The proposed sPHENIX detector at RHIC will allow state-of-the-art measurements of jets and jet correlations, making use of recent technological and conceptual advances. The kinematic reach of these measurements will overlap with those made at the LHC by taking advantage of the increased luminosity due to RHIC accelerator upgrades and the sPHENIX acceptance and rate capability. Particle jets, formed when a hard scattered parton fragments and then hadronizes into a spray of particles, have been proposed as a probe of the Quark-Gluon Plasma (QGP) and used extensively at the LHC. As these partons traverse the QGP, they lose energy to the medium, an effect called “jet quenching.” To answer fundamental questions about parton energy loss and the microscopic nature of the QGP, we need to characterize both the medium induced modification of the jet fragmentation and the correlation of the lost energy with the jet axis. Photon-jet correlations are especially useful as the photon kinematics are more tightly correlated with the hard scattered parton. Jet fragmentation and jet structure measurements, which require the precise tracking and calorimetry that are part of sPHENIX, will provide highly detailed information about the interaction of the parton with the medium. We will show the performance of jet and photon-jet observables within the sPHENIX simulation framework developed for understanding the performance of the new detector.

Jet physics at sPHENIX

- Uniform and hermetic in |η|<0.65 and 0<|φ|<2π
- Electro-Magnetic Calorimeter (3B X0, 1 μ)
- tungsten-scintillating fiber
- located between EMCal and SC Magnet
- Potential to be instrumented for increased performance
- Outer Hadronic Calorimeter (3.8 μ)
- Steel plates and scintillating tiles with WLS fibers
- Also serves as the flux return
- Jet radius down to R=0.2 (fine segmentation)
- Jet radius resolution:
  - dR<120%/E_p in p+p for R=0.2, 0.4
  - dR<150%/E in central Au+Au for R=0.2
- Jet energy resolution in EMCal: dE/E<15%/E
- Tracking resolution: dφ=0.2% (for 40 GeV jet)
- Track reconstruction efficiency ~90 % for p_t > 5 GeV/C
- Jet Simulation
  - Anti-k_t algorithm with Fastjet package
  - Full GEANT4 simulation
  - NuPy@4 simulation
  - PYTHIA jets for p+p
  - PYTHIA+HIJING for Au+Au
  - p_t=0-4 fm (0-7%)
  - p_t=4-8 fm (7-30%)

Jet Response and Resolution

- Reconstructed calorimeter jet p_t / Particle-level truth jet p_t
- Similar response in p+p and Au+Au (no centrality dependence) for the same R
- JER is worse for larger R
- At large R and low p_t dominated by fluctuations in the underlying event
- At small R or high p_t dominated by an intrinsic resolution of calorimeter system

Jet Response

Jet Energy Resolution

Dijet Asymmetry

- Sensitive observable to jet quenching in QGP
- Dijet observables are much less contaminated by fake jets as inclusive jet measurements
- No centrality dependence at RECO level

Photon+Jet p_t balance

- Photon provides good access to parent parton energy of the associated jet
- Also useful for jet energy calibration
- y Jessie mainly initiated by quarks
- Flavor comparison between quark and gluon jets
- TRuth p_t information is used

Fragmentation Function

- Redistribution of energy within parton shower is an important observable for understanding the underlying dynamics of jet quenching
- jTruth charged-particle kinematics are used

Calibration study in p+p

- Different EMCal calibration to EM vs. hadronic showers
- Response depends on longitudinal center of gravity
- Calorimeter segments need to be calibrated separately
- EMCal clusters with hadronic energy (E_{had,EMCal}) and with EM energy (E_{EMCal}) are separated using
  1) Cluster-Track matching and 2) E_{EMCal}/E_{had,EMCal} cut
  - Scale factors A, B, and C (B+0 for MIE 2018 configuration)

Data-driven calibration technique using y-jet events

- Reconstructed photon energy as a reference
- A,B,E determined by minimizing the quantity with MINUIT:
  $\frac{\sum (E^{\text{gen}}_{\gamma} - E^{\text{rec}}_{\gamma})^2}{\sum E^{\text{gen}}_{\gamma}^2}$

Conclusions and Outlook

- Jet measurements provide us better understanding of parton energy loss mechanisms in the QGP
- sPHENIX, the new generation experiment at RHIC, will allow a direct comparison to the LHC
- Expanded kinematic range (jet up to ~70 GeV)
- Jet performance satisfies our specification
- Investigation into the various LHC-inspired observables (A, k_T, fragmentation, etc.) is underway
- Calibration using y-jet events is developed in p+p
- Need further study to extend calibrations to Au+Au

Jet Simulation

Jet Response

Jet Energy Resolution

Dijet Asymmetry

Photon-tagged jet

Sensitivity of jet energy to parton energy