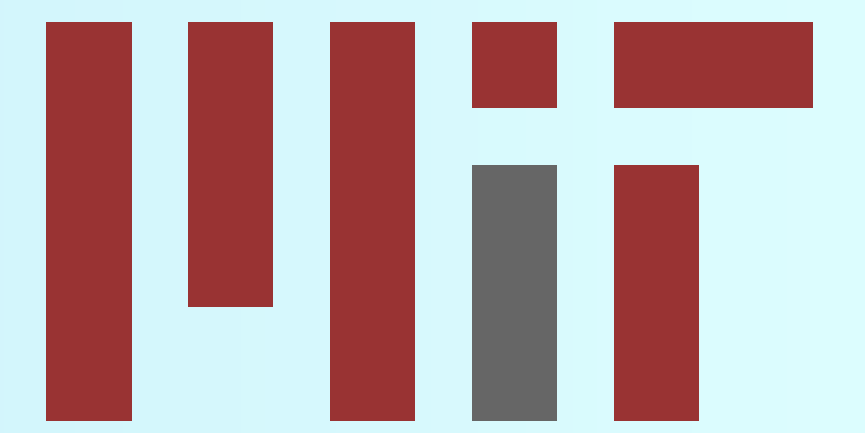




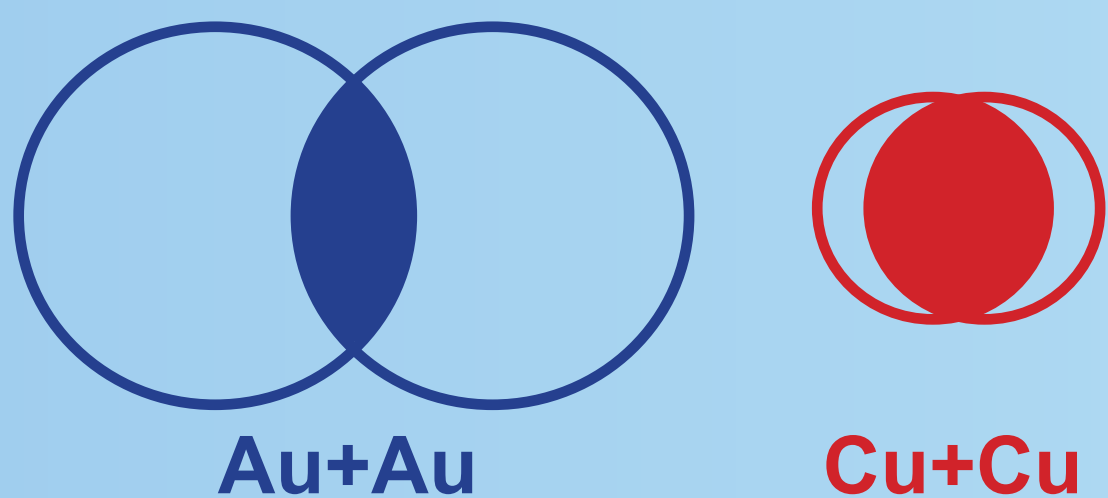
System size, energy, centrality, and pseudorapidity dependence of charged-particle density in Au+Au and Cu+Cu collisions at RHIC



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Motivation. The charged particle pseudorapidity distribution $dN_{ch}/d\eta$ is a well defined experimental quantity that reflects the initial conditions of the system, i.e. parton shadowing and gluon saturation, and also the effects of rescattering and hadronic final state interactions: it represents the time-integral of the particle production throughout the entire collision. With the Cu+Cu collisions at RHIC the system size dependence of important observables can be studied using different collision geometries. The Cu+Cu results test the simple scaling features observed previously in Au+Au collisions [2-3]. They significantly extend the N_{part} range covered in Au+Au collisions, while the two systems can also be compared at the same N_{part} , as illustrated below.



Detector. The data were collected with the multiplicity array of the PHOBOS detector [5] during the RHIC 2005 run. The array consists of single-layered silicon sensors in the long, tube-shaped Octagon detector surrounding the collision point, and in the three Ring sensors on each side, detecting large- $|\eta|$ particles. Simulations of the detector performance were based on the HIJING event generator and GEANT, including the response of the scintillator Paddle trigger counters.

Data analysis. Data from the Cu+Cu and Au+Au collisions were analyzed using the "hit-counting" and "analog" methods [6]. The latter was corrected for multiply-charged fragments emitted at large η . This correction decreases with centrality and collision energy, and it is <6% of the total number of charged particles.

Centrality. The centrality of the collision was estimated from the Paddle scintillator signals. The estimated trigger efficiency is $84 \pm 5\%$ and $75 \pm 5\%$ in Cu+Cu collisions at 200 and 62.4 GeV. At 22.4 and 19.6 GeV, the pathlength-corrected energy sum [3] deposited in the Octagon was used ($|\eta| < 3.2$). A Glauber-model calculation was used to estimate $\langle N_{part} \rangle$ for each centrality bin.

Results. The $dN_{ch}/d\eta$ distributions in Cu+Cu collisions for various collision energies and centralities are shown in Fig. 1. On the right panel the Cu+Cu and Au+Au collisions are compared, where the centrality bins are chosen such that $\langle N_{part} \rangle$ in both systems are similar. One can conclude that although the distributions agree at the same $\langle N_{part} \rangle$ to first order, there are differences at large $|\eta|$ and low energies. Note that the two nuclear spectator remnants are larger in Au+Au than in Cu+Cu collisions.

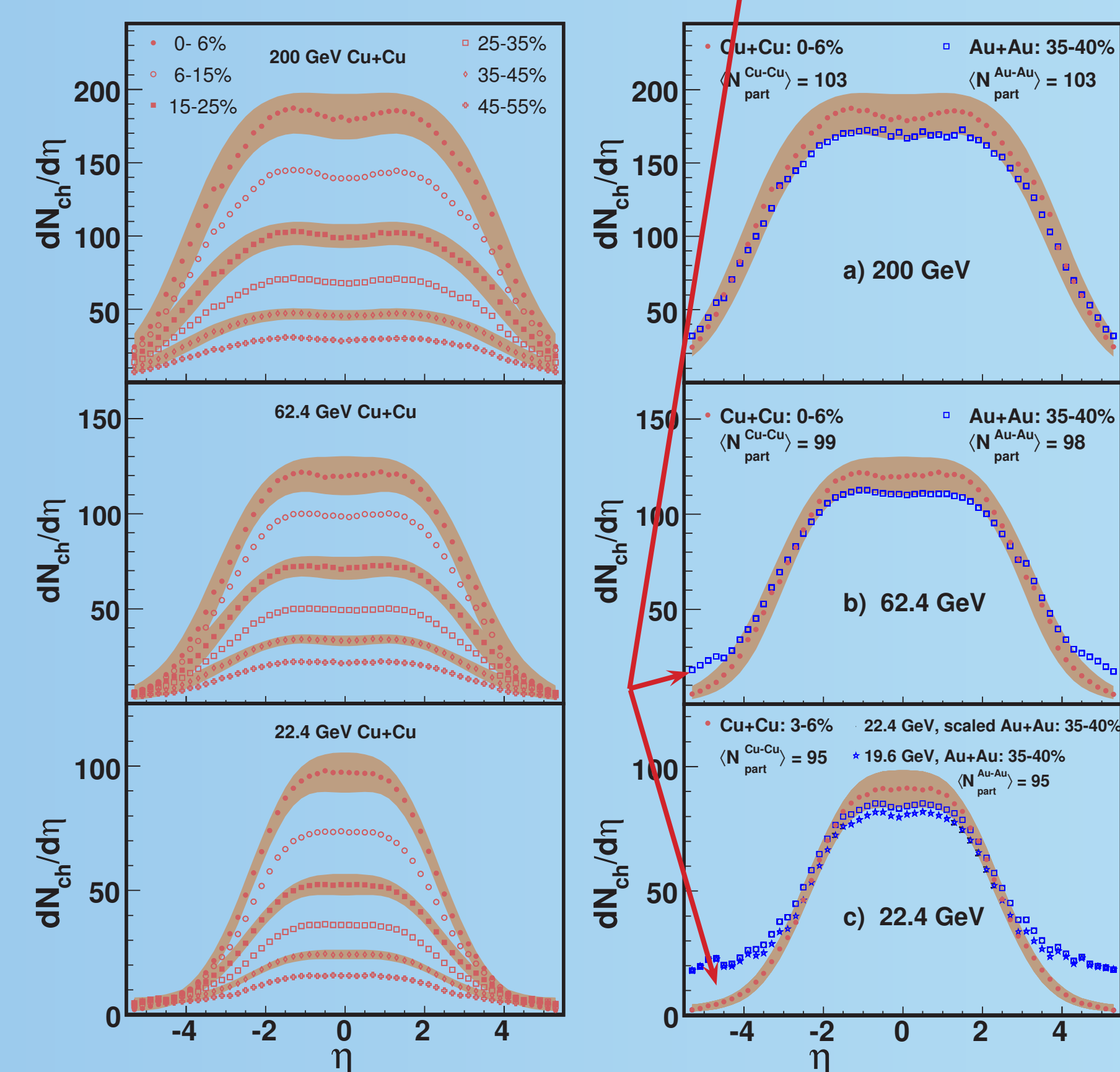
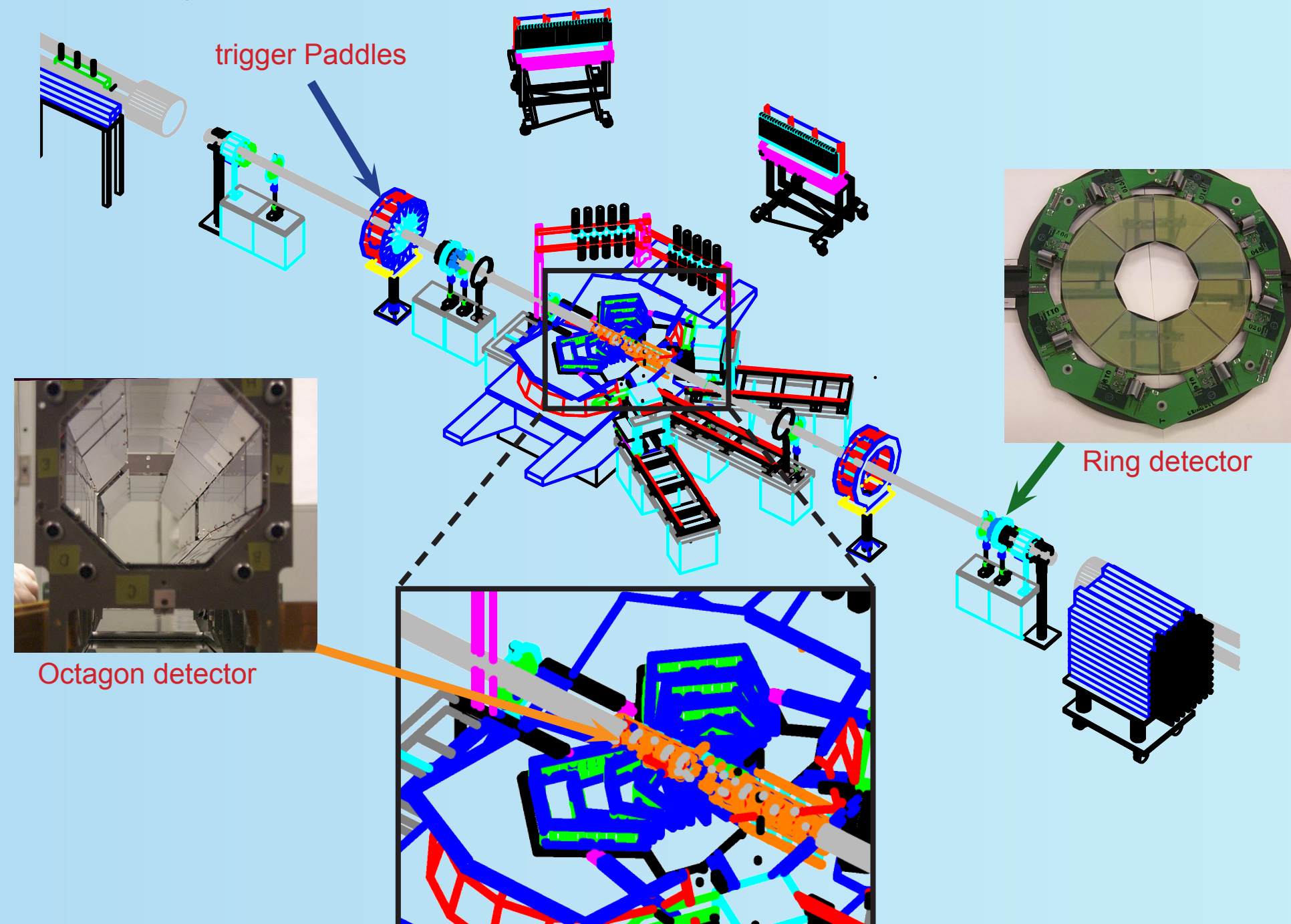


Figure 1: Left: $dN_{ch}/d\eta$ distributions of primary charged particles from Cu+Cu collisions at 22.4, 62.4 and 200 GeV collision energy per nucleon pair for various centrality bins. Right: Comparison of $dN_{ch}/d\eta$ distributions in Cu+Cu and Au+Au collisions - corresponding to the same $\langle N_{part} \rangle$. 90% C.L. systematic errors are shown as bands.



Abstract: This poster presents data from the PHOBOS experiment at RHIC on charged particle pseudorapidity distributions in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}} = 19.6, 22.4, 62.4, 130$ and 200 GeV, as a function of collision centrality. The Cu+Cu data at 22.4 GeV are presented for the first time [1]. The measurements were made by the same detector over a broad range in pseudorapidity, $|\eta| < 5.4$, allowing for a reliable systematic study of particle production as a function of energy, centrality and system size. Comparing Cu+Cu and Au+Au results, we find that the total number of produced charged particles and the rough shape (height and width) of the pseudorapidity distributions are determined by the number of nucleon participants, N_{part} . Detailed comparisons reveal that the matching of the shape of the Cu+Cu and Au+Au pseudorapidity distributions over the full range of η is better for the same $N_{part}/2A$ value rather than the same N_{part} value. In other words, it is the collision geometry rather than just the number of nucleon participants that drives the detailed shape of the pseudorapidity distribution and its centrality dependence.

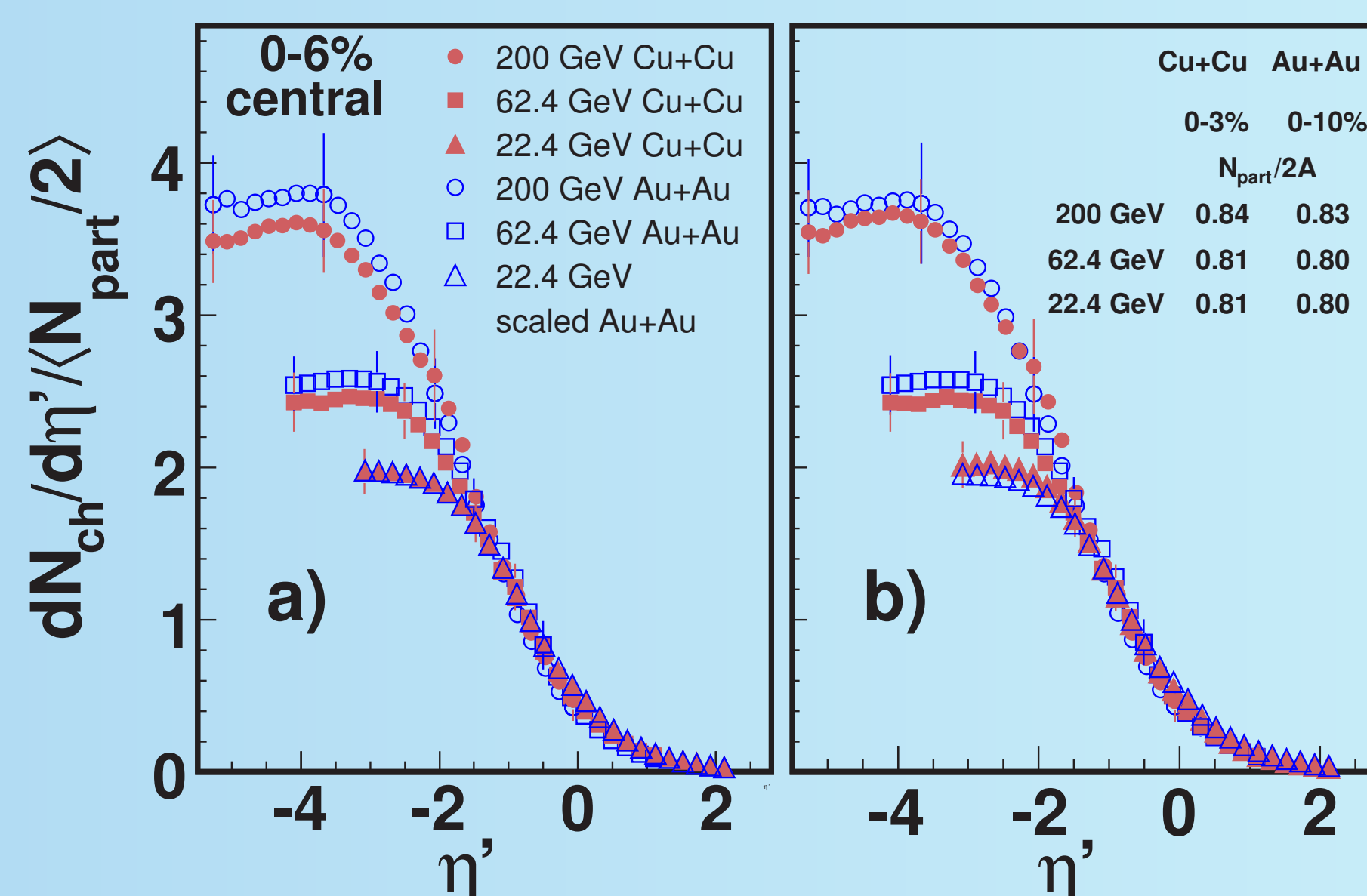


Figure 2: Pseudorapidity distributions in Cu+Cu and Au+Au collisions at various RHIC energies, normalized by the number of participant pairs, plotted as a function of $\eta' = \eta - y_{beam}$, for a) the 6% most central events and b) central events with similar $N_{part}/2A$. 90% C.L. systematic errors are shown for a few typical data points.

• The $dN_{ch}/d\eta$ distributions exhibit longitudinal scaling when observed from the rest frame of one of the colliding nuclei. The coordinate transformation to the 'target' frame approximately corresponds to a shift by the beam rapidity, y_{beam} .

• Figure 2 compares the $dN_{ch}/d\eta$ distributions (where $\eta' = \eta - y_{beam}$) after normalization by N_{part} : a) data from the Cu+Cu and Au+Au systems plotted at the same fraction of the total cross section (0-6% most central bin), and b) the same value of $N_{part}/2A$ (where A is the mass number). Both cases indicate that the scaled particle density at $\eta \sim 0$ only depends on the collision energy and geometry, but not on the size of the nuclei.

• The longitudinal scaling is similarly present in the Cu+Cu and in the Au+Au data. The $dN_{ch}/d\eta / \langle N_{part} \rangle$ distributions for the same centrality in both systems agree within errors, and the agreement becomes even better if the centralities are compared on the basis of the $N_{part}/2A$ quantity (the fraction of participating nucleons).

• The factorization between collision energy and centrality can be most precisely studied by examining the ratios of the $dN_{ch}/d\eta / \langle N_{part} \rangle$ distributions in central and semi-central collisions, denoted by $R_{PC}^{N_{part}}$, at various energies. The published Au+Au results [4] are shown by the inset of Fig. 3a, exhibiting the same factorization feature as the recent Cu+Cu data. The above ratio for Cu+Cu data is similar to that in Au+Au data, except at the highest η' values.

• Fig. 3b shows the $R_{PC}^{N_{part}}$ ratio for Cu+Cu and Au+Au for centrality bins where the $N_{part}/2A$ values are matched. The latter quantity characterizes the initial geometry most precisely, and indeed, the centrality evolution of the $dN_{ch}/d\eta$ distributions measured in Cu+Cu and Au+Au collisions are most similar if the centrality is quantified by $N_{part}/2A$.

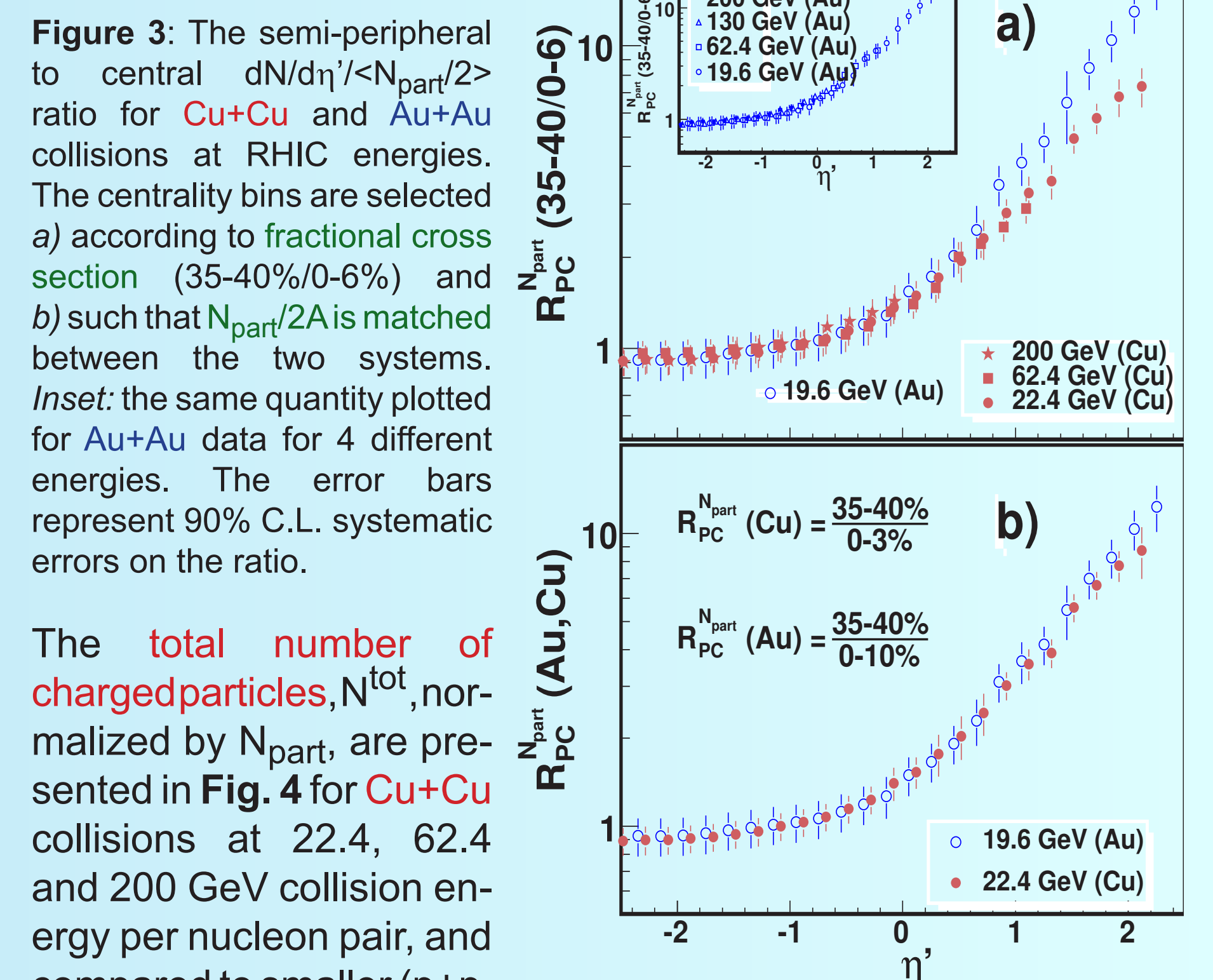


Figure 3: The semi-peripheral to central $dN_{ch}/d\eta / \langle N_{part}/2 \rangle$ ratio for Cu+Cu and Au+Au collisions at RHIC energies. The centrality bins are selected a) according to fractional cross section (35-40%/0-6%) and b) such that $N_{part}/2A$ is matched between the two systems. Inset: the same quantity plotted for Au+Au data for 4 different energies. The error bars represent 90% C.L. systematic errors on the ratio.

The total number of charged particles, N_{ch}^{tot} , normalized by N_{part} , are presented in Fig. 4 for Cu+Cu collisions at 22.4, 62.4 and 200 GeV collision energy per nucleon pair, and compared to smaller (p+p, d+Au) and larger (Au+Au) systems as a function of centrality. One can conclude that N_{ch}^{tot} scales approximately linearly with N_{part} , and the normalized yield has similar values for the two heavy colliding systems. The d+Au data do not seem to interpolate smoothly between the p+p and heavy ion data points.

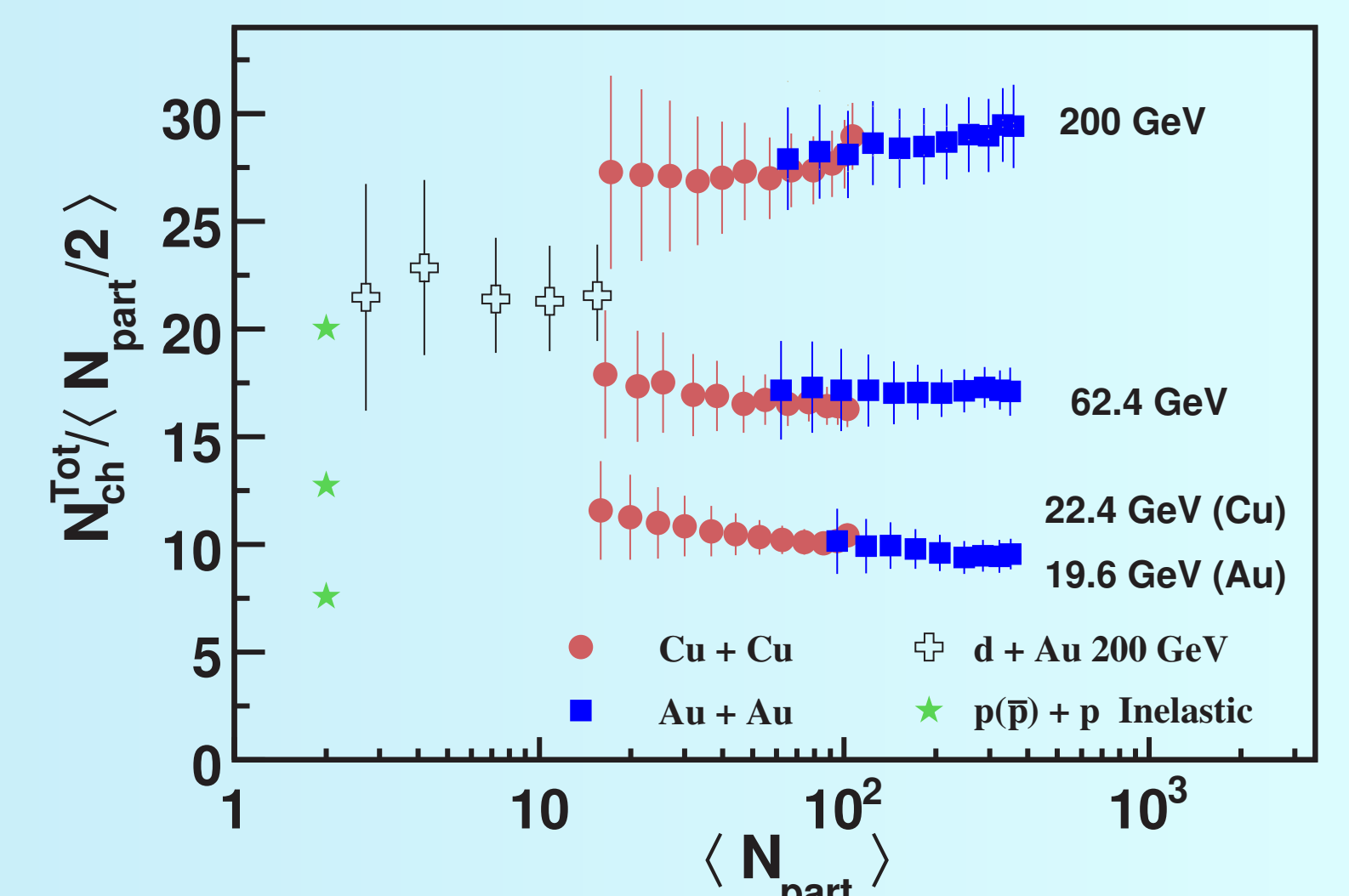


Figure 4: The integrated number of charged particles, scaled by N_{part} , in p+p, d+Au, Cu+Cu and Au+Au collisions as a function of centrality [4,7]. The uncertainty of N_{part} has been included in the error bars.

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