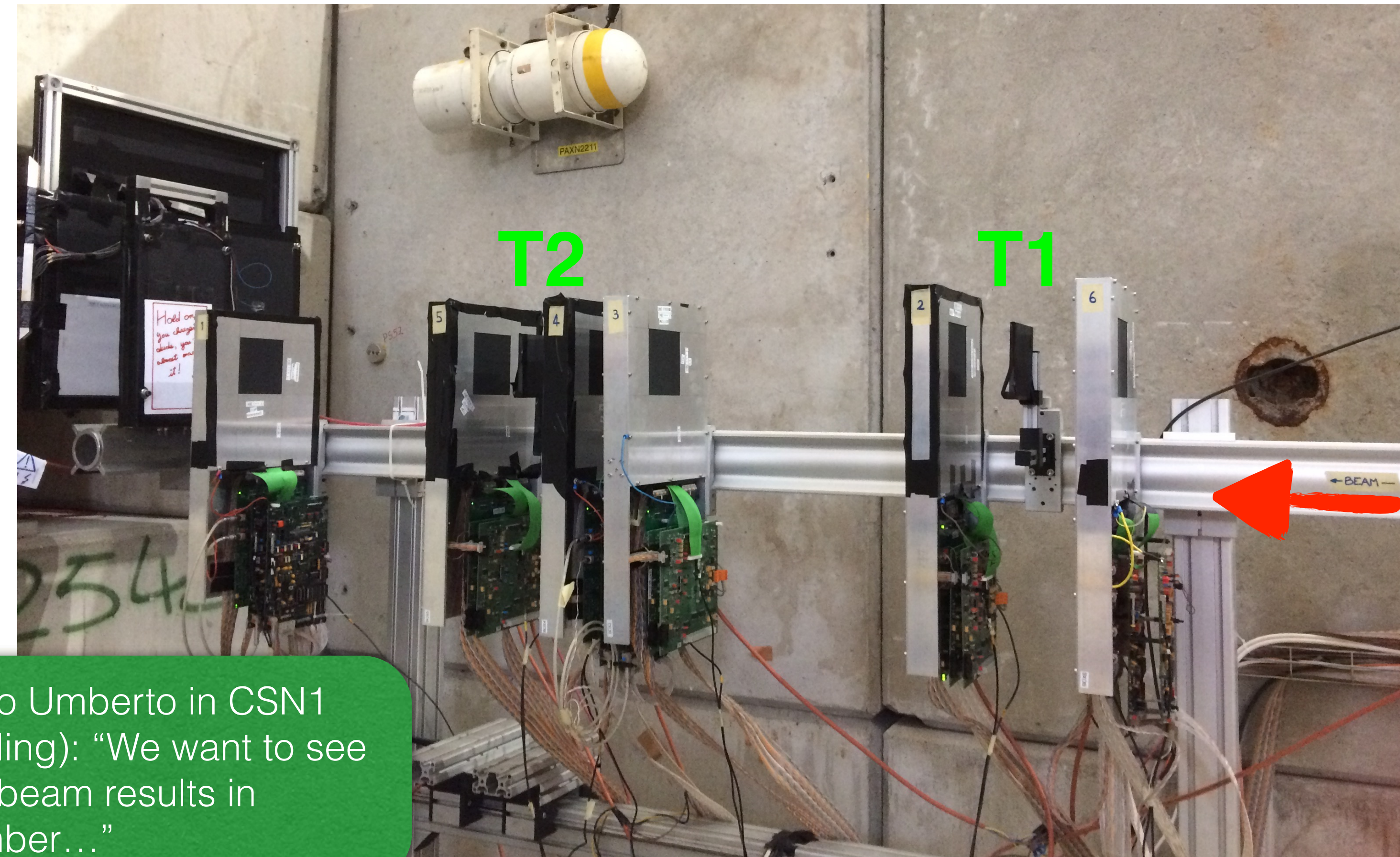
First checks on quality and alignment: test beam 2018 (first run 300118)

v.1 (1° meeting 15/6/2018)

A. Principe

Apparatus TB 2018: AGILE + MUonE



Nadia to Umberto in CSN1 (not smiling): “We want to see the test beam results in September…”

The key players…

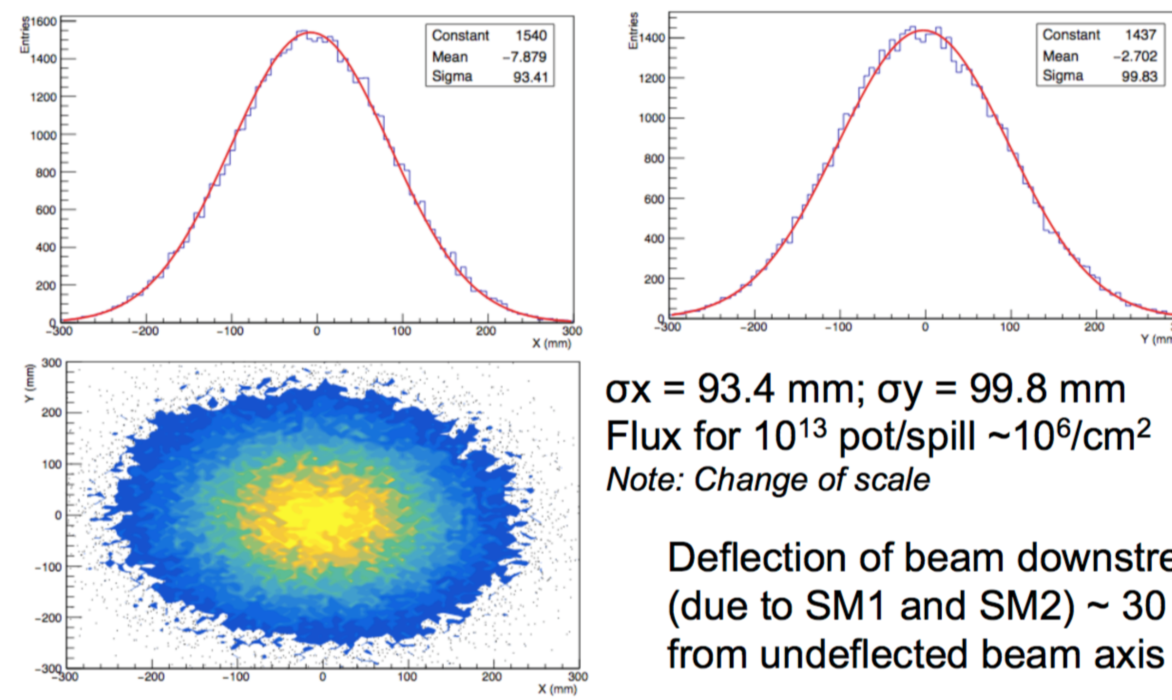
Preliminary simulation of muons behind COMPASS

3 beam conditions (with **different** beam profiles in **energy / angular spread**):

- muons from modified M2 (two weeks in April);
- muons from nominal M2;
- muons from pi decays.

We must link these conditions to each of our runs. !

M2 beam



σx = 93.4 mm; σy = 99.8 mm

Flux for 10^{13} pot/spill ~10^{6}/cm^{2}

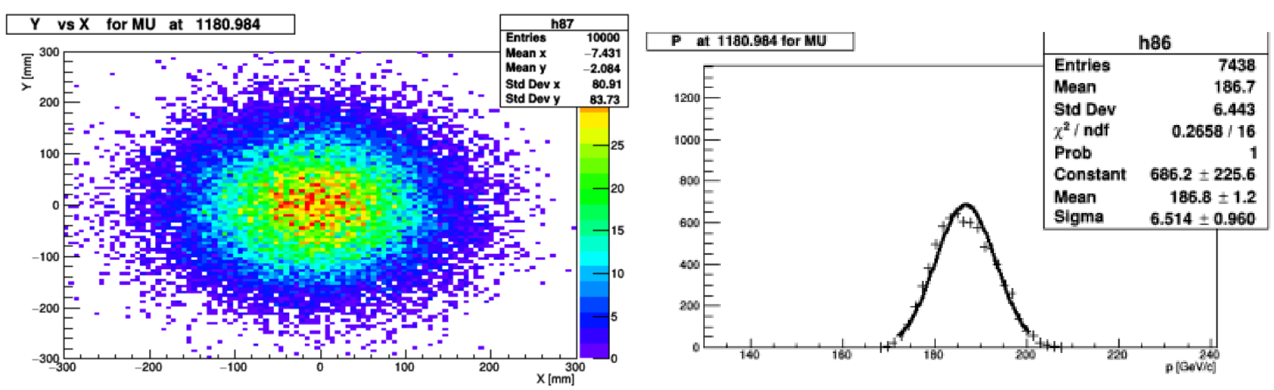
Note: Change of scale

Deflection of beam downstream (due to SM1 and SM2) ~ 30 cm from undeflected beam axis

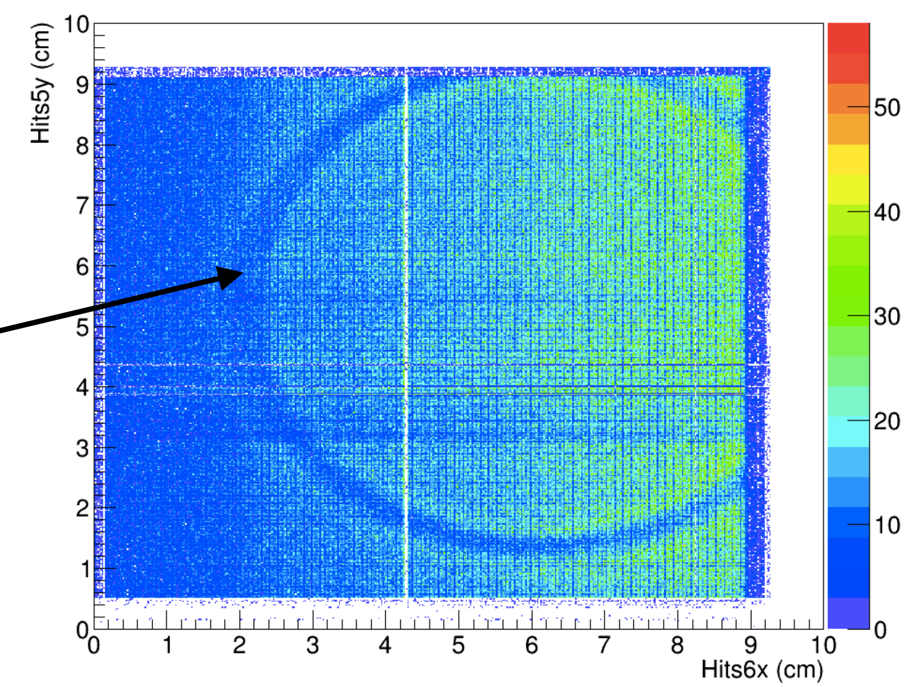
190 GeV/c μ-beam at the MuonE test-setup position : Y vs X and Pμ

σ_X = 80.9 mm
σ_Y = 83.7 mm

<Pμ> = 186.8 GeV
$\sigma_{P\mu}$ = 6.5 GeV



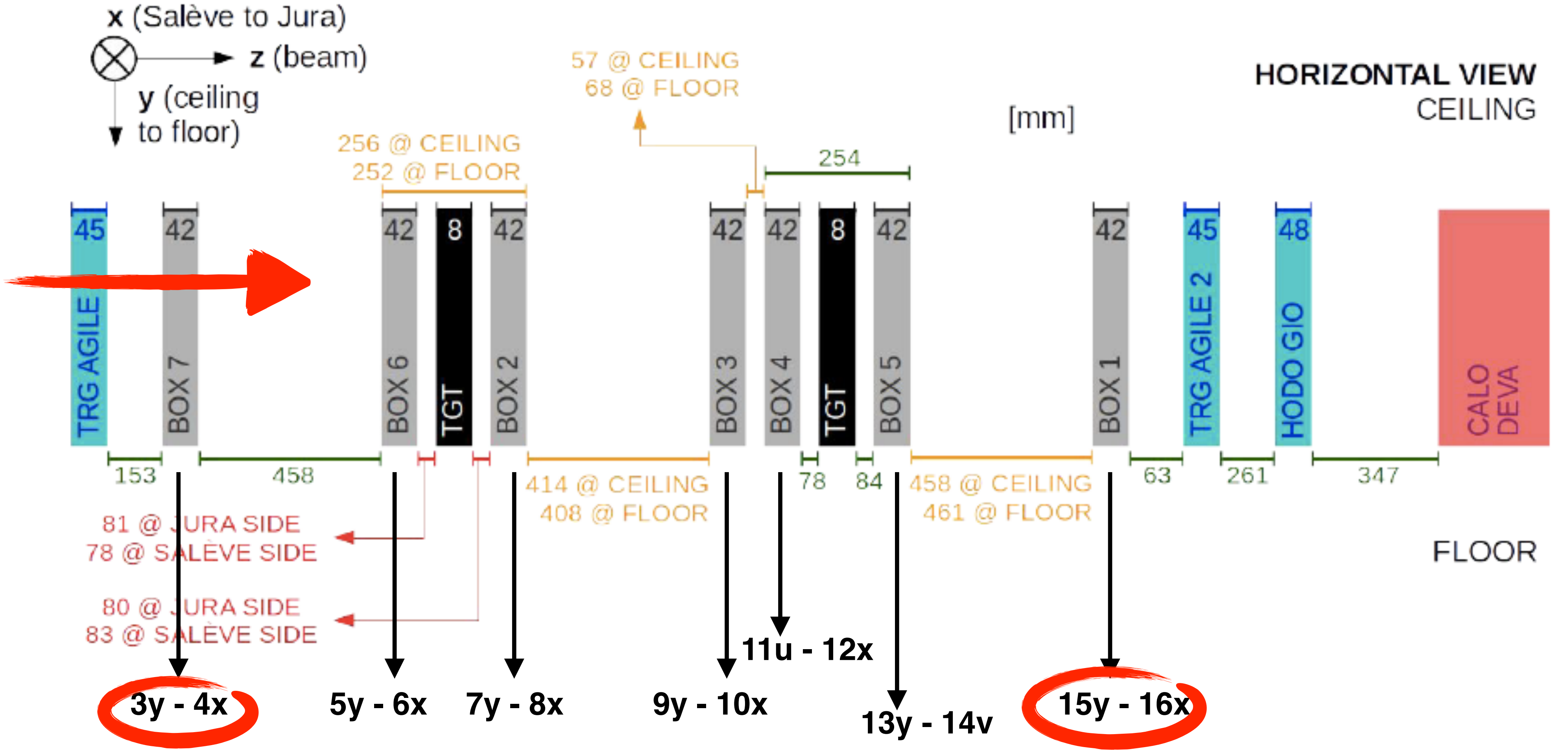
One of the first nice results of our preliminary analysis: mysterious circles on hits patterns? No, muon radiography of COMPASS TPC!



First setup, without box 8 (1y-2x) before 7

muONe installation – 09/04 setup

* from Mattia Soldani



Some features of AGILE silicon strip detectors:

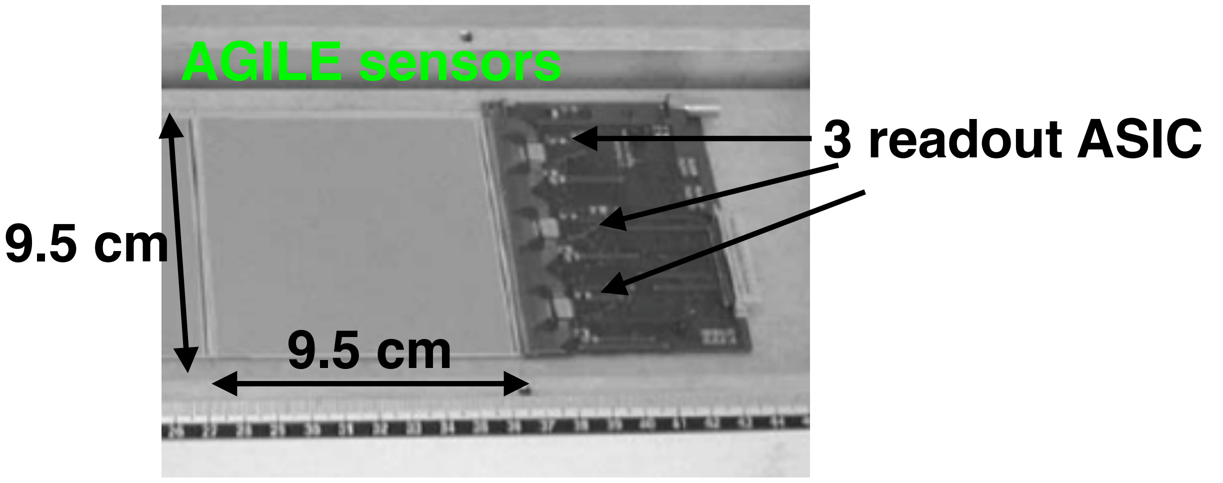
- 7(+1) stations;
- single-sided, AC-coupled;
- thickness: 410 um;
- 9.5 x 9.5 cm^2;
- readout pitch: 242 um with floating strip.

N.B.

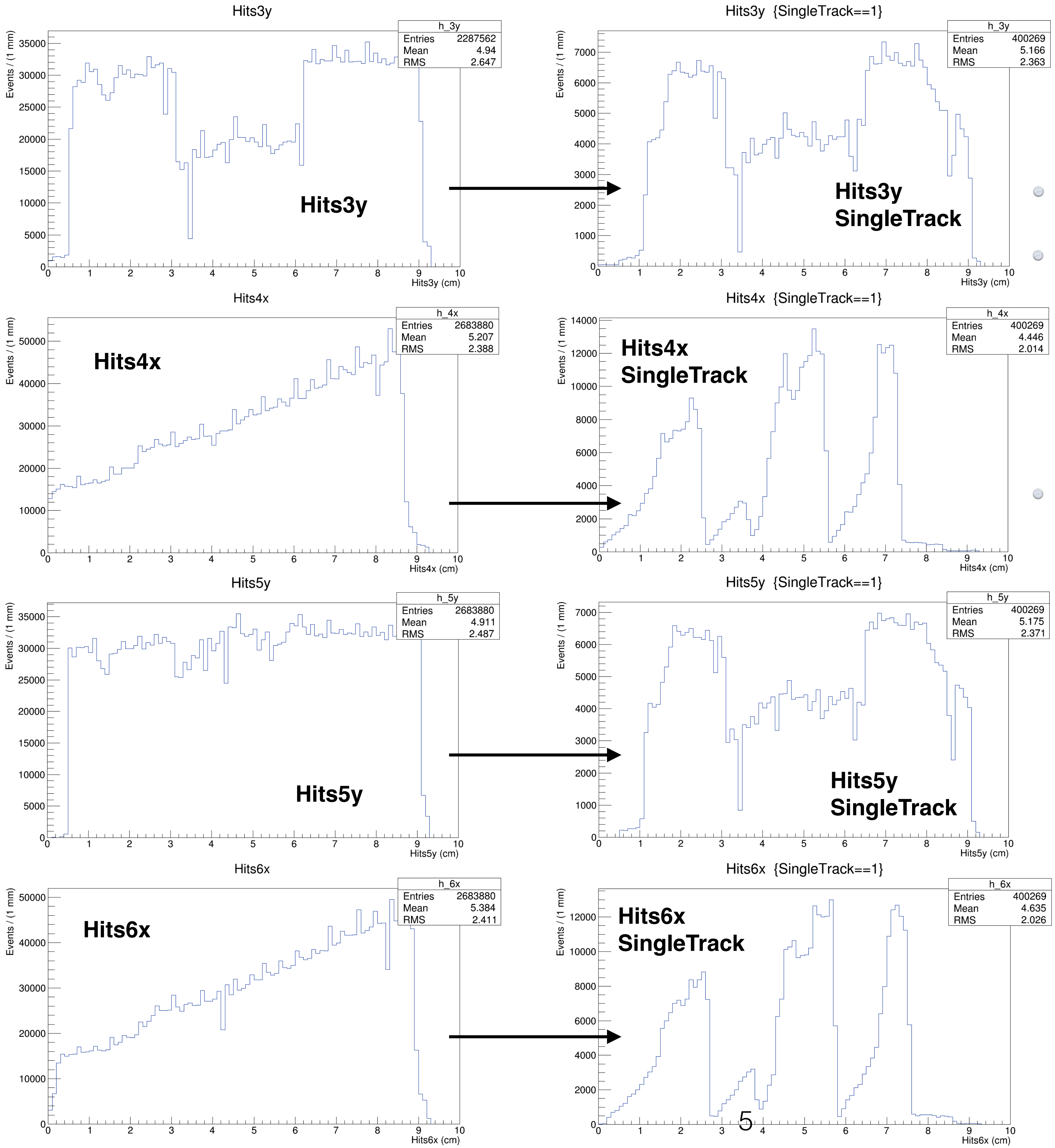
! **Upstream condition**: multiplicity 1 or 2 on all x plane (2x, 4x, 6x) and on 5y before first target. !

As already discussed with Michela, counting problems with:

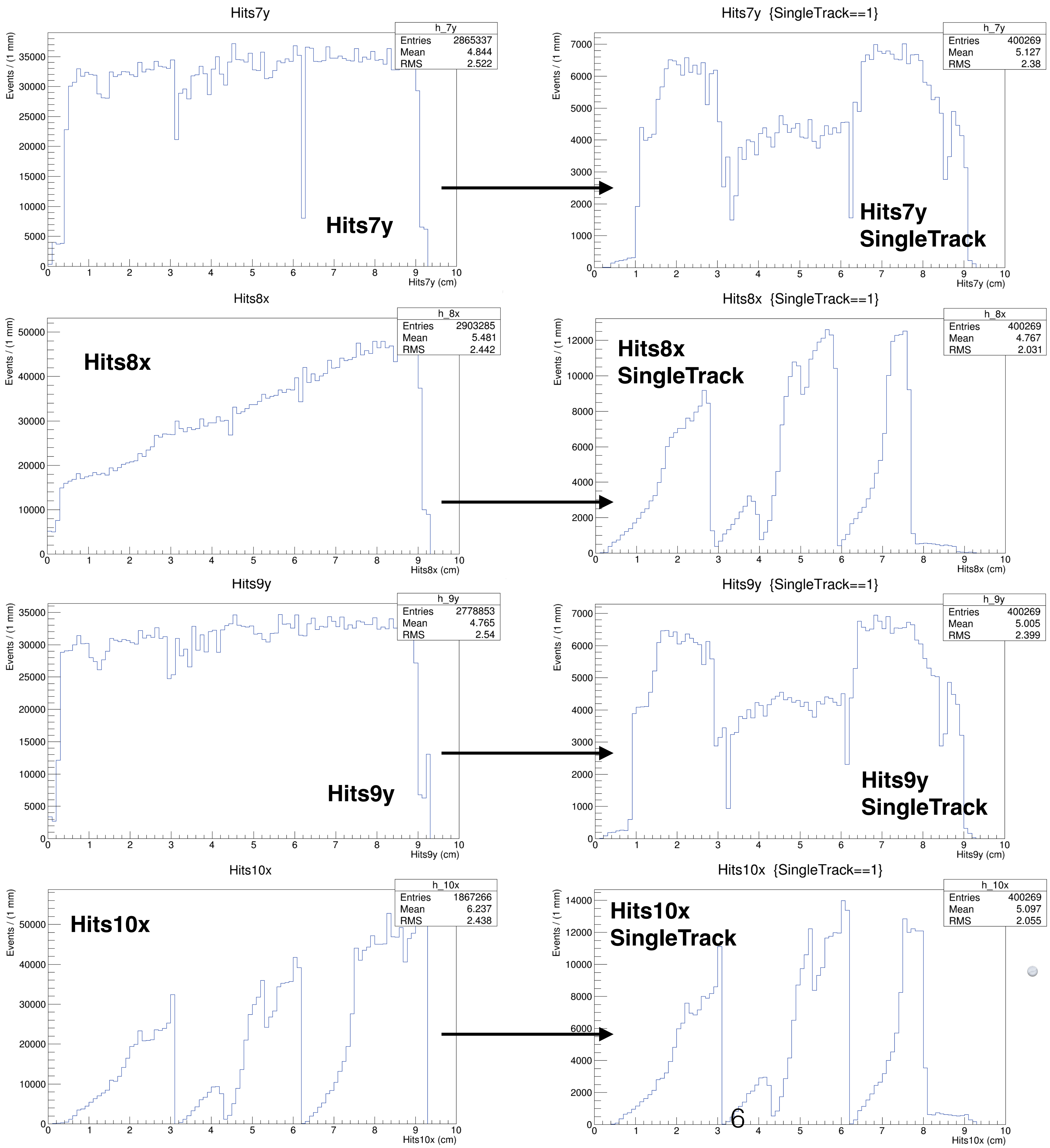
- **plane 3y** (2nd ASIC);
- **plane 10x** (all 3 ASIC): see next slides.



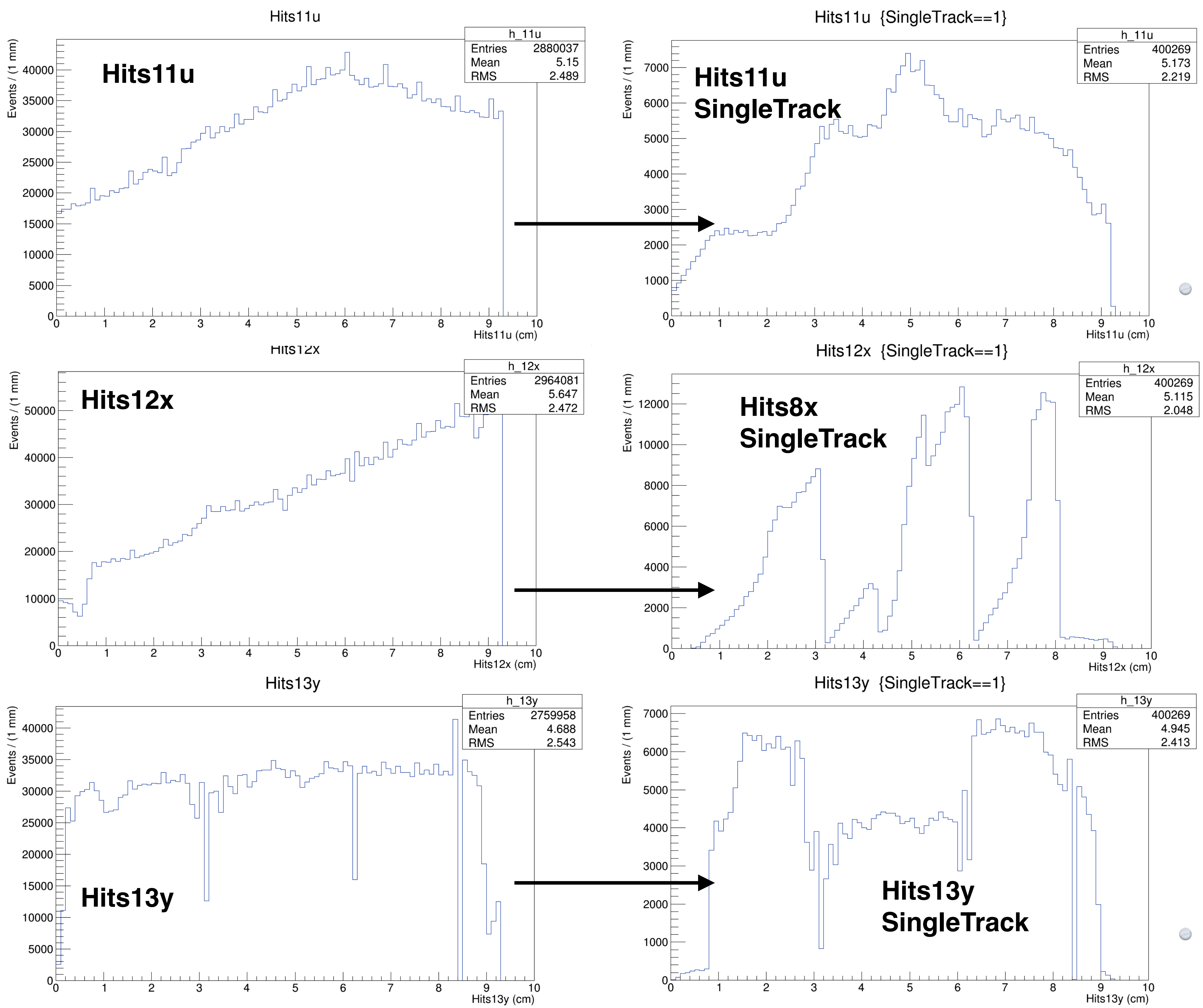
Un-aligned hits (in cm)



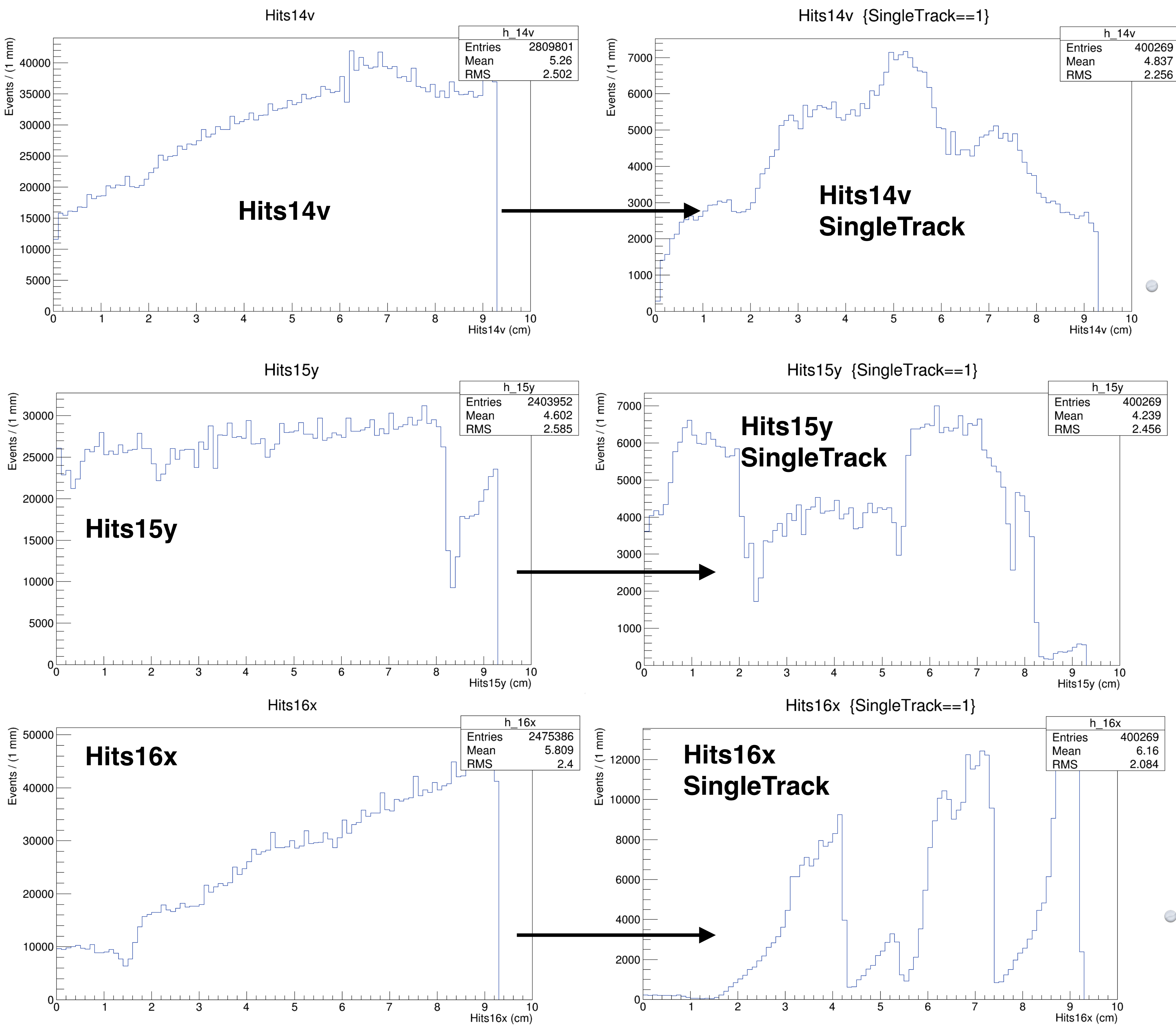
- <u>**SingleTrack: m =1 on all planes.**</u>
- **Hits3y** have some counting problems (middle ASIC), even not selecting conditions: <u>this inefficiency pattern propagates itself at the all y planes, if singletrack is required</u>.
- **Hits4x** doesn't have problems, but requiring singletrack it acquires pattern of plane **10x**: see next slide.



- **Hits10x** have some counting problems on all ASIC, even not selecting conditions: this inefficiency pattern propagates at the all x planes, if singletrack is required.



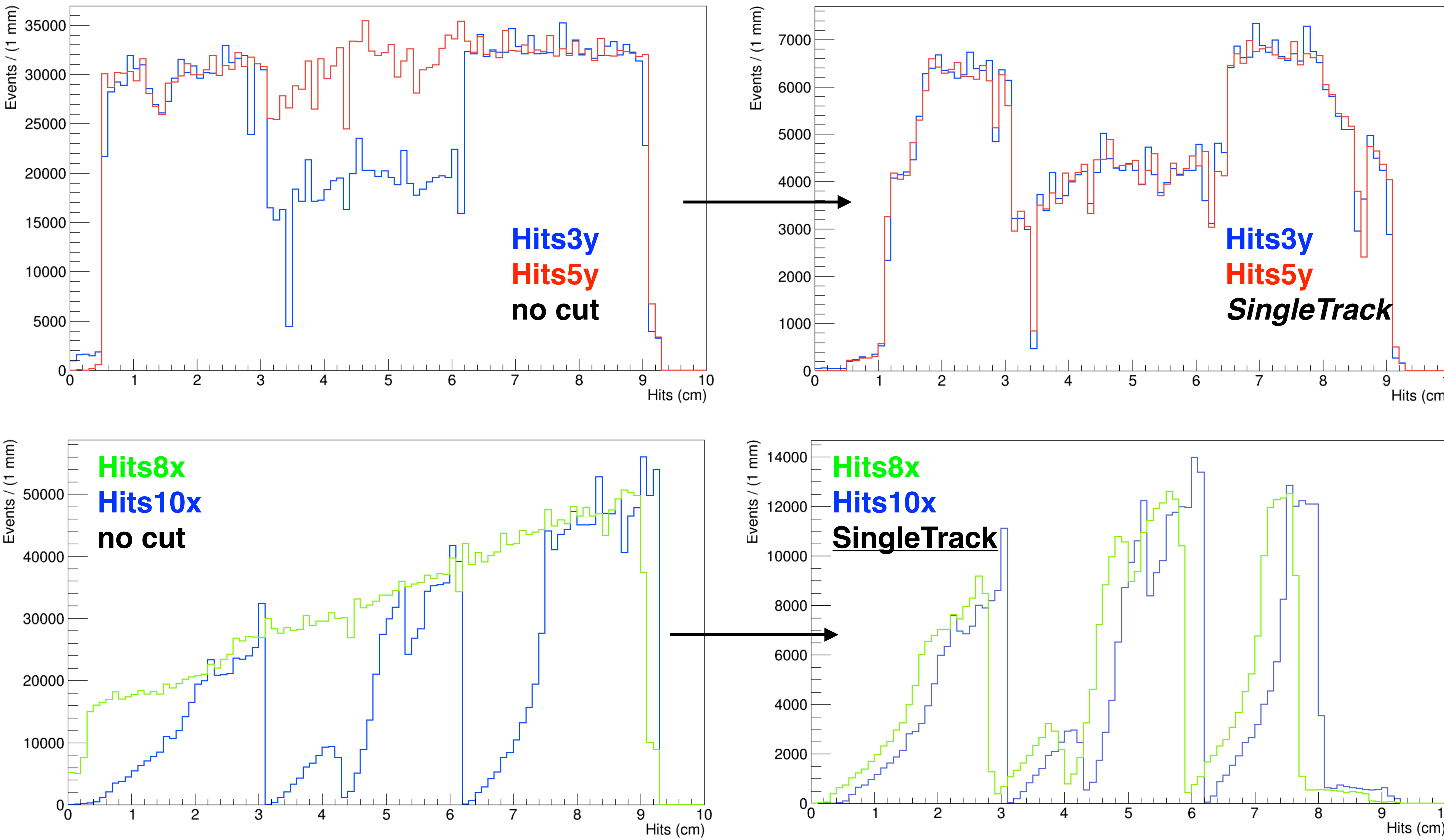
- **stereo u plane:** +45° (see next slide).
- **hits13y:** as for the other planes, some strips may be inefficient or dead.



- **stereo v plane:** -45° (see next slide).

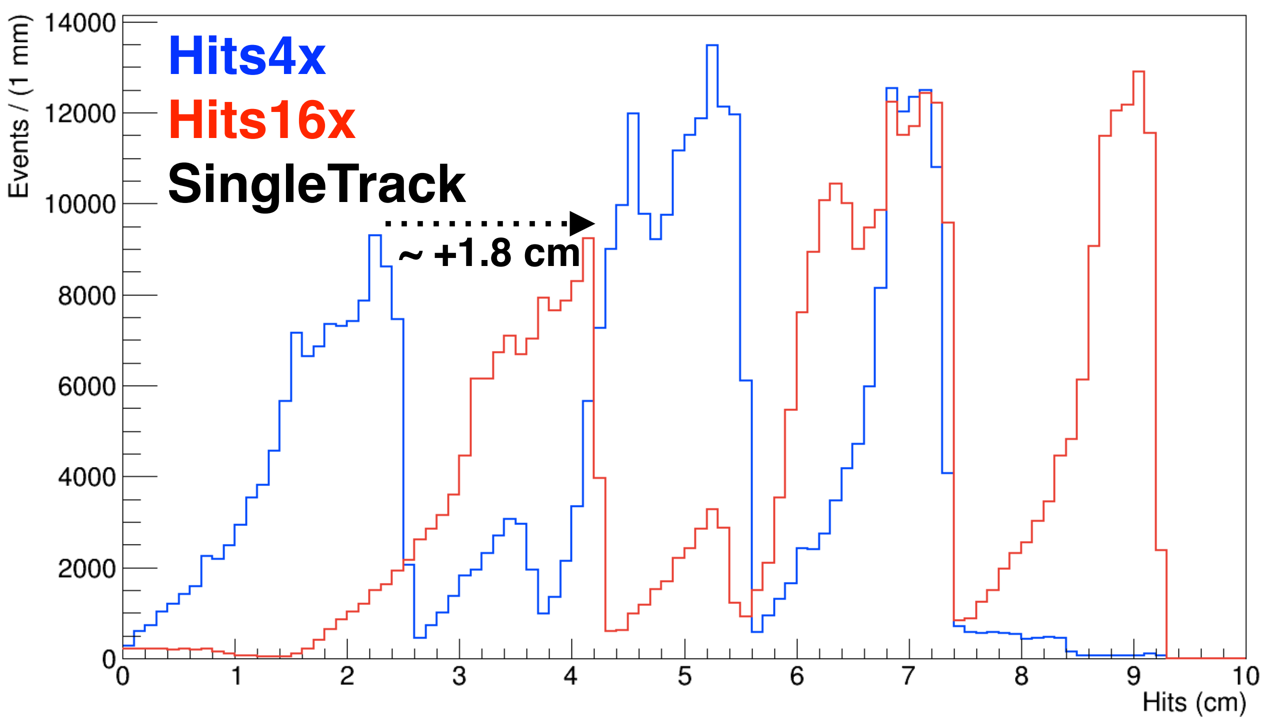
- Pattern of 15y and 16 x (last planes) are shifted on the sensors edges: see slide 8.

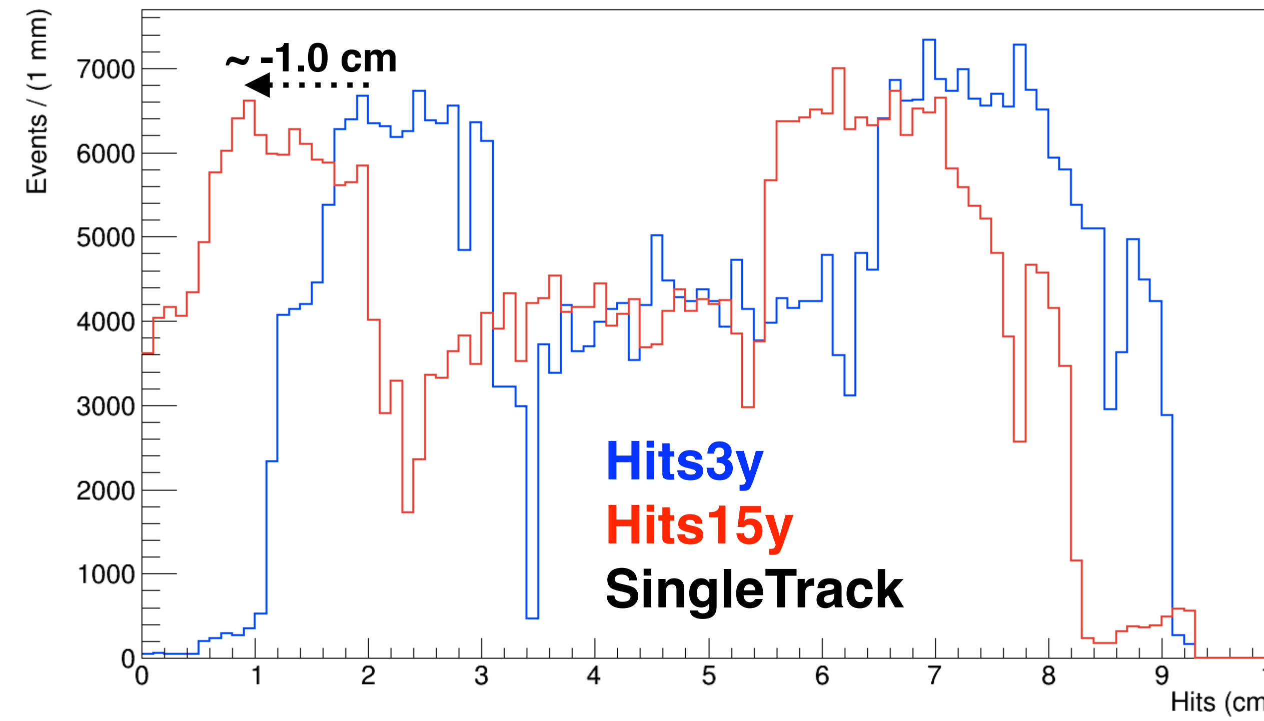
Inefficiency patterns

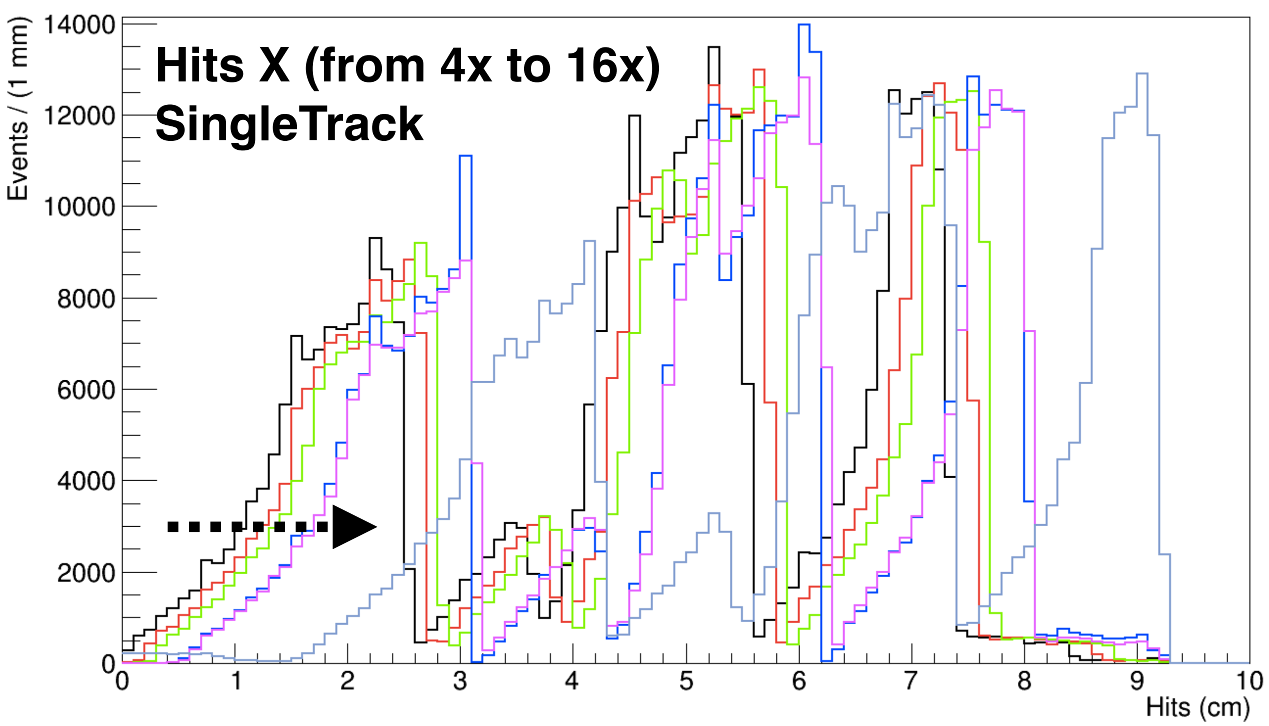


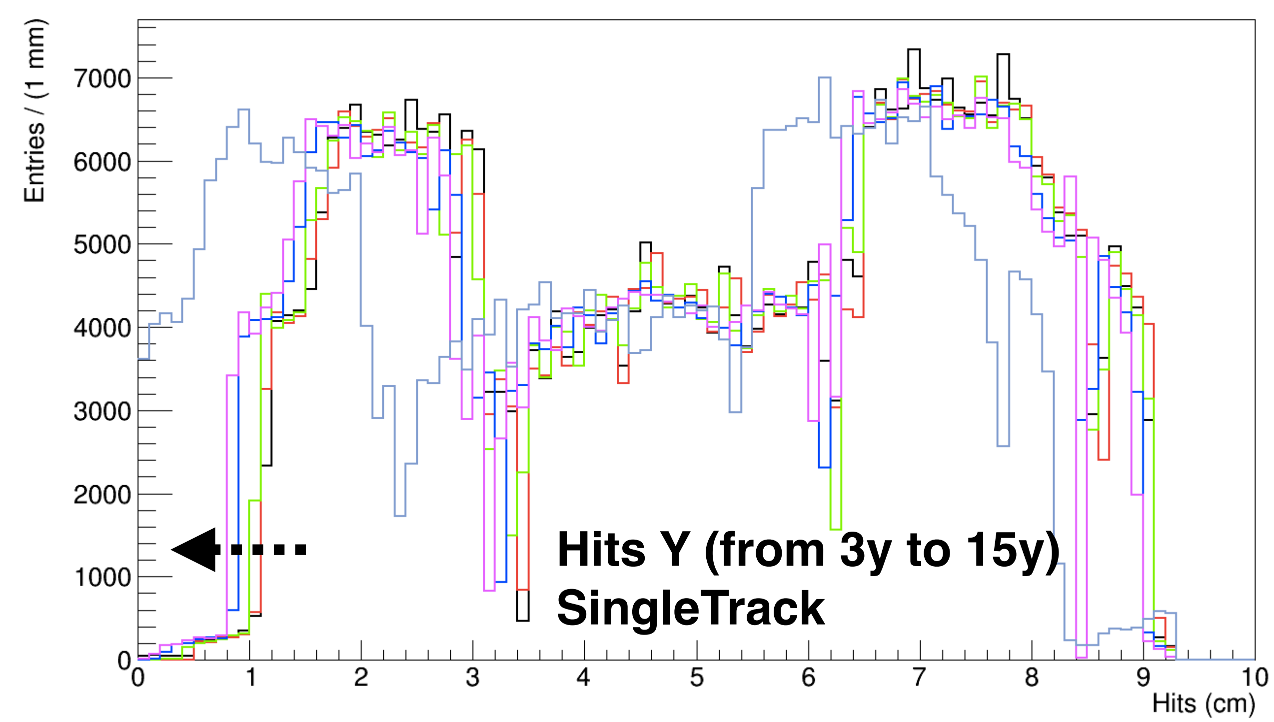
- SingleTrack condition correlates all plane x/y: 3y and 10x transmit their patterns to the other ones.

Planes shift along z axis









- It seems that efficiency patterns (due to 10x for x hits and to 3y for y) shift proportional to the distances of first reference plane. **<u>These hits are un-aligned</u>**, but it can be a sign that apparatus is off-axis with respect to the beam or last planes (taken as a reference) are particularly shifted respect to the others.
- Roughly speaking, in x there may be an angle offset of +1.8 cm / 196.30 cm (total x arm) = +9.2 mrad;
- in y: -1.0 cm / 199.6 cm (total y arm) = -5.0 mrad. These offset should be observe after alignment taking 4x-16x and 3y-15y as a references (see slide 11).

Trackers alignment

Alignment procedure:

- transverse x/y shift correction using residuals means;
- rotations about the z-axis using correlations between residuals along x (or y) coordinate and hits in the y (or x) direction.

Possible transformations, along all 3 axis:

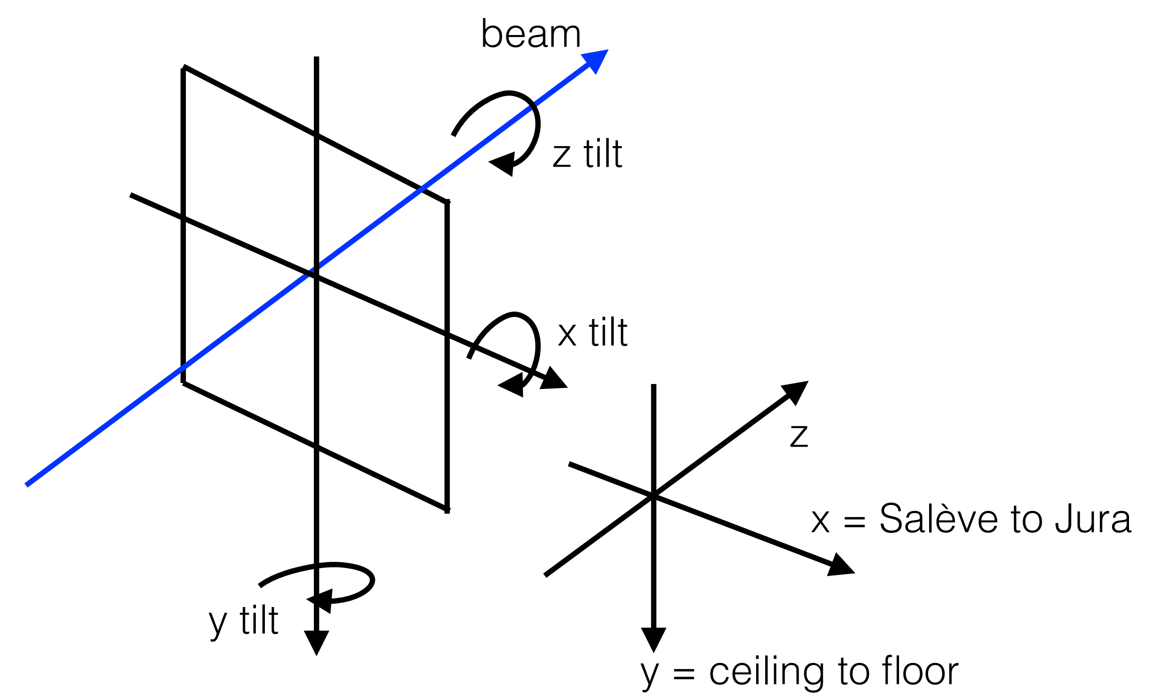
- 3 translations
- 3 rotations

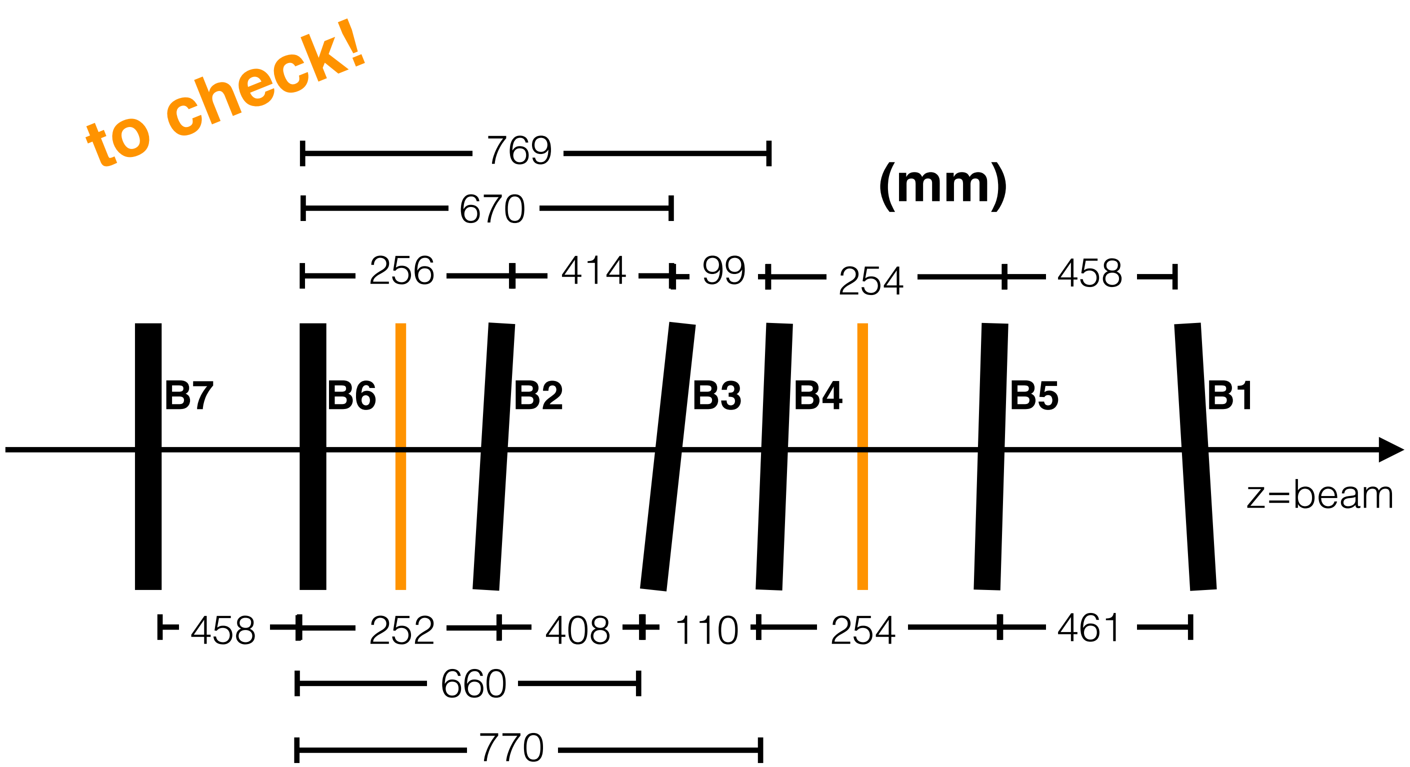
Reading the distances scheme, <u>some boxes are affect of all these transformations except translations along z respect to the nominal distances</u> (we hope so).

<u>Selecting singletrack</u>, I tried to correct <u>only</u> rotations about z-axis <u>and</u> transverse translations along x and y using an iterative code (like the one used for the previous test beam):

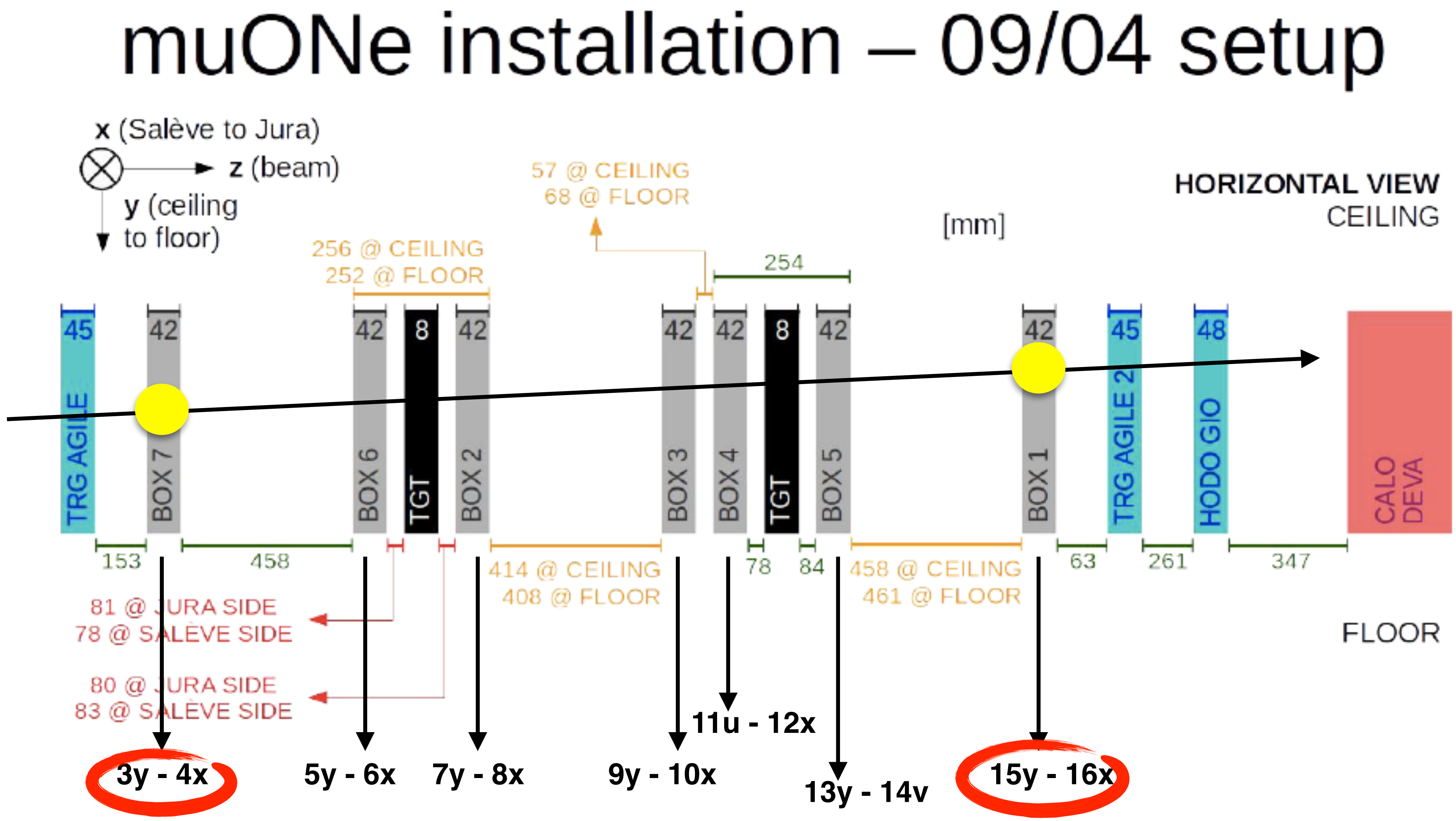
x’ = **x** - *s_resx* - *s_anglex****y**
y’ = **y** - *s_resy* - *s_angley****x**

(*s_res*: sum shifts after n iterations, *s_angle*: sum angle corrections after n iterations.)



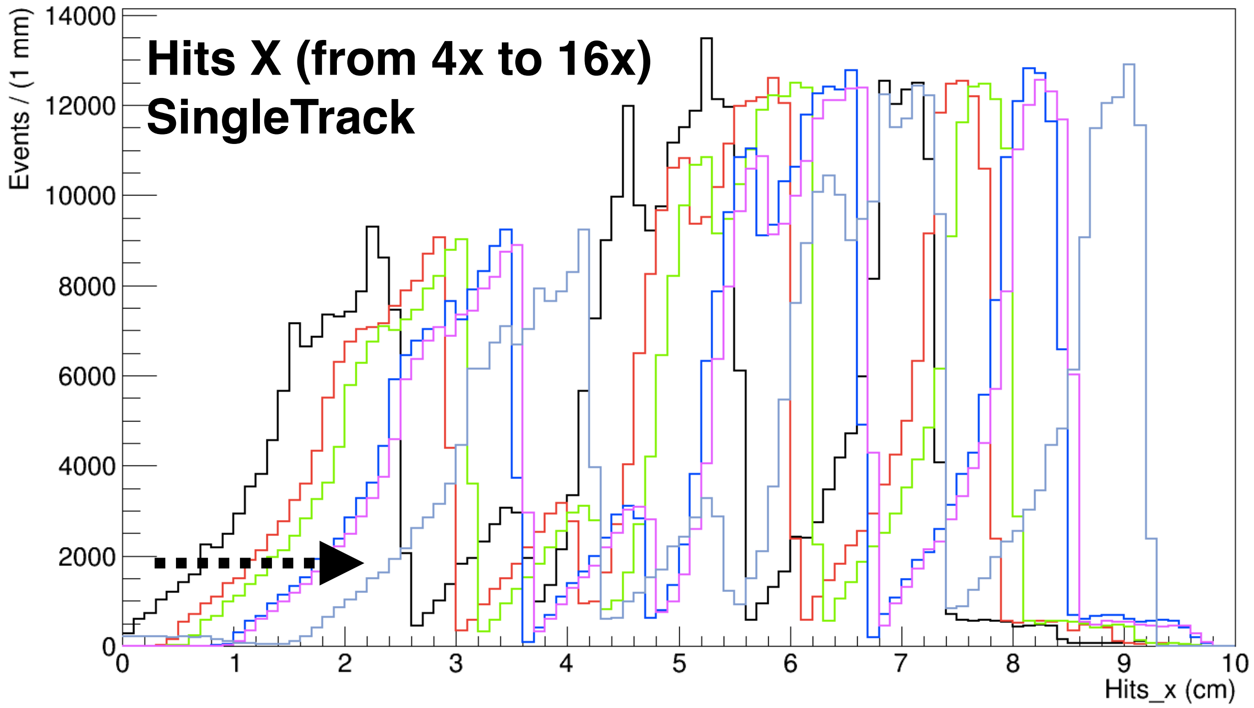


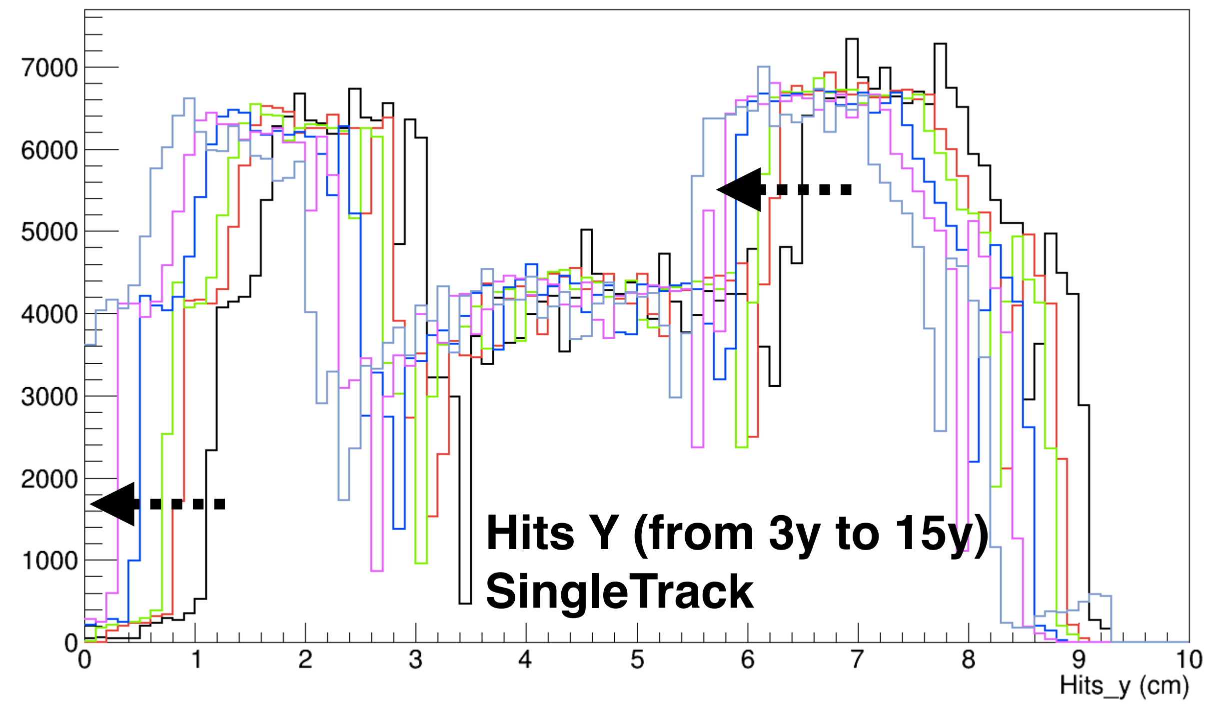
Alignment strategy



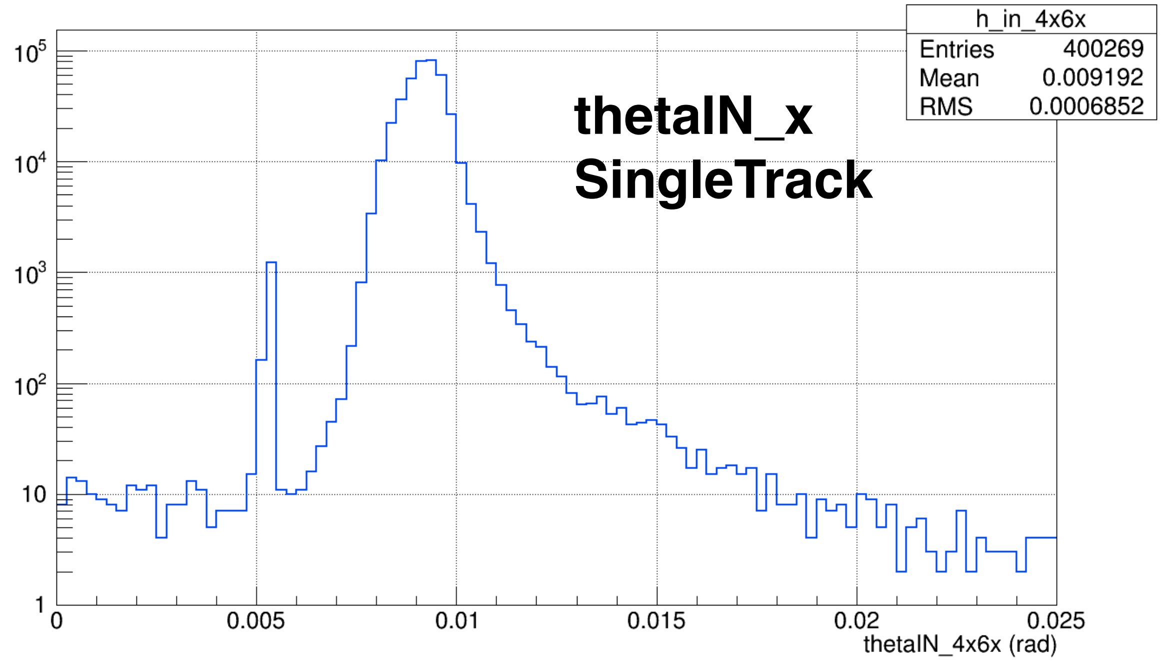
- **<u>Y reference planes: 3y - 15 y.</u>**
- **<u>X reference planes: 4x - 16x.</u>**
- Checking residuals on the other ones and correlations between residuals and hits.
- Also checking possible correlations between some residuals and income direction to looking for possible problems in the z direction.

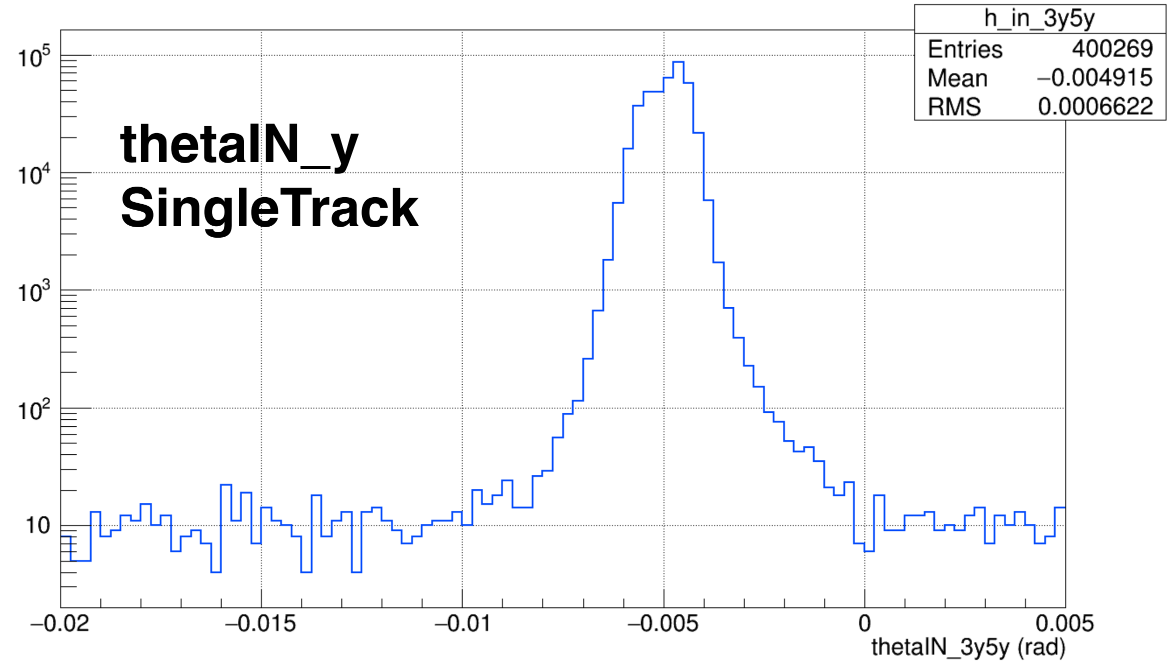
Hits <u>post</u> alignment



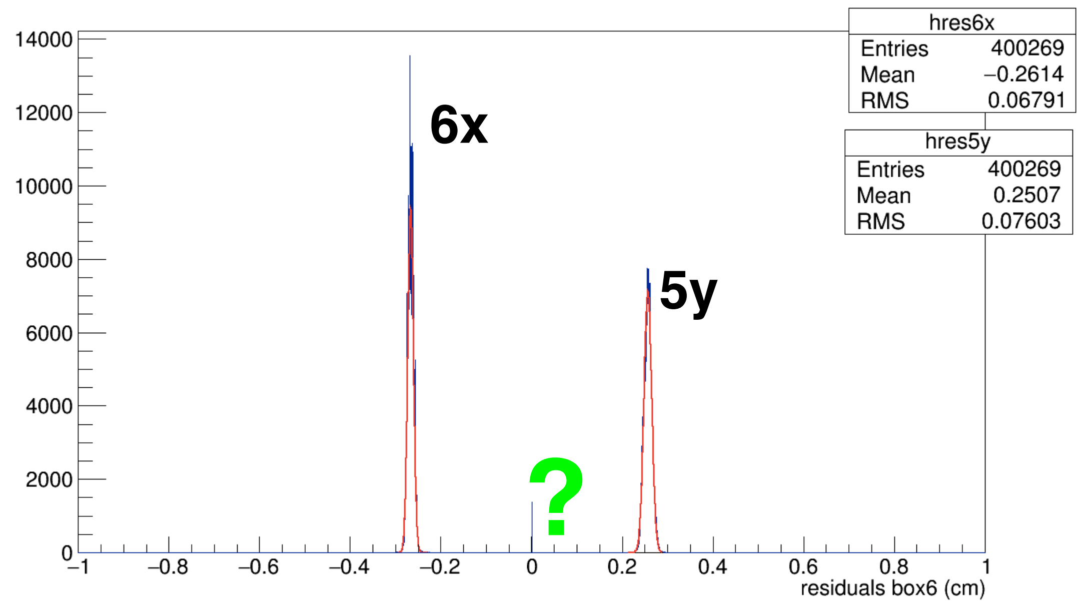


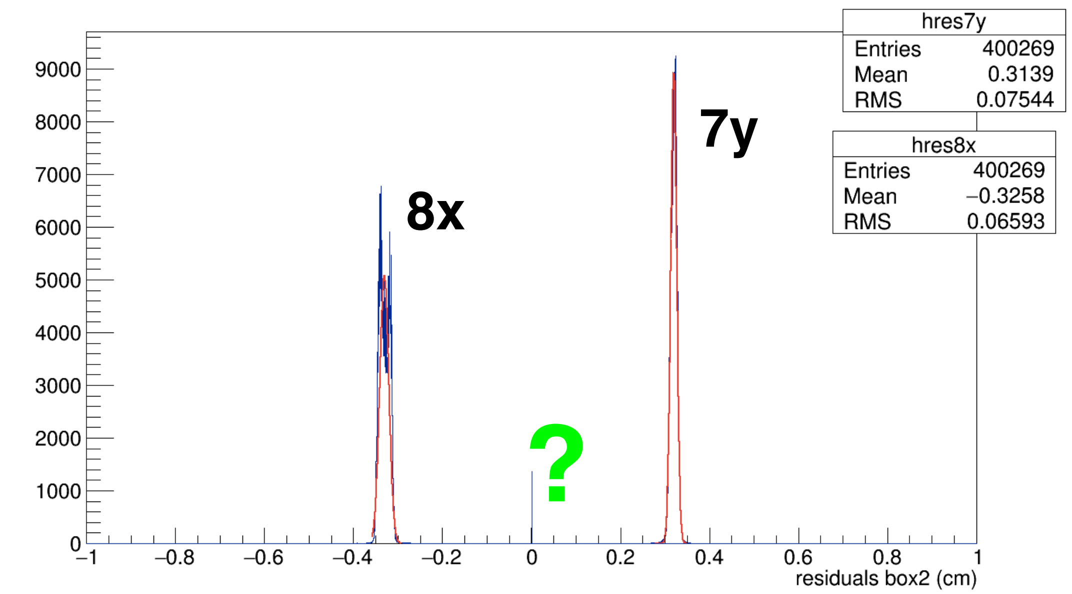
- Patterns shift proportional to z distances, these behaviors are confirmed even after alignment: taking as reference first and last boxes, muon beam should have an angle, compared to the apparatus, of roughly +9.2 mrad in x and -5.0 mrad in y.
- This observation is found in the incoming angle distribution:

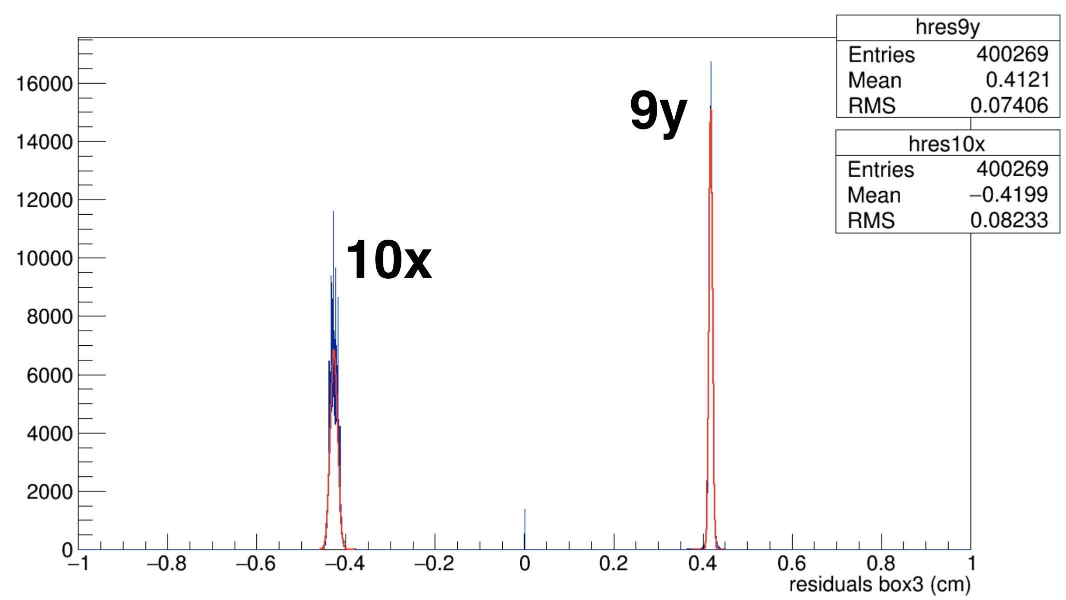


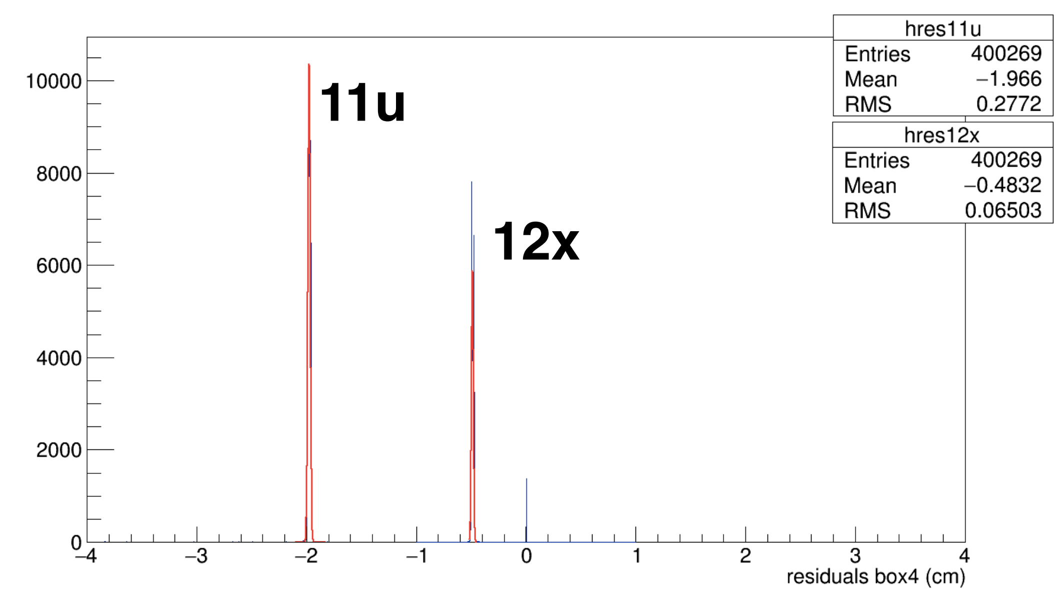


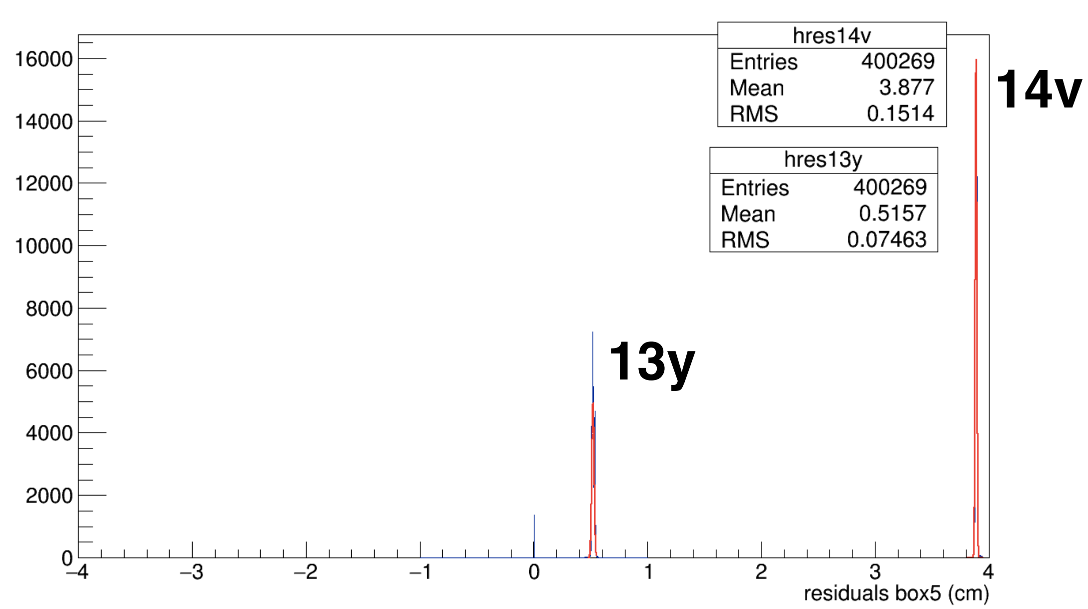
Residuals before alignment





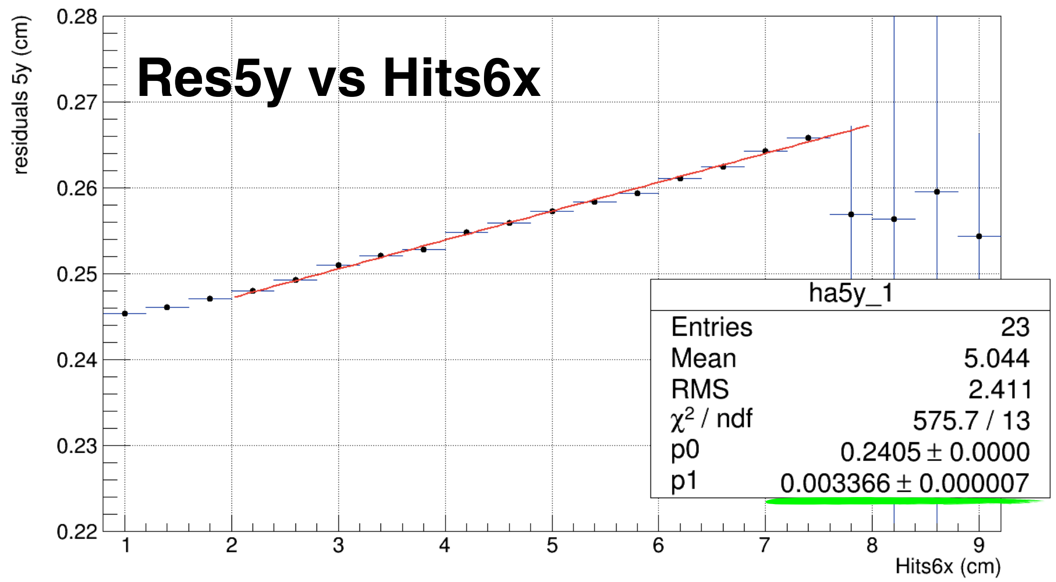


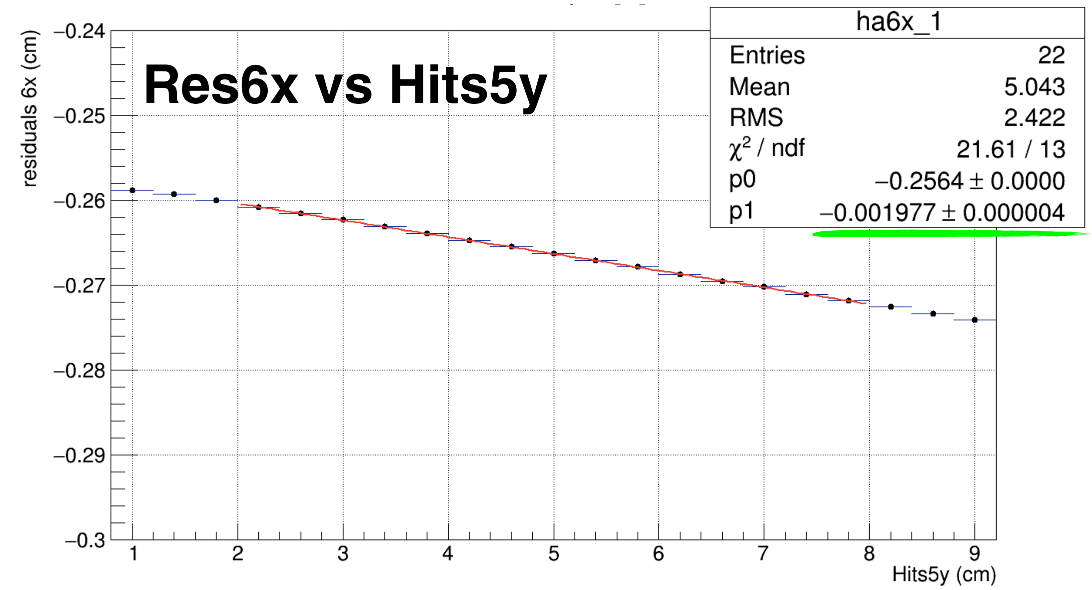


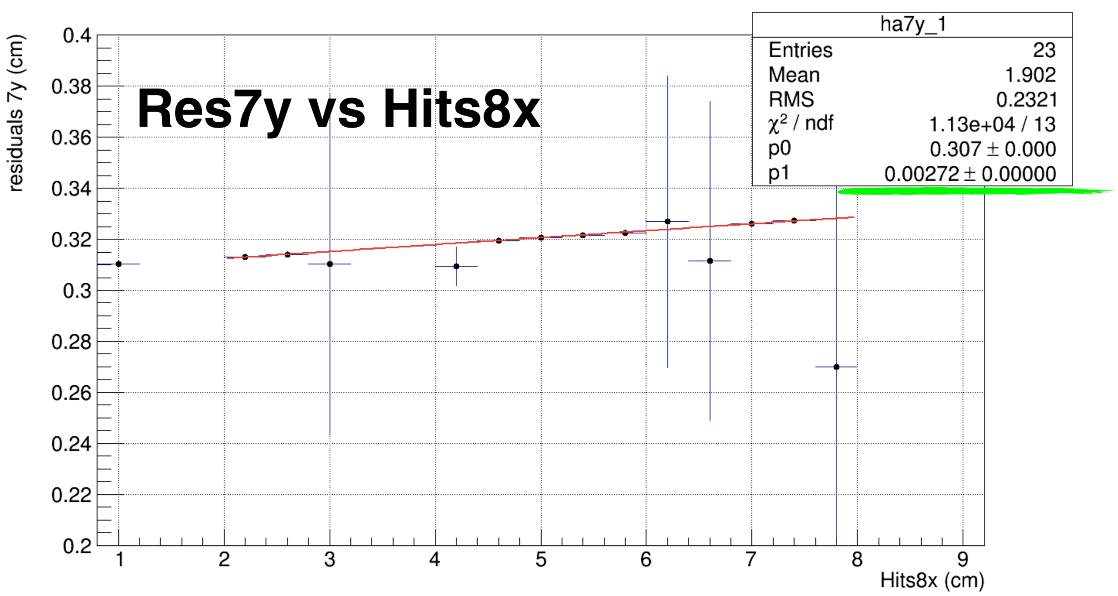


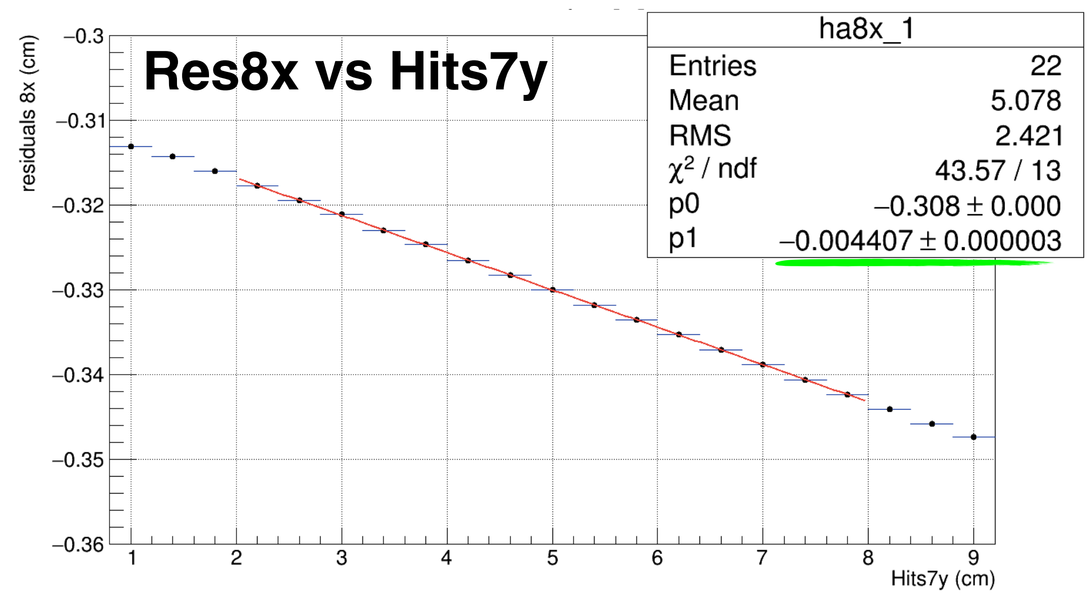
- Skipping the stereo planes, which will require a special treatment, all x/y translations are within 5 mm.
- In these plot, residuals of uv planes are determined with the reference straight line rotated of +/- 45°.

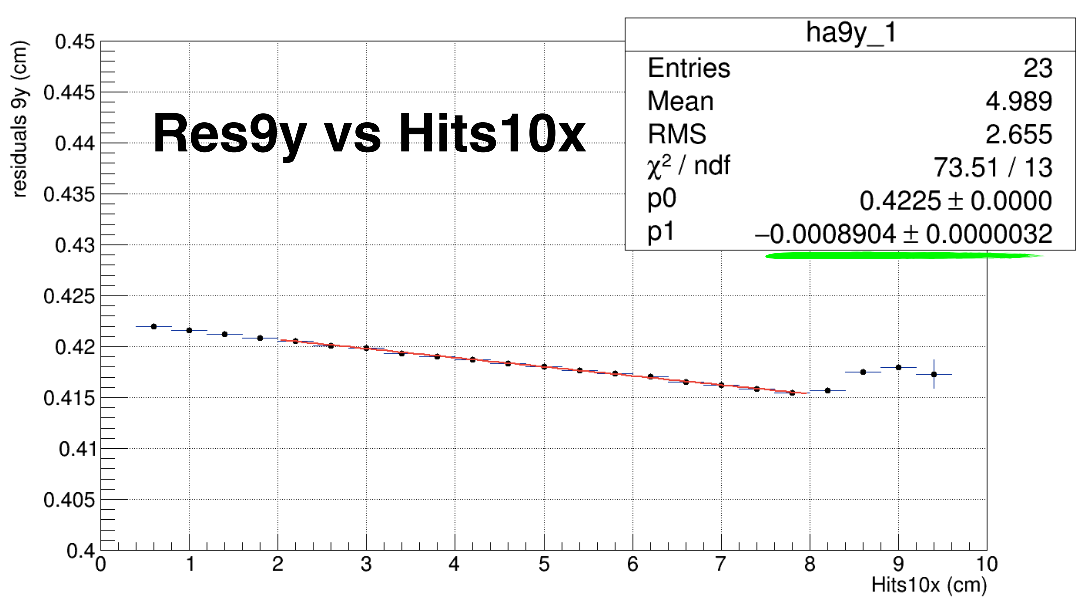
Residuals vs Hits before alignment

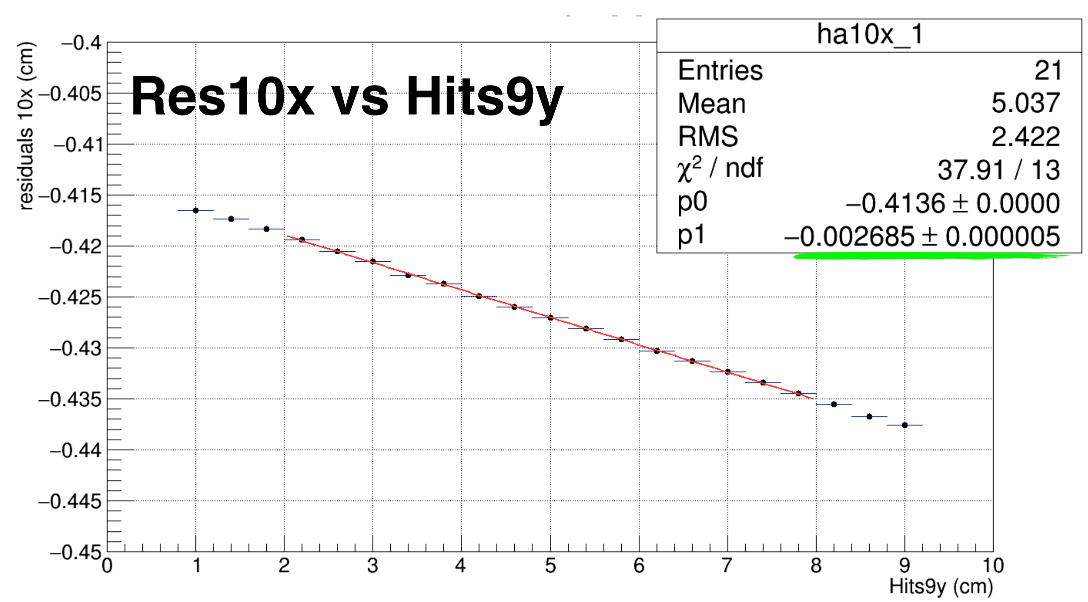




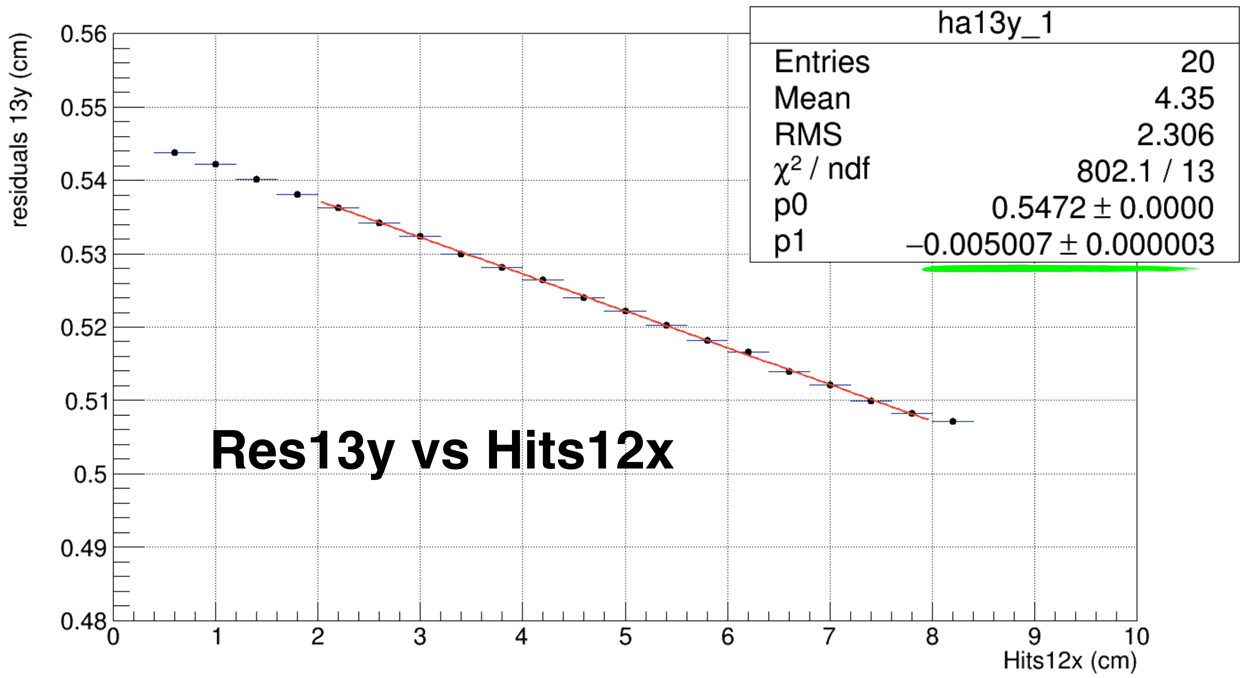


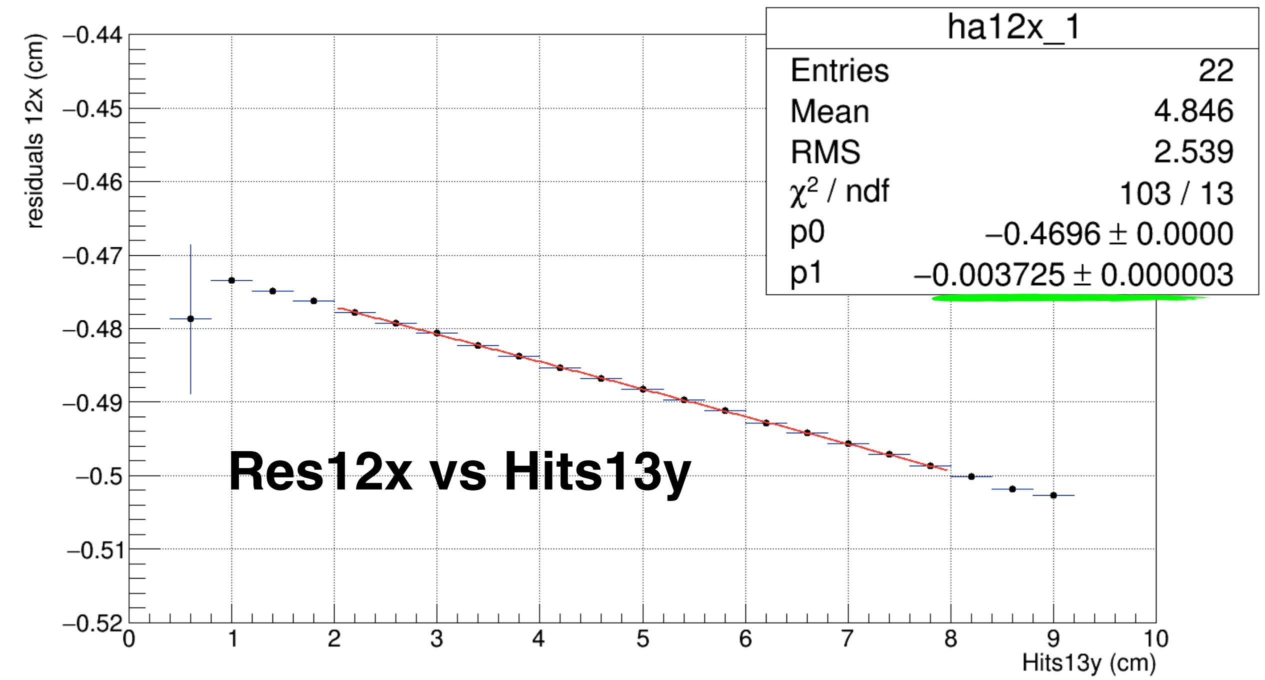


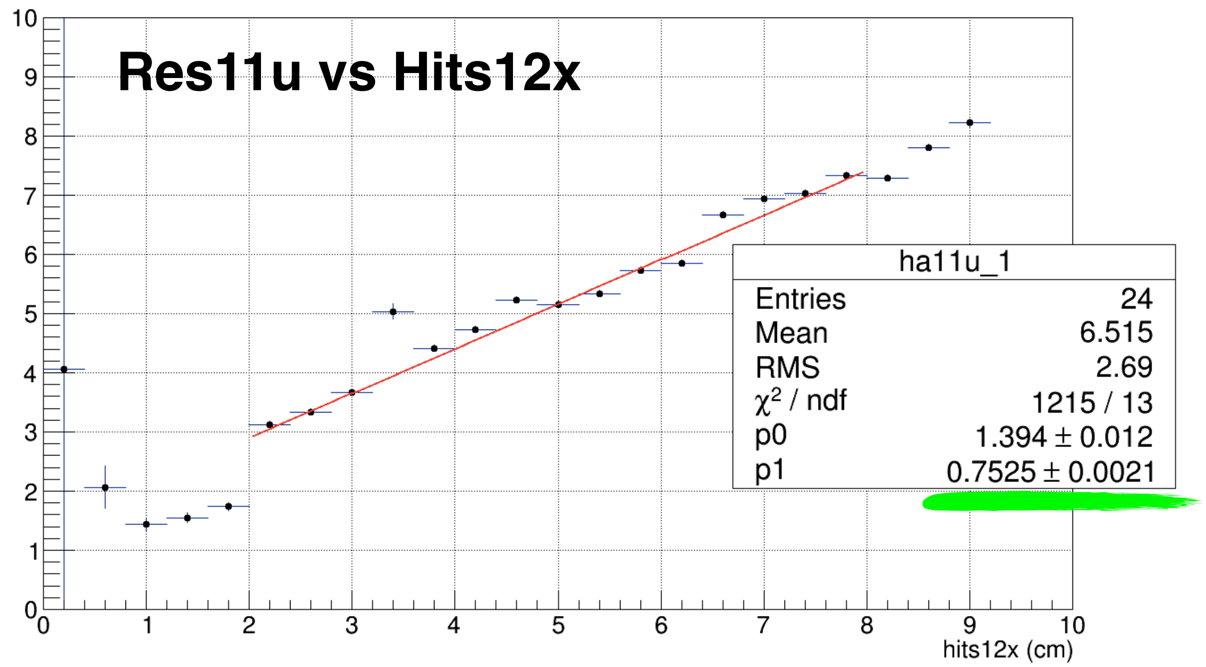


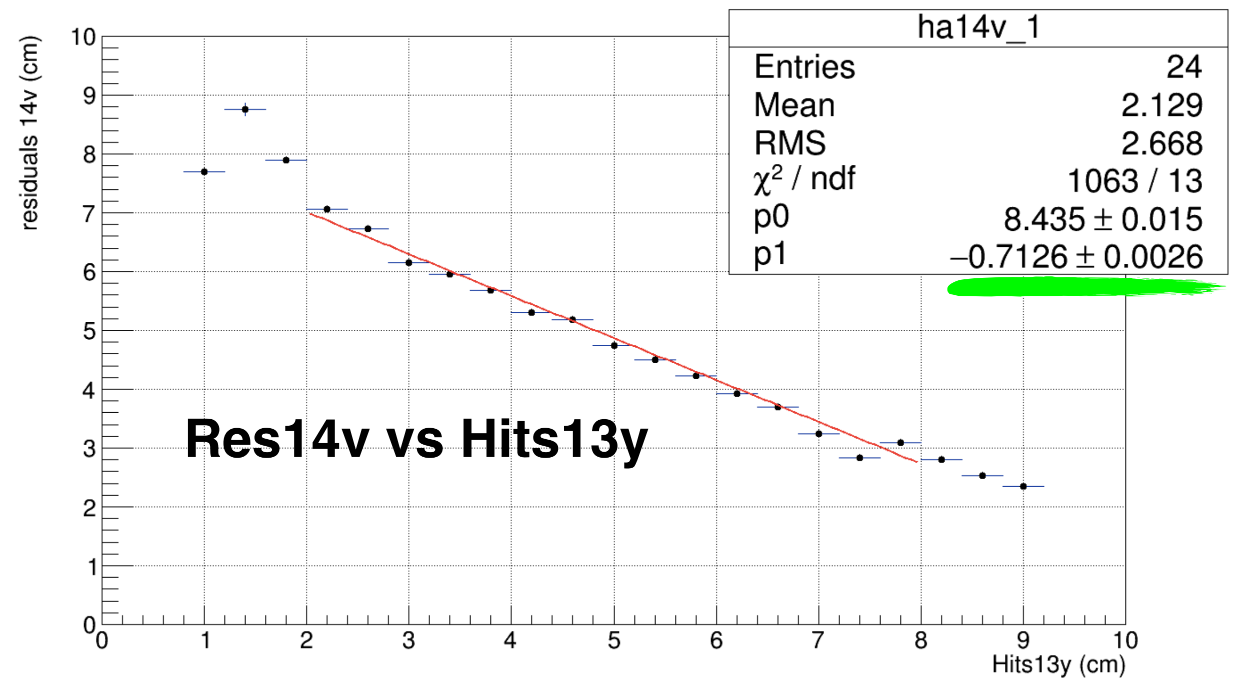


Residuals vs Hits before alignment

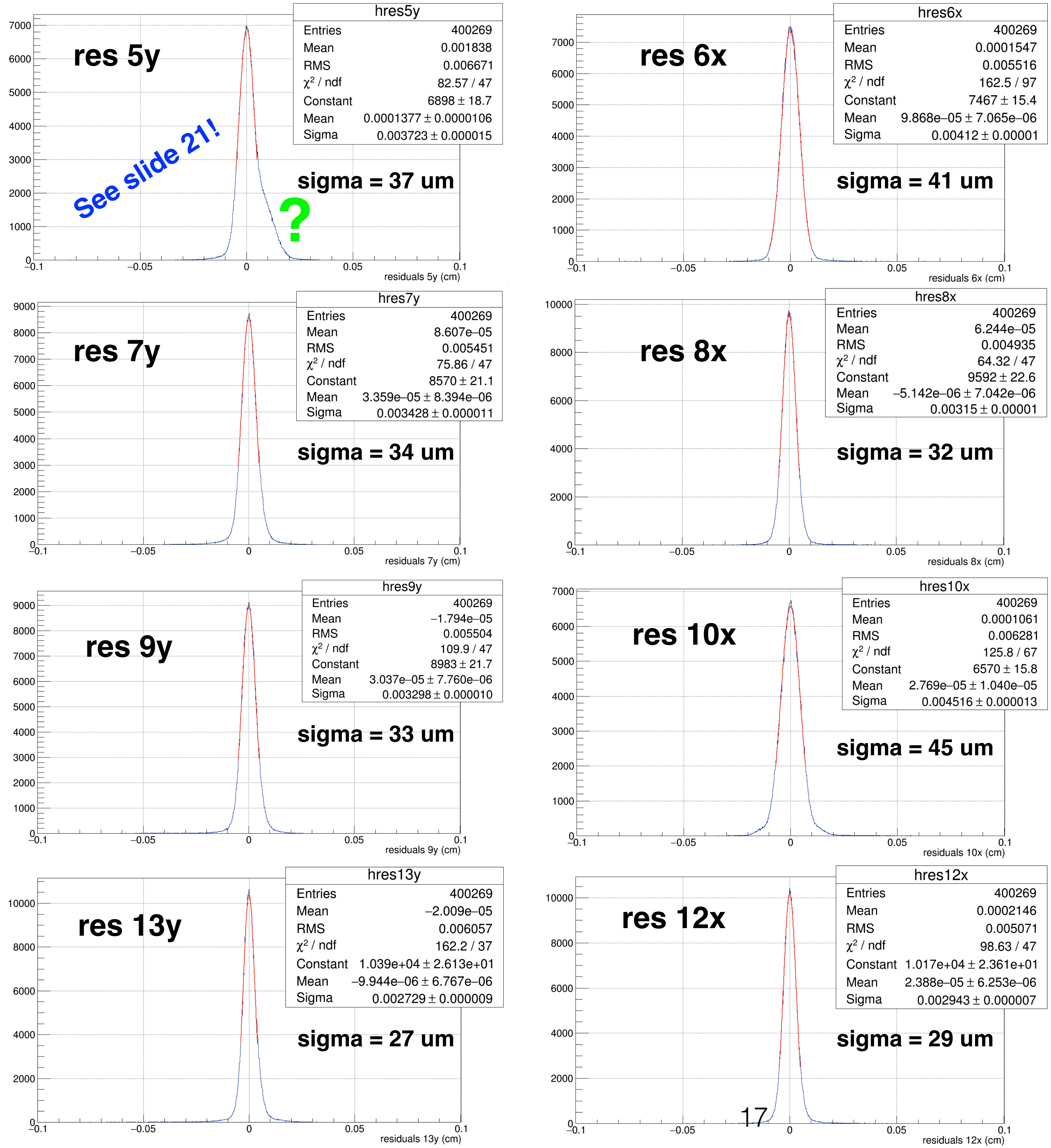








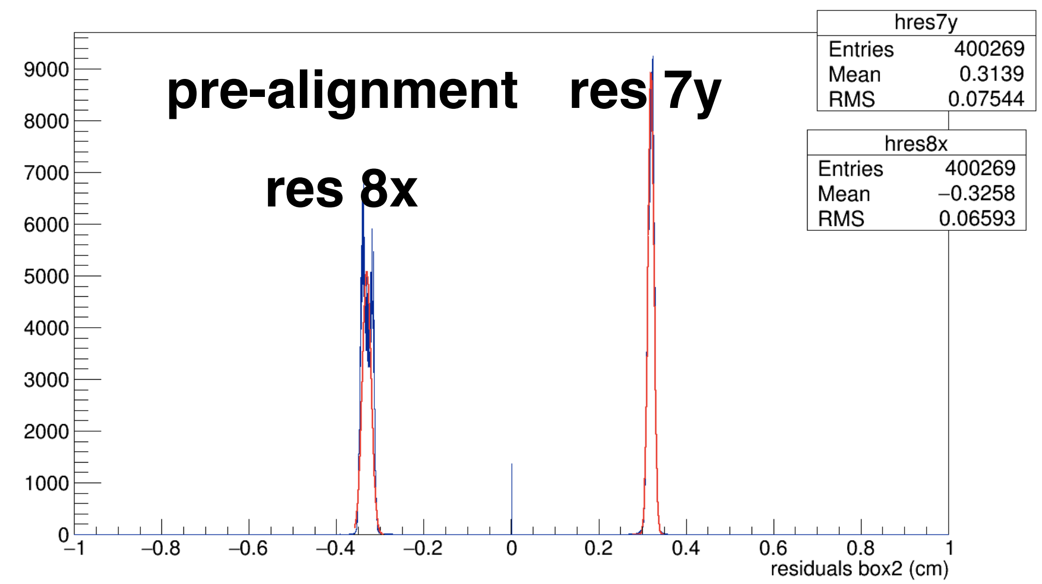
- All x/y rotations (along z axis) are within 5 mrad: plane 13y is the one with the highest corrections.
- uv planes confirm their angles: roughly +45° for 11u, -45° for 14v.



Residuals <u>after</u> alignment

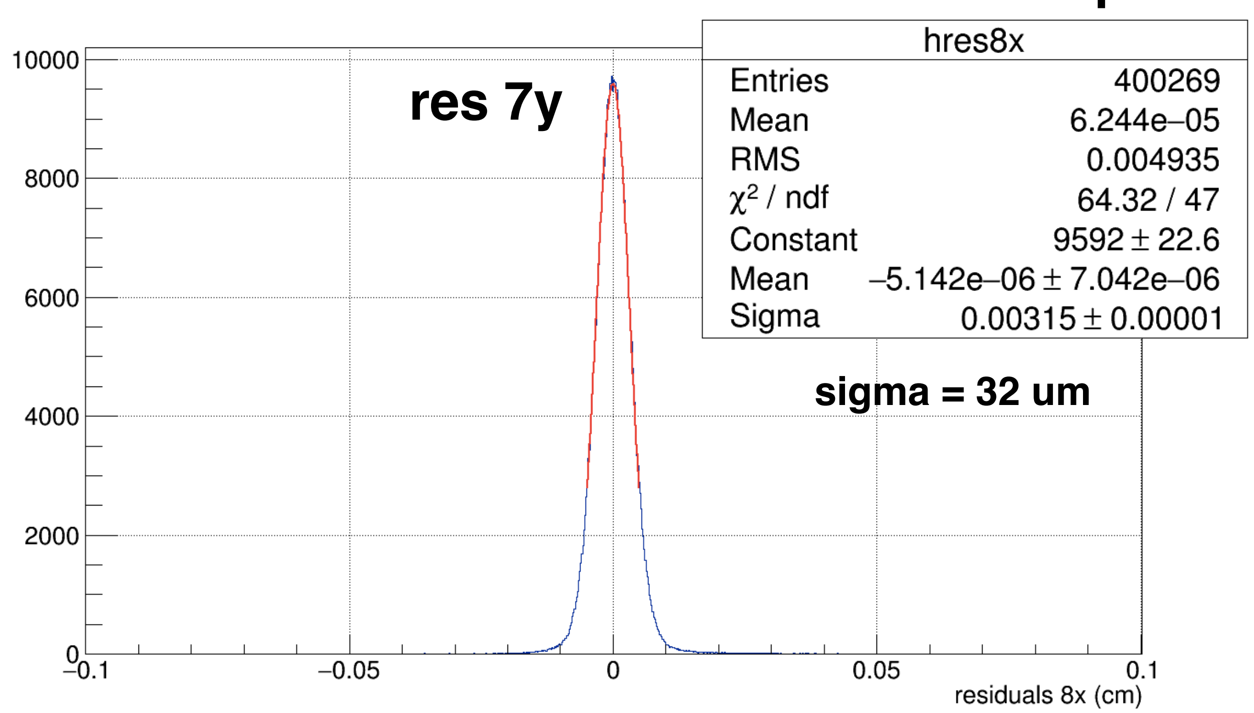
- Plane 5y surely has <u>some alignment problem or something else</u>: no gaussian shape. Maybe problems with hits of different ASIC->**slide 21**.
- Residual of plane 10x are wider than the other ones: it may indicate also some alignment problems.
- Anyway with this alignment attempt, residual means show it is possible to go **below 1 um** = 1e-4 cm.

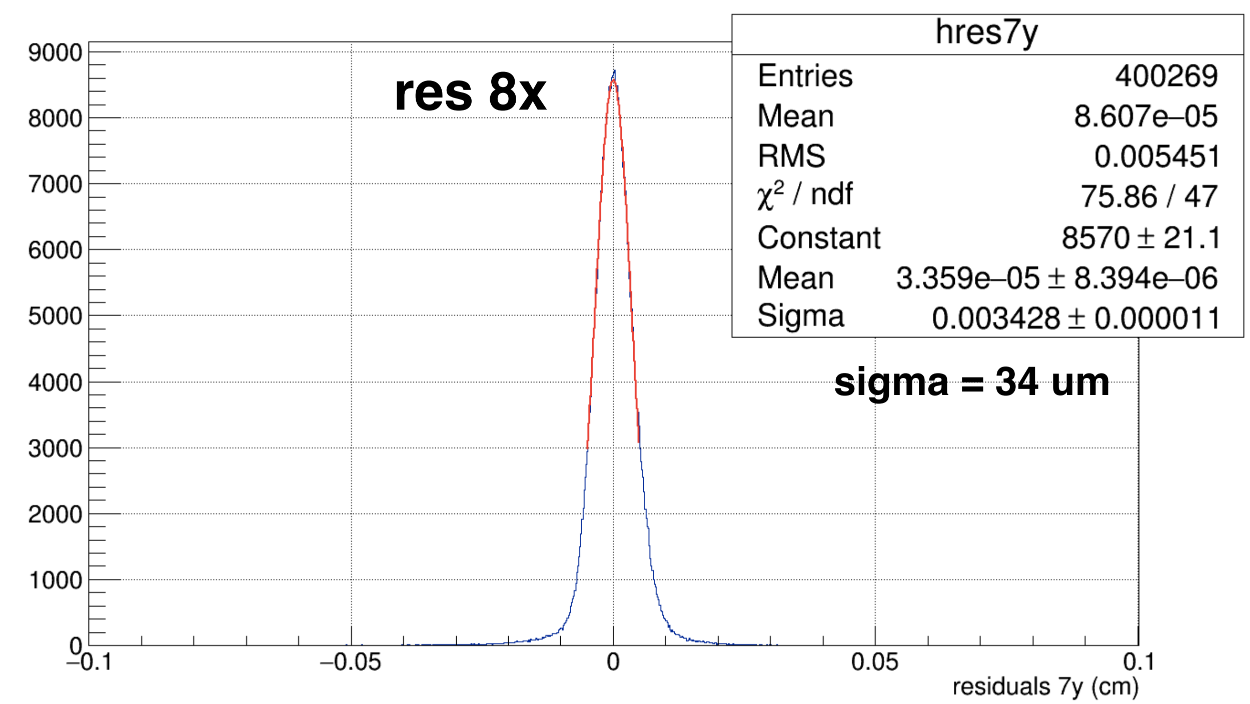
Intrinsic resolution: residuals analysis



- From residual distributions can be disentangled multiple scattering effect and point silicon resolution: in this case, as a first approximation (->180-190 GeV muons), residuals sigma can be considered the intrinsic resolution of silicon trackers.

post-alignment

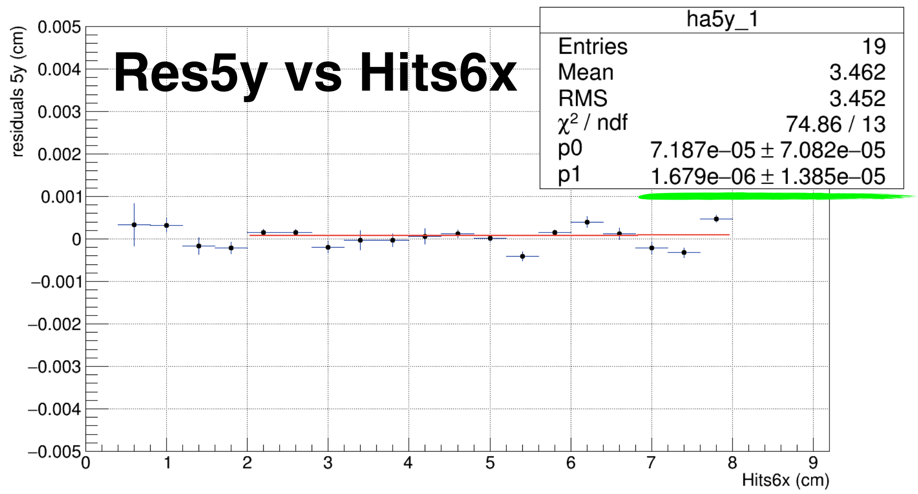


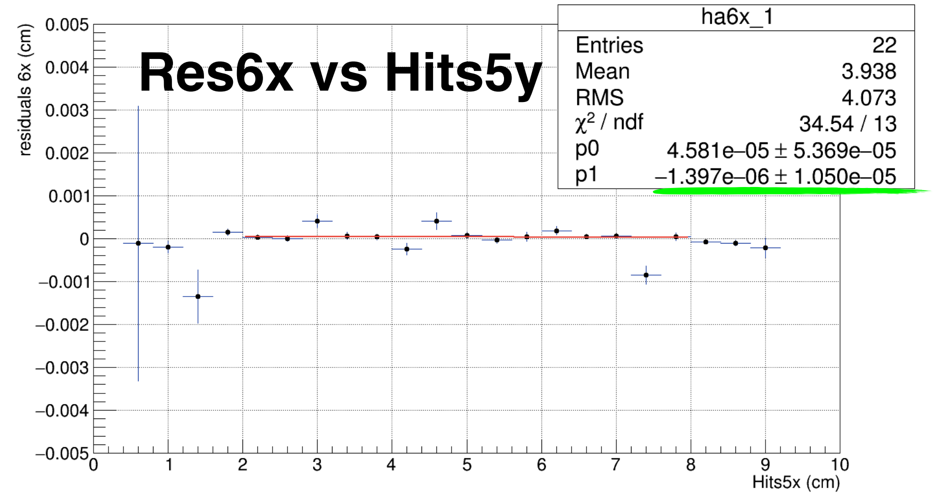


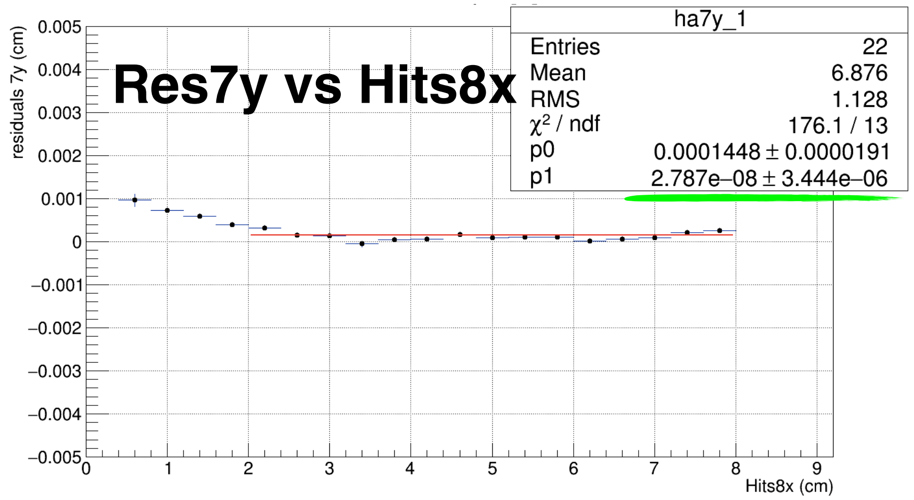
- A position resolution of roughly 37-47 micron is indicated as a reference in (1).
- AGILE readout strip pitch: **242 um** with "floating strip" (2).
- So geometrical tracker resolution is: 242/2 / sqrt(12) = **34.9 micron**.
- Residual sigmas from our high energy muon data confirm these numbers and also show us that maybe from the "residuals point of view" we can't do anything much better.

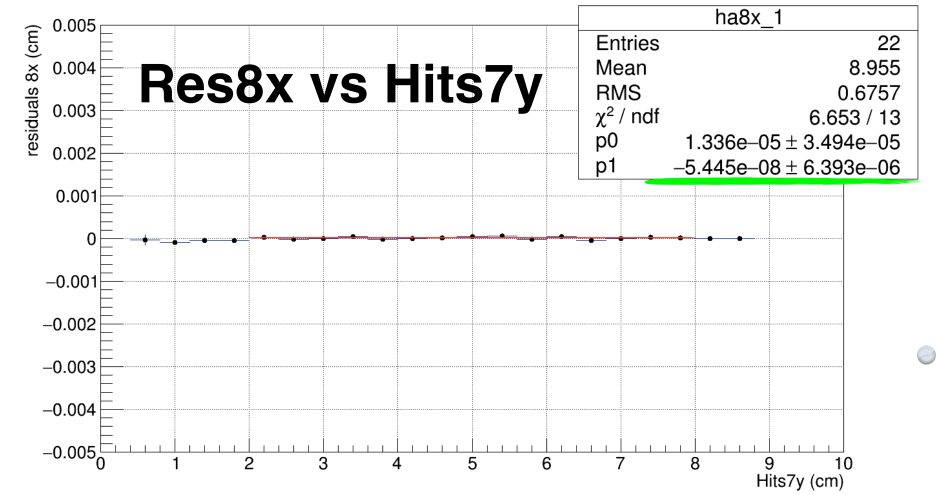
! (1) https://www.lnf.infn.it/acceleratori/public/BTF_user/AGILE/nima490agile.pdf
(2) https://www.lnf.infn.it/acceleratori/public/BTF_user/AGILE/nima501agile.pdf !

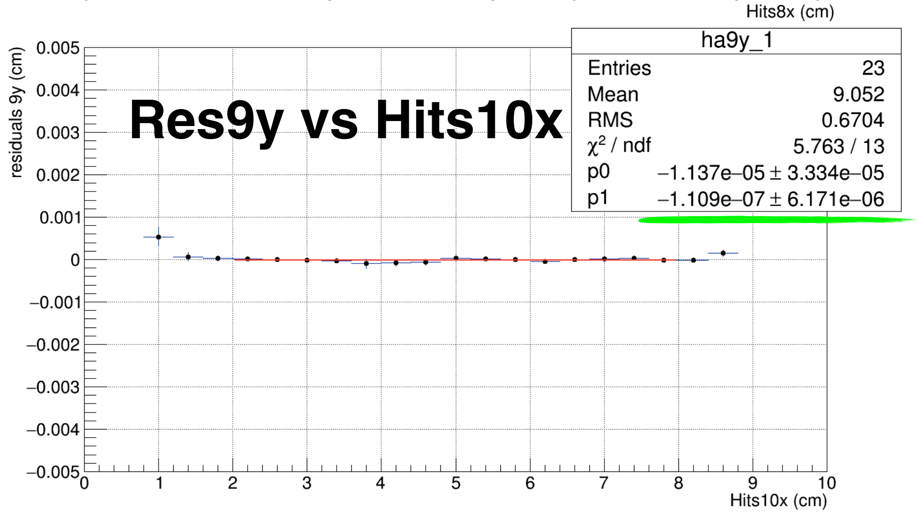
Residuals vs Hits <u>after</u> alignment

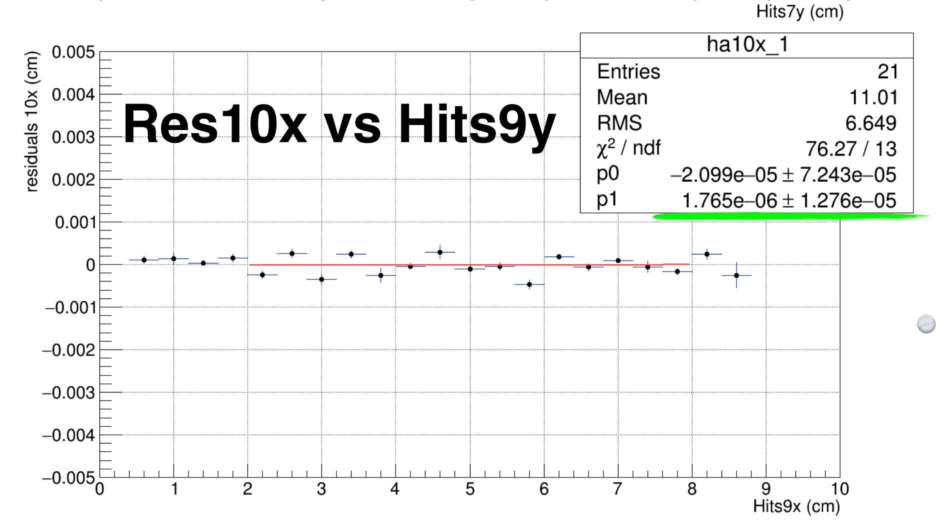


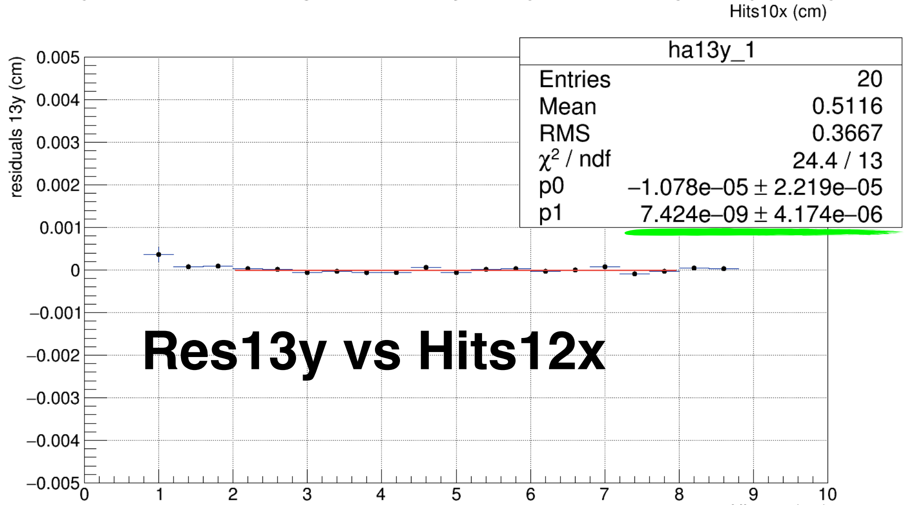


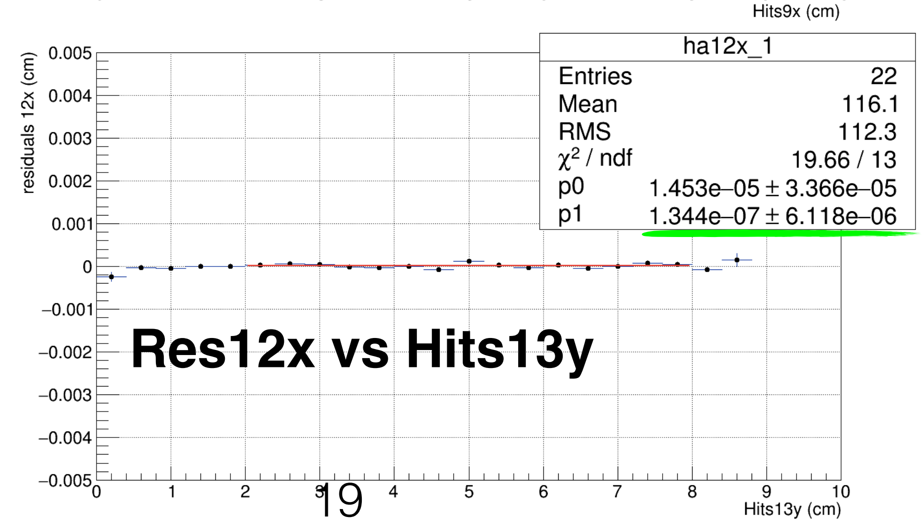






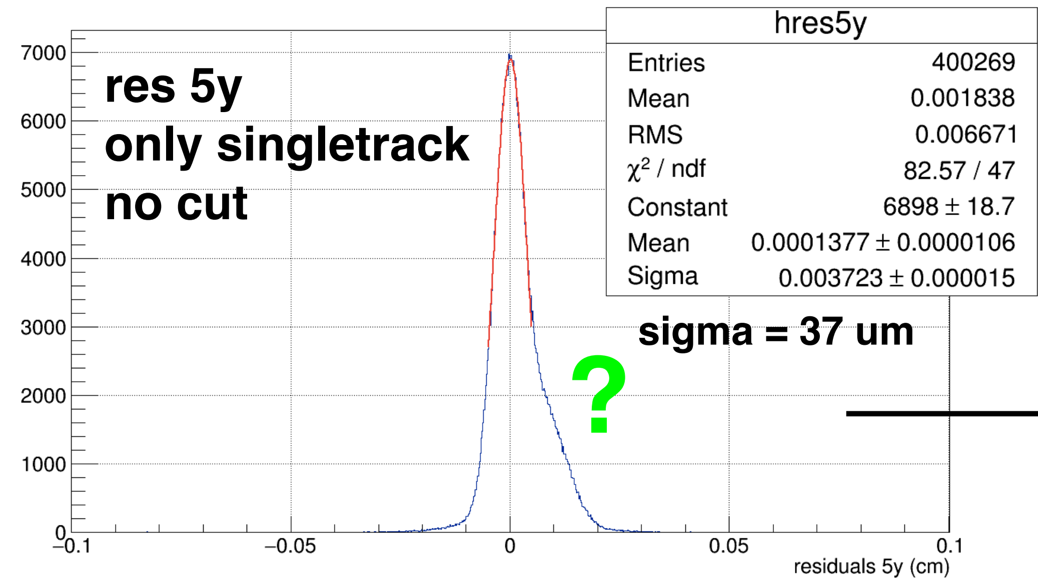




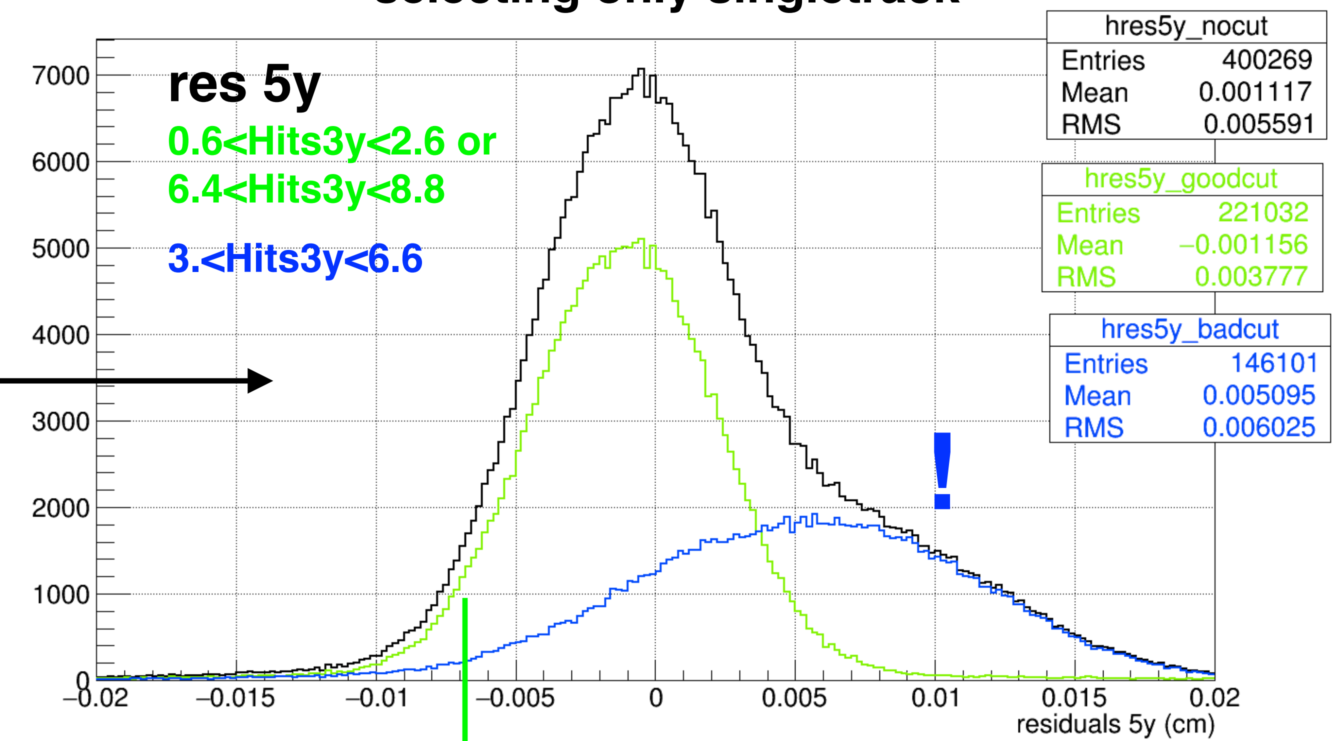


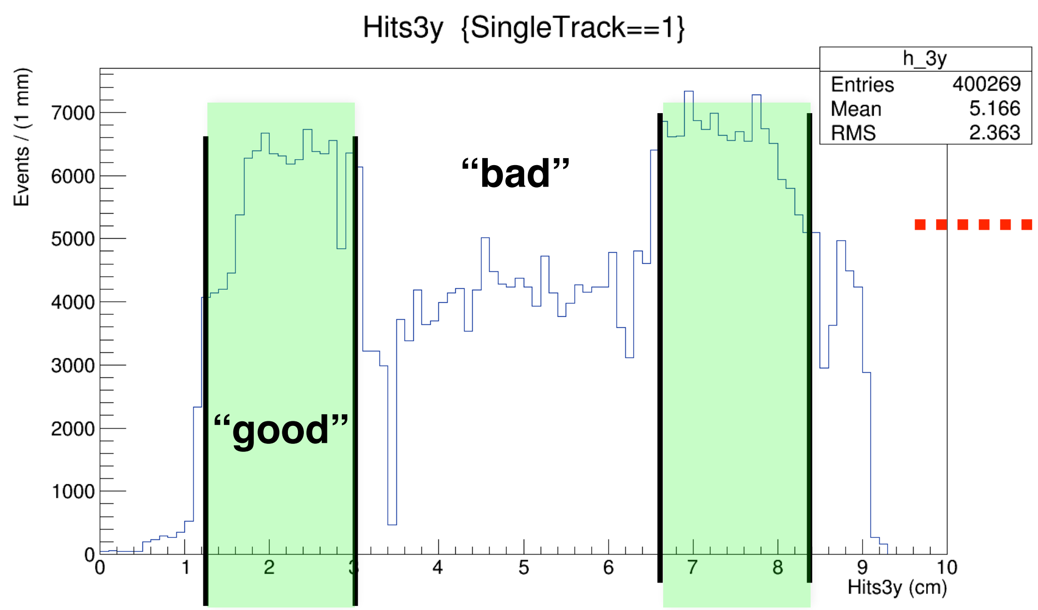
- Planes 5y, 6x, 10x have noisy behaviors; planes 7y has some edge problem. Part of these can be solved with quality cuts (next slides).
- These plots show it is possible to correct rotations along z axis **within 0.001 mrad**.

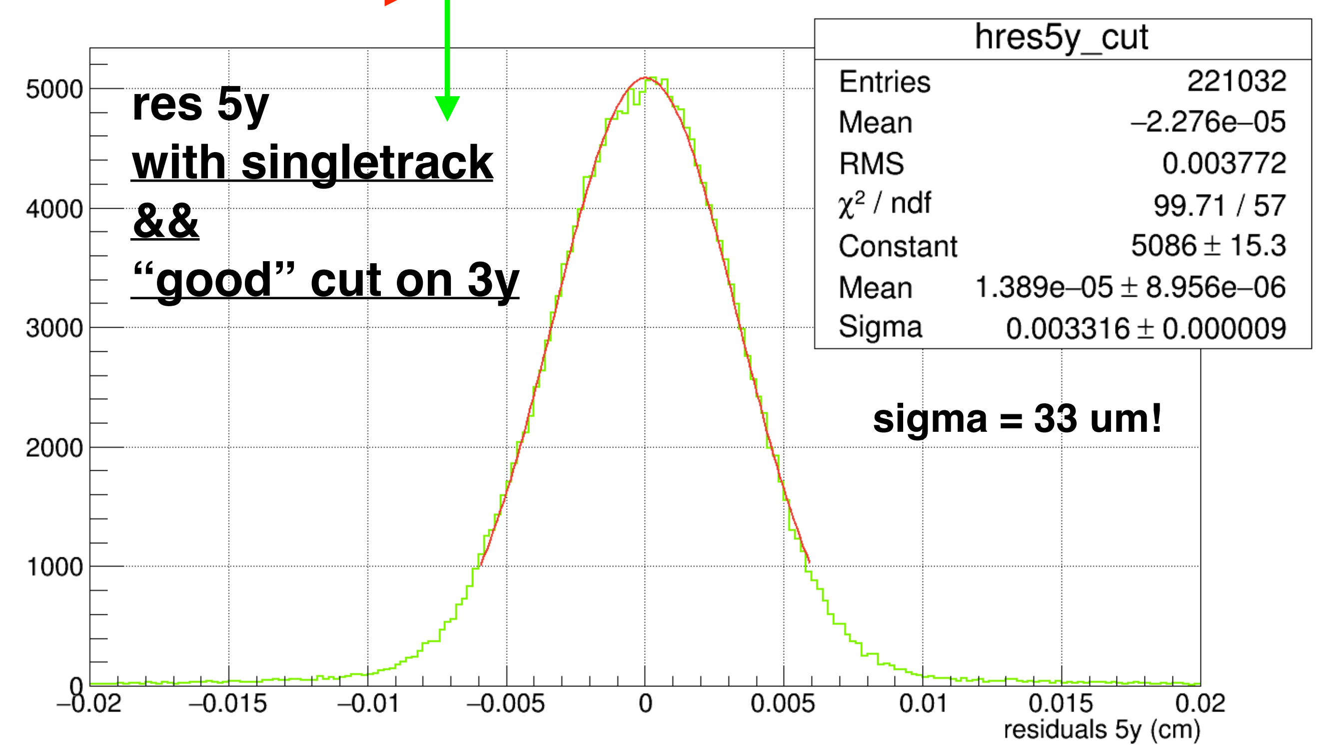
Fiducial cut on 3y (1): solving problems on y



selecting only singletrack



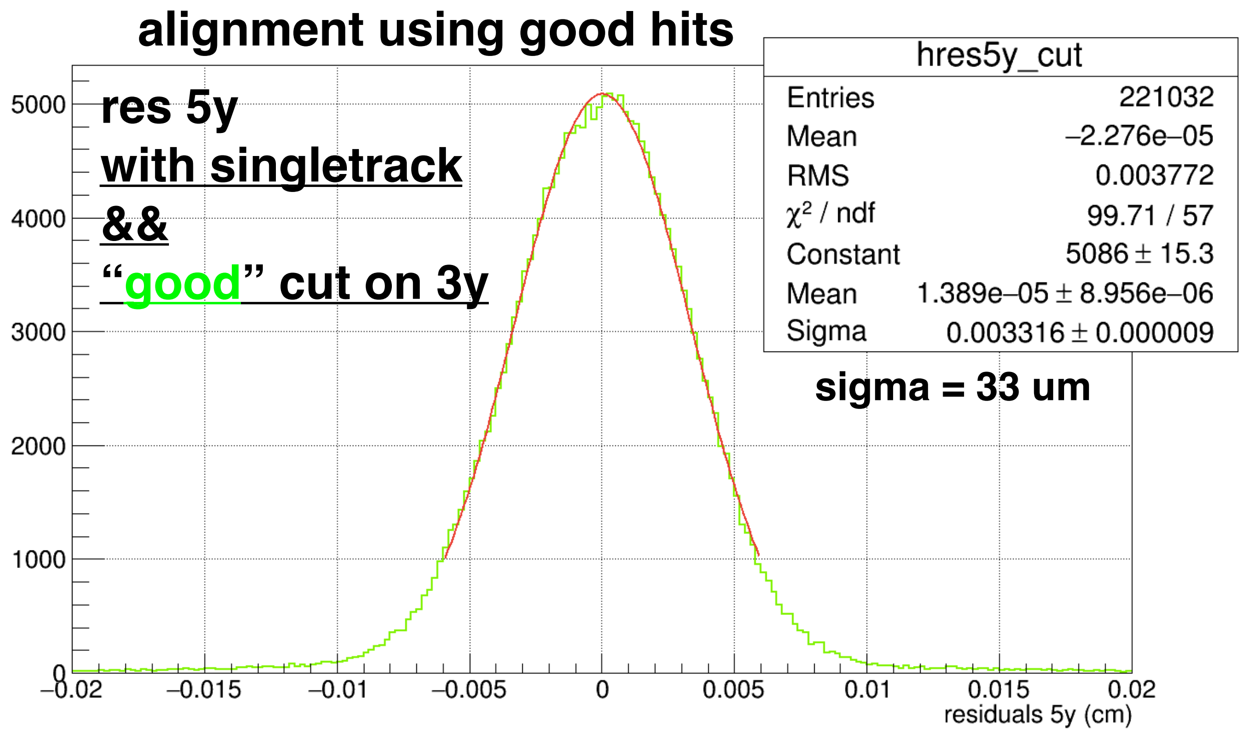


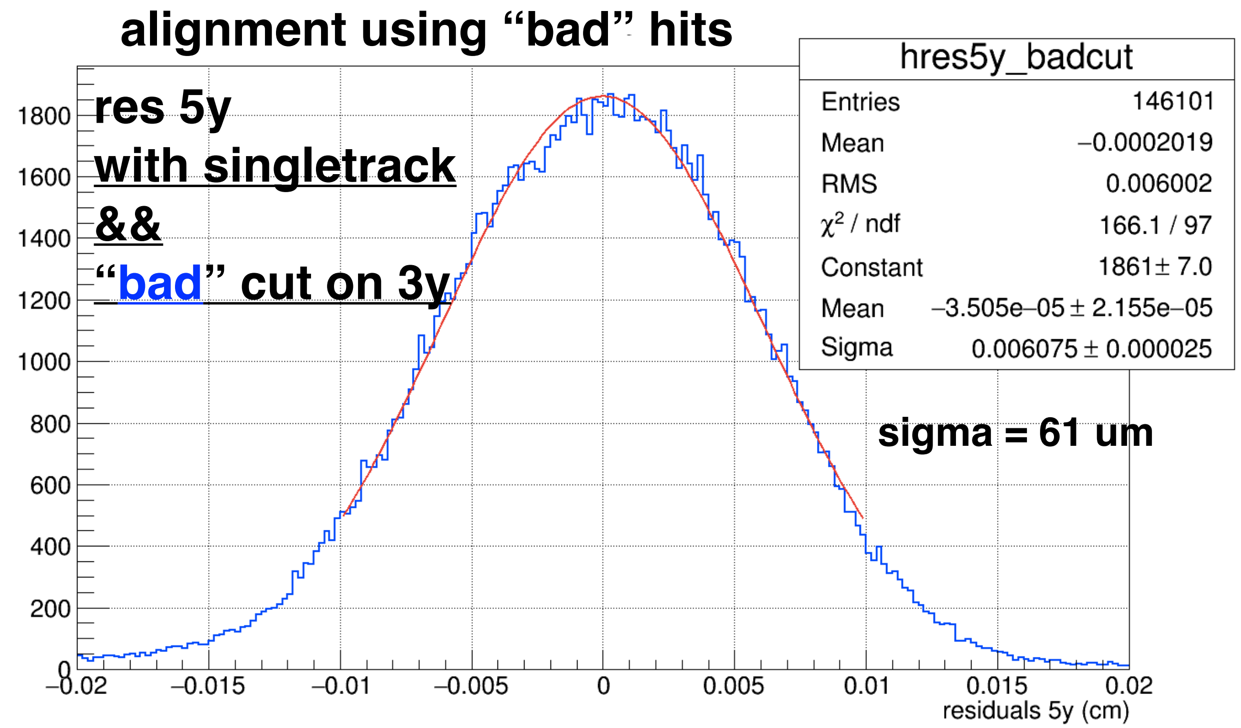


cut on 3y:
1.2<Hits3y<3 ll 6.6<Hits3y<8.4

- Selecting only hits on first and third ASIC (of 3y), residual on plane 5y considerably improves: it becomes gaussian like the others and its sigma becomes comparable with the intrinsic limit value.

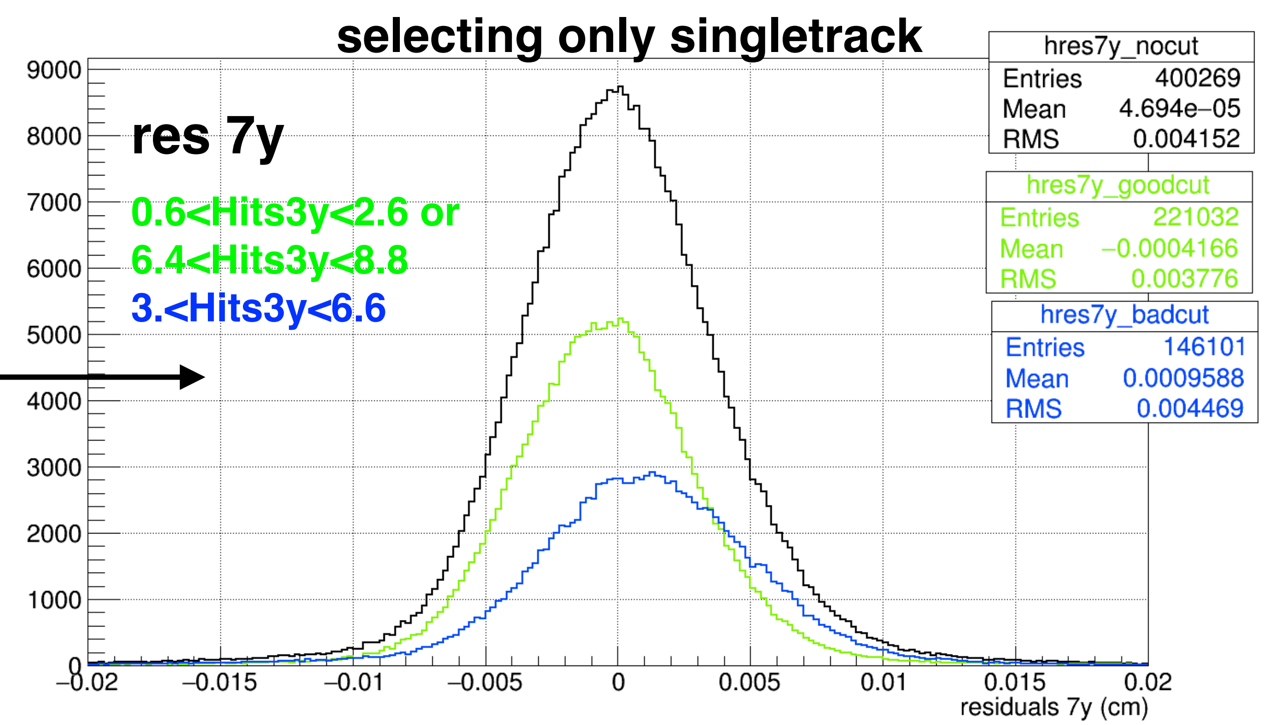
Fiducial cut on 3y (2)





- Decoupling the two hits groups (**1°-3°** / **2°** ASIC of 3y), they seem to align themselves: the best group (**1°-3° ASIC**) achieves a good alignment; for the other one, the distribution seems centered, but the sigma is too high.
- At first sight, it looks like weird: if we use only "good" hits for alignment, we must check that final alignment coefficients work well also for the hits group in the middle (not used to extract these coefficients).

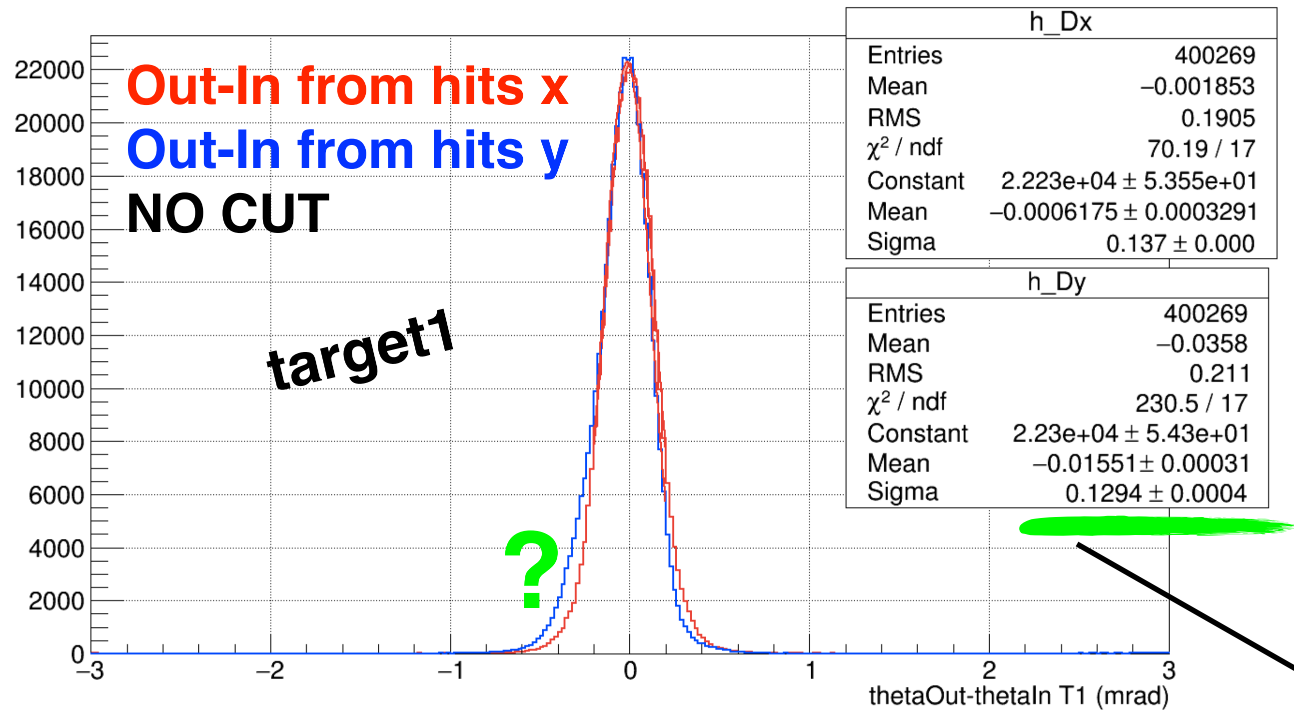
- Also on the other y planes there are same quality problems, but less pronounced.



Muon deflection distributions on target 1/2, <u>AFTER</u> alignment

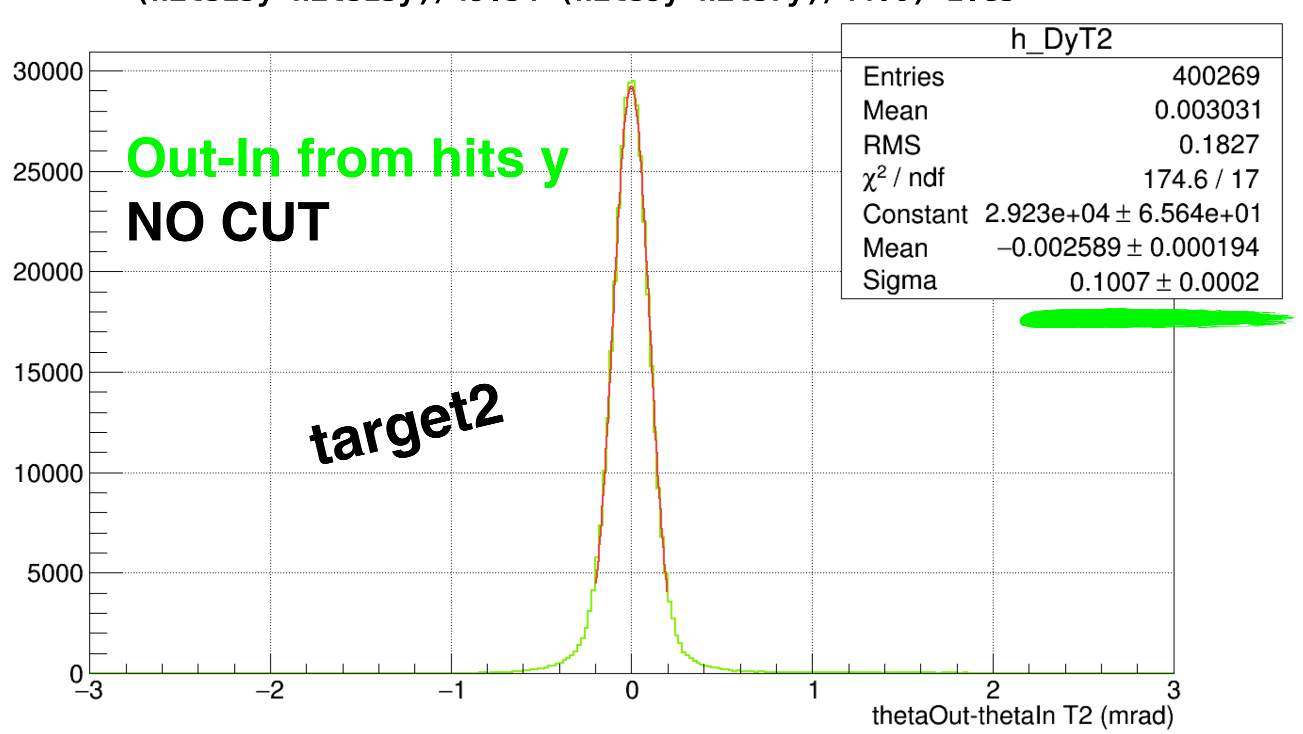
(Hits10x-Hits8x)/45.43-(Hits6x-Hits4x)/50.)*1.e3

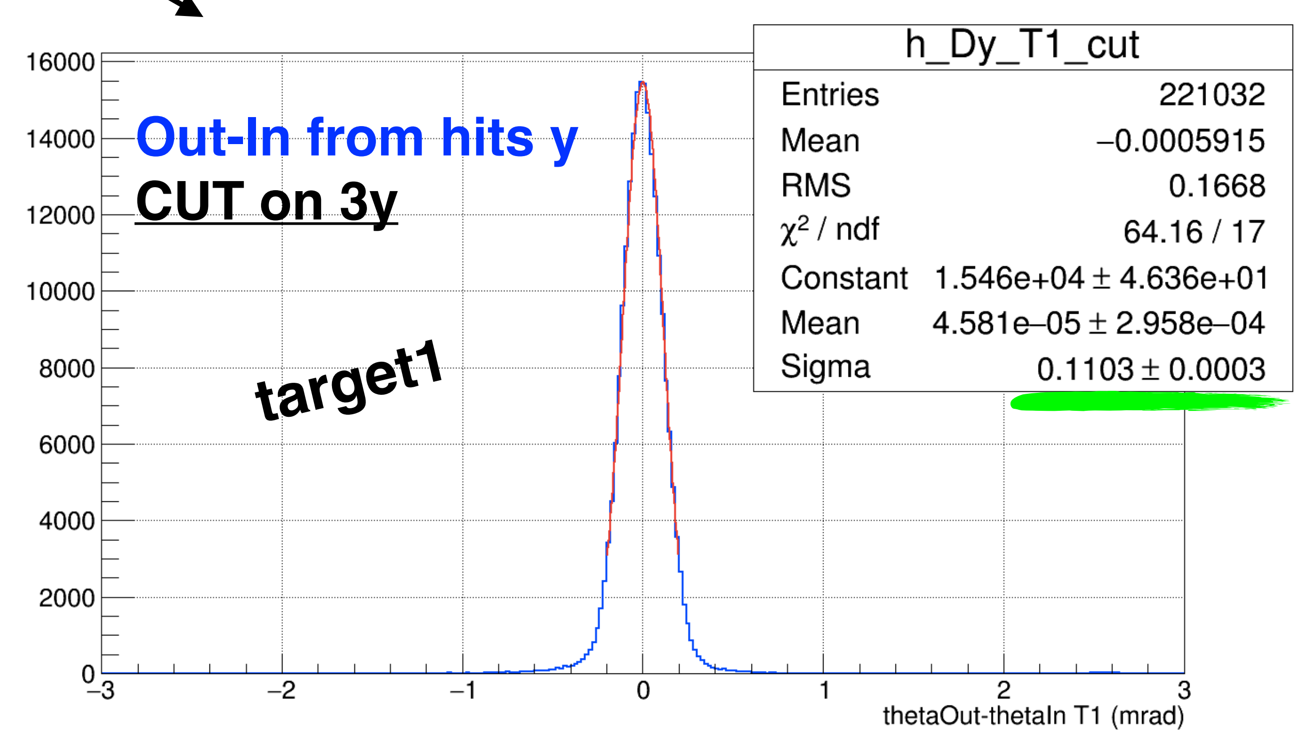
(Hits9y-Hits7y)/44.6-(Hits5y-Hits3y)/50.)*1.e3



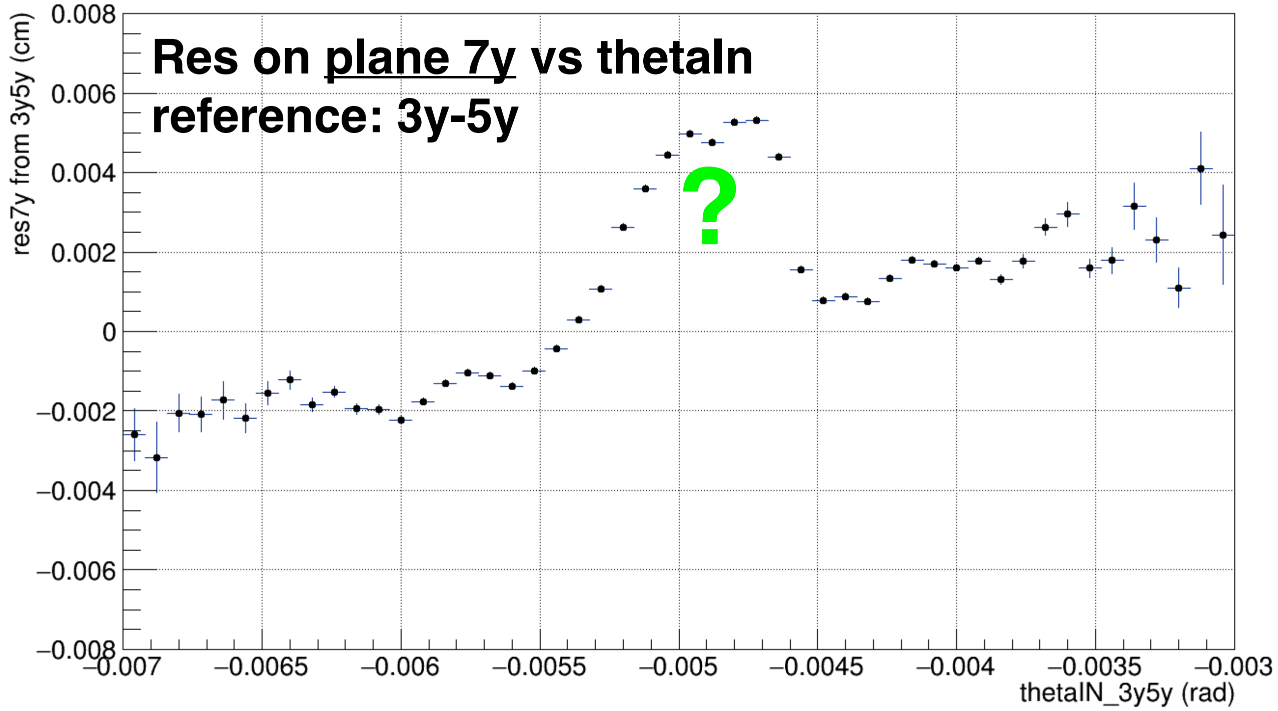
- Beyond roughly angle definitions, all these distributions look like too wider (for 180-190 GeV muon) and their sigmas are not compatible, in particular the y one shows some problems: although Dx (for T1) and Dy (for T2) have acceptable offsets, within few urad, these plots clearly show the data need more work.
- Plane 5y / 6x / 7y / 10x have something unclear that obviously affects these distributions: <u>**cutting on Hits3y**</u>, angle distributions significantly improve.

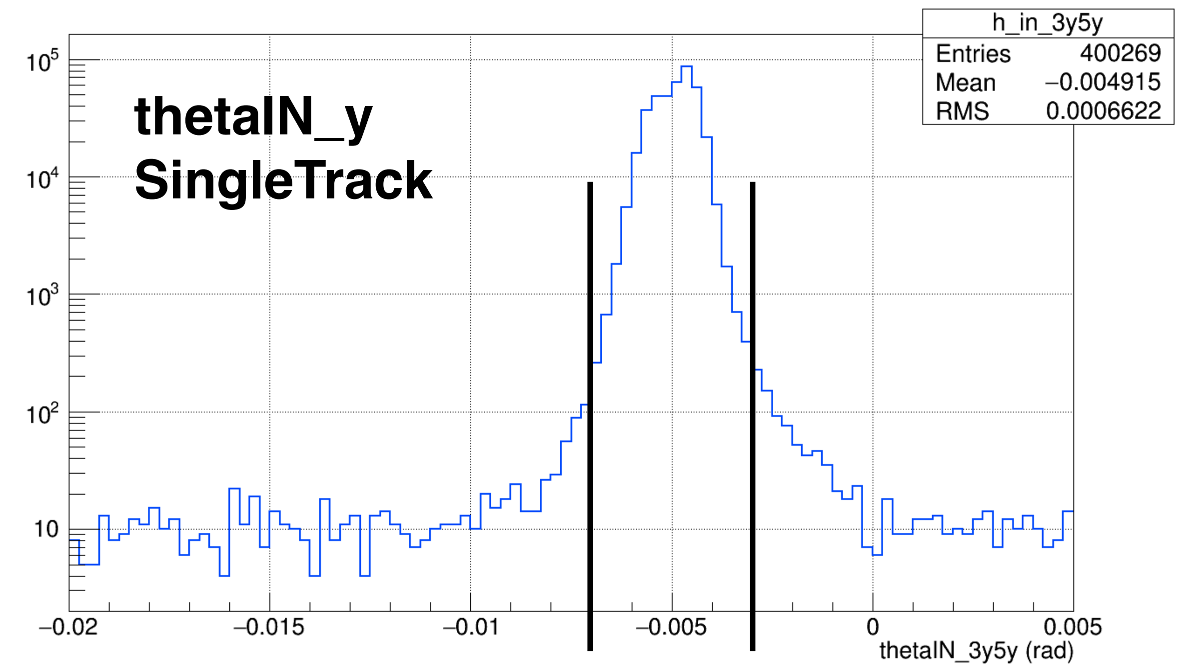
(Hits15y-Hits13y)/49.34-(Hits9y-Hits7y)/44.6)*1.e3

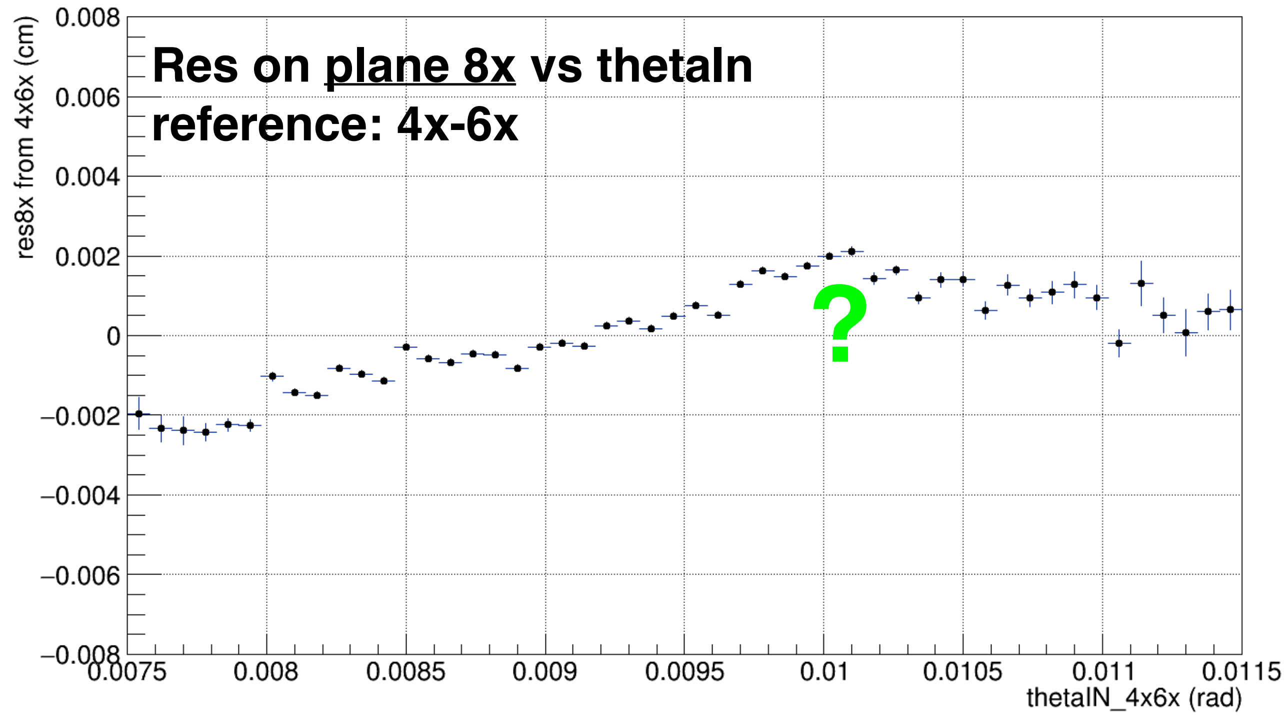


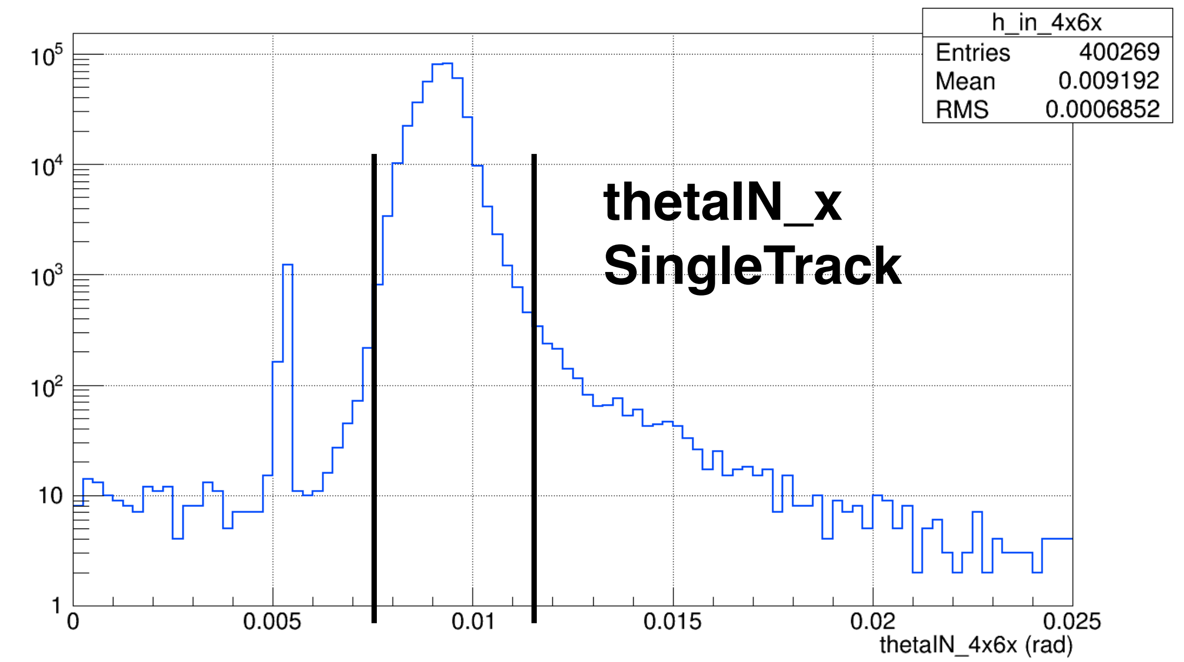


Possible directions: check other misalignments?









- These hits are now partially(?) aligned: correlations between residuals on some planes (here taking as a reference first planes before T1) and incoming direction (before T1) can show us there are clearly other corrections to apply. These behaviors, in particular positive -> negative correlations, suggest there may be problems along z axis, for example related to the tilt along x and y axis, declared in the provided diagrams. They particularly afflict planes in box2 and box3.

Remarks

- Some silicon sensors have **counting problems** probably due to high beam intensity.
- To recover efficiency (lost in these planes), we will use the other ones, up and downstream: in particular another box has been added to recover 3y.
- An alignment procedure, like that of previous test beam, was performed with good results, for all x/y planes: residual means **below 1 um** and rotation along z axis **within 0.001 mrad** seem possible to achieve with a correct alignment.
- Residual distributions from data are compatible with declared **intrinsic resolution** of AGILE trackers.
- Some unclear points remain, in particular on **quality cuts** to choose events for alignment; also the questions concerning sensor rotations along x and y axis.
- Once alignment procedure has been established, it will be necessary to figure out how to correctly handle the stereo u/v planes.