sPHENIX TPC in Acts

Joe Osborn
Acts Developers TPC/DC Discussion
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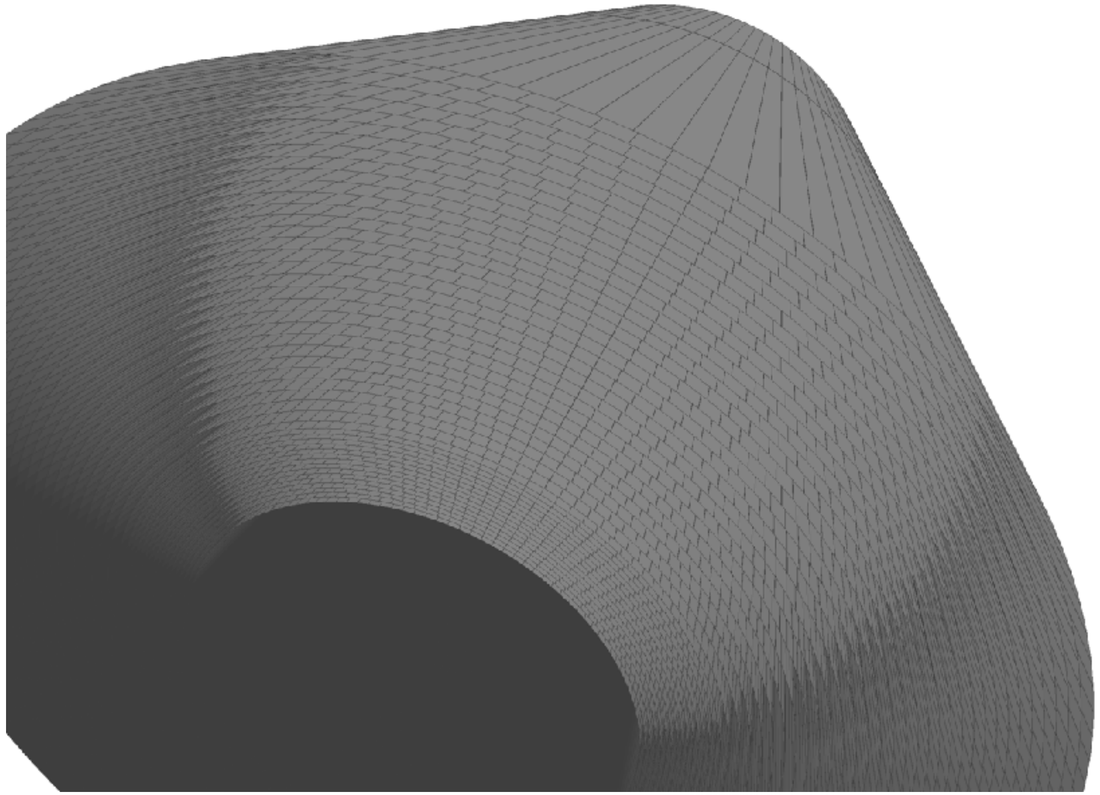
TPC Challenge

- In simulation, truth positions of clusters can exist anywhere within the 3D volume of the TPC
- Charge is readout at the pad planes on the TPC endcaps with a drift time (not a z position!)
- Acts measurements need to be bound to surfaces - therefore, we need a way to represent the TPC with physical surfaces in the volume
- Not as simple as the TGeo/DD4Hep plugin which translates reconstruction geometry object to Acts::TrackingGeometry

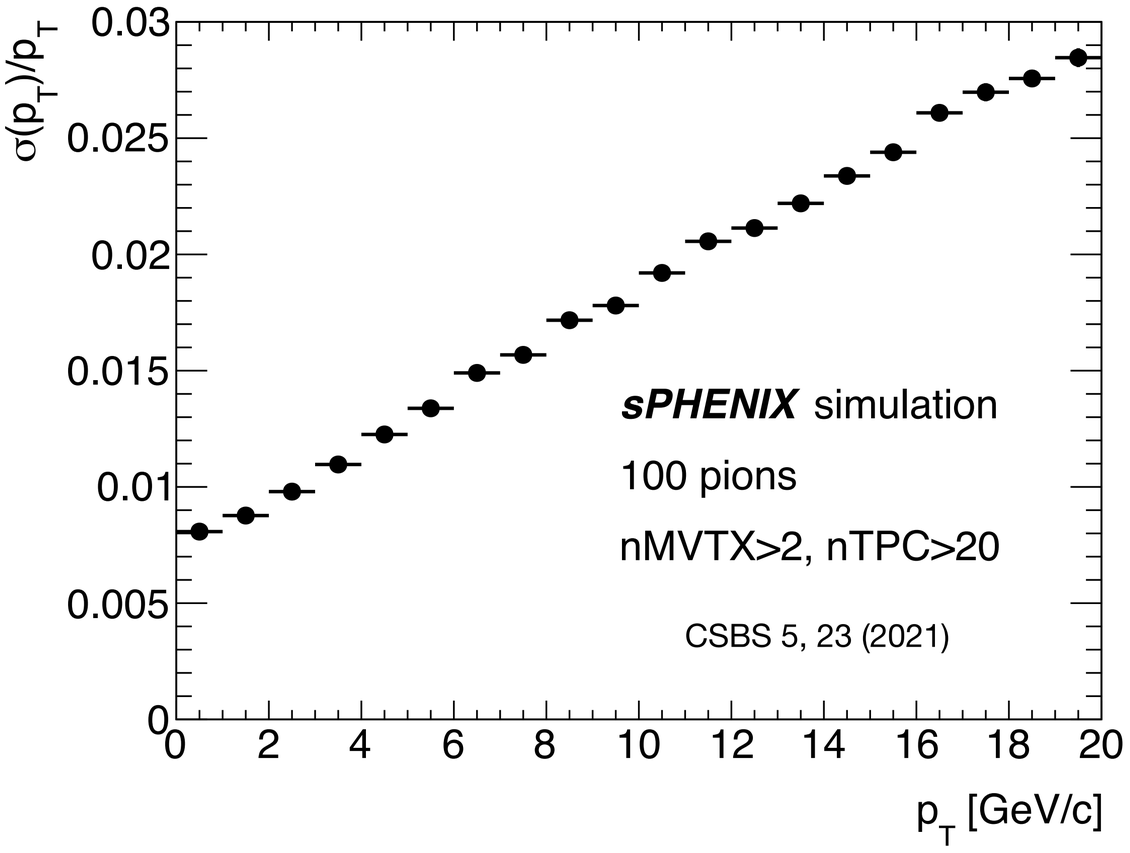
sPHENIX “Solution”

- Our “solution” is to explicitly modify the TGeo geometry and create planar surfaces that approximate cylinders at the pad plane readout radii
    - Then let Acts read these in normally with the TGeo Plugin
- Cluster resolution is minimally impacted if planar azimuthal width is small enough
- Material description is the same if the TGeo boxes are treated as filled with gas - same 3D volume



Challenges

- The description works well and returns our nominal expected momentum resolution (2021, with simulation)
- However, there are challenges that it creates (2024, with real data)
  - TPC space charge distortion corrections
  - Streaming readout - drift time extends beyond physical volume of TPC!



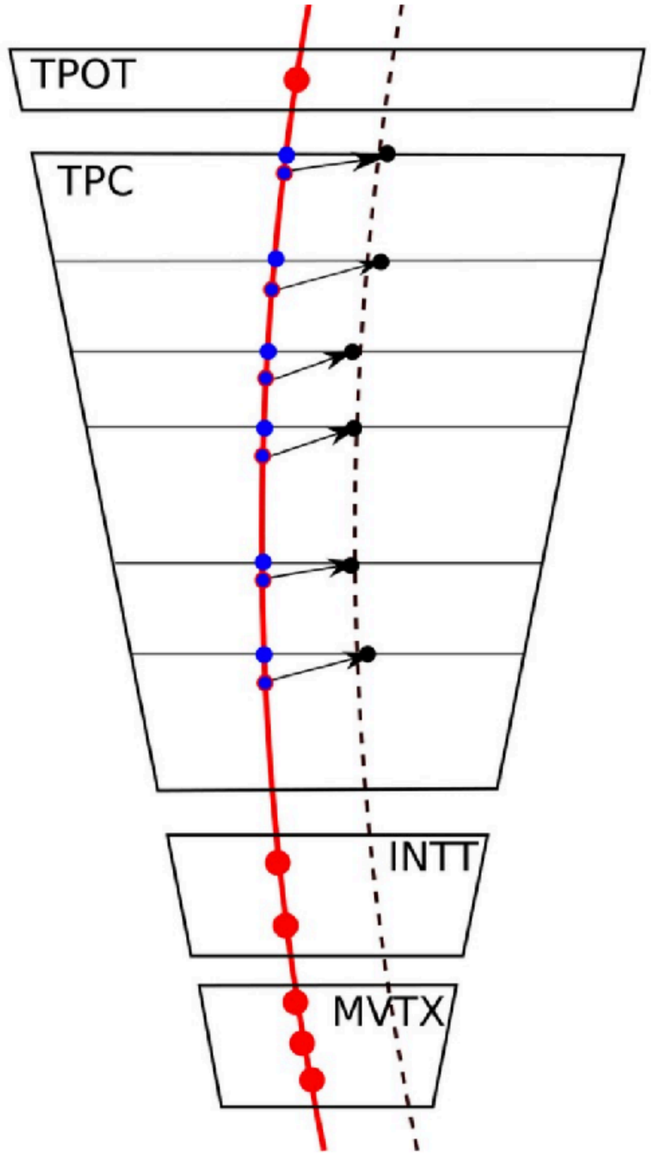
Challenge - Distortion Corrections

- Distortion effects modify the truth cluster position (blue dot, red outline) to the actual measured position (black dot)

- Distortion corrections need to move the cluster back to its original truth position

- Because measurements need to be bound to surfaces, we have to “transport” the cluster along the track trajectory (blue dot, no outline)

    - Introduces uncertainty —> your transport is limited by how well you know the track trajectory at any given time



Challenge - Streaming Readout

- The TPC actually measures a local rphi and drift time, not a z coordinate
- If the nominal drift time is 13 μs, but we collect data for 50 μs, that means doing a simple translation of drift time * drift velocity = z position gives you unphysical cluster z locations
    - Therefore, cannot bind measurements to surface -> exist outside physical TPC volume
- Impossible to know the actual z position of the track until matched with other subsystems - how to handle tracks from conversions, or highly displaced tracks (e.g. from high p_T Λs?)

Summary

- Utilizing TPC geometries in Acts is possible and successful with the current tools available
- There are nonetheless challenges that are involved, but can be overcome
- 3D fitting would be a valuable development. Fabian Klimpel did a lot of work on this for his dissertation (see here, chapter 8) but it was never formalized. Unaware of the current status - would need a dedicated person to spend significant time on it