Internal alignment with new version (v2)

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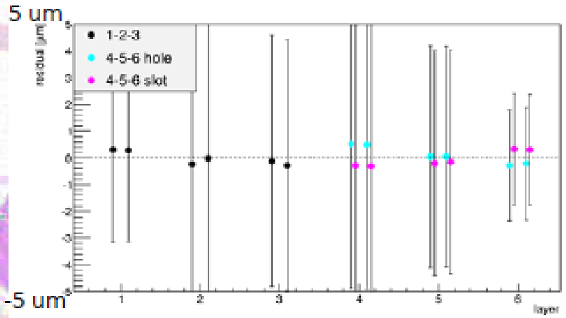
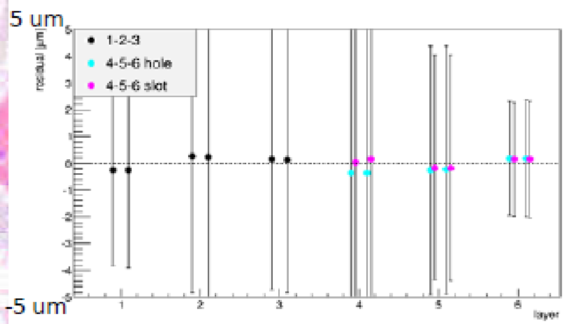
2016 data @ 0.5 mm: where we stand

- The current version v5.3 used for pass1 is decently good as far as internal residuals, global alignment offsets and beam resolutions are concerned
- Further work improved the “microscopic” alignment (up to v5.65) without major benefits to resolutions

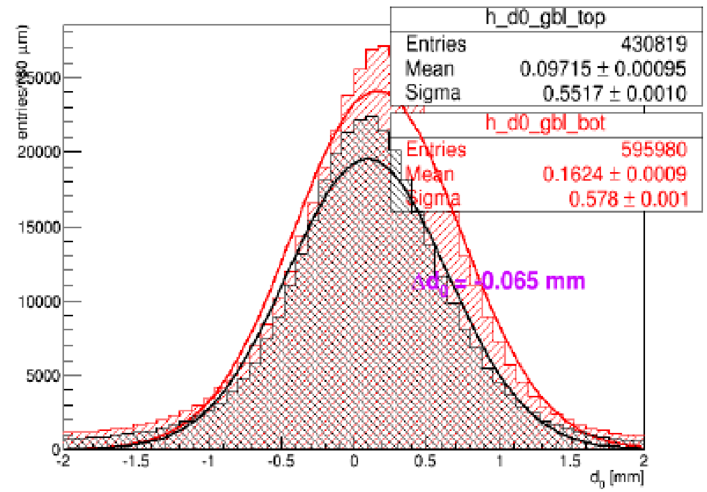
- Problem: vertex localization
  - Reconstruction says: the target is not at (0,0,0)
  - The beam coordinates are external parameters in the reconstruction (inserted by hand in the compact.xml file), do not affect alignment but track reconstruction (i.e. particle momentum)
  - x, y beam centering to (0,0) can be done relatively easy based on the alignment equalizing d_0, z_0 impact parameters
  - This procedure moves the z further away
  - Depending on the used sample (FEE, Mollers, all tracks) the z coordinate of the vertex is different

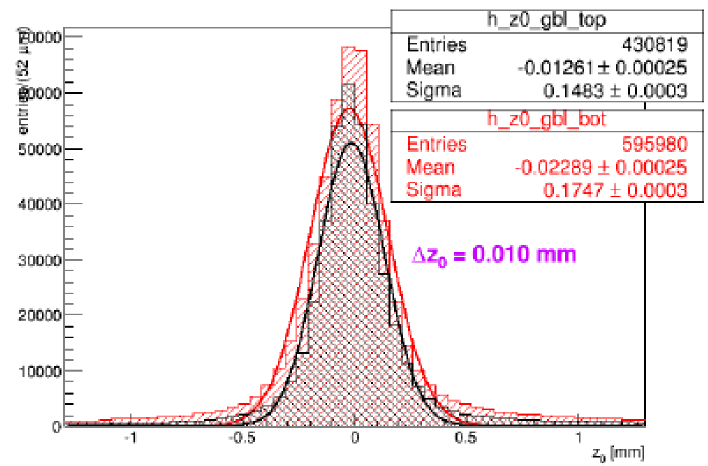
2016: pass1 alignment (v5-3)– how bad is it?

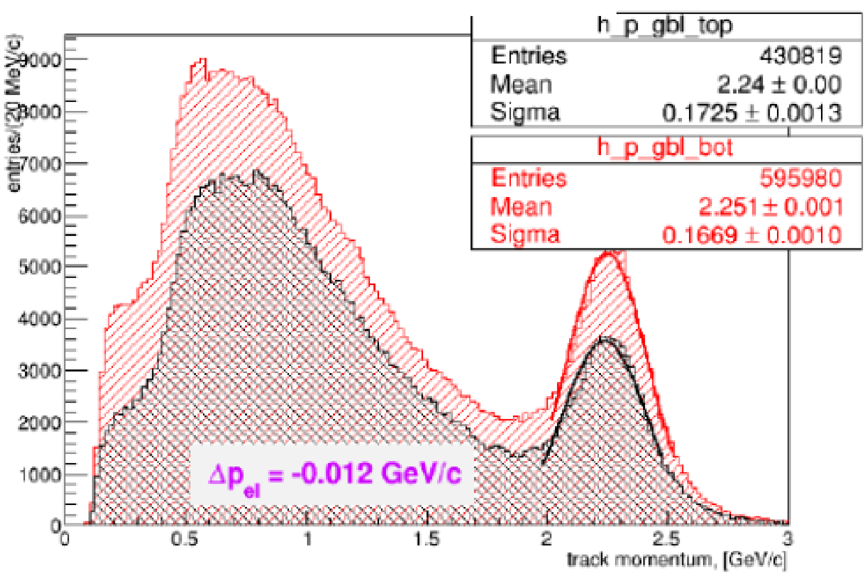




- Satisfactory internal alignment for curved tracks
- Tuning of impact parameters can be improved, but not dramatic

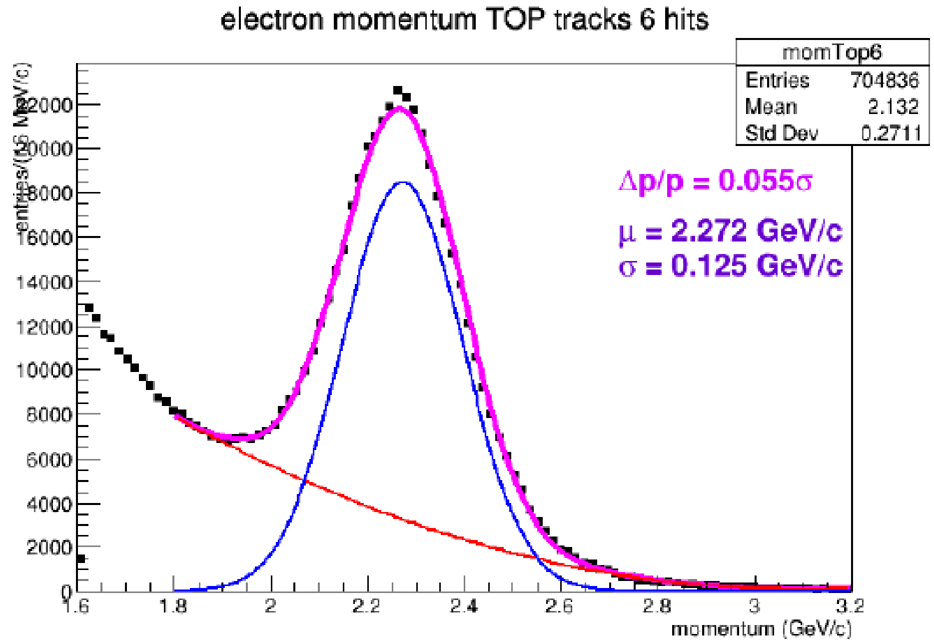


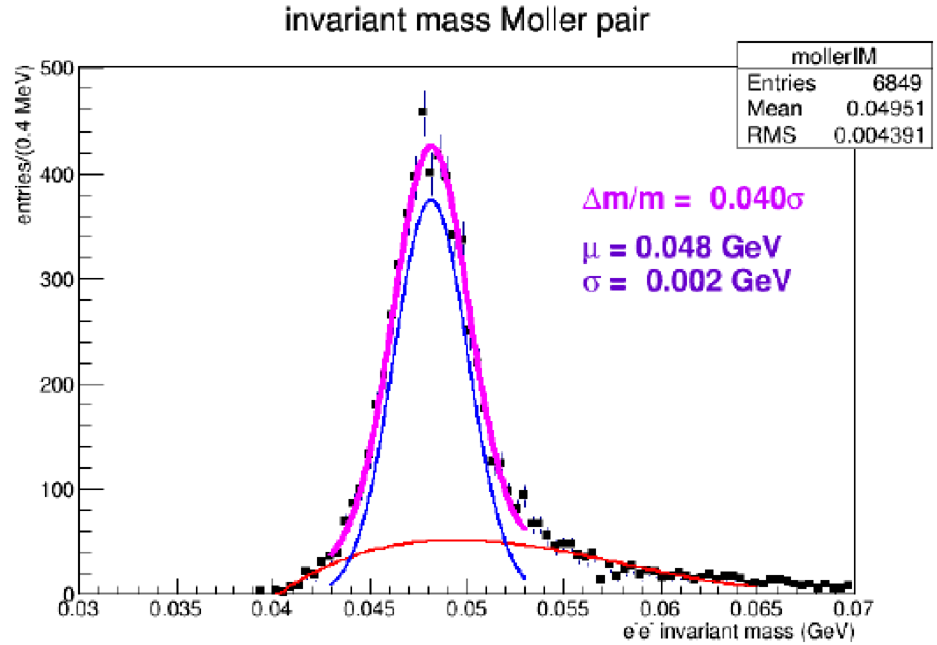




- Raw momentum spectrum (no quality cut): top/bottom alignment within 12 MeV/c at the elastic peak
- Systematic on the momenta of more than 70 MeV/c (wrt to nominal beam value)

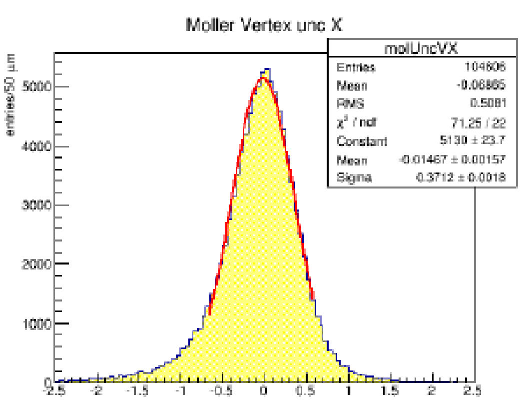
Resolutions with 2016-pass1 detector

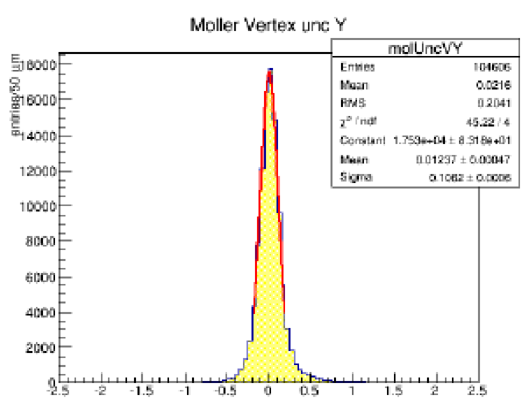


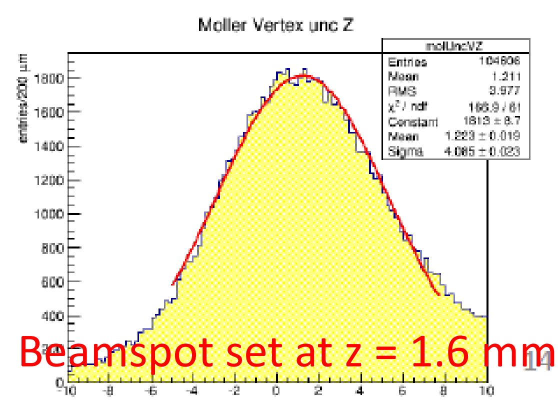


- good resolutions on momenta (5.5-5.8%σ) and invariant mass (4%σ)
- but… where is the target located?

Vertex coordinates for Møller events: **z misplacement of ~1.2 mm**







2016 global alignment development - where is the target?

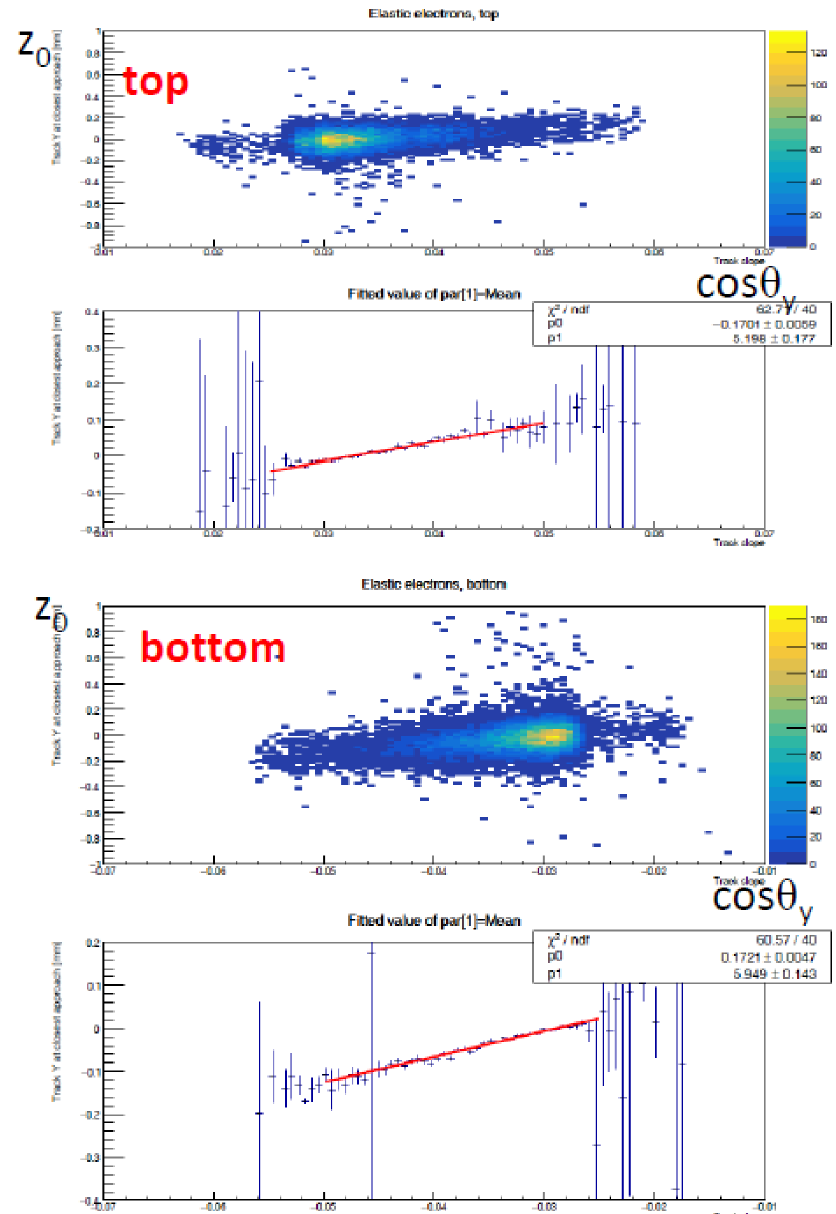
- Same technique as done for 2015 on FEE selected sample: the z coordinate of the vertex is always around -5,-6 mm

- Is this information contradictory with the z vertex estimation from Møller pairs?

	Top	Bottom
P0	-0.17	0.17
P1	5.20	5.95

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

(for small angles: $\tan\lambda = \sin(90-\theta_y)$)



2016 data @ 0.5 mm alignment: new version

- New detector (v2) provided by Norman
  - No internal+external alignment
  - Starting from 2015 survey

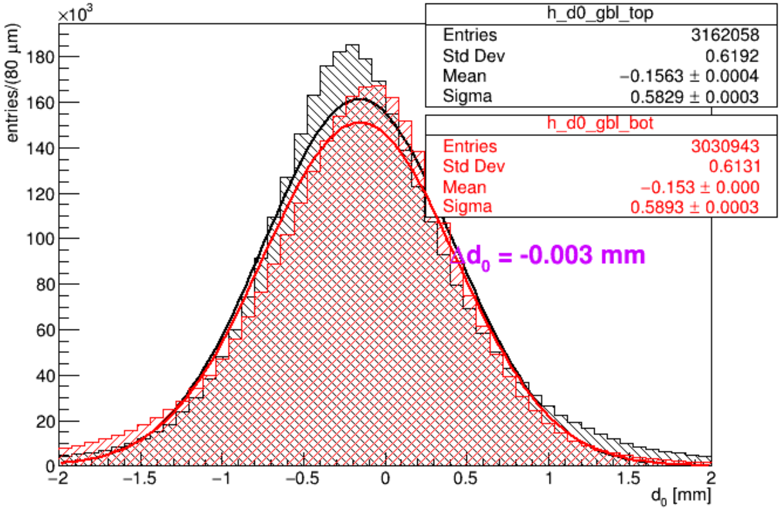
  - Modified parameters:
    - Global opening angles:
      - TOP
        - Rotation around u: 0 -> 0.0002
        - Rotation around v: 0
        - Rotaton around z: 0 -> -0.001
      - BOTTOM
        - Rotation around u: 0 -> -0.00026
        - Rotation around v: 0
        - Rotaton around z: 0

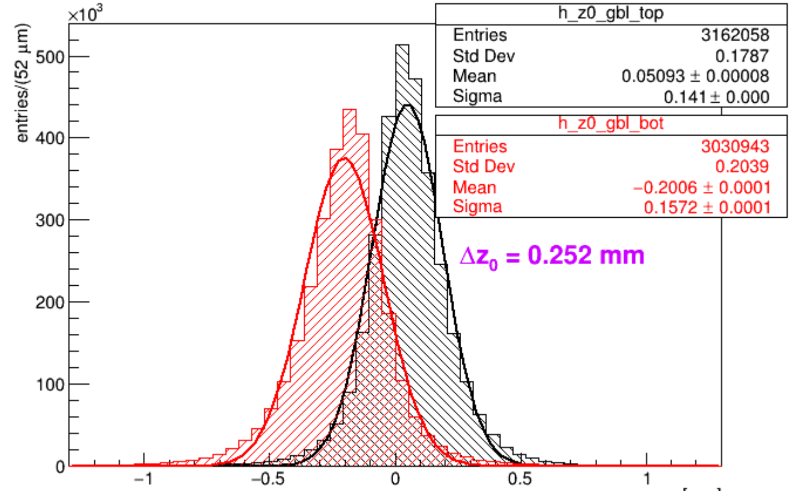
    - The bottom array is translated along x (u?) of +1mm

  - Target position in the reconstruction: (0,0,0)
  - Old fieldmap

- With this detector TOP and BOT track momenta are equalized, the z of the target is located at -5 mm (from Moller events) – see Norman's slides

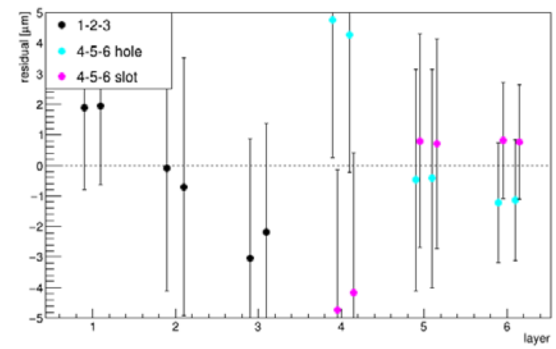
2016 v2 w fieldmap, 0.5mm
curved tracks only, NO alignment - START

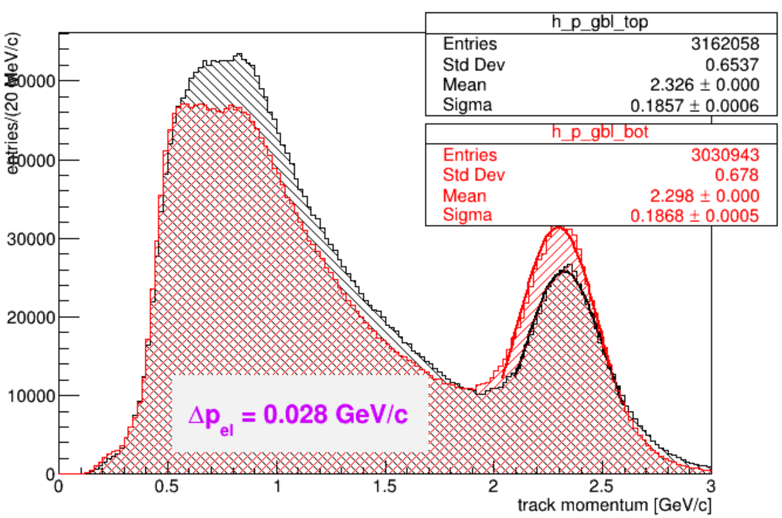




Good alignment top/bottom d_0 BUT they are not zero: ~150 μm

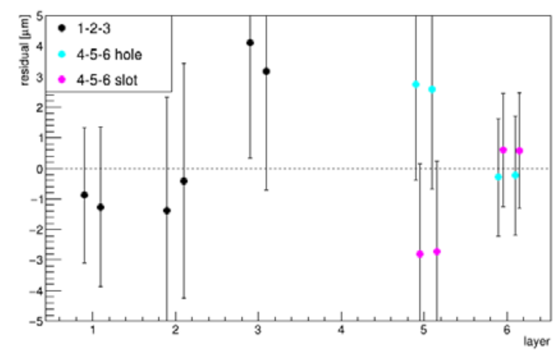
T/B diff
Δd_0 = 3 μm
Δz_0 = 252 μm
Δp = 28 MeV/c





p_{top} = 2.326 MeV/c
p_{bot} = 2.298 MeV/c

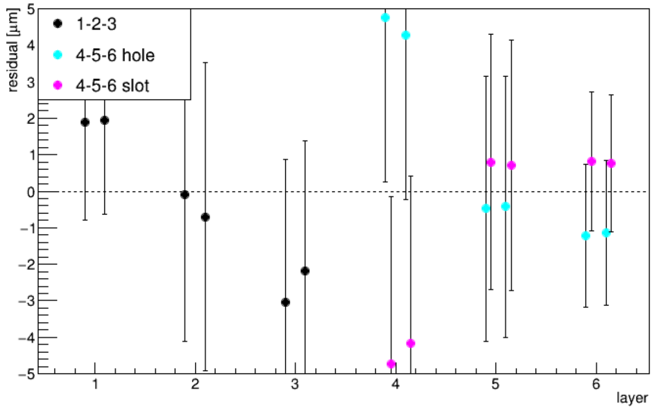
The elastic peak momentum is **not** underestimated!

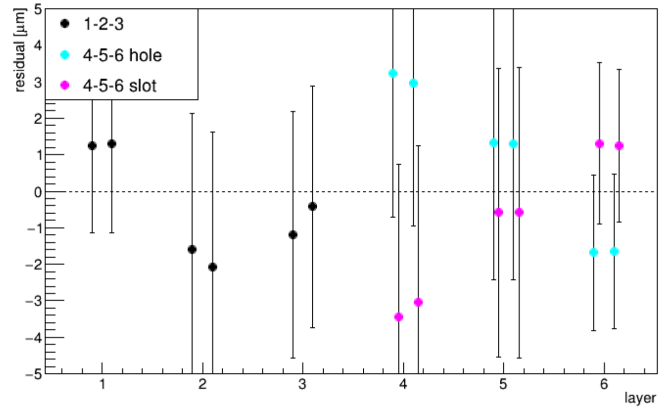


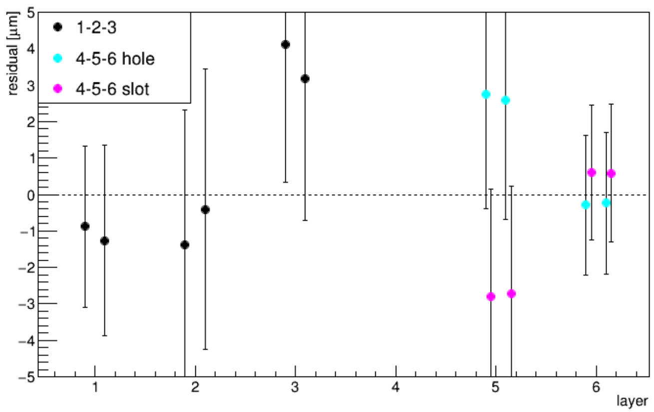
V2 detector internal residuals

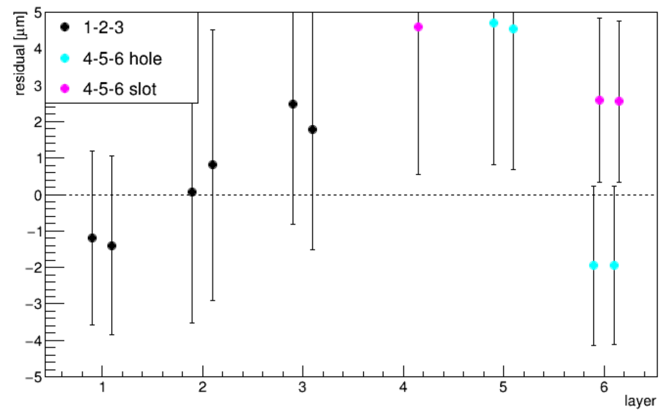
Curved tracks

Straight tracks







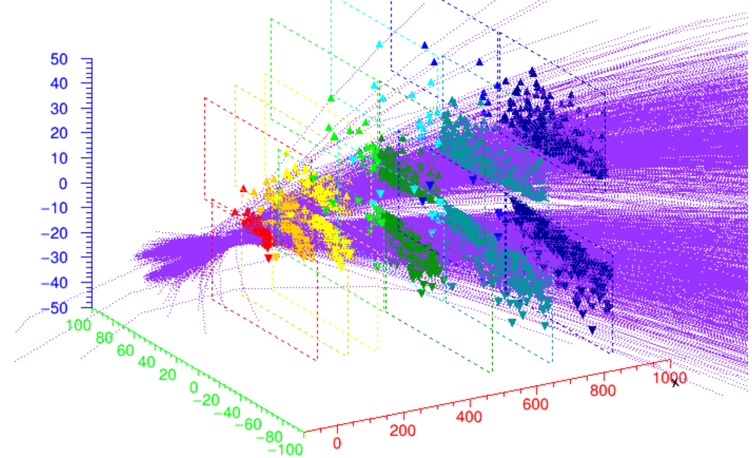


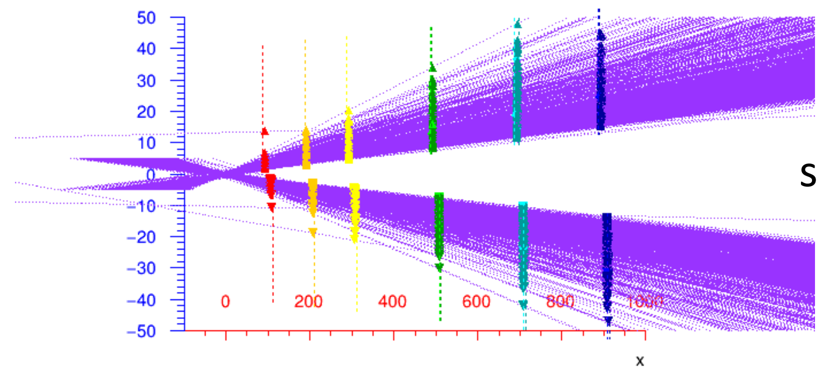
The internal alignment from the surveyed coordinates + added fixes is very bad

Target location?

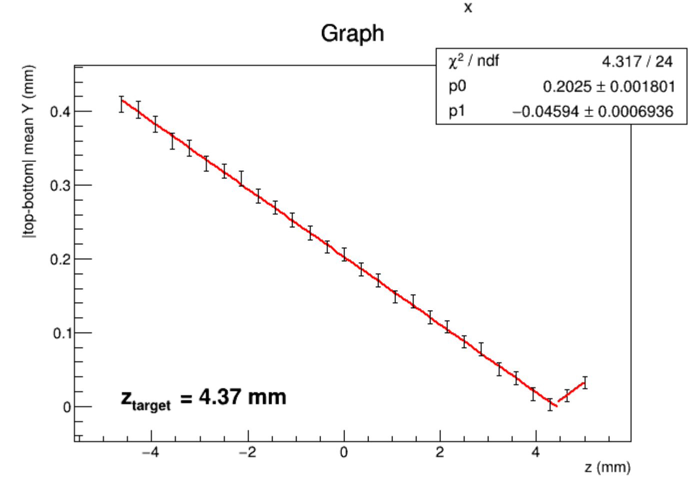
- Studies of Moller/FEE sample find the target z at about -5 mm (from hps-java)
- Location confirmed by ntuples
- Location confirmed by beam-slicing method for all tracks and Mollers
  - Visually, the track bunches are rather dirty (in spite of hard cut on χ^2) and the two sets of electron tracks have a rather large emittance, which implies a wide spot at the target position – the minimum is ~16 mm in y)
  - The target is located at the z coordinate where there is maximum overlap between the beam spots
  - Minimum found at 4.37 mm
  - Systematic uncertainty of the method (estimated by MC electron gun at 2.3 GeV/c): <0.8 mm

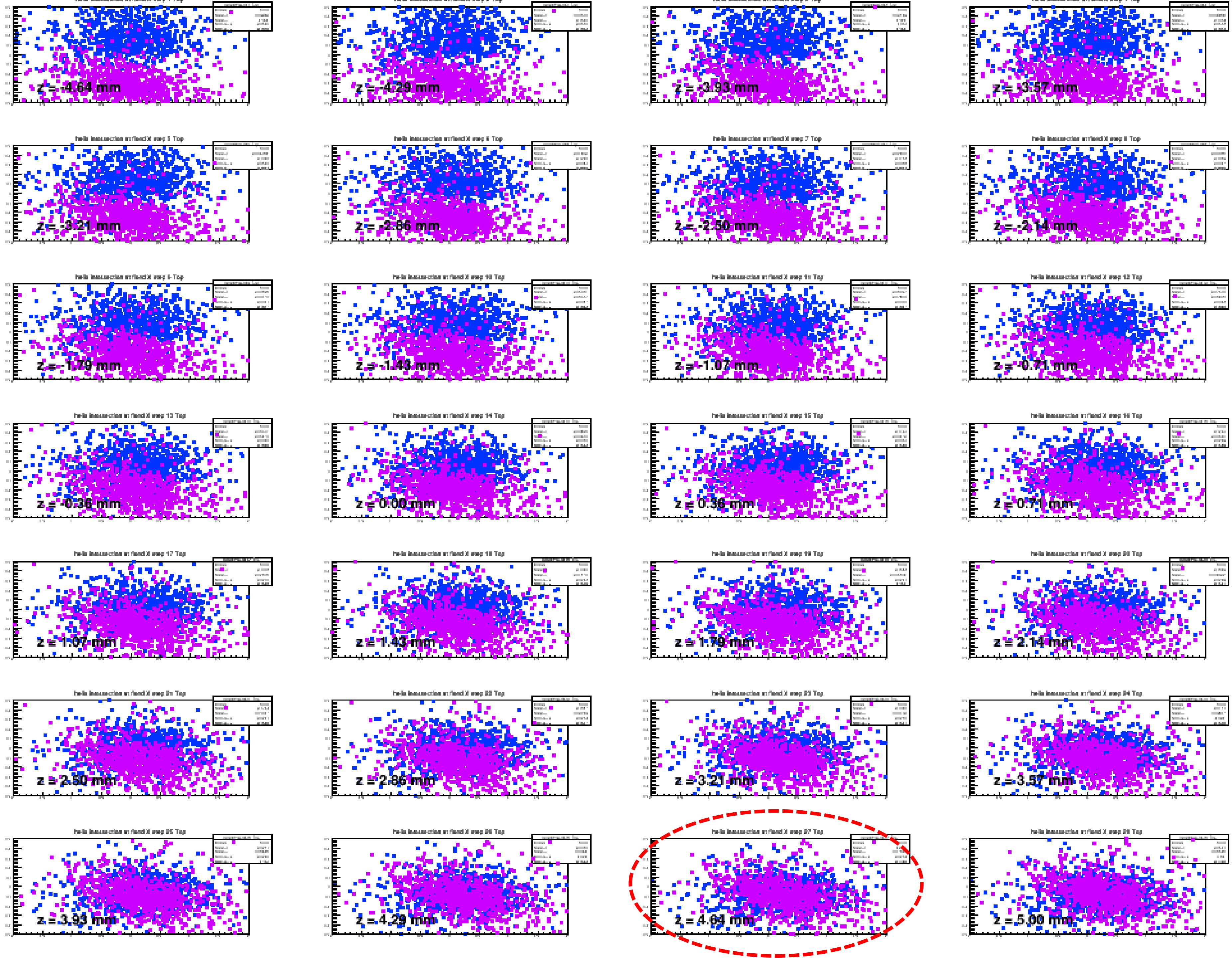
Moller events v2





side




z = -4.64 mm
z = -4.29 mm
z = -3.93 mm
z = -3.57 mm
z = -3.21 mm
z = -2.86 mm
z = -2.50 mm
z = -2.14 mm
z = -1.79 mm
z = -1.43 mm
z = -1.07 mm
z = -0.71 mm
z = -0.36 mm
z = 0.00 mm
z = 0.36 mm
z = 0.71 mm
z = 1.07 mm
z = 1.43 mm
z = 1.79 mm
z = 2.14 mm
z = 2.50 mm
z = 2.86 mm
z = 3.21 mm
z = 3.57 mm
z = 3.93 mm
z = 4.29 mm
z = 4.64 mm
z = 5.00 mm

Internal alignment (usual) procedure

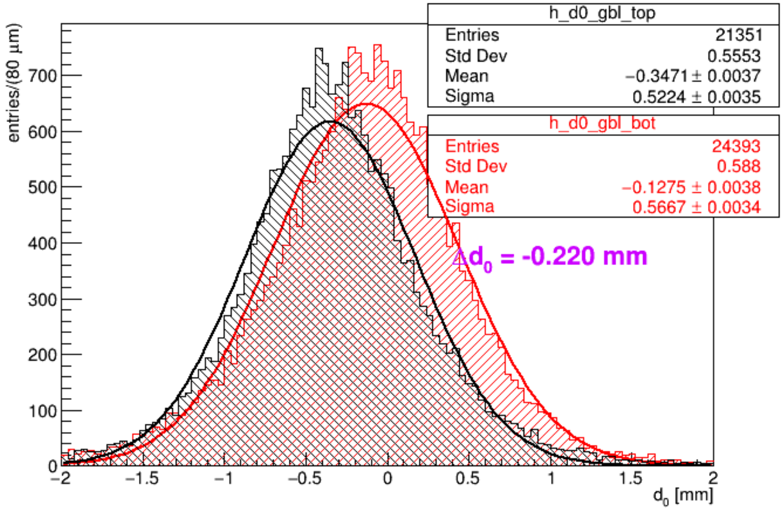
- Reconstruction with (0,0,0) target position
- No global alignment (impact parameter equalization)
- Usual iterative procedure based on residual analysis
- Minimization on curved + straight tracks

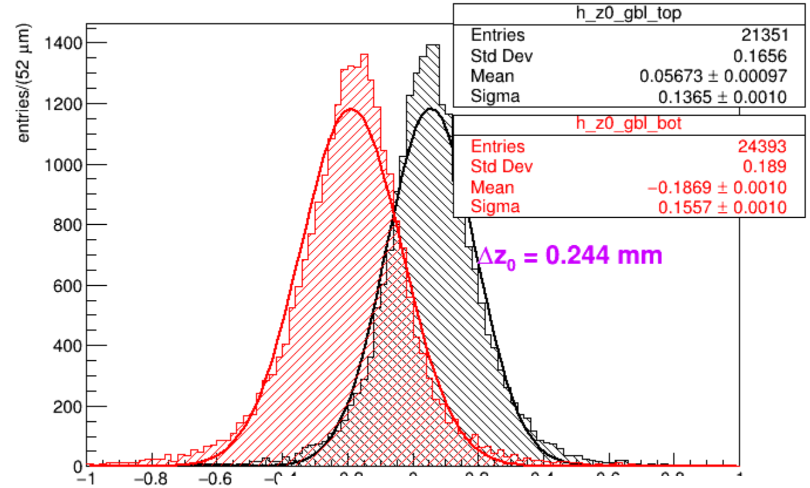
- Two/three sensors at a time at most
  - U translations, W translations, …, repeat, …
  - Float central sensors 3-4, float 2-5, float 3-4-5, float 2-3-4,…, repeat, …
  - Pass to rotations once a steady tuning with translations is achieved
- Check elastic peak momentum consistency, Moller total momentum, Moller e^-e^- invariant mass, …
- Check/find vertex location

- Work in progress, see some intermediate steps (on small statistics, reco run on 100K events, with old fieldmap)
- Starting from a very misaligned detector
- A look at the first 7 steps…

#1

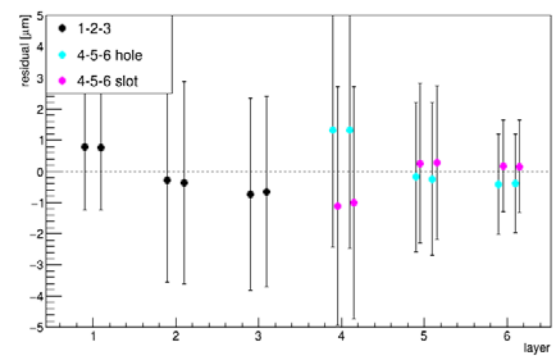
2016 v2-1 w fieldmap, 0.5mm all curved tracks (reduced sample) – 3-4-5 tu

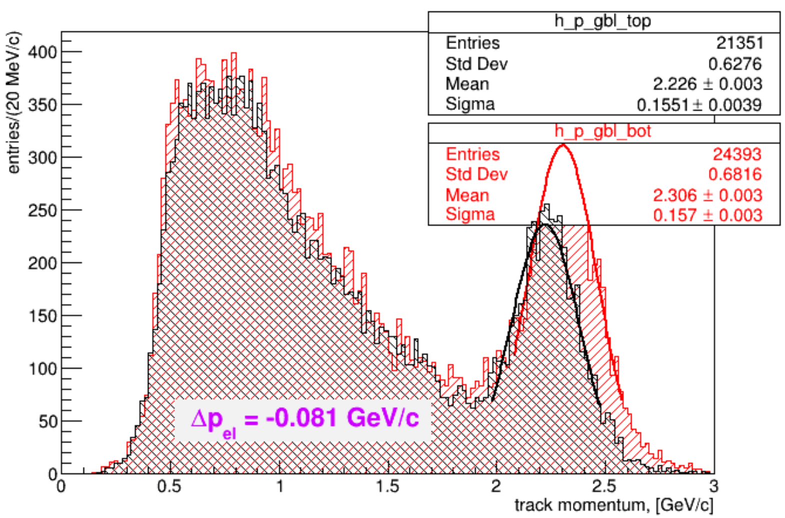




d_0 t/b are no more aligned (top moves away, about twice the distance)

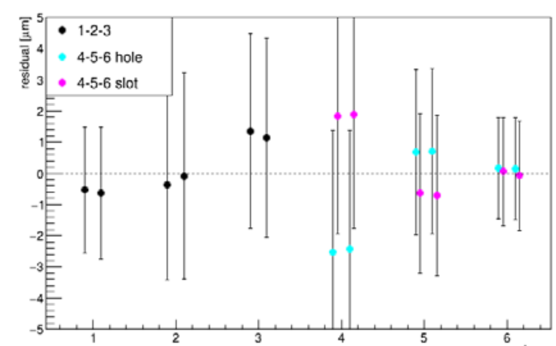
T/B diff
Δd_0 = 220 μm
Δz_0 = 244 μm
Δp = 81 MeV/c





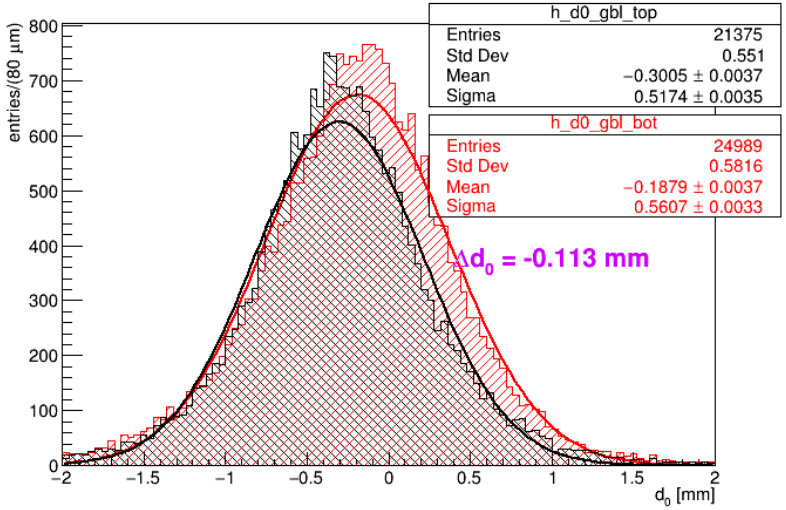
p_{top} = 2.226 MeV/c
p_{bot} = 2.306 MeV/c

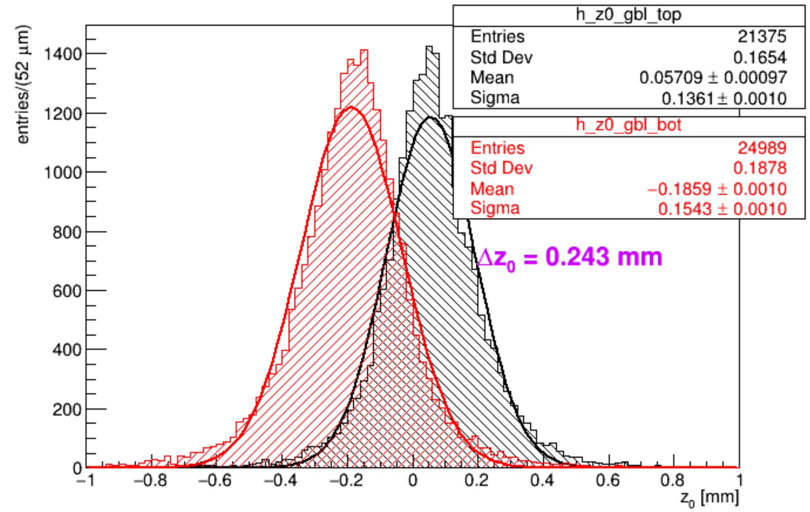
The elastic peak momentum is not underestimated!



#2

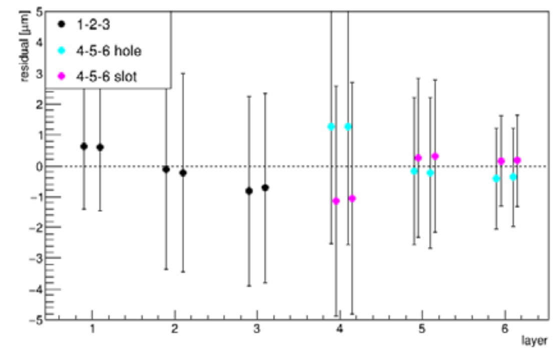
2016 v2-2 w fieldmap, 0.5mm
all curved tracks (reduced sample) – 2-3-4-5 tu

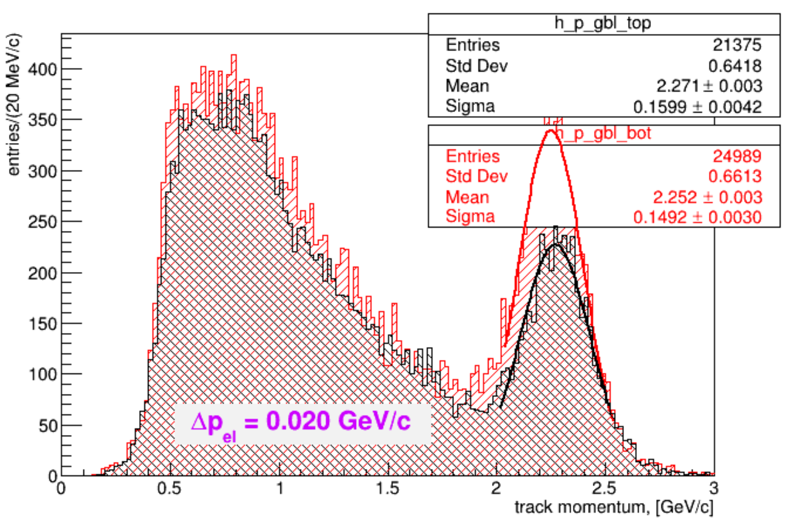




d_0 t/b are no more aligned (top moves away)

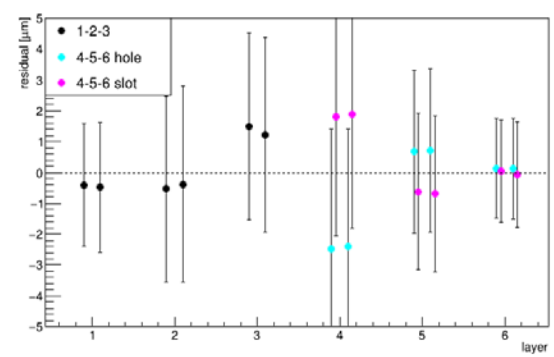
T/B diff
Δd_0 = -113 μm
Δz_0 = 243 μm
Δp = 20 MeV/c





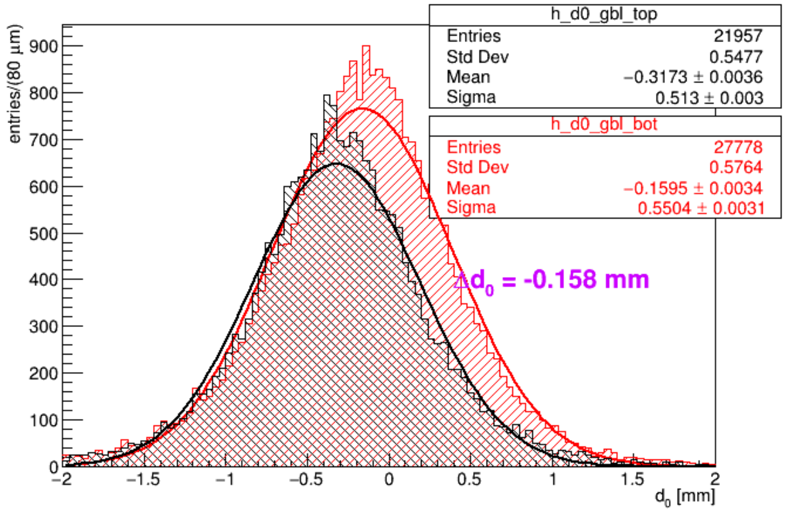
p_{top} = 2.271 MeV/c
p_{bot} = 2.252 MeV/c

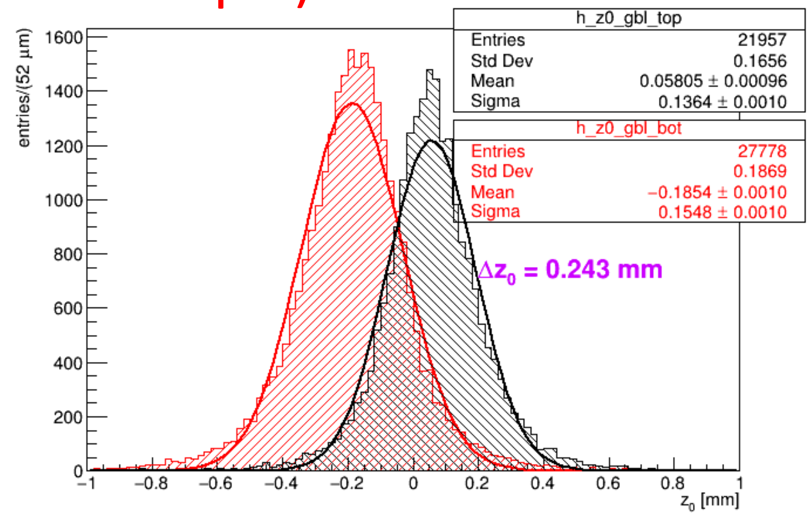
Elastic peak momentum underestimated again



#3

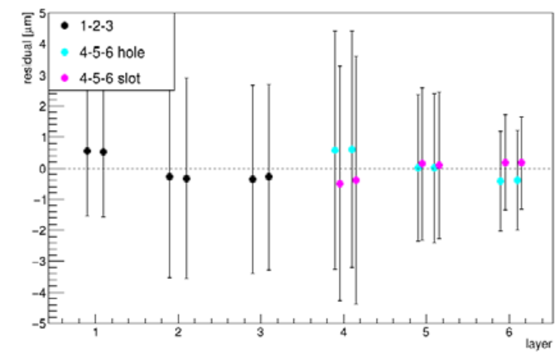
2016 v2-3 w fieldmap, 0.5mm
all curved tracks (reduced sample) – 3-4 tu

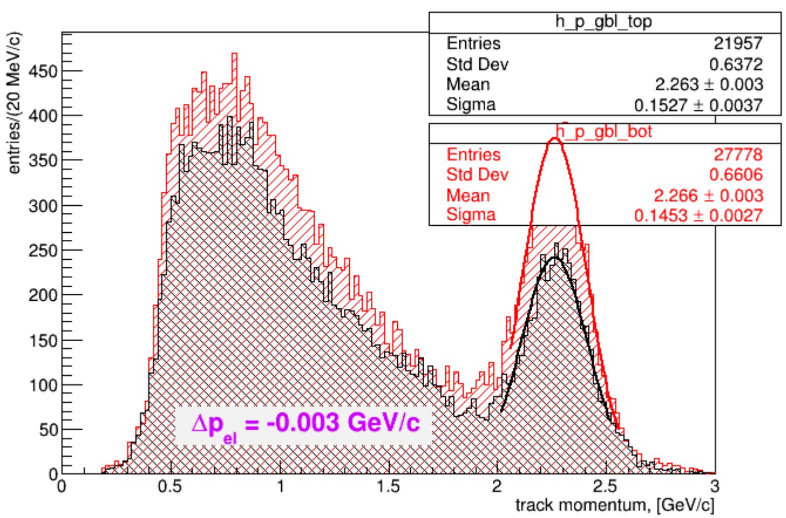




d_0 t/b are no more aligned (top moves away)

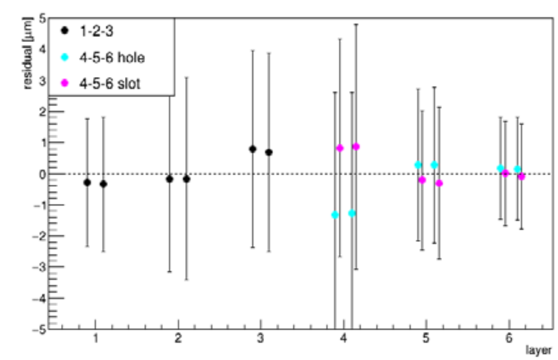
T/B diff
Δd_0 = -158 μm
Δz_0 = 243 μm
Δp = 3 MeV/c





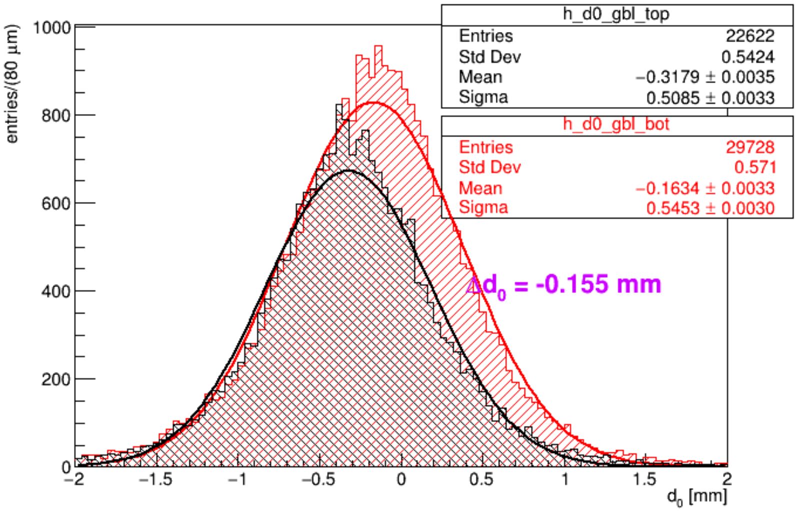
p_{top} = 2.263 MeV/c
p_{bot} = 2.266 MeV/c

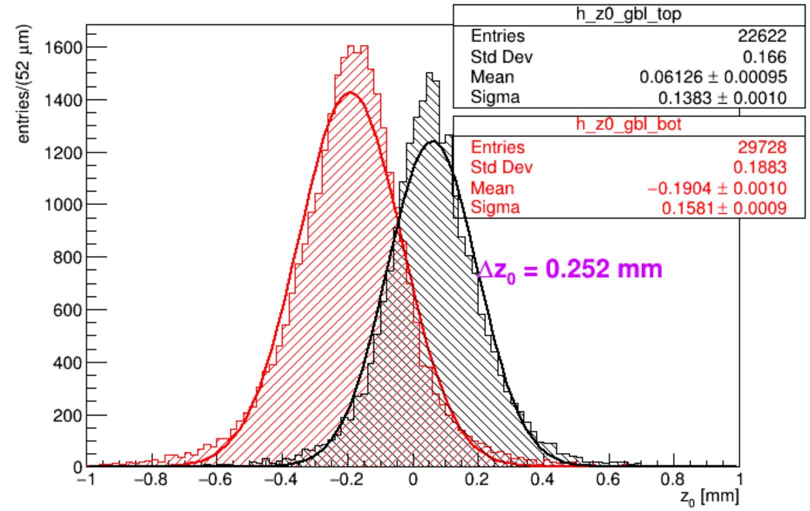
Elastic peak momentum underestimated



2016 v2-4 w fieldmap, 0.5mm
all curved tracks (redced sample) – 3-4 tu+tw

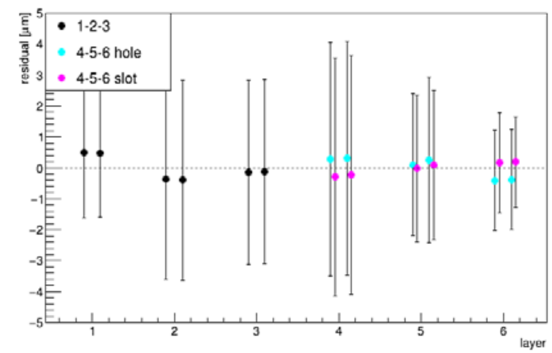
#4

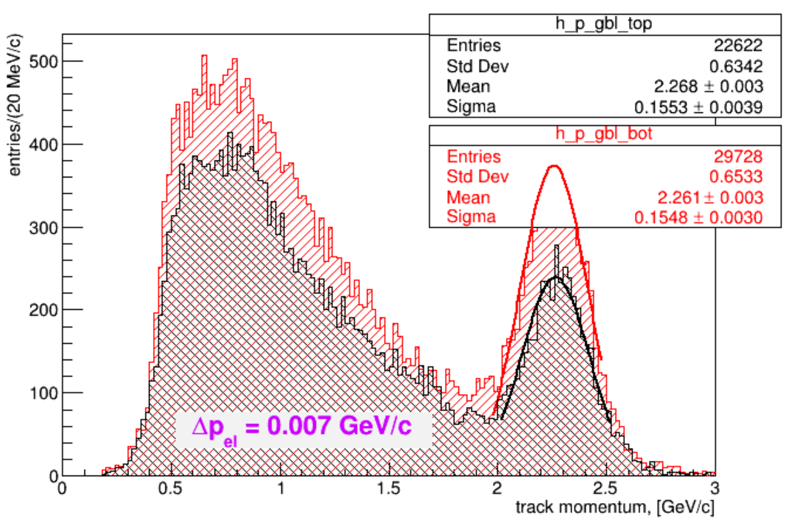




d_0 t/b are no more aligned (top moves away)

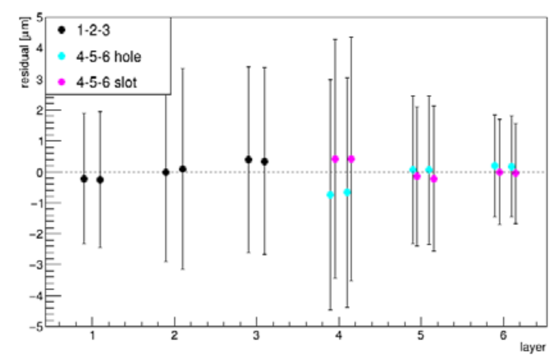
T/B diff
Δd_0 = -155 μm
Δz_0 = 243 μm
Δp = 7 MeV/c





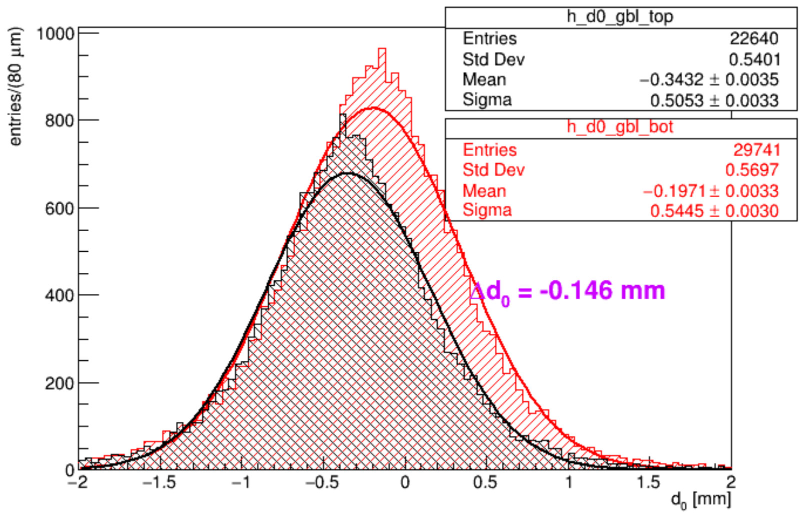
p_{top} = 2.268 MeV/c
p_{bot} = 2.261 MeV/c

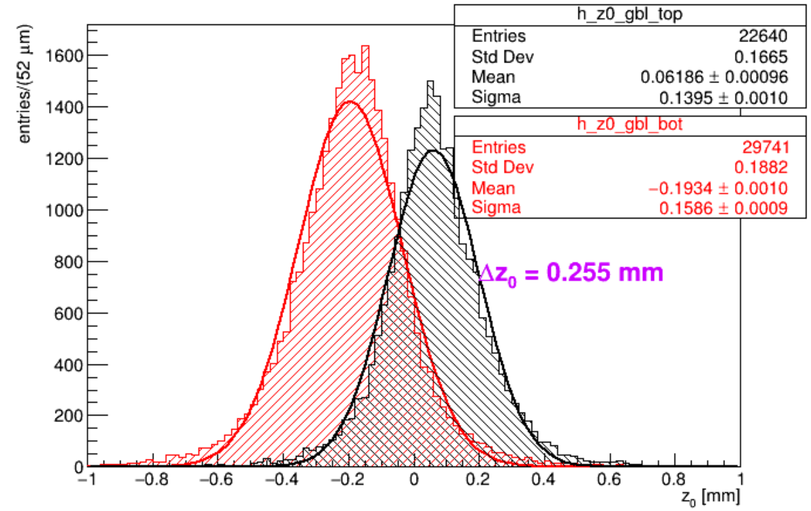
Elastic peak momentum underestimated



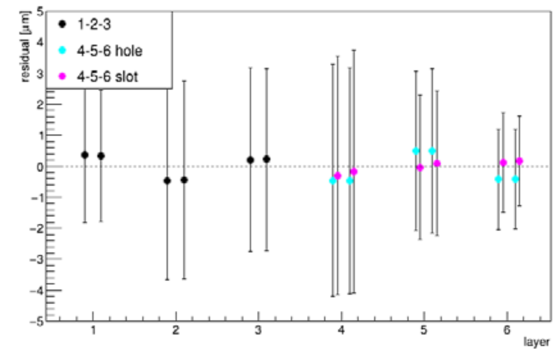
#5

2016 v2-5 w fieldmap, 0.5mm curved tracks (reduced sample) – 3-4 all rot



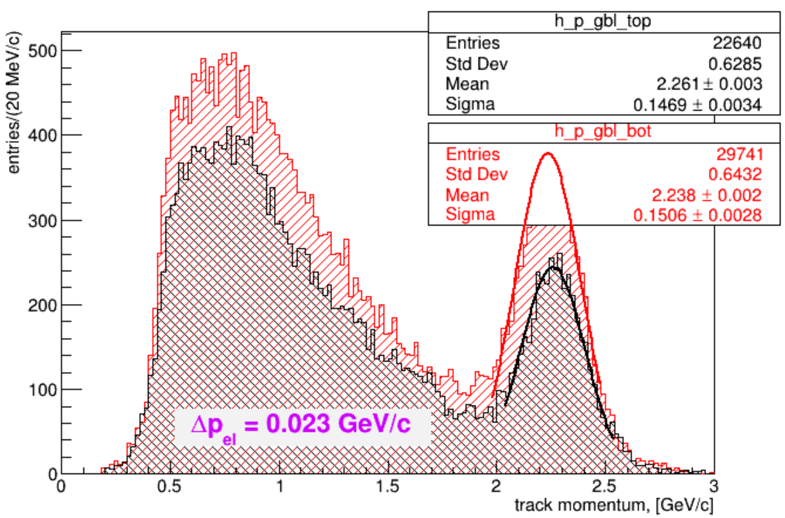


d_0 t/b are no more aligned (top moves away)

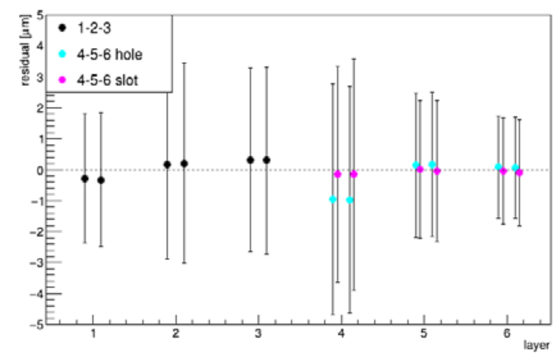


T/B diff
Δd_0 = -146 μm
Δz_0 = 255 μm
Δp = 23 MeV/c

p_{top} = 2.261 MeV/c
p_{bot} = 2.238 MeV/c

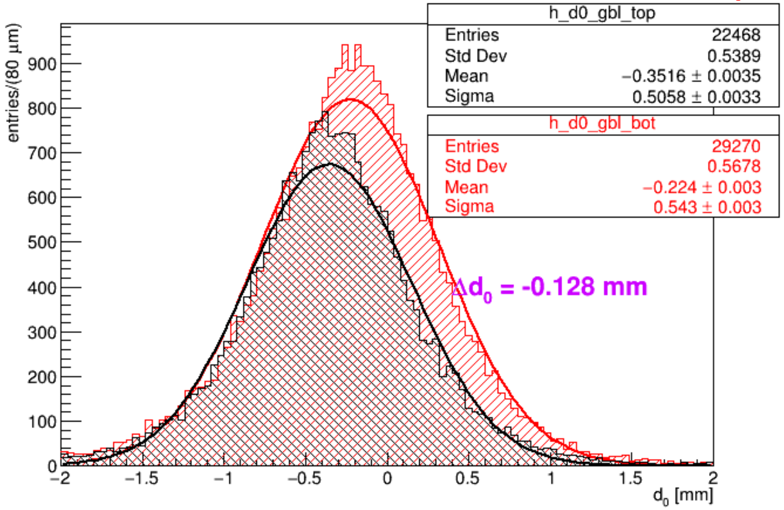


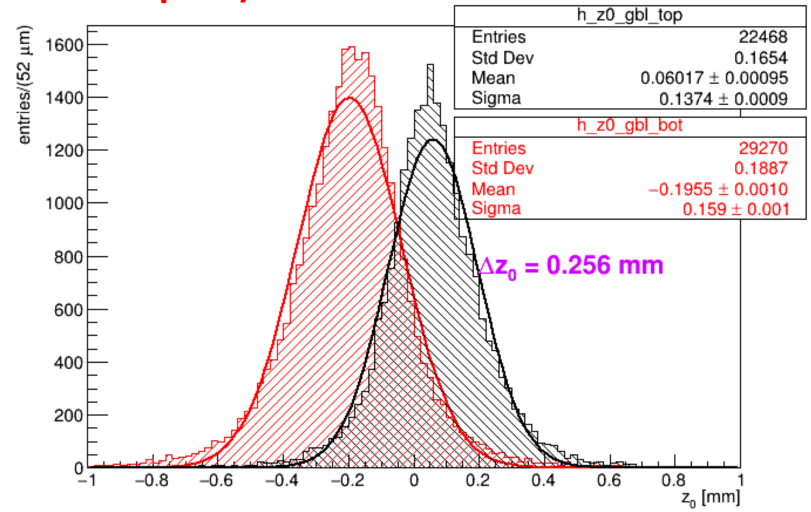
Elastic peak momentum underestimated



#6

2016 v2-5 w fieldmap, 0.5mm
all curved tracks (reduced sample) – 2-3-4-5 tu

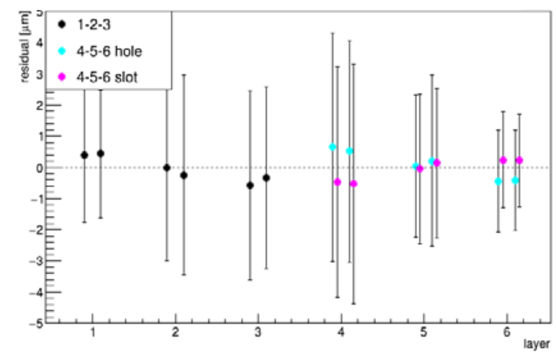


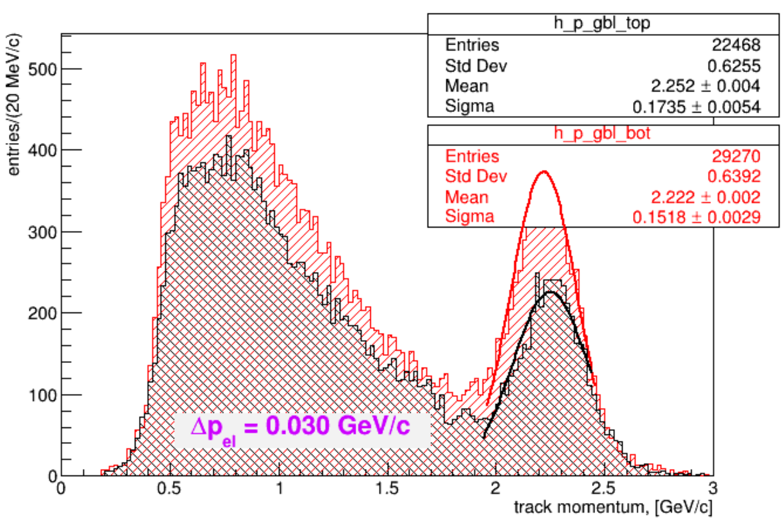


d_0 t/b are no more aligned (top moves away)

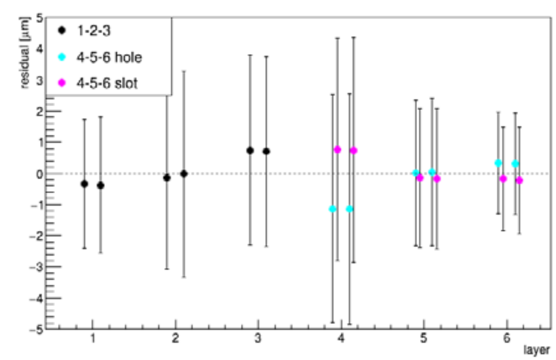
T/B diff
Δd_0 = -128μm
Δz_0 = 256 μm
Δp = 30 MeV/c

p_{top} = 2.252 MeV/c
p_{bot} = 2.222 MeV/c



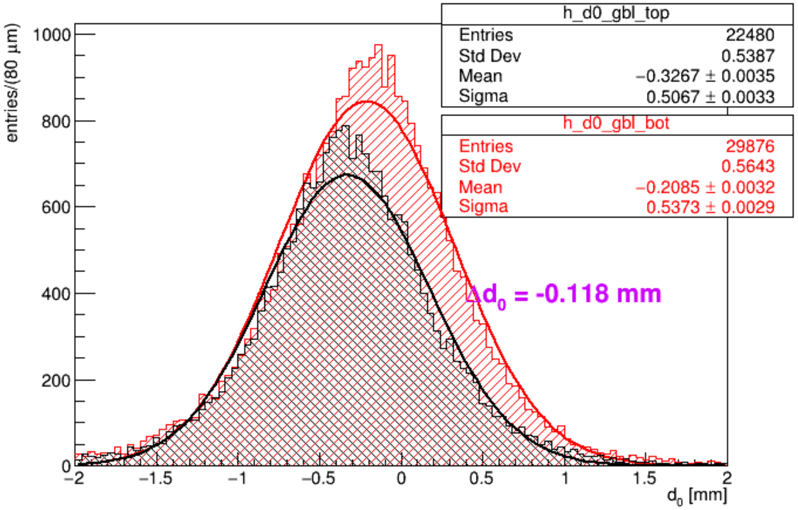


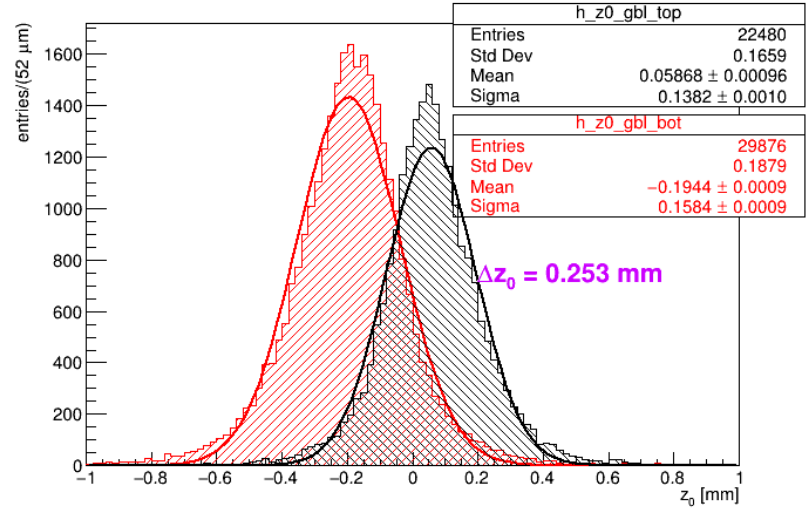
Elastic peak momentum underestimated



#7

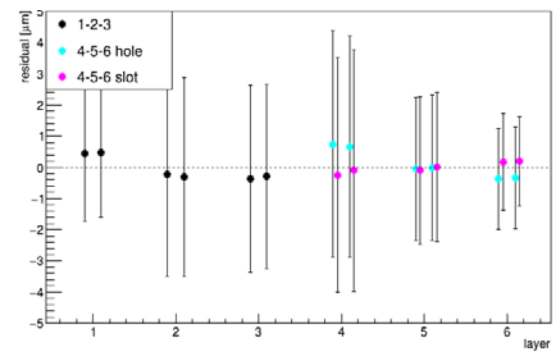
2016 v2-7 w fieldmap, 0.5mm
all curved tracks (reduced sample) – 3-4 tu-tw

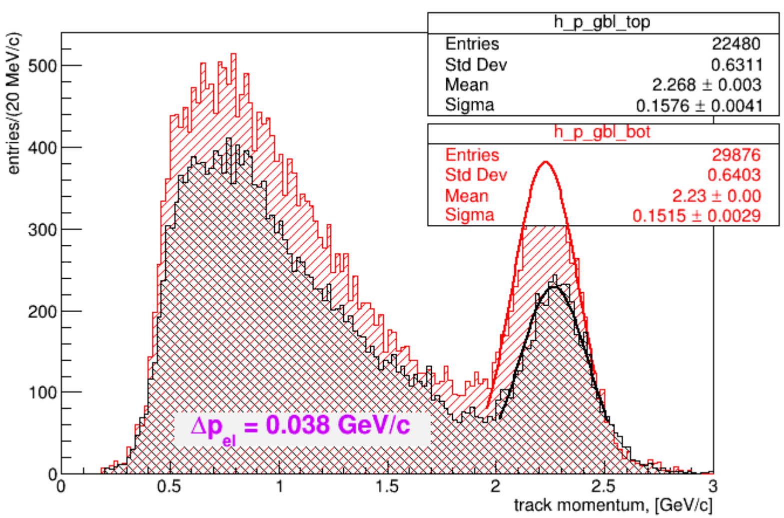




d_0 t/b are no more aligned (top moves away)

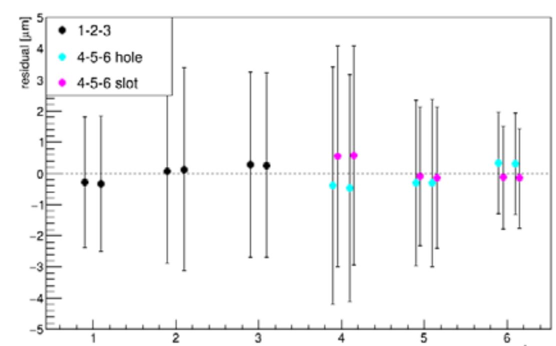
T/B diff
Δd_0 = -118μm
Δz_0 = 253μm
Δp = 38 MeV/c





p_{top} = 2.268 MeV/c
p_{bot} = 2.23 MeV/c

Elastic peak momentum underestimated



1^{st} week wrap-up

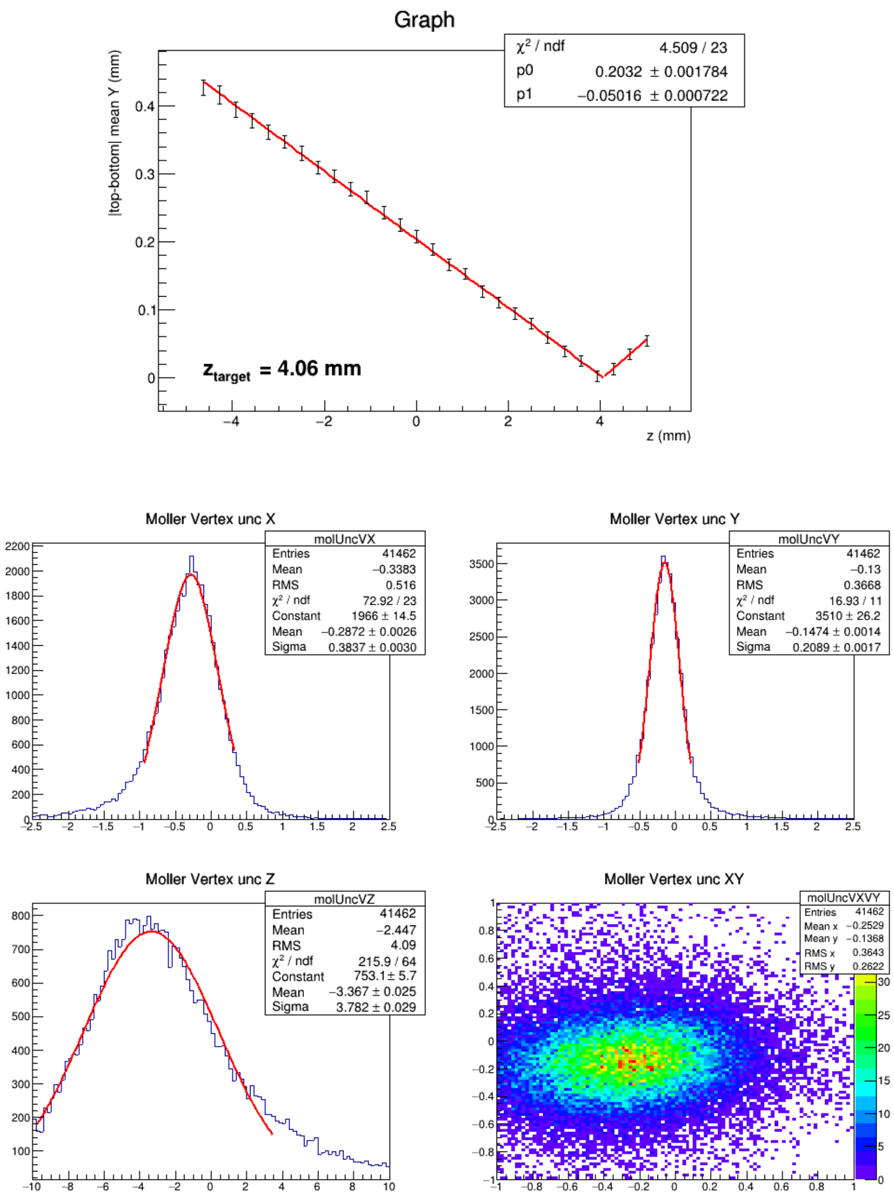
- d_0 t/b symmetry lost, z_0 not affected by internal alignment (it can however be recovered by external alignment, if necessary)
- The internal alignment lowers the elastic peak momentum (t/b symmetry preserved, sometimes even improved)

- Further minimizations after rotations: not improving
- Best residual centering: #4, #5, #7 (last two include rotations)
- Retune from #4 or continue from #7
- Keep rotations as last instance

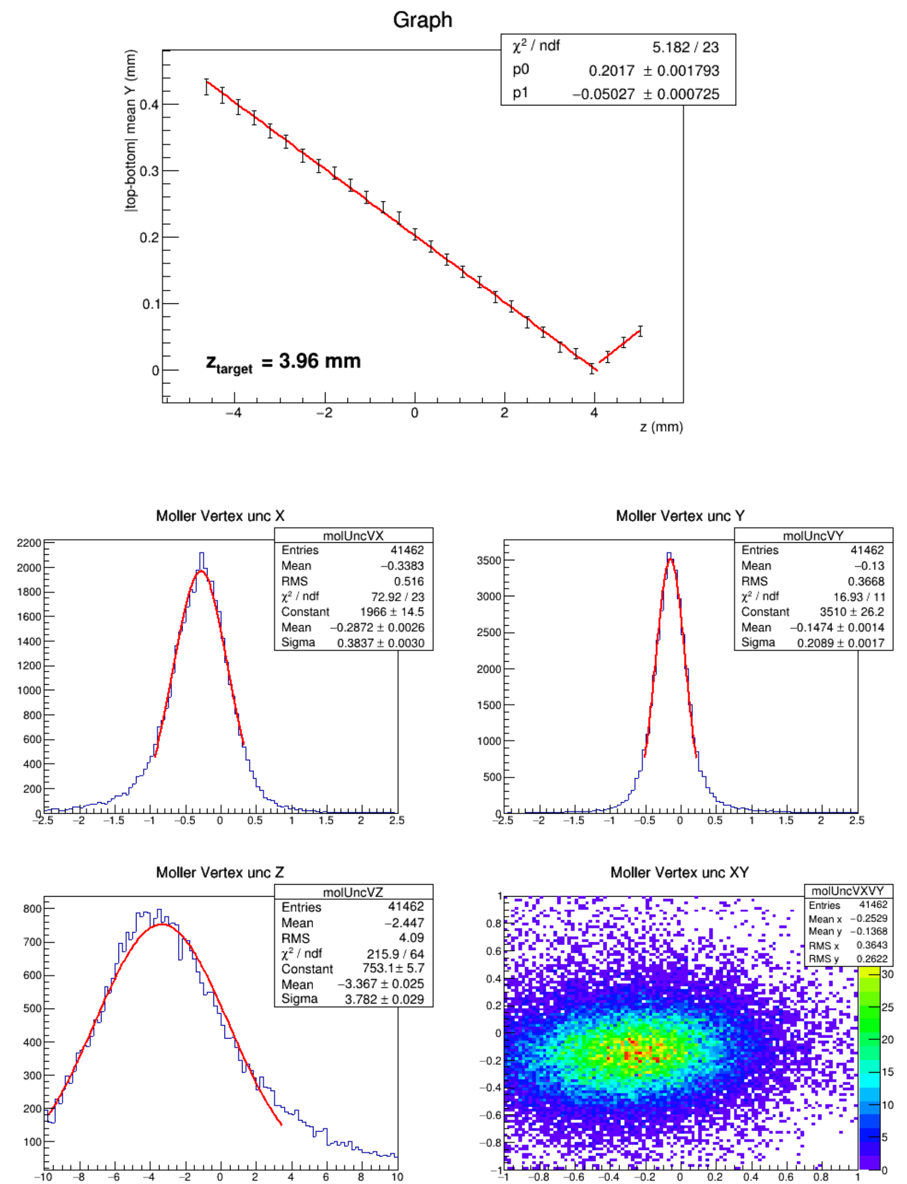
- How do physical distributions look like?
  - practically, the same

Target position, Moller events

V 2-4



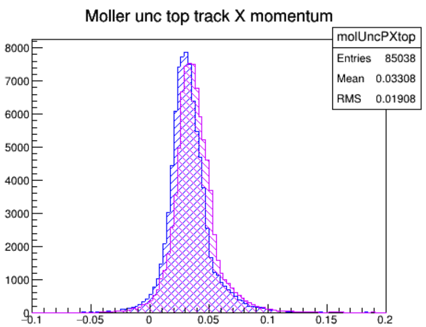
V 2-5

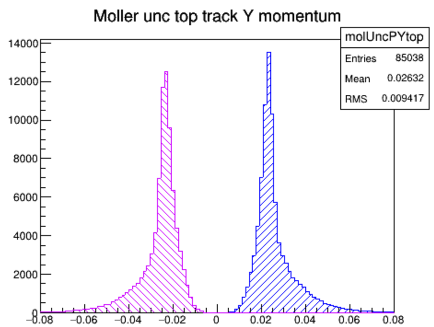


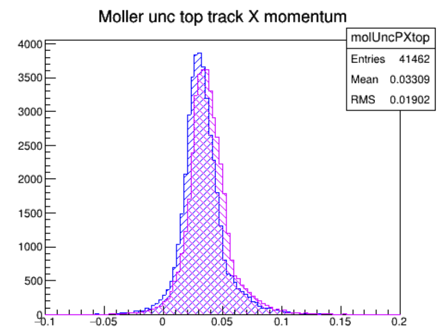
Momentum components, Moller events

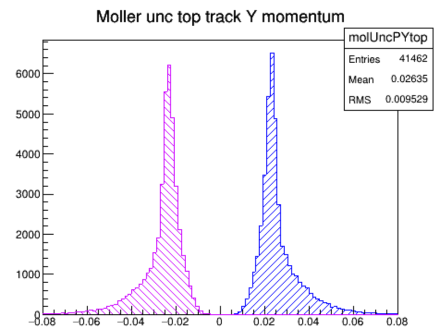
V 2-4

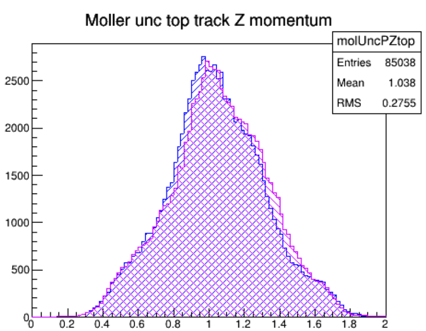
V 2-5

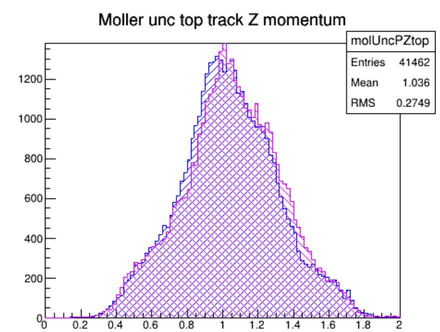










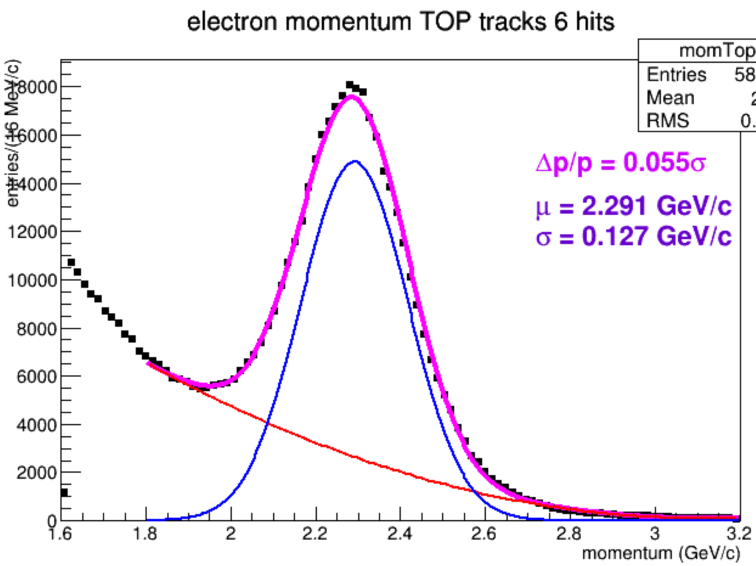


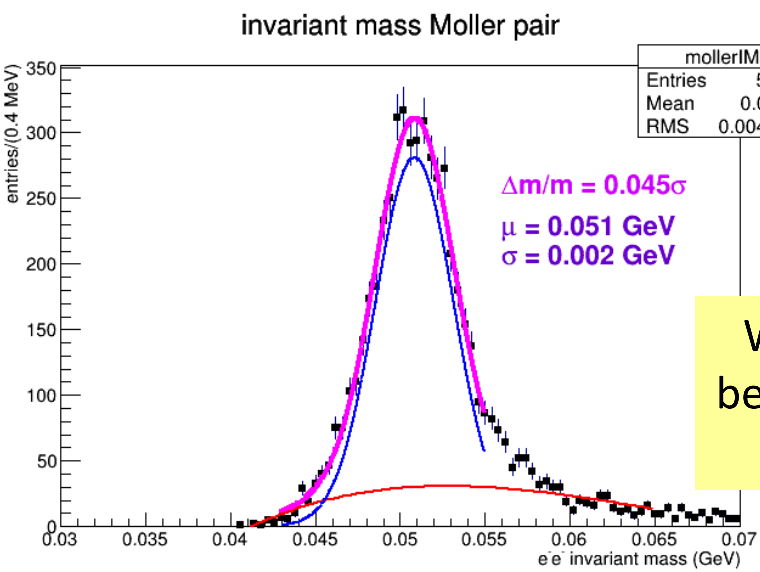
In both cases it looks like the bottom spectra (violet) are slightly harder than the top ones

The difference is very tiny

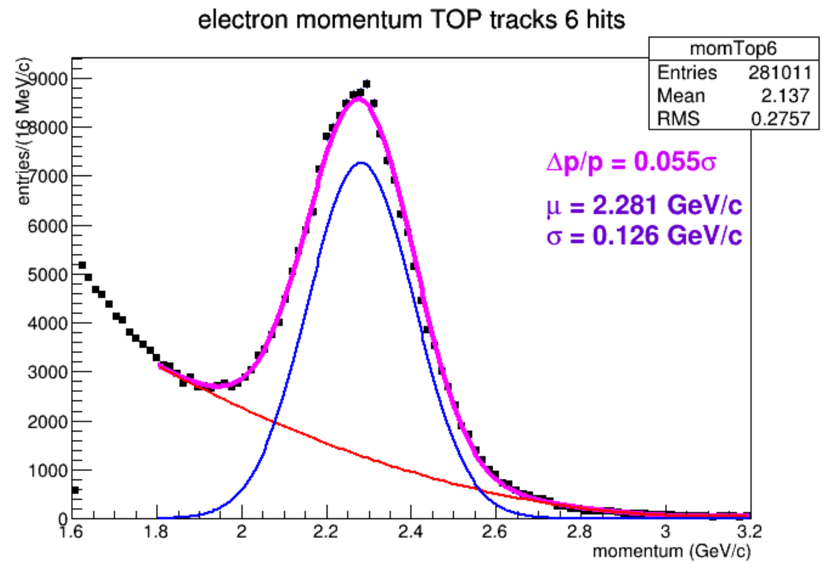
FEE momentum/ e^-e^- invariant mass resolutions

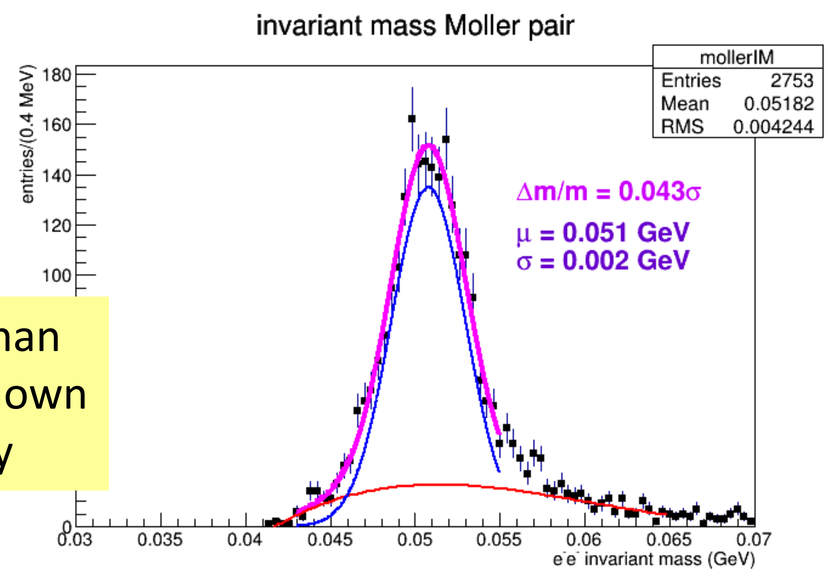
V 2-6





V 2-5





Worse than best ali shown in may