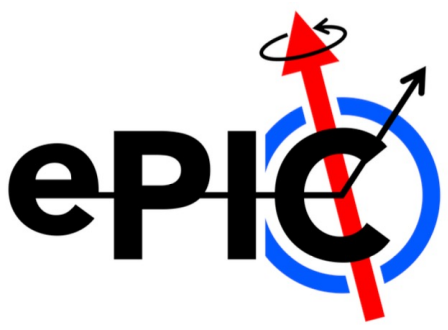




Λ_c^+ / D^0 vs multiplicity

Baidyanath Sahoo¹, Chitrasen Jena¹, Shyam Kumar²

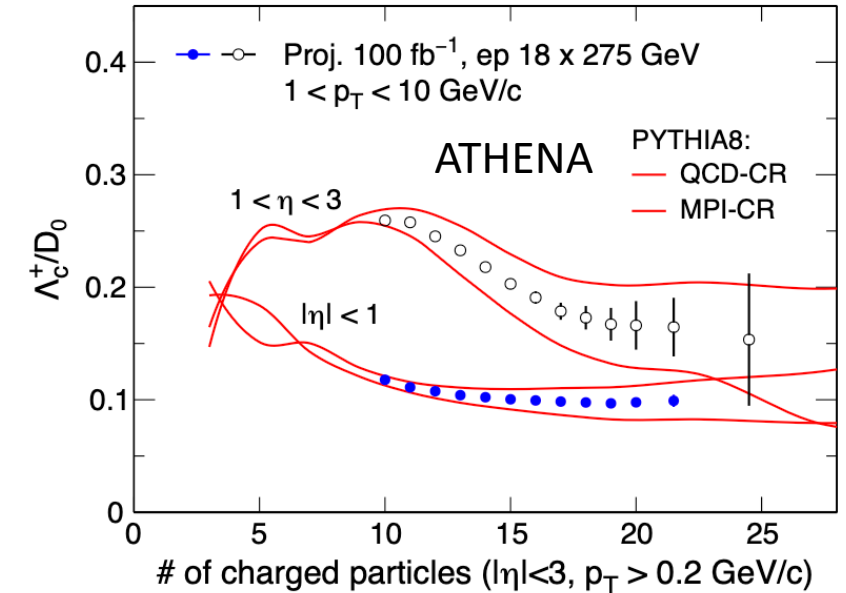
¹IISER Tirupati, ²UOH

Jets and HF Working Group Meeting
22nd Sep, 2026

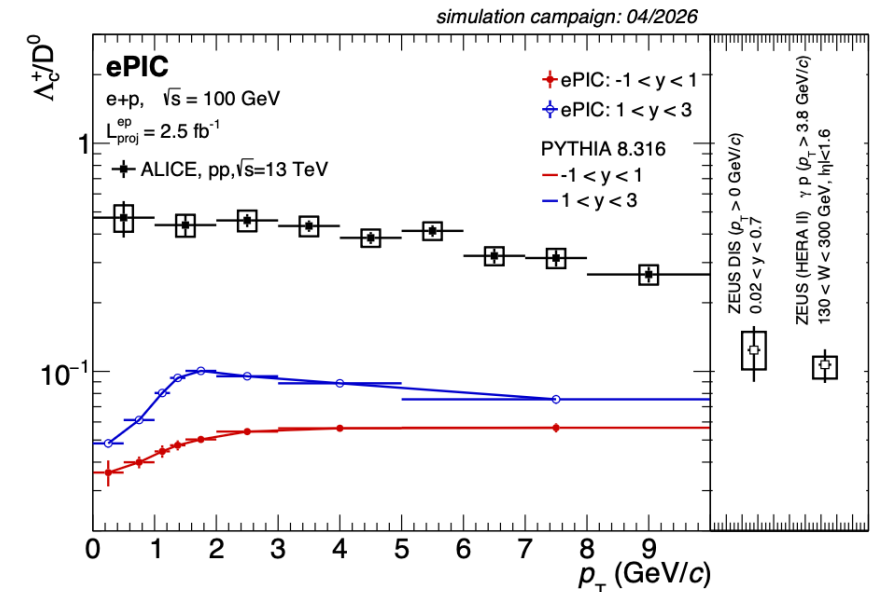
Introduction

- Λ_c^+/D^0 probes charm-quark hadronization and the observed non-universality of charm fragmentation across e^+e^- , $e + p$, and pp collisions
- ATHENA projected Λ_c^+/D^0 vs charged-particle multiplicity in $e + p$ using FastSim, providing sensitivity to different PYTHIA8 color-reconnection scenarios
- ATHENA FastSim used $10 \mu m$ SVT pixels; current ePIC full simulation uses $20 \mu m$ pixels with more realistic detector effects and reconstruction
- ePIC demonstrated Λ_c^+/D^0 vs p_T with April campaign in two rapidity regions
- This work extended the ePIC analysis to Λ_c^+/D^0 vs multiplicity with July campaign

[JINST 17 \(2022\) 10, P10019](#)



[arxiv:2608.05377](#)



Data Samples: July campaign

- 26.07.1 campaign, $e+p@ \sqrt{s}(9x275) = 99.5 \text{ GeV}$, $Q^2 > 1 \text{ GeV}^2$, Int. Lumi.: 2.5 fb^{-1}
- D^0 sample
 - `epic:/RECO/26.07.1/epic_craterlake/SIDIS/D0_ABCONV/HFsim-PYTHIA/pythia8.316-1.0/ep/9x275/q2_1`
- Λ_c^+ sample
 - `epic:/RECO/26.07.1/epic_craterlake/SIDIS/Lc_ABCONV/HFsim-PYTHIA/pythia8.316-1.0/ep/9x275/q2_1`
- NC, DIS sample
 - `epic:/RECO/26.07.1/epic_craterlake/DIS/pythia8.316-1.0/NC/noRad/ep/9x275/q2_1to10`
 - `epic:/RECO/26.07.1/epic_craterlake/DIS/pythia8.316-1.0/NC/noRad/ep/9x275/q2_10to100`
 - `epic:/RECO/26.07.1/epic_craterlake/DIS/pythia8.316-1.0/NC/noRad/ep/9x275/q2_100to1000`
 - `epic:/RECO/26.07.1/epic_craterlake/DIS/pythia8.316-1.0/NC/noRad/ep/9x275/q2_1000toINF`

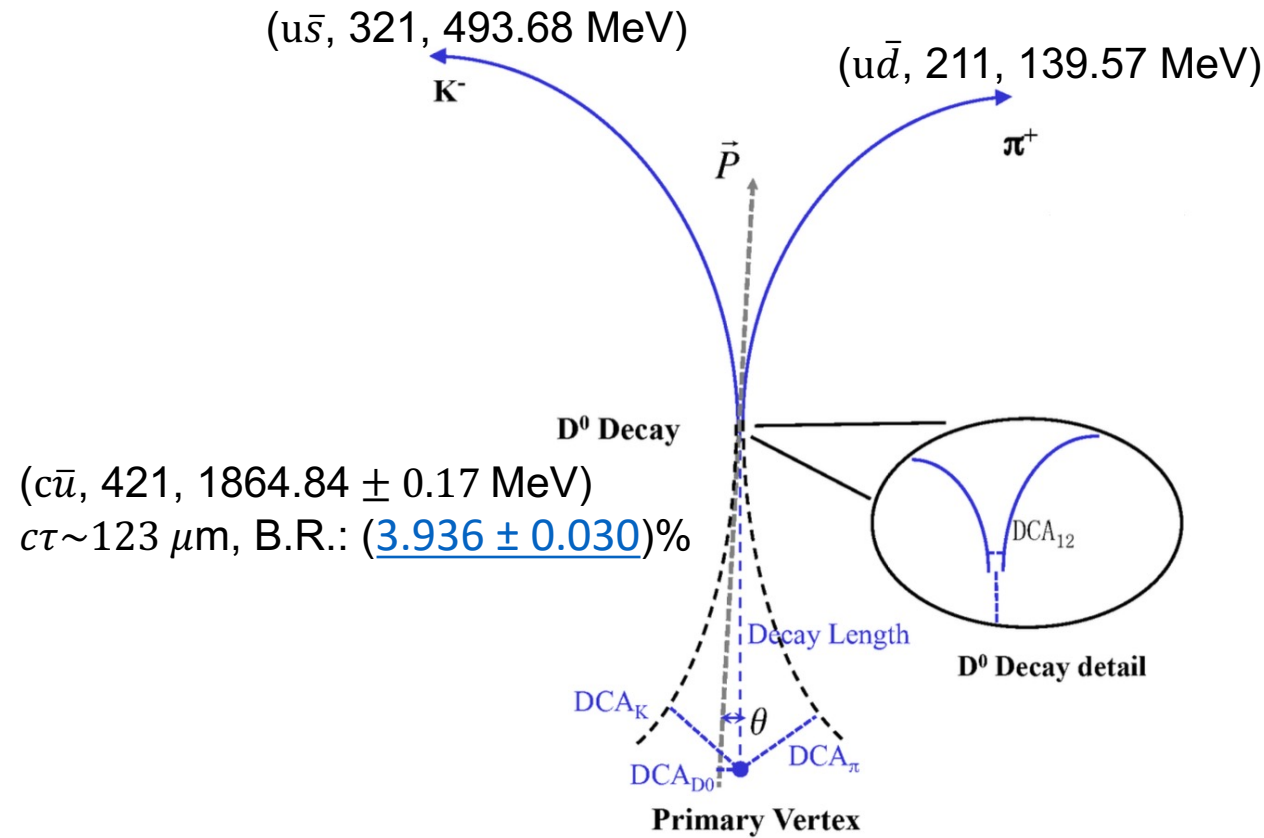
Data Samples: April campaign

- 26.04.1 campaign, $e+p@ \sqrt{s}(10 \times 250) = 100 \text{ GeV}$, $Q^2 > 1 \text{ GeV}^2$, Int. Lumi.: 2.5 fb^{-1}
- D^0 sample
 - `epic:/RECO/26.04.1/epic_craterlake/SIDIS/D0_ABCONV/HFsim-PYTHIA/pythia8.312-2.0/ep/10x250/q2_1`
- Λ_c^+ sample
 - `epic:/RECO/26.04.1/epic_craterlake/SIDIS/Lc_ABCONV/HFsim-PYTHIA/pythia8.312-2.0/ep/10x250/q2_1`
- NC, DIS sample
 - `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`

Decay channels

D^0 decay

$$D^0 \rightarrow \pi^+ K^-$$



[Phys. Rev. C 102, 014905 \(2020\)](#)

Λ_c^+ decay

$$\Lambda_c^+ \rightarrow p \pi^+ K^-$$

Λ_c^+ : cud , 4122, $2286.46 \pm 0.14 \text{ MeV}$
 $c\tau \sim 60 \mu\text{m}$, B.R.: $(6.37 \pm 0.21)\%$

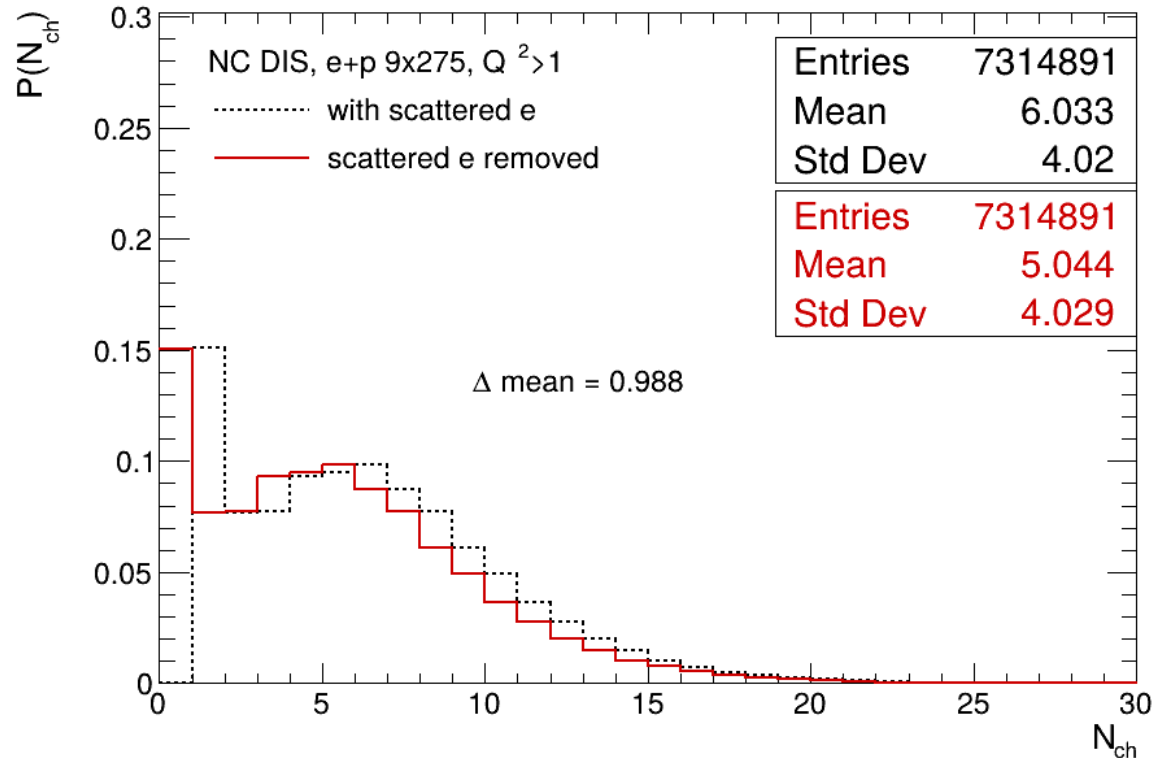
p : uud , 2212, 938.27 MeV

π^+ : $u\bar{d}$, 211, 139.57 MeV

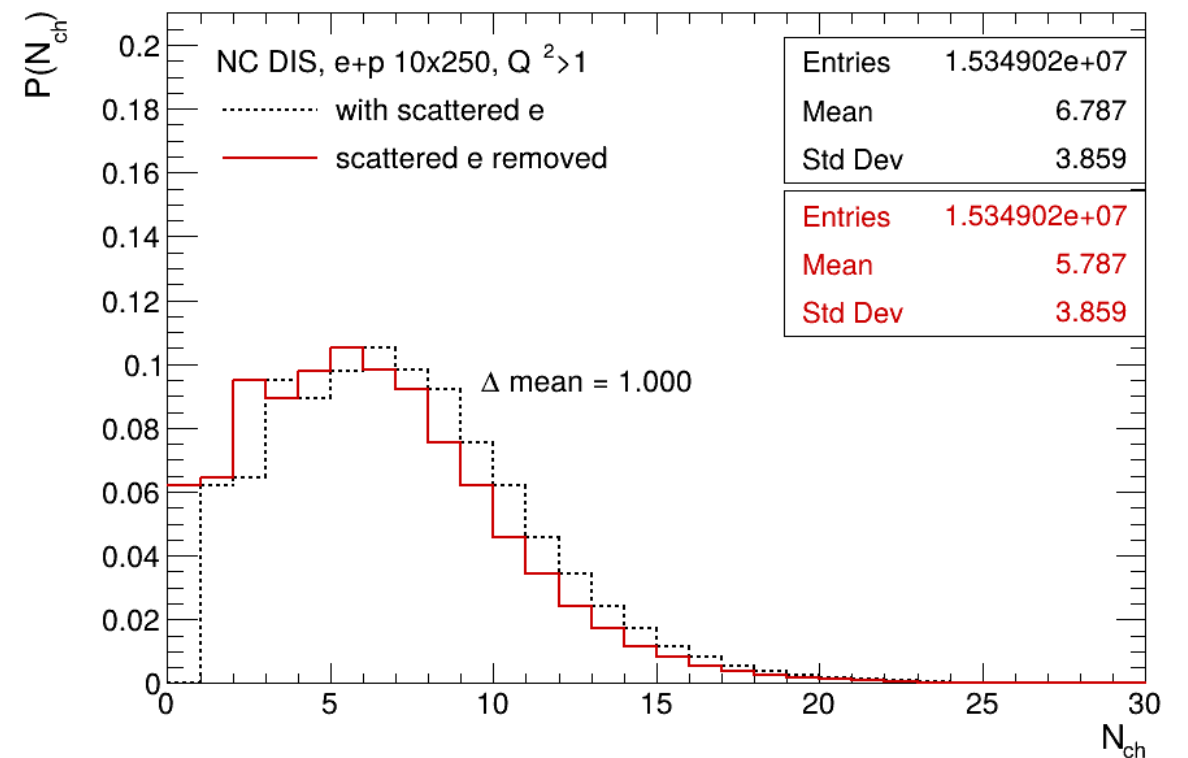
K^- : $u\bar{s}$, 321, 493.68 MeV

Charged particle multiplicity

July campaign



April campaign



Compared the multiplicity with and without scattered electron for two campaigns

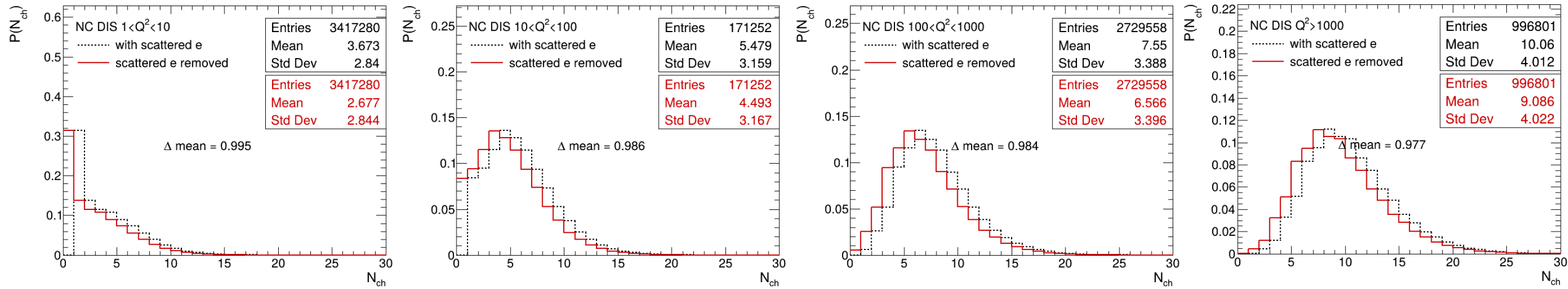
Github code used to remove scattered electron:

<https://github.com/eic/snippets/blob/bd8d81e5e28980f1610170856055b99583acbb65/JetsAndHF/D0-taggedjets/analysis.cxx#L457>

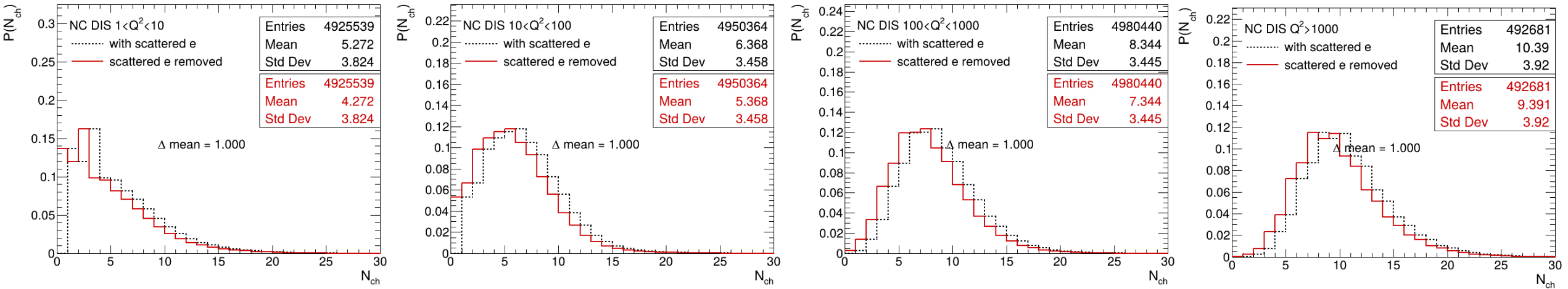
```
TTreeReaderArray<int> ScatElecGenId = {treereader, "MCScatteredElectrons_objIdx.index"};  
const int iScatElec = (ScatElecGenId.GetSize() > 0) ? ScatElecGenId[0] : -1;
```

Charged particle multiplicity in different Q^2

July campaign



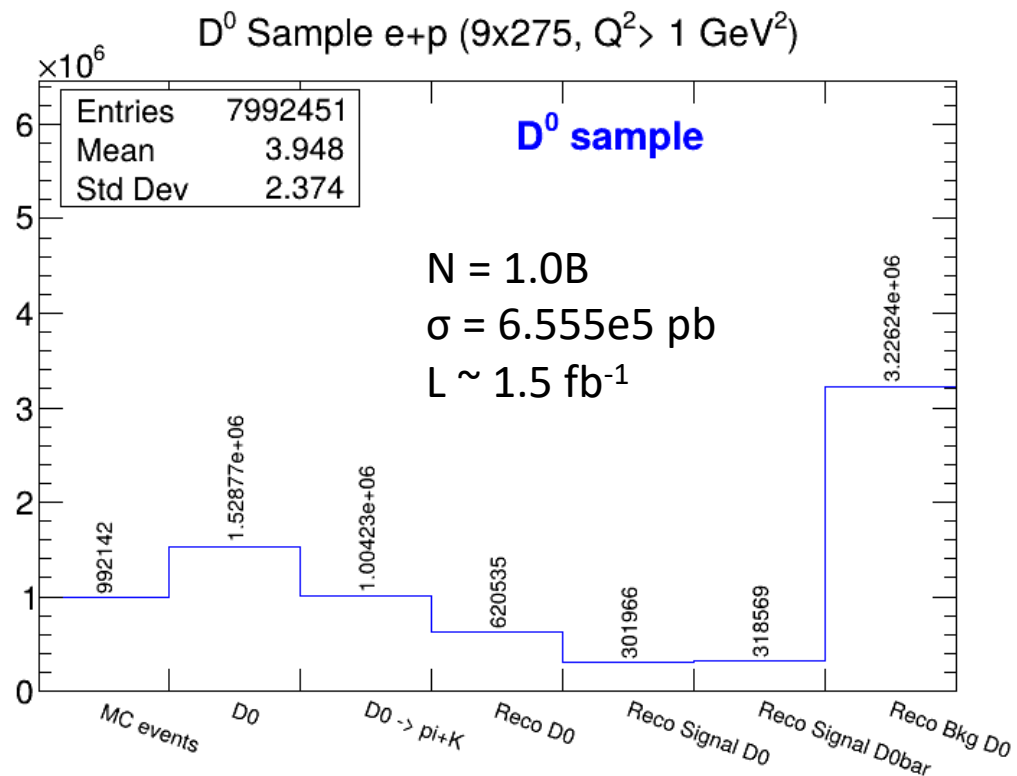
April campaign



Event Statistics (D⁰ meson): D⁰ sample

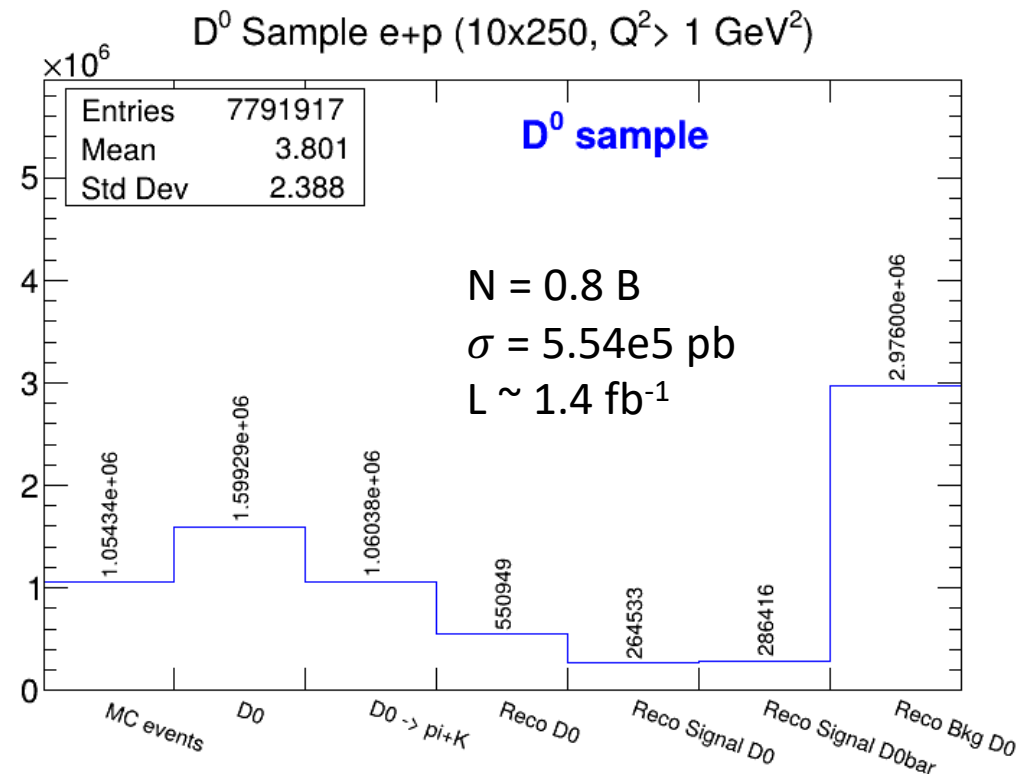
[HF sim](#)

July campaign



Efficiency = 620535/1.00423e+06 ~ 61%

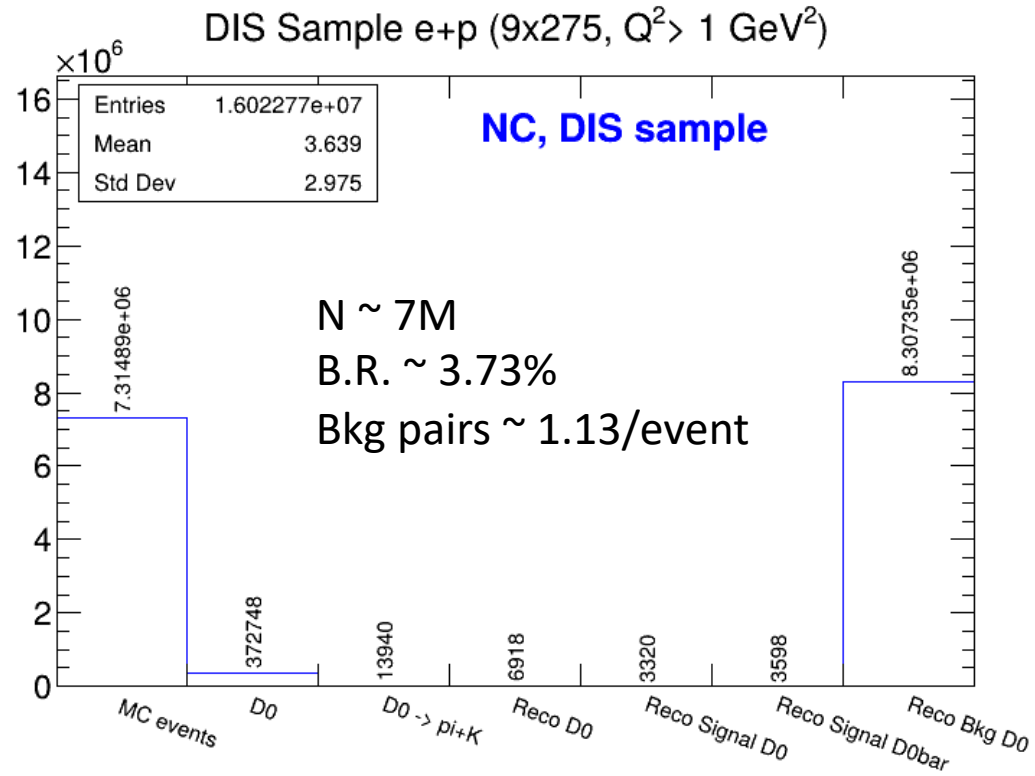
April campaign



Efficiency = 550949/1.06038e+06 ~ 52%

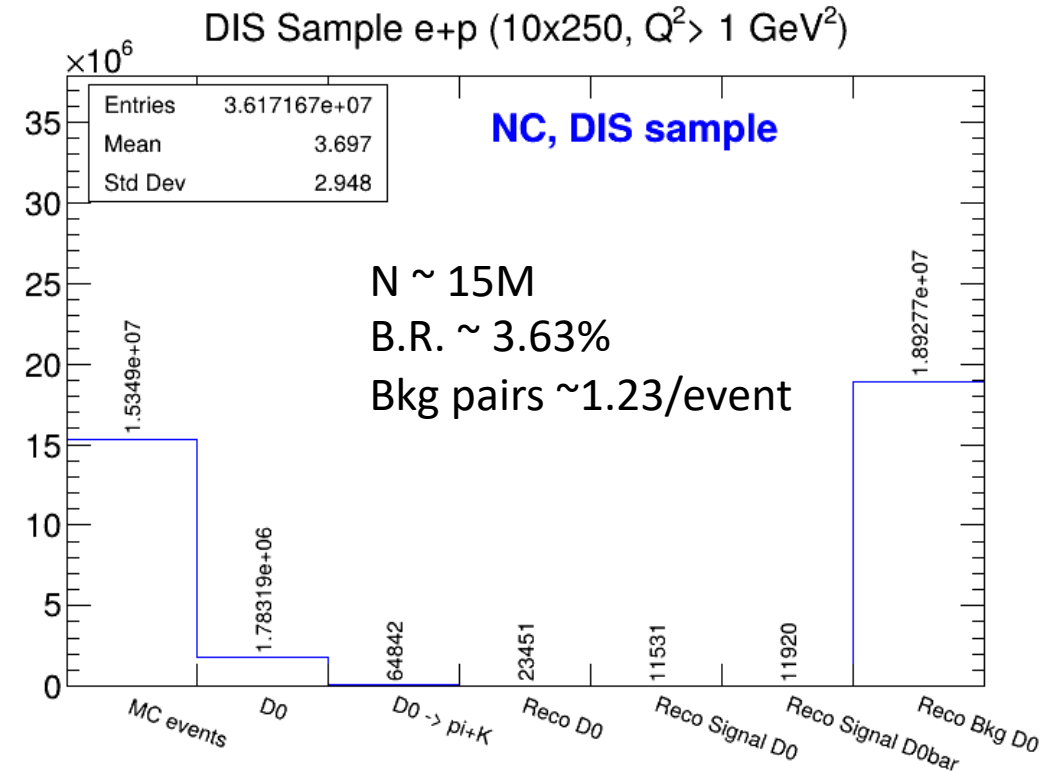
Event Statistics (D^0 meson): DIS sample

July campaign



Efficiency = $6918/13940 \sim 50\%$

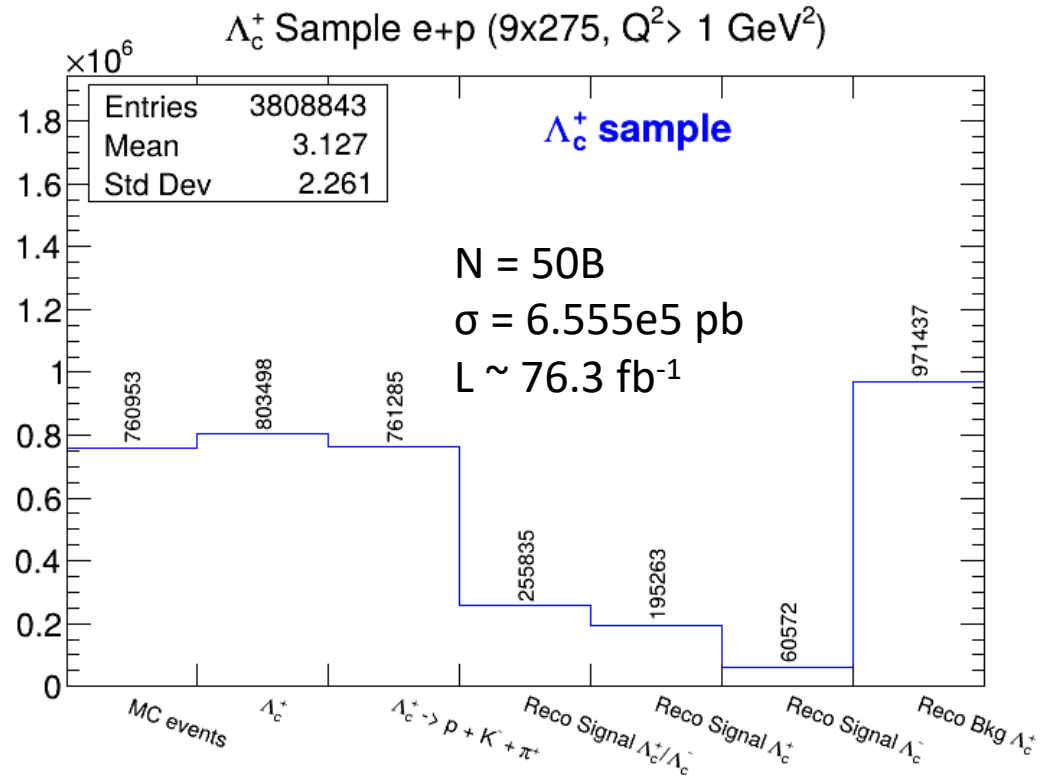
April campaign



Efficiency = $23451/64842 \sim 36\%$

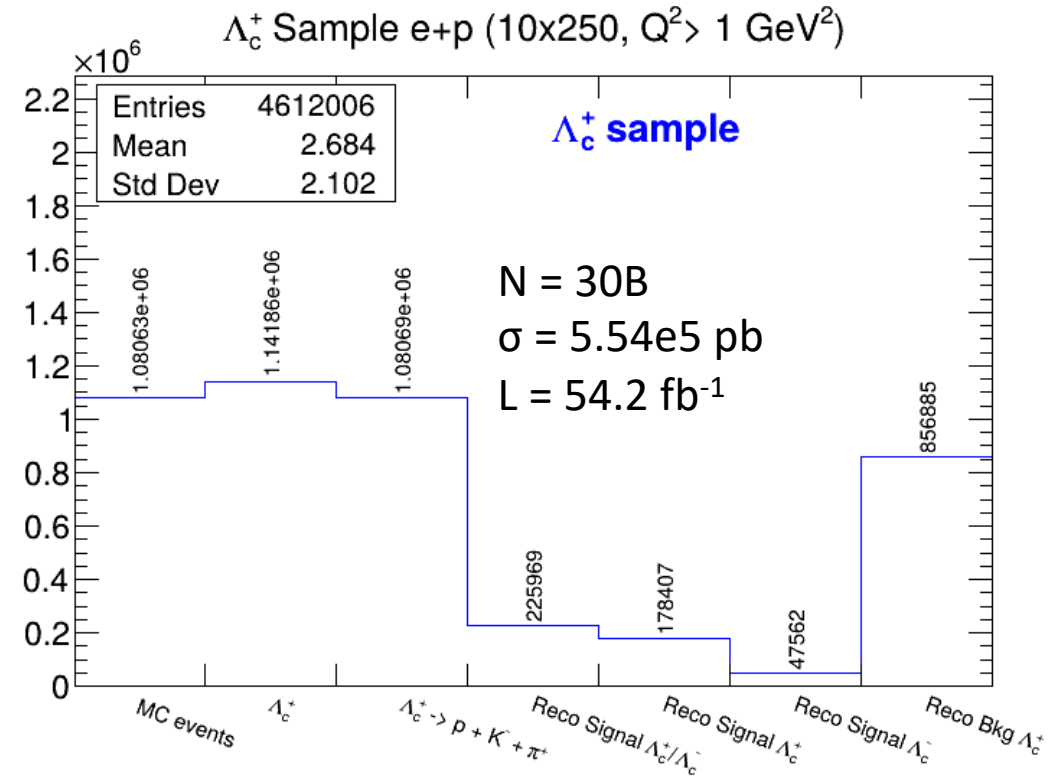
Event Statistics (Λ_c^+ baryon): Λ_c^+ sample

July campaign



Efficiency = $255835/761285 \sim 34\%$

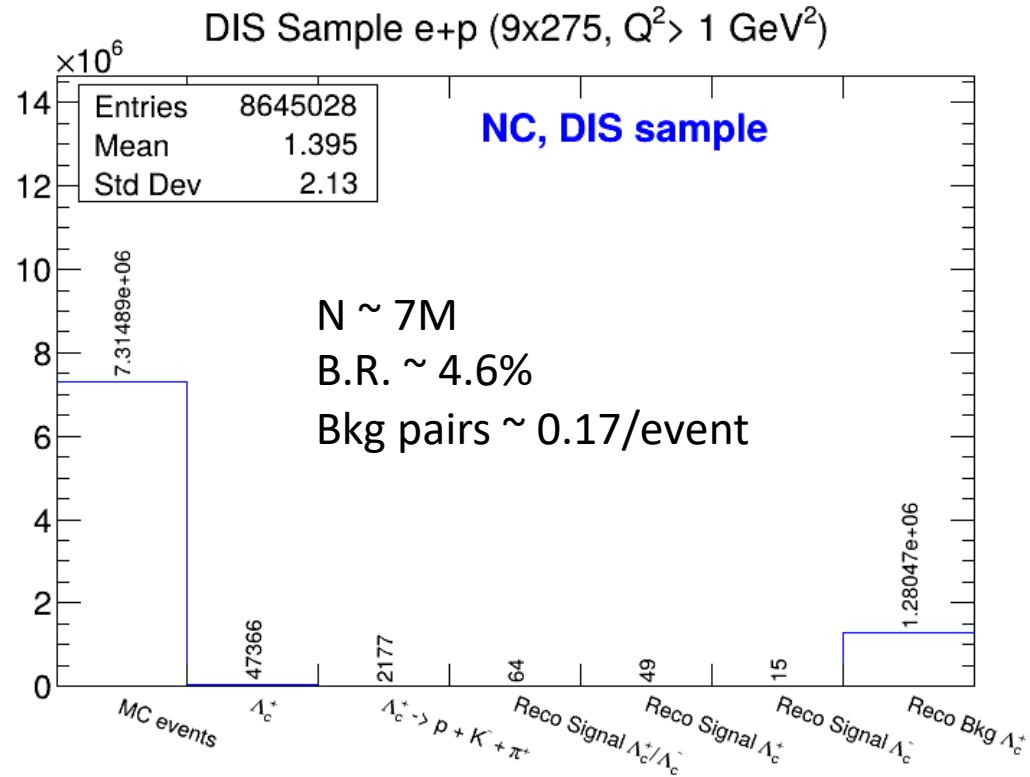
April campaign



Efficiency = $225969/1.08069\text{e}+06 \sim 21\%$

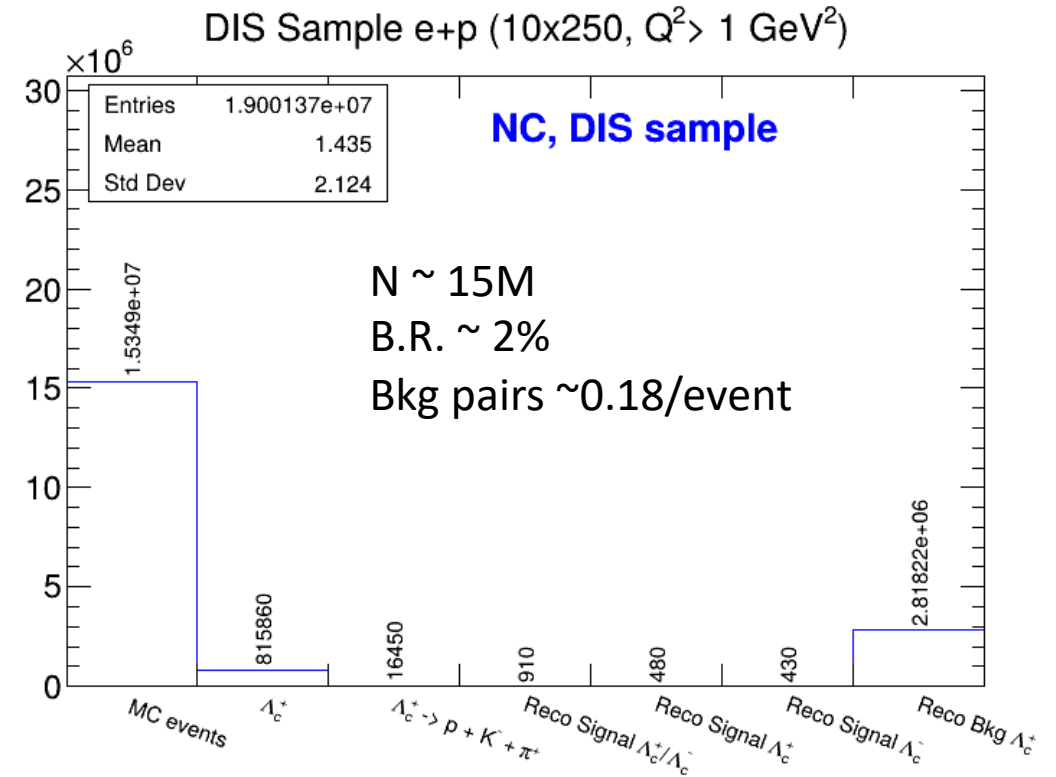
Event Statistics (Λ_c^+ baryon): DIS sample

July campaign



Efficiency = $64/2177 \sim 2.9\%$

April campaign



Efficiency = $910/16450 \sim 5.5\%$

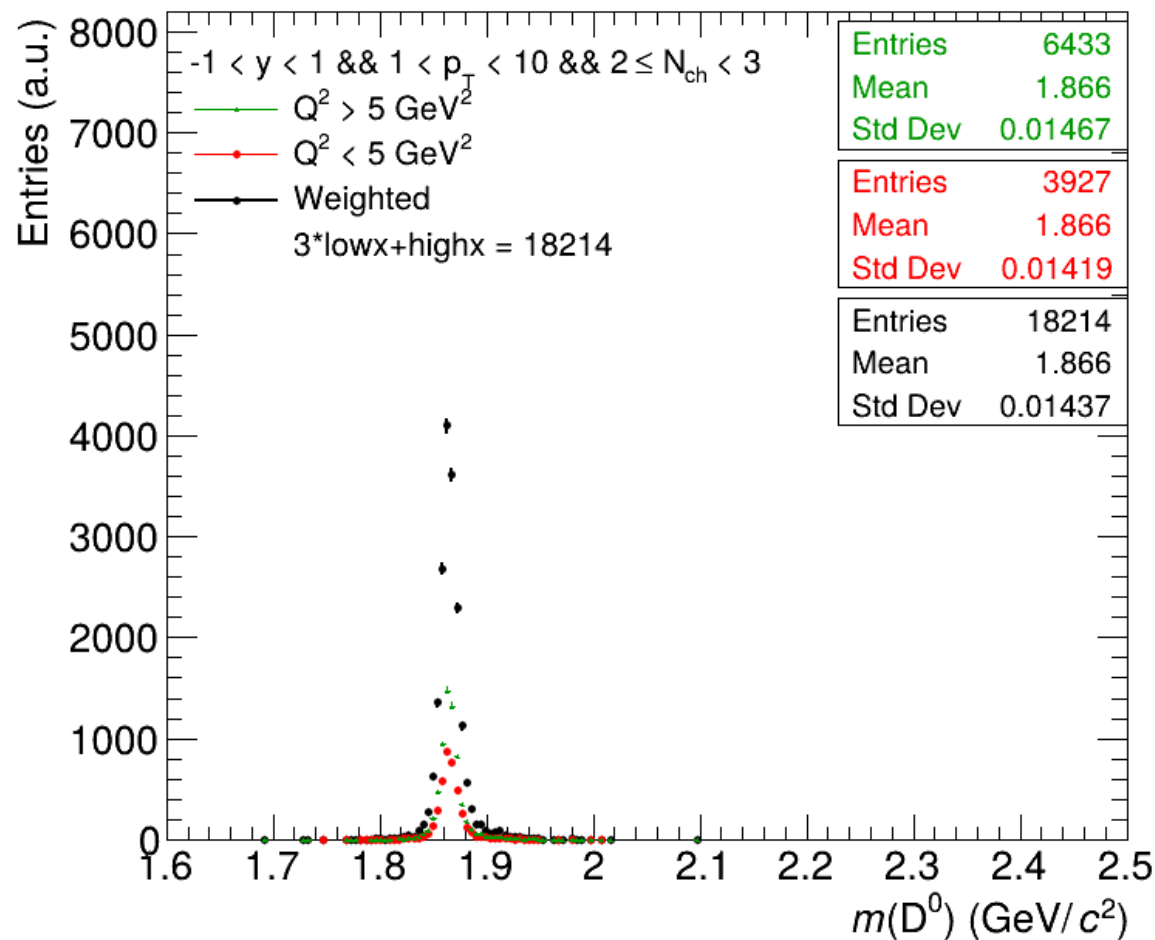
D⁰ reconstruction

- Signal from D0 sample
 - Corrections:
 - ✓ Weight factor of 3 on signal for $Q^2 < 5 \text{ GeV}^2$
 - ✓ Scaling to target luminosity 2.5 fb^{-1}
- Combinatorial background from DIS sample
 - Scaling to target luminosity
- Preselection cuts: '(mass_D0 > 1.6 && mass_D0 < 2.5) && d0xy_pi<100. && d0xy_k<100. && decay_length <100.'

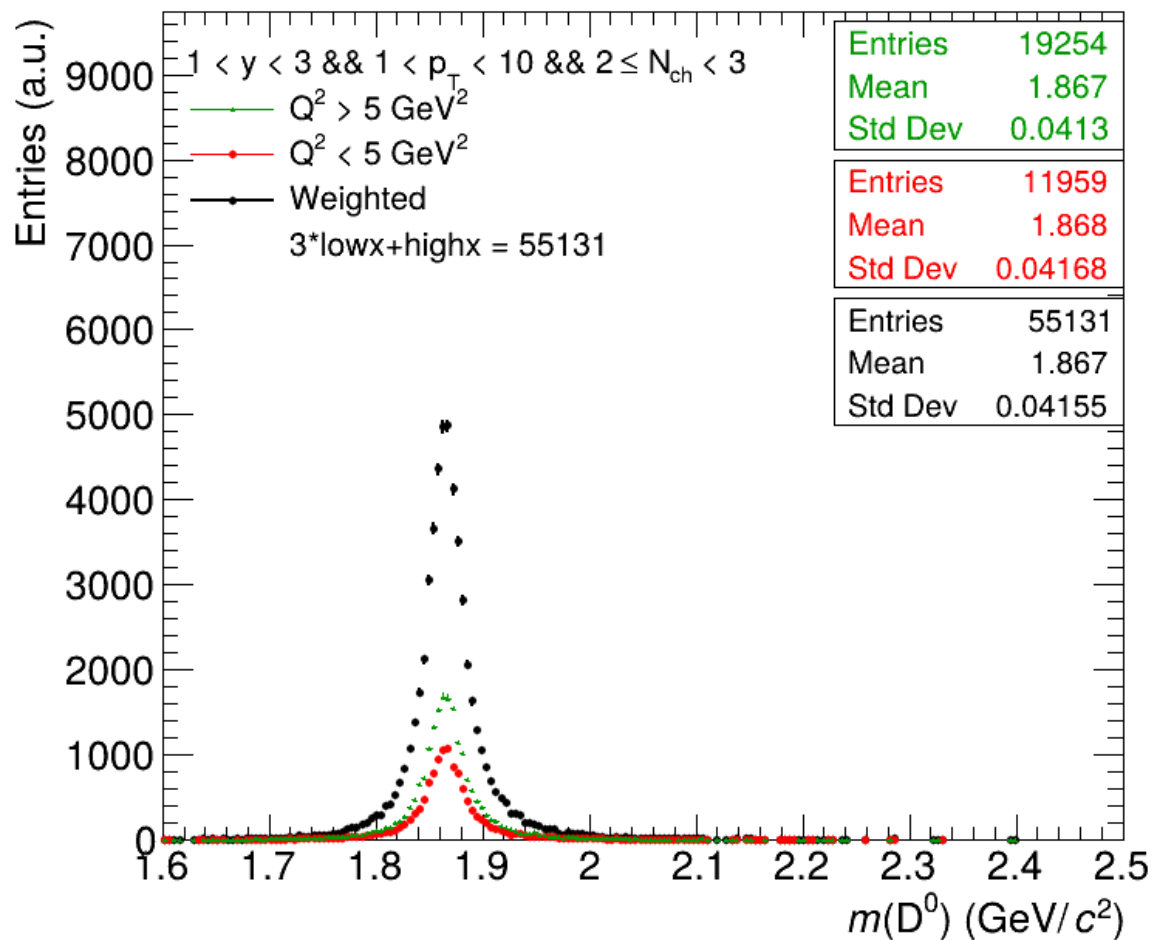
Applying weight factors on signal

July campaign

Mid rapidity



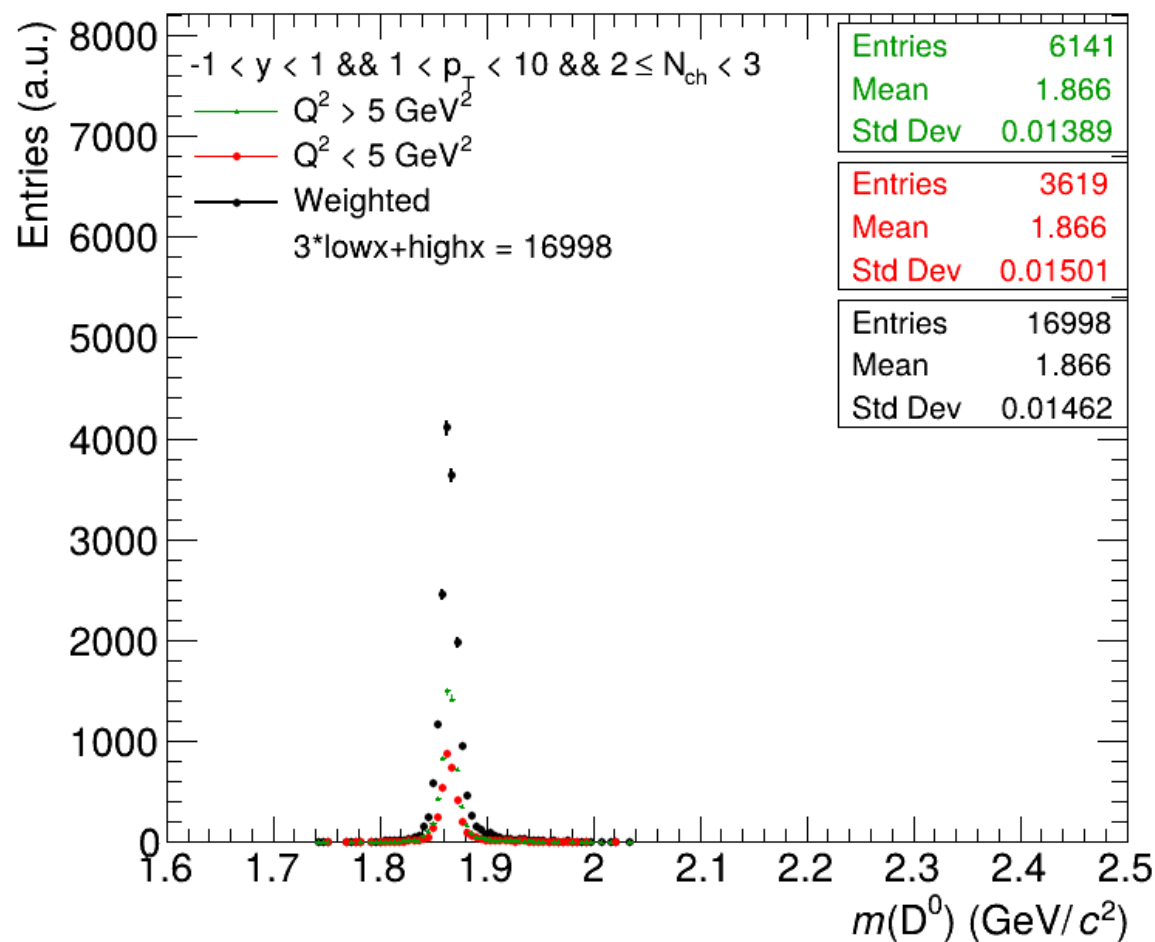
Forward rapidity



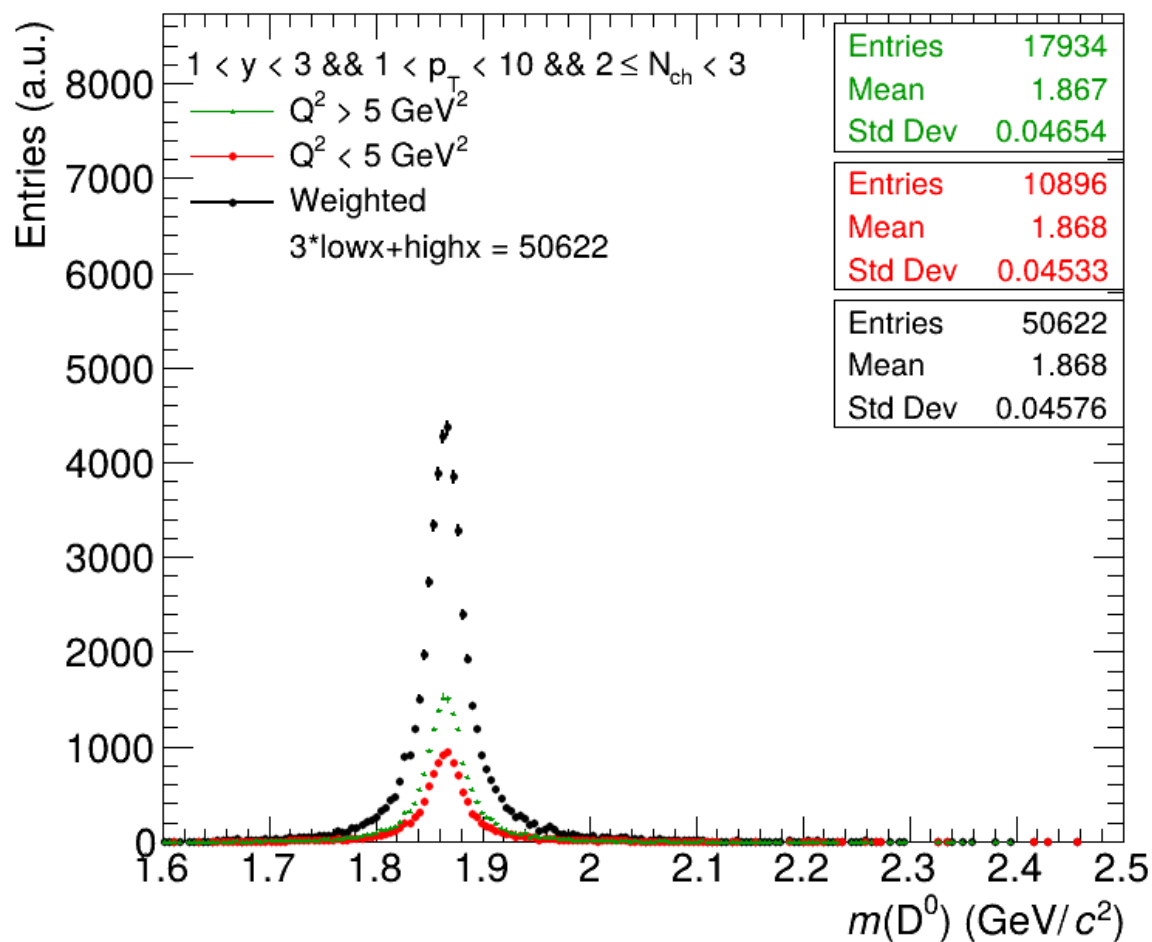
Applying weight factors on signal

April campaign

Mid rapidity



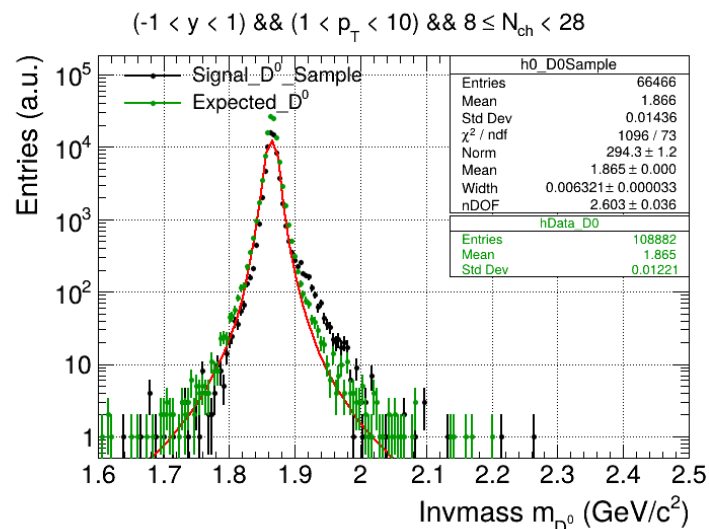
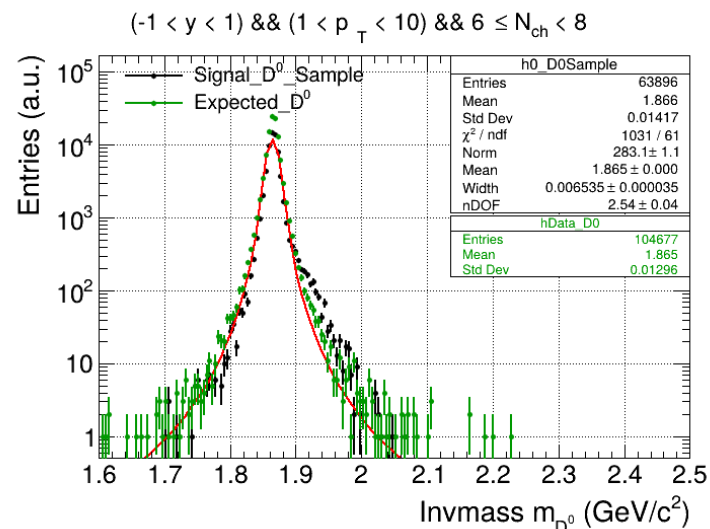
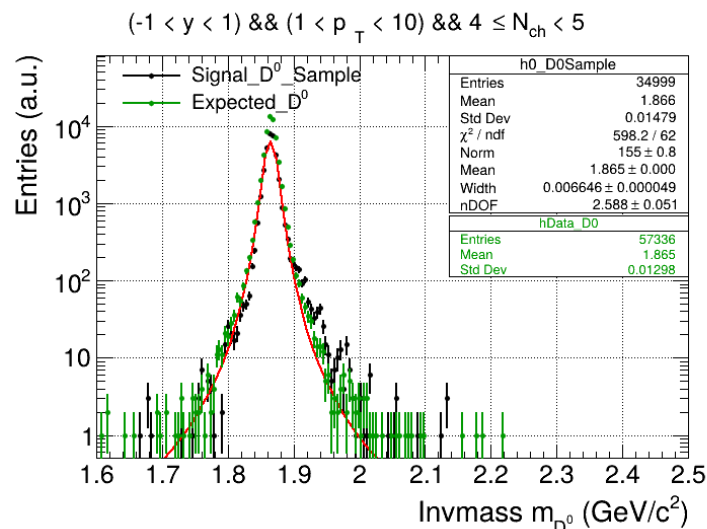
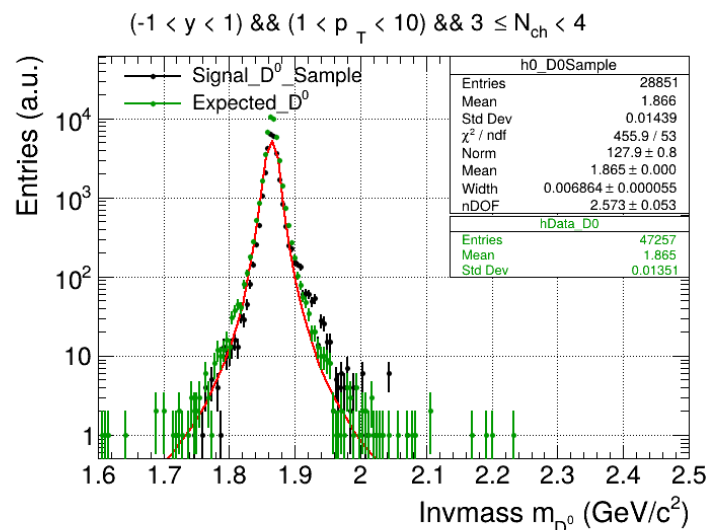
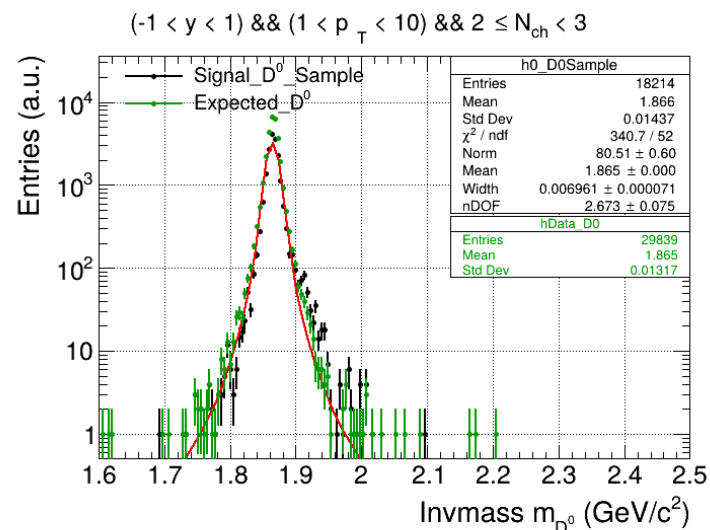
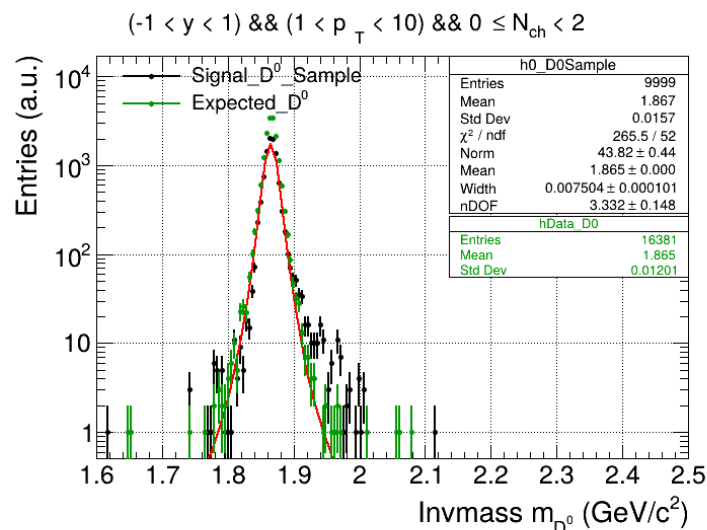
Forward rapidity



Sampling Signal ($-1 < y < 1$)

$L_{\text{int}} = 1.5 \text{ fb}^{-1}$

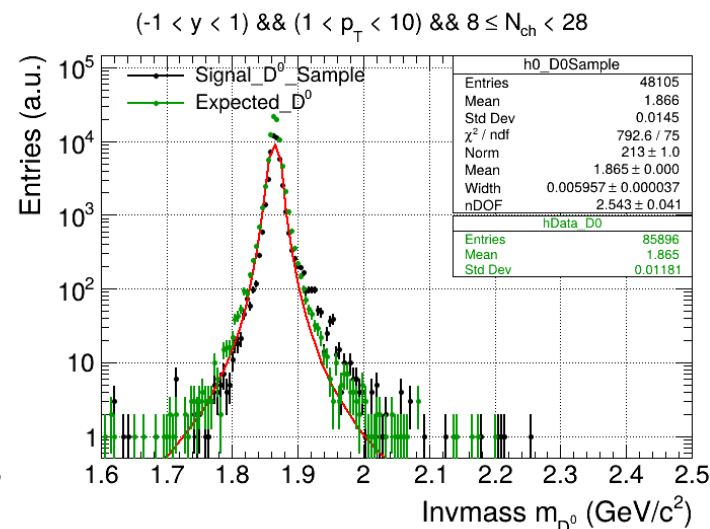
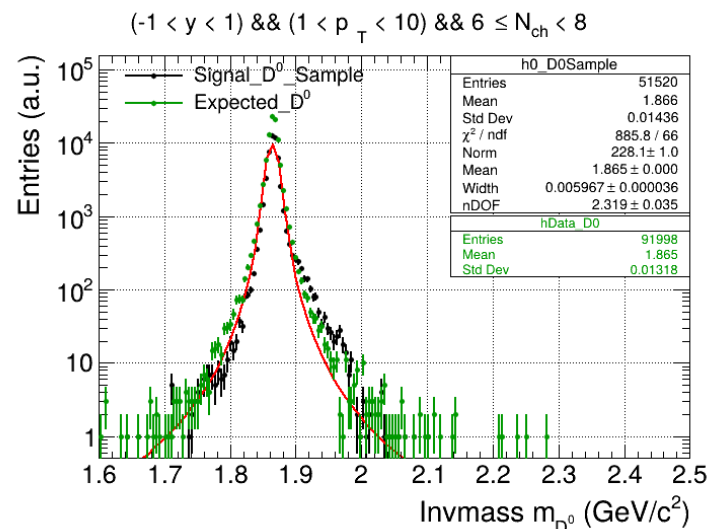
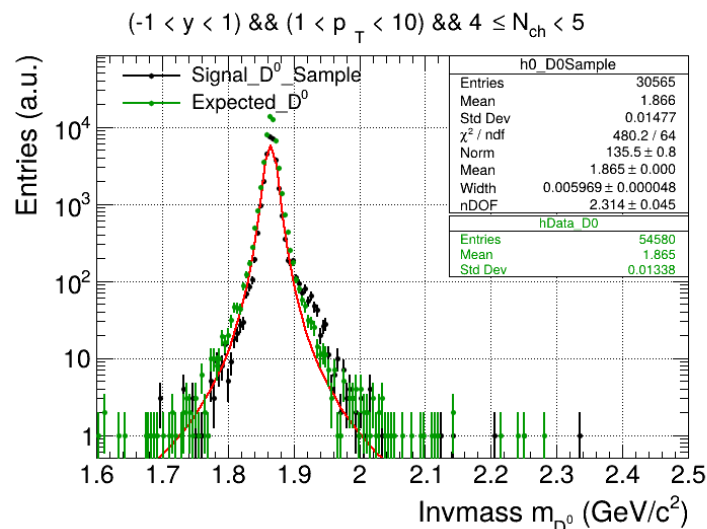
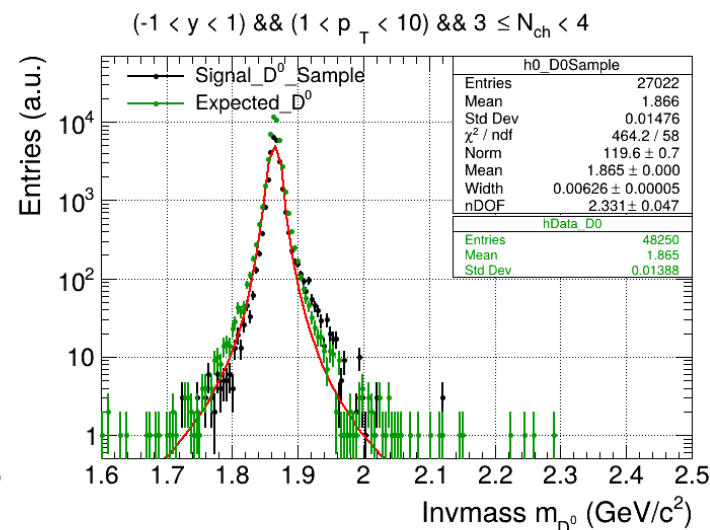
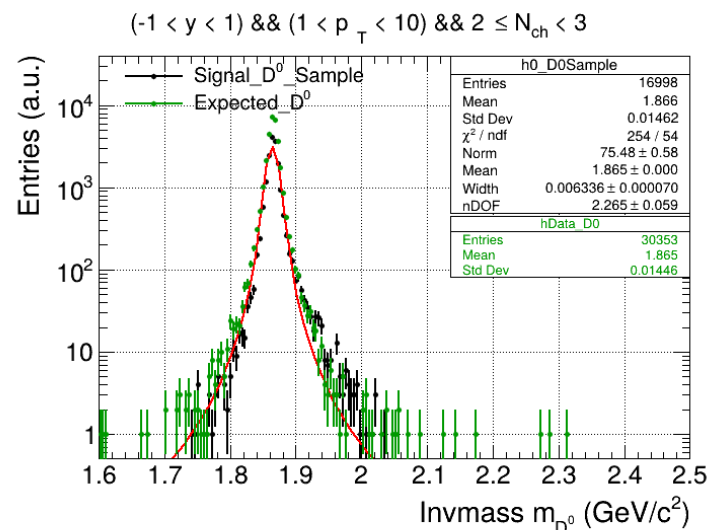
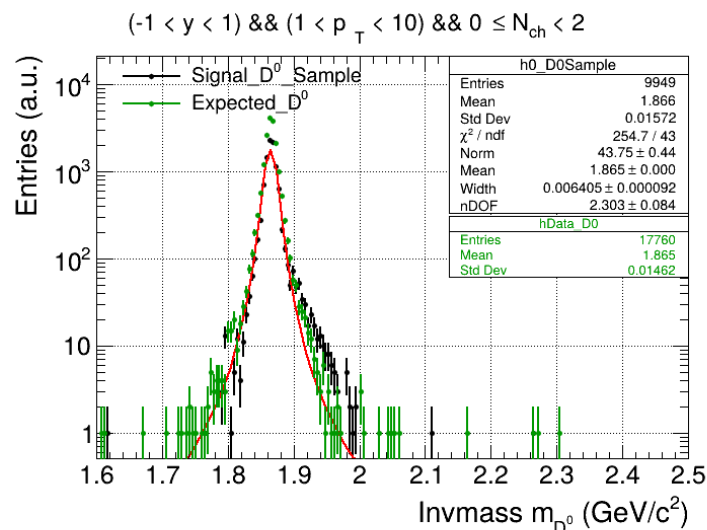
$L_{\text{int}} = 2.5 \text{ fb}^{-1}$



Sampling Signal ($-1 < y < 1$)

$L_{\text{int}} = 1.4 \text{ fb}^{-1}$

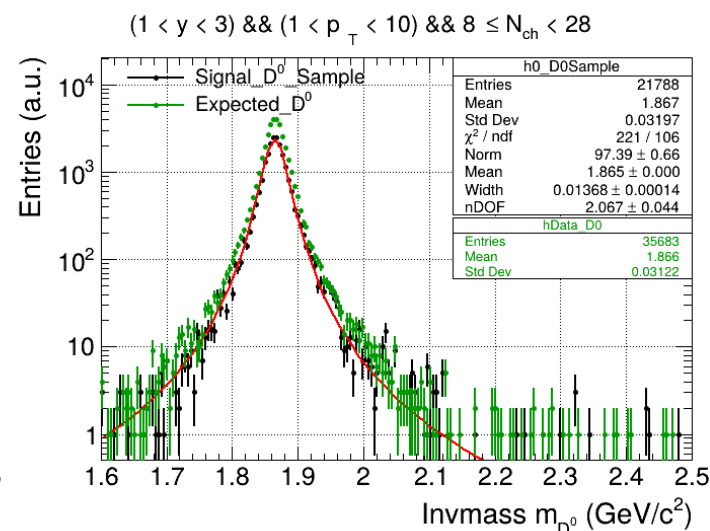
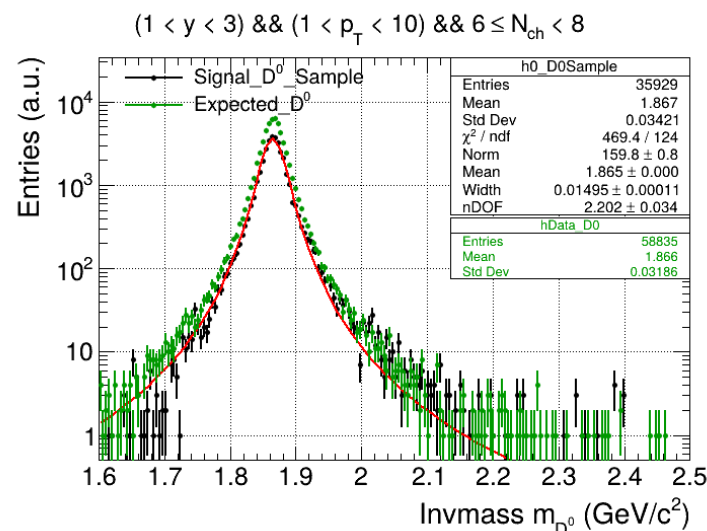
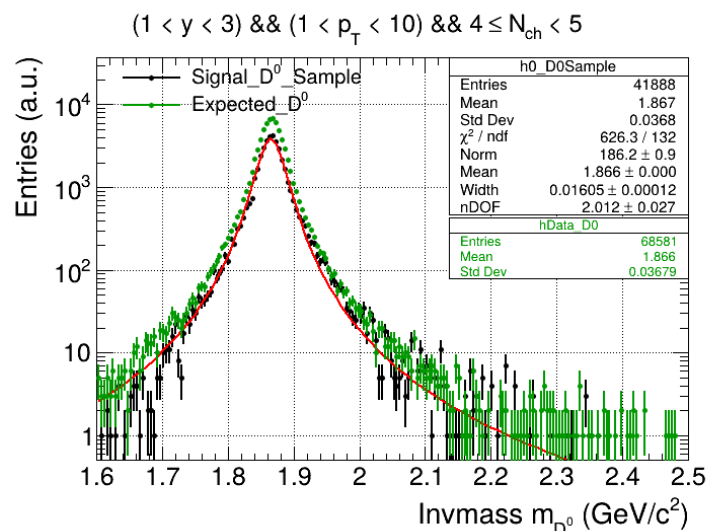
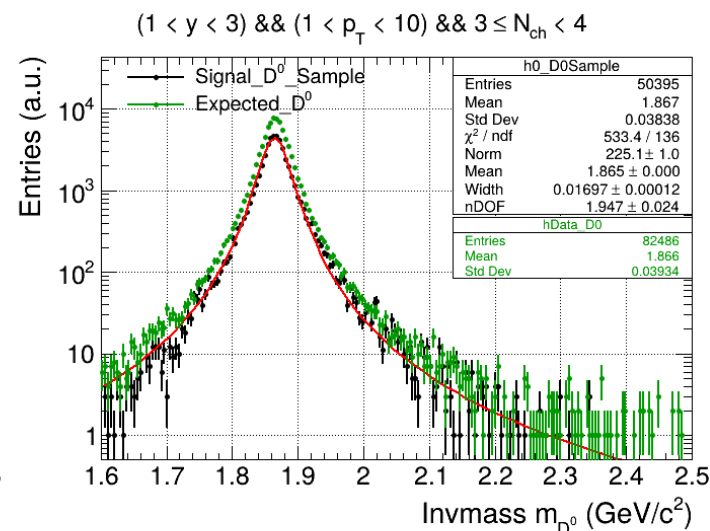
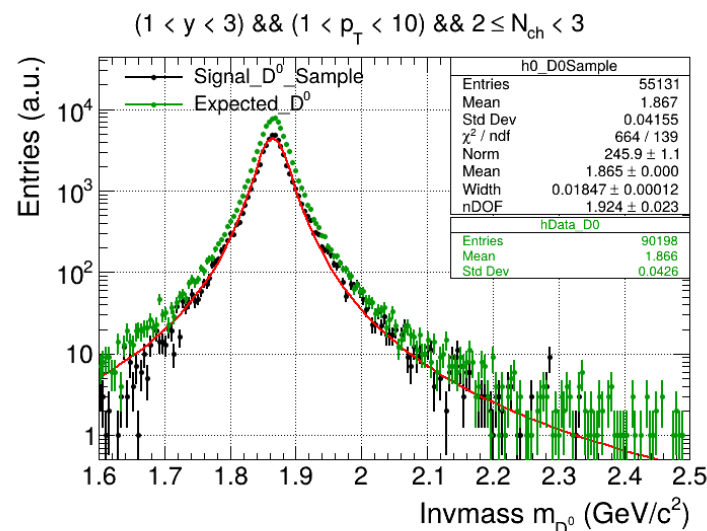
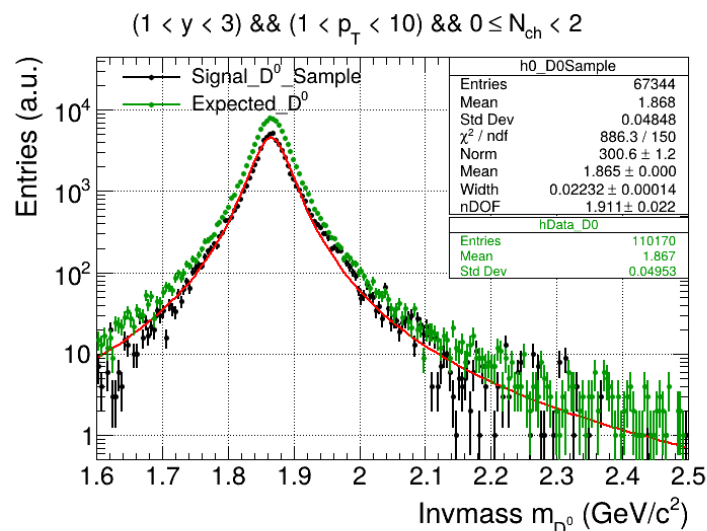
$L_{\text{int}} = 2.5 \text{ fb}^{-1}$



Sampling Signal ($1 < y < 3$)

$L_{\text{int}} = 1.5 \text{ fb}^{-1}$

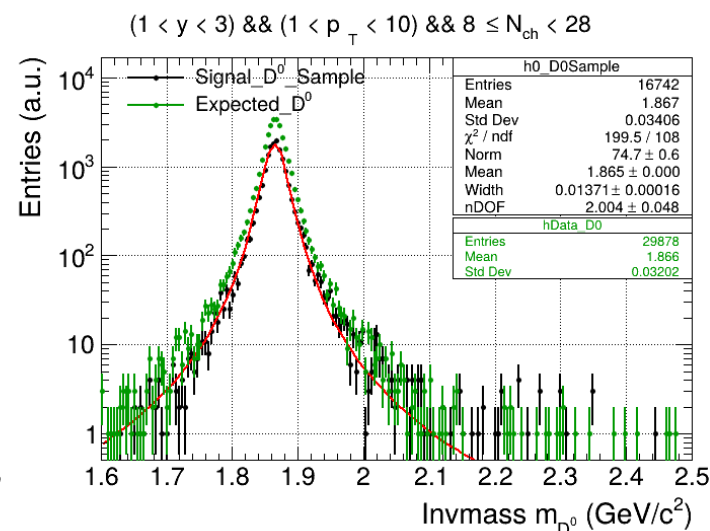
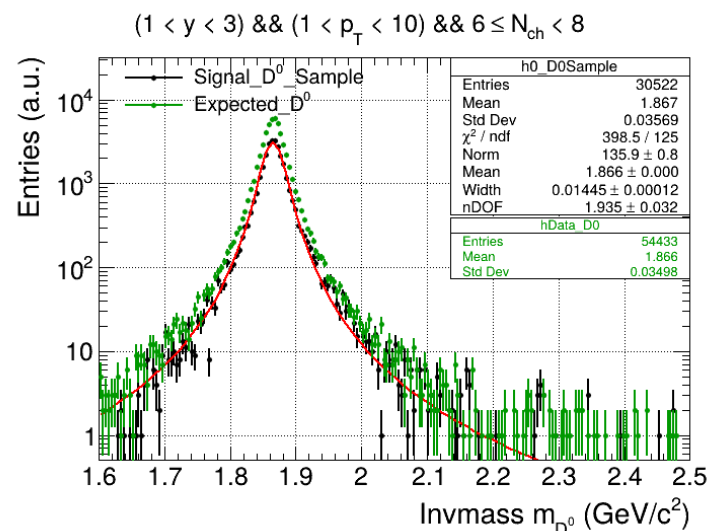
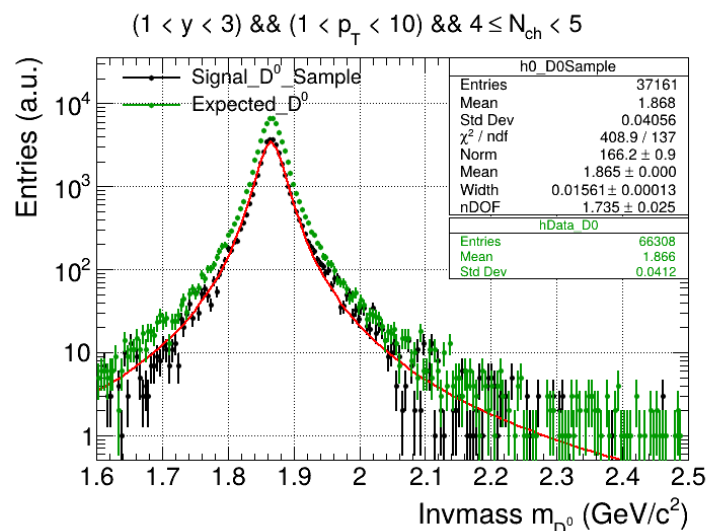
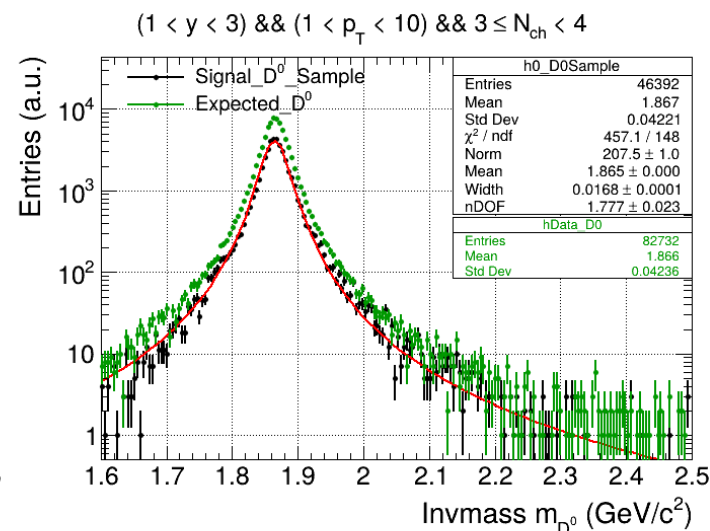
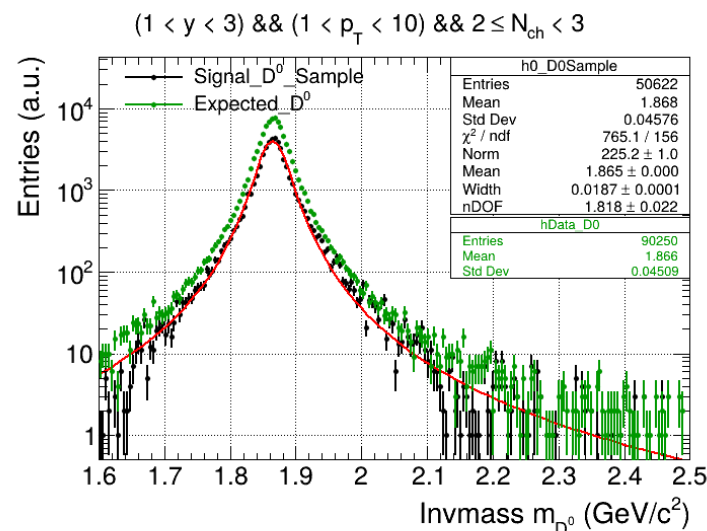
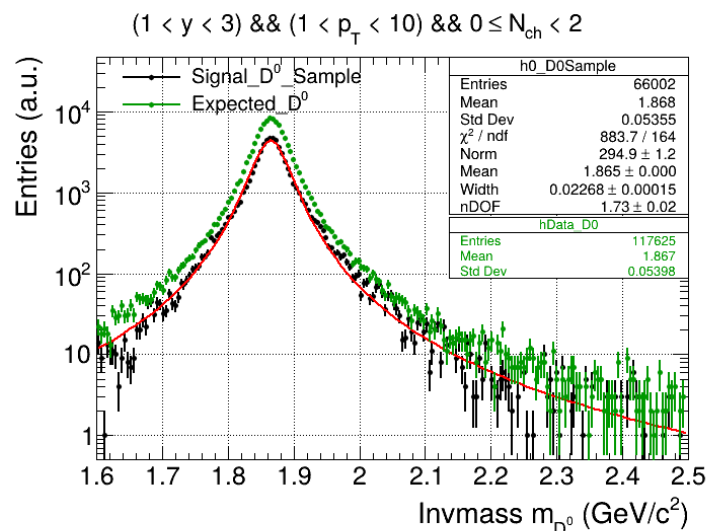
$L_{\text{int}} = 2.5 \text{ fb}^{-1}$



Sampling Signal ($1 < y < 3$)

$L_{\text{int}} = 1.4 \text{ fb}^{-1}$

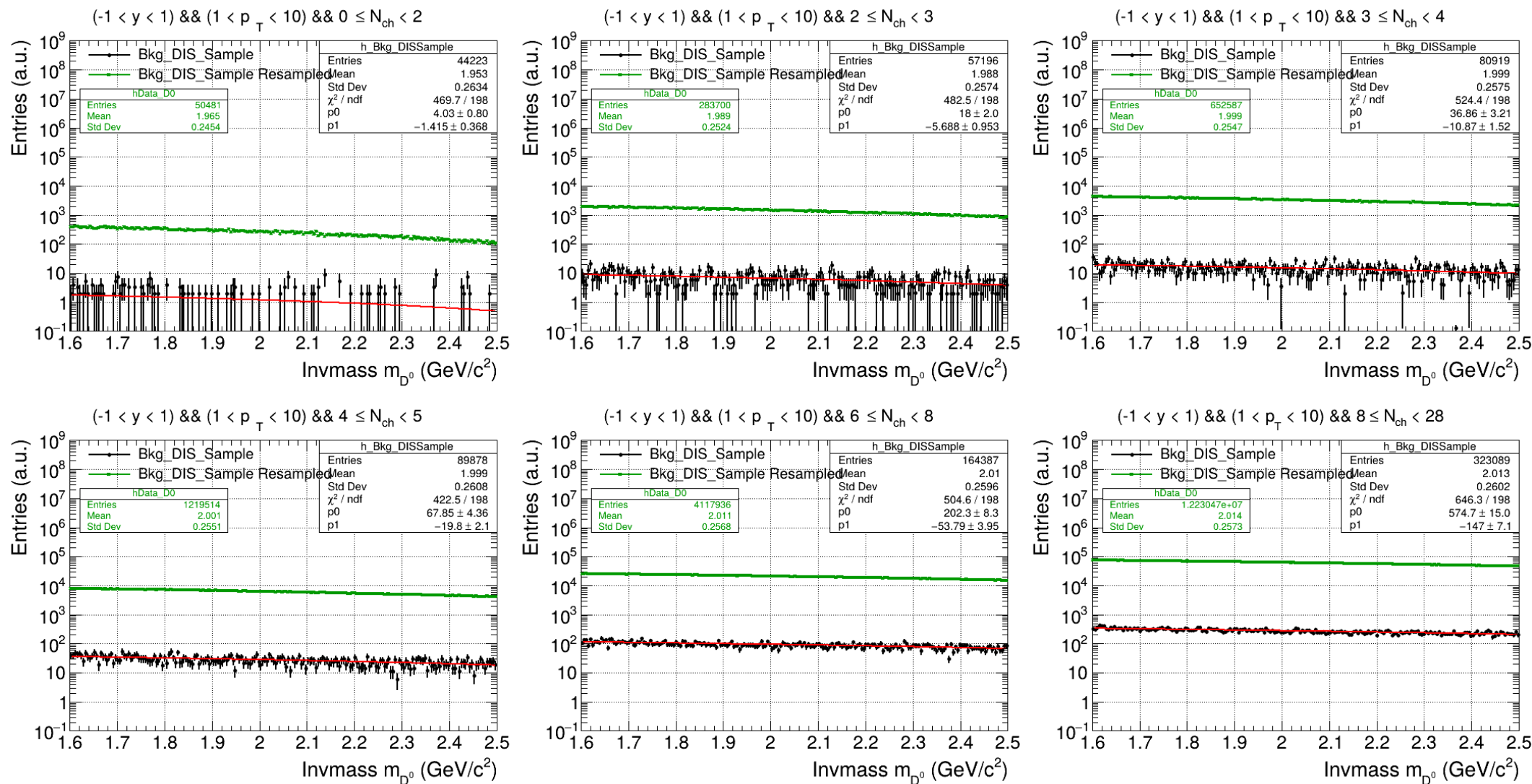
$L_{\text{int}} = 2.5 \text{ fb}^{-1}$



Sampling Background ($-1 < y < 1$)

$$L_{\text{int}} = 0.011174597 \text{ fb}^{-1}$$

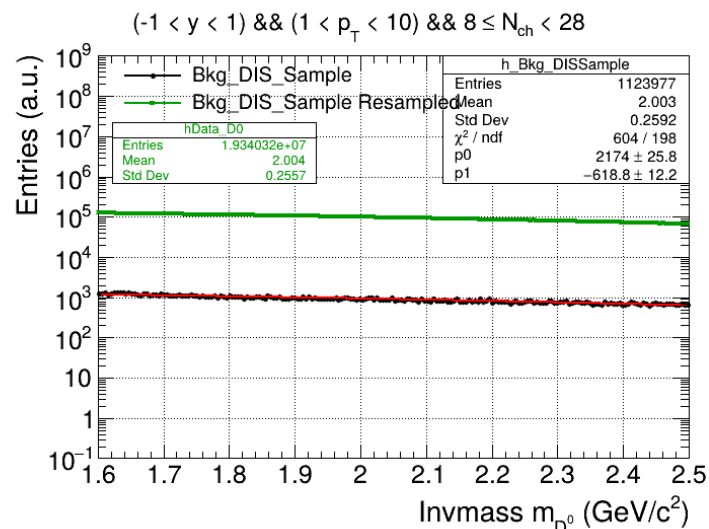
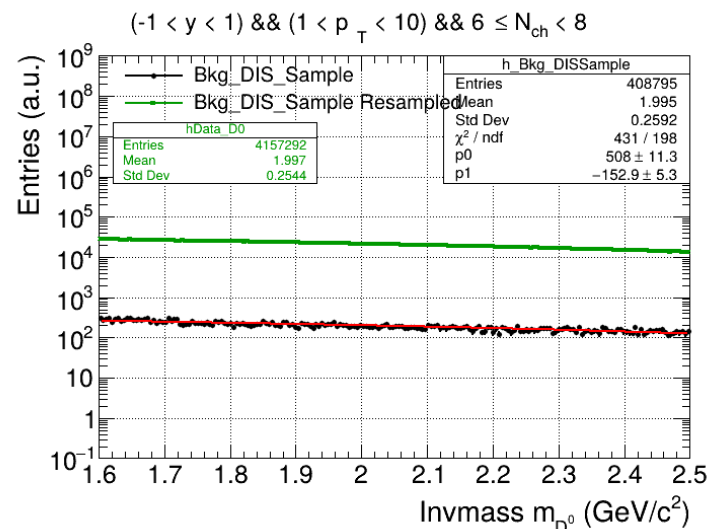
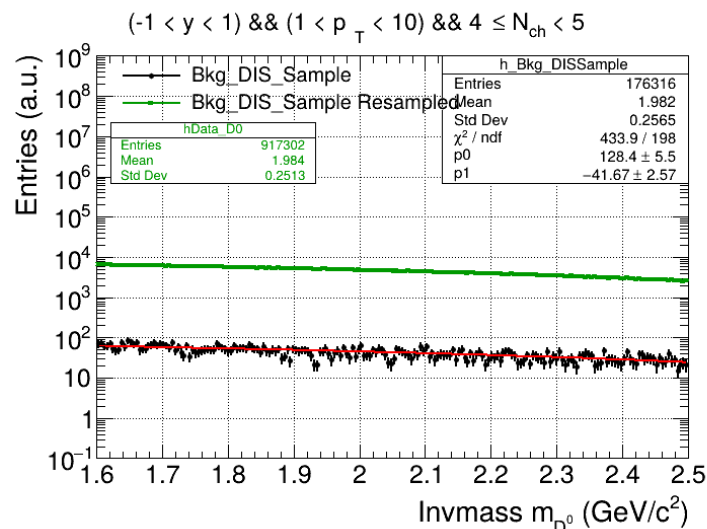
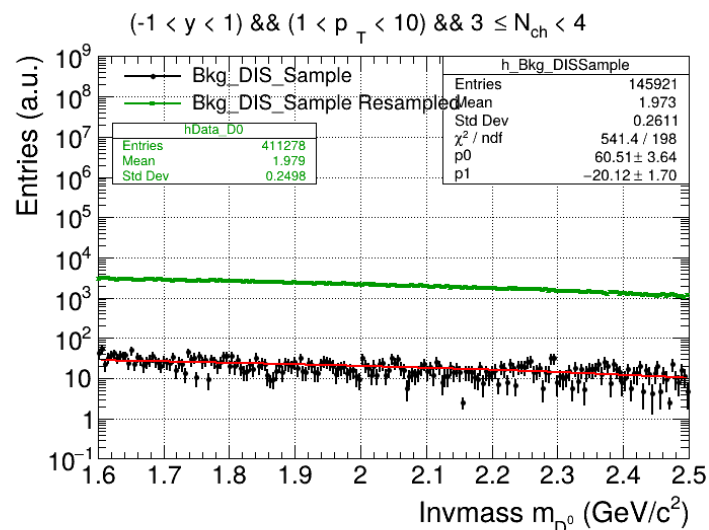
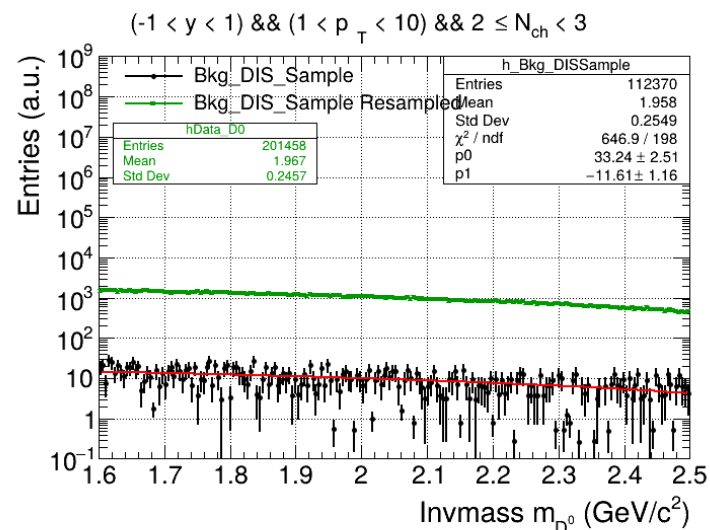
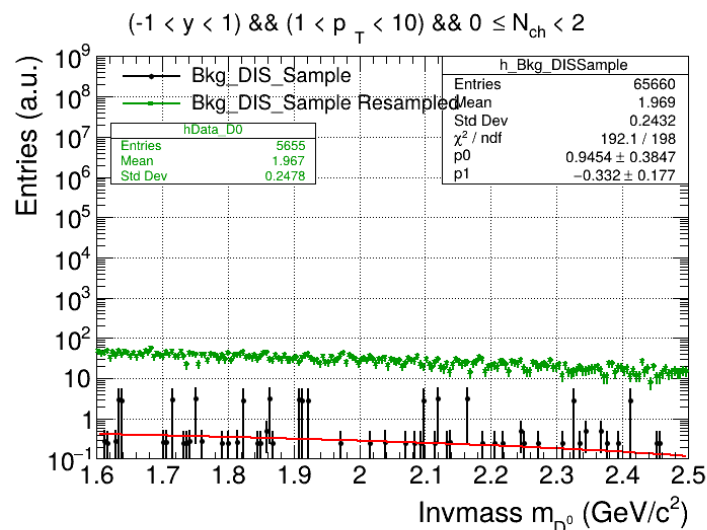
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($-1 < y < 1$)

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

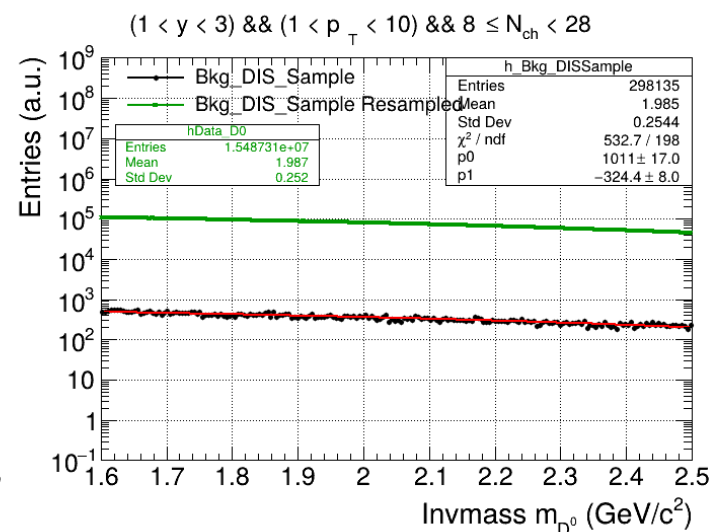
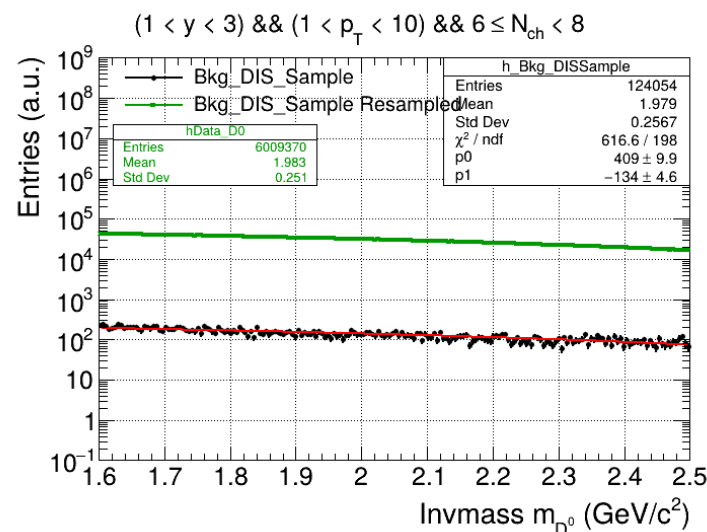
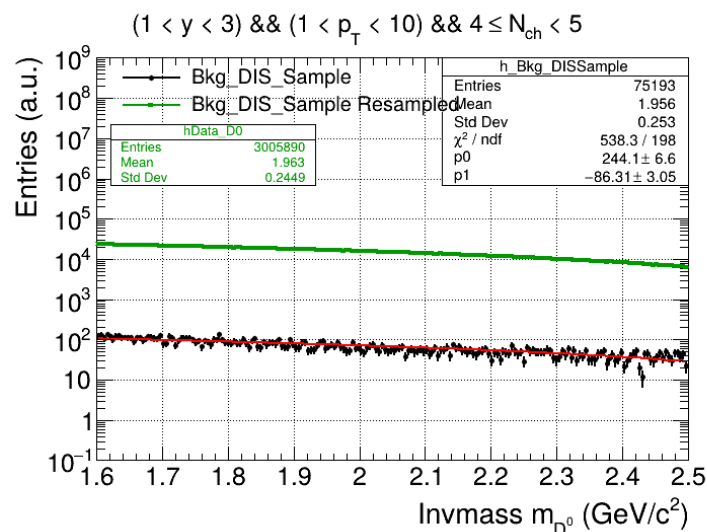
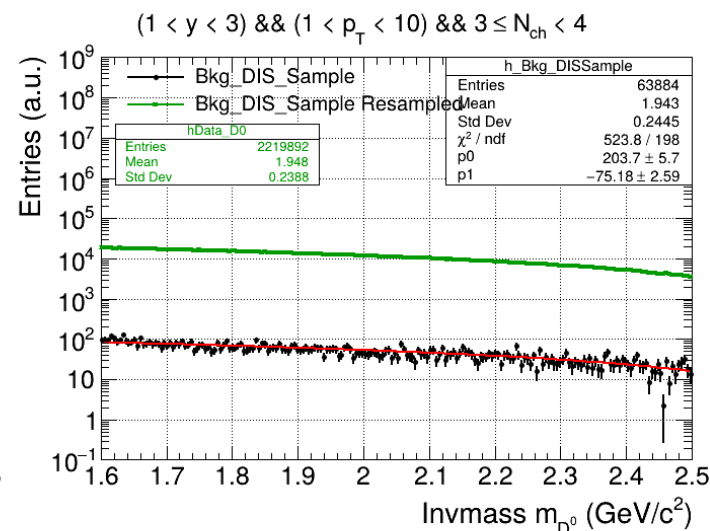
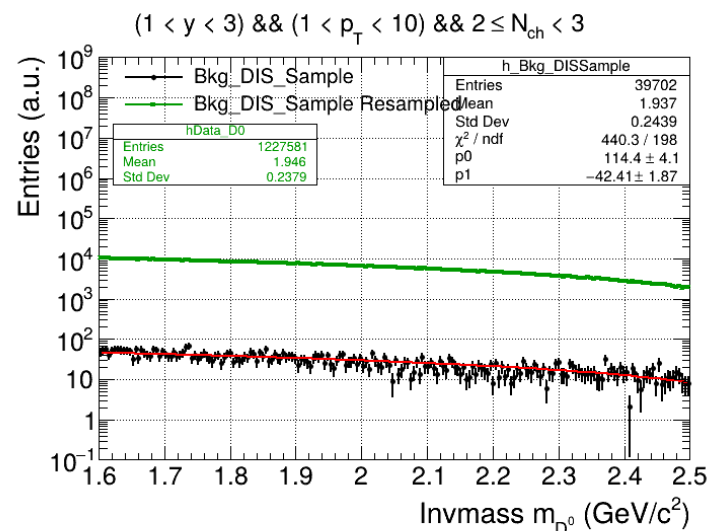
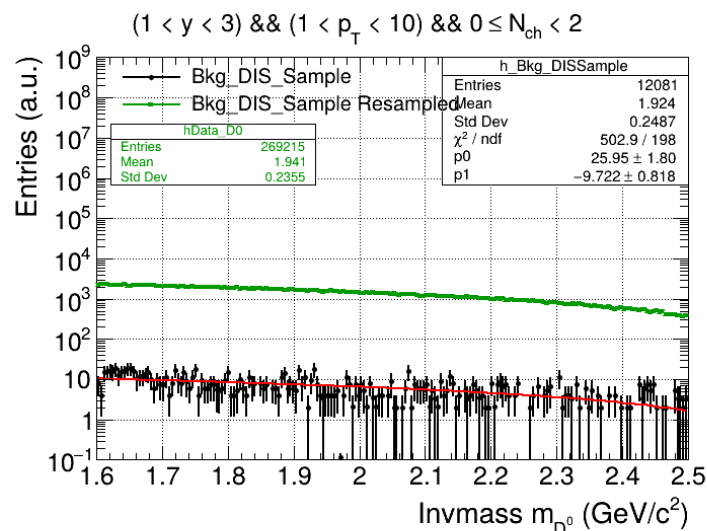
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($1 < y < 3$)

$$L_{\text{int}} = 0.011174597 \text{ fb}^{-1}$$

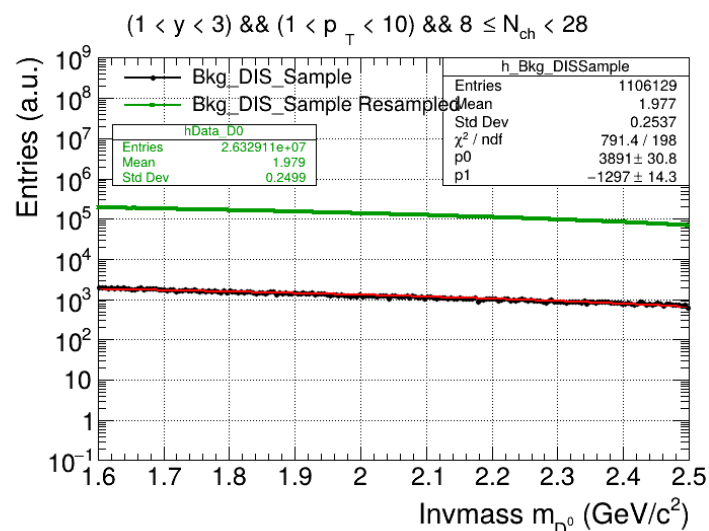
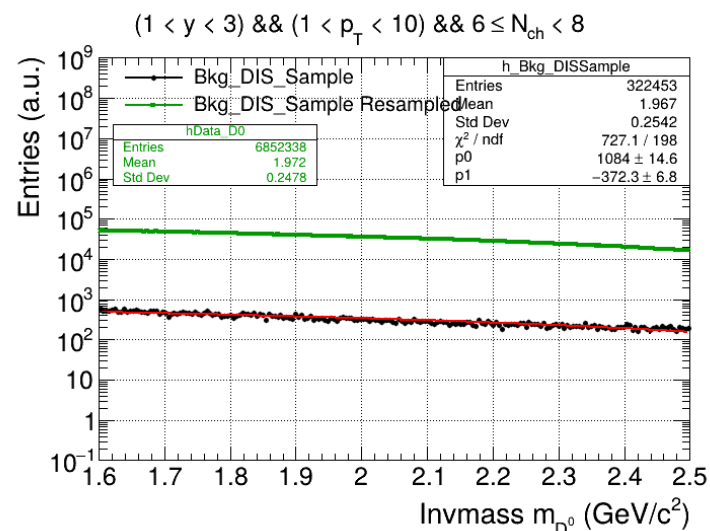
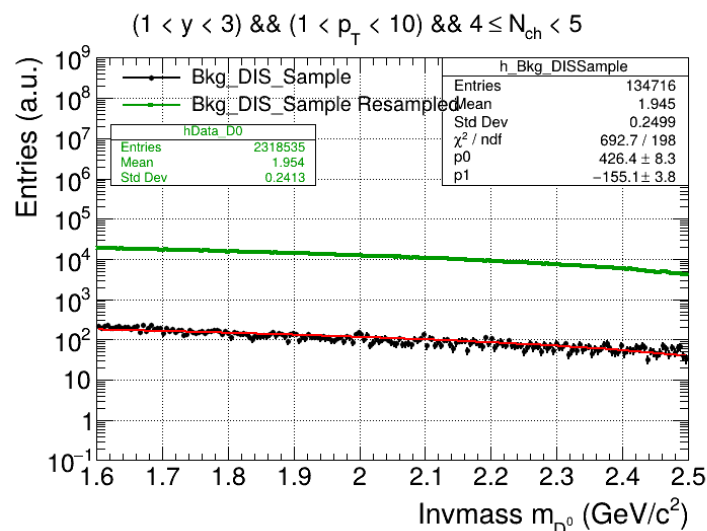
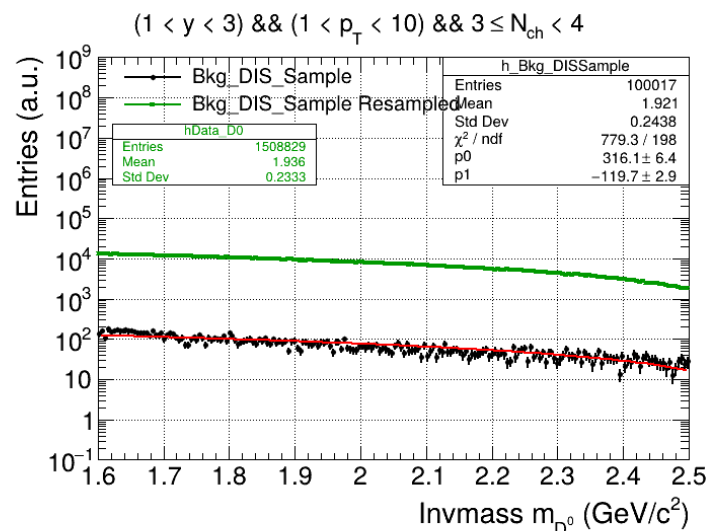
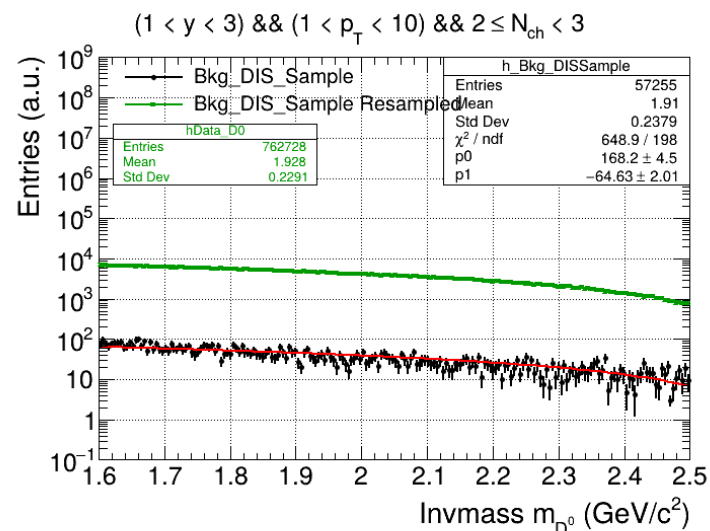
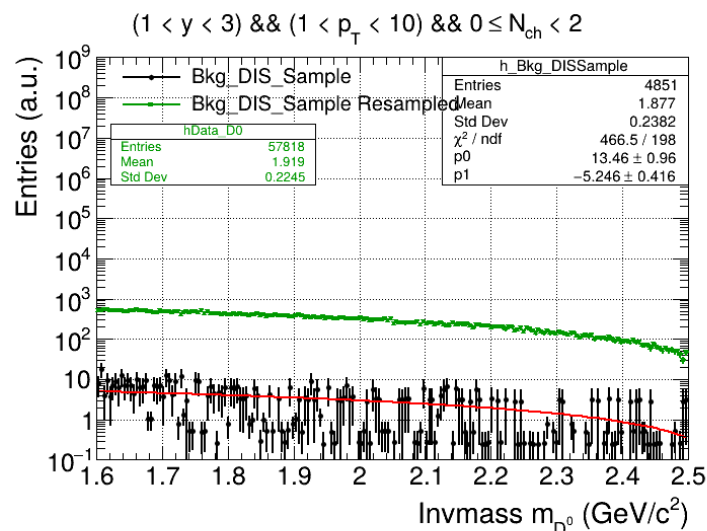
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($1 < y < 3$)

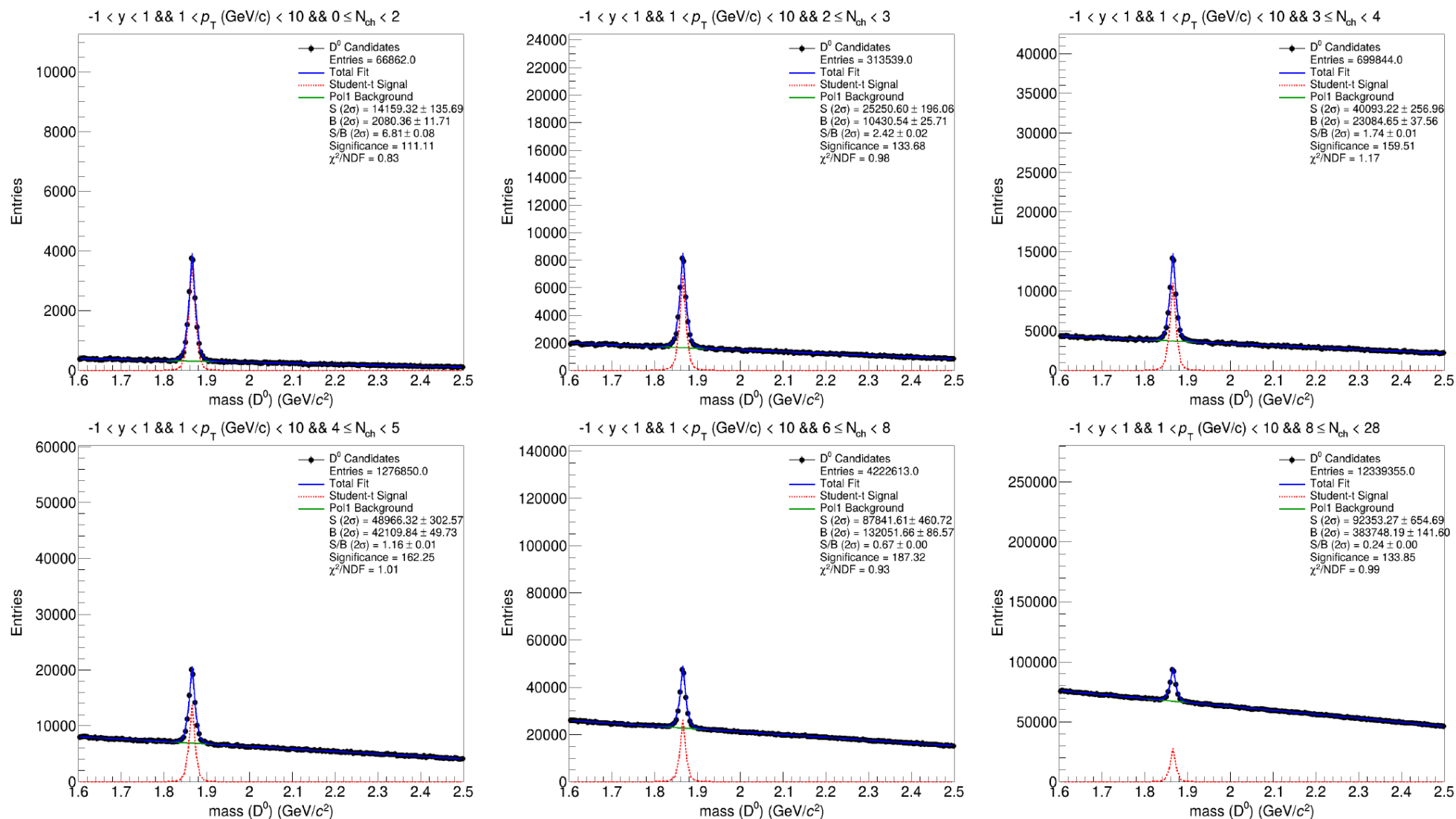
$$L_{\text{int}} = 0.020602717 \text{ fb}^{-1}$$

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



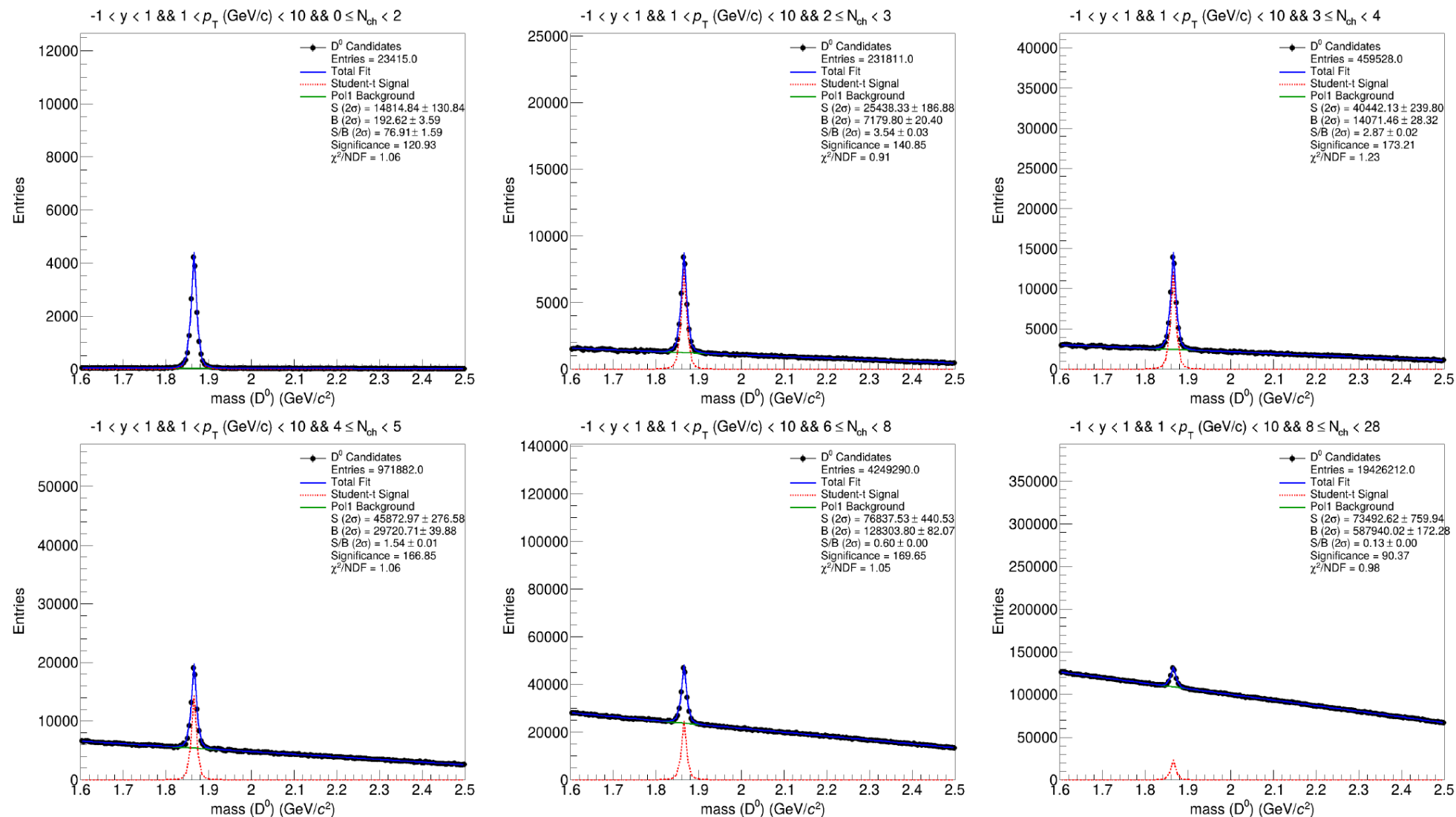
Invariant Mass (D^0): ($-1 < y < 1$)

After PID + Preselection



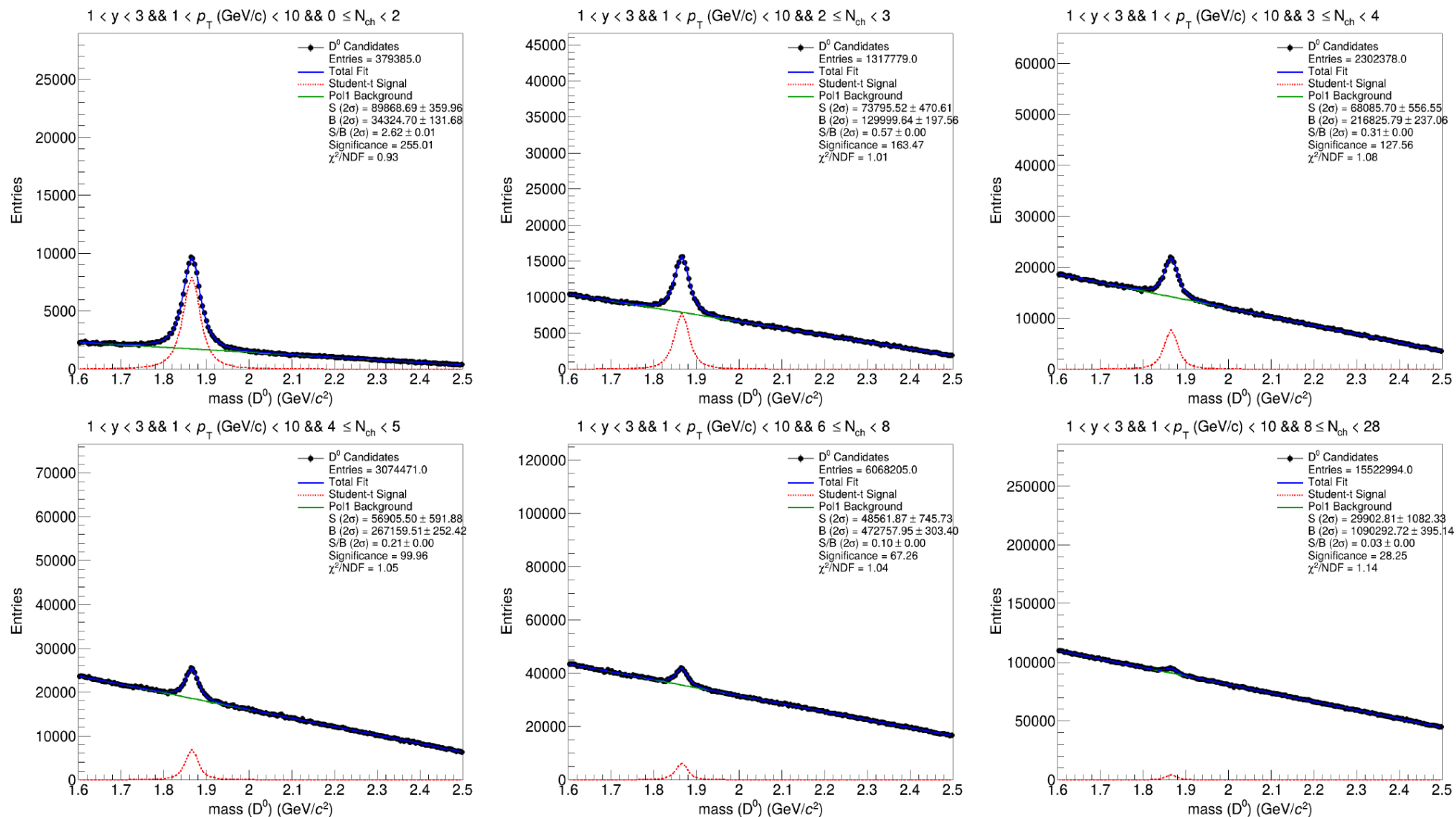
Invariant Mass (D^0): ($-1 < y < 1$)

After PID + Preselection



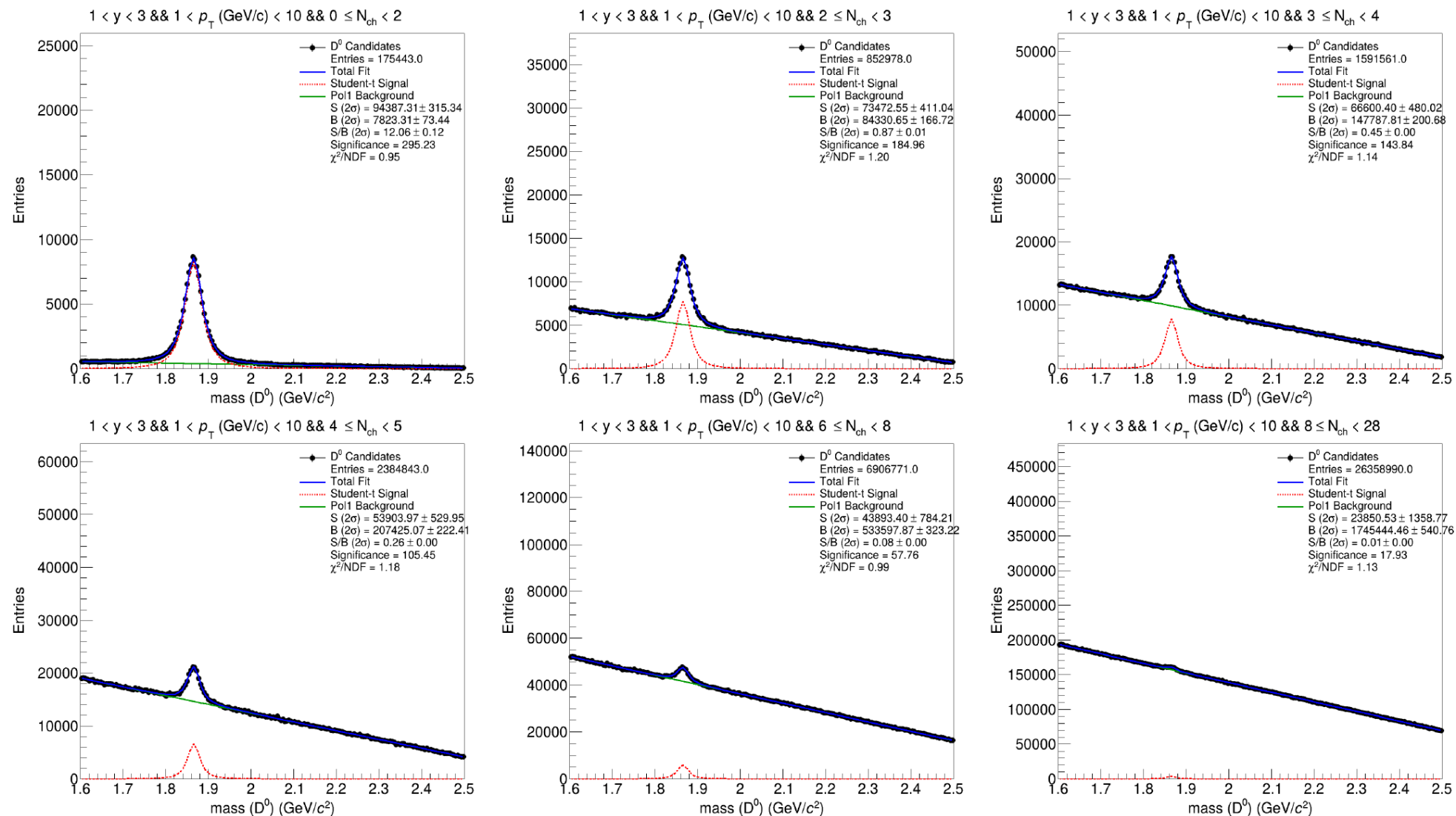
Invariant Mass (D^0): ($1 < y < 3$)

After PID + Preselection



Invariant Mass (D^0): ($1 < y < 3$)

After PID + Preselection



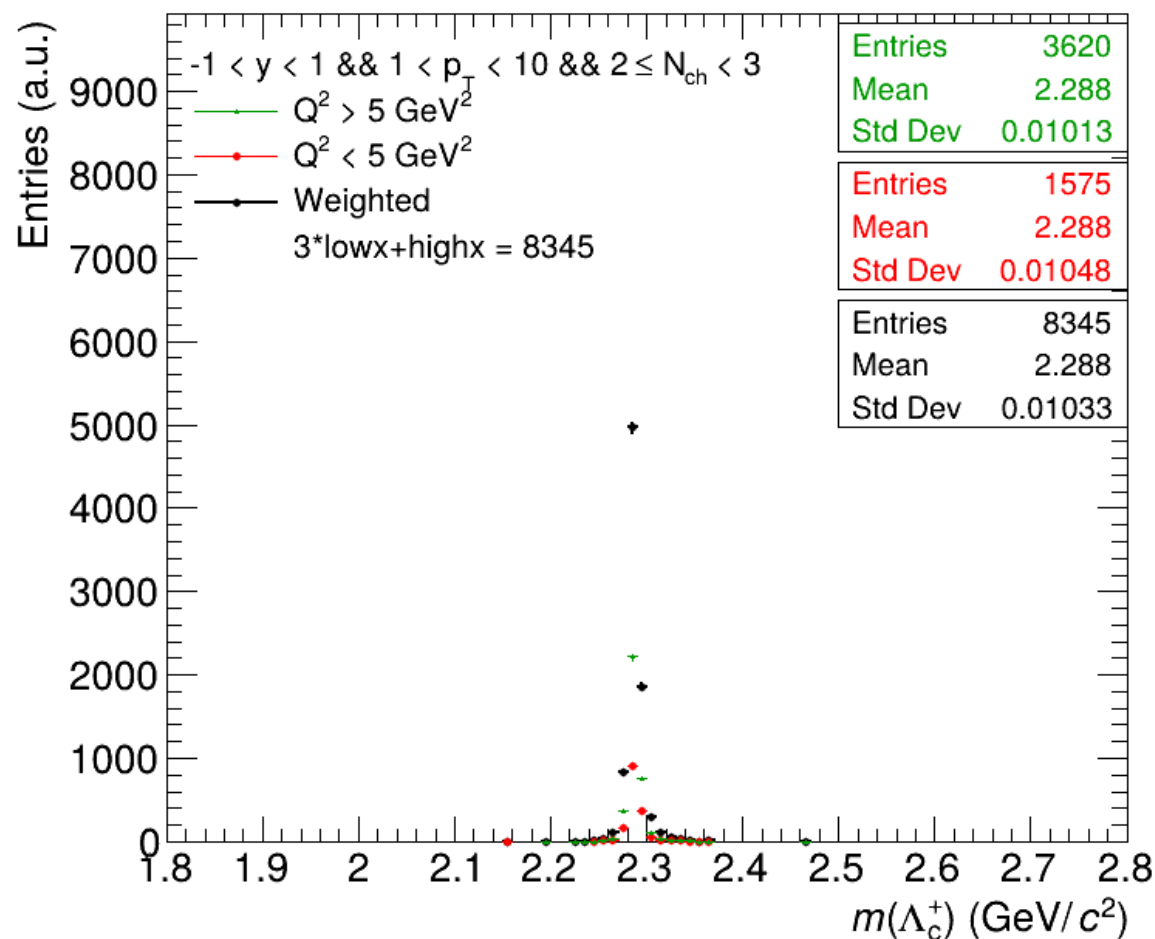
Λ_c^+ reconstruction

- Signal from Λ_c^+ sample
 - Corrections:
 - ✓ Weight factor of 3 on signal for $Q^2 < 5 \text{ GeV}^2$
 - ✓ Scaling to target luminosity 2.5 fb^{-1}
- Combinatorial background from DIS sample
 - Scaling to target luminosity
- Preselection cuts: '(mass_Lcp > 1.8 && mass_Lcp < 2.8) && d0xy_p<10. && d0xy_pi<10. && d0xy_k<10. && chi2 <10.'

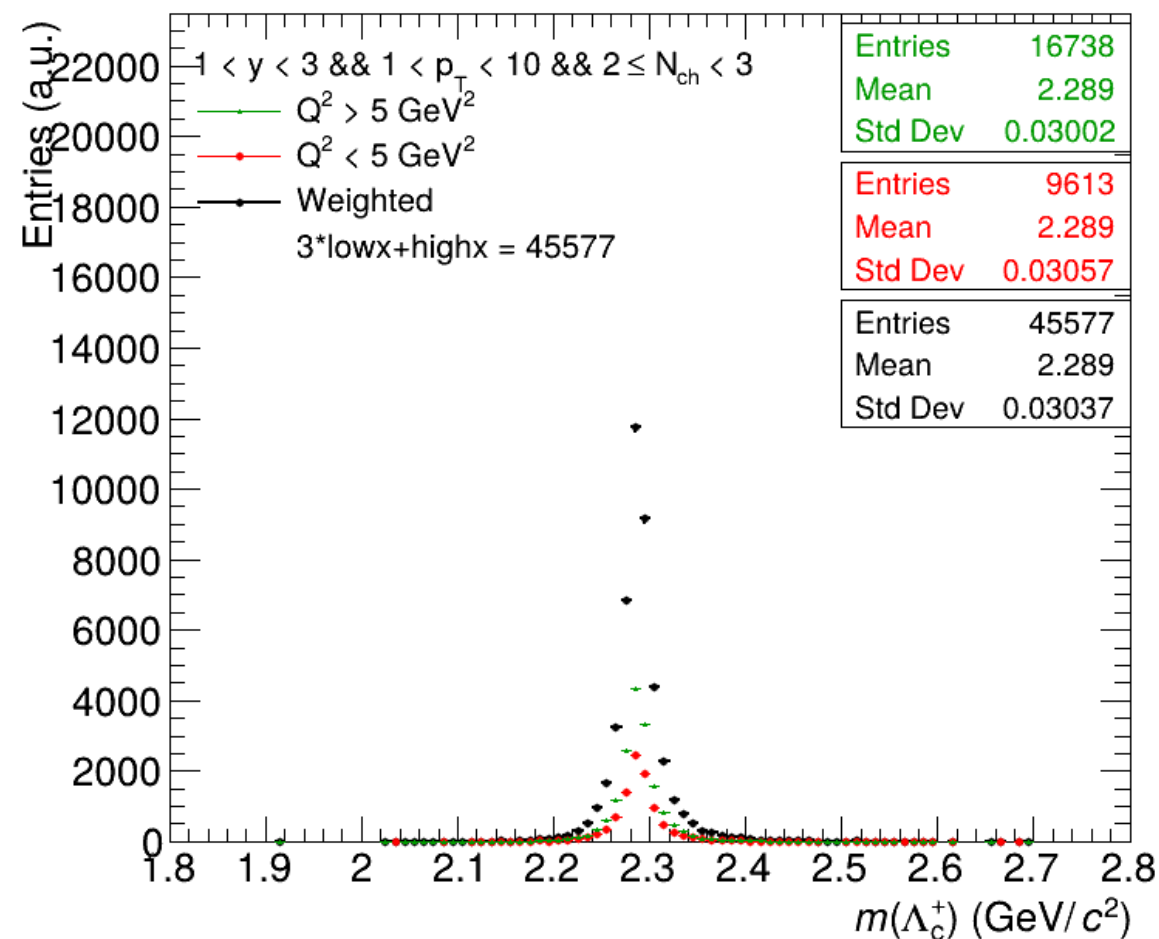
Applying weight factors on signal

July campaign

Mid rapidity



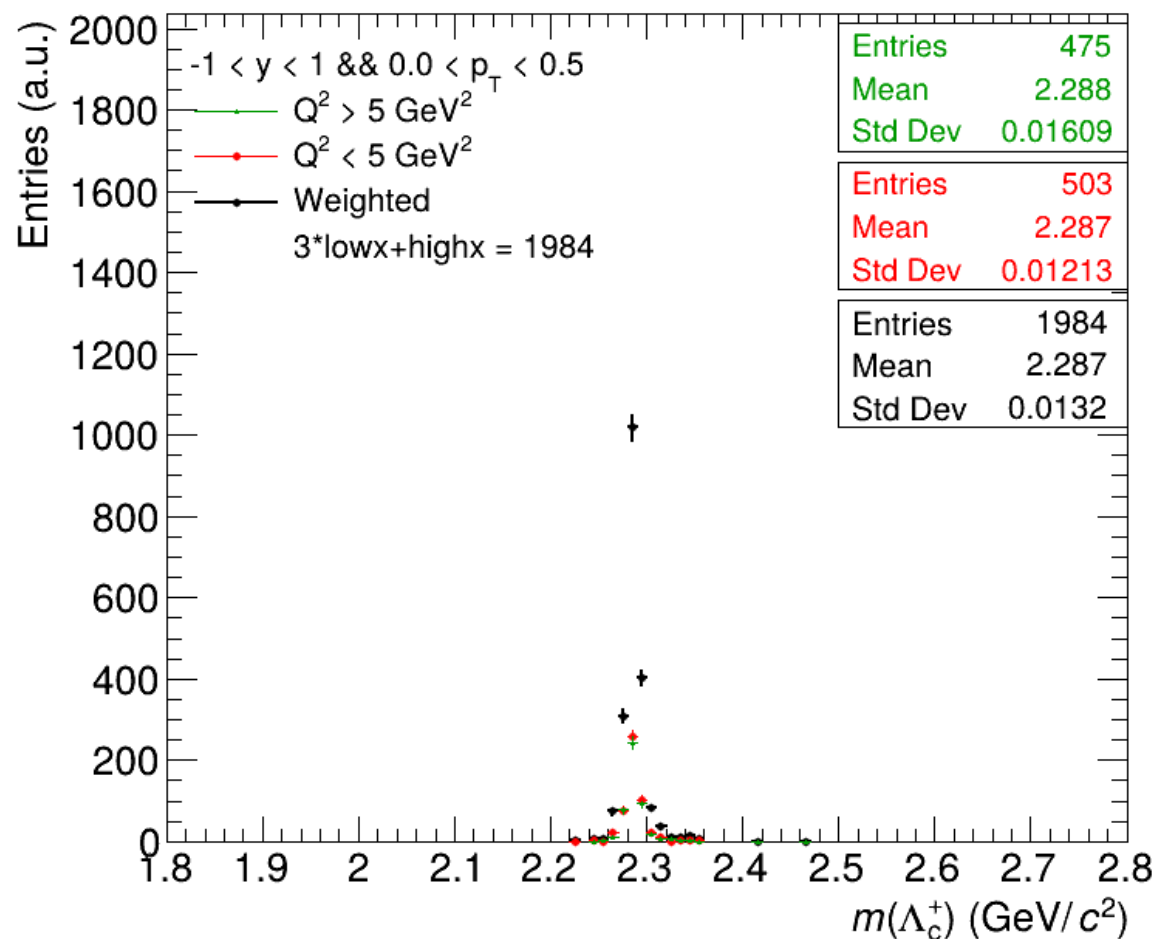
Forward rapidity



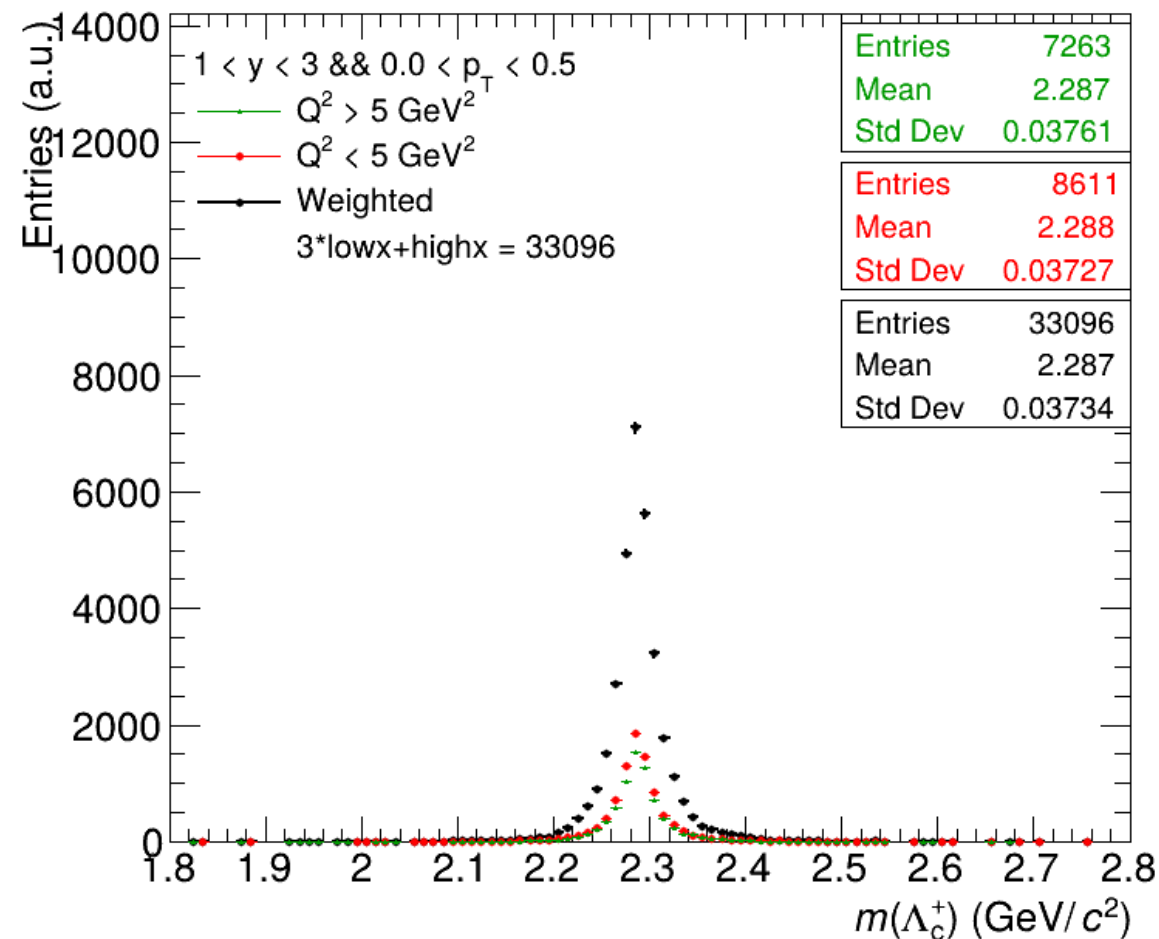
Applying weight factors on signal

April campaign

Mid rapidity



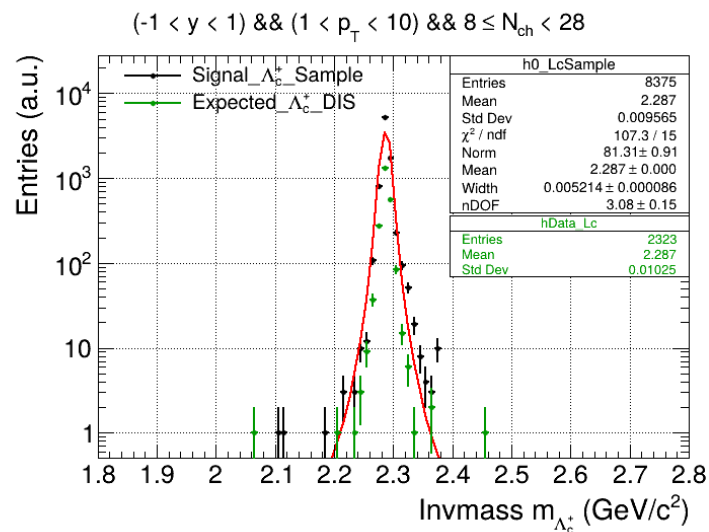
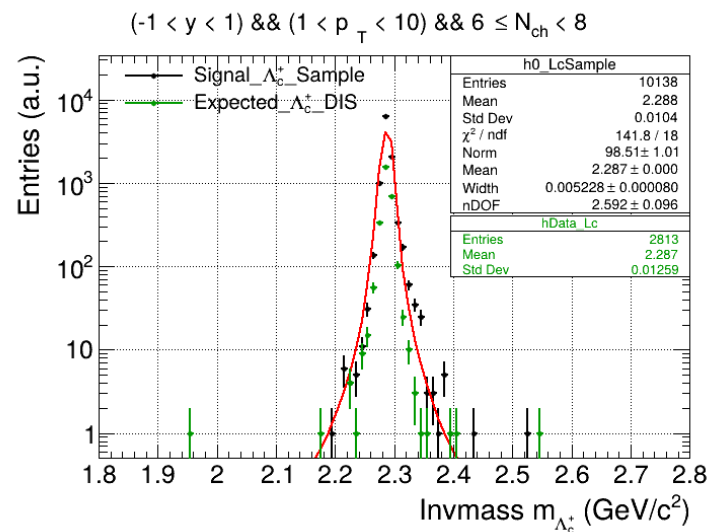
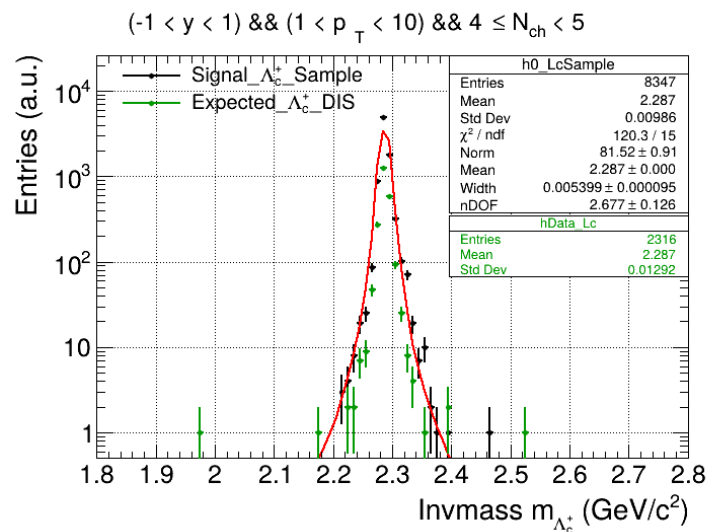
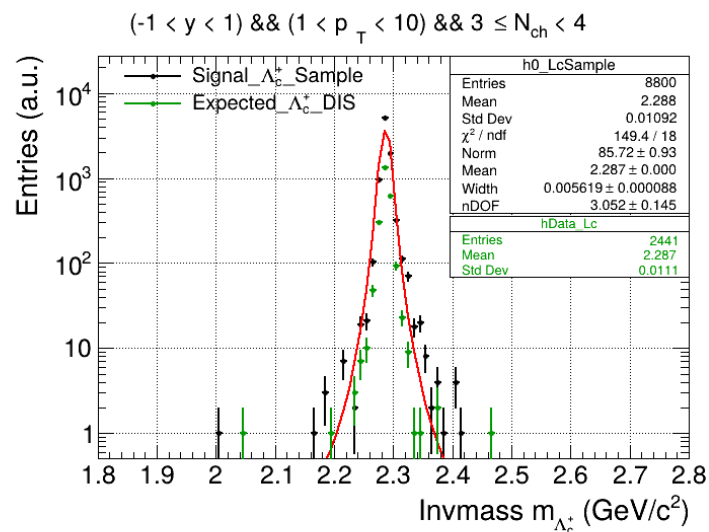
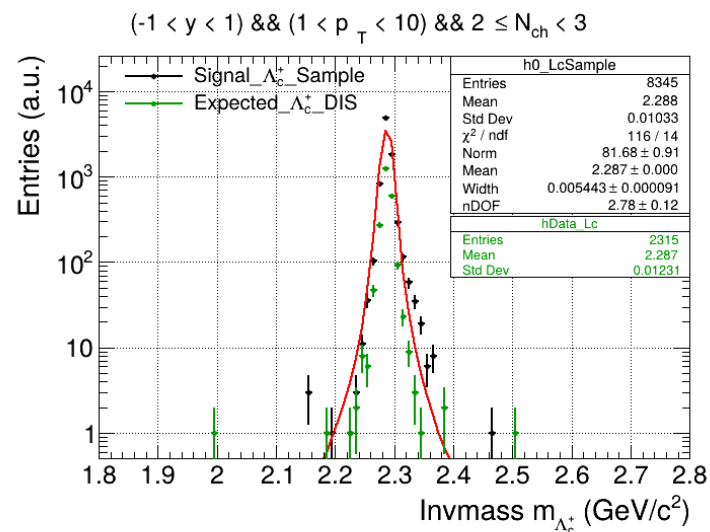
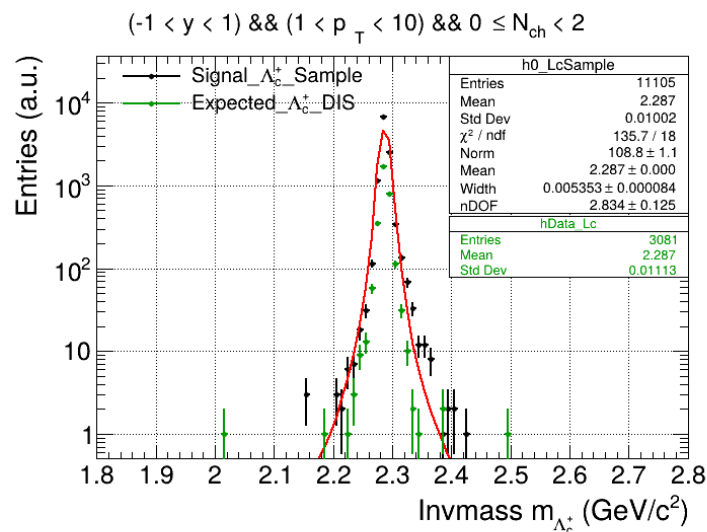
Forward rapidity



Sampling Signal ($-1 < y < 1$)

Int. Lumi.: 76.3 fb^{-1}

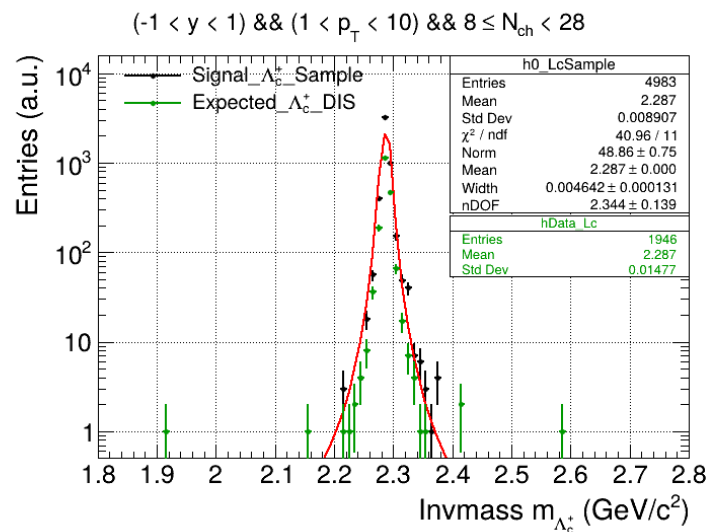
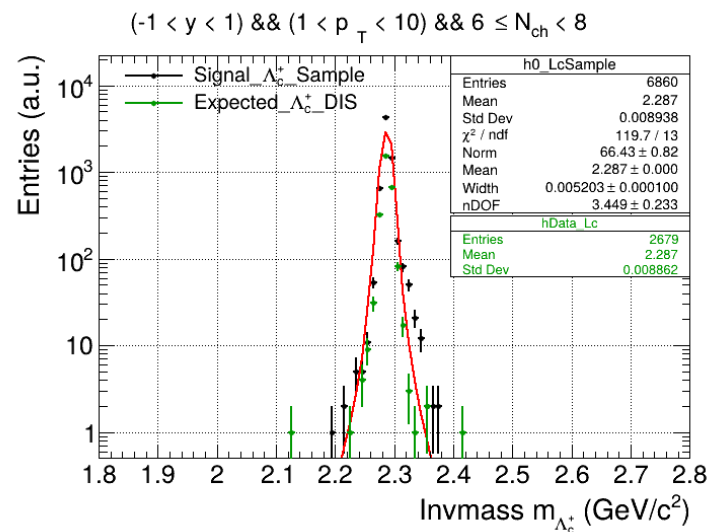
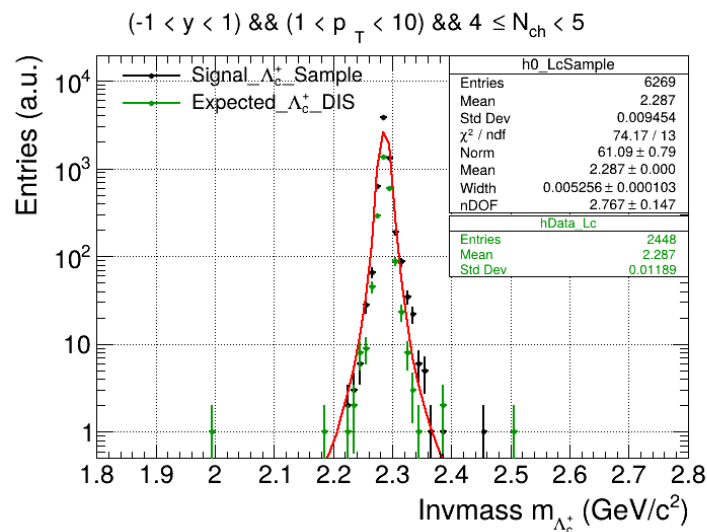
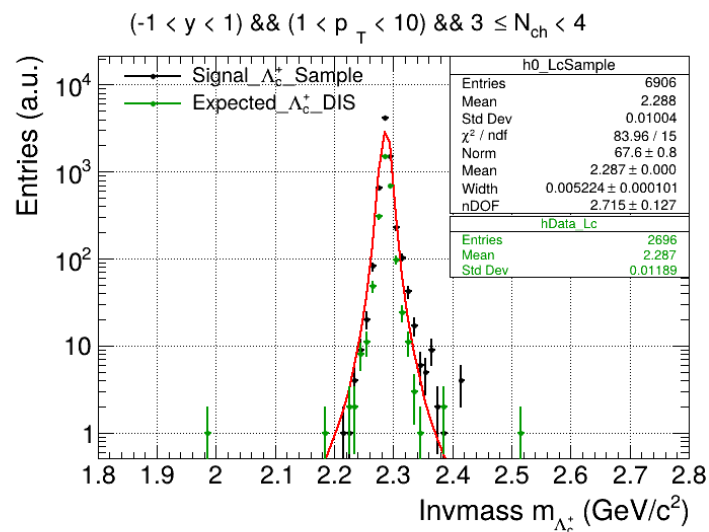
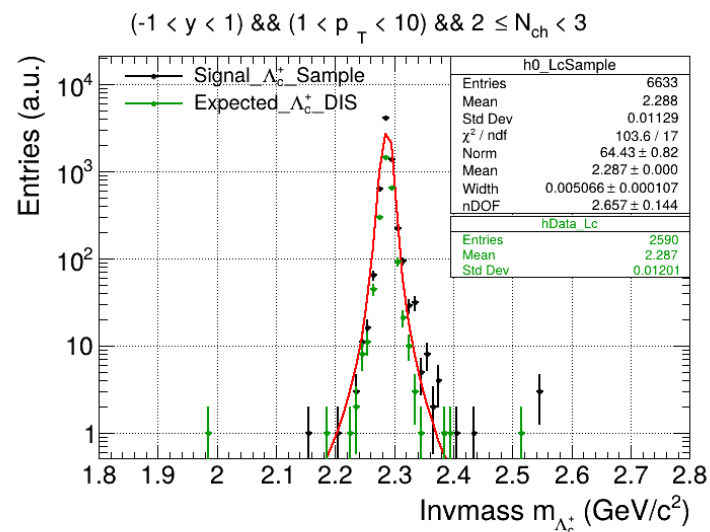
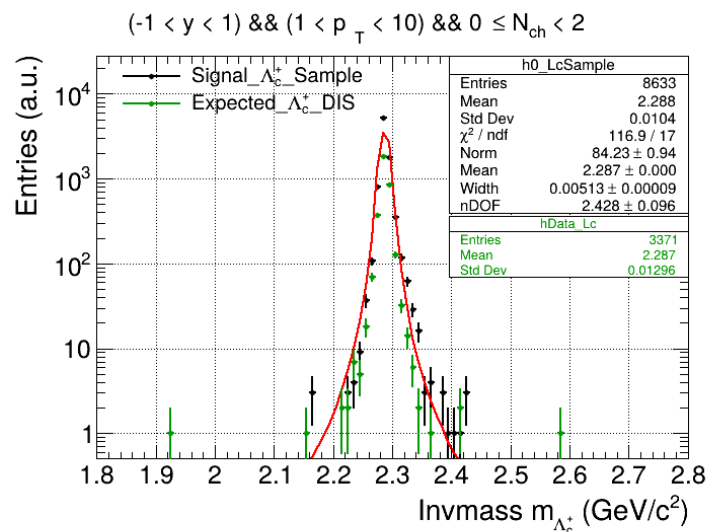
Int. Lumi.: 2.5 fb^{-1}



Sampling Signal ($-1 < y < 1$)

Int. Lumi.: 54.2 fb^{-1}

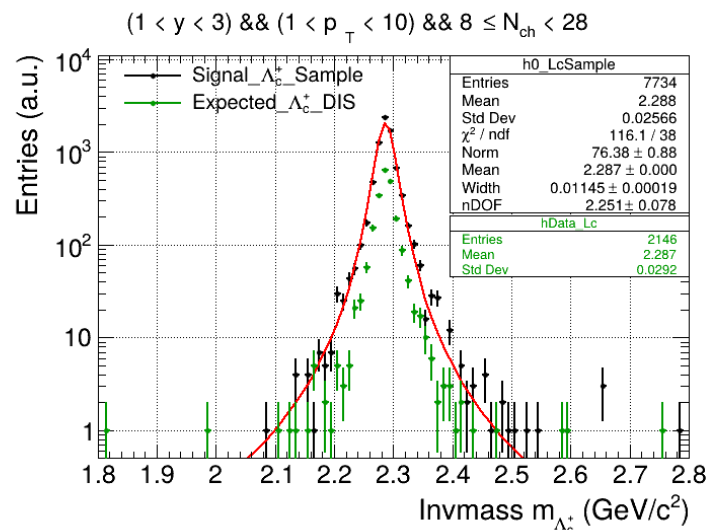
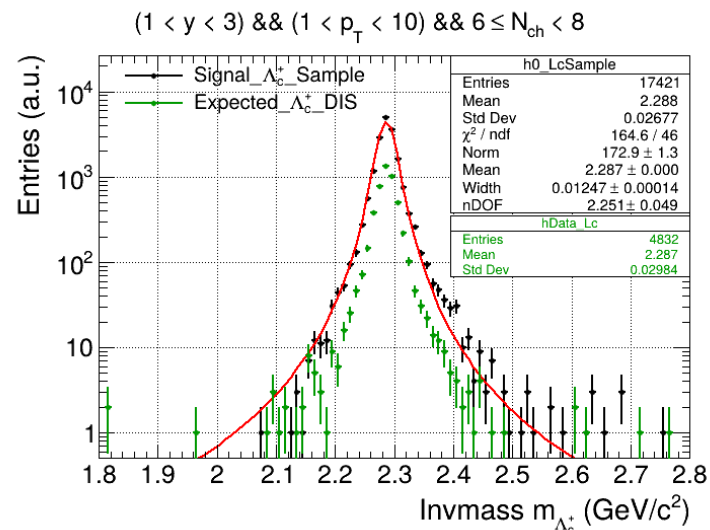
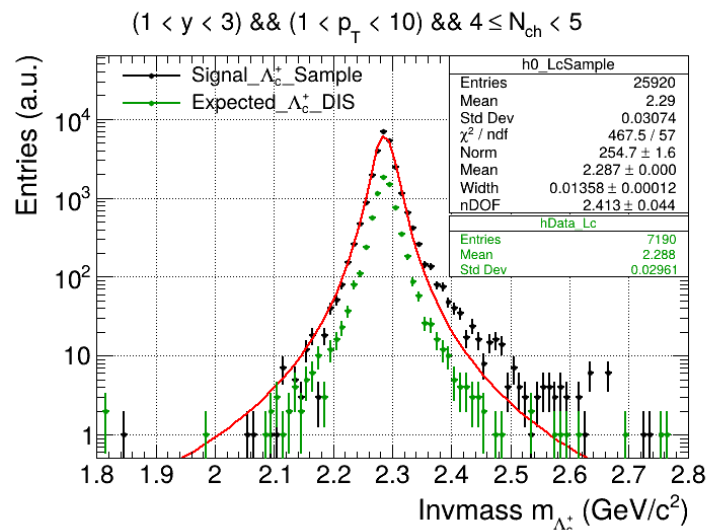
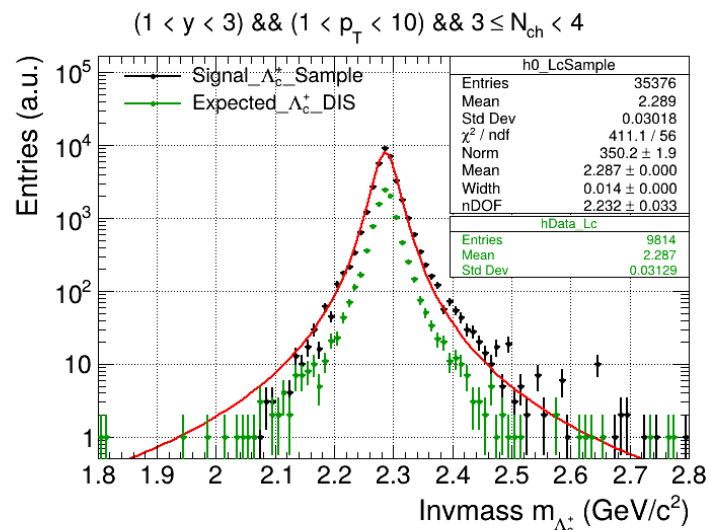
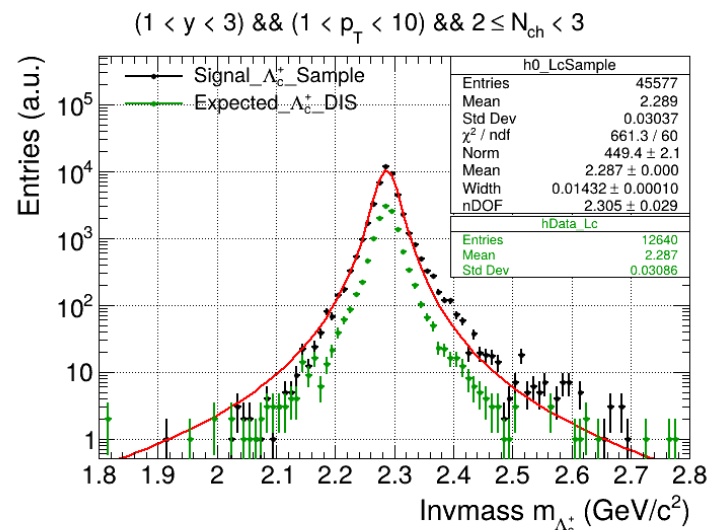
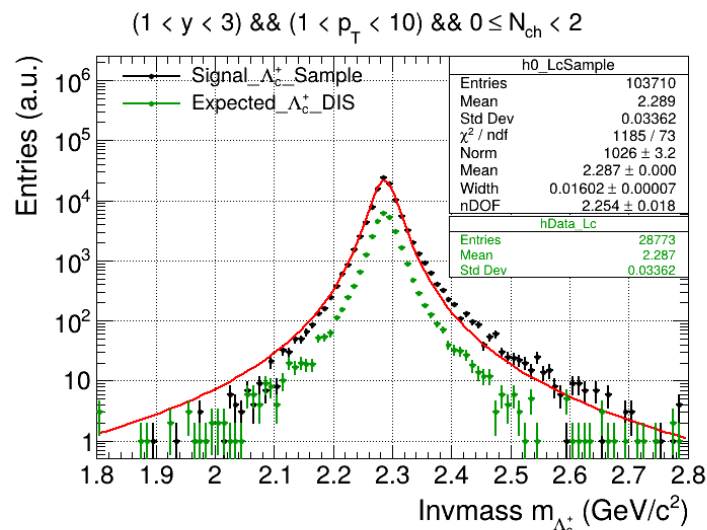
Int. Lumi.: 2.5 fb^{-1}



Sampling Signal ($1 < y < 3$)

Int. Lumi.: 76.3 fb^{-1}

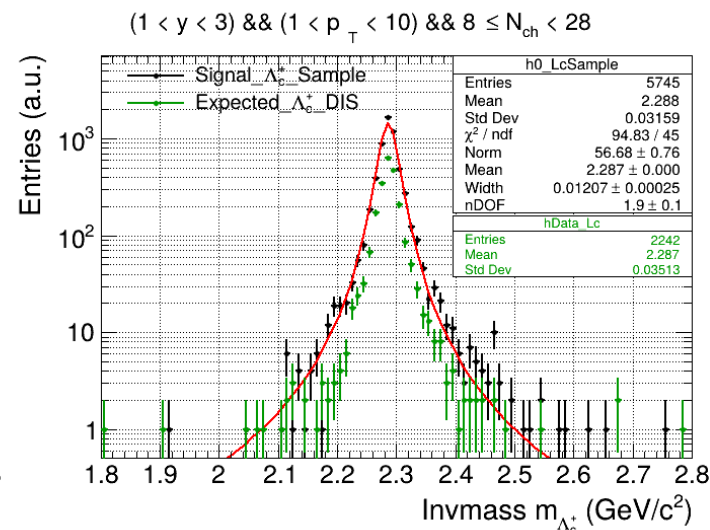
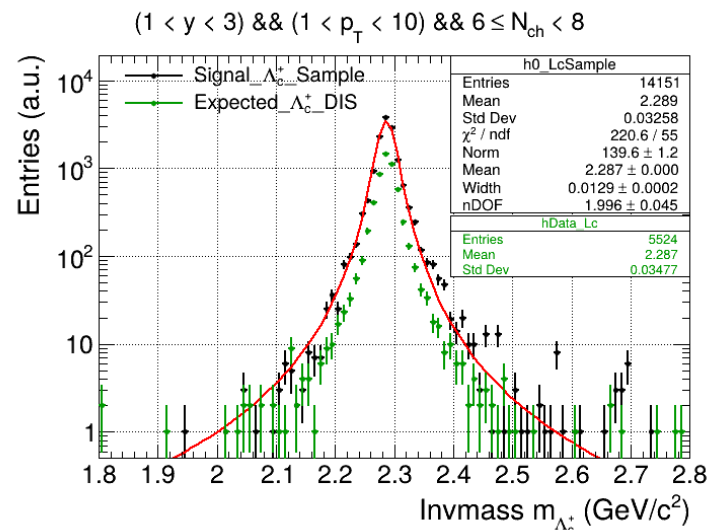
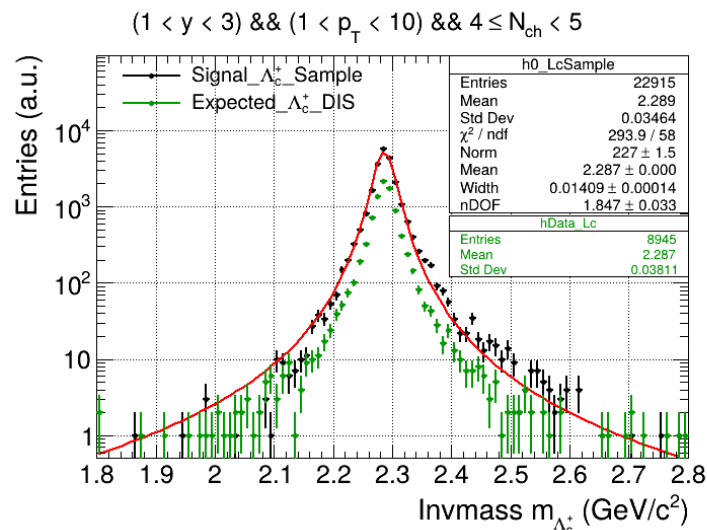
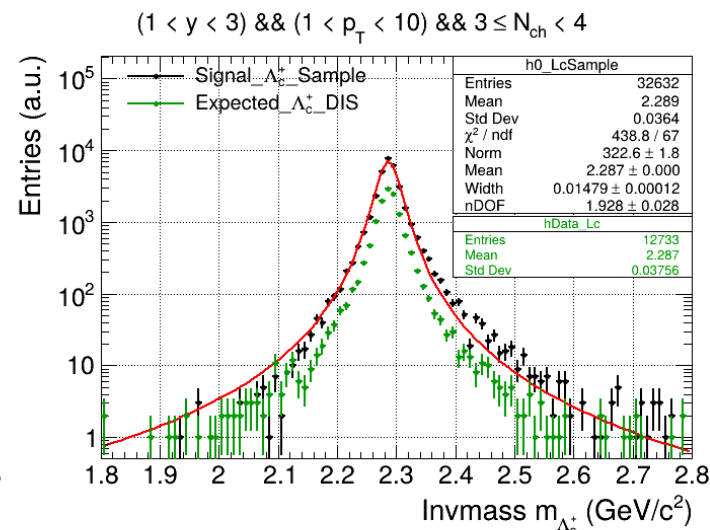
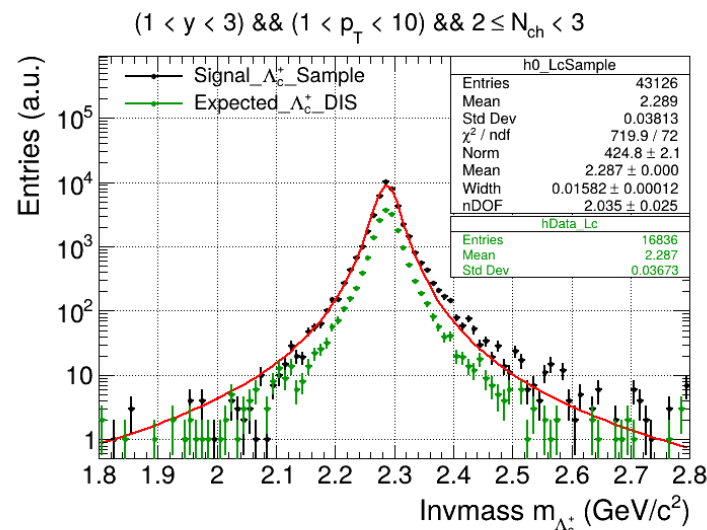
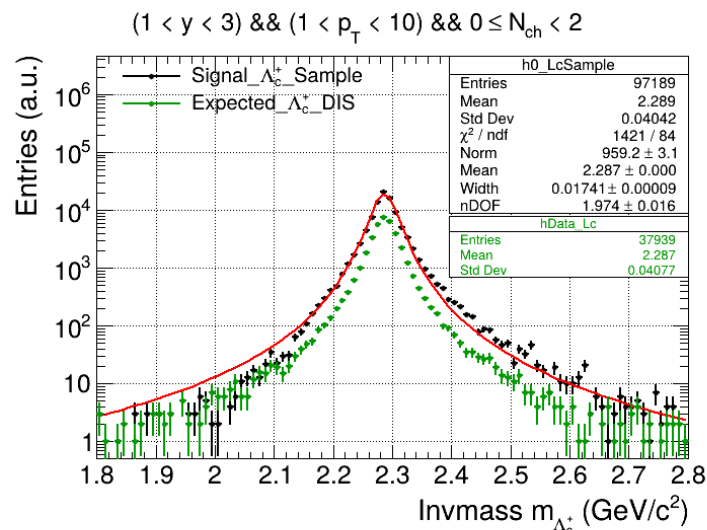
Int. Lumi.: 2.5 fb^{-1}



Sampling Signal ($1 < y < 3$)

Int. Lumi.: 54.2 fb^{-1}

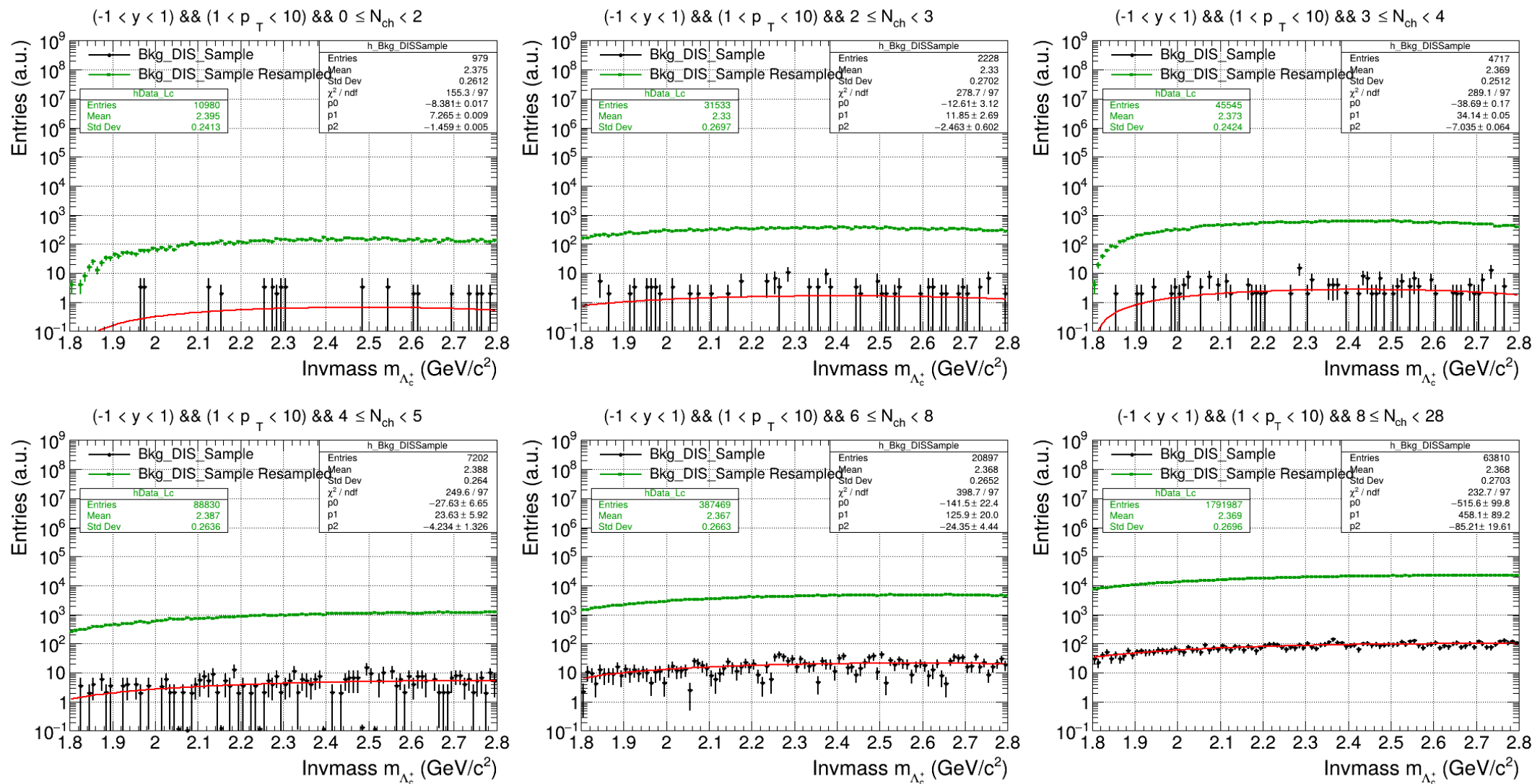
Int. Lumi.: 2.5 fb^{-1}



Sampling Background ($-1 < y < 1$)

$$L_{\text{int}} = 0.011174597 \text{ fb}^{-1}$$

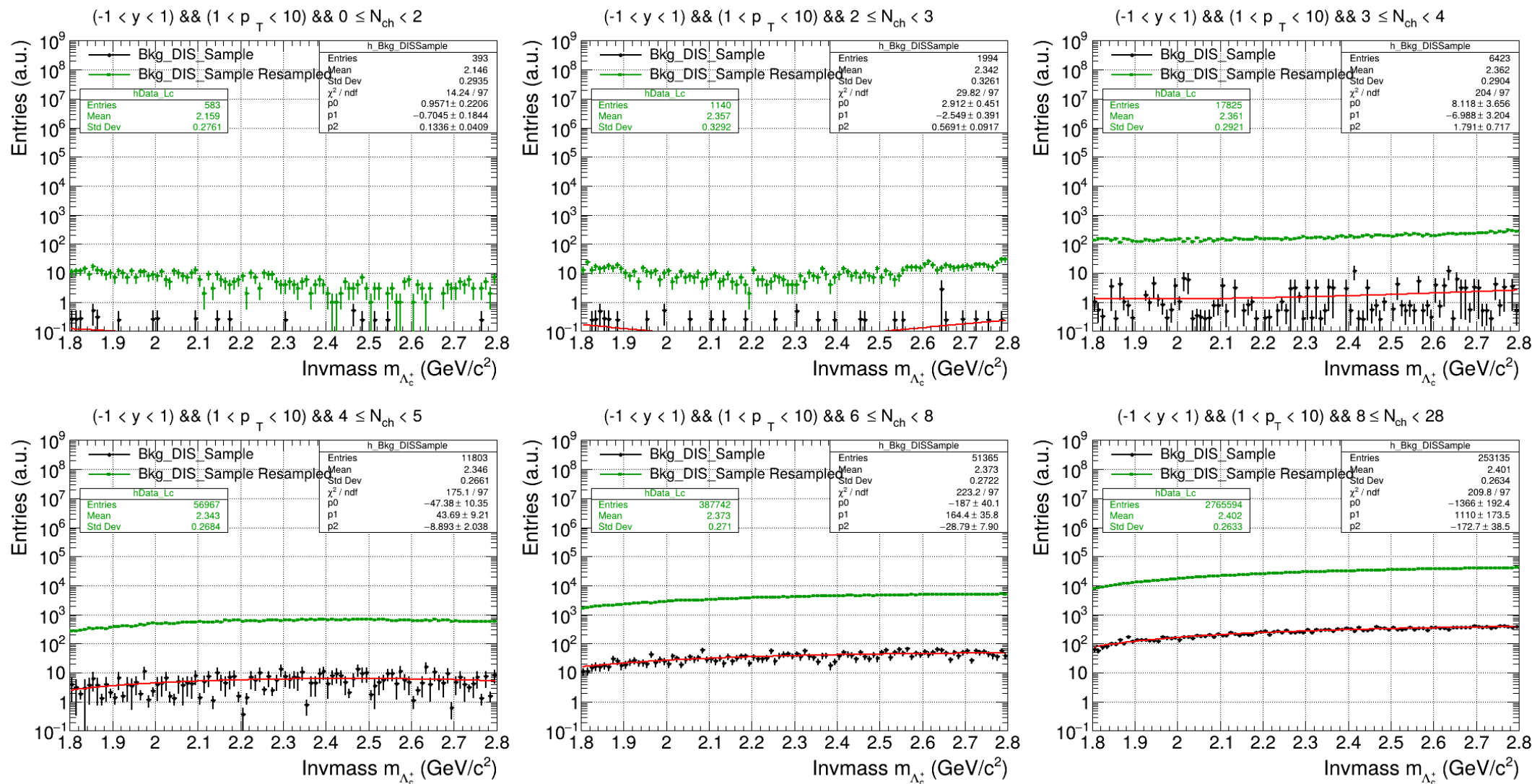
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($-1 < y < 1$)

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

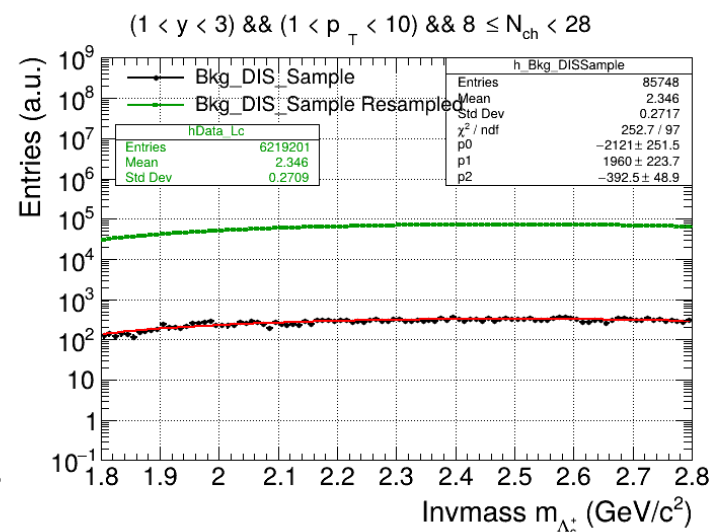
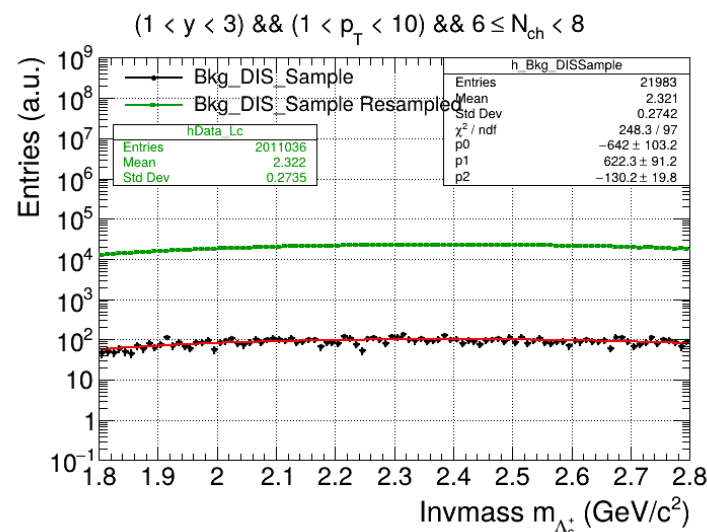
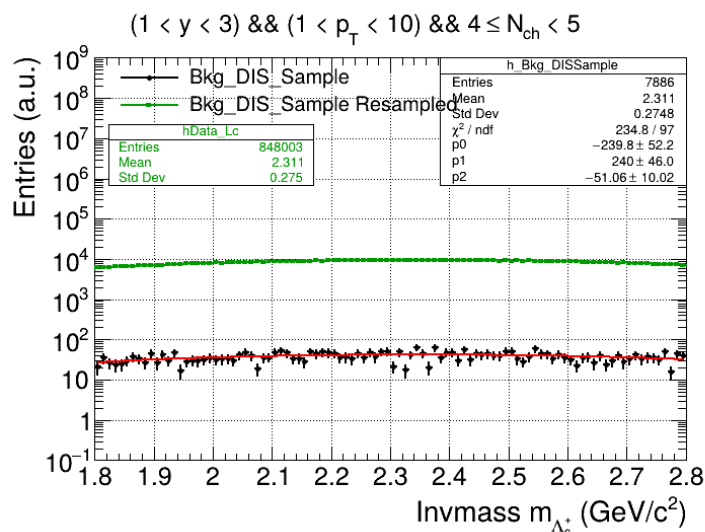
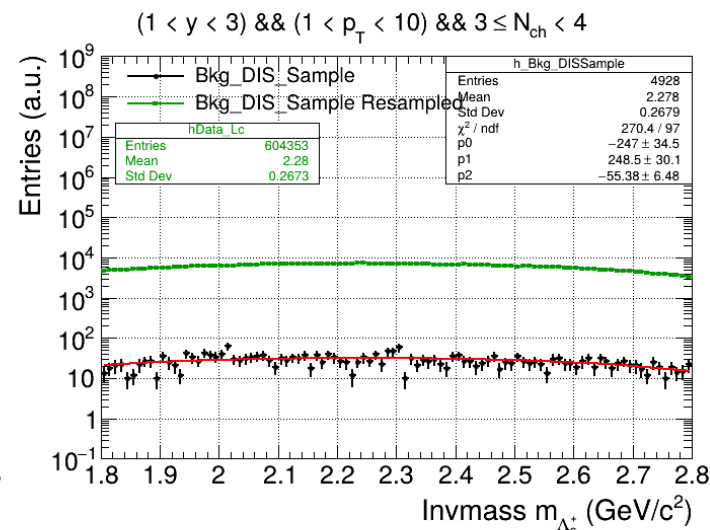
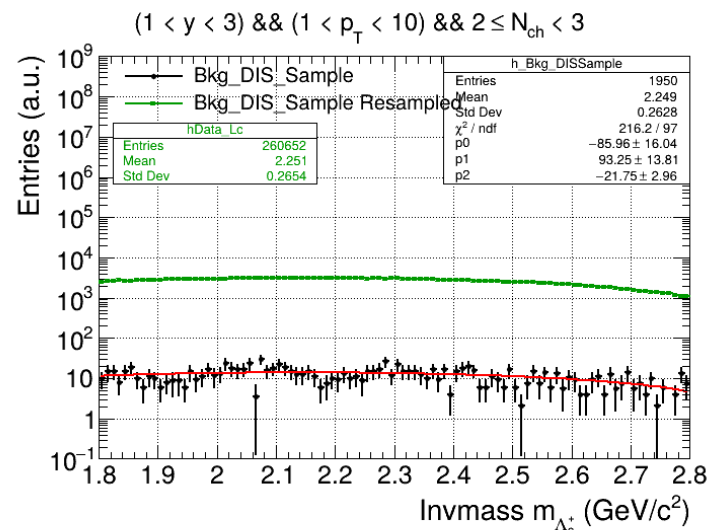
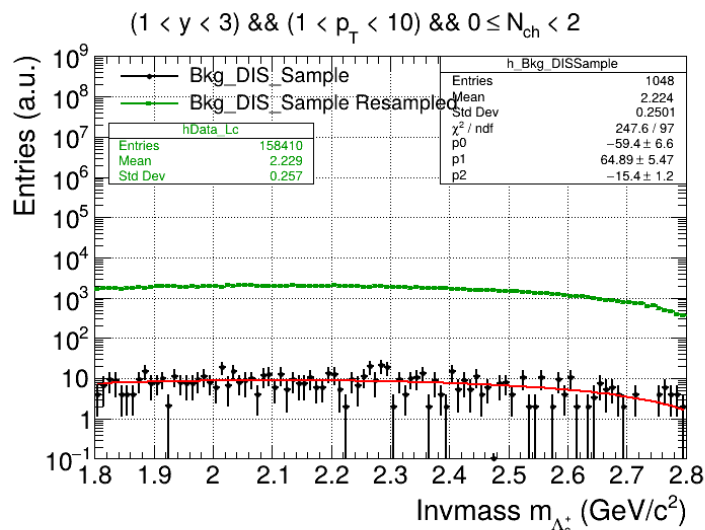
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($1 < y < 3$)

$$L_{\text{int}} = 0.011174597 \text{ fb}^{-1}$$

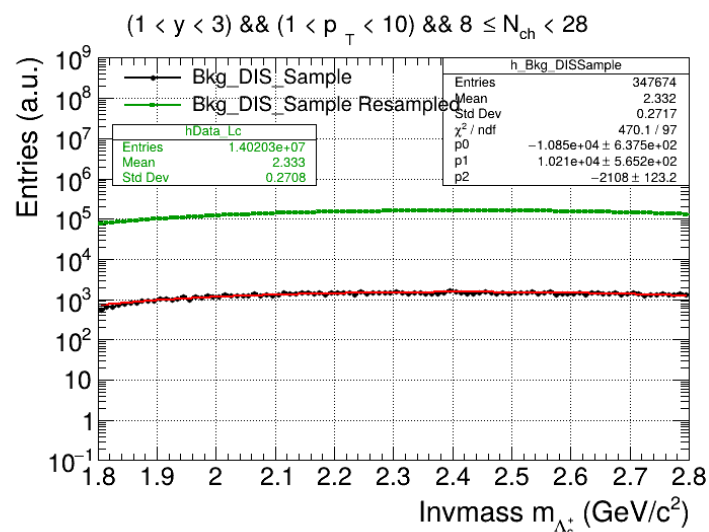
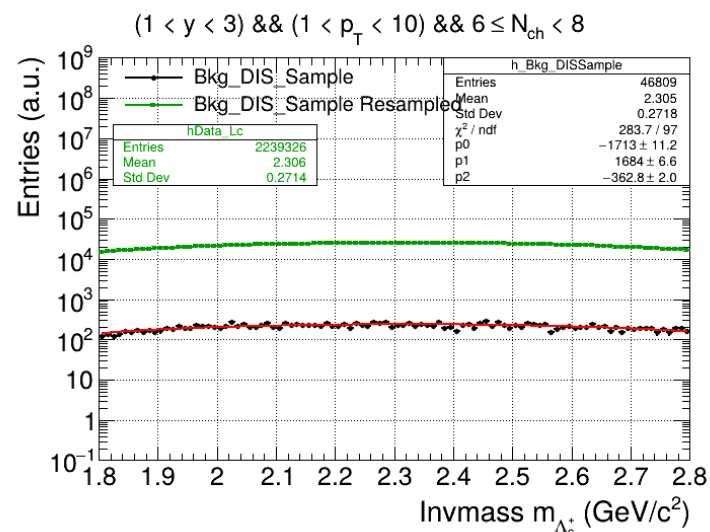
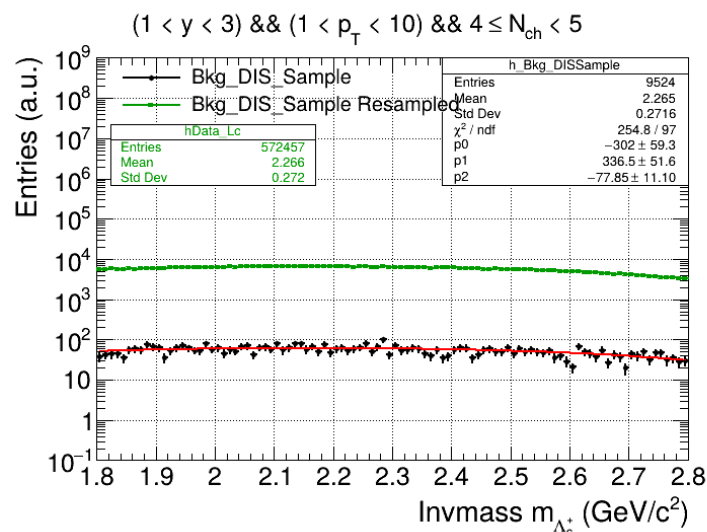
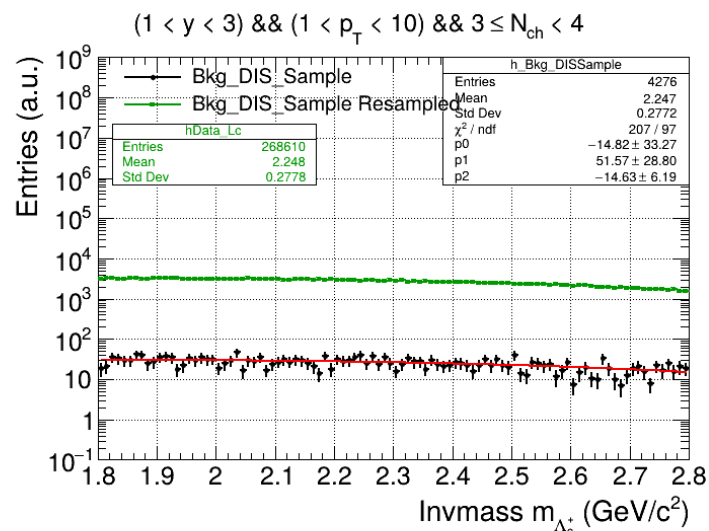
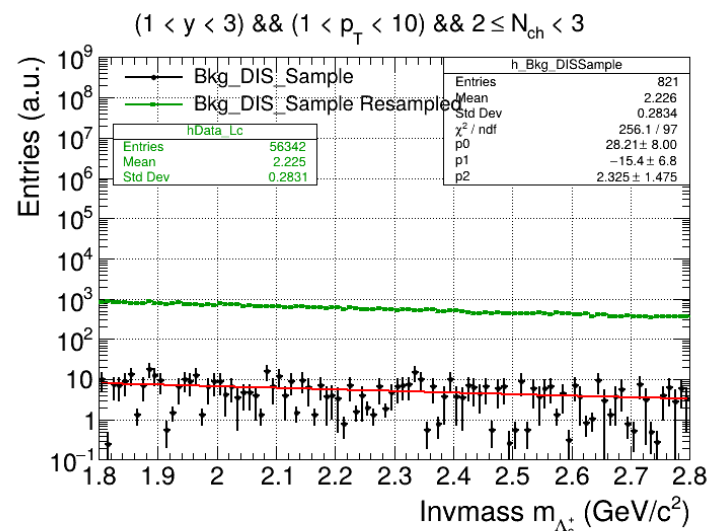
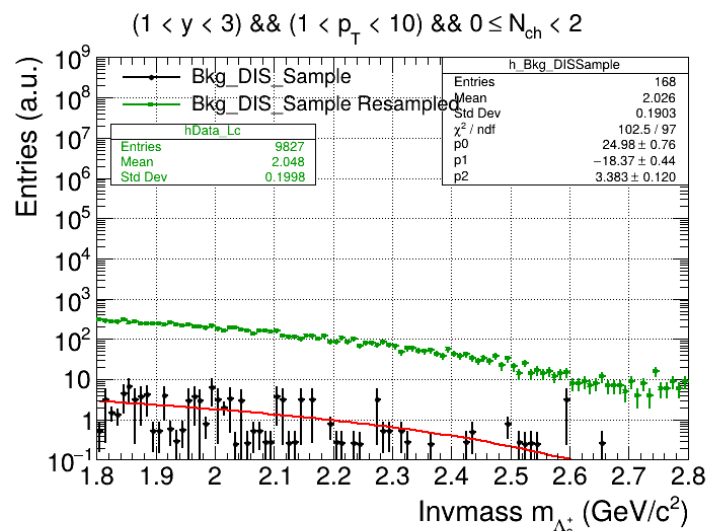
$$L_{\text{int}} = 2.5 \text{ fb}^{-1}$$



Sampling Background ($1 < y < 3$)

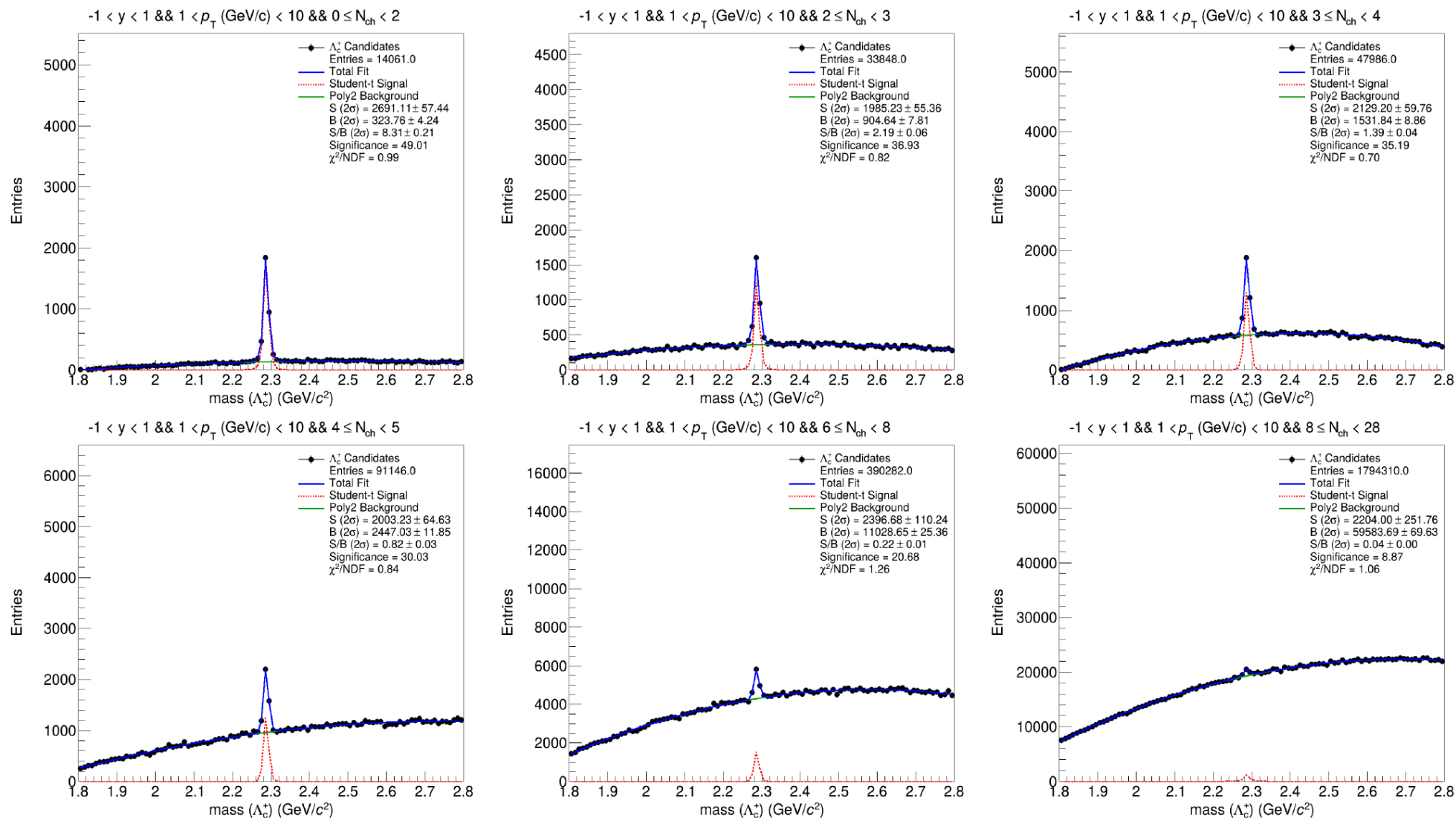
$$L_{\text{int}} = 0.020602717 \text{ fb}^{-1}$$

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



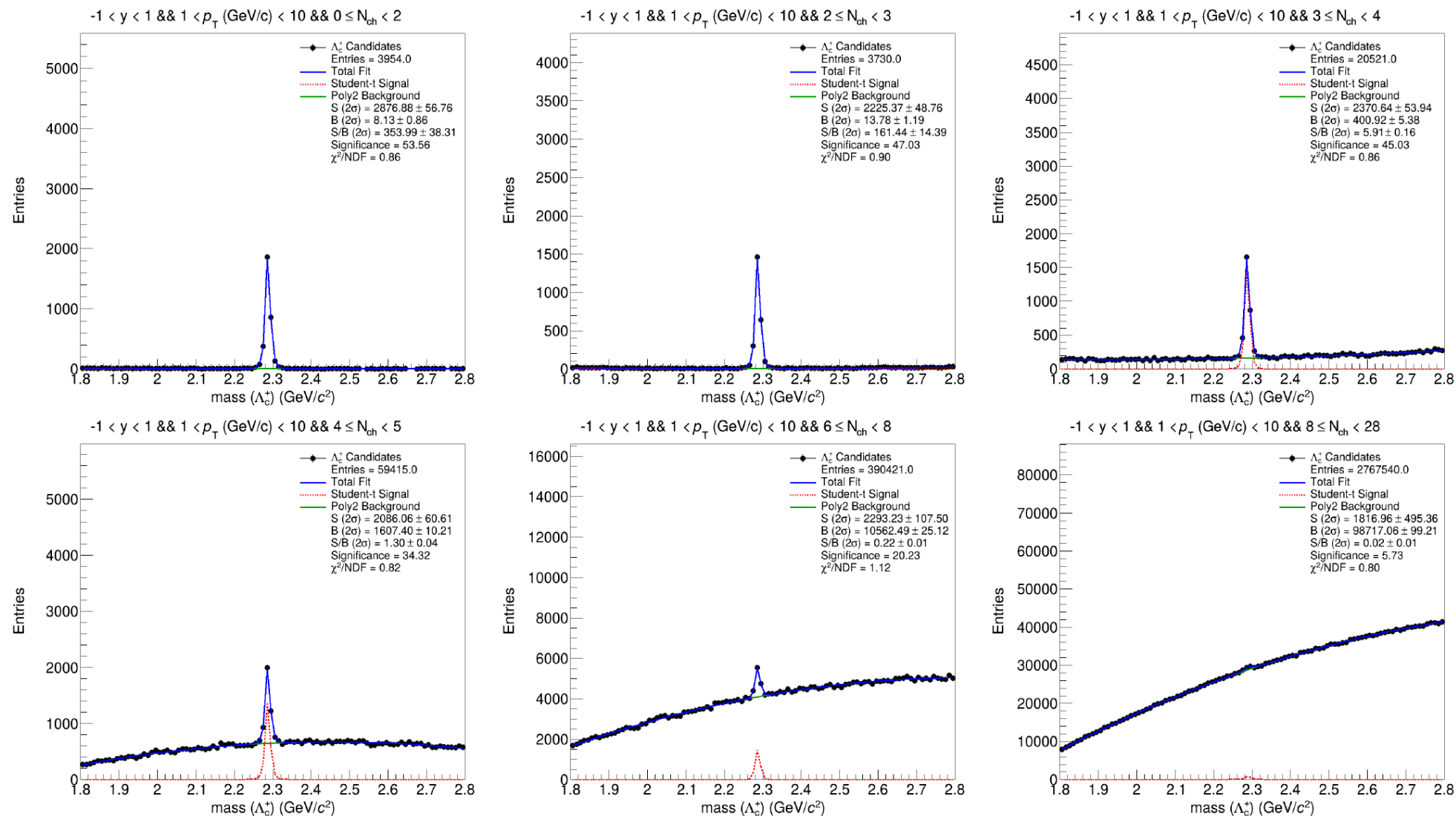
Invariant Mass (Λ_c^+): ($-1 < y < 1$)

After PID + Preselection



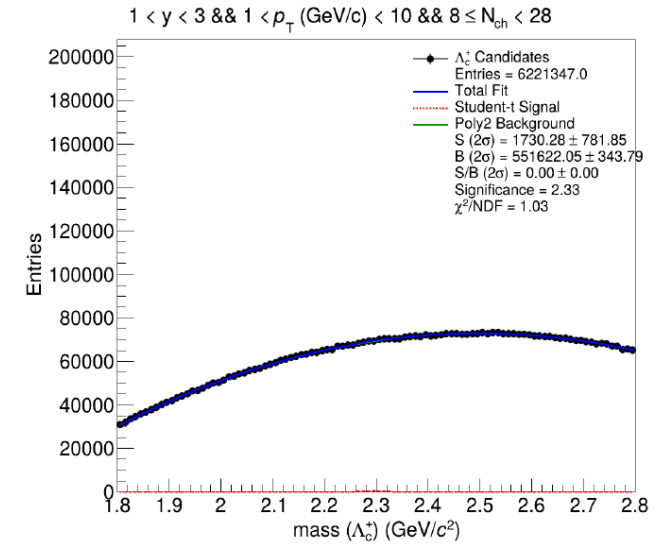
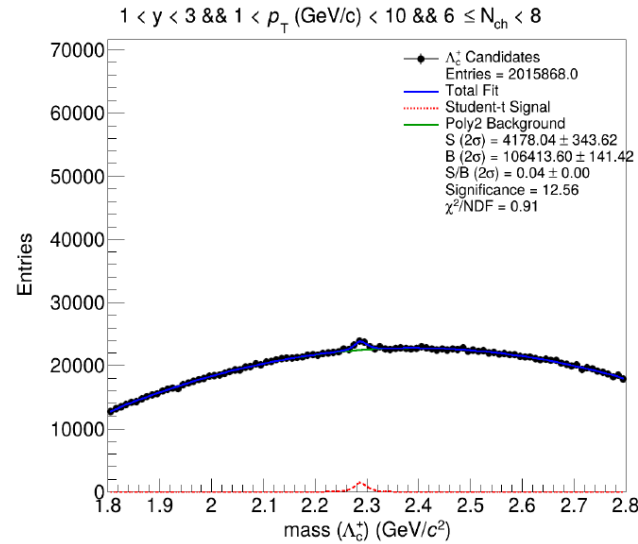
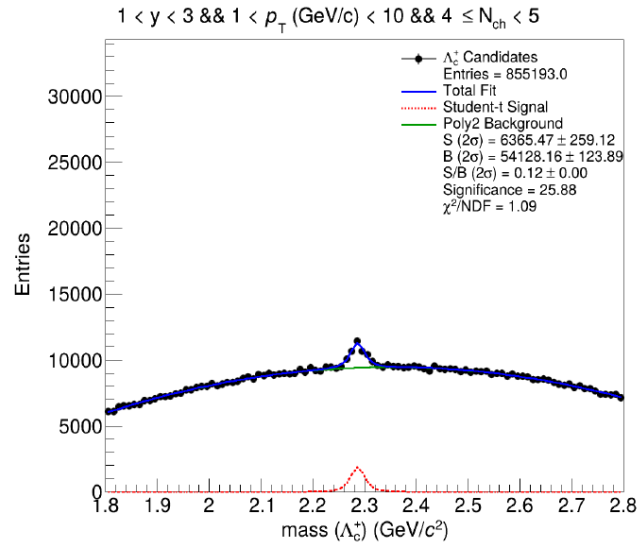
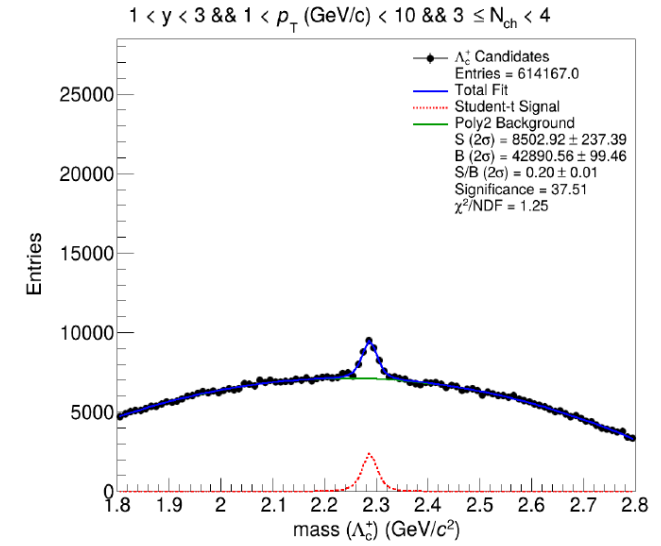
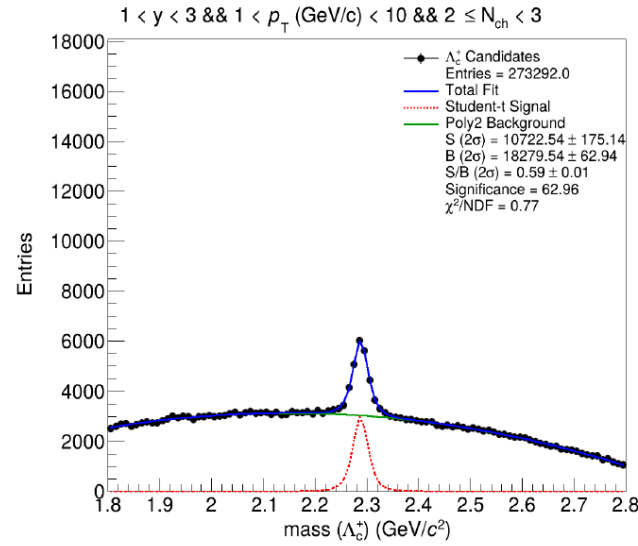
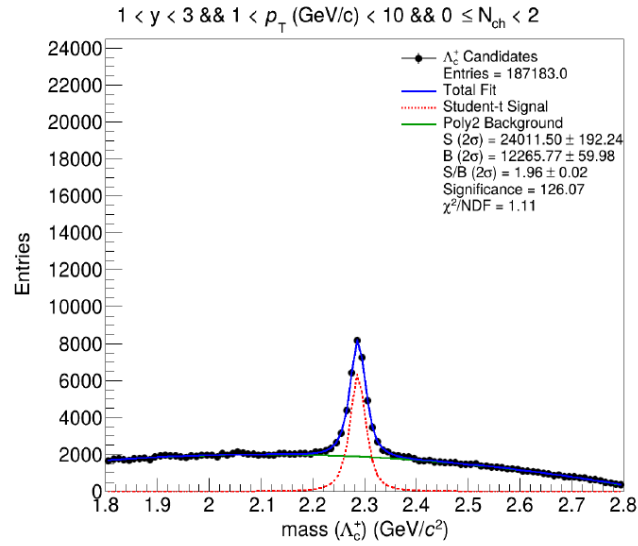
Invariant Mass (Λ_c^+): ($-1 < y < 1$)

After PID + Preselection



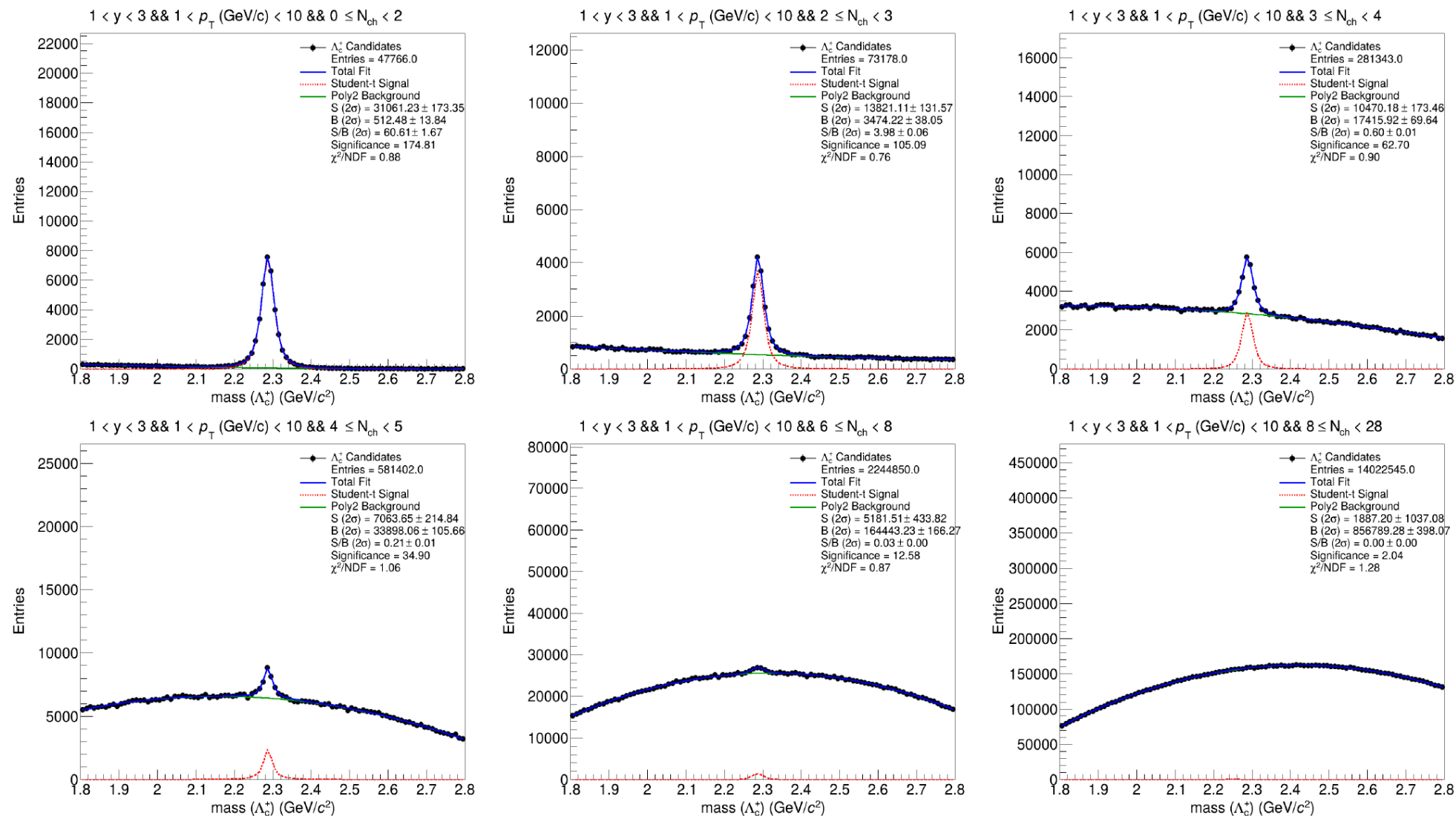
Invariant Mass (Λ_c^+): ($1 < y < 3$)

After PID + Preselection



Invariant Mass (Λ_c^+): ($1 < y < 3$)

After PID + Preselection



Summary and future plan

- Compared Λ_c^+ and D^0 production in different multiplicity classes for two (April and July) campaigns.
- Working on Λ_c^+/D^0 ratio vs multiplicity
- Plan for NIMA special issue, [Oct 2026](#) with July campaign
- Request to give access to [Overleaf](#)

Thank you for your attention!