Development of algorithms and methods for hyperon reconstruction on MPD at NICA (Results)

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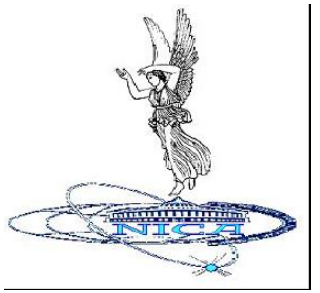
Outline



- **Motivation**
- **Detector MPD & Analysis Method**
- **Maximization of significance**
- **Study of hyperon production:**

$\Lambda \rightarrow p + \pi^-$

$\Lambda_{bar} \rightarrow p^- + \pi^+$

$\Xi^- \rightarrow \Lambda + \pi^- \rightarrow p + \pi^- + \pi^-$

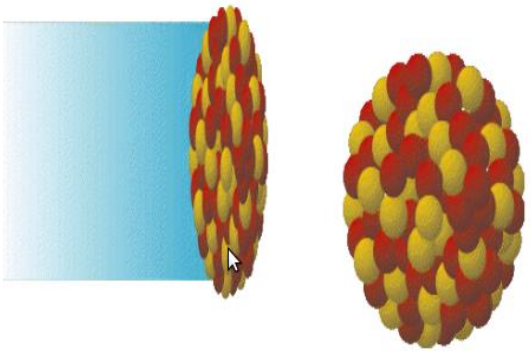
- Conclusions and outlook

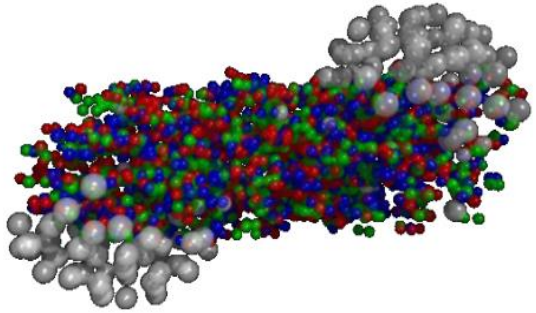
Physics motivation

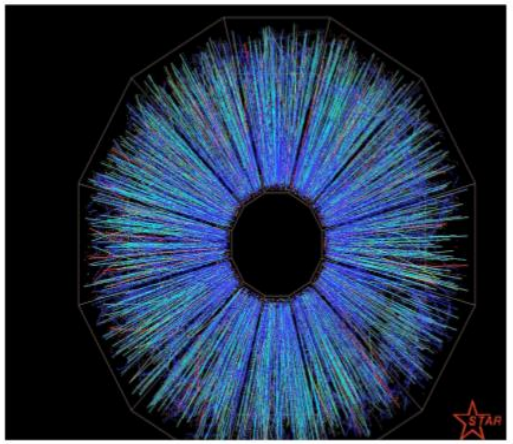
- Hyperons (especially Λ) are produced in relatively large quantities and have very attractive experimental features (resonance structure and simple decay mode). They can serve as detector performance monitoring tools.

- The study of hyperons helps to understand strong interactions and QGP.

- Heavy strange objects could provide essential signatures of the excited and compressed baryonic matter.







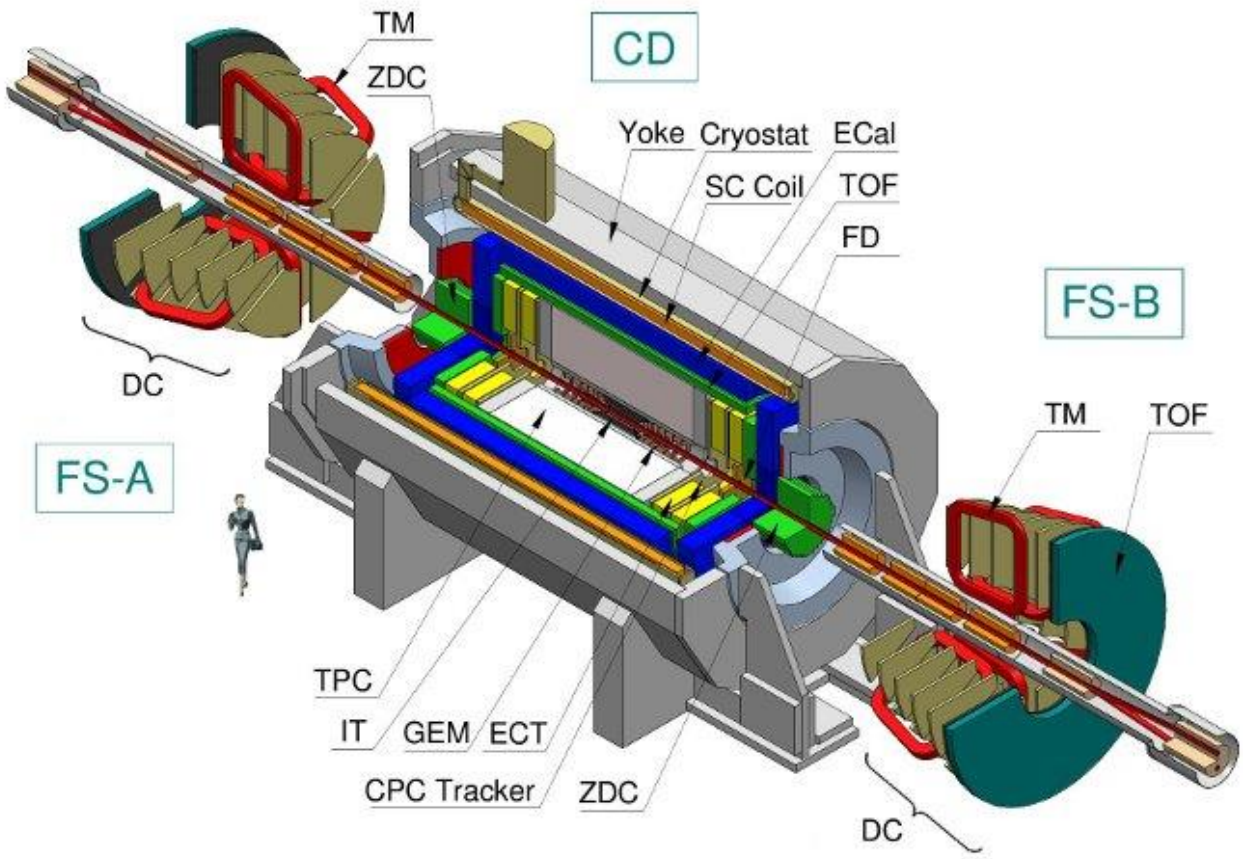
The goal of this study

Identification and reconstruction of strange objects should be one of the most important tasks of any experiment with heavy ions, including MPD/NICA.

That’s why our goal was:

- To demonstrate the MPD start version's ability to measure strange objects;
- To check the performance of reconstruction algorithms and software for this task.

Multi-Purpose Detector general view



Stage I:

- TPC barrel
- TOF barrel
- Ecal barrel
- ZDC
- FFD

Data set

- **Generators:** UrQMD & DCM, Au+Au @ 9A GeV & 5A GeV central (0-3 fm), 10k, 40k events

- **Detectors:** start version of MPD with up-to-date TPC & TOF

Analysis

- Track acceptance criterion: $|\eta| < 1.3$, $N_{hits} \geq 10$

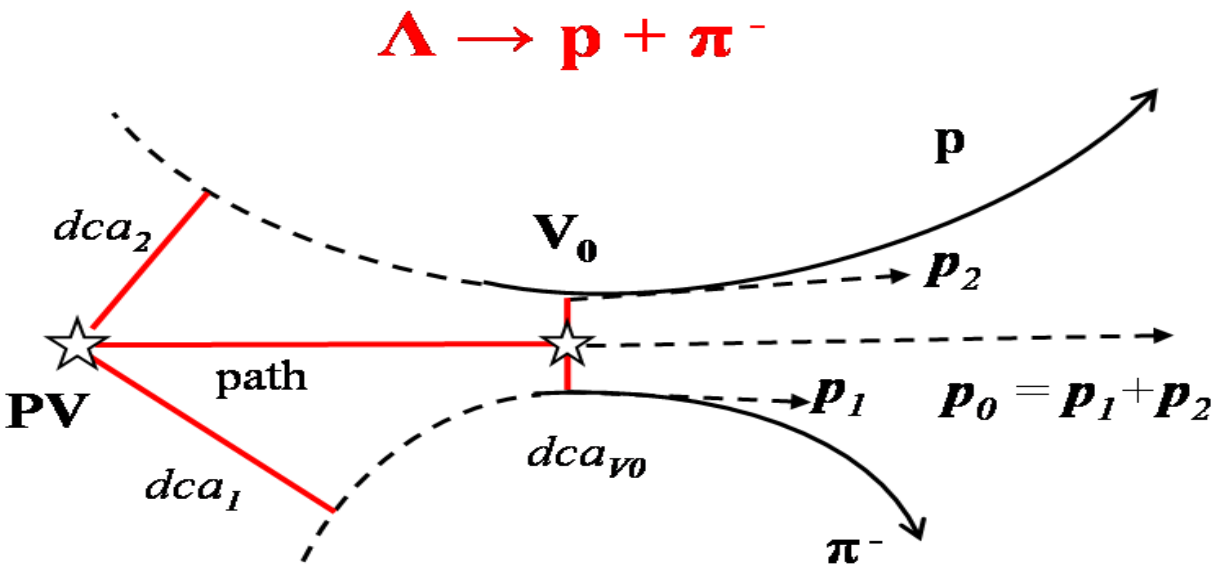
  A. Zinchenko

- Particle identification in TPC & TOF

  V. Kolesnikov

- Maximization of significance $S/\sqrt{(S+B)}$

Analysis Method: Secondary Vertex Finding Technique



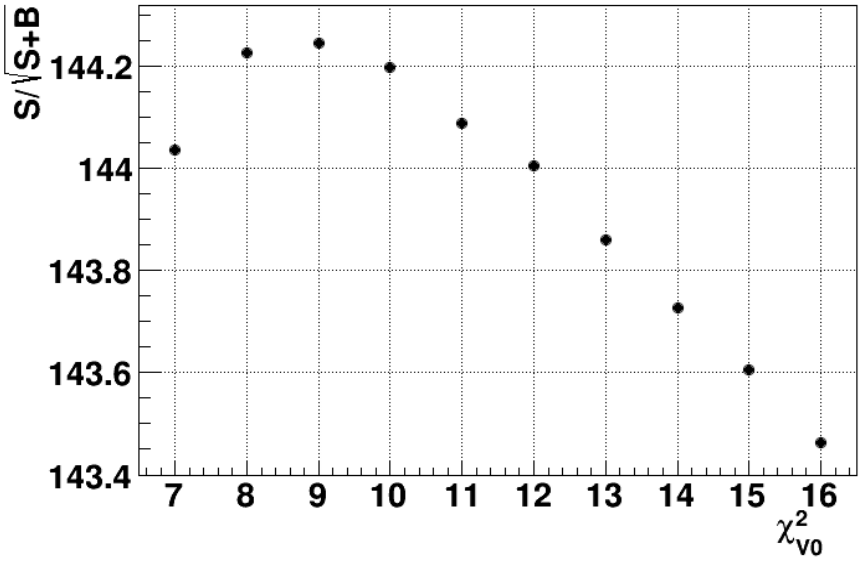
Event topology of two-particle decay of the neutral particle:

- ✓ PV – primary vertex
- ✓ V_0 – vertex of Λ decay
- ✓ dca – distance of the closest approach
- ✓ path – decay length

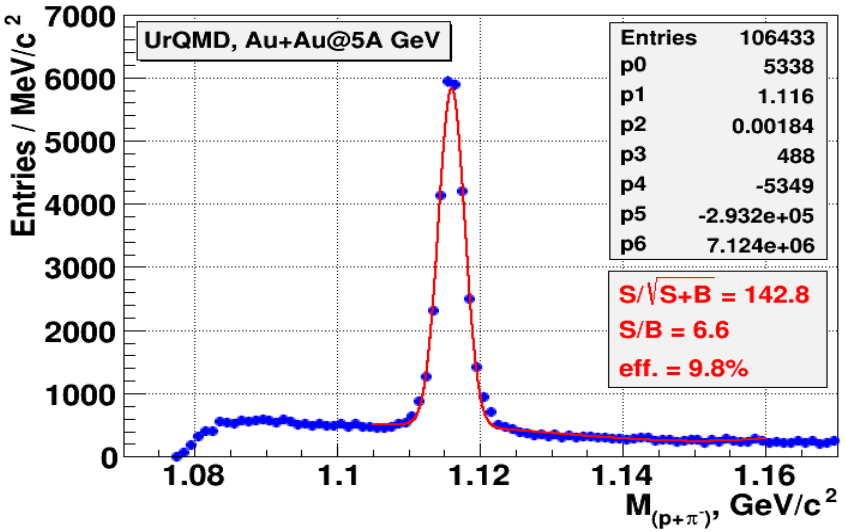
Maximization of significance

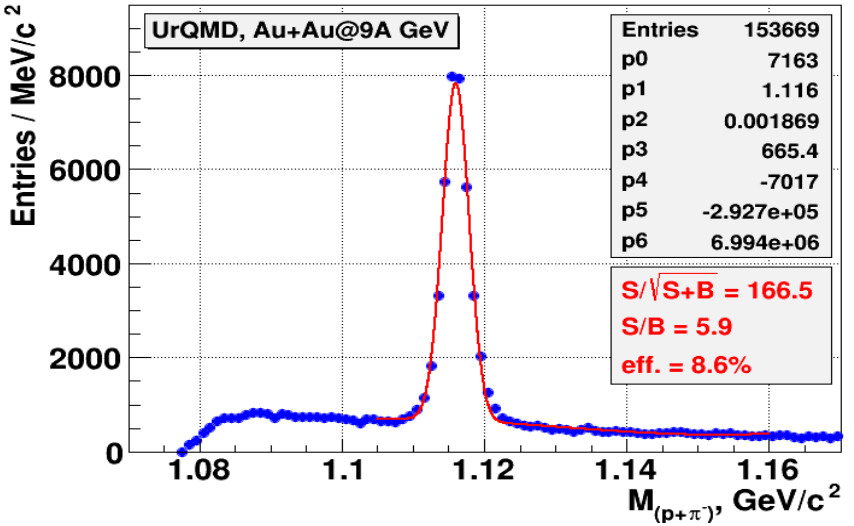
1.Significance is defined as $S/\sqrt{(S+B)}$, where S and B are total numbers of signal and background combinations inside ±2σ interval around the peak position.
2.Set of 6 cuts for Λ selection: χ^2_π (dca_1), χ^2_p (dca_2), χ^2_{V0}, dca_{V0}, path, angle between ***p*** and ***r*** of Λ.
3.Variation of 6 cuts with small steps and production of invariant mass distributions for each set of cuts.
4.Fitting to the sum of gaussian and polynomial functions and computing the significance.
5.Selection of maximum significance with corresponding cuts (see Fig.).

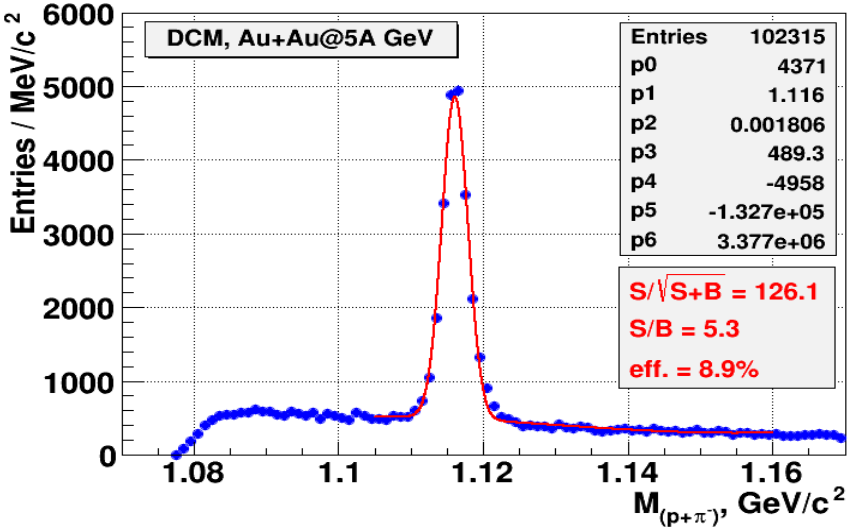
While different physics analyses might prefer different selection quality criteria, the significance looks convenient to quantitatively evaluate effect of different factors on the reconstruction quality.

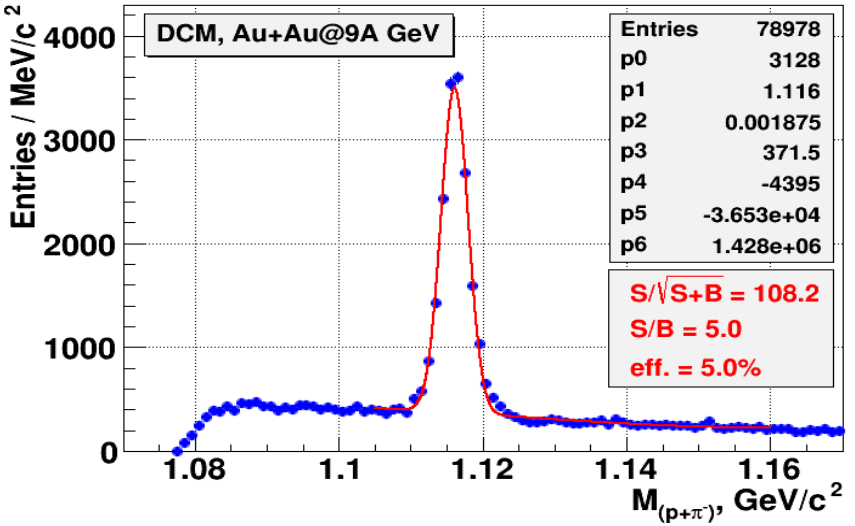


UrQMD vs DCM & 5A GeV vs 9A GeV for $\Lambda \rightarrow p + \pi^-$ (30s @ 6 kHz)





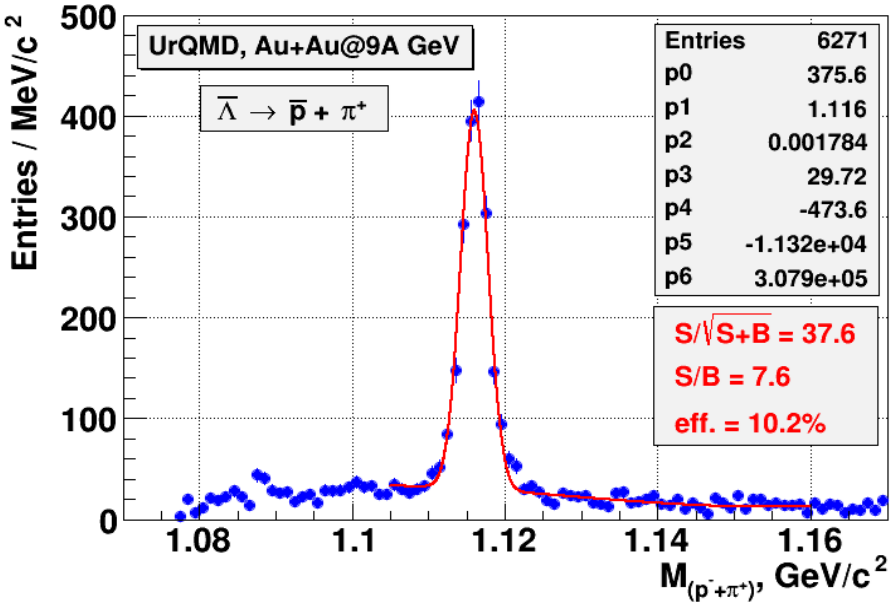


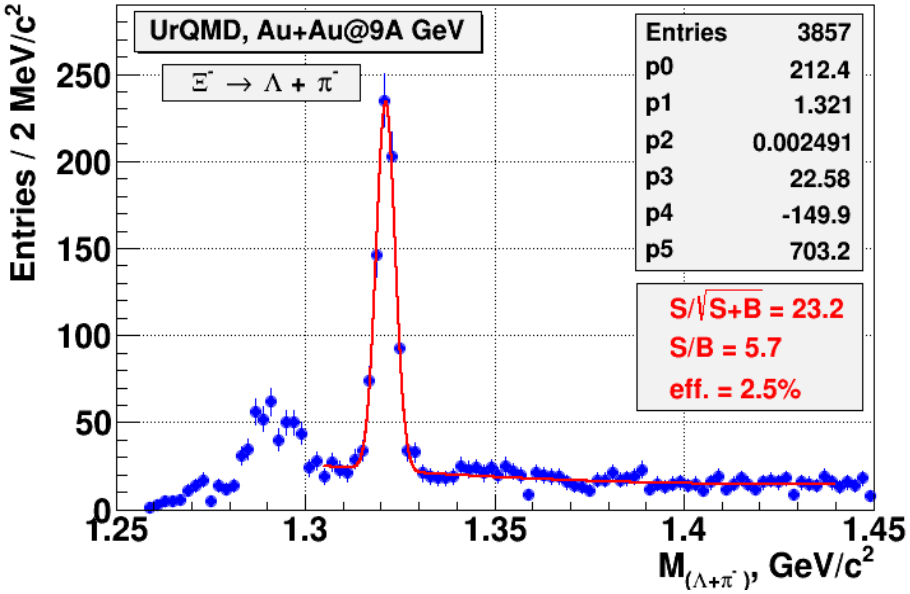


Invariant mass at max. significance:

$\Lambda_{bar} \rightarrow p^- + \pi^+$ & $\Xi^- \rightarrow \Lambda + \pi^-$

UrQMD, Au+Au @ 9A GeV, central (0-3 fm),
40k events – 2 min. @ 6 kHz
PID in TPC & TOF





Conclusions and outlook

- MPD start version will provide a good opportunity for a study of the strangeness production at NICA (mass resolution 2-3 MeV/c^2 and high enough yields).
- Work is ongoing on the reconstruction of more rare strange probes (Ω^- hyperons).
- Effects of increased detector acceptance (higher η-coverage, detector upgrade) as well as more realistic detector response simulation are under evaluation.

Evaluation of the MPD detector capabilities for the study of the strangeness production at the NICA collider

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Abstract

One of the main tasks of the NICA/MPD physics program is the study of the strangeness production in nuclear collisions. In this paper the MPD detector performance is presented for measurements of K^0_S-mesons, $\Lambda(\bar{\Lambda})$-hyperons and hypertritons in central Au+Au collisions at NICA energies.

The investigation has been performed at the Laboratory of High Energy Physics, JINR

Оценка возможностей установки MPD по изучению рождения странности на коллайдере NICA

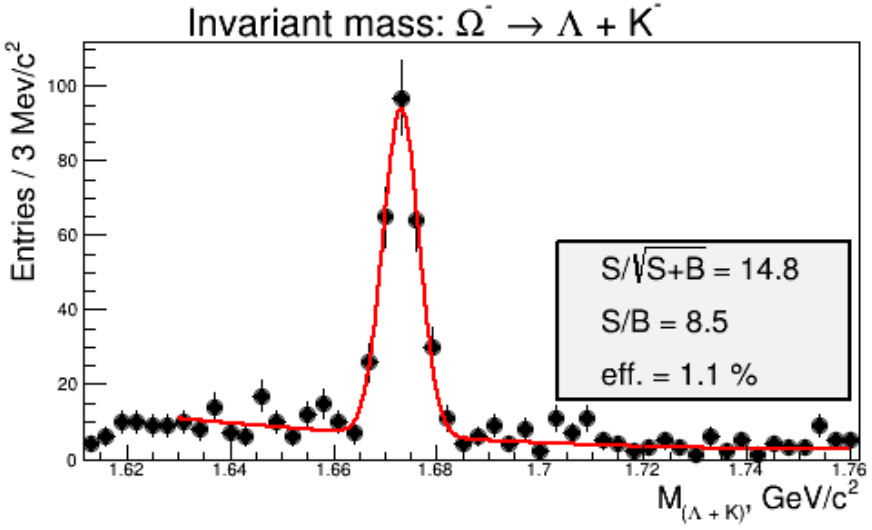
М.А. Илиева, В.И. Колесников, Ю.А. Мурин, Д.А. Сувариева, В.А. Васендина, А.И. Зинченко, Е.И. Литвиненко, К.К. Гудима

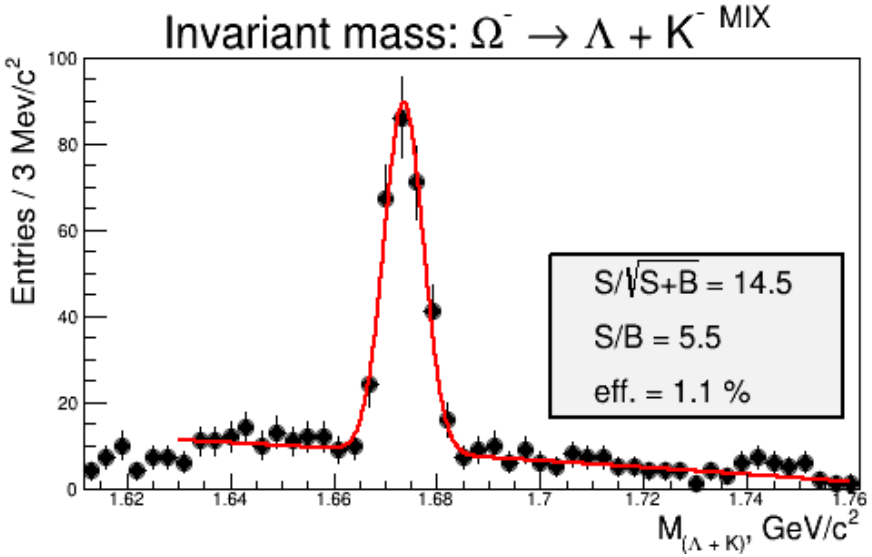
Одной из основных задач физической программы эксперимента MPD на комплексе NICA является изучение рождения странности в ядерных взаимодействиях. В данной работе представлены возможности детектора MPD по измерению K^0_S-мезонов, $\Lambda(\bar{\Lambda})$-гиперонов и гипертритонов в центральных взаимодействиях Au+Au при энергиях NICA.

Работа выполнена в Лаборатории физики высоких энергий ОИЯИ.

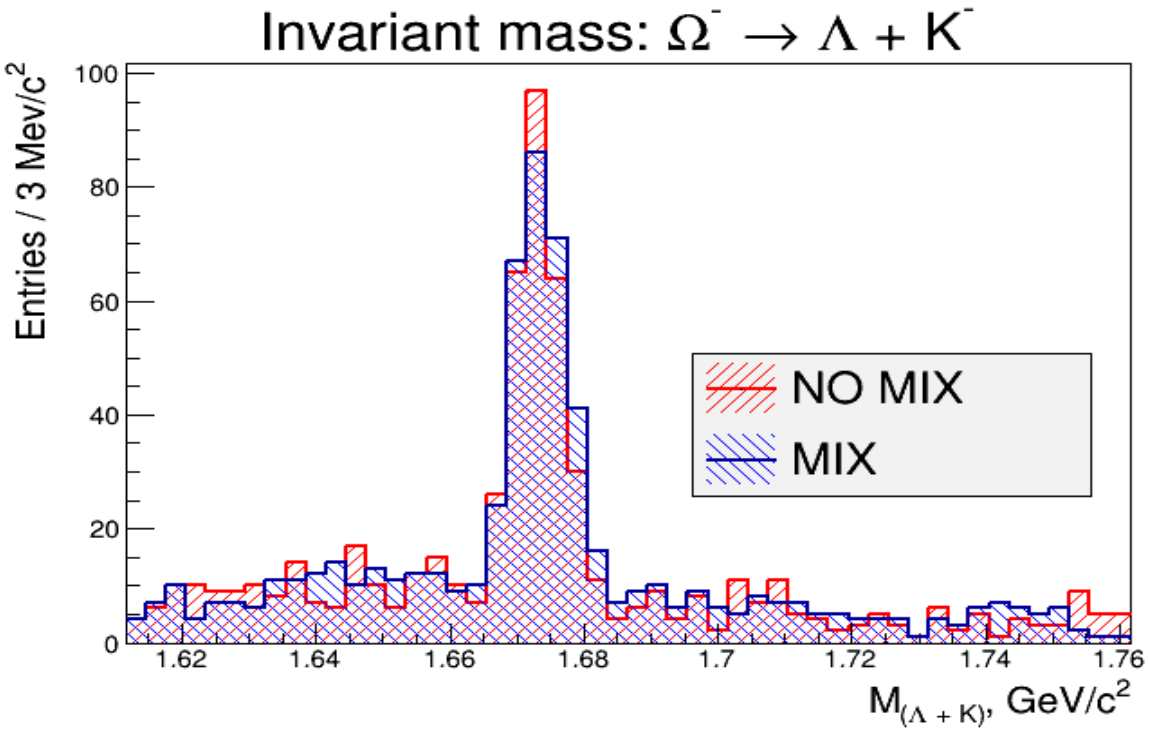
Invariant mass at max. significance: $\Omega^- \rightarrow \Lambda + K^-$ & $\Omega^- \rightarrow \Lambda + K^-$ MIX

UrQMD, Au+Au @ 9A GeV, central (0-3 fm),
300 k events
22 k events for mix
PID in TPC & TOF





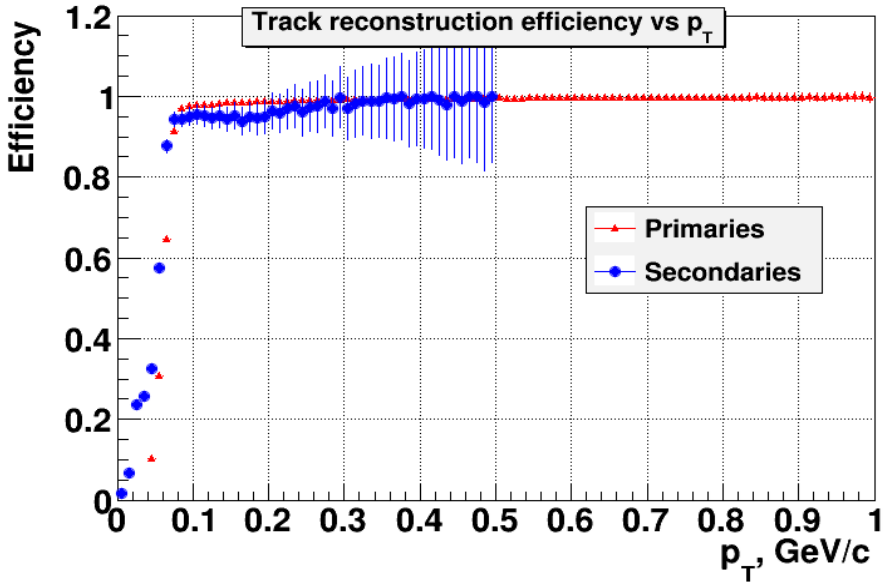
Comparison between Ω^- and Ω^- MIX

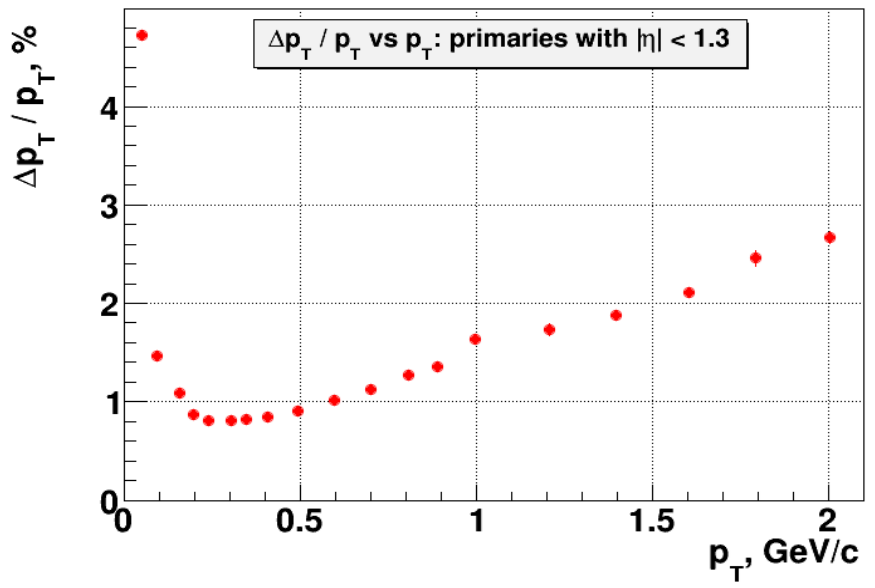


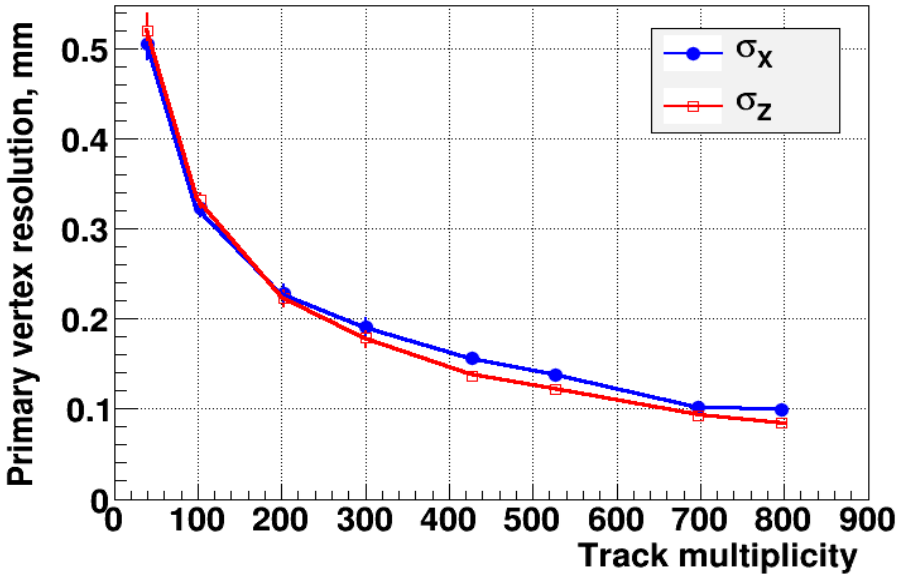
Thank you for your attention!

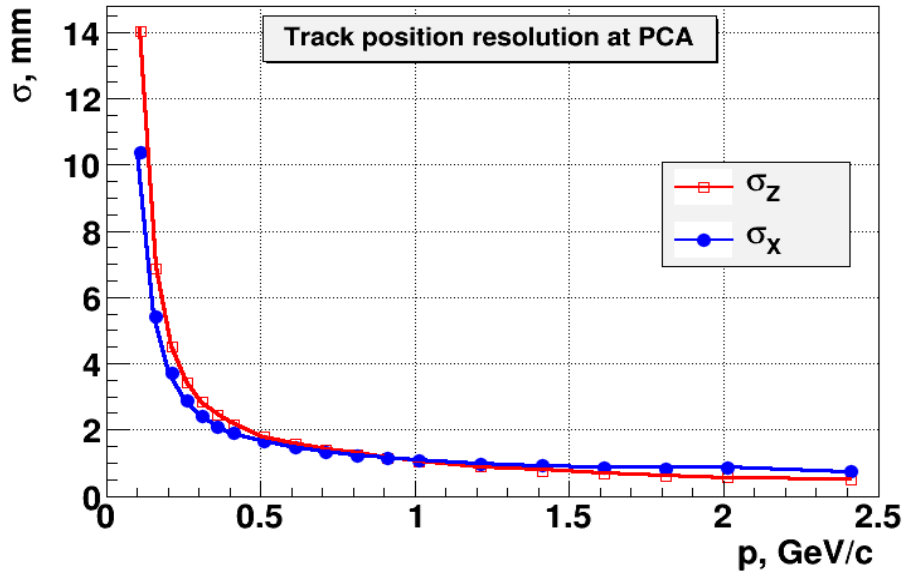
Backup

Detector performance







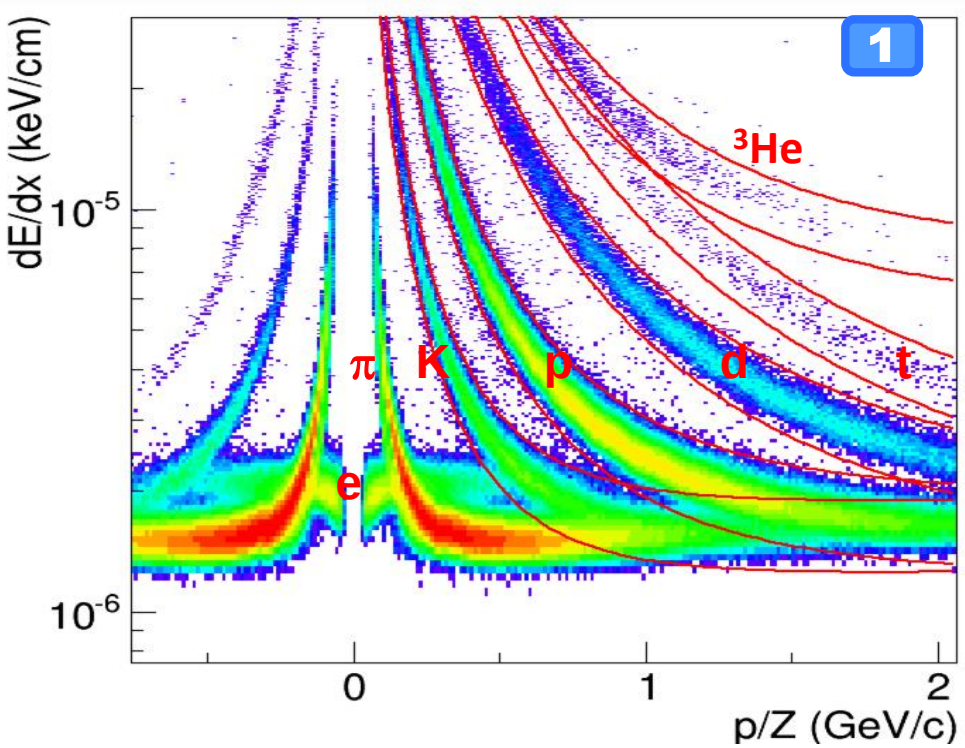


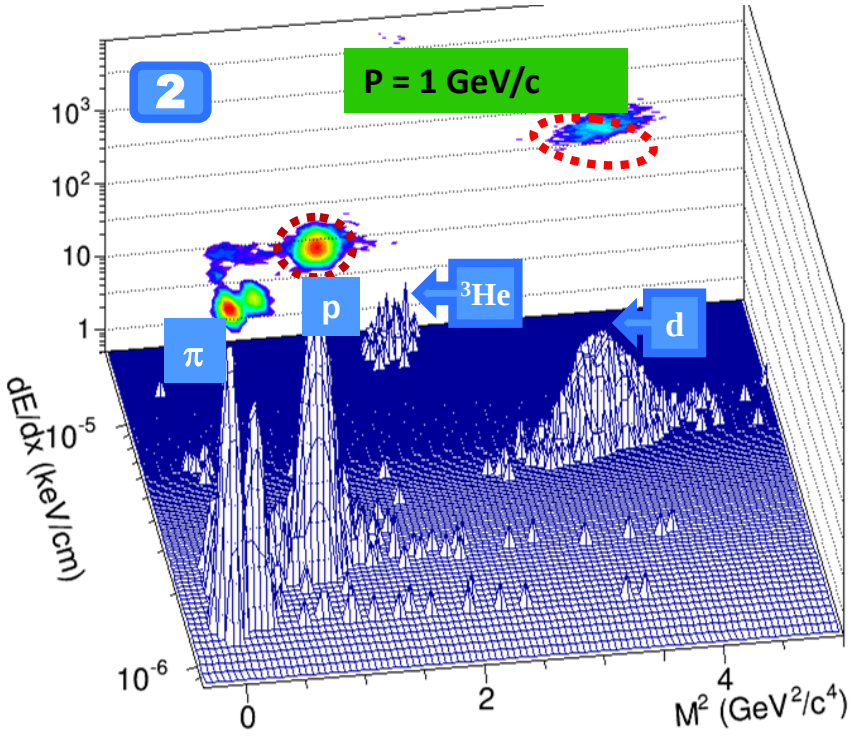
MPD Particle Identification (PID)

PID is achieved by dE/dx (TPC) and time-of-flight (TOF) measurements

Mass square calculated using the measurements of momentum (p), time-of-flight (T) and trajectory length (L)

$$m^2 = p^2 \left(\frac{c^2 T^2}{L^2} - 1\right)$$





Particles are selected within 3σ cuts in 'dE/dx vs p' (1) or 'dE/dx vs m^2' space in momentum bins (2)