# Particle identification (PID) and prospects for the study of event-by-event fluctuations at MPD

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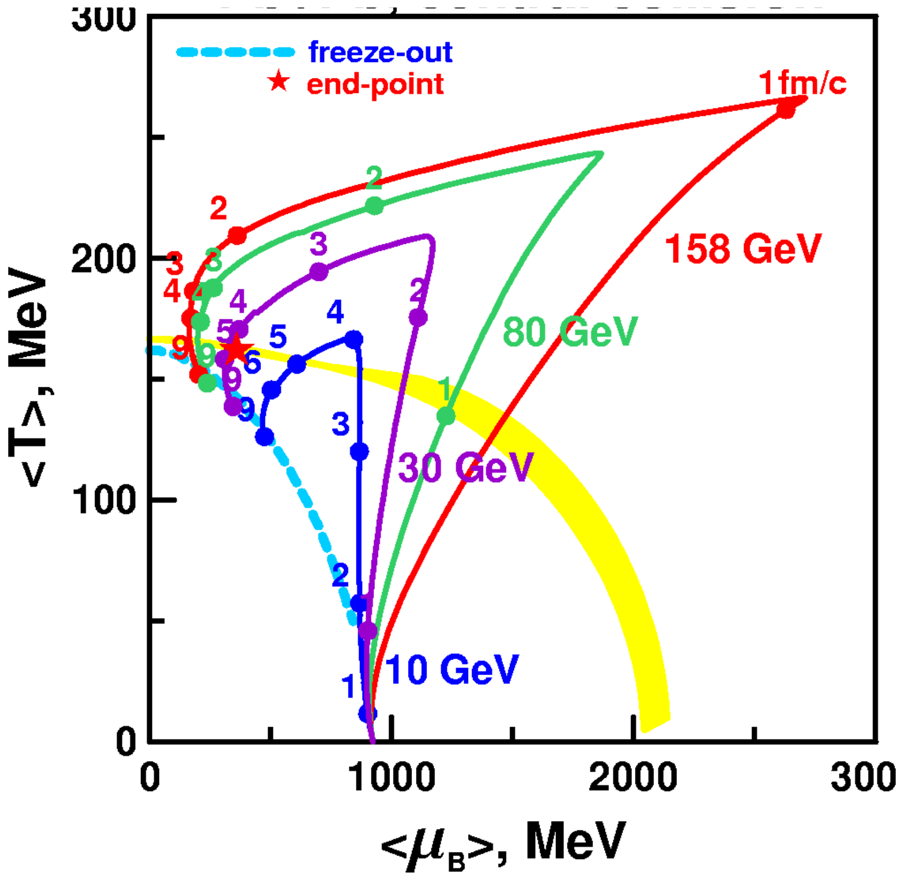
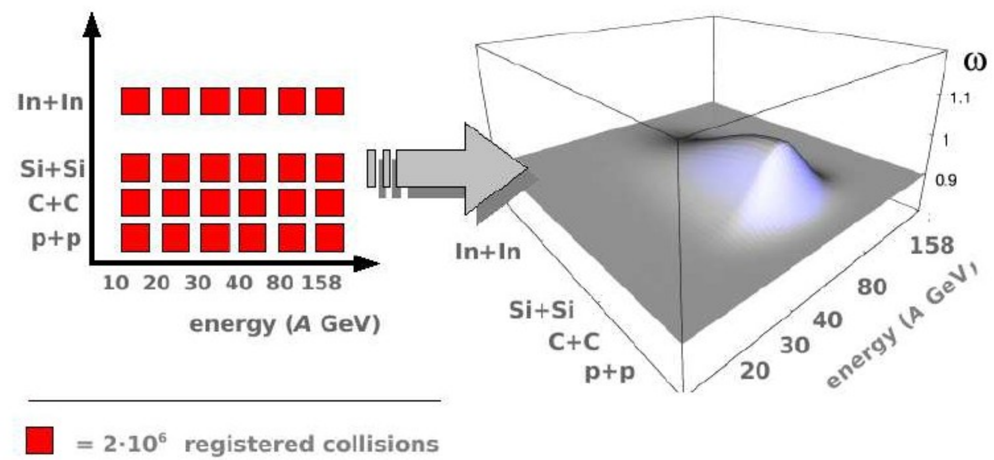
# QCD phase diagram. Critical end point (CEP)

Trajectories calculated by the 3-fluid hydrodynamics model
Toneev & Ivanov




**If the trajectory is in the vicinity of the critical endpoint – abnormal fluctuations can be observed**




**Observables - event-by-event fluctuations:**

- multiplicity, charge number
- particle ratios
- mean pT, azimuthal angle
- baryon number

**Experimental challenge:** fluctuation signal may be suppressed due to final state interactions that washed out the signal. True CEP signal should show consistency in several observables!

# MPD detector: data set and selection criteria

**Data set:**

**1) UrQMD v3.4 generator**

**2) Au + Au**

**3) Center-of-mass energy: 8 GeV**

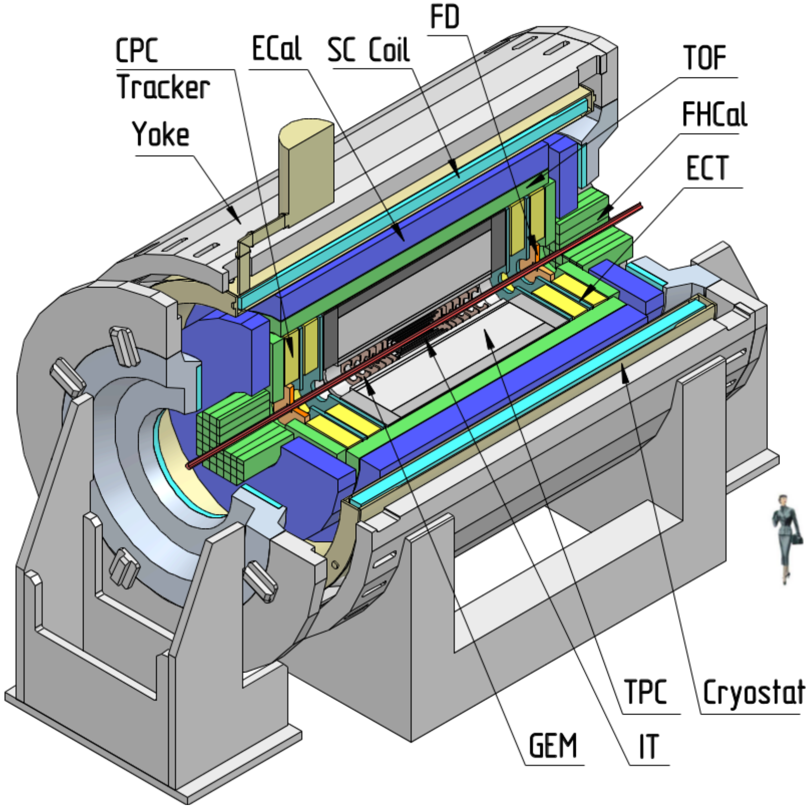
**4) Impact parameter: 0..3 fm**

**Track selection criteria:**

**1) |η| < 1.4** *(TPC+TOF acceptance limit)*

**2) nHits ≥ 20**

**3) TPC edge cut** *(removes tracks with significant difference between simulated and reconstructed momenta)*




**PID is based on the latest version of the realistic tracking.**

**It takes into account as many TPC response details as possible.**

# General idea of Particle Identification (PID)

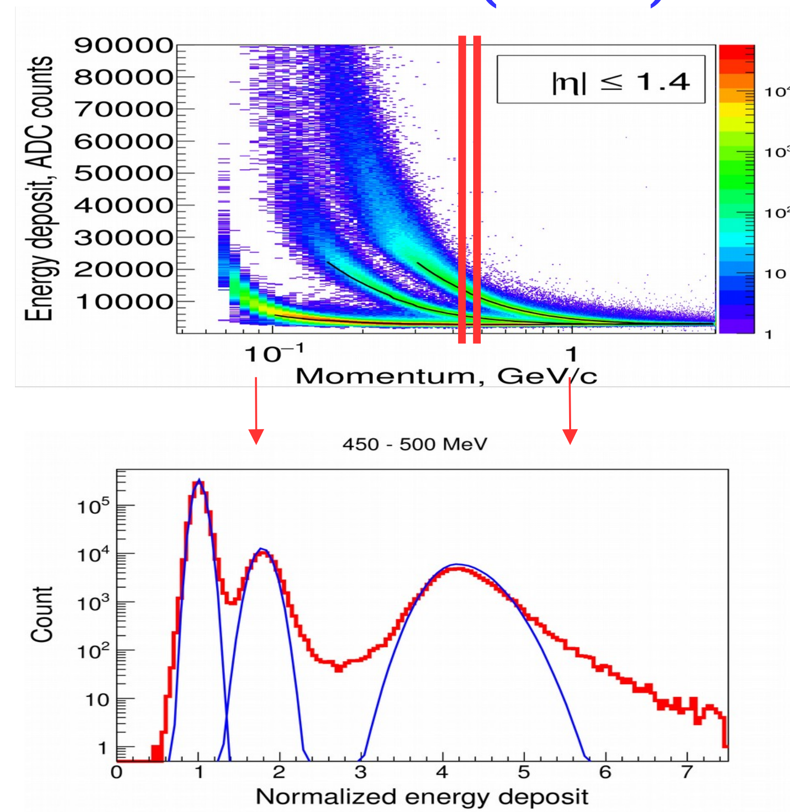
**TPC partial probability**

**TOF partial probability**

**ECAL partial probability**

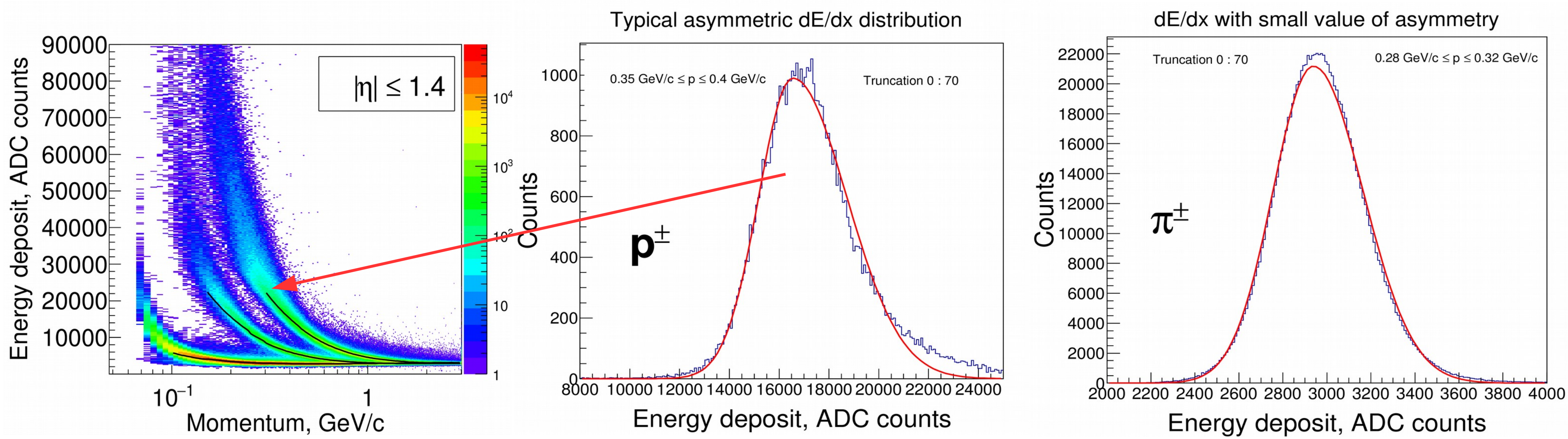
**...**

**Combined probability**




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

# dE/dx parameterization




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

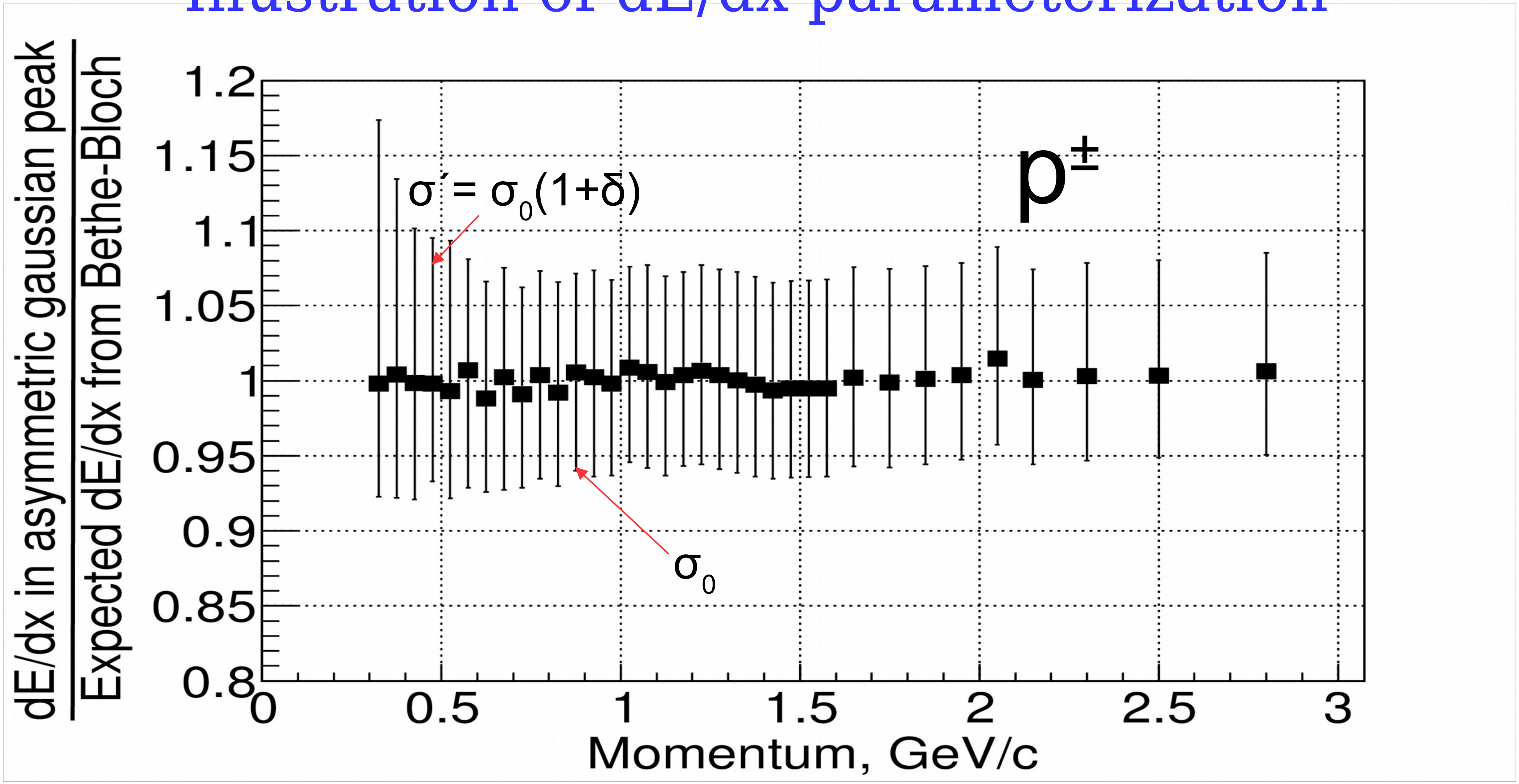
$$\frac{dE}{dx} = \frac{a_0}{\left(\frac{p}{E}\right)^{a_3}} \cdot \left(a_1 - \left(\frac{p}{E}\right)^{a_3}\right) - \ln\left(a_2 + \left(\frac{m}{p}\right)^{a_4}\right)$$

Asymmetric gaussian function:

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

*Sources of asymmetry:*
*1) Strong dE/dx dependence in low momenta*
*2) Truncation cannot remove asymmetry*
*3) Etc...*

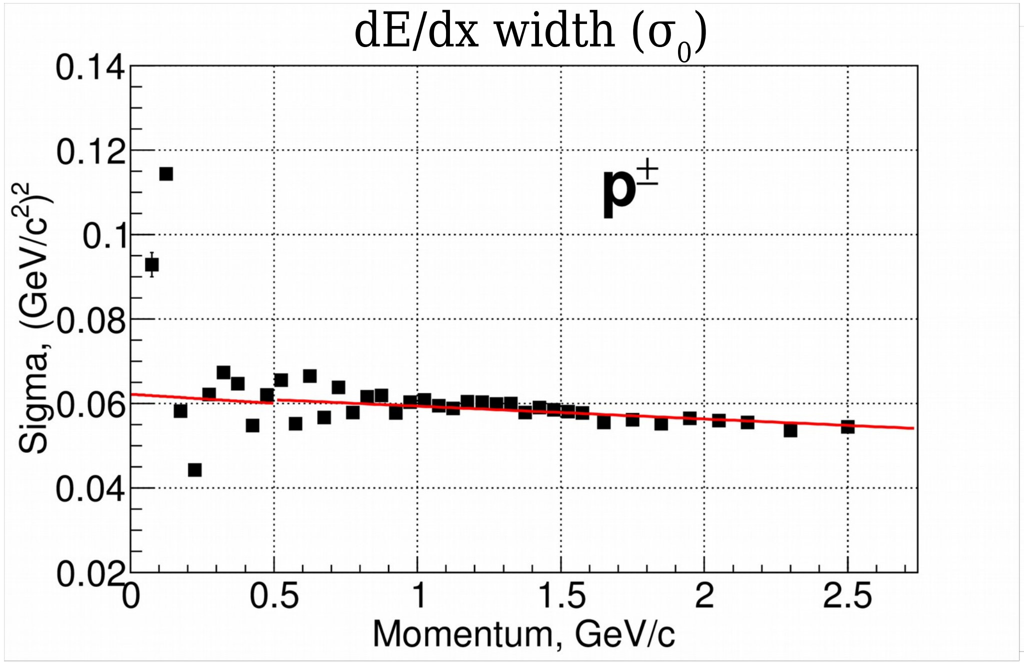
# Illustration of dE/dx parameterization

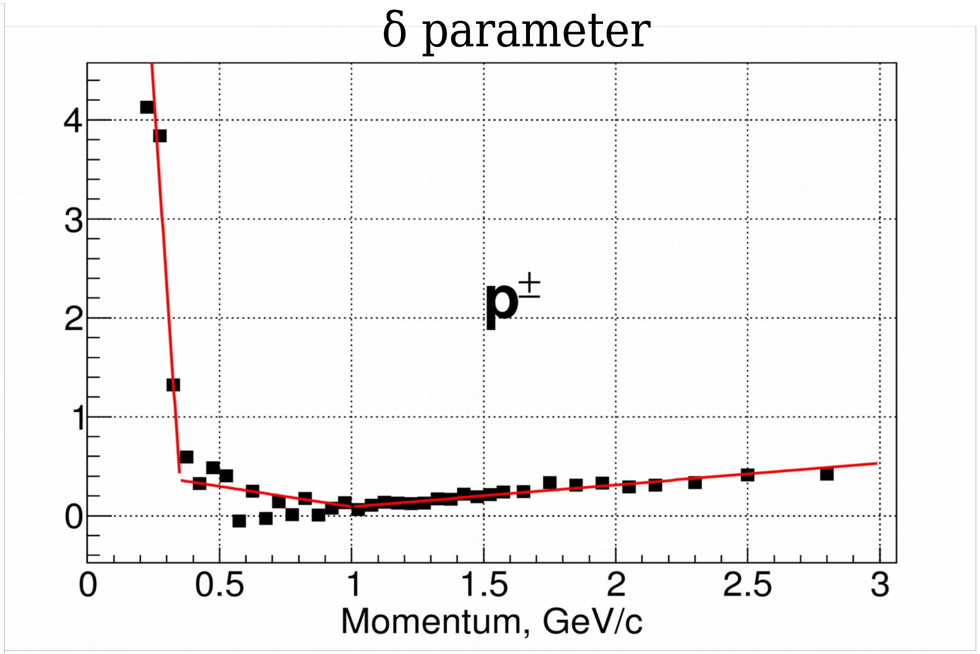



The ratio of dE/dx value in asymmetric gaussian peak over dE/dx value expected from Bethe-Bloch is used to estimate the PID parameterization quality. It has been performed for all particle species included in MPD PID.

Typical value of $\sigma_0$ is 6%, $\sigma'$ is 8%

# Width and asymmetry parameter parameterizations




Asymmetric gaussian function:

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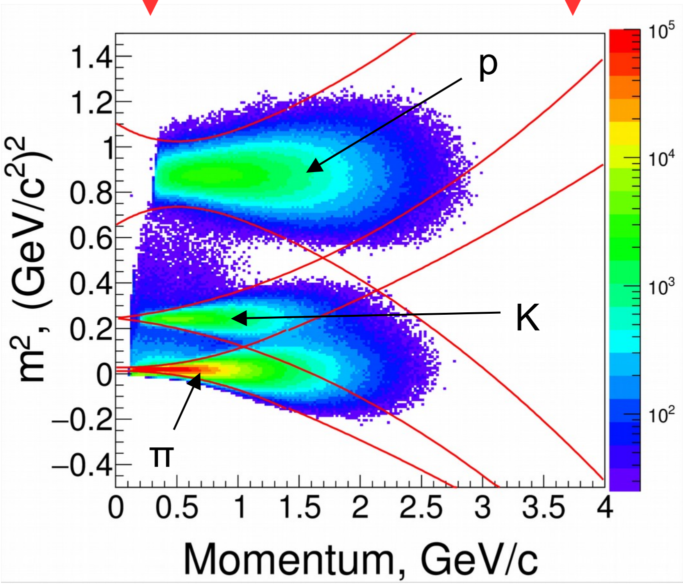
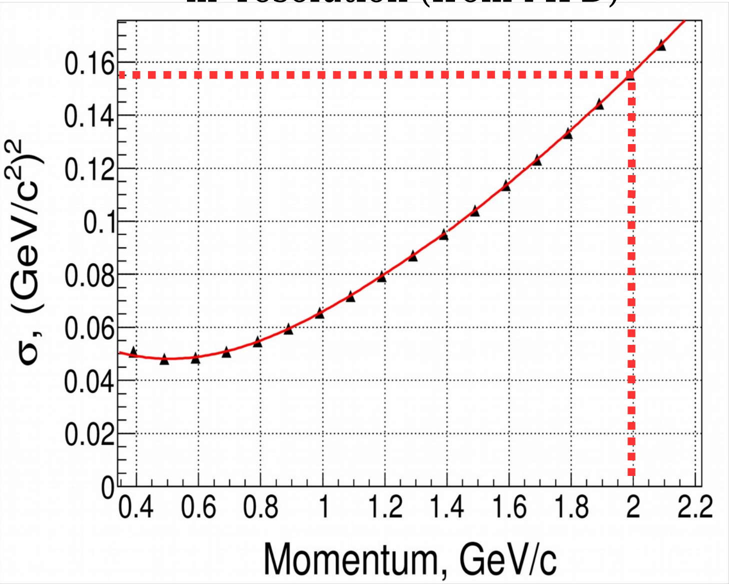
# $m^2$ parameterization

Red lines depict 3σ bands

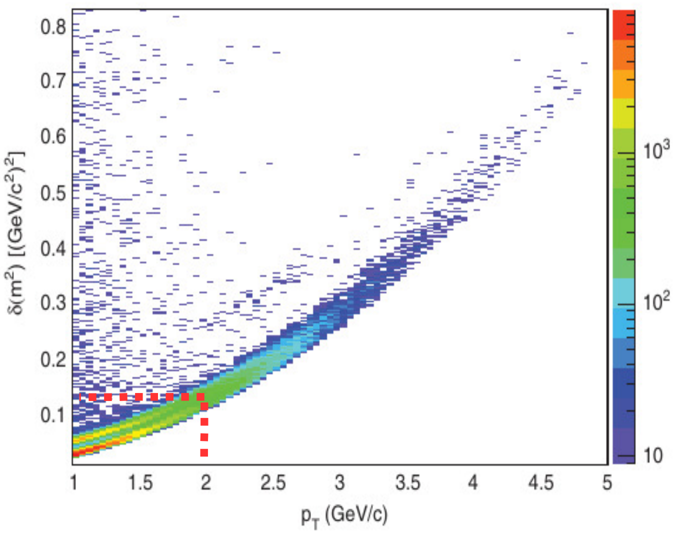


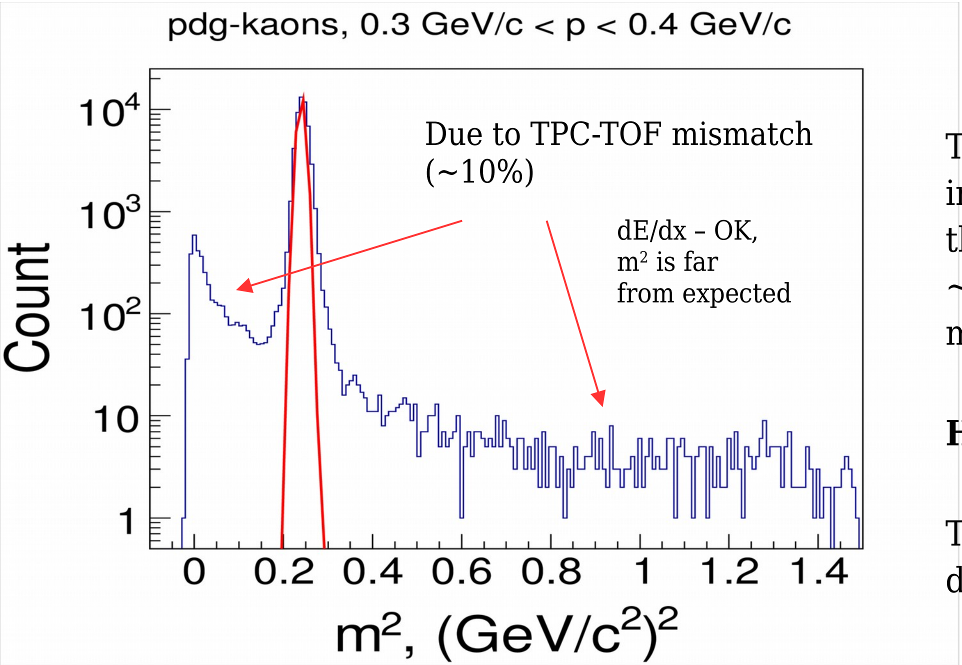

m² resolution (from MPD)




doi:10.1016/j.nima.2005.11.251

m² resolution (from STAR)



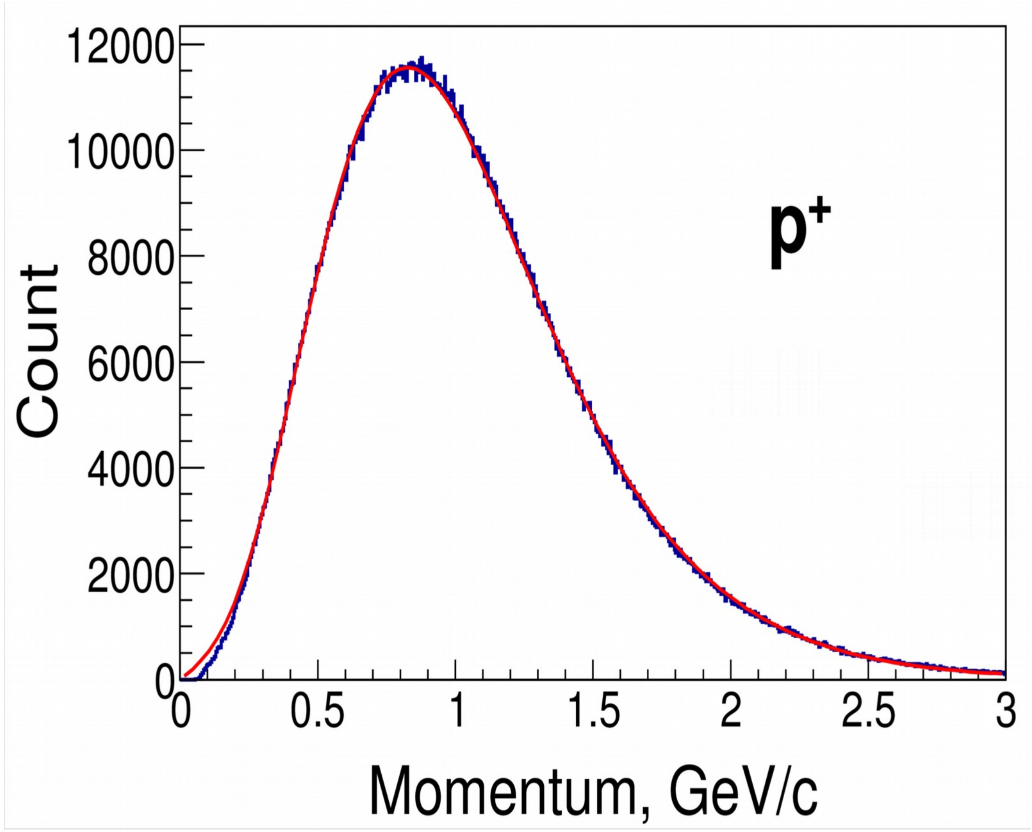

TPC-TOF mismatch:

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 $m^2$ 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?**

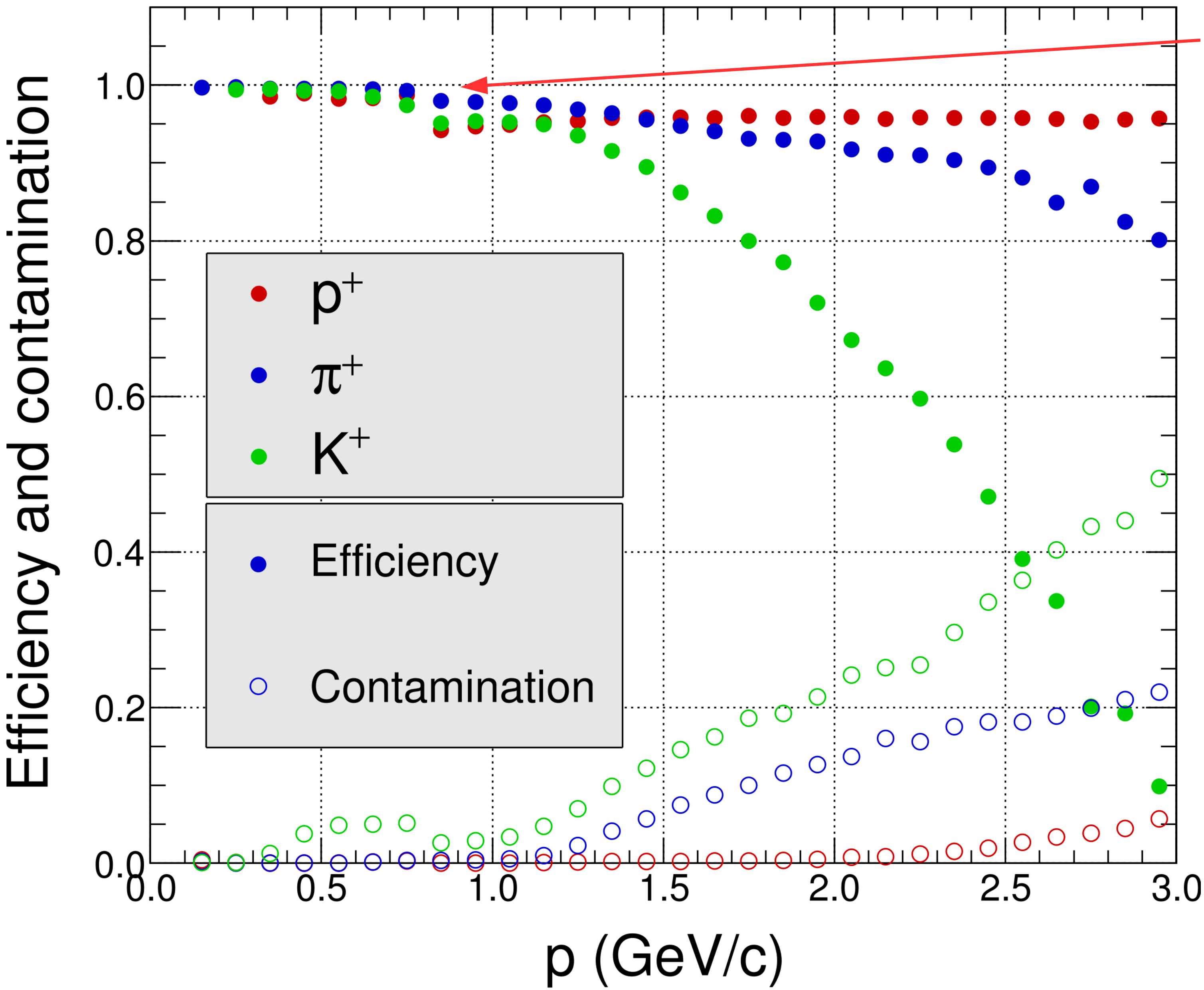
The suggestion is to ignore the TOF information and identify them by dE/dx value, **but only for low momenta particles (p < 0.8 GeV/c).**

# 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 hadron momentum distributions reasonably well
- So, we can use model abundancies of different particle species (momentum dependent) in our PID fits in addition to the standard n-sigma method (implemented in MPD PID as well)

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



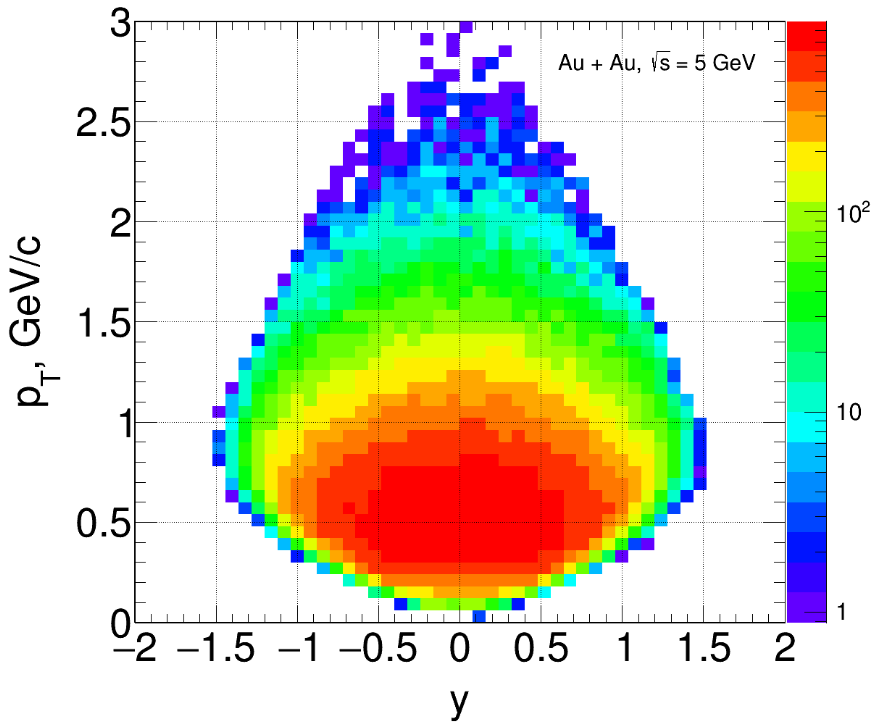

Step-like behavior of the efficiency and contamination arises as a result of redirection to the dE/dx identification

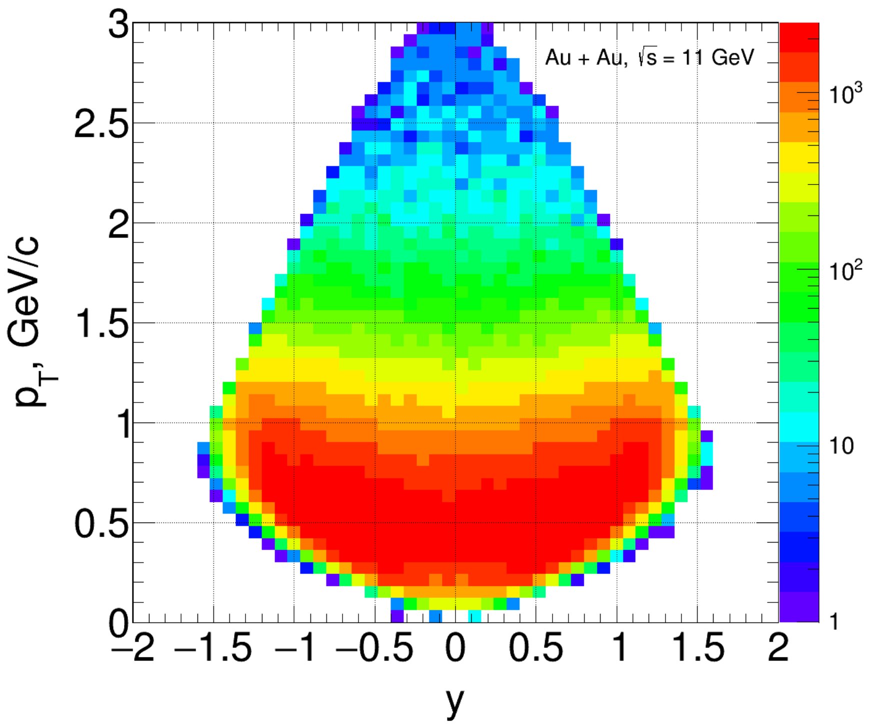
$$eff = \frac{correctly\ identified}{reconstructed}$$

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

# MPD phase-space

- The search for the possible critical end point in the QGP diagram requires excellent PID capability over as large as possible phase space volume
- **~55-65** identified protons per central Au-Au collision in the stage 1 configuration (TPC+TOF)
- Uniform midrapidity phase-space coverage ($|y| < 1$, $p_T < 2.5$ GeV/c)
- By adding endcaps (tracking + TOF + ECAL), the identified protons yield will be increased by **~20%**



# Summary

■ MPD PID based on the recent developments of the realistic tracking has been worked out and implemented in the MPDRoot software package.

■ Effective π/K separation works up to 1.5 GeV/c, π/p separation works up to 3 GeV/c

■ PID can identify ~60 protons per event in barrel part (stage 1). Adding endcaps (stage 2) allow increasing the number of identified protons by 20%