D^0 Tagged Jets at ePIC

Diptanil Roy
Rutgers University
ePIC Jet & HF Working Group Meeting
Jul 26, 2024

Analysis Details

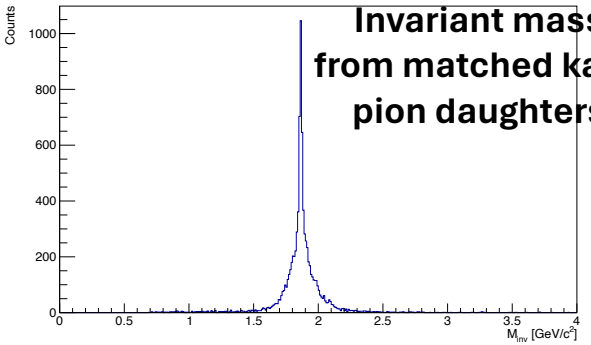
Dataset location:
`/gpfs/mnt/gpfs02/eic/bpage/home/EPIC/fromOlga/d0Sample/recoOut/individual`

Sample: 18x275 GeV^2, **Campaign**: 23.12.0

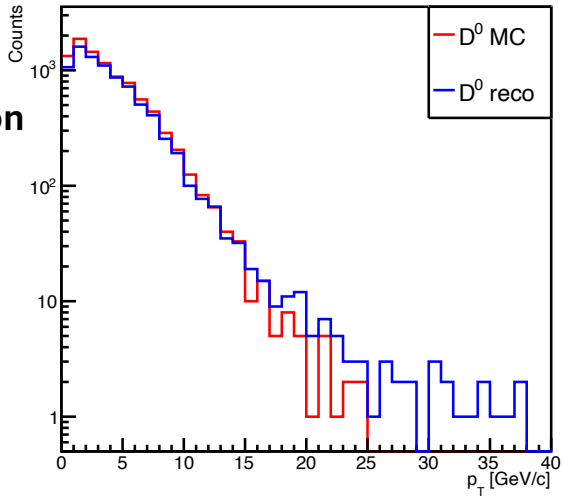
Basic Cuts:

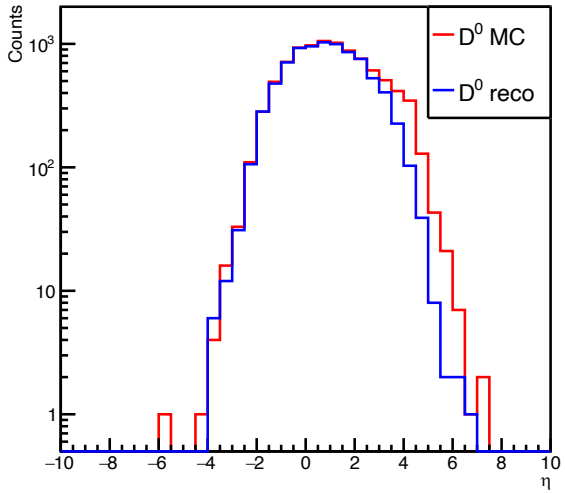
- **D^0 reconstructed from *Kpi* channel only (***We can revisit other channels, but ideally all D^0s should decay to Kpi in simulation***)**
- No cuts on D^0 kinematics
- No cuts on pion/kaon kinematics
- D^0 – pre-clustered jet matching
- Reco Level D^0 jet tagged by D^0 as the constituent

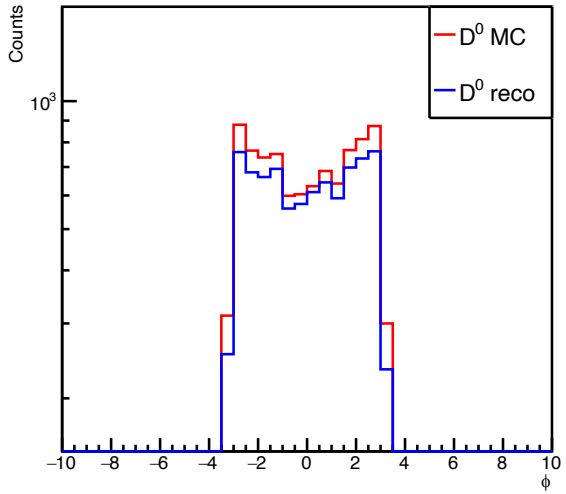
Reconstructing D^0 Using Truth Level Information



Invariant mass from matched kaon pion daughters

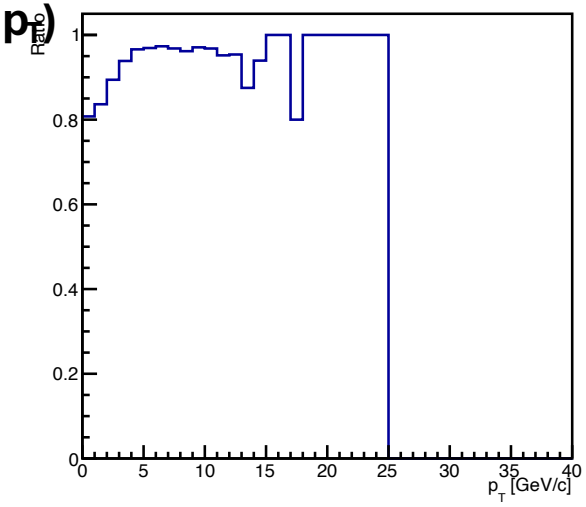


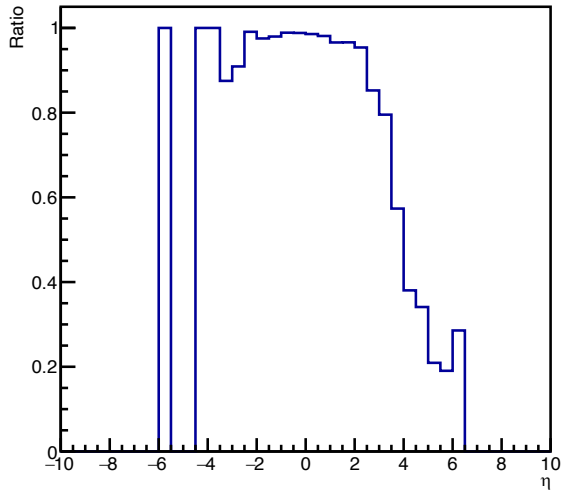


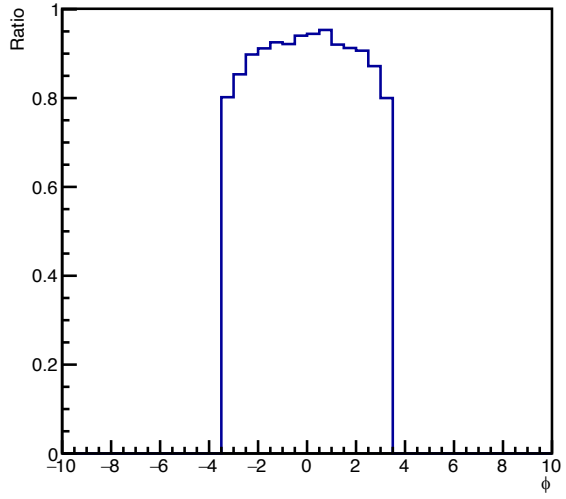


We recover most of the D^0 mesons (especially at high p_T)

Ratio plot made with truth level p_T only.

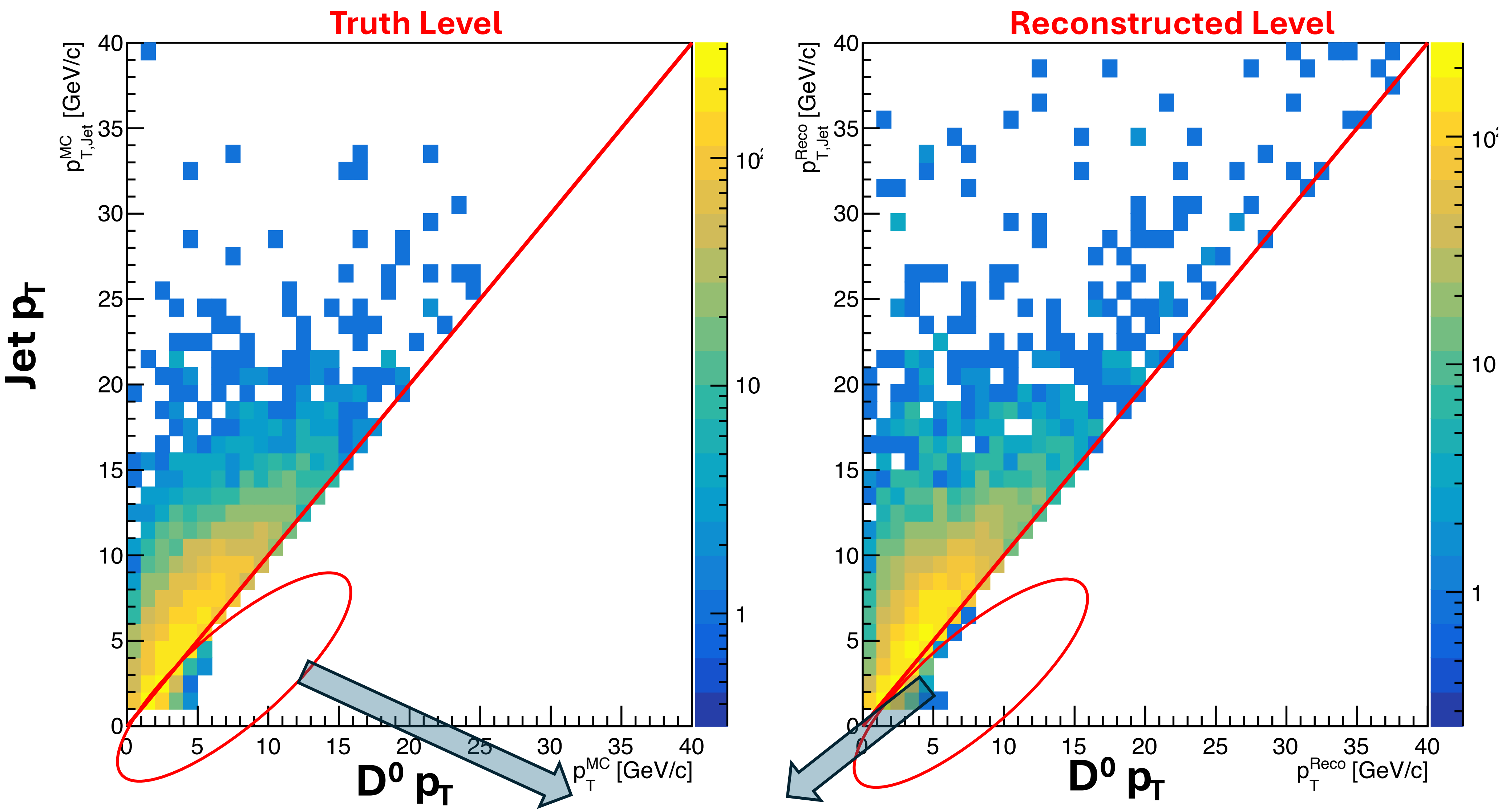






D^0-Jet Matching

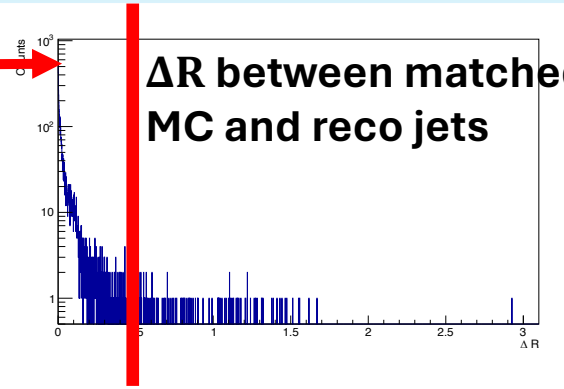
Matching Condition → $\Delta R < 0.8$ for R = 1 Jets (arbitrary, can play around with the cutoff)



Can remove excess here with more stringent matching

Resolution From Matched Jets in MC and Reco for matched D^0

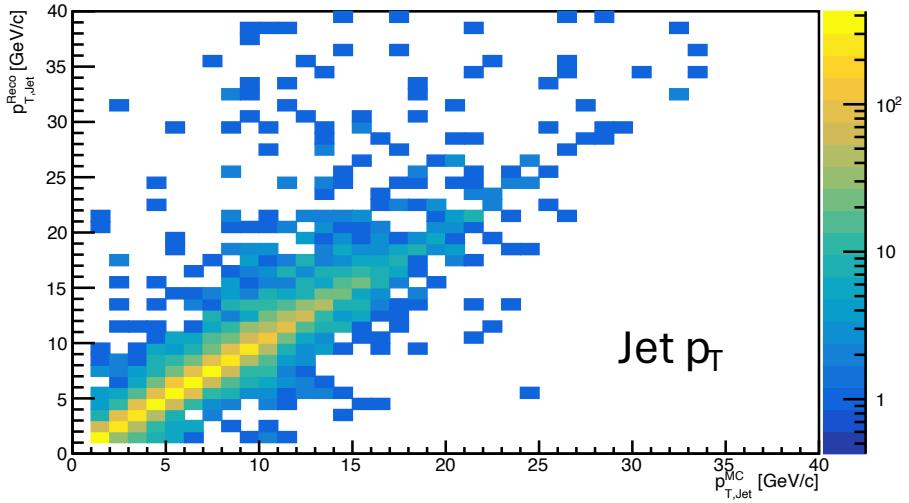
No separate matching condition on jets in MC-Reco due to D^0 being used as a tag

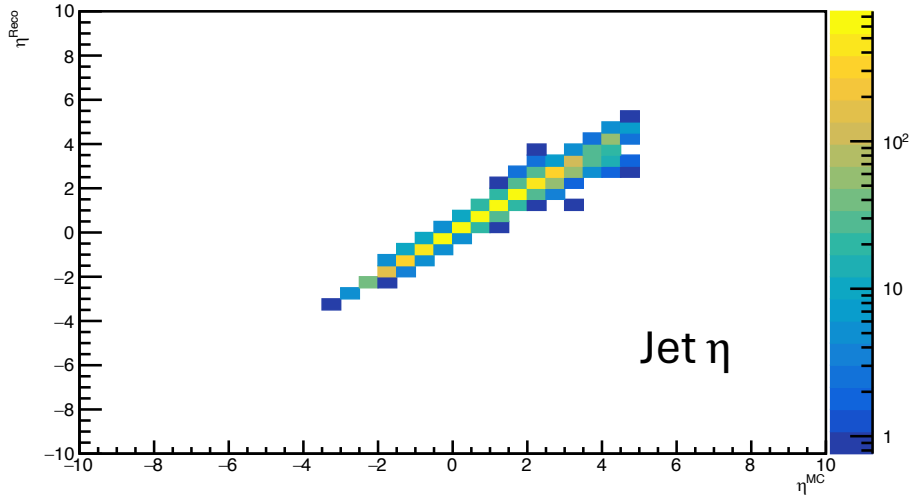


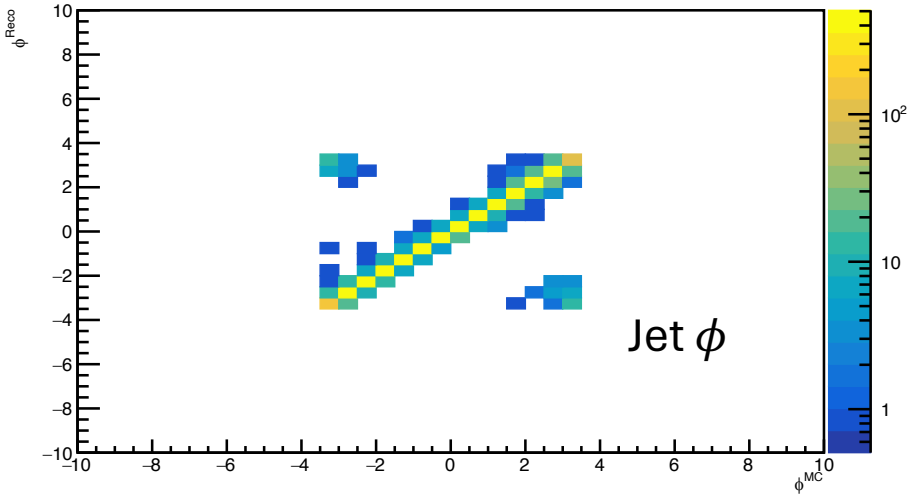
ΔR between matched MC and reco jets

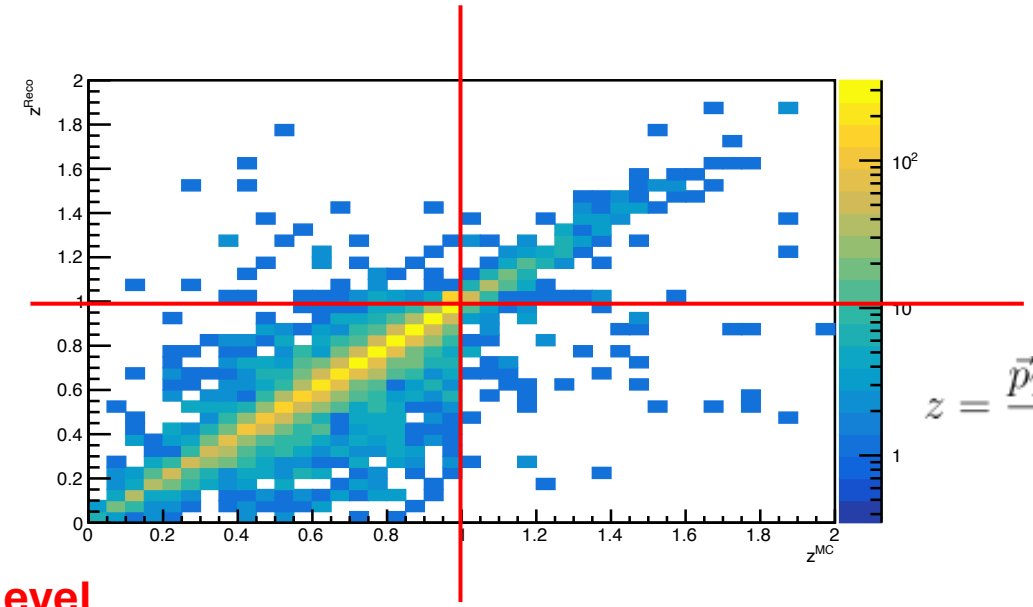
$\Delta R < 0.5$ **between most truth and reco jets**

Reconstructed Level









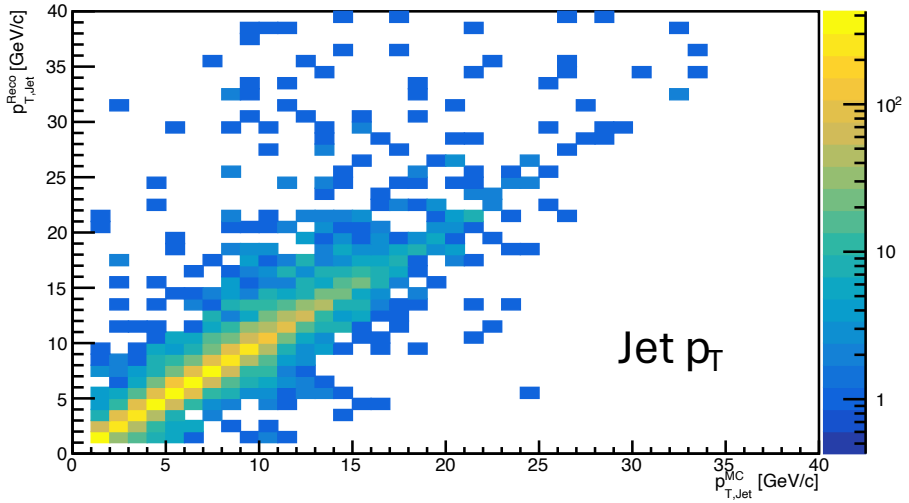
$$z = \frac{\vec{p}_{T,D^0} \cdot \vec{p}_{T,Jet}}{|\vec{p}_{T,Jet}|^2}$$

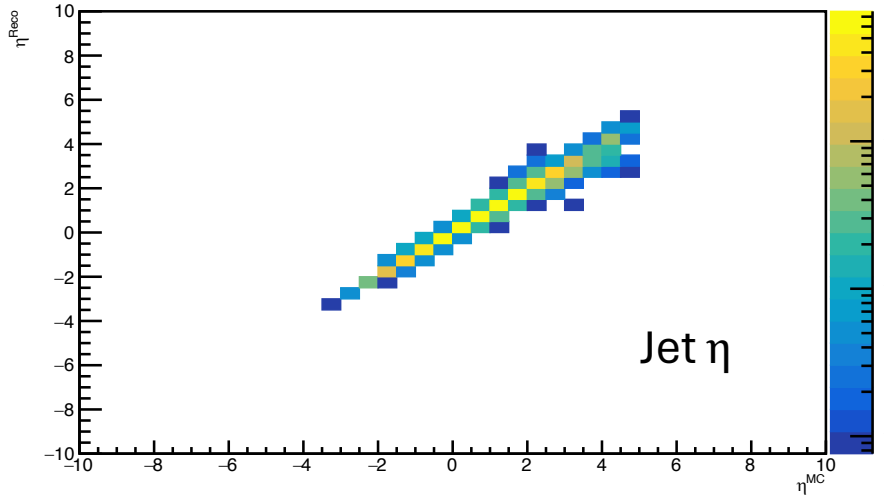
Truth Level

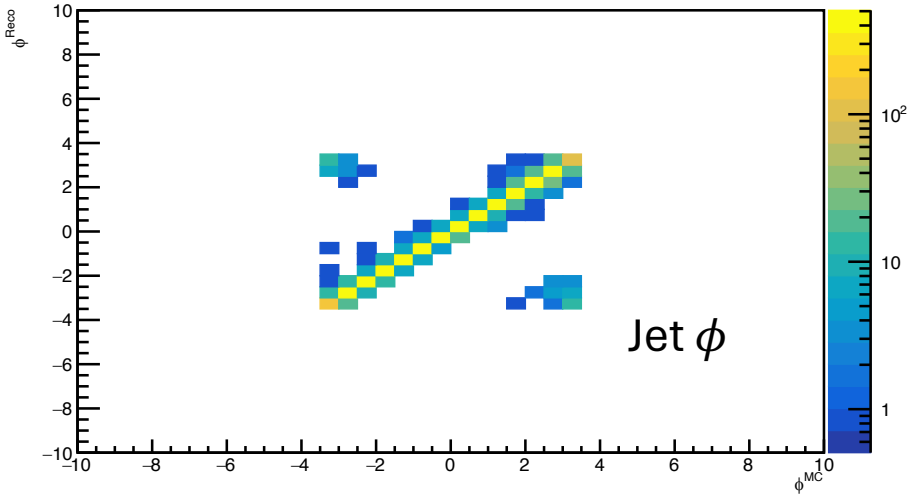
Resolution From Matched Jets in MC and Reco for matched D^0

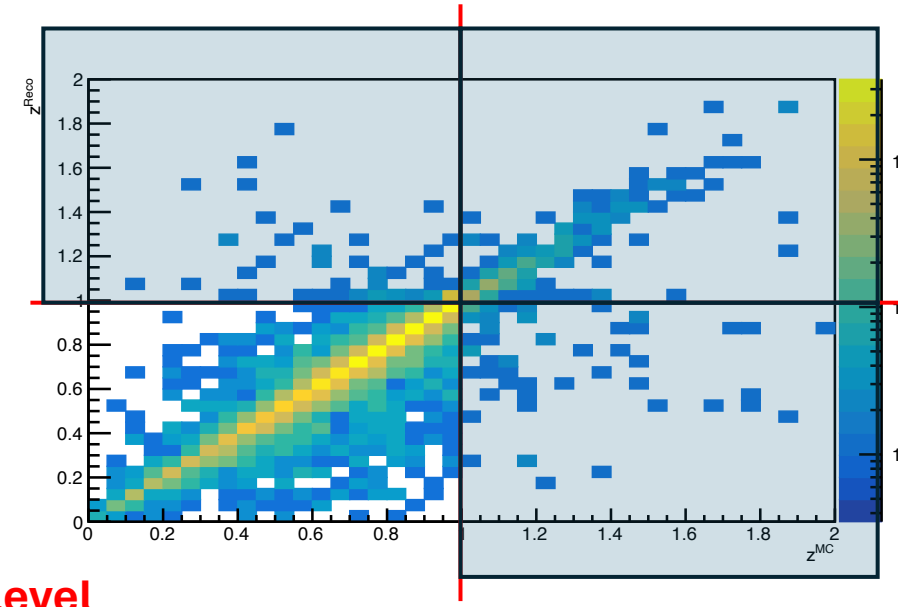
No separate matching condition on jets in MC-Reco due to D^0 being used as a tag

Reconstructed Level









Truth Level

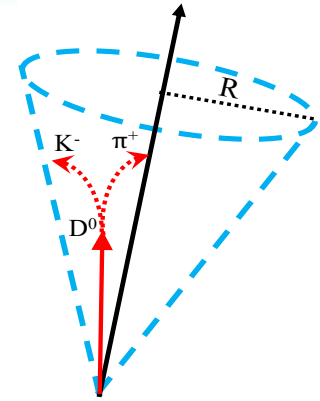
Shaded regions can be trimmed

1. with tighter cuts
2. **Reconstructing jets with the D^0 meson as a constituent**

$$z = \frac{\vec{p}_{T,D^0} \cdot \vec{p}_{T,Jet}}{|\vec{p}_{T,Jet}|^2}$$

${}_s\mathcal{P}lot$

- Native class in RooStats, and widely used in HEP
- Unbinned maximum likelihood fit to invariant mass integrated over all kinematics
- $p_{T,jet}$ and related distributions with all D^0-tagged jet candidates using sWeights
- Easy to include reconstruction efficiencies versus D^0 kinematics



$$ {}_s\mathcal{P}_n(m_{K\pi,i}) = \frac{\sum_{j=1}^{N_T} V_{nj} f_j(m_{K\pi,i})}{\sum_{k=1}^{N_T} N_k f_k(m_{K\pi,i})} $$

Unbinned max. likelihood fit

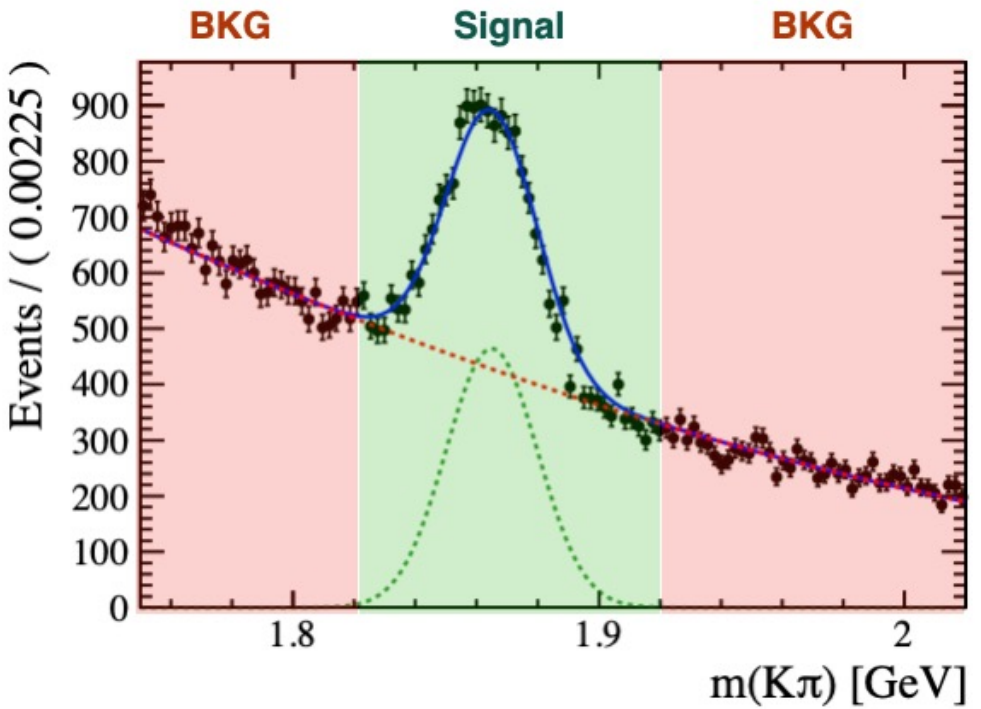
n = n-th fit component(sig/bkg)

N_k = k-th yield (T=2)

$f_k(m_{K\pi,i})$ = per-event PDF value with k^{th} hypothesis

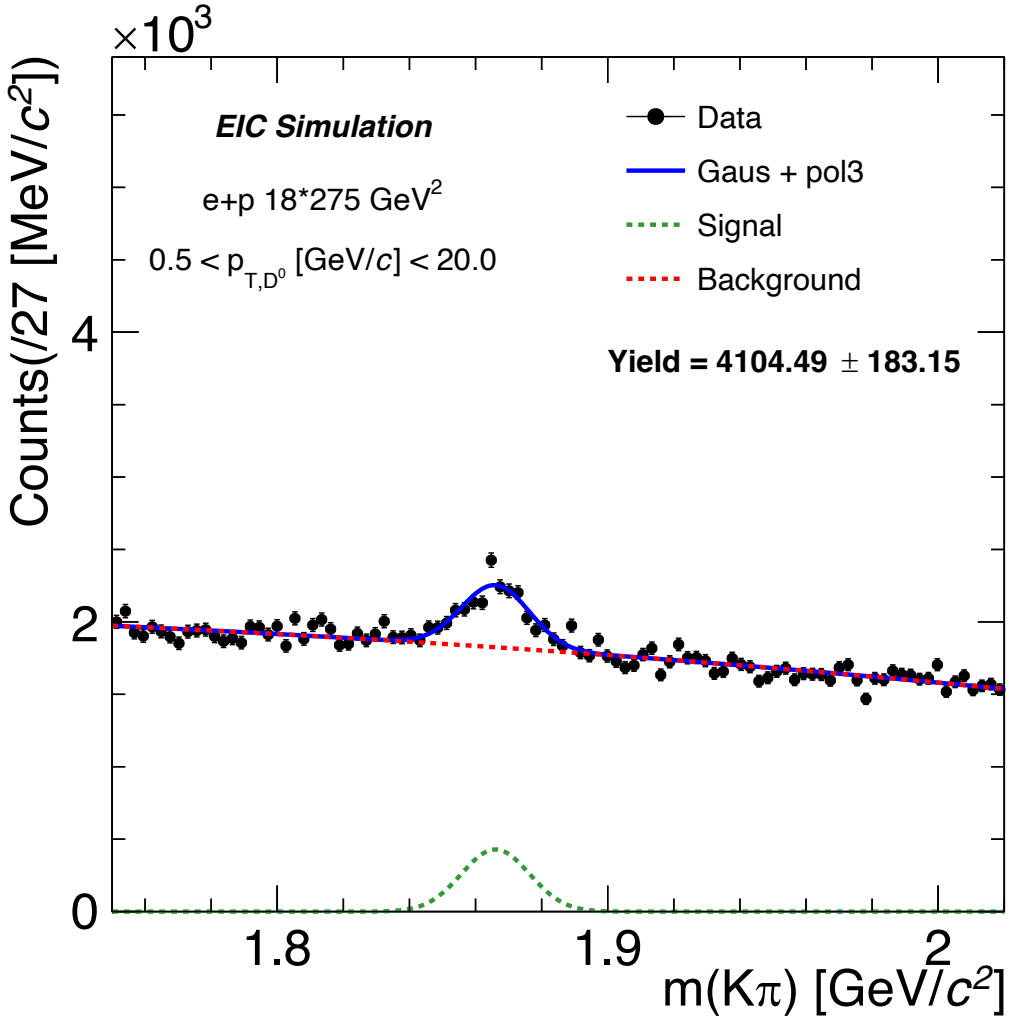
V = cov. matrix

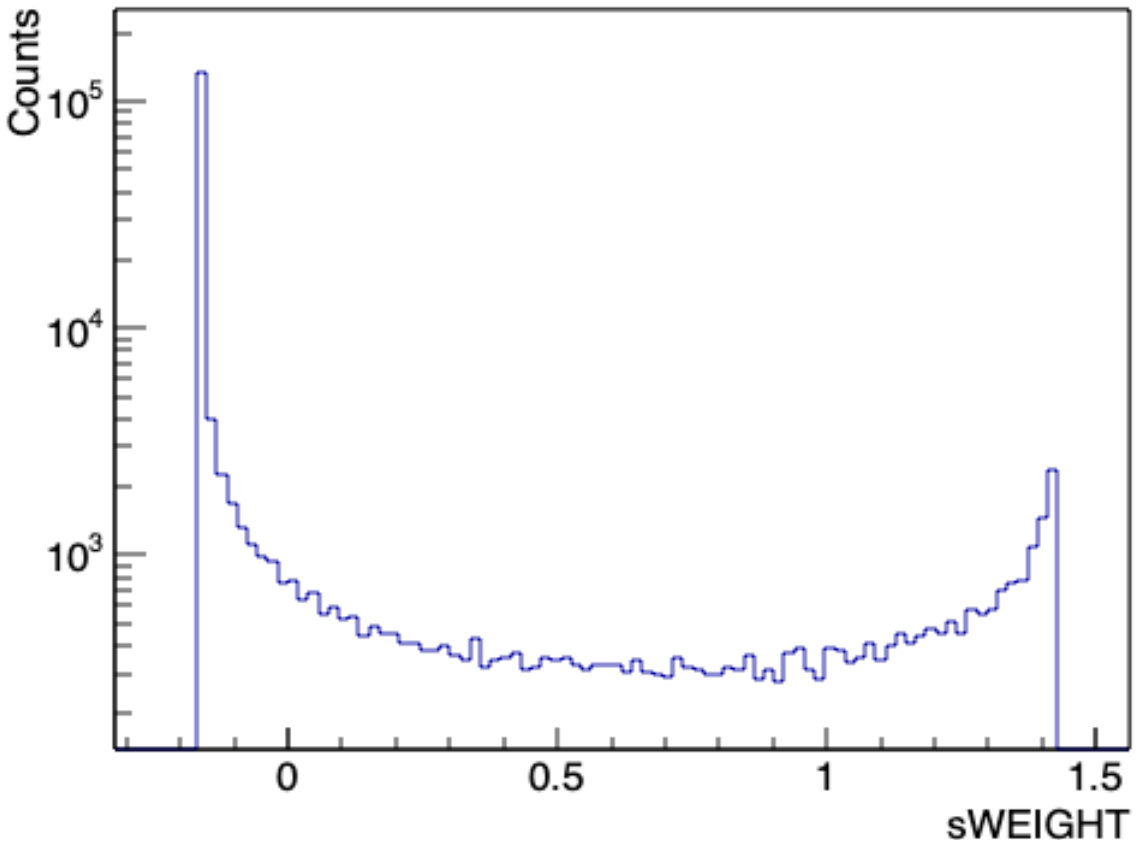
Efficiency Correction → $$ {}_s\mathcal{P}_n(m_{K\pi,i}) \rightarrow \frac{{}_s\mathcal{P}_n(m_{K\pi,i})}{\varepsilon(m_{K\pi,i})} $$



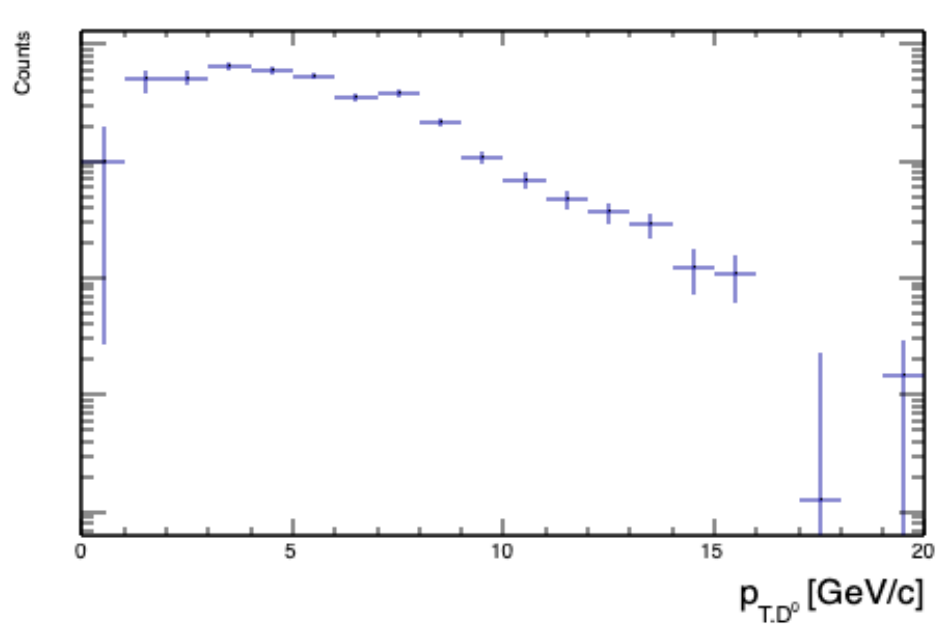
sPlot : https://doi.org/10.1016/j.nima.2005.08.106

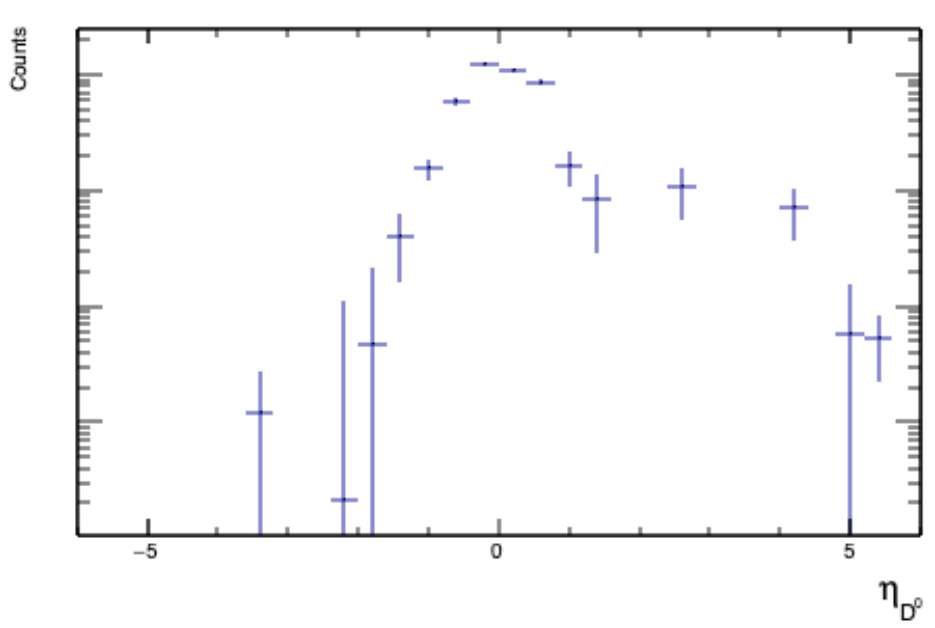
$_s$Plot

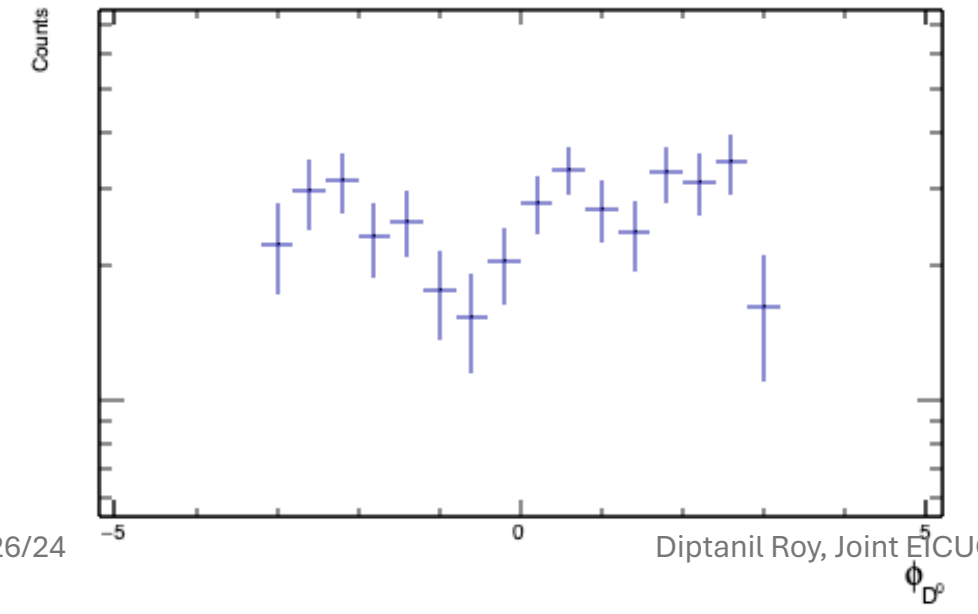

×10^3
EIC Simulation
e+p 18*275 GeV^2
0.5 < p_T,D^0 [GeV/c] < 20.0
Data
Gaus + pol3
Signal
Background
Yield = 4104.49 ± 183.15
Counts(/27 [MeV/c^2])
m(Kπ) [GeV/c^2]

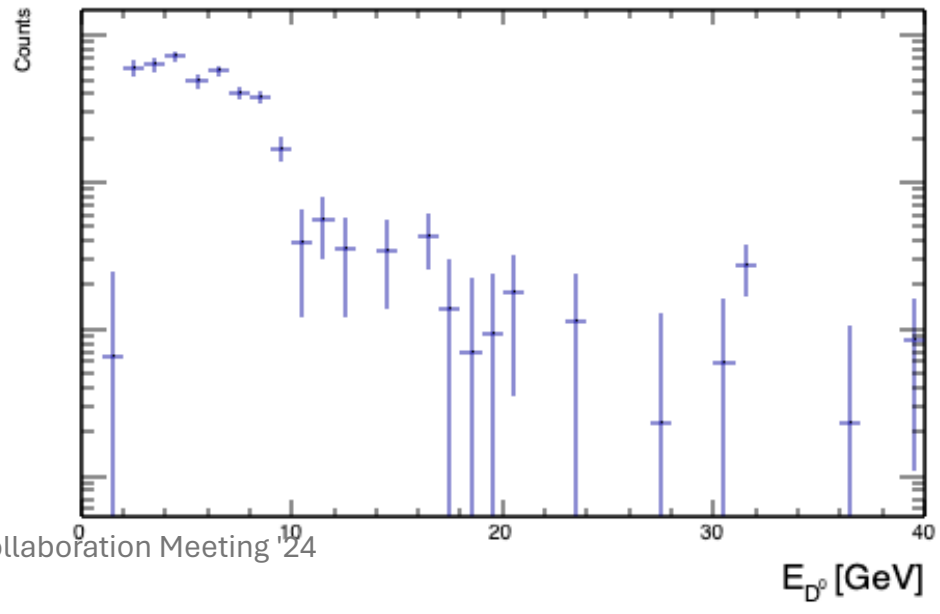

Counts
sWEIGHT

D^0 Spectra (Reconstructed Level Only)

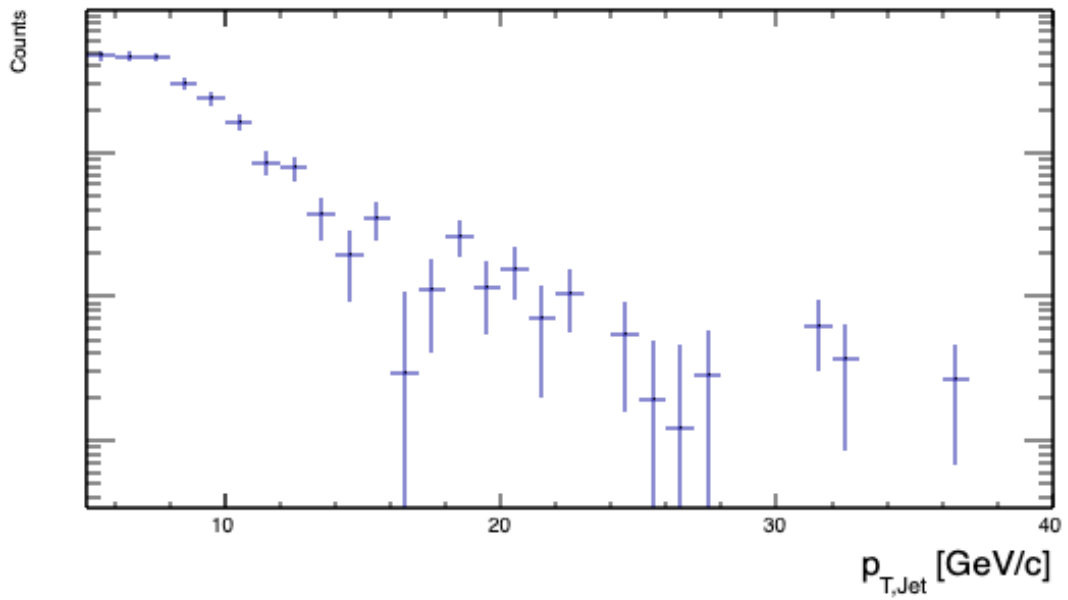


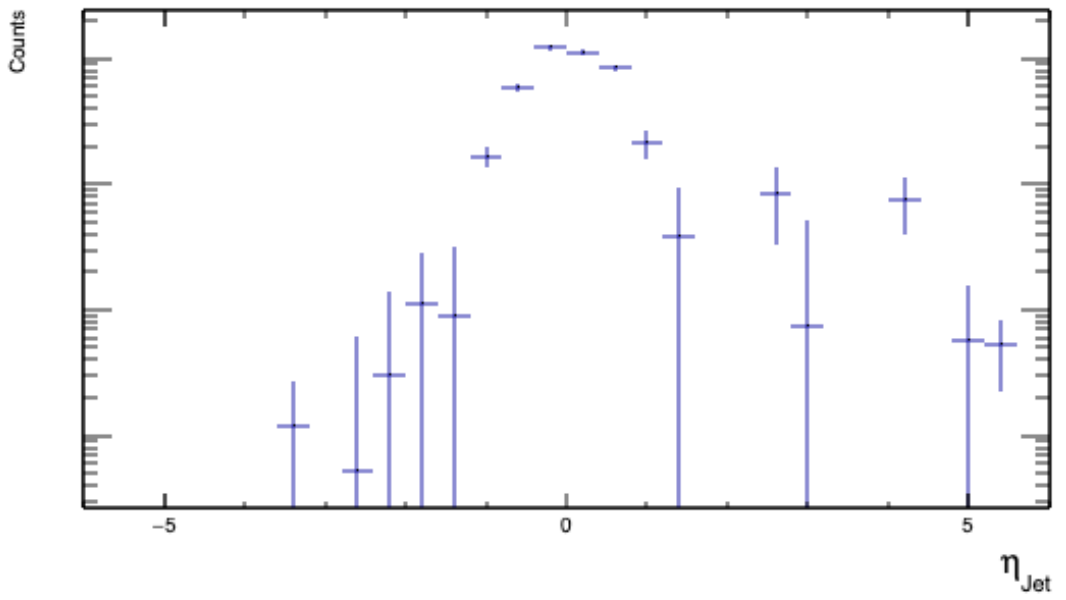


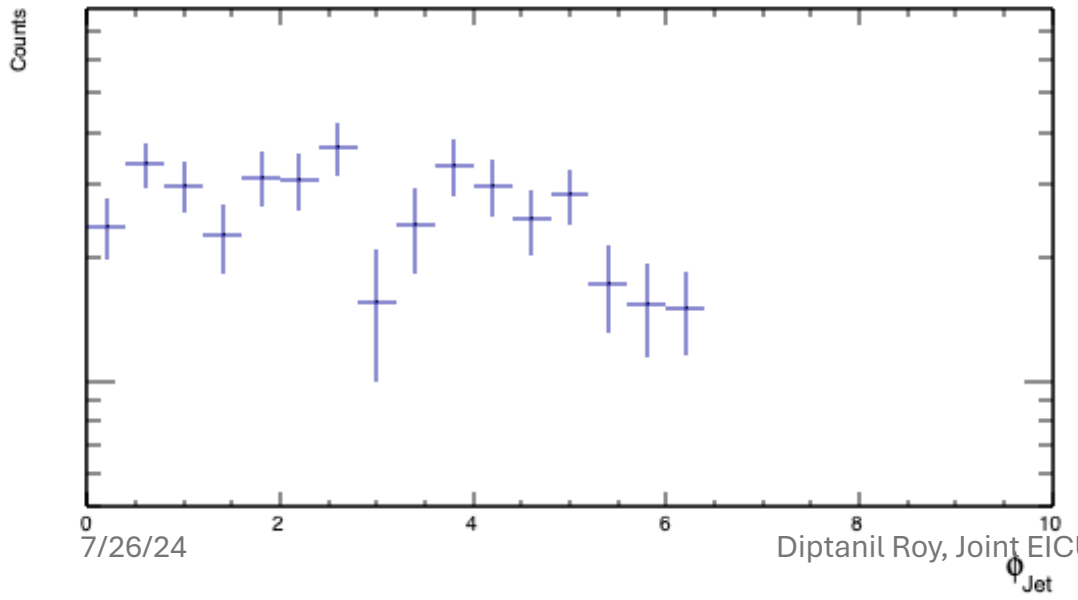


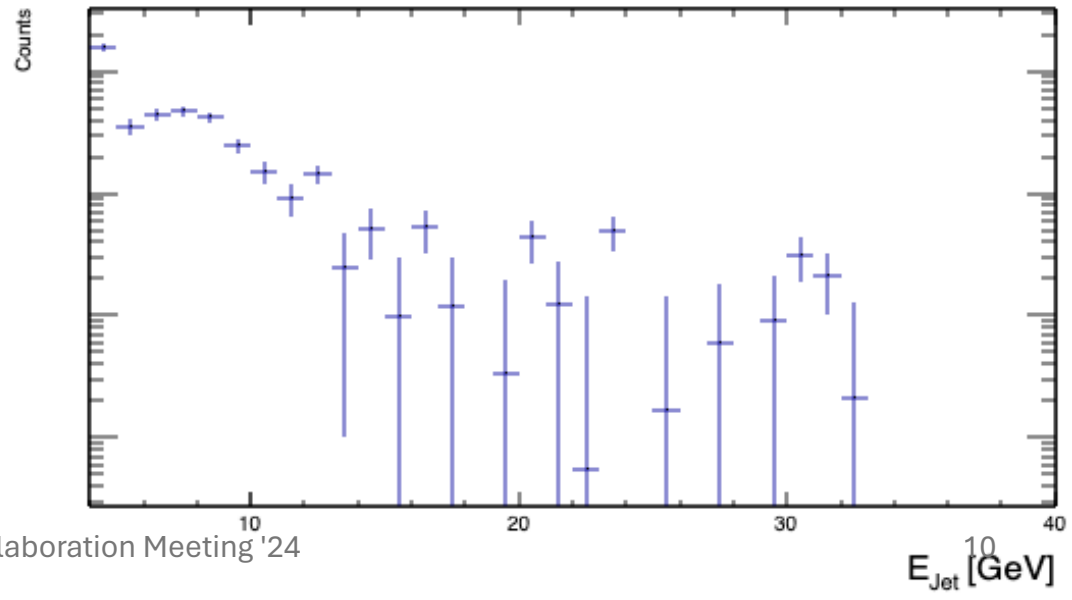


D^0 Jet Spectra (Reconstructed Level Only)









Outlook

1. Larger sample for a more systematic study
2. Update to the June 2024 campaign
3. Comparison with side band method for the jets