Particle identification (PID) in MPD

A. Mudrokh (VBLHEP)
on behalf of the MPD team

Outline

- **General idea of PID**
- **Data set configuration and selection criteria**
- **TPC edge cut**
- **dE/dx parameterization**
  - *Typical asymmetric distribution*
  - *Illustration of dE/dx parameterization*
  - *Width and asymmetry parameter parameterizations*
- **m^2 parameterization**
  - *Width parameterization*
  - *TOF reconstruction at STAR and MPD*
- **Multiplicity parameterization**
- **Results: PID efficiency and contamination**
- **Summary**

General idea of Particle Identification (PID)

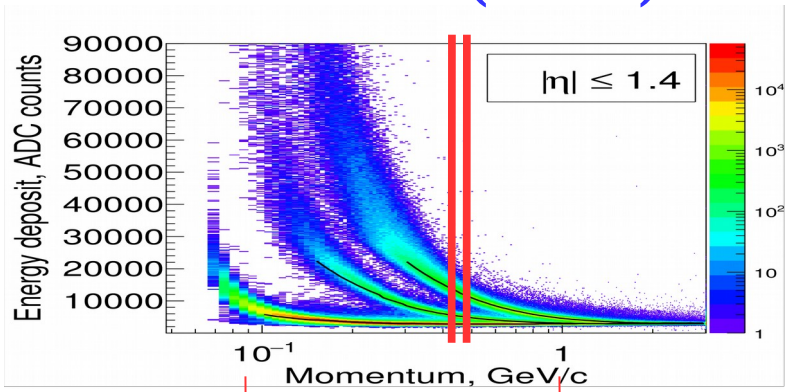
TPC partial probability

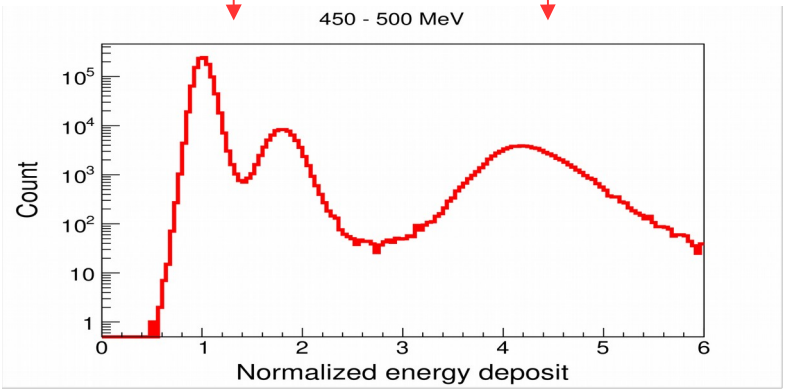
TOF partial probability

ECAL partial probability

…

Combined probability





Parameterizations:
dE/dx (mean, sigma, delta and amplitude vs momentum)
m^2 (mean, sigma and amplitude vs momentum)

Data set and track selection criteria

Data set:

1) UrQMD v3.4 generator

2) Au + Au

3) Center-of-mass energy: 8 GeV

4) Impact parameter: 0..3 fm

Track selection criteria:

1) $|\eta| < 1.4$ *(TPC+TOF acceptance limit)*

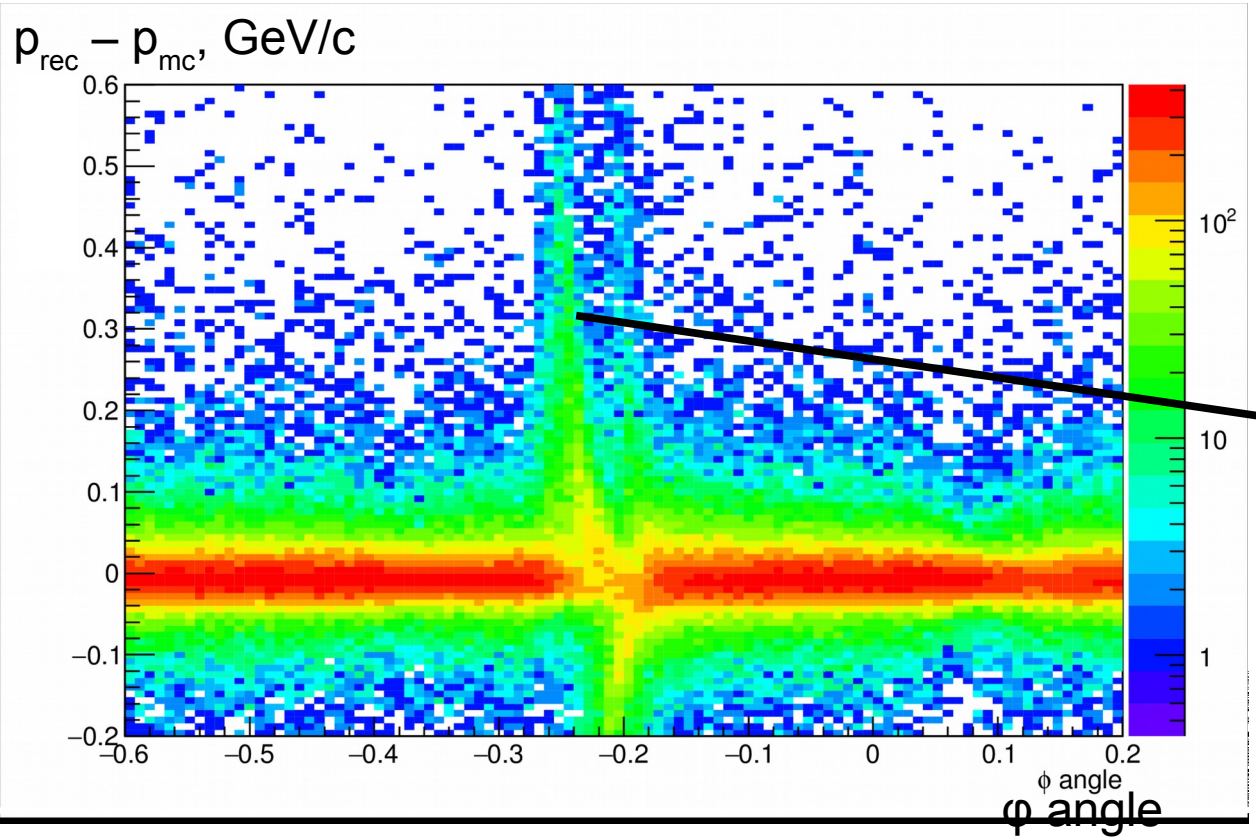
2) nHits ≥ 20

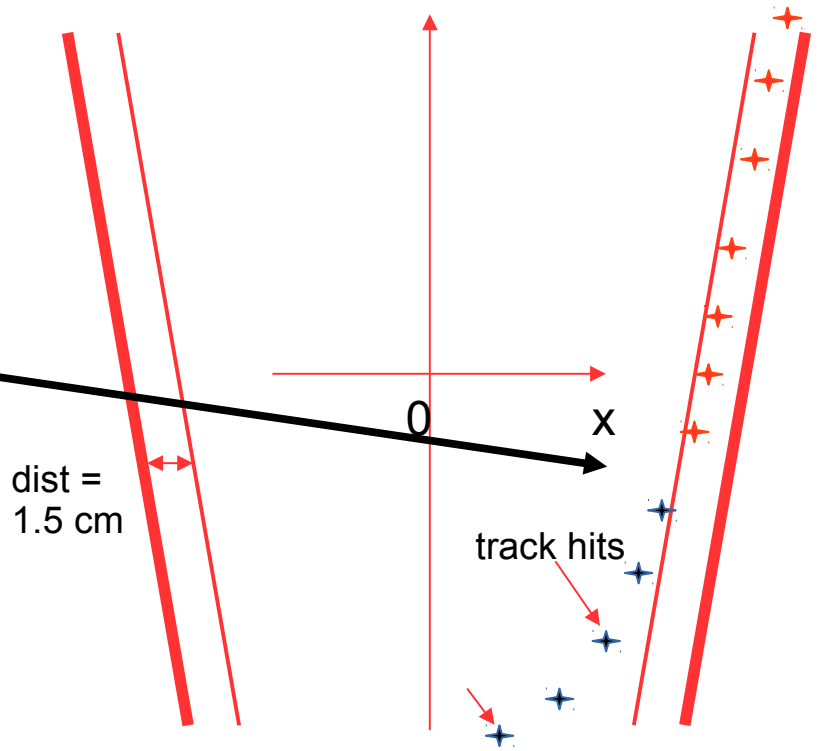
3) TPC edge cut

(will be explained on the next slide)

PID is based on the latest version of the realistic tracking (i.e. it takes into account as many TPC response details as possible). Description of the traking is given in the previous report by A.Zinchenko.

TPC edge cut



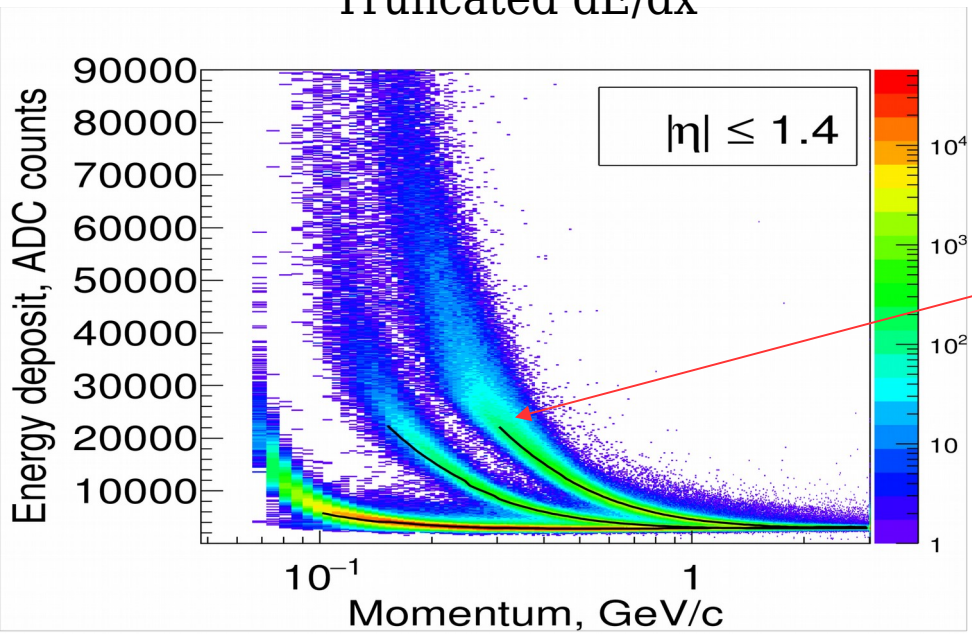


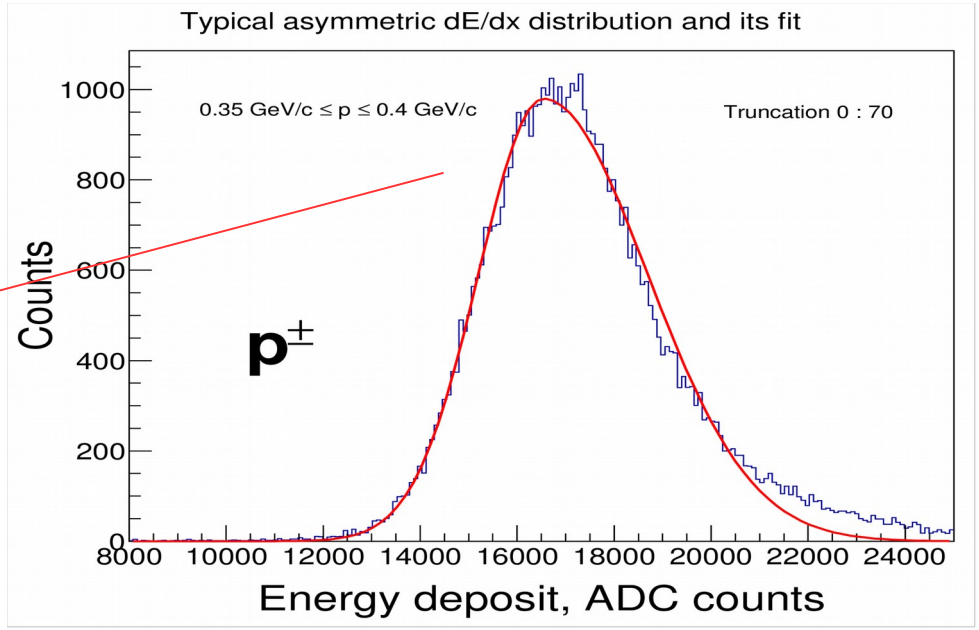
If track hits are close to TPC sector boundary, correct charge collection and momentum reconstruction are difficult. Thus the following criterion has been suggested: if 50% hits (or more) are closer then 1.5 cm to the sector boundary --- remove this track.

Suggested criterion removes ~4% tracks from the data.

dE/dx parameterization

Truncated dE/dx





Bethe-Bloch function (5 parameters) to associate with the average dE/dx:

$$\frac{dE}{dx} = \frac{a_0}{\left(\frac{p}{E}\right)^{a_3}} \cdot \left(a_1 - \left(\frac{p}{E}\right)^{a_3} - \ln\left(a_2 + \left(\frac{m}{p}\right)^{a_4}\right)\right)$$

Asymmetric gaussian function:

$$f(x) = \begin{cases} A \cdot e^{\frac{-(x-\bar{x})^2}{2\sigma_0^2}} & x < x \\ A \cdot e^{\frac{-(x-\bar{x})^2}{2\left(\sigma_0 \cdot (1+\delta)\right)^2}} & x \geq x \end{cases}$$

Sources of asymmetry:

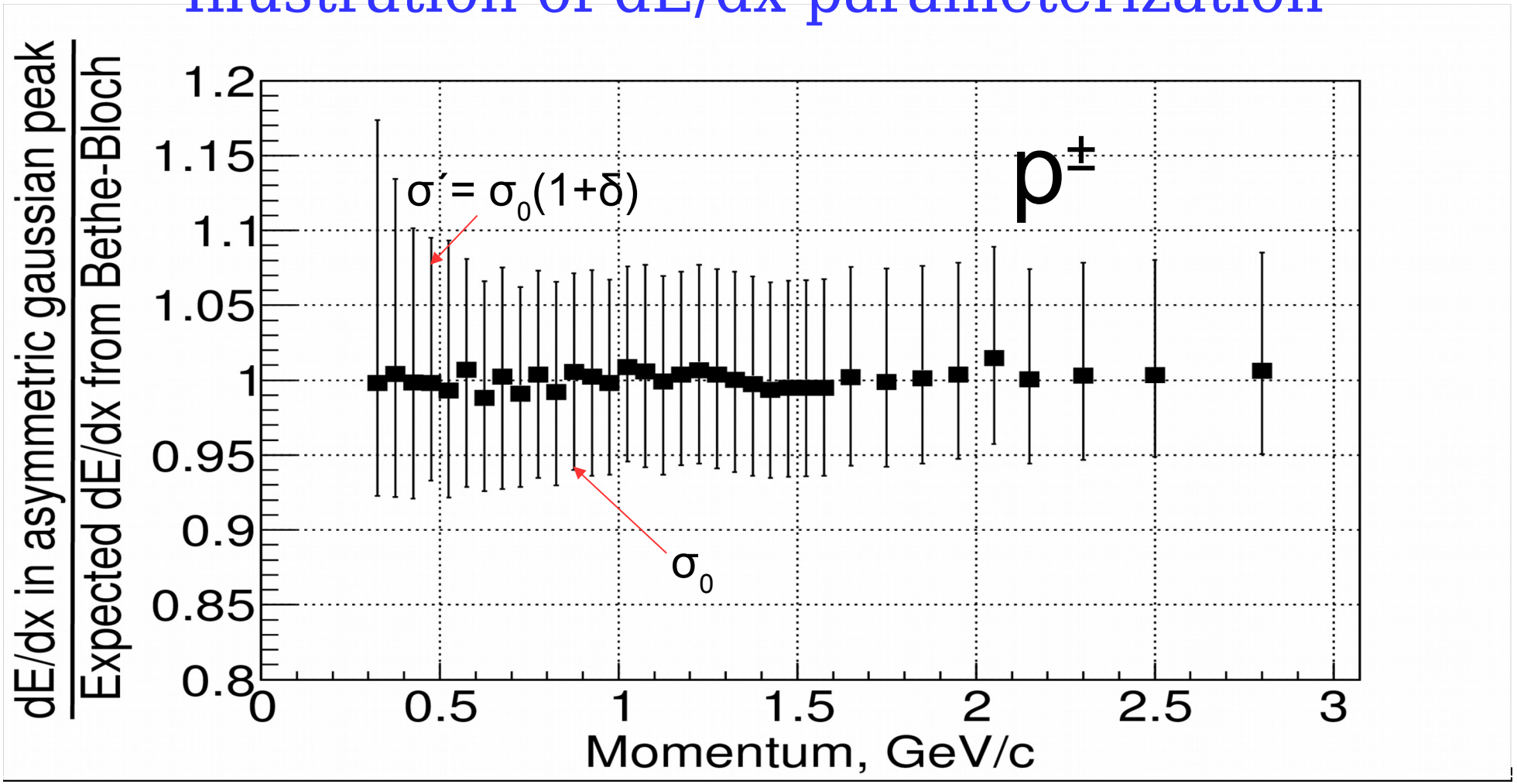
1) Strong dE/dx dependence in low momenta

2) Truncation cannot remove asymmetry

3) Flavor mismatch: all particles are defined as pions during the momentum and dE/dx reconstruction process

4) Etc...

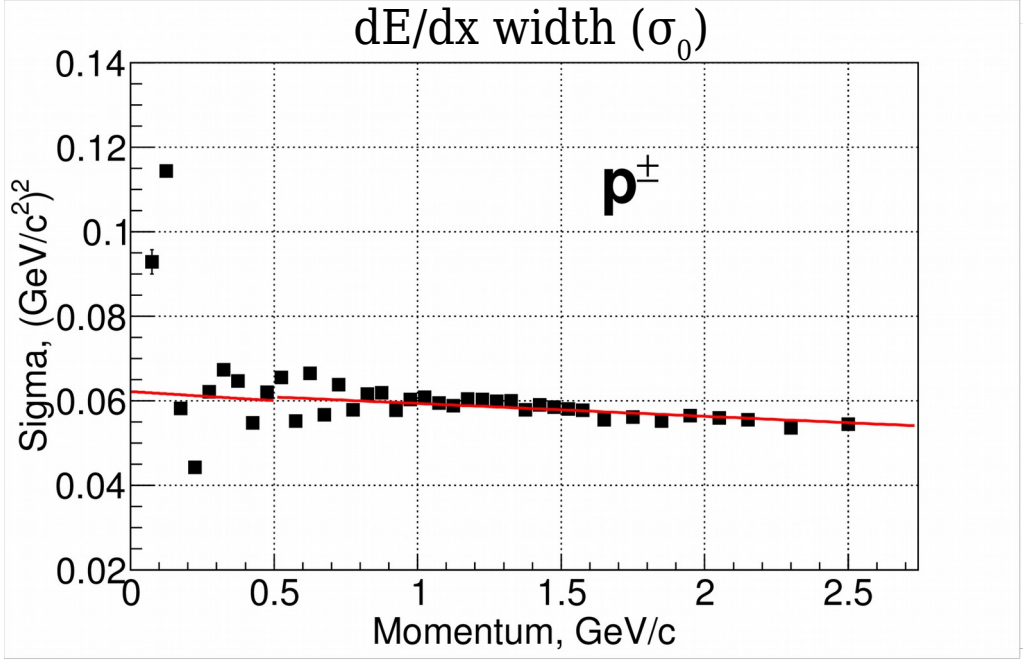
Illustration of dE/dx parameterization

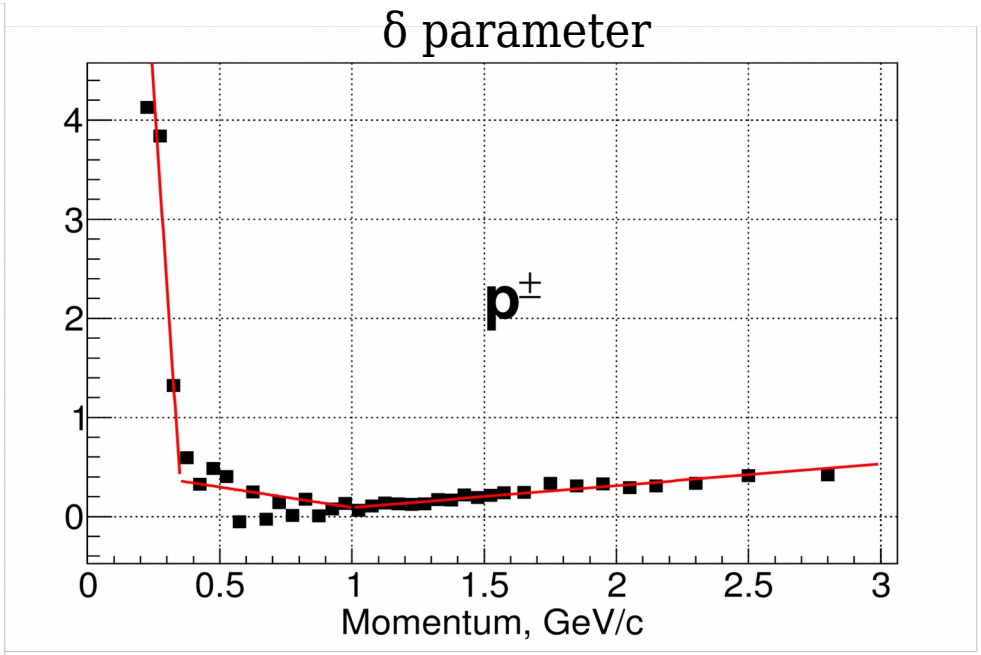


The ratio of dE/dx value in asymmetric gaussian peak over dE/dx value expected from PID is used for estimating PID parameterization quality. It has been done for all particle species included in MPD PID.

Typical value of σ_0 is 6%, σ' is 8%

Width and asymmetry parameter parameterizations



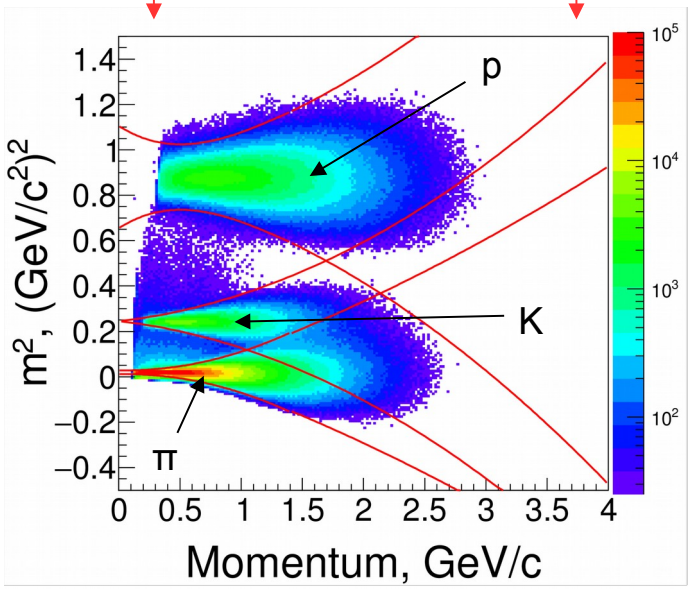


Asymmetric gaussian function:

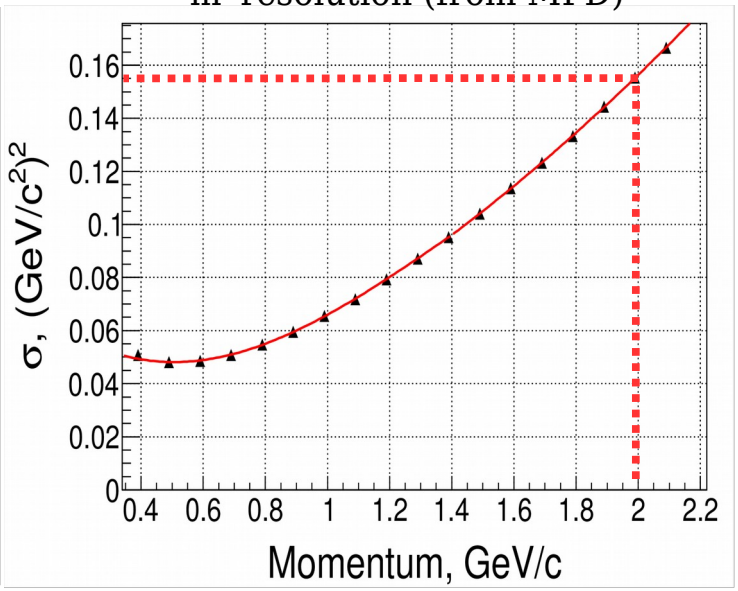
$$f(x) = \begin{cases} A \cdot e^{\frac{-(x-\bar{x})^2}{2\sigma_0^2}} & x < x \\ A \cdot e^{\frac{-(x-\bar{x})^2}{2(\sigma_0 \cdot (1+\delta))^2}} & x \geq x \end{cases}$$

m^2 parameterization

Red lines depict 3σ bands

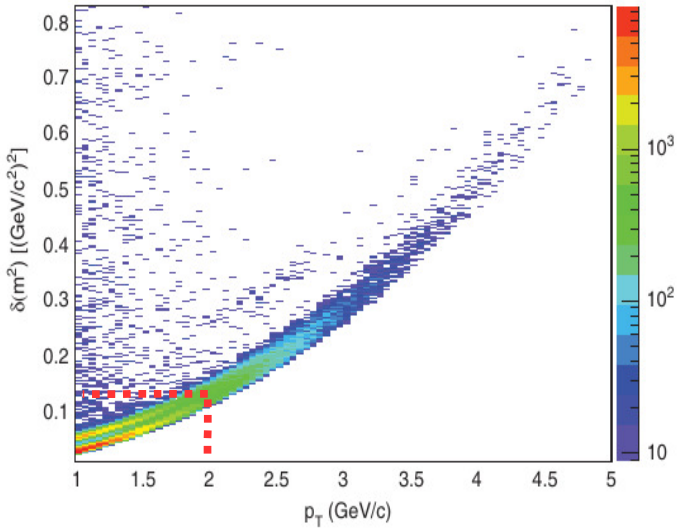


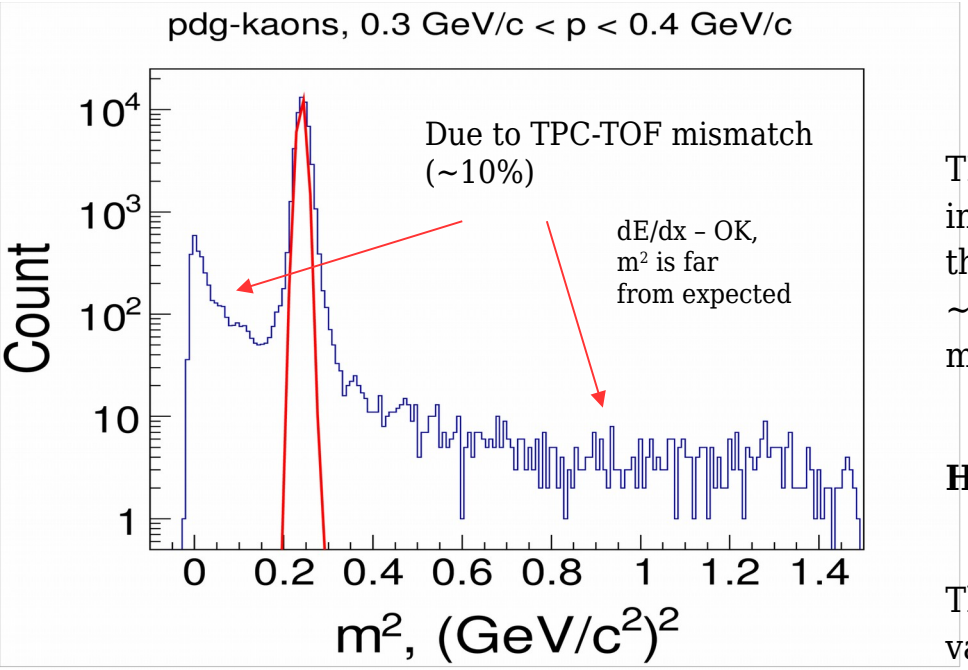
m^2 resolution (from MPD)



doi:10.1016/j.nima.2005.11.251

m^2 resolution (from STAR)





TPC-TOF mismatch:

TPC tracks and TOF hits can be mismatched. This effect is significant in low momenta. Typical example of TPC-TOF mismatch is shown on the left. PDG-kaon's m^2 value has been incorrectly reconstructed for ~10% of the tracks with $0.3 < p < 0.4$ GeV/c. The fraction of mismatched tracks decreases to ~2% in high momenta region.

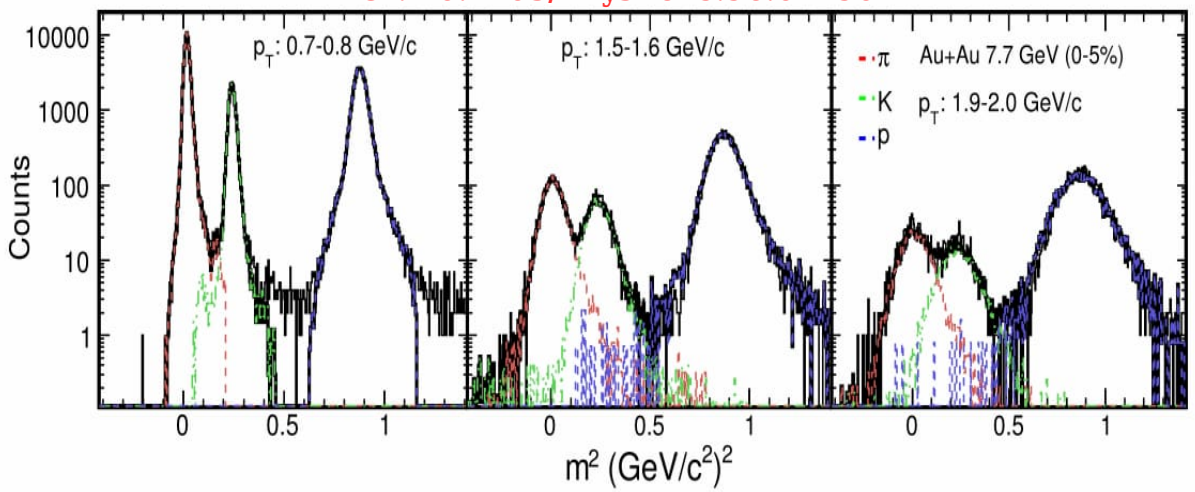
How to deal with mismatches?

The suggestion is to ignore TOF information and identify by dE/dx value, **but only for low momenta particles (p < 0.8 GeV/c).**

TOF reconstruction at STAR and MPD

STAR

DOI: 10.1103/PhysRevC.96.044904



The m^2 distributions for positively charged hadrons used to extract raw yields for pions, kaons, and protons in $|y| < 0.1$ for Au+Au collisions at 7.7 GeV at three different p_T ranges. The curves are predicted m^2 fits representing contributions from pions (dashed-red), kaons (dashed-green), and protons (dashed-blue).

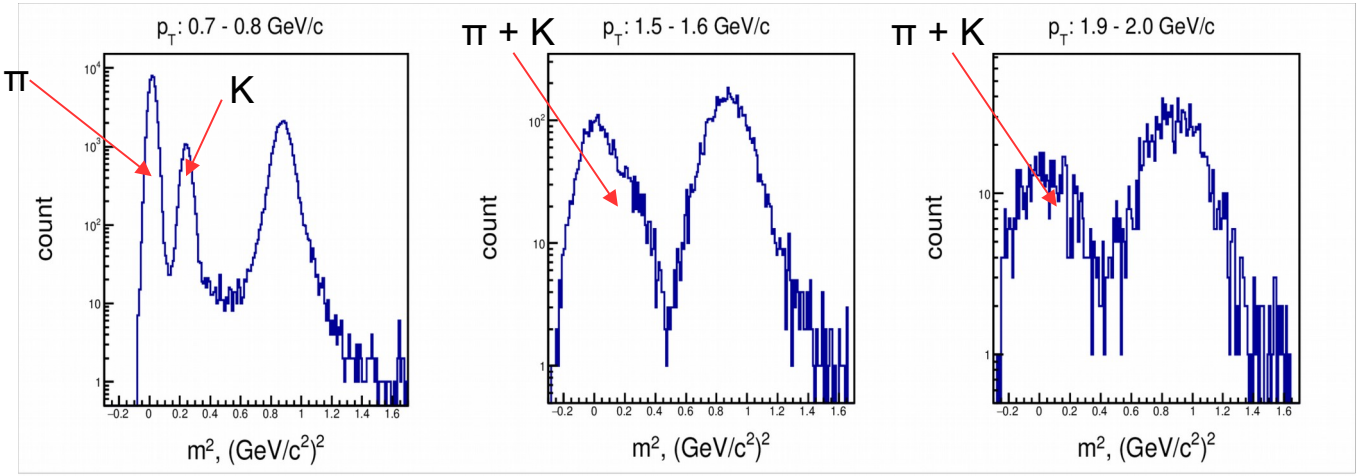
Particle separation properties (STAR):

Time resolution δt = 70 ps
Length uncertainty δL = 0.5 cm
Track length L = 400 cm
Momentum resolution δp = 3,5%

MPD

In order to achieve more accurate identification in MPD particle multiplicities should be taken into account

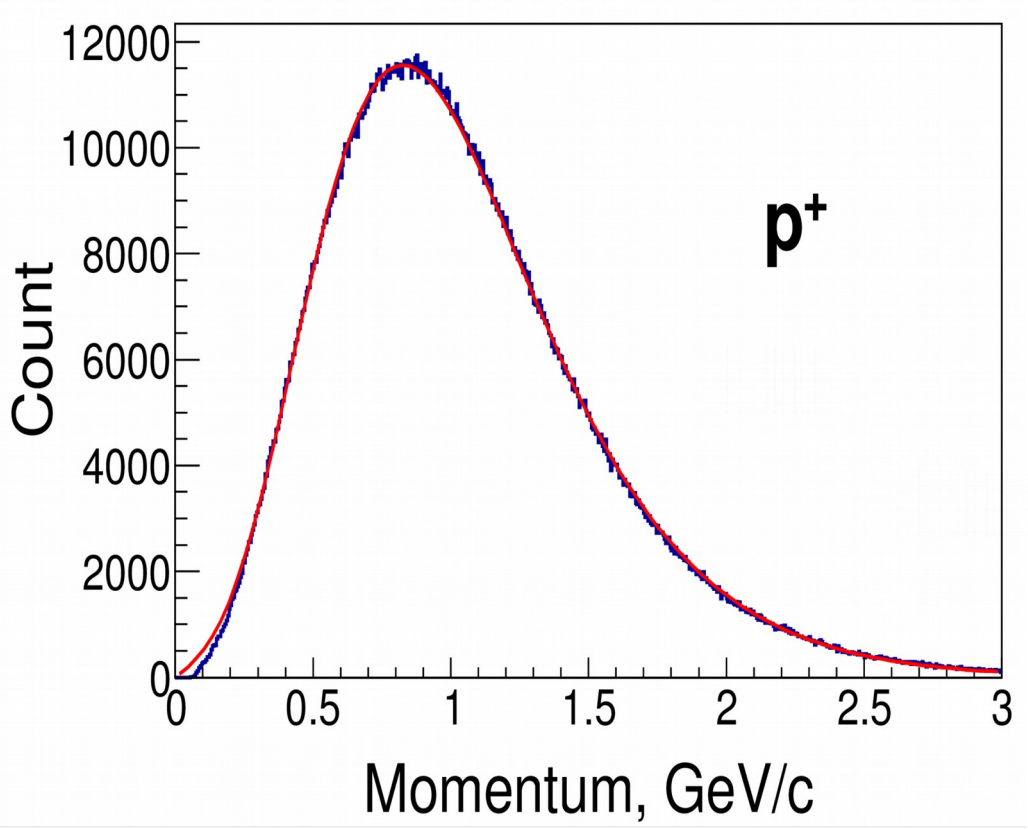
$$m^2 = p^2 \cdot \left(\frac{1-\beta^2}{\beta^2} \right) \qquad \beta = \frac{L}{ct}$$



Particle separation properties (MPD):

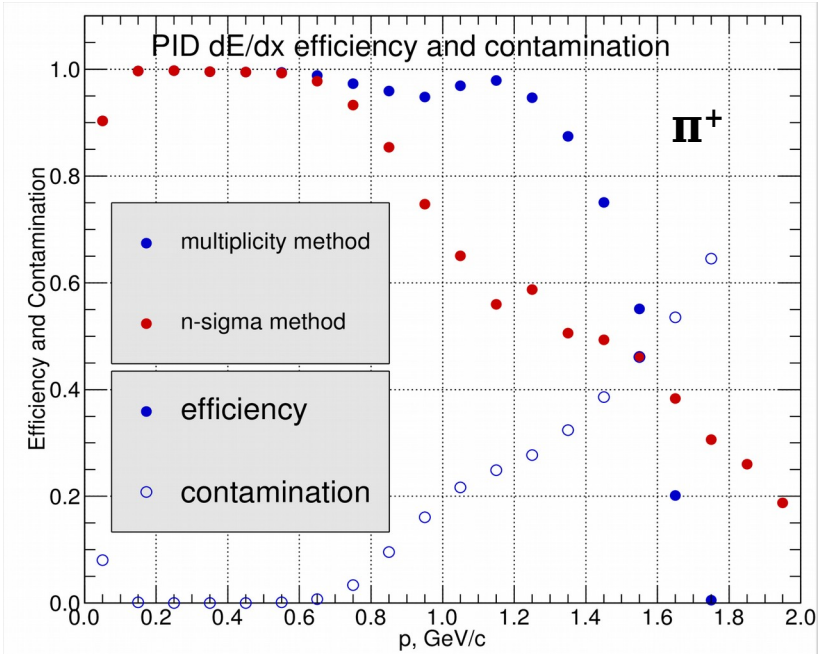
Time resolution δt = 100 ps
Length uncertainty δL = 0.2 cm
Track length L = 220 cm
Momentum resolution δp = 3%

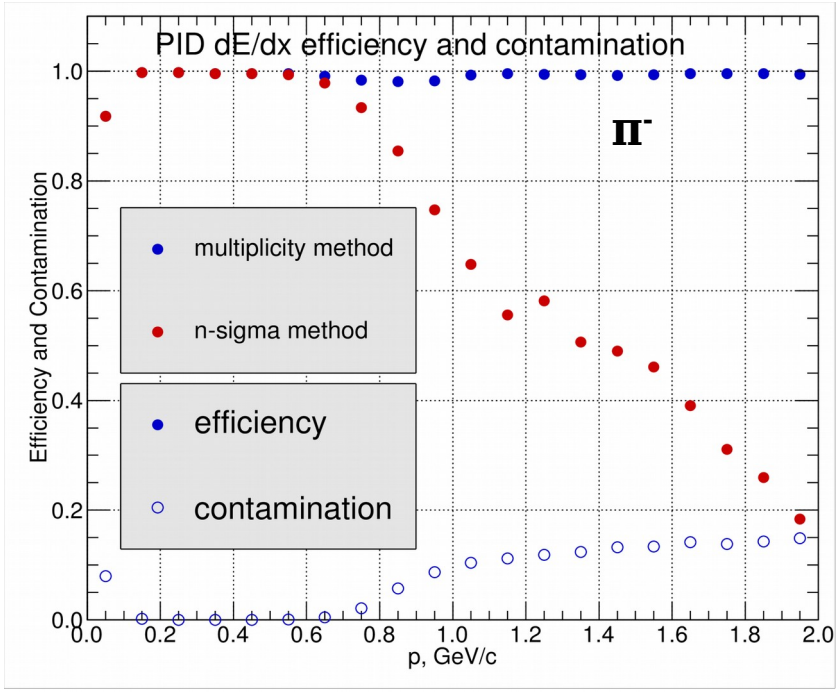
Multiplicity parameterization

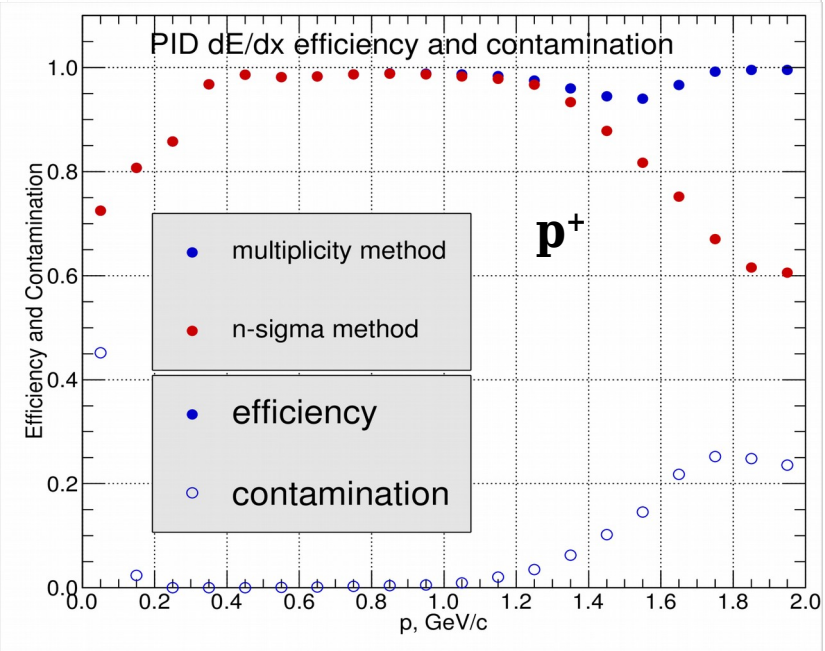


- Particle yields depend on collision energy, centrality and event generator
- However, at NICA energies the hadron yields are quite well known from SPS and RHIC data (both, rapidity spectra and pT-distributions)
- UrQMD reproduces experimental data on momentum distributions of hadrons reasonably well
- So, we can use the model abundancies of different particle specie (momentum dependent) in our PID fits in addition to the standard n-sigma method (implemented in MPD PID as well)

PID dE/dx efficiency, 0 < |η| < 1.4





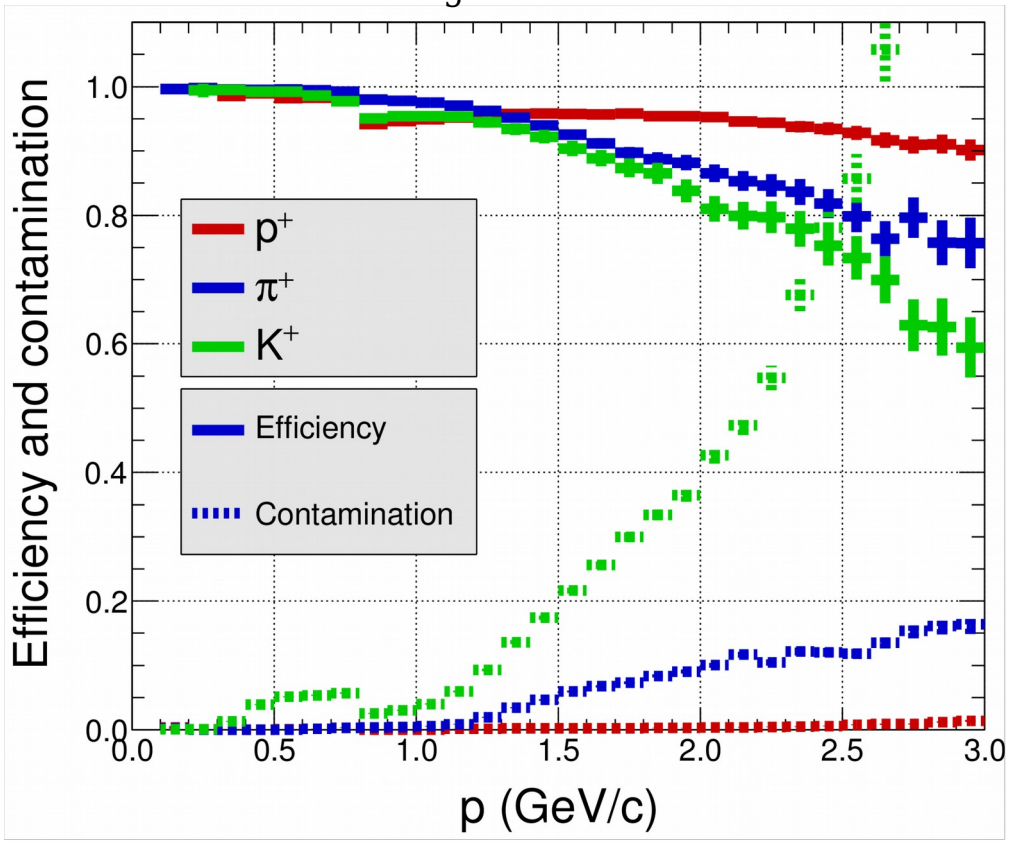


$$eff = \frac{correctly\ \ identified}{reconstructed}$$

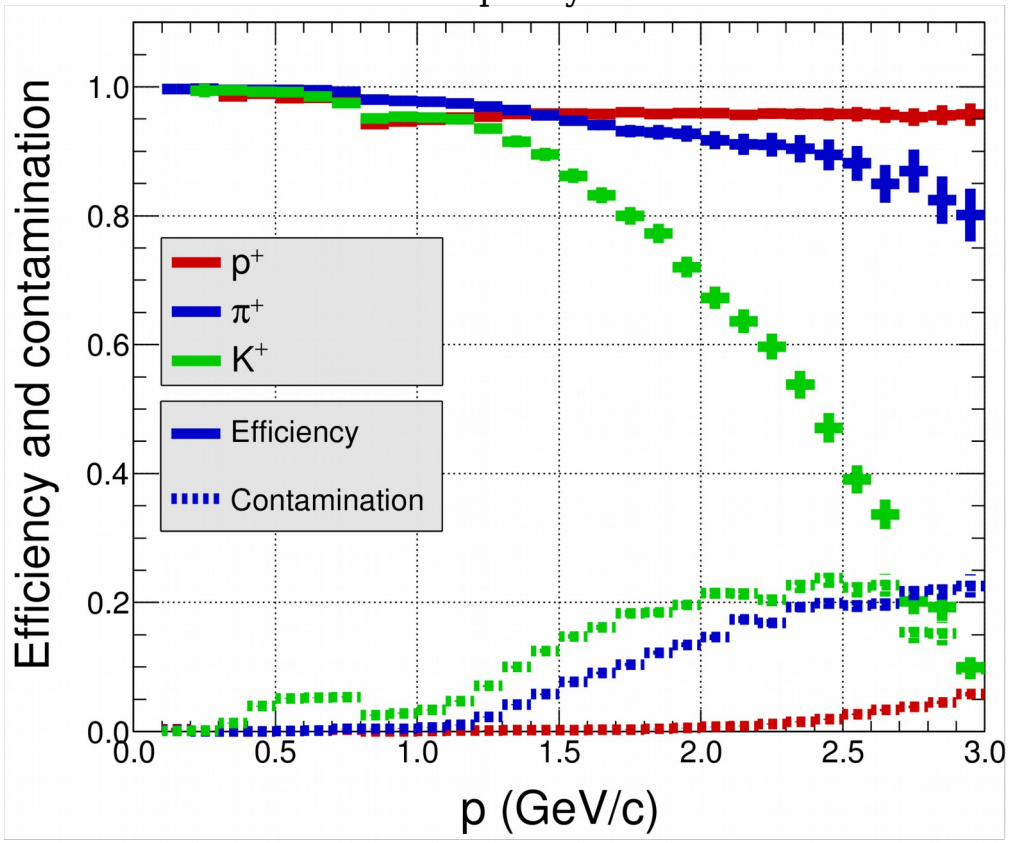
$$cont = \frac{incorrectly\ \ identified}{identified}$$

Combined PID efficiency and contamination, 0 < |η| < 1.4

n-sigma method



multiplicity method



Summary

MPD PID based on the recent developments of the realistic tracking has been worked out. Results of multiplicity and n-sigma methods have been compared. Multiplicity method provides identification with less contamination than n-sigma. Both methods have been implemented in MPDRoot software package and can be used.