Reconstruction of neutral-triggered charged recoil jets in $\sqrt{s} = 200$ GeV p+p collisions at the STAR experiment

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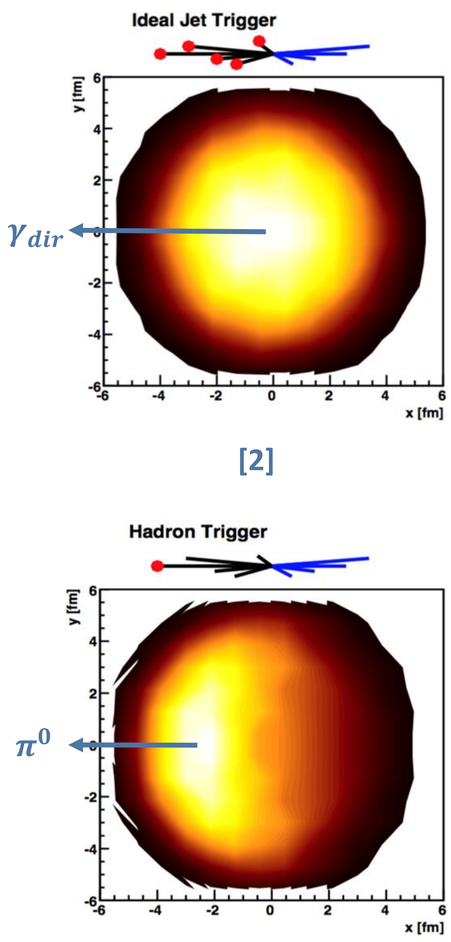
Abstract

Jets – collimated sprays of hadrons – are produced by the hard-scattering of partons during the early stages of heavy-ion collisions. Hence, they provide a valuable probe of the complex, multi-particle dynamics within the hot, dense medium produced in such collisions. In particular, the study of jets recoiling from direct photons (γ_{dir}+jet) and those recoiling from energetic π^0 (π^0+jet) may shed light on the path-length and initial flavor (quark vs. gluon) dependence of the energy-loss experienced by a parton as it traverses the medium. We present here the measurement of the yields of charged recoil jets tagged by γ_{dir} and π^0 in p+p collisions at $\sqrt{s} = 200$ GeV recorded during the running year 2009 which will serve as a vacuum fragmentation reference for an upcoming measurement in Au+Au collisions.

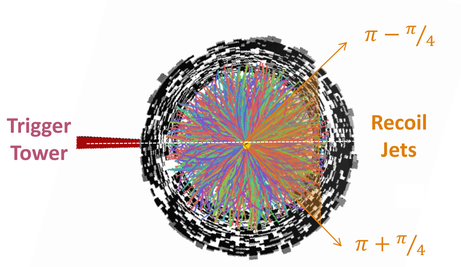
Motivation

- **Prompt Photons (γ_{prompt}):** photons produced by the hard scatter of partons
  $$\Rightarrow E_T^{\gamma} \approx E_T^{parton}(t_0)$$
  ∴ Recoiling partons are well calibrated probes of energy loss [1]
- Experimentally measure **direct photons (γ_{dir}):**
  - Mixture of prompt, thermal, and fragmentation photons
- Comparing γ_{dir}+jet to π^0+jet:
  a) Production of π^0 biased towards surface; γ_{dir} have no such bias [2]
  b) Production of γ_{dir} dominated by q-g Compton Scattering
  ⇒ Recoil jets from γ_{dir} should be **less suppressed** on average
- I_{AA}: quantifies level of suppression
  $$I_{AA} \equiv D^{AuAu}/D^{pp}$$
  - D^{AuAu} and D^{pp} are per-trigger yields in Au+Au and p+p collisions
  - For recent measurement by STAR see [3]
- Measuring γ_{dir}/ π^0-triggered charged jet spectra in p+p for I_{AA} baseline



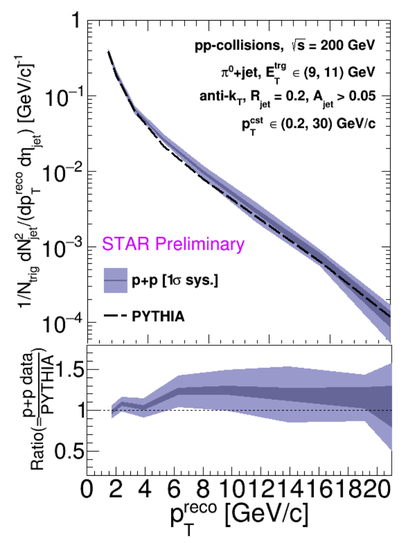
Jet Reconstruction

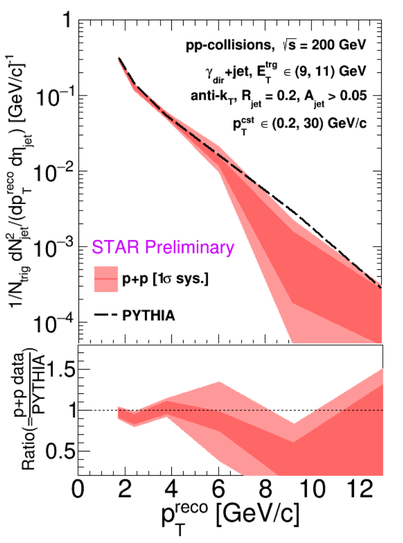
- Jets reconstructed using anti-k_T algorithm w/ $R_{jet} = 0.2$ using
  - TPC tracks w/ $p_T^{trk} \in (0.2, 30)$ GeV/c and $|\eta^{trk}| < 1$
  - Clustered using Fastjet 3.0.6 [5]
- Reconstructed Jets satisfy
  - $A_{jet} > 0.05$, $p_T^{jet,raw} > 0.2$, and $|\eta^{jet}| < 1 - R_{jet}$
- $p_T^{jet,raw}$ adjusted for background energy density via
  $$p_T^{reco} = p_T^{jet,raw} - \rho \cdot A_{jet}$$
  - Where $\rho \equiv \text{median}\{p_{T,i}^{jet,raw}/A_{jet,i}\}$ (excluding hardest jet in event)



- **Recoil jet:** any jet satisfying $\Delta\varphi^{jet} \in (3\pi/4, 5\pi/4)$
- **Charged jet:** a jet consisting only of TPC tracks

Corrected Spectra

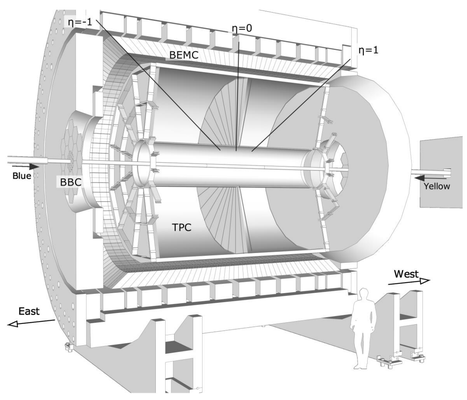


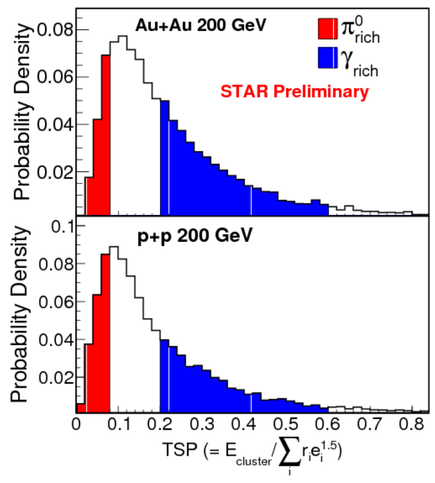


- Correction scheme follows recent $h^{\pm}$-jet measurement by STAR [6]
  - Jets corrected for detector effects and background fluctuations via iterative unfolding procedure
    - Bayesian algorithm w/ $n_{iter} = 4$ via RooUnfold [7]
  - Jet reconstruction efficiency then corrected bin-by-bin
- Corrected data are compared against Pythia 8 [8]
  - Darker bands indicate statistical uncertainty
  - **Dominant uncertainties:**
    - Unfolding (prior, algorithm, etc.)
    - Tracking efficiency
    - γ_{rich} background subtraction scheme (γ_{dir} only)

STAR and Neutral Triggers

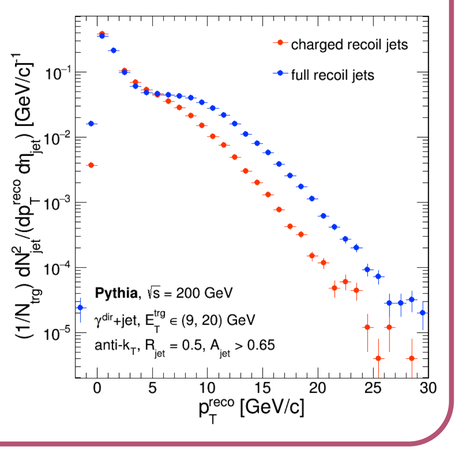
- Relevant subsystems:
  a) Time Projection Chamber (TPC):
  - Measure charged particle (track) p_T, η, φ, etc.
  b) Barrel Electromagnetic Calorimeter (BEMC):
  - Trigger on p+p collision w/ energetic γ_{dir}/π^0
- Triggers satisfy $E_T^{trg} \in (9, 20)$ GeV and $|\eta^{trg}| < 0.9$
  - Split into bins of E_T^{trg} w/ 9 – 11, 11 – 15, and 15 – 20 GeV
- **Barrel Shower Maximum Detector (BSMD):**
  - Grid of readout wires inside BEMC
  - Distinguishes γ_{dir}/π^0 via shower shape
- **Transverse Shower Profile (TSP):** quantifies shower shape [4]
  $$\text{TSP} \equiv E_{cluster}/\Sigma_i e_i r_i^{1.5}$$
  - $E_{cluster}$ is total energy of 1 – 2 tower cluster
  - e_i, r_i are energy, distance from cluster centroid of ith BSMD strip
- TSP used to split data into two samples:
  i. Sample of identified π^0 satisfying TSP < 0.08
  ii. Sample with enhanced fraction of γ_{dir} (labeled γ_{rich}) satisfying TSP $\in (0.2, 0.6)$
- Background level of γ_{rich} signal in p+p for $E_T^{trg} \in (9,11)$ GeV measured to be:
  $$B \approx 0.57 \pm 0.05$$





Conclusions and Future Work

- Charged recoil jets have been reconstructed in p+p collisions for γ_{dir}/π^0 triggers w/ $E_T^{trg} \in (9, 11)$ GeV
  - Corrected spectra are consistent with Pythia 8
- **Future work:**
  - Correct charged jet spectra for γ_{dir} and π^0 triggers with $E_T^{trg} \in (11, 15)$ and $(15, 20)$ GeV for $R_{jet} = 0.2, 0.5$
  - Extend analysis to full jets (consisting of TPC tracks and BEMC towers)



References

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