Jet spectra and jet structure measurements with sPHENIX

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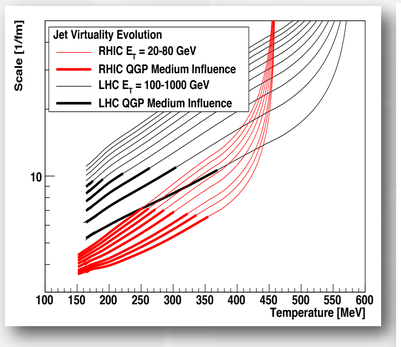
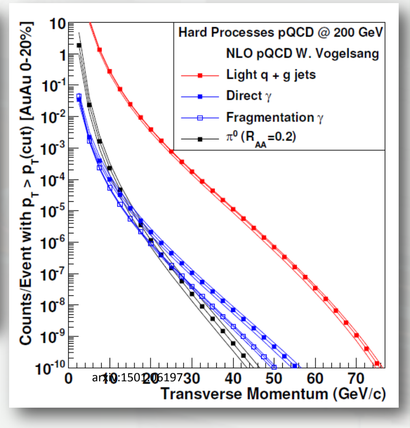
Abstract

The sPHENIX proposal is for a second generation experiment at RHIC, which will take advantage of the increased luminosity due to accelerator upgrades, and allow measurements of jets and jet correlations with a kinematic reach that will overlap with measurements made at the Large Hadron Collider (LHC). Particle jets, formed when a hard scatter parton fragments and then hadronizes into a spray of particles, were proposed as a probe of the Quark Gluon Plasma formed in heavy-ion collisions. As they traverse the QGP, the hard scattered partons probe the medium at a variety of length scales, which is called jet quenching. To answer the fundamental questions of how and why partons lose energy in the QGP, we need to characterize both the medium induced modification of the jet fragmentation pattern and the correlation of the lost energy with the jet axis. Some observables that help elucidate these effects are gamma-jet correlations and jet fragmentation functions, which require the precise tracking and calorimetry that sPHENIX will have. We will show the performance of these observables as well as that for jet and hadron spectra measurements, which are necessary for a baseline understanding, based on detector simulations.

Jets at sPHENIX

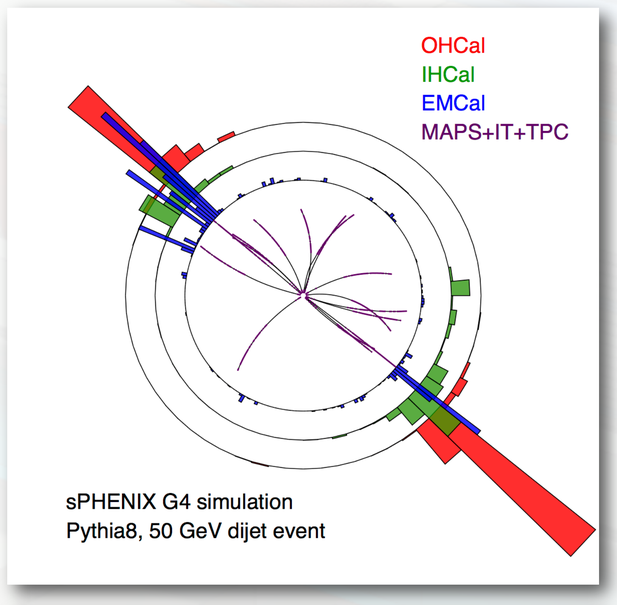
- Sample ~50 billion Au+Au events in 1 year
  - 10^7 jets > 20 GeV
  - 10^6 jets > 30 GeV
  - 80% are dijet events
  - 10^4 direct γ > 20 GeV
- Required Detector Performance
  - Single particle resolution: $\sigma_E/E < 100\%/\sqrt{E}$
  - Jet: $\sigma_E/E < 120(150)\%/\sqrt{E}$ in p+p(Au+Au)
  - Photon Energy resolution $\sigma_E/E<15\%/\sqrt{E}$
  - dp/p ~ 0.2% p to > 40 GeV/
- Jets interact minimally until their virtuality ~ medium virtuality
  - Jets from the highest collision energies are mostly vacuum (pQCD) dominated
    - **Measure low E_T jets at RHIC energies!**



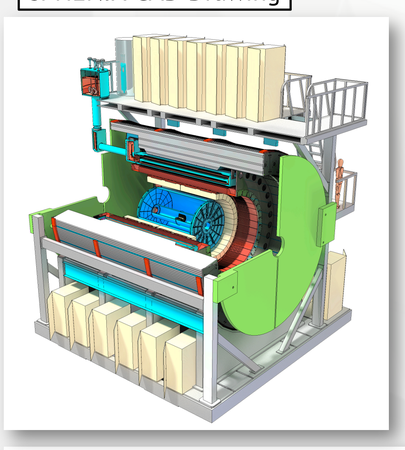


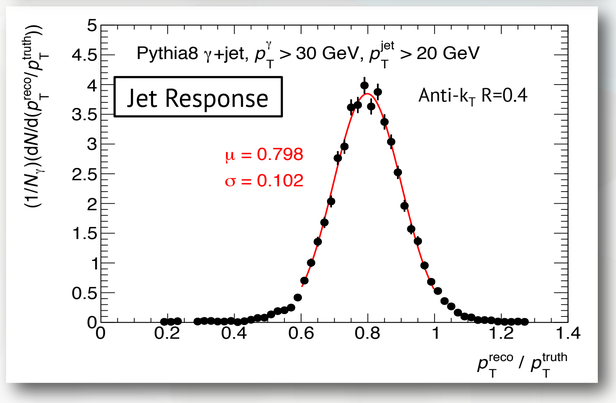
Di-Jet Event Display

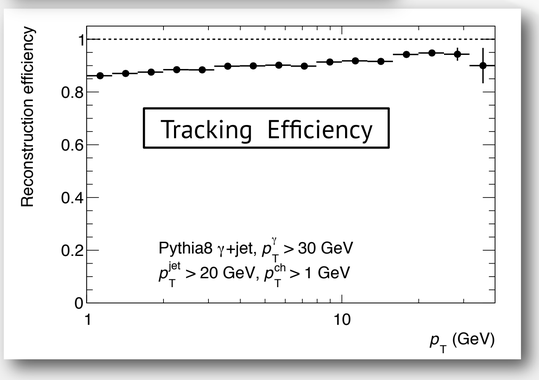
- We have been testing the performance of jet, photon, and track reconstruction with the latest G4 simulations of sPHENIX
  - Full G4 simulations + more sophisticated detector description
- EMCal + HCAL give hermetic jet measurement
  - High resolution tracker will allow jet structure measurements
    - Jet modification
    - Energy flow
  - No autocorrelations!
- Jet algorithms for clustering and background removal are under investigation
- γ-jet events
  - Photon clustering algorithm

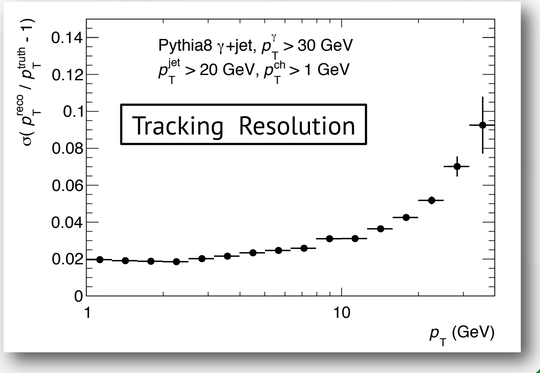


sPHENIX CAD Drawing



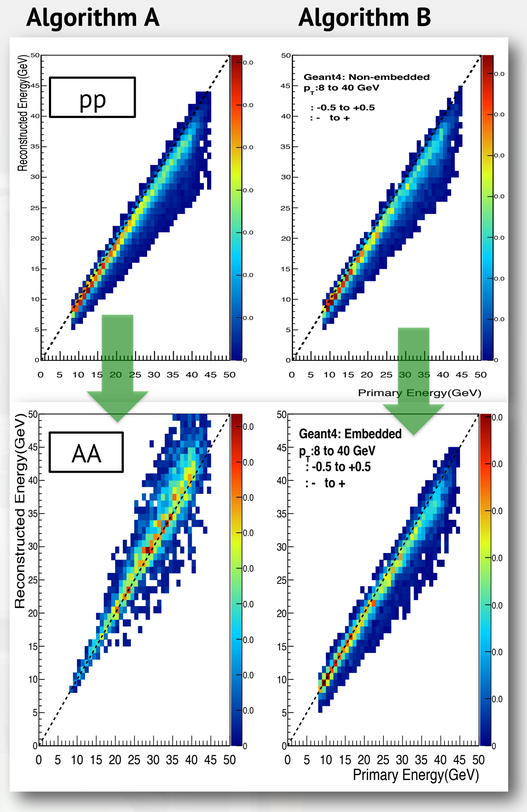


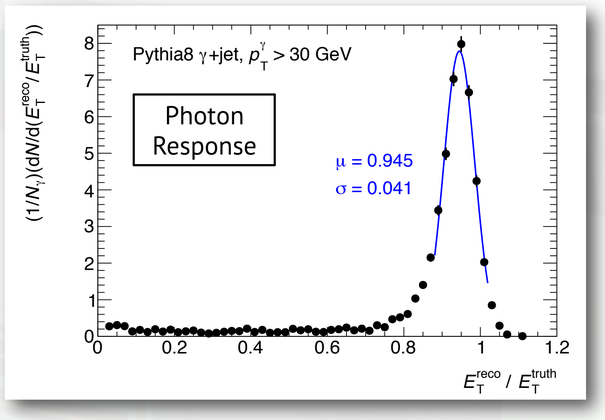




Photon Clustering Algorithms

- Algorithm A
  - Cluster = contiguous towers E > $E_{threshold}$
- Algorithm B
  - Noise reduction → E > $E_{threshold}$
    - Neighboring towers which satisfy noise threshold = "isolated cluster"
  - Find "local max tower" and "peak area" around it
  - E_{tower} with contribution from 2+ peak areas divided into peak areas
    - Parameterized shower shape function
  - Redefine "core cluster" within cluster area as towers E_{sum} > $E_{threshold}$ of peak area



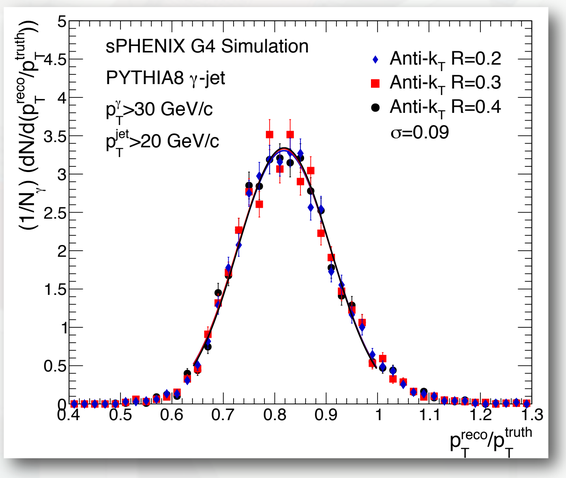


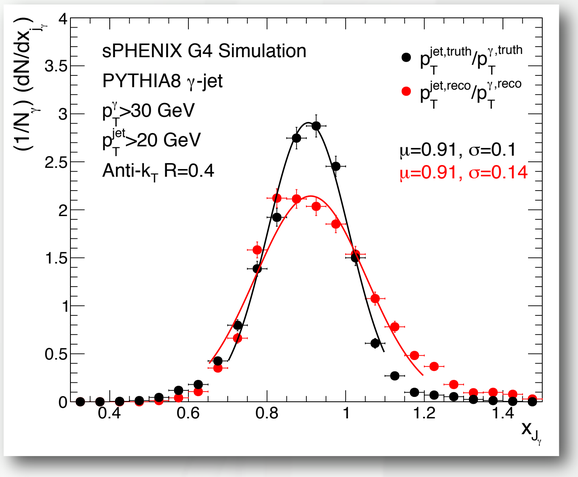
Algorithm B is the PHENIX clustering algorithm

Jet-to-photon p_T balance

- Simulation of γ-jet events with PYTHIA
  - γ events are the "golden" probe
  - Compare energy clustered into jet versus photon
  - Effect of detector resolution

$$X_{J\gamma} = \frac{p_T^\gamma}{p_T^{jet}}$$

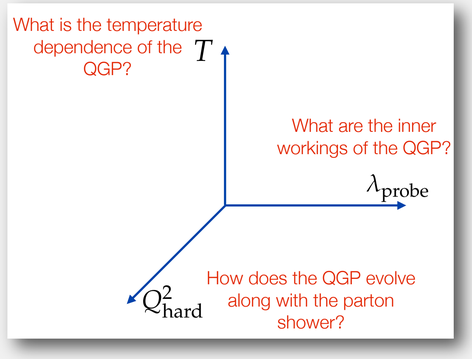




- Performance with heavy ion background needs to be quantified
  - **What is the best R choice?**
- γ-jet events dominated by quark jets
- Allows a flavor comparison between quarks and gluons
- Other observables under consideration

Conclusions and Outlook

- Jets allow us to address the important fundamental questions of "how" and "why" partons lose energy in the QGP
  - There has been significant progress in our understanding of quenching
- Jet quenching measurements at RHIC provide significant constraints on the partonic E_{loss} mechanisms
- sPhenix increased capabilities will allow a direct comparison to the LHC
  - Large data rate will allow data collection without imposing online trigger "biases
  - LHC inspired observables will be measured at RHIC
- Progress is underway in evaluating the effect of detector design choices on jet structure observable
- Investigation into the significance of the various LHC inspired observables underway
- Fully embedded PYTHIA + HIJING events will be used "to evaluate the performance of the background subtraction
  - jet energy measurements
  - photon isolation
  - calorimeter clustering



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