Baryon-to-meson Ratios in Jets from Au+Au and p+p collisions a 200 GeV

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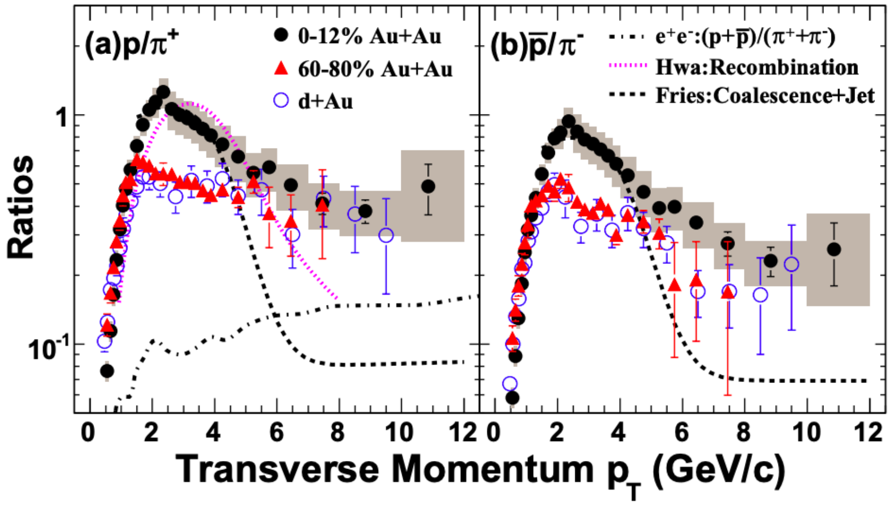
UNIVERSITY/LAB LOGO/ADDITIONAL FUNDING SOURCES

STAR Collaboration

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

- Two prominent signatures of QGP:
  - **Baryon enhancement**
  - Jet quenching/Jet modification

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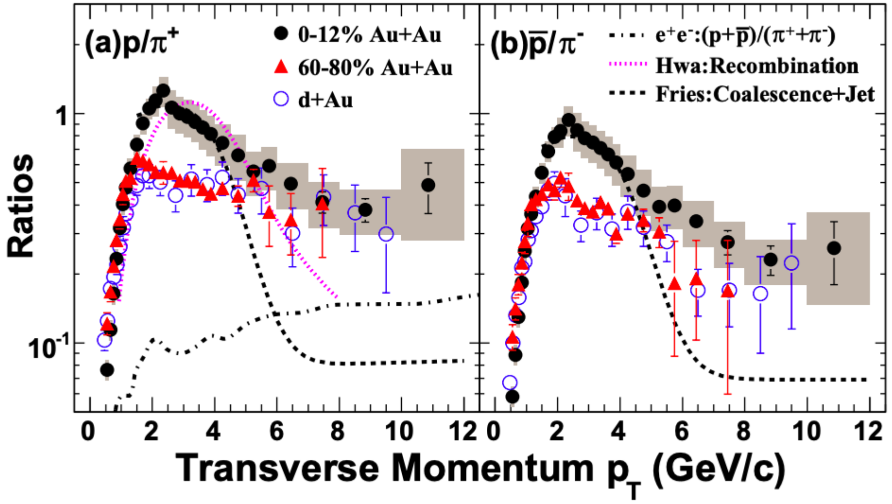

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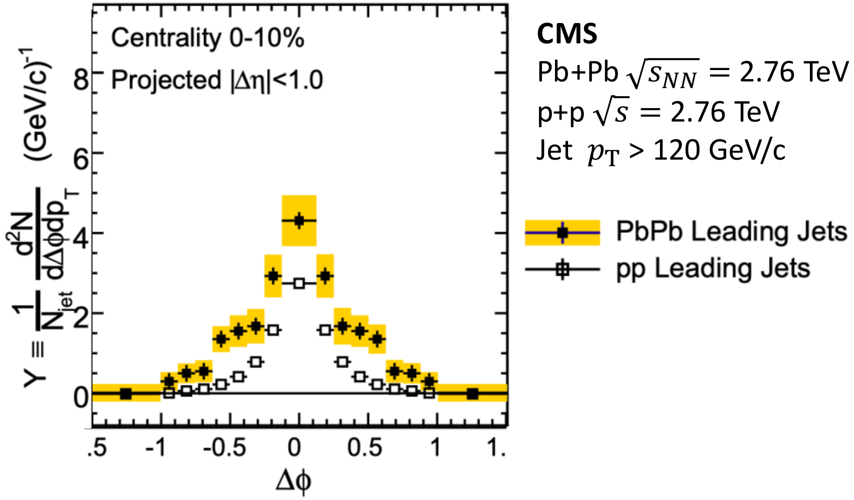
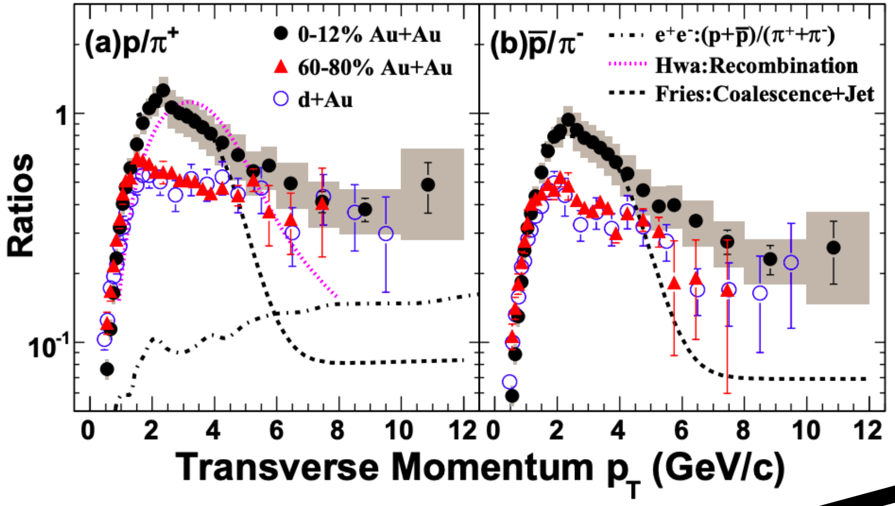


[JHEP 11 (2016) 055]

CMS
Pb+Pb $\sqrt{s_{NN}} = 2.76$ TeV
p+p $\sqrt{s} = 2.76$ TeV
Jet $p_{\mathrm{T}} > 120$ GeV/c

Motivation



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- **Shower Parton Recombination** [PR(2004)0312271]

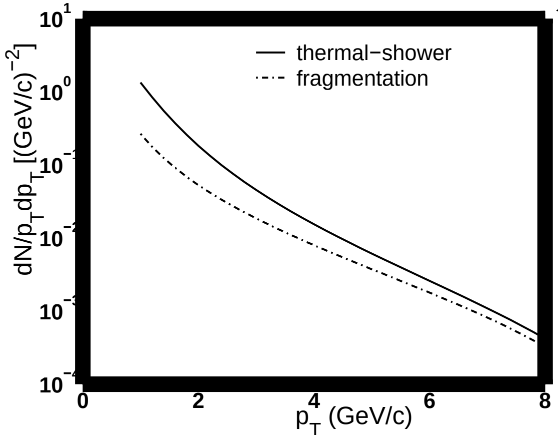
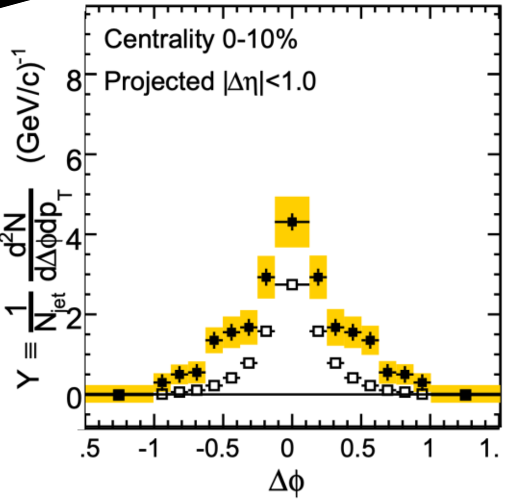


FIG. 4: Distributions of π^+ in p_T arising from thermal-shower recombination (solid line) and shower-shower recombination, i.e. fragmentation (dash-dot line).



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PbPb Leading Jets
pp Leading Jets

[JHEP 11 (2016) 055]

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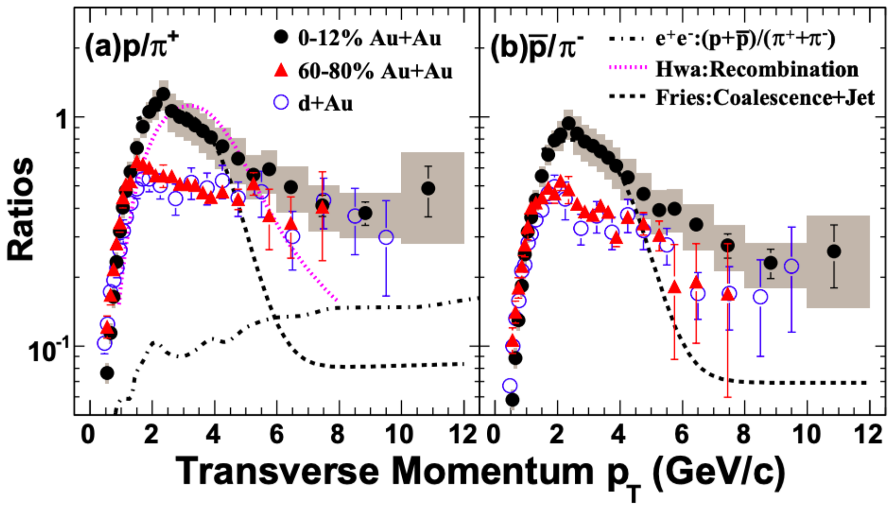

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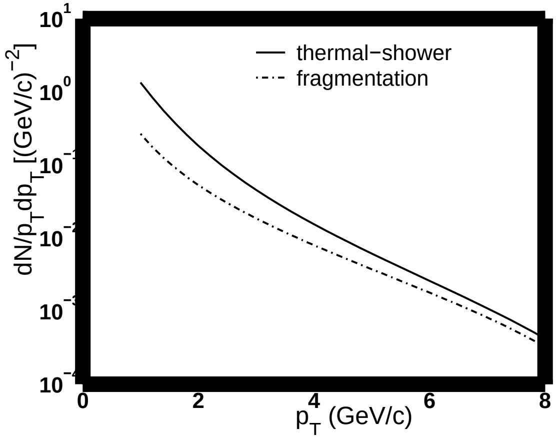
- **AMPT simulations: baryon/meson is modified for jets in QGP** [PLB(2022)137638]



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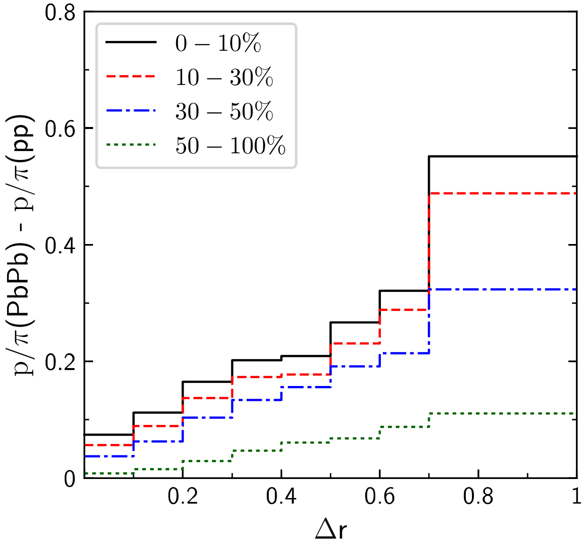

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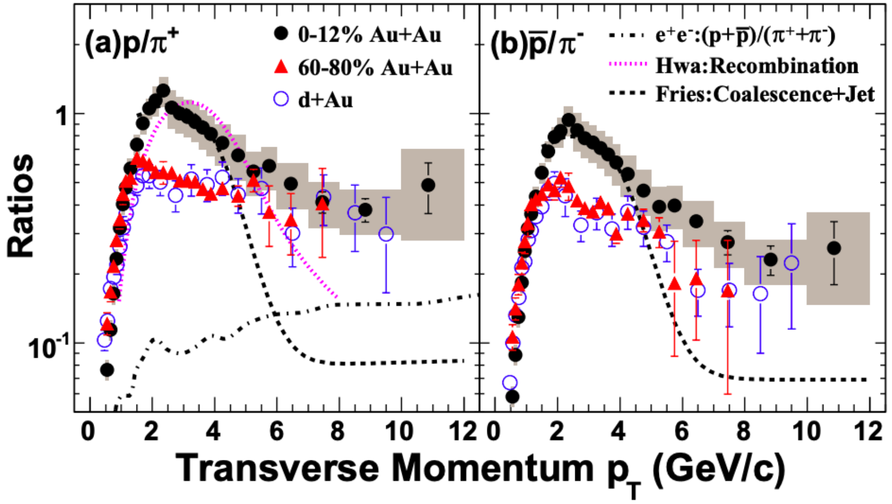

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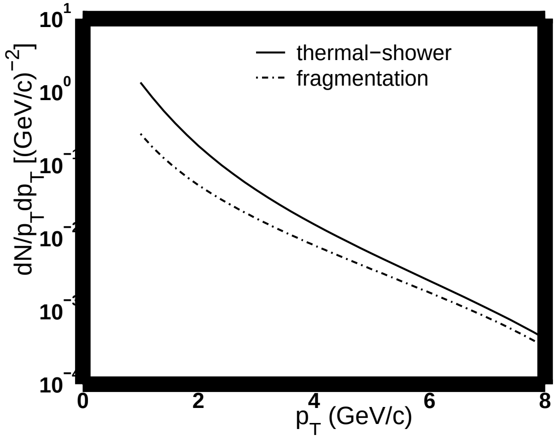

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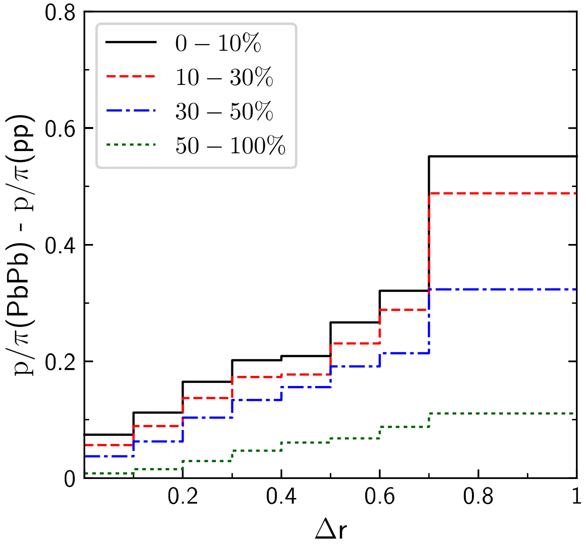

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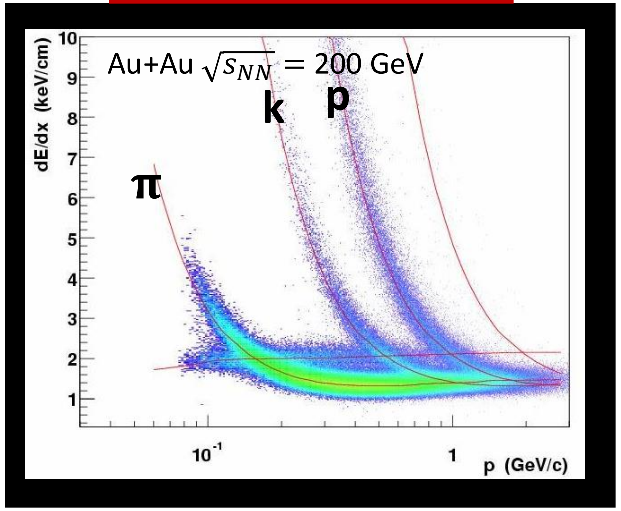
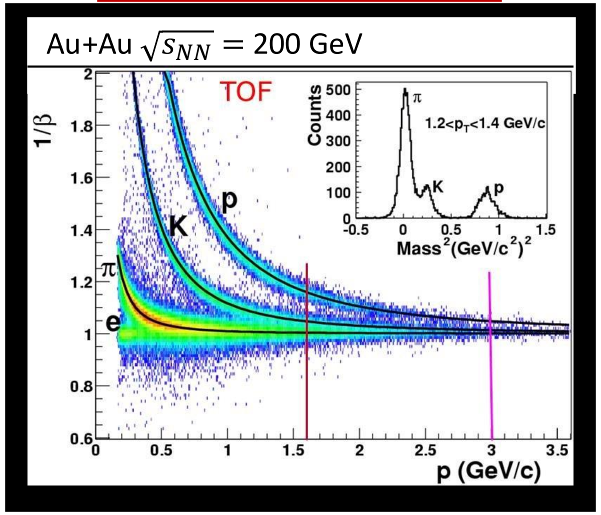
- Shower Parton Recombination [PR(2004)0312271]
- **AMPT simulations: baryon/meson is modified for jets in QGP** [PLB(2022)137638]
- **Is jet fragmentation modified by QGP?**
- We measure **p/π in jets** using **jet-hadron correlations**

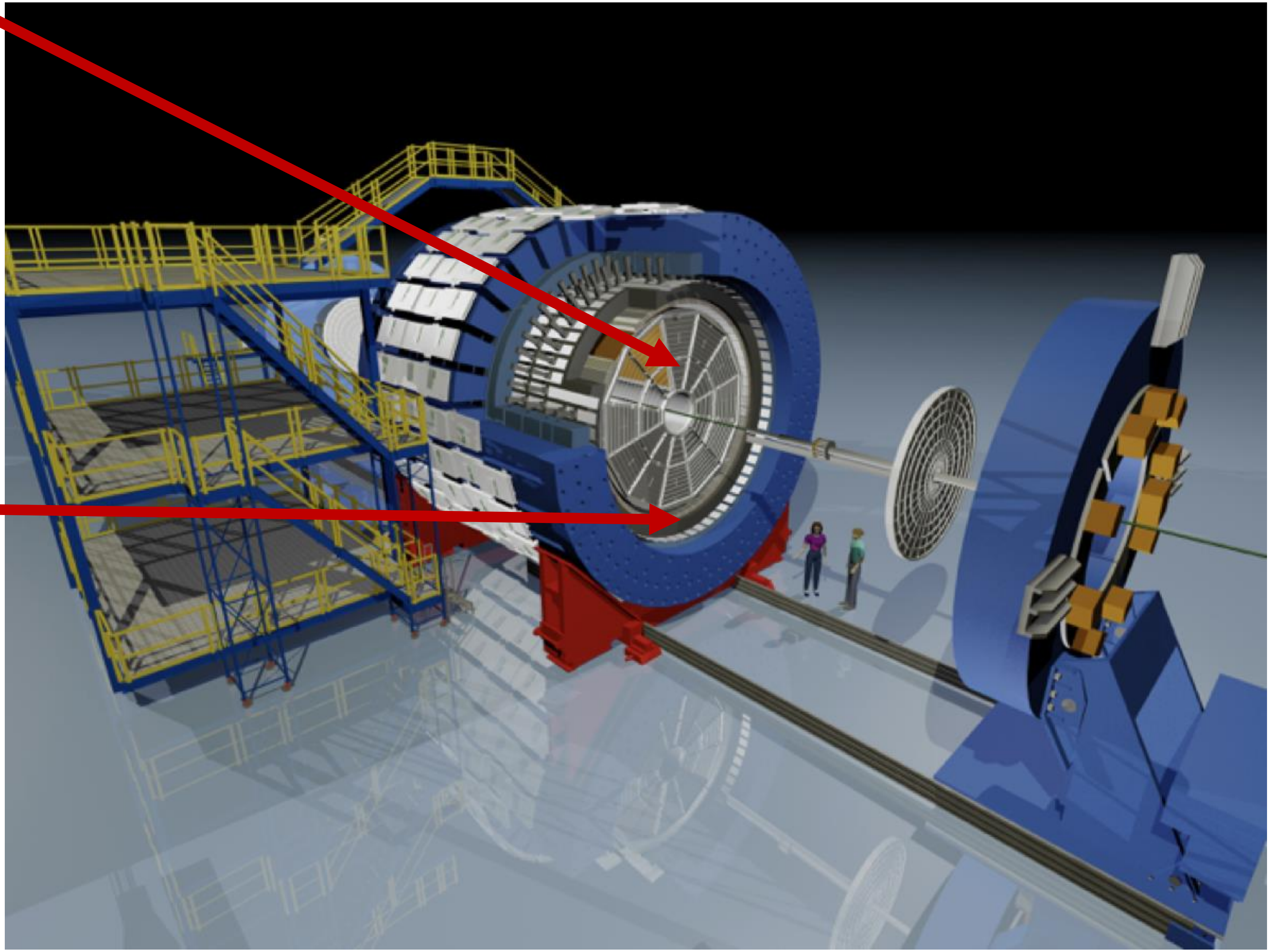
STAR Detector

dE/dx from TPC



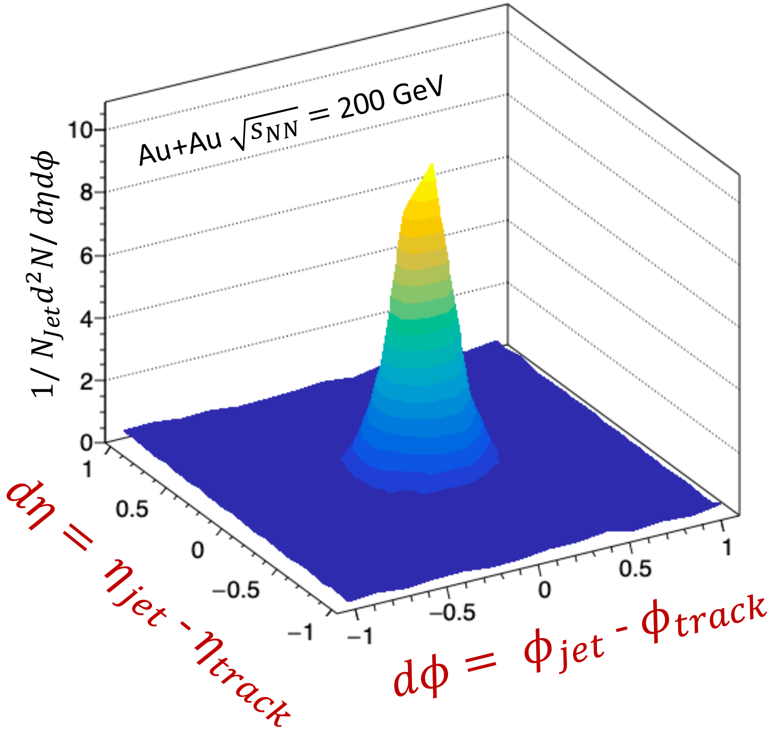
β from ToF



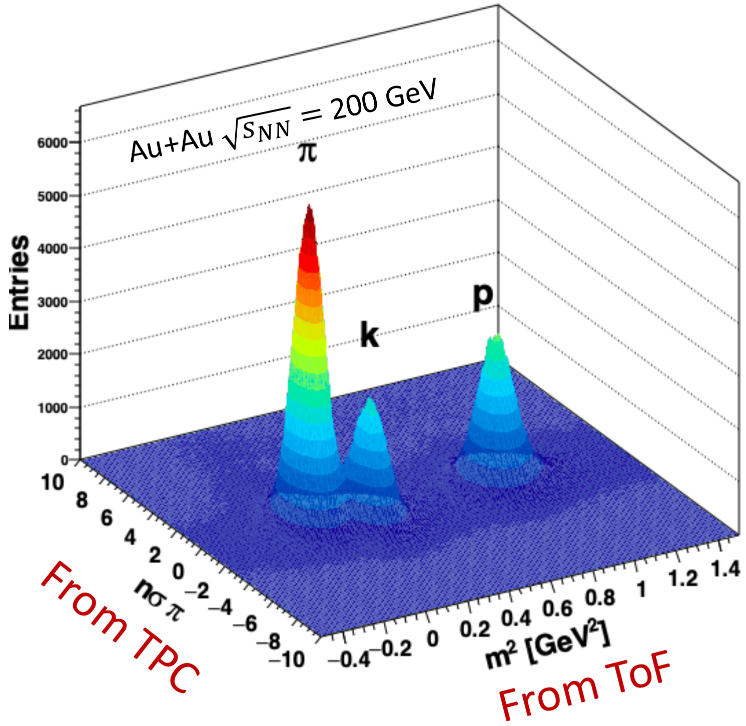


Measurement Technique

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**

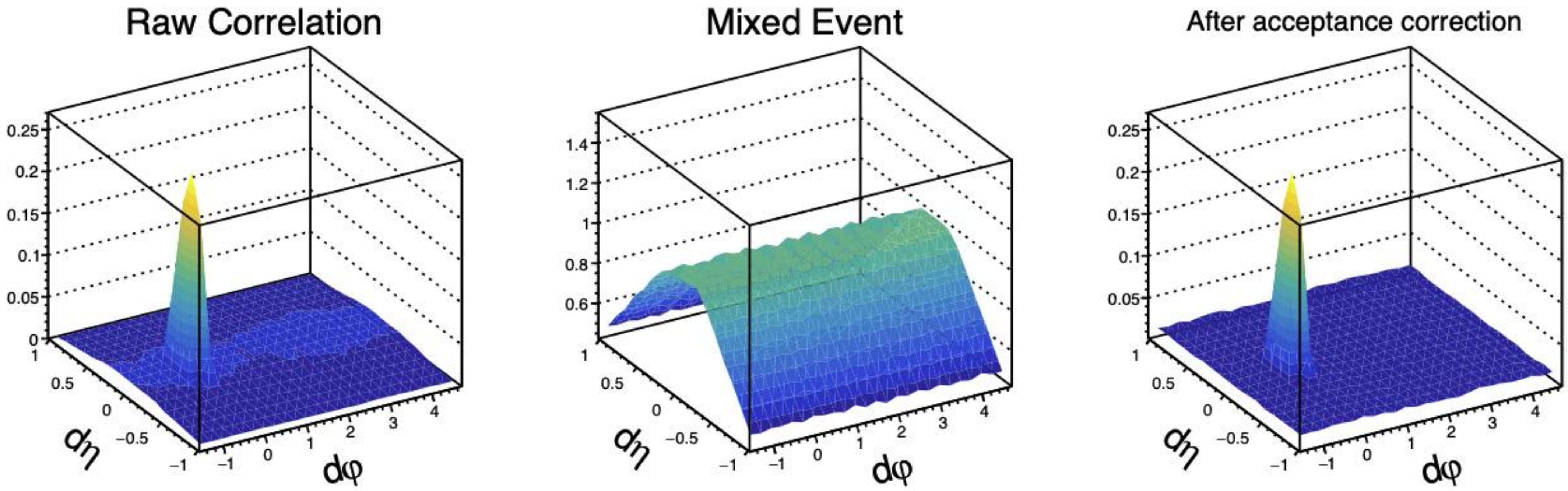
Data Samples

- p+p collisions at $\sqrt{s} = 200$ GeV (2015)
- 0-10% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, (2014)

Jet Reconstruction

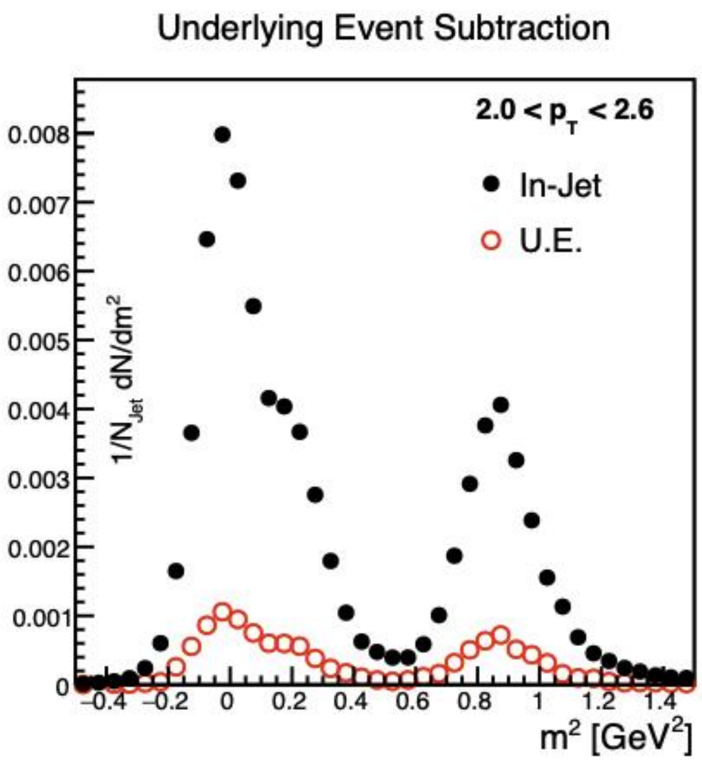
- **Anti- k_T**
- Jet R = 0.2, 0.3, 0.4
- Constituent selections
  - p_T^{const} > 2.0 GeV/c
  - p_T^{const} > 3.0 GeV/c
- **Jet p_T^{raw} > 9 GeV/c**
- **Inclusive Jets**

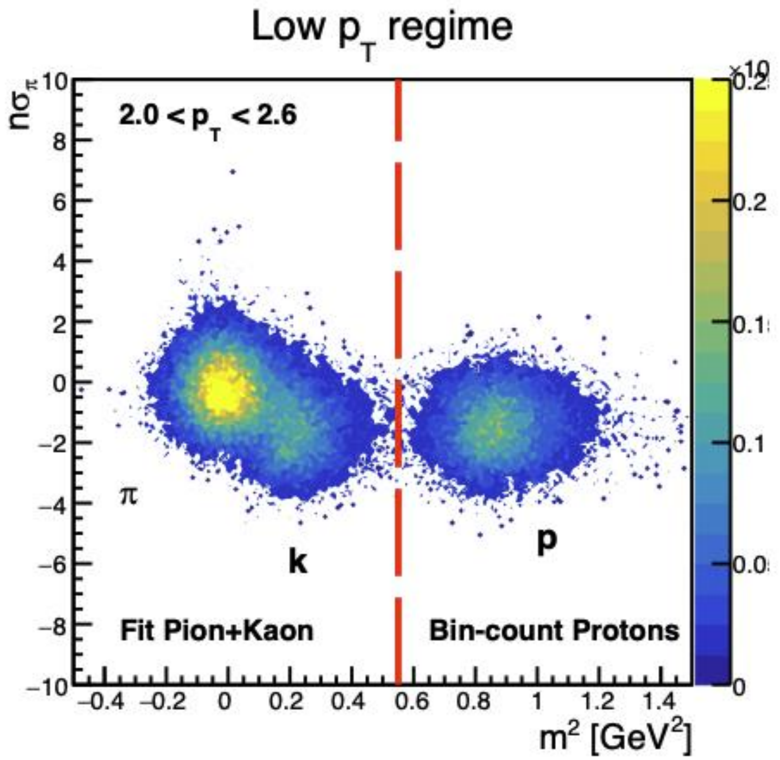
Jet-Track Correlation

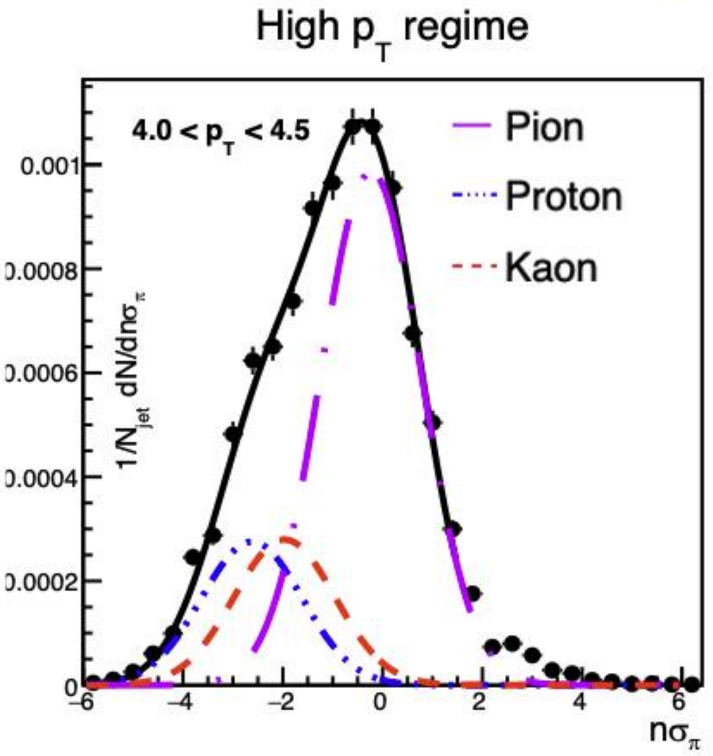


- Run Anti-k_{T} algorithm to identify Jet Axis
- Perform correlations with all tracks within $|\eta_{\mathrm{track}}| < 0.5$
- Build Mixed event for pair acceptance correction
- Divide signal correlation by mixed event
- Select regions of equal area for jet and underlying event for every p_{T} bin from 2.0 GeV/c to 5.0 GeV/c

Particle Identification

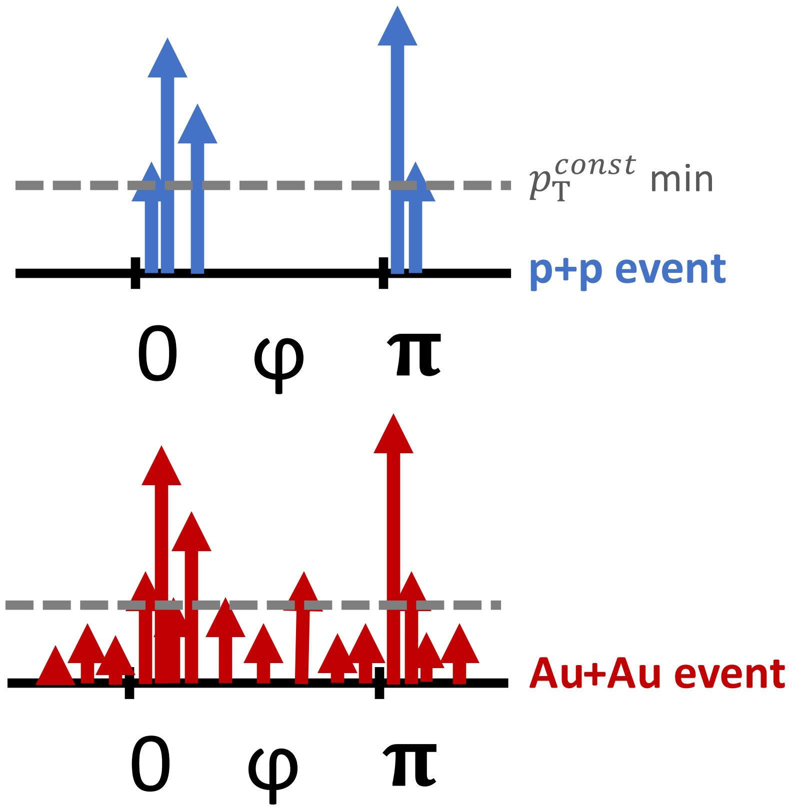






- Subtract UE from Jet in dφ, dη, $n\boldsymbol{\sigma}_{\boldsymbol{\pi}}$, and m^2
- Identify Pion, Proton, Kaon yields from remaining Jet Signal
- Low p_{T} regime: p_{T} < 3.0 GeV/c → bin-count protons
- High p_{T} regime: p_{T} > 3.0 GeV/c → triple Gaussian fit
- Divide proton yield by pion yield to measure ratio

Correlated Background Removal



The Challenge:

Jet selection threshold coupled with upward fluctuation in underlying event causes the jetfinder algorithm to pick up background tracks at a higher rate

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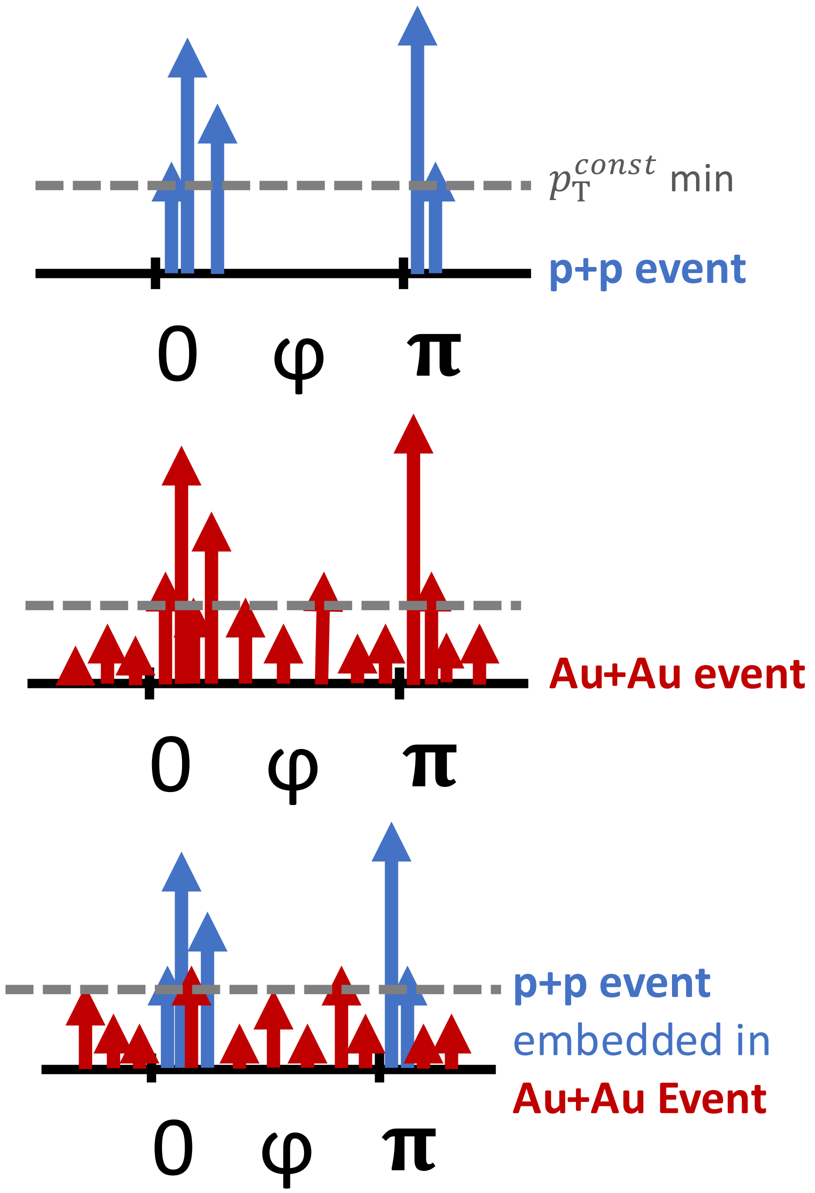

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The Solution:

Pseudo-embedding: take *p+p* jets down to low p_T → overlay with mixed constituent Au+Au event → run jet finder → match to original *p+p* jet → construct jet+track correlations with Au+Au event and perform uncorrelated UE subtraction

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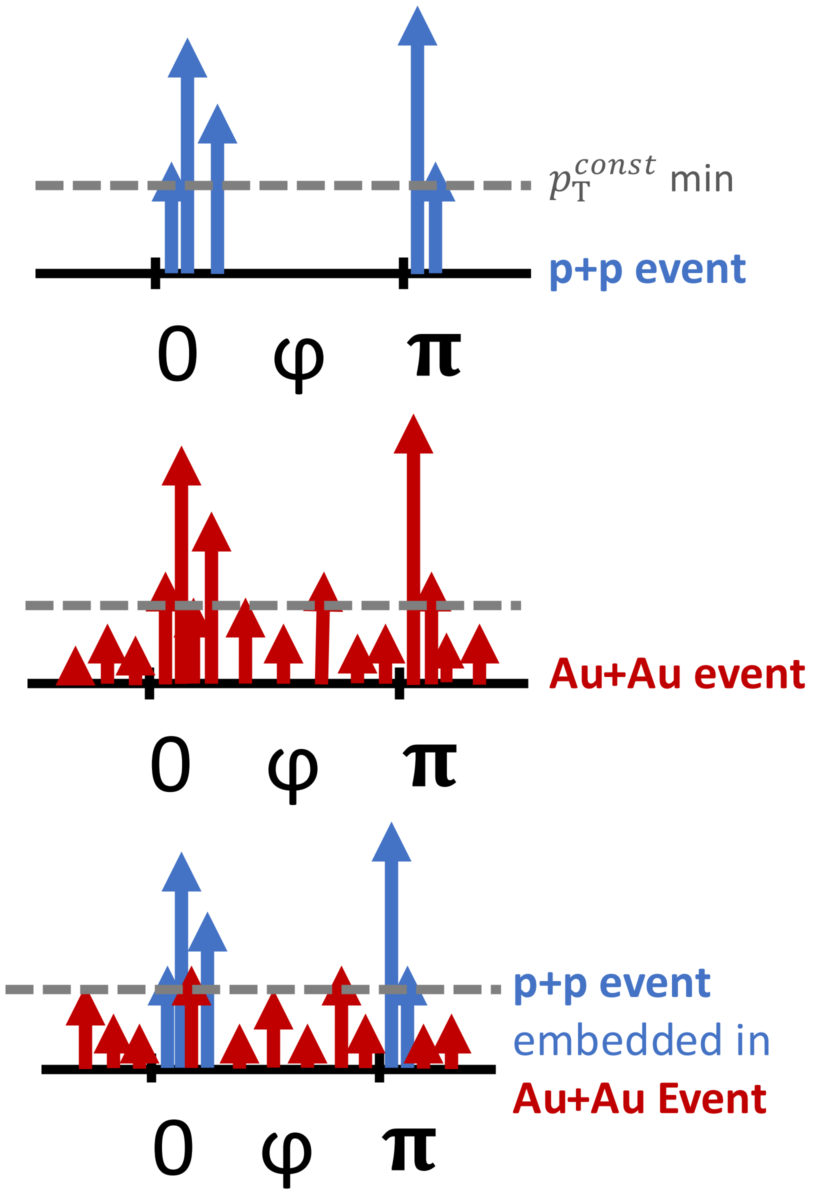

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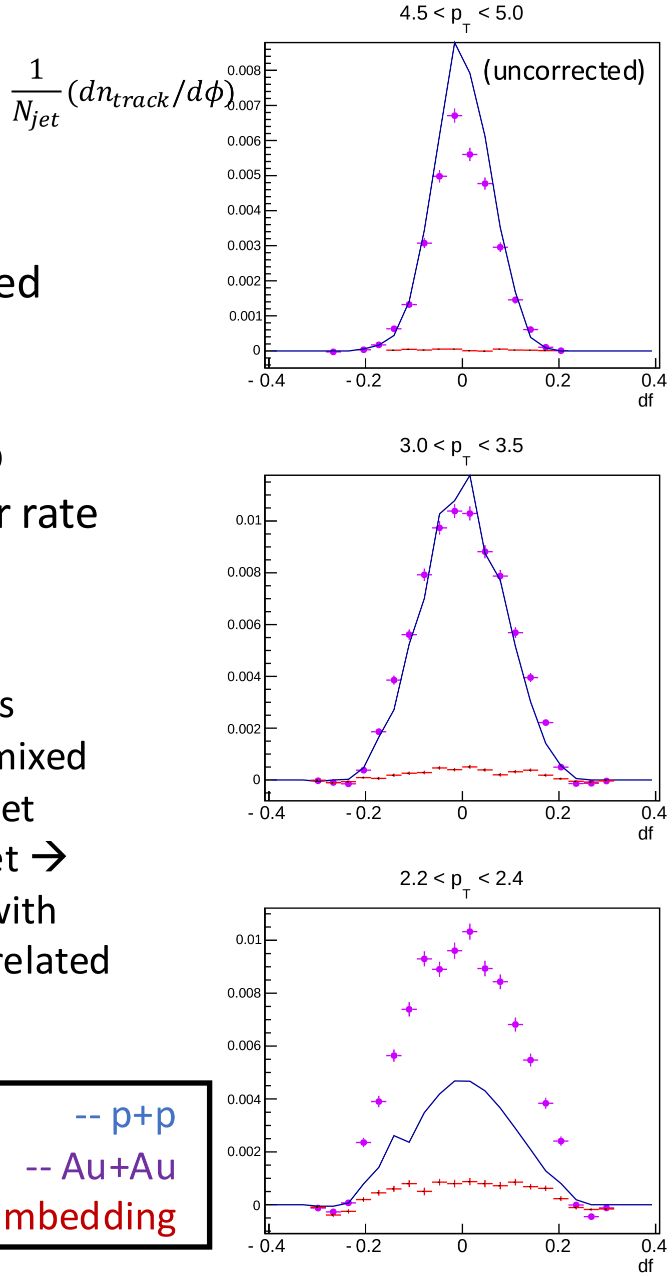
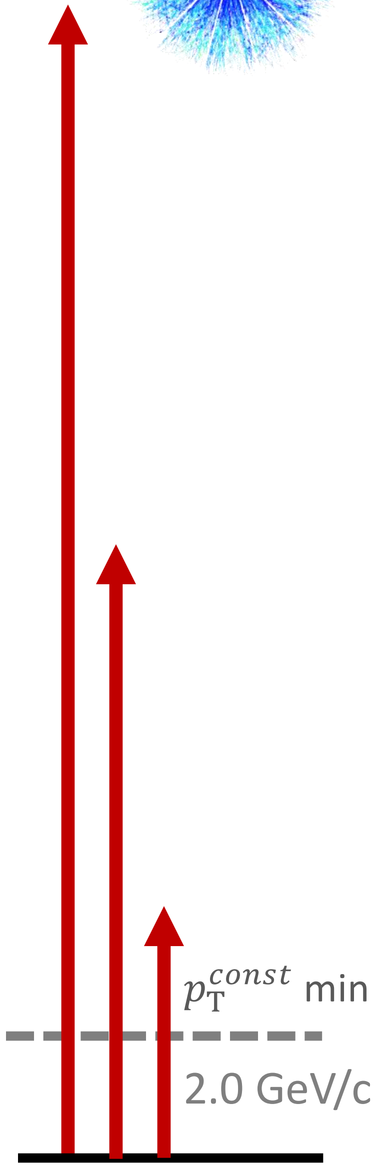
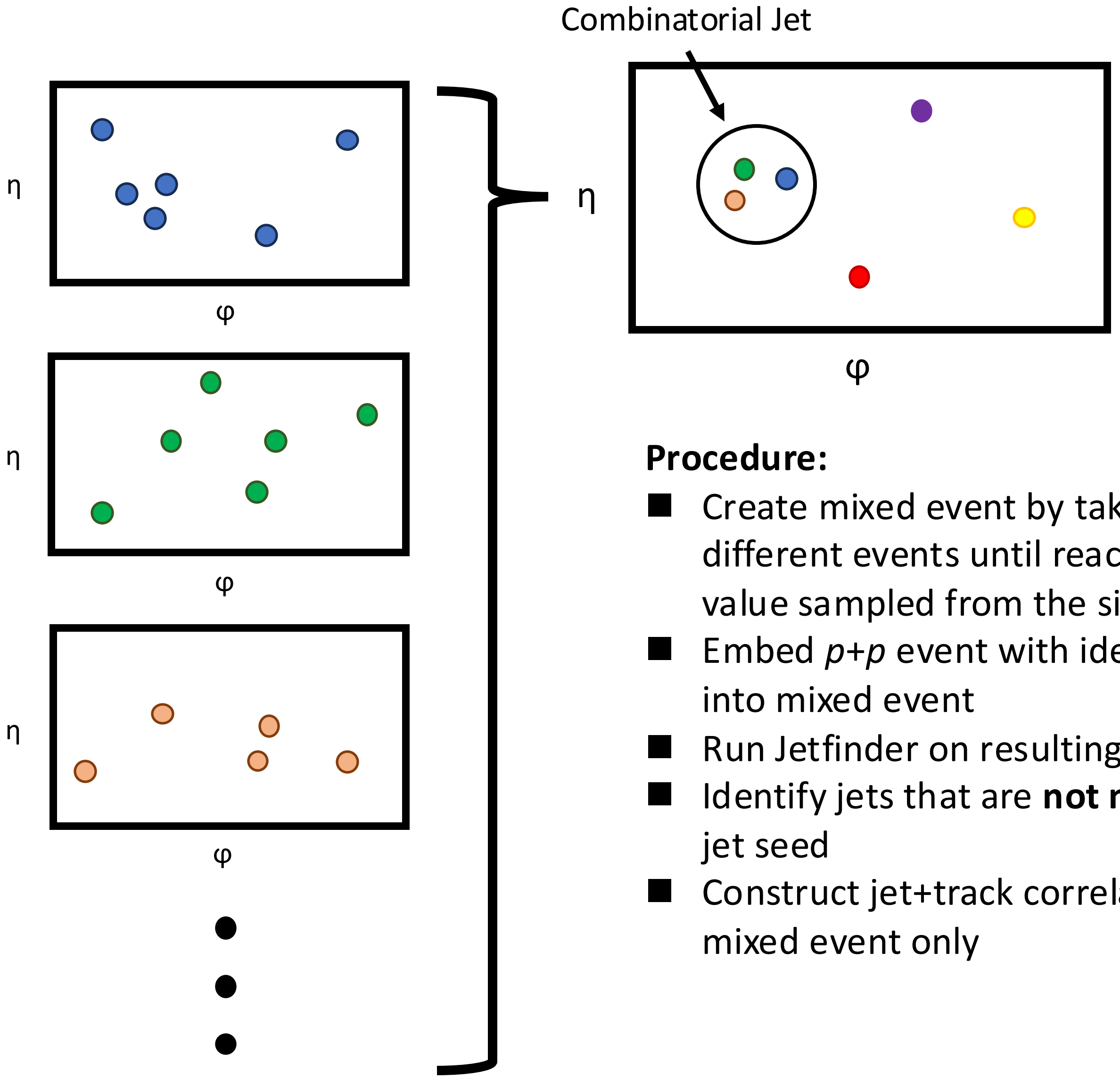


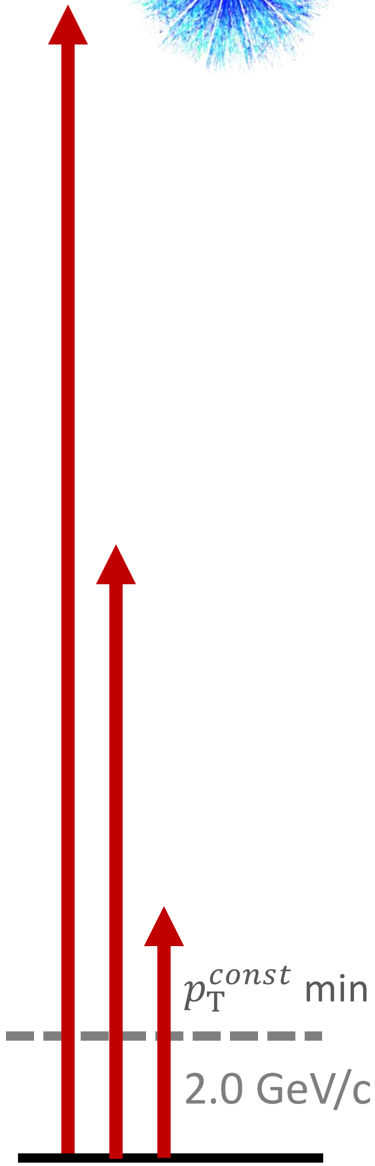


Evaluating Contribution from Combinatorial Jets



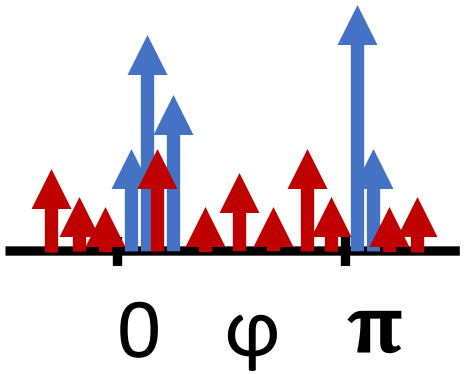
Procedure:

- Create mixed event by taking one track from different events until reaching an n_{track} value sampled from the signal distribution
- Embed *p+p* event with identified jet seed into mixed event
- Run Jetfinder on resulting combined event
- Identify jets that are **not matched** to a *p+p* jet seed
- Construct jet+track correlations with Au+Au mixed event only



Correlated Background Removal: Embed into Mixed Constituent Event

p+p event
embedded in
Au+Au Mixed Event



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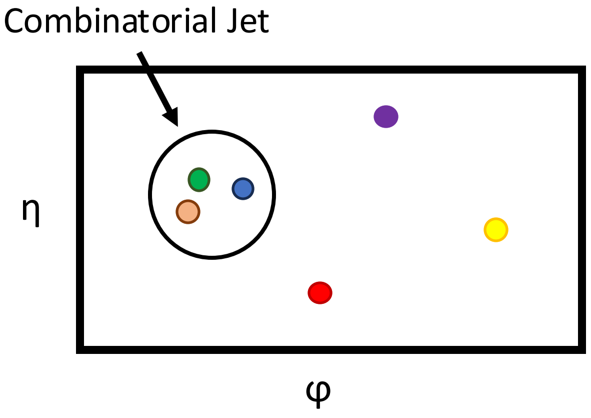


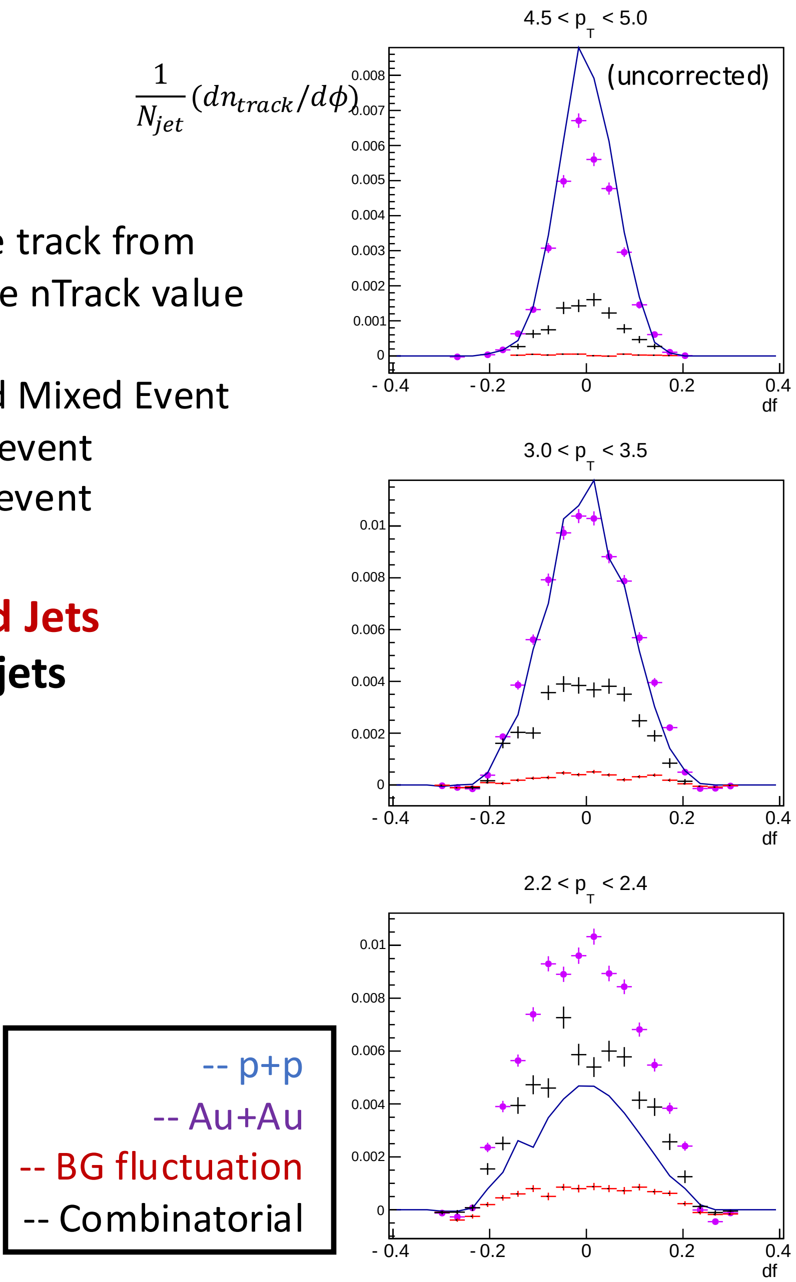
Procedure:

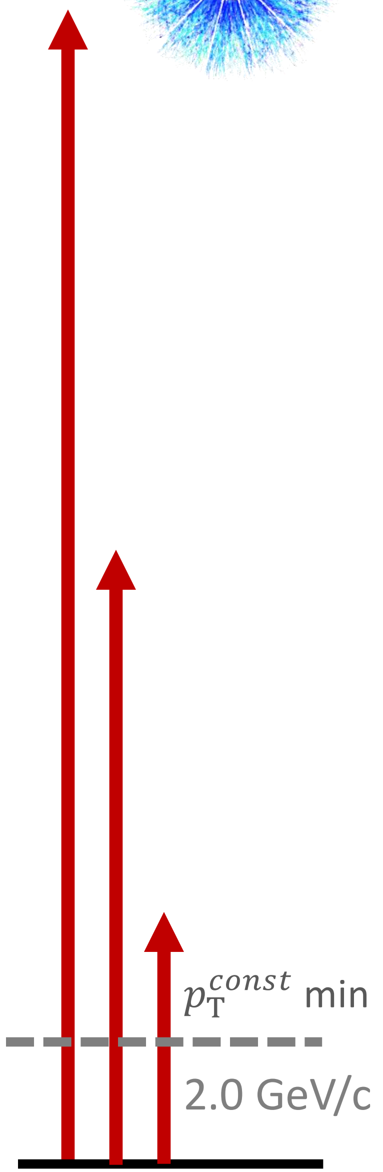
- Run Jetfinder on *p+p* event
- Create Mixed event by taking one track from different events until a reasonable nTrack value is reached
- Combine *p+p* event (with jet) and Mixed Event
- Run Jetfinder on resulting mixed event
- Perform correlations with mixed event

Pseudo-embedding → Matched Jets
Combinatorials → Unmatched jets

Fake Rate Determination:

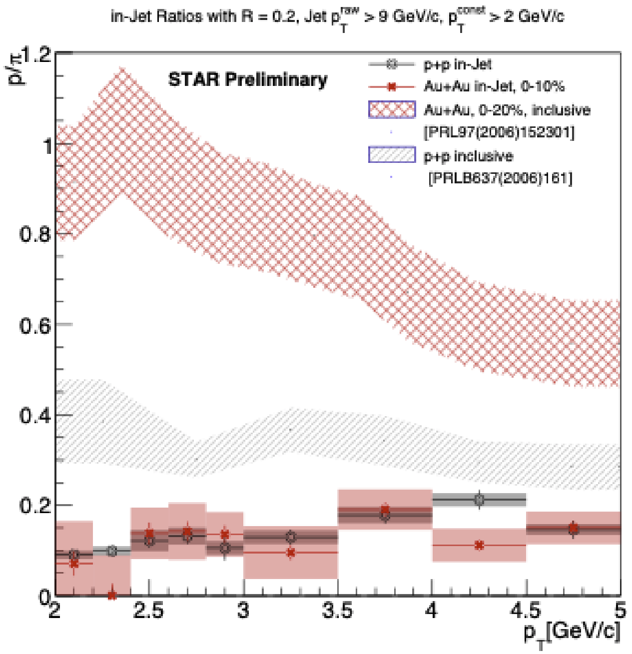
- Fake Rate = $\dfrac{n_{jet}^{combi}/n_{event}^{combi}}{n_{jet}^{signal}/n_{event}^{signal}}$
- Scale per-jet combinatorial yields by Fake Rate
- Scale per-jet fluctuation yields by (1-Fake Rate)
- Subtract correlated background from jet signal



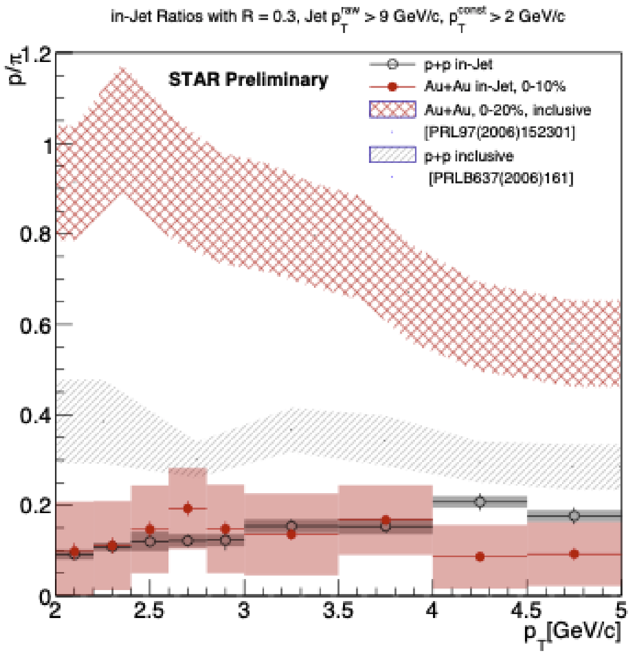


Preliminary plots from HP24

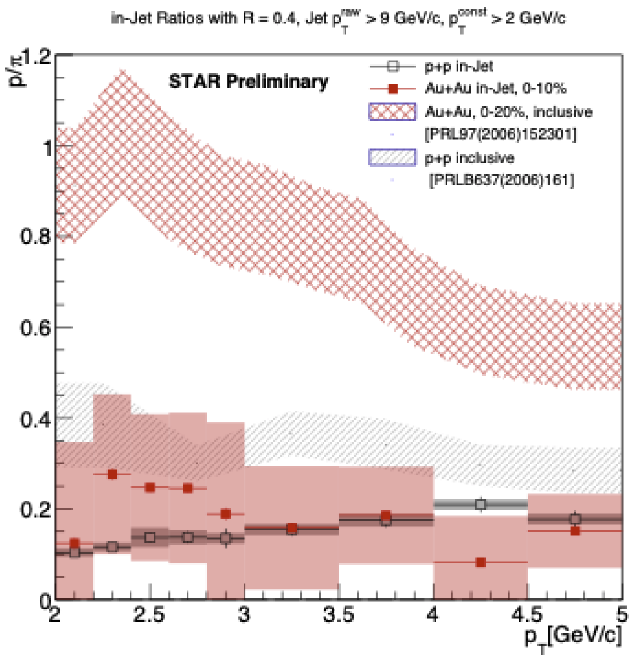
R = 0.2



R = 0.3

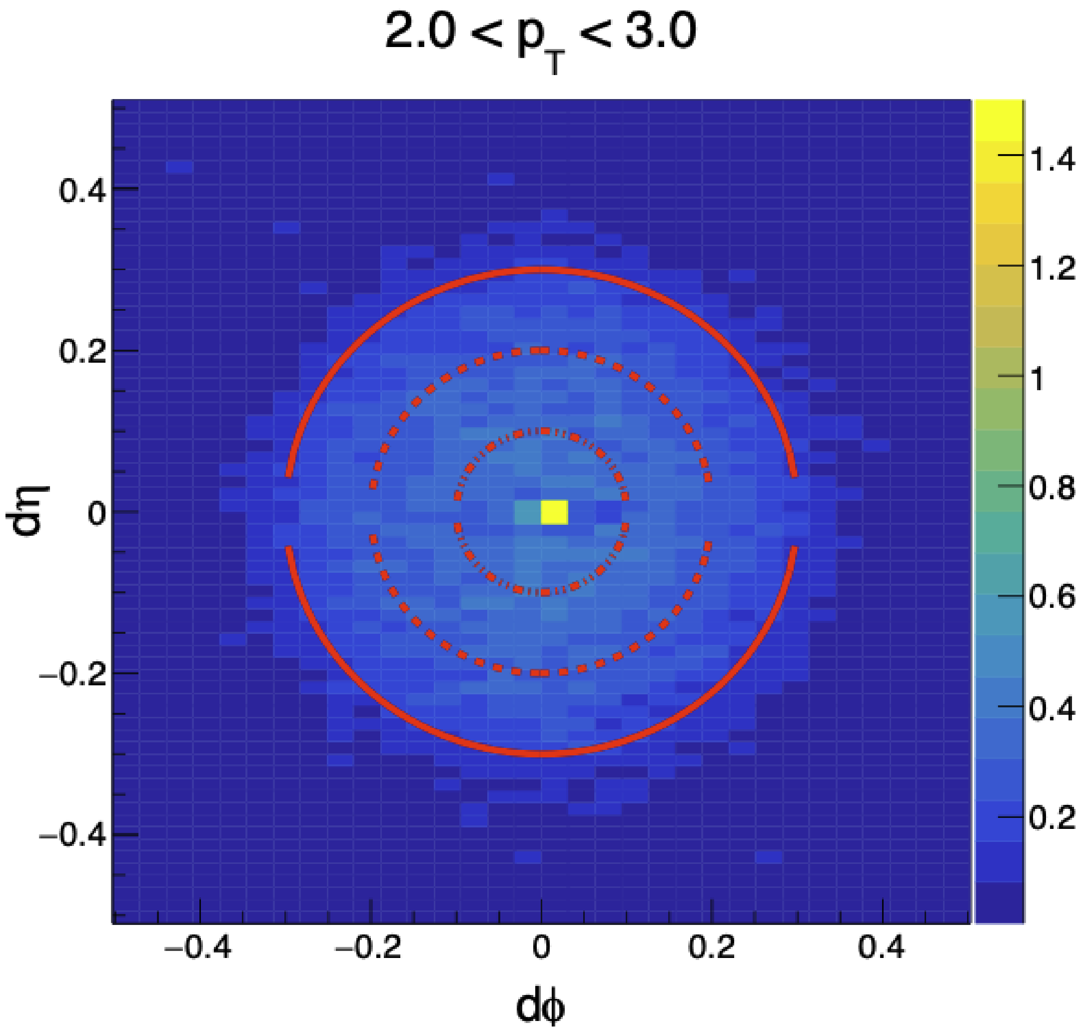


R = 0.4



- We present the first ever in-Jet p/**π** study with jet R dependence from STAR
- Study shows jets with p_{T}^{const} > 2.0 GeV/c and jet $p_{\mathrm{T}}^{\mathrm{raw}}$> 9.0 GeV/$c$
- In p+p collisions, the in-jet p/**π** ratio sits below the p/**π** ratio from inclusive hadrons, with no dependence on jet R
- For every jet R studied, in-jet p/**π** ratios measured in central Au+Au are consistent with those from p+p, with no evidence for enhancement between the two systems

Yields as a function of Δr

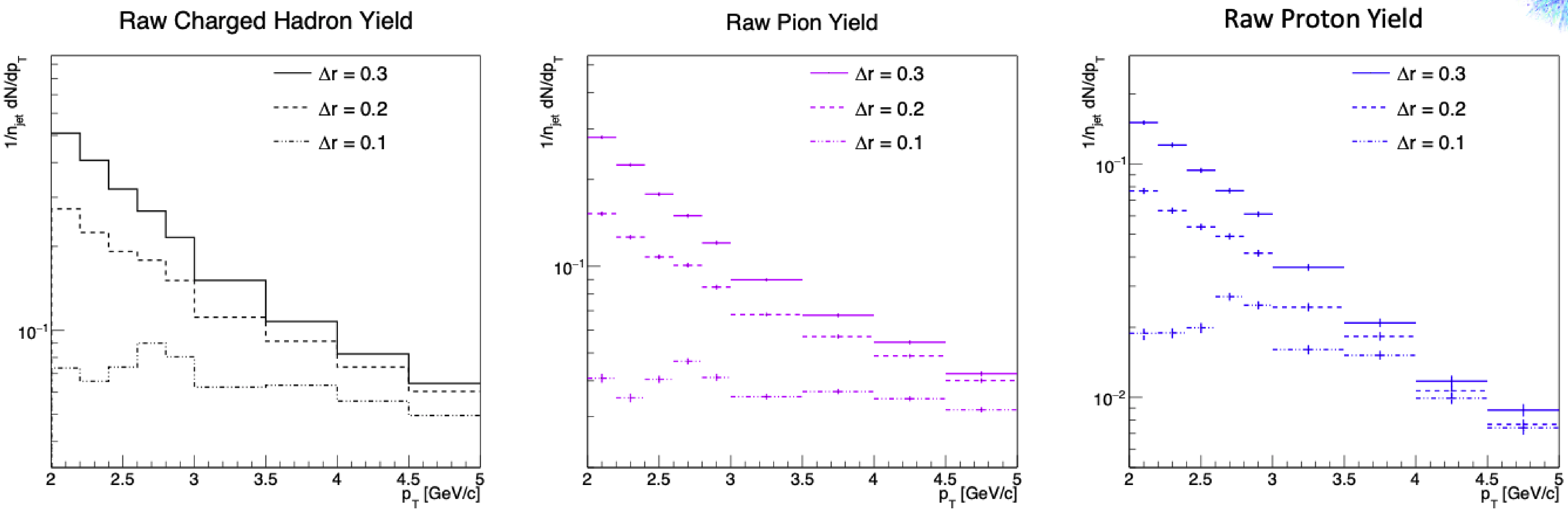


- Δr is defined as the distance to the jet axis for any particular track.

$$\Delta r = \sqrt{(\eta_{\mathrm{jet}} - \eta_{\mathrm{track}})^2 + (\varphi_{\mathrm{jet}} - \varphi_{\mathrm{track}})^2}$$

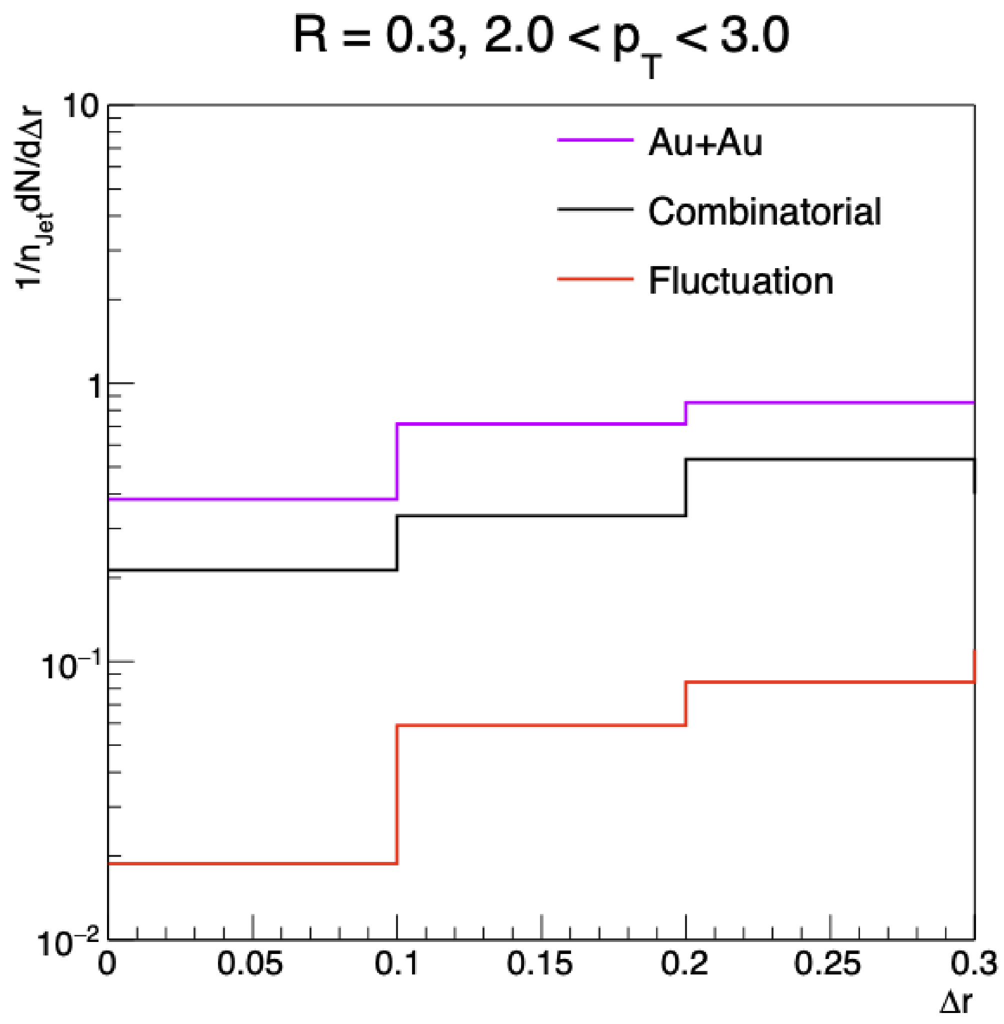
- All previous results are integrated using Δr = R
- To study identified particle content as a function of Δr, we keep a fixed Jet R for clustering, and vary the integration radius, performing PID on resulting distributions
- For this study we use R = 0.3 and Δr = 0.1, 0.2, 0.3
- A range of 2.0 < p_{T} < 3.0 Gev/c is chosen for this study to ensure the cleanest PID results, given we can bin-count proton yield from ToF information in that regime

Yields as a function of ΔR

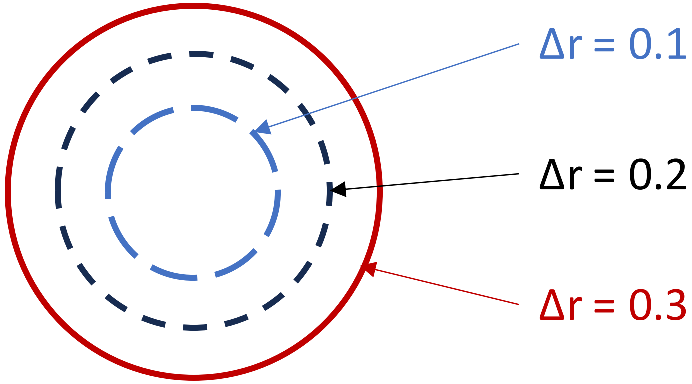


- Raw (before correlated background correction) yields for charged hadrons, identified protons and pions from jets with R = 0.3 at Δr = 0.1, 0.2, 0.3
- To isolate yield for each ring in Δr, we subtract smaller Δr yields from larger Δr yields

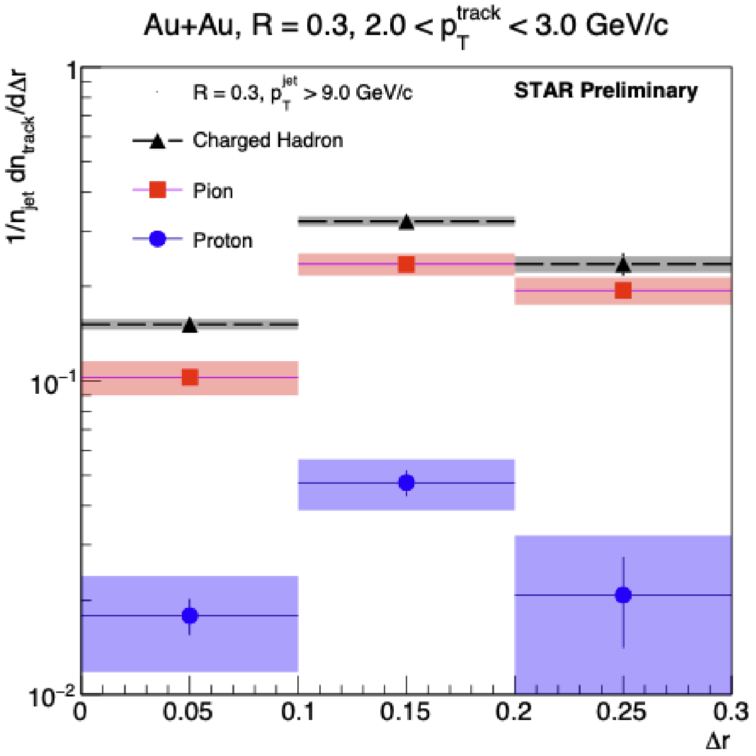
Correlated Background correction in ΔR

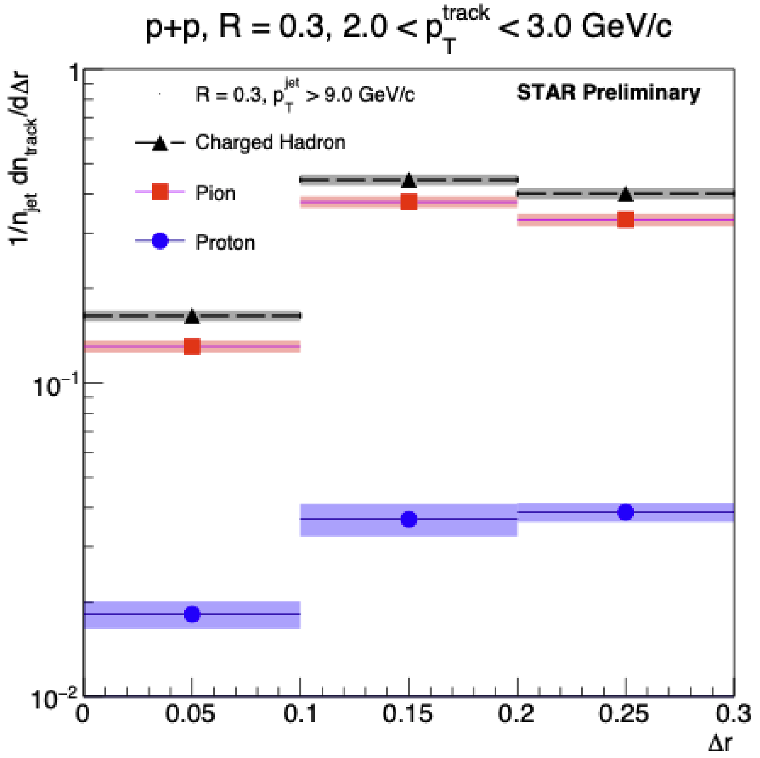


- Combining bins in the range $2.0 < p_{\mathrm{T}} < 3.0$ Gev/c, we subtract inner from outter radii to measure yield as a function of Δr
- The same procedure is followed for correlated background contribution from combinatorial jets and upward fluctuation into our jet yield

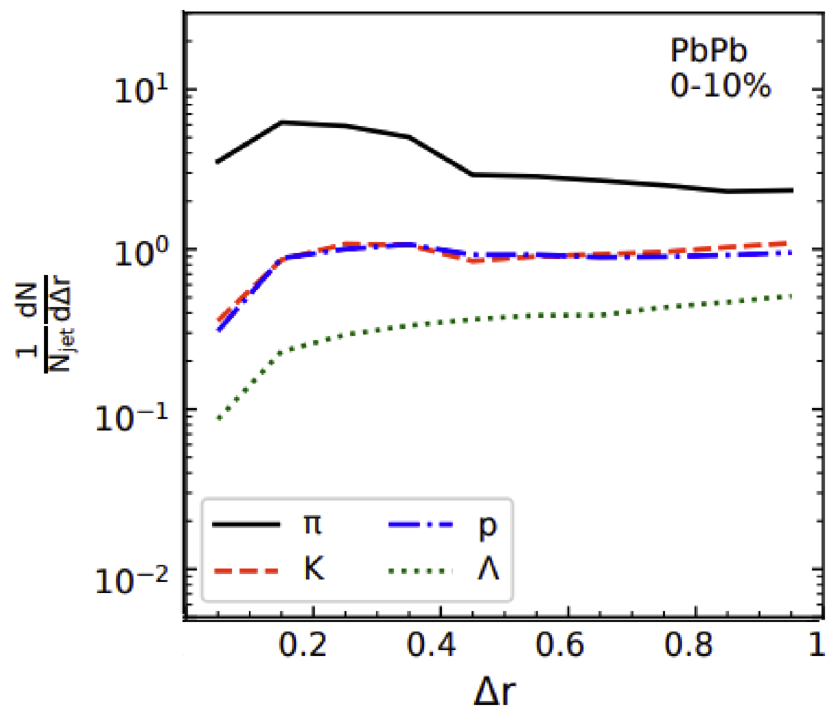


Identified Yields as a function of Δr



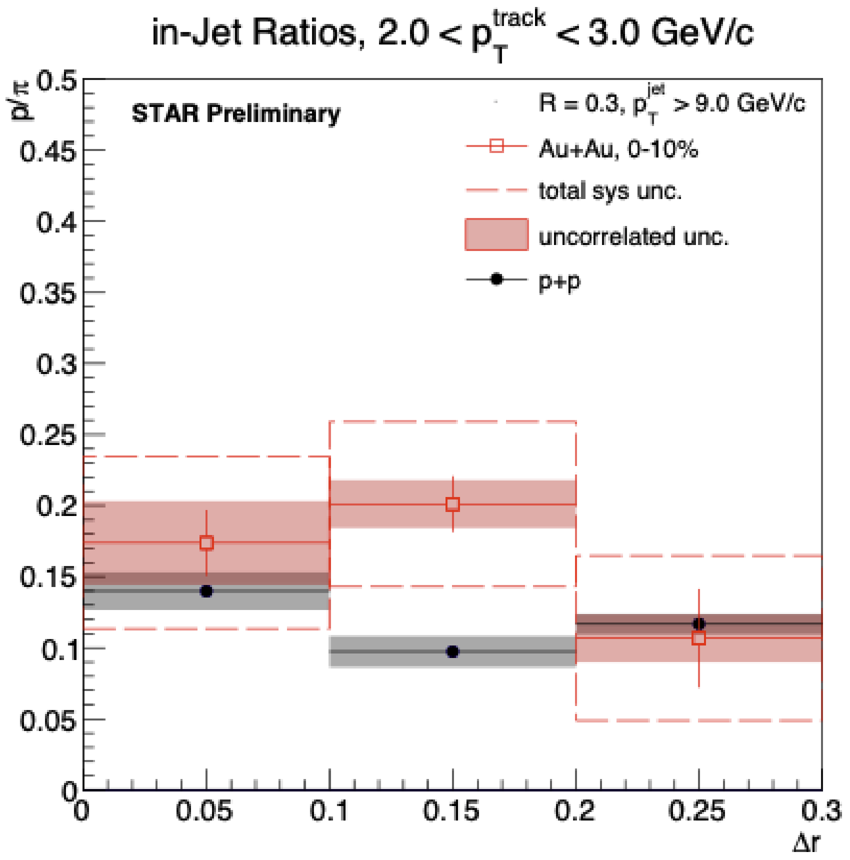


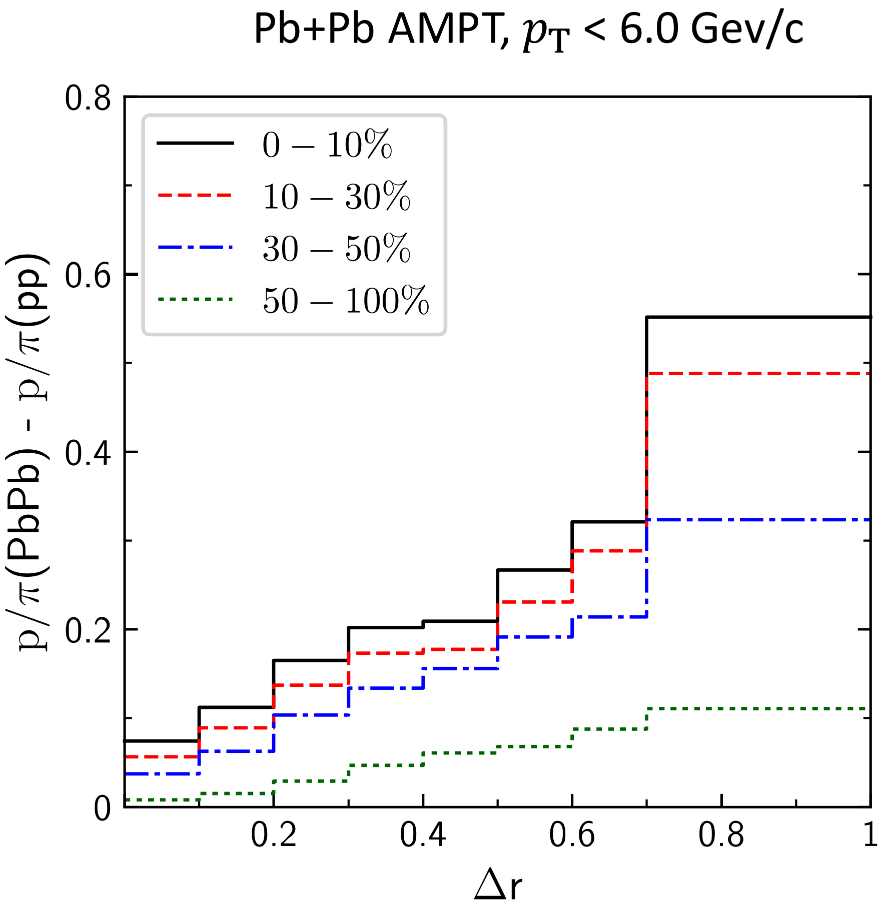
AMPT, p_{T} < 6.0 Gev/c



- Per-Jet Identified hadron yields are shown as function of Δr for jets with R = 0.3 in p+p and 0-10% central Au+Au collisions at 200 GeV
- Total charged hadron yield is shown to provide reference for the overall radial distribution

p/π Δr Dependence

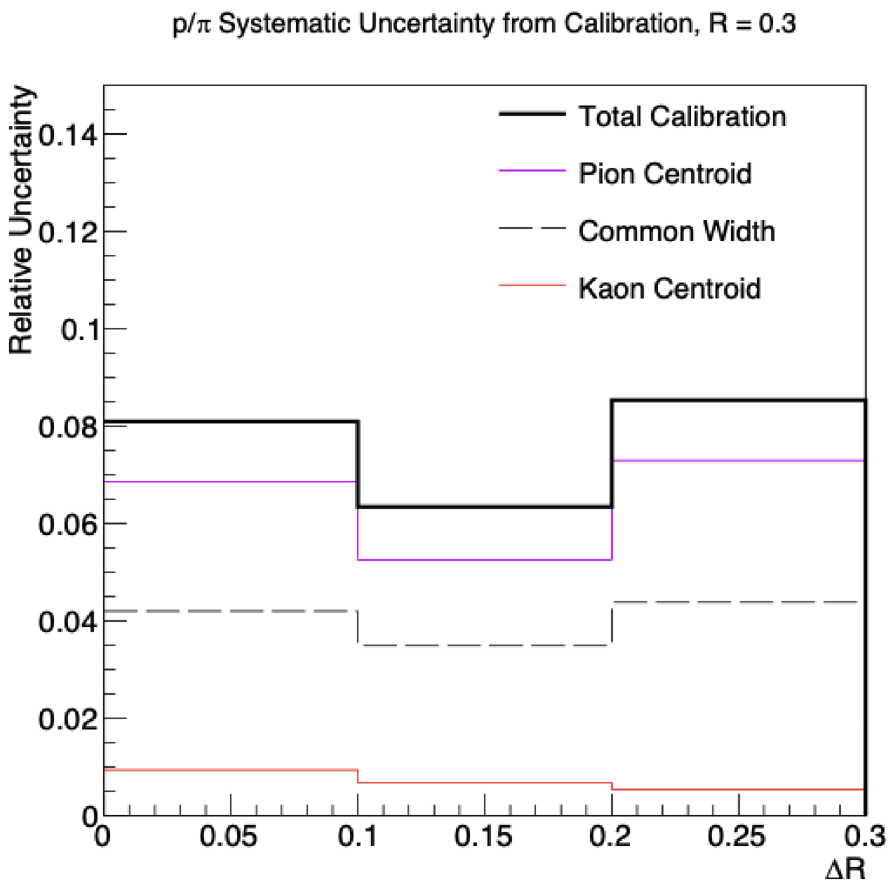


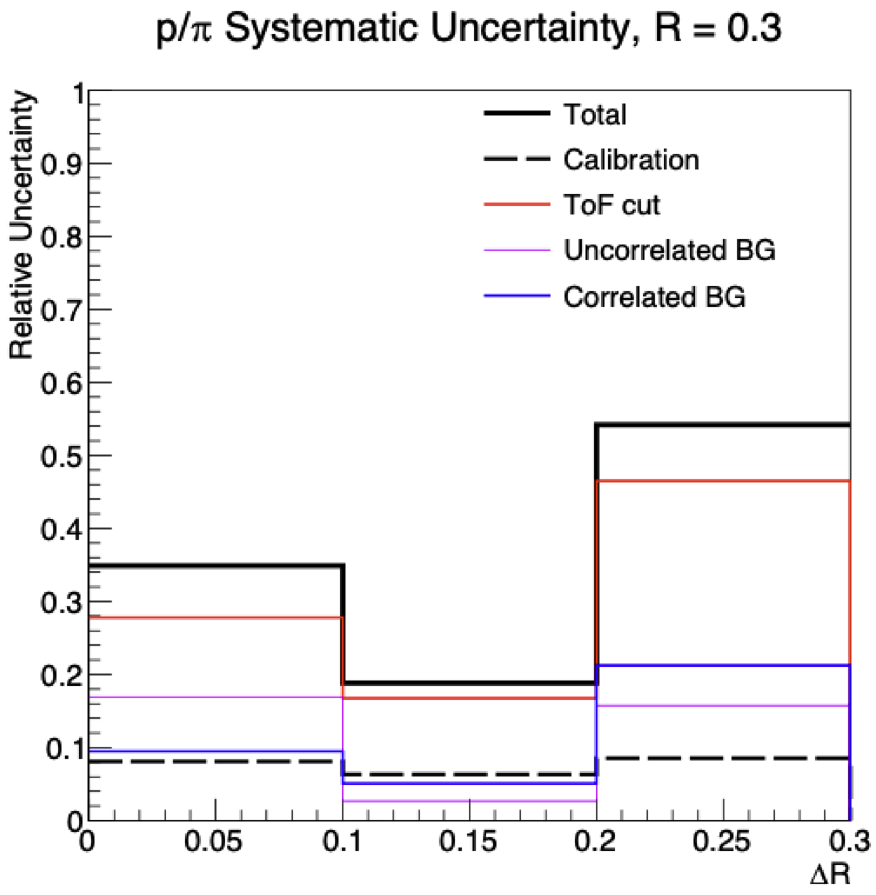


- For Tracks with 2.0 < p_T < 3.0 Gev/c in jets with R = 0.3, p_T^{const} > 2.0 GeV/c and jet p_T^{raw}> 9.0 GeV/*c*, we observe no significant difference in the in-cone radial evolution of p/**π** between 0-10% Au+Au and p+p collisions at 200 GeV

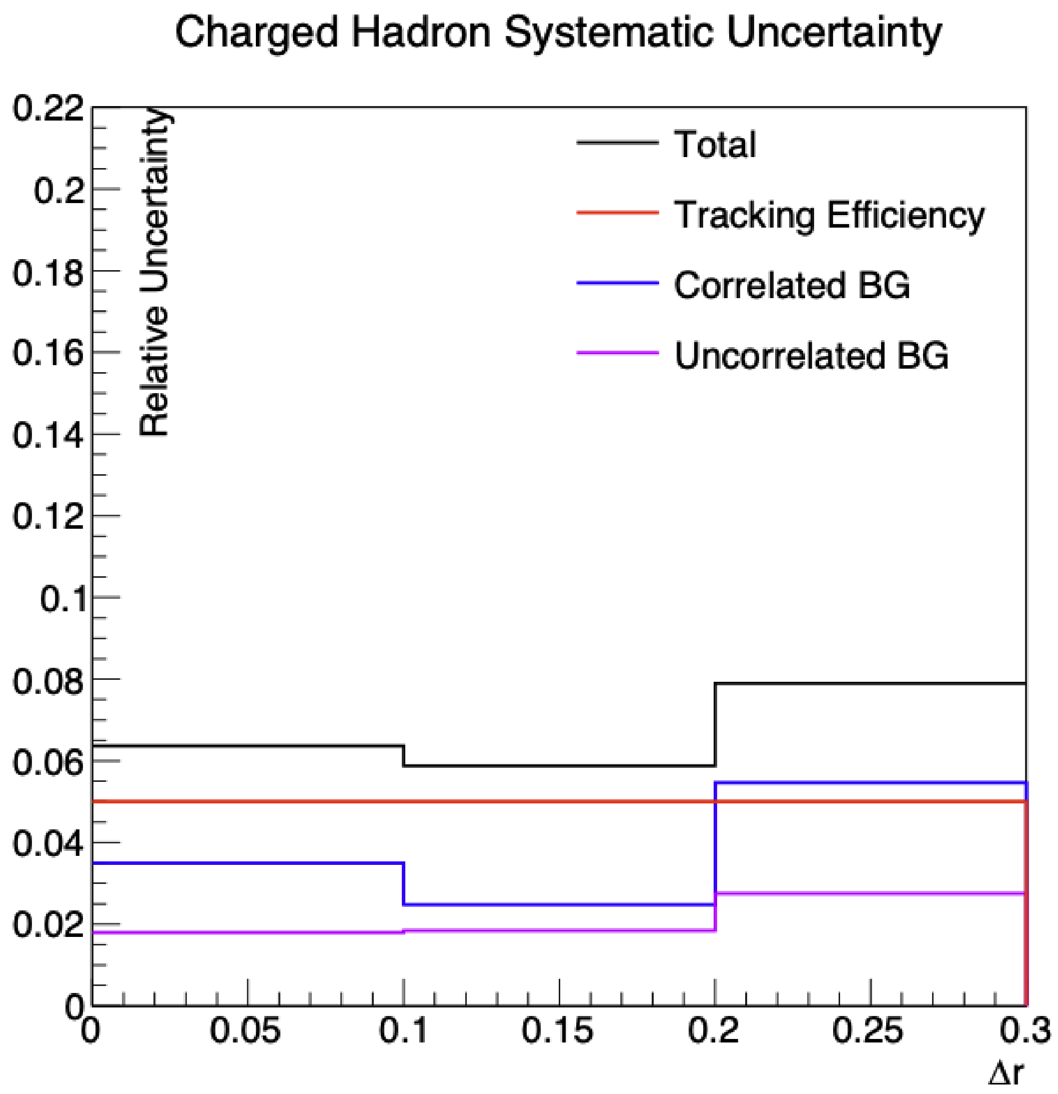
Backup

Au+Au p/π Δr Systematics

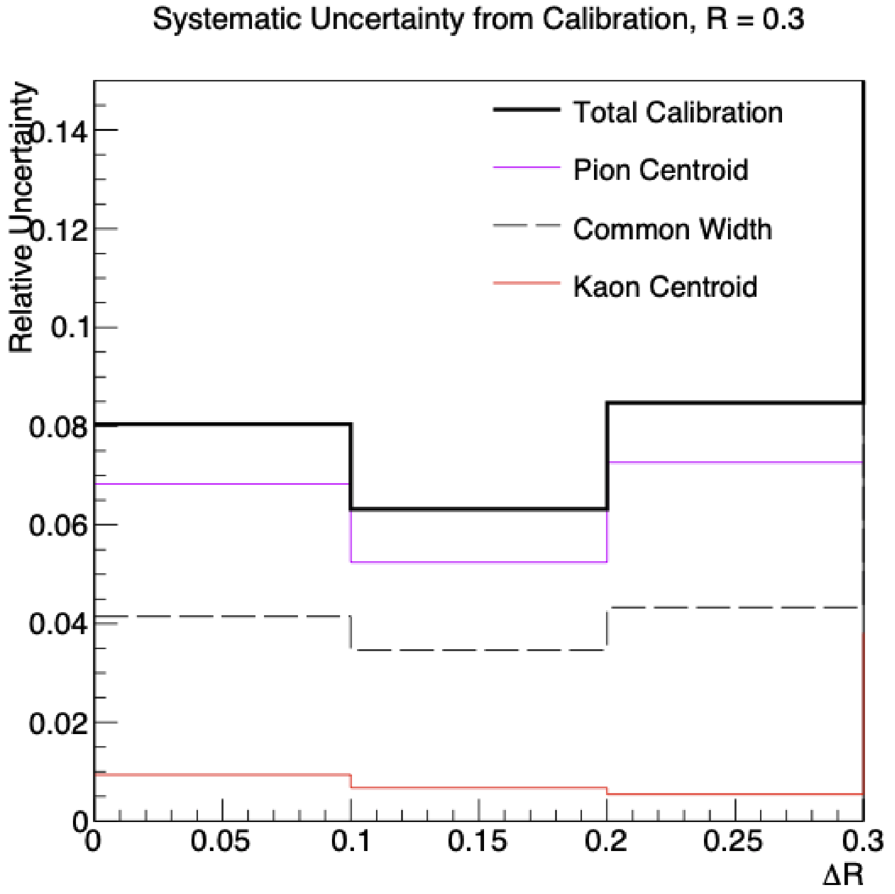


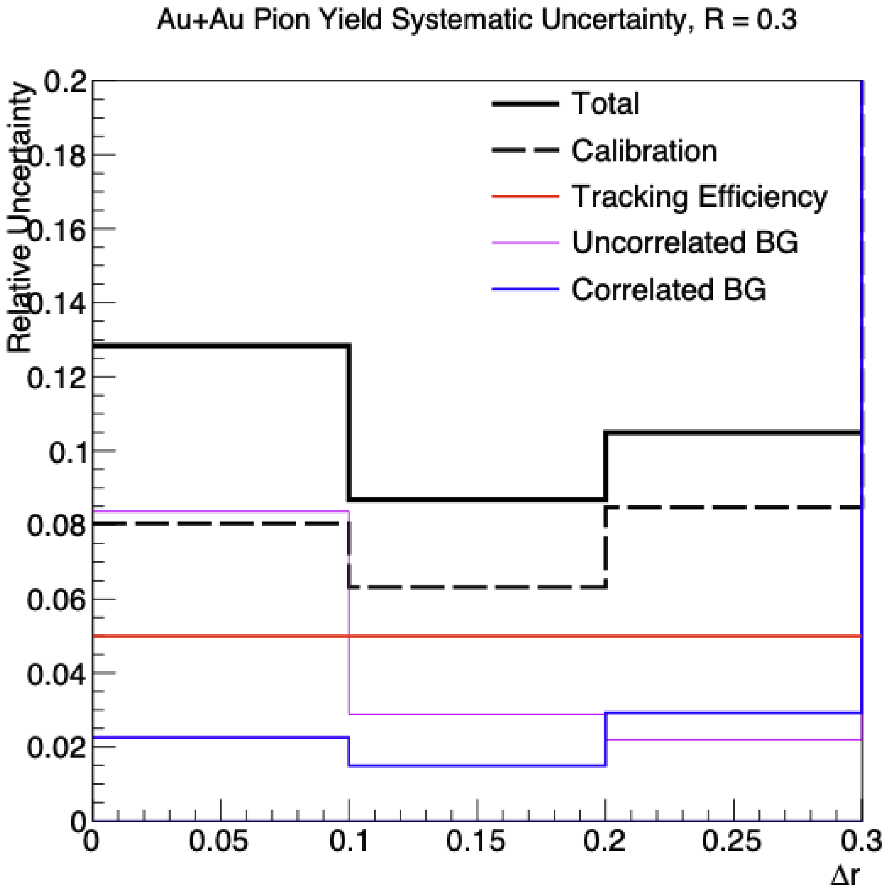


Au+Au Charged Hadron Yield Δr Systematics

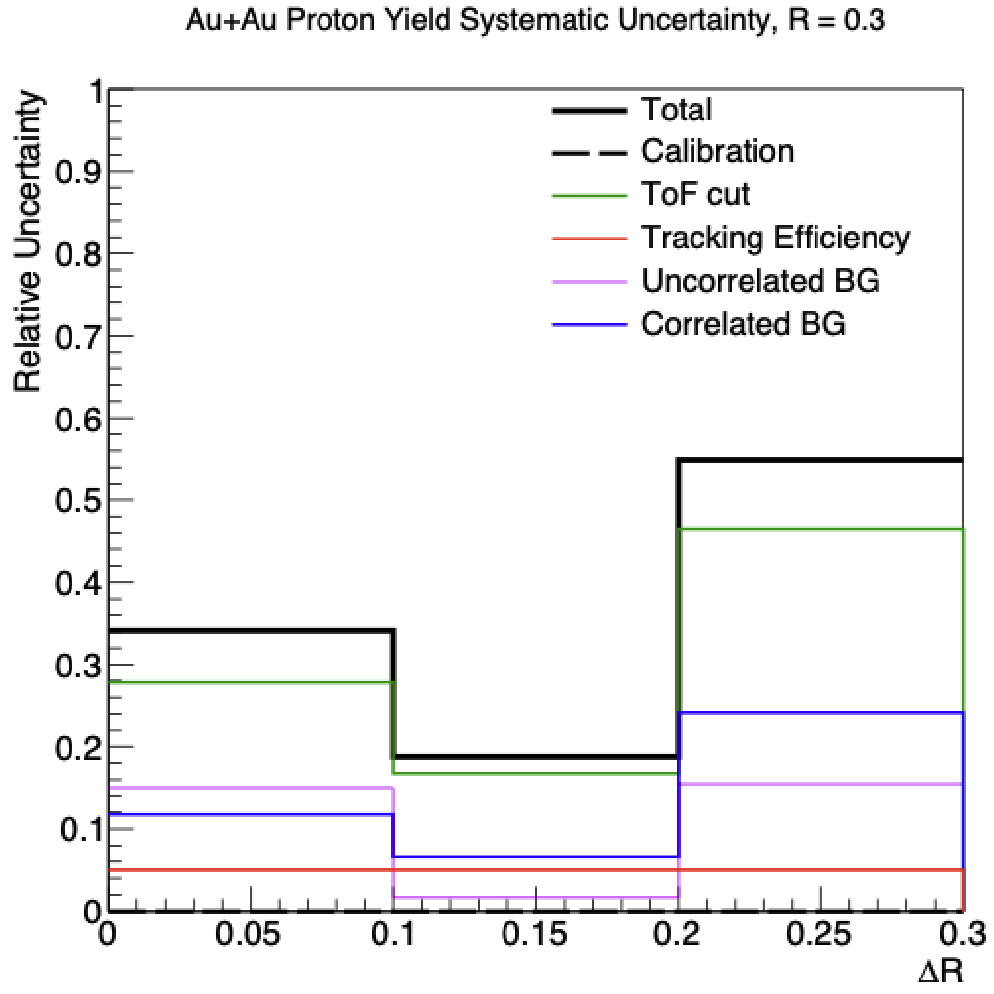


Au+Au Pion Yield Δr Systematics

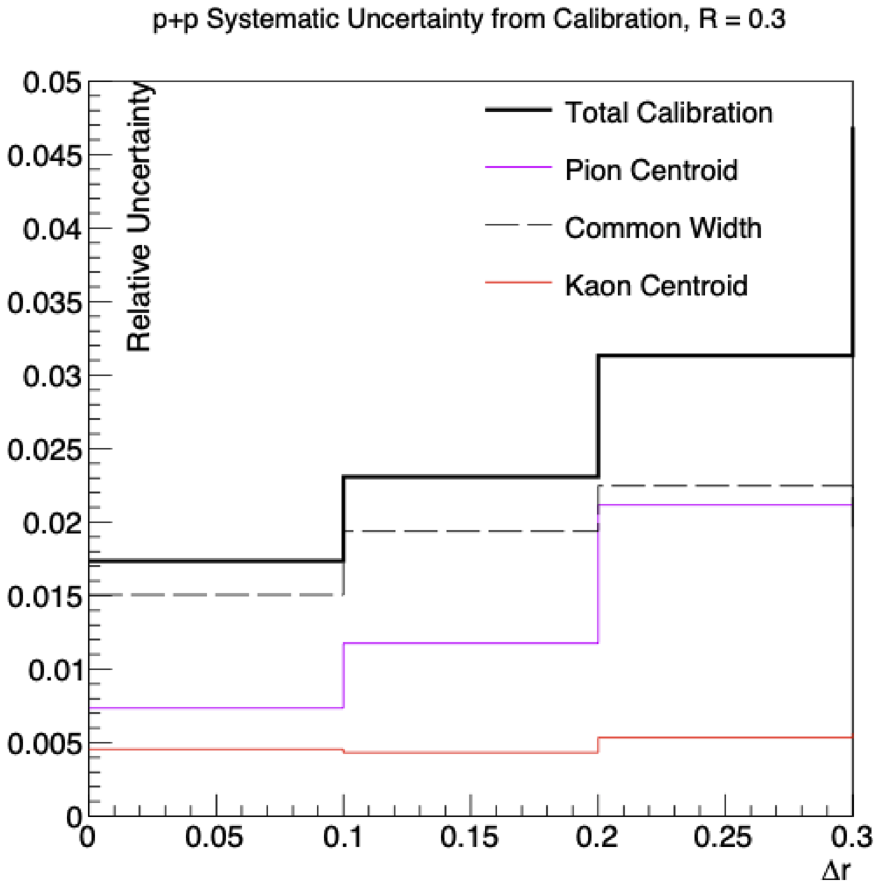


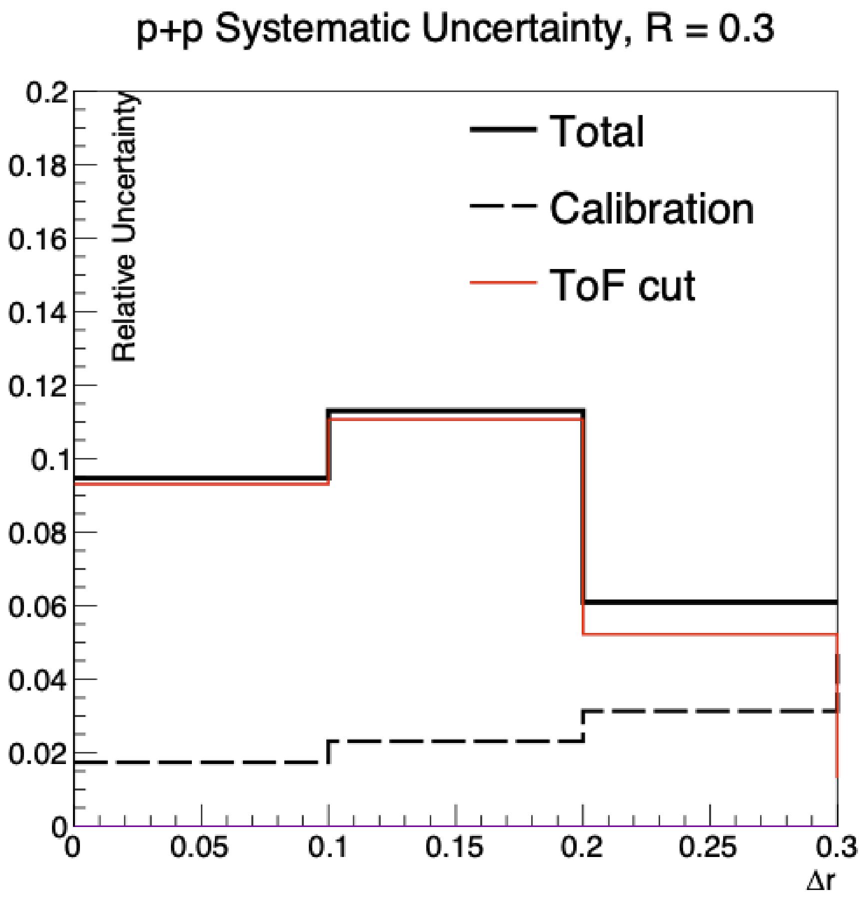


Au+Au Proton Yield Δr Systematics

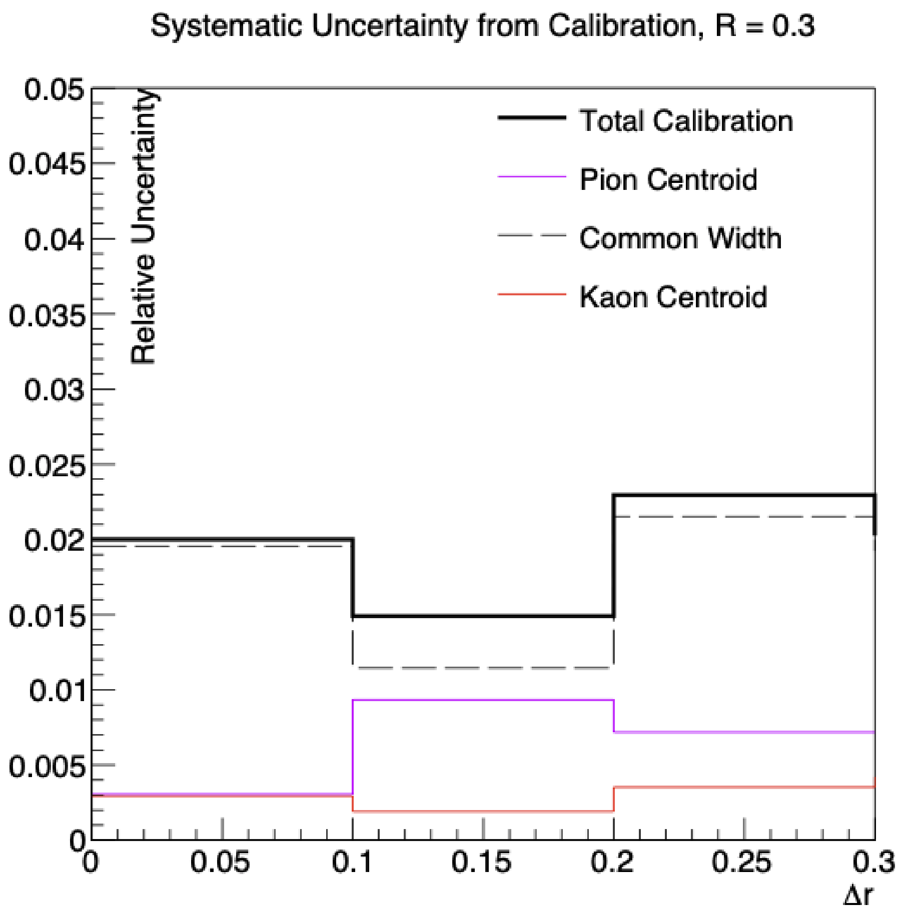


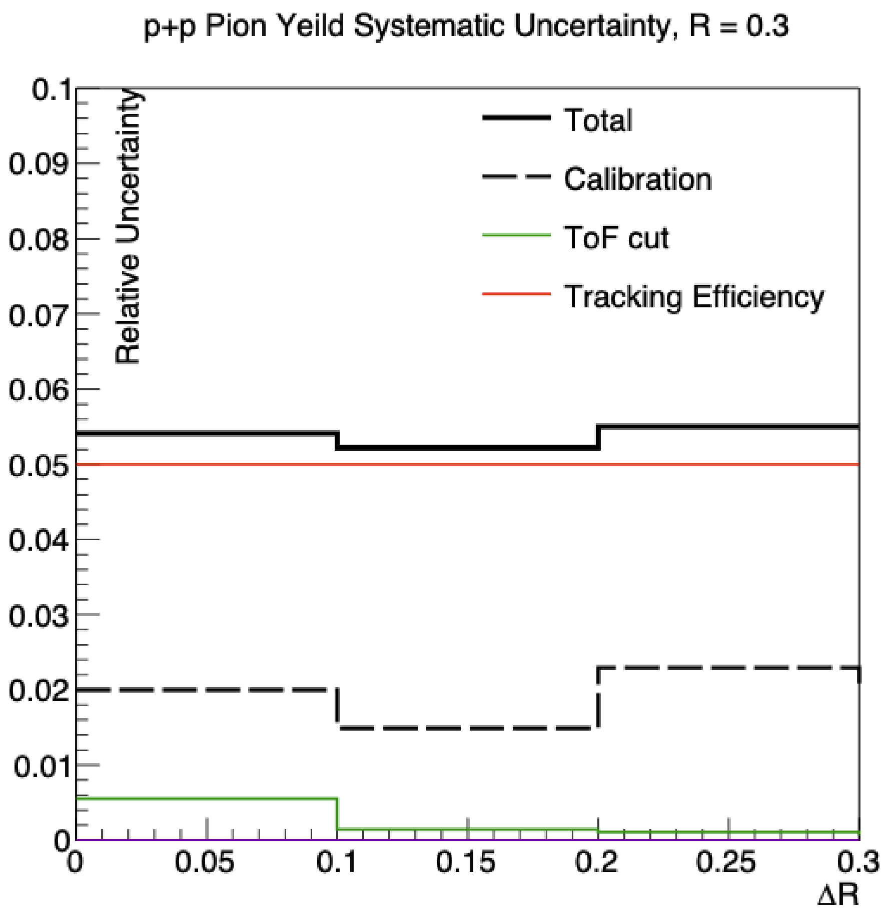
p+p p/π Δr Systematics



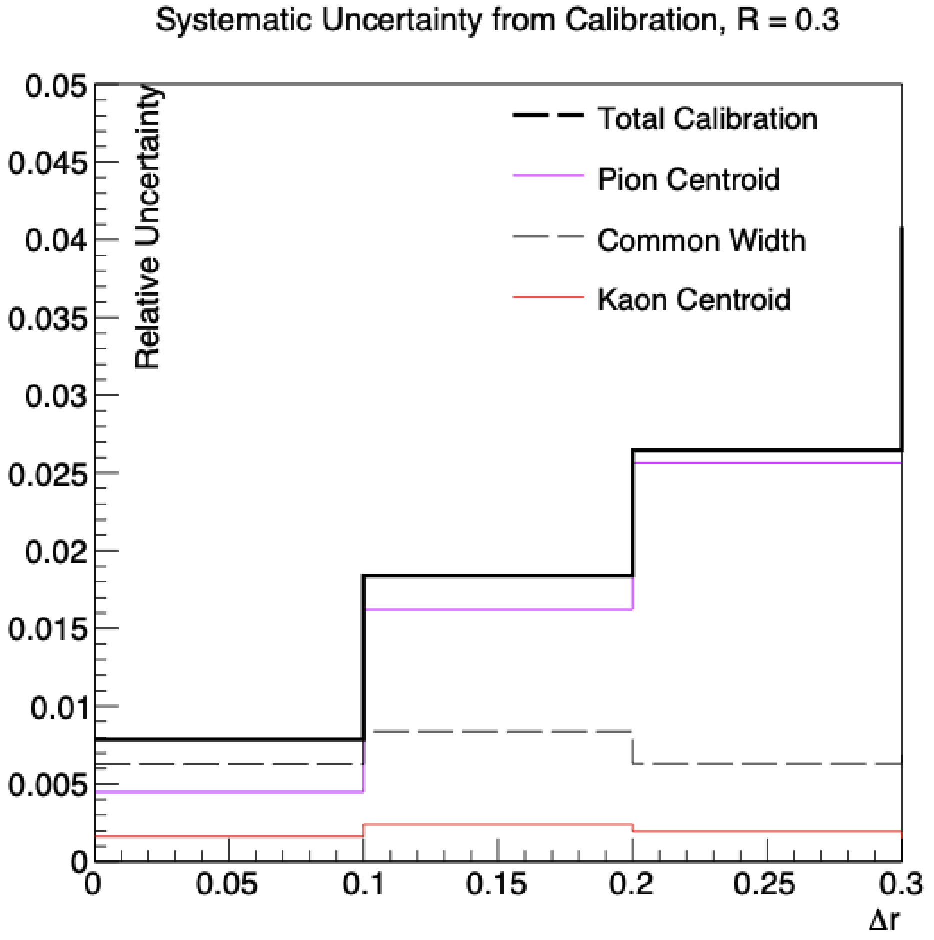


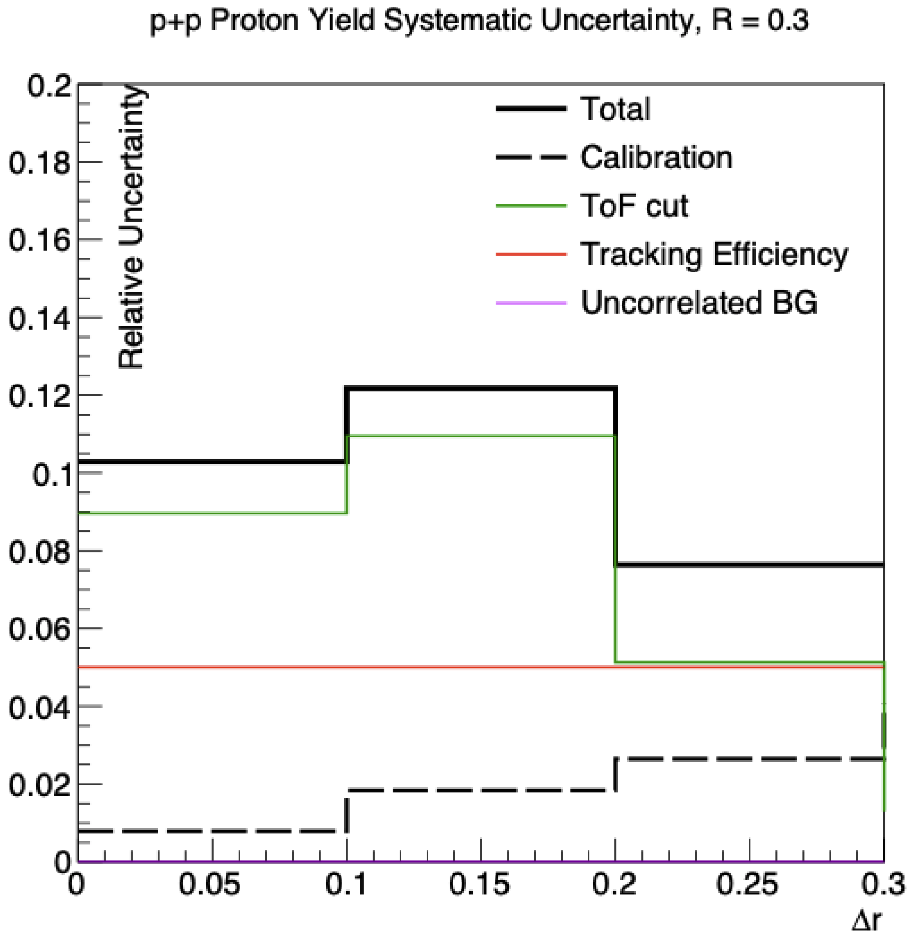
p+p Pion Yield Δr Systematics



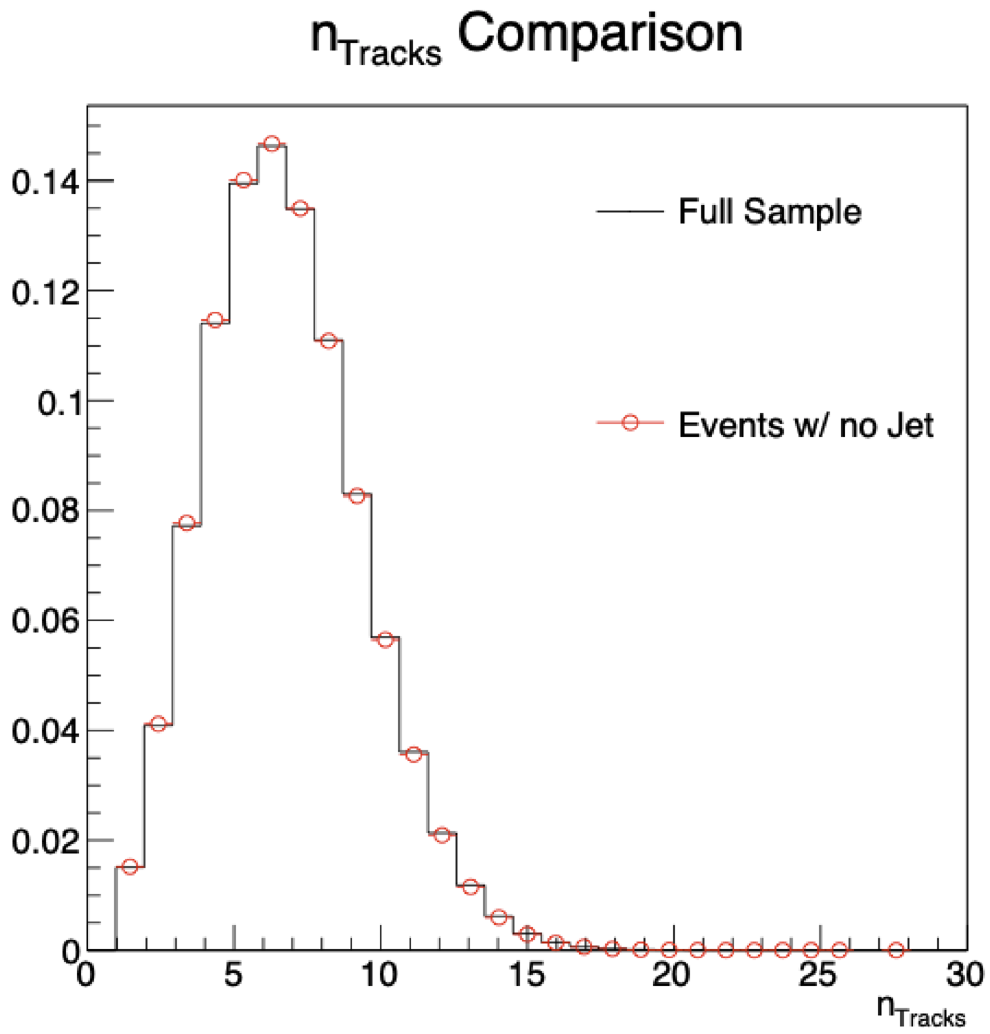


p+p Proton Yield Δr Systematics





Combinatorial Evaluation Uncertainty



Sample	nEvents	Mean nTracks
Full	20,058,323	6.691
Events w/o Jet	19,898,309	6.471

- When building Mixed events we match the nTrack per event distribution from signal.

- Constructing Mixed Events with non-jetty ntrack distribution yields a 0.2% variation in resulting Fake rate