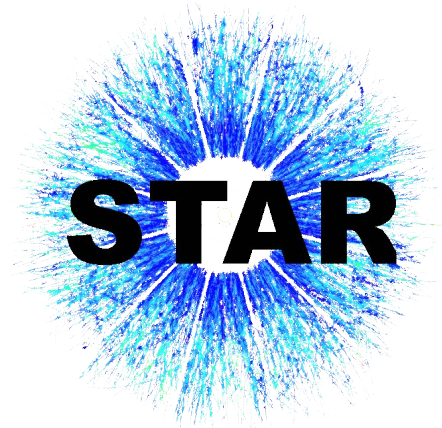


Measurement of photon-jet correlations in p+p and central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV by STAR

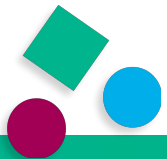


Jace Tyler
For the STAR Collaboration
March 18th 2025



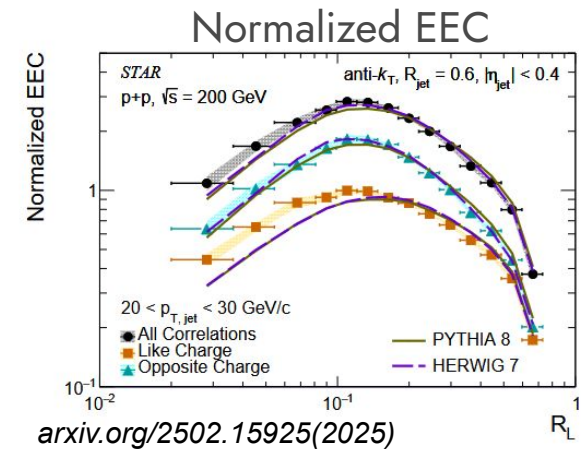
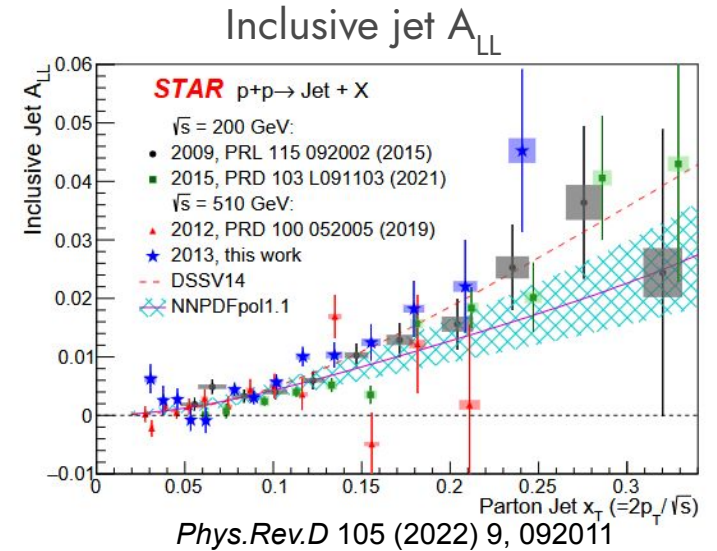
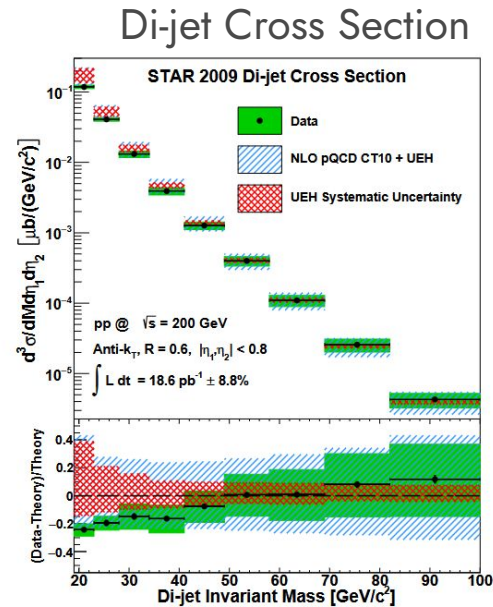
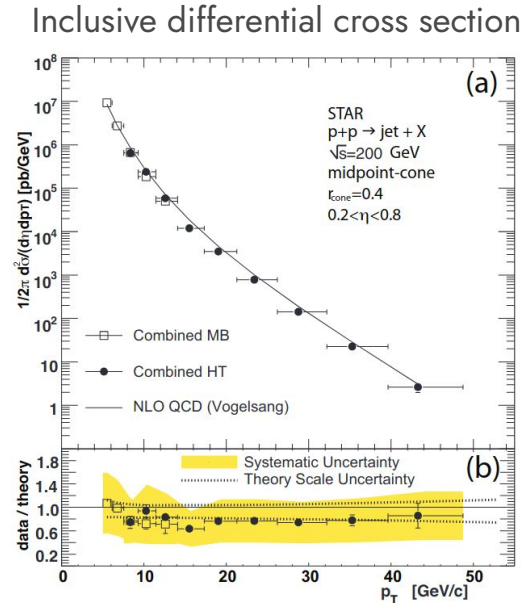
Overview

- STAR
- Motivation
- Jet Measurement
- Trigger Identification
- Corrections
- Systematics
- Conclusion and Prospects



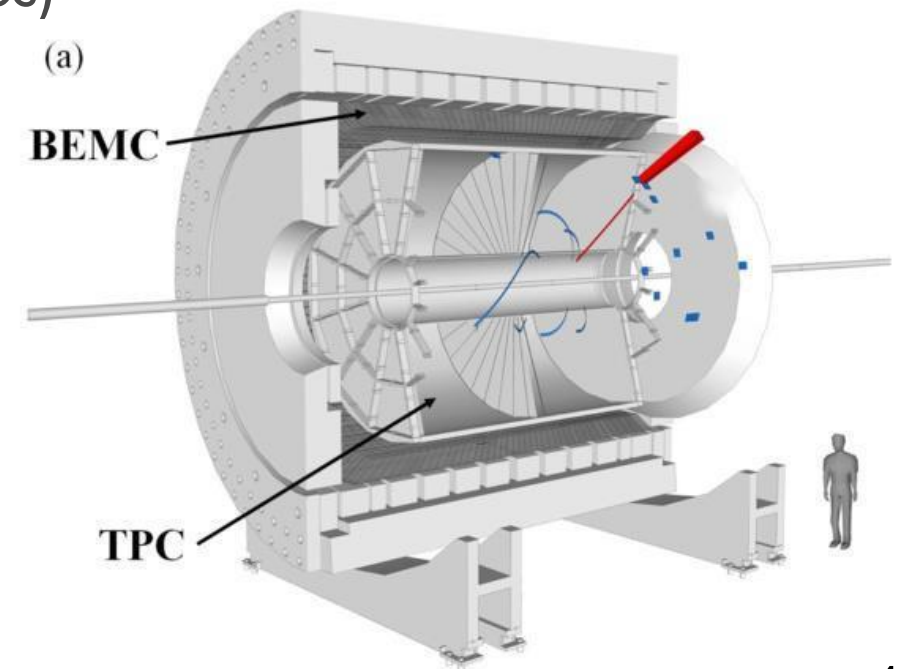
Fully Reconstructed Jets Measured by STAR

- STAR has done full jet reconstruction for pp at $\sqrt{s}_{NN} = 200$ GeV previously



The STAR Detector

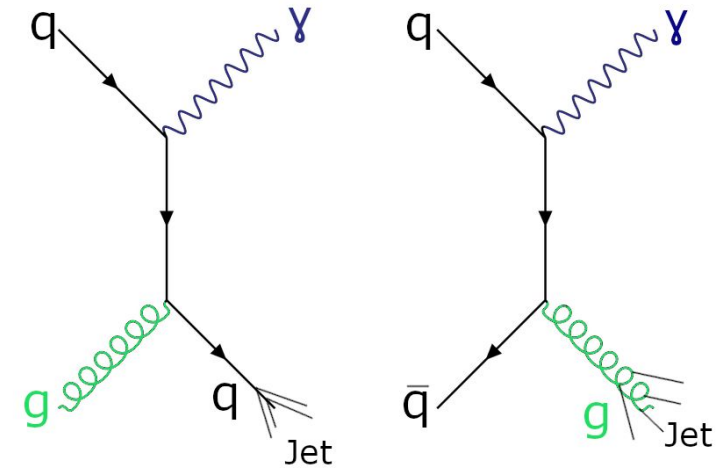
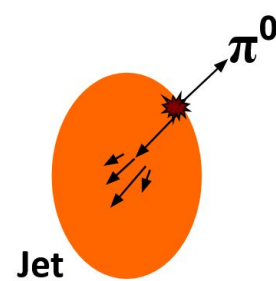
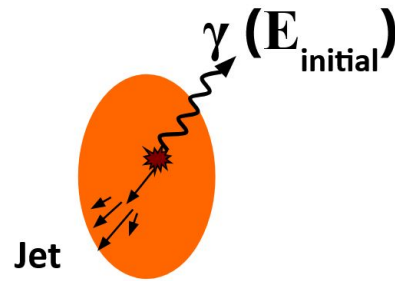
- The Solenoidal Tracker at RHIC (STAR) has two detectors of particular interest to this analysis
 - TPC for **charged** particles
 - BEMC for **photons** (direct and decay particles)
 - BSMD for π^0/γ discrimination



Motivation

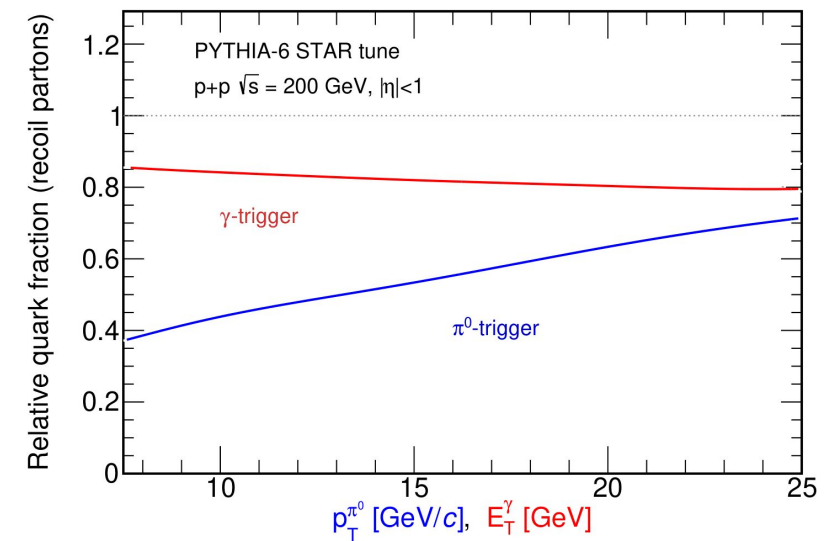
- γ +jet provides reference scale for jet quenching
- Also useful to compare to QCD calculations
- Nuclear modification factor I_{AA} measures medium effect
- γ +jet vs. π^0 +jet tests path length and quark vs. gluon dependence on energy loss
- Previous STAR γ/π^0 +jet measurement with charged jets only (arxiv.org/abs/2309.00156)

$$I_{AA} = \frac{Y^{Au+Au}(p_{T,jet}, R)}{Y^{p+p}(p_{T,jet}, R)}$$



Primary mechanism
Compton scattering

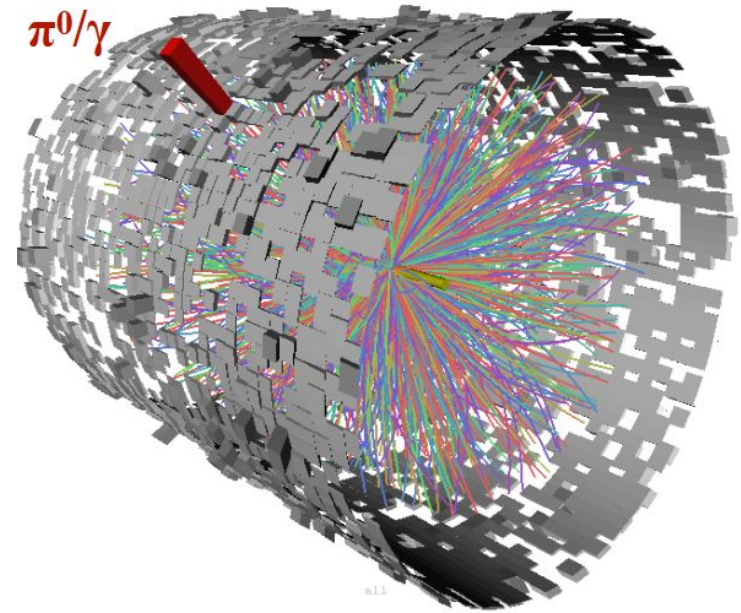
Some $q\bar{q}$ annihilation



Jet Measurement

- Full includes **charged** and **neutral** energy
- Reconstruction using anti- k_T , $R=0.2, 0.5$
- Highest fidelity reconstruction of scattered quark energy
- Jet axis within $\pi \pm \frac{\pi}{4}$ relative to π^0 or γ trigger

Online trigger: BEMC High Tower (HT) trigger to select events of large energy depositions



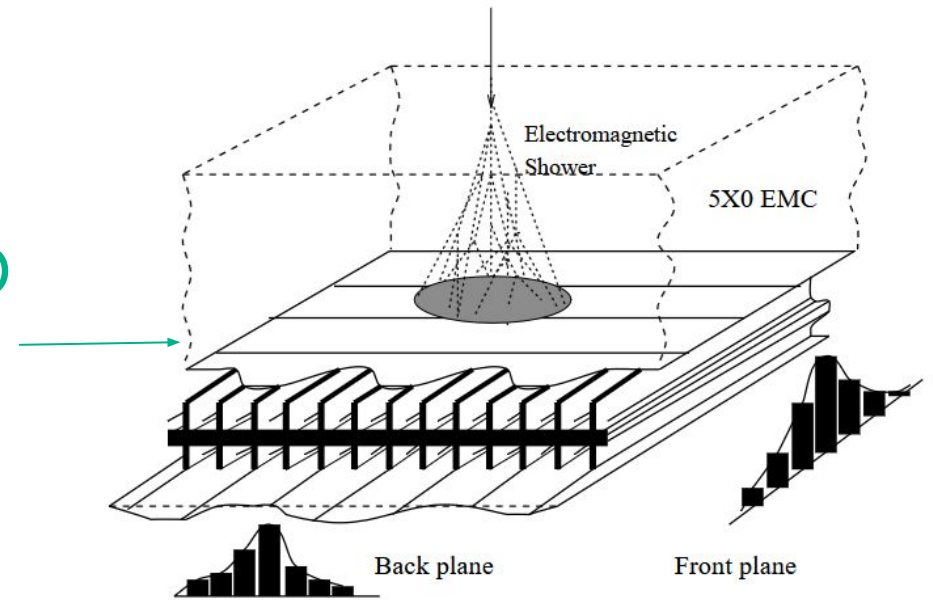
Event display
AuAu $\sqrt{s_{NN}} = 200$ GeV

Trigger Identification

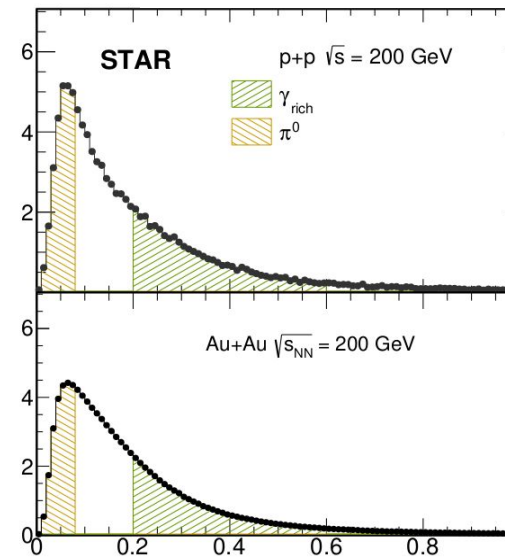
- **BSMD** measures shower shape for γ/π^0 triggers
- π^0 decays into two photons decreasing **Transverse Shower Profile (TSP)**

$$\text{TSP} = \frac{E_{\text{Tower}}}{\sum_i e_i r^{1.5}}$$

BSMD



Probability Density



TSP

(arXiv:2309.00156)

Jet Reconstruction

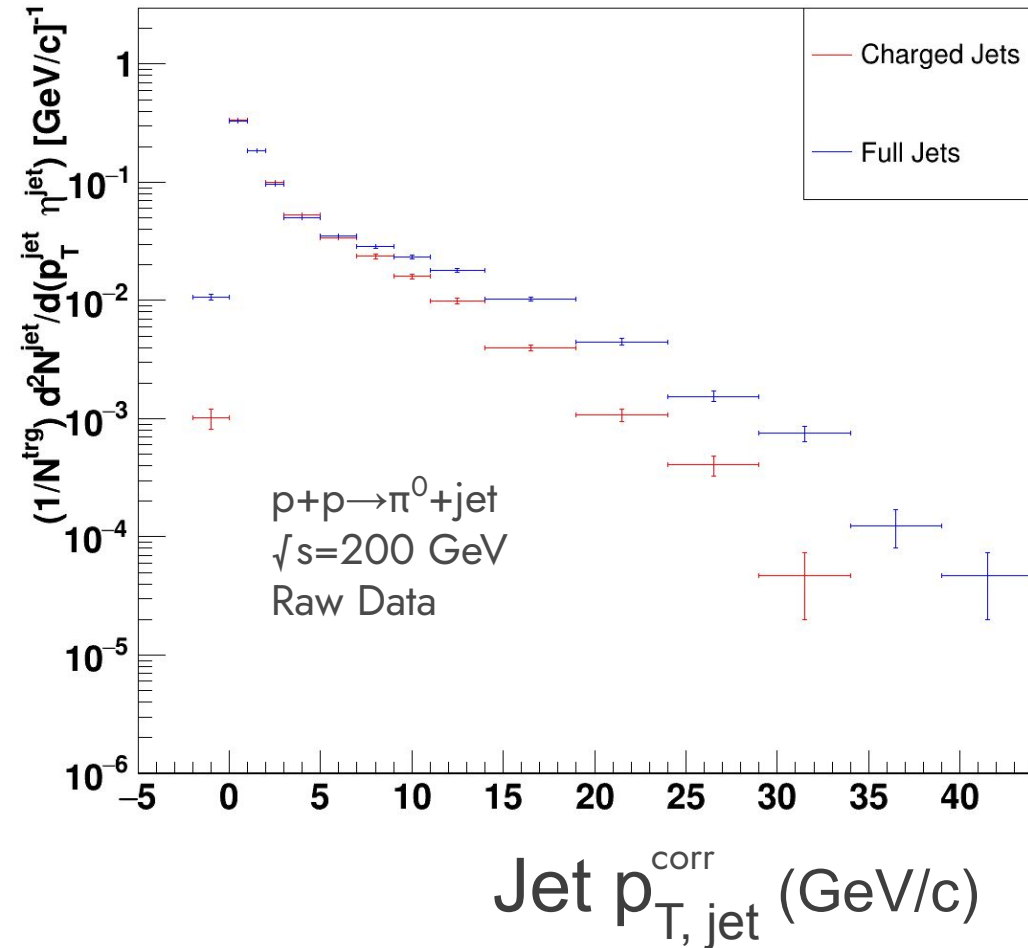
- Data points Raw per trigger jet yield
- Full reconstruction extends kinematic range cf. charged

$p_{T,jet}^{raw}$ = raw jet transverse momentum

ϱ = median background energy density

A_{jet} = jet area $p_{T,jet}^{corr} = p_{T,jet}^{raw} - \varrho A_{jet}$

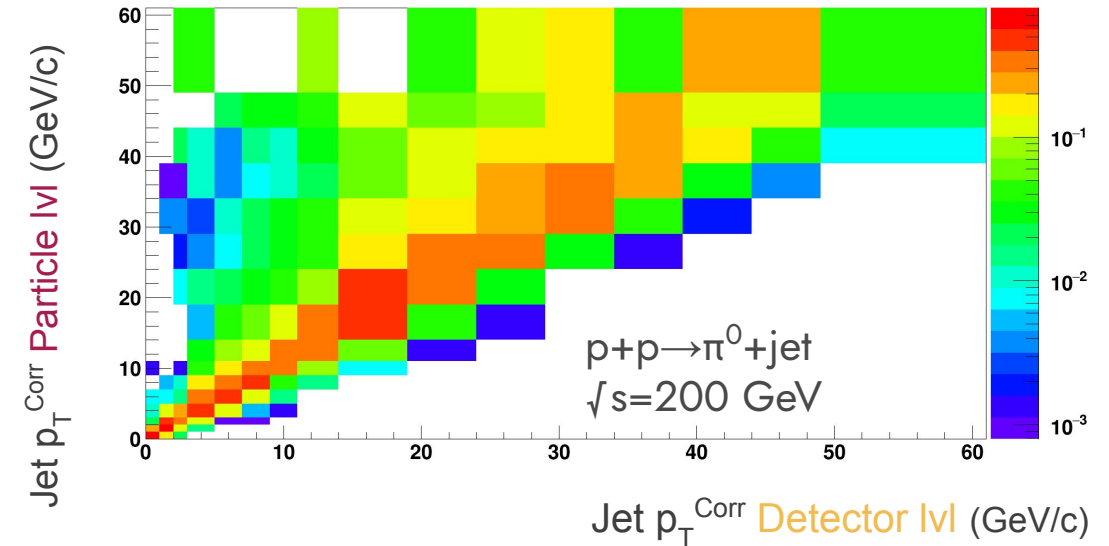
Raw Data Jet p_T Spectra
 $E_T \pi^0 = 9-11 \text{ GeV}$ $R=0.5$



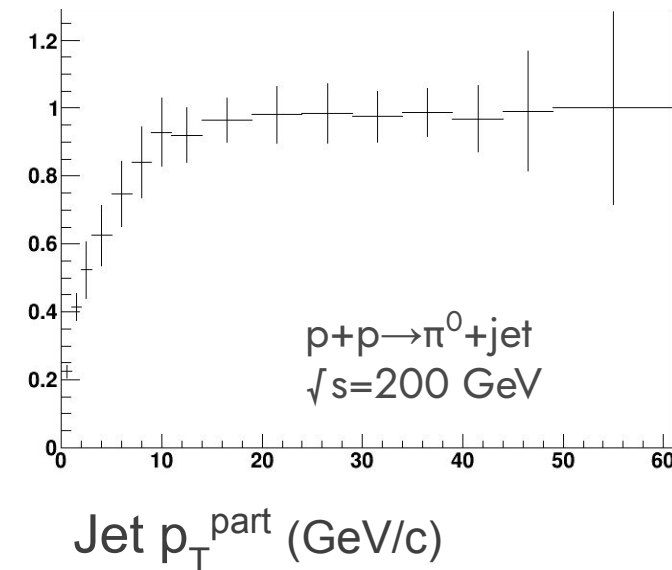
Corrections

- Detector effects correction handled by embedding
- **Simulated** di-jet jets from Pythia
- Run through GEANT & **embedded** in min bias data
- Matched based on closest in η - ϕ
- **Efficiency**: ratio of matched sim jets to total sim jets by jet- p_T bin

Response Matrix for $E_T \pi^0 = 9-11$ GeV $R=0.5$ full jets



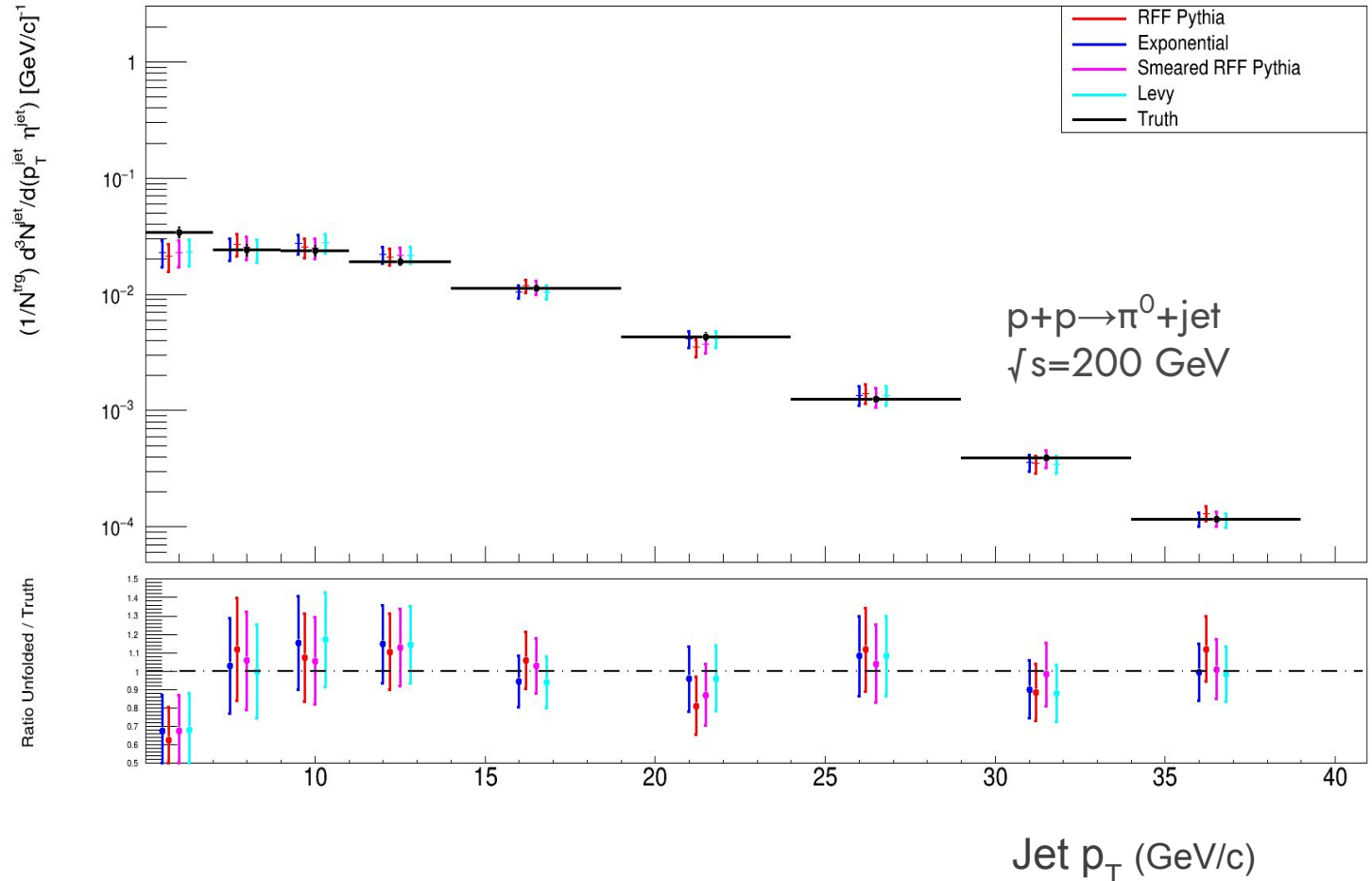
Jet Matching Efficiency for $E_T \pi^0 = 9-11$ GeV $R=0.5$ full jets



Closure of Method

- Divide embedding sample into two groups
- Unfold first group using **Response** and **Efficiency** from second
- Vary prior by fitting Pythia to function **Pythia subsample**, **Exponential fit**, **Levy-Tsallis fit**, **measured spectrum**
- Compare with truth from embedding

Comparison of Unfolded subsamples by prior choice
 $E_T \pi^0 = 9-11 \text{ GeV } R=0.5$



Systematics

- Detector:
 - Tracking efficiency / resolution
 - BEMC Tower efficiency / resolution
- Unfolding:
 - Prior
 - Regularization
- π^0 background for direct- γ triggers
- Fragmentation model

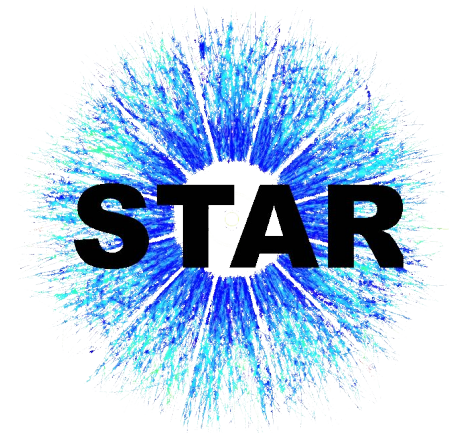
Conclusion and Prospects

- In pp, unfolding with full systematic studies underway
- In AuAu, in addition to detector effects, heavy ion background must be accounted for

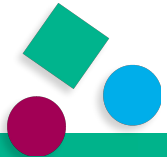


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Questions



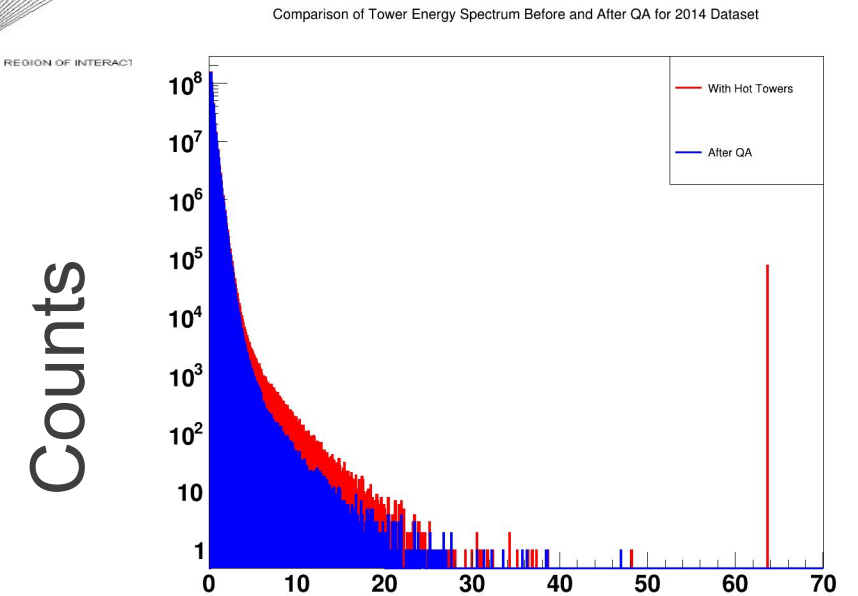
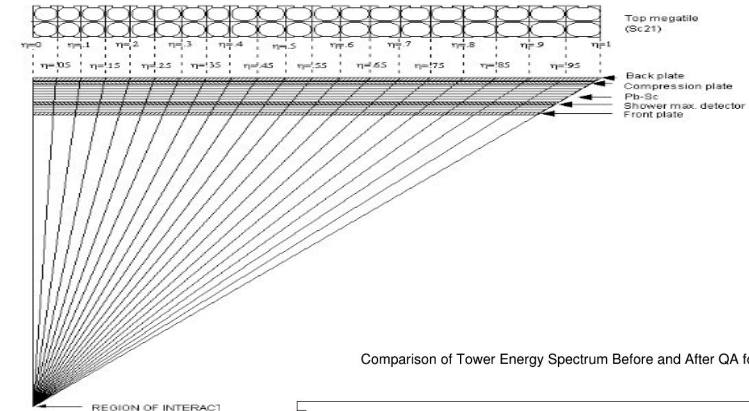
Backup Slides

- Detector Descriptions
- Hadronic correction
- Prior Choices
- Corrections in Heavy Ion Environment
- Systematics

Barrel Electromagnetic Calorimeter

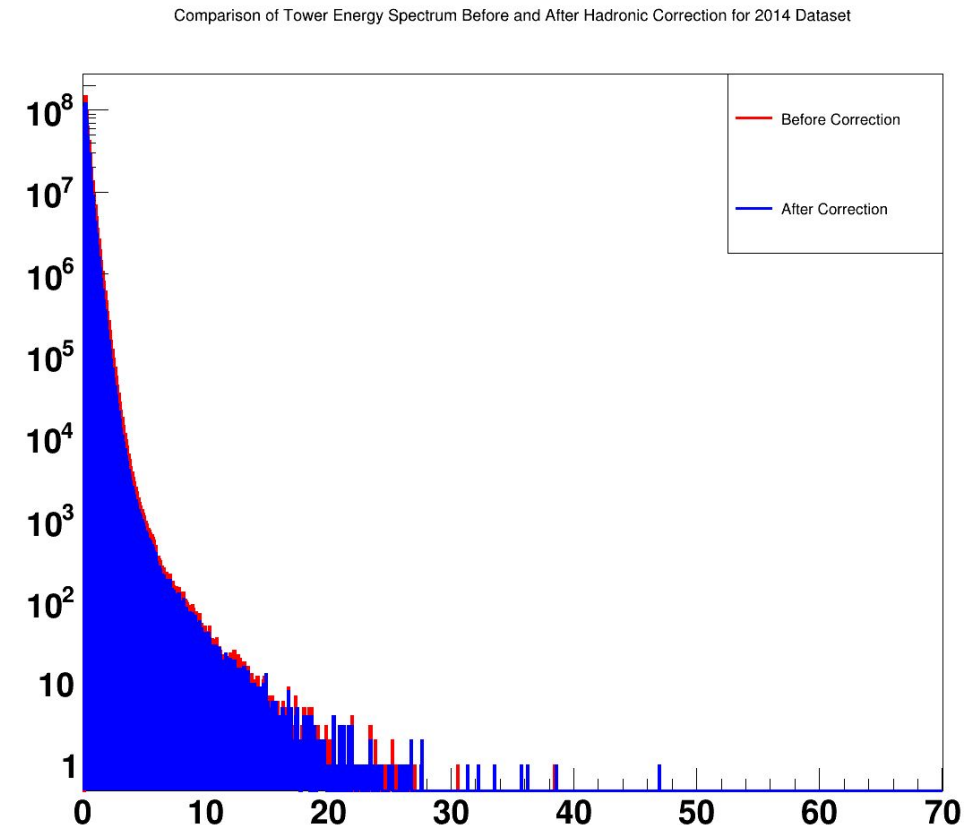
- projective nature of towers pictured top
- Towers with # of hits $> 5\sigma$ from mean are rejected as “hot”
- Tower energy distribution for non-trigger towers in Au+Au dataset before QA (red) and after QA (blue) pictured bottom

Single module of the BEMC covering $\Delta\eta = 1$, $\Delta\phi = 0.1$



Hadronic Correction

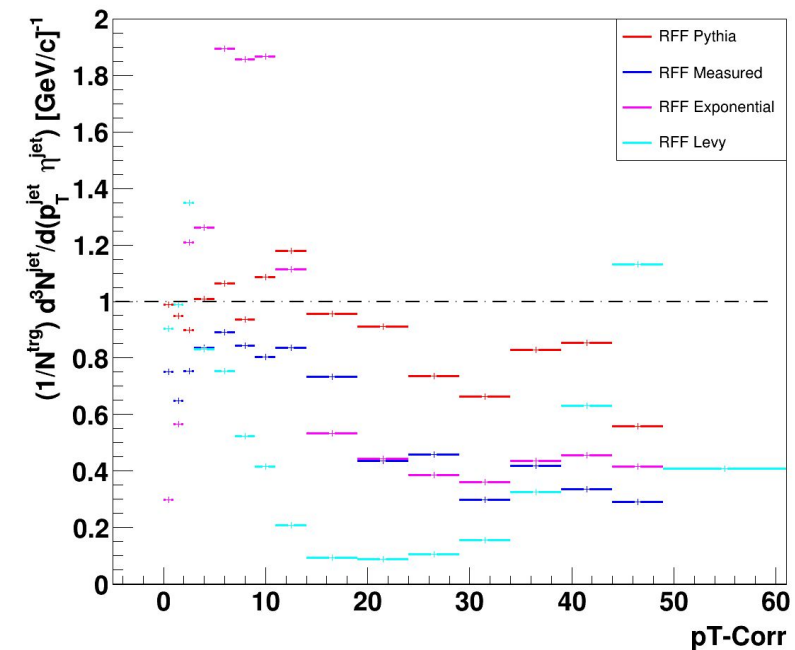
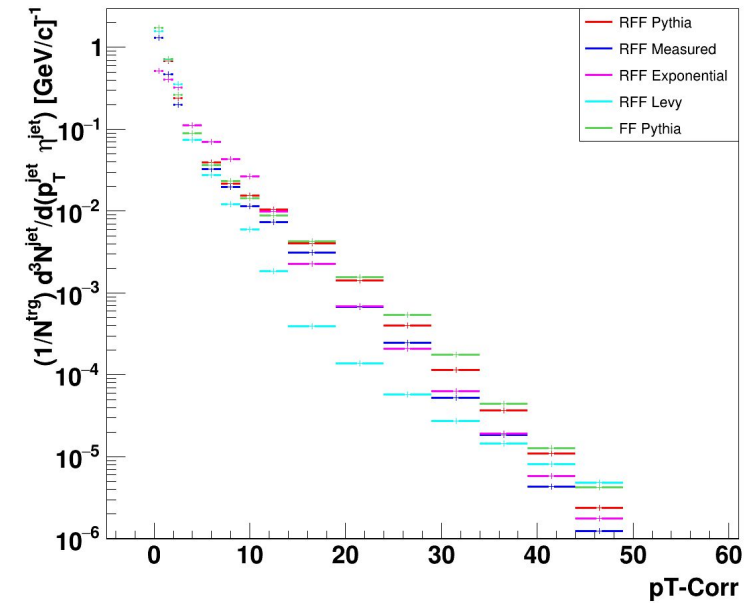
- Reduce tower energy by 100% of energy recorded by TPC as hitting tower
- Comparison of tower energy spectrum **before** (red) and **after** (blue) hadronic subtraction pictured right



Choice of Prior

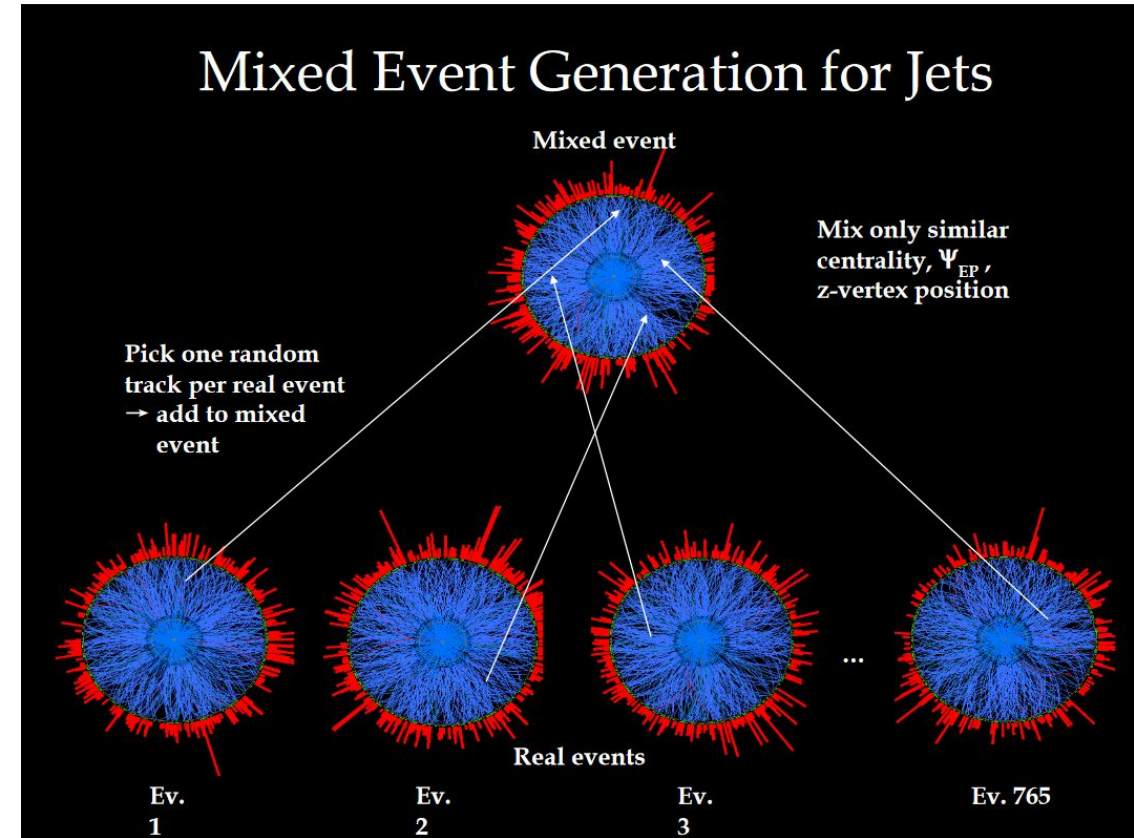
- Four choices of prior were used in unfolding
- **Pythia subsample (red)**,
- **Exponential fit (dark blue)**,
- **Levy-Tsalis fit (light blue)**,
- **measured spectrum (purple)**
- Jet pT spectrum pictured top
- Prior / truth pictured bottom

Comparison of prior choices used in closure, π^0 $E_T = 9-11$, $R=0.2$



Heavy Ion Background

- Central Au+Au events contain many jets that are “combinatoric”
- Event mixing takes tracks and towers randomly assigned into a new “mixed event”
- Same event statistics but none of the underlying physics correlations



A figure describing event mixing for tracks