Development of algorithms for track reconstruction and matching in the ITS and TPC detectors at MPD/NICA.*

Dmitrii Zinchenko, Alexander Zinchenko

Veksler and Baldin Laboratory of High Energy Physics, Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia

Eduard Nikonov

Laboratory of Information Technologies, Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia

As one of the possible MPD/NICA upgrade steps, an Inner Tracking System (ITS) is considered to be installed between the beam pipe and the Time Projection Chamber (TPC). It is expected that the new detector will increase the experiment's research potential, if its advantages are fully exploited. For this, a special track reconstruction algorithm, called "Vector Finder", is developed. This paper explains an approach used to match ITS and TPC tracks and presents some performance results for Monte Carlo simulated data.

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1. Introduction

The construction of the accelerator complex NICA [1] is currently well under way at JINR (Dubna). One of the experimental setups MPD (Multi-Purpose Detector) [2] was designed to investigate nucleus-nucleus, proton-nucleus and proton-proton interactions.

An Inner Tracking System (ITS) based on the next generation silicon pixel detectors [3] is considered as a possible MPD upgrade step. It is expected that such a detector between the beam line and the Time Projection chamber (TPC) (Fig. 1) will increase the research potential of the experiment for both the proton-proton (high luminosity) and nucleus-nucleus (high particle multiplicity) interactions.

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The existing in MPD track reconstruction method is based on the Kalman filter in the TPC. Its simple extension to the ITS is not seen as the best approach to the track reconstruction in the new detector. That is why another algorithm was developed, based on a combinatorial search of hit pairs belonging to the same track ("vectors") using prior constraints to reduce the combinatorics. Such a method should produce good results for tracks with relatively small number of hits (as is the case for the stand-alone ITS tracking) and can be efficiently implemented in terms of the processing speed.

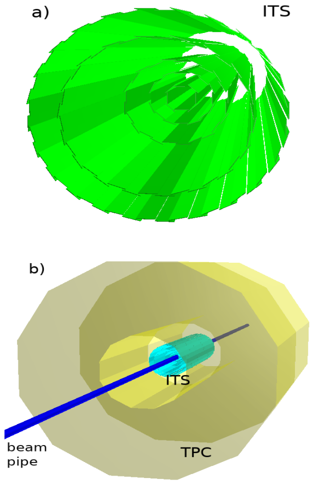
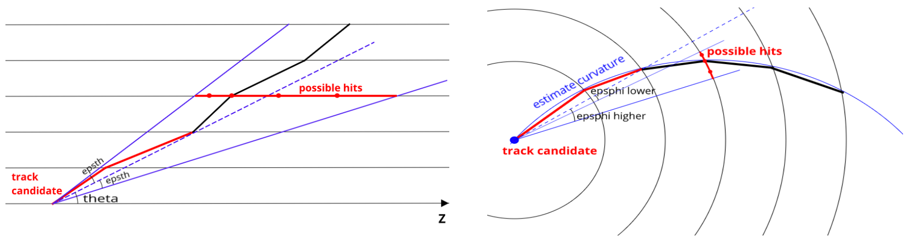


Fig. 1: a) 5-layer ITS geometry; b) ITS+TPC model.

2. "Vector Finder" approach

The proposed method is based on the combinatorial search with prior constraints. The constraints define the acceptance windows on consecuitive detector layers where track candidates look for their continuation, i.e. for a given hit on a given layer there is a limited set of hits on the next layer which are selected as possible candidates for building the next track segment ("vector") (Fig. 2). The hit selection criteria (*epsth* and *epsphi*) are based on the hit angular positions in longitudinal (non-bending) and transverse (bending) projections.



(a) (b)

Fig. 2: a) Track scheme in longitudinal projection; b) Track scheme in transverse projection.

After all track candidates are found, they are fitted by the Kalman filter track fitter procedure. Tracks with the highest χ^2 are discarded if there are candidates with shared hits. A more detailed Vector Finder method description can be found in Ref. [4].

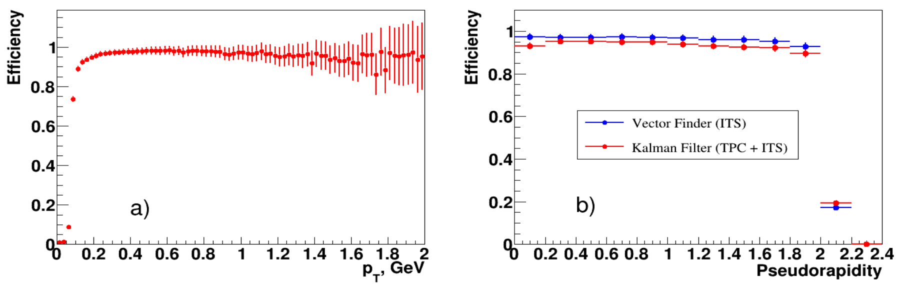


Fig. 3: a) Efficiency vs p_T; b) efficiency vs η for the TPC-based Kalman Filter track following approach (red) and Vector Finder (blue).

The Vector Finder approach was implemented for a standalone ITS track reconstruction within the MpdRoot framework and tested with UrQMD simulated events of central $Au + Au$ collisions at $\sqrt{s_{NN}} = 9$ GeV. Some results can be seen in Fig. 3, where track reconstruction efficiency is shown as a function of transverse momentum p_T and pseudorapidity η. A more detailed description of obtained results can be found in [5].

3. TPC and ITS track matching

The next important step towards a combined MPD track reconstruction is a development of a matching algorithm for ITS and TPC tracks. The folowing track matching procedure was implemented:

1. Propagate TPC and ITS tracks to a cylinder surface with a radius of 27.0 cm from the beam line (between ITS and TPC);
2. Update track parameters (longitudinal and transverse track positions z and $rphi$);
3. For each ITS track find a set of TPC tracks with z and $rphi$ lying in a preset window around ITS track parameters (Fig. 4);
4. Combine TPC and ITS tracks, i.e. add ITS hits to the TPC track if they are close enough (χ^2 of the hit below 10);
5. If no TPC track was found within the window, ITS standalone track is stored.

If there are non-unique matches, only the matches with the highest quality are kept where the quality function is defined as

$$quality = N_{hits} + (100.0 - min(\chi^2, 100.0))/101.0,$$

with N_{hits} is the number of hits on the track and χ^2 is its total χ^2-value.

The matching procedure was tested on the same Monte Carlo event sample as above. The results for primary tracks can be seen in Fig. 5.

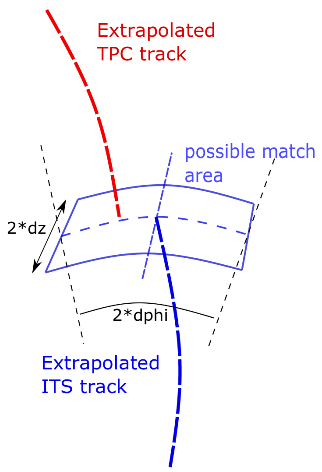


Fig. 4: Track matching scheme.

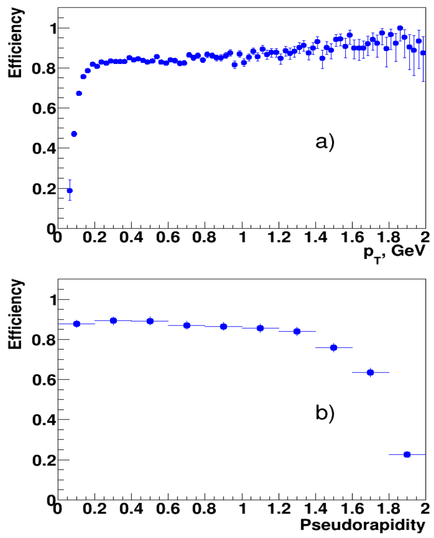


Fig. 5: a) Track matching efficiency vs p_T; b) Track matching efficiency vs η.

4. Future plans

Future plans include the Vector Finder algorithm and matching procedure tuning for secondary track reconstruction.

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