sPHENIX Experience with ACTS

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ORNL
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U.S. DEPARTMENT OF ENERGY

sPHENIX Tracking Challenges

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  - On average, 3-8 (heavy ion!) pileup events per bunch crossing

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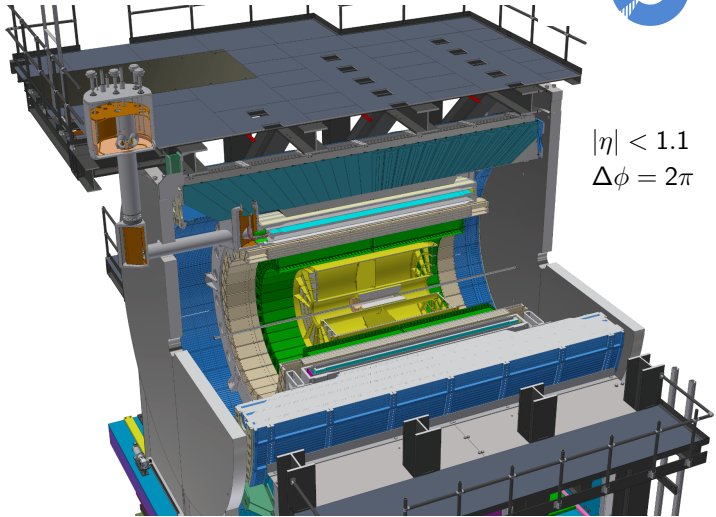
- Data processing planned for fixed latency, finite size computing center at BNL
- Require high speed, efficient, and precise tracking in an environment where $\mathcal{O}(100{,}000)$ hits are expected
- Need to reduce tracking time to less than 5 seconds per event in these conditions

sPHENIX Detector

- MAPS Vertex Detector (MVTX)
- Intermediate Tracker (INTT)
- TPC
- EMCal
- Inner HCal
- Outer HCal



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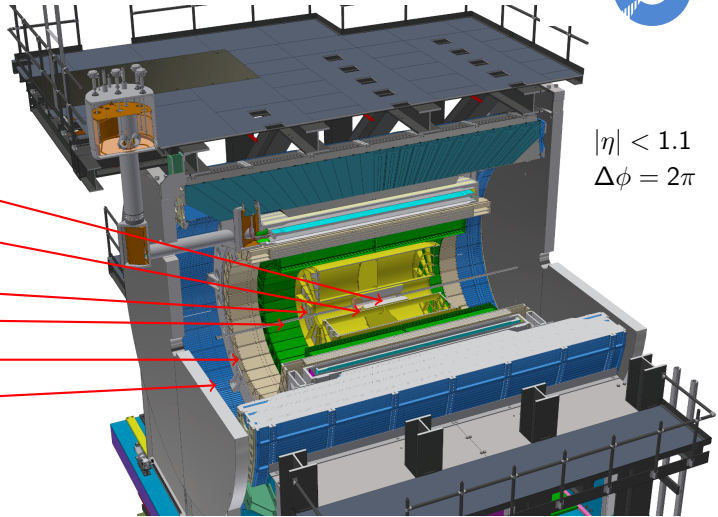
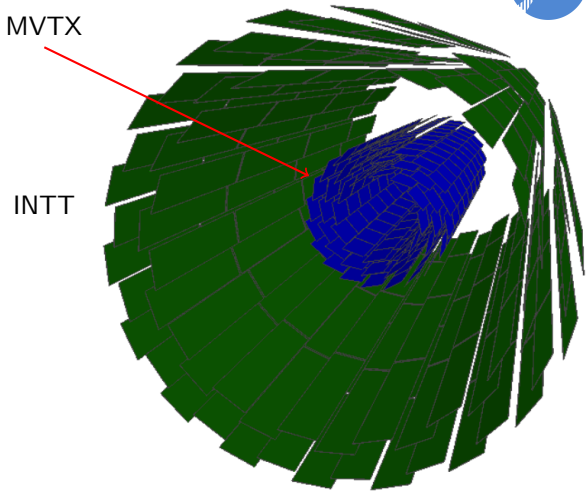


$|\eta| < 1.1$
$\Delta\phi = 2\pi$

sPHENIX and ACTS

- Github migration very useful for us, and possibly other external (CERN) experiments also
- Using TGeo plugin within Acts to construct silicon surfaces



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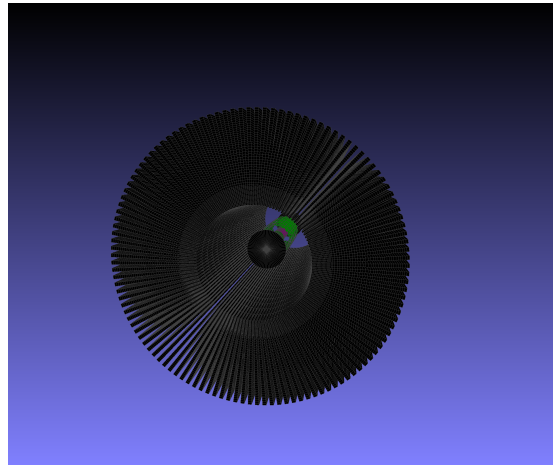

sPHENIX and ACTS

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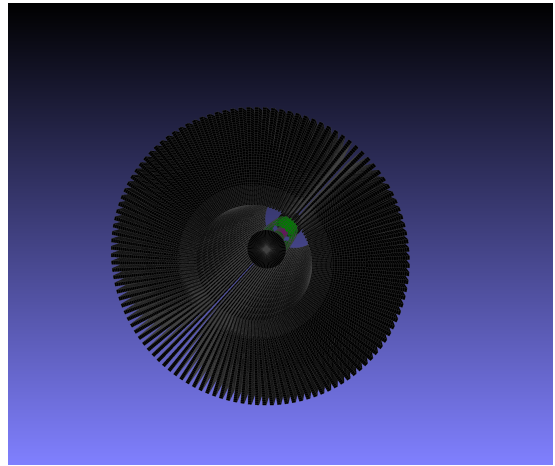
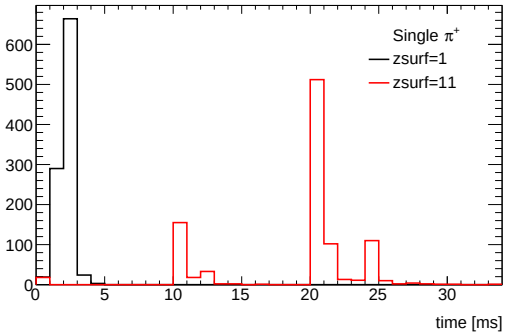
- Using TGeo plugin within Acts to construct silicon surfaces
- TPC remains a challenge, as Acts does not support these kinds of geometries currently
- Currently we modify TGeoManager to build TPC boxes, which then the TGeo Acts plugin picks up and builds surfaces out of
- However, this isn't viable long term



sPHENIX + Acts Status

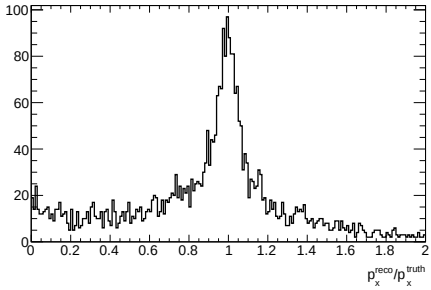


- Very preliminary
- ∼70000 TPC surfaces
- ∼7000 TPC surfaces

- Can run Acts Kalman track fitter, combinatorial Kalman track finder
  - Currently only using KF. Will investigate CKF later
- Run KF time tests per single ∼4 GeV π^+ track
- Time per track depends significantly on number of z surfaces in TPC (unsurprising)
- Track fit doesn't seem to be completely correct due to covariance matrix rotation (more next slide)

sPHENIX+ Acts Status

- Track fitting in place
- Still not convinced covariance matrix rotation is correctly implemented
- Large tails present in distributions
  - These show 1000 events of five π^+ with $1 < p_T^{\pi} < 6$ GeV



sPHENIX+ Acts Status

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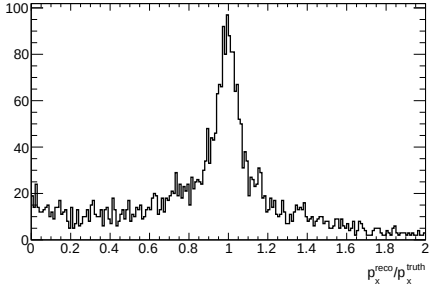
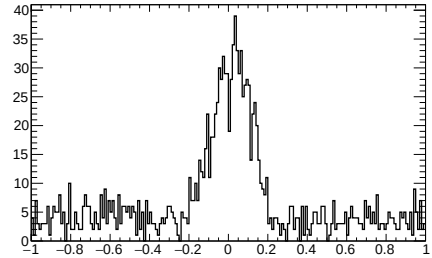
- Additionally z_{vtx} point of closest appraoch is very poorly fit (notice scale of y axis compared to other histogram)





Challenges Faced

- TPC - how do we implement it long term?
  - Idea to dynamically generate surfaces on the fly based on a measurement position
    - Pros - flexible, could be implemented for virtually any geometry
    - Cons - Probably memory hungry, especially for TPC scenario where $\mathcal{O}(100,000)$ hits are expected per event
  - How to handle space charge distortions?
    - Strong induced electric field from ionized charge displaces measurements by $\mathcal{O}(\text{mm})$ - how to handle in Acts?

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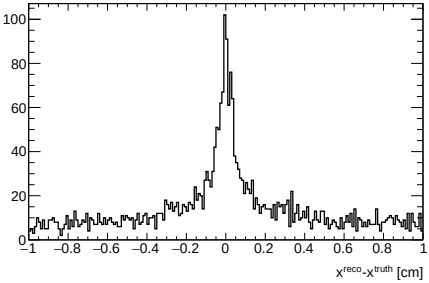
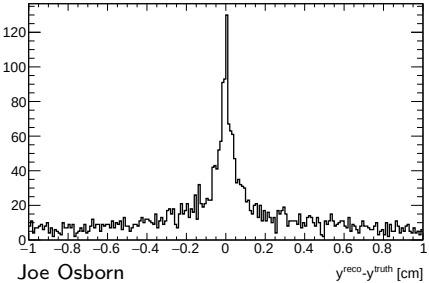
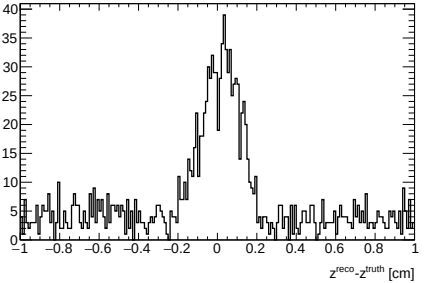
- Covariance matrix rotation for `FW::TrackParameters`
  - Firstly, it wasn't obvious that covariance matrix should be in local coordinates since `FW::TrackParameters` takes global position and momentum vectors (I had assumed it should all be global)
  - sPHENIX track covariance matrix comes in global (x, y, z, p_x, p_y, p_z) basis. Acts expects local $(d_0, z_0, \phi, \theta, q/p, t)$
    - No robust documentation discussing how to use the tools, other than `RecTruthTracks.cpp` example (e.g. what is meant by local)
    - A "realistic" example starting from a detector object and running through the entire track fitting process would be useful (not just passing resolutions as in `RecTruthTracks`)

Back Up

PCA Fit Results







Momentum Fit Results