Hadron-Φ(1020) Angular Correlations in pp collisions at $\sqrt{s} = 13.6$ TeV in ALICE Run 3

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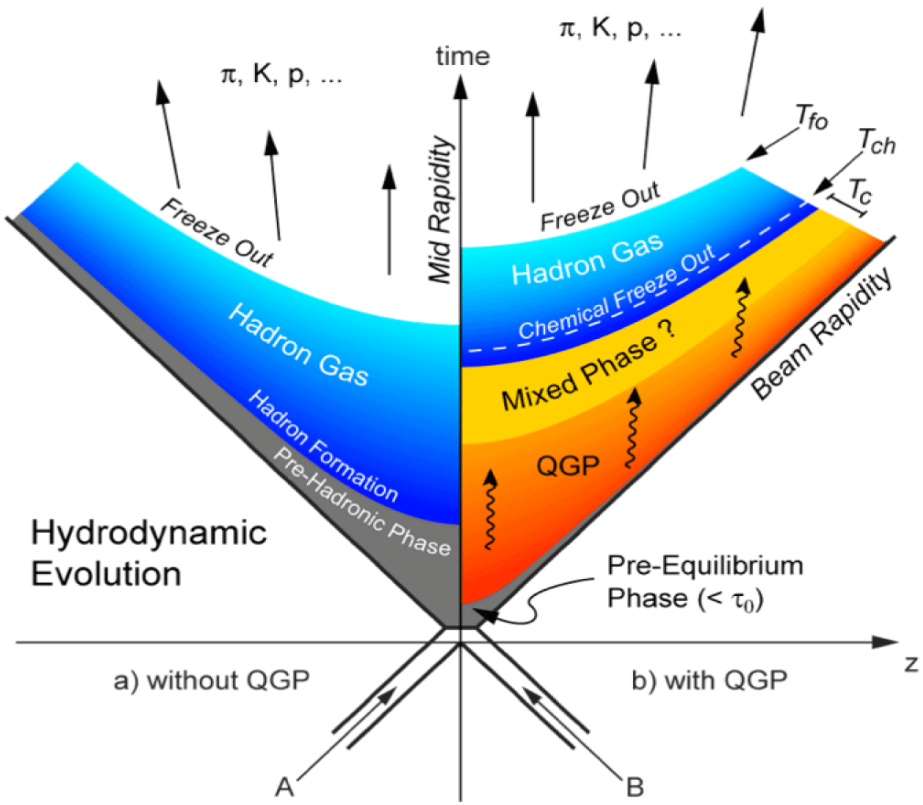
June 24, 2024

Overview

- Motivation
- Methodology
- Hadron-ϕ analysis
- Summary

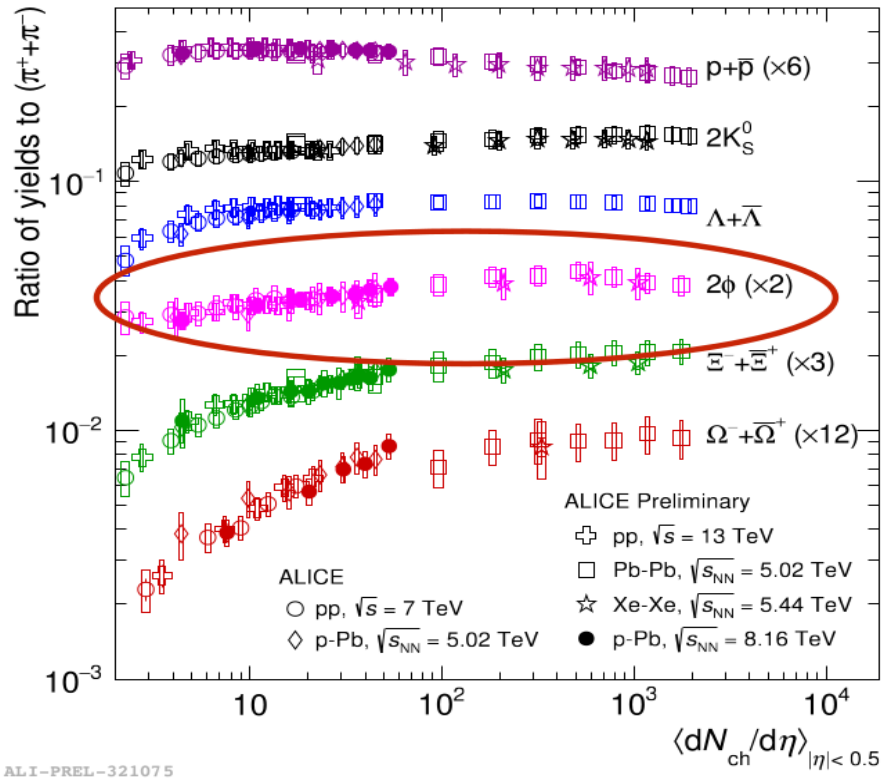
Motivation (QGP formation)

- Relativistic heavy ion collisions
  $\rightarrow$ Quark Gluon Plasma(QGP)
- Signatures of QGP.
  - Strangeness Enhancement
  - Jet quenching
  - Collective flow
  - ...
- Small systems(p-p, p-Pb)
  $\rightarrow$ QGP formation not yet completely established.
- Some signatures are present
  $\rightarrow$ evidence of the formation of "QGP droplets"



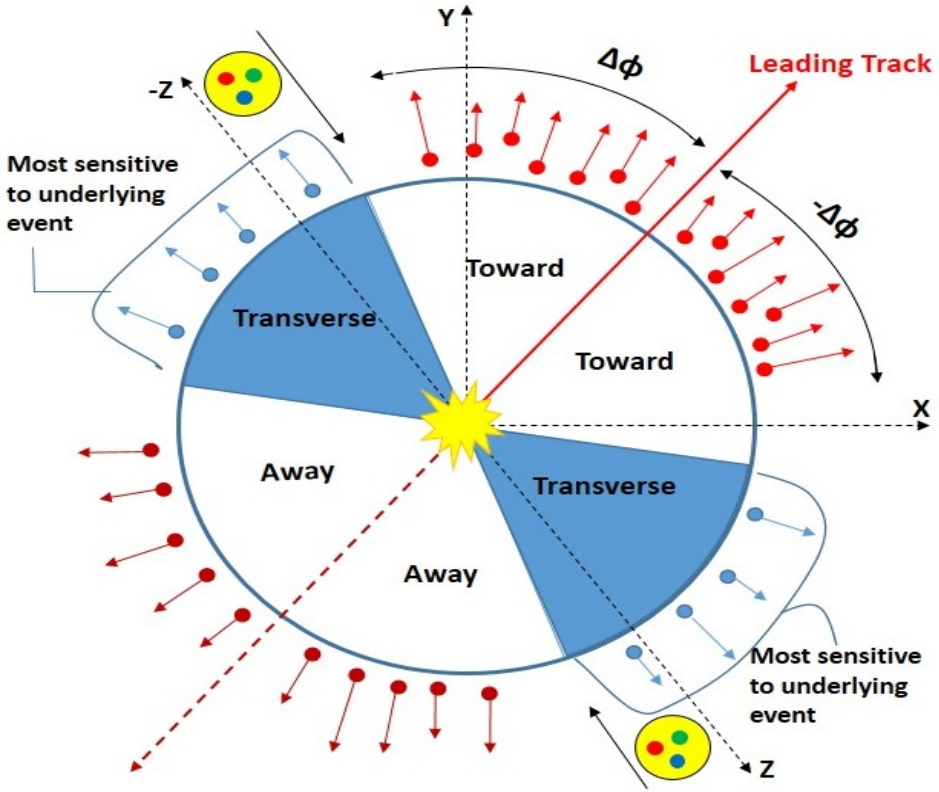
Motivation (Strangeness enhancement)

- Small collision systems (p-p and p-Pb) $\rightarrow$ baseline for heavy ion collisions.
- Strangeness Enhancement $\rightarrow$ Increase in strangeness production as a function of multiplicity across all collision systems.



Motivation (Origin of strangeness enhancement)

- Cause of enhancement
  $\rightarrow$ due to jet fragmentation, or
  $\rightarrow$ due to soft production in the underlying event.
- To Investigate the origin
  $\rightarrow$ Comparison of differential particle ratios in the "Jet peak" (near and away) with the "Underlying event".



Methodology

- Similar work in Run 2 (p-Pb):
  https://alice-notes.web.cern.ch/node/919 (Justin Blair)
- Angular Correlations

$$C(\psi_t, \eta_t, \psi_a, \eta_a) = \frac{P(\psi_t, \eta_t, \psi_a, \eta_a)}{P(\psi_t, \eta_t) * P(\psi_a, \eta_a)} \tag{1}$$

- In terms of $\Delta\eta$ and $\Delta\phi$

$$C(\Delta\eta, \Delta\phi) \approx \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)} \tag{2}$$

  $S(\Delta\eta, \Delta\phi)$ - obtained from same event correlation
  $B(\Delta\eta, \Delta\phi)$ - obtained from mixed event correlation
- Efficiency corrected per-trigger yield is

$$C_{trig}(\Delta\eta, \Delta\phi) \approx \frac{1}{N_{trig}^{corr}} \frac{1}{\epsilon_{trig} * \epsilon_{assoc}} \frac{B(0,0) * S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)} \tag{3}$$

Methodology

- Per-trigger hadron-ϕ angular correlation function

$$C_{h-\phi}(\Delta\varphi,\Delta\eta) = k_{\text{Signal}}\Bigg(C_{trig}^{h-(KK)\ \text{Peak}}(\Delta\varphi,\Delta\eta) - \frac{k_{LS}}{2} * \left[\frac{1}{N_{Ent}^{LSB}} C_{trig}^{h-(KK)\ \text{LSB}}(\Delta\varphi,\Delta\eta) + \frac{1}{N_{Ent}^{RSB}} C_{trig}^{h-(KK)\ \text{RSB}}(\Delta\varphi,\Delta\eta)\right]\Bigg) \tag{4}$$

- Per-trigger hadron-hadron angular correlation function

$$C_{h-h}(\Delta\eta,\Delta\phi) \approx \frac{1}{N_{trig}^{corr}} \frac{1}{\epsilon_{trig} * \epsilon_{assoc}} \frac{B(0,0) * S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)} \tag{5}$$

Analysis Details

DataSet Used

- pp_LHC22o_526641_apass6

Event Selection

- sel8()
- $|z| < 10$ cm

ϕ Reconstruction

- Decay Channel $\phi \rightarrow K^+K^-$

Trigger Hadron Selection

- $p_T \in$ [4.0-8.0] GeV/c

Track Selection

- $p_T > 0.15$ GeV/c
- $|\eta| < 0.8$
- $|dcaZ| < 2$ cm
- $|dcaXY| < 2$ cm
- $tpcNClsCrossedRows > 70$
- GlobalTracks()

Associated ϕ/hadron Selection

- $p_T \in$ (0.0-2.0) GeV/c
- $p_T \in$ (2.0-4.0) GeV/c

Particle Identification

Kaon Identification

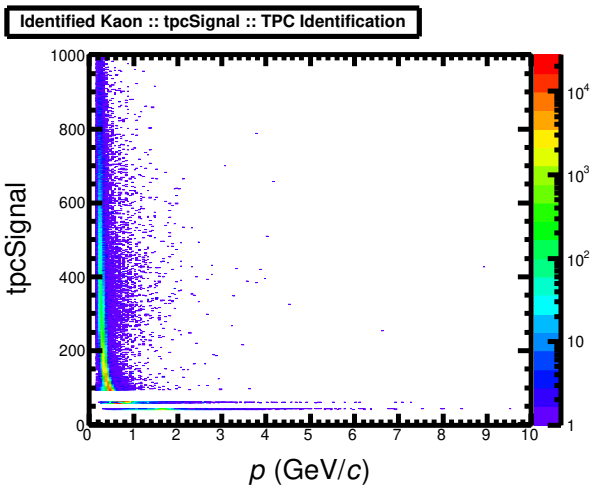
Primary identfication using TPC

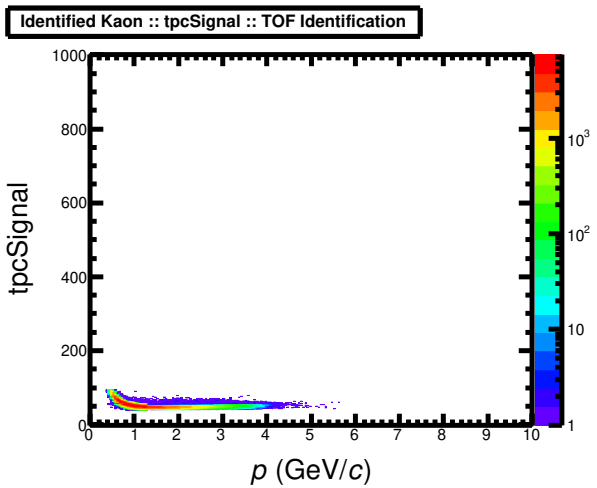
- $\star$ $|n\sigma^{El}_{TPC}| > 3$ && $|n\sigma^{Pi}_{TPC}| > 3$ && $|n\sigma^{Pr}_{TPC}| > 3$ && $|n\sigma^{De}_{TPC}| > 3$
- $|n\sigma^{Ka}_{TPC}| < 7$ for $tpcInnerParam \in [0.05, 0.30)$ GeV/c
- $|n\sigma^{Ka}_{TPC}| < 6$ for $tpcInnerParam \in [0.30, 0.40)$ GeV/c
- $|n\sigma^{Ka}_{TPC}| < 4$ for $tpcInnerParam \in [0.40, 0.45)$ GeV/c
- $|n\sigma^{Ka}_{TPC}| < 3$ for $tpcInnerParam \in [0.45, 0.70)$ GeV/c
- $|n\sigma^{Ka}_{TPC}| < 2$ for $tpcInnerParam \in [0.70, \infty)$ GeV/c

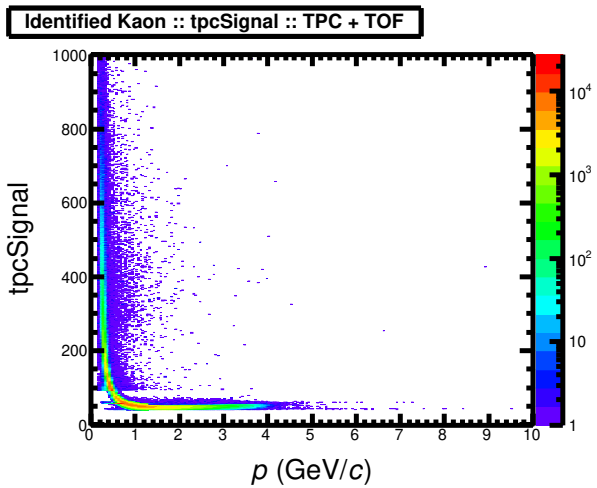
TOF identification for unidentified in TPC

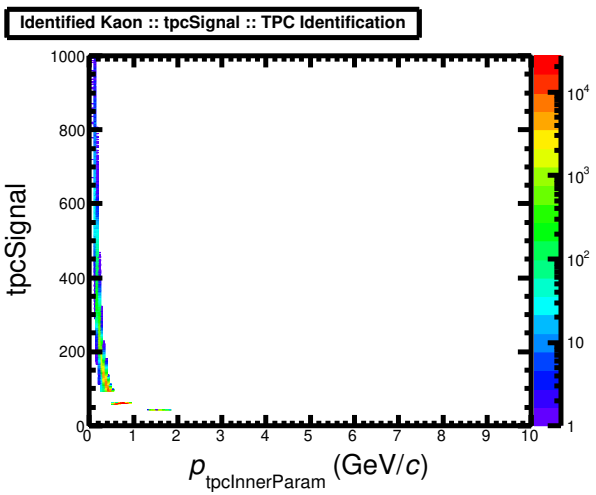
- $|n\sigma^{Ka}_{TPC}| < 3$ && $|n\sigma^{Ka}_{TOF}| < 3$ for $tpcInnerParam < 0.75$ GeV/c
- $|n\sigma^{Ka}_{TPC}| < 3$ && $|n\sigma^{Ka}_{TOF}| < 3$ for $tpcInnerParam \in [0.75, 1.30]$ GeV/c && $|n\sigma^{El}_{TOF}| > 3$ && $|n\sigma^{Pi}_{TOF}| > 3$
- $|n\sigma^{El}_{TOF}| > 3$ && $|n\sigma^{Pi}_{TOF}| > 3$ && $|n\sigma^{Pr}_{TOF}| > 3$ && $|n\sigma^{De}_{TOF}| > 3$ $|n\sigma^{Ka}_{TPC}| < 2$ && $|n\sigma^{Ka}_{TOF}| < 2$ for $p_T > 1.30$ GeV/c

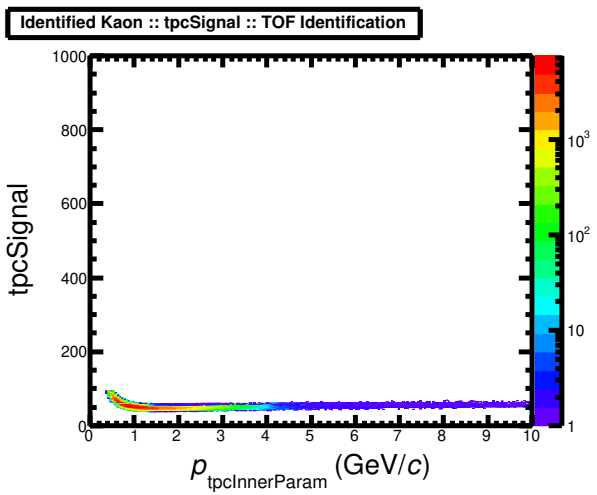
Kaon Identification- tpcSignal ($\frac{-dE}{dx}$)

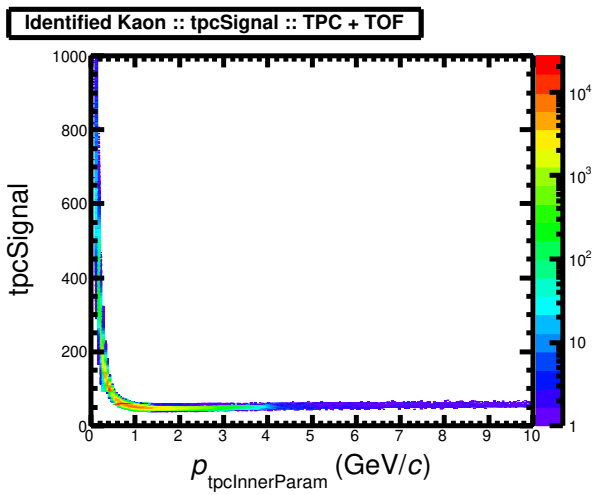




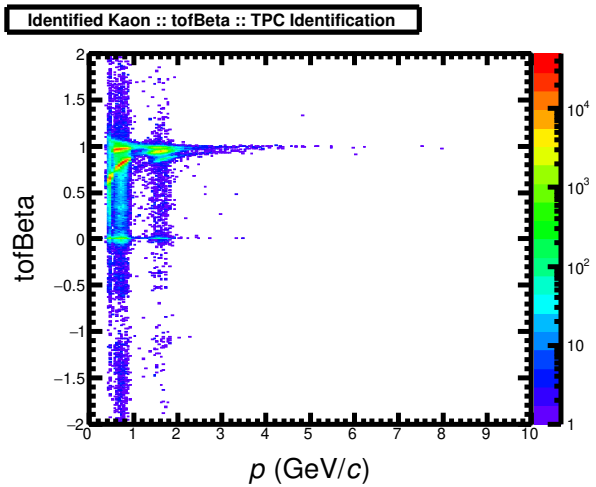


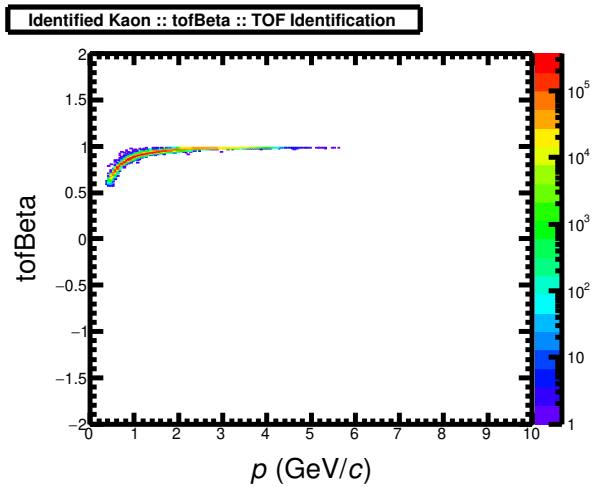


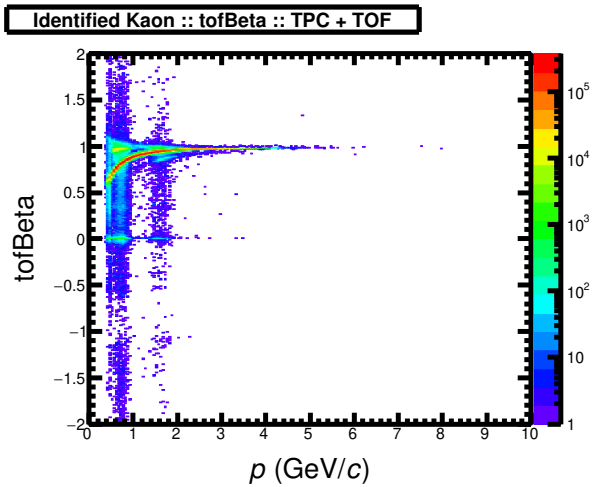


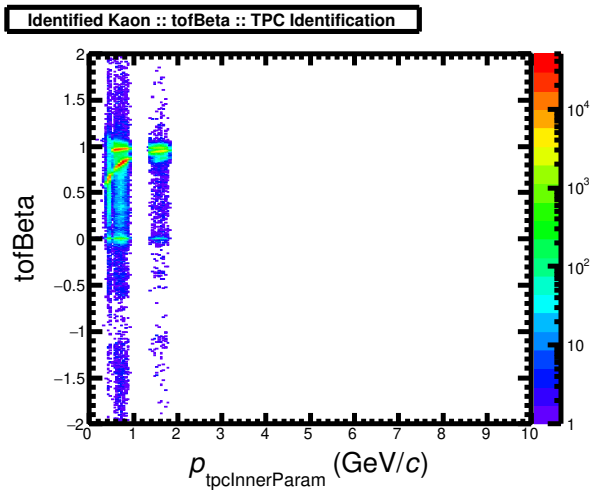


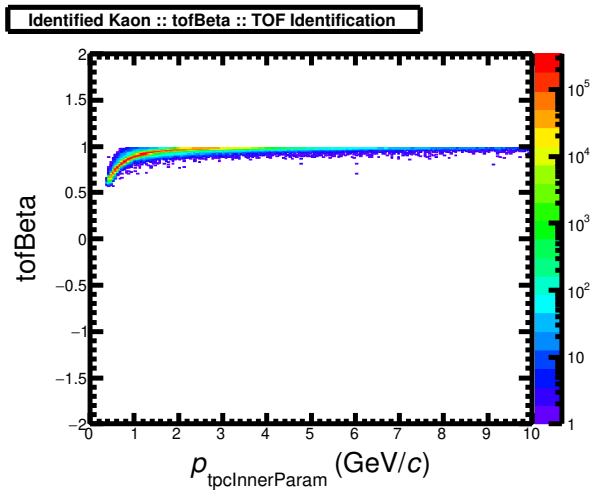
Kaon Identification- tofBeta (β)

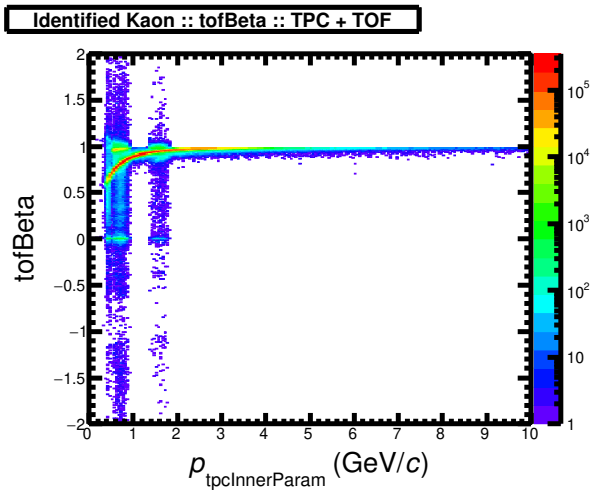




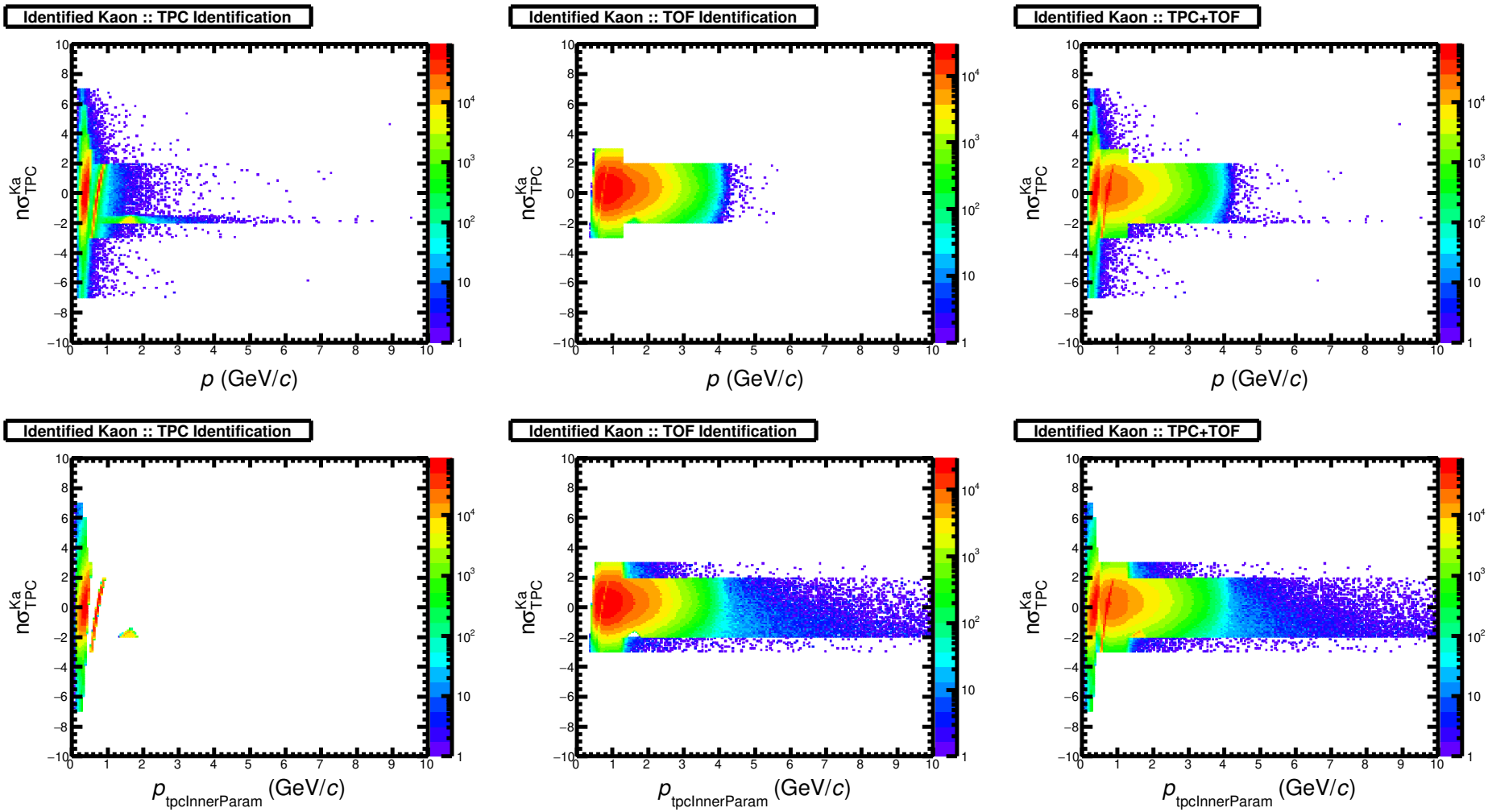




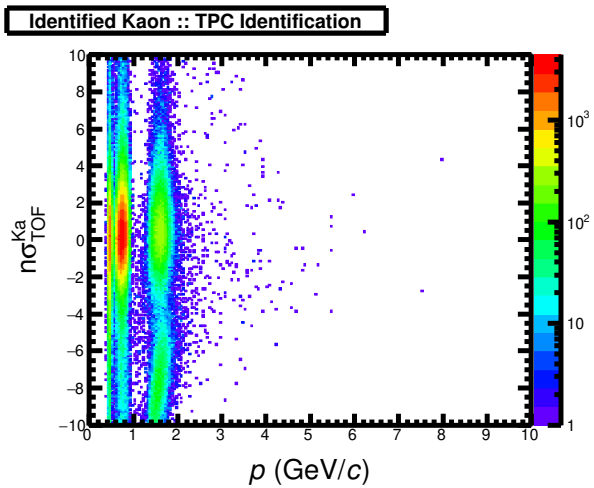


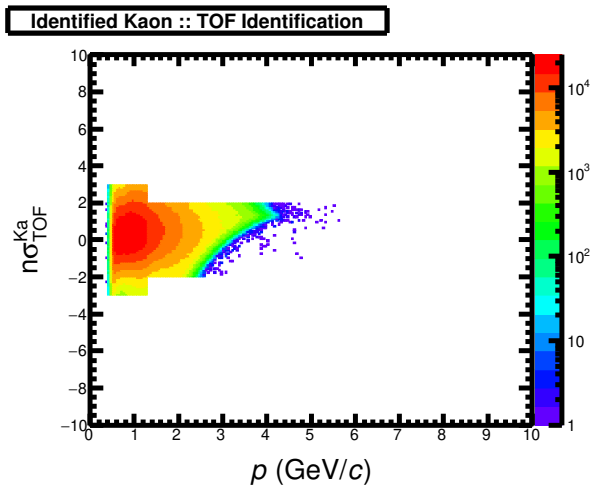


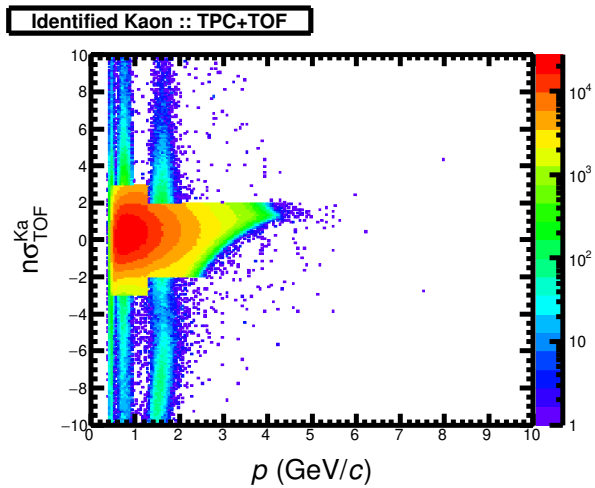
Kaon Identification- $n\sigma^{Ka}_{TPC}$

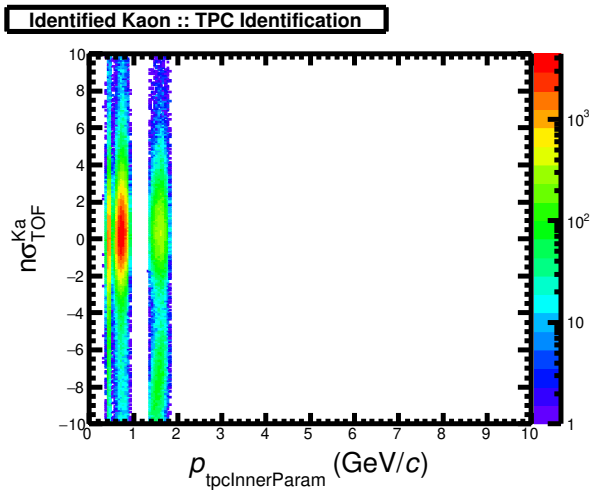


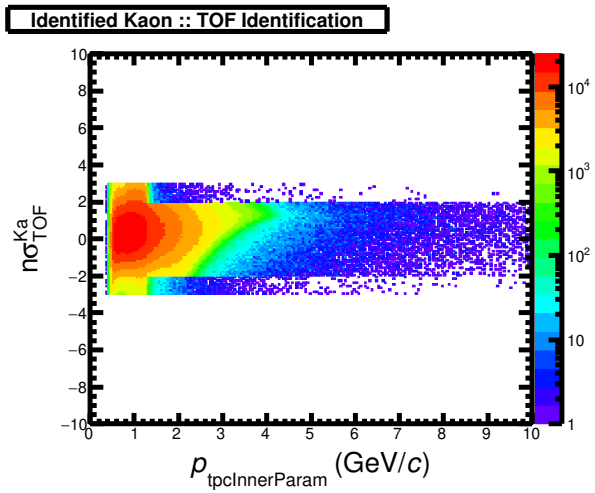
Kaon Identification- $n\sigma^{Ka}_{TOF}$

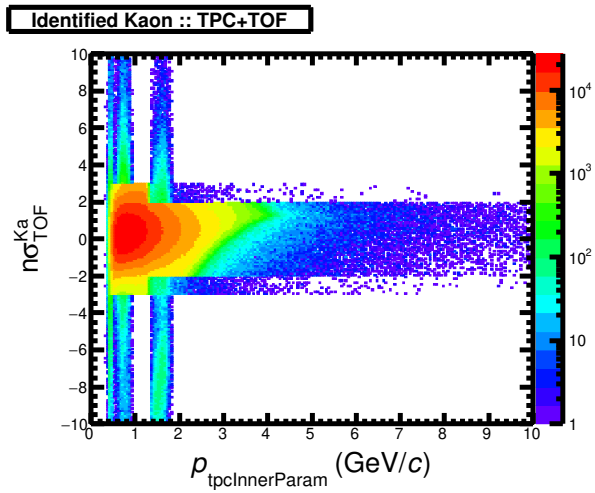




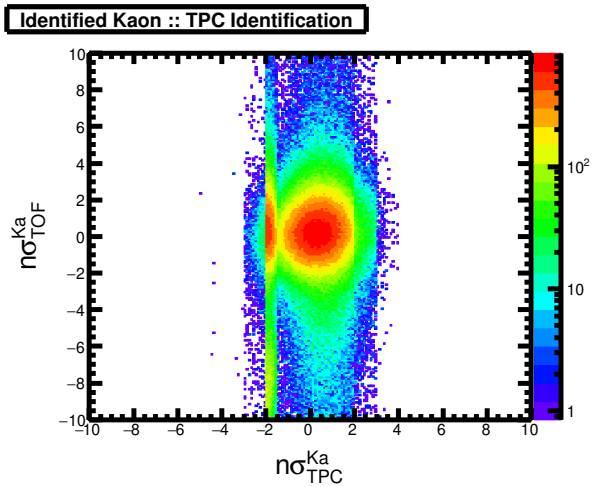


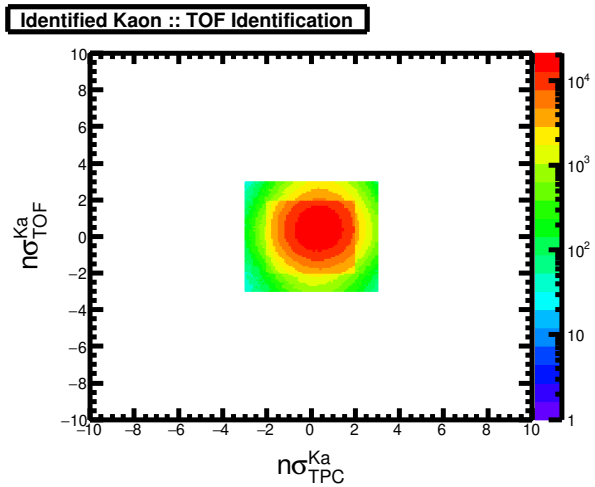


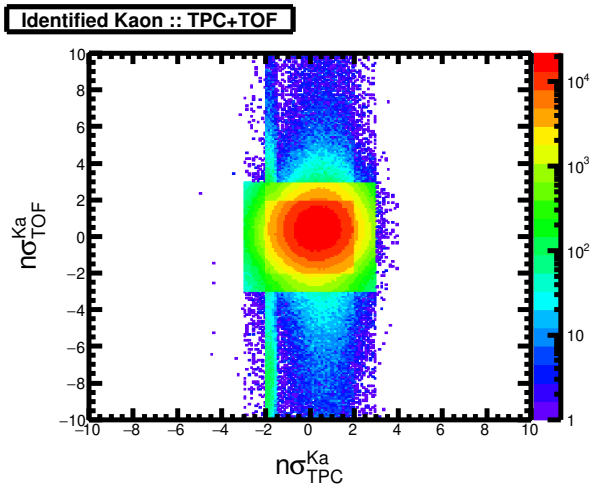




Kaon Identification- $n\sigma^{Ka}_{TOF}$ vs $n\sigma^{Ka}_{TPC}$



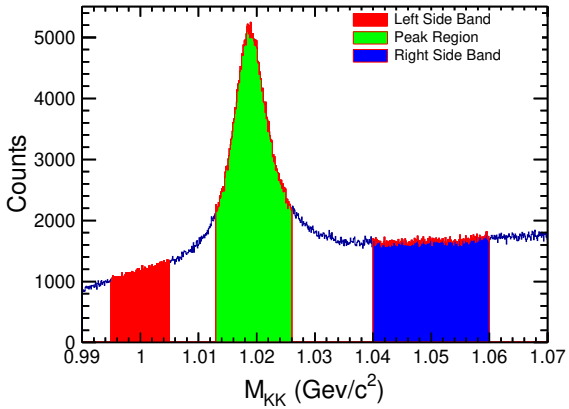




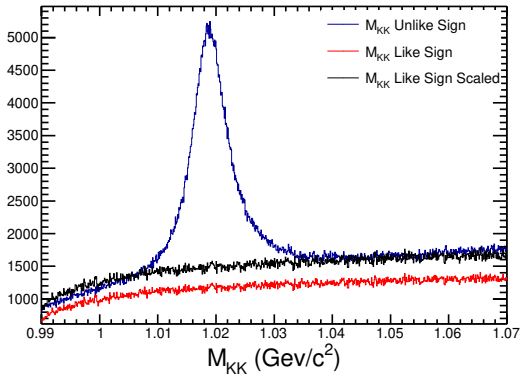
ϕ Meson Reconstruction

Side Band Method

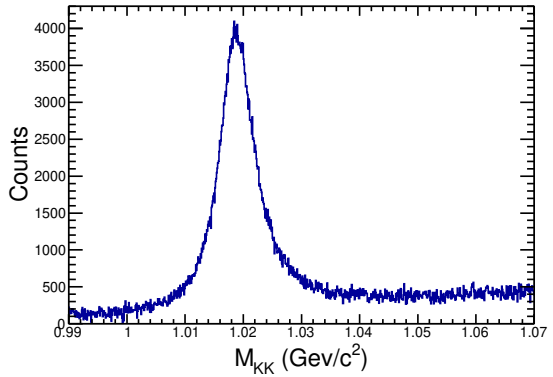
- LSB: $0.995 GeV/c^2 < M_{KK} < 1.005 GeV/c^2$
- Peak: $1.013 GeV/c^2 < M_{KK} < 1.026 GeV/c^2$
- RSB: $1.040 GeV/c^2 < M_{KK} < 1.060 GeV/c^2$



LSB, Peak, RSB regions



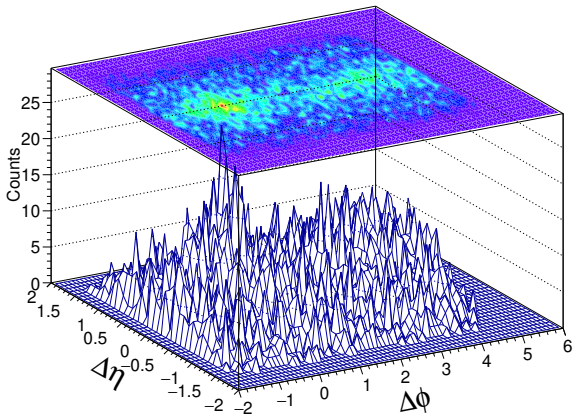
Invariant mass of KK with Background



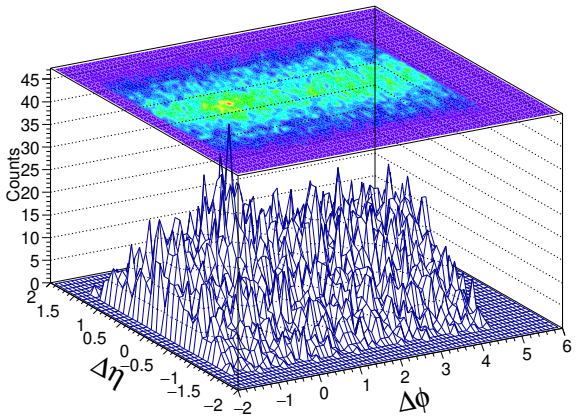
BG removed invariant mass

Hadron-KK correlations (Unlike Sign)(Bulk)

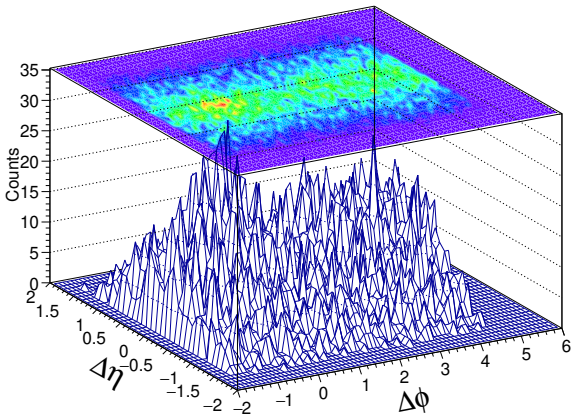
- $K^{\pm}K^{\mp}$ Selection : $p_{T_{K^{\pm}K^{\mp}}} \in$ (0.0 - 2.0) GeV/c
- Trigger Hadron Selection : $p_{T_{hadron}} \in$ [4.0 - 8.0] GeV/c



$S^{Bulk}_{LSB}(\Delta\eta,\Delta\Phi)$



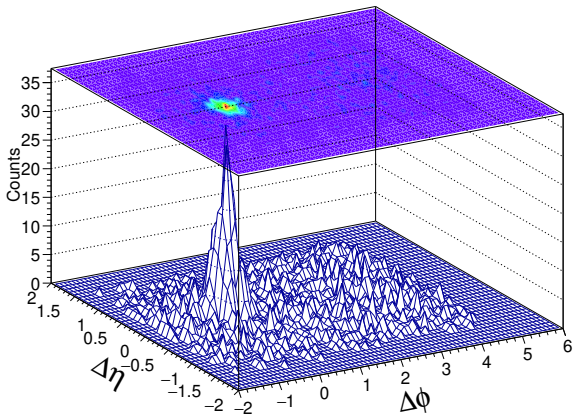
$S^{Bulk}_{Peak}(\Delta\eta,\Delta\Phi)$



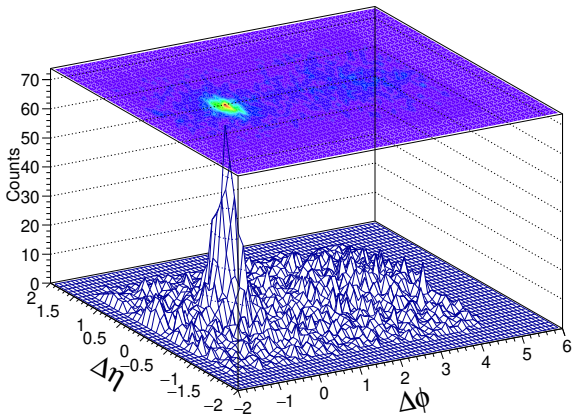
$S^{Bulk}_{RSB}(\Delta\eta,\Delta\Phi)$

Hadron-KK correlations (Unlike Sign)

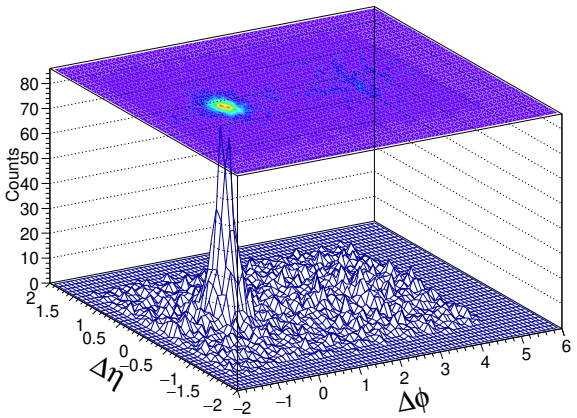
- $K^{\pm}K^{\mp}$ Selection : $p_{T_{K^{\pm}K^{\mp}}} \in$ (2.0 - 4.0) GeV/c
- Trigger Hadron Selection : $p_{T_{hadron}} \in$ [4.0 - 8.0] GeV/c



$S_{LSB}(\Delta\eta,\Delta\Phi)$



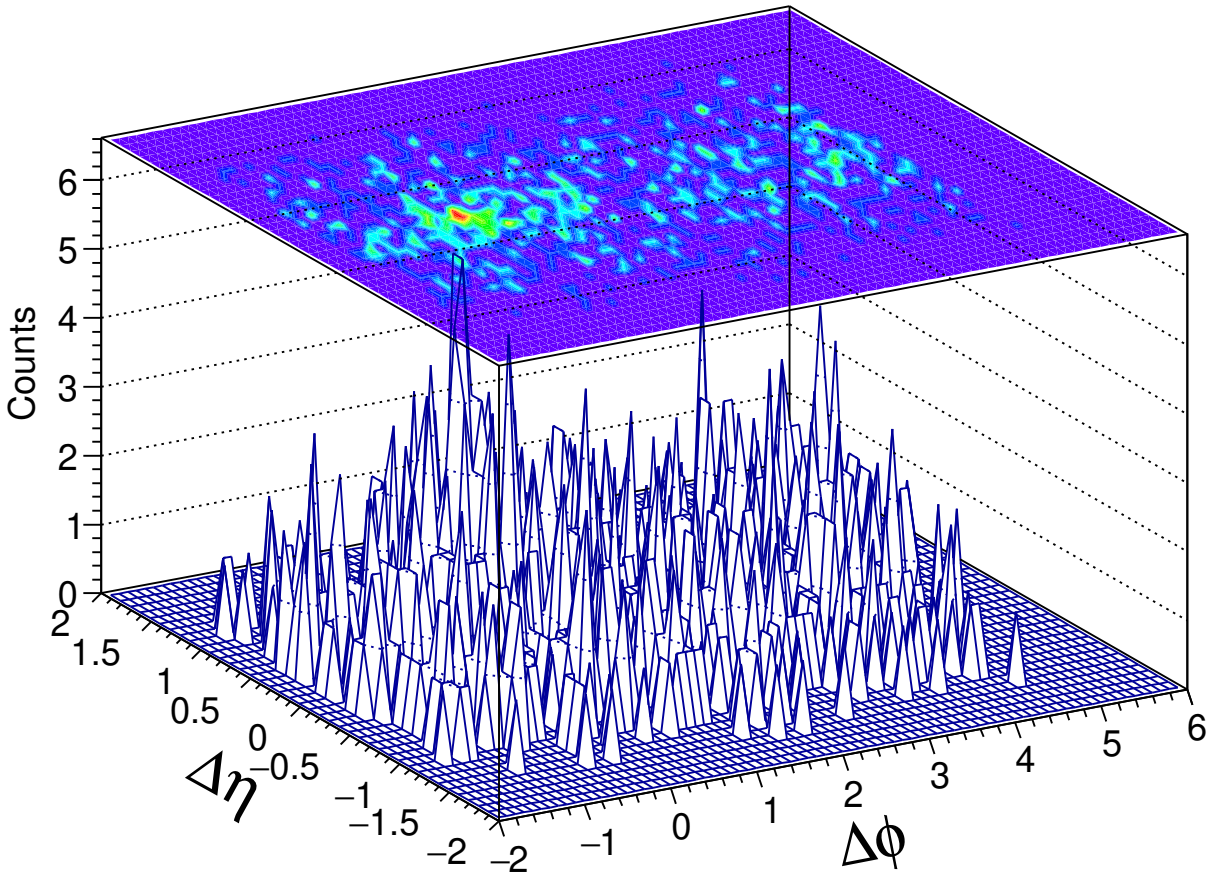
$S_{Peak}(\Delta\eta,\Delta\Phi)$



$S_{RSB}(\Delta\eta,\Delta\Phi)$

ϕ-ϕ correlations

- ϕ ($K^{\pm}K^{\mp}$) Selection : $M_{KK} \in (1.013 - 1.026) GeV/c^2$



$S^{\phi-\phi}(\Delta\eta, \Delta\Phi)$

Summary and Outlook

- This is the 1st result in h-phi correlation in pp collisions in run3.
- We have reconstructed phi and have seen the phi-phi , h-phi correlation
- Same event correlation distributions have been obtained.
- Our group is working towards obtaining mixed event correlation distributions from Run 3 data and efficiency corrections using monte carlo data.

Thank you for your attention

Backup Slides

Backup - Identification

o2::aod::StoredTracksExtra_001

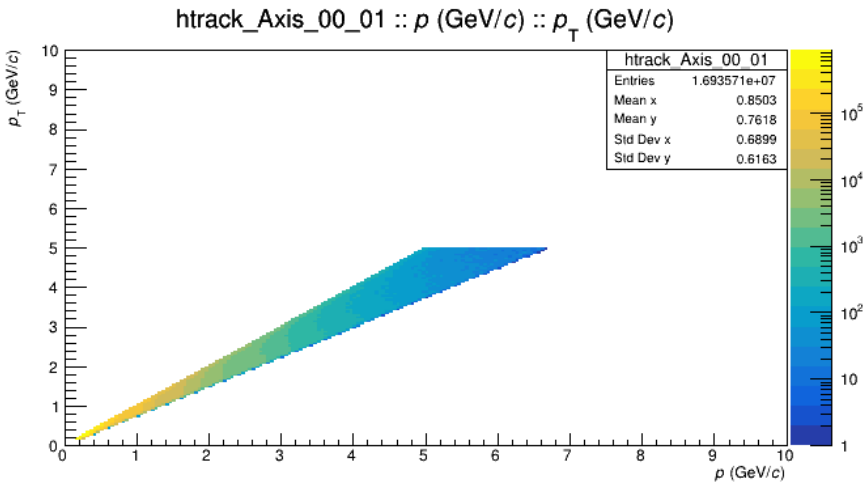
Header file: Framework/Core/include/Framework/AnalysisDataModel.h

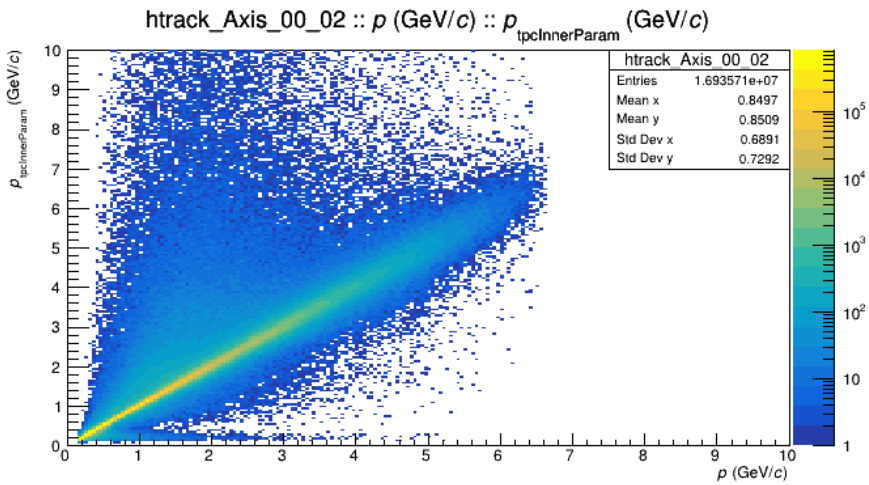
Is used in:

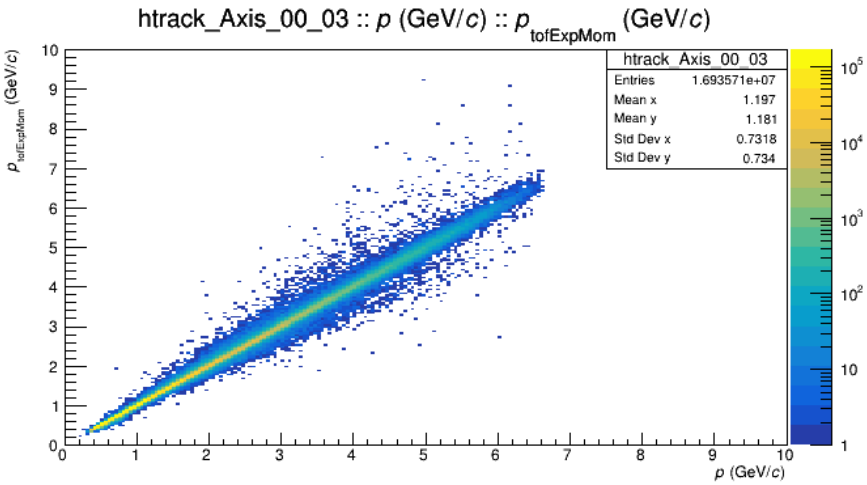
- o2::aod::StoredTracksExtra = o2::aod::StoredTracksExtra_001

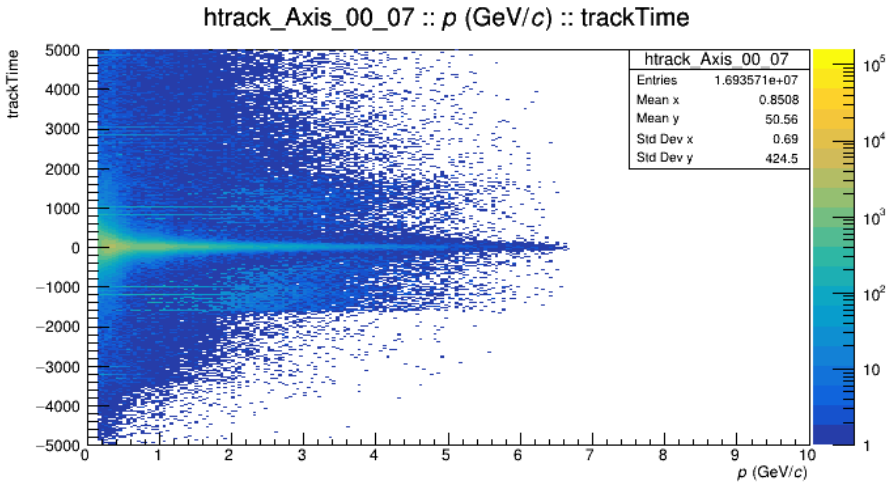
Name		Getter	Type	Comment
o2::aod::track::TPCInnerParam		tpcInnerParam	float	Momentum at inner wall of the TPC
o2::aod::track::TRDSignal		trdSignal	float	PID signal in the TRD
o2::aod::track::Length		length	float	Track length
o2::aod::track::TOFExpMom		tofExpMom	float	TOF expected momentum obtained in tracking, used to compute the expected times
o2::aod::track::PIDForTracking	D	pidForTracking	uint32_t	PID hypothesis used during tracking. See the constants in the class PID in PID.h
o2::aod::track::IsPVContributor	D	isPVContributor	bool	Run 3: Has this track contributed to the collision vertex fit
o2::aod::track::TrackEtaEMCAL		trackEtaEmcal	float	
o2::aod::track::TrackPhiEMCAL		trackPhiEmcal	float	
o2::aod::track::TrackTime		trackTime	float	Estimated time of the track in ns wrt collision().bc() or ambiguoustrack.bcSlice()[0]
o2::aod::track::TrackTimeRes		trackTimeRes	float	Resolution of the track time in ns (see TrackFlags::TrackTimeResIsRange)

Backup - Identification- Momentums

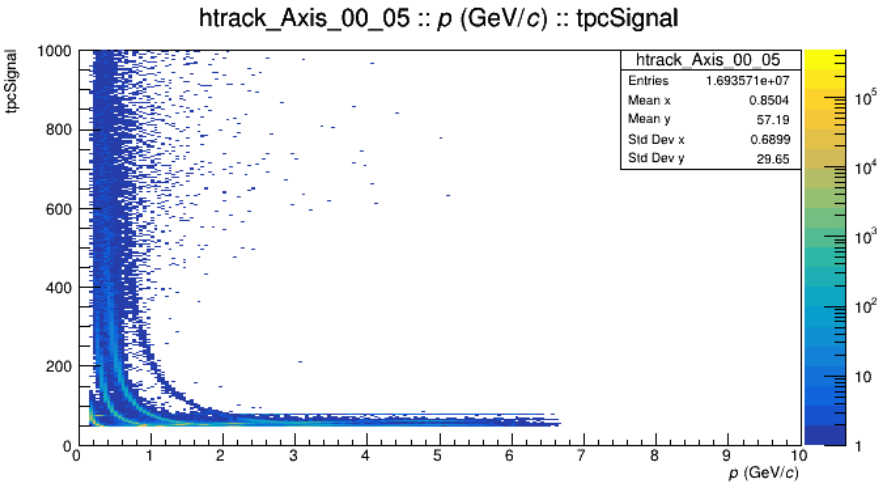


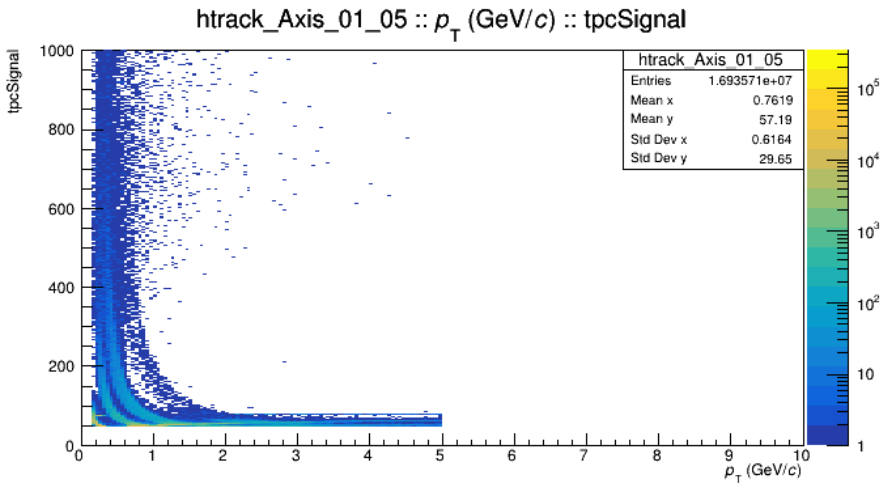


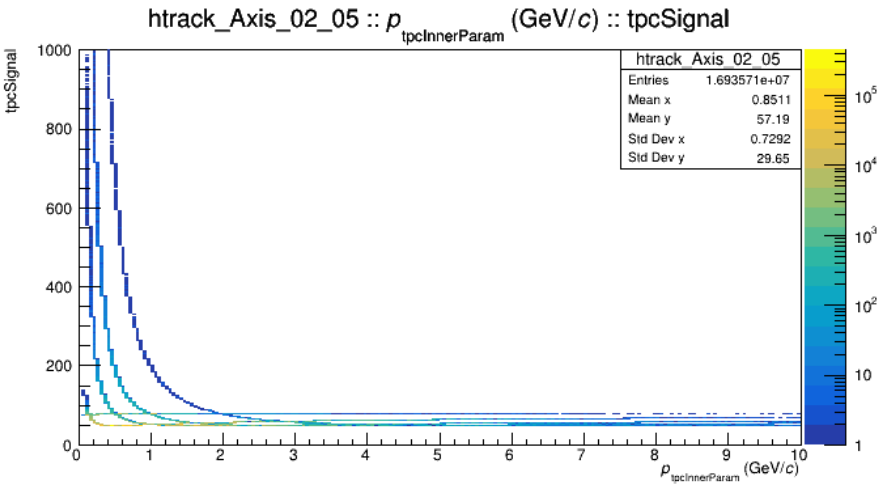


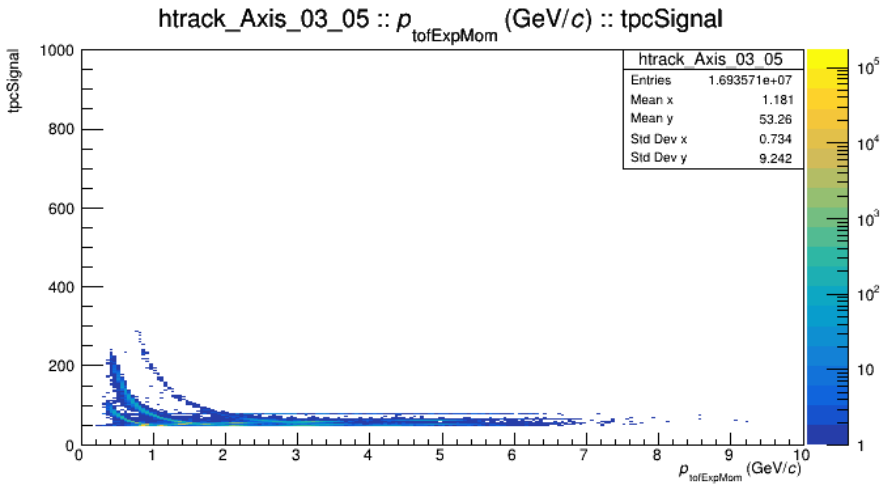


Backup - Identification- tpcSignal $|n\sigma_{TPC}^{Pi,Ka,Pr,El}| < 0.01$

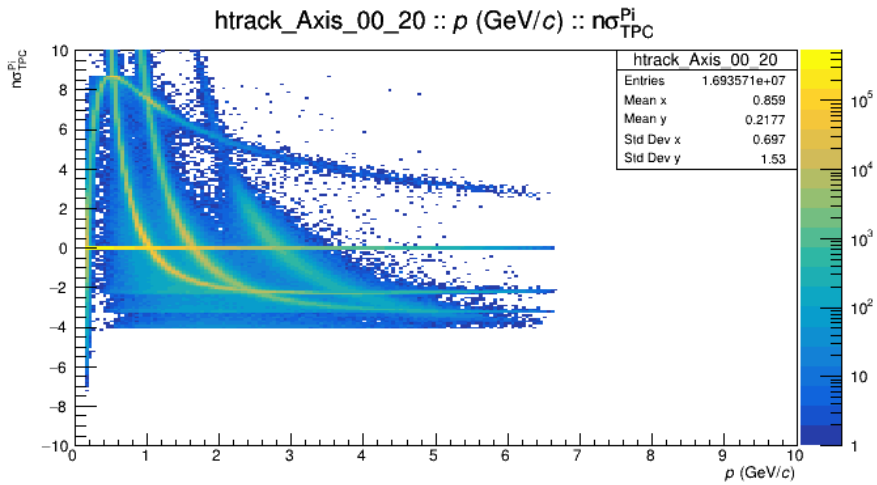


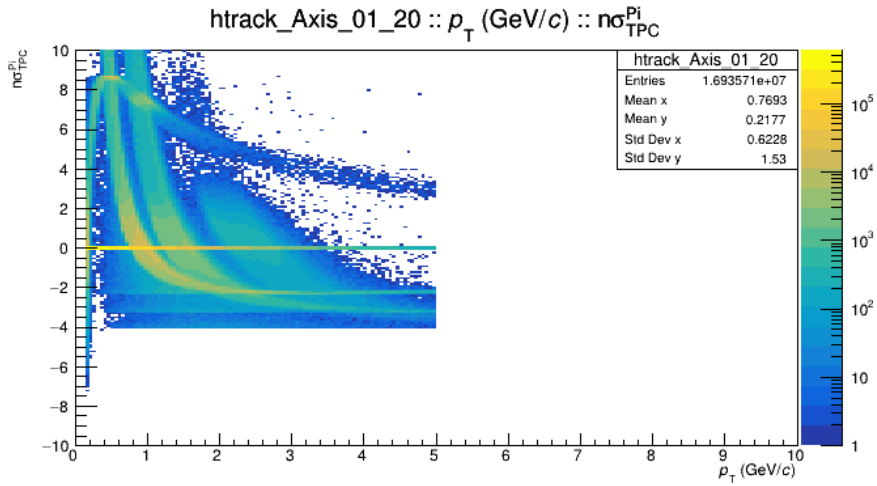


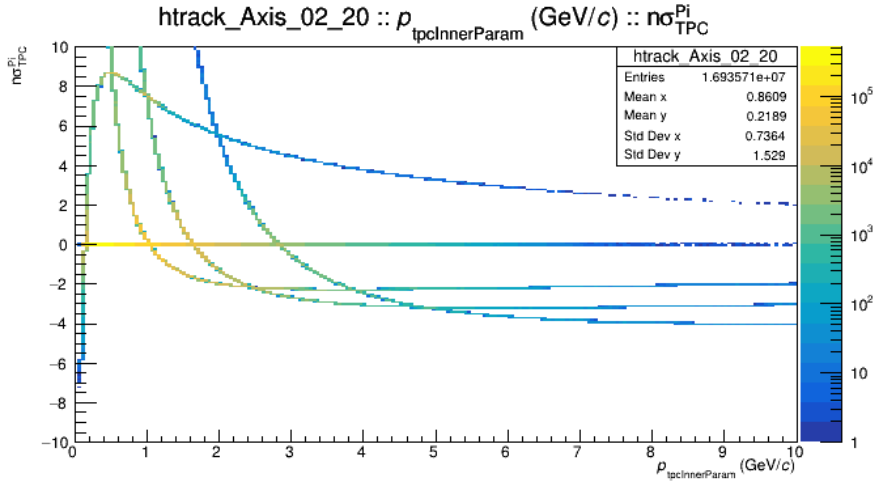


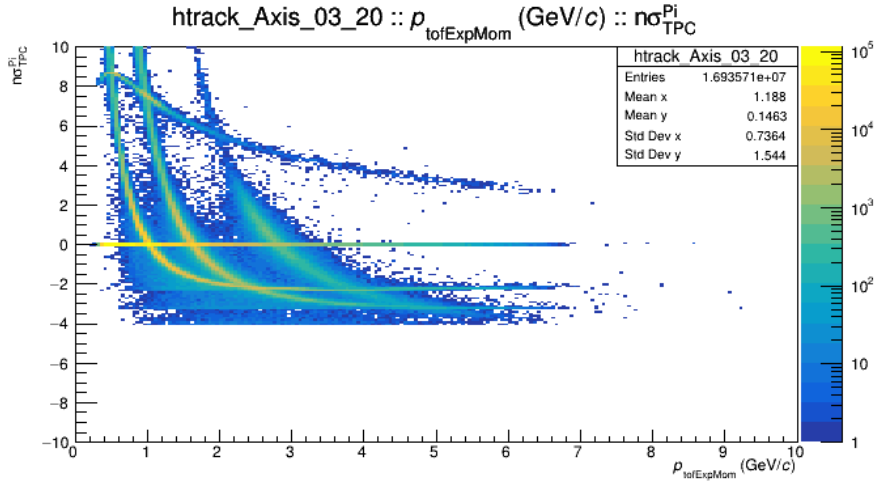


Backup - Identification- $|n\sigma^{Pi}_{TPC}|$

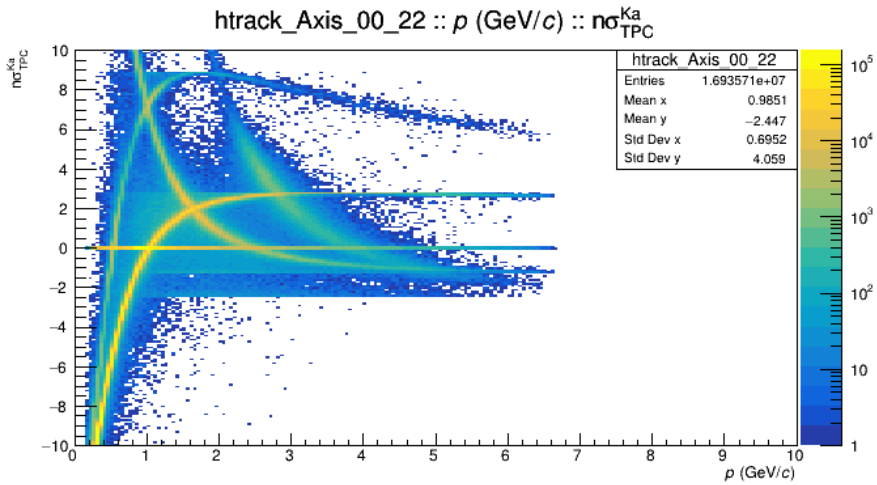


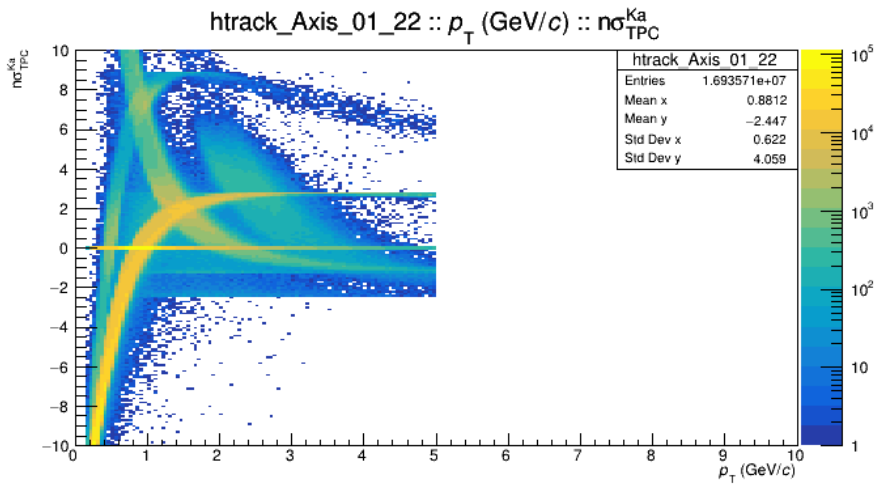


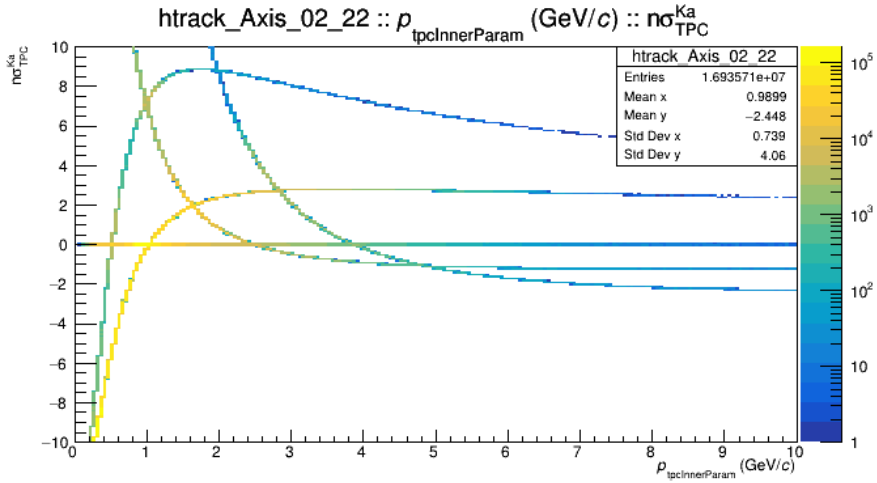


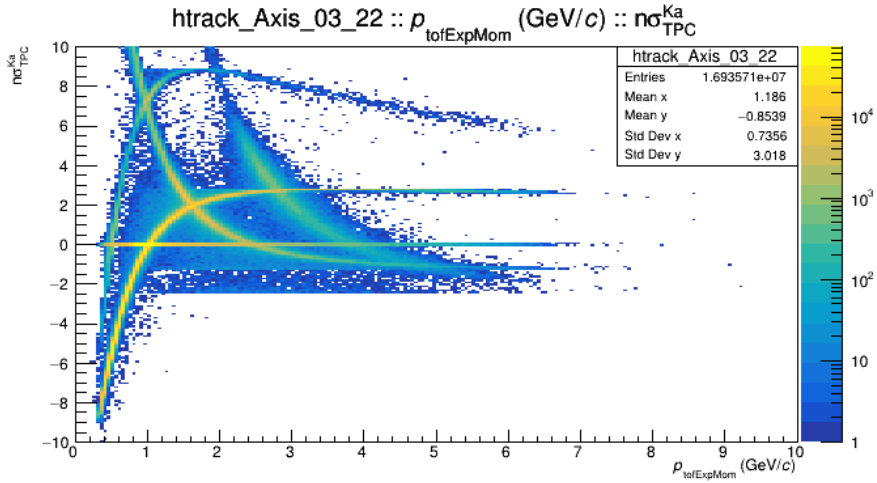


Backup - Identification- $|n\sigma^{Ka}_{TPC}|$

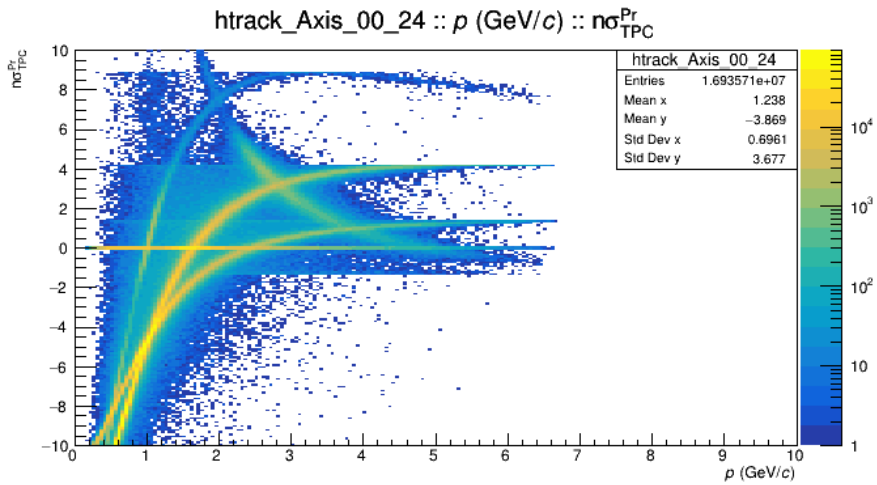


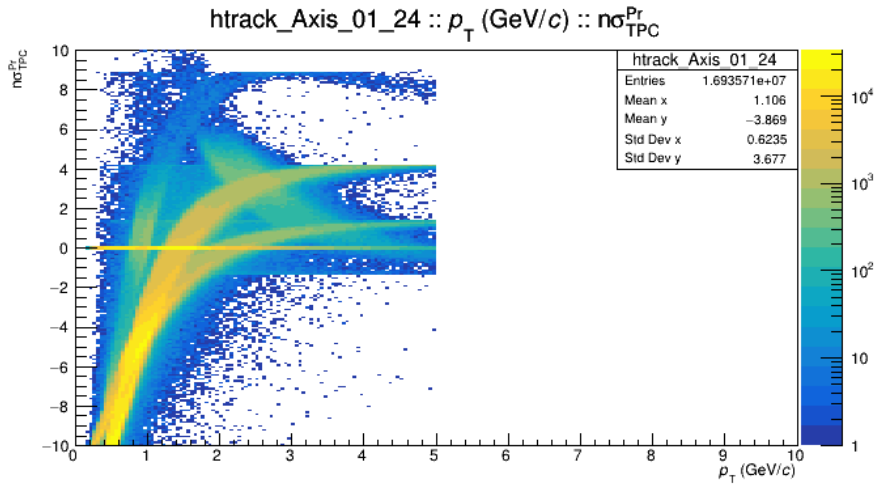


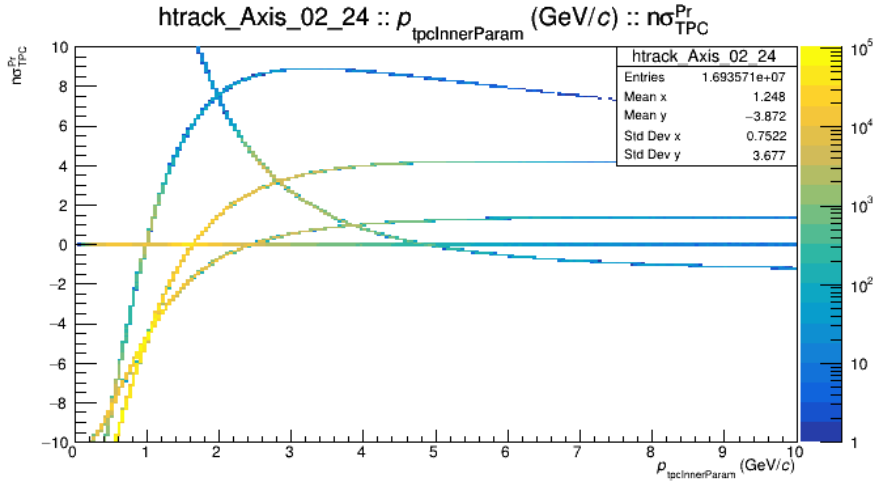


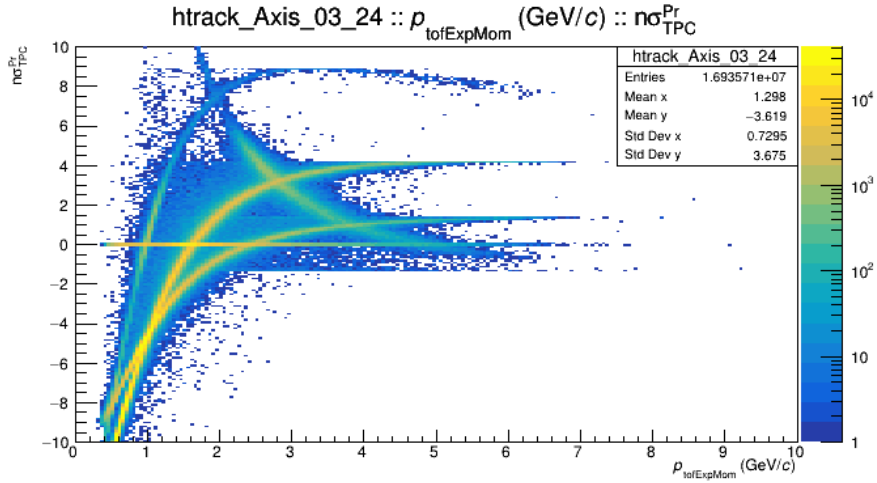


Backup - Identification- $|n\sigma^{Pr}_{TPC}|$

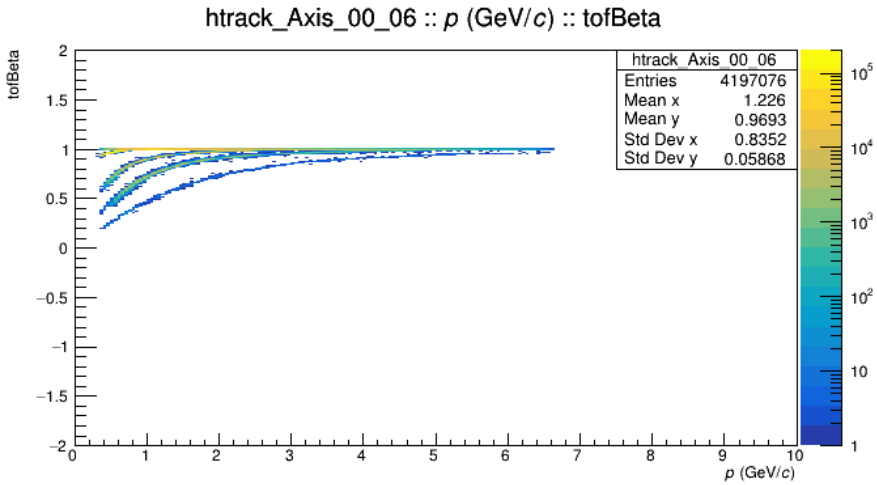


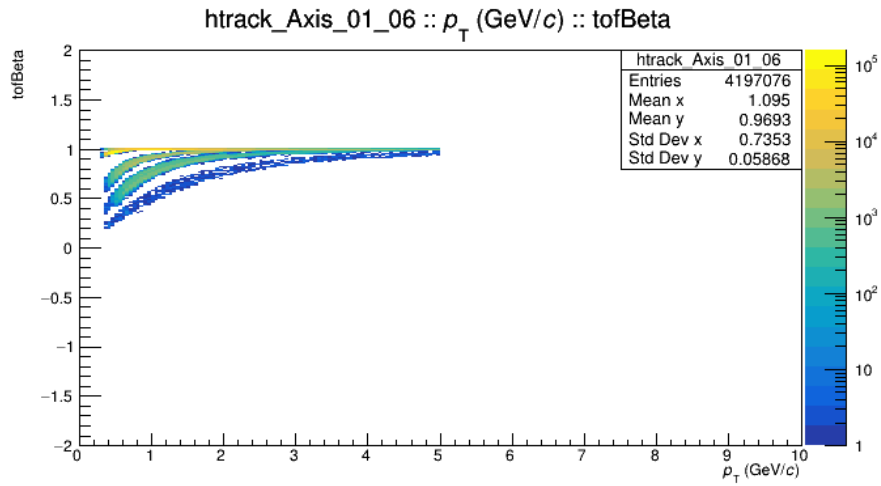


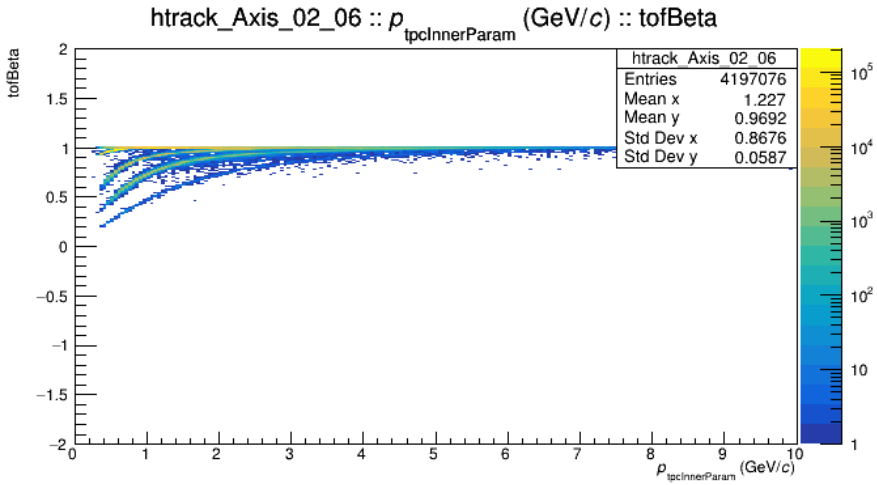


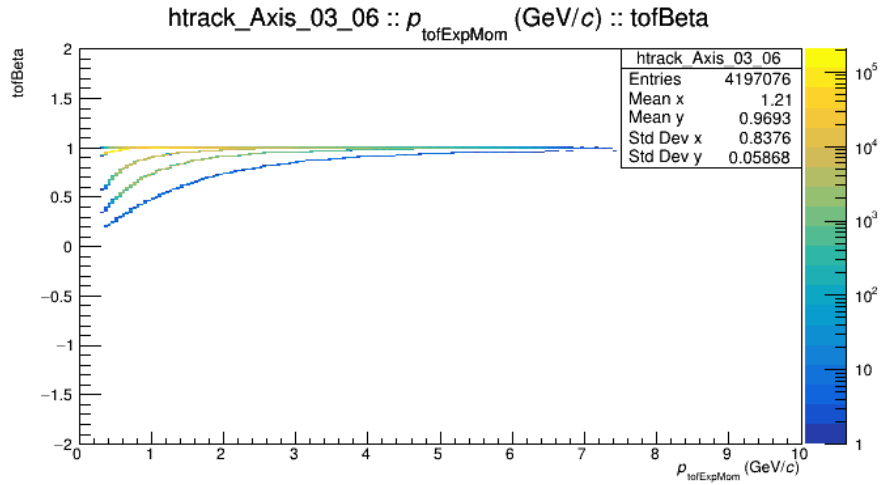


Backup - Identification- tofBeta $|n\sigma_{TOF}^{Pi,Ka,Pr,El}| < 0.01$

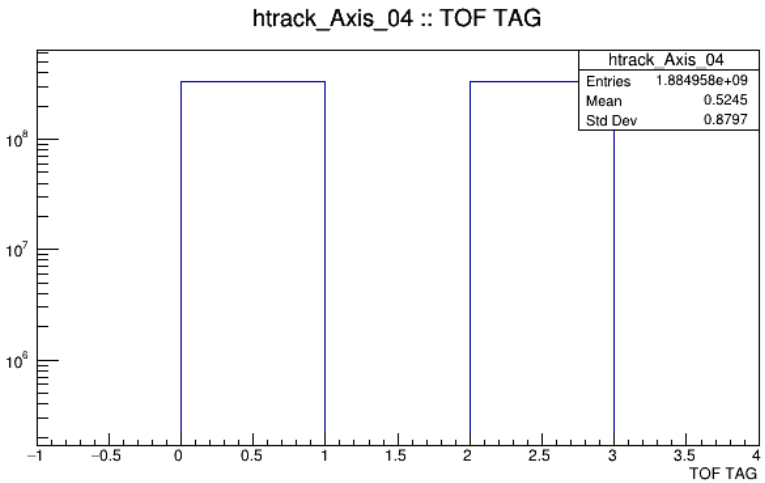


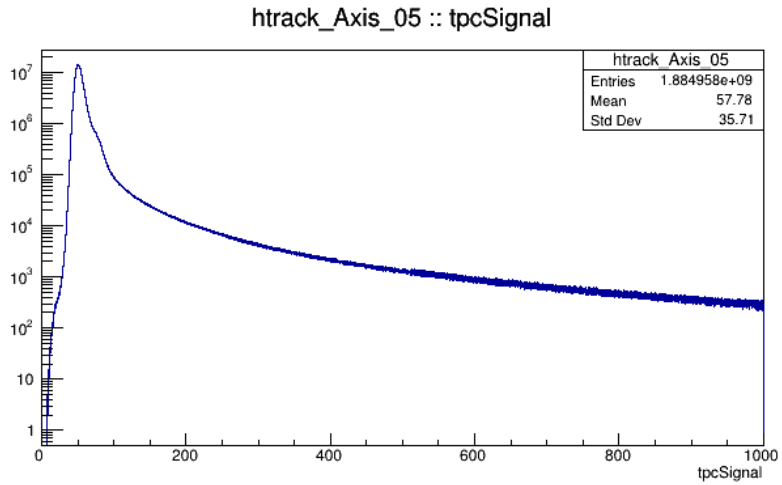


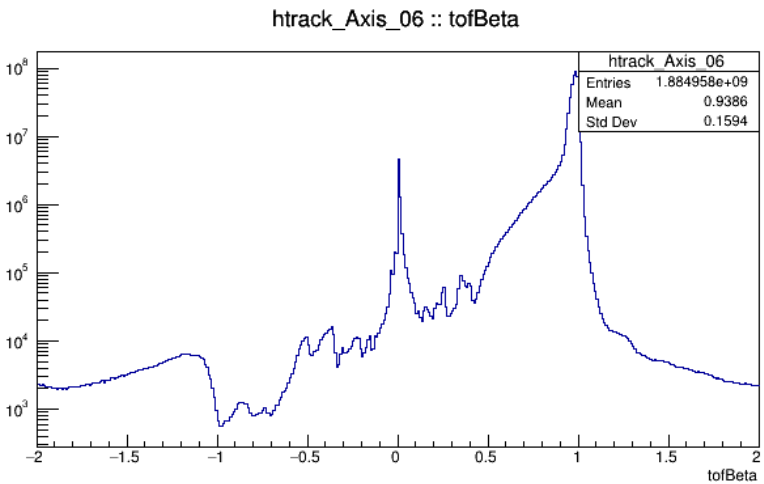


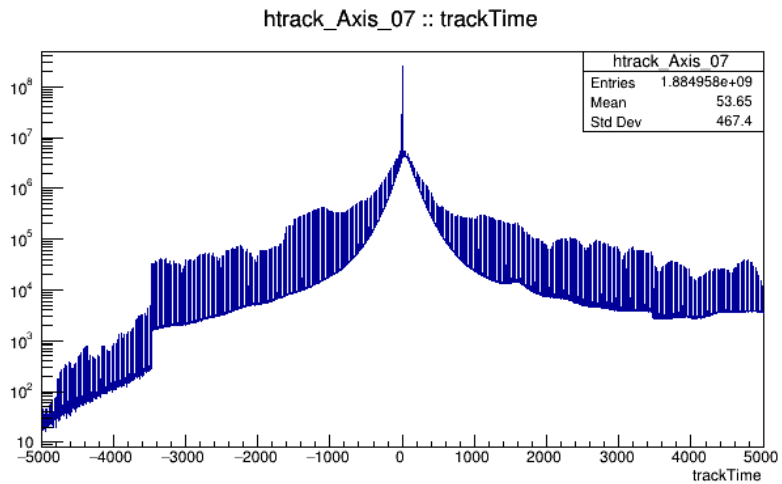


Backup - Identification - track time and tof β

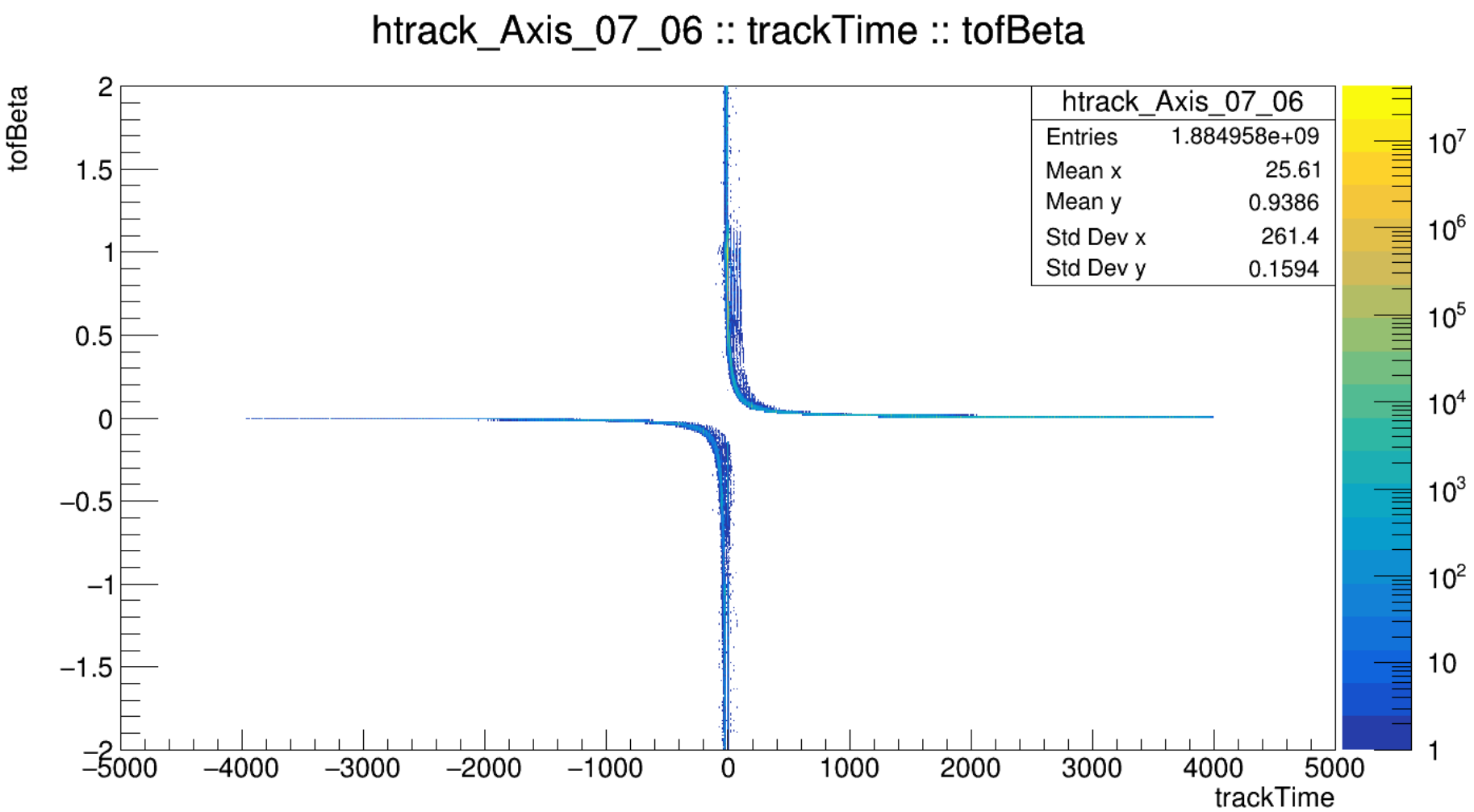








Backup - Identification - tof β vs track time



Backup - Identification- Negative β