Spherocity-Dependent study of $K^*(892)$production in pp collisions at $\sqrt{s} = 13.6 TeV$

Sayan Dhani(M.Sc. Physics, IITB)
Prof. Sadhana Dash, Prof. Basanta Kumar Nandi

Department of Physics, IIT Bombay

December, 2023

Contents

Introduction $K^*(892)$ Resonance

- Invariant mass $M_{K^*(892)}$ is 891.66 ± 0.26 MeV
- Decay width Γ of $K^*(892)$ is 46.2 ± 1.3 MeV
- Mean lifetime of $K^*(892)$ in its rest frame is $\sim 4fm/c$
- Some dominant decay modes of $K^*(892)$ resonance,
  1. $K^* \rightarrow K\pi$
  2. $K^* \rightarrow K\gamma$
  3. $K^* \rightarrow K\pi\pi$
- Branching Ratio $\Gamma(K\pi)/\Gamma_{Total}$ is 99.901 ± 0.009 to ~ 100

ref:Particle Data Group

Qark-Gluon Plasma and its Evolution

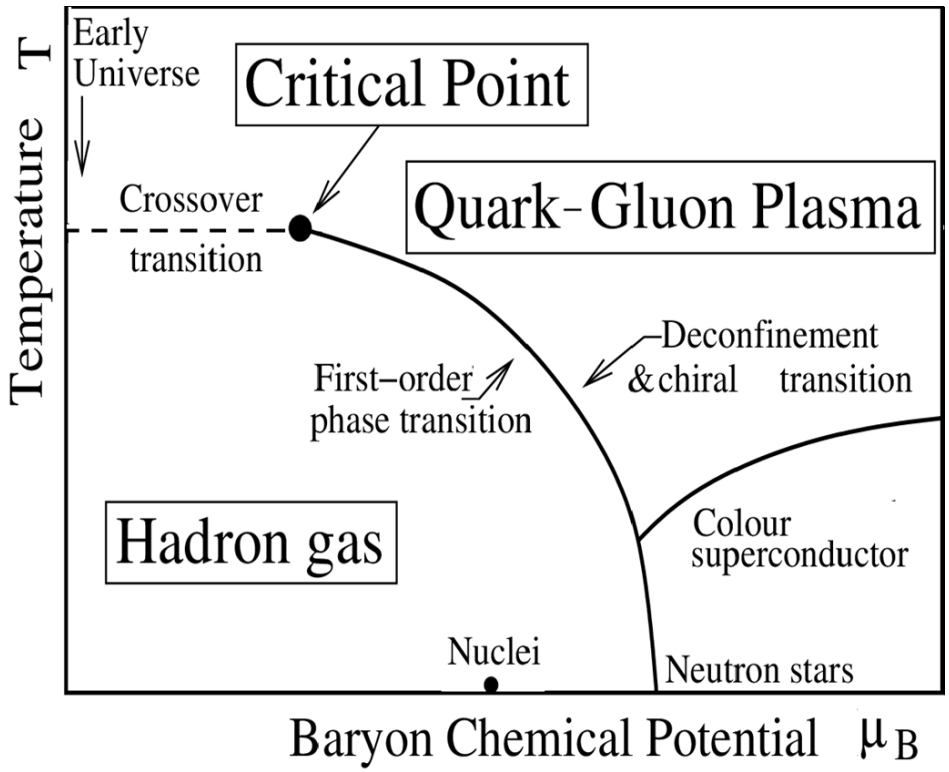


Figure: Phase Transition to QGP

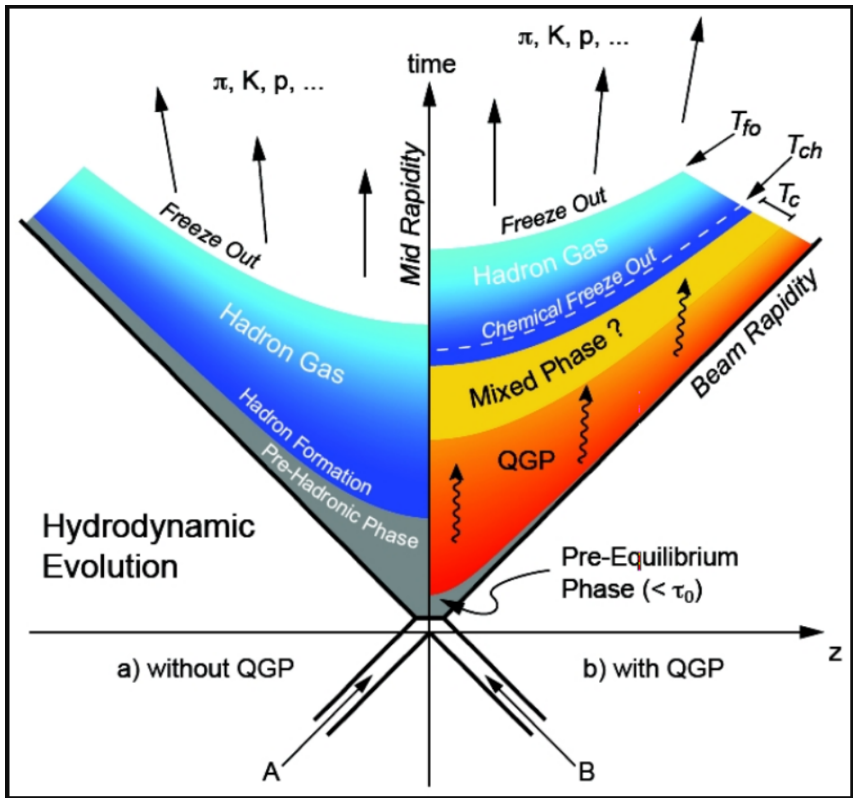


Figure: Spacetime Evolution of QGP

Motivation

- K*'s short lifetime$(\tau) \sim 4\ fm/C$. (avg.)
- So, decays, re-scatter, and re-generate within QGP's hadronic medium.
- K* has a strange quark$\rightarrow$Helps strangeness production study$\rightarrow$leads to QGP Formation.

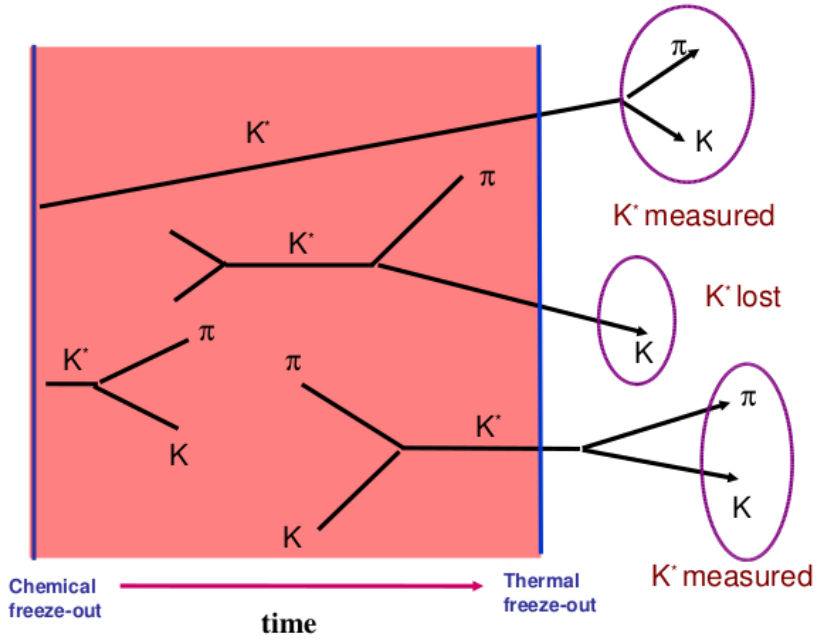


Figure: Decay, Re-scatter, and Re-generation of K* in QGP phase

Spherocity-dependent perspective$\rightarrow$ Identity the Jetty and Isotropic Events.

Transverse Spherocity

An event shape variable,

Def: Transverse Spherocity

$$S_0 = \frac{\pi^2}{4} min_{\hat{n}} \left(\frac{\Sigma_i \, |\vec{P_{T_i}} \times \hat{n}|}{\Sigma_i \, |\vec{P_{T_i}}|} \right)^2 \quad \forall \, |\vec{P_{T_i}}| = 1$$

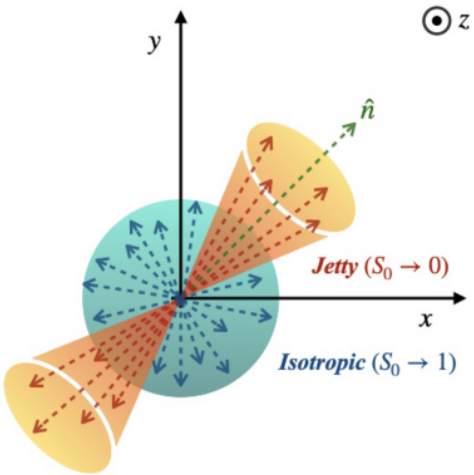


Figure: Event Shape corresponds p-p collisions

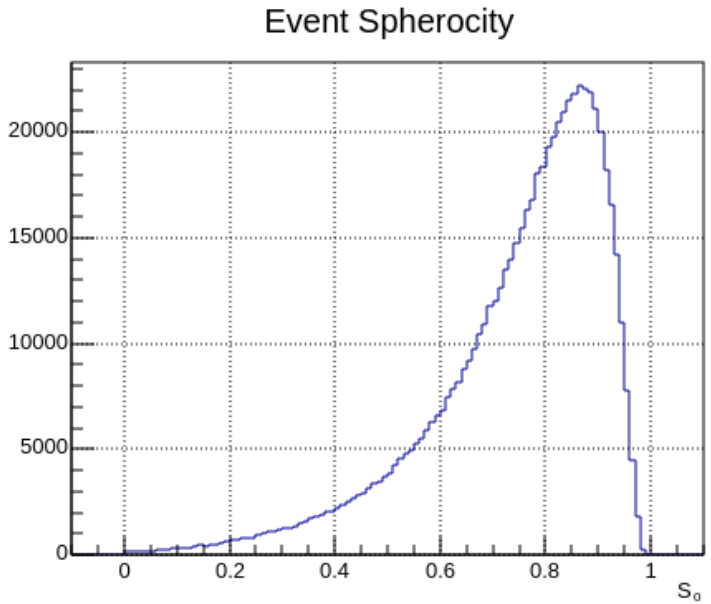


Figure: Transverse Spherocity distribution in p-p collision

Event and Track Selection Condition

p-p Collision

Center of Mass energy, $\sqrt{s} = 13.6 TeV$

Data Set

LHC22o pass4 medium

Event Selection

- |Vz | < 10cm
- sel8() Trigger

Track Selection

- P_T > 0.15 GeV/c
- $|\eta| < 0.8$
- |DCAz | < 1 cm
- |DCAxy | < 0.1 cm
- GlobalTracks() and PVContributor()

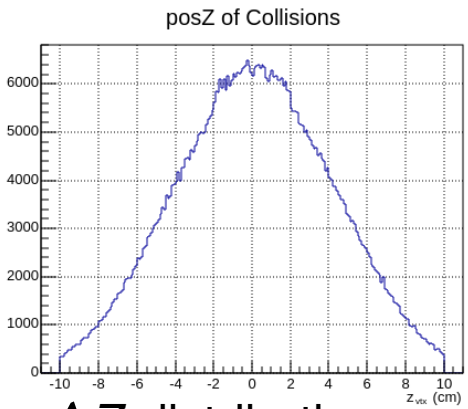


Figure: ΔZ distribution around the Primary Vertex

TPC and TOF PID for Kaons and Protons

PID Setections

- TPC only cuts $P_T \leq 1.1 GeV/c$ for Pions
  - $|n\sigma TPC| < 3 \quad \forall\ 0.15 \leq P_T < 1.1$
- TPC only cuts $P_T \leq 0.6 GeV/c$ for Kaons,
  - $|n\sigma TPC| < 3\ \forall\ 0.15 \leq P_T < 0.6$
- TPC + TOF cuts for $P_T \geq 1.1 GeV/c$ for Pions and $P_T \geq 0.6 GeV/c$ for Kaons,
  - $|n\sigma TOF| < 3$ and $|n\sigma TPC| < 3$
  - Only those TPC tracks are selected which are also present in TOF otherwise, they are discarded

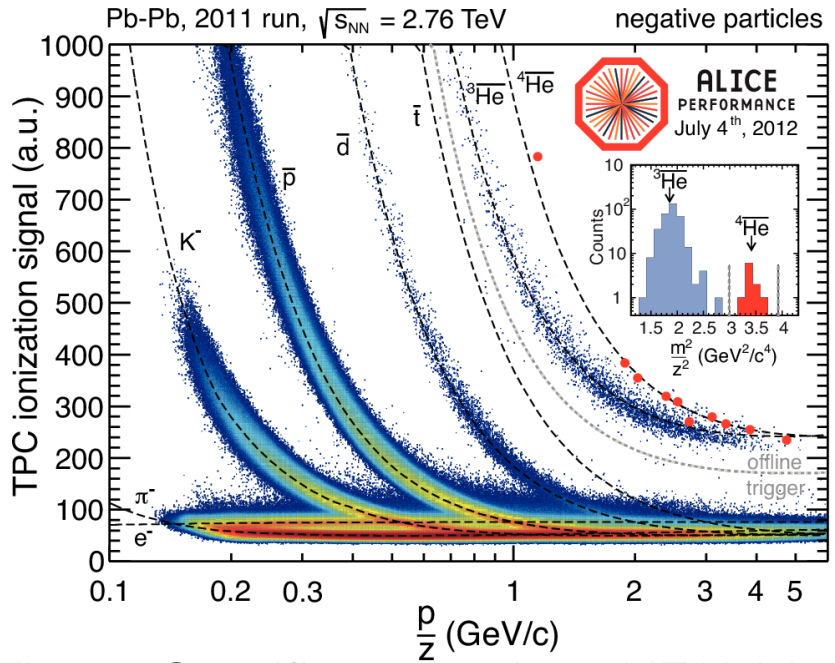


Figure: Specific energy loss (dE/dx) in the TPC versus particle momentum

Quality Assurance PID : before PID

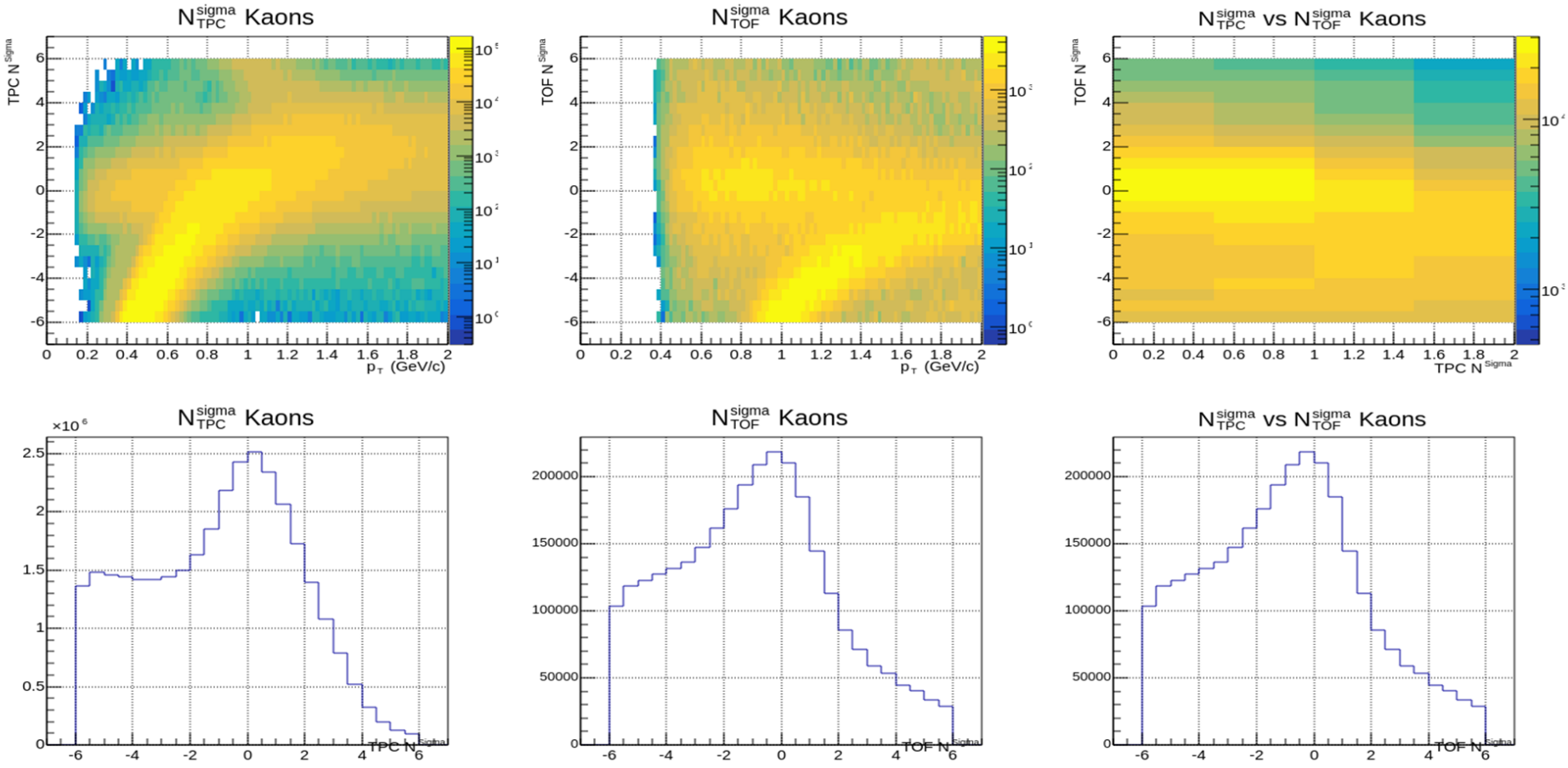


Figure: before PID : Kaons

Quality Assurance PID : before PID

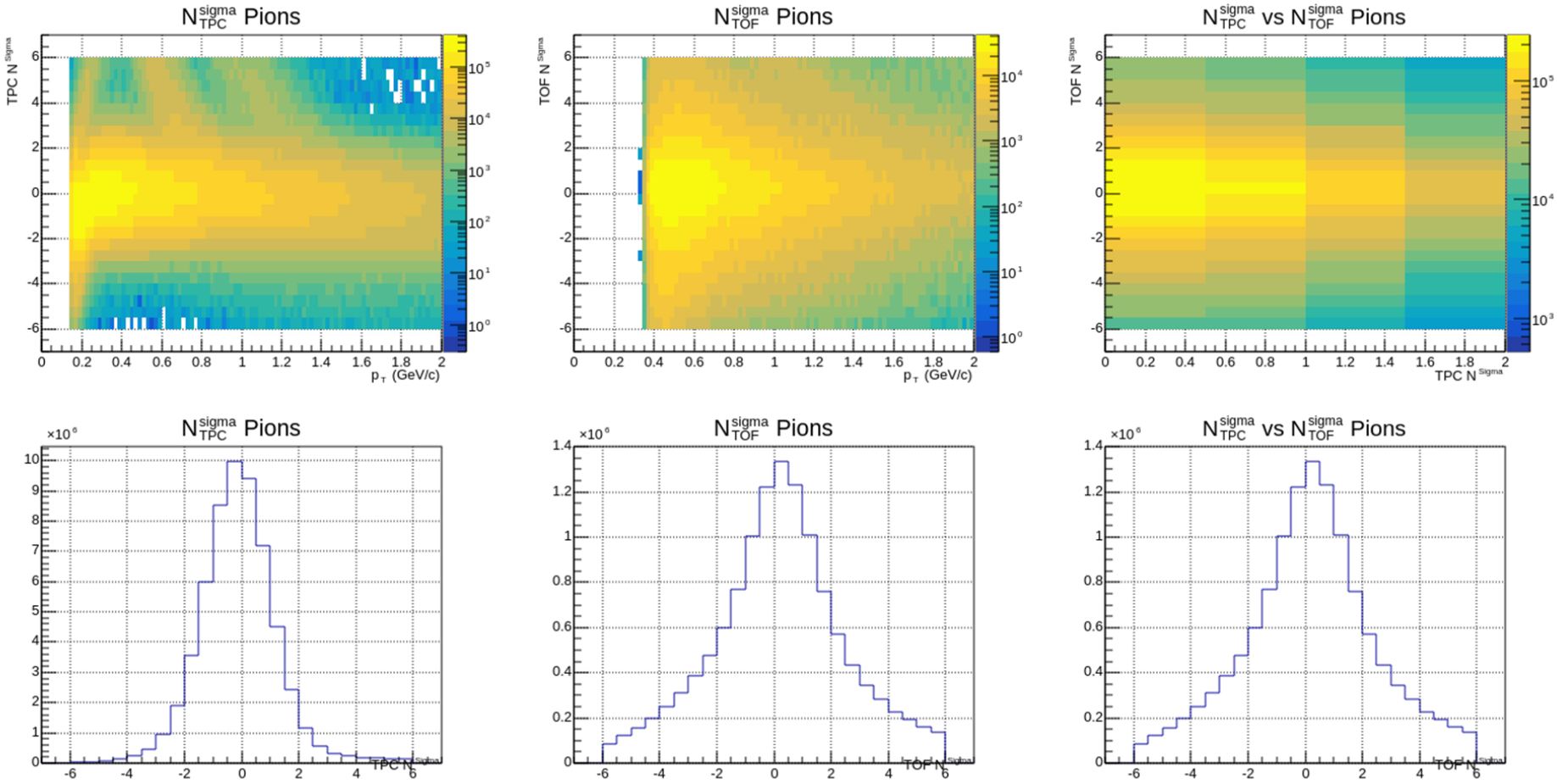


Figure: before PID : Pions

Quality Assurance PID : After PID

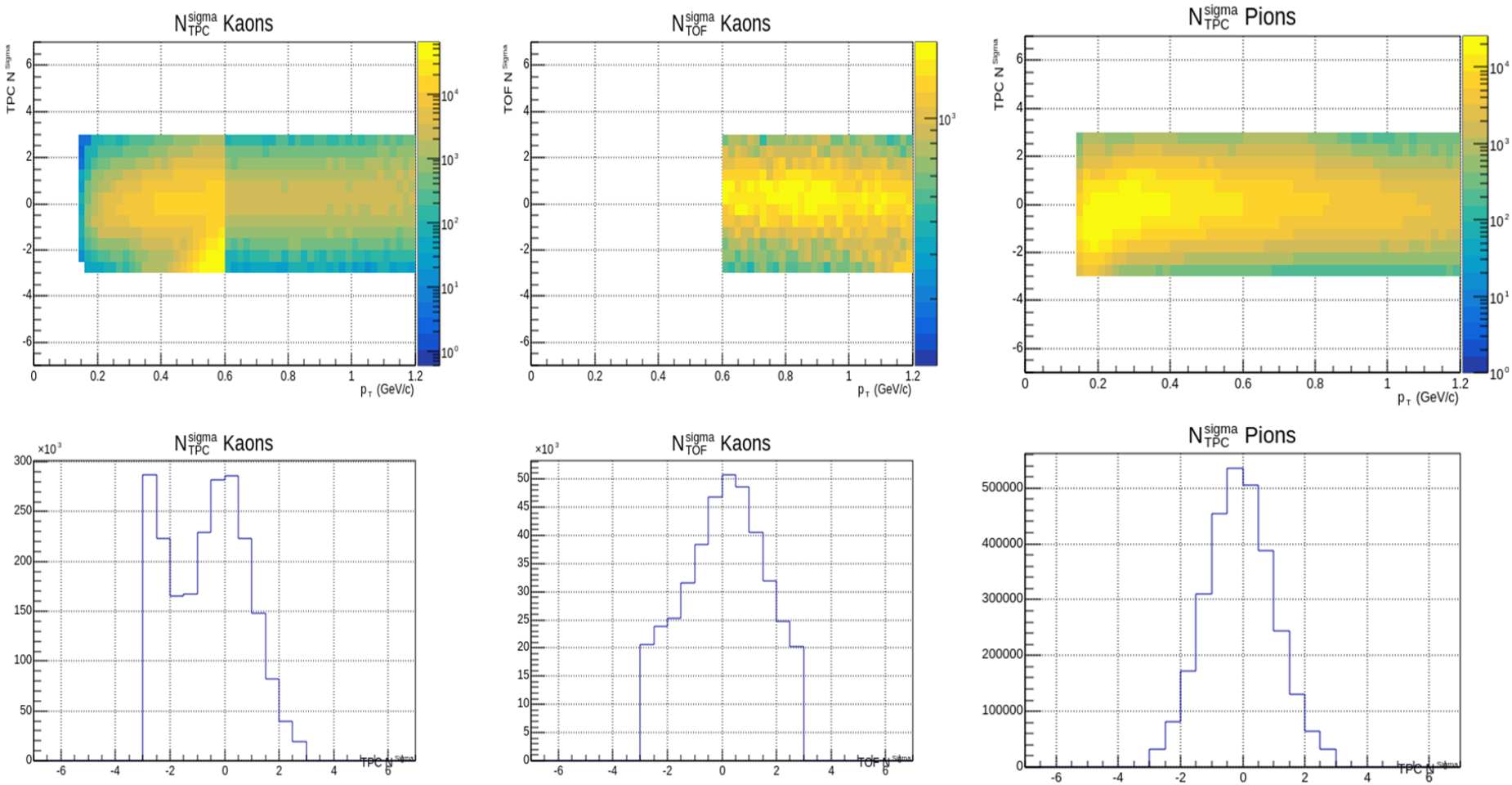


Figure: After PID

Results

Analysis Details

- **Spherocity Classes :**
  - 0 – 100 % FT0M 20 % Jetty :: Spherocity Range : 0.00 - 0.62.
  - 0 – 100 % FT0M 20 % Jetty & Isotropic Mixed :: Spherocity Range : 0.62 - 0.88.
  - 0 – 100 % FT0M 20 % Isotropic :: Spherocity Range : 0.88 - 1.00.
- Normalization mass range for like Sign Background in all Spherocity Classes : 1.1 - 1.4.
- Fitting is done using the Breit-Wigner Function.
- Fitting range : 0.64 - 1.14 (for all Spherocity(S_0) classes).

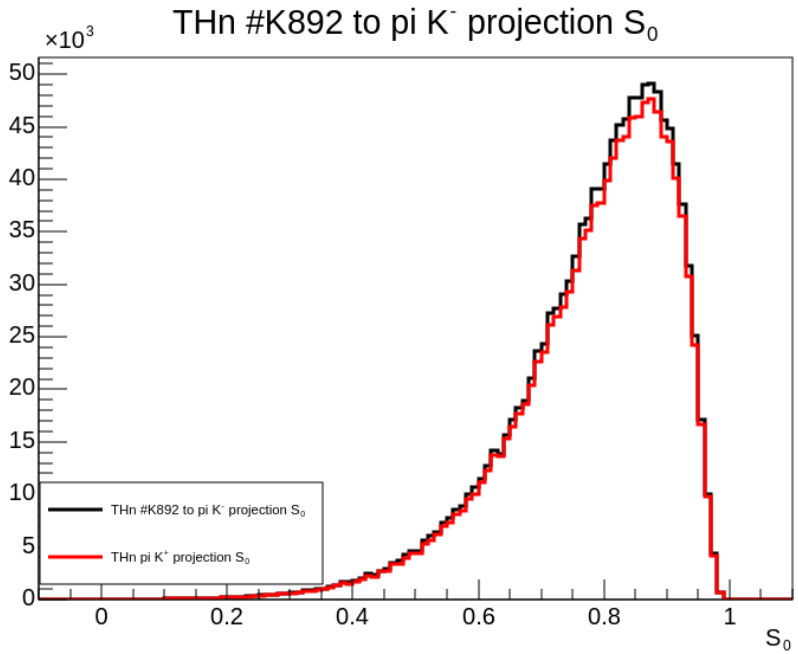


Figure: Transverse Spherocity distribution

$K^*(892)$ Invariant Mass

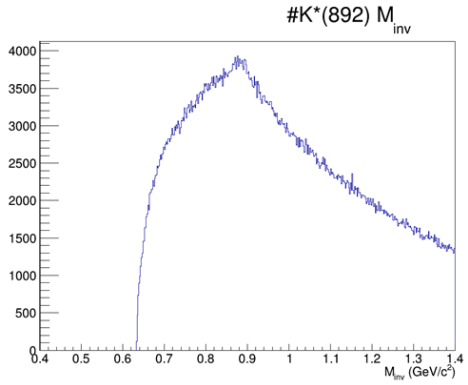


Figure: Unlike Sign($K^+\pi^-$ *or* $K^-\pi^+$)

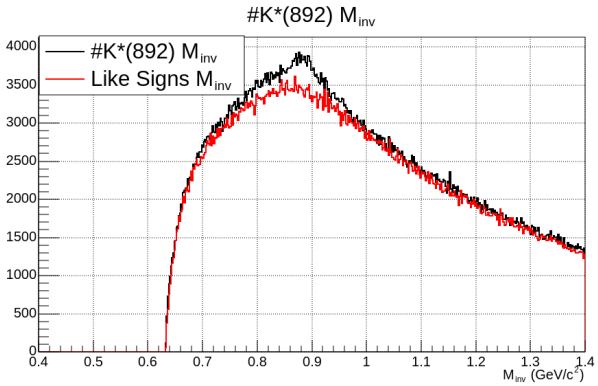


Figure: Unlike and Like Sign together

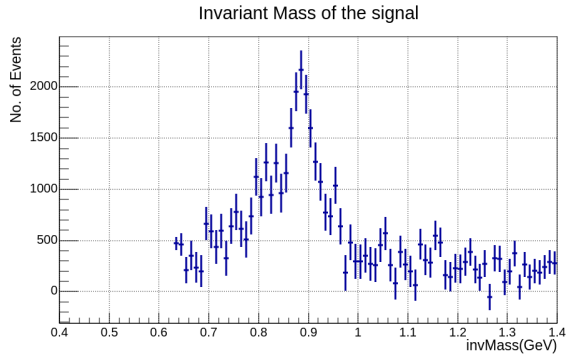


Figure: Extracted Signal(integrated P_T bins

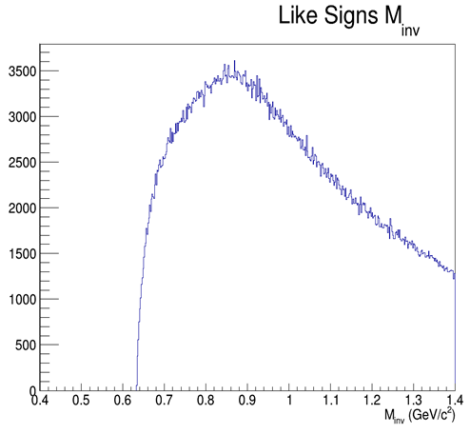


Figure: Like Sign($K^+\pi^+$ *or* $K^-\pi^-$)

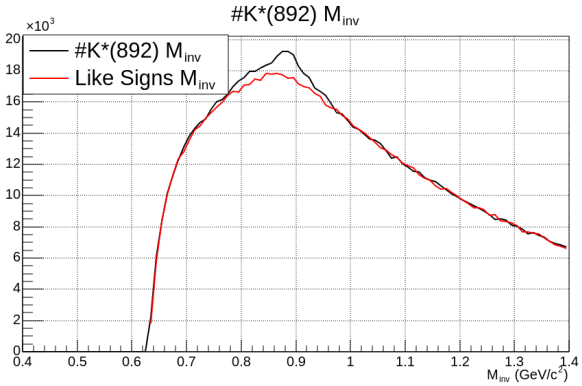


Figure: Normalization of Like Sign

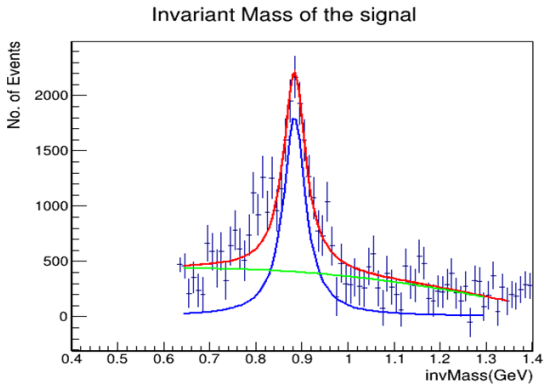
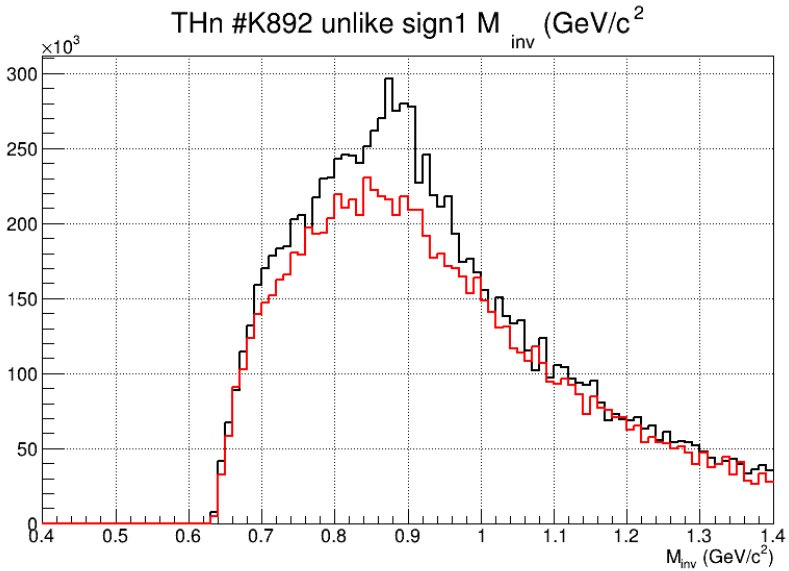
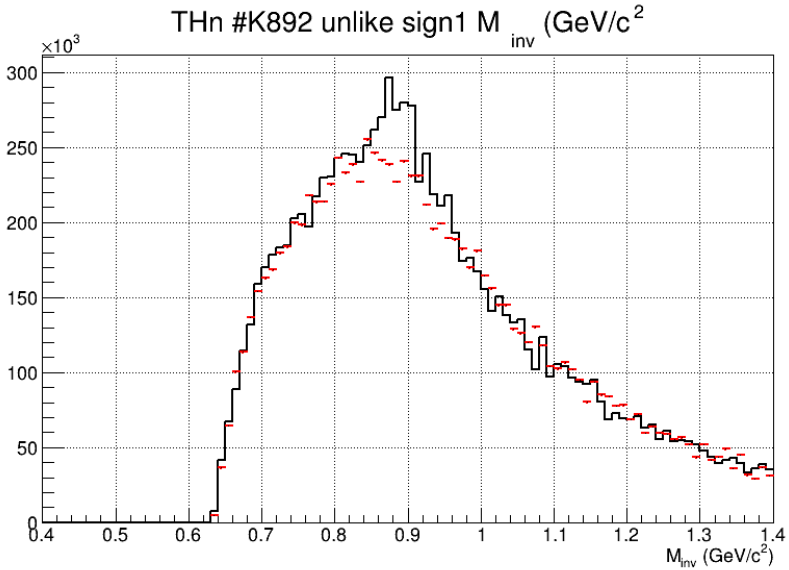
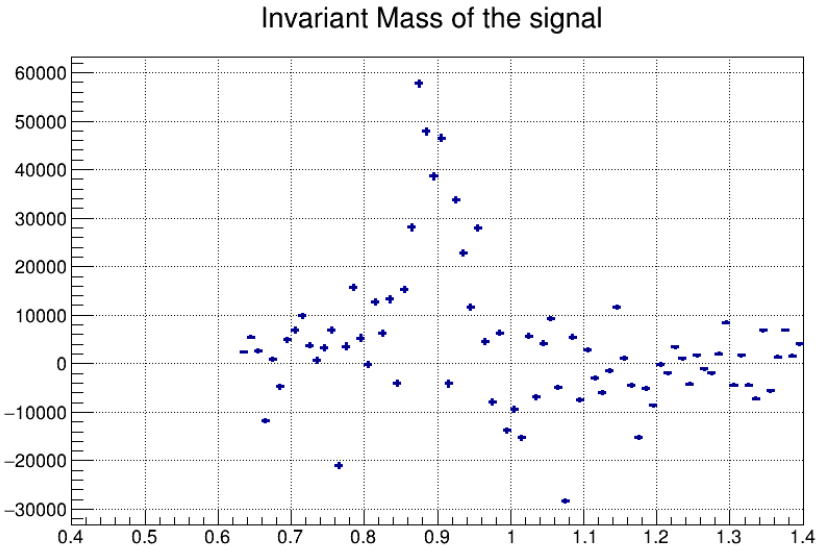


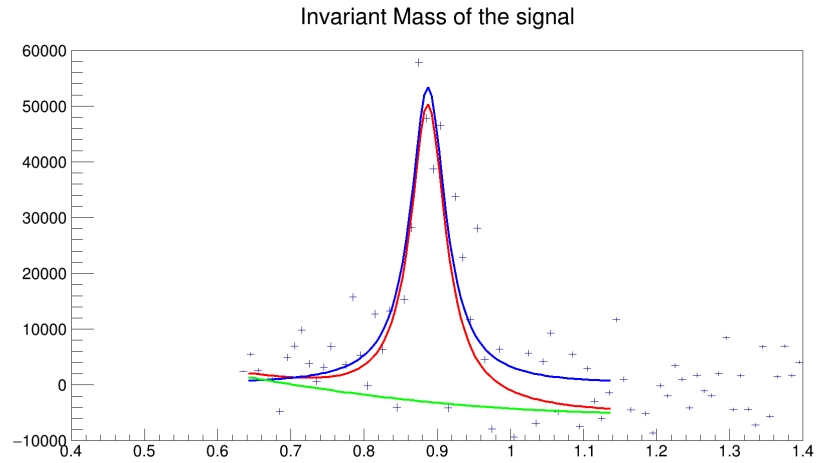
Figure: Fitting with Breit-Wigner Function

0 – 100% FT0M : 20% Jetty

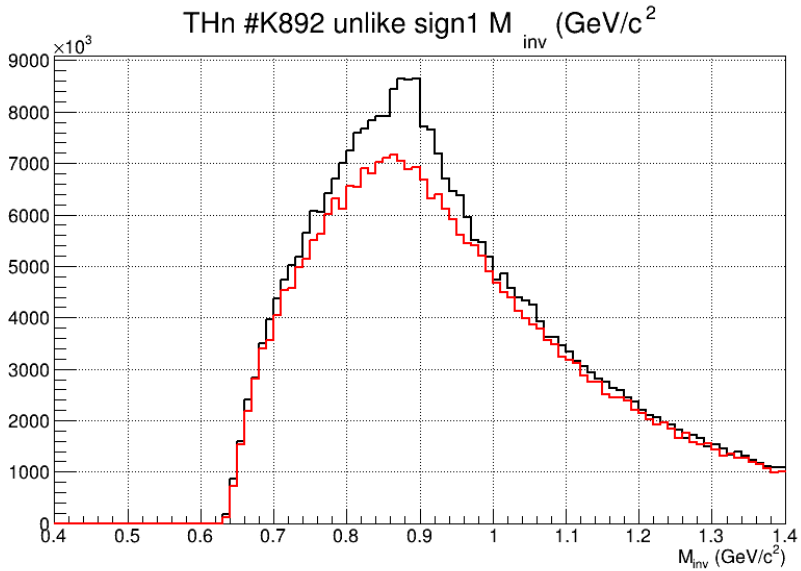


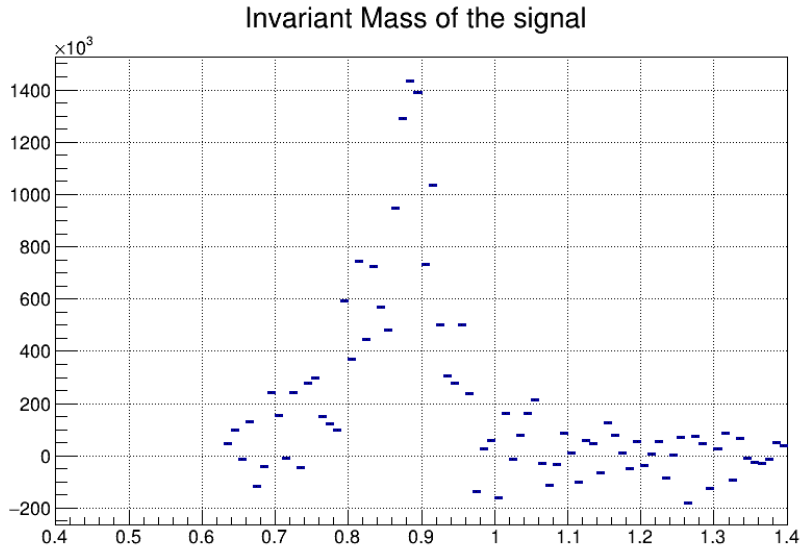


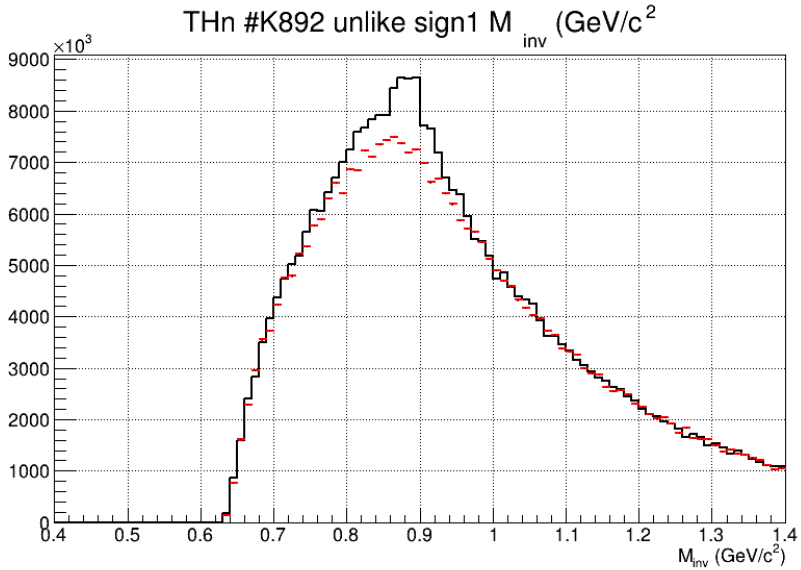


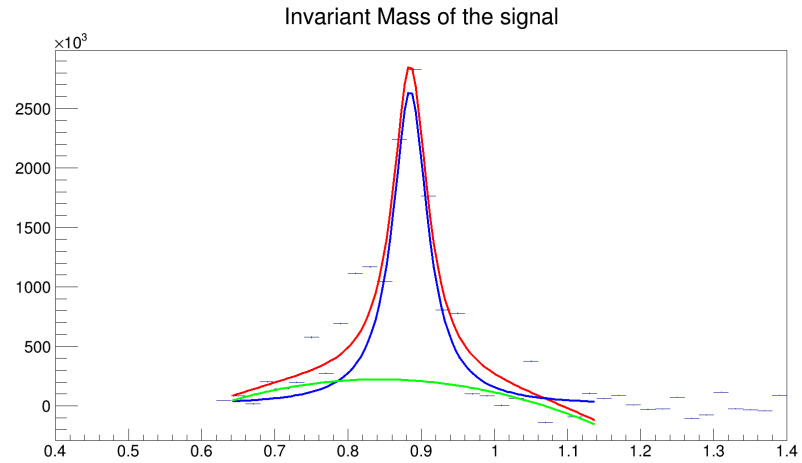


0 – 100% FT0M : 20 – 80% Jetty & Isotropic Mixed

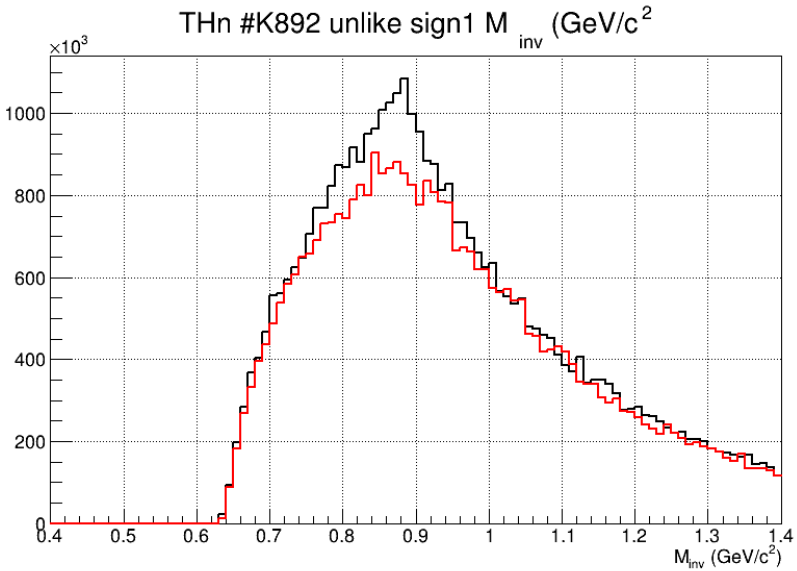


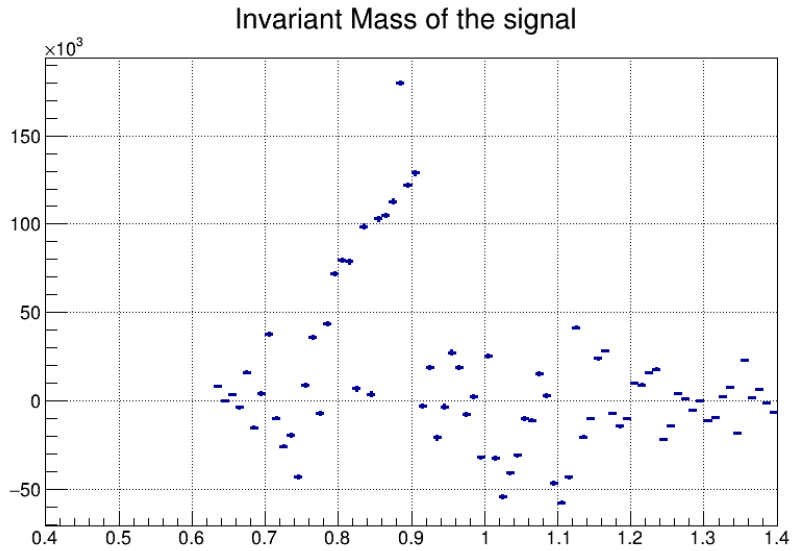


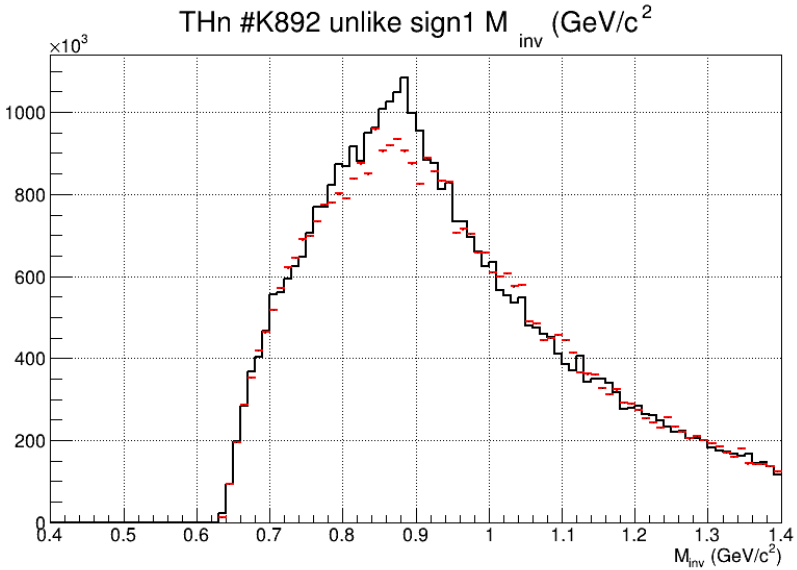


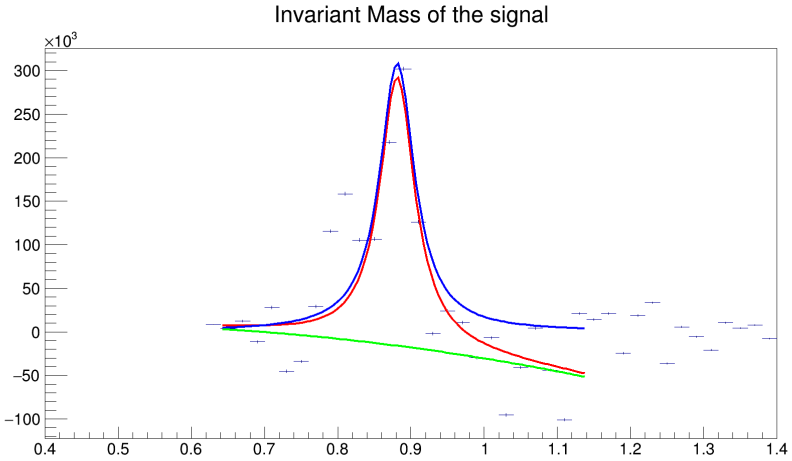


0 – 100% FT0M : 20% Isotropic









Conclusion and Future Work

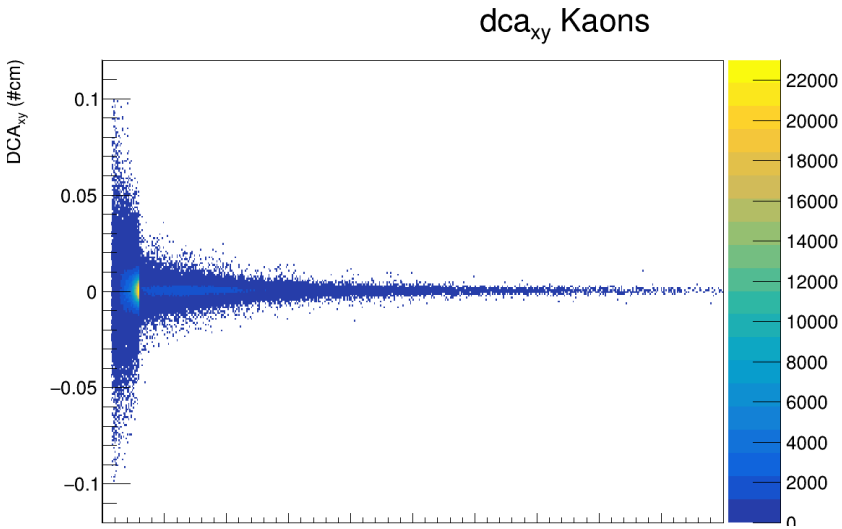
- Reconstruction of invariant mass distribution in integrated P_T bins was achieved successfully. Need to do it in the differential P_T bins.
- Peaks in the invariant mass distribution indicate a mass shift in the true mass of $K^*(892)$. Also need to see whether it also happens in differential P_T bins.
- We need to perform corrections and need higher statistics for that.

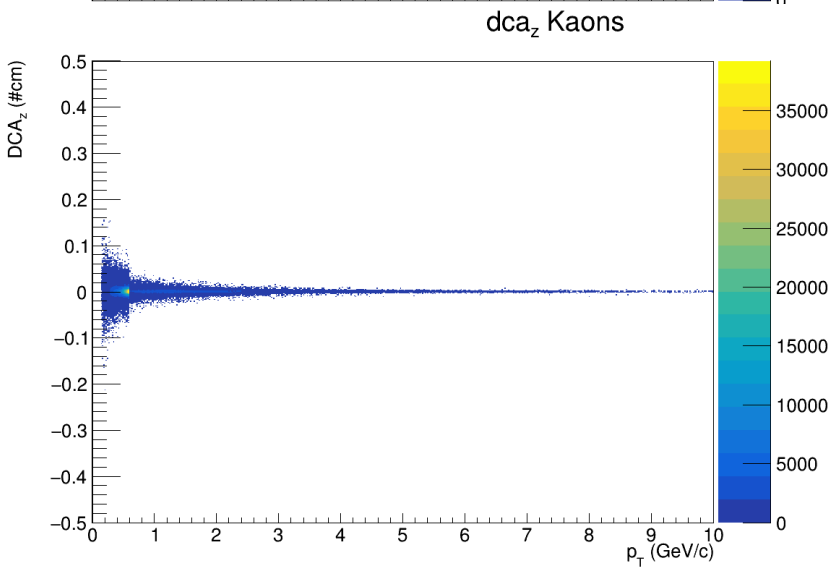
Comments, Questions?

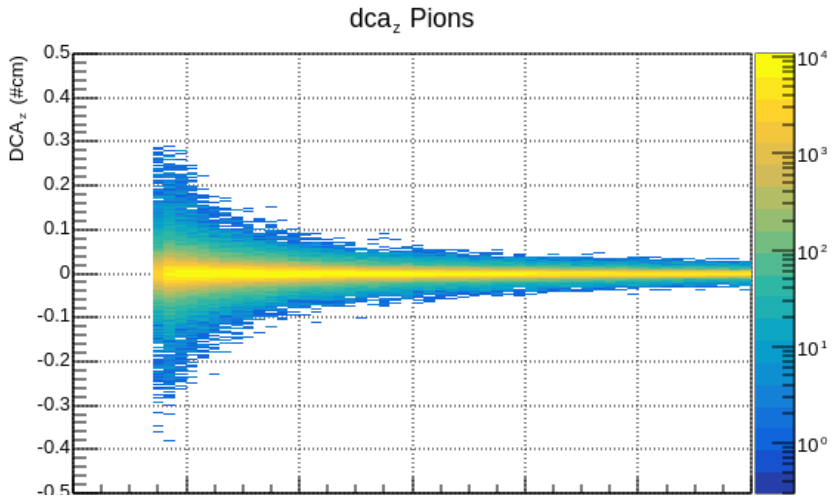
Thank  *you !!*

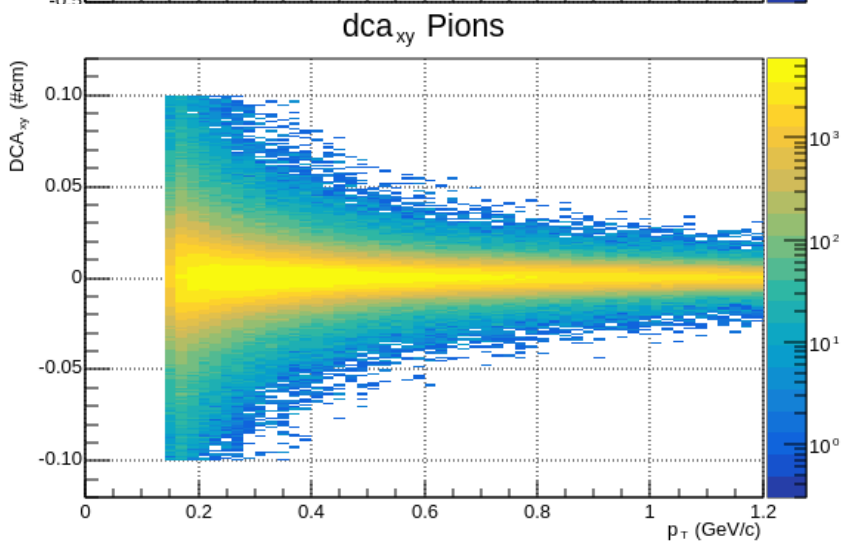
Backup

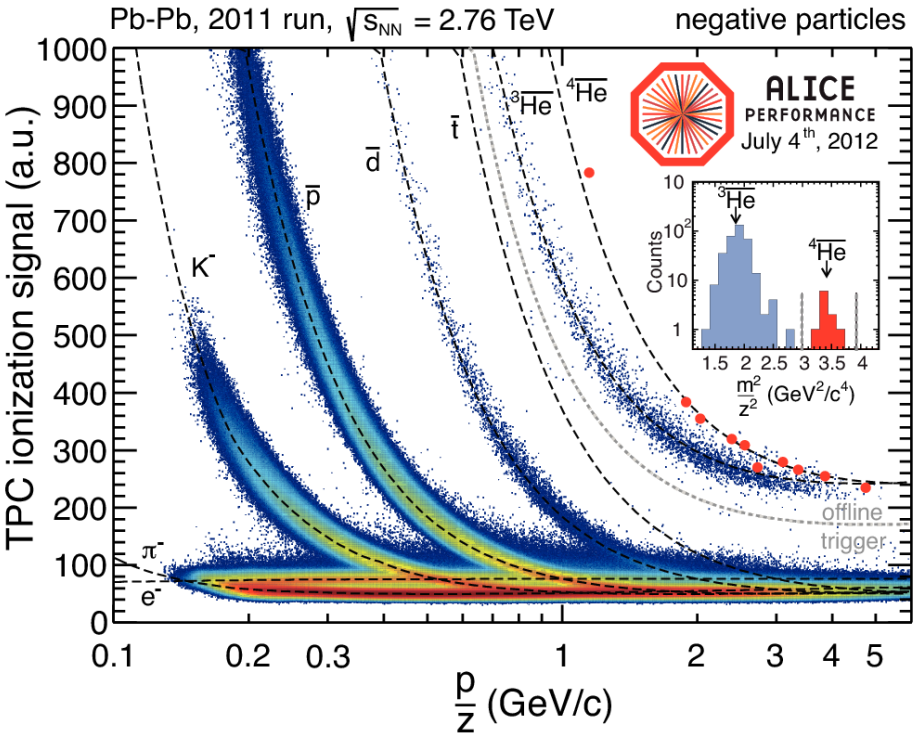
Quality Assurance

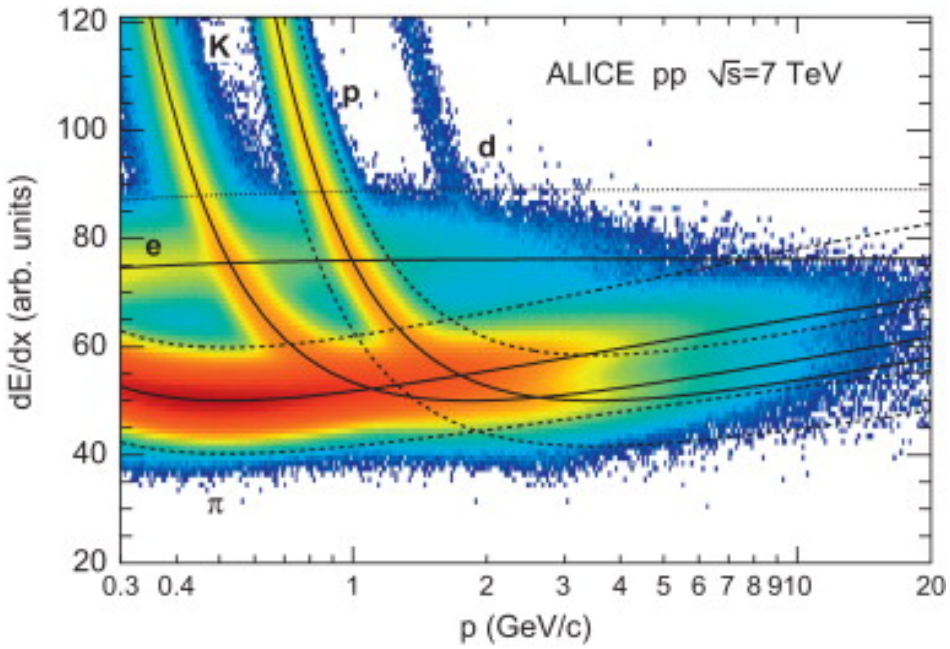




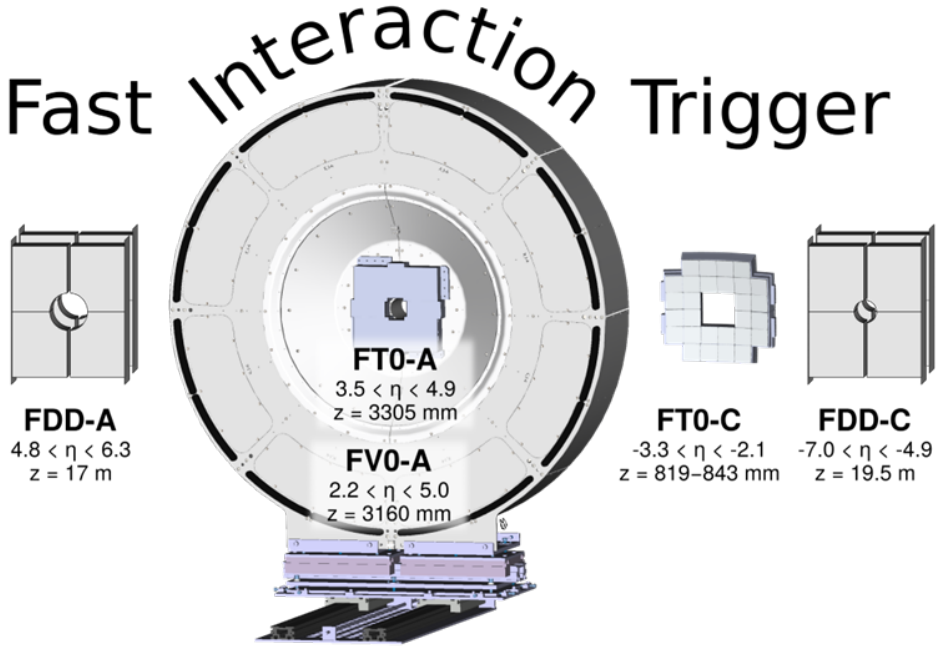








Specific energy loss (dE/dx) in the TPC v/s particle momentum


Fast Interaction Trigger
FDD-A
4.8 < η < 6.3
z = 17 m
FT0-A
3.5 < η < 4.9
z = 3305 mm
FV0-A
2.2 < η < 5.0
z = 3160 mm
FT0-C
-3.3 < η < -2.1
z = 819–843 mm
FDD-C
-7.0 < η < -4.9
z = 19.5 m