Pseudorapidity density of charged particles at midrapidity in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV

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The charged-particle pseudorapidity density ($\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$) is one of the fundamental global observables that allows us to study and investigate the underlying description of particle production in high-energy nuclear collisions. At the Large Hadron Collider energies, final-state particle production results from the interplay of soft and hard quantum chromodynamics (QCD) interactions and is sensitive to non-linear QCD evolution in the initial state. The study of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ and its dependence on centre-of-mass energy and collision geometry is important to understand the relative contributions of these interactions to particle production. These measurements also provide important constraints to model calculations based on different particle production mechanisms and initial conditions.

This contribution aims to present the ALICE measurements of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ at midrapidity in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36\,\mathrm{TeV}$ based on Run 3 data analysed using the newly developed online-offline (O^2) software framework. The dependence of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ on collision energy and centrality is studied and compared to earlier measurements at lower collision energies and to theoretical model predictions.

This analysis uses the upgraded ALICE detector, including the Inner Tracking System (ITS), Time Projection Chamber (TPC), and the newly installed Fast Interaction Trigger (FIT) [1]. Events are selected based on their timing relative to the bunch crossing and the corresponding FIT signal. Events which are close in time to the ITS read-out time frame borders are rejected. Events where the vertex position estimated from FIT is more than 1 cm away from the vertex position determined from TPC and ITS tracks are also not considered. The selected events ensured to have a reconstructed vertex within $\pm$ 10 cm from the nominal interaction point along the beam direction. Centrality classes are determined using the amplitude measured by the FT0C, sub-system of the FIT detector, following the method developed previously [2]. The average number of participating nucleons in a given centrality class, $\langle N_{\mathrm{part}} \rangle$, reflects the collision geometry and is obtained using Glauber modeling [3]. The charged-particle tracks available for the analysis are categorised into global tracks (i.e. tracks that combine hits in ITS and TPC), ITS-only tracks, and TPC-only tracks. TPC-only tracks are excluded due to insufficient pointing resolution when propagated to the vertex and significant secondary particle contamination. Both global and ITS-only tracks are required to pass quality cuts for ITS (and TPC) contributions, including a criterion on distance of closest approach to ensure they originate from primary particles. The correction procedure and the method to estimate systematic uncertainties are identical to those described in Ref. [4]. The total systematic uncertainty on $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ amounts to 2.6% (6.2%) for the most central (most peripheral) events. The statistical uncertainties are found to be negligible.

The resulting charged-particle pseudorapidity density averaged over $|\eta| < 0.5$ in most central (0–5%) collisions is $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle = 2004 \pm 52$, which corresponds to 10.5 ± 0.3 per participant pair. In Fig. 1, $(2/\langle N_{\mathrm{part}} \rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$ (solid red circle) is plotted as a function of $\sqrt{s_{\mathrm{NN}}}$ together with the existing data at lower energies (see [4] and references therein) and the CMS data at $\sqrt{s_{\mathrm{NN}}} = 5.36\,\mathrm{TeV}$ [5]. The dependence

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of $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ on $\sqrt{s_{\mathrm{NN}}}$ is fitted with a power-law ($\alpha \cdot s_{\mathrm{NN}}^{\beta}$) that gives $\beta = 0.156 \pm 0.003$. The results at $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV confirms the trend established by lower-energy data since β does not change significantly when the new point is included in the fit.

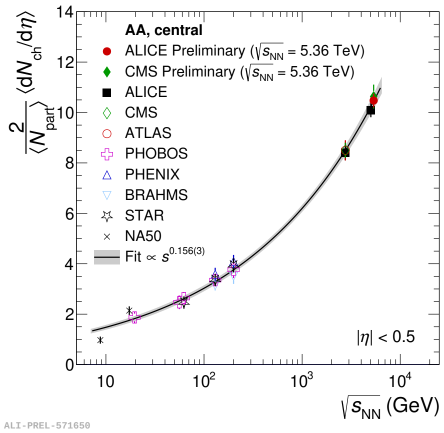

FIG. 1: Values of $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ for central heavy-ion collisions as a function of $\sqrt{s_{\mathrm{NN}}}$.

Figure 2 presents the measured $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ (solid circles) as a function of $\langle N_{\mathrm{part}}\rangle$ in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV. The gray bands represent the total systematic uncertainties, and the statistical uncertainties are within the symbol size. A strong centrality dependence is observed, with $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ decreasing by a factor of 1.7 from the most central collisions, large $\langle N_{\mathrm{part}}\rangle$, to the most peripheral, small $\langle N_{\mathrm{part}}\rangle$. This trend is consistent with the data (not shown) from lower-energy Pb–Pb collisions [4].

The dependence of $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ on centrality is further compared with predictions from HYDJET event generator [6], saturation-based IP-Glasma [7], and McDIPPER [8] models. Both IP-Glasma and McDIPPER models exhibit trends similar to the data, whereas HYDJET fails to reproduce the measurements.

In summary, the charged-particle pseudorapidity density is measured at midrapidity in Pb–Pb collisions at the highest available centre-of-mass energy $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV. The observed centrality dependence of $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ is similar to that previously measured in lower-energy Pb–Pb collisions. Our data will provide constraints for models describing high-energy heavy-ion collisions at this new energy regime.

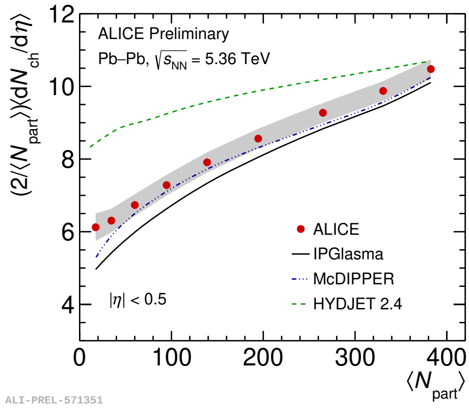

FIG. 2: Centrality evolution of $(2/\langle N_{\mathrm{part}}\rangle)\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle$ in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV. Predictions from theoretical models are superimposed.

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