Studying Jet Quenching Effects in Jets Recoiled From Direct Photons

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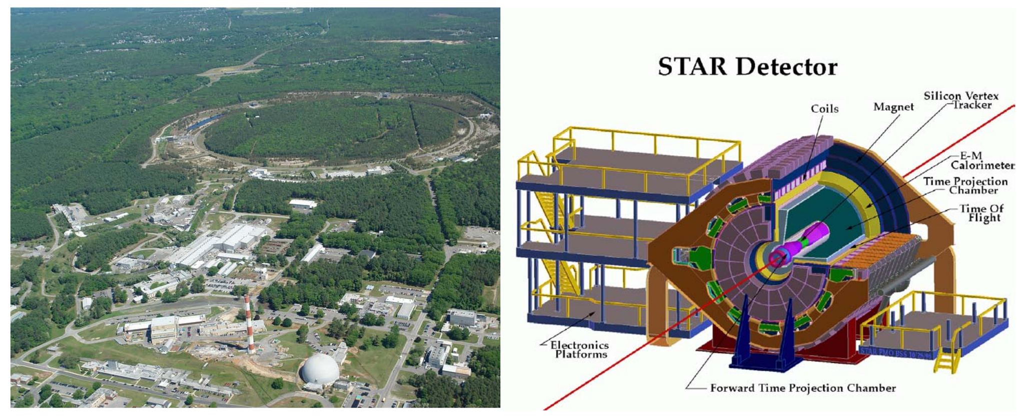
STAR at RHIC

- the Detector: Solenoidal Tracker at RHIC (**STAR**)
- the Collider: Relativistic Heavy Ion Collider (**RHIC**)
- located at Brookhaven National Laboratory
- 3.8 km in circumference
- capable of accelerating particles as heavy as gold to nearly the speed of light
- the STAR project consists of over 600 collaborators from 55 institutions and 12 countries around the world



Aerial view of RHIC (*left*) Diagram of the STAR Detector (*right*)

Quark-Gluon Plasma

- quarks are fundamental building blocks of matter and interact via the strong nuclear force, which is mediated by gluons
- quarks are confined to exist in pairs (mesons) or triplets (baryons), which are collectively called hadrons
- at high enough temperatures/densities, quarks can lose confinement property and exist in a new state of matter
- the Big Bang created temperatures that were high enough such that the universe consisted entirely of this different state of matter
- this matter is referred to as quark-gluon plasma (**QGP**)
- shortly after (10^{-6} seconds) the Big Bang, the quarks combined to create hadrons and the QGP ceased to exist

QGP at RHIC

- gold ions are collided at center-of-mass energies up to 200 GeV to create the plasma
- goal is to recreate the conditions of the early universe in hopes of discovering new physics
- QGP exists for ~10^{-23} s
- challenge of detectors is to characterize the matter based on particles emitted

Studying the QGP

- because the QGP exists for such a short period of time and in such a small volume in the laboratory, it is difficult to study the medium directly
- one method for probing the matter is through the study of jets

Jets and Jet Quenching

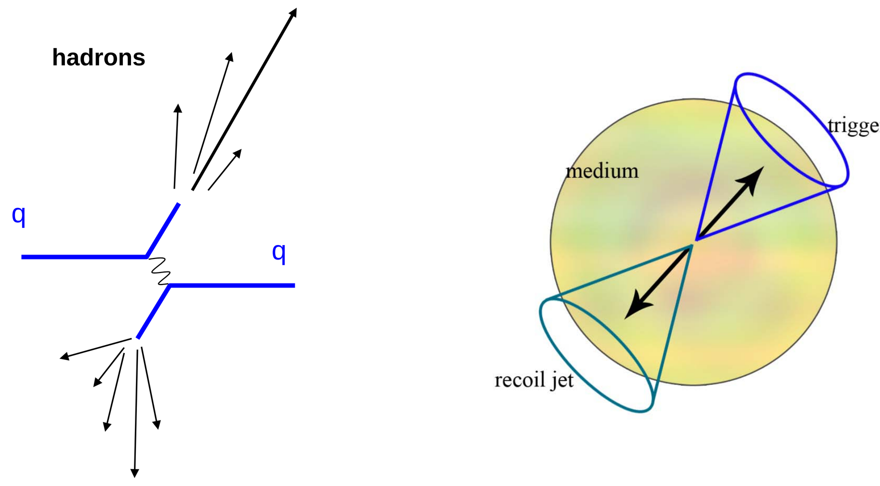
- jets are cone-like clusters of particles with high transverse momentum (**p_T**)
- jets are created in hard parton (quark/gluon) collisions as a result of confinement
- when a parton interacts with the dense color-charged medium, it loses energy, resulting in the quenching of jets [1]
- jet measurements in gold-gold collisions are a probe of the matter created

Jet Reconstruction

- must recombine individual particles into their associated jets
- not every particle is part of a jet, so background particles must be subtracted
- The algorithm used in this analysis is the "Anti-k_T" algorithm [2]
  - sequential recombination algorithm based around the idea of grouping particles close in proximity and with close p_T

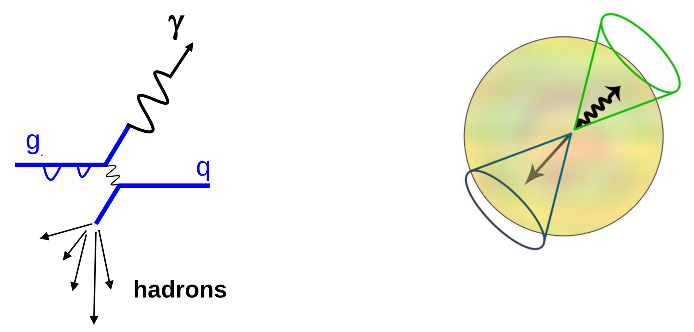
Di-Jet Events

- to investigate jet-quenching, one can select a high energy trigger jet and look for a recoil jet on the opposite side
- by comparing the yields and momenta of recoil jets to trigger jets, one can quantify effects of jet quenching
- if the trigger jet also traversed medium, the measured jet energy may not reflect the original parton energy



Photon-Jet Events

- sometimes when a parton is scattered, it creates a jet and a direct photon, rather than two jets



- the purpose of this study is to investigate the usefulness of these direct photons as the selection for the triggers
- because the photons carry no color charge, they will not interact with the dense color-charged medium
- because they do not interact with the medium, the measured photon energy is nearly equivalent to the original recoil parton energy
- photons' ability to penetrate the color-charged medium will allow for a measurement relative to the original parton energy, as well as future studies of fragmentation photons

Direct Photons vs. Decay Photons

- a common particle found in jets is the π^0 meson, which quickly decays into a pair of photons
- to differentiate a direct photon from a decay photon, a transverse shower profile (**TSP**) is measured in the Shower Maximum Detector, which is embedded in the Barrel Electro-Magnetic Calorimeter [3] at ~ $5X_0$.
- γ^{rich} sample is ~60-70% direct photons in 10% most central Au+Au events

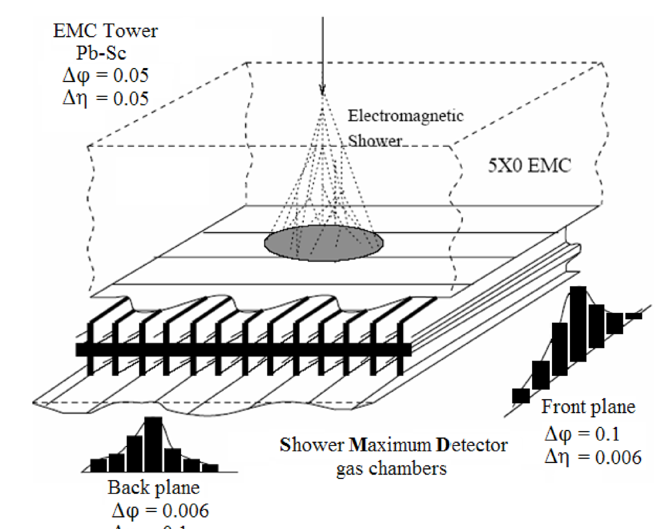
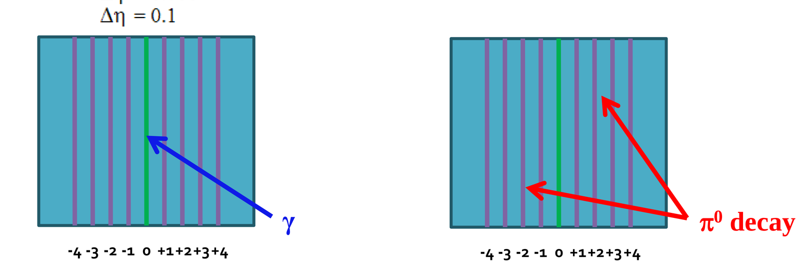
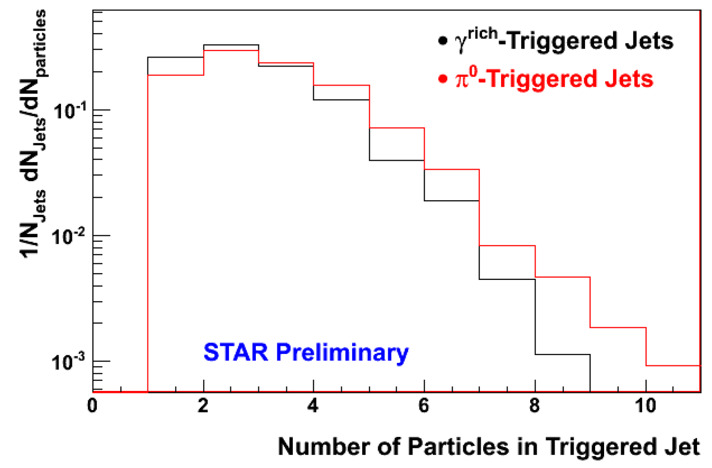


Diagram of the Shower Maximum Detector (*left*); A π^0 will have a shower wider than that of a single γ (*below*)

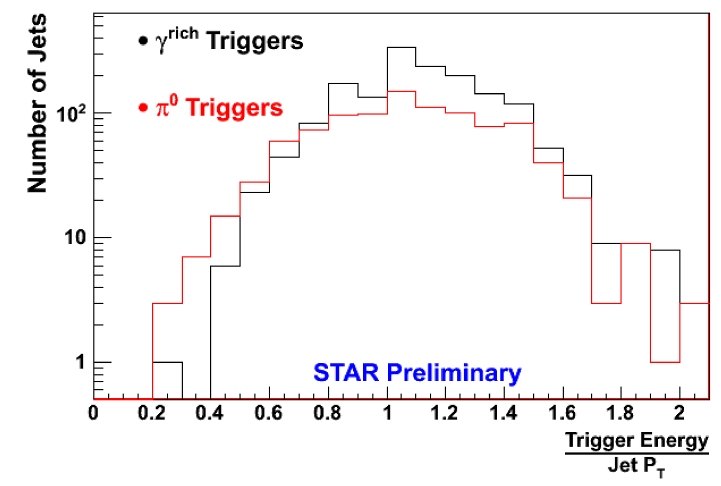


Results

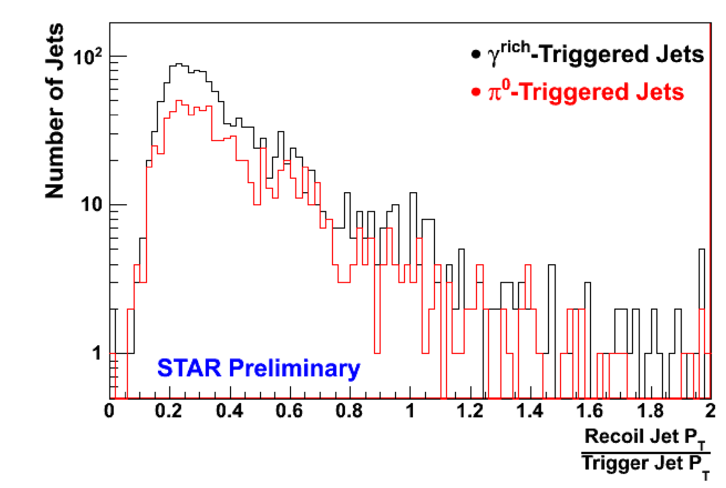
- data from Au+Au collisions in 2007, triggered on high energy photon, was used for this study
- the anti-k_T algorithm was used to reconstruct jets with FastJet software [2].
- p_T cut for particles included in jet is $p_{T particle}$>2 GeV
- 0-10% most central events
- no corrections for fake jets



- On average, jets containing a π^0 have slightly more particles than jets containing γ^{rich}
  - π^0 jets: $\langle N_{particles} \rangle \approx 2.80$
  - γ^{rich} jets: $\langle N_{particles} \rangle \approx 2.42$



- On average, γ^{rich} triggers carry slightly larger fractional energy of total jet p_T than π^0 triggers



- No difference is observed in the comparison of total p_T of recoil jets for γ^{rich} vs. π^0 jets

References

[1] S.S. Adler et al., Phys. Rev. Lett. 91, 072301 (2003), J. Adams et al., Phys. Rev. Lett. **97**, 162301 (2006).
[2] Matteo Cacciari, Gavin P. Salam. B **641**, 57 (2006), M. Cacciari, G.P. Salam and G. Soyez, http://fastjet.fr/
[3] M. Beddo et al., Nucl. Instrum. Meth. A**499**, 725 (2003)