Multiplicities of Hadrons Within Jets at STAR

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ABSTRACT

Jet measurements have long been tools used to understand QCD phenomena. There is still much to be learned from the production of hadrons inside of jets. In particular, hadron yields within jets from proton-proton collisions have been proposed as a way to unearth more information on gluon fragmentation functions. In 2011, the STAR experiment at RHIC collected 23 pb^{-1} of data from proton-proton collisions at $\sqrt{s} = 500\ GeV$. The jets of most interest for gluon fragmentation functions are those with transverse momentum around 6-15 GeV/c. Large acceptance charged particle tracking and electromagnetic calorimetry make STAR an excellent jet detector. Time-of-flight and specific energy loss in the tracking system allow particle identification on the various types of hadrons within the jets, e.g., distinguishing pions from kaons and protons. An integral part of analyzing the data collected is understanding how the finite resolutions of the various detector subsystems influence the measured jet and hadron kinematics. For this reason, Monte Carlo simulations can be used to track the shifting of the hadron and jet kinematics between the generator level and the detector reconstruction level. The status of this analysis will be presented.

ACKNOWLEDGEMENTS

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BACKGROUND

Jets are the shower of particles generated by hadronizing scattered partons; the partons fragment into a jet. Simply, jets form when a single color-carrying parton fragments into many color-neutral hadrons.

We study the production of hadrons inside jets because the observable provides a window on to so-called "**fragmentation functions**" that describe the particle structure of the jets. Proton-proton (p+p) scattering involves a very different mix of parton interactions, e.g. compared to e+p and $e^+ + e^-$, and has the potential to provide unique information to existing fragmentation functions, as well as new information, particularly with gluons.

Jets can be studied on three different levels (Fig.1).

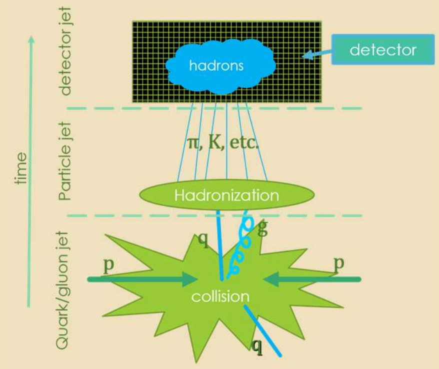


Figure 1. Pictorial representation of jet "levels".

KINEMATICS of PIONS WITHIN JETS

$$Z: \frac{momentum\ of\ pion}{momentum\ of\ jet}$$

$$j_t: pion\ momenum\ perpendicular\ to\ jet$$

RHIC and STAR

The Relativistic Heavy Ion Collider (RHIC) (Fig.2) is located at Brookhaven National Laboratory (BNL). The Solenoidal Tracker at RHIC (STAR) (Fig.3) detector is an excellent detector for jet measurements due to its large acceptance for detecting charged particles and neutral energy, and its ability to identify particles, thus allowing us to study hadronization of specific particles. STAR's full jet reconstruction capability is unique to RHIC.

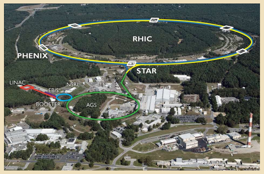


Figure 2. Aerial photo of RHIC.

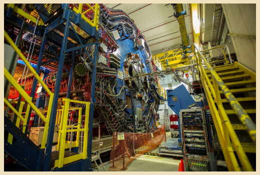


Figure 3. The STAR detector.

STAR SUBSYSTEMS

Some of the subsytems used for our analysis are the **Time Projection Chamber** (TPC), **the Time of Flight** (TOF), and the **Barrell Electromagnetic Calorimeter** (BEMC) (Fig. 4). Part of the TOF system is the **Vertex Position Detector** (VPD), which provides timing information for particle ID and serves as a minimum bias event trigger. The TPC at STAR, was developed for high-multiplicity events and can handle more than 1000 tracks. It measures the dE/dx of individual tracks with a resolution of about 8%.

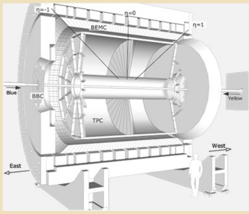


Figure 4. Cross section of the STAR detector showing the TPC and BEMC.

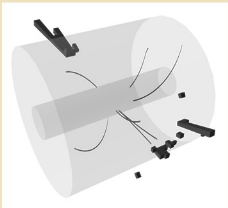


Figure 5. DiJet event at the detector level.

DATA AND METHODS OF ANALYSIS

Since detectors are imperfect, it is important to understand how the raw data values are distorted from the true values due to effects such as finite detector energy and position resolution or sensitivity to background events. Physics and detector simulations are such tools that can be used to correct collected data as well as to select the most desired events efficiently. The p+p interactions are simulated with PYTHIA 6.426 using the Perugia 0 tune, while the detector simulation uses GEANT3.21/08. To set up the detector simulation as realistically as possible we configure the simulations to have the same detector gains, efficiencies, and geometries as used by STAR in the 2011 run.

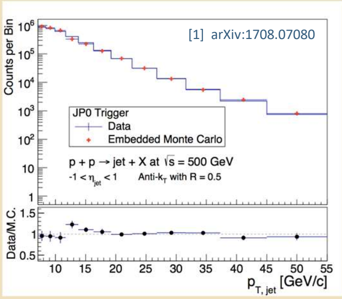


Figure 6: Detector level response and how it correlates with simulation data [1]

In order to understand the detector-induced distortions or "shifts" of the true kinematic information, we plot the shifting as a functions of j_T and z.

RESULTS/FUTURE WORK

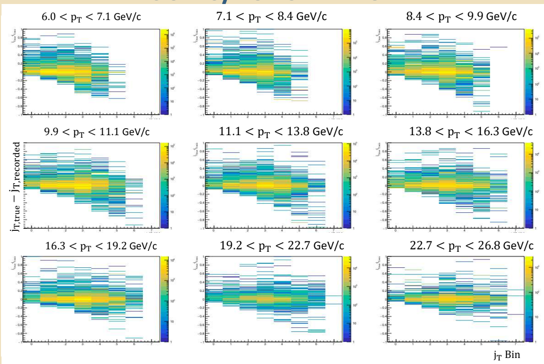


Figure 7. Results for π^+ and π^- (not shown) are consistent. The mean shift in j_T ranges from 0.005 to 0.02. The standard deviation is ~0.05 GeV/c with no strong dependence on j_T

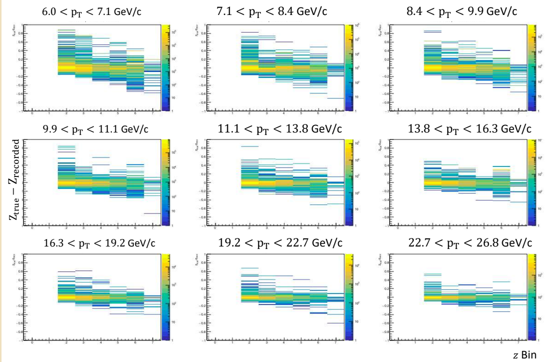
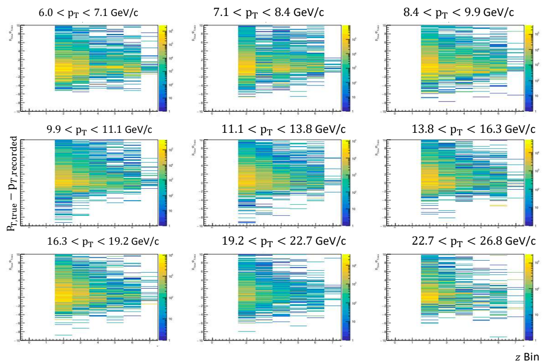


Figure 8 (above). The mean shift in Z ranges from 0.012 at low jet p_T and falls to 0.005 by 10 GeV/c. Over the same range, the standard deviation reduces from 0.056 to 0.02.

Figure 9 (below). The mean shift in p_T ranges from 0.05 at low jet p_T and rises to 0.2 by 10 GeV/c. Over the same range, the relative standard deviation falls slowly from ~0.25 to ~0.18.



An important next step is to decouple the various contributions to the irresolution in z, e.g. jet momentum resolution vs. pion momentum resolution. Optimizing the size of the bins at lower momenta may also lead to smaller systematic corrections. These serve as critical inputs for the future multidimensional "unfolding" procedure to correct reconstructed kinematics to their true values.

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