Charged-particle multiplicity

The multiplicity of produced particles is an important property of the collisions related to the collision geometry, the initial parton densities and the energy density produced.

The three probed collision systems, AA, pA and pp have widely different particle production yields and phase space distributions and their comparison can produce insights into the complicated picture of strongly interacting matter.
Particle density in mid-rapidity of Xe–Xe collisions as a function of $N_{\text{part}}$ compared to model predictions and pseudorapidity density in centrality classes

ALICE has measured pseudorapidity densities in wide $\eta$ intervals for various collision systems. In particular, measurements of Xe–Xe collisions confirm trends previously observed in Pb–Pb collisions providing even more opportunities for assessing quality of phenomenological and theoretical models in different scenarios.

However, no single model reproduces both shape and centrality dependence of particle density, although saturation-based models generally perform better both in terms of shape and magnitude.

Anton Alkin (CERN), QM22, 06/04/2022
Pseudorapidity density of charged particles and photons in p–Pb collisions as a function of centrality

Run 2 menu included Photon Multiplicity Detector covering intermediate rapidity. Centrality evolution of photon multiplicity (~ 94% $\pi^0$ decays) follows that of charged-particle multiplicity. Models based on pQCD + soft processes do not reproduce the increase.

Pseudorapidity density in p–Pb collisions has expected peak in ion-going direction. The particle density rapidly increases with centrality, although still considerably slower than in Pb–Pb collisions, indicating an overlap of individual proton-nucleon scatterings.

Photon multiplicity is consistently lower than charged-particle multiplicity in forward direction, and the difference increases with centrality. Notably, general purpose Monte Carlo generators, while capturing the overall trend, are unable to reproduce neither the magnitude nor the shape of these distributions.

Anton Alkin(CERN), QM22, 06/04/2022
Pseudorapidity density of charged particles in pp collisions as a function of forward multiplicity class


\[ V_0 M = V_0 A + V_0 C \]

Particle density in pp collisions demonstrates moderate growth with multiplicity percentile, reaching values comparable to those in p–Pb collisions.

It is not possible to define centrality for pp collisions in the same way as for p–A and A–A. However, it is still possible to subdivide the total cross-section into multiplicity percentiles based on multiplicity in a different phase space region.

These multiplicity-binned pseudorapidity distributions are particularly important for tuning phenomenological models.

Anton Alkin (CERN), QM22, 06/04/2022
ALICE underwent significant upgrades during LS2. One of the prominent features is the new and improved Inner Tracking System based on Monolithic Active Pixel Sensors. Full analysis chain was tested using data, collected in October of 2021 with 900 GeV pilot beam. Pseudorapidity density was measured to benchmark the tracking and reconstruction capabilities, as well as new software analysis framework.

Link: ALICE upgrades and preparations for physics in Run 3

Anton Alkin (CERN), QM22, 06/04/2022
BACKUP
Particle density in mid-rapidity of Pb–Pb collisions as a function of $N_{\text{part}}$ compared to model predictions

**Average particle density** in mid-rapidity provides insight into the balance between hard and soft processes. Comparison with two-component (pQCD + soft) and saturation-based models highlights advantages and disadvantages of these approaches.

Saturation-inspired models fix an energy-dependent saturation scale limiting the number of produced particles. This results in a factorization of the energy and centrality dependence of the multiplicity, similar to what is observed in data.