ITS3: Report on the analysis/paper on micro-ITS3

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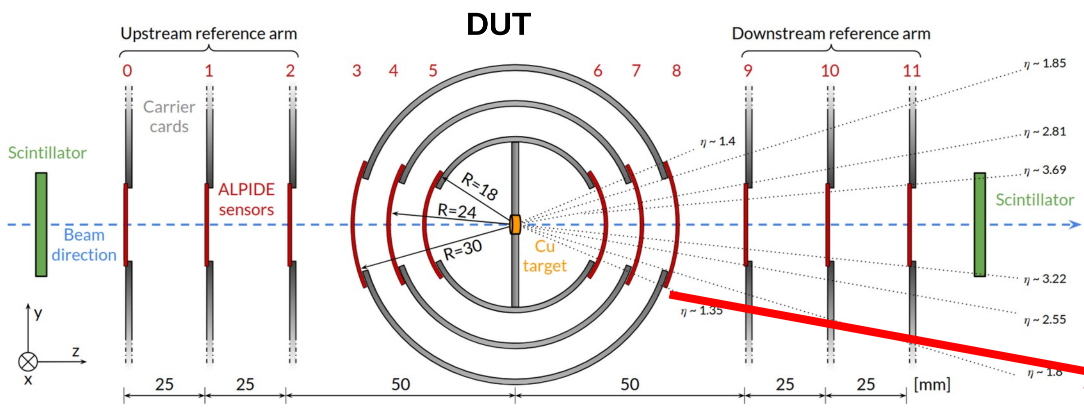
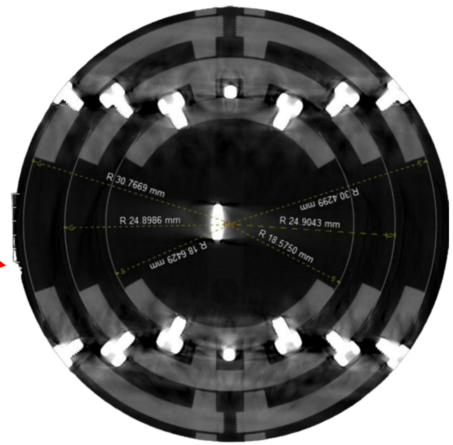
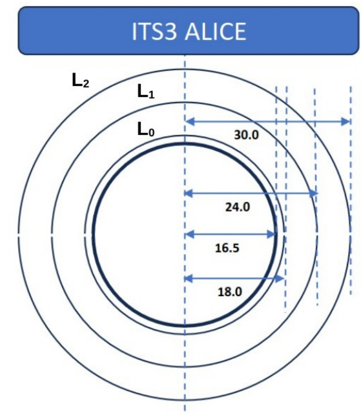
Micro-ITS3 test beam data analysis

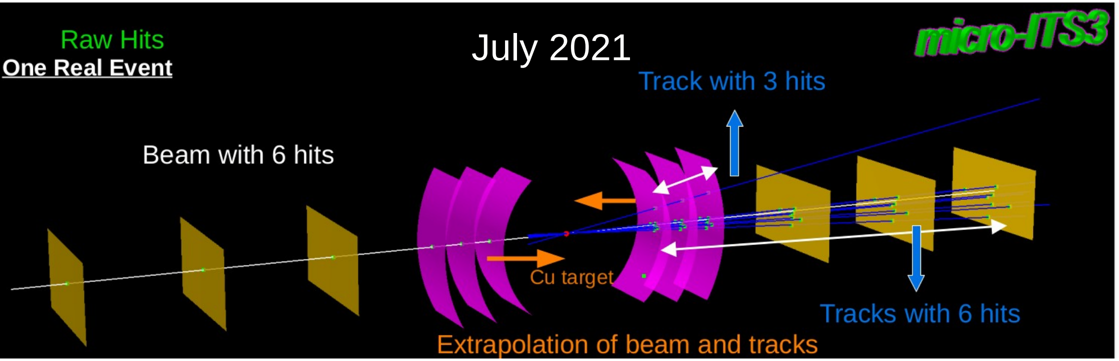


micro-ITS3 setup using ALPIDE bent sensors (DUT)



X-ray tomography





Demonstration of tracking capabilities of bent ALPIDE MAPS mimicking a truly cylindrical barrel configuration in view of the ITS3 upgrade of ALICE

ALICE ITS project*

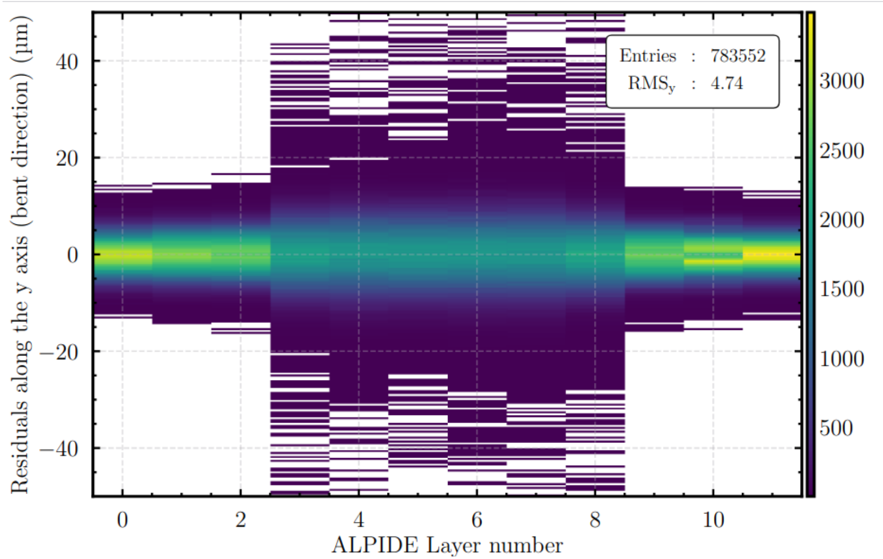
Analysis using Corryvreckan software and local scripts:

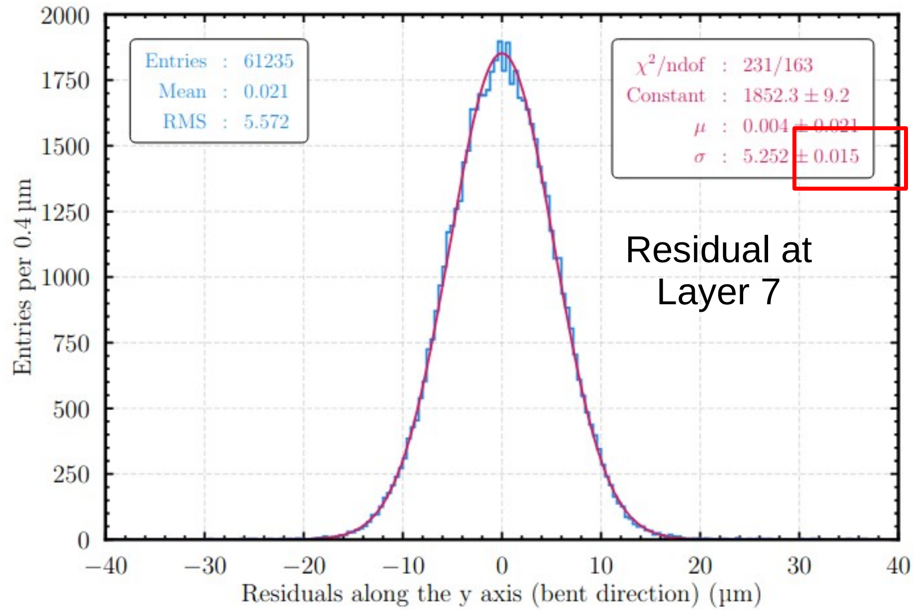
- Alignment
- Tracking
- Vertexing
- Event display

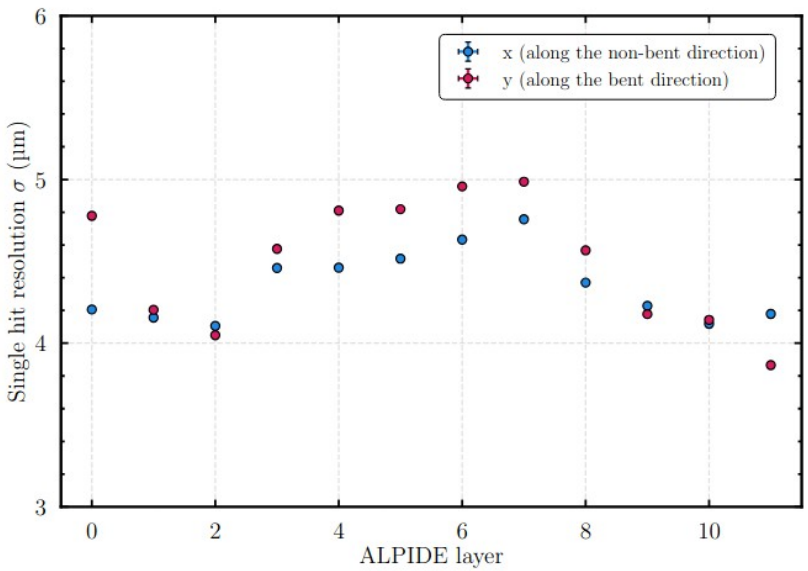
Difficult to align bent sensors so developed local scripts

Estimation of DCA between beam and tracks and interaction vertex

Alignment using ROOT code







Single hit resolution after subtracting tracking resolution

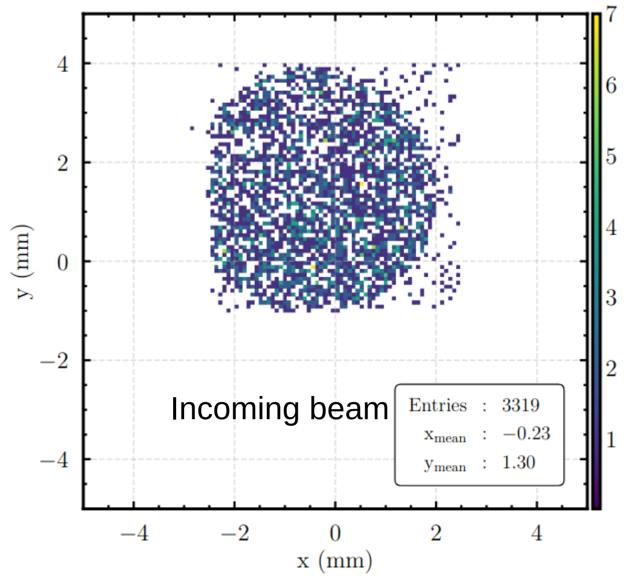
$$res_{x/y} = reco_{x/y} - meas_{x/y}$$

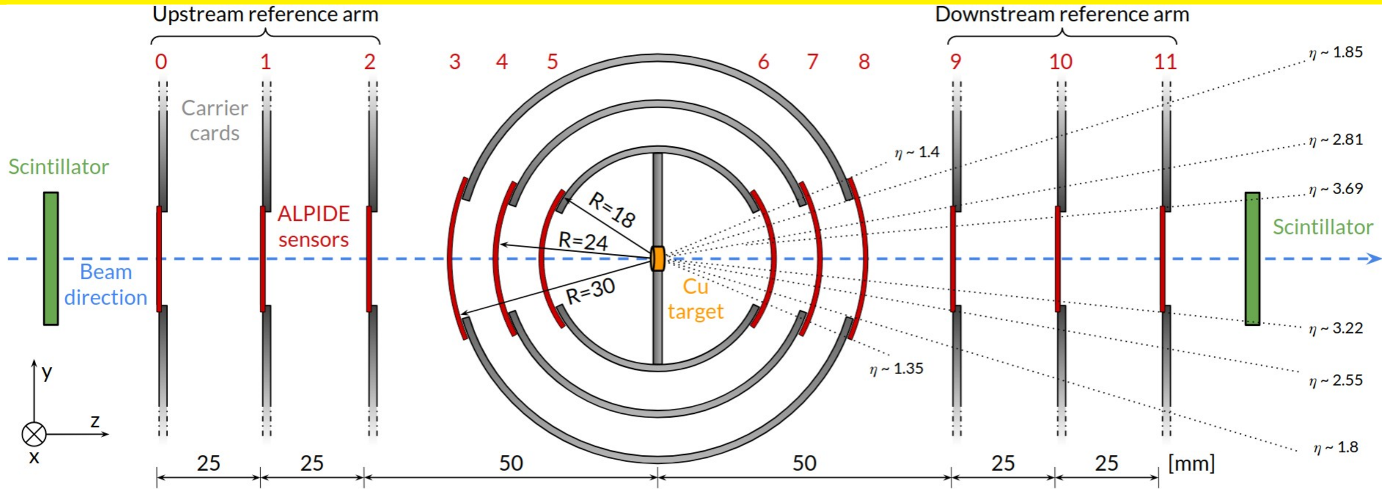
Unbiased:

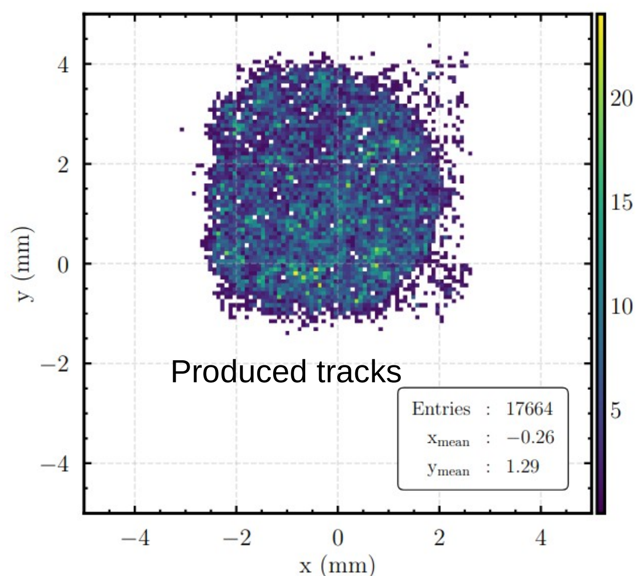
$$\sigma_{single\ hit\ x/y} = \sqrt{\sigma^2_{res\ x/y} - \sigma^2_{tracking}}$$

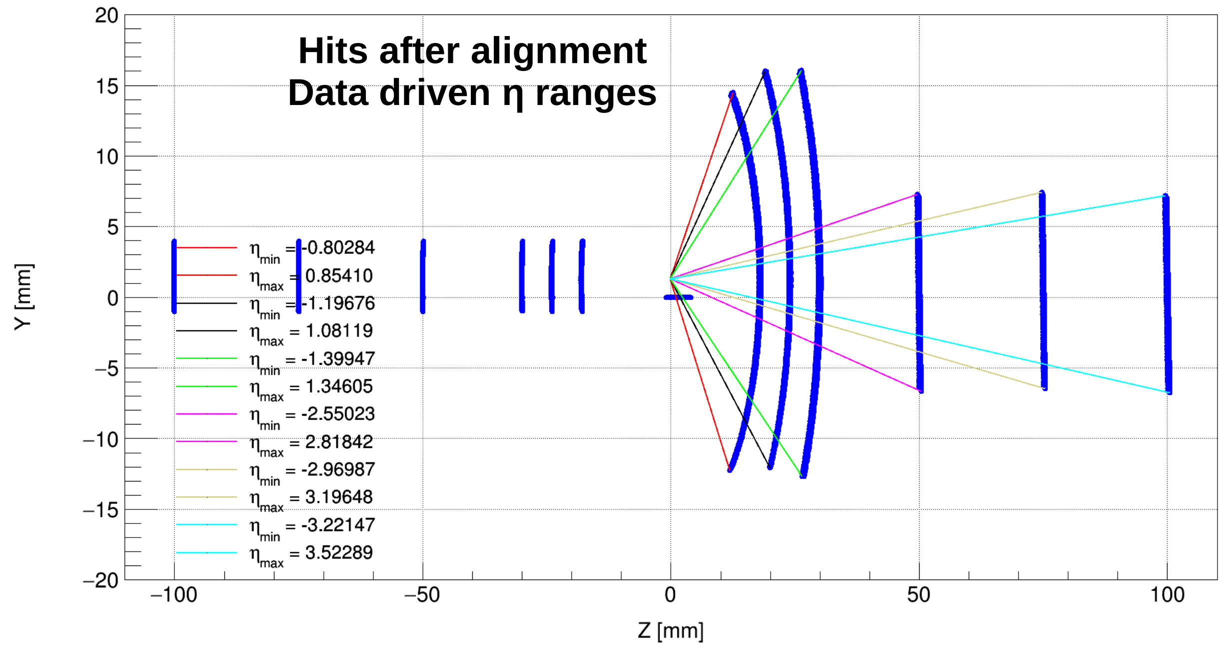
Is uncertainity underestimated?

Track fitting and Modified Sketch (η-ranges)









Test beam data analysis: Results

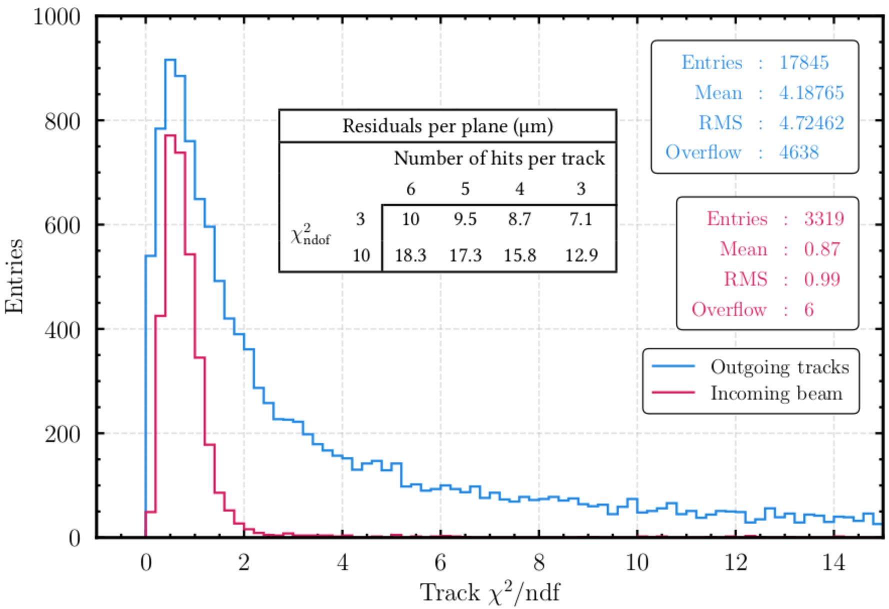
Selection of tracks based on p-value: To avoid sensitivity to the ndf

$$\text{p-value} = 1 - \mathrm{CDF}\left(\chi^2, ndf\right)$$

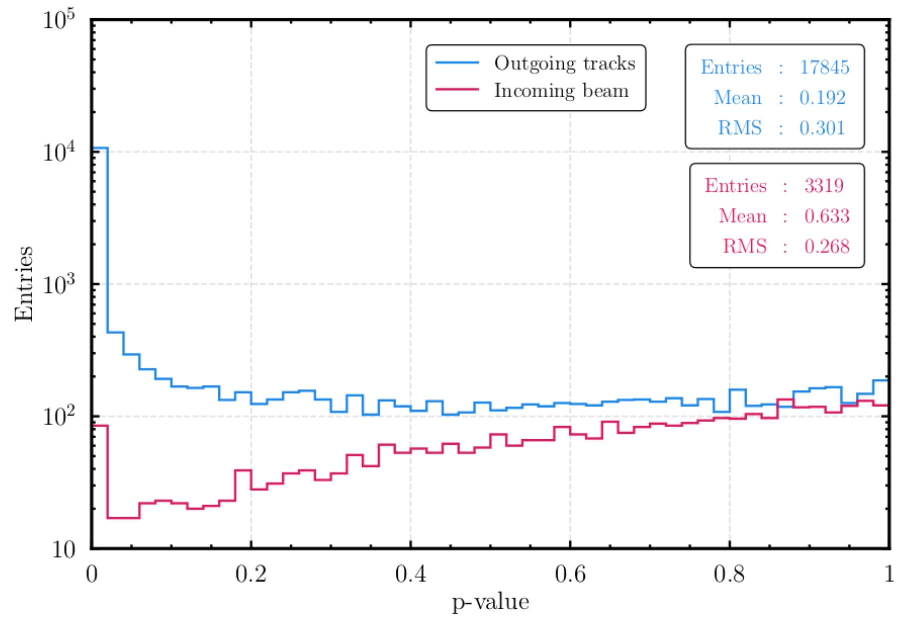
3, 4, 5, and 6 hits tracks: ndf are 2, 4, 6, 8 respectively

```
double pvalue = ROOT::Math::chisquared_cdf_c(chi2, ndf);
```

p-value is the probability of having χ^2 value larger than what you observed, i.e. $P(\chi^2 > \chi^2 \text{fit})$. If this probability is very small, it means that the hypothesis that your fit function is a good representation of your data is very unlikely

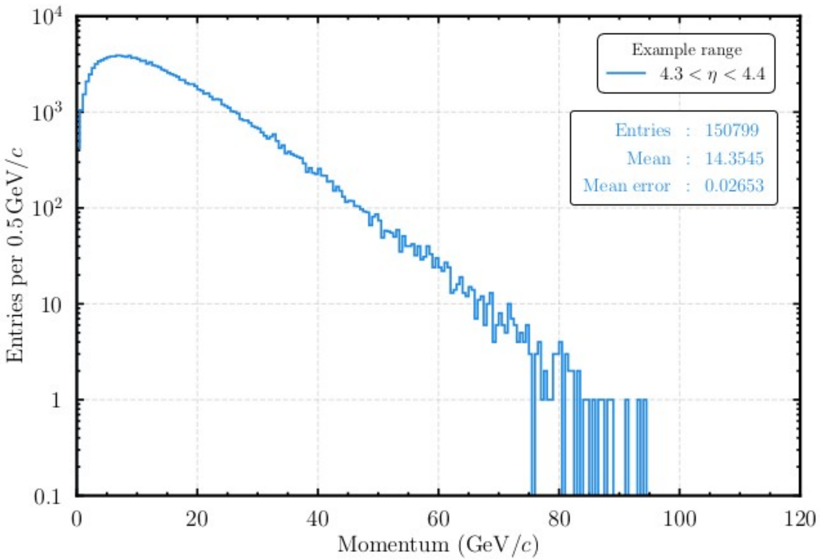


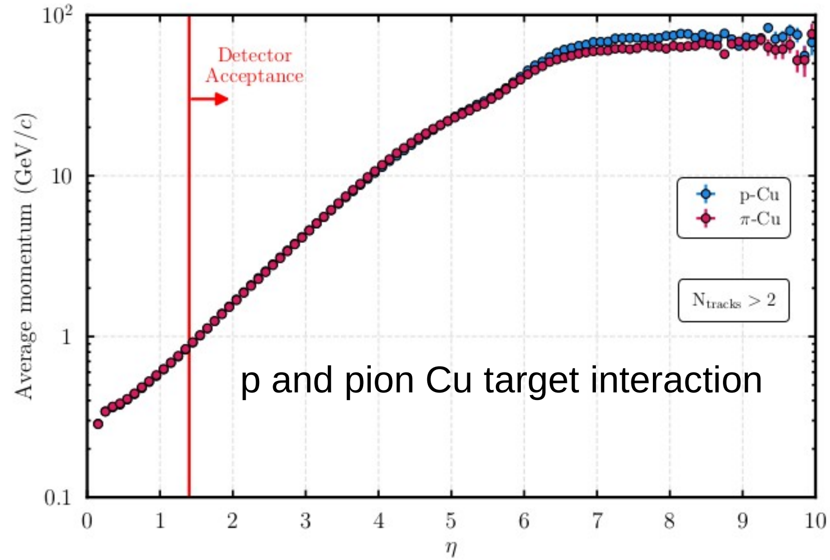
Residuals per plane (µm)					
		Number of hits per track			
		6	5	4	3
χ^2_{ndof}	3	10	9.5	8.7	7.1
	10	18.3	17.3	15.8	12.9

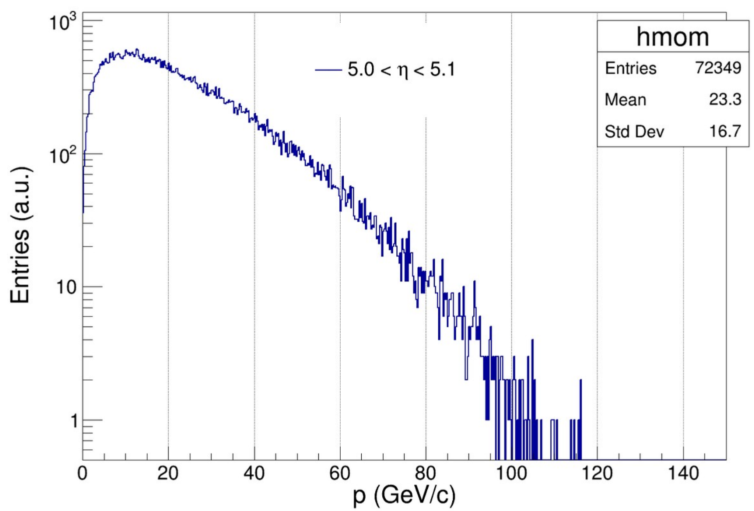


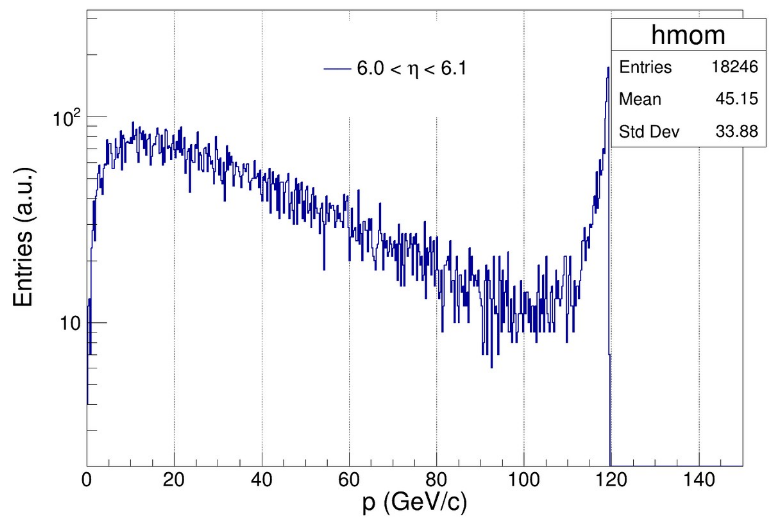
$$\chi^2 = R^{\mathrm{T}} V_{\mathrm{SR}}^{-1} R = \sum_i \frac{d_{x_i}^2}{\sigma_{x_i}^2} + \frac{d_{y_i}^2}{\sigma_{y_i}^2}$$

PYTHIA8 Simulation









Mean is not a good estimator but use some kind of weighted mean ?

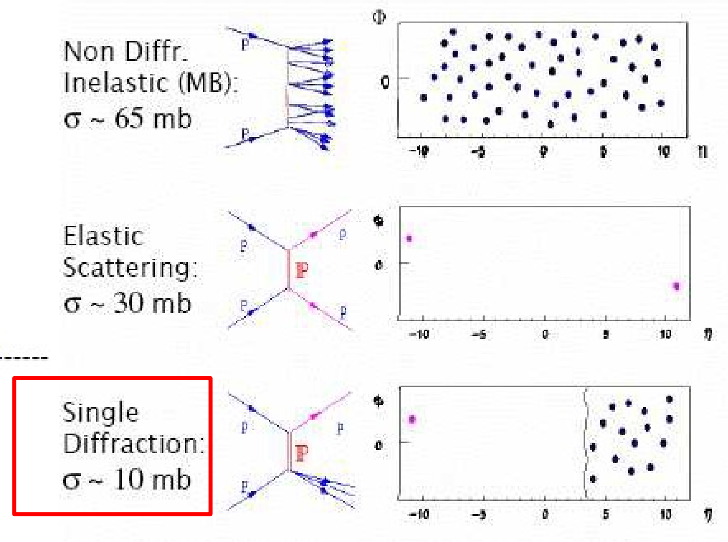
Process A B -> X B single diffractive with code 103 is 2 -> 2.
It has s = 2.269e+02, t = -2.522e-01, u = -2.120e+02,
pT = 4.870e-01, m3 = 3.467e+00, m4 = 9.383e-01,
theta = 6.863e-02, phi = 7.014e-01.

-------- End PYTHIA Info Listing -----------------------------------

-------- PYTHIA Event Listing (complete event) ---

no	id	name	status	mothers		daughters		colours		p_x	p_y	p_z	e	m
0	90	(system)	-11	0	0	0	0	0	0	0.000	0.000	119.996	178.618	132.308
1	2212	(p+)	-12	0	0	3	0	0	0	0.000	0.000	119.996	120.000	0.938
2	1000290630	(63Cu)	-12	0	0	4	0	0	0	0.000	0.000	-0.000	58.618	58.619
3	2212	(p+)	-13	1	0	5	0	0	0	0.000	0.000	119.996	120.000	0.938
4	2212	(p+)	-13	2	0	6	0	0	0	0.000	0.000	-0.000	0.938	0.938
5	9902210	(p_diffr+)	-15	3	0	7	8	0	0	0.372	0.314	119.814	119.866	3.467
6	**2212**	**p+**	**14**	**4**	**0**	**0**	**0**	**0**	**0**	**-0.372**	**-0.314**	**0.182**	**1.073**	**0.938**
7	**2**	**(u)**	**-24**	**5**	**0**	**10**	**12**	**201**	**0**	**0.386**	**0.326**	**3.630**	**3.679**	**0.325**
8	**2101**	**(ud_0)**	**-63**	**5**	**0**	**10**	**12**	**0**	**201**	**-0.014**	**-0.011**	**116.184**	**116.186**	**0.650**
9	**1000280629**	**NucRem**	**14**	**2**	**0**	**0**	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**57.680**	**57.680**
10	**111**	**(pi0)**	**-83**	**7**	**8**	**13**	**14**	**0**	**0**	**-0.179**	**0.155**	**1.580**	**1.604**	**0.135**
11	**2212**	**p+**	**83**	**7**	**8**	**0**	**0**	**0**	**0**	**0.822**	**0.415**	**32.150**	**32.177**	**0.938**
12	**111**	**(pi0)**	**-84**	**7**	**8**	**15**	**16**	**0**	**0**	**-0.271**	**-0.256**	**86.084**	**86.085**	**0.135**
13	**22**	**gamma**	**91**	**10**	**0**	**0**	**0**	**0**	**0**	**-0.037**	**0.025**	**0.086**	**0.097**	**0.000**
14	**22**	**gamma**	**91**	**10**	**0**	**0**	**0**	**0**	**0**	**-0.141**	**0.130**	**1.494**	**1.507**	**0.000**
15	**22**	**gamma**	**91**	**12**	**0**	**0**	**0**	**0**	**0**	**-0.193**	**-0.190**	**47.011**	**47.012**	**0.000**
16	**22**	**gamma**	**91**	**12**	**0**	**0**	**0**	**0**	**0**	**-0.079**	**-0.066**	**39.073**	**39.073**	**0.000**

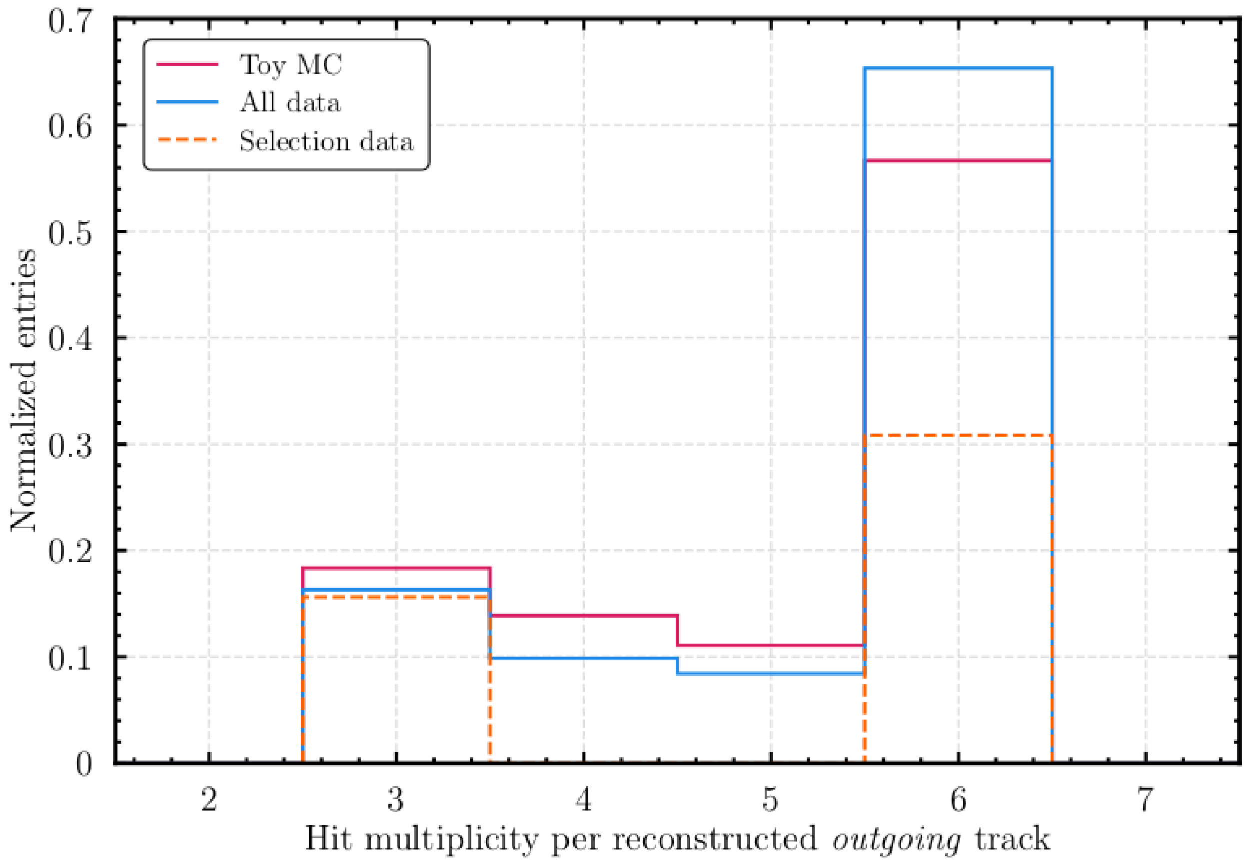
Charge sum: 30.000 Momentum sum: 0.000 0.000 119.996 178.618 132.308



$$p + Cu \rightarrow p + \pi^0(\gamma\gamma)$$

Hit Multiplicity

6 hits more combinations in data



Why tracks are rejected?

My idea is just try once outward->Inward fitting (?)

Check event display with all properties of tracks

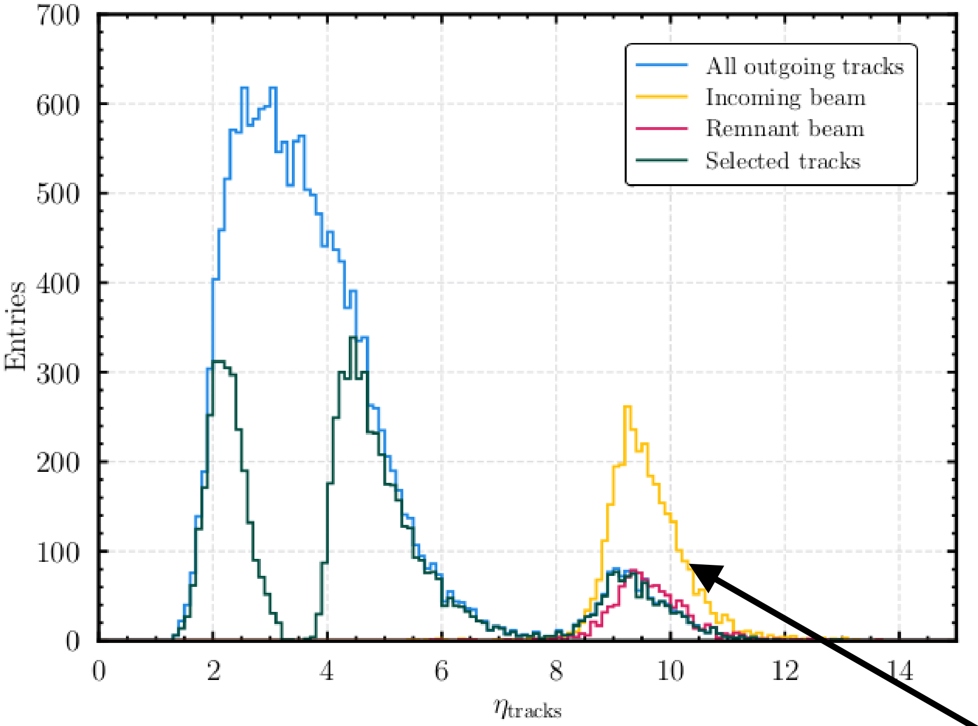
Eta distribution

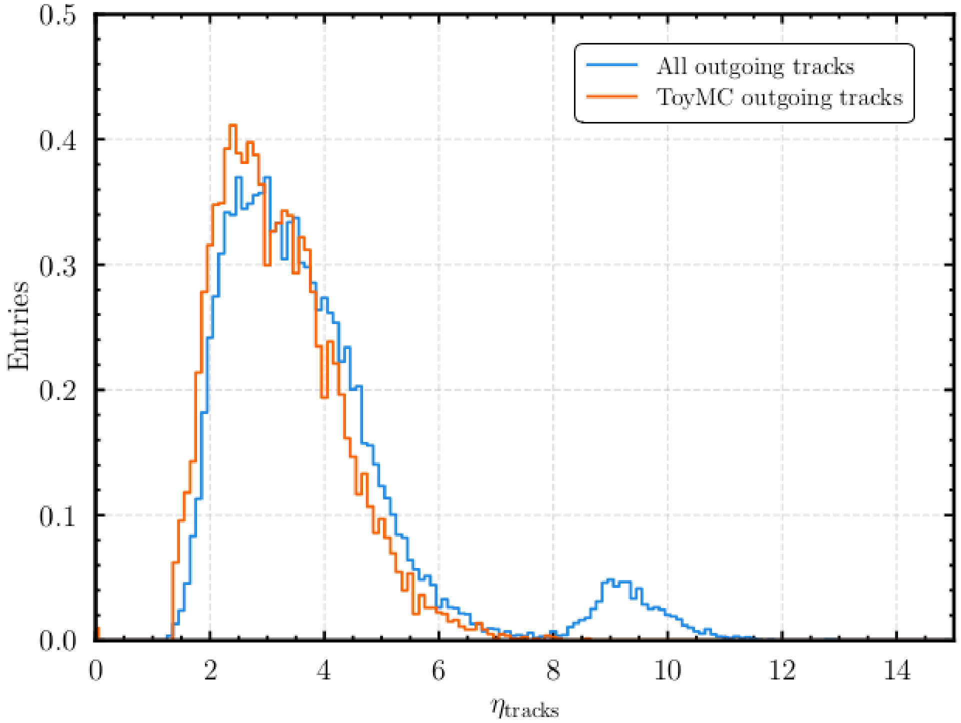
All Outgoing tracks (p-value>=0)

Selected tracks (p-value>0.001)

Remnant beam tracks (tracks formed with 12 hits)

Incoming beam (3319 Events)





In PYTHIA 8 simulation beam is along z-axis but in data it has a an angle with respect to z-axis

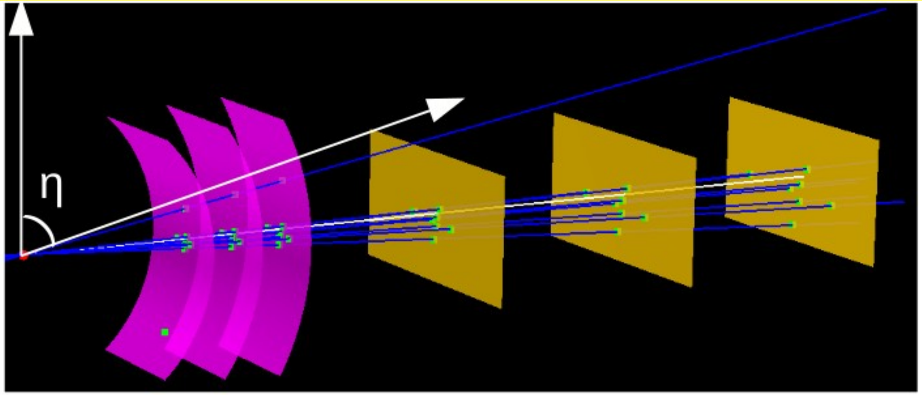
DCA Resolution vs Nhits

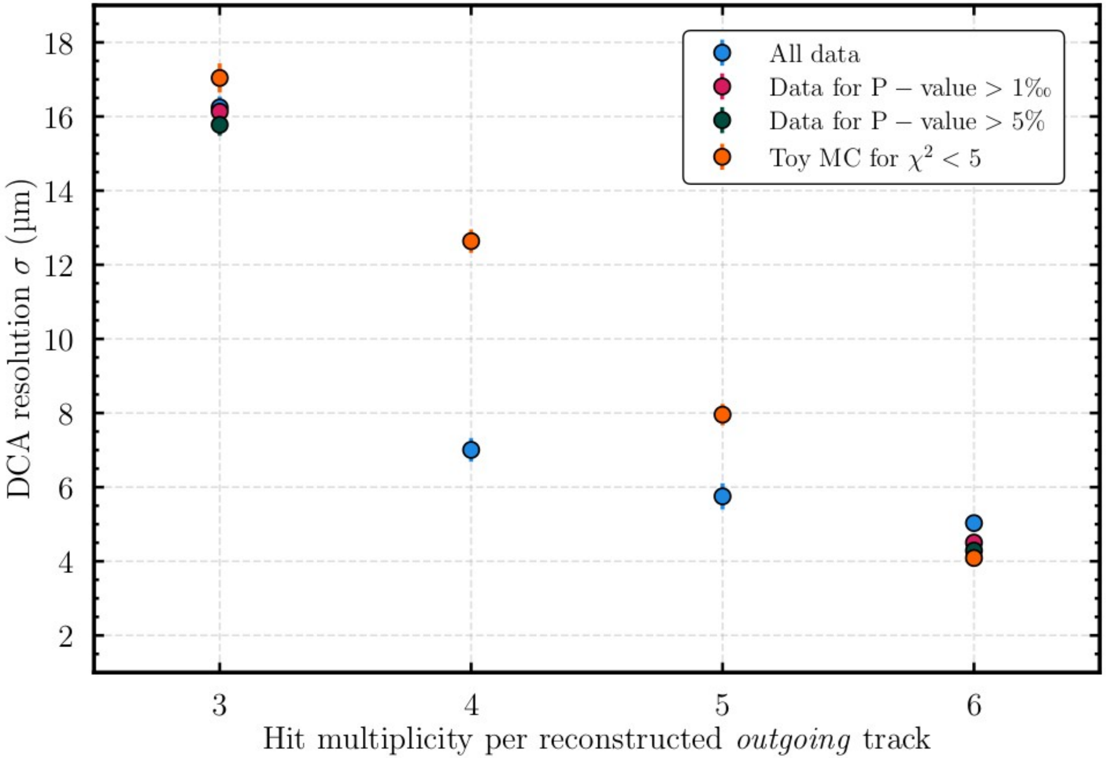
All data (p-value>=0)

Data with (p-value >0.001)

Data with (p-value >0.05)

ToyMC (χ^2<5)



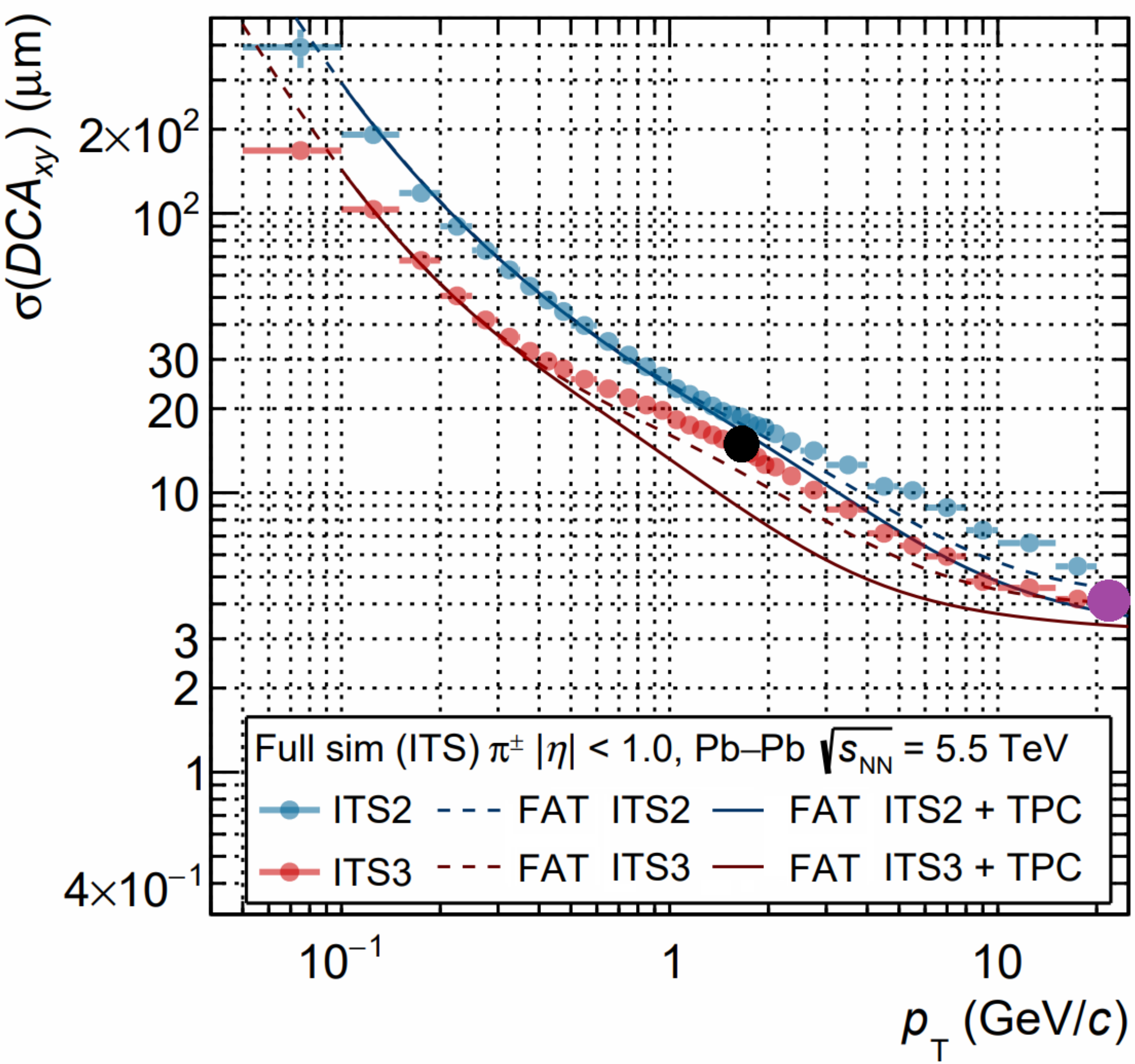


4 hits and 5-hits tracks are suppressed after applying a selection based on p-value?

Issue by Andrea and Fabrizio (solved):

- Comment: we are using only large eta-tracks only means using not using bent region
- Answer: **Now we are also showing results for pure 3 hits means accessing bent region of DUT**

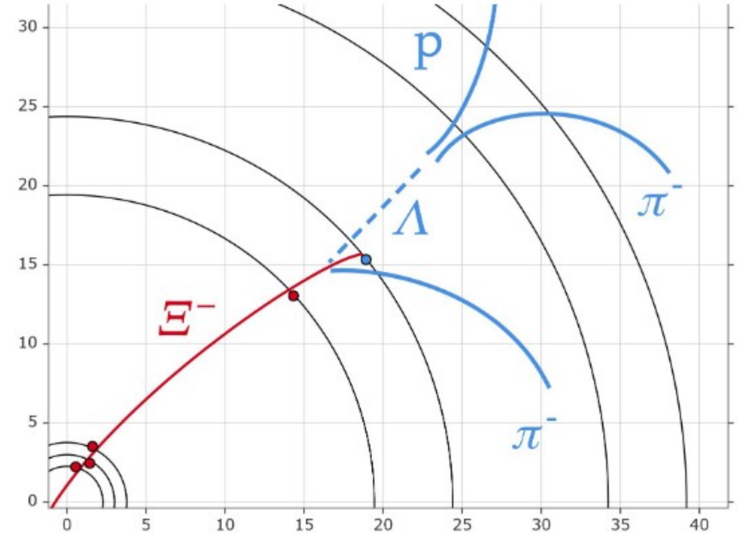
DCAxy Resolution for ITS3



Qualitative Comparison:

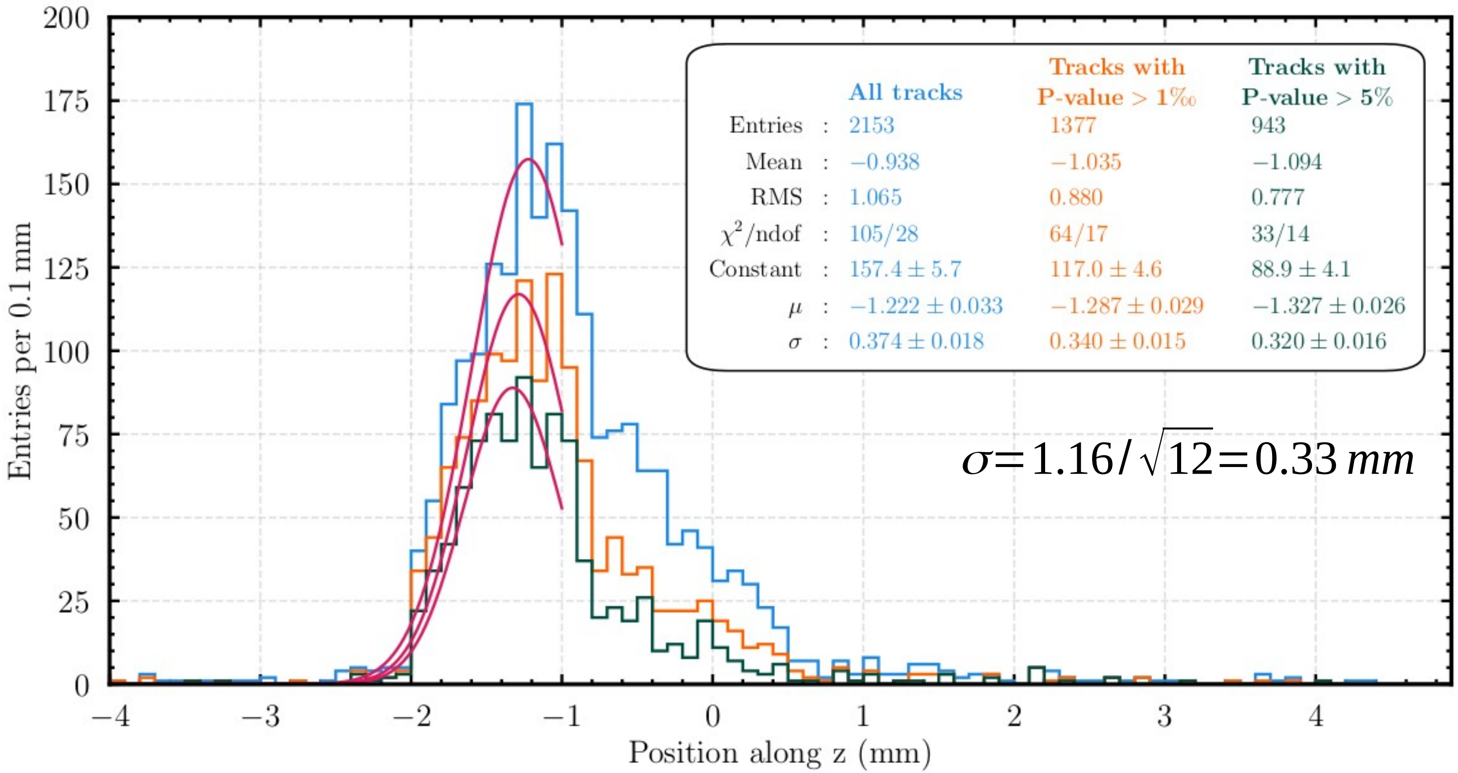
- Black marker with 3 hits (our result)
- Magenta marker with 6 hits (our results)
- Three hits case can be compared with the hyperon tracking

Values of the DCA resolution in the order of 30 μm are found when the tracks of the hyperons are made of three or more hits



Position of Interaction Vertex

Cu-target thickness = 1.16 mm



$$\sigma = 1.16/\sqrt{12} = 0.33\, mm$$

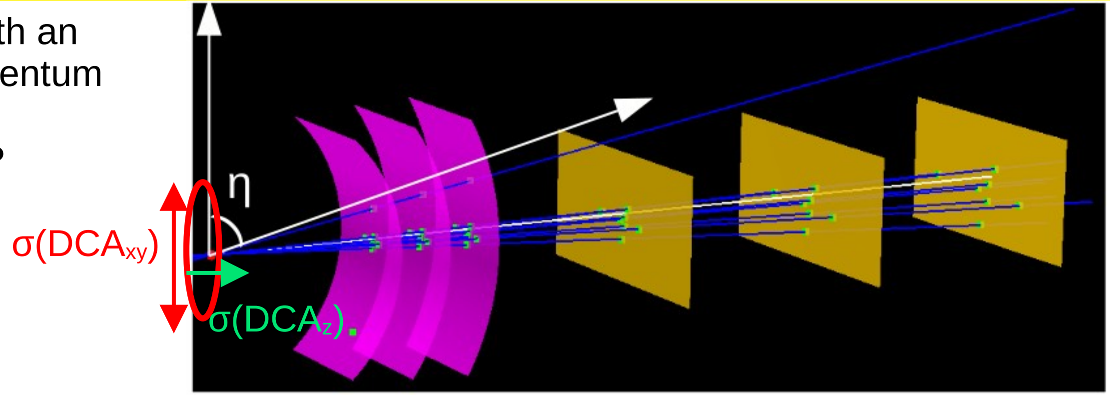
$$\sigma_{V_z} = \sigma_{DCA_z} \oplus 0.33\, mm$$

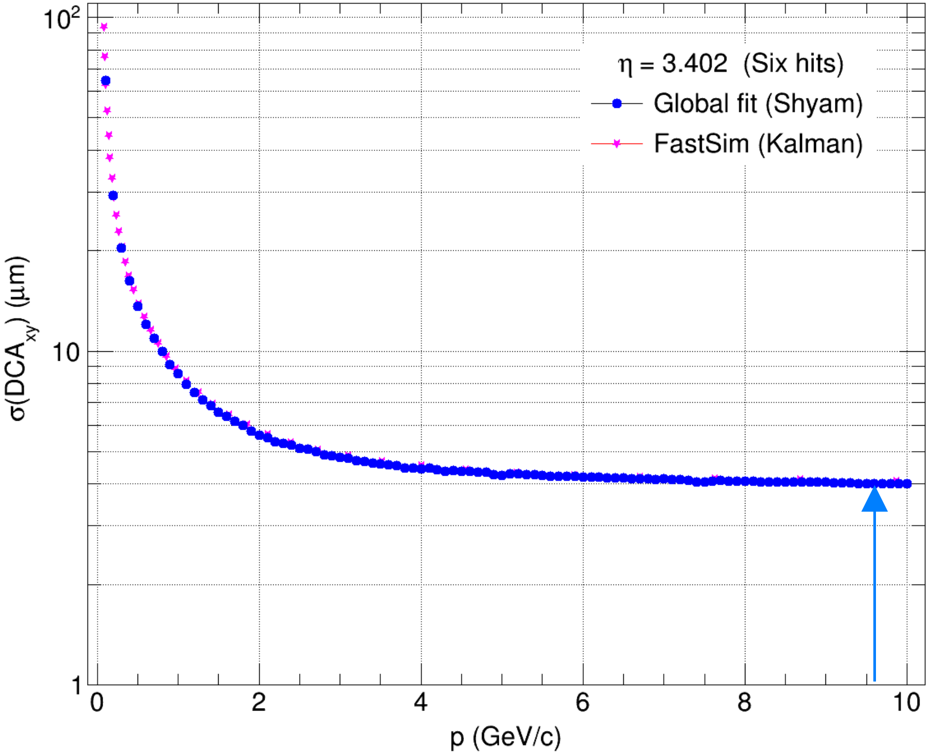
Z-vertex resolution must include DCAz resolution: Fit with step function convoluted with Gaussain?

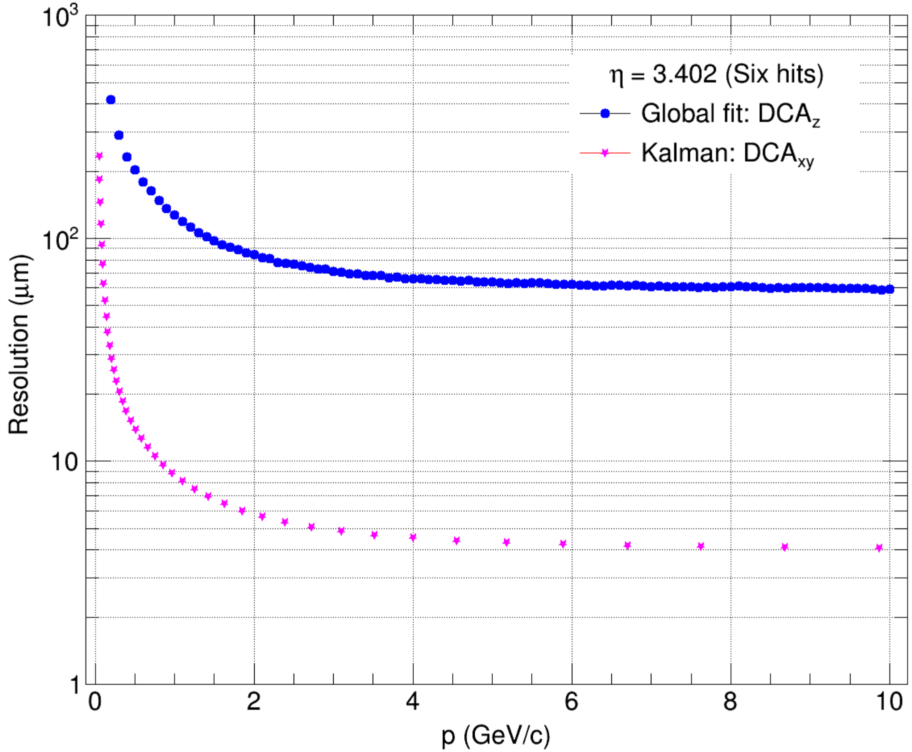
DCA_{xy} and DCA_z Resolution

Beam is precisely known in transverse plane with an uncertainity of ~ 4 µm because of very high-momentum

What about z-position of interaction vertex?
Fit the vertex using produced tracks



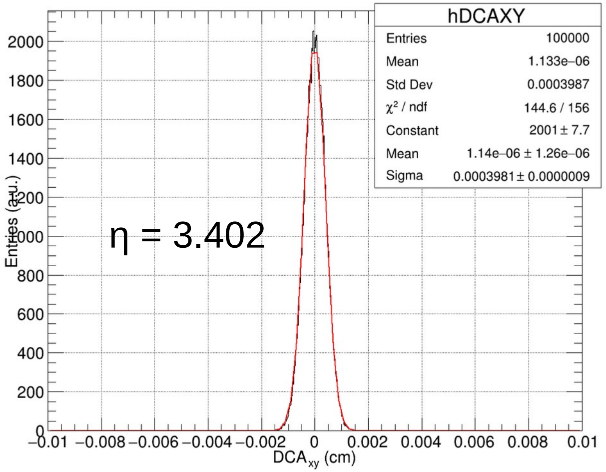


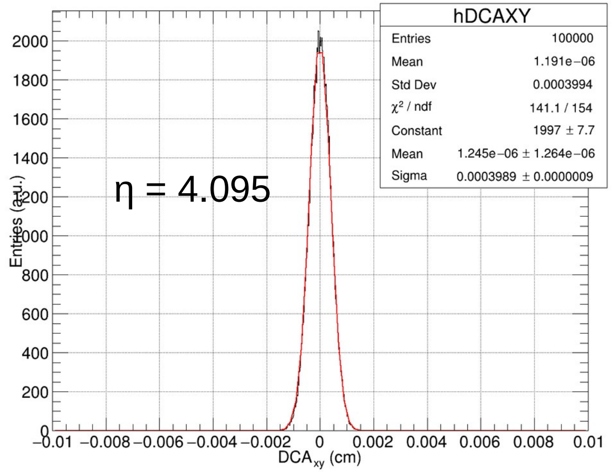


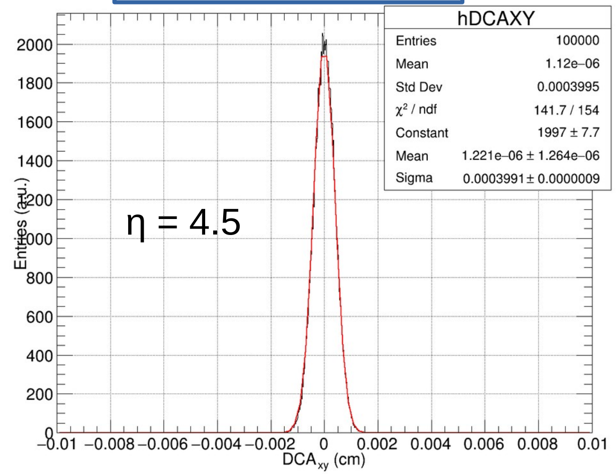
DCA_{xy} and DCA_z Resolution

Considering 6 hit tracks with a very high momentum: fast simulations

$$\sigma_{DCA_z} = \frac{\sigma_{DCA_{xy}}}{\sin(\theta)}$$



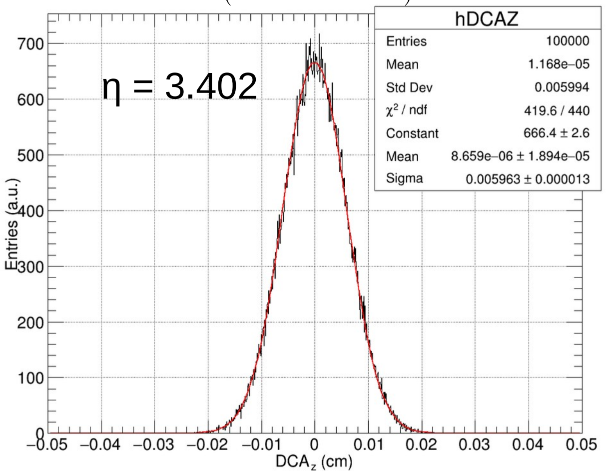


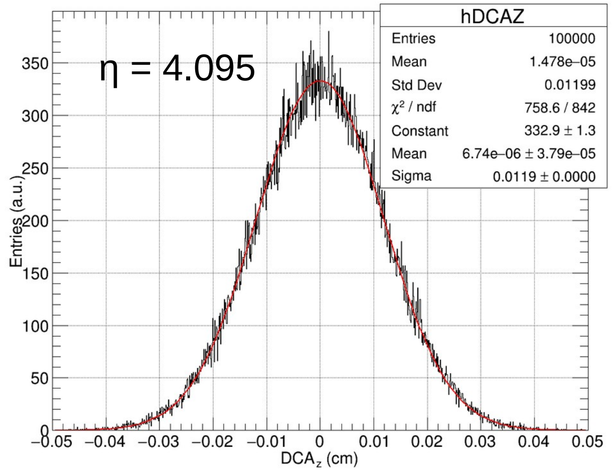


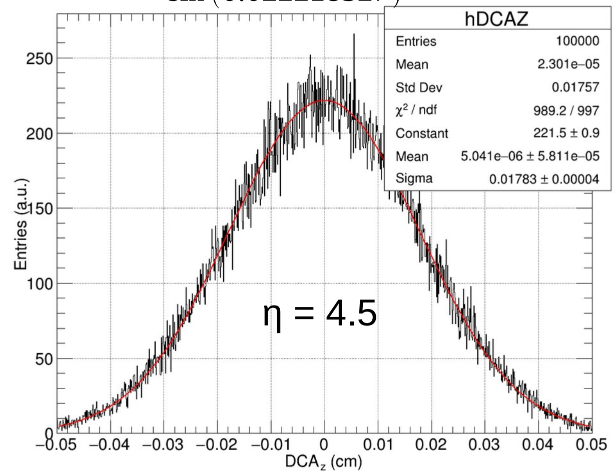
$$\sigma_{DCA_z} = \frac{3.98}{\sin(0.066568127)} \approx 59.83\,\mu m$$

$$\sigma_{DCA_z} = \frac{3.99}{\sin(0.033321027)} \approx 119.76\,\mu m$$

$$\sigma_{DCA_z} = \frac{3.99}{\sin(0.022218527)} \approx 179.59\,\mu m$$



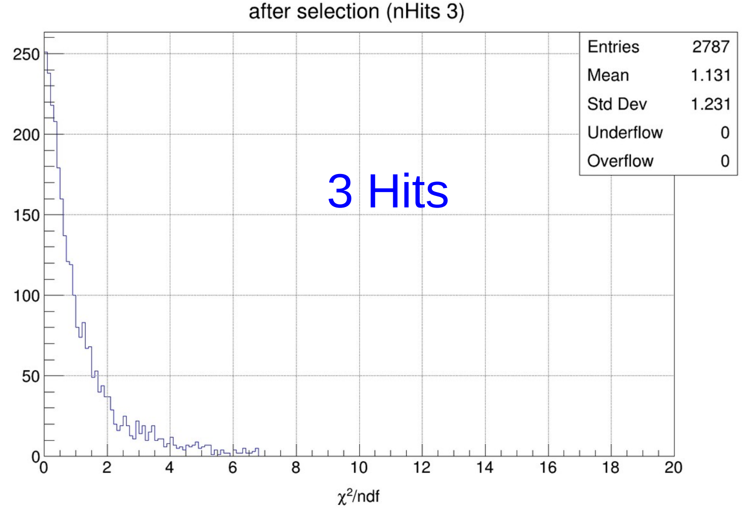


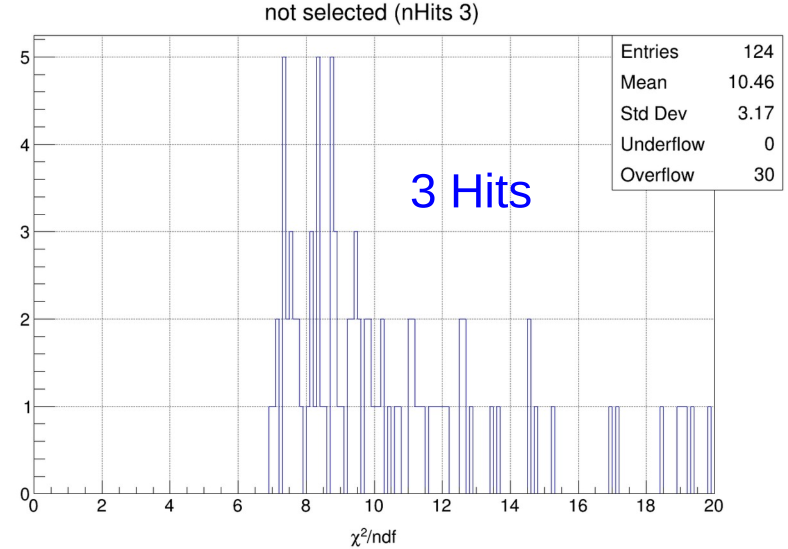


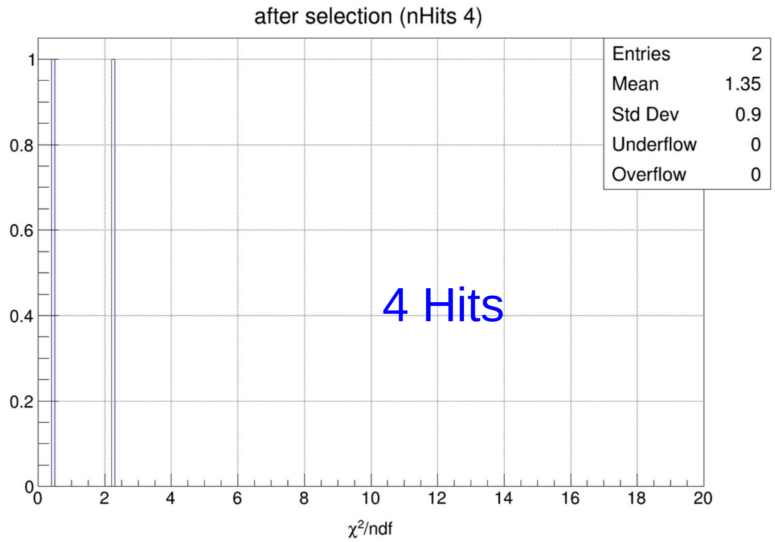
Selected and Rejected tracks

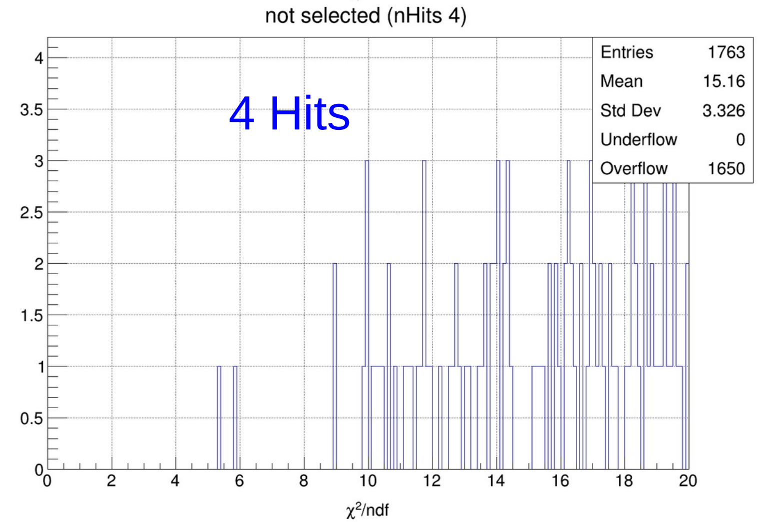
P-val (>0.001) vs Chi2 (selected)

Rejected









Selected and Rejected tracks

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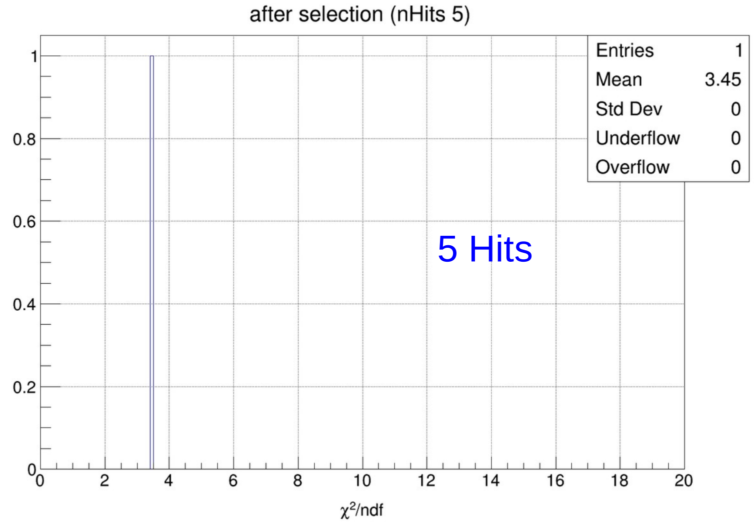
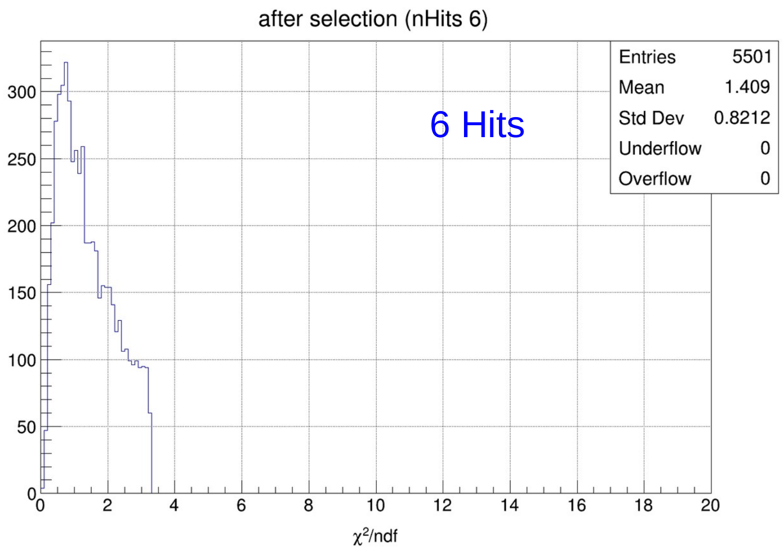
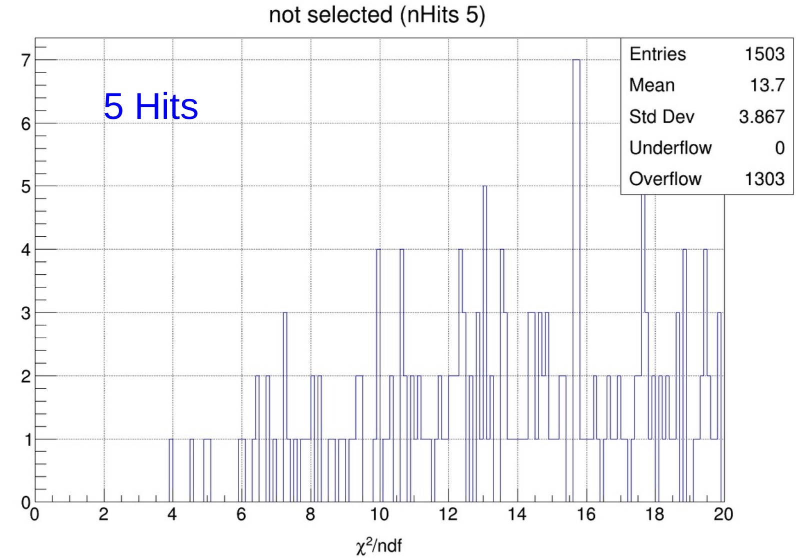
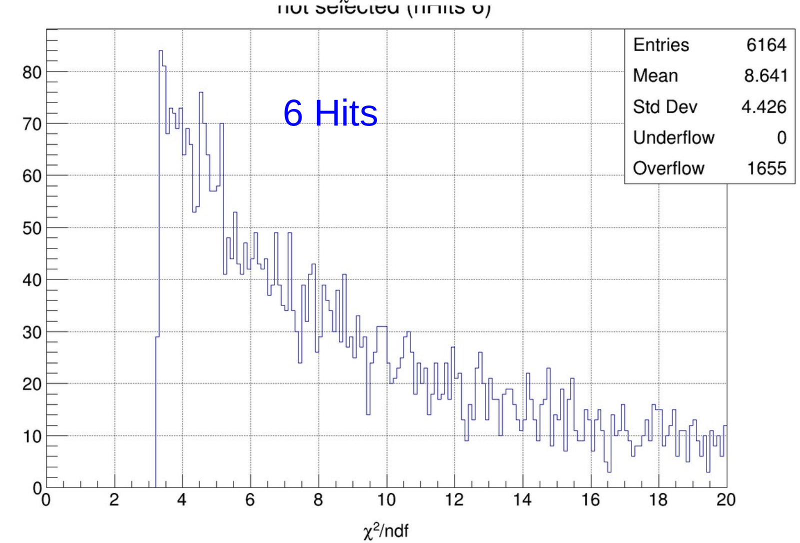




Rejected

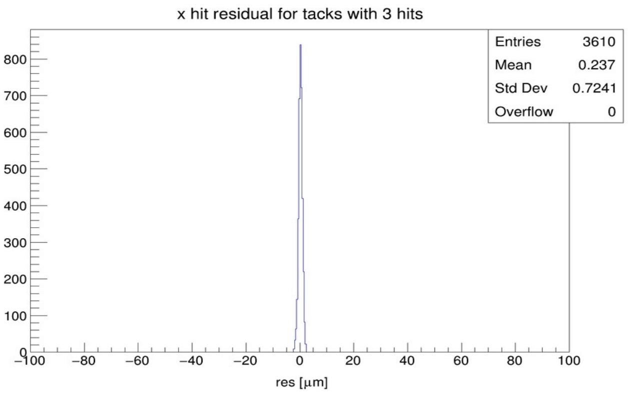




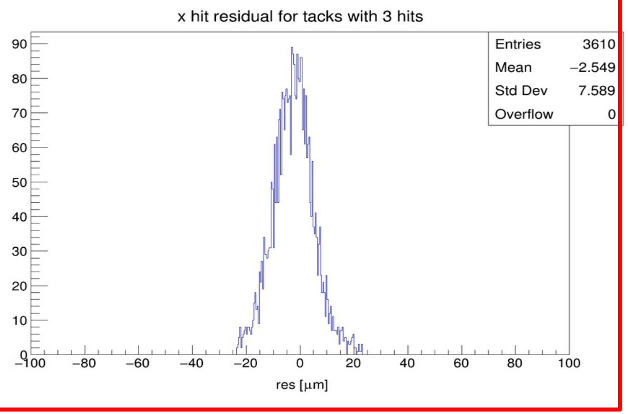
X Residuals for selected tracks with 3 hits

Layer 7 has large residuals

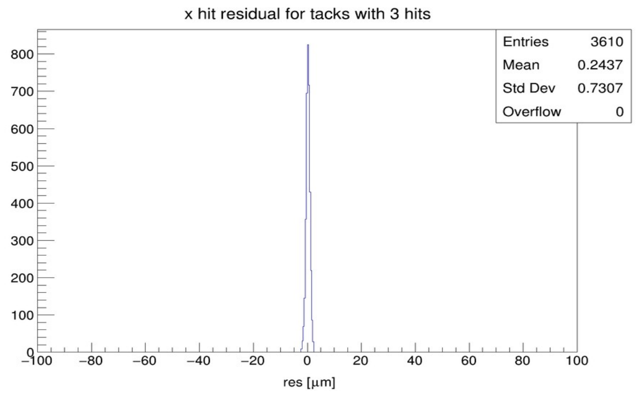
Layer 6



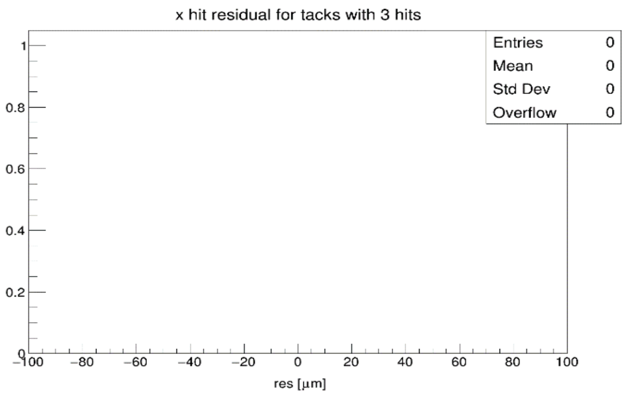
Layer 7



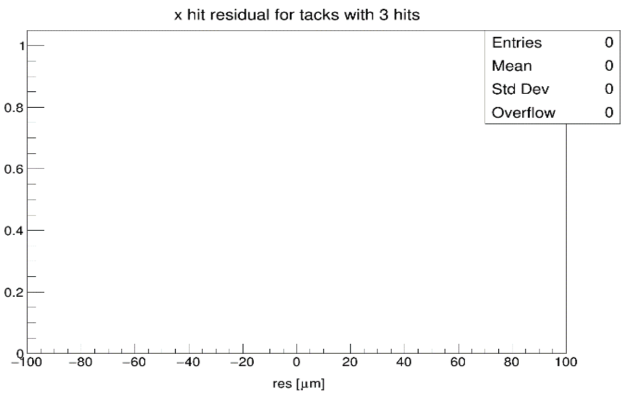
Layer 8



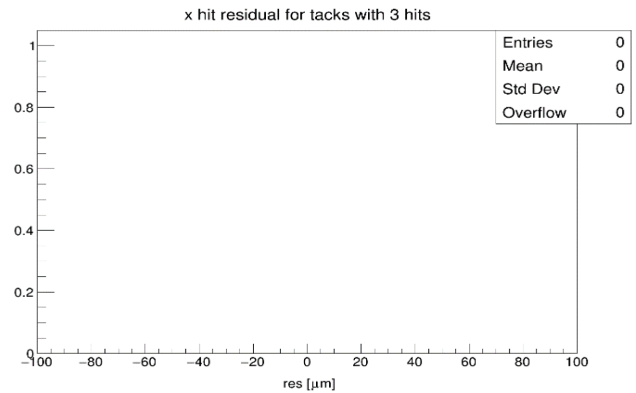
Layer 9



Layer 10



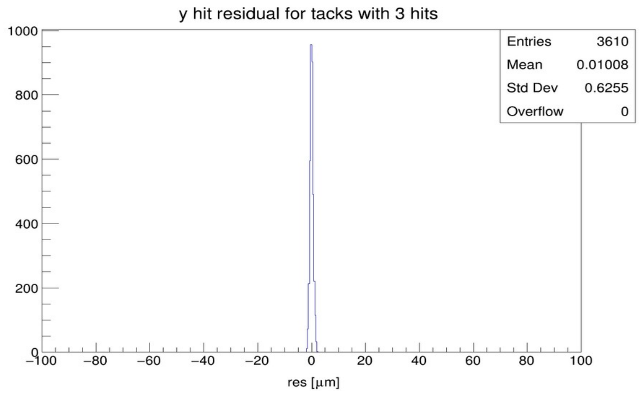
Layer 11



Y Residuals for selected tracks with 3 hits

Layer 7 has large residuals

Layer 6



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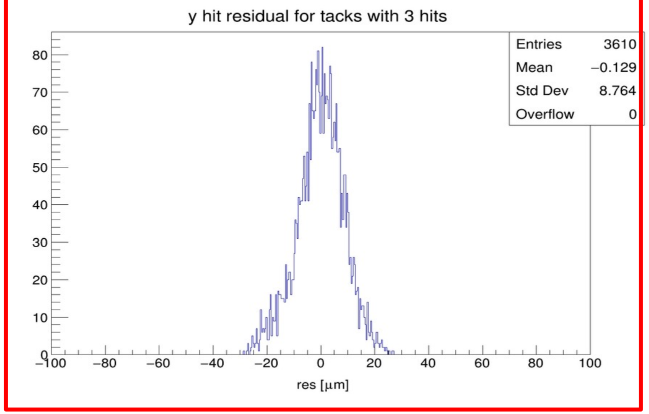

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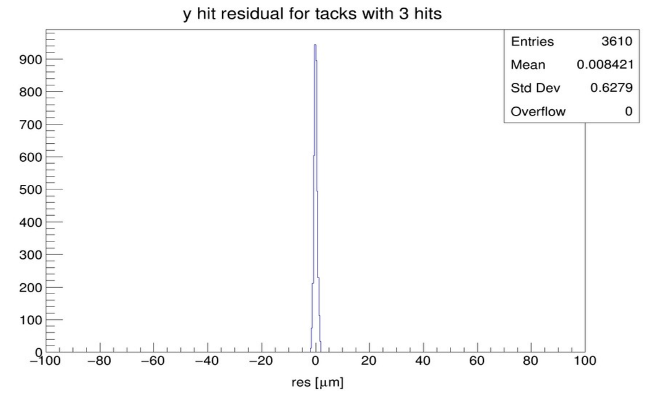
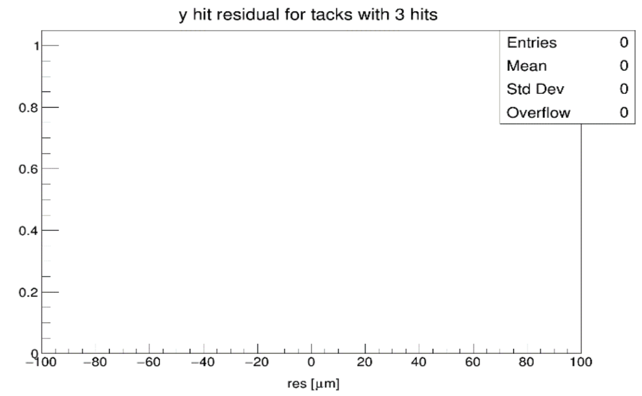


Layer 9



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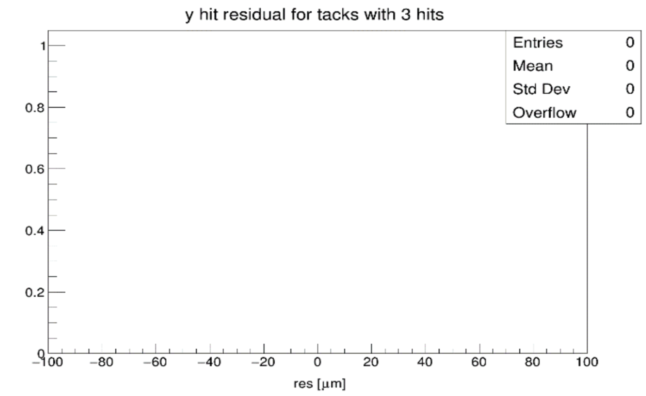

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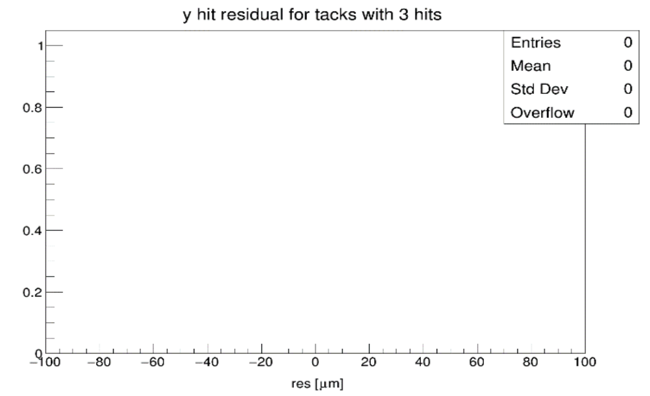
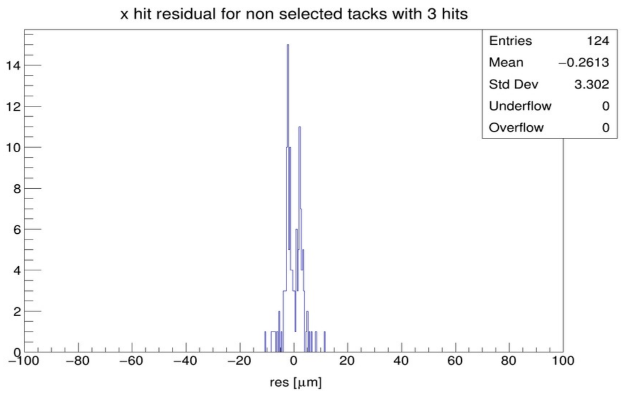


X Residuals for rejected tracks with 3 hits

Layer 7 has large residuals

Layer 6



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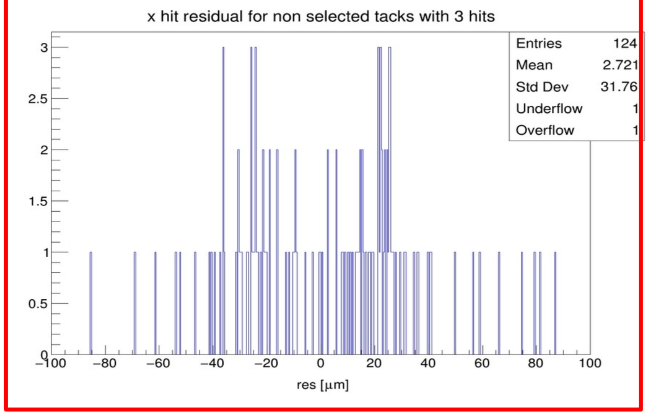

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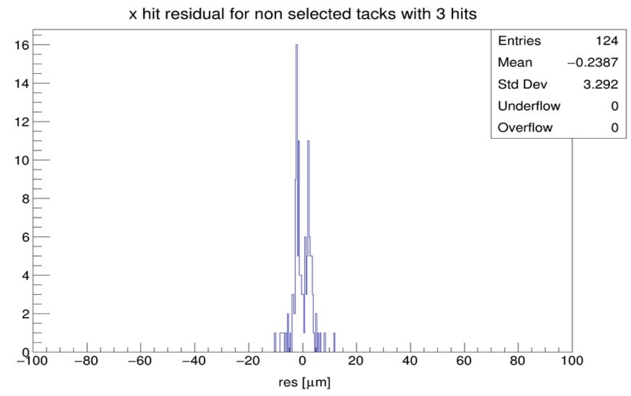

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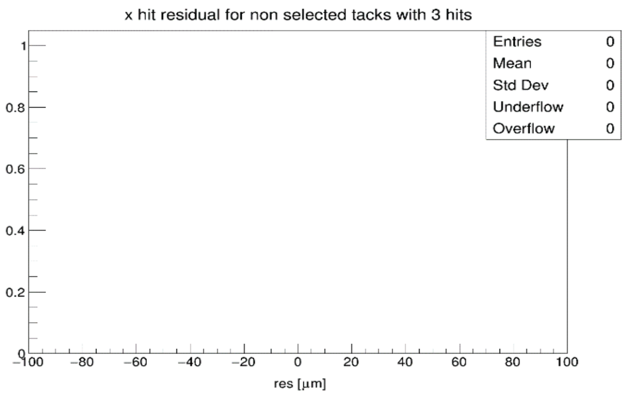

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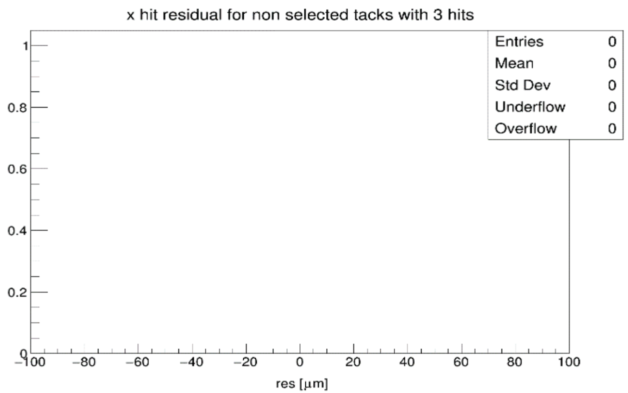

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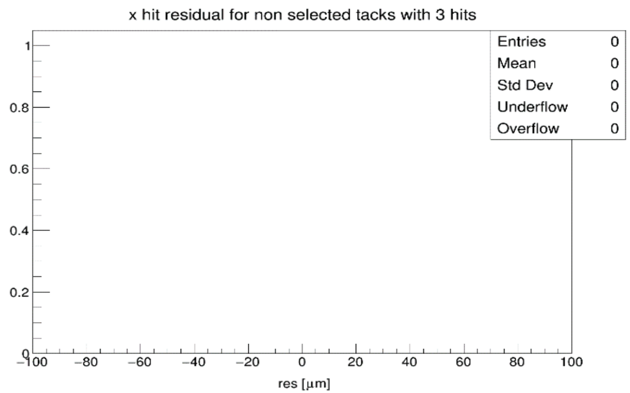
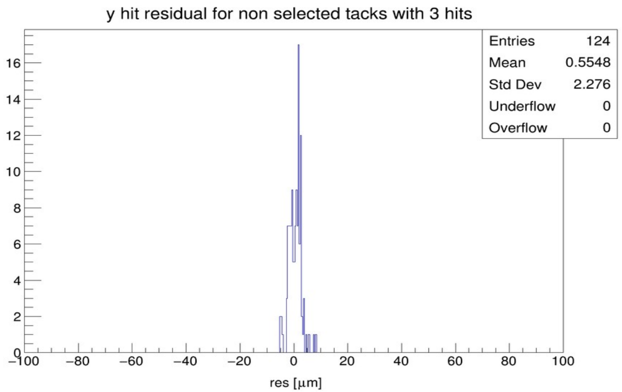


Y Residuals for rejected tracks with 3 hits

Layer 7 has large residuals

Layer 6



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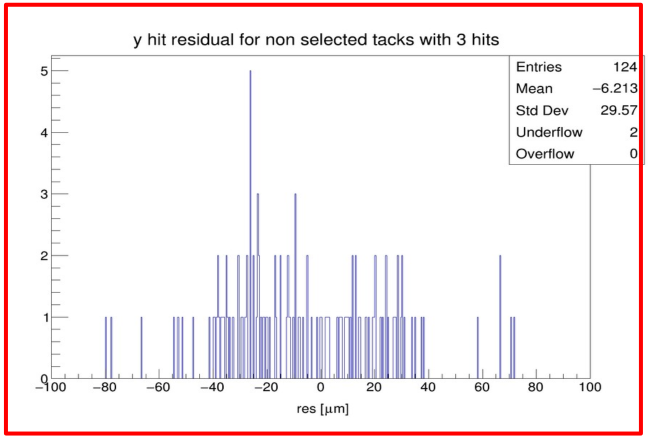

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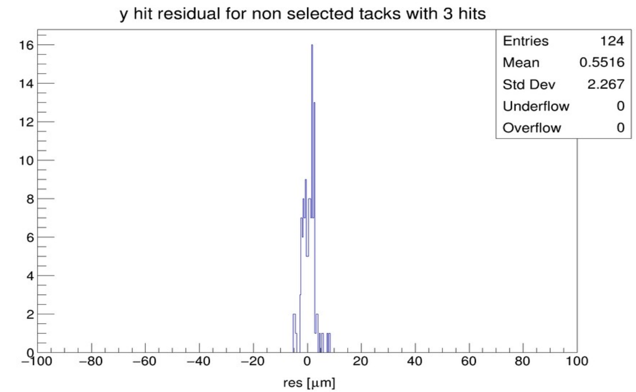

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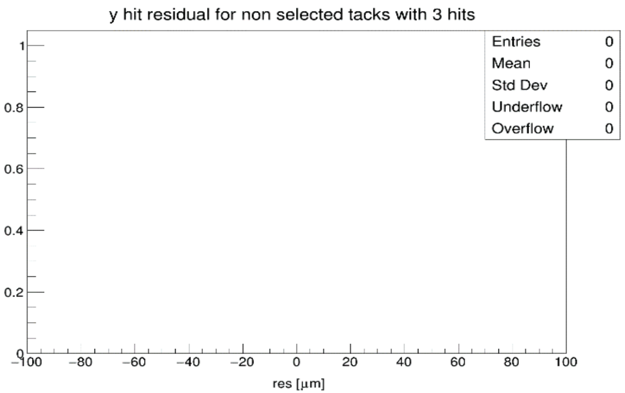

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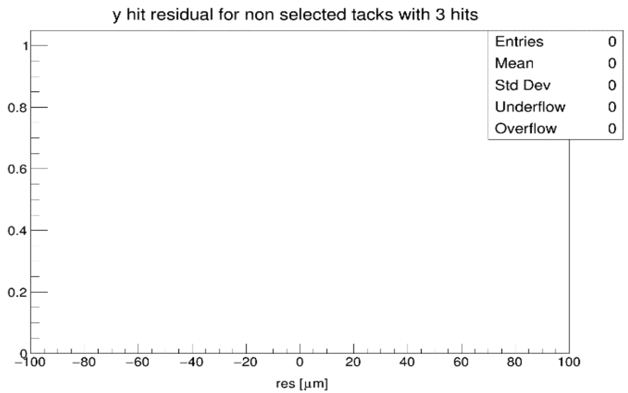

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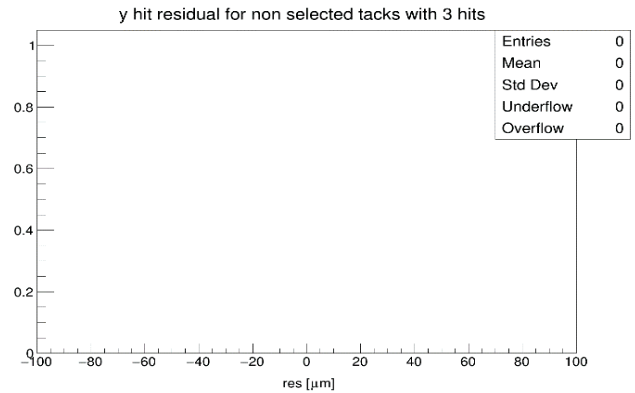
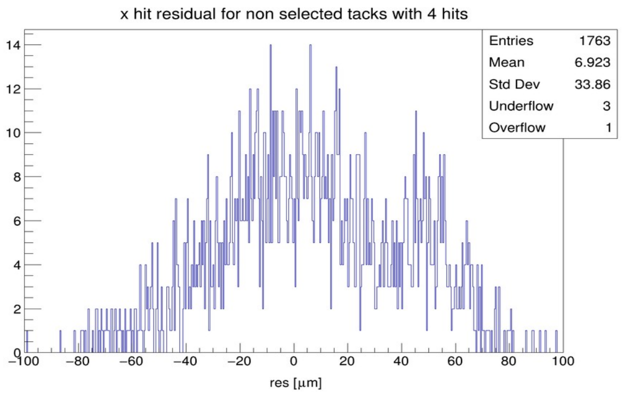


X Residuals for rejected tracks with 4 hits

Layer 6



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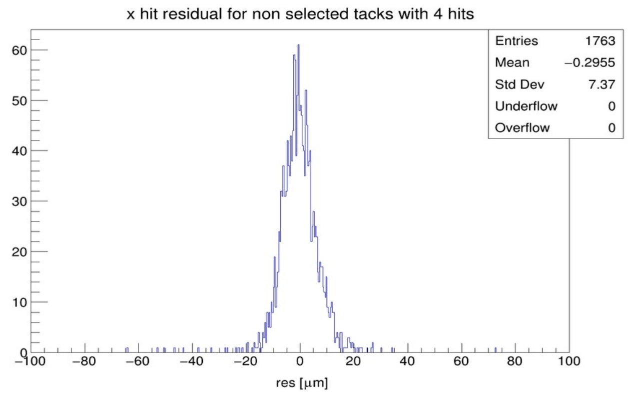

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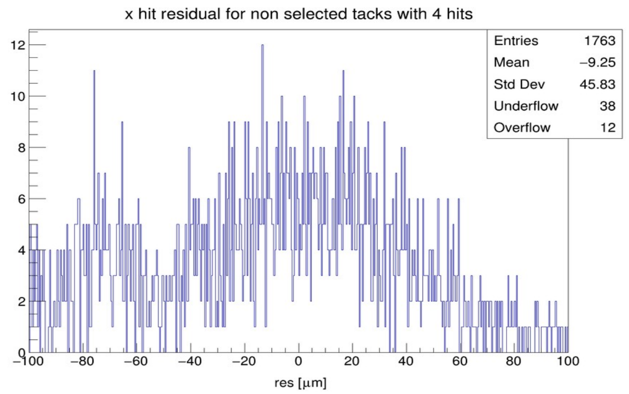

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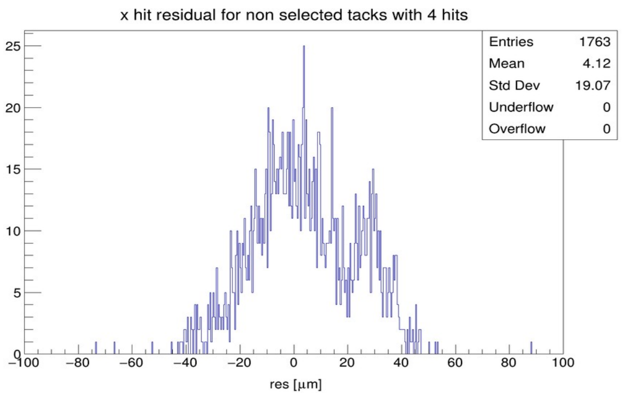

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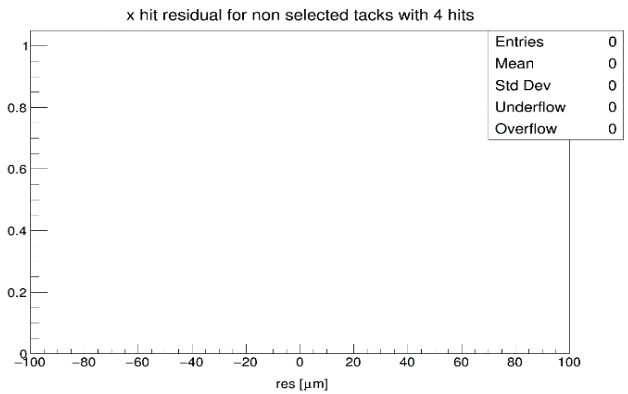

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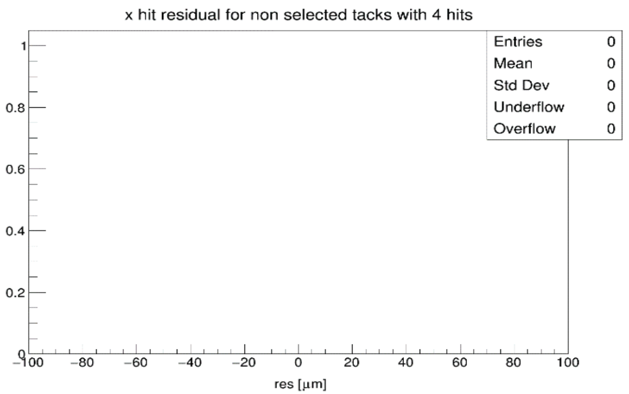
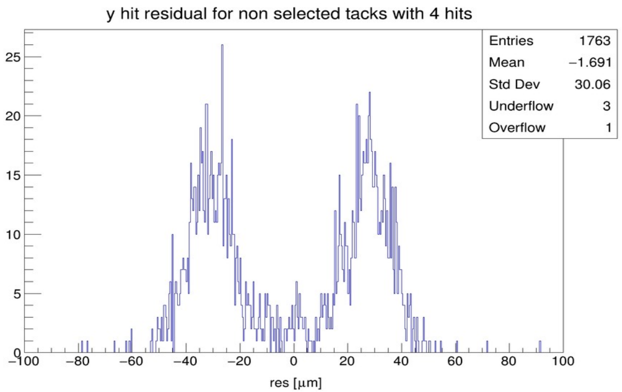


Y Residuals for rejected tracks with 4 hits

Layer 6



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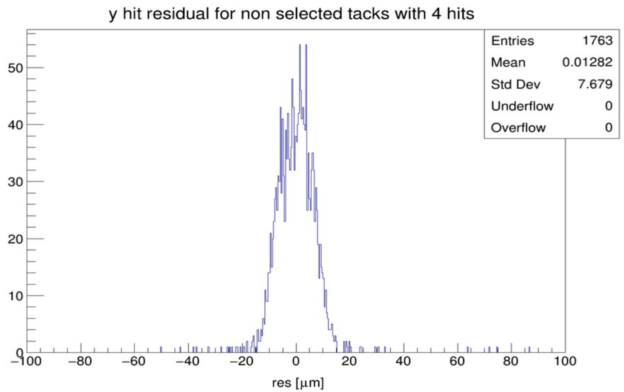

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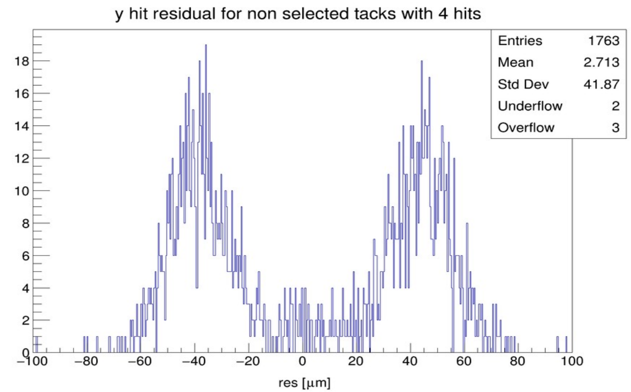

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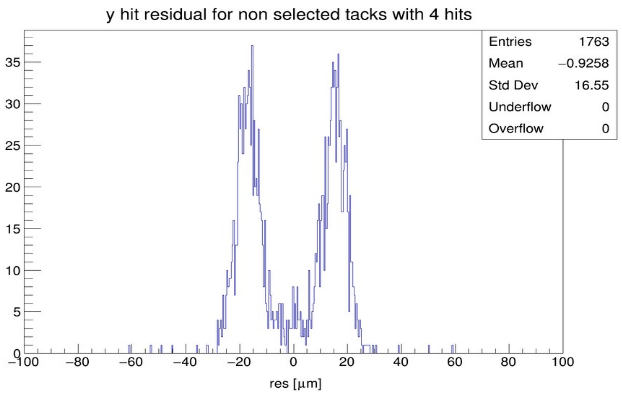

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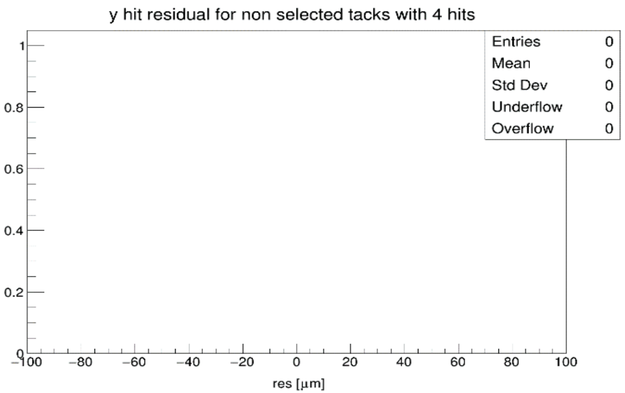

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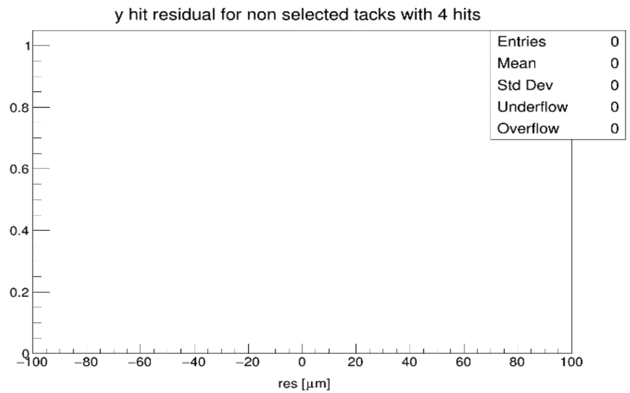
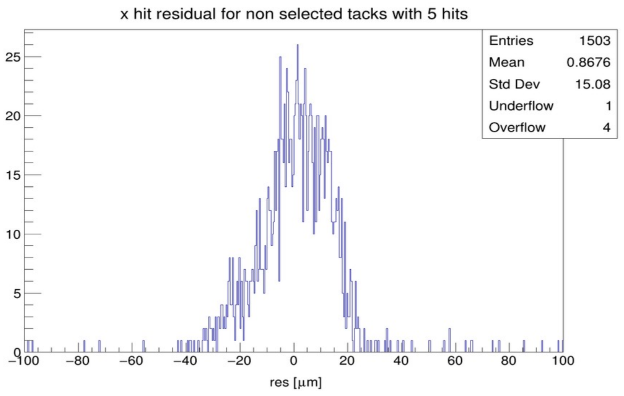


X Residuals for rejected tracks with 5 hits

Layer 6



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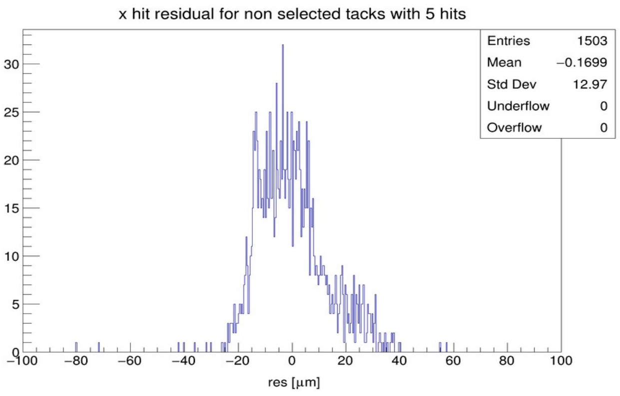

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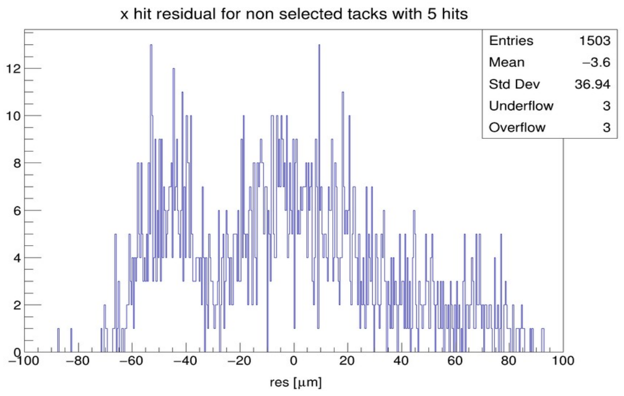

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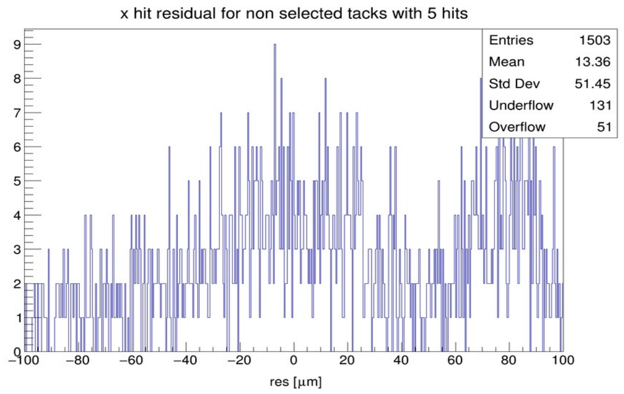

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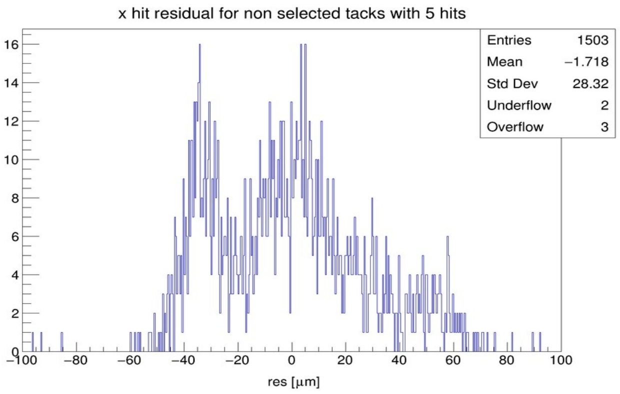

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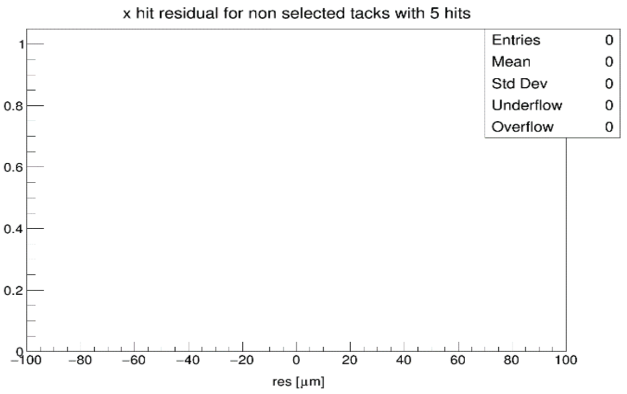
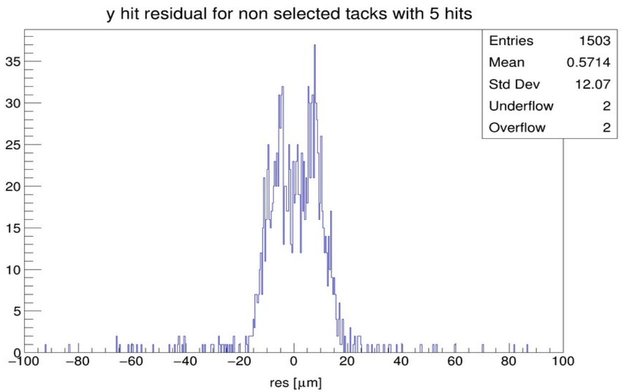


Y Residuals for rejected tracks with 5 hits

Layer 6



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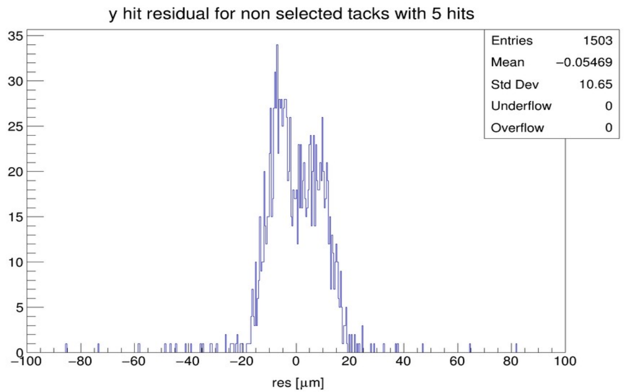

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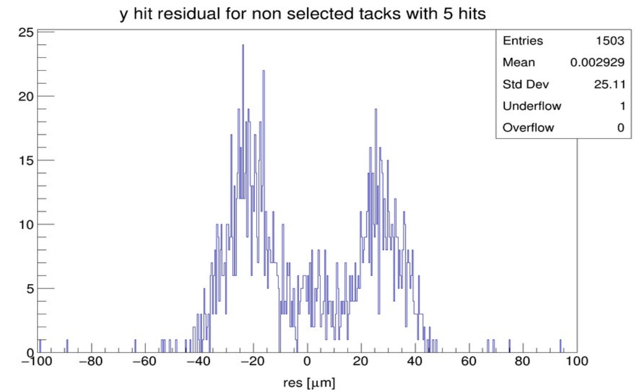

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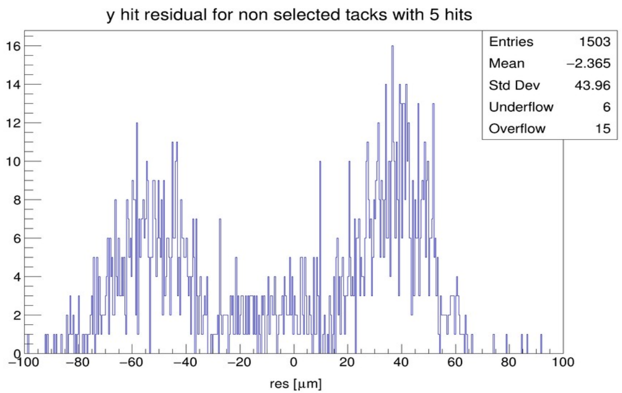

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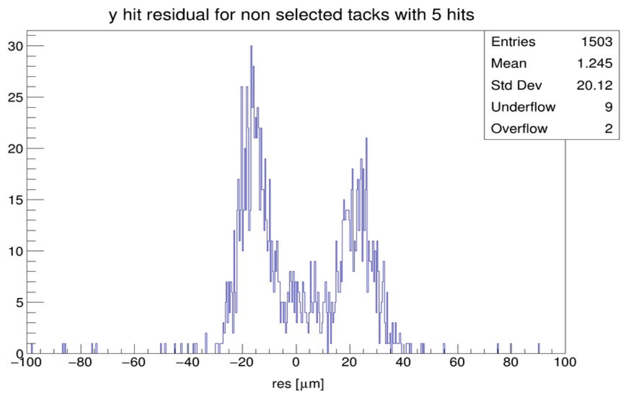

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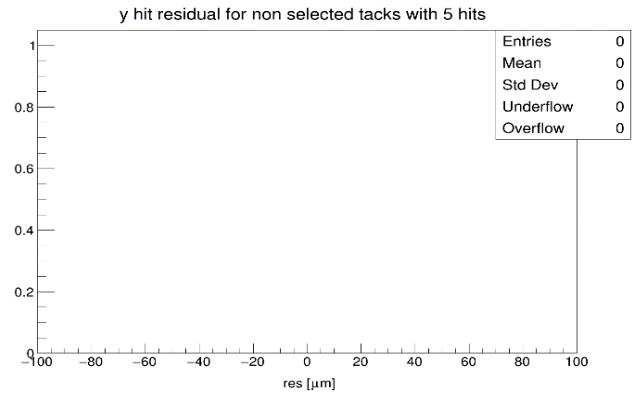
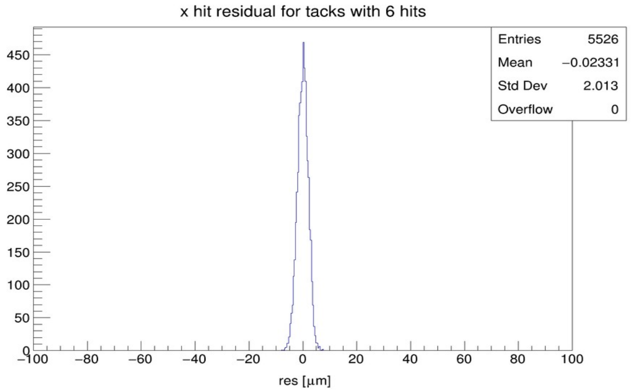


X Residuals for selected tracks with 6 hits

Layer 6



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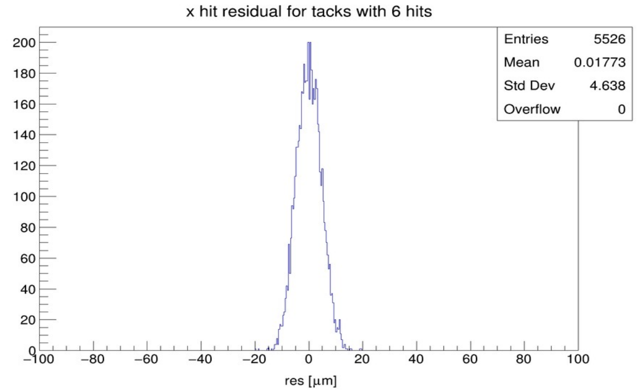

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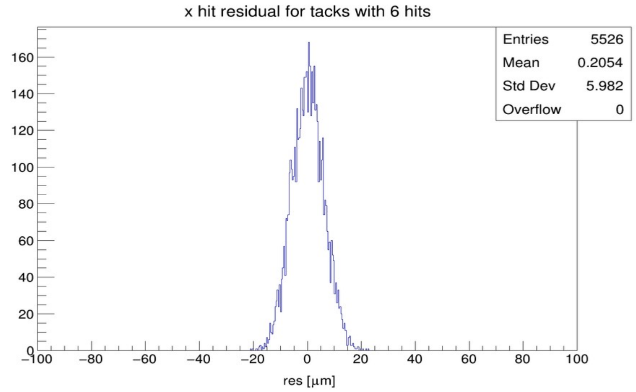

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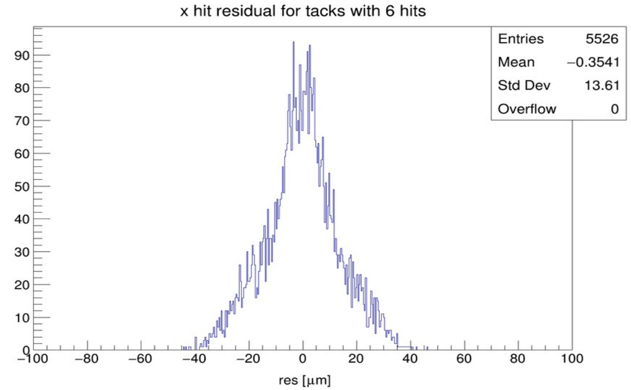

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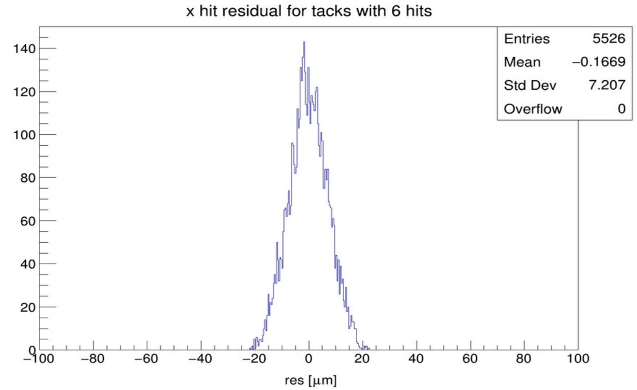

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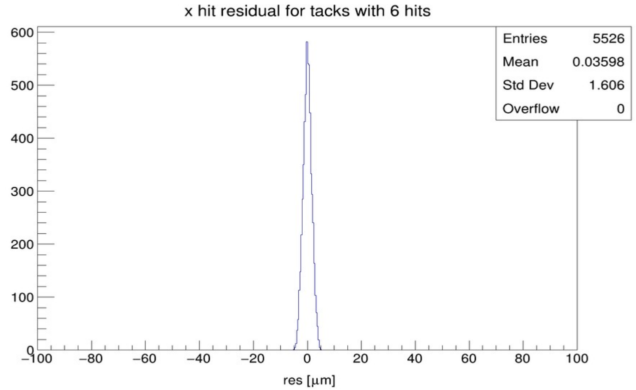
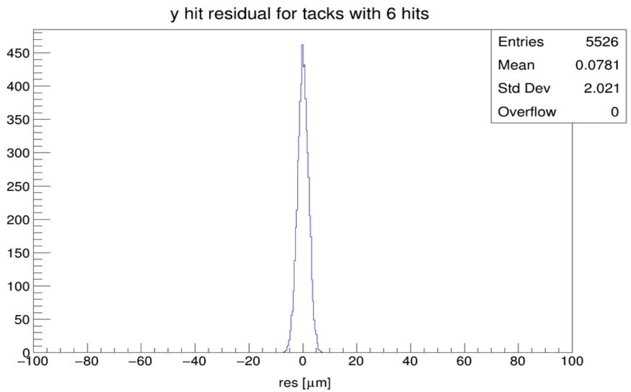


Y Residuals for selected tracks with 6 hits

Layer 6



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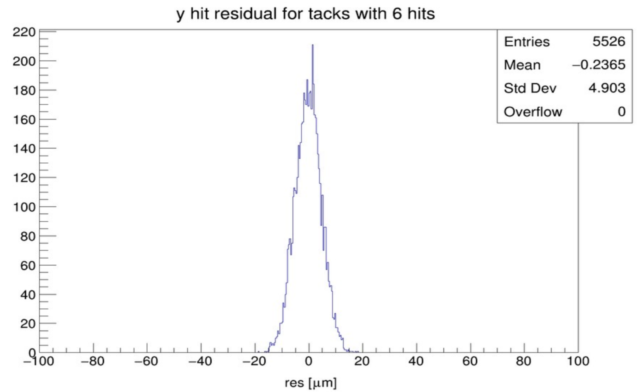

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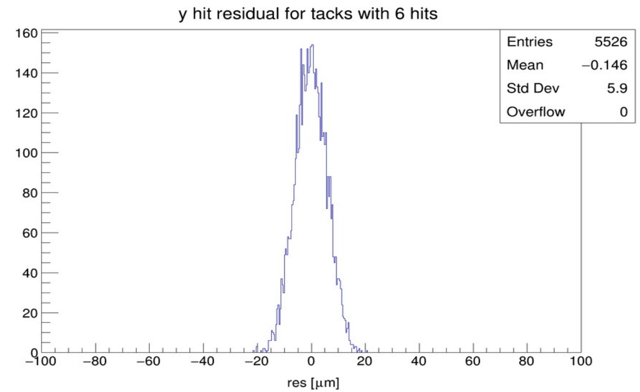

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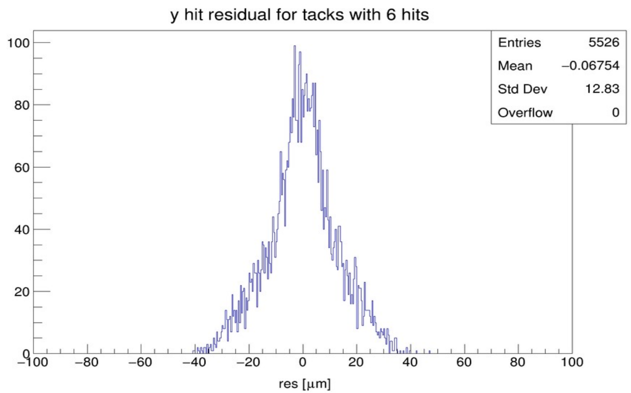

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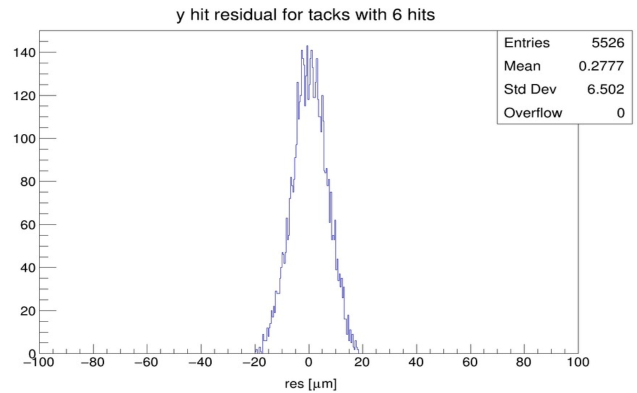

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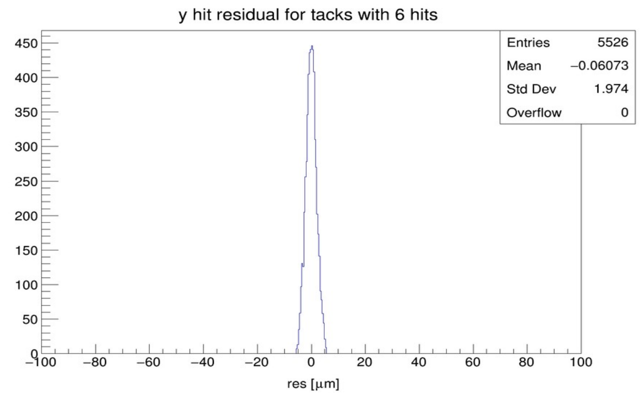
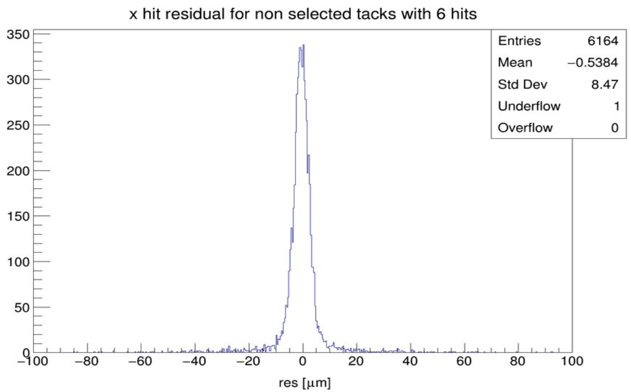


X Residuals for rejected tracks with 6 hits

Layer 6



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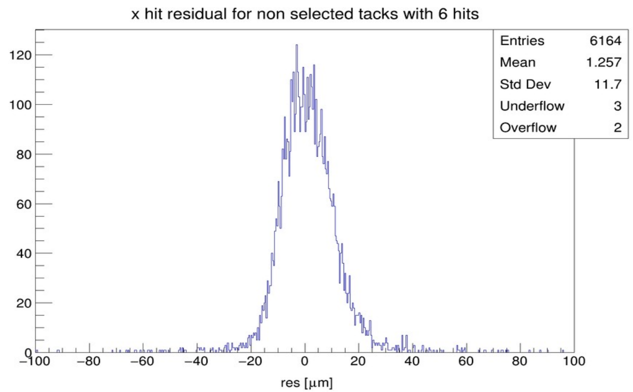

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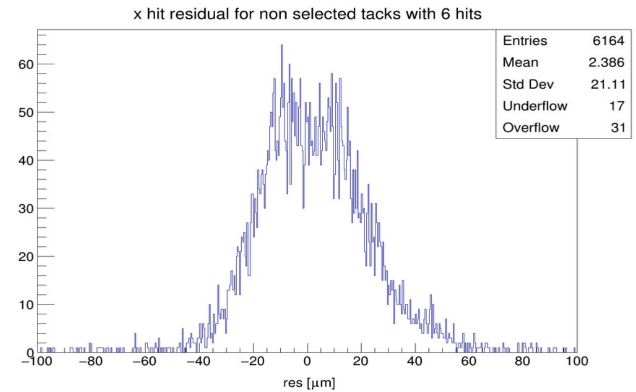

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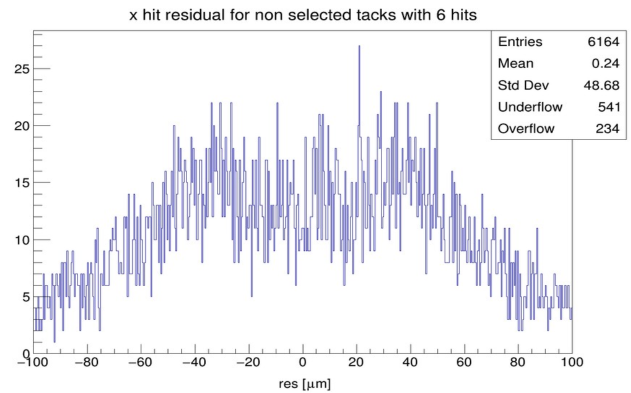

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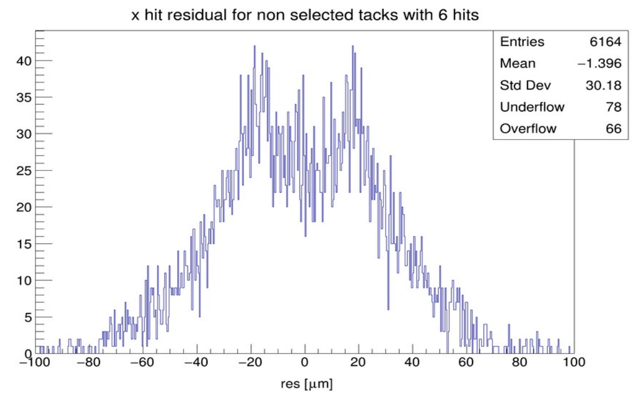

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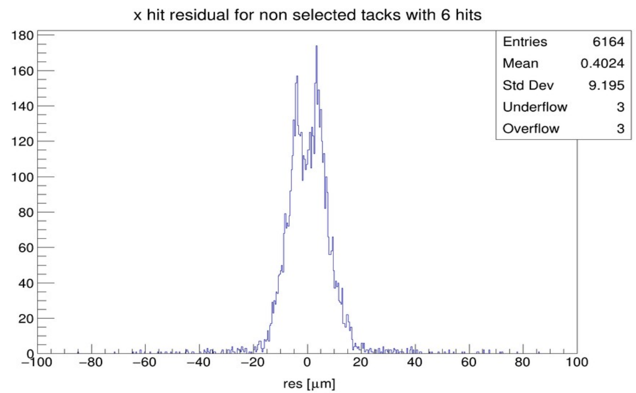
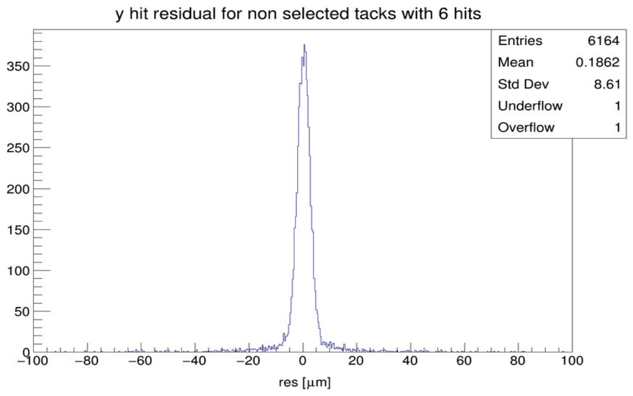


Y Residuals for rejected tracks with 6 hits

Layer 6



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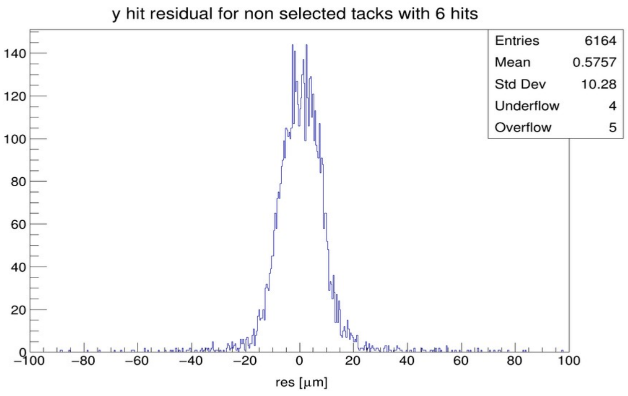

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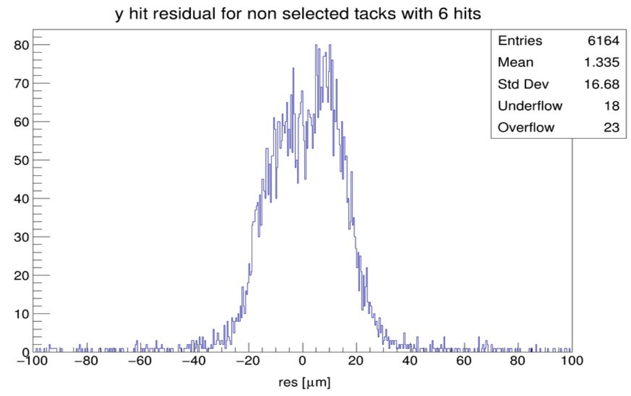

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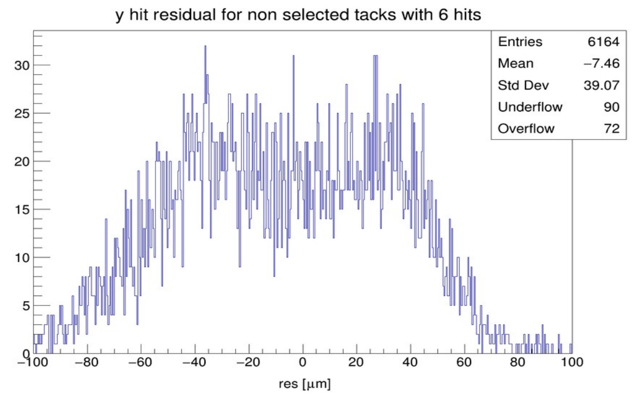

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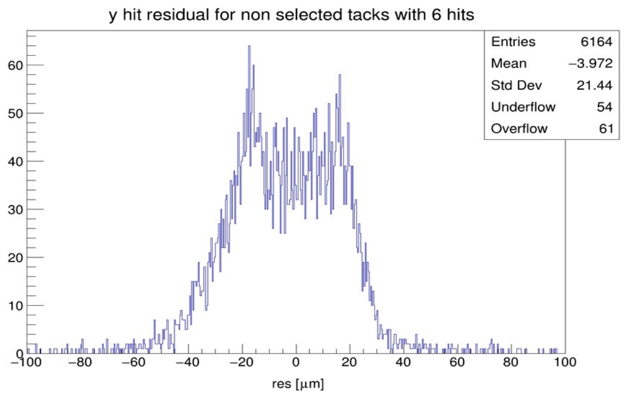

Layer 11