Study of v_2 depending on multiplicity with ZDC energy event categorization

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The PHENIX experiment was operated at BNL-RHIC, which collides heavy ions at relativistic energy to create a hot state in a second. In this state, quarks and gluons are deconfined, and this state is called quark-gluon plasma (QGP) the collective motion of QGP is known. In hydrodynamic models, the detailed azimuthal correlation structure of emitted particles resulting from the collective motion is typically characterized by its Fourier components, known as the elliptic flow (v_2).[1)]

In the past decade, some results have suggested the possibility of QGP-like matter creation during extremely high multiplicity events in a lighter collision system than that of heavy ions.[3–7)] However, the mechanism of that possibility has not been revealed. One helpful fact is that the ridge structure and collective motion are measured only in extremely high multiplicity events, where multiparton interactions become more relevant.[8)]

The effect of multiparton interactions in heavy ion collision is of interest to us. Selecting events with the same number of participating nucleons in the collision is crucial to study the multiparton interaction effect because much more nucleons interact in heavy ion collisions than in proton-proton collisions. We can not directory measure the number of participating nucleons because they change to new particles after interactions. However, the number of spectator (not participated in collision) neutrons can be directory detected by the zero degree calorimeter (ZDC). In high-energy heavy-ion collisions, most of the spectator nucleons outside of the overlap region are causally disconnected from the matter produced by the participating nucleons, so we measure the energy of spectator neutrons captured by ZDC. We classify the events with the number of participating nucleons in the collision as in $p+p$ collision by selecting the events with the same energy measured by ZDC, thus creating a simple situation to study multiparton collision. Furthermore, the multiplicity has a width at some ZDC energy sum events. We assumed that the effect of the multiparton interaction makes this width. If the multiparton interaction effect is more relevant, a larger multiplicity should be obtained from events with the same number of participating nucleons. Because v_2 increases as a function of the number of tracks in $p+p$ collision,[7)] v_2 will be larger in events where the multiparton interaction effect is more relevant. Analyzing v_2 as a function of multiplicity at the same energy in the ZDC detector can tell us if the multiparton interaction effect is worth consideration in heavy ion collision.

Our goal is to analyze v_2 as a function of multiplicity using the ZDC energy sum event categorization in Au + Au collision data taken at $\sqrt{s_{NN}} = 200$ GeV in the PHENIX experiment. Such an event categorization has never been used to analyze v_2, so we worked on the reaction plane angle calibration to make its distribution flat. Figure 1 shows the reaction plane angle distribution after calibration of the one of the event classes. A fitting to these distributions with a straight line gave a $\chi 2$/ndf of approximately 1.0. We checked the flatness for all event classes for all runs and finally confirmed that the calibration had been done successfully. We are now at the stage of analyzing v_2 as a function of multiplicity using calibrated events. The results will be published in the near future.

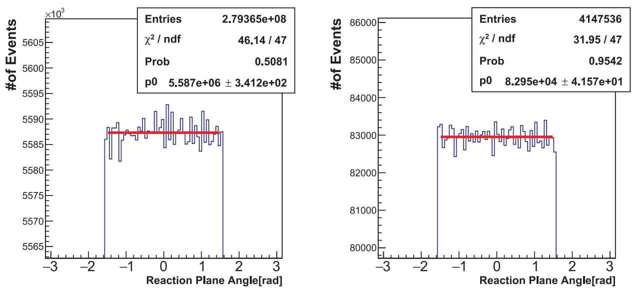

Fig. 1. Reaction plane angle distribution after calibration in events whose the number of normalized FVTX tracks is larger than 0.50 and less than 0.55. Left: with no ZDCe event selection. Right: events in 900 < ZDCe < 910.

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