



Event-by-Event $\langle p_T \rangle$ Fluctuations of Identified Particles in pp Collisions at $\sqrt{s} = 13.6$ TeV in Run-3 Data

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Overview

- Motivation
- Observable
- Analysis Details
 - Event Selection Criterion
 - Track Selection Criterion
 - PID Selection
- Results
- Summary

Motivation

- “**Dynamical**” fluctuations reflect the **dynamics and responses of the system**.
- Help to characterize the properties of the bulk description of the system.
- **Mean transverse momentum fluctuation** is sensitive to **temperature/energy fluctuation**.
- Fluctuations of $\langle p_T \rangle$ arise from many kinds of correlations among the p_T of the final-state particles, such as resonance decays, jets etc...
- So, E-by-E $\langle p_T \rangle$ fluctuations in pp collisions can be used as a model-independent baseline to search for non-trivial fluctuations in heavy-ion collisions.
- By studying this for **identified particles**, one can get an insight into the **production and dynamics of the specific particles**.

Observable

Moments of p_T

$$Q_n = \sum_{i=1}^{N_{ch}} (p_i)^n$$

Mean p_T

$$\langle\langle p_T \rangle\rangle = \left\langle \frac{Q_1}{N_{ch}} \right\rangle$$

Two Particle Correlator

$$\langle\Delta p_i \Delta p_j\rangle = \left\langle \frac{Q_1^2 - Q_2}{N_{ch}(N_{ch} - 1)} \right\rangle - \left\langle \frac{Q_1}{N_{ch}} \right\rangle^2$$

- p_i : transverse momentum of the i^{th} particle
- Angular brackets denote an average over events in a multiplicity class

Observable (cont'd)

$$\frac{\sqrt{\langle \Delta p_i \Delta p_j \rangle}}{\langle \langle p_T \rangle \rangle} \rightarrow \text{Dynamical } \langle p_T \rangle \text{ fluctuations relative to } \langle p_T \rangle$$

- Reduces the dependence on the detection efficiency

<https://journals.aps.org/prc/pdf/10.1103/PhysRevC.103.024910>

Event Selection Criterion

System

- pp Collisions
- 13.6 TeV

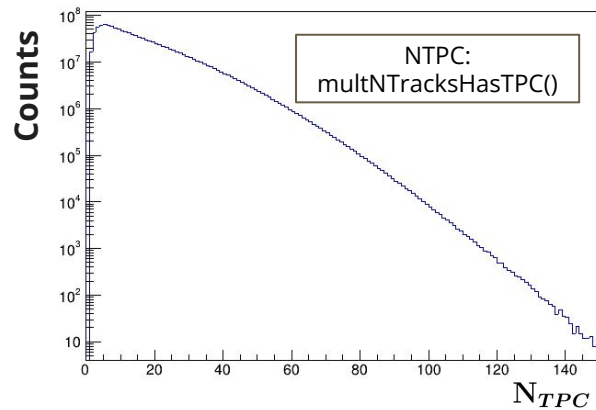
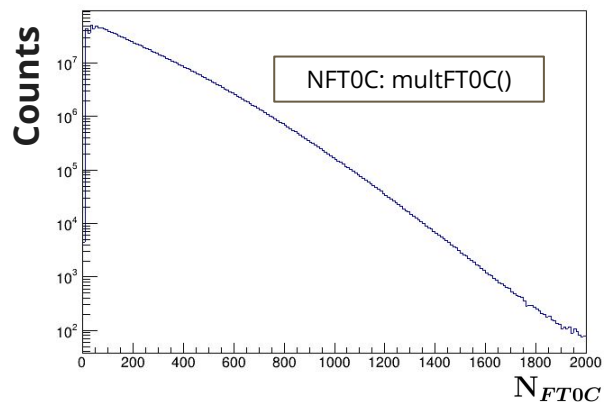
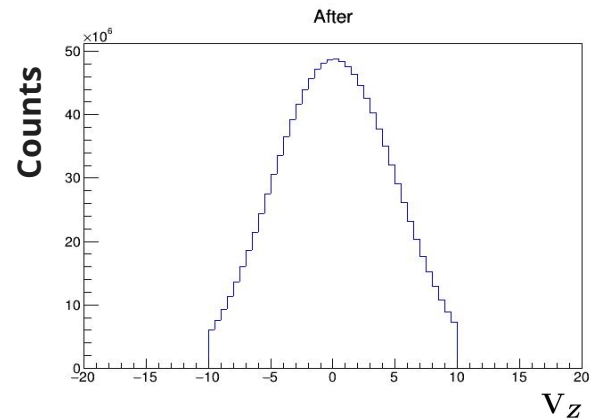
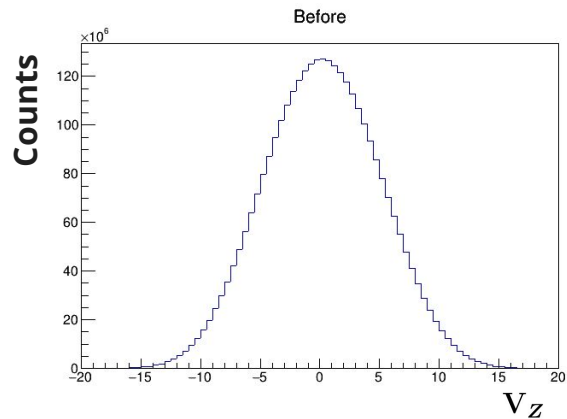
Data Set

- LHC22o_pass6_small
- # of events: 1.2 B

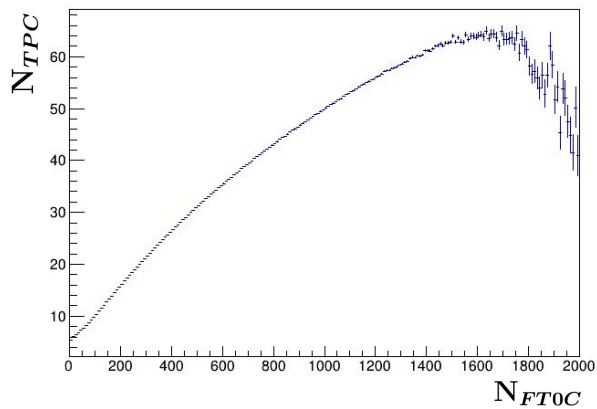
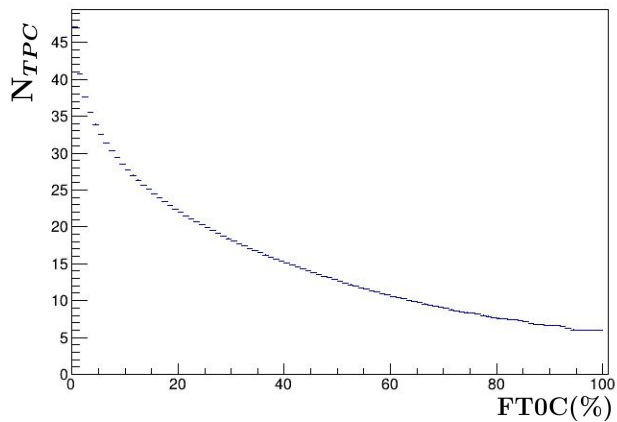
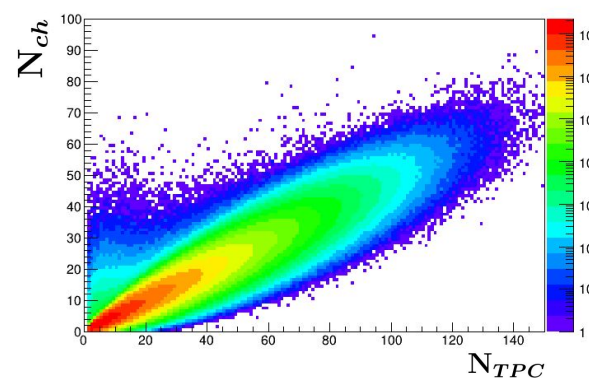
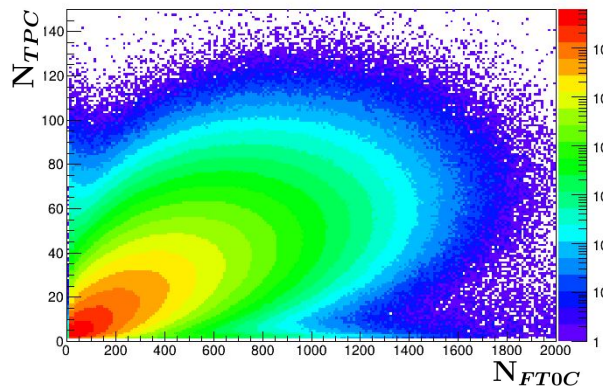
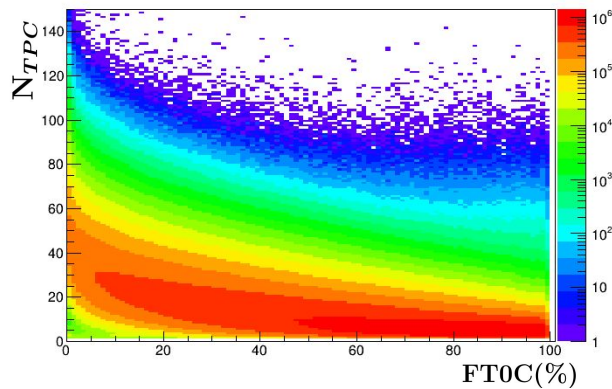
Event Selection

- $|V_z| < 10$ cm
- sel8()
- kNoSameBunchPileup()
- kIsGoodZvtxFT0vsPV()
- kIsVertexITSTPC()

Event Selection (Cont'd)



Event Selection (Cont'd)

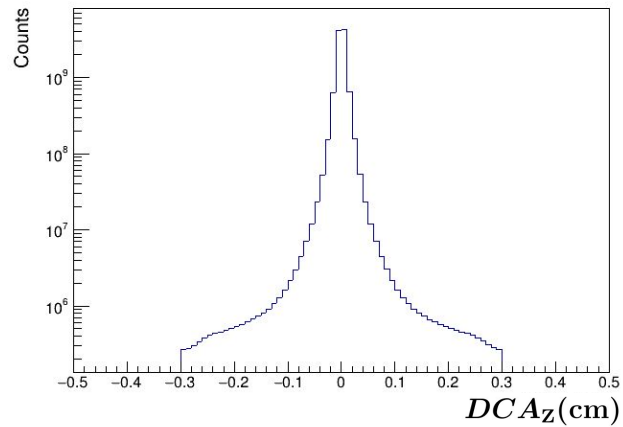
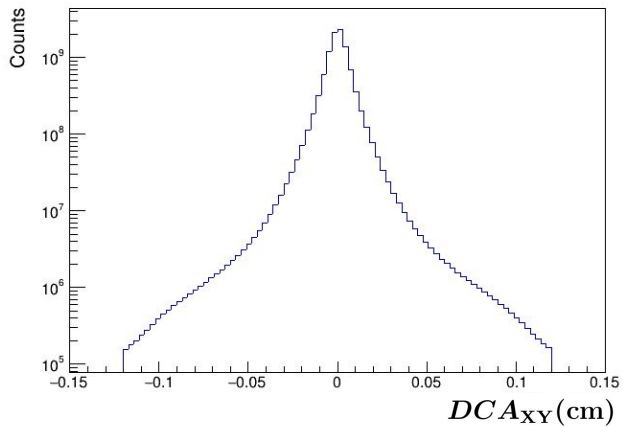
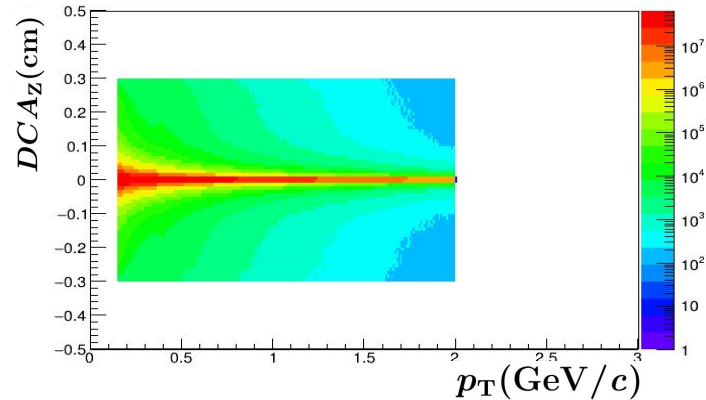
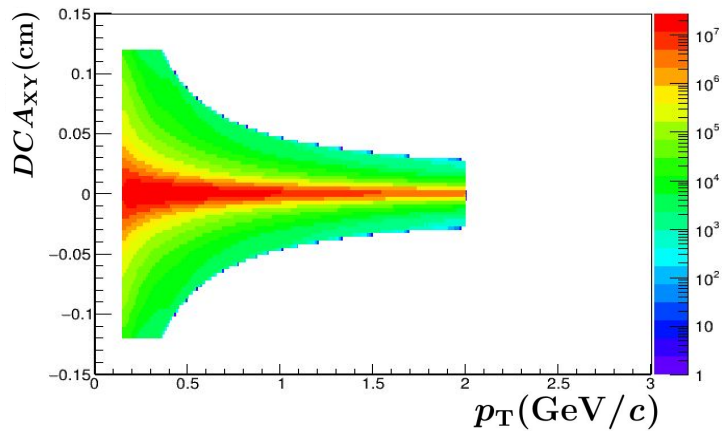


Track Selection Criterion

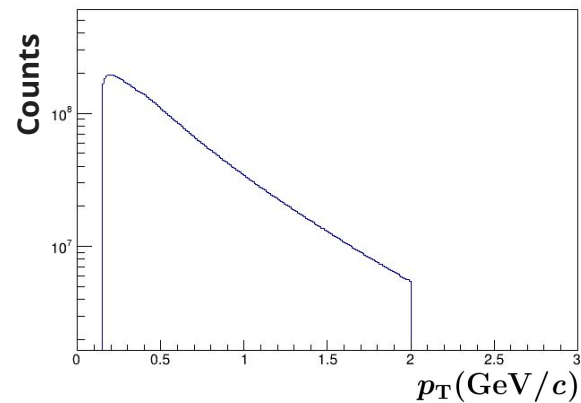
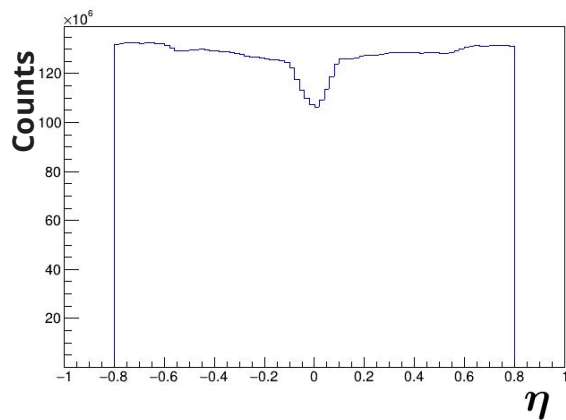
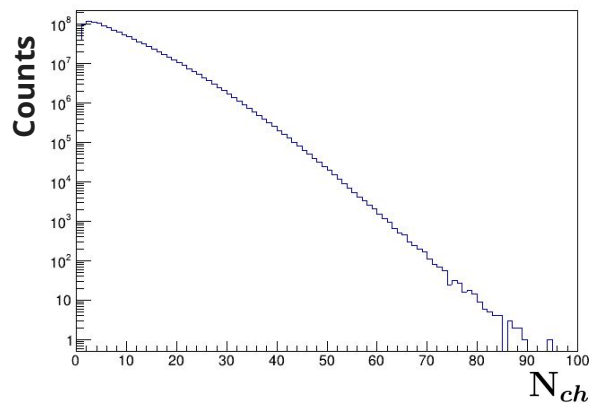
- $0.2 < p_T < 2.0$ GeV/c
- `isGlobalTrackWoPtEta()` →
- $|\mathbf{DCA}_{xy}| < 0.12$ cm
- $|\mathbf{DCA}_z| < 0.3$ cm
- $|\eta| < 0.8$

Cuts	globalTrack
min number of crossed rows TPC	70
min ratio of crossed rows over findable clusters TPC	0.8
max chi2 per cluster TPC	4.0
max chi2 per cluster ITS	36.0
require TPC refit	true
require ITS refit	true
max DCA to vertex z	2.0
max DCA to vertex xy	$0.0105 * 0.035 / p_T^{1.1}$
cluster requirement ITS	Run 2 (Run 3): at least one hit in SPD (in 3 innermost ITS layers) [*]

Track Selection (Cont'd)

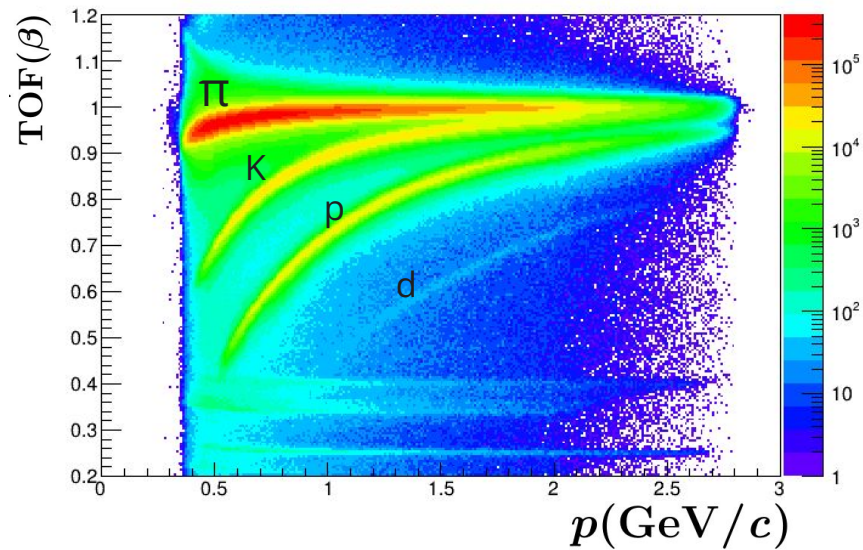
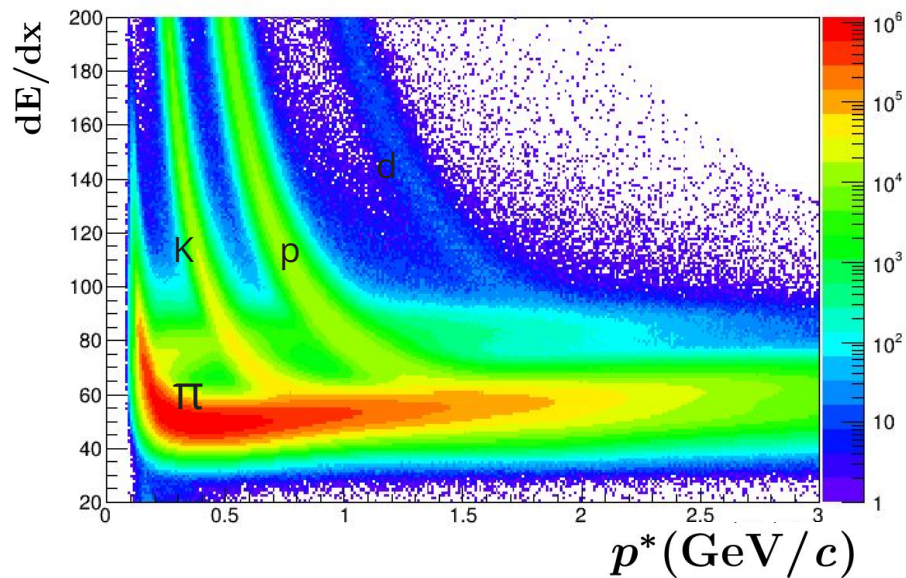


Track Selection (Cont'd)



PID Selection

Before



p^* : TPC Inner Parameter (momentum)

PID Selection (Cont'd)

- $|y| < 0.5$
- When track is not present in TOF
 - $|n\sigma|_{TPC,El} > 1.5$
 - Pions: ($p_T \geq 0.2$ GeV/c)
 - * $|n\sigma|_{TPC} < 3$ ($p^* \leq 0.65$ GeV/c)
 - * $|n\sigma|_{TPC} < 2$ ($0.65 < p^* \leq 0.75$ GeV/c)
 - Kaons: ($p_T \geq 0.3$ GeV/c)
 - * $|n\sigma|_{TPC} < 3$ ($p^* \leq 0.5$ GeV/c)
 - * $|n\sigma|_{TPC} < 2$ ($0.5 < p^* \leq 0.6$ GeV/c)
 - Protons: ($p_T \geq 0.5$ GeV/c)
 - * $|n\sigma|_{TPC} < 3$ ($p^* \leq 0.9$ GeV/c)
 - * $|n\sigma|_{TPC} < 2$ ($0.9 < p^* \leq 1.0$ GeV/c)

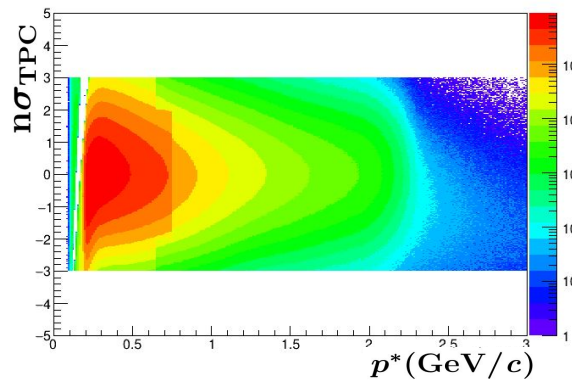
p^* : TPC Inner Parameter (momentum)

- When track is present in TOF
 - $|n\sigma|_{TPC} < 3$ & $|n\sigma|_{TOF,El} > 1.5$
 - Pions: ($p_T \geq 0.2$ GeV/c)
 - * $|n\sigma|_{TOF} < 3$
 - Kaons: ($p_T \geq 0.3$ GeV/c)
 - * $|n\sigma|_{TOF} < 3$ ($p \leq 1.6$ GeV/c)
 - * $|n\sigma|_{TOF} < 2$ ($p > 1.6$ GeV/c)
 - Protons: ($p_T \geq 0.5$ GeV/c)
 - * $|n\sigma|_{TOF} < 3$

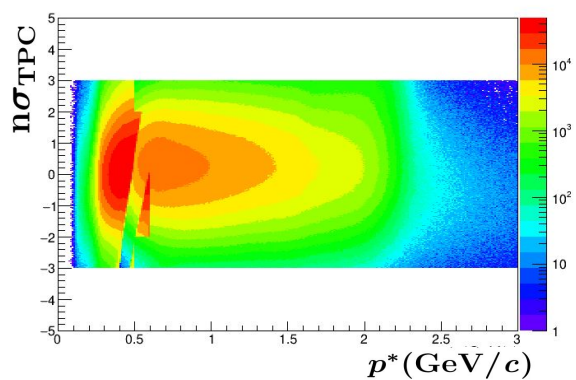
p : momentum

PID Selection (Cont'd)

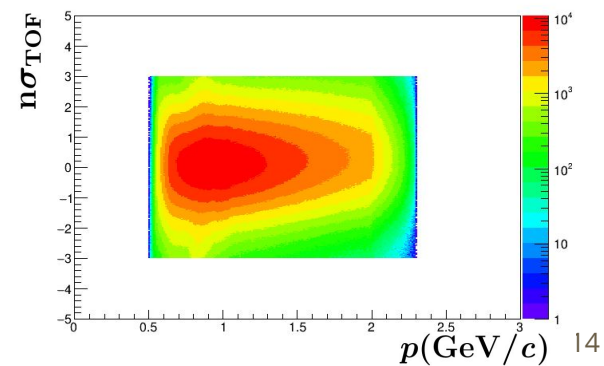
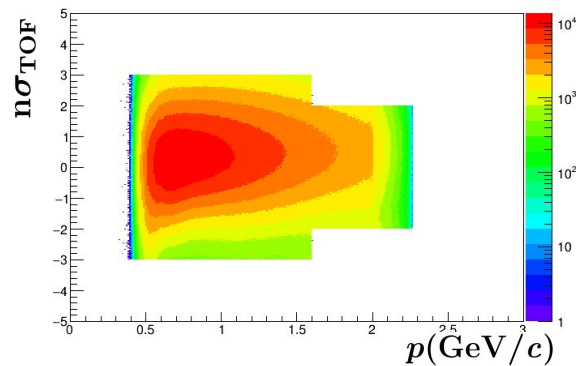
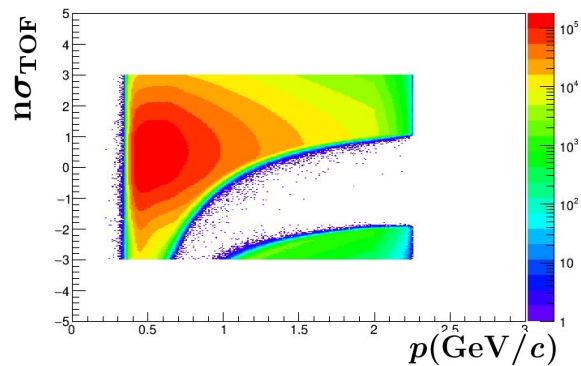
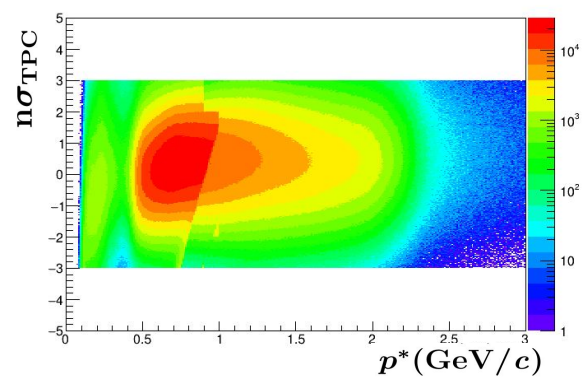
Pions



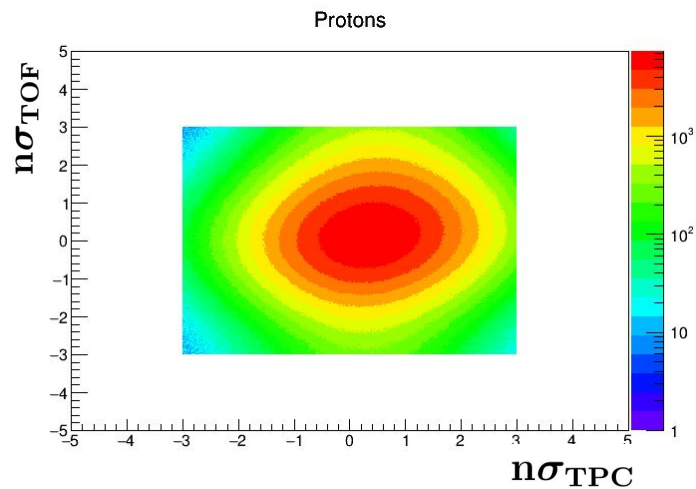
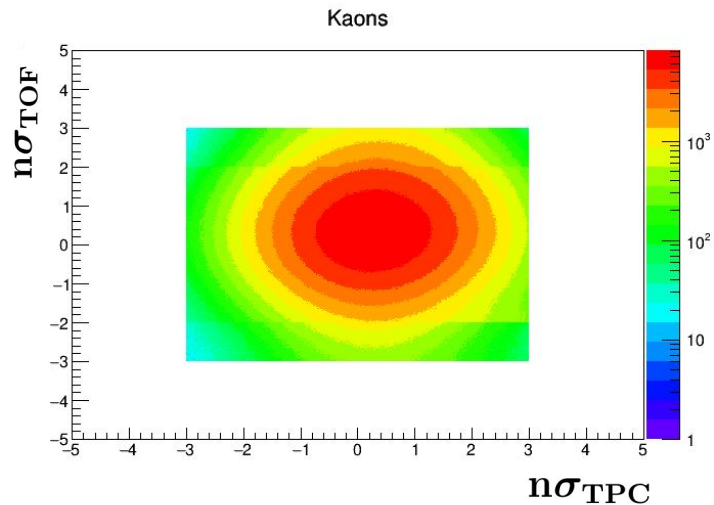
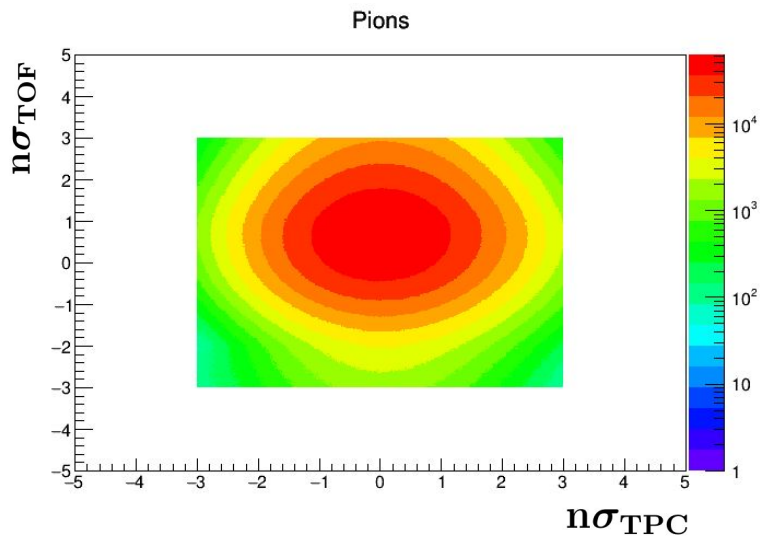
Kaons



Protons

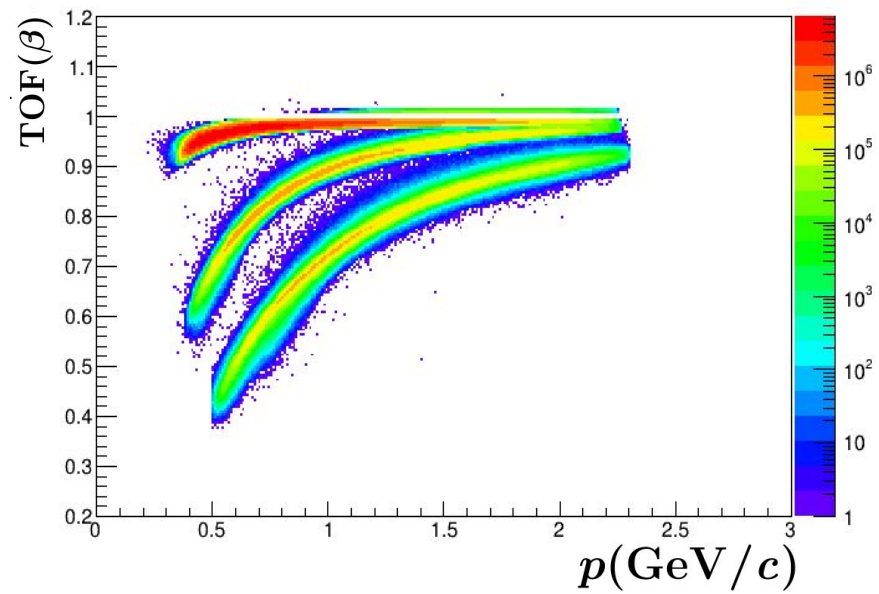
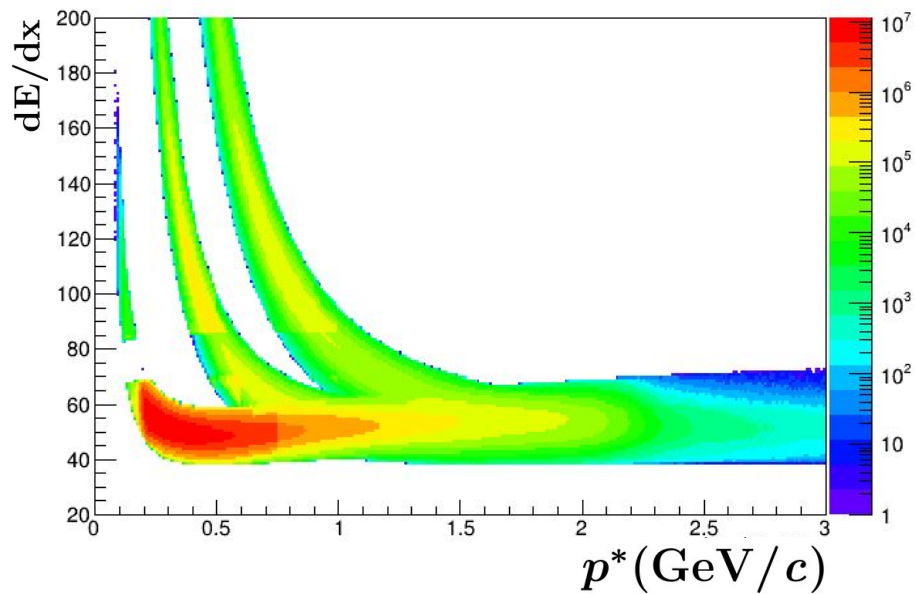


PID Selection (Cont'd)



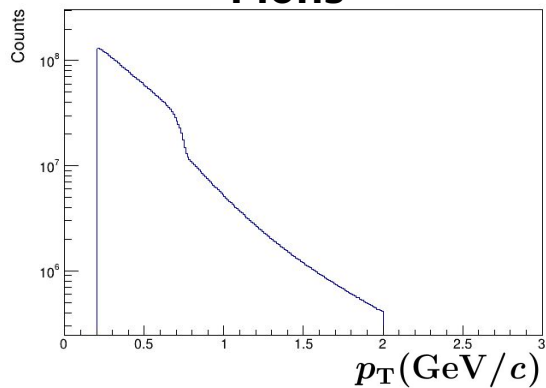
PID Selection (Cont'd)

After

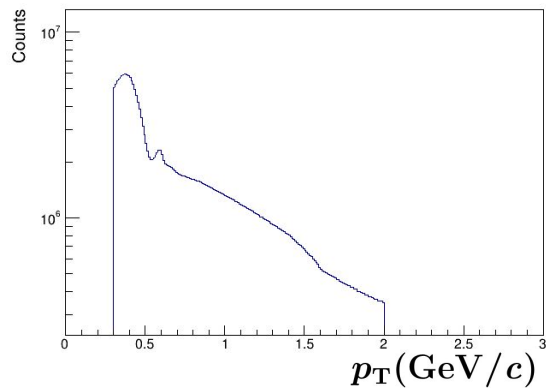


PID Selection (Cont'd)

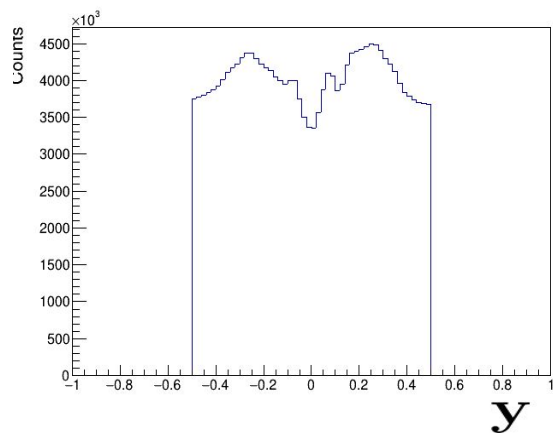
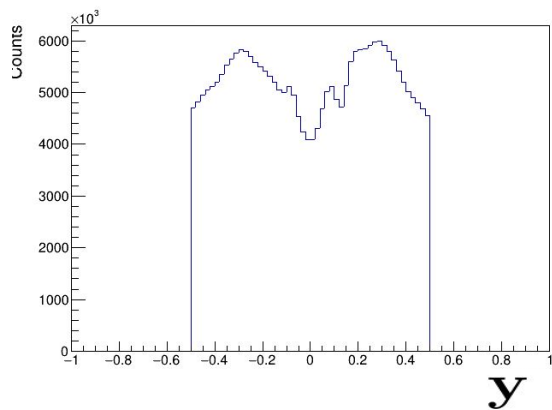
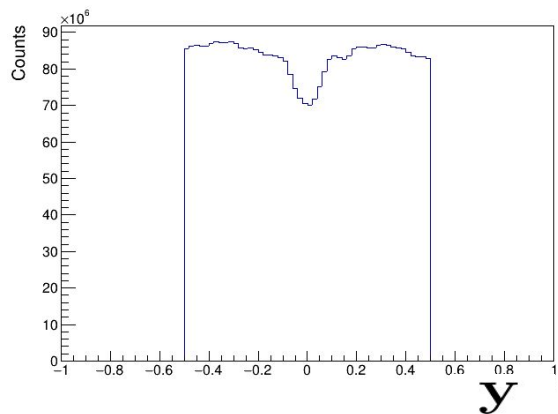
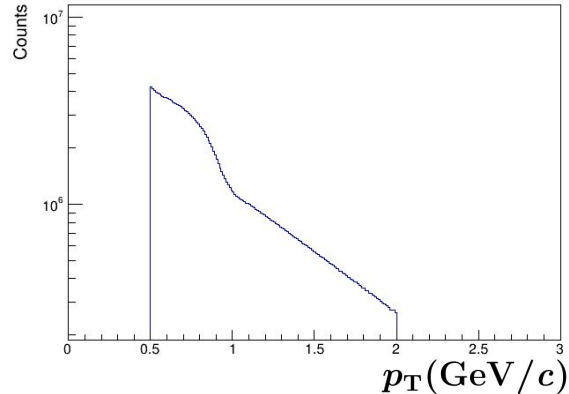
Pions



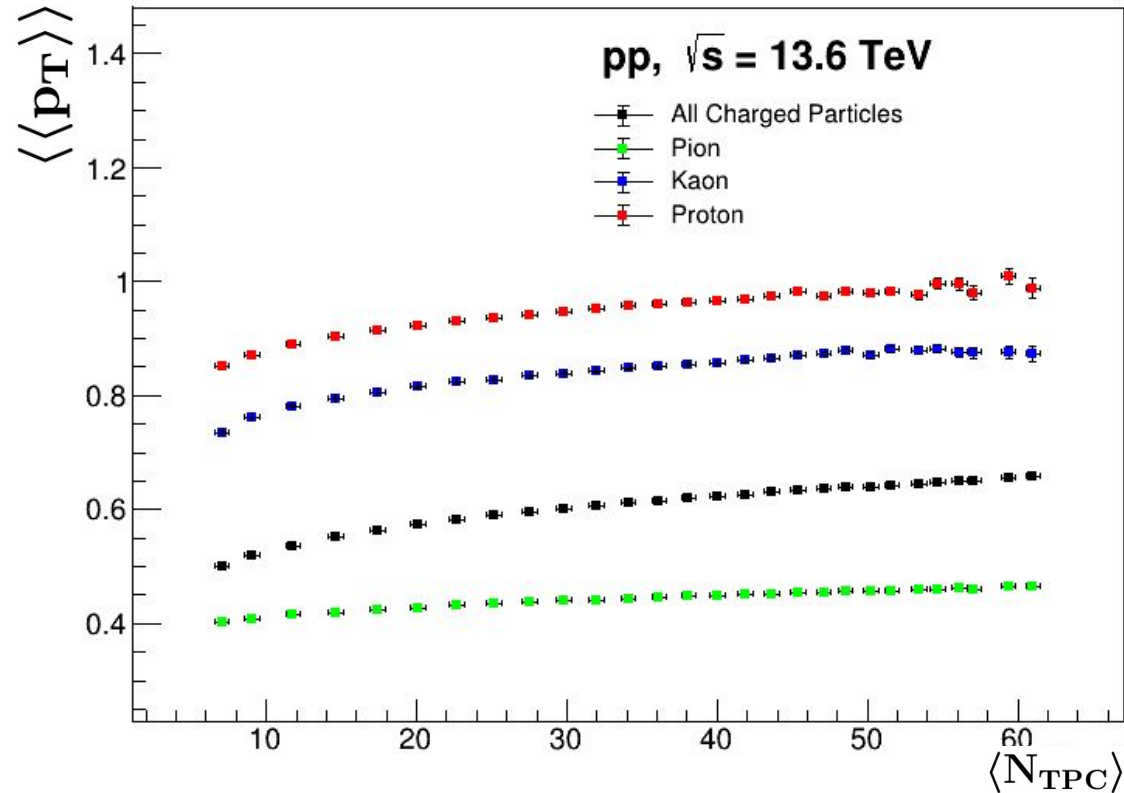
Kaons



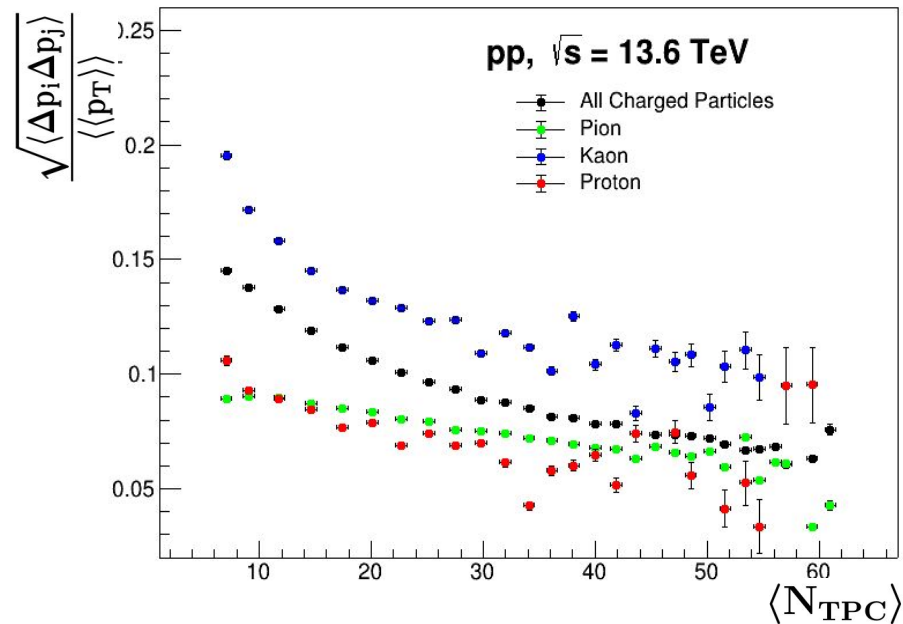
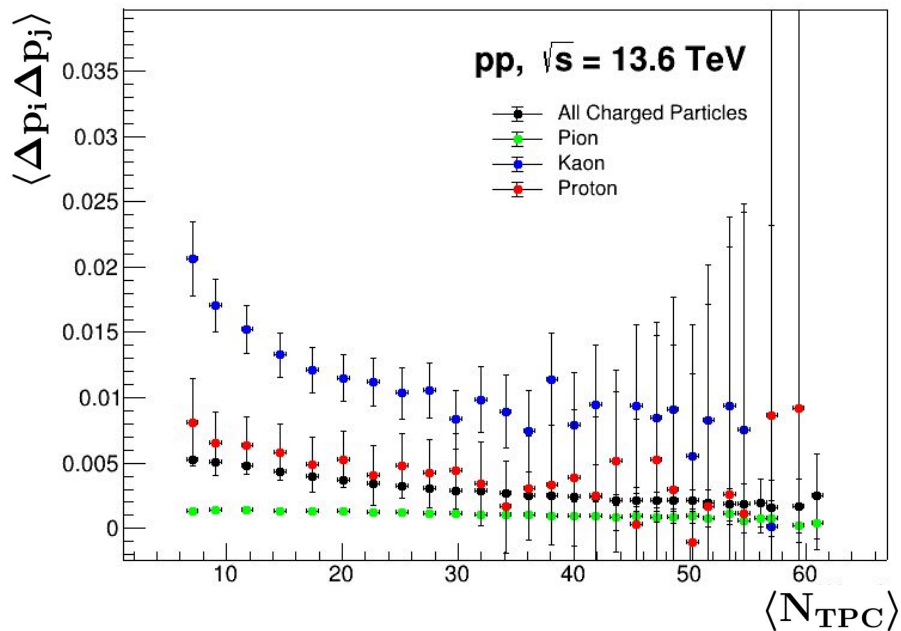
Protons



Mean p_T Distribution



Two particle Correlator

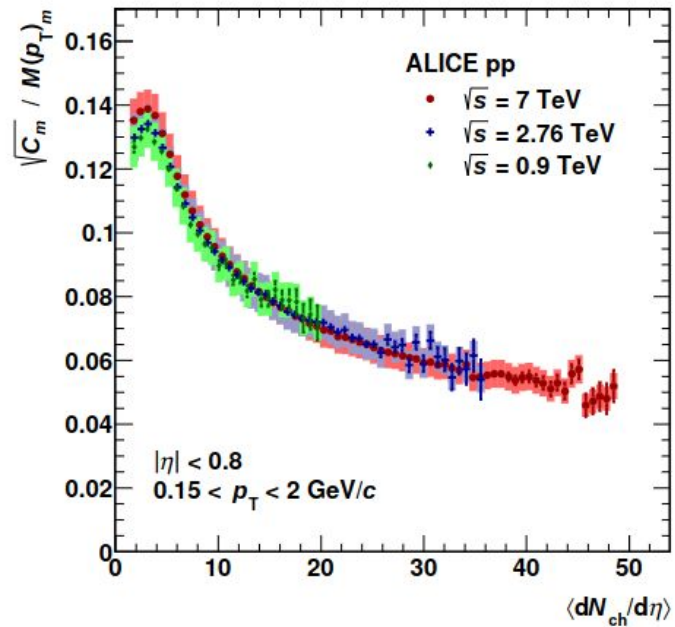


Summary

- Significantly dynamical fluctuations decreasing with multiplicity
- Dynamical fluctuations is large for Kaons

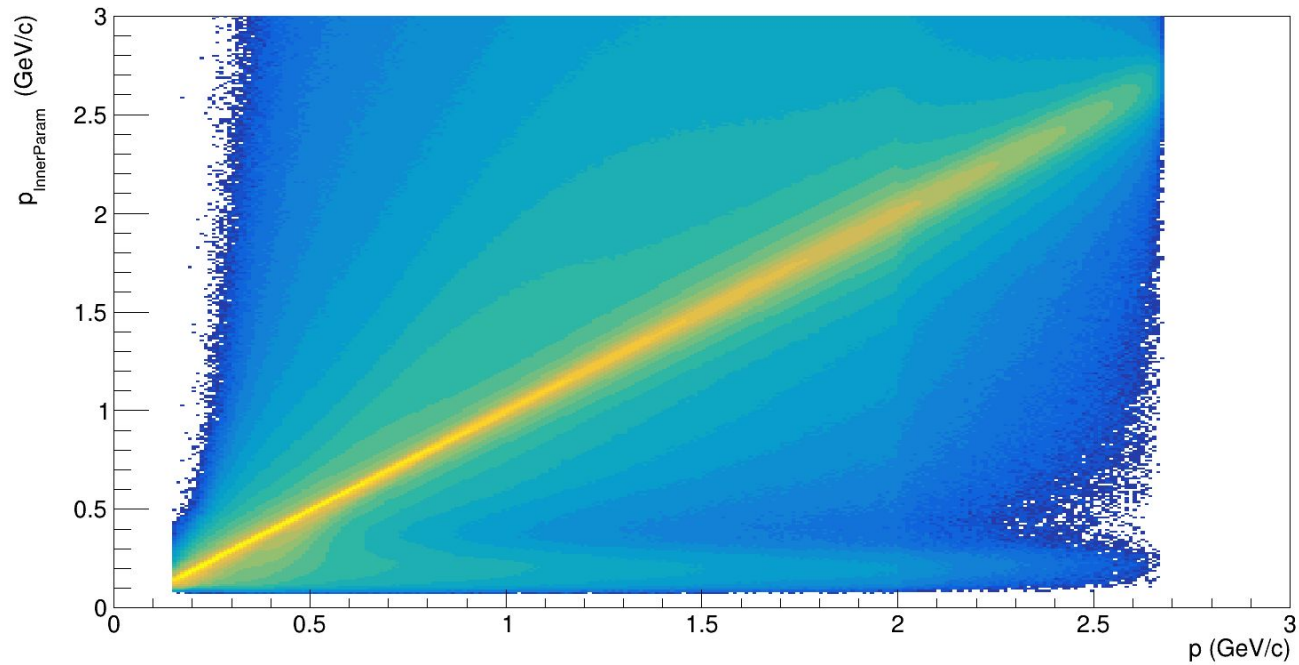
thank
you

Backup



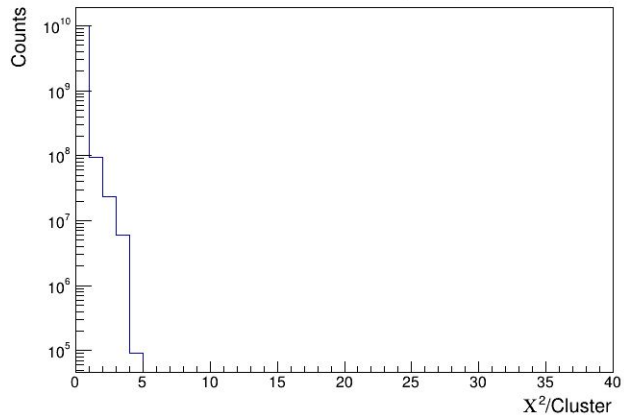
p vs p

TPC Inner Parameter

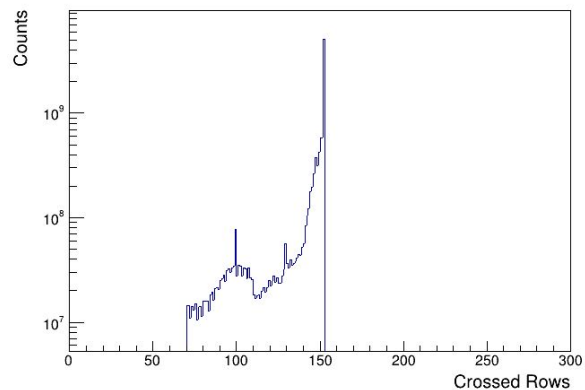


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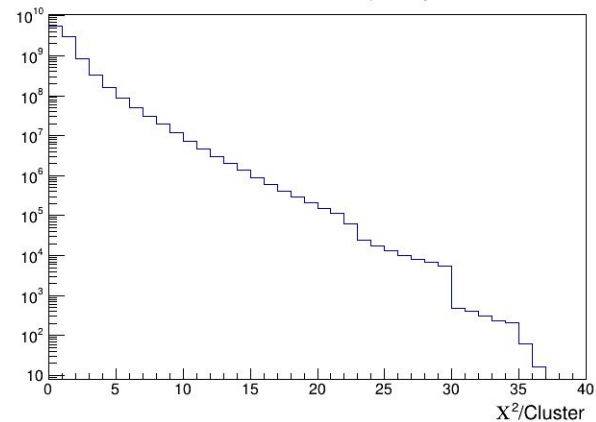
TPC $\chi^2/\text{Cluster}$ (After)



Number of crossed TPC Rows (After)

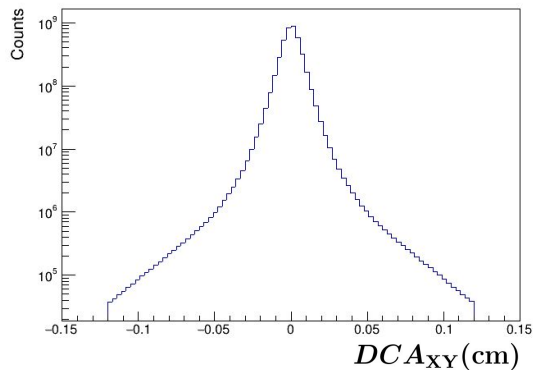


ITS $\chi^2/\text{Cluster}$ (After)

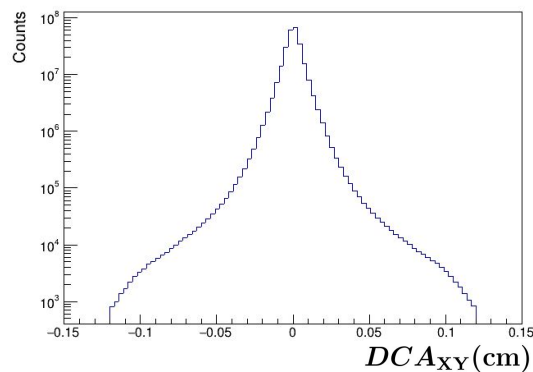


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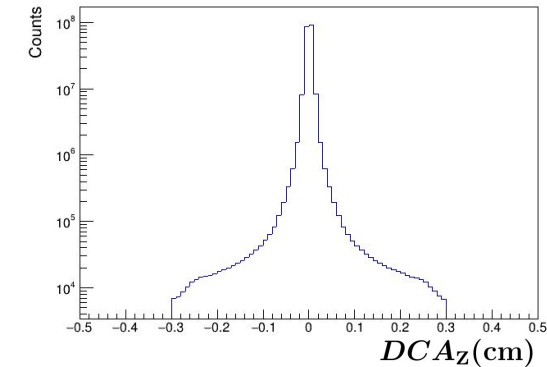
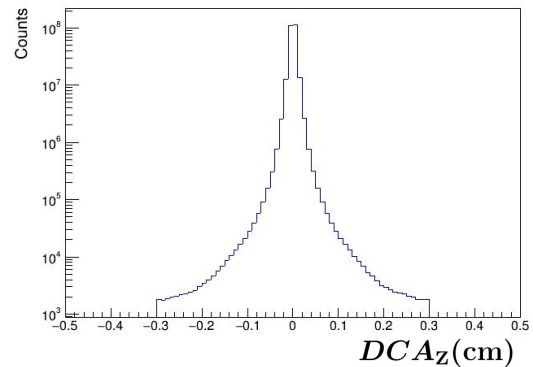
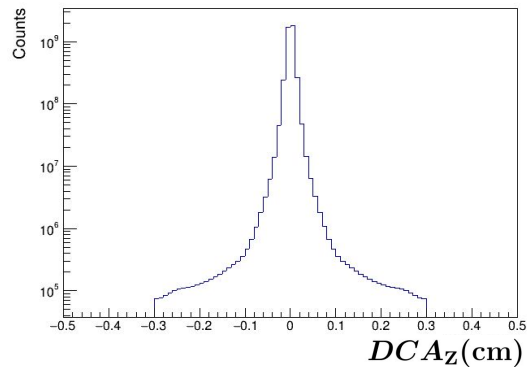
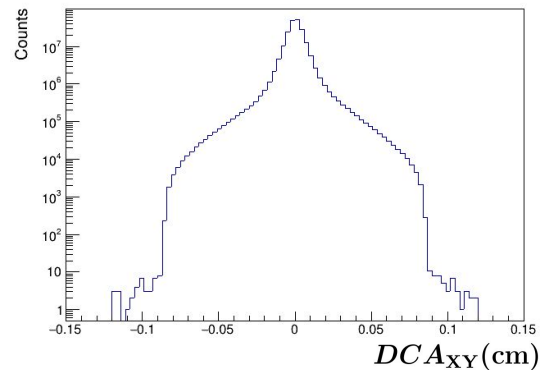
Pions

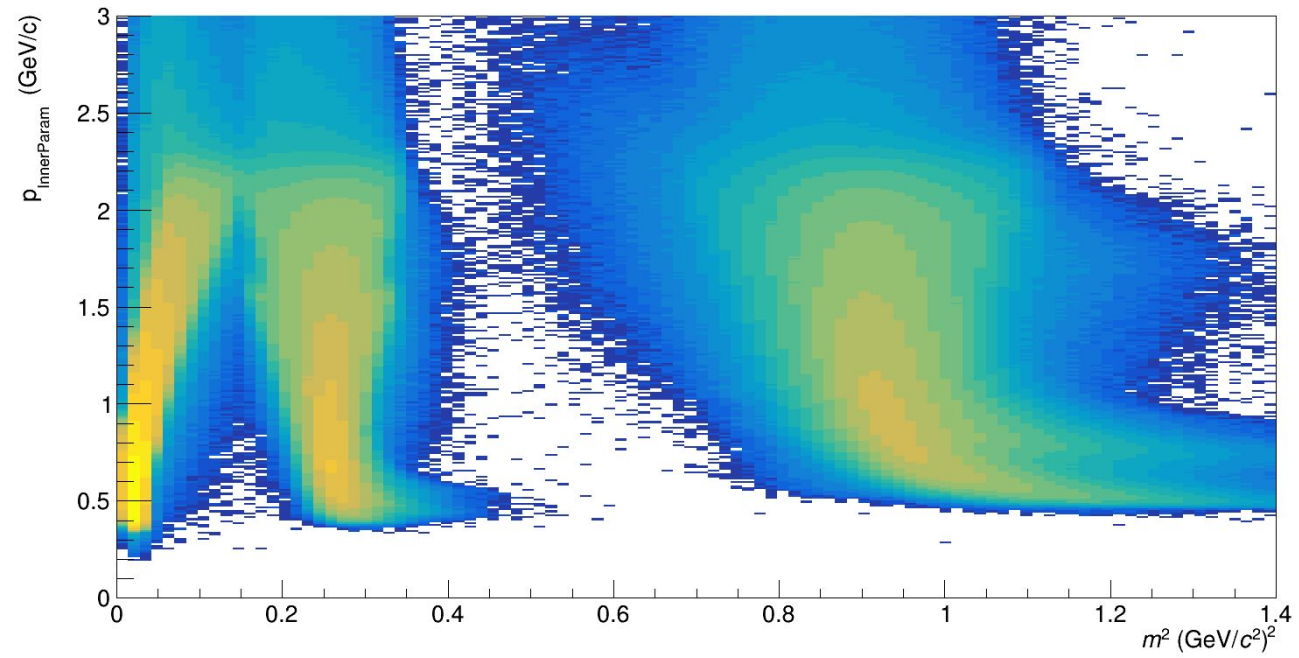


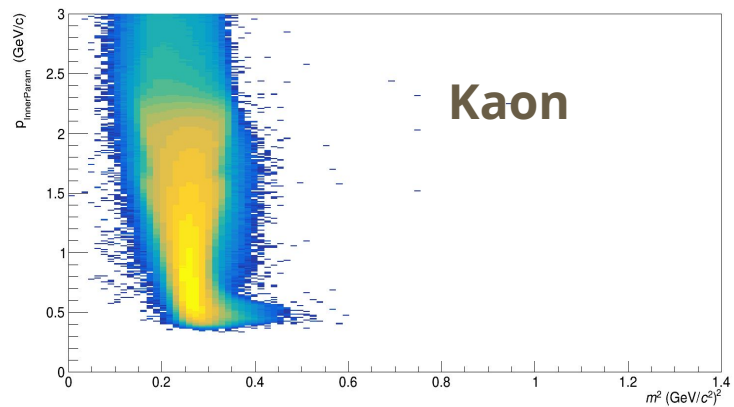
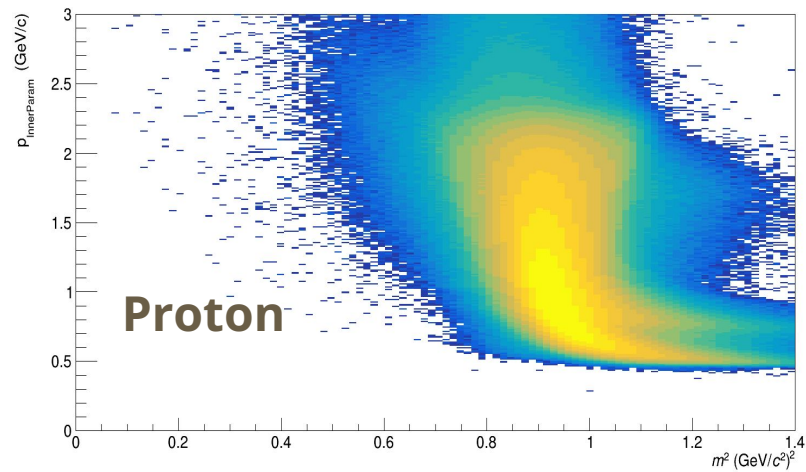
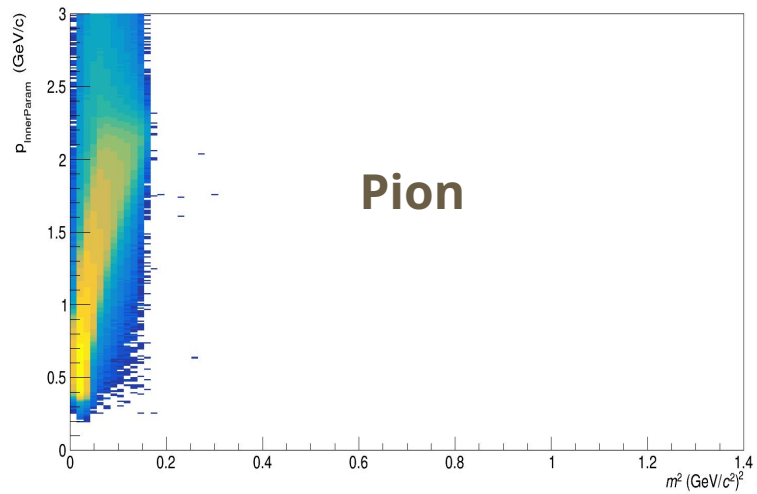
Kaons

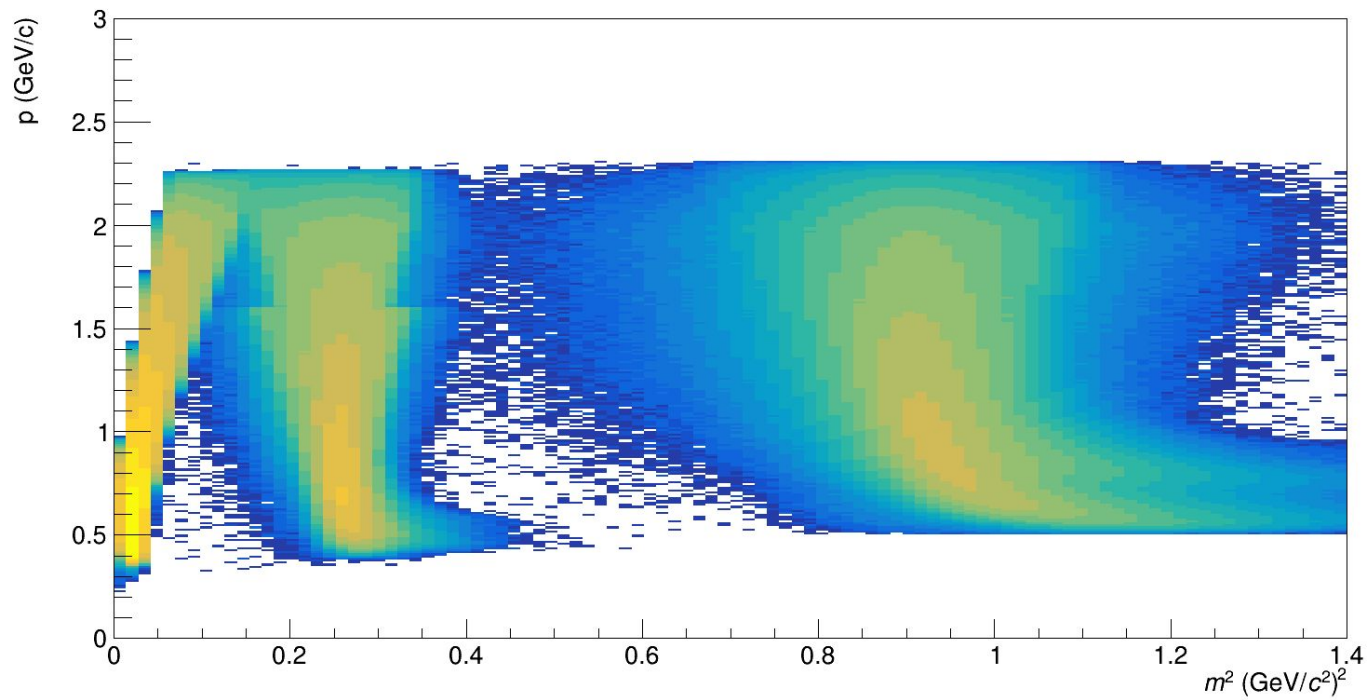


Protons



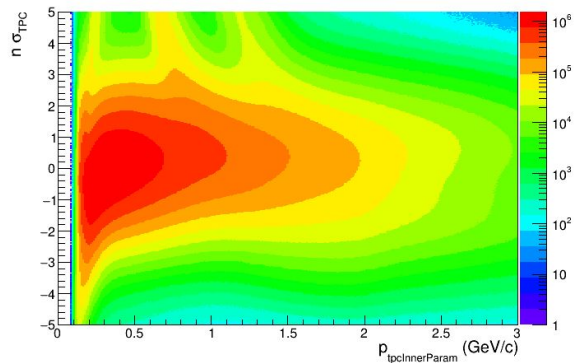




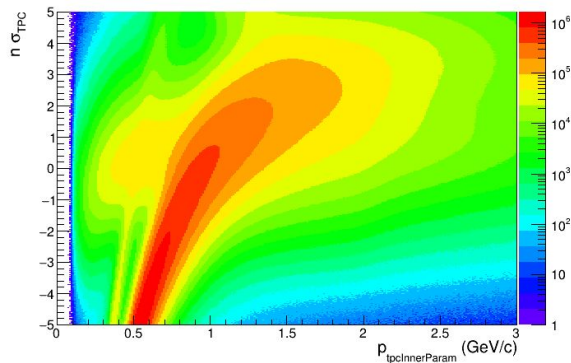


Data (before)

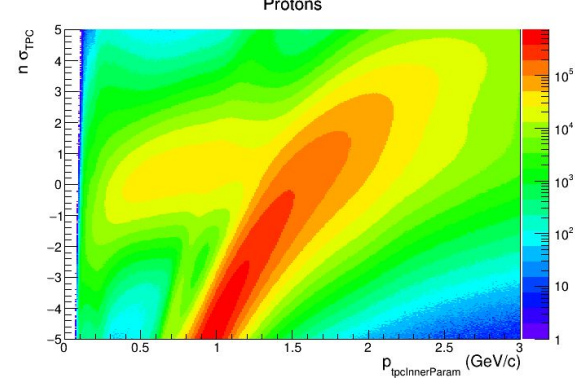
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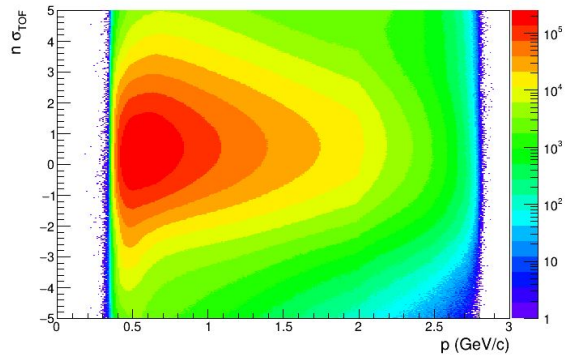
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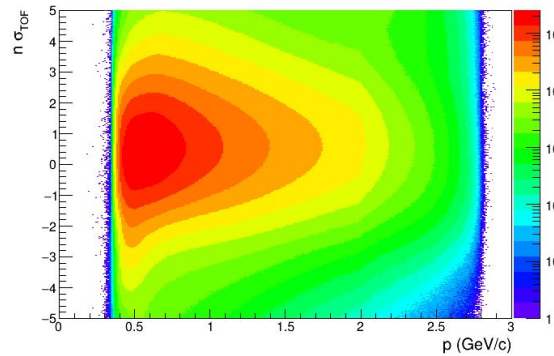
Protons



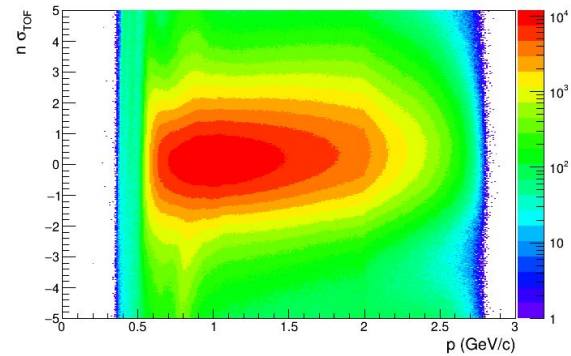
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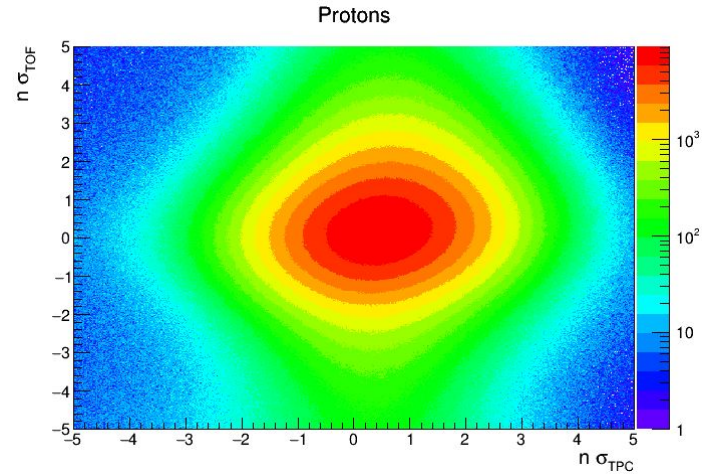
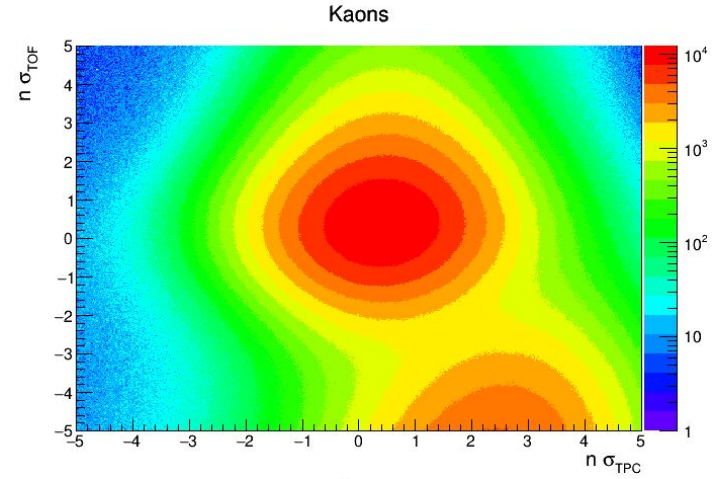
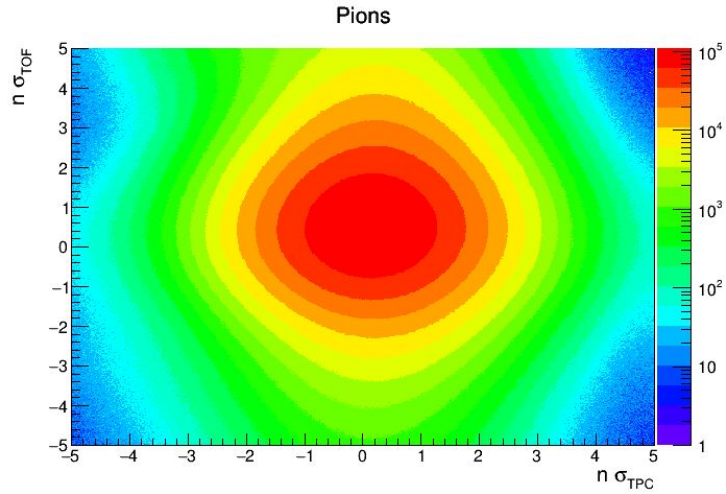
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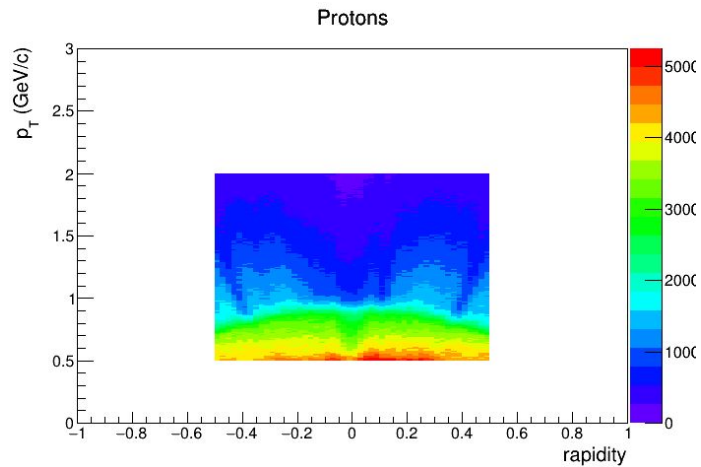
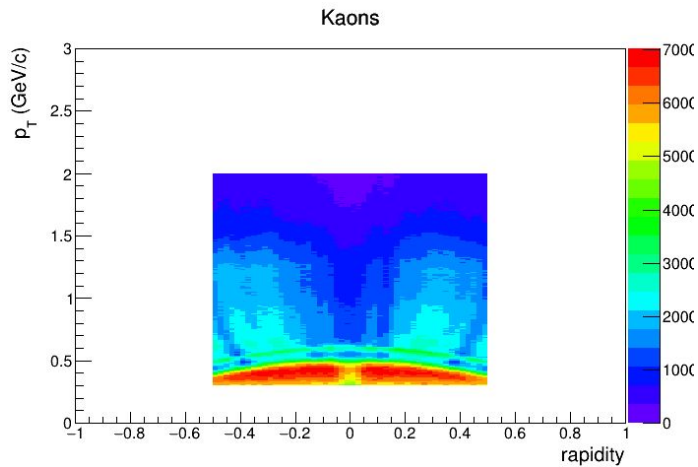
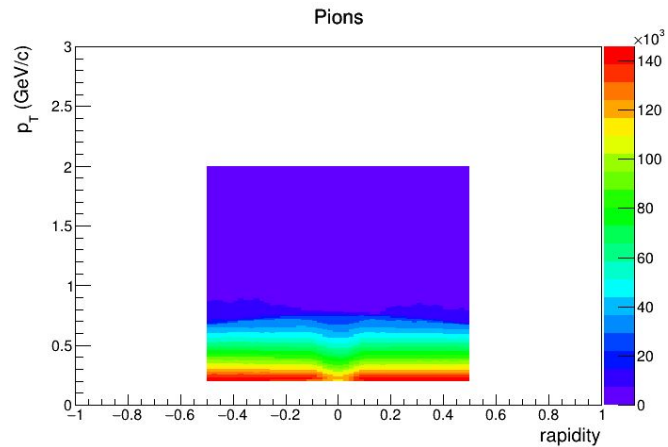
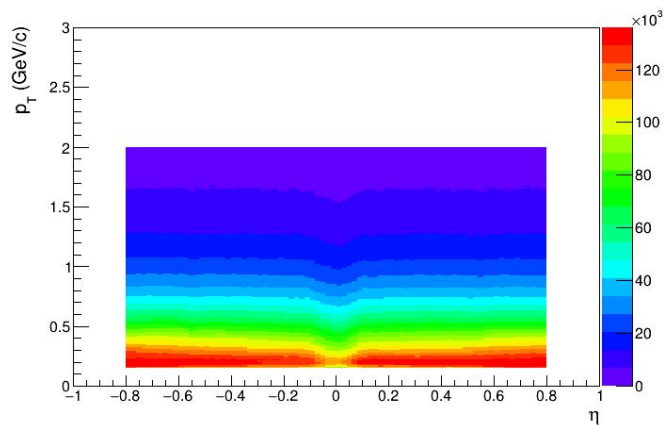
Protons



Data (before)

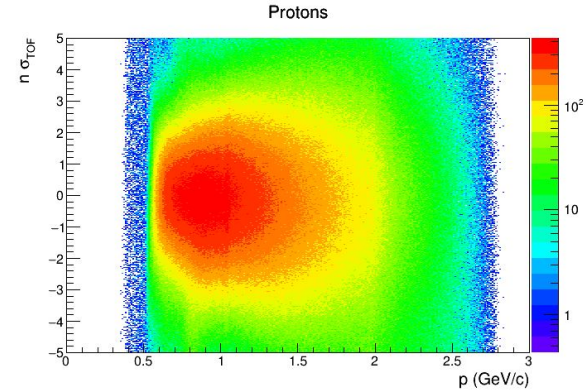
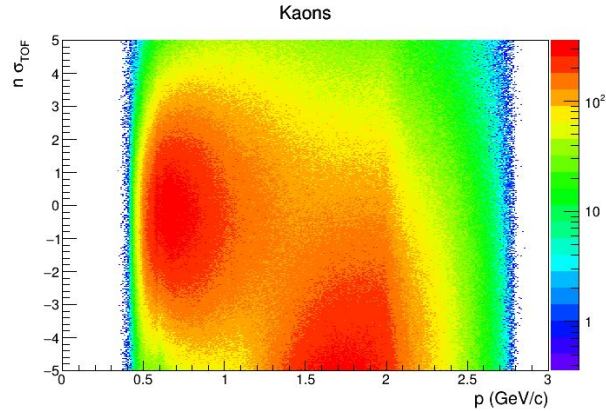
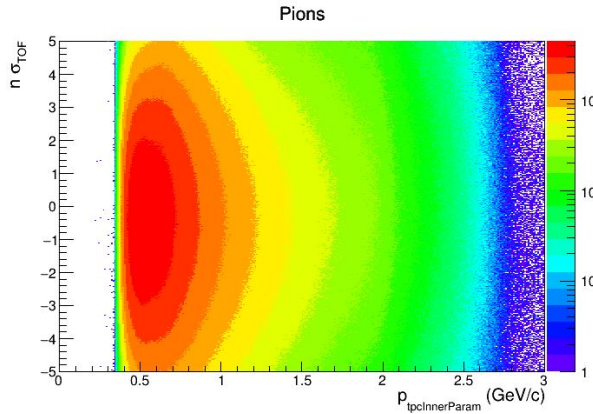
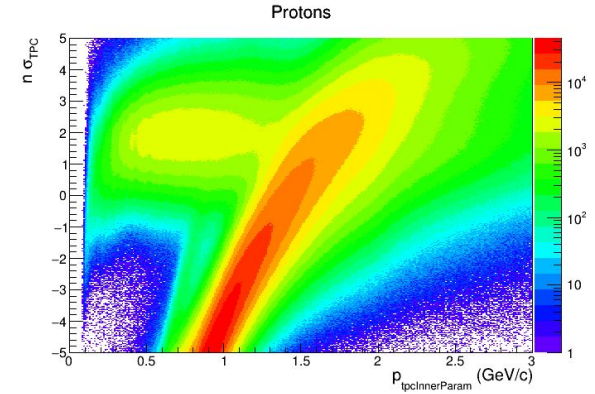
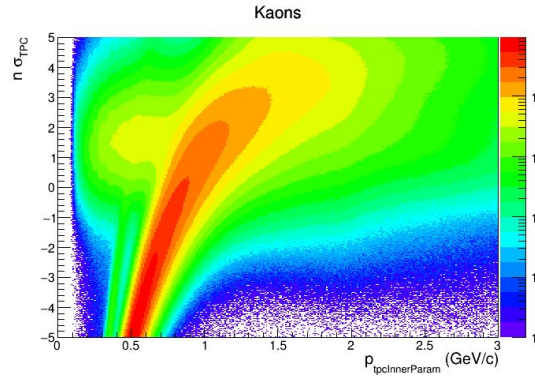
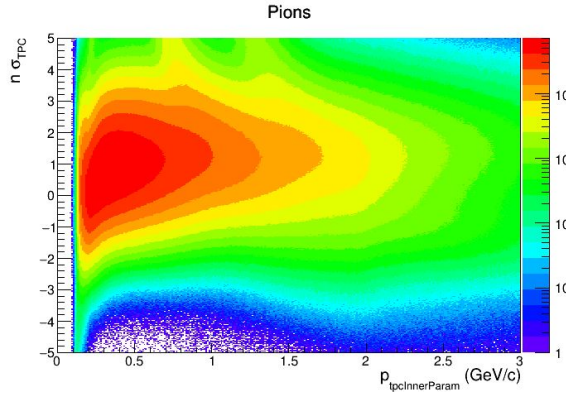


Data



MC

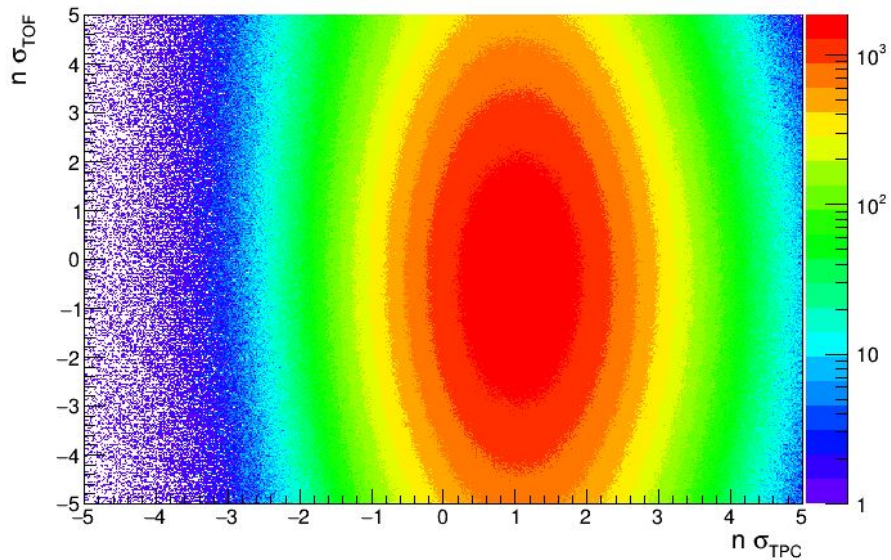
Before



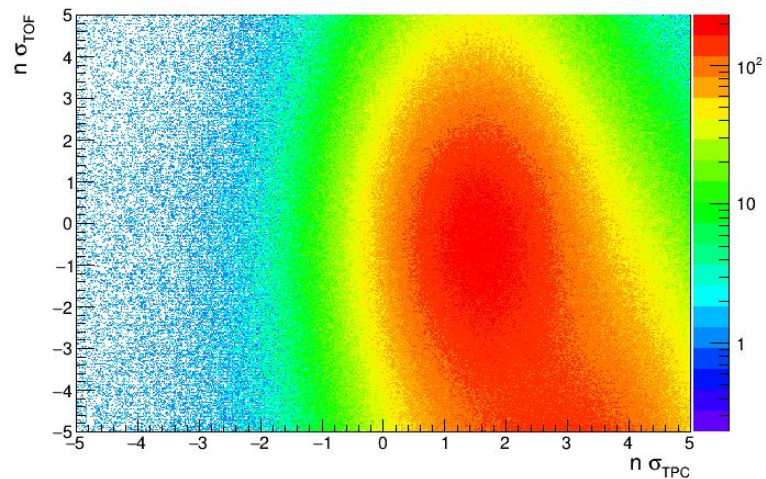
MC (Cont'd)

Before

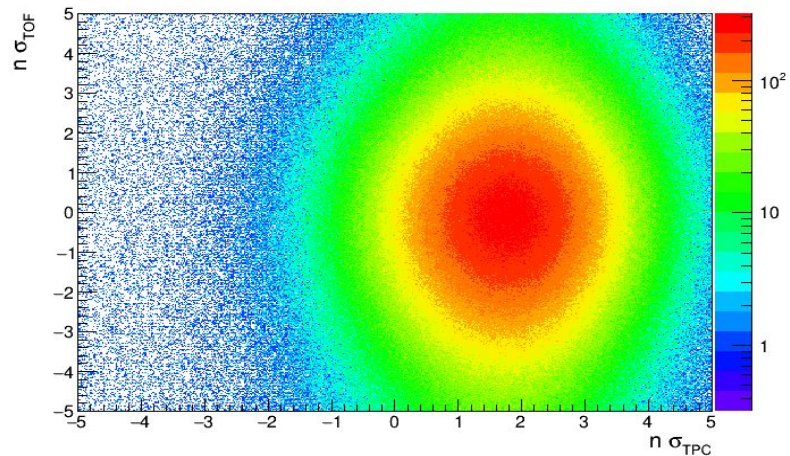
Pions



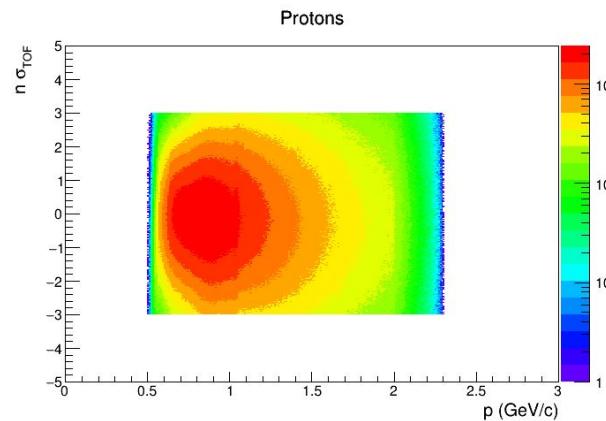
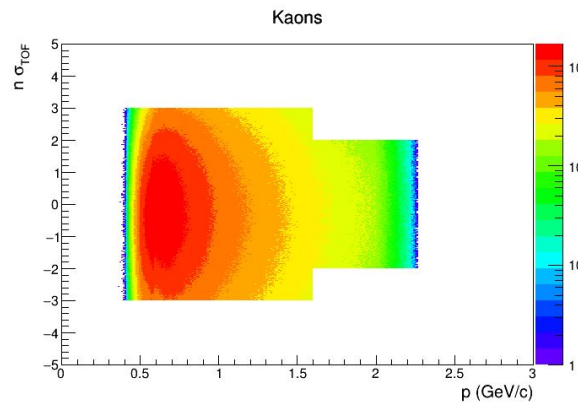
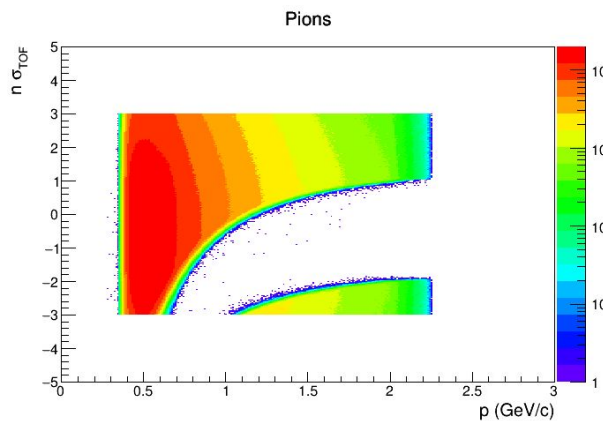
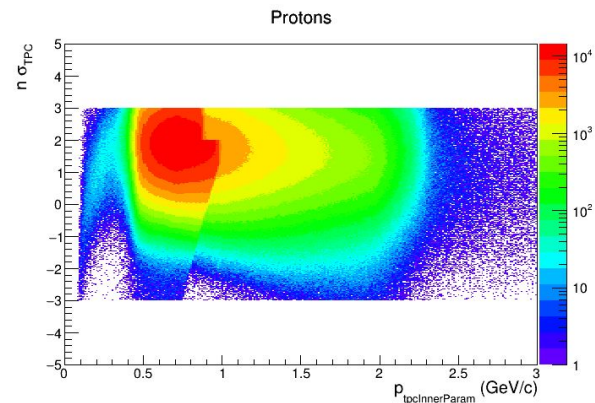
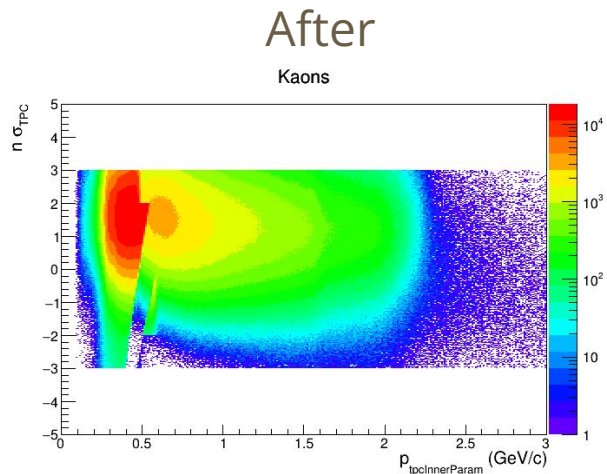
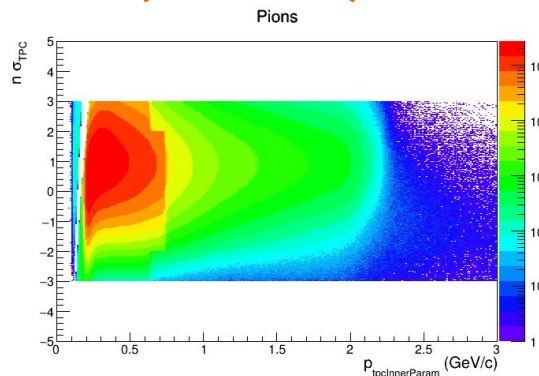
Kaons



Protons

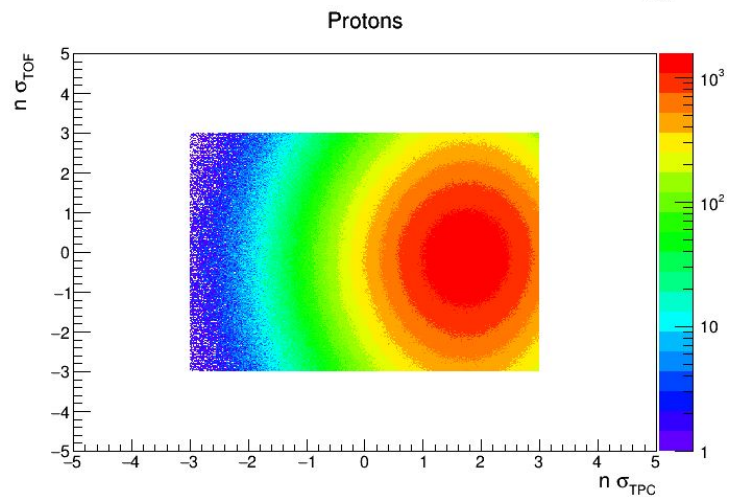
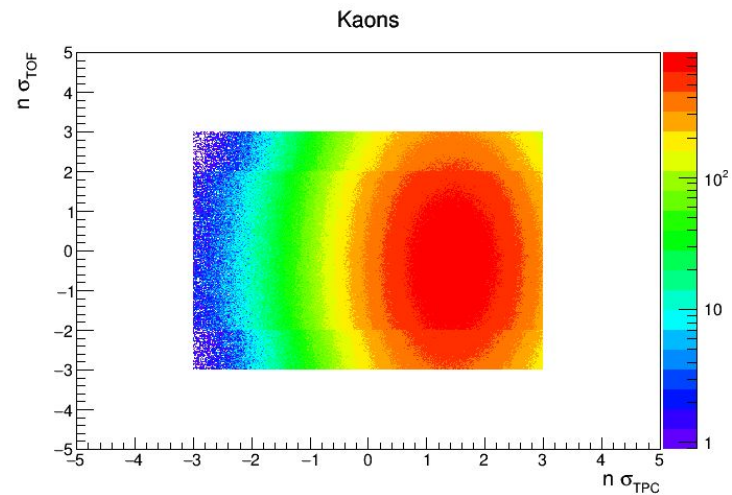
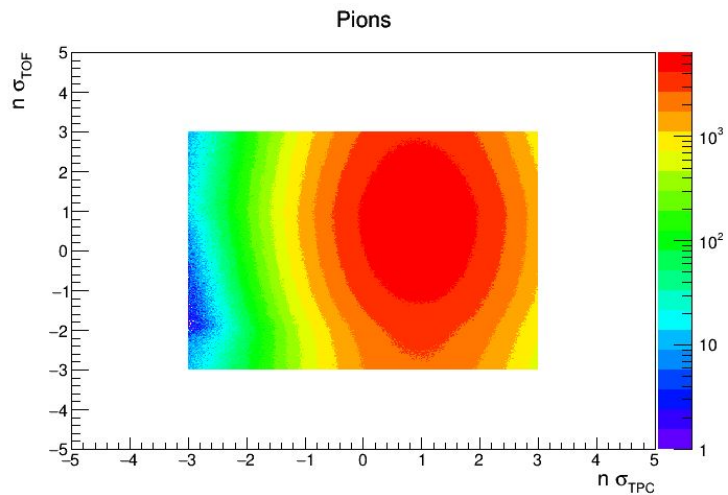


MC (Cont'd)



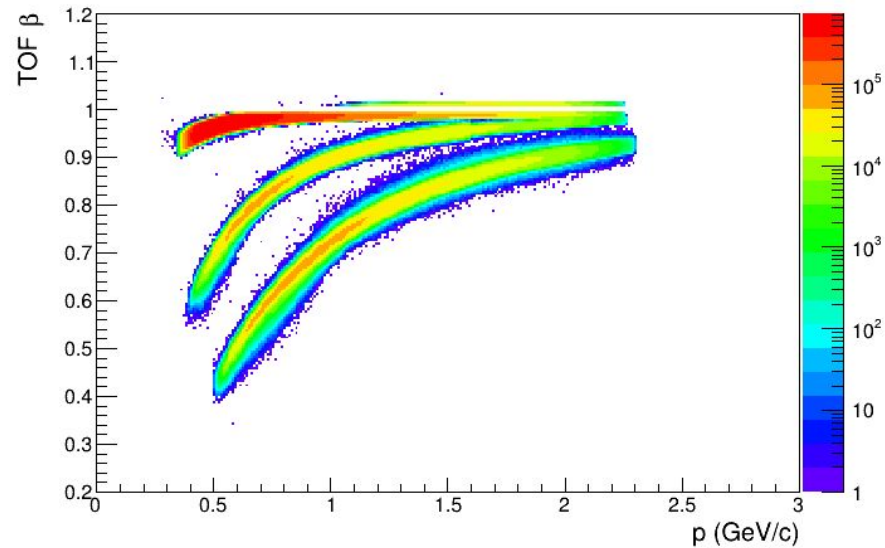
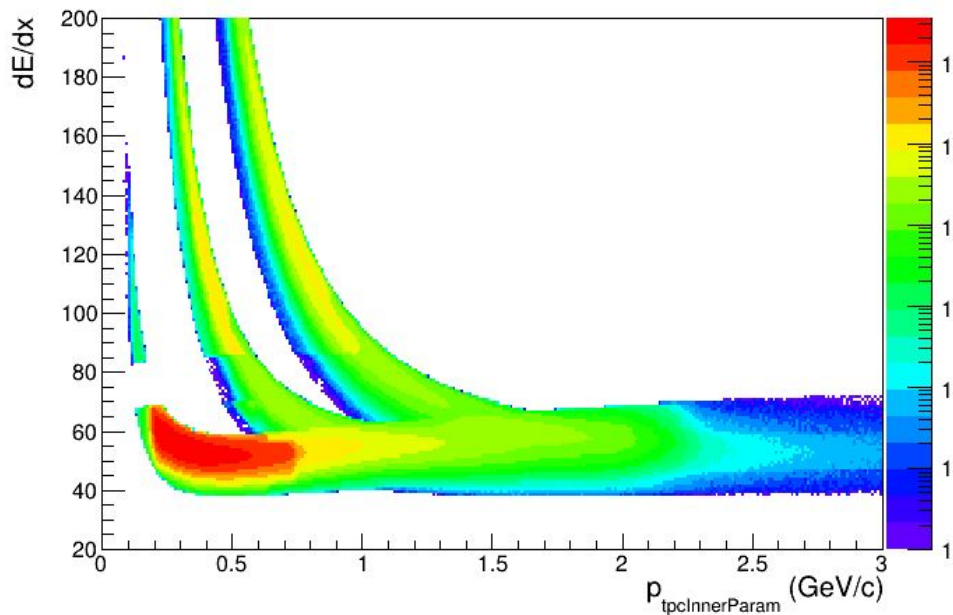
MC (Cont'd)

After



MC (cont'd)

After

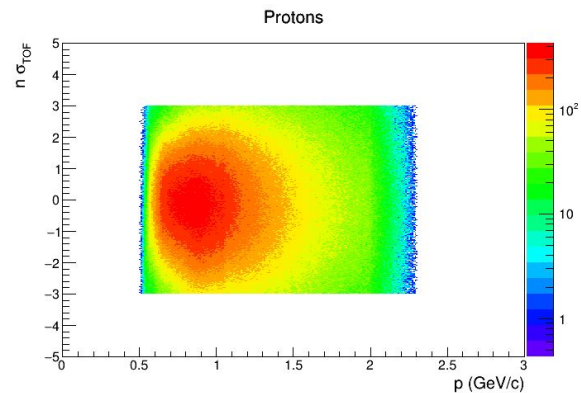
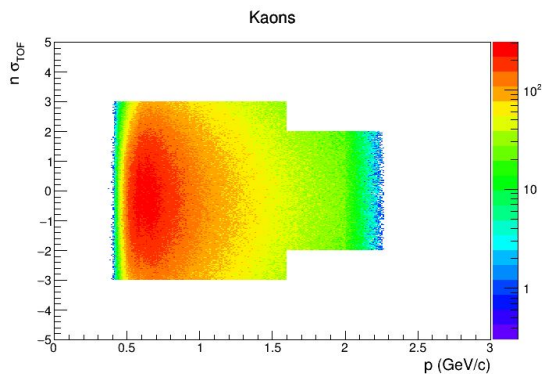
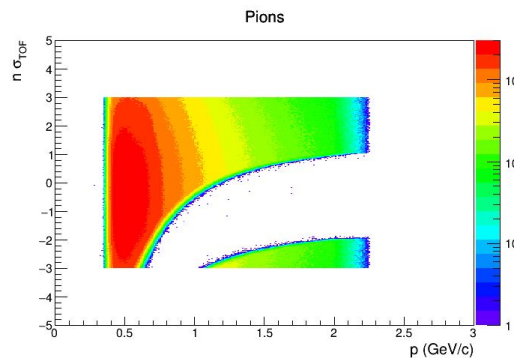
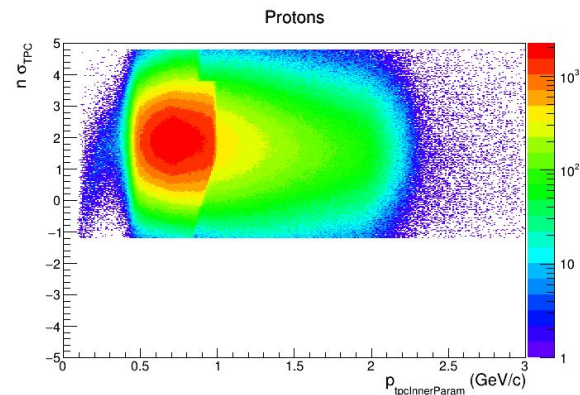
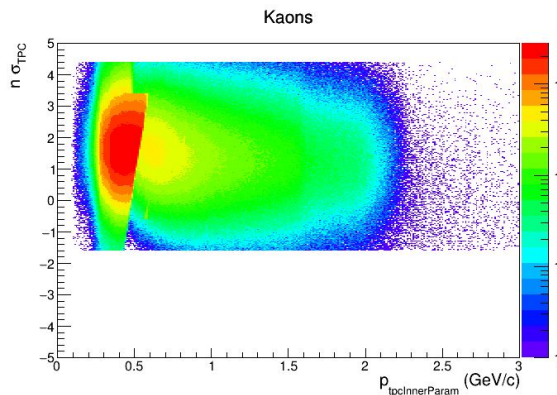
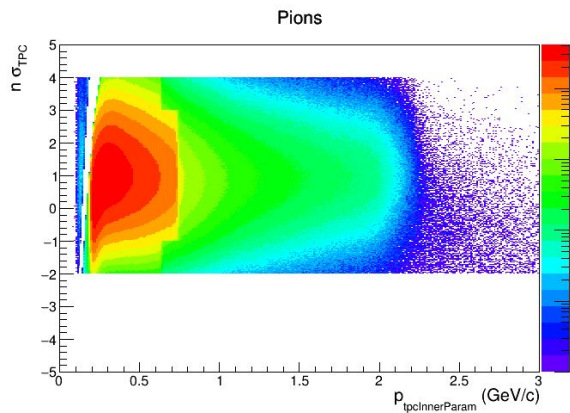


MC (Cont'd)

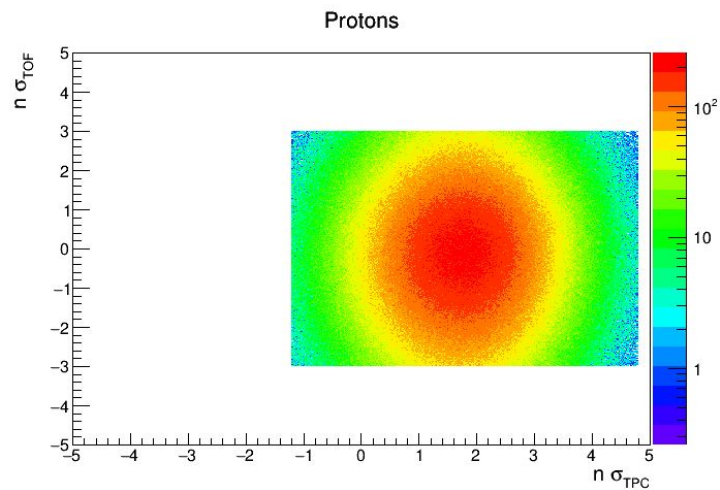
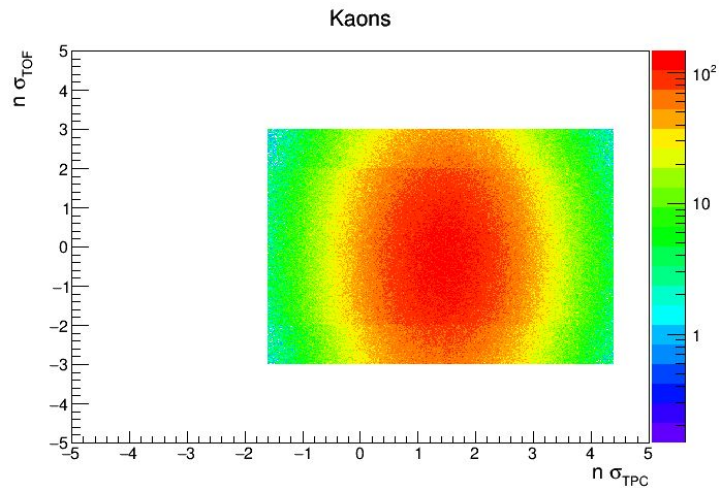
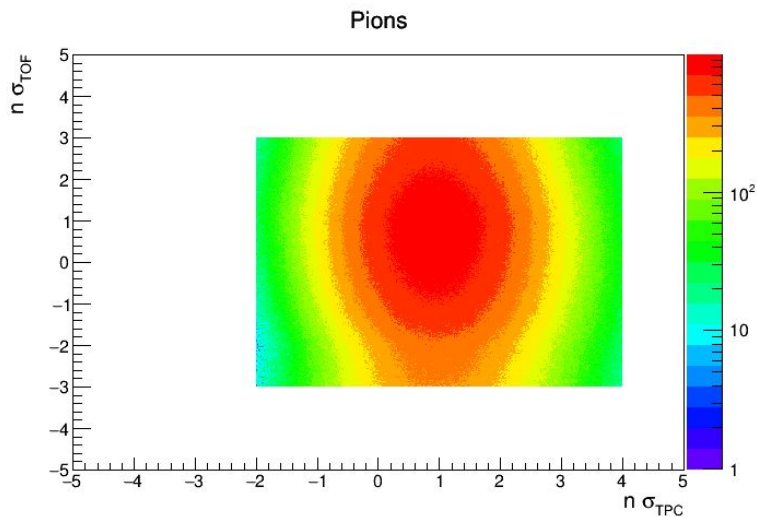
$|\text{n}\sigma - 1.0|_{\text{TPC}, \pi}$

$|\text{n}\sigma - 1.5|_{\text{TPC}, k}$

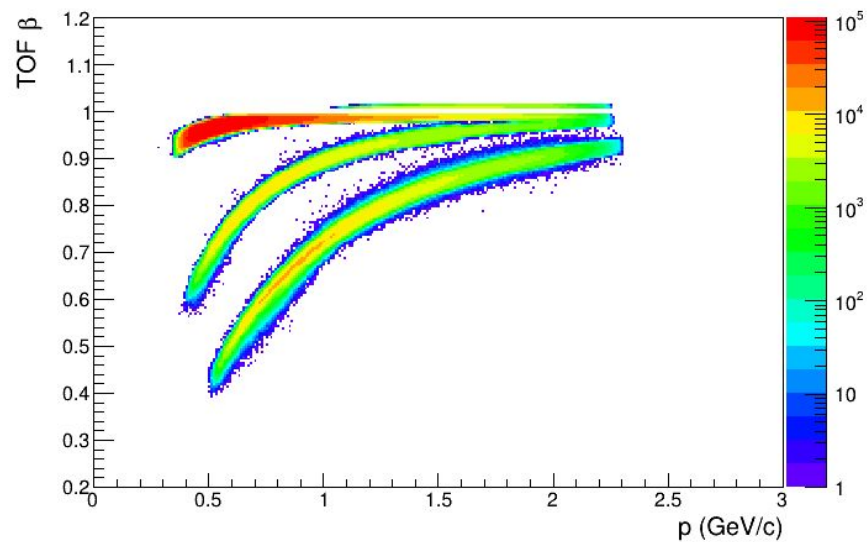
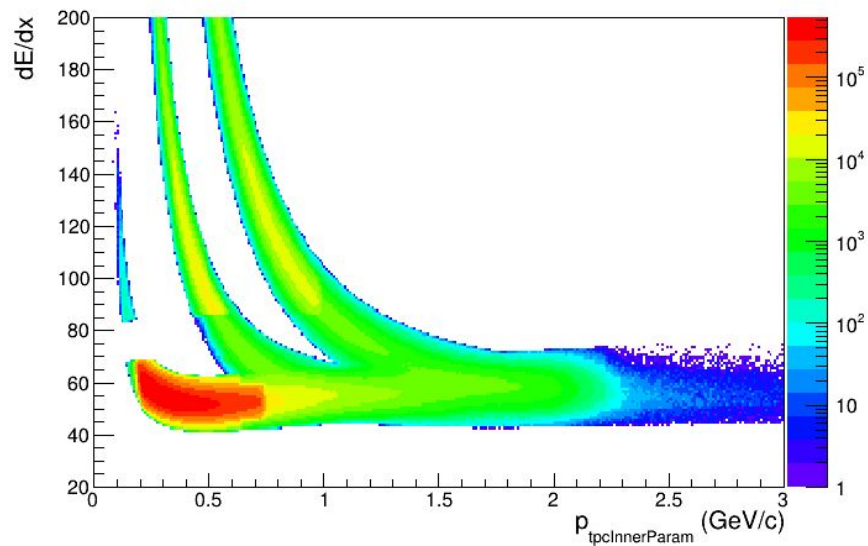
$|\text{n}\sigma - 1.7|_{\text{TPC}, p}$



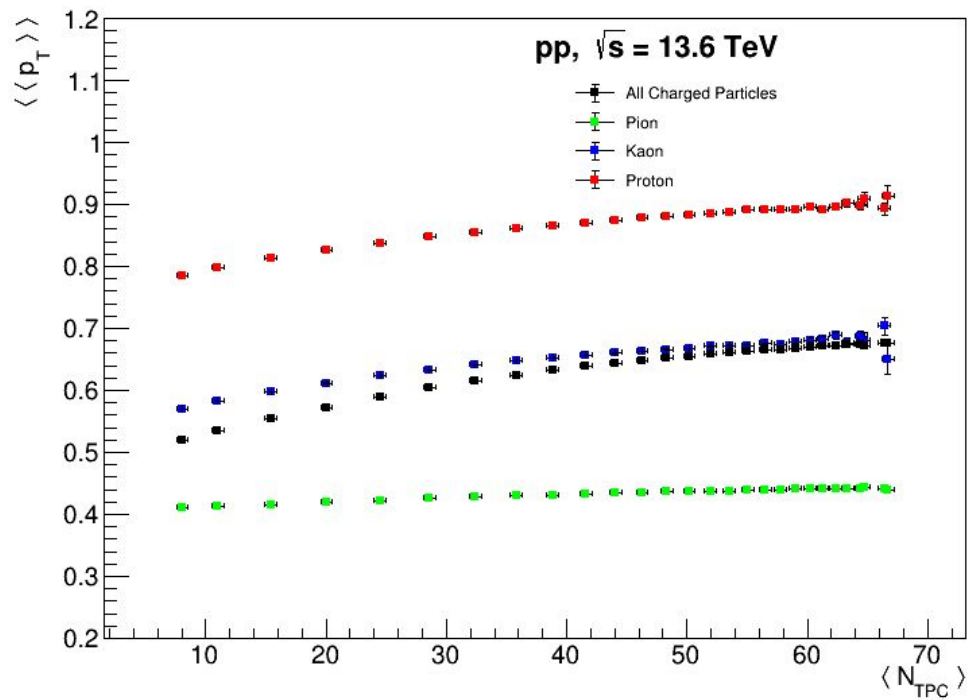
MC (Cont'd)



MC (Cont'd)

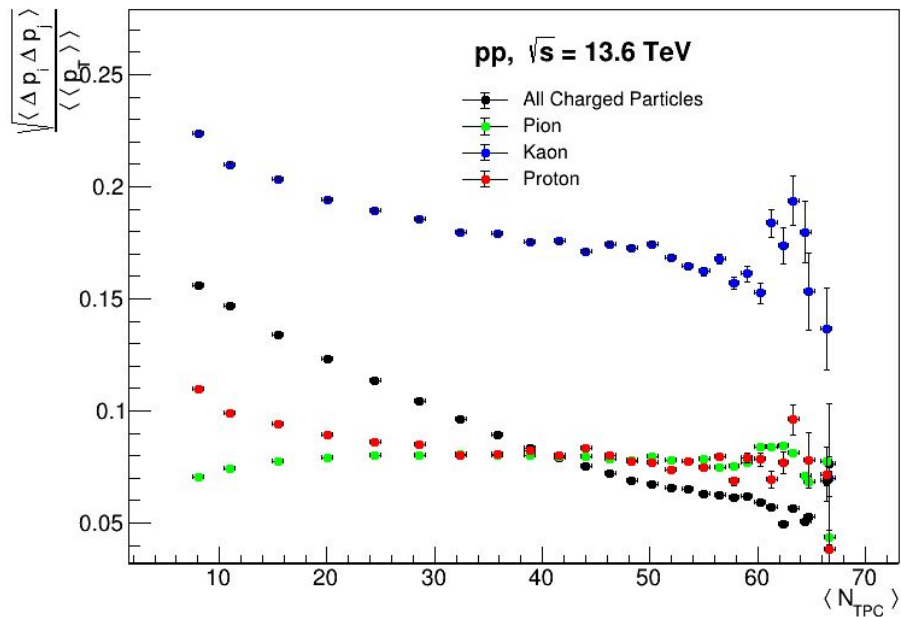


MC (cont'd)



Reco

MC (cont'd)



Reco

