Looking for global alignment constraints

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2016 data @ 0.5 mm global alignment

- Several version of internal alignment basically equivalent
- Need for more external constraints
- In reconstruction: fixed beamspot (0,0) and z_{target}=0
- Selected samples distributions show that these coordinates should be changed to better center distributions
  - This information is obtained from the study of Moller events and FEE tracks contained in ntuples which are written after mass and vertex constrained fits
    - their content depend on the injected coordinates for beamspot and target
    - For 2016 data they are provided from the steering file (not sure which steering file people are using, though)
      - these calibration constants cannot be so volatile but need to be embedded into the compact file – potential source of big mess…

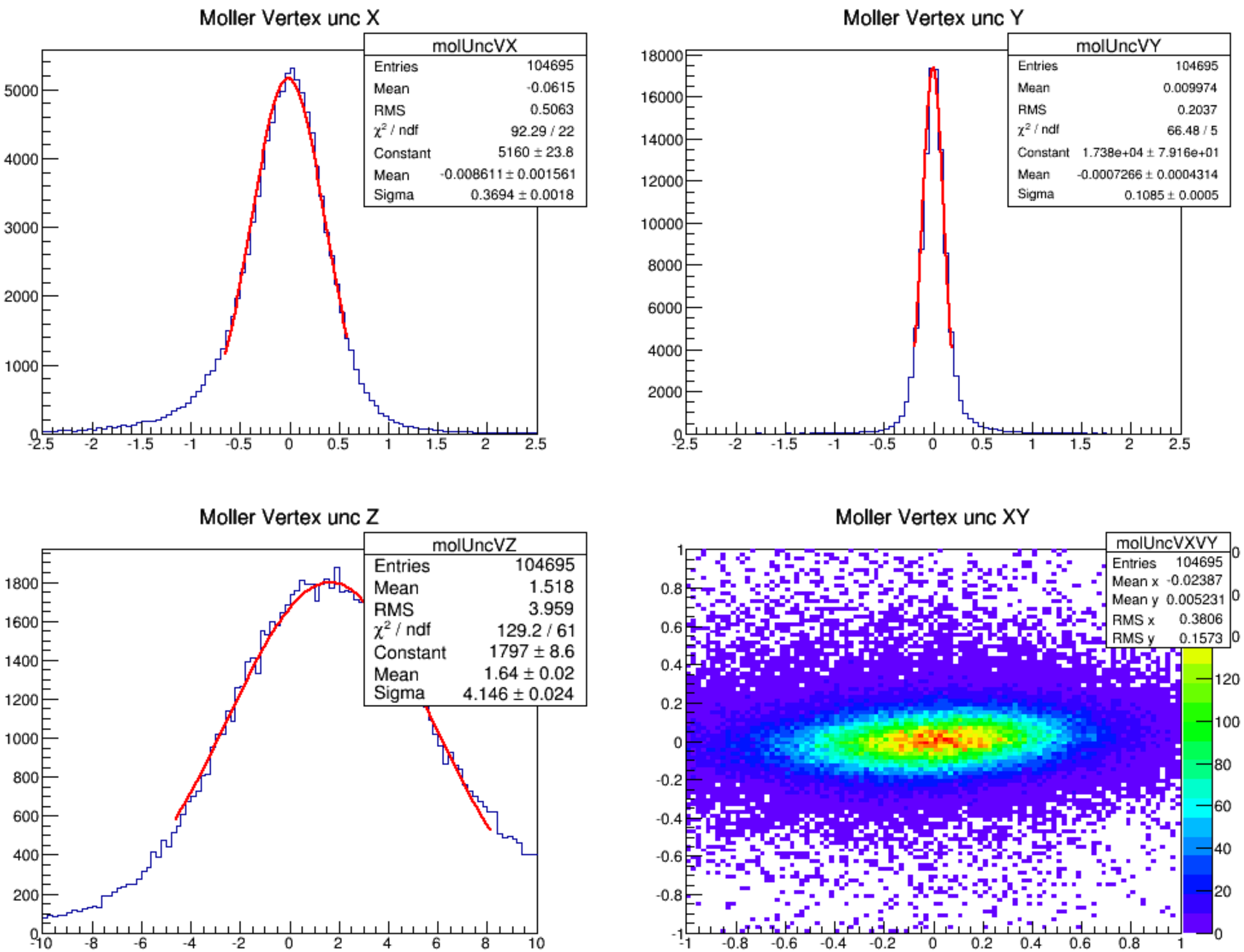
BUT

  - The alignment does not depend on the beamspot coordinates (unless this is explicitely forced): GBL tracks as input for alignment are picked up before mass and vertex constrained fits are made

Insert vertex information in alignment procedure?

- Possible, but not straightforward
- The code to this purpose existed, but it was removed (anyway, I retrieved it from an old code release)
- What can be done:
  - Use the information from unconstrained distribution to identify the beamspot coordinates and feed them into alignment: this point stands as the center of a new (fake) sensor pair
  - Force the tracks to pass through this hit (with an uncertainty given by the sigma of the beamspot)
  - Run alignment keeping this point as fixed and floating needed sensors
  - Produce new geometry
  - Test results
    - Ntuples will need to be produced inserting the new vertex position in the reconstruction (if not, just a slight change can be seen in the new distributions)
    - Compare with some 2015 distributions (from Sho)

Moller sample (run 7798, v5-7 geometry): vertex coordinates

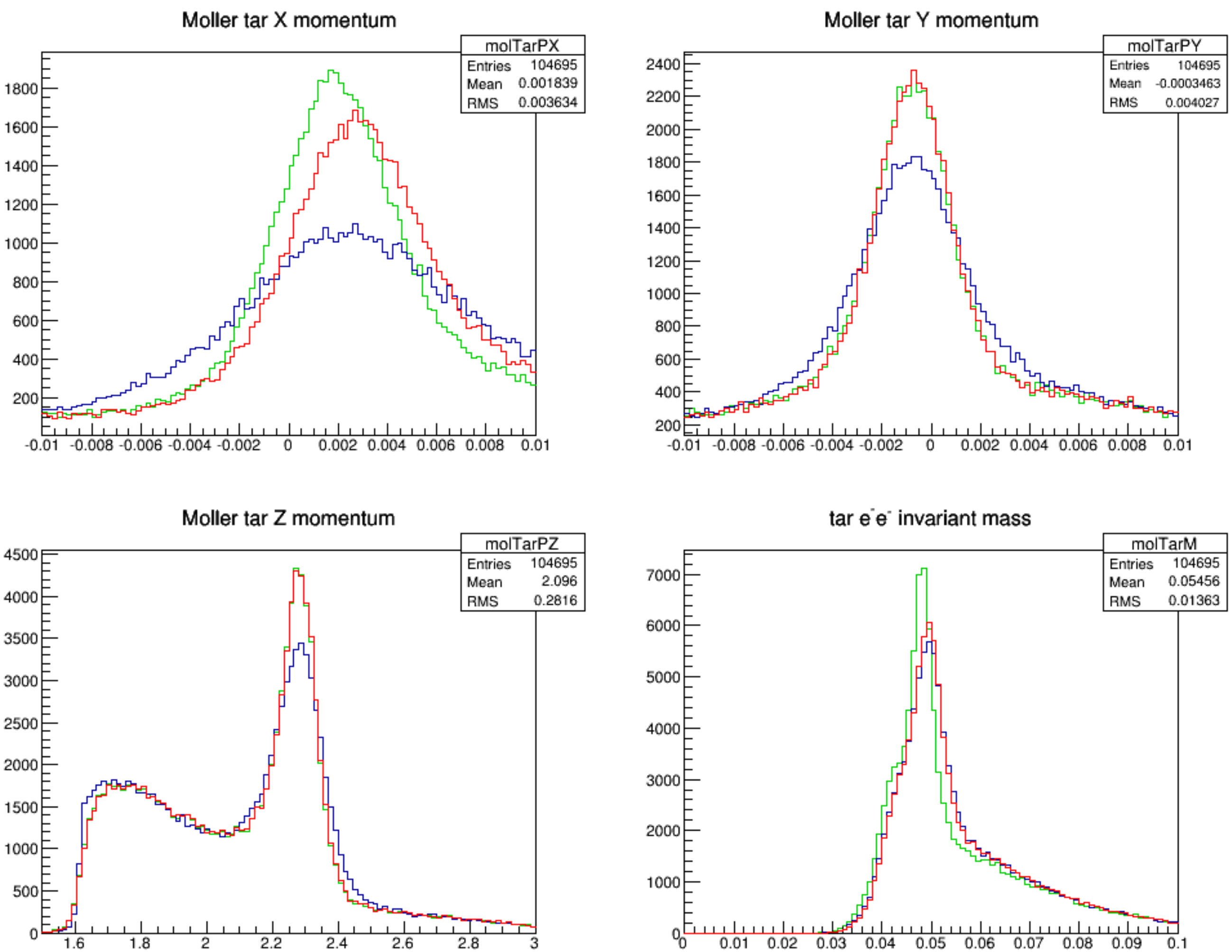


Unconstrained vertex distributions

- X coordinate
  - μ = - 9 μm
  - σ = 3.7 mm
- Y coordinate
  - μ = -0.7 μm
  - σ = 1 mm
- Z coordinate
  - μ =1.64 cm
  - σ = 4.1 cm

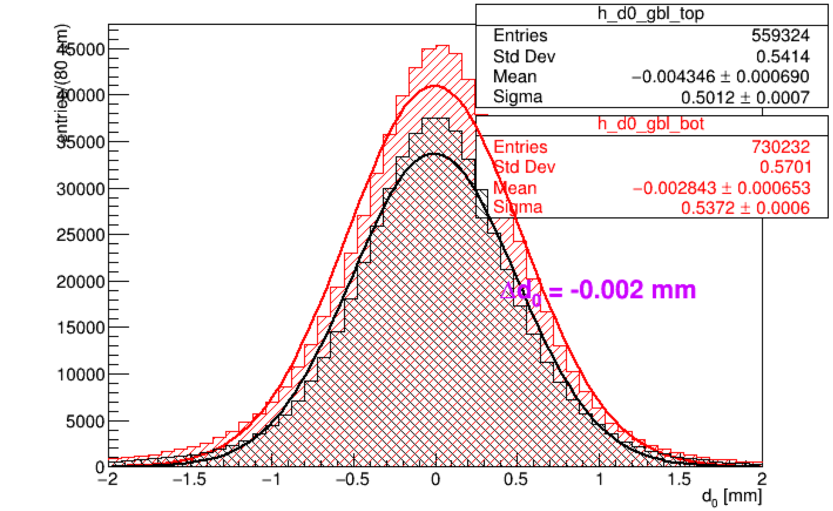
Reconstruction with (0,0,0) as beamspot

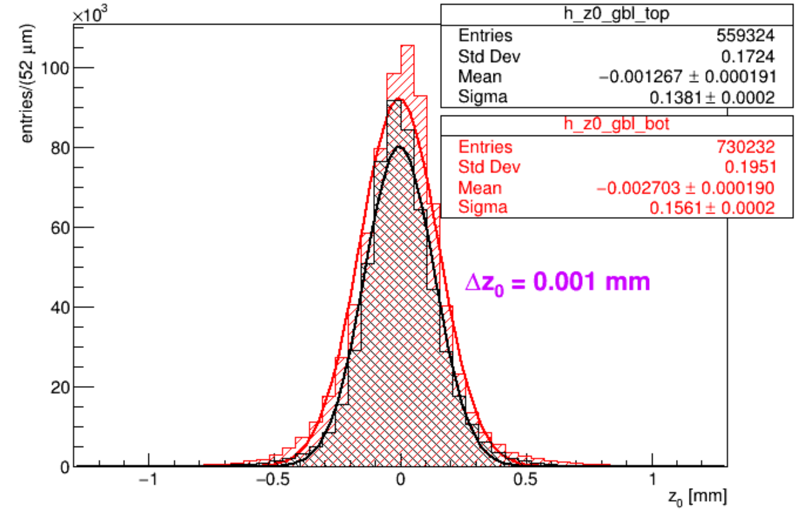
Moller sample (run 7798, v5-7 geometry): momentum components



- Unconstrained momentum components
  - PX coordinate
    - μ = 3 MeV/c
    - σ = 5 MeV/c
  - PY coordinate
    - μ = -0.7 MeV/c
    - σ = 3 MeV/c
  - PZ coordinate
    - μ = 2.27 GeV/c
    - σ = 84 MeV/c

v5.7 detector w fieldmap, 0.5mm
curved + straight tracks + global alignment





Cut on track χ^2 (<40)

T/B diff

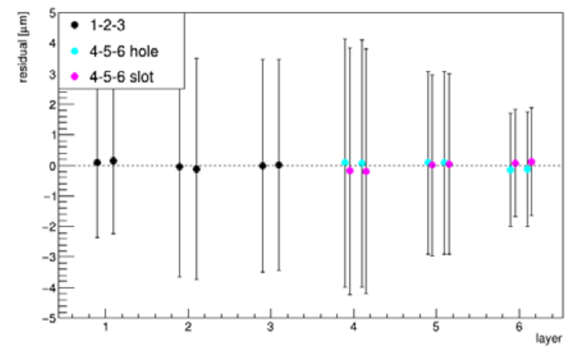
Δd_0 = 2 μm

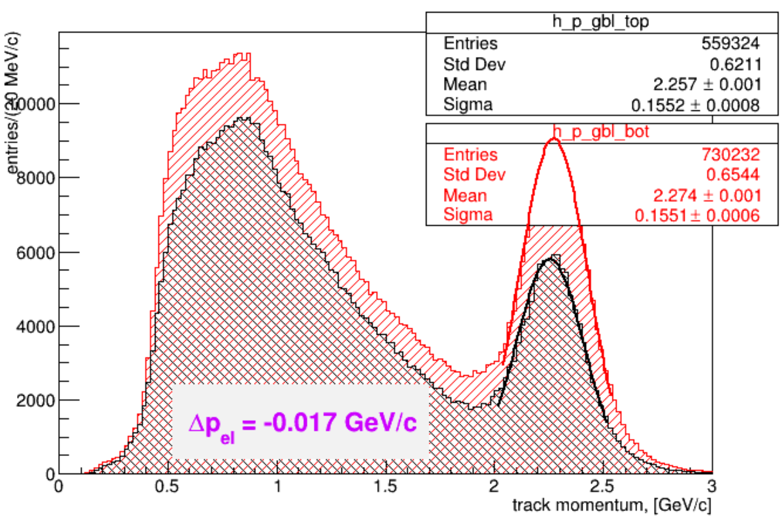
Δz_0 = 1 μm

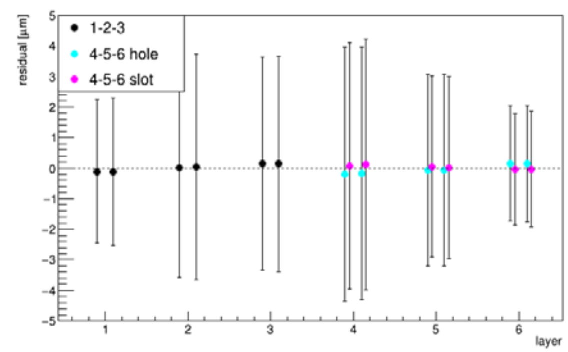
Δp = -17 MeV/c

p_{top} = 2.257 MeV/c

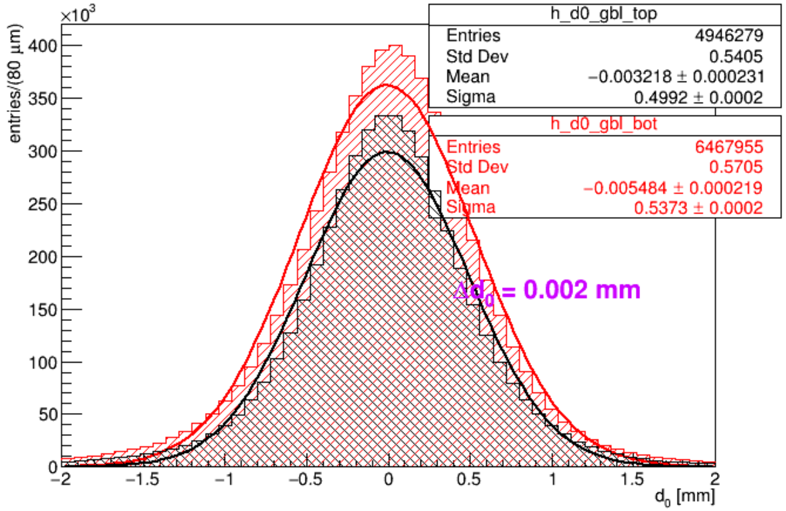
p_{bot} = 2.274 MeV/c

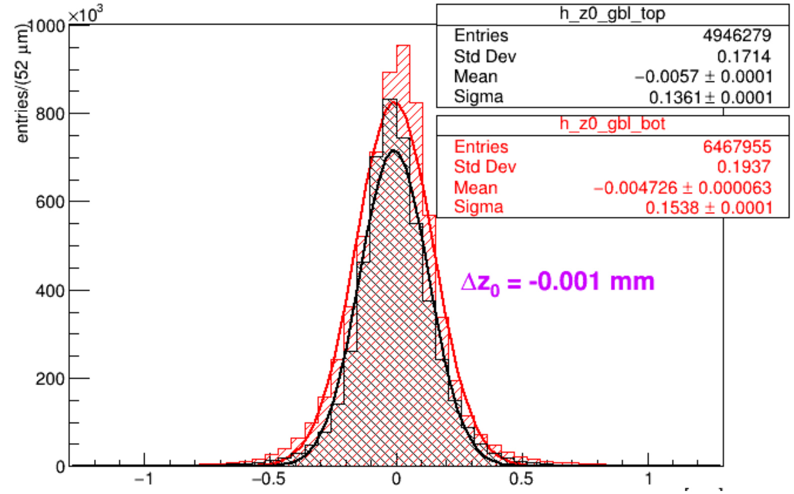




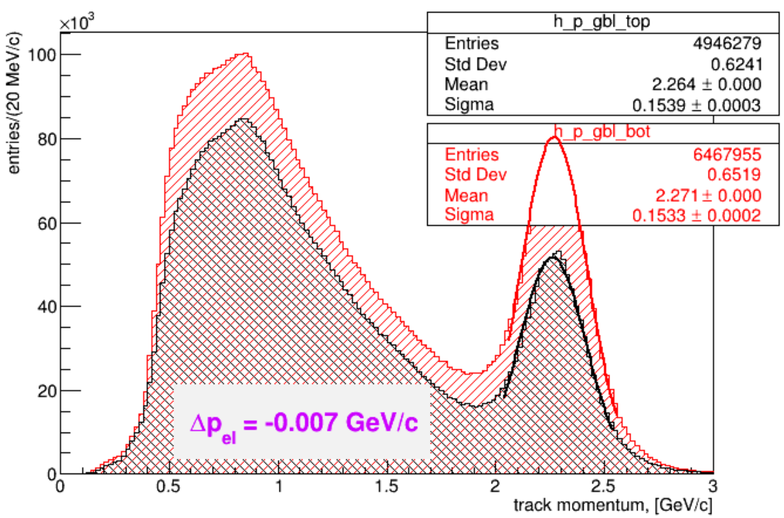


2016 new geometry with beamspot (v5.21) w fieldmap, 0.5mm curved + straight tracks + global alignment



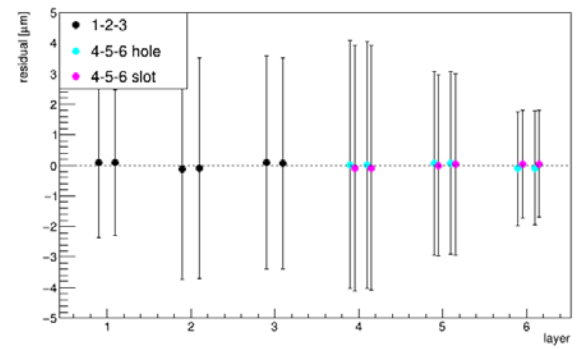


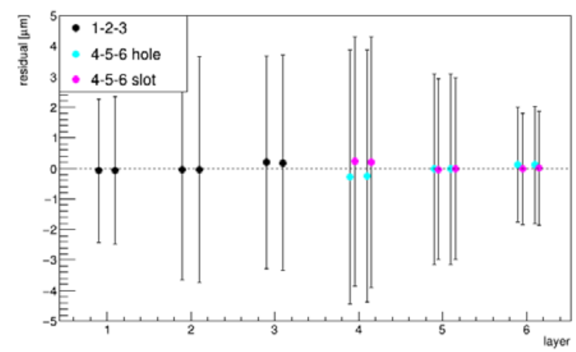
Alignment forced to include the beamspot found at (1.6, -0.9, 0) (uvw reference system: z->x, x->y)



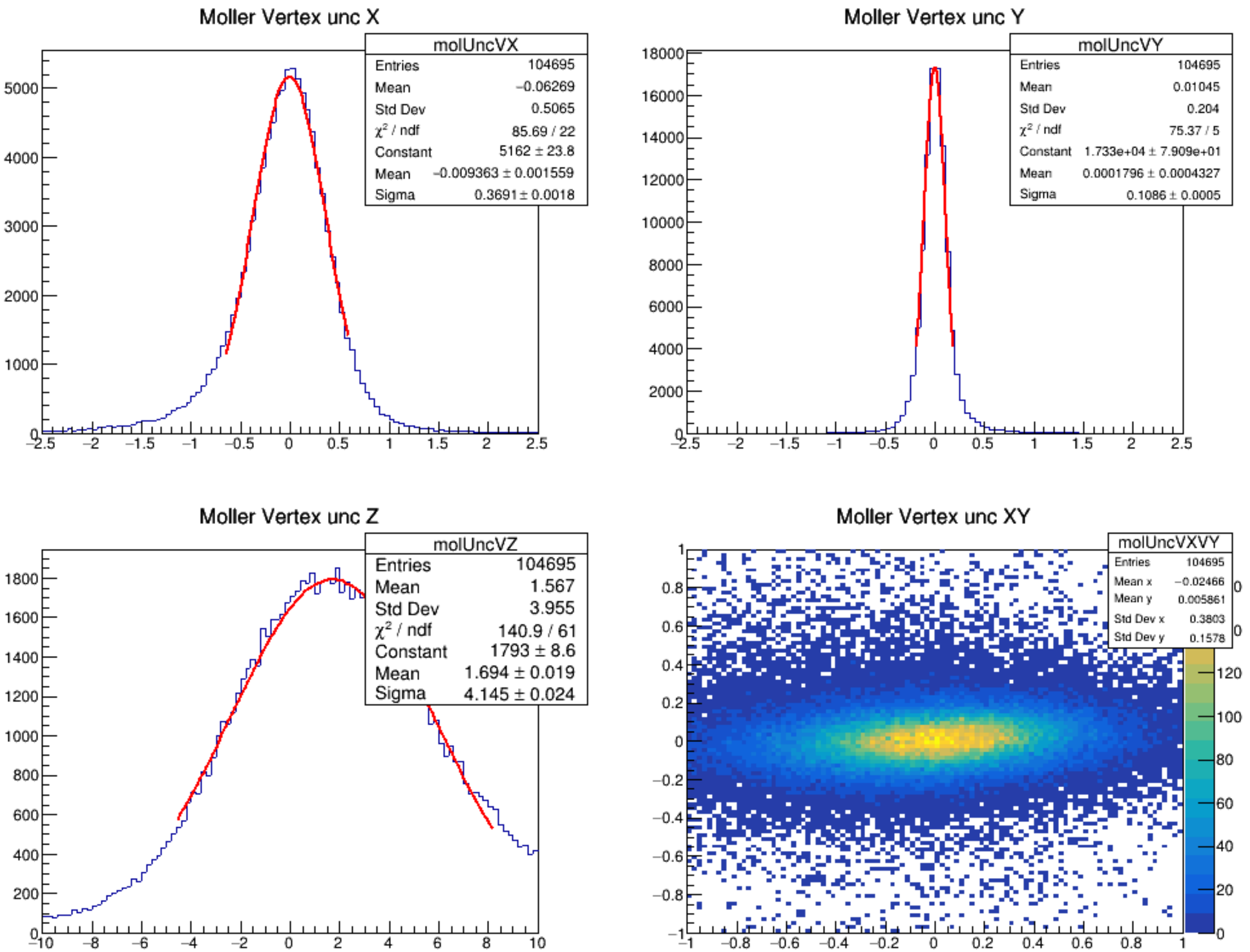
T/B diff
$\Delta d_0 = 2\ \mu m$
$\Delta z_0 = 1\ \mu m$
$\Delta p = -7$ MeV/c

$p_{top} = 2.264$ MeV/c
$p_{bot} = 2.271$ MeV/c





Moller sample (run 7798, v5-21 geometry): vertex coordinates



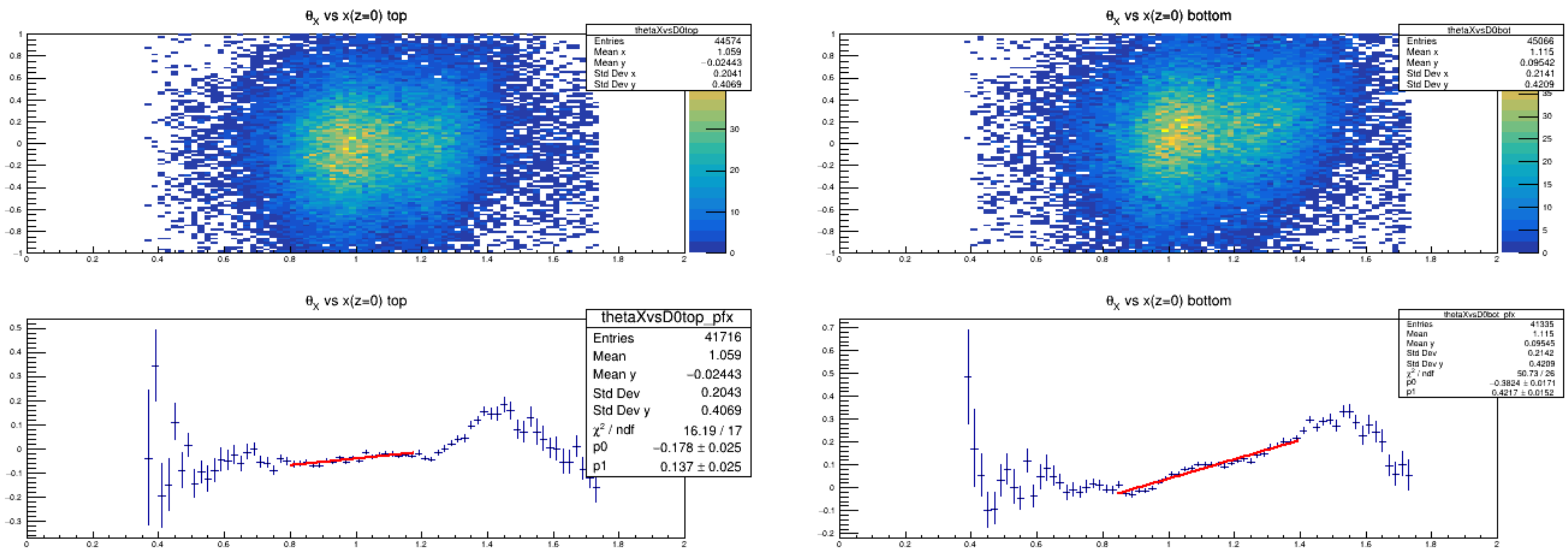
Unconstrained vertex distributions

- X coordinate
  - μ = - 9 μm
  - σ = 3.7 mm
- Y coordinate
  - μ = -0.2 μm
  - σ = 1 mm
- Z coordinate
  - μ =1.69 cm
  - σ = 4.1 cm

Reconstruction with (0,0,0) as beamspot

No change expected when using ntuple contents if beamspot coordinates aren't moved

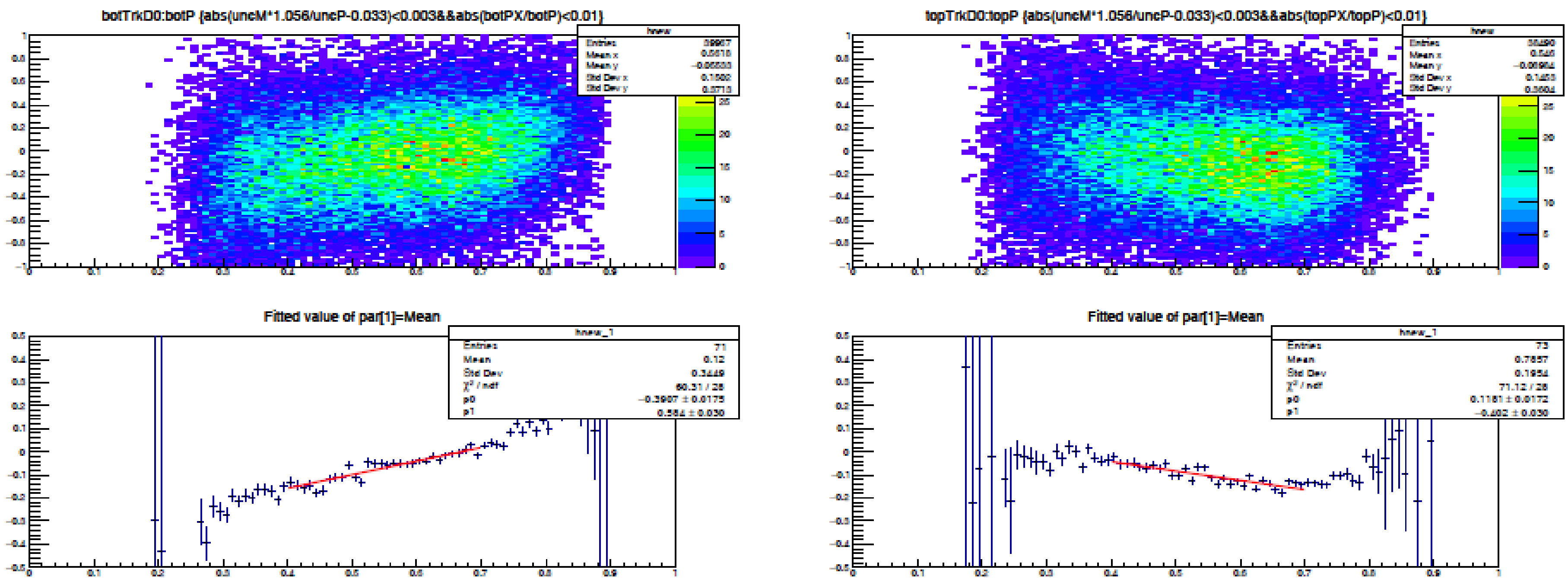
Moller sample: detector 5.21 cosθ_X vs d_0 ($x_{beamspot}$ @z=0)



- The linear fit gives the dependence of the angle of the track with the x axis on the d0 impact parameter (~x coordinate of the beamspot at z=0)
- P0: horizontal offset

	Top	Bottom
P0	-0.78	-0.38
P1	0.14	0.42

To be compared with… 2015 data $\cos\theta_X$ x vs d_0 (Sho)



Note: 2015 data were always reconstructed fixing z_{tar} = -0.5 cm

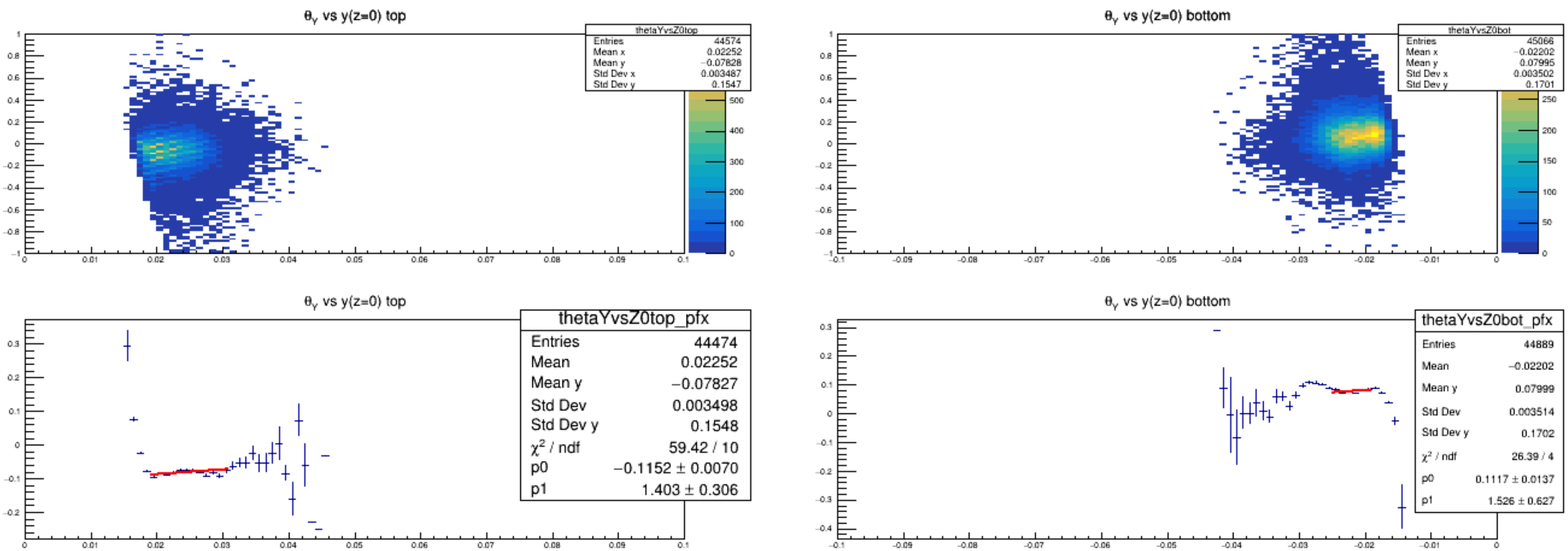
2015 fit results

	Top	Bottom
P0	-0.39	-0.12
P1	0.58	-0.002

2016 fit results

	Top	Bottom
P0	-0.78	-0.38
P1	0.14	0.42

Moller sample:detector v5.21
$\cos\theta_Y$ vs z_0 ($y_{beamspot}$ @z=0)



- The linear fit gives the dependence of the angle of the track with the y axis on the z0 impact parameter (~y coordinate of the beamspot at z=0)
- P0: vertical offset
- P1: z offset (target position*sinθ)

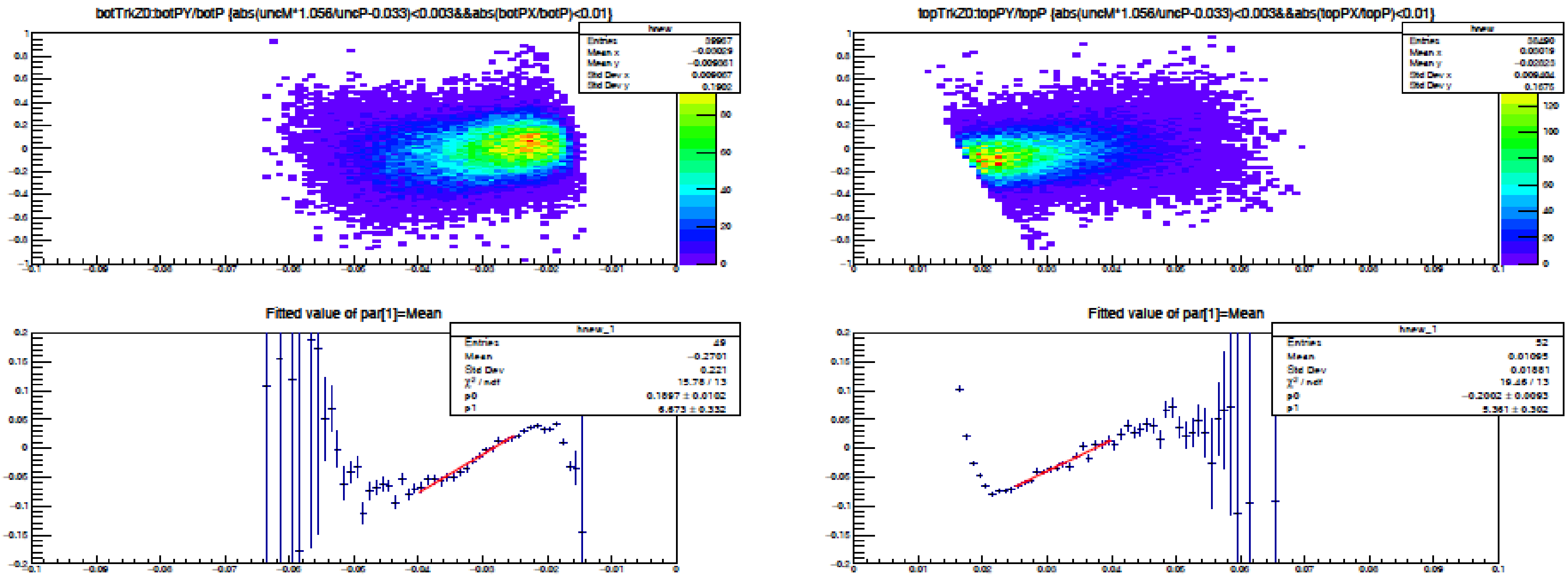
$$\left. y_T \right|_{z=0} = \underbrace{y_{tgt}}_{p_0} - \underbrace{z_{tgt}}_{-p_1} \cdot \tan\lambda$$

	Top	Bottom
P0	-0.11	0.11
P1	1.40	1.52

2015 data $\cos\theta_Y$ x vs z_0 (Sho)

bottom

top



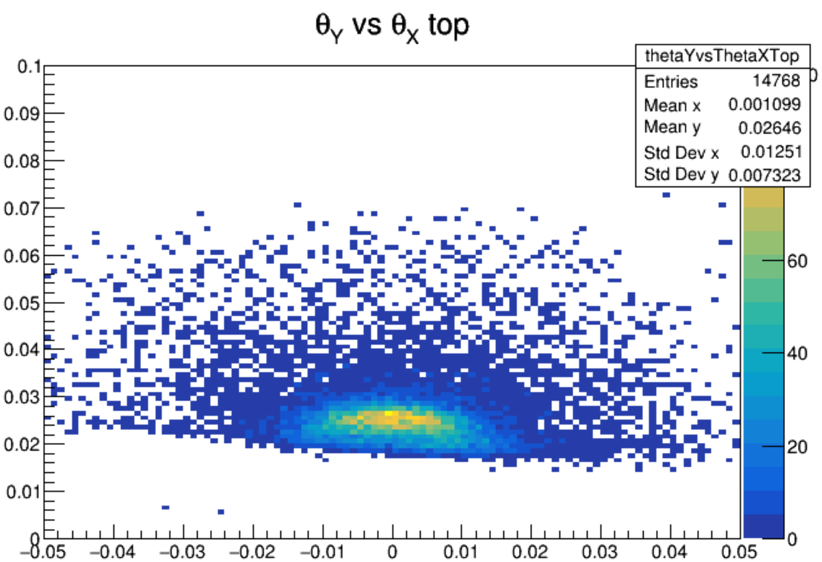
	Top	Bottom
P0	-0.20	0.19
P1	5.36	6.67

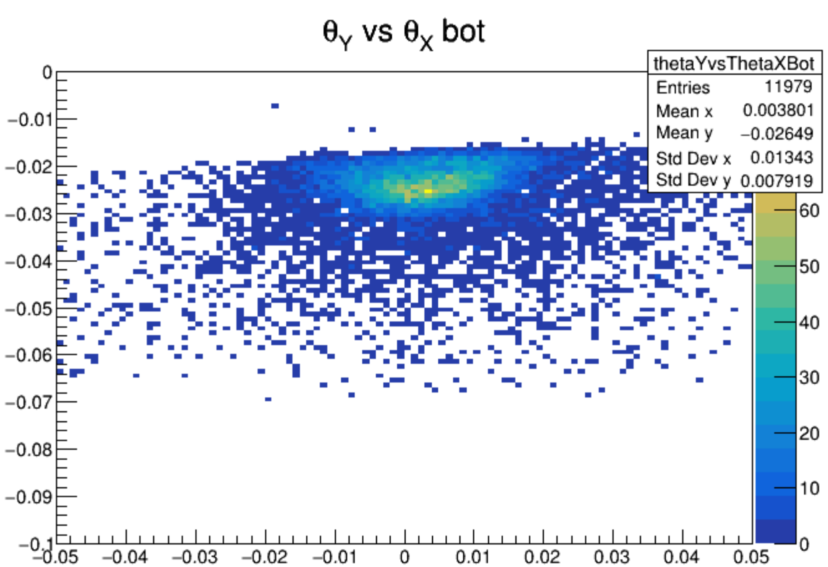
2015 fit results

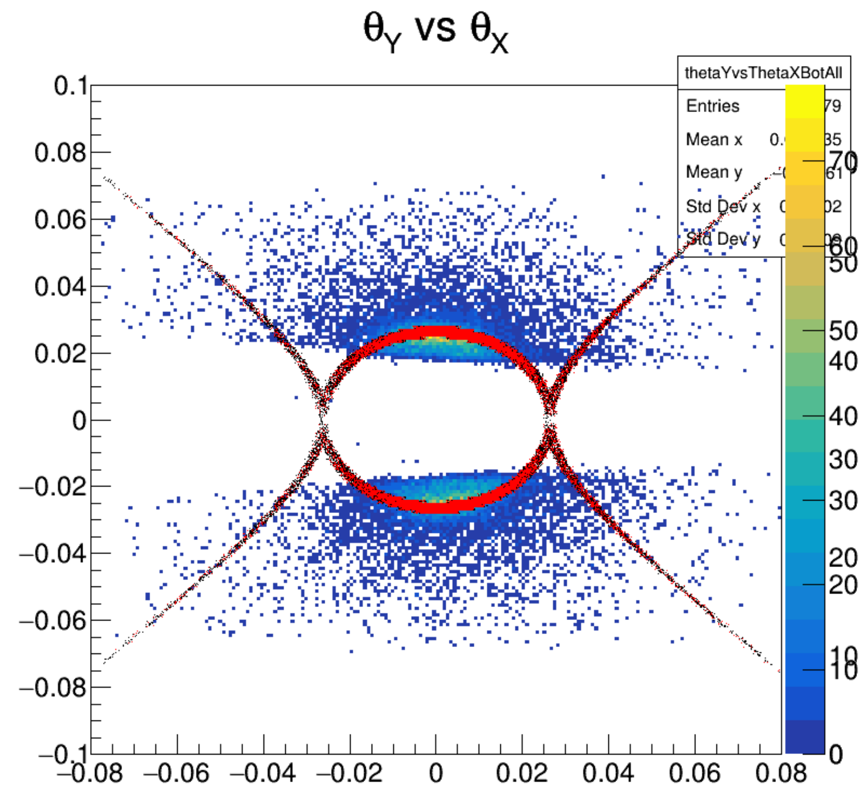
	Top	Bottom
P0	-0.11	0.11
P1	1.40	1.52

2016 fit results

Moller sample: $\cos\theta_Y$ vs $\cos\theta_X$ (at E_e = 900±50 MeV) det 5.21





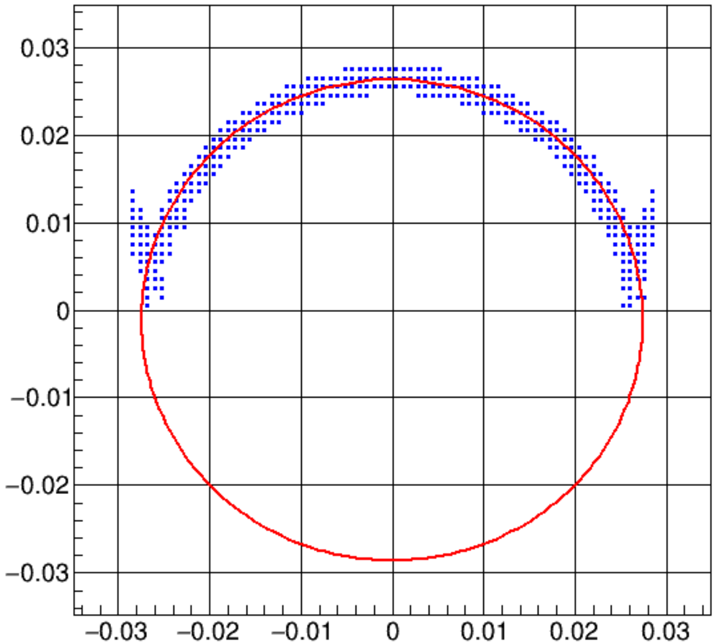


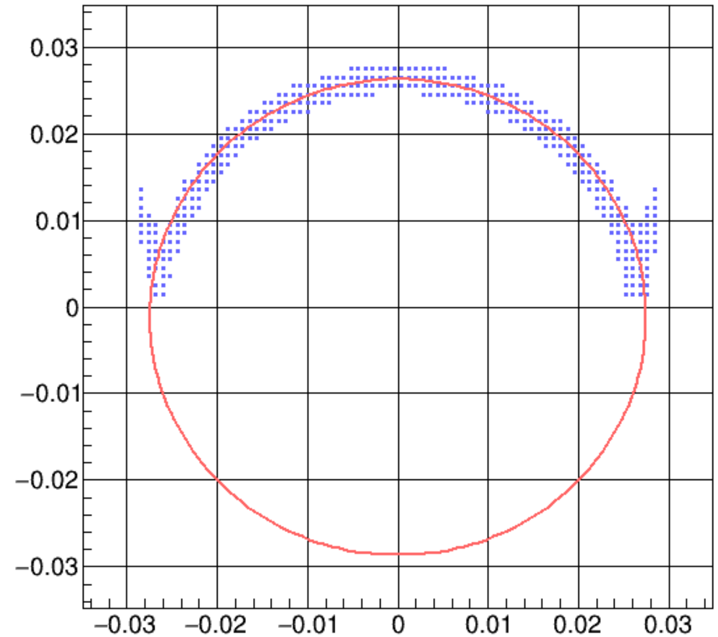
- The points should lie on a circle given by the relationship
  $\cos\theta = 1 - m_e(1/E - 1/E_{beam})$
- The circle should be centered at (0,0) for top and bottom tracks
- “almost”, but not exactly – some sort of tilt exists
- Can this information be exploited?

Detector v5.21, E_e = 900±50 MeV

Moller vertex -> target coordinates (x,y)

Distributions: $\pm\sqrt{}(1- \cos^2\theta_x - (1-m_e(1/E-1/E_{beam})^2)$ vs $\cos\theta_x$





TOP

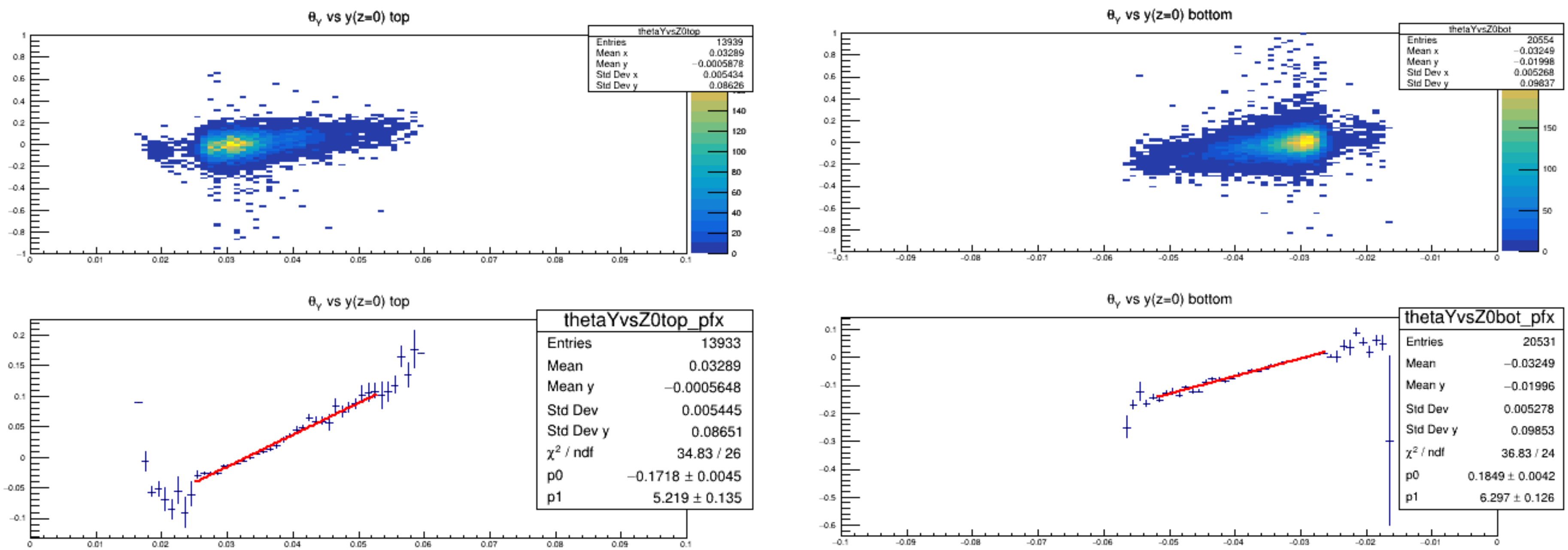
- x_c = -2.6e-5 cm
- y_c = -0.001 cm
- R = 0.027 cm (@ 900 MeV)

BOTTOM

- x_c = 1.05e-6 cm
- y_c = -0.001 cm
- R = 0.027 cm (@ 900 MeV)

From this plots it looks like the global (x,y) alignment works!

FEE sample: kinematic correlations $\cos\theta_Y$ vs z_0 ($y_{beamspot}$ @z=0)

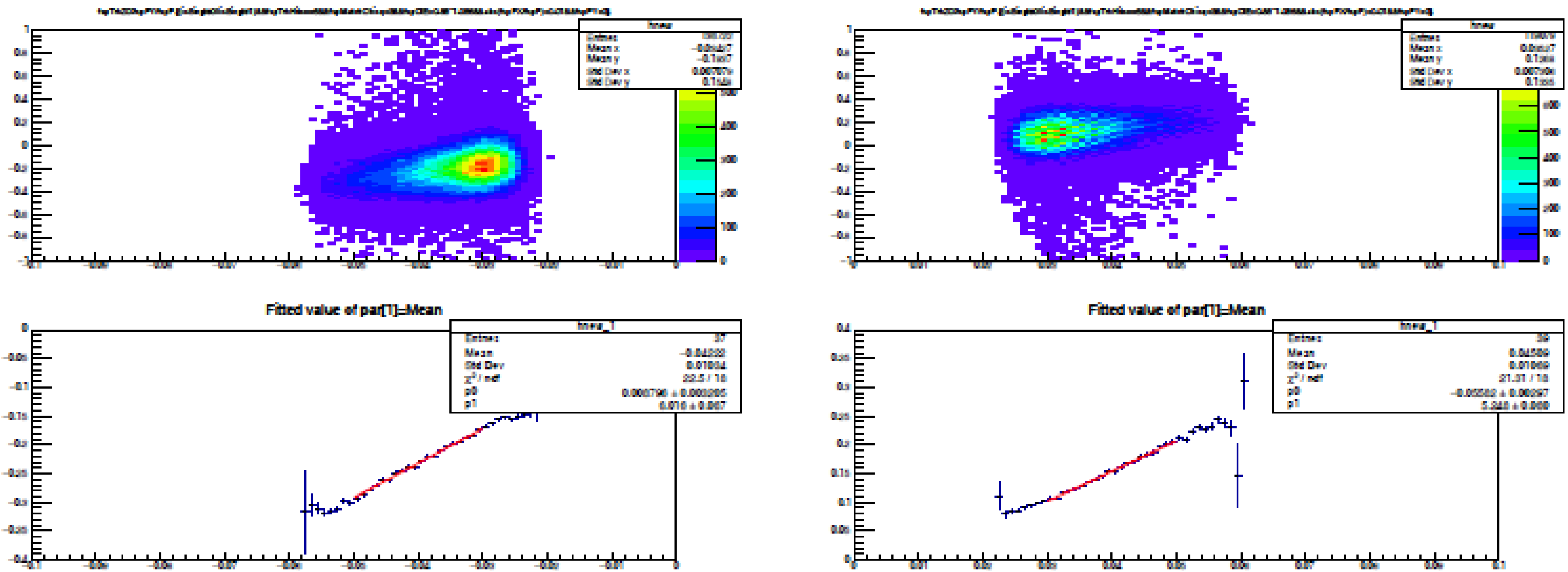


- The linear fit gives the dependence of the angle of the track with the y axis on the z0 impact parameter (~y coordinate of the beamspot at z=0) $y_T\big|_{z=0} = \underbrace{y_{tgt}}_{p_0} - \underbrace{z_{tgt}}_{-p_1} \cdot \tan\lambda$
- P0: vertical offset
- P1: z offset – attention!! This is not $\tan\lambda$ but $\cos\theta$!!
  (but the difference is very small)

	Top	Bottom
P0	-0.17	0.18
P1	5.21	6.30

2015 data $\cos\theta_Y$ vs z_0 FEE (Sho)

bottom top



	Top	Bottom
P0	-0.0056	0.009
P1	5.248	6.02

	Top	Bottom
P0	-0.17	0.18
P1	5.21	6.30

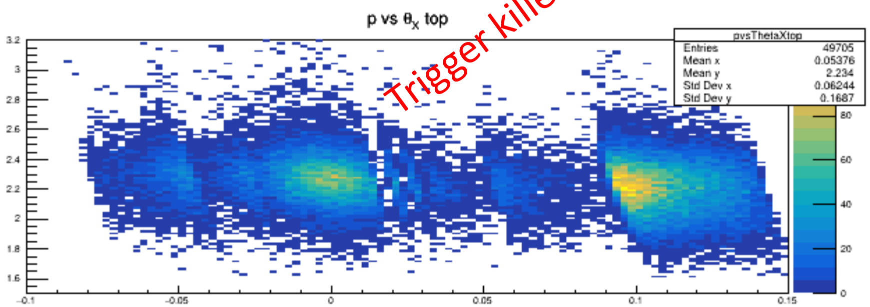
This is $z_{target}/\sin\theta$ (but practically $\sin\theta \sim 1$)

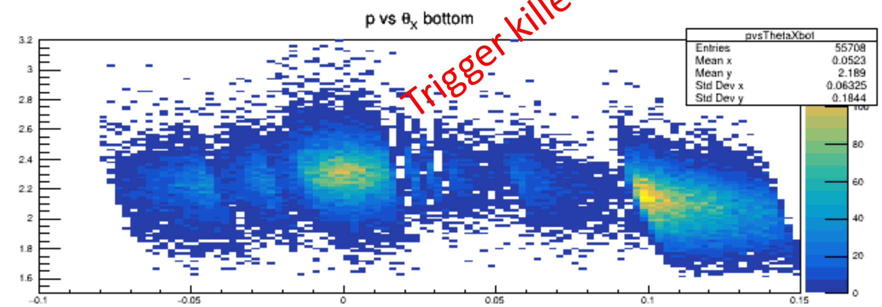
Values in agreement 2015 vs 2016

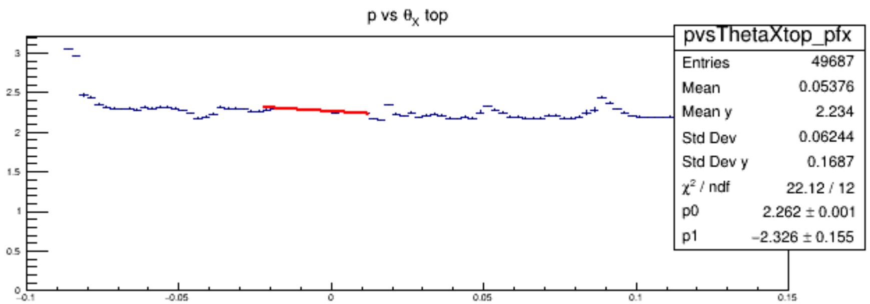
$\mathrm{tg}\lambda = \mathrm{ctg}\theta$

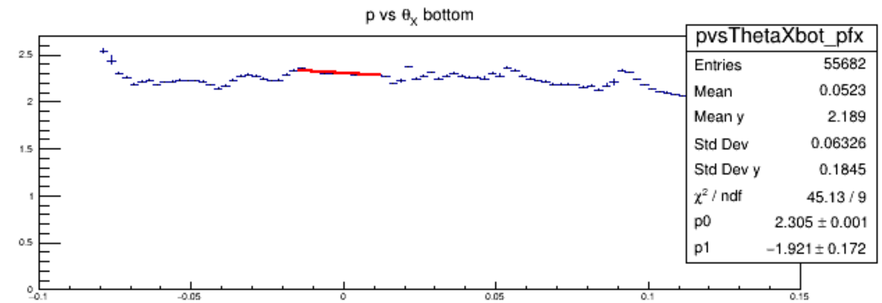
$= \cos\theta / \sqrt{(1-\cos^2\theta)}$

FEE sample: kinematic correlations p vs cosθ_x – electron side only







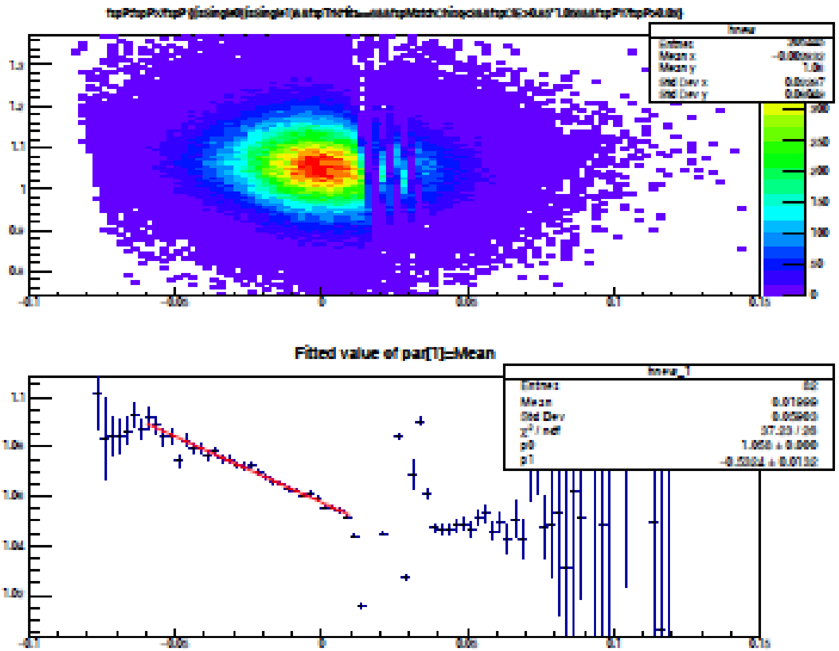


- Same trends, similar coefficients from the fits
- Largest momentum on electron side (left? Check)
- Coherent dependence of momentum on the opening angle wrt to x axis: global tilt of the full detector (or at least slot side only?)

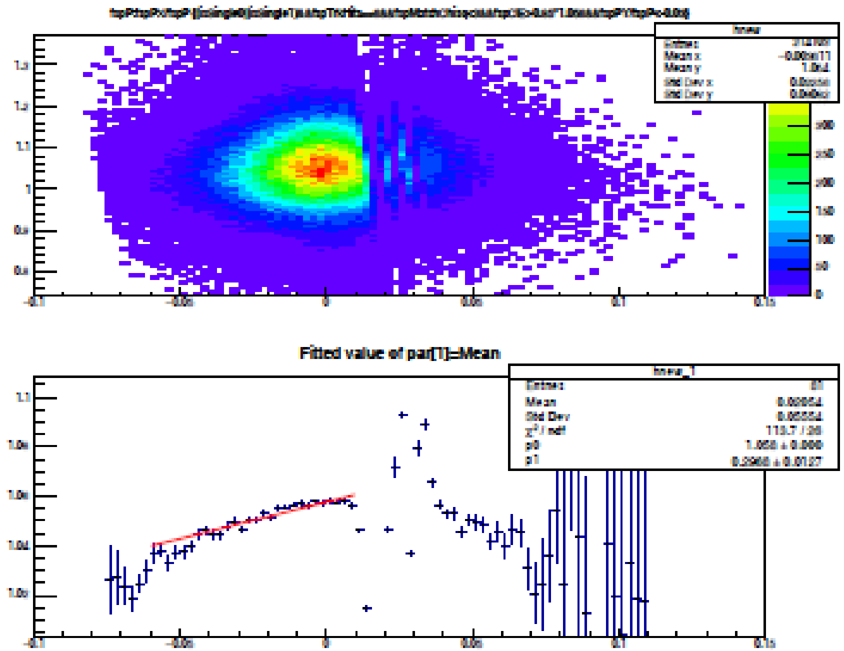
	Top	Bottom
P0	2.26	2.31
P1	-2.33	-1.92

2015 data p vs cosθ_X FEE (Sho)

top



bottom



	Top	Bottom
P0	1.058	1.058
P1	-0.53	0.30

2015 fit results

	Top	Bottom
P0	2.26	2.31
P1	-2.33	-1.92

2016 fit results

Additional notes and next steps

- Check signs of z offsets (some doubts for slot side)
  - At the moment a global translation along z does not provide the expected results
- Extract from these distributions information on angular offsets (vertical and horizontal)
  - Some of them were hardcoded in the makeNtuple driver for 2015 data (dangerous… another source of mess), need to understand what they are and how they are extracted from the profile distributions. Hard to understand, not documented at all.
  - Corrections provided to the coordinate along the measurement and along the strip as a function of z, linear and quadratic, and λ (slope? 90-θ_Y?), (which verse?), ω (θ_X?) angles
  - These only affect global offsets – internal alignment works pretty well