SVT Alignment present status and plans

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Alignment status as of May, 2018

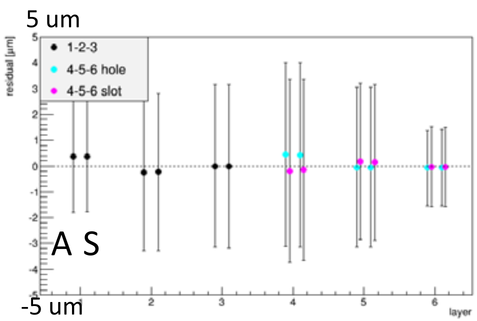
- Two detectors are available in hps-java (since last May2017) providing the best "current" alignment:
  - 2015 data: v6.0_fieldmap
  - 2016 data: v5.3_fieldmap_globalAlign

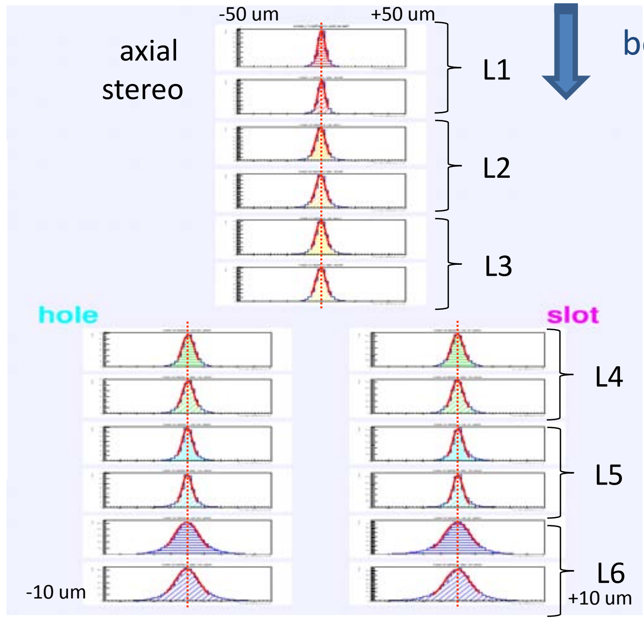
- **2015 geometry tested and validated**
  - Internal alignment achieved mixing straight and curved tracks, based on translations and rotations
  - Global alignment with curved tracks tuned requiring the beamspot to be centered at $(0., 0., z_{target})$
    - z_{target} = -5 mm
  - 0.5 mm detector: used for last passes
  - 1.5 mm detector: same internal alignment, plus additional offset to take into account the opening angle
  - NO tweaks introducing a dependence of offsets on angles
  - Internal offsets on sensor positions inserted in the db, the beamspot coordinates need to be provided in the steering file

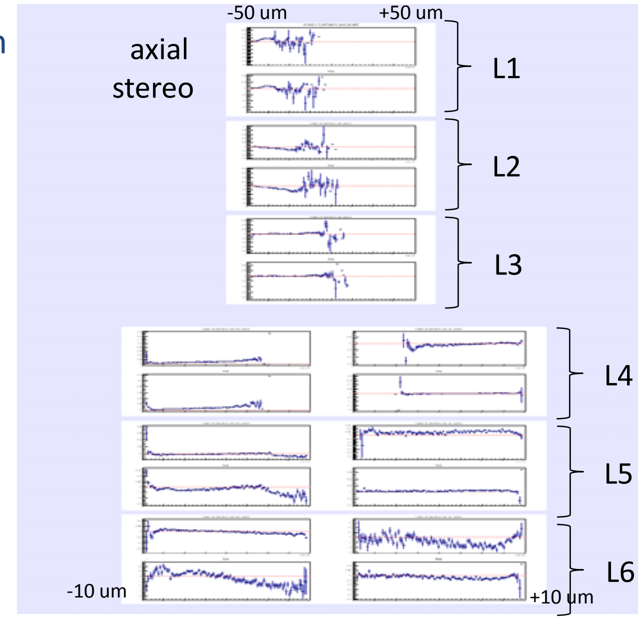
2015 alignment: figures of merit and achievements

2015 internal alignment: curved tracks - detectors at 0.5 mm

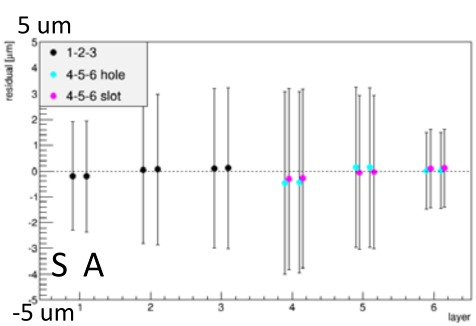
TOP

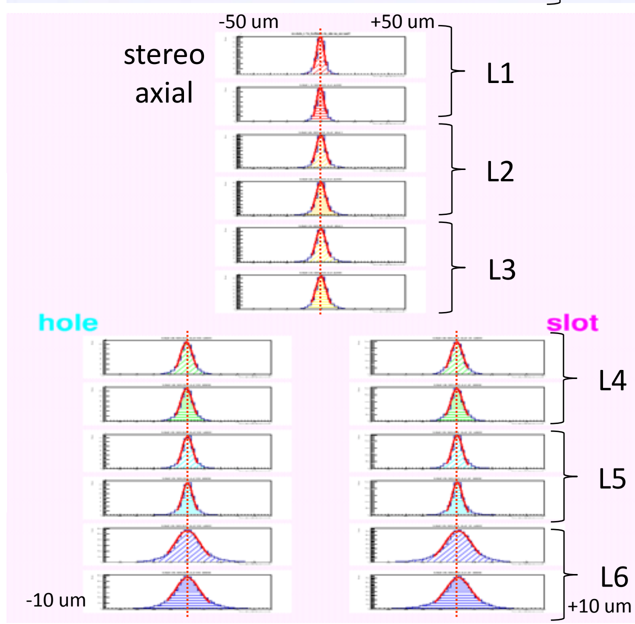


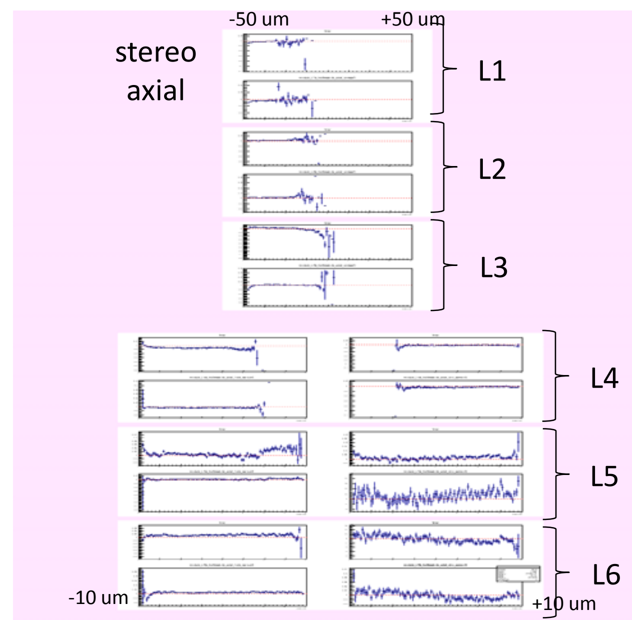




BOTTOM

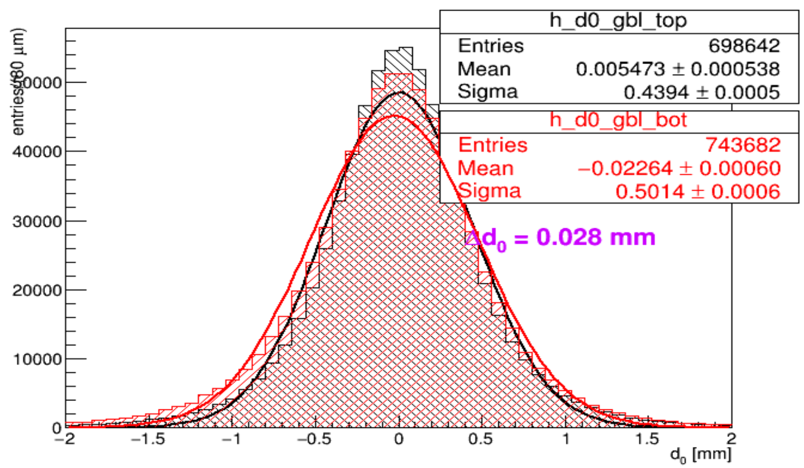


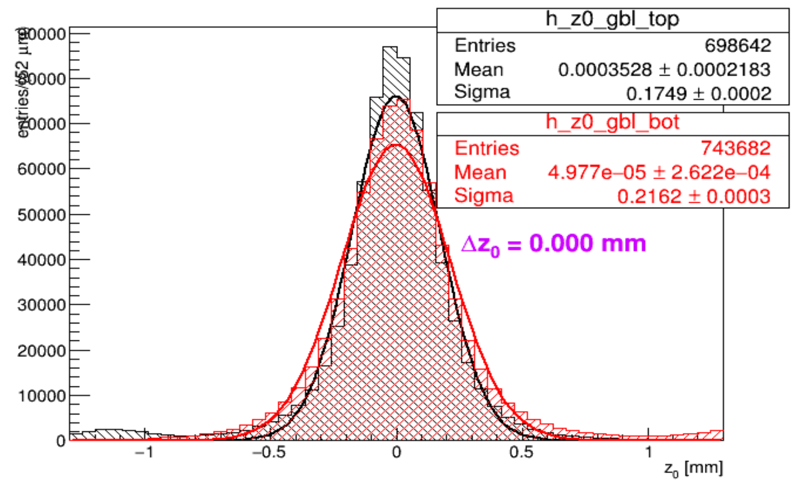


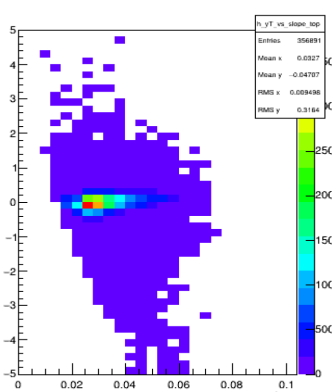


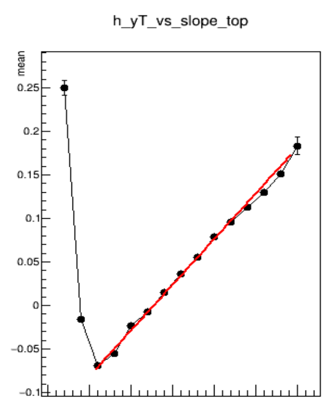
2015 alignment: beamspot location

- beamspot (x,y) position: global alignment performed as to center to zero, for both the detector halves, the impact parameters along the two axes
  - (0,0) is assumed to be the center of the target
- The z target coordinate is deduced from the distribution of y(@z=0) vs slope for FEE tracks





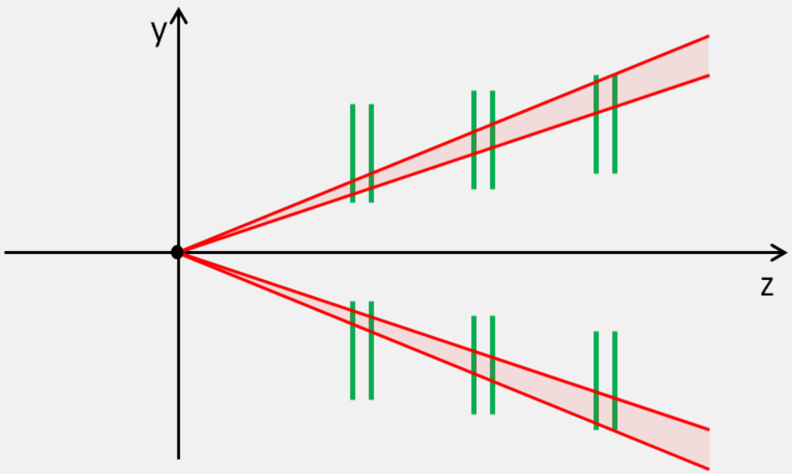




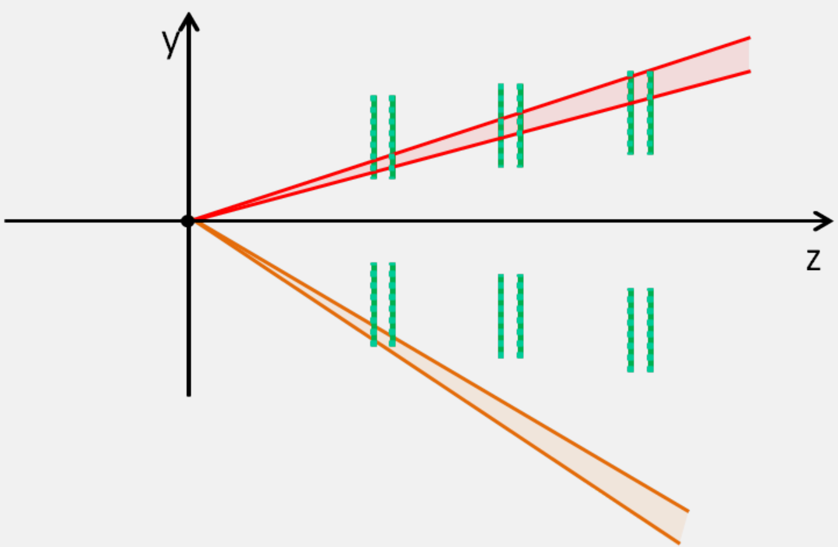
$$y_T\Big|_{z=0} = \underbrace{y_{tgt}}_{p_0} - \underbrace{z_{tgt}}_{-p_1} \cdot \tan\lambda$$

Top tracks:
p_0 = -0.185 mm, p_1 = 5.23 mm

Vertex vs beamspot coordinates Møller and FEE events

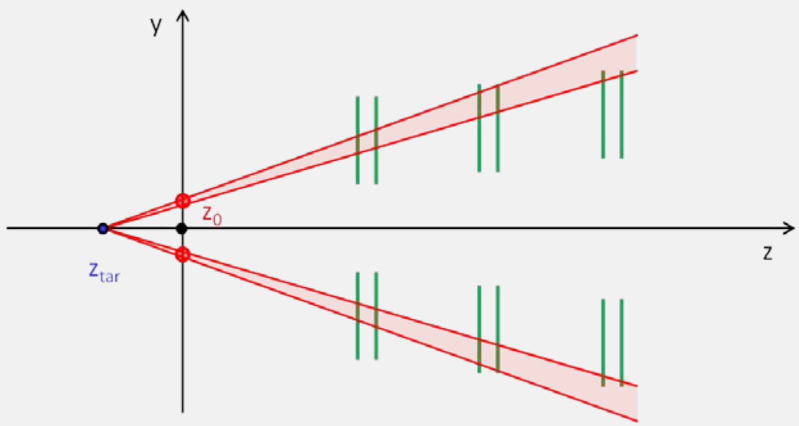


Møller event ideal case: target coincident with origin of coordinates (same for d_0 for the x axis)

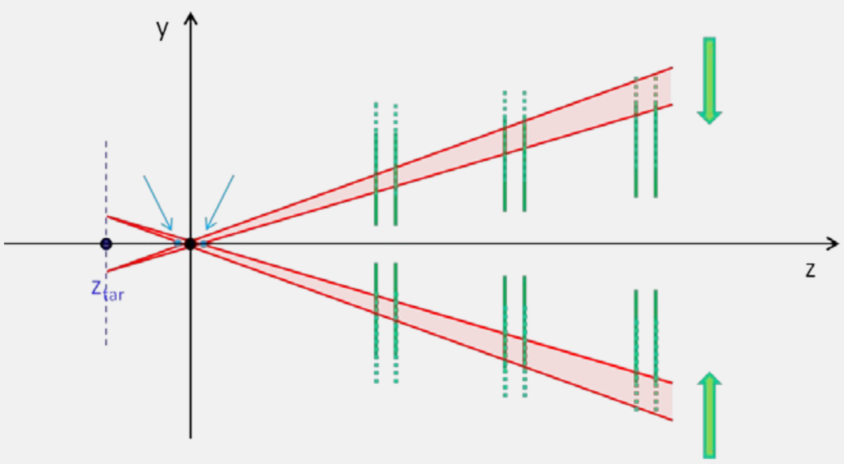


Elastic event – ideal case One tracks only (the electron) enter the SVT acceptance

Møller events: t&b beamspot "equalization"



Internal alignment: target at a given z coordinate, not necessarily zero
Two beamspots on the yz plane, for top and bottom halves, not necessarily symmetric with respect to the z axis (this depends on the beam/z angle)

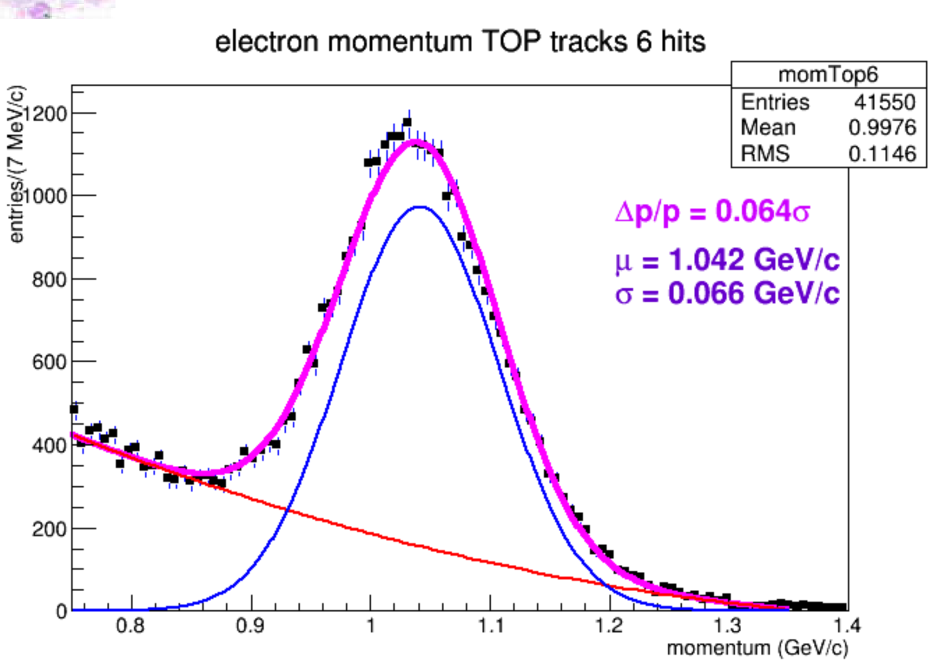


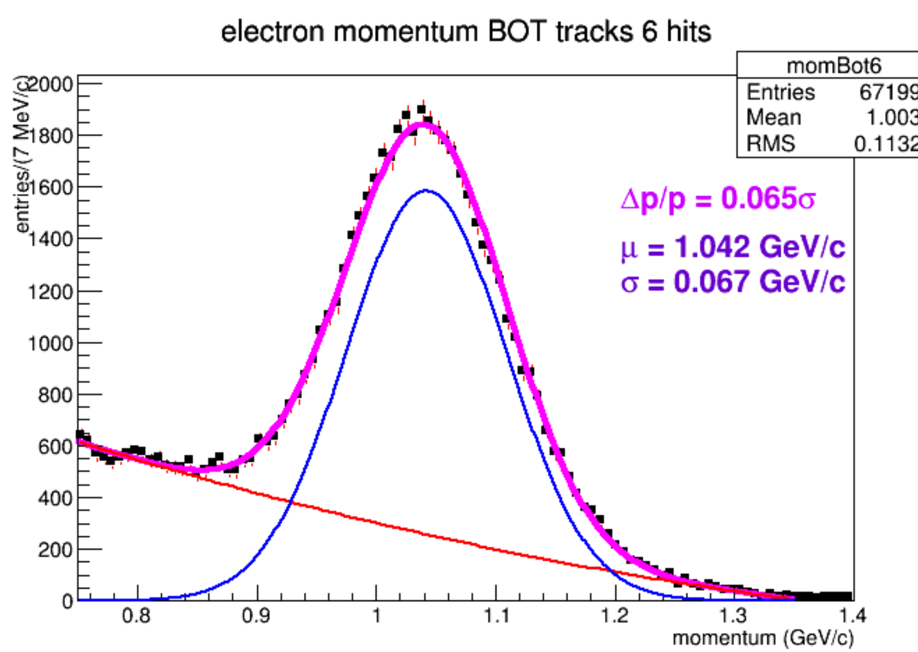
Effect of global alignment:
- the beamspots are pushed so that $z_0 \rightarrow 0$
- the SVT halves are closed towards the beamline
- the z true coordinate of the target remains in the same place but…

2015 alignment: momentum resolution, @0.5 mm

- FEE selected tracks, for top and bottom
  - 6 hits tracks
  - Single1 || Single0 trigger
  - Top/bottom time alignment (3 ns)
  - SVT-ECAL matching (χ^2 cut)
  - Good quality from track fitting (track χ^2 cut)

- **Momentum resolution: 6.5% σ**
- Momentum systematic of ~15 MeV/c from nominal expected value

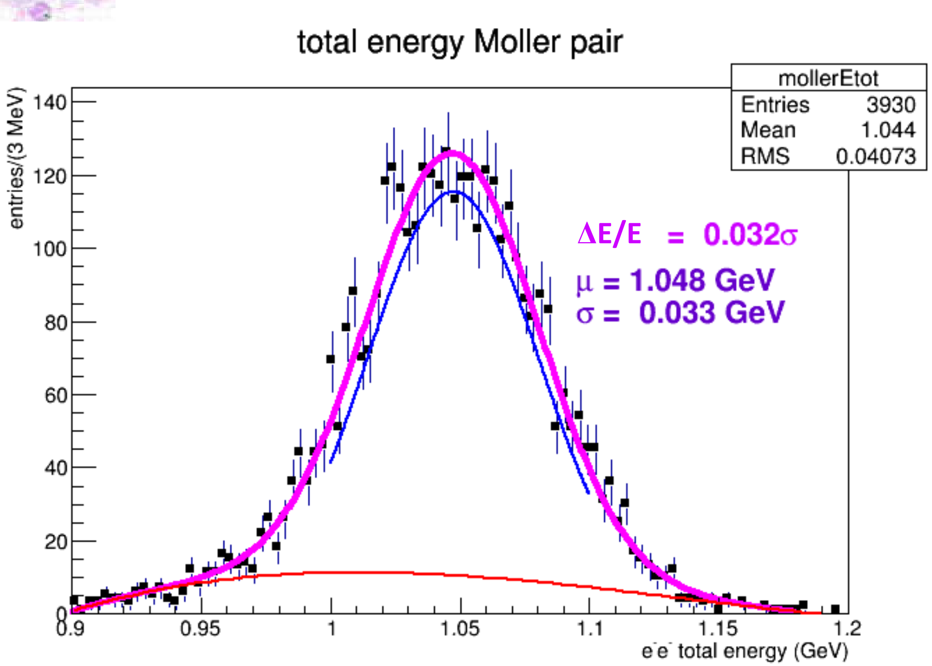


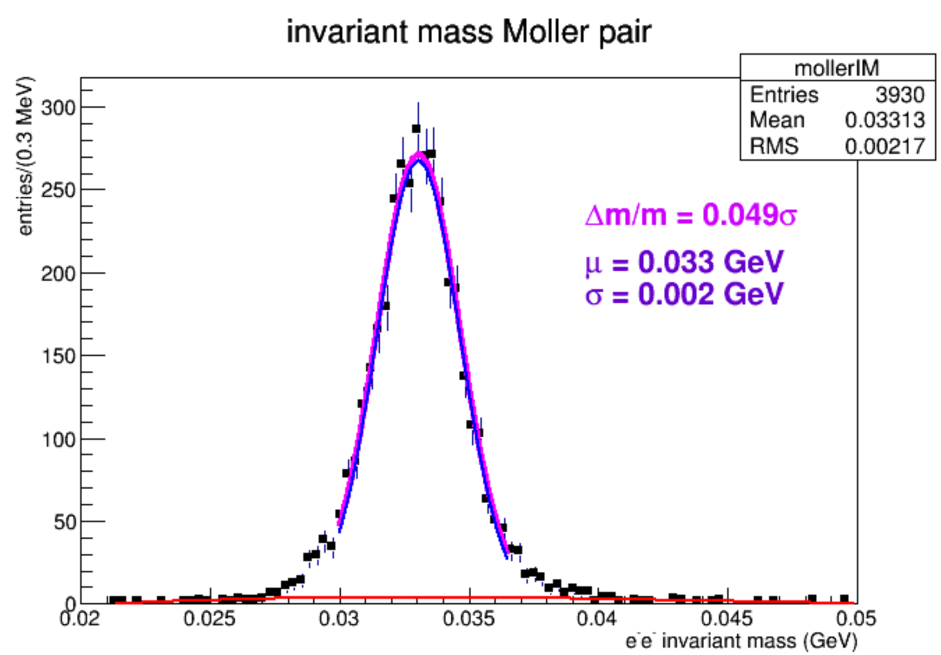


2015 alignment: energy/mass resolution, @0.5 mm

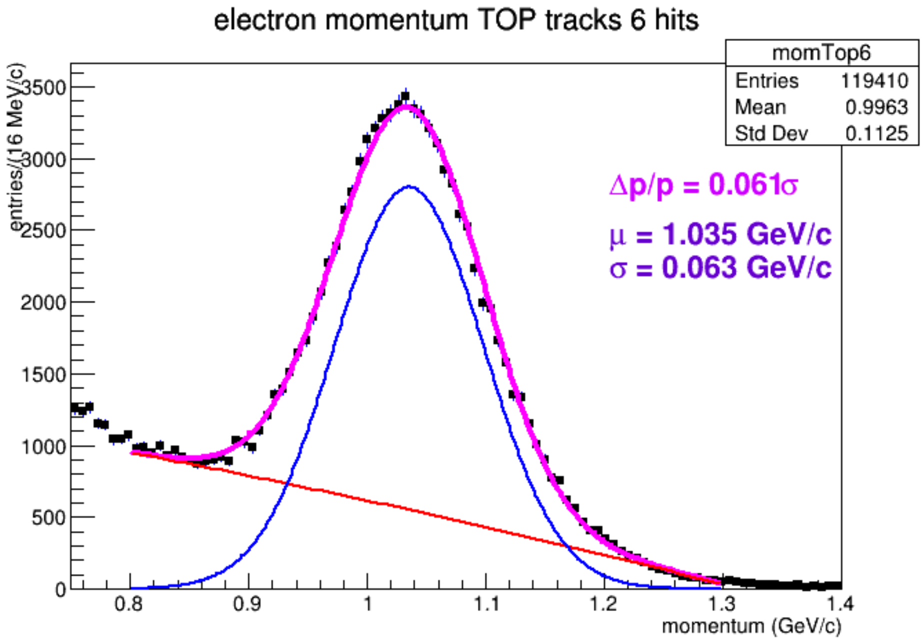
- Energy and mass resolution deduced from Møller events
  - Top/bottom time alignment (3 ns)
  - Good quality tracks
  - No topological constraints
  - Both tracks in detector acceptance and close to the beam plane (large θ_x and θ_y angles from the x-y axes)

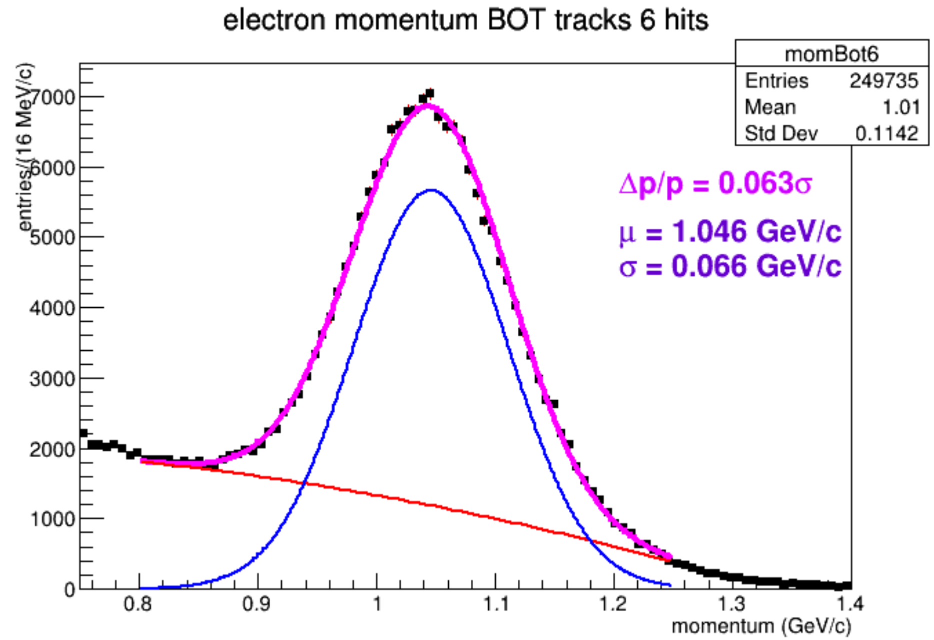
- **Invariant mass resolution: 4.9%σ**

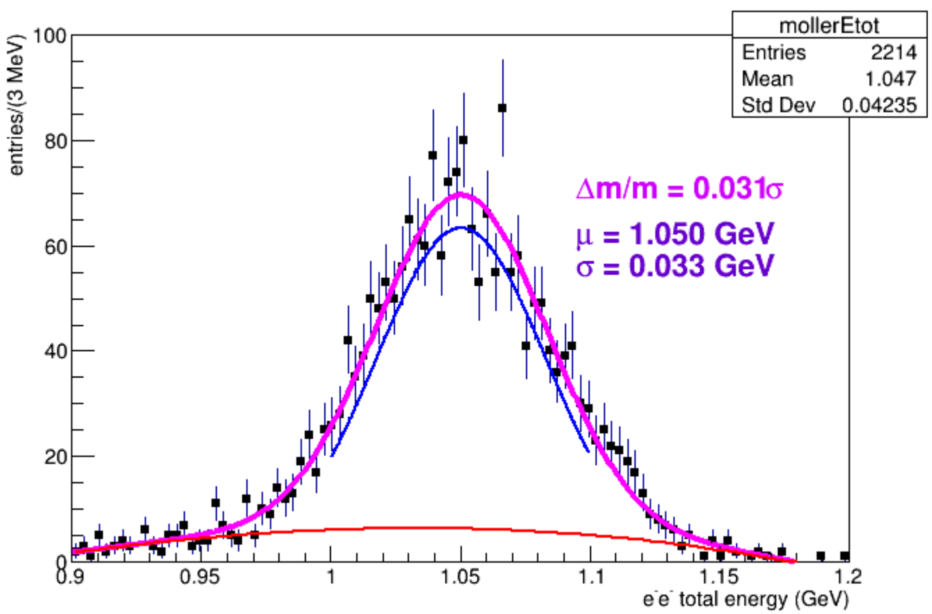


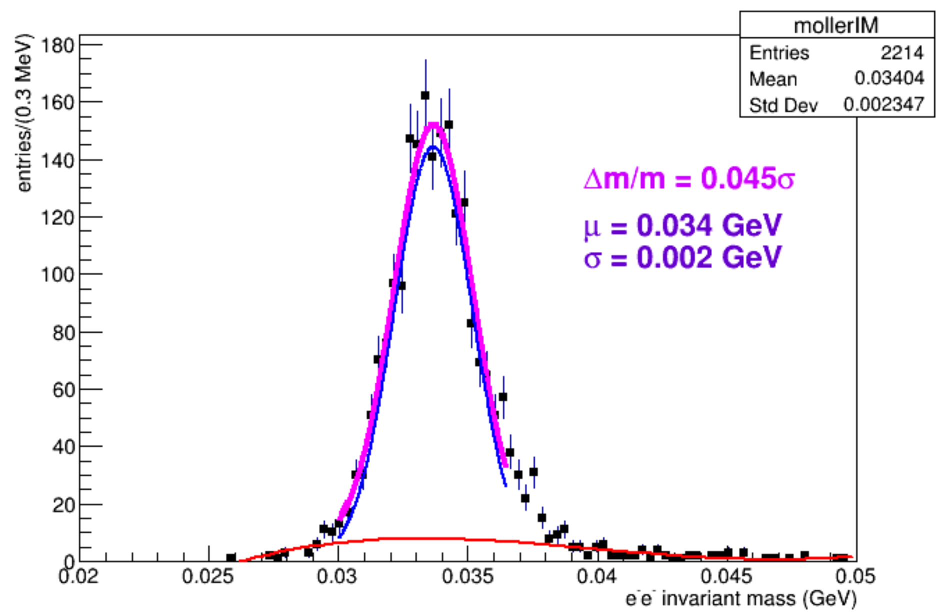


2015 alignment: resolutions @1.5 mm









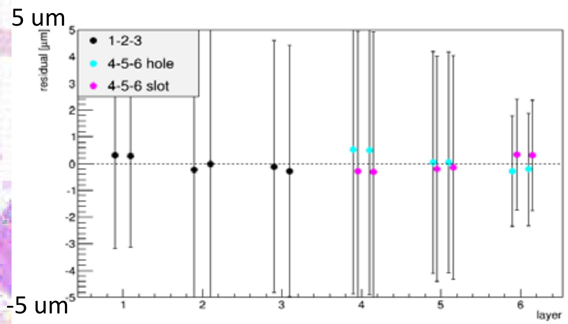
2016 alignment status
detectors at 0.5 mm

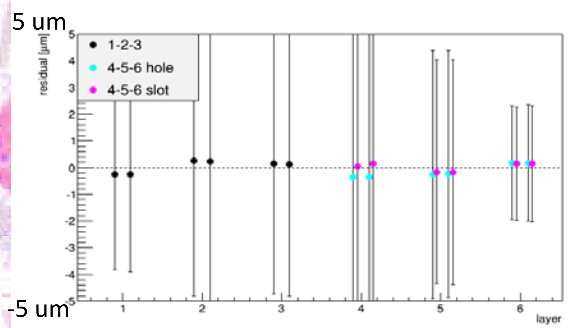
2016 data alignment quality: pass1 and beyond

- A partial test (pass1) was performed on some 2016 runs to check calibrations and new alignment (v5.3)
  - See presentation at Nov17 CM for check improvements of pass1 vs pass0 (pass0=2015 internal alignment)

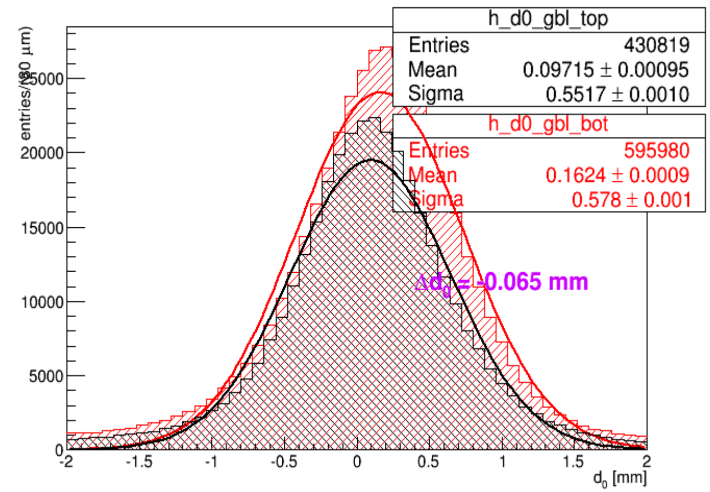
- Larger sensor occupancy, long running times: less smooth than 2015 alignment
  - Some practical problems to run extensive tests – much larger processing time/event
- Alignment needs to be worked out resorting to selected samples of tracks (FEE and Møller events), in addition to straight tracks for which one run only was taken (at the end of the data taking)
  - The trigger distorts track acceptance
  - Still some tuning required
- Several versions for internal alignment prepared, all of them are satisfactory BUT there are some inconsistencies when looking at physical distributions
  - Target location determination is more problematic

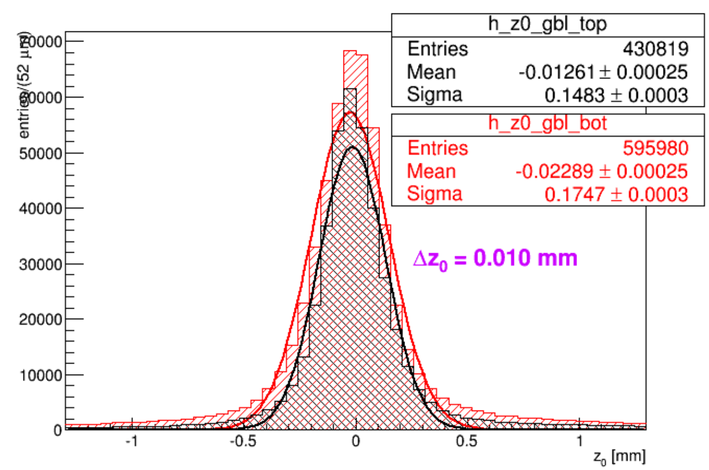
2016: pass1 alignment (v5-3)– how bad is it?

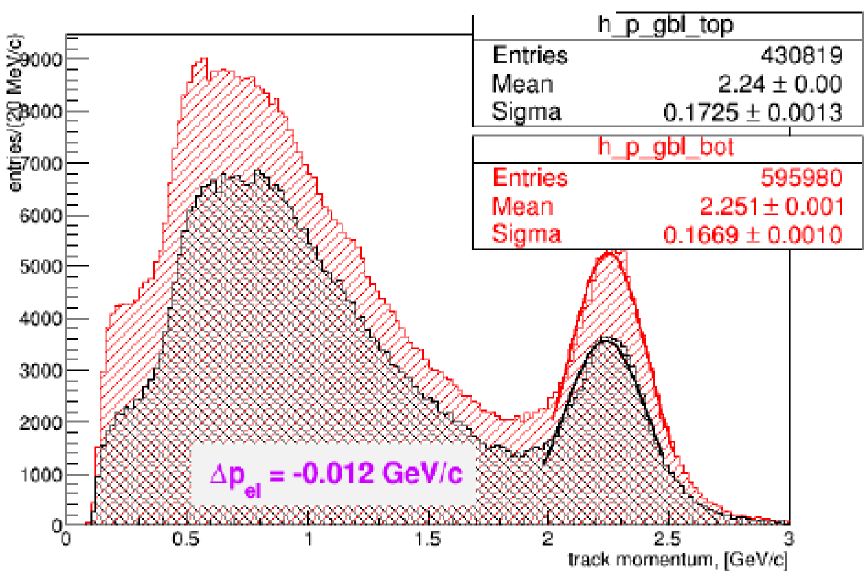




- Satisfactory internal alignment for curved tracks
- Tuning of impact parameters can be improved, but not dramatic

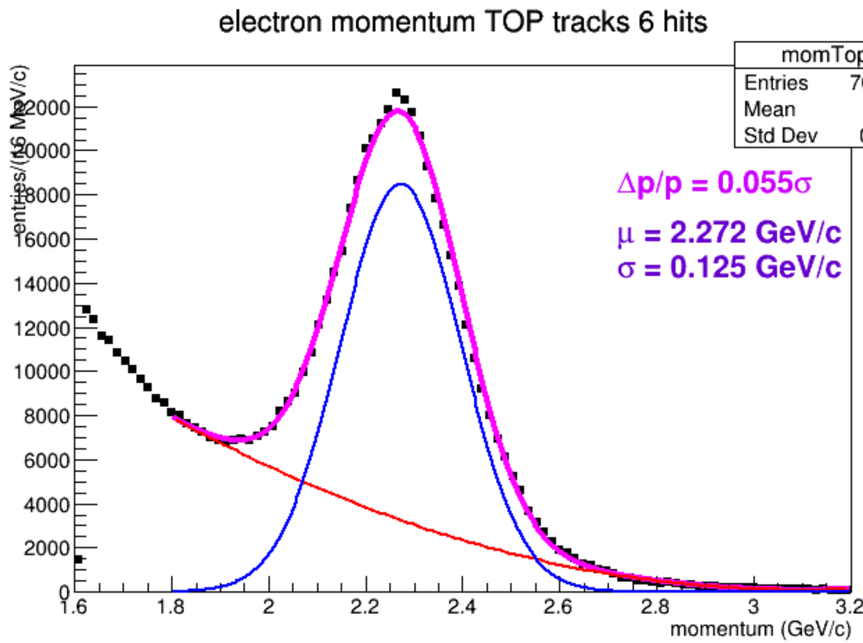


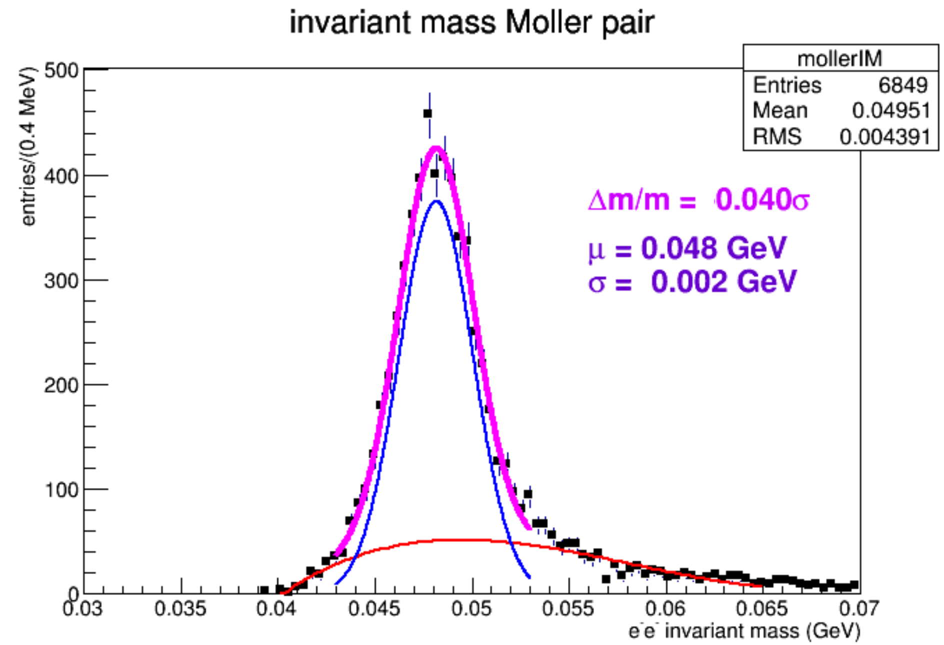




- Raw momentum spectrum (no quality cut): top/bottom alignment within 12 MeV/c at the elastic peak
- Systematic on the momenta of more than 70 MeV/c (wrt to nominal beam value)

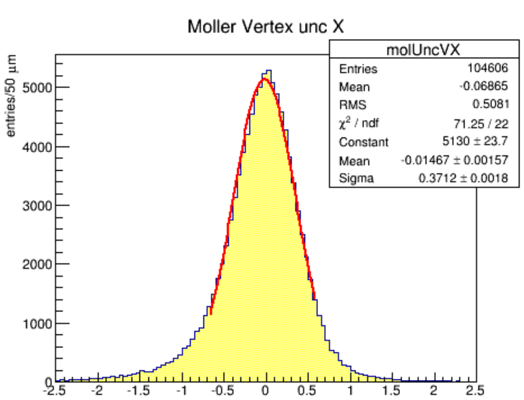
Resolutions with 2016-pass1 detector

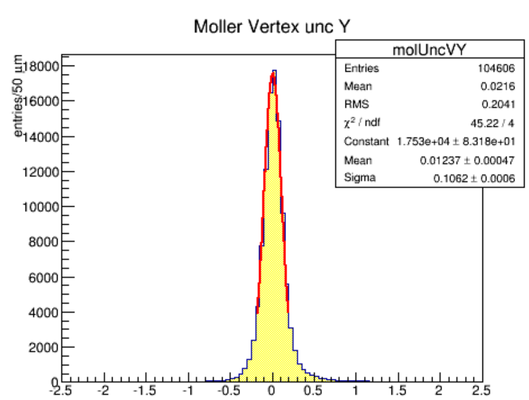


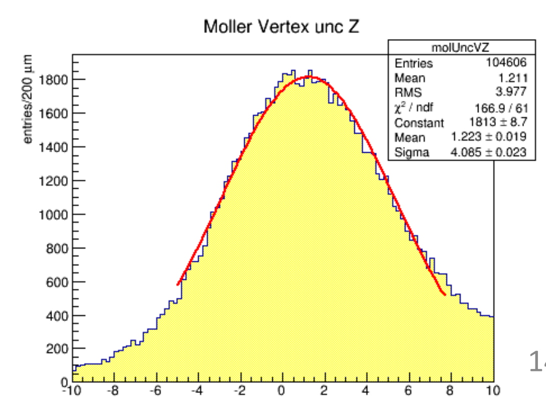


- good resolutions on momenta (5.5-5.8%σ) and invariant mass (4%σ)
- but… where is the target located?

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

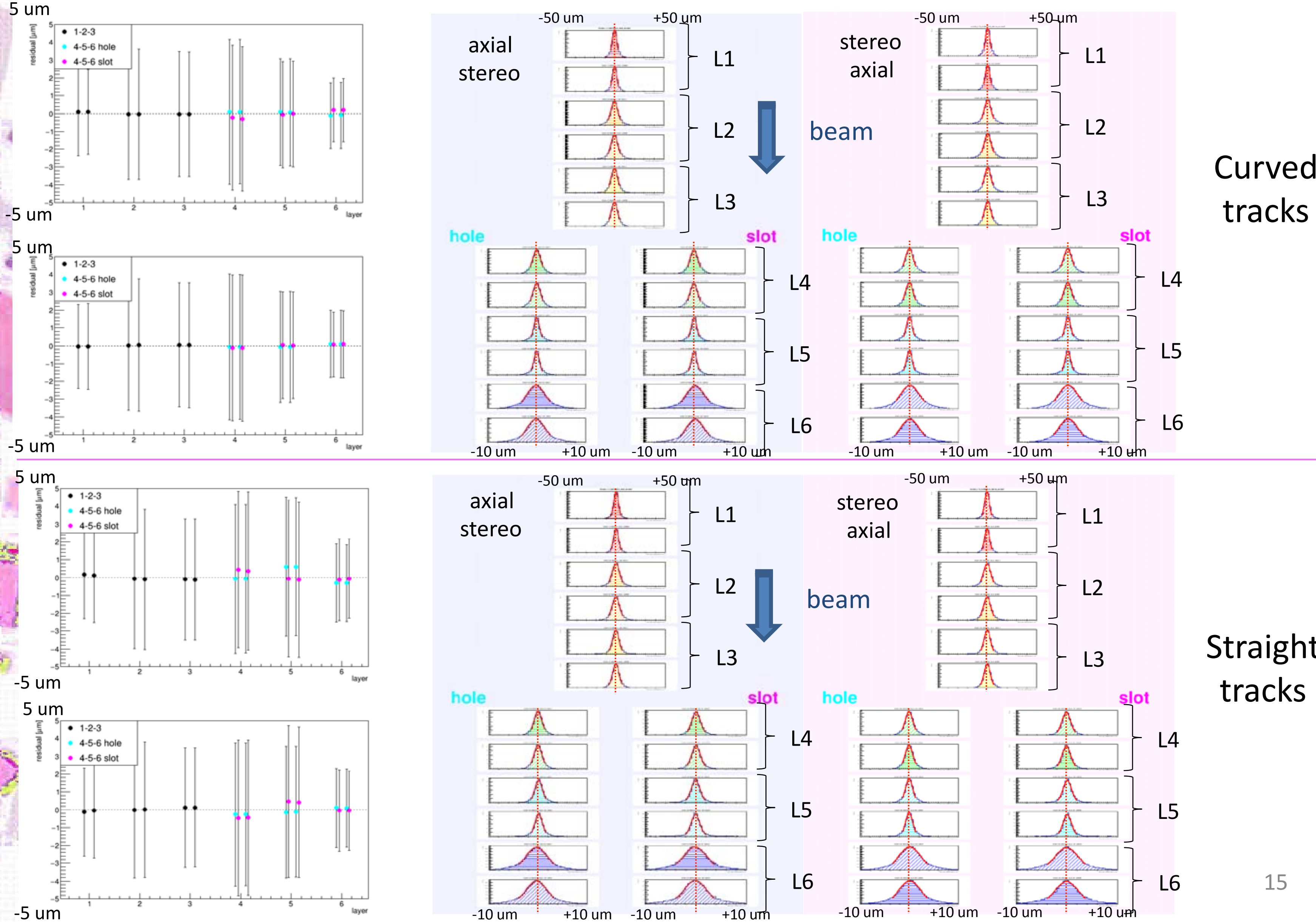




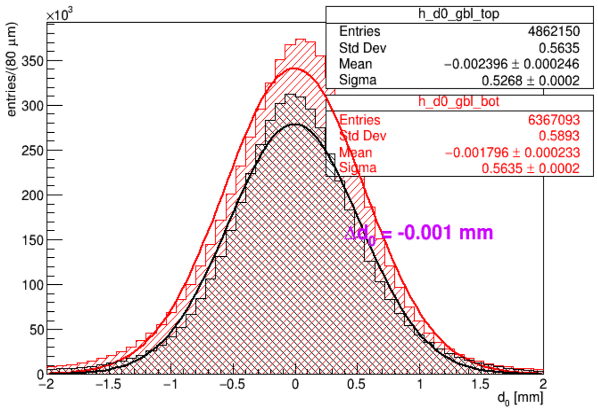


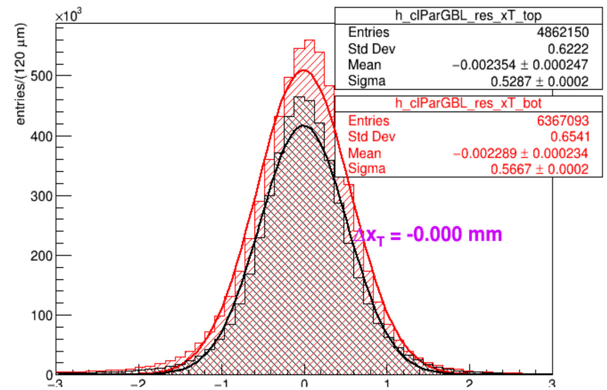
2016 internal alignment - development

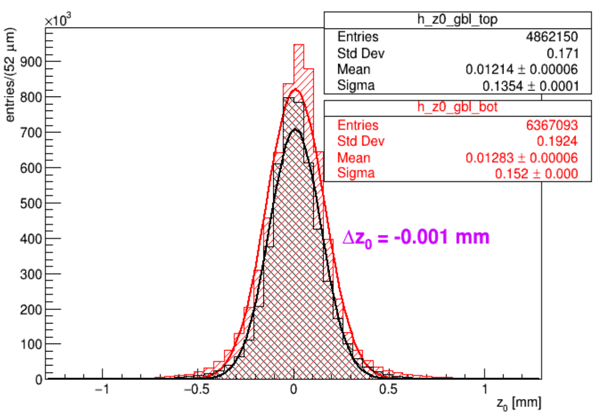
Good alignment of residual distributions for both curved and straight tracks

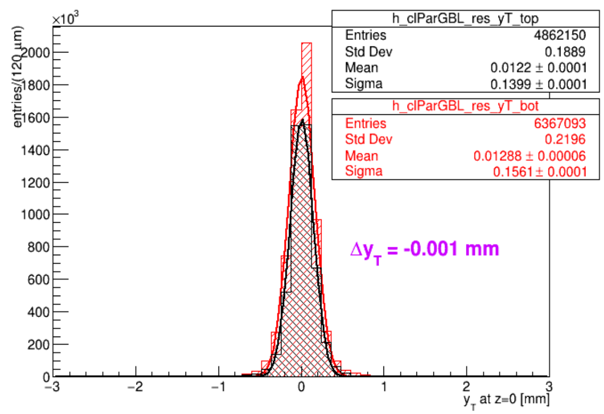


2016 global alignment devel: impact parameters tuning





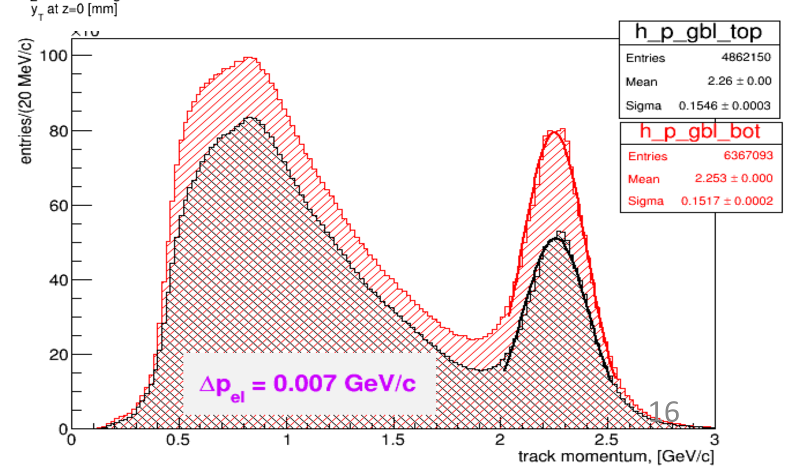




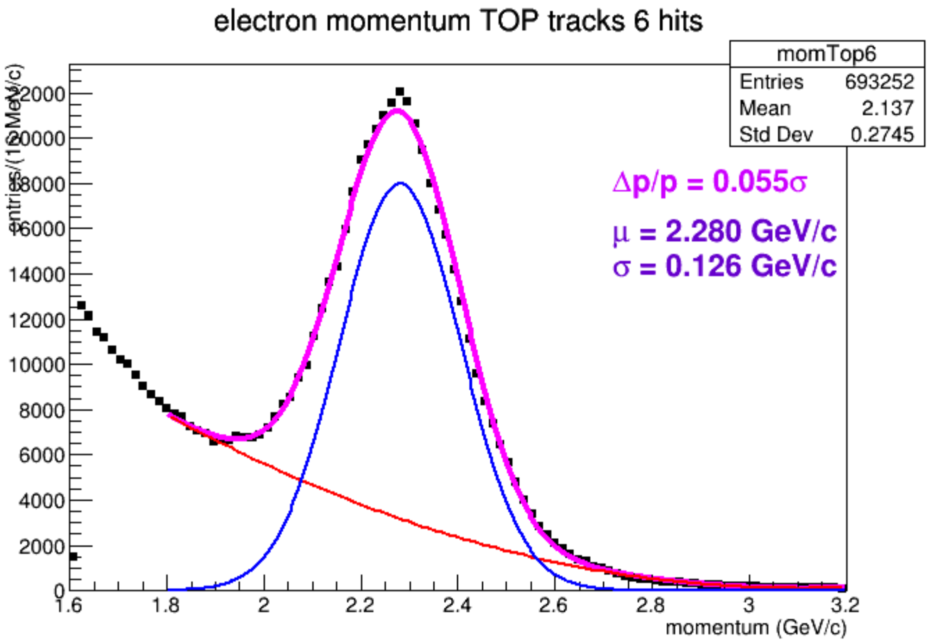
Global alignment brings to zero both impact parameters (d_0 along ~x and z_0 along ~y) and x_T and y_T beamspots (curvilinear coordinates)

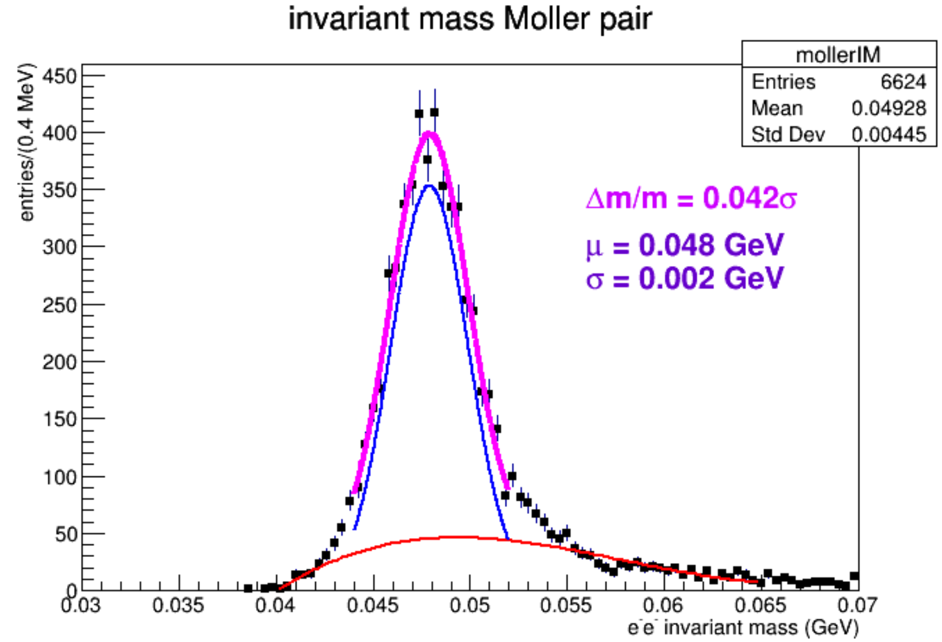
Raw momentum spectrum (with a mild cut on track χ^2, $\chi^2<40$):

- improvement top/bottom elastic calibration: 7 MeV/c
- reduction of systematic error on absolute calibration

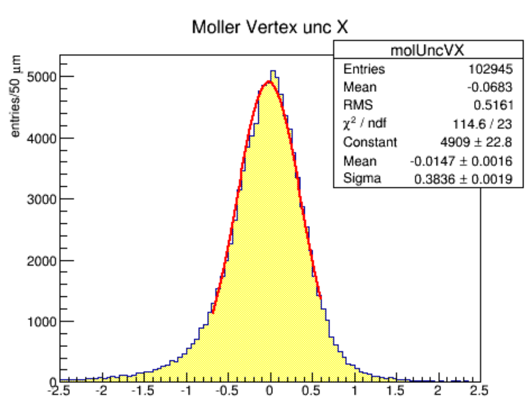


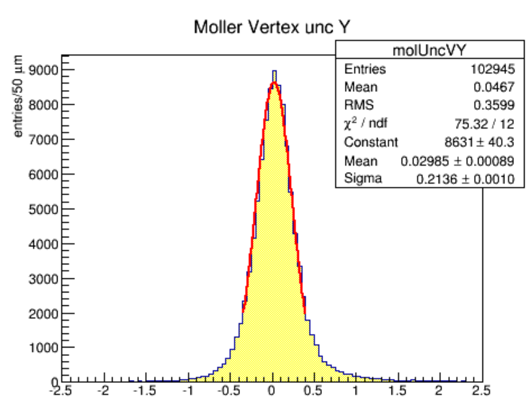
2016 i&g alignment development: resolutions

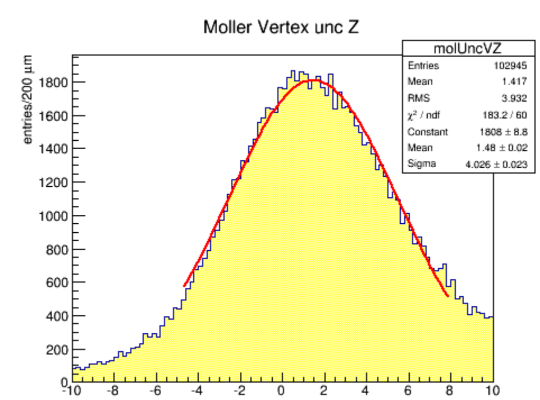




- resolutions don't improve
- unconstrained vertex coordinates for Møller events: **same z misplacement (~1.4 mm)**
- a production with this detector might not bring any extraordinary breakthrough







2016 global alignment development - where is the target?

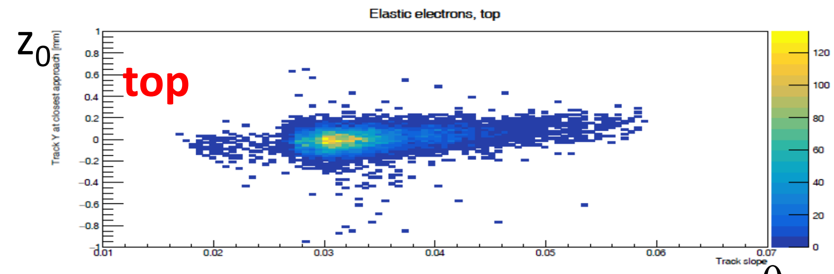
- Same technique as done for 2015 on FEE selected sample: the z coordinate of the vertex is always around -5,-6 mm

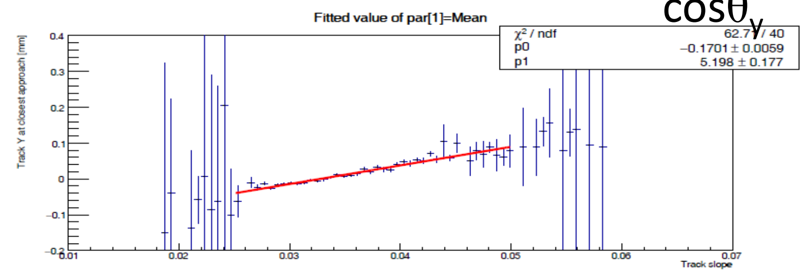
- Is this information contradictory with the z vertex estimation from Møller pairs?

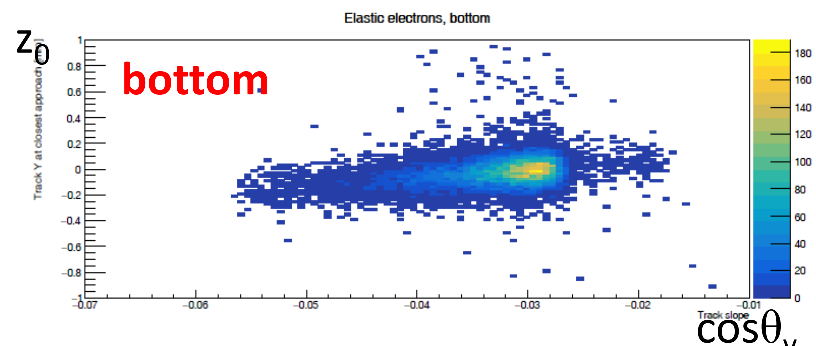
	Top	Bottom
P0	-0.17	0.17
P1	5.20	5.95

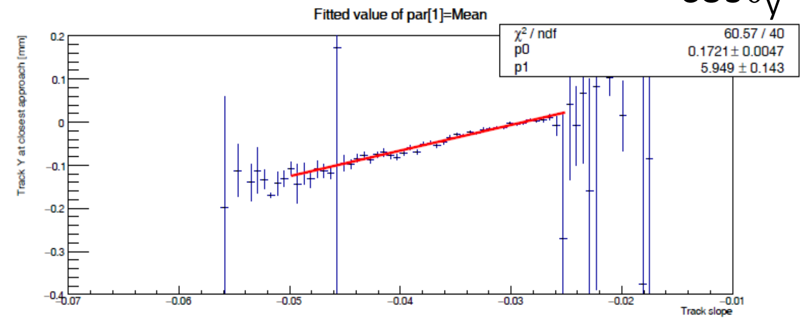
$$y_T\Big|_{z=0} = \underbrace{y_{tgt}}_{p_0} - \underbrace{z_{tgt}}_{-p_1} \cdot \tan\lambda$$

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

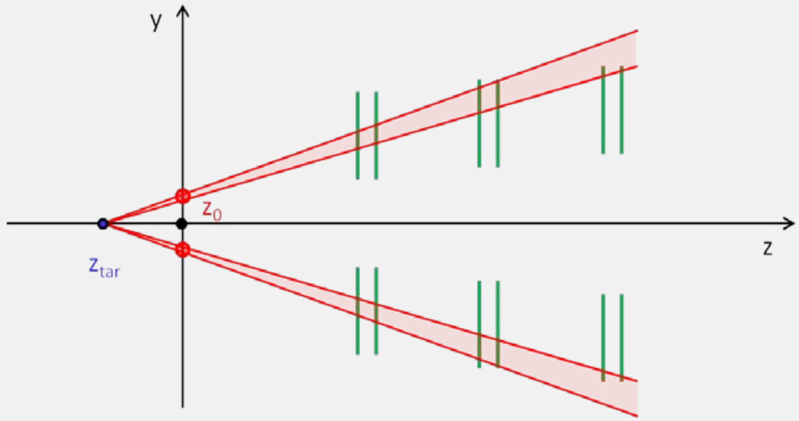




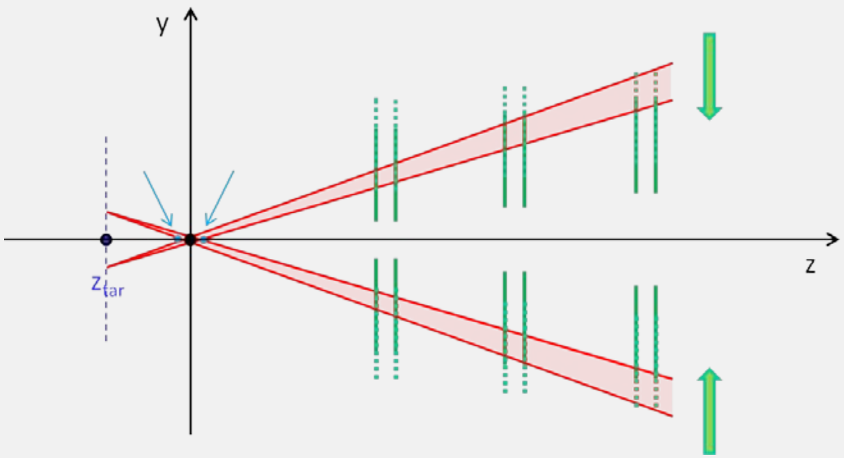




Møller events: t&b beamspot "equalization"



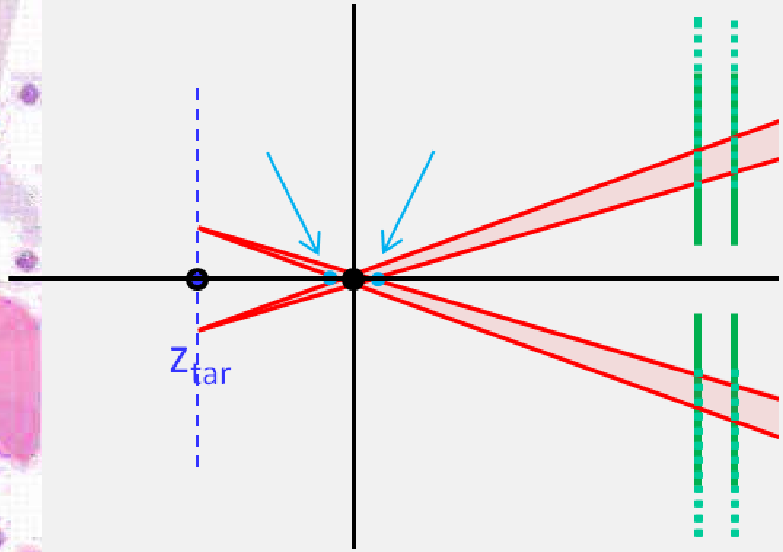
Internal alignment: target at a given z coordinate, not necessarily zero
Two beamspots on the yz plane, for top and bottom halves, not necessarily symmetric with respect to the z axis (this depends on the beam/z angle)



Effect of global alignment:

- the beamspots are pushed so that $z_0 \rightarrow 0$
- the SVT halves are closed towards the beamline
- the z true coordinate of the target remains in the same place but…

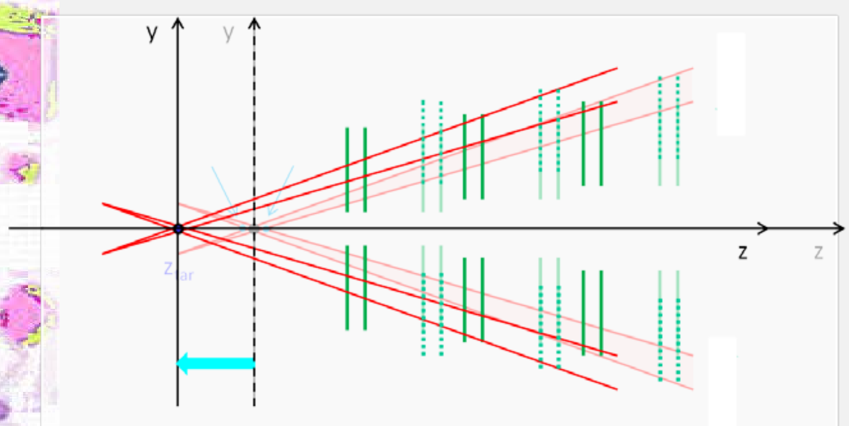
Møller events: finding/moving the vertex



Effect of global alignment:

• … the point of closest approach of the Møller tracks to the z axis depends on the opening angle of the tracks: **two vertices** large angle (large mass) and small angle (small mass)

• this accounts for the observed mismatch between the values found for the target z coordinate in FEE vs Møller events



If z_{Tar} is moved backwards to the position of the target as determined from FEE tracks, the sensors need to be moved along the y coordinate to compensate the origin retreat

• a new version for the internal alignment is needed

$\Rightarrow$ New sequence of iterations

Future plans/toDo list

- **Open issues**
  - 2015 data: steady state ✓
    - Consistency checks required when major changes on reconstruction are applied
    - Waiting from analyzers' feedback before considering further tunings
  - 2016 data, 0.5 mm:
    - Internal alignment ok ✓
    - final tuning of global alignment (if necessary)
    - 1.5 mm should be straightforward (only a tuning on global alignment could be required)
    - Evaluation of energy lost in sensors still awaiting for improvements (MC)
  - Long write-up in preparation (procedure instruction already available on confluence and working)

- **Further developments**
  - 2019++ data: alignment framework to be **fully** set up (additional layer0) and tested
  - Long term project: call millepede directly from the recostruction (in hps-java, and not as a standalone procedure as it is now)

- **Help needed to step over on this task for future data takings**

Summary of performances

- **2015 alignment, detectors @0.5 mm**
  - Detector final version (v6.0)
    - Momentum resolution: 6.4%σ
    - Mass resolution of $(e^- e^-)$ pair: 4.9%σ

- **2016 alignment, detectors @0.5 mm**
  - Pass1 production detector (v5-3-fieldmap)
    - Momentum resolution: 5.5%σ
    - Mass resolution of $(e^- e^-)$ pair: 4%σ
  - Development version
    - Same – not a real improvement so far on resolutions
      - Residuals are improved but their widths need to be reduced
    - With the present best-devel detector no real breakthrough on resolution is expected, even with a better internal tuning of the sensor positions

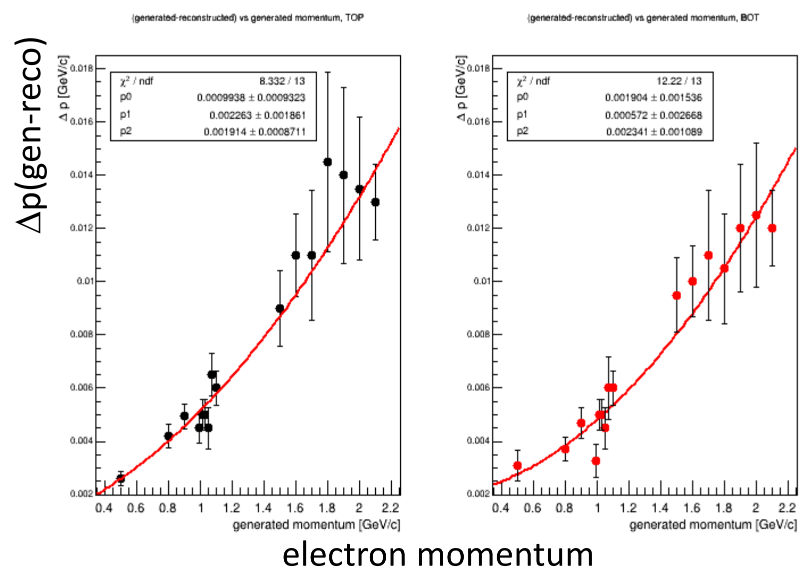
- Work in progress (often with problems between keyboard and chair)

BACKUP

Momentum calibration systematics

- Momentum calibration, 2 sources of systematics from real data:
  - Difference in mean values of elastic peak for top and bottom
    - 2015 data: ~ 2 MeV/c, 2016 data: ~8 MeVc
  - Deviation from expected nominal momentum value (lower)
    - 2015 data: -20 MeV/c, 2016 data: -30 MeV/c

- From MC electron gun generation:
  - Energy loss in sensors, multiple scattering of tracks in silicon
    - From Montecarlo: 5-6 MeV/c expected to be lost for 1.056 GeV/c electrons, ~15 MeV/c at 2.3 GeV/c (*including reco errors*)



  - Imperfect knowledge of magnetic field normalization
    - 2015 data: +9 G in the absolute field normalization could adjust the momentum scale (value probably within the measured magnetic field precision)