2019 Alignment Update

Elizabeth Berzin
Collaboration Meeting
October 20, 2026

U.S. DEPARTMENT OF ENERGY
Office of Science

Stanford University

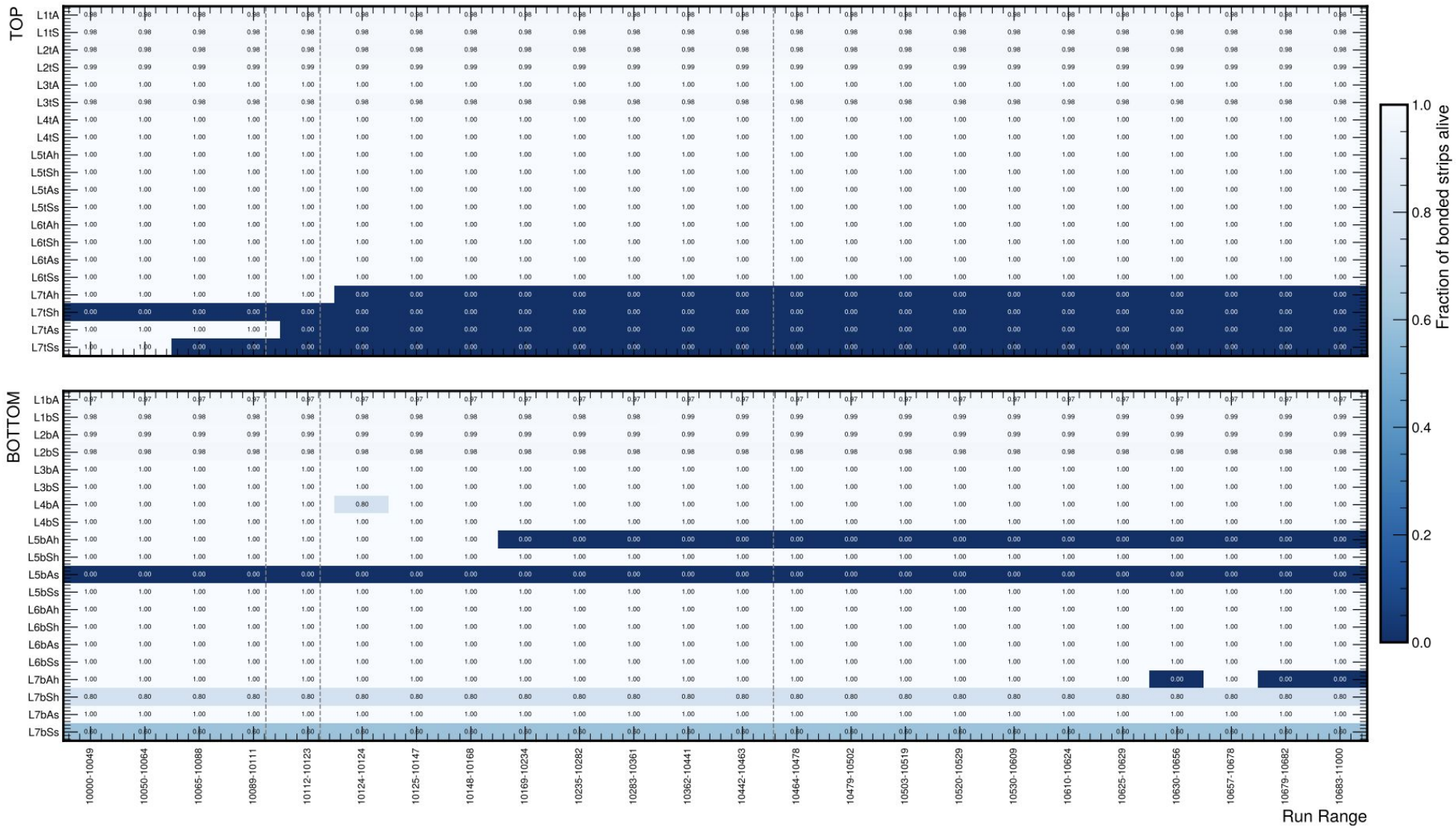
SLAC NATIONAL ACCELERATOR LABORATORY

Outline

- Current 1% pass over full dataset showed good stability run-by-run in tracking efficiency, FEE momentum, vertex-z position.
- Previous pass was reconstructed without L5b, due to missing axial/stereo pairs that required by-hand tuning.
  - Noticed L7t showing same issue in early runs.
- Today: alignment status compared to 2021, with L5b, L7t active.
  - L5 alignment.
  - Momentum scale/angular trends in FEEs (new alignment).
  - Vertex positions from FEE multi-event vertices..
  - E/p in physics runs.
  - Track-cluster matching (most problematic).
  - Hit-efficiencies.
  - Tracking efficiencies.
  - Beam spot.

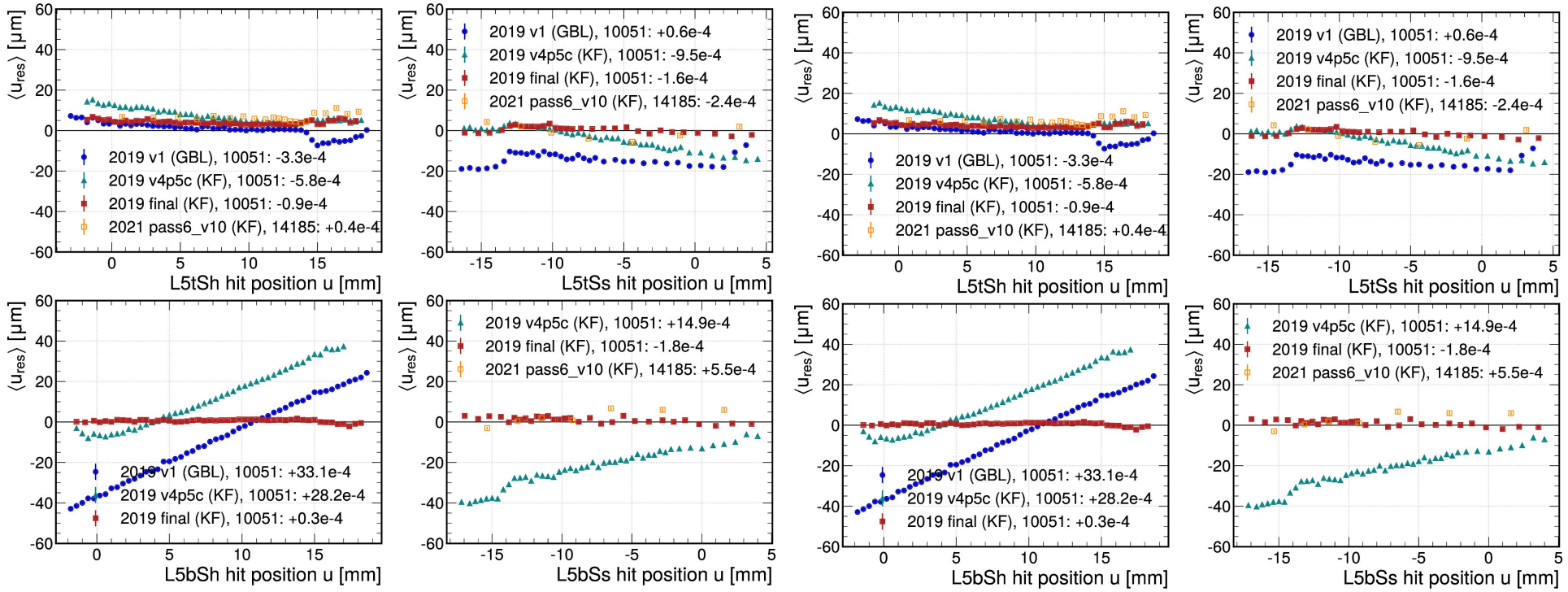
Epoch	Runs	Detector
1	$<$10105	v4p19_L7tslot_10064
T	10105–10119	v4p19_L5trans2_10064_v2a_<run>
H	10120–10123	v4p17_L5slot_10235_yaw_0p00317_L7tAhTu0p30
2	10124–10464	v4p17_L5slot_10235_yaw_0p00317
3	$\geq$10465	v4p17_L5slot_10615_yaw_0p00317_L5bSh2

Layer Configuration



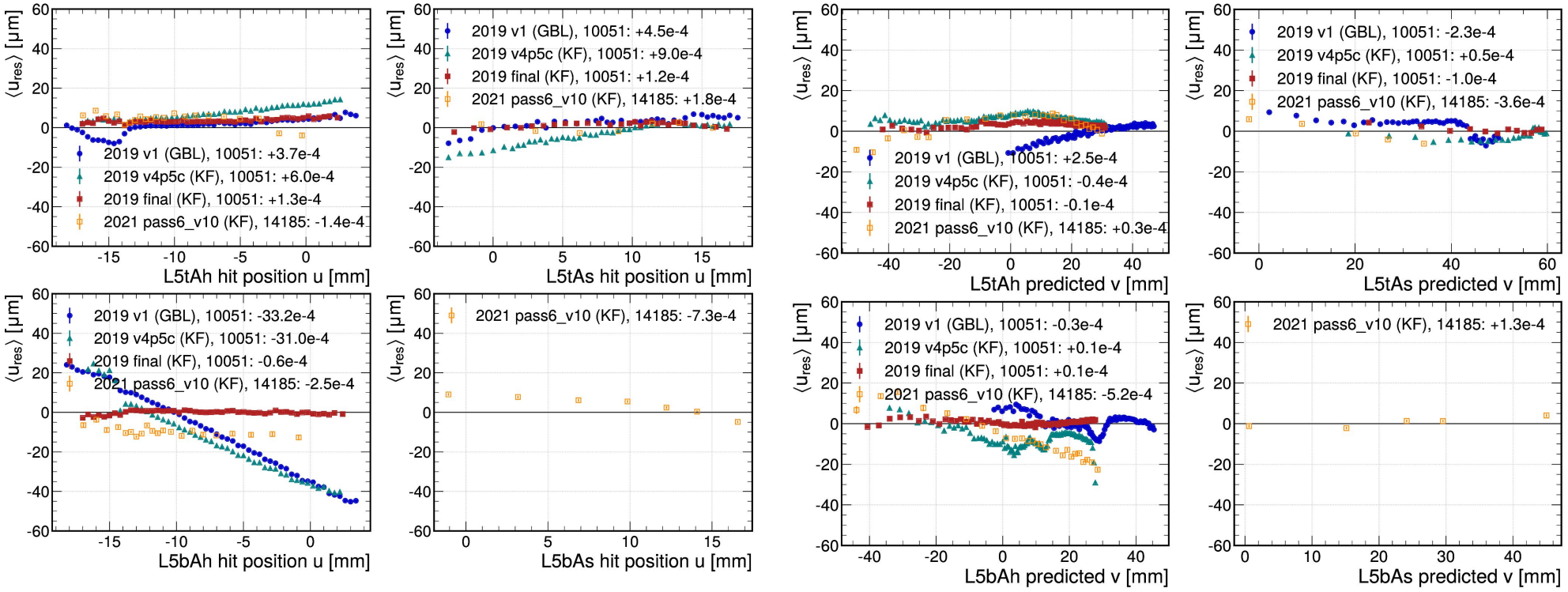
L5 Alignment

- Layer 5 is missing both axial layers in the bottom volume, meaning that standard GBL-based millipede alignment does not produce alignment constants.
- Aligned by hand through scan of Tw, Rw, Tu. KF residuals look consistent with other layers.
- Across all layers, residuals are similar, across the run period, to 2021.



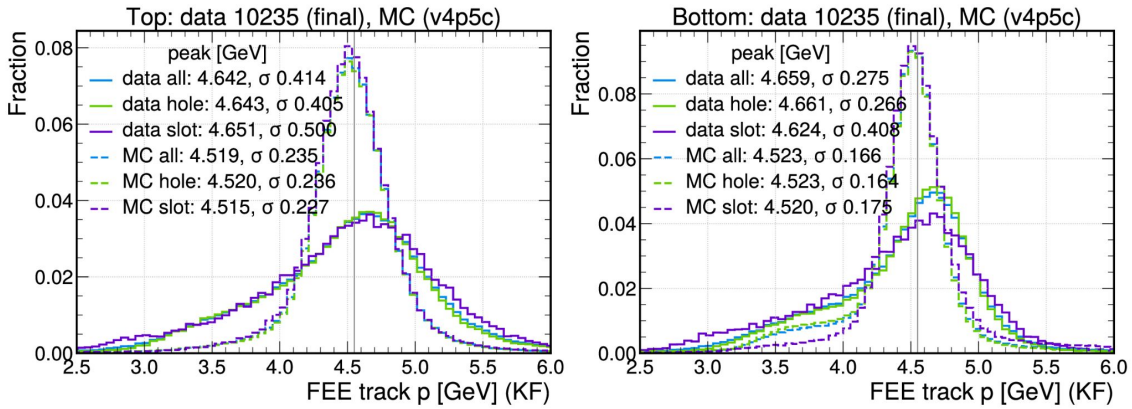
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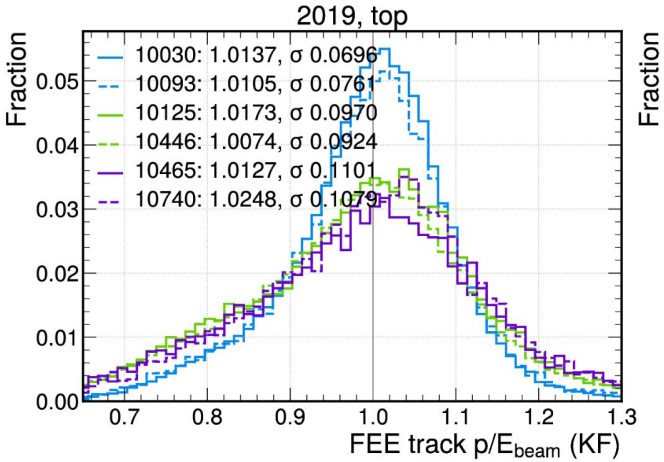
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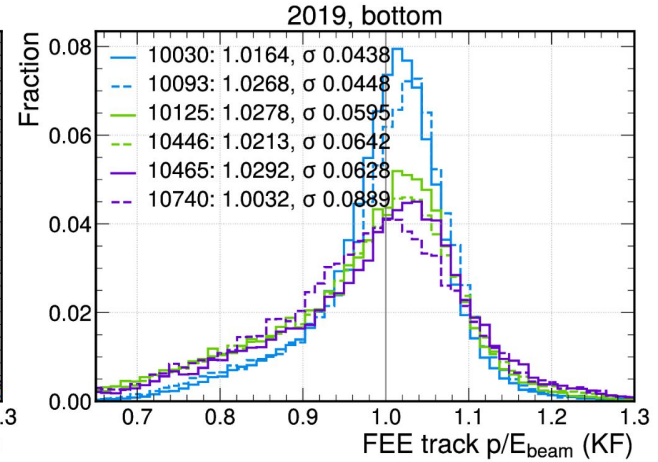


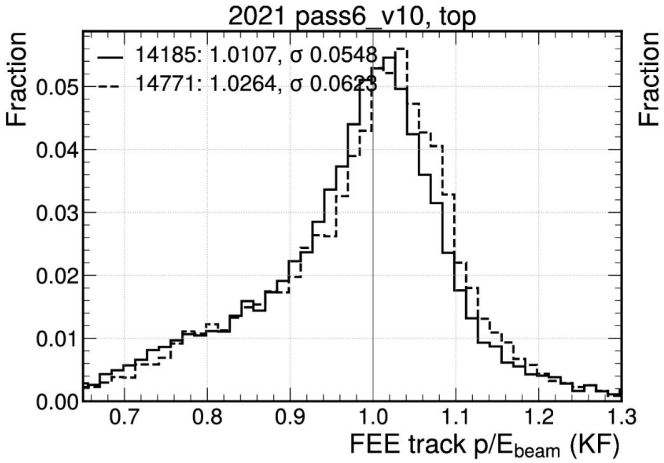
FEE Momentum Scale

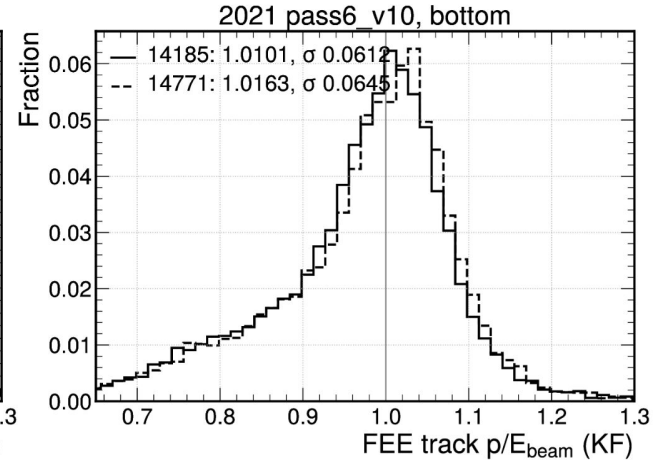
- FEE momentum scale ~1-2% high in 2019, ~1% high in 2021.
- With all layers active, FEE momentum resolution matches 2021, degrades in later runs after loss of layer 7 in top volume.
  - Also slight worsening in bottom volume (losing L5?)





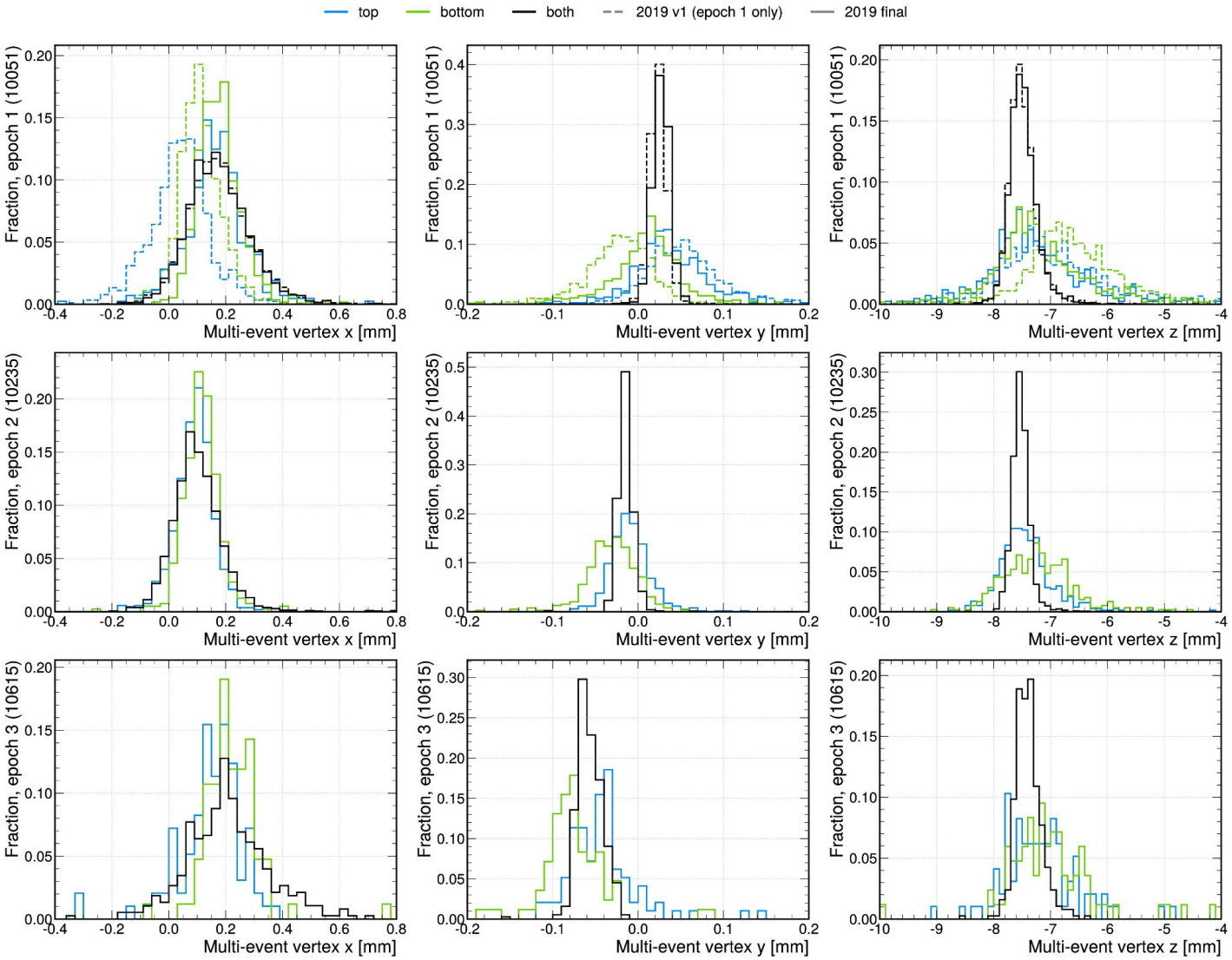






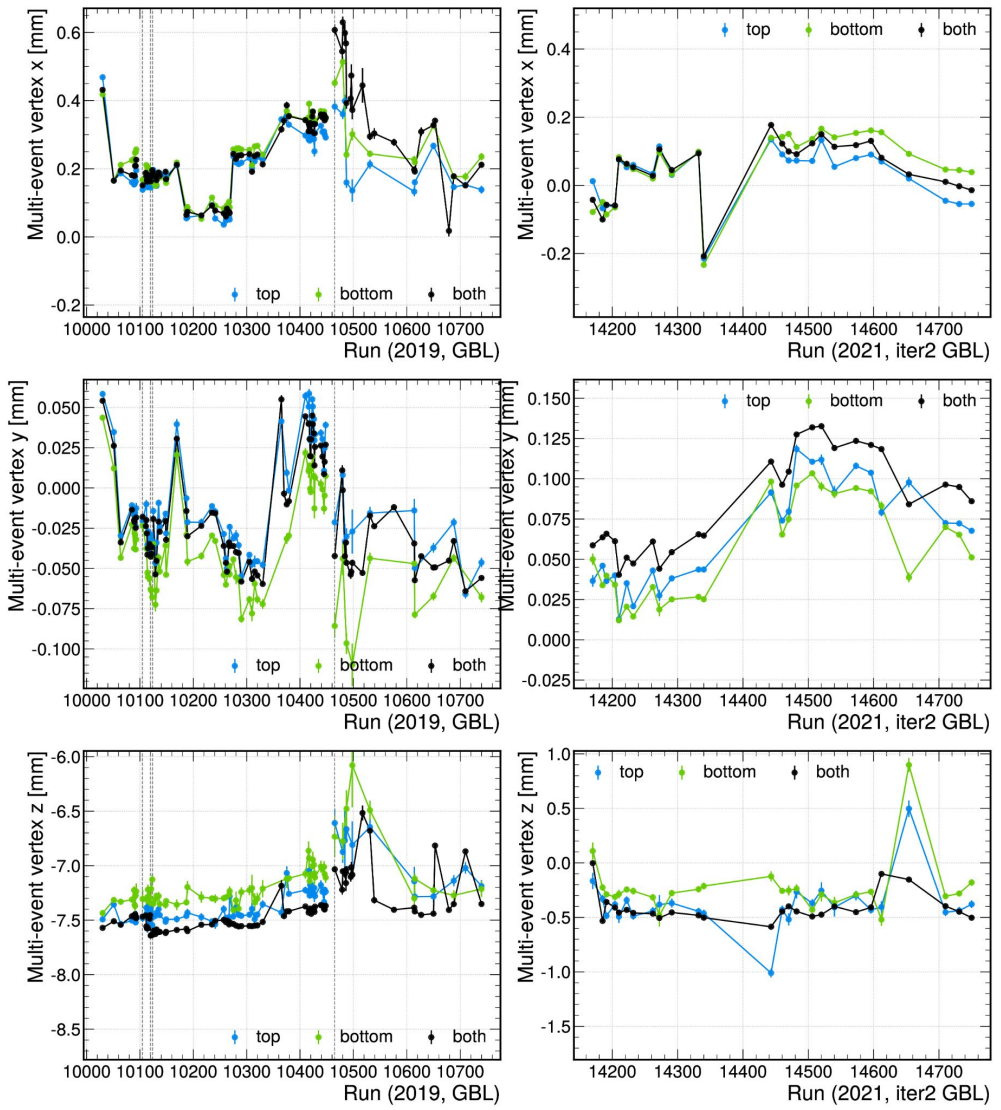
Vertices

- Multi-event vertices are in agreement between top and bottom volumes individually and together, in all three alignment periods.



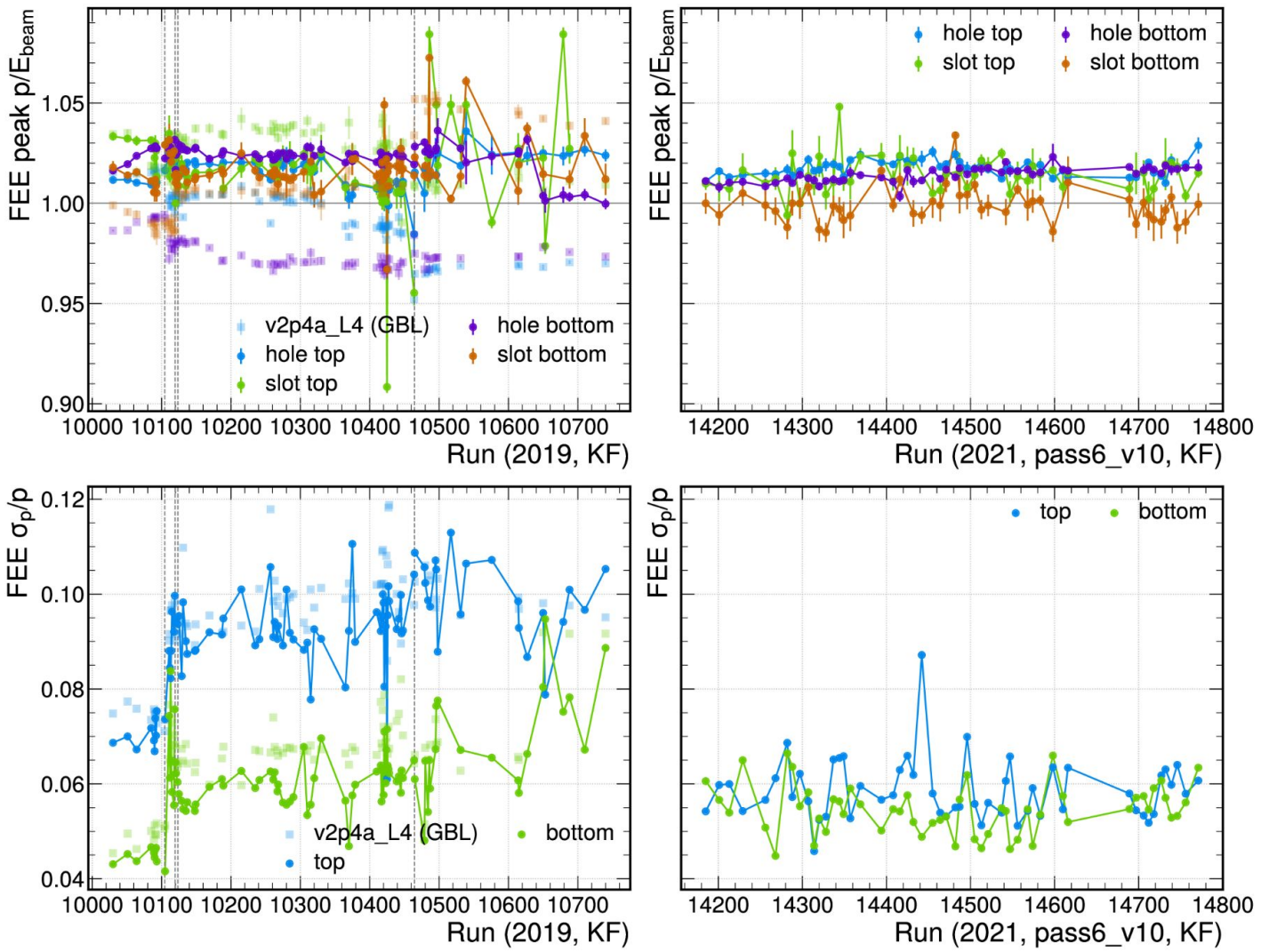
Vertices

- Multi-event vertices are in agreement between top and bottom volumes individually and together, in all three alignment periods.
- Top/bottom/both volume agreement is consistent as a function of run number.
- Agreement is comparable to 2021.



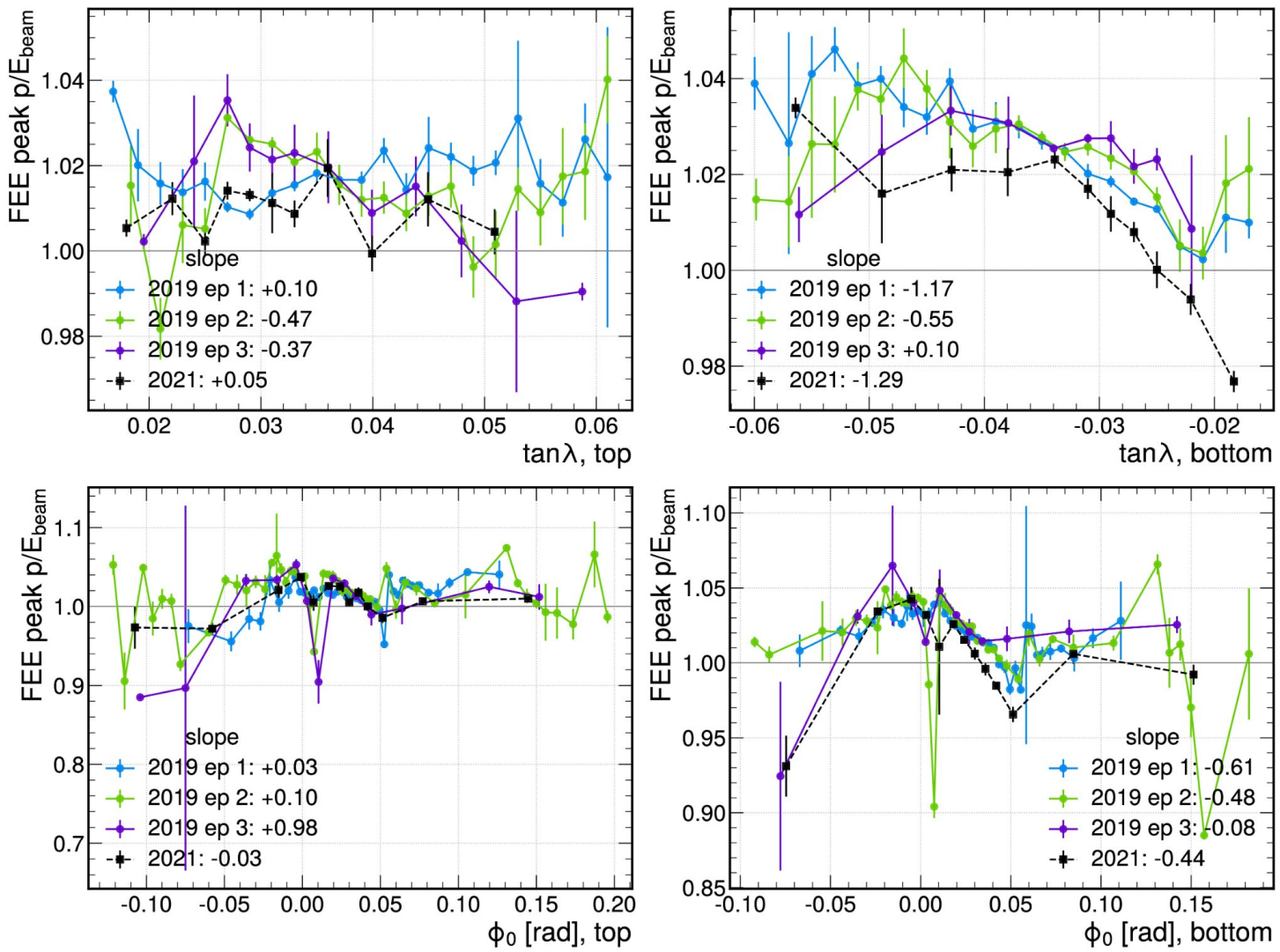
FEE Momentum Scale

- FEE scale is stable as a function of run number, with some variation in top/bottom and slot/hole slides, similar to what is seen in 2021.
- Resolution in bottom volume is comparable to 2021.
- Top volume has worse resolution, associated with loss of L7 layers.



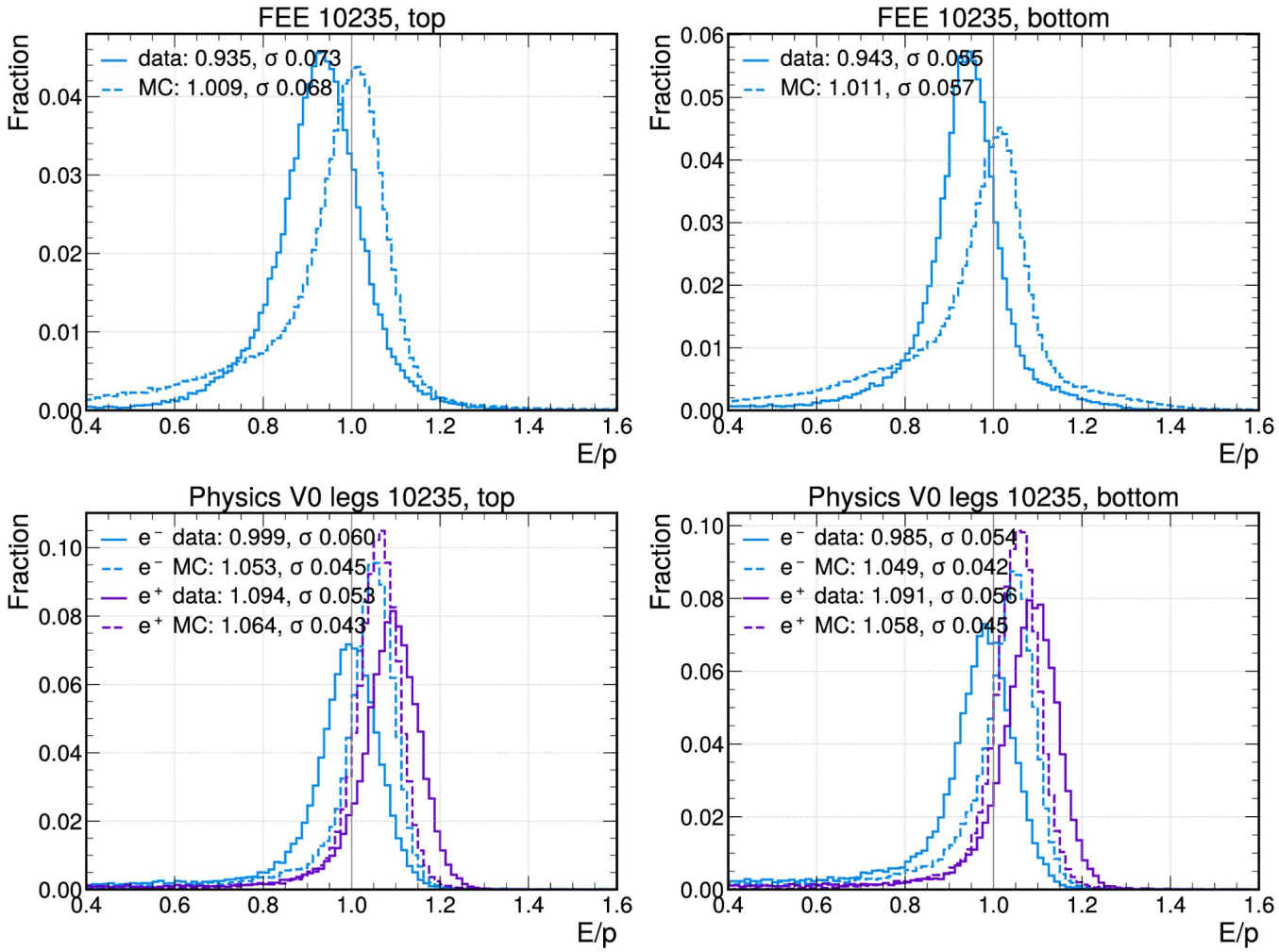
FEE Momentum Scale

- Angular profiles continue to show some trends, particularly in tan_lambda in the bottom volume.
- Trends are consistent with what we see in 2021.



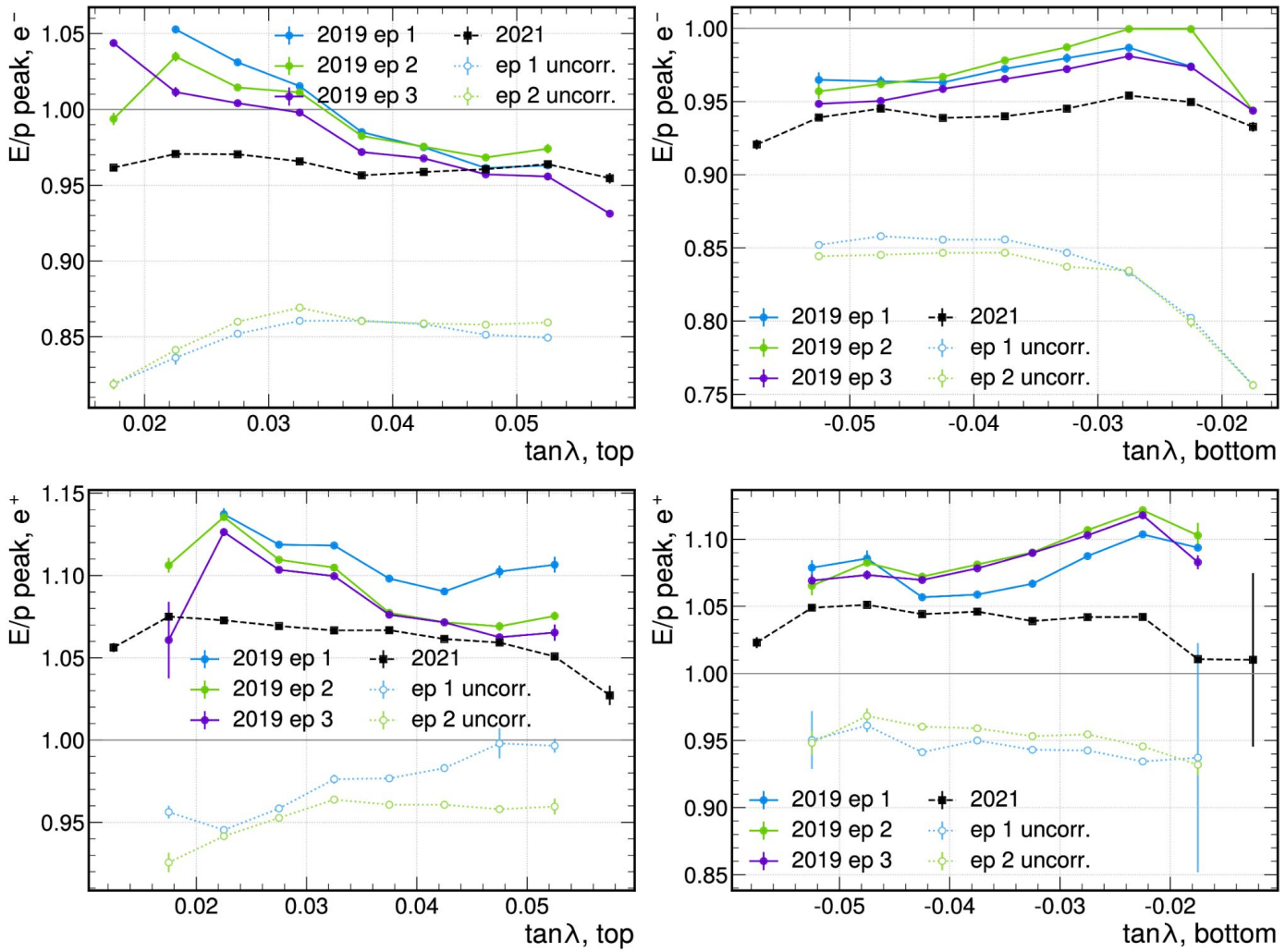
E/p Scale

- In FEEs, E/p varies from 1.0 by more than what can be explained by the tracker FEE momentum scale.
- In physics data, significant difference between electrons and positrons.
  - Persistent issue, unclear where this is coming from.
  - See backup for plots binned in 2D in various variables—difference remains in all binnings, with and without ECal corrections.



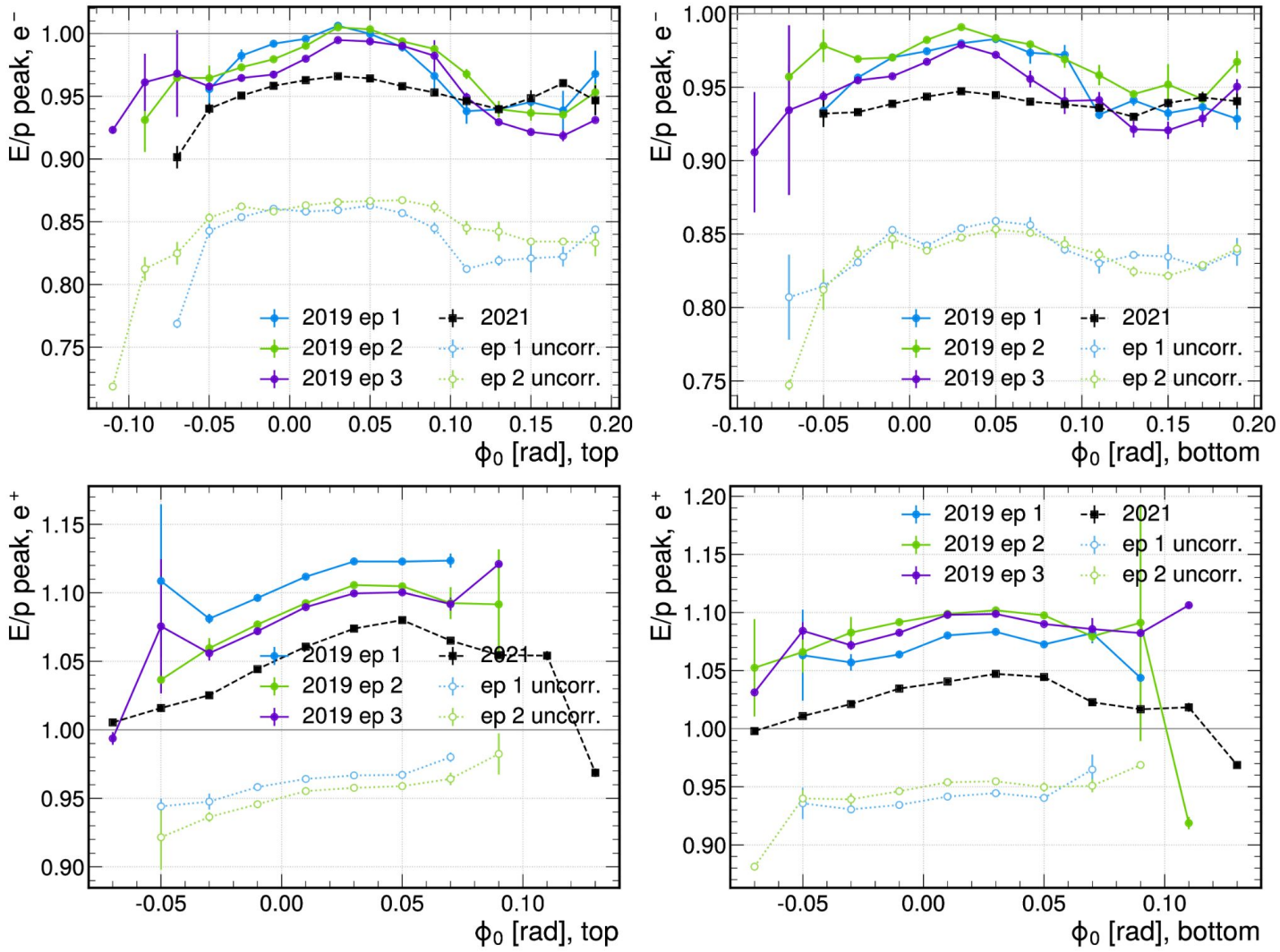
E/p Angular Trends

- Both top and bottom volumes show similar trends in tan_Lambda—FEEs do not show this behavior in the top volume.
- Trends change significantly, becoming flatter, without ECal corrections applied to the FinalStateParticles collection.
- 2021 trends look better overall.



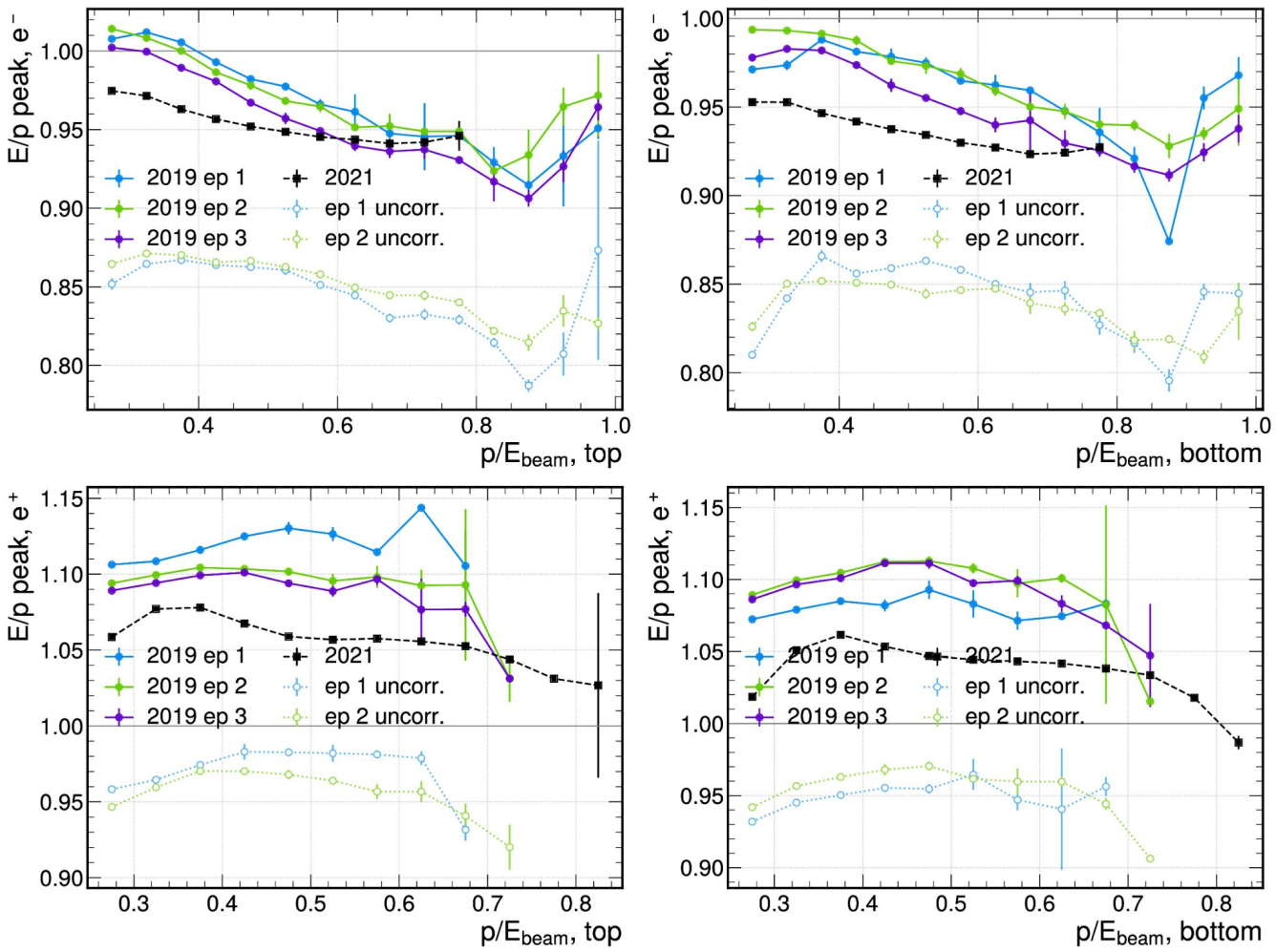
E/p Angular Trends

- In phi0, trends in 2019 are similar to 2021 trends.
- Also dependent on ECal corrections.



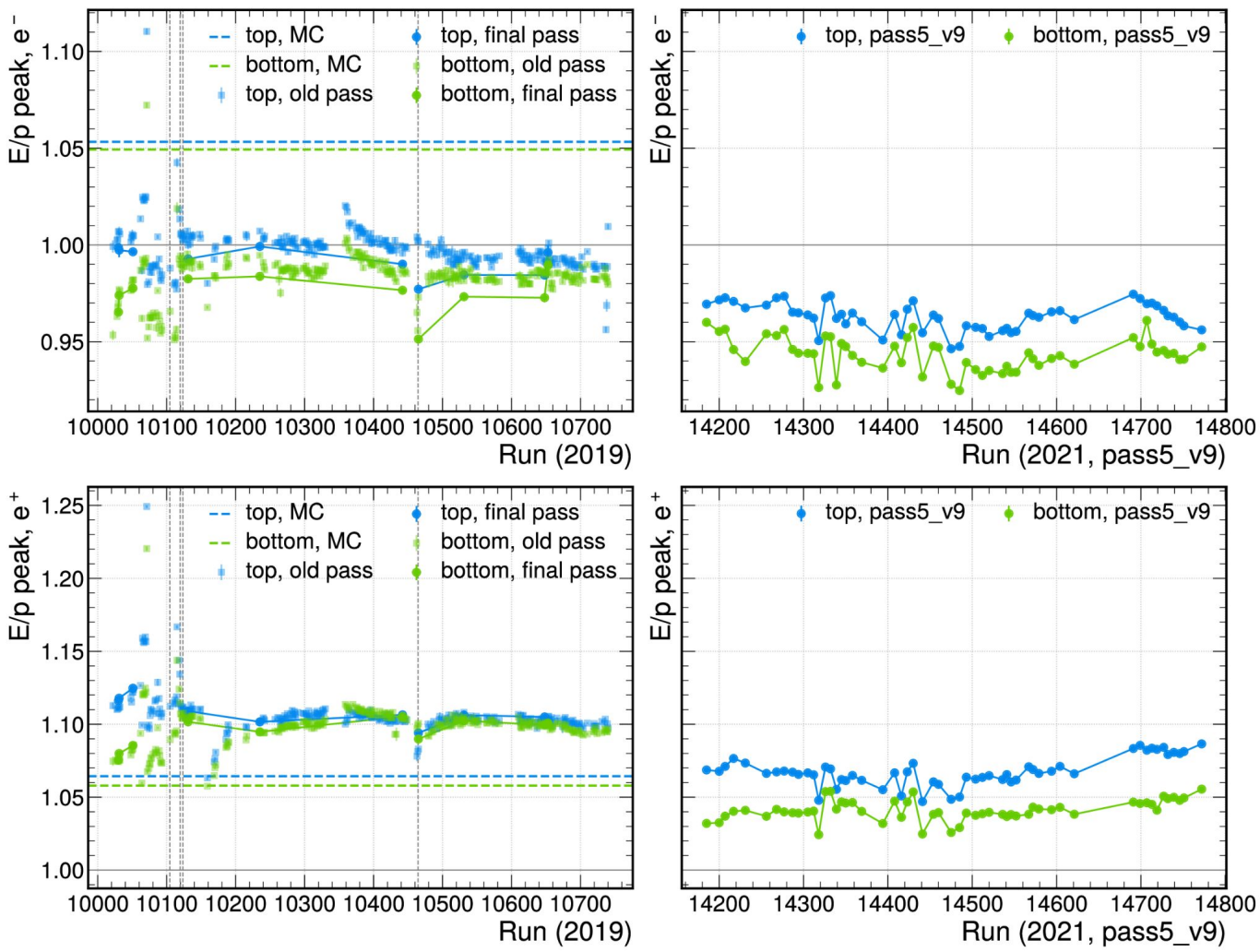
E/p Momentum Trends

- ~5% trends as a function of momentum in electrons, consistent before and after ECal corrections.
- Slightly better behaved in 2021.
- Near FEE region, E/p region is inconsistent with tracker-only momentum scale.



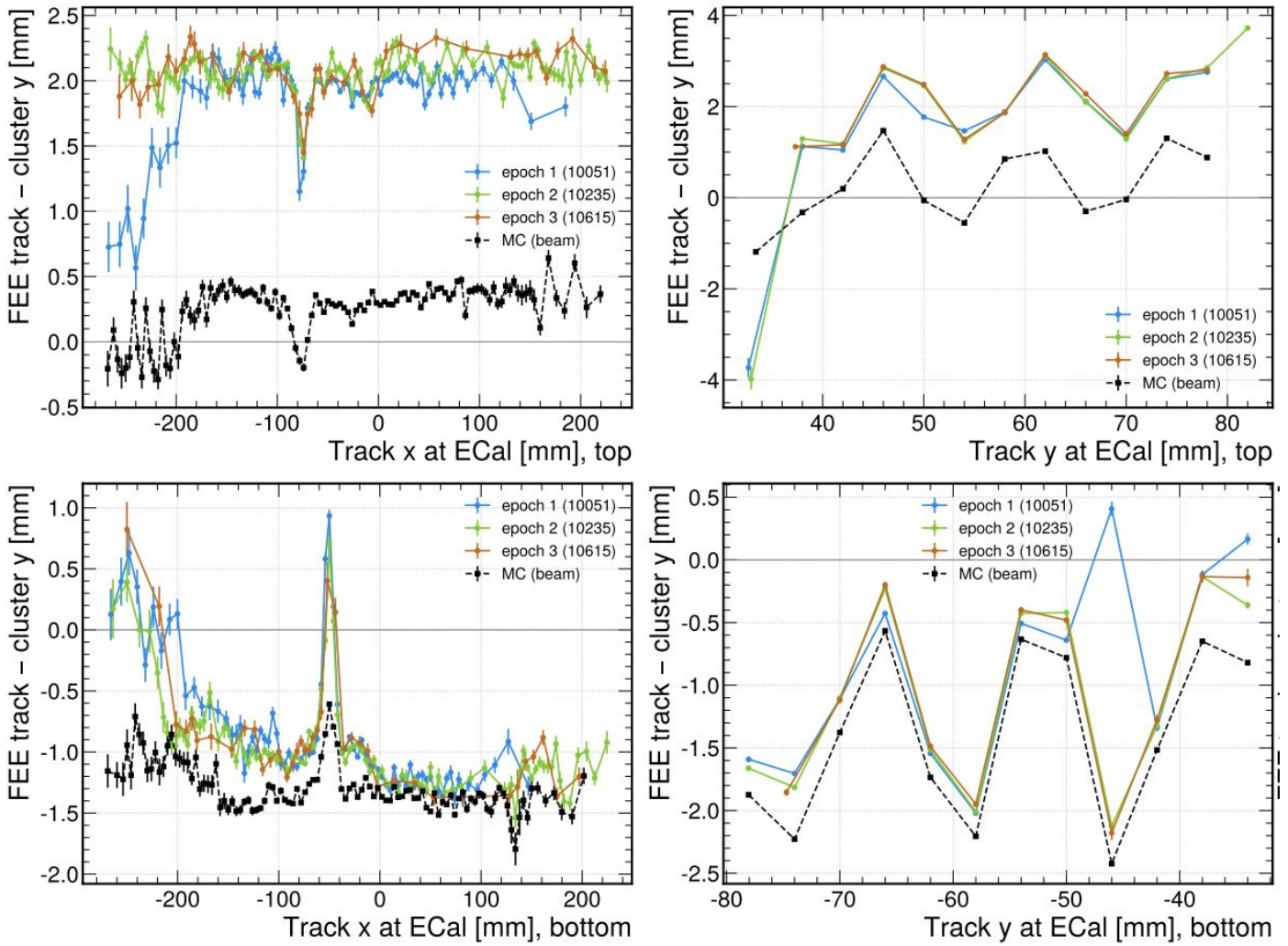
E/p Run Dependence

- E/p run dependence is stable, comparable to 2021.
- 2021 also shows some electron/positron scale differences, less extreme than 2019.
- Top/bottom agreement similar to 2021.



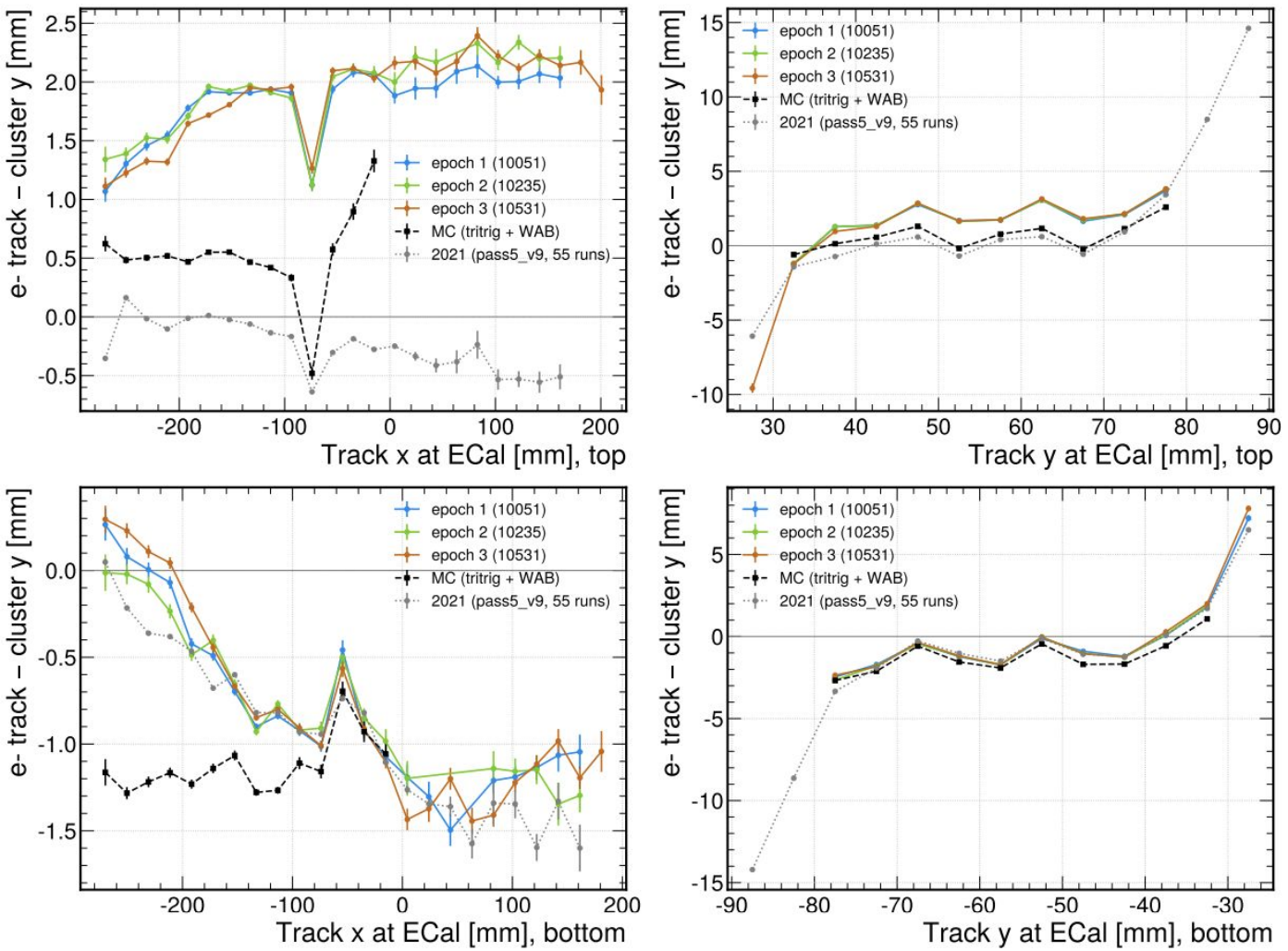
Track/Cluster Matching (y-residuals)

- In y residuals, 1-2 mm offset it top volume relative to MC.
- Offset is consistent in both FEEs and physics electrons/positrons.
- Residuals in track-cluster y are largely stable with respect to track (x, y) at the ECal.
- Remaining slopes are consistent between 2021 and 2019 runs.
- **Mitigations:** Opening angle in top volume, or ECal top half offset (?)



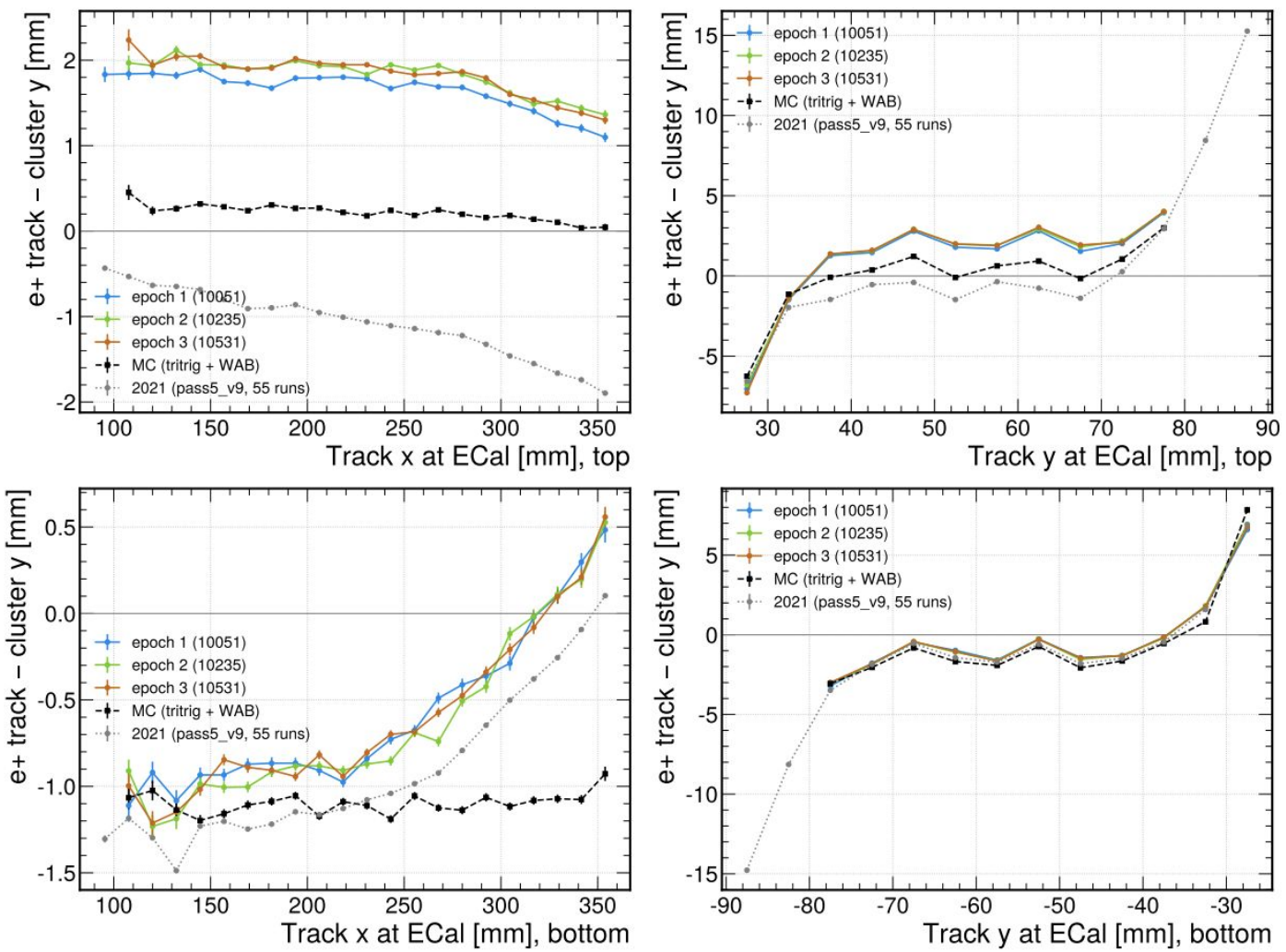
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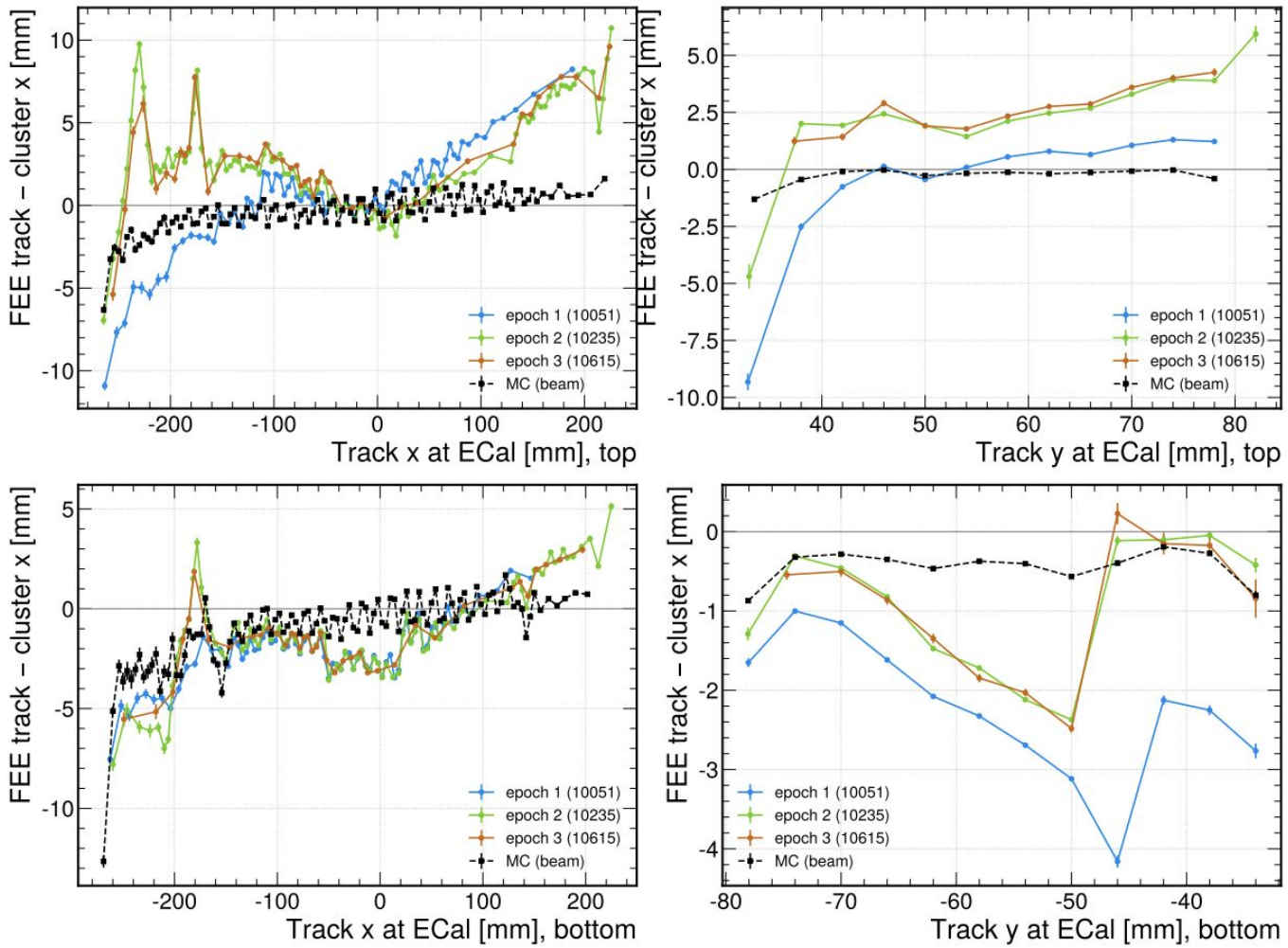
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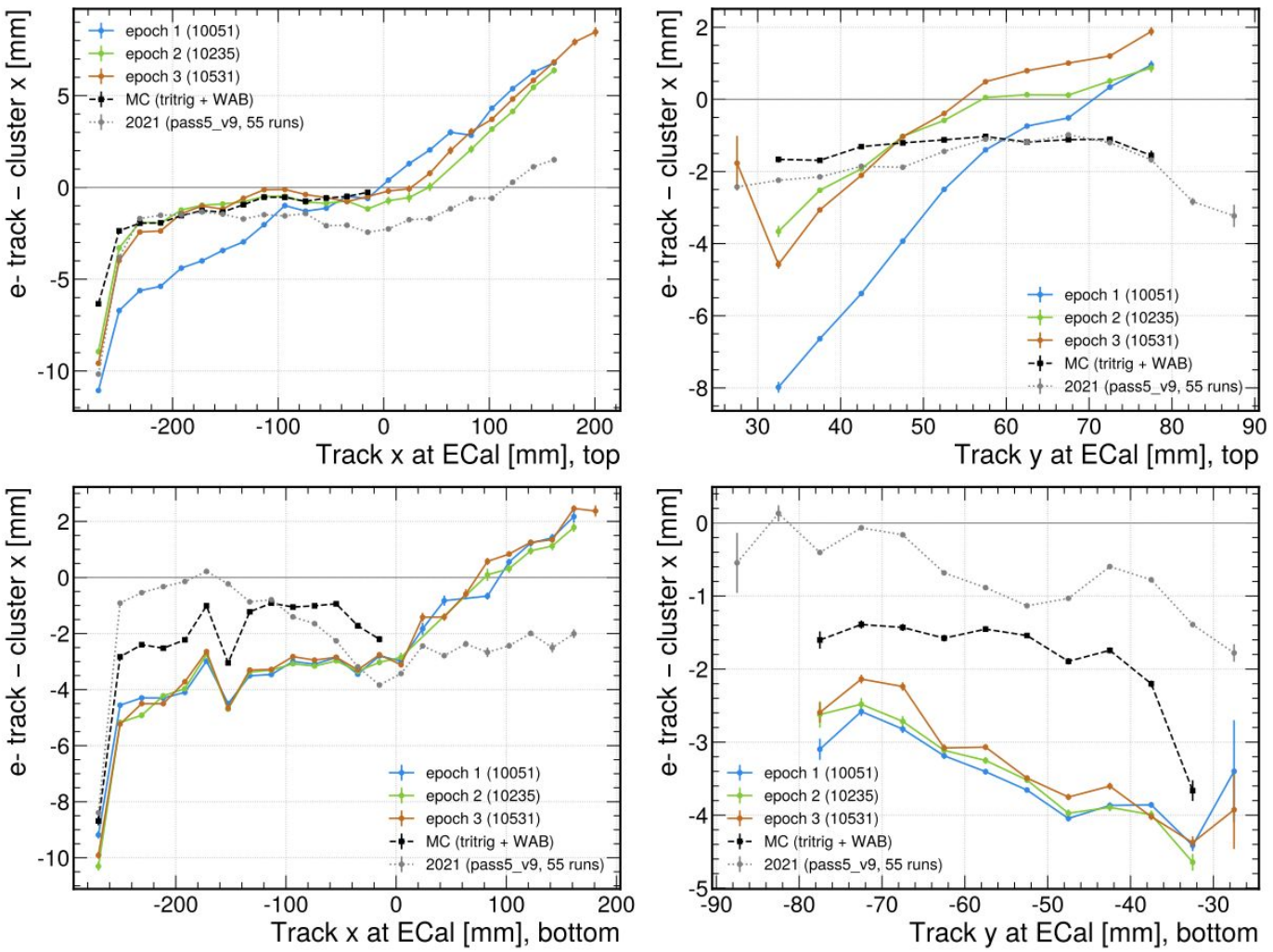
Track/Cluster Matching (x-residuals)

- x residuals are messier, showing a potential combination of SVT/ECal calibration issues.
- Data shows significant slopes in x relative to MC, and moderate slopes in y.
- y-dependent profiles are consistent between FEEs and physics electrons, but distinct in positrons, most significantly in the top volume. Among electrons, the x-residual trend in y flips sign between volumes; among positrons, epochs 2 and 3 show the same behavior in both volumes.



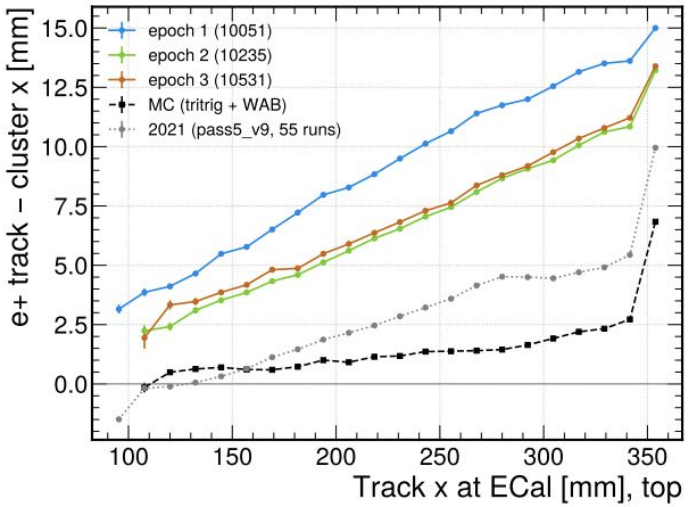
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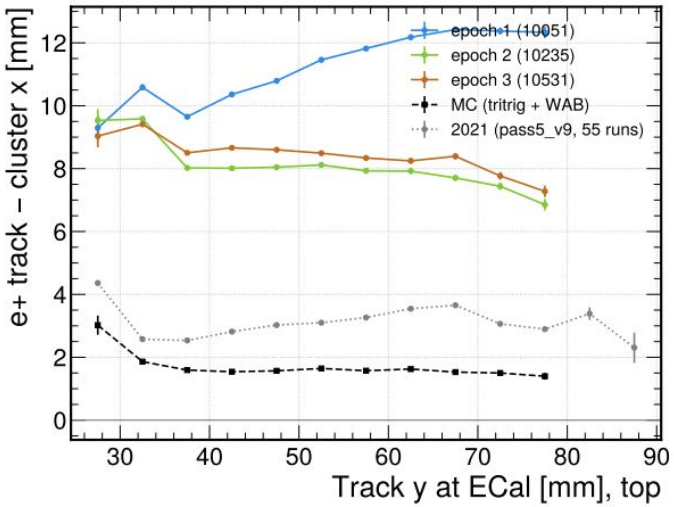
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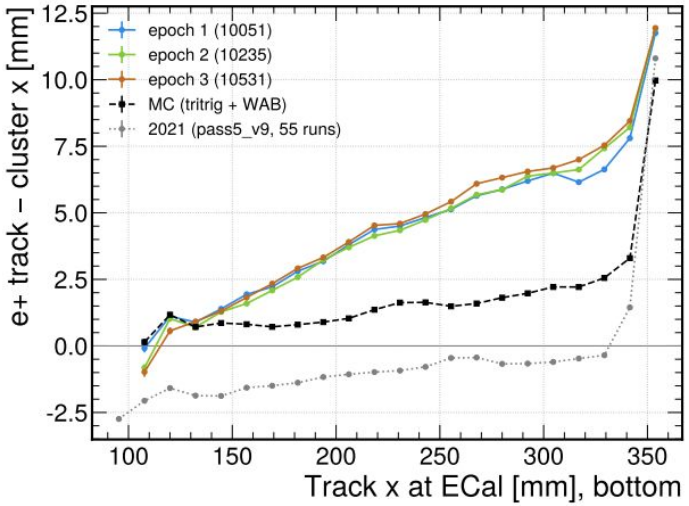


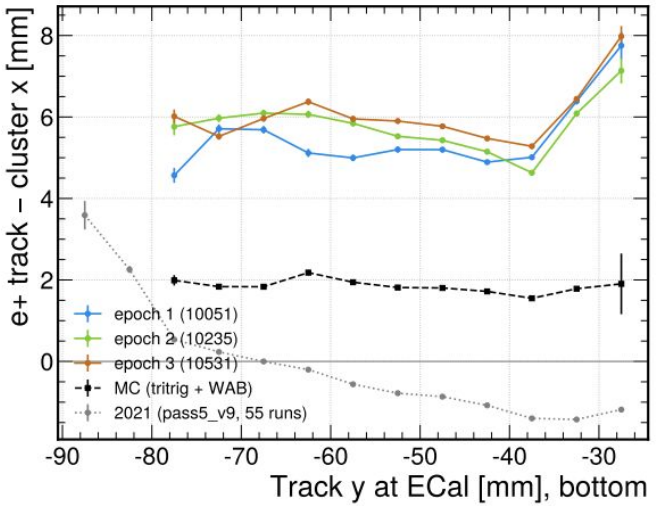
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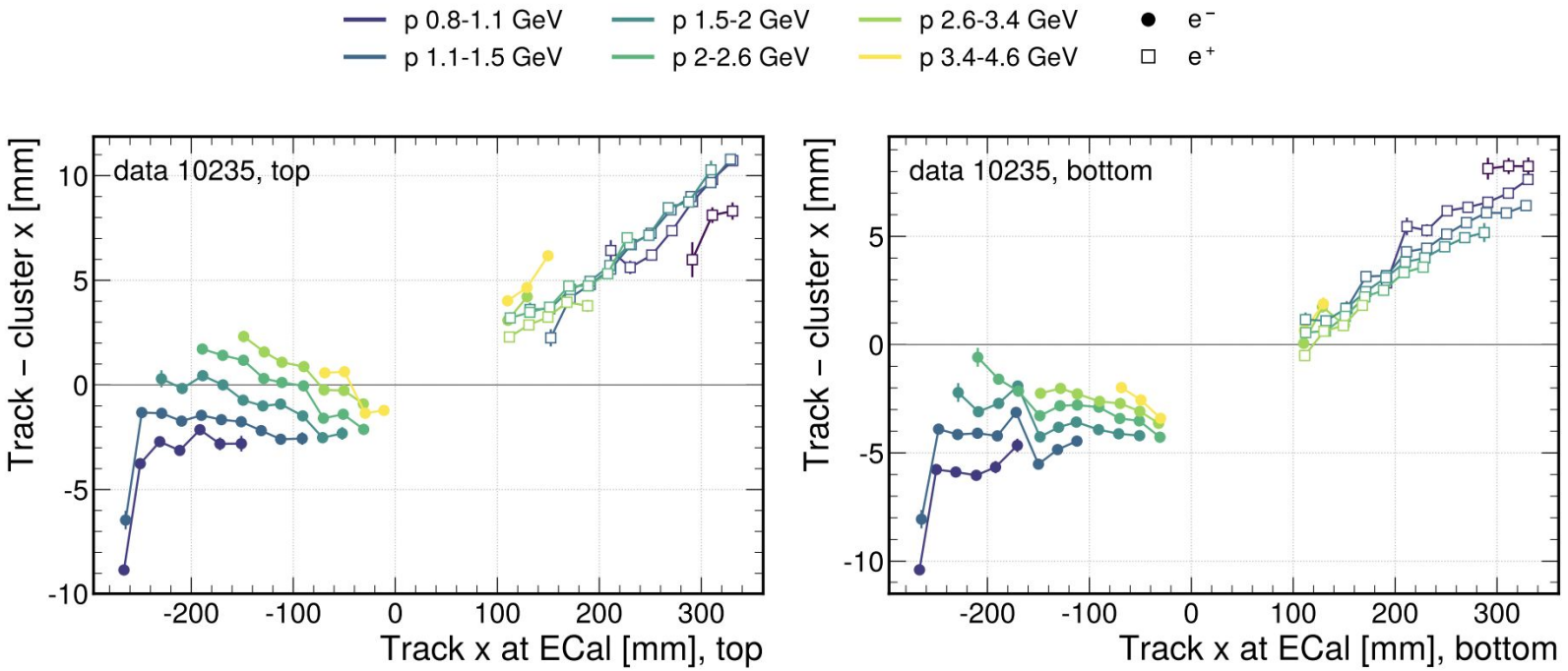






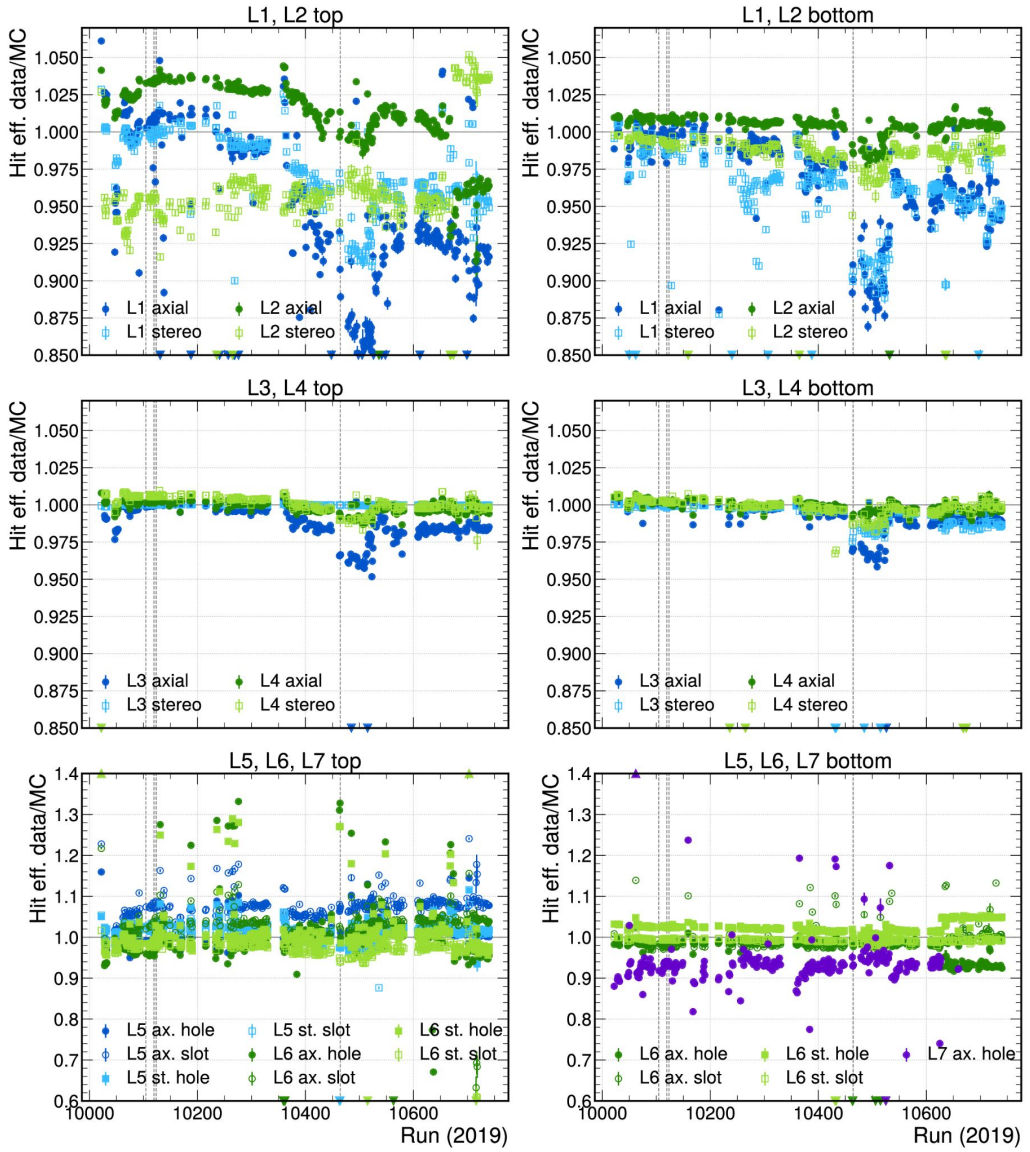
Track/Cluster Matching (x-residuals, x trends)

- x-dependent profiles indicate significant slot-side trends vs. track x-position, seen most prominently in positrons (similar behavior is seen in 2021 data in the top volume).
- The slope of this residual x-dependence is very similar in both top and bottom volumes, and is stable over time.
  - Slot side, in both electrons and positrons, we see very little momentum dependence, but strong x-dependence; stronger momentum dependence on hole side.



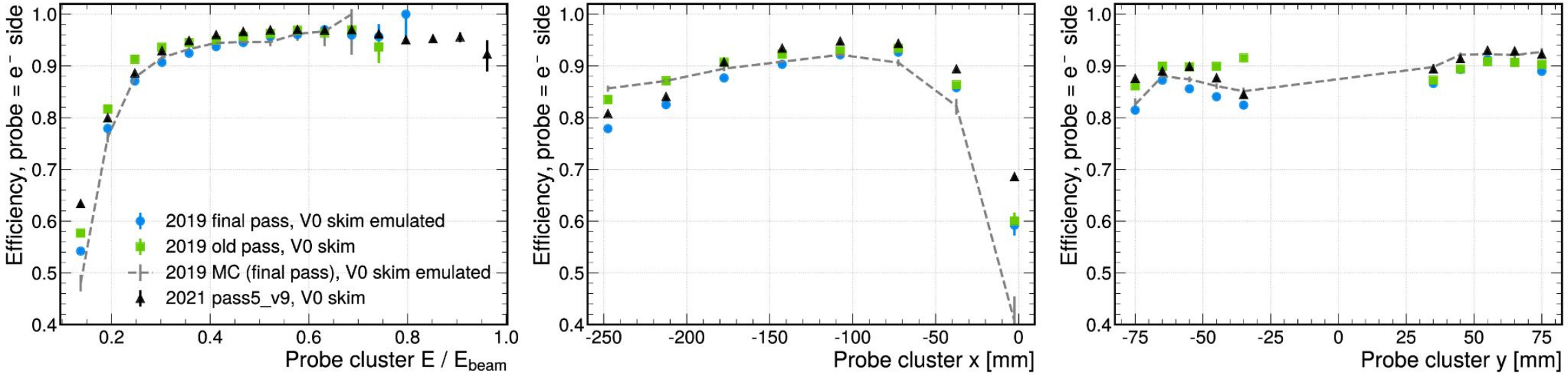
Hit Efficiencies

- As in 2021, hit efficiencies drop in L1 over the run period.
- Drop is less significant than 2021 (~10% as opposed to ~40%)
- Efficiencies in the outer layers are stable.



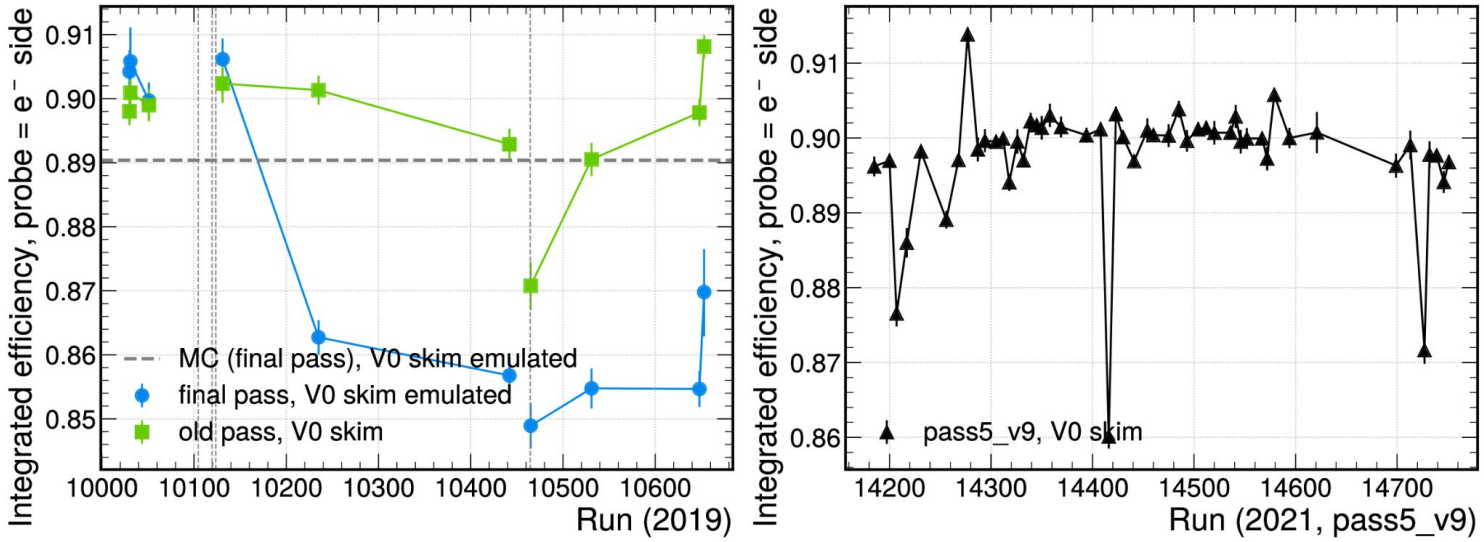
Tracking Efficiencies

- Tag-and-probe tracking efficiencies are similar between 2019 and 2021.
- Tracking efficiency is consistent with 2019 MC.



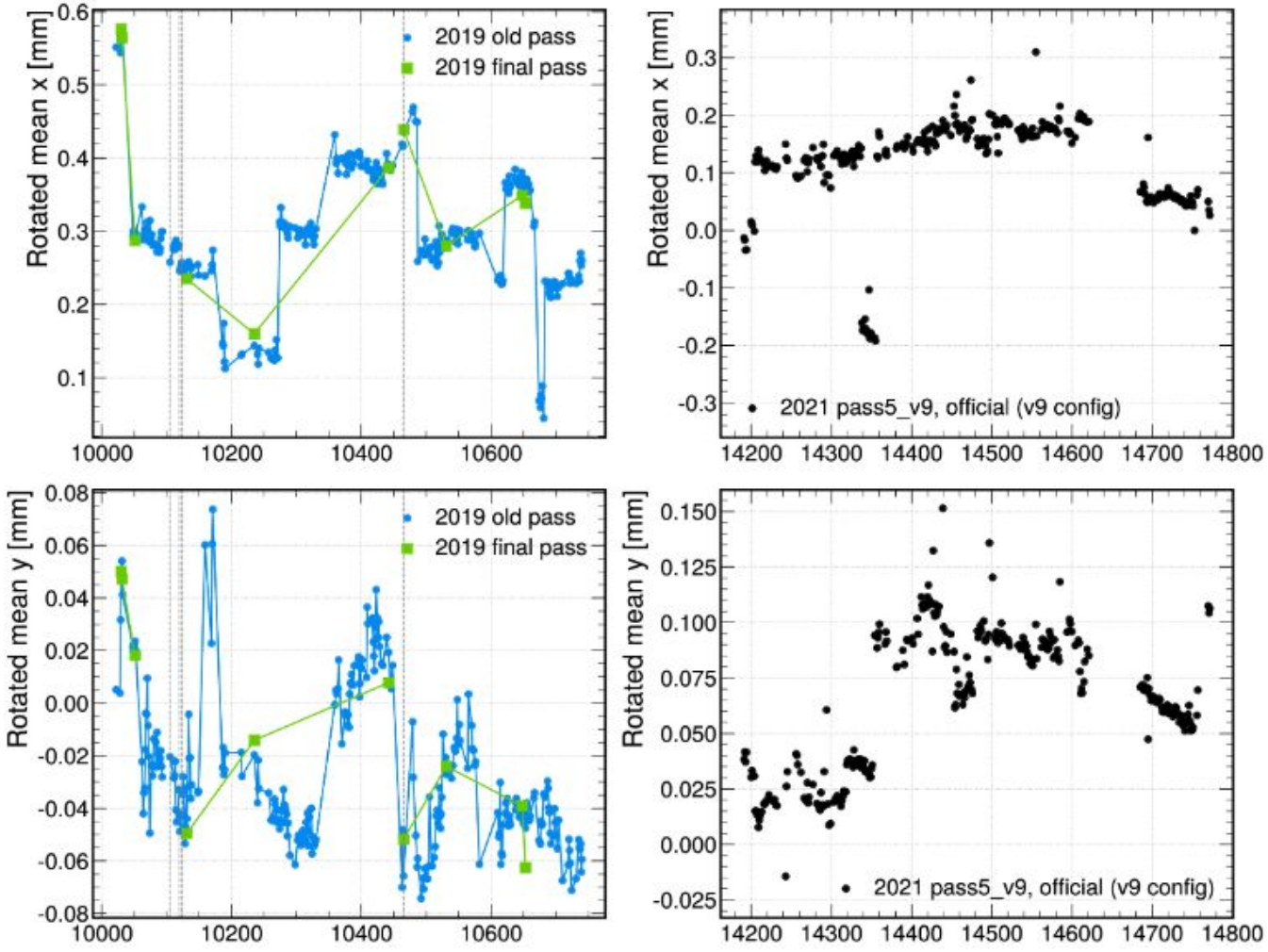
Tracking Efficiencies

- As a function of run number, new pass shows ~4% drop in tracking efficiency after loss of L5 axial layer—still investigating what is causing this.



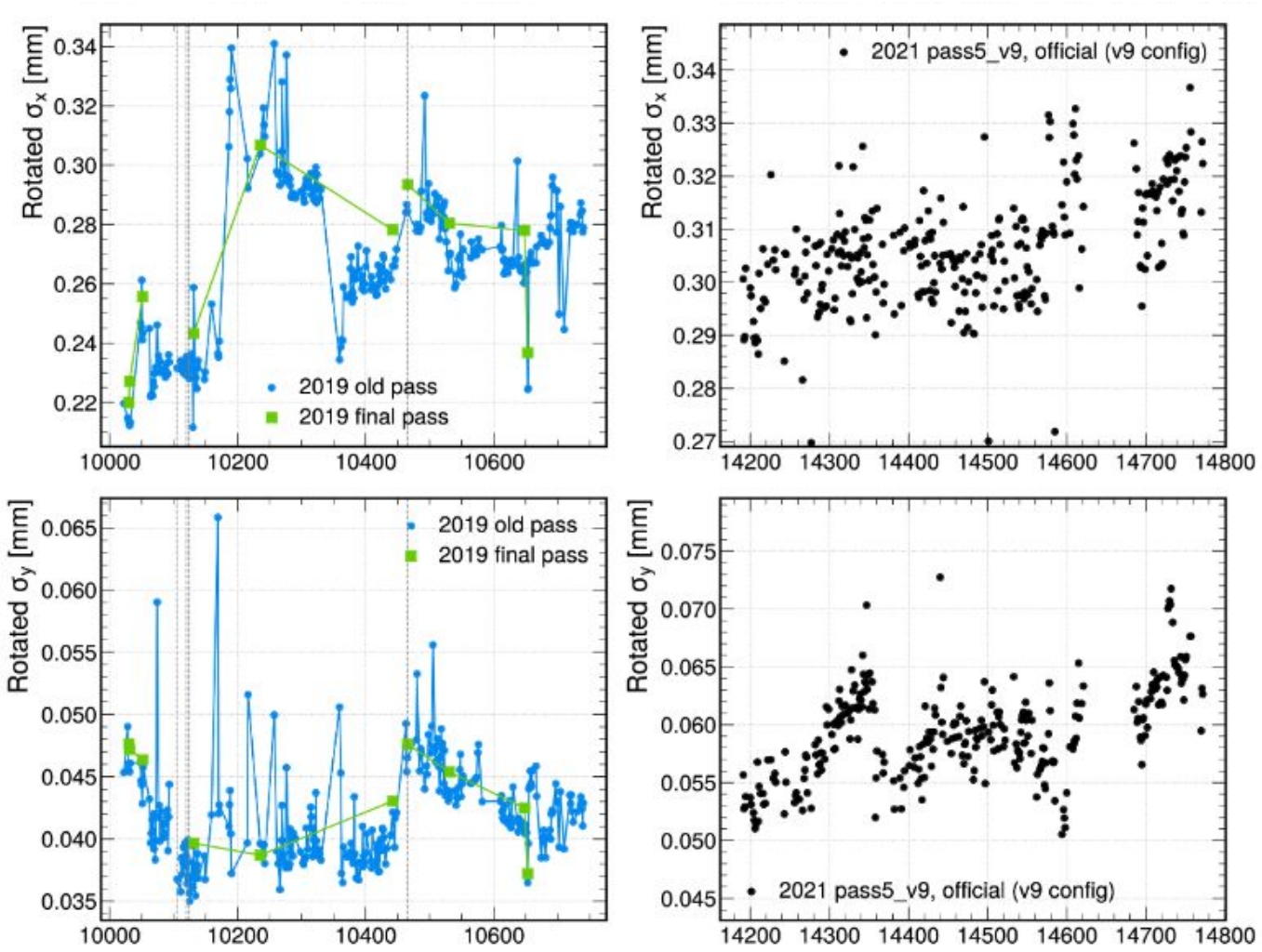
Beamspot

- Beam (x, y) positions are consistent between old and new alignment.
- Several discrete steps in (x, y), most of which are related to notes in the log book:
  - 10030: “Beam x drift: 2C24 BPM position alarms and beam drop-outs”
  - 10484: “harp and SVT bottom wire scans between runs; beam re-steered,” etc.
- Overall variation across run period is consistent between 2019 and 2021.



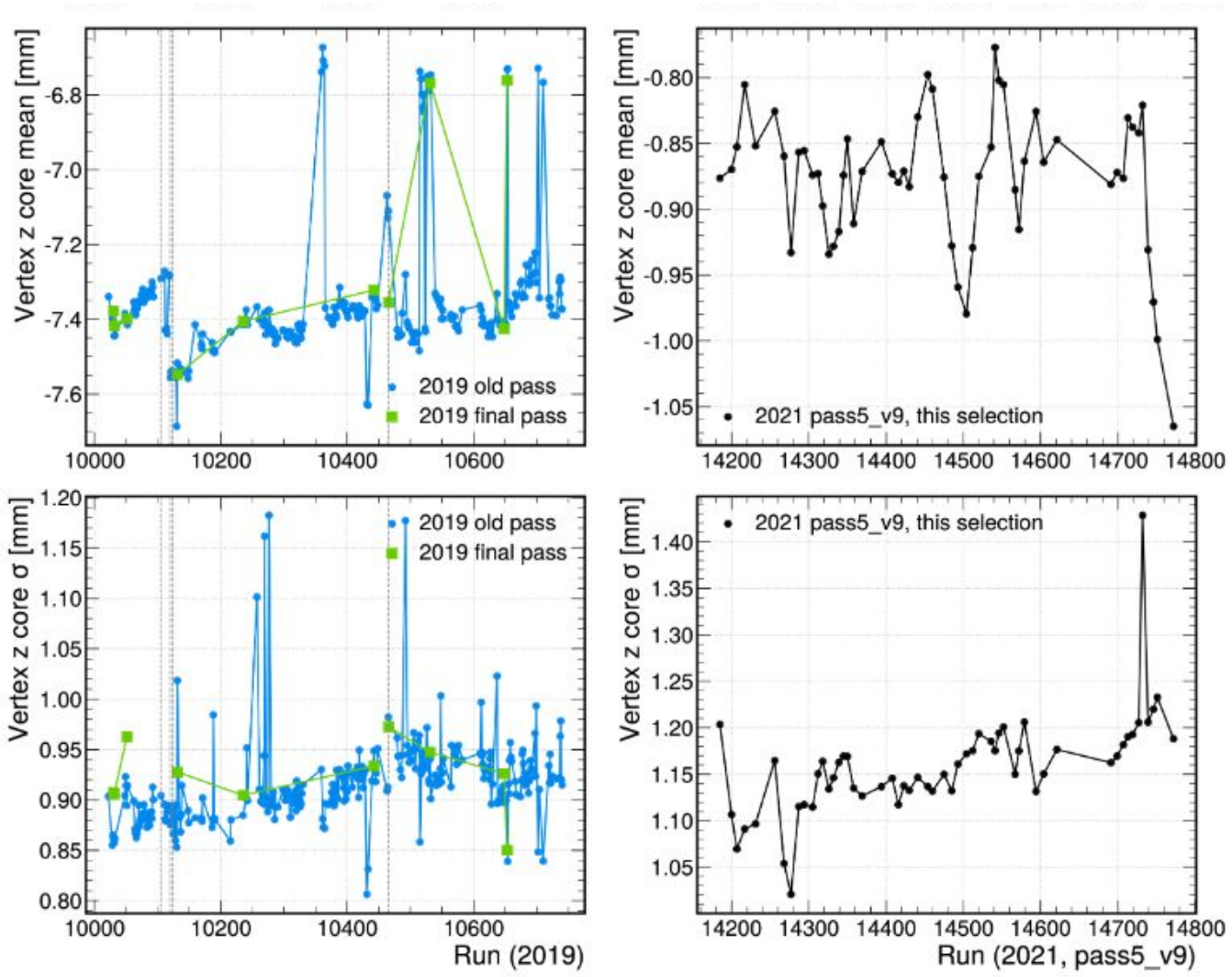
Beamspot

- Beam widths are similar between 2019 and 2021.
- Consistent between old and new alignments.



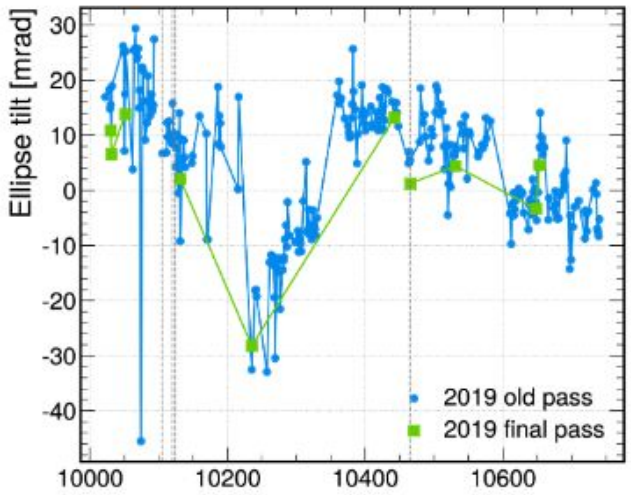
Beamspot

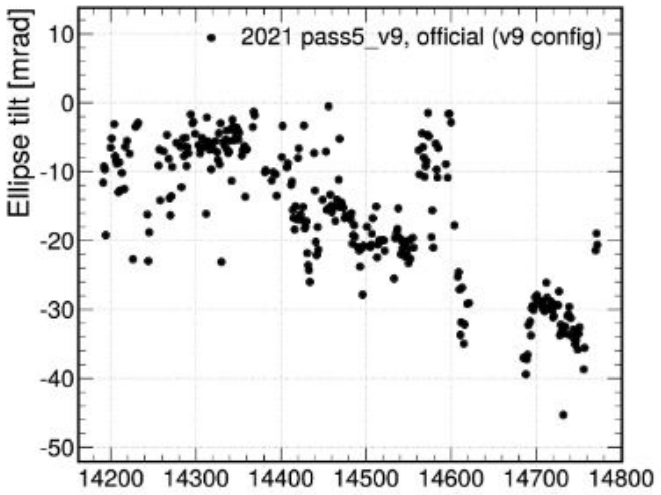
- Vertex z and vertex z widths are largely stable as a function of run number, apart from individual anomalous runs, most of which have explanations in the logbook.
- Vertex z widths are consistent between 2019 and 2021 (slightly narrower in 2019).



Beamspot

- Beam tilt is also similar in scale and variation over the run period between 2021 and 2019.



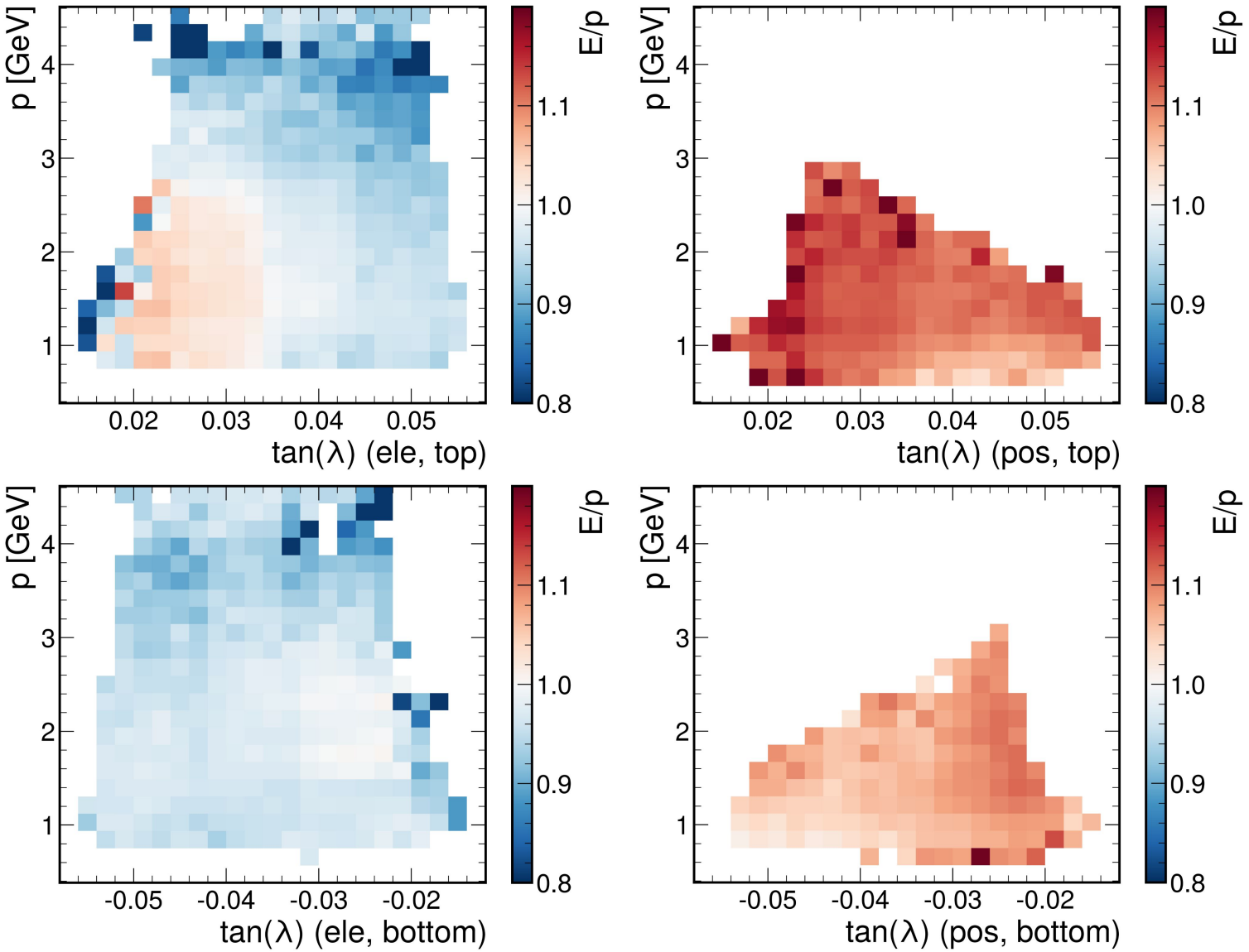


Summary

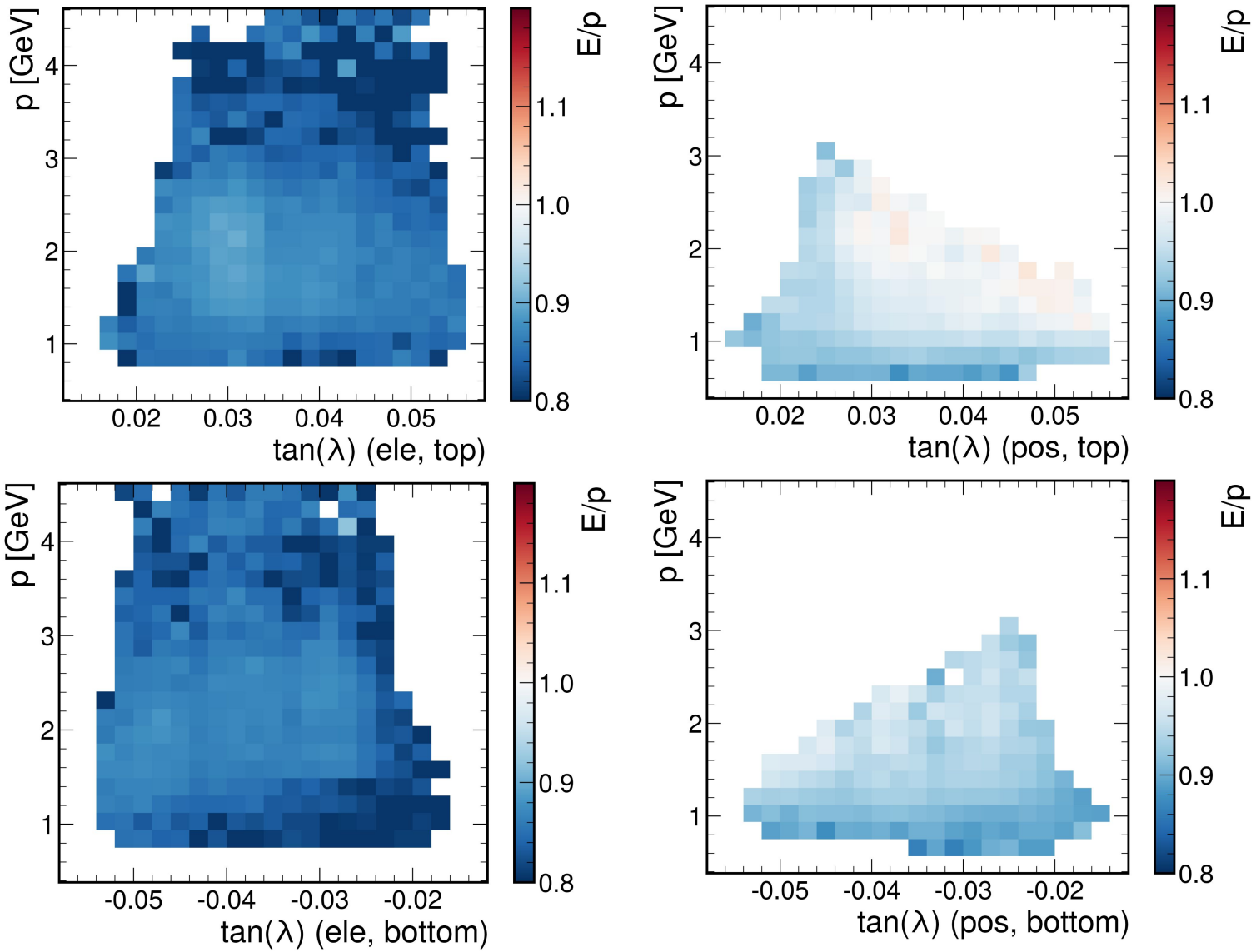
- 2019 SVT calibration performs similarly to 2021 in FEEs.
- List of unresolved issues:
  - FEE scale is ~2% high—can be rescaled.
  - E/p electron/positron scale mismatch.
  - Track/cluster matching residuals—offsets (mm-scale) can be calibrated through yaw, opening angle global movements. Trends in x,y still need to be understood.
  - ~4% drop in tracking efficiency after loss of L5.

Backup

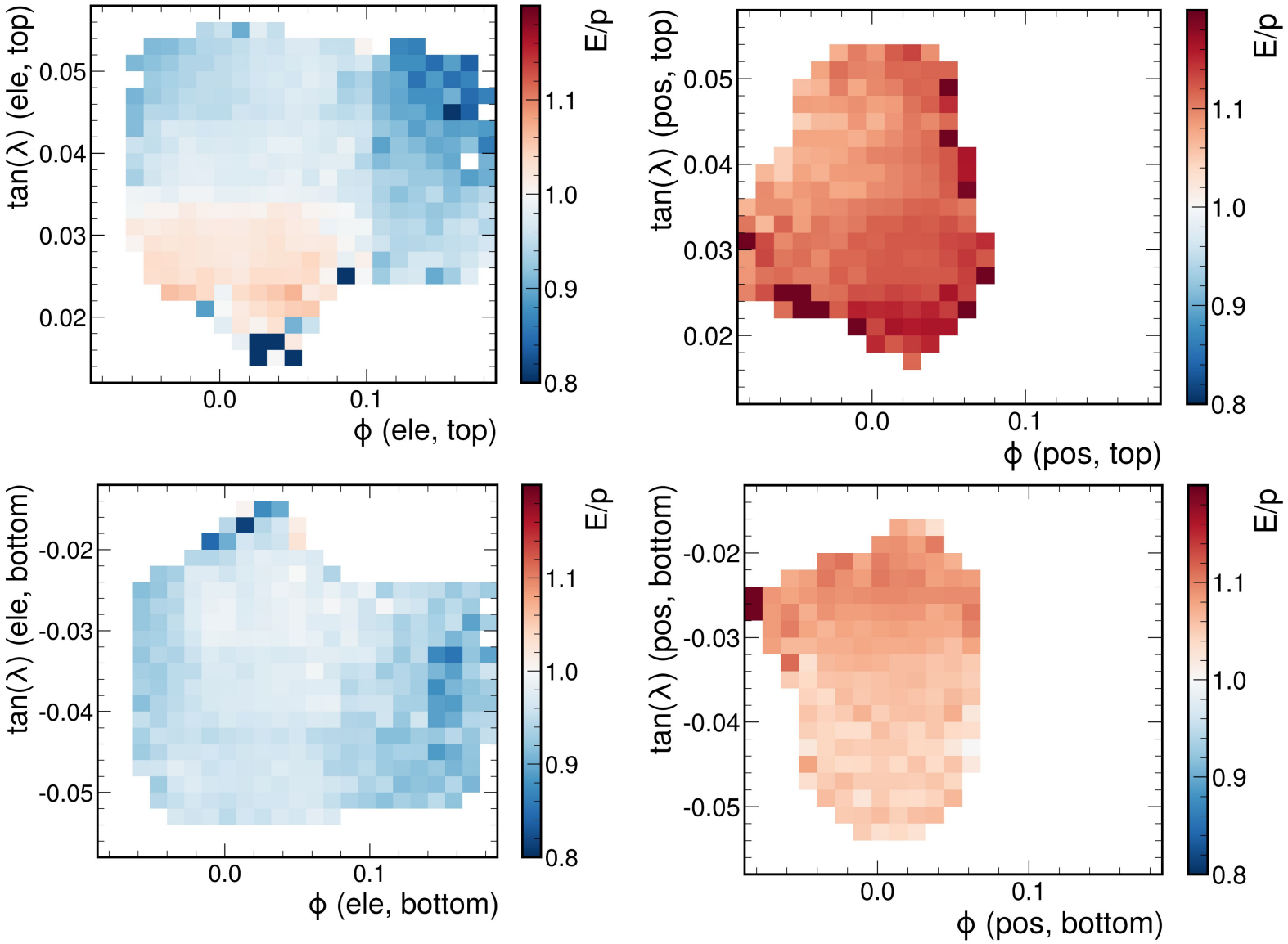
E/p vs. tan(λ), p



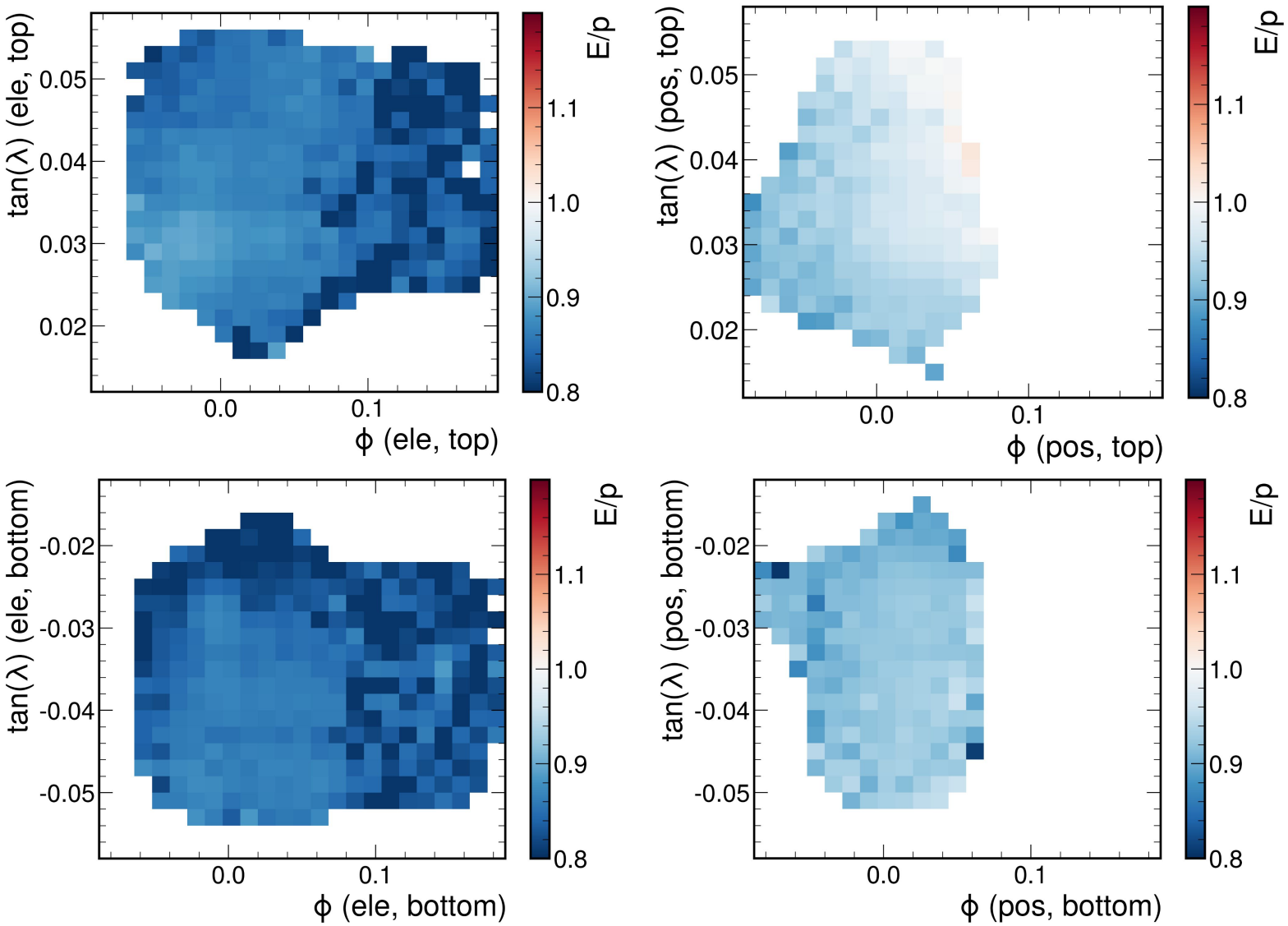
E/p vs. tan(λ), p (no corrections)



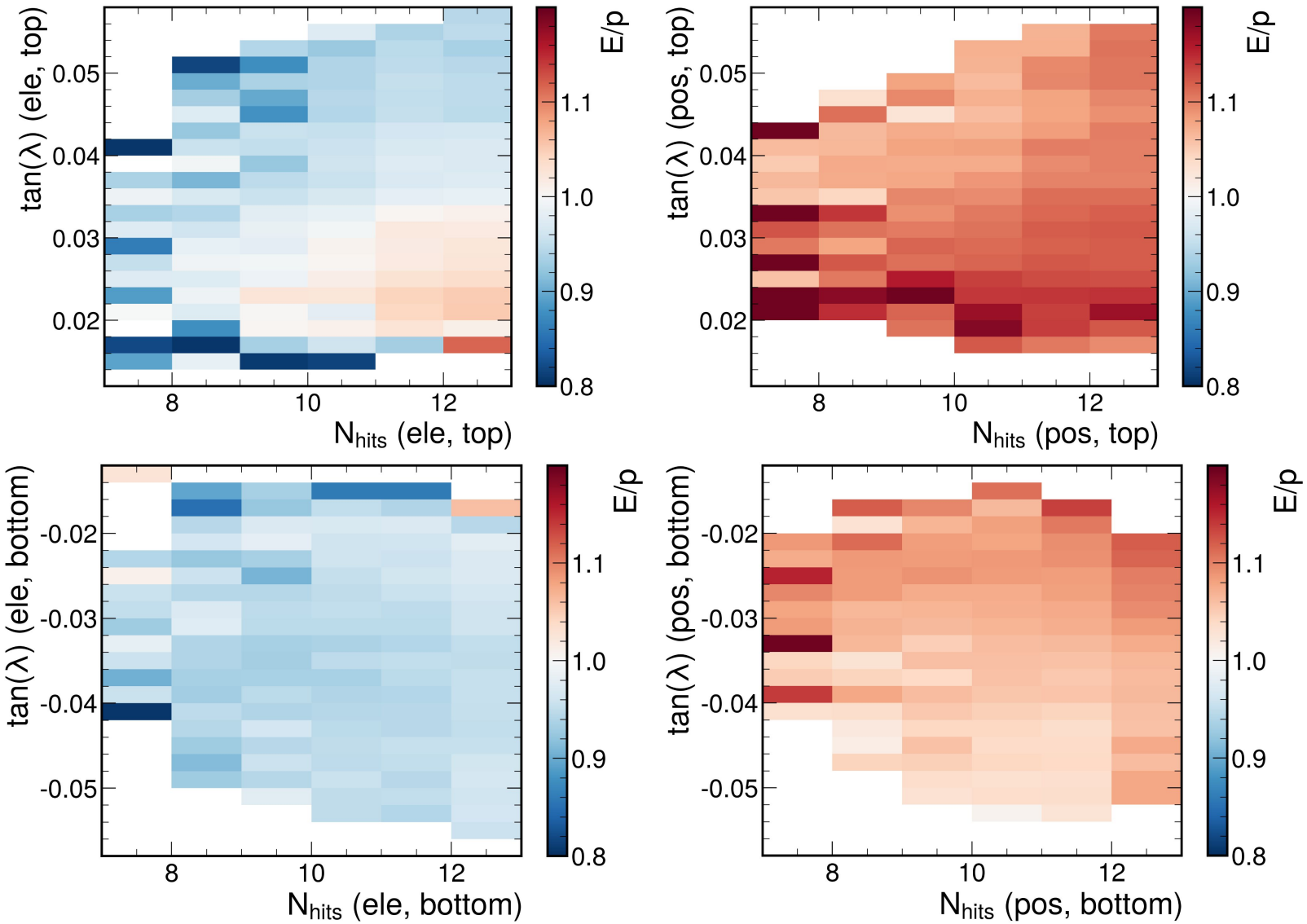
E/p vs. tan(λ), ϕ



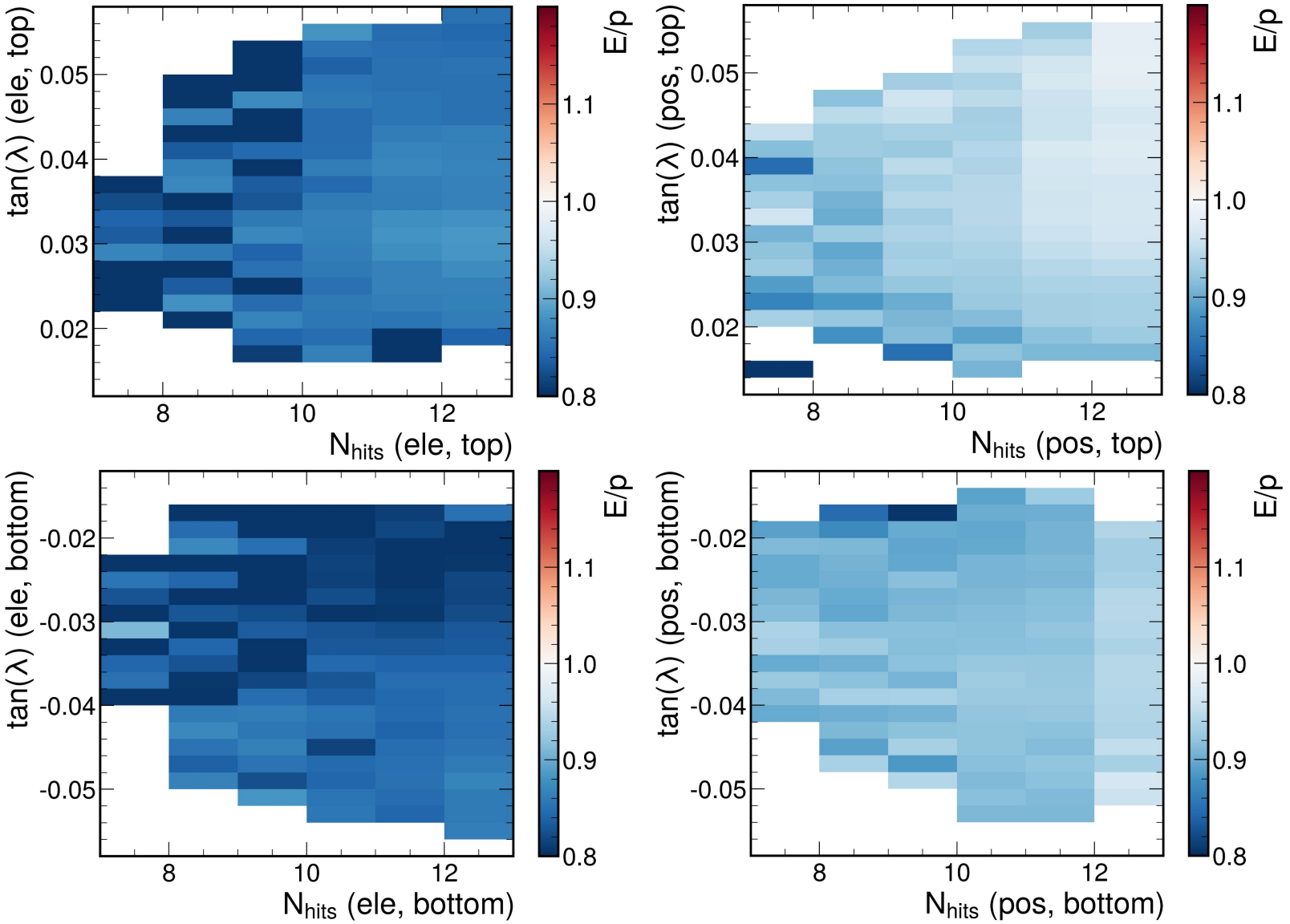
E/p vs. tan(λ), ϕ (no corrections)



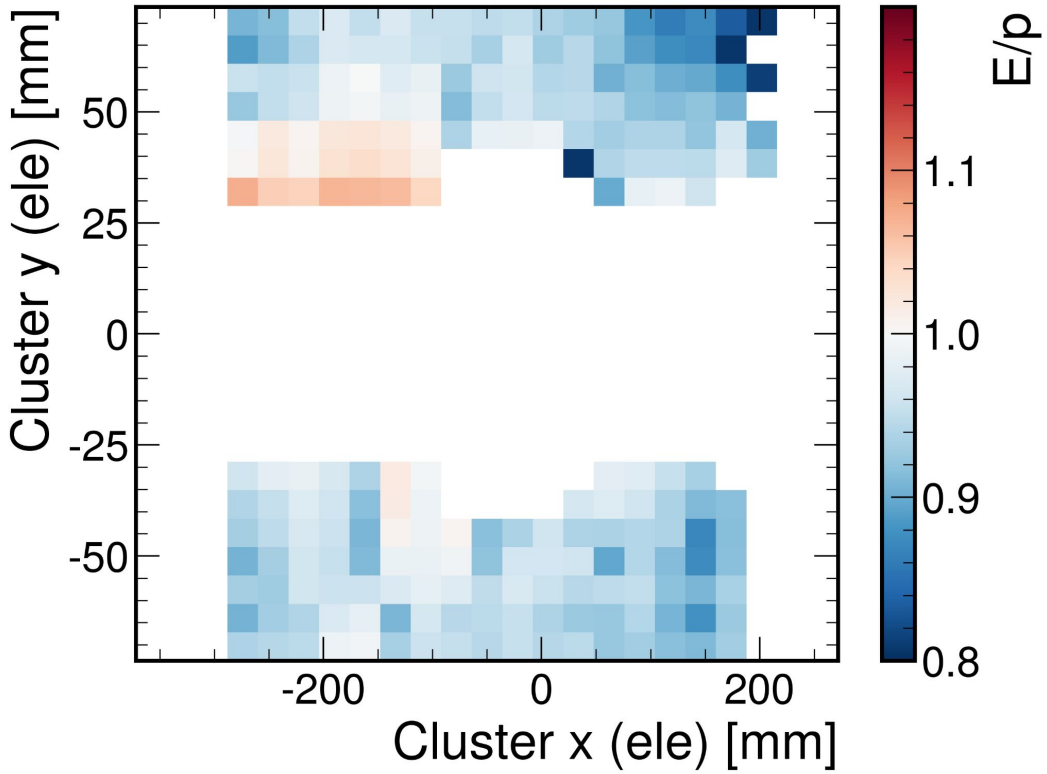
E/p vs. tan(λ), Nhits

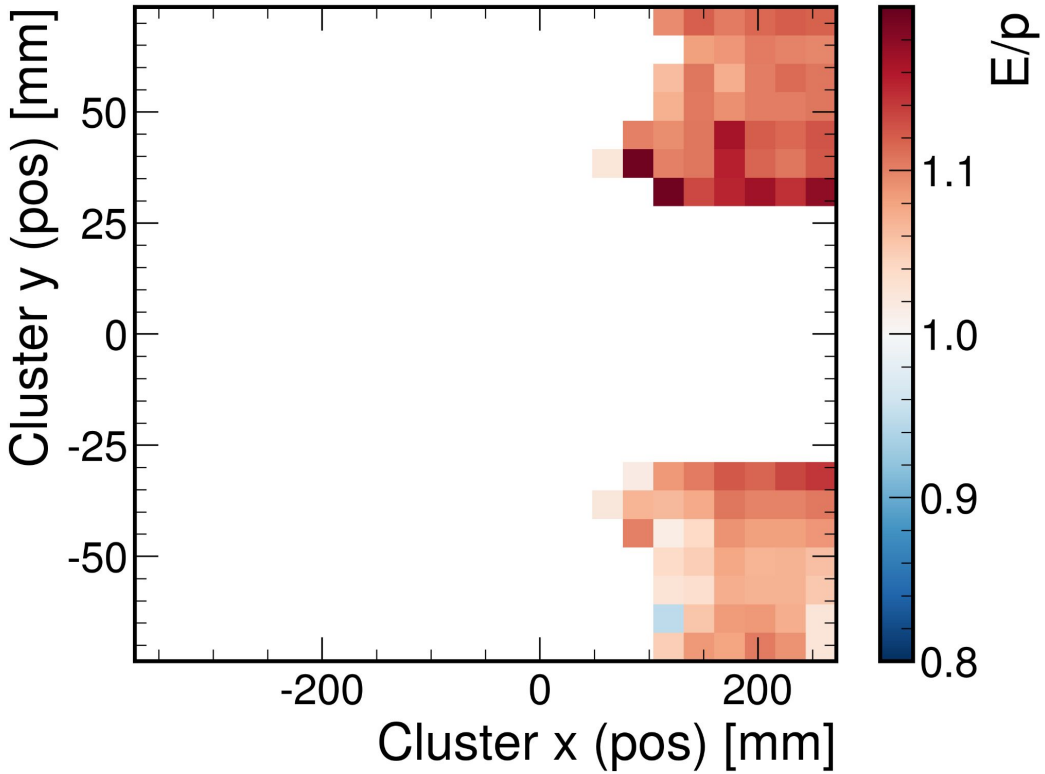


E/p vs. tan(λ), Nhits (no corrections)



E/p vs. cluster x, y





E/p vs. cluster x, y (no corrections)

