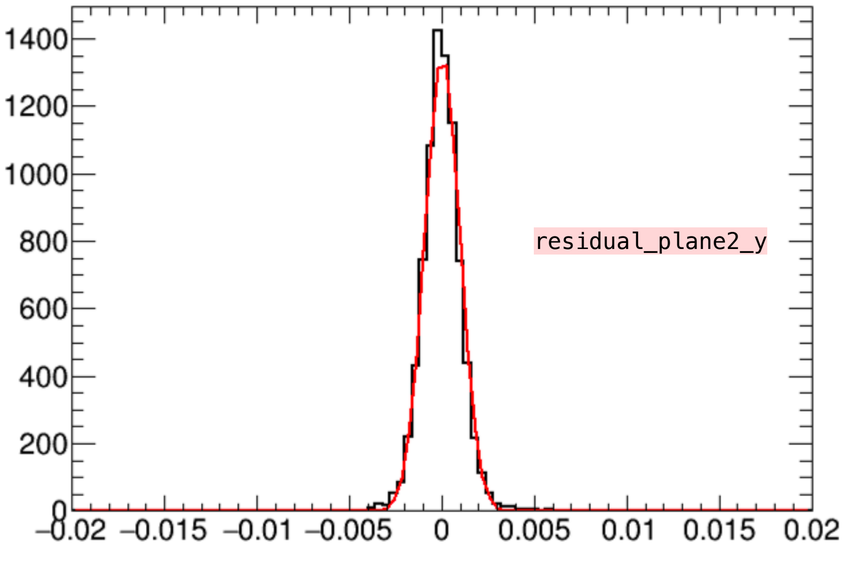
- f(x)=a1*z+b1+x; f(y)=a2*z+b2+y
- Residual for every sensor plane

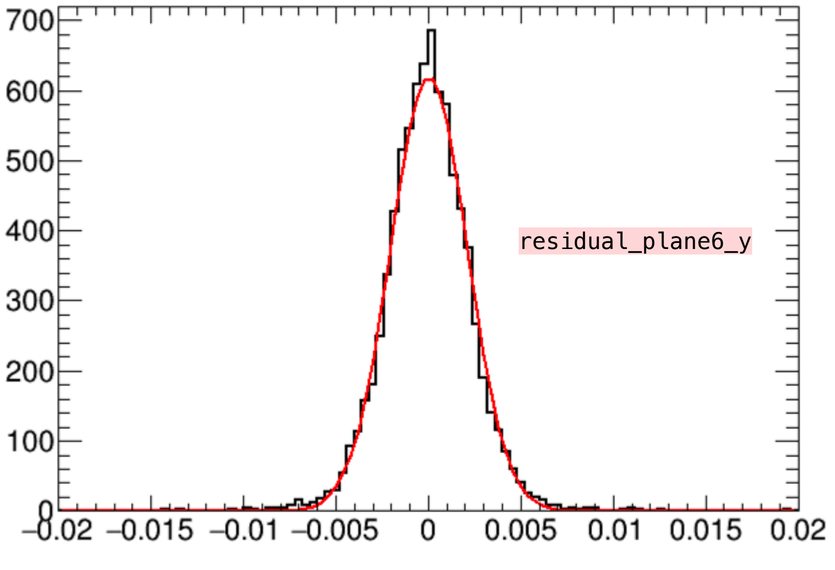


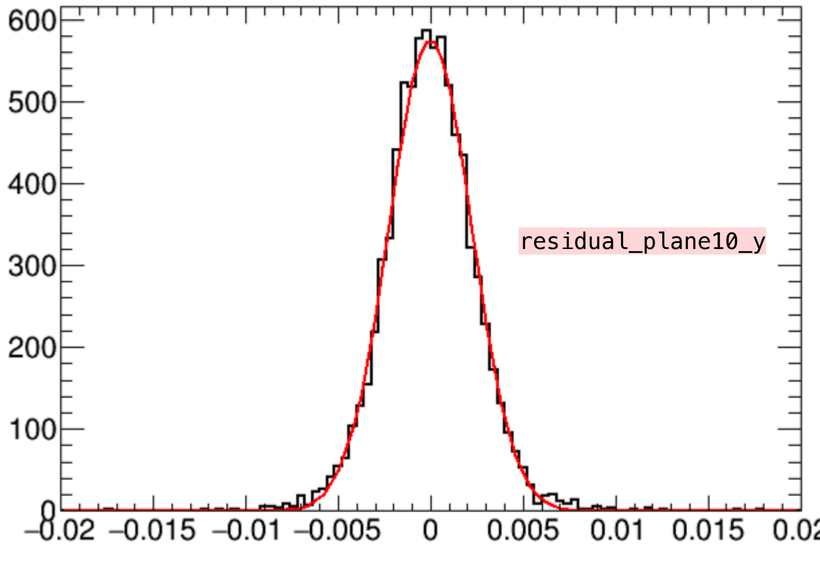








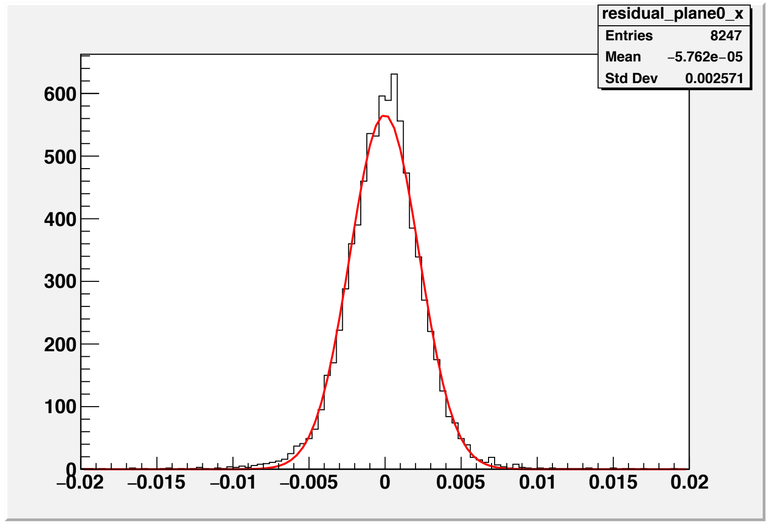


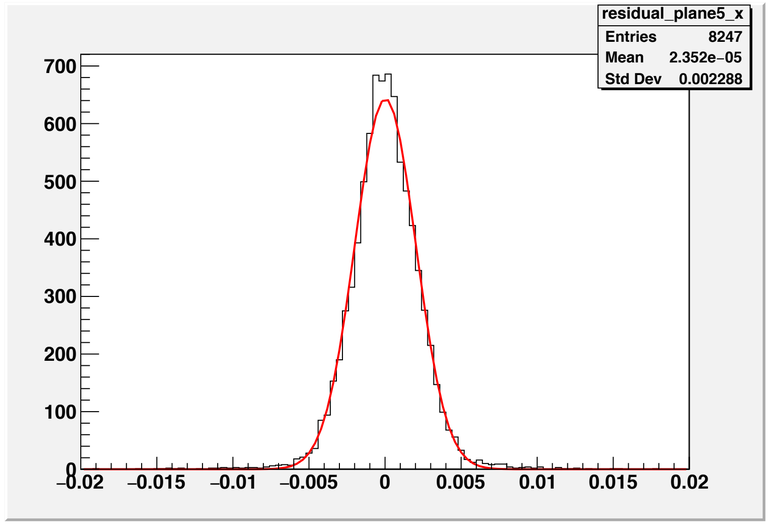


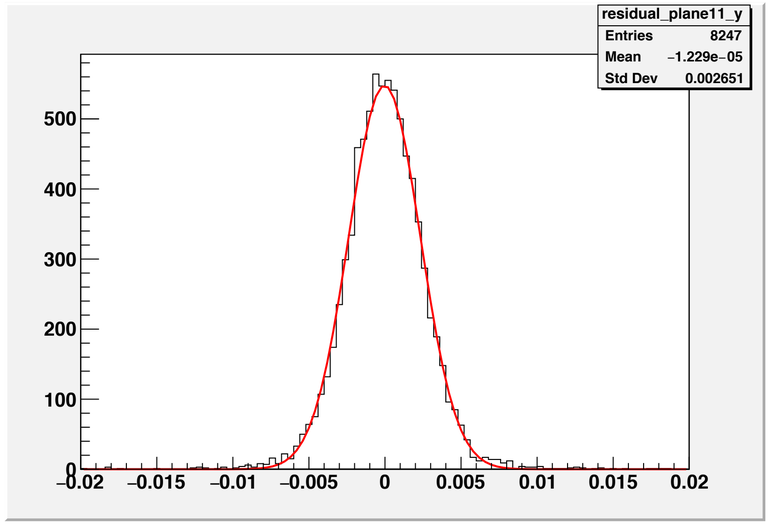
Next plan

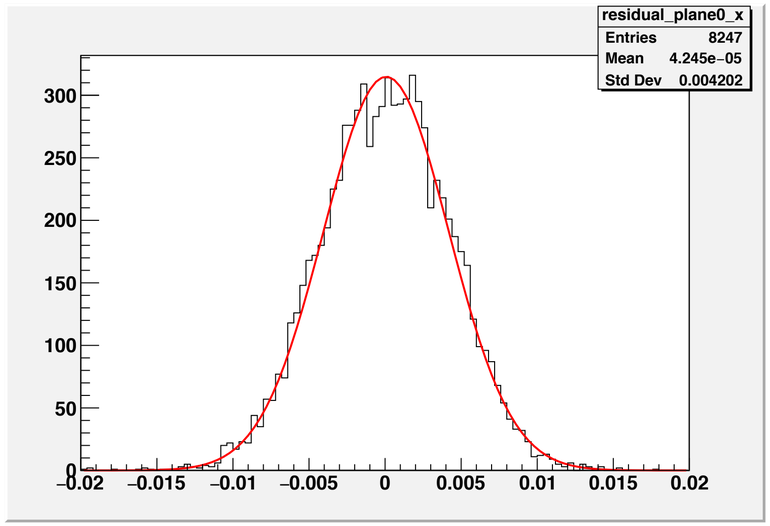
- simulated hit information digitation
- applied simple alignment free degree (translation along x,y and rotation around Z)

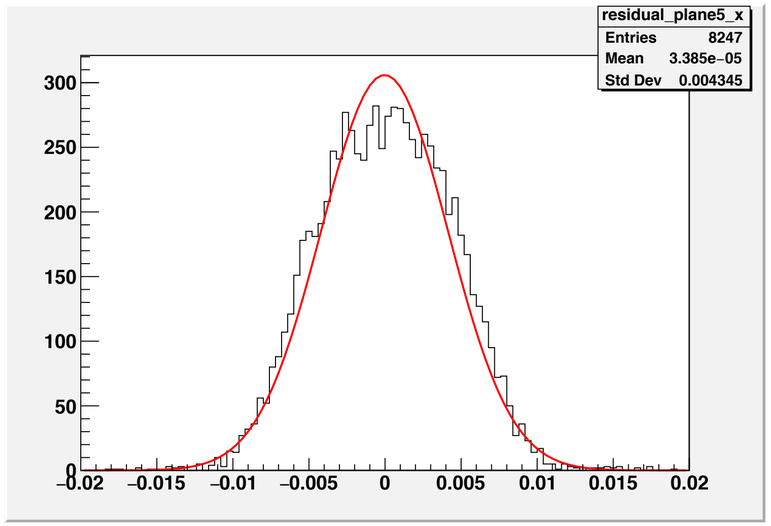
Added detector smearing effect 7um

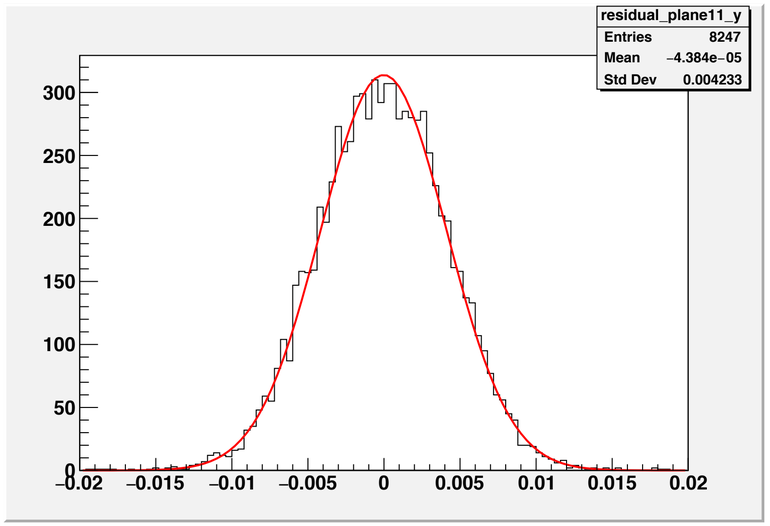


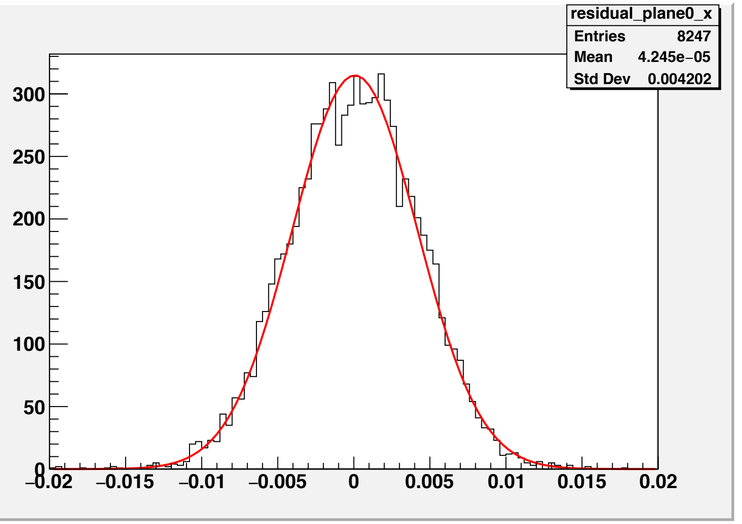




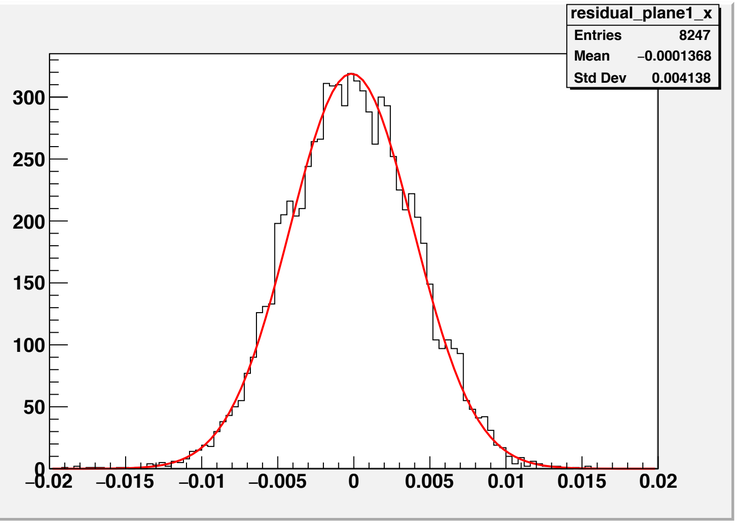


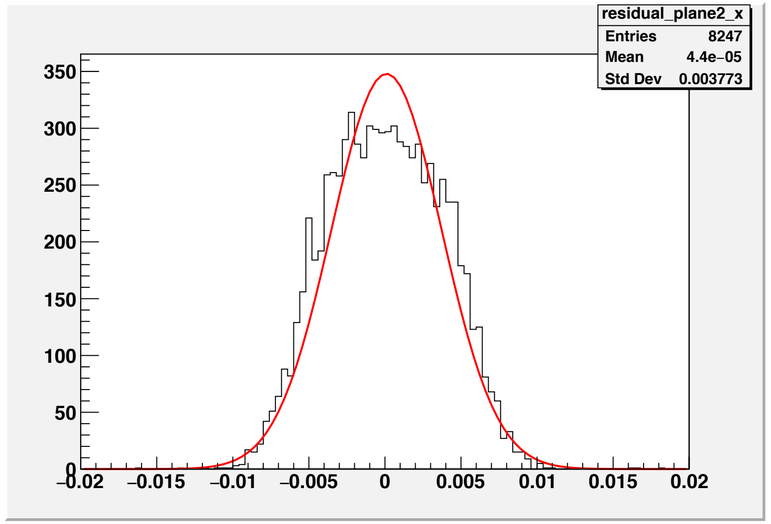




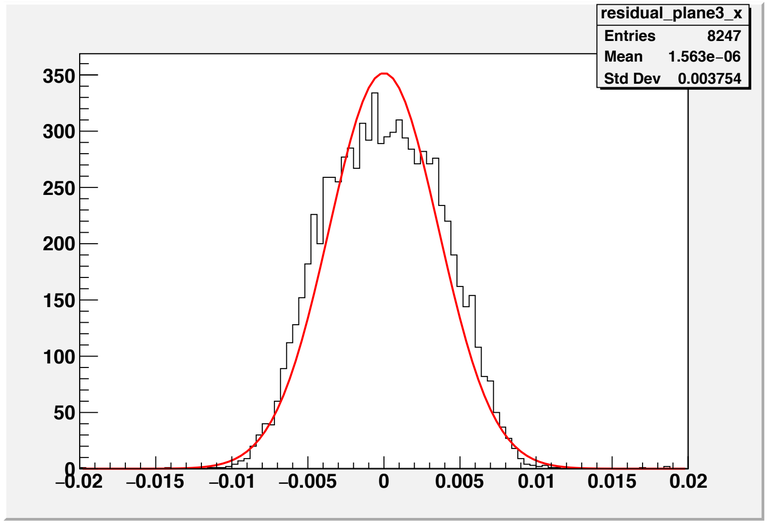


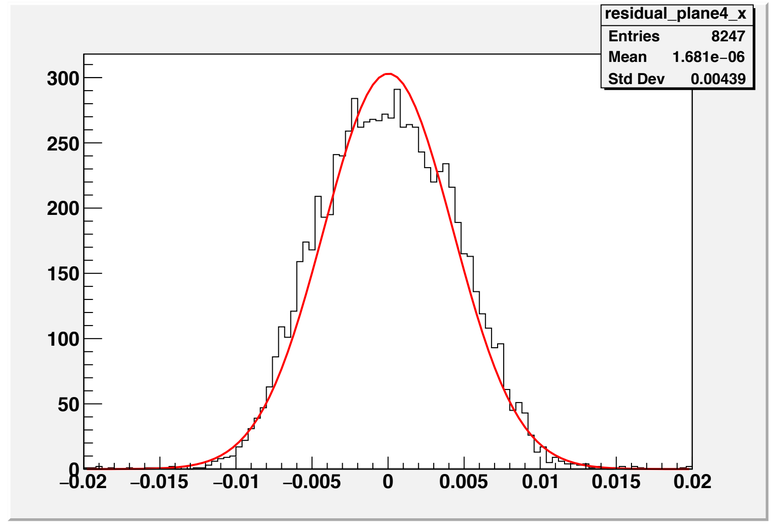
sigma=4.2um





sigma=3.7um





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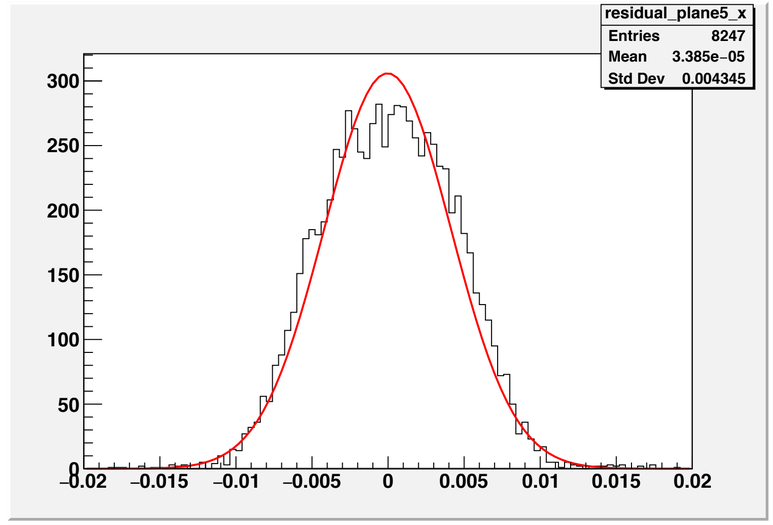
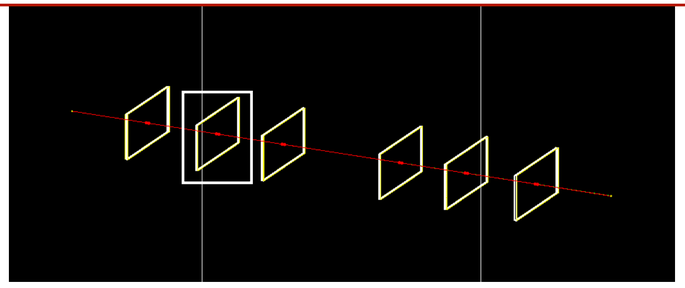
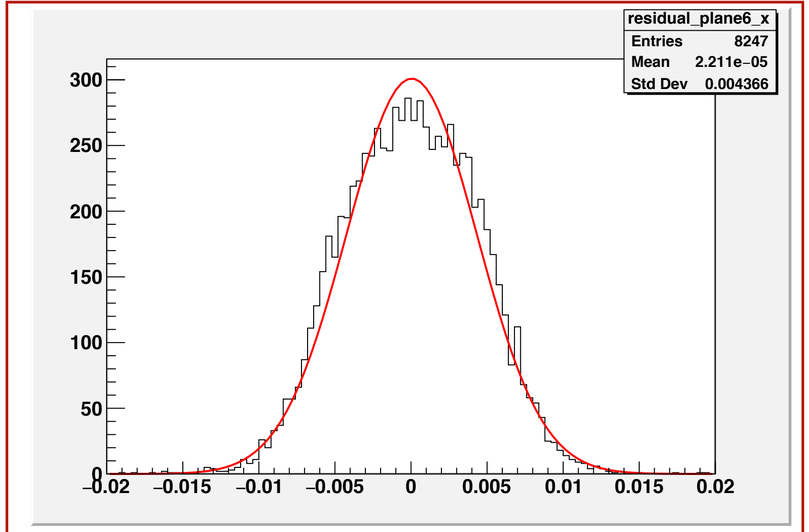
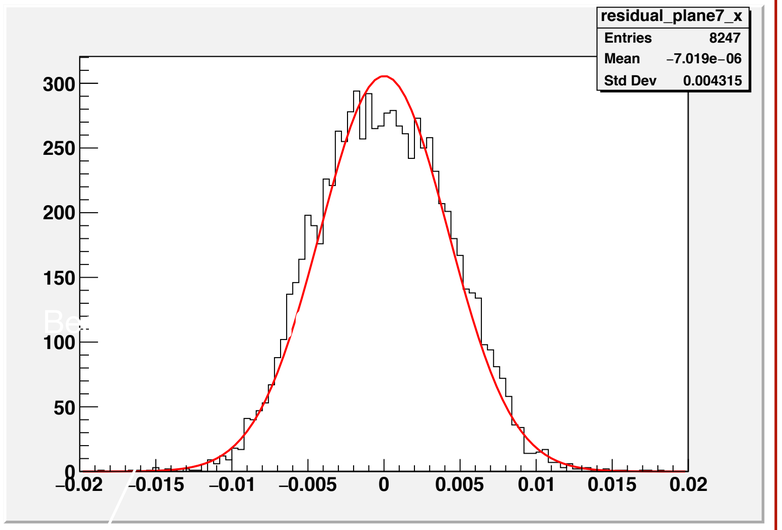


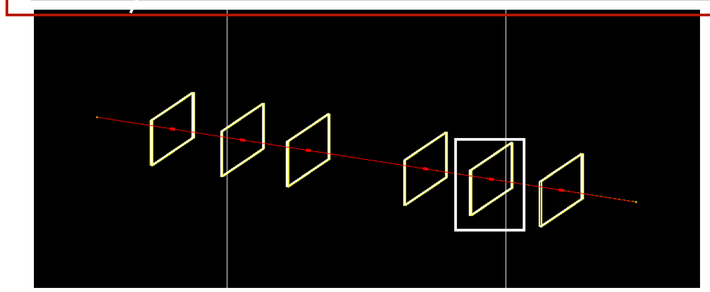


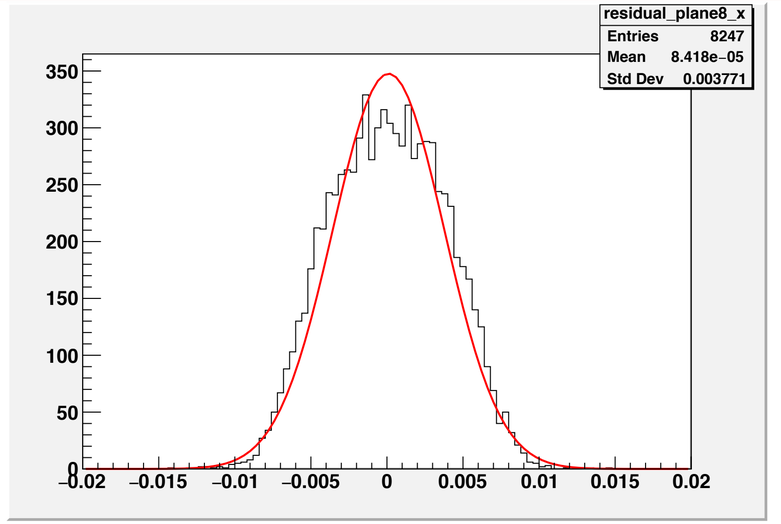
Adding detector smearing effect 7um



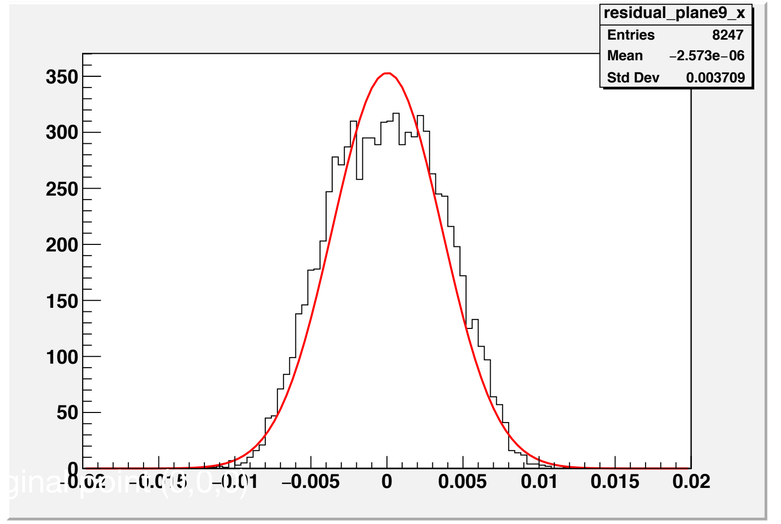
sigma=4.35um

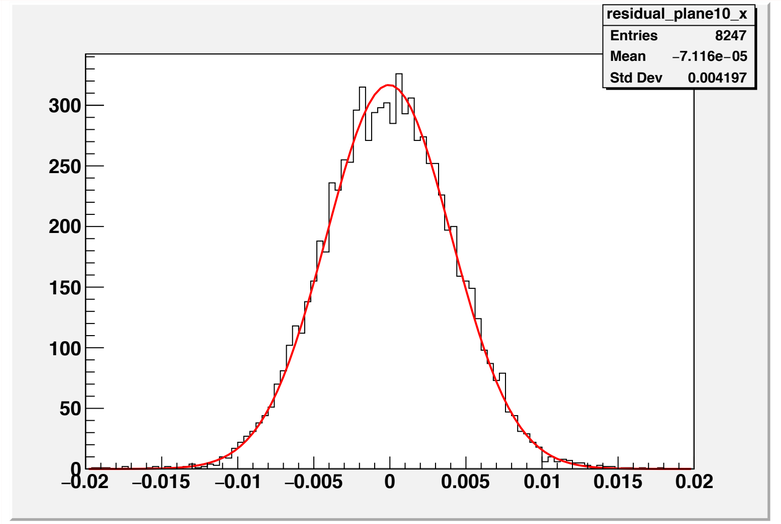






sigma=3.7um





sigma=4.2um