Semi-inclusive γ^{rich}- and π^0-triggered full jet spectra

Hard Probes PWG
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Presentation Overview

- Motivation
- Reconstruction of raw data
- Correction of detector effects
- Closure of method
- Conclusion

Motivation

- pp collisions provide a baseline from which to study heavy ion collisions
- This will be used in a study of full jet correlations measured in pp and central AuAu collisions
- Previous analysis only included charged jets (jet constituents only taken from TPC tracks)
- The direct-photon trigger energy provides the hard scale for full jet measurements
- For pp, comparison between fully corrected full and charged jets
  - Working on comparison with Pythia
- For AuAu, working on including the towers in event mixing and embedding

Run 9 Data Statistics

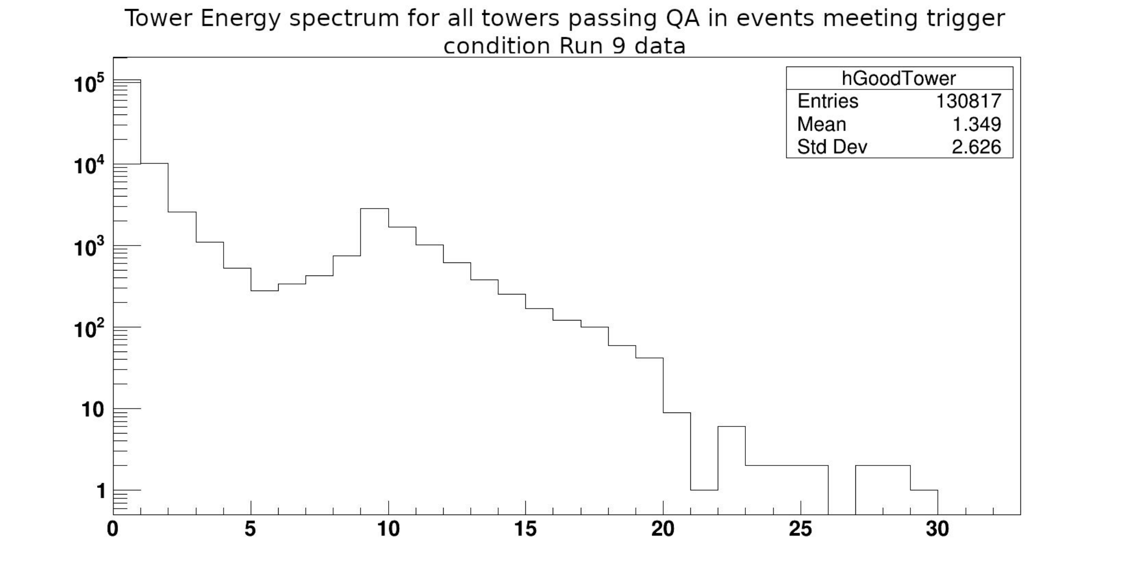
Trigger	9-11 GeV	11-15 GeV	15-20 GeV
γ	15,232	7,328	1,522
π^0	12,869	4,918	699

Same trigger stats as our recent publication arxiv.org/abs/2309.00145

- L2Gamma trigger
- Hadronic correction 100%
- Tracks: 0.2 < pT < 30 GeV/c, |eta| < 1
- Towers: pT > 0.2 GeV/c, |eta| < 1
- Jets reconstructed with anti-kT algorithm (underlying energy density ρ estimated with kT algorithm) for R=0.2 and 0.5
- Jets: pT > 0.2 GeV/c, |eta| < 1-R
- Event, track, and trigger tower QA from Anderson, D. (2022). "Reconstruction of Neutral-Triggered Recoil Jets in $\sqrt{s}$ = 200 GeV P+P Collisions at the STAR Experiment" [Doctoral dissertation, Texas A&M University].

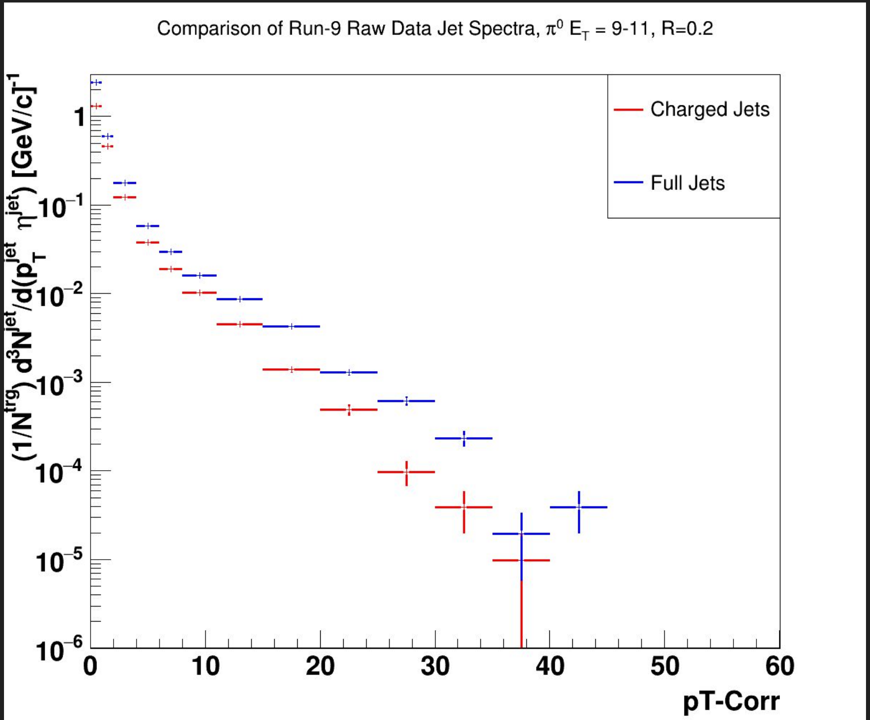
BEMC Towers Included in Jet Reconstruction

- ET distribution for all towers in events with π^0 or γ^{rich} trigger after hadronic correction (pictured)
- Towers with # of hits > 5 sigma excluded as “hot”



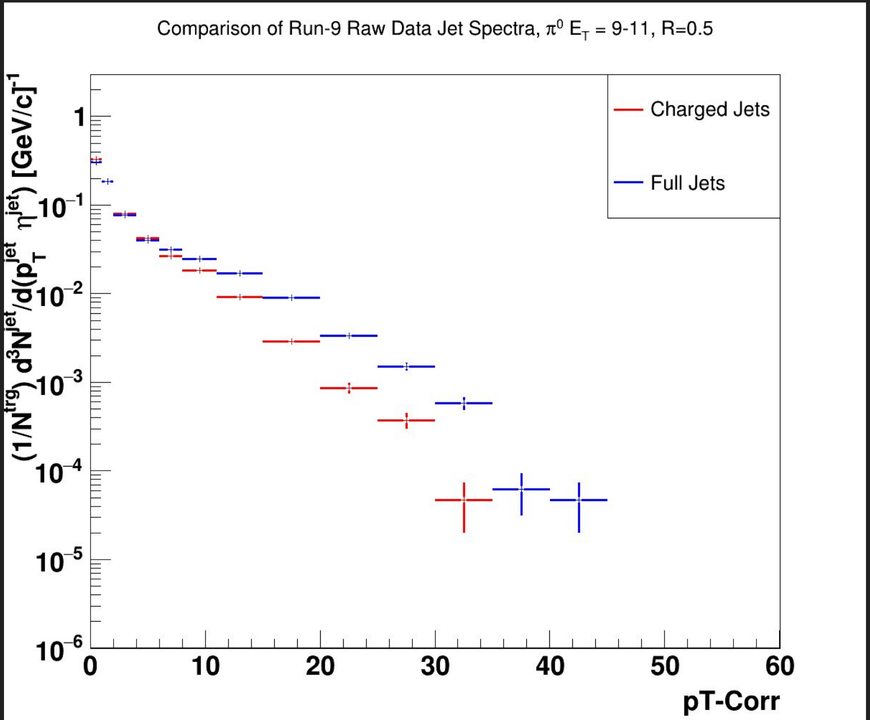
Raw Data spectrum

- Pictured is the Run-9 per-trigger raw jet-pT spectrum for charged (Red) and full (Blue) jets for R=0.2, π^0 triggered Et=9-11 GeV
- Pt-corr is $pT_{jet} - \rho\, A_{rea}$



Raw Data spectrum

- Pictured is the Run-9 per-trigger raw jet-pT spectra for charged (Red) and full (Blue) jets for R=0.5, π^0 triggered Et=9-11 GeV
- Pt-corr is pT_{jet}- ρ A rea

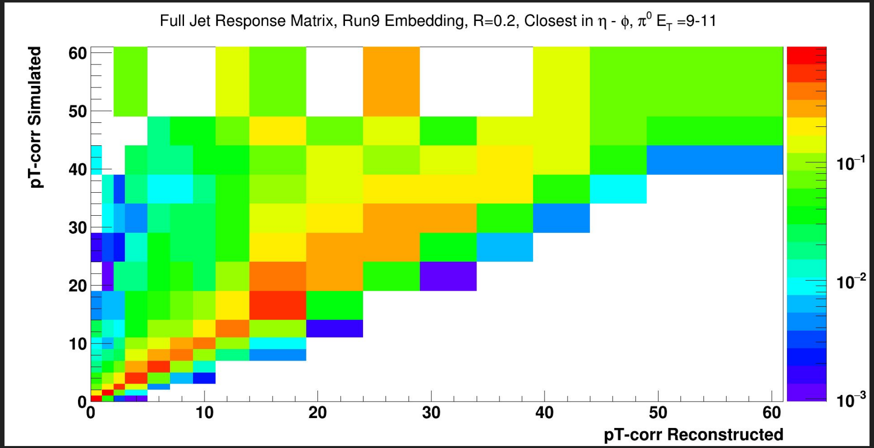


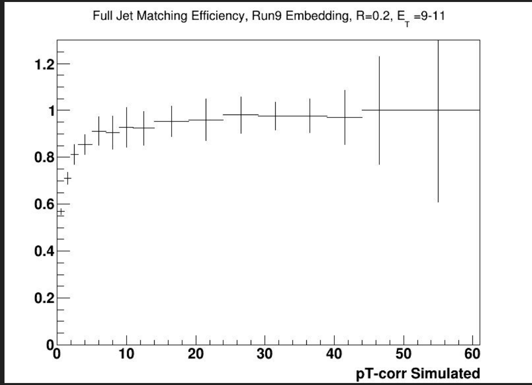
Correction for Detector Effects

- Embedding is Pythia in zero bias pp events
- Run-9 Embedding was reconstructed as in data
- Reconstructed jets were considered potential matches if they fell within delta R 0.1, 0.2 for R=0.2, R=0.5
- Potential jet matches were ranked according to closest in eta-phi space
- The best potential match was chosen to fill response matrix
- Simulated jets with no potential matches added to inefficiency

Embedding Response and Efficiency

- Pictured top: the response matrix for full jets R=0.2, pi0 trigger, ET=9-11 GeV, matched closest in eta-phi space
- Pictured bottom: the full jet matching efficiency for R=0.2, π^0trigger, ET=9-11 GeV





Embedding Response and Efficiency

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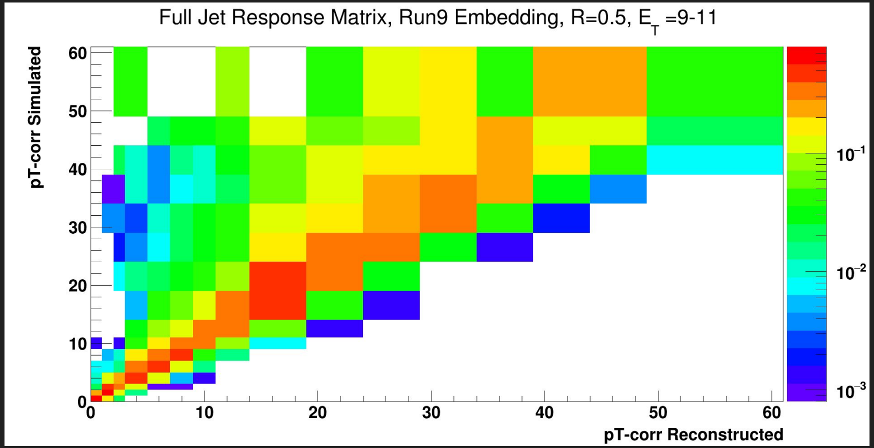
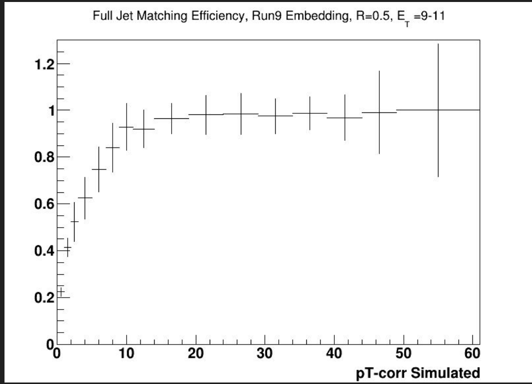


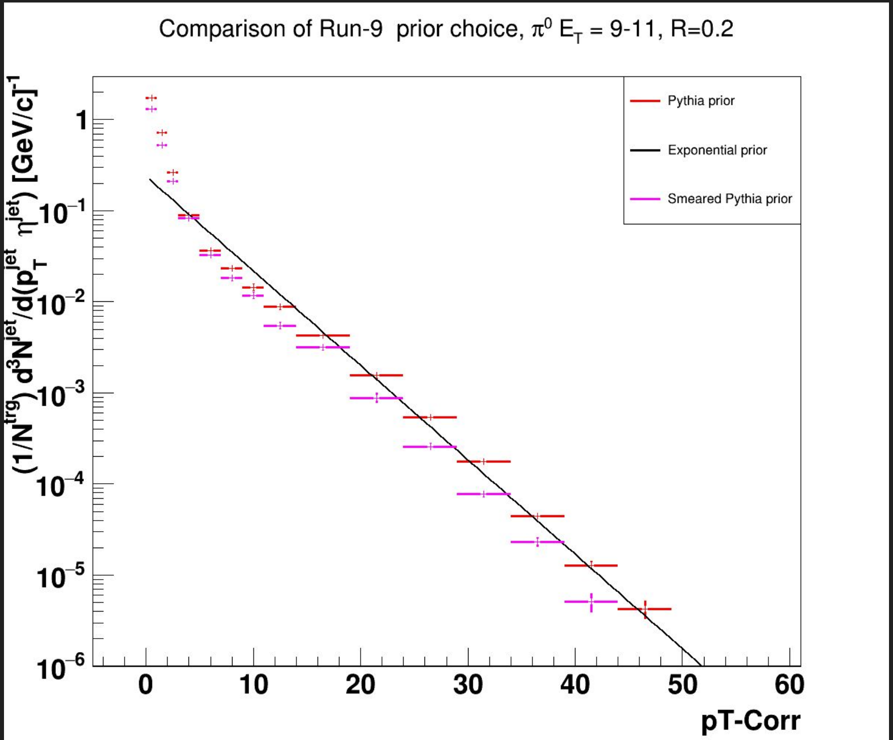


Closure of method

- This Closure test consists of using the response matrix and efficiency generated from the Reverse Full Field (RFF) embedding subsample to unfold the Full Field (FF) Matched jet pT spectrum
- Unfolding is handled by the iterative “bayesian” method from the RooUnfold package [T. Adye, “Unfolding algorithms and tests using RooUnfold,” in *Proceedings of the PHYSTAT 2011 Workshop*, (Geneva, Switzerland), pp. 313–318, CERN, 2011.]
- The unfolded RFF spectrum is then compared with the FF simulated jet pT spectrum
- Choice of Prior has 3 variations: pythia, an exponential fit to pythia, and the Matched jet pT spectrum

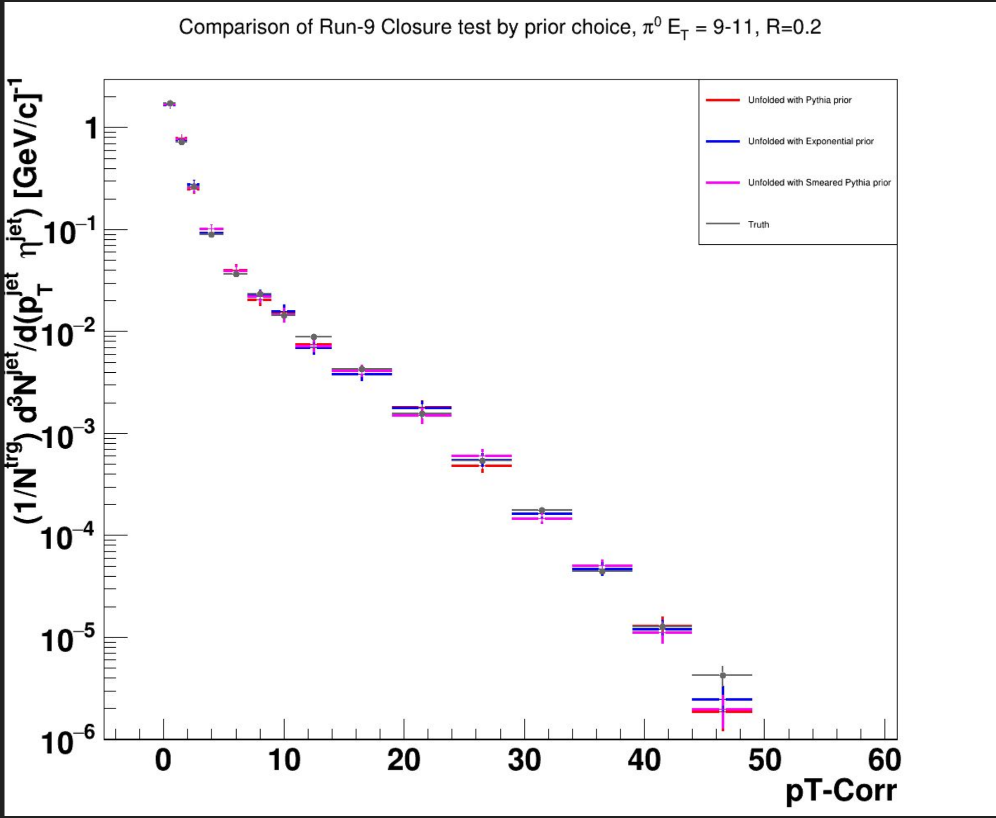
Prior Choice Comparison

- Pictured left: comparison of prior choices with Pythia (red), an exponential fit to Pythia (black), and the Matched jet-pT spectrum (purple) for full jets R=0.2, pi0 trigger, ET=9-11 GeV



Closure Test R=0.2

- Pictured is the per-trigger jet pT spectra of the FF simulated sample (grey), compared with the unfolded Matched jet-pT spectra for various prior choices: Pythia (red), exponential fit (blue), Matched jet-pT spectrum (purple) for R=0.2, π^0 trigger Et=9-11 GeV
- Bayesian Unfolding, 6 iterations



Closure Test R=0.2

- Pictured is the ratio of the unfolded Matched jet-pT spectra for various prior choices: Pythia (red), exponential fit (blue), Matched jet-pT spectrum (purple) divided by per-trigger jet pT spectra of the FF simulated sample for R=0.2, π^0 trigger Et=9-11 GeV
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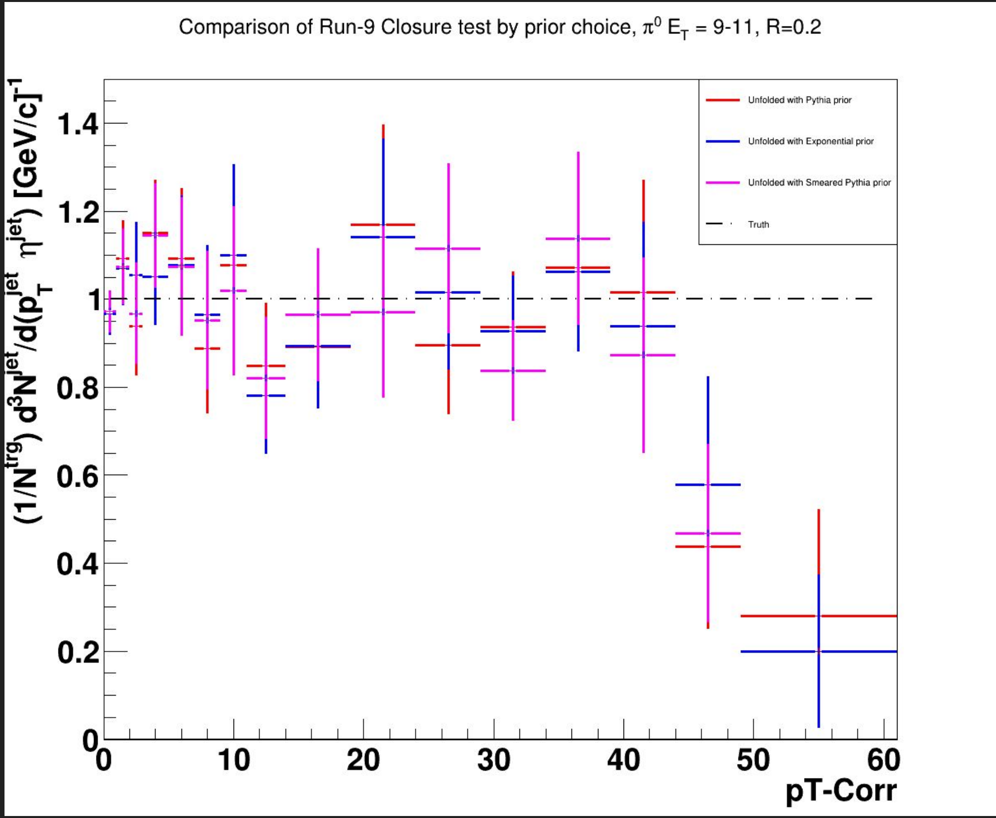
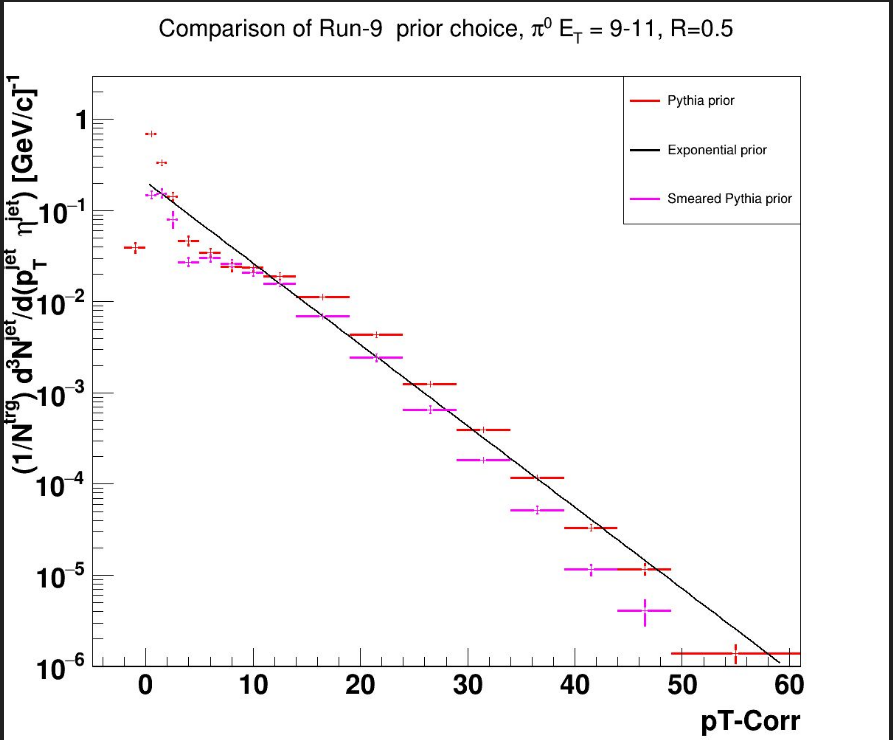


Prior Choice Comparison

- Pictured left: comparison of prior choices with Pythia (red), an exponential fit to Pythia (black), and the Matched jet-pT spectrum (purple) for full jets R=0.5, pi0 trigger, ET=9-11 GeV



Closure Test R=0.5

- Pictured is the per-trigger jet pT spectra of the FF simulated sample (grey), compared with the unfolded Matched jet-pT spectra for various prior choices: Pythia (red), exponential fit (blue), Matched jet-pT spectrum (purple) for R=0.5, π^0 trigger Et=9-11 GeV
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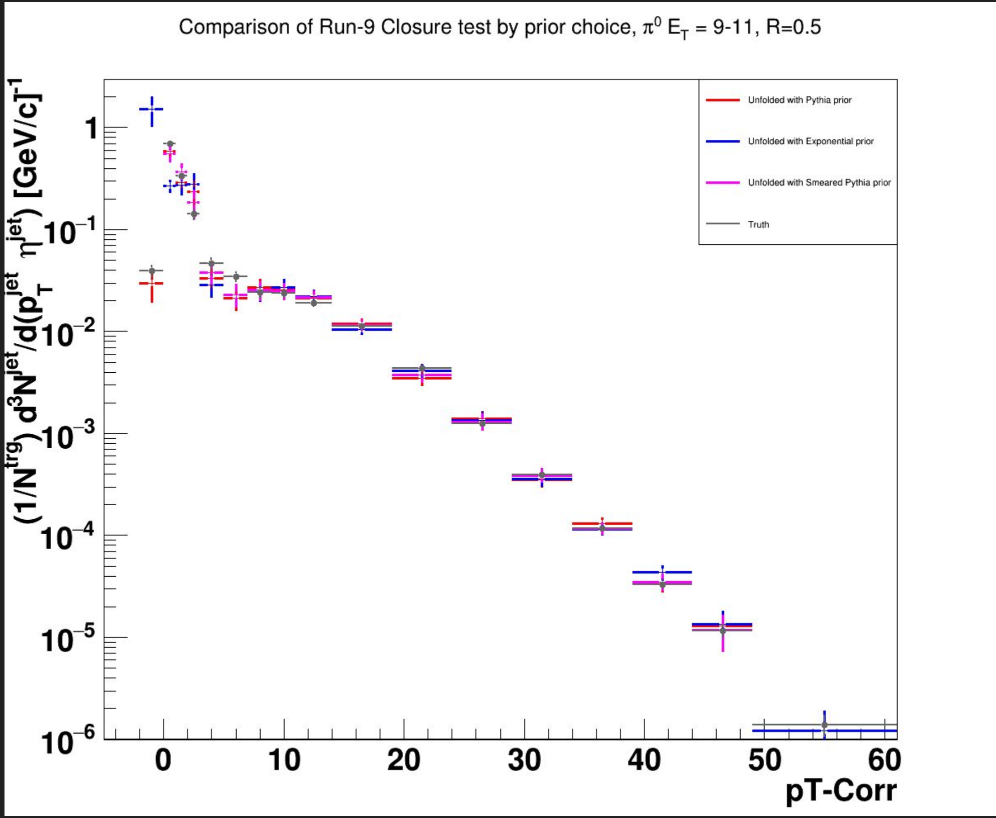

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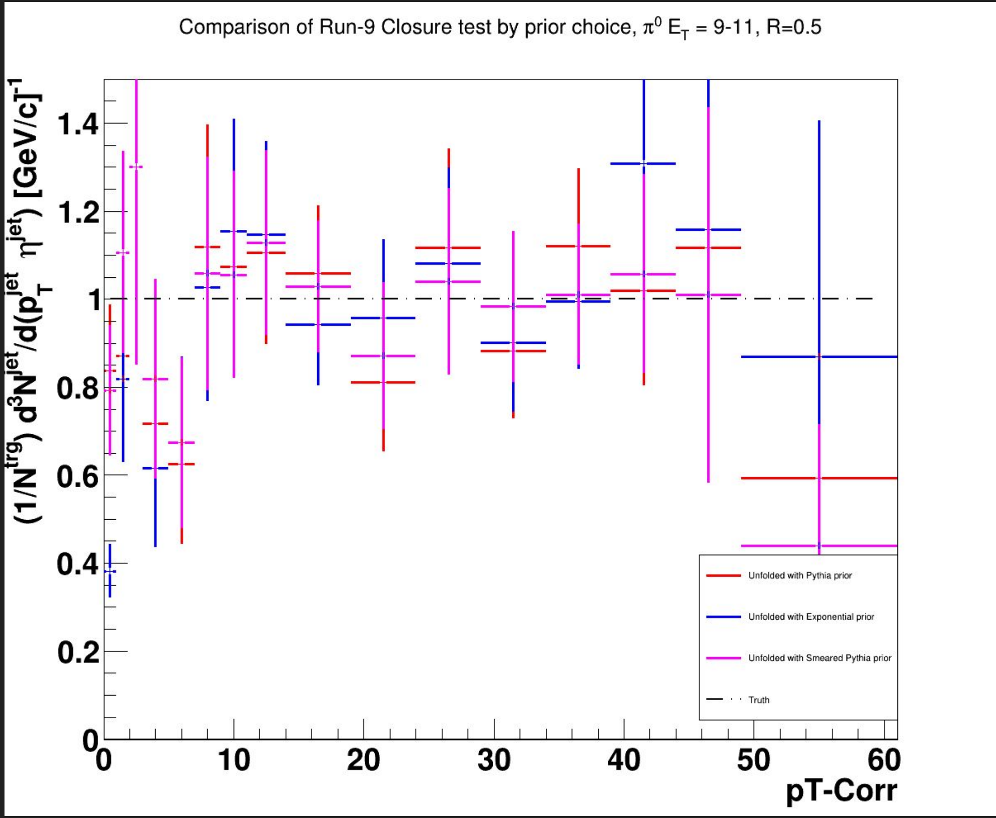


Conclusion and Next Steps

- Prior choice does not significantly impact closure
- Plan to show Unfolded data with comparison to Pythia next week
- APS global physics summit begins March 16th

Additional Figures

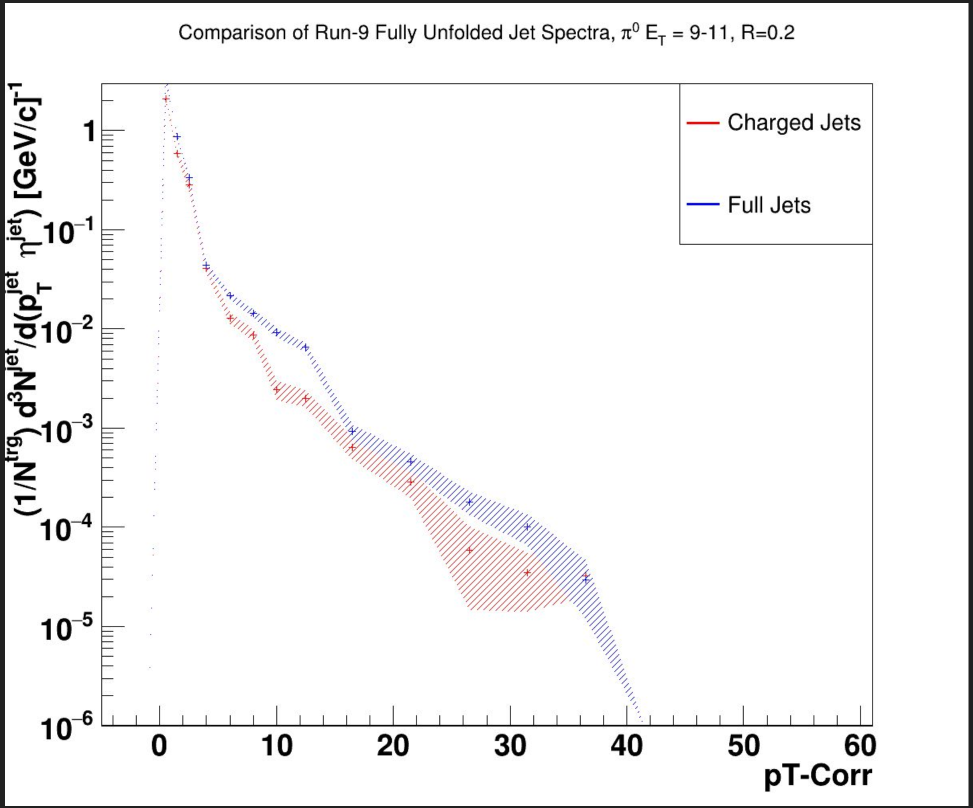
- Unfolded data without comparison to Pythia
- Response Matrices and efficiency histograms for other trigger ranges
- Back folding for understanding nonclosure at high pT
- Additional explanation of jet matching parameters

Results

- The following slides show a comparison of the fully unfolded full jet pt spectrum and the fully unfolded charged jet spectrum
- Pythia comparisons will follow

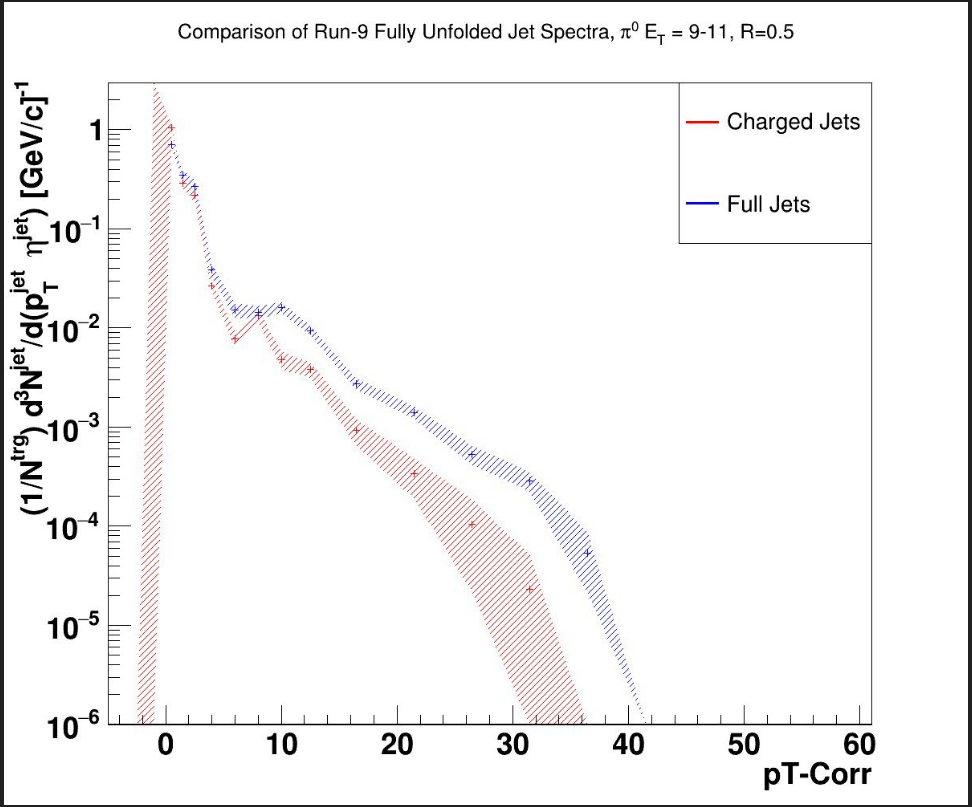
Unfolded spectrum

- Pictured is a comparison of the fully corrected per-trigger full jet-pT spectrum, compared with the fully corrected charged jet-pT spectrum R=0.2, π^0 triggered Et =9-11 GeV



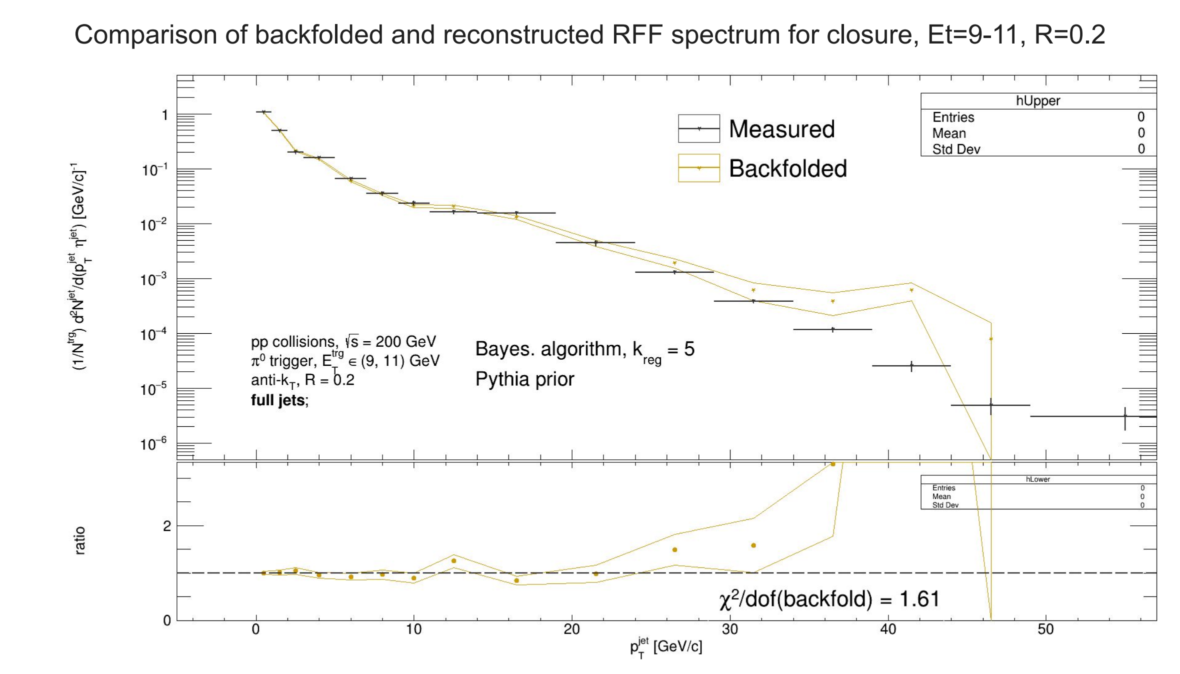
Unfolded spectrum

- Pictured is a comparison of the fully corrected per trigger full jet pT spectrum, compared with the fully unfolded charged jet spectrum R=0.5, π⁰ triggered Et =9-11 GeV

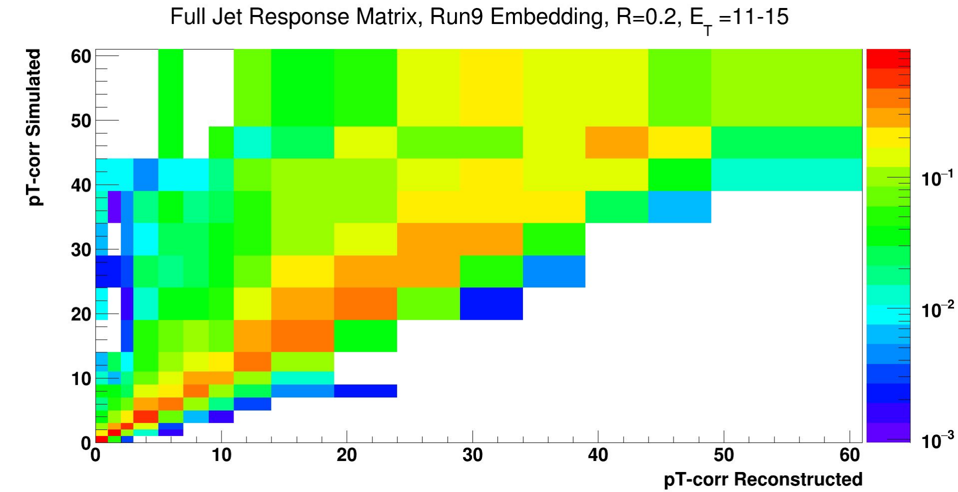


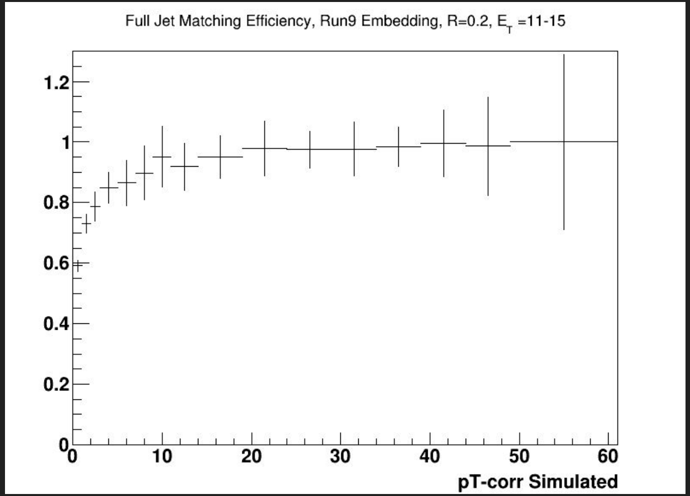
Backfolding Run 9 closure test

- In closure test, due to low statistics at high pt, backfolding does not converge on measured (reconstructed RFF matched) spectrum
- Pictured: backfolded (yellow) and reconstructed RFF matched (black) spectrum form Run9 embedding, Et=9-11, R=0.2



Embedding Response and Efficiency R=0.2





Embedding Response and Efficiency R=0.2

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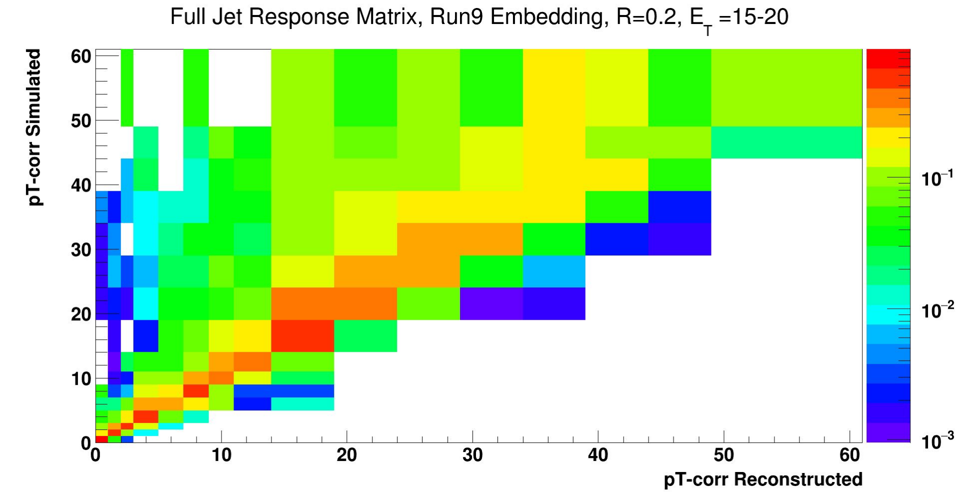

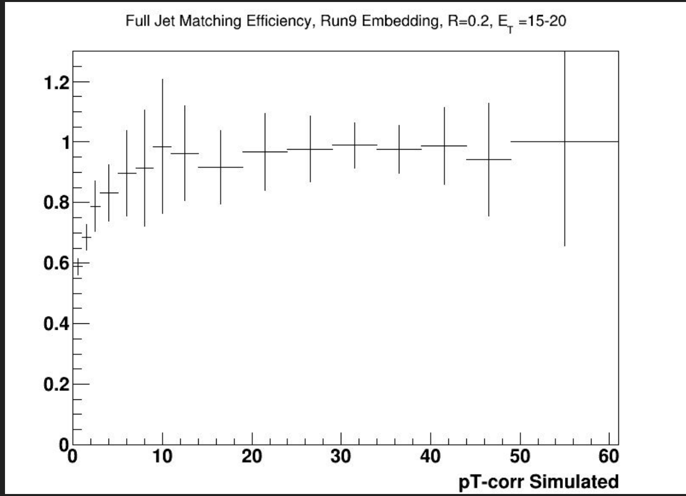

Embedding Response and Efficiency R=0.5

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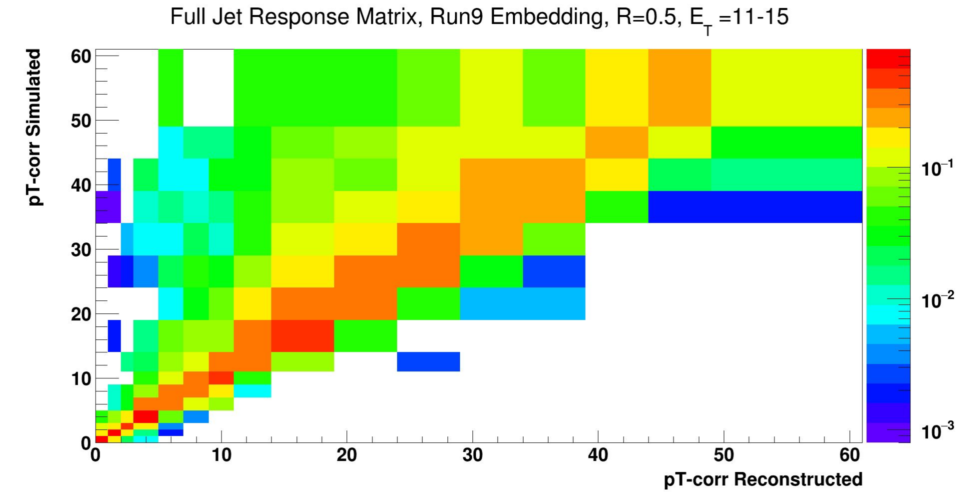

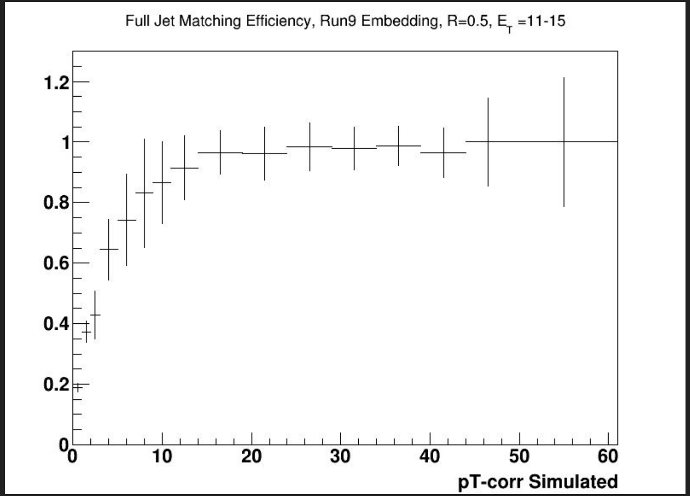

Embedding Response and Efficiency R=0.5

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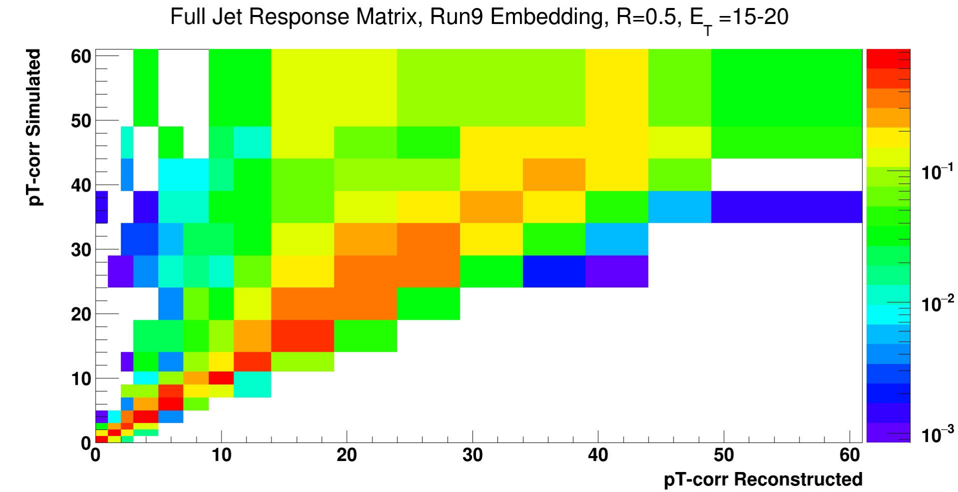

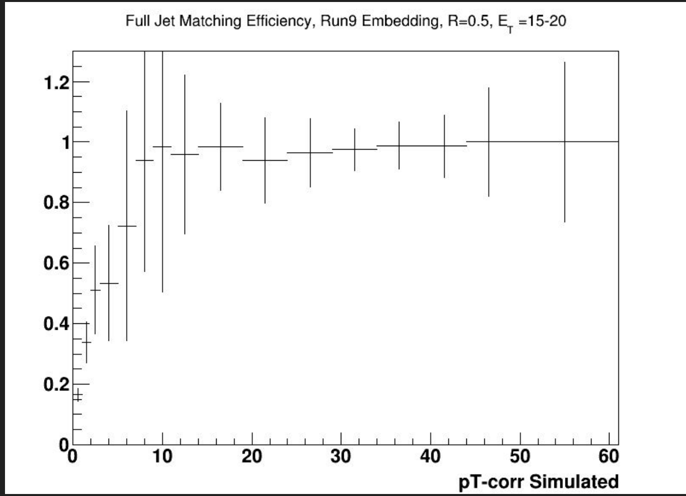

Jet Definition

- Jet reconstruction is handled by FASTJet using the anti-kt method
- Two choices of jet resolution parameter used: 0.2, 0.5
- Single tower momentum is loaded into fast jet after hadronic correction
- Background energy is estimated by using kt method, removing highest energy jet for pp, three highest for AuAu

Jet Matching criteria

- Considered three choices in ranking
  - Closest in pT jet
  - Closest in charged particle pT contribution
  - Closest in eta-phi space
- Considered two choices of cut
  - Distance in eta-phi space
  - Ratio of pT reconstructed / pT simulated
- Final choice was ranking based on distance, and cut based on distance