sPHENIX calorimeter highlights and physics

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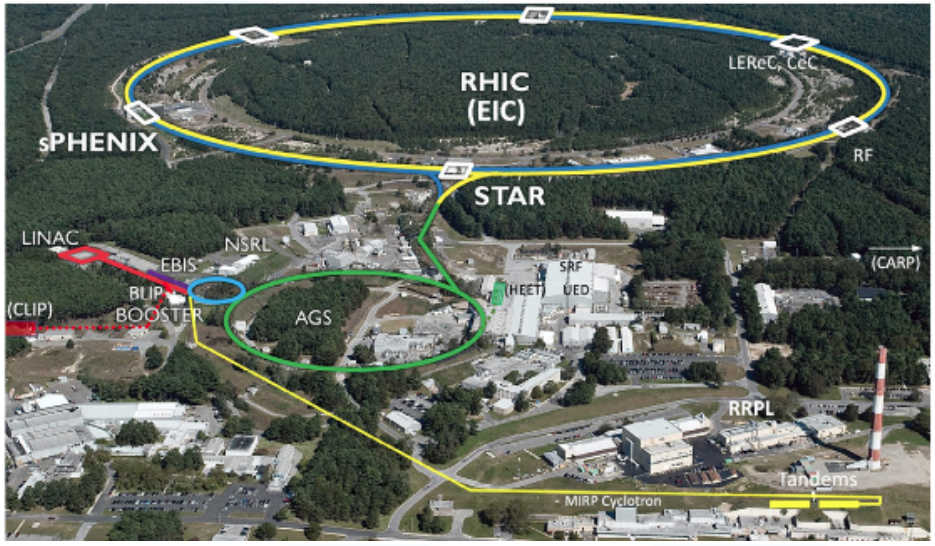
sPHENIX Experiment

- sPHENIX is the first major experiment to be built at the Relativistic Heavy Ion Collider (RHIC) in ∼20 years
- Established as essential in the 2015 Long Range Plan and necessary to capitalize on in the 2023 Long Range Plan
- Approval to operate and first commissioning data began in May 2023

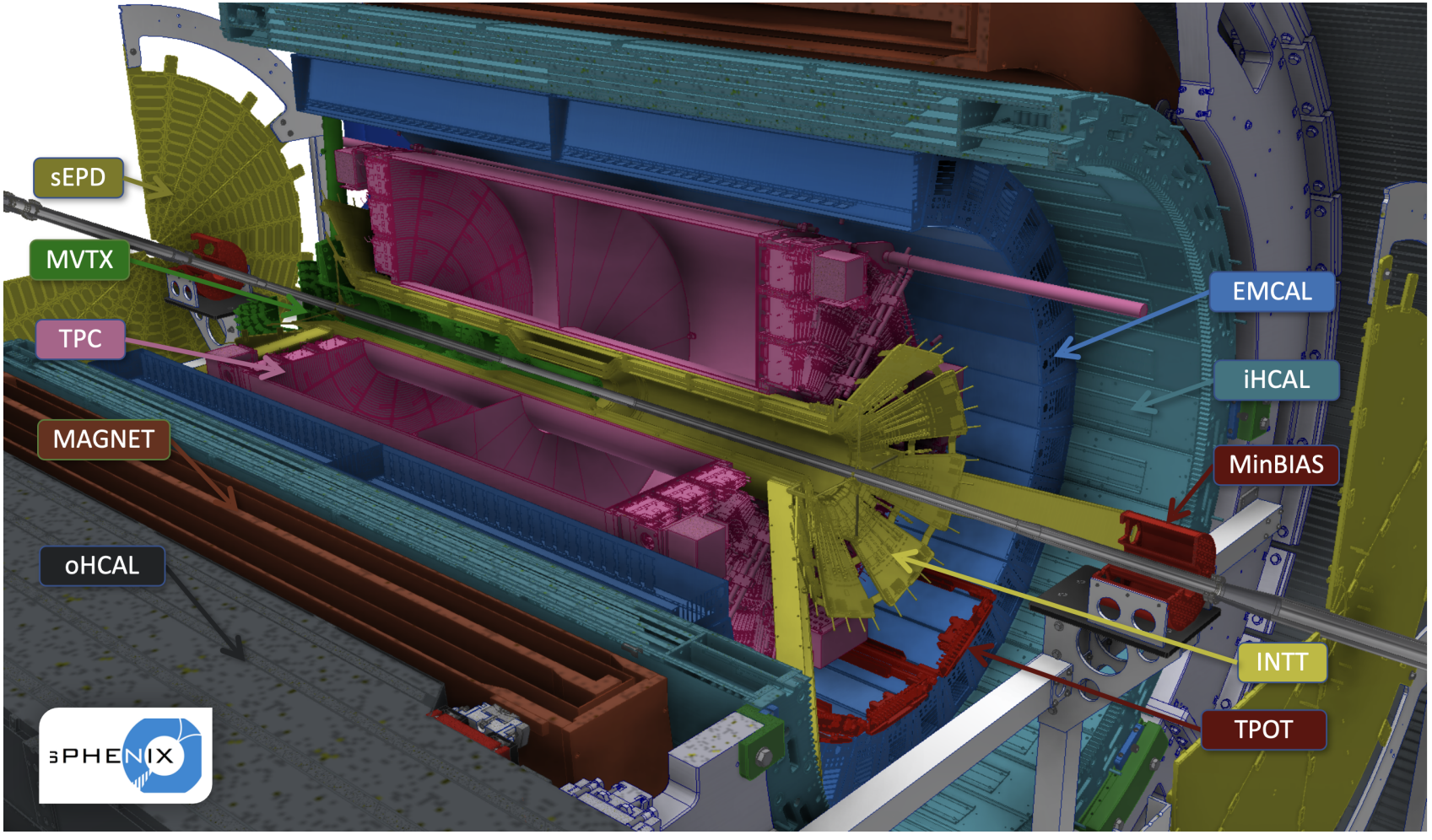


After more than a decade of discovery science, the 2015 NSAC Long Range Plan identified two important goals for the RHIC science mission: "There are two central goals: (1) Probe the inner workings of the QGP by resolving its properties at shorter and shorter length scales...as is a state-of-the-art jet detector at RHIC, called sPHENIX; (2) Map the phase diagram of QCD with experiments planned at RHIC."

sPHENIX Detector

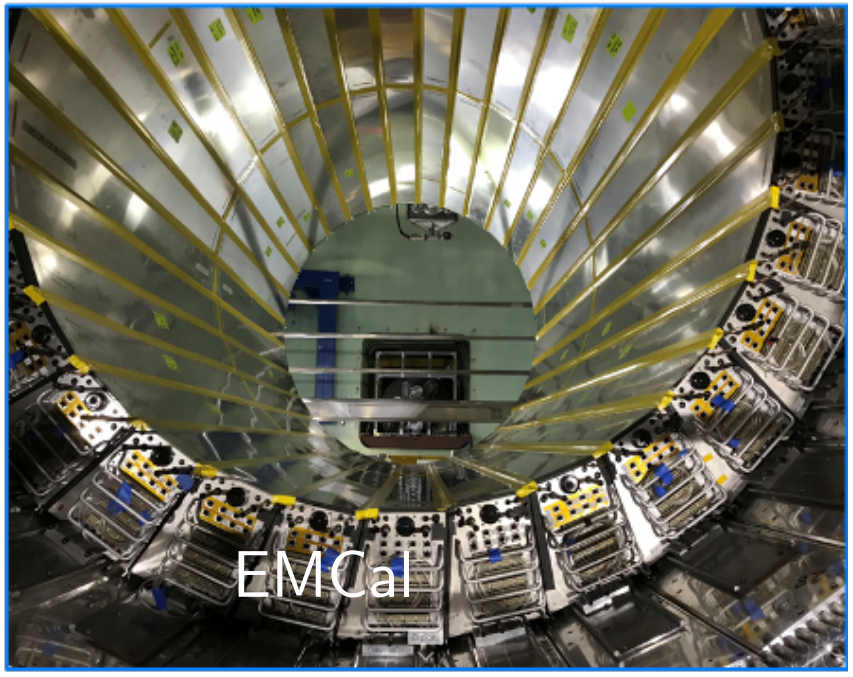
- sPHENIX first at RHIC with complete mid-rapidity calorimeter system
- Precision tracking and vertexing
- Event characterization detectors

sPHENIX Detector



Calorimeters

- Large acceptance calorimeter system covering $|\eta| < 1.1$ and 2π in azimuth
- Hadronic calorimeter system enables first measurement of neutral hadron component to midrapidity jets at RHIC



Calorimeters

See Charles Hughes' talk for tracking

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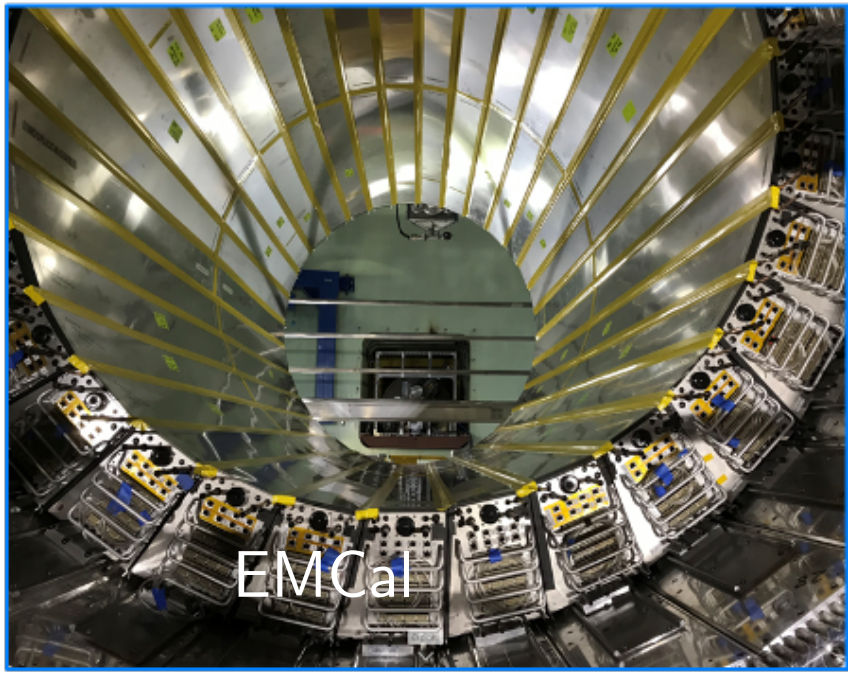
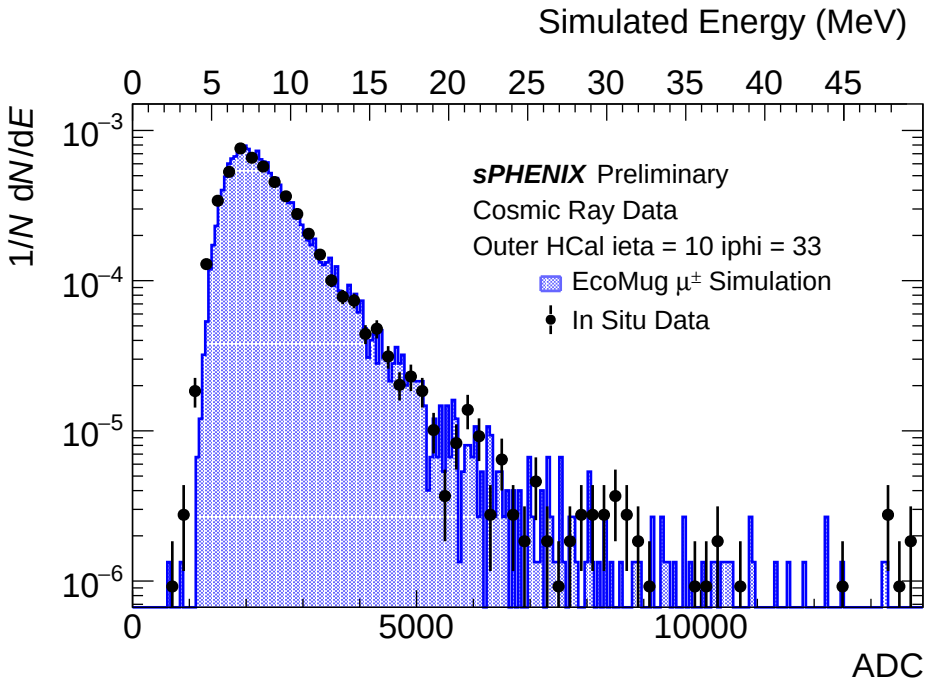


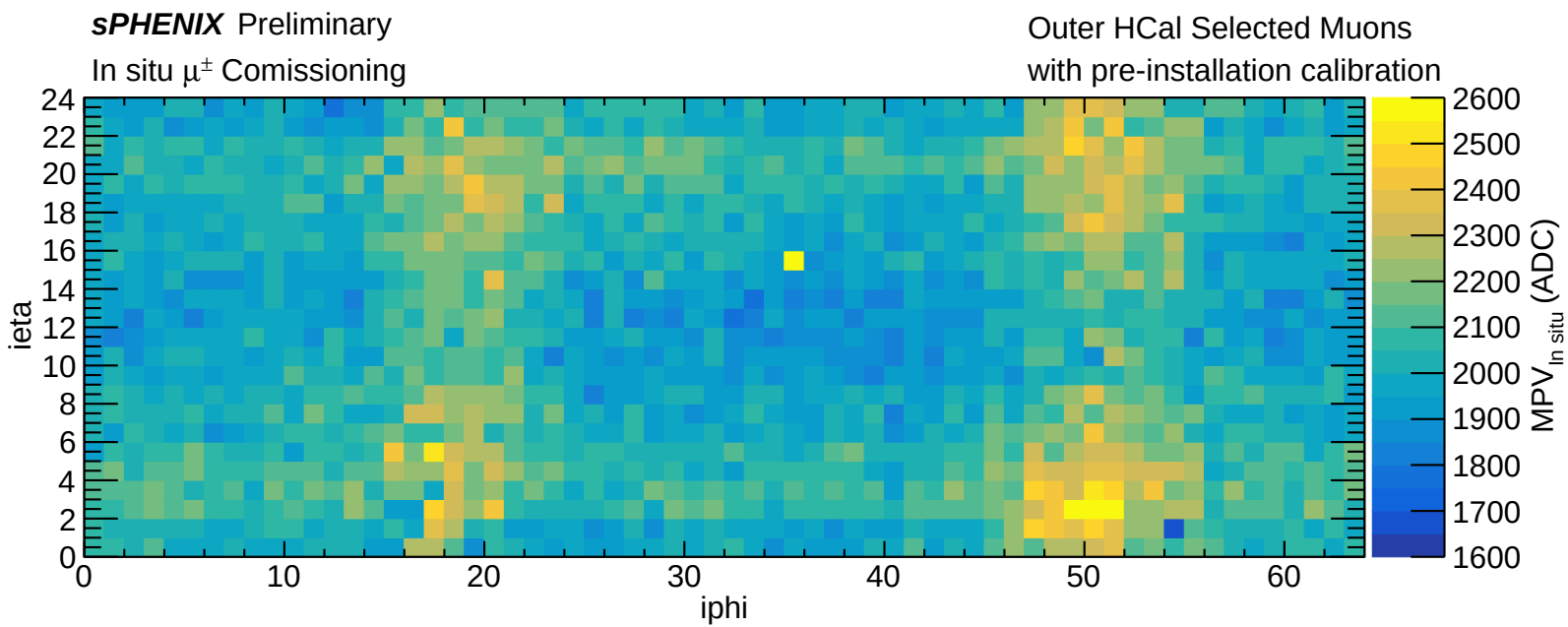
Run 2023 Data Taking

- Run 2023 began in May of 2023 with Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV
- In August RHIC experienced a failure that caused data taking to end ∼8 weeks early
- Much of sPHENIX's commissioning was able to be completed
  - Some commissioning items remain to be finished at beginning of 2024 run
- Continued 24-7 shifts through October 3rd, collecting cosmic data and commissioning subsystems
- Active physics studies ongoing using available physics data

Hadronic Calorimeter

- Hadronic calorimeter functionality validated with and without beam
- Cosmics signals match expectations from simulations
- Signals observed in 100% of towers





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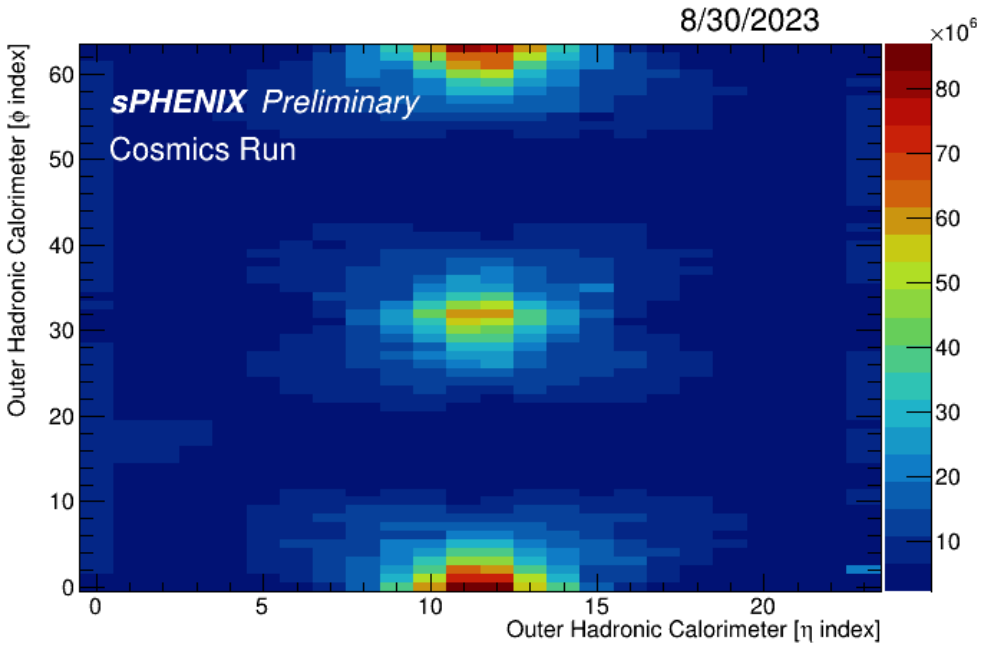
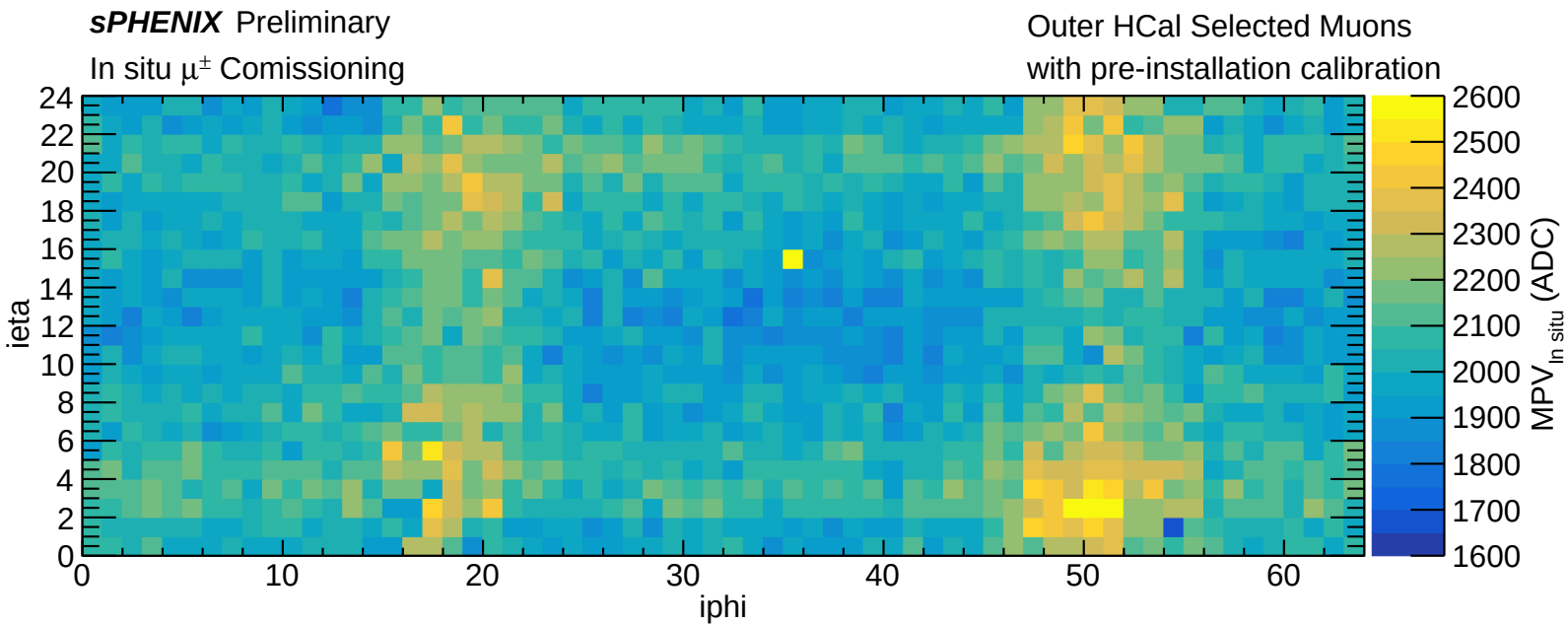
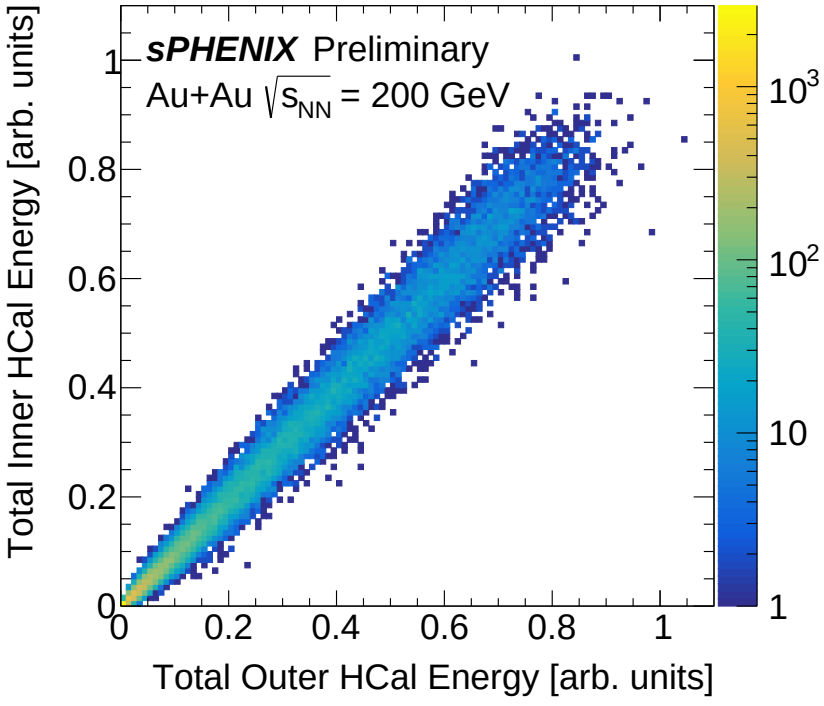
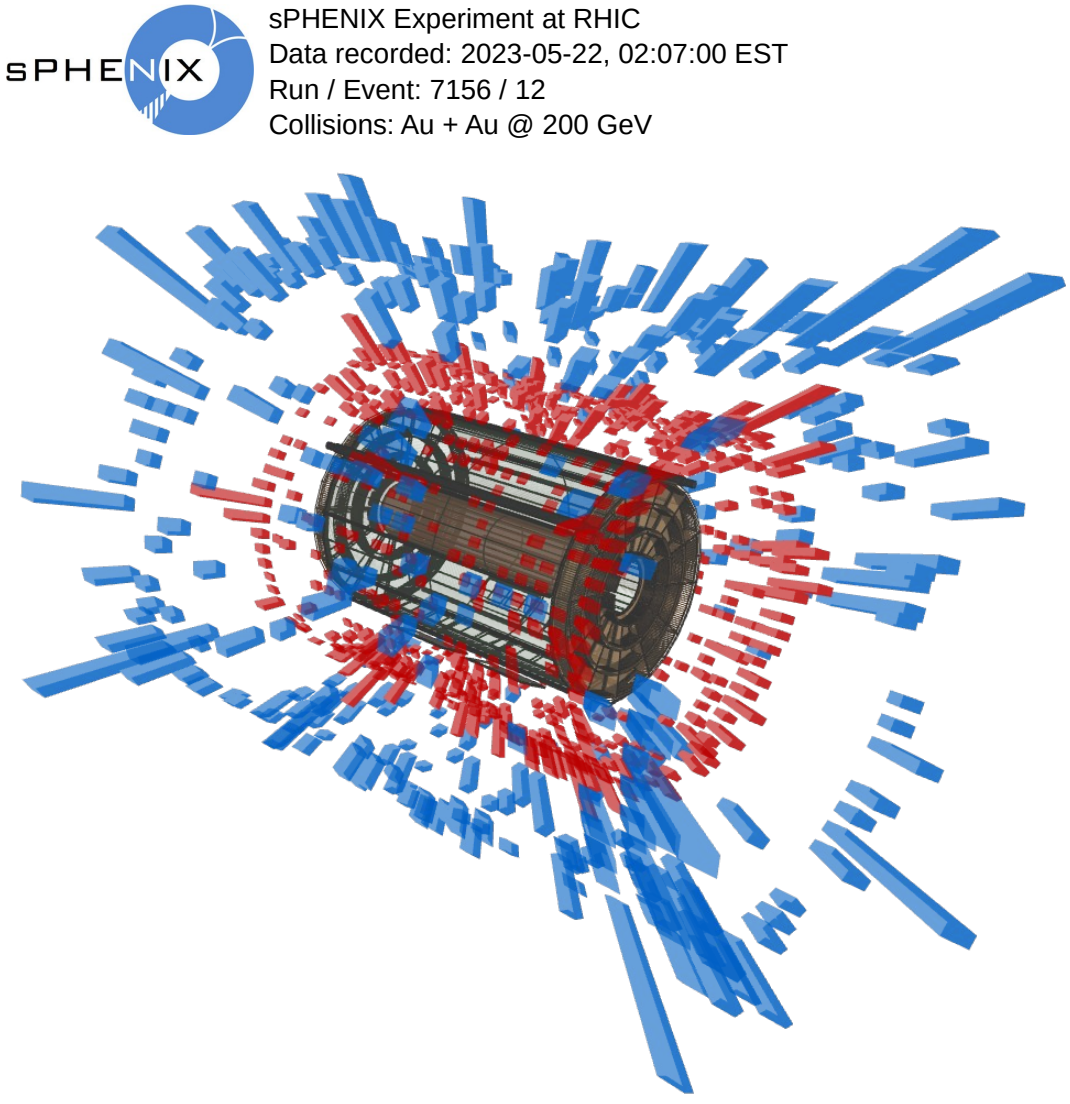




Hadronic Calorimeter

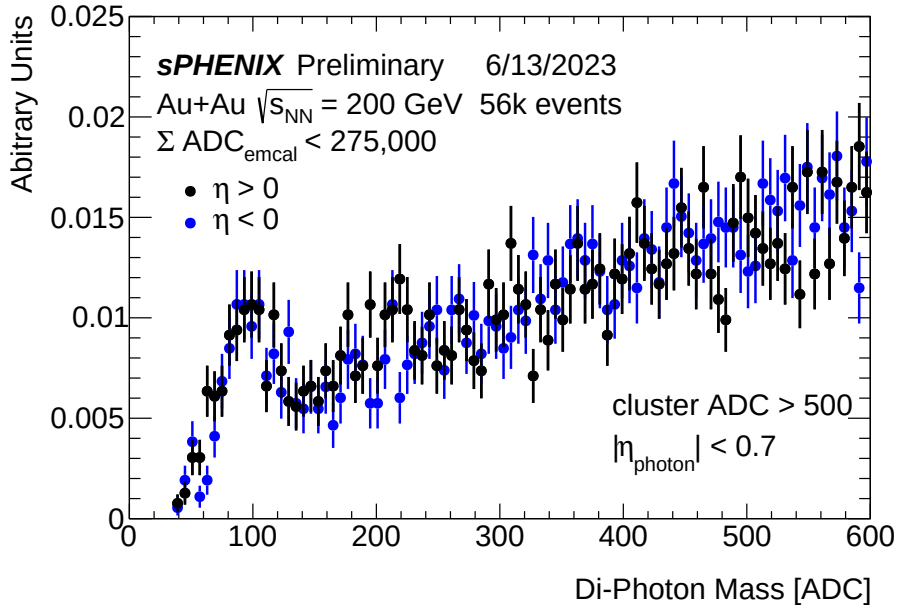
- Two-part hadronic calorimeter was fully validated with collisions

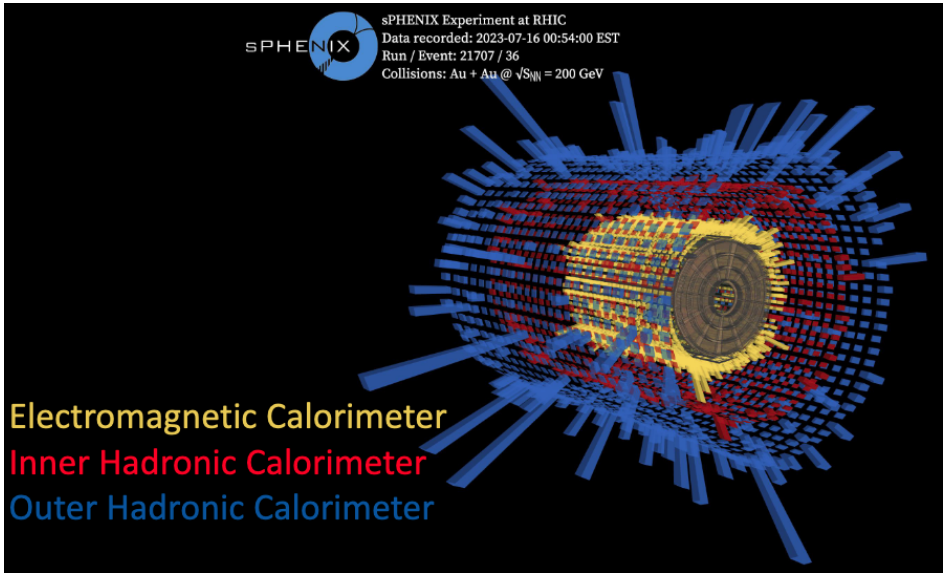




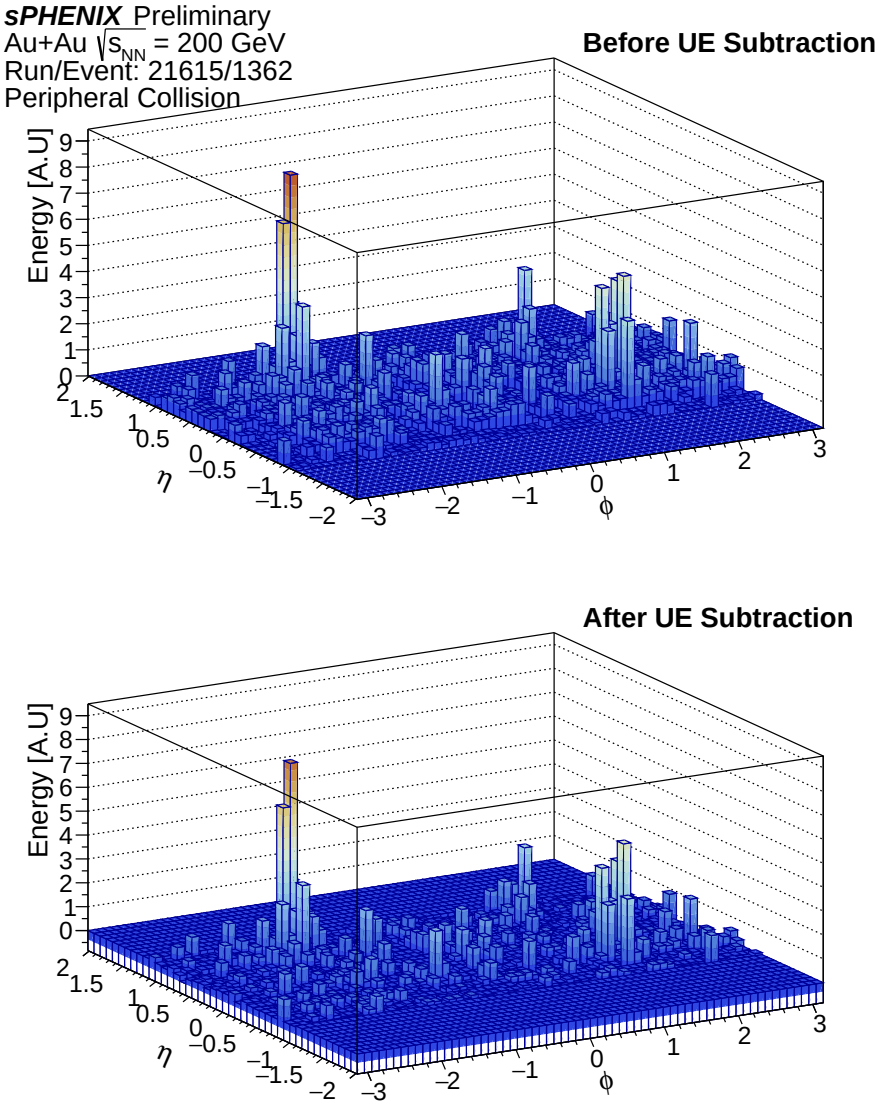
Electromagnetic Calorimeter

- EMCal performance confirmed with over 99% live channels
- π^0 mass peak observed in di-photon mass distribution from commissioning data
- Calorimeters correlated and reading physics data





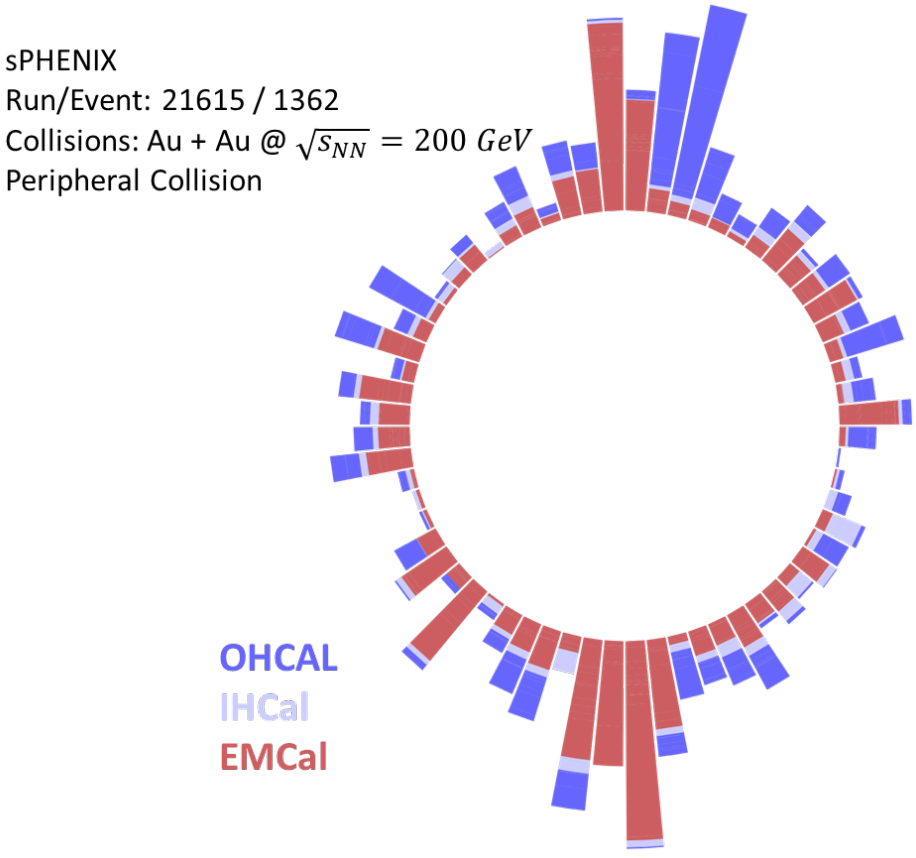
Jet Reconstruction in Au+Au

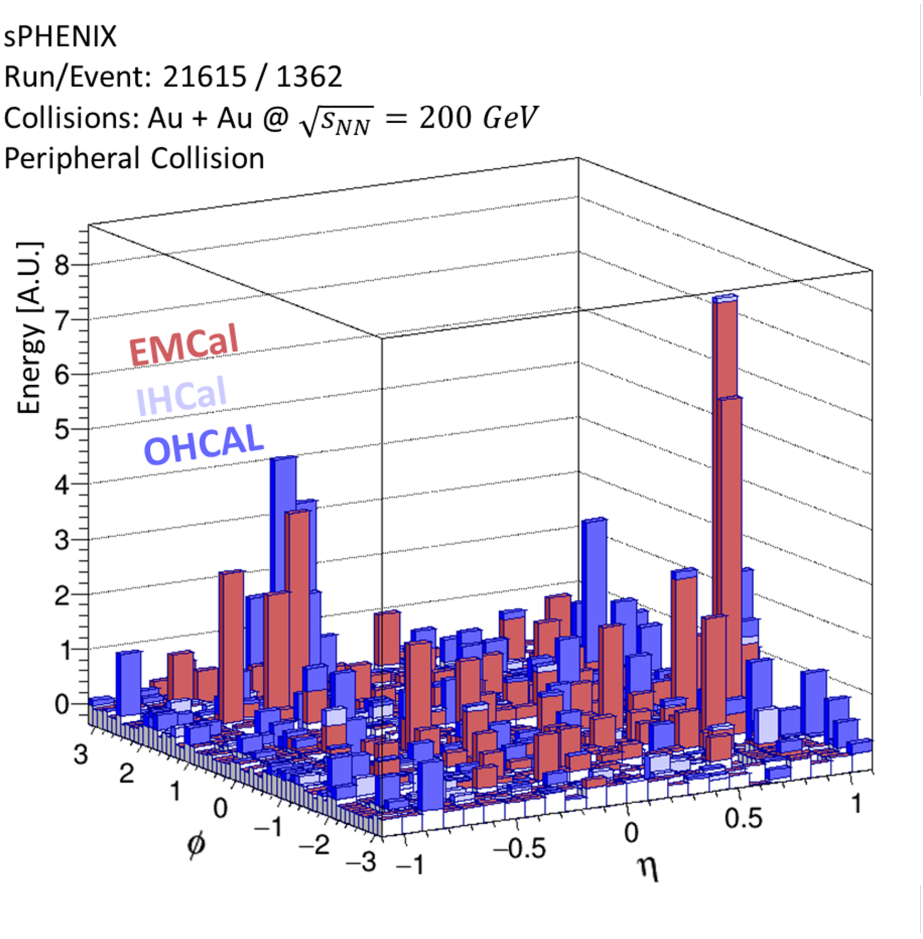


1. Reconstruct R=0.2 seed jets
2. Determine event v_n excluding regions near seeds
3. Determine underlying event $\langle E \rangle$ away from seeds and subtract with flow modulation
4. Repeat (1-3) with new seed jets from subtracted towers
5. Run jet reconstruction on subtracted towers

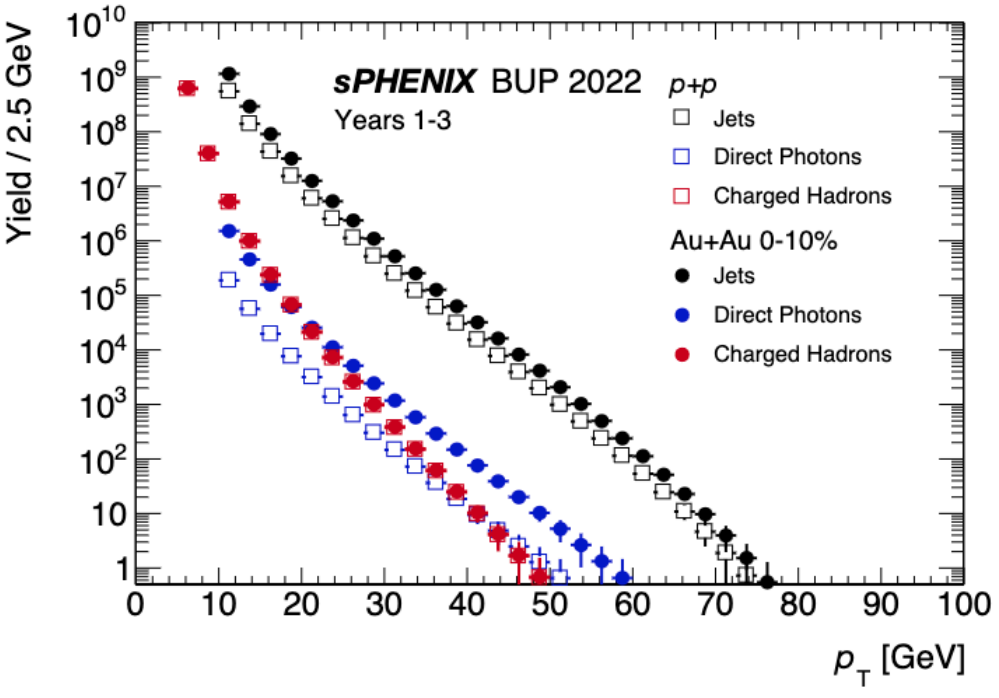
Early Measurement of Dijets

- sPHENIX will perform unfolded jet measurements to provide insights into a variety of cold and hot QCD physics



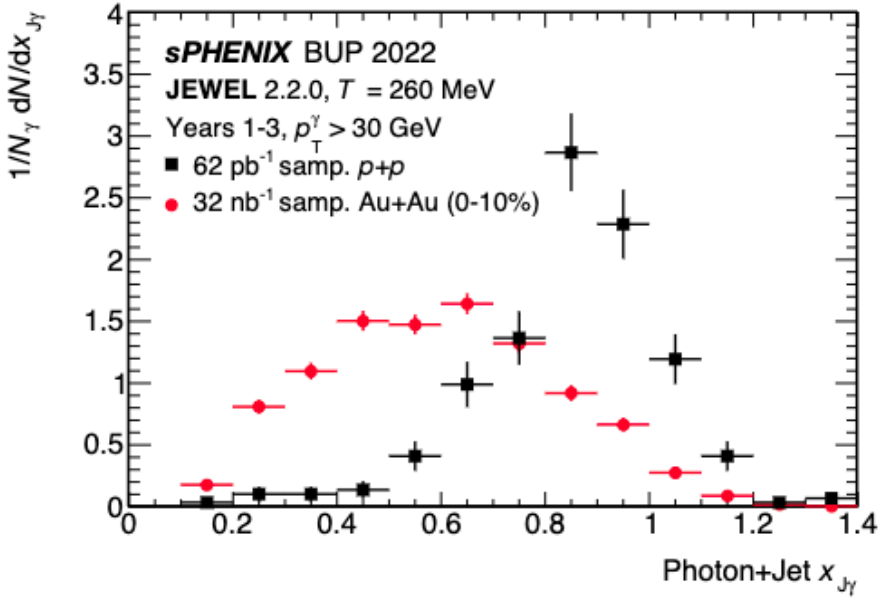


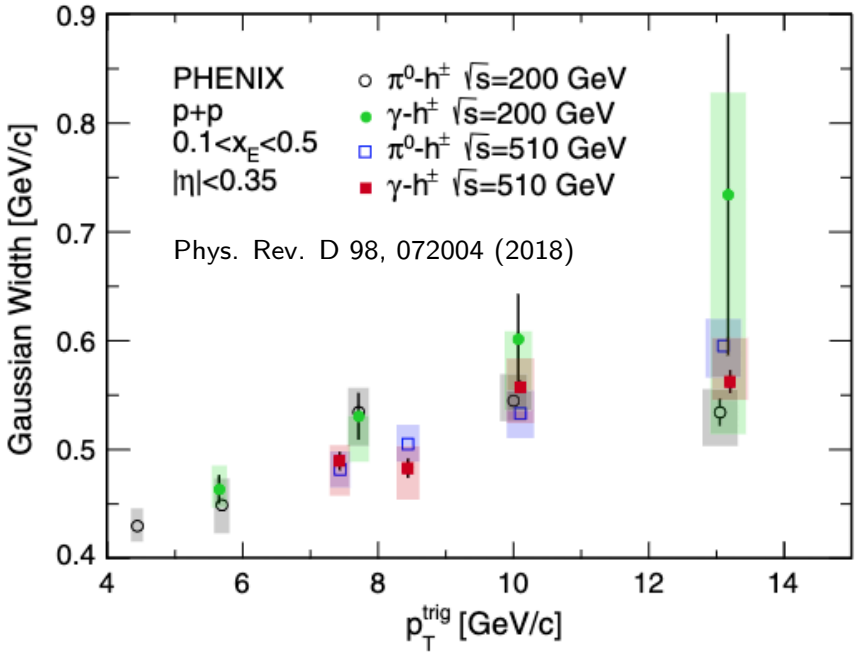
sPHENIX Physics



- Year 1 of sPHENIX data taking has enabled significant commissioning progress
  - First physics studies using calorimeters ongoing
- High statistics $p + p$ and Au+Au data samples coming in 2024 and 2025
- Will enable differential jet and rare probes measurements

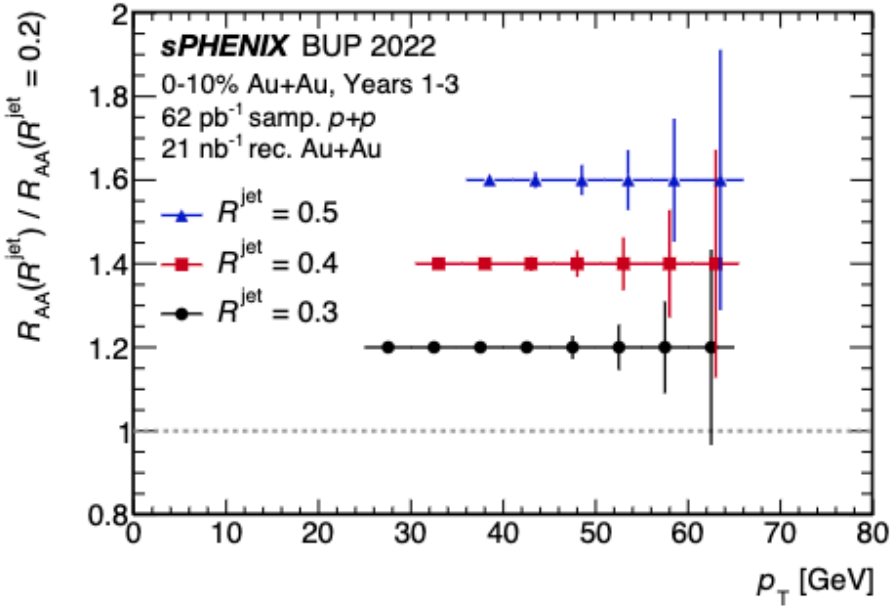
Photon-Jet Correlations

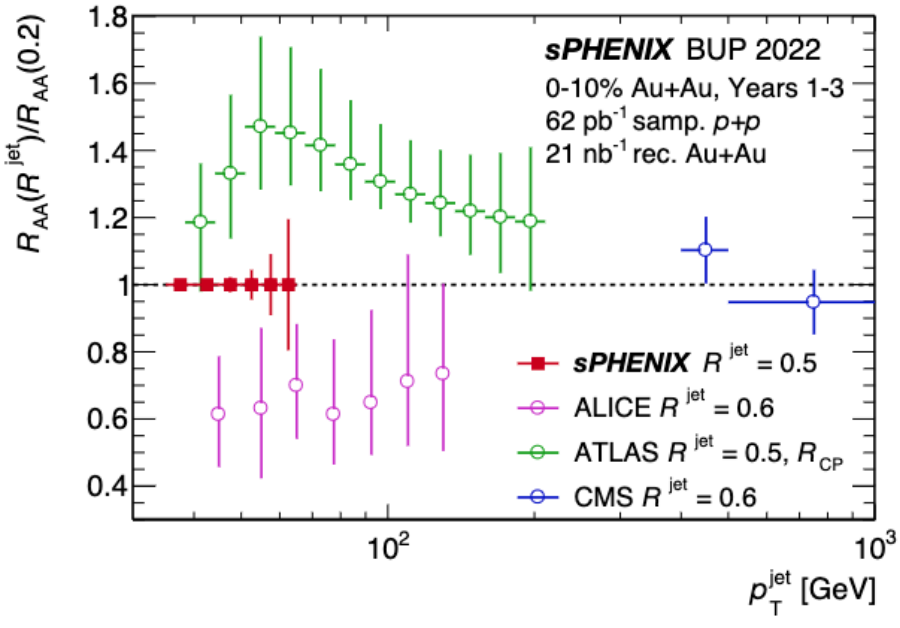




- Precision measurements of direct γ-jet correlations
- Wide range of physics sensitive to perturbatve-nonpeturbative interplay can be probed
  - Medium response and wake properties in QGP
  - Transverse momentum dependent factorization breaking
  - Hadronization/fragmentation in nuclear environment
  - And much more...

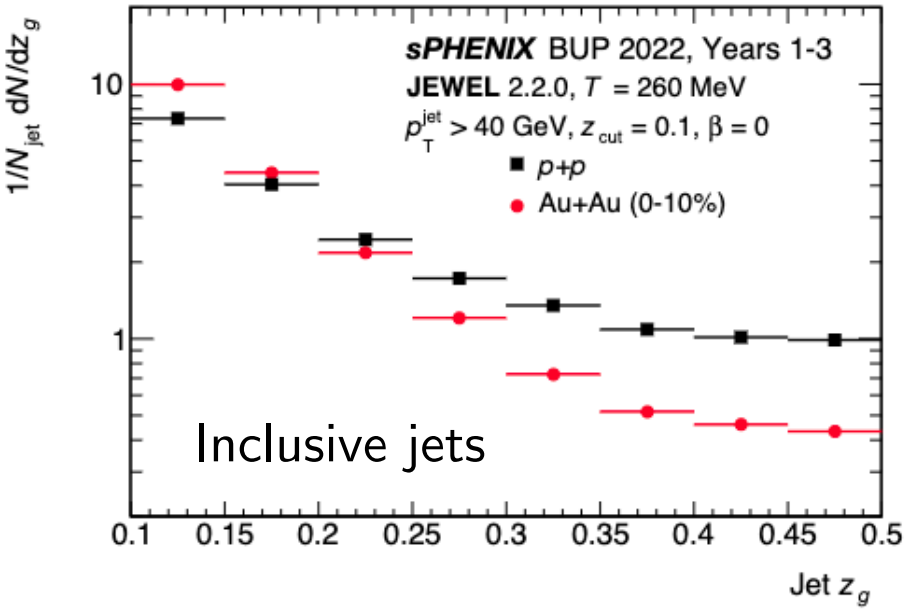
Jet Size

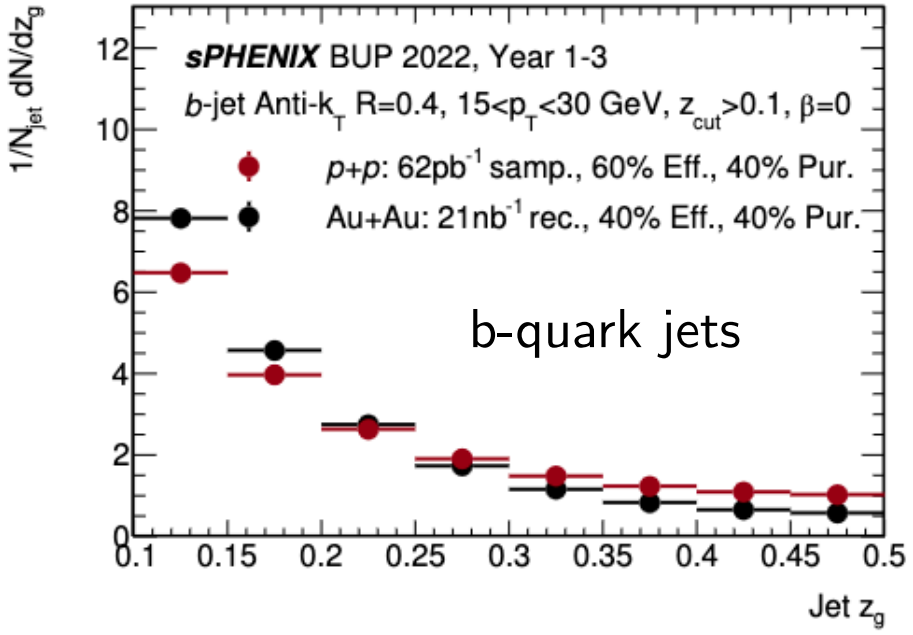




- Varying jet cone radius probes interplay of out-of-cone energy loss
- Sensitive to angular distribution of medium response effects
- Opportunity for input to significant tension seen at the LHC in low jet p_T region

Jet Substructure



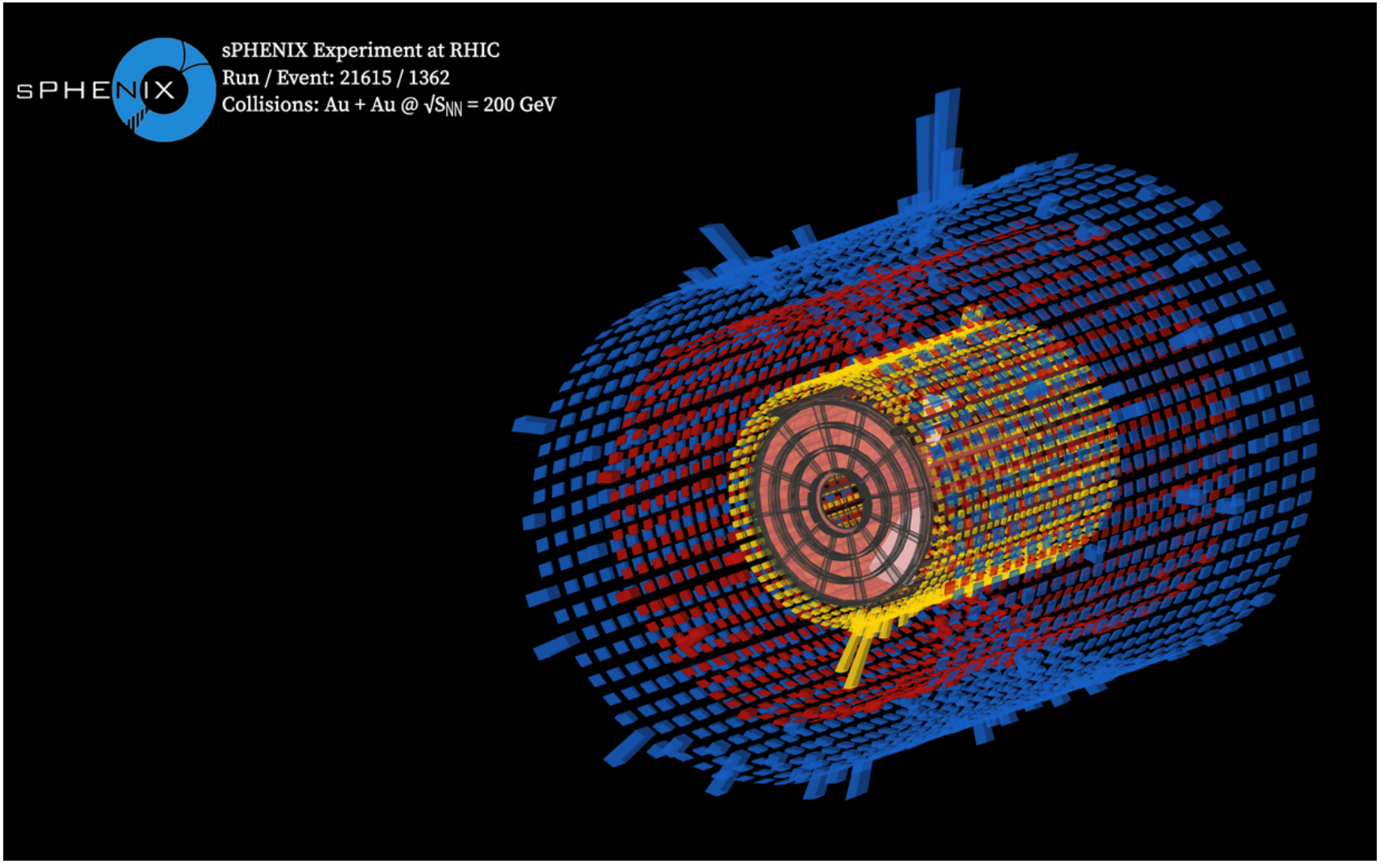


- Broad jet substructure program utilizing calorimeter and particle flow jets
- Studying interplay between nonperturbative and perturbative physics with
  - Groomed jets
  - Energy-energy correlators
  - Lund plane measurements
- See Derek Anderson's talk and Jin Huang's talk

Summary

- sPHENIX began data taking in 2023 with a successful commissioning run
- All calorimeter systems have performed to expectation
- Commissioning and calibration efforts are ongoing with run 2023 physics data
  - Physics efforts ongoing with limited 2023 physics data collected due to RHIC failure
- Data in 2024 and 2025 will enable precision measurements of complete jets for comparison to LHC measurements
- Will also provide golden data sets in similar kinematic regime to EIC data, where comparisons between $p + p$ and $e + p$ will be critical

Summary

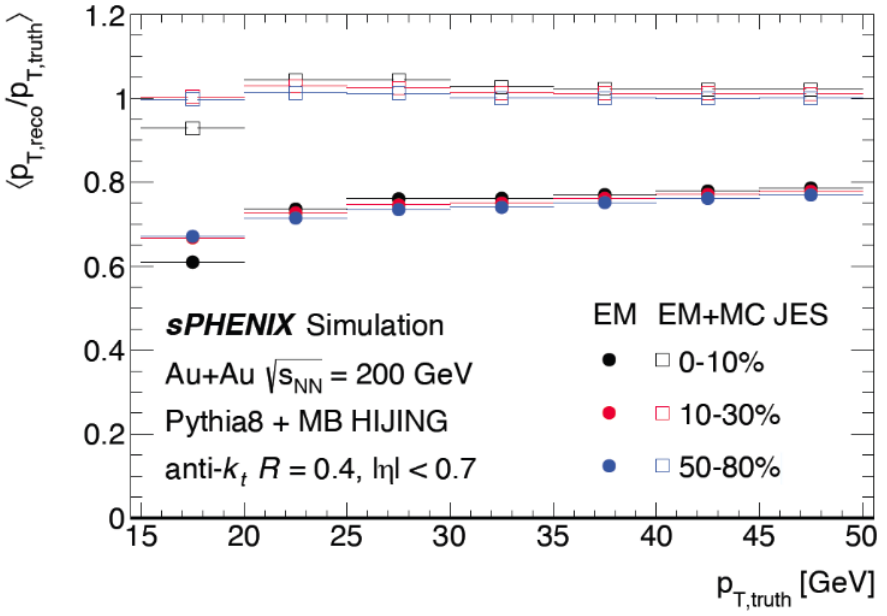


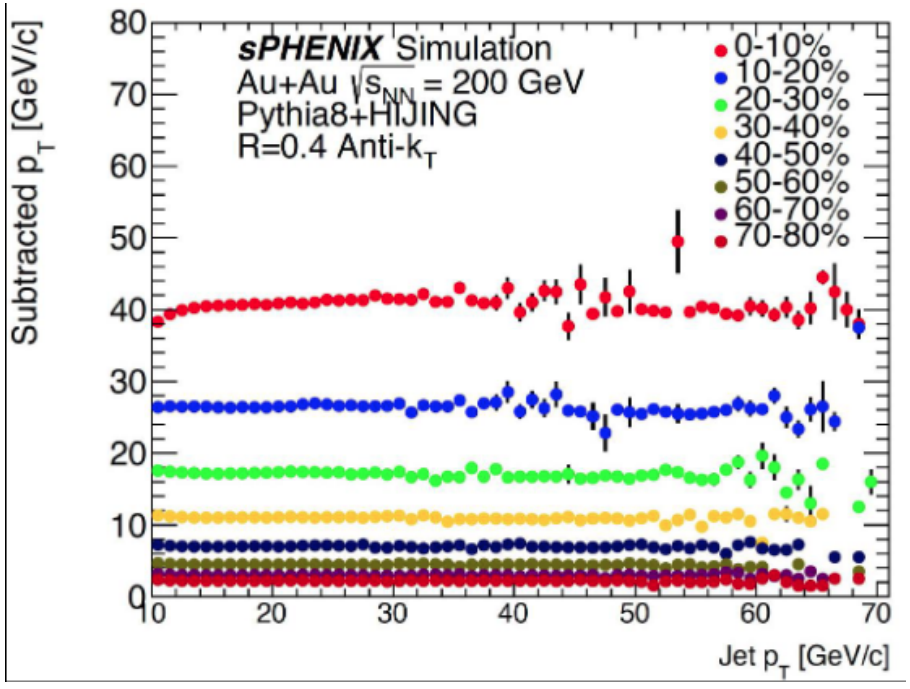
Much more from sPHENIX coming!

Back up

Jet reconstruction and calibration

- Jets are reconstructed from EM-scale calibrated EMCal and HCal towers utilizing an iterative event-by-event UE subtraction
- Jets are calibrated with a multi-step calibration
  - MC derived JES calibration
  - Data driven calibration which accounts for data-MC differences





Event Plane Detector

- Event plane characterization capabilities with Event Plane Detector (sEPD) and Minimum Bias Detector (MBD)
- Both installed and well into commissioning period