A Jet Shape Analysis with Au+Au Collisions Collected by STAR

Marcelo Almora Rios for the STAR Collaboration

Physics Department, Harvey Mudd College & Department of Physics and Astronomy, Rutgers University, USA

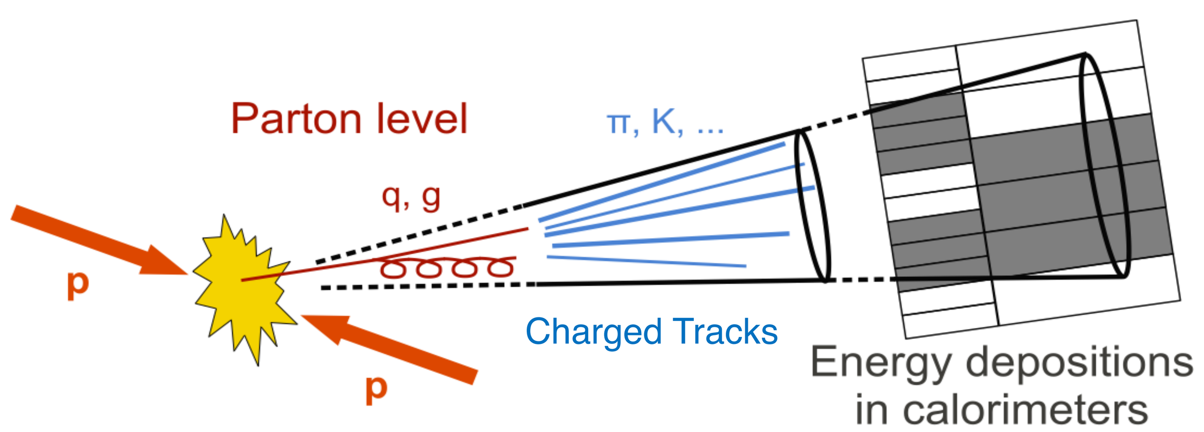
malmorarios@g.hmc.edu

Abstract

Quark-gluon plasma (QGP) is a unique state of matter that can be produced in relativistic heavy ion collisions. One way to study the properties of the QGP is by observing its "quenching" effects on the products of hard-scattered particles, or jets. Jets are studied in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using STAR experiment data taken at the Relativistic Heavy Ion Collider (RHIC). The jet shape observable, $\rho(r)$, is defined as the fraction of the total transverse momenta from charged particle constituents of a jet to the transverse momentum of the jet itself [1]. In this poster, we present the current status of a jet shape analysis for jets reconstructed with the anti-k_T sequential recombination algorithm in heavy ion collisions [2].

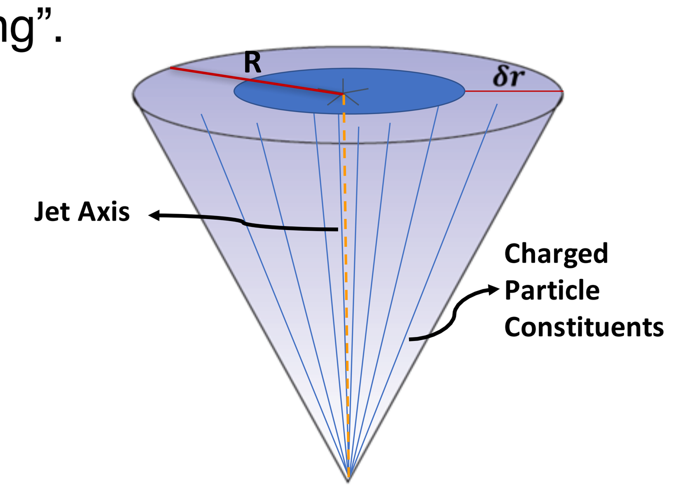
Introduction

In particle collisions, a hard (high momentum transfer) scattering, can occur between two partons resulting in a collimated spray of highly energetic product particles, known as a *jet*.

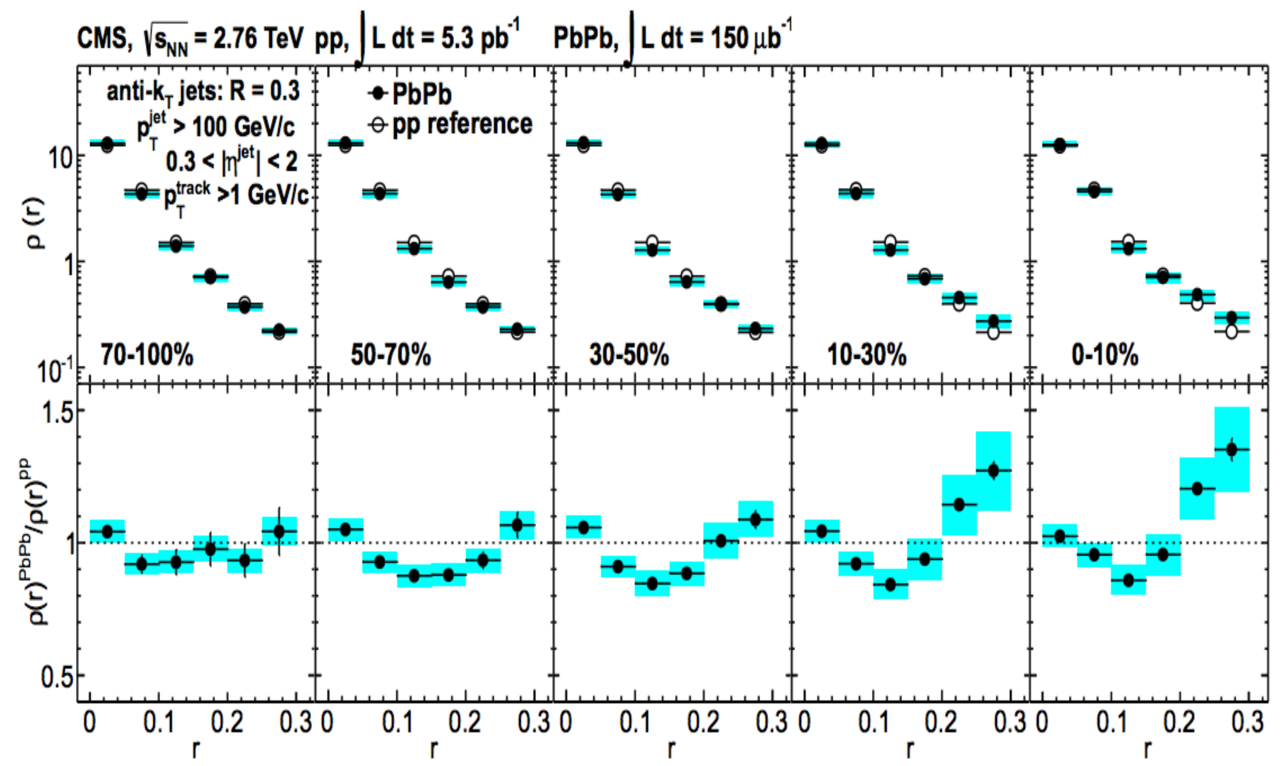


Jets are useful probes to study the properties of the QGP as their energy and shape distributions are expected to alter when they interact with the medium, known as "jet quenching".

$$\rho(r) = \frac{1}{\delta r}\frac{1}{N_{\text{jet}}}\sum_{\text{jets}}\frac{\sum_{\text{tracks}\in[r_a,\,r_b)} p_T^{\text{track}}}{p_T^{\text{jet}}}$$



The differential jet shape, $\rho(r)$, measures the jet's charged energy distribution as a function of radial distance $r = \sqrt{\Delta\eta^2 + \Delta\phi^2}$ from the jet axis. This can be constructed with the above formula using $\frac{R}{\delta r}$ annuli bins, where *R* is the jet resolution parameter, and δr is the radial width of each annulus. Jet *broadening,* as a result of jet-medium interactions, is observed by the CMS experiment at the Large Hadron Collider (LHC) with these jet shape measurements [1]. When comparing jet shapes between Pb+Pb and p+p (proton + proton) collisions, as Pb+Pb collisions become more central (head on), $\rho(r)^{\text{Pb+Pb}}$ grows relative to



Centrality-dependent jet shape as measured by CMS [1].

$\rho(r)^{\text{p+p}}$ at larger distances from the jet axis, meaning a greater percentage of the jet's energy is allocated at larger distances from this jet axis. This change is due to interactions between the jet and the hot dense medium as the jet traverses the medium. Larger changes are observed for the most central collisions due to increased interactions with the medium.

Analysis

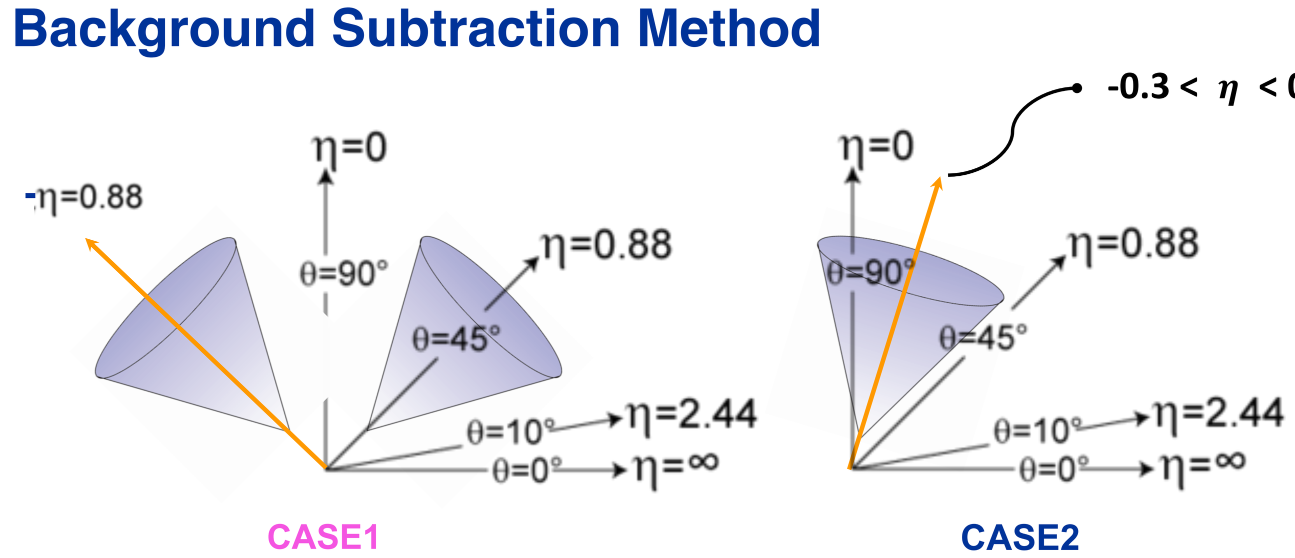
Event Selection

Events are selected with a high tower trigger requiring a transverse energy E_T > 4-5 GeV in one calorimeter tower. Note that the neutral energy fraction bias of jets containing this high tower will be further investigated in the future. 350M triggered events collected by STAR in 2014 were used in this analysis.

Jet Analysis

Jets are reconstructed with the anti-k_T sequential reconstruction algorithm within the FastJet [2] framework with charged and neutral constituents for R = 0.3. The underlying average background energy per unit area is estimated by using the k_T algorithm and subtracted from the raw jet momentum. A jet area A_{jet} is also measured by FastJet and used in this subtraction.

Background Subtraction Method



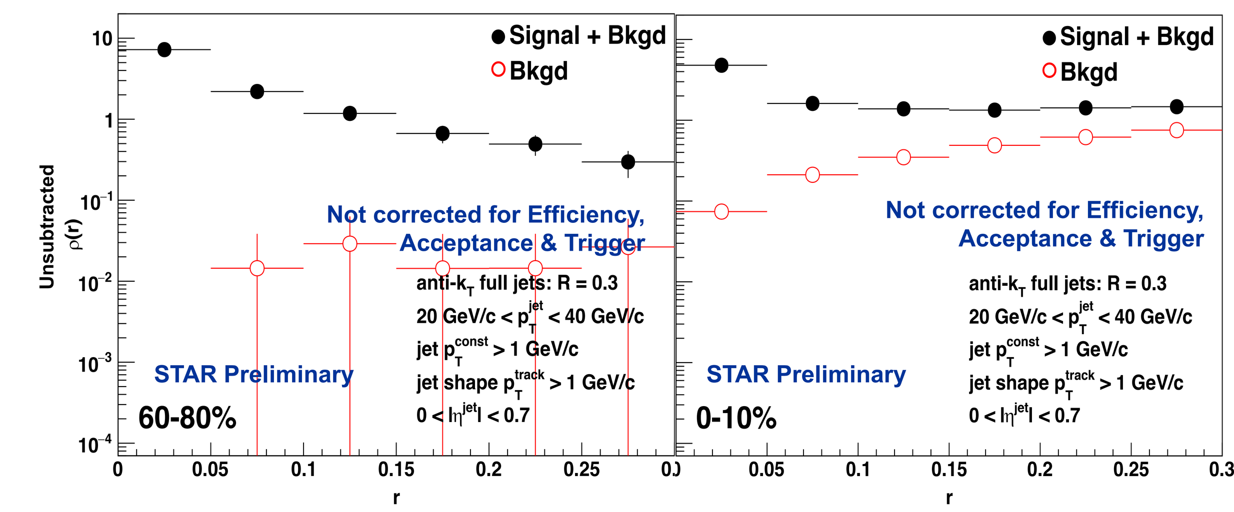
Case1: η reflection method.
Case2: φ shift method.

Case1: Jet axis $|\eta|$ > 0.3, background jet axis defined with η to -η reflection.

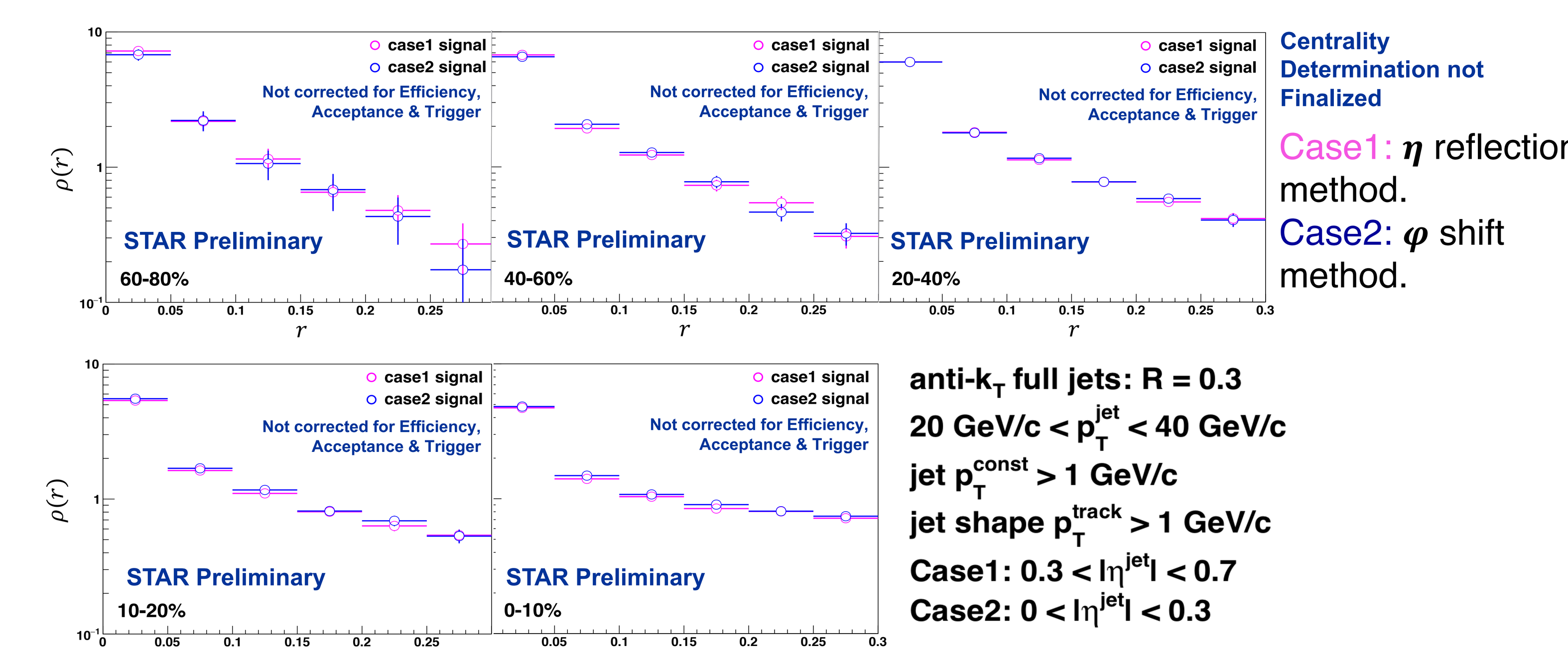
Case2: Jets axis $|\eta|$ < 0.3, background jet axis defined with a 90° shift in φ.

Current Results

Inclusive jet shapes before background subtraction (black circles) and background jet shapes (red circles) in peripheral and central Au+Au collisions are measured. This jet shape measurement is not corrected for efficiency, detector acceptance and trigger effects. Background energy



increases with increasing r due to the increase in area of each annulus. Background is also larger in central collisions than the peripheral due to higher multiplicities contributing to larger values of $\rho(r)$. A first look at the comparison of jet shapes after background subtraction for different centrality bins is presented in the figure below for two separate cases.



A good agreement of jet shapes corrected with two different methods is observed. To make a centrality dependent comparison of jet shapes and evaluate the jet broadening at RHIC energies, tracking efficiency and acceptance corrections together with the effect of high tower trigger selection needs to be estimated. Future work includes finalizing all corrections including p_T smearing, and analyzing p+p collisions for the jet shape $\rho(r)^{\text{p+p}}$ in order to compare our findings for $\rho(r)^{\text{Au+Au}}$.

Acknowledgements

This project has been supported by funding from National Science Foundation grant no. PHY-1560077 and PHY-1352081.

References

[1] Chatrchyan S. et al., Modification of jet shapes in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV, Phys. Lett. B730 (2014) 243-263

[2] Cacciari M., Salam G. P. and Soyez G., FastJet User Manual, CERN-PH-TH-2011-297