JOINT INSTITUTE FOR NUCLEAR RESEARCH

Veksler and Baldin Laboratory of High Energy Physics

FINAL REPORT ON THE SUMMER STUDENT PROGRAM

Identification of light nuclei at Multi-Purpose Detector

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Abstract

One of the main physic goals of the Multi Purpose Detector (MPD) is to investigate hot and dense baryonic matter in heavy ion collisions at NICA energies to search for the possible critical end point (CEP). Since the location of CEP is not clear the entire accessible region of the QCD phase diagram needs to be explored by scanning the full range of available beam energies. In case of CEP existence it can be observed by abnormal fluctuations of various quantities such as net-proton multiplicity.

This task requires excellent particle identification (PID) capability over as large as possible phase space volume. The identification of light nuclei is achieved at the momenta of 0.2 Gev/c - 3 GeV/c. The results of light nuclei parameterization of particle yields will be presented.

Contents

1 Introduction

The main scientific goal of the NICA/MPD project is to explore the phase diagram of strongly interacting matter in the region of highly compressed and hot baryonic matter [1]. The search for the possible critical end point [2] in the QGP diagram requires excellent particle identification capability over as large as possible phase space volume.

To study the hyper nuclei at the NICA collider, effective identification of their decay products such as light nuclei (d,t,^3He,^4He) is needed to restore the primary particle. In this work, the identification of these light nuclei was developed using data from the TPC and TOF detectors.

The parameterization of particle yields of light nuclei (d, t, ^3He, ^4He) was carried out based on the data of the LAQGSM model (Total number of events is 900k).

2 NICA/MPD

The MPD (fig. 1) apparatus has been designed as a 4 spectrometer capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions at high luminosity in the energy range of the NICA collider. To reach this goal, the detector will comprise a precise 3-D tracking system and a high-performance particle identification (PID) system based on the time-of-flight measurements.

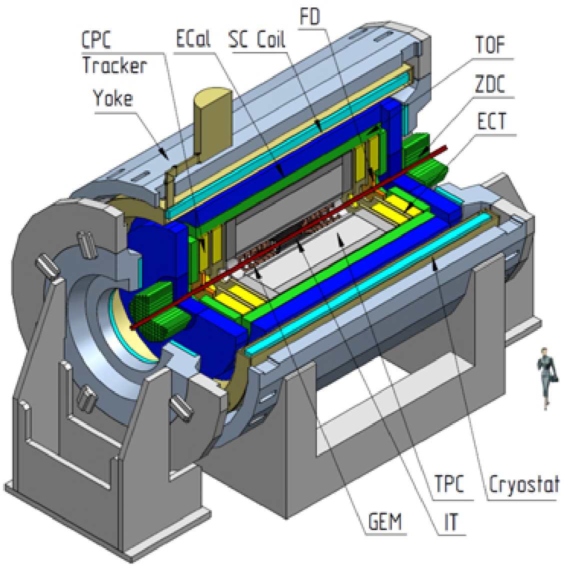

Figure 1: Perspective view of the MPD, with a cutaway for viewing inner detector systems.

The identification of light nuclei is achieved by time-of flight (TOF) measurements which are complemented by the energy loss (dE/dx) information from TPC.

3 PID parametrization

Energy loss technique dE/dx those measuring the average energy loss of charged particles is an important method for particle identification. It works especially well for particles with a small momentum.

The following criteria were used to select the data: N_{hits}>20, $|\eta| < 1.6$.

3.1 dE/dx parameterization

Distribution of dE/dx described by a Bethe-Bloch function with 5 parameters(Fig.2):

$$\frac{dE}{dx} = \frac{a_0}{\left(\frac{p}{E}\right)^{a_3}} \left[a_1 - \left(\frac{p}{E}\right)^{a_3} - ln\left(a_2 + \left(\frac{m}{p}\right)^{a_4}\right)\right] \tag{1}$$

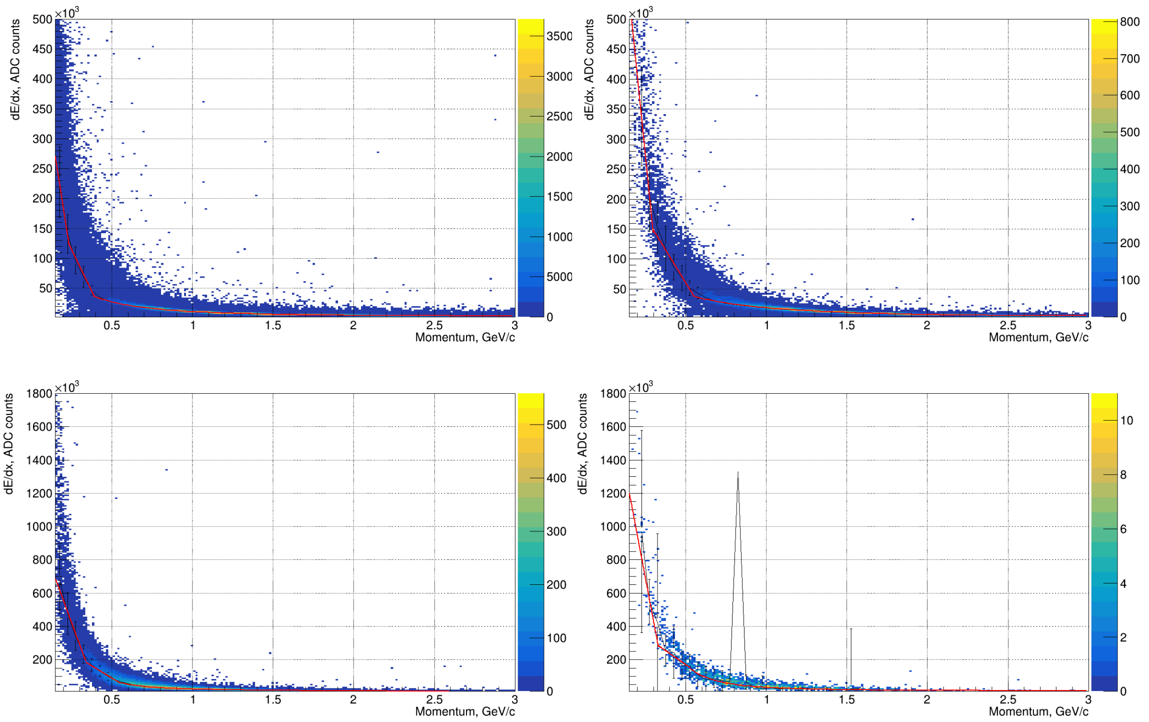

Figure 2: d - top right, t - top left,^3He - bot right, ^4He - bot left.

Slice of energy deposit described by the asymmetric gaussian function:

$$f(x) = \begin{cases} Ae^{-\frac{(x-\bar{x})^2}{2\sigma^2}}, for x < \bar{x}; \\ Ae^{-\frac{(x-\bar{x})^2}{2(\sigma(1+\delta))^2}}, for x \geq \bar{x}, \end{cases} \tag{2}$$

where is δ - the asymmetry parameter.

The asymmetry may stem from the strong dE/dx dependence in the low momenta region. Truncation procedure can not remove this effect. Parameterization of the σ and δ is shown in the Fig.3.

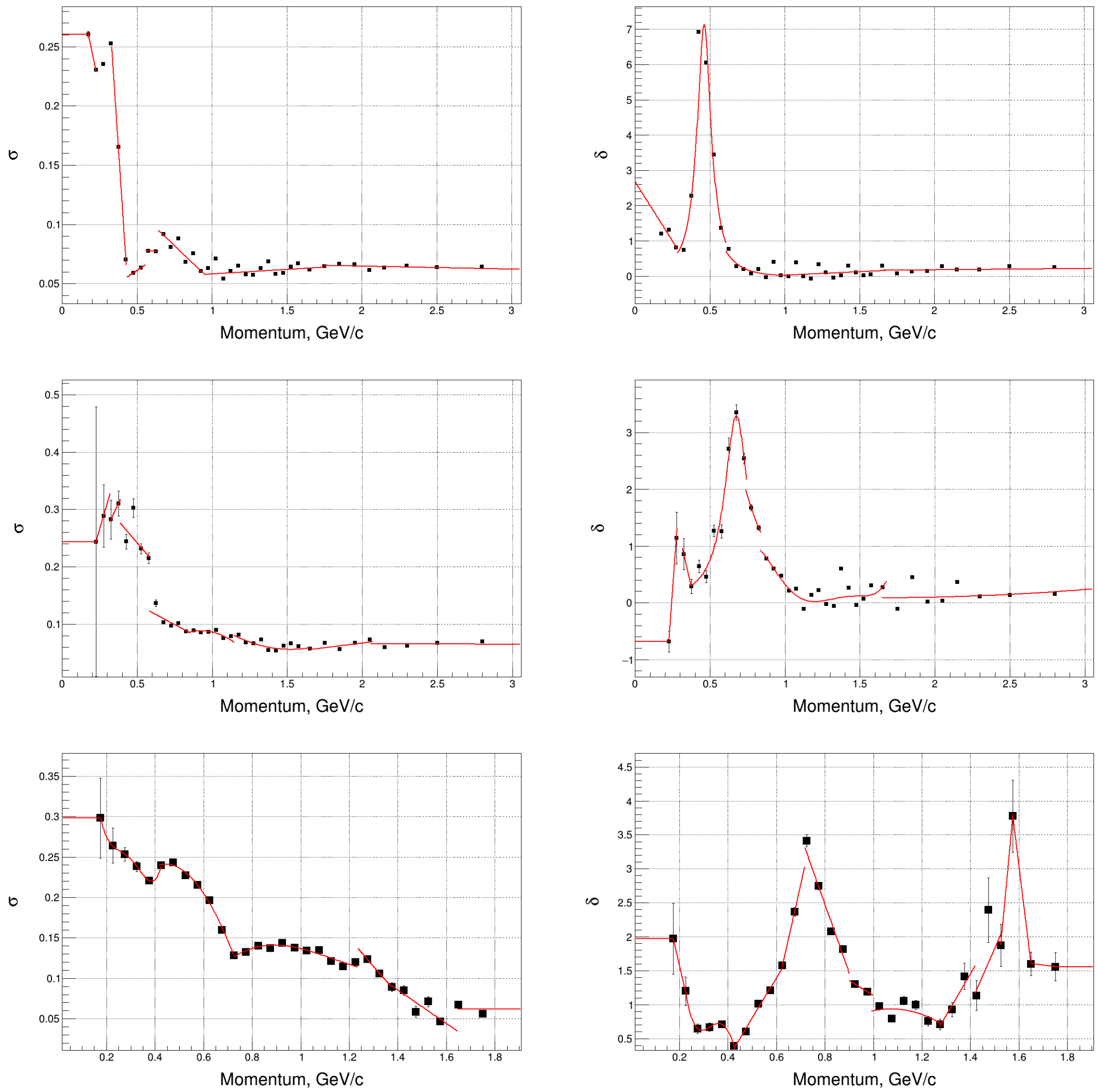

Figure 3: σ parameter d - top right, δ parameter d - top left, σ parameter t - middle right, δ parameter t - middle left, σ parameter ^3He - bottom right, δ parameter ^3He - bottom left

3.2 m^2 parametrization

Slice of mass square described by the gaussian function(Fig.4):

$$f(x) = Ae^{-\frac{(x-\bar{x})^2}{2\sigma^2}} \tag{3}$$

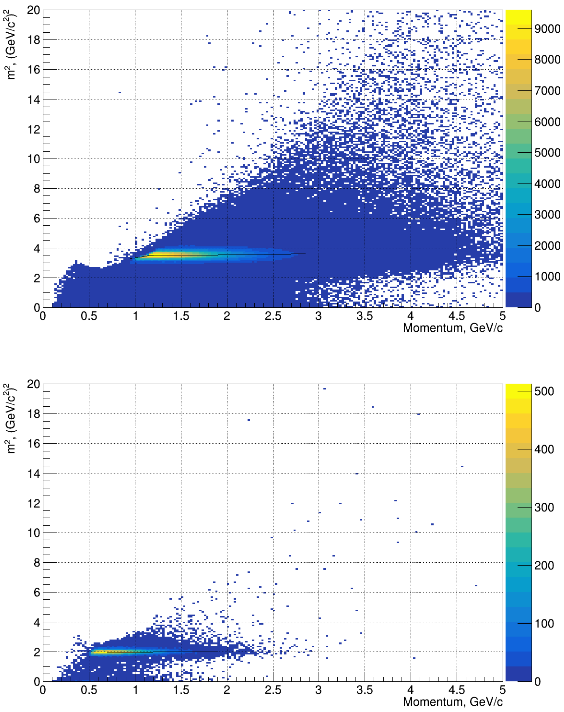

Figure 4: d - top left, t - top right, ^3He - bottom right, ^4He - bottom left

Parameterization of the width of Gaussian distribution is presented in Fig.5

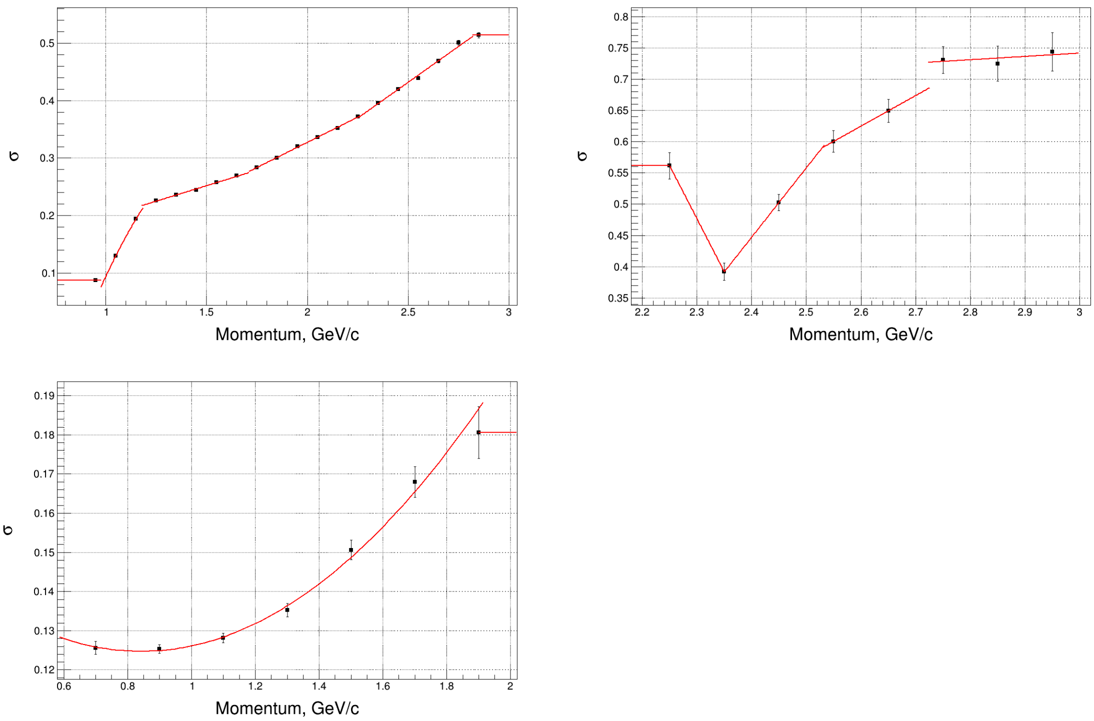

Figure 5: d - top left, t - top right, ^3He - bottom right

3.3 Particle yields parametrization

To form a priori coefficients and use the Bayesian PID approach, it is necessary to evaluate the model yields of particles of each sort and also parameterize them depending on the total momentum, which was done(Fig.6).

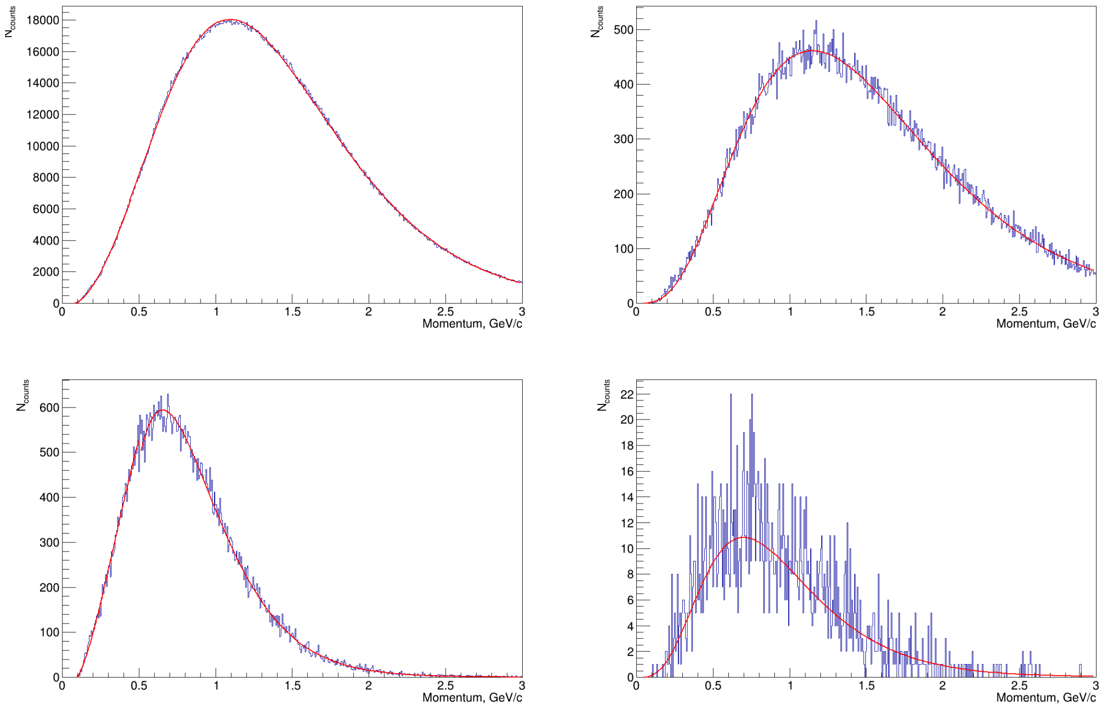

Figure 6: d - top left, t - top right, ^{3}He - bottom right, ^{4}He - bottom left

4 Conclusion

In this work, the parameterization of particle yields light nuclei (d, t, ^3He, ^4He) was carried out, in the range of the total momentum from 0.2 GeV/c to 3.0 GeV/c.

References

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[3] A. Bzdak and V. Koch, Phys. Rev. C 86, 044904 (2012).

[4] A. Bzdak and V. Koch, Phys. Rev. C 91, 027901 (2015).