Update on identification of π, K, p with ALICE-TPC detector for LHC Run 3 pp data

Dhrubajyoti Choudhury & Buddhadeb Bhattacharjee
Nuclear and Radiation Physics Research Laboratory,
Department of Physics
Gauhati University, Guwahati - 781014

ALICE-STAR-India collaboration meeting,
November 21 - 24, 2023
Jammu University

Outline

- Introduction
- Analysis Details
- Results
- Summary
- Outlook

Introduction

- The general motivation is to study the physics of strongly interacting matter, and in particular the properties of Quark-Gluon Plasma (QGP), using proton-proton, nucleus-nucleus and proton-nucleus collisions at high energies.

- Proton-proton (pp) collisions are used as a reference to study heavy-ion collisions (HIC).

- In this report I shall give an brief account of identification of π, K, p for Run 3 pp data using ALICE TPC detector.

- To study particle to antiparticle ratio as well as kaon to pion ratio and proton to pion ratio.

Analysis Details

- ALICE data : pp at $\sqrt{s}$ = 13.6 TeV
- Periods : LHC22f_pass4
- Run Number : 520473, 520472, 520471, 520294, 520259
- MC data : pp at $\sqrt{s}$ = 13.6 TeV
- Periods : LHC23d1k (anchored to pass4)
- Run Number : 520473, 520472, 520471, 520294, 520259

Analysis Details

Event Selection

- bool sel8() = selection[kIsBBT0A] & selection[kIsBBT0C]
- $|Z_{vertex}|$ < 10 cm

Track Selection

- Minimum TPC crossed row : 70
- Minimum ratio of crossed rows over findable clusters TPC : 0.8
- Maximum χ^2/TPC cluster : 4
- Maximum χ^2/ITS cluster : 36
- TPC Refit & ITS Refit
- DCA to Z_{vertex} : 2 cm
- $|\eta| < 0.8$
- $|y| < 0.5$

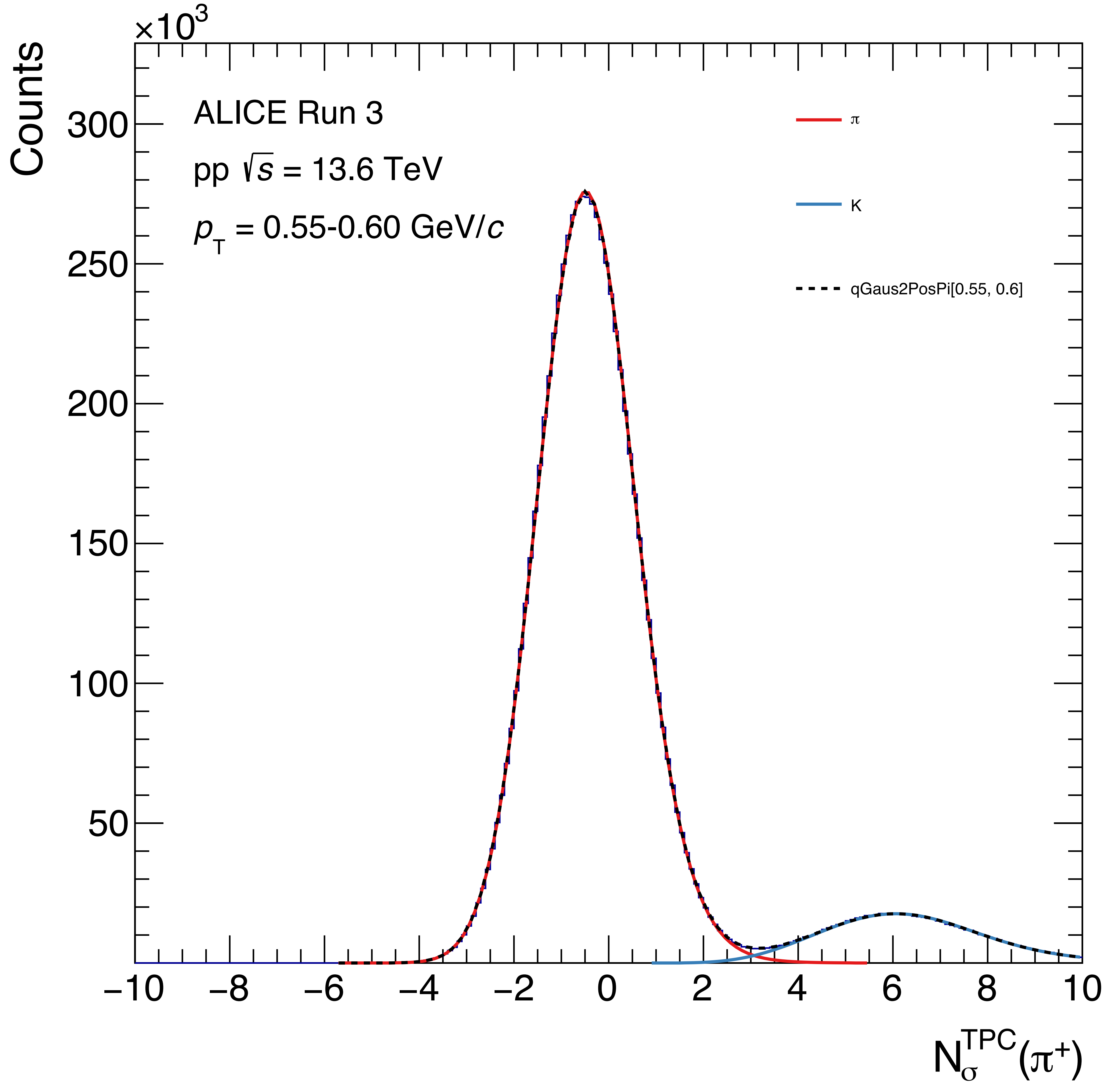
~ 80 M events

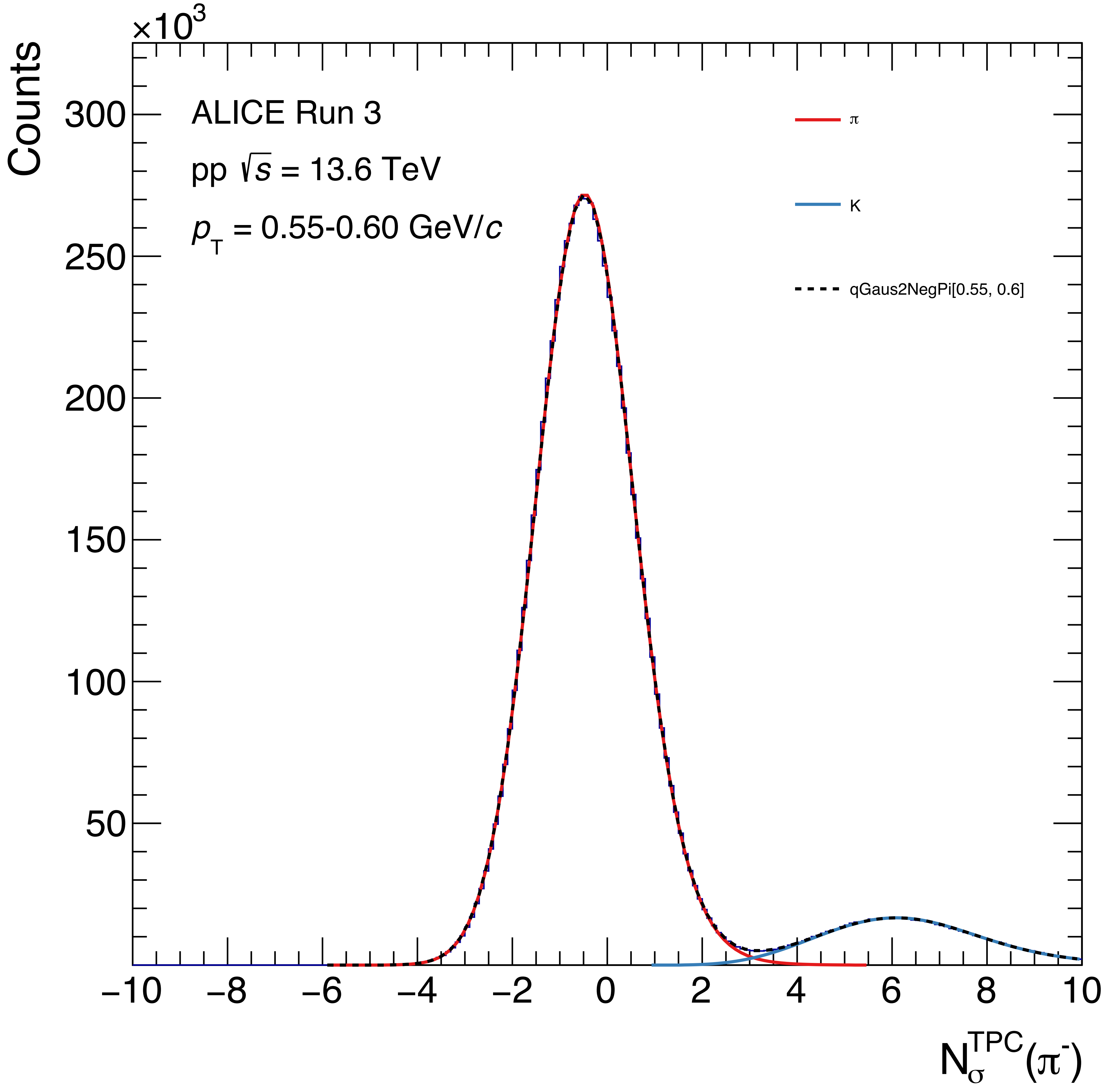
Analysis Details

- Detector used : Time Projection Chamber (TPC)
- Method : Statistical unfolding of TPC signal
- Variable p_T bin :
- { 0.0, 0.1, 0.12, 0.14, 0.16, 0.18, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8, 5.0 }

Results

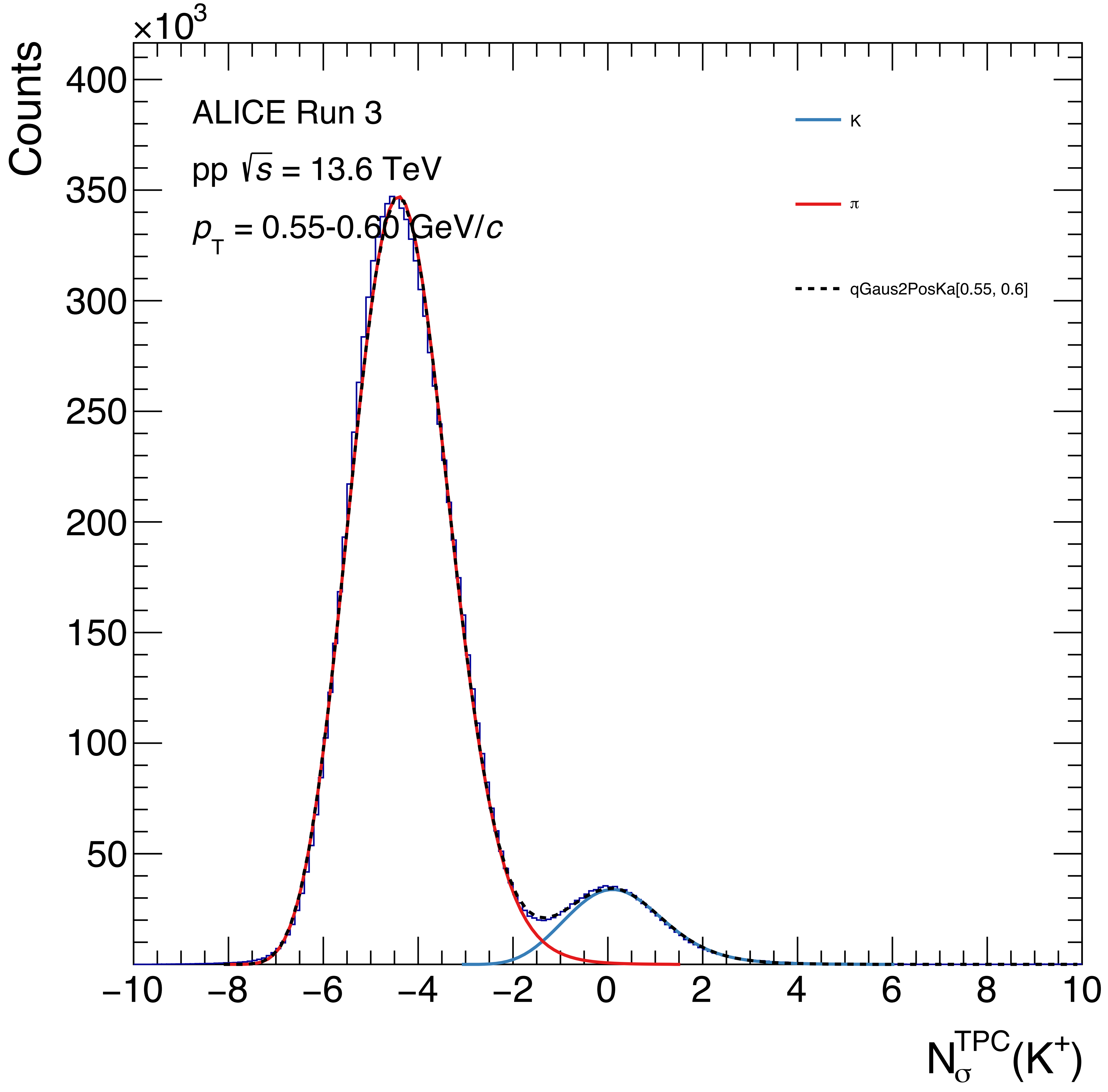
Fitting of TPC signal for π^+, π^-

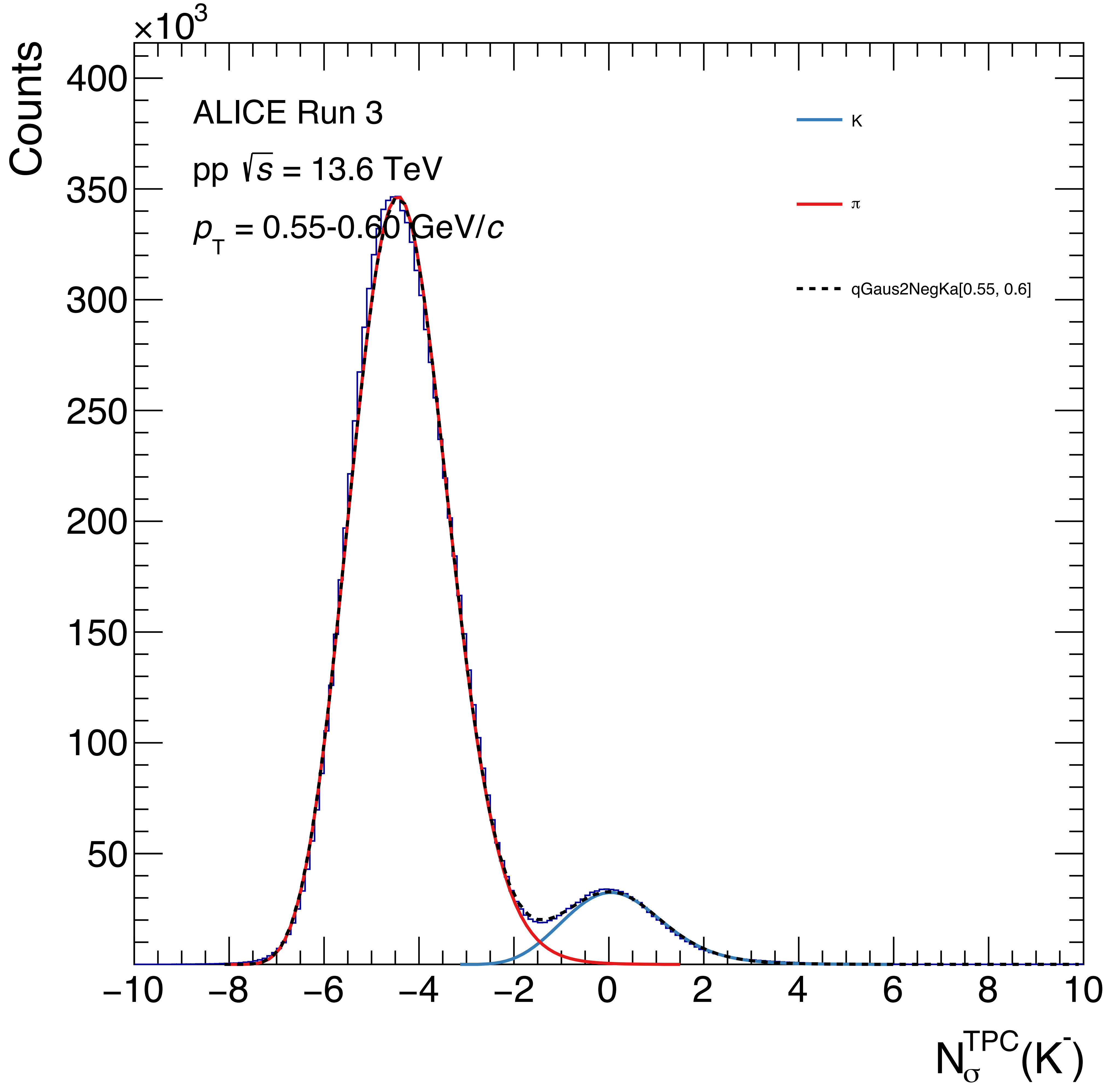




Results

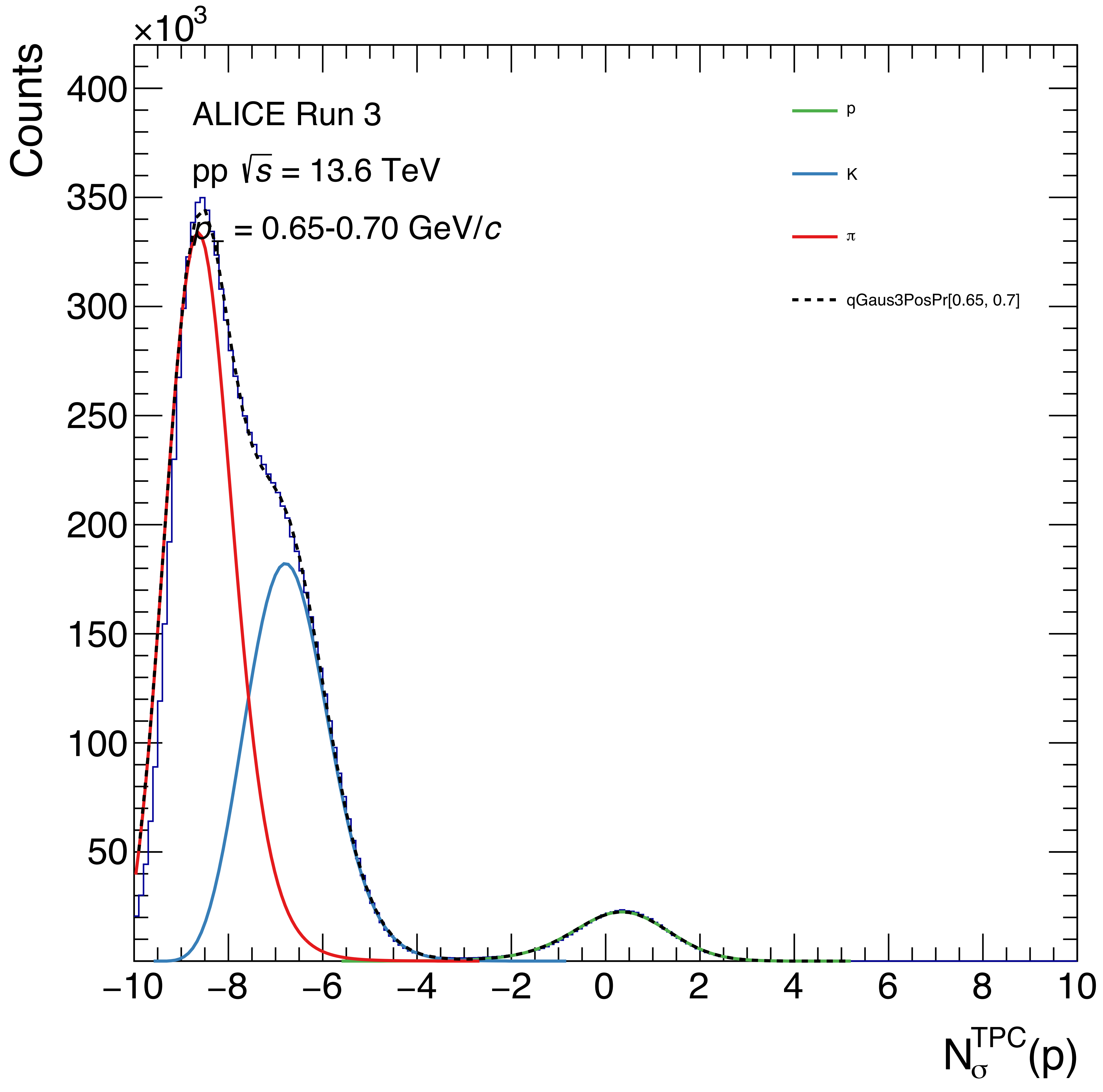
Fitting of TPC signal for K^+, K^-

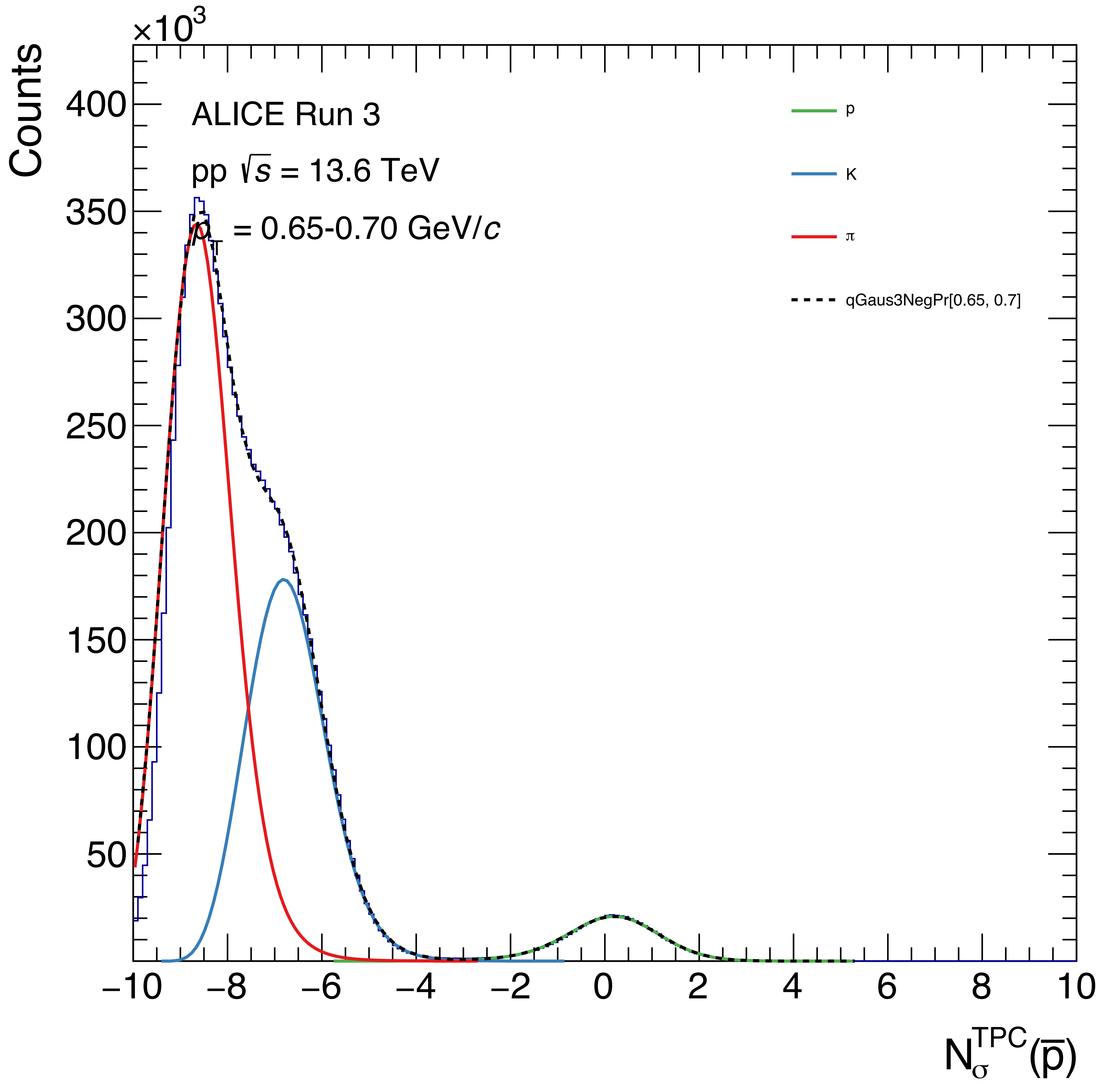




Results

Fitting of TPC signal for $p, \bar{p}$



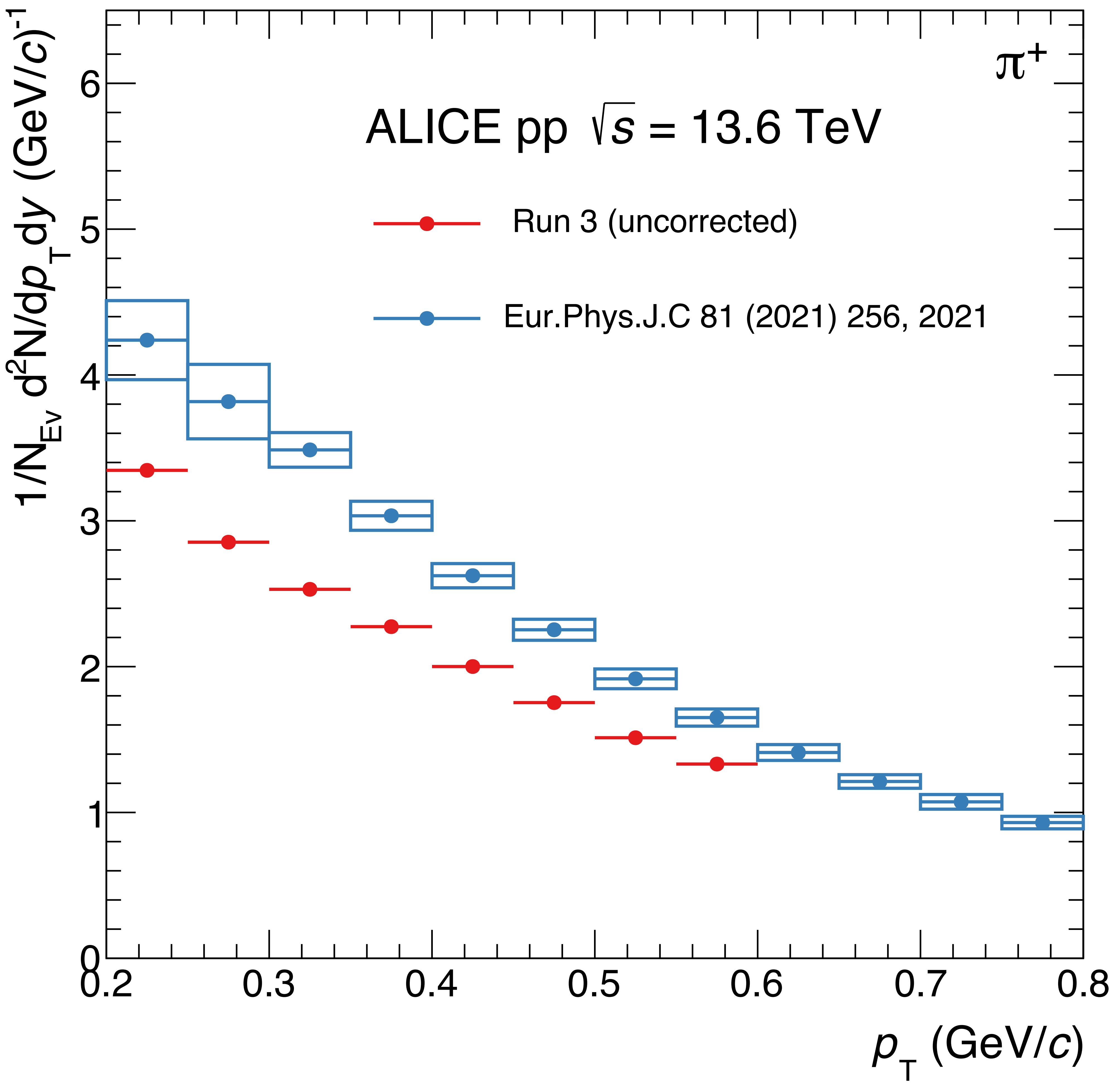


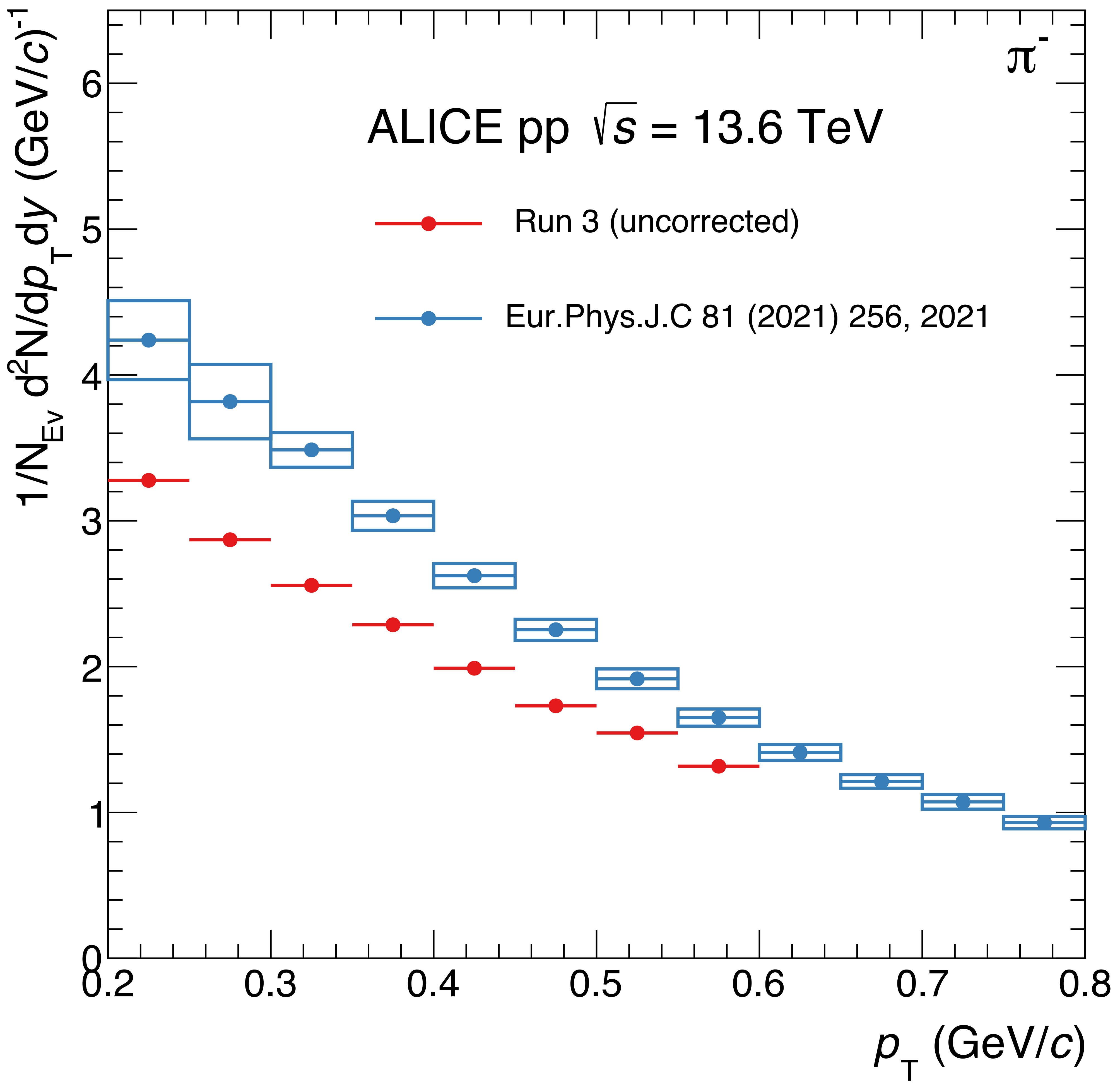
TPC PID p_T range

- Pion : (0.2 - 0.6) GeV/c
- Kaon : (0.2 - 0.6) GeV/c
- Proton : (0.4 - 0.8) Gev/c

Results

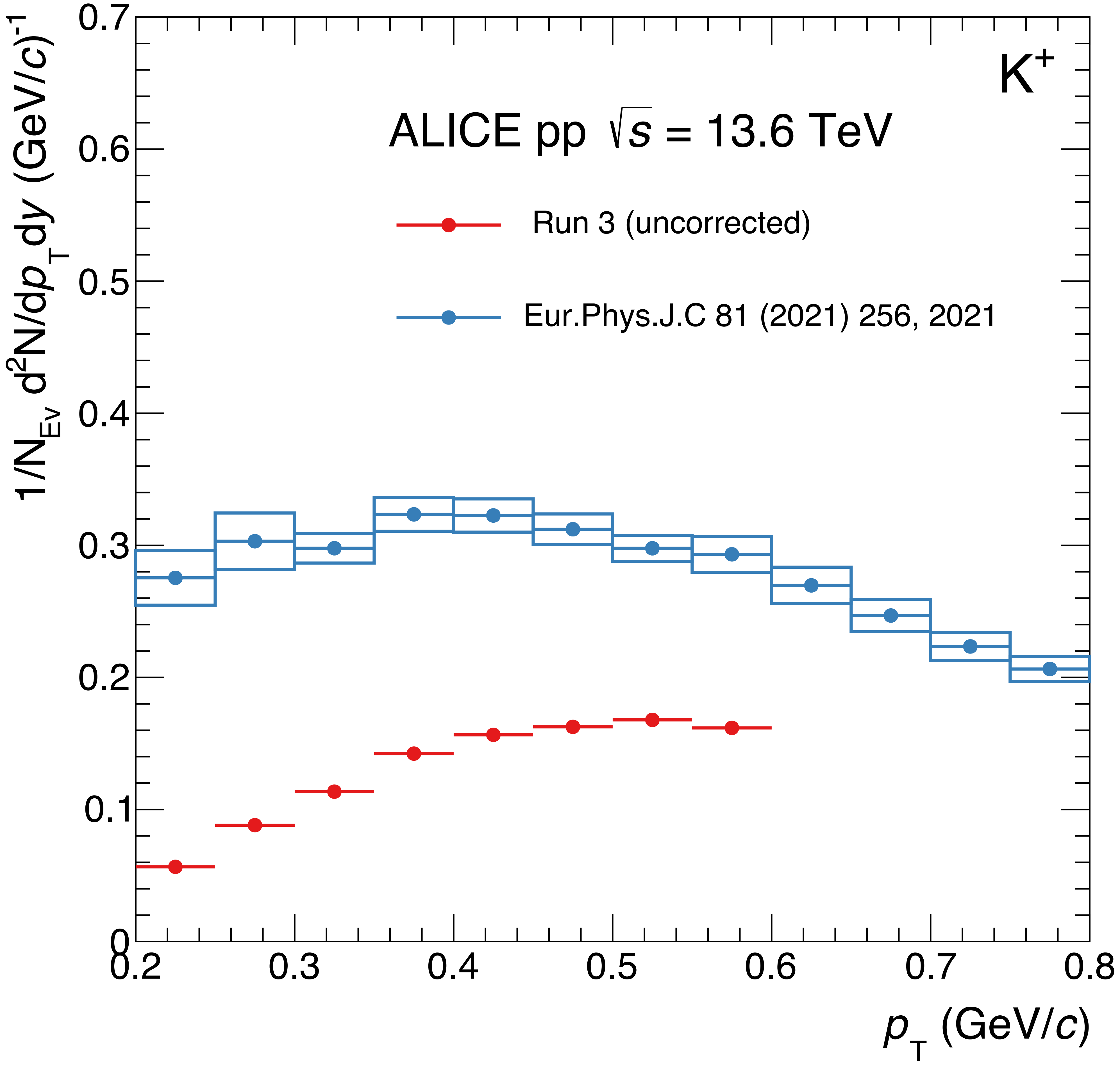
Raw transverse momentum spectra for π^+, π^-

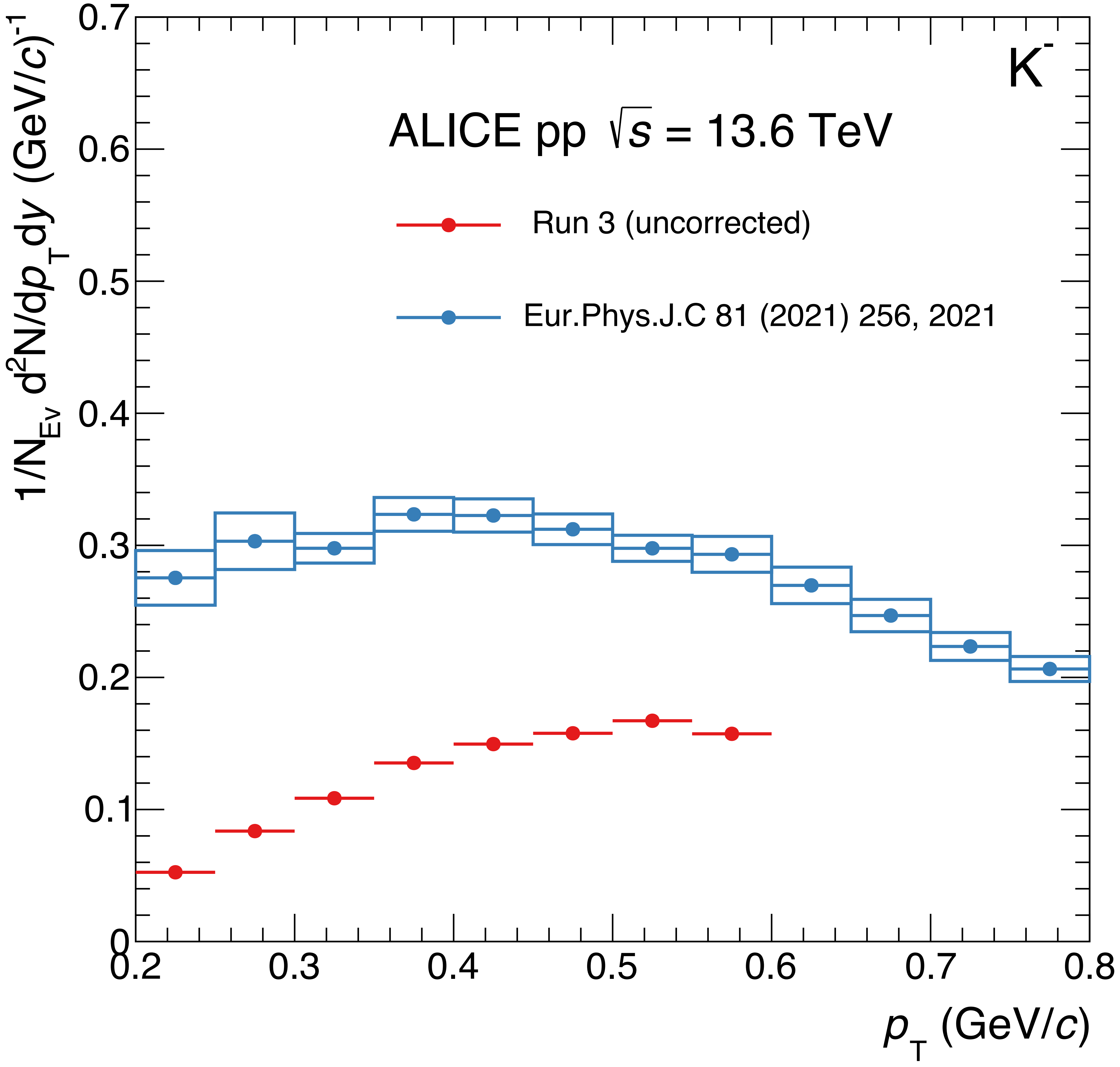




Results

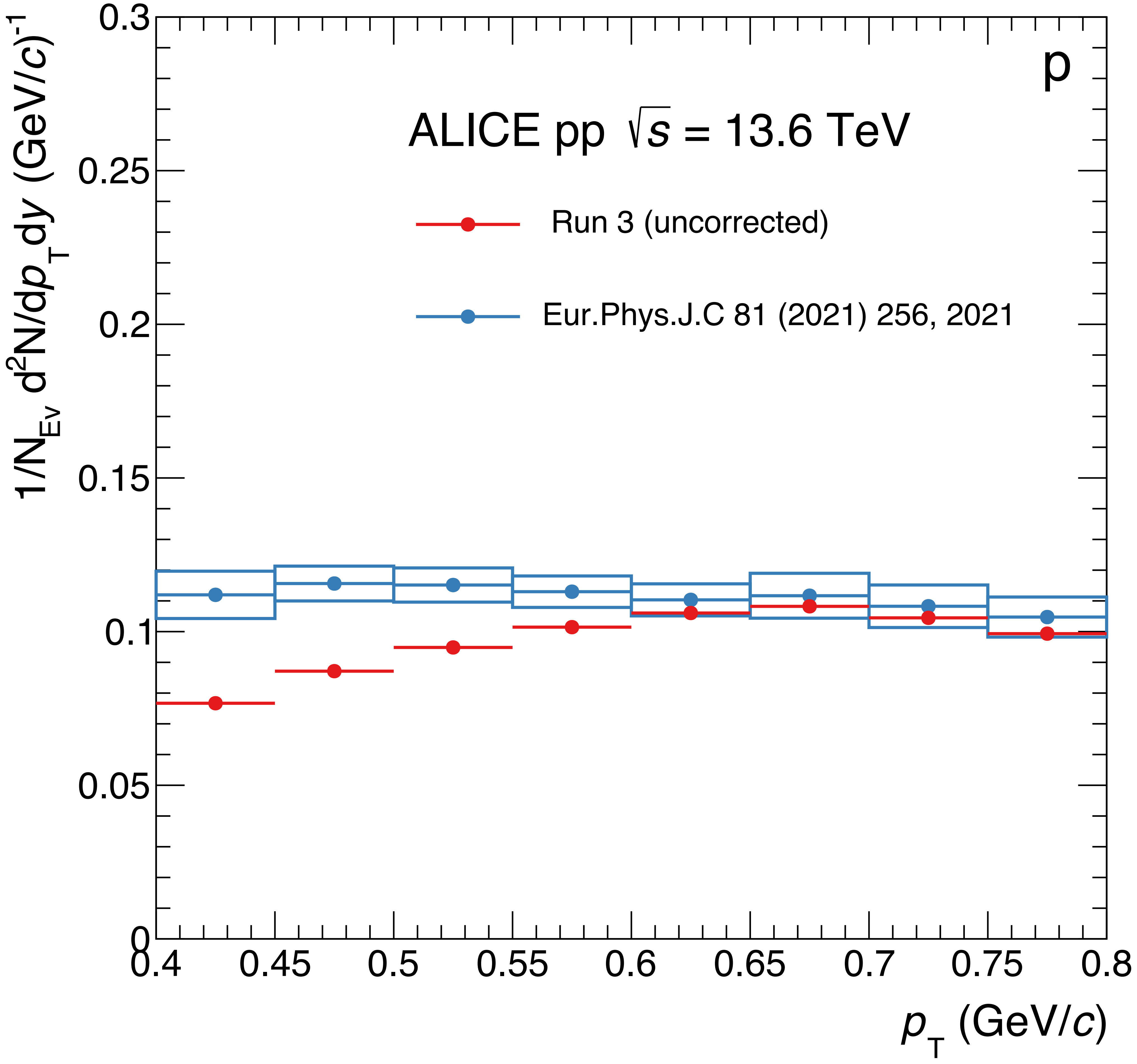
Raw transverse momentum spectra for K^{+}, K^{-}

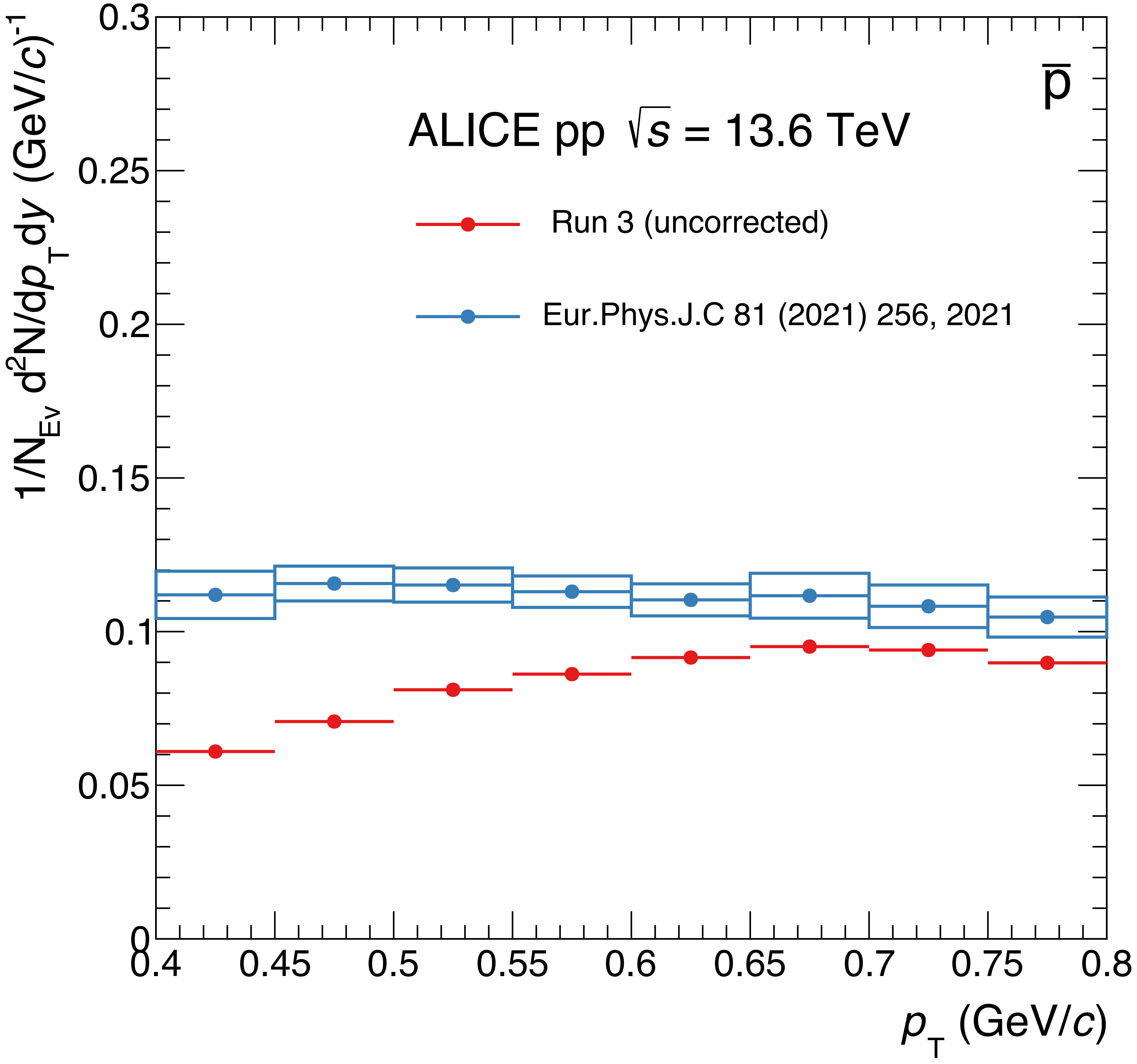




Results

Raw transverse momentum spectra for $p, \bar{p}$





Tracking efficiency

- It is obtained by dividing all reconstructed tracks within the detector acceptance by all generated tracks using Monte-Carlo information.

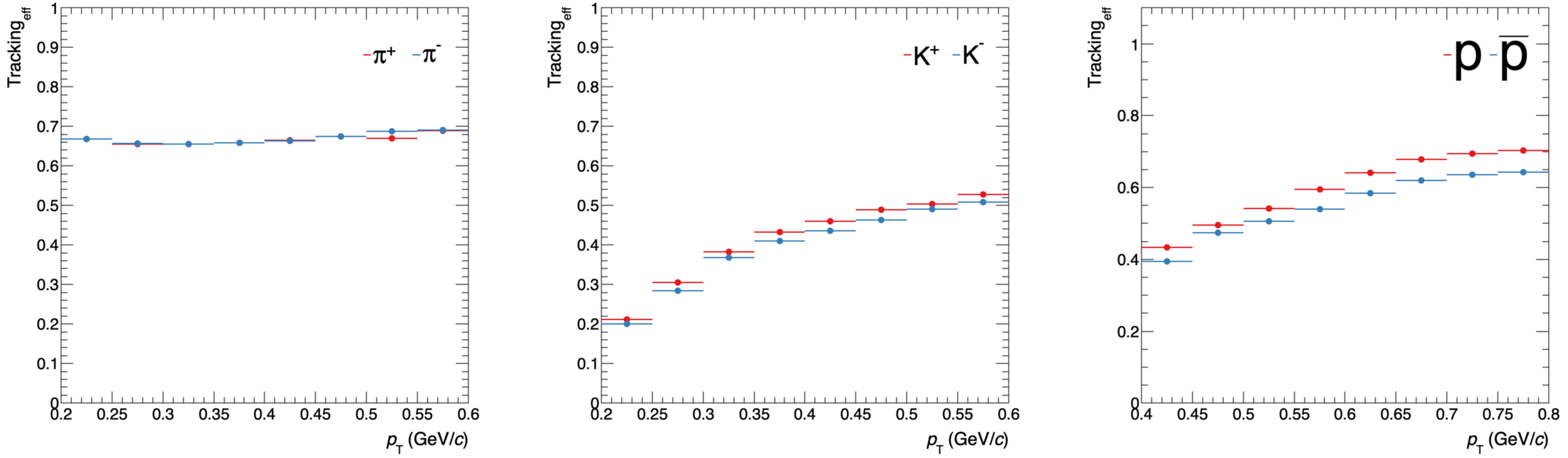
Generated tracks

- Only primary particles are selected
- Pseudo rapidity cut : $|\eta| < 0.8$
- Rapidity cut : $|y| < 0.5$
- PID selection : MC truth with PDG code

Reconstructed Tracks

- Track reconstructed in TPC
- Only primary particles are selected
- PID selection : MC truth with PDG code

Results
Tracking efficiency



Feed down correction

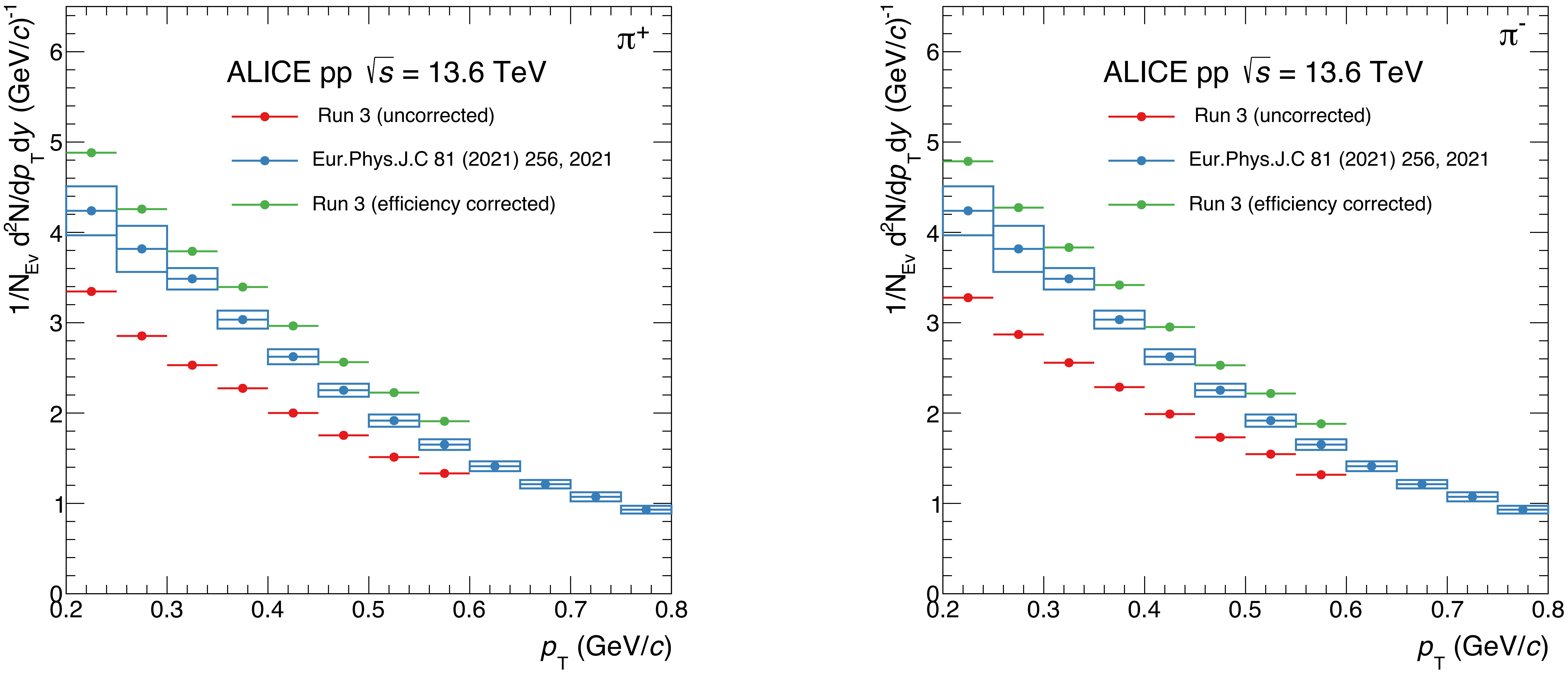
- In order to get the spectra of primary particles i.e the particles which are produced directly in the collisions or in strong decays, one needs to estimate the feed-down correction.

- To select primary tracks, the distance of closest approach of the tracks to the primary vertex in the xy-plane (DCA_{xy}) as a function of p_T has been applied in the raw spectra of the particles.

- The contamination of secondary (i.e. from weak decay and the material knock out particles which are not removed by the p_T dependent DCA_{xy} cut) has been taken into account by estimated primary fraction of particles using models.

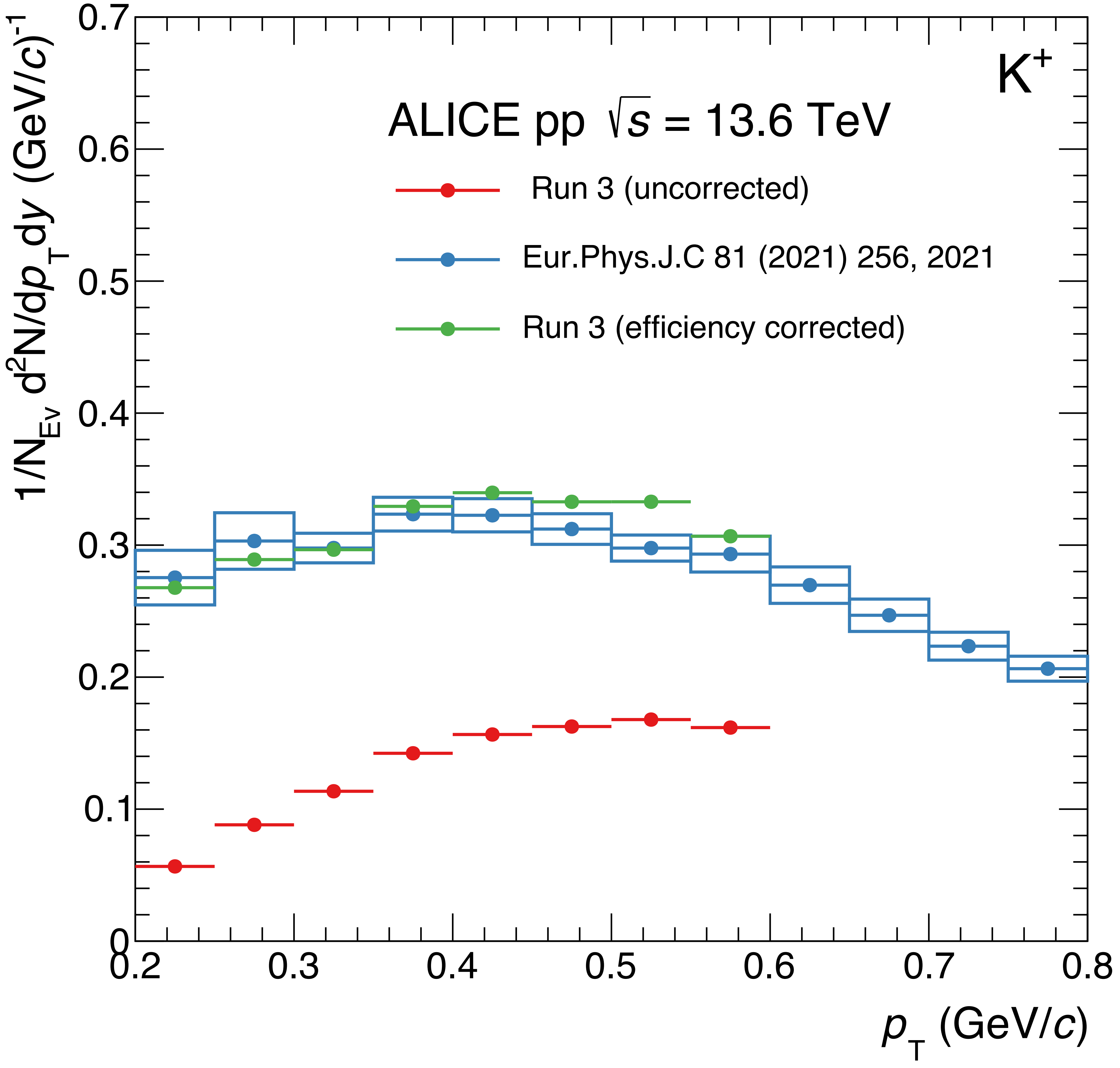
Results

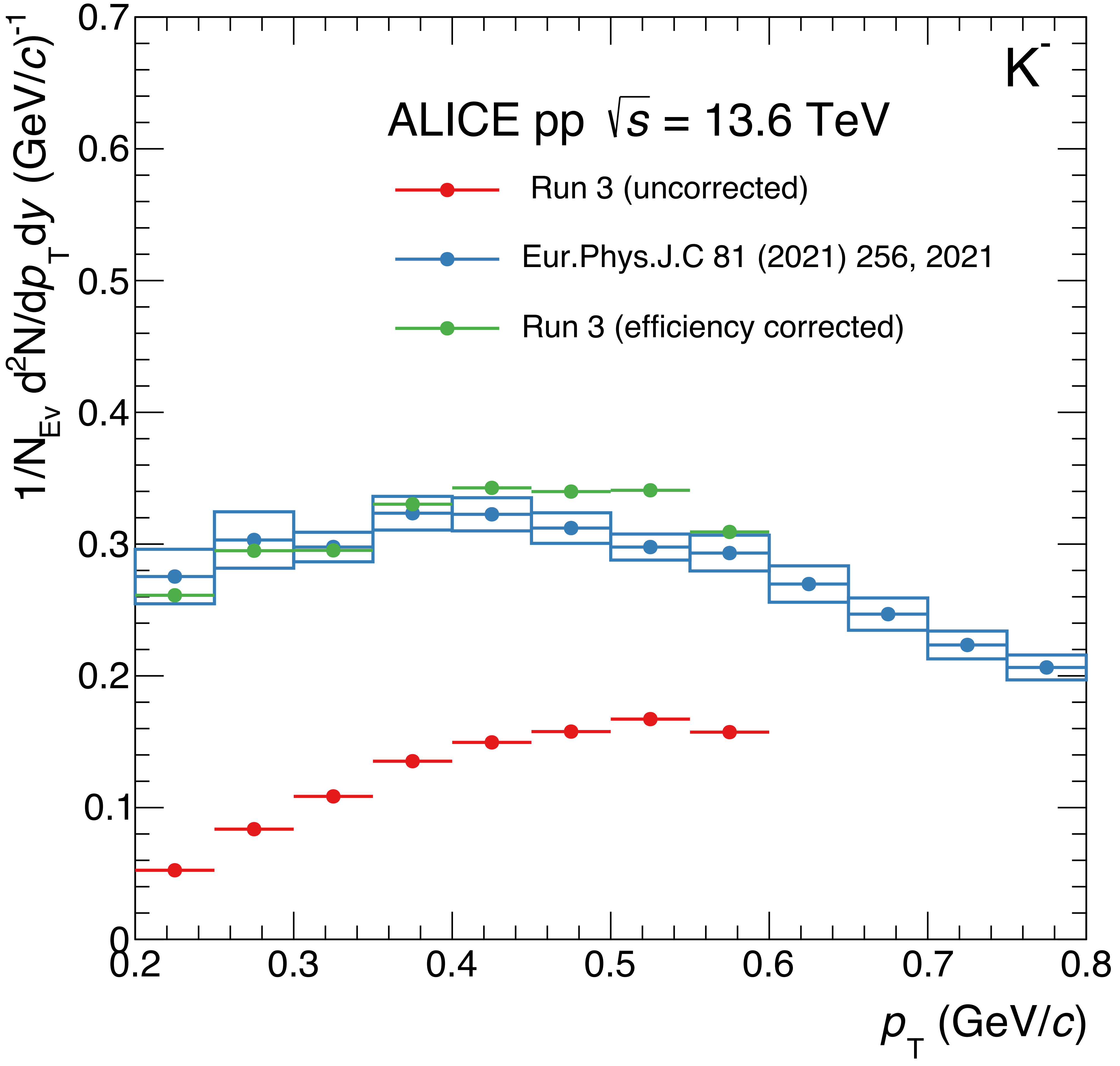
Corrected transverse momentum spectra for π^+, π^-



Results

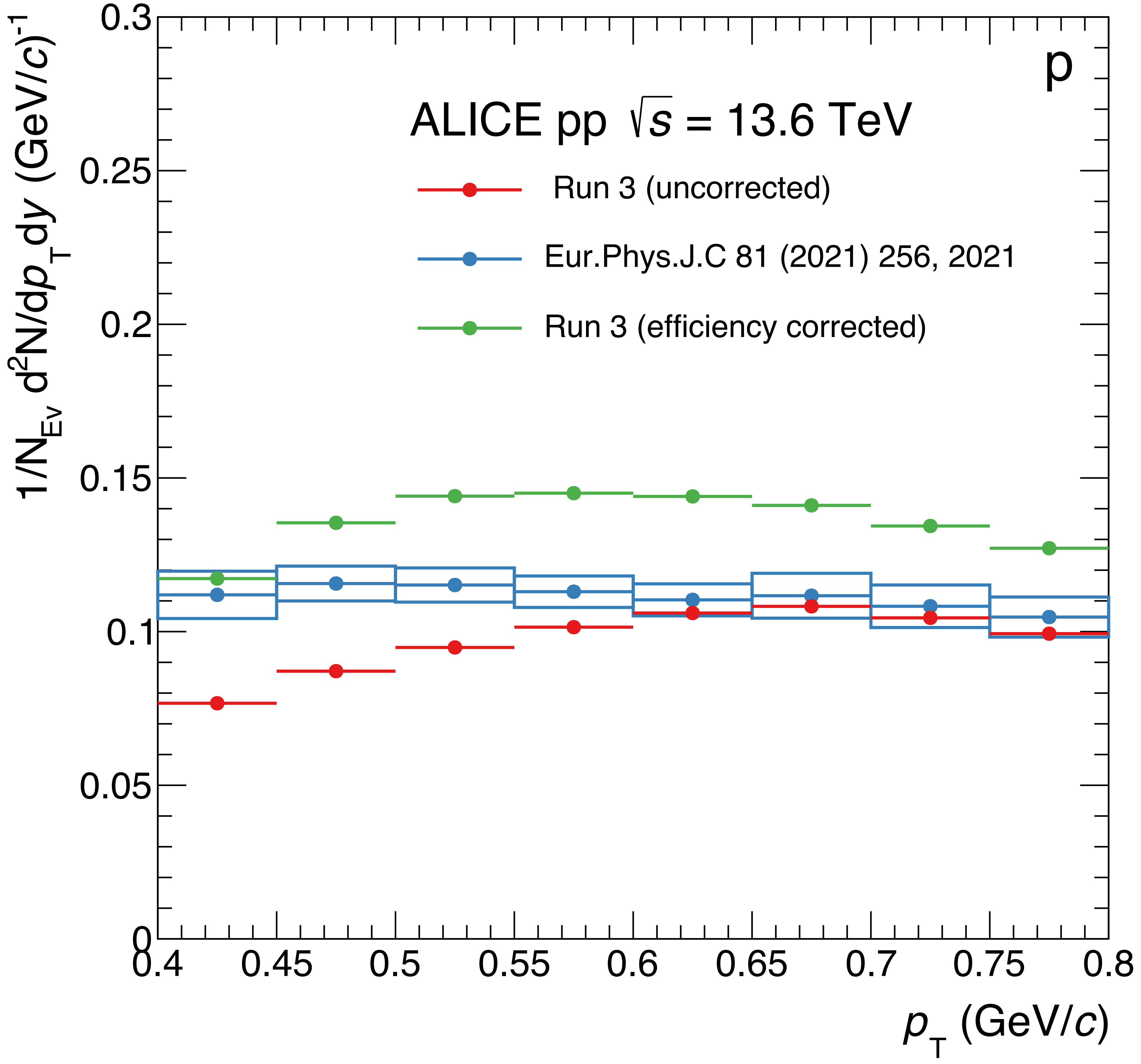
Corrected transverse momentum spectra for K^+, K^-

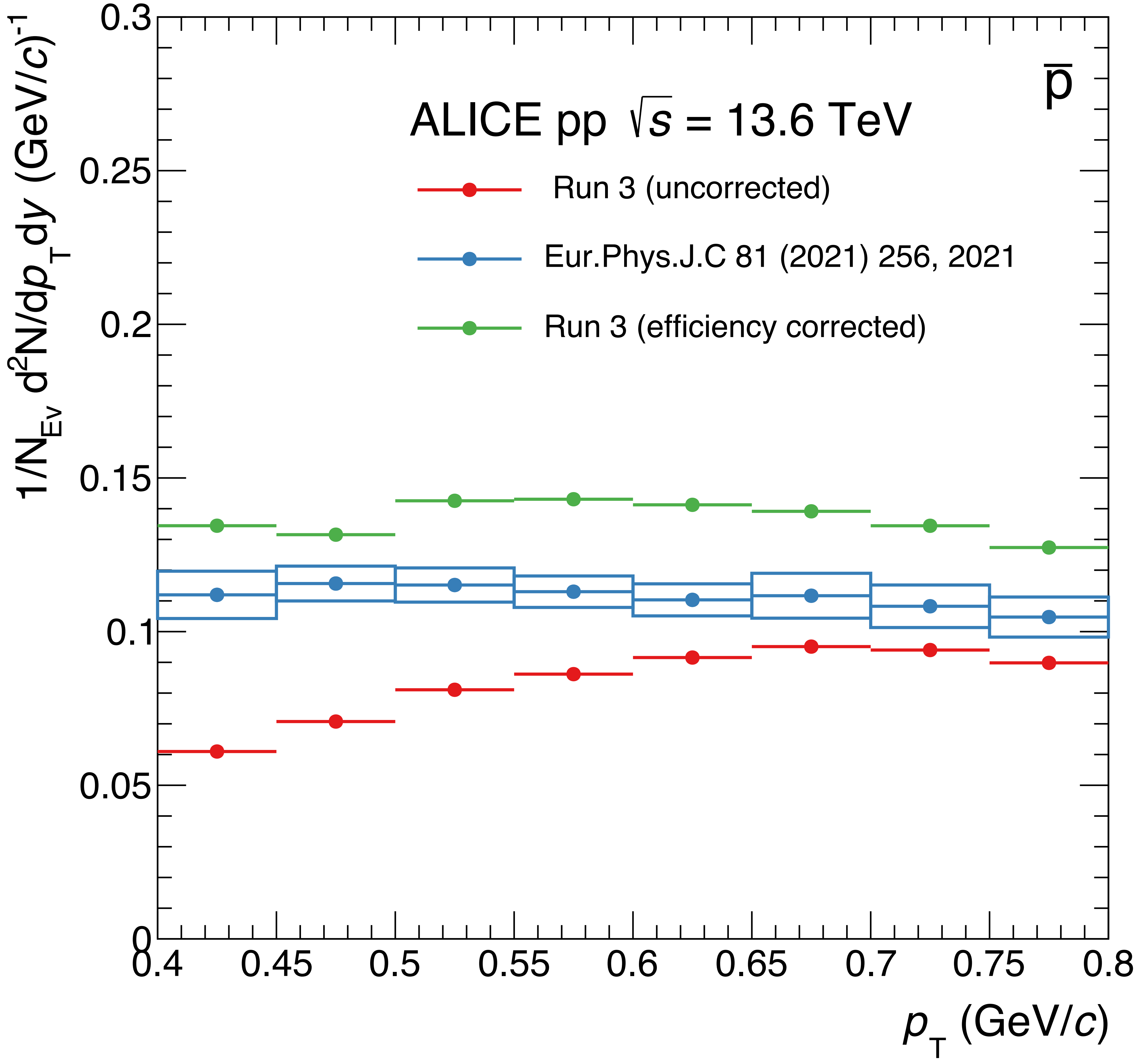




Results

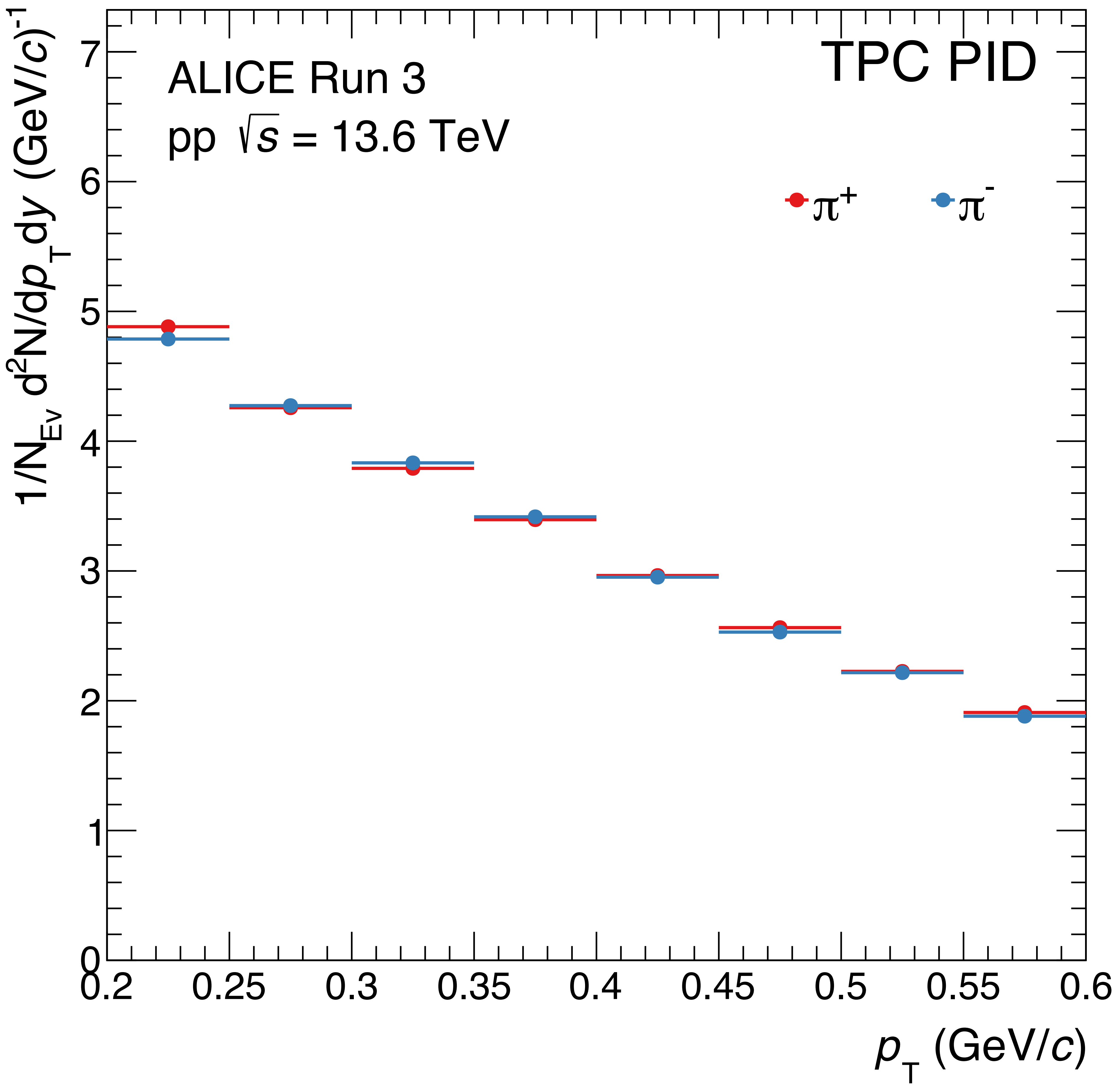
Corrected transverse momentum spectra for $p, \bar{p}$

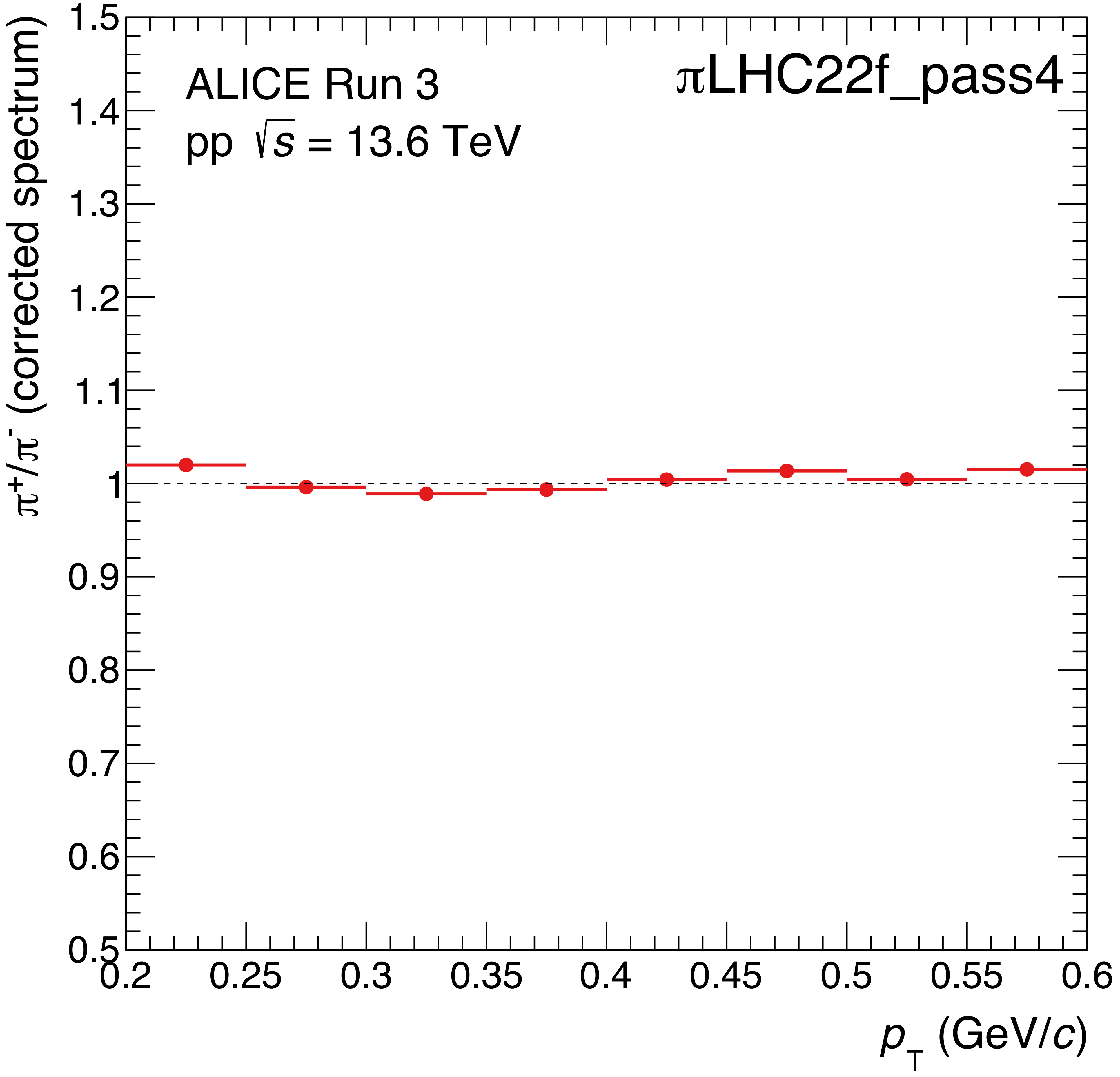




Results

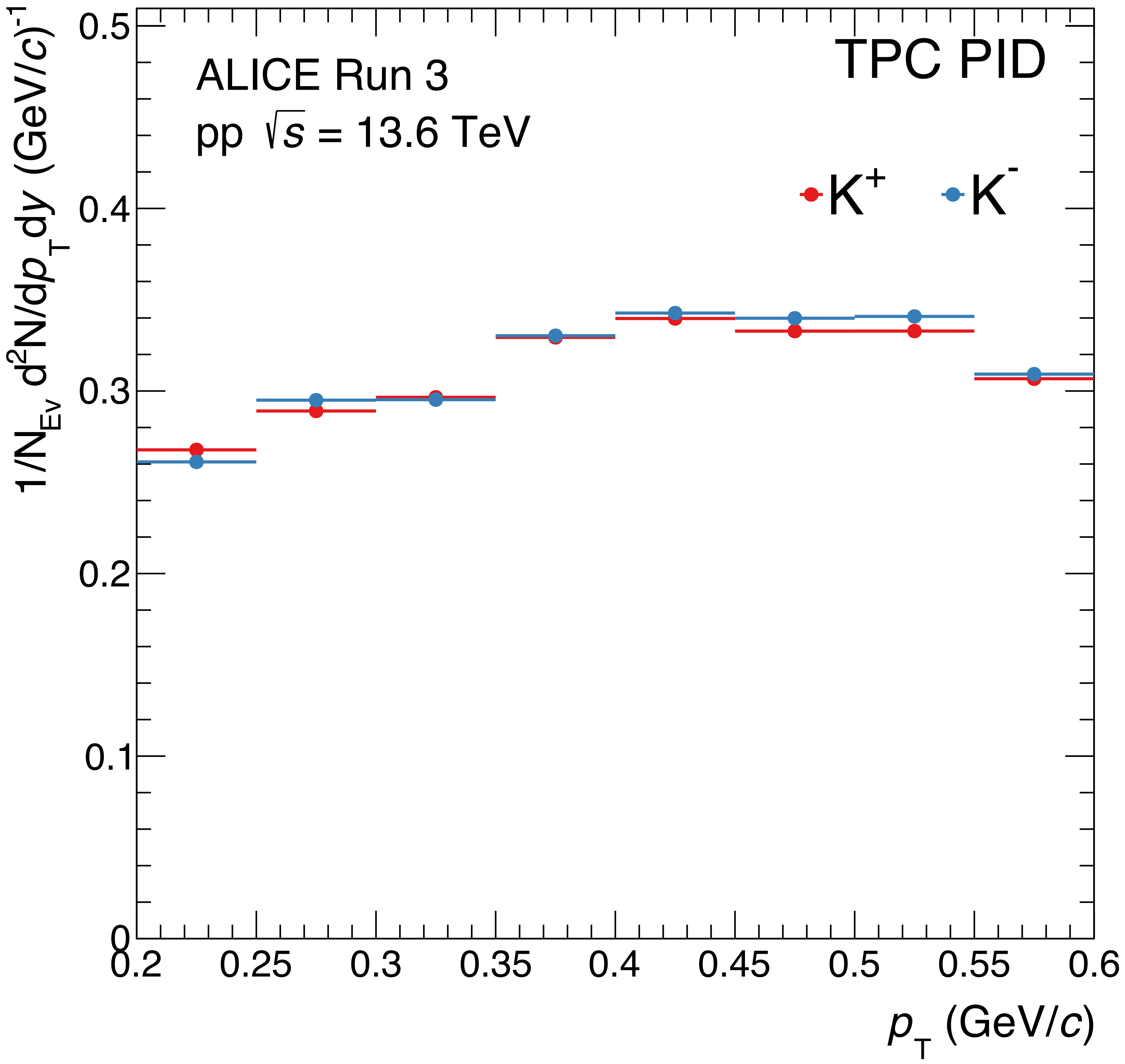
π^+/π^- plot

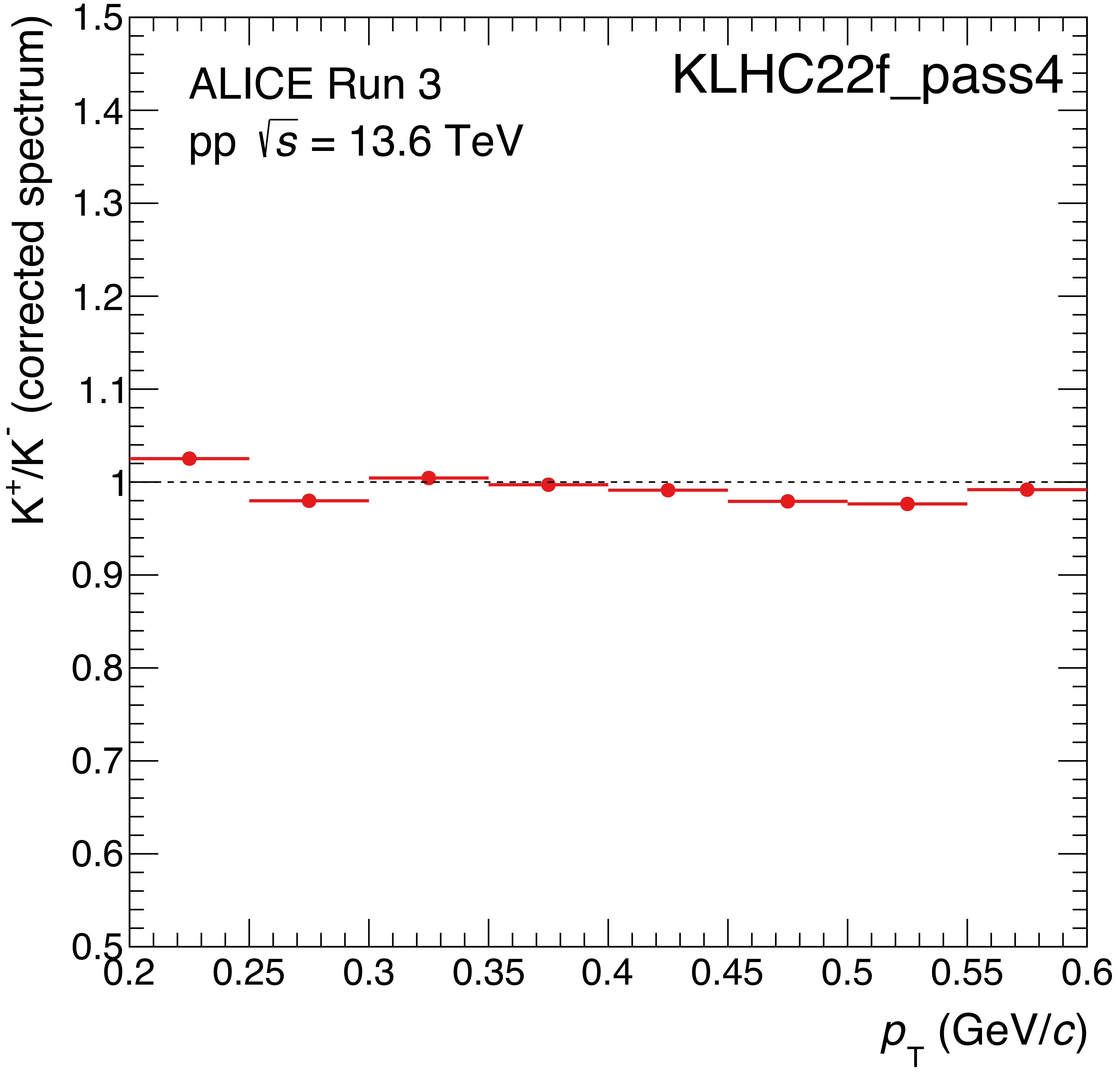




Results

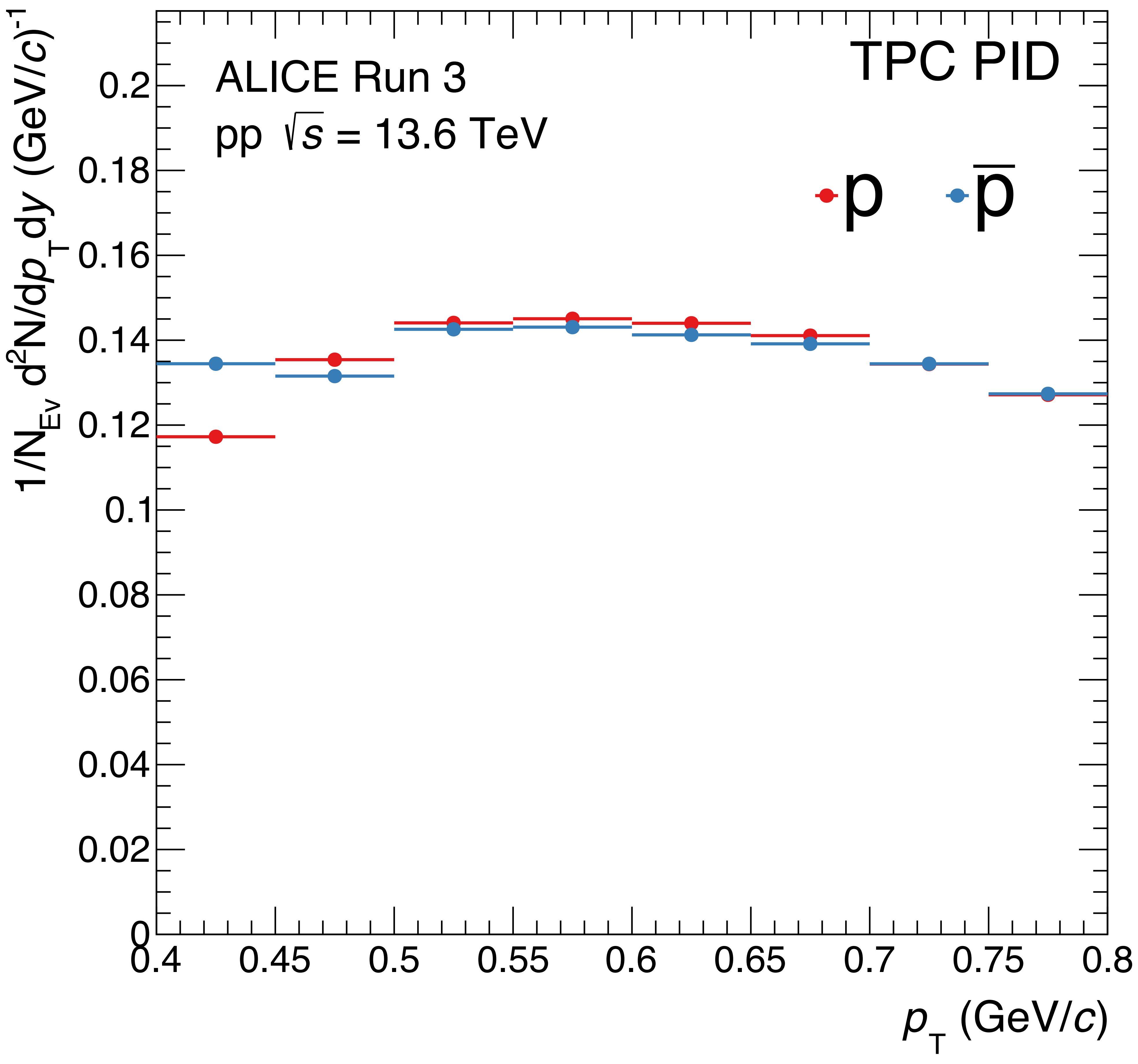
K^+/K^- plot

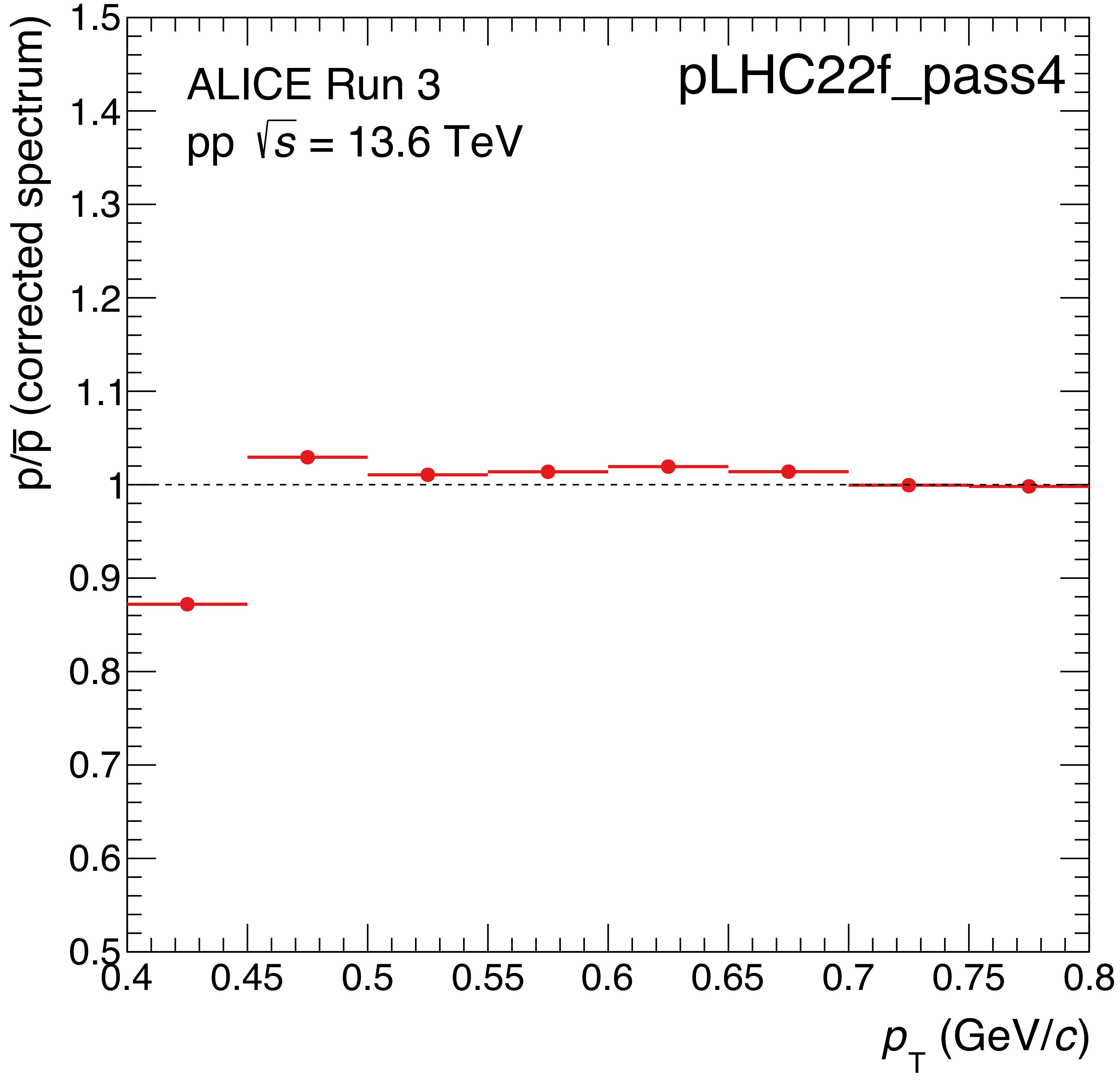




Results

$p/\bar{p}$ plot





Summary

- The respective fitting of TPC signals for π, K, p are well matched with Gaussian distribution, giving an indication of proper identification of light flavour particles.

- The corrected p_T spectra for π and K are showing a good qualitative agreement with that of Run 2 pp results.

- However the corrected p_T spectra for proton and antiproton are not found satisfactory which need further investigation.

Outlook

- Improve the corrected transverse momentum spectra for both proton and antiproton.
- To study the spectra of all species for each centrality classes.
- The multiplicity dependent yield ratio of different light flavour particles to pion will be discussed.

Acknowledgement

- I would like to acknowledge, Department of Science and Technology, Govt. of India for financial assistance through the project entitled “Indian Participation in the ALICE Experiment at CERN” by No. SR/MF/PS-02/2021-GU (E-37122)

- I also want to acknowledge PWGLF-Spectra coordinators, PWGLF-convener Dr. Nicolo Jacazio and my lab mate Mr. Banajit Barman for their constant support in the analysis.

- I want to acknowledge Jammu University for organising ALICE-STAR-India collaboration meeting.

Thank you

Backup slides

Particle identification (PID) through TPC detector

- Charged particles passing through the TPC gas loose kinetic energy by ionisation processes.
- The mean energy loss of a particle passing through a medium can be calculated from Bethe-Bloch formula.
- For a given momentum, the mean energy loss of a particle depends only on the charge and mass of the particle.
- Using Bethe-Bloch formula, one can identify the different particles passing through the same medium.

Bethe-Bloch formula

$$< \frac{dE}{dx} > = \frac{4\pi N e^4}{mc^2}\frac{Z^2}{\beta^2}(ln\frac{2mc^2\beta^2\gamma^2}{I} - \beta^2 - \frac{\delta(\beta)}{2})$$

$$\beta = \frac{v}{c} = \frac{mv}{mc} = \frac{p}{mc}$$

N - number density of electron in the traversed medium

e - elementary charge

Z - charge of the projectile

mc^2 - rest energy of electron

β - velocity of the projectile

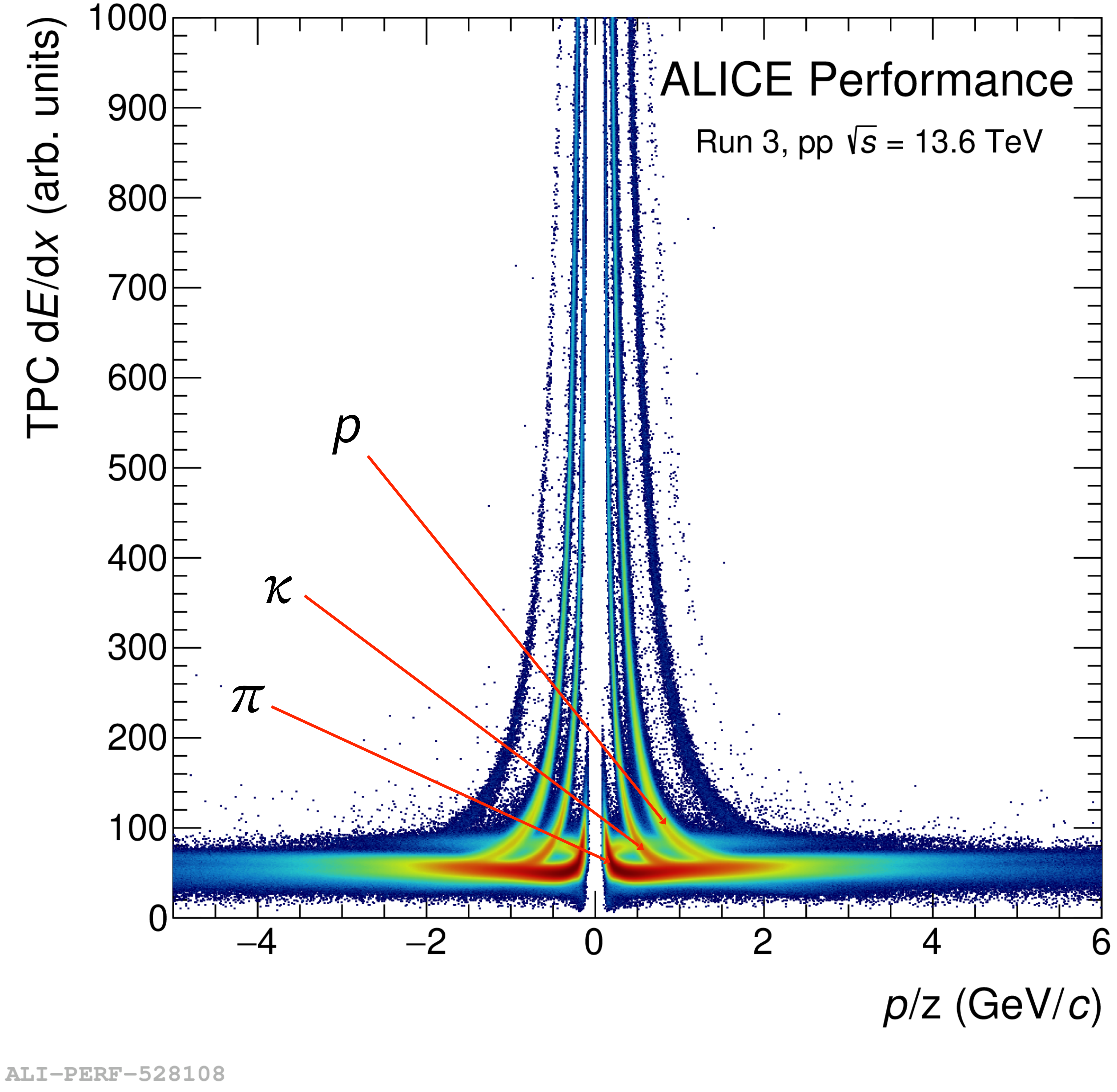
I - mean excitation energy of the atom

$\delta(\beta)$ - correction term

$$< \frac{dE}{dx} > \propto m^2$$

For a given momentum, the mean energy loss of a particle depends of the mass of the particle

Performance of TPC detector



TPC detector performance plot

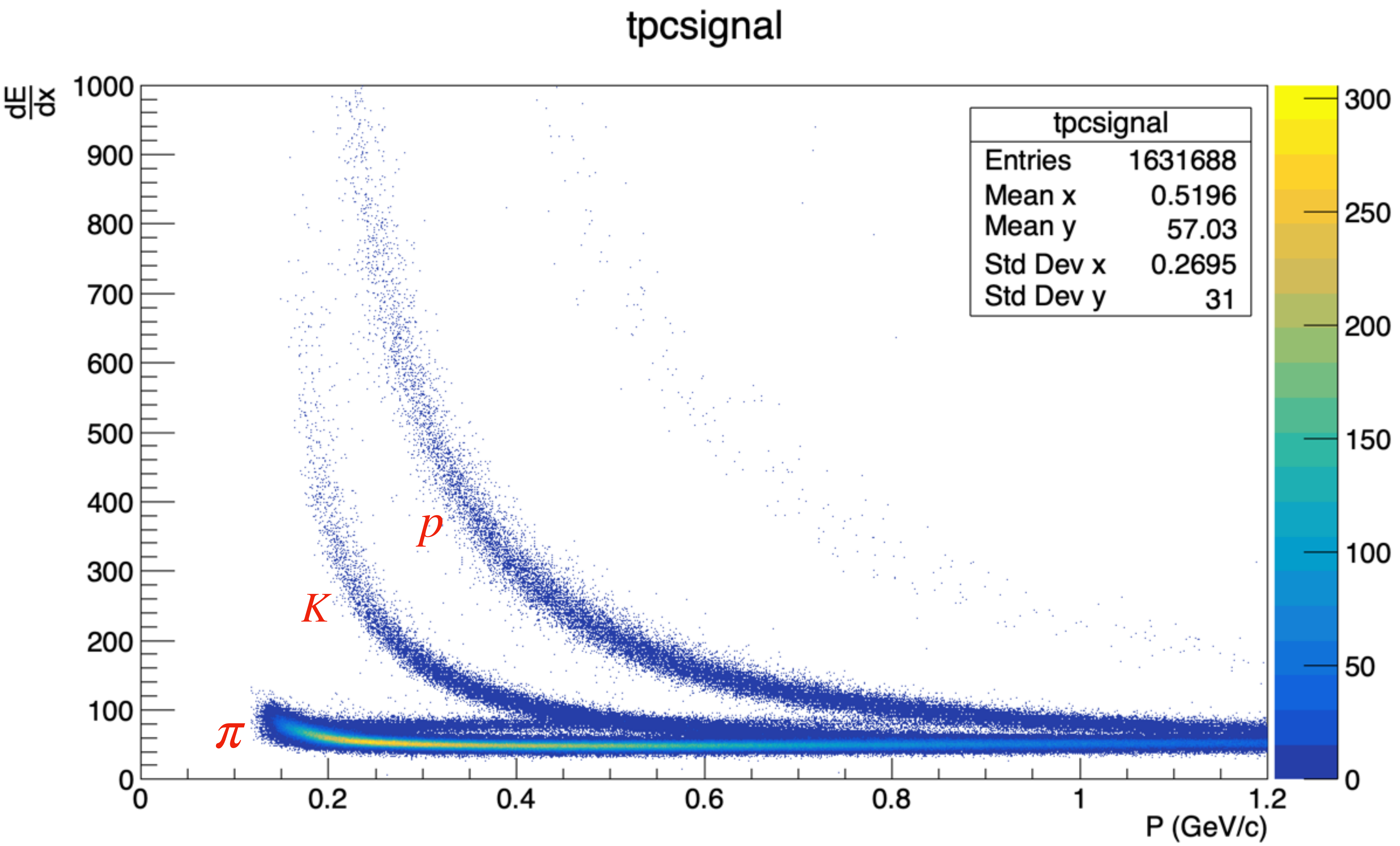


Fig. dE/dx distribution as a function of momentum in pp collisions at $\sqrt{s}$ = 13.6 TeV

TPC-Nsigma, N_σ^{TPC}

$$<\frac{dE}{dx}>_{expected}$$

$$<\frac{dE}{dx}>_{measured}$$

$$N_\sigma^{TPC} = \frac{<\frac{dE}{dx}>_{expected} - <\frac{dE}{dx}>_{measured}}{\sigma_{\frac{dE}{dx}measured}}$$