



Performance evaluation of the Stage-I Inner Tracker System for hyperon reconstruction at MPD/NICA.



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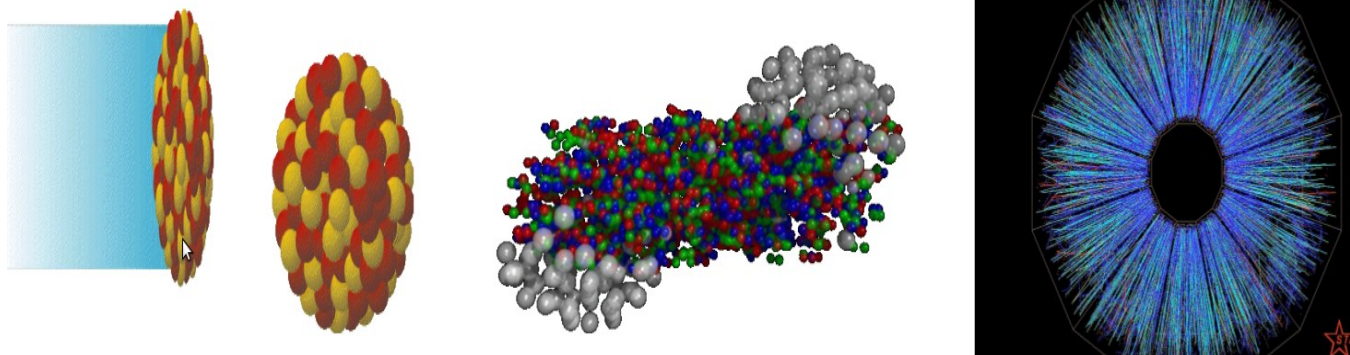
Plovdiv, Bulgaria



- ✓ Motivation
- ✓ Detector MPD (TPC, TPC + ITS(2 layers) and TPC + ITS(5 layers))
- ✓ Analysis Method
- ✓ Study of hyperon production:
 - ✓ $\Lambda \rightarrow p + \pi$
 - ✓ $\Xi^- \rightarrow \Lambda + \pi \rightarrow p + \pi + \pi$
 - ✓ $\Omega^- \rightarrow \Lambda + K^+ \rightarrow p + \pi + K^+$
- ✓ 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.
- ✓ Heavy strange objects could provide essential signatures of the excited and compressed baryonic matter.
- ✓ The study of hyperons helps to understand strong interactions and QGP.



The goal of this study



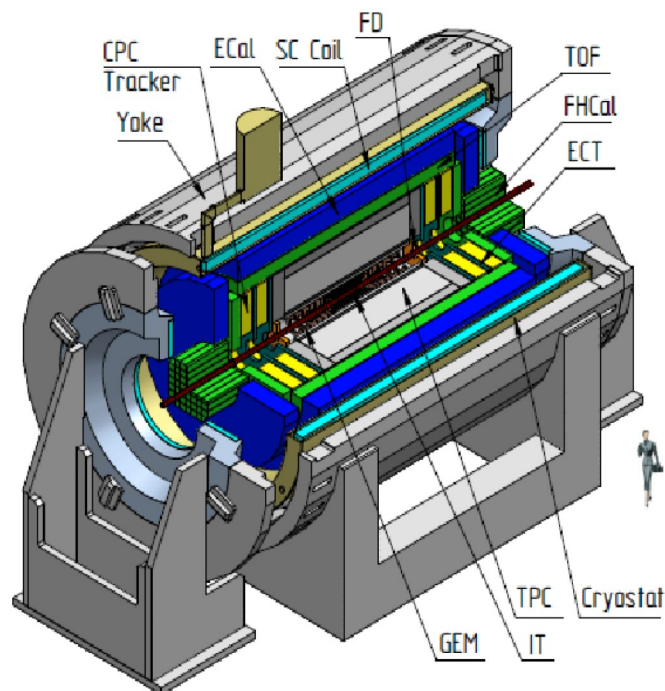
Identification and reconstruction of strange objects should be one of the most important tasks of any experiment with heavy ions, including MPD/NICA.

In order to study production of charmed particles, it is planned to install an Inner Tracking System (ITS) based on Monolithic Active Pixel Sensors (MAPS). The main purpose of the ITS is to improve the quality and precision of track, primary and secondary vertex reconstruction in MPD in the region close to the interaction point. At the first stage the ITS will contain 2 outer layers.

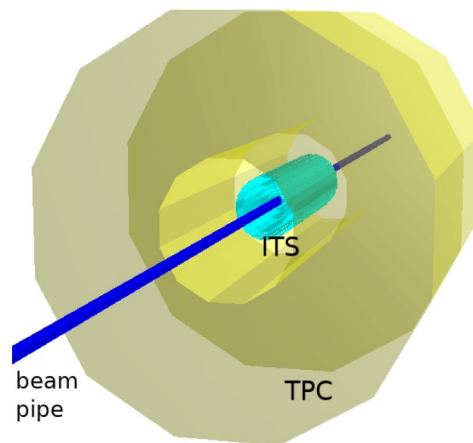
That's why our goal was:

- ✓ To study the MPD detector performance with different configurations (TPC, TPC + ITS(2 layers) and TPC + ITS(5 layers)) for reconstruction of strange objects, in particular, to see how 2 outer layers will improve results.
- ✓ To check the performance of reconstruction algorithms and software for this task.

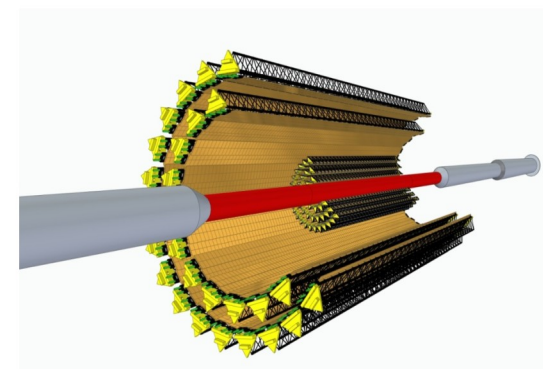
Multi-Purpose Detector general view



(a) Three-dimensional view of the MPD detector



(b) Beam pipe, TPC and ITS geometry representation in the simulation package.



(c) Technical Drawing of the ITS cut view

Shown are the beam pipe, three inner layers with an effective thickness of $50 \mu\text{m}$ of Si and two outer layers with an effective thickness of $700 \mu\text{m}$ of Si. Average layer radii are 24, 43, 63, 146 and 196 mm.

✓ <http://mpd.jinr.ru/mpd/>

Data set



- ✓ **Generators:** UrQMD Au+Au @ 9A GeV central (0 -- 3 fm), 10k, 250k events
- ✓ **Detectors:** MPD (TPC, TPC + ITS(2 layers) and TPC + ITS(5 layers))

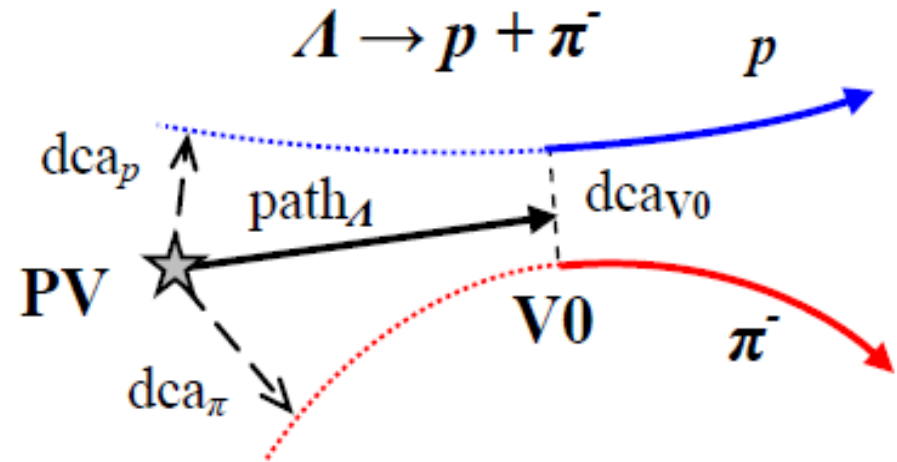
Reconstruction and Analysis

- ✓ Track acceptance criterion: $|\eta| < 1.3$, $N_{hits} \geq 10$
- ✓ Kalman filter (KF) in TPC
- ✓ KF track extension to 2-layer ITS
- ✓ standalone Vector Finder in 5-layer ITS and track merging with TPC KF tracks
- ✓ Maximization of significance of the invariant mass peak of hyperon decay products $S/\sqrt{(S+B)}$

Analysis Method: Secondary Vertex Finding Technique



- **PV** – primary vertex
- **V₀** – vertex of Λ decay
- **dca** – distance of the closest approach
- **path** – decay length

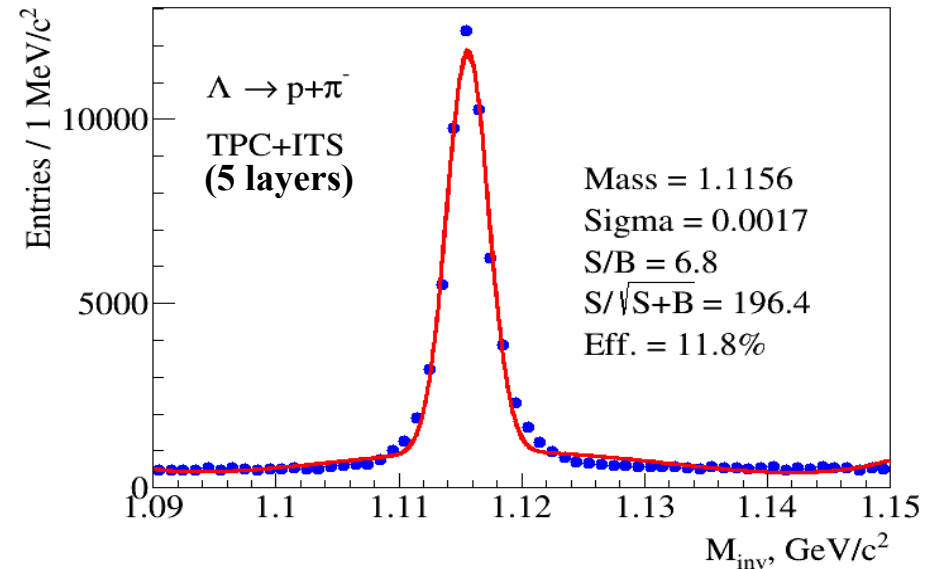
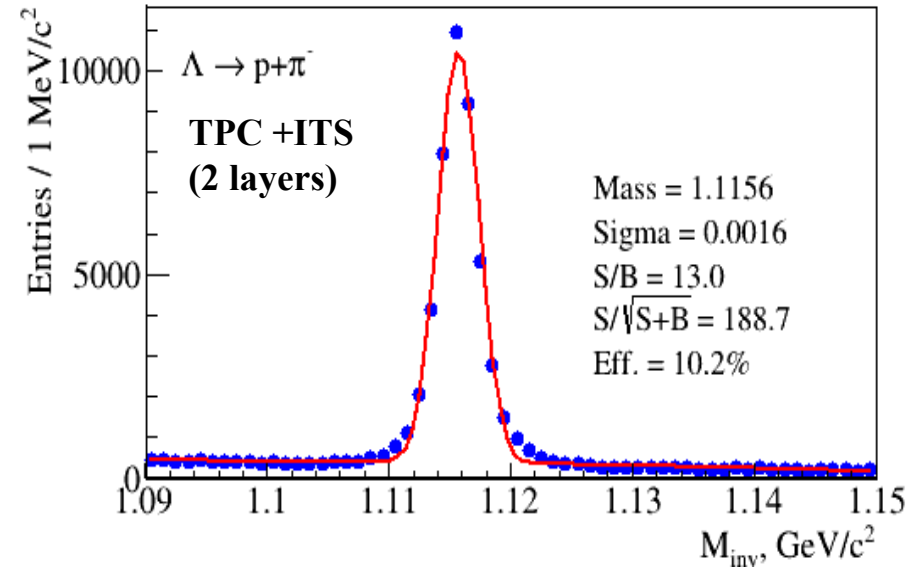
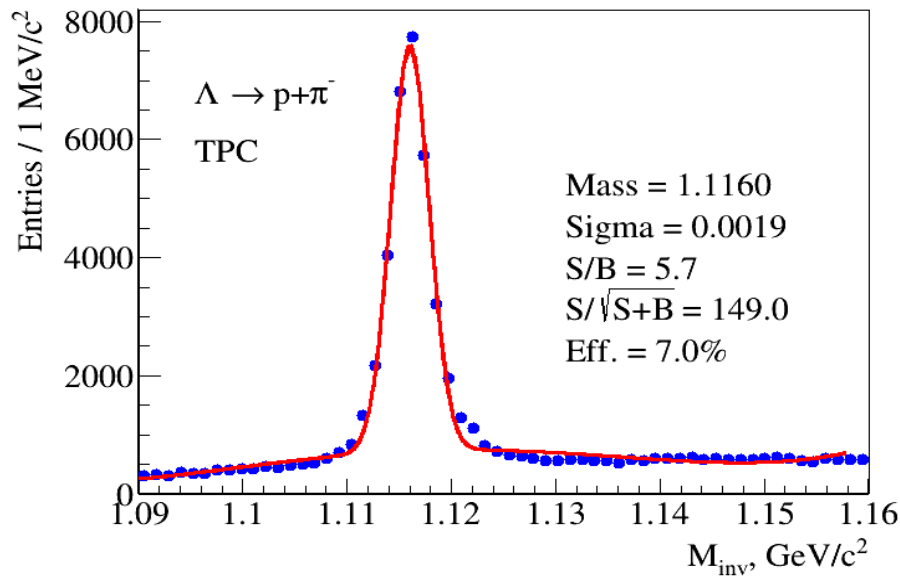


Maximization of significance: Significance is defined as $S/\sqrt{(S+B)}$, where **S** and **B** are total numbers of signal and background combinations inside $\pm 2\sigma$ interval around the peak position.

Comparison between different configuration for Invariant mass: $\Lambda \rightarrow p + \pi$

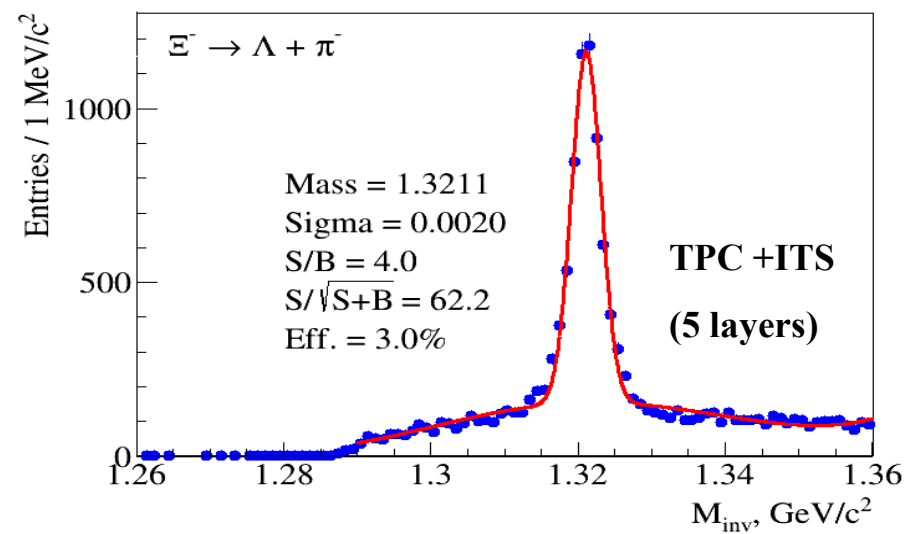
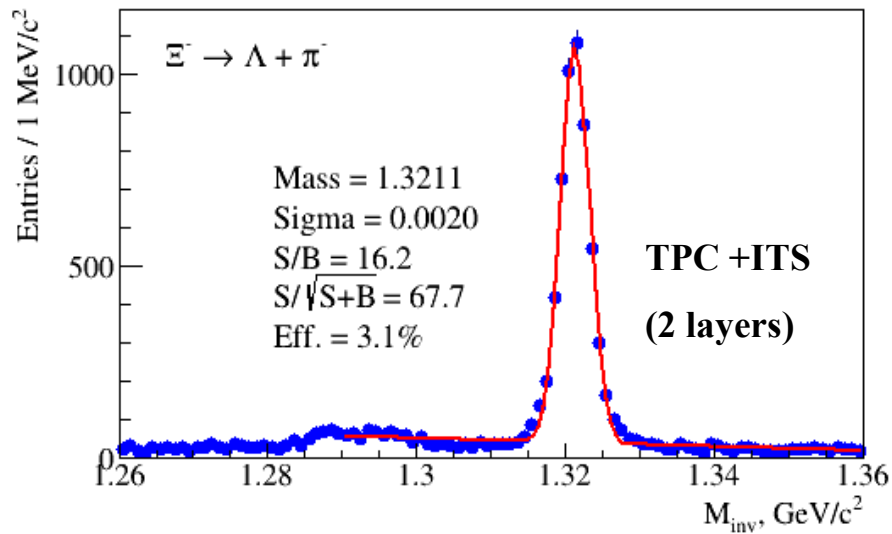
UrQMD, Au+Au @ 9A GeV, central (0 -- 3 fm),

10k events



Comparison between different configuration for Invariant mass: $\Xi^- \rightarrow \Lambda + \pi^- \rightarrow p + \pi^- + \pi^-$

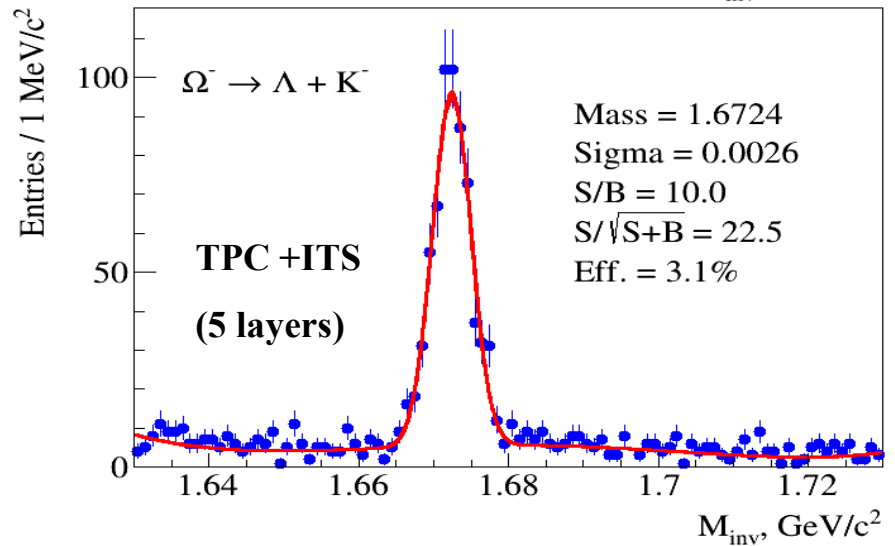
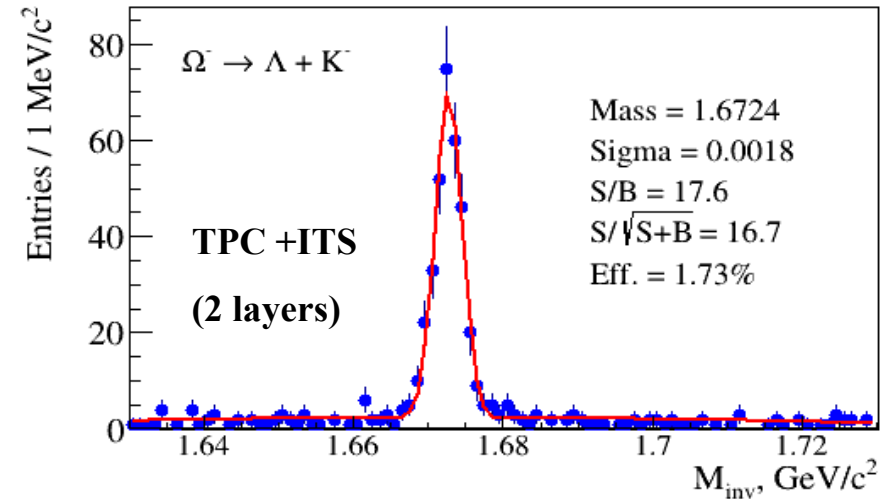
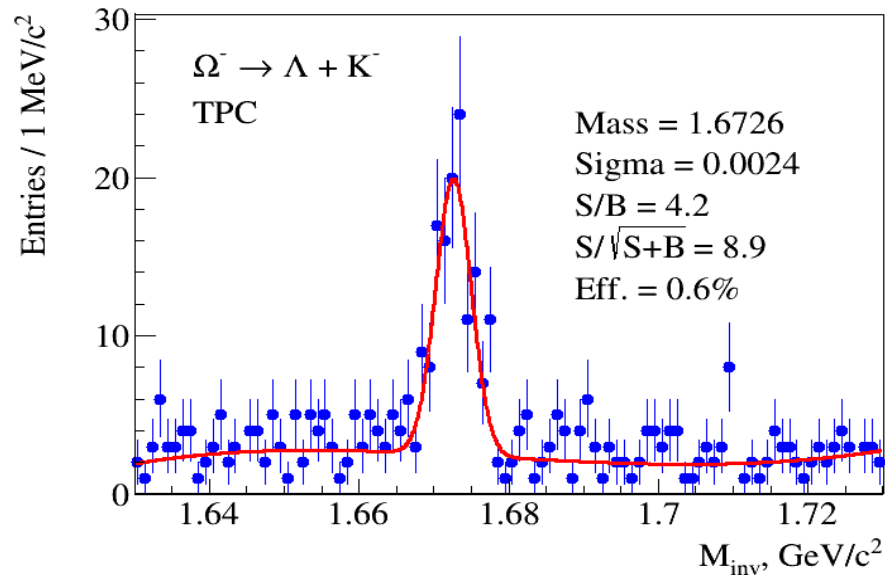
UrQMD, Au+Au @ 9A GeV, central (0 -- 3 fm), 250k events



Comparison between different configuration for Invariant mass: $\Omega^- \rightarrow \Lambda + K^- \rightarrow p + \pi^- + K^-$

UrQMD, Au+Au @ 9A GeV, central (0 -- 3 fm),

250k events



Conclusions and outlook

- ✓ MPD ITS Stage-I demonstrated good performance results for reconstruction of hyperons in simulated high-multiplicity events of Au + Au collisions
- ✓ As one could expect, additional silicon detector layers closer to the beam line improve the performance for more rare and shorter-lived particles (as Ω hyperons)
- ✓ Similarly, one can expect that the ITS will improve the MPD performance for reconstruction of hypernuclei (to be checked in future)



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Thank you for your attention!

Backup

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 $\pm 2\sigma$ interval around the peak position.
2. Set of 6 cuts for Λ selection: χ^2_π (dca₁), χ^2_p (dca₂), χ^2_{V0} , dca_{V0}, path, angle between \mathbf{p} and \mathbf{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.

