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

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Jets and Heavy-Ion Collisions

o Heavy-ion collisions produce a hot, dense medium consistent with QGP
  – e.g. Au+Au collisions at RHIC

o **Jets:** collimated sprays of hadrons from the fragmentation of partons
  – Produced in early stages of heavy-ion collisions
  ∴ Excellent probes of the medium

o **Jet Quenching:** suppression of energetic particles due to partonic energy loss
  – Partons lose energy via radiative and collisional interactions with medium
  – Depends on path length, "flavor" of jet, etc.

Schematic Time Evolution

Adapted from Tatsuya Chujo, JPS RHIC Symposium 2001
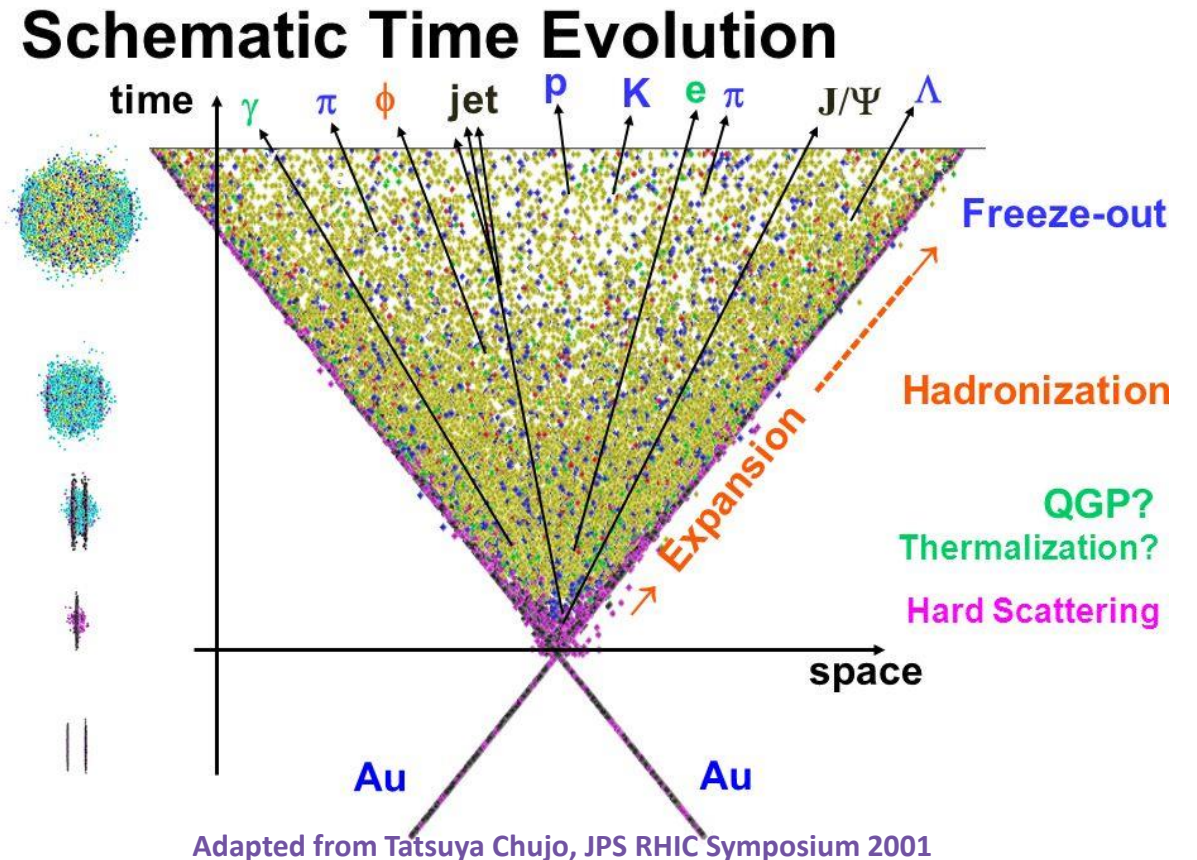
Prompt and Direct Photons

○ **Prompt photon (γ_{prompt}):** photon scattered from energetic partons

  – Doesn't strongly interact with medium so (to leading order)

  $$E_T^{\gamma} \approx E_T^{parton}(t_0)$$

  ∴ Recoiling parton provides a well-calibrated probe of partonic energy loss…

    › Wang et al.; PRL 77, 231 (1996)

○ An admixture of prompt, thermal, and fragmentation photons is measured

  – Collectively referred to as **direct photons (γ_{dir})**

  – Thermal contribution is negligible (at sufficiently large energies)

  – **Background dominated by hadronic decays**

Campbell; PRC 92, 014907 (2015)
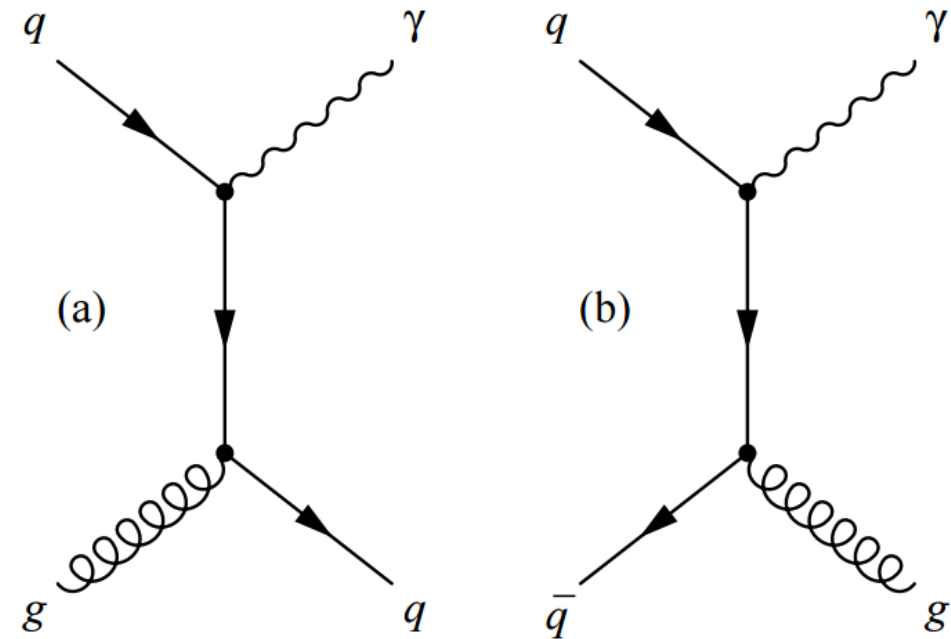
Neutral Triggers

○ Comparing γ_{dir} to π^0 triggers:

   a) Production of π^0 biased towards surface while γ_{dir} have no such bias

     › T. Renk, Phys. Rev. C **88**, 054902 (2013)

   b) Production of γ_{dir} dominated by quark-gluon Compton scattering

  ⇒ On average, jets recoiling from γ_{dir} should be **less suppressed** than those from π^0

○ I_{AA}: quantifies level of suppression

$$I_{AA} \equiv \frac{D^{AuAu}}{D^{pp}}$$

 – Where D^{AuAu} and D^{pp} are the per-trigger yields in Au+Au and p+p collisions

○ Now measuring charged jet spectra for γ_{dir} and π^0 triggers as a baseline for I_{AA}

Hadron Trigger — Ideal Jet Trigger

π^0 γ^{dir}
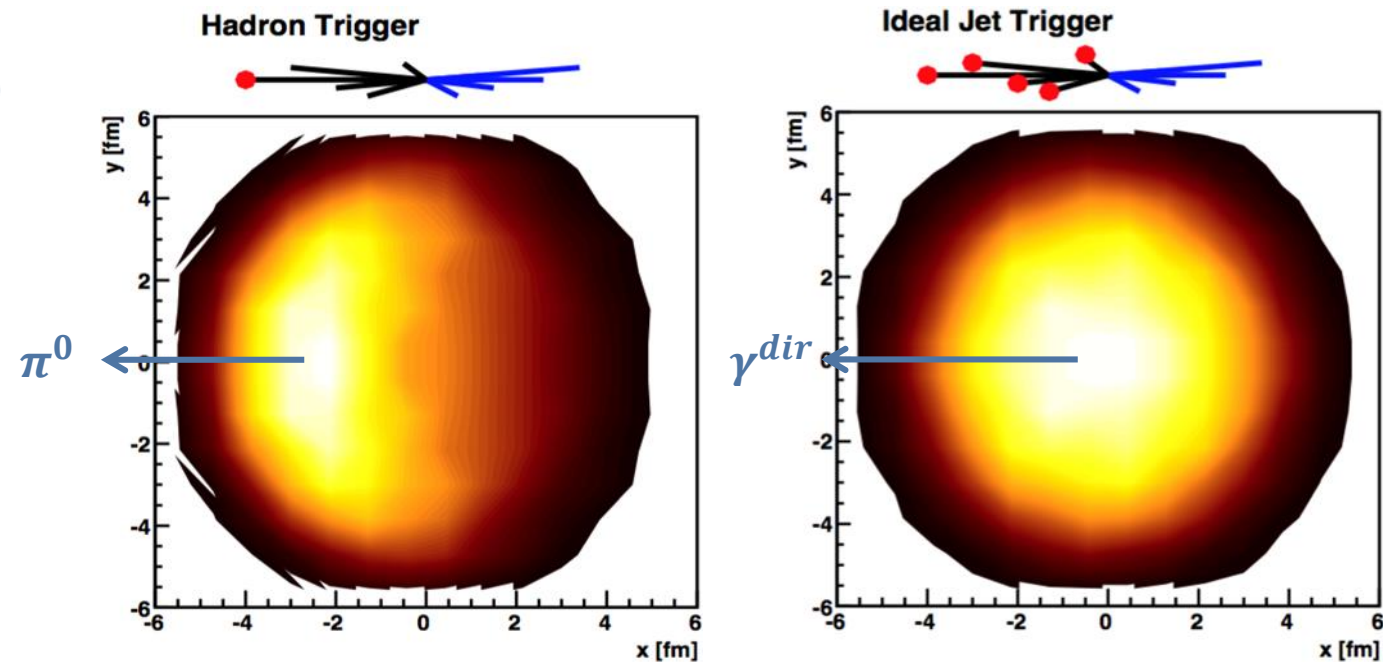
T. Renk; arXiv:1212.0646

STAR Detector

○ Relevant subsystems:

a) Time Projection Chamber (TPC):

› Measure charged particle (track) p_T, η, φ, etc.

b) Barrel Electromagnetic Calorimeter (BEMC):

› Used to trigger on p+p collision containing energetic γ_{dir} or π^0

○ Triggers satisfy $E_T^{trg} \in (9, 20)$ GeV and $|\eta^{trg}| < 0.9$

– Triggers then split into bins of E_T^{trg} with $(9, 11)$, $(11, 15)$, and $(15, 20)$ GeV

○ **Barrel Shower Maximum Detector (BSMD):**

– Located inside BEMC

– Distinguishes γ_{dir} and π^0 based on shower shape
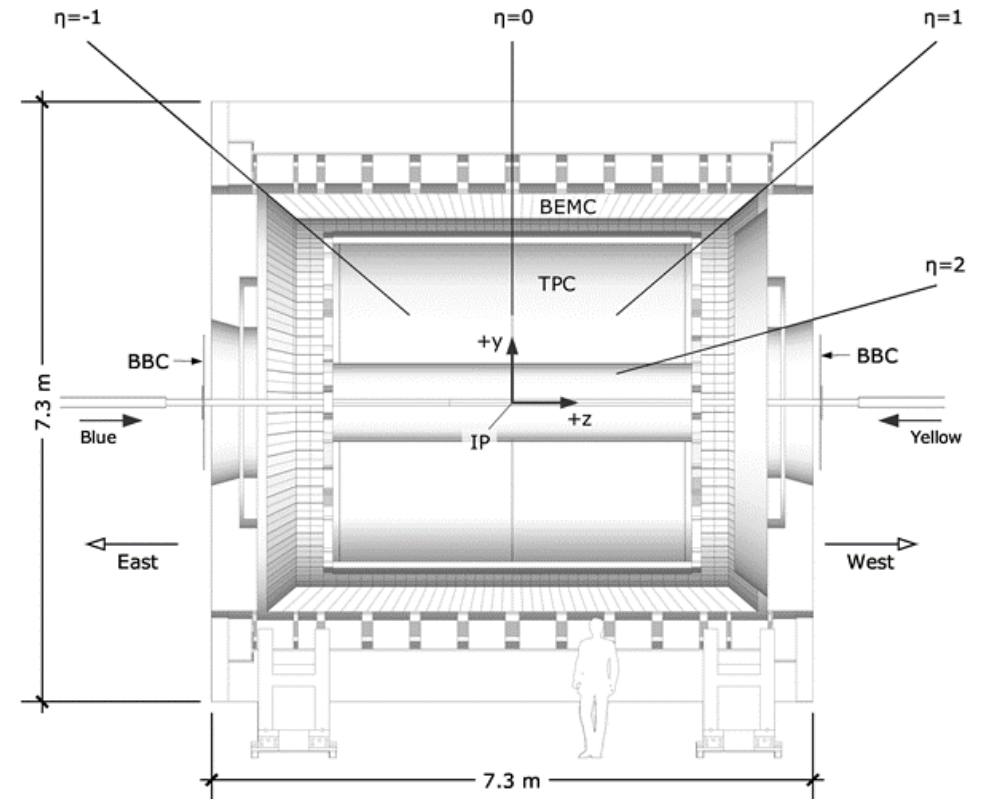
STAR; PRD 86, 032006 (2012)

TSP

- **Transverse Shower Profile (TSP):** quantifies shower shape

$$\text{TSP} \equiv \frac{E_{cluster}}{\sum_i e_i r_i^{1.5}}$$

  - $E_{cluster}$ is total energy of $1-2$ tower cluster
  - e_i and r_i are the energy and distance from cluster centroid of the ith strip
    - STAR, Phys. Rev. C **82**, 034909 (2010)

- TSP used to split data into two samples:
  i. A 95% pure sample of identified π^0 satisfying TSP < 0.08
  ii. A sample with an 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 is measured to be:
$$B \approx 0.57 \pm 0.05$$
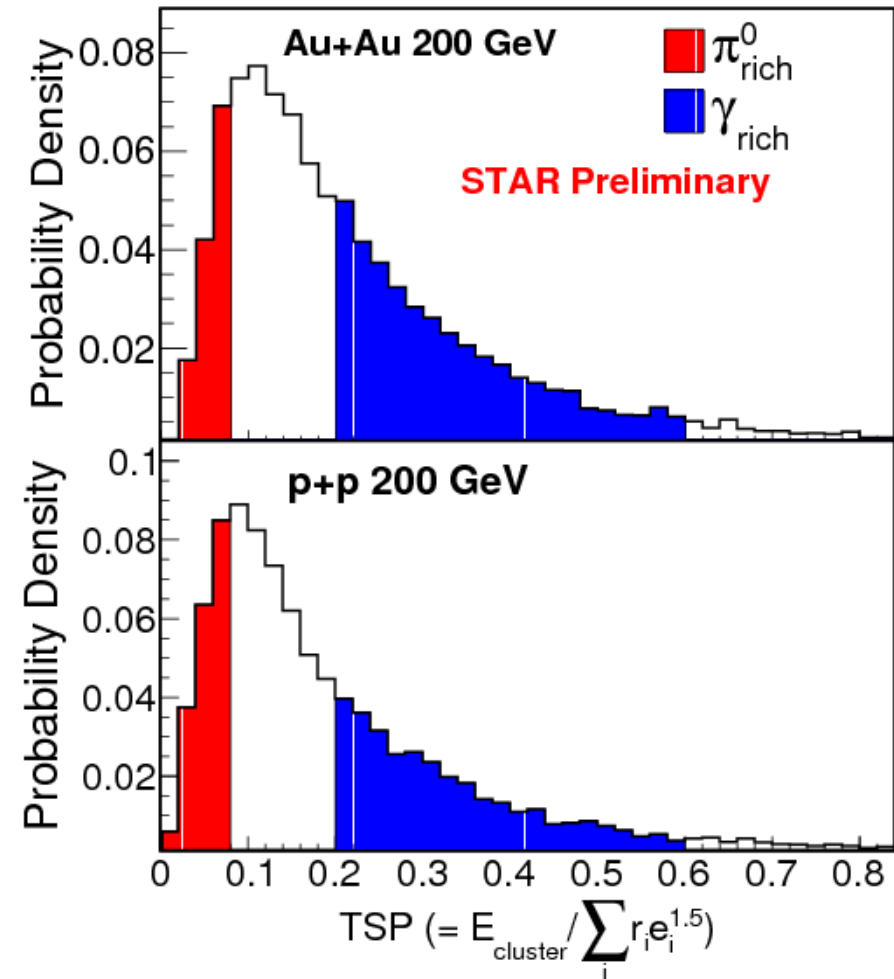
Jet Reconstruction

o Jets are reconstructed using the anti-k_T algorithm from
  - TPC tracks with $p_T^{trk} \in (0.2, 30)$ GeV/c and $|\eta^{trk}| < 1$
  - Clustered using Fastjet 3.0.6 for $R_{jet} = 0.2$ (0.5 and others in progress)
    › M. Cacciari, G. P. Salam, and G. Soyez, Eur. Phys. J. **C72**, 1896 (2012)

o Jet p_T adjusted for background energy density via

$$\boldsymbol{p_T^{reco} = p_T^{jet,raw} - \rho \cdot A_{jet}}$$

  - Where $\rho \equiv \text{median}\{p_{T,i}^{jet,raw}/A_{jet,i}\}$ excluding the hardest jet in the event

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

$\pi - \pi/4$

Trigger Tower

Recoil Jets

$\pi + \pi/4$
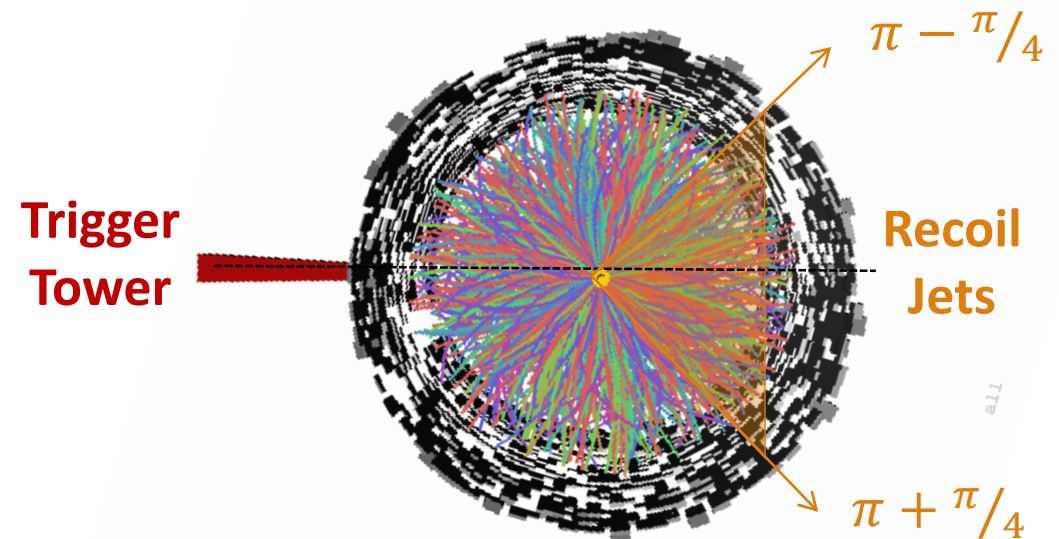
o Jets shown here satisfy
  - $A_{jet} > 0.05$
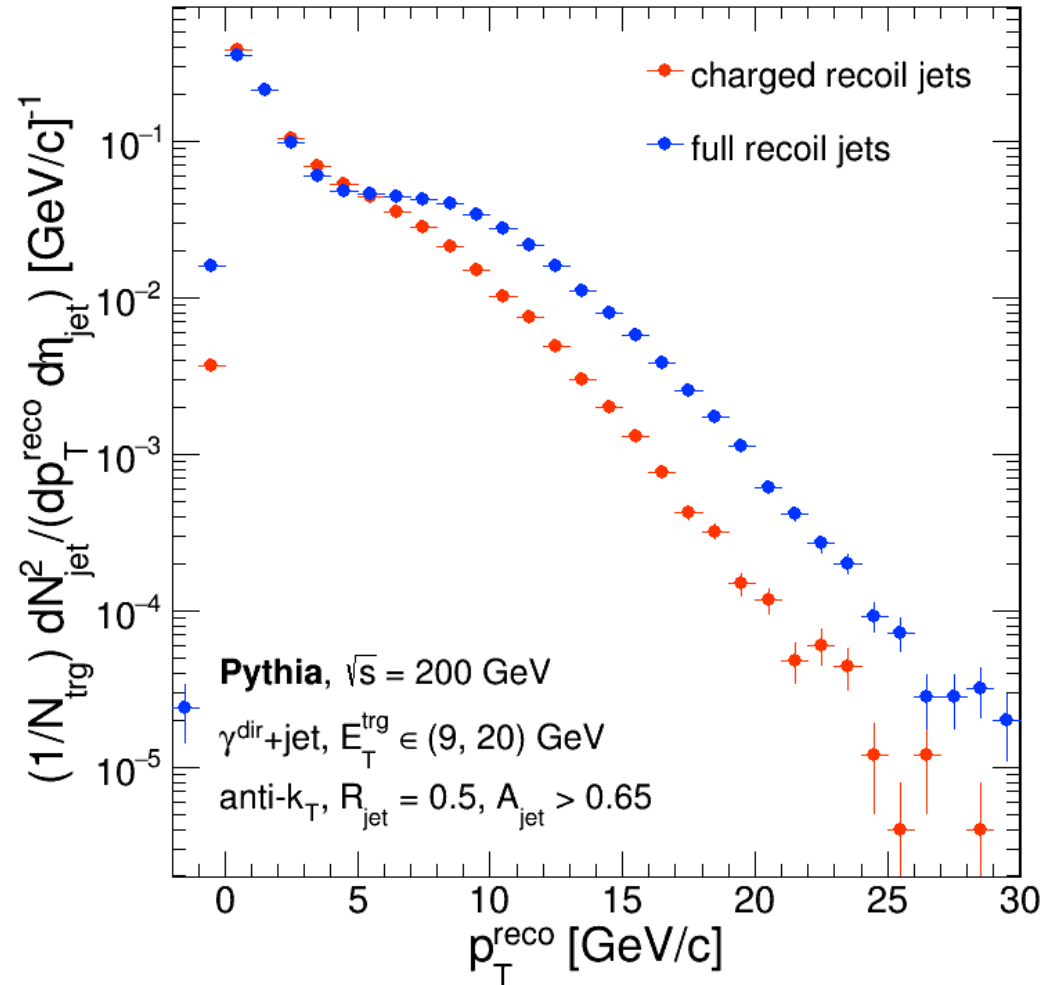 - $p_T^{jet,raw} > 0.2$ GeV/c
  - $|\eta^{jet}| < 1 - R_{jet}$

Corrected Spectra

o Correction scheme follows recent $h^{\pm}$-jet measurement by the STAR collaboration

– STAR, Phys. Rev. C **96**, 024905 (2017)

o Corrected data are compared against Pythia 8.185

– T. Sjöstrand, S. Mrenna, and P. Z. Skands, Comput. Phys. Commun. **178**, 852 (2008)

– Darker bands indicate statistical uncertainty

– **Dominant uncertainties:**

› Unfolding (prior, algorithm, etc.)

› Tracking efficiency

› γ_{rich} background subtraction scheme (γ_{dir} only)

o **Corrected data Consistent with Pythia8!**
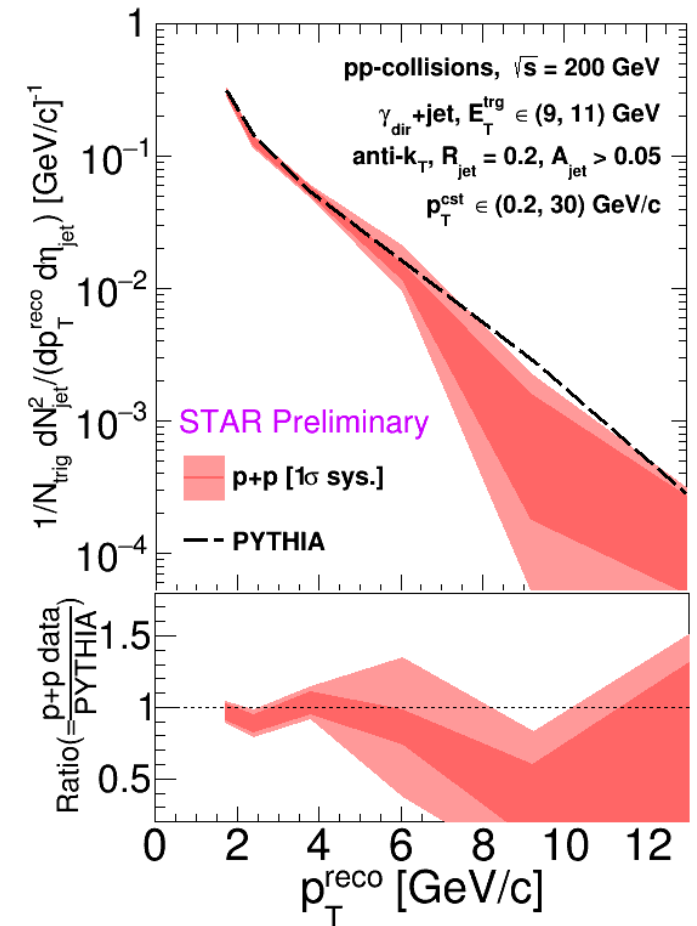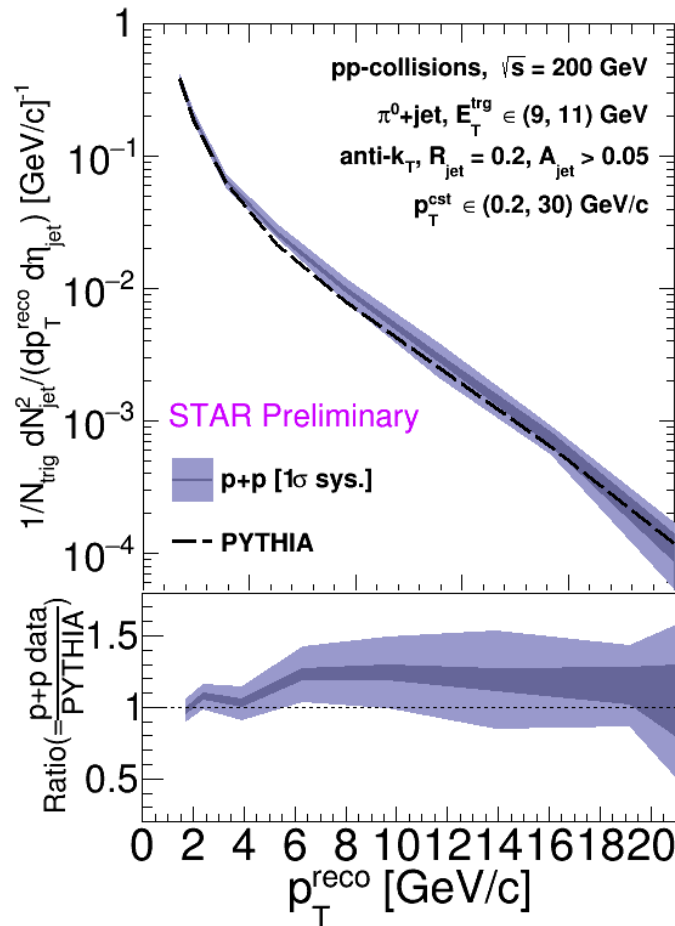
Conclusions and Future Work

o Charged $R_{jet} = 0.2$ recoil jets have been reconstructed in p+p collisions for π^0 and γ_{dir} triggers with $E_T^{trg} \in (9, 11)$ GeV

   – Spectra corrected for detector effects are consistent with Pythia 8

o **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)

- charged recoil jets
- full recoil jets

Pythia, $\sqrt{s}$ = 200 GeV

γ^{dir}+jet, $E_T^{trg} \in (9, 20)$ GeV

anti-k_T, R_{jet} = 0.5, A_{jet} > 0.65

y-axis: $(1/N_{trg})\, dN^2_{jet}/(dp_T^{reco}\, d\eta_{jet})$ [GeV/c]$^{-1}$

x-axis: p_T^{reco} [GeV/c]

Thank You!