Baryon to Meson Ratios in Au+Au and p+p collisions at $\sqrt{s_{NN}} = 200$ GeV

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On behalf of the STAR collaboration

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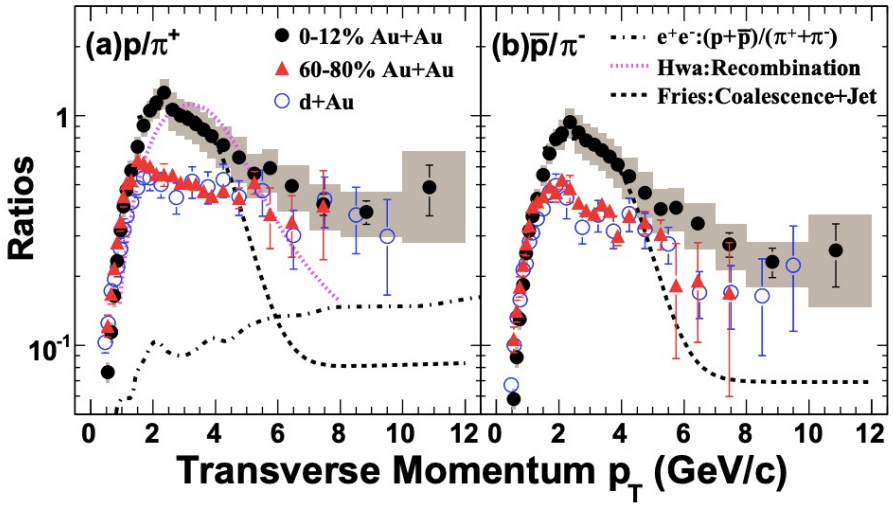
U.S. DEPARTMENT OF ENERGY

Motivation



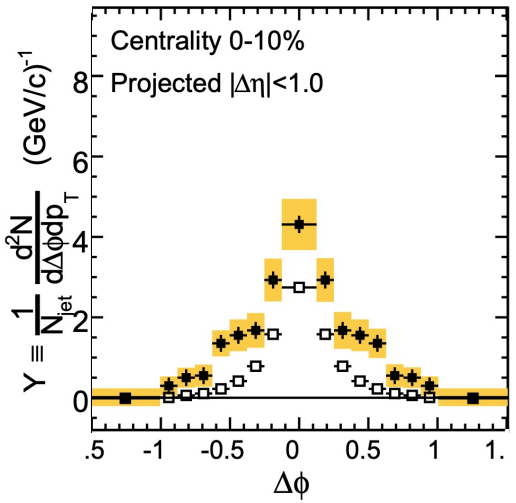
[PRL97(2006)152301]

STAR

d+Au $\sqrt{s_{NN}} = 200$ GeV

Au+Au $\sqrt{s_{NN}} = 200$ GeV

$e^+ + e^-$ $\sqrt{s} = 91.2$ GeV



[JHEP 11 (2016) 055]

CMS

Pb+Pb $\sqrt{s_{NN}} = 2.76$ TeV

p+p $\sqrt{s} = 2.76$ TeV

Jet $p_T > 120$ GeV/c

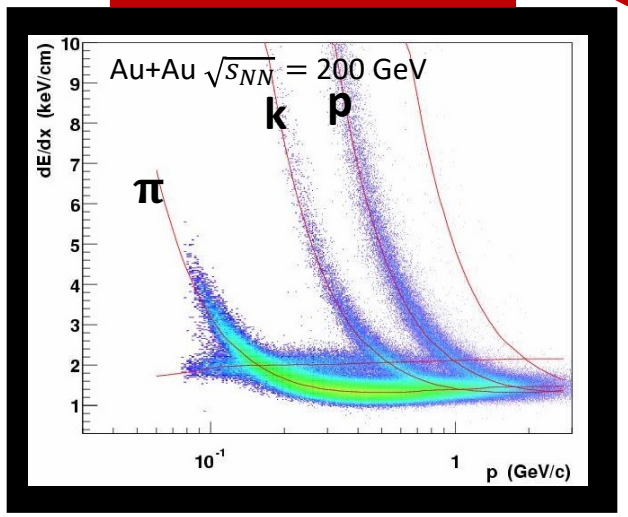
PbPb Leading Jets

pp Leading Jets

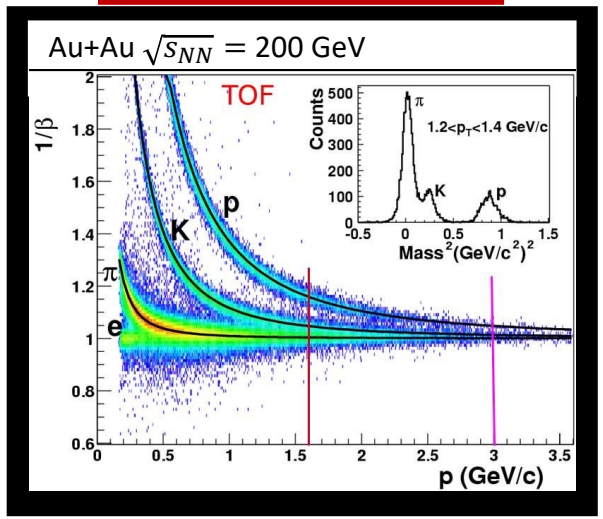
- Two prominent signatures of QGP:
  - Baryon enhancement
  - Jet modification
- AMPT simulations: baryon/meson is modified for jets in QGP [PLB(2022)137638]
- **Is jet fragmentation modified by QGP?**
- **How does QGP hadronize?**
- We measure **p/π in jets** using **jet-track correlations**

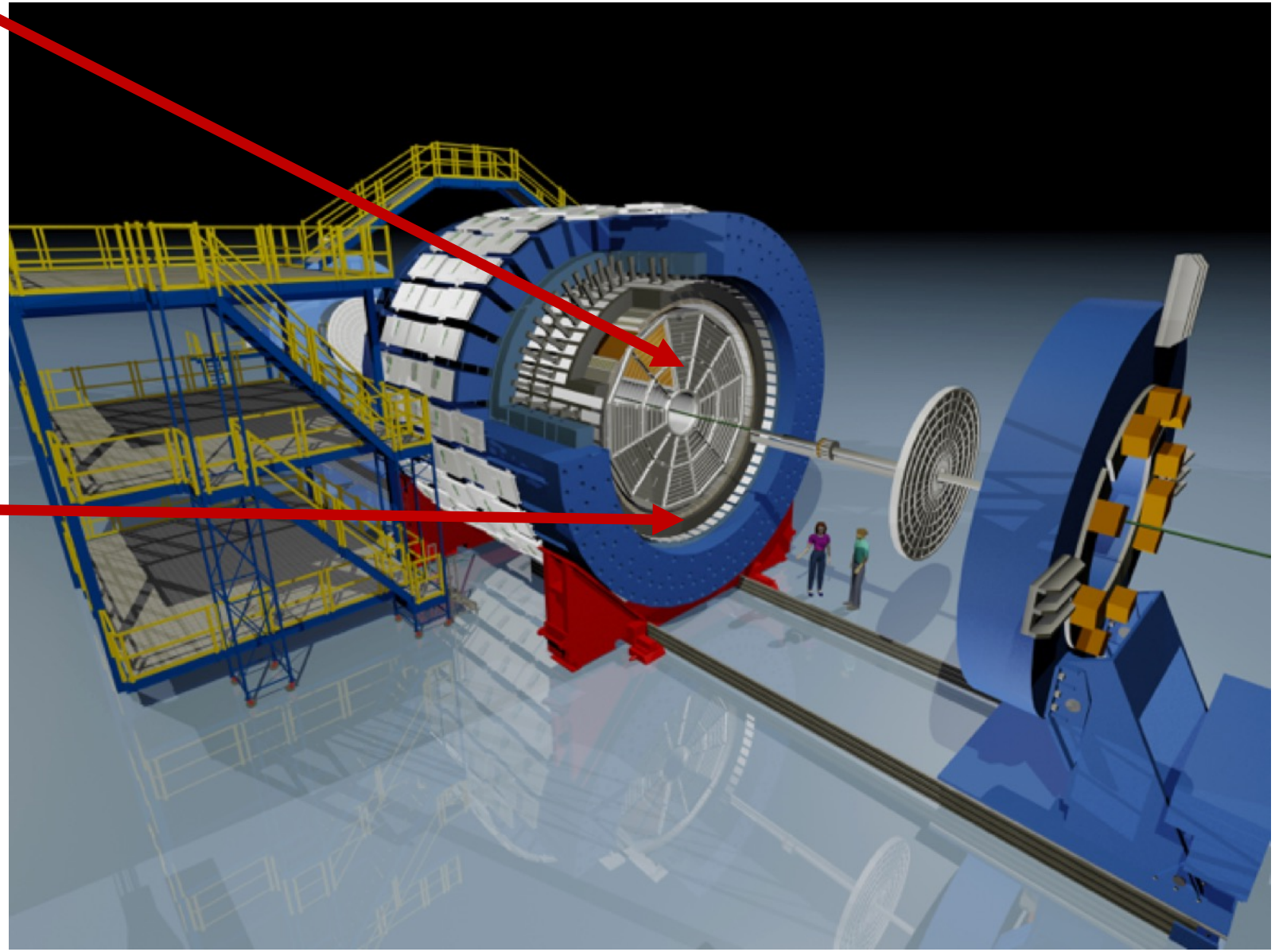
STAR Detector

dE/dx from TPC



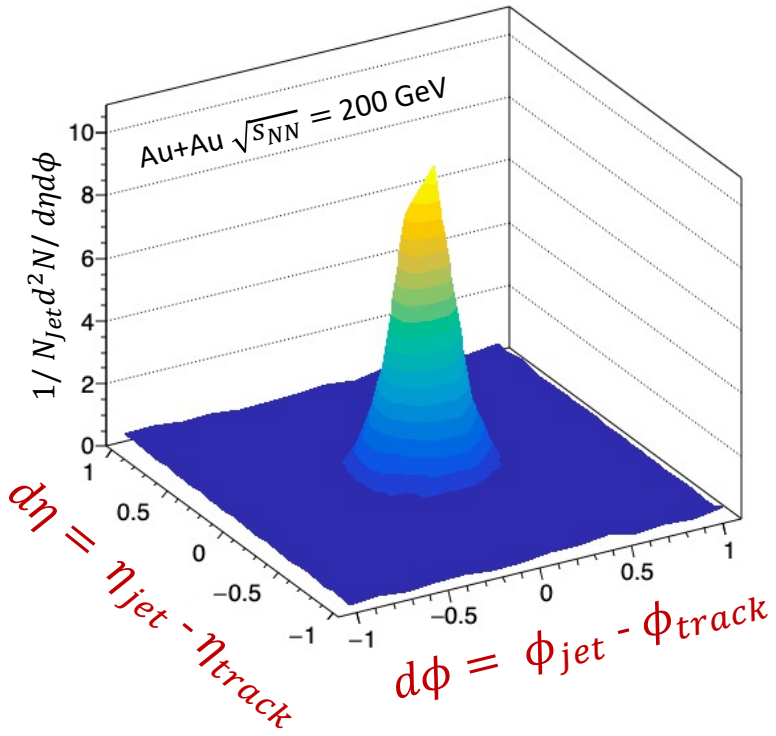
β from ToF



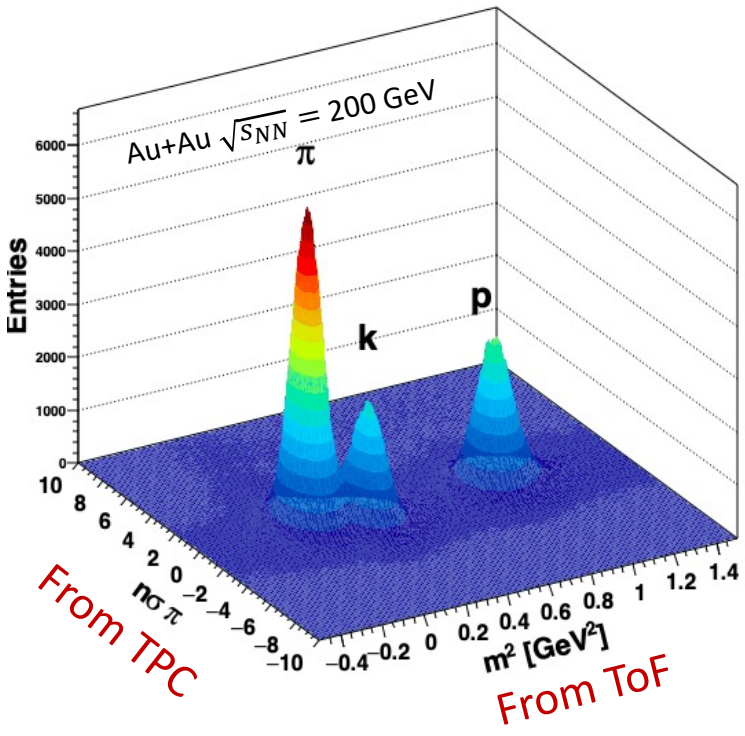


Measurement Technique

2D jet-track correlation



Particle Identification



Fully reconstructed jets with tracks identified by **Time of Flight (ToF)** and **Time Projection Chamber (TPC)** information
=> **Particle Identification in jets**

Data Samples

- p+p collisions at $\sqrt{s} = 200$ GeV (2015)
- 0-20% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, (2014)

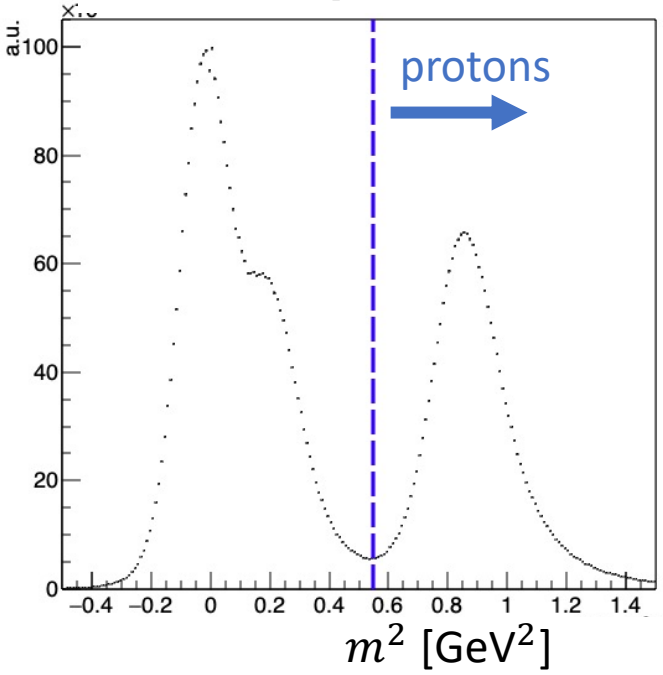
Jet Reconstruction

- **Anti- k_T**
- Various jet radius, R
- Constituent selections
  - p_T^{const} > 2.0 GeV/c
  - p_T^{const} > 3.0 GeV/c
- **Jet p_T^{raw} > 10 GeV/c**

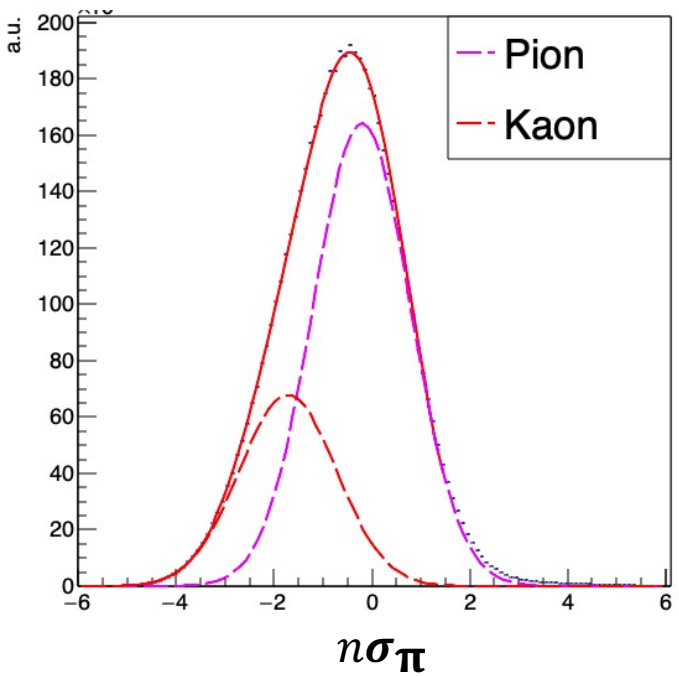
Particle Identification Technique

Au+Au $\sqrt{s_{NN}} = 200$ GeV, 0-20%

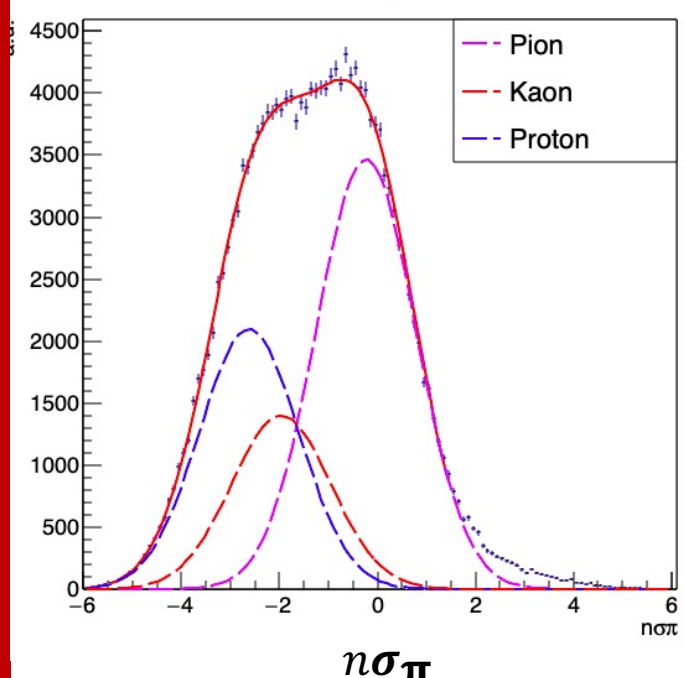
2.0 GeV/c < p_T < 2.2 GeV/c



2.0 GeV/c < p_T < 2.2 GeV/c



4.0 GeV/c < p_T < 4.5 GeV/c



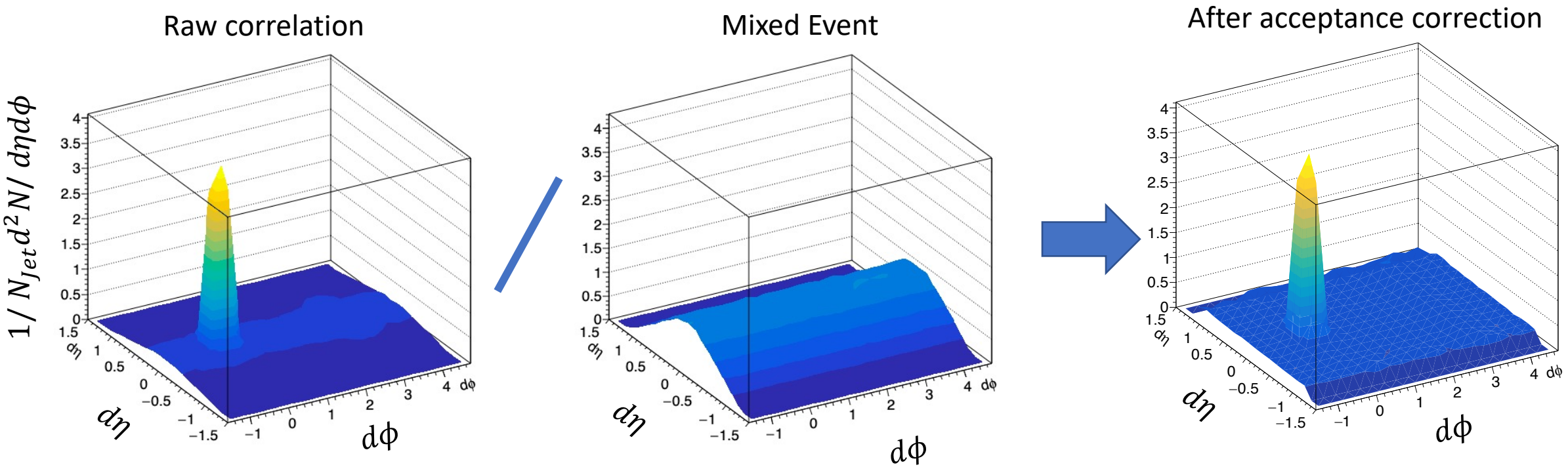
Low, 2.0 GeV/c < p_T < 3.5 GeV/c

- Bin count protons
- Fit for pions and kaons

High, p_T > 3.5 GeV/c

- dE/dx calibration informed by ToF
- Fit for pions, kaons, protons

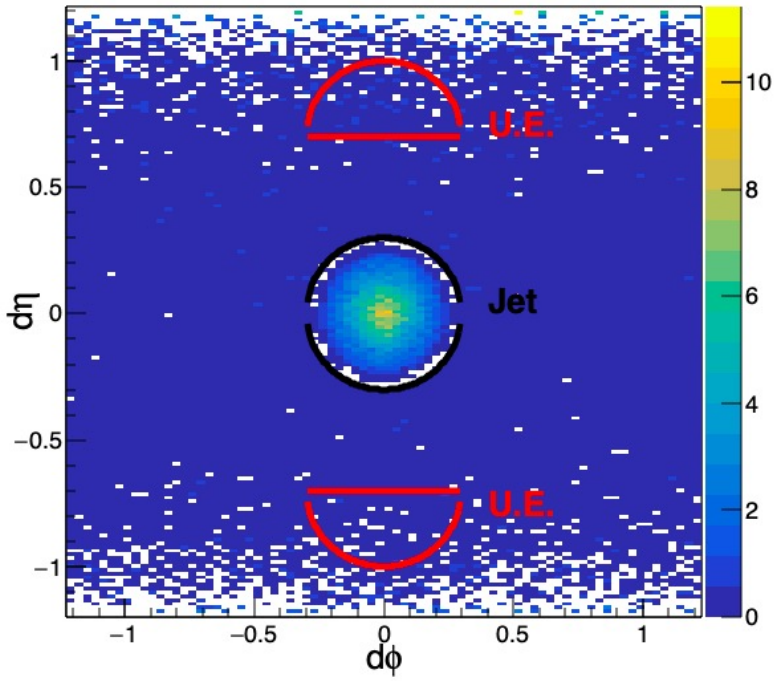
Jet-Track Correlations



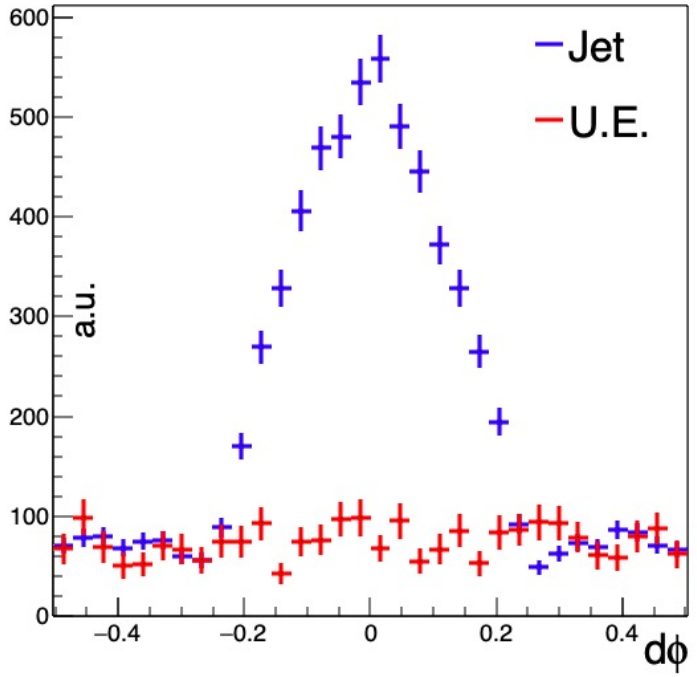
- Jet-Track correlations are used after acceptance correction and Underlying Event (UE) removal
  1. Mixed events (normalized to 1 at maximum) for pair-acceptance correction

Underlying Event Subtraction

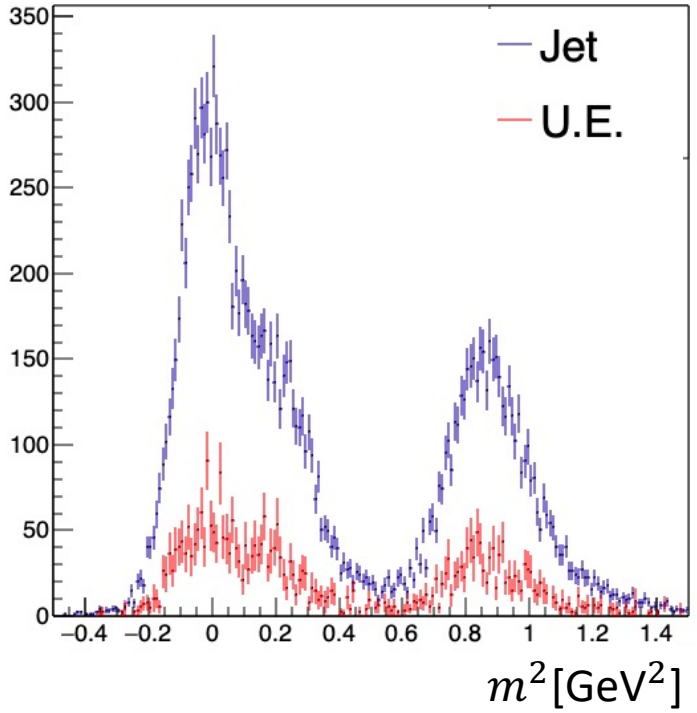
After acceptance correction



UE subtraction for correlation

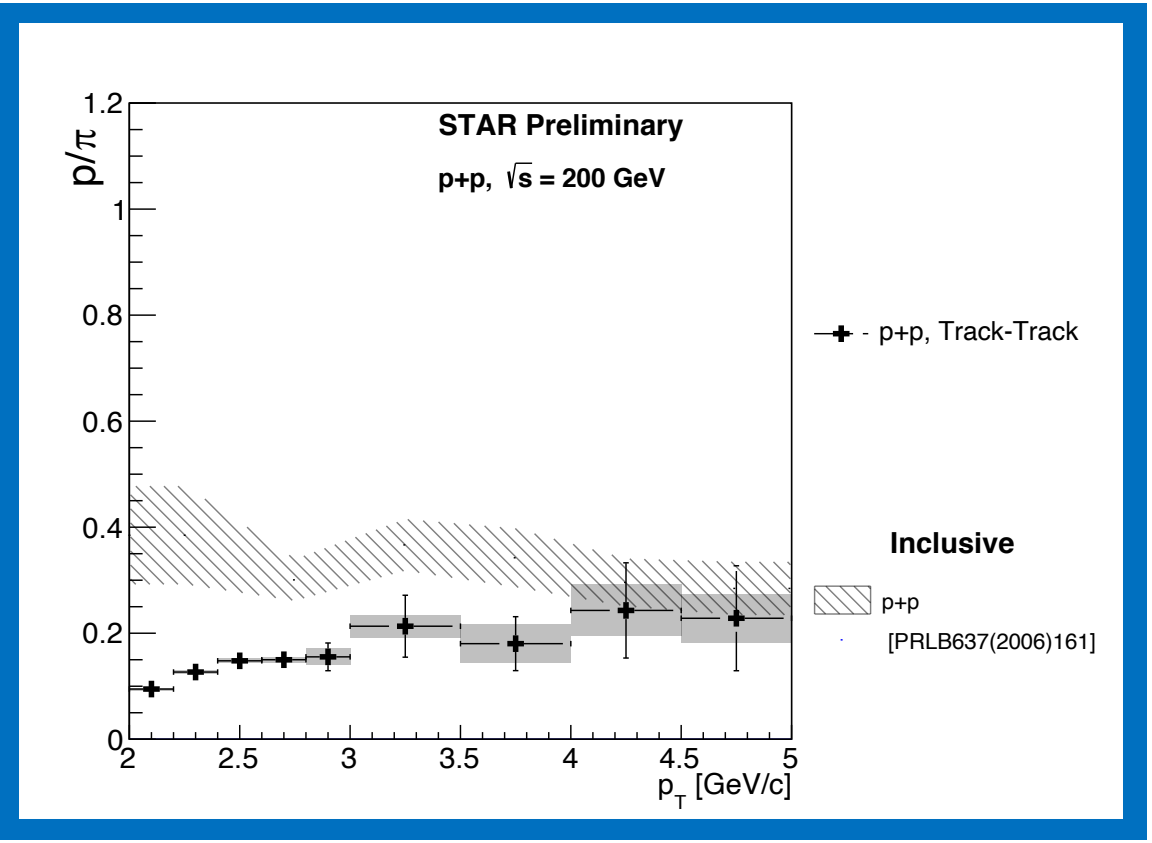


UE subtraction for PID



- Jet-Track correlations are used after acceptance correction and Underlying Event (UE) removal
  1. Mixed events (normalized to 1 at maximum) for pair-acceptance correction
  2. Subtract UE derived from data with rapidity gap

Track-Track Correlations from p+p collisions

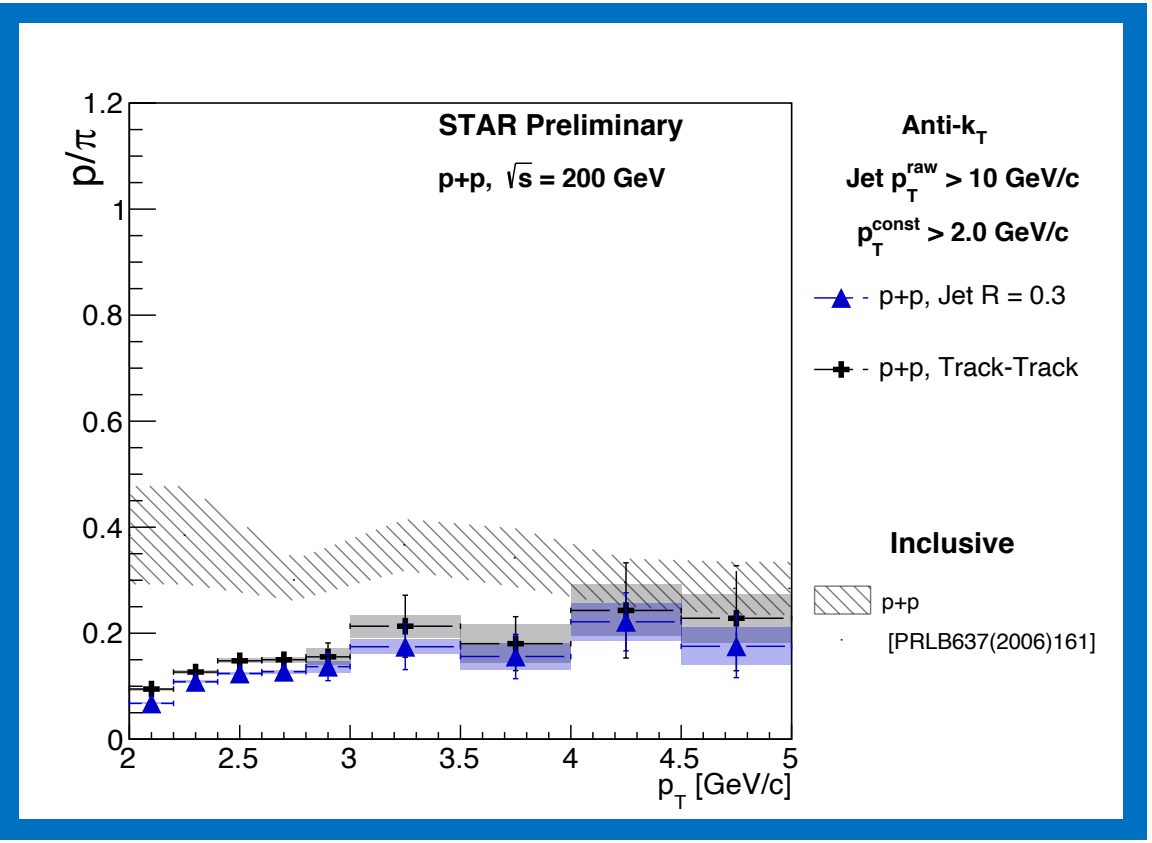


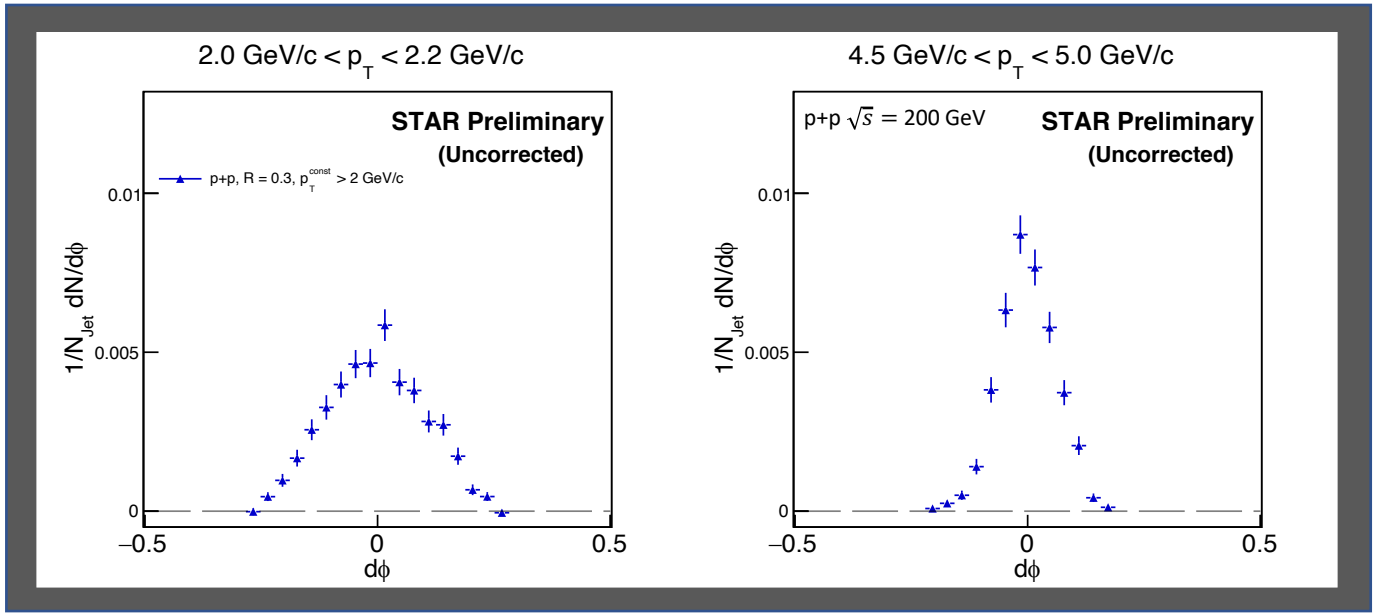
- Track-Track correlation with a leading hadron – simplest proxy for jets
- Leading hadron is highest p_{T} particle with p_{T} > 6.0 GeV/c and |η| < 1.0
- Associated hadrons identified within the radial distance dR = $\sqrt{d\eta^2 + d\phi^2}$ = 0.5 of leading hadron

- **p/π around leading hadron < p/π from inclusive p+p**

NOTE: p/π is used as shorthand for $(p^+ + p^-)/(\pi^+ + \pi^-)$ throughout this presentation

Particle Composition in Jets from p+p





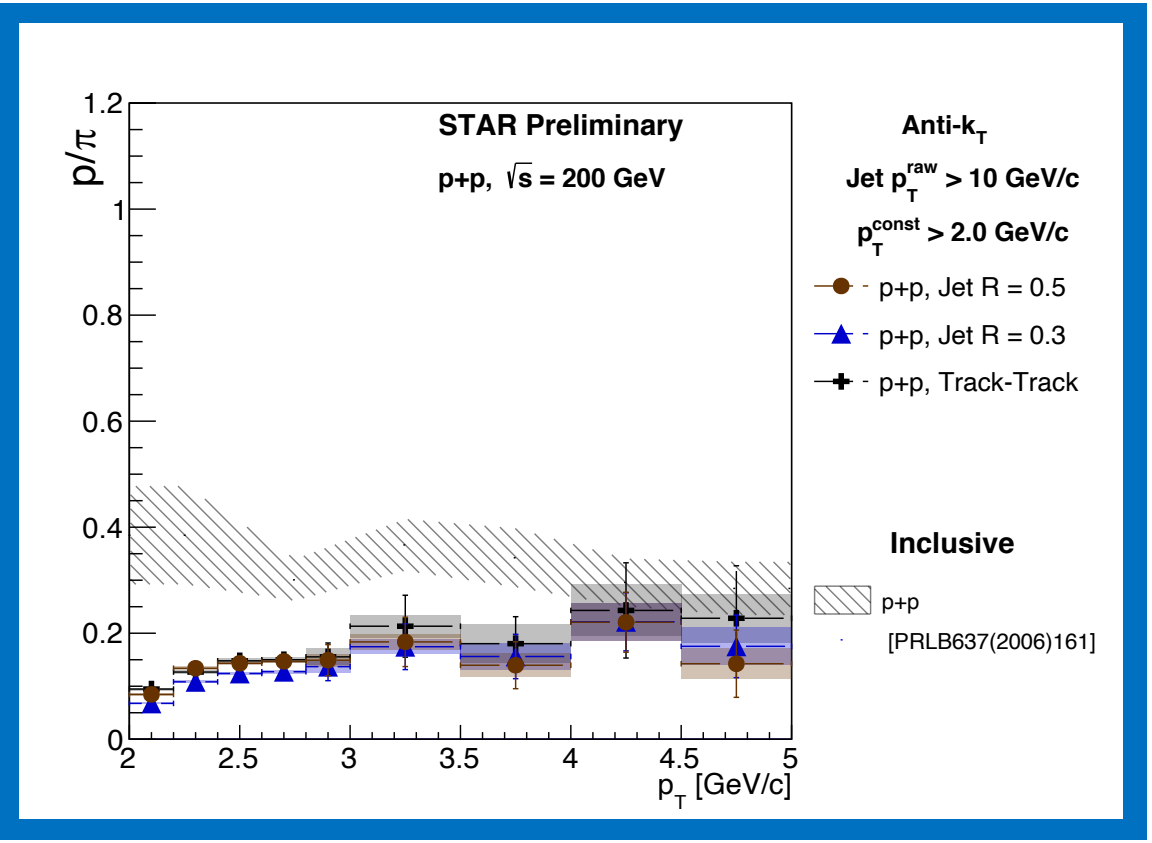
Low p_T ← correlations → High p_T

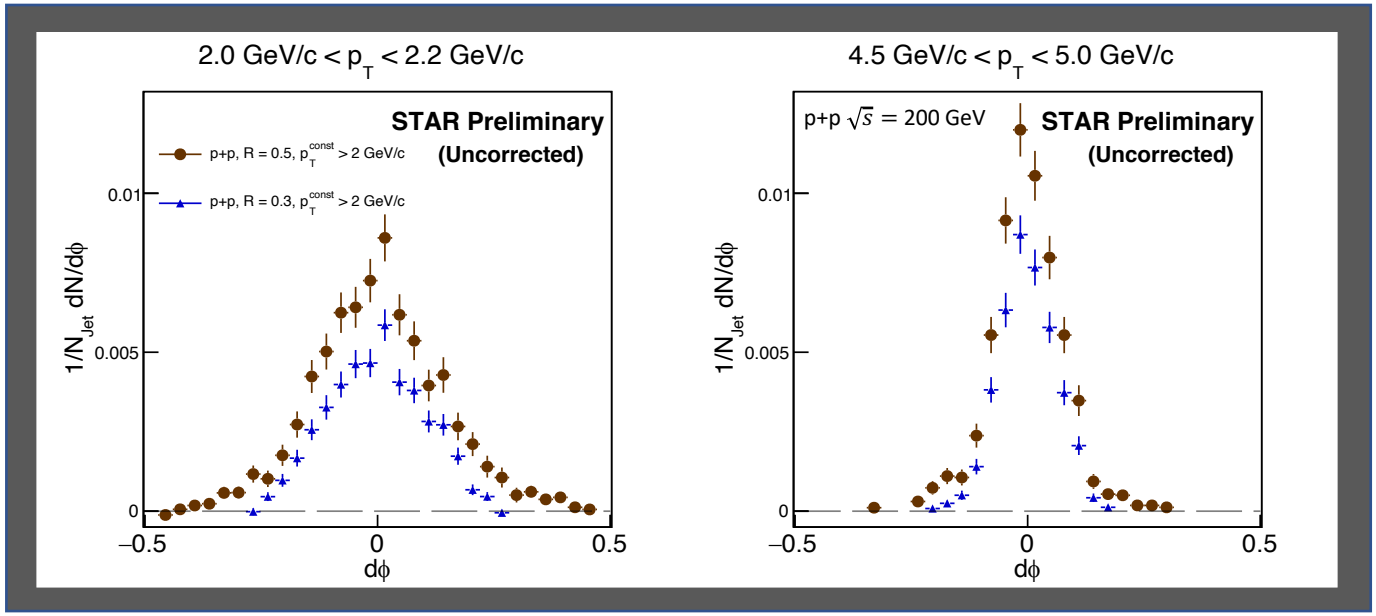
Particle composition for various jets

- R = 0.3, p_T^{const} > 2.0 GeV/c

Strong preference for π over p

Particle Composition in Jets from p+p





Low p_T ← correlations → High p_T

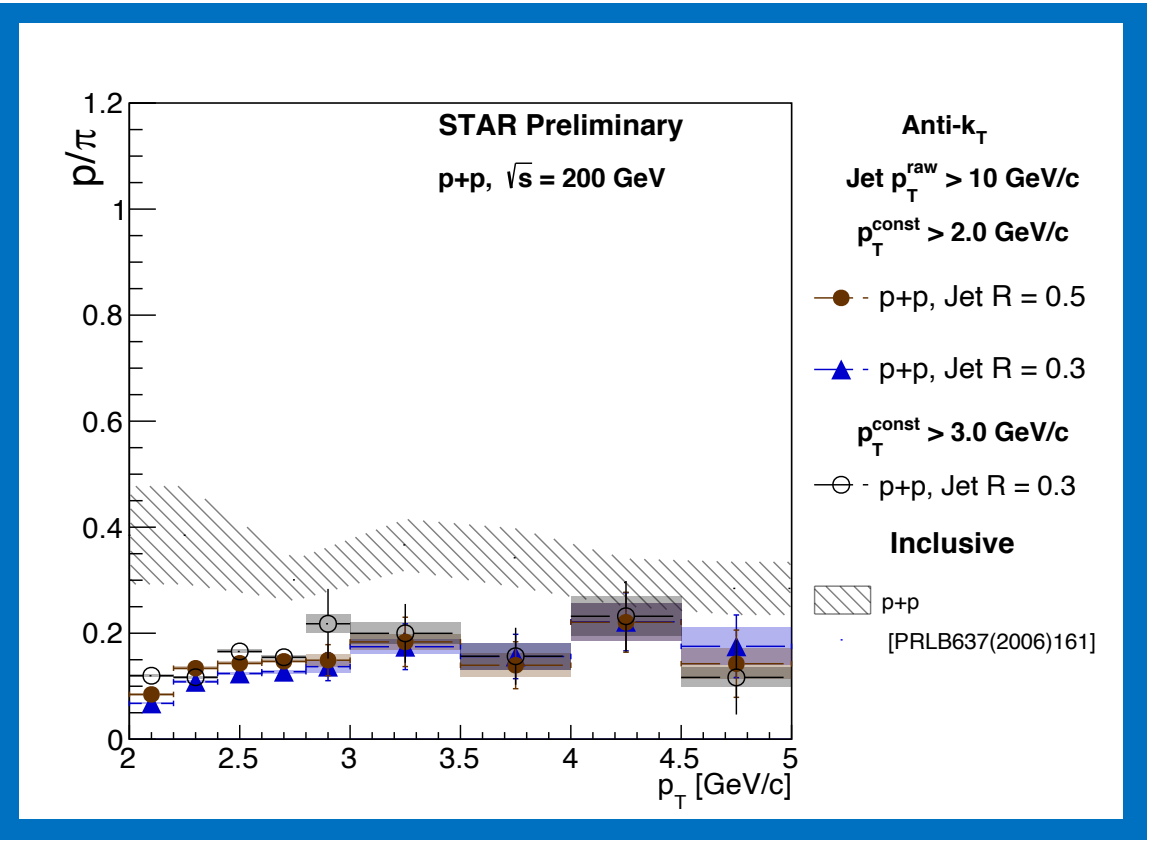
Particle composition for various jets

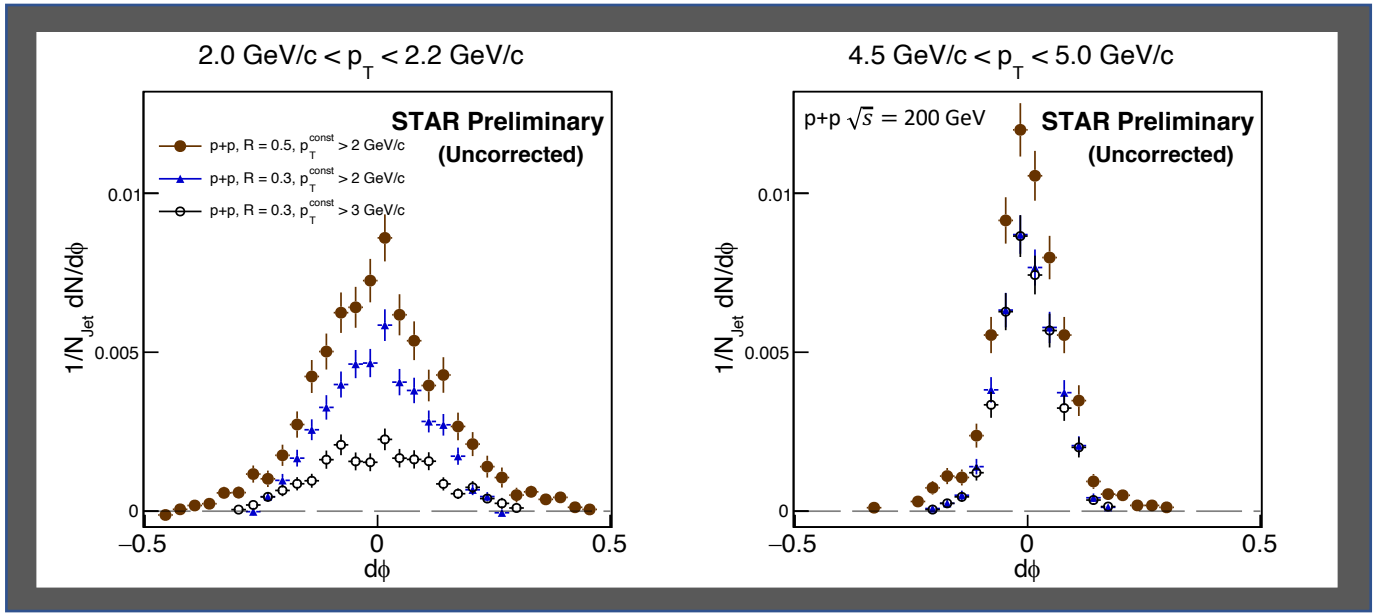
- R = 0.3, p_T^{const} > 2.0 GeV/c
- R = 0.5, p_T^{const} > 2.0 GeV/c

Strong preference for π over p

- Large R → moderate increase in associated yields

Particle Composition in Jets from p+p





Low p_T ← correlations → High p_T

Particle composition for various jets

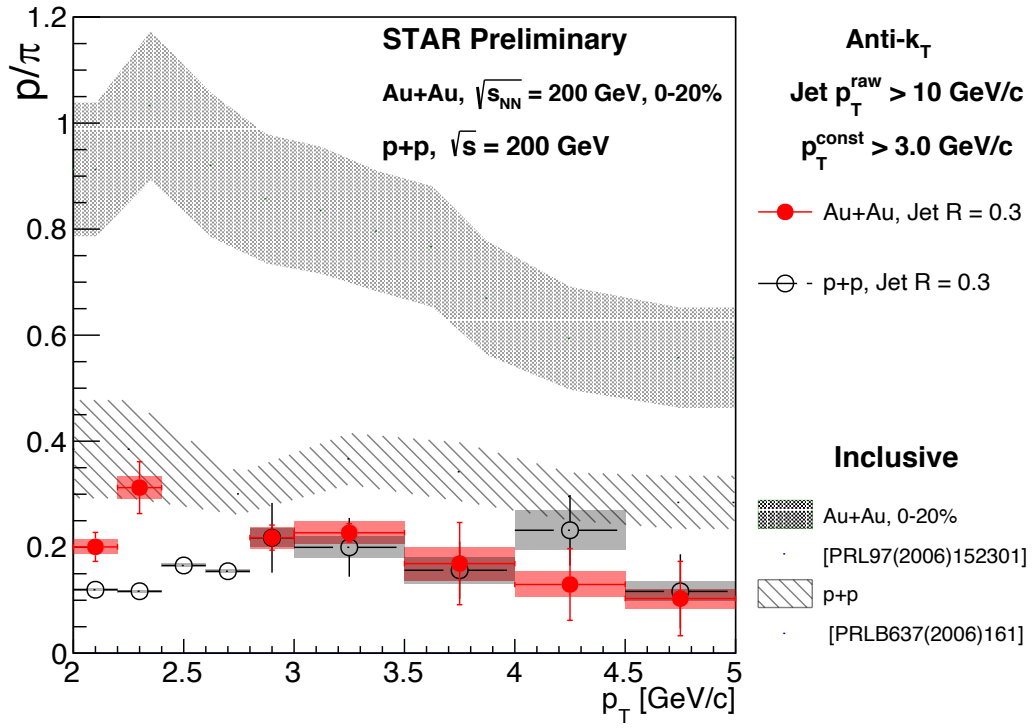
- R = 0.3, p_T^{const} > 2.0 GeV/c
- R = 0.5, p_T^{const} > 2.0 GeV/c
- R = 0.3, p_T^{const} > 3.0 GeV/c

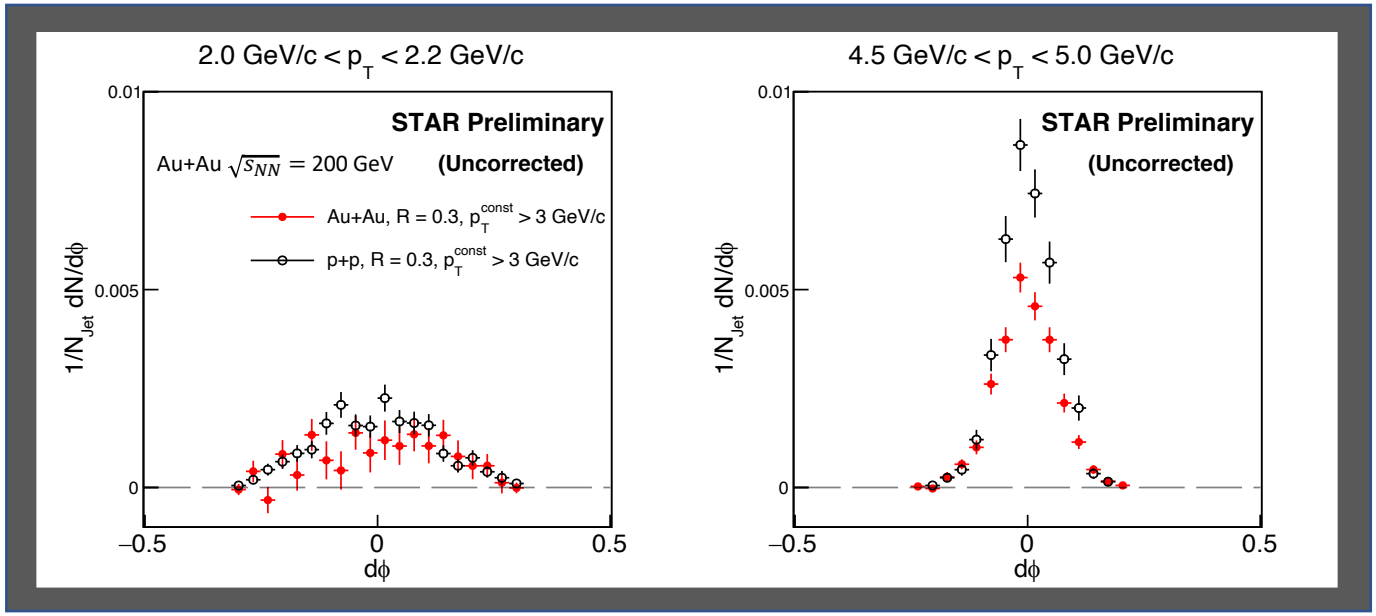
Strong preference for π over p for all jets in p+p

Similar in-jet ratios were observed in p+p collisions at LHC (INSPIRE:1429564)

- Large R → moderate increase in associated yields
- Lower p_T^{const} threshold → larger associated yields near threshold

Particle Composition in Jets from Au+Au





Low p_T ← correlations → High p_T

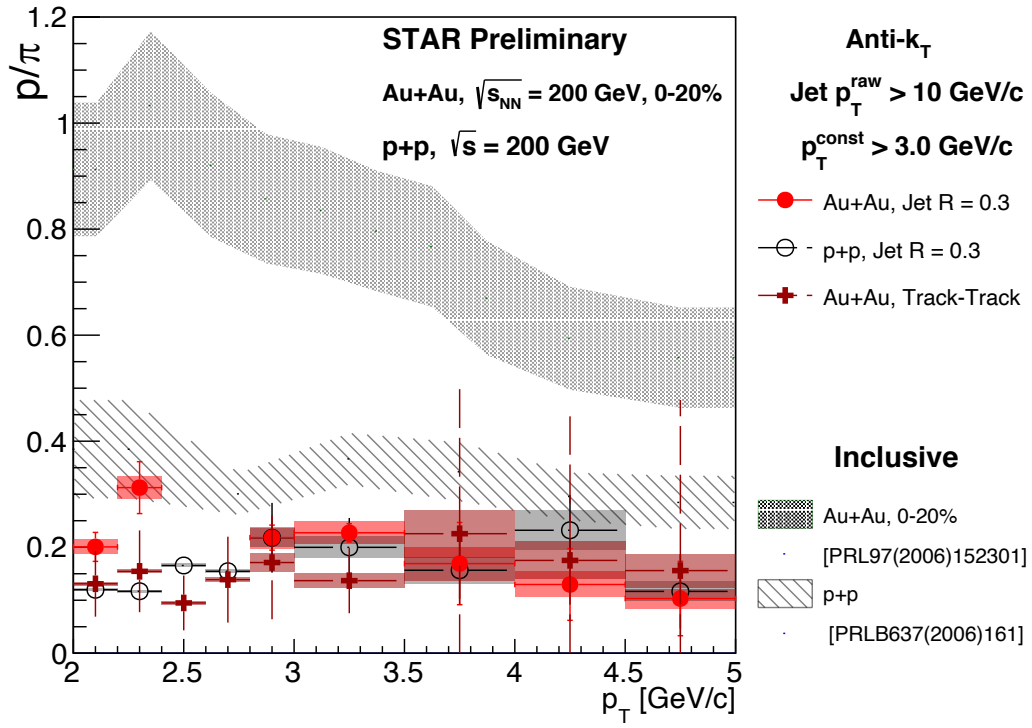
Jets with p_T^{const} > 3.0 GeV/c

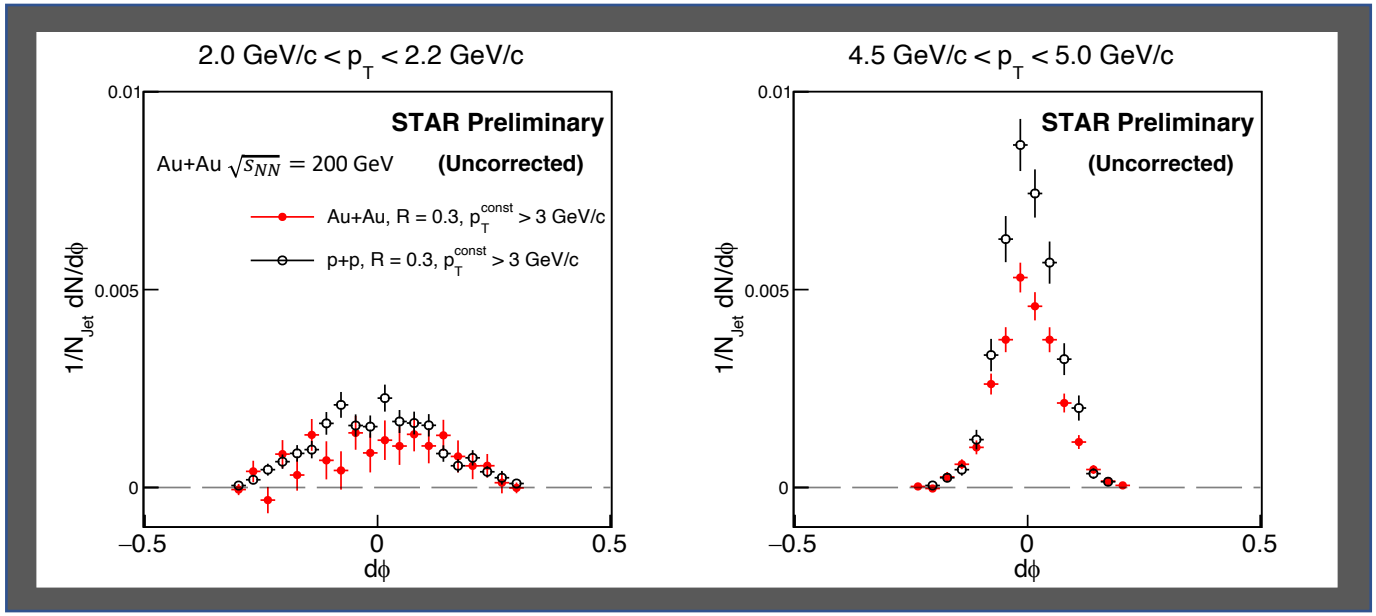
- Au+Au, R = 0.3
- p+p, R = 0.3

- Higher p_T^{const} threshold → Similar correlation shapes for 2.0 GeV/c < p_T < 2.2 GeV/c in Au+Au and p+p

Strong preference for π over p in hard constituent jets

Particle Composition in Jets from Au+Au





Low p_T ← correlations → High p_T

Jets with p_T^{const} > 3.0 GeV/c

- Au+Au, R = 0.3
- p+p, R = 0.3
- Au+Au, Track-Track correlation

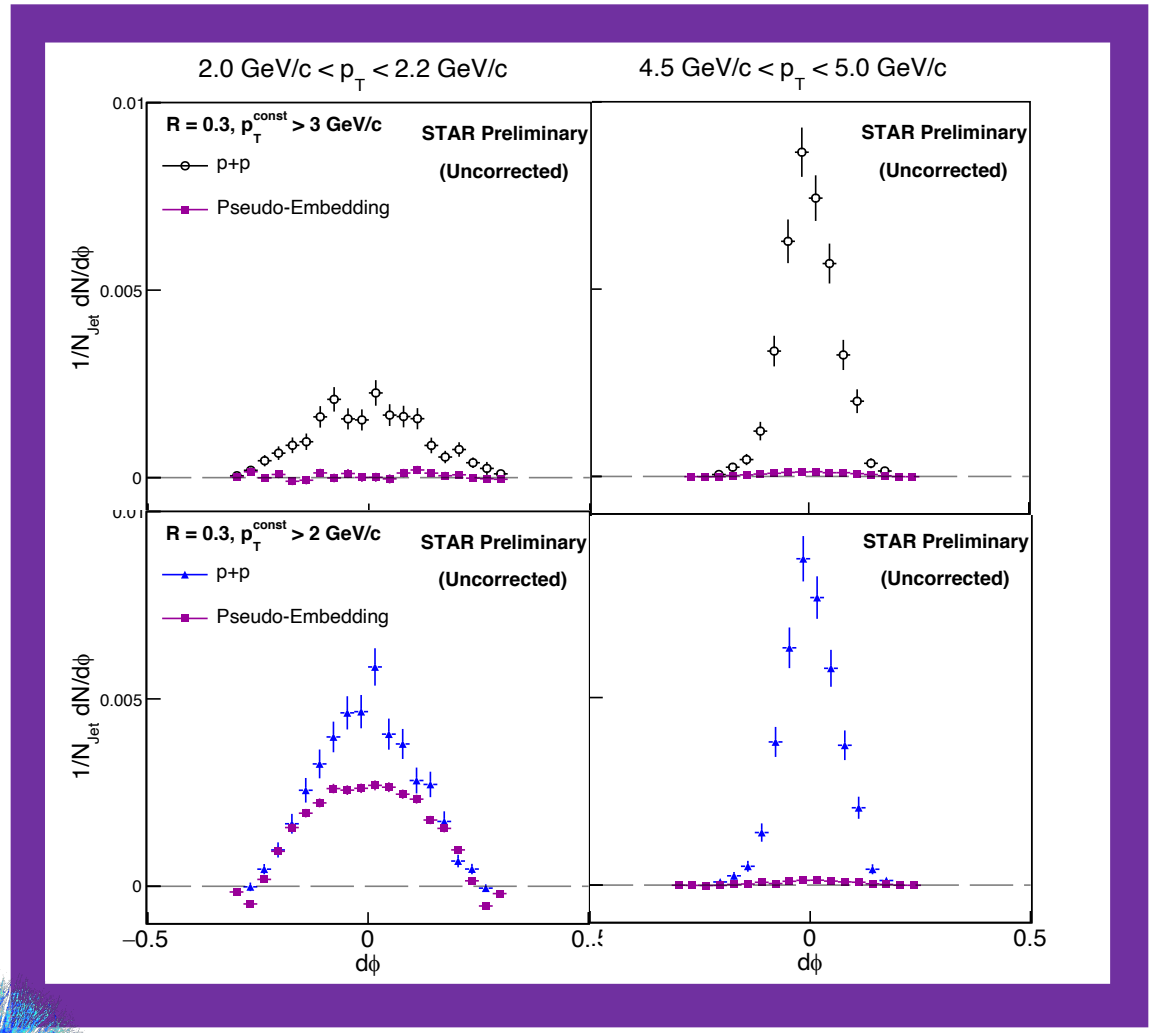
Strong preference for π over p in hard constituent jets

- Higher p_T^{const} threshold → Similar correlation shapes for 2.0 GeV/c < p_T < 2.2 GeV/c in Au+Au and p+p

Parsing Impact of Background Fluctuation on Jet Reconstruction

p_T^{const} > 3 GeV/c

p_T^{const} > 2 GeV/c



Pseudo-embedding: take p+p jets down to low pt → overlay with central Au+Au event → run jet finder → match to original p+p jet → construct jet track correlation with Au+Au event and perform UE subtraction

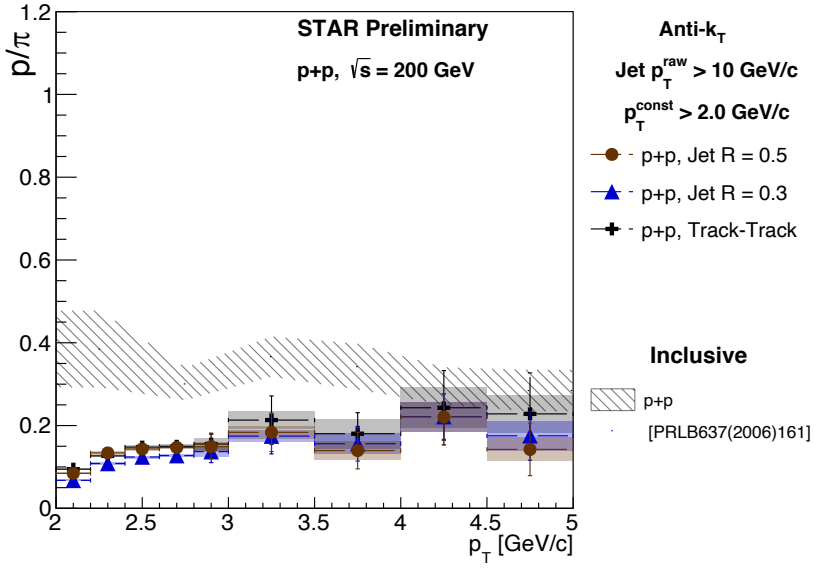
p_T^{const} > 3 GeV/c

- Jet reconstruction bias due to UE results in minimal correlated background contribution
- Correlated background has negligeable effect on harder constituent jets

p_T^{const} > 2 GeV/c

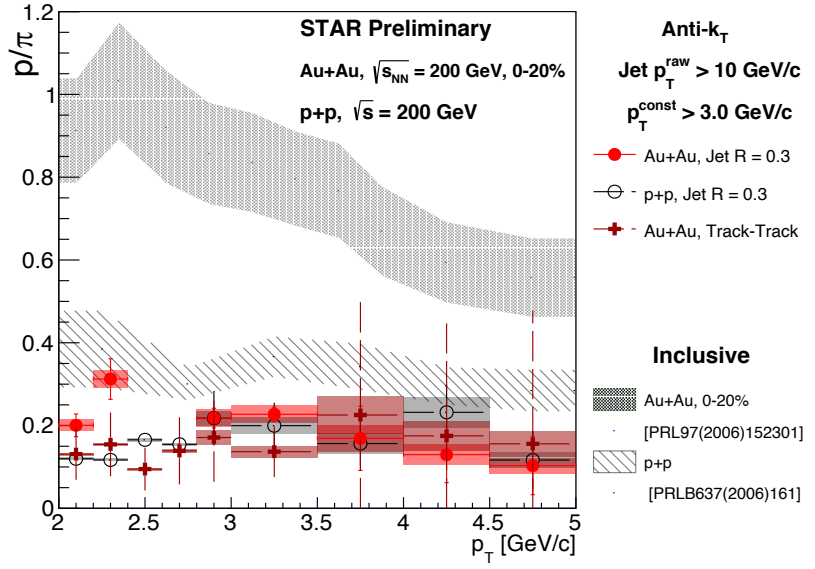
- Jet reconstruction bias due to UE results in greater correlated background contribution
- Work to understand this contribution is ongoing

Summary



Jets in p+p

- First in-jet PID measurement from STAR
- Strong preference for **π** over p production in jets

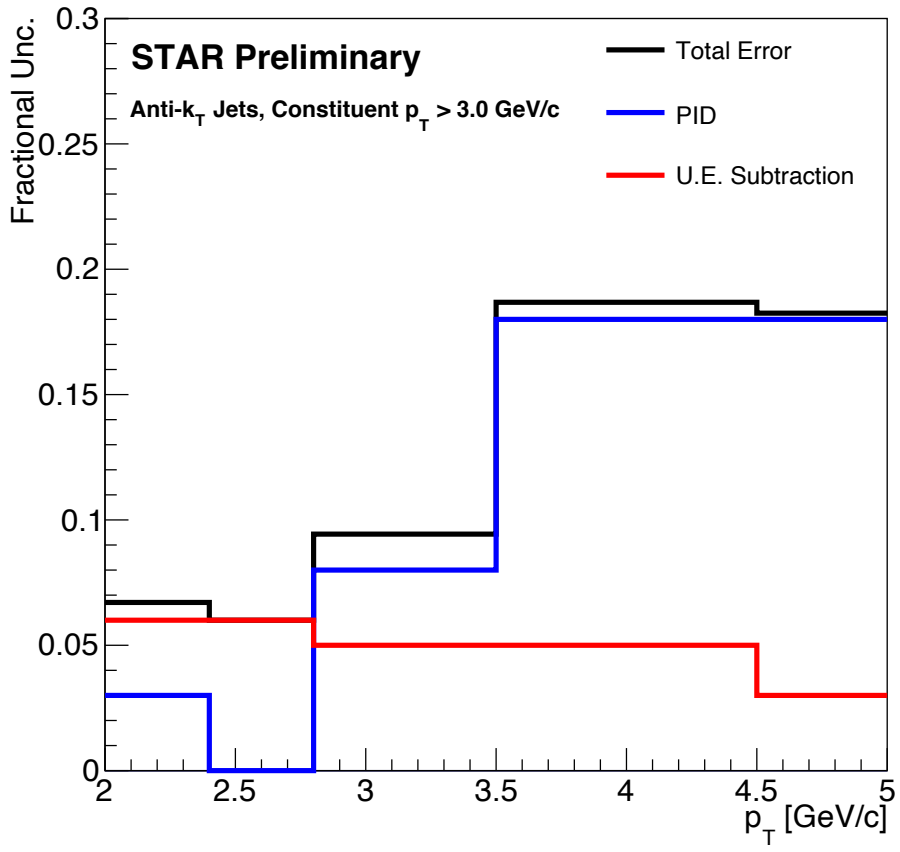


Jets in Au+Au

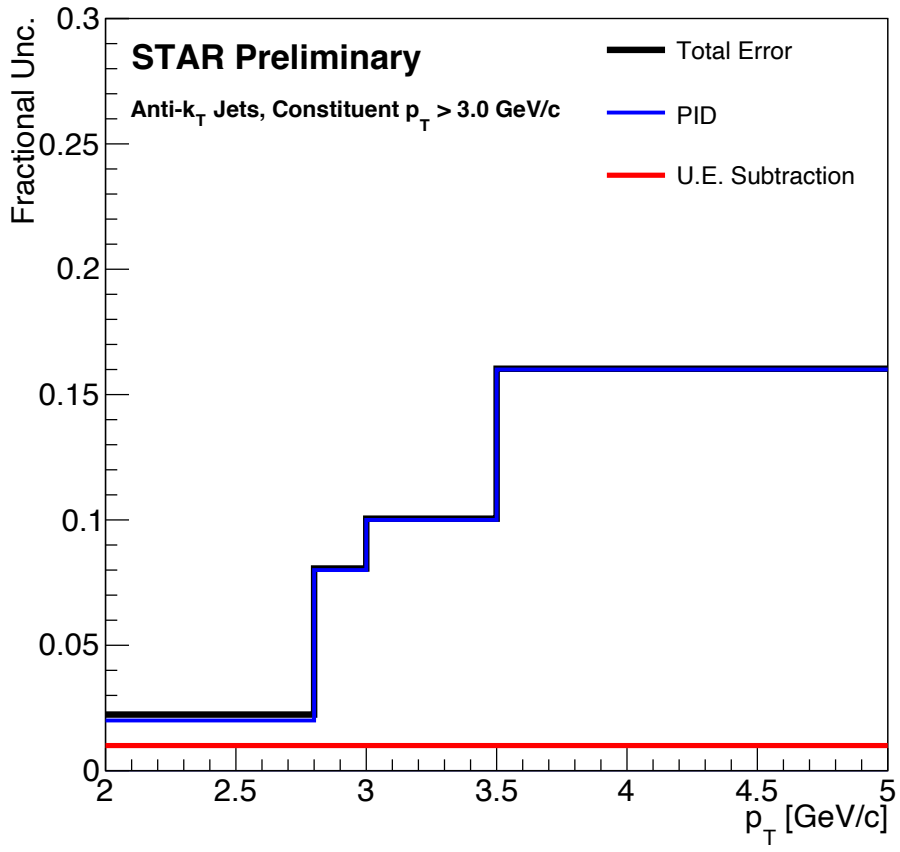
- First in-jet PID measurement from STAR
- Hard constituent jets (p_{T}^{const} > 3 GeV/c):
  - similar p/**π** ratios in Au+Au and p+p
  - Strong preference for **π** over p production in jets

Backup

R = 0.3, Au+Au Systematic Uncertainty

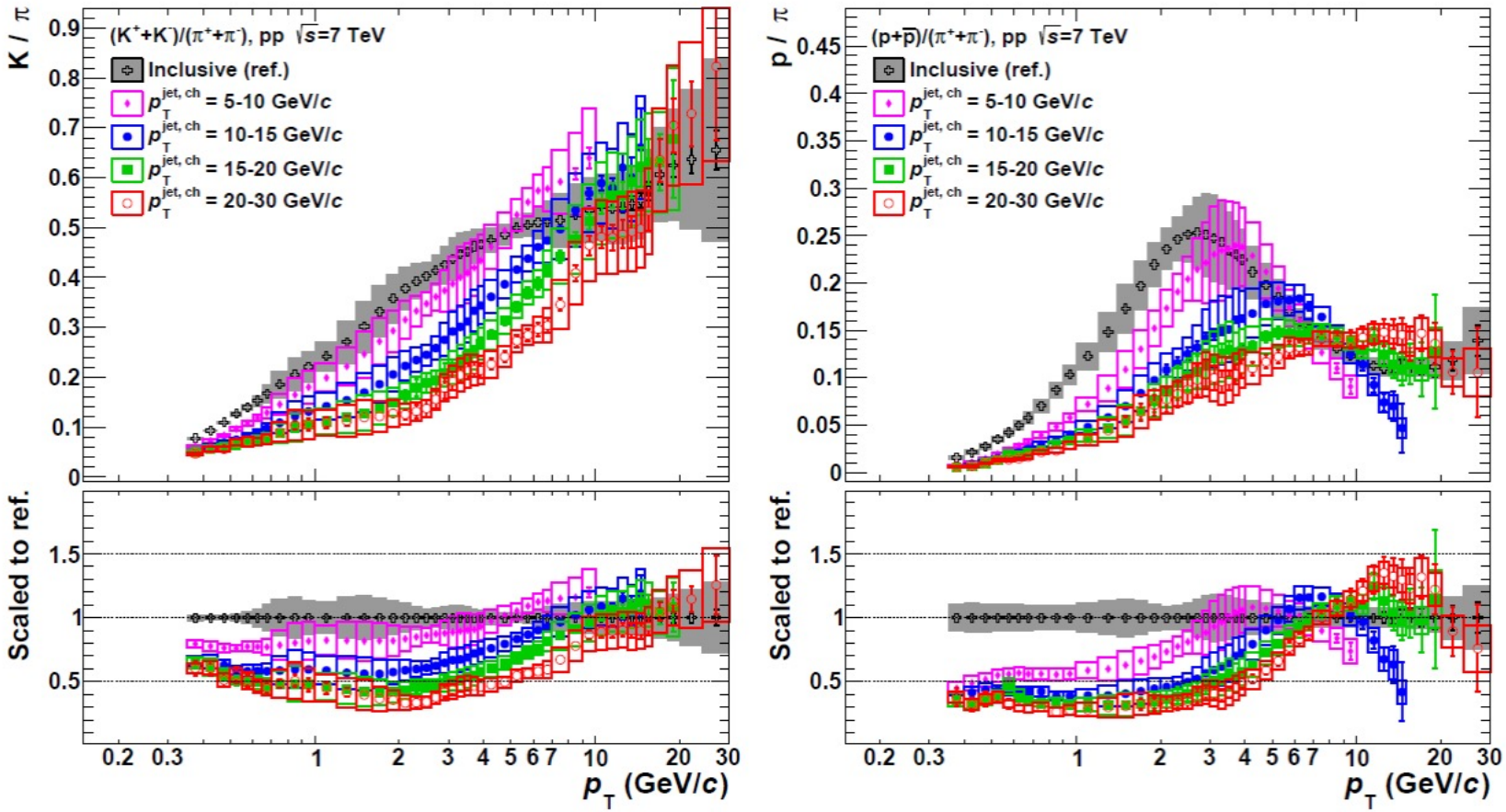


R = 0.3, p+p Systematic Uncertainty



Two main sources of systematic error were evaluated:

- **PID error,** determined by independently varying fit input parameters.
- **U.E. subtraction error,** determined by varying the mixed event normalization applied to the raw correlation, which in turn scales the background level that is subtracted from the jet peak.
- Individual errors deviate only slightly from these characteristic levels.



(https://inspirehep.net/literature/1429564)

Data set (200 GeV)	Energy, Particle level	Energy, Jet level
p+p, R = 0.3, p_{T}^{const} > 2 GeV/c	12.94	12.75
p+p, R = 0.5, p_{T}^{const} > 2 GeV/c	13.39	12.76
p+p, R = 0.3, p_{T}^{const} > 3 GeV/c	13.27	12.74
Au+Au, R = 0.3, p_{T}^{const} > 3 GeV/c	13.21	12.86