sPHENIX and Acts

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for sPHENIX

Acts Developers Workshop
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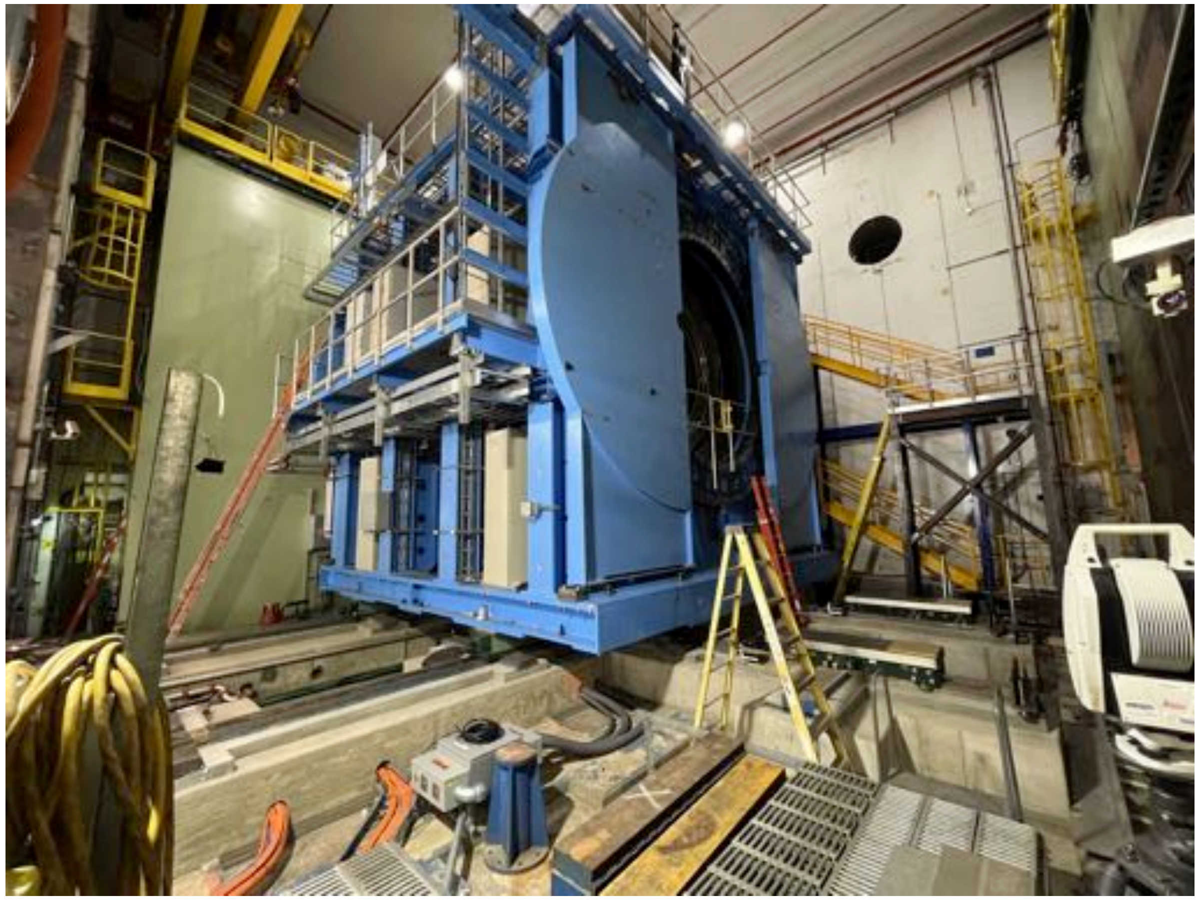
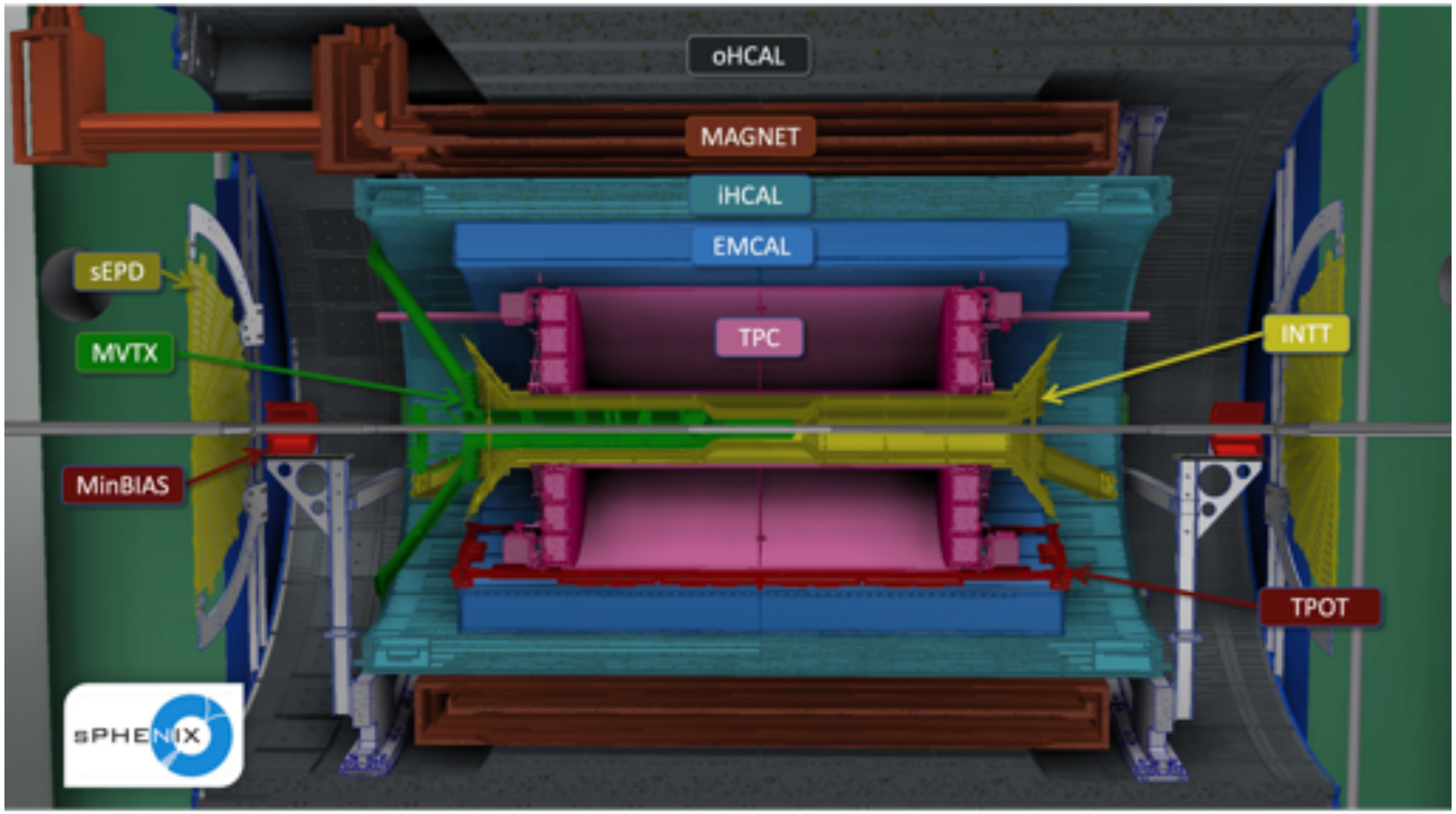


sPHENIX is scheduled to be commissioned starting in March of 2023

We are in the last few months of preparing to take data ....



The sPHENIX tracker (1.4 T magnetic field) consists of:

- A three layer silicon vertex detector (2.3-3.9 cm rad) (**MVTX**)
- A four (x 1/2) layer silicon strip detector (6-12 cm rad) (**INTT**)
- A **TPC** with 48 readout layers (30 cm - 76 cm rad)
- A partial outer tracker designed to help calibrate distortions in the TPC (**TPOT**)

What is unique to sPHENIX?

Functions:

- The momentum measurement is from the TPC ($r\Delta\phi$ ~ 150 μm)
- The MVTX provides a precise track vertex measurement ($r\Delta\phi$ ~ 5 μm)
- The silicon strip detector ($r\Delta\phi$ ~25 μm) provides pattern recognition, precise timing
  - It is the only detector that can resolve a bunch crossing - critical for pp running
- The outer tracker provides a space point outside the TPC for distortion measurement
  - Supplemented by laser flashes on the TPC central membrane
    - Used to extrapolate outer tracker distortion corrections to full coverage

TPC clusters are:

- Moved up to 2 cm by static E x B effects (calibrated by a directed laser system)
- Moved up to 1 mm by average beam induced space charge effects
- Moved up to 100 μm by fluctuations in space charge effects

Tracking challenges

E x B and space charge distortions in the TPC have to be corrected to < 100 μm to achieve the required momentum resolution

The TPC occupancy approaches 30% in the inner layers in central collisions

- Leads to cluster overlaps that deteriorate p_T resolution in central events

The gap between the silicon and TPC is large

- Track seeds in the TPC must be projected 18 cm to the outer silicon layers
- The projection accuracy results in 2-3 possible matches to silicon clusters
- Therefore we match full TPC seeds to full silicon seeds using (η, ϕ, x, y, z) windows
- Keep all matches, and let the Acts fit find the best one - this works well

The TPC electron drift time is 13.2 μs - the bunch crossing time is 106 ns
The TPC cluster z position is calculated from the time after the event trigger
In Au+Au running we assume the bunch crossing is the triggered one

- We effectively discard all clusters from out of time crossings

In pp running, we stream the readout for 7 μs after each trigger to get incidental MB data

- We get clusters of interest from up to 70 bunch crossings, 20 events per trigger
- The TPC z position can only be known after matching to the silicon track seeds
  - Since only the silicon strip detectors know the crossing number

TPC fake surfaces

The TPC is a large continuous gas volume
The only segmentation is in the readout plane

- Electron drift (with distortions) is simulated after the GEANT simulation
- Then distorted hits are associated with readout pads

For compatibility with Acts we create fake planar "surfaces" in the TPC volume
GEANT does not know about them, they are added after the simulation

- Centered on the readout layer
- Spaced 2.5^0 apart in ϕ, extending from central membrane to readout plane
- Reasonable approximation to a cylinder
- Added to the TGeo object and incorporated into the Acts surface list

This works well enough

All cluster positions are kept in local coordinates on Acts surfaces throughout the reconstruction chain
For the TPC, the cluster positions are kept as the raw values on the readout surface

- All corrections are made at point of use
- After correction, clusters are moved back to the surface along the track direction
- Distortion corrections may cause a cluster to change surfaces, handled on the fly

Performance with ideal geometry

Pions embedded in

- AuAu with 50 kHz pileup
- pp with 3 MHz pileup

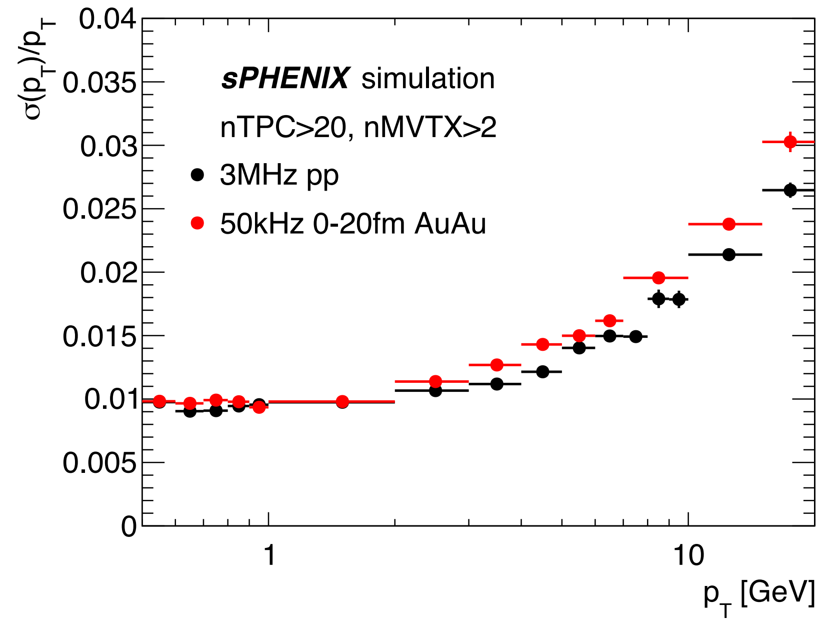
All embedded tracks:

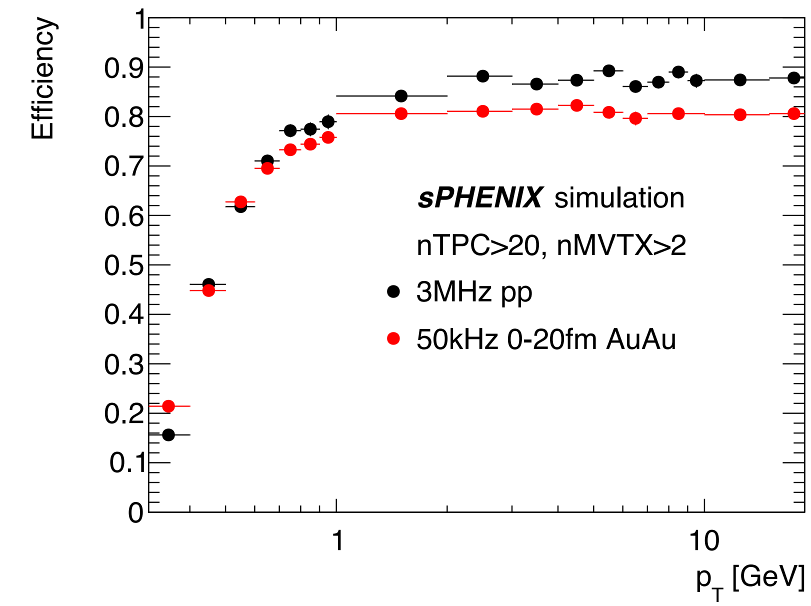
- > 2 MVTX hits
- > 20 TPC hits

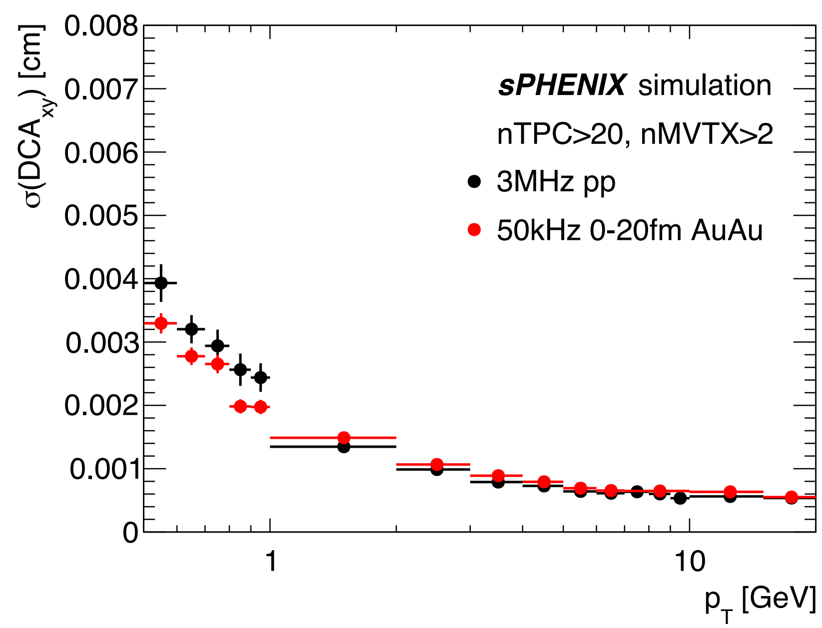
Lower right:

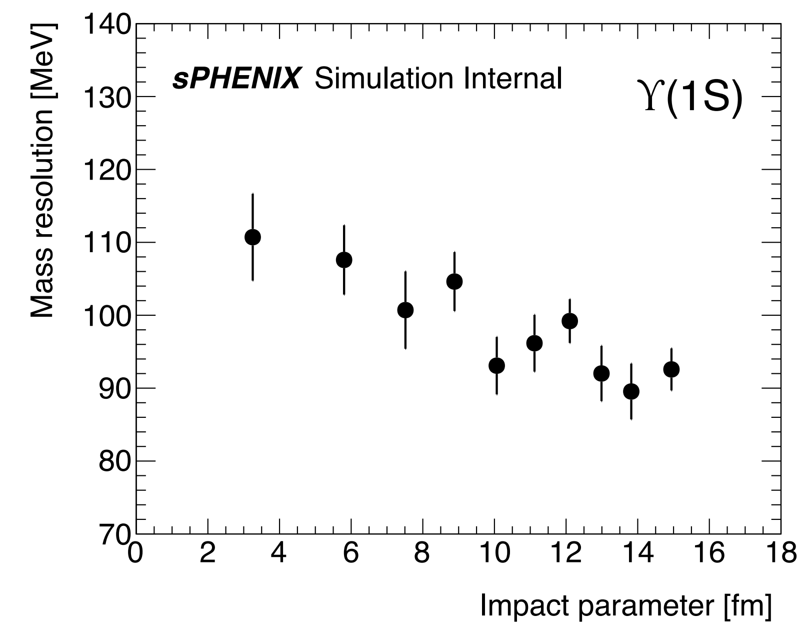
Upsilon(1S) mass resolution versus centrality

- AuAu with 50 kHz pileup









Alignment

Our GeometryContext consists of a map of ActsTransform3 objects for each surface

The transform incorporates alignment corrections:

α, β, γ, dx, dy, dz

where:

α, β, γ are small rotations around the x, y, z axes in the frame of the surface
dx, dy, dz are translations of the surface center in the global frame

We plan to use Millepede to perform the tracking detector alignment

— We have some experience in the collaboration with Millepede
— We are just now starting on the procedure for doing this

Commissioning issues

We will presumably start commissioning with poor alignment
— We are not sure yet how poor …

Our TPC track seeding works with no need for distortion corrections
— and probably no need for alignment

Presently testing if our silicon track seeding will work with poor alignment

Our observation is that Acts tracking is sensitive to the quality of the track seeds

- The track position needs to be close, or the tracker drops clusters
  - Not a problem with properly aligned silicon - track seeds give good positions
- We are concerned that with poor alignment we will not be able to fit tracks at all
- Which will make aligning the detector impossible …

Is it feasible to open up the Acts search windows to tolerate poor alignment?

- The alternative is that we start commissioning with a dumb helical fitter until we correct the gross misalignments
- Then fine tune the alignment with Acts fitting

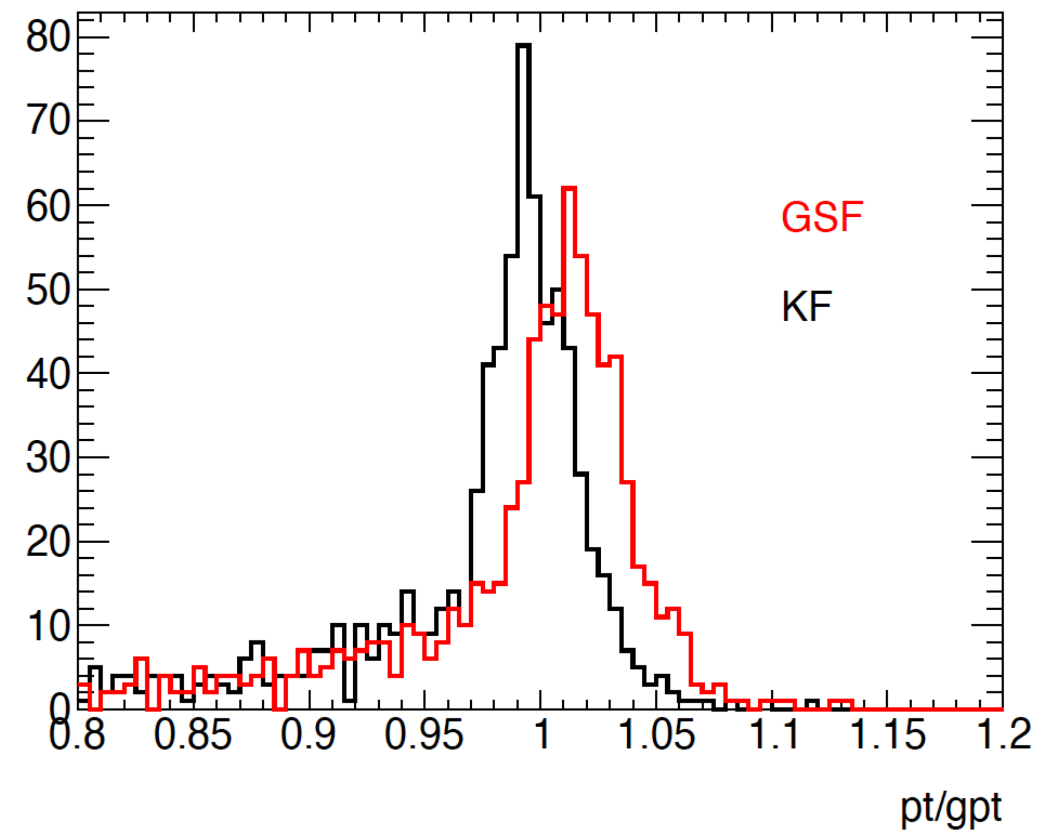
Gaussian Sum Filter

A major component of our physics program is the measurement of the modification of Y states in Au+Au collisions

The measurement is made by reconstructing Y-> e+e- decays

We see a substantial tail on the mass peak due to radiative energy losses of the electrons in the detector material

First try with the GSF suggests it is not physics ready yet



The GSF will be important to our physics program
Any advice on how to set up / tune it?

Summary

What would be most helpful to us:

Consultation and/or guidance on commissioning a new detector with Acts
— what we should look out for, expect, etc.

The GSF to be physics ready