

Multiplicity dependence of $\Lambda_c^+ - h$ Azimuthal Correlations in p-p at $\sqrt{s} = 13.6$ TeV



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Introduction

- Heavy quarks like charm and beauty are formed at the beginning of high-energy collisions and help us to study the matter created in these events.
- Proton-proton (pp) collisions are used as a reference to understand what happens in heavy-ion collisions.
- Differences in how charmed particles are formed (fragmentation) are seen in nature, So studying Λ_c^+ and hadron correlations can give new insights.
- Studying the effects of multiplicity on correlation would widen our current understanding of charm quark fragmentation, which is why it is important.

- The production cross section function of charm hadrons can be described as convolution of the following :

$$\frac{d\sigma^{H_c}}{dp_T}(p_T; \mu_F, \mu_R) = \text{PDF}(x_1, \mu_F) \otimes \text{PDF}(x_2, \mu_F) \otimes \frac{d\sigma^c}{dp_T^c}(p_T; \mu_F, \mu_R) \otimes D_{c \rightarrow H_c}(z = p_{H_c}/p_c, \mu_F)$$

Parton Distribution Functions

Hard scattering cross section (pQCD)

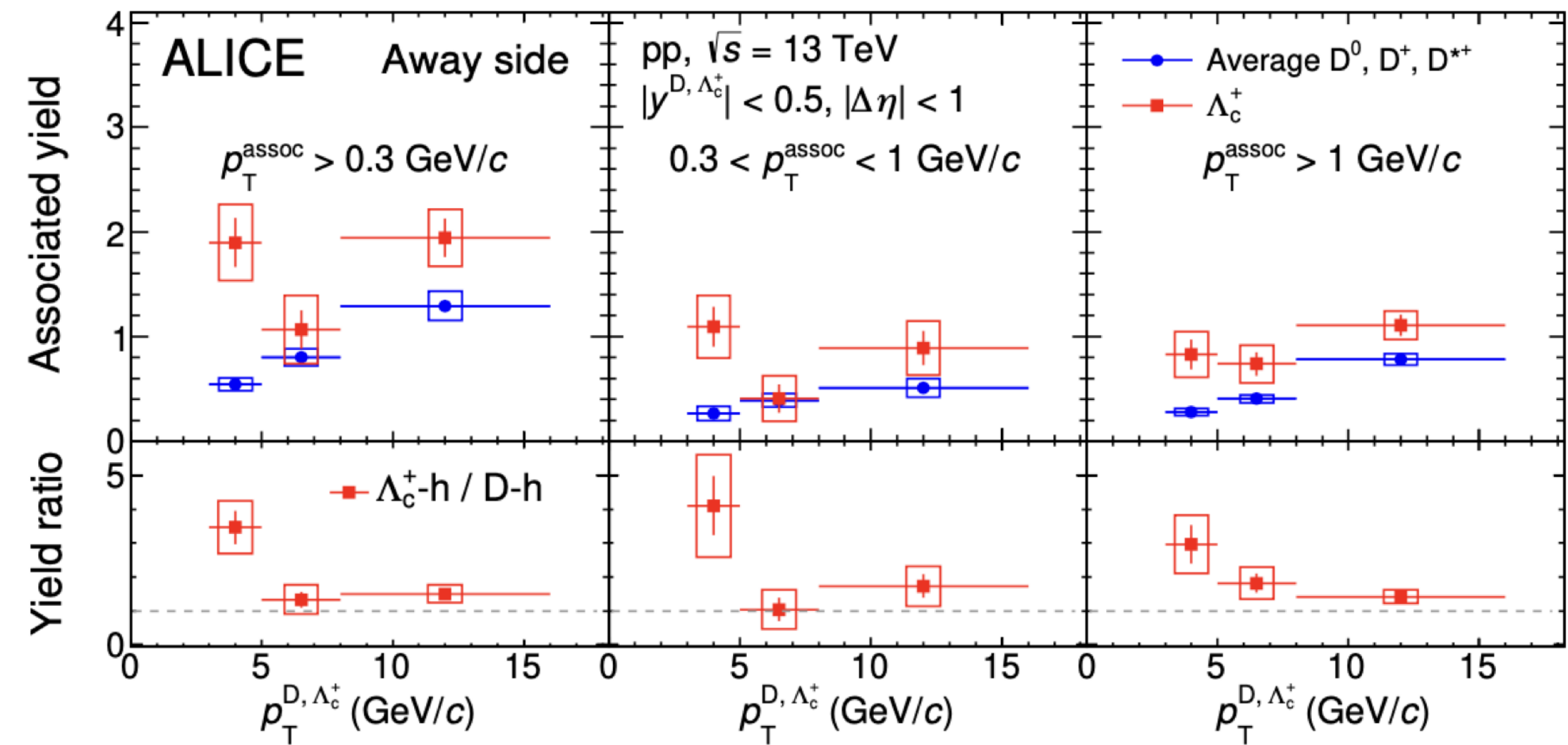
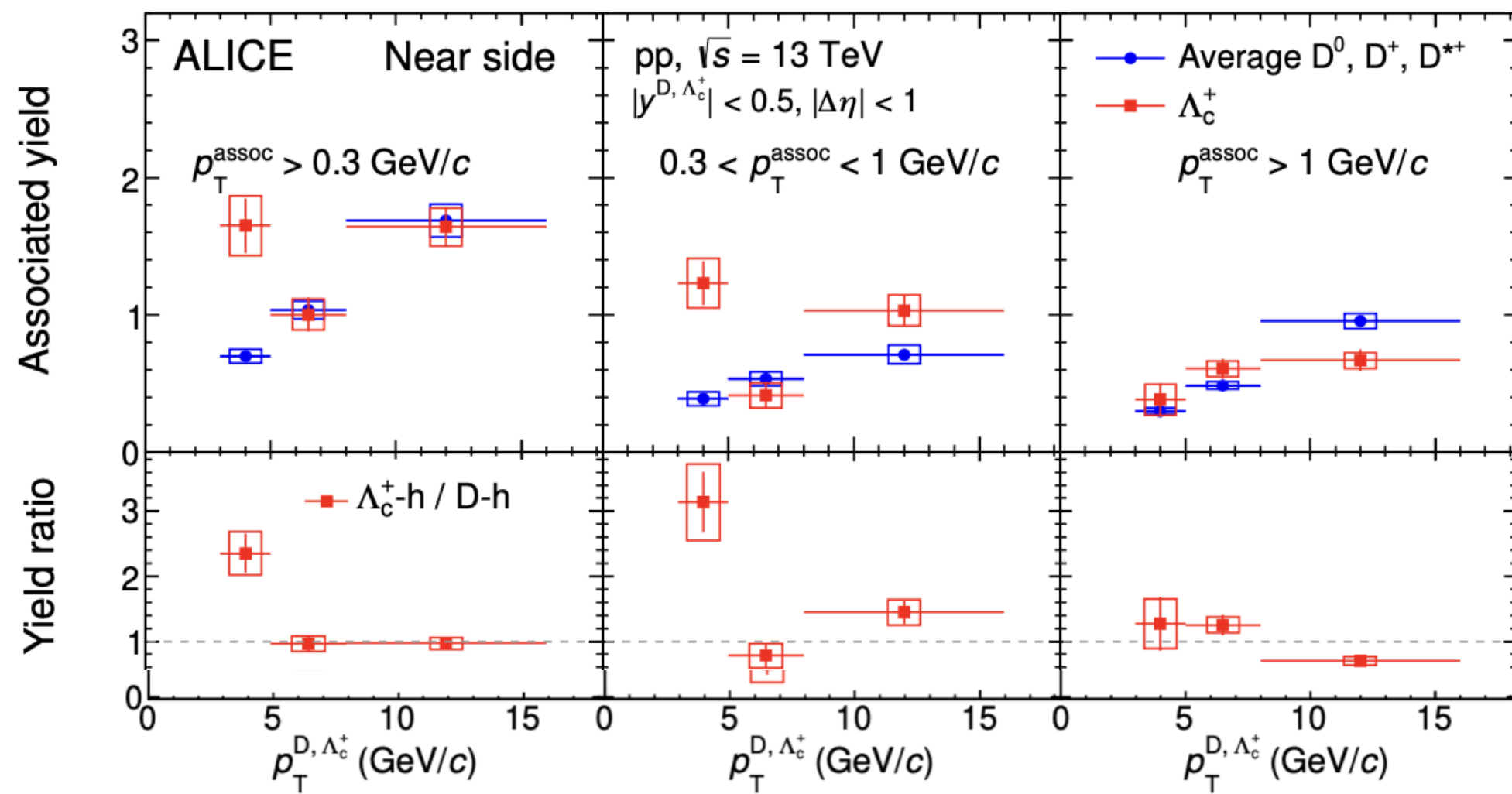
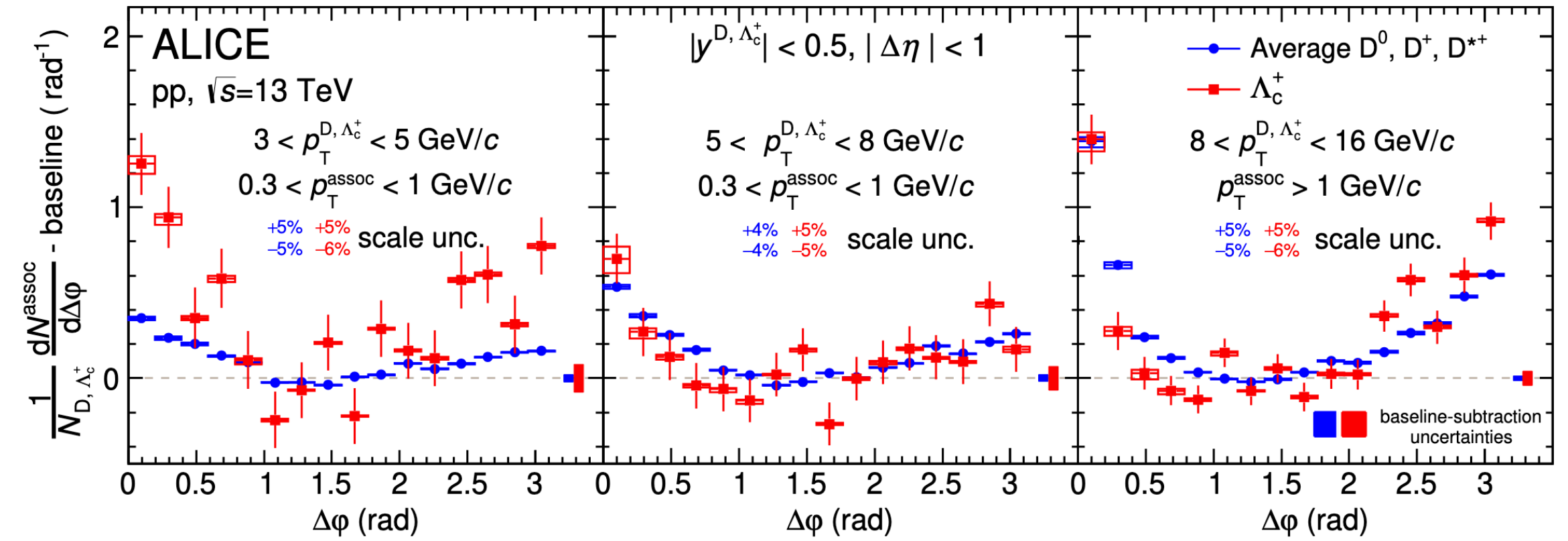
Fragmentation functions (hadronisation)

Assumed **universal** across collision systems (ee,..., AA)

- The fragmentation function can't be computed perturbatively, it is parameterized from measurements on e^+e^- and ep
- While the D mesons were described well by fragmentation function, Results on charm baryon production has disproved the universality assumption.^{2,3}

2: Eur. J. Phys. C 76 (2016) 397
 3: Eur. J. Phys. C. 75 (2015) 197

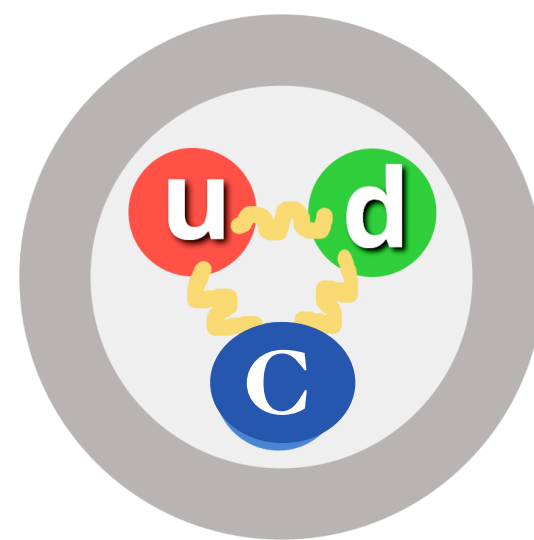
- At low p_T associated yield is higher for Λ_c^+ than D Meson, which can be seen in the plot below.
- Aim of our Analysis is to study multiplicity dependence of Lc-h correlation distributions in pp at 13.6 TeV.



Reference : [arXiv:2411.10104 \[hep-ex\]](https://arxiv.org/abs/2411.10104)

- Azimuthal correlations of $\Lambda_c^+ - h$ with dependence of multiplicity.
- System: Proton-Proton Collisions (p-p)
- Energy $\sqrt{s} := 13.6$ TeV
- Dataset: HF_LHC22o_pass7_minBias_medium_2P3PDStar

Train: 280362



Λ_c^+ is a charmed baryon in family of Λ

Mass = 2286.46 ± 0.14 MeV

Mean life $\tau = (200 \pm 6) * 10^{-15} s$

$c\tau = 59.9 \mu m$

$\Lambda_c^+ \rightarrow p K^- \pi^+$ B.R. = $(6.24 \pm 0.28)\%$

- 1.) Updated the following codes to include centrality information
 - i.) `PWGHE/HFC/TableProducer/correlatorLcHadrons.cxx`
 - ii.) `PWGHE/HFC/Tasks/taskCorrelationLcHadrons.cxx`
 - iii.) `PWGHE/HFC/DataModel/CorrelationTables.h`
- 2.) Tested the code offline
- 3.) Submitted Pull Request to O2Physics #11724
- 4.) Ran and Analyzed data offline.

Event Cuts:

- FT0-A and FT0-C coincidence (sel8 events): A valid collision by requiring signals in both forward detectors. Includes Time Frame and ITS ReadOut Frame border rejections.
- Primary vertex position: The vertex z-position must lie within ± 10 cm of the nominal interaction point which ensures uniform detector acceptance and optimal tracking performance.

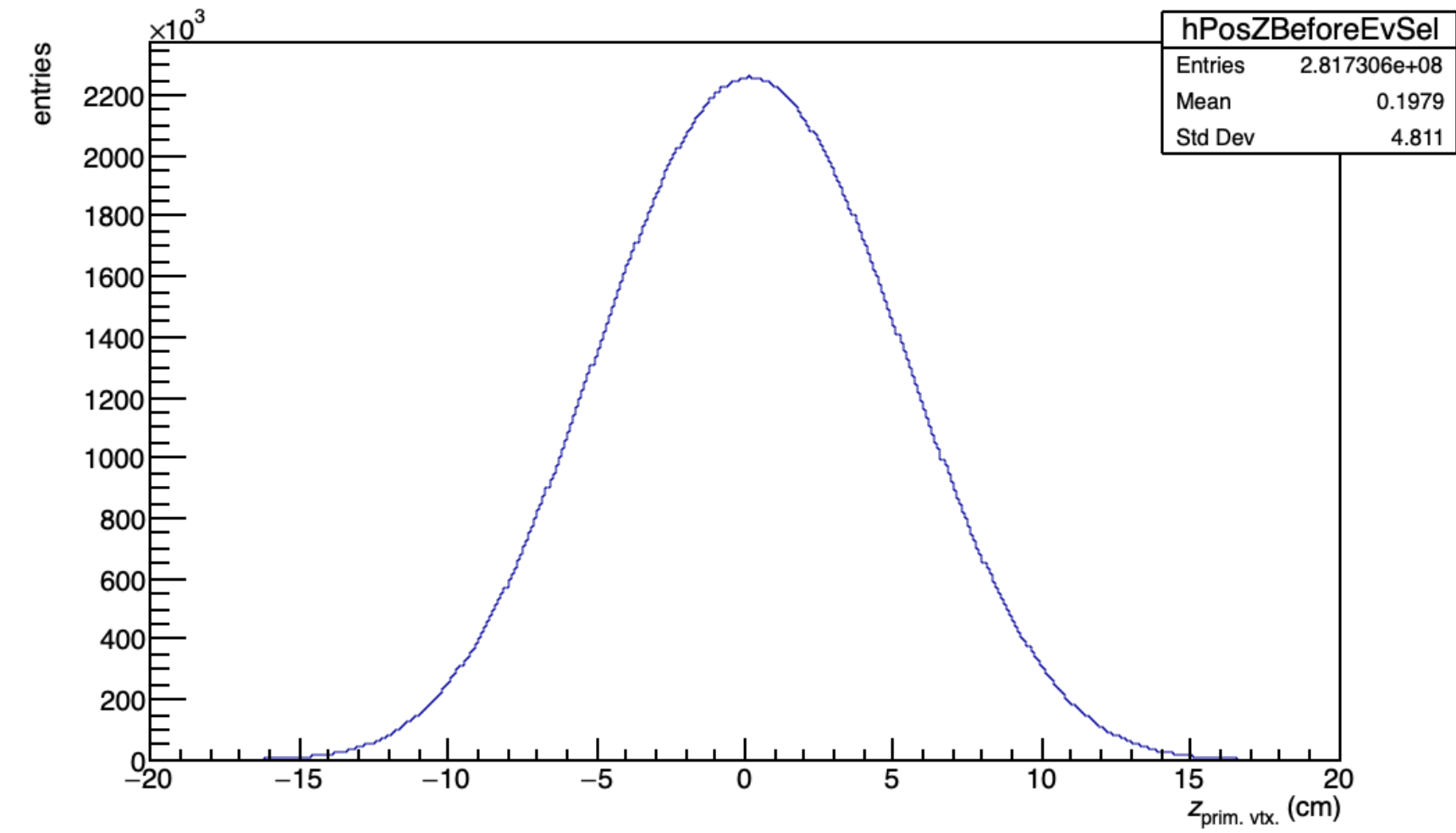
Track Cuts:

- Tracks with $p_T > 0.3$ GeV/c and $|\eta| < 0.8$
- DCA cuts: DCA_{xy} and $DCA_z < 1$ cm

Track PID Cuts:

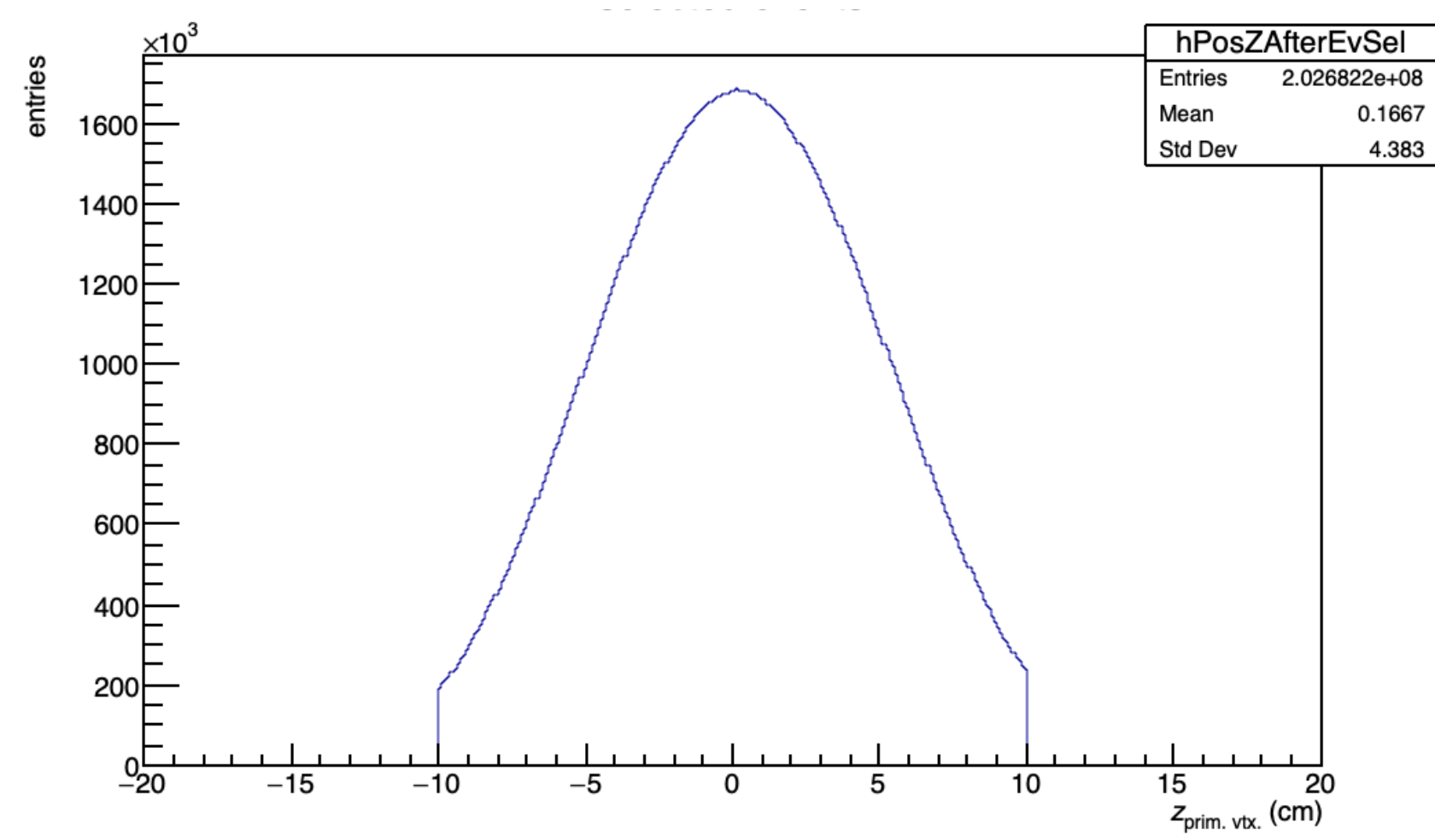
- $|n\text{SigmaTPC}| \ \& \ |n\text{SigmaTOF}| < 3$
- $|n\text{SigmaTofCombined}| \ \& \ |n\text{SigmaTPCCombined}| < 5$

All events



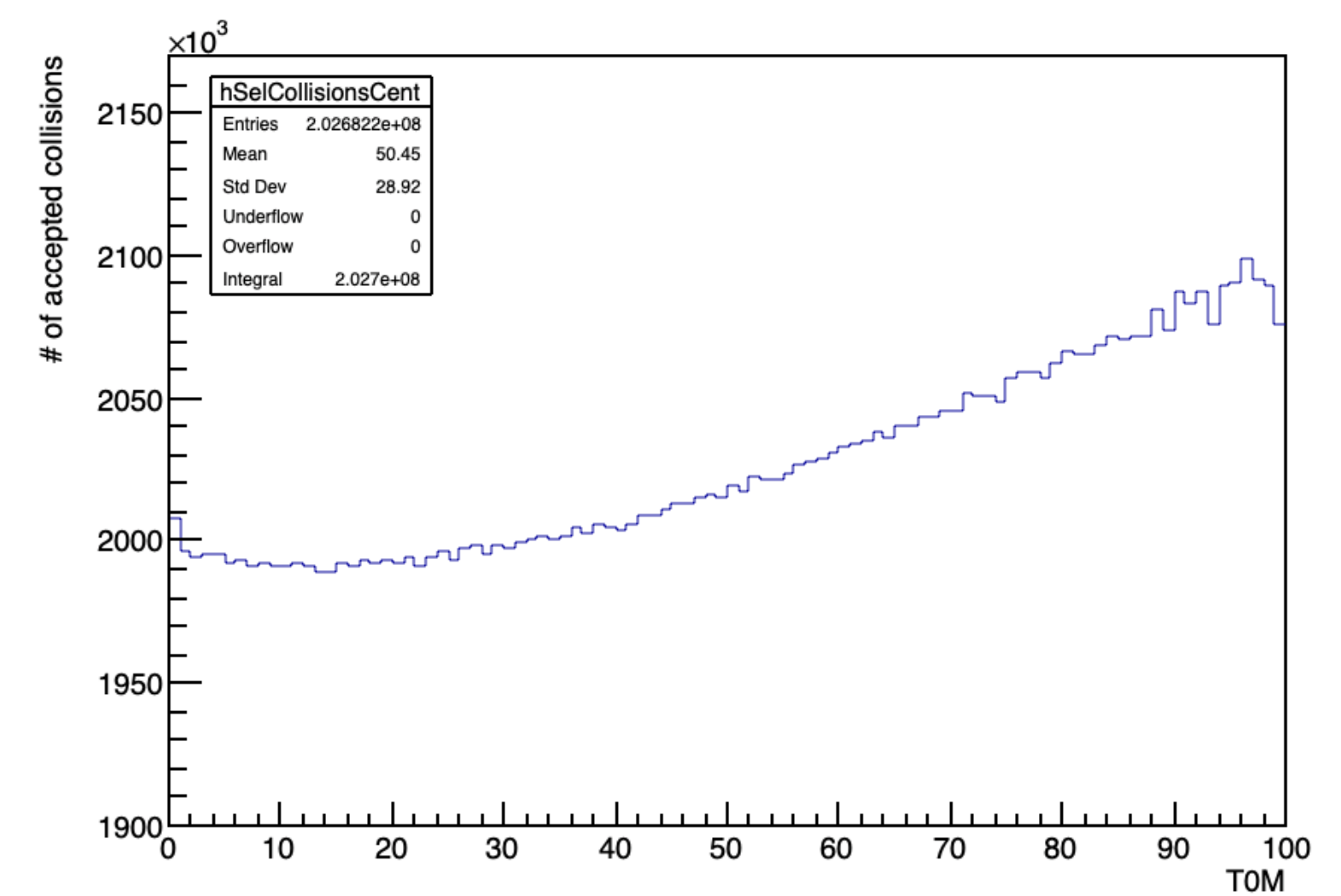
Z Vertex Distribution

Selected events



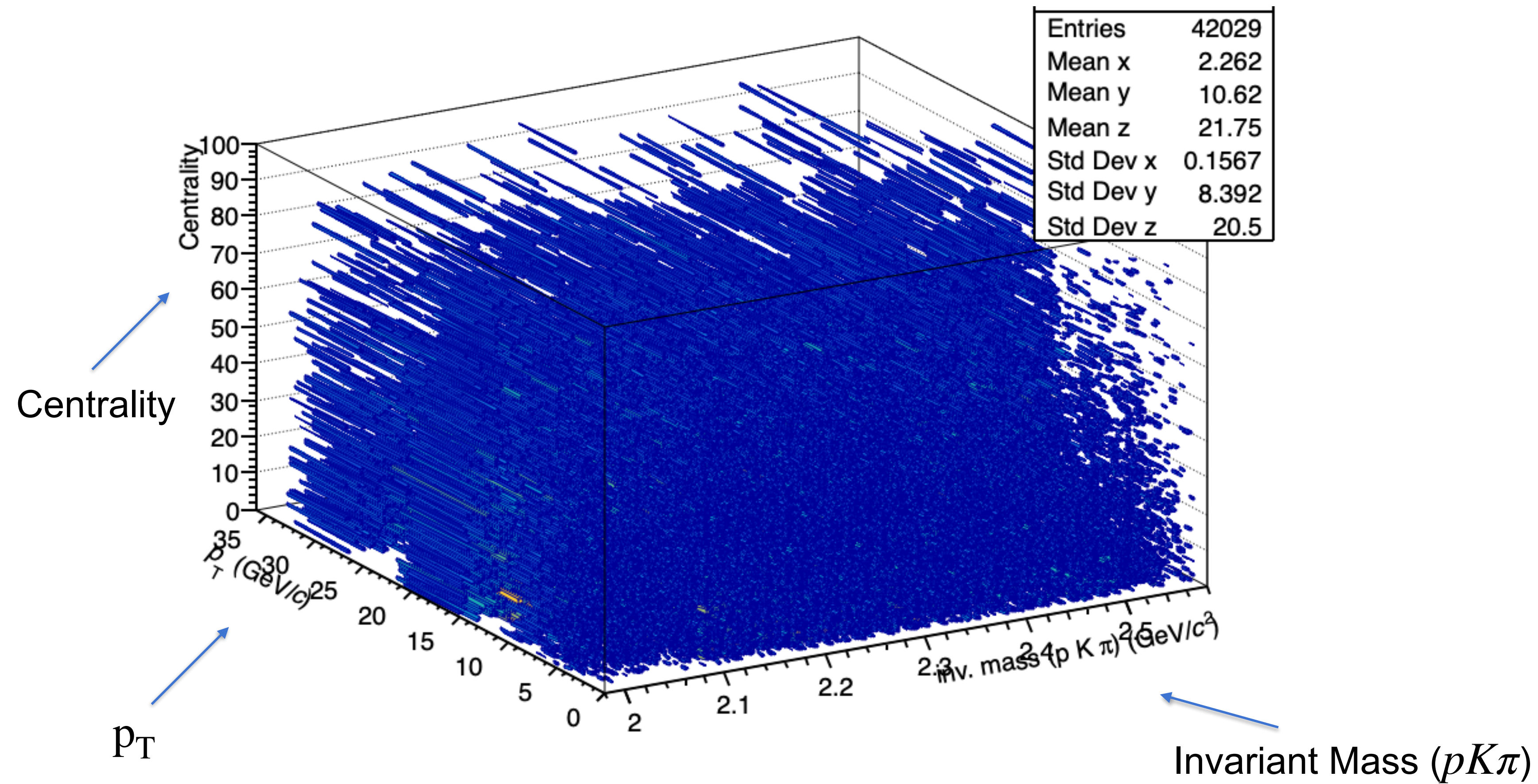
Z Vertex Distribution

Selected events



Centrality Distribution

3D Histogram: Invariant Mass vs p_T vs Centrality



Centrality Bins in our Analysis

0-10%

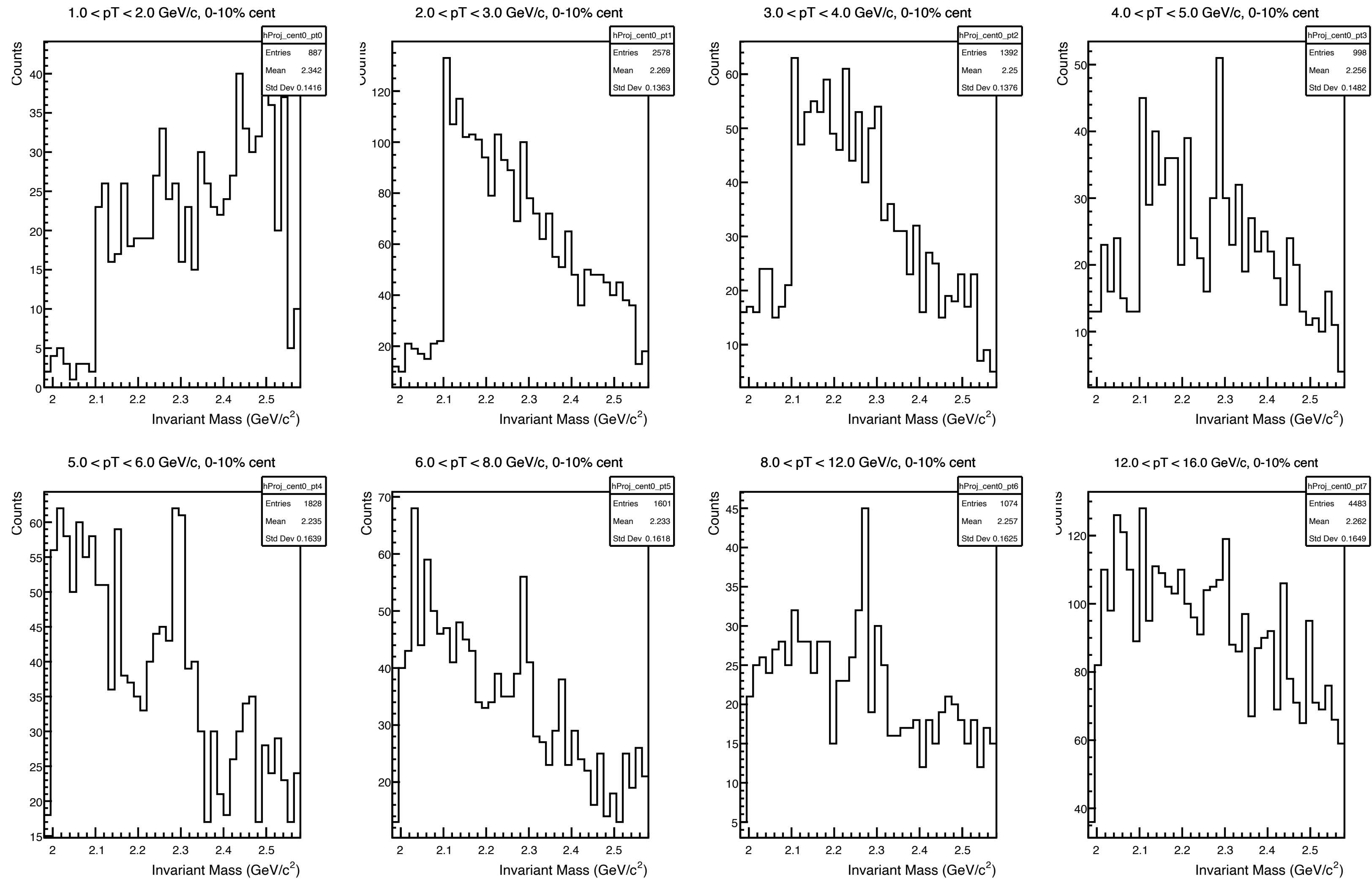
10-30%

30-60%

60-100%

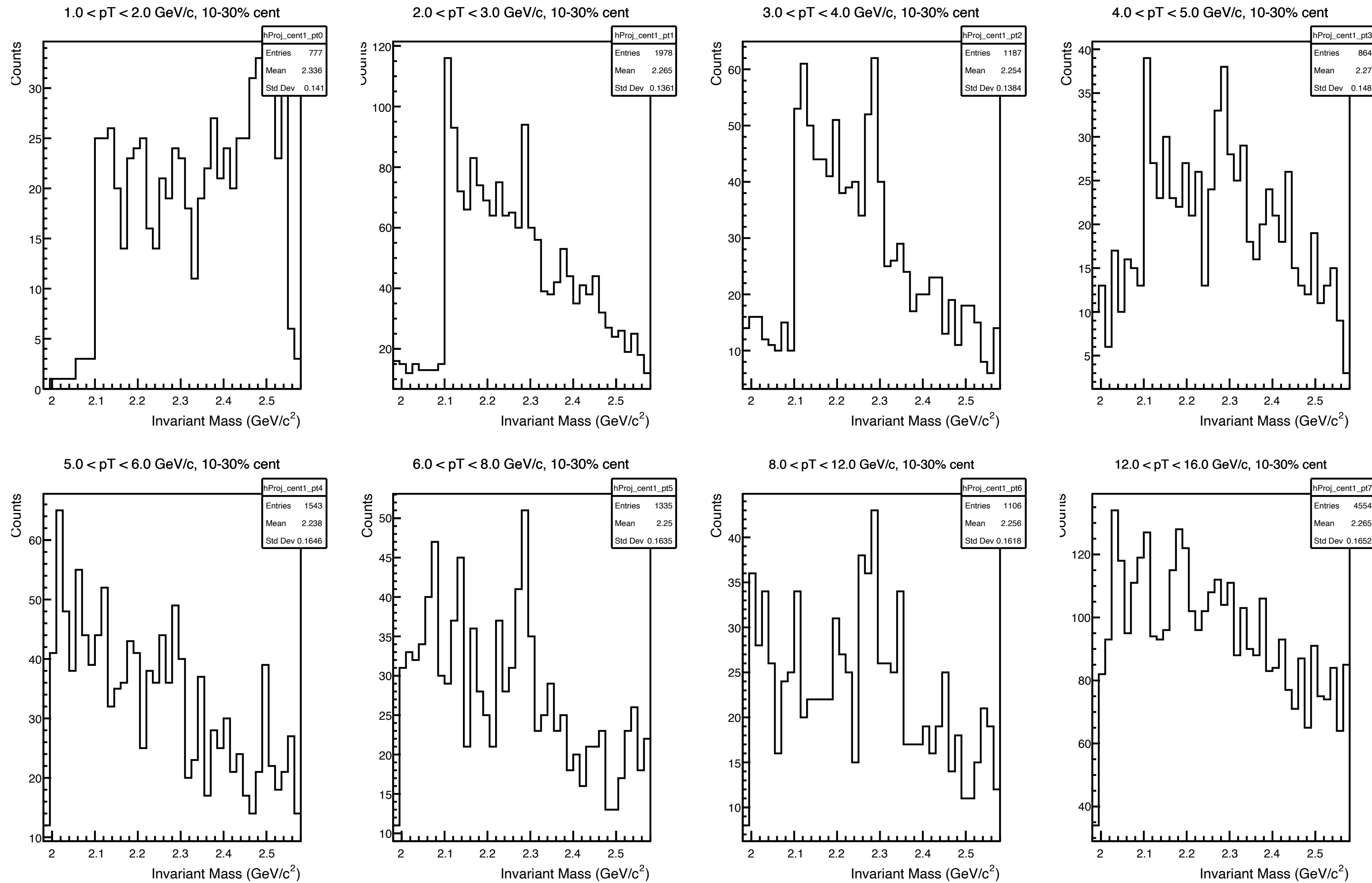
Invariant Mass in various pT ranges

Centrality: 0-10%



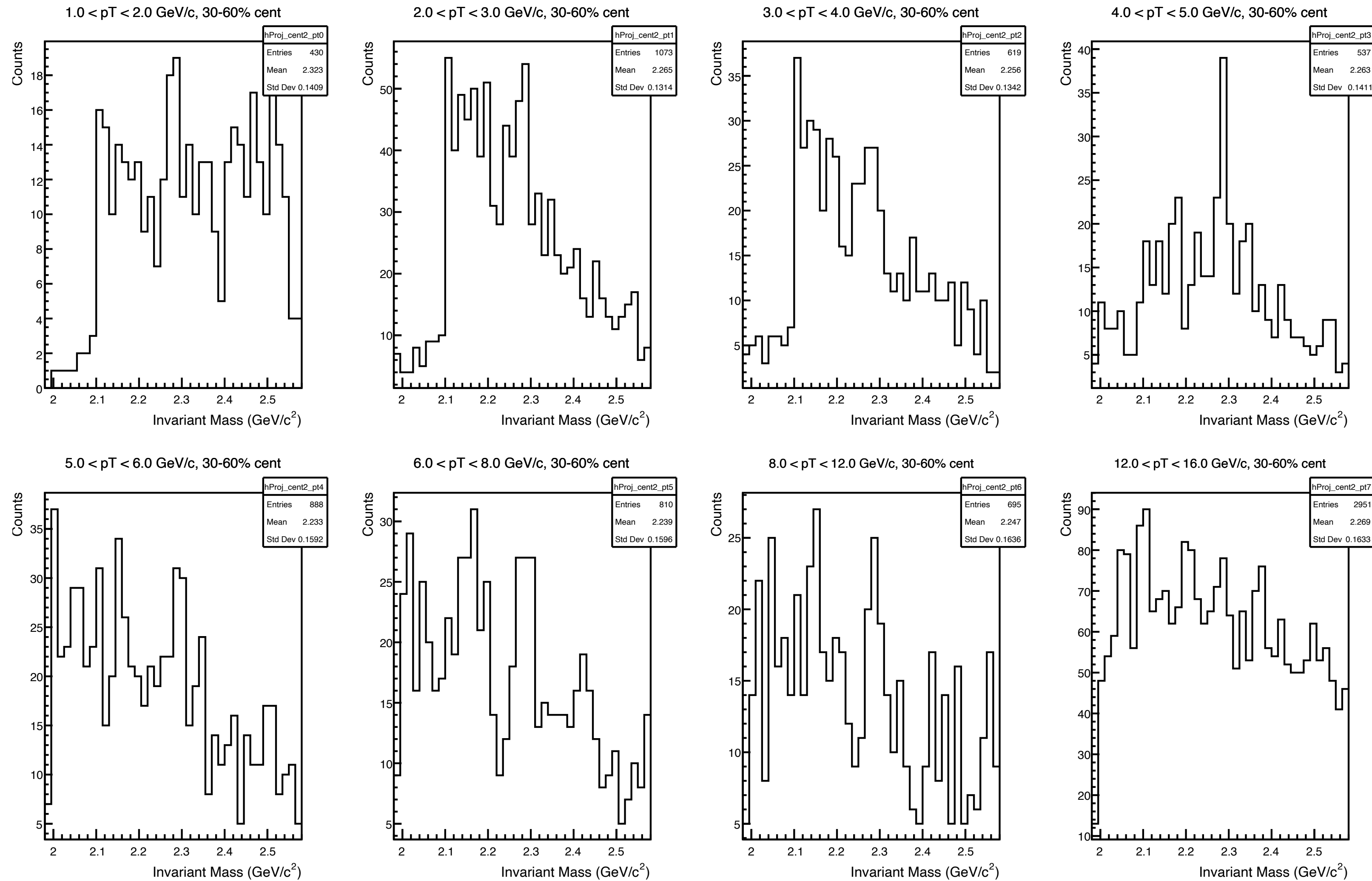
Invariant Mass in various p_T ranges

Centrality: 10-30%



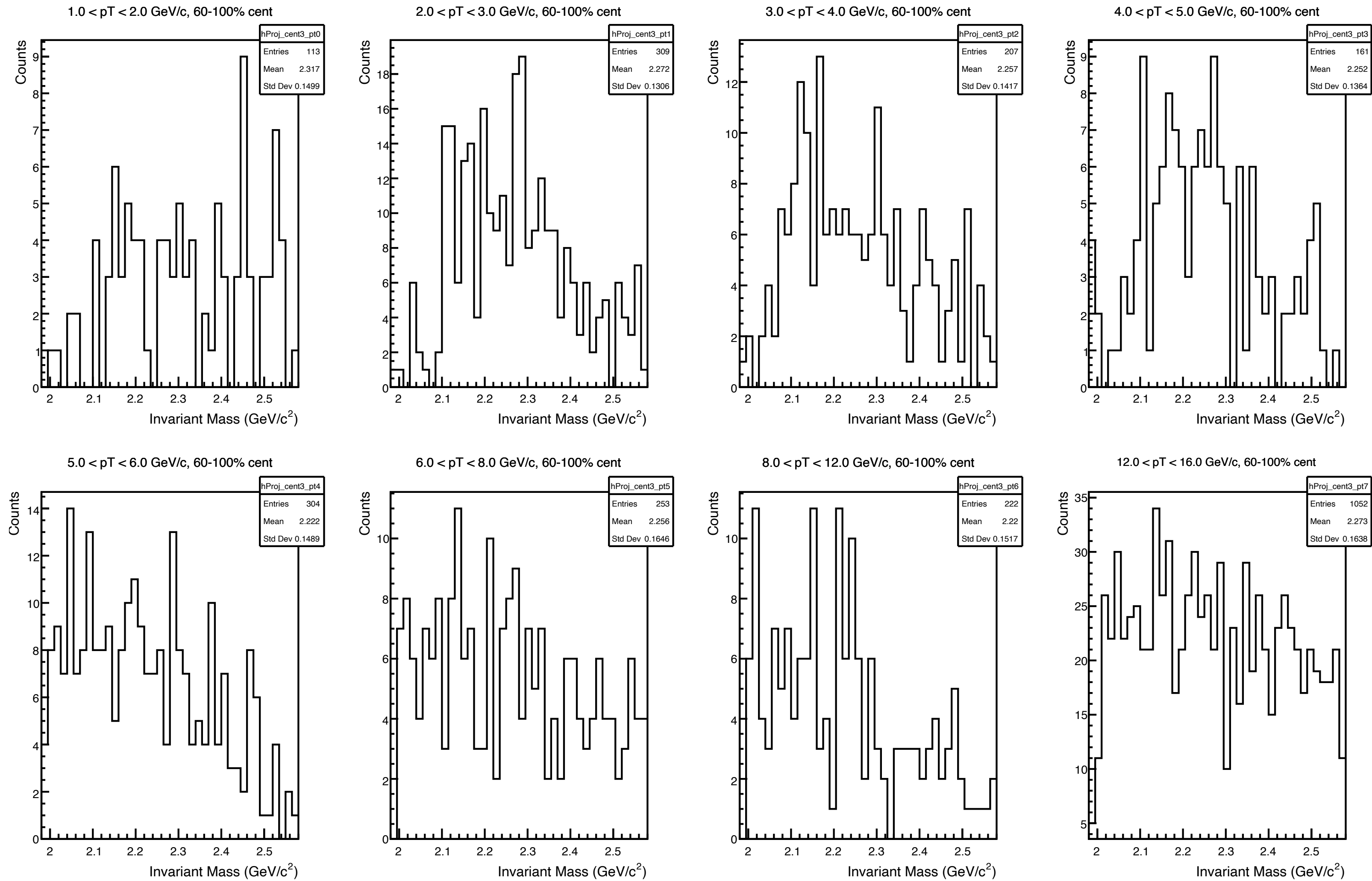
Invariant Mass in various p_T ranges

Centrality: 30-60%



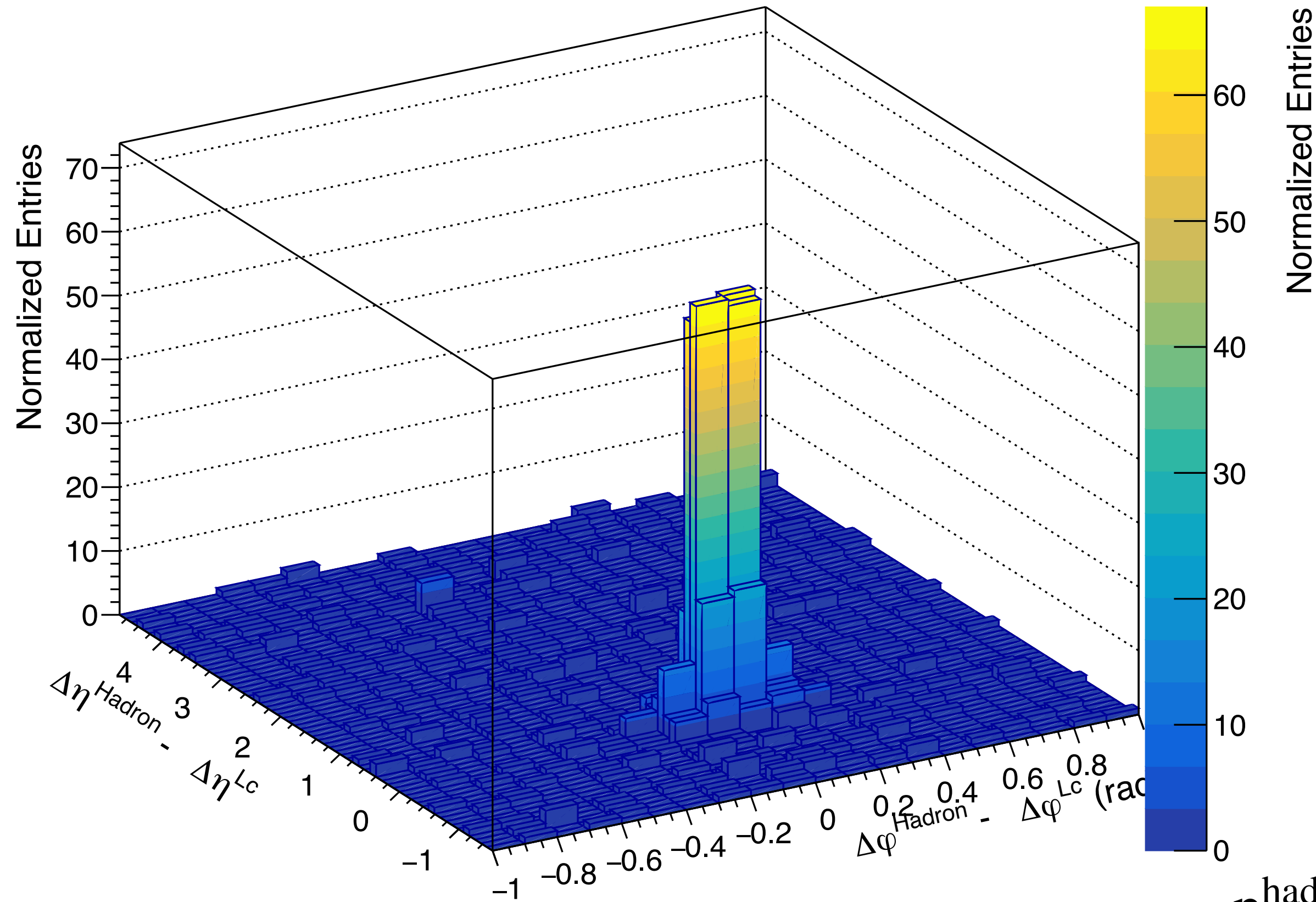
Invariant Mass in various pT ranges

Centrality: 60-100%

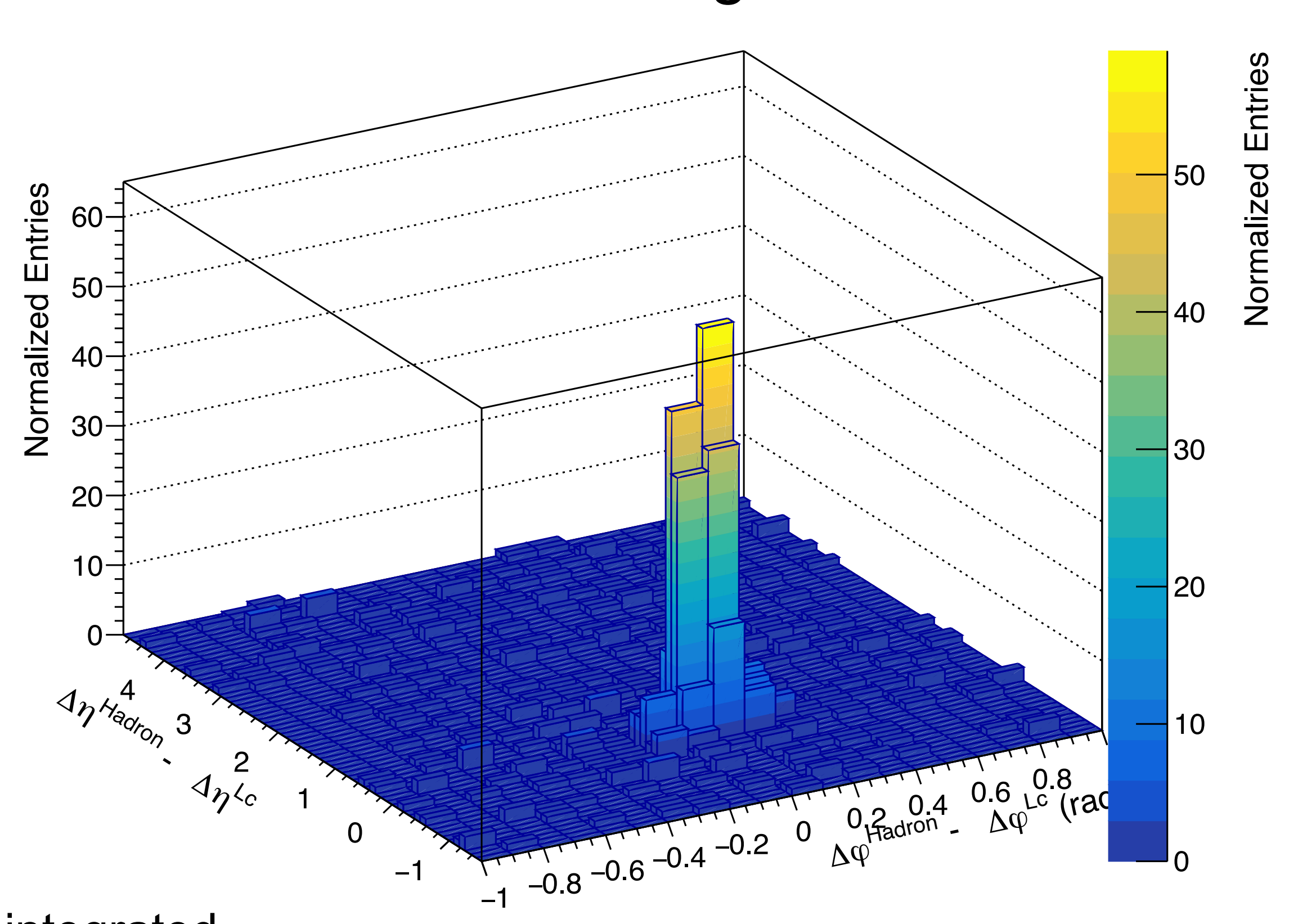


$\Delta\eta\Delta\phi$ Distribution 0-10%

Signal Region



Sideband Region

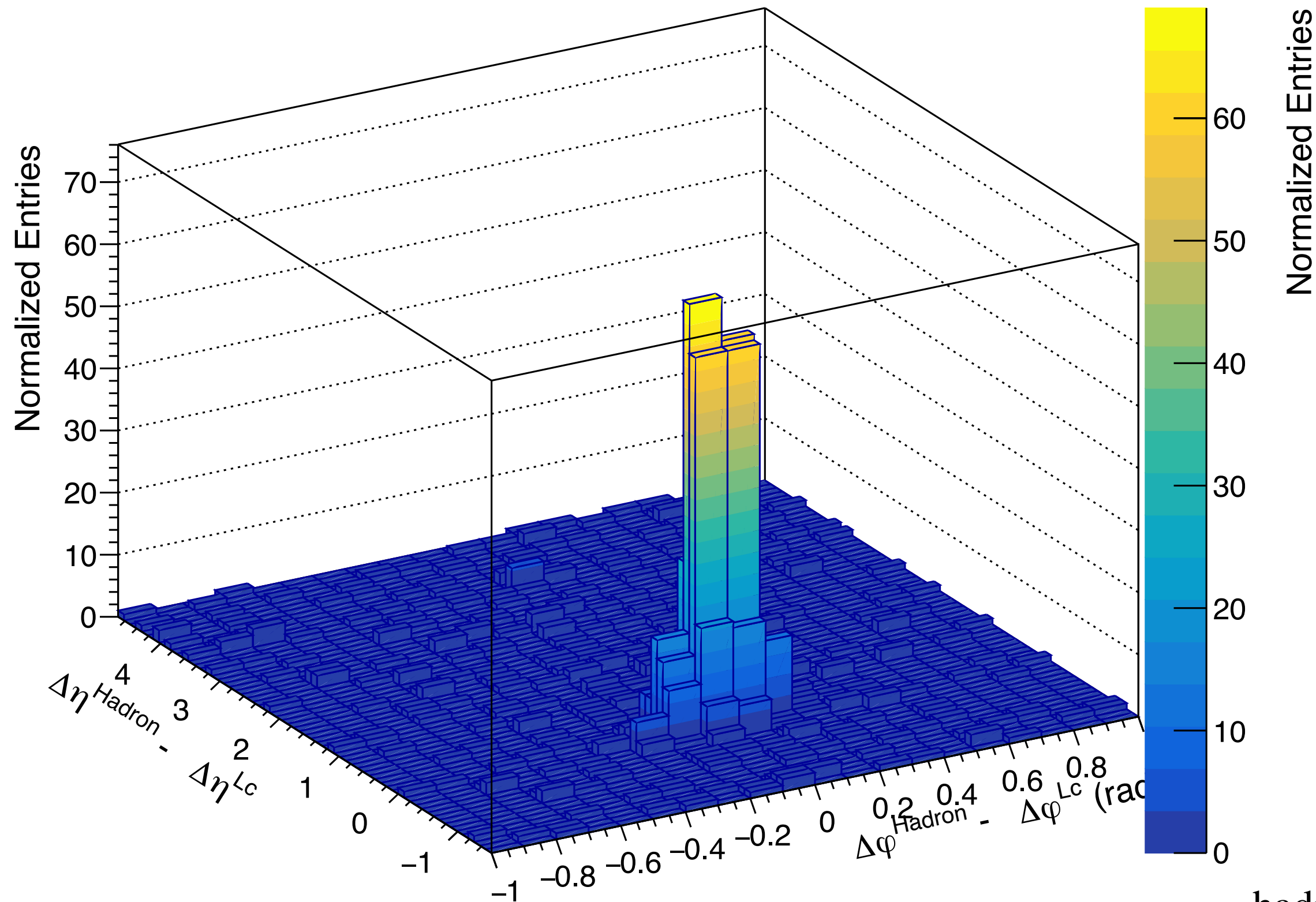


p_T^{hadrons} & $p_T^{\Lambda_c^+}$ integrated

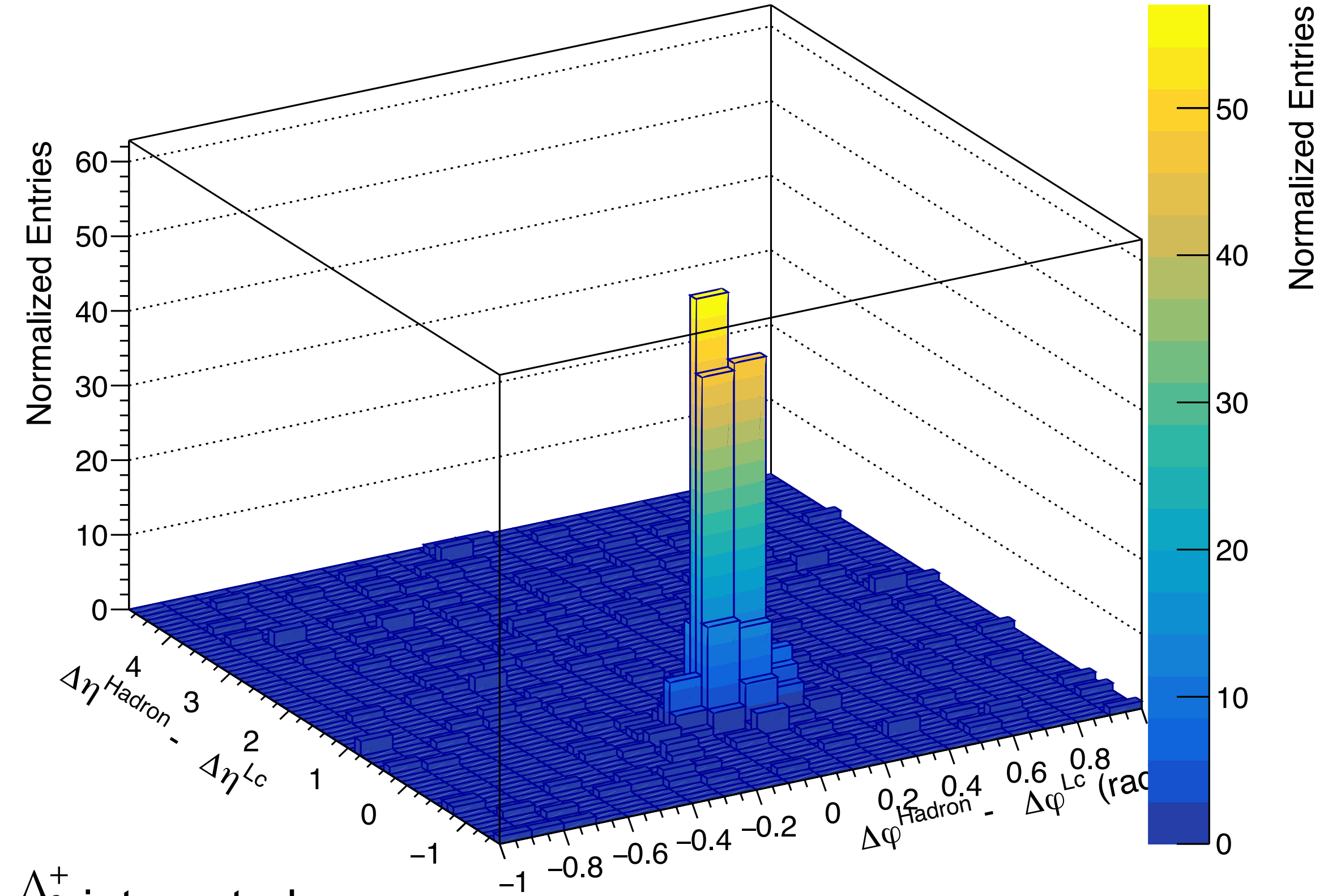
Results

$\Delta\eta\Delta\phi$ Distribution 10-30%

Signal Region



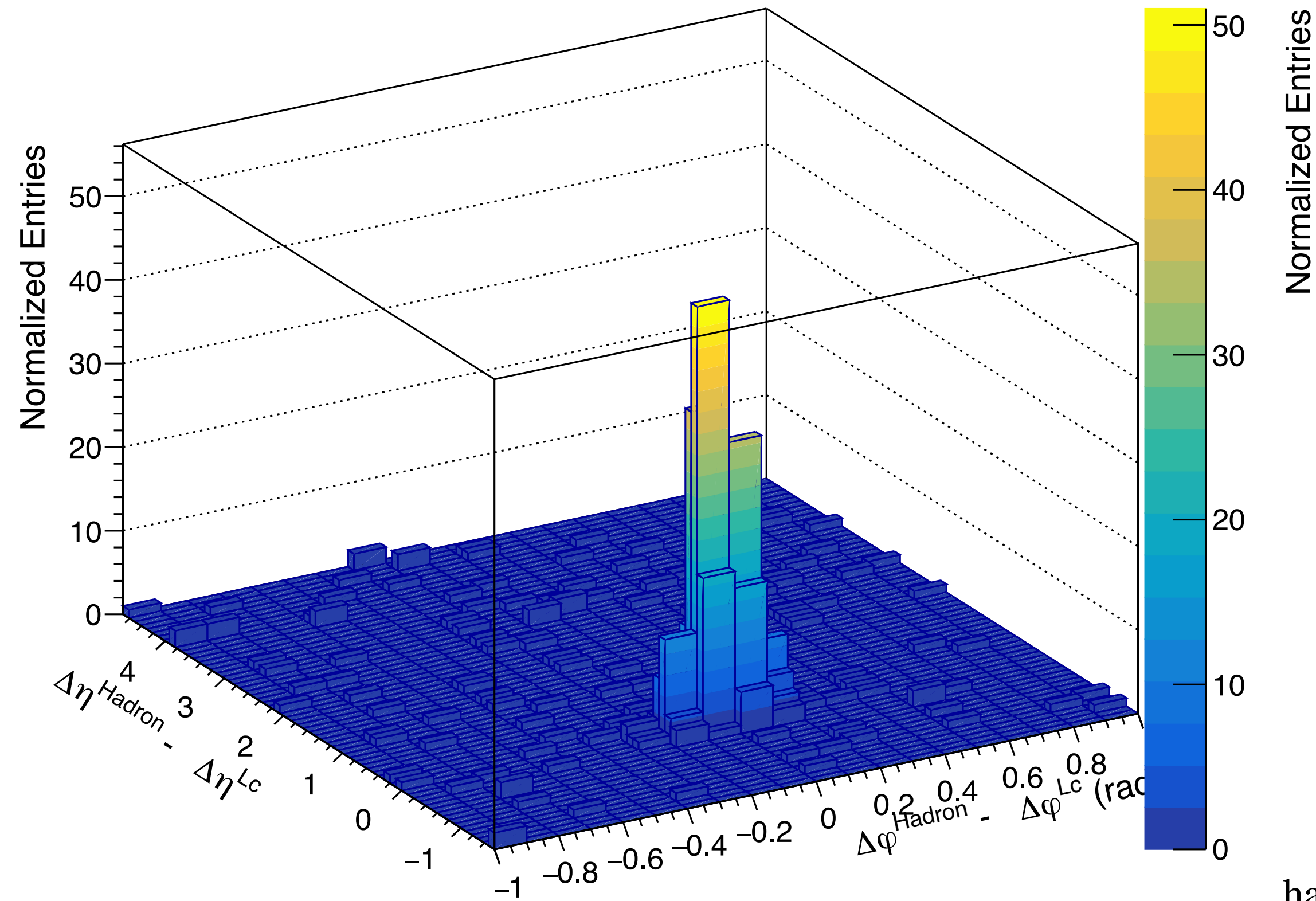
Sideband Region



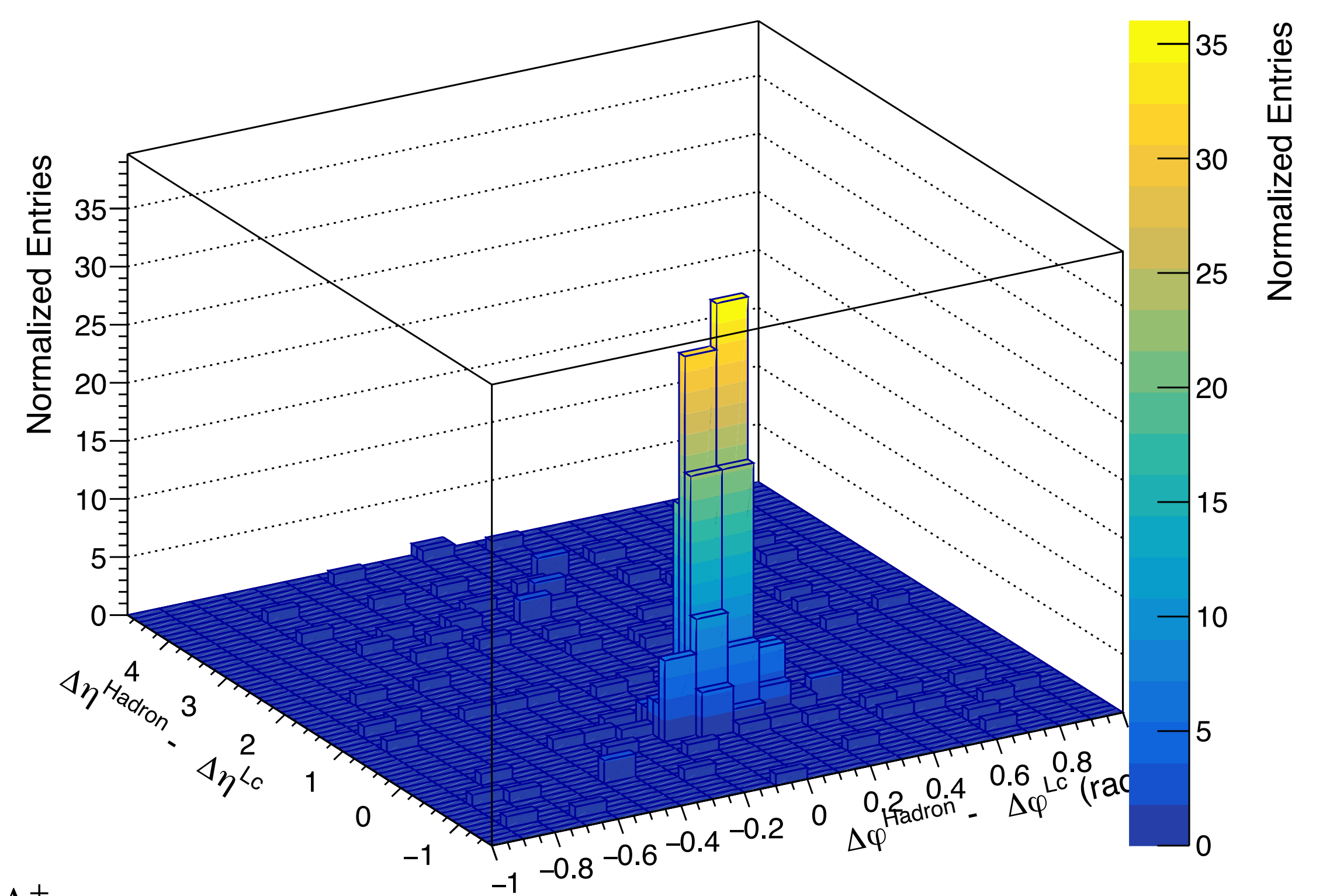
p_T^{hadrons} & $p_T^{\Lambda_c^+}$ integrated

$\Delta\eta\Delta\phi$ Distribution 30-60%

Signal Region



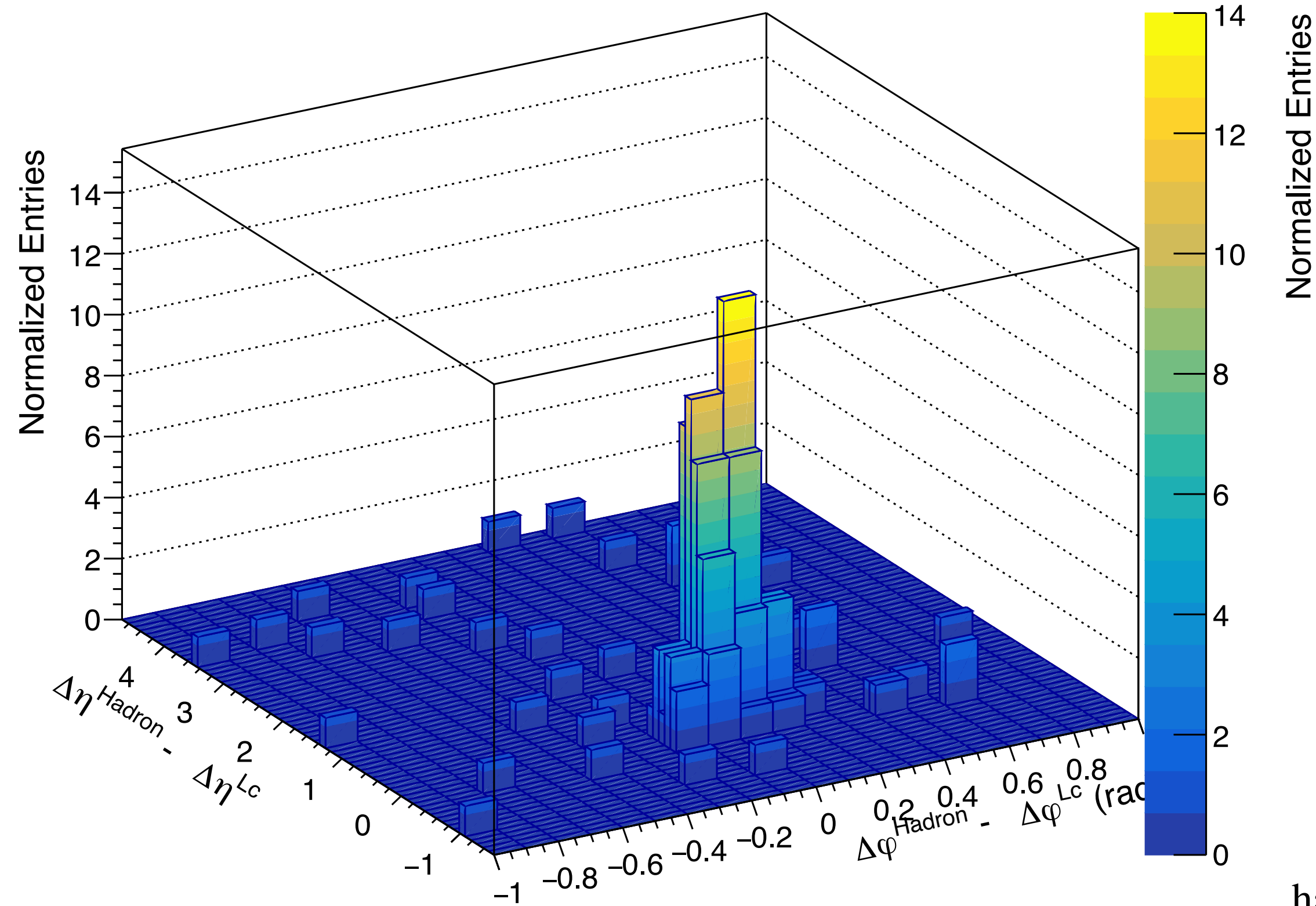
Sideband Region



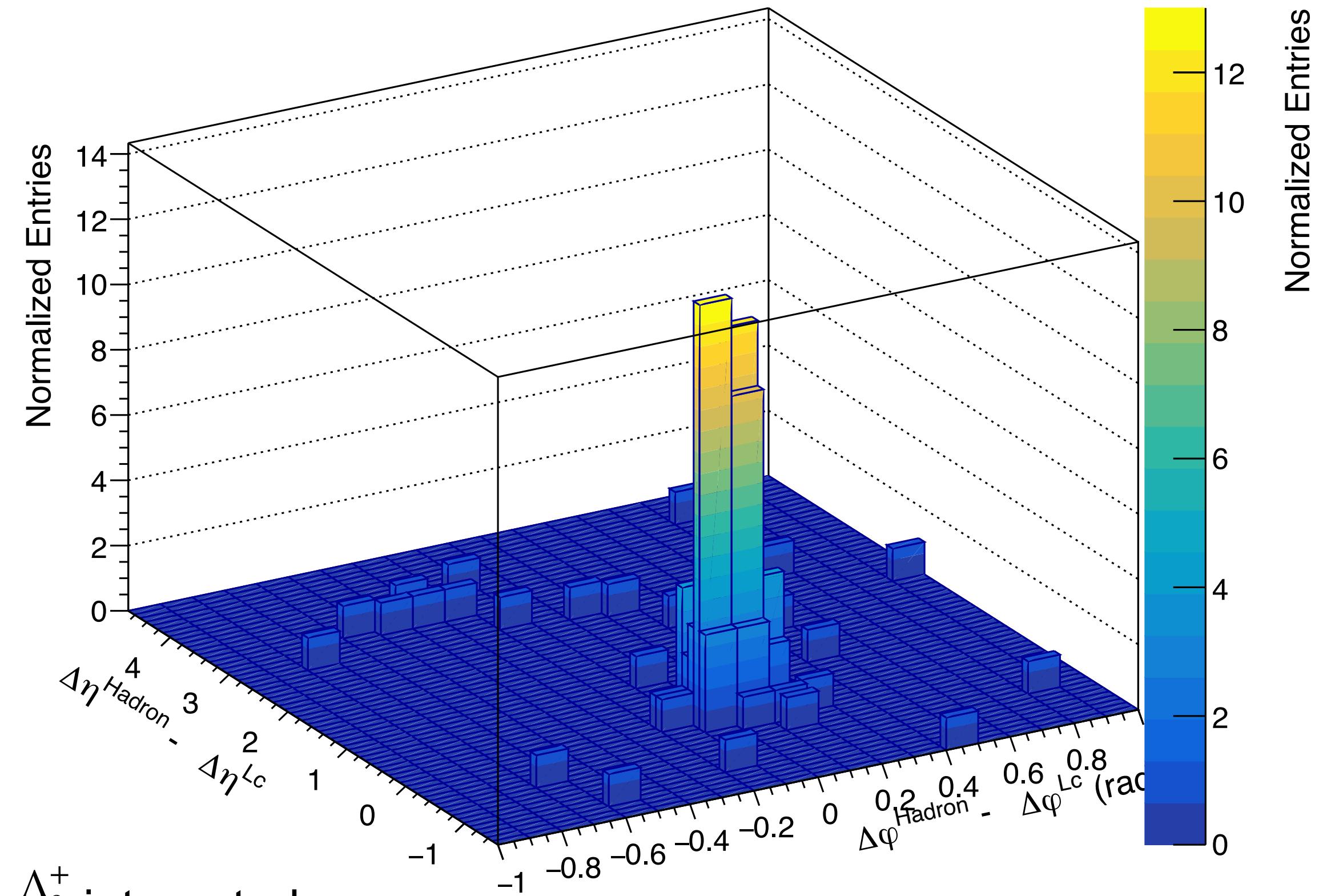
p_T^{hadrons} & $p_T^{\Lambda_c^+}$ integrated

$\Delta\eta\Delta\phi$ Distribution 60-100%

Signal Region



Sideband Region



$p_{\text{T}}^{\text{hadrons}}$ & $p_{\text{T}}^{\Lambda_c^+}$ integrated

Summary:

- Looking for Multiplicity dependence of $\Lambda_c^+ - h$ Azimuthal Correlation in pp at 13.6 TeV
- Presented first look of Invariant Mass in different pT ranges and various Centrality bins
- Looked at $\Delta\eta\Delta\varphi$ Distribution in Signal and Sideband region of $\Lambda_c^+ - h$ pairs in various Centrality Bins
- Initial work has been presented in PAG-HFCL on 27th June 2025

Outlook:

- Proceed with O2Physics Commit
- Run on Hyperloop for better statistics
- Do Mixed Event Corrections
- ...



Thank You