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Centrality Detector for Collider-based Heavy Ion Experiments

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Parameters of the initial state of the heavy-ion (HI) interaction are commonly denoted by the term "centrality". Centrality includes the impact parameter of the interaction, amount of interacting material and relative orientation of colliding nuclei. Unfortunately, none of these parameters can be directly measured. In all currently operating and planned HI experiments centrality is measured indirectly, using particles produced in the HI interactions, usually at high-rapidity. That requires assumptions about the high-rapidity particle production mechanisms that are not very well studied, and also requires a model relating produced particles to the initial state geometry, the Glauber model. These two assumptions lead to significant systematic uncertainties in centrality determination. Further, use of produced particles is affected by the correlations between the centrality determination rapidity and the rest of the detector coverage, where the physics measurements are done. This, in turn, requires additional corrections resulting in additional systematic uncertainties. Recent results from the LHC experiments reveal the importance of the long-range rapidity correlations in HI interactions. The proton-lead results also demonstrate that the Glauber model itself may require further adjustments.

In collider-based HI experiments there is a unique possibility to measure centrality parameters by registering spectator fragments remaining from the collision on both sides. Spectator fragmentation mechanism is decoupled from particle production mechanism. This approach does not require Glauber model as spectators and participants are related via the total number of nucleons in the colliding species. Spectators continue flying along the direction of the colliding beams retaining practically unmodified longitudinal momentum, however their mass-to-charge ratio is typically lower than that of the colliding species.

We propose a concept of the Centrality Detector, which measures masses of most of the fragments by measuring their deflection in the magnetic field of the collider elements and their charges. The field, and a set of detectors integrated in the structure of collider rings act as a very precise mass-spectrometer for such fragments. First calculations based on the DPMJet generator show that the Centrality Detector can provide better accuracy than currently used methods. Main factors affecting its performance will be discussed in the presentation.

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