Erratum: Hadron spectra and elliptic flow for 200A GeV Au + Au collisions from viscous hydrodynamics coupled to a Boltzmann cascade [Phys. Rev. C 83, 054910 (2011)]

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In the version of VISHNU used in the original paper, the baryon-antibaryon annihilation channels in the hadron cascade module UrQMD were accidentally turned off. When redoing the calculations with those channels turned on, we found that baryon-antibaryon annihilation in the late hadronic stage reduces the final proton and antiproton multiplicities by about 30% in central (0–5% centrality) and by about 15% in peripheral (60–70% centrality) collisions while simultaneously slightly increasing the pion and kaon multiplicities. These observations are consistent with recent analyses presented in Refs. [1,2]. To compensate for the resulting slight overall increase in the final total charged hadron multiplicity when using the corrected version of VISHNU, we had to reduce the normalization of initial entropy density by about 4%. Keeping the original parameter sets for η/s and $\tau_0(\eta/s)$, we confirmed that (within the statistical uncertainties of the results presented in the original paper) the changes in the hydrodynamic evolution caused by this slight renormalization of the initial density profile are negligible, and the main effects of including $B-\bar{B}$ annihilation are a small change in the chemical composition of the hadron gas phase, as well as a renormalization and slight hardening of the proton p_T spectra. The hardening of the proton spectra arises from preferential annihilation of low-p_T baryons and antibaryons.
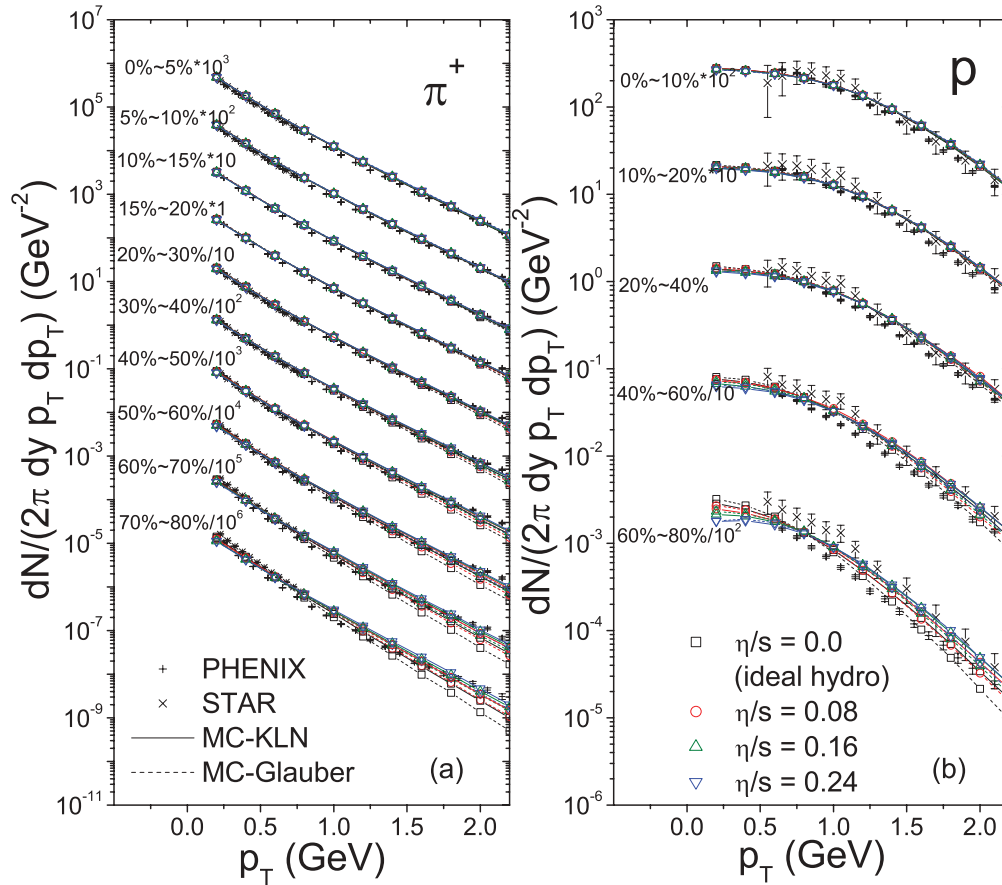

FIG. 1. (Color online) p_T spectra of pions (left) and protons (right) for 200A GeV Au + Au collisions of different centralities as indicated. Data from the STAR ($\times$, [4–6]) and PHENIX ($+$, [7]) experiments are compared with VISHNU calculations using MC-Glauber (dashed lines) or MC-KLN initial conditions (solid lines) and different values η/s for the QGP shear viscosity as indicated. Different η/s values are associated with different starting times τ_0 for the hydrodynamic evolution as discussed in the text. The STAR and PHENIX proton data shown in the right column are feeddown-corrected by removing protons from weak hyperon decays [4,7]. Where necessary, PHENIX yields from neighboring narrower centrality bins were averaged to obtain data in the wider centrality bins used by the STAR Collaboration.
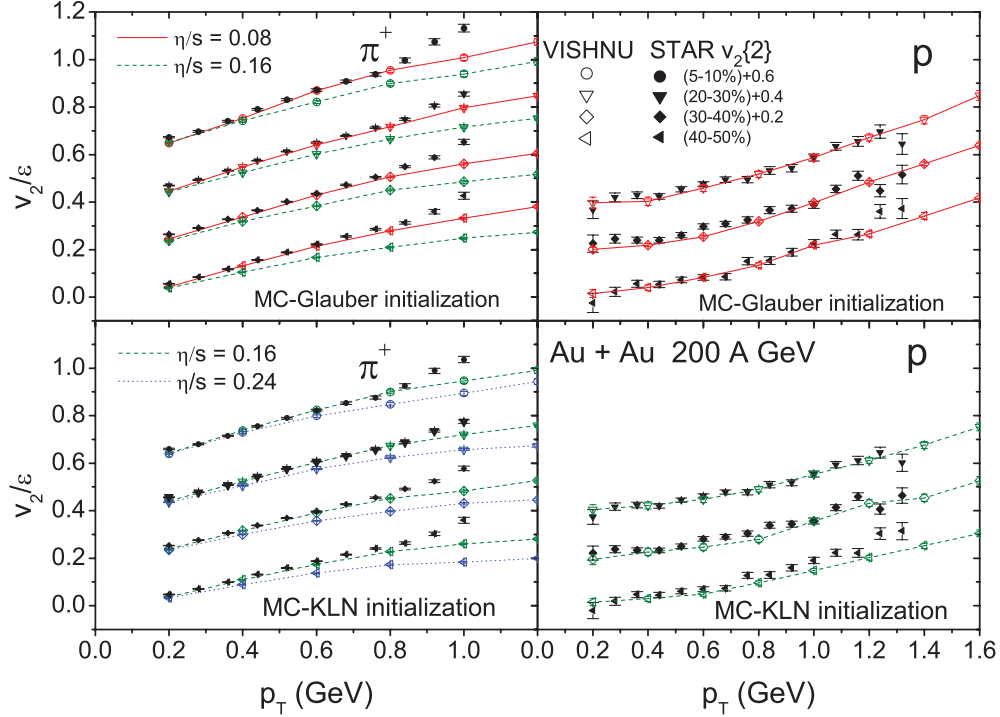
FIG. 5. (Color online) Eccentricity-scaled elliptic flow v_2/ε as a function of p_T for identified pions (left column) and protons (right column). Solid symbols denote measurements of $v_2\{2\}/\langle\varepsilon^2_{\rm part}\rangle^{1/2}$ from the STAR experiment [8], solid and dashed lines with open symbols show $\langle v_2\rangle/\langle\varepsilon_{\rm part}\rangle$ from VISHNU calculations with $(\eta/s)_{\rm QGP} = 0.08$ and 0.16, respectively, using MC-Glauber (top row) and MC-KLN (bottom row) initial conditions. Different symbols denote different collision centralities as indicated.
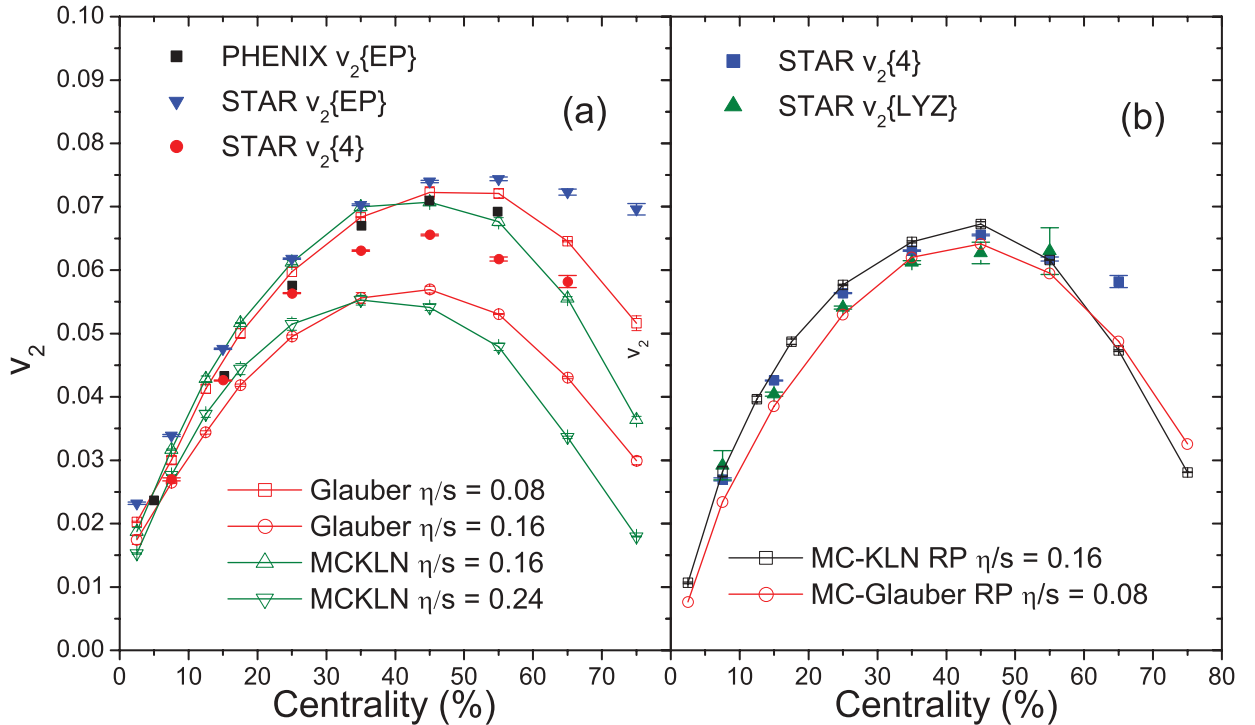

FIG. 6. (Color online) Integrated charged hadron elliptic flow as a function of collision centrality from the PHENIX [9] and STAR [8,10] experiments are compared with VISHNU calculations using participant plane (PP) averaged (a) and reaction plane (RP) averaged (b) initial conditions from the MC-KLN and MC-Glauber models and $(\eta/s)_{\rm QGP}$ values as indicated. In the STAR data and the calculations v_2 was integrated over the range $0.15 < p_T < 2$ GeV/c; the PHENIX data were integrated over $0.2 < p_T < 8$ GeV/c.

We here present corrected versions of Figs. 1, 5, and 6. For corrected versions of Figs. 8 and 9, see the Erratum for Ref. [3]; including baryon-antibaryon annihilation shifts all v_2/ε vs $(1/S)(dN_{ch}/dy)$ curves in these figures downward by about 3%, without changing the conclusions. Corrections to Figs. 2 and 3 are negligible within the statistical precision of the calculations. The largest effect from baryon-antibaryon annihilation arises for the proton p_T spectra in the right panel of Fig. 1 where the reduced proton yields lead to an improved description of the experimental data, especially in central collisions. The pion spectra [Fig. 1(a)] and elliptic flow (left panels in Fig. 5) remain unchanged within statistical errors. Small changes are visible in the differential proton elliptic flow (right panels in Fig. 5) without, however, affecting the overall good agreement between theory and experimental data. The correction of the error slightly reduces the p_T-integrated charged hadron elliptic flow in Fig. 6, again without changing any of the conclusions.

In summary, proper inclusion of baryon-antibaryon annihilation channels in UrQMD improves the description of the proton yields and p_T spectra, without negatively affecting the otherwise good description of charged hadron spectra and charged hadron, pion, and proton elliptic flow.

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[1] F. Becattini, M. Bleicher, T. Kollegger, M. Mitrovski, T. Schuster, and R. Stock, Phys. Rev. C **85**, 044921 (2012).

[2] J. Steinheimer, J. Aichelin, and M. Bleicher, arXiv:1203.5302.

[3] H. Song, S. A. Bass, U. Heinz, T. Hirano, and C. Shen, Phys. Rev. Lett. **106**, 192301 (2011).

[4] J. Adams *et al.* (STAR Collaboration), Phys. Rev. Lett. **92**, 112301 (2004).

[5] The data shown in [4] are available in tabular form at http://drupal.star.bnl.gov/STAR/files/starpublications/65/data.html.

[6] B. I. Abelev *et al.* (STAR Collaboration), Phys. Rev. C **79**, 034909 (2009).

[7] S. S. Adler *et al.* (PHENIX Collaboration), Phys. Rev. C **69**, 034909 (2004).

[8] J. Adams *et al.* (STAR Collaboration), Phys. Rev. C **72**, 014904 (2005).

[9] S. Afanasiev *et al.* (PHENIX Collaboration), Phys. Rev. C **80**, 024909 (2009).

[10] K. Aamodt *et al.* (ALICE Collaboration), Phys. Rev. Lett. **105**, 252302 (2010).