Frame Investigation

Introduction

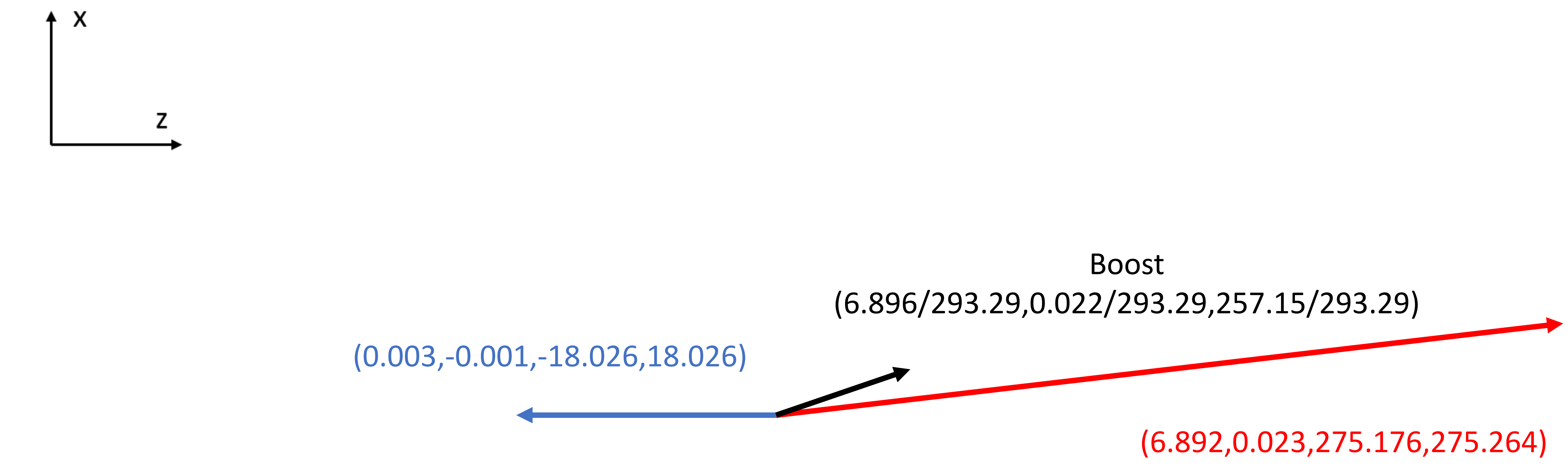
- My previous studies have shown what the distribution of particles will look like in the detector in the presence of a crossing angle (and other beam effects)

- This is relevant because this is what the detector will see and therefore will define the resolutions and acceptances we work with

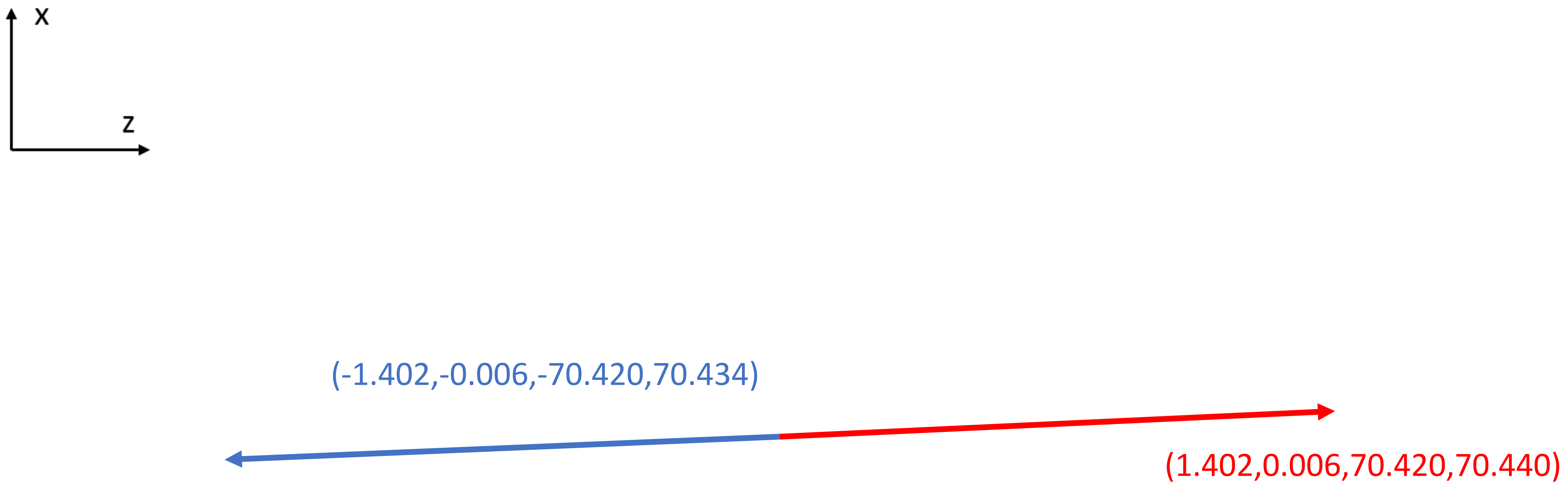
- As Alexander pointed out though, the lab/detector frame is not necessarily the one in which we will do analyses as it is in principle possible to transform to a frame in which the crossing angle effects are negated

- Below, I describe this transformation and look at a few relevant issues

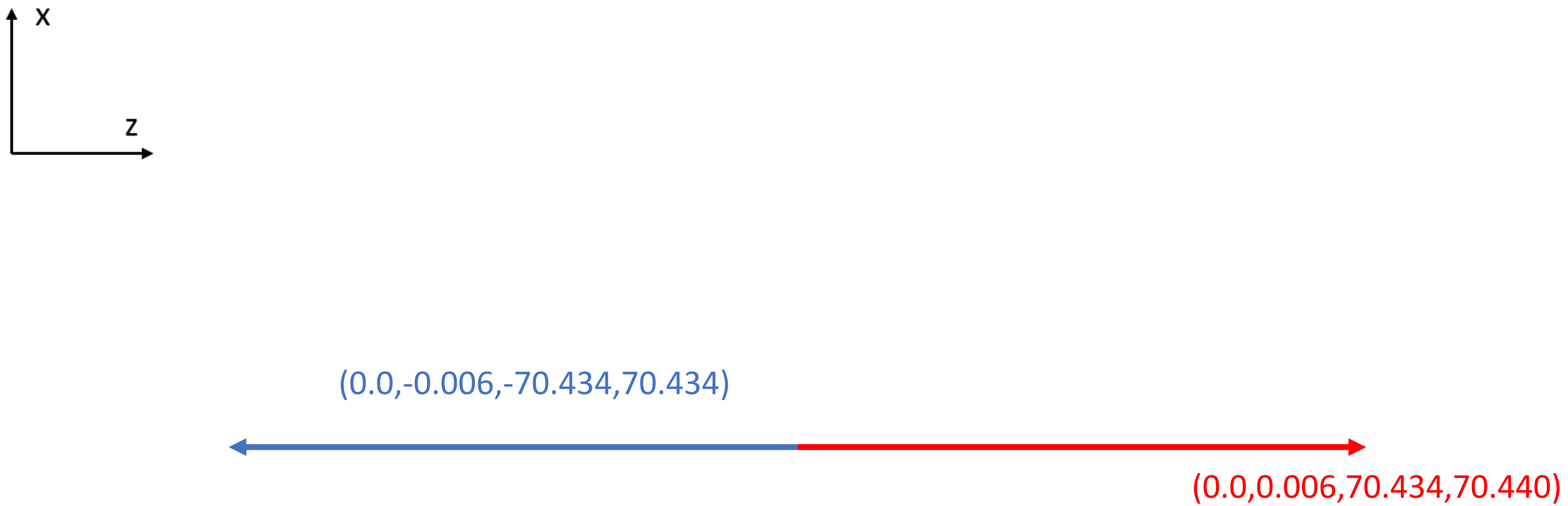
- TL;DR: Transformation from lab frame to frame where anisotropies due to crossing angle disappear is relatively well behaved in central detector; need to be aware of some acceptance effects; good PID/energy measurements will help



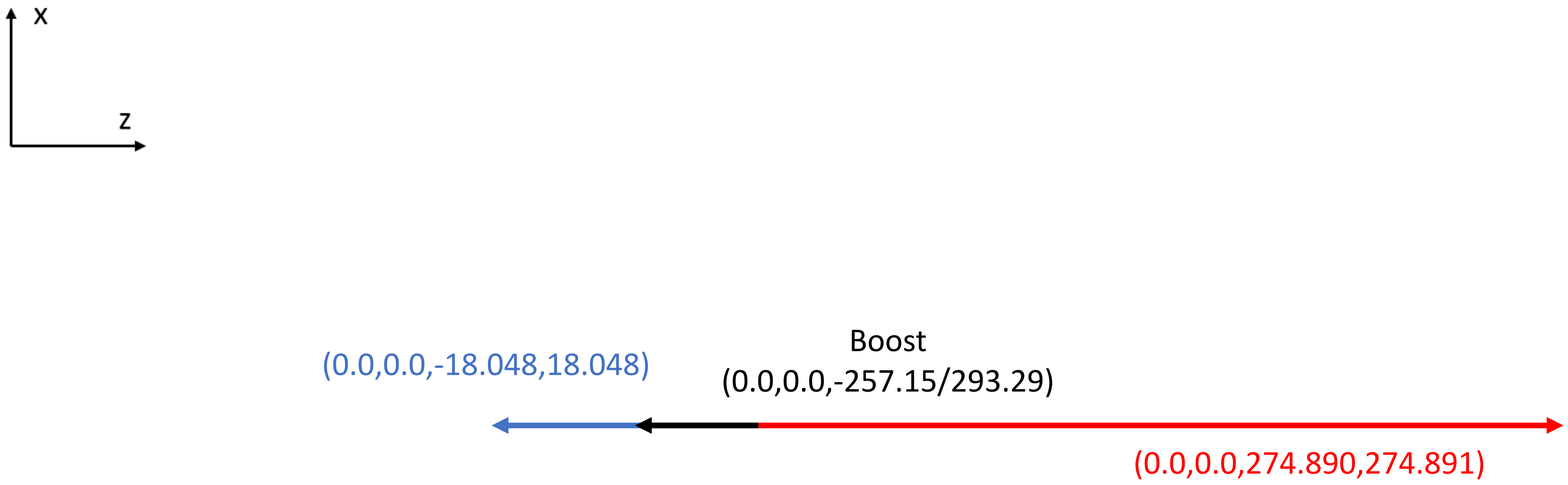
1. Initial Configuration in the Lab Frame



1. Initial Configuration in the Lab Frame
2. Boost by sum of beam 4-momenta to get to CM Frame

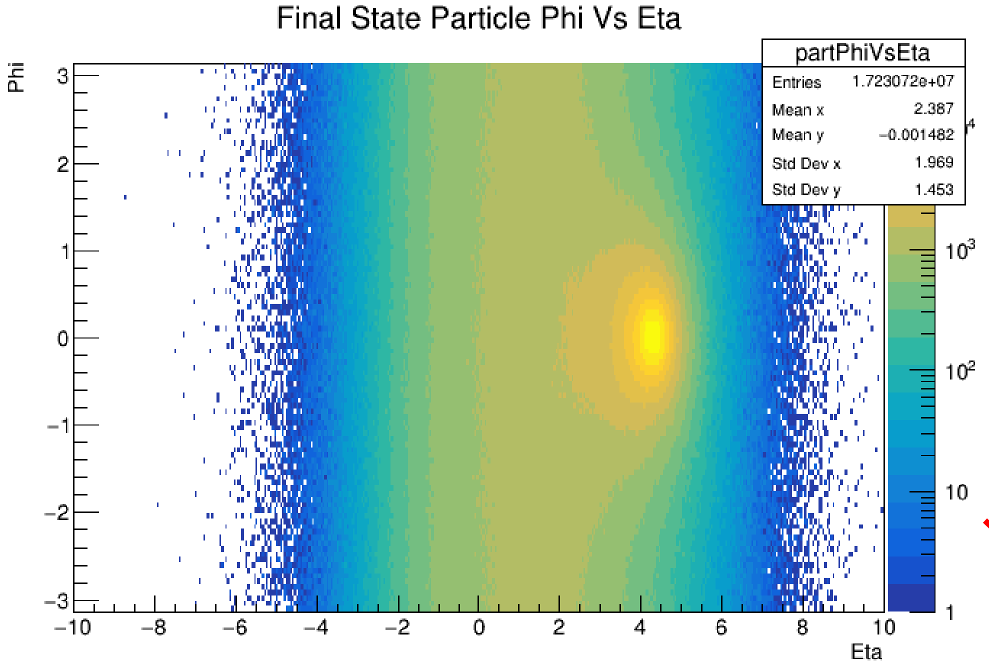


1. Initial Configuration in the Lab Frame
2. Boost by sum of beam 4-momenta to get to CM Frame
3. Rotate about y-axis to eliminate x-component of momentum

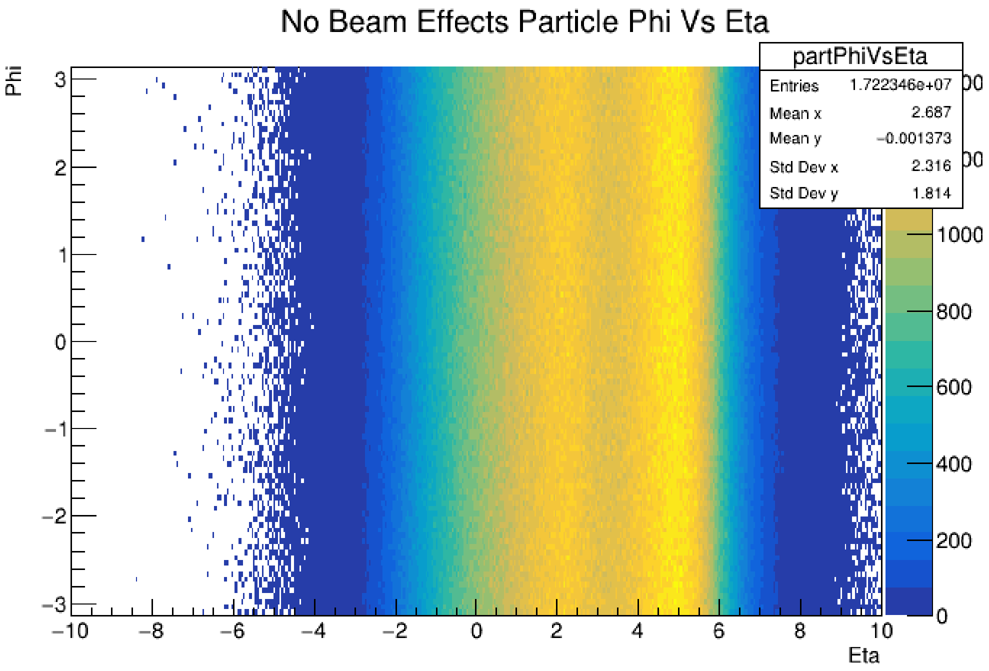


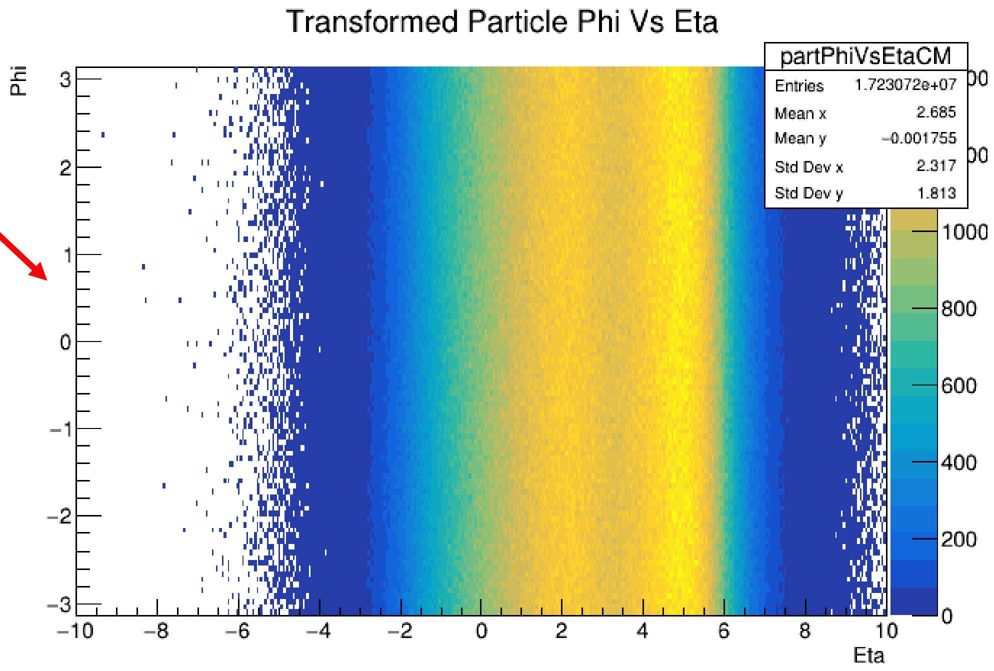
1. Initial Configuration in the Lab Frame
2. Boost by sum of beam 4-momenta to get to CM Frame
3. Rotate about y-axis to eliminate x-component of momentum
4. Rotate about x-axis to eliminate y-component of momentum (not shown)
5. Boost back along z to (nearly) restore original beam energies

Frame Comparison: Phi Vs Eta



Transform





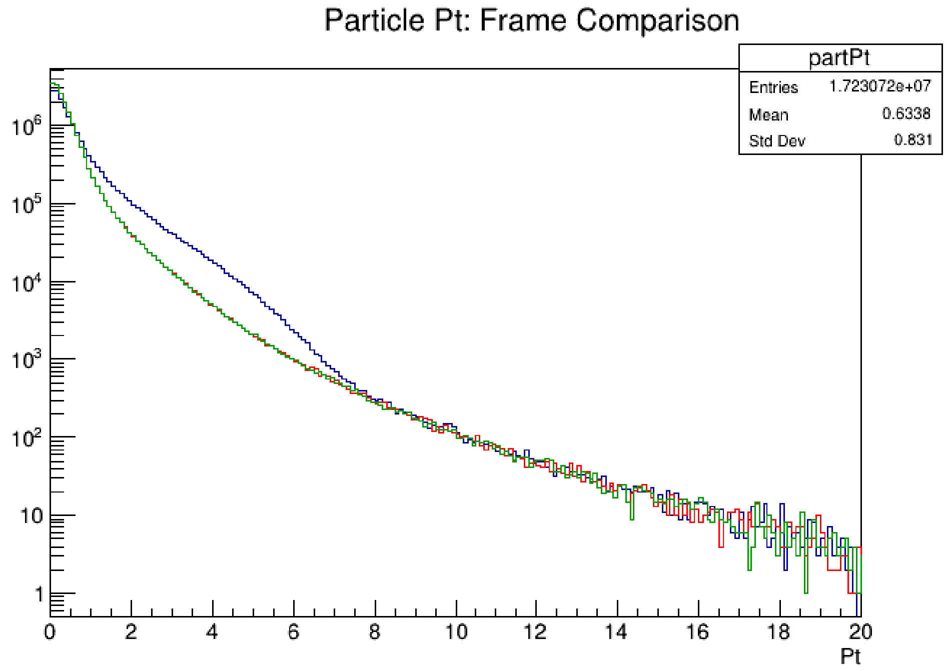
- Crossing angle introduces a hot-spot at phi = 0 and eta = ~4.2 in the lab frame (top left)
- Transformation described above removes phi modulation and smooths out eta (bottom right)
- Matches very well with distribution obtained from default Pythia with no beam effects included (top right)

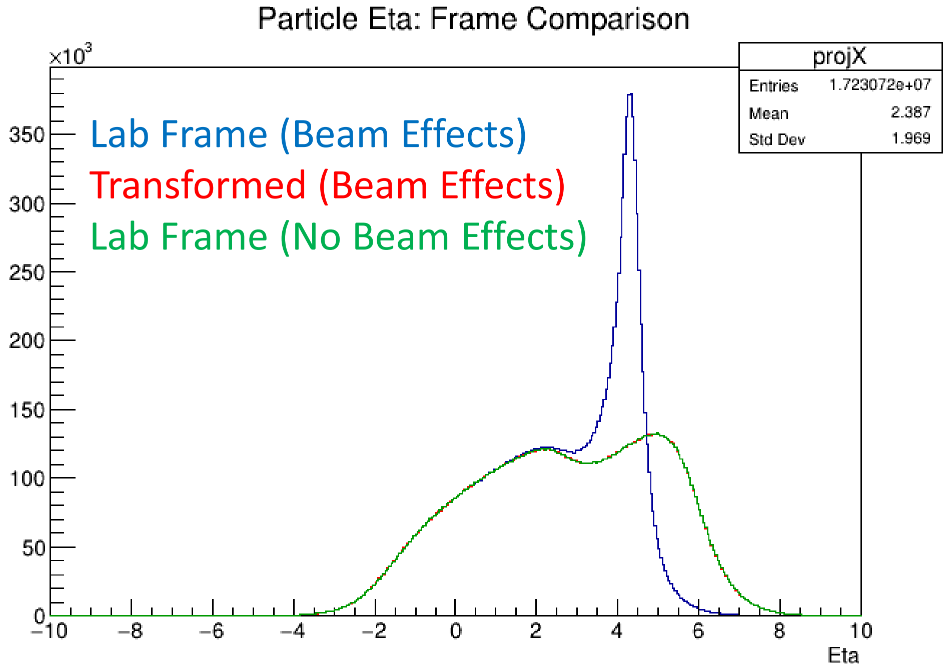
Frame Comparison: Pt, Eta, & Phi

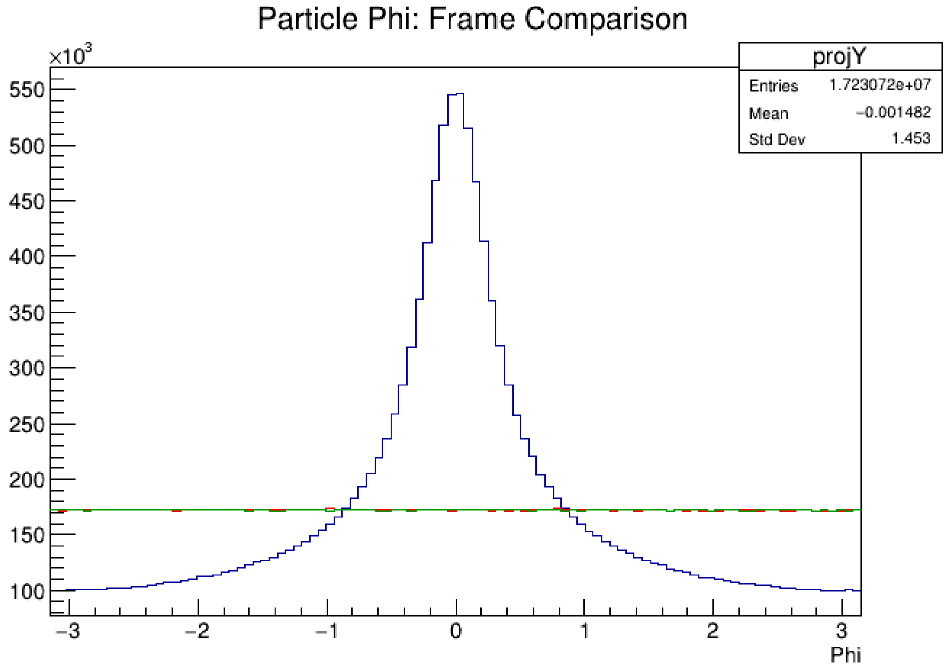
- Transformed eta and phi distributions from Pythia sample with beam effects matches exactly the lab frame distributions from default Pythia

- Particle Pt distributions match as well

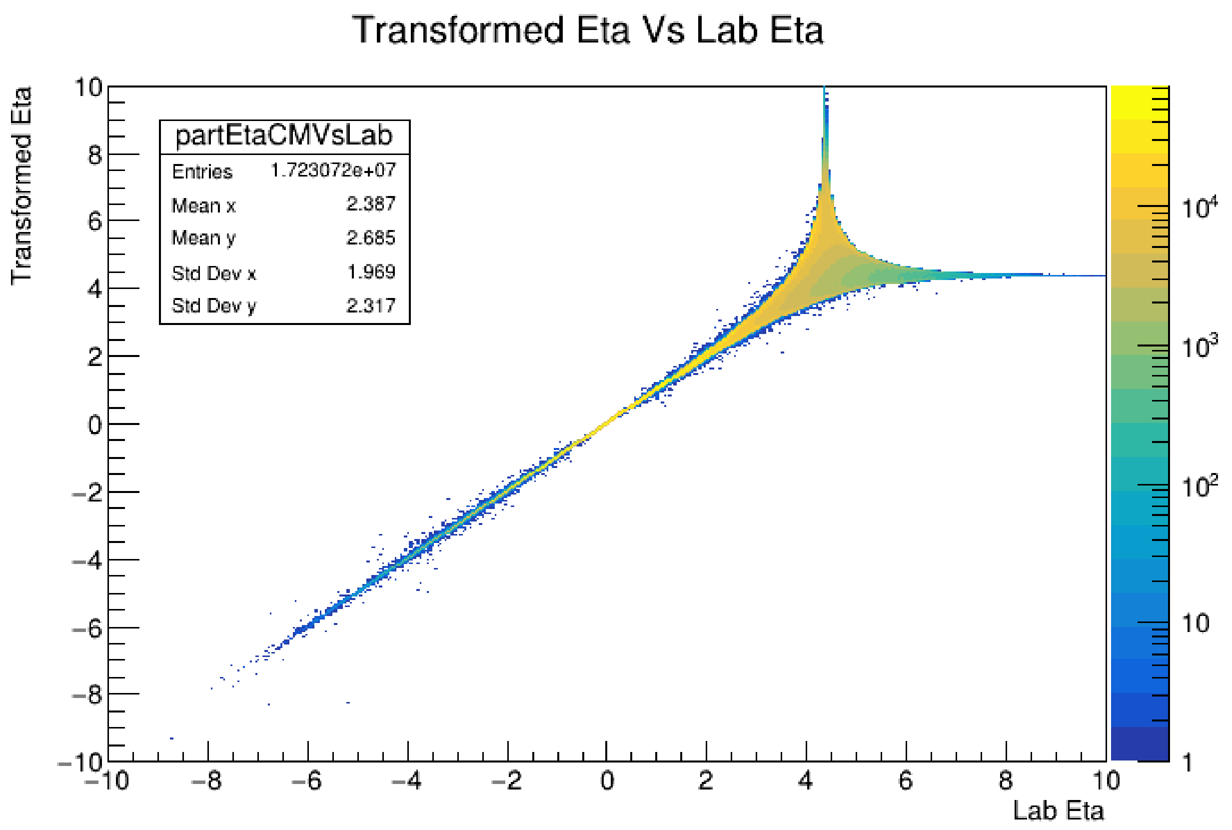
- Transformation does what we expect



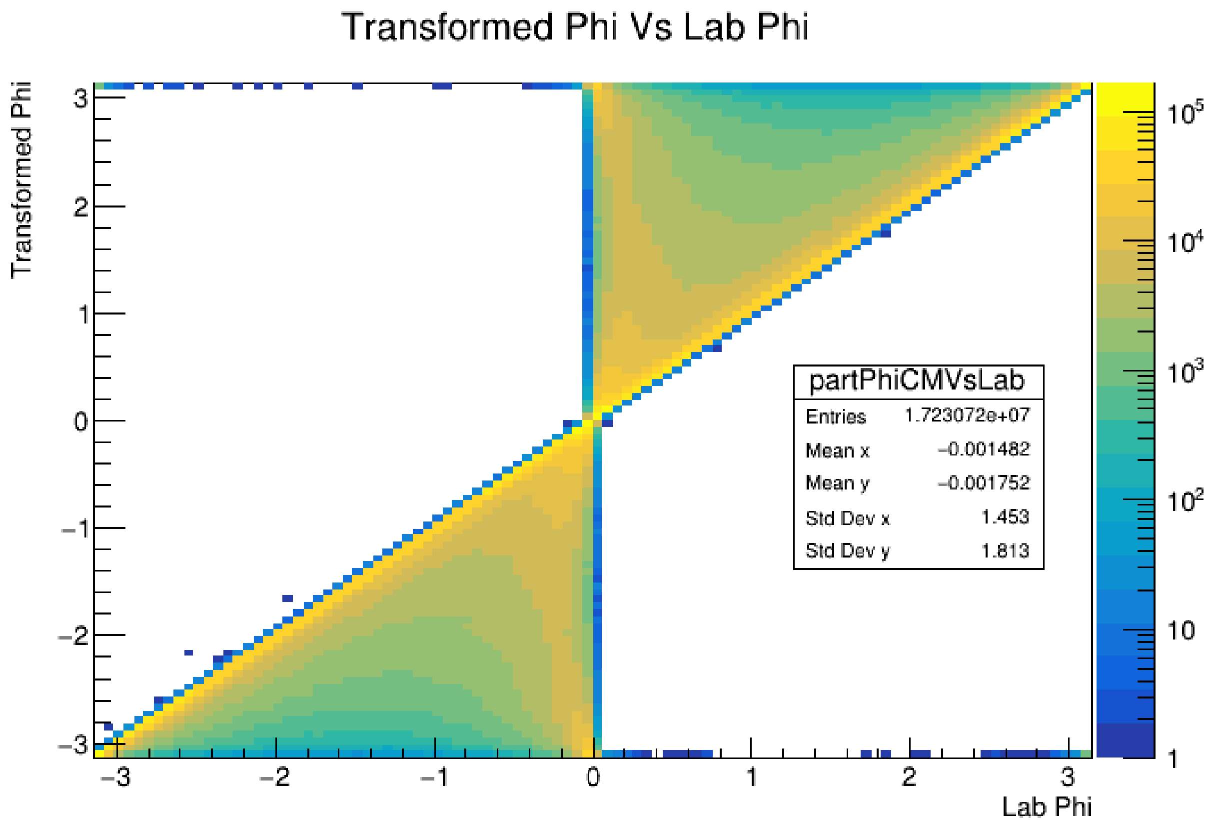




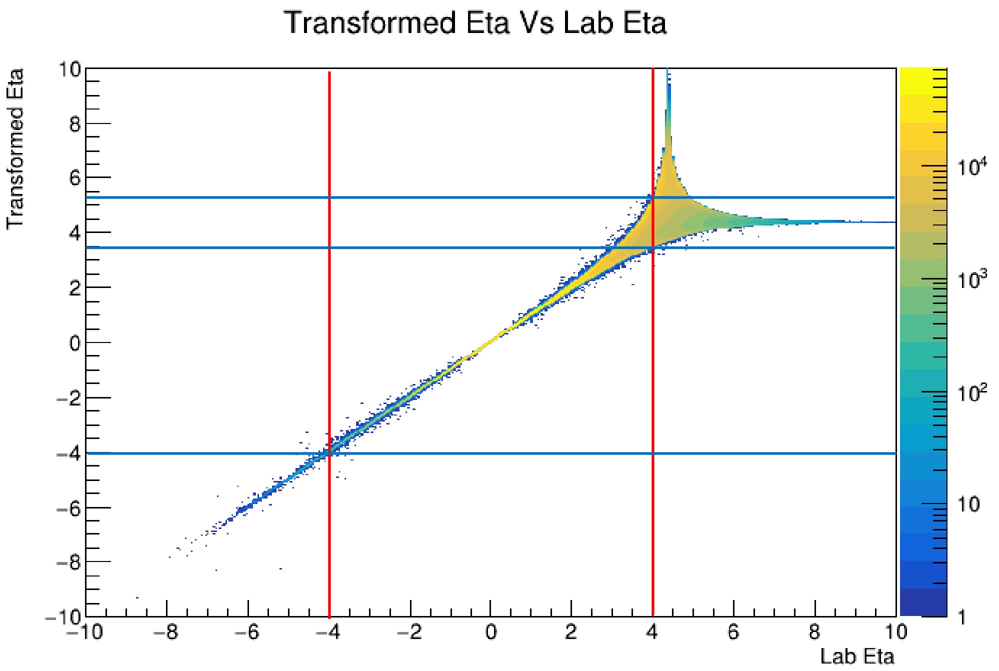
Transformed Vs Original Phi and Eta

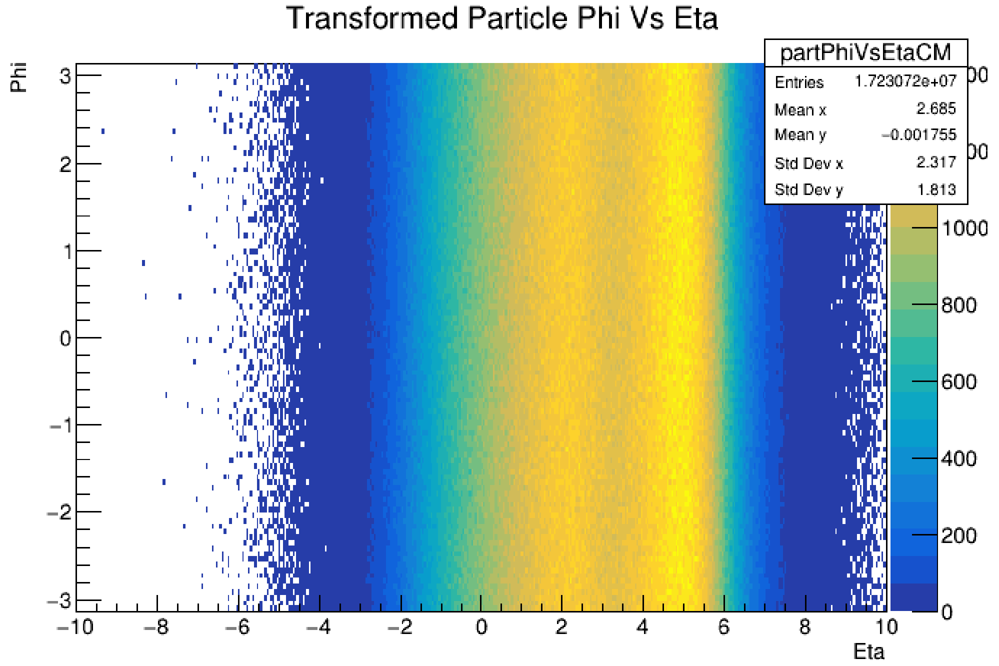


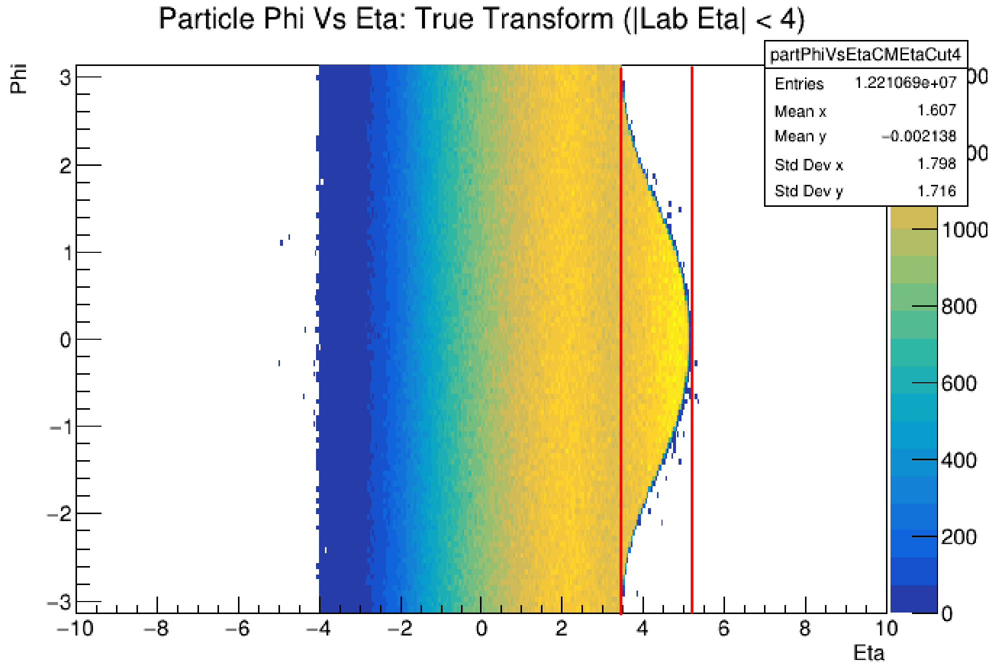
- Correlation between transformed and lab eta for Pythia sample with beam effects is one-to-one for low eta
- Correlation begins to smear out at higher eta with singular behavior near eta = 4.2



Acceptance Effects: Lab Eta < 4





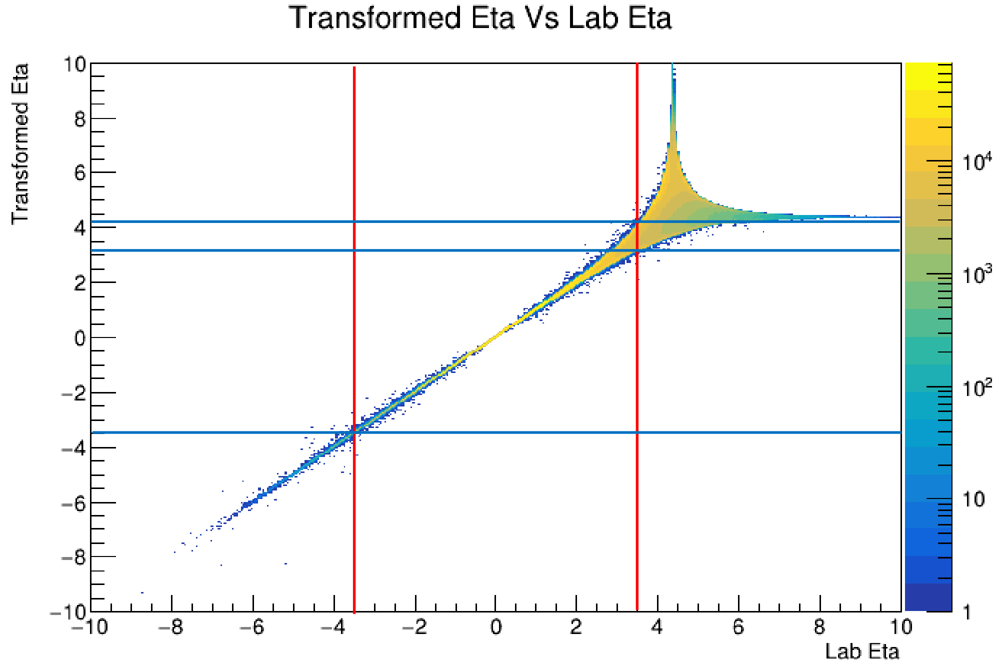


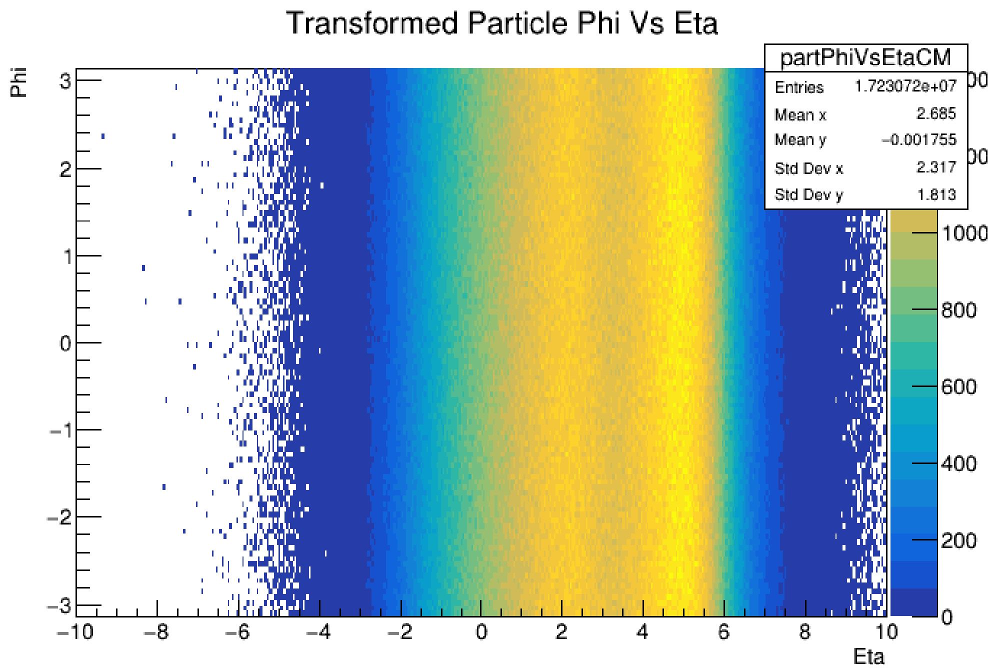
- We have seen that the transformed eta/phi distributions match the default Pythia values very well when considering all particles

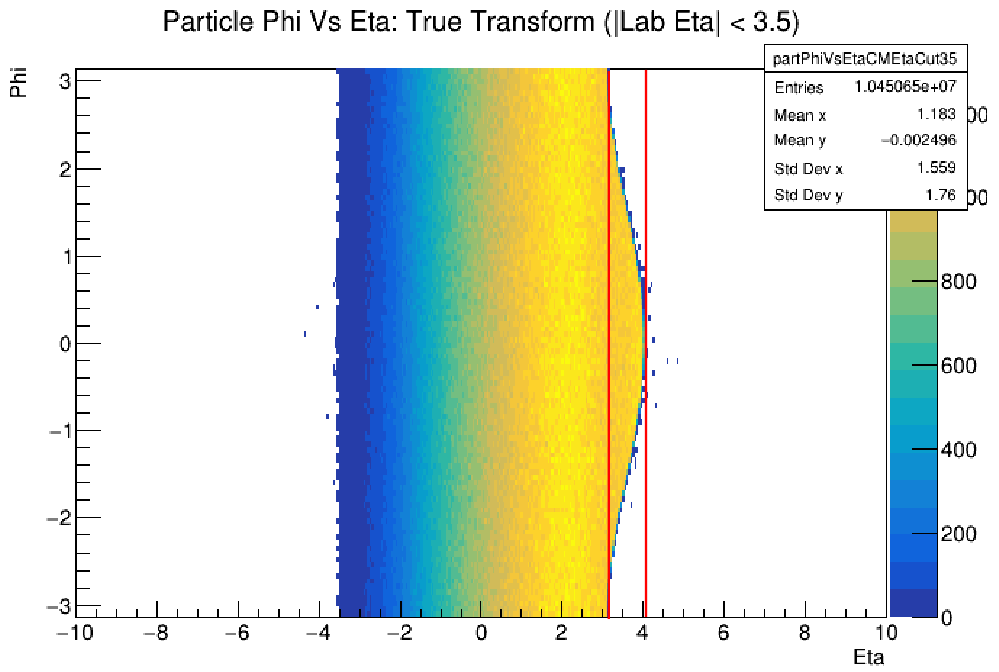
- How does limiting acceptance due to finite detector acceptance effect transformed distribution

- See the ‘bulge’ from crossing angle, but particle distribution is still flat in phi within this region

Acceptance Effects: Lab Eta < 3.5



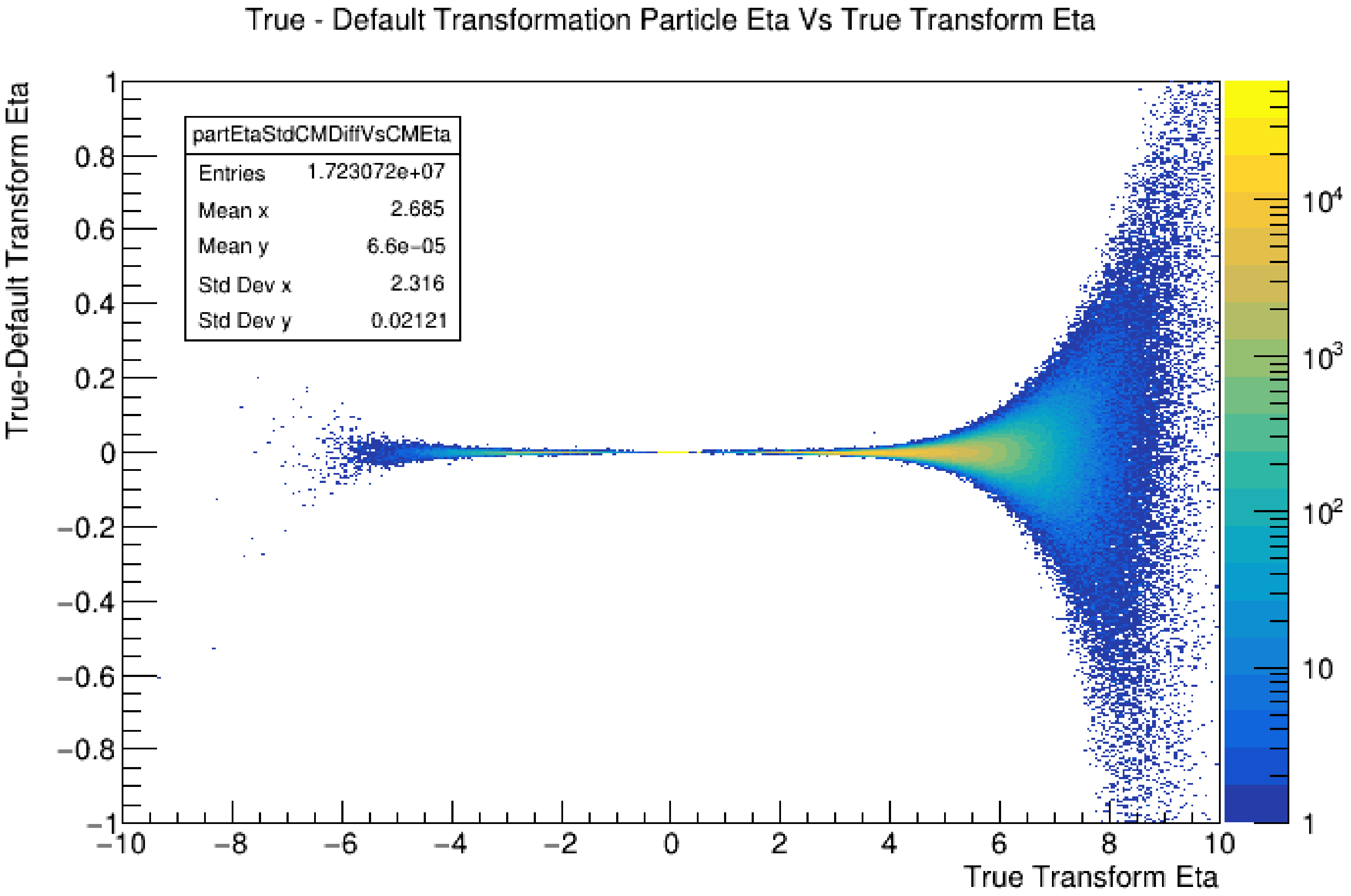




- If we look at acceptance of eta between +/- 3.5 in the lab frame (nominal tracking range), 'bulge' decreases, but eta range also decreases (no surprise)

Beam Smearing Effects

- All plots above used transformation constructed assuming perfect knowledge of incoming beams
- Divergence, beam energy spread, etc introduce momentum deviations which cannot be measured event by event
- Compare true transformation (assuming perfect knowledge) with default transformation (assume nominal beam energies and crossing angle)
- Deviations are small at mid-rapidity but grow sizable as you move forward



Beam Smearing Without PID

- Lorentz transformation depends on momentum and energy of the particle being transformed
- How is the transformation affected if we don't know the energy of the track
- Assume all tracks are pions and all neutrals are massless
- Look at deviation between true transformation and transformation assuming nominal crossing angle and beam energy as well as the pion mass and massless neutrals assumptions
- TODO: Look at detector smearing