OAK RIDGE National Laboratory

ACTS Experience at sPHENIX

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June 17, 2020

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U.S. DEPARTMENT OF ENERGY

OAK RIDGE National Laboratory

sPHENIX Tracking Overview

- RHIC will deliver Au+Au collisions up to ∼200 kHz
  - On average, 3-8 pileup events per bunch crossing
- Over 3 year running period, will collect ∼250 Petabytes of data!
- Data processing planned for fixed latency, finite size computing center at BNL

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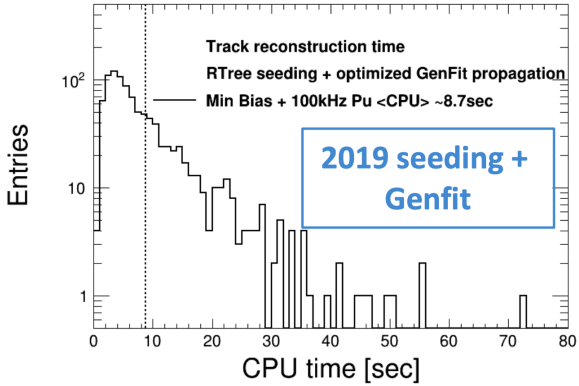
- Data processing planned for fixed latency, finite size computing center at BNL
- Require high speed, efficient, and precise tracking in an environment where $\mathcal{O}(100{,}000)$ hits are expected
- Need to reduce tracking time to 5 seconds per event in these conditions

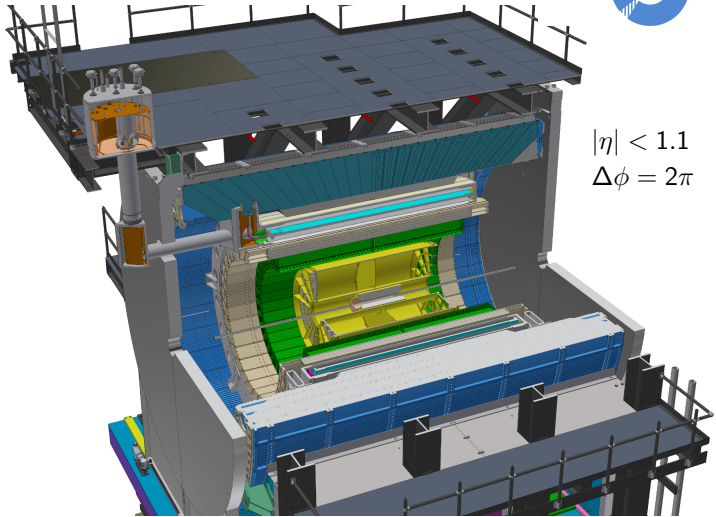
Current Status: Track Propagation and Fitting



- Track propagation performed using GenFit
- Currently average $\sim$9 seconds for track reconstruction in realistic background environment
  - Goal is $<$ 5 seconds per event
- Actively exploring ACTS for track propagation and fitting

sPHENIX Detector

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



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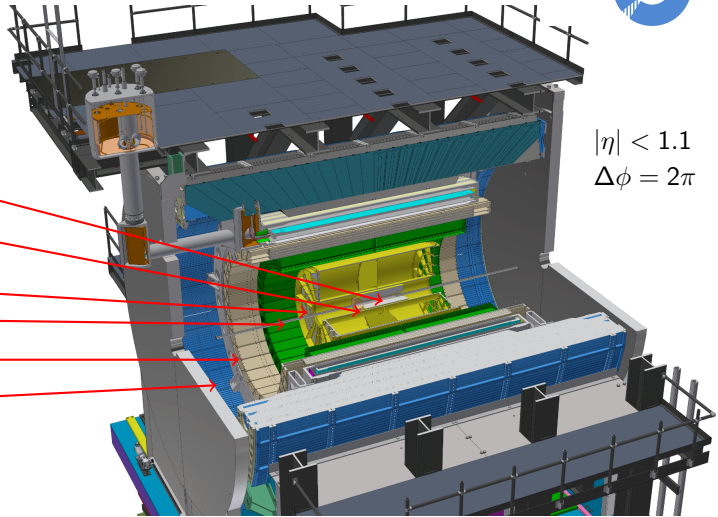
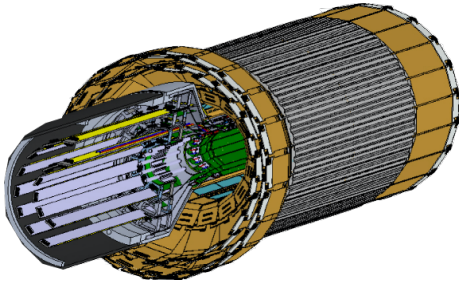


$|\eta| < 1.1$
$\Delta\phi = 2\pi$

Tracking Detectors



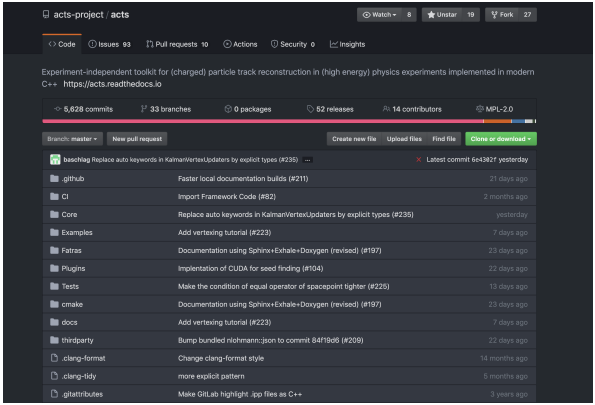
- MVTX
  - Monolothic Active Pixel Sensor (MAPS)
  - 3 layers, based on ALICE ITS
- INTT
  - Two layers of silicon strips

- Compact, continuous readout TPC
- ∼160k channels

A Common Tracking Software (ACTS)

- ACTS is a software project being developed by ATLAS/Belle2/LHCb (and other) collaborators
- User base is growing - CEPC, sPHENIX...
- Intended to be an experiment independent set of track reconstruction tools
- Performant and flexible algorithms for track reconstruction
- See Xiaocong Ai's and Bastian Schlag's talks at Connecting The Dots 2020 workshop

sPHENIX and ACTS



- ACTS recently migrated from CERN hosted Gitlab to Github
- www.github.com/acts-project/acts
- Very welcome change for outside experiments/contributors
- sPHENIX has a fork which we include in our nightly builds, update when needed, etc.

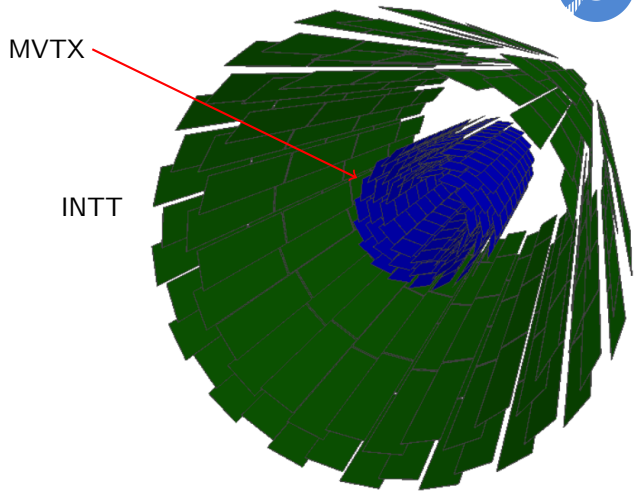
sPHENIX and ACTS Interactions

- Nonetheless, there are several sPHENIX specific ACTS classes
- ACTS requires a `ACTS::SourceLink` class that contains measurement info
- sPHENIX created maps correlate ACTS objects to sPHENIX objects
  - e.g. `std::map<TrkrDefs::cluskey, ACTS::TrkrClusterSourceLink>`

```
/// Instantiate with a hitid, associated surface, and values that actually
/// make the measurement. Acts requires the surface be available in this class
TrkrClusterSourceLink(unsigned int hitid,
                      std::shared_ptr<const Acts::Surface> surface,
                      Acts::BoundVector loc,
                      Acts::BoundMatrix cov)
  : m_hitid(hitid)
  , m_surface(surface)
  , m_geoId(surface->geoID())
  , m_loc(loc)
  , m_cov(cov)
{
}
```

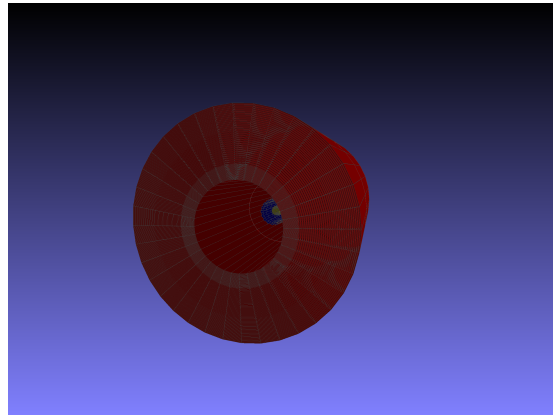
sPHENIX and ACTS Geometry

- ACTS contains a ROOT TGeo plugin
- Like most experiments, sPHENIX has a full Geant4 description
- Provide ACTS with (already created) `TGeoManager` object to build tracking detectors
- ACTS creates Surfaces that correspond to TGeo objects in the G4 description



TPC in ACTS

- Currently ACTS does not support continuous TPC geometries
- At the moment, we build `ACTS::PlaneSurfaces` ourselves that approximate the TPC readout geometry as concentric cylinderical surfaces



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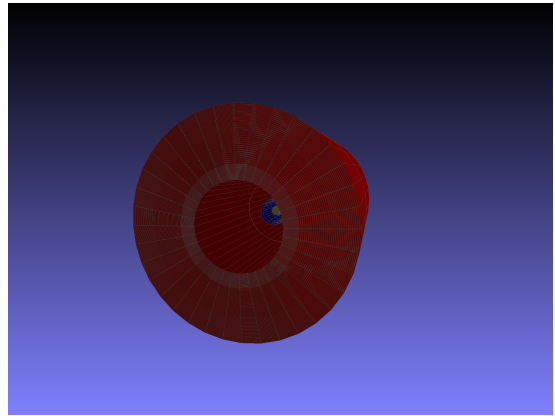
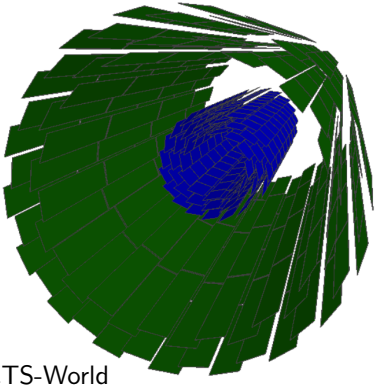
- ACTS Workshop 2020 conclusion: develop global track fitting methods
- Currently, all ACTS measurements are tied to a surface. Not conducive for TPC/DC geometries
- Significant interest from sPHENIX, Belle2, and CEPC

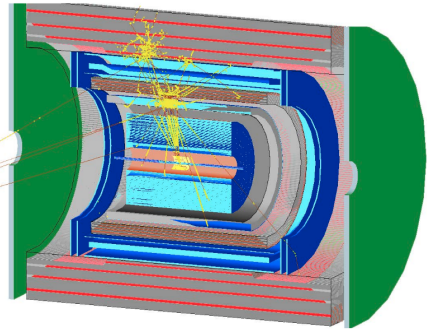


TGeo and ACTS Interactions



ACTS-World

`std::map<TGeoNode, ACTS::Surface>`

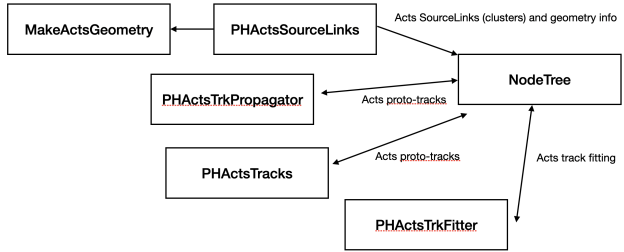


Geant4-World

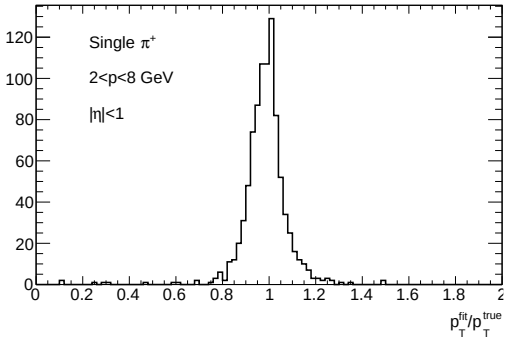
- Software design is intended to keep sPHENIX specific code within sPHENIX
  - Allows simple updates of ACTS, simplified debugging
- Construct maps that correlate TGeo objects to ACTS::Surfaces

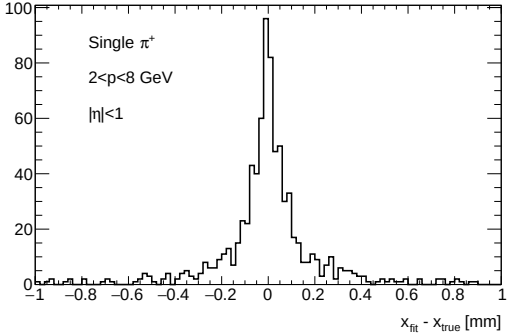
Software Design

- sPHENIX software is open source at github.com
- Designed for flexibility - can interchange the various seeding, propagating, fitting algorithms available



Understanding and Debugging ACTS





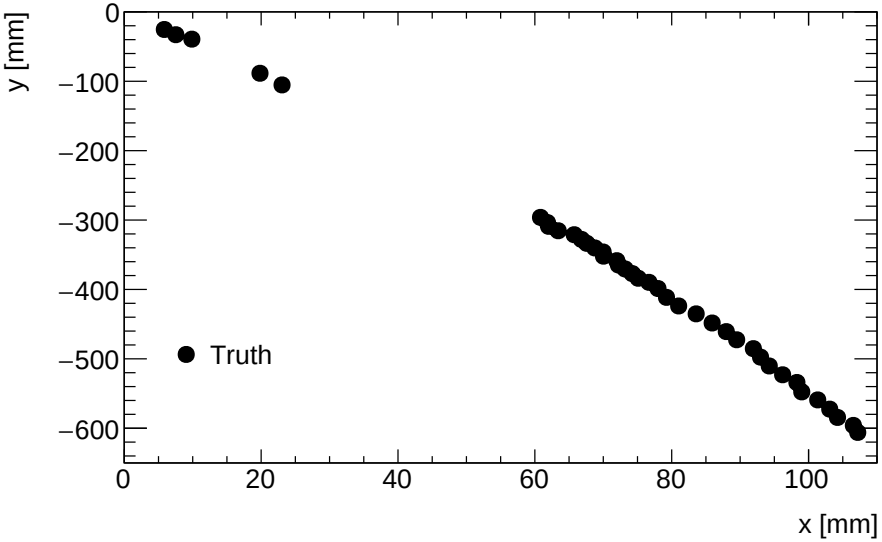
- Track fitting is a somewhat stable state
- Still learning what options the fitter can take, how we can use it, estimating performance, etc.
- Nonetheless, have made a lot of progress in several months of using ACTS

Conclusions

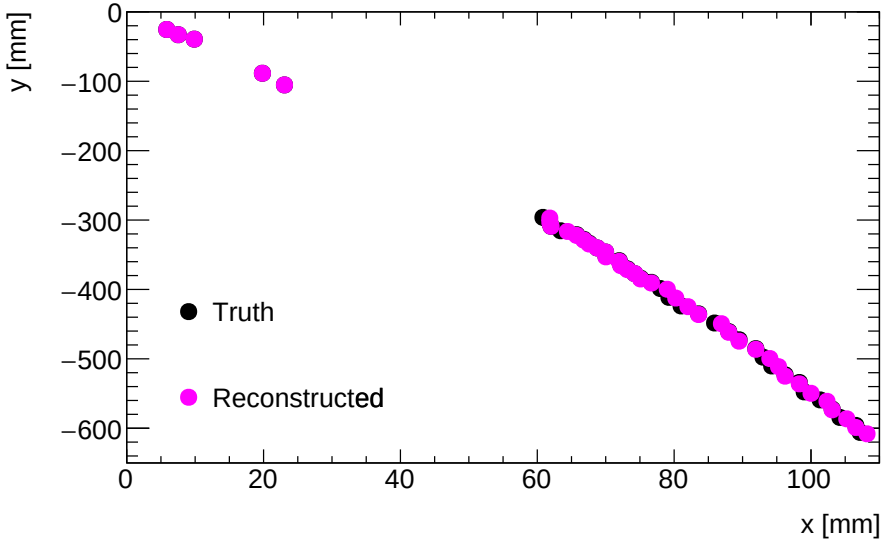
- sPHENIX is a dedicated jet and heavy flavor experiment being constructed at the Relativistic Heavy Ion Collider
- Computational challenges: Reconstruct ∼100 billion heavy ion collisions on a fixed computational center
- Track reconstruction dominates current event reconstruction time - aim to get below 5 seconds per event (down from 9 seconds)
- Exploring ACTS as a track reconstruction toolkit in sPHENIX
- Continuing to learn a lot about ACTS software, and we are quickly becoming more proficient with it
- Will continue to tune ACTS and learn about its functionality. Need to start thinking about TPC space charge distortions and applying these corrections to ACTS

Back up

Fitting Process



Fitting Process



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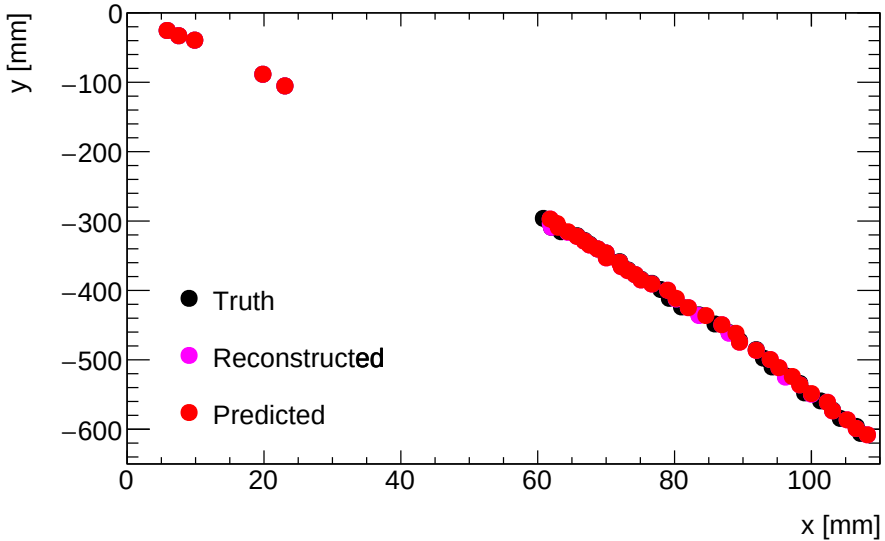

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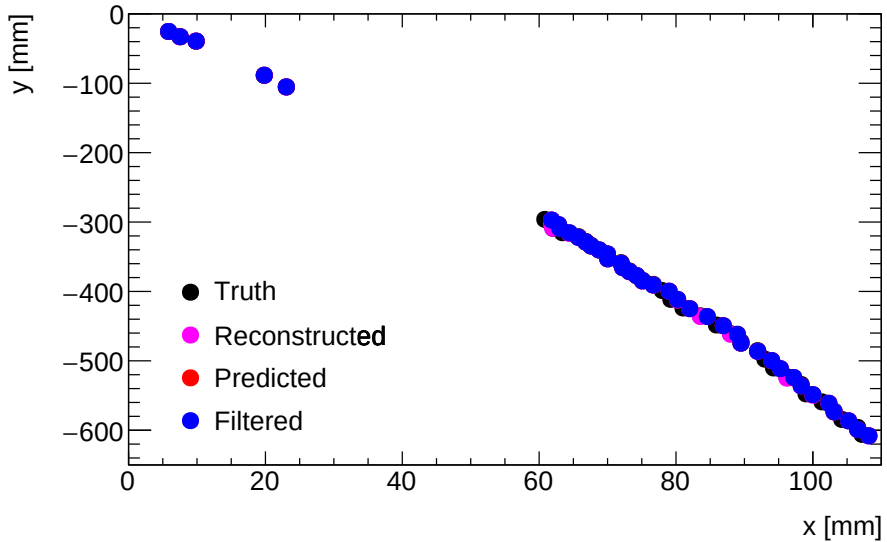

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