Status of Λ_c^+/D^0 ratio in the ePIC Experiment

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Event Statistics

October 2025 Campaigns

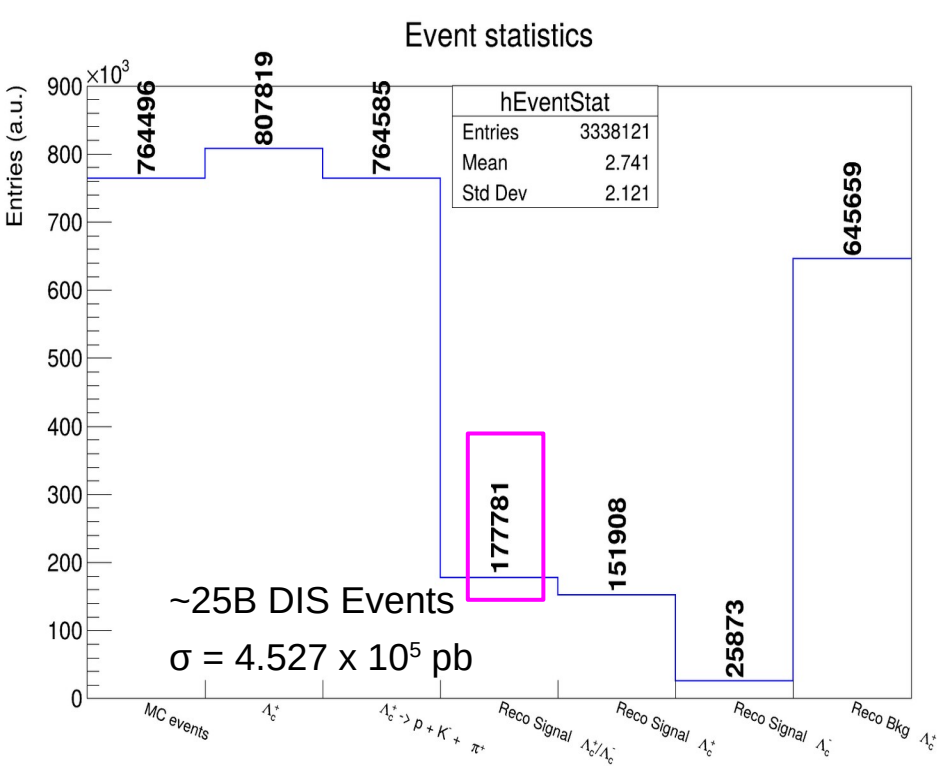
Slide 14

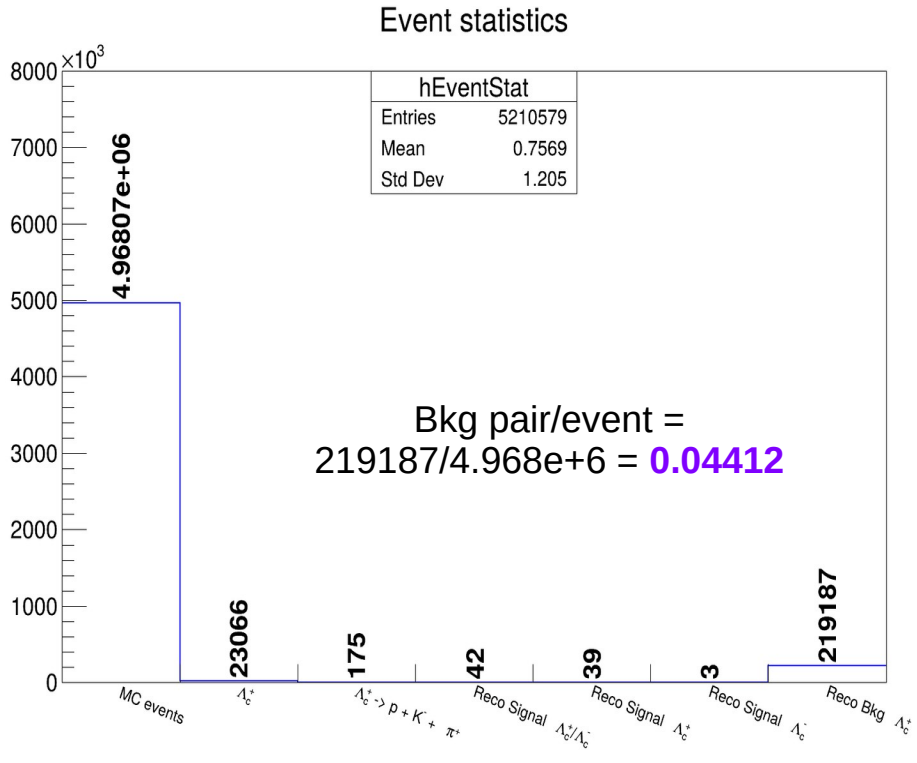
$$L_{int} = \frac{250 \times 10^8}{4.527 \times 10^8 \text{ fb}} = 55.22421 \text{ fb}^{-1}$$

Real PID

Λ_c^+ Sample

DIS Sample



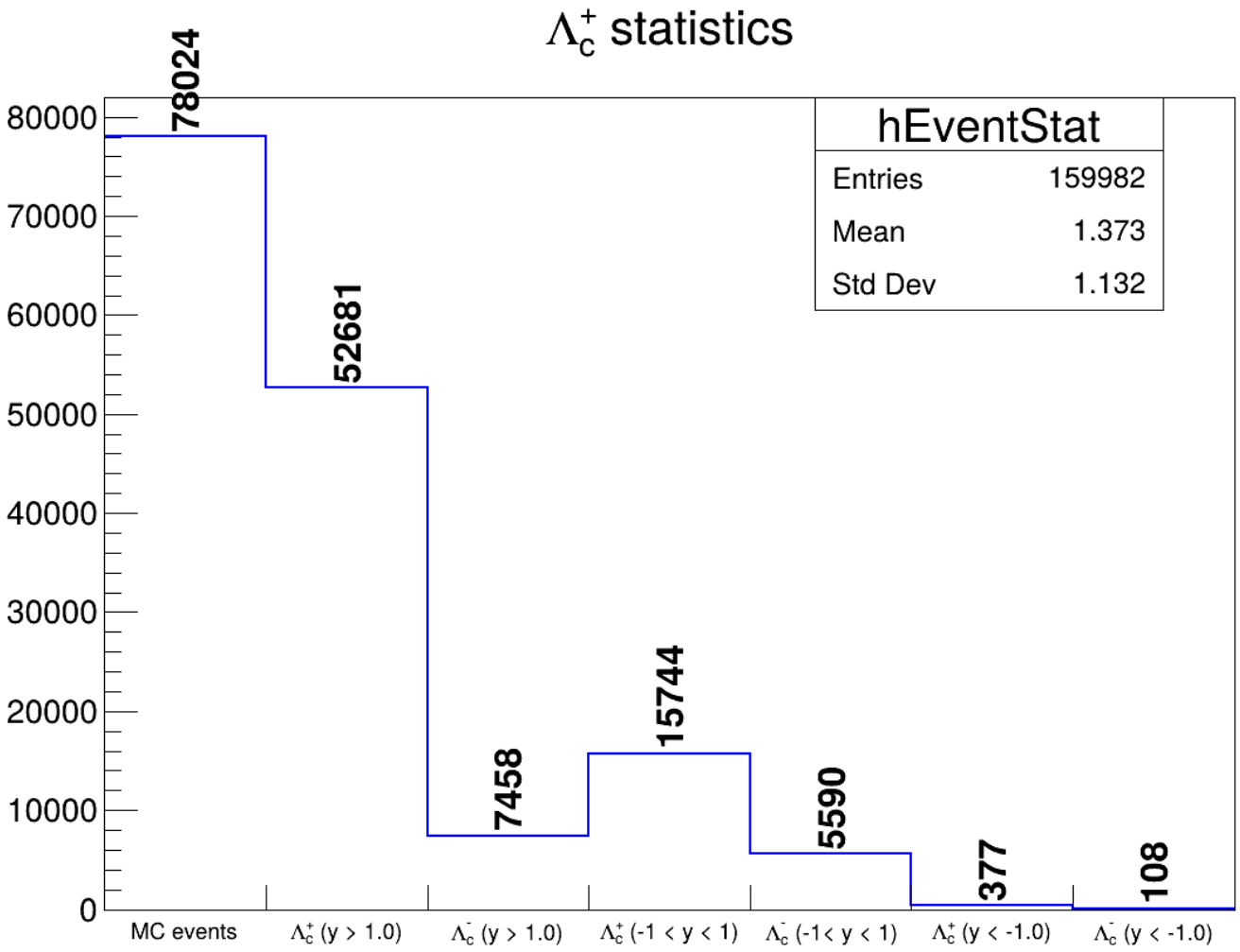


Reco efficiency = 177781/764585 = 0.233

Reco efficiency = 41/175 = 0.24

Λ_c Statistics Generated level

Inclusive Λ_c statistics



Sampling Signal

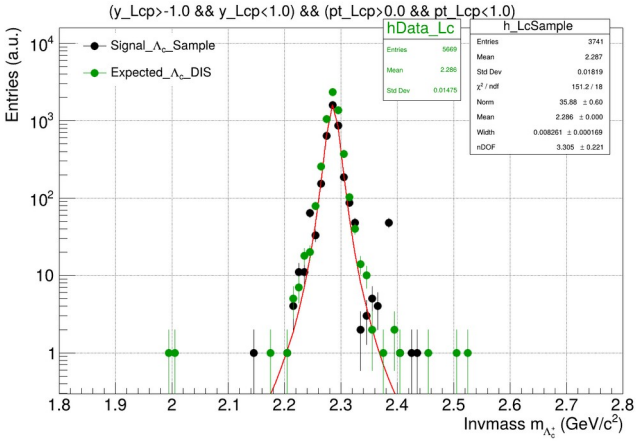
$10\,\mathrm{fb}^{-1} = 4.527\,\mathrm{B}$ Events

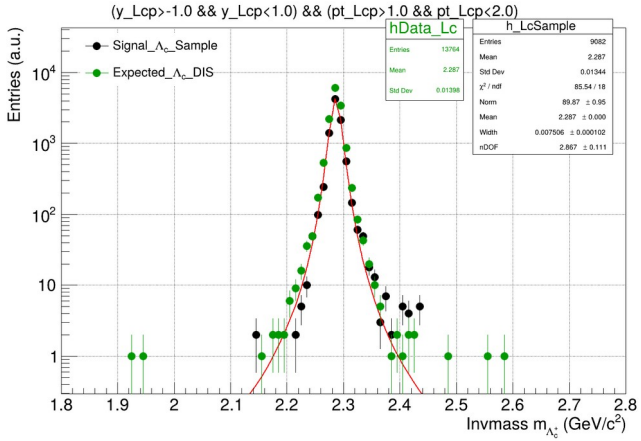
Mid rapidity

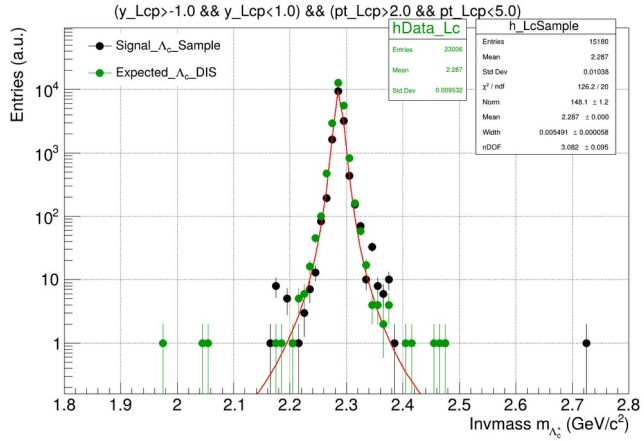
B.R. Scaling = 6.35/0.75

~25B Events

~(4.5B x B.R. Scaling) Events

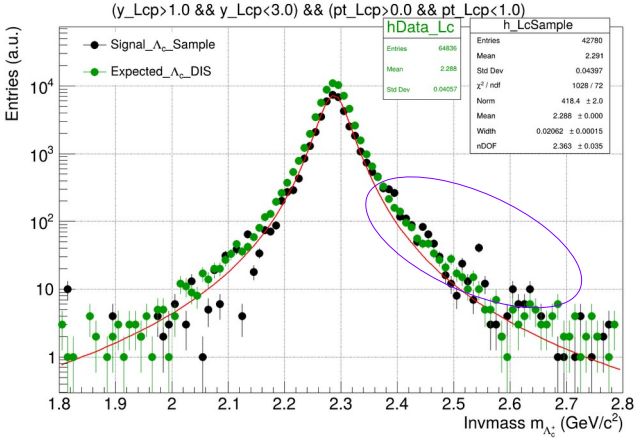


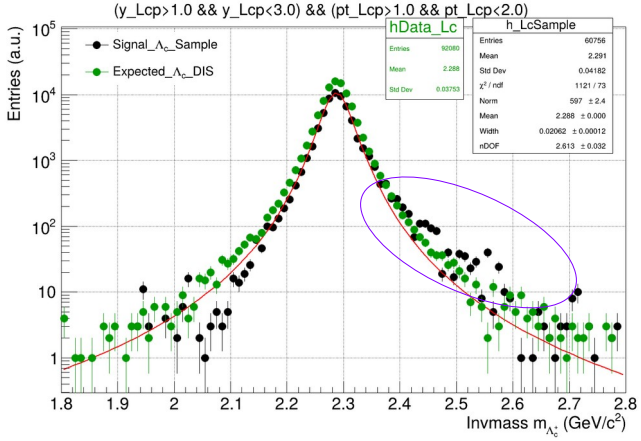


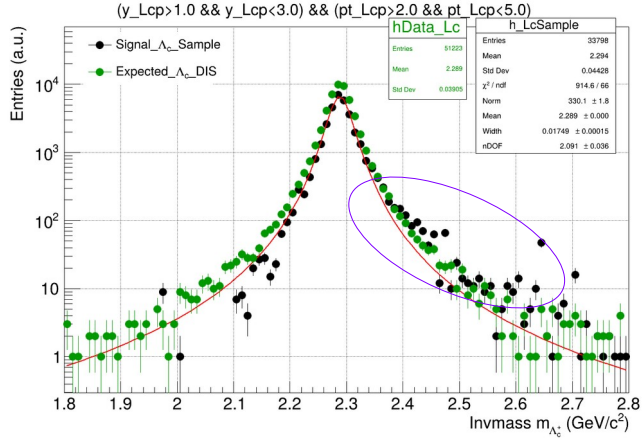


Forward rapidity

Preselections: ($m_{\Lambda c} > 1.8$ && $m_{\Lambda c} < 2.8$) && $d_{0xy\_p} < 10.0$ && $d_{0xy\_pi} < 10.0$ && $d_{0xy\_k} < 10.0$ && chi2 < 10.0







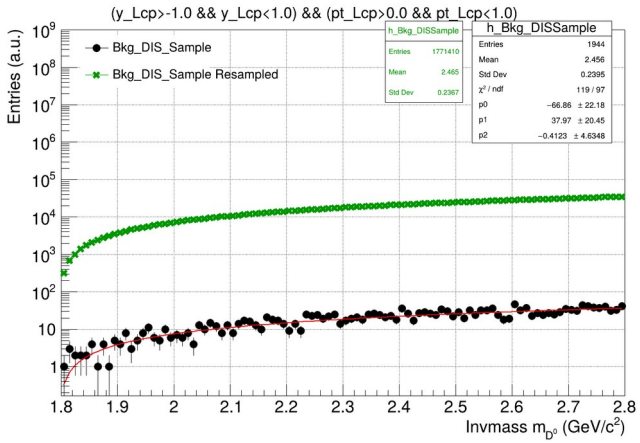
Sampling Background

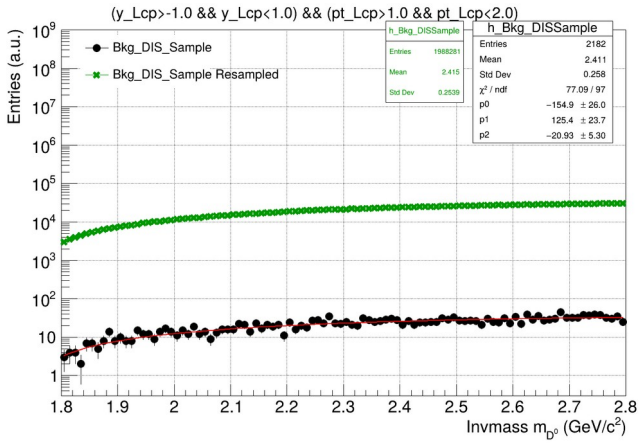
$10\,\mathrm{fb}^{-1} = 4.527\,\mathrm{B}$ Events

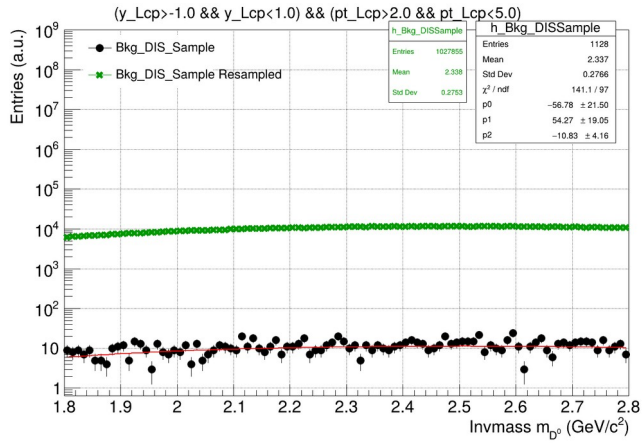
~5M Events

Mid rapidity

~4.5B Events

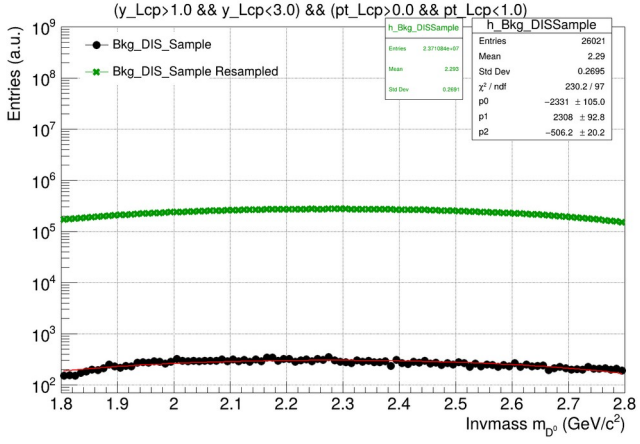


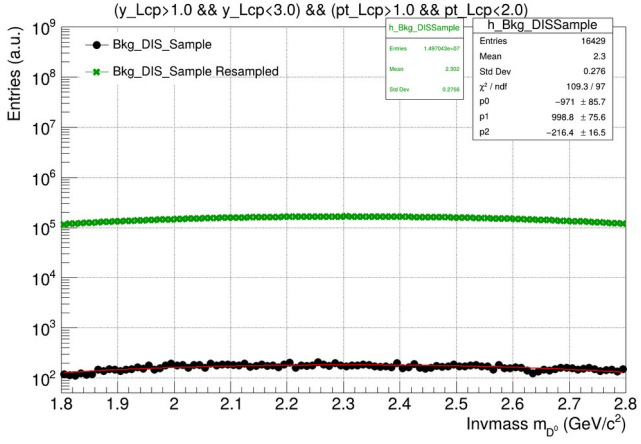


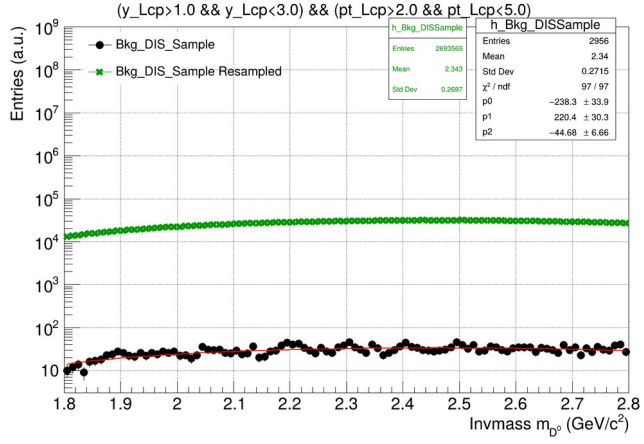


Forward rapidity

Preselections: ($m_{\Lambda c} > 1.8$ && $m_{\Lambda c} < 2.8$) && $d_{0xy\_p} < 10.0$ && $d_{0xy\_pi} < 10.0$ && $d_{0xy\_k} < 10.0$ && chi2 < 10.0



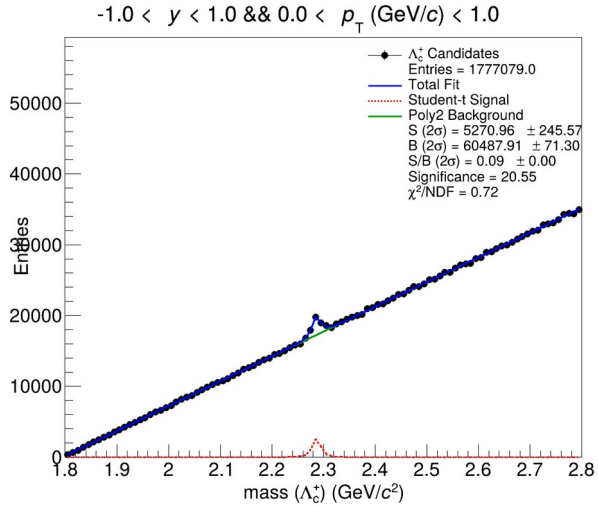


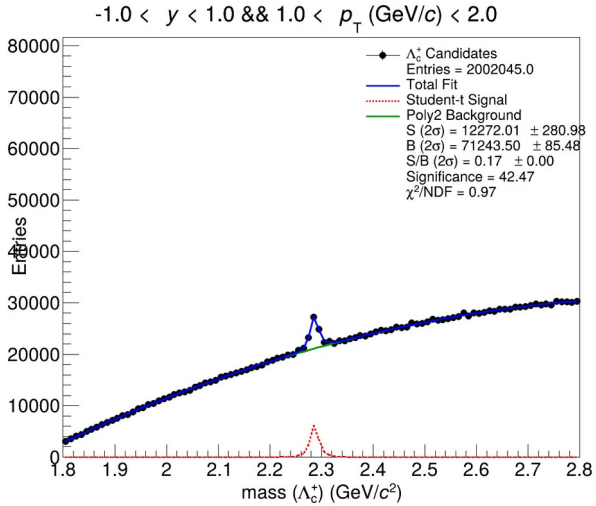


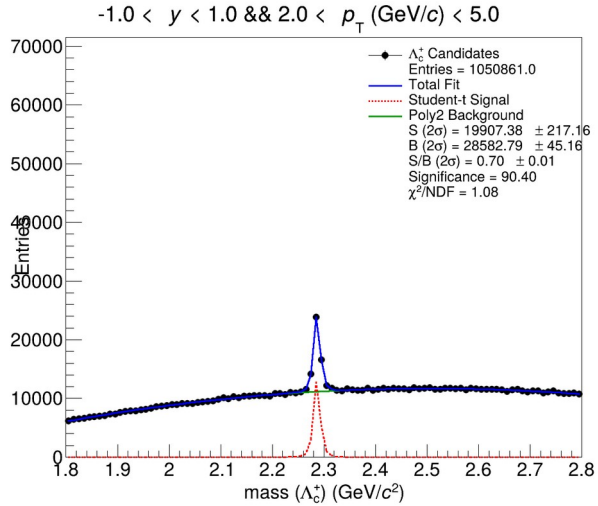
Invariant Mass Plots

Mid rapidity

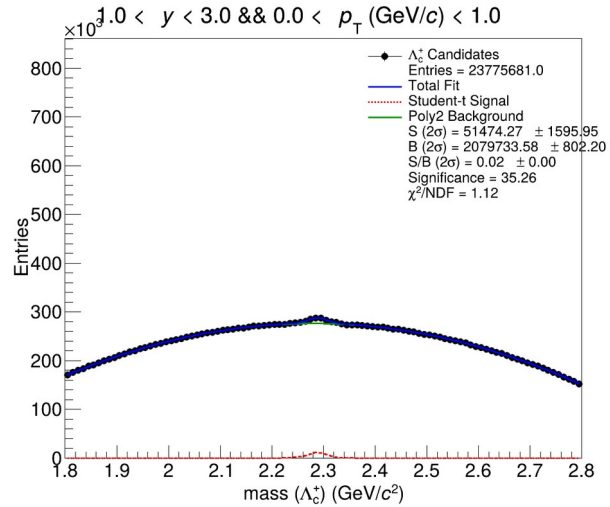
Real PID

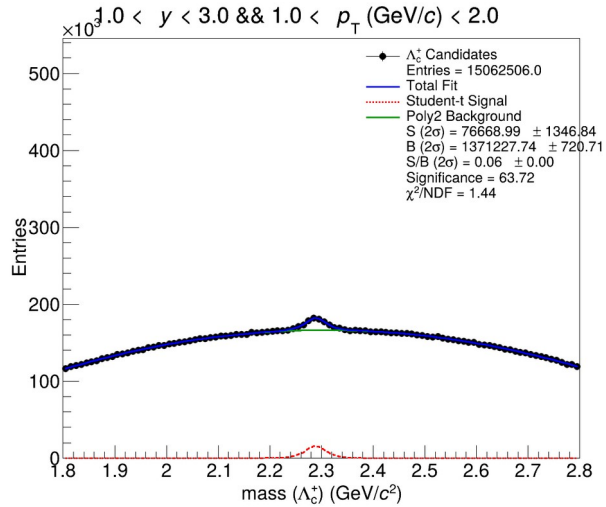


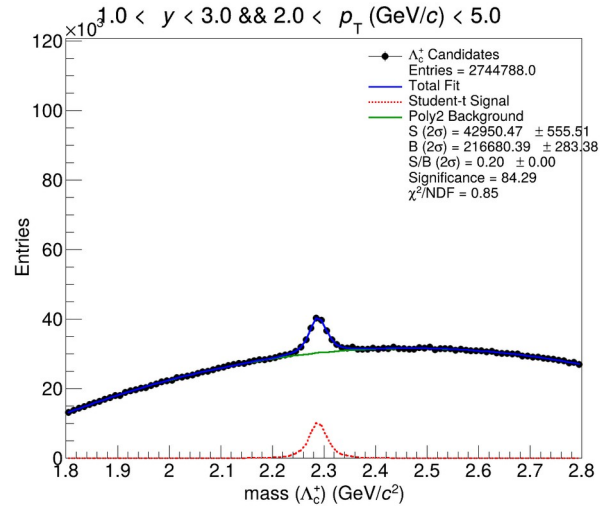




Forward rapidity



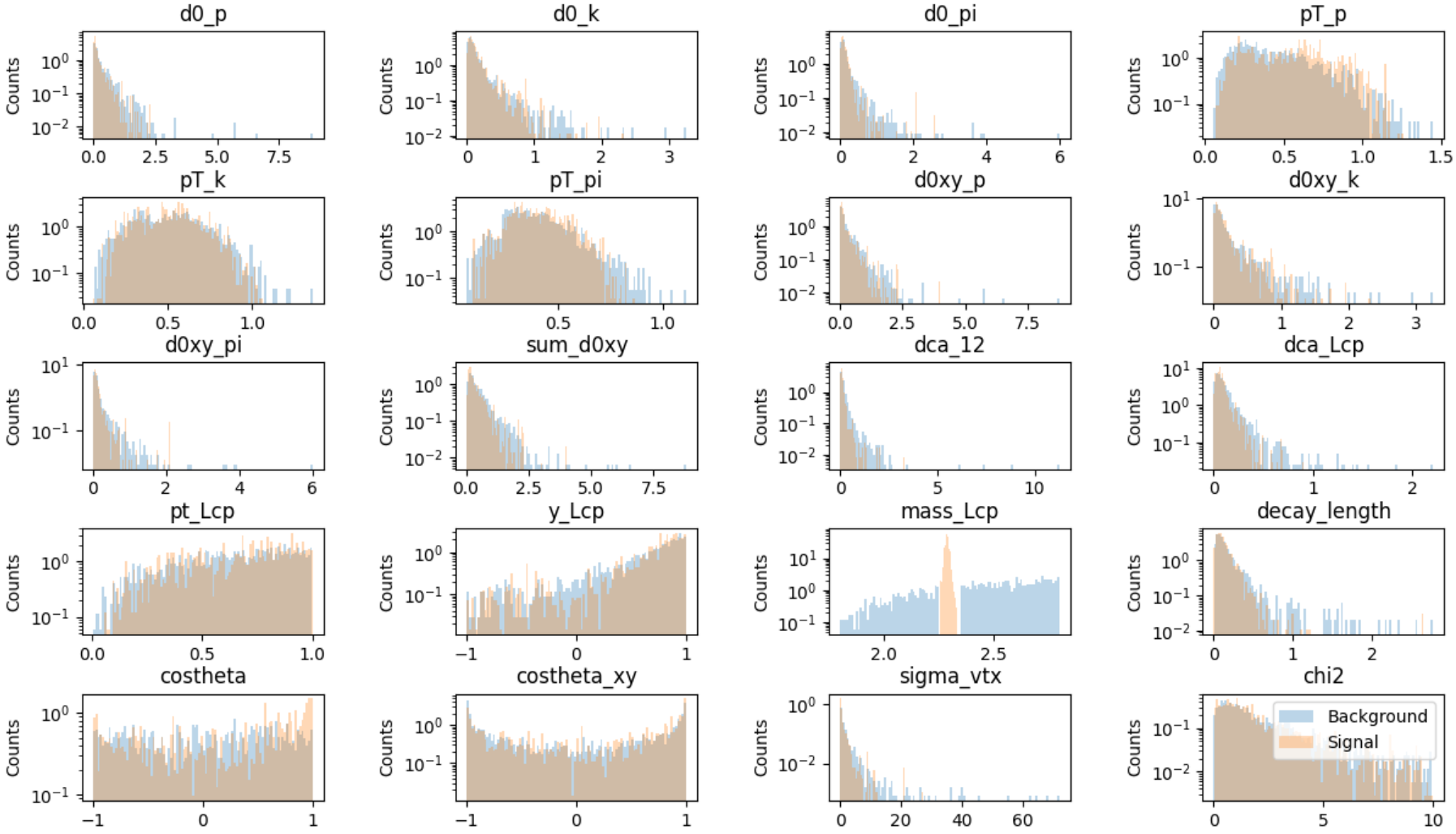




Machine Learning (ML) Approach

Preselections: ($m_{\Lambda c} > 1.8$ && $m_{\Lambda c} < 2.8$) && $d_{0xy\_p} < 10.0$ && $d_{0xy\_pi} < 10.0$ && $d_{0xy\_k} < 10.0$ && chi2 < 10.0

$-1 < y_{\Lambda c} < 1$, $0 < p_T(\Lambda_c) < 1$ GeV/c



Available statistics for ML

Preselections: ($m_{\Lambda c}$ > 1.8 && $m_{\Lambda c}$ < 2.8) && d_{0xy_p} < 10.0 && d_{0xy_pi} < 10.0 && d_{0xy_k} < 10.0 && chi2 < 10.0

Available statistics for ML after preselection

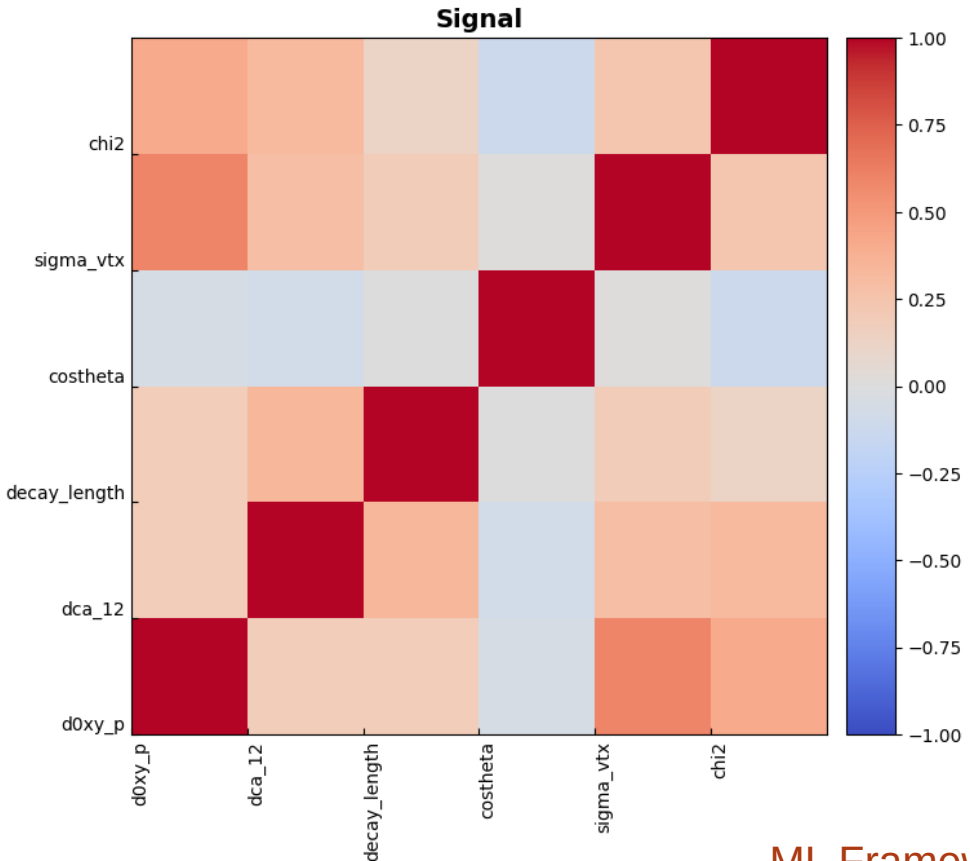
p_T (GeV/c)	0-1	1-10
-1 < y < 1	Sig: 3589 Bkg: 1740	Sig: 25110 Bkg: 2982
1 < y < 3	Sig: 36296 Bkg: 23029	Sig: 83033 Bkg: 17246

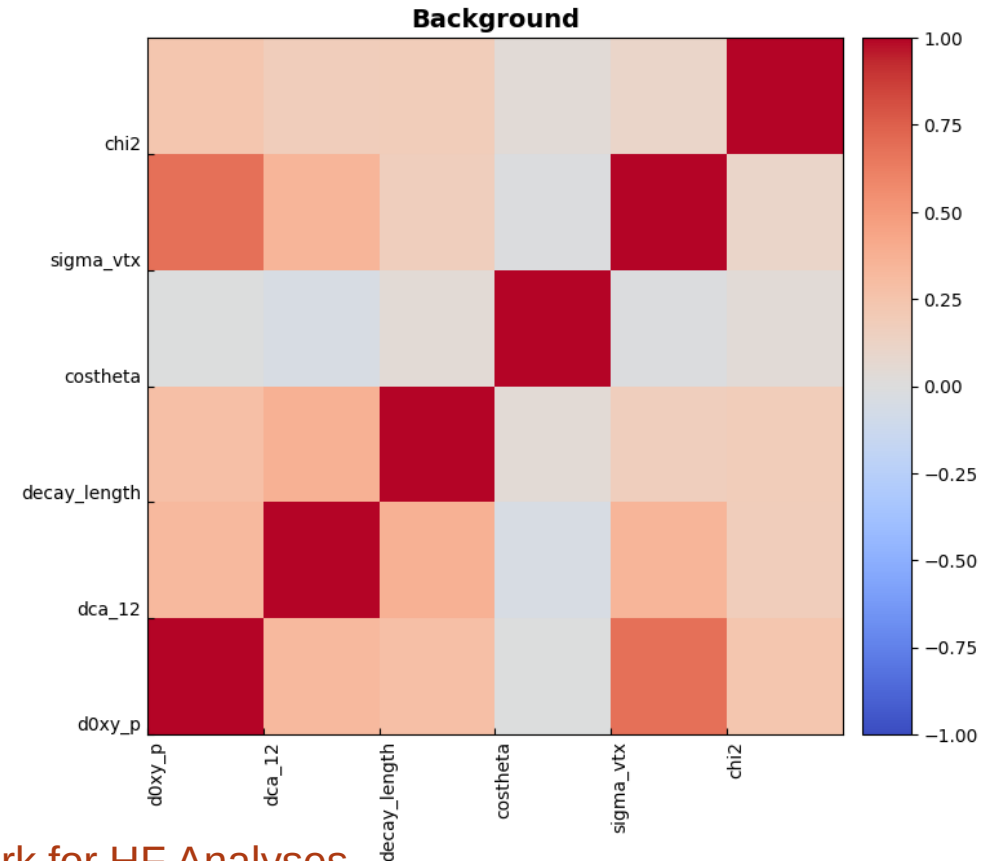
Training is done in two pt bins 0-1 and 1-10 GeV/c considering the imbalanced factor in the training

For the ES, I requested a large data sample for training
Signal stats ~1M
Bkg Stats ~50 M

Correlation Matrix

Features used in the training for the Machine learning (ML)
Signal candidates for ML: 3589 Background candidates for ML: 1740

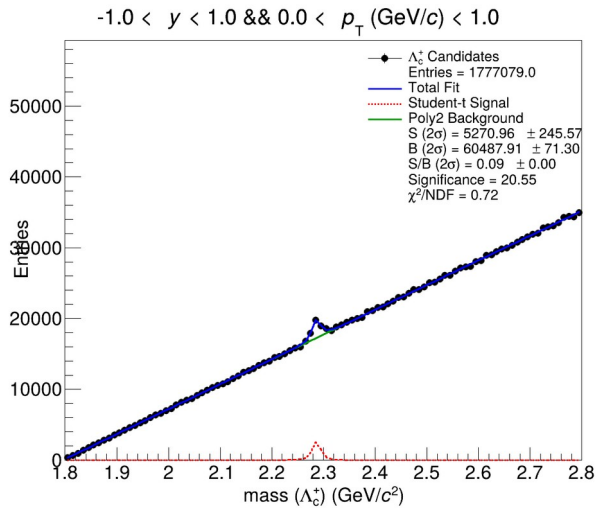


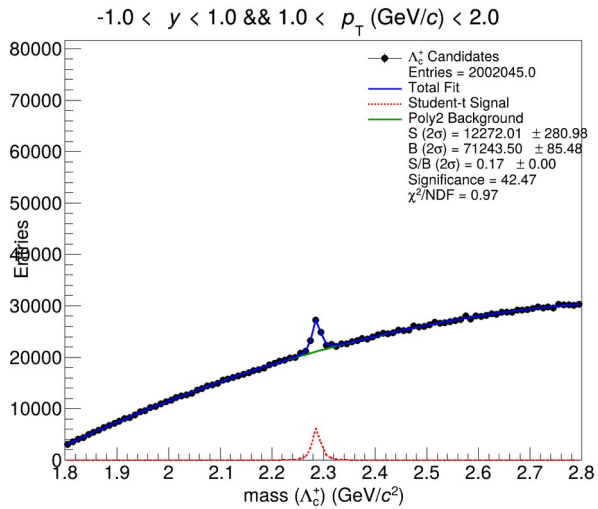


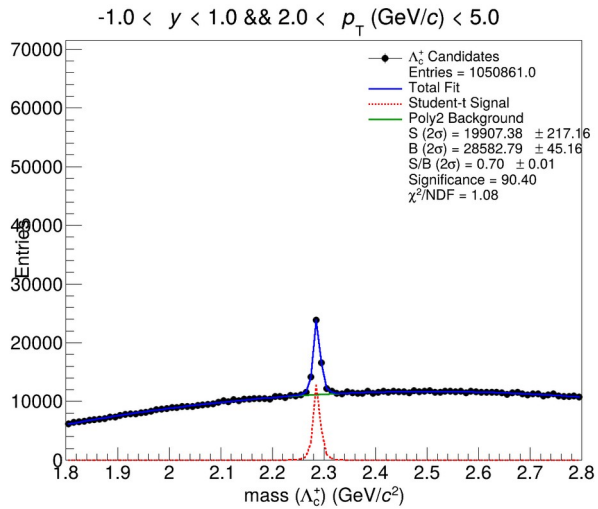
ML Framework for HF Analyses

FAIR (Future Artificial Intelligence Research) Spoke 6 Project, funded by the NextGenerationEU program in Italy

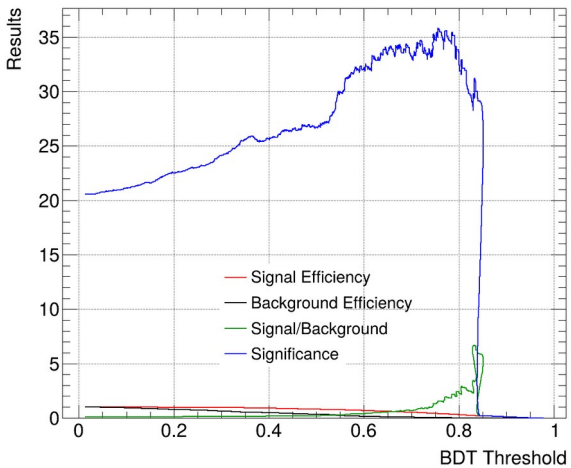
Invariant Mass with ML

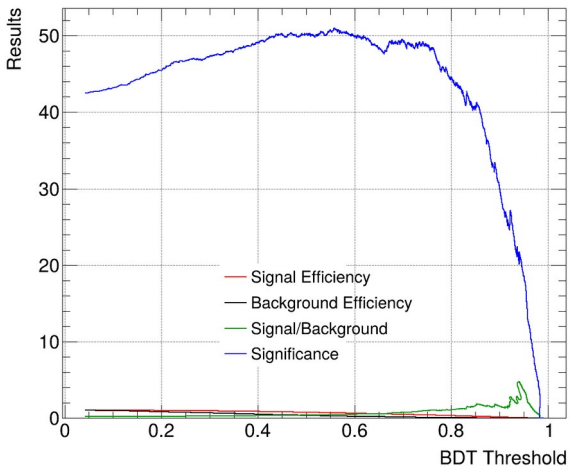


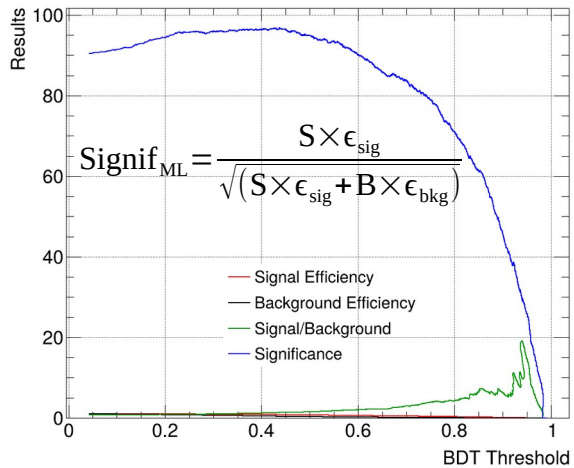




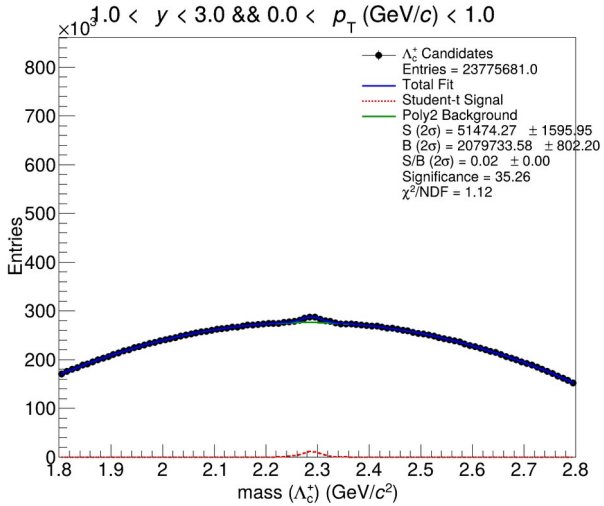
Maximum significance (need to increase stats)

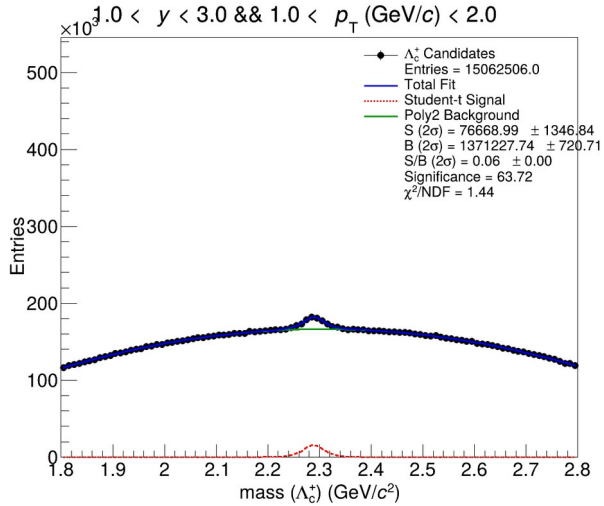


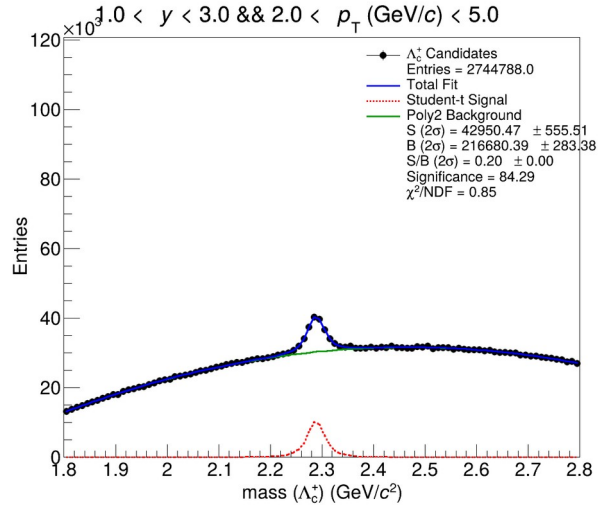




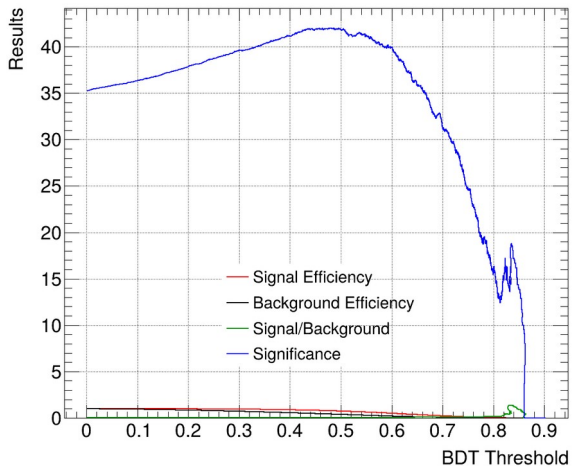
Invariant Mass with ML

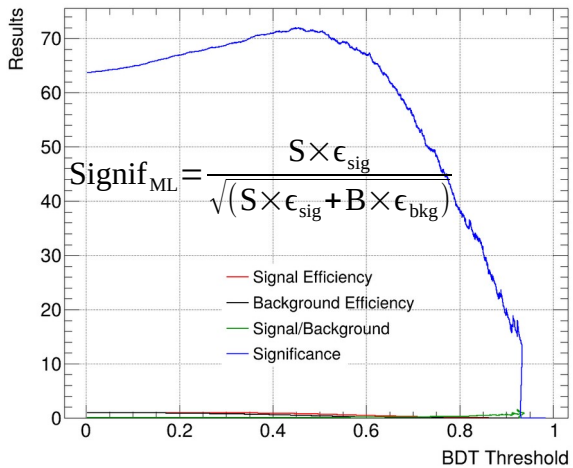


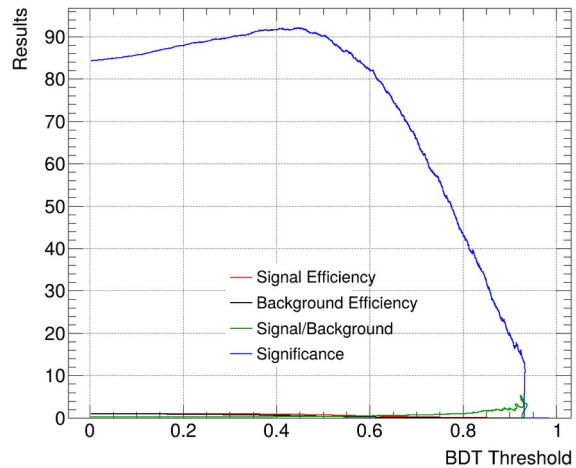




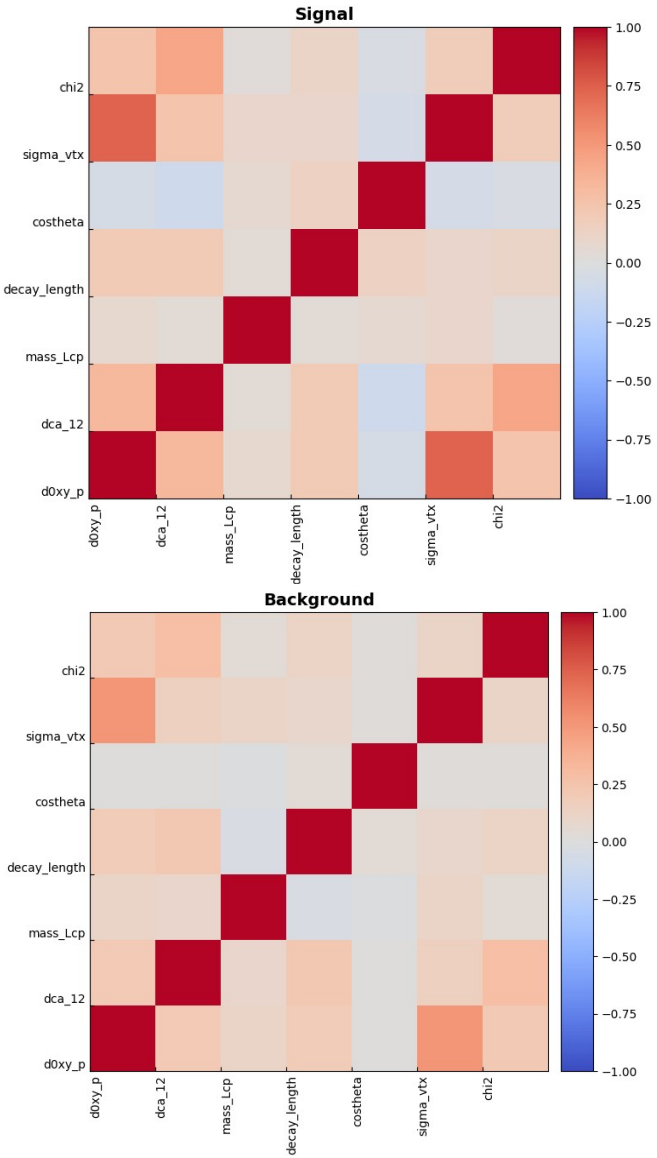
Maximum significance (need to increase stats)

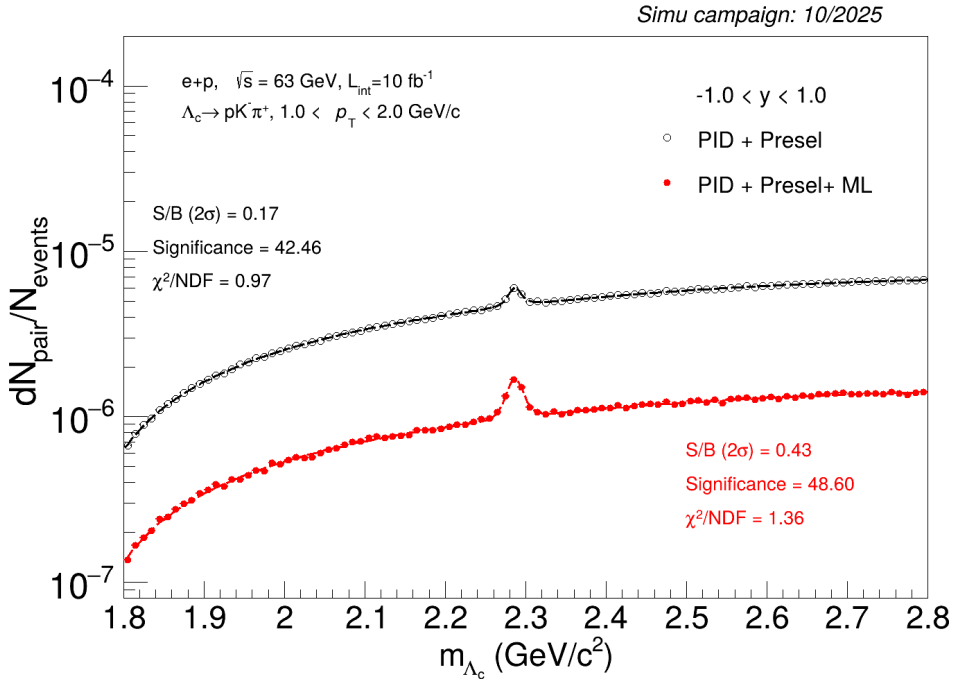






Invariant mass plot w/o vs w ML





Correlation of Invariant mass with topolgical variables (weak correlation)

Relative uncertanity

$$\frac{\sigma_{\Lambda_c/D^0}}{\Lambda_c/D^0} = \sqrt{\left(\frac{\sigma_{\Lambda_c}}{\Lambda_c}\right)^2 + \left(\frac{\sigma_{D^0}}{D^0}\right)^2}$$

wo ML

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0,1)-------
Lc_ep: S/sqrt(S+B) =35.2596 Inverse Significance = 0.0284 rel sqrt(S+B)/S =0.0284
D0_ep: S/sqrt(S+B) =98.4876 Inverse Significance = 0.0102 rel sqrt(S+B)/S=0.0102
(relative uncertainty after adding in quadrature = 0.0301 = 3.0124%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1,2)-------
Lc_ep: S/sqrt(S+B) =63.7164 Inverse Significance = 0.0157 rel sqrt(S+B)/S =0.0157
D0_ep: S/sqrt(S+B) =97.3847 Inverse Significance = 0.0103 rel sqrt(S+B)/S=0.0103
(relative uncertainty after adding in quadrature = 0.0188 = 1.8755%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (2,5)-------
Lc_ep: S/sqrt(S+B) =84.2927 Inverse Significance = 0.0119 rel sqrt(S+B)/S =0.0119
D0_ep: S/sqrt(S+B) =93.7587 Inverse Significance = 0.0107 rel sqrt(S+B)/S=0.0107
(relative uncertainty after adding in quadrature = 0.0160 = 1.5953%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0,1)-------
Lc_ep: S/sqrt(S+B) =20.5548 Inverse Significance = 0.0487 rel sqrt(S+B)/S =0.0487
D0_ep: S/sqrt(S+B) =141.4296 Inverse Significance = 0.0071 rel sqrt(S+B)/S=0.0071
(relative uncertainty after adding in quadrature = 0.0492 = 4.9162%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1,2)-------
Lc_ep: S/sqrt(S+B) =42.4651 Inverse Significance = 0.0235 rel sqrt(S+B)/S =0.0235
D0_ep: S/sqrt(S+B) =198.7278 Inverse Significance = 0.0050 rel sqrt(S+B)/S=0.0050
(relative uncertainty after adding in quadrature = 0.0241 = 2.4080%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (2,5)-------
Lc_ep: S/sqrt(S+B) =90.4039 Inverse Significance = 0.0111 rel sqrt(S+B)/S =0.0111
D0_ep: S/sqrt(S+B) =216.2916 Inverse Significance = 0.0046 rel sqrt(S+B)/S=0.0046
(relative uncertainty after adding in quadrature = 0.0120 = 1.1989%)

w ML

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (0,1)-------
Lc_ep (ML): S/sqrt(S+B) =42.0460 Inverse Significance = 0.0238 rel sqrt(S+B)/S =0.0238
D0_ep (ML): S/sqrt(S+B) =220.0056 Inverse Significance = 0.0045 rel sqrt(S+B)/S=0.0045
(relative uncertainty after adding in quadrature = 0.0242 = 2.4214%)

-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (1,2)-------
Lc_ep (ML): S/sqrt(S+B) =71.9687 Inverse Significance = 0.0139 rel sqrt(S+B)/S =0.0139
D0_ep (ML): S/sqrt(S+B) =183.6558 Inverse Significance = 0.0054 rel sqrt(S+B)/S=0.0054
(relative uncertainty after adding in quadrature = 0.0149 = 1.4924%)

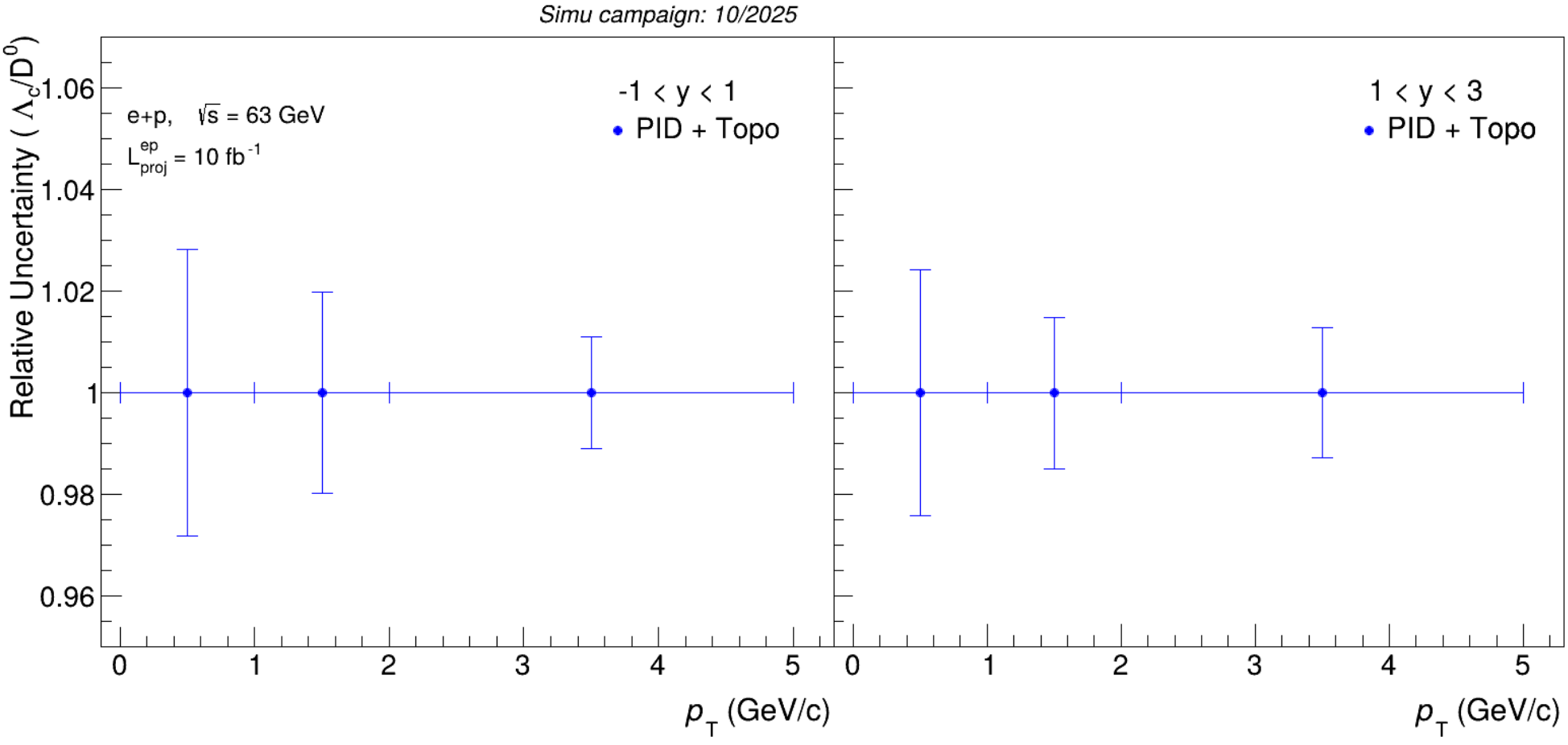
-->(ymin, ymax) = (1,3)-->(ptmin, ptmax) = (2,5)-------
Lc_ep (ML): S/sqrt(S+B) =92.0581 Inverse Significance = 0.0109 rel sqrt(S+B)/S =0.0109
D0_ep (ML): S/sqrt(S+B) =148.5929 Inverse Significance = 0.0067 rel sqrt(S+B)/S=0.0067
(relative uncertainty after adding in quadrature = 0.0128 = 1.2778%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (0,1)-------
Lc_ep (ML): S/sqrt(S+B) =35.8469 Inverse Significance = 0.0279 rel sqrt(S+B)/S =0.0279
D0_ep (ML): S/sqrt(S+B) =254.0291 Inverse Significance = 0.0039 rel sqrt(S+B)/S=0.0039
(relative uncertainty after adding in quadrature = 0.0282 = 2.8173%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (1,2)-------
Lc_ep (ML): S/sqrt(S+B) =51.0444 Inverse Significance = 0.0196 rel sqrt(S+B)/S =0.0196
D0_ep (ML): S/sqrt(S+B) =295.3255 Inverse Significance = 0.0034 rel sqrt(S+B)/S=0.0034
(relative uncertainty after adding in quadrature = 0.0199 = 1.9881%)

-->(ymin, ymax) = (-1,1)-->(ptmin, ptmax) = (2,5)-------
Lc_ep (ML): S/sqrt(S+B) =96.8064 Inverse Significance = 0.0103 rel sqrt(S+B)/S =0.0103
D0_ep (ML): S/sqrt(S+B) =259.1516 Inverse Significance = 0.0039 rel sqrt(S+B)/S=0.0039
(relative uncertainty after adding in quadrature = 0.0110 = 1.1027%)

Relative uncertainty on Λ_c/D^0 Ratio



Summary and Future Plan

- Presented the results on Λ_c^+ reconstruction with real PID
- Further optimize ML to improve the results in different rapidity and momentum bins
- Need more statistics for training to produce stable results (machinery is already in place)
- Next to extract also R_{eAu} for D0 meson as a function of fragmentation variable (z)

Thank you for your attention!