

Update on the 2021 SVT alignment

October 15th 2024

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- Investigated the differences between the two detectors that have been optimized for the start and end of dataset
- Attempted an alignment of runs in the middle of dataset, where neither of the two optimized detectors provides satisfactory performance
 - Looked at alignment in physics and FEE selected datasets. Observe some differences, and throughout the process attempted alignment on both datasets
- Implemented FEE skimming into a pre-existing 2019 reconstruction driver, ran over EVIO files with best detectors — looked at run-by-run differences in the unbiased residuals, and attempted an alignment on these newly created datasets

Understanding changes: Top detector

- The differences between *HPS_Run2021Pass1_v5* and *HPS_Run2021Pass1_v4newBot* detectors are all isolated to L5, L6 and L7

Detector	v4	v5	$\Delta_{(v5-v4)}$
module_L5t_halfmodule_stereo_hole (11110)	-105.303	-77.960	27.343
module_L5t_halfmodule_stereo_slot (11112)	-0.099	-23.950	-23.851
module_L6t_halfmodule_axial_hole (11113)	31.428	31.428	0.000
module_L6t_halfmodule_stereo_hole (11114)	-134.322	-190.945	-56.623
module_L6t_halfmodule_axial_slot (11115)	61.091	61.091	0.000
module_L6t_halfmodule_stereo_slot (11116)	101.808	241.917	140.109
module_L7t_halfmodule_stereo_hole (11118)	-109.844	-118.154	-8.310
module_L7t_halfmodule_axial_slot (11119)	2.304	2.304	0.000
module_L7t_halfmodule_stereo_slot (11120)	-1.948	53.144	55.092
module_L5t_halfmodule_stereo_hole (12310)	-0.107	-0.421	-0.314
module_L5t_halfmodule_stereo_slot (12312)	-4.797	-4.613	0.184
module_L6t_halfmodule_stereo_hole (12314)	1.623	1.579	-0.044
module_L6t_halfmodule_stereo_slot (12316)	-3.461	-2.283	1.178
module_L7t_halfmodule_stereo_hole (12318)	1.492	0.706	-0.786
module_L7t_halfmodule_axial_slot (12319)	4.624	4.624	0.000
module_L7t_halfmodule_stereo_slot (12320)	-5.176	-4.239	0.937

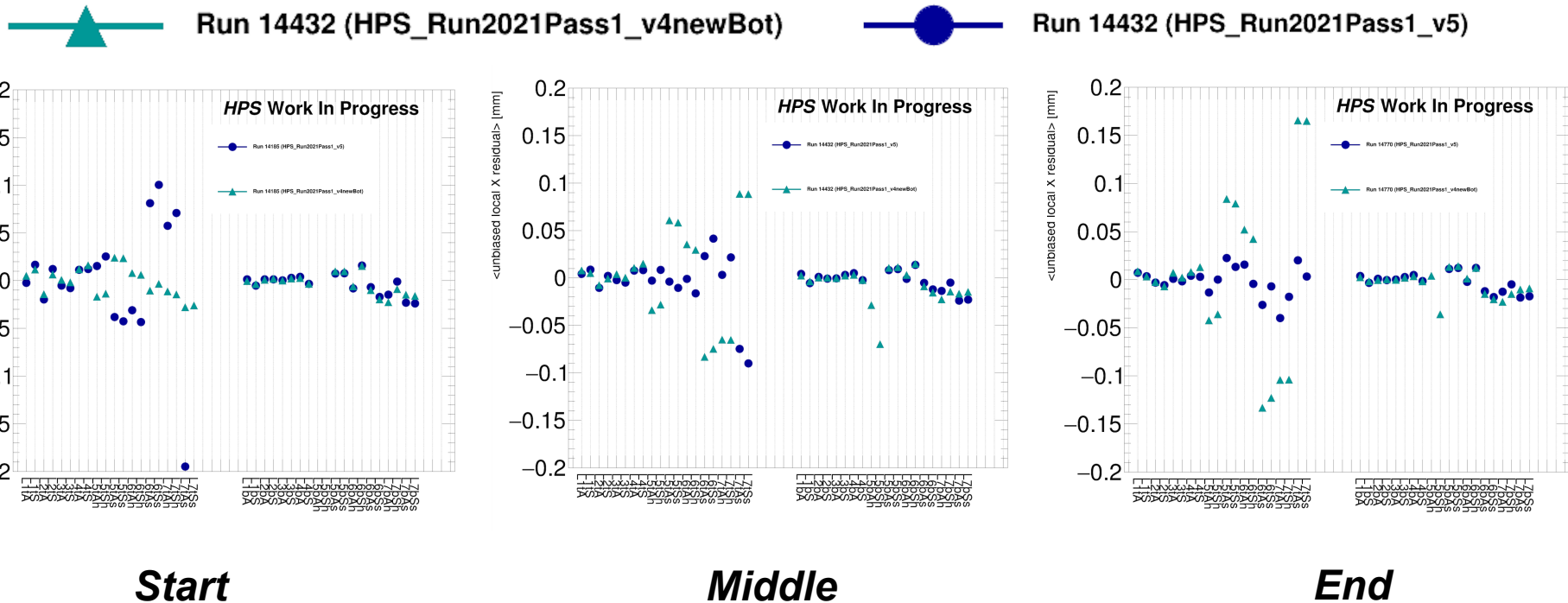
Understanding changes: Bottom detector

Detector	v_4	v_5	$\Delta_{(v_5-v_4)}$
module_L4b_halfmodule_stereo (21107)	-30.069	-29.844	0.225
module_L4b_halfmodule_axial (21108)	-10.851	-11.042	-0.191
module_L5b_halfmodule_axial_hole (21110)	174.220	68.386	-105.834
module_L5b_halfmodule_axial_slot (21112)	-141.251	-148.923	-7.672
module_L6b_halfmodule_stereo_hole (21113)	-182.467	-208.073	-25.606
module_L6b_halfmodule_axial_hole (21114)	175.160	210.847	35.687
module_L6b_halfmodule_stereo_slot (21115)	182.220	190.502	8.282
module_L6b_halfmodule_axial_slot (21116)	-186.198	-205.312	-19.114
module_L7b_halfmodule_stereo_hole (21117)	-265.976	-307.464	-41.488
module_L7b_halfmodule_axial_hole (21118)	388.625	441.052	52.427
module_L7b_halfmodule_stereo_slot (21119)	246.229	260.745	14.516
module_L7b_halfmodule_axial_slot (21120)	-343.234	-382.148	-38.914
module_L5b_halfmodule_stereo_slot (22311)	-0.100	-0.174	-0.074
module_L6b_halfmodule_stereo_hole (22313)	0.368	0.969	0.601
module_L6b_halfmodule_stereo_slot (22315)	-1.651	-1.775	-0.124
module_L7b_halfmodule_stereo_hole (22317)	1.160	2.531	1.371
module_L7b_halfmodule_stereo_slot (22319)	-3.439	-3.685	-0.246

- Looking at the following “physics datasets” (mostly because this is what’s available in SLCIO on S3DF). Conveniently, they are roughly split throughout the 14185 (start), 14432 (middle) & 14770 (end) of dataset
- Ran with both ***HPS_Run2021Pass1_v5*** and ***HPS_Run2021Pass1_v4newBot*** detectors
- For FEEs, I have been running with the momentum constrained driver, while for physics was using the “chi2” driver (as the PC doesn’t make much sense here...)

Physics run residuals

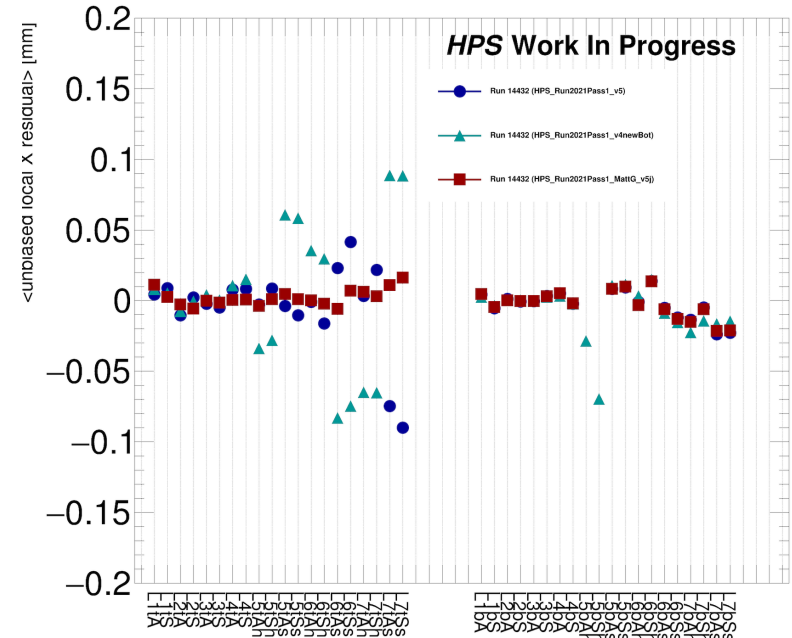
- Unbiased residuals for three runs:
 - v4 works well for the early run (room for improvement in top)
 - v5 works well for the end run (room for improvement in top)
 - **Neither v4 and v5 good for top detector in the middle runs**



Attempts at tuning middle run

- Started with v5, and after several iterations ended up with “Matt_v5j” detector (red squares) after aligning the Run 14432 “physics dataset”
- Updated alignment looks pretty good in-situ, but required relatively large u -translations in L7

Detector	$\Delta(v5j - v5)$
module_L6t_halfmodule_axial_hole (11113)	-58.172
module_L6t_halfmodule_stereo_hole (11114)	67.510
module_L6t_halfmodule_axial_slot (11115)	42.531
module_L6t_halfmodule_stereo_slot (11116)	-43.121
module_L7t_halfmodule_axial_slot (11119)	-70.085
module_L7t_halfmodule_stereo_slot (11120)	202.355
module_L7t_halfmodule_axial_slot (12319)	0.633
module_L7t_halfmodule_stereo_slot (12320)	-0.423

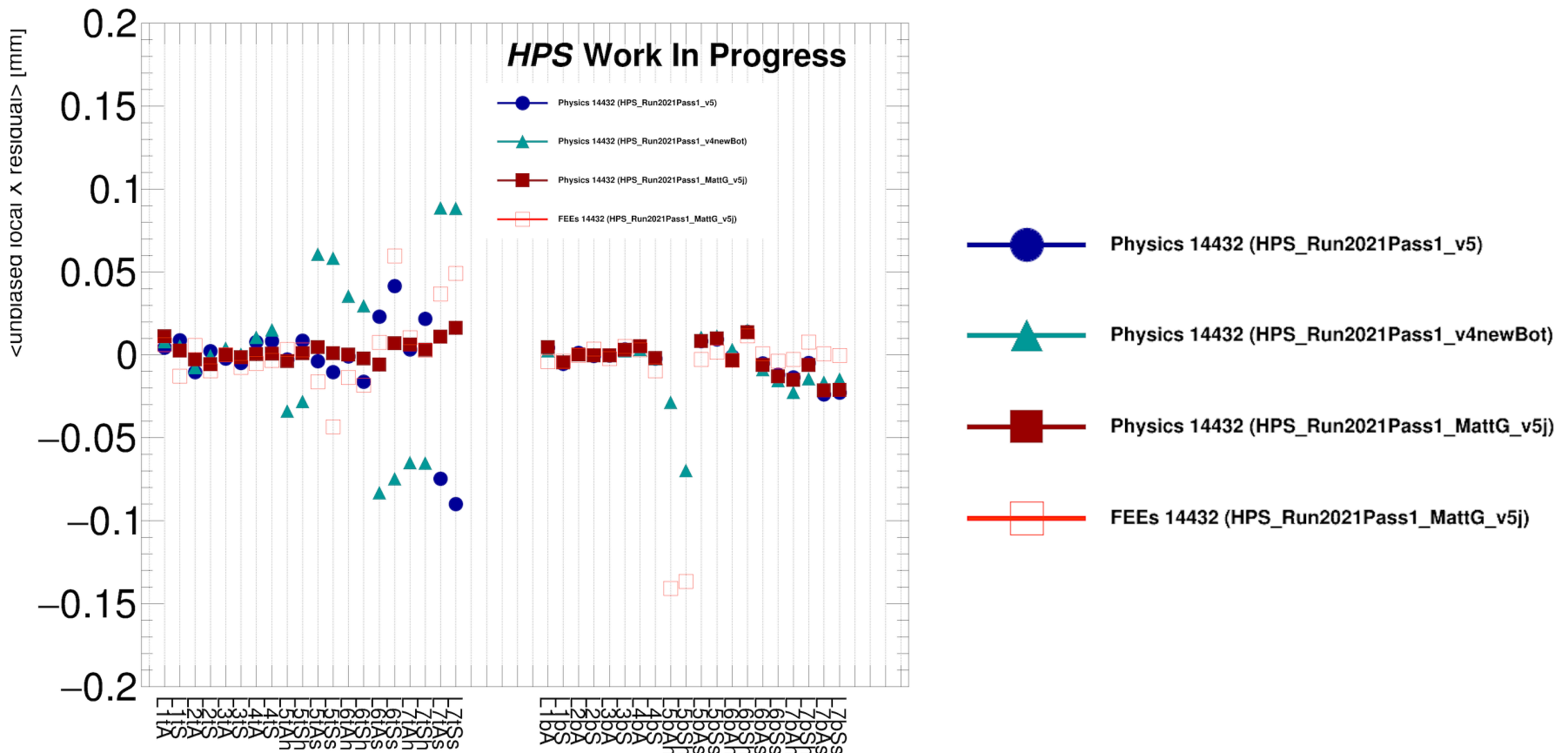


Cross checking with FEEs

- Thought to check performance of this “Matt_v5j” alignment attempt in FEEs, as the physics dataset was dominated by mostly low momentum tracks
- Cam has some “FEE skims” — unclear how these were produced. Should follow up with him. Are these just FEE runs with a dedicated trigger? Or physics runs that have been filtered to select FEEs?
- Two runs available: 14466 and 14432
 - Both of these are roughly in the middle of the run period: good to look at the newly tuned detector & v5
- For FEEs, running with the momentum constrained driver, while for physics was using the “chi2” driver

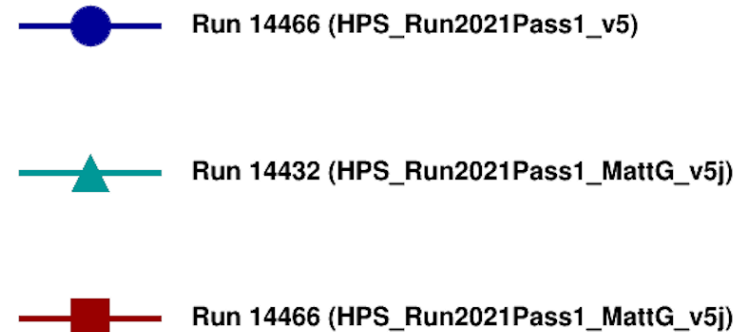
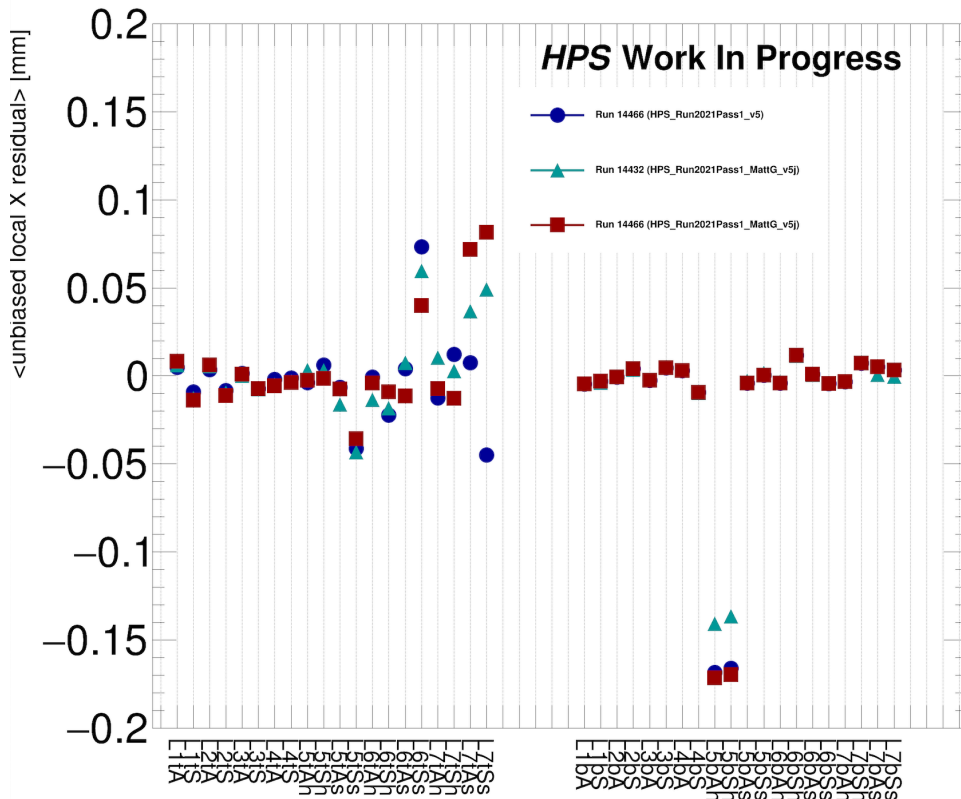
FEEs: Run 14432

- Physics looks good in v5j, but FEEs show $\sim 50\mu\text{m}$ differences for several (slot side) layers



FEEs: Run 14466

- Similar issues observed with the other FEE dataset (Run 14466), slot side: L6tSs, L7tAs and L7tSs



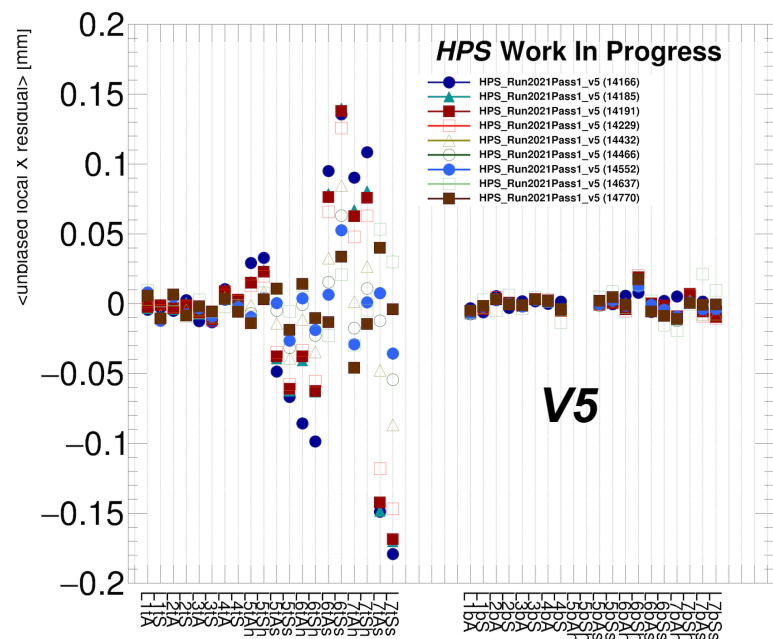
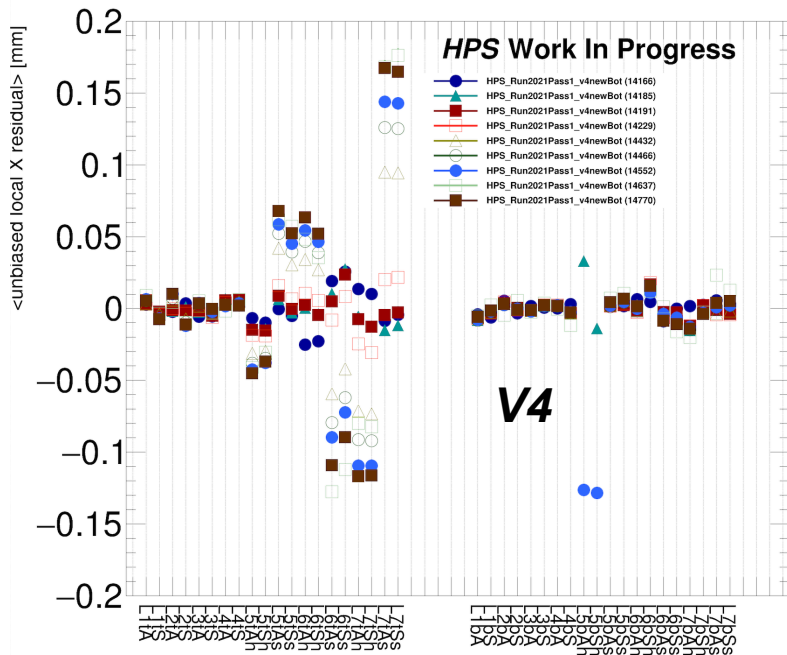
Creating “FEE Skims”

- Wanted to run the momentum constrained alignment driver on FEEs across a variety of runs
- Matt G pointed me to “FEEFilterDriver” — was able to integrate this into the “PhysicsRun2019FullRecon.lcsim” to filter events containing:
 - ECal Seed with >1.0 GeV
 - ECal Cluster with >1.8 GeV

*** Unsure about these cuts **
(e.g. what’s the ECal resolution?)*
- Ran over ~1500 EVIO files spread across ~10 runs
 - Filter efficiency relatively low (5%), still resulted into ~1.5 TB of skimmed SLCIO files
- Re-reconstructed these SLCIO files using the momentum constrained alignment driver for v4 and v5 detectors

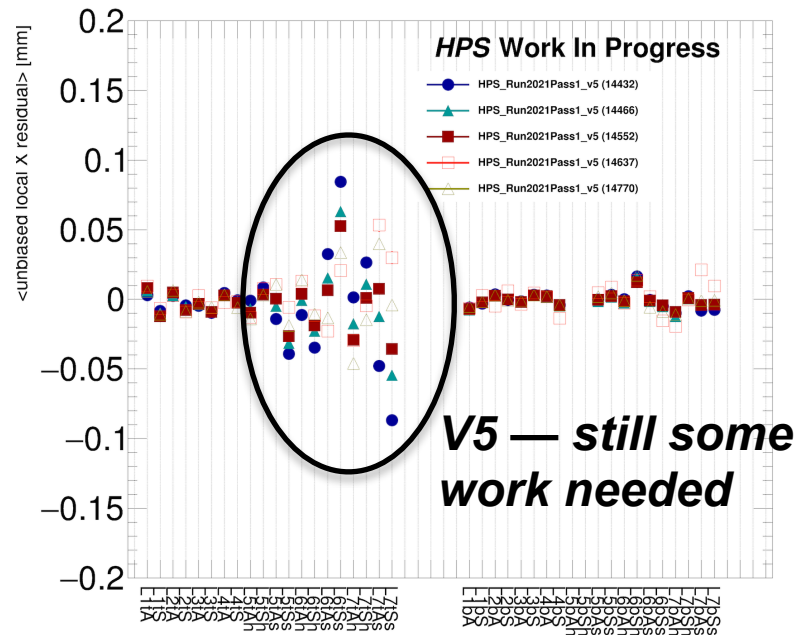
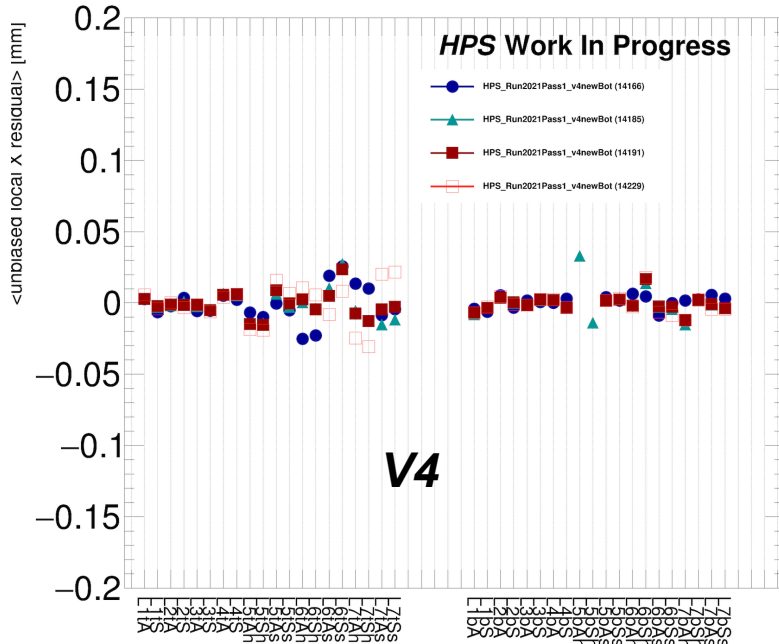
Looking at several runs

- Early runs up to ~14229 look reasonably good in v4, but start to diverge at this point. Later runs all seem to move in progressively larger but similar ways
- Later runs look better in v5, but still significant residuals in outer layers of the detector



Looking at several runs

- Early runs up to ~14229 look reasonably good in v4, but start to diverge at this point. Later runs all seem to move in progressively larger but similar ways
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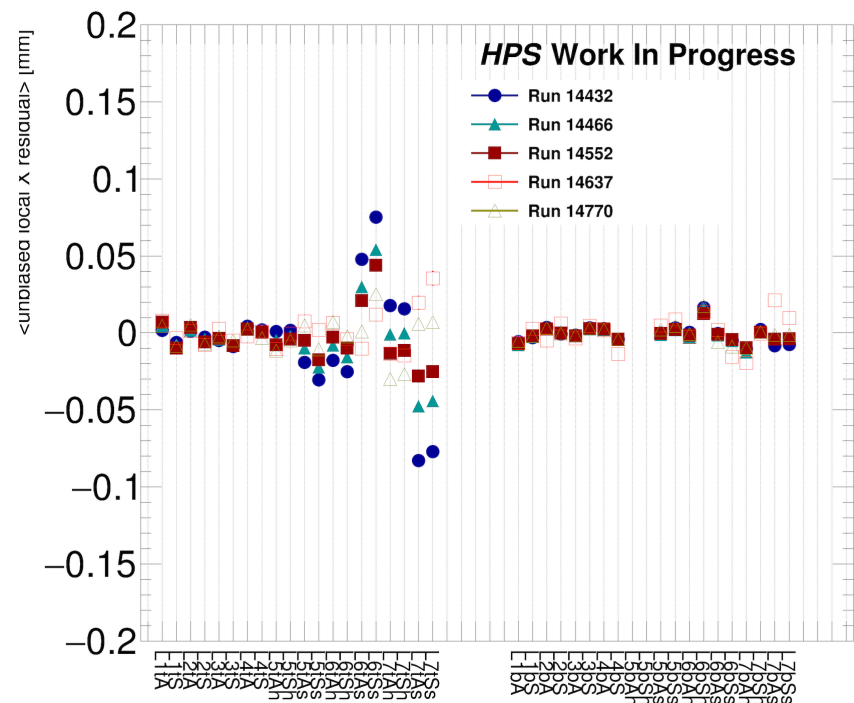
Another alignment attempt

- Using FEEs datasets from previous slide, attempted to **align run 14637 FEE dataset (end)** using the “v5j” alignment from the physics dataset as starting point
 - Offloaded the movements from L7 to L6 with overall smaller u -translations, but similar performance

Detector	$\Delta(\text{v5j} - \text{v5})$	$\Delta(\text{v5n} - \text{v5})$
module_L6t_halfmodule_axial_hole (11113)	-58.172	-58.172
module_L6t_halfmodule_stereo_hole (11114)	67.510	67.510
module_L6t_halfmodule_axial_slot (11115)	42.531	78.393
module_L6t_halfmodule_stereo_slot (11116)	-43.121	-80.052
module_L7t_halfmodule_axial_slot (11119)	-70.085	-70.085
module_L7t_halfmodule_stereo_slot (11120)	202.355	57.052
module_L7t_halfmodule_axial_slot (12319)	0.633	0.633
module_L7t_halfmodule_stereo_slot (12320)	-0.423	-0.423

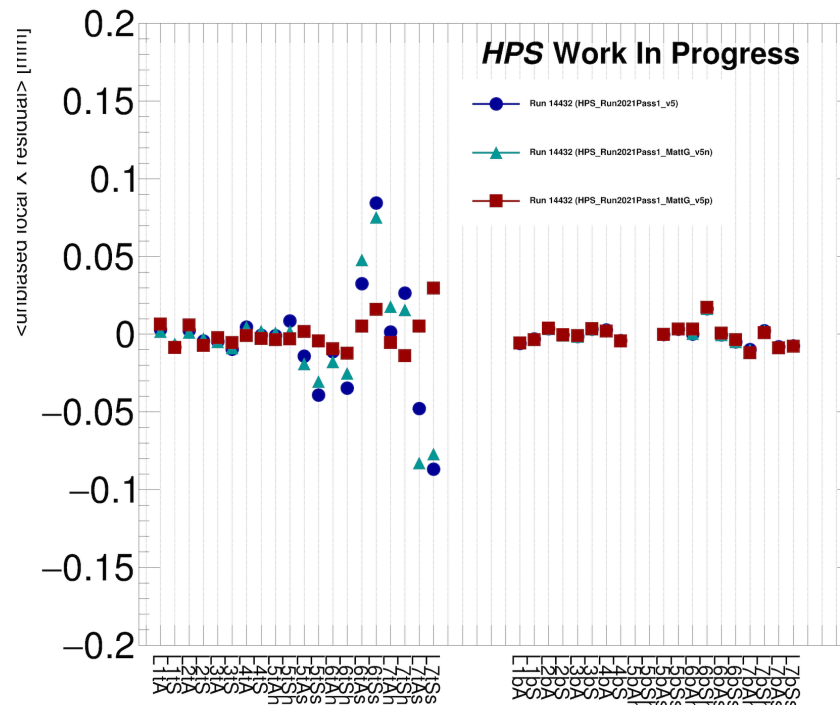
Another alignment attempt (1)

- Reasonably successful — remaining differences in earlier runs seem consistent with movements in L6t slot
 - Hoping to reduce refinements beyond this to movements of L6t only for middle runs
- Most layers do not want to move in any sizable way at this point after running Millepede — limitation of FEE dataset?
 - Tried “by eye” movements of L6 & L7 (next slide)



Another alignment attempt (2)

- Focused on Run 14432 — shows the largest residuals
 - Moved L6tSs by +80um, L6tSh -20um,, L7tSs +30um
 - Improvements (red squares), but could be still be refined and improved



Millepede errors

- For many runs, I am getting errors from Millepede (presumably about bad input data?).
 - Anyone run into this before? Or know what it means?

```
Data rejected in previous loop:
      0 (rank deficit/NaN)          0 (Ndf=0)          0 (huge)          42081 (large)
Too many rejects (>33.3%) - stop
```

Conclusions

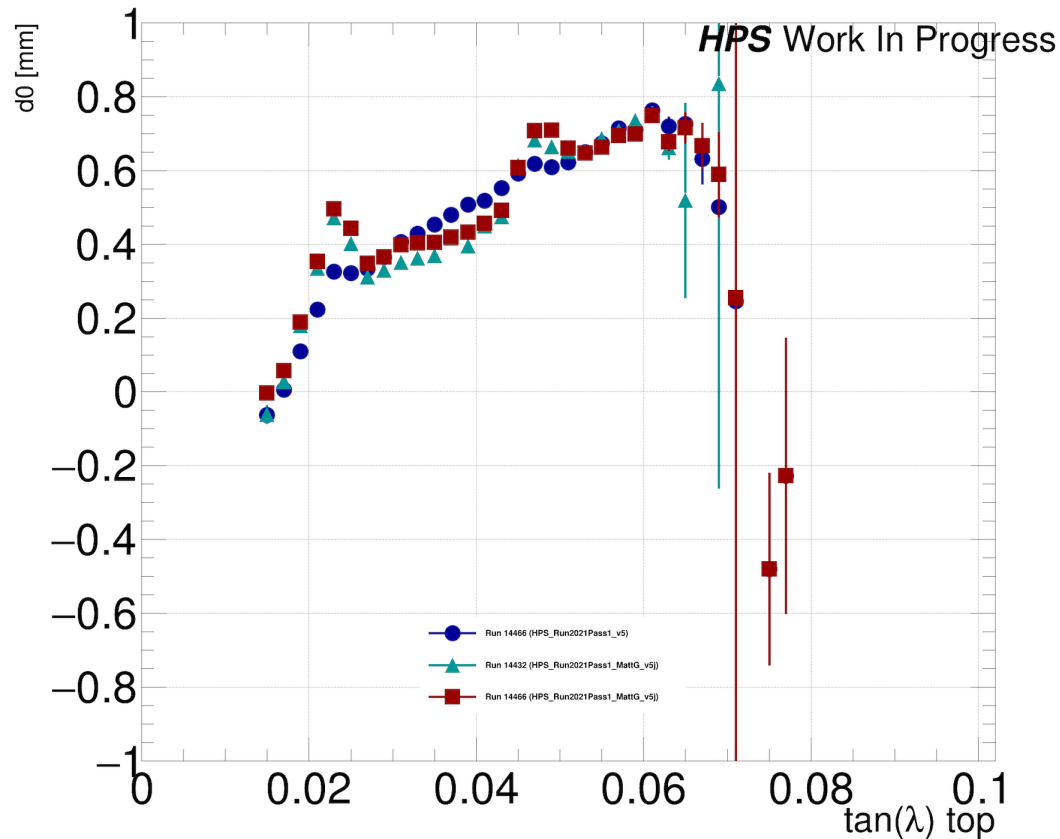
- Gaining some experience with the alignment machinery, and have attempted to align certain runs that showed unsatisfactory performance with existing alignments
 - Mildly successful, but observed differences between physics and FEE selected datasets. At the very least, a good exercise to learn basic alignment effects
- Observed run-by-run differences in the unbiased residuals, occurring around ~ 14229 . Residuals indicate (to me) that the detector is moving in a consistent way (size of residuals are increasing with time in same detector elements)
- Attempted a second alignment, built upon the physics attempt above and re-ran all FEEs in later runs. Remaining movement would be consistent with L6tS moving as Cam had mentioned.

Questions



P vs tanL

- As Tim mentioned, there is a slope in d_0 vs $\tan L$. All detectors show the same trend...



- Mostly low momentum tracks in the physics dataset

