Probing particle-production mechanisms in hadronic collisions at the LHC with charged-particle density measurements in ALICE Run 3

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Global observables such as the pseudorapidity distributions of particle multiplicities in the final state are crucial to shed light on the physics processes involved in hadronic collisions. Particle production at the LHC energies arises from the interplay between hard and soft QCD processes and is sensitive to non-linear QCD evolution in the initial state. For Run 3 of the LHC, ALICE has upgraded its detectors, increasing its pseudorapidity coverage and tracking of charged particles over a wider range of pseudorapidity by combining the information from the upgraded Inner Tracking System (ITS) and the newly installed Muon Forward Tracker (MFT). These new detectors enable the exploration of particle-production mechanisms by addressing the charged-particle pseudorapidity densities, measured over a wide η range, in pp and Pb–Pb collisions. In this talk, the first measurements of the charged-particle pseudorapidity density, $dN_{ch}/d\eta$, in proton–proton (pp) collisions at $\sqrt{s} = 13.6$ TeV and in lead–lead (Pb–Pb) collisions at $\sqrt{s_{NN}} = 5.36$ TeV will be presented. The average charged-particle pseudorapidity density $\langle dN_{ch}/d\eta \rangle$ in pp collisions is measured at midrapidity ($|\eta| < 0.5$) with the upgraded central barrel detectors and, at forward pseudorapidity ($-3.6 < \eta < -2.4$), using the MFT. The measurements will be compared with models based on various particle-production mechanisms and different initial conditions at mid and forward rapidities.
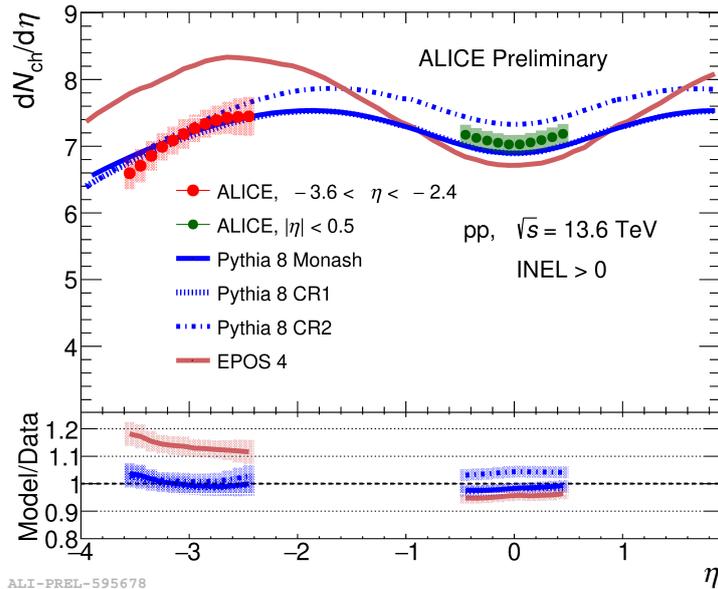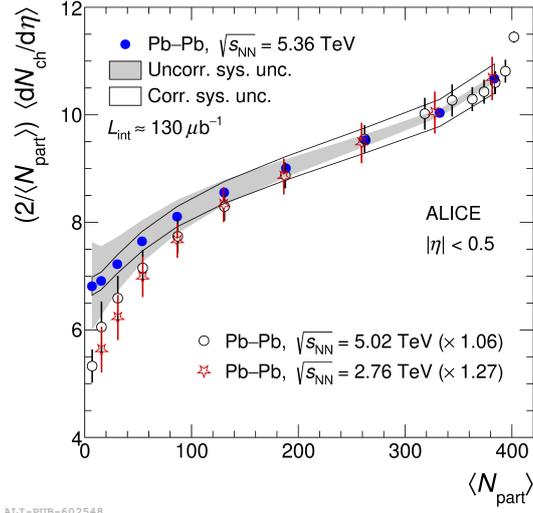
Figure 1 – Upper panel: Pseudorapidity dependence of the charged-particle pseudorapidity density for pp collisions at $\sqrt{s} = 13.6$ TeV at forward pseudorapidity (red solid circles) and at midrapidity (green solid circles). The results are compared with EPOS4 and different tunes of PYTHIA 8. Lower panel: the ratio of model to data.

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Figure 2 – Centrality dependence of $(2/\langle N_{part}\rangle)\langle dN_{ch}/d\eta\rangle$ in Pb–Pb collisions at $\sqrt{s_{NN}} = 5.36$ TeV. Grey bands and open boxes represent uncorrelated and correlated uncertainties. Scaled data from 2.76 TeV ($\times 1.27$) and 5.02 TeV ($\times 1.06$) are also shown for comparison.