Mass Resolution Status and Update

Lewis Wolf

HPS Fall 26 Collaboration Meeting

10/21/26

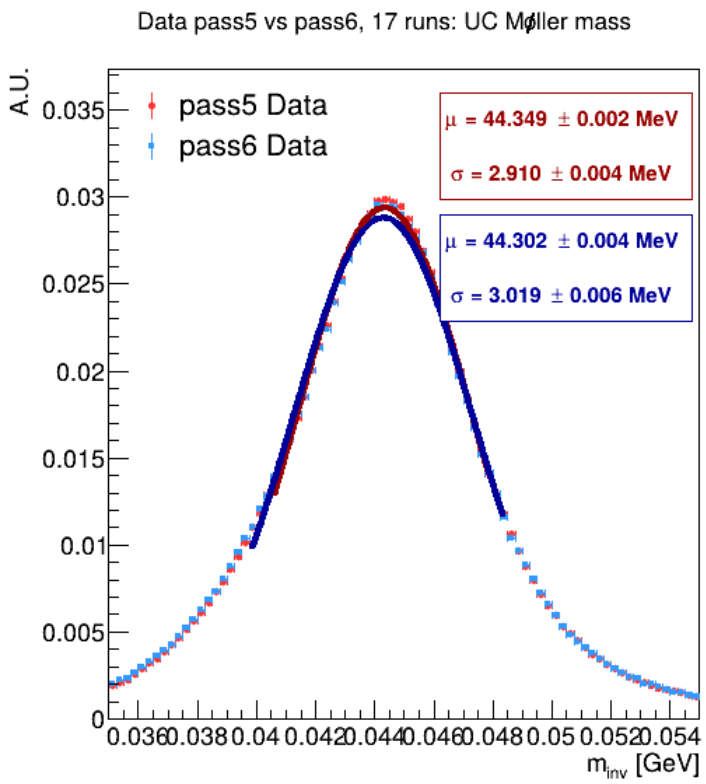
Introduction

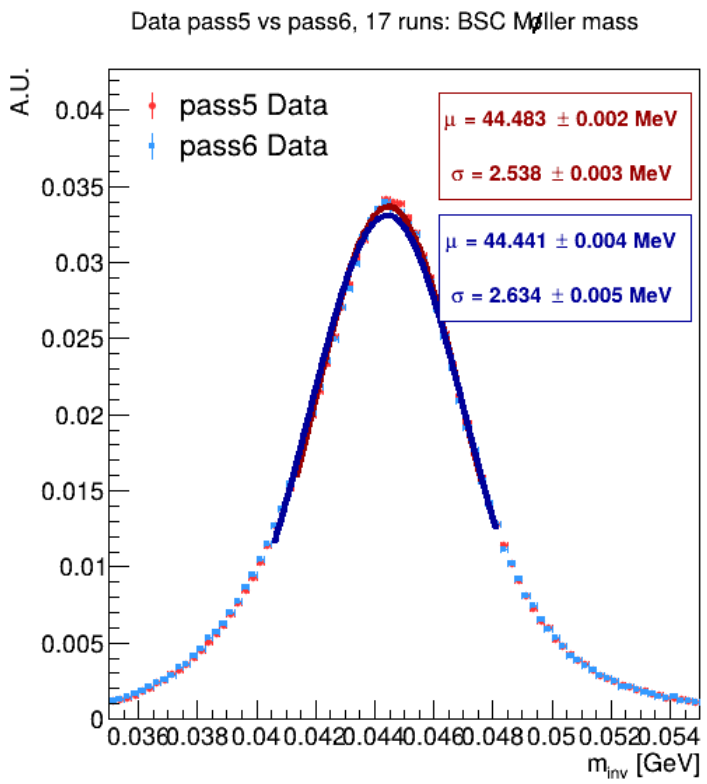
- Mollers and fully-resolved tridents were in a good spot with the latest large pass (pass5_v9), but there were a few outstanding issues
  - 3-prong trident energy scale was a bit high (3.76GeV), and the target constrained Moller vertices showed some strange behavior when comparing the vertex-refitted quantities to the track quantities
  - Quite a few fixes applied: low momentum tracking, beamspot characterization, target constraint issues…

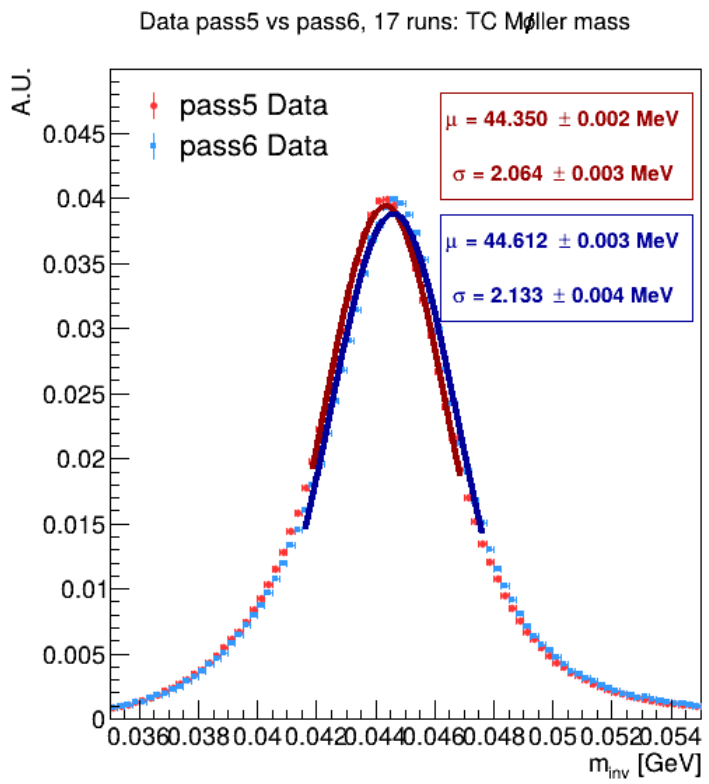
- Tridents in the previous pass were in a really good spot, and are even further improved with pass6.
  - TC chi-squared issue in 2019

2021 1.92GeV Mollers

Moller invariant mass distribution with the updated pass6_v10 detector and low momentum sum fixe applied







Invariant mass means are slightly shifted, most notably with the TC plot on the right.

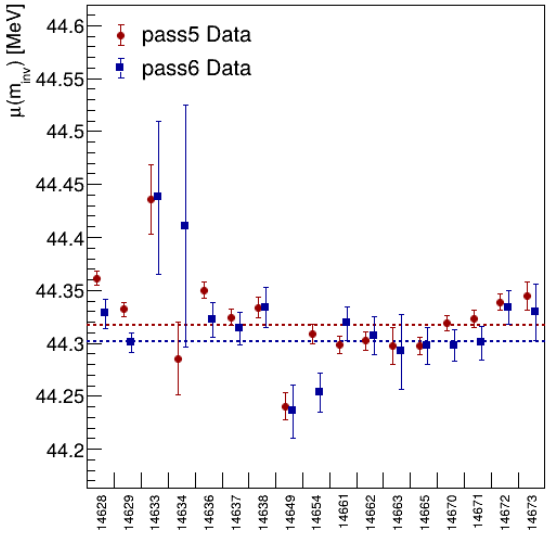
2021 1.92GeV Mollers, pass6

Top plot is a run-by-run comparison of the mean mass values, bottom is the same for the widths.

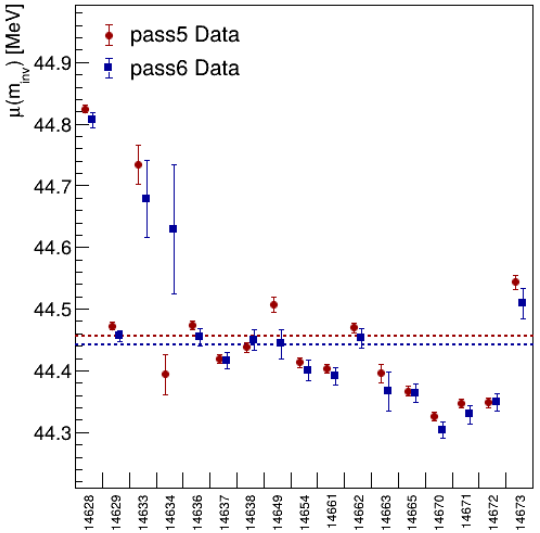
Target constrained Moller mass in pass6 is consistently elevated compared to pass5.

Widths are comparable for the most part.

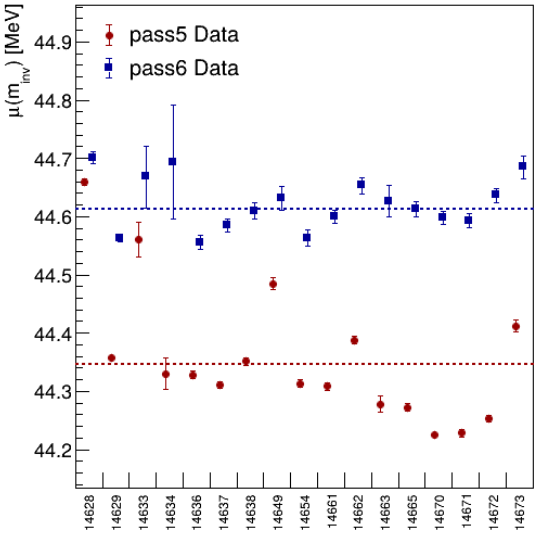
UC: Møller mass mean per run, pass5 vs pass6



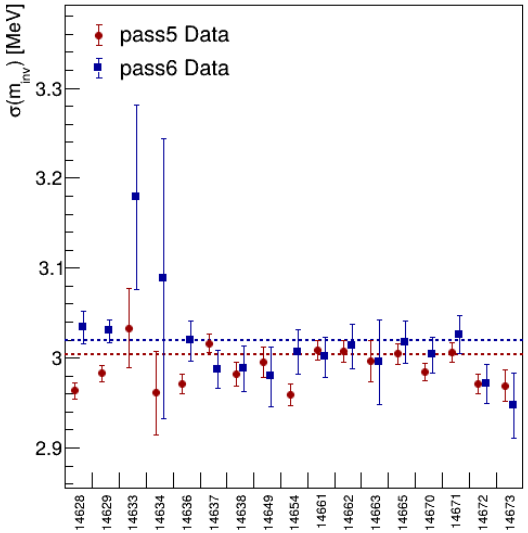
BSC: Møller mass mean per run, pass5 vs pass6



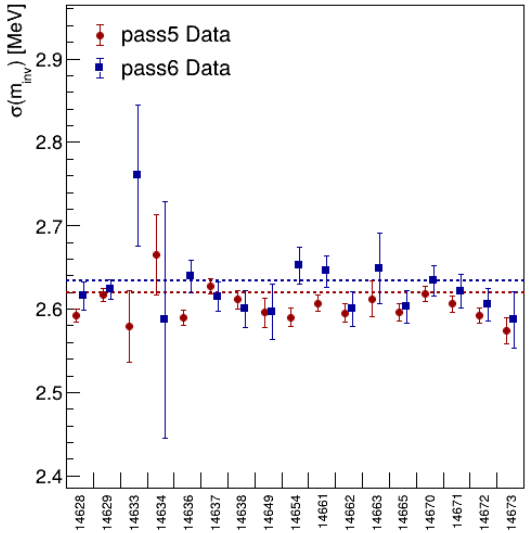
TC: Møller mass mean per run, pass5 vs pass6



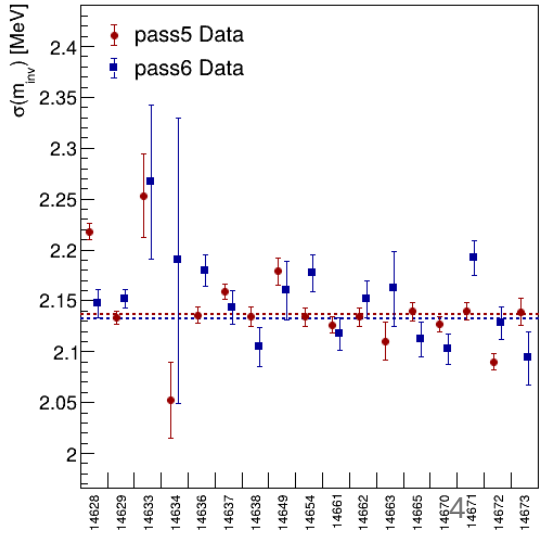
UC: Møller mass width per run, pass5 vs pass6



BSC: Møller mass width per run, pass5 vs pass6

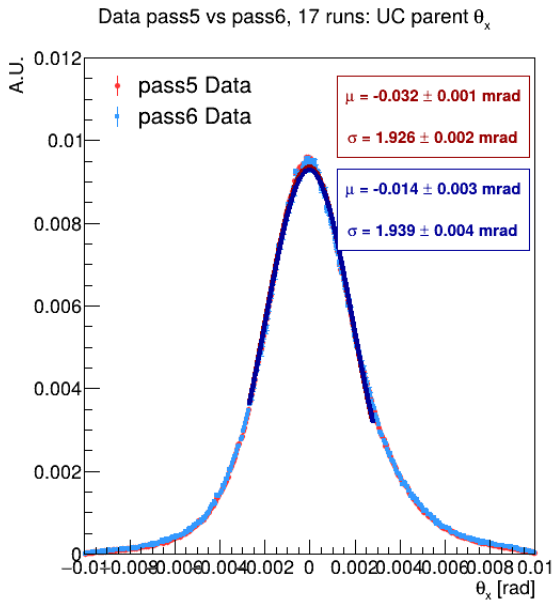


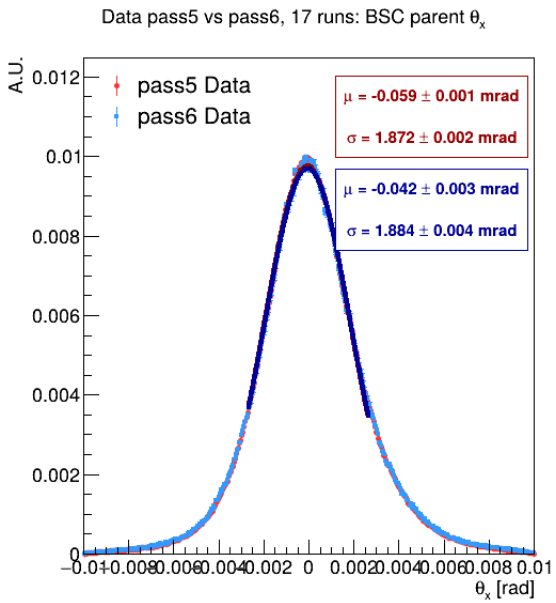
TC: Møller mass width per run, pass5 vs pass6

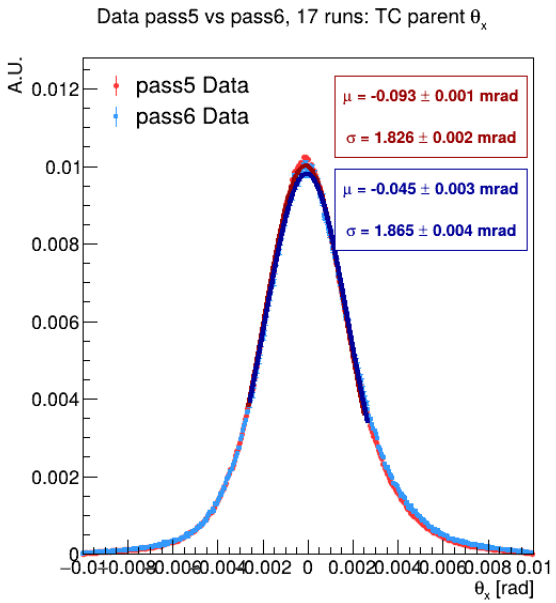


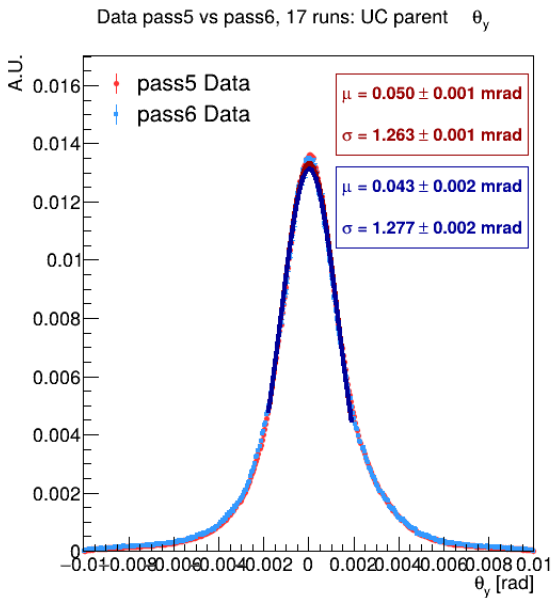
2021 1.92GeV Mollers, pass6

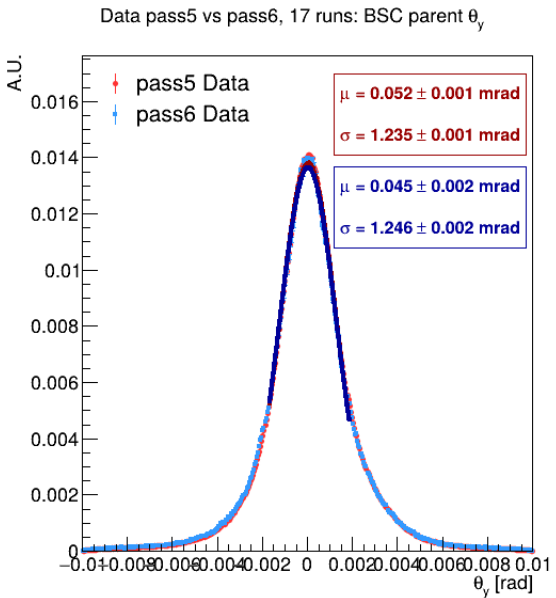
Beam directions are consistent and unchanged.

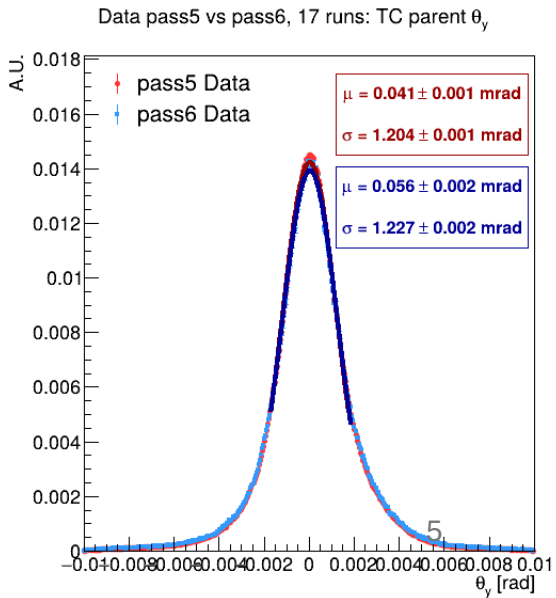










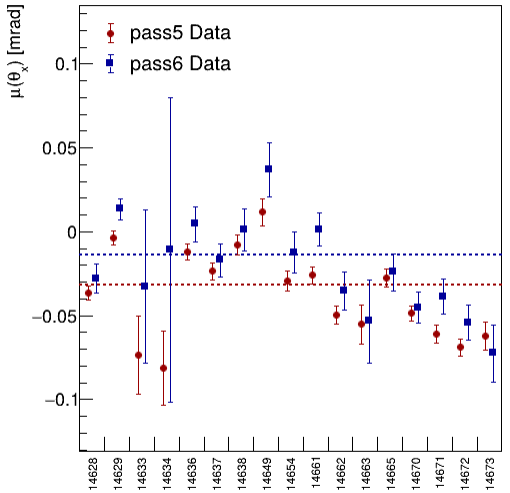


2021 1.92GeV Mollers, pass6

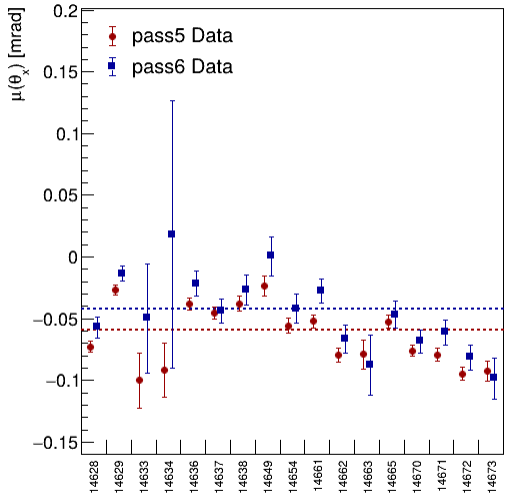
Run-by-run beam directions for each kind of vertex.

Minor differences present here

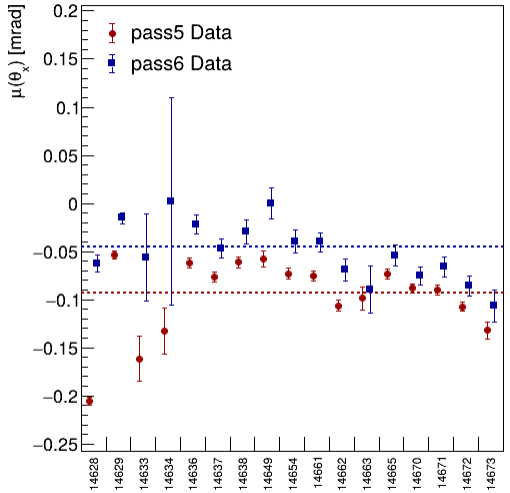
UC: parent θ_x mean per run, pass5 vs pass6



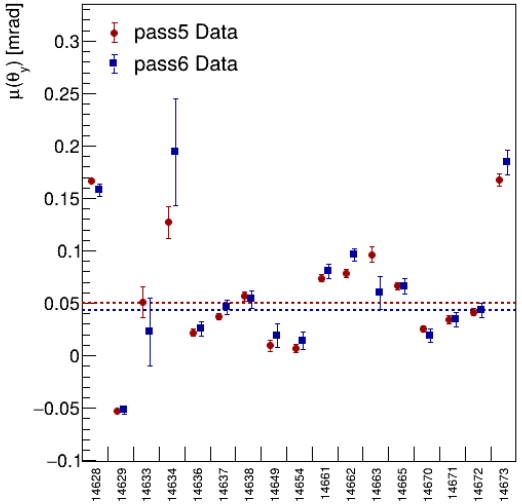
BSC: parent θ_x mean per run, pass5 vs pass6



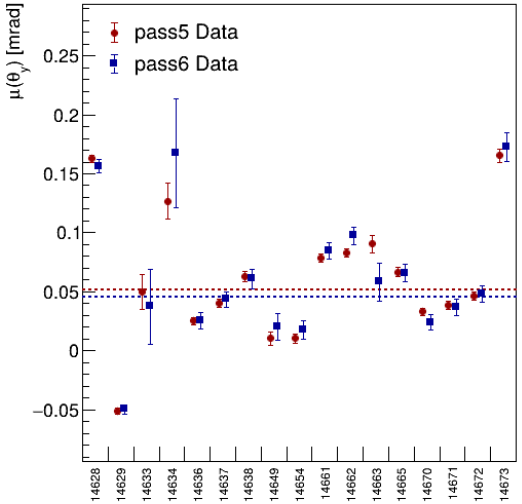
TC: parent θ_x mean per run, pass5 vs pass6



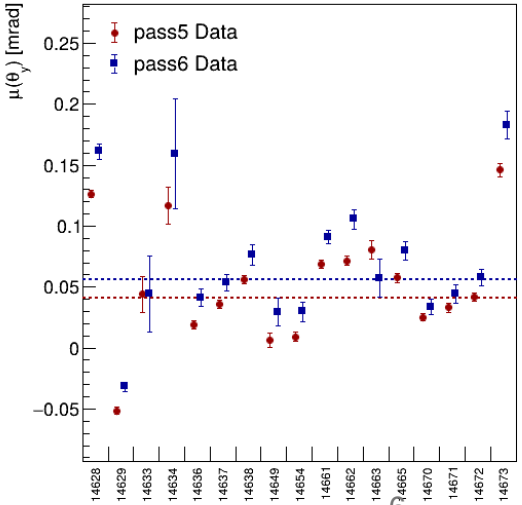
UC: parent θ_y mean per run, pass5 vs pass6



BSC: parent θ_y mean per run, pass5 vs pass6



TC: parent θ_y mean per run, pass5 vs pass6

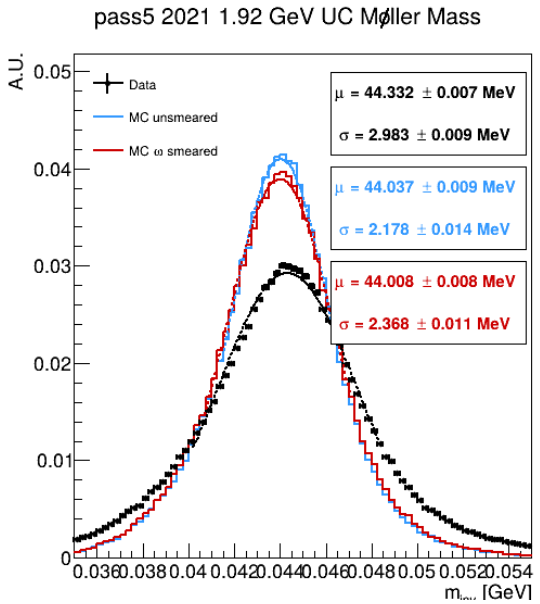


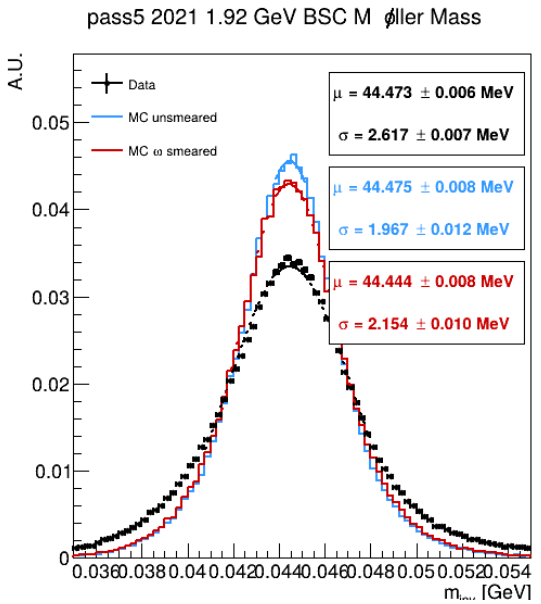
2021 1.92GeV Mollers

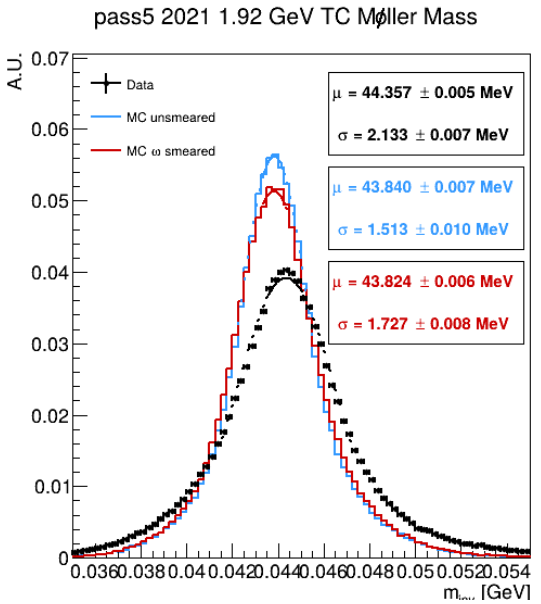
Small sample of (pure) moller mc generated with the pass6_v10 pipeline.

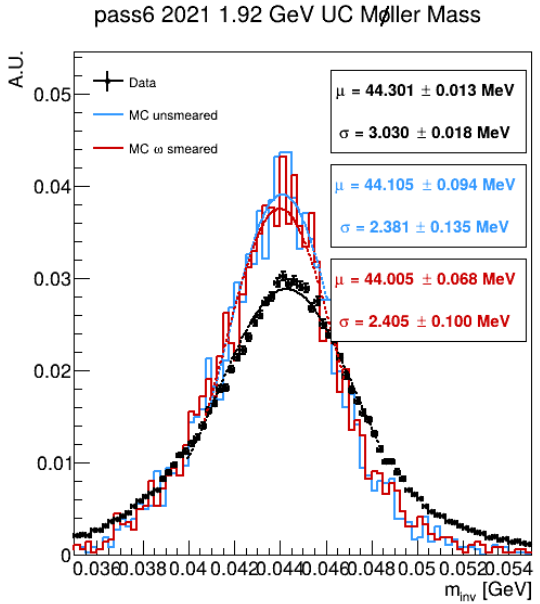
Top plot compares all things pass5_v9: data, mc unsmeared, and mc curvature smeared.

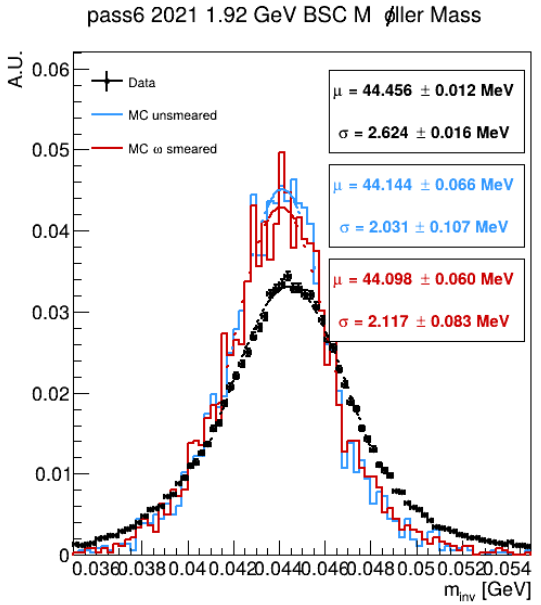
Bottom is the same for pass6_v10.

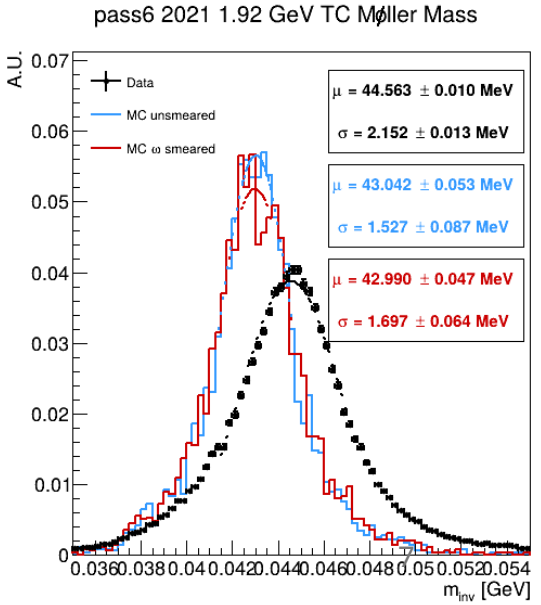










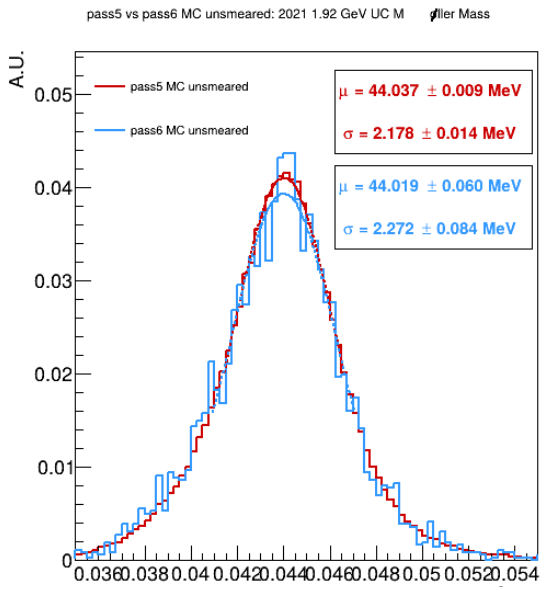


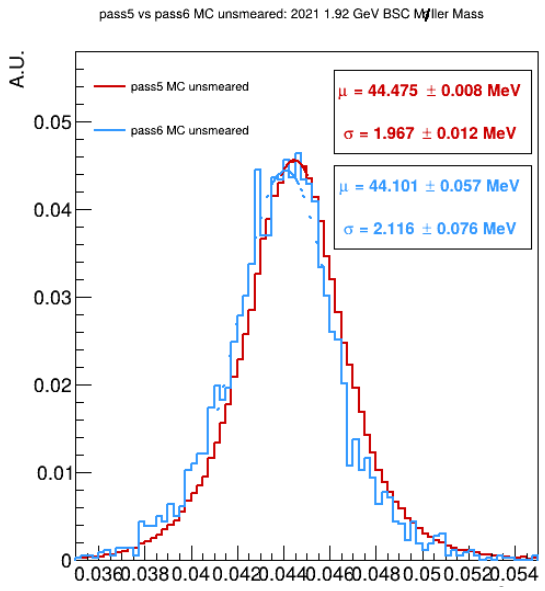
2021 1.92GeV Mollers, pass6

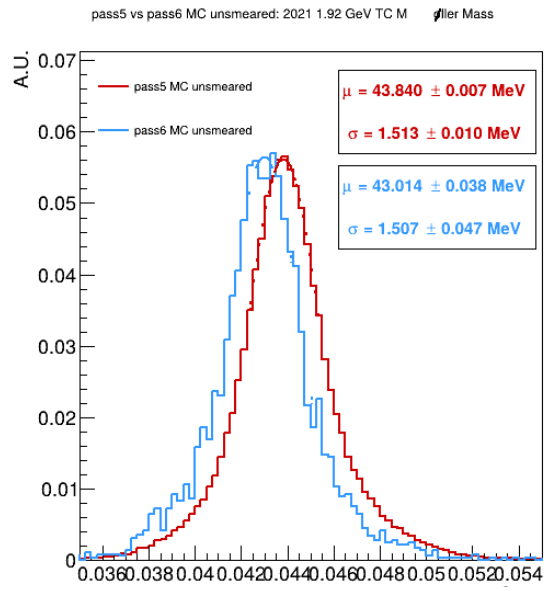
Comparing the mc samples directly is a bit more interesting.

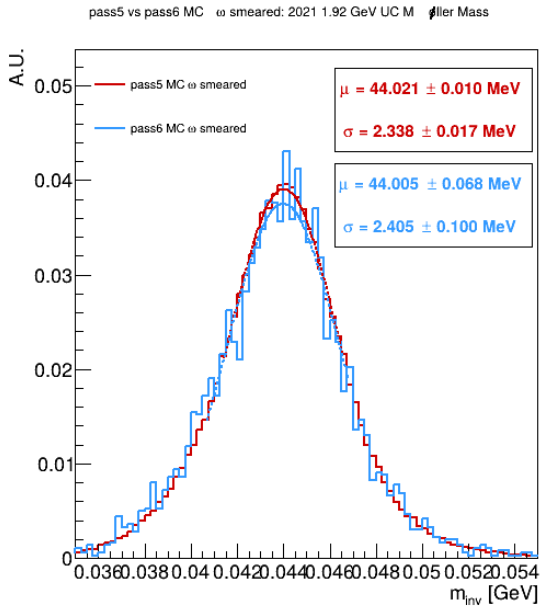
The top row compares pass5 to pass6 unsmeared, and the bottom is the same for the curvature smeared invariant mass distributions. Using the same smearing constants, the pass6 widths are slightly wider.

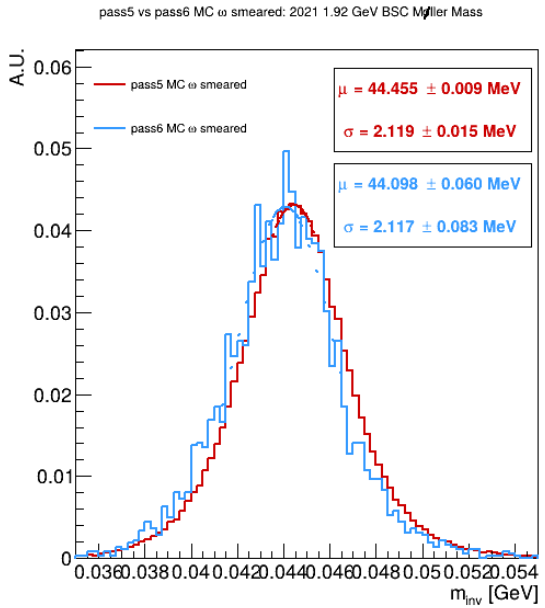
Target constrained mass distributions shifted in mean value, but comparable width.

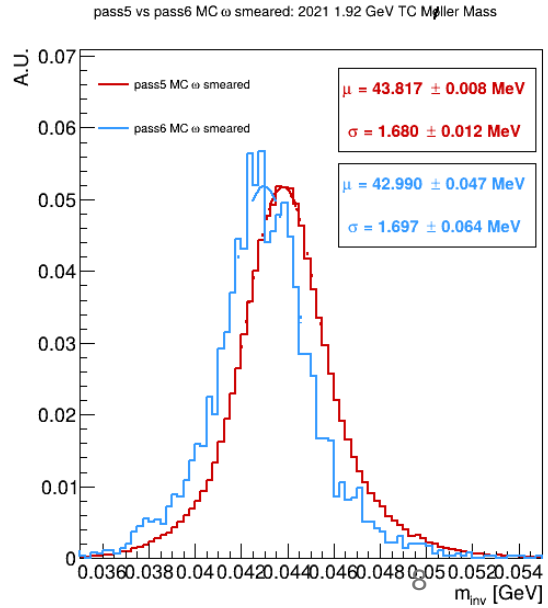




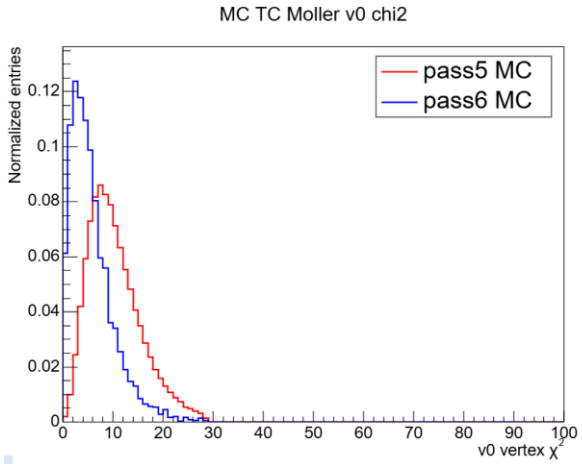


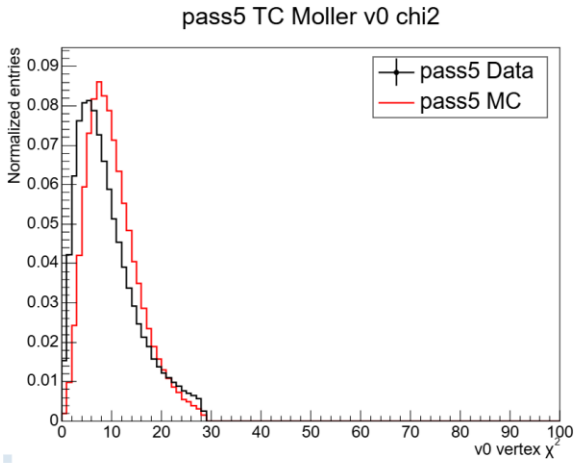


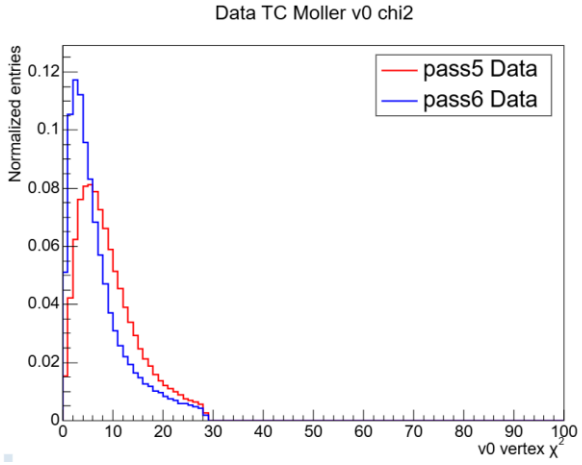


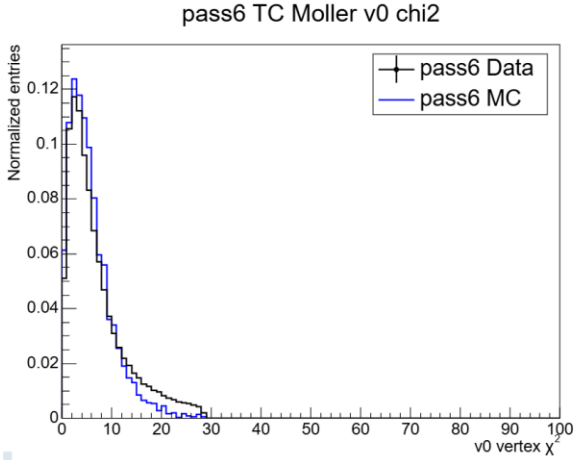


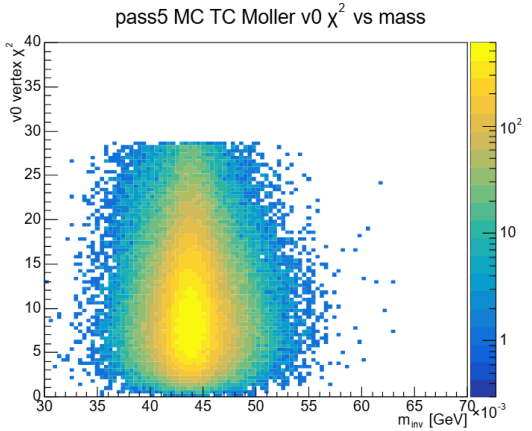
2021 1.92GeV Mollers, vertex chi2

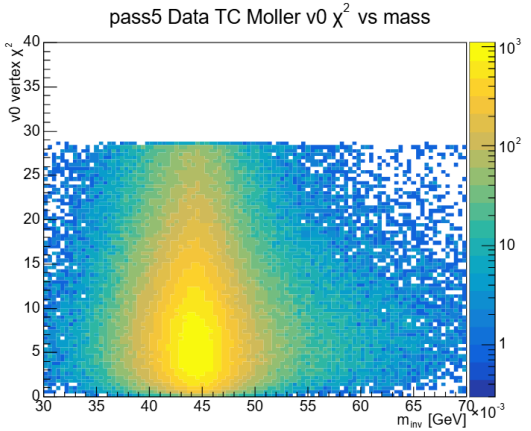


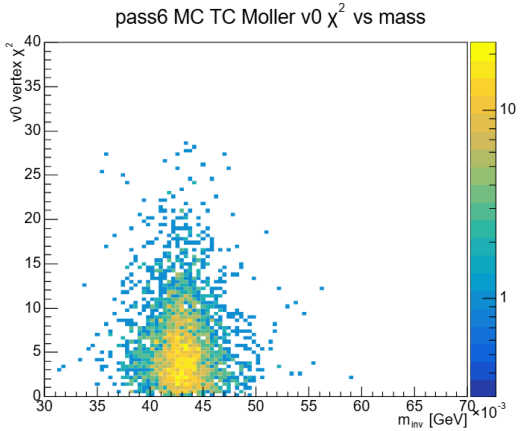


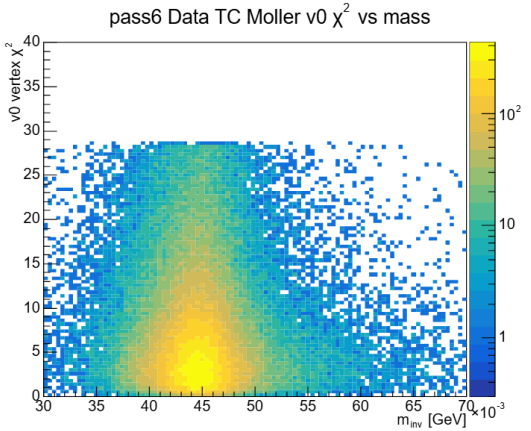








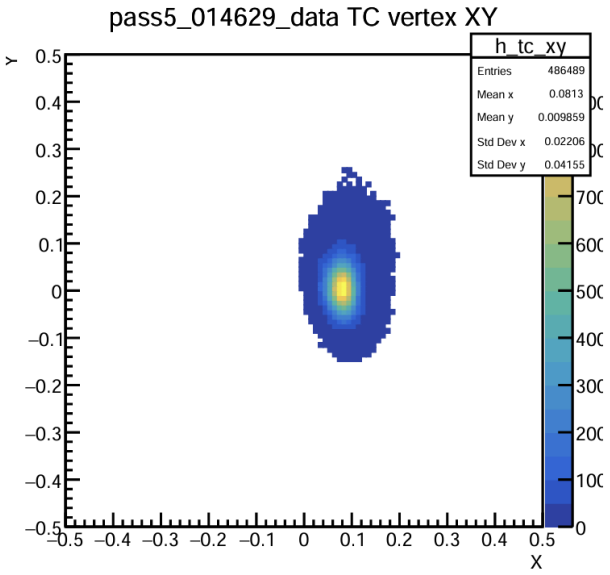


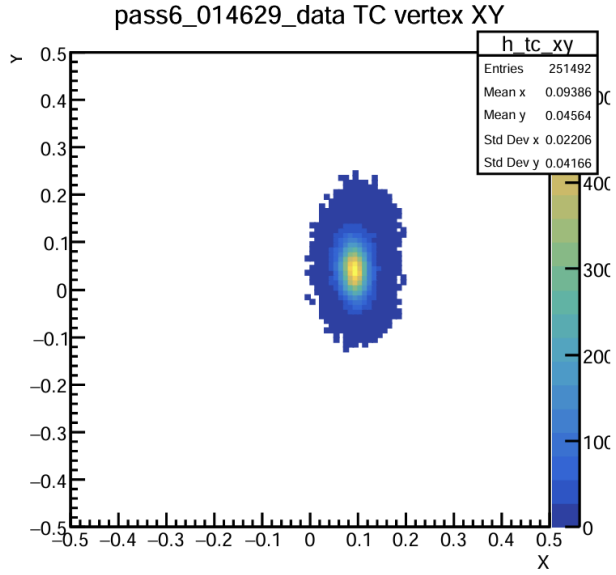


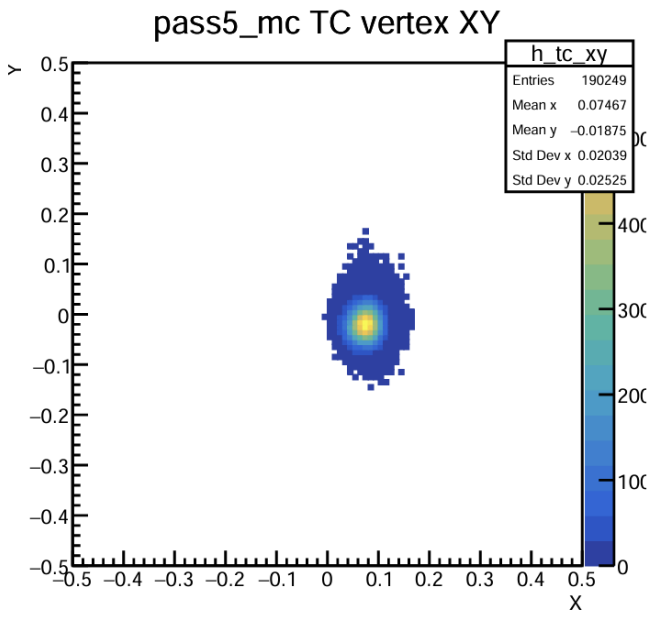
Pass6 target constrained vertex chi2 is much improved, and the pass6 data and MC are closer to alignment as well.

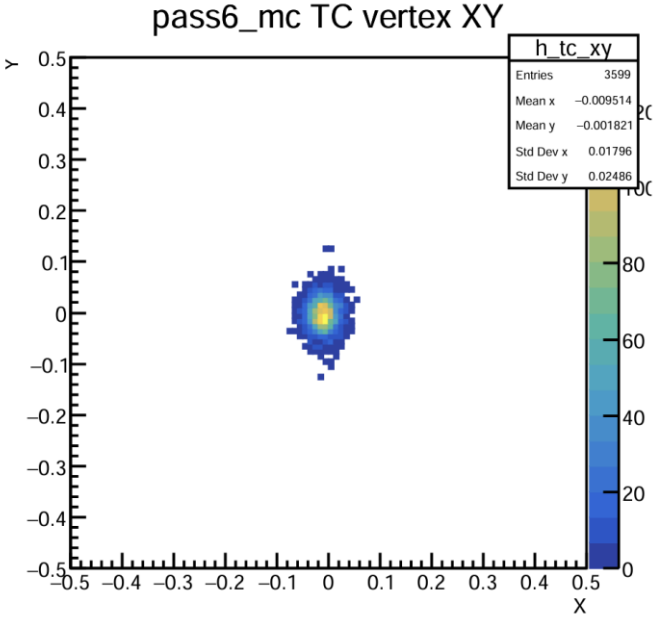
No obvious dependence of moller mass on vertex chi2 in the target constrained sample.

2021 1.92GeV Mollers, vertex chi2









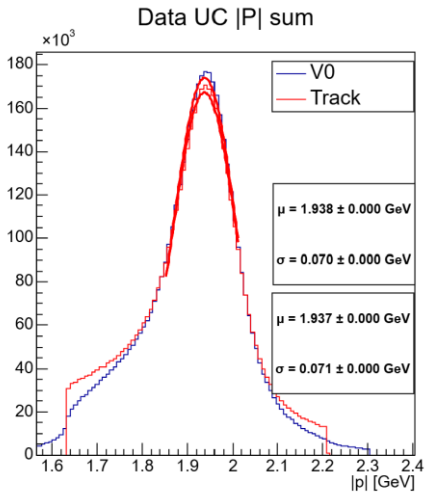
Looking at TC vertex x vs vertex y shows that the TC fix is working as intended.

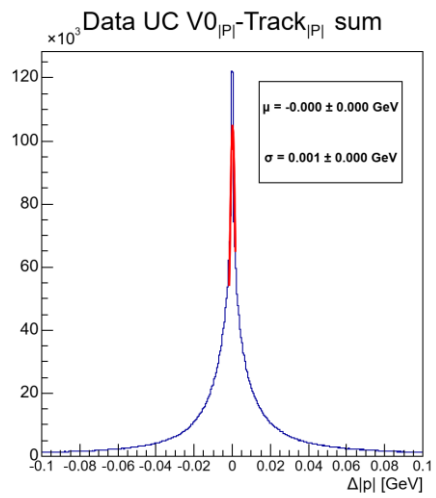
Pass5 MC samples (bottom row) samples show the mean x and y not quite at zero

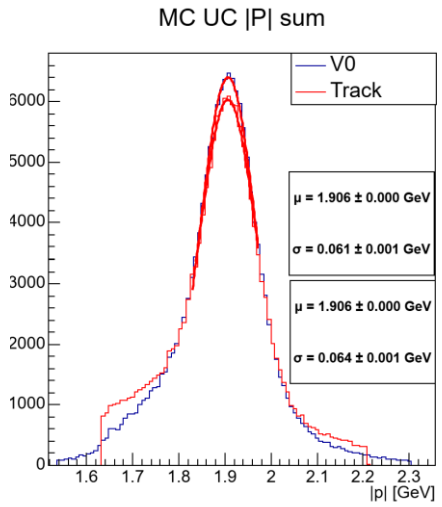
Vertex Refit Beam Energy: https://indico.slac.stanford.edu/event/10316/

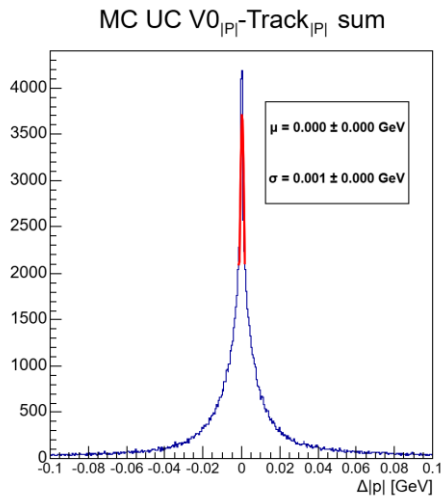
In the pass5_v9 data and mc, the moller electron momentum sum showed a shift when looking at the TC v0s. This was present in both data and MC.

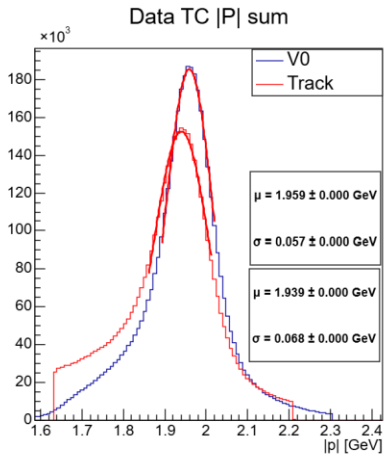
- Not the case for unconstrained v0s.

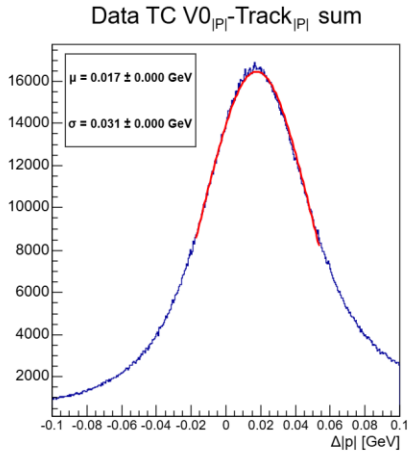


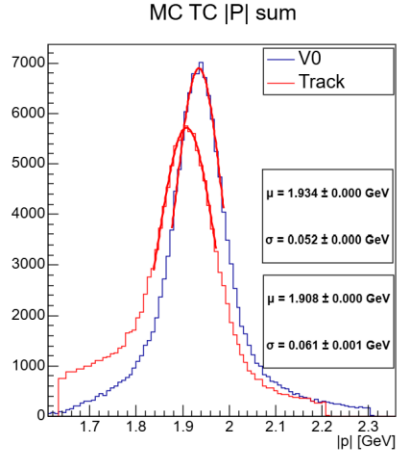


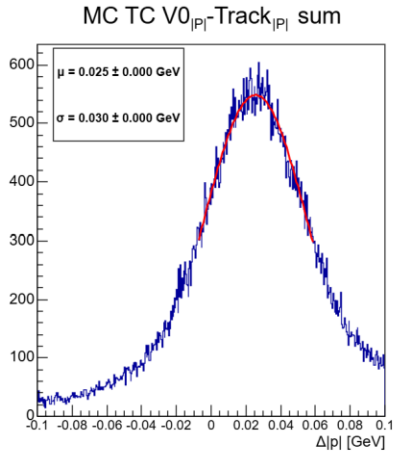






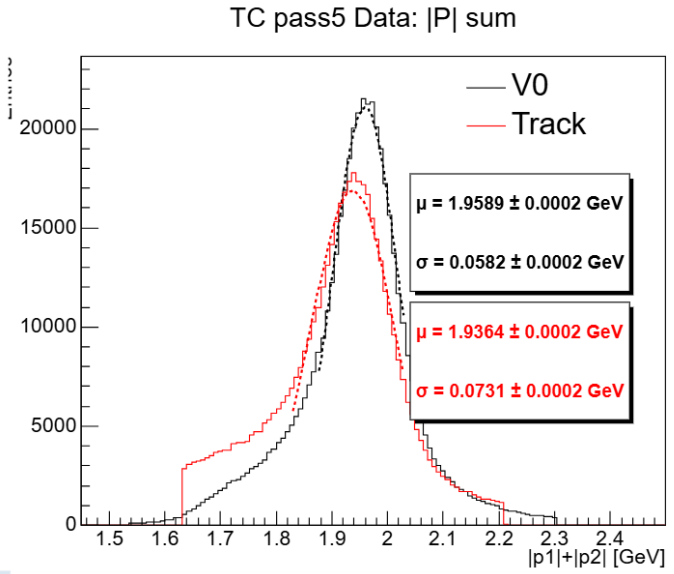


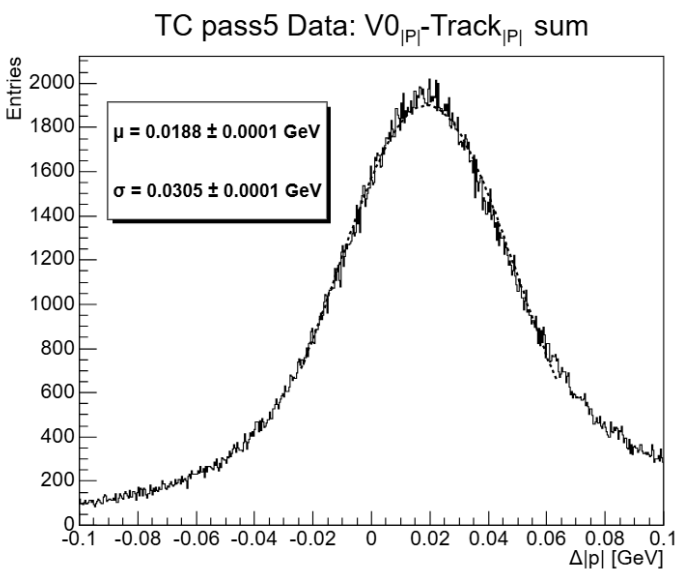


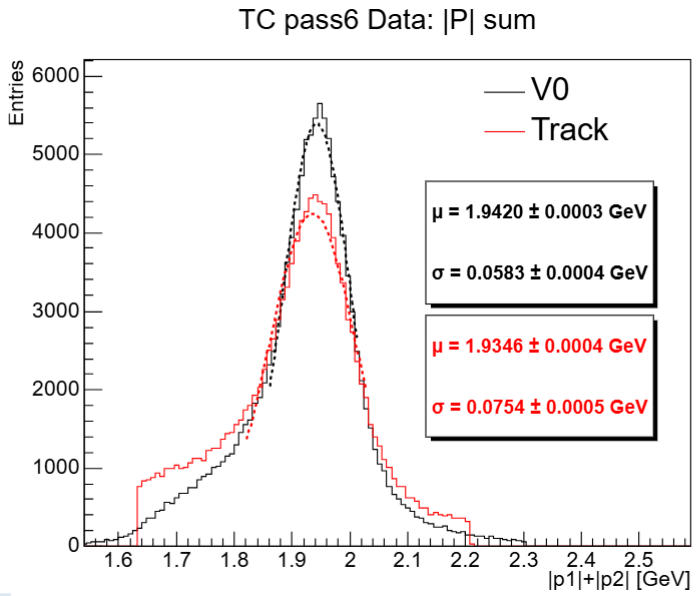


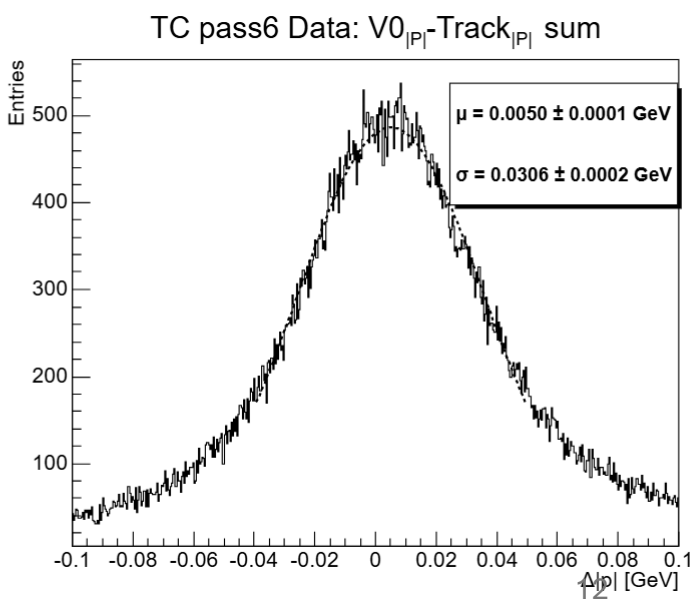
Vertex Refit Beam Energy

The vertex-refitted moller electron momentum sum is much better in pass6, and the residual between vertex-computed |P| and track-computed |P| is centered on ~0.





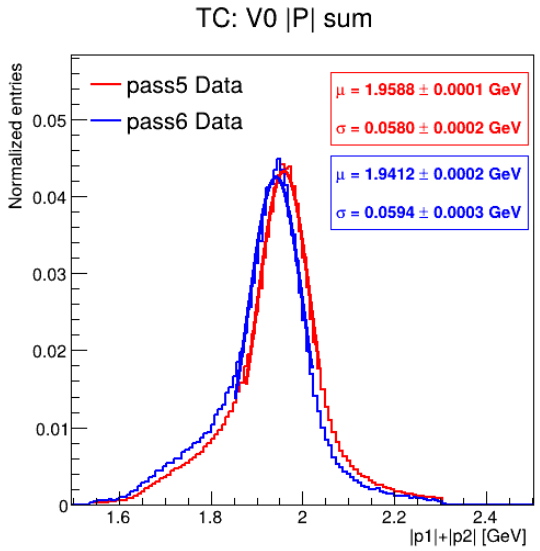


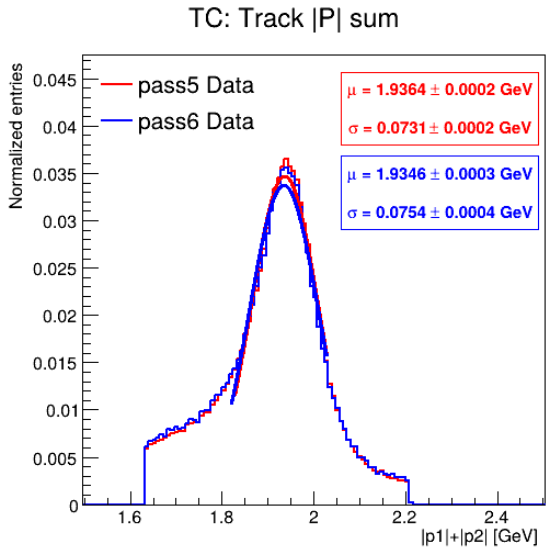


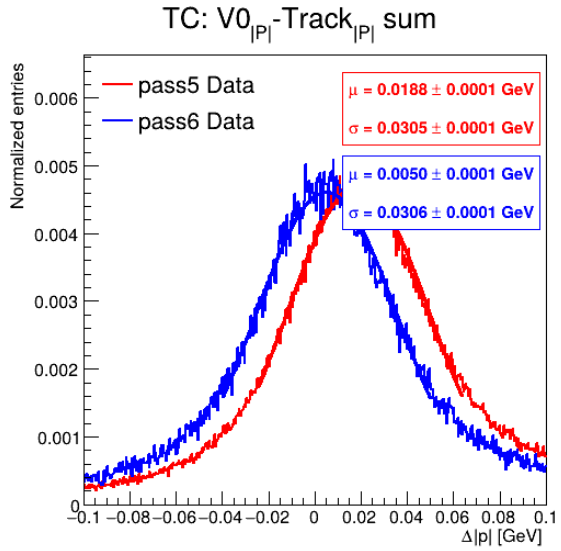
Vertex Refit Beam Energy

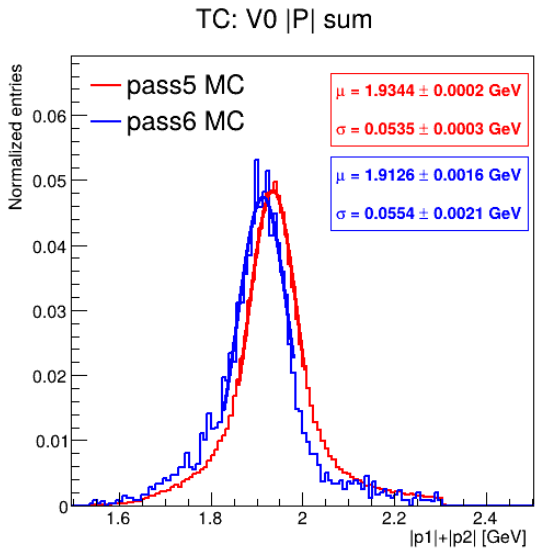
Changes in pass6 TC is apparent when comparing it to pass 5, even in MC.

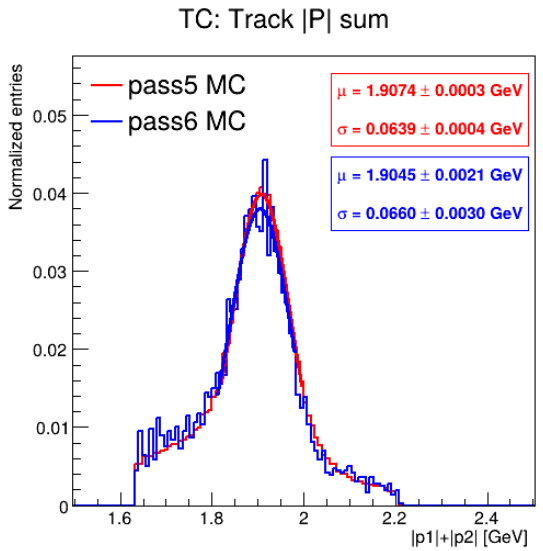
Vertex – track residuals centered much closer to zero for TC now.

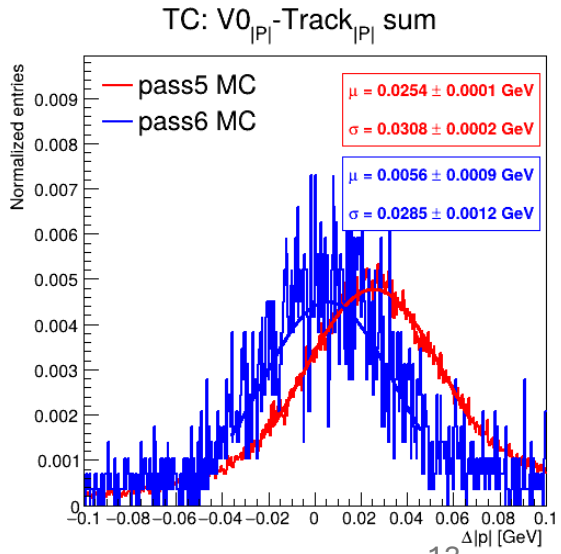








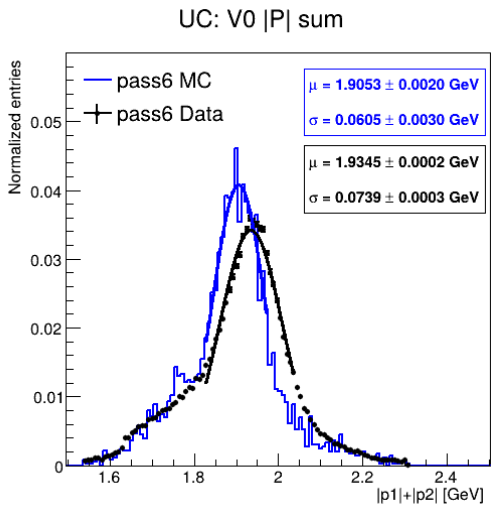


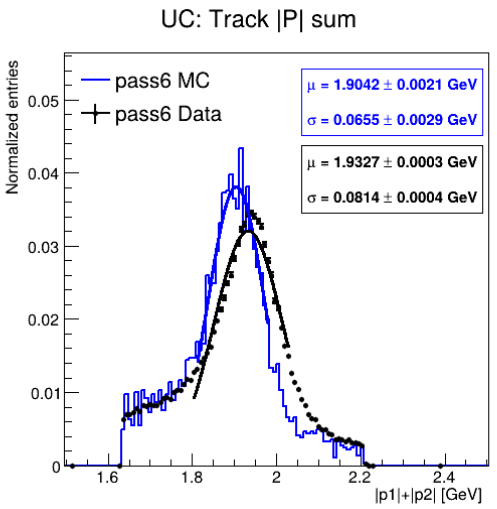


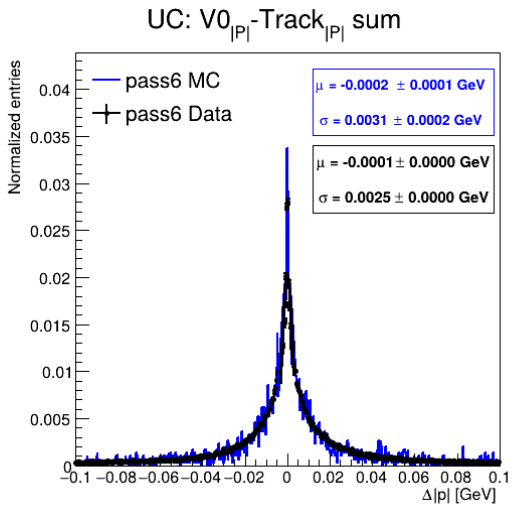
Vertex Refit Beam Energy: Pass6

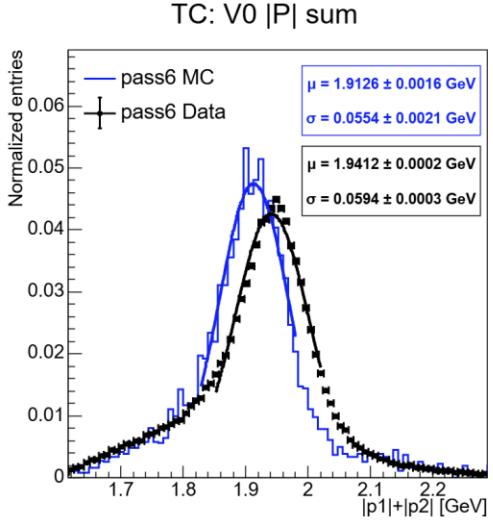
Pass6 data/mc agreement in the momentum sum still shows a discrepancy.

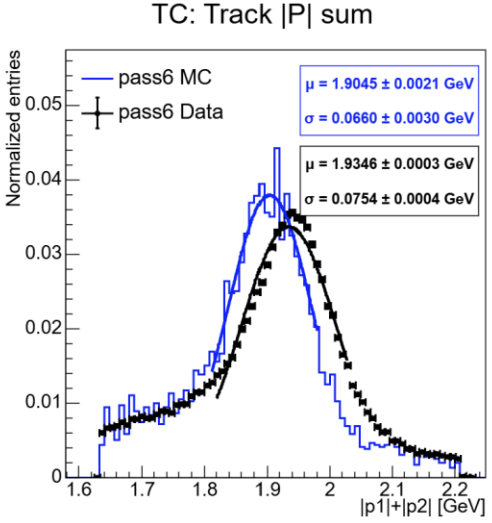
However, this discrepancy is now consistent between the v0 calculation and the track calculation.

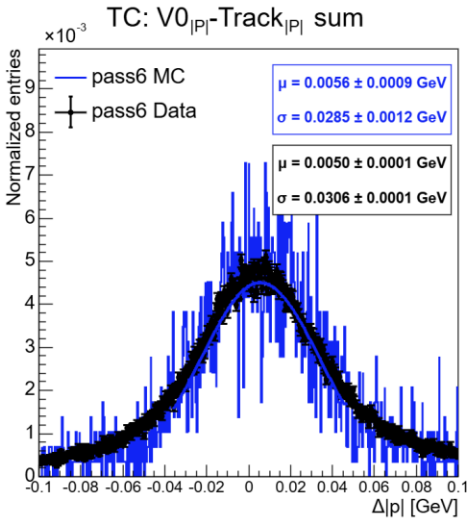










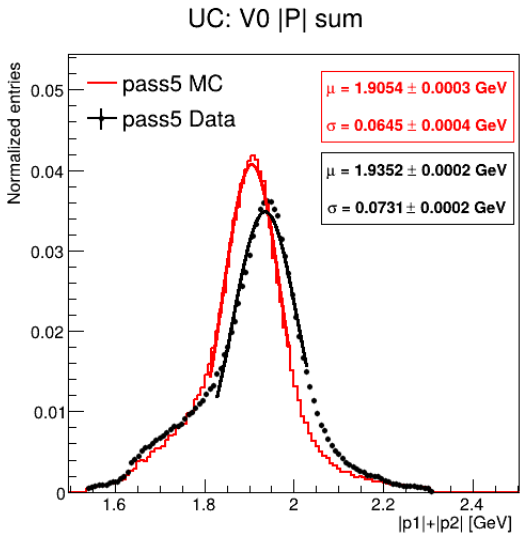


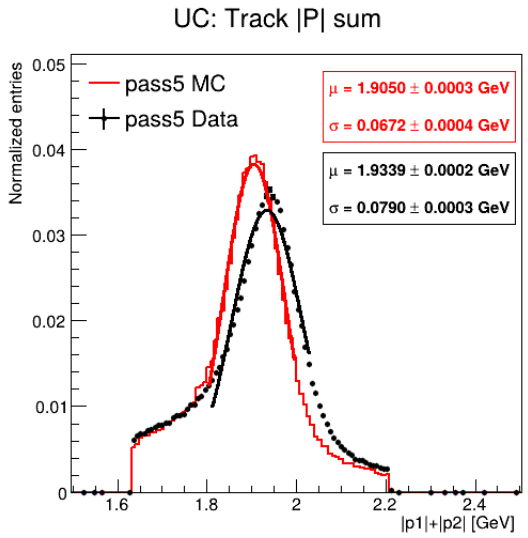
Vertex Refit Beam Energy: Pass5

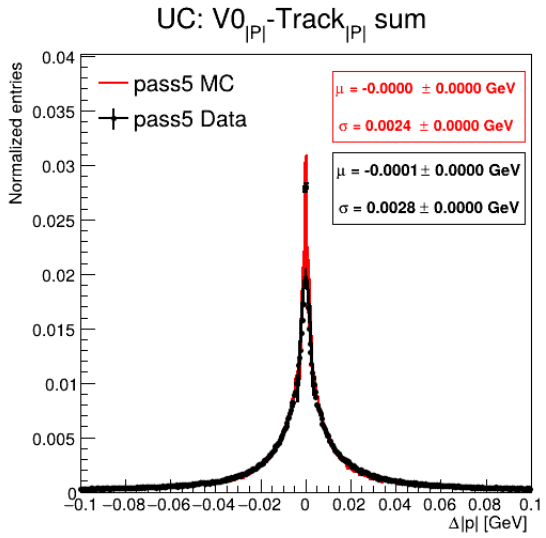
Pass6 data/mc agreement in the momentum sum still shows a discrepancy.

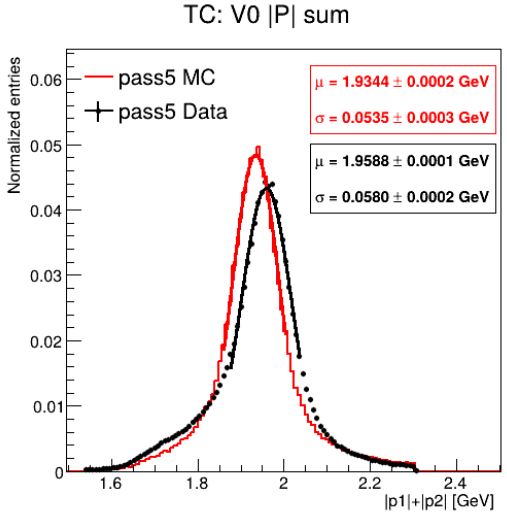
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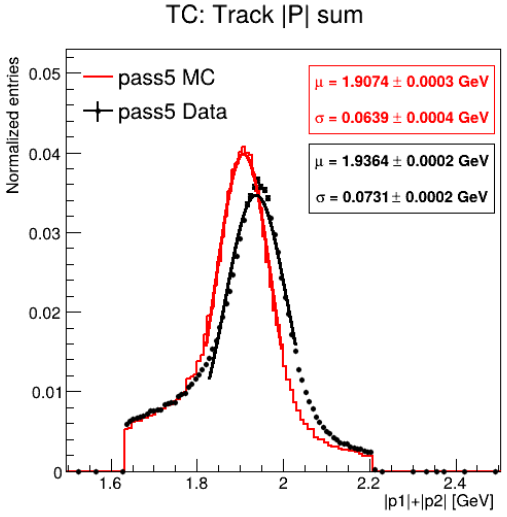
Pass5 shows roughly the same discrepancy between data/mc in this regard, though the TC is shifted to higher momentum.

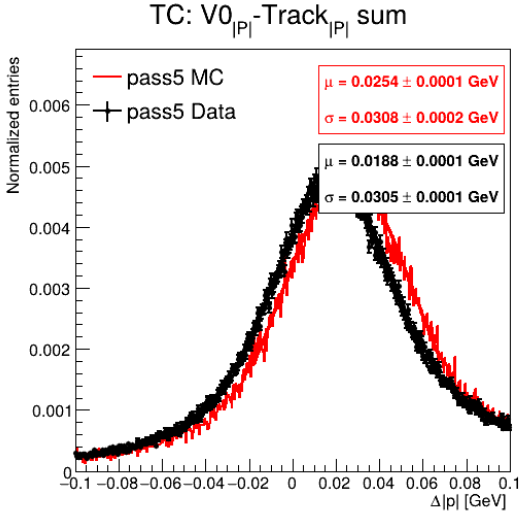








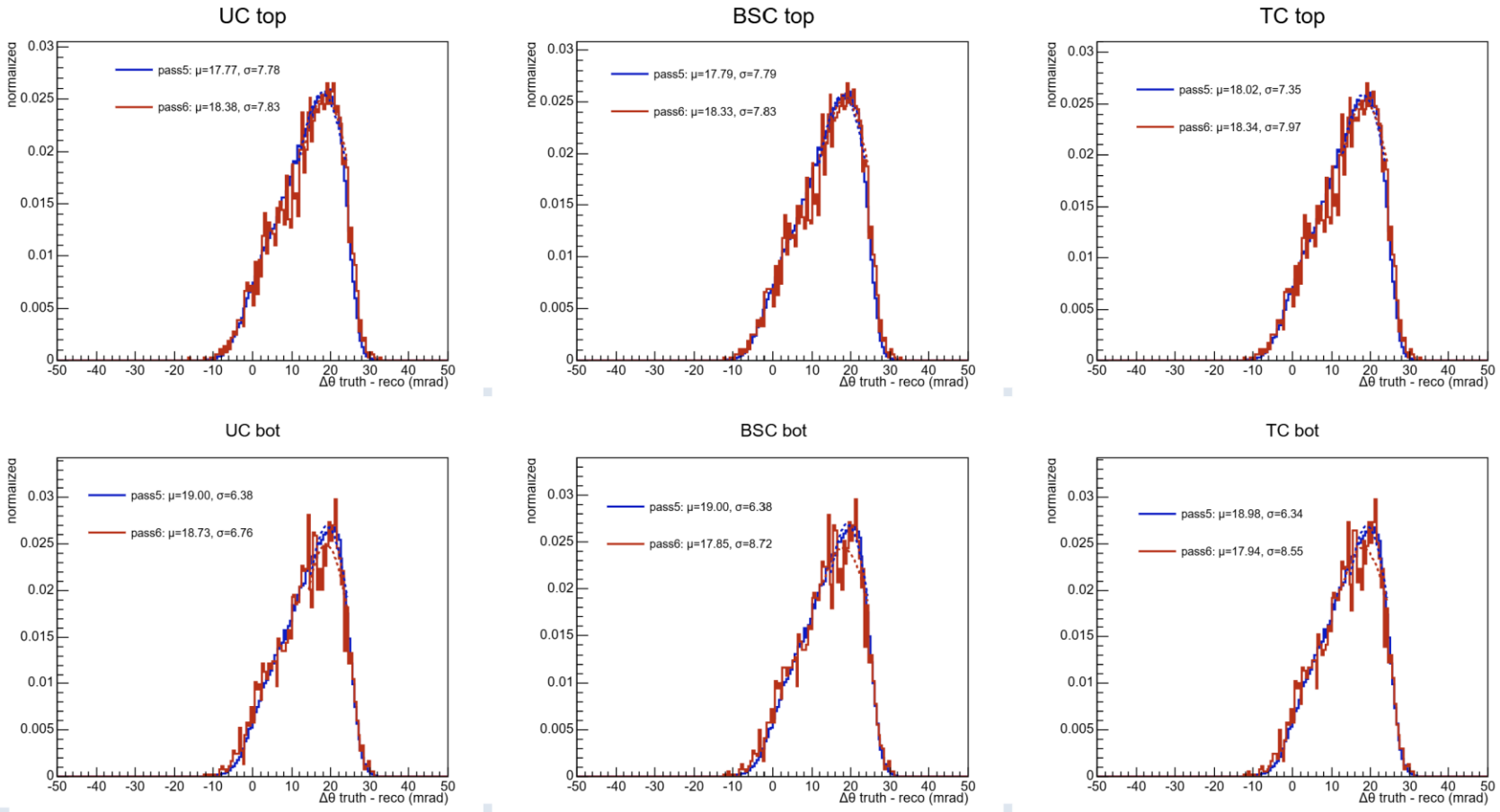




Moller Angular Smearing

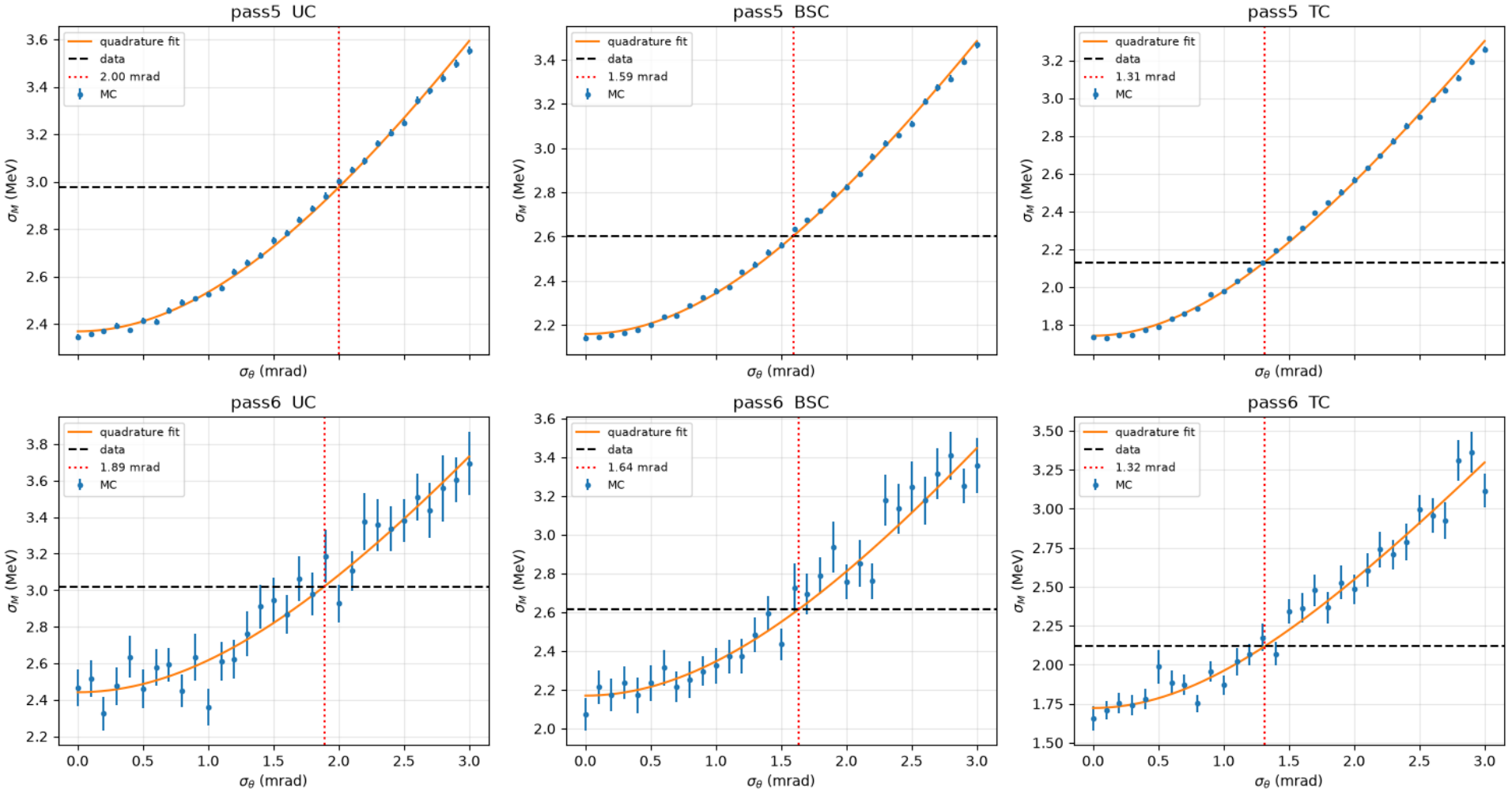
I previously explored smearing the polar angle, theta, in pass5_v9 moller MC

Initial observation was that there are large residuals between truth and reconstructed polar angle in the MC



Moller Angular Smearing

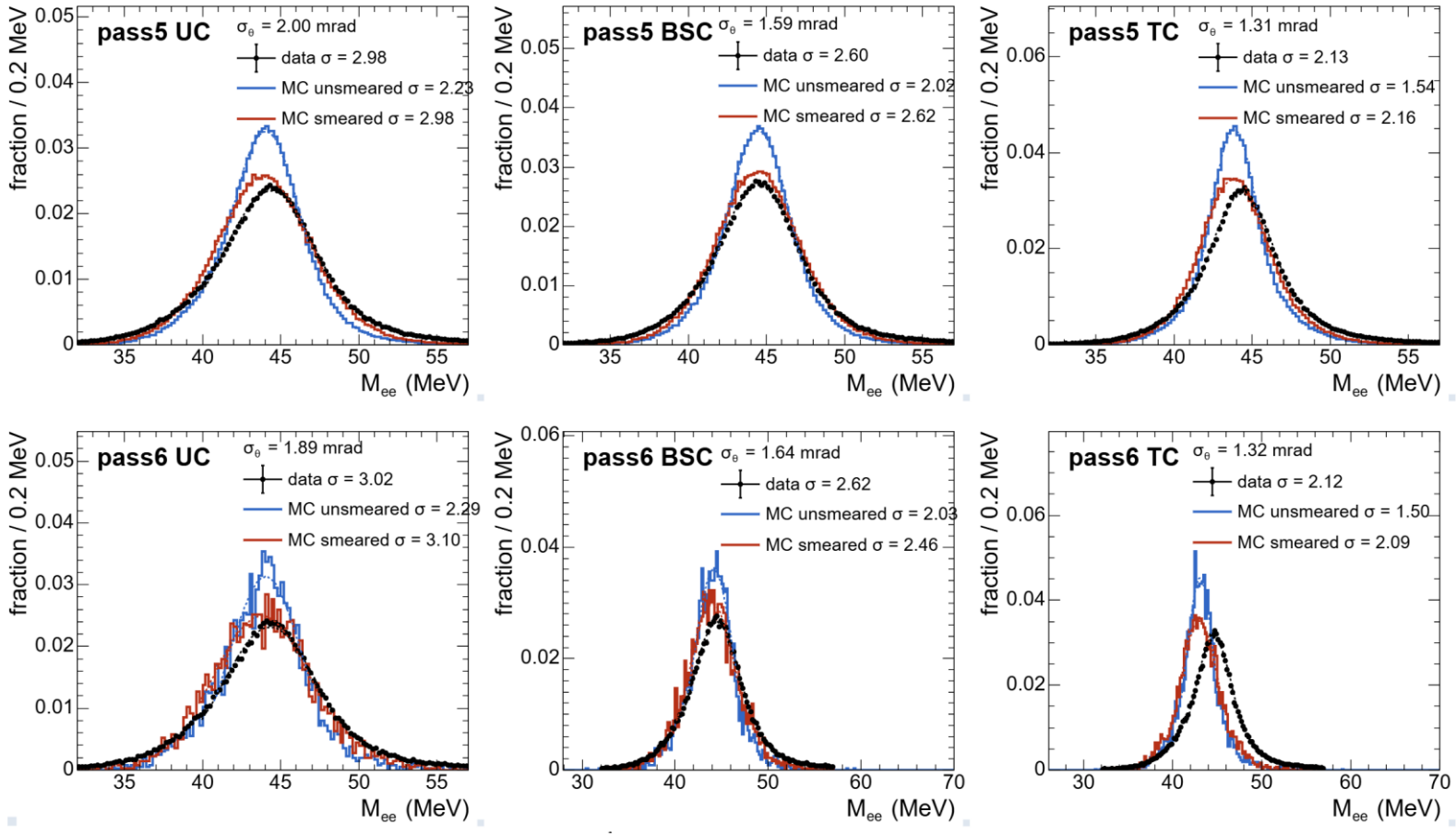
Scanned over various smearing values to find intersection between the smeared moller mass width and the data widths for each vertex type.



Moller Angular Smearing

Level of smearing required changes for the different vertex types but is very powerful.

Smearing required between pass5 and pass6 is similar, UC requires a bit less in pass6.

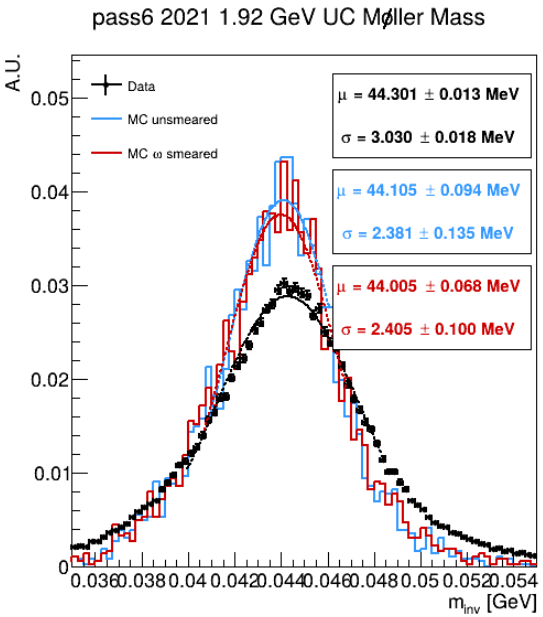


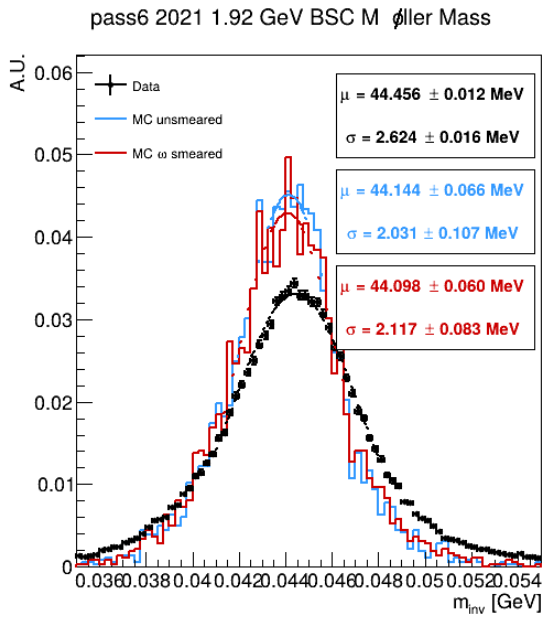
	UC	BSC	TC
Pass5	2.00mRad	1.59mRad	1.31mRad
Pass6	1.89mRad	1.64mRad	1.32mRad

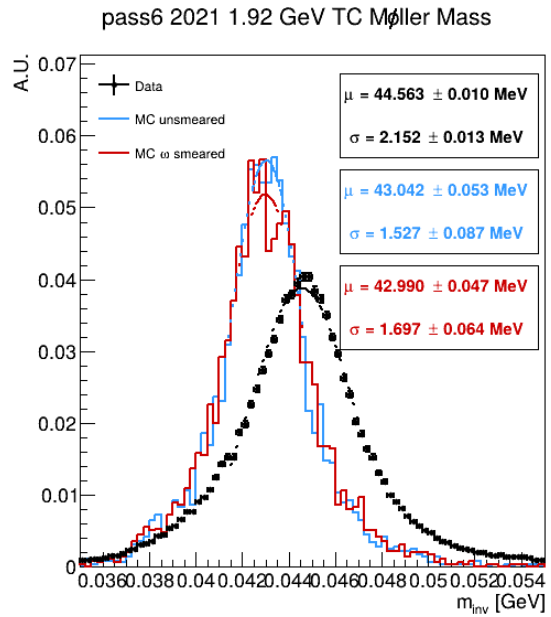
Moller Summary

- Many improvements with pass6
  - Chi-squared issue fixed, track and v0 momenta more in agreement
- A few outstanding issues still, including TC mass being shifted high and the MC beam energy calculation being low across vertex constraint types.

- Mean masses are a bit higher than pass5, especially in the TC. Widths roughly the same, minor changes.
  - Same curvature smearing values across pass5 and pass6 produce slightly wider distributions in the MC. Still about half an MeV too narrow in MC.



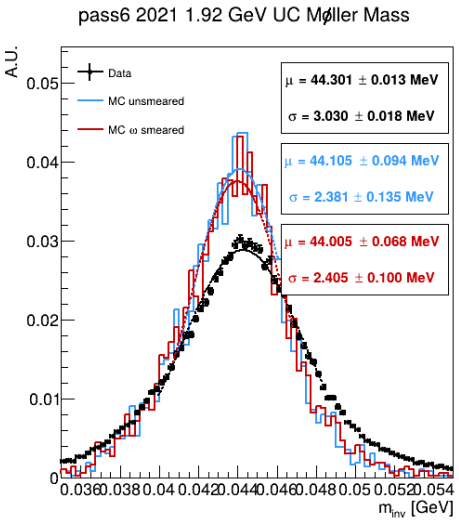


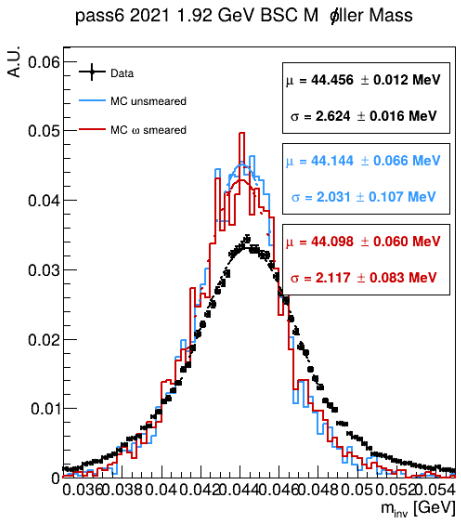


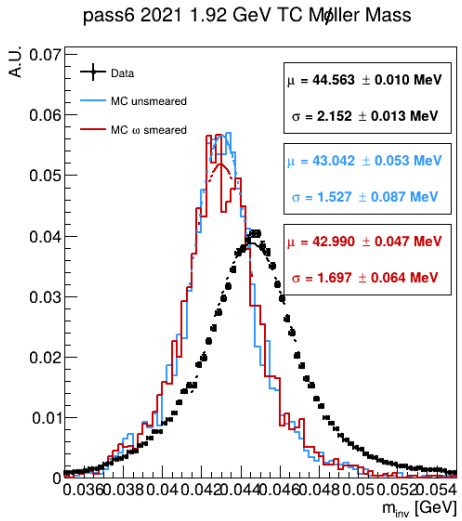
Moller Summary

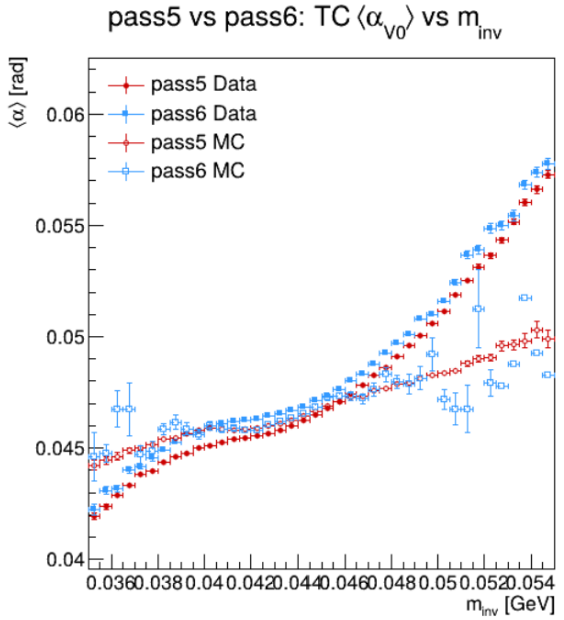
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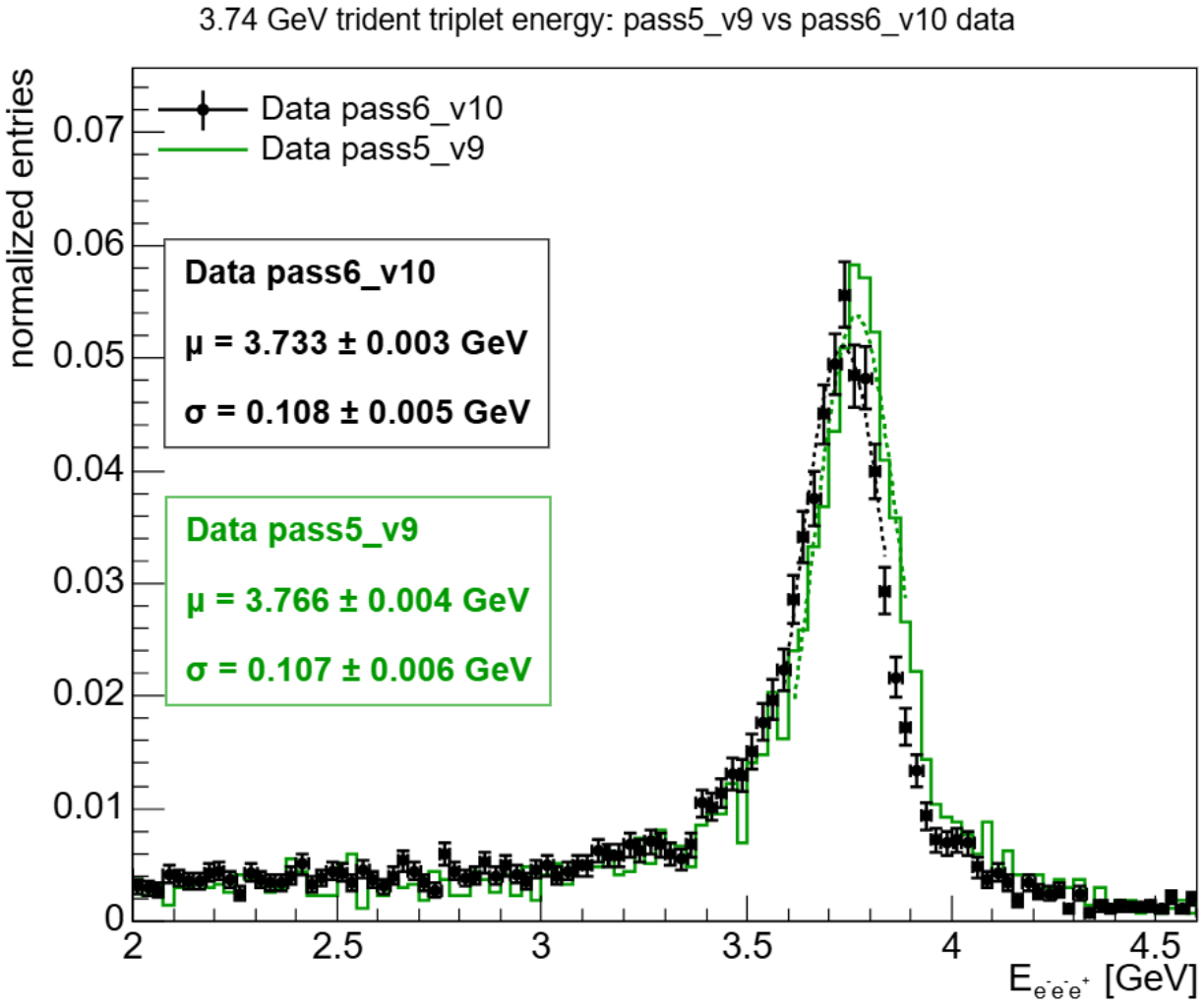


High mass tail & relationship to opening angle, how to think about this?

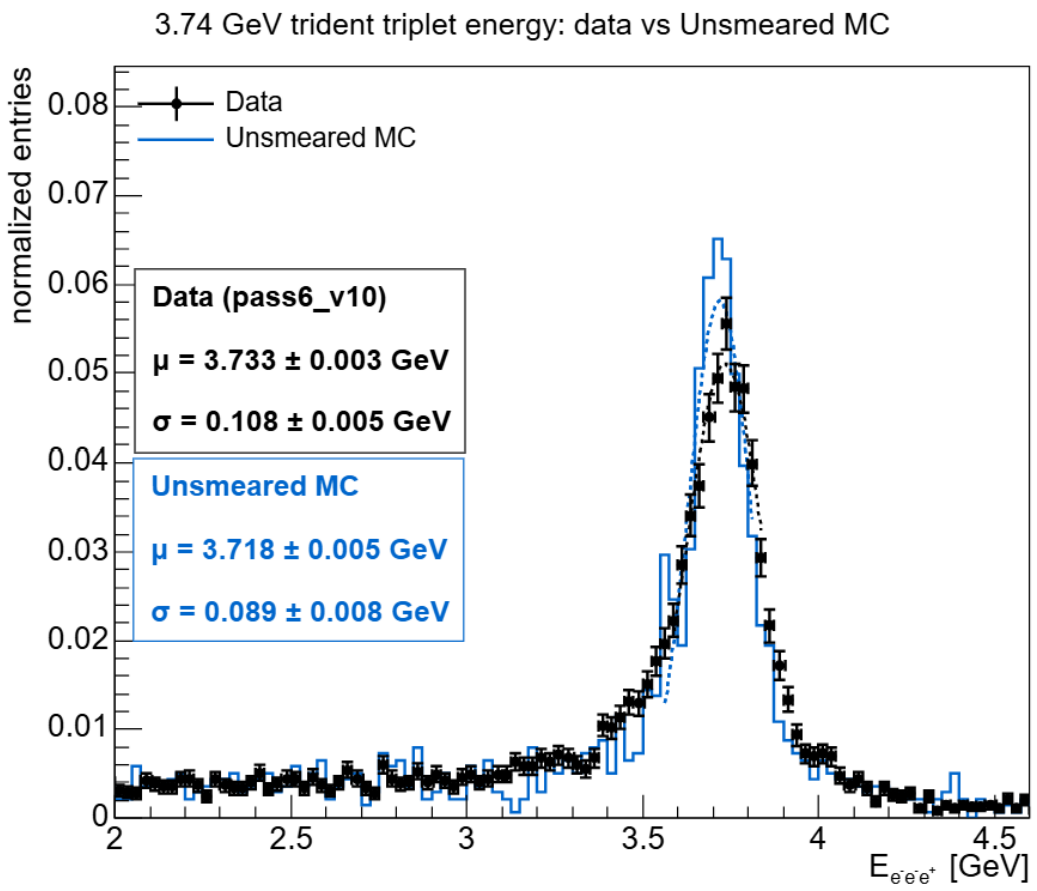
2021 3.74GeV Fully-reconstructed Tridents

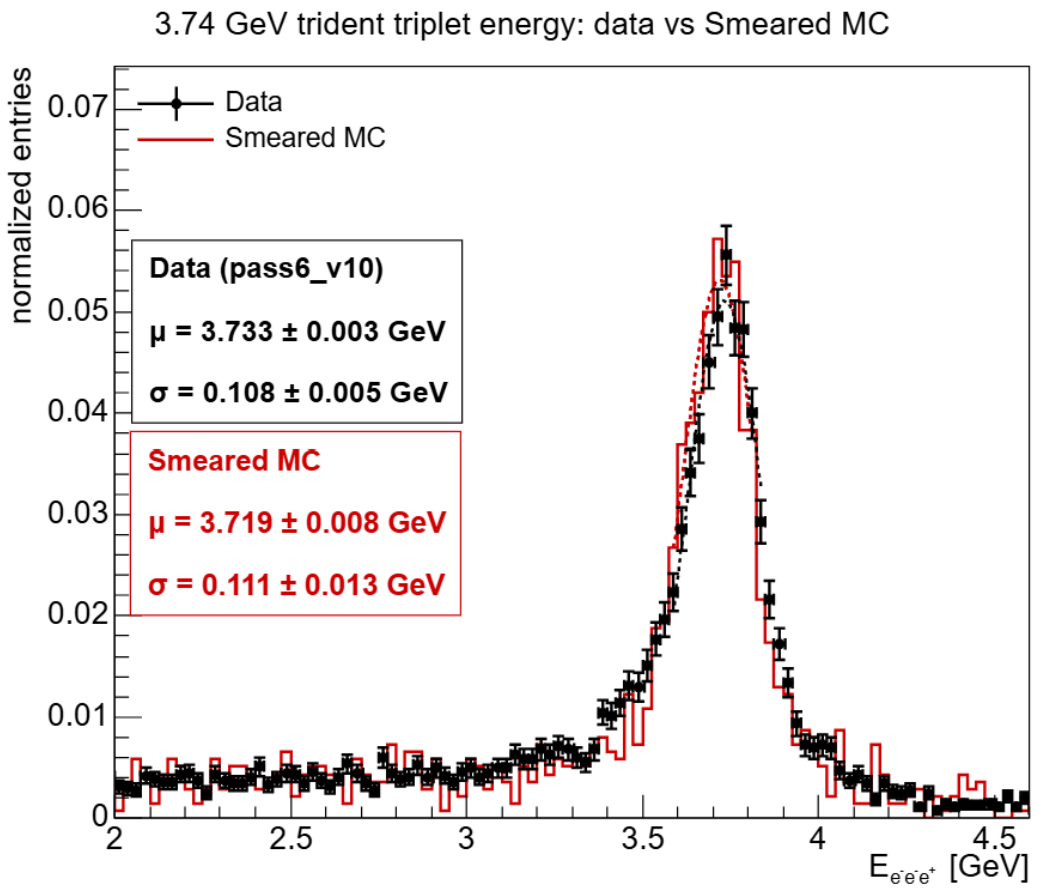
Fully-resolved trident energy sum distribution looks even better in pass6_v10 with the low p tracking changes, very nice to see.

Widths are the same, but the mean of the peak has been shifted closer to the beam energy.



2021 3.74GeV Fully-reconstructed Tridents





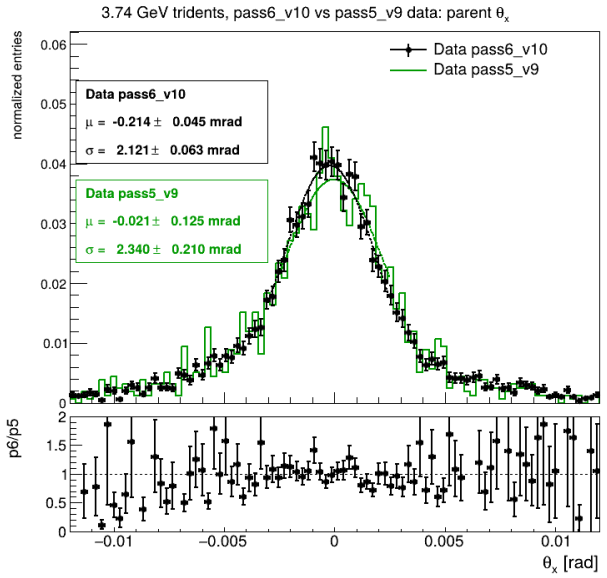
Same curvature smearing values applied as with the Mollers, works well to align MC with Data here in pass6 as it also did in pass5.

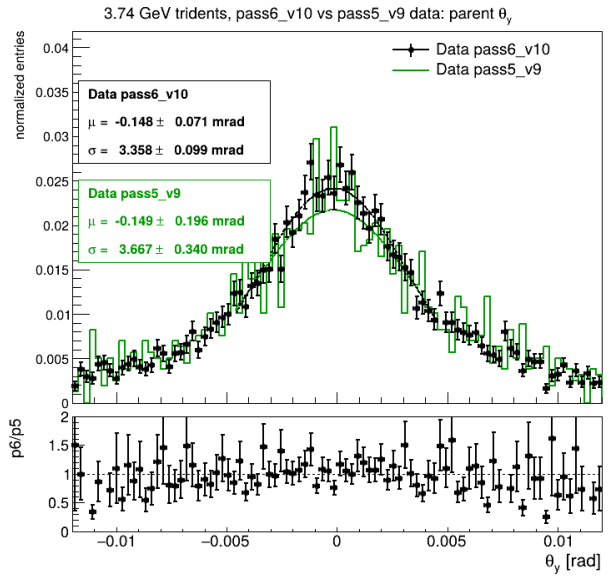
2021 3.74GeV Fully-reconstructed Tridents

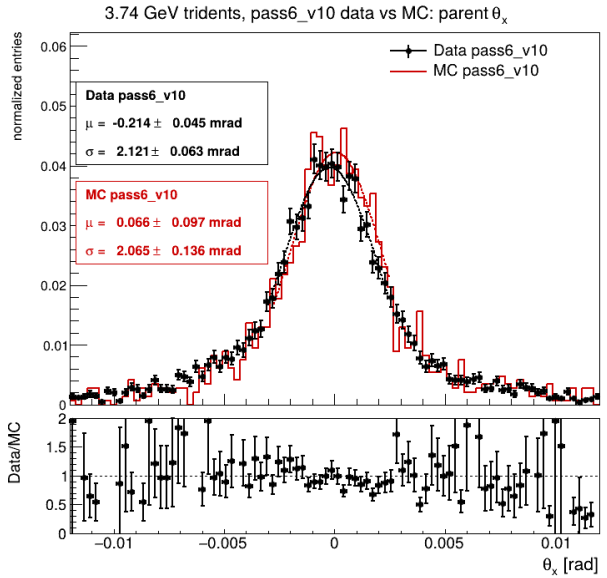
Beam directions roughly unchanged, slight shift in beam x via tridents.

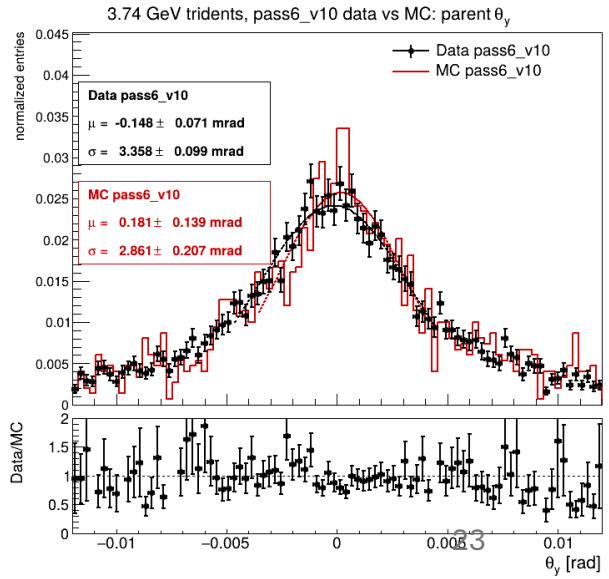
Fully-resolved trident efficiency (after all cuts) is increased in pass6 data and mc.

```
fully-resolved trident efficiency, pass6 data: 0.132%
fully-resolved trident efficiency, pass6 mc: 0.322%
fully-resolved trident efficiency, pass5 data: 0.082%
fully-resolved trident efficiency, pass5 mc: 0.212%
```



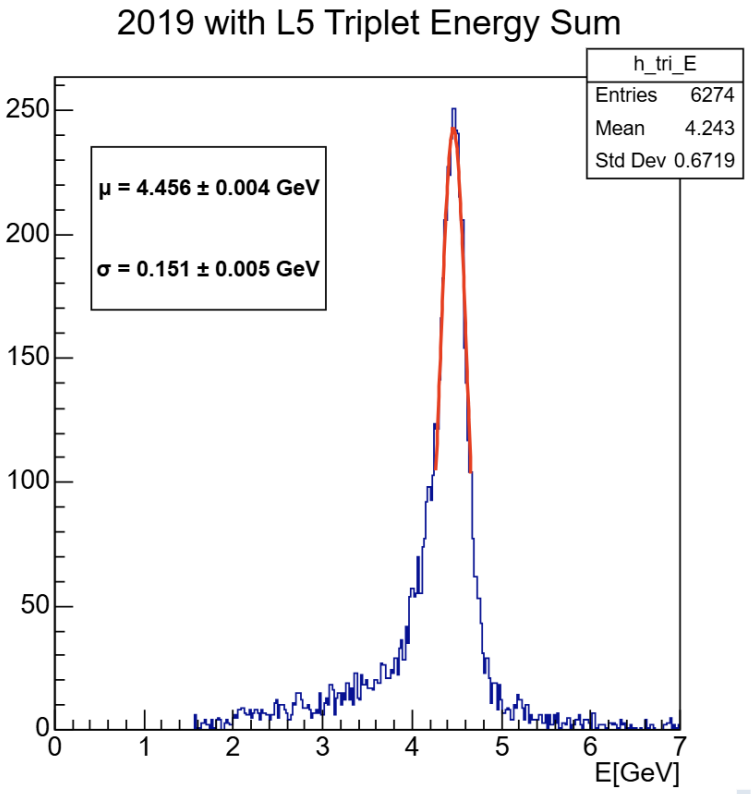


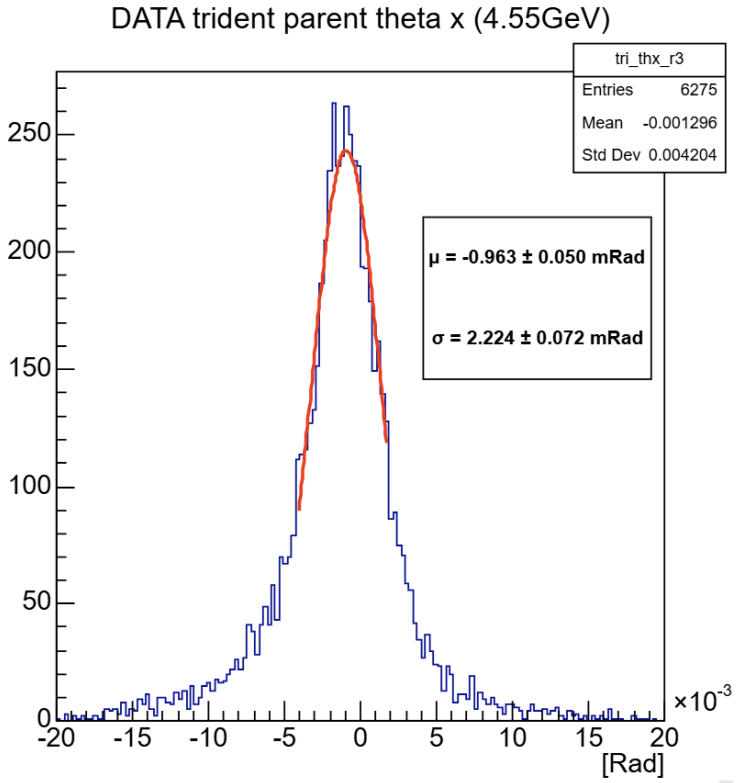


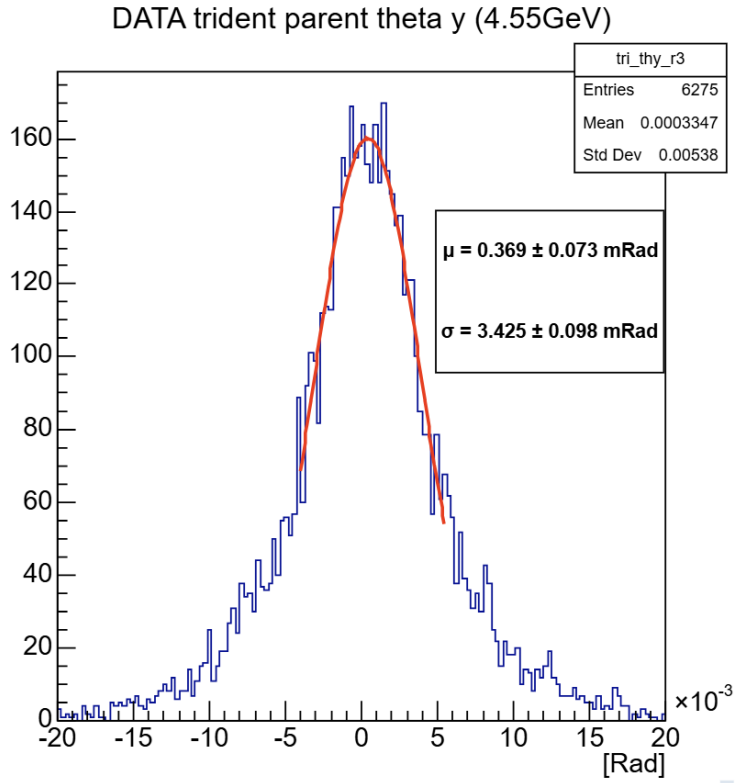


2019 4.55GeV Fully-reconstructed Tridents

Elizabeth's addition of L5 has a minimal impact on the 4.55GeV trident triplet energy sum distribution, but overall, the 2019 tridents are looking quite good!



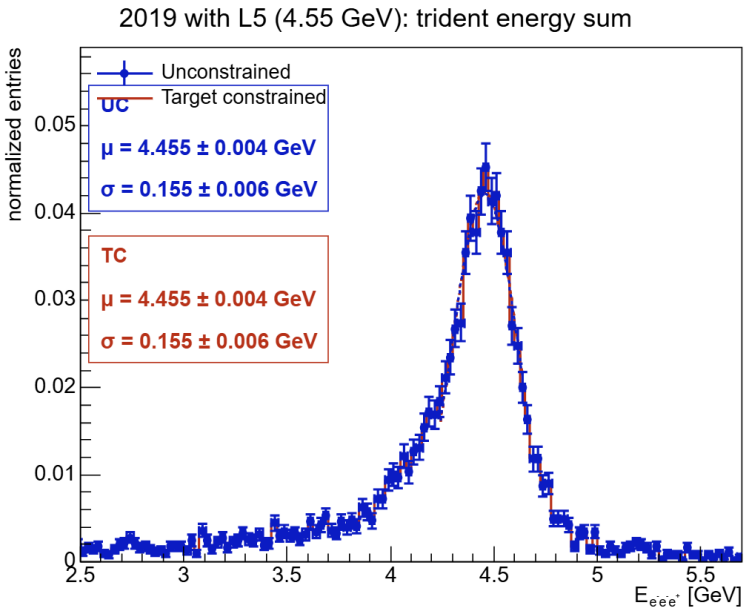


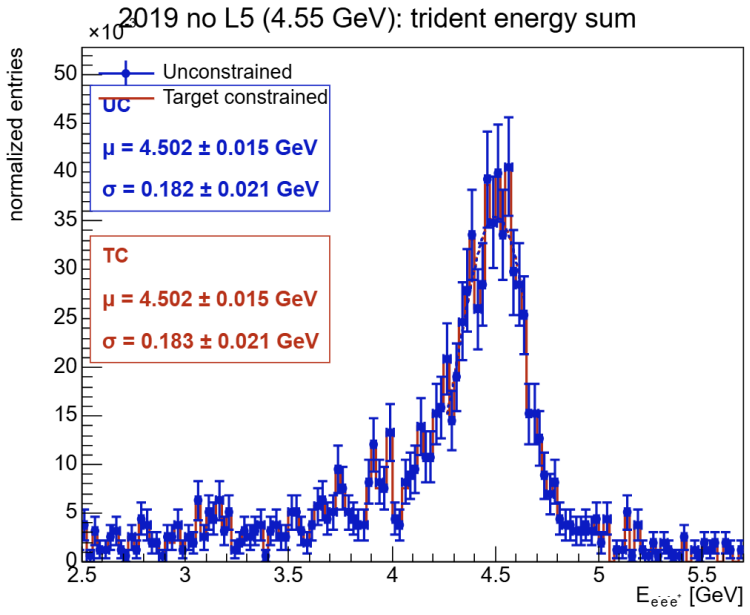


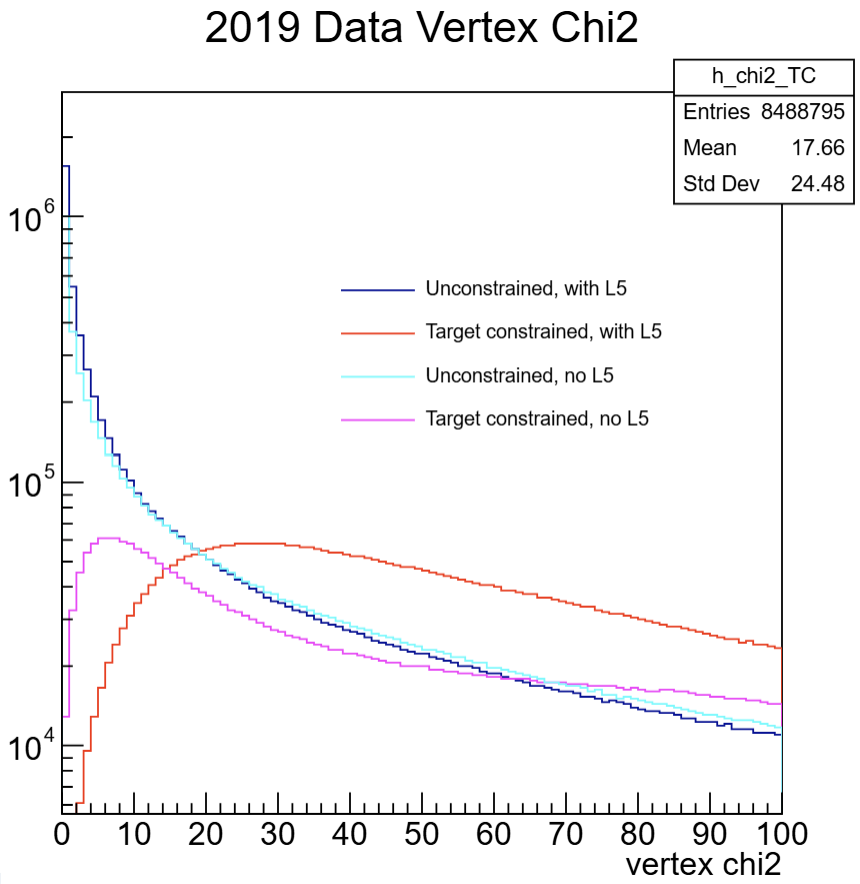
2019 4.55GeV Fully-reconstructed Tridents

Target constrained vertex chi-squared varies across the 2019 samples. The shifted peak seen in the ‘with L5’ sample to the left is also seen in the 2019 1%.

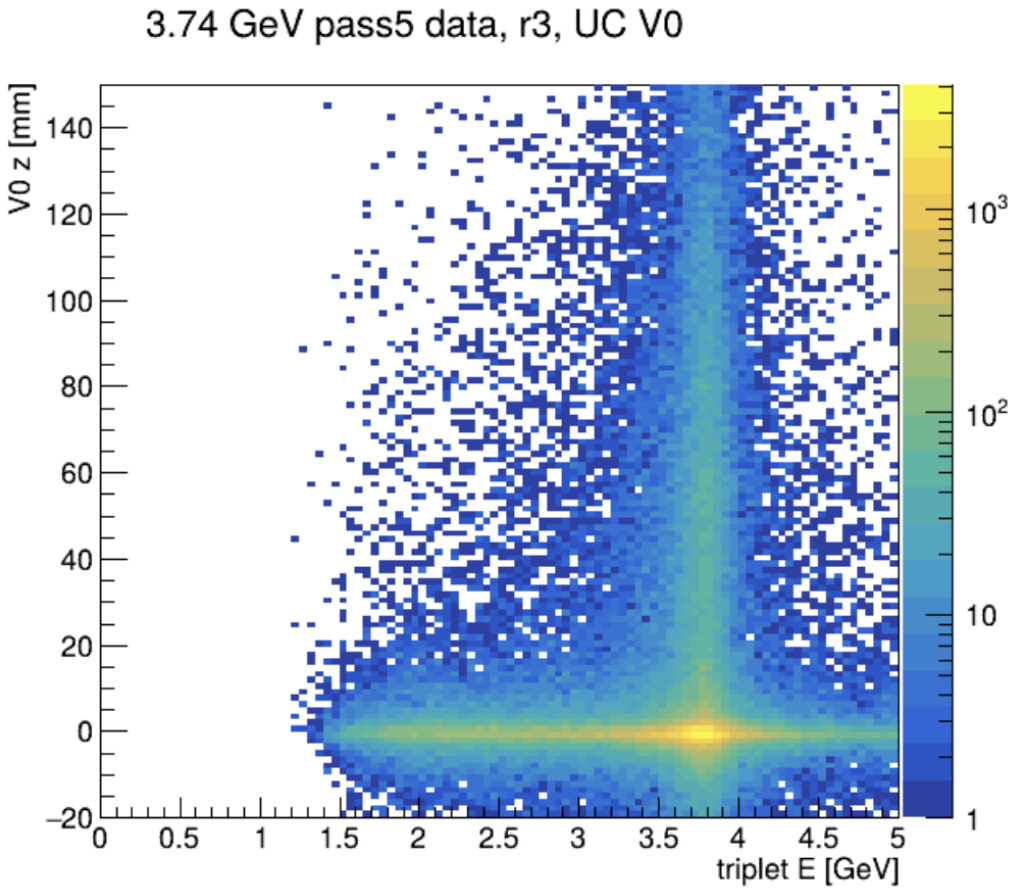
This seems to not have an adverse effect on the triplet energy peak.







2021 Aside: Trident production in L1/L2



This is the final UC trident selection in a sample of pass5_v9 3.74GeV data. The left plot shows the vertex z of the v0 linked to a fully-reconstructed trident vs its triplet energy sum.

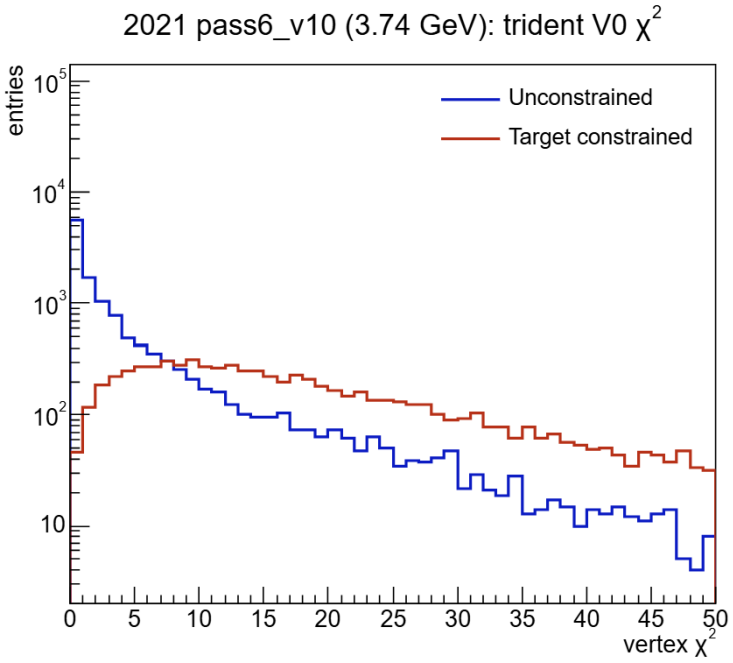
Summary

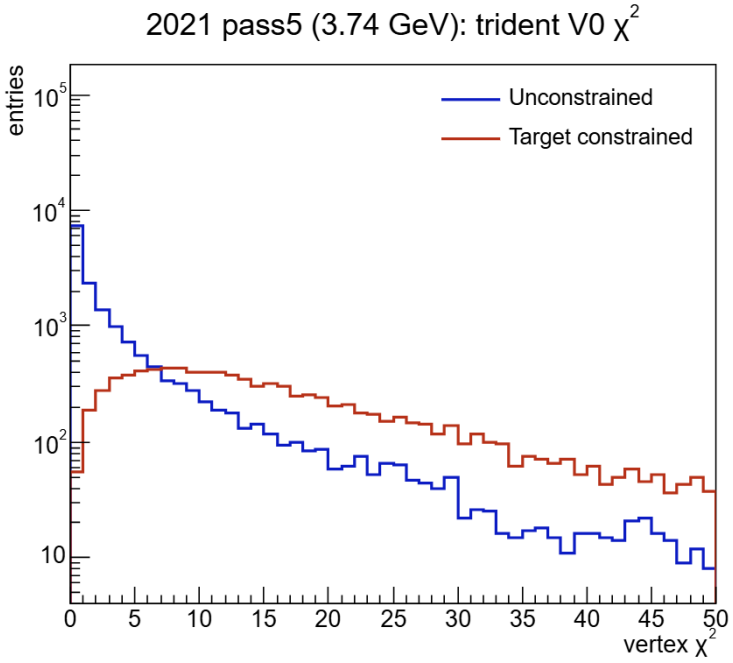
- 2021 Moller invariant masses are a bit higher in pass6, but comparable in width to pass5 overall.
- Track versus V0 beam energy calculations in the pass6 sample are much more aligned, but MC is consistently lower than the beam energy for both v0 and track beam energy calculations across the three vertex types in both pass5 and pass6.
- Curvature smearing with the same constants produces slightly wider mass distributions in the pass6 Moller MC, but still about .4-.5MeV narrower than data.
    - Angular smearing works well but requires a large smearing amounts (1.3 mRad for TC, 1.9mRad for UC)

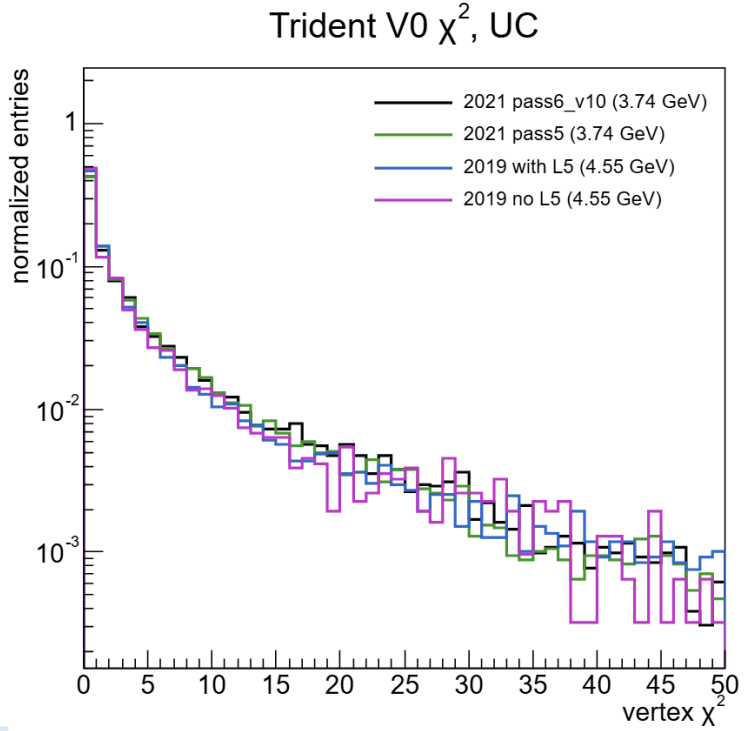
- Tridents also show an improvement in the 2021 pass6 data, and the same curvature smearing in the pass6 Tritrig MC works as well as it did in pass5.

- Tridents in the 2019 4.55GeV data also look quite good, but there is an issue with the TC chi-squared values in these datasets that is present in some samples and absent in others. Positron E/P issue is seen in tridents as well.

BACKUP: 2021 3.74GeV Trident Chi2







2021 fully-reconstructed trident TC vertex chi-squared is better. UC across both 2021 and 2019 is consistently good.

BACKUP: 2019 4.55GeV Trident E/P

