Performance of the MPD Detector for the Study of Multi-strange Baryon Production in Heavy-ion Collisions at NICA

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for the **MPD Collaboration**

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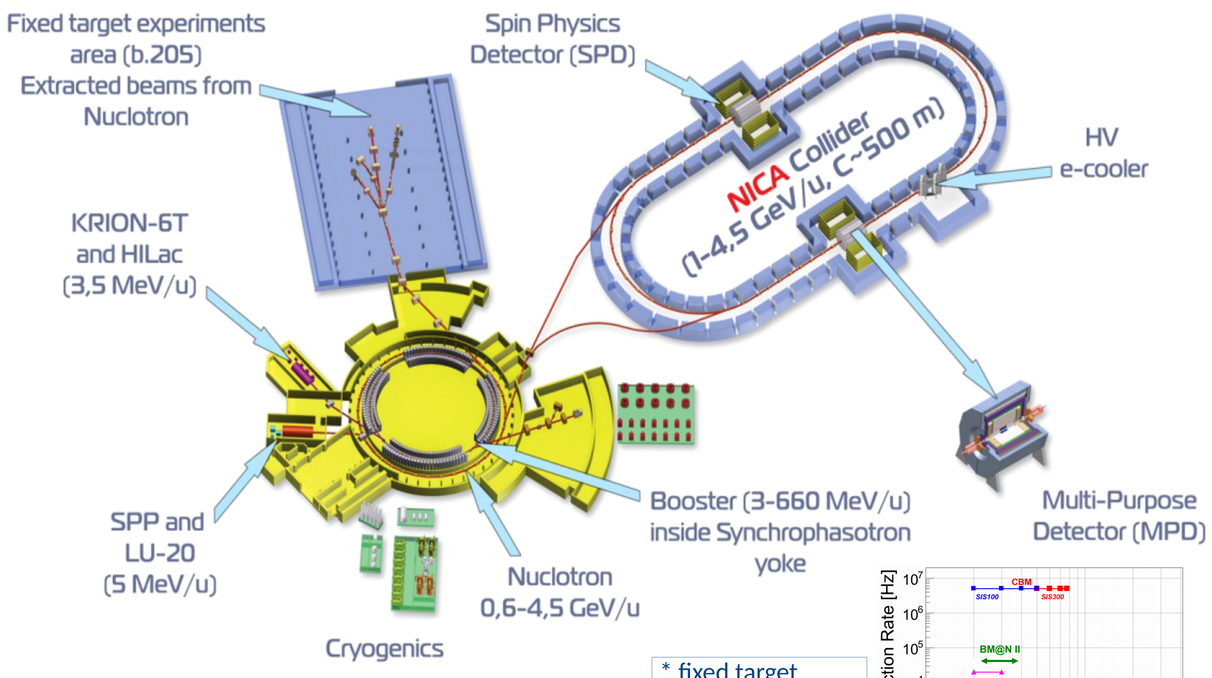
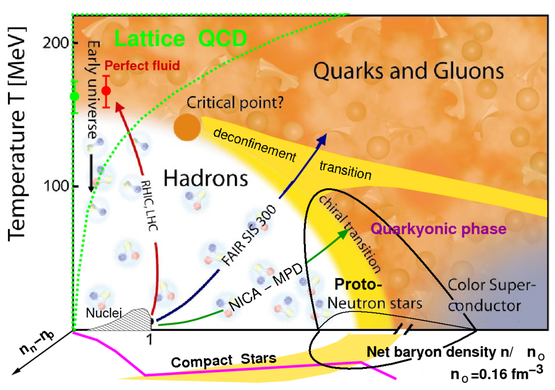
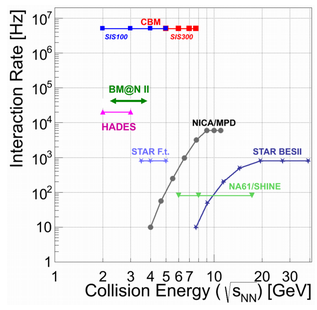
Heavy-ion collisions at NICA are well suitable to investigate fundamental problem of strongly interacting matter such as its EOS, bulk properties, state of QCD vacuum, and criticality.
The production of (anti)hyperons is sensitive to the early stage of the collision, thus the degree of partonic collectivity can be tested by means of multi-strange baryon yields, spectra, and anisotropic flow coefficients. Moreover, the difference in production rates as well as in azimuthal anisotropy between hyperons and antihyperons could depend on the baryon density and EOS in the hadronic stage of the medium. Hence, multi-strange baryons can be a valuable probe to test multiple stages of the evolution of a heavy-ion collision.
The MPD detector is a spectrometer with a large uniform acceptance capable of detecting and identifying hadrons, electrons and gammas at the very high event rate achieved at NICA. Event reconstruction in MPD is expected to provide a high accuracy in collision centrality and event plane determination, as well as a good performance in secondary vertex finding.

Nuclotron-based Ion Collider Facility





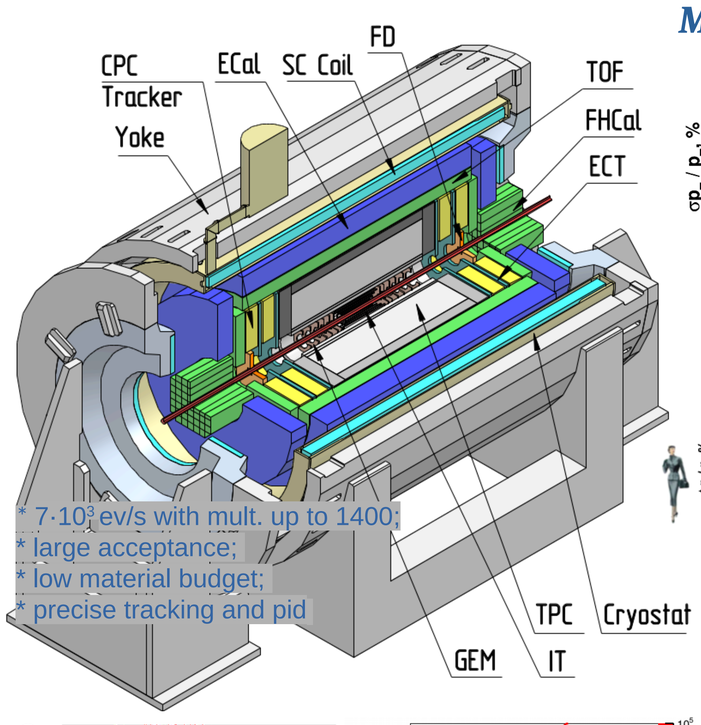
* fixed target
* collider mode
* pp, pA, AA, AB
* polarized beams
* HIC physics
* Med & Industry



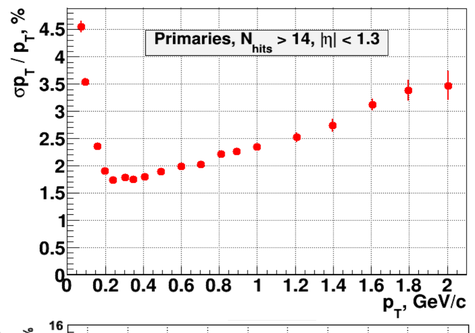
Motivation for NICA/MPD

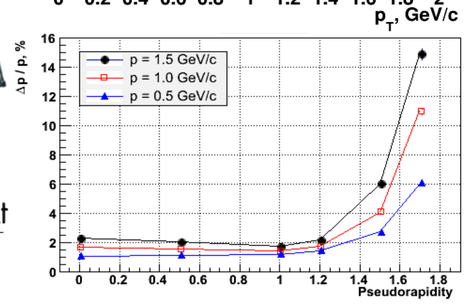
* Study Hot and Dense Baryon Matter
* Region of Highest Net Baryon Density
* Equation of State, Phase Transition
* Multiplicity, Ratios, Critical phenomena, HBT, EM probes, Collective flow, etc...

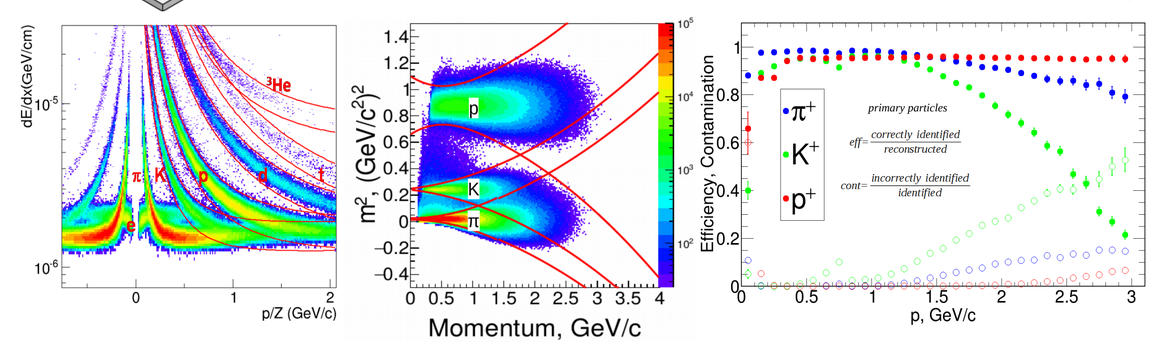
Multi-Purpose Detector



* 1st stage: TPC, TOF, ECAL, FHCal, FFD



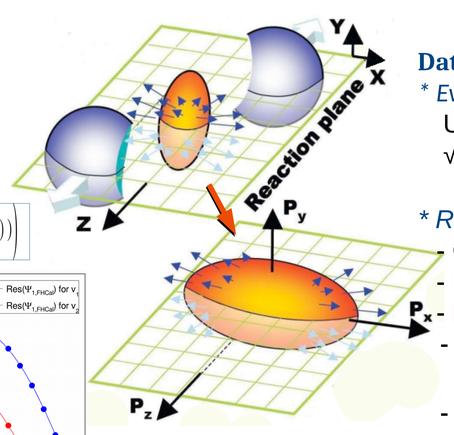




Anisotropic Flow of Reconstructed Decays

* Non-zero impact parameter
* Spatial anisotropy
* Pressure gradient
* Momentum anisotropy

$$E\frac{d^3N}{d^3p} = \frac{dN}{2\pi\, p_T\, dp_T\, dy}\left(1 + 2\sum_{n=1}^{\infty} v_n(p_T, y)\cos(n(\phi - \Psi_n))\right)$$

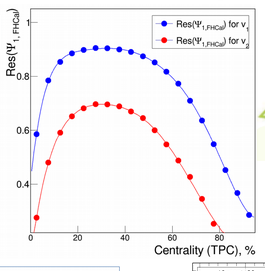


FHCal Event-plane Method

$$Q_x^m = \frac{\sum E_i \cos(m\phi_i)}{\sum E_i}$$

$$Q_y^n = \frac{\sum E_i \sin(m\phi_i)}{\sum E_i}$$

$$\Psi_m^{EP} = \frac{1}{m} Atan2(Q_y^m, Q_x^m)$$



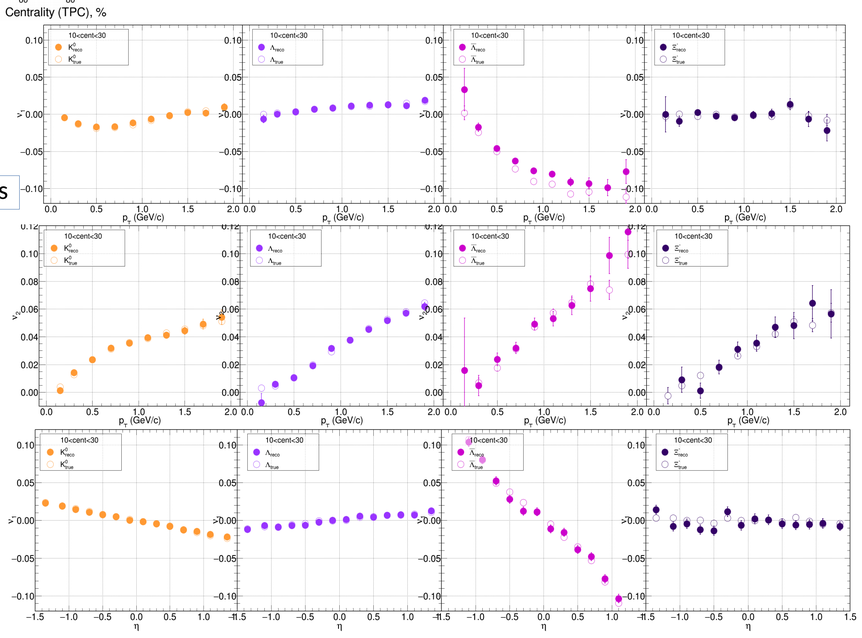
$$Res^2\{\Psi_n^{EP,L}, \Psi_n^{EP,R}\} = \langle\cos(n(\Psi_n^{EP,L} - \Psi_n^{EP,R}))\rangle$$

$$v_n = \frac{\langle\cos(n(\varphi - \Psi_n^{EP}))\rangle}{Res\{\Psi_n^{EP}\}}$$

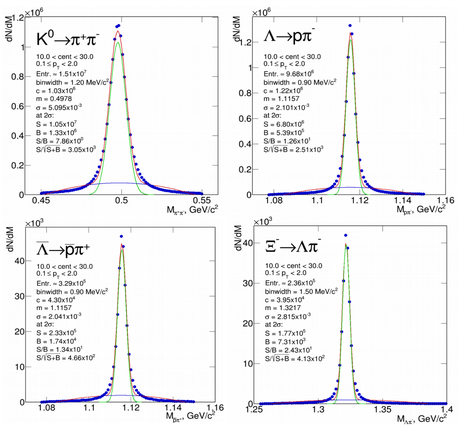
Data Set, Simulation & Analysis

* *Event Generator:*
  UrQMD 3.4 (non-hydro), $Au^{79+}Au^{79+}$, $\sqrt{s_{NN}}$=11 GeV, 0..16 fm, 25M events

* *Realistic MPD Simulation*
  - Geant4 transport,
  - Realistic **TPC** Cluster Simulation
  - **FHCal** Energy Deposition by ch
  - Track selection
    TPC_{hits}>30, |η|<1.5, p_T>0.1 GeV/c
  - Realistic PID by **TPC** and **TOF**
  - Realistic Particle Reconstruction
  - Realistic Anisotropic Flow



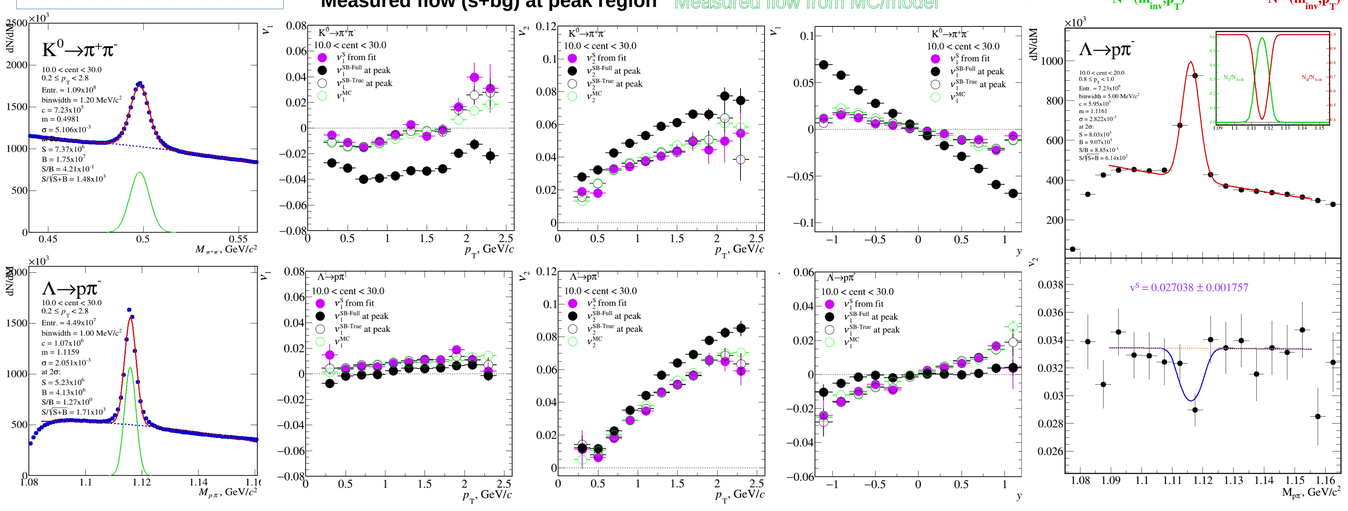
True Reco Particles, Reconstruction Params



Reconstructed Particles

Extracted flow signal after fit
Measured flow (s+bg) at peak region
Measured flow only for True
Measured flow from MC/model

$$v_2^{SB}(m_{inv}, p_T) = v_2^{S}(p_T)\frac{N^S(m_{inv}, p_T)}{N^{SB}(m_{inv}, p_T)} + v_2^{B}(m_{inv}, p_T)\frac{N^B(m_{inv}, p_T)}{N^{SB}(m_{inv}, p_T)}$$

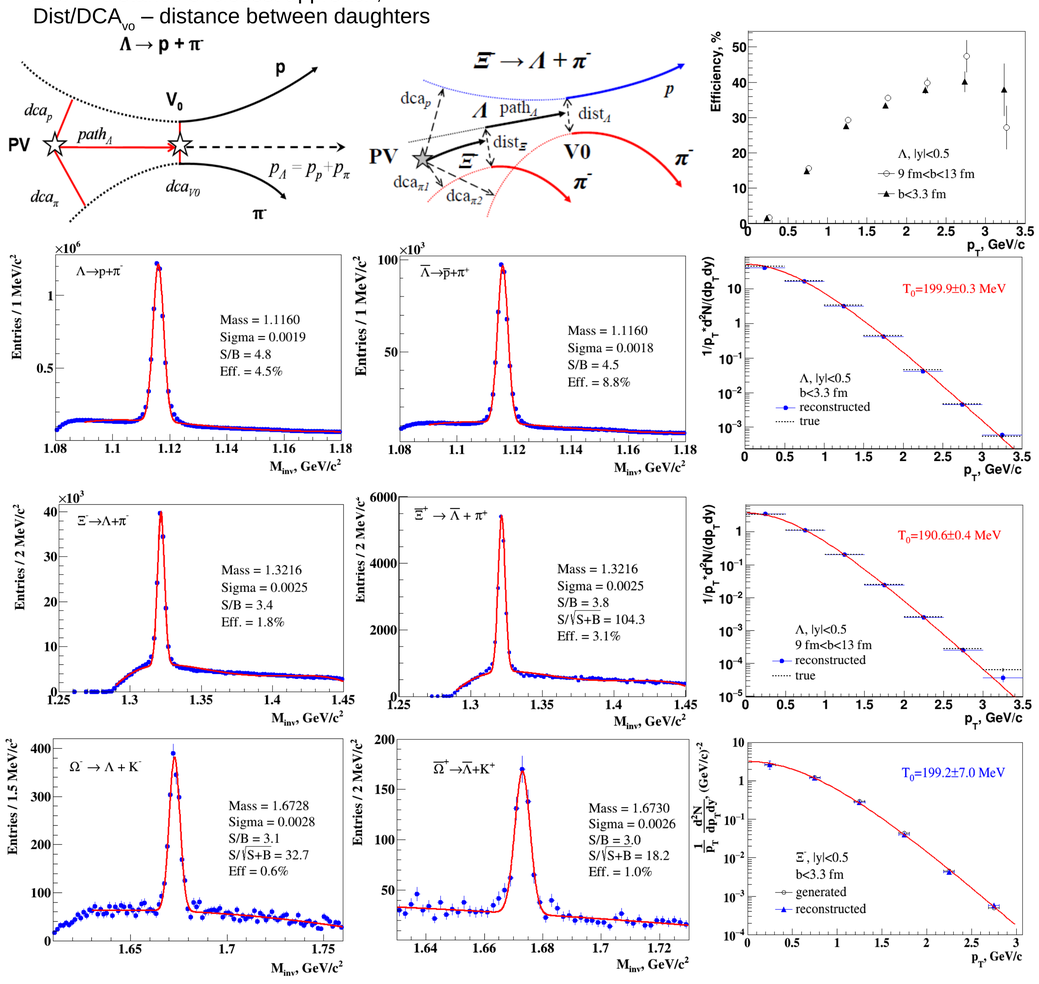


Performance of Hyperon Reconstruction

We present the performance of the MPD detector for reconstruction of strange and multi-strange baryons (Lambda, Xi, Omega and their antiparticles) in heavy-ion collisions. The results, which are obtained from the full MPD simulation and reconstruction chain, include the yields, spectra, and anisotropy coefficients for (anti)hyperons from centrality selected Au+Au collisions.

Decay topology:
PV – vrimary vertex; V_0 – vertex of decay; Path – decay length
DCA – distance of closest approach;
Dist/DCA_{V0} – distance between daughters

Model: PHSD, $Au^{79+}Au^{79+}$
$\sqrt{s_{NN}}$=11 GeV, min. bias, 8M events
Realistic MPD sim and reco



Conclusion

The MPD detector provides good tracking and particle identification performance. The study of multi-strange baryon production and anisotropic flow at NICA was presented. Both the transverse momenta slope parameters and flow coefficients of the reconstructed particles were analyzed. The model-generated values were in good agreement with the reconstructed results. In order to achieve this an efficiency and acceptance correction was applied and a flow-signal-extraction procedure was developed.

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Acknowledgement

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