Joint Institute for Nuclear Research
Laboratory of High Energy Physics

Charged particles identification by time of flight in te BM@N experiment

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Abstract

NICA (Nuclotron-based Ion Collider fAcility) is a new accelerator complex designed at the Joint Institue for Nuclear Research to study a special state of matter - hot and dence baryonic matter. One of the issues of experiment is particle identification. The main goal of this work was to perform a method to identify the particles in conditions of Au+Au collisions. Experimental data based on information from GEM and TOF-400 detectors. The results are analyzed for efficiency and contaminations.

Introduction

BM@N (Barionic Matter At Nuclotron) experiment has detection system, which able to give us opportunity to restore path of high-energy particles and analyse some of their properties. In this work we consider reconstruction of Monte-Carlo tracks and methods of identification of corresponding particles.
To support the BM@N experiment, the software framework BmnRoot is developed. It provides a powerful tool for detector performance studies, event simulation, and development of algorithms for reconstruction and physics analys of data of the fixed target events registered by the BM@N facility.
The program developed within Summer Student Program was implemented in BmnRoot as part of which is responsible for track reconstructing and particle identification.

Global tracking

Detectors can give information about hits - points where particles went through. GEM detector is the closest to target. It consist of 12 planes. Each of them register coordinates of hits. After first step of data reconstruction GEM hits are combined to tracks. Using extrapolation with Kalman Filter we found the expected point of track intersection with next detector - TOF-400 (Time Of Flight). Closest TOF-hit we brought into compliance with this track and calculated its length.

In the Figure 1 you can see histogram of residuals(R^2) between MC TOF-400 hit and point on the plane of detector where extrapolated track goes through. Average value is 3 cm, almost all tracks has R^2 under 20 cm.

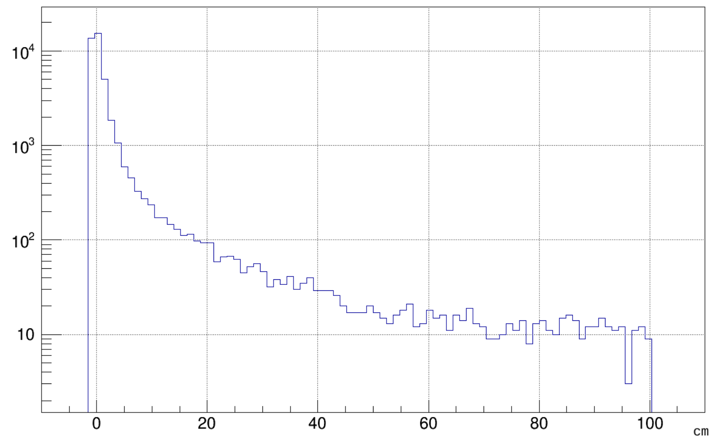


Figure 1: Entries(R^2, cm)

We analysed quality of matching. In the Figure 2 shown histogram of percentage of rightly corresponded track and TOF hit. For Au-Au events quality of matching (percetage of correctly corresponded hits) 71%.

Particle identfication

TOF-400 can measure time between start of event and achievement of the detector by particle. According to this time and track length we can calculate two properties: m and $\beta(= v/c)$.

Main mathematical basis of used identification methods represented by equation 1:

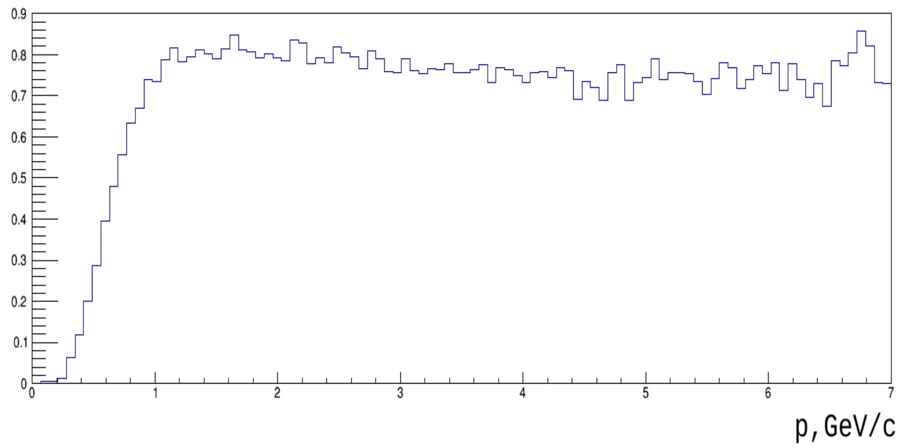


Figure 2: Quality of matching, Entries (Energy, Gev/c)

$$mc^2 = pc\sqrt{\frac{t^2c^2}{l^2} - 1} \tag{1}$$

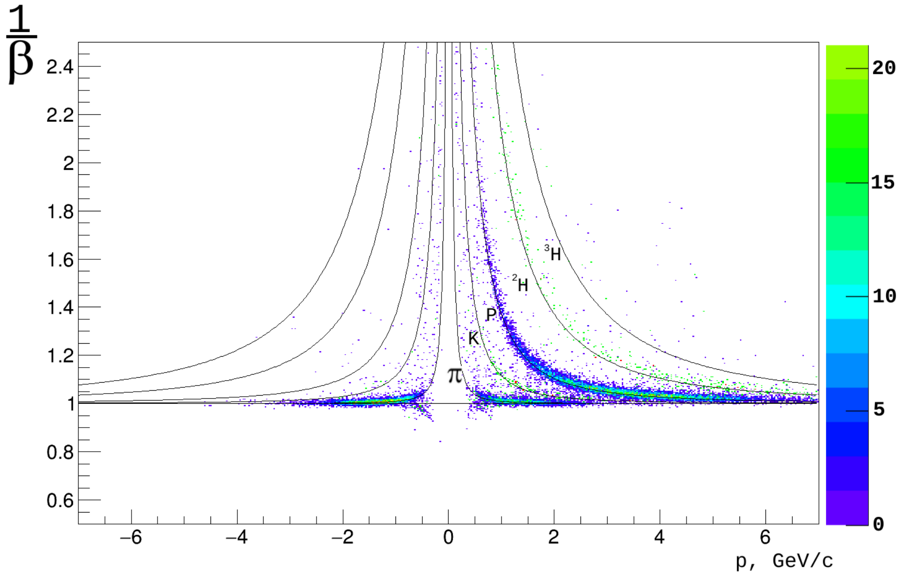
According this we can get equations for m^2 and $1/\beta$:

$$m^2 = p^2(\frac{t^2c^2}{l^2} - 1) \tag{2}$$

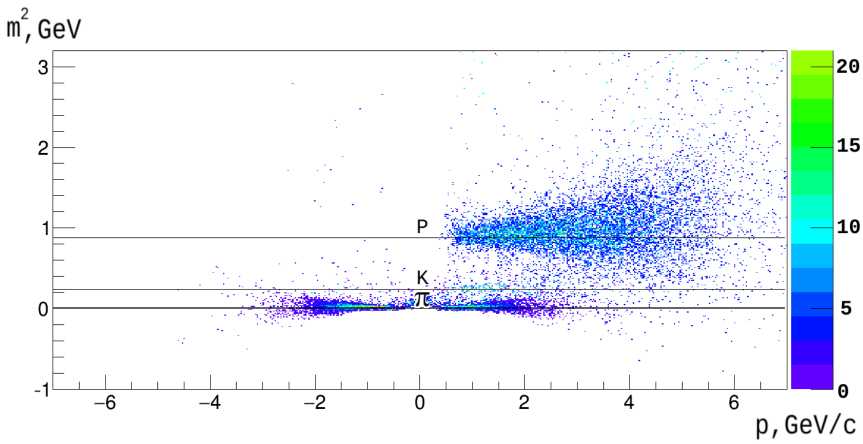
$$1/\beta = \frac{ct}{l} \tag{3}$$

As we can see, for each type of charged particle dependence between $1/\beta$ and p - hyperbolic. For particles with different mass we can expect different hyperbole. So, knowing length of track and its time of flight we can calculate mass and beta of particle. It allows us to separate them by this properties.

In figure 3 showed histograms of $1/\beta(p)$ and m^2. Black lines correspond with analytical expectation. As we can see, on some parts of p range we can expect particle to be one of the type with high probability. But sometimes point lies between expected lines. In this case, we assume it to belong nearest expected line.



$1/\beta$ (p, GeV/c)



m^2 (p, GeV/c)

Figure 3: Particle identification, based on two methods

For identification estimation we use two quantities: efficiency and contamination for each type of particles.

$$Eff = \frac{N_{good}}{N_{MC}} \tag{4}$$

$$Cont = \frac{N_{bad}}{N_{rec}} \tag{5}$$

where:

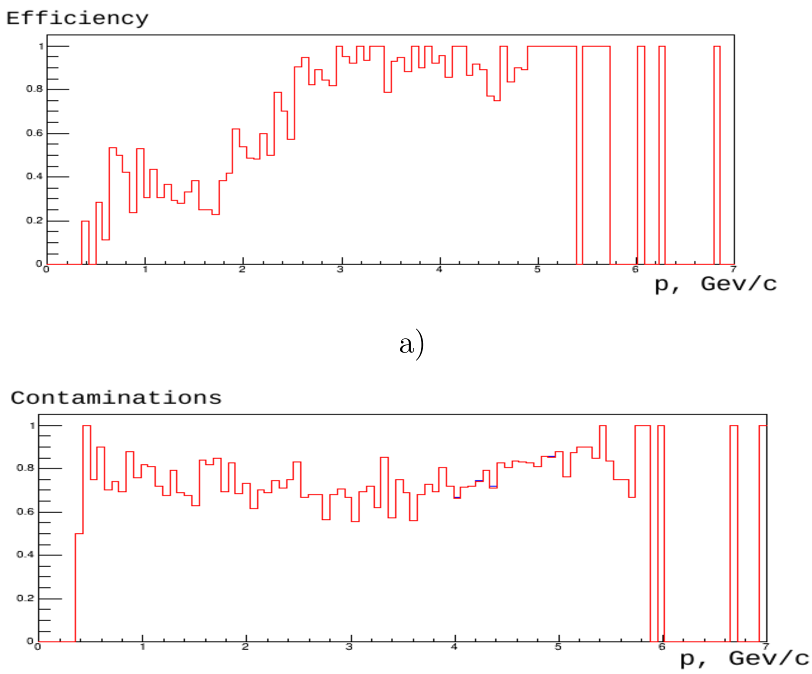
N_{good} - number of correctly identified particles of this type;

N_{MC} - number of Monte-Carlo tracks;

N_{bad} - number of incorrectly identified particles of this type;

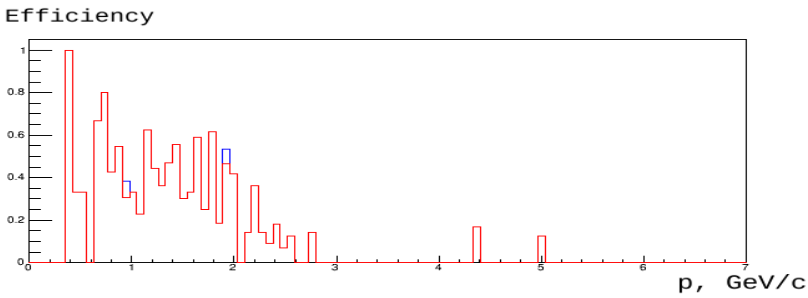
N_{rec} - number of reconstructed tracks.

In figures 4 and 5 showed efficiency and contammination of identification of protons, pi-mesons.

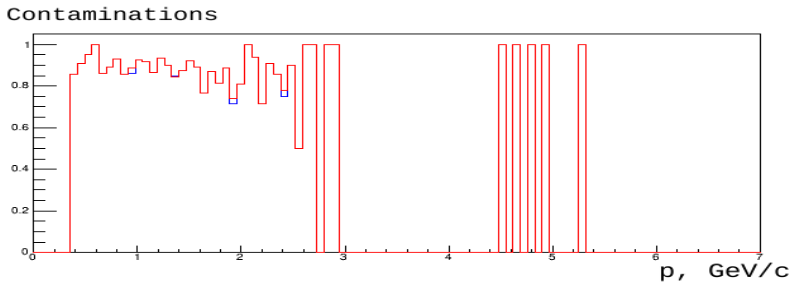


a) b)

Figure 4: Efficiency (a) and contaminations (b) of proton identification



a)



b)

Figure 5: Efficiency (a) and contaminations (b) of pion identification

Results

The methods described above were tested on simulated Au-Au events and gave us following results.

Quality of matching TOF-hits: 71%

In the table represented values of efficiency and contamination of particle identification averaged over the momentum.

Efficiency (p) = 78%	Contamination(p) = 7%
Efficiency (π) = 63%	Contamination(π) = 19%
Efficiency (k) = 80%	Contamination(k) = 92%

Conclusions

On the Summer Student program I got a valuable work expirience, acquainted with real research work. Plan is to add data from TOF-700 into program for better identification.
Results of practice:

- TOF-400 hit matching was performed, quality was assessed.
- Two methods of particle identification was tested and compared.
- Program performing track reconstruction, TOF-400 matching and particle identificaton was implemented in BmnRoot.

Acknowledgements

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