SVT Alignment update

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Outline

- Why is a new version of alignment needed?
- Focus on 2015 alignment: curved+straight tracks
  - Internal alignment
  - Global alignment:
    - Impact parameters
    - Beam spot (target) coordinates study
    - Momentum calibration
- First results on 2016 alignment (preliminary, work in progress)

2015 data: current and new alignment

Current alignment status

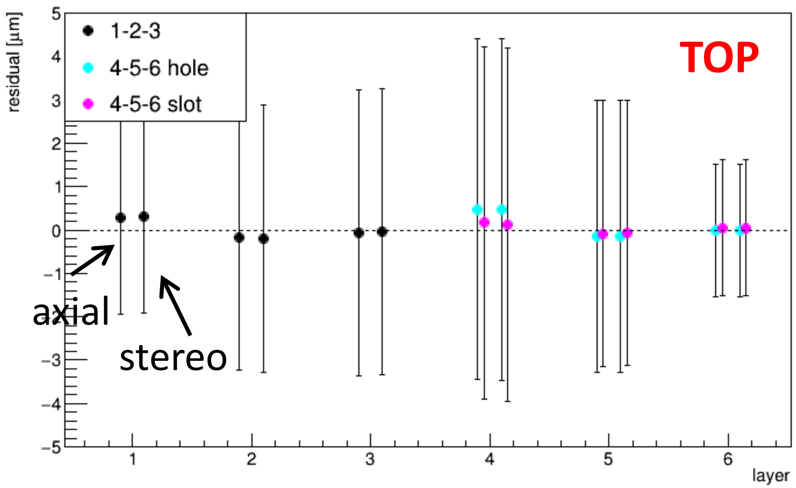
- Same alignment geometry available for 2015 and 2016 data, **tuned on 2015 curved tracks only (version 5.0)**
- Strategy: adjust sensor position and rotation (internal alignment) + tune weak modes (global translations)
  - Internal alignment: 6 degrees of freedom per sensor (actually, 5)
- Two steps:
  - Internal alignment provided by additive offsets by MillepedeII software leaving u translations only free to float (one offset per sensor)
  - Global alignment provided by tweaks: additive offsets applied to translational degrees of freedom for ALL sensors
    - Coherent displacement of a group of sensors
    - Information from selected samples: full energy electrons, Møller events

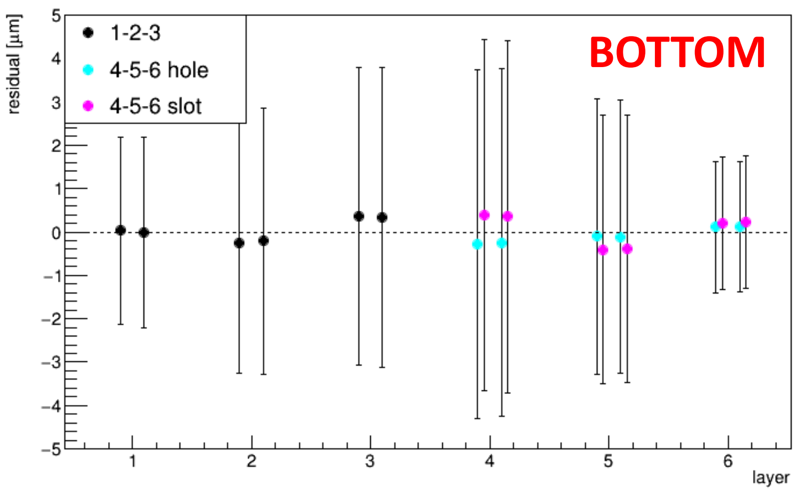
- **Tracks with magnetic field**: good results for 2015 data, satisfactory for 2016
- **Straight tracks**: *very bad* alignment quality

- Purpose of new studies: provide a geometry which works for both curved and straight tracks – goal: achieve residuals better than 2 μm, width below 5 μm

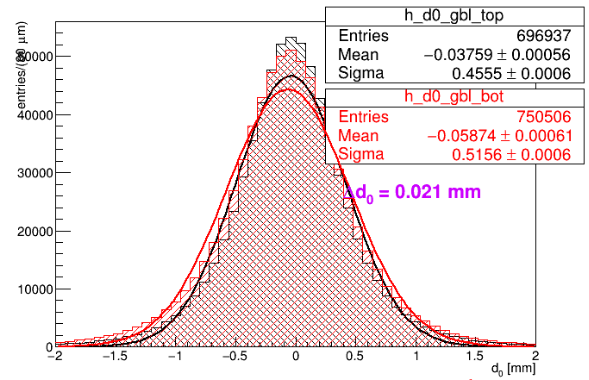
Current alignment 2015: curved tracks

u residual mean value/σ

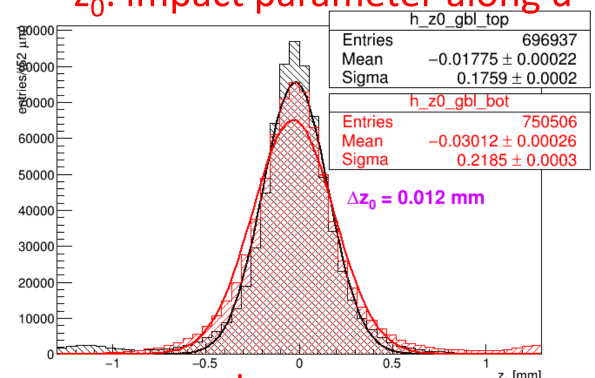




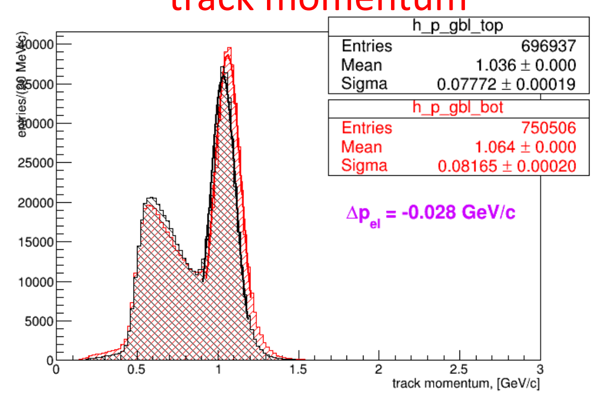
d_0: ~impact parameter along v



z_0: impact parameter along u

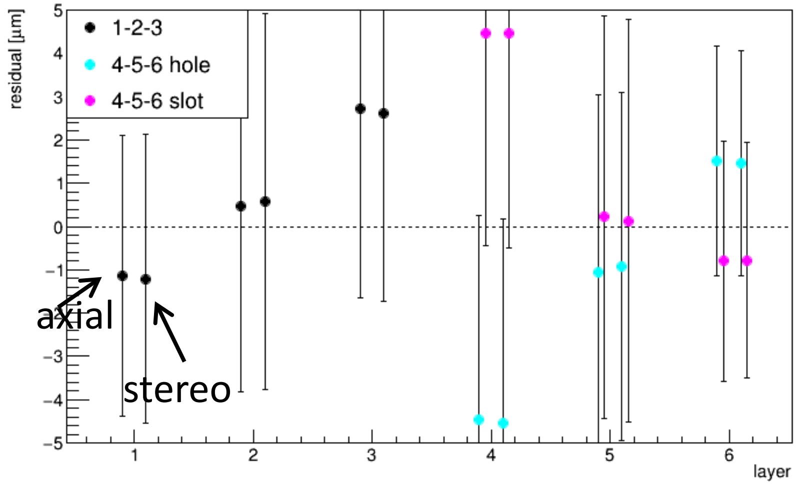


track momentum

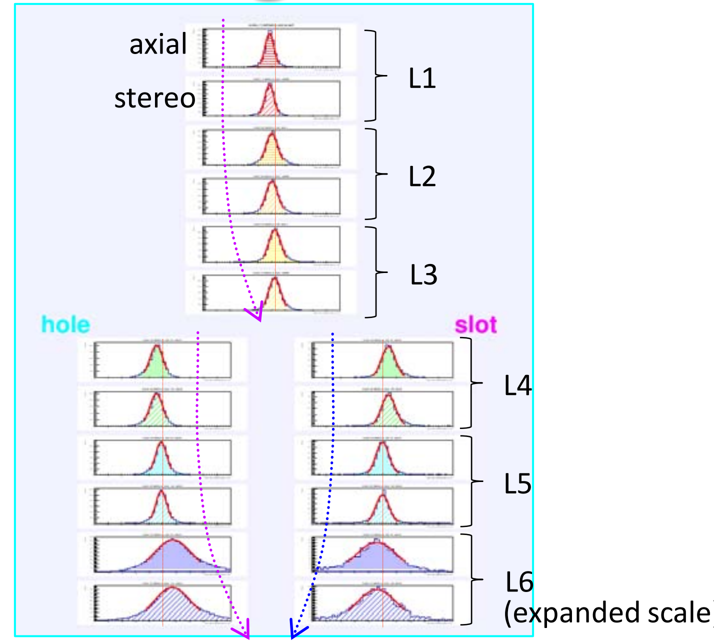


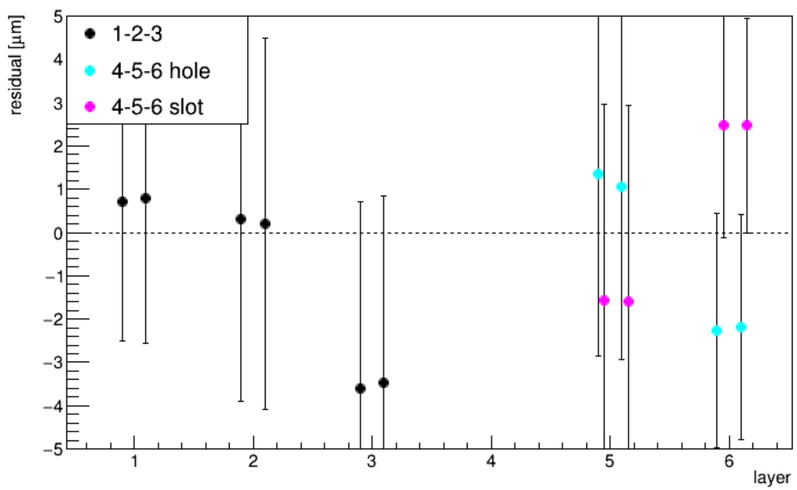
Current alignment 2015: straight tracks

u residual mean value/σ

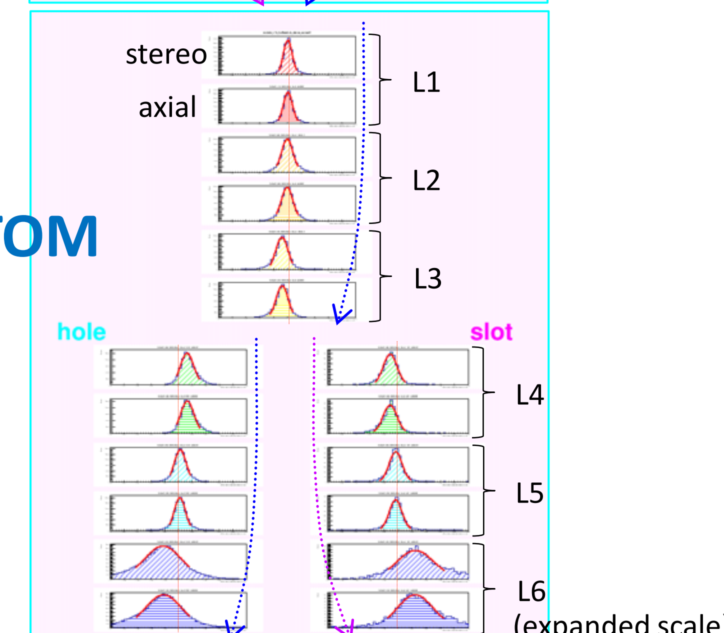


TOP





BOTTOM



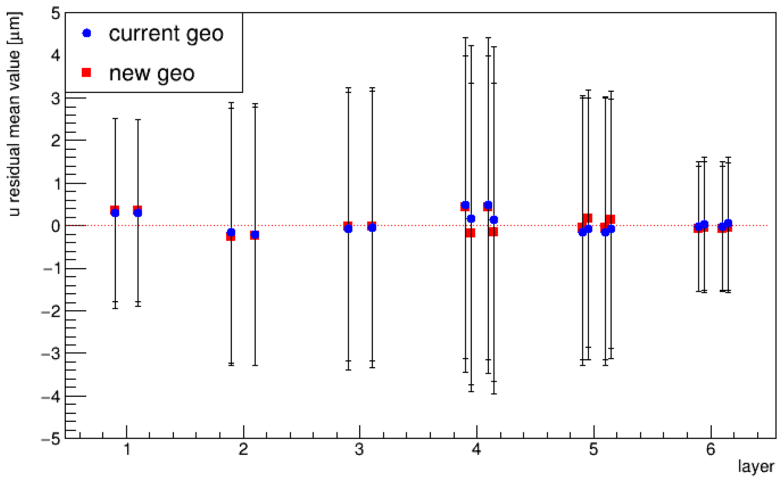
New-geo 2015: systematic approach for internal alignment

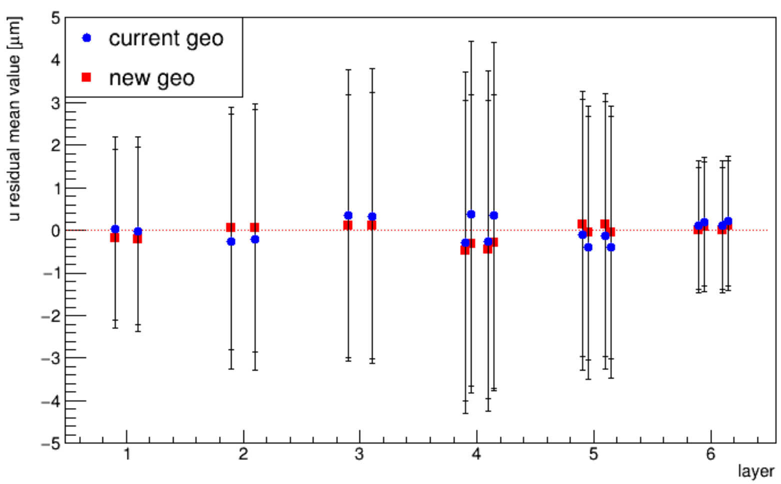
- Start from scratch from ideal geometry including optical survey
- Standard reconstruction: all tracks with at least 5 hits accepted out of all strategies, just ghost hits removed
- Work out stepwise alignment learning from the results of the previous iteration
- Apply Millepede on a mixed track sample, curved/straight tracks (700K x2) equally weighted
- Float sensors one by one (or groups of sensors belonging to the same stack), including , in order:
  - u translations (measurement direction, ~y axis in jlab ref system)
  - w translation (~z axis)
  - rotations around all axes
    - Rotations provide a way to modify the position of the sensor along the strip direction
- Last step: inclusion of the beam spot/vertex (curvilinear/perigee frames) constraints
  - As Millepede offsets
  - introducing “global” alignment tweaks as translational offsets to all sensors

2015 new alignment: u residuals

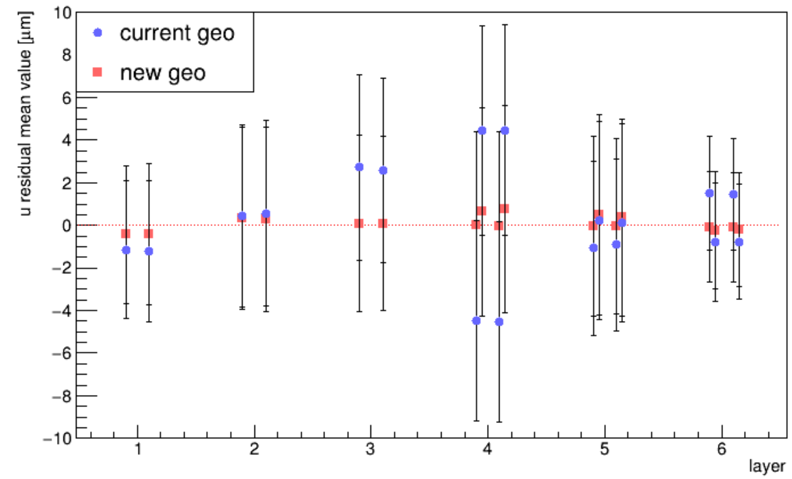
Blue: current geo
Red: new geo

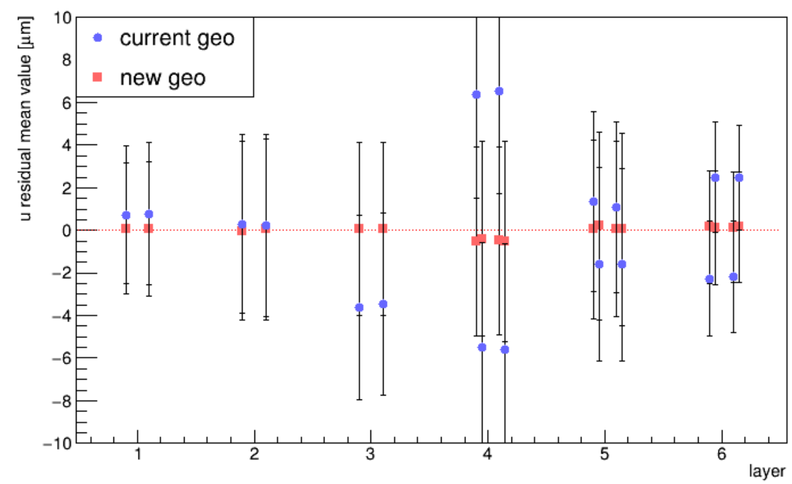
New geometry curved tracks





New geometry straight tracks



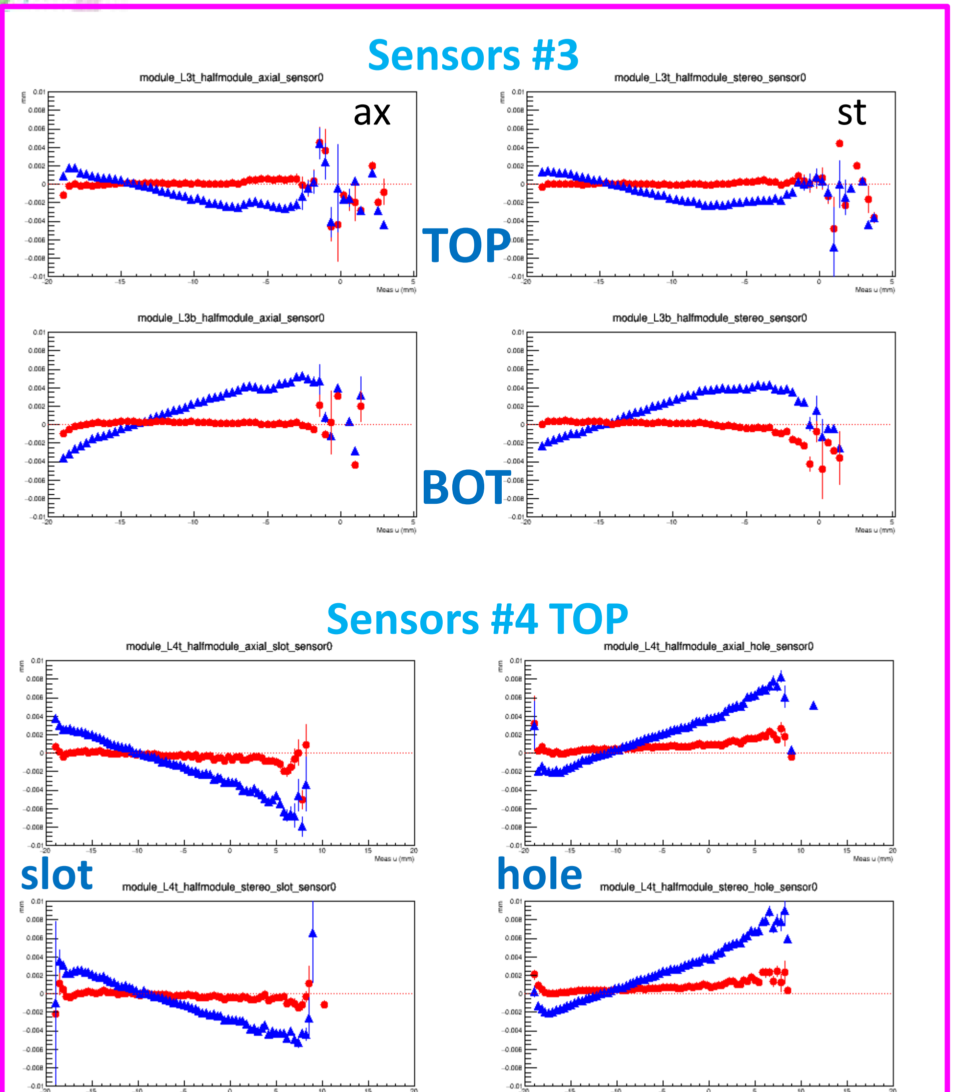


New alignment quality: u res vs u scatter plots

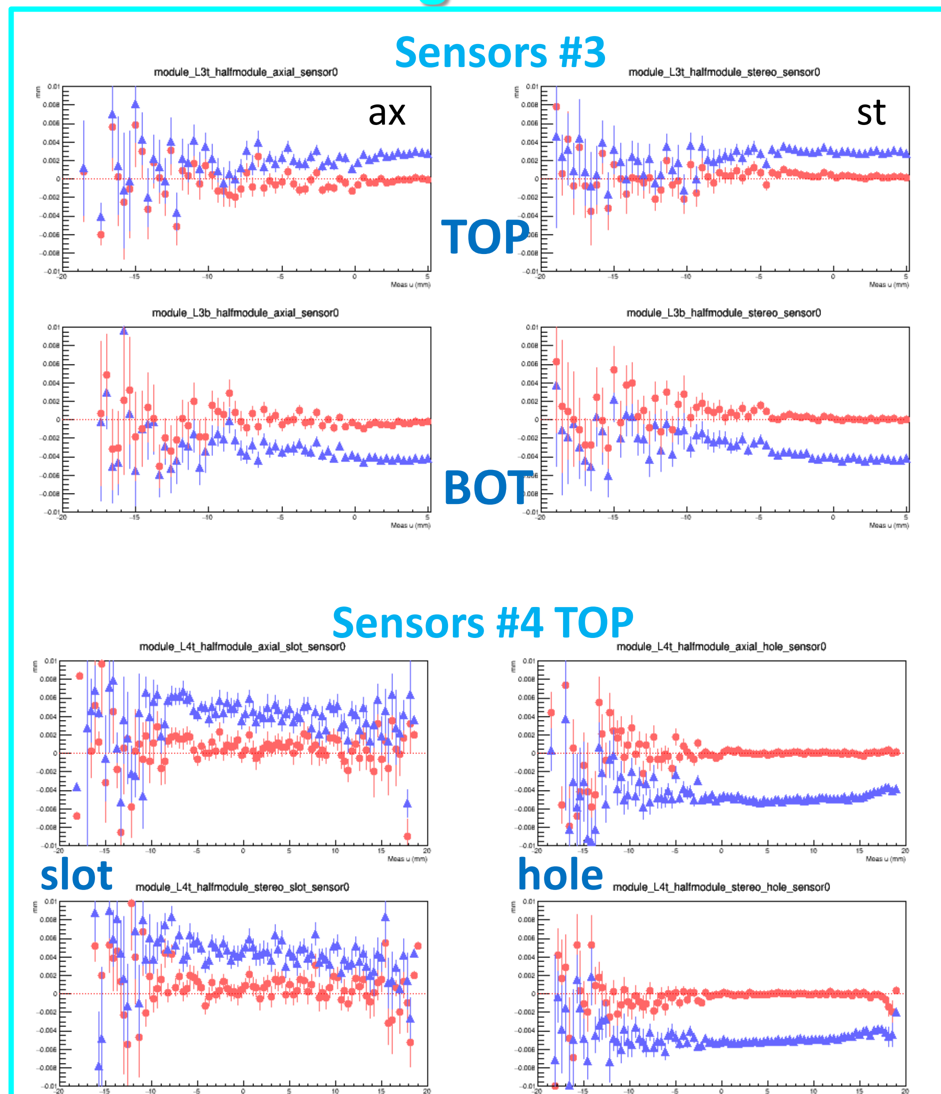
Sensitive to rotations around w axis

Blue: current geo
Red: new geo

Curved tracks



Straight tracks

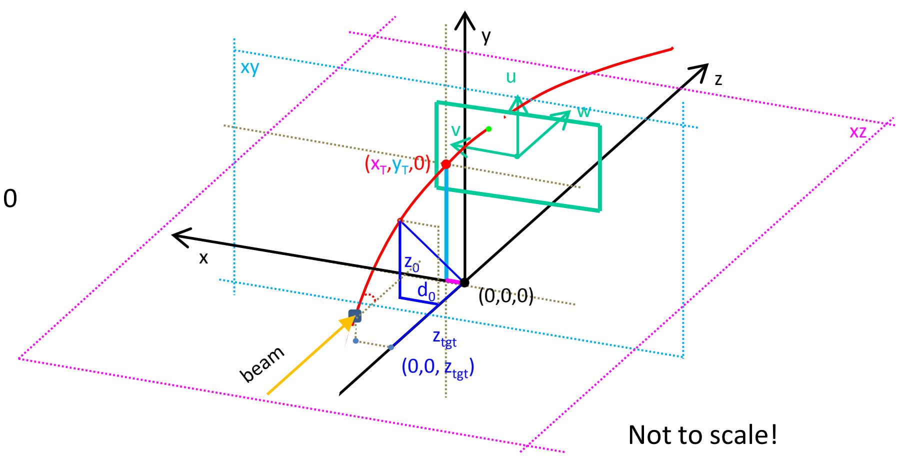


Beam spot constraints

- The beam spot coordinates introduction *is not* a weak mode of the alignment
  - Sizeable impact on the internal alignment quality

– Millepede based approach
  - Insert two fake additional layers-0 (T&B) centered at the axis origin and determine by MP the translational offsets necessary to make the top and bottom tracks pass through the same point on this layer
    - 6 more degrees of freedom bound by three constraints relating top/bottom
    - Difficult to get a reasonable convergence of the minimization
    - very limited improvement on the overall alignment

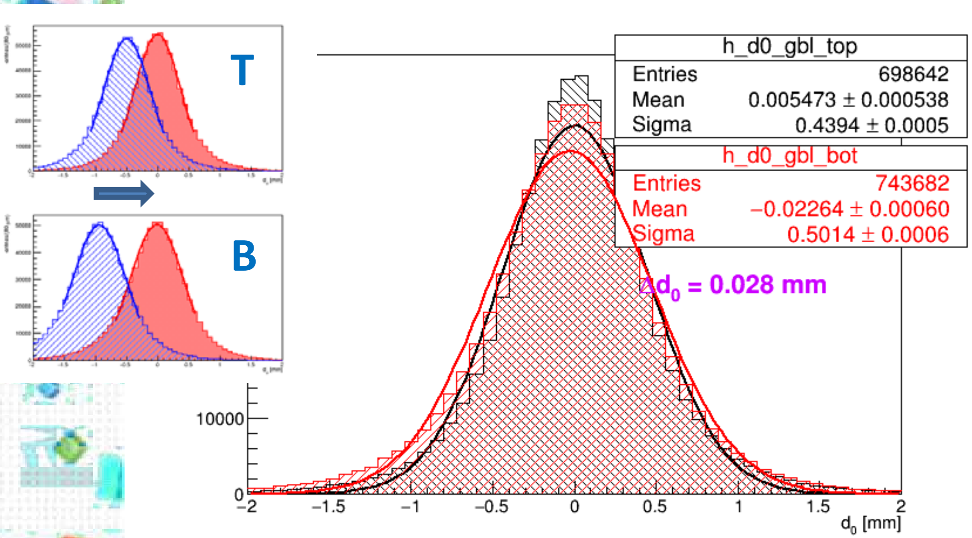
– Use impact parameter distributions and exploit correlation of the target position with the dip angle
  - Global offset along measurement direction u: ~z_0
  - Global offset along the strip direction v: ~d_0
  - Global offset along w: study $\tan\lambda$ vs y_T correlation

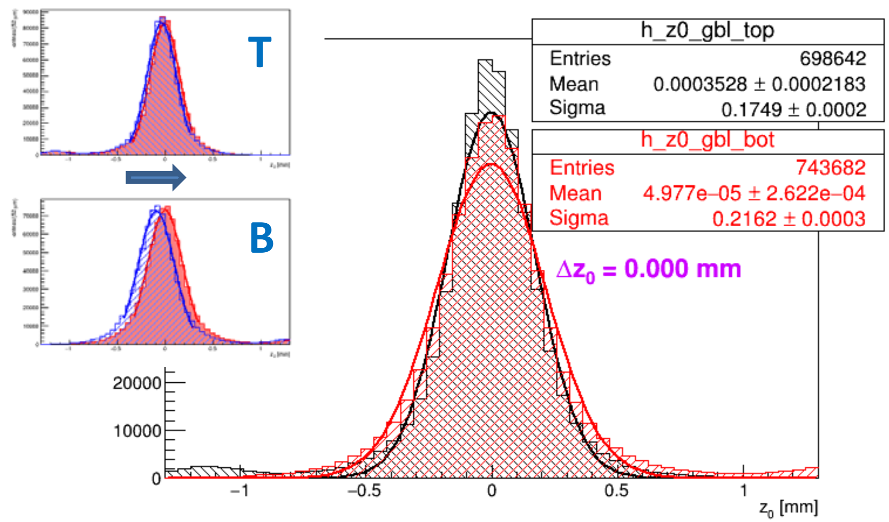


Not to scale!

Global alignment 2015: impact parameters and target coordinates

- Impact parameters d_0 and z_0 are used to bring to (0,0,0) the (x_T,y_T, z_T=0) coordinates (point of closest approach in the plane z_T=0)



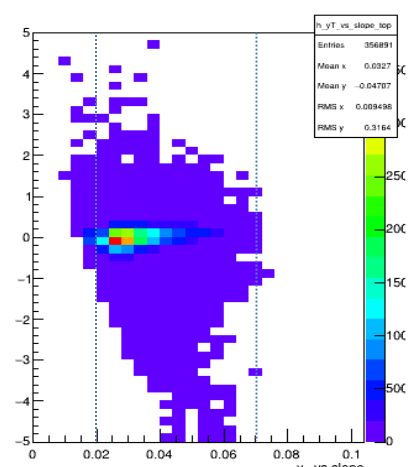


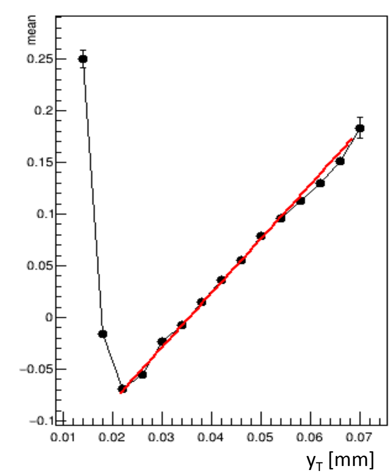
- Information on target coordinates: y_T (x_T) vs slope correlation for FEE tracks

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

Top tracks:

p_0 = -0.185 mm, p_1 = 5.23 mm

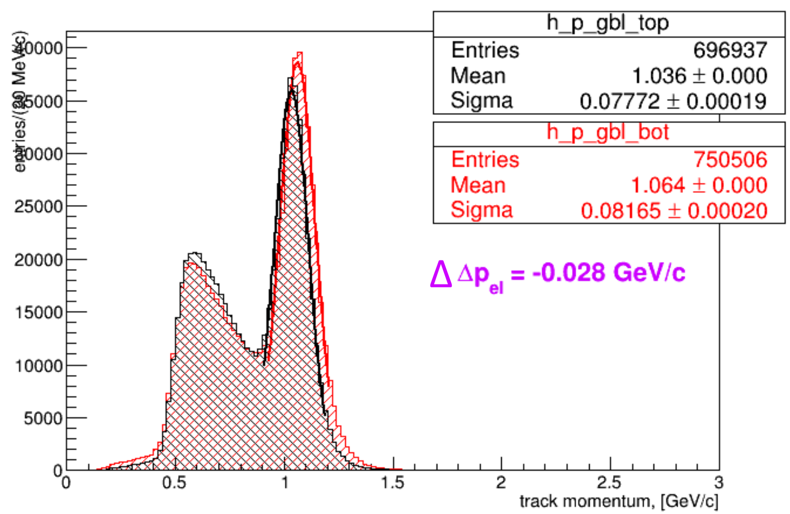




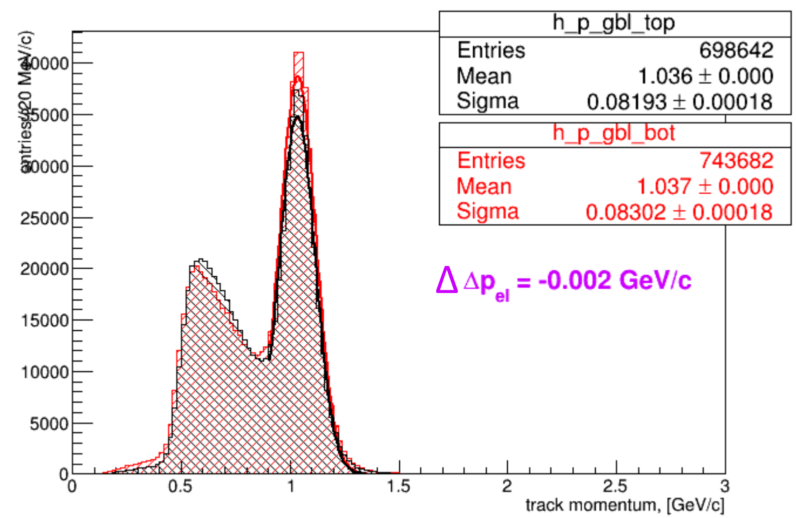
2015 data: momentum calibration

- Last global calibration: momentum scale
- Depends on the track curvature: not a weak mode
- Study on elastic peak: require convergence of top and bottom estimations to the same mean value AND calibration to the nominal expected momentum
- Systematic underestimation of about 20 MeV/c (also present with current alignment)

Current geometry



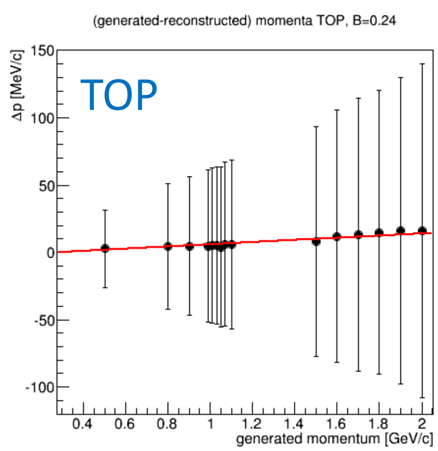
New geometry



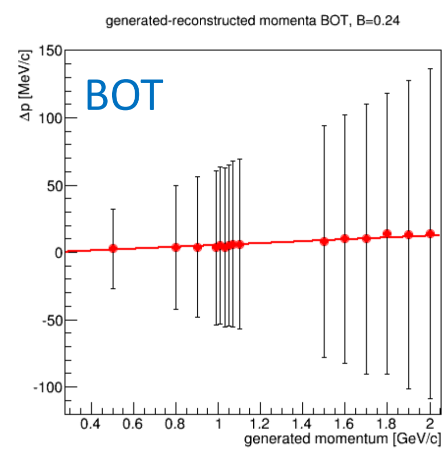
Montecarlo studies of energy loss

- Purpose: study the source of this underestimation by Montecarlo data
  - Energy loss in the sensors not properly taken into account by GBL?
  - Energy lost in the target before emission?
  - Radiative losses? (slightly asymmetric peak)

- Study of the reconstruction response to fixed momentum electrons
  - Simulation: include energy loss in the silicon layers and multiple scattering effects
  - Reconstruction through GBL as for real data
  - Slightly linear trend of the underestimation: about 5-6 MeV/c of systematic error for 1.056 GeV/c tracks



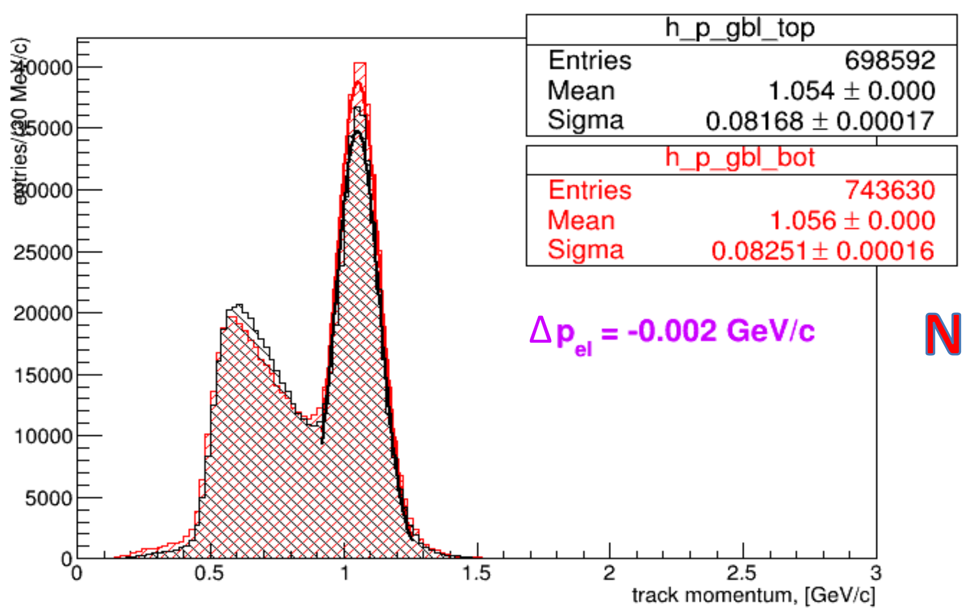
Δp (MeV/c) = -2.4 + 8.2p_{gen} (GeV/c)



Δp (MeV/c) = -1.6 + 6.9p_{gen} (GeV/c)

Magnetic field issue?

- Some simple tests replacing the magnetic field map with a constant field along y with a small change in the overall intensity
- 2015 map: maximum field B_y = -0.2436 T
- A constant magnetic field of intensity B_y = -0.2445 T can help moving the elastic peak to the expected position (ΔB_y = 9 G)
- No effect on internal alignment quality

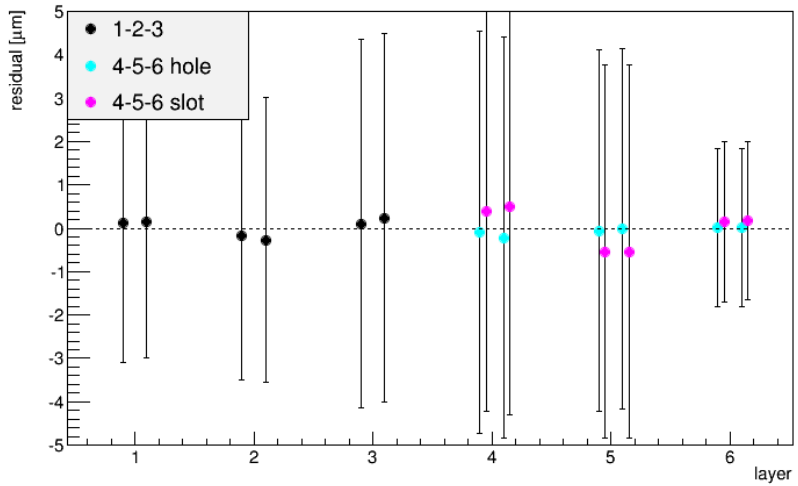


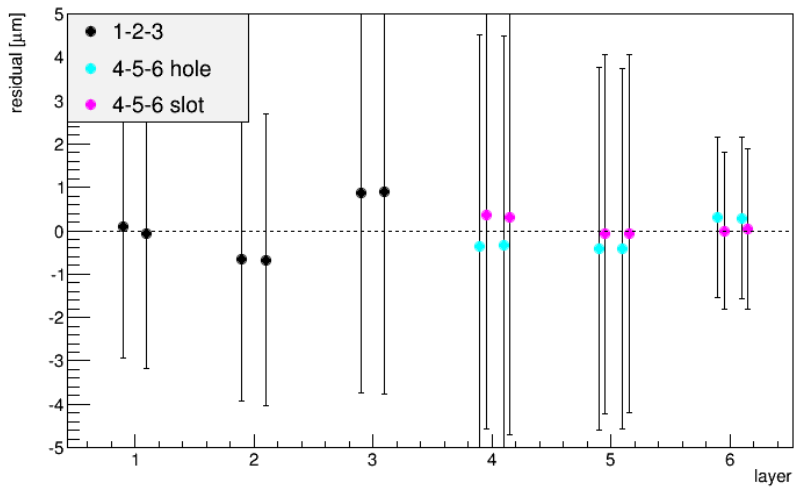
New geometry & B_z = -0.2445

2016 data: current vs new alignment – preliminary results

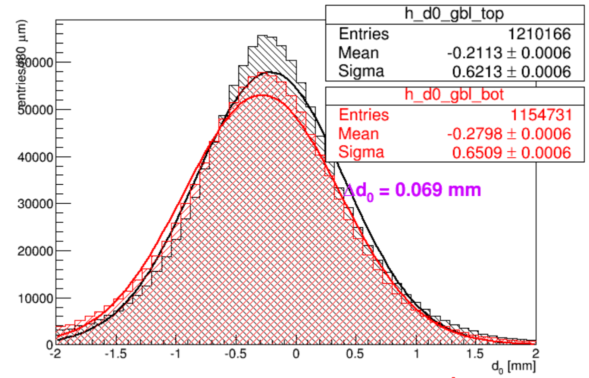
Current alignment 2016: curved tracks

Not optimized for 2016 data taking

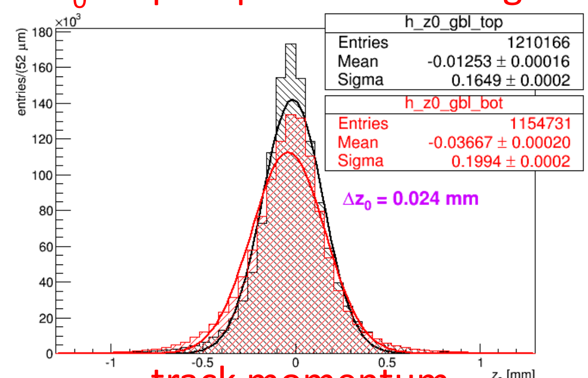




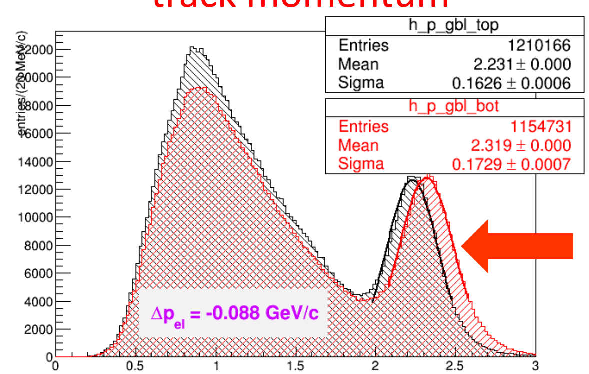
d_0: ~impact parameter along v



z_0: impact parameter along u



track momentum

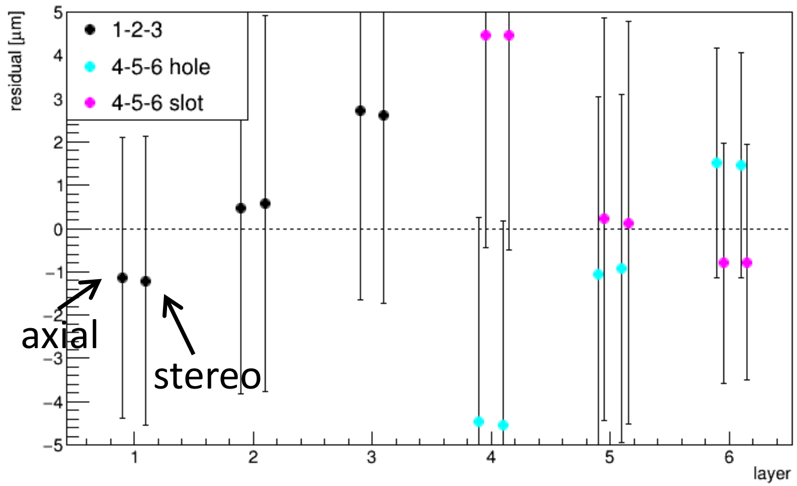


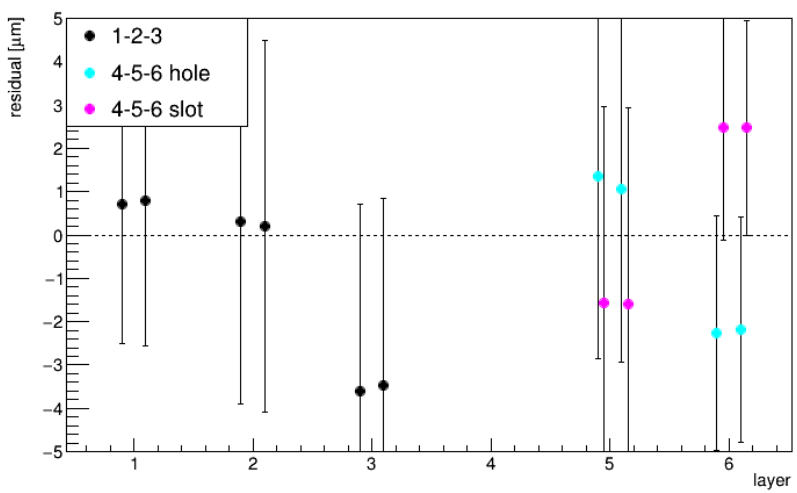
Bottom section more critical (vacuum pulling effect?)

Current alignment 2016: straight tracks

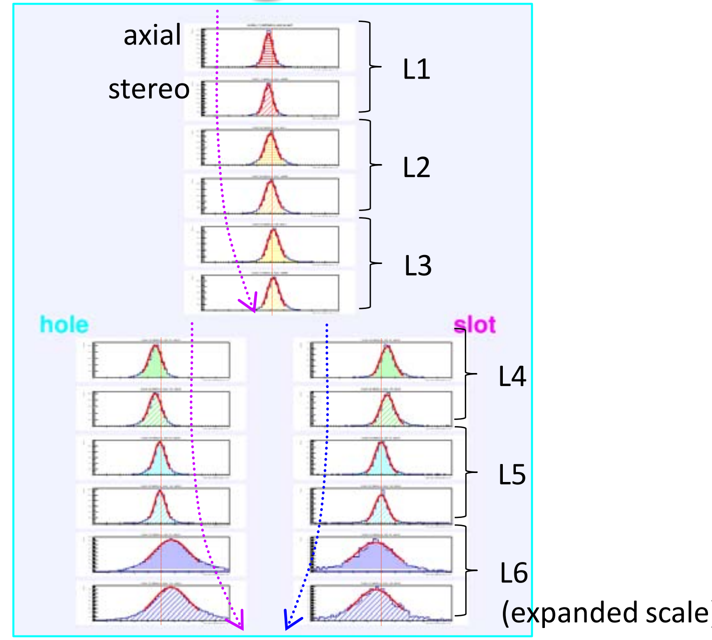
Not expected to any be better than for 2015 data!

u residual mean value/σ

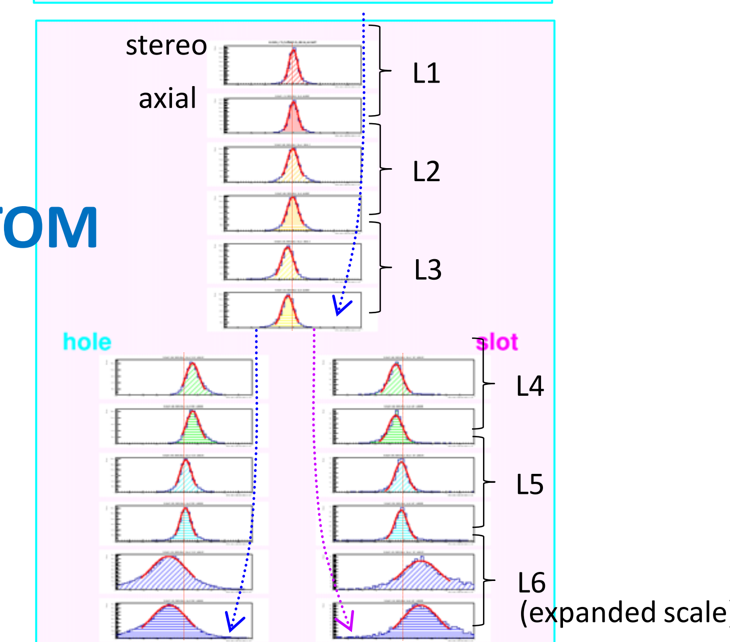




TOP

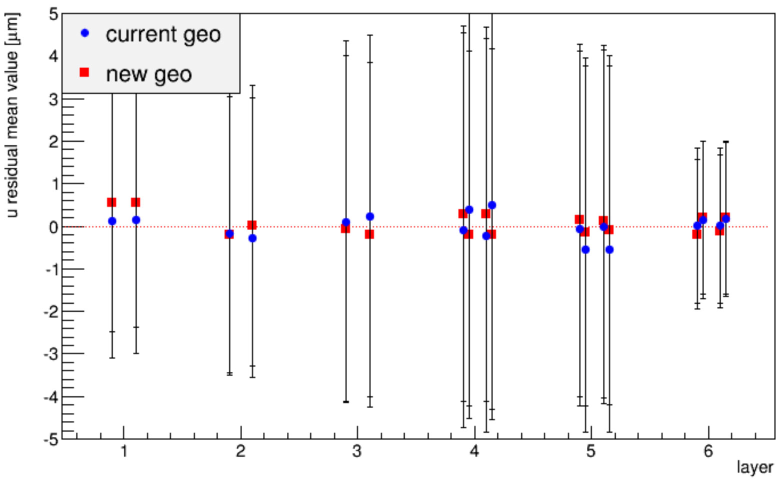


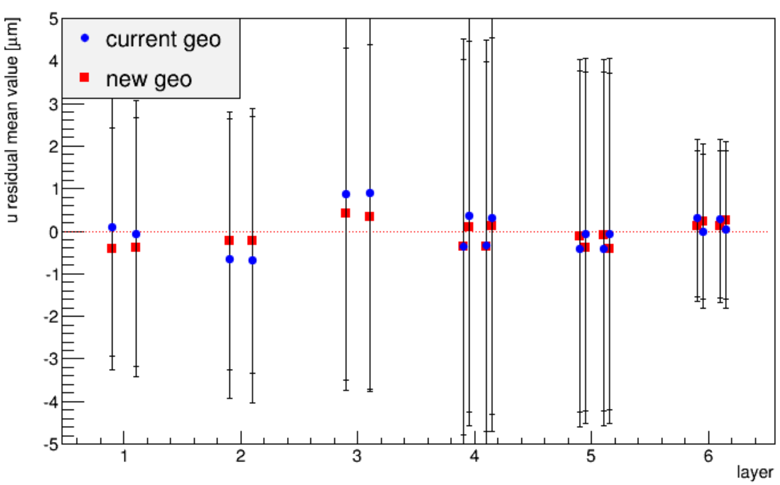
BOTTOM



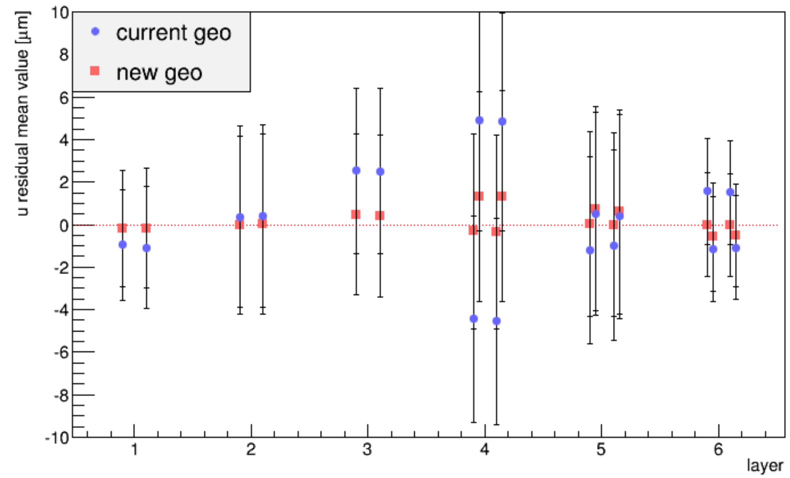
2016 internal alignment: preliminary results and comparison with current geo

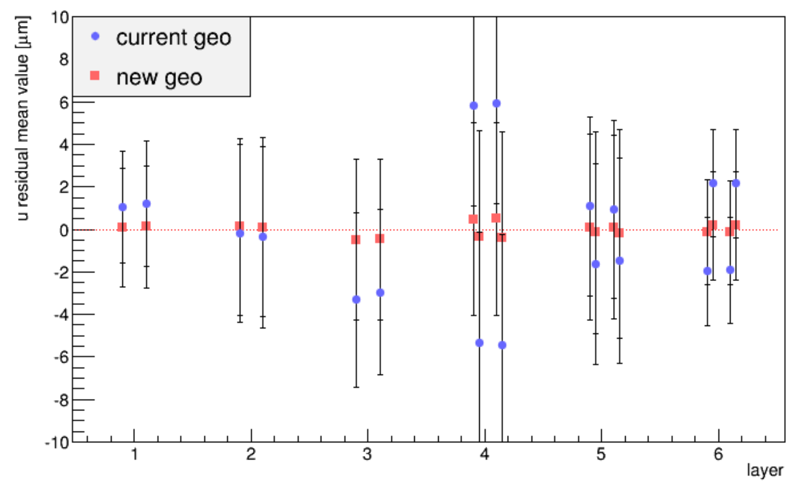
New geometry curved tracks





New geometry straight tracks



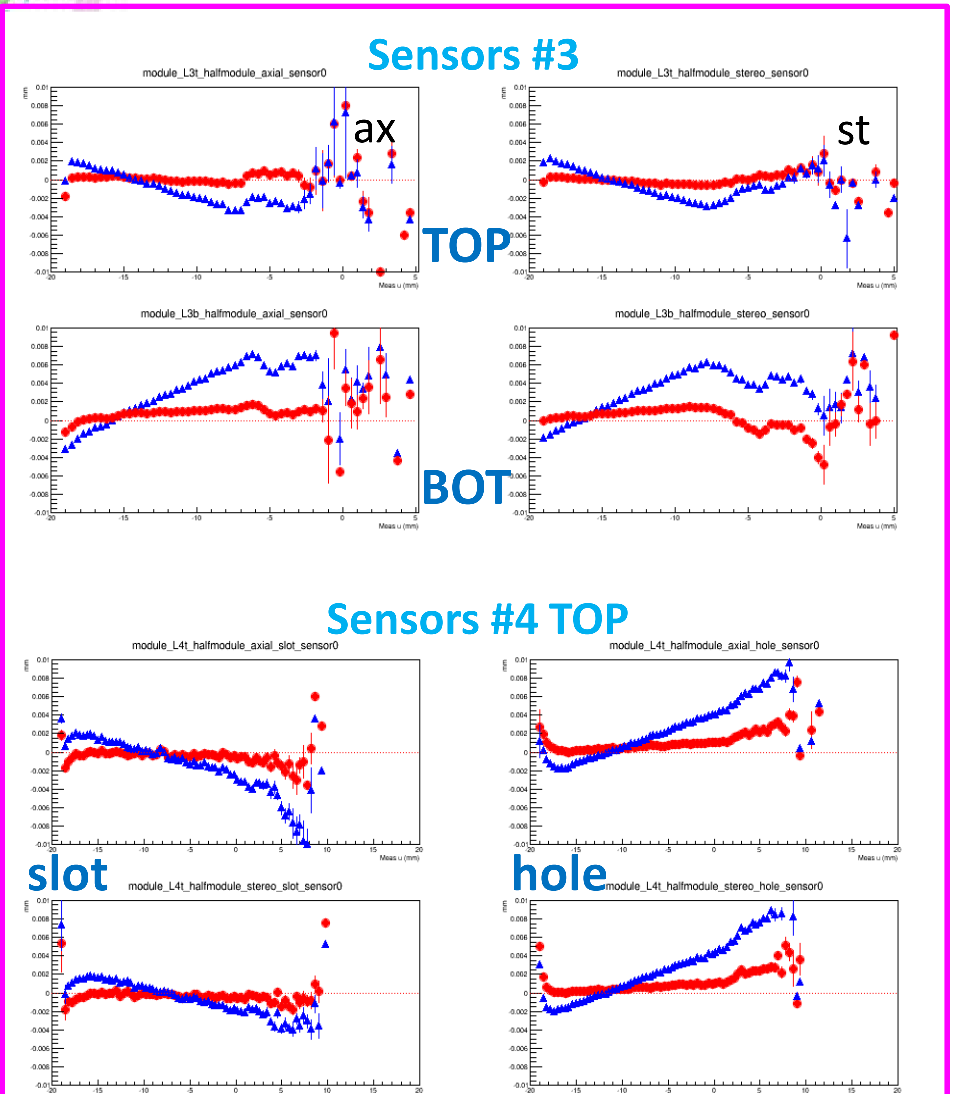


New alignment 2016: u res vs u scatter plots

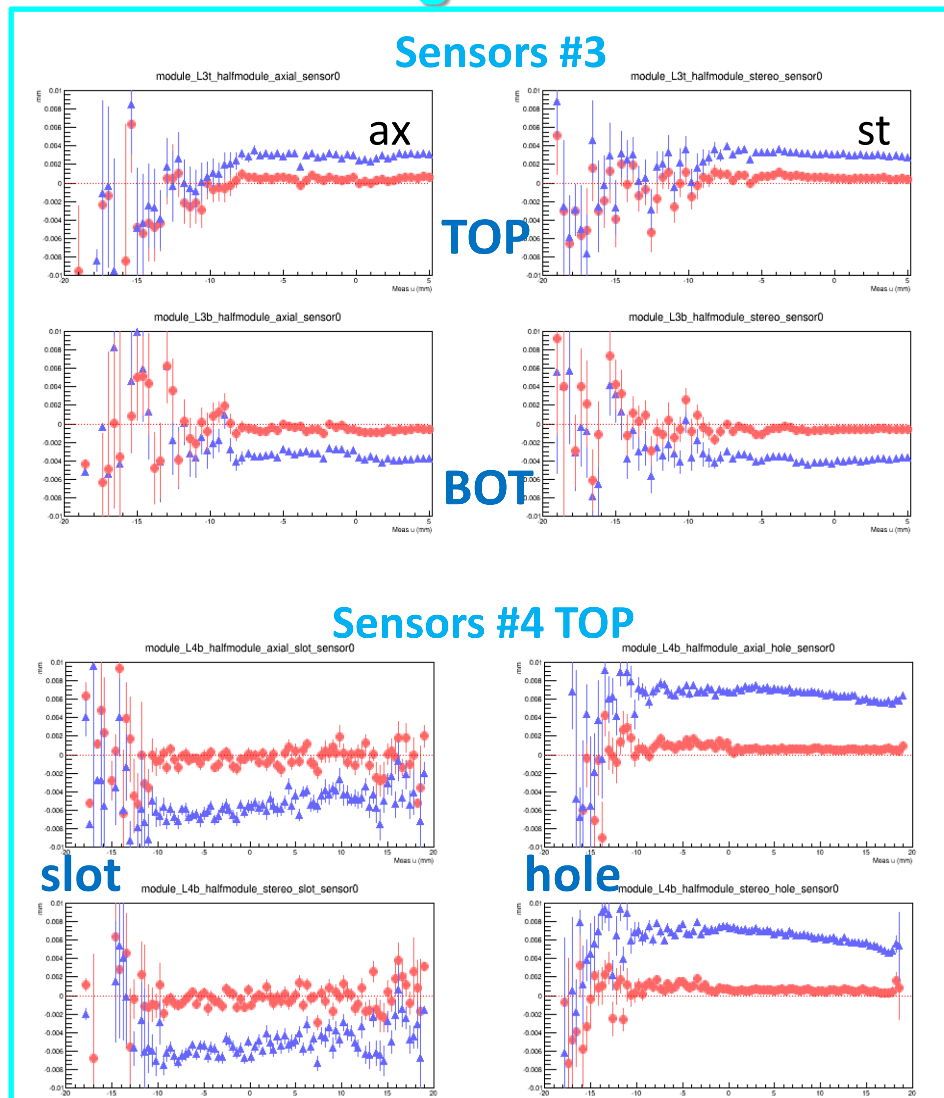
Sensitive to rotations around w axis

Blue: current geo
Red: new geo

Curved tracks

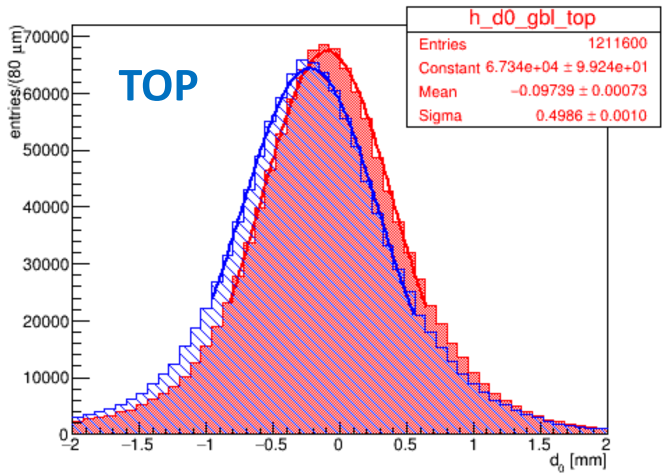


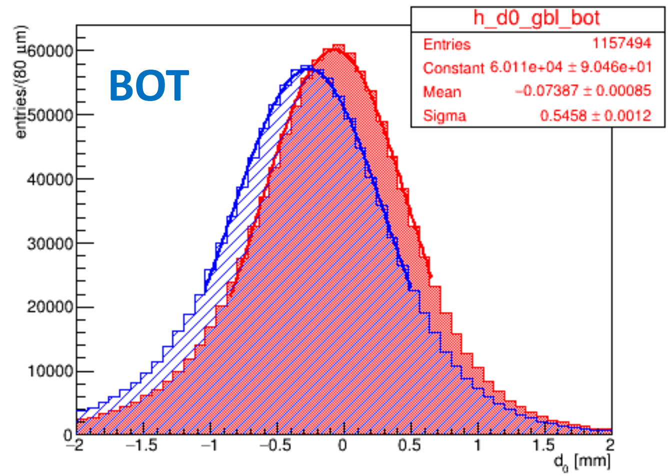
Straight tracks



2016 global alignment (impact parameters)

d_0 impact parameters



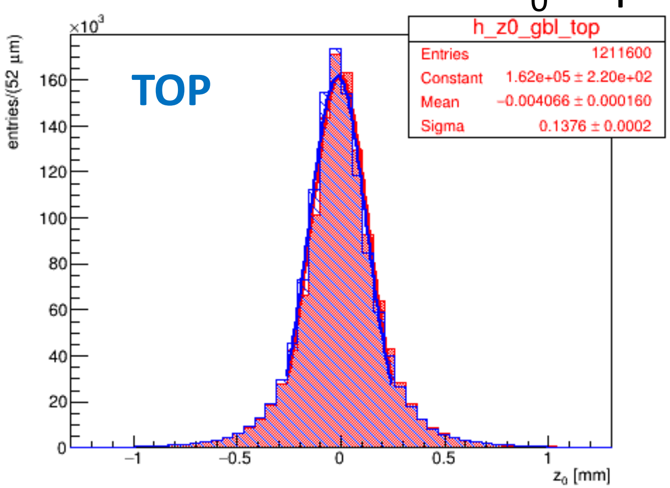


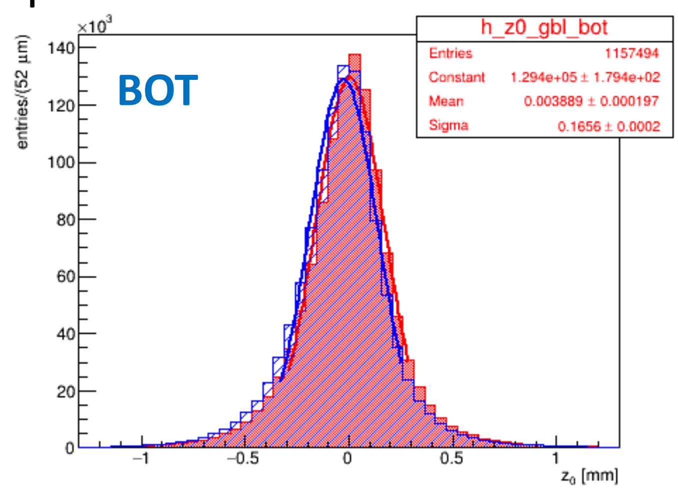
Current geo

New geo

The new geometry provides a better centering to (0,0) (~90 μm along v, ~4 μm along u)

z_0 impact parameters

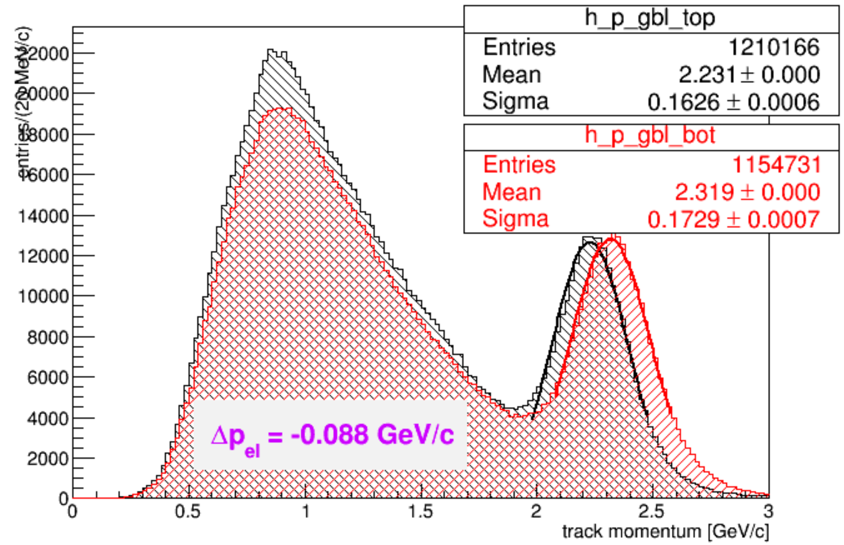




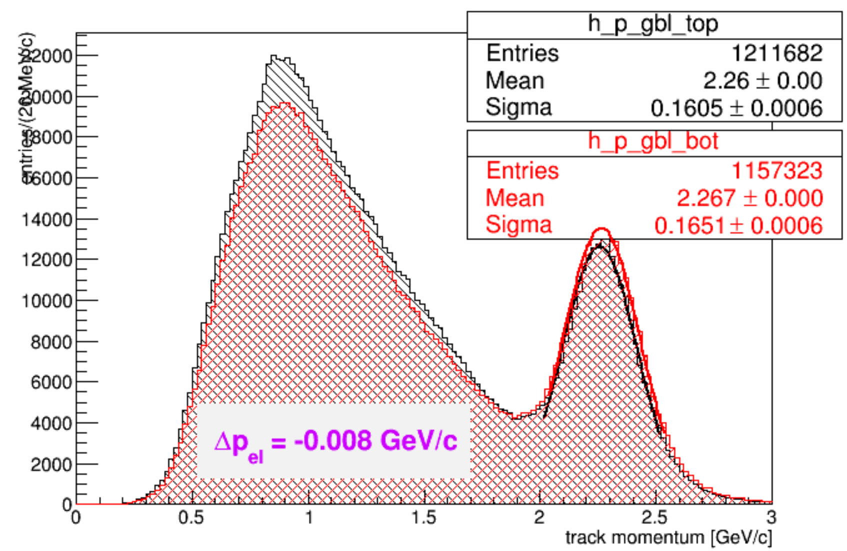
2016 momentum calibration: elastic peak

- Current geometry
  - Mismatch mismatch top vs bottom: 88 MeV/c
- New geometry
  - agreement top/bot within 8 MeV/c
  - Underestimation of ~30 MeV/c wrt to nominal beam momentum
  - Magnetic field correction currently under study

Current geometry



New geometry



Outlook

- **2015 data taking:**
  - Few more tunings related to the absolute momentum calibration/possible magnetic field issues
  - New-geo 2015 ready for release as compact.xml file: massive test on a consistent data sample needed
    - Possibly the same set used for current analyses, to compare results quality with the same set of cuts
- **2016 data taking:**
  - Some work still needed to optimize aligned geometry
    - Speedier procedure (now that the path is defined and a good starting point is available, following the same steps as for 2015 data)
    - Slower data reconstruction (…so it takes time, anyway)
- Codes for alignment and analysis available on git for the braves who want to enter the challenge and help out

Software git repositories

- How-to instructions for GBL+Millepede analysis
  - http://confluence.slac.stanford.edu/display/hpsg/SVT+Detector+Alignment
- GBL software (forked from phansson git repo)
  - https://github.com/afilippi67/hps-gbl.git
  - Checkout Align2016 branch
- MillepedeII software (forked from phansson git repo)
  - https://github.com/afilippi67/hps-mille.git
  - Checkout Align2016 branch
- Data quality checks: root macros
  - https://github.com/afilippi67/DataQualityMacros.git

    (check out branch root6, master branch compliant to root 5.34)