SVT Alignment

Per Hansson Adrian for the SVT group

HPS Collaboration Meeting – 10/26/2015

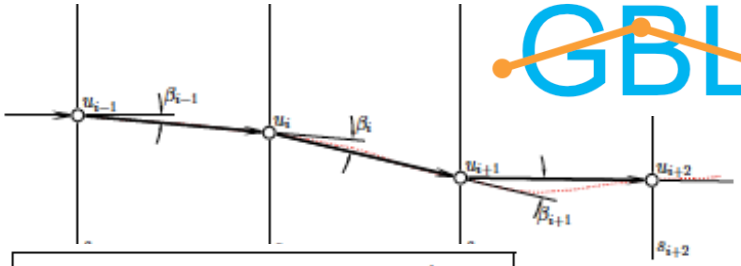
Outline

Where we have been

What we have been doing

Where we are

Where we are going



$$S(\boldsymbol{u}) = \sum_{i=1}^{n} \frac{(y_i - u_i)^2}{\sigma_i^2} + \sum_{i=2}^{n-1} \frac{\beta_i^2}{\sigma_{\beta,i}^2}$$

MPII

Minimize a “chi2” from entire data sample

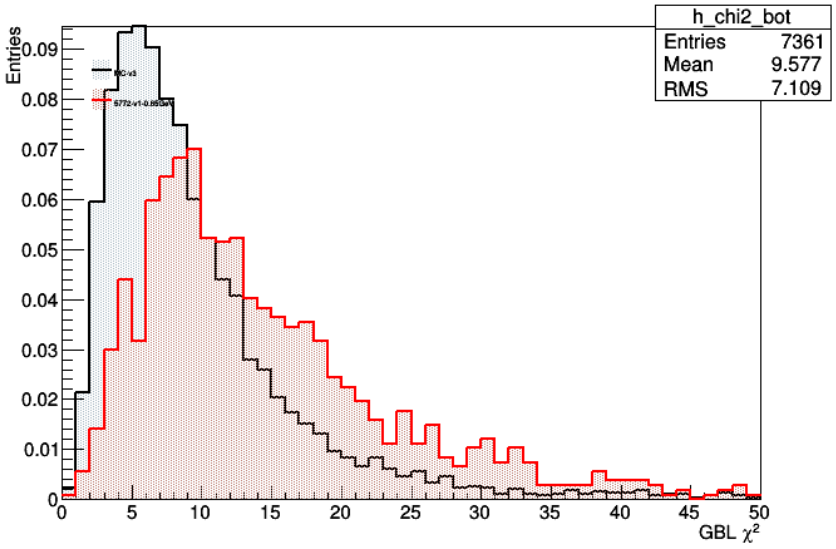
$$\chi^2 = F(\mathbf{q},\mathbf{p}) = \sum_i \left(\frac{(y_i - f(x_i,\mathbf{q}_j,\mathbf{p}))^2}{\sigma_i^2} \right)$$

Wiggly path

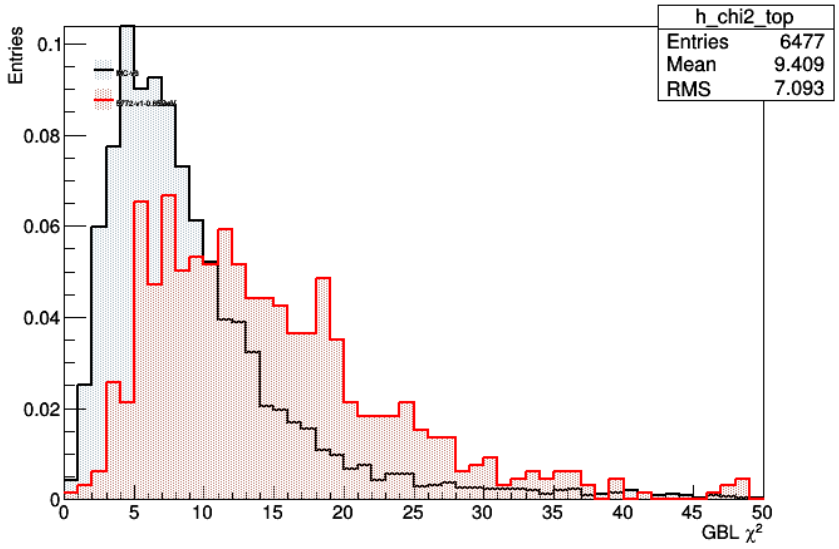
- Start with “as designed”; opening angle corrections (during run)
- Process and apply survey
- Add “simple” global constraints
- Refine internal alignment
- Include beamspot constraints for top and bottom

Where we started: fit quality

bottom

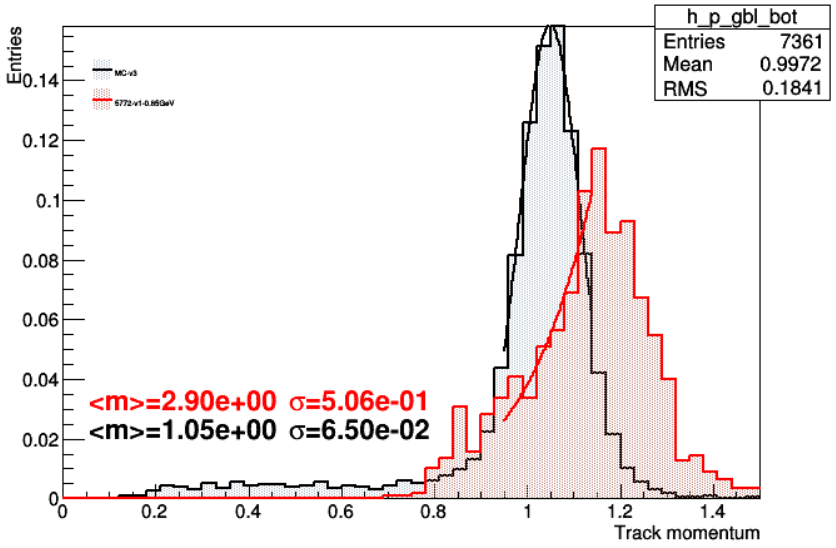


top



Where we started: momentum

bottom



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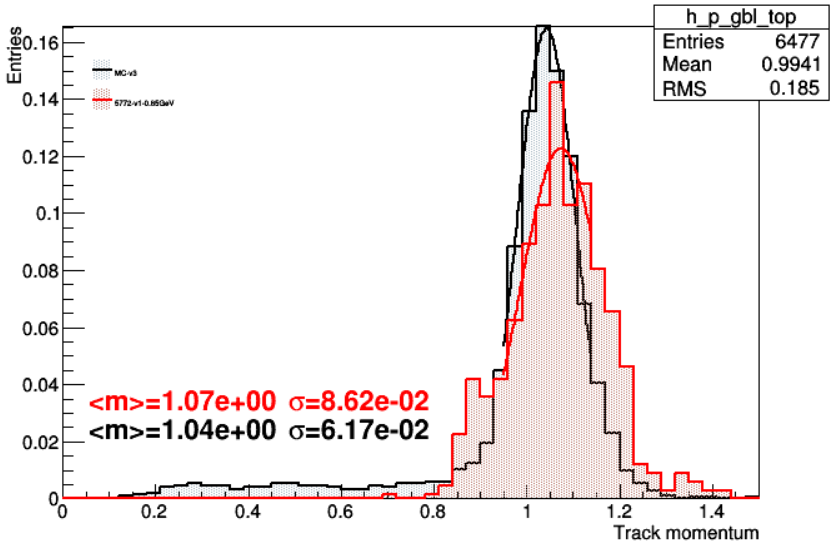
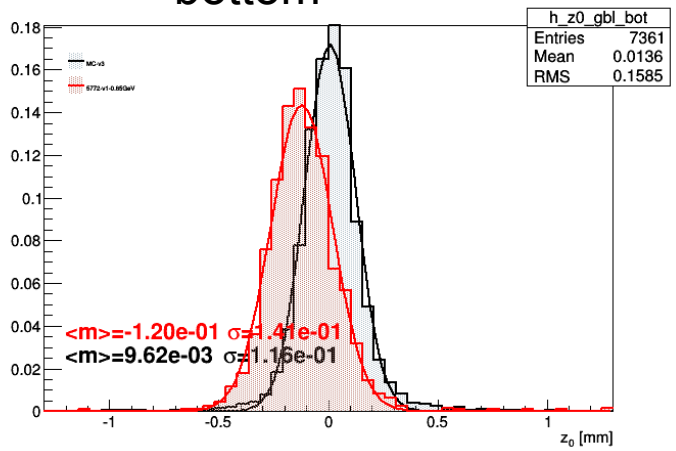


Where we started: impact parameters

bottom



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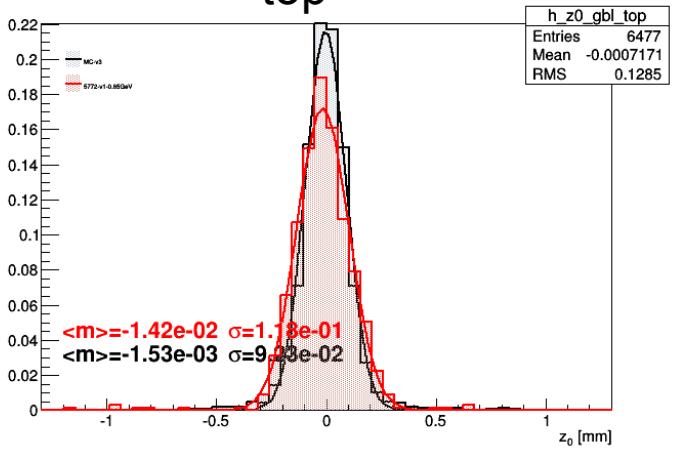
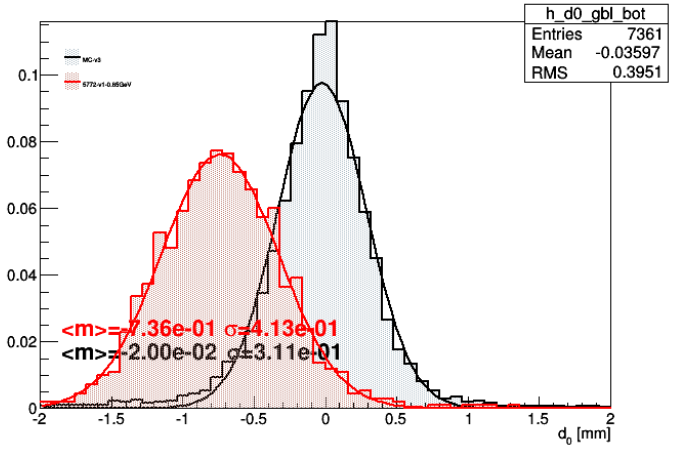
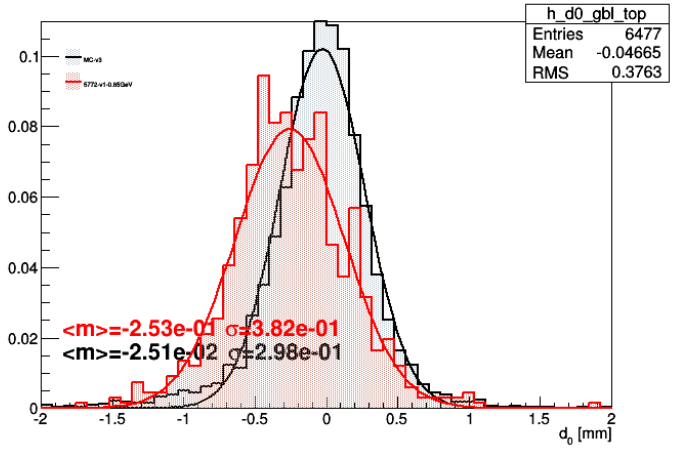
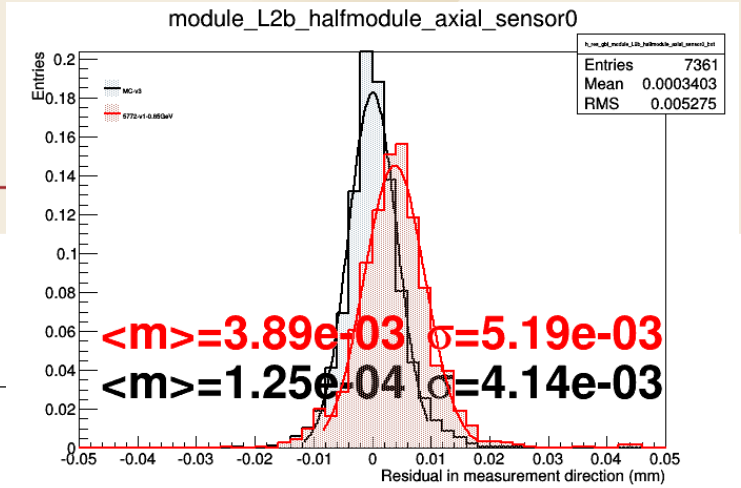


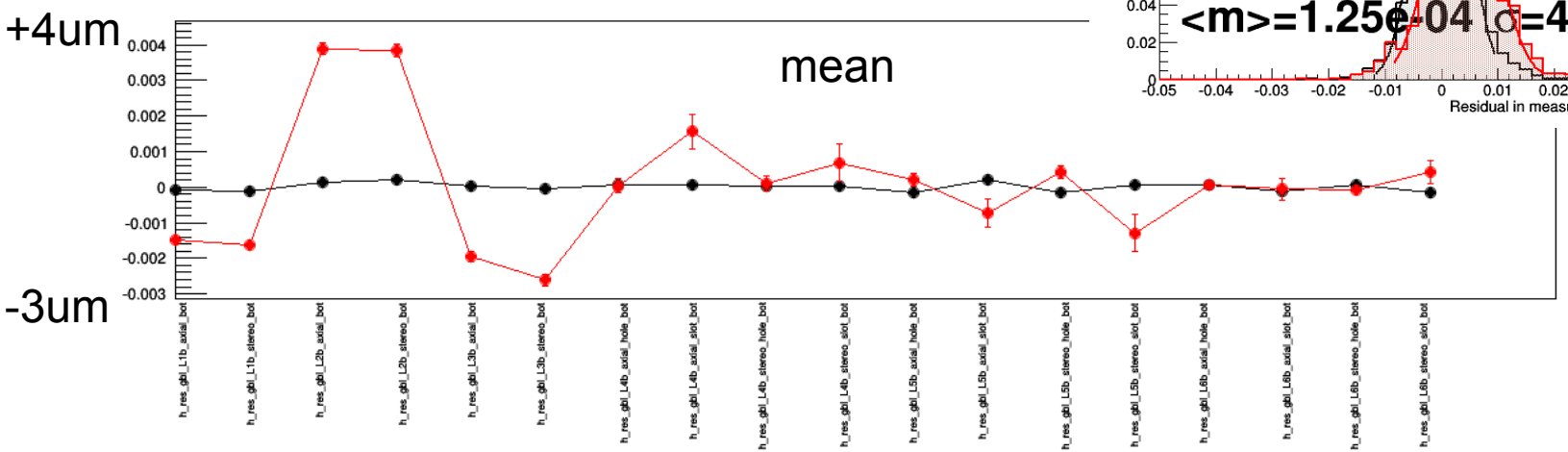


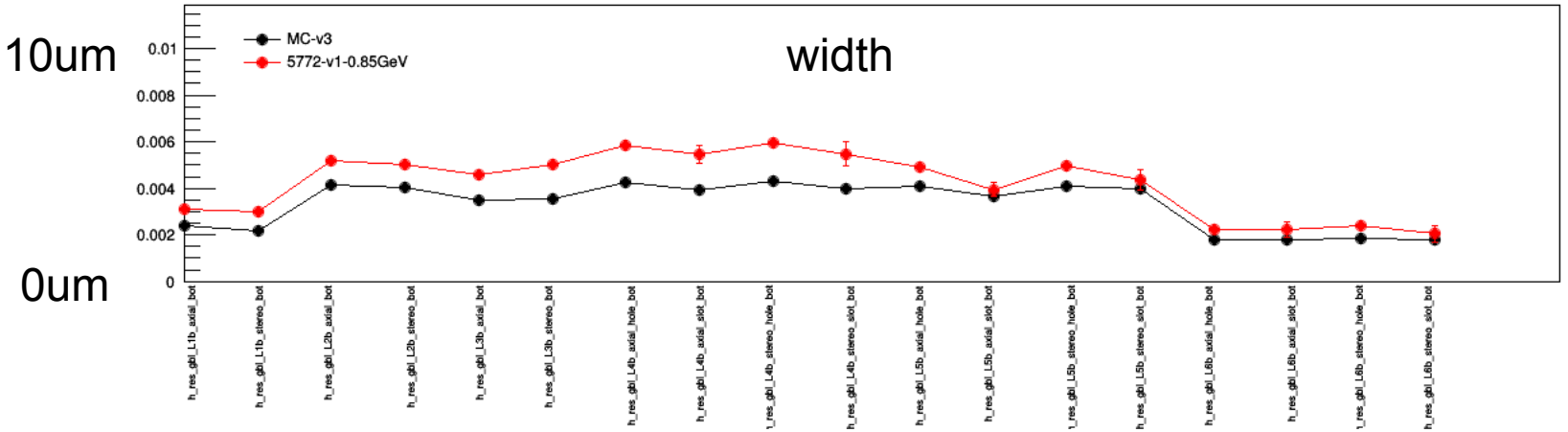


Where we started: residuals

Bottom local sensor residuals







Incorporate Mechanical Survey

Mechanical survey

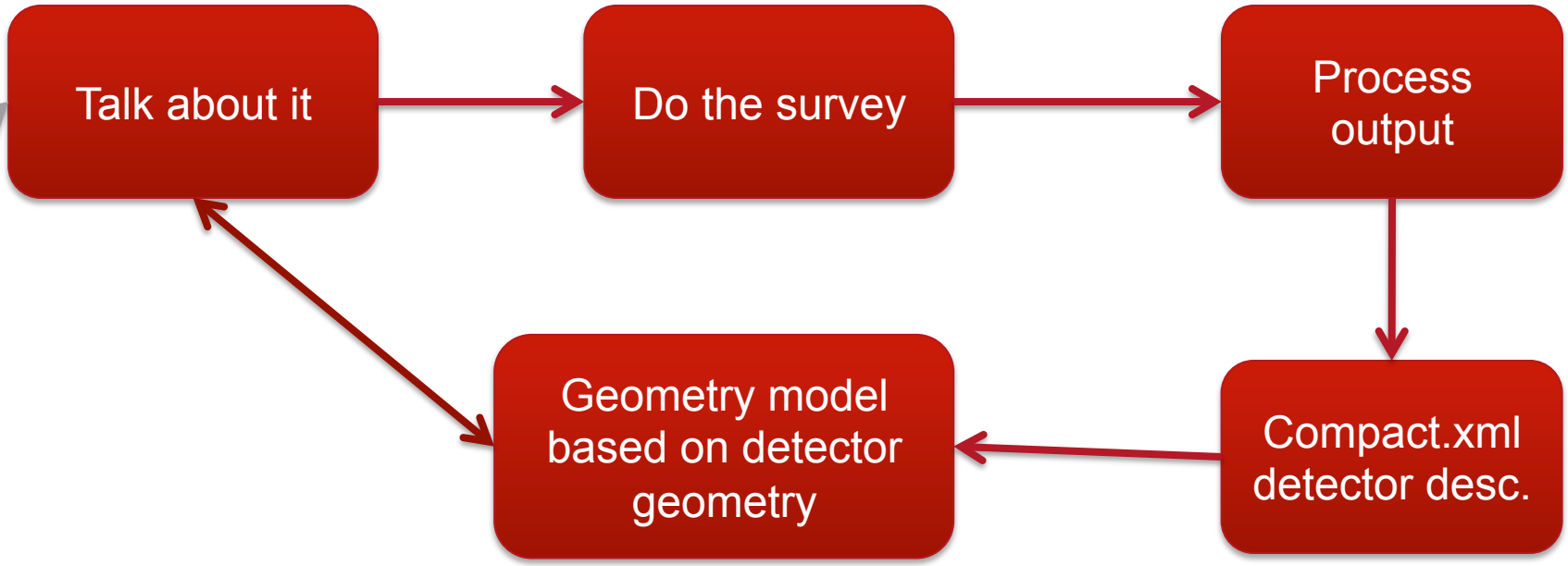
⇒ Relate sensors to module mounts

⇒ Relate module mounts to U-channel

⇒ Relate U-channels to SVT box

⇒ Place and relate SVT box to beam line

Survey - overview

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<detectors>
  <detector id="1" name="Tracker" type="HPSTracker2014v1" readout="TrackerHits">

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            </SurveyVolume>
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            </SurveyVolume>
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Results from tracking

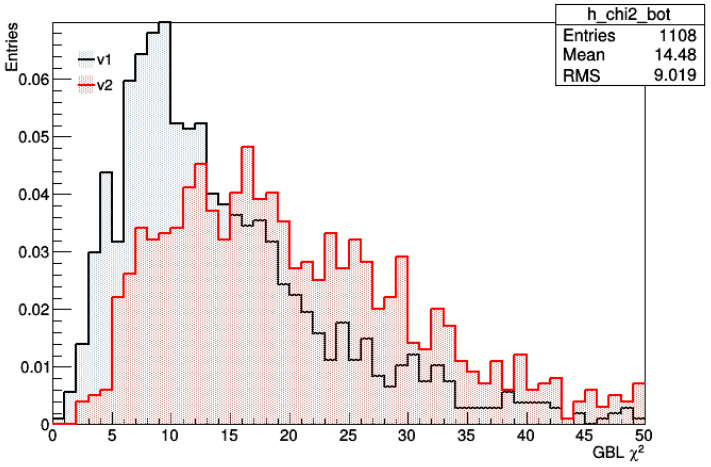
Post-Survey: fit quality and momentum

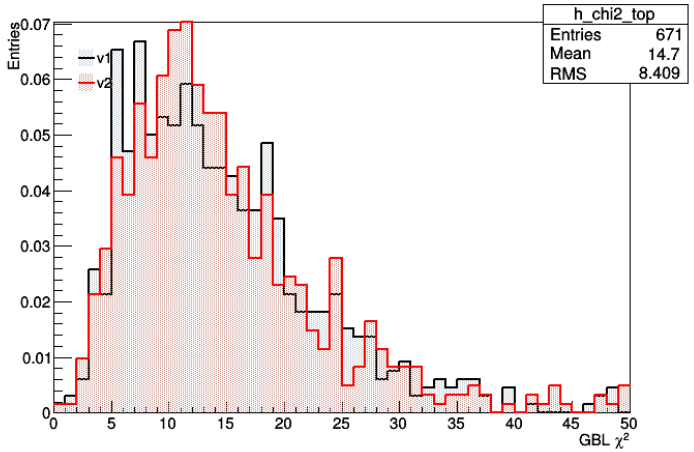
Pre-survey
Post-survey

bottom

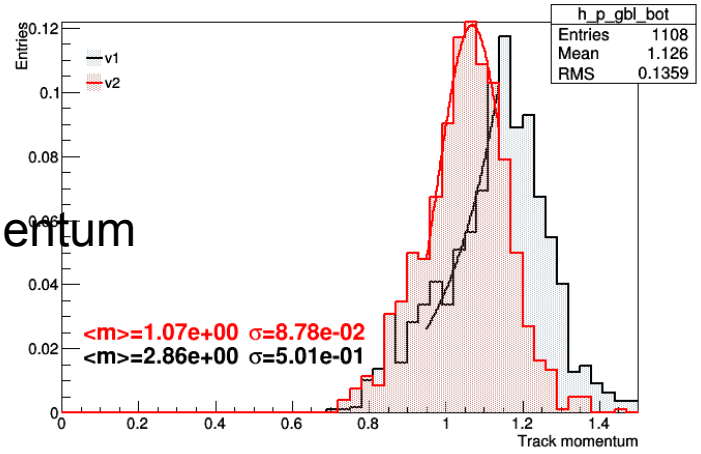
top

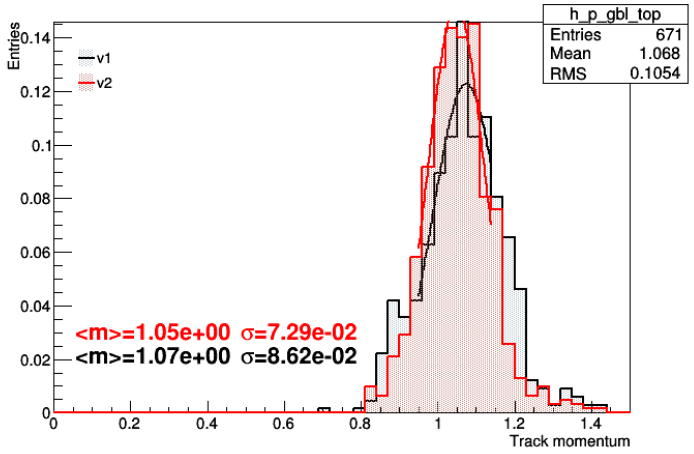
chi2





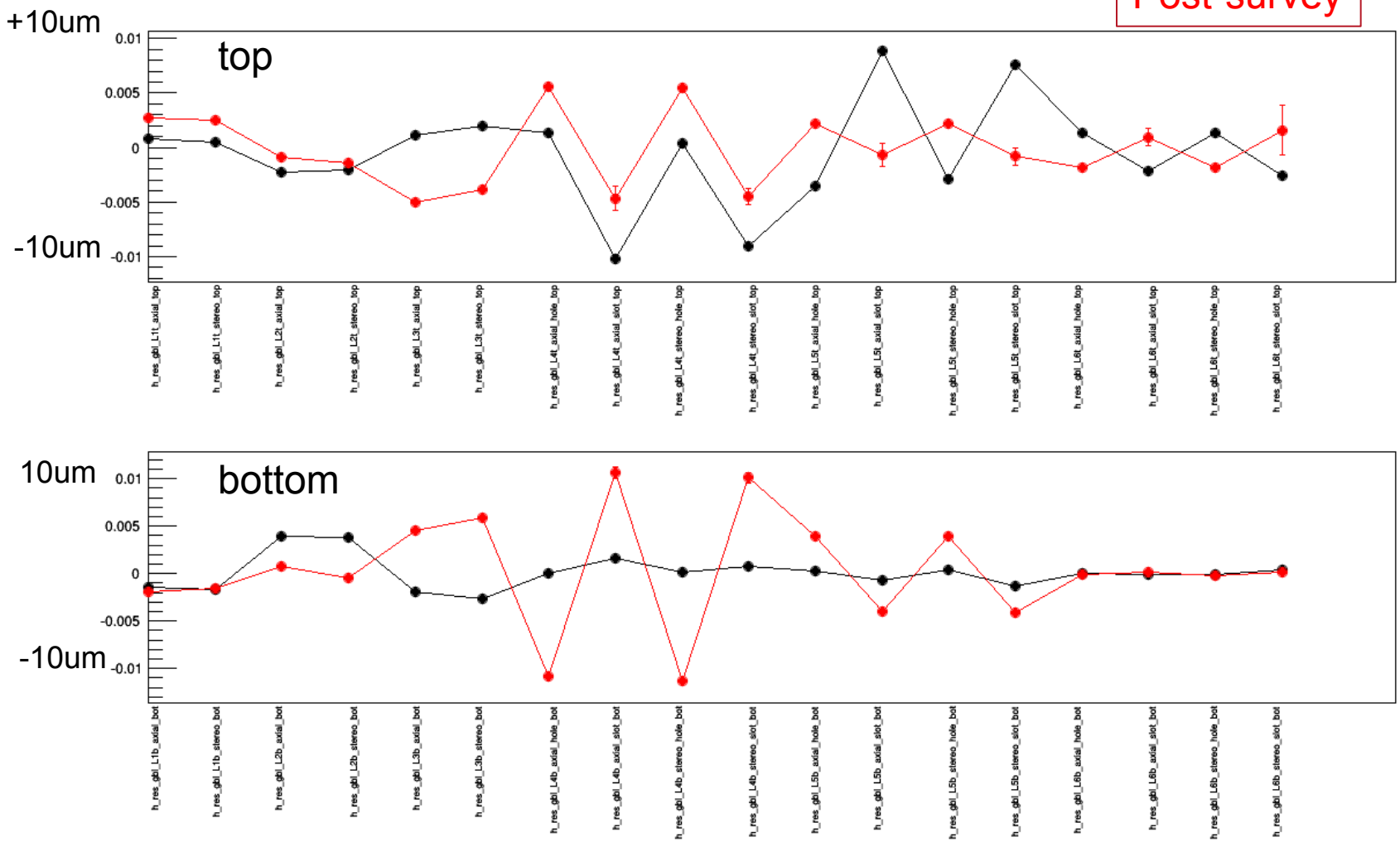
momentum





Post-Survey: residuals

Pre-survey
Post-survey



Widths of residuals are similar…

Post-Survey

Not obvious that survey detector was “better”

- Another pass of internal alignment got v2 into better shape
- Embarked on iteratively aligning v1 internally in parallel

Studied “external constraints”

- Really good to get a feeling for the changes we are looking for
  - Weak modes and it’s impact on observables
  - Momentum scale and impact parameters shifts
  - Needed to look at GBL kinks and residuals in detail (widths)
- Put survey uncertainties into context
- Highlighted the question of what is “better”

1st Stab at External Constraints

Can we get the most obvious external observables to look better without making internal alignment obviously worse?

Estimate weak modes in (u-)translations that affect

- Track curvature (momentum)
- Impact parameters

Use surveyed detector and adjust track parameters subject to real external constraints

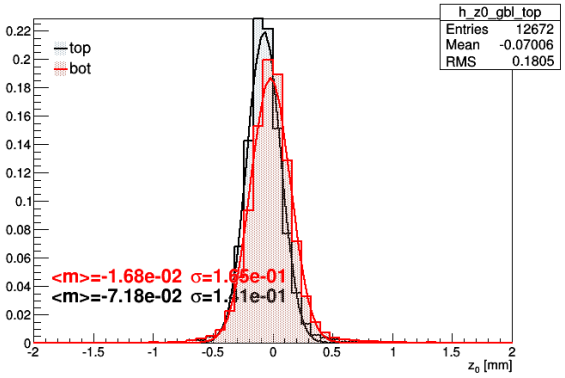
- Least-square minimization of translations
- Make sure that the translations are within estimated survey uncertainty
- Approximations so expect iterations with internal (MP) alignment

External Constraints and improvements

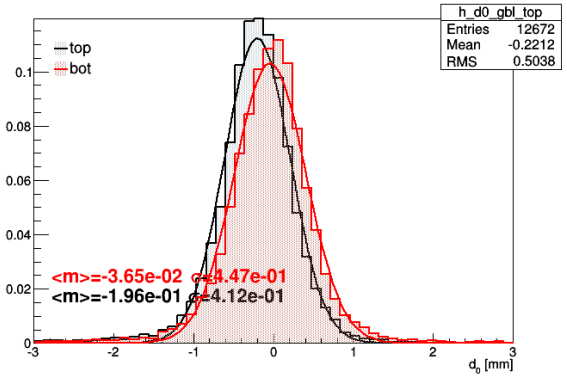
Seems to work

- Momentum scale and impact parameters are closer: to each other in top and bottom (by construction!)
- The widths of impact parameters got slightly wider (~10%)
- Momentum scale and width got a lot better

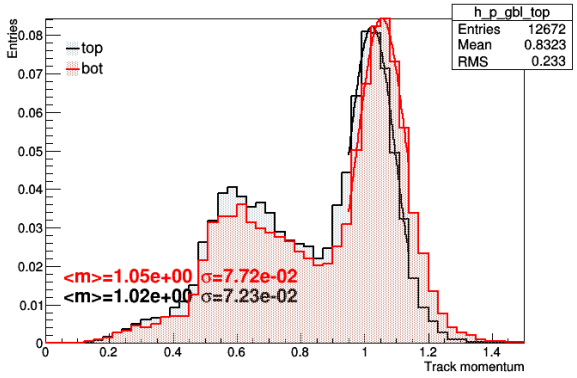
z0



d0



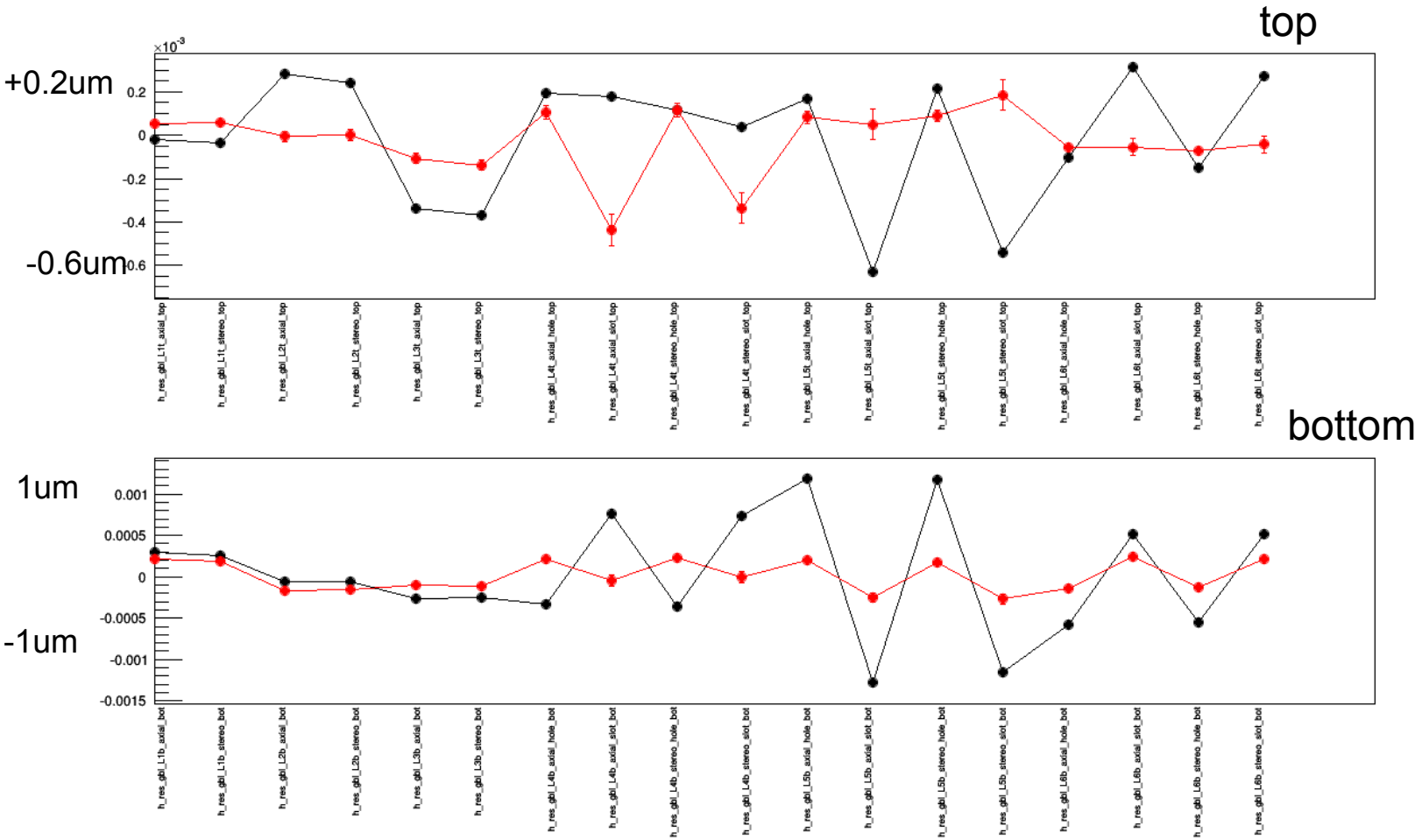
momentum



⇒ Apply round of internal alignment to the results
⇒ Keep L1 and L6 fixed.

External Constraints and improvements

Residuals improve

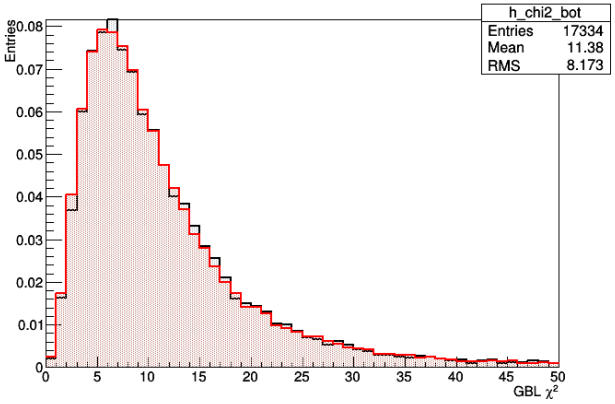


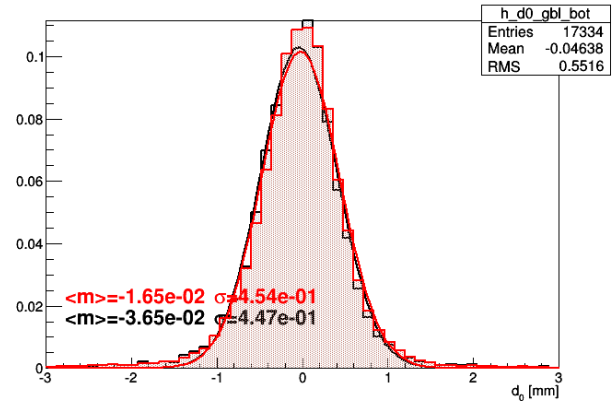
Widths of residuals are similar, kinks also improves slightly…

External Constraints and improvements

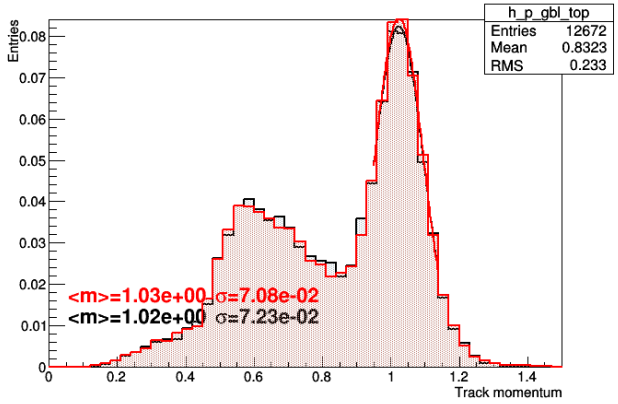
Overall “quality” is unchanged

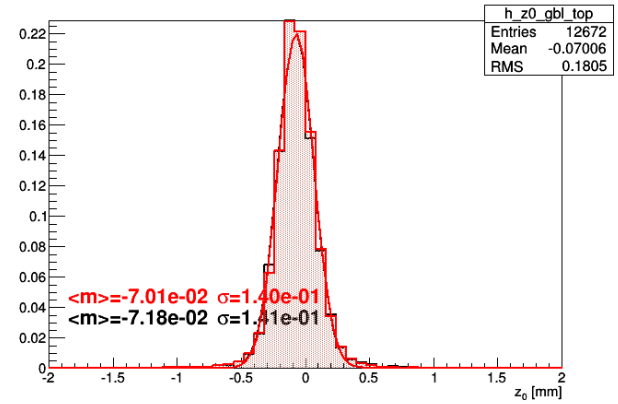
bottom





top



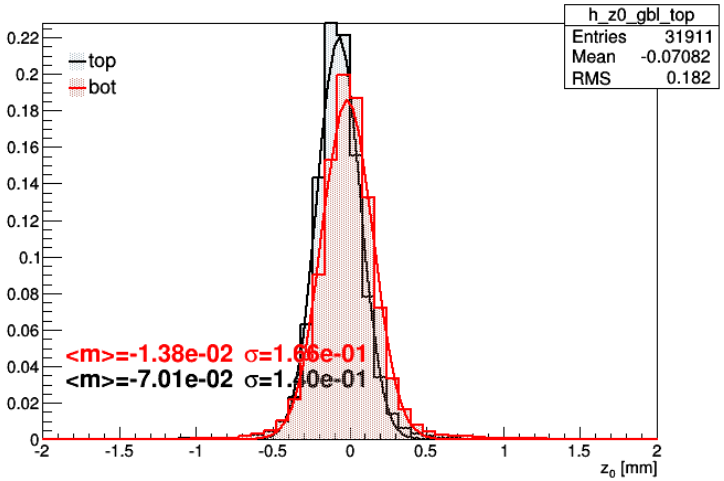


v3-1
v3-2

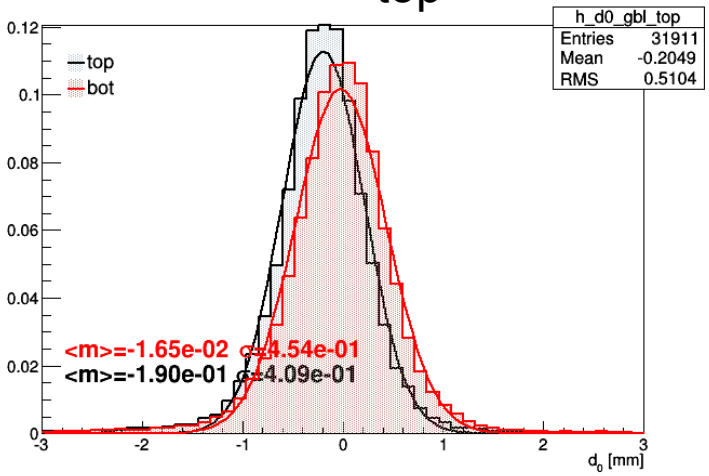
Beamspot Constraint

Tracks in top and bottom should come from the same beamspot

bottom



top

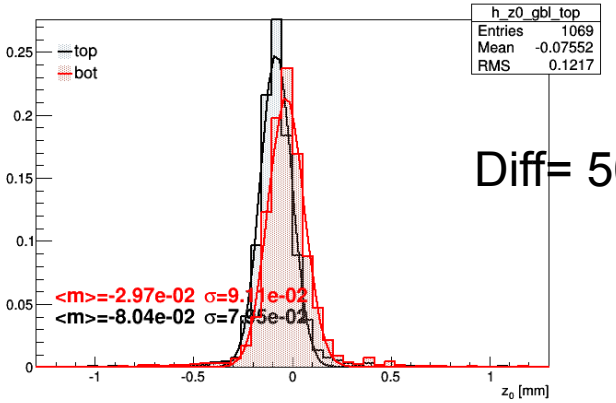


Construct beamspot that we can use in alignment

- Create fake “pair” sensors at z=0
- Adjust material thickness (GBL kink) and stereo angle
- Rotate fake sensors to take into account tilt
- Include hits in GBL and Millepede fit to align both halves to it

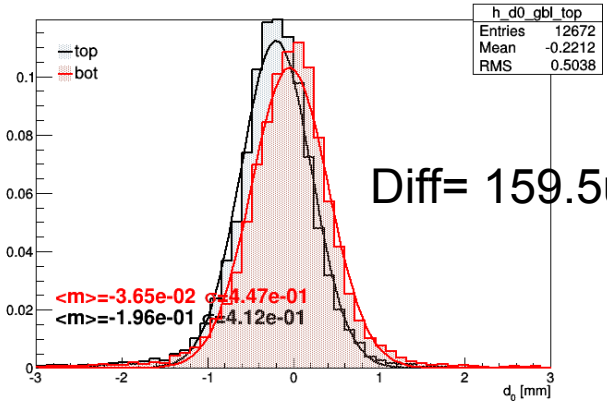
Beamspot Constraint

Start by adjusting beamspot so that impact parameters to minimum average between top and bottom

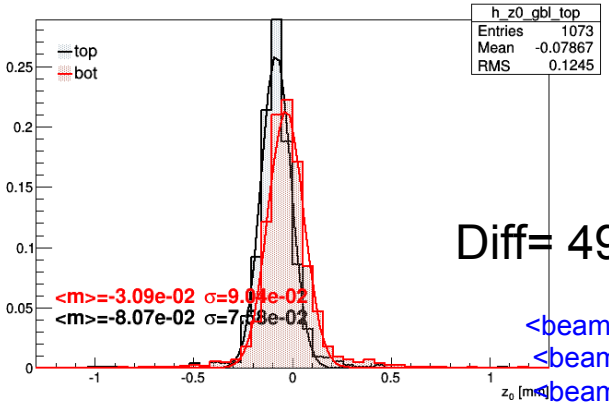


Diff= 50.7um

before

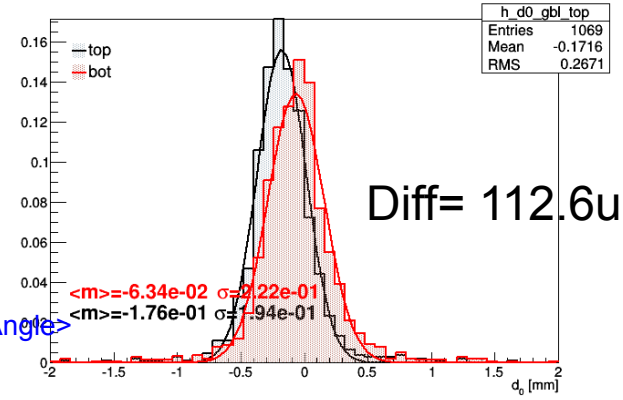


Diff= 159.5um



Diff= 49.8um

after



Diff= 112.6um

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<beamspotWidthZ>0.05</beamspotWidthZ>
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<beamspotTiltZOverY>0.26</beamspotTiltZOverY>
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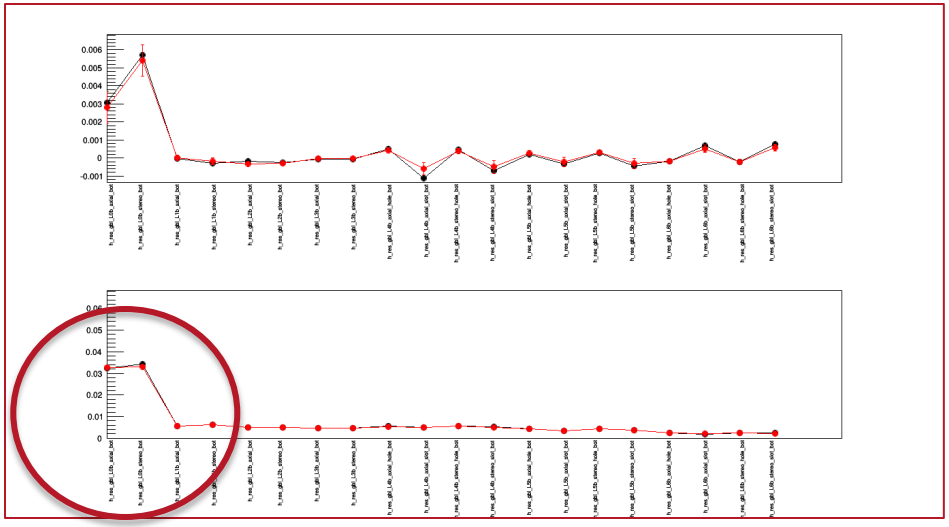
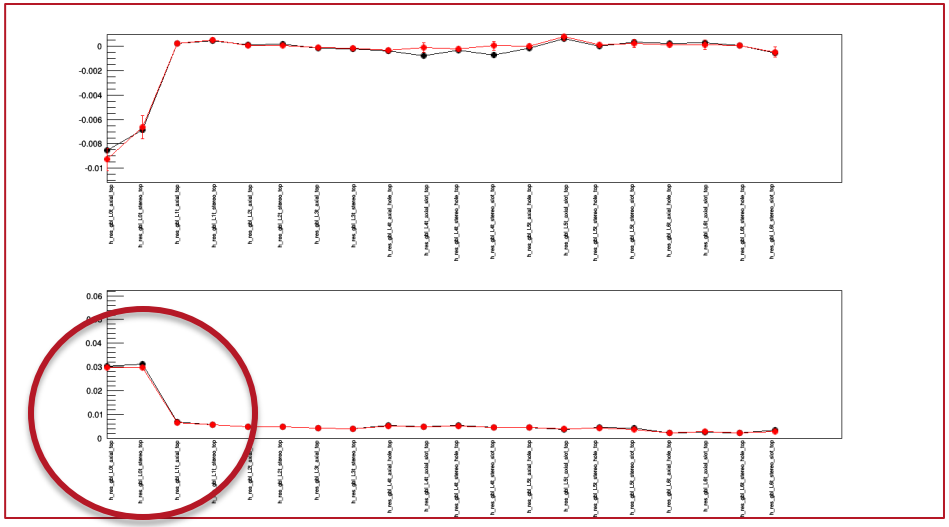
Beamspot Constraint

Start by adjusting beamspot so that impact parameters to minimum average between top and bottom

Top (mean & width)



Bottom (mean & width)



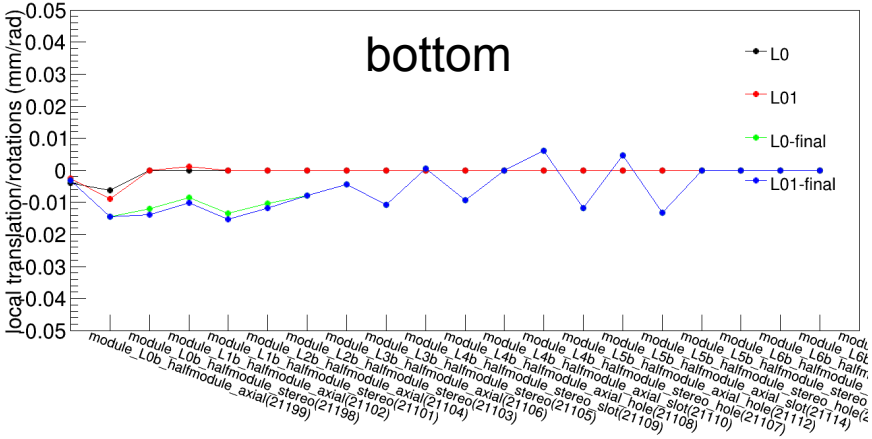
As expected tension in first layer

Beamspot Fit

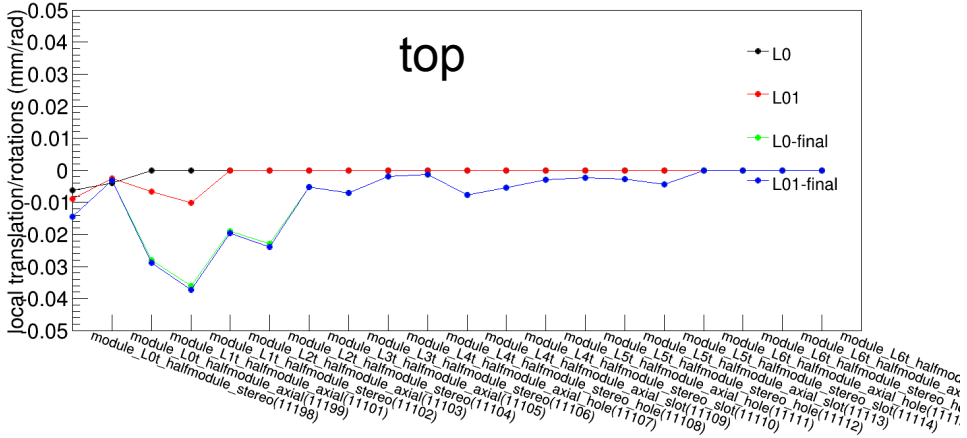
Fit beamspot and u-translation of sensors at the same time

- Require that the beamspot for top tracks and bottom tracks move together
- Effectively we are fitting one beamspot (starts out at the same place for top and bottom)

Millepede corrections per sensor



Millepede corrections per sensor

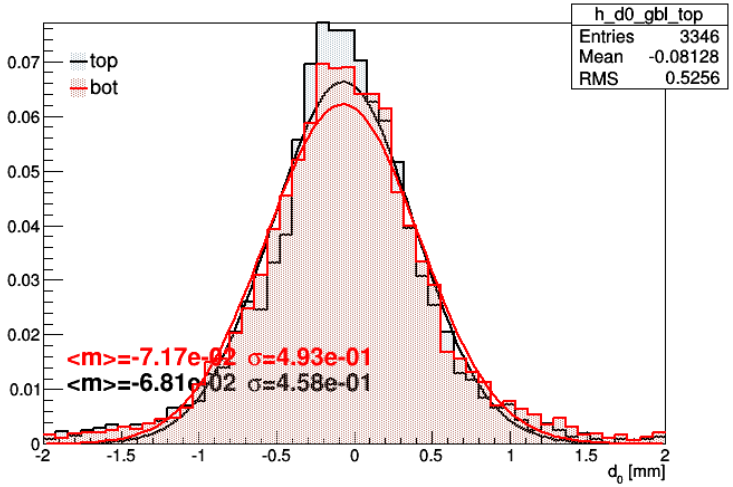


As expected beamspot and first layers get pulled

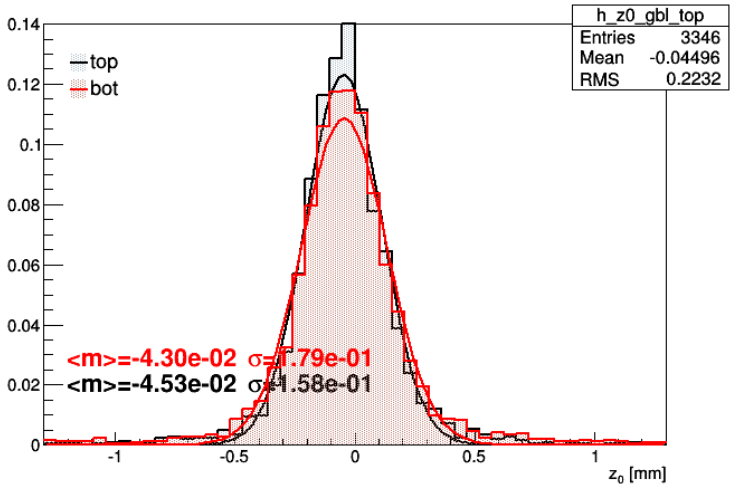
Beamspot Fit Impact

Impact parameters agree within 3-4um

bottom



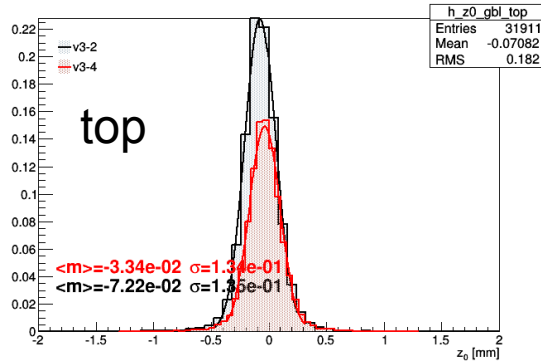
top

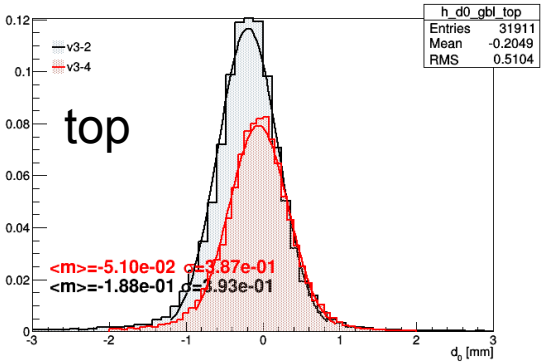


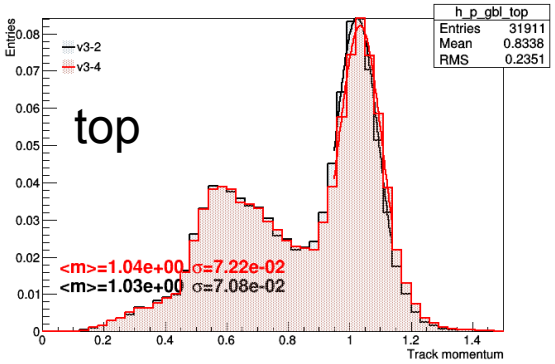
Beamspot Fit Impact

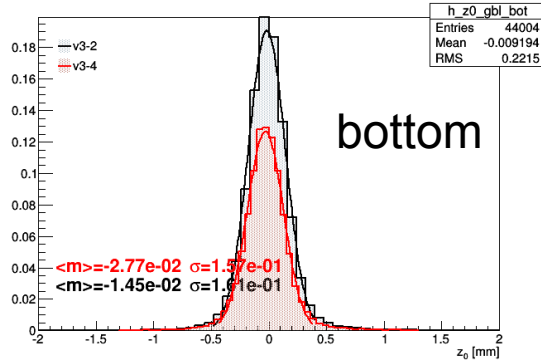
1-2% decrease in impact parameter widths

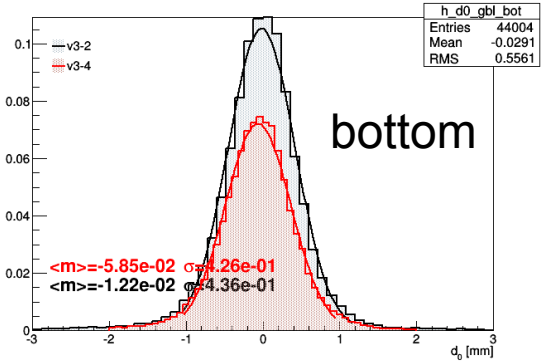
1-2% increase in momentum resolution widths

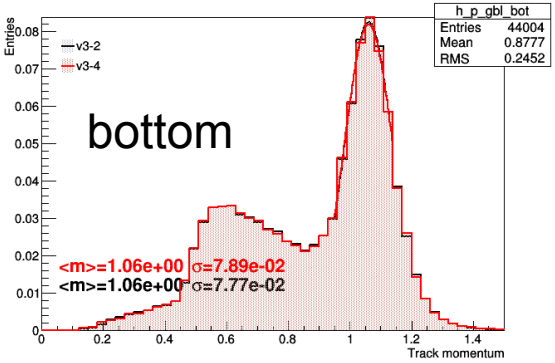






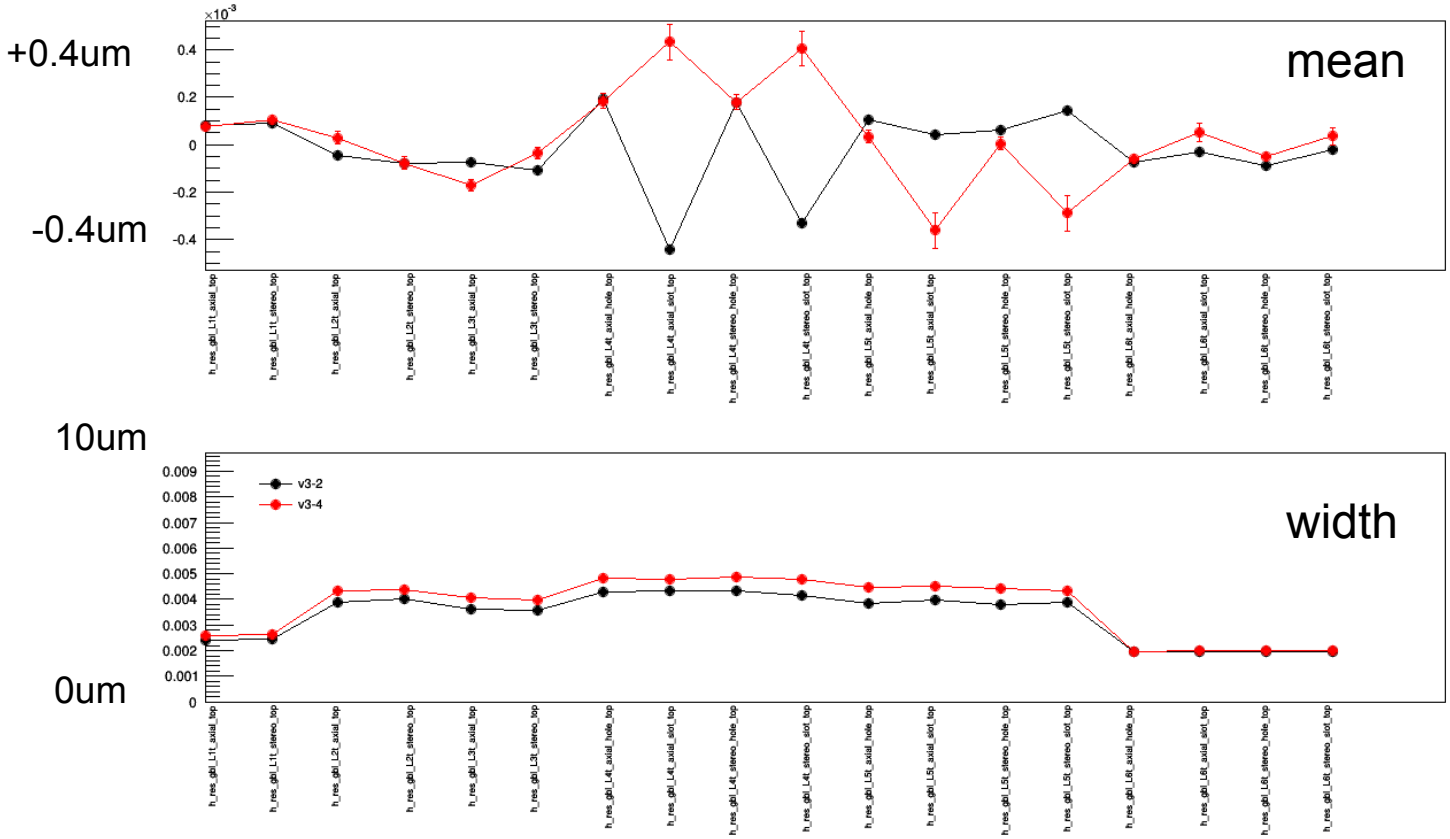






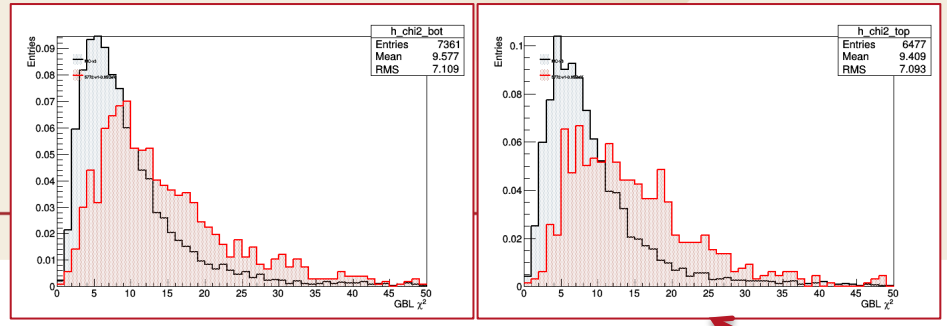
Beamspot Fit Impact

Top tracks



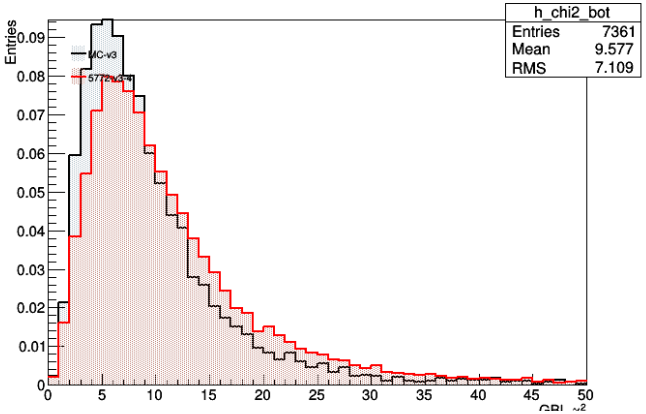
Looks like slight widening (not there for beam electron tracks…)
Similar for bottom tracks
Kinks look very similar in the two geometries

Where we are: fit quality

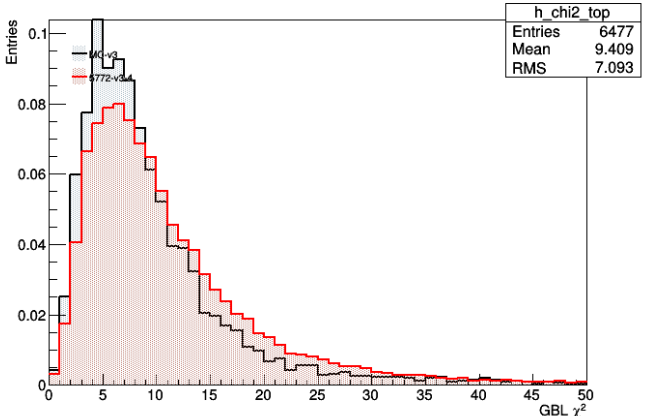


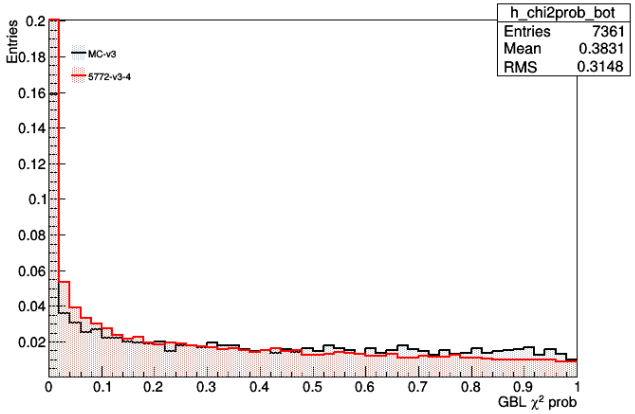
At the start

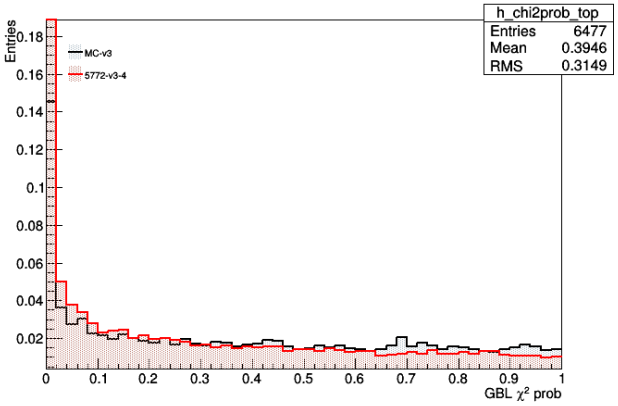
bottom



top



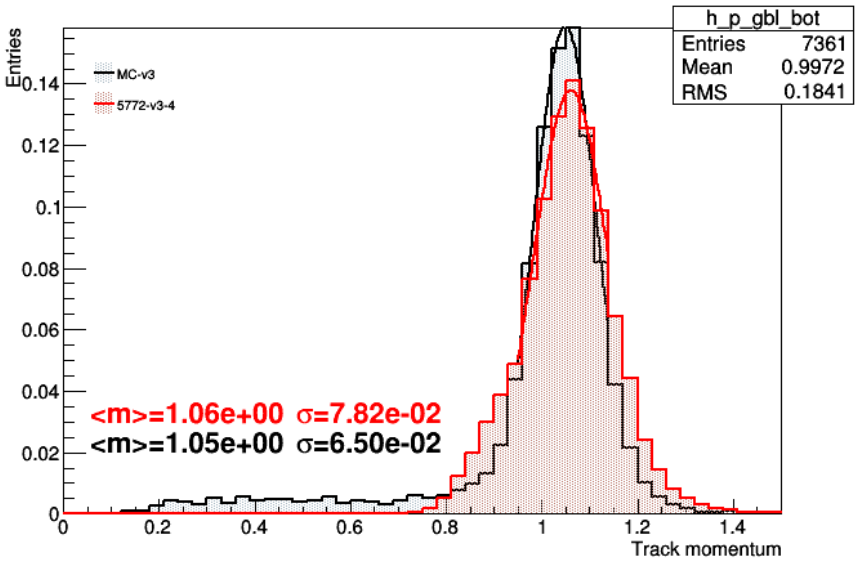




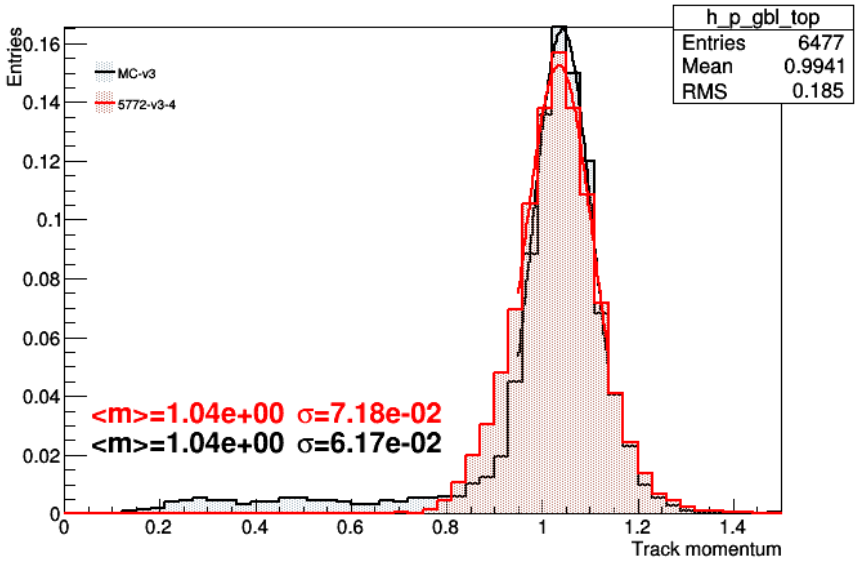
Chi2 of the fit now looks pretty good

Where we are: momentum

bottom



top

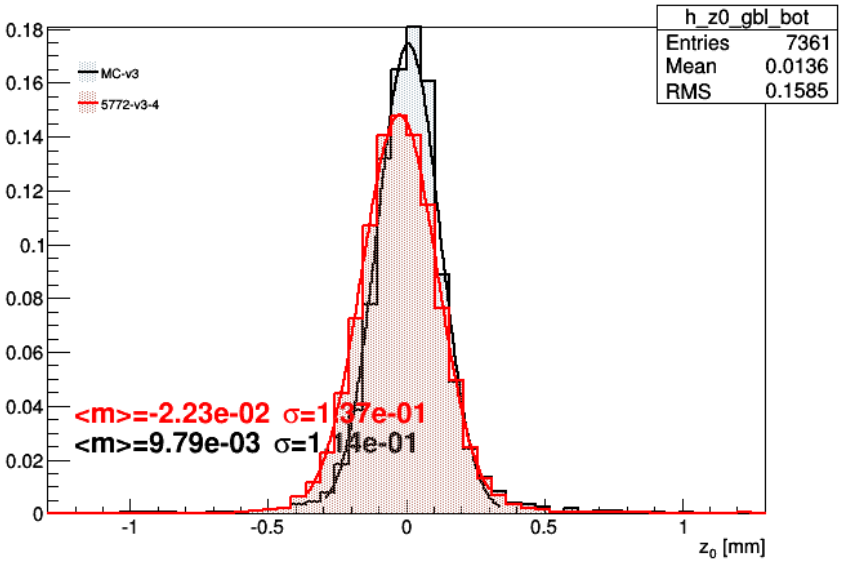


Momentum resolution agrees to within 10 (12) MeV (~15%) for top (bottom)
Momentum scale looks alright with GBL

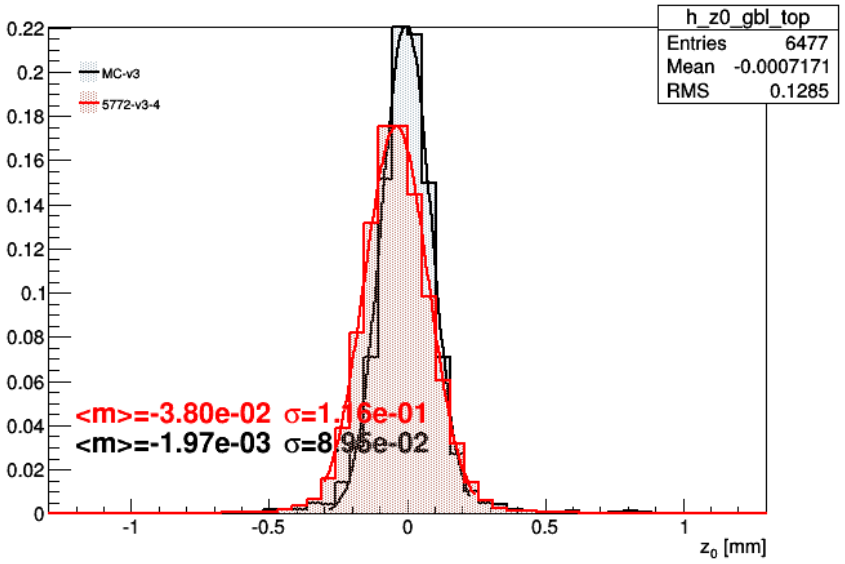
Where we are: impact parameter

z0: vertical dist. @ closest approach

bottom



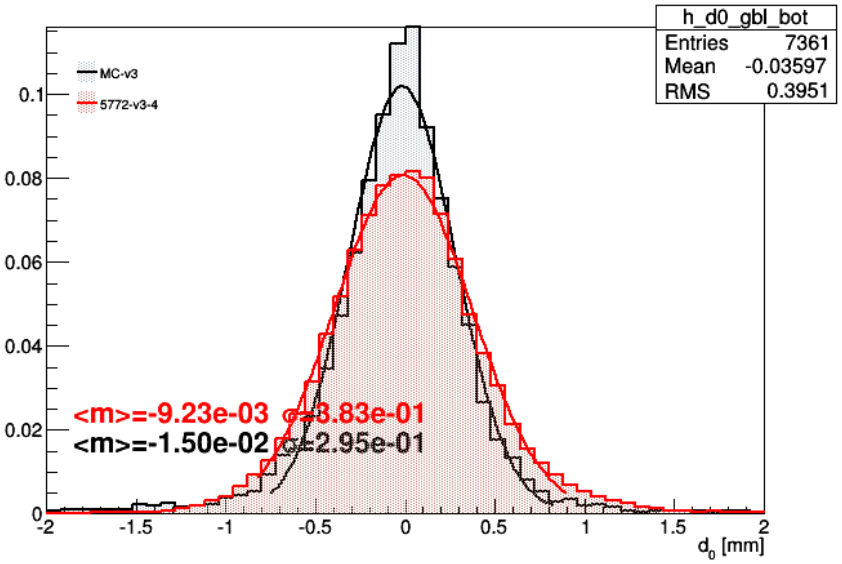
top



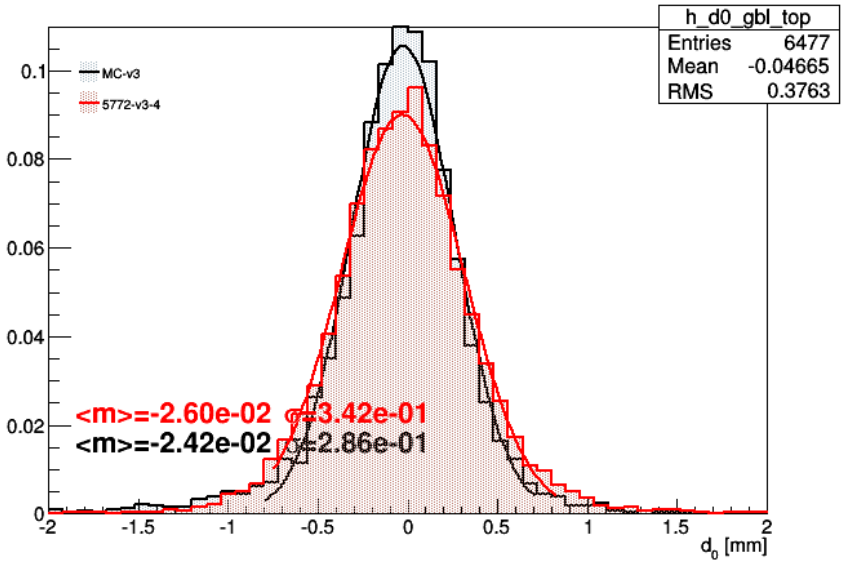
z0 top and bottom agree to within ~15um (MC to 10um)
Widths are within 20um (~20%) to MC

Where we are: impact parameter

bottom

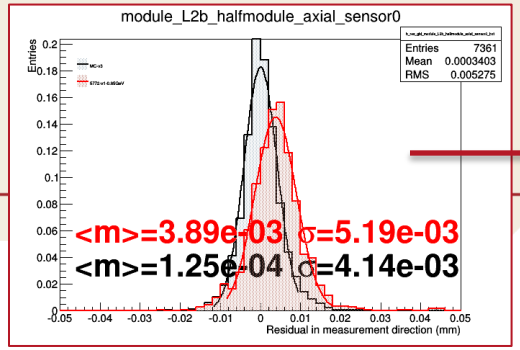


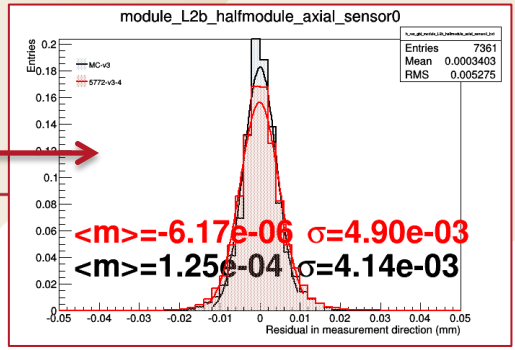
top



d0 top and bottom agree to within ~20um (MC to ~10um)
Widths are within 80um (20-30%) to MC

Where we are: residuals

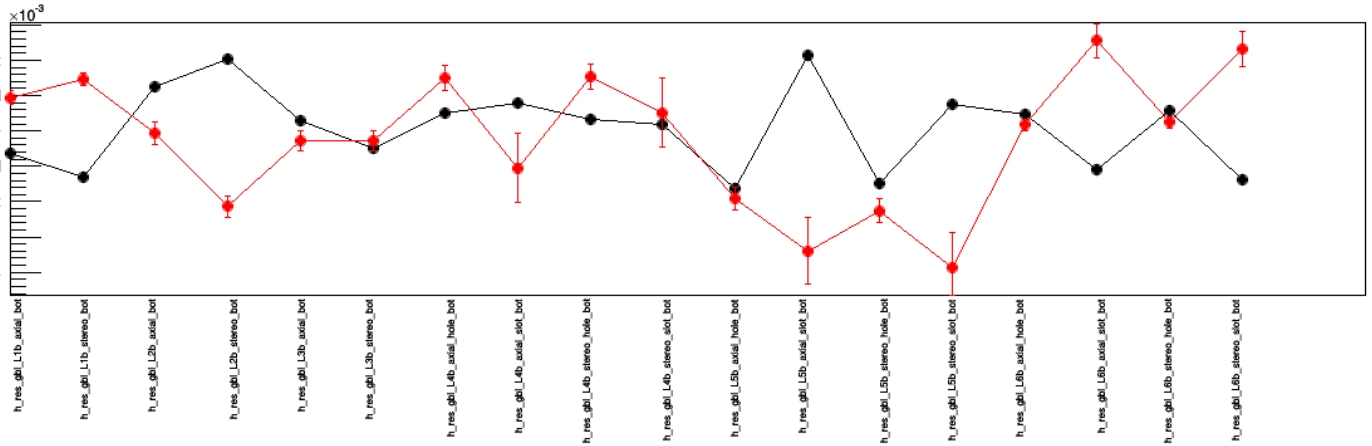




Bottom

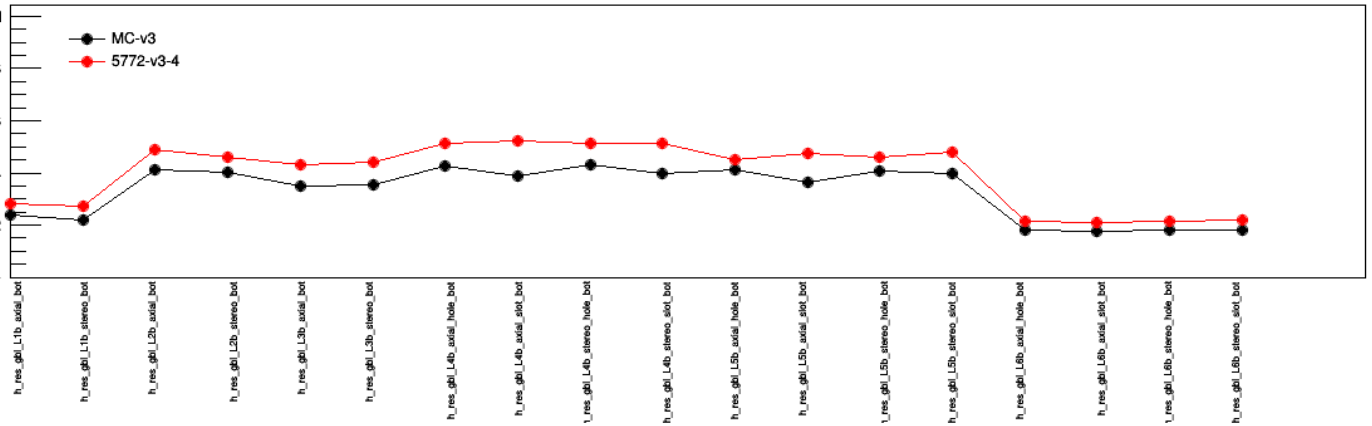
+0.3um

-0.4um



10um

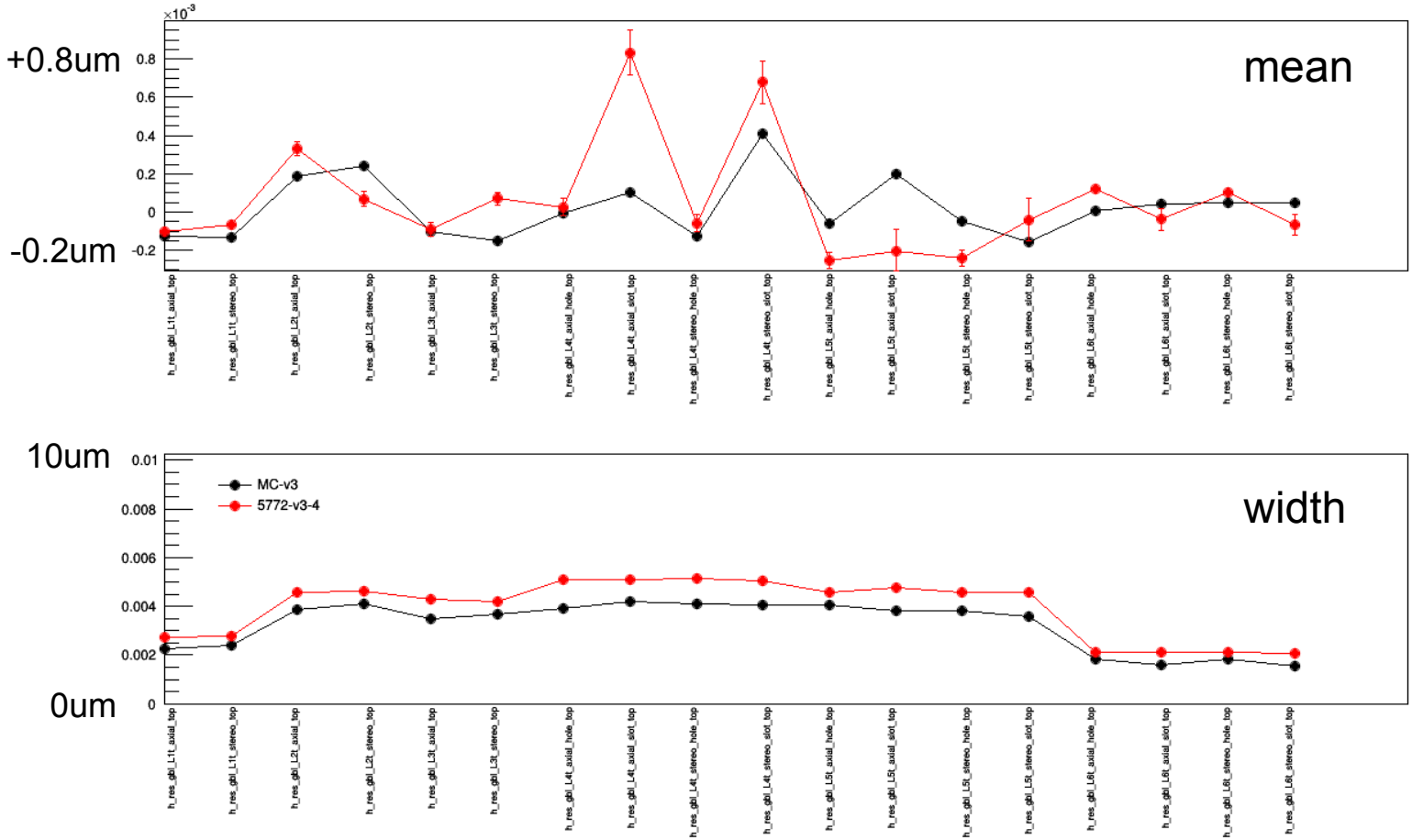
0um



Residual means similar to MC. Widths are 20% wider

Where we are: residuals

Top



Residual means similar to MC. Widths are 20% wider

Where we are going

Internal alignment

- Unclear if some rotations work; fix that
- Further u-translation only might not be worth at this point

Start to use all we have: straight trough's (, upstream background?)

External constraints

- Combine top and bottom (e.g. beamspot constraint)
- Look at using e.g. Mollers for global alignment