

# Alignment for back, bottom 2021 detector

Matt Graham

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# Overview

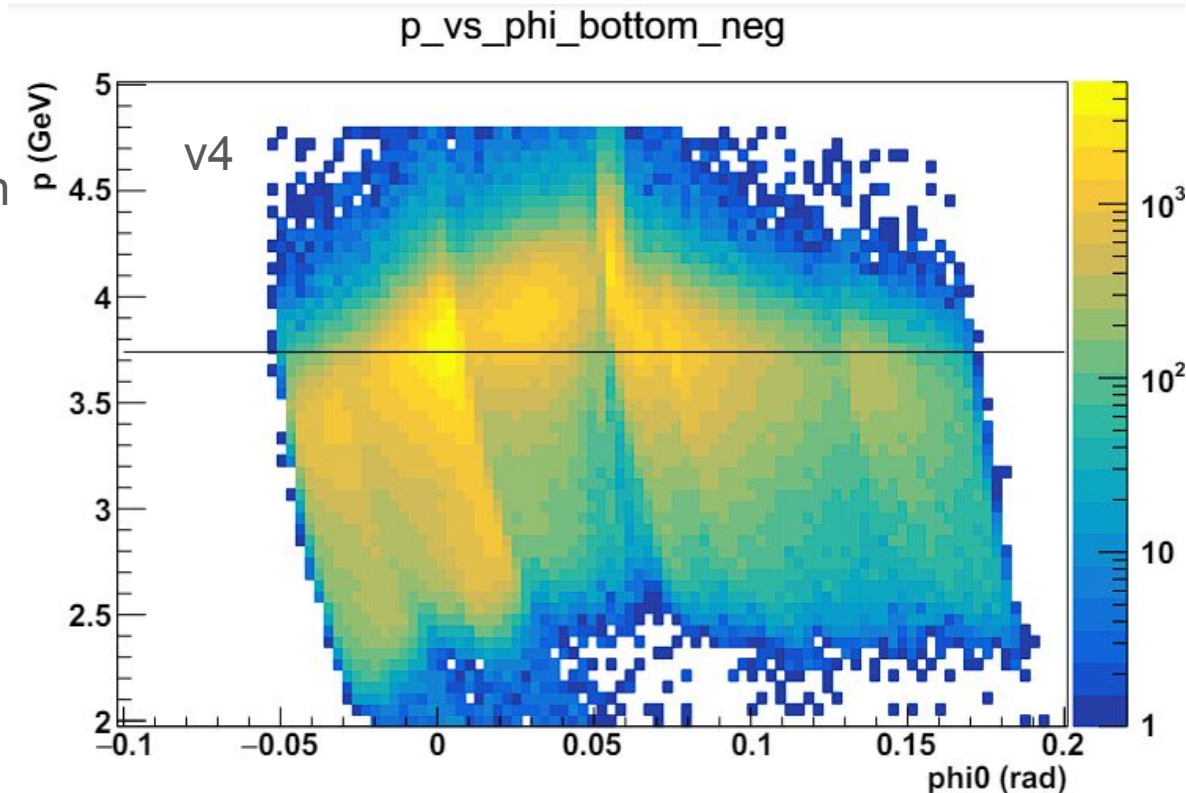
- Trying to help out Cameron on the alignment...speed things up
  - I am not speeding anything up!
- The starting project was well defined:
  - there is a  $\phi_0$  dependence on the momentum in the bottom detector.
  - this can be fixed by rotating (rw) the back (L6+L7) stereo sensors
  - then, use MPIL to adjust the tus of the back axial sensors using momentum constrained FEEs
- There were plenty of mistakes, misunderstandings, typos etc...on my side...and here we are.

# Setup

- I'm using the latest master of hps-java ++ a few minor changes that I will commit shortly
- Using skimmed FEEs from run 14168:
  - /fs/ddn/sdf/group/hps/users/bravo/run/run14168/output/hps\_014168/HPS\_Run2021Pass1\_v4/
- We run a few different steering files (I'm not sure if they are committed) which run & control a different combination of drivers
  - For getting .bin files for MPIL, we do ST+SimpleGBLTrajAliDriver, which has options for performing a number of constraints (e.g. FEE momentum constraint) and selections
  - For plotting (bigger picture) we use KF+SimpleGBLTrajAliDriver (no constraints)
- The “plots” are the alignment monitoring plots in GBLOutputDriver (it can also plot from KF tracks/particles)

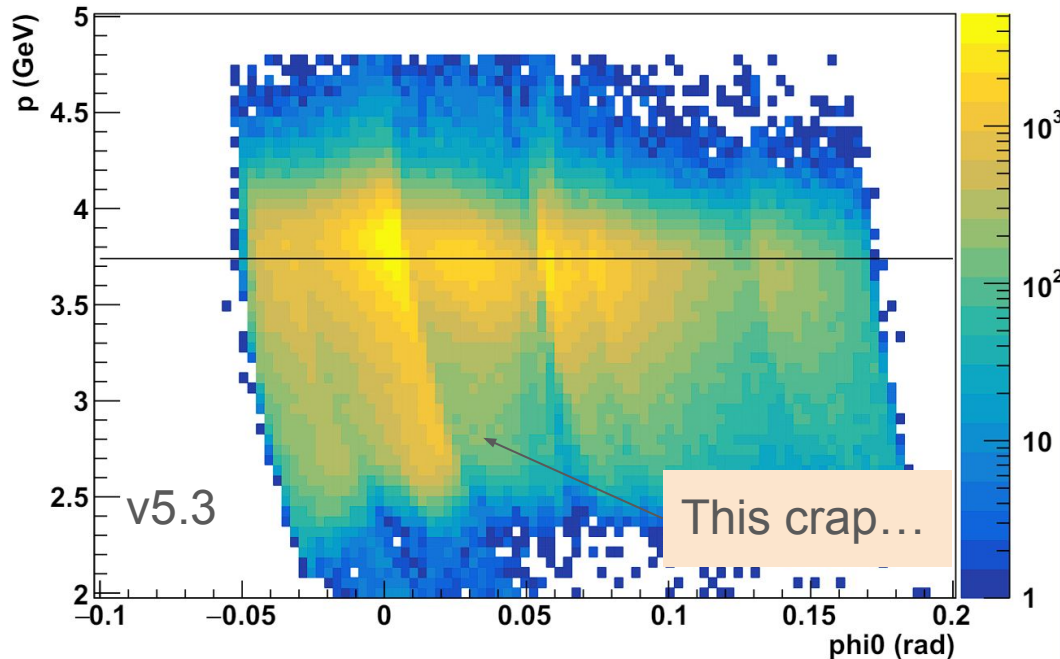
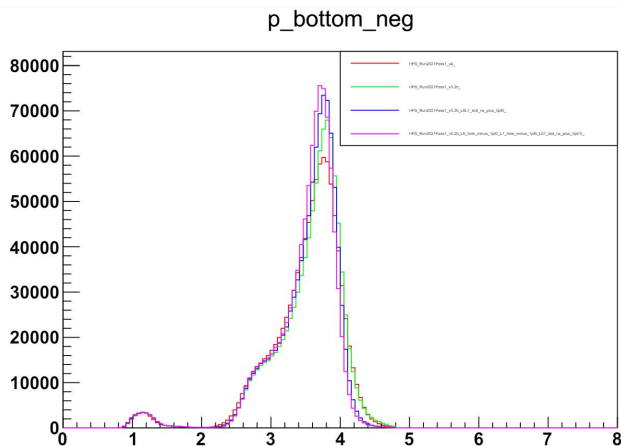
# 2021 v4 detector, bottom p vs phi0

These correlations broaden the FEE momentum peak and generally make our momentum resolution worse..this weirdness is what we want to fix with rws.



# After adjusting L6&7 stereo slot & hole sensors by hand

p\_vs\_phi\_bottom\_neg



Red: v4 detector

Magenta: after "best" rotations

Significant improvement with rotations...

- L6 stereo hole: ~~-1.0 mrad~~ whoops, actually -0.1mrad
- L6 stereo slot: +0.75 mrad
- L7 stereo hole: -1.5 mrad
- L7 stereo slot: +0.75 mrad

# FEE Residuals for a few select detectors

v4: current early run standard

v4.2b: v4+L5-7 axial tus + stereo rws based on PC FEEs (+ movement of L5Sh)

v4.3b: v4.2b+L5-7 axial tus + stereo rws based on EoP FEEs (Fiducial only)

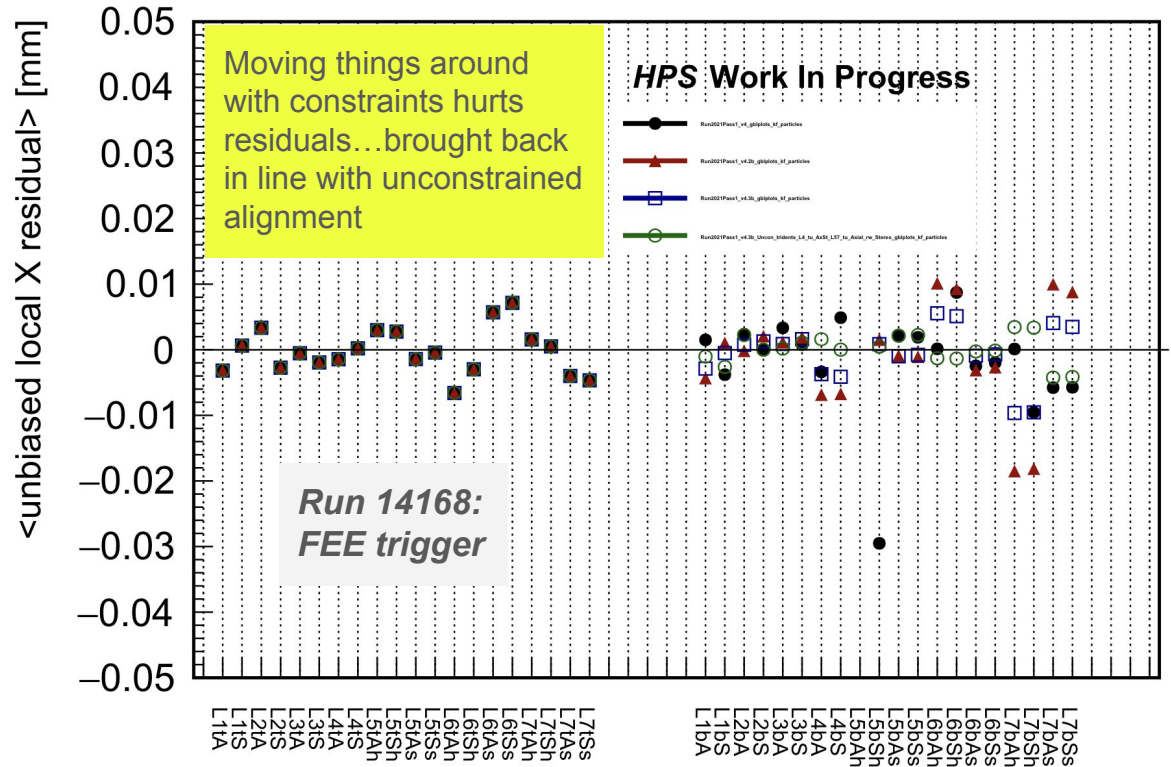
v4.3b + unconstrained

L4 Ax/St tus + L5-7 axial tus  
+ stereo rws

[All plots are here](#)

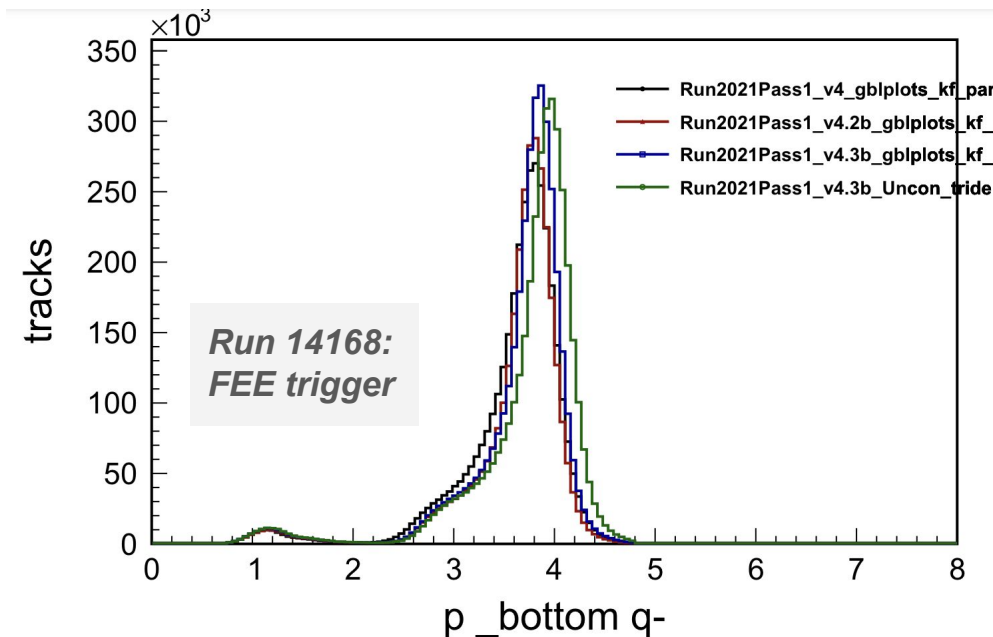
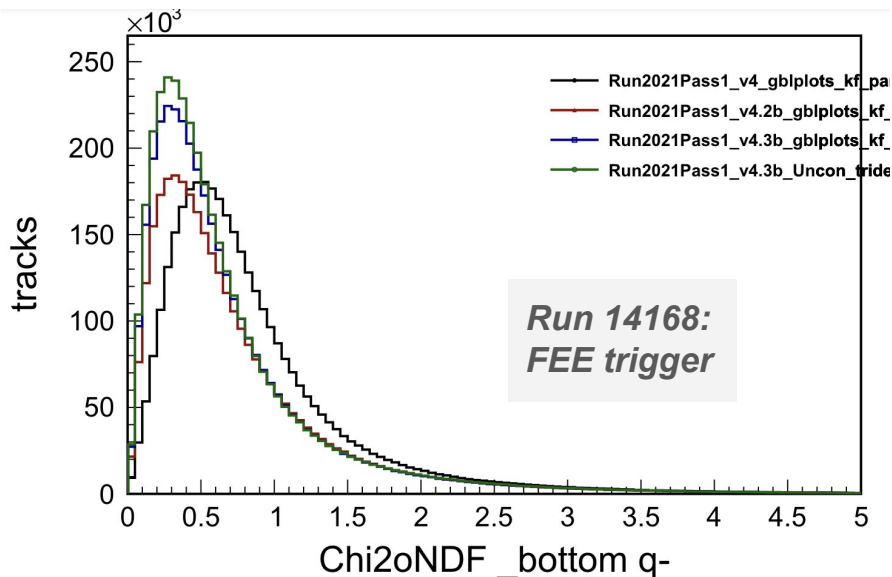
All alignments and plots  
required cluster-matched  
tracks.

E/p constrained alignment  
require fiducial clusters.



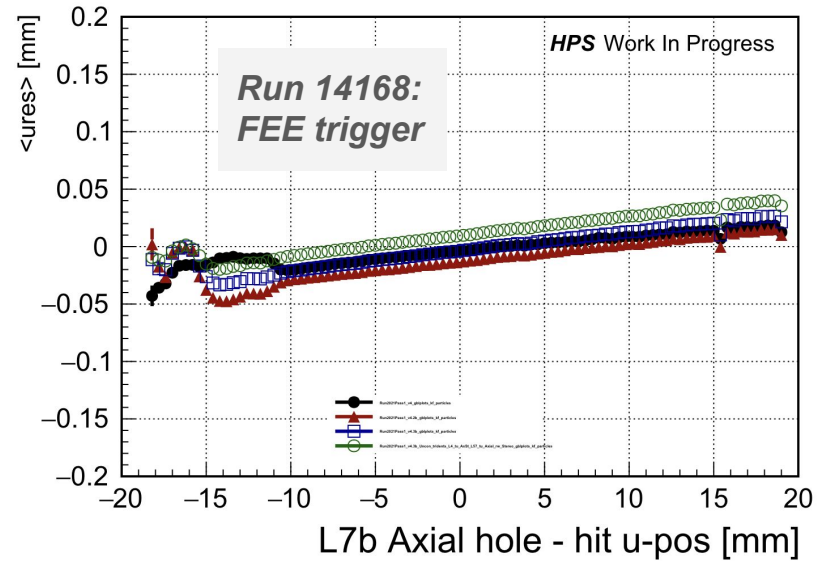
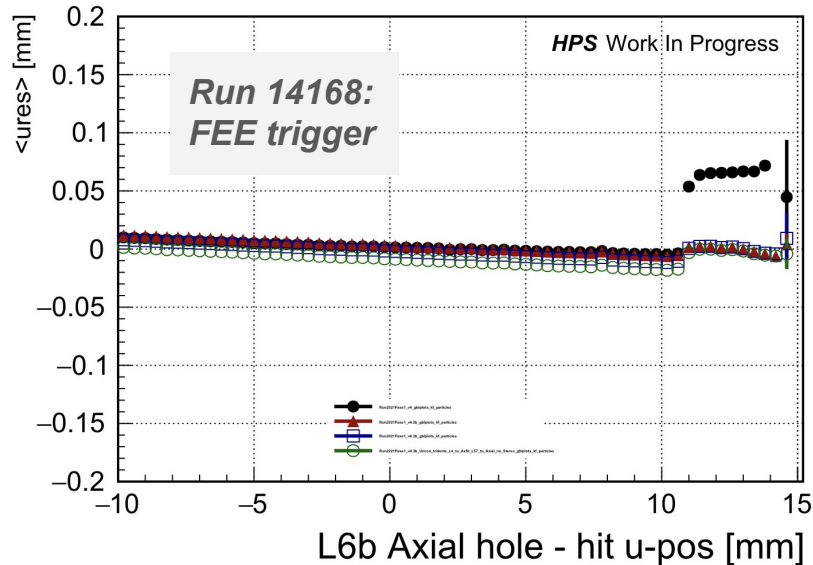
# FEE Run Track chi2 and momentum

- Chi2/NDF improves from v4, mostly because of L5Sh movement
- Momentum is sharpened up; unconstrained alignment shifts FEE peak to  $\sim 4\text{GeV}$  ( $\sim 7\%$  too high)



# FEE Run Residual Trends

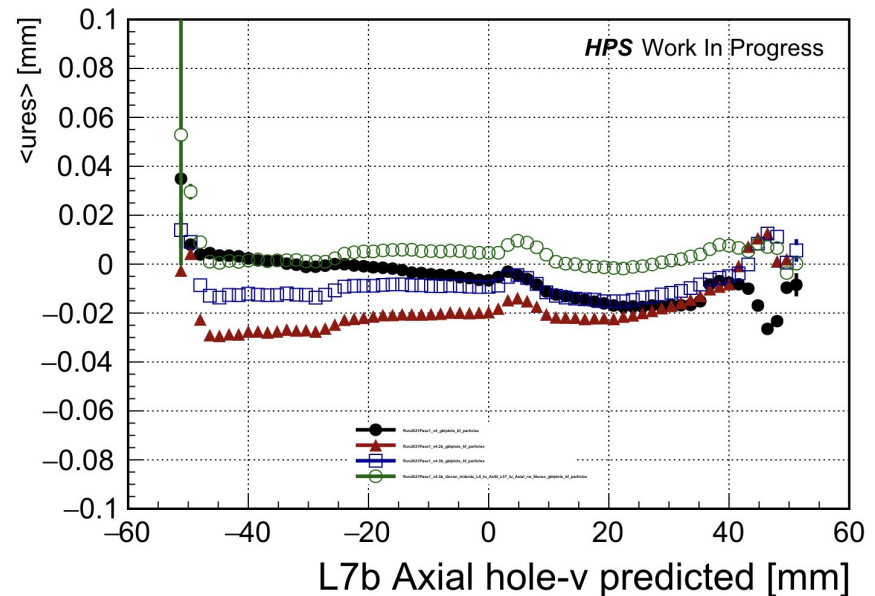
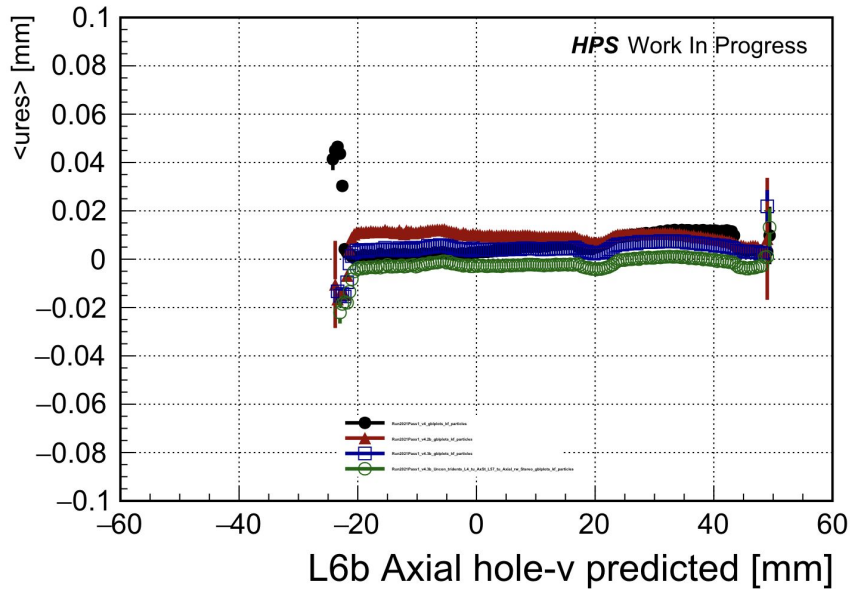
- Mostly these are roughly the same or have a bit better behavior...not huge changes



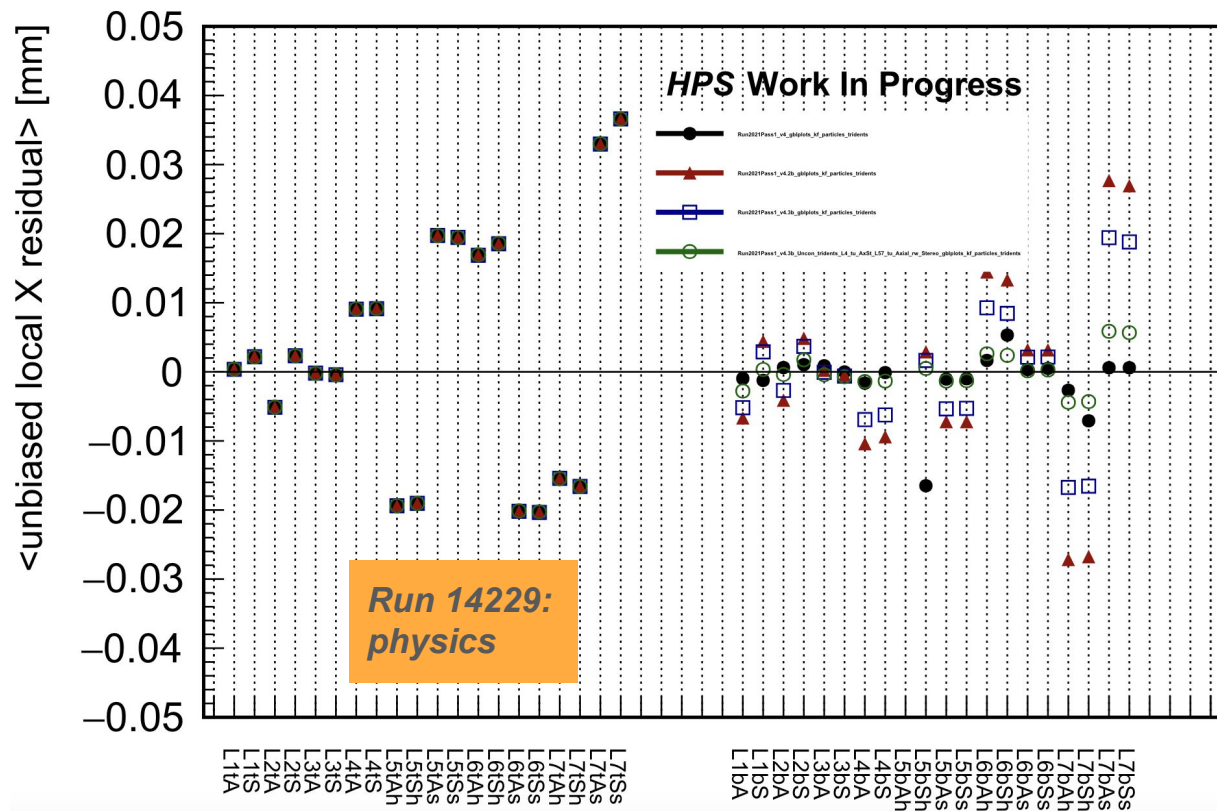


# FEE Run Residual Trends vs predicted v

...some more stuff comes up here, and some get better with new alignments.



# $e^+$ and $e^-$ physics track residuals for a few select detectors



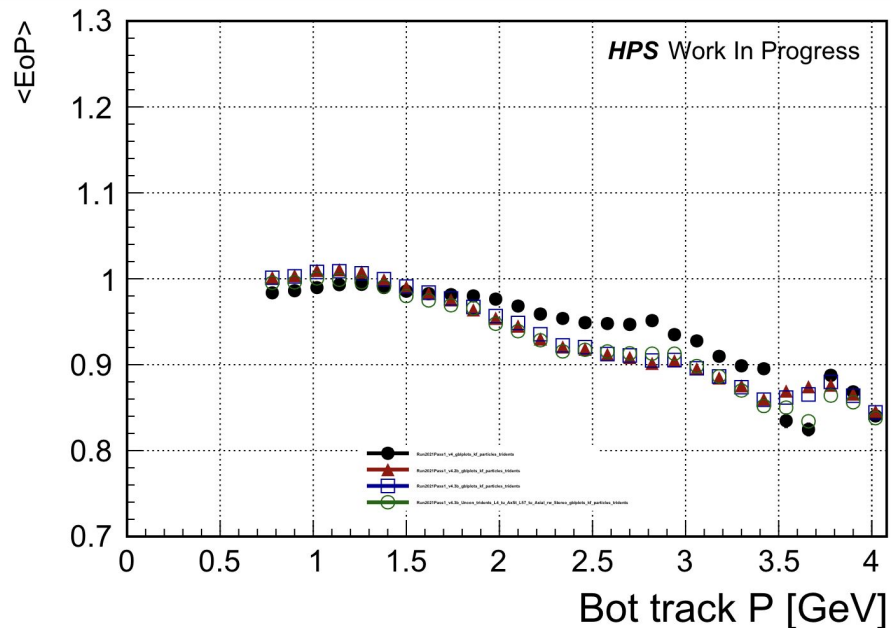
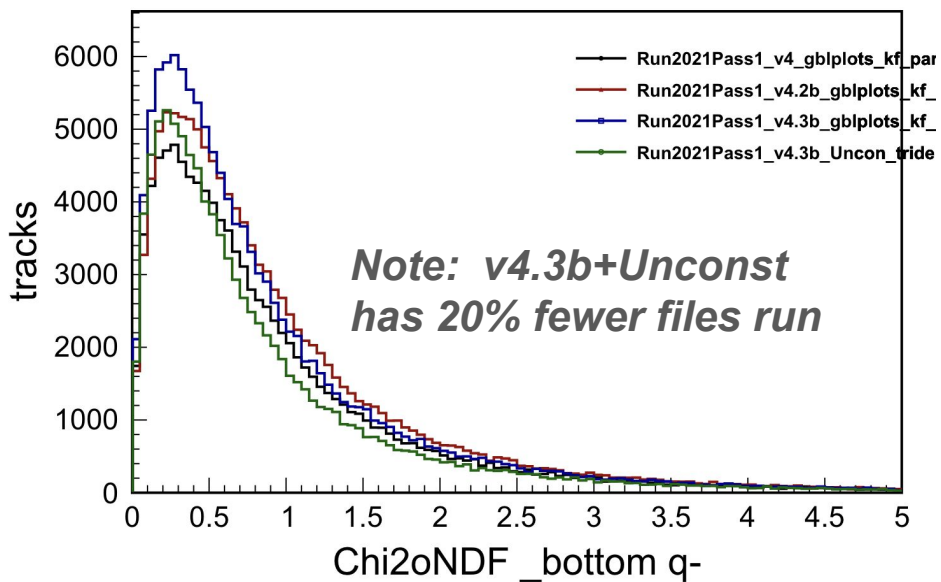
These are for all tracks (not from V0s)

Really, these only look good for the unconst alignment (and the v4 baseline).

[All plots are here](#)

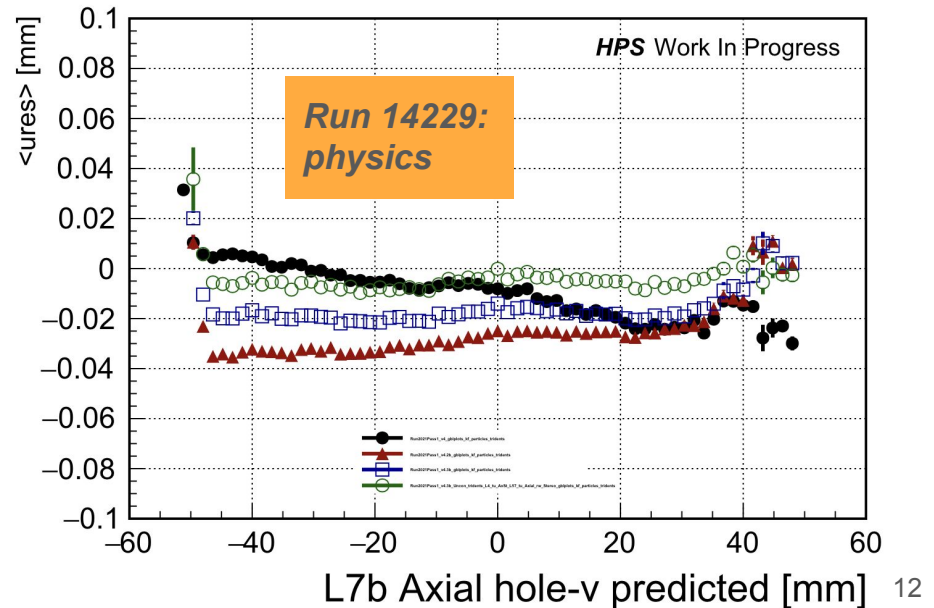
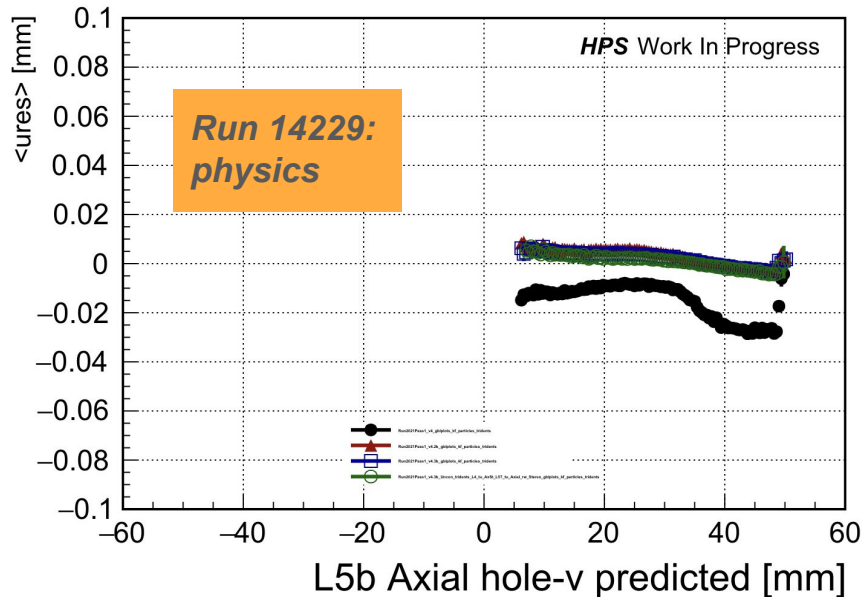
# Electrons from physics run 14229...chi2 and E/p

I include E/p here but I think I fell prey to the ECal energy correction bug...how did the E/p trident optimization work & help?



# Residual trend using physics tracks

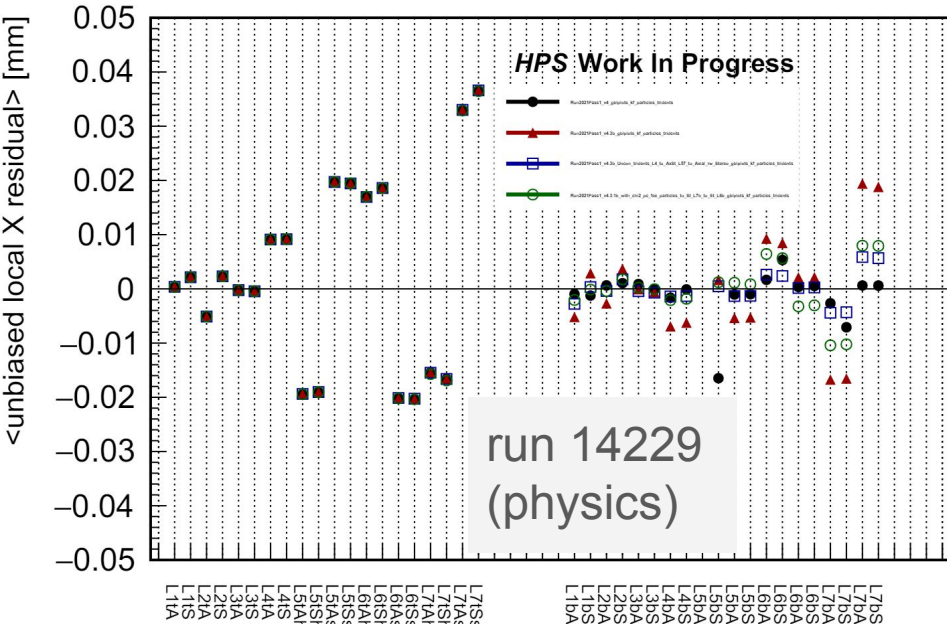
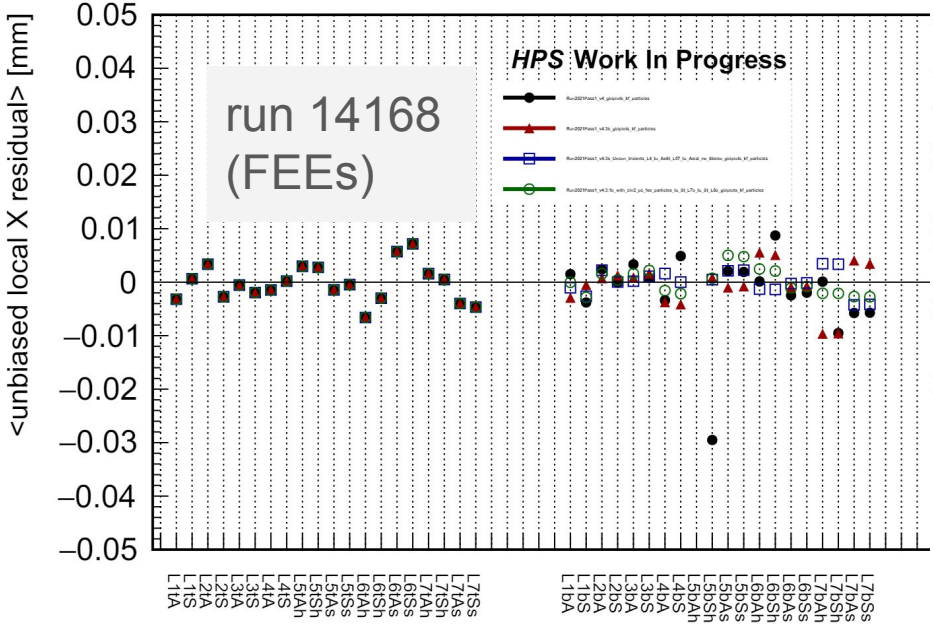
...generally, see somewhat better trends, particularly after the unconstrained optimization.



# June 11 update: Momentum scale

Use PC FEEs varying the L6&7 stereo tus to fix the momentum scale...  
Doesn't effect the residuals much!

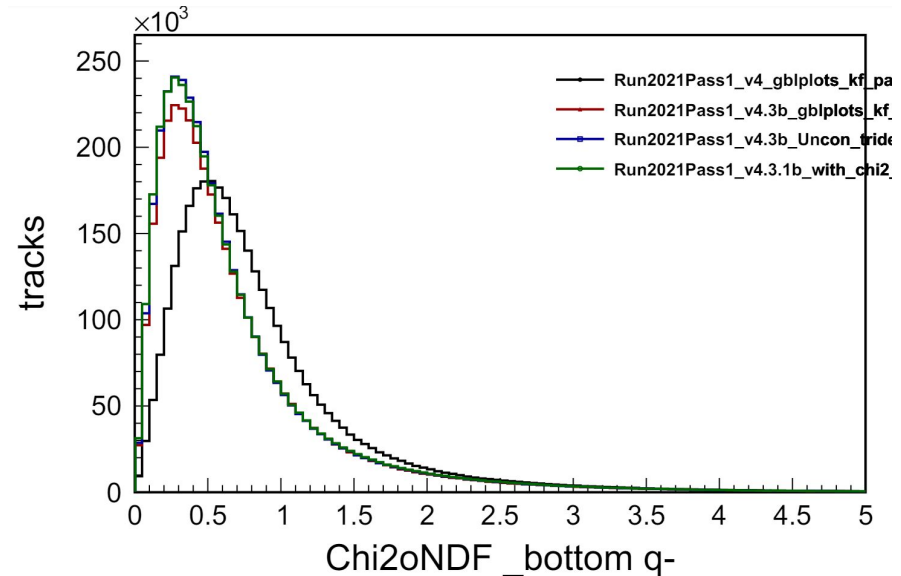
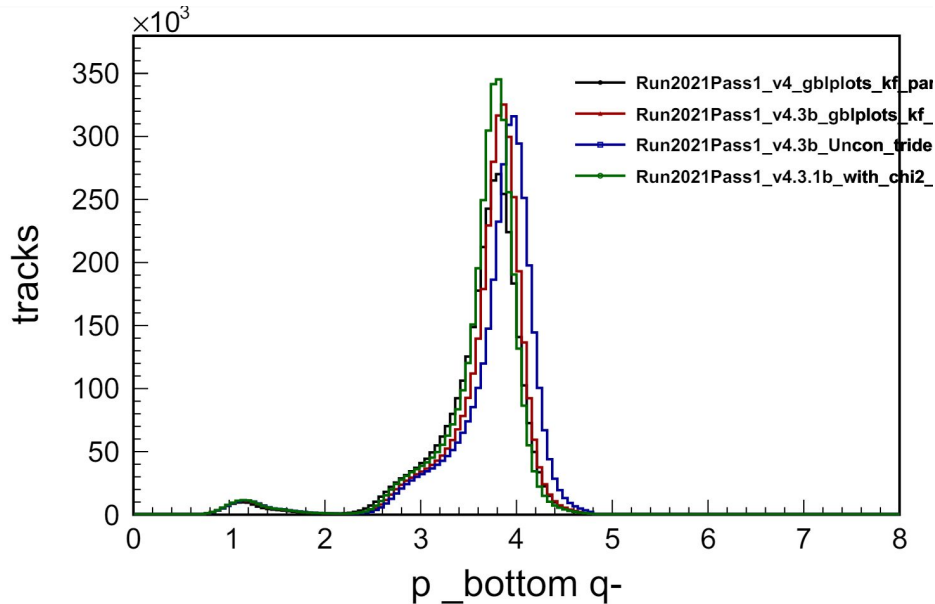
“physics run” for this final detector only had 3 files finish...fix this.



# June 11 update: Momentum scale

This does what we want! Moves the FEE peak to  $\sim 3.8$  GeV and chi2 is essentially the same. Both resolution and chi2 are better than v4.

This is true for physics as well, but I need to normalize those plots correctly.



# Good enough? Good enough!

- You and see all the summary plots for [run 14168](#) (FEE) and [run 14229](#) (physics)

- The “recipe” I used:

*v4: current early run standard*

*v4.2b: v4+L5-7 axial tus + stereo rws based on PC FEEs (+ movement of L5Sh) – gets rids of p/phi0 dependence*

*v4.3b: v4.2b+L5-7 axial tus + stereo rws based on EoP tridents (Fiducial only)*

*v4.3.1: v4.3b + unconstrained L4 Ax/St tus + L5-7 axial tus + stereo rws – improve trident residuals*

*v4.4: v4.3.1b + PC FEE L6-7 stereo tus – fixes momentum scale*

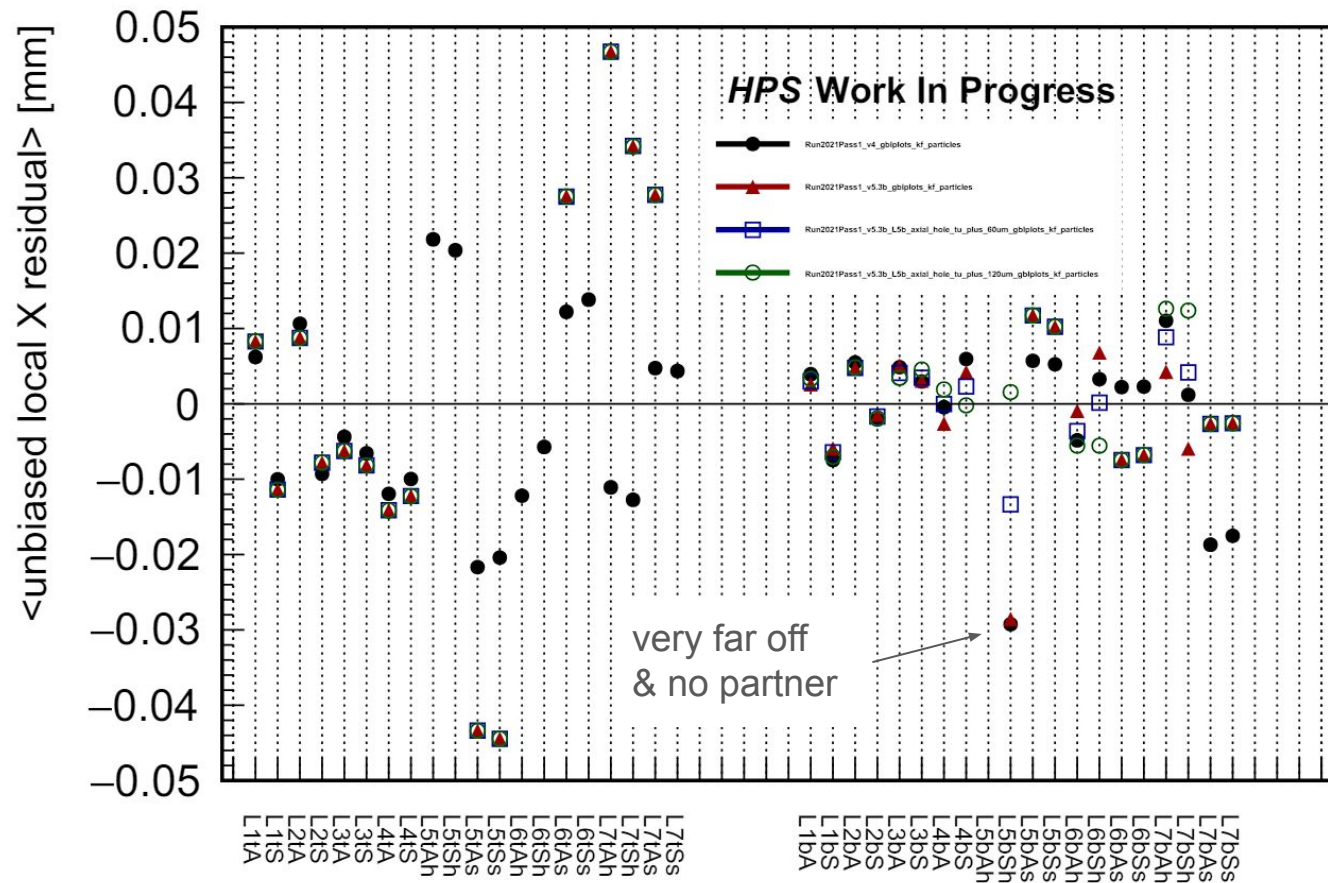
- Maybe could have skipped the second step: “EoP tridents”
- Overall I think this is a good detector, at least for these 2 runs. Need to look at run dependence.
  - I’m still seeing E/p dependence in run 14229...I tried turning off “applyCorrections” and it got worse, not better.

Cameron says we can move the momentum with impunity, so IMO we could just shift the “v4.3b + unconstrained tridents” in momentum and call it a day.

Old stuff on next slides



# One more “by hand”: L5 stereo hole



Bottom residuals look ok except for L5Sh ...L5Ah is dead so with no stereo pair, ST will never get a hit so it was never aligned?

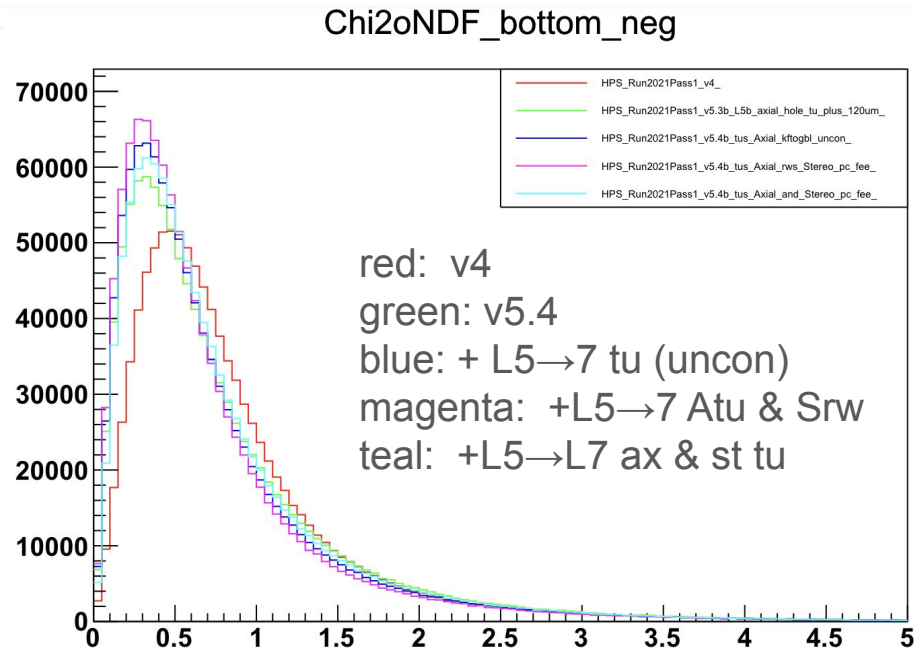
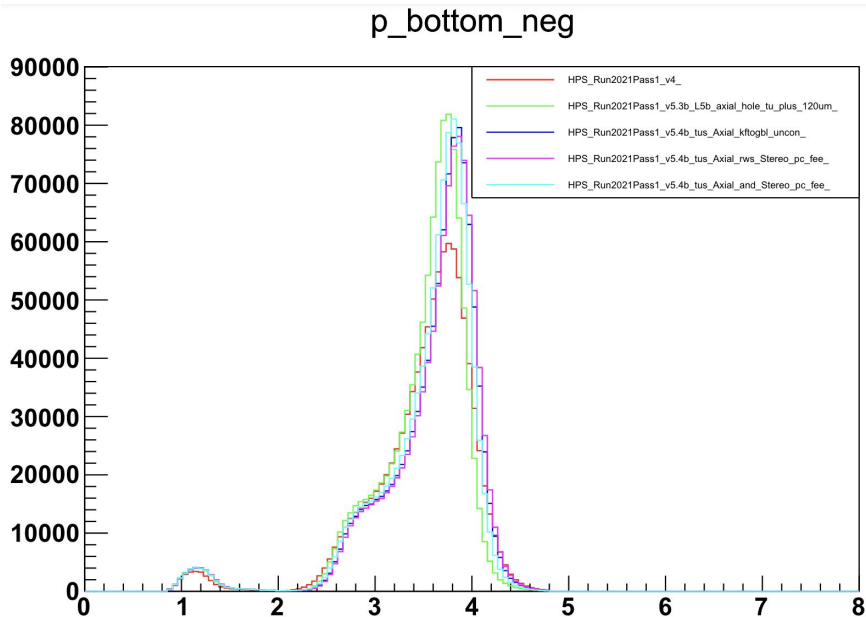
whatever...I moved it by hand by 120u(!) and will try to fix it in MPII

this takes us to v5.4

# Momentum constraint + MP11 to get tus

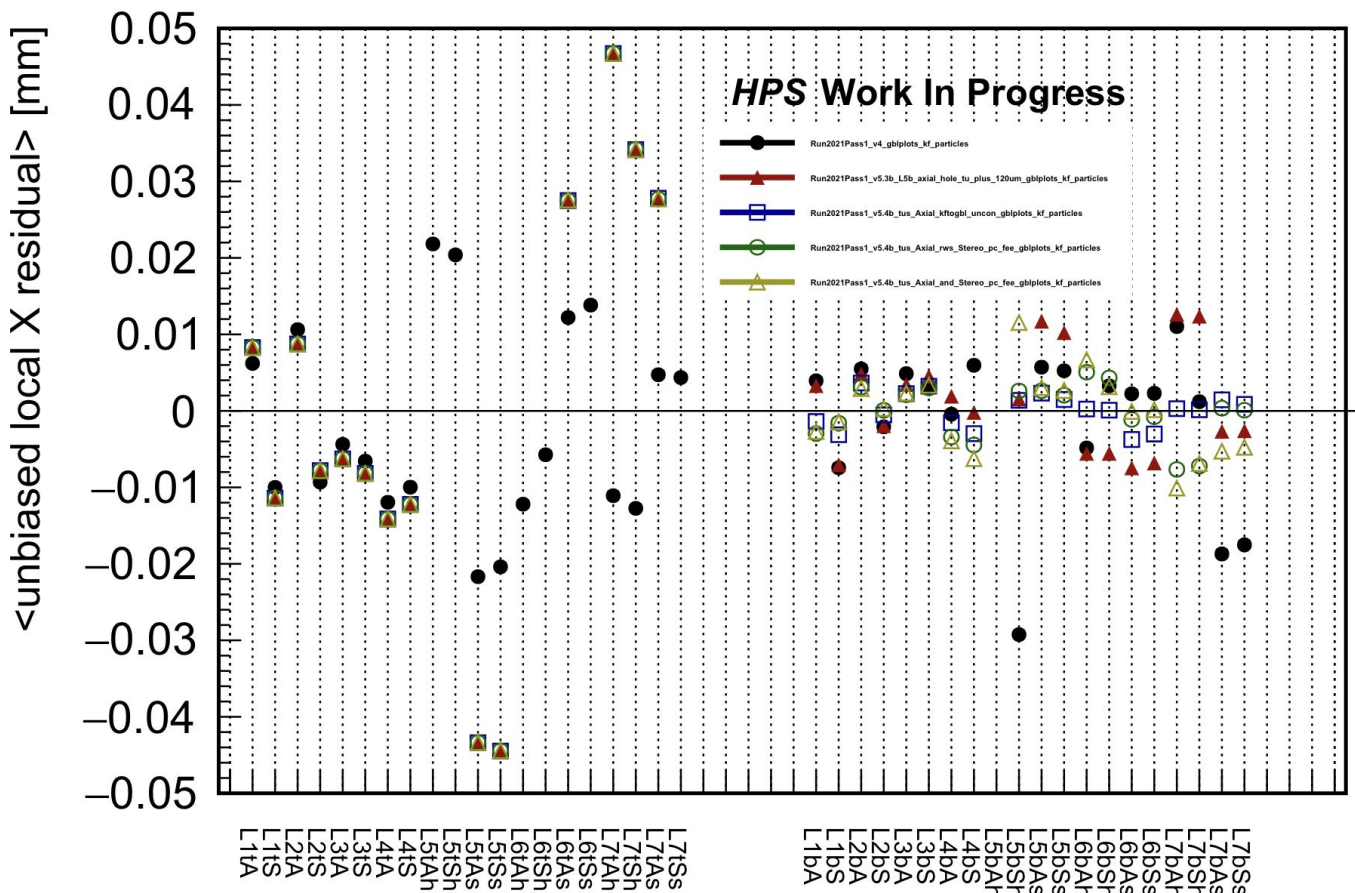
- For the events that go into MP11 for optimization:
  - $2.0 < p < 4.8$  GeV
  - must be matched to a cluster in the fiducial region of the ECal
  - $3.2 < clE < 4.2$  GeV
  - ...these are fairly strict cuts to make sure we are really getting FEEs
- I tried a few different sets of free parameters in MP11
  - L5-7 just axial Tus (I did this unconstrained for some reason)
  - L5-7 axial Tus and stereo Rws
  - L5-7 axial and stereo Rws

# Momentum and chi2



- All of these have better momentum resolution than v4... $\phi_0$  dependence mostly removed
- Resolution ~same for the 4 updated detectors
- The v5.4 is closest to 3.74 GeV...others are a bit high
- $\chi^2/NDF$  significantly improved wrt v4, although moving L5Sh is a big part of that

I think the blue boxes might be best here...thats from the kf->GBL unconstrained, axial tu only fits.

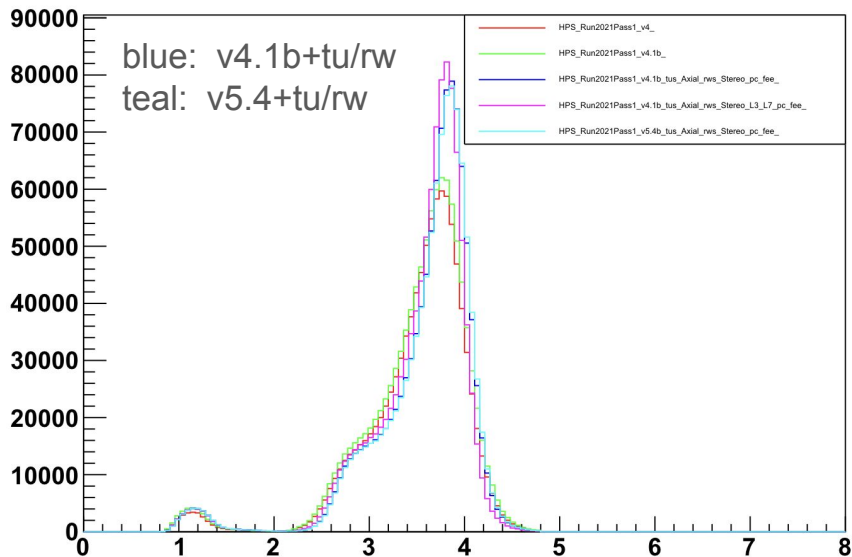


# Can I get to the same place just using millipede?

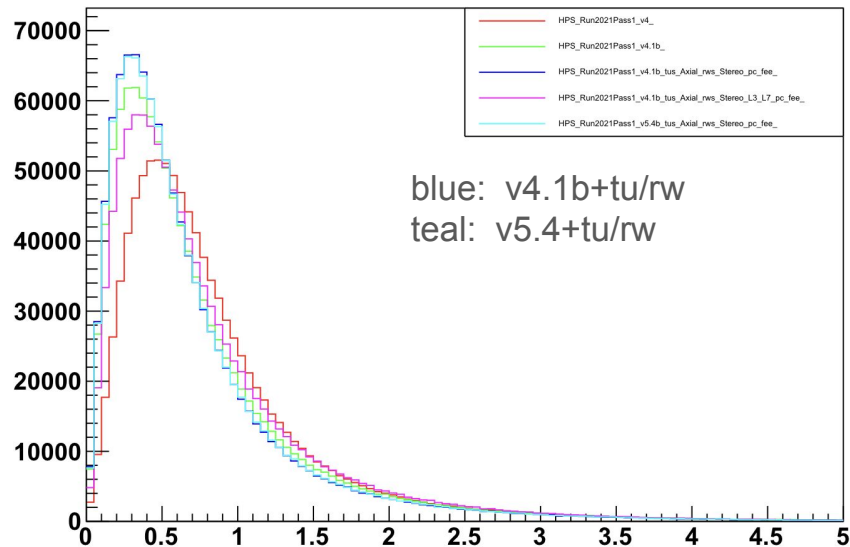
Ran PC on a “v4.1b” detector, which is just v4 but with the 120um L5Sh (bottom) fix  
In MPII try floating L5→L7 axial tu/stereo RW (compare to v5.4 with same floating)  
Also see about L3→L7 axial tu/stereo RW

The v4.1b+tu/rw and v5.4+tu/rw look very similar basically everywhere...

p\_bottom\_neg



Chi2oNDF\_bottom\_neg

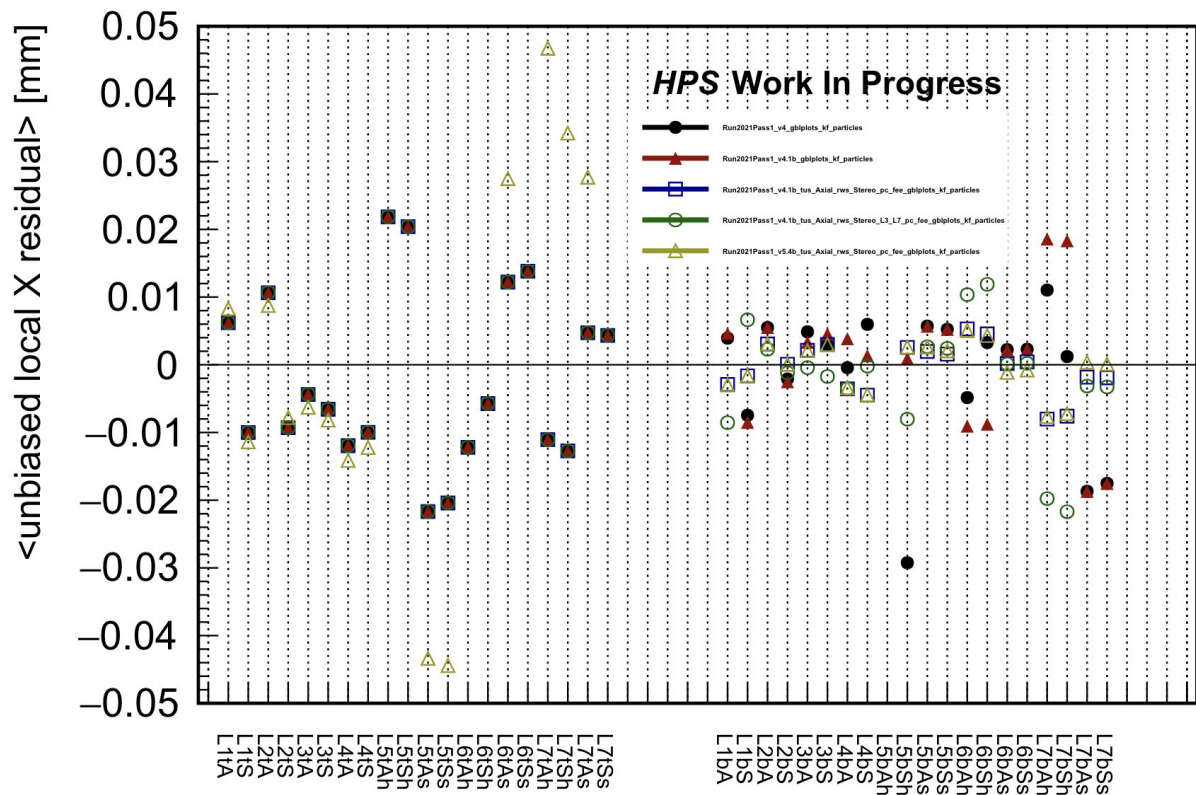


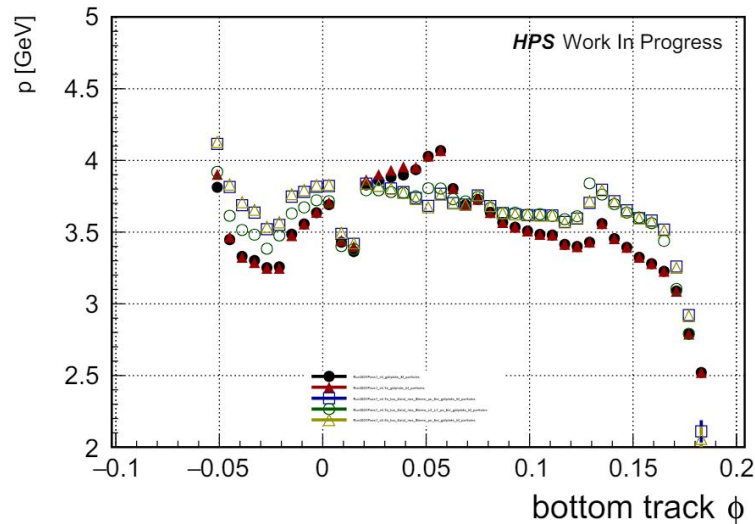
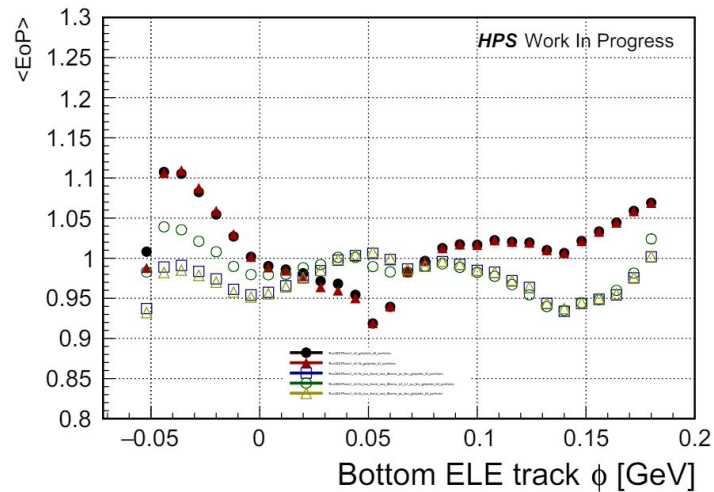
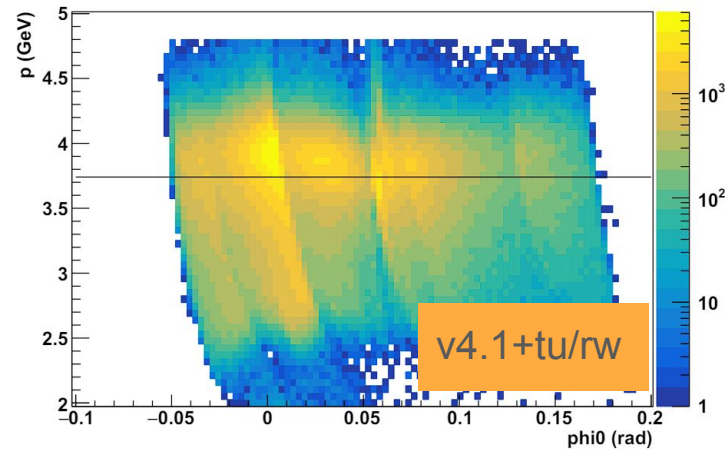
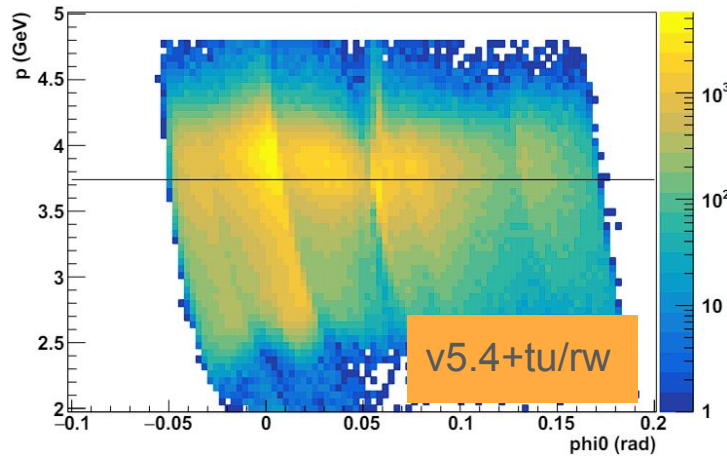
# v4.1b vs v5.4 residuals

v4.1+tu/sw (blue squares)  
v5.4+tu/sw (yellow tri)

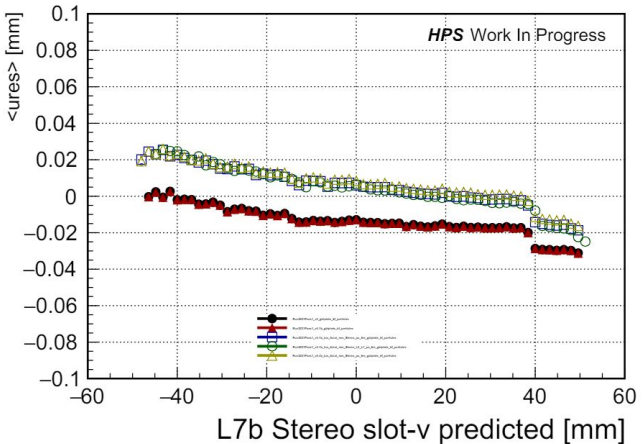
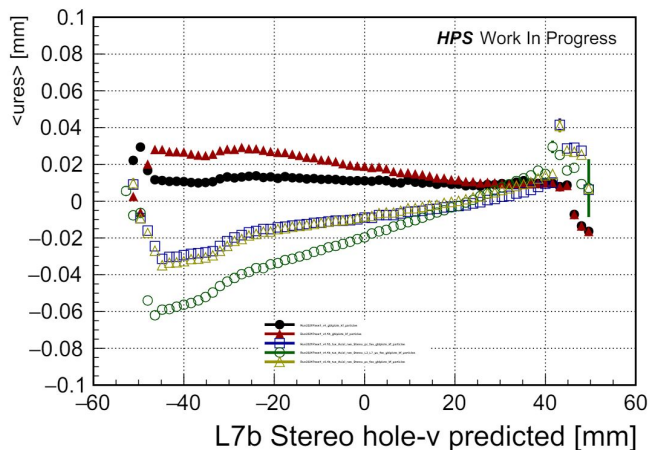
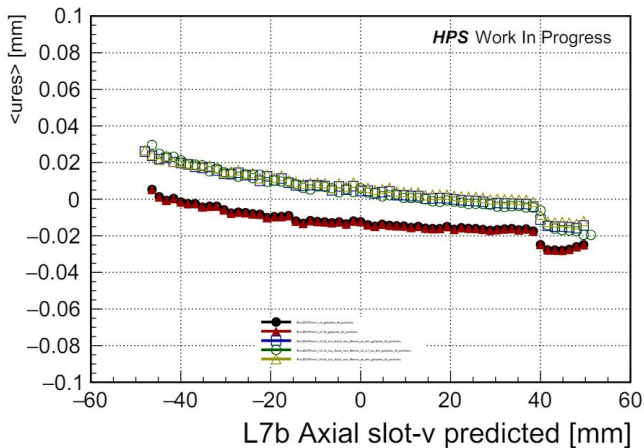
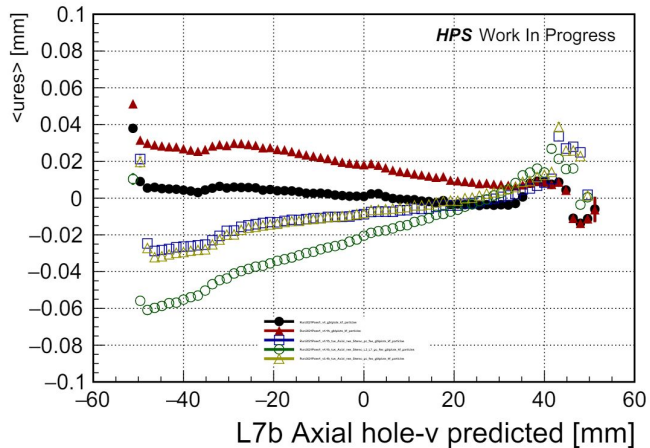
The residuals for these two are very close...practically identical.

Overall, small but significant improval of u-residuals





# It's not all guns & roses

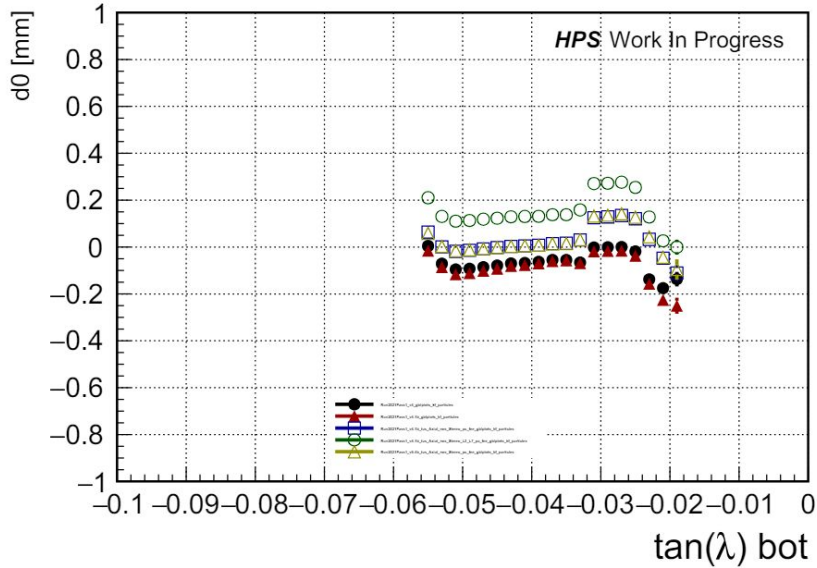


Seems to introduce some trends in (particularly hole-side)  $\langle u_{res} \rangle$  vs  $v$ .

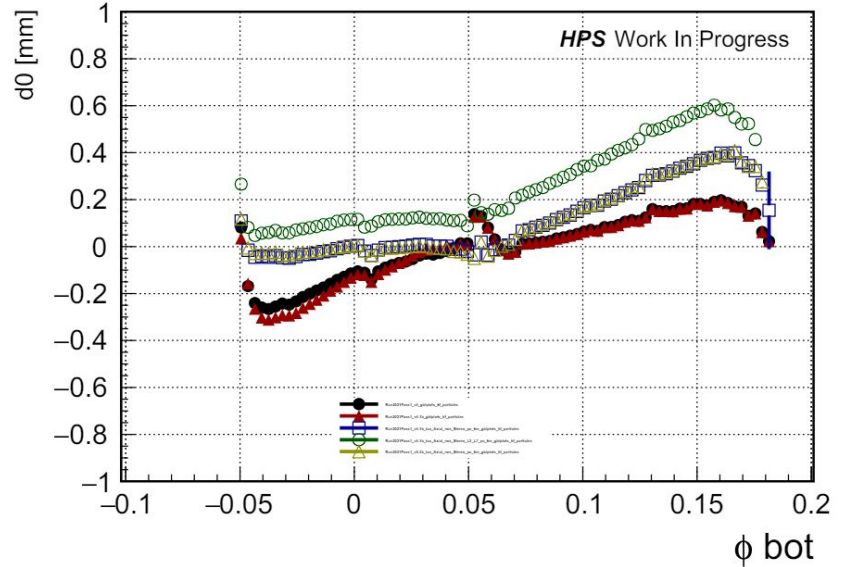


All residuals plot are here

this basically just moved up to  $\sim 0$

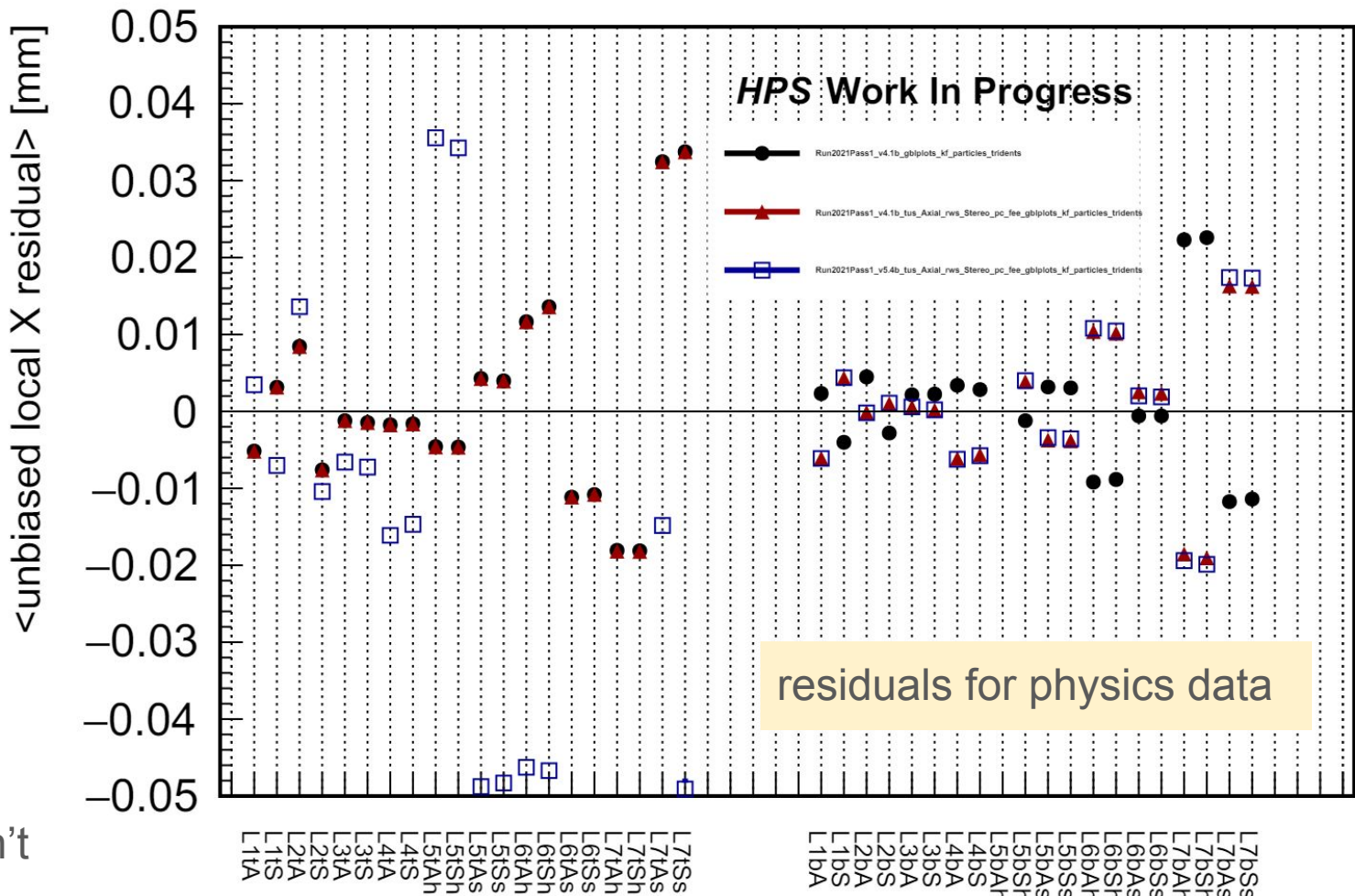


Better on -ive phi, worse on +ive



# Next steps?

- According to these early run, low lumi FEEs, we've improved the v4 detector to some extent...p-resolution (from p-phi correlation), chi2, u-residuals are somewhat better. Added some new correlations and weirdness in  $\langle ures \rangle$  vs  $v$ .
- Want to look at all tracks from data, particularly E/p and cluster deltaX/Y
-



so, this doesn't look great...