Status of Λ_c/D^0 ratio for the ES

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Data Sample

- D^0 Sample, e+p, 10x250, $Q^2 > 1\ GeV^2$
  - epic:/RECO/**26.04.1**/epic_craterlake/SIDIS/D0_ABCONV/HFsim-PYTHIA/**pythia8.312-2.0**/ep/10x250/q2_1
- Λc Sample, e+p, 10x250, $Q^2 > 1\ GeV^2$
  - epic:/RECO/**26.04.1**/epic_craterlake/SIDIS/Lc_ABCONV/HFsim-PYTHIA/**pythia8.312-2.0**/ep/10x250/q2_1
- NC, DIS Sample e+p, 10x250, $Q^2 > 1\ GeV^2$
  - Command: rucio did list --short "epic:/RECO/26.04.1/epic_craterlake/DIS/pythia6.428-1.0/NC/noRad/ep/10x250/*"
  - epic:/RECO/**26.04.1**/epic_craterlake/DIS/**pythia6.428-1.0**/NC/noRad/ep/10x250/q2_1to10
  - epic:/RECO/**26.04.1**/epic_craterlake/DIS/**pythia6.428-1.0**/NC/noRad/ep/10x250/q2_10to100
  - epic:/RECO/**26.04.1**/epic_craterlake/DIS/**pythia6.428-1.0**/NC/noRad/ep/10x250/q2_100to1000
  - epic:/RECO/**26.04.1**/epic_craterlake/DIS/**pythia6.428-1.0**/NC/noRad/ep/10x250/q2_1000to10000

Prepare file: test.list for the analysis using the script Prepare_file_ep.sh

Note that gold thickness is increased from 5 μm to 10 μm (degradation in DCA_T ~20%)

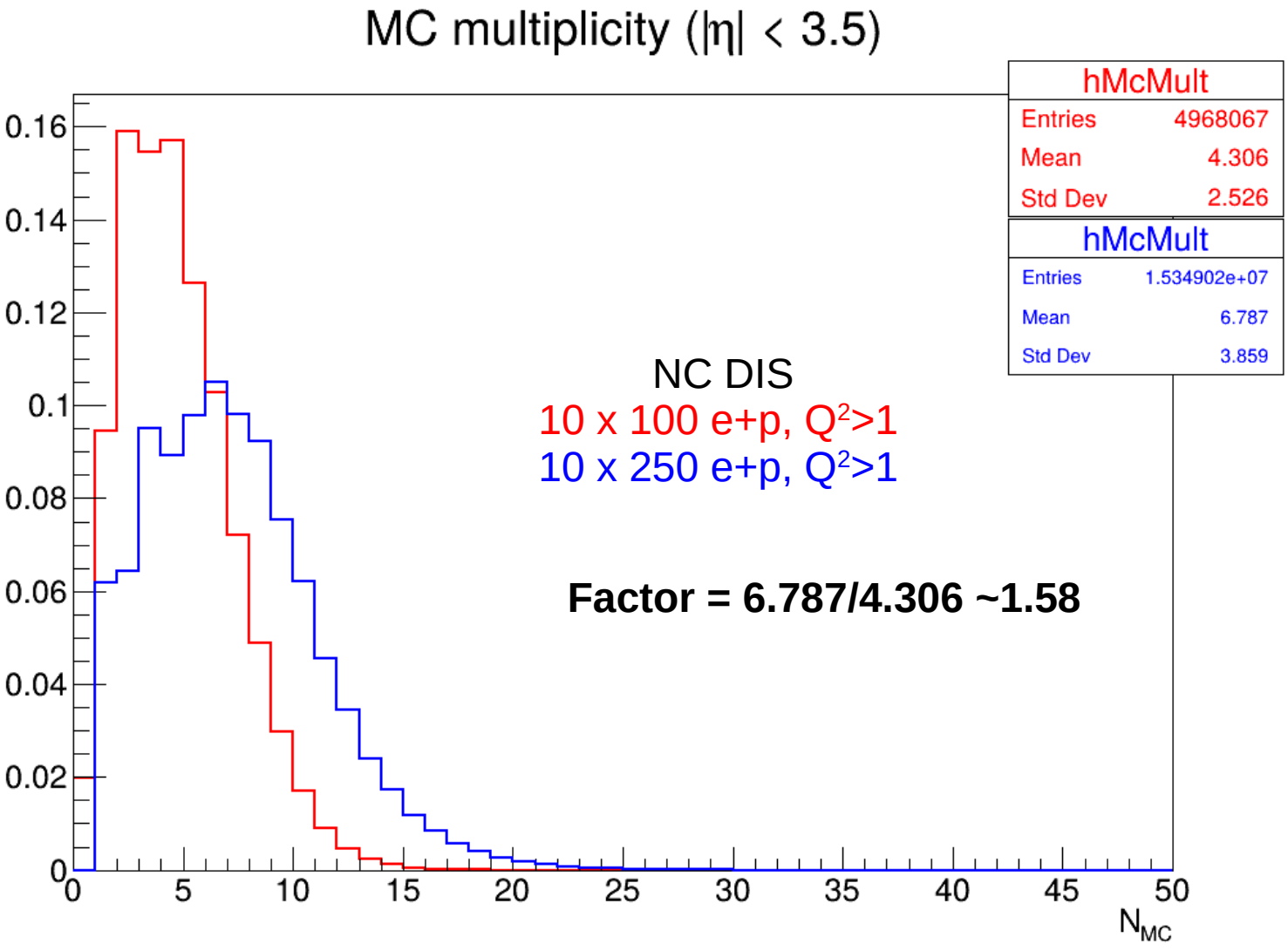
$$\sqrt{s}(10\times250)\sim100\,\text{GeV}$$

$$\sqrt{s}(9\times275)\sim100\,\text{GeV}$$

Species	Beam energy (GeV)	Integrated luminosity	Electron-beam polarization	Hadron-beam polarization
e+Ag	9×115	1.0 fb^{-1}	NO	N/A
e+D	9×130	1.5 fb^{-1}	LONG	NO
$e+p$	9×130	1.0 fb^{-1}	LONG	TRANS and/or LONG
$e+p$	9×275	2.5 fb^{-1}	LONG	TRANS and/or LONG
e+Au	9×100	1.0 fb^{-1}	LONG	N/A
$e+^3$He	9×166	1.5 fb^{-1}	LONG	TRANS and/or LONG

Table 1: EIC Early Science Matrix. The eA luminosity is per nucleon.

Multiplicity

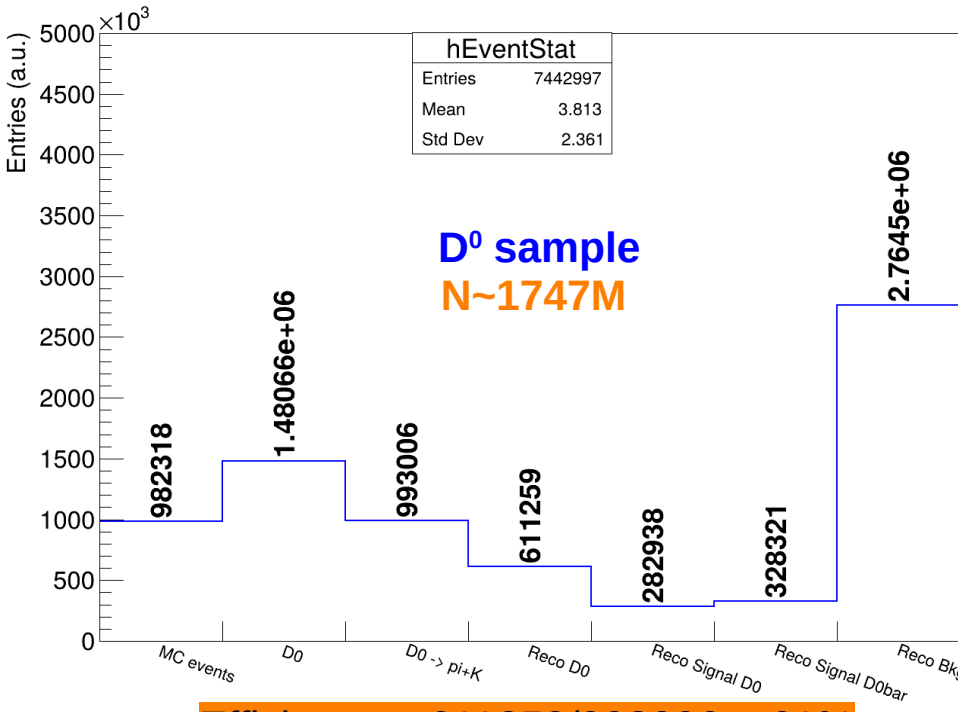


Event Statistics (D^0 meson)

D^0 sample using Real PID

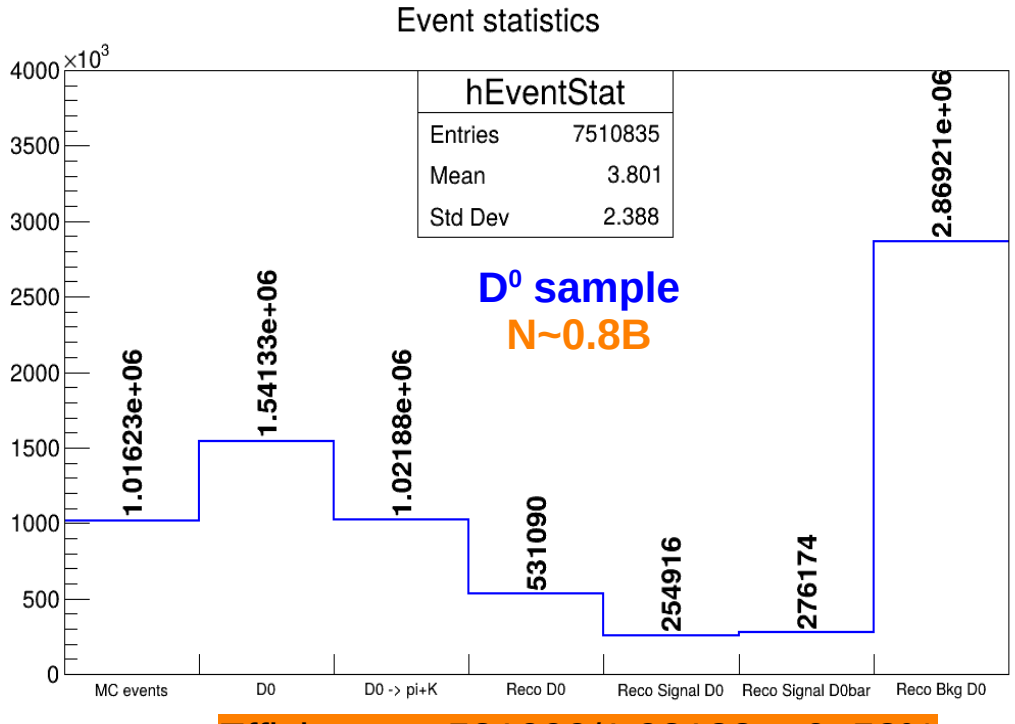
Slide 12

October 2025 (PYTHIA8)
D^0 Sample e+p (**10x100**, Q^2> 1 GeV^2)



Efficiency = 611259/993006 ~ 61%

April 2026 (PYTHIA8)
D^0 Sample e+p (**10x250**, Q^2> 1 GeV^2)



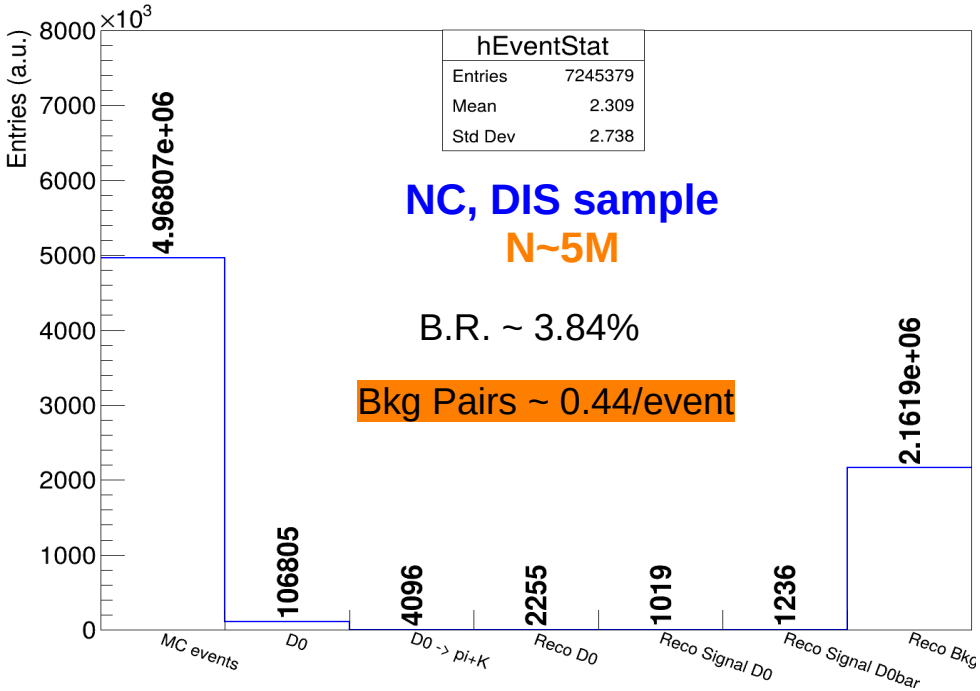
Efficiency = 531090/1.02188e+6~52%

Event Statistics (D^0 meson)

NC DIS sample using Real PID

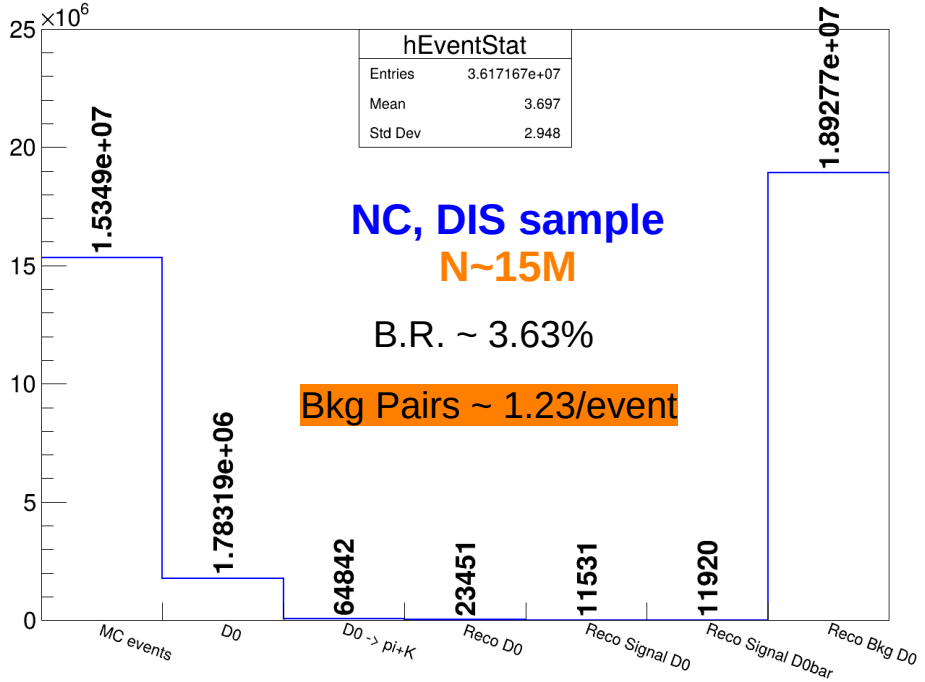
Slide 12

October 2025 (PYTHIA8)
DIS Sample e+p (**10x100**, $Q^2 > 1$ GeV^2)



Efficiency = 2255/4096 ~ 55%

April 2026 (PYTHIA6)
DIS Sample e+p (**10x250**, $Q^2 > 1$ GeV^2)



Efficiency = 23451./64842 ~ 36%

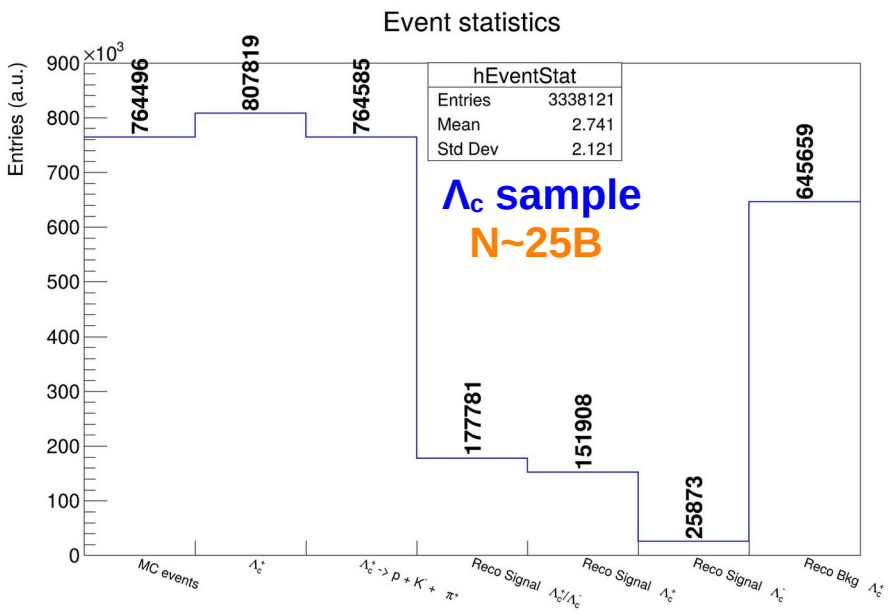
Event Statistics (Λ_c baryon)

Λ_c sample using Real PID

Slide 12

October 2025 (PYTHIA8)

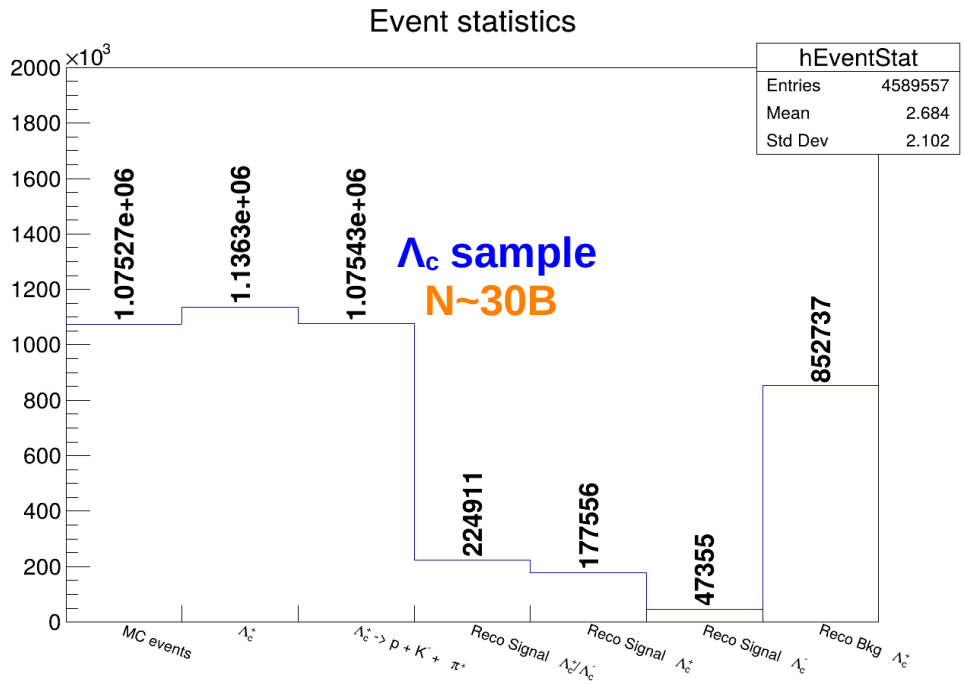
Λ_c Sample e+p (**10x100**, Q^2> 1 GeV^2)



Efficiency = 177781/764585 ~ 23%

April 2026 (PYTHIA8)

D^0 Sample e+p (**10x250**, Q^2> 1 GeV^2)



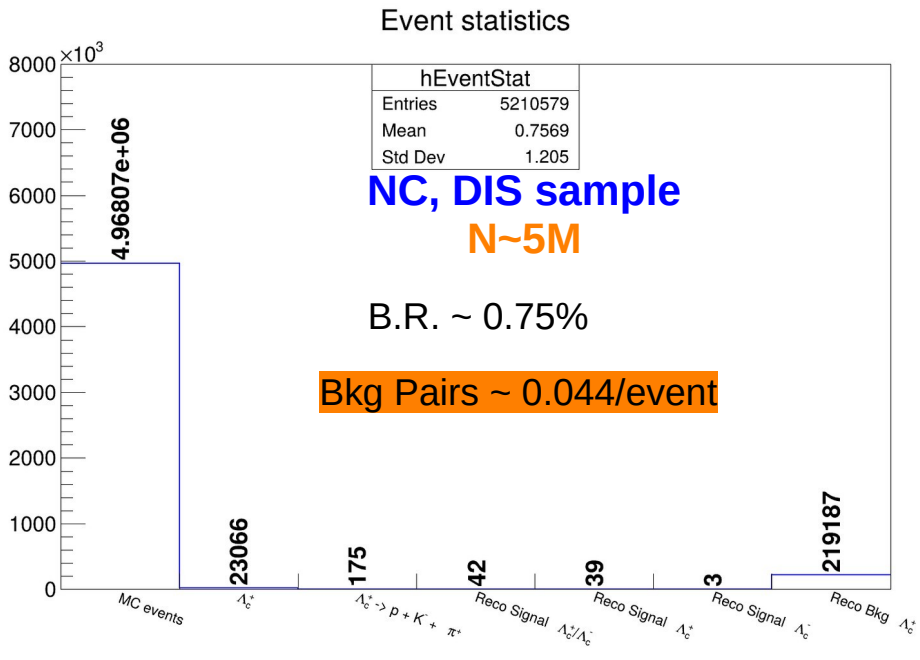
Efficiency = 224911/1.07543e+6 ~ 21%

Event Statistics (Λ_c baryon)

NC DIS sample using Real PID

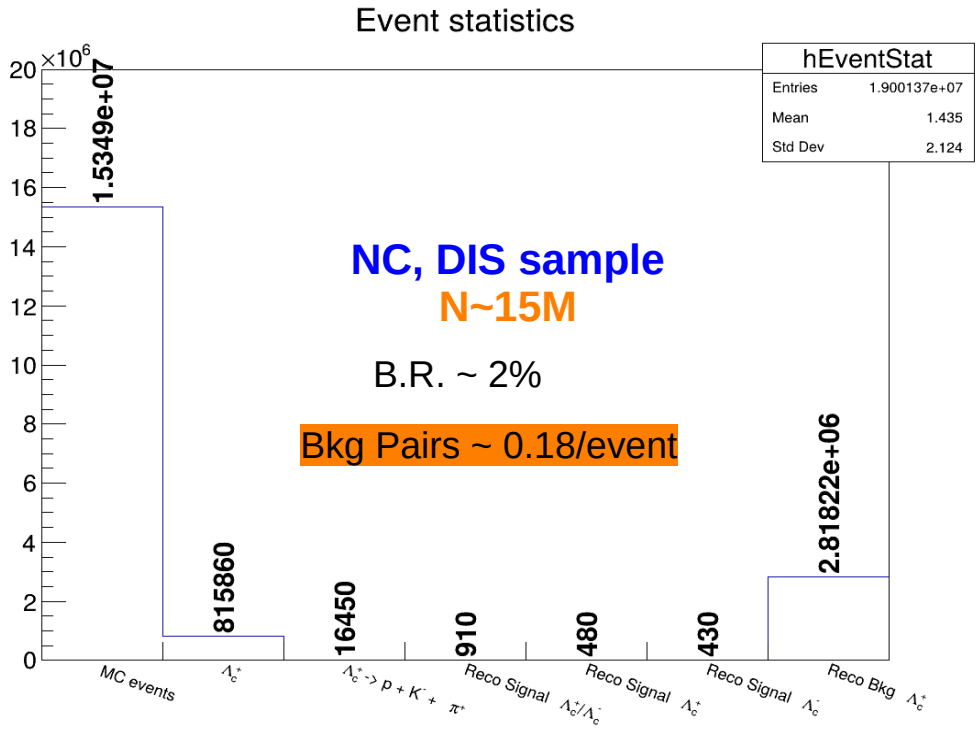
Slide 12

October 2025 (PYTHIA8)
DIS Sample e+p (**10x100**, Q^2> 1 GeV^2)



Efficiency = 42/175 ~ 24%

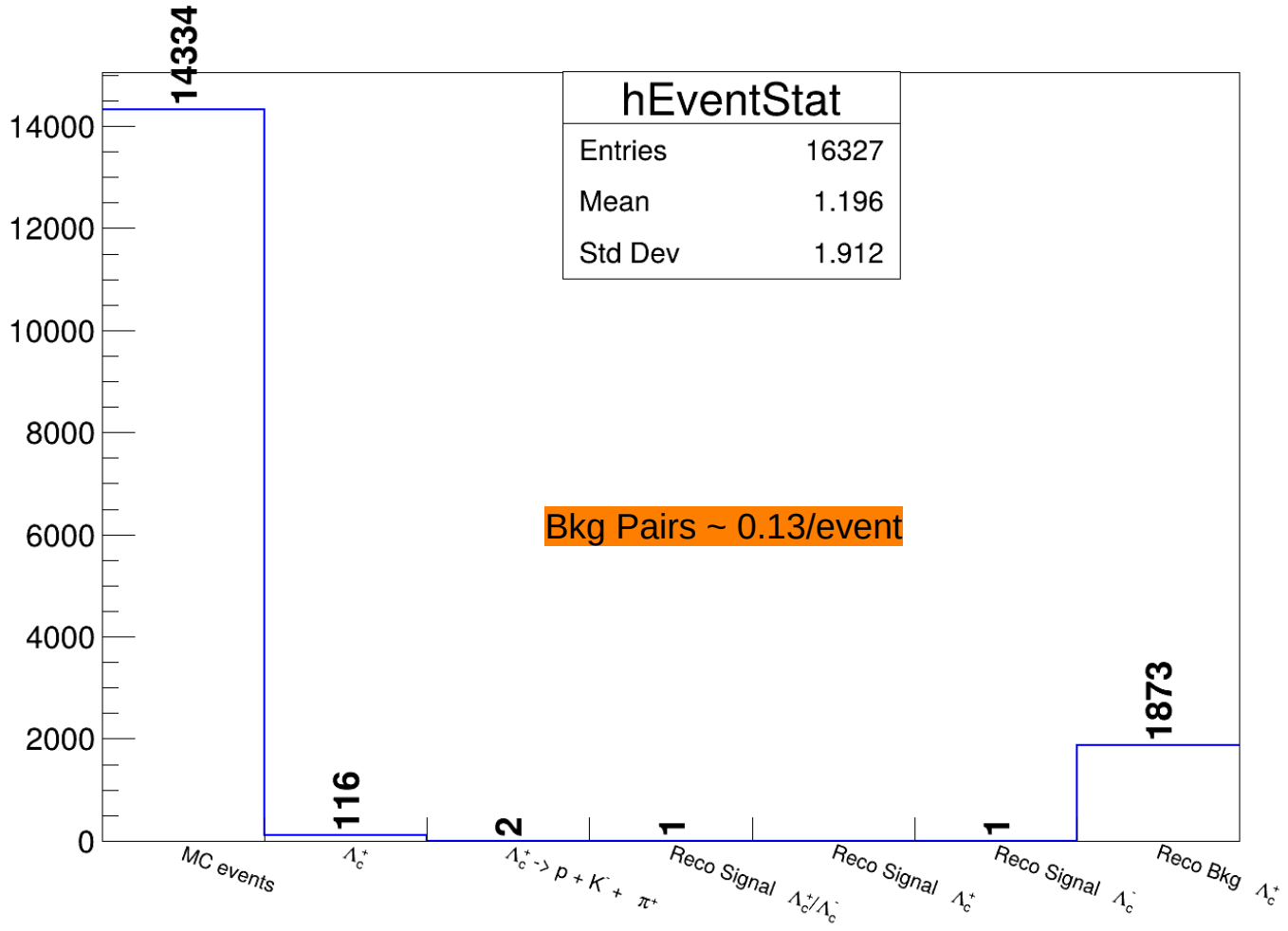
April 2026 (PYTHIA6)
DIS Sample e+p (**10x250**, Q^2> 1 GeV^2)



Efficiency = 910/16450 ~ 5.5%

DIS Sample (May Campaign)

"epic:/RECO/**26.05.0**/epic_craterlake/DIS/**pythia8.316-1.0**/NC/noRad/ep/10x250/q2_1to10"
"epic:/RECO/**26.05.0**/epic_craterlake/DIS/**pythia8.316-1.0**/NC/noRad/ep/10x250/q2_10to100
"epic:/RECO/**26.05.0**/epic_craterlake/DIS/**pythia8.316-1.0**/NC/noRad/ep/10x250/q2_100to1000"



Λ_c Reconstruction

Signal for Λc sample while combinatorial bkg from DIS Sample

Corrections on signal:

1. Weight factor of 3 on signal for $Q^2 < 5\ GeV^2$
2. Branching Ratio Scaling
3. Scaling to target luminosity 2.5 fb^{-1}

Bkg:

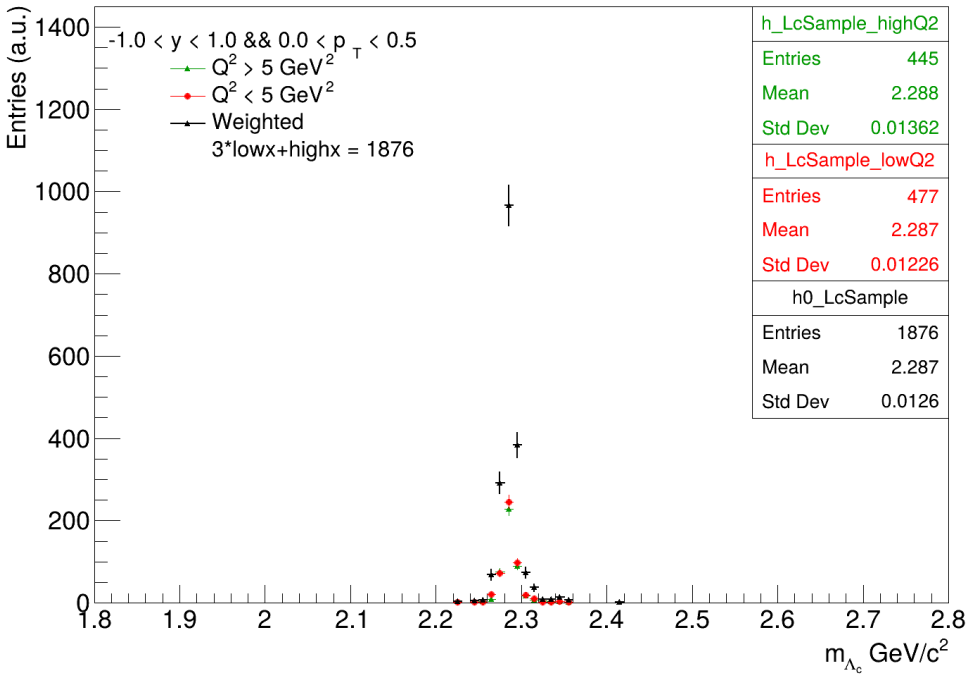
1. Scaling to targeted luminosity

preselection_cuts='(mass_Lcp > 1.8 && mass_Lcp < 2.8) && d0xy_p<10. && d0xy_pi<10. && d0xy_k<10. && chi2 <10.'

Applying weight factor on Signal (Checks)

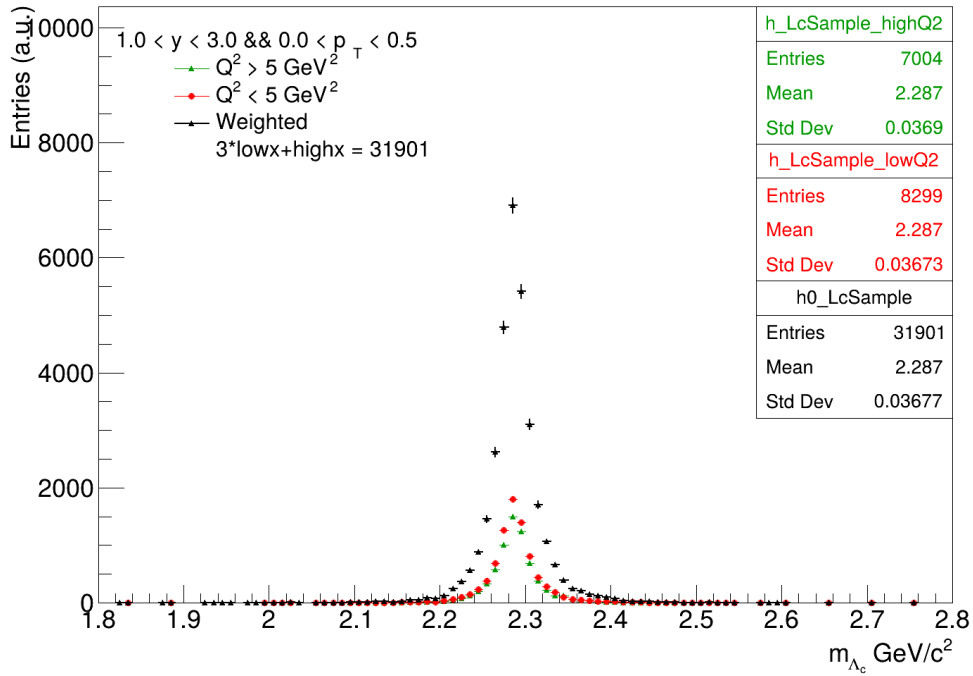
Weight factor of 3 on signal for $Q^2 < 5\ GeV^2$

Mid rapidity



bin 49 x=2.285 low=246+/-15.6844 high=228+/-15.0997
weighted=966+/-49.4166 expected=966+/-49.4166

Forward rapidity

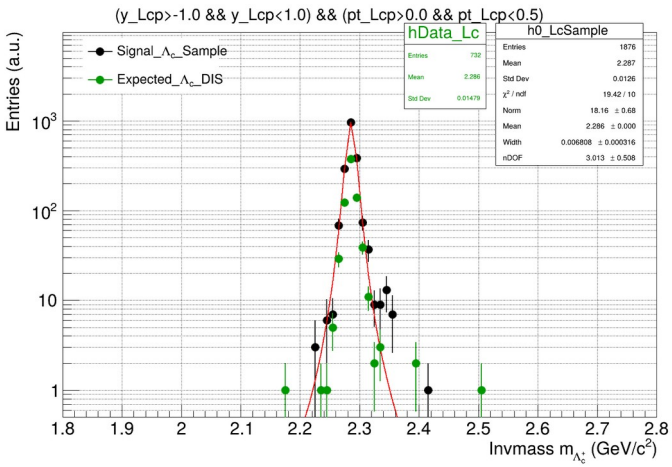


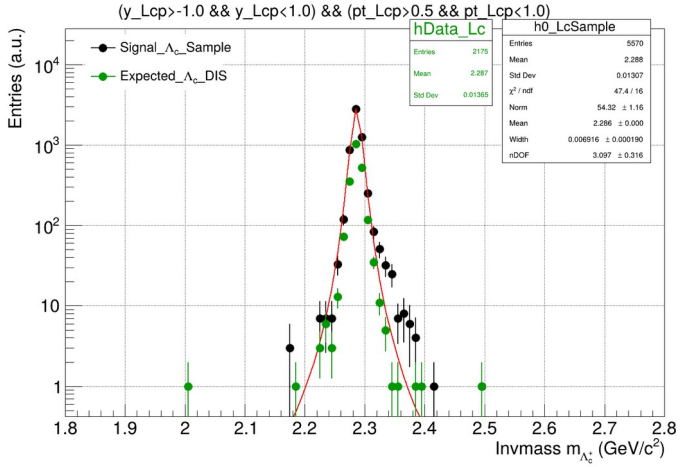
bin 49 x=2.285 low=1804+/-42.4735 high=1497+/-38.6911
weighted=6909+/-133.165 expected=6909+/-133.165

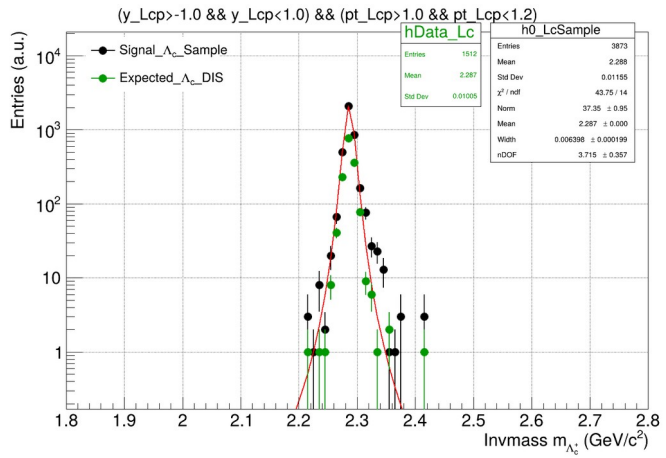
Sampling Signal (-1 < y < 1)

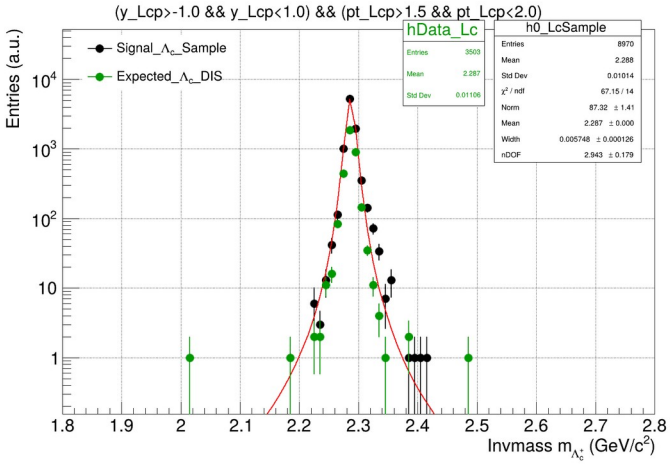
B.R. Scaling = 0.0635/0.0075 ~8.47

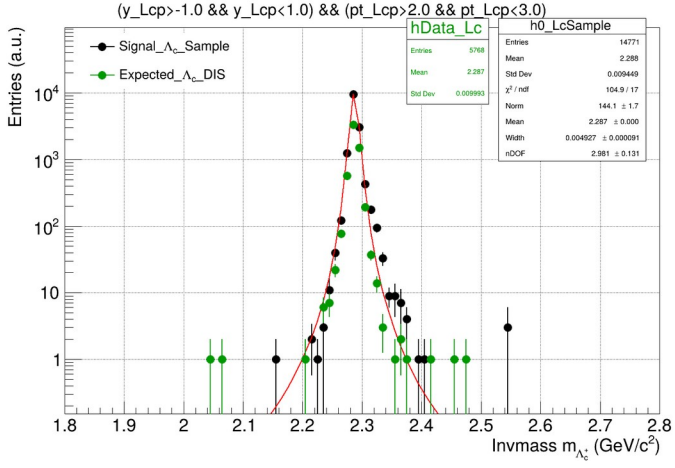
$L_{int} = 54.2\,fb^{-1}$ (Q2 Weighted) $L_{int} = 2.5\,fb^{-1}$

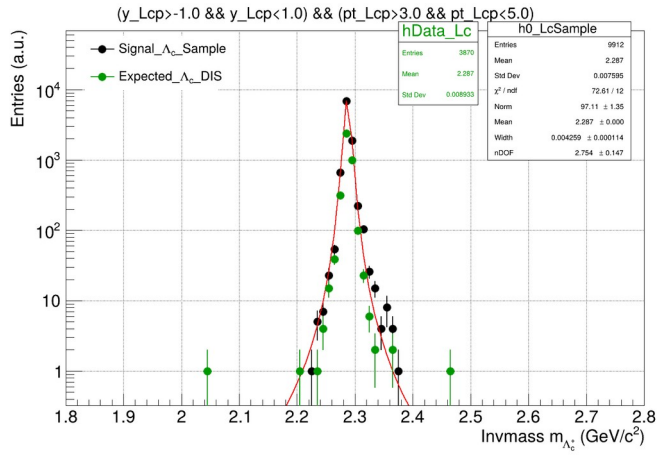








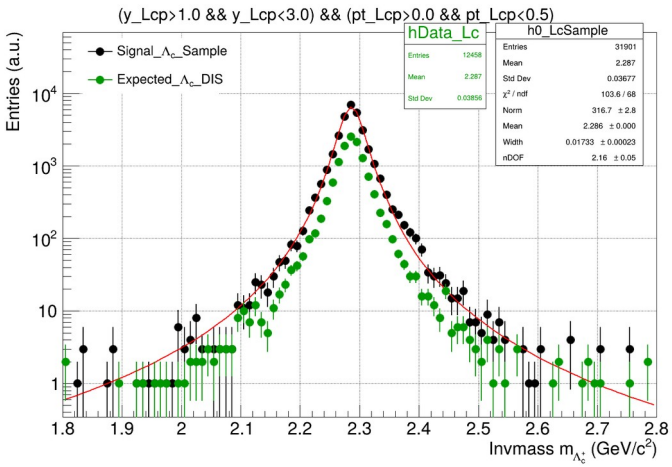


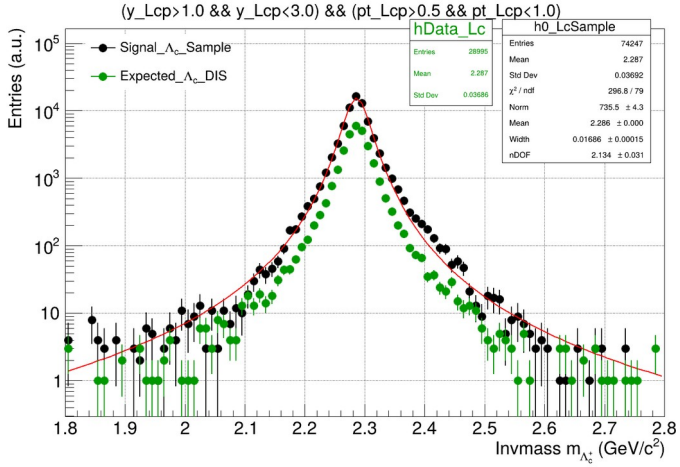


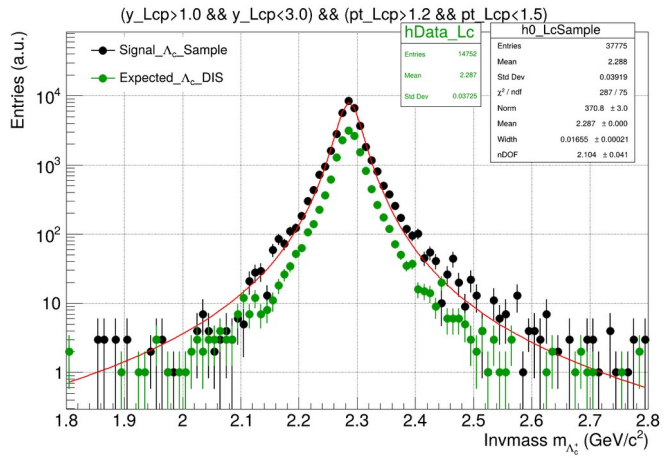
Sampling Signal (1 < y < 3)

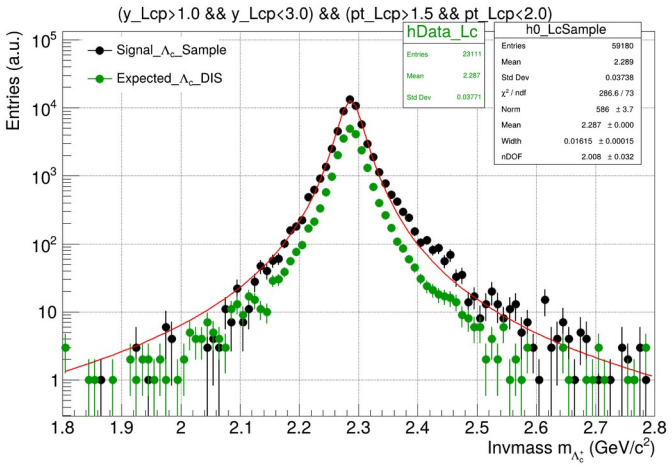
B.R. Scaling = 0.0635/0.0075 ~8.47

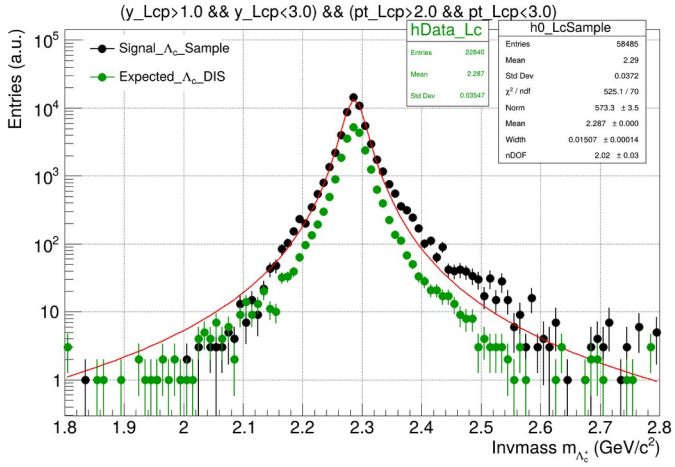
$L_{int} = 54.2\,fb^{-1}$ (Q2 Weighted) $L_{int} = 2.5\,fb^{-1}$

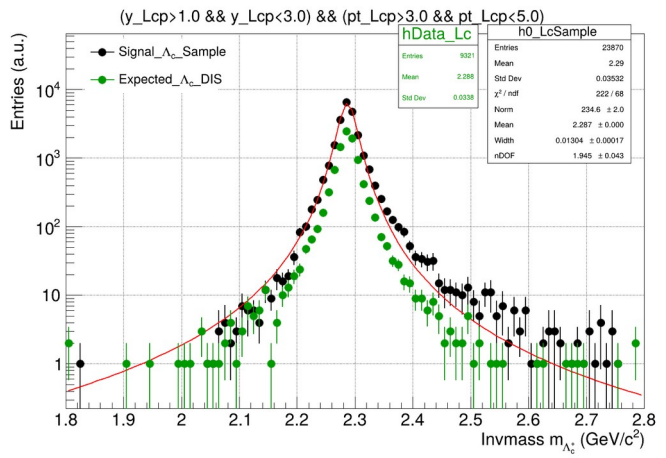






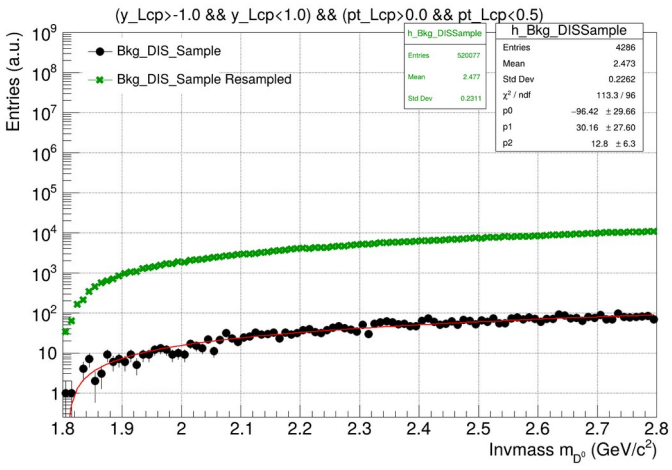


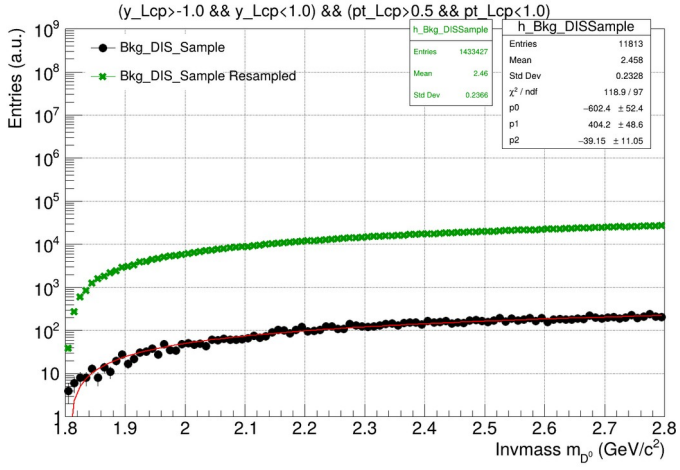


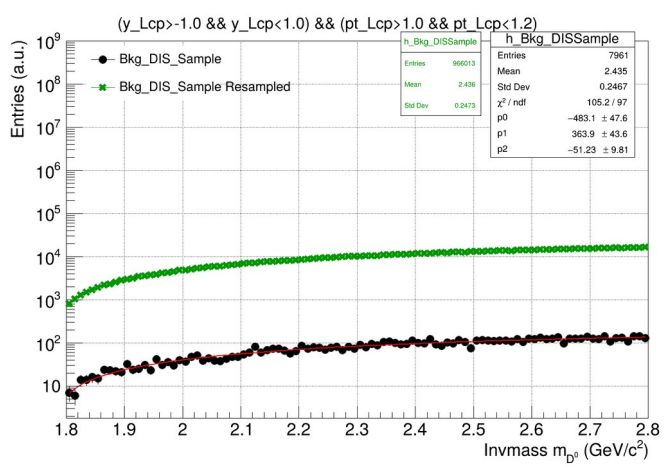


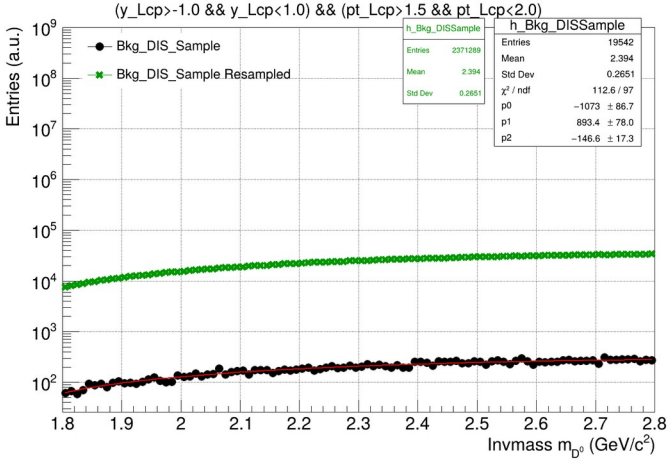
Sampling Background (-1 < y < 1)

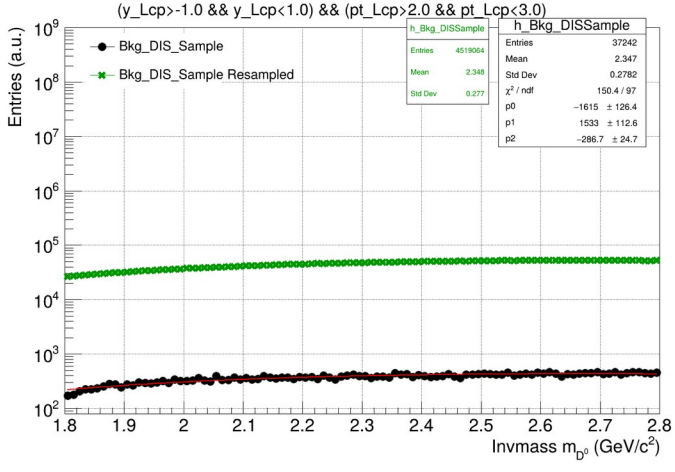
$L_{int} = 0.020602717\ fb^{-1}$ $L_{int} = 2.5\ fb^{-1}$

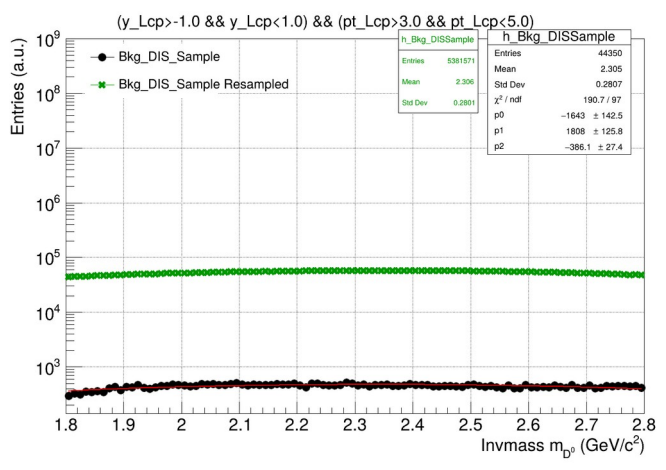












Sampling Background (1 < y < 3)

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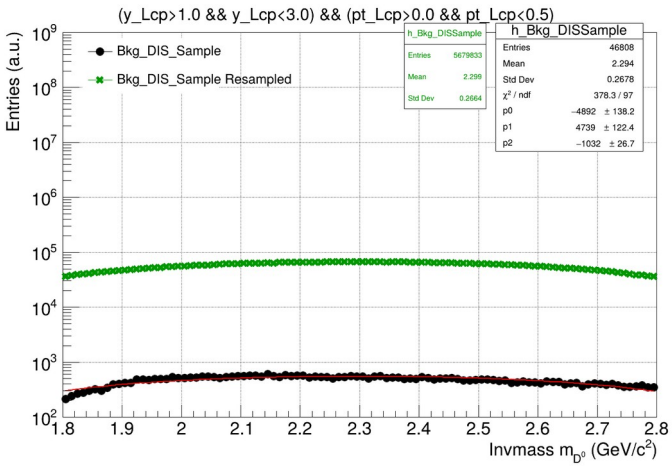
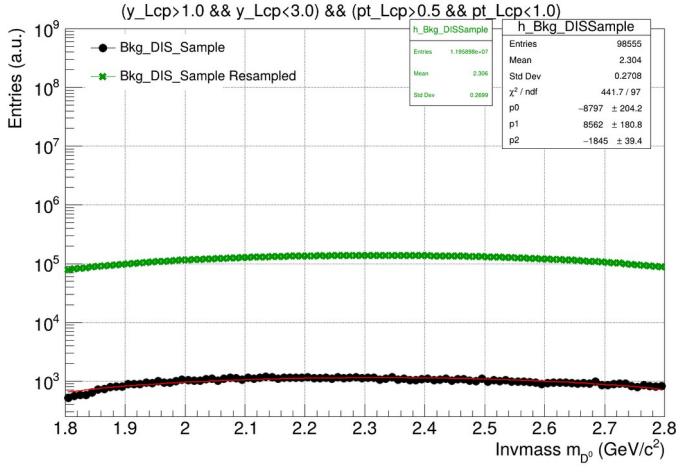
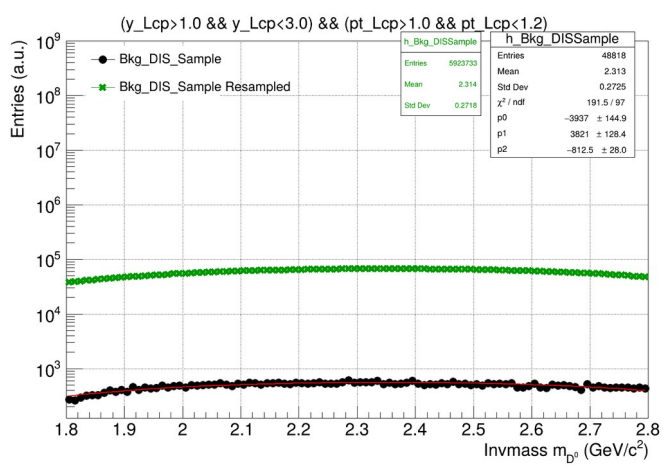
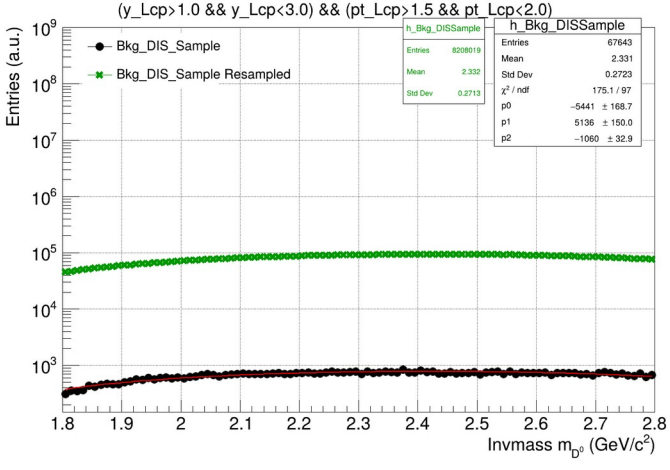
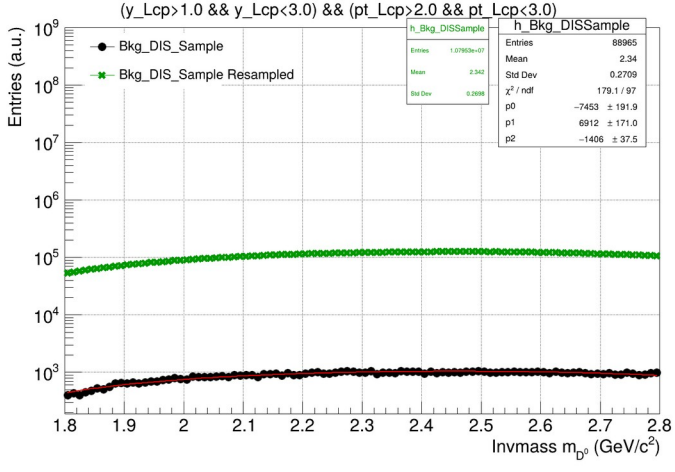
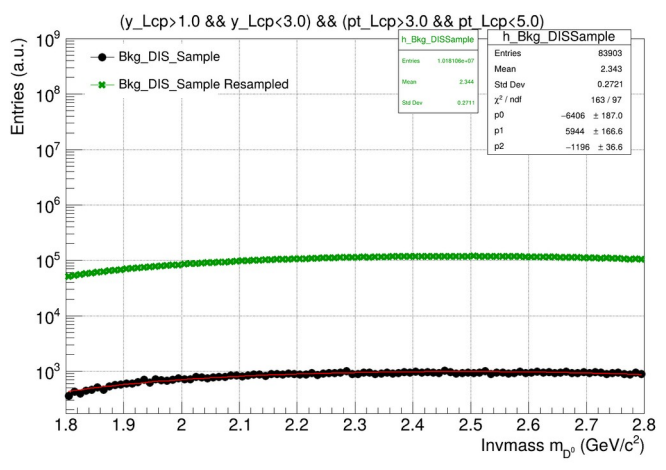






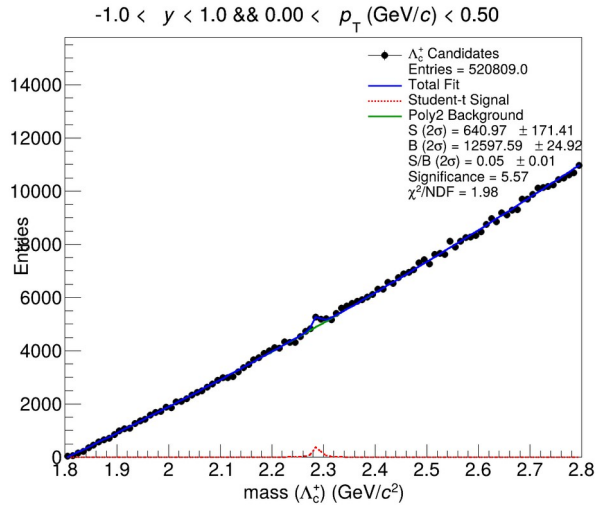


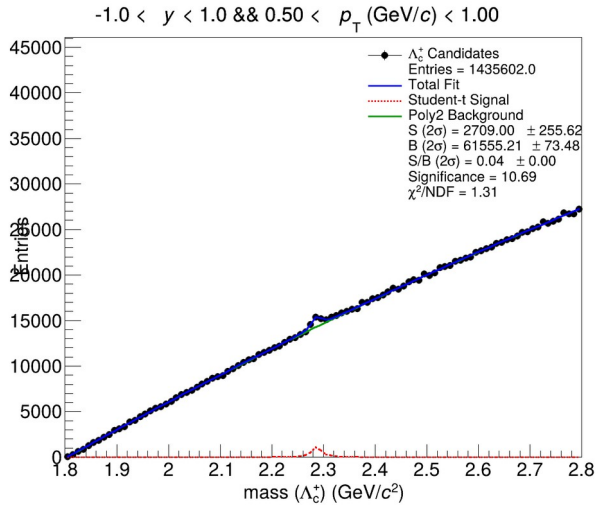


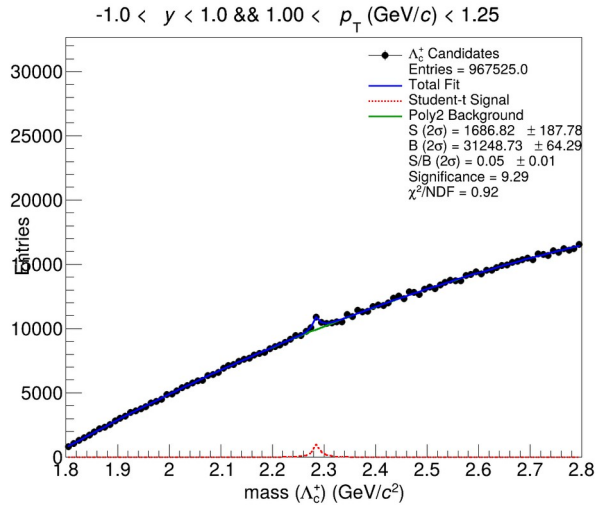


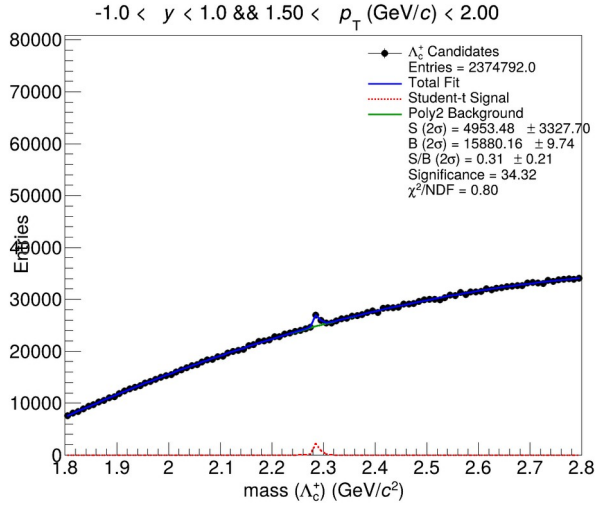
Invariant Mass (Λ_c)

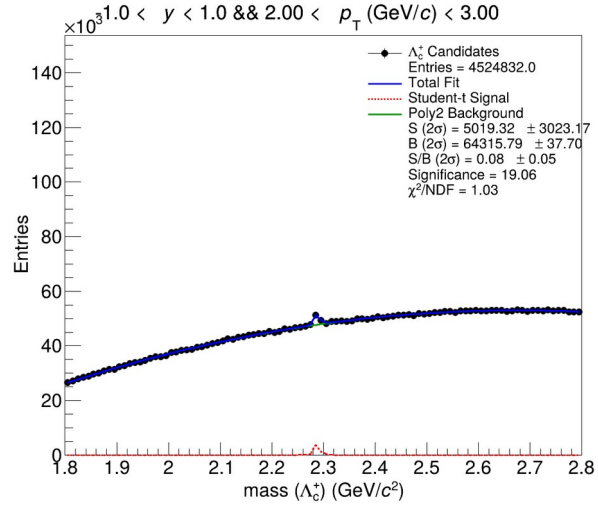
After PID+ Preselection on slide 9

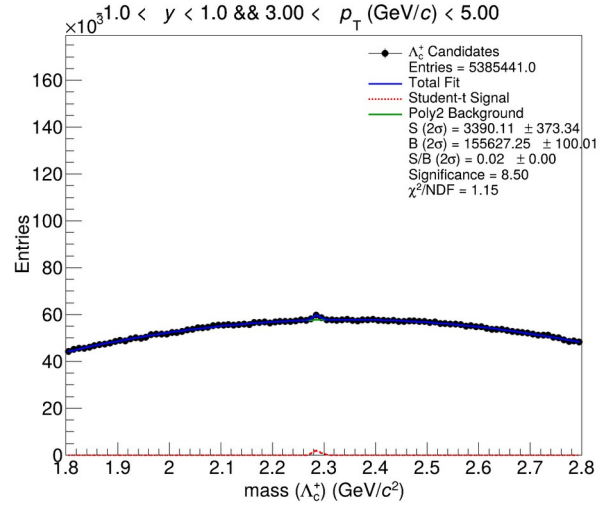






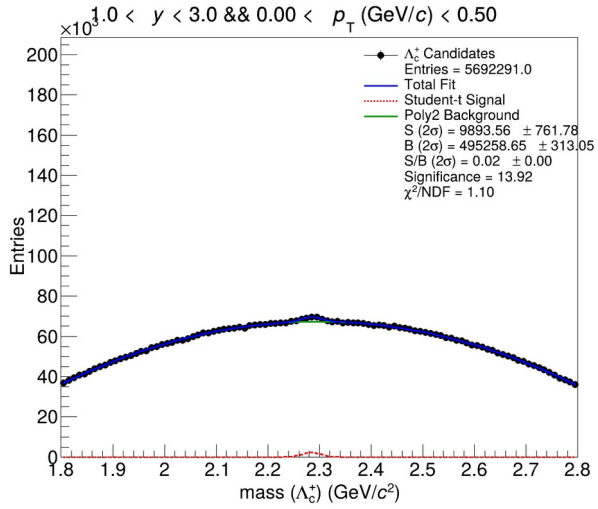


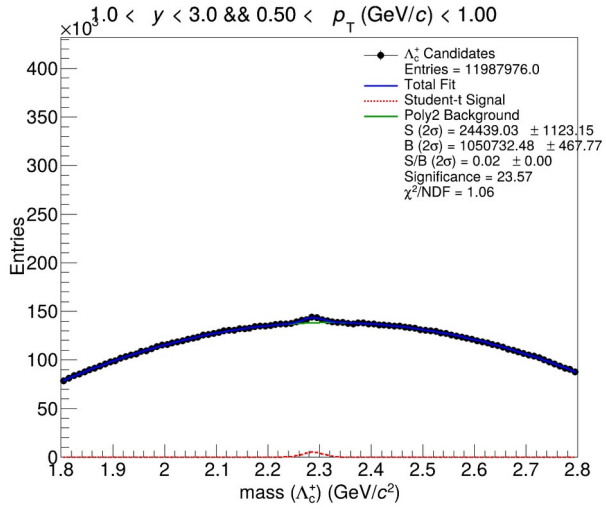


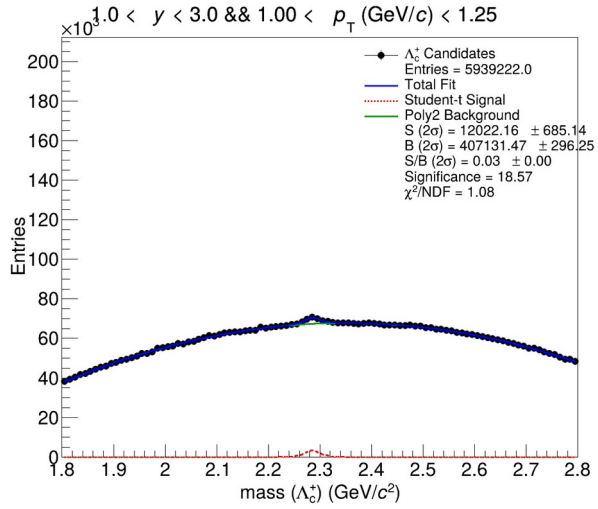


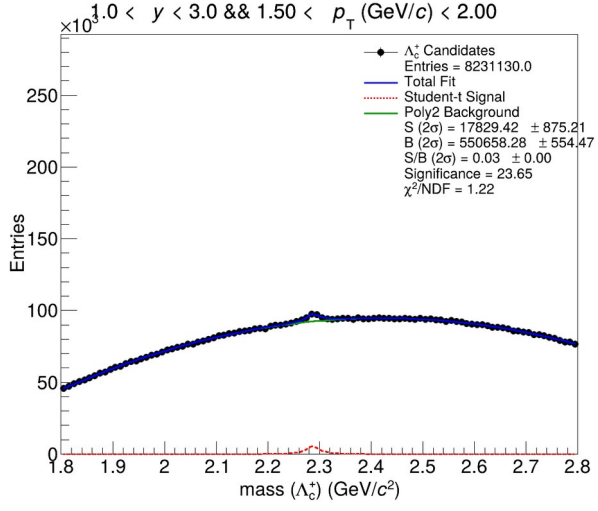
Invariant Mass (Λ_c)

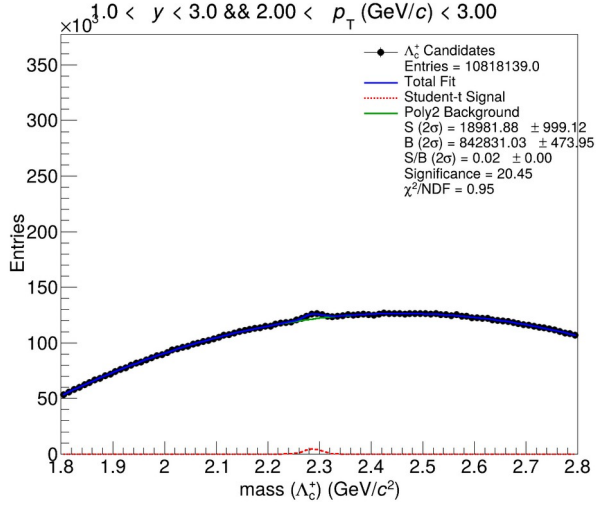
After PID+ Preselection on slide 9

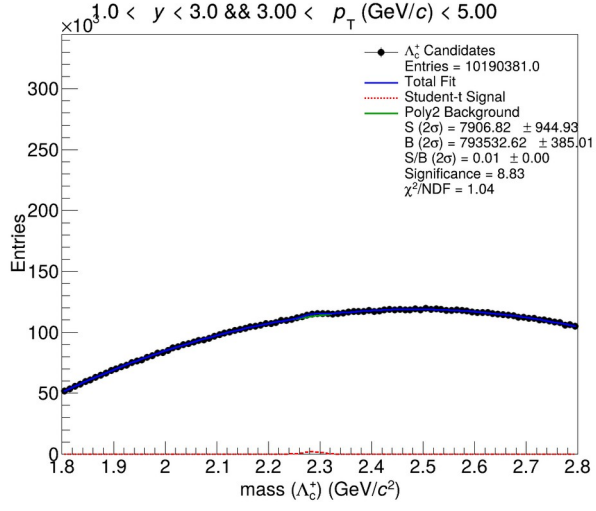












D^0 Reconstruction

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

Corrections on signal:

1. Weight factor of 3 on signal for $Q^2 < 5\ GeV^2$
2. Scaling to target luminosity 2.5 fb^{-1}

Bkg:

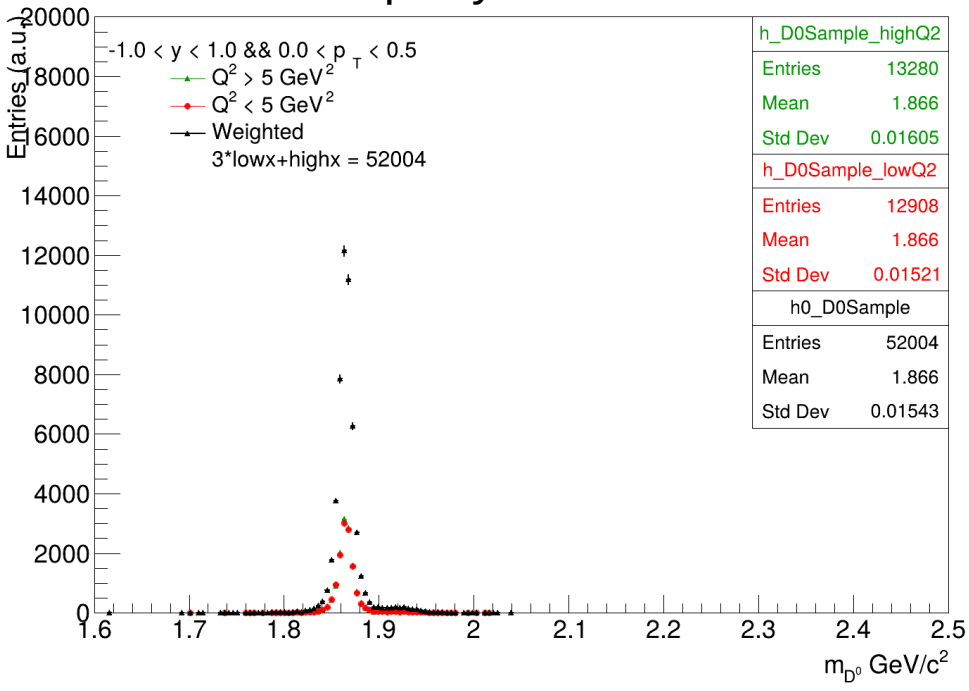
1. Scaling to targeted luminosity

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

Applying weight factor on Signal (Checks)

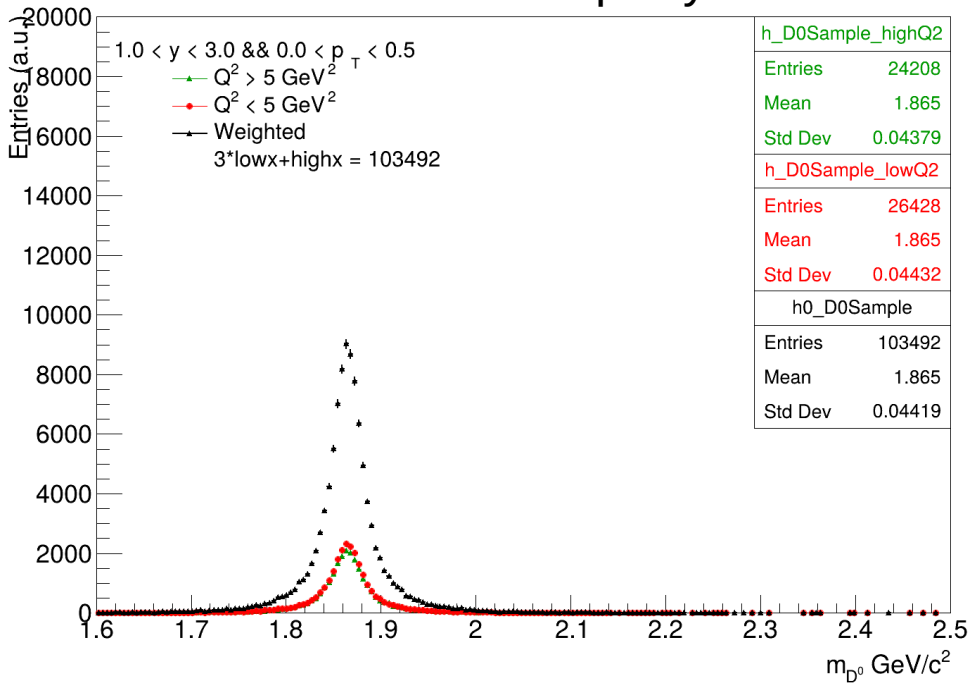
Weight factor of 3 on signal for $Q^2 < 5$ GeV^2

Mid rapidity



bin 49 x=1.81825 low=8+/-2.82843 high=8+/-2.82843
weighted=32+/-8.94427 expected=32+/-8.94427

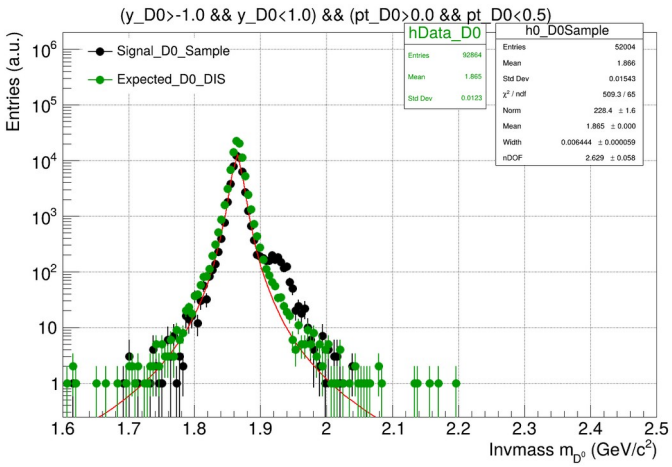
Forward rapidity

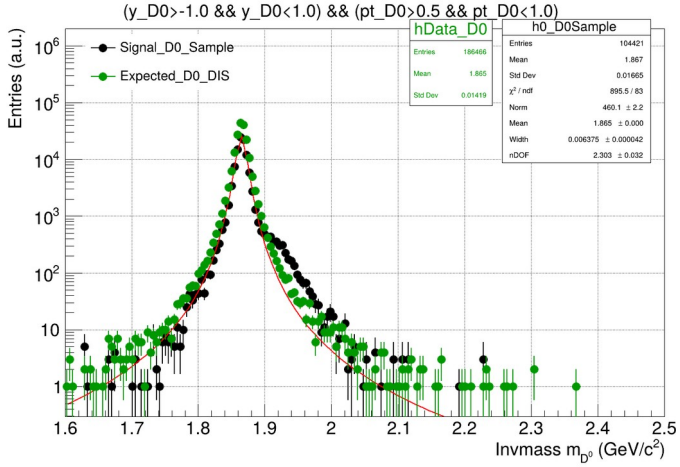


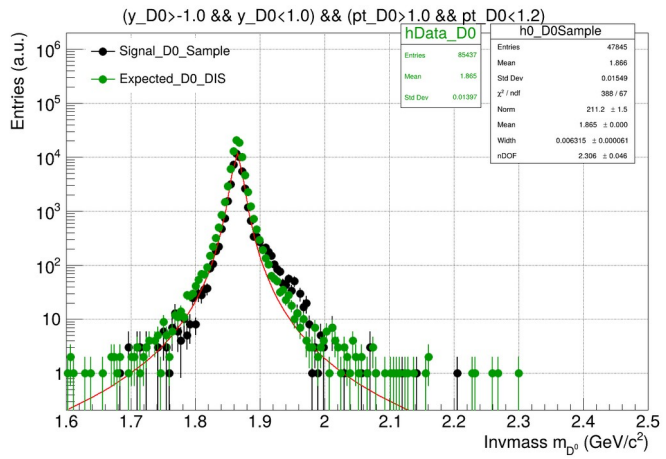
bin 49 x=1.81825 low=281+/-16.7631 high=261+/-16.1555
weighted=1104+/-52.8205 expected=1104+/-52.8205

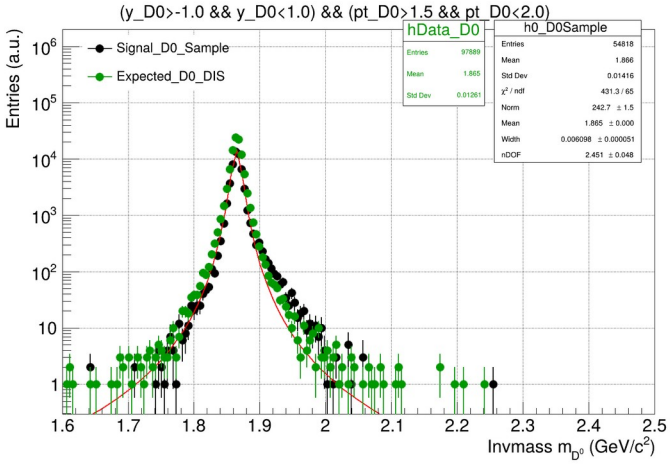
Sampling Signal (-1 < y < 1)

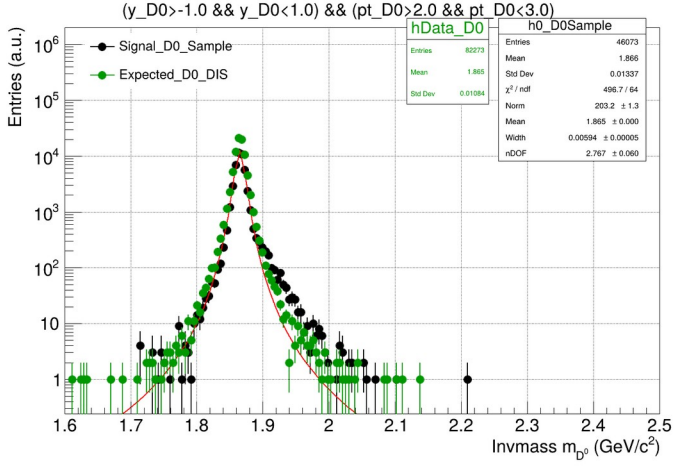
$L_{int} = 1.4\,fb^{-1}$ (Q2 Weighted) $L_{int} = 2.5\,fb^{-1}$

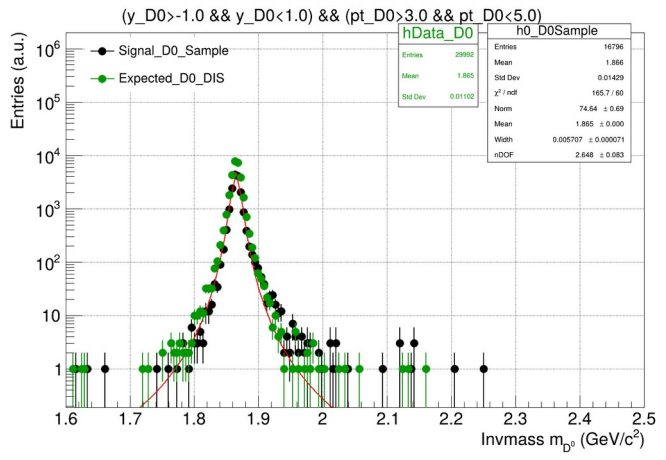






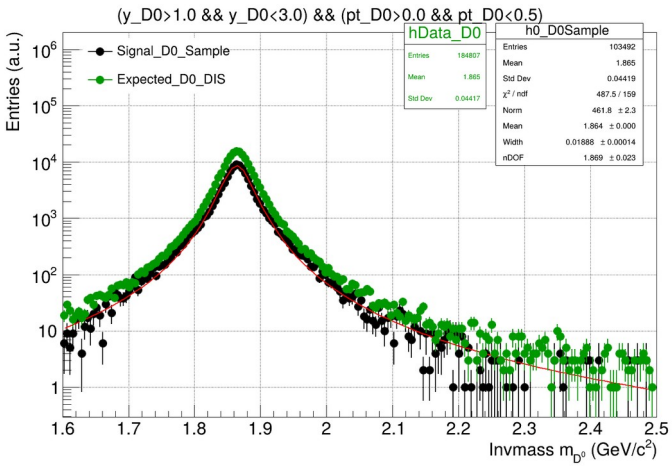


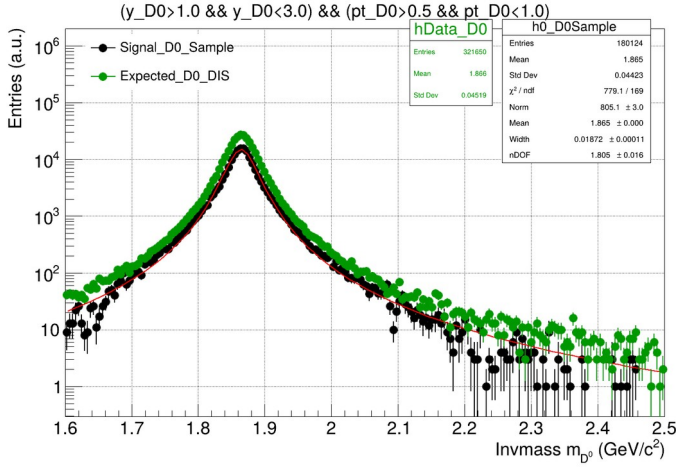


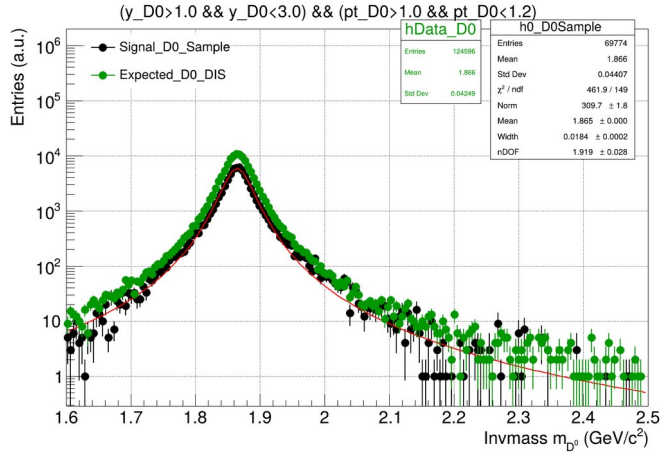


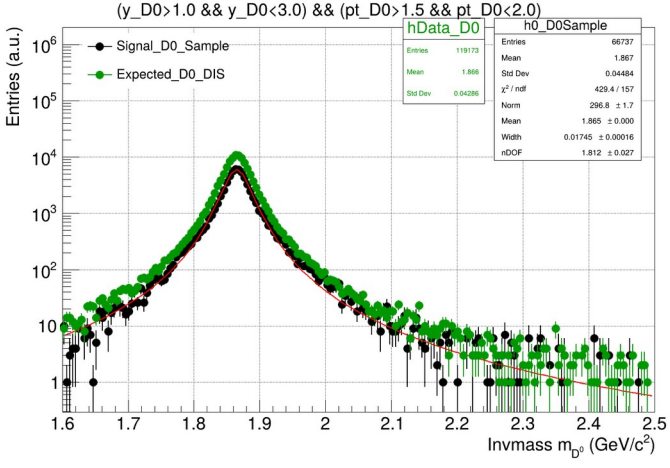
Sampling Signal (1 < y < 3)

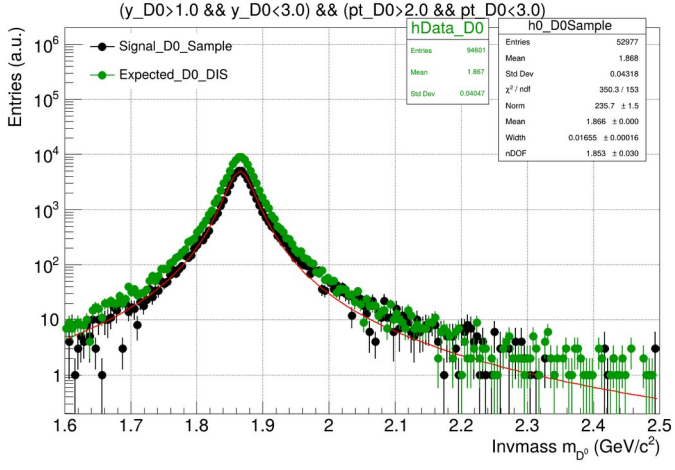
$L_{int} = 1.4\,fb^{-1}$ (Q2 Weighted) $L_{int} = 2.5\,fb^{-1}$

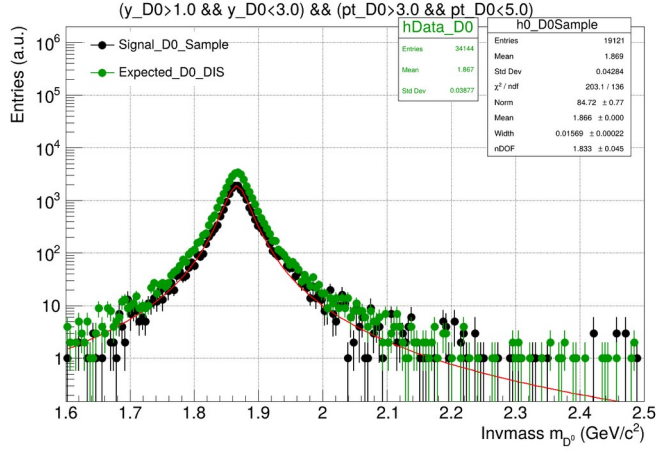






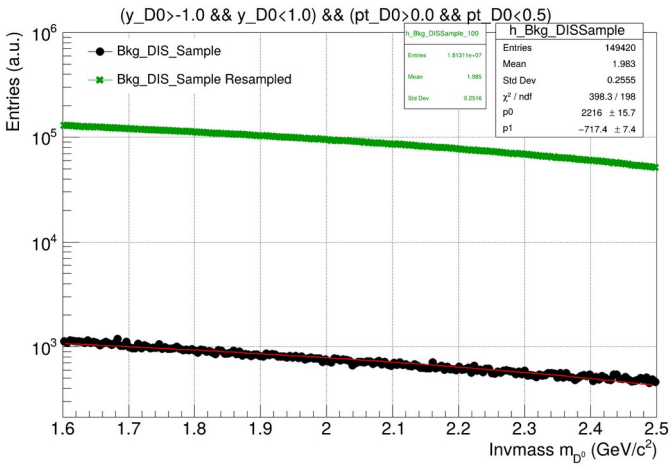


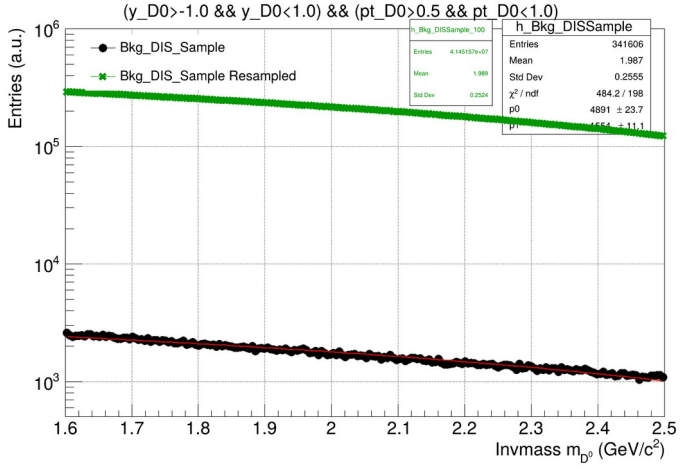


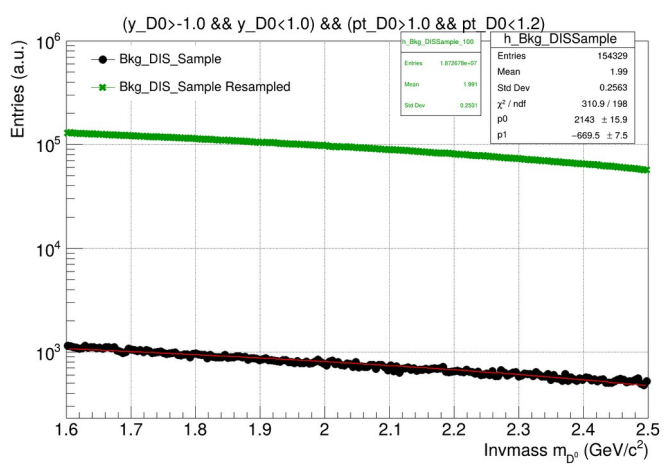


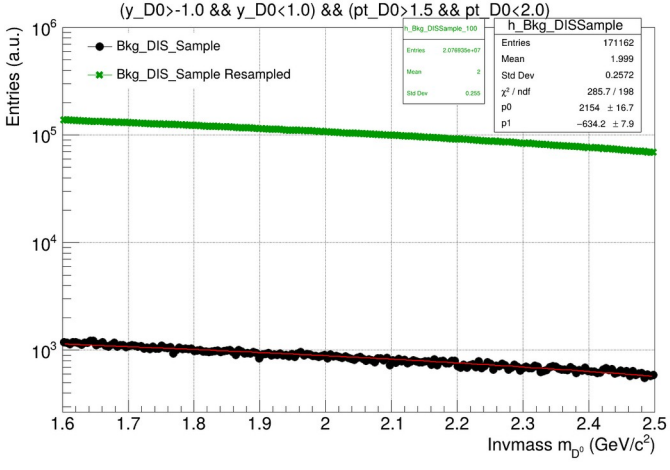
Sampling Background (-1 < y < 1)

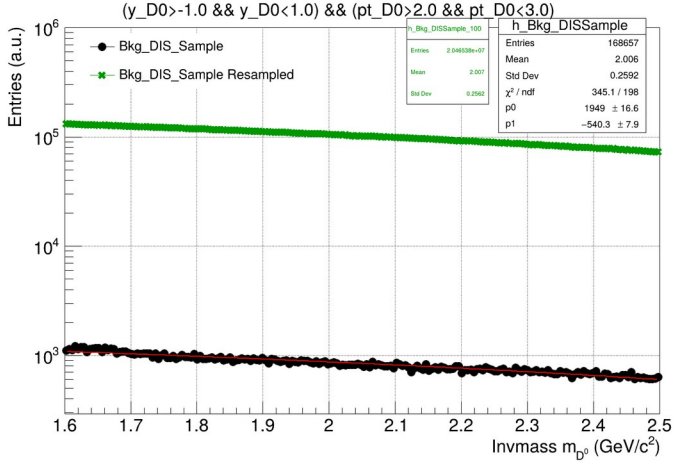
$L_{int} = 0.020602717\ fb^{-1}$ $L_{int} = 2.5\ fb^{-1}$

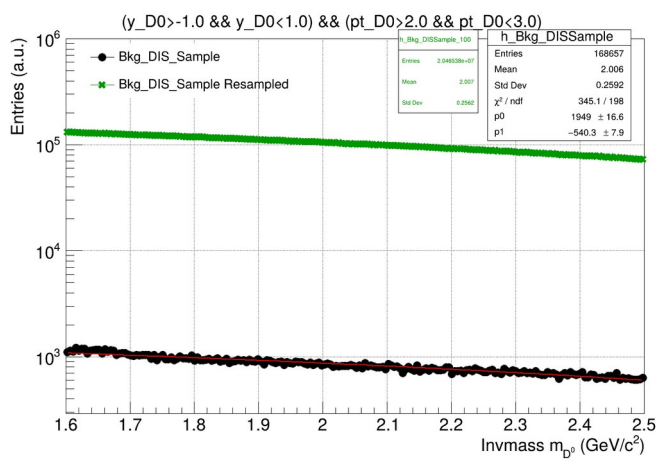






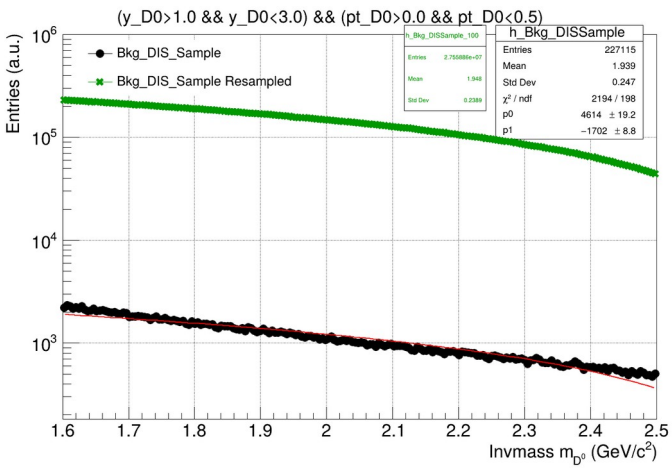


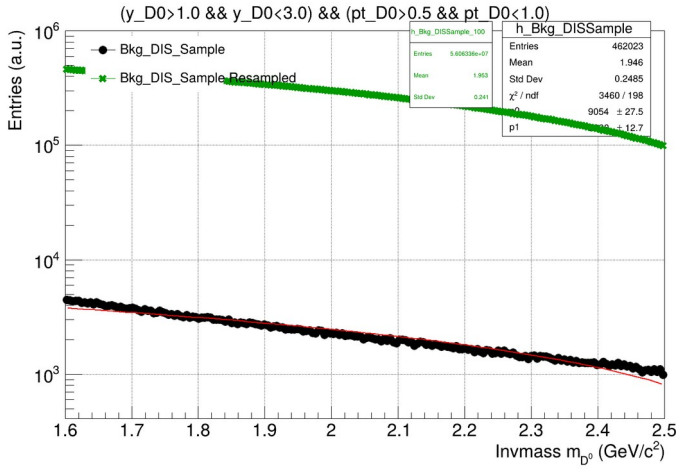


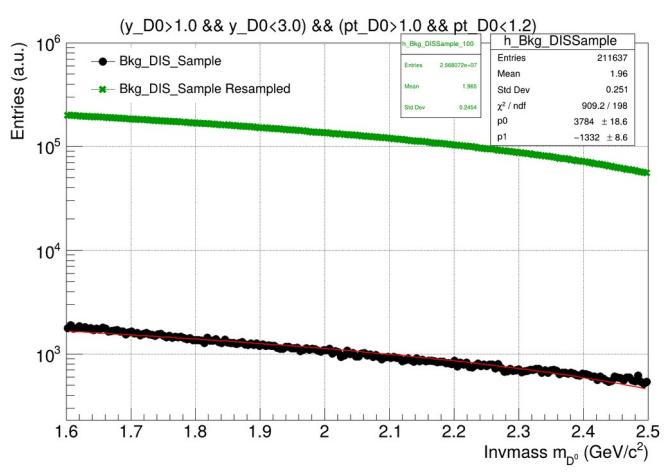


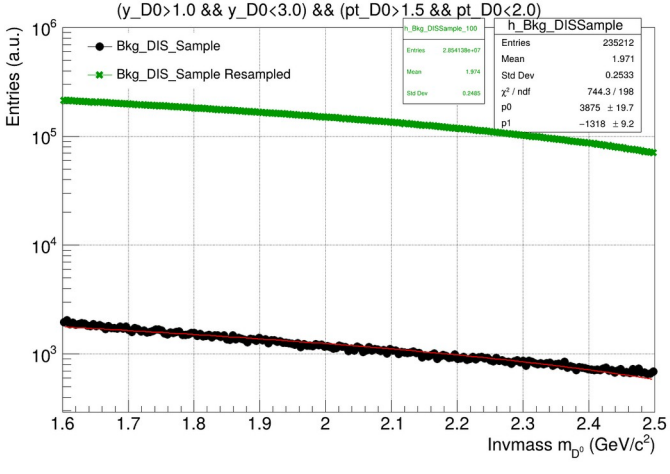
Sampling Background (1 < y < 3)

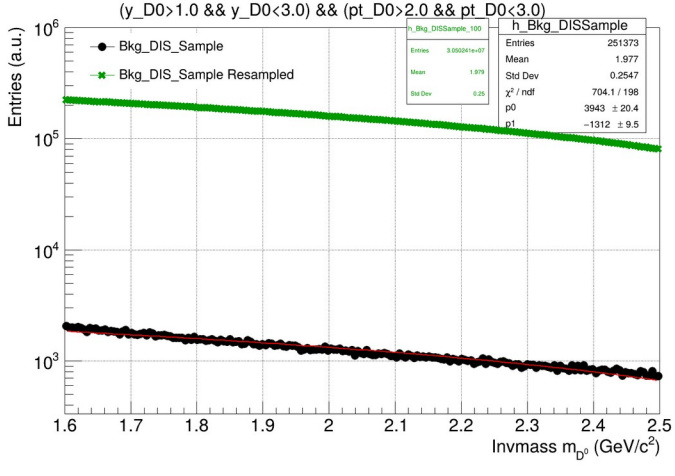
$L_{int} = 0.020602717\ fb^{-1}$ $L_{int} = 2.5\ fb^{-1}$

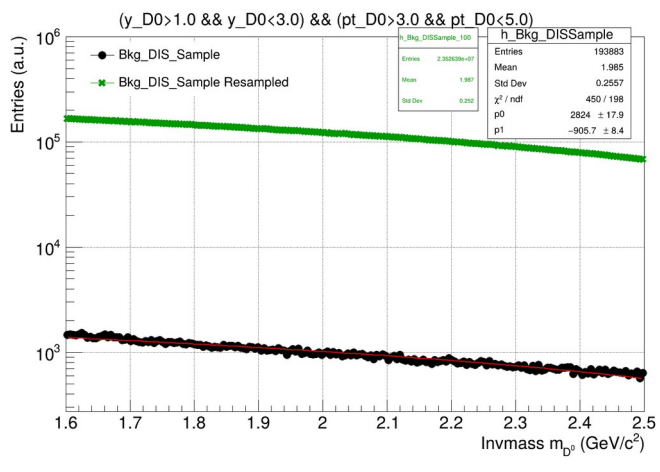






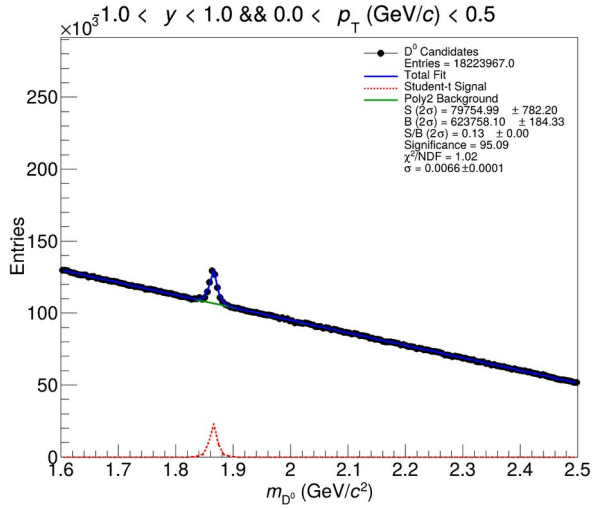


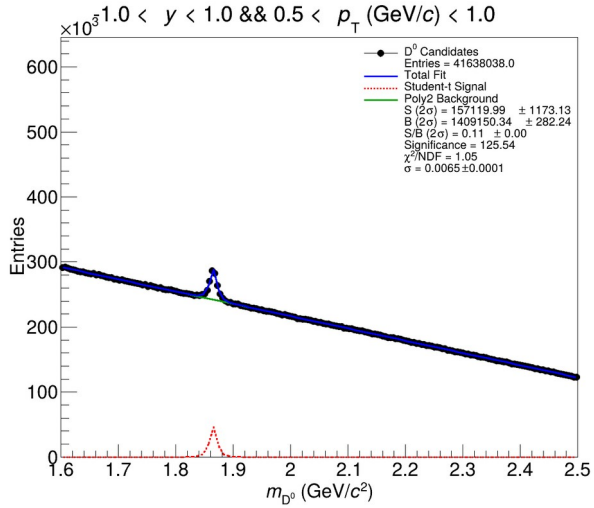


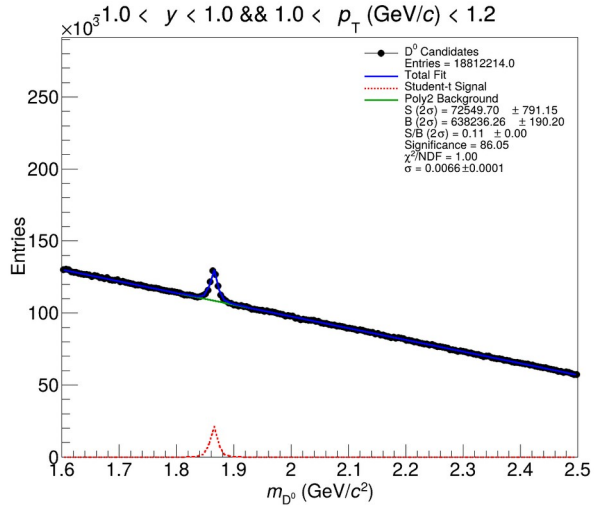


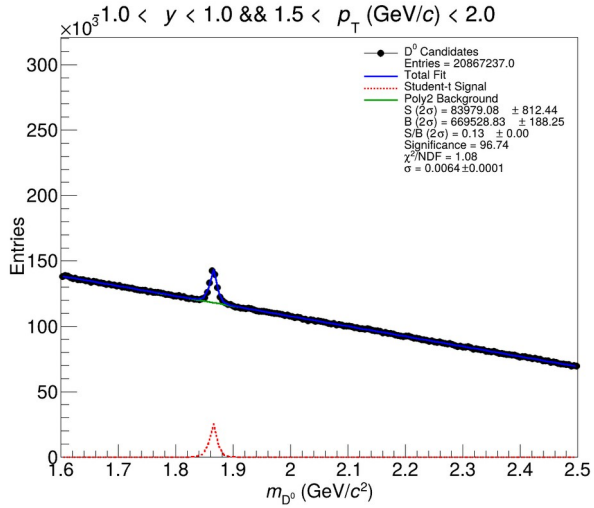
Invariant Mass (D^0)

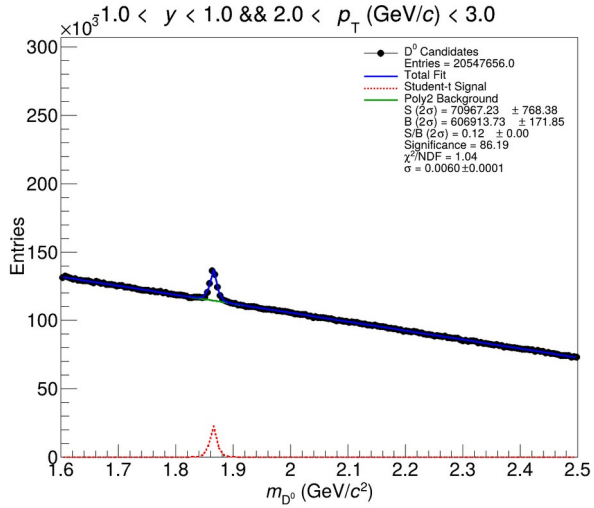
After PID+ Preselection on slide 9

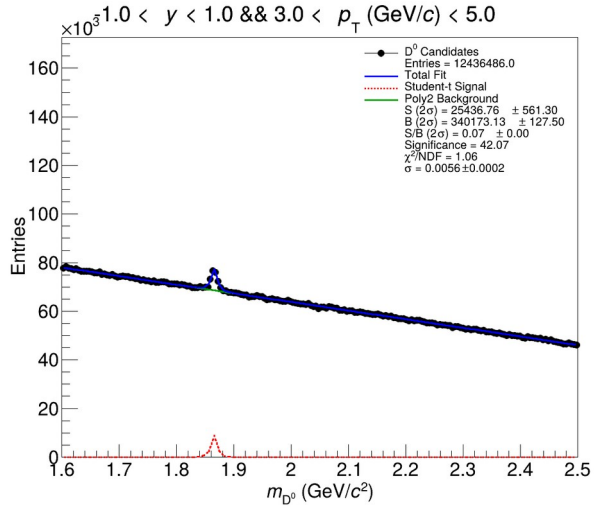






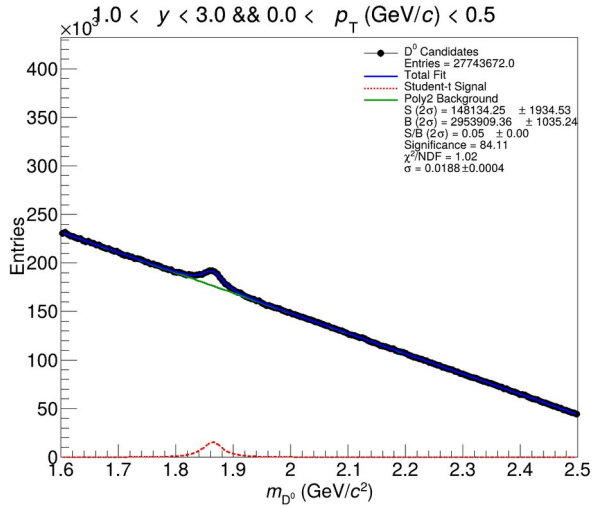


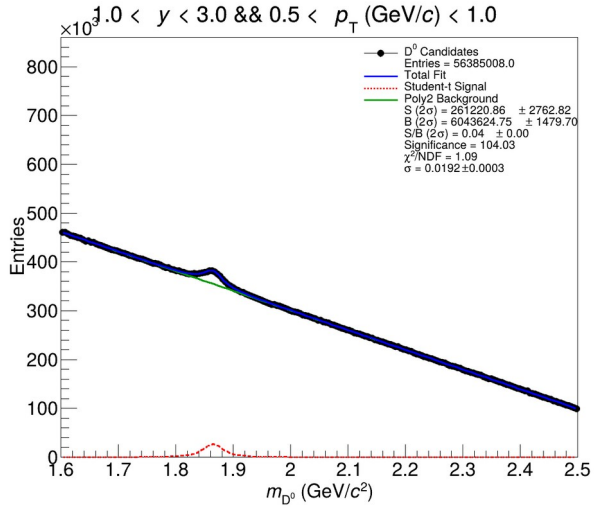


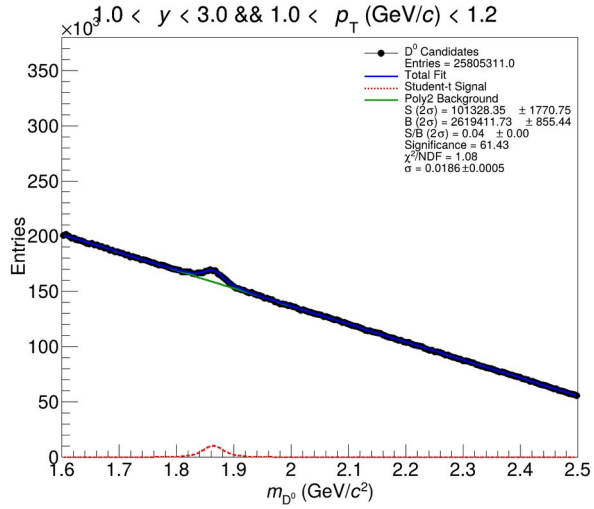


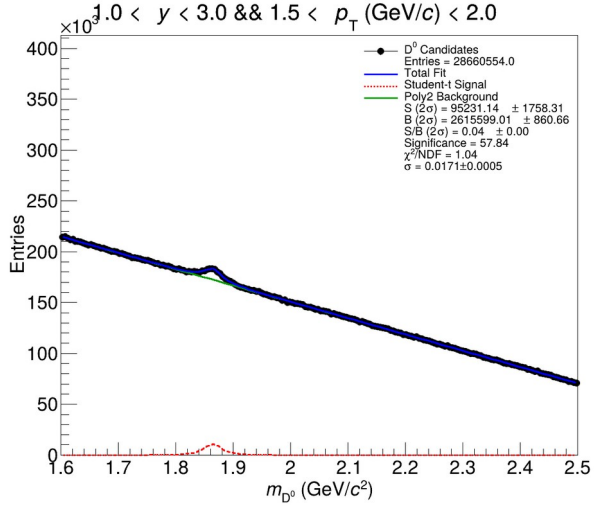
Invariant Mass (D^0)

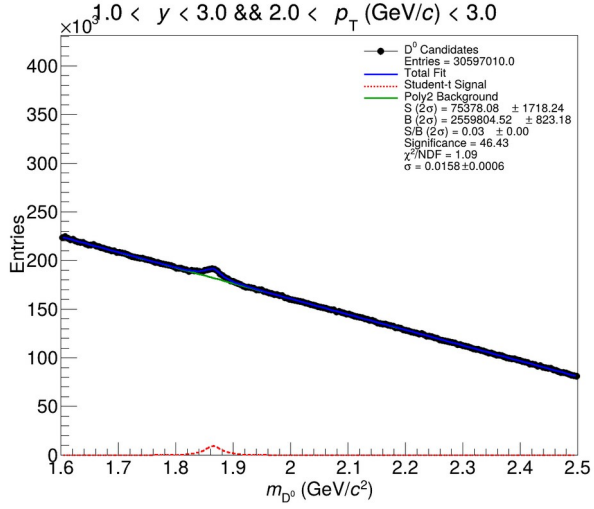
After PID+ Preselection on slide 9

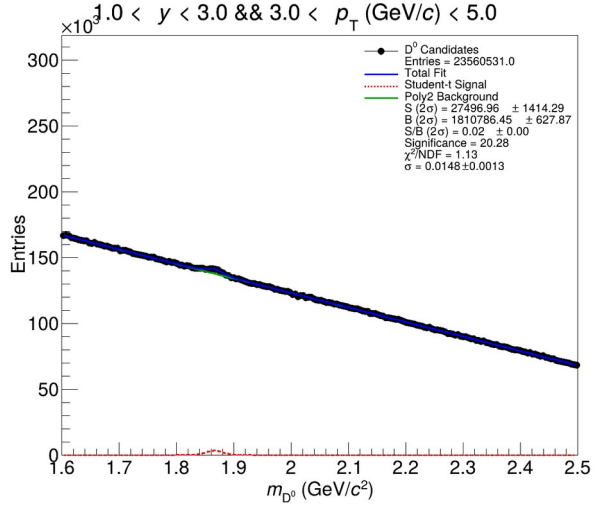










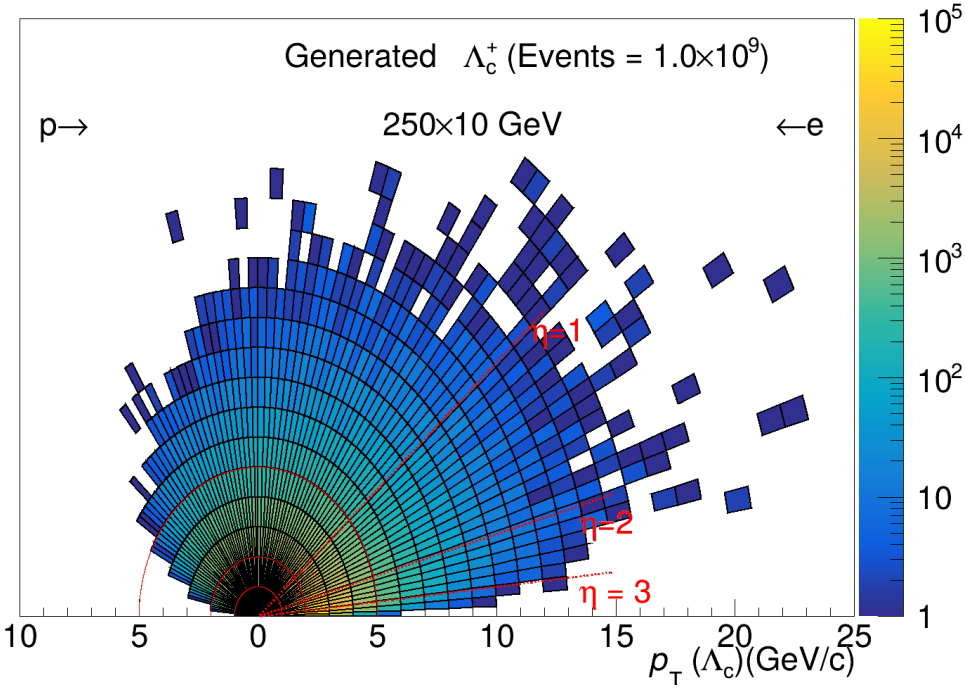


Machine Learning

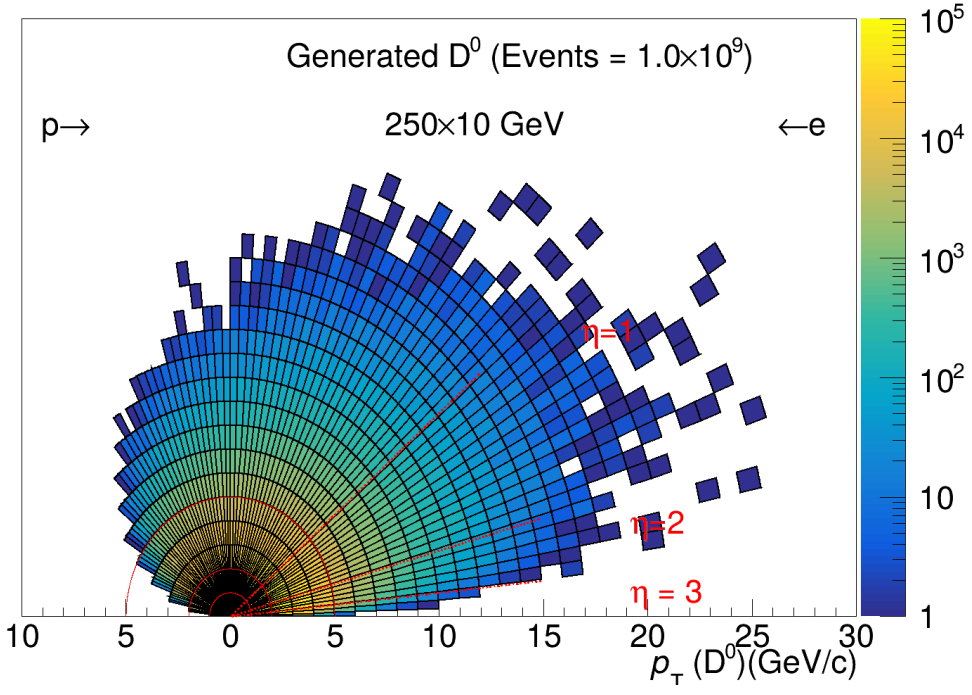
Train the model in two bins (p_T < 1 and p_T > 1 GeV/c) at mid and forward rapidities
Maximization of Significance

Phase Space (PYTHIA8307 Simulation)

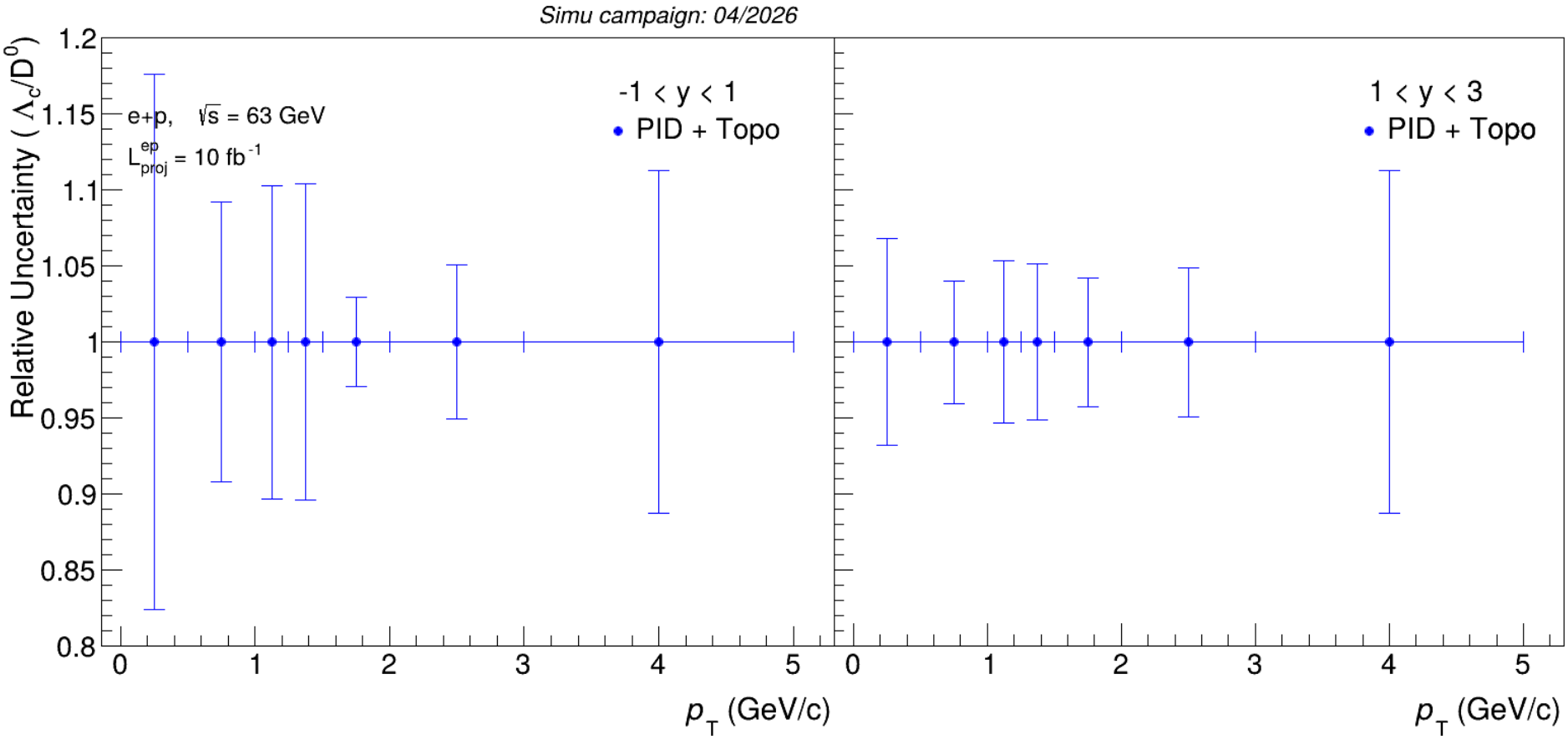
main41_D0_from_piK_NoEtaCut.cc



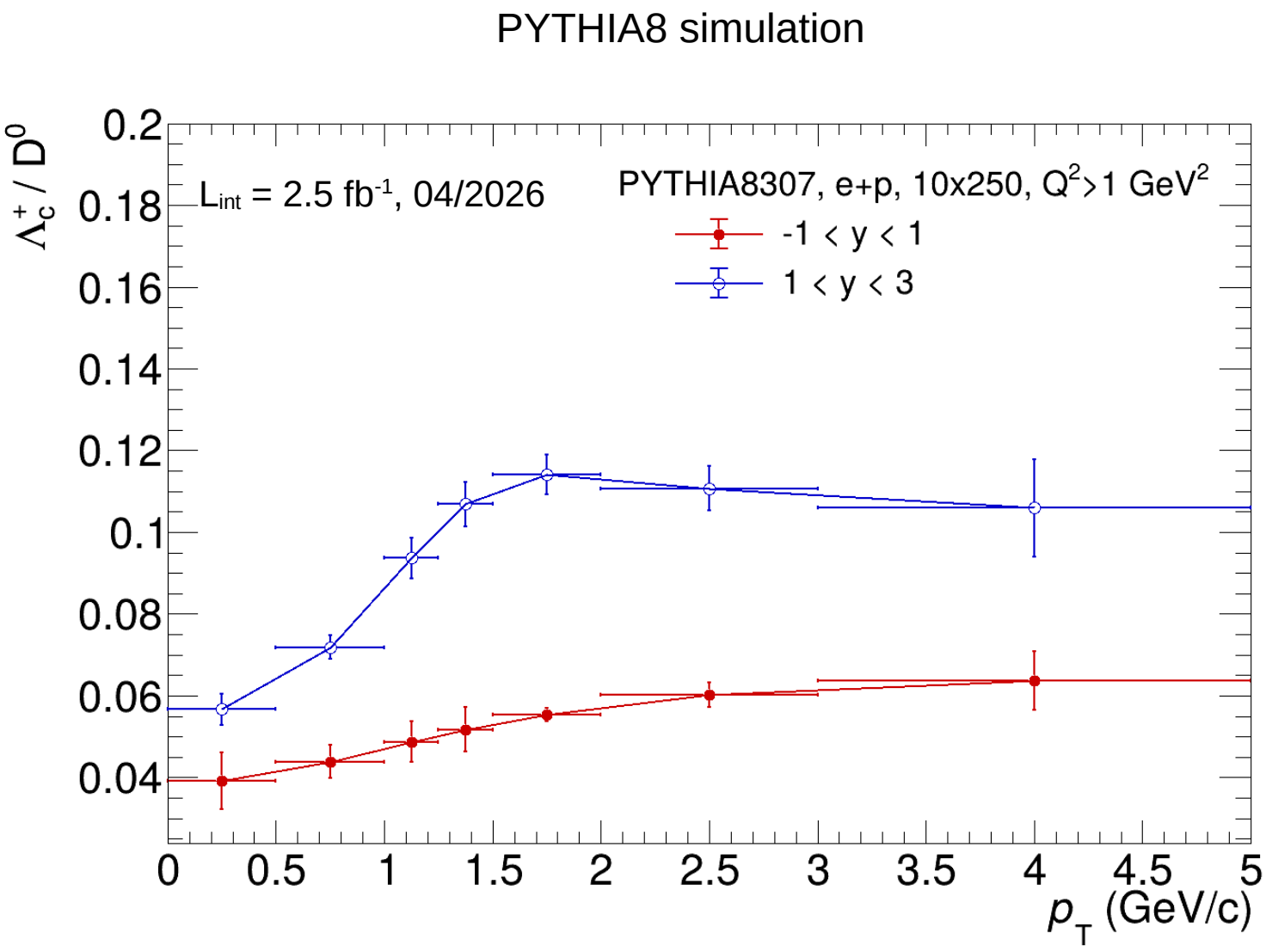
main41_LcToPiKp.cc



Statistical Projection for Λ_c/D^0 ratio



Statistical Projection for Λ_c/D^0 ratio



Summary and Future Plan

- First Λ_c/D^0 ratio result presented
- Analysis cross-checks in progress
- Optimization of selection is ongoing
- Results to be included in Early Science report

Thank you for your attention!

Results (w PID+ Preselection)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0,0.5)-------
Lc_ep: S/sqrt(S+B) =13.9201 Inverse Significance = 0.0718 rel sqrt(S+B)/S =0.0718
D0_ep: S/sqrt(S+B) =84.1069 Inverse Significance = 0.0119 rel sqrt(S+B)/S=0.0119
(relative uncertainty after adding in quadrature = 0.0728 = 7.2816%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0.5,1)-------
Lc_ep: S/sqrt(S+B) =23.5692 Inverse Significance = 0.0424 rel sqrt(S+B)/S =0.0424
D0_ep: S/sqrt(S+B) =104.0329 Inverse Significance = 0.0096 rel sqrt(S+B)/S=0.0096
(relative uncertainty after adding in quadrature = 0.0435 = 4.3503%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1,1.25)-------
Lc_ep: S/sqrt(S+B) =18.5693 Inverse Significance = 0.0539 rel sqrt(S+B)/S =0.0539
D0_ep: S/sqrt(S+B) =61.4310 Inverse Significance = 0.0163 rel sqrt(S+B)/S=0.0163
(relative uncertainty after adding in quadrature = 0.0563 = 5.6259%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1.25,1.5)-------
Lc_ep: S/sqrt(S+B) =19.4182 Inverse Significance = 0.0515 rel sqrt(S+B)/S =0.0515
D0_ep: S/sqrt(S+B) =52.0017 Inverse Significance = 0.0192 rel sqrt(S+B)/S=0.0192
(relative uncertainty after adding in quadrature = 0.0550 = 5.4971%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1.5,2)-------
Lc_ep: S/sqrt(S+B) =23.6470 Inverse Significance = 0.0423 rel sqrt(S+B)/S =0.0423
D0_ep: S/sqrt(S+B) =57.8399 Inverse Significance = 0.0173 rel sqrt(S+B)/S=0.0173
(relative uncertainty after adding in quadrature = 0.0457 = 4.5686%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (2,3)-------
Lc_ep: S/sqrt(S+B) =20.4471 Inverse Significance = 0.0489 rel sqrt(S+B)/S =0.0489
D0_ep: S/sqrt(S+B) =46.4344 Inverse Significance = 0.0215 rel sqrt(S+B)/S=0.0215
(relative uncertainty after adding in quadrature = 0.0534 = 5.3438%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (3,5)-------
Lc_ep: S/sqrt(S+B) =8.8321 Inverse Significance = 0.1132 rel sqrt(S+B)/S =0.1132
D0_ep: S/sqrt(S+B) =20.2805 Inverse Significance = 0.0493 rel sqrt(S+B)/S=0.0493
(relative uncertainty after adding in quadrature = 0.1235 = 12.3494%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0,0.5)-------
Lc_ep: S/sqrt(S+B) =5.5708 Inverse Significance = 0.1795 rel sqrt(S+B)/S =0.1795
D0_ep: S/sqrt(S+B) =95.0871 Inverse Significance = 0.0105 rel sqrt(S+B)/S=0.0105
(relative uncertainty after adding in quadrature = 0.1798 = 17.9815%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0.5,1)-------
Lc_ep: S/sqrt(S+B) =10.6862 Inverse Significance = 0.0936 rel sqrt(S+B)/S =0.0936
D0_ep: S/sqrt(S+B) =125.5446 Inverse Significance = 0.0080 rel sqrt(S+B)/S=0.0080
(relative uncertainty after adding in quadrature = 0.0939 = 9.3917%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1,1.25)-------
Lc_ep: S/sqrt(S+B) =9.2947 Inverse Significance = 0.1076 rel sqrt(S+B)/S =0.1076
D0_ep: S/sqrt(S+B) =86.0530 Inverse Significance = 0.0116 rel sqrt(S+B)/S=0.0116
(relative uncertainty after adding in quadrature = 0.1082 = 10.8214%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1.25,1.5)-------
Lc_ep: S/sqrt(S+B) =9.2118 Inverse Significance = 0.1086 rel sqrt(S+B)/S =0.1086
D0_ep: S/sqrt(S+B) =81.1401 Inverse Significance = 0.0123 rel sqrt(S+B)/S=0.0123
(relative uncertainty after adding in quadrature = 0.1093 = 10.9254%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1.5,2)-------
Lc_ep: S/sqrt(S+B) =34.3185 Inverse Significance = 0.0291 rel sqrt(S+B)/S =0.0291
D0_ep: S/sqrt(S+B) =96.7447 Inverse Significance = 0.0103 rel sqrt(S+B)/S=0.0103
(relative uncertainty after adding in quadrature = 0.0309 = 3.0918%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (2,3)-------
Lc_ep: S/sqrt(S+B) =19.0620 Inverse Significance = 0.0525 rel sqrt(S+B)/S =0.0525
D0_ep: S/sqrt(S+B) =86.1948 Inverse Significance = 0.0116 rel sqrt(S+B)/S=0.0116
(relative uncertainty after adding in quadrature = 0.0537 = 5.3728%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (3,5)-------
Lc_ep: S/sqrt(S+B) =8.5014 Inverse Significance = 0.1176 rel sqrt(S+B)/S =0.1176
D0_ep: S/sqrt(S+B) =42.0681 Inverse Significance = 0.0238 rel sqrt(S+B)/S=0.0238
(relative uncertainty after adding in quadrature = 0.1200 = 12.0005%)

Results (w PID+ Preselection+ML)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0,0.5)-------
Lc_ep (ML): S/sqrt(S+B) =14.7755 Inverse Significance = 0.0677 rel sqrt(S+B)/S =0.0677
D0_ep (ML): S/sqrt(S+B) =137.9000 Inverse Significance = 0.0073 rel sqrt(S+B)/S=0.0073
(relative uncertainty after adding in quadrature = 0.0681 = 6.8067%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0.5,1)-------
Lc_ep (ML): S/sqrt(S+B) =25.0078 Inverse Significance = 0.0400 rel sqrt(S+B)/S =0.0400
D0_ep (ML): S/sqrt(S+B) =174.2302 Inverse Significance = 0.0057 rel sqrt(S+B)/S=0.0057
(relative uncertainty after adding in quadrature = 0.0404 = 4.0397%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1,1.25)-------
Lc_ep (ML): S/sqrt(S+B) =19.1876 Inverse Significance = 0.0521 rel sqrt(S+B)/S =0.0521
D0_ep (ML): S/sqrt(S+B) =96.4536 Inverse Significance = 0.0104 rel sqrt(S+B)/S=0.0104
(relative uncertainty after adding in quadrature = 0.0531 = 5.3138%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1.25,1.5)-------
Lc_ep (ML): S/sqrt(S+B) =20.0571 Inverse Significance = 0.0499 rel sqrt(S+B)/S =0.0499
D0_ep (ML): S/sqrt(S+B) =82.1295 Inverse Significance = 0.0122 rel sqrt(S+B)/S=0.0122
(relative uncertainty after adding in quadrature = 0.0513 = 5.1323%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1.5,2)-------
Lc_ep (ML): S/sqrt(S+B) =24.4284 Inverse Significance = 0.0409 rel sqrt(S+B)/S =0.0409
D0_ep (ML): S/sqrt(S+B) =91.7066 Inverse Significance = 0.0109 rel sqrt(S+B)/S=0.0109
(relative uncertainty after adding in quadrature = 0.0424 = 4.2363%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (2,3)-------
Lc_ep (ML): S/sqrt(S+B) =21.1406 Inverse Significance = 0.0473 rel sqrt(S+B)/S =0.0473
D0_ep (ML): S/sqrt(S+B) =76.3624 Inverse Significance = 0.0131 rel sqrt(S+B)/S=0.0131
(relative uncertainty after adding in quadrature = 0.0491 = 4.9082%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (3,5)-------
Lc_ep (ML): S/sqrt(S+B) =9.1417 Inverse Significance = 0.1094 rel sqrt(S+B)/S =0.1094
D0_ep (ML): S/sqrt(S+B) =37.8221 Inverse Significance = 0.0264 rel sqrt(S+B)/S=0.0264
(relative uncertainty after adding in quadrature = 0.1125 = 11.2539%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0,0.5)-------
Lc_ep (ML): S/sqrt(S+B) =5.6819 Inverse Significance = 0.1760 rel sqrt(S+B)/S =0.1760
D0_ep (ML): S/sqrt(S+B) =132.4646 Inverse Significance = 0.0075 rel sqrt(S+B)/S=0.0075
(relative uncertainty after adding in quadrature = 0.1762 = 17.6160%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0.5,1)-------
Lc_ep (ML): S/sqrt(S+B) =10.9021 Inverse Significance = 0.0917 rel sqrt(S+B)/S =0.0917
D0_ep (ML): S/sqrt(S+B) =177.0742 Inverse Significance = 0.0056 rel sqrt(S+B)/S=0.0056
(relative uncertainty after adding in quadrature = 0.0919 = 9.1900%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1,1.25)-------
Lc_ep (ML): S/sqrt(S+B) =9.7265 Inverse Significance = 0.1028 rel sqrt(S+B)/S =0.1028
D0_ep (ML): S/sqrt(S+B) =132.8674 Inverse Significance = 0.0075 rel sqrt(S+B)/S=0.0075
(relative uncertainty after adding in quadrature = 0.1031 = 10.3088%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1.25,1.5)-------
Lc_ep (ML): S/sqrt(S+B) =9.6495 Inverse Significance = 0.1036 rel sqrt(S+B)/S =0.1036
D0_ep (ML): S/sqrt(S+B) =124.0020 Inverse Significance = 0.0081 rel sqrt(S+B)/S=0.0081
(relative uncertainty after adding in quadrature = 0.1039 = 10.3946%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1.5,2)-------
Lc_ep (ML): S/sqrt(S+B) =35.0718 Inverse Significance = 0.0285 rel sqrt(S+B)/S =0.0285
D0_ep (ML): S/sqrt(S+B) =146.0845 Inverse Significance = 0.0068 rel sqrt(S+B)/S=0.0068
(relative uncertainty after adding in quadrature = 0.0293 = 2.9323%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (2,3)-------
Lc_ep (ML): S/sqrt(S+B) =19.8776 Inverse Significance = 0.0503 rel sqrt(S+B)/S =0.0503
D0_ep (ML): S/sqrt(S+B) =132.2475 Inverse Significance = 0.0076 rel sqrt(S+B)/S=0.0076
(relative uncertainty after adding in quadrature = 0.0509 = 5.0873%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (3,5)-------
Lc_ep (ML): S/sqrt(S+B) =8.9446 Inverse Significance = 0.1118 rel sqrt(S+B)/S =0.1118
D0_ep (ML): S/sqrt(S+B) =72.4858 Inverse Significance = 0.0138 rel sqrt(S+B)/S=0.0138
(relative uncertainty after adding in quadrature = 0.1126 = 11.2648%)