A MAPS-based Inner Tracking System for the Multi-Purpose Detector at the NICA collider

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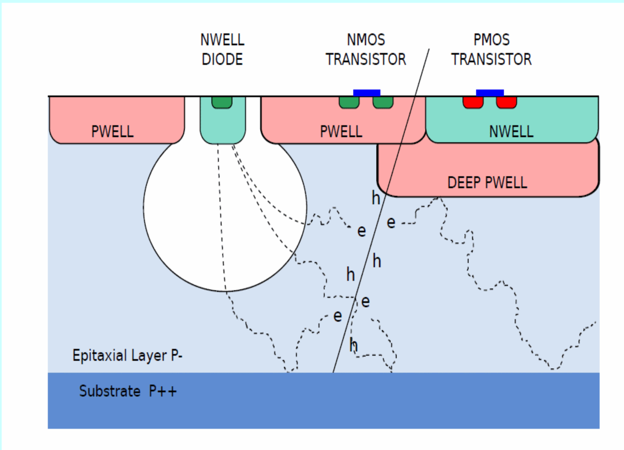
An Inner Tracking System (ITS) based on the Monolithic Active Pixel Sensors (MAPS) is under design by the emerging MPD-ITS collaboration in Dubna and Wuhan. The ultra-light carbon fiber structure carries five layers of CMOS ALPIDE sensors recently elaborated by the ALICE collaboration. The two layers of the Outer Barrel (OB) are built out of 42 staves developed for the new ALICE ITS to be installed at CERN next year. The MPD ITS mainframe mechanics and the OB installation is planned to be completed in 2023. The Inner Barrel (IB) will use novel MAPS sensors of enlarged area and reduced thickness to be developed together with the ALICE collaboration within 2020-2025 and installed after the reduction of the diameter of the MPD beam pipe to optimal value of 40 mm.

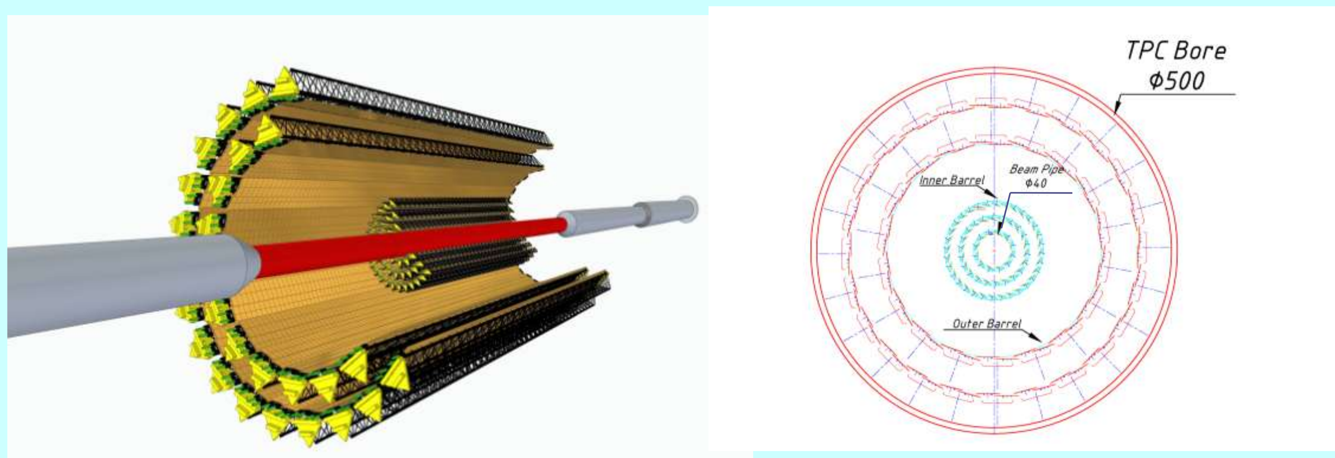
The poster presents the main details of the MPD ITS layout, Monte-Carlo simulations of the pointing resolution gained with the system, as well as a quality assessment of the MPD tracking system including ITS and Time Projection Chamber used for the reconstruction of the multi-strange hyperons and the D-mesons produced in the central Au-Au collisions at $\sqrt{S_{NN}}$ = 9 GeV.

Monolithic Active Pixel Sensor (MAPS)



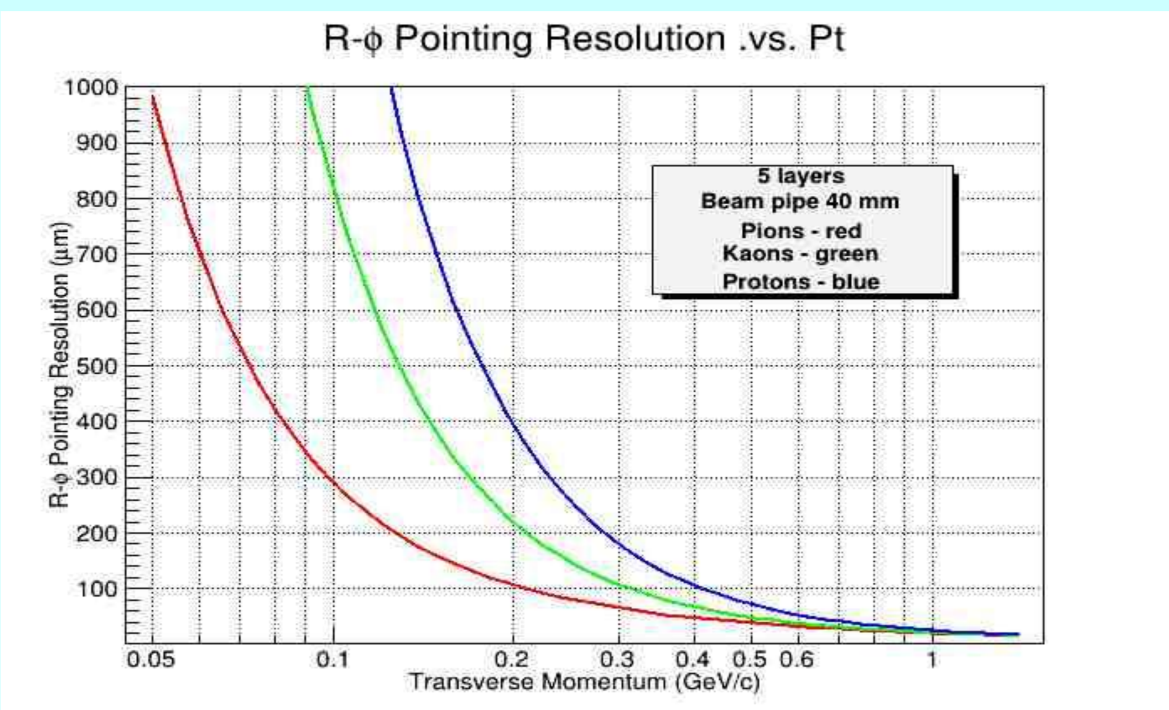
Sensitive area: 15×30 mm^2
Thickness: 50 µm
Number of pixels: 512×1024
Pixel size: 27×29 µm^2.
Space resolution:
$\sigma_{r\phi}$ = 5 µm , σ_z = 5 µm

ITS geometric model



Layer	Number of ladders	Number of ALPIDEs in ladder	R_{min}, mm	R_{max}, mm	Ladder length, mm	Effective thickness, µm
1	12	18	22.4	26.7	542	50
2	22	18	40.7	45.9	542	50
3	32	18	59.8	65.1	542	50
4	36	98	144.5	147.9	1468	700
5	48	98	194.4	197.6	1468	700

ITS pointing resolution

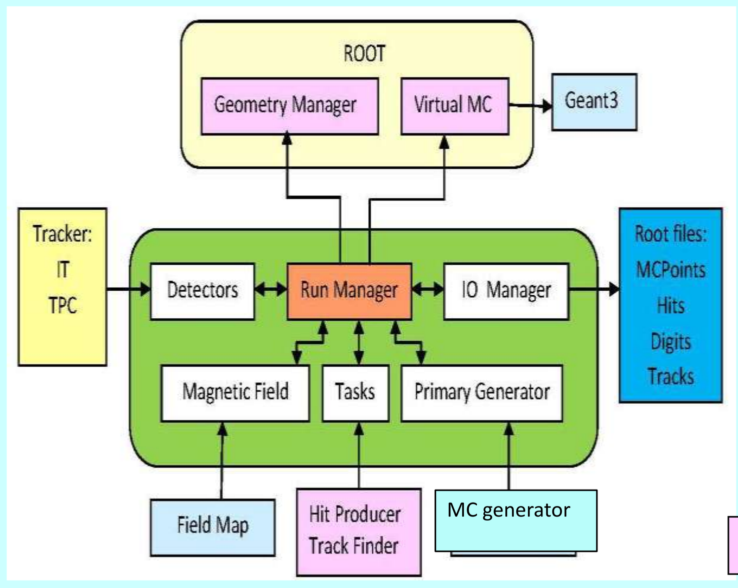


Physical motivation of using ITS

The Multi-Purpose Detector(MPD) is being constructed to study the properties of extremely dense nuclear matter formed in relativistic nucleus-nucleus collisions at NICA energies. The yields of strange and charmed particles are the important observables sensitive to critical phenomena in phase transitions of the QGP-matter at high net-baryon density. Highly efficient registration of such short-lived products of nuclear interactions using a vertex silicon detectors will play a key role in the analysis of the possible onset of deconfinement enforced by fluctuations of dense nuclear matter under critical conditions.

Quality assessment of strange and charmed particles reconstruction

IT Monte-Carlo simulation scheme within MpdRoot

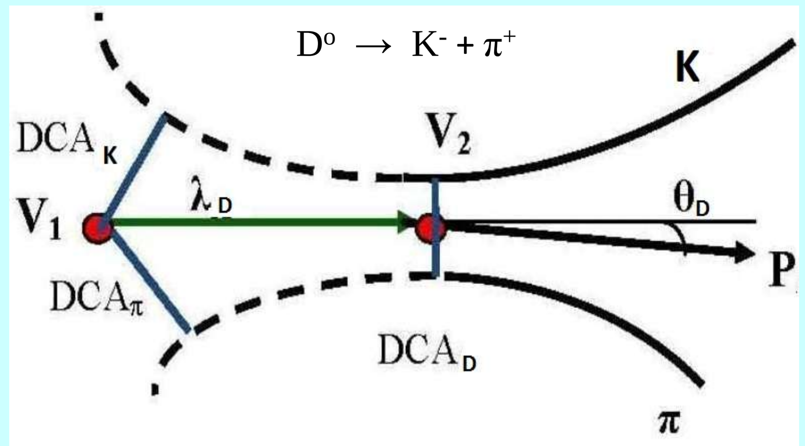


MC generator: DCQGSM
MC transport: GEANT3
Hit generation
Track finding: KF
Verticies reconstruction

At the reconstruction stage the main simulation tasks include:

- generation of detector responses (Hit Producer);
- reconstruction of particle tracks using generated hits (Track Finder) ;
- reconstruction of the primary and secondary interaction vertices (Track Analysis).

Selection criteria for two-particles decay



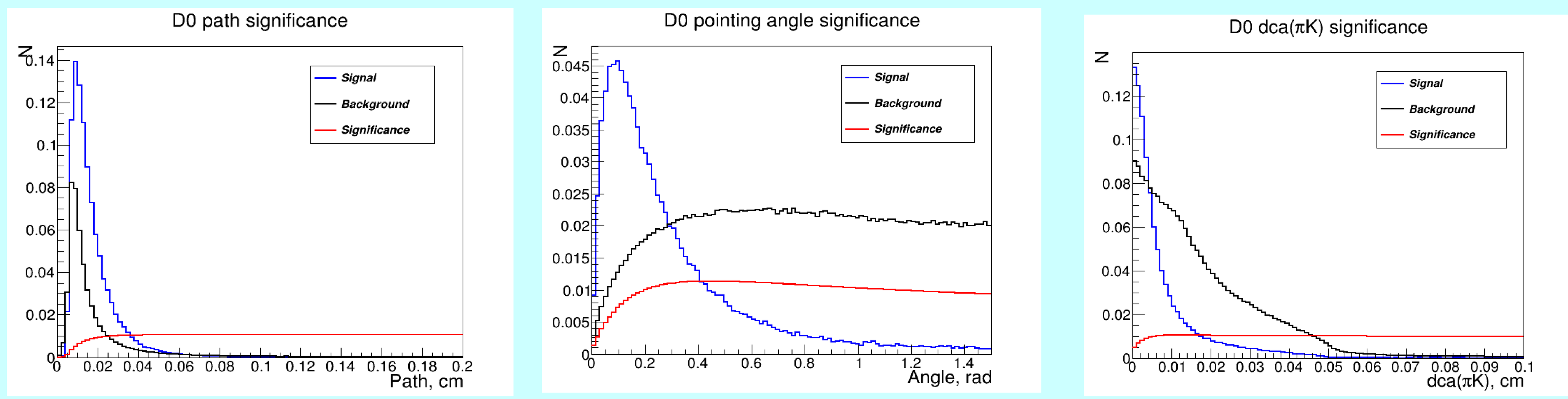
$DCA_\pi > C_1$ & $DCA_K > C_2$ & $DCA_D < C_3$ & $\lambda_D > C_4$ & $\theta_D < C_5$

Topological cuts are optimized by maximizing significance:

$$Sg(a) = \int_0^a \frac{S}{\sqrt{S+B}} da$$

a - cut
S - signal
B - background .

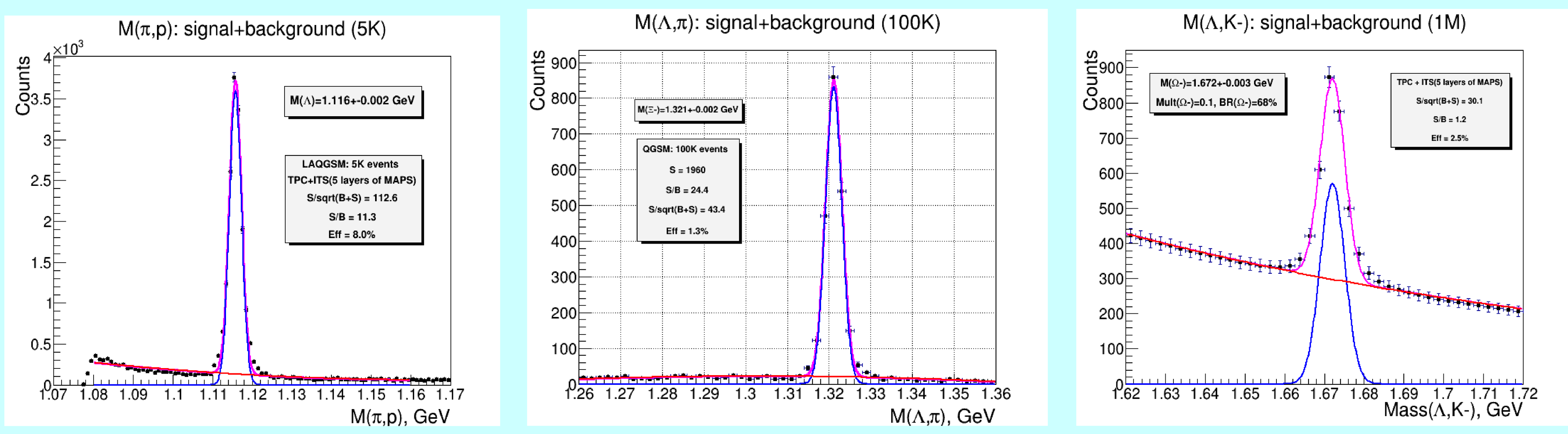
Significance functions for D^0 topological cuts



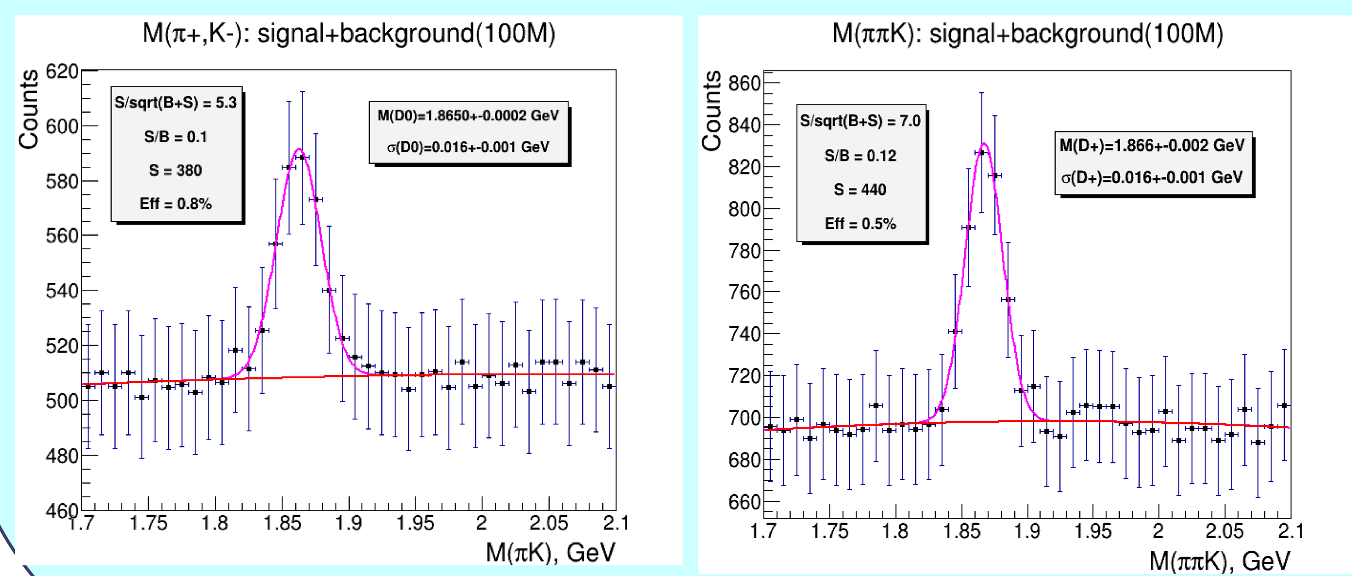
Chosen values for D^0 topological cuts

DCA_π > 0.01 cm & DCA_K > 0.01 cm & DCA_D < 0.019 cm & λ_D < 0.04 cm & λ_D <0.25 rad

Reconstructed invariant mass distribution of strange particles normalized on 5·10^3 central Au+Au QGSM events for Λ, 10^5 - for Ξ^- and 10^6 - for Ω^-



Reconstructed invariant mass distribution of charmed particles normalized on 10^8 central Au+Au QGSM events



Conclusions

Physics analysis of proposed 5-layer MAPS-based ITS grouped in two barrels demonstrates feasibility of the charmed physics program for gold-gold collisions with the NICA MPD setup provided the beampipe diameter is reduced to 40 mm.

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