ALICE-STAR India Collaboration Meeting

Event-by-event $\langle p_T \rangle$ fluctuations in identified particle in Pb-Pb collisions at 5.36 TeV

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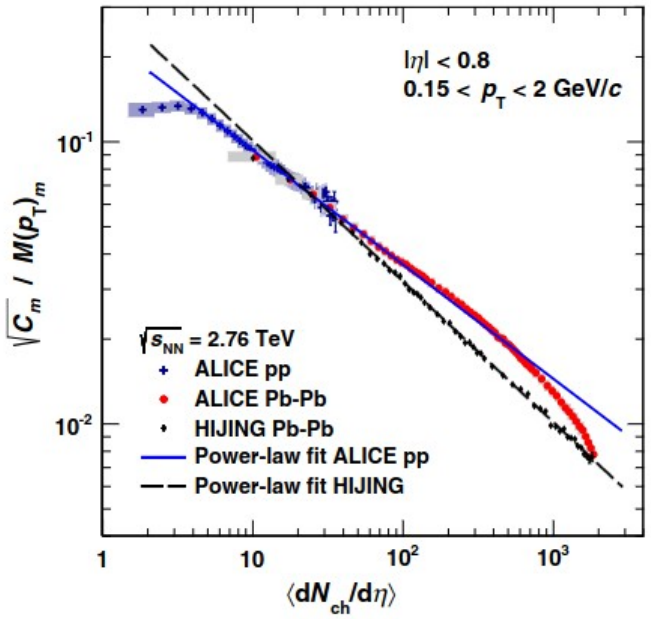
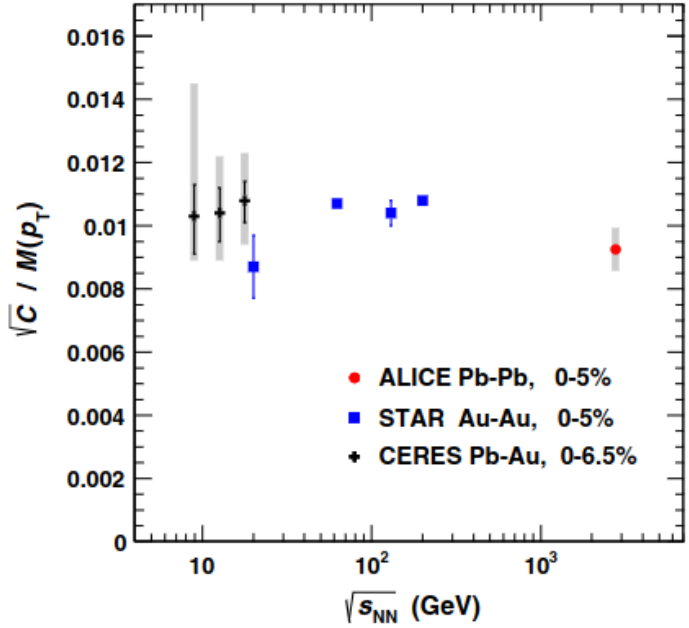
Under the supervision of

Prof. Zubayer Ahammed Prof. Shakeel Ahmad

Motivation:

B. Albeve et al., ALICE Coll., Eur. Phys. J. C 74 (2014) 3077

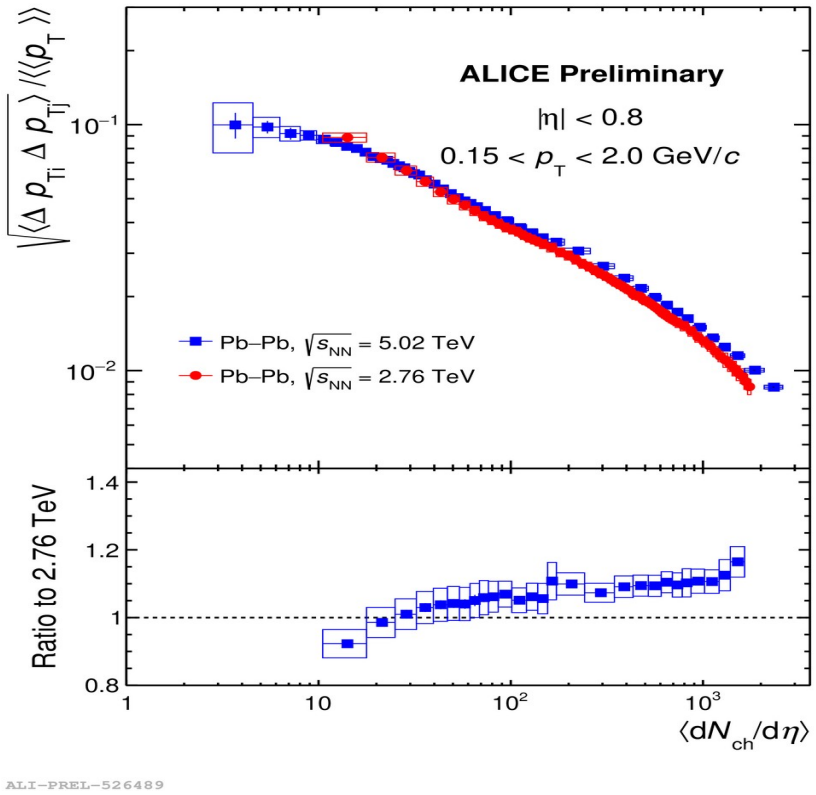




$\sqrt{C_m}$ / M(p_T) decreases with <$dN_{ch}/d\eta$> and follow a power law.

Eur. Phys. J. C (2014) 74:3077

Motivation:



https://alice-figure.web.cern.ch/node/24008

- EbyE M(p_T) in Heavy-ion collisions are composed of statistical and dynamical contributions.
- Two particle transverse momentum correlator (C_m) is a measure of dynamical fluctuations.
- For Pb-Pb collisions, significant dynamical fluctuations as well as a strong decrease with multiplicity are observed.

Observable: Two particle correlator

- Two particle p_T correlator using cumulant method:

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

where,

$$Q_1 = \sum_i^{Nch} pi$$

$$Q_2 = \sum_i^{Nch} pi * pi$$

https://alice-notes.web.cern.ch/node/1231

Analysis Details:

- **Dataset**: LHC23zzf_pass2
- **System**: Pb-Pb (5.36TeV)
- **Events**: 0.1M

Events selection criterion:

- |Vz| < 10 cm
- Sel8()
- Centrality- FT0C

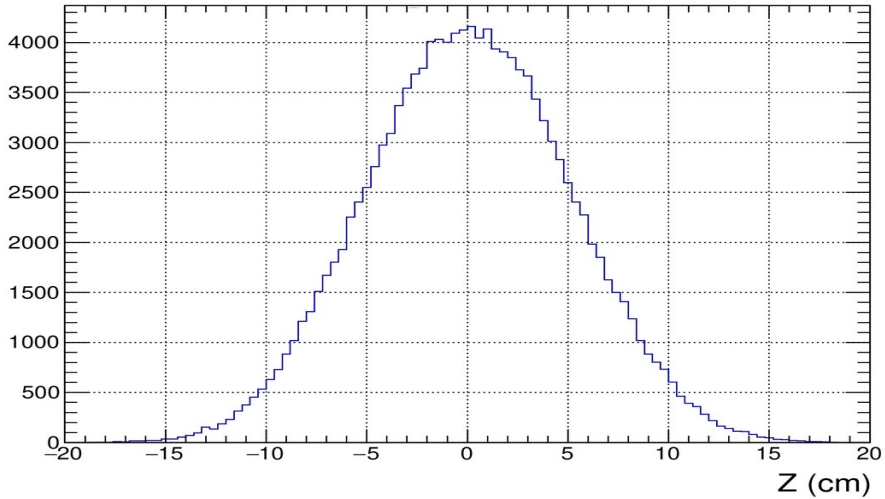
Track selection criterion:

- Global Tracks()
  - ✔ One hit in any of the SPD layers required
  - ✔ ITS refit required
  - ✔ χ2/ ITS cluster < 32
  - ✔ atleast least 70 TPC clusters
  - ✔ TPC refit required
  - ✔ χ2/ TPC cluster < 4
  - ✔ reject kink daughters
  - ✔ DCA_{xy} < 0.0182 cm
  - ✔ DCA_{z} < 2 cm
  - ✔ Global TPC χ2 < 32
- |η| < 0.8
- |y| < 0.5
- 0.15 < p_T < 2.0 GeV/c

https://alice-notes.web.cern.ch/node/1408

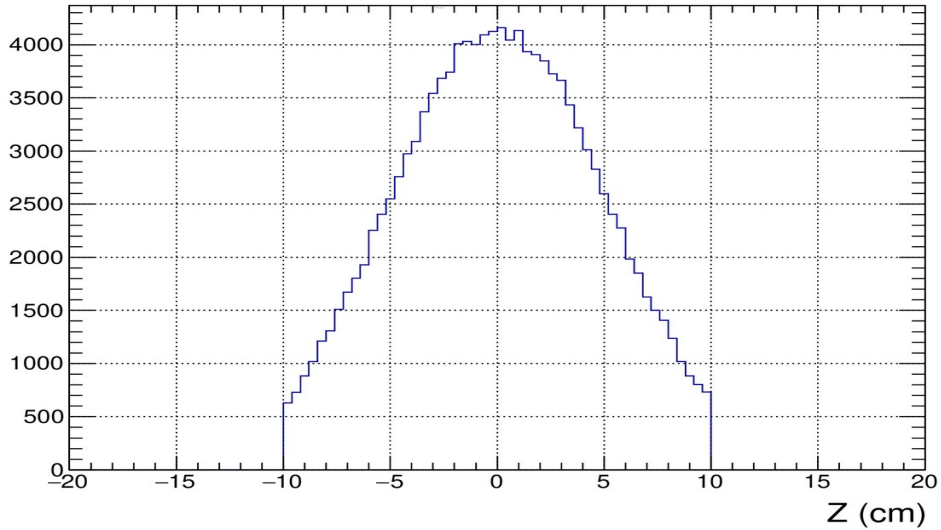
V_z distribution:

before selection



No. of Events: 133467

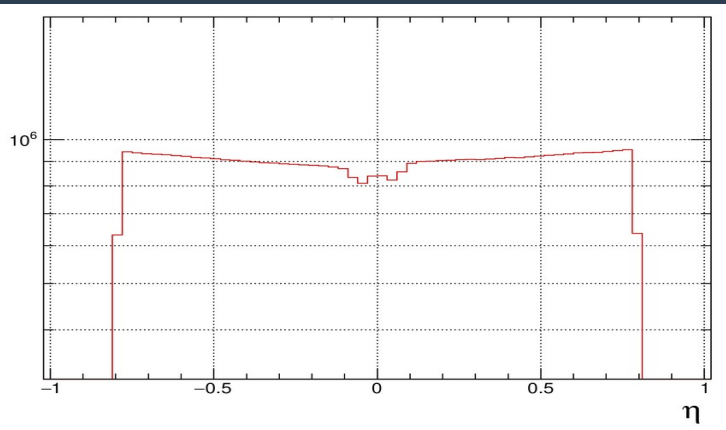
after selection



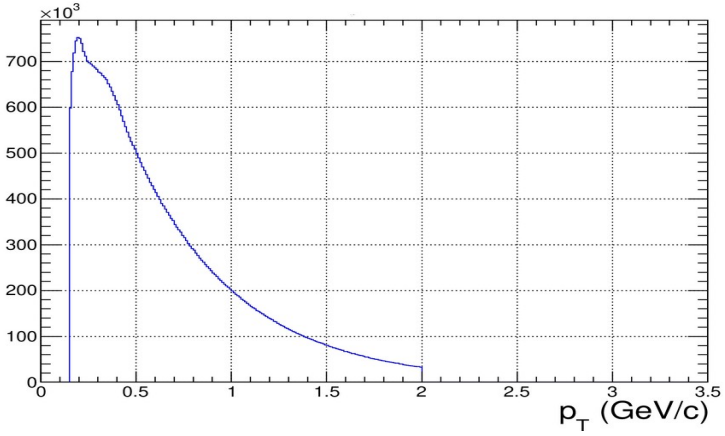
No. of Events: 122674

8.08% decrease

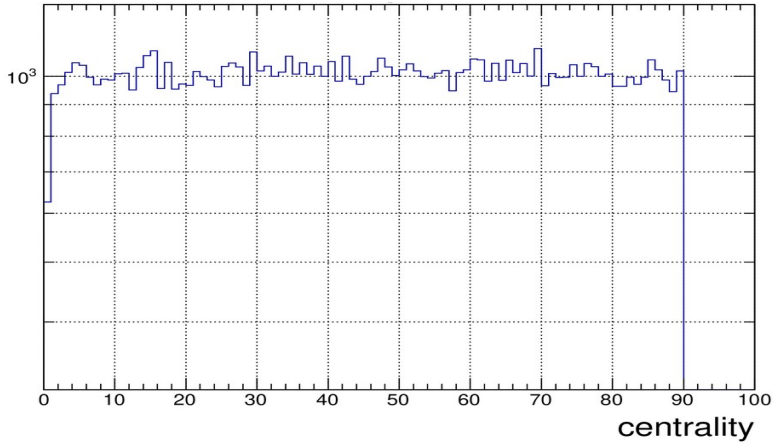
η - distribution



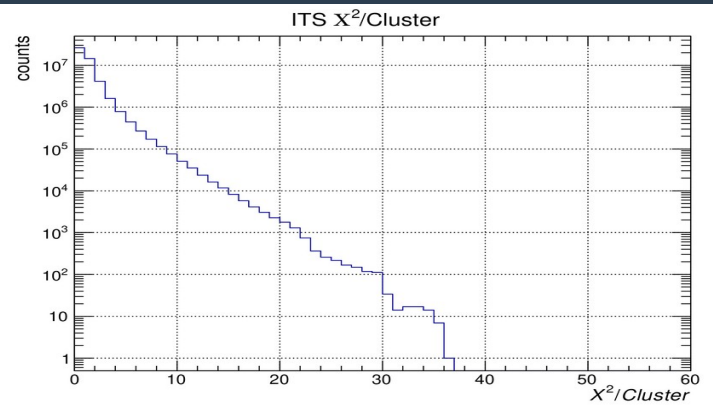
p_T- distribution



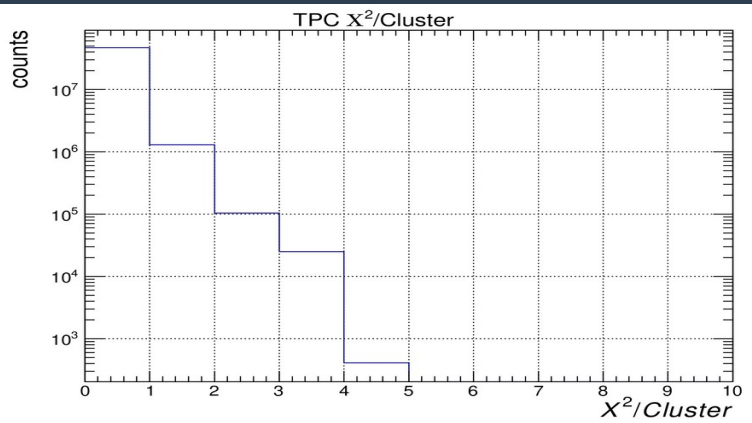
centrality



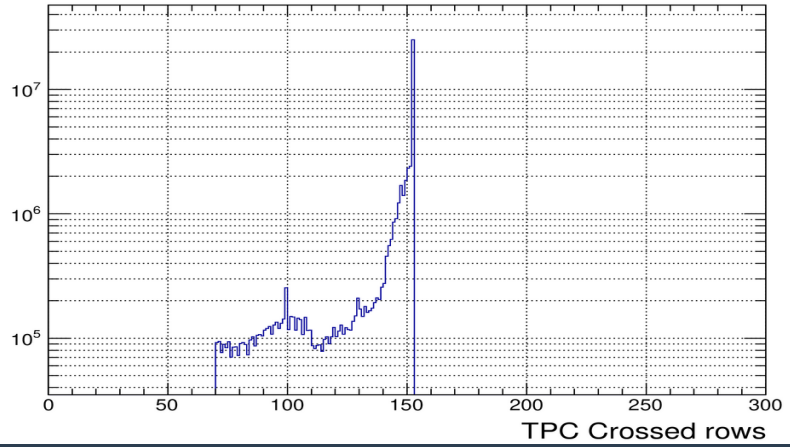
ITS X^2 /cluster



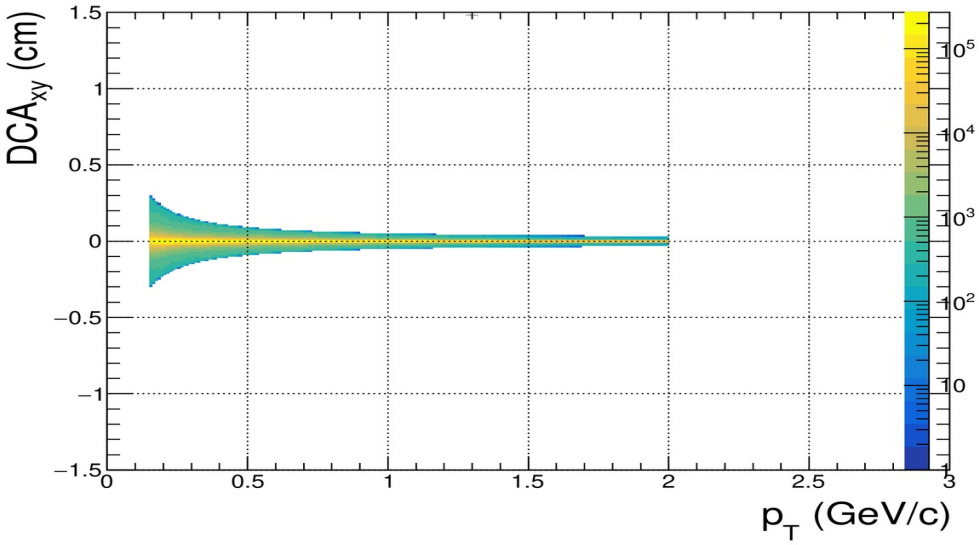
TPC X^2 /cluster



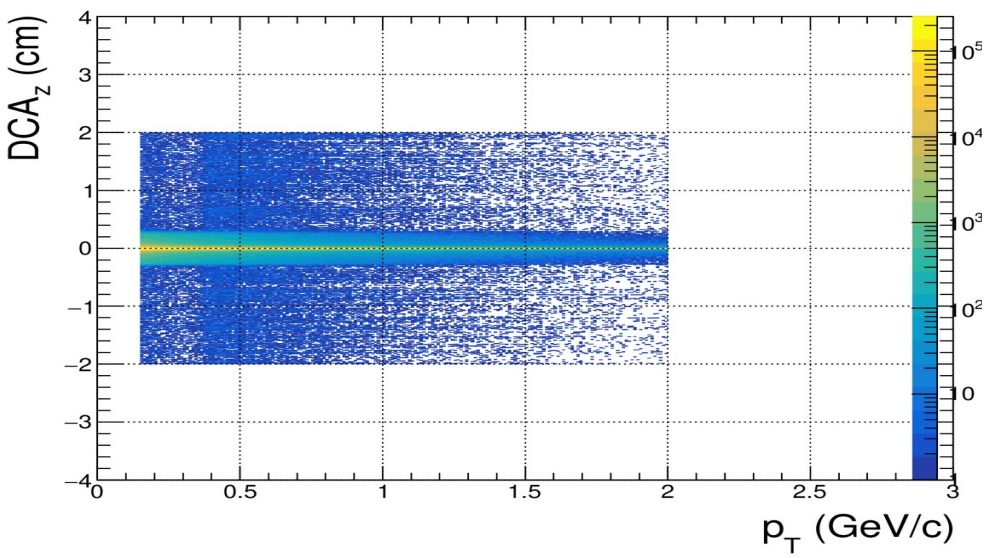
Number of crossed TPC rows



DCA$_{xy}$ vs p_T



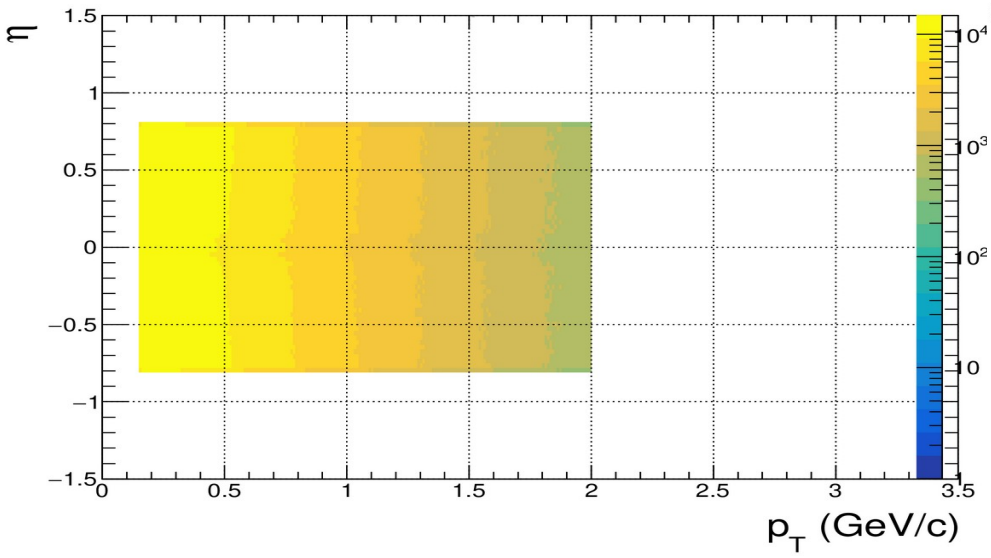
DCA$_z$ vs p_T



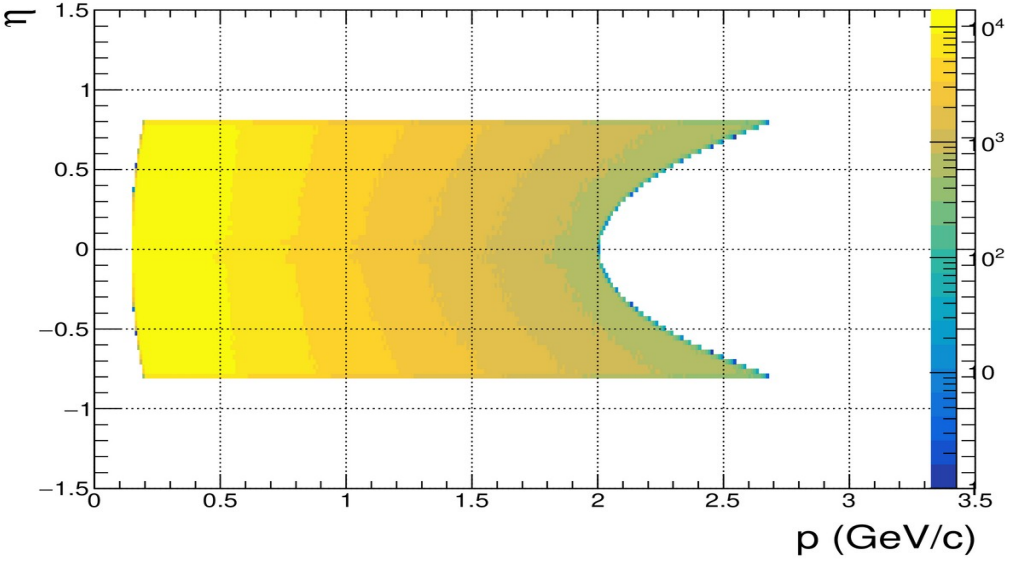
DCA$_{XY}$ < 0.02 cm

DCA$_z$ < 2 cm

η vs p_T


η
1.5
1
0.5
0
−0.5
−1
−1.5
0
0.5
1
1.5
2
2.5
3
3.5
p_T (GeV/c)
10^4
10^3
10^2
10
1

η vs p


η
1.5
1
0.5
0
−0.5
−1
−1.5
0
0.5
1
1.5
2
2.5
3
3.5
p (GeV/c)
10^4
10^3
10^2
10
1

PID Selection:

Pions, Kaons

p_T: [0.15, 0.65] GeV/c

- track.hasTPC()
- $|N_{\sigma TPC(\pi)}| < 2$
- $|N_{\sigma TPC(k)}| > 2$, $|N_{\sigma TPC(p)}| > 2$
- $|N_{\sigma TPC(e)}| > 1$

p_T: [0.65, 2.0] GeV/c

- track.hasTPC()
- track.hasTOF()
- $|N_{\sigma TPC\text{-}TOF(\pi)}| < 2$
- $|N_{\sigma TOF(k)}| > 2$, $|N_{\sigma TOF(p)}| > 2$
  - $N_{\sigma TPC\text{-}TOF} = (N^2_{\sigma TPC} + N^2_{\sigma TOF})^{1/2}$

p_T: [0.4, 0.85] GeV/c

- track.hasTPC()
- $|N_{\sigma TPC(p)}| < 2$
- $|N_{\sigma TPC(\pi)}| > 2$, $|N_{\sigma TPC(k)}| > 2$
- $|N_{\sigma TPC(e)}| > 1$

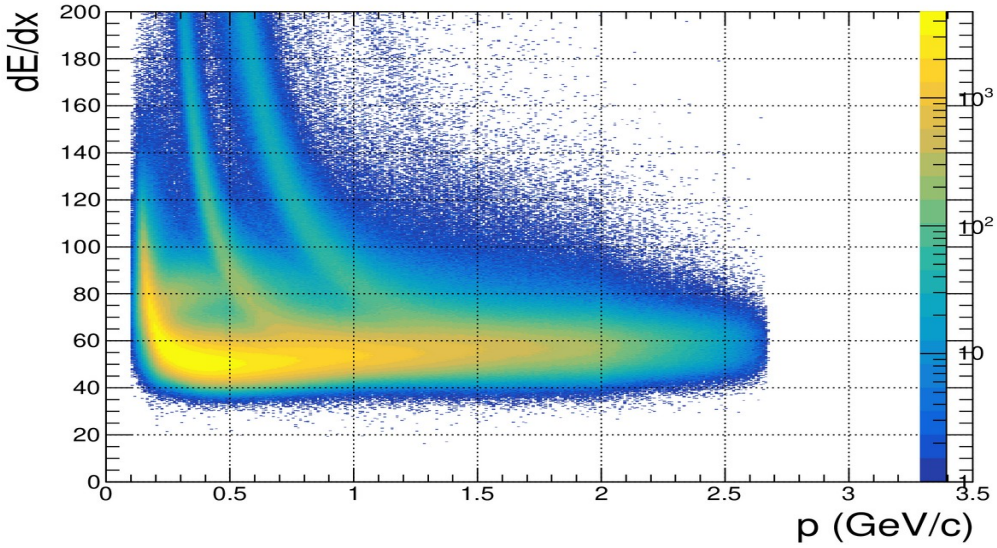
p_T: [0.85, 2.0] GeV/c

- track.hasTPC()
- track.hasTOF()
- $|N_{\sigma TPC\text{-}TOF(p)}| < 2$
- $|N_{\sigma TOF(\pi)}| > 2$, $|N_{\sigma TOF(k)}| > 2$
  - $N_{\sigma TPC\text{-}TOF} = (N^2_{\sigma TPC} + N^2_{\sigma TOF})^{1/2}$

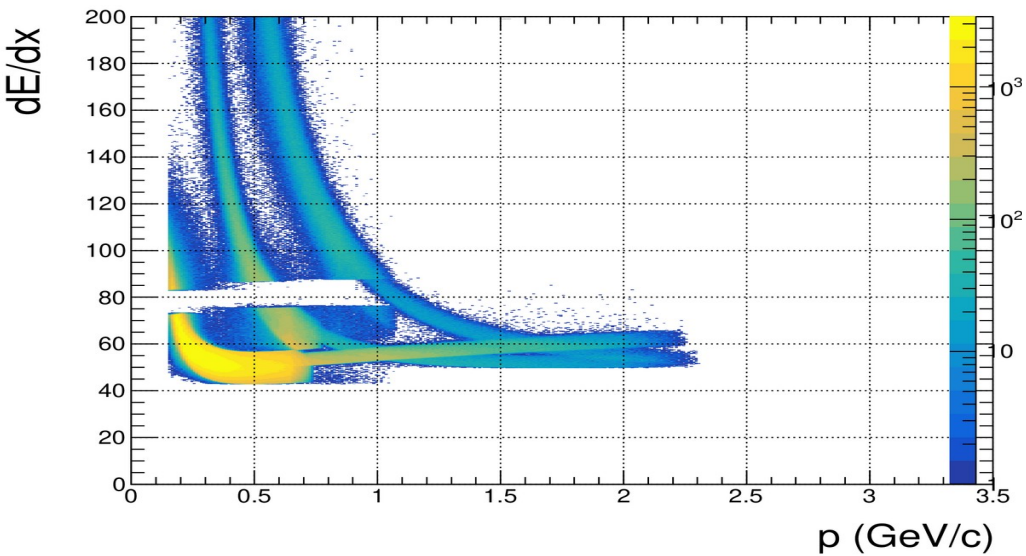
Protons

dE/dx vs *p*:

before selection

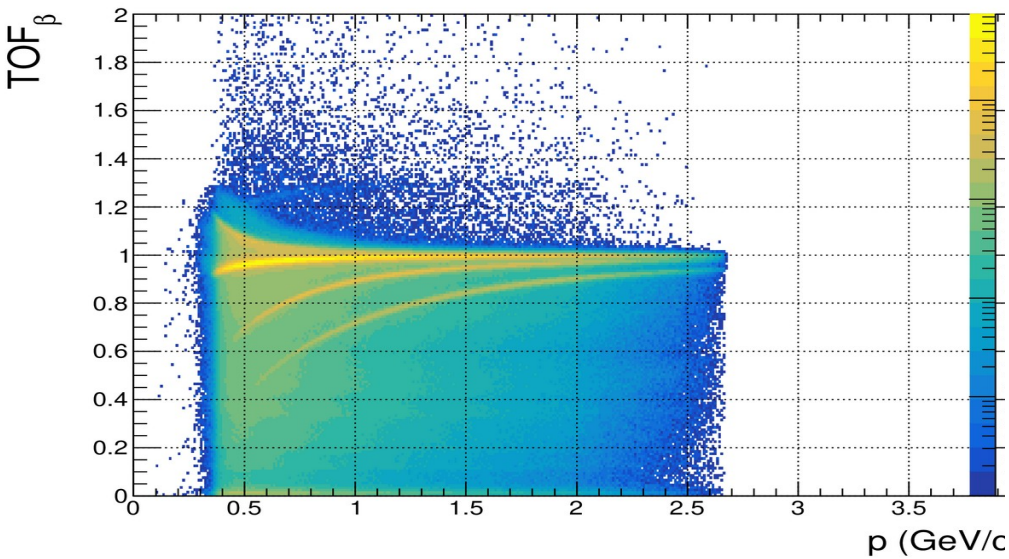


after selection

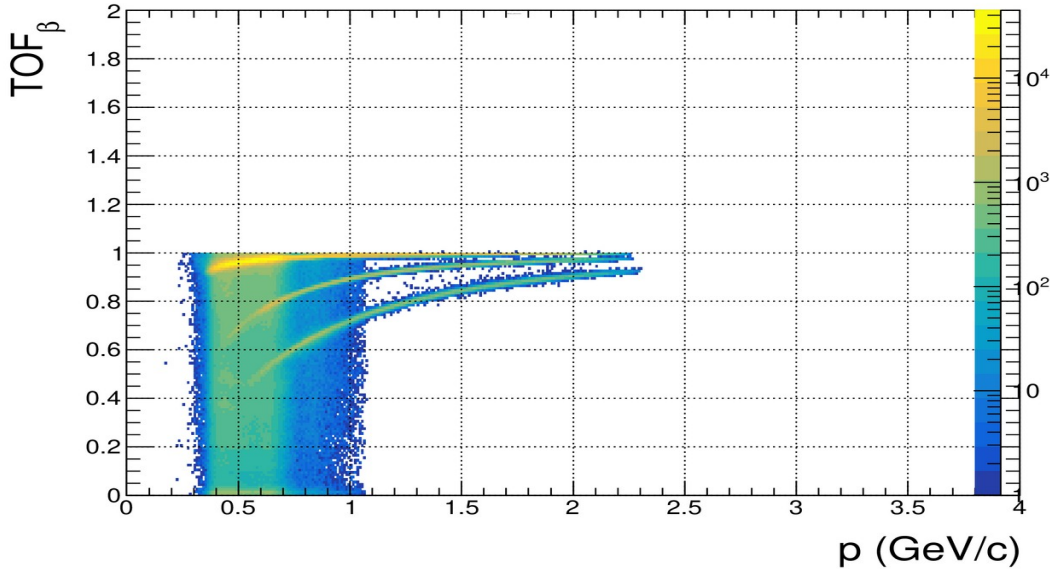


TOF_β vs *p*:

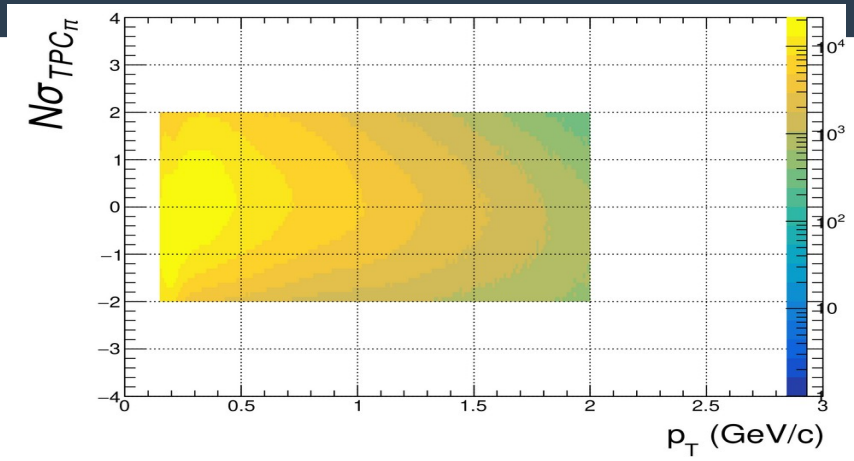
before selection

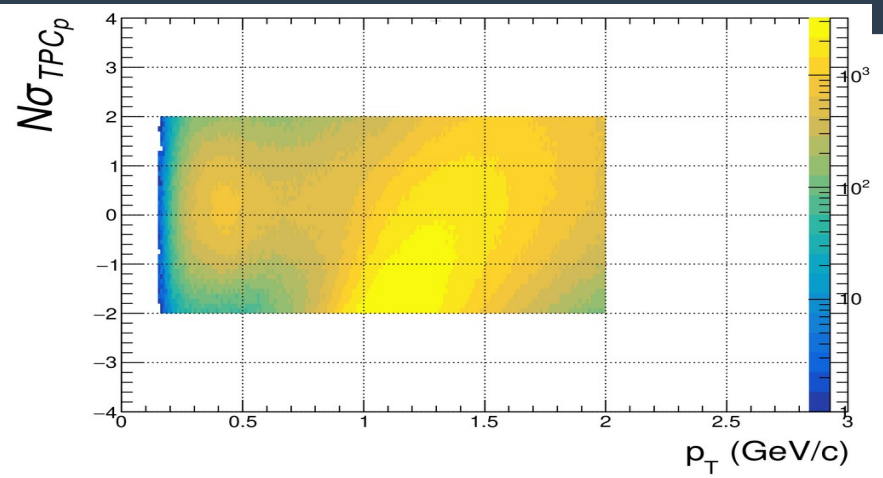


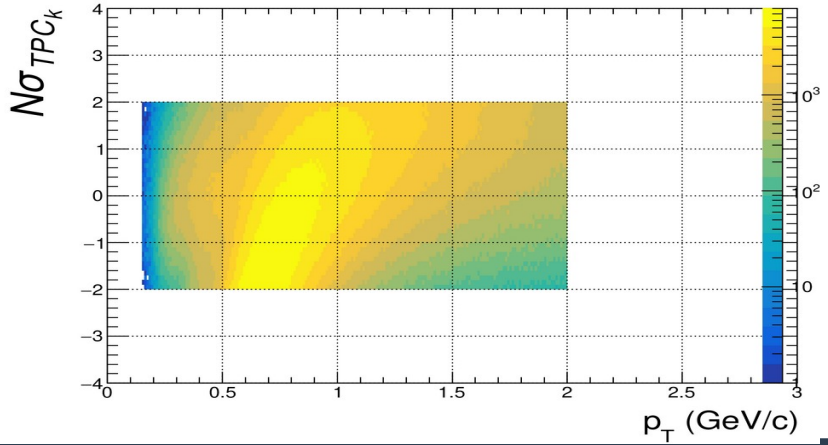
after selection



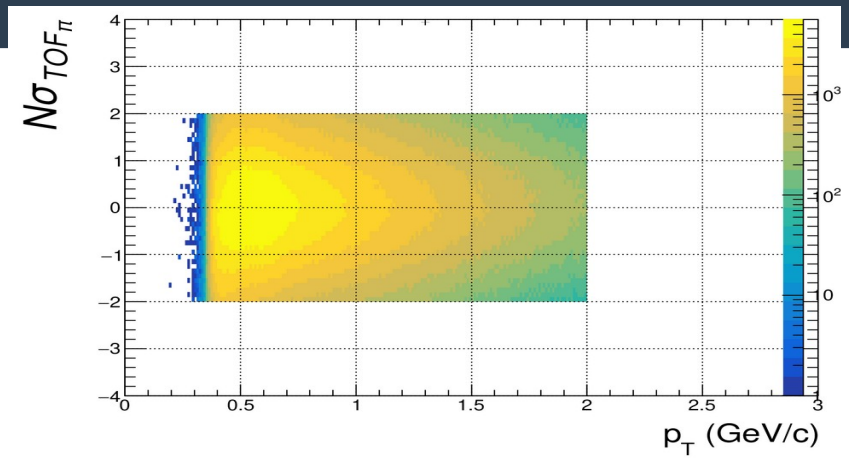
$N_{\sigma TPC}$ vs p_T for identified particles:

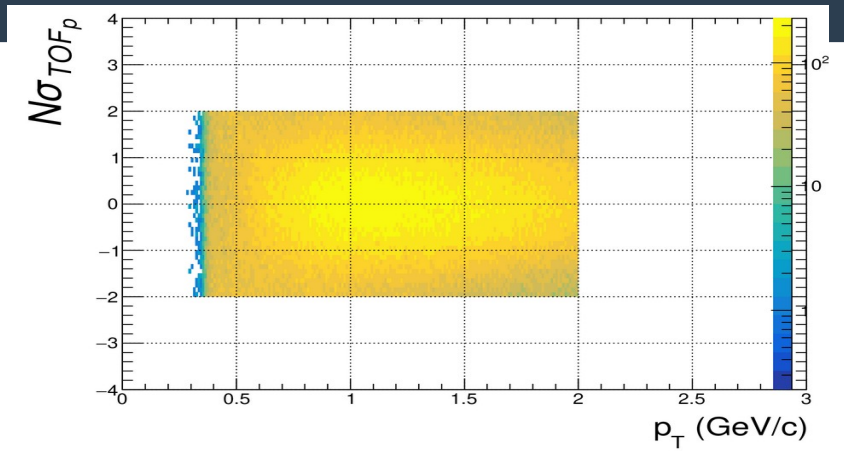


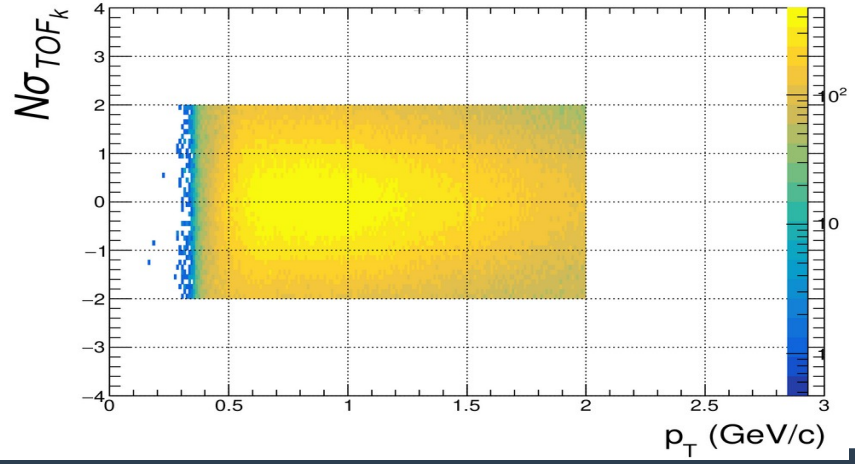




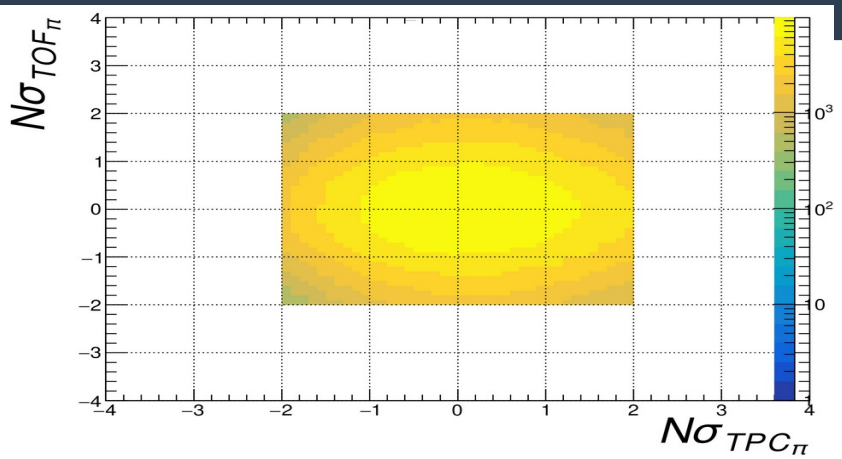
$N_{\sigma TOF}$ vs p_T for identified particles:

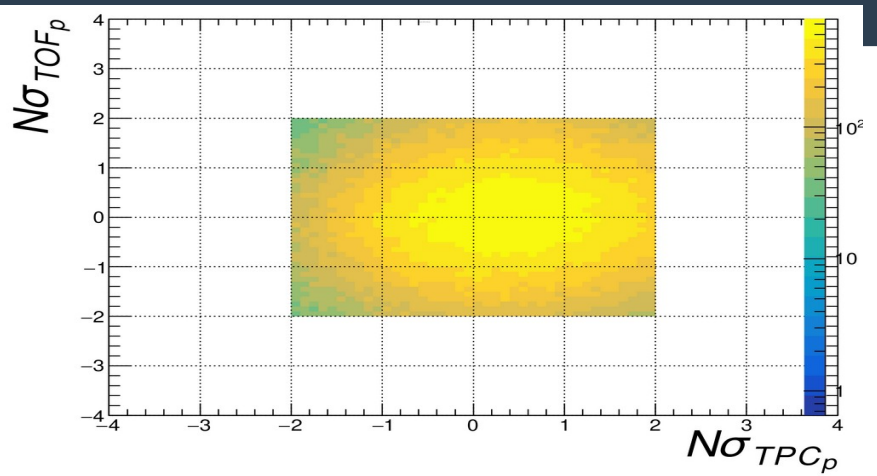


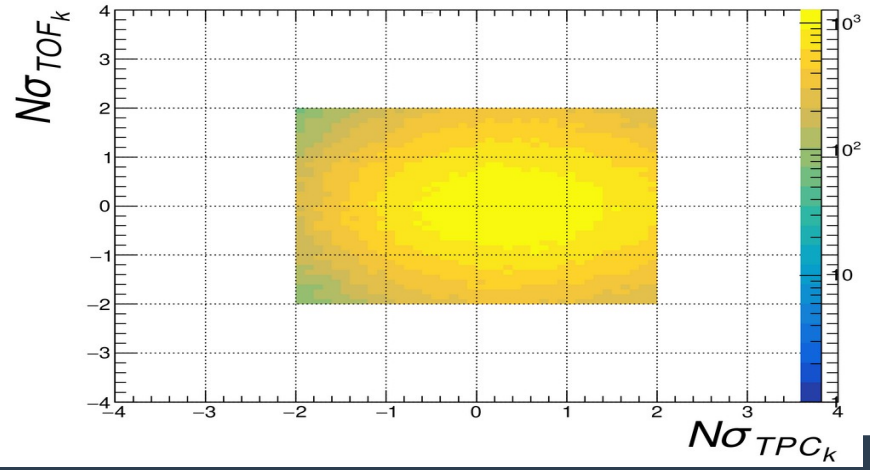




$N_{\sigma TOF}$ vs $N_{\sigma TPC}$ for identified particles:

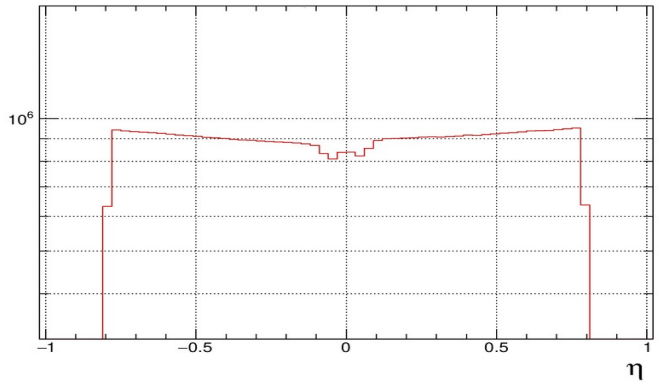




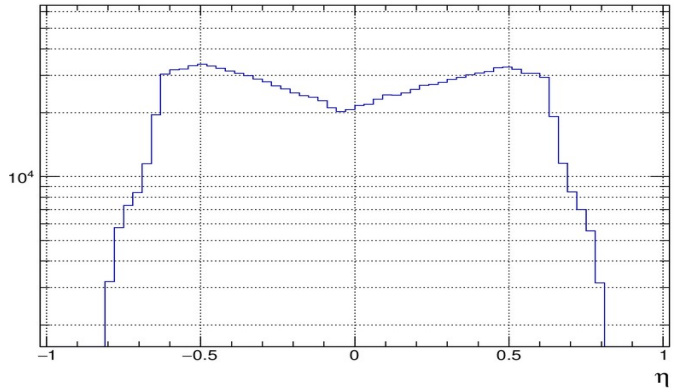


η- distribution for all species:

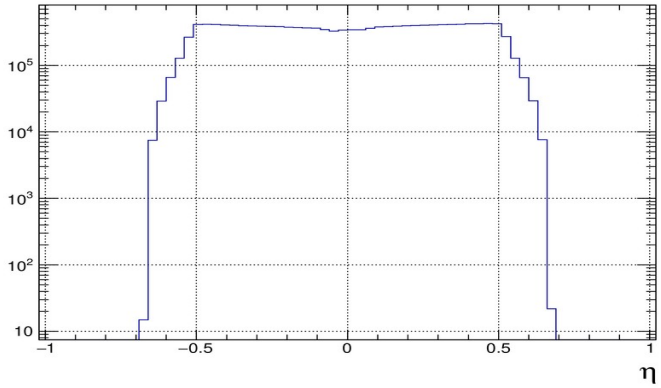
η allcharge



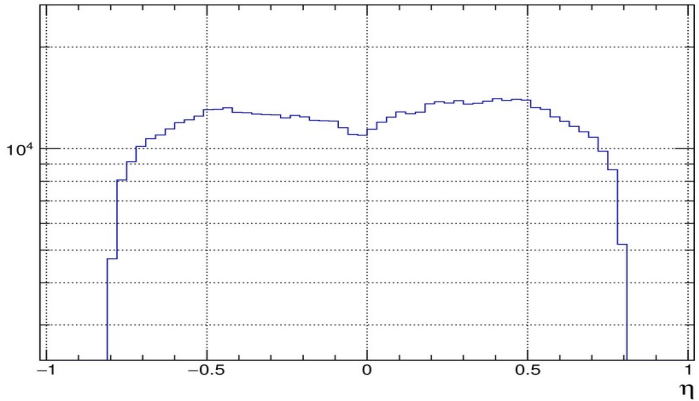
η kaon



η pion

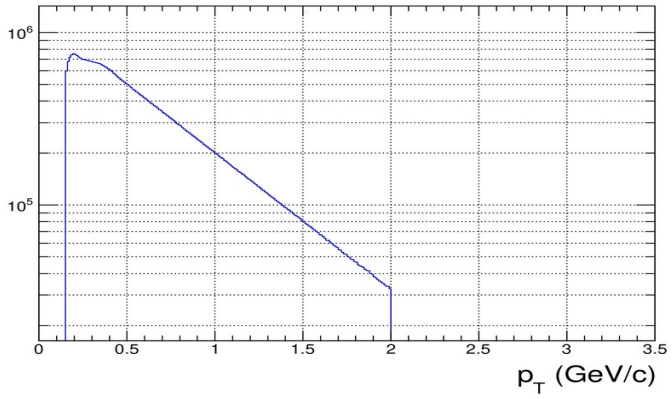


η proton

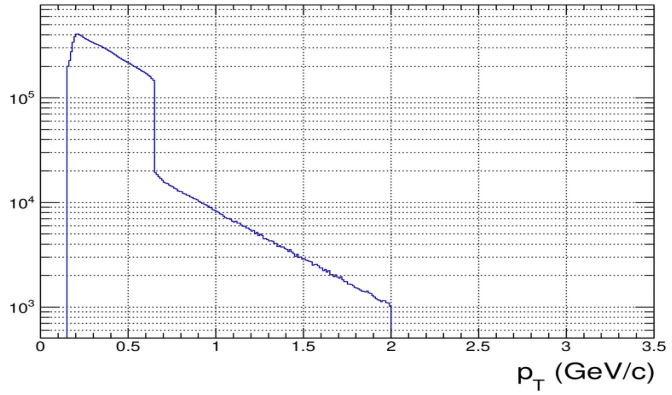


p_T distribution for identified particles:

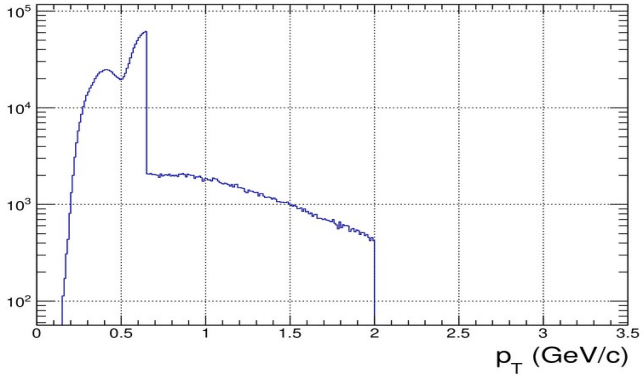
p_T allcharge



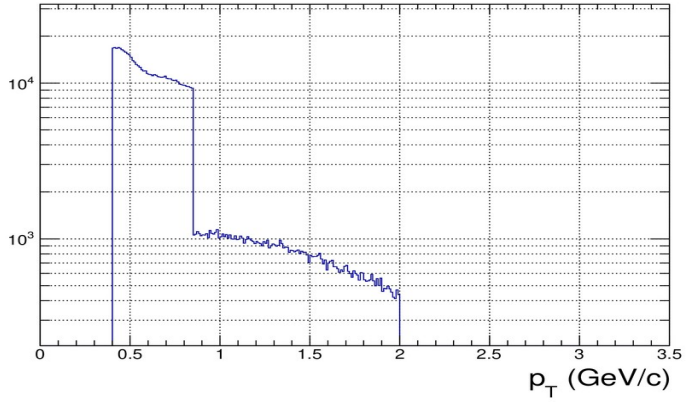
p_T pion



p_T kaon

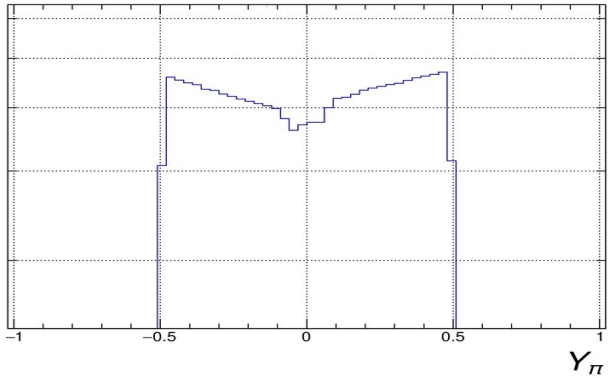


p_T proton

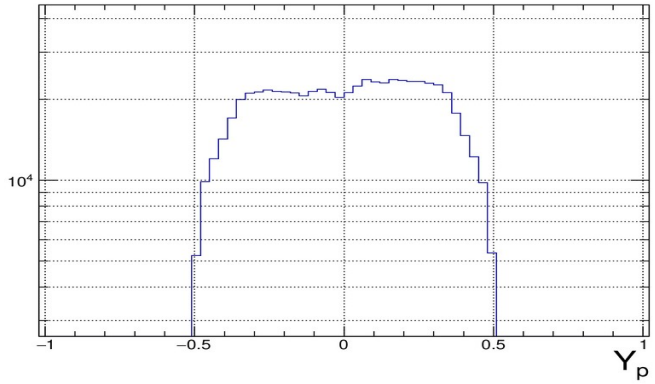


y-distribution for identified particles:

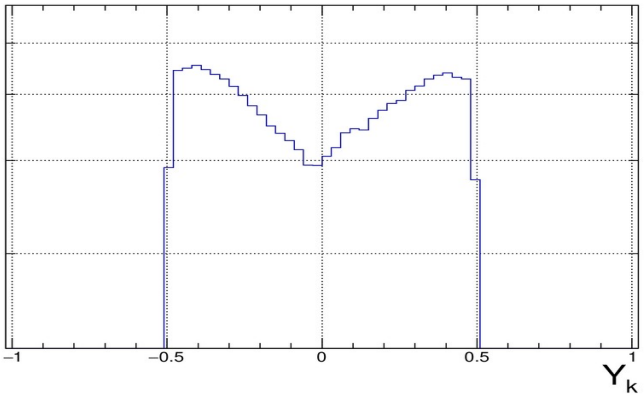
pion



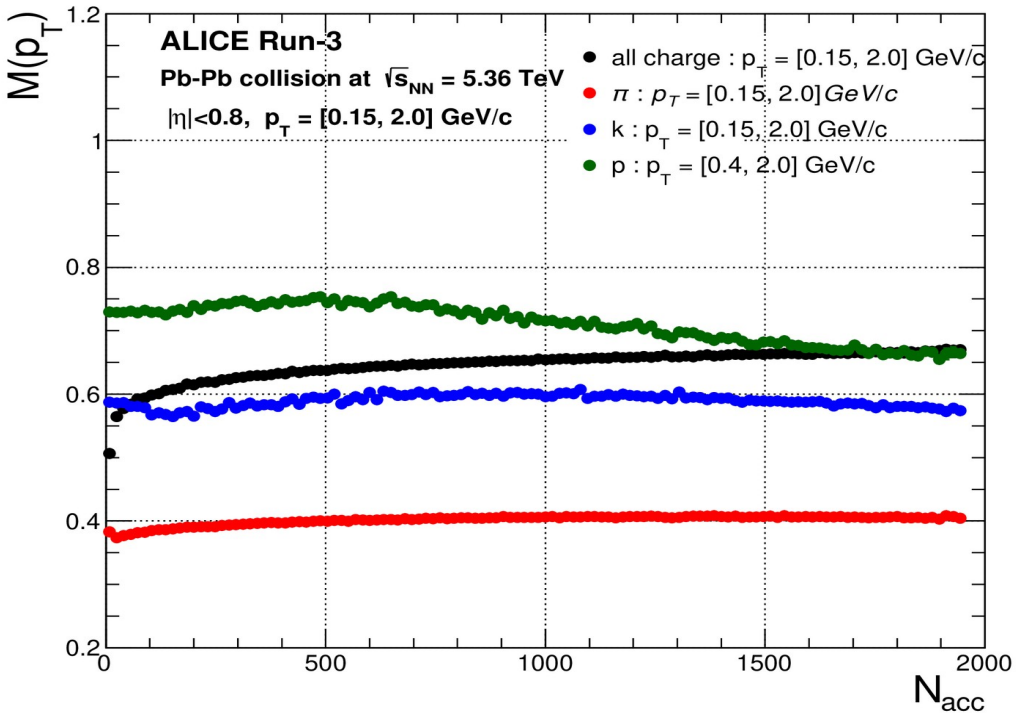
proton



kaon



Mean p_T as a function of N_{acc} :



$$M(p_T)_p > M(p_T)_{allcherge}$$

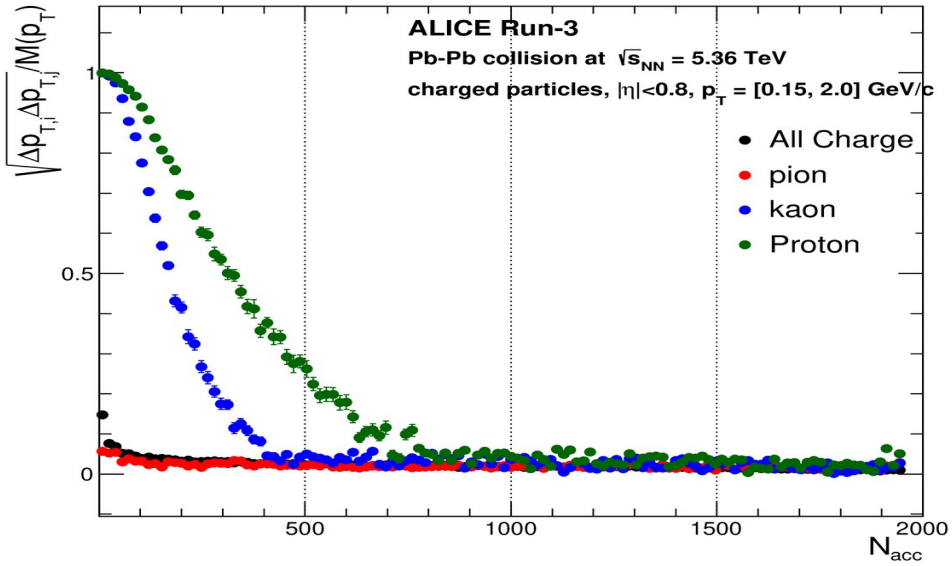
$$M(p_T)_k < M(p_T)_{allcherge}$$

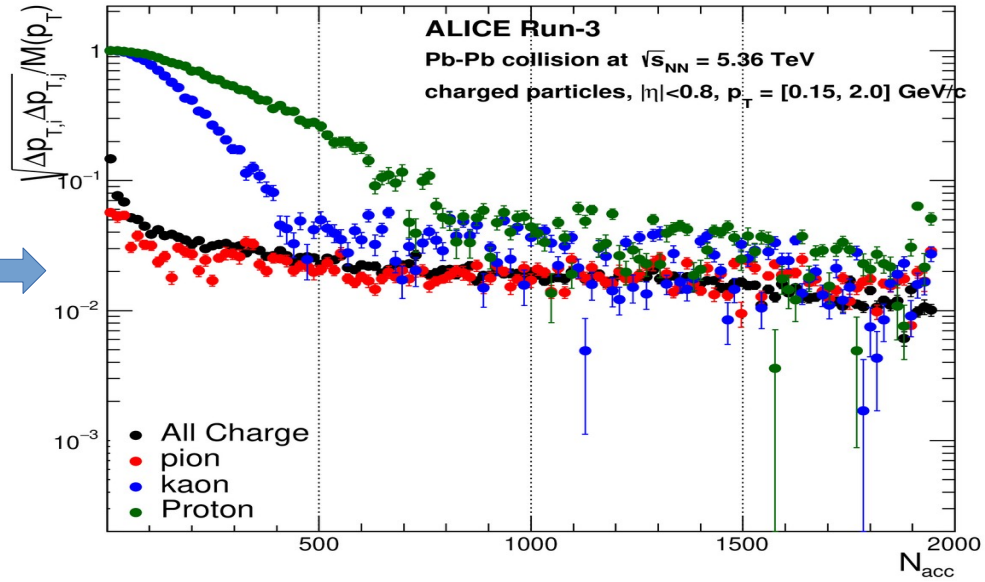
$$M(p_T)_\pi < M(p_T)_{allcherge}$$

- errors are calculated using subsample method.
- errors are too small to be visible.

N_{acc}: number of accepted particles

Two particle correlator as a function of N_{acc} :





- For clarity sake this plot is shown over log scale.
- A sharp decrease in lower multiplicity can be seen for p and k.

MC Study

Analysis Details:

- **MC Dataset**: LHC23k6e_apass2
- **System**: Pb-Pb (5.36TeV)
- **Events**: ~ 26202

Events selection criterion:

- |Vz| < 10 cm
- Sel8()

Track selection criterion:

- Global Tracks()
- |η| < 0.8, |y| < 0.5
- 0.15 < p_T < 2.0 GeV/c

- ✔ One hit in any of the two ITS layers required
- ✔ ITS refit required
- ✔ χ2/ ITS cluster < 36
- ✔ atleast least 70 TPC crossed rows
- ✔ atleast least 80% TPC crossed rows over TPC findable cluster ratio
- ✔ TPC refit required
- ✔ χ2/ TPC cluster < 4
- ✔ DCA_{xy} < 0.0105 cm
- ✔ DCA_z < 2 cm
- ✔ Global TPC χ2 < 32

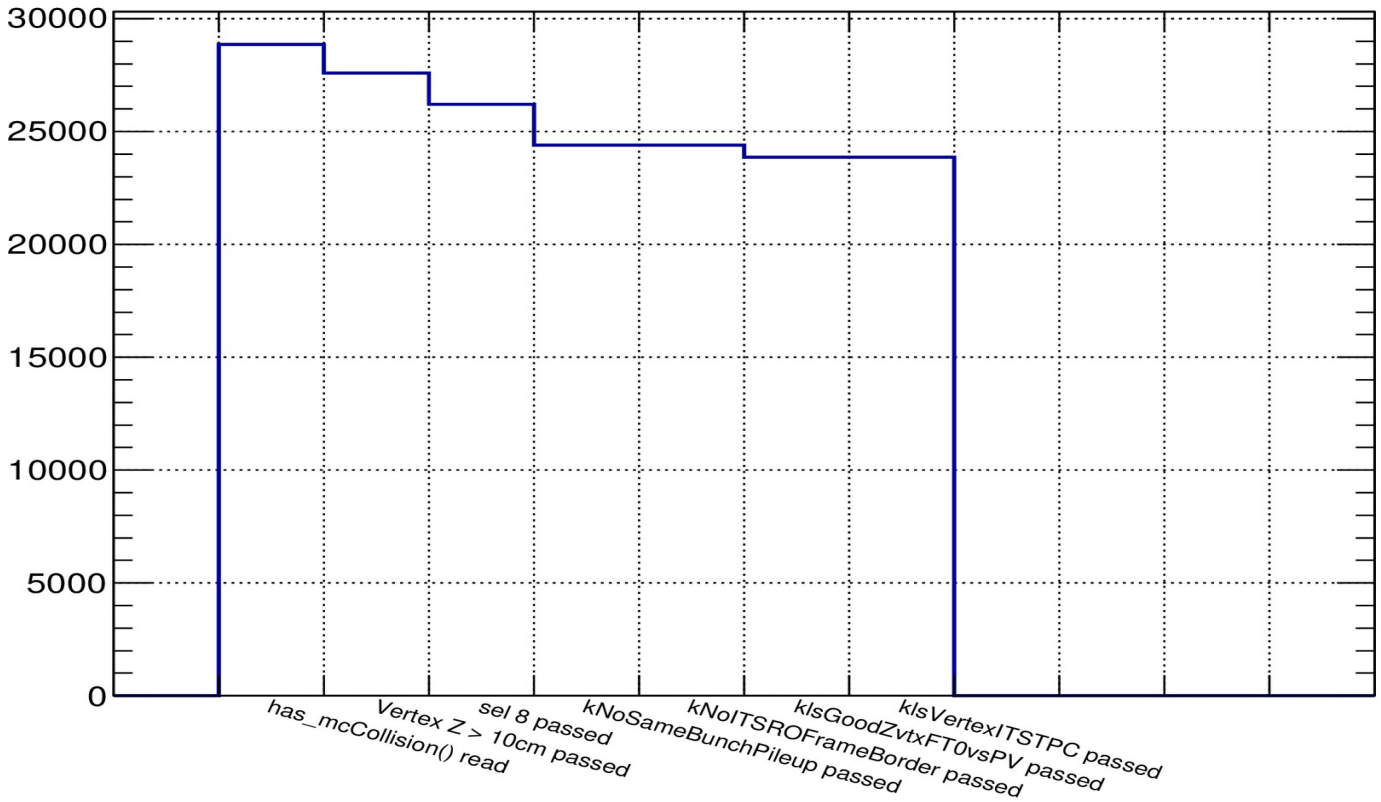
Victor Gonzalez: https://alice-notes.web.cern.ch/node/1408

Analysis Details:

PileUp Rejection:

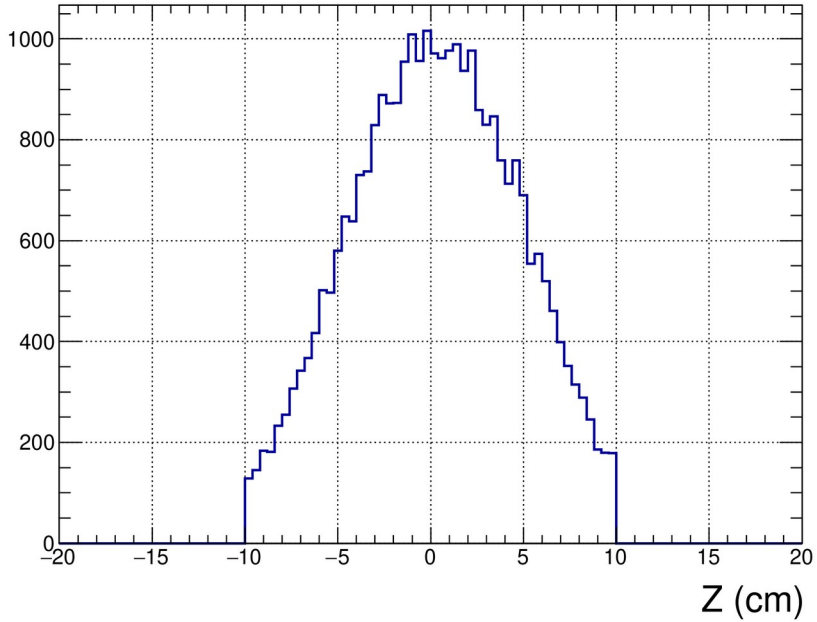
- **KNoSameBunchPileup:** rejects collisions which are associated with the same “found-by-T0” bunch crossing.
- **KNoITSROFrameBorder**: reject more events affected by the ITS ROF border.
- **KIsGoodZvtxFT0vsPV:** rejects collisions with large difference between z of PV by tracks and z of PV from FT0 A-C time difference.
- **KIsVertexITSTPC:** atleast one ITS-TPC track.

Track Selection:



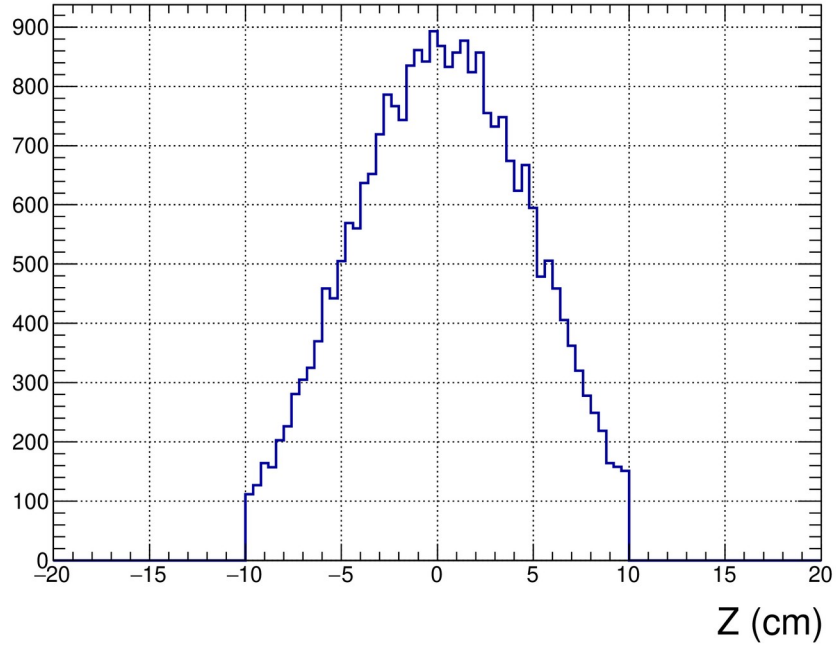
V_z distribution:

Generated MC



No. of Events: 29815

Reconstructed MC



No. of Events: 26202

PID Selection:

Electron Rejection :

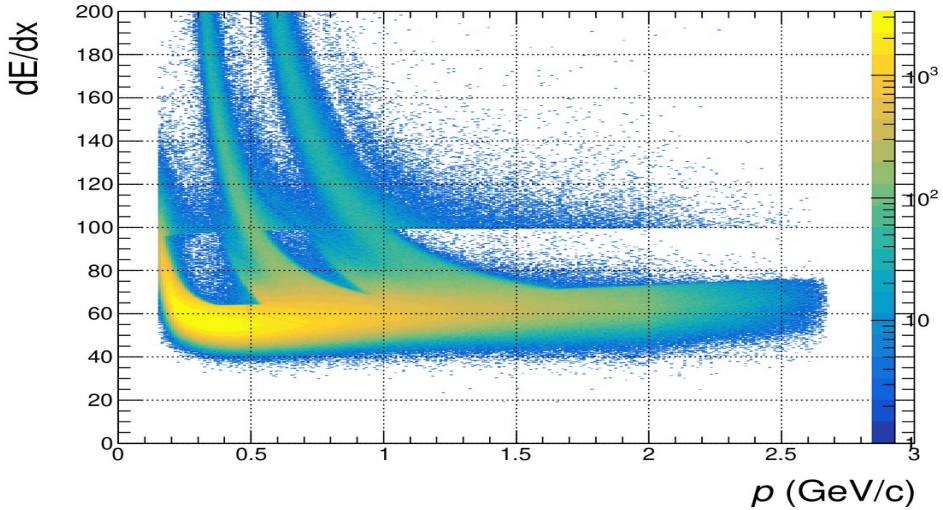
$$-3 < N_{\sigma TPC(e)} < 3,\ |N_{\sigma TPC(\pi)}| > 3,\ |N_{\sigma TPC(k)}| > 3,\ |N_{\sigma TPC(p)}| > 3$$

PID Selection:

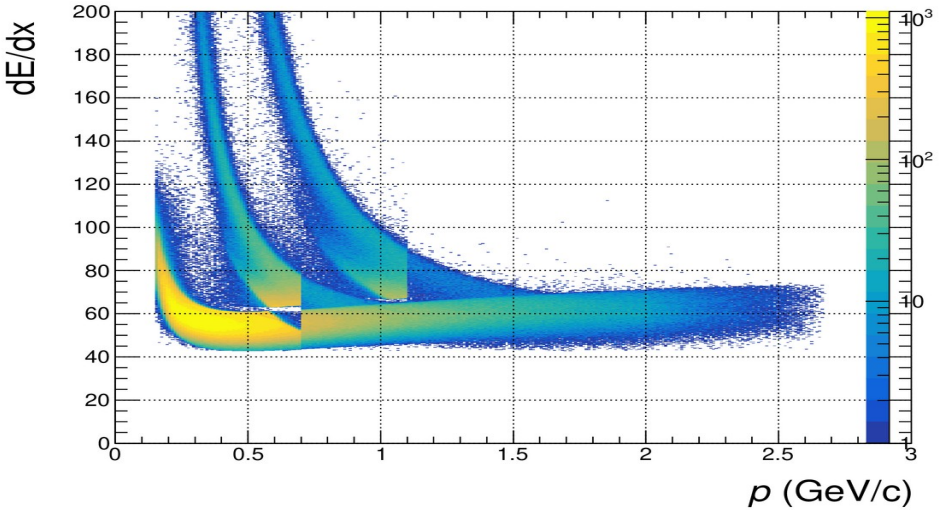
Pion	Kaon	Proton
***p* < 0.7 GeV/c**	***p* < 0.7 GeV/c**	***P* < 1.1 GeV/c**
✔ track.hasTPC() ✔ $\lvert N_{\sigma TPC(\pi)}\rvert < 2.5$ ✔ $\lvert N_{\sigma TPC(k)}\rvert > 3$, $\lvert N_{\sigma TPC(p)}\rvert > 3$	✔ track.hasTPC() ✔ $\lvert N_{\sigma TPC(k)}\rvert < 2.5$ ✔ $\lvert N_{\sigma TPC(\pi)}\rvert > 3$, $\lvert N_{\sigma TPC(p)}\rvert > 3$	✔ track.hasTPC() ✔ $\lvert N_{\sigma TPC(p)}\rvert < 2.5$ ✔ $\lvert N_{\sigma TPC(k)}\rvert > 3$, $\lvert N_{\sigma TPC(\pi)}\rvert > 3$
***p* >= 0.7 GeV/c**	***p* >= 0.7 GeV/c**	***P* >= 1.1 GeV/c**
✔ track.hasTPC(), track.hasTOF()	✔ track.hasTPC(), track.hasTOF()	✔ track.hasTPC(), track.hasTOF()
• -2.5, -3.0 < $\lvert N_{\sigma TPC\text{-}TOF(\pi)}\rvert < 2.5, 3.0$ $\lvert N_{\sigma TPC\text{-}TOF(\pi)}\rvert = ((N_{\sigma TPC})^2 / (2.5)^2 + (N_{\sigma TOF})^2 / (3.0)^2)^{1/2}$	• -2.5, -3.0 < $\lvert N_{\sigma TPC\text{-}TOF(k)}\rvert < 2.5, 3.0$ $\lvert N_{\sigma TPC\text{-}TOF(k)}\rvert = ((N_{\sigma TPC})^2 / (2.5)^2 + (N_{\sigma TOF})^2 / (3.0)^2)^{1/2}$	• -2.5, -3.0 < $\lvert N_{\sigma TPC\text{-}TOF(p)}\rvert < 2.5, 3.0$ $\lvert N_{\sigma TPC\text{-}TOF(p)}\rvert = ((N_{\sigma TPC})^2 / (2.5)^2 + (N_{\sigma TOF})^2 / (3.0)^2)^{1/2}$
• $\lvert N_{\sigma TPC\text{-}TOF(k)}\rvert > 3$, $\lvert N_{\sigma TPC\text{-}TOF(p)}\rvert > 3$ ↘ $N_{\sigma TPC\text{-}TOF} = (N^2_{\sigma TPC} + N^2_{\sigma TOF})^{1/2}$	• $\lvert N_{\sigma TPC\text{-}TOF(\pi)}\rvert > 3$, $\lvert N_{\sigma TPC\text{-}TOF(p)}\rvert > 3$ ↘ $N_{\sigma TPC\text{-}TOF} = (N^2_{\sigma TPC} + N^2_{\sigma TOF})^{1/2}$	• $\lvert N_{\sigma TPC\text{-}TOF(k)}\rvert > 3$, $\lvert N_{\sigma TPC\text{-}TOF(\pi)}\rvert > 3$ ↘ $N_{\sigma TPC\text{-}TOF} = (N^2_{\sigma TPC} + N^2_{\sigma TOF})^{1/2}$

dE/dx vs *p*:

before selection

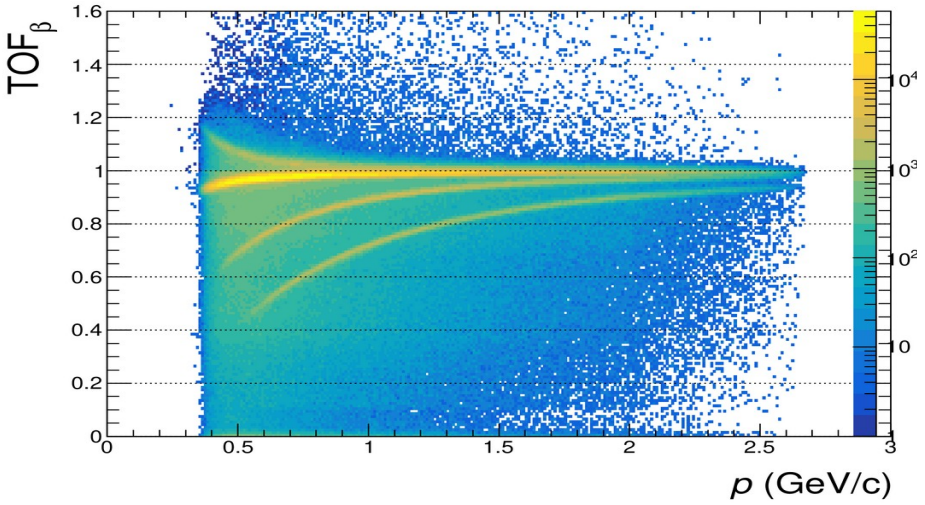


after selection

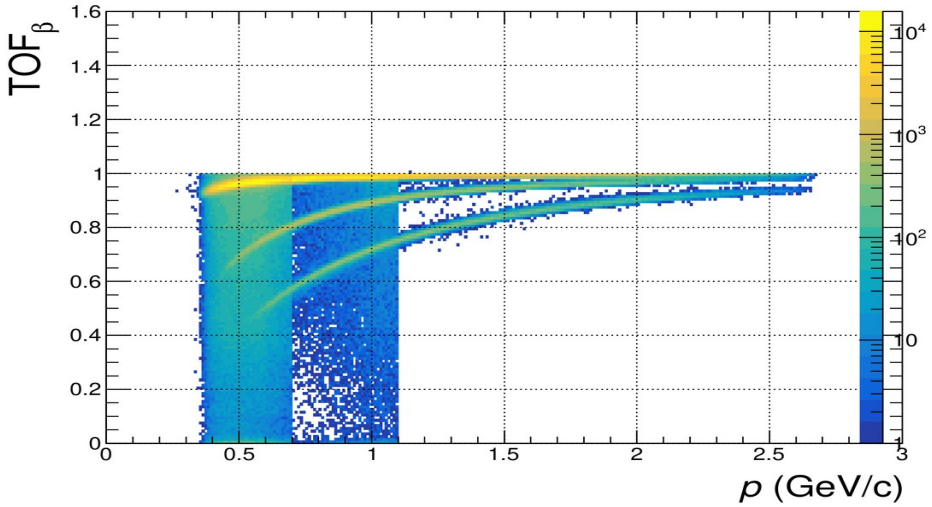


TOF_β vs p:

before selection

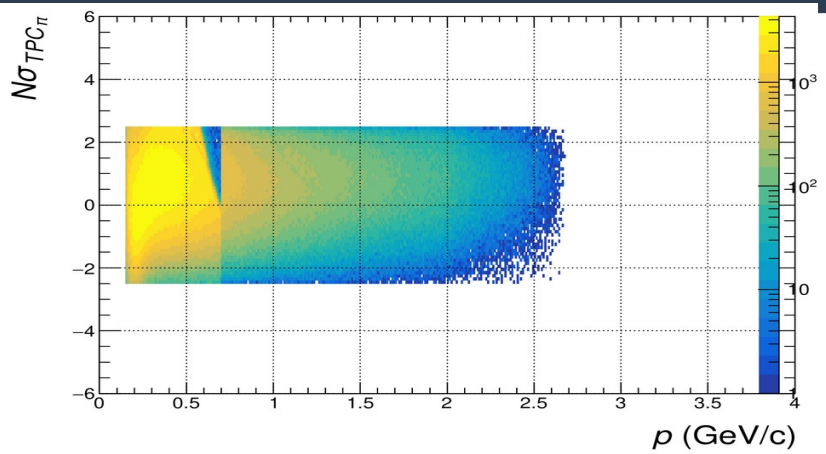


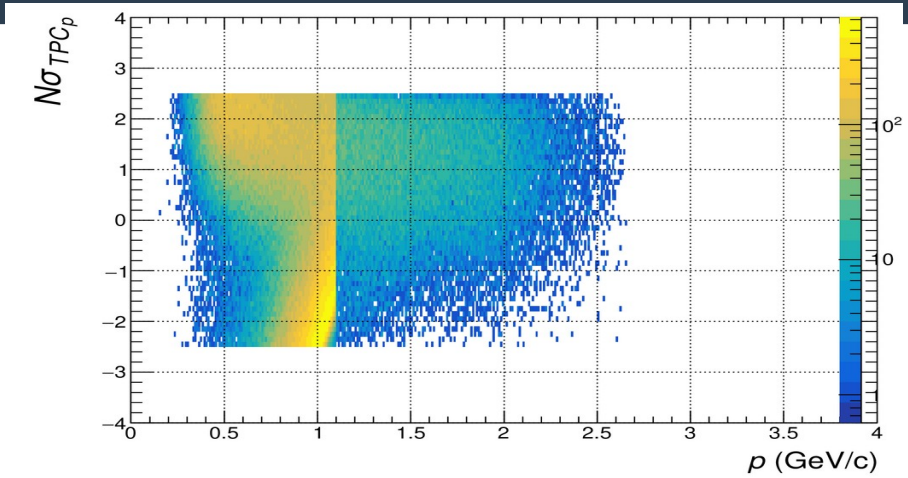
after selection

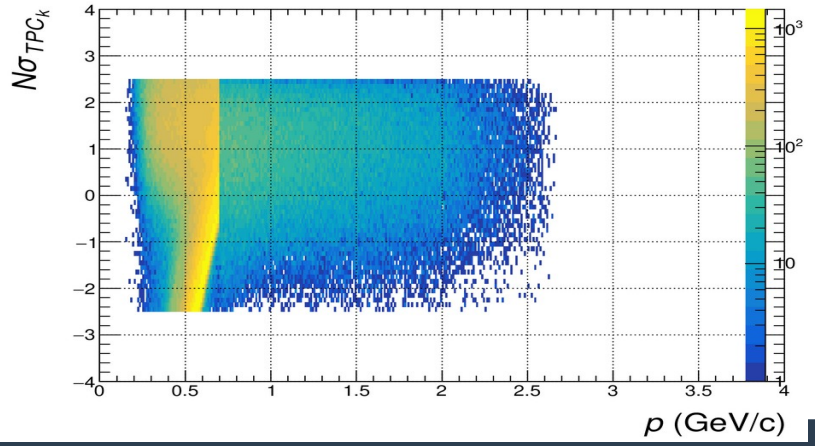


$N_{\sigma TPC}$ vs *p* for identified particles:

After PID selection

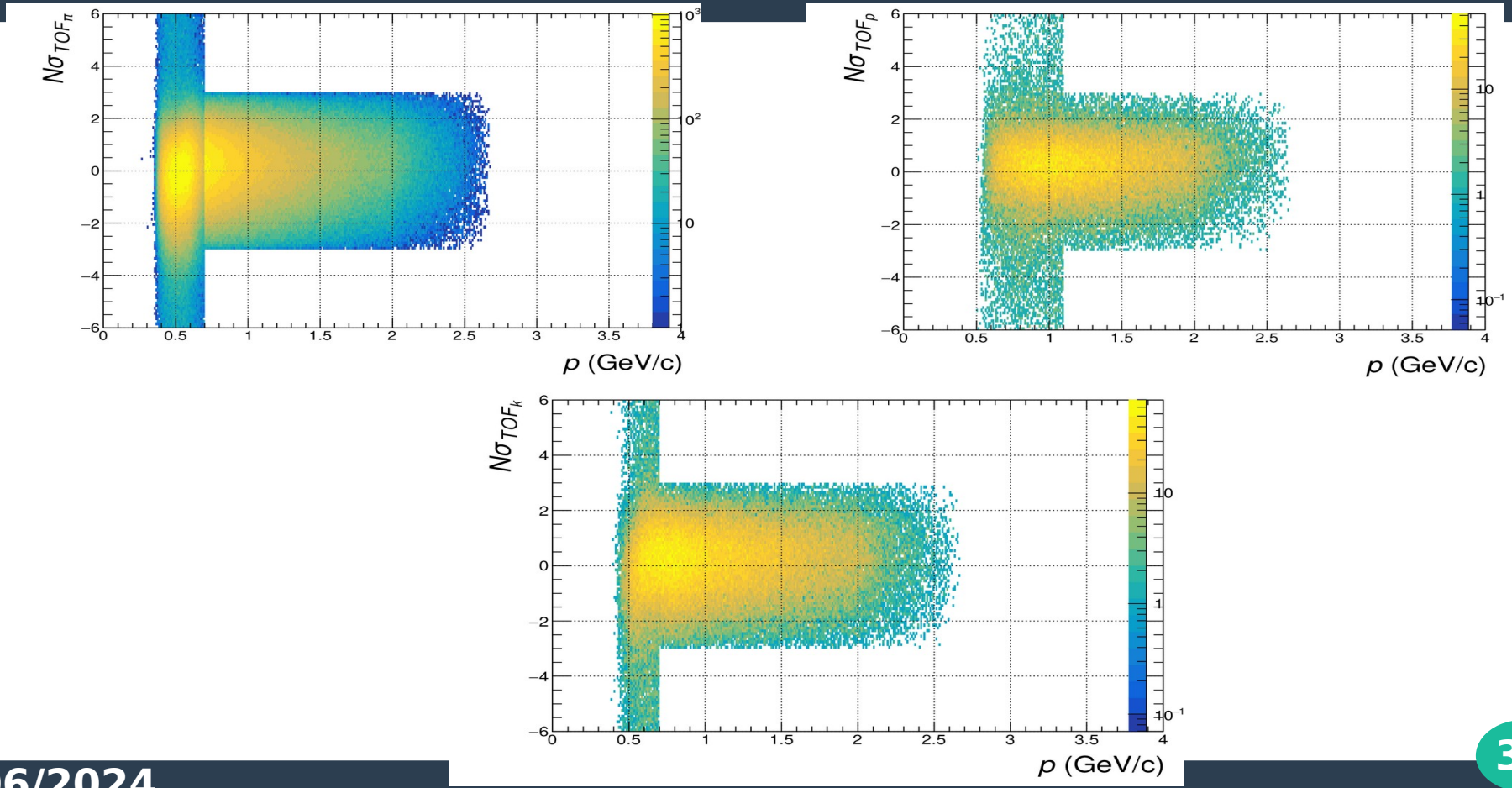






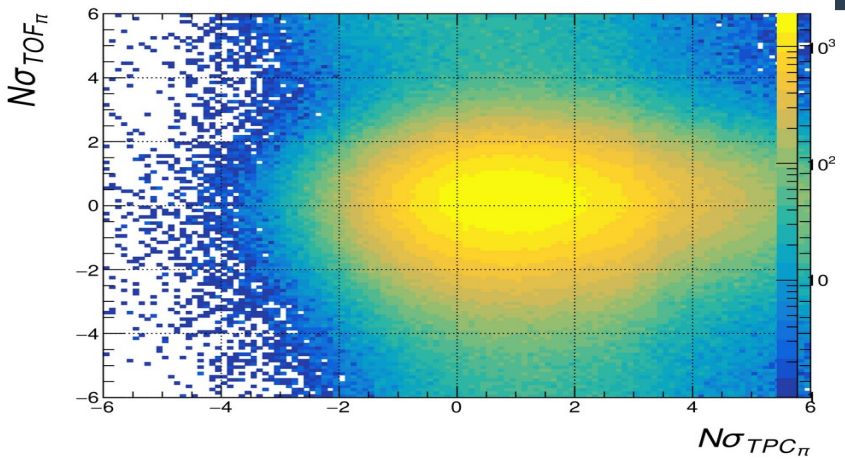
$N_{\sigma TOF}$ vs *p* for identified particles:

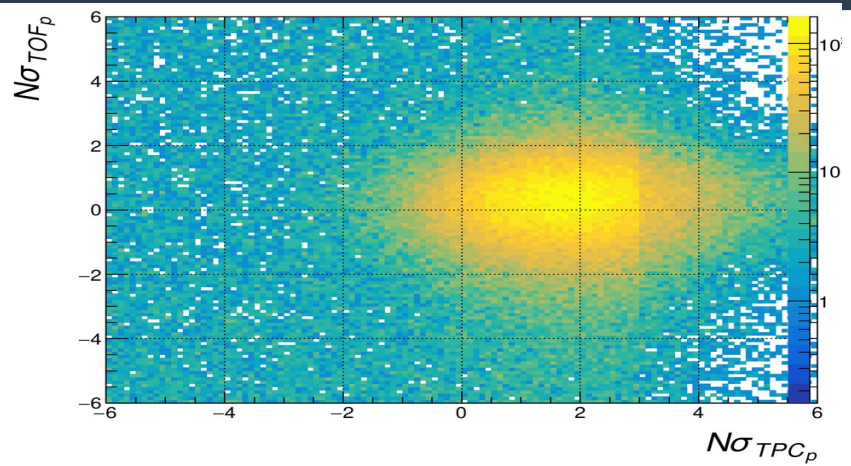
After PID selection

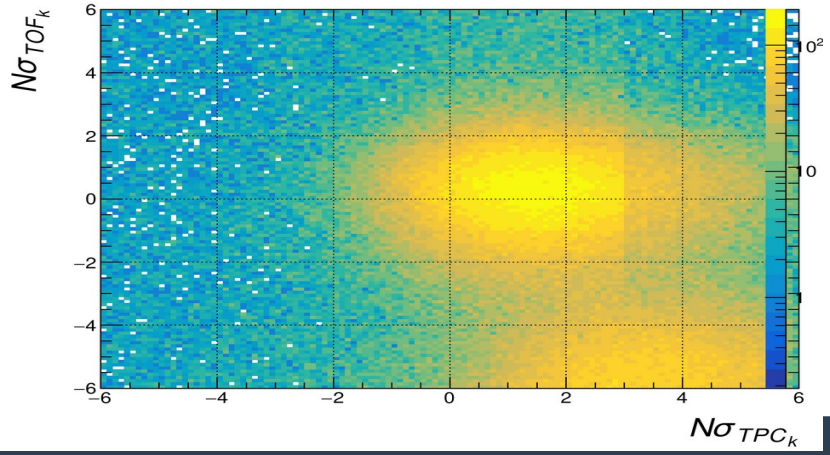


$N_{\sigma TOF}$ vs $N_{\sigma TPC}$ for identified particles:

Before PID selection

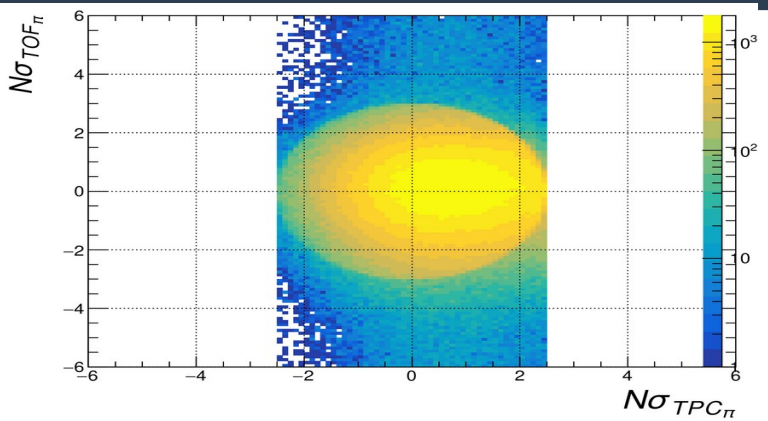


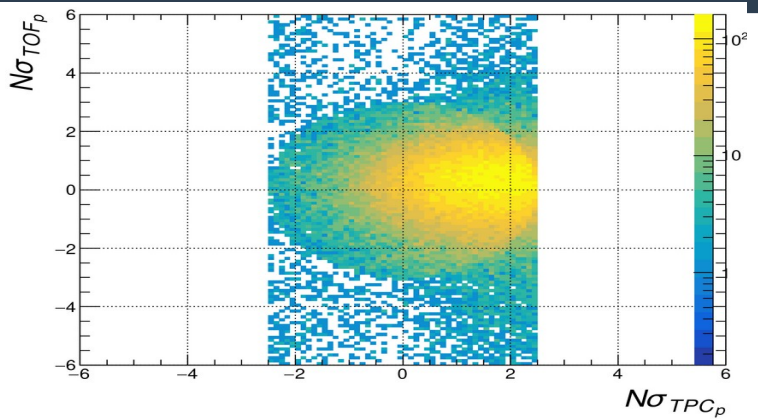


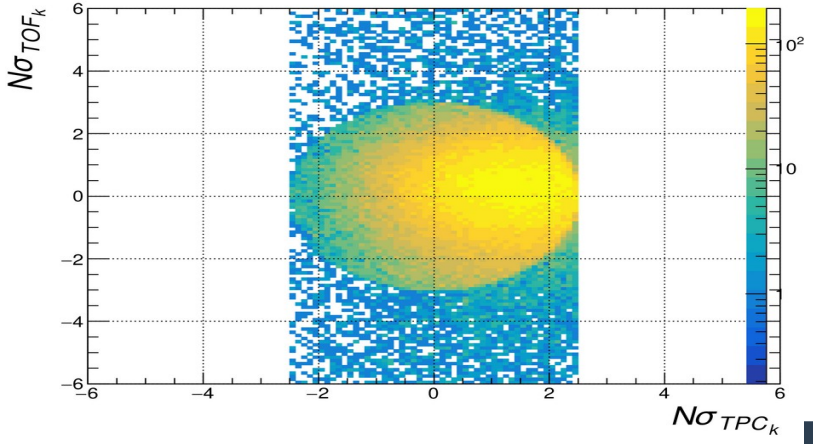


$N_{\sigma TOF}$ vs $N_{\sigma TPC}$ for identified particles:

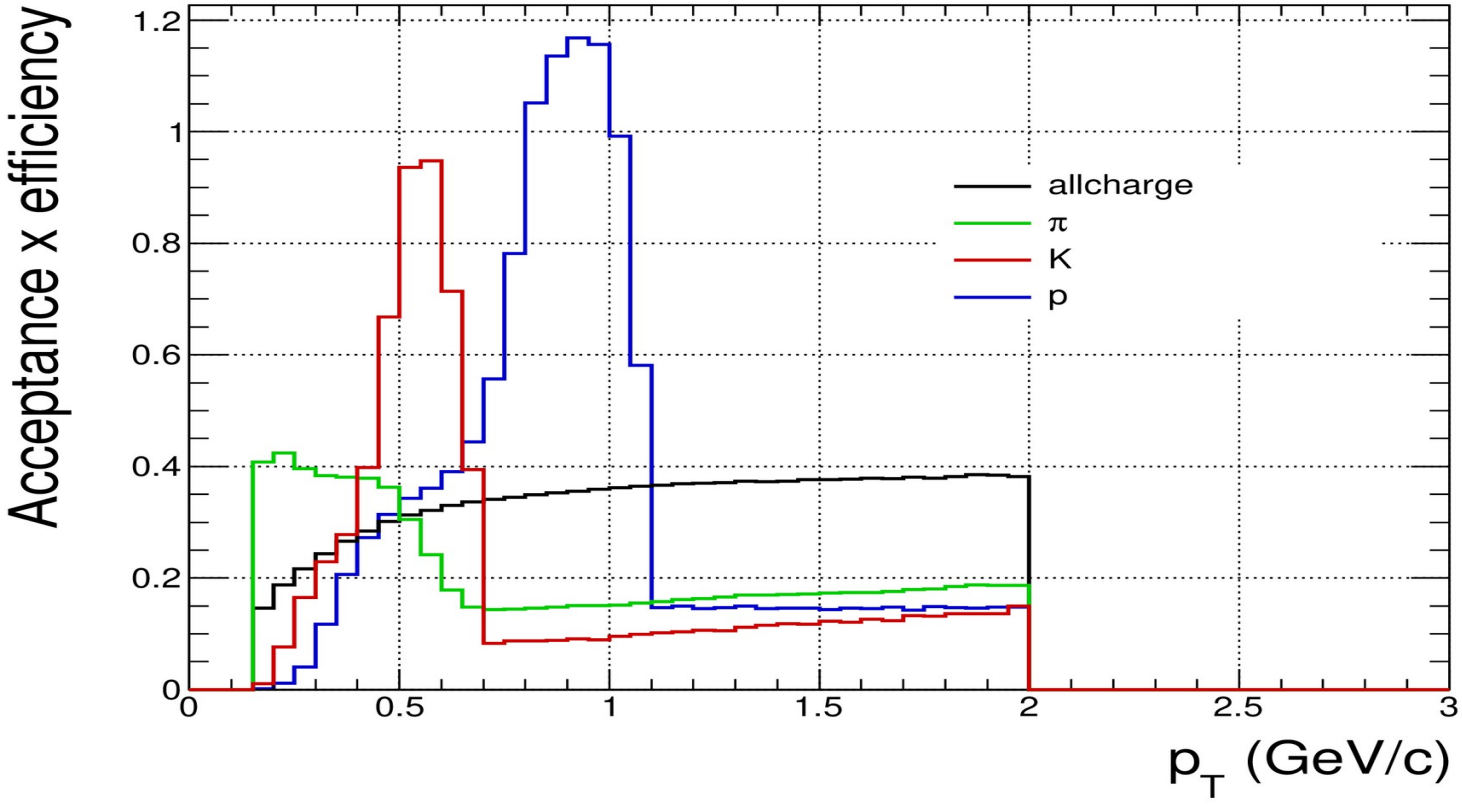
After PID selection



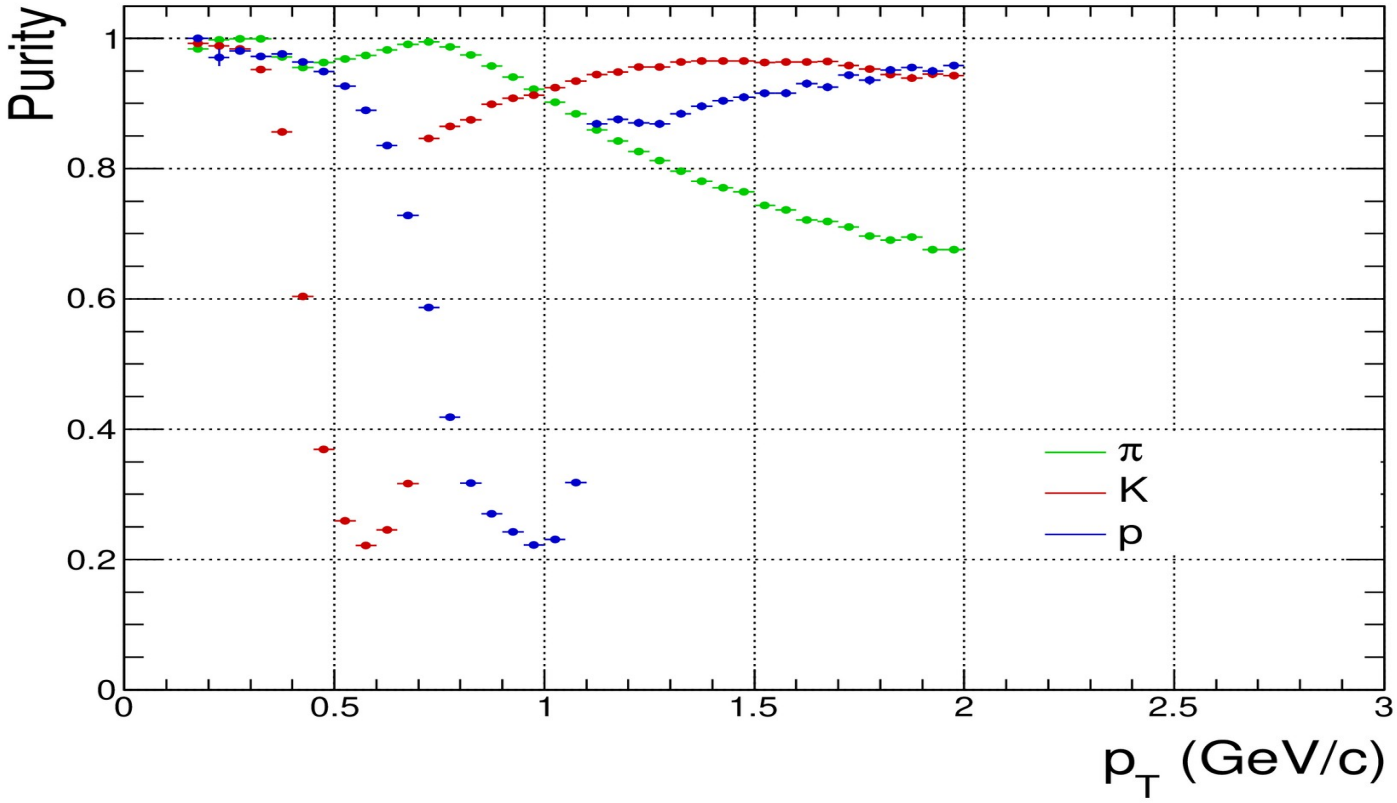




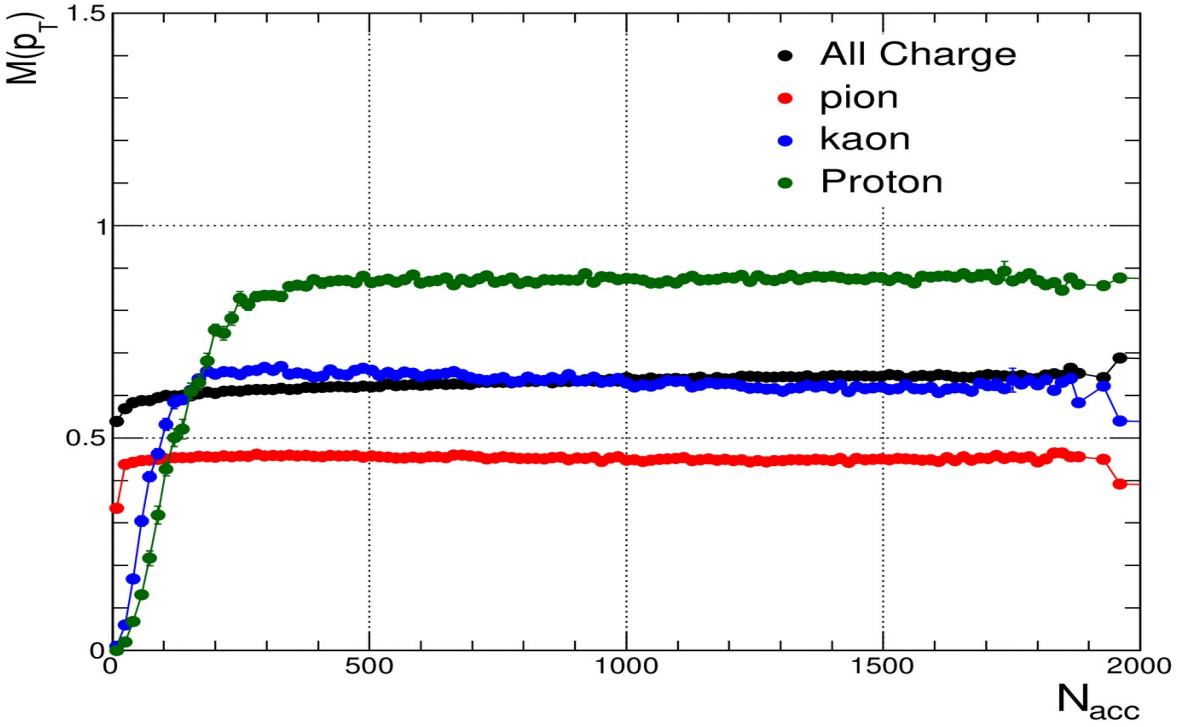
Efficiency plot:



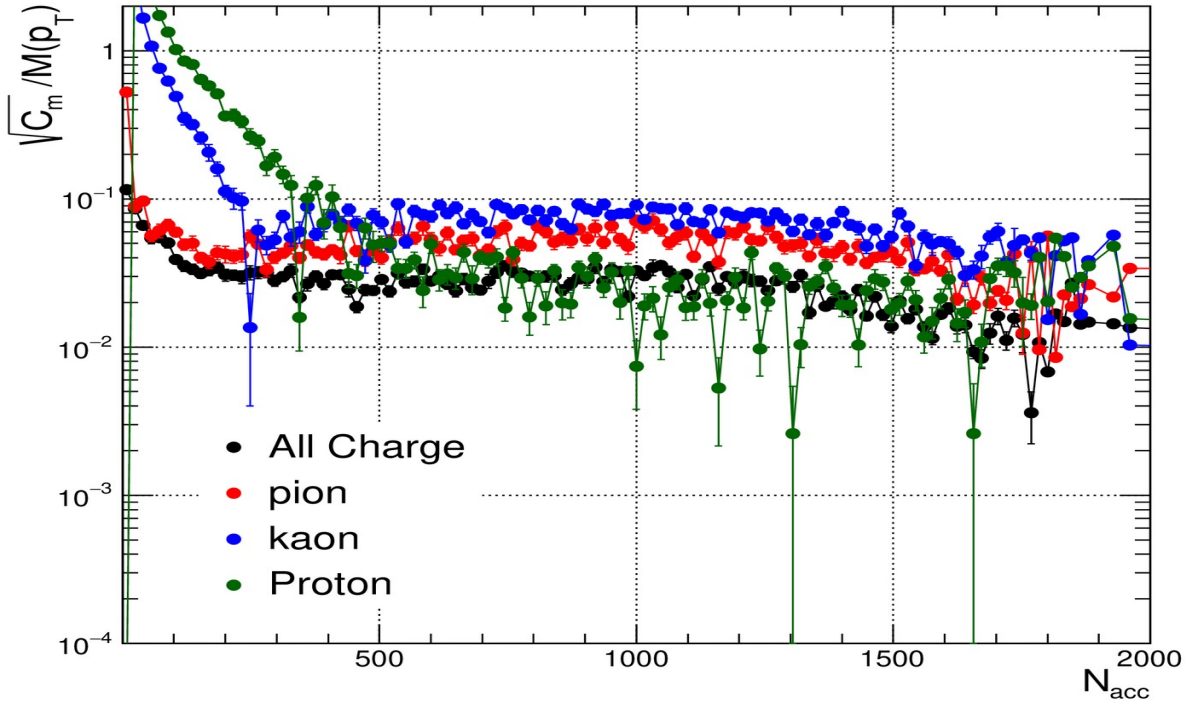
Purity plot:



Mean p_T as a function of N_{acc} :



Two particle correlator as a function of N_{acc} :



To Do:

- **To work on higher statistics.**
- **To work on better purity and efficiency correction for MC data.**

Thank You