Update on ALPIDE telescope data analysis

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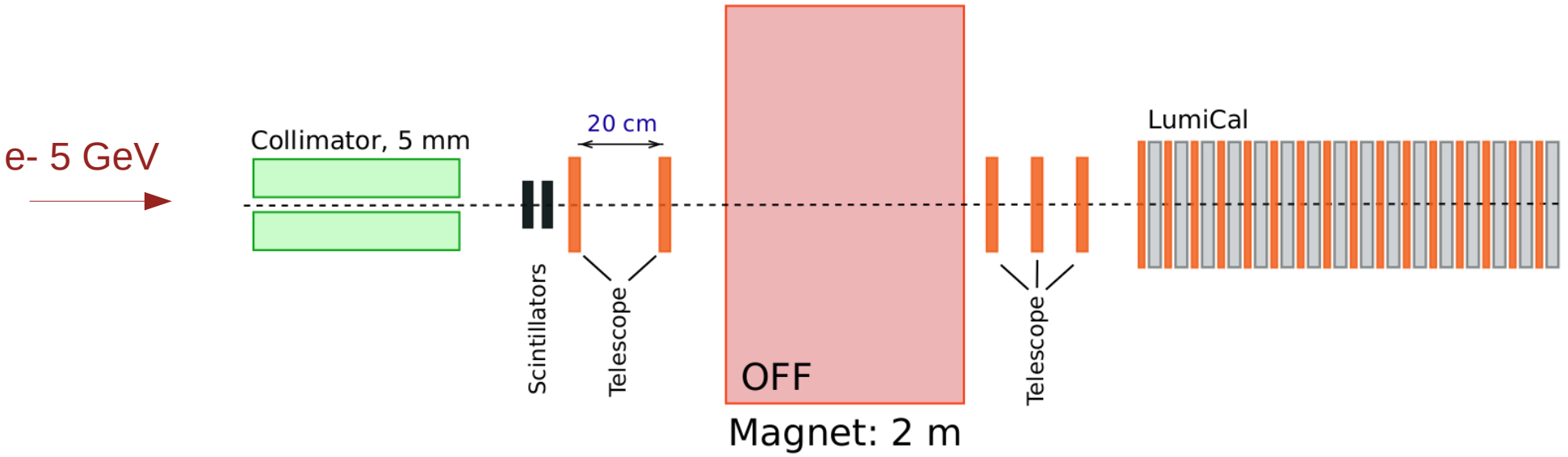
FCAL meeting
February 05, 2020

Outline

- Telescope planes alignment and track reconstruction performance;
  - 5 planes;
  - 3 planes;
  - 4 planes;

Setup 1



- Measure the effect of the air ~2 m.
- Collimator with 5 mm square cross section?

Data processing

- Data converter from raw format to LCIO
- Eutelescope software. It uses ILC software:
  - for geometry settings (GEAR)
  - Marlin (Modular Analysis and Reconstruction for the LINear Collider) for data processing;
  - LCIO for input/output;
  - Converting data to root format;
  - Alignment and track reconstruction.

Noisy pixels (default settings for threshold)

Run 49

```
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Noisy Pixel Finder summary:
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 0
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 1
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 2
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 1 noisy pixels on sensor: 3
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 4
```

Run 60

```
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Noisy Pixel Finder summary:
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jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 1
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 2
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 1 noisy pixels on sensor: 3
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 4
```
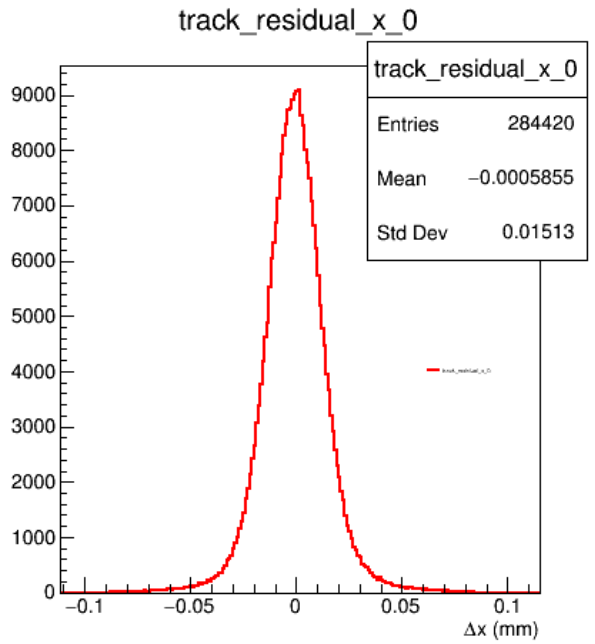
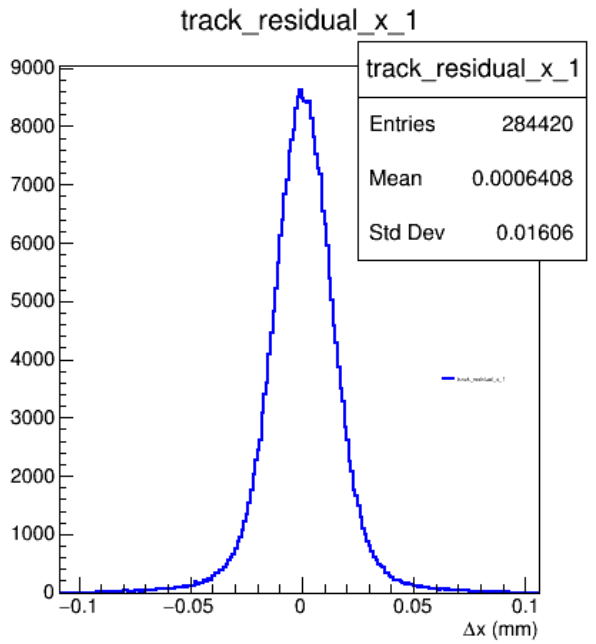
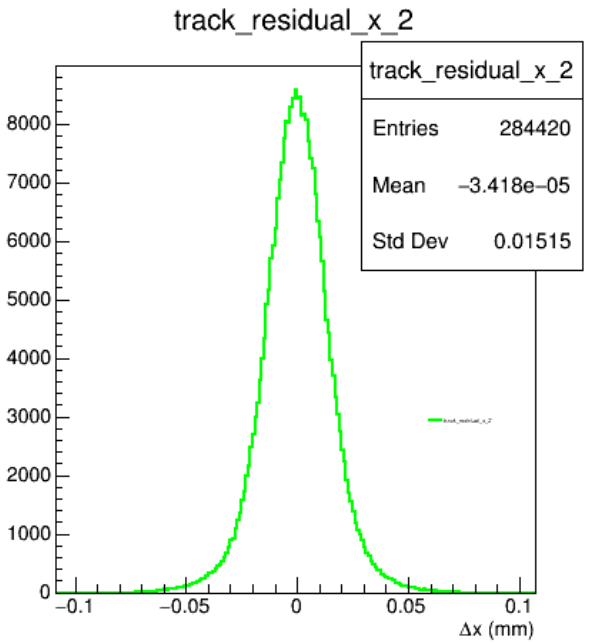
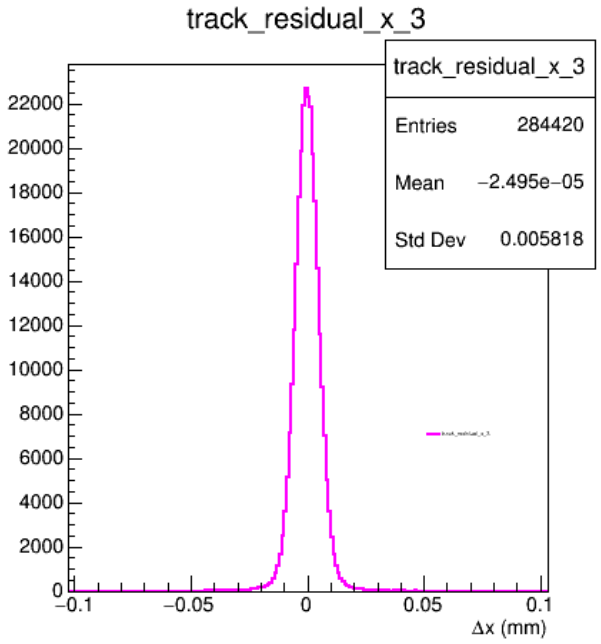
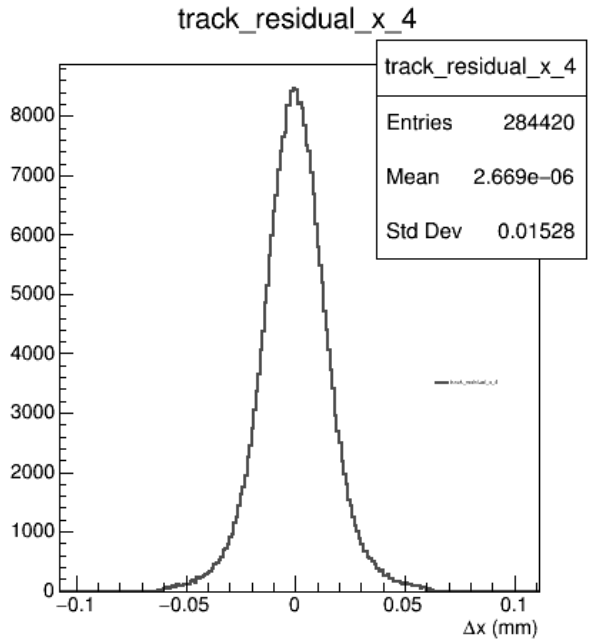

Run 60, Single track fit for all 5 planes



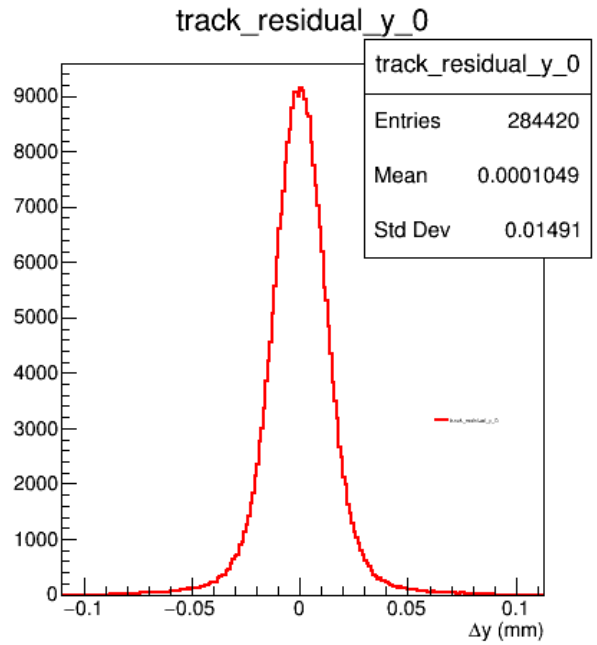


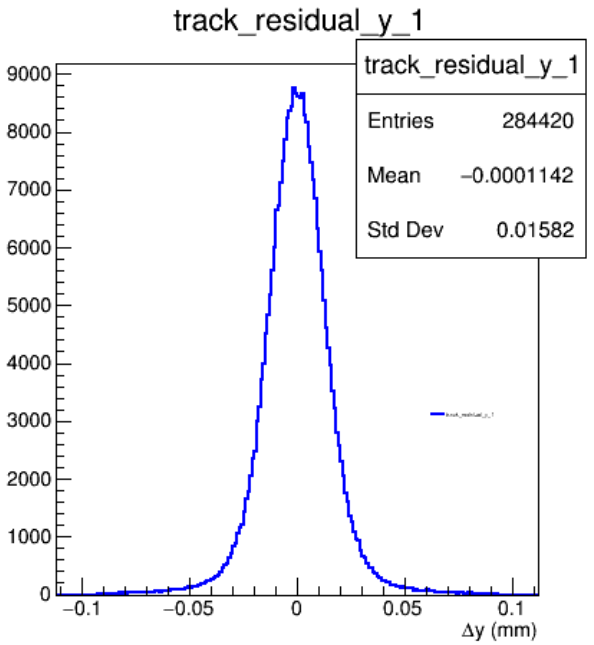


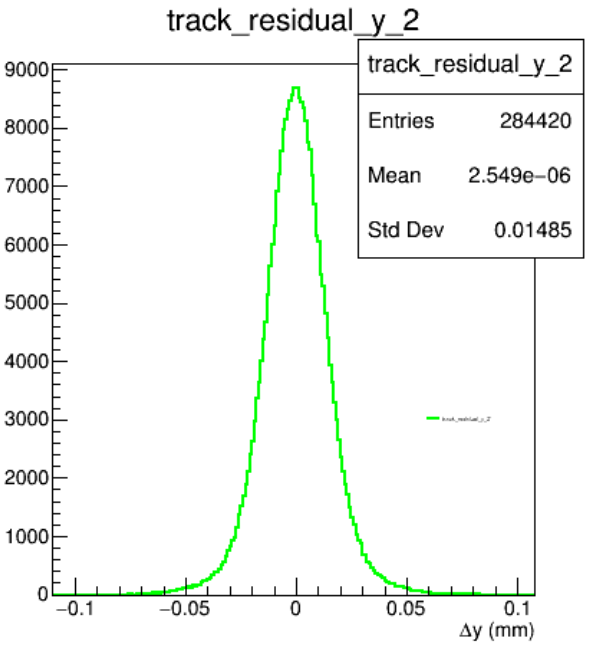


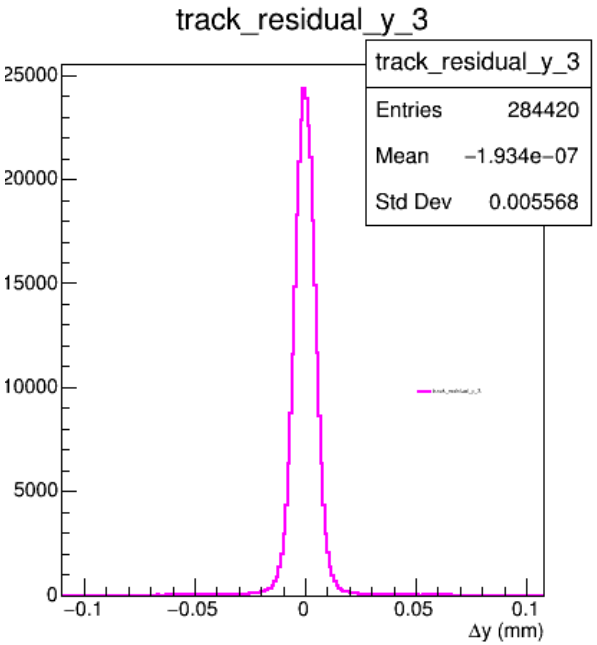


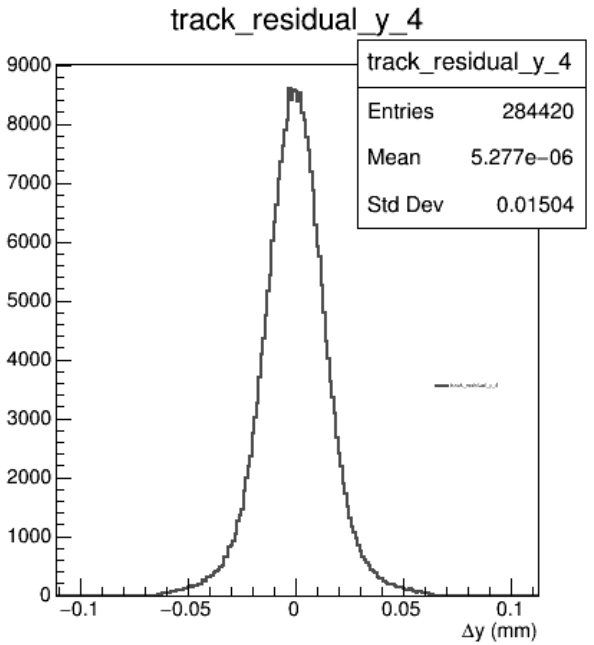
Run 60, Single track fit for all 5 planes



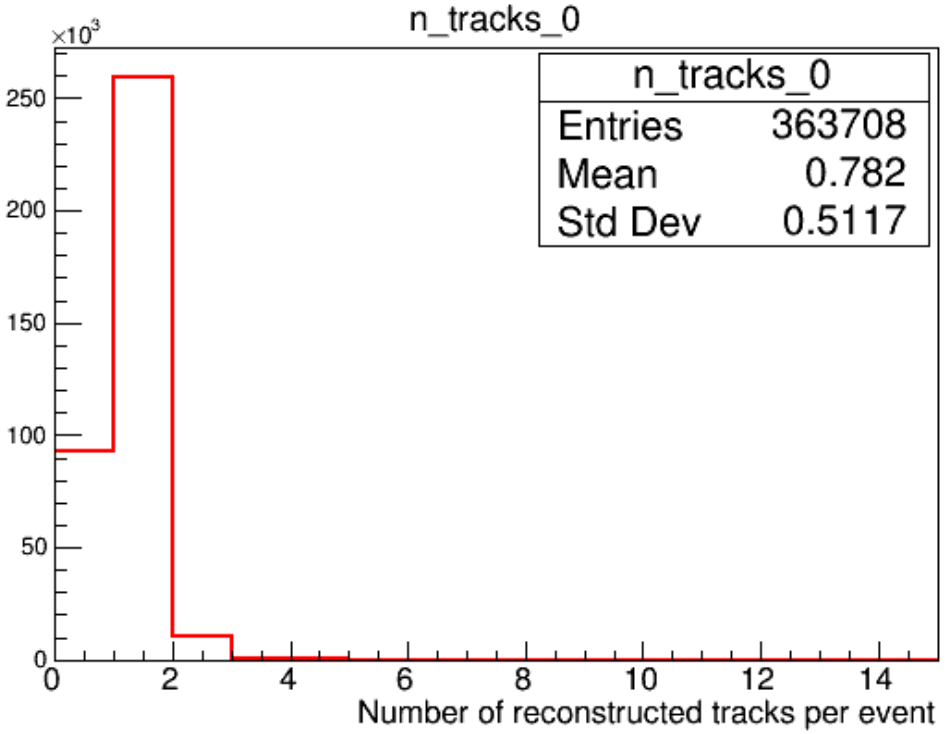


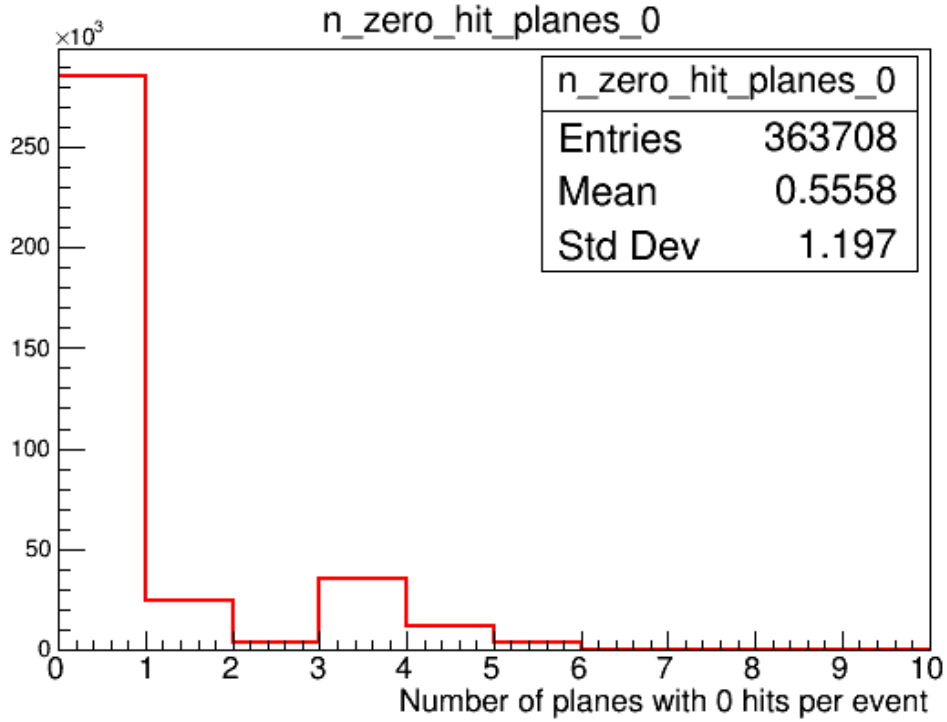


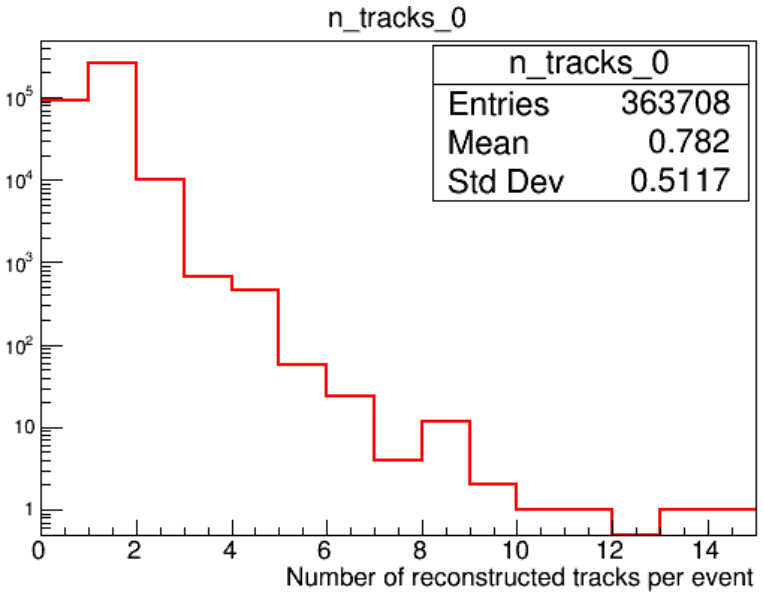




Number of reconstructed tracks

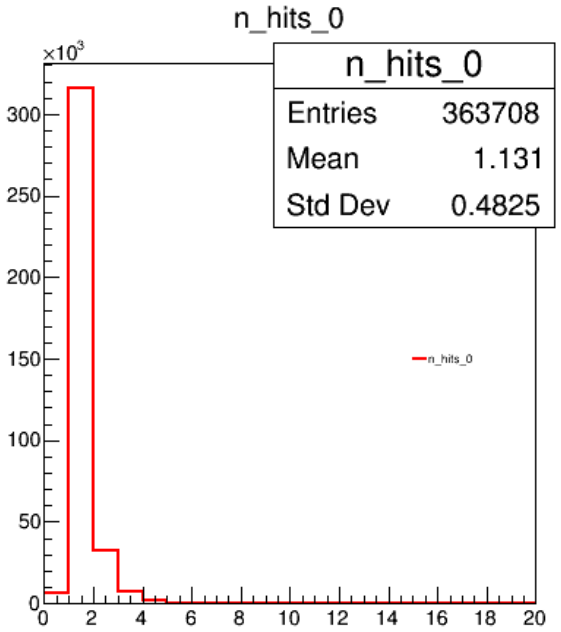


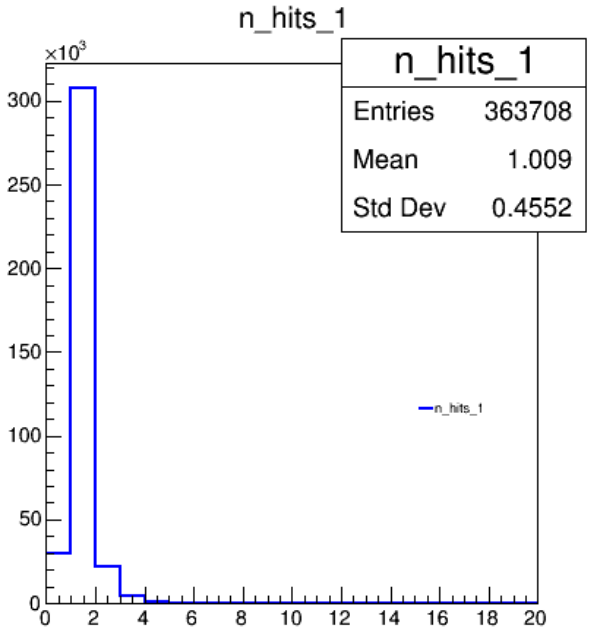


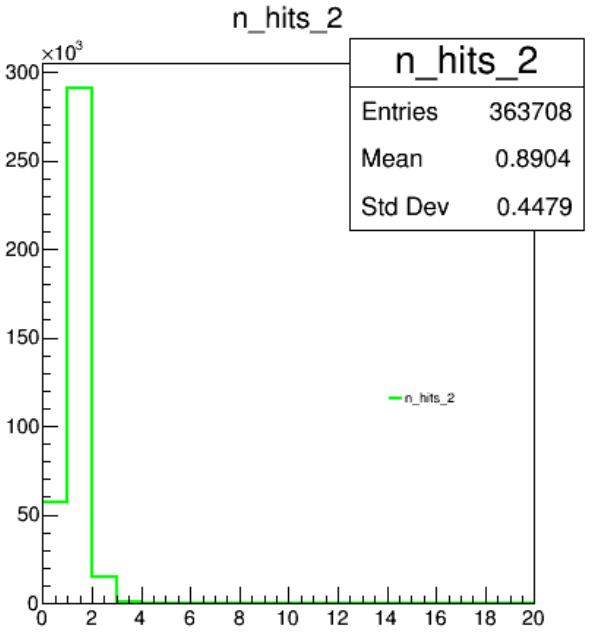


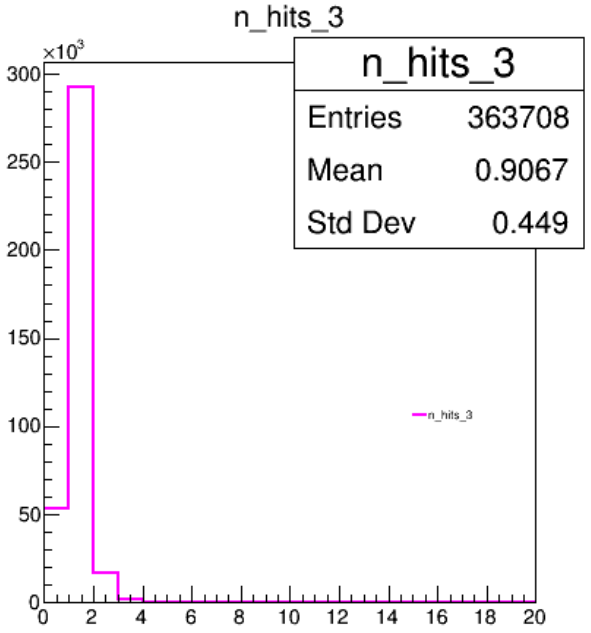
- Number of reconstructed tracks: 284420;
- Number of events with at least one plane with 0 hits: 78640;
- 363708 – 78640 = 285068;
- 285068 – 284420 = 648 - number of events without reconstructed track but with hits in all planes.

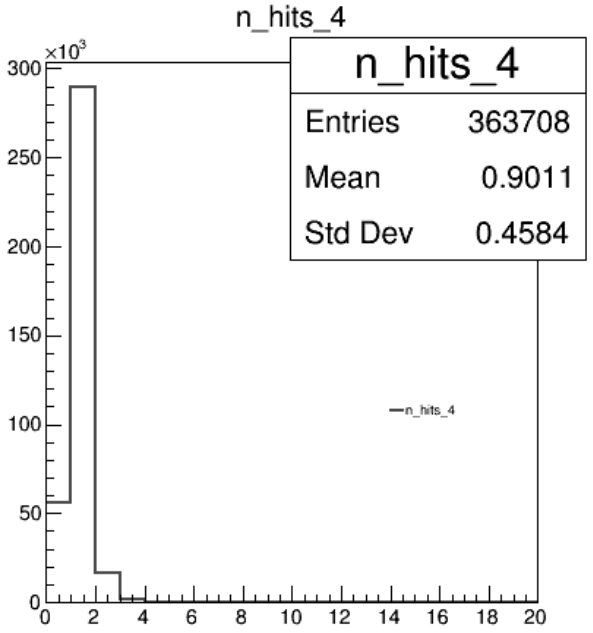
Number of clusters per plane



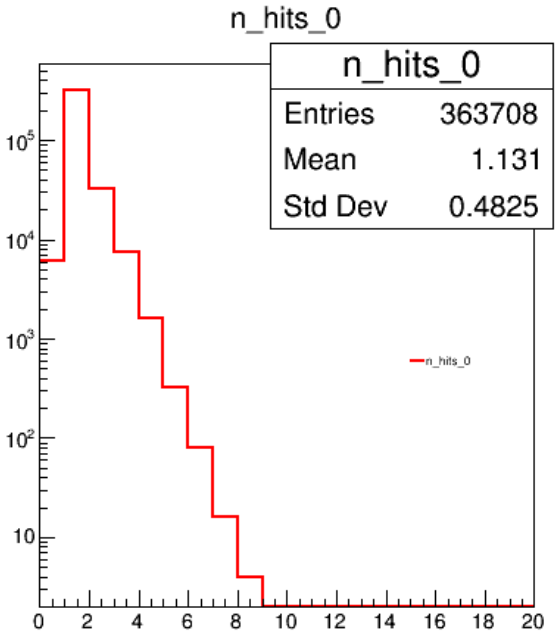


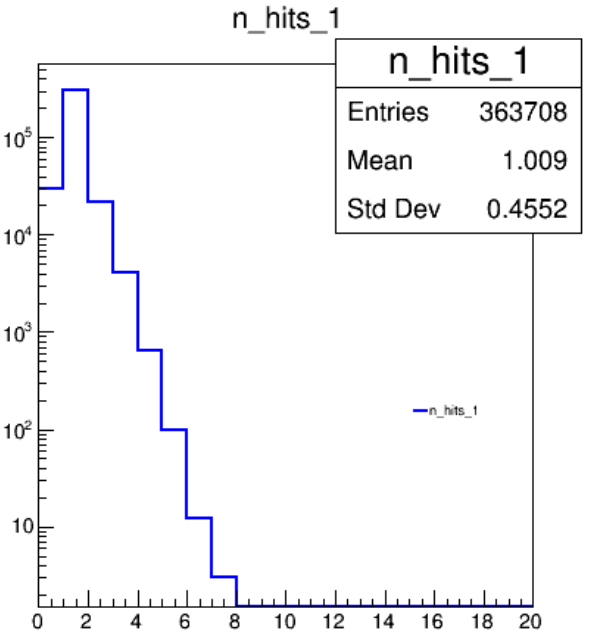


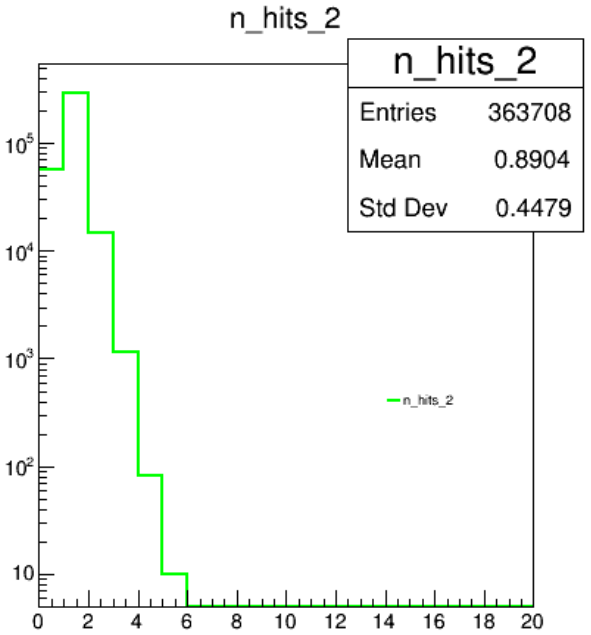


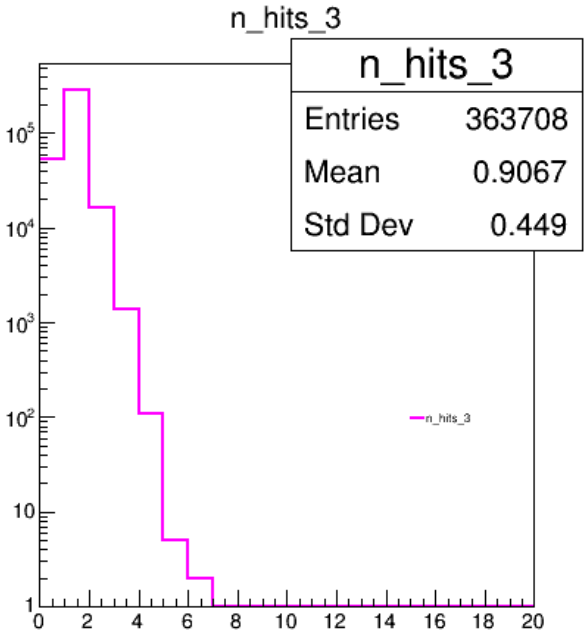


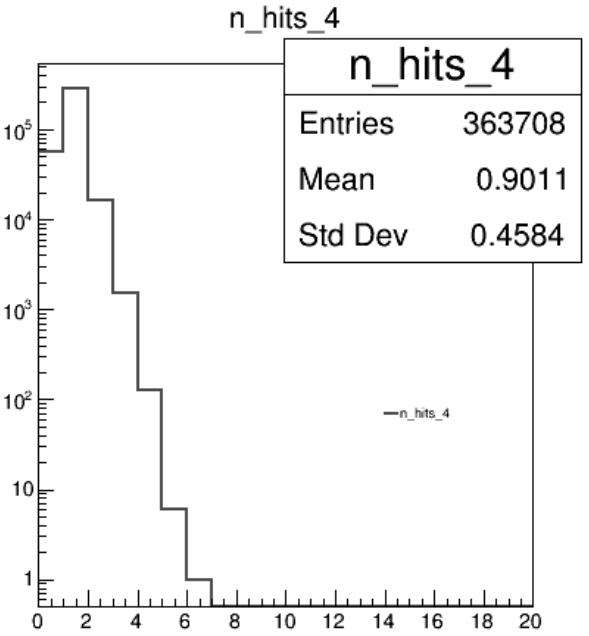
Number of clusters per plane





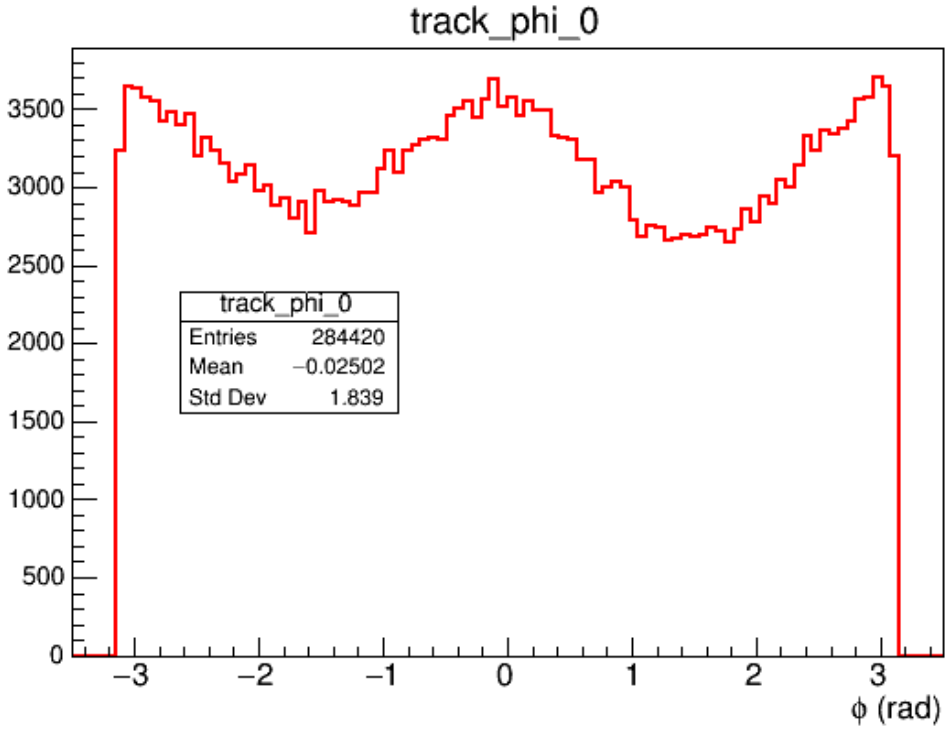


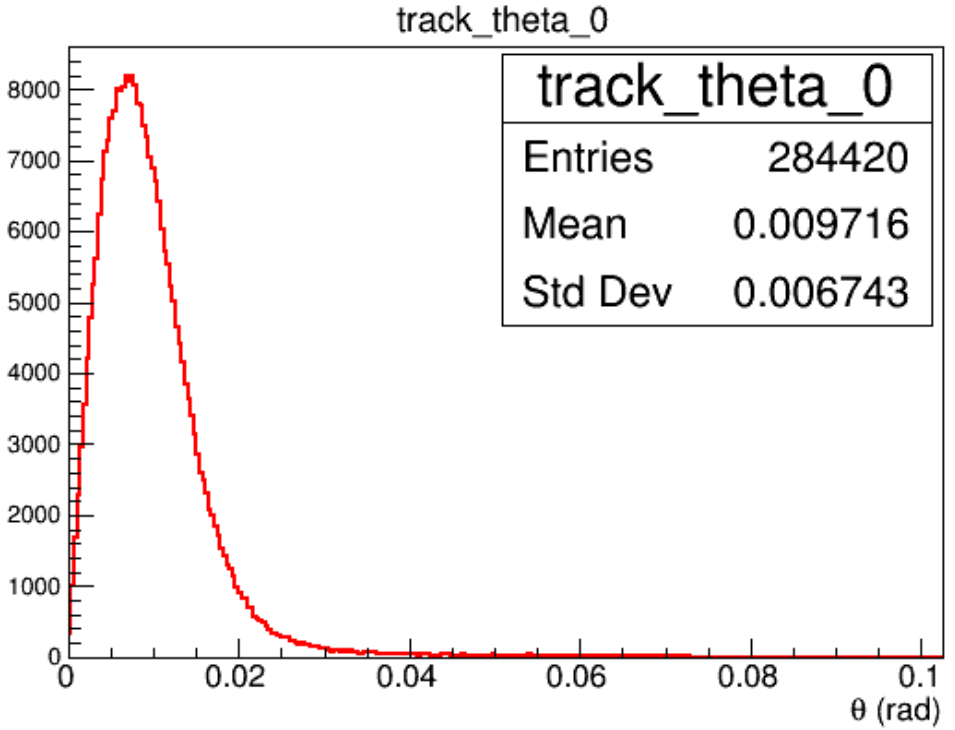




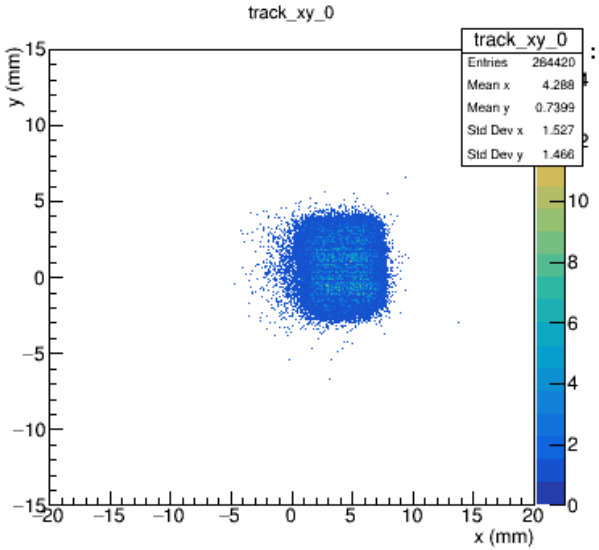
- Seems to be too many events with many (4+) tracks reconstructed;
- Need to check it.

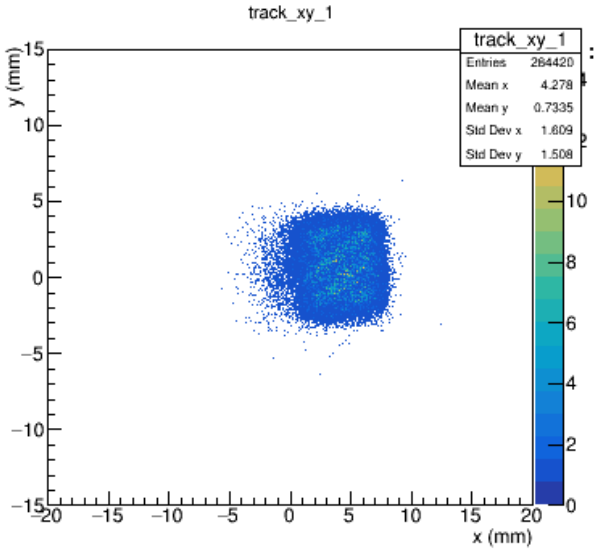
Angular distributions of the tracks

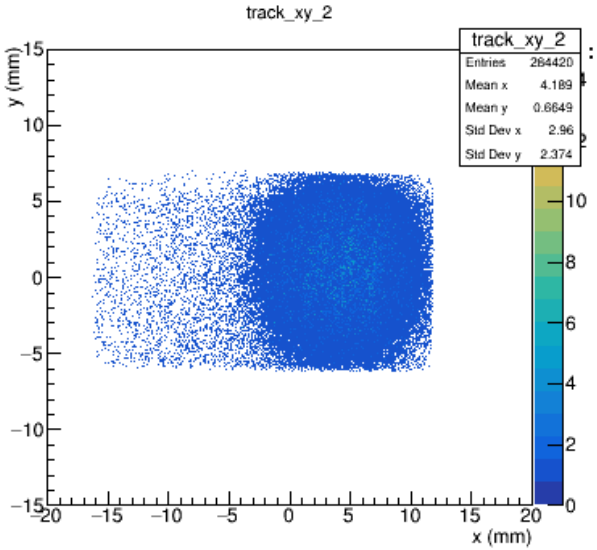


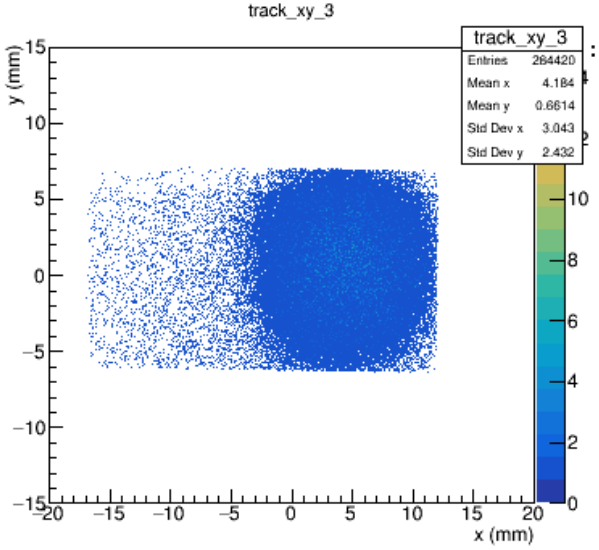


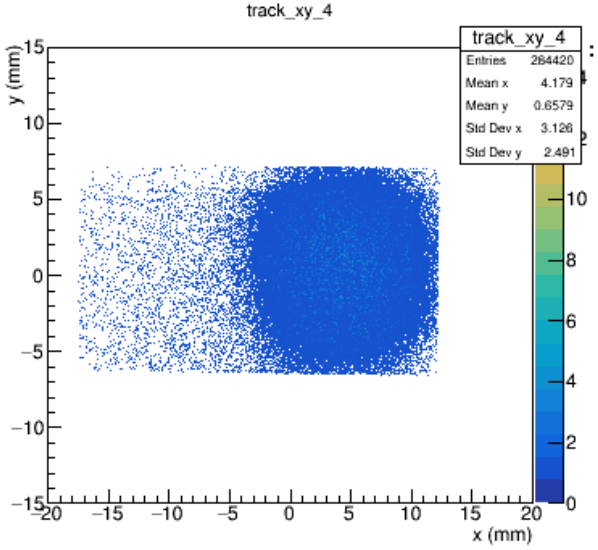
Hits assigned to tracks



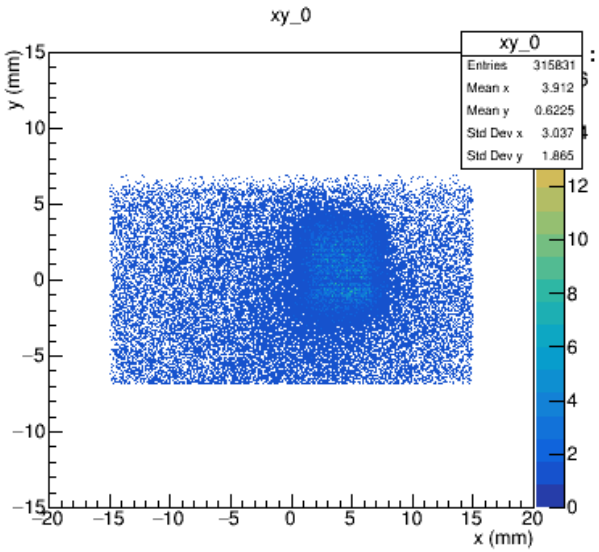


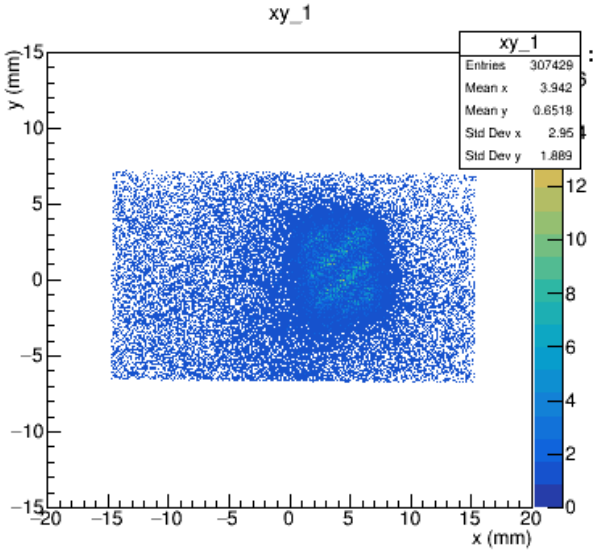


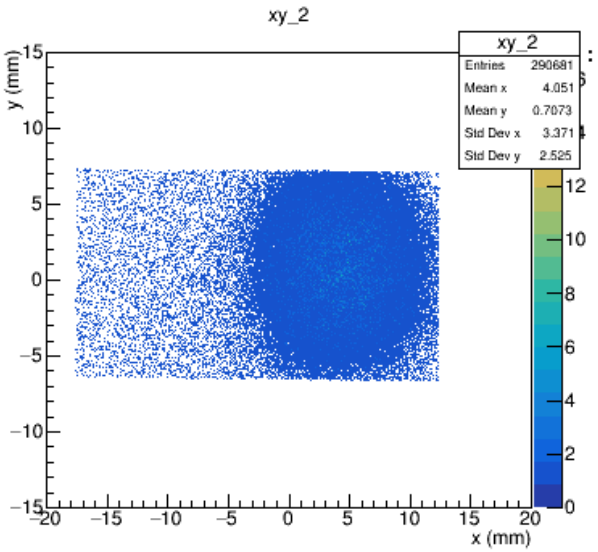


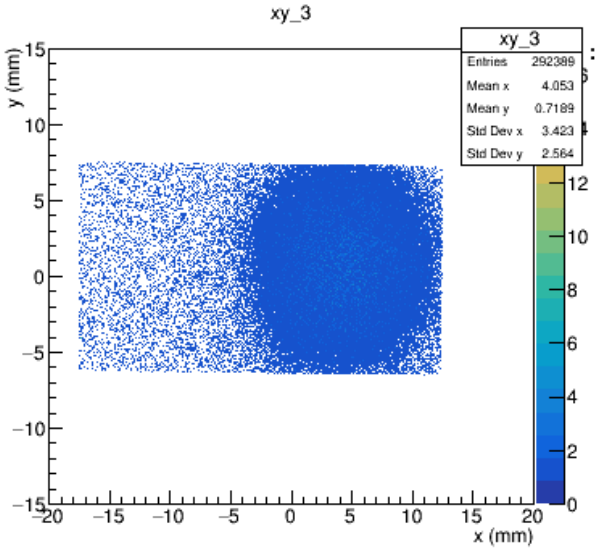


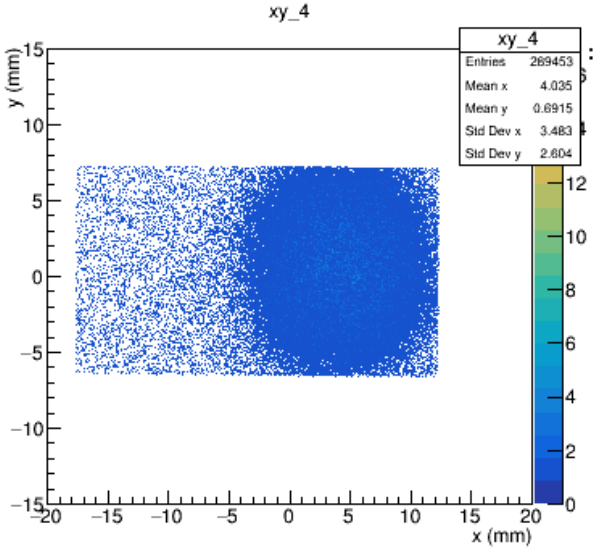
All hits


xy_0
xy_0
Entries 315831
Mean x 3.912
Mean y 0.6225
Std Dev x 3.037
Std Dev y 1.865
y (mm)
x (mm)

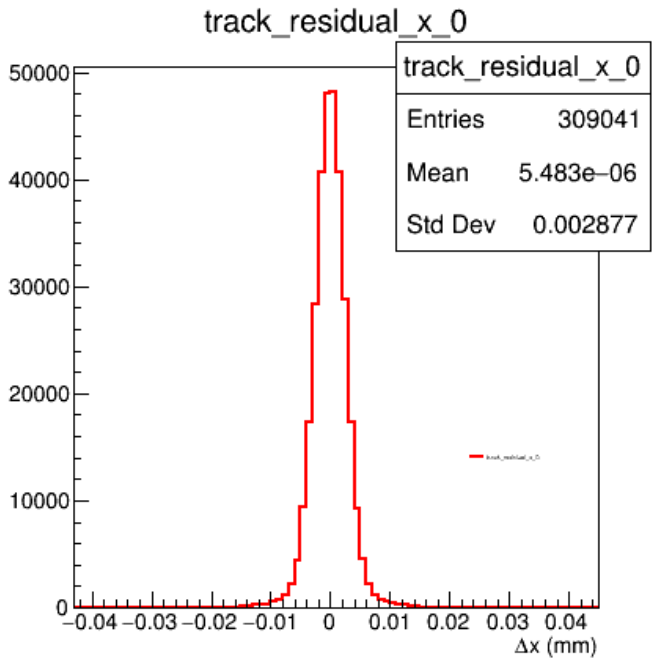

xy_1
xy_1
Entries 307429
Mean x 3.942
Mean y 0.6518
Std Dev x 2.95
Std Dev y 1.889
y (mm)
x (mm)

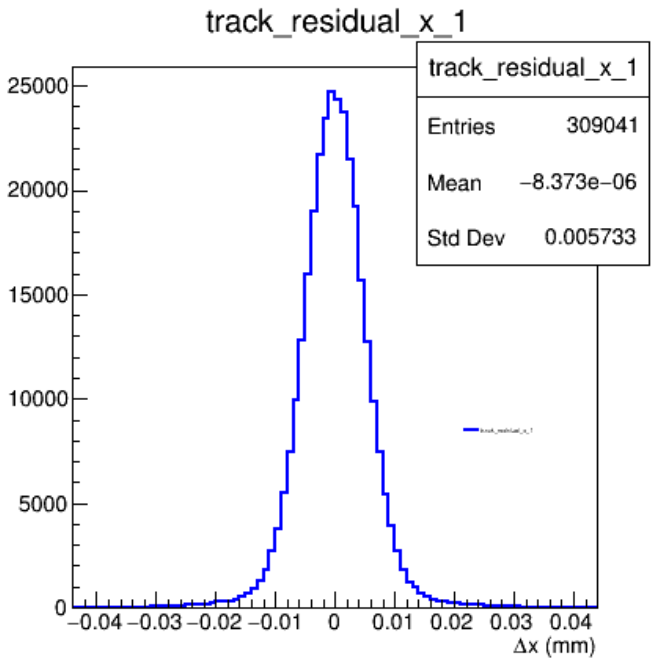

xy_2
xy_2
Entries 290681
Mean x 4.051
Mean y 0.7073
Std Dev x 3.371
Std Dev y 2.525
y (mm)
x (mm)

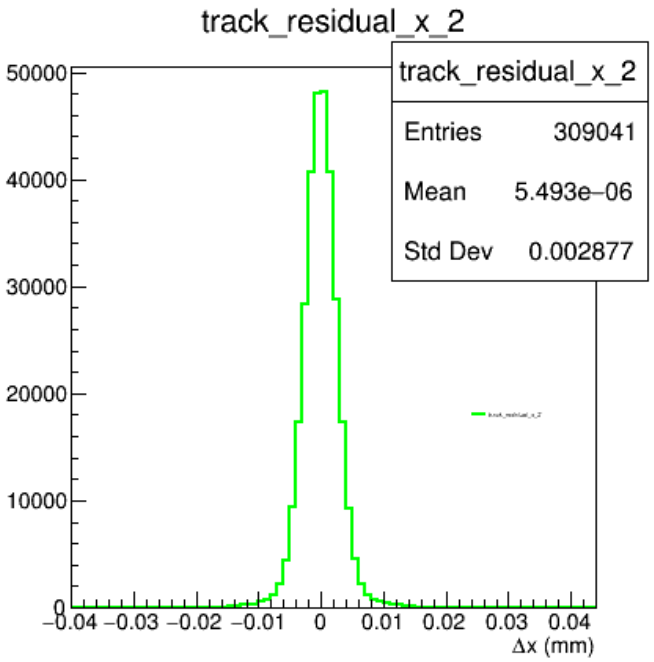

xy_3
xy_3
Entries 292389
Mean x 4.053
Mean y 0.7189
Std Dev x 3.423
Std Dev y 2.564
y (mm)
x (mm)

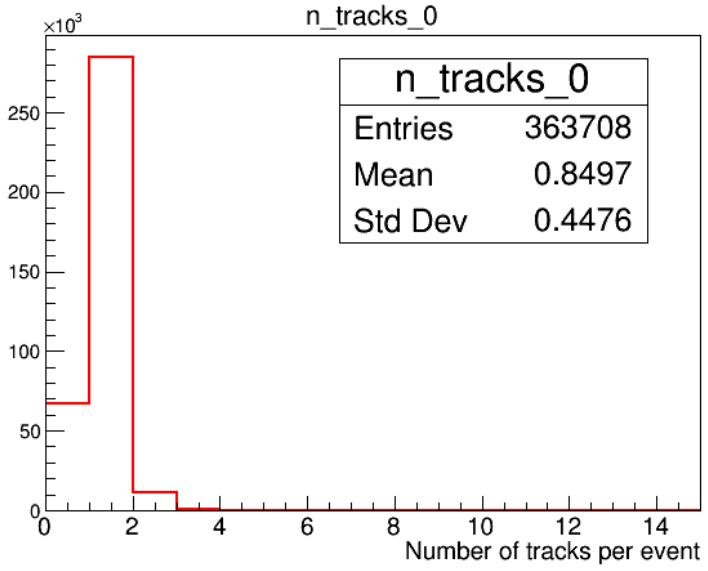

xy_4
xy_4
Entries 269453
Mean x 4.035
Mean y 0.6915
Std Dev x 3.483
Std Dev y 2.604
y (mm)
x (mm)

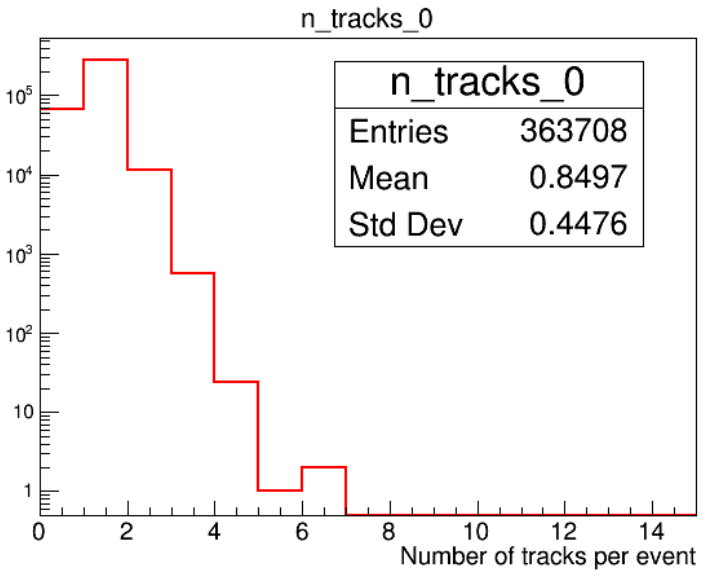
Track reconstruction in three planes after the magnet



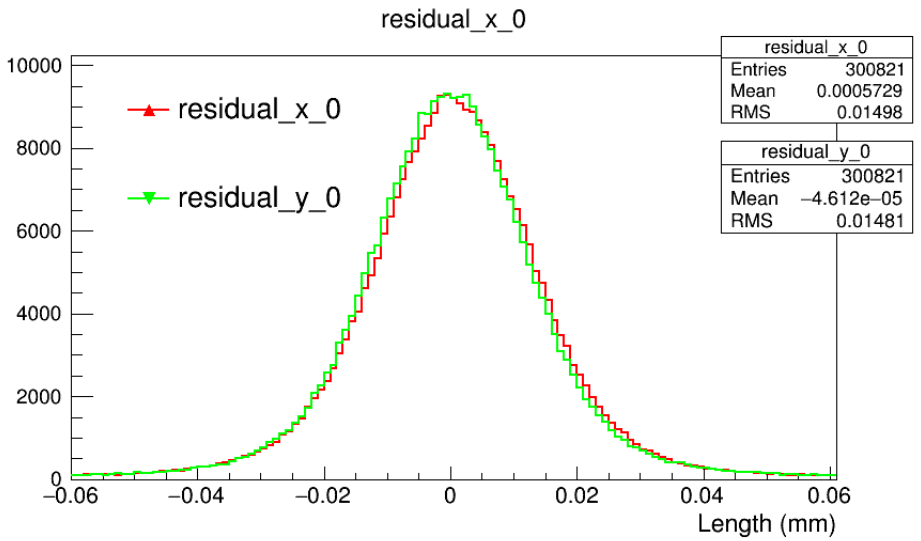


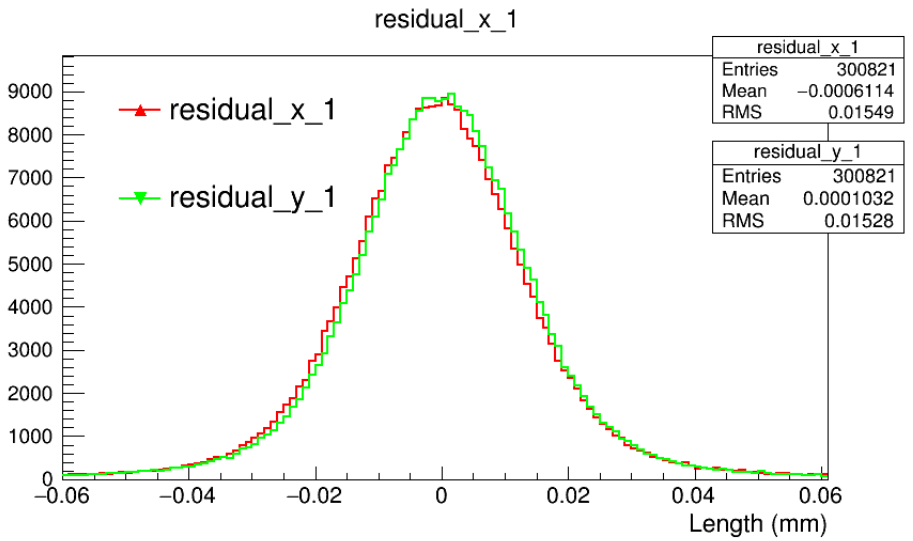


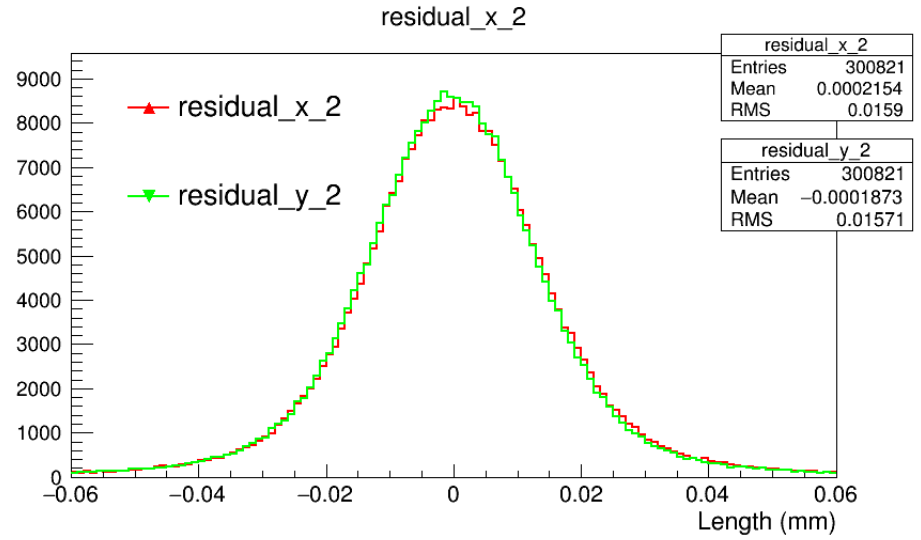


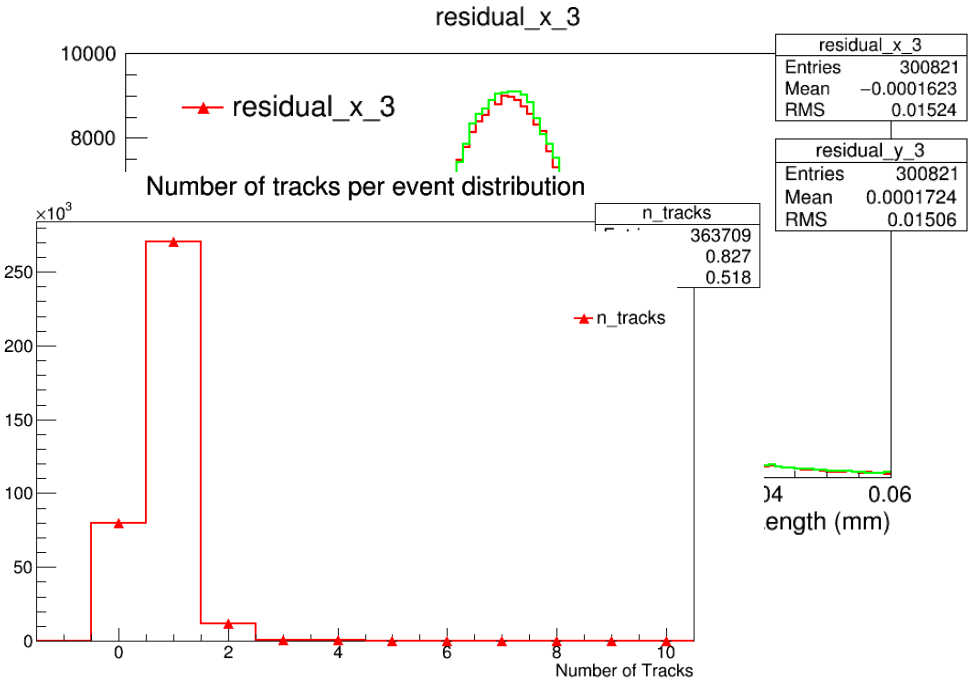


Test with 4 planes: 1,2 and 3,5









ALPIDE spacial resolution

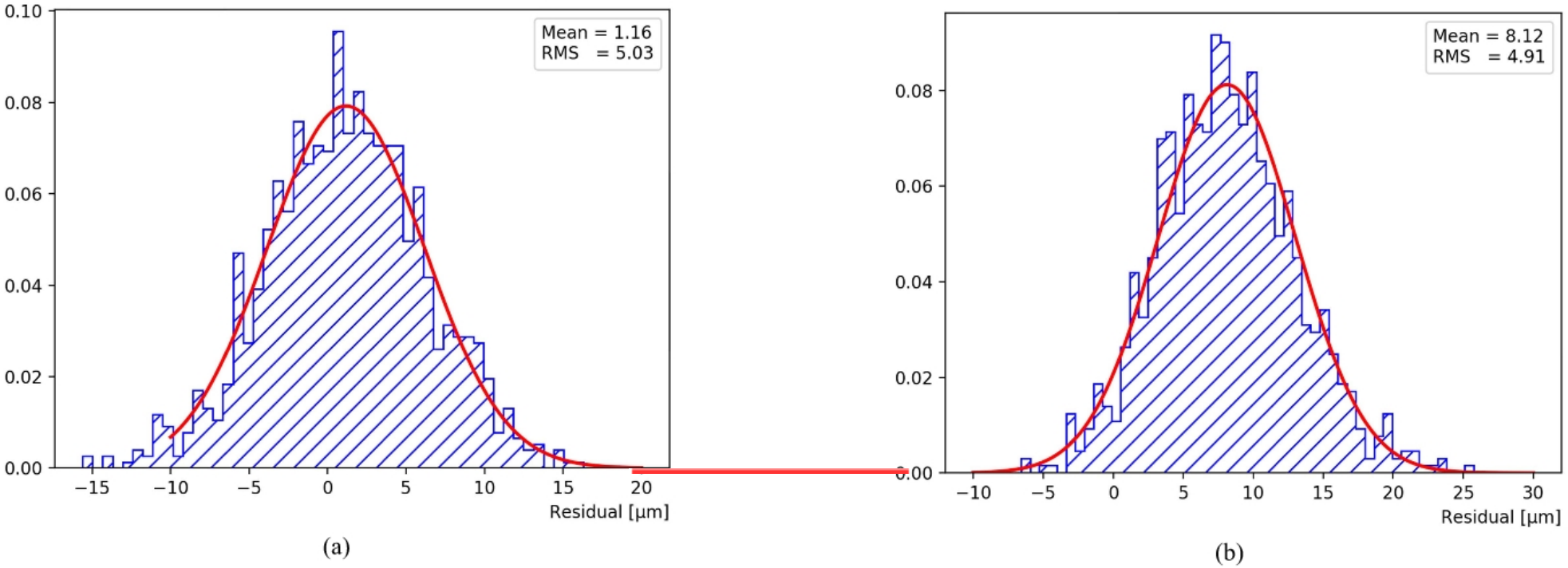


Fig. 17.Residual distribution for stage movements in (a)X-direction and(b)Y-direction. Red line: Gaussian fit results.

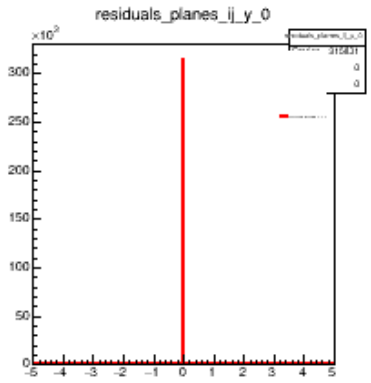
in the X-direction of the XY stage, and 4.91 μm in the Y-direction. The influence of the XY stage movement resolution was rather small and ignored. The mean values being not zero were caused by the error in the measurement at the origin position. Taking the rotation angle between the ALPIDE chip and the XY stage into consideration, the resolution was calculated to be 5.18 μm in the X-direction of ALPIDE chip where the pixel size is 29.24μm, and 4.75 μm in the Y-direction where the pixel size is 26.88 μm.

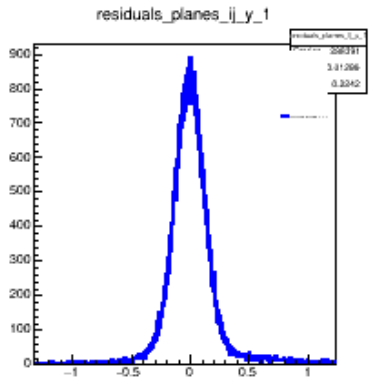
Summary

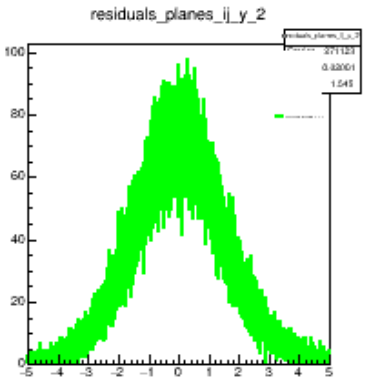
- Converter for ALPIDE raw data to LCIO works reasonably well.
- Noisy pixel analysis, clustering and hits reconstruction produces reasonable results.
- Alignment procedure converges reasonably well after good prealignment.
- Track reconstruction test for one run (run 60). Look reasonable, but some tuning of reconstruction algorithm parameters are needed.
- Continue with other runs and analysis of scattering angle.

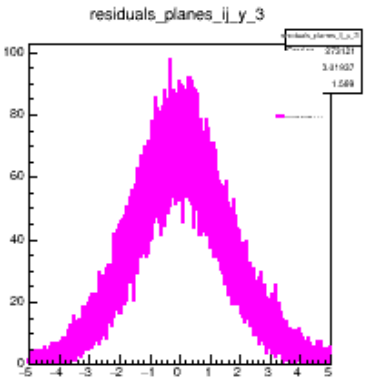
Back up

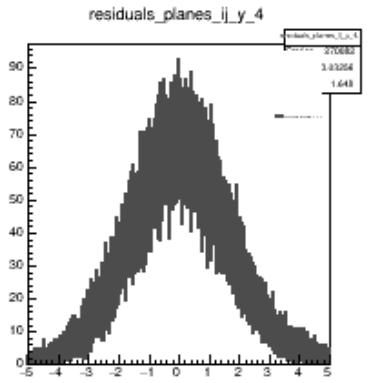
Prealignment. Y correlations between planes

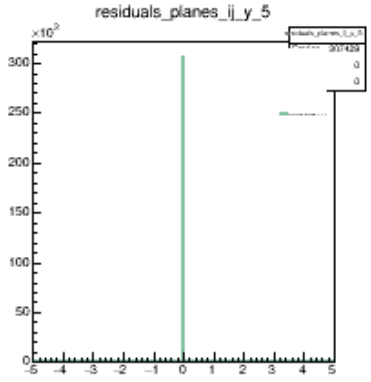


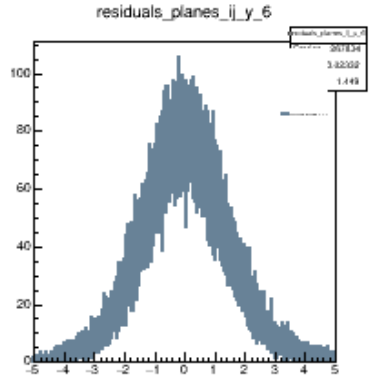


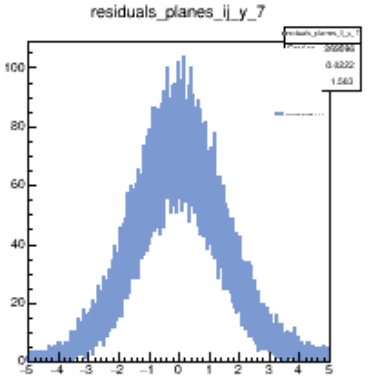


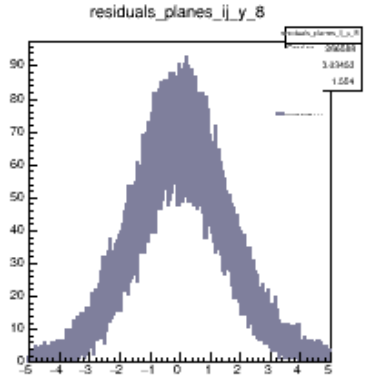


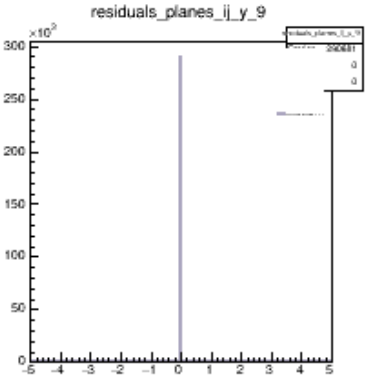


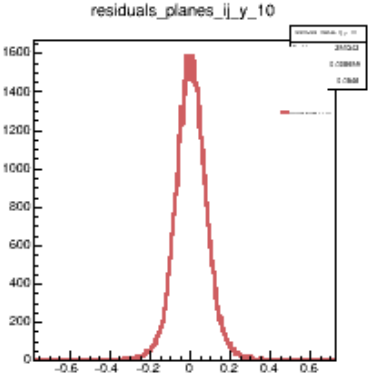


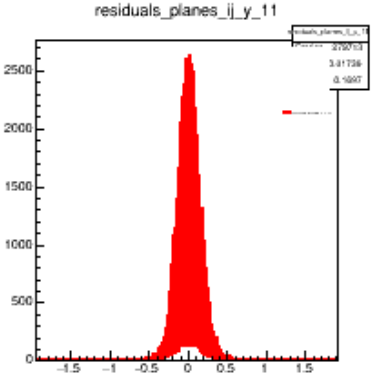


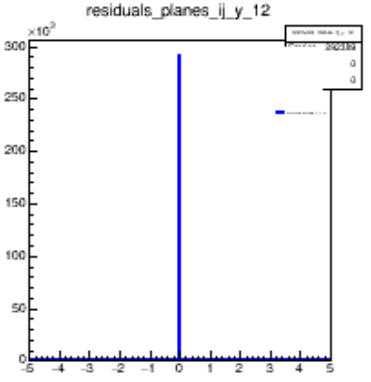


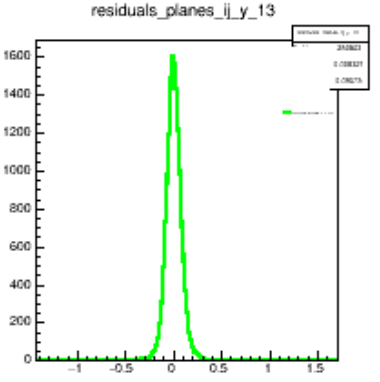


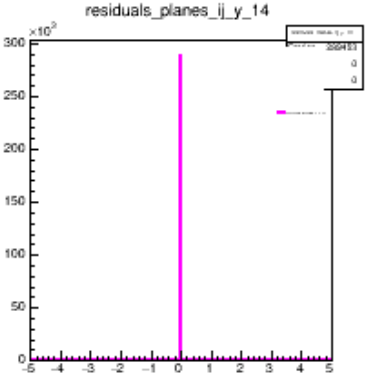




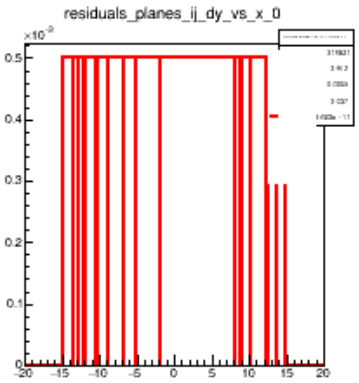


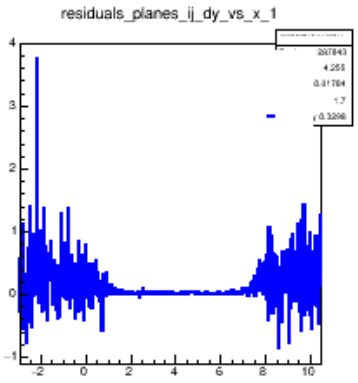


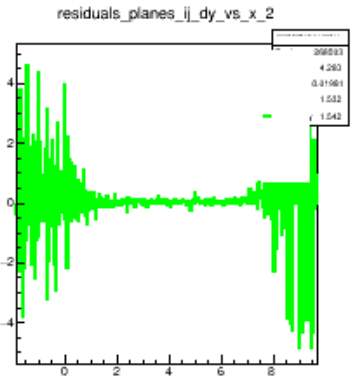


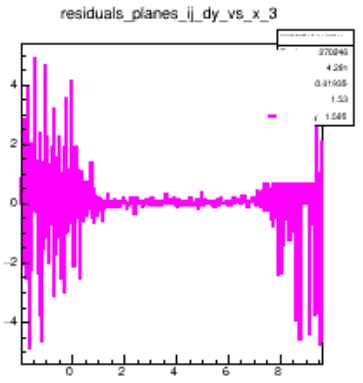


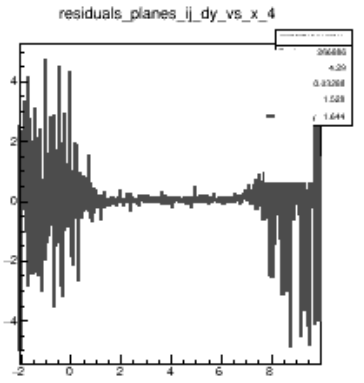
Prealignment of rotation around Z.
Profiling plot of dy vs x distribution.

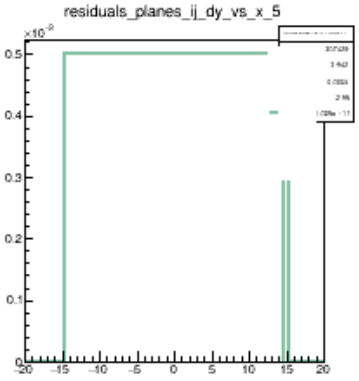


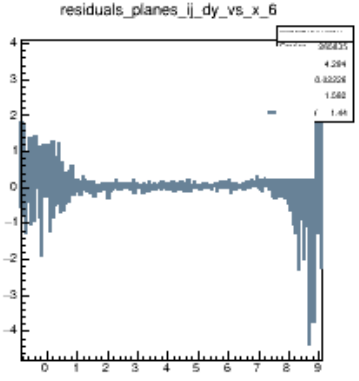


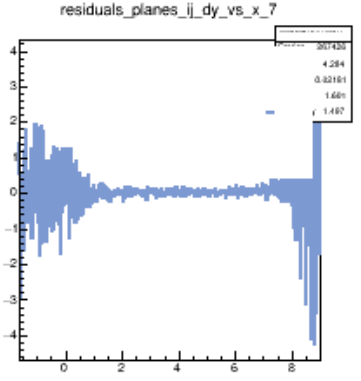


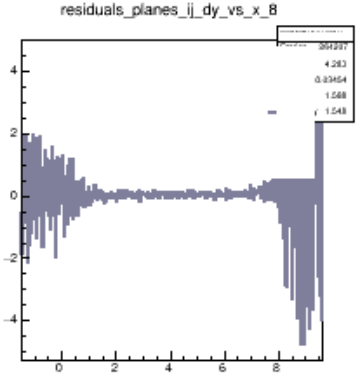


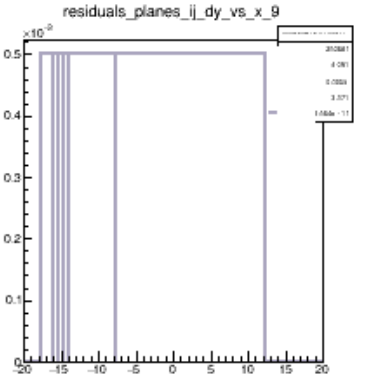


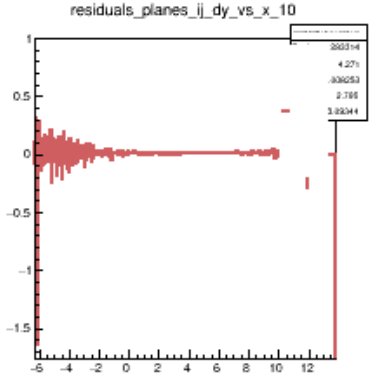


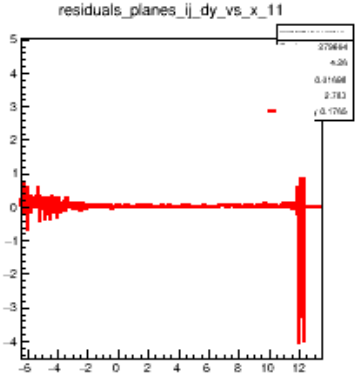


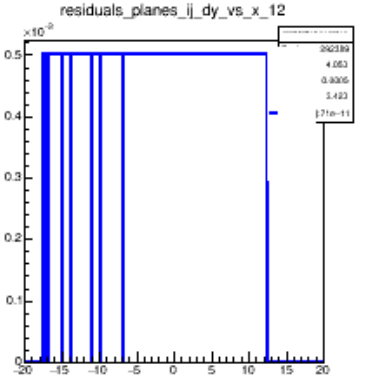


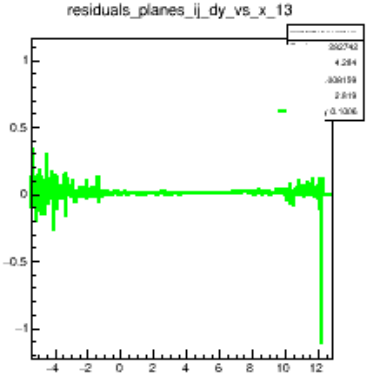


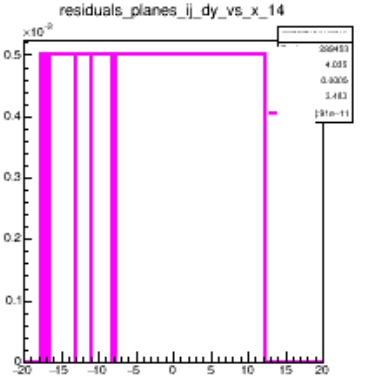












Least square fit of line to 3 points

$$\hat{\mathbf{x}} = (A^T A)^{-1} A^T \mathbf{b}$$

```
(%i1) A: matrix( [x0,1],  [x0+d,1],  [x0+2*d,1]);
```

$$\begin{bmatrix} x0 & 1 \\ x0+d & 1 \\ x0+2\,d & 1 \end{bmatrix}$$

```
(%i2) Y: matrix( [y0],  [y1],  [y2]);
```

$$\begin{bmatrix} y0 \\ y1 \\ y2 \end{bmatrix}$$

```
(%i3) B: ratsimp(invert(transpose(A) . A) . transpose(A) . Y);
```

$$\begin{bmatrix} \frac{y2-y0}{2\,d} \\ -\frac{(-3\,x0-5\,d)\,y0-2\,d\,y1+(3\,x0+d)\,y2}{6\,d} \end{bmatrix}$$

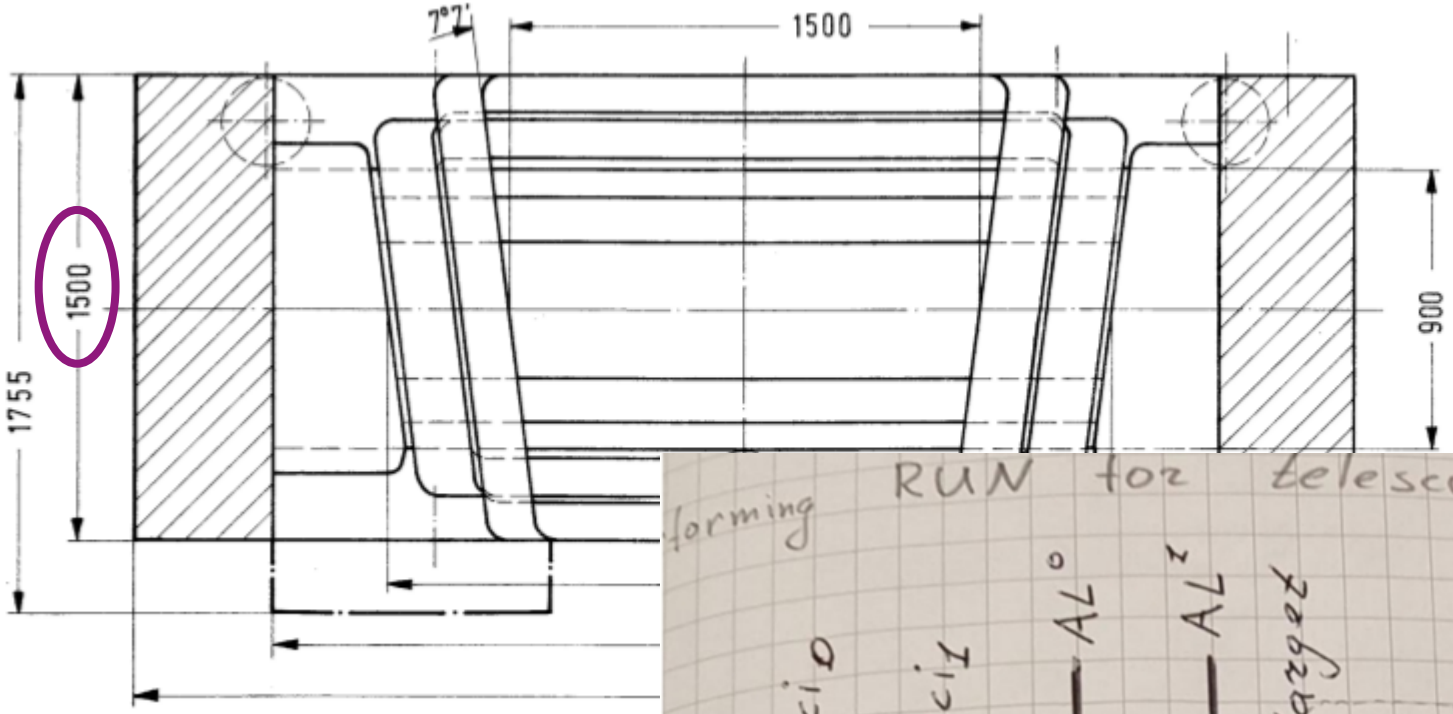
Slope is determined by the two outer points

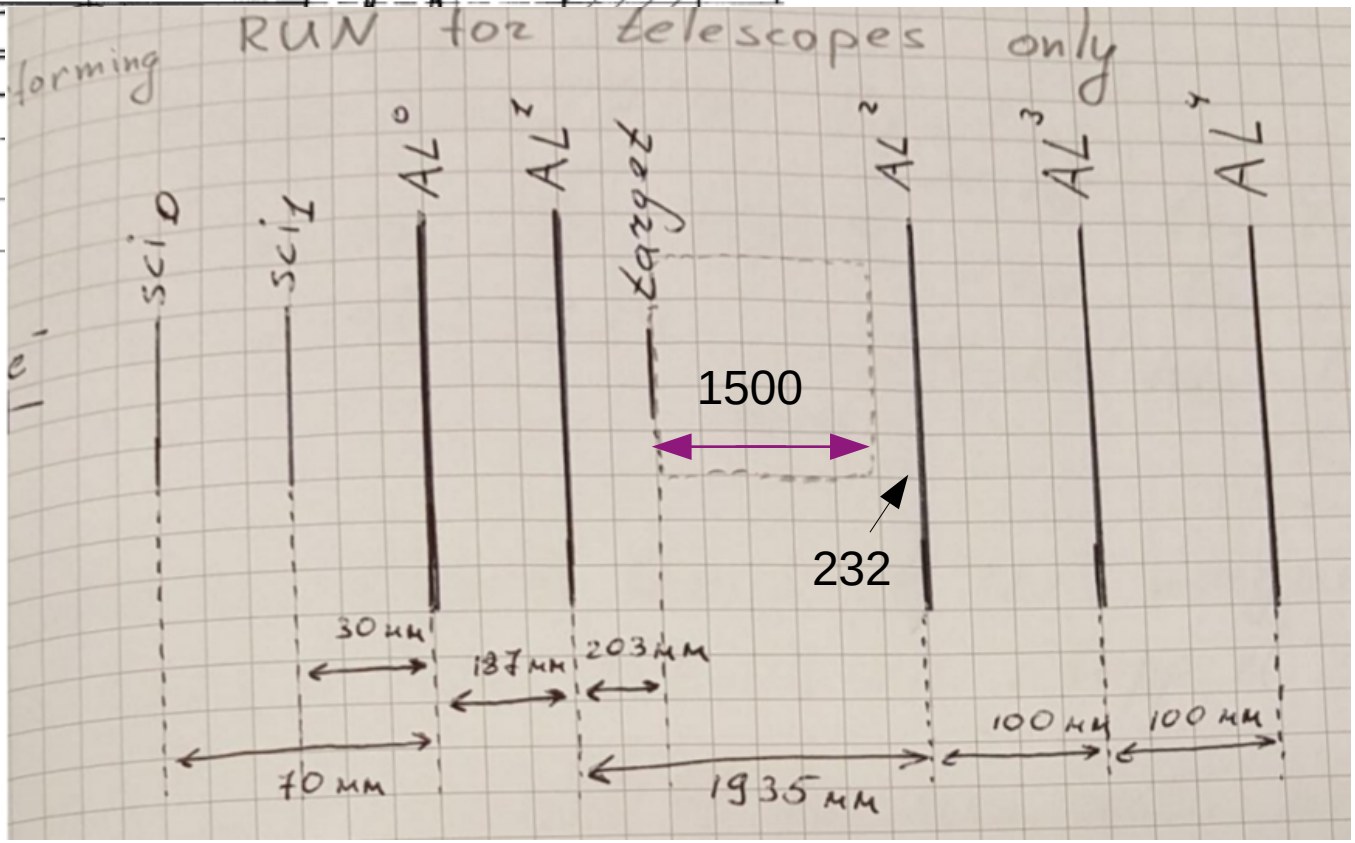
```
(%i4) ratsimp(A . B - Y);
```

$$\begin{bmatrix} -\frac{y0-2\,y1+y2}{6} \\ \frac{y0-2\,y1+y2}{3} \\ -\frac{y0-2\,y1+y2}{6} \end{bmatrix}$$

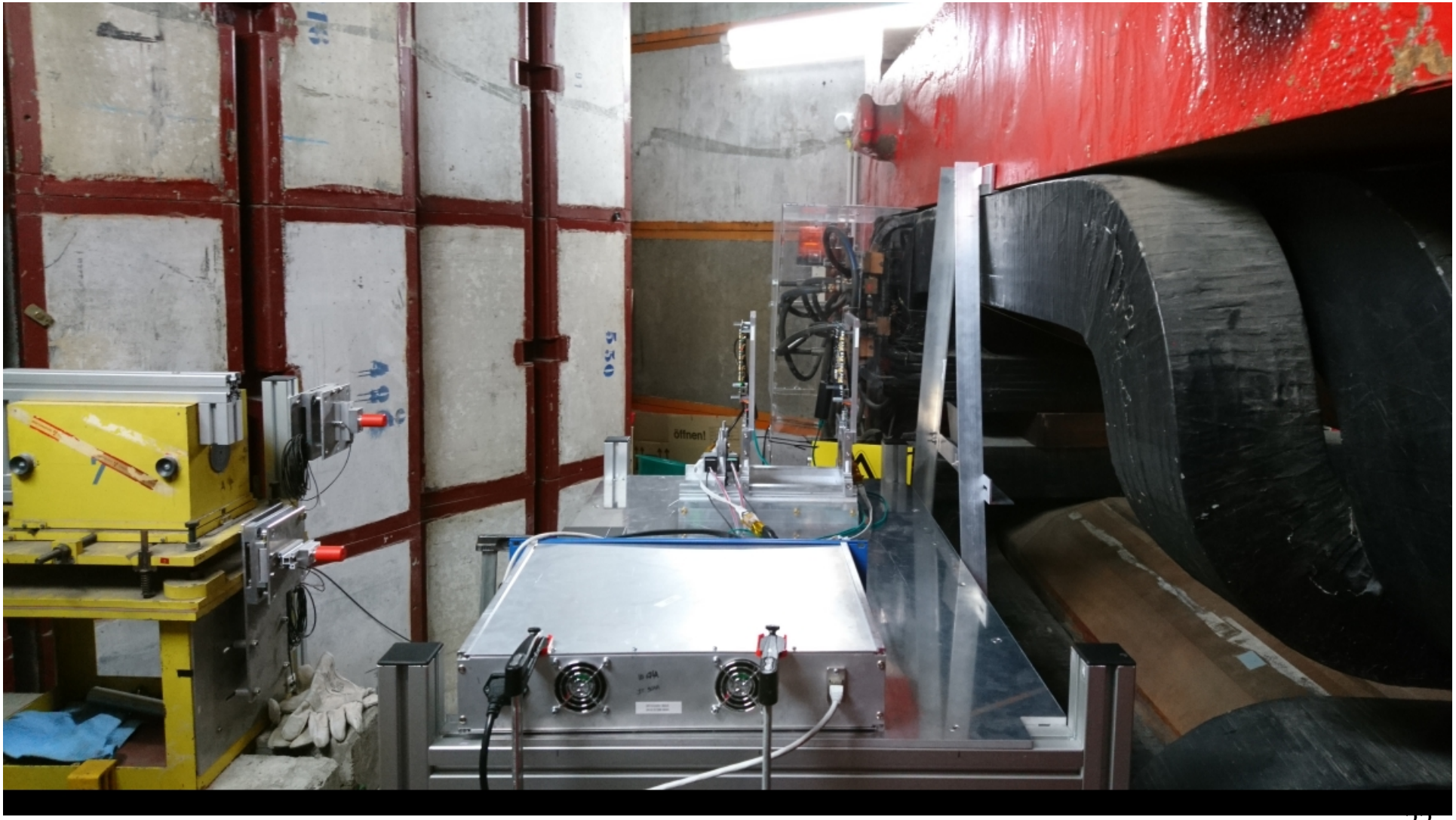
The distance to outer points is twice smaller than to middle one

Magnet and TB setup geometry

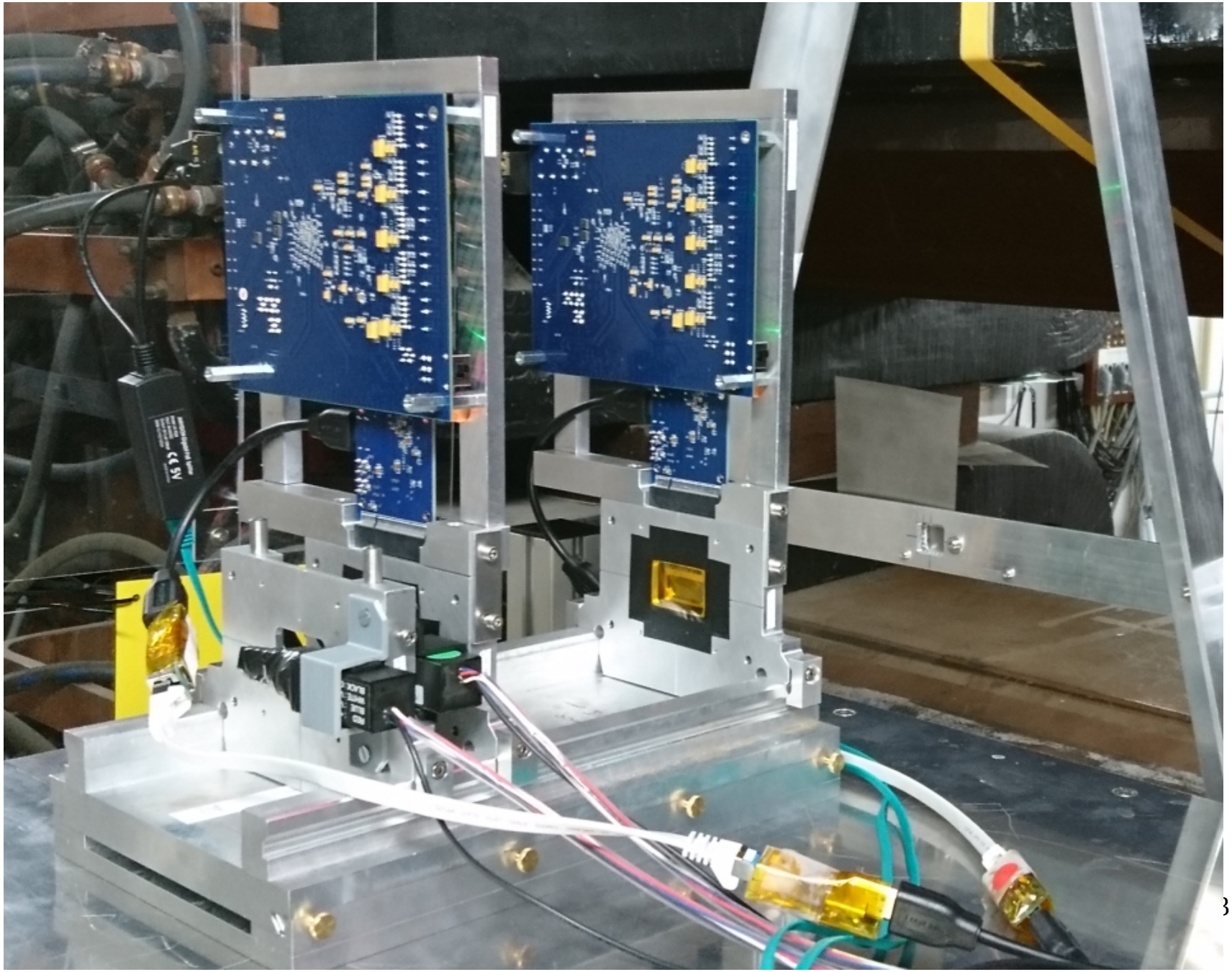




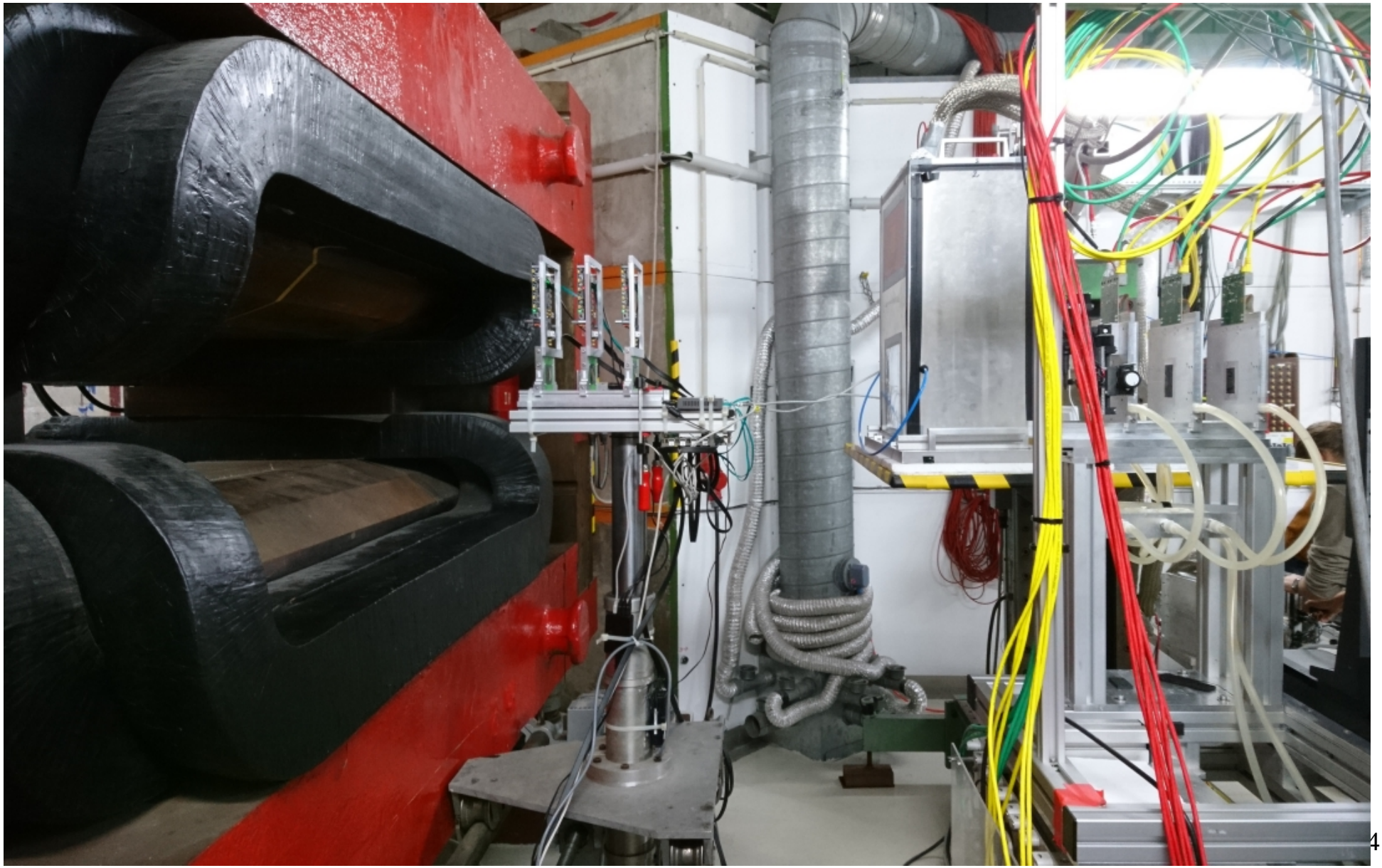
Upstream of the target



Upstream of the target



Downstream of the target



Downstream of the target