ITS3: A Cylindrical Marvel in ALICE - Physics Performance Insights

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The ALICE Collaboration is currently carrying out an extensive R&D program to upgrade the inner barrel of the ALICE Inner Tracking System (ITS) during Long Shutdown 3 (LS3) for the LHC Run 4 (2029 - 2032). The three innermost layers of the current ITS (called ITS2) as from Run 4 onwards will be replaced by a new detector called ITS3. The ITS3 consists of three ultra-thin cylindrically bent silicon layers (thickness $\approx$ 50 μm) of Monolithic Active Pixel Sensors (MAPS). The chips will be implemented in a 65 nm CMOS imaging technology with stitching to manufacture sensors of about 10 $\times$ 26 cm^2 size. They will be bent to half-cylindrical shapes of $\approx$ 18, 24, 30 mm bending radii for layer 0, 1, 2, respectively. The ITS3 will thus be comprising six stitched sensors, kept in place using slices of carbon foam, with a very low power consumption of about 20 mV/cm^2 that allows for air cooling. The material budget will be extremely low, with an unprecedented value of about 0.05% X_0 per layer. The ITS3 will improve the pointing resolution by a factor of two as shown in Fig. 1 and increase the tracking efficiency at momenta below 0.3 GeV/c. This gain in performance will allow for the first measurements of Λ_b^0 and Ξ_c^+, and will significantly improve the precision of the measurement for B_s^0 and prompt and non-prompt D_s^+ in heavy-ion collisions at LHC energies. The first studies on the existence of the exotic c-deuteron might be in reach. In this contribution the performance of ITS3 [3] for the reconstruction of heavy-flavour signals in the centrality interval 0-10% in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV, for an integrated luminosity L_{int} = 10 nb^{-1}, are presented.

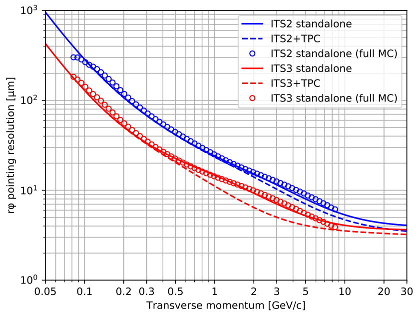

FIG. 1: Pointing resolution improvement of the ITS3 compared to ITS2.

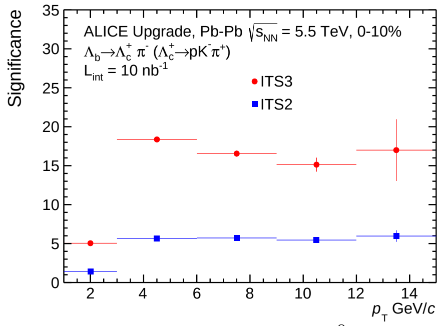

FIG. 2: Statistical significance of Λ_b^0 as a function of p_T with ITS2 and ITS3.

The estimated statistical significance of Λ_b^0 as a function of transverse momentum (p_T) is shown in Fig. 2. The improvement in significance provided by the ITS3 is larger, in relative terms, in the low-momentum region where the decay length is shorter. Remarkably, the ITS3 will allow for a measurement down to p_T = 1 GeV/c and to cover, with a statistical uncertainty lower than 10%, the p_T region below the Λ_b^0 mass, a very sensitivity region for constraining quark-coalescence models [4].

Figure 3 shows the p_T-differential nuclear modification factor (R_{AA}) of B_s^0 mesons. It is expected that the precision on the B_s^0 measurement achievable with the ITS3 will be sufficient to discriminate between the predicted

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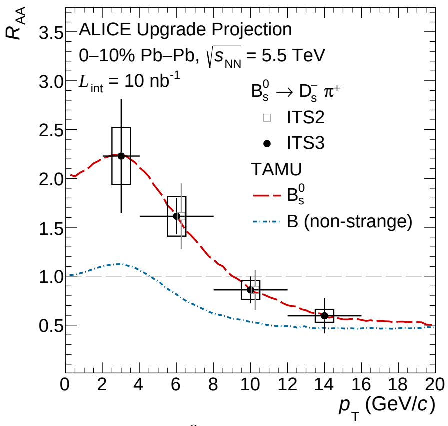

FIG. 3: $R_{\rm AA}$ of $\rm B^0_s$ mesons as a function of $p_{\rm T}$ compared to the predictions for strange (red dashed line) and non-strange B mesons (blue dotted line) from the TAMU model [5].

difference of non-strange and strange B meson $R_{\rm AA}$. The improvement with respect to ITS2 is again clearly visible in Fig. 3.

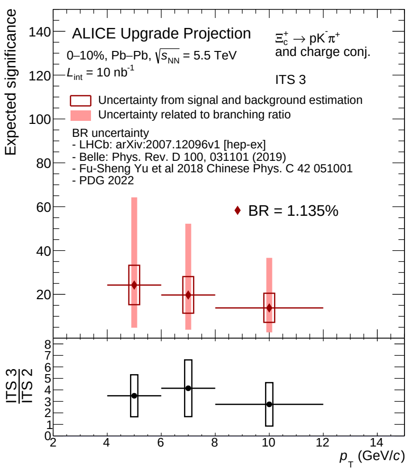

FIG. 4: Expected significance of Ξ_c^+ as a function of $p_{\rm T}$ with ITS3. The gain with respect to the estimate performed with ITS2 is shown with the ratio in the bottom panel.

The expected significance of Ξ_c^+ as a function of $p_{\rm T}$ is shown in Fig. 4. A gain of a factor between three and four as compared to ITS2 is achievable, which assures the feasibility of the measurement with small-enough statistical uncertainty to possibly appreciate differences at the 10% level between the modifications of the $\Xi_c^+/\rm D^0$ and $\Lambda_c^+/\rm D^0$ baryon-to-meson ratios from pp to Pb–Pb collisions.

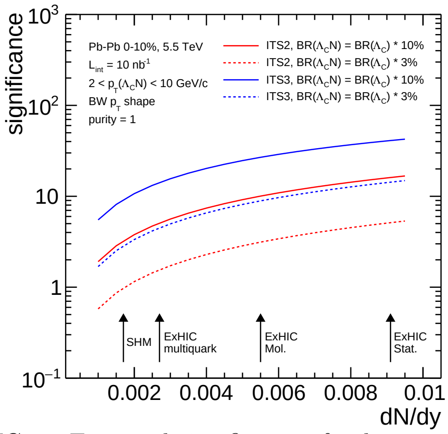

FIG. 5: Expected significance of c-deuteron with ITS2 and ITS3 as a function of the c-deuteron yield.

Figure 5 shows the achievable significance of c-deuteron with the ITS2 and ITS3. The significance improves by a factor of about 3 with ITS3 compared to ITS2. Under the assumptions that deuterons can be identified with high efficiency and 100% purity using the Time Projection Chamber and Time-of-Flight detector information, an observation with significance larger than 5 is possible with the ITS3 for all yield hypotheses if we assume the $p_{\rm T}$ shape to be a blast-wave and the branching ratio to be 10% of $\Lambda_c^+ \to \rm pK^-\pi^+$.

The ITS3 will also allow ALICE to better explore a novel analysis technique called "strangeness tracking" consisting in identifying the pixels fired by the passage of charged strange baryons before they decay and thus trace their trajectory in the vicinity of the primary vertex with high precision. This technique may boost the reconstruction performance of charm-strange baryons.

References

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