

Heavy-flavor studies for Early Science (ES)

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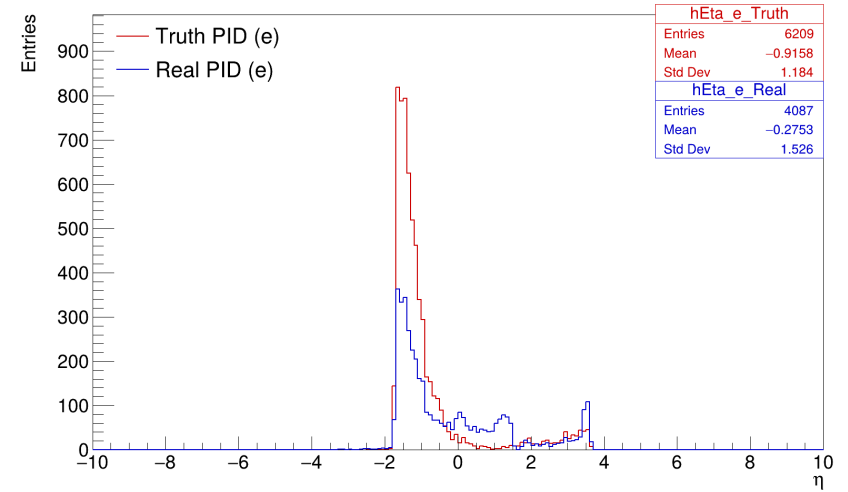
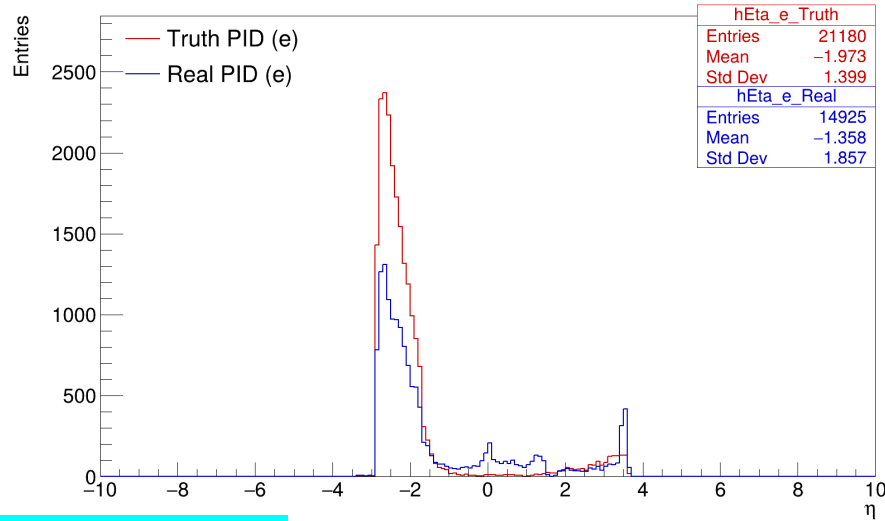


Charged Particles η distributions (e+Au)

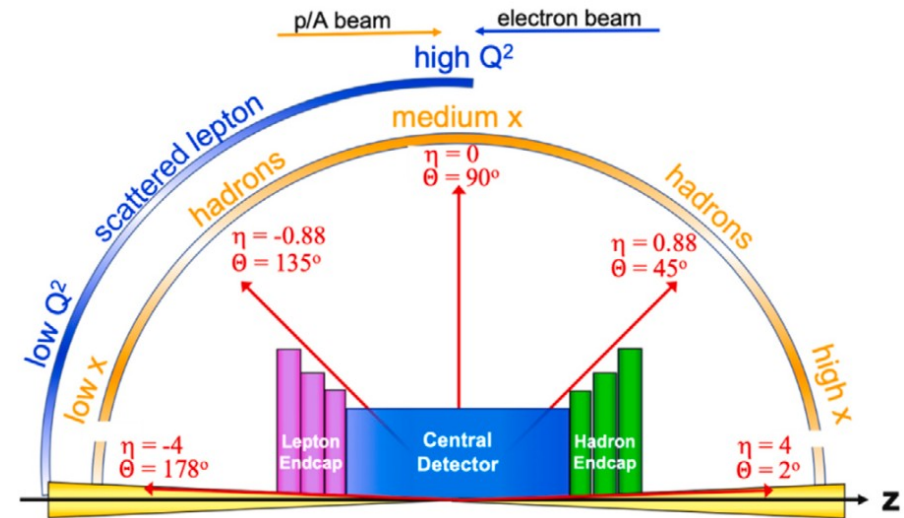
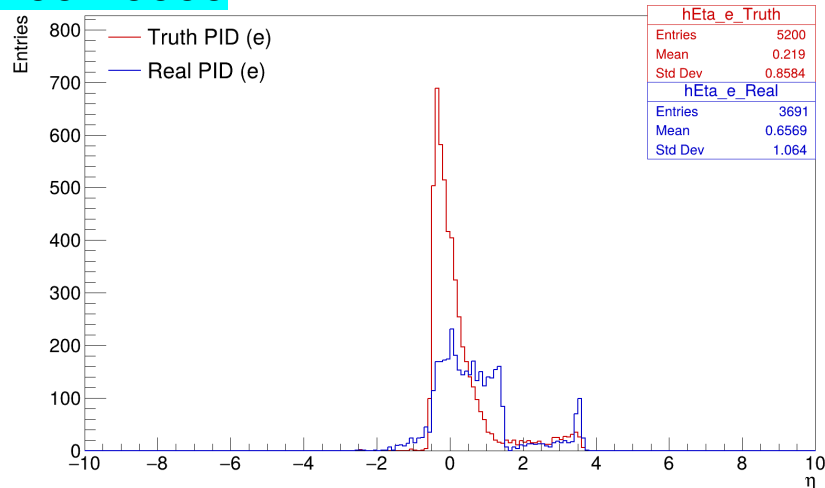
Q2:1-10

e+Au, 9x100, Biased DIS sample

Q2:10-100



Q2:100-10000

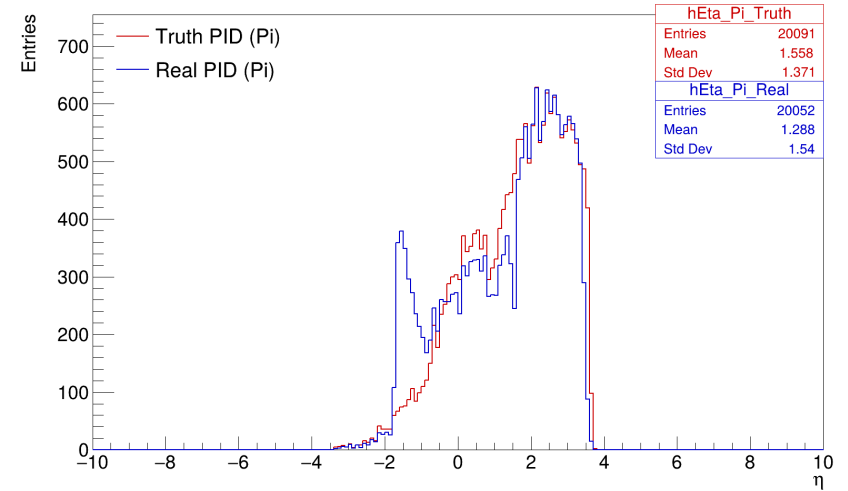
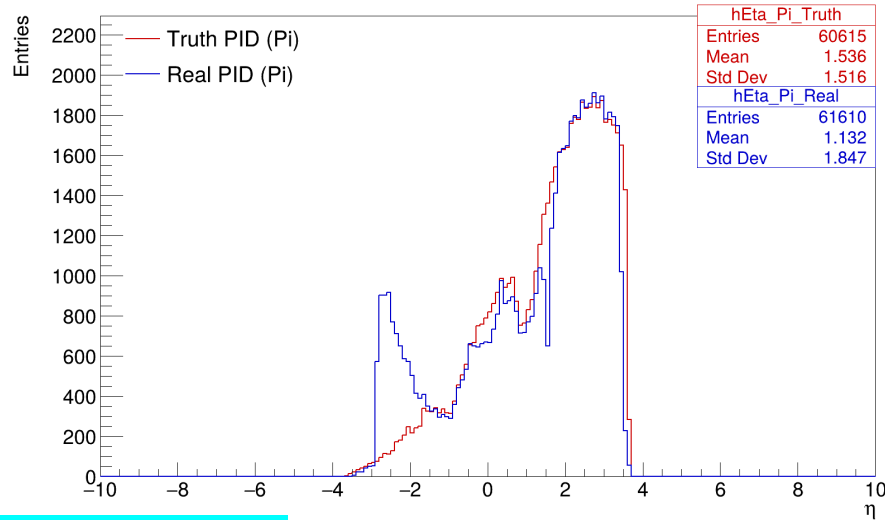


Charged Particles η distributions (e+Au)

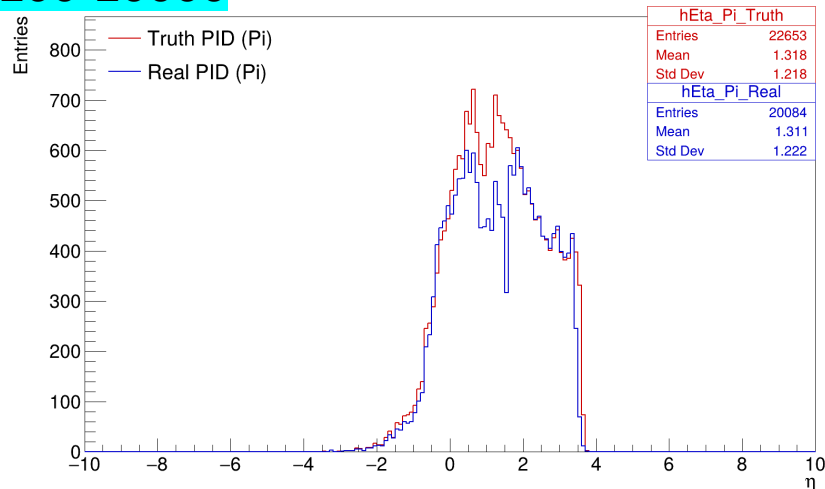
Q2:1-10

e+Au, 9x100, Biased DIS sample

Q2:10-100



Q2:100-10000



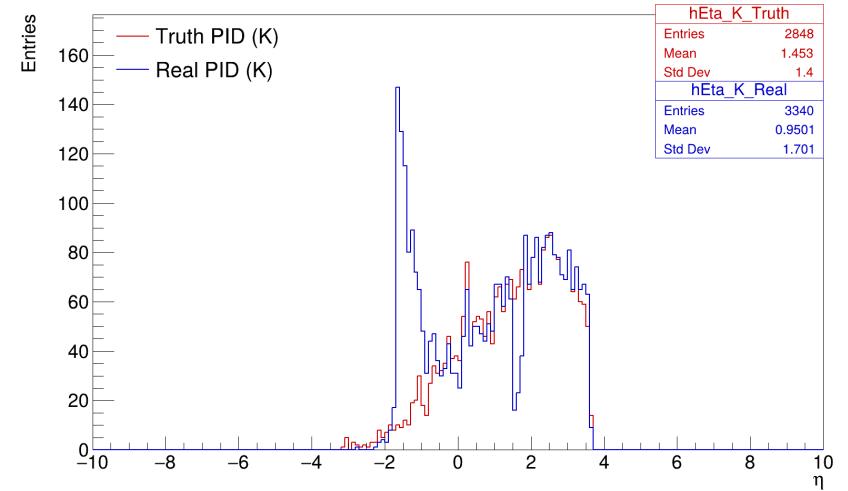
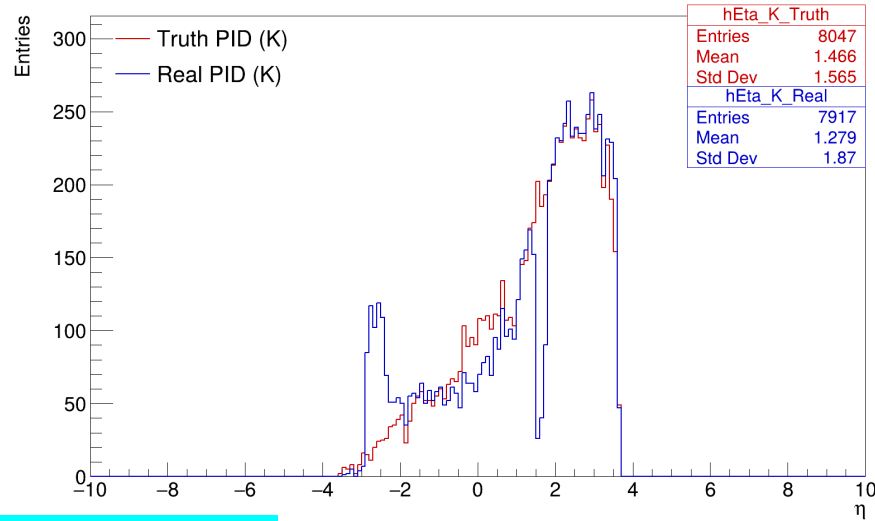
Moving toward the barrel region: Improvement in PID due to available TOF+DIRC

Charged Particles η distributions (e+Au)

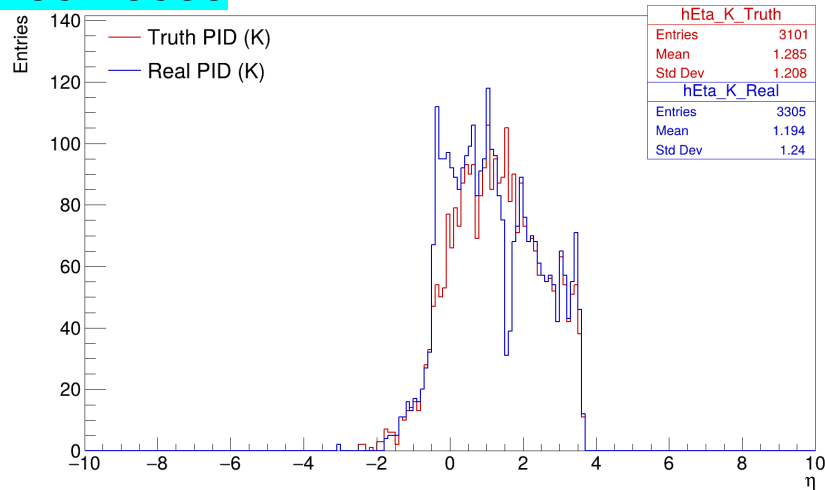
Q2:1-10

e+Au, 9x100, Biased DIS sample

Q2:10-100



Q2:100-10000

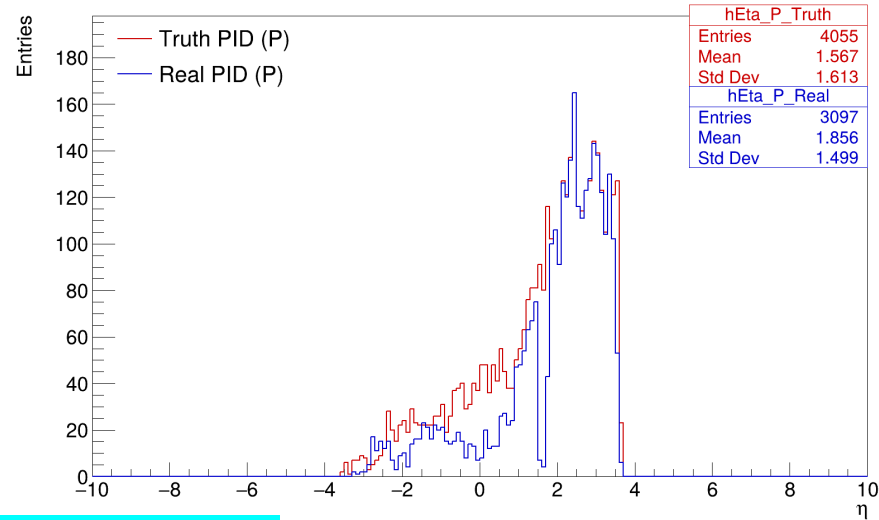


Moving toward the barrel region: Improvement in PID due to available TOF+DIRC

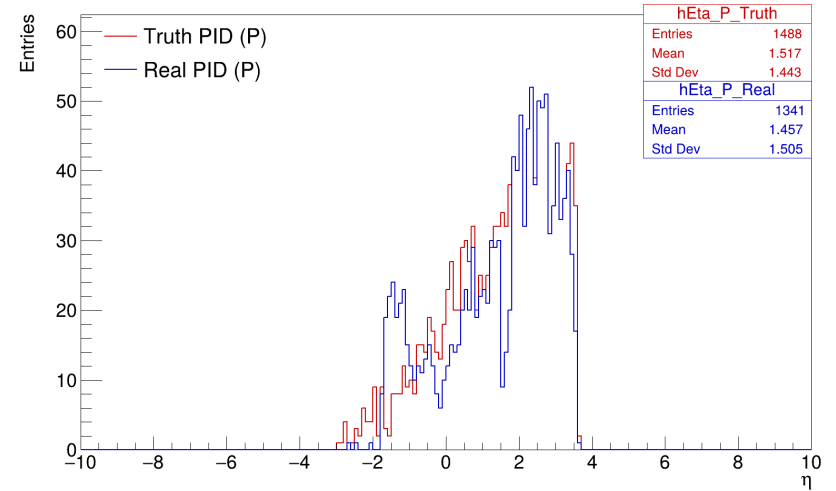
Charged Particles η distributions (e+Au)

e+Au, 9x100, Biased DIS sample

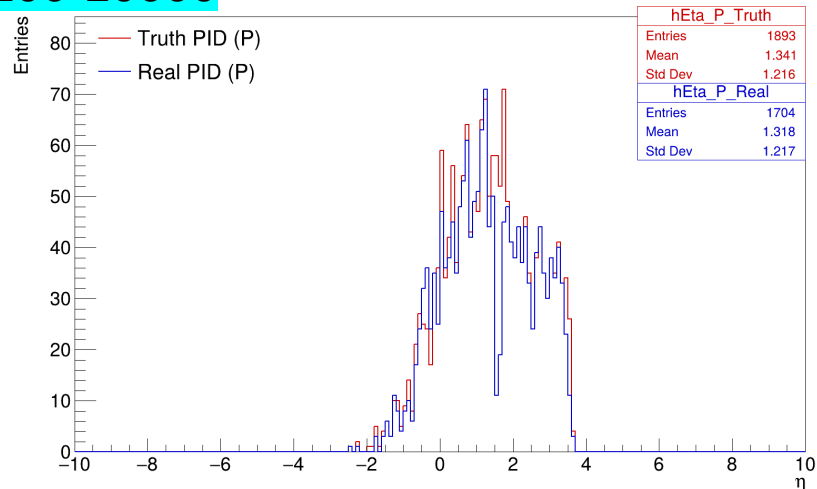
Q2:1-10



Q2:10-100



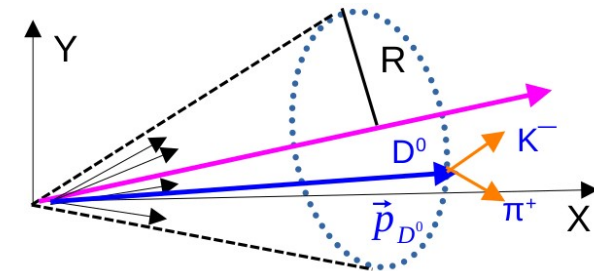
Q2:100-10000



Moving toward the barrel region: Improvement in PID due to available TOF+DIRC

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**

Current scaling factor

$$f_i = \frac{\sigma_i}{\sigma(Q^2 > 1)}$$

Cross section in different Q^2 bins

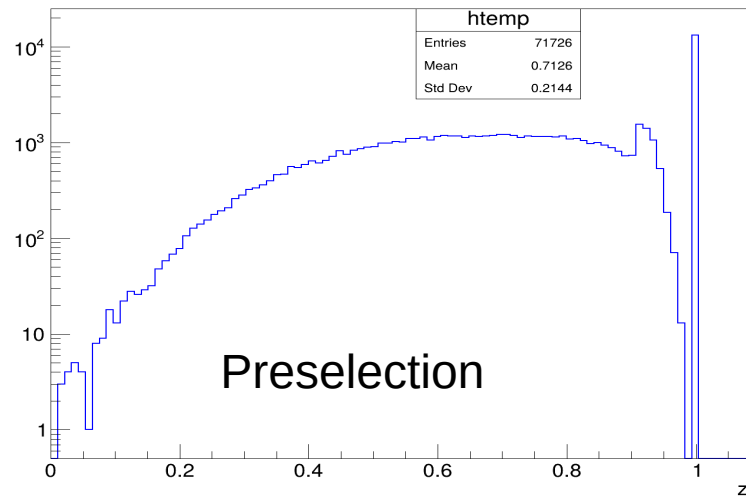
Event generator and energy	$Q^2 > 1$	$1 < Q^2 < 10$	$10 < Q^2 < 100$	$1e2 < Q^2 < 1e3$	$1e3 < Q^2 < 1e4$
PYTHIA 8.316, 9x130	5.719e5 pb	5.307e5 pb	4.048e4 pb	1.475e3 pb	1.001e1 pb

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

Fragmentation Variable (e+p)

Signal pairs from D^0 Sample

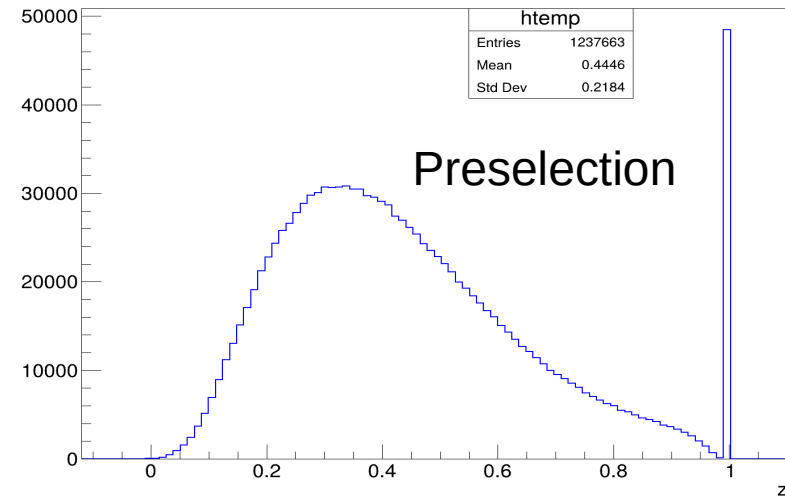
$z \{p_{Tjet} > 3\}$



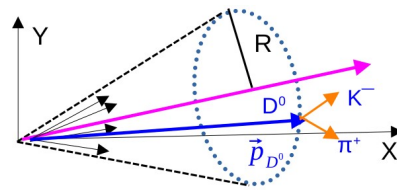
e+p, 9 x130, D^0 sample, **Biased** DIS sample

Bkg pairs from DIS

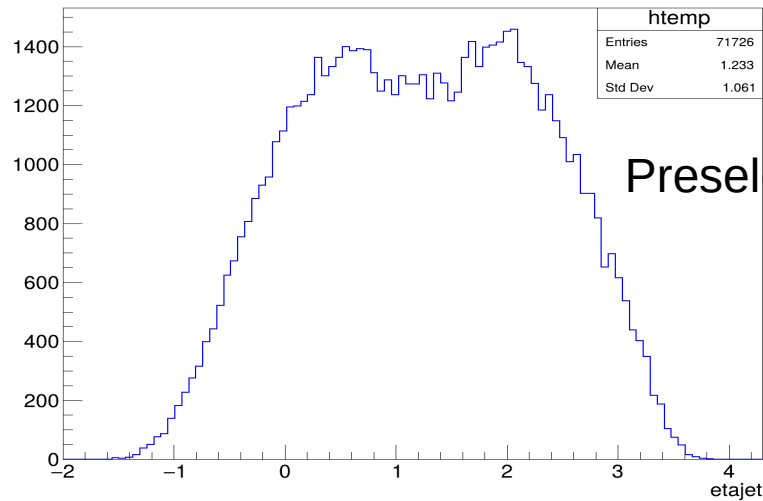
$z \{p_{Tjet} > 3\}$



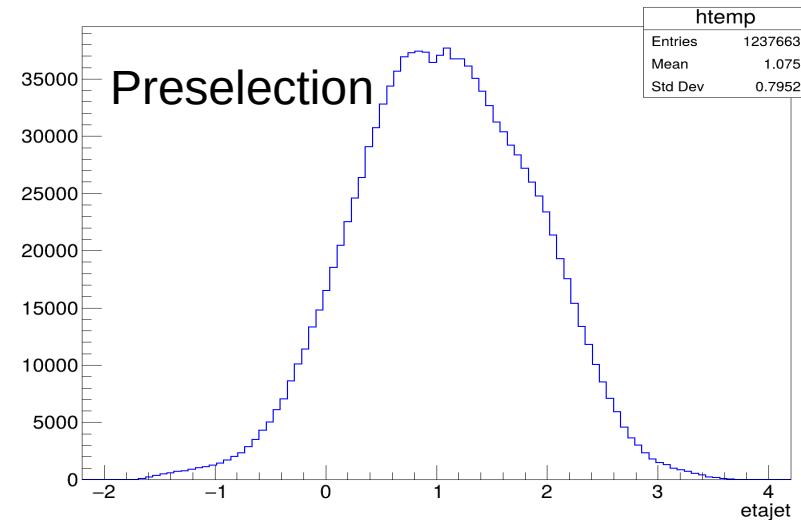
Anti- k_T , $R = 1$,
 $p_{Tjet} > 3 \text{ GeV}/c$



$$z = z_{proj} = \frac{\vec{p}_{D0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$

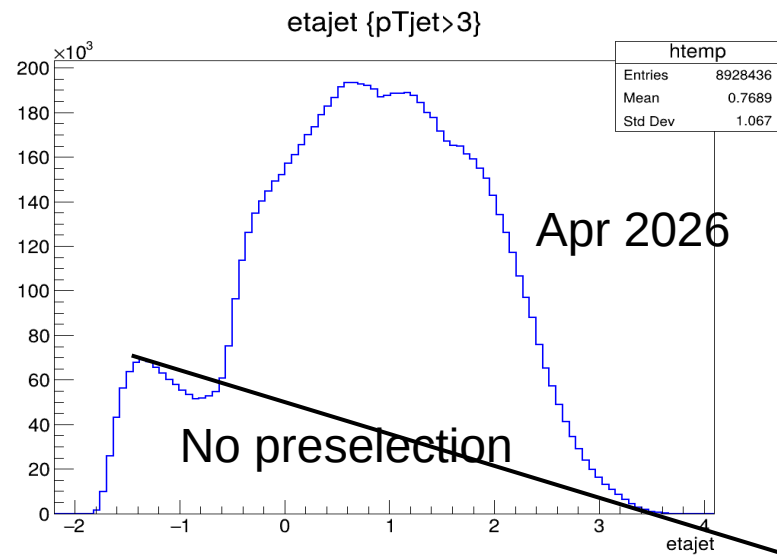


Preselection



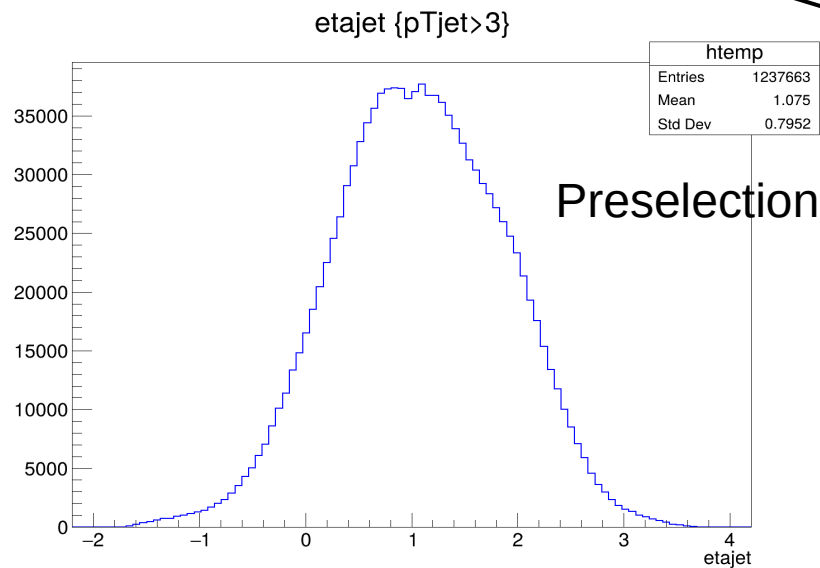
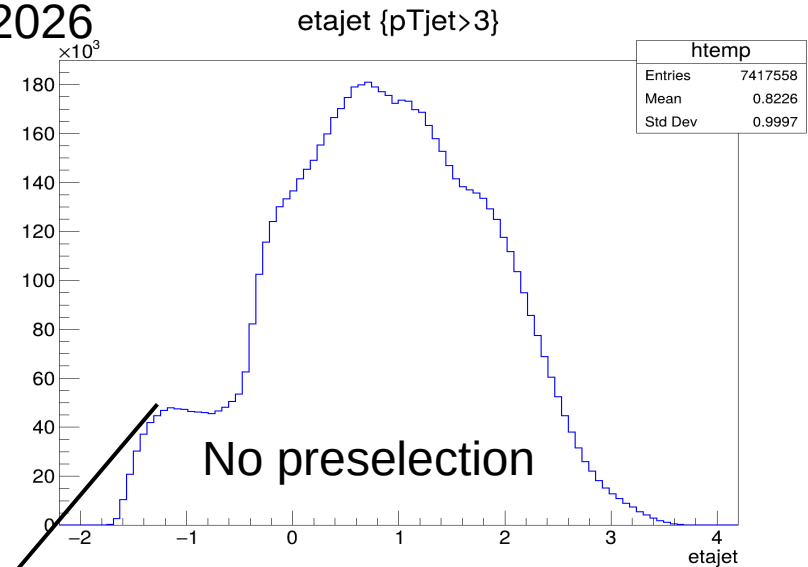
Preselection

Fragmentation Variable (e+p)



Bkg η distribution
(e+p, DIS Sample)

Jul 2026



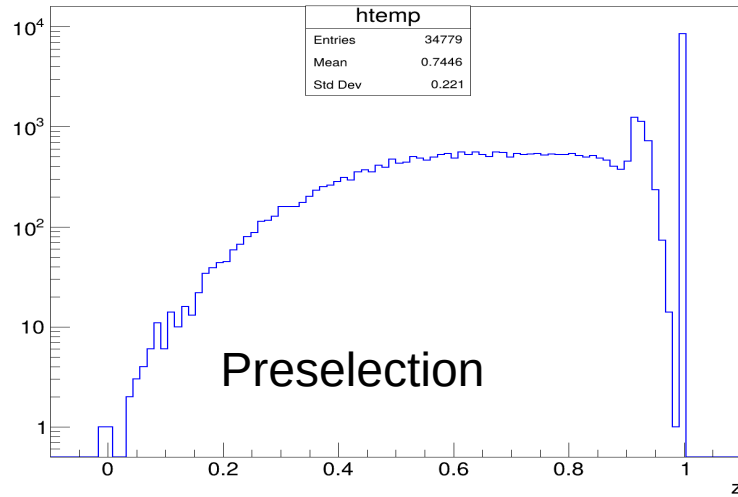
electron misidentification
with pion/kaon

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

Fragmentation Variable (e+Au)

Signal pairs from D^0 Sample

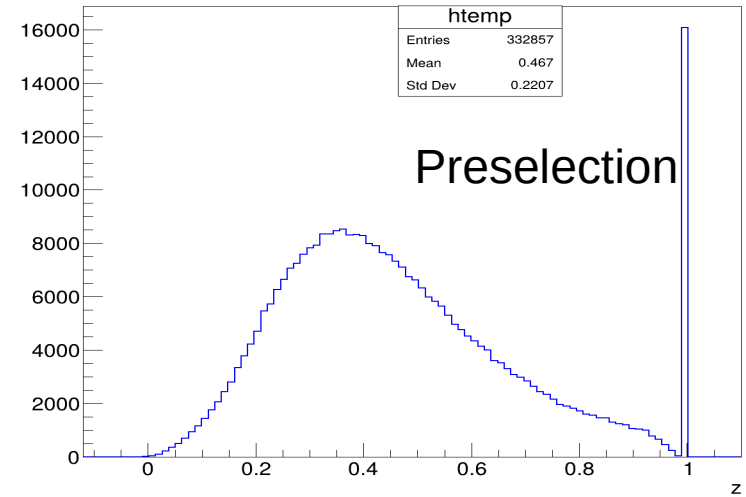
$z \{p_{Tjet} > 3\}$



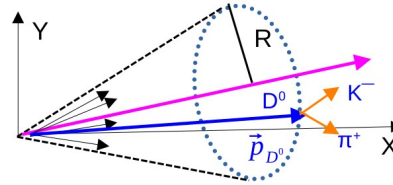
e+Au, 9 x100, D^0 sample, **Biased** DIS sample

Bkg pairs from DIS

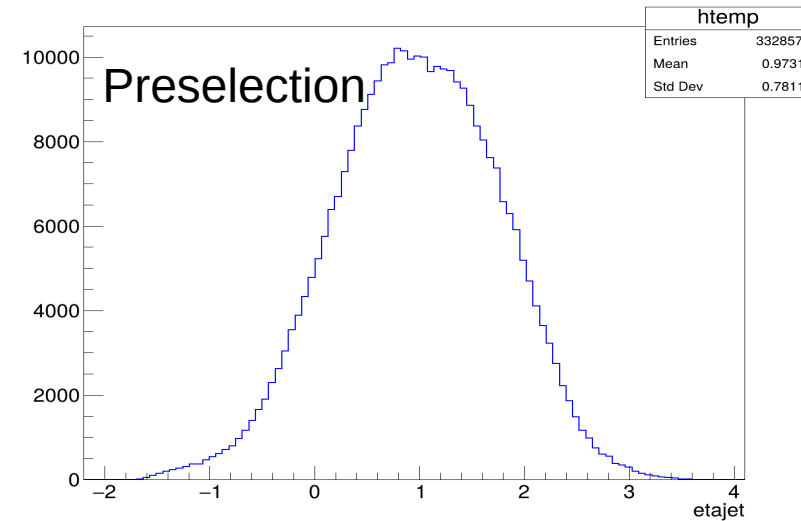
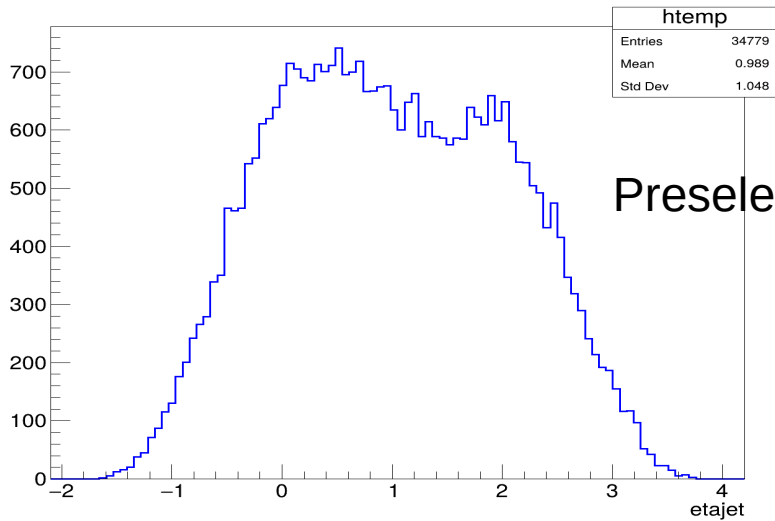
$z \{p_{Tjet} > 3\}$



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



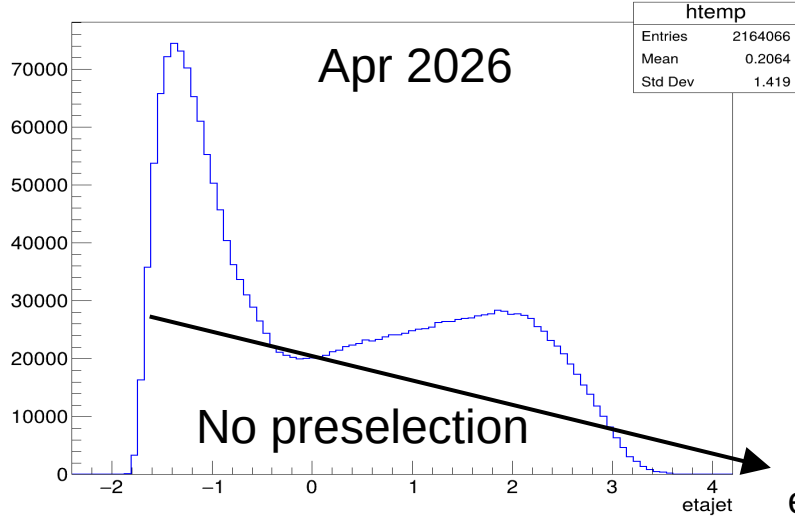
$$z = z_{proj} = \frac{\vec{p}_{D^0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$



Fragmentation Variable (e+Au)

etajet {pTjet>3}

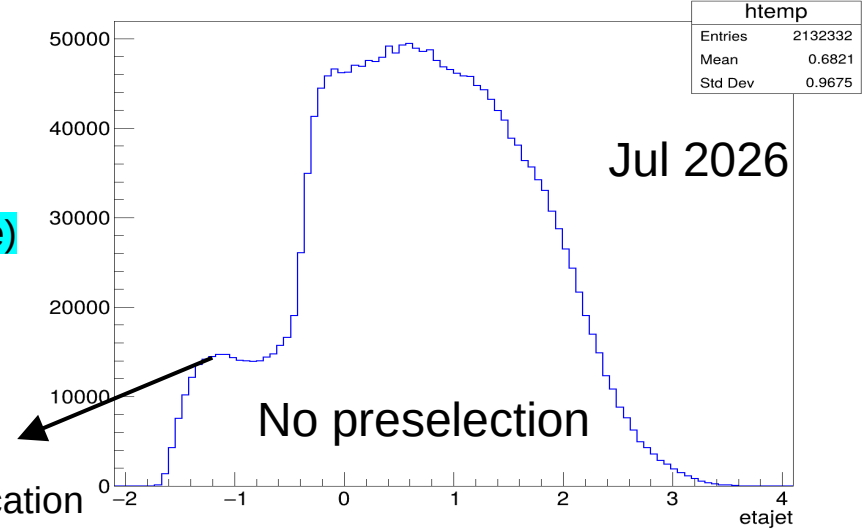
Apr 2026



etajet {pTjet>3 && (mass_D0 > 1.6 && mass_D0 < 2.5) && d0xy_pi<100. && d0xy_k<100. && decay_length <100.}

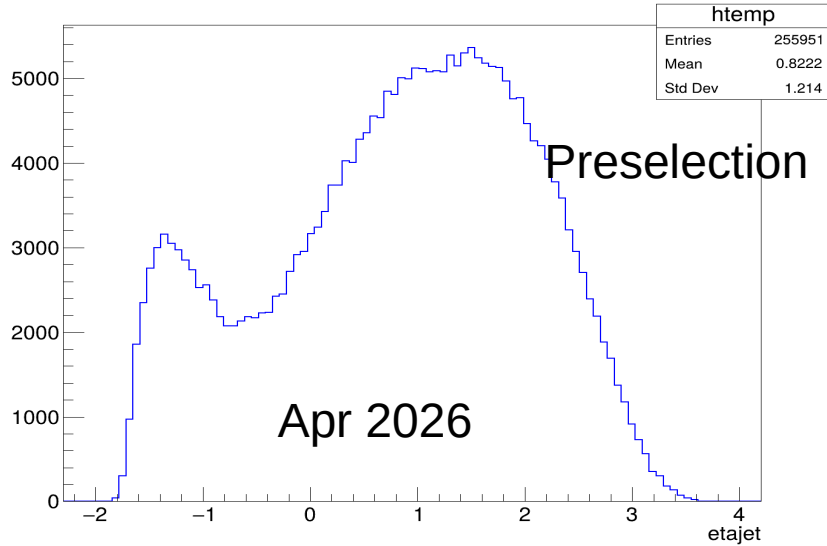
etajet {pTjet>3}

Jul 2026



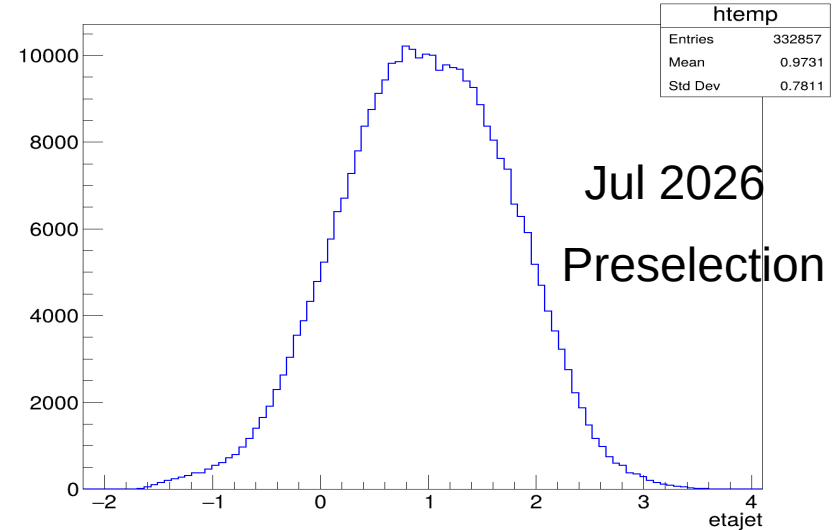
etajet {pTjet>3}

Apr 2026



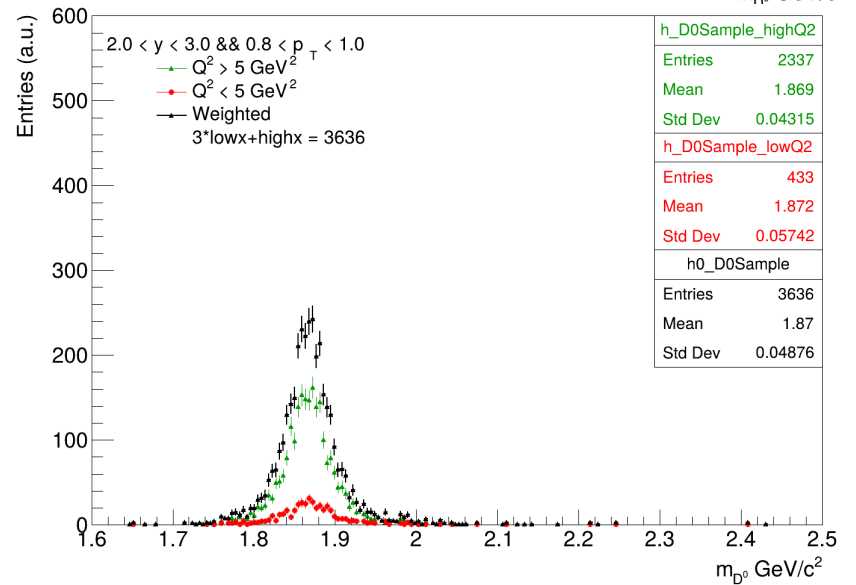
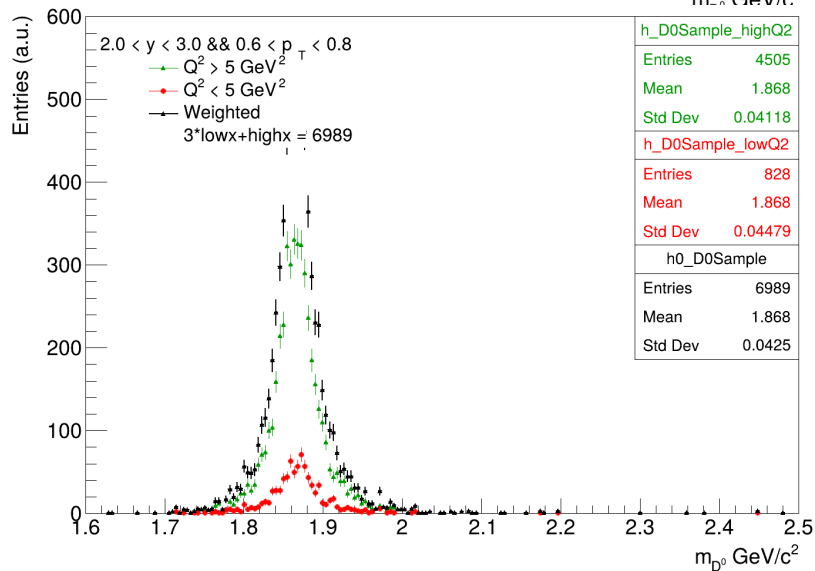
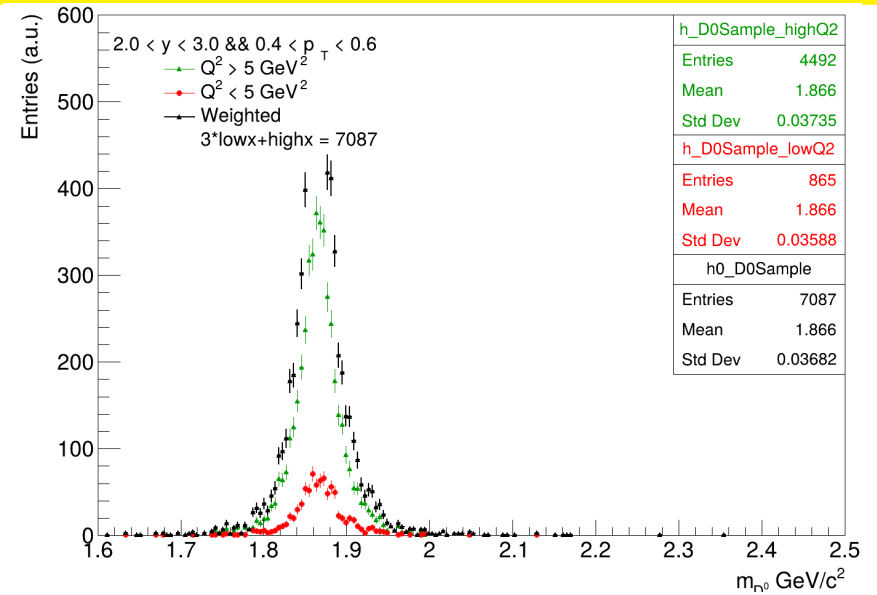
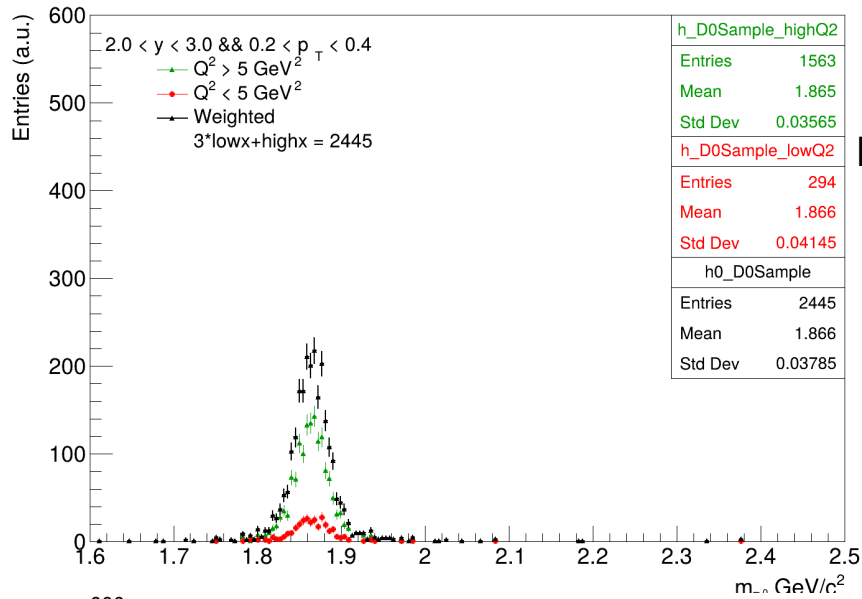
Jul 2026

Preselection

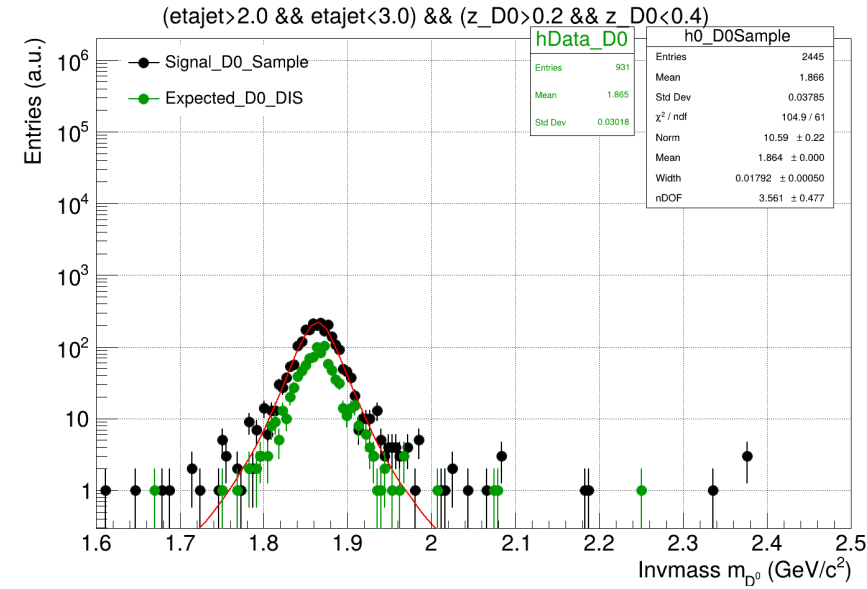


Signal Weighting (e+p)

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

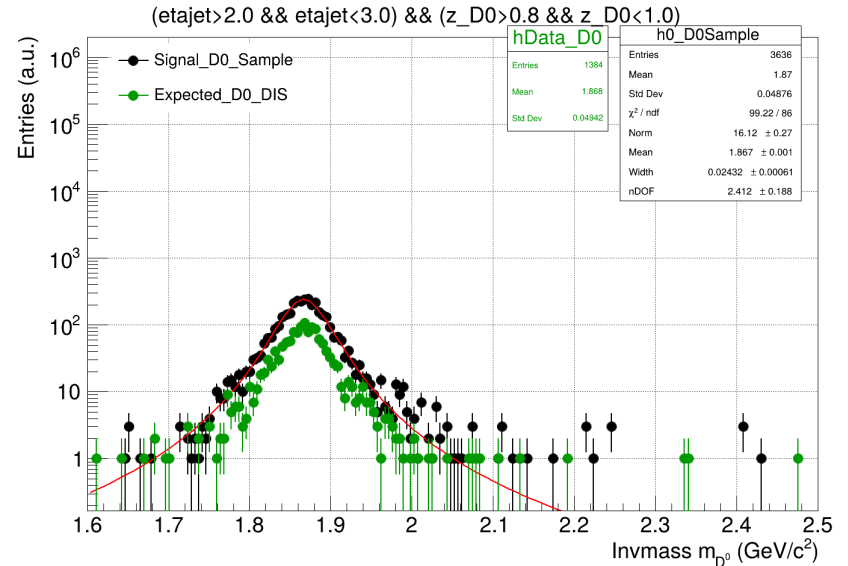
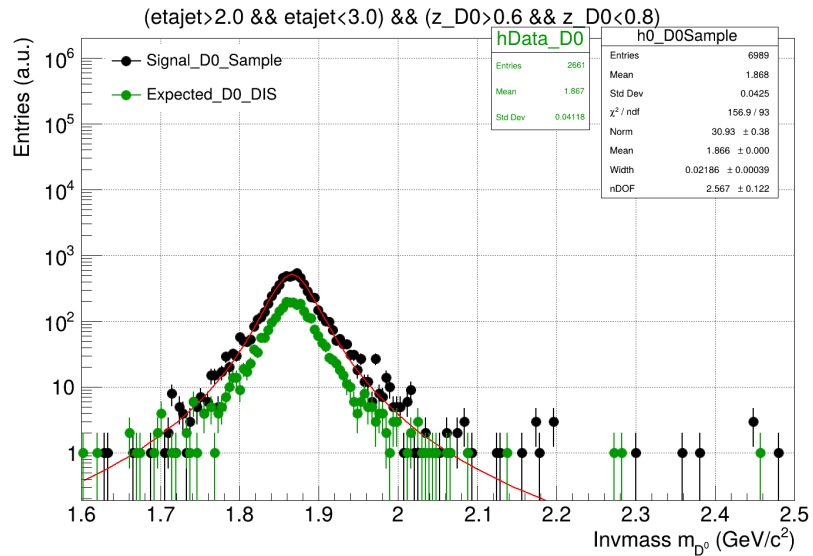
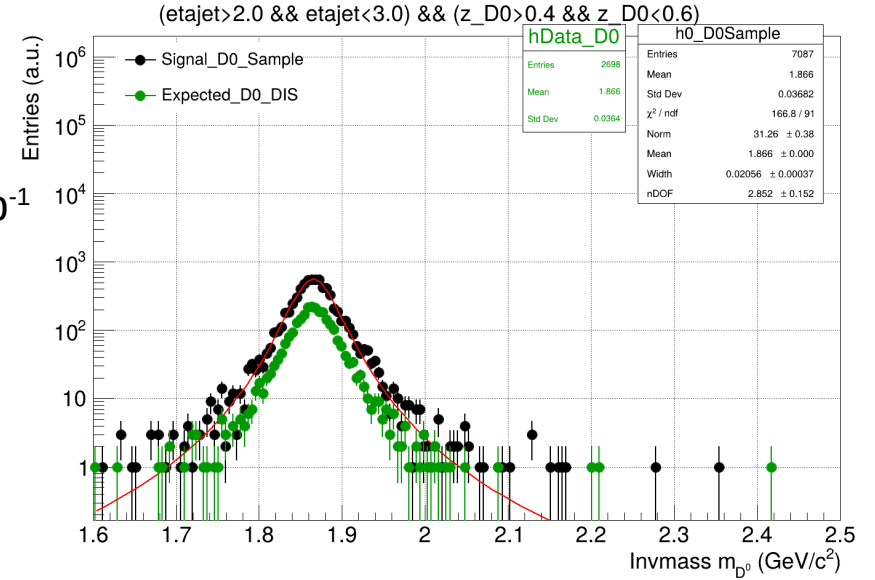


Signal Sampling (e+p)

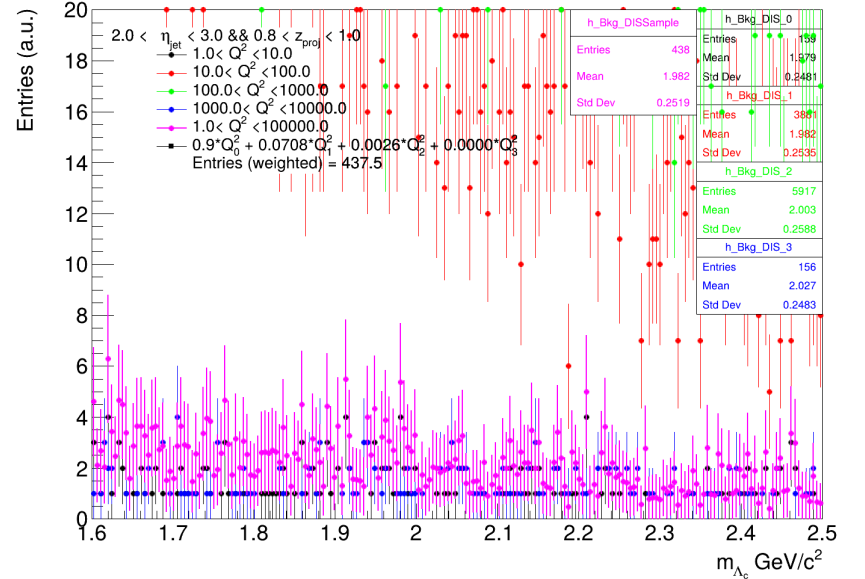
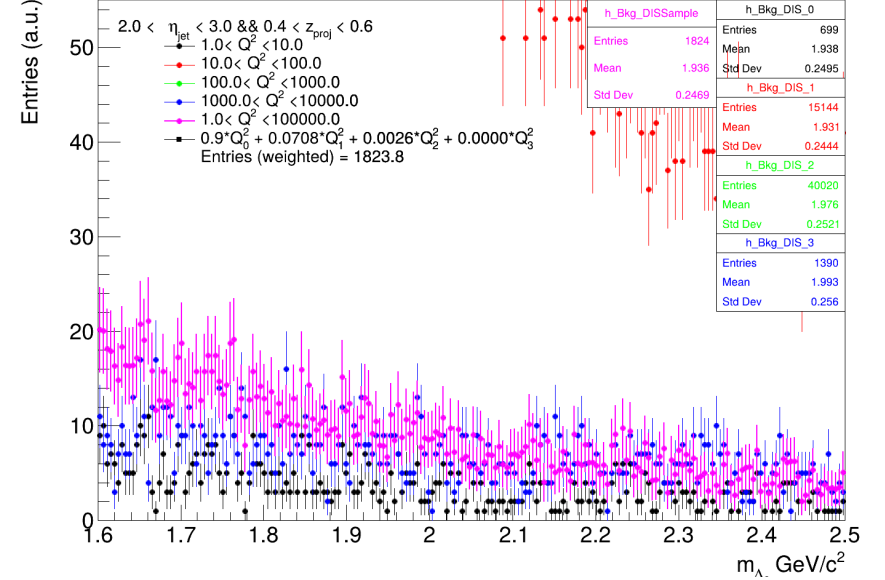
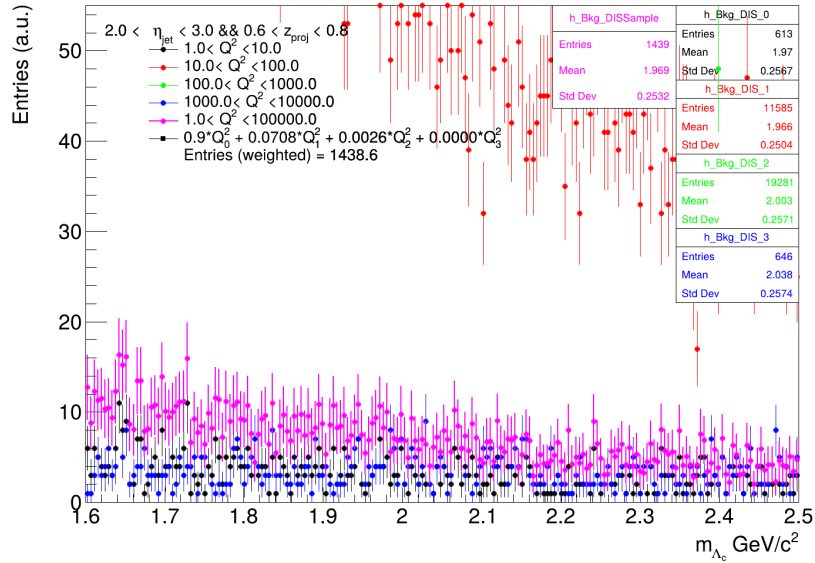
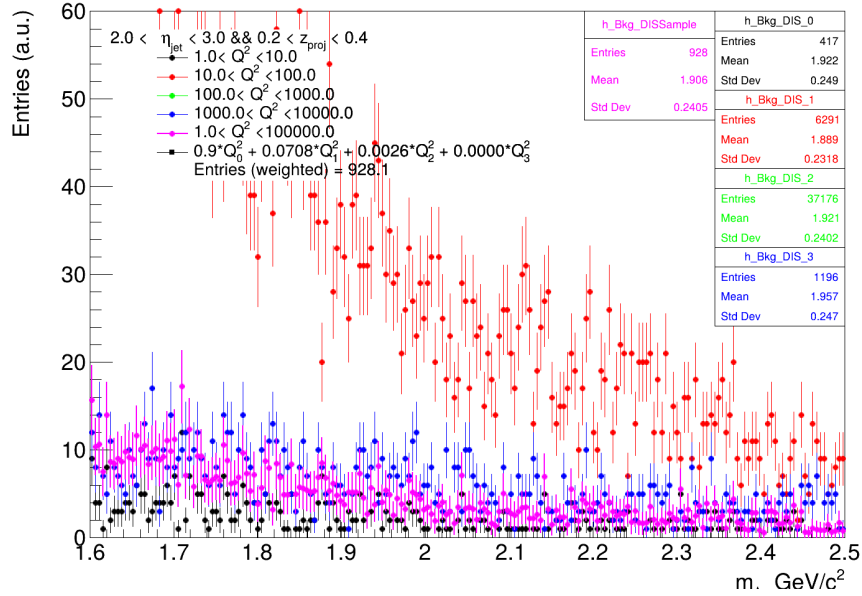


$L_{\text{sim}} \sim 2.6 \text{ fb}^{-1}$

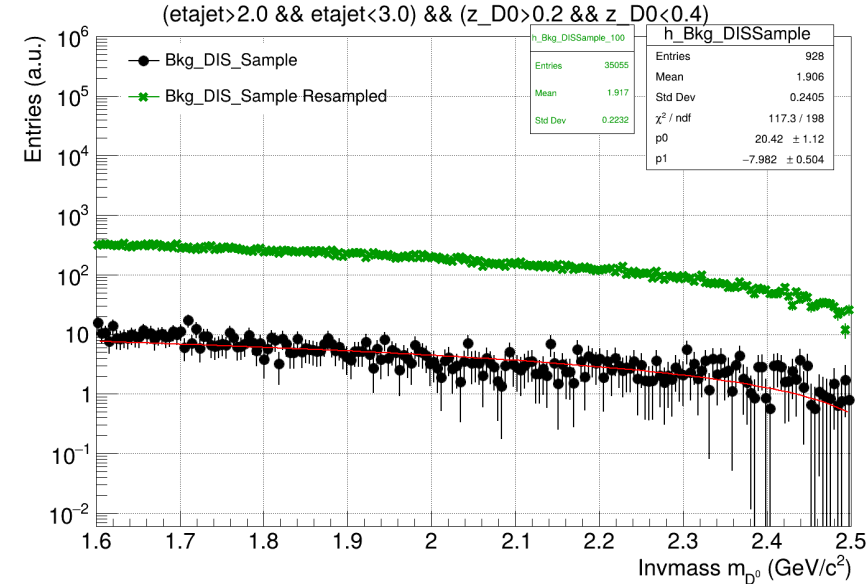
$L_{\text{ES}} \sim 1 \text{ fb}^{-1}$



Background Weighting (e+p)



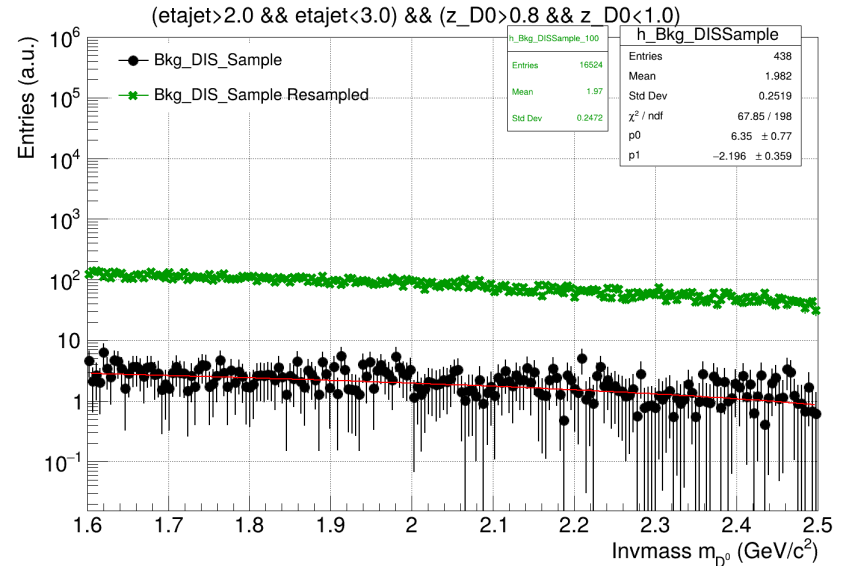
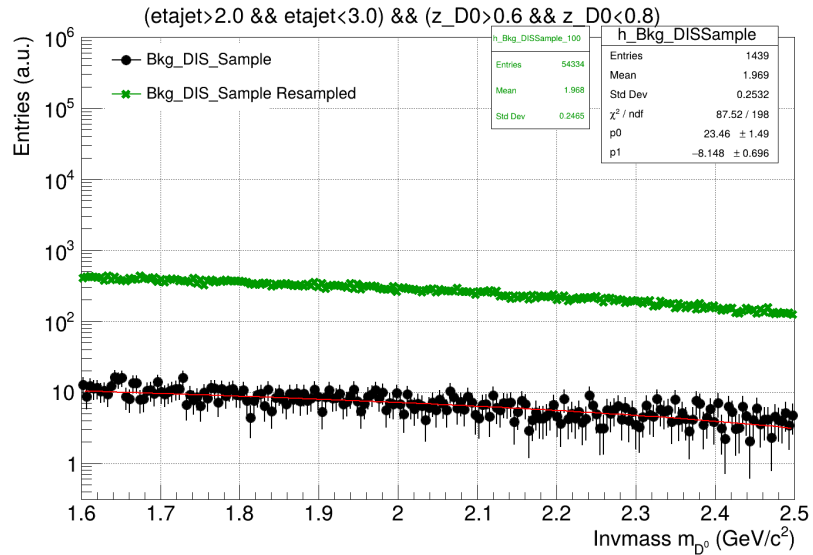
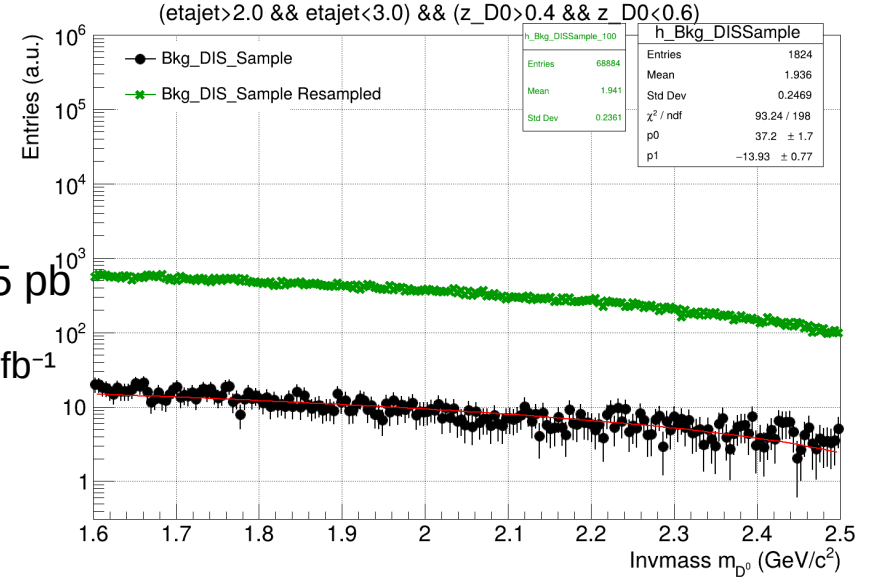
Bkg Sampling (e+p)



$N_{\text{ev}} \sim 15\text{M}$

$\sigma = 5.719\text{e5 pb}$

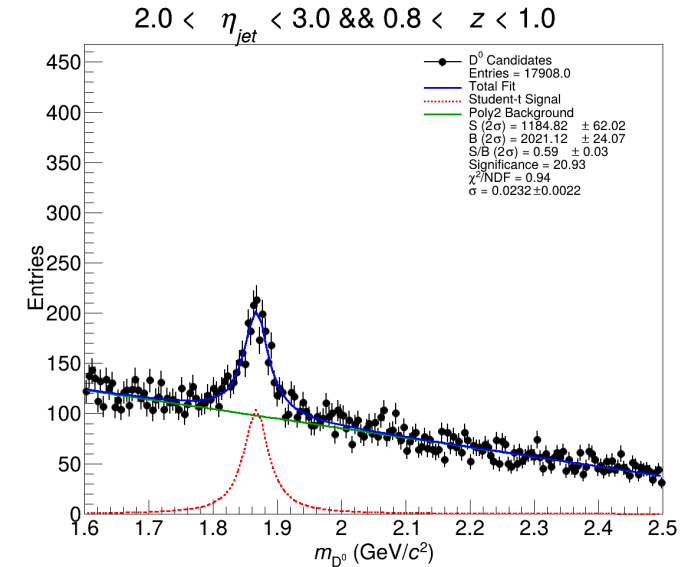
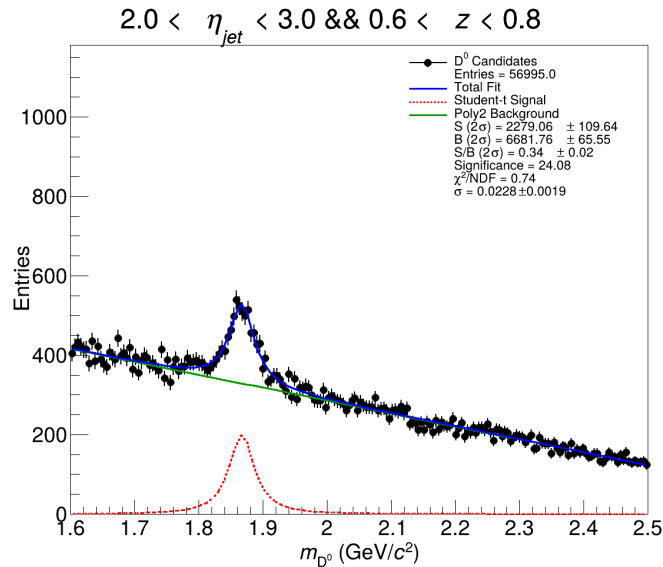
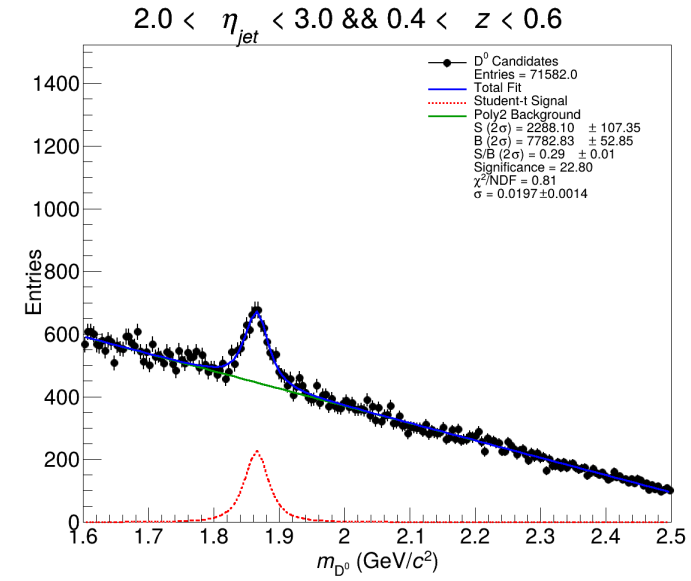
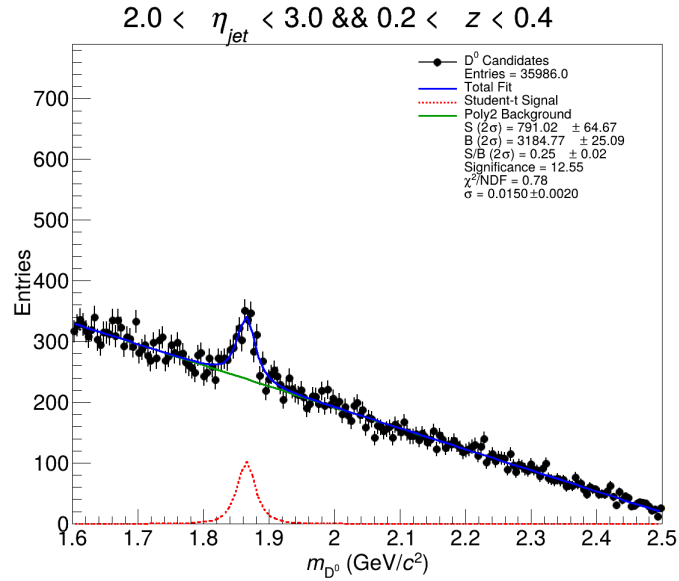
$L_{\text{sim}} \sim 0.0265 \text{ fb}^{-1}$



Invariant Mass Spectra (e+p): July Campaign

After PID+ Preselection

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

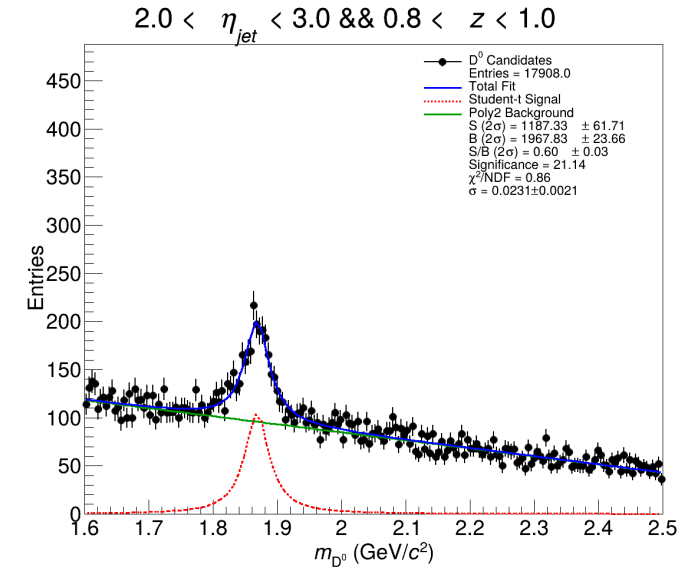
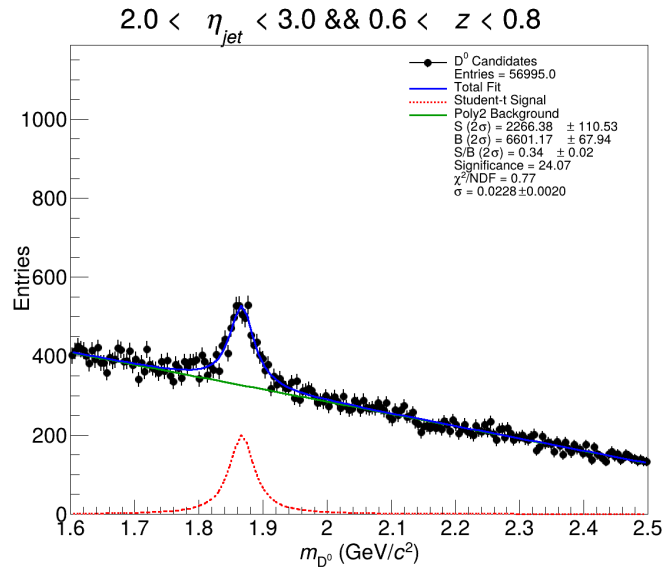
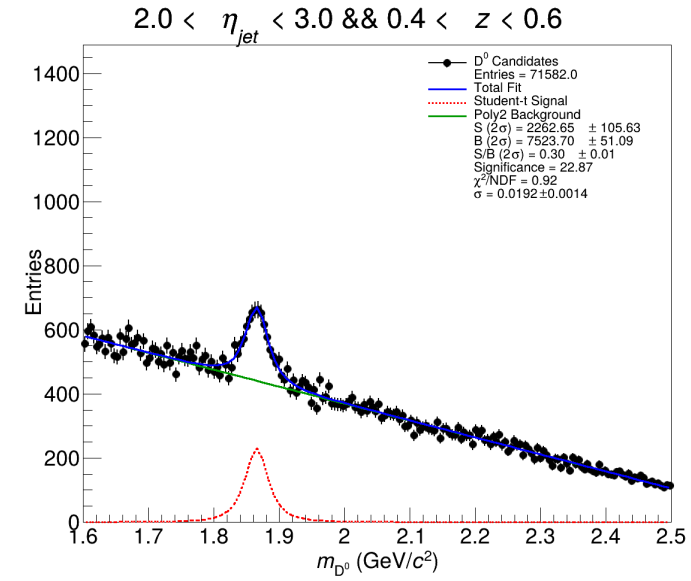
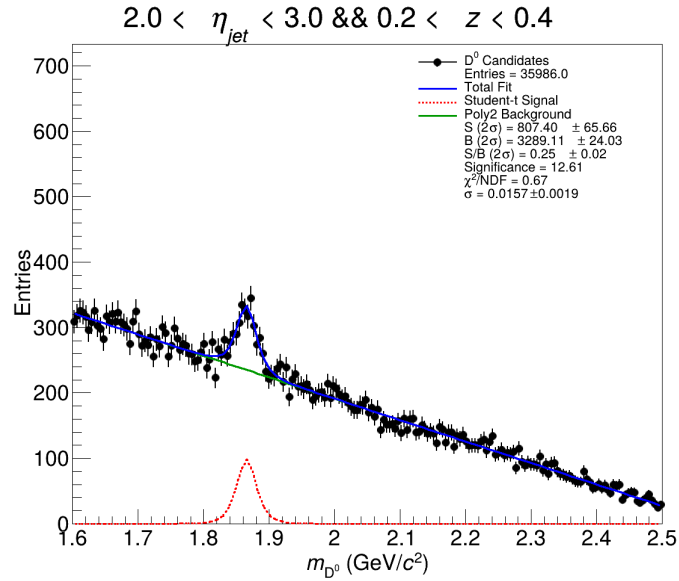


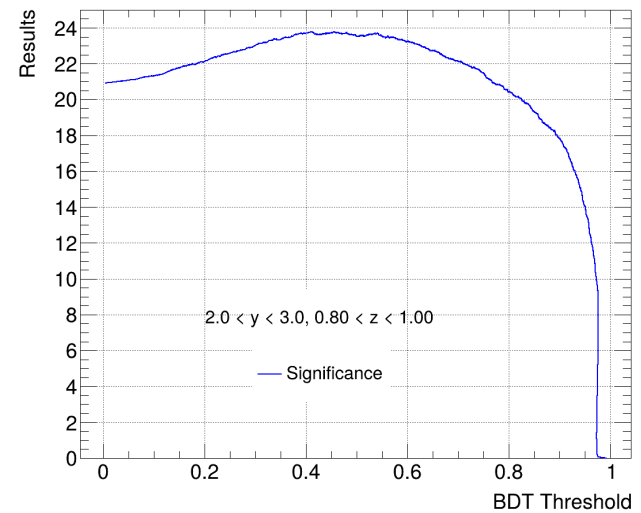
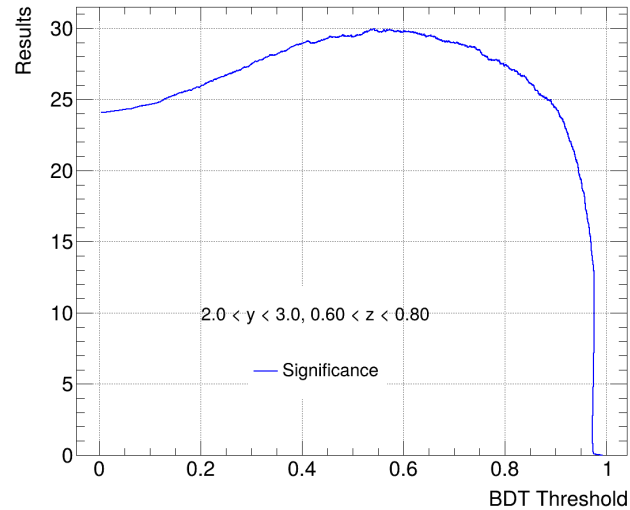
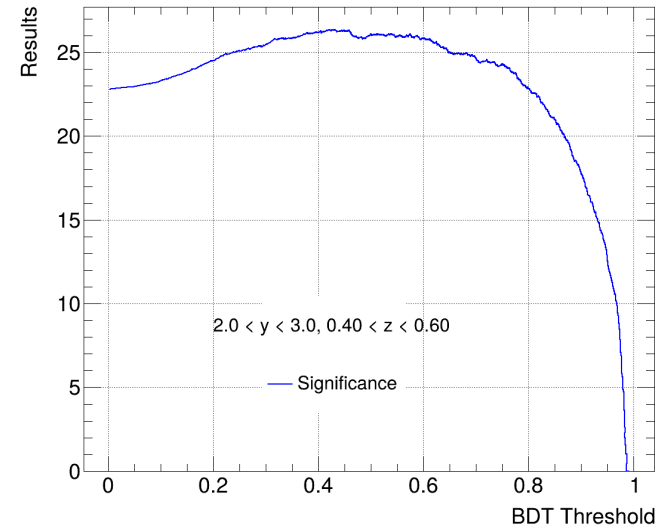
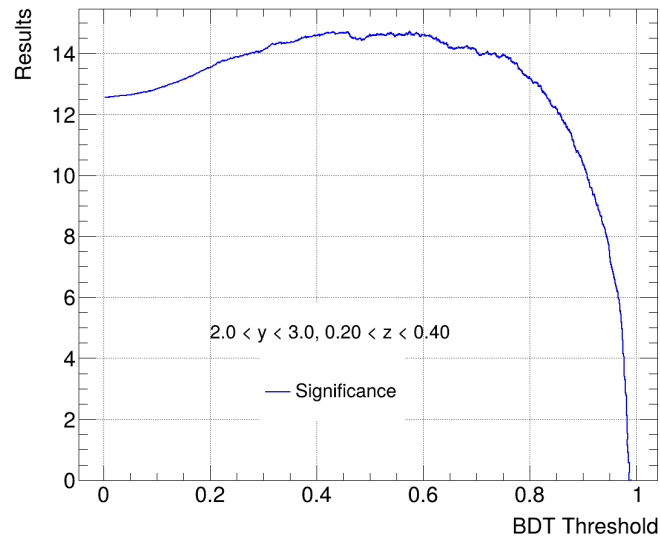
Invariant Mass Spectra (e+p): July Campaign

After PID+ Preselection

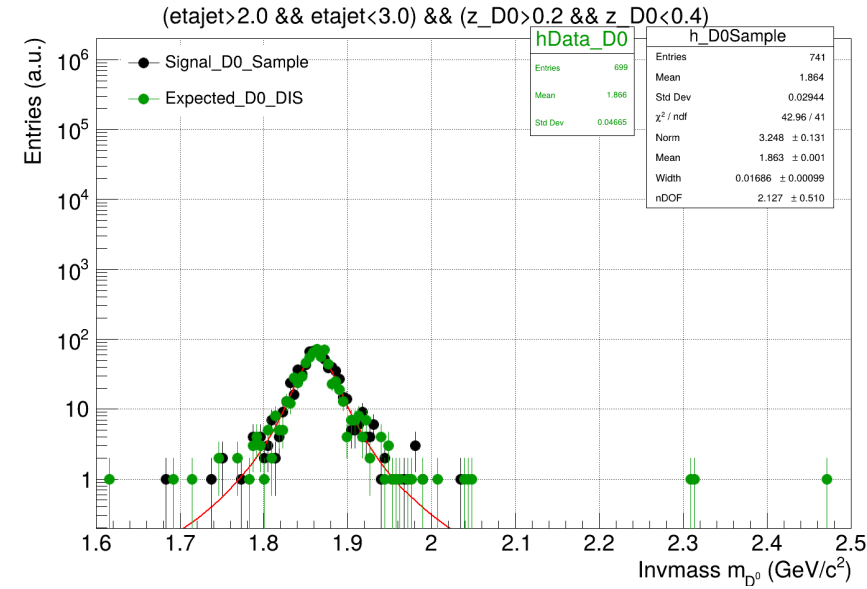
$$z = z_{proj} = \frac{\vec{p}_{D^0} \cdot \vec{p}_{jet}}{p_{jet}^2}$$

Background fitted
with Rebin(5)



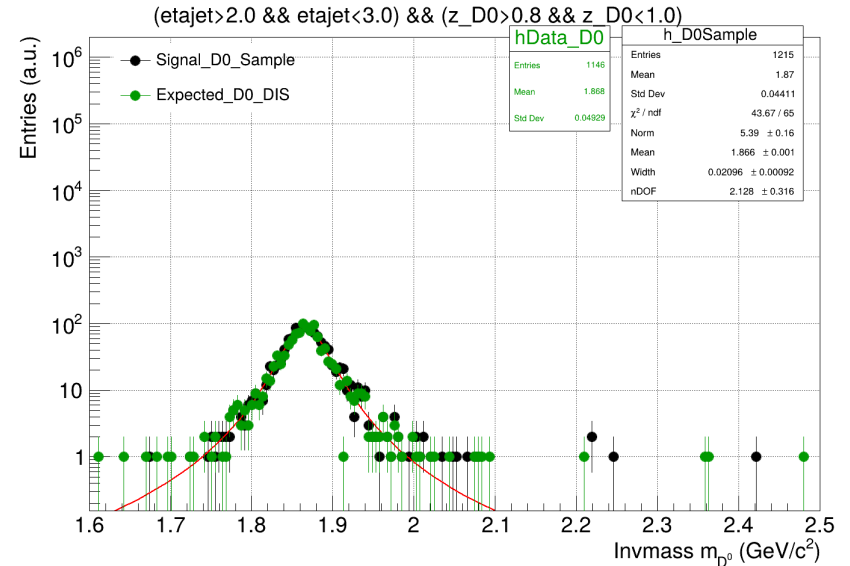
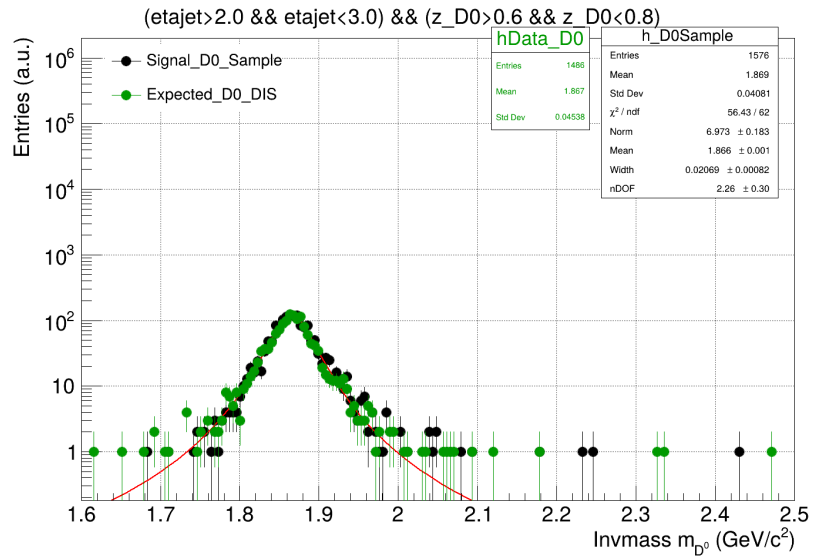
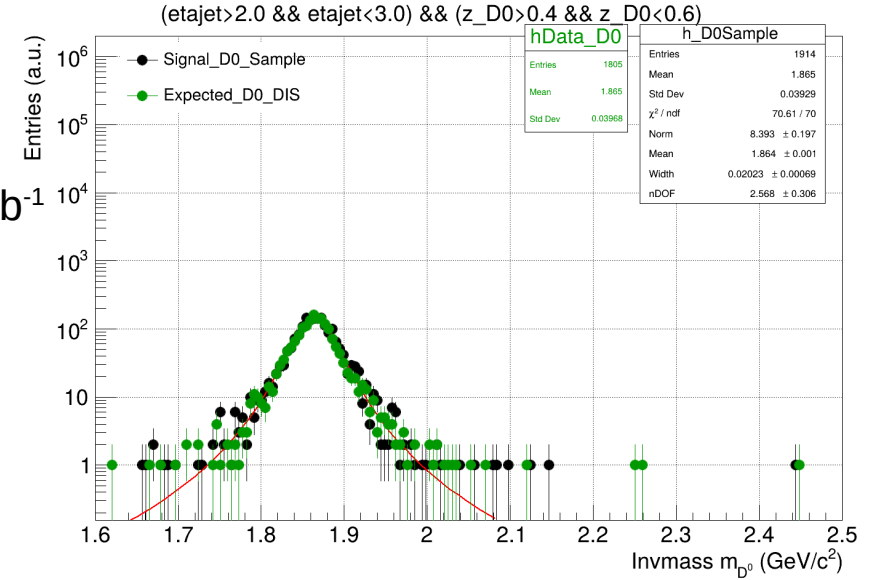


Signal Sampling (e+Au)

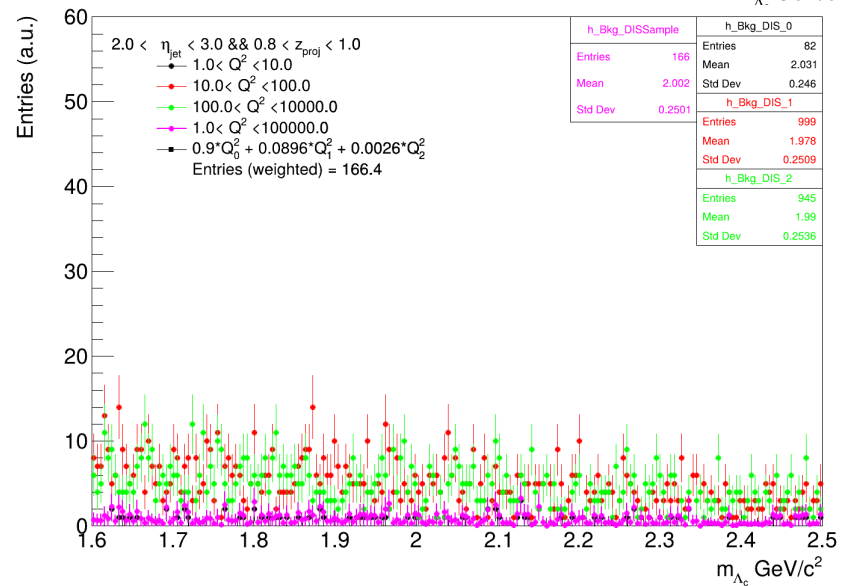
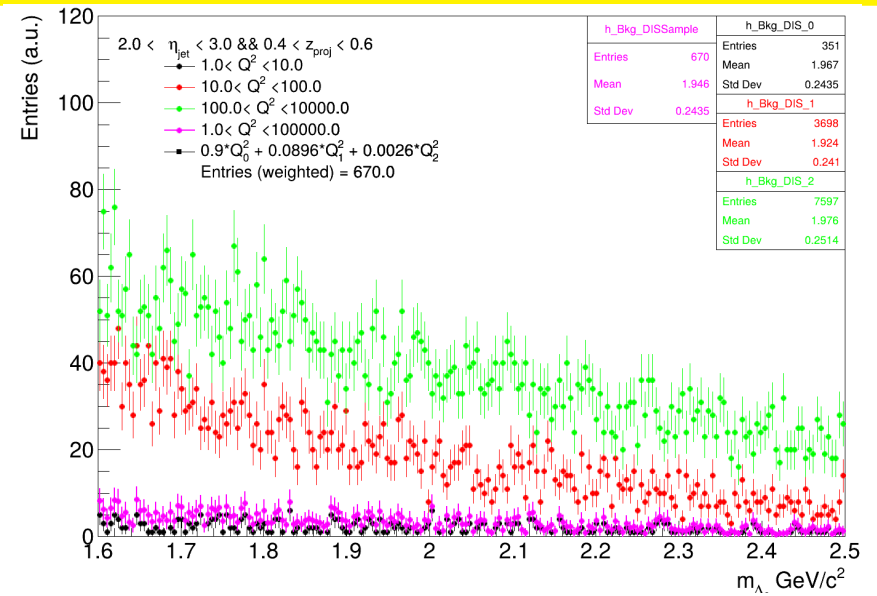
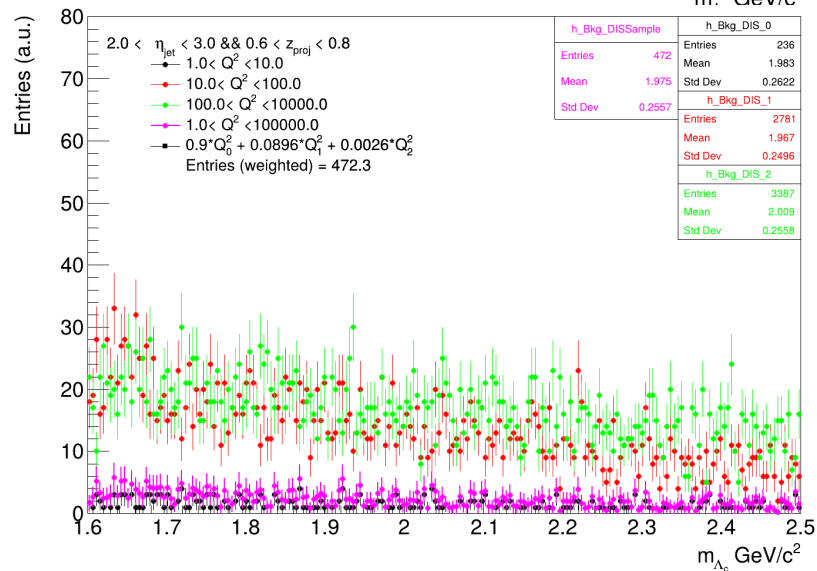
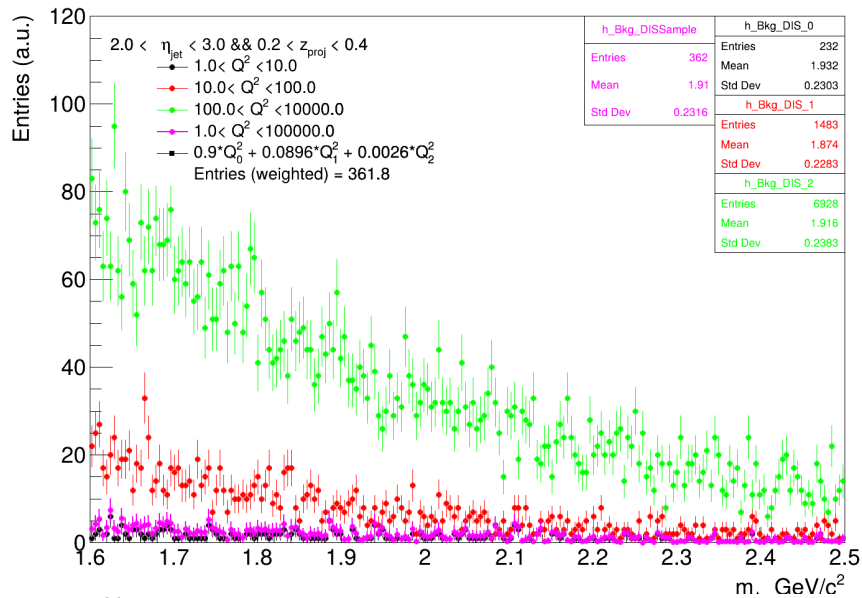


$$L_{\text{sim}} \sim 1.06 \text{ fb}^{-1}$$

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



Background Weighting (e+Au)

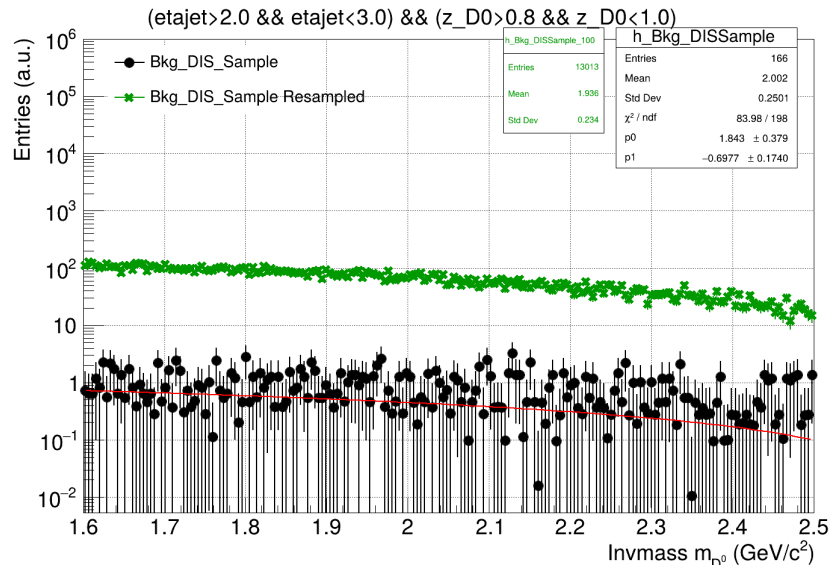
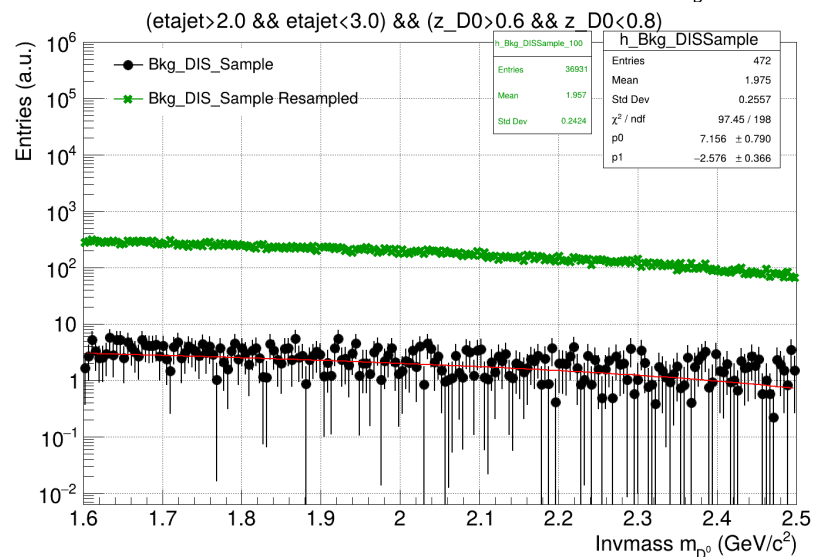
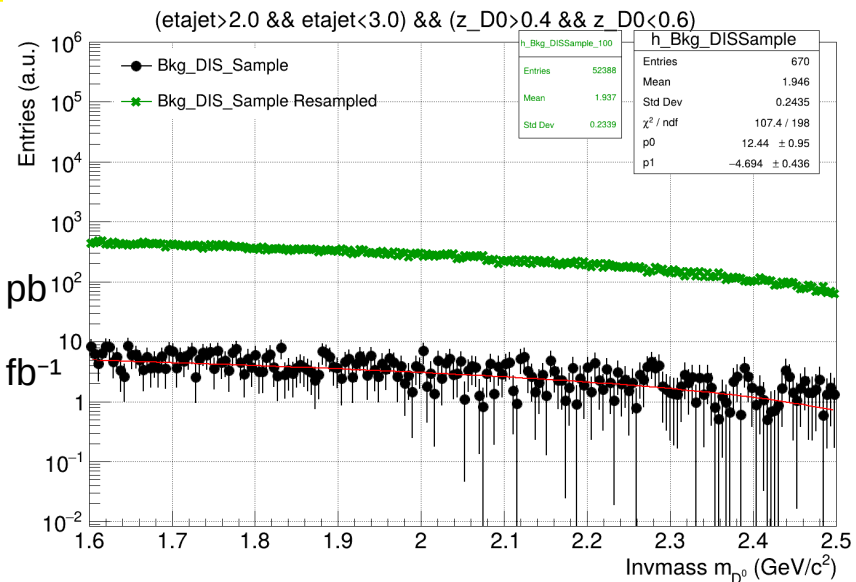
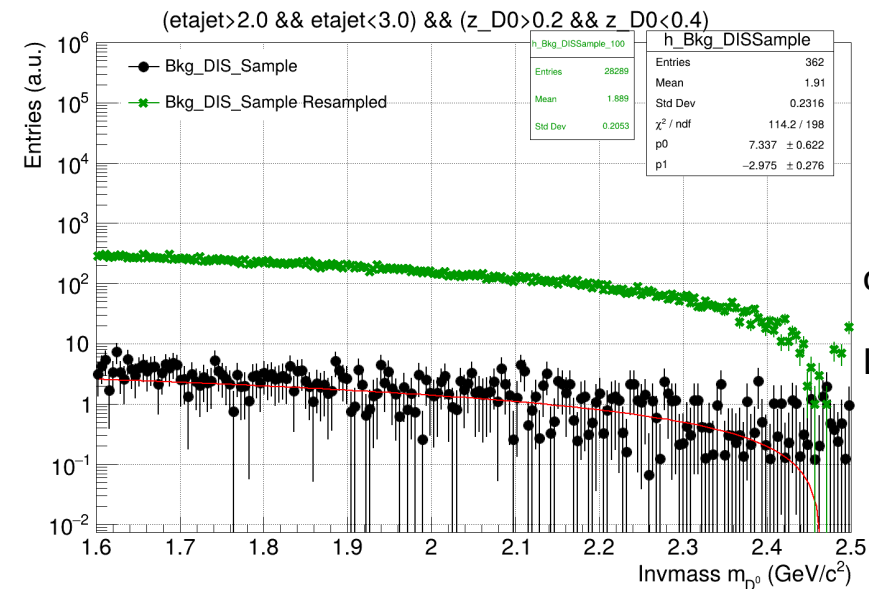


Bkg Sampling (e+Au)

$$N_{ev} \sim 5M$$

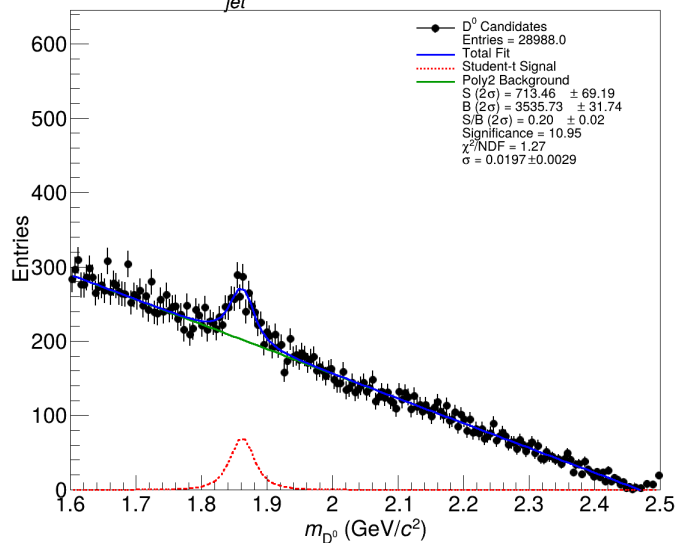
$$\sigma = 3.7289e5 \text{ pb}$$

$$L_{sim} \sim 0.01279 \text{ fb}^{-1}$$



Invariant Mass Spectra (e+Au): July Campaign

$2.0 < \eta_{jet} < 3.0 \ \&\& \ 0.2 < z < 0.4$



After PID+ Preselection

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

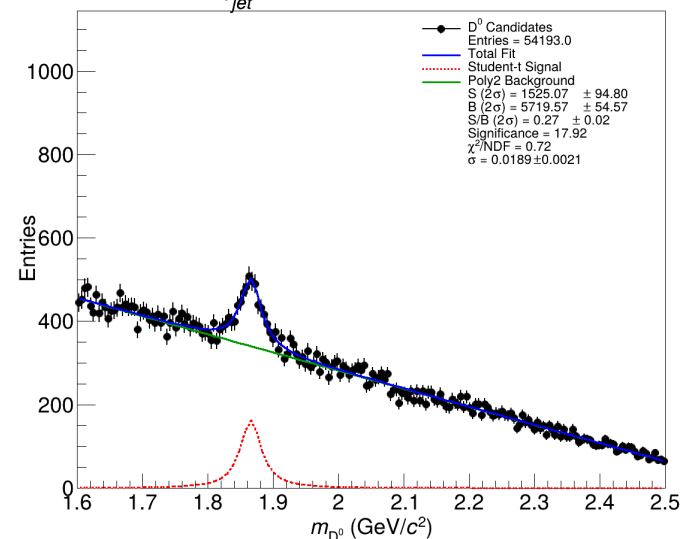
$$L_{int}(sim) = \frac{N_{DIS}}{\sigma_{MB}(Q^2 > 1)}$$

Q_i bins: 1-10, 10-100, 100-10000

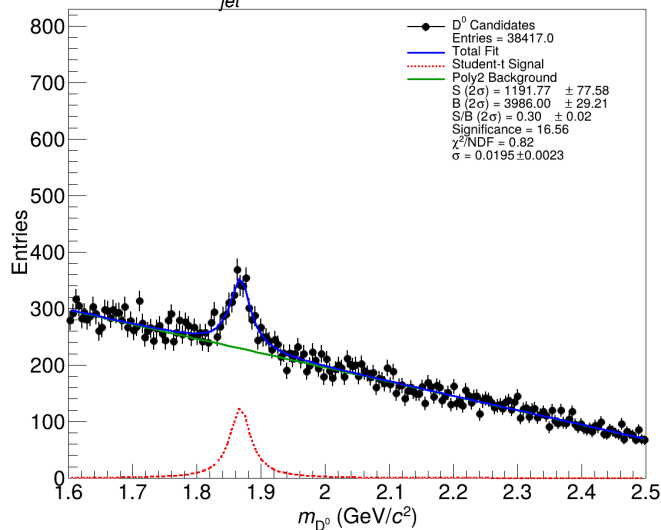
$$f_i = \frac{\sigma(Q_i^2)}{\sigma(Q^2 > 1)}$$

Scaling on cross section

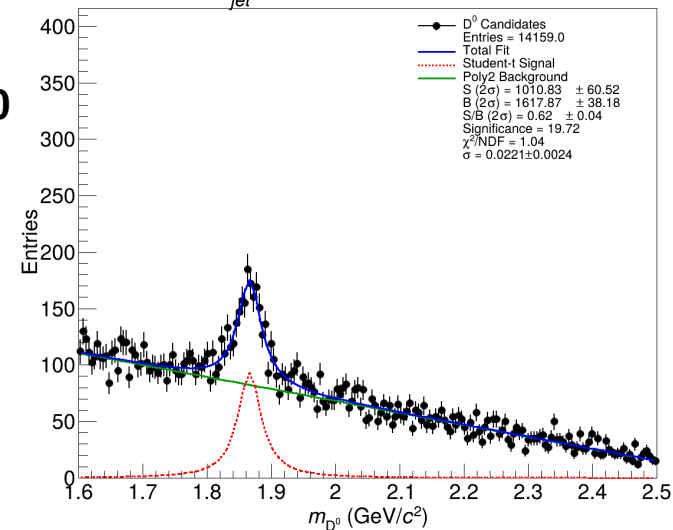
$2.0 < \eta_{jet} < 3.0 \ \&\& \ 0.4 < z < 0.6$

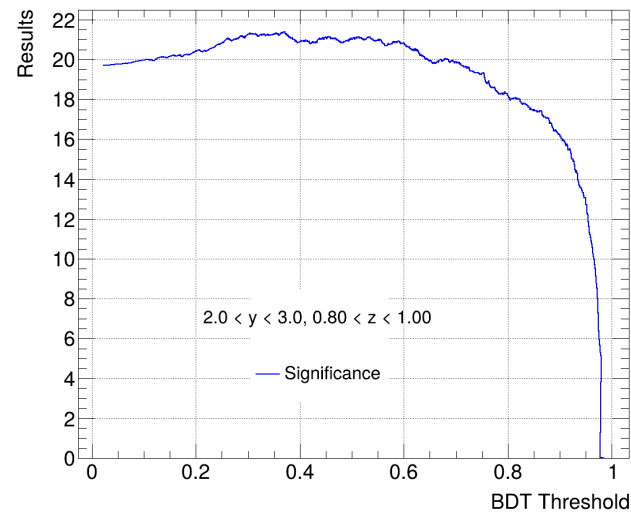
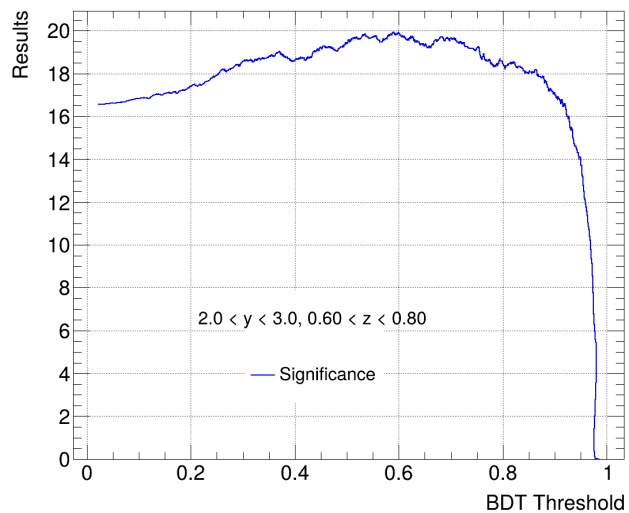
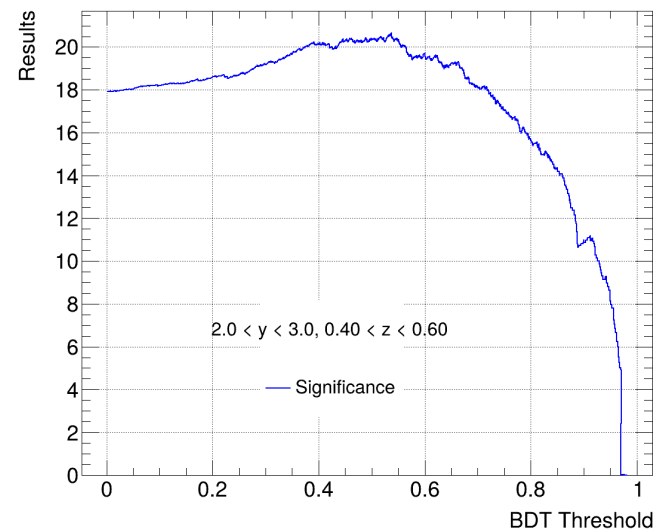
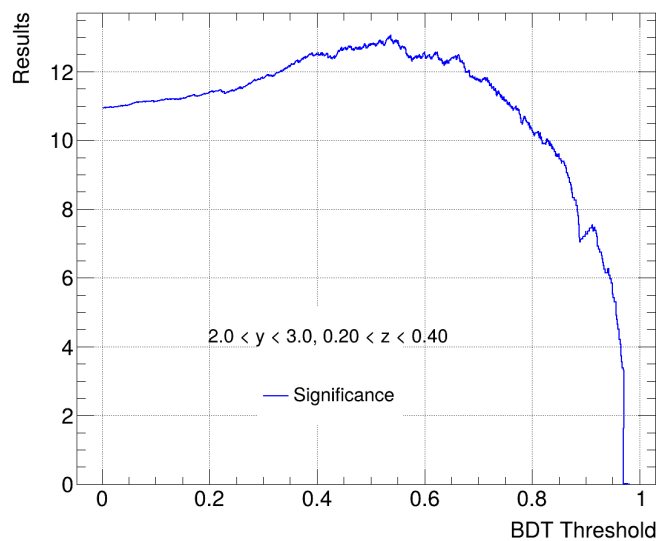


$2.0 < \eta_{jet} < 3.0 \ \&\& \ 0.6 < z < 0.8$



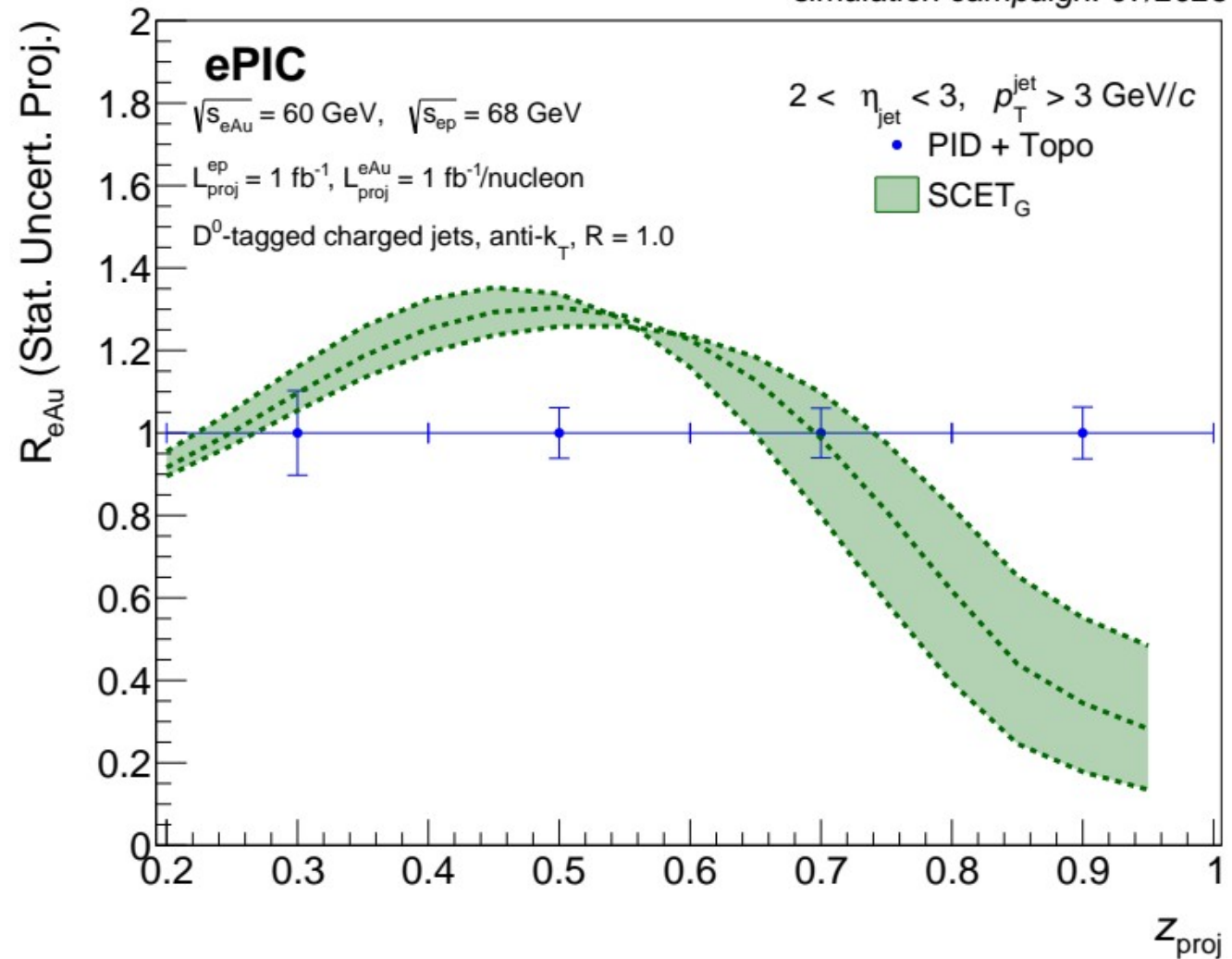
$2.0 < \eta_{jet} < 3.0 \ \&\& \ 0.8 < z < 1.0$





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

Comparison between April and July Campaign

April 2026

0.2-0.4	0.0952326
0.4-0.6	0.0525816
0.6-0.8	0.054752
0.8-1	0.057535

July 2026

0.2-0.4	0.102427
0.4-0.6	0.0615028
0.6-0.8	0.0602676
0.8-1.0	0.0628237

The results in July campaign are 10-15% worse w.r.t. April campaign

Λ_c Branching Ratio

Event Statistics

October 2025 Campaigns

Slide 14

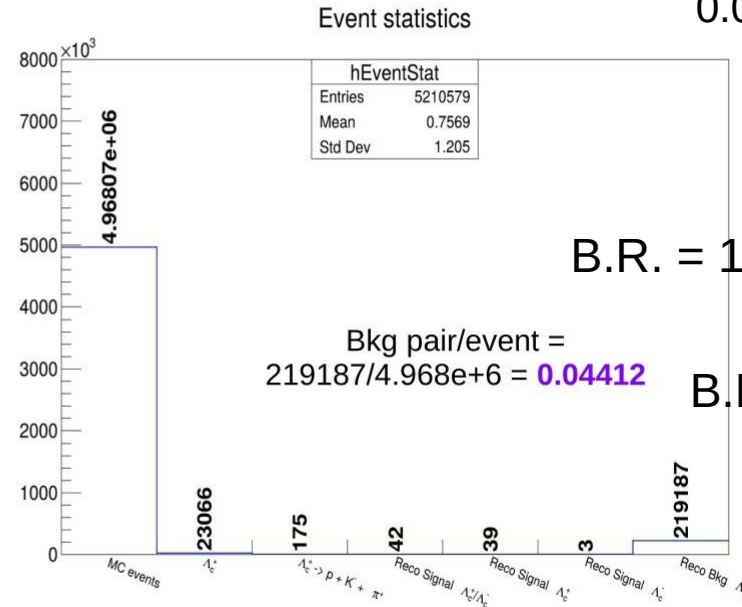
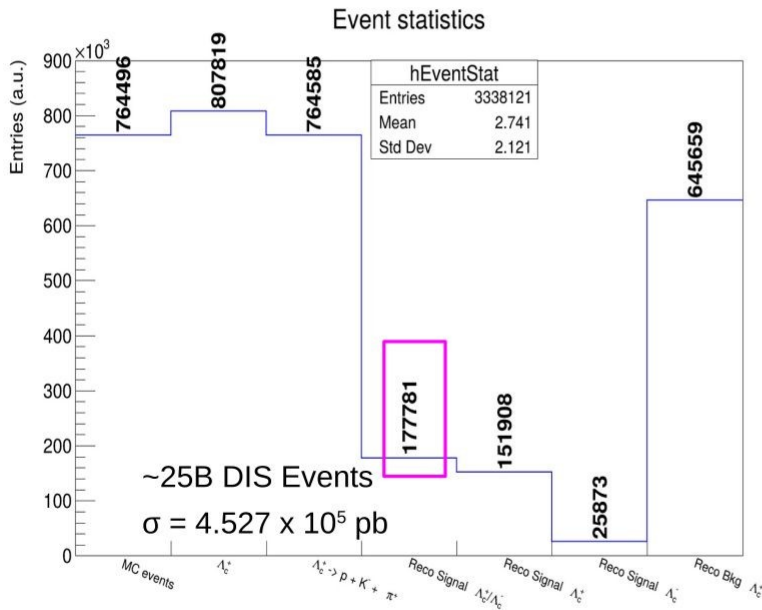
$$L_{\text{int}} = \frac{250 \times 10^8}{4.527 \times 10^8 \text{ fb}} = 55.22421 \text{ fb}^{-1}$$

Real PID

Λ_c^+ Sample

DIS Sample

B.R. Scaling =
0.0635/0.0075 ~8.47



B.R. = $175./23066 = 0.0075$

B.R. is independent of
collision energy

10/02/26

HF Studies: Shyam Kumar

2

22/09/26

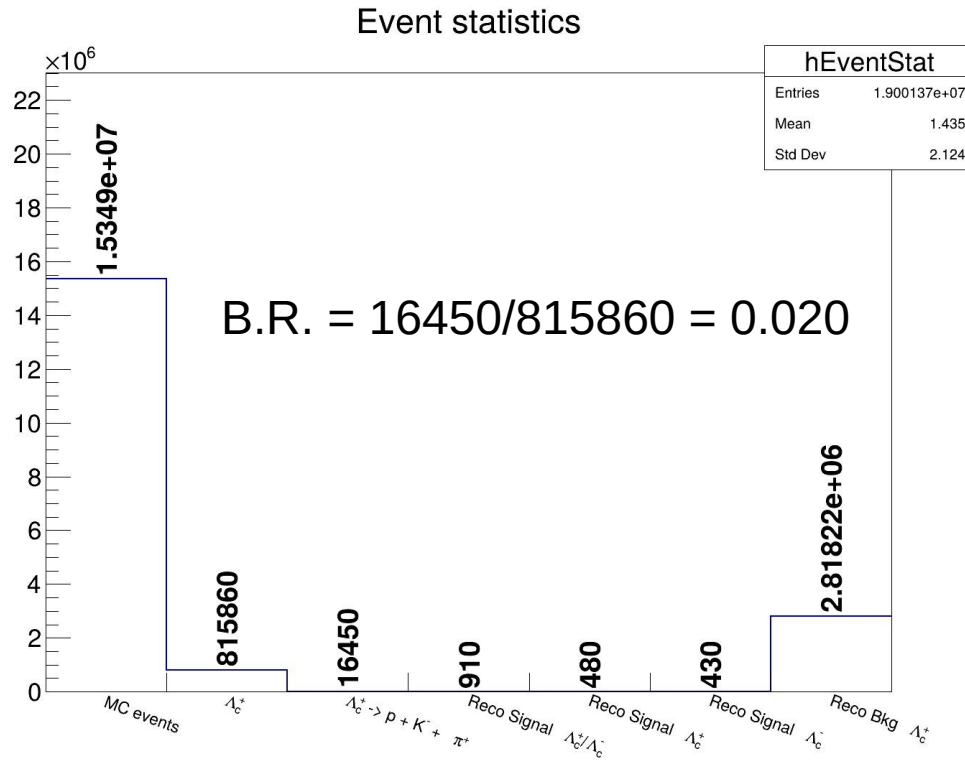
Analysis Update: Shyam Kumar

26

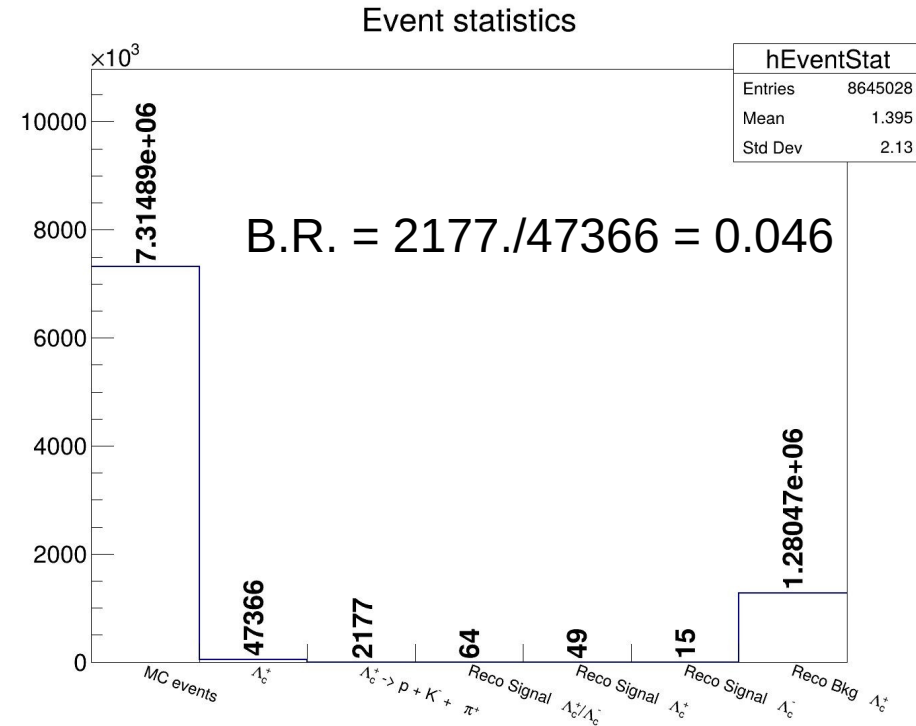
Λ_c Branching Ratio

Issues with DIS sample (Branching Ratio)

April Campaign (DIS Sample)



July Campaign (DIS Sample)

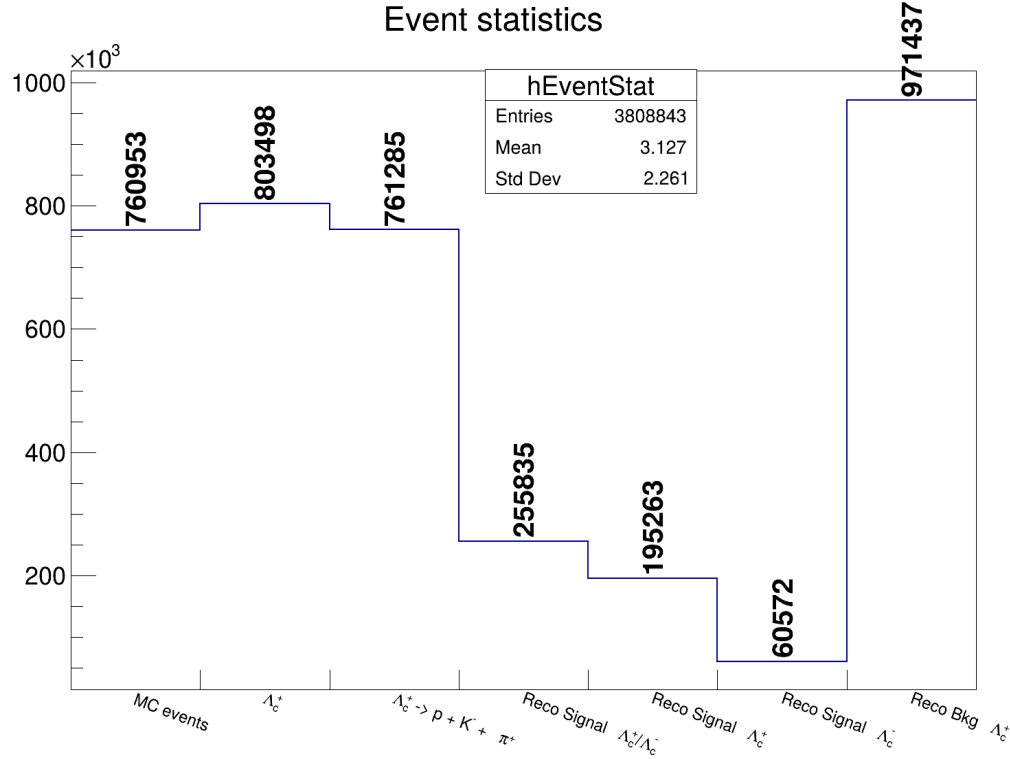


Λ_c Branching Ratio

Issues with DIS sample (Branching Ratio)

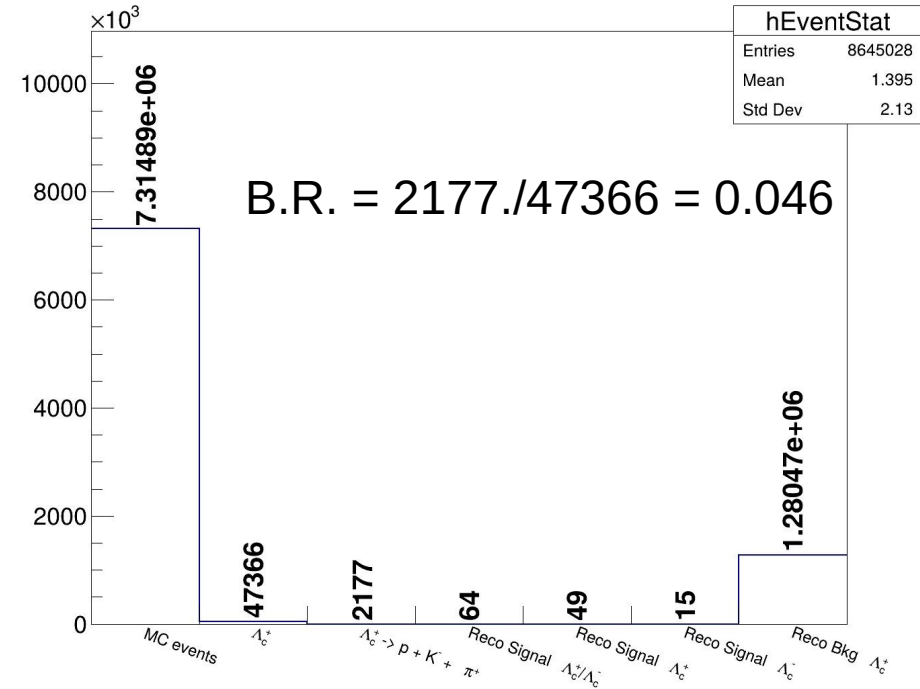
July Campaign (Lc Sample)

Event statistics

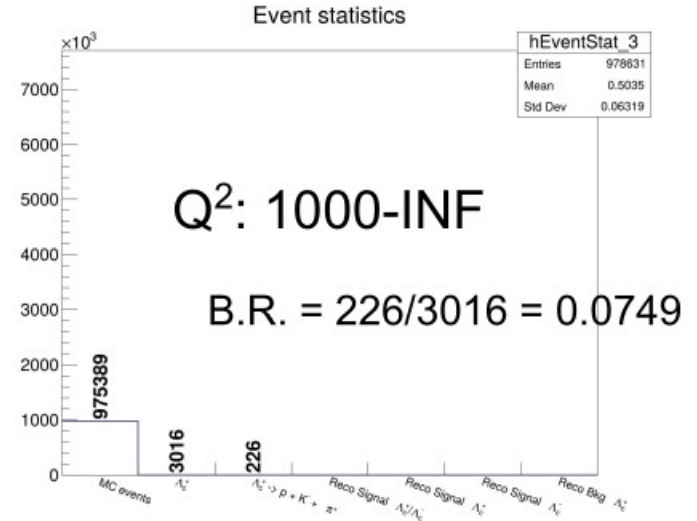
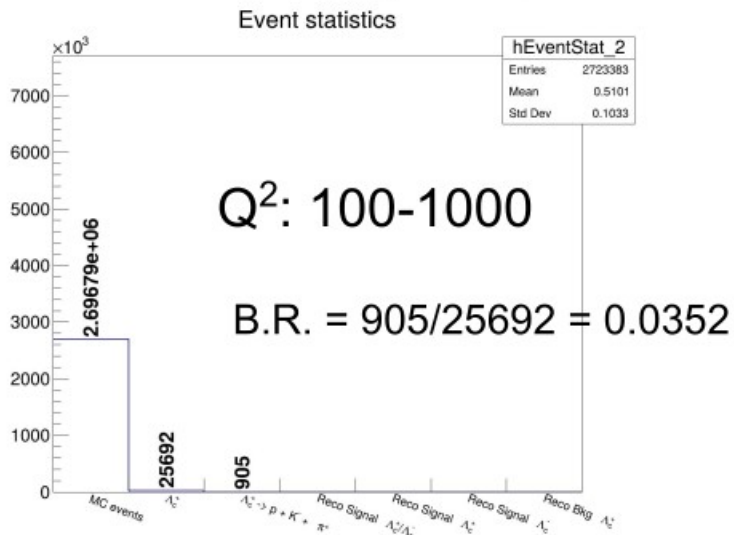
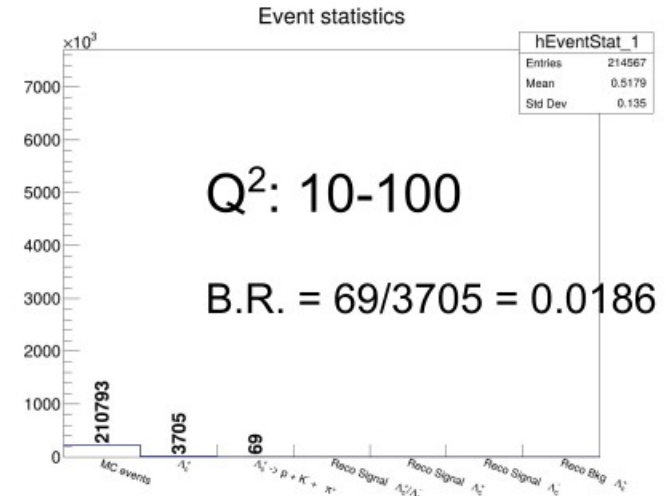
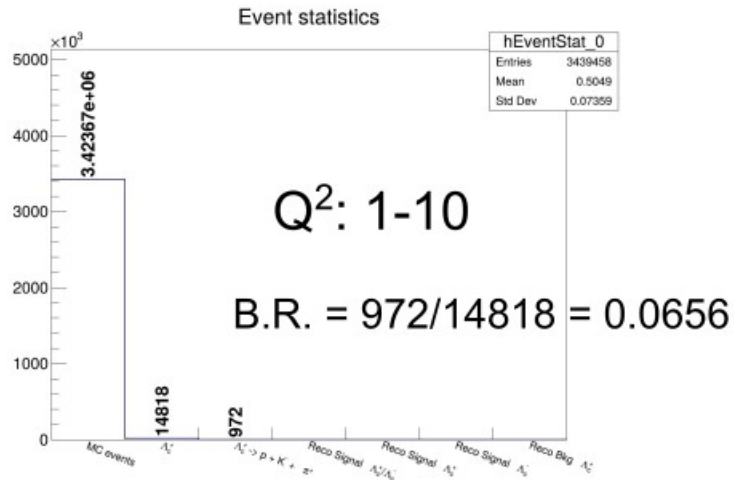


July Campaign (DIS Sample)

Event statistics



Issues with DIS sample July Campaign (DIS Sample)



Local Pythia simulation (PYTHIA8316)

Q^2 : 1-10 GeV^2

Total events scanned = 10000000

Total Lambda_c (+/-) = 41031

Lambda_c (+/-) $\rightarrow$ p K pi = 226

Branching ratio = 5.508e-03

Branching ratio (%) = 5.508e-01%

Q^2 : 10-100 GeV^2

Total events scanned = 10000000

Total Lambda_c (+/-) = 138843

Lambda_c (+/-) $\rightarrow$ p K pi = 793

Branching ratio = 5.711e-03

Branching ratio (%) = 5.711e-01%

Q^2 : 100-1000 GeV^2

Total events scanned = 10000000

Total Lambda_c (+/-) = 94181

Lambda_c (+/-) $\rightarrow$ p K pi = 566

Branching ratio = 6.010e-03

Branching ratio (%) = 6.010e-01%

$Q^2 > 1 \text{ GeV}^2$

Total events scanned = 10000000

Total Lambda_c (+/-) = 49204

Lambda_c (+/-) $\rightarrow$ p K pi = 297

Branching ratio = 6.036e-03

Branching ratio (%) = 6.036e-01%

Matches with the October campaign

Local test in the container

$Q^2 > 1 \text{ GeV}^2$

Total events scanned = 10000000

Total Λ_c (+/-) = 49204

Λ_c (+/-) $\rightarrow$ p K pi = 297

Branching ratio = 6.036e-03

Branching ratio (%) = 6.036e-01 %

$Q^2 : 1-10 \text{ GeV}^2$

Total events scanned = 10000000

Total Λ_c (+/-) = 41031

Λ_c (+/-) $\rightarrow$ p K pi = 226

Branching ratio = 5.508e-03

Branching ratio (%) = 5.508e-01 %

BNL Server: Rongrong

$1 < Q^2 < 10$

Total events scanned = 10000000

Total Λ_c (+/-) = 41031

Λ_c (+/-) $\rightarrow$ p K pi = 226

Branching ratio = 5.508e-03

Branching ratio (%) = 5.508e-01 %

$10 < Q^2 < 100$

Total events scanned = 10000000

Total Λ_c (+/-) = 138623

Λ_c (+/-) $\rightarrow$ p K pi = 783

Branching ratio = 5.648e-03

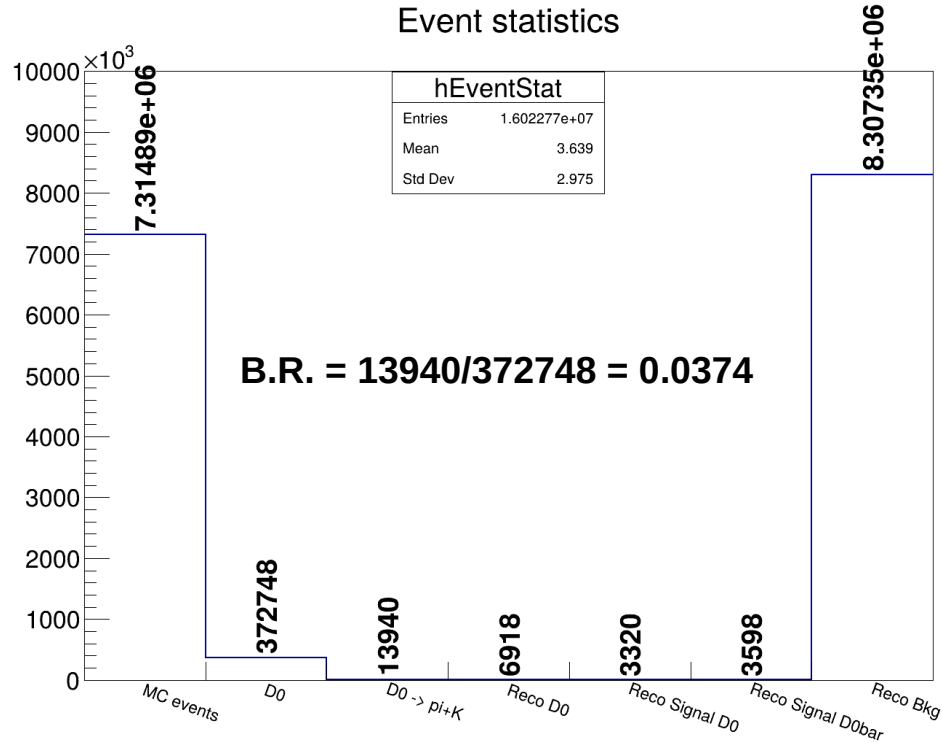
Branching ratio (%) = 5.648e-01 %

D⁰ Branching Ratio

Issues with DIS sample (Branching Ratio)

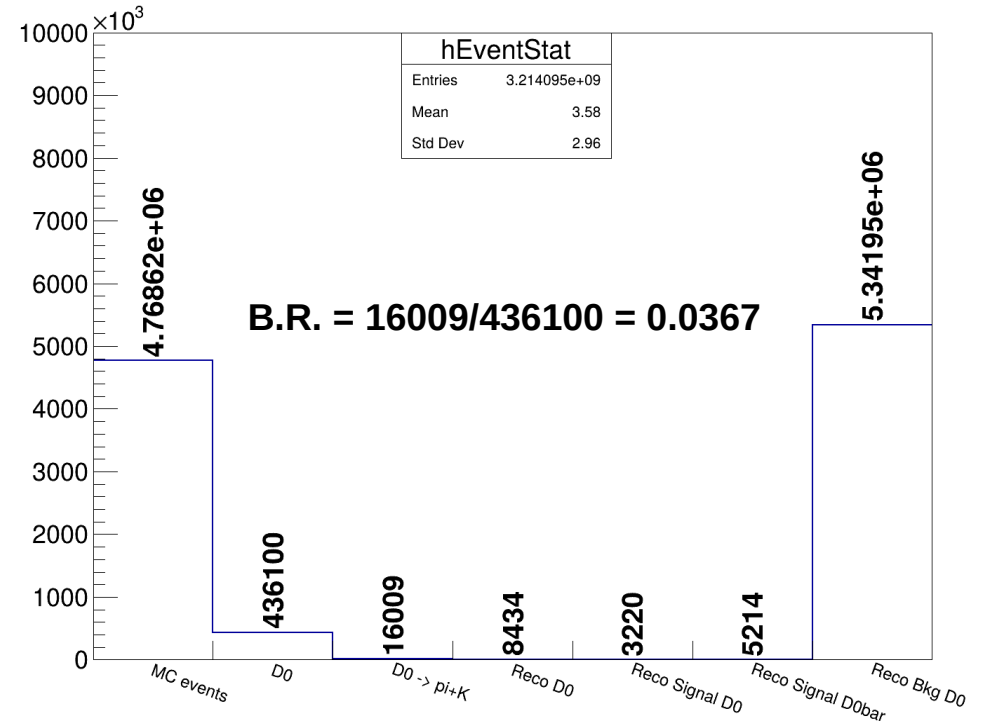
July Campaign (DIS Sample)
e+p (9x275)

Event statistics



July Campaign (DIS Sample)
e+Au (9x100)

Event statistics



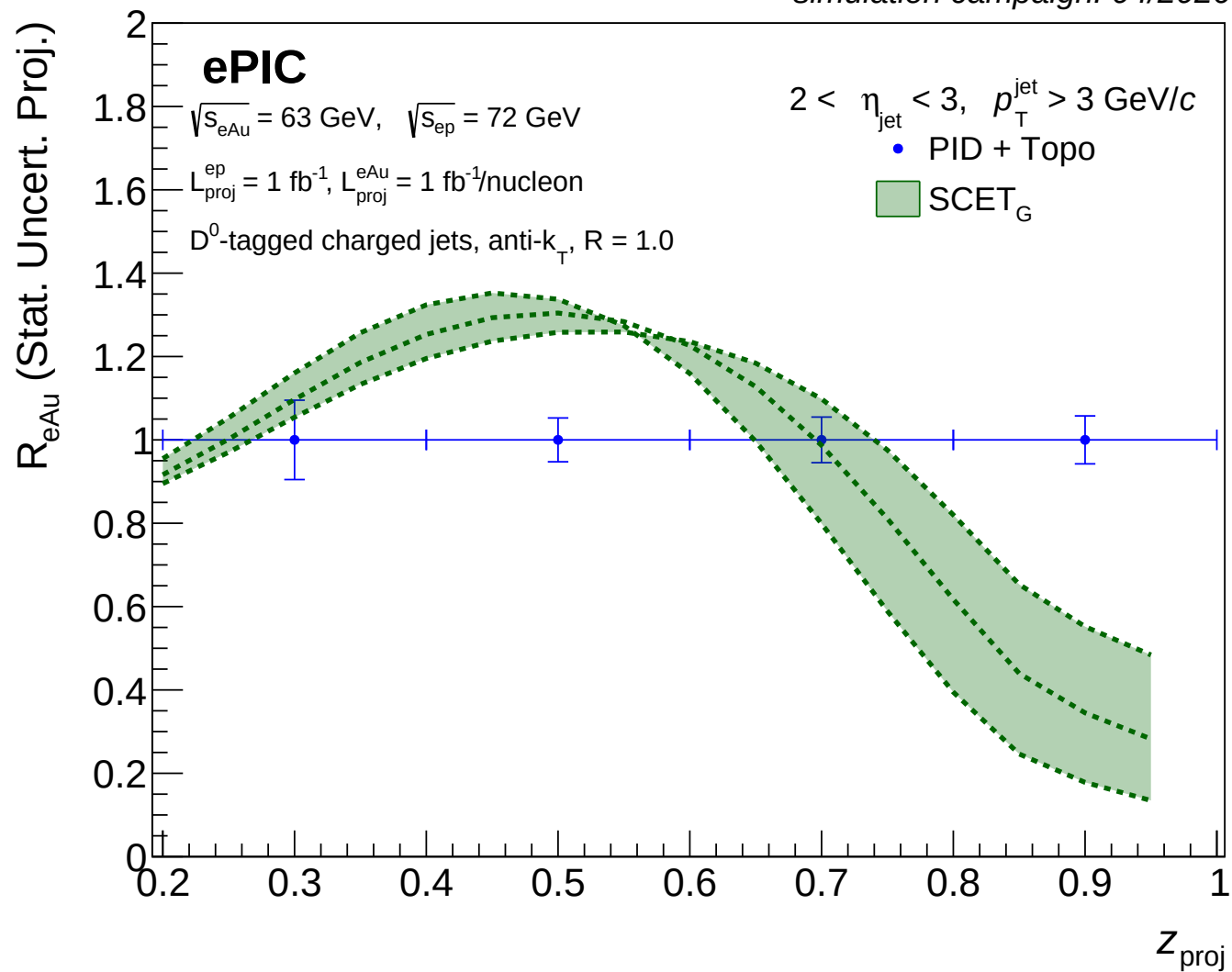
Summary and Future Plan

- Result of R_{eAu} vs z_{proj} is already in place for ES Report
- Checks for BR for Λ_c is in progress
- Next to produce Λ_c/D^0 ratio plot

Thank you for your attention!

Nuclear Modification Factor (R_{eAu})

simulation campaign: 04/2026

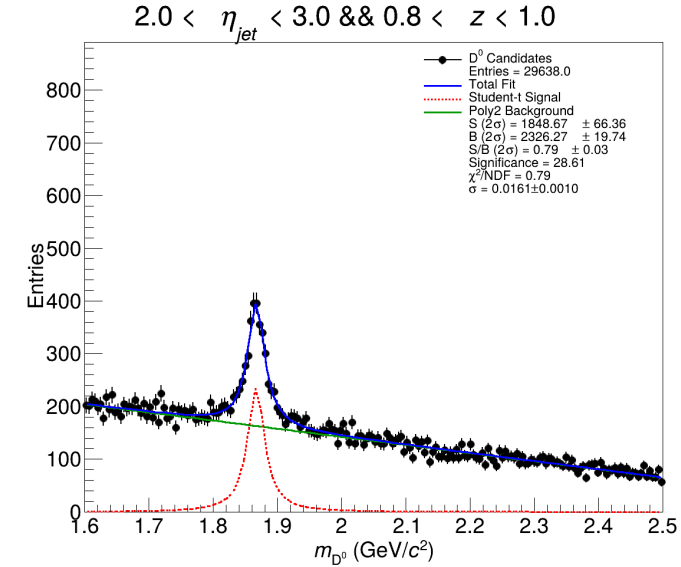
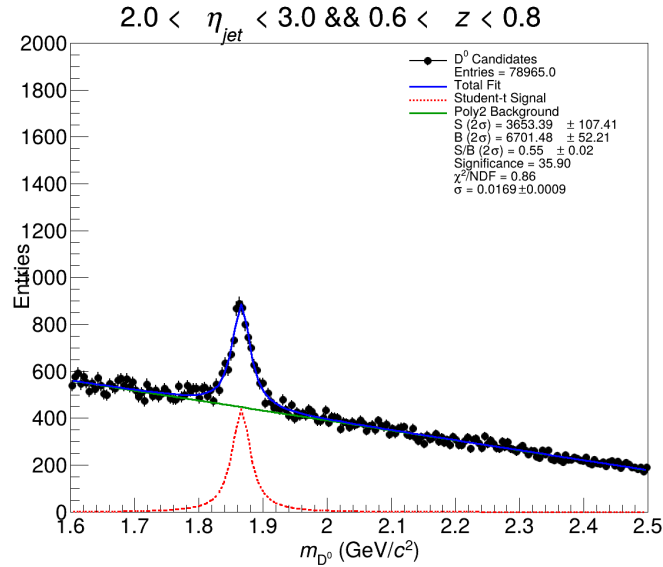
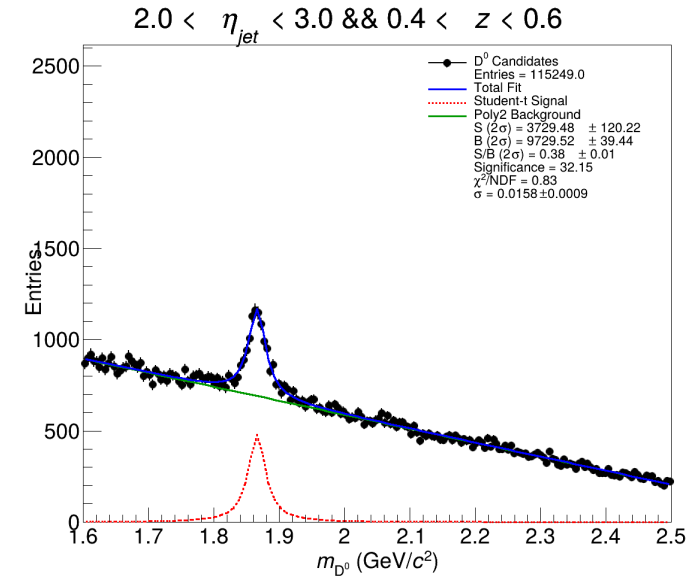
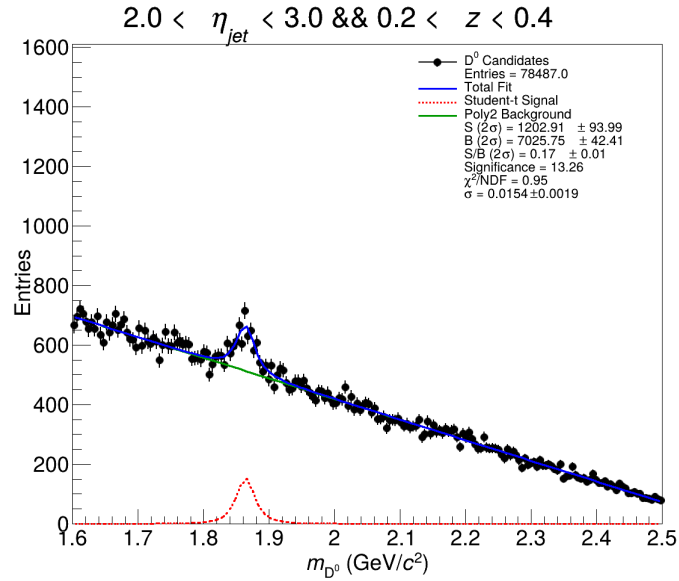


After PID+ Preselection + ML

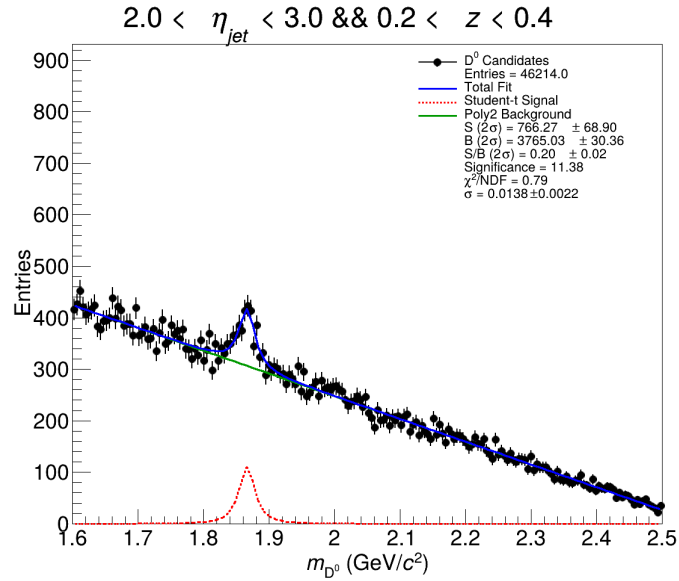
Invariant Mass Spectra (e+p): April Campaign

After PID+ Preselection

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



Invariant Mass Spectra (e+Au): April Campaign



After PID+ Preselection

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

$$L_{int}(sim) = \frac{N_{DIS}}{\sigma_{MB}(Q^2 > 1)}$$

Q_i bins: 1-10, 10-100

$$f_i = \frac{\sigma(Q_i^2)}{\sigma(Q^2 > 1)}$$

Slide 5

Scaling on cross section

