Update on ALPIDE telescope data analysis

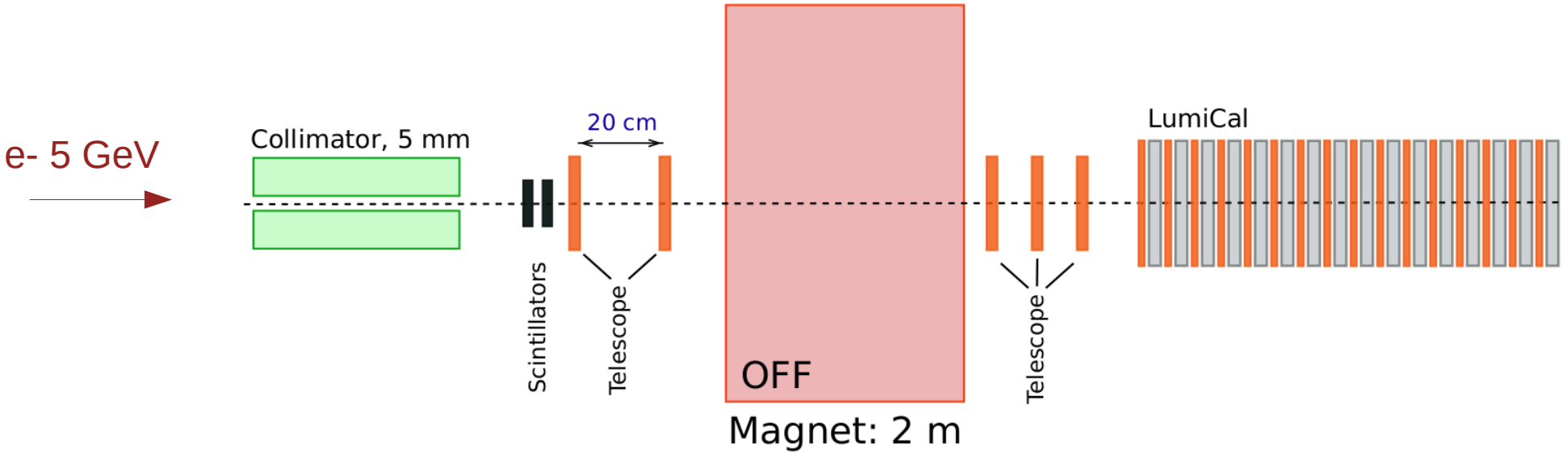
Oleksandr Borysov

LUXE meeting
January 16, 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)

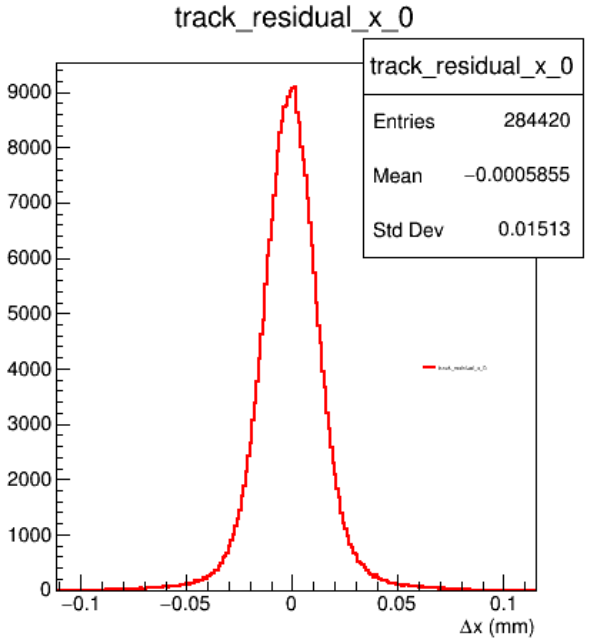
Run 49

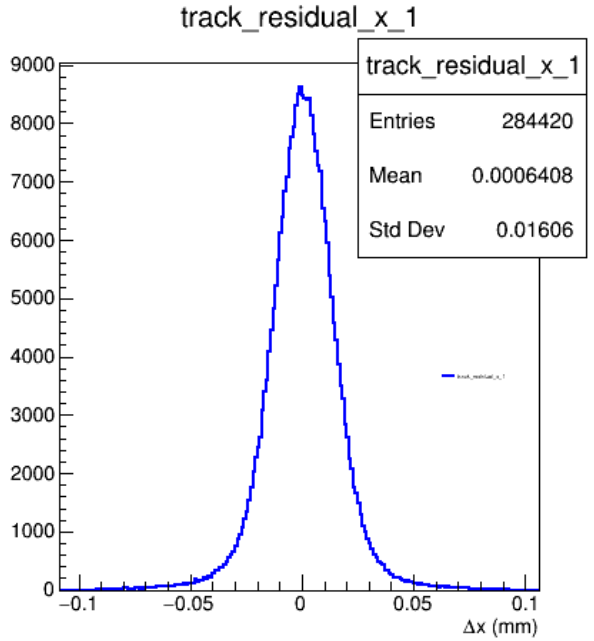
```
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Noisy Pixel Finder summary:
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 0
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 1
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"]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

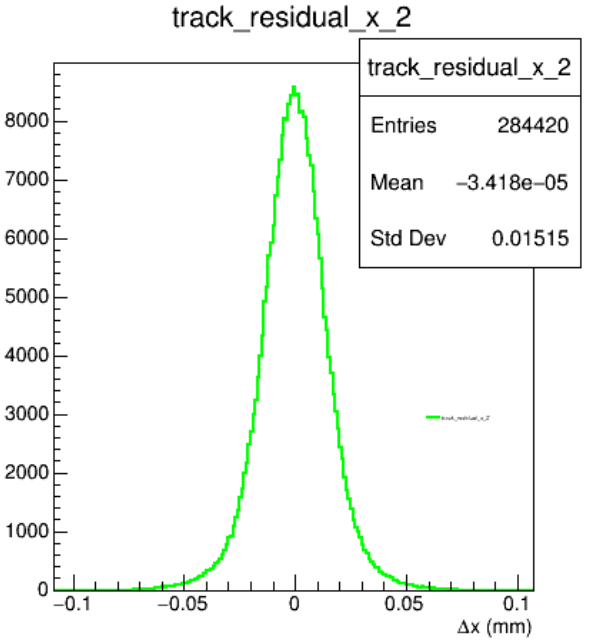
Run 60

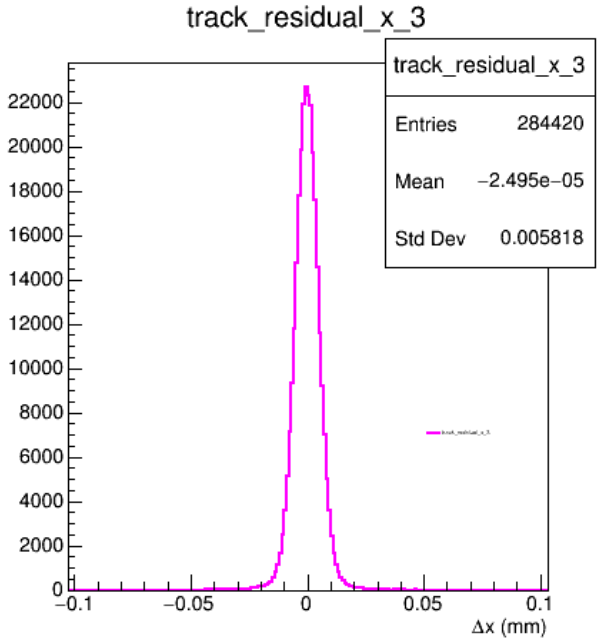
```
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Noisy Pixel Finder summary:
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 1 noisy pixels on sensor: 0
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"] Found 0 noisy pixels on sensor: 1
jobsub.noisypixel(INFO): [ MESSAGE5 "HotPixelMasker"]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

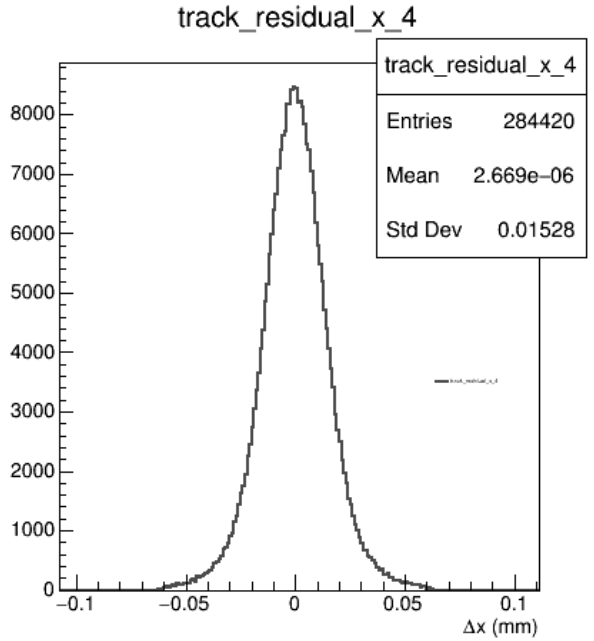
Run 60, Single track fit for all 5 planes



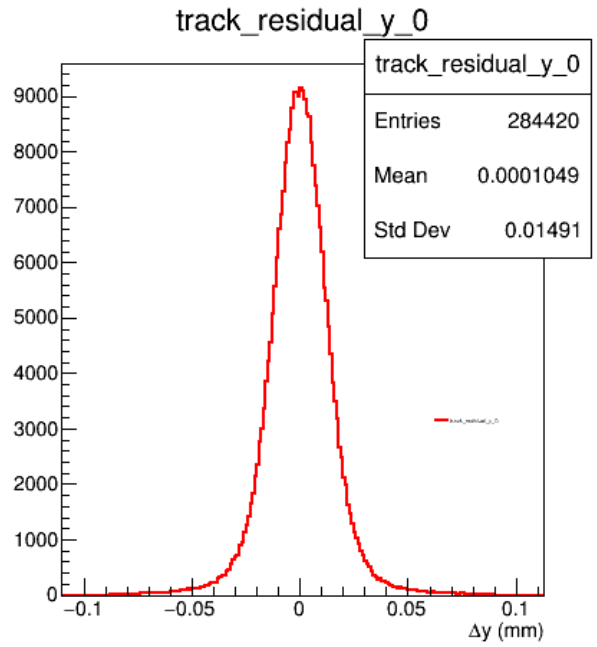


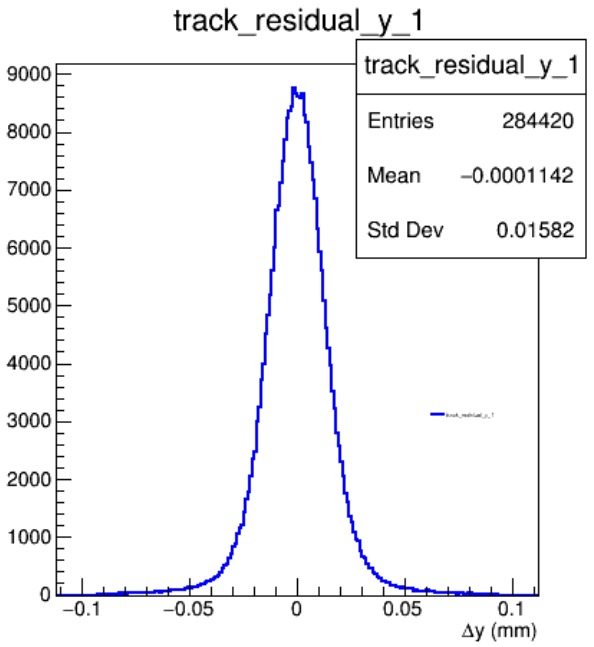


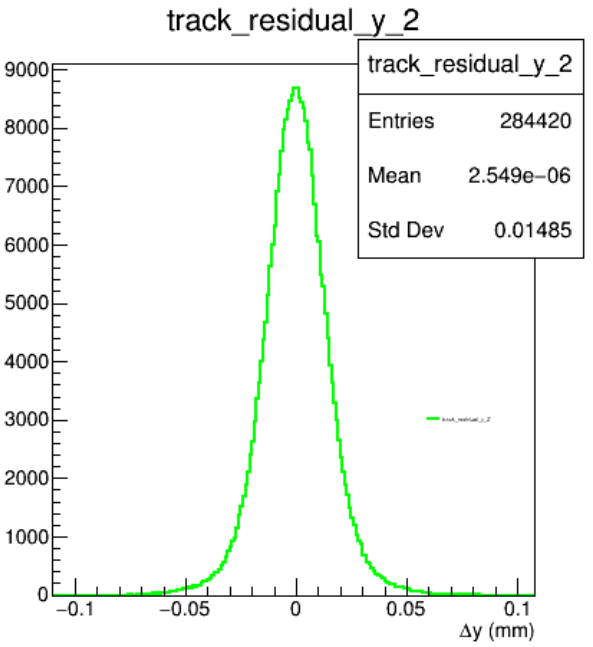


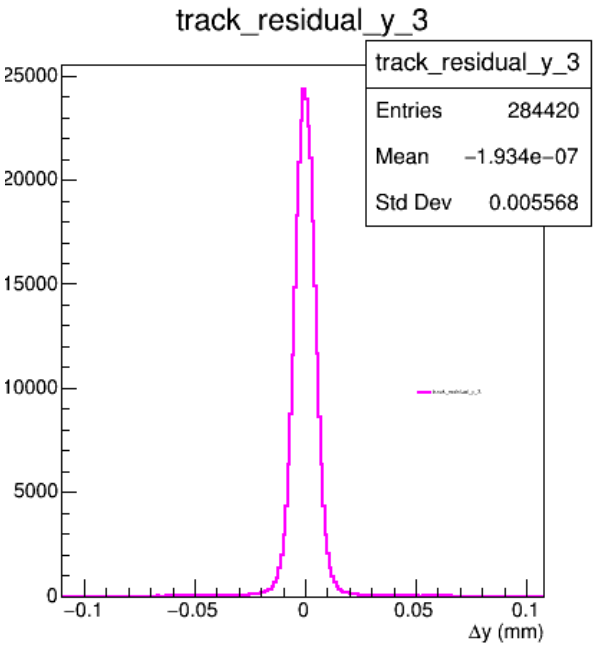


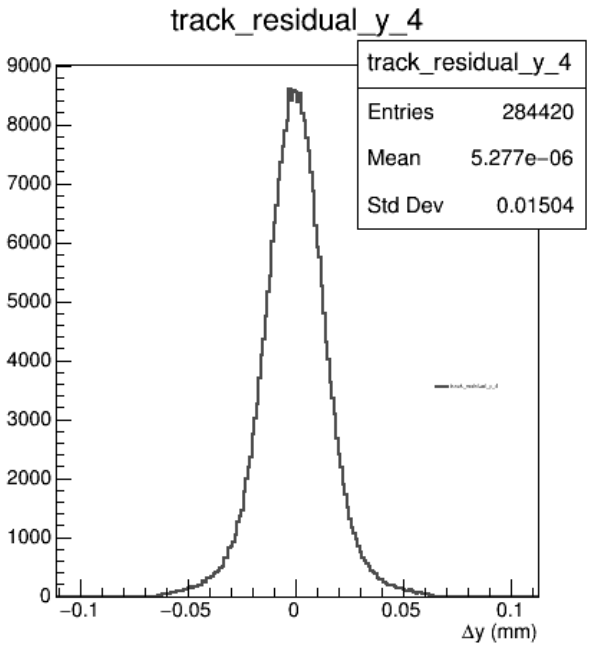
Run 60, Single track fit for all 5 planes



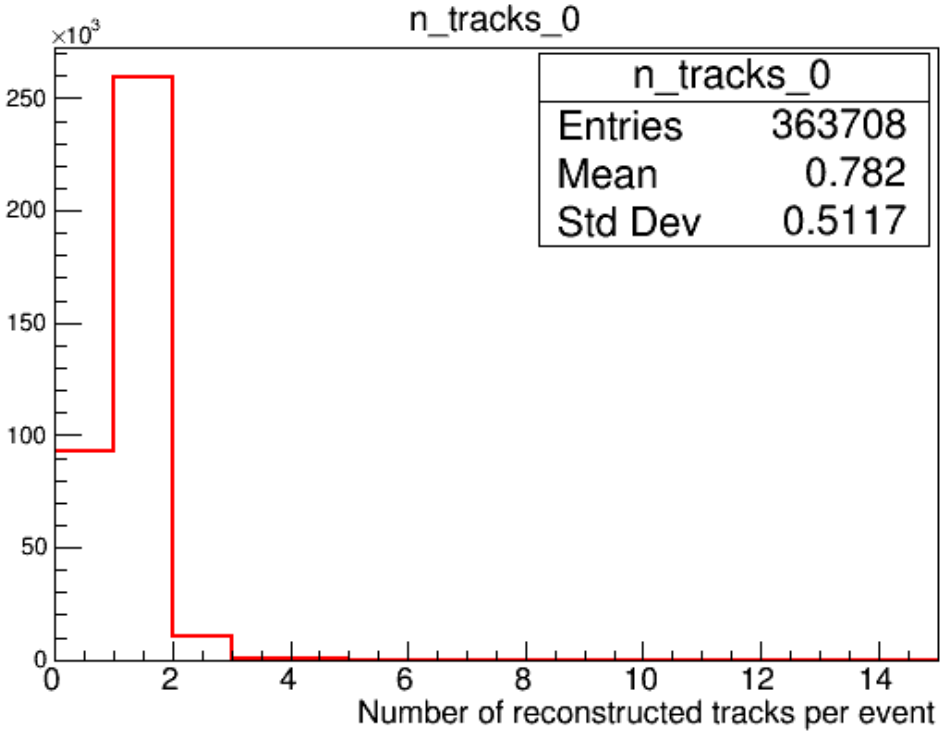


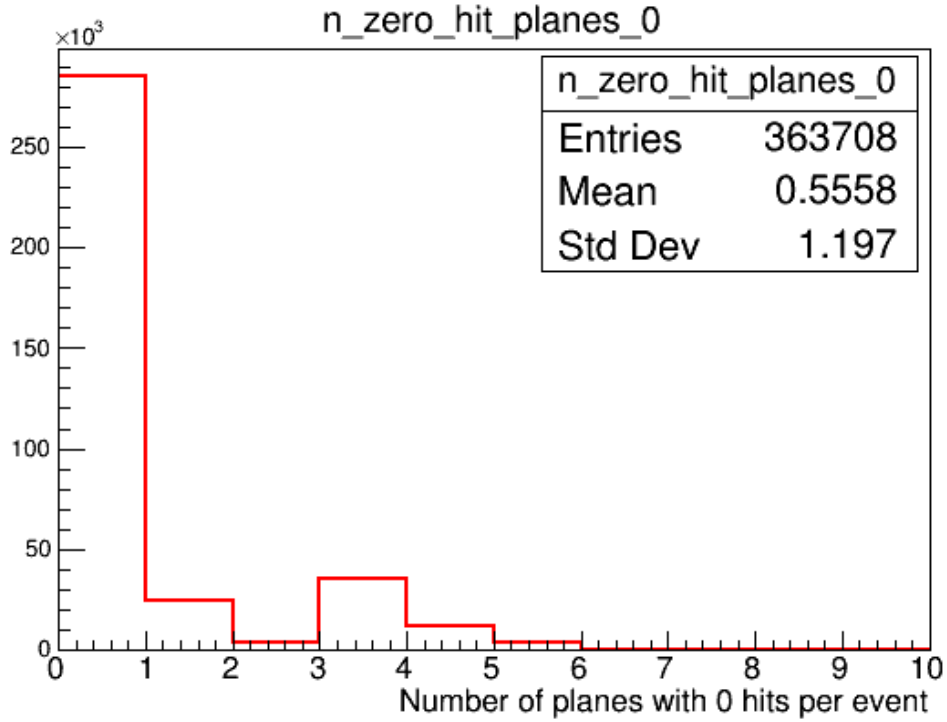


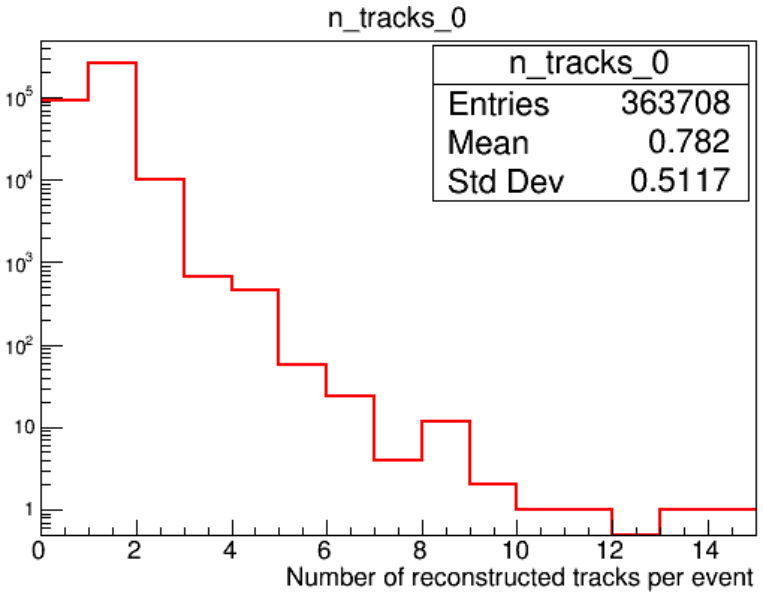




Number of reconstructed tracks

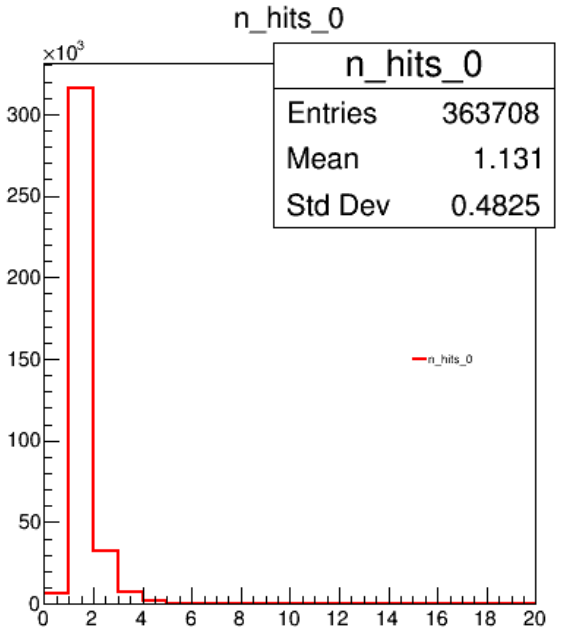


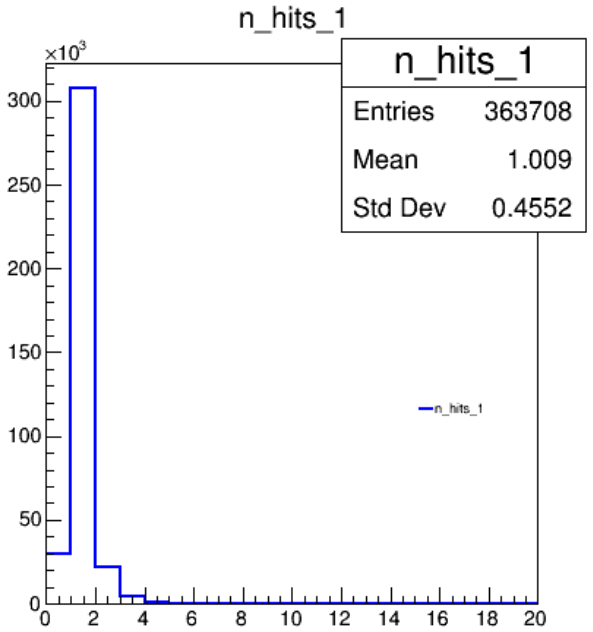


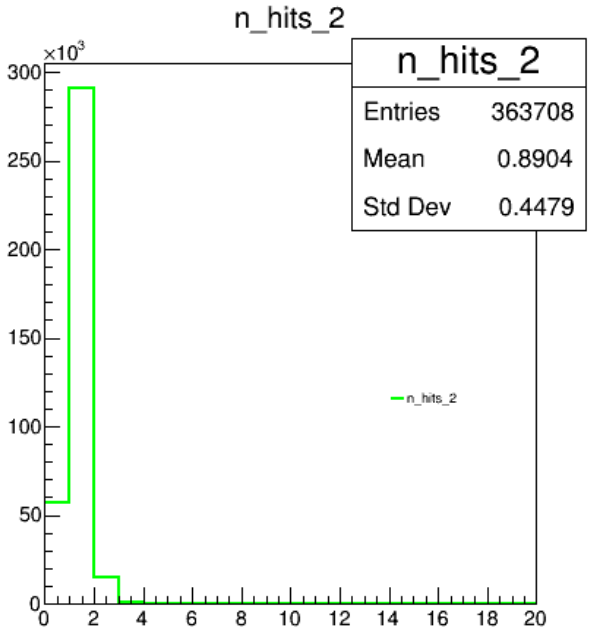


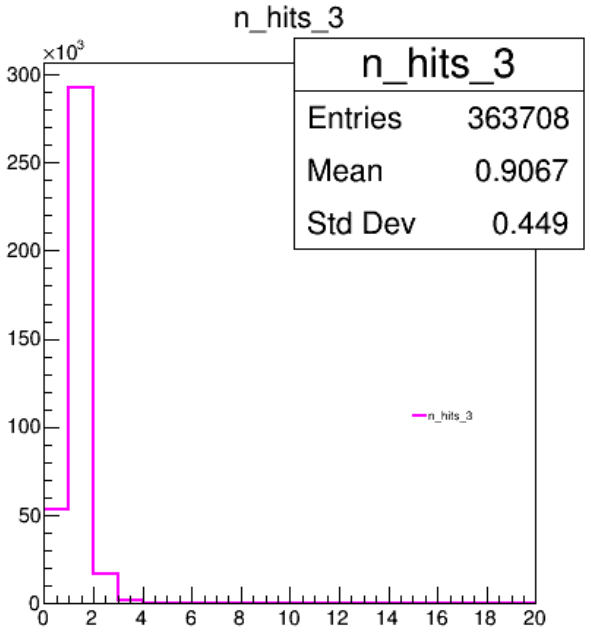
- Number of reconstructed tracks: 284420;
- Number of events with at least one plane with 0 hits: 78640;
- 363708 – 78640 = 285068;
- 285068 – 284420 = 648 - number of events without reconstructed track but with hits in all planes.

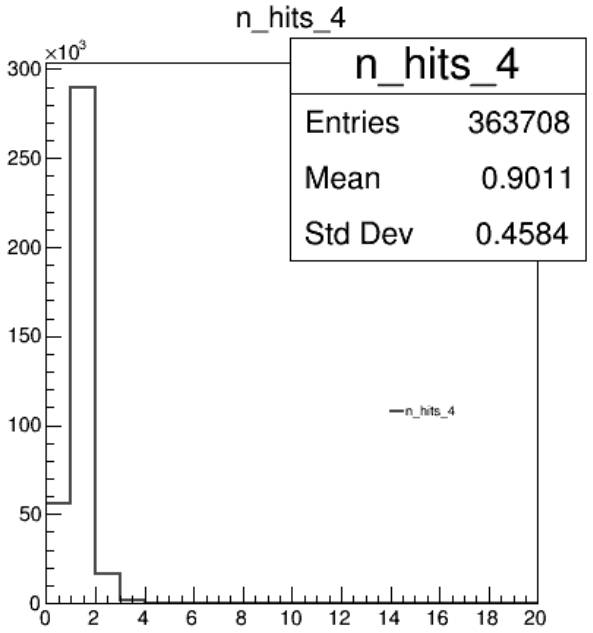
Number of hits per plane



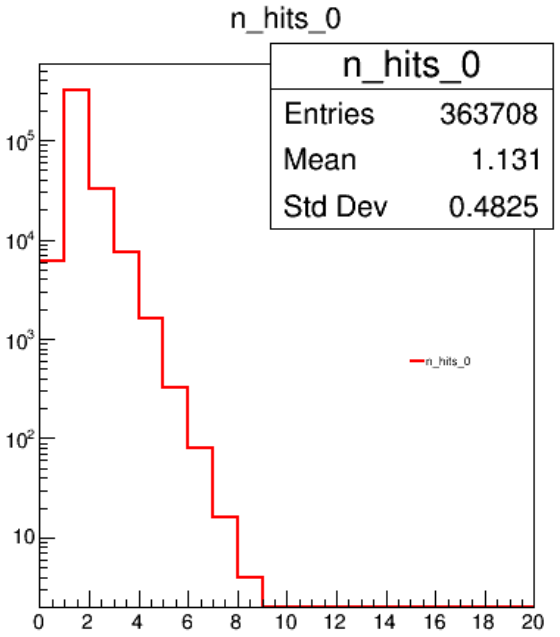


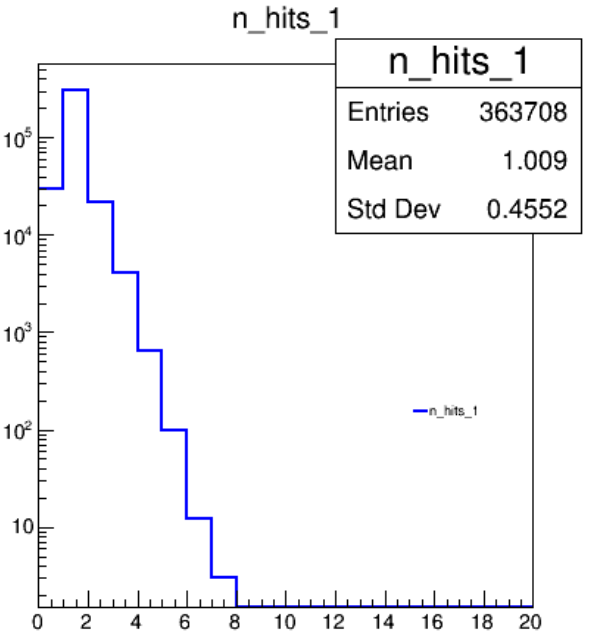


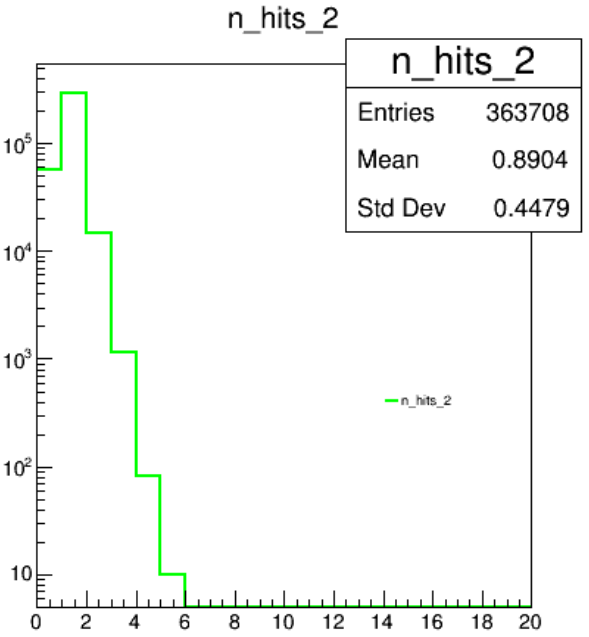


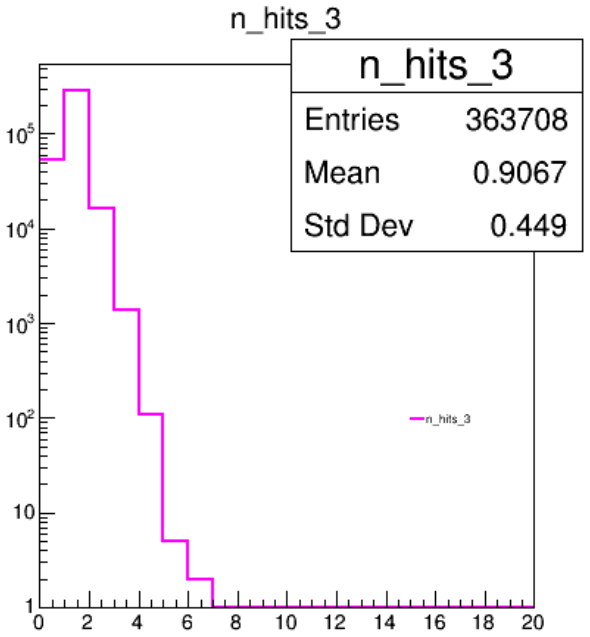


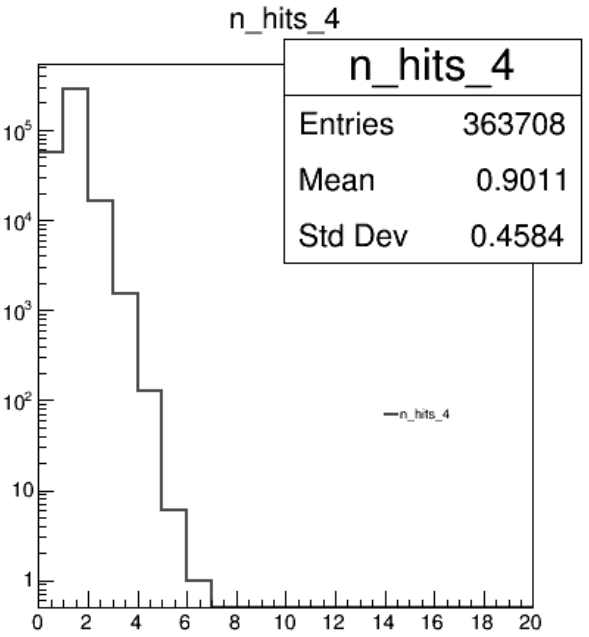
Number of hits per plane





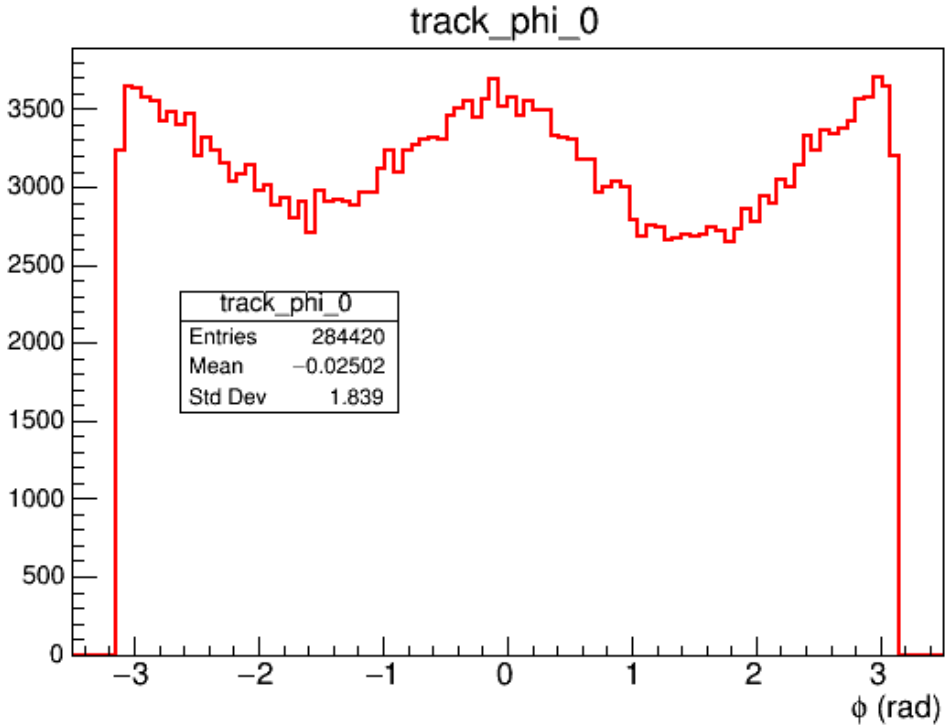


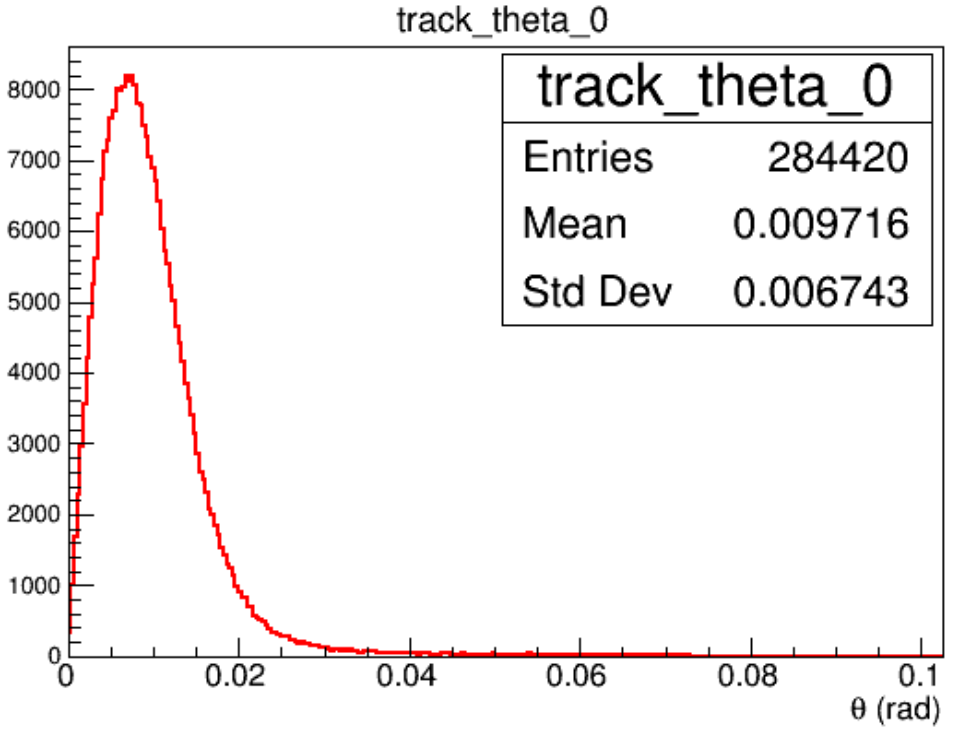




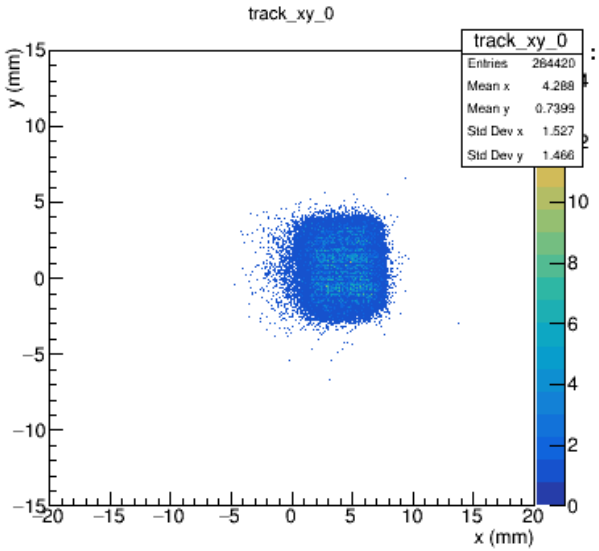
- Seems to be too many events with many (4+) tracks reconstructed;
- Need to check it.

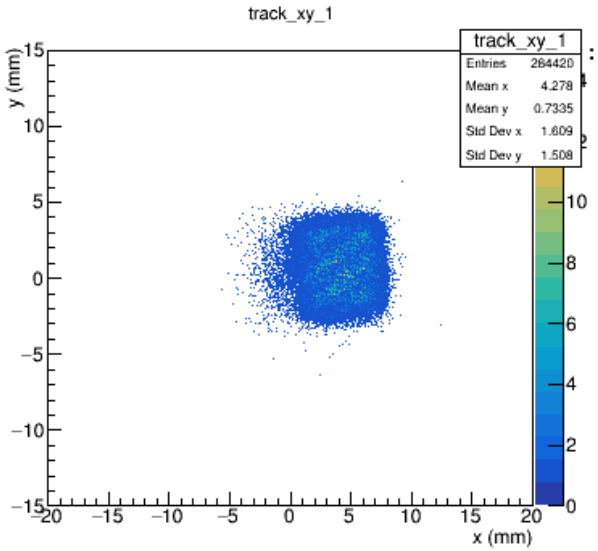
Angular distributions of the tracks

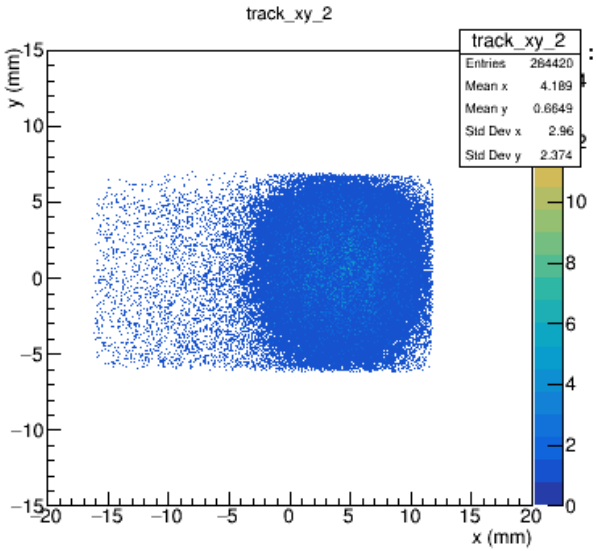


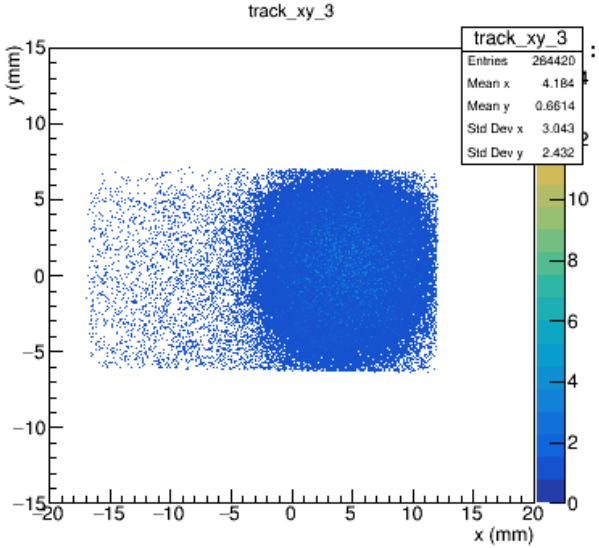


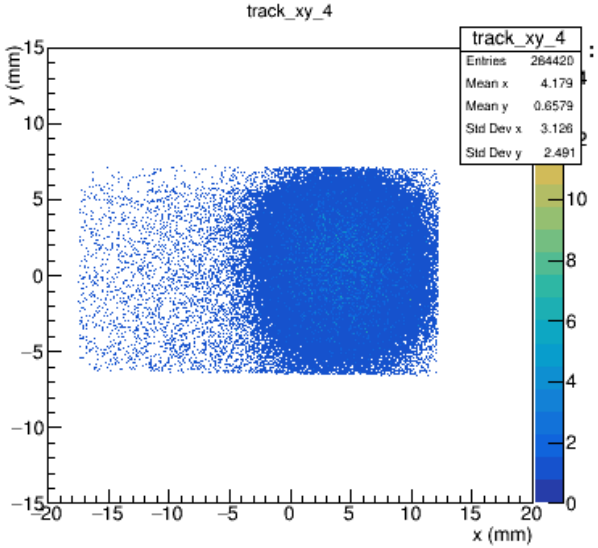
Hits assigned to tracks



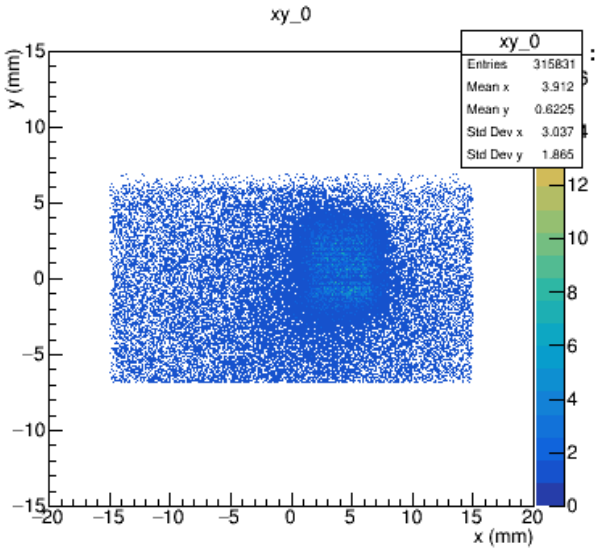


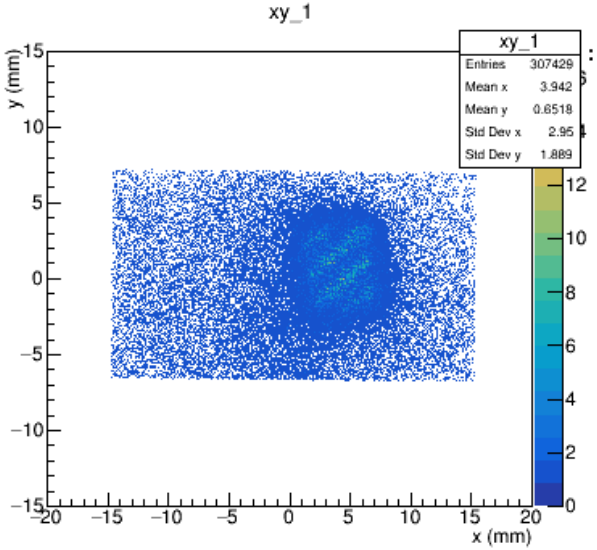


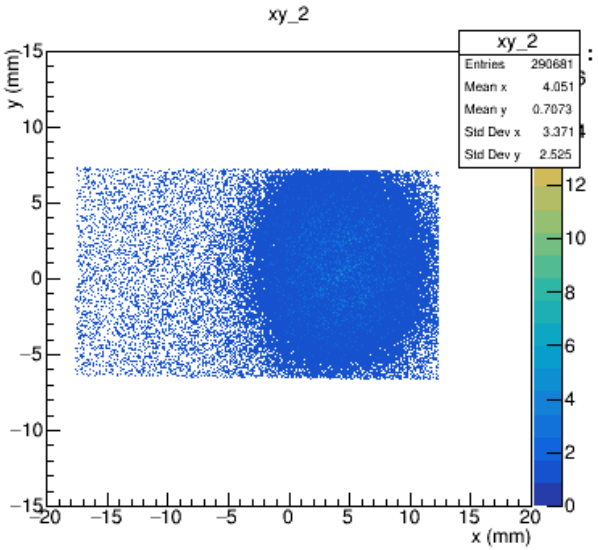


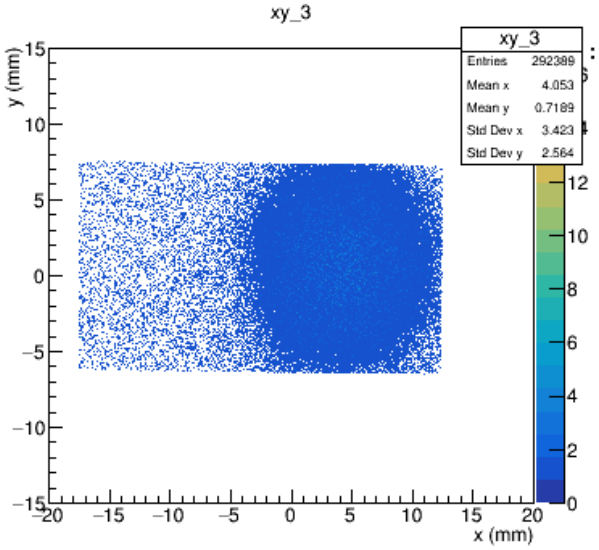


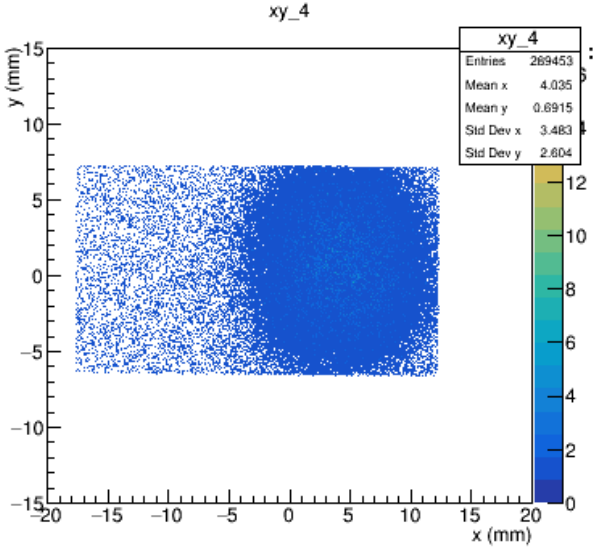
All hits


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)

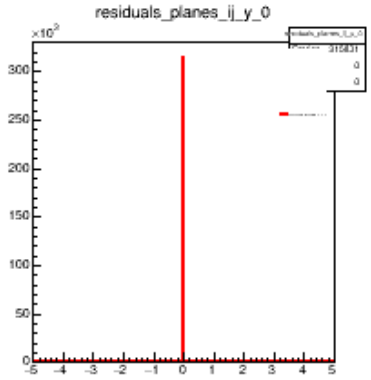

xy_1
xy_1
Entries 307429
Mean x 3.942
Mean y 0.6518
Std Dev x 2.95
Std Dev y 1.889
y (mm)
x (mm)

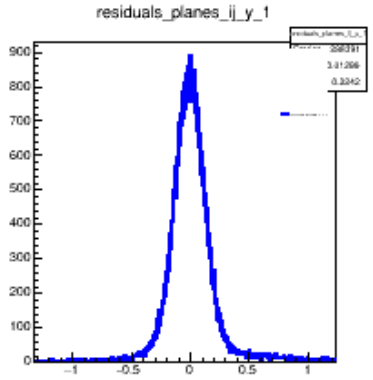

xy_2
xy_2
Entries 290681
Mean x 4.051
Mean y 0.7073
Std Dev x 3.371
Std Dev y 2.525
y (mm)
x (mm)

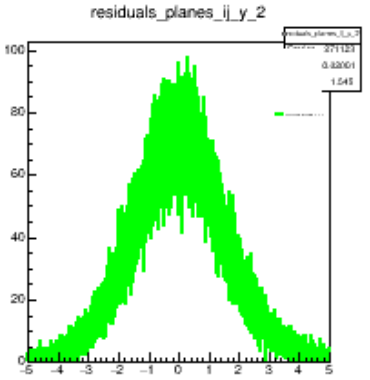

xy_3
xy_3
Entries 292389
Mean x 4.053
Mean y 0.7189
Std Dev x 3.423
Std Dev y 2.564
y (mm)
x (mm)

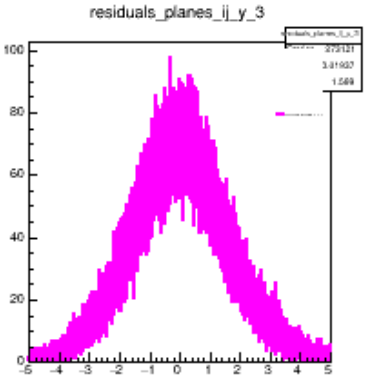

xy_4
xy_4
Entries 269453
Mean x 4.035
Mean y 0.6915
Std Dev x 3.483
Std Dev y 2.604
y (mm)
x (mm)

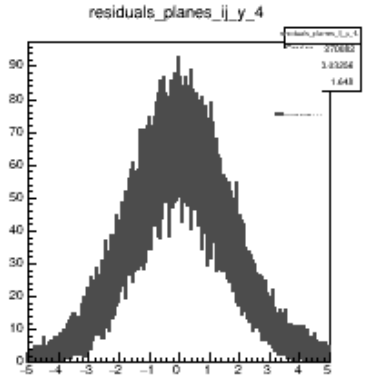
Prealignment. Y correlations between planes

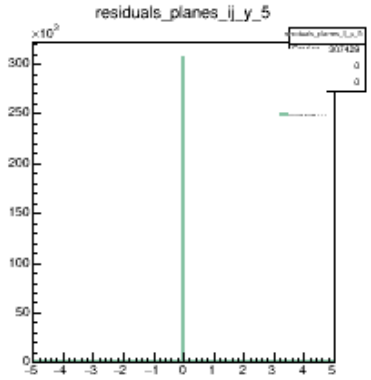


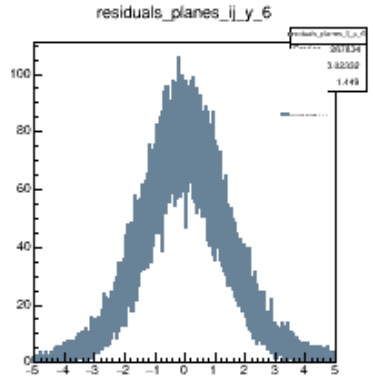


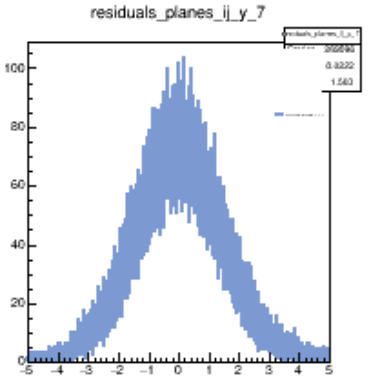


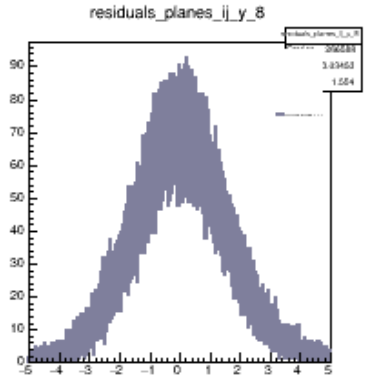


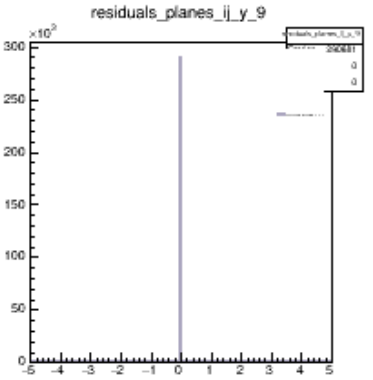


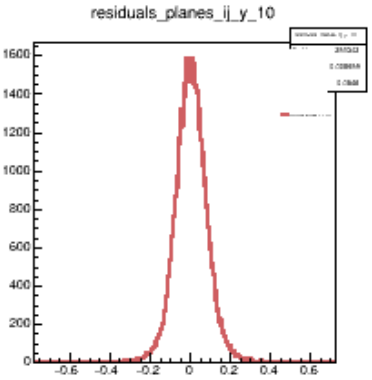


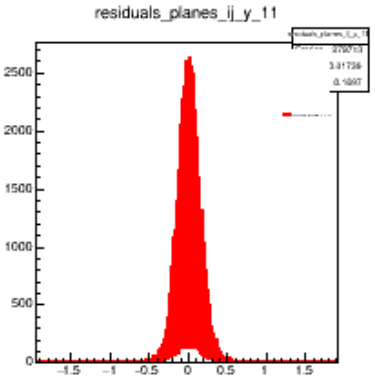


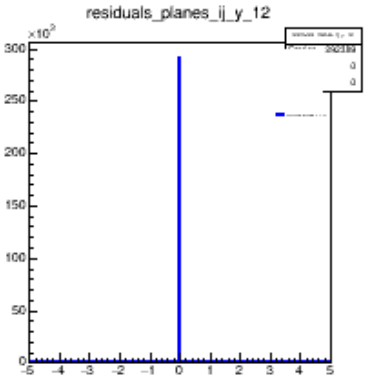


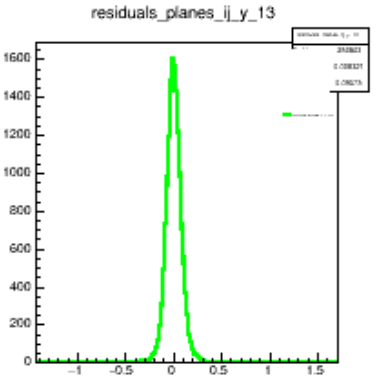


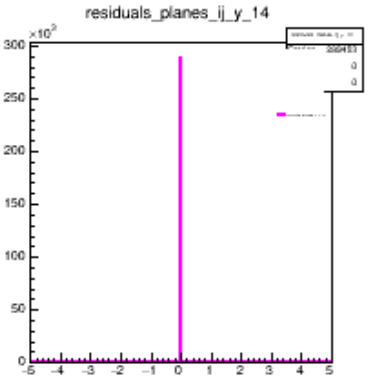




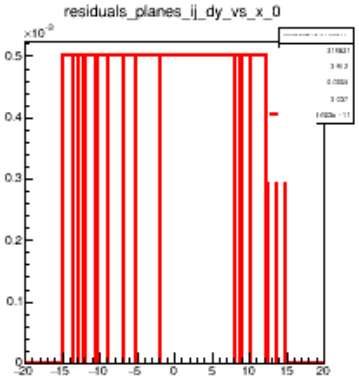


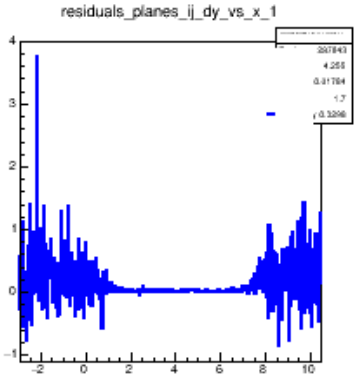


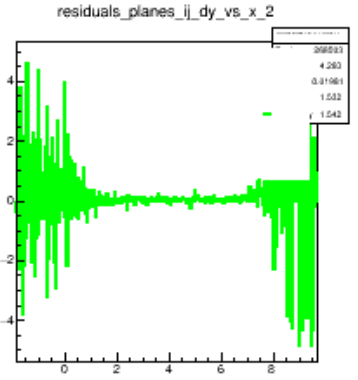


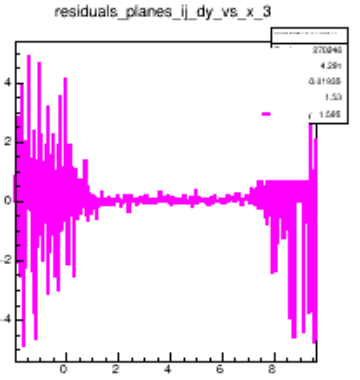


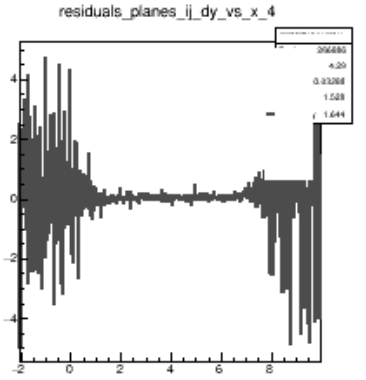
Prealignment of rotation around Z.
Profiling plot of dy vs x distribution.

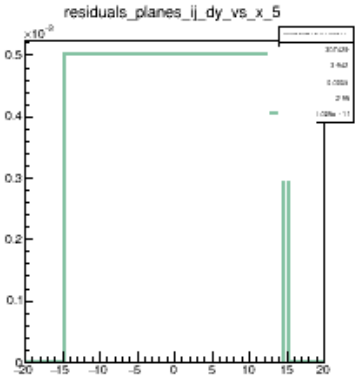


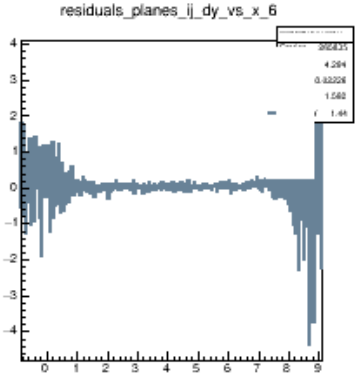


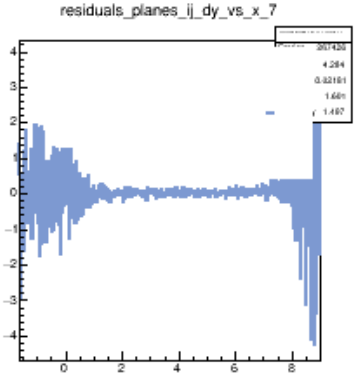


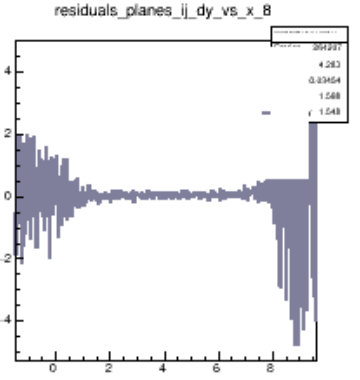


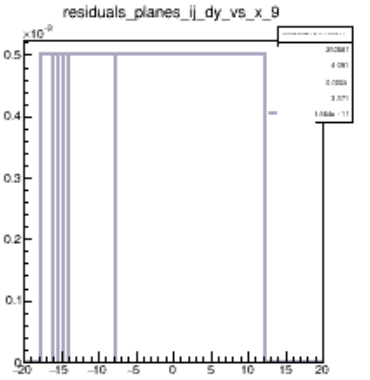


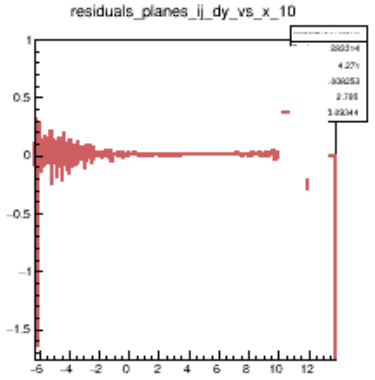


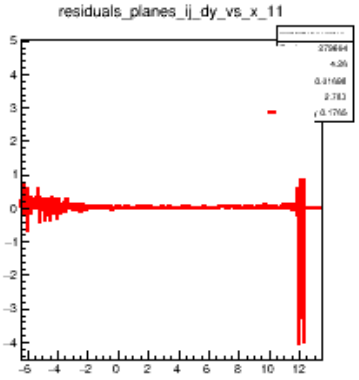


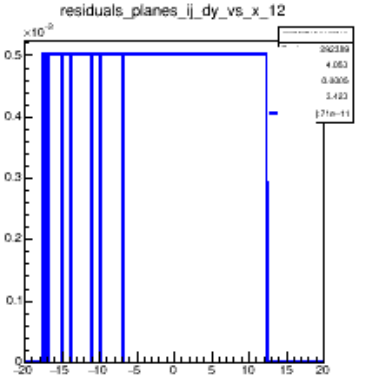


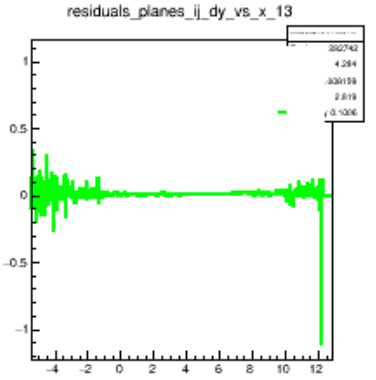


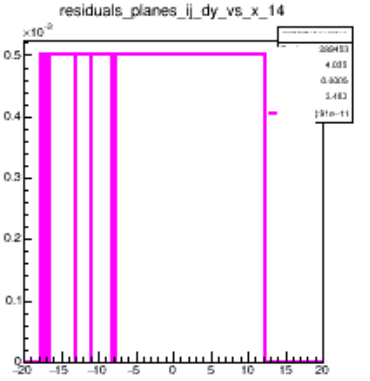




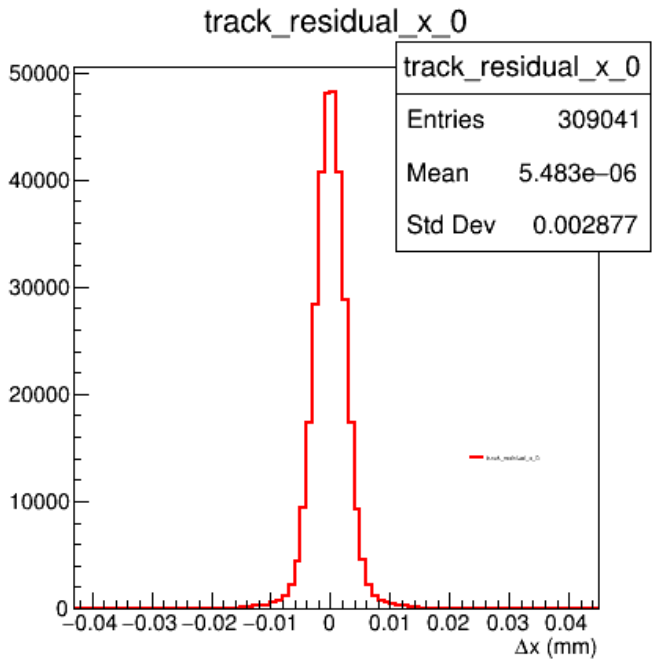


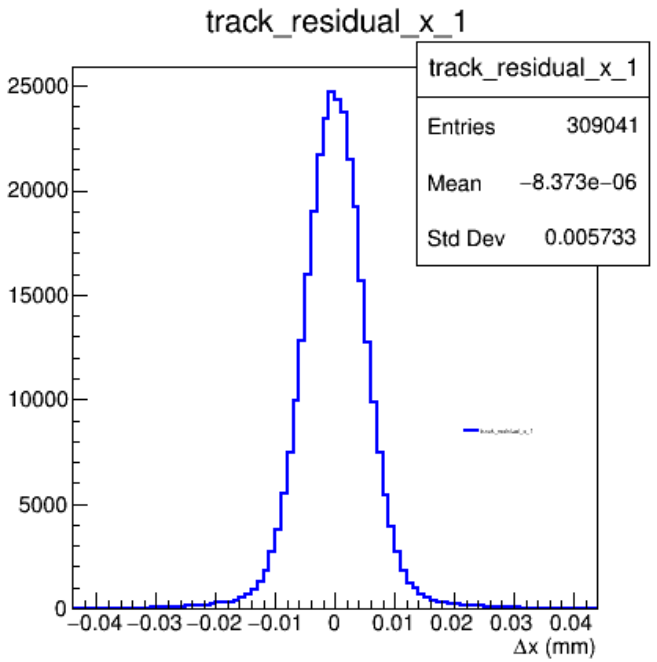


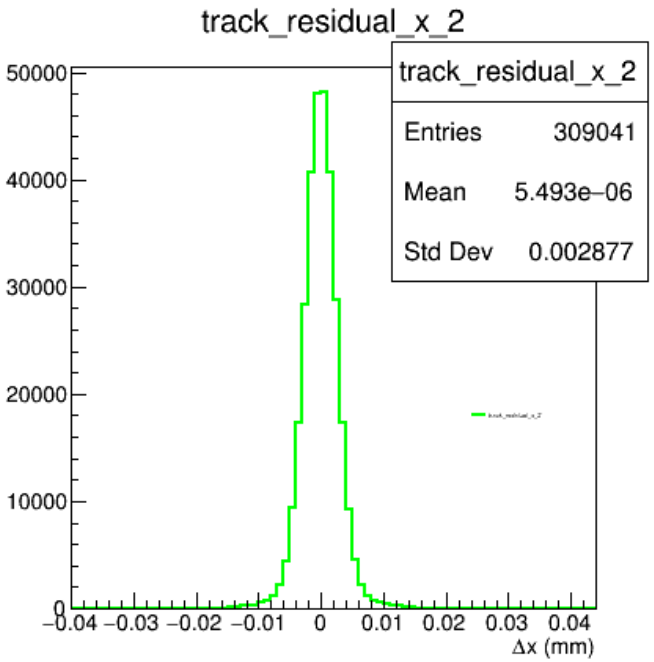


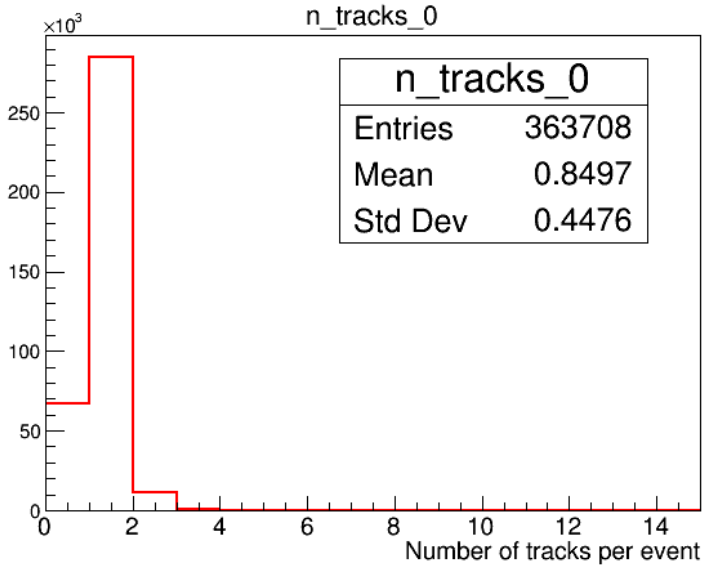


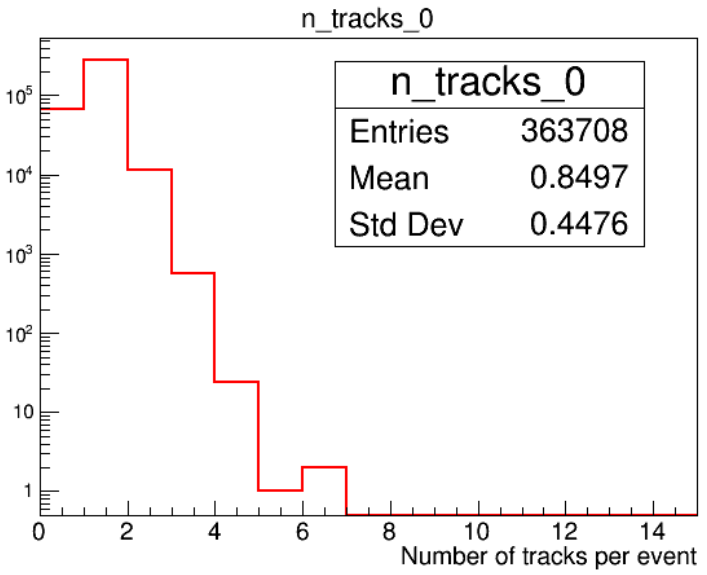
Track reconstruction in three planes after the magnet



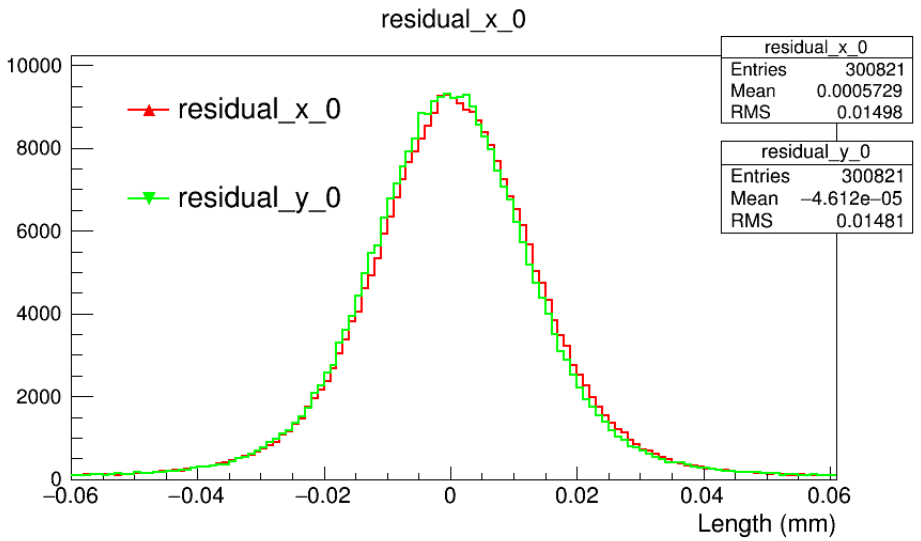


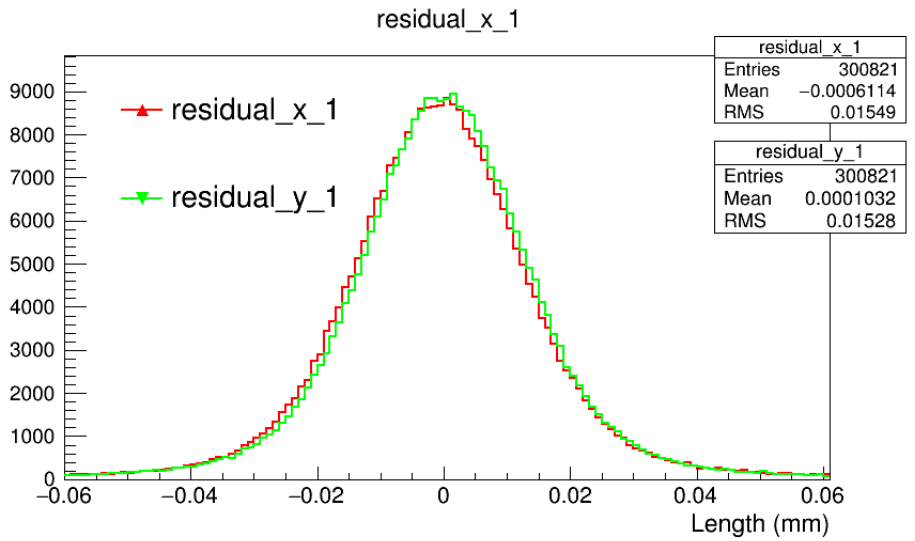


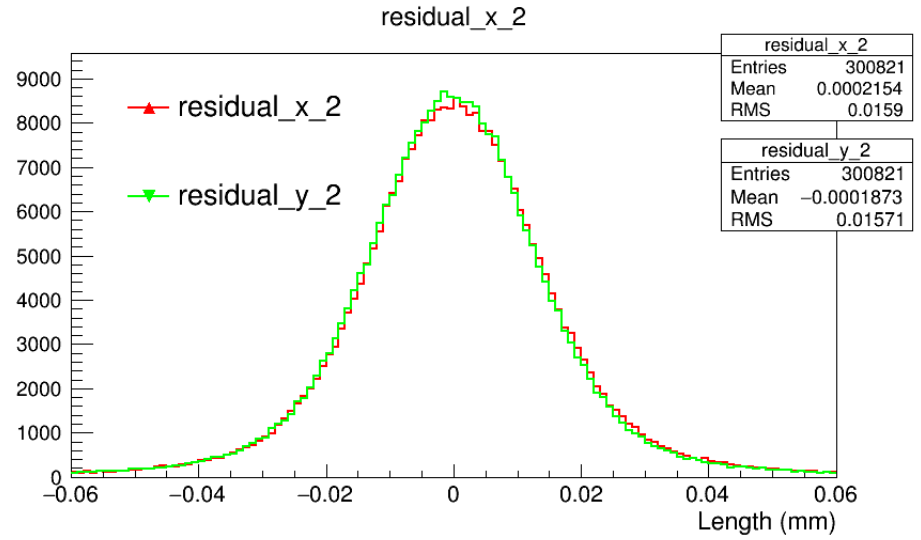


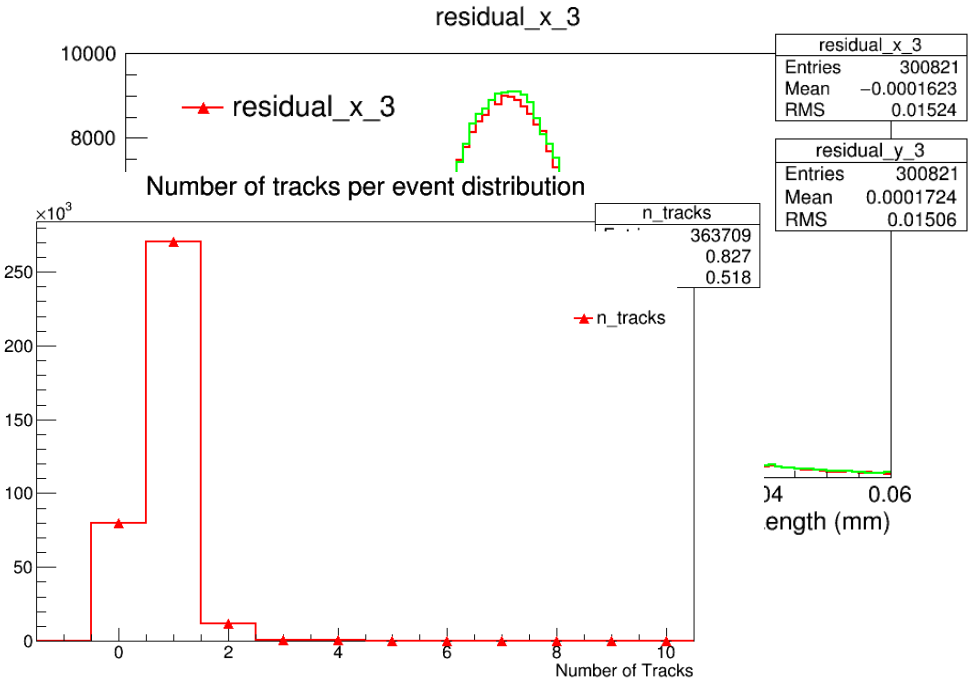


Test with 4 planes: 1,2 and 3,5

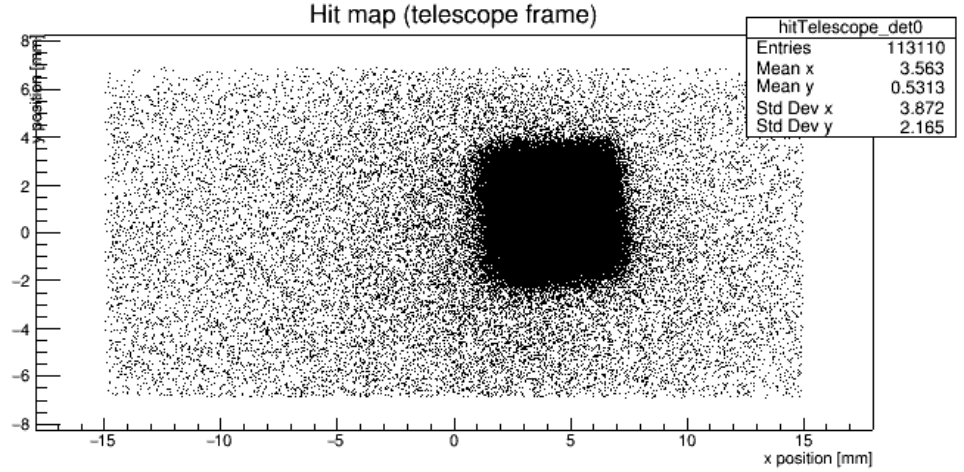


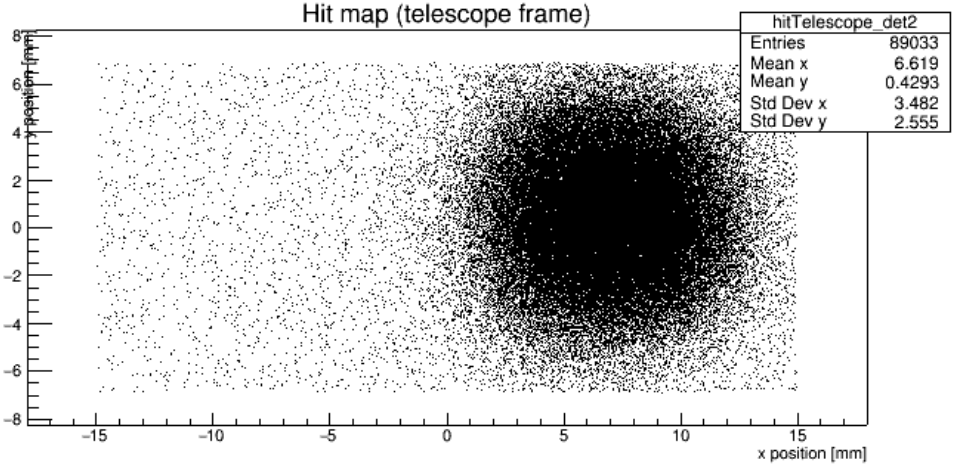


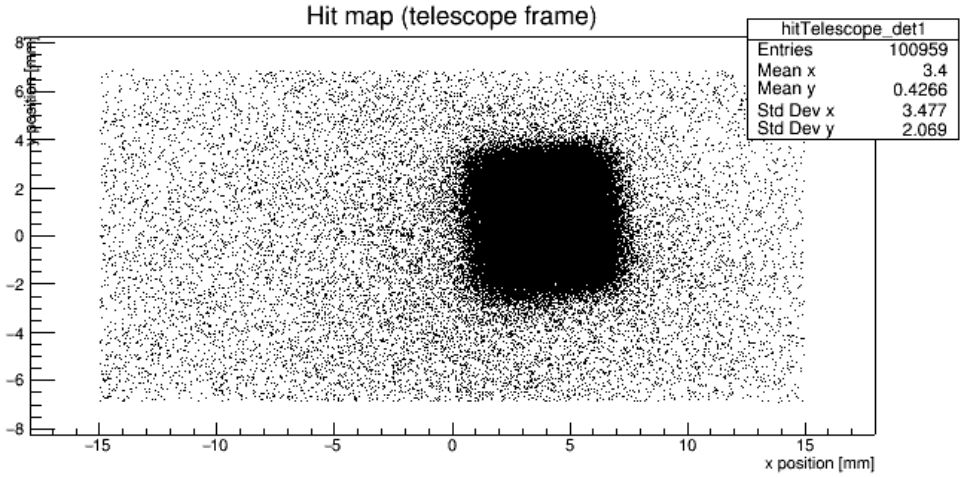


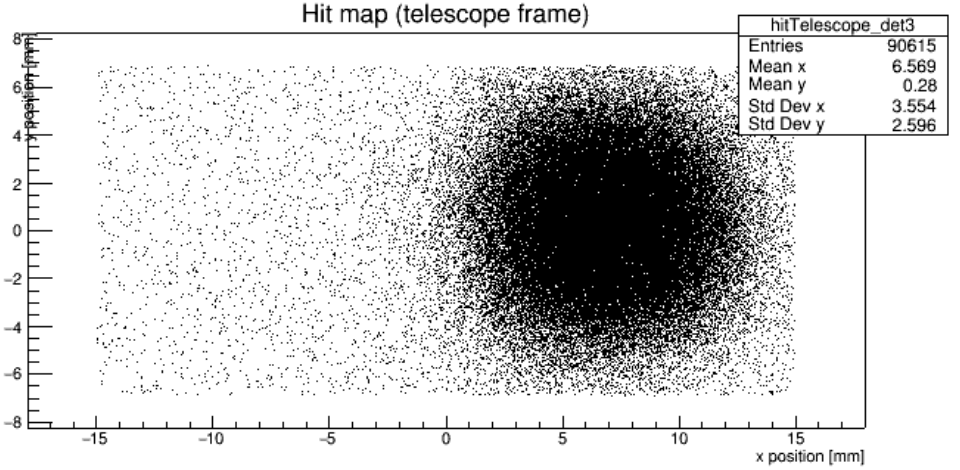


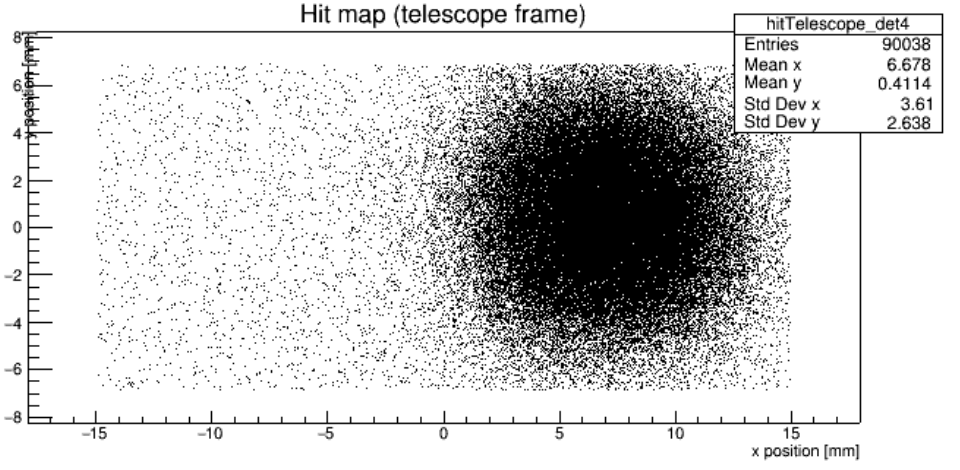
Hits, run 60, magnet off



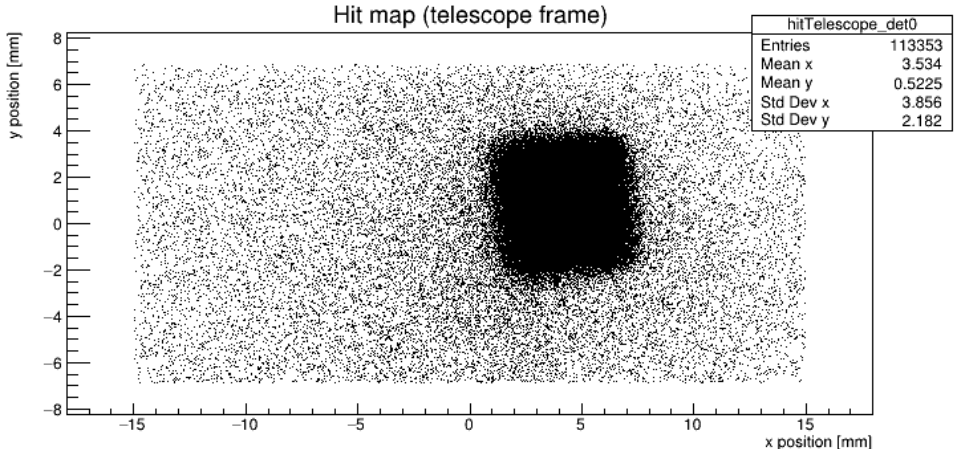


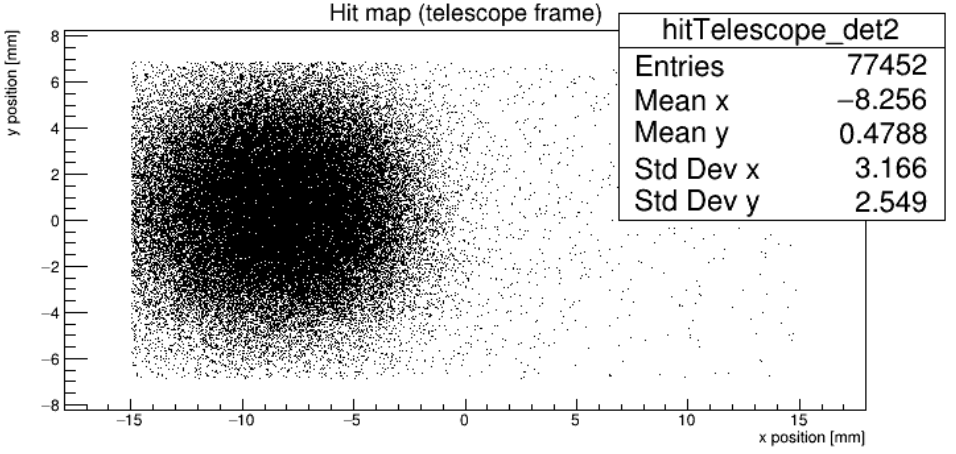


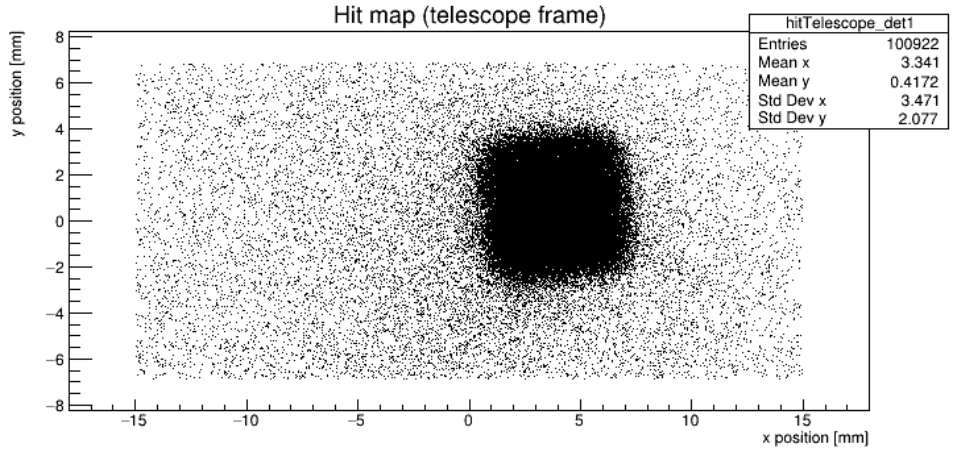


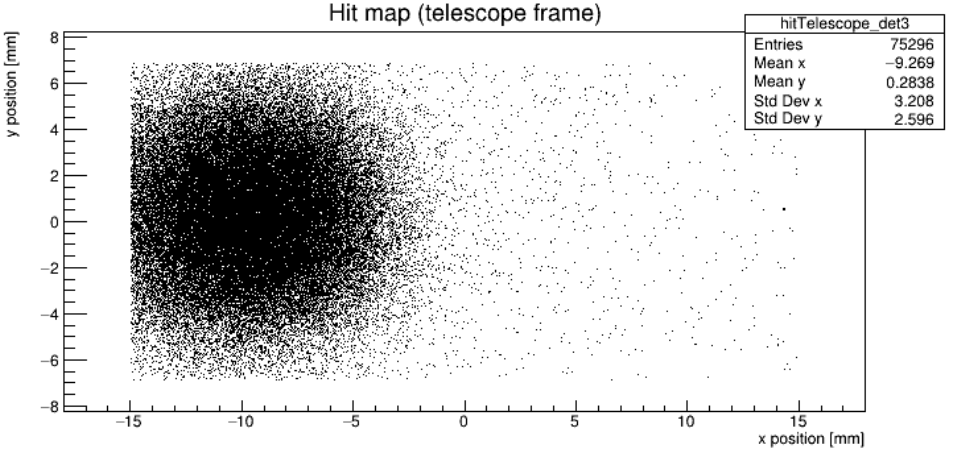


Hits, run 49, magnet current 200A

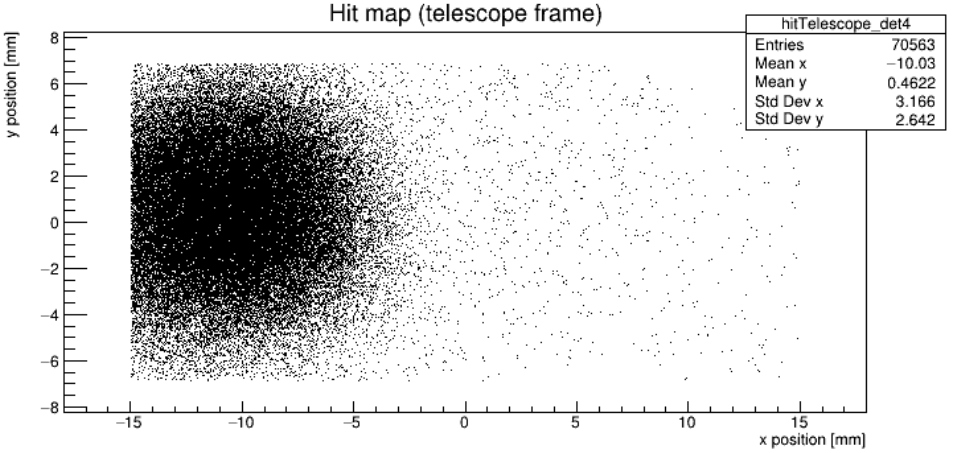








Displacement in first plane after the magnet:
6.619 + 8.256 = 14.875 mm



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 will be useful.
- Continue with other runs and analysis of scattering angle.

Back up

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]);
```

$$(\%o1)\quad \begin{bmatrix} x0 & 1 \\ x0+d & 1 \\ x0+2\,d & 1 \end{bmatrix}$$

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

$$(\%o2)\quad \begin{bmatrix} y0 \\ y1 \\ y2 \end{bmatrix}$$

Slope is determined by the two outer points

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

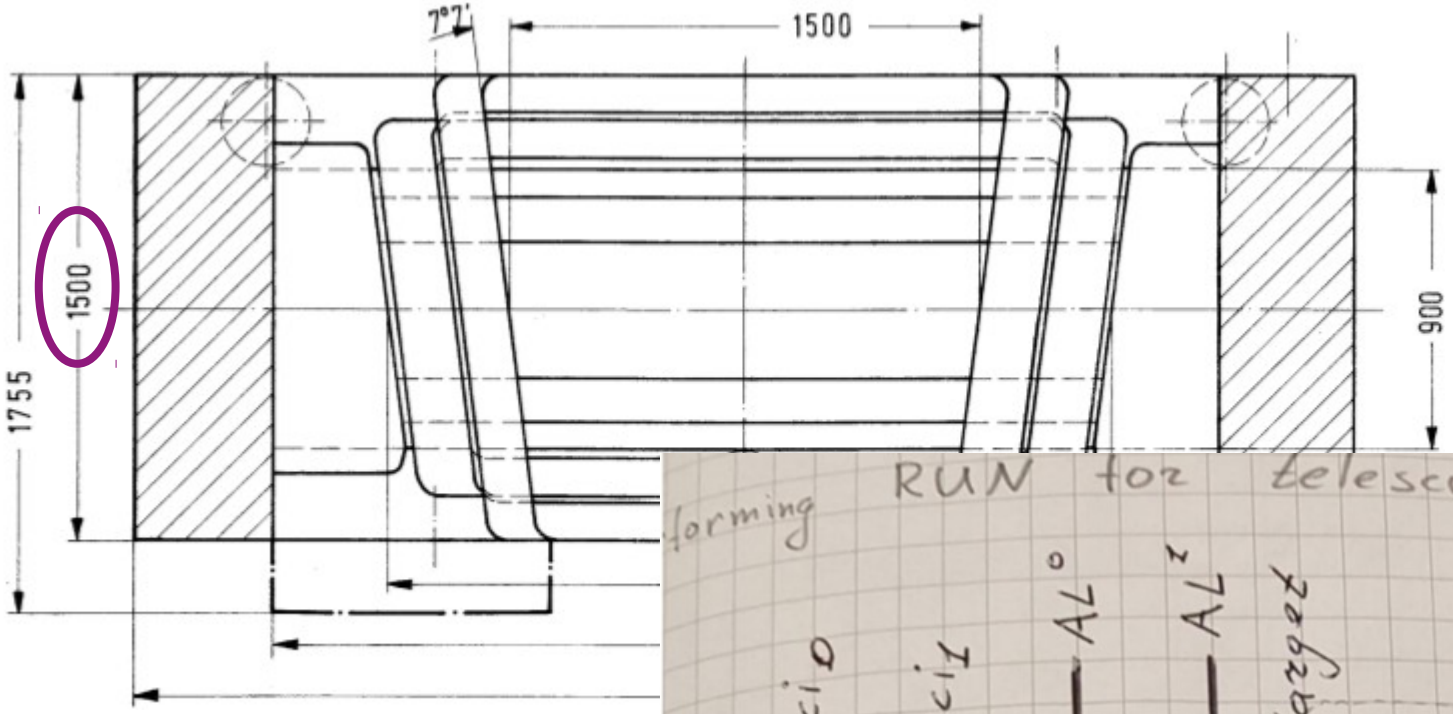
$$(\%o3)\quad \begin{bmatrix} \frac{y2-y0}{2\,d} \\ -\frac{(-3\,x0-5\,d)\,y0-2\,d\,y1+(3\,x0+d)\,y2}{6\,d} \end{bmatrix}$$

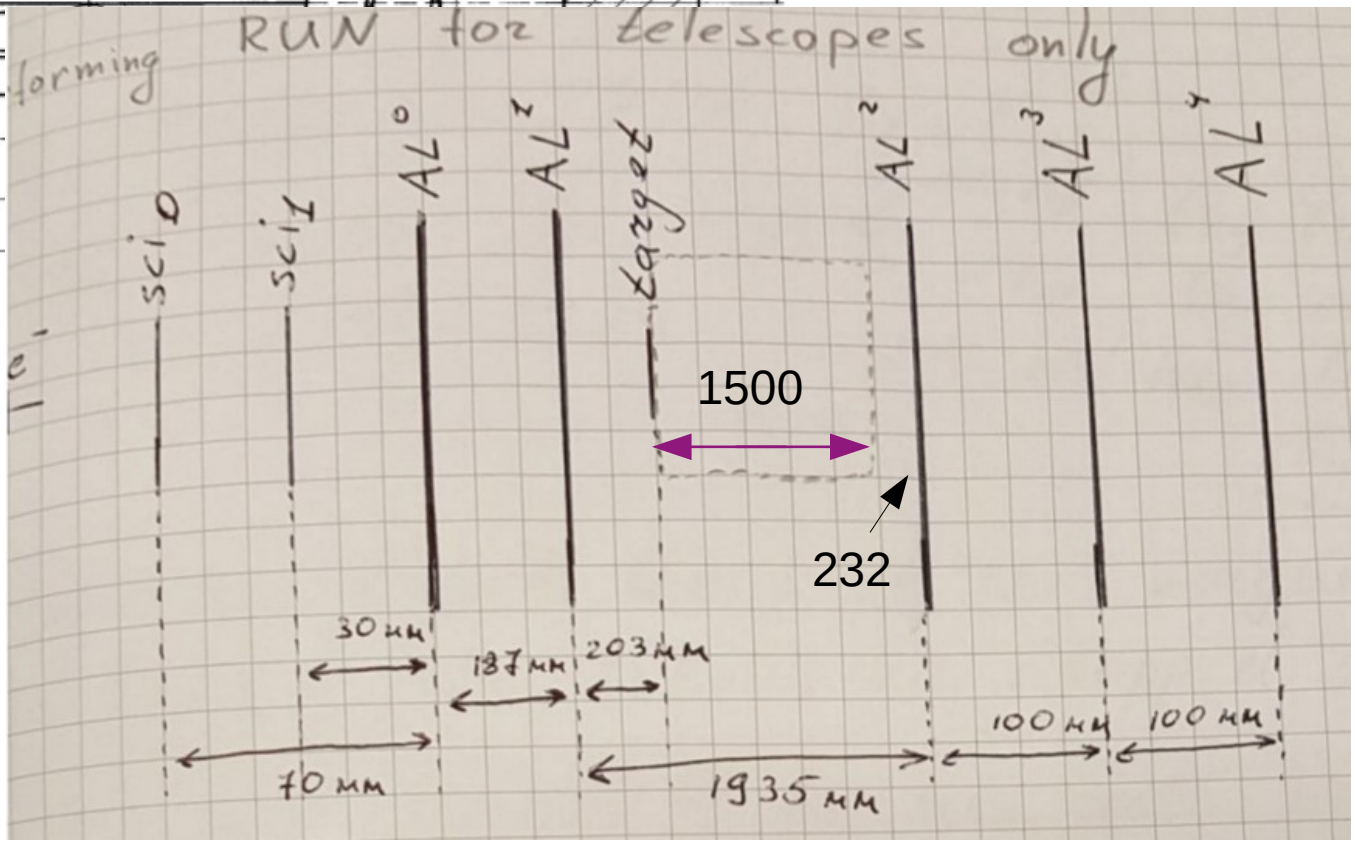
The distance to outer points is twice smaller than to middle one

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

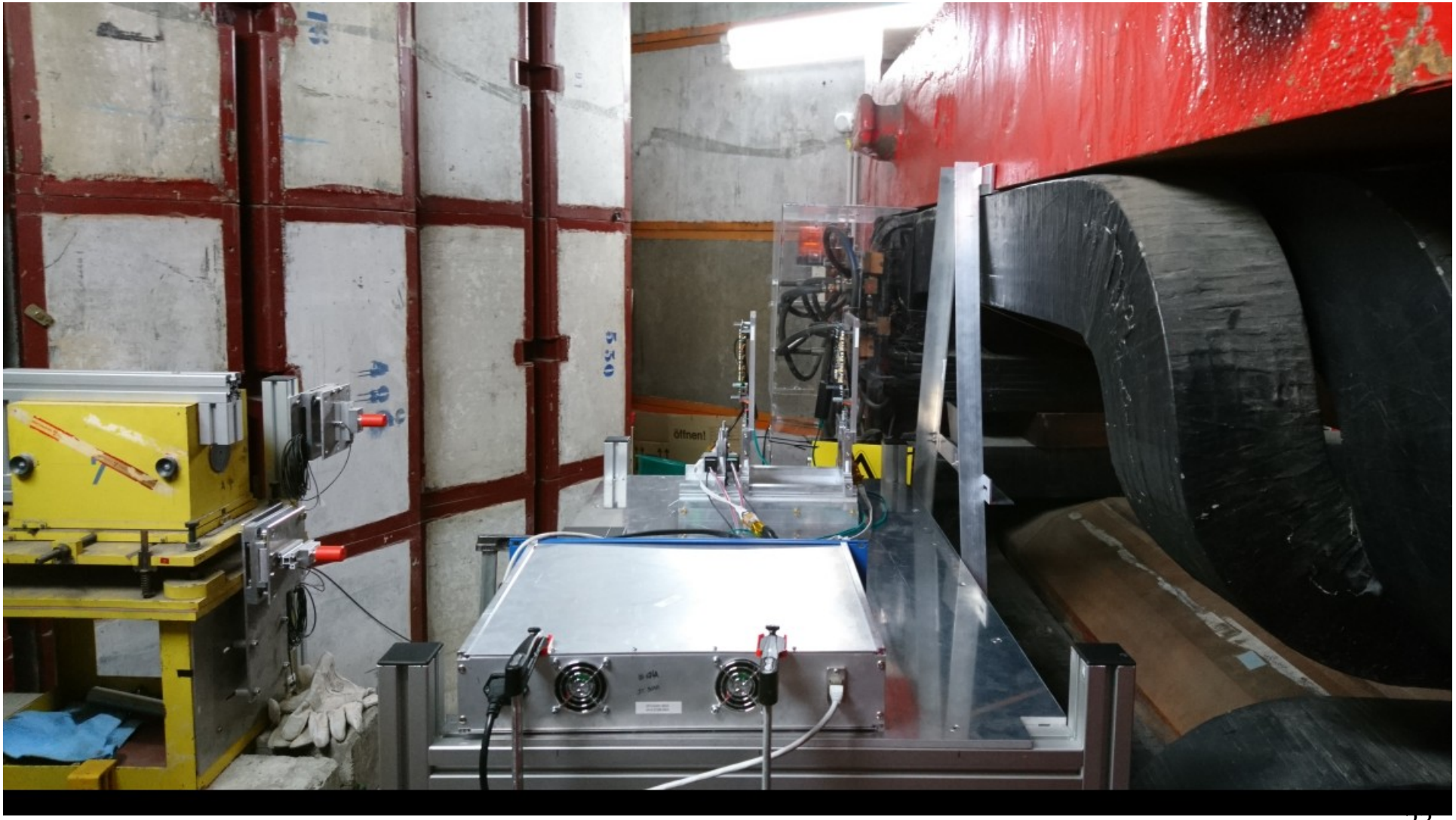
$$(\%o4)\quad \begin{bmatrix} -\frac{y0-2\,y1+y2}{6} \\ \frac{y0-2\,y1+y2}{3} \\ -\frac{y0-2\,y1+y2}{6} \end{bmatrix}$$

Magnet and TB setup geometry

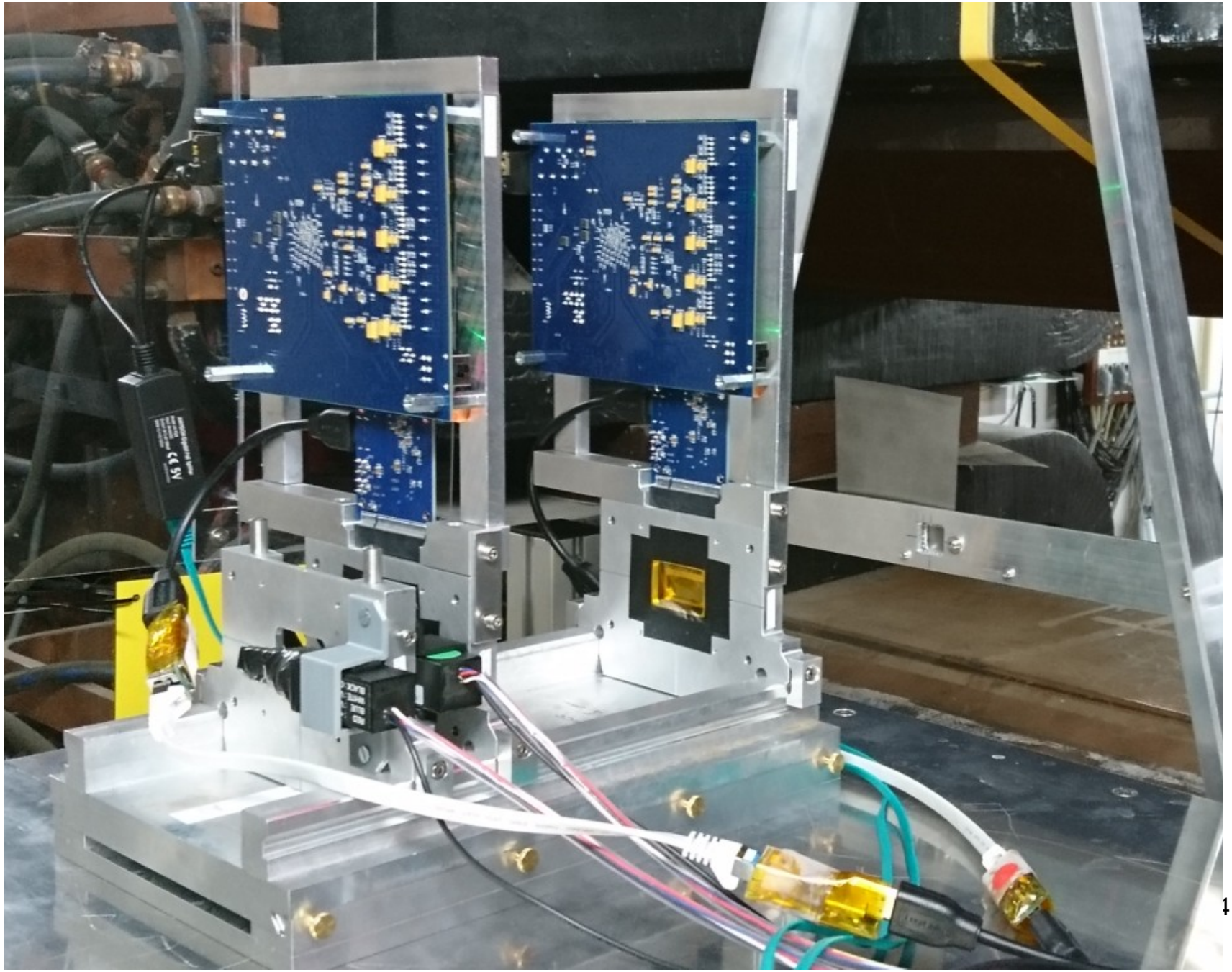




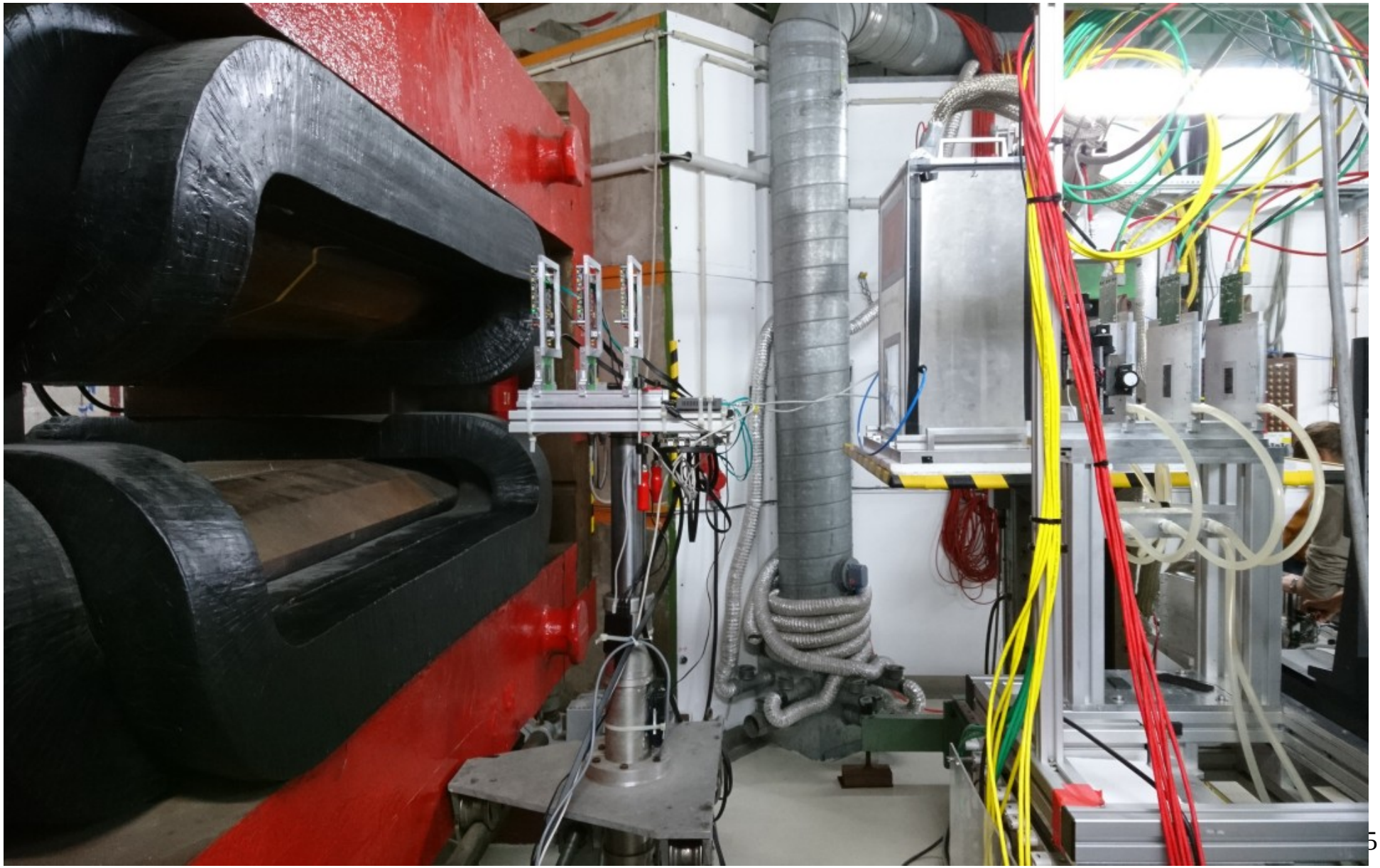
Upstream of the target



Upstream of the target



Downstream of the target



Downstream of the target