Heavy Flavor Tagged Jets in Au+Au 200 GeV

Diptanil Roy

Rutgers University

roydiptanil@gmail.com

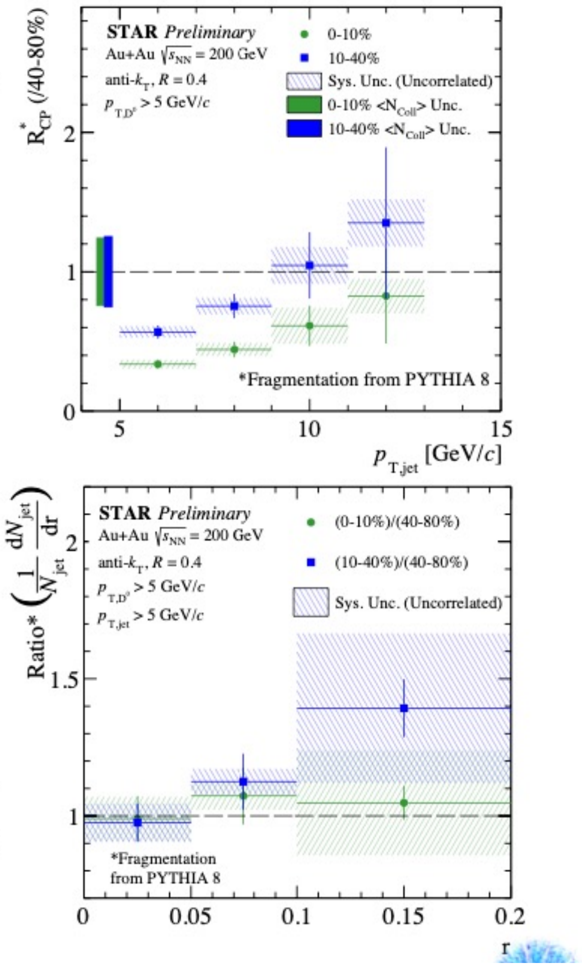
RECAP From QM '22

Summary

- First D^0-tagged measurement at RHIC energies
- Fragmentation from PYTHIA 8 used for correcting jet momenta and substructure
  - ✓ Spectra for D^0-tagged jets in central and mid-central events consistent with being suppressed with respect to peripheral events
  - ✓ Radial profile of D^0 mesons in jets consistent with unity within uncertainties.

Outlook

- Measure fragmentation function for D^0-tagged jets in Au+Au collisions
- Extend kinematic reach to low D^0 p_T to get closer to charm quark mass



ISSUES

1. Fragmentation function for PYTHIA is 'too' hard

2. For low D^0 p_T in jets, unfolding is dependent on the fragmentation function

Details here: https://drupal.star.bnl.gov/STAR/system/files/Kelsey_JetCorr_17Mar2022.pdf

Analysis Details

Event Selection:

- Au+Au $\sqrt{s_{NN}}$ = 200 GeV, Year 2014
- Minimum bias (MB)
- Centrality ∈ [0, 80]% (3 bins: [0-10], [10-40], [40-80])

Constituent Selection:

- $0.2 < p_{T,\mathrm{track}}$ [GeV/c] < 30 ; $0.2 < E_{T,\mathrm{tower}}$ [GeV] < 30
- $|\eta_{\mathrm{track}}| < 1$; $|\eta_{\mathrm{tower}}| < 1$
- $D^0 \rightarrow K^{\mp} + \pi^{\pm}$ [B.R. = 3.82 %]
- For D^0 reconstruction: Tracks need at least three hits on HFT
- $1 < p_{T,D^0}$ [GeV/c] < 10

D^0 Jet Selection:

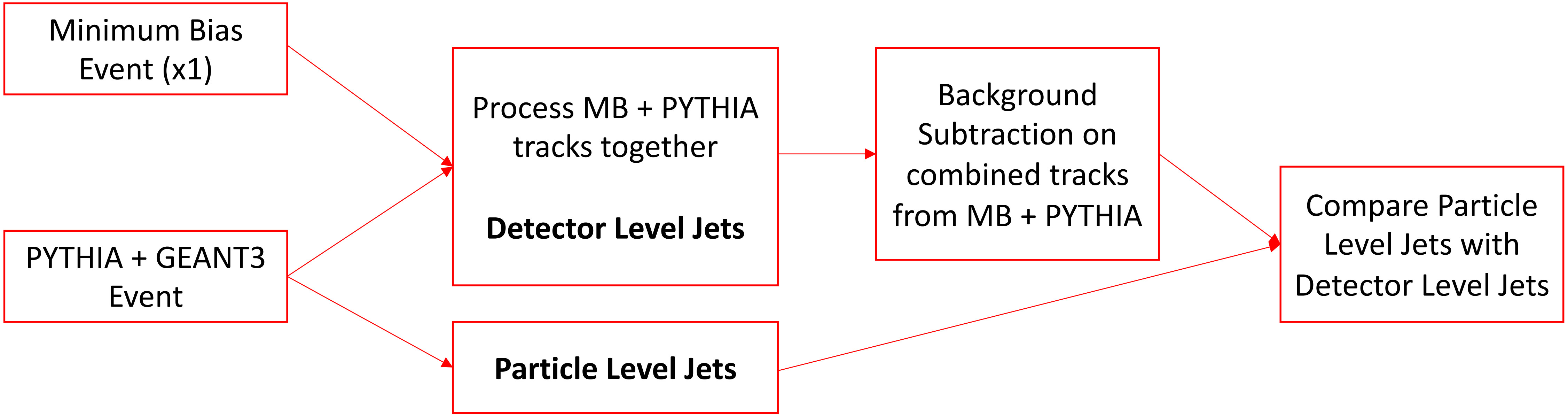
- Anti-k_T full jets of radius R = 0.4, area-based background subtraction
- $|\eta_{\mathrm{Jet}}| < 0.6$

Response Matrix Definition

- Particle Level: $5 < p_{T,\mathrm{Jet}}$ [GeV/c] < 20
- Detector Level: $0 < p_{T,\mathrm{Jet}}$ [GeV/c] < 30

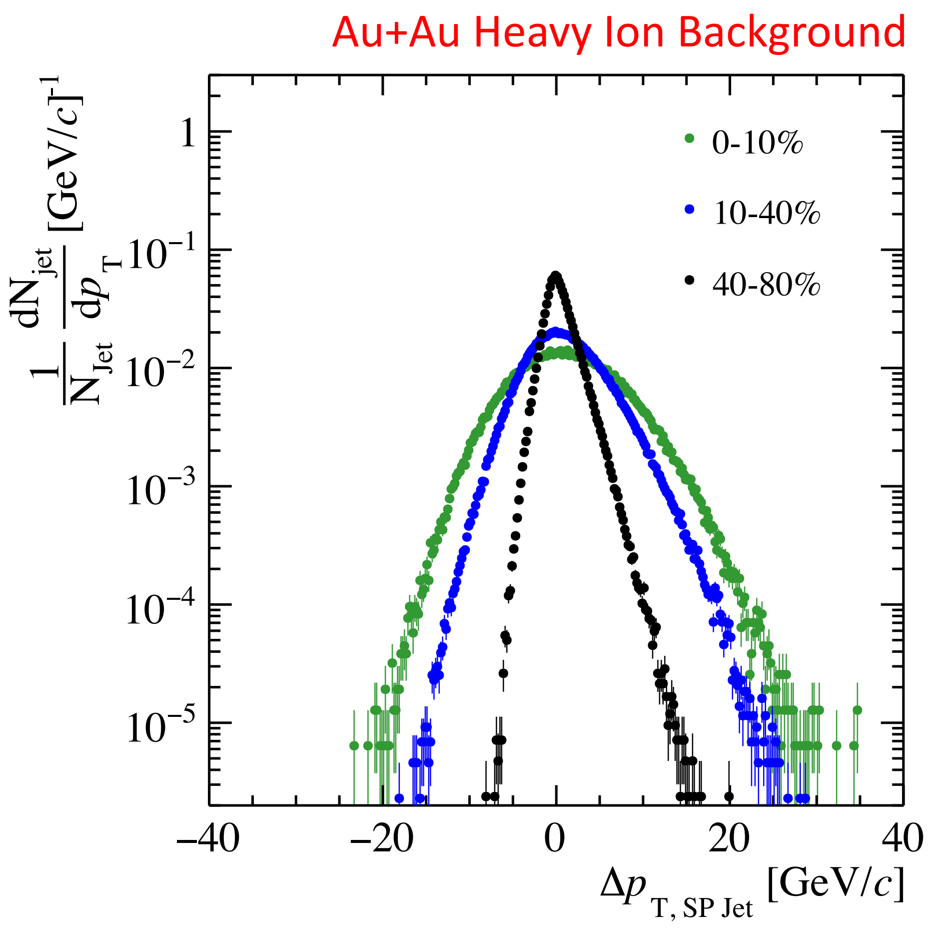
Updating the simulation

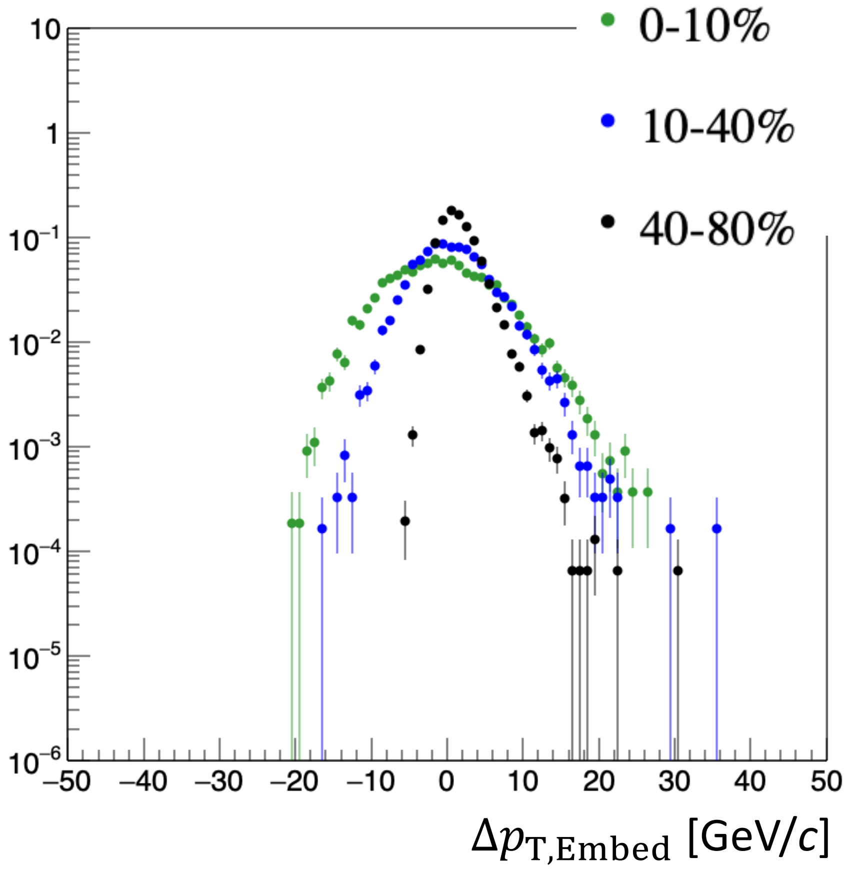
Earlier, single particle embedded in minimum bias event to determine background fluctuation



- Get a minimum bias event
- Sample ~10 random PYTHIA events for each minimum bias event
- Run jet maker on the PYTHIA events ‘**embedded**’ in the minimum bias event -> This is **PARTICLE** level
- Run jet maker on the combined PYTHIA+Minbias event -> This is **DETECTOR** level

Comparing the background fluctuations



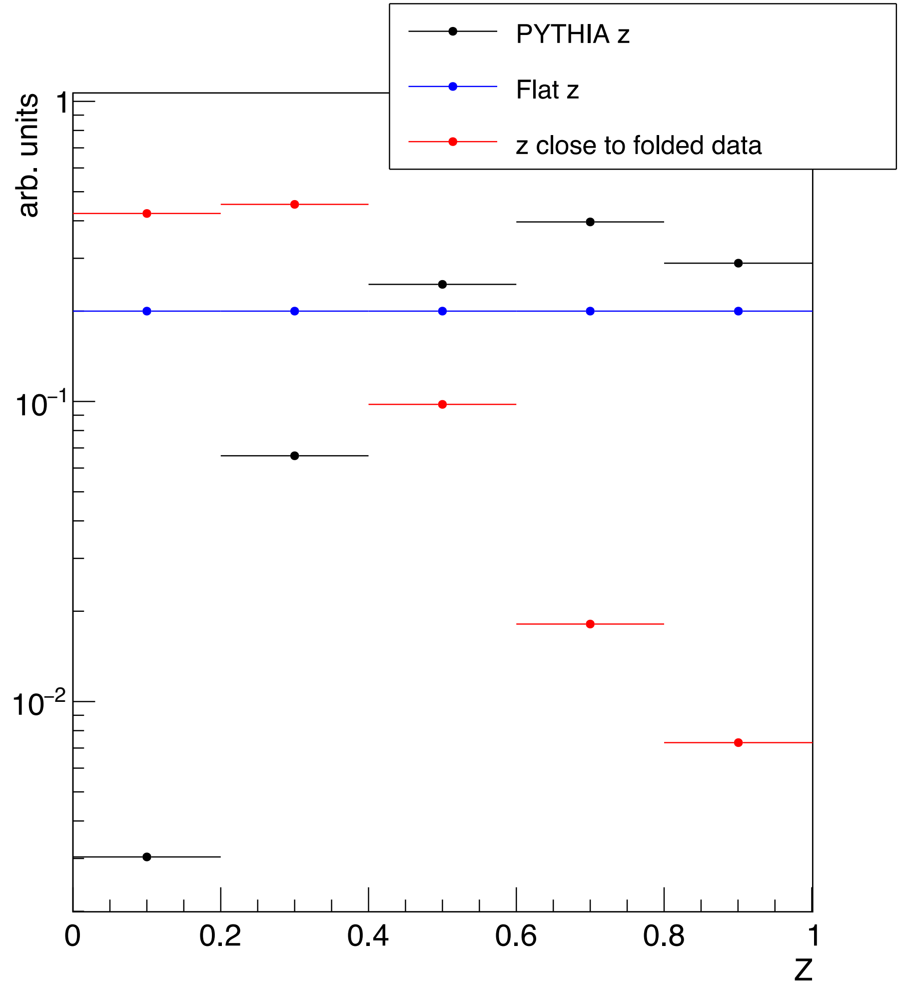


	Widths [GeV/c]
Central	6.69
Mid-Central	4.60
Peripheral	2.16

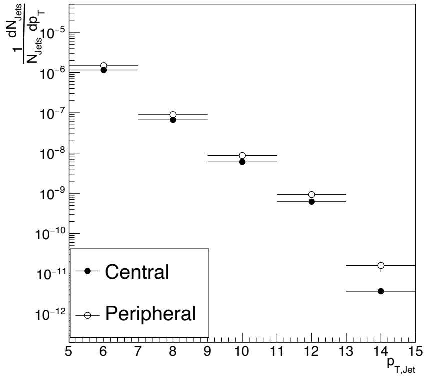
Similar background fluctuation in the two cases

Fragmentation Function (z)

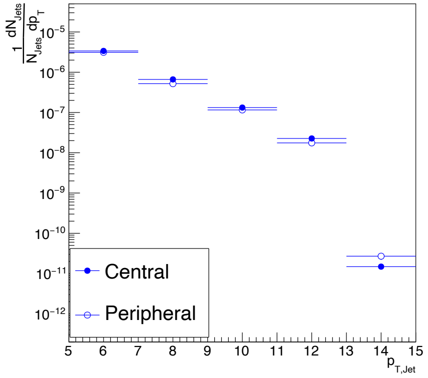
$$z = \frac{p_{\mathrm{T,D^0}}}{p_{\mathrm{T,Jet}}}$$



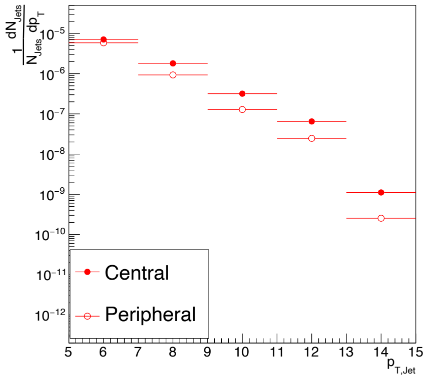
Pythia z

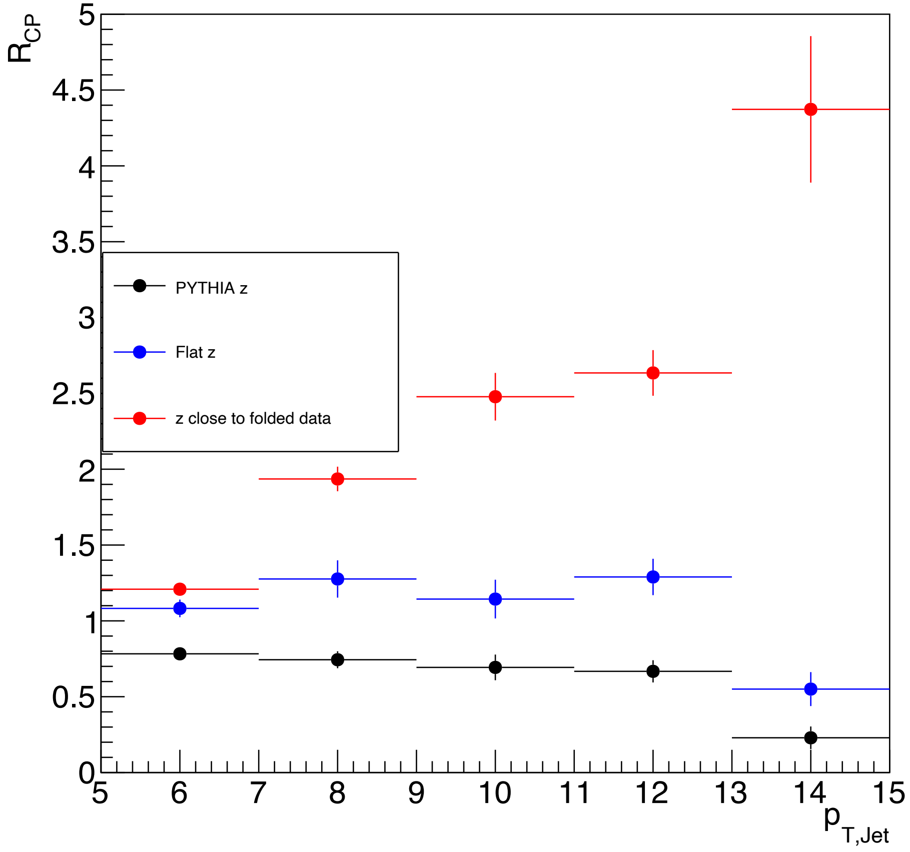


Flat z



z close to folded data





Depending on the z distribution, the spectra can look wildly different

Looking for a different idea: SUPER-ITERATION

Details in these papers: https://arxiv.org/pdf/2106.13235.pdf ; https://arxiv.org/pdf/1701.05116.pdf

$$z = \frac{p_{\mathrm{T,D^0}}}{p_{\mathrm{T,Jet}}}$$

PYTHIA Z

Flatten Z distribution

Unfold the 2D jet p_T vs Z from data with flat Z distribution

Use unfolded Z distribution as prior for new response matrix

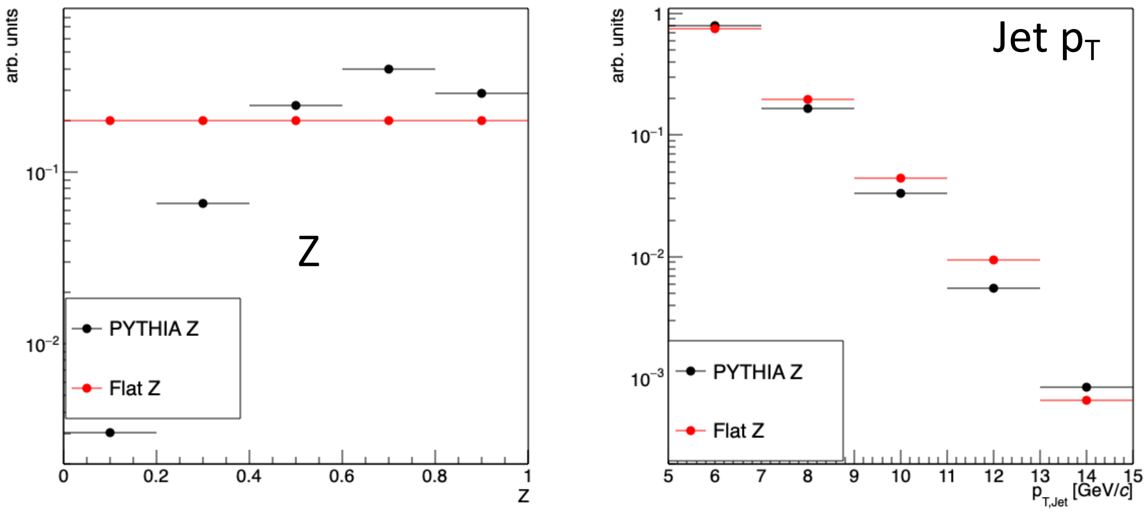
Unfold the 2D jet p_T vs Z from data with new response matrix

Call this ‘SUPER-ITERATION’

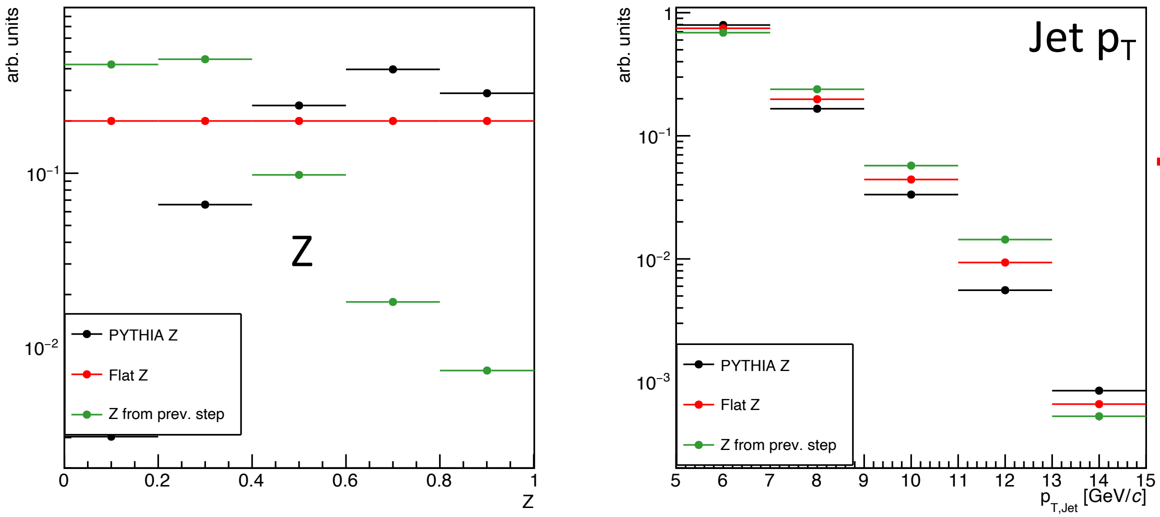
- ***Allows us to avoid using the inaccurate shape of ‘z’ distribution from PYTHIA simulation***

SUPER-ITERATION: Step-by-step

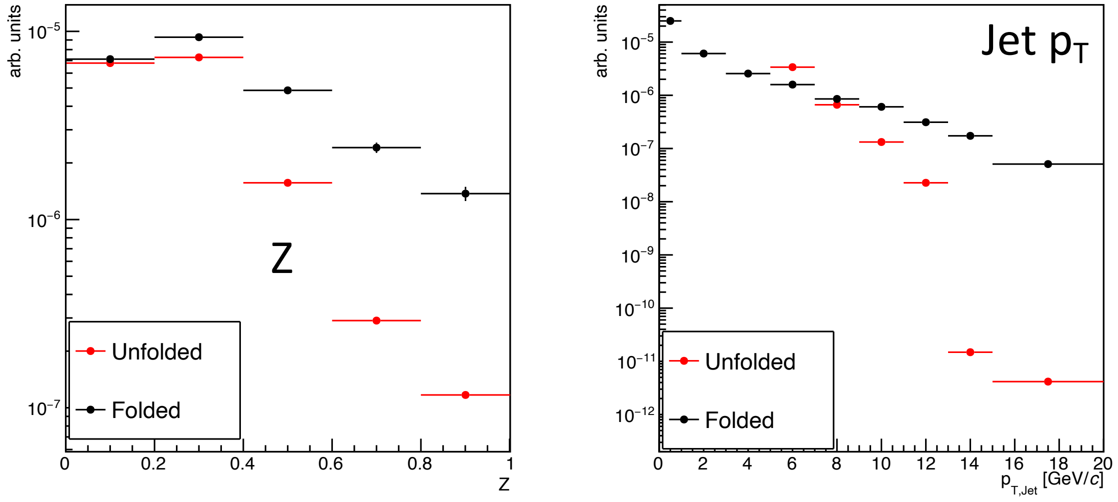
Step 1: Flattening PYTHIA Z



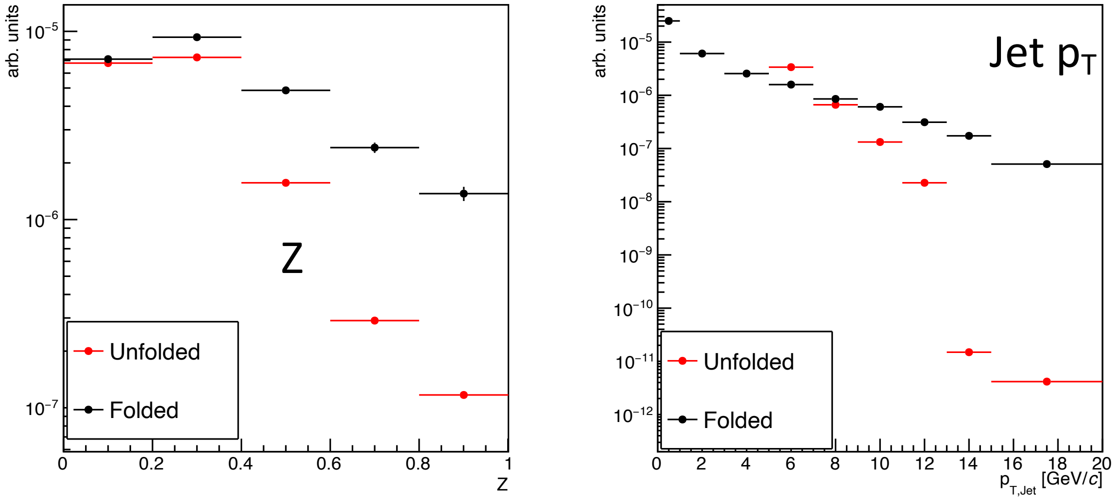
Step 3: Unfolded Z distribution used as "Prior"



Step 2: Unfold the distribution from data

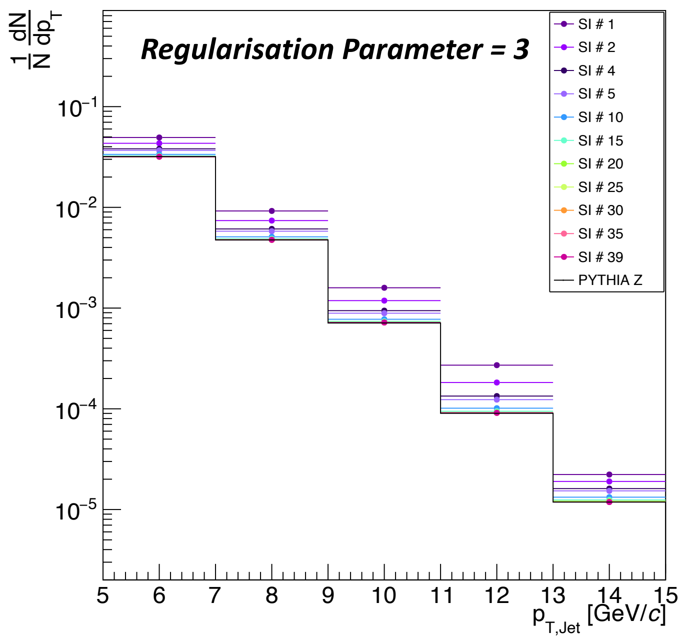


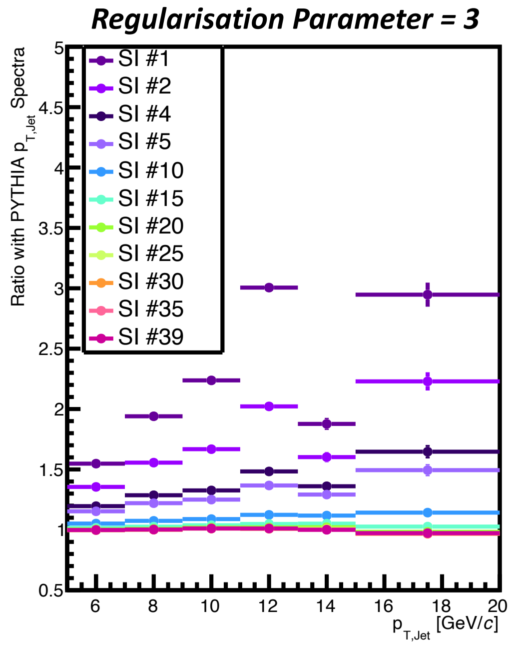
Step 4: Use response matrix from Step 3 to unfold



SUPER-ITERATION

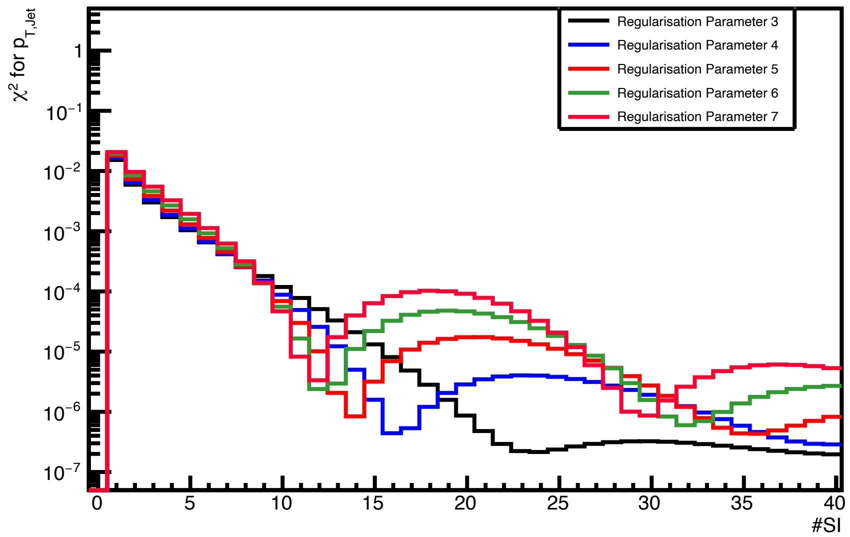
SUPER-ITERATION: Self Closure

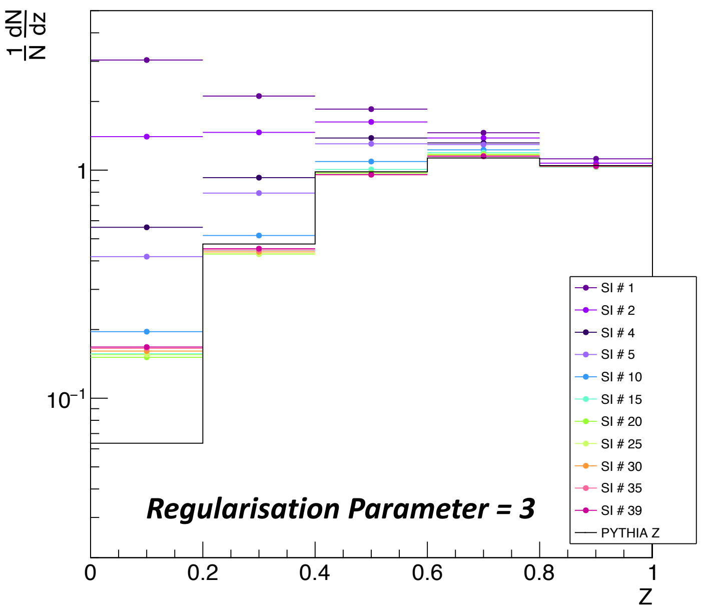


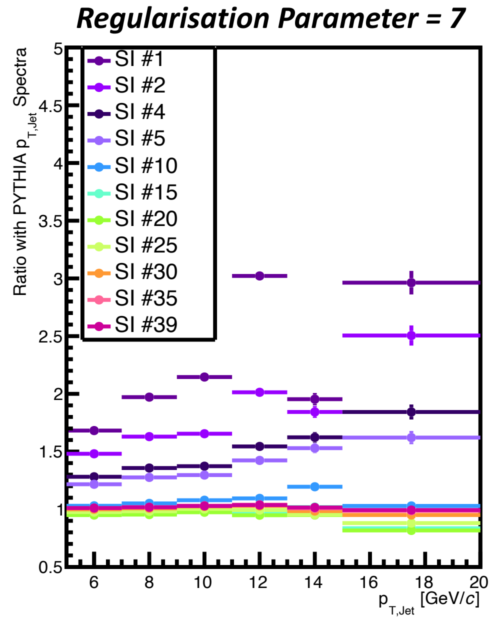


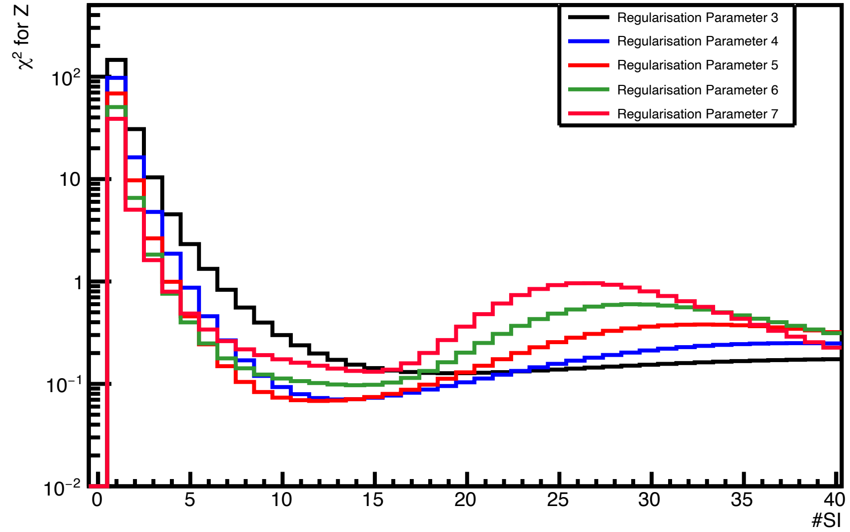
χ^2 vs Super-iteration

(For different regularization parameters)



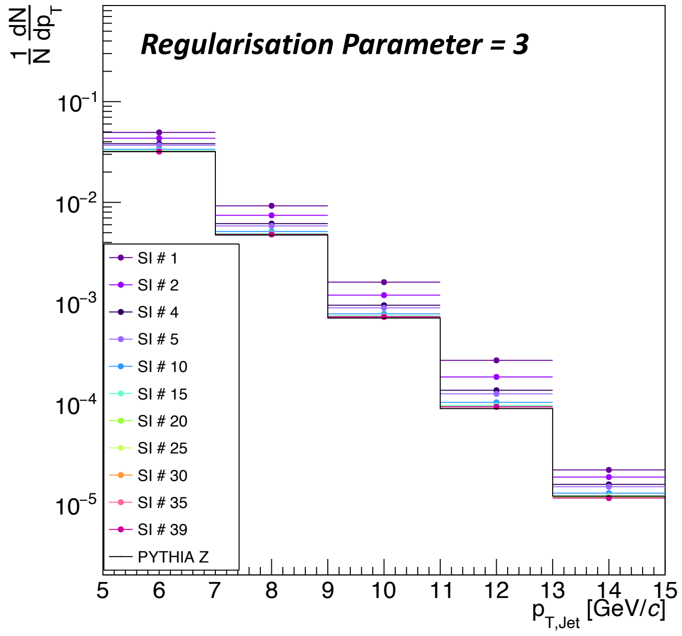


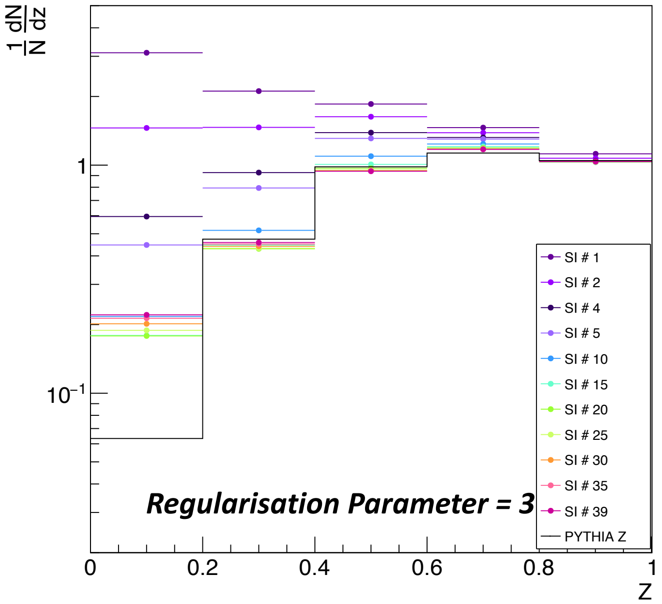




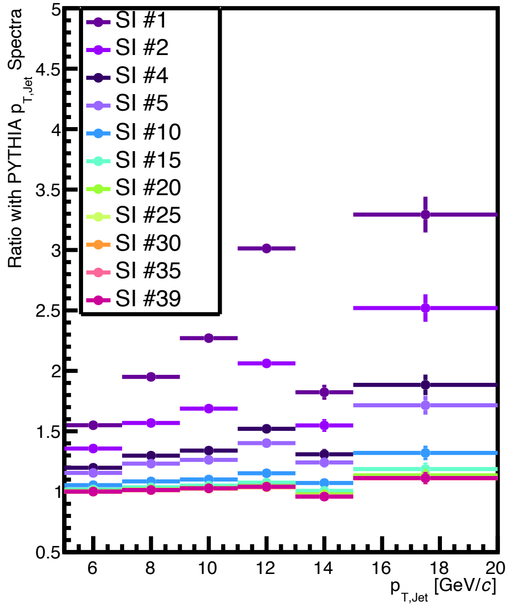
Self-Closure can be established after ~20 superiterations

SUPER-ITERATION: Test-Train Split

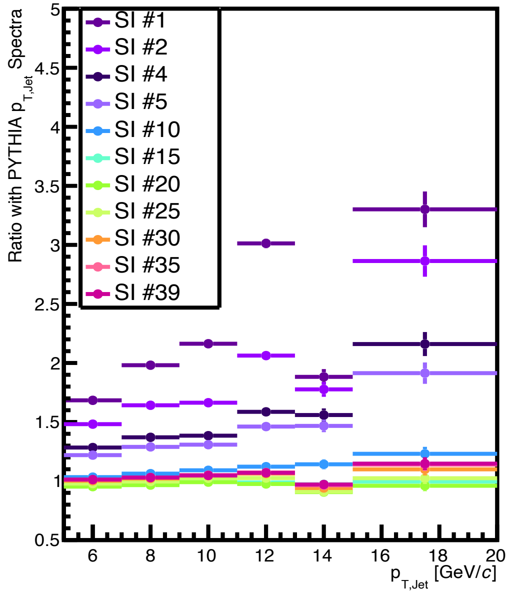




Regularisation Parameter = 3

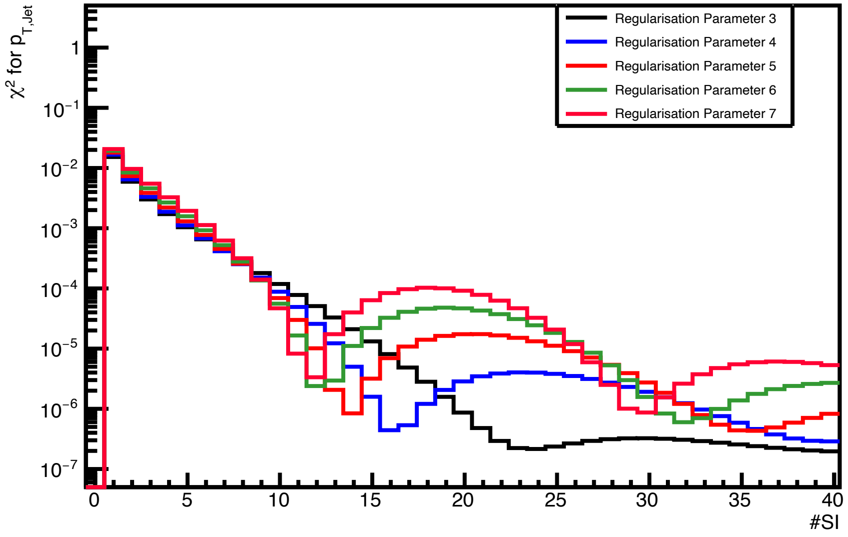


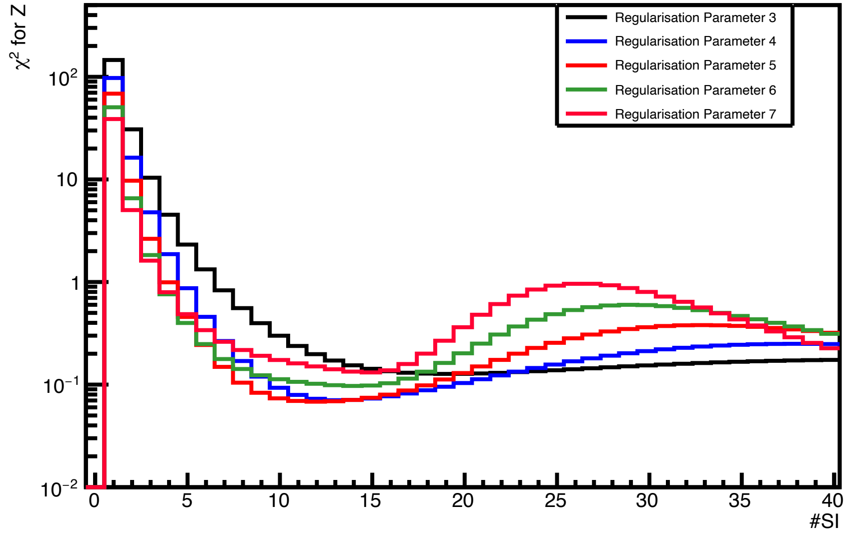
Regularisation Parameter = 7



χ^2 vs Super-iteration

(For different regularization parameters)





Closure is retained with a test sample after ~20 superiterations

Summary and Outlook

1. Super-iteration method closes with a PYTHIA sample ‘**embedded**’ in minimum bias event
2. Closure is consistent across all centralities.
3. Data comparisons coming up with the super-iteration method.
4. Investigating making a PYTHIA sample flat in Z.
5. Extending this unfolding to include $\Delta\mathrm{R}$.