

Heavy-flavor studies for Early Science (ES)

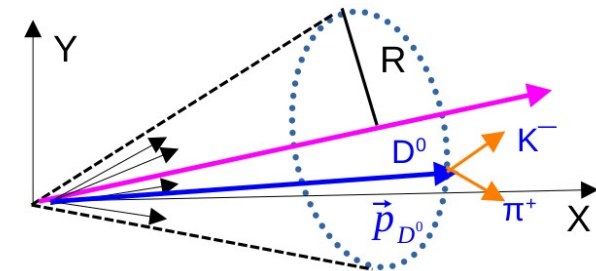
Shyam Kumar

University of Houston, Texas, USA



R_{eAu} vs fragmentation (z_{proj}) for D^0 -tagged jets

- e+p 9x130, e+Au 9x100: 1 fb⁻¹ sample with July 26 campaign
- R_{eAu} vs z_{proj} :
 - Real particle identification for D^0 reconstruction
 - Scattered electron is removed using the reconstructed information
 - $p_{\text{Tjet}} > 3$ GeV/c on D^0 -in-charged jets
 - Scaling on cross section for e+Au DIS sample
 - PID+Topo: stands for BDT binary classifier used for the D^0 -in-jet reconstruction



- Signal for D^0 sample while combinatorial bkg from DIS Sample

- **Corrections on signal:**

- Weight factor of 3 on signal (Pythia8) for $Q^2 < 5$ GeV²
- Projection in different rapidity bins
- Scaling to target luminosity 1.0 fb⁻¹

- **Bkg:**

- Scaling to targeted luminosity (1.0 fb⁻¹)
- Cross section scaling for **biased** DIS sample
- Projection in different η and z bins
- Training in ML: $0 < z < 0.6$ and $0.6 < z < 1$

preselection_cuts='(mass_D0 > 1.6 && mass_D0 < 2.5) && d0xy_pi<100. && d0xy_k<100. && decay_length <100.'

Data Sample (e+p/Au)

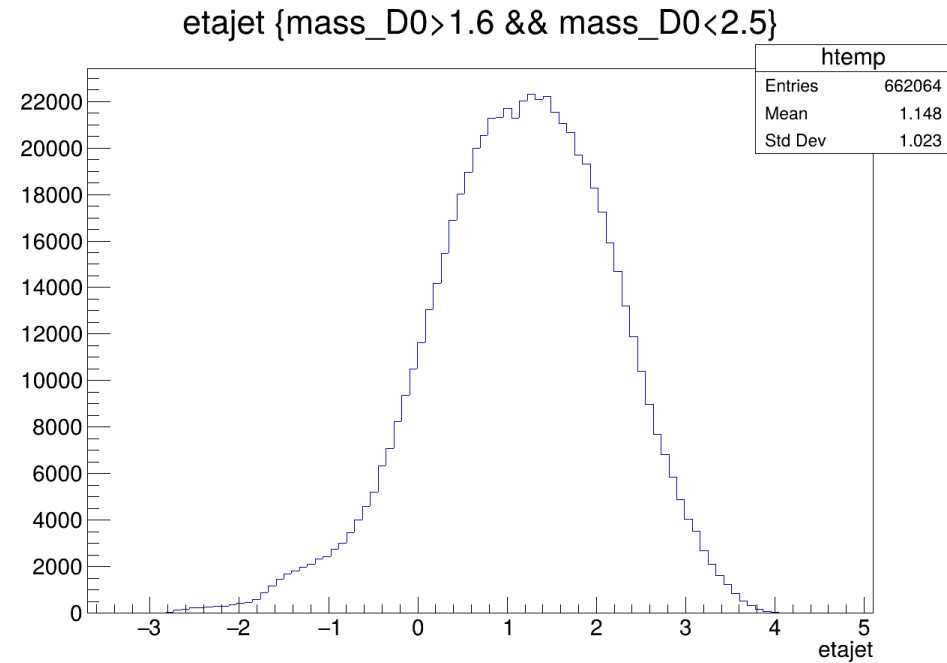
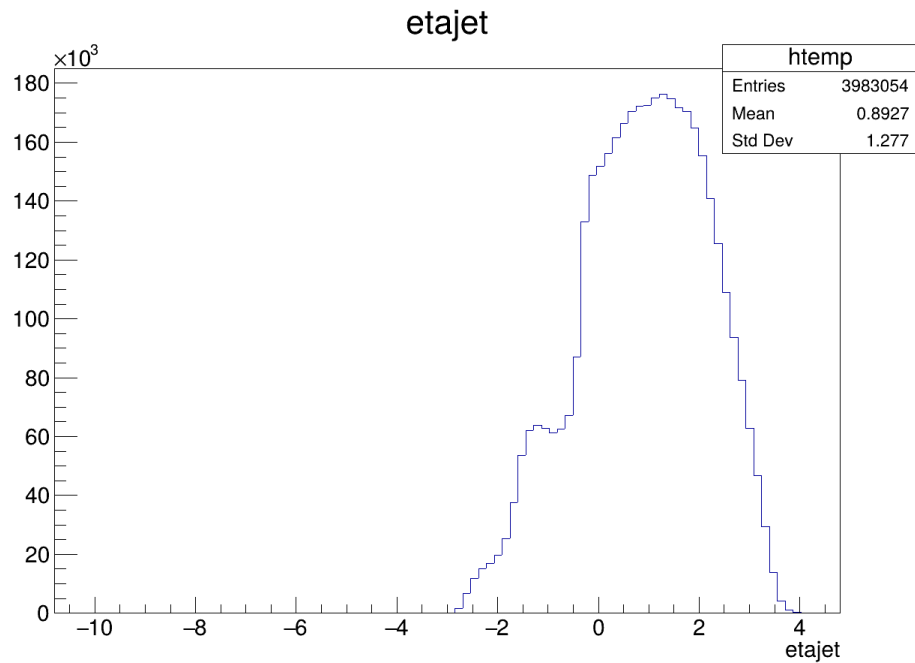
- D⁰ Sample, e+p, 9x130, $Q^2 > 1 \text{ GeV}^2$
 - epic:/RECO/26.07.1/epic_craterlake/SIDIS/D0_ABCONV/HFsim-PYTHIA/pythia8.316-1.0/ep/9x130/q2_1
- D⁰ Sample, e+Au, 9x100, $Q^2 > 1 \text{ GeV}^2$ (Pythia6)
 - epic:/RECO/26.07.1/epic_craterlake/SIDIS/D0_ABCONV/HFsim-BeAGLE/BeAGLE1.03.02-1.0/eAu/9x100/q2_1
- **Biased** NC, DIS Sample e+p, 9x130, $Q^2 > 1 \text{ GeV}^2$ (Biased in different Q^2 bins)
- NC, DIS Sample e+Au, 9x100, **Q^2 : 1-10000 GeV^2**

Cross section in different Q^2 bins

Event generator and energy	$Q^2 > 1$	$1 < Q^2 < 10$	$10 < Q^2 < 100$	$1e2 < Q^2 < 1e3$	$1e3 < Q^2 < 1e4$
PYTHIA 8.316, 9x130	5.719e5 pb	5.307e5 pb	4.048e4 pb	1.475e3 pb	1.001e1 pb

Event generator and energy	$1 < Q^2 < 10$	$10 < Q^2 < 100$	$1e2 < Q^2 < 1e4$
BeAGLE 1.03.02, eAu, 9x100	3.385e5 pb	3.34e4 pb	9.867e2 pb

η Distribution of Bkg Jets (e+Au)



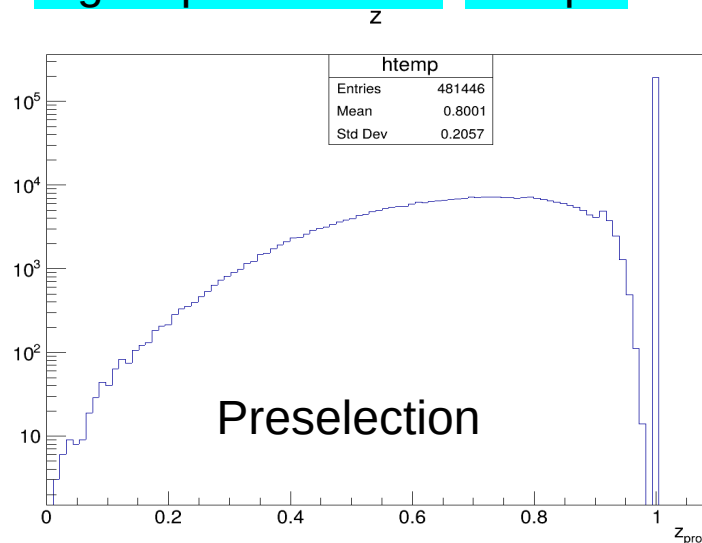
Applying invariant mass cut suppresses the peak due to misidentification

Fragmentation Variable (e+p)

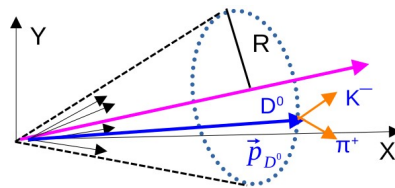
Signal pairs from D⁰ Sample

e+p, 9 x130, D⁰ sample, **Biased** DIS sample

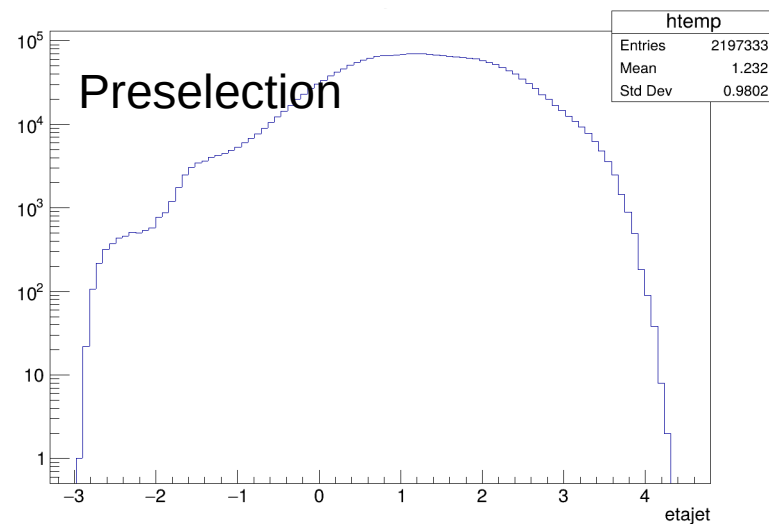
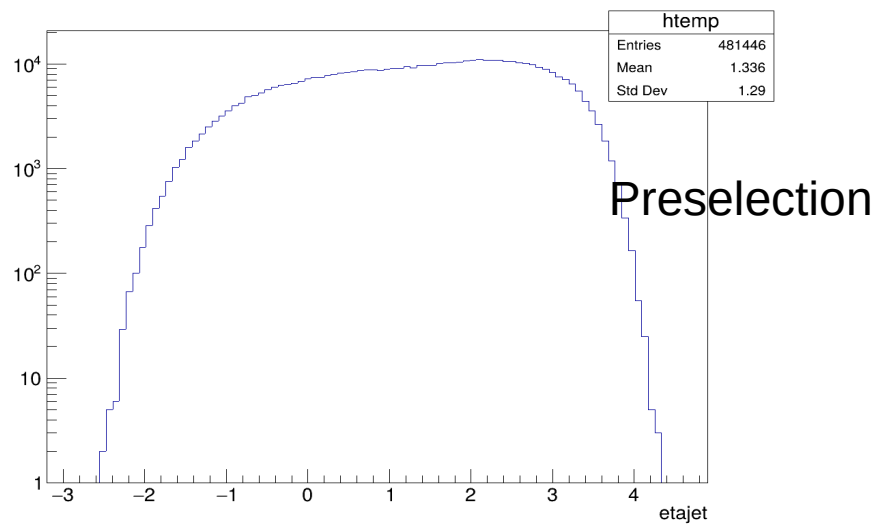
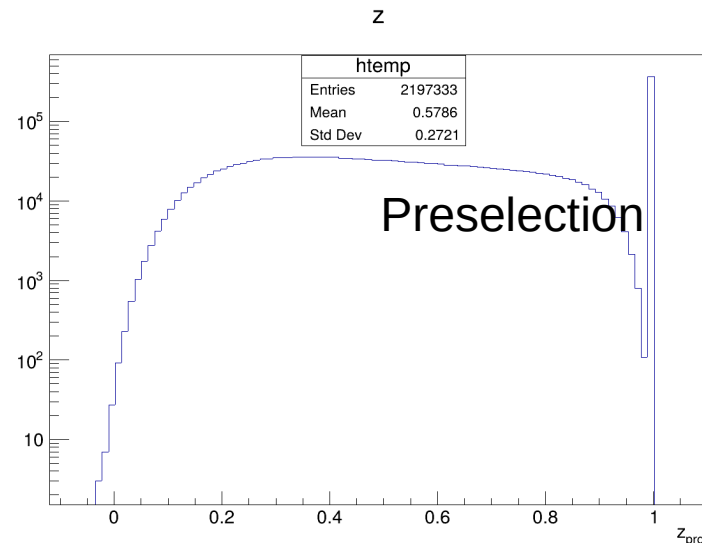
Bkg pairs from DIS



Anti-k_T, R = 1,
p_{Tjet} > 3 GeV/c



$$z = z_{proj} = \frac{\vec{p}_{D^0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$

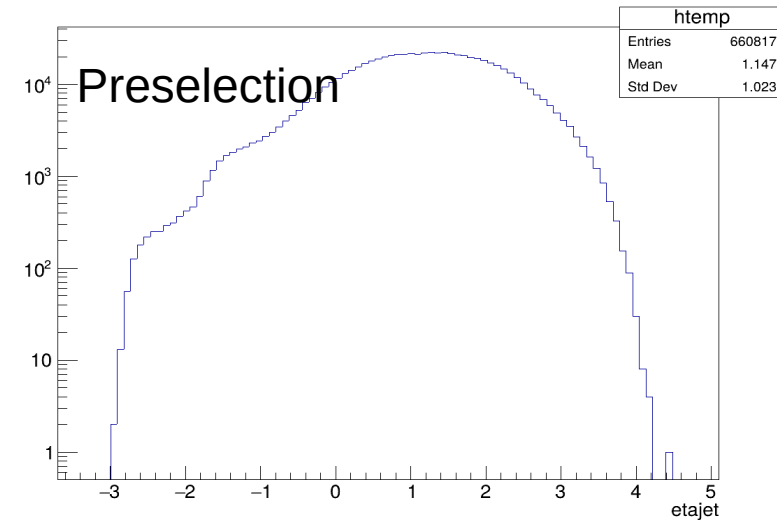
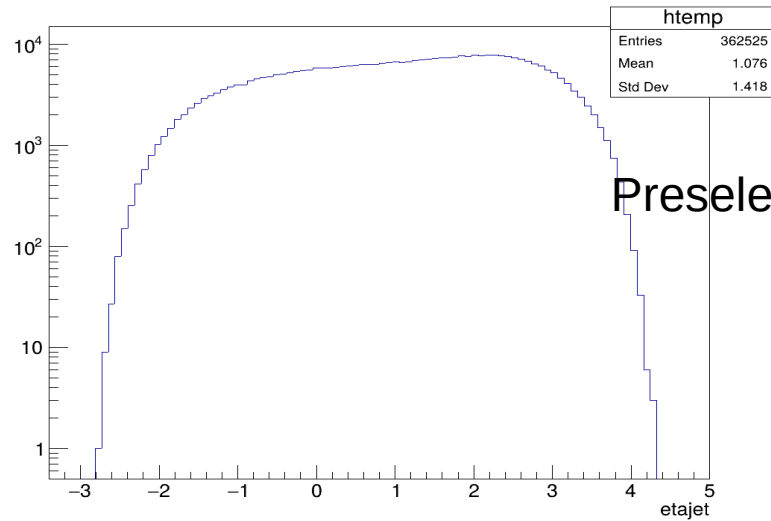
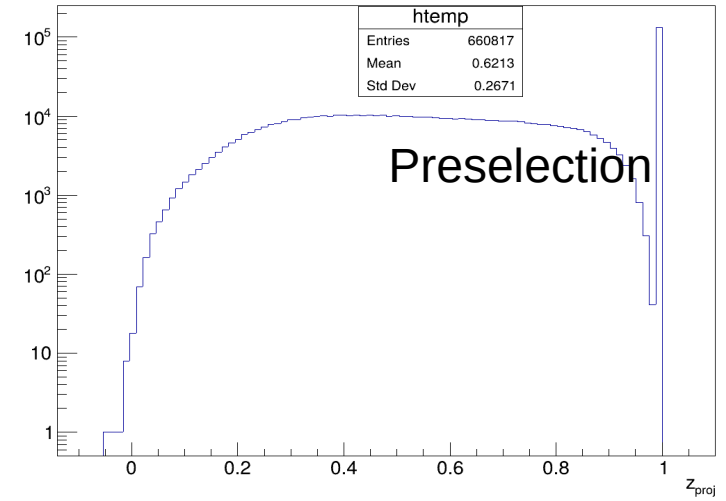
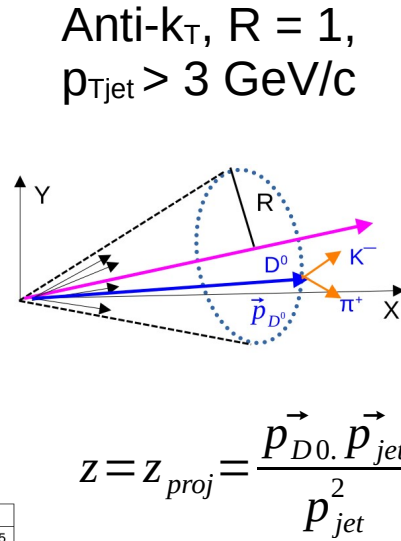
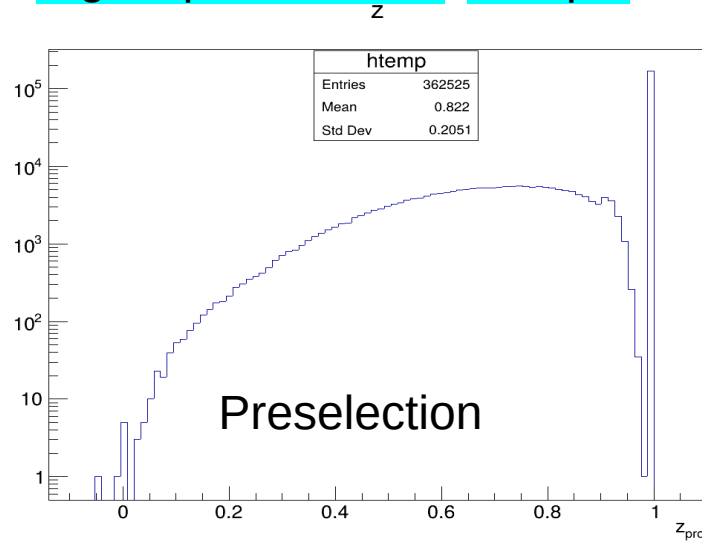


Fragmentation Variable (e+Au)

Signal pairs from D⁰ Sample

e+Au, 9 x100, D⁰ sample, **Biased** DIS sample

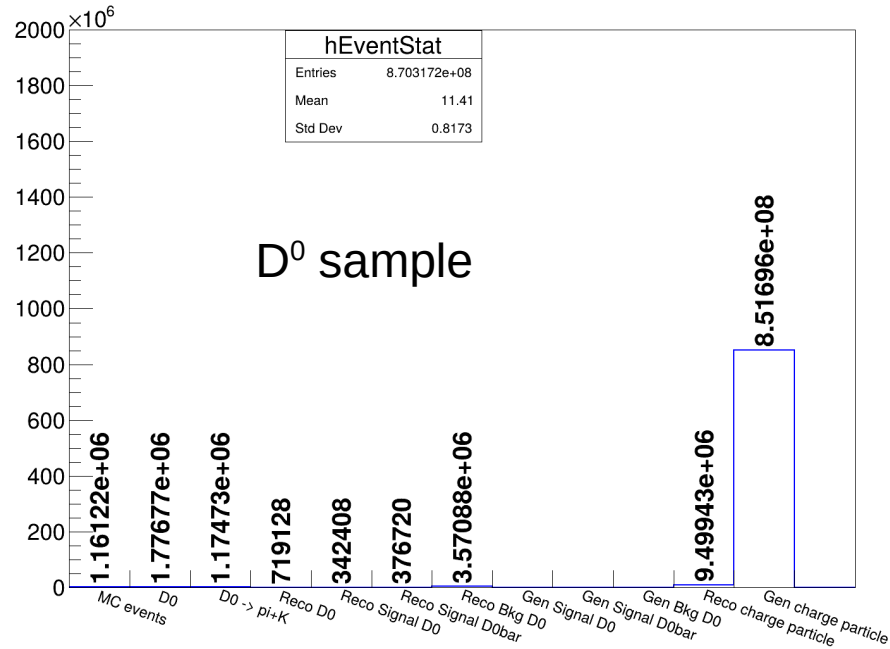
Bkg pairs from DIS



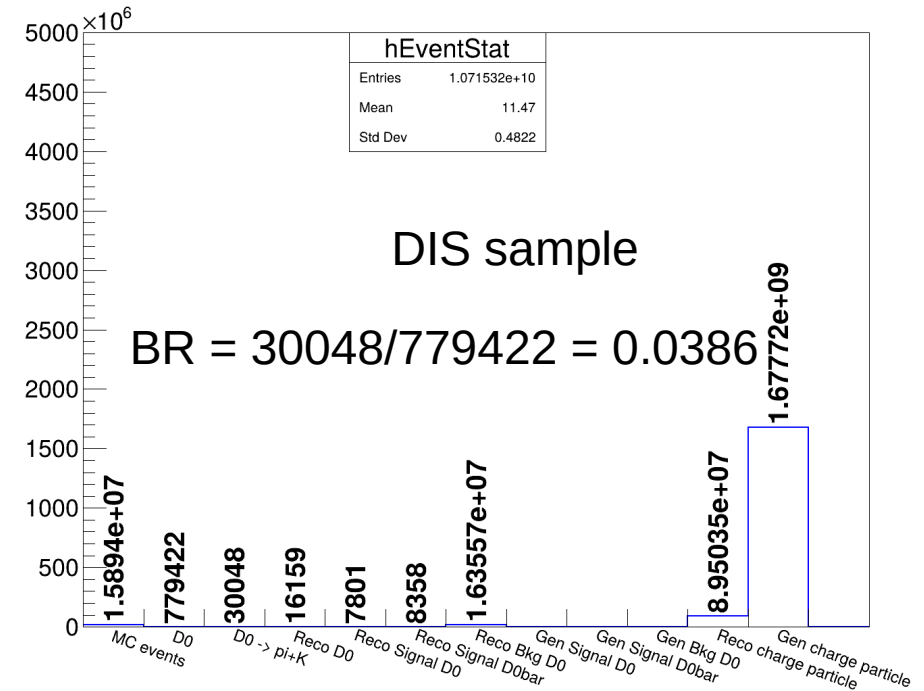
Data Sample

e+p, 9x130 (July Campaign)

Event statistics



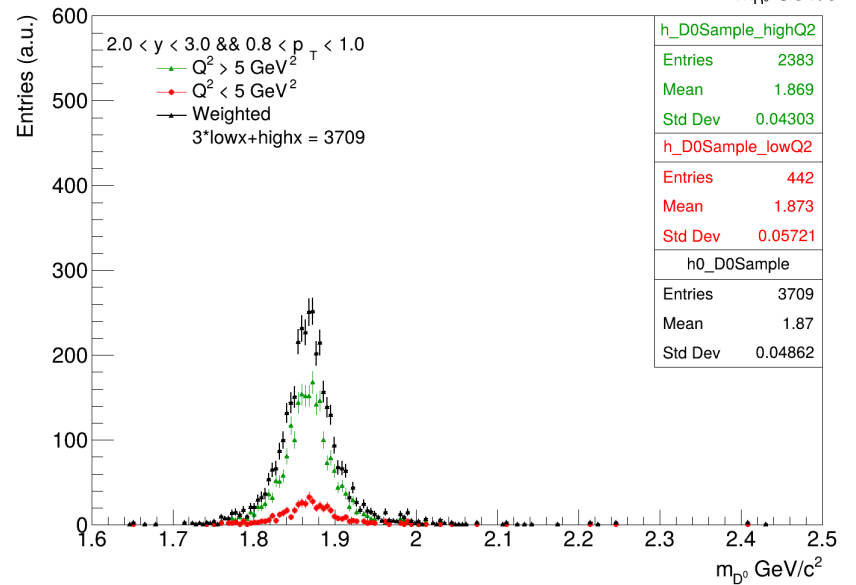
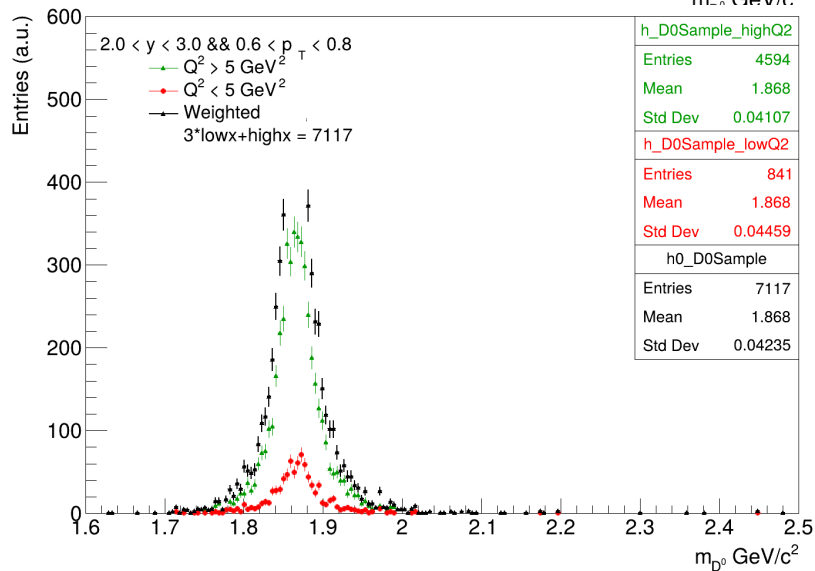
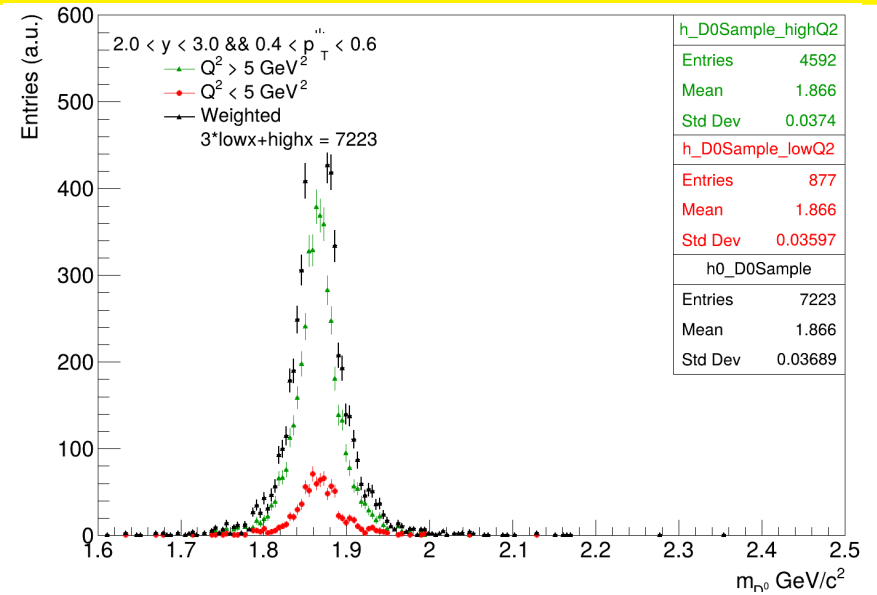
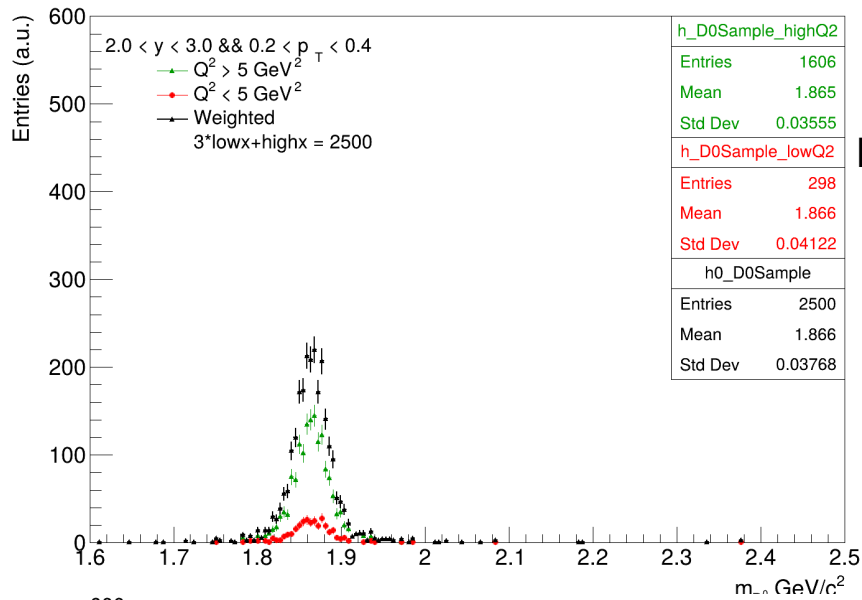
B.R. (PDG): $(3.936 \pm 0.030)\%$
Event statistics



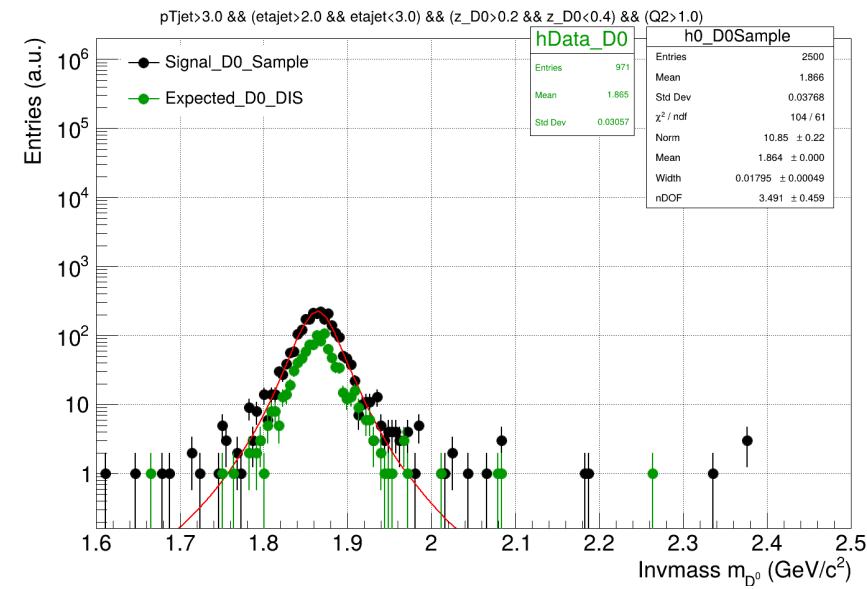
Bin = 0, L_{ES} = 1.0, sigma_MB = 530700000.00 (fb^{-1}), NEvents = 5025761.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 105.595949
 Bin = 1, L_{ES} = 1.0, sigma_MB = 40480000.00 (fb^{-1}), NEvents = 5011401.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 8.077581
 Bin = 2, L_{ES} = 1.0, sigma_MB = 1475000.00 (fb^{-1}), NEvents = 4857399.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 0.303660
 Bin = 3, L_{ES} = 1.0, sigma_MB = 10010.00 (fb^{-1}), NEvents = 981497.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 0.010199

Signal Weighting (e+p)

$L \sim 2.6 \text{ fb}^{-1}$

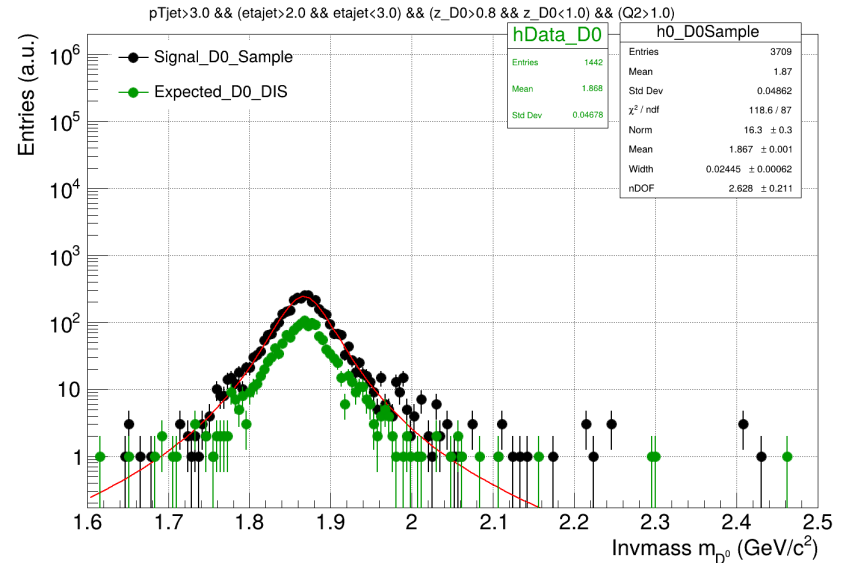
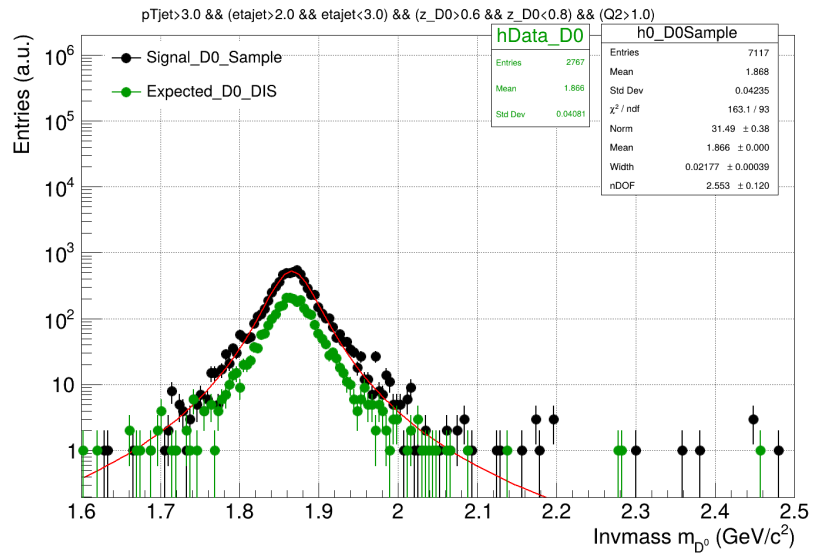
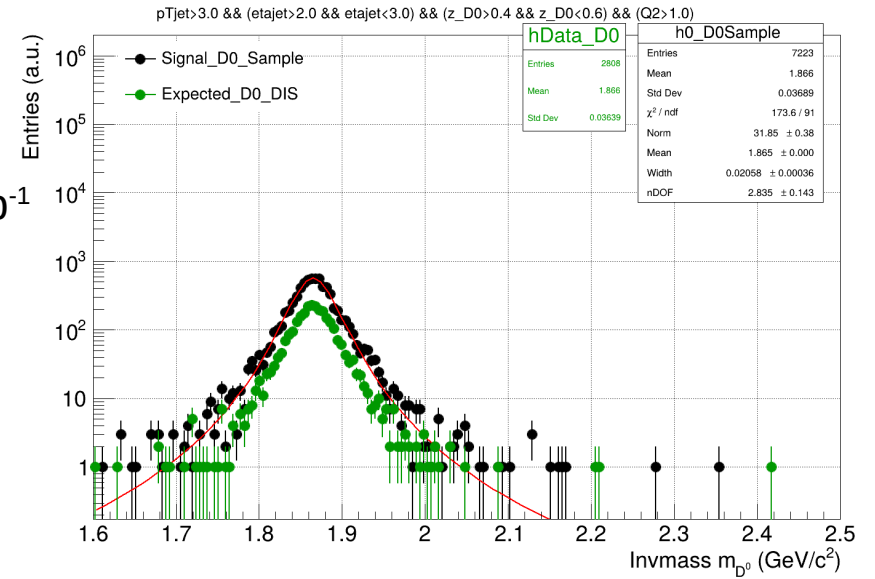


Signal Sampling (e+p)



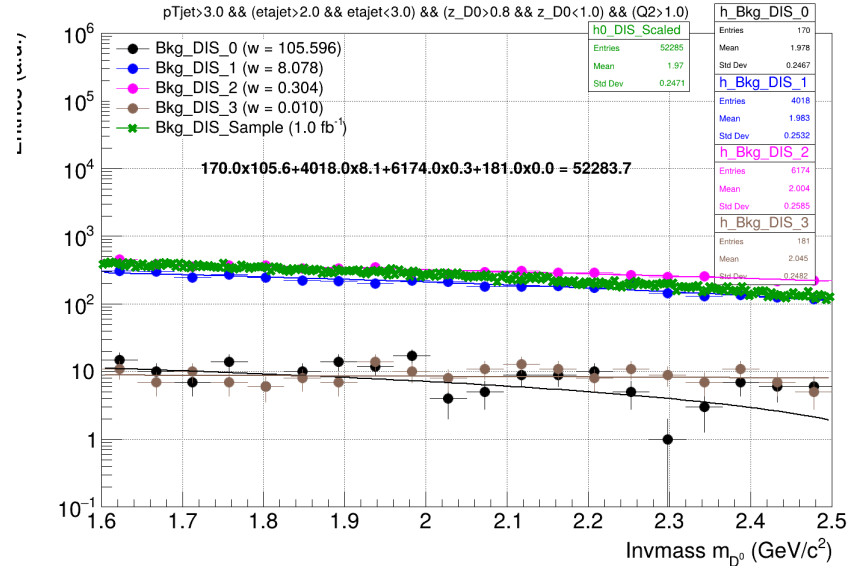
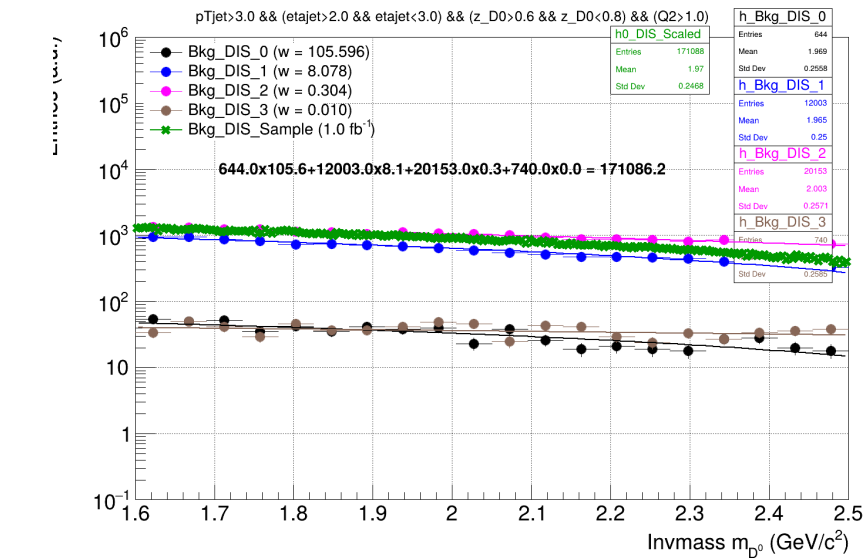
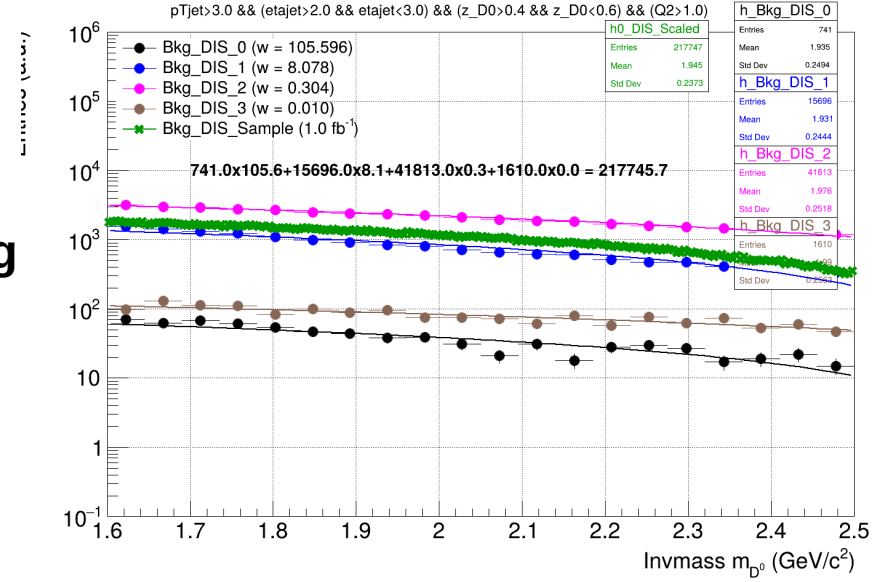
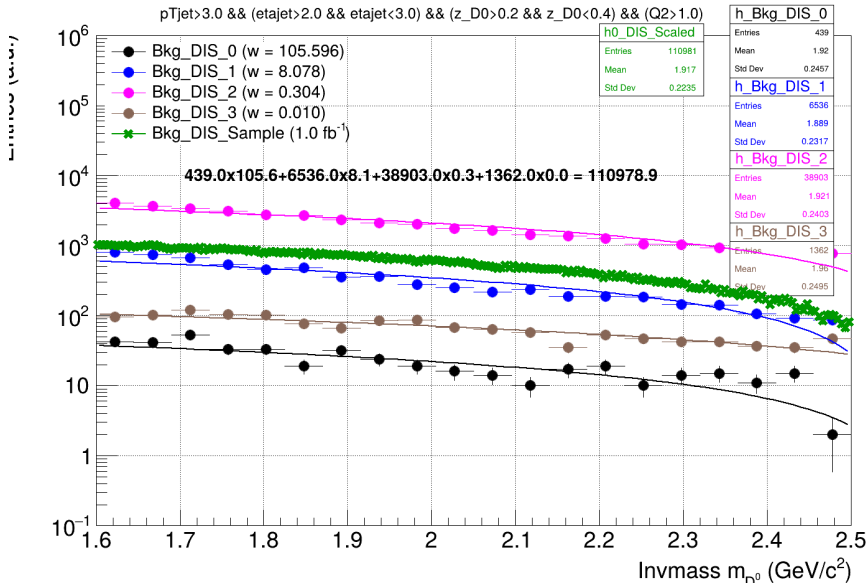
$L_{\text{sim}} \sim 2.6 \text{ fb}^{-1}$

$L_{\text{ES}} \sim 1 \text{ fb}^{-1}$



Background Sample (e+p)

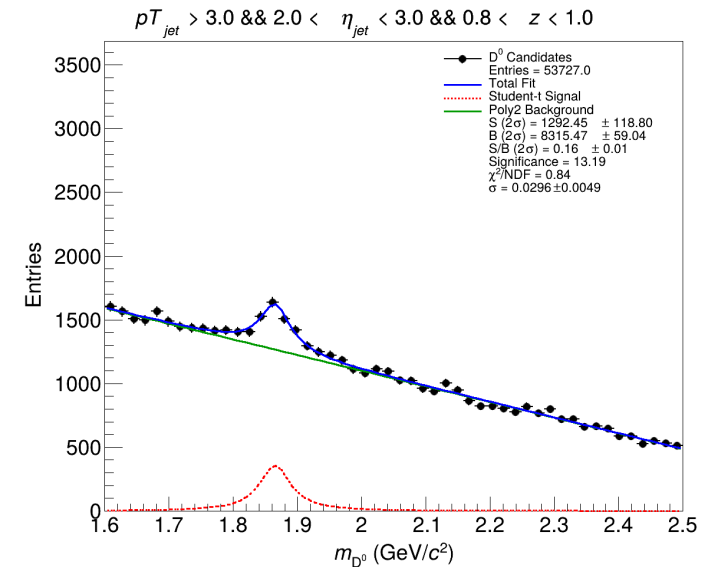
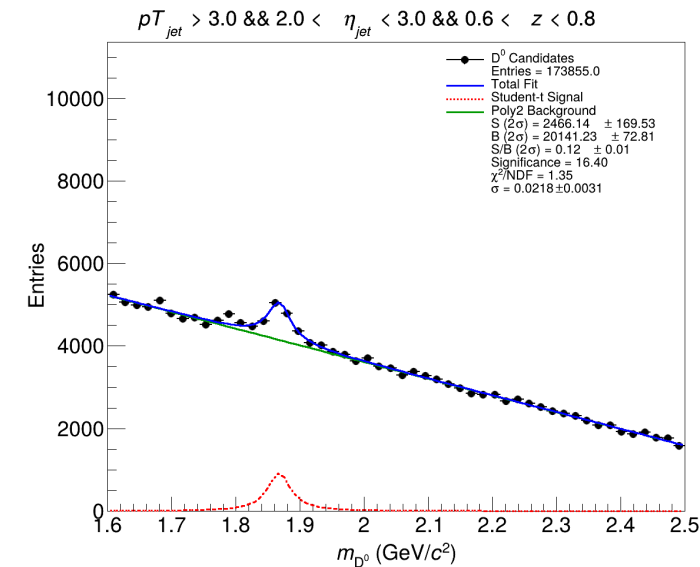
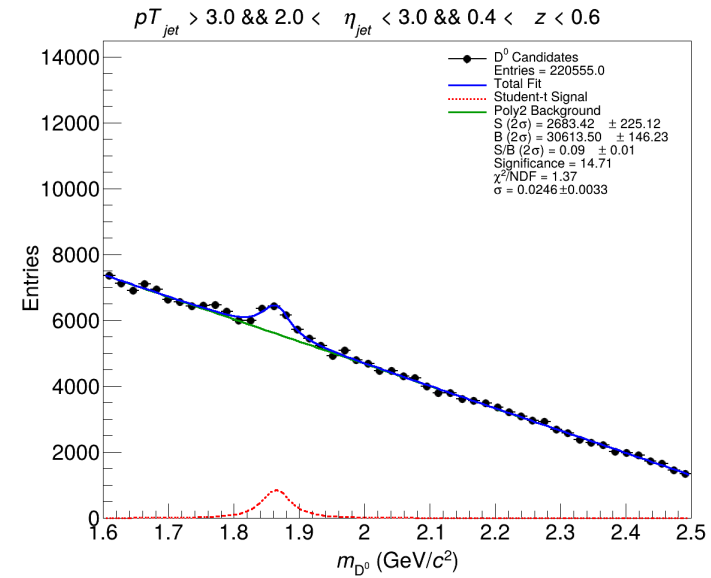
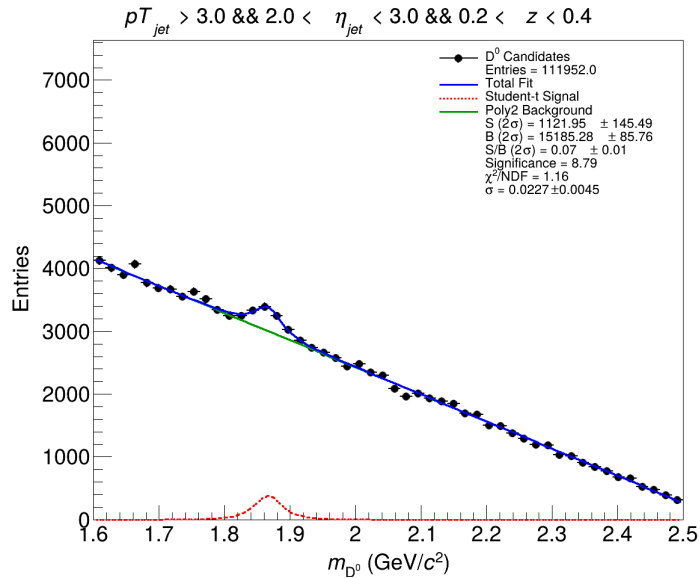
Stitching



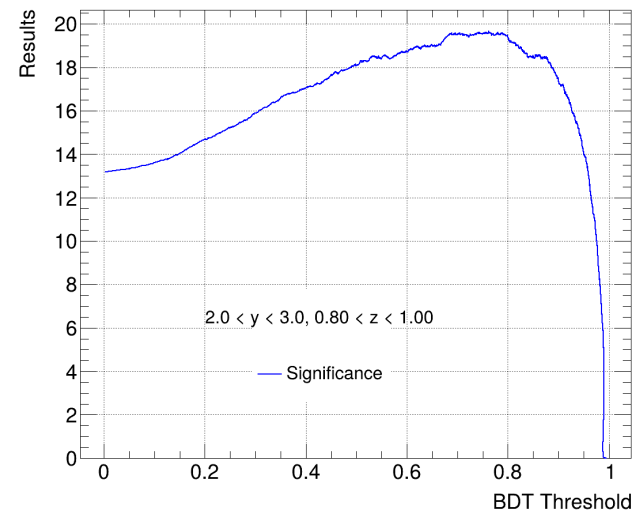
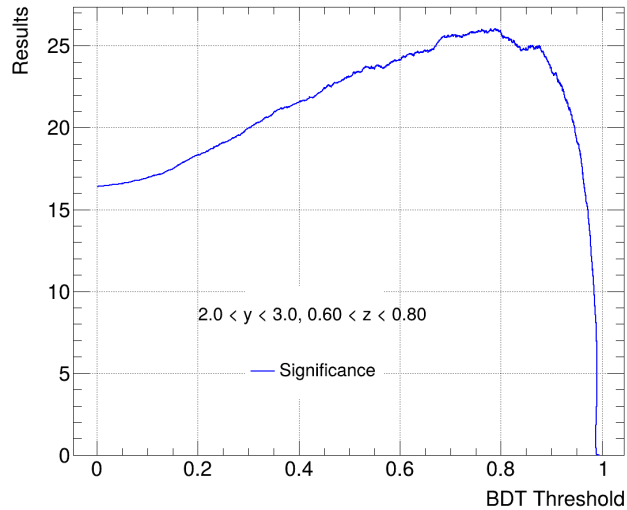
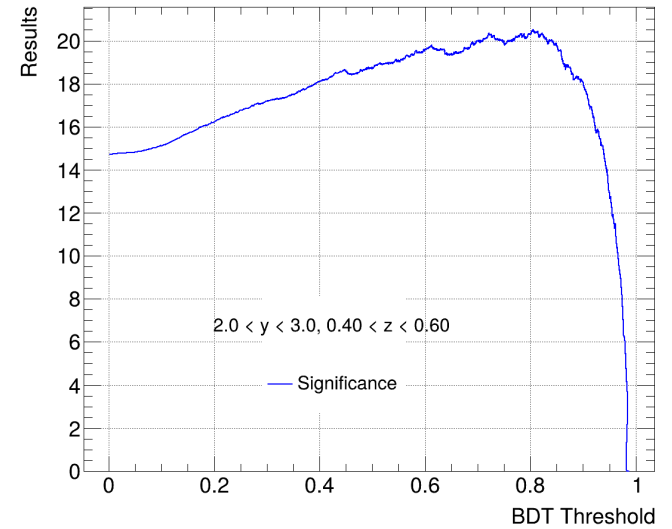
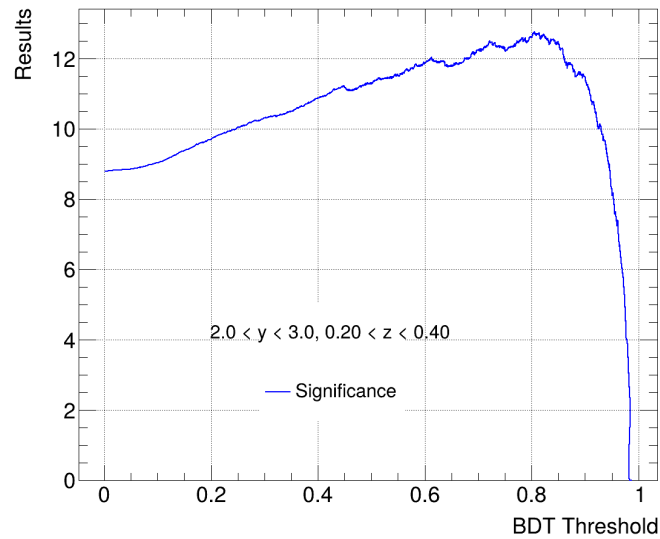
Invariant Mass Spectra (e+p): July Campaign

After PID+ Preselection

$$z = z_{proj} = \frac{\vec{p}_{D^0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$



Machine Learning (e+p)

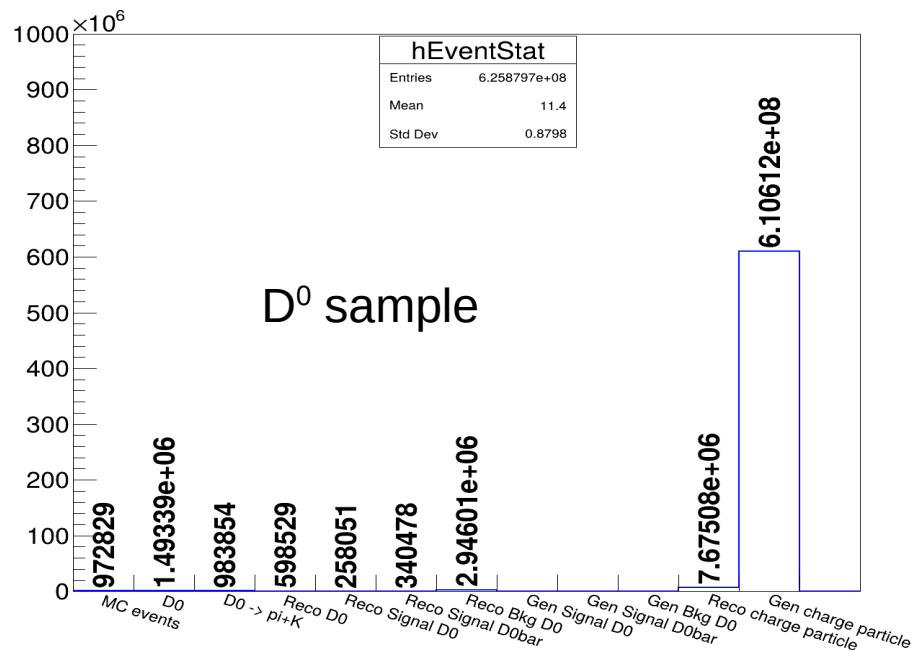


Data Sample

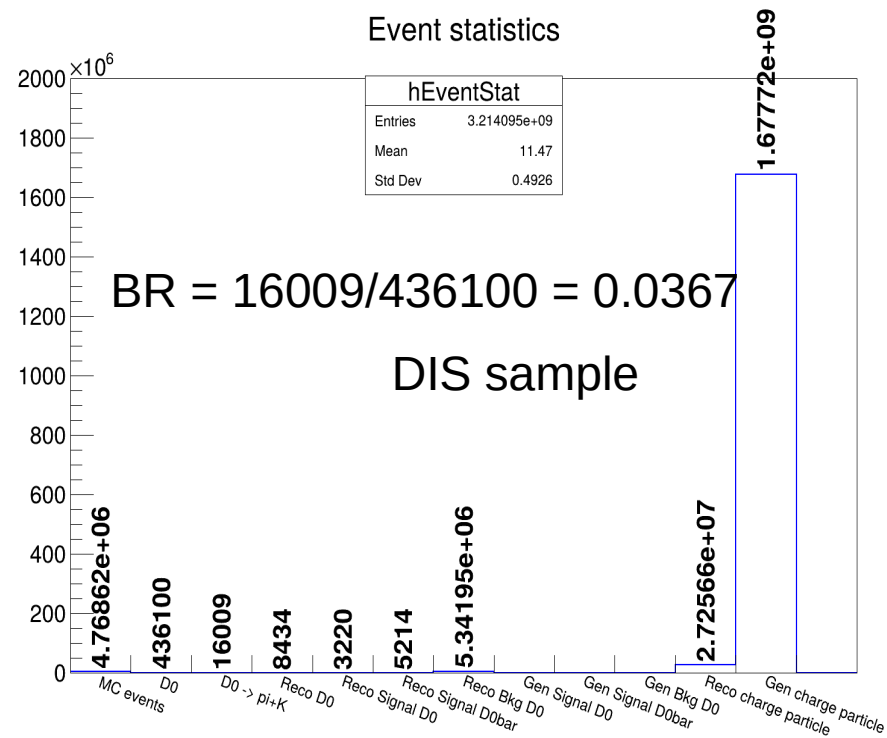
e+Au, 9x100 (July Campaign)

B.R. (PDG): $(3.936 \pm 0.030)\%$

Event statistics

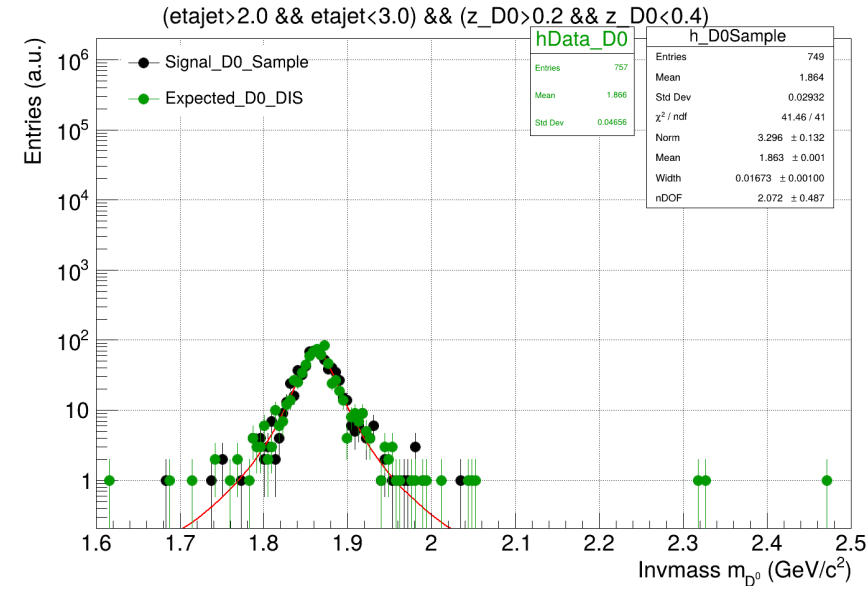


Event statistics



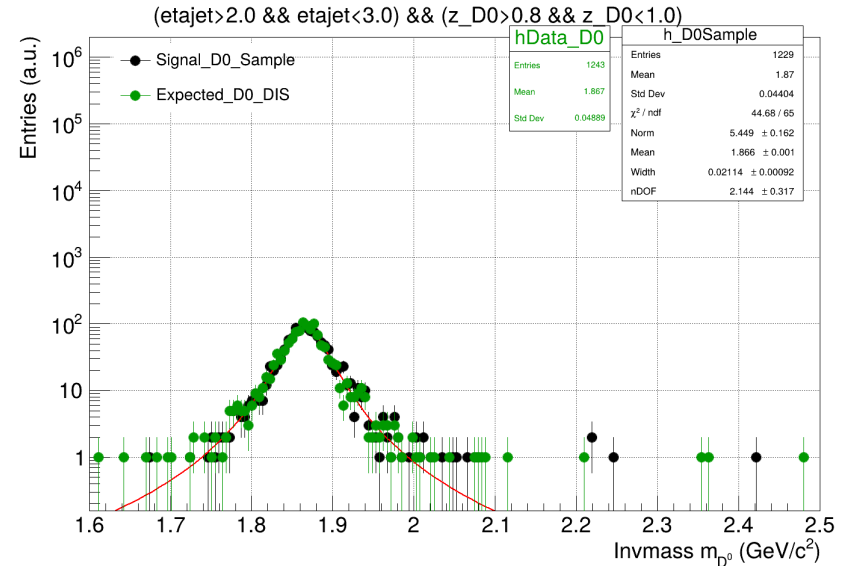
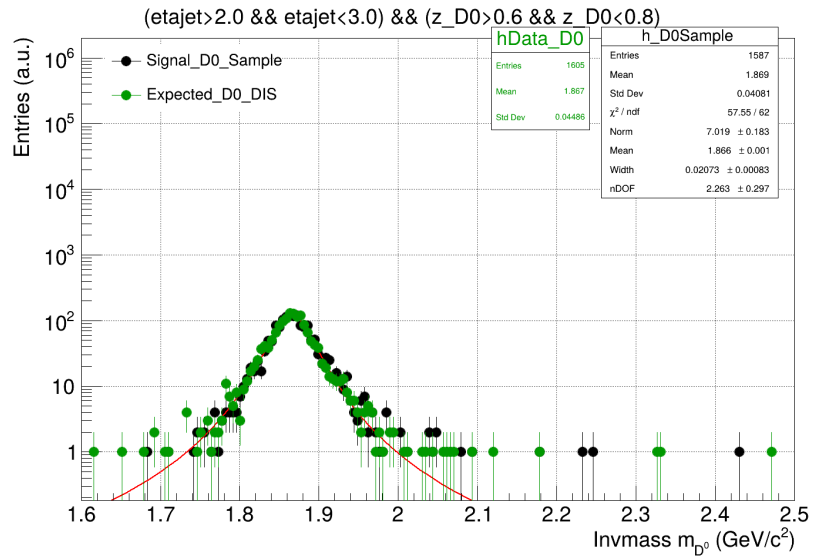
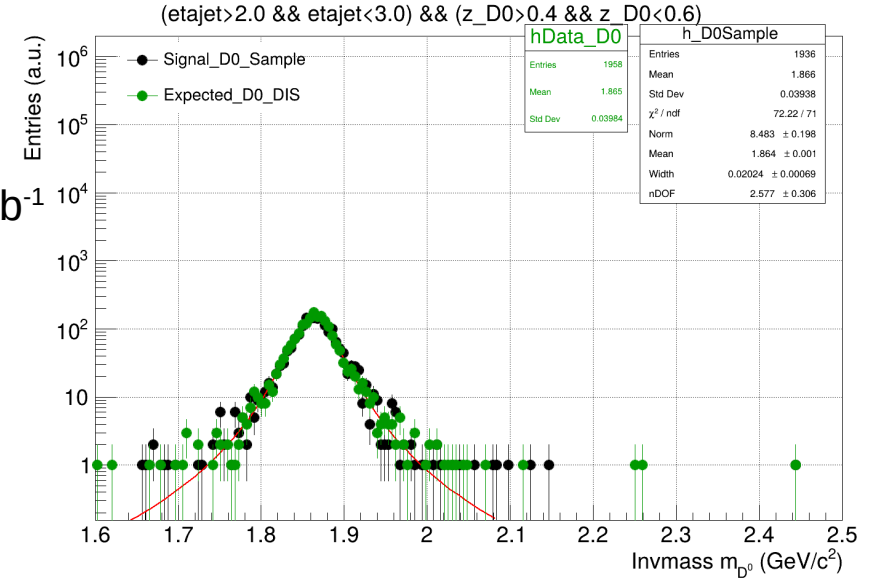
Bin = 0, L_{ES} = 1.0, sigma_MB = 338500000.00 (fb^{-1}), NEvents = 5025761.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 67.352984
 Bin = 1, L_{ES} = 1.0, sigma_MB = 334000000.00 (fb^{-1}), NEvents = 5011401.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 6.664803
 Bin = 2, L_{ES} = 1.0, sigma_MB = 986700.00 (fb^{-1}), NEvents = 4857399.0, Weight factor (L_{ES}*sigma_MB/NEvents) = 0.203133

Signal Sampling (e+Au)



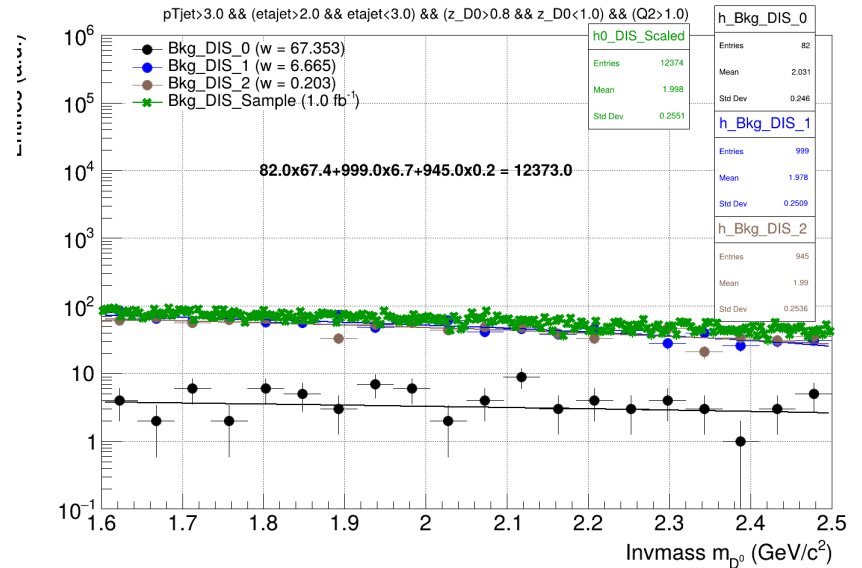
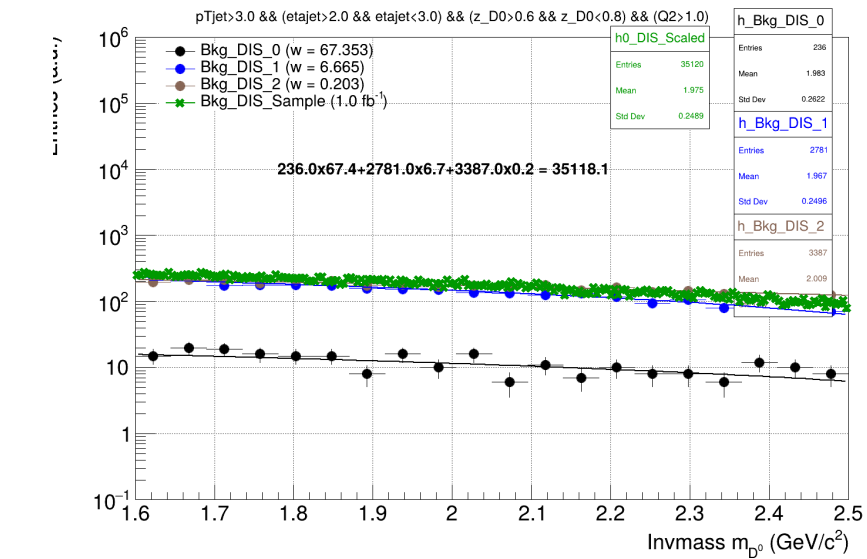
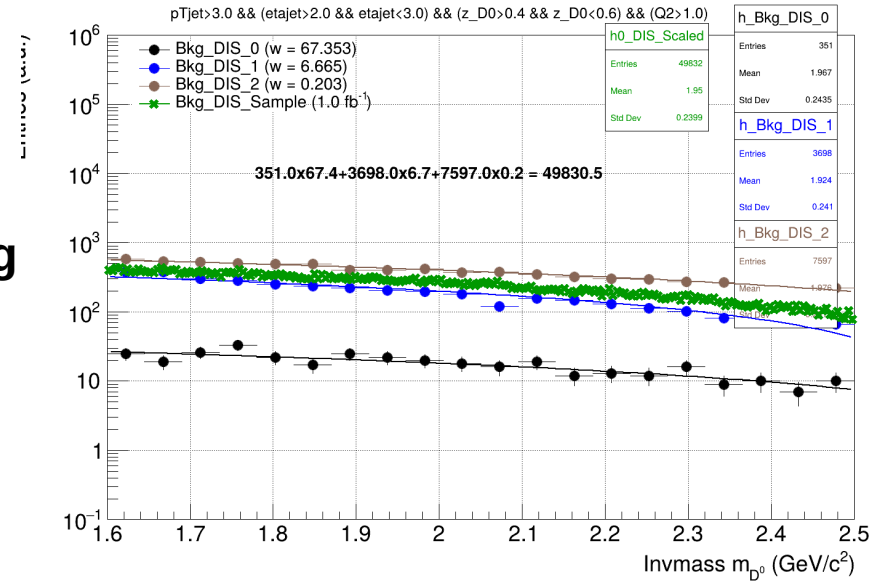
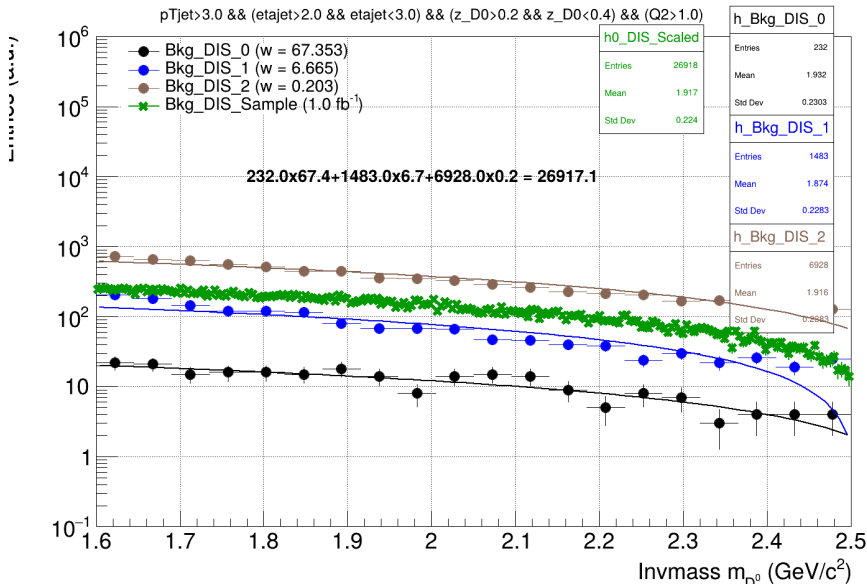
$$L_{\text{sim}} \sim 1.06 \text{ fb}^{-1}$$

$$L_{\text{ES}} \sim 1 \text{ fb}^{-1}$$



Background Sample (e+Au)

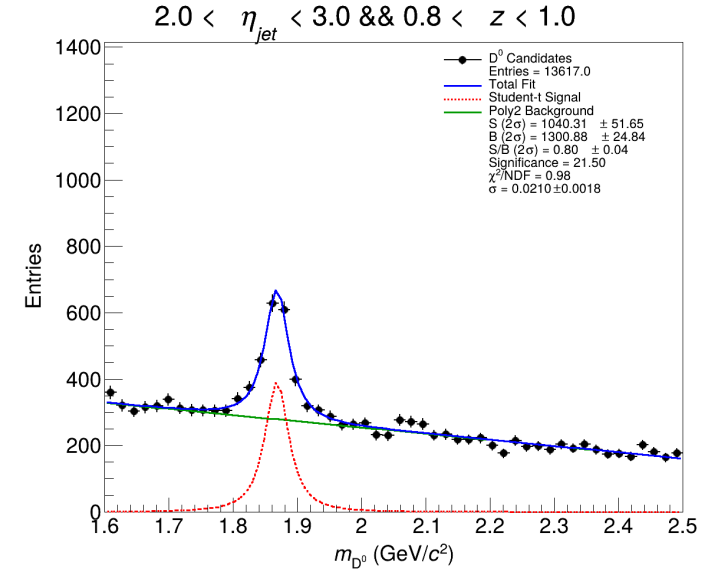
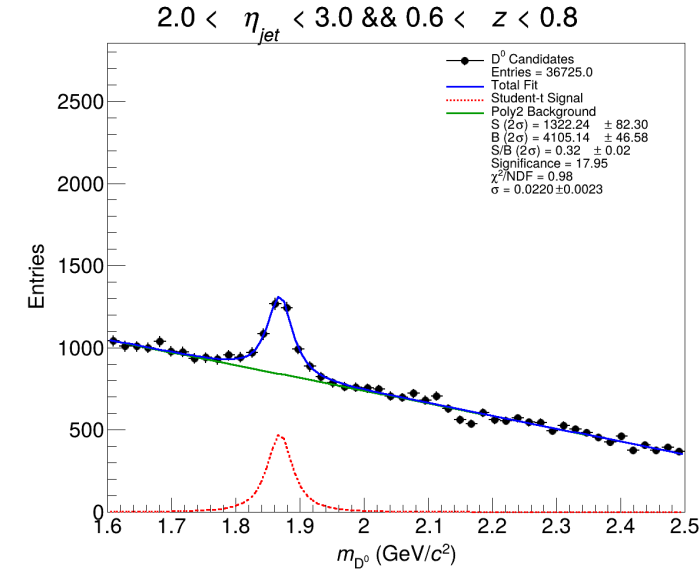
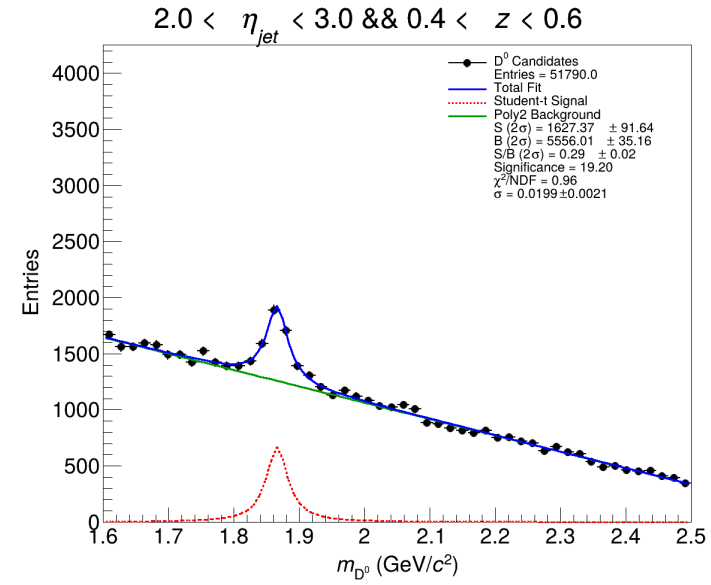
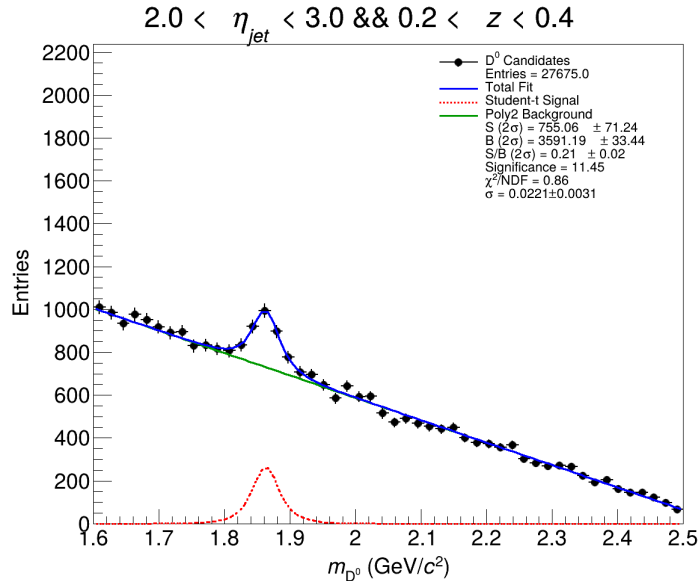
Stitching



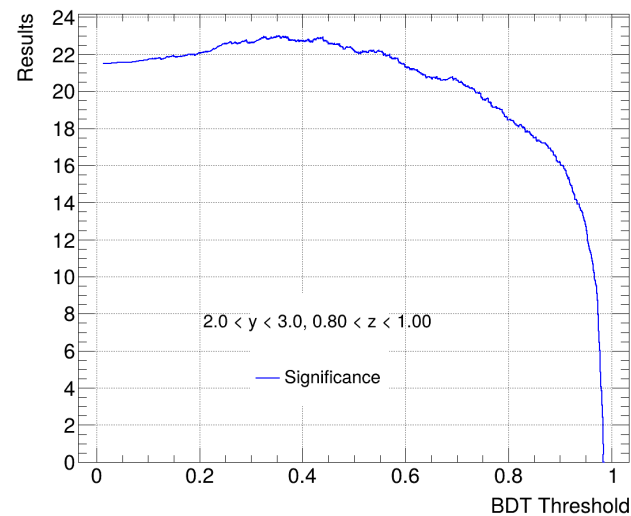
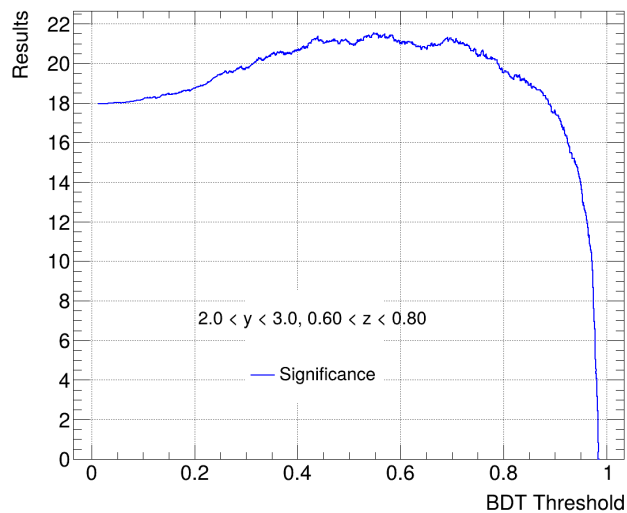
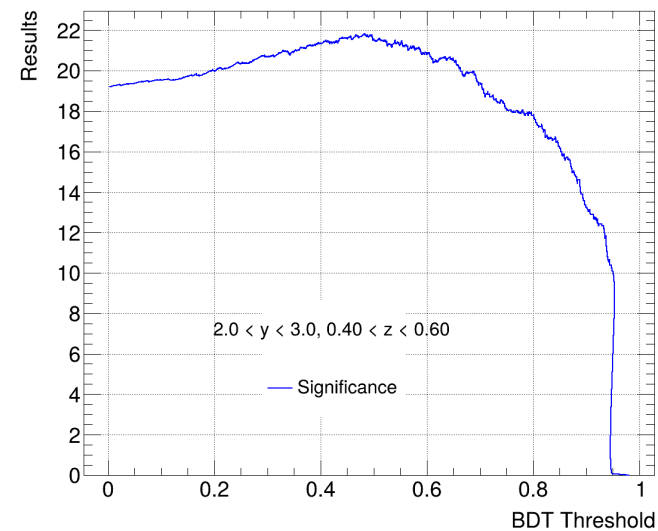
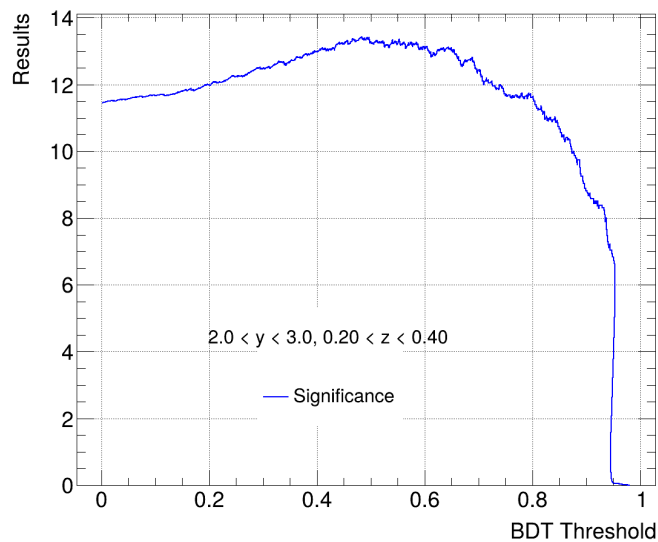
Invariant Mass Spectra (e+Au): July Campaign

After PID+ Preselection

$$z = z_{proj} = \frac{\vec{p}_{D^0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$

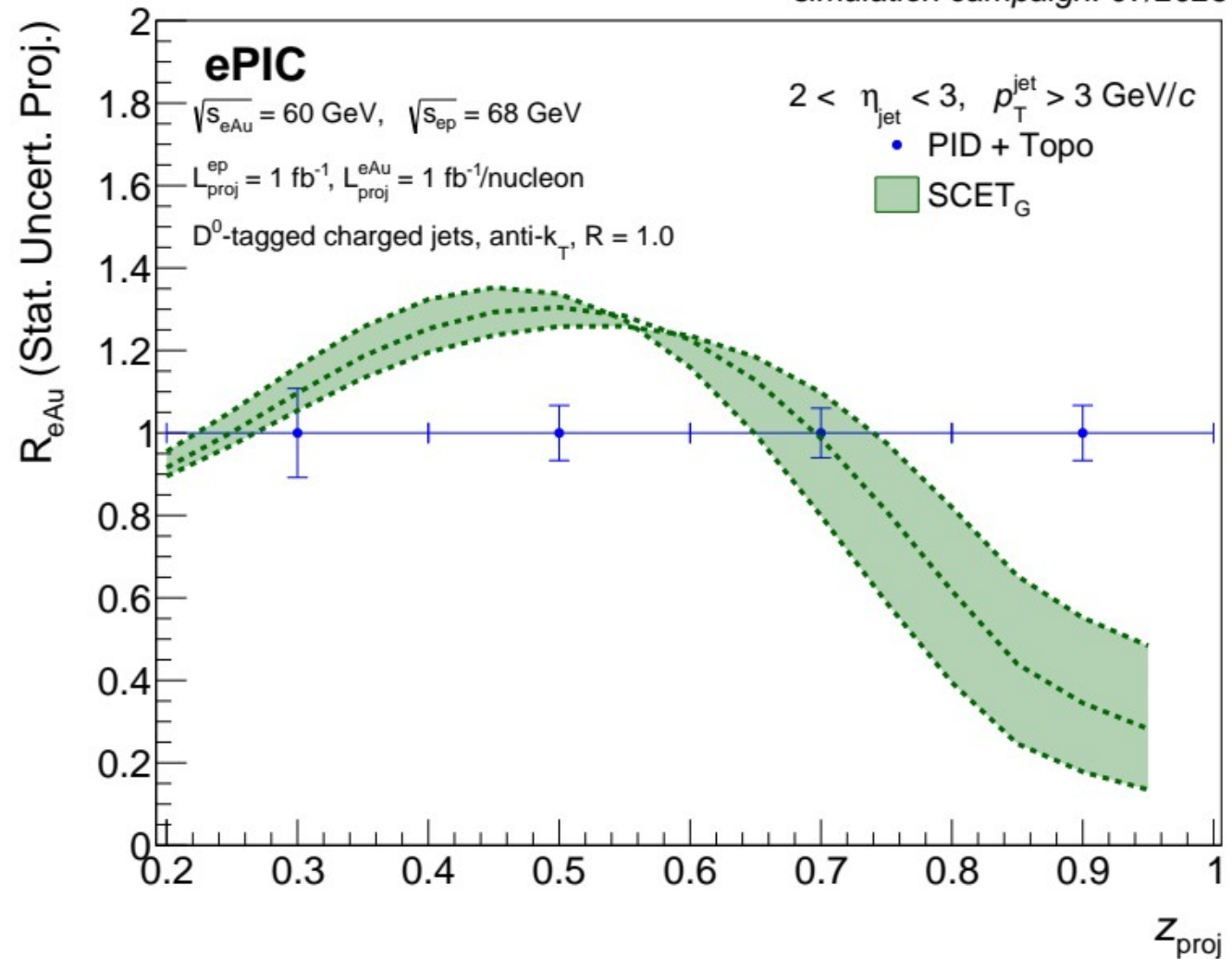


Machine Learning (e+Au)



Nuclear Modification Factor (R_{eAu})

simulation campaign: 07/2026



After PID+ Preselection + ML

Hai Tao Li, Ze Long Liu, Ivan Vitev, Physics Letters B 816 (2021) 136261

Summary and Future Plan

- R_{eAu} vs z_{proj} is ready for ES Report
- Next to produce Λ_c/D^0 ratio plot

Thank you for your attention!