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Erratum

Erratum to: Measurements of higher-order cumulants of multiplicity and net-electric charge distributions in inelastic proton-proton interactions by NA61/SHINE

NA61/SHINE Collaboration

H. Adhikary[11], P. Adrich[13], K. K. Allison[24], N. Amin[4], E. V. Andronov[20], I.-C. Arsene[10], M. Bajda[14], Y. Balkova[16], D. Battaglia[23], A. Bazgir[11], S. Bhosale[12], M. Bielewicz[13], A. Blondel[3], M. Bogomilov[2], Y. Bondar[11], A. Borucka[19], A. Brandin[20], W. Bryliński[19], J. Brzychczyk[14], M. Buryakov[20], A. F. Camino[26], M. Ćirković[21], M. Csanád[6], J. Cybowska[19], T. Czopowicz[11], C. Dalmazzone[3], N. Davis[12], A. Dmitriev[20], P. von Doetinchem[25], W. Dominik[17], J. Dumarchez[3], R. Engel[4], G. A. Feofilov[20], L. Fields[23], Z. Fodor[5,18], M. Friend[7], M. Gaździcki[11], O. Golosov[20], V. Golovatyuk[20], M. Golubeva[20], K. Grebieszkow[19], F. Guber[20], S. N. Igolkin[20], S. Ilieva[2], A. Ivashkin[20], A. Izvestnyy[20], N. Kargin[20], N. Karpushkin[20], E. Kashirin[20], M. Kiełbowicz[12], V. A. Kireyeu[20], R. Kolesnikov[20], D. Kolev[2], Y. Koshio[8], V. N. Kovalenko[20], S. Kowalski[16], B. Kozłowski[19], A. Krasnoperov[20], W. Kucewicz[15], M. Kuchowicz[18], M. Kuich[17], A. Kurepin[20], A. László[5], M. Lewicki[18], G. Lykasov[20], V. V. Lyubushkin[20], M. Maćkowiak-Pawłowska[19,a], Z. Majka[14], A. Makhnev[20], B. Maksiak[13], A. I. Malakhov[20], A. Marcinek[12], A. D. Marino[24], H.-J. Mathes[4], T. Matulewicz[17], V. Matveev[20], G. L. Melkumov[20], A. Merzlaya[10], Ł. Mik[15], S. Morozov[20], Y. Nagai[6], T. Nakadaira[7], M. Naskręt[18], S. Nishimori[7], A. Olivier[23], V. Ozvenchuk[12], O. Panova[11], V. Paolone[26], O. Petukhov[20], I. Pidhurskyi[11], R. Płaneta[14], P. Podlaski[17], B. A. Popov[20,3], B. Pórfy[5,6], D. S. Prokhorova[20], D. Pszczel[13], S. Puławski[16], J. Puzović[21,*], R. Renfordt[16], L. Ren[24], V. Z. Reyna Ortiz[11], D. Röhrich[9], E. Rondio[13], M. Roth[4], Ł. Rozpłochowski[12], B. T. Rumberger[24], M. Rumyantsev[20], A. Rustamov[1], M. Rybczynski[11], A. Rybicki[12], D. Rybka[13], K. Sakashita[7], K. Schmidt[16], A. Yu. Seryakov[20], P. Seyboth[11], U. A. Shah[11], Y. Shiraishi[8], A. Shukla[25], M. Słodkowski[19], P. Staszel[14], G. Stefanek[11], J. Stepaniak[13], M. Strikhanov[20], Ł. Świderski[13], J. Szewiński[13], R. Szukiewicz[18], A. Taranenko[20], A. Tefelska[19], D. Tefelski[19], V. Tereshchenko[20], R. Tsenov[2], L. Turko[18], T. S. Tveter[10], M. Unger[4], M. Urbaniak[16], F. F. Valiev[20], D. Veberič[4], V. V. Vechernin[20], O. Vitiuk[18], V. Volkov[20], A. Wickremasinghe[22], K. Witek[15], K. Wójcik[16], O. Wyszyński[11], A. Zaitsev[20], E. Zherebtsova[18], E. D. Zimmerman[24], A. Zviagina[20], R. Zwaska[22]

[1] National Nuclear Research Center, Baku, Azerbaijan
[2] Faculty of Physics, University of Sofia, Sofia, Bulgaria
[3] LPNHE, Sorbonne University, CNRS/IN2P3, Paris, France
[4] Karlsruhe Institute of Technology, Karlsruhe, Germany
[5] HUN-REN Wigner Research Centre for Physics, Budapest, Hungary
[6] Eötvös Loránd University, Budapest, Hungary
[7] Institute for Particle and Nuclear Studies, Tsukuba, Japan
[8] Okayama University, Okayama, Japan
[9] University of Bergen, Bergen, Norway
[10] University of Oslo, Oslo, Norway
[11] Jan Kochanowski University, Kielce, Poland
[12] Institute of Nuclear Physics, Polish Academy of Sciences, Cracow, Poland
[13] National Centre for Nuclear Research, Warsaw, Poland
[14] Jagiellonian University, Cracow, Poland
[15] AGH-University of Science and Technology, Cracow, Poland
[16] University of Silesia, Katowice, Poland
[17] University of Warsaw, Warsaw, Poland
[18] University of Wrocław, Wrocław, Poland
[19] Warsaw University of Technology, Warsaw, Poland
[20] Affiliated with an Institution Covered by a Cooperation Agreement with CERN, Meyrin, Switzerland
[21] University of Belgrade, Belgrade, Serbia

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[22] Fermilab, Batavia, USA
[23] University of Notre Dame, Notre Dame, USA
[24] University of Colorado, Boulder, USA
[25] University of Hawaii at Manoa, Honolulu, USA
[26] University of Pittsburgh, Pittsburgh, USA
* Deceased

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This Erratum replaces, due to a discovery of coding mistakes, the following quantities: κ_3/κ_1 of the $h^+ - h^-$ distribution presented in Fig. 6 and Table 6, κ_4 listed in Table 4, and $\hat{C}_4$ presented in Fig. 7 and Table 5. All mentioned figures and tables were updated.

The following paragraph in Sect. 4.5 requires modification:

A dominant source of uncertainty becomes apparent from the comparison of different event and track selection criteria. On average, this uncertainty is 3.2 times larger than that emerging from the comparison of unfolding procedures using different models. In less than 20% cases, the dominating uncertainty emerges from the comparison of unfolding with EPOS1.99 and FTFP-BERT models – this takes place usually in the case of single cumulants and rarely in the case of ratios. For the ratio of κ_4/κ_2 the dominant effect is nearly always the comparison of the event and track selection (the exception is the h^- at the lowest energy where the effects are comparable).

The replacement of Fig. 6 requires modification of the last paragraph of Sect. 5.2 with the following updated version:

Figure 6 shows the energy dependence of net-charge fluctuations compared with model predictions. Second-order cumulant ratios of $h^+ - h^-$ distribution decreases with collision energy, whereas $\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$ and $\kappa_4[h^+ - h^-]/\kappa_2[h^+ - h^-]$ increase with collision energy. The measured signal for the majority of collected energies remains below unity. Both model predictions reproduce the observed $\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$ and magnitude of $\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$. Only $\kappa_4[h^+ - h^-]/\kappa_2[h^+ - h^-]$ at the two top energies is higher than unity. The EPOS1.99 model reproduces this rise with interaction energy, whereas FTFP-BERT underestimates its strength.

Secondly, Fig. 7 was also replaced so the following paragraph in Sec. 5.3 requires an update:

Factorial cumulants are quantities that allow extracting the correlation function of a given order (and without lower-order terms) from the measured distribution [2,3].

The energy dependence of factorial cumulants measured in $p+p$ interactions is presented in Fig. 7. The $\hat{C}_2$ signal of h^+ and h^- distributions slowly increases from values close to zero to positive values at top energy. In contrast, $\hat{C}_3$ of h^+ and h^- and $\hat{C}_4$ of h^+ decrease with interaction energy. For h^+ the magnitude of the decrease is larger for $\hat{C}_3$ than for $\hat{C}_4$.

Both models generally describe the trends and magnitudes of the measured factorial cumulants, except the FTFP-BERT model, which does not describe the energy dependence of $\hat{C}_4$.

The corrections included in the Erratum do not change the paper's conclusions.

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[a] e-mail: maja.pawlowska@pw.edu.pl (corresponding author)

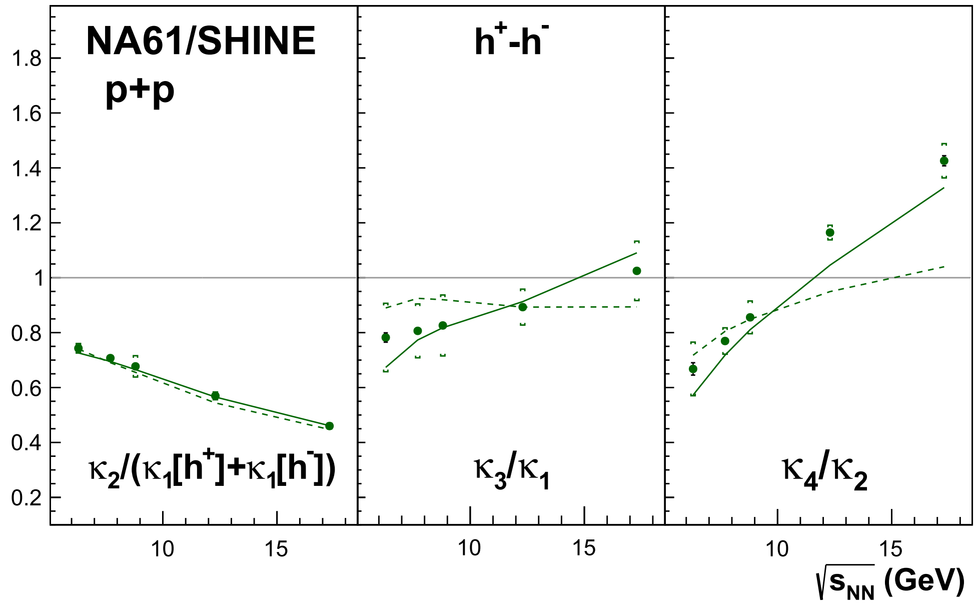

Fig. 6 Energy dependence of intensive quantities of net-charge distribution in p+p interactions at $\sqrt{s_{NN}}$ = 6.3, 7.7, 8.8, 12.3, and 17.3 GeV in the phase-space region as defined in Ref. [1]. The statistical uncertainty is indicated with a color bar (often smaller than the marker), and systematic uncertainty is indicated with a square bracket. Results are compared with EPOS1.99 (solid line) and FTFP-BERT (dashed line) predictions

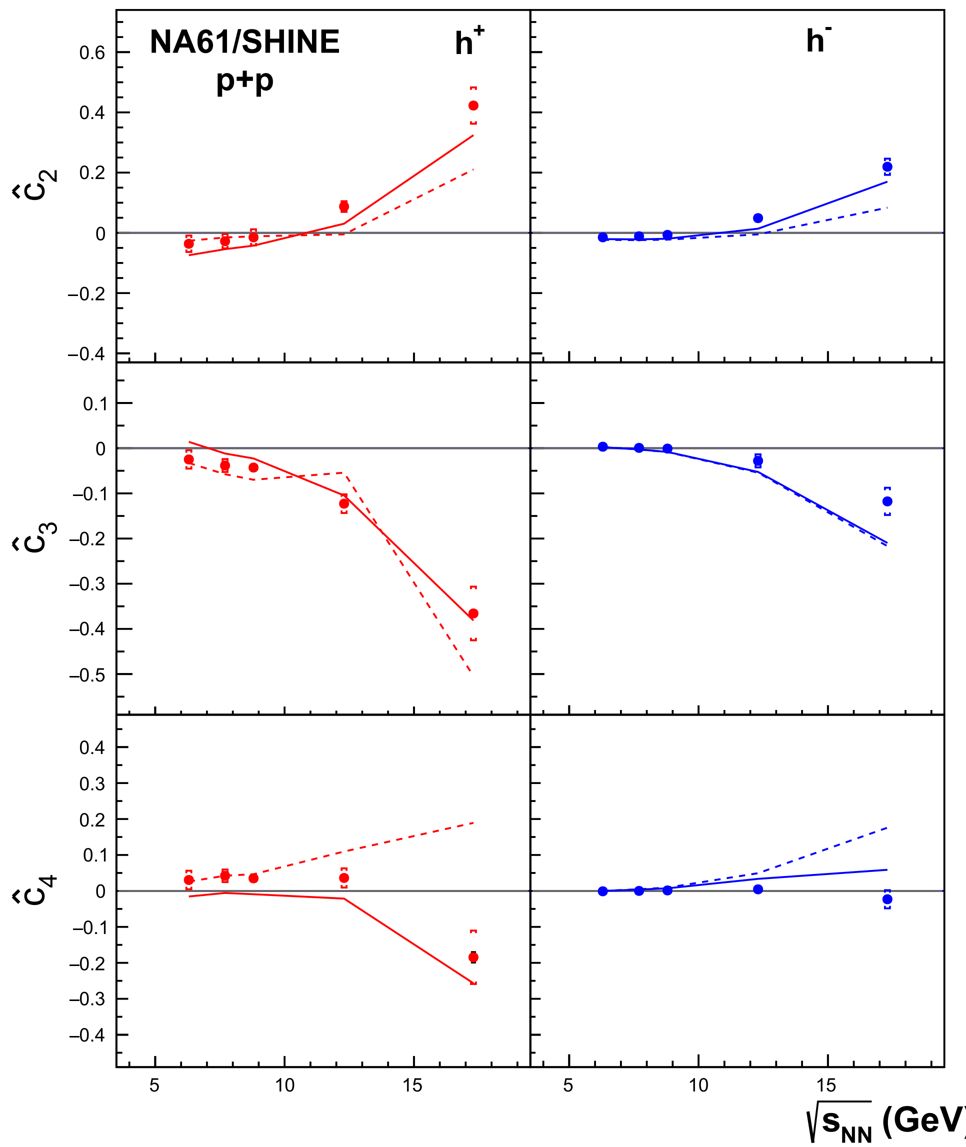

Fig. 7 Energy dependence of factorial cumulants of multiplicity distributions of h^+ and h^- in p+p interactions at $\sqrt{s_{NN}}$ = 6.3, 7.7, 8.8, 12.3, and 17.3 GeV in the phase-space region as defined in Ref. [1]. The statistical uncertainty is indicated with a color bar (often smaller than the marker), and systematic uncertainty is indicated with a square bracket. Results are compared with EPOS1.99 (solid line) and FTFP-BERT (dashed line) predictions

Table 4 Numerical values of cumulants and cumulant ratios of $h^+ + h^-$, h^+, h^-, and $h^+ - h^-$

$\sqrt{s_{NN}}$ (GeV)	Quantity	$h^+ + h^-$	h^+	h^-	$h^+ - h^-$
6.3	κ_1	$1.0222 \pm 0.0027 \pm 0.071$	$0.7242 \pm 0.0020 \pm 0.038$	$0.3027 \pm 0.0012 \pm 0.025$	$0.4270 \pm 0.0022 \pm 0.012$
7.7	κ_1	$1.2381 \pm 0.0015 \pm 0.055$	$0.8365 \pm 0.0011 \pm 0.031$	$0.40468 \pm 0.00070 \pm 0.018$	$0.4325 \pm 0.0012 \pm 0.011$
8.8	κ_1	$1.3913 \pm 0.0010 \pm 0.16$	$0.91188 \pm 0.00063 \pm 0.096$	$0.48169 \pm 0.00043 \pm 0.057$	$0.43230 \pm 0.00068 \pm 0.033$
12.3	κ_1	$1.9373 \pm 0.0017 \pm 0.12$	$1.1922 \pm 0.0010 \pm 0.066$	$0.75133 \pm 0.00077 \pm 0.048$	$0.4493 \pm 0.0010 \pm 0.014$
17.3	κ_1	$2.6839 \pm 0.0025 \pm 0.11$	$1.5781 \pm 0.0014 \pm 0.055$	$1.1348 \pm 0.0011 \pm 0.039$	$0.4758 \pm 0.0011 \pm 0.0061$
6.3	κ_2	$1.1854 \pm 0.0047 \pm 0.042$	$0.6879 \pm 0.0023 \pm 0.014$	$0.2879 \pm 0.0014 \pm 0.023$	$0.7614 \pm 0.0032 \pm 0.030$
7.7	κ_2	$1.5250 \pm 0.0029 \pm 0.033$	$0.8088 \pm 0.0013 \pm 0.016$	$0.39328 \pm 0.00090 \pm 0.013$	$0.8777 \pm 0.0017 \pm 0.024$
8.8	κ_2	$1.7987 \pm 0.0019 \pm 0.19$	$0.89692 \pm 0.00092 \pm 0.070$	$0.47492 \pm 0.00059 \pm 0.053$	$0.9436 \pm 0.0010 \pm 0.056$
12.3	κ_2	$3.0518 \pm 0.0041 \pm 0.15$	$1.2795 \pm 0.0019 \pm 0.049$	$0.8002 \pm 0.0013 \pm 0.046$	$1.1072 \pm 0.0017 \pm 0.037$
17.3	κ_2	$5.4738 \pm 0.0067 \pm 0.15$	$2.0008 \pm 0.0027 \pm 0.065$	$1.3541 \pm 0.0018 \pm 0.025$	$1.2476 \pm 0.0020 \pm 0.041$
6.3	κ_3	$1.391 \pm 0.015 \pm 0.034$	$0.5903 \pm 0.0056 \pm 0.024$	$0.2616 \pm 0.0028 \pm 0.019$	$0.3340 \pm 0.0060 \pm 0.044$
7.7	κ_3	$1.944 \pm 0.010 \pm 0.071$	$0.7150 \pm 0.0037 \pm 0.026$	$0.3712 \pm 0.0020 \pm 0.010$	$0.3488 \pm 0.0039 \pm 0.033$
8.8	κ_3	$2.4540 \pm 0.0071 \pm 0.19$	$0.8241 \pm 0.0024 \pm 0.021$	$0.4605 \pm 0.0014 \pm 0.040$	$0.3571 \pm 0.0024 \pm 0.018$
12.3	κ_3	$5.173 \pm 0.021 \pm 0.13$	$1.3313 \pm 0.0055 \pm 0.049$	$0.8699 \pm 0.0035 \pm 0.028$	$0.4012 \pm 0.0047 \pm 0.027$
17.3	κ_3	$11.692 \pm 0.042 \pm 0.85$	$2.480 \pm 0.010 \pm 0.15$	$1.6751 \pm 0.0064 \pm 0.072$	$0.4877 \pm 0.0064 \pm 0.056$
6.3	κ_4	$1.442 \pm 0.057 \pm 0.041$	$0.351 \pm 0.015 \pm 0.056$	$0.2179 \pm 0.0075 \pm 0.015$	$0.534 \pm 0.021 \pm 0.052$
7.7	κ_4	$2.217 \pm 0.043 \pm 0.33$	$0.455 \pm 0.010 \pm 0.067$	$0.3292 \pm 0.0050 \pm 0.019$	$0.675 \pm 0.011 \pm 0.022$
8.8	κ_4	$3.098 \pm 0.012 \pm 0.10$	$0.5851 \pm 0.0087 \pm 0.082$	$0.4304 \pm 0.0041 \pm 0.018$	$0.8074 \pm 0.0078 \pm 0.022$
12.3	κ_4	$7.62 \pm 0.12 \pm 0.66$	$1.103 \pm 0.019 \pm 0.094$	$0.930 \pm 0.019 \pm 0.053$	$1.289 \pm 0.015 \pm 0.054$
17.3	κ_4	$18.51 \pm 0.31 \pm 4.4$	$2.157 \pm 0.041 \pm 0.43$	$1.941 \pm 0.028 \pm 0.31$	$1.779 \pm 0.025 \pm 0.13$
6.3	κ_2/κ_1	$1.1596 \pm 0.0040 \pm 0.041$	$0.9499 \pm 0.0028 \pm 0.036$	$0.9511 \pm 0.0030 \pm 0.0051$	$1.7831 \pm 0.0094 \pm 0.028$
7.7	κ_2/κ_1	$1.2317 \pm 0.0019 \pm 0.042$	$0.9669 \pm 0.0014 \pm 0.028$	$0.9718 \pm 0.0014 \pm 0.012$	$2.0295 \pm 0.0054 \pm 0.011$
8.8	κ_2/κ_1	$1.2929 \pm 0.0011 \pm 0.014$	$0.98359 \pm 0.00092 \pm 0.031$	$0.98596 \pm 0.00088 \pm 0.010$	$2.1828 \pm 0.0036 \pm 0.039$
12.3	κ_2/κ_1	$1.5753 \pm 0.0021 \pm 0.021$	$1.0732 \pm 0.0014 \pm 0.019$	$1.0650 \pm 0.0013 \pm 0.0070$	$2.4641 \pm 0.0049 \pm 0.067$
17.3	κ_2/κ_1	$2.0395 \pm 0.0027 \pm 0.098$	$1.2678 \pm 0.0017 \pm 0.049$	$1.1933 \pm 0.0013 \pm 0.032$	$2.6221 \pm 0.0062 \pm 0.057$
6.3	κ_3/κ_2	$1.1731 \pm 0.0093 \pm 0.037$	$0.8582 \pm 0.0064 \pm 0.048$	$0.9086 \pm 0.0068 \pm 0.0081$	$0.4387 \pm 0.0075 \pm 0.077$
7.7	κ_3/κ_2	$1.2748 \pm 0.0048 \pm 0.063$	$0.8841 \pm 0.0035 \pm 0.041$	$0.9438 \pm 0.0034 \pm 0.026$	$0.3973 \pm 0.0043 \pm 0.050$
8.8	κ_3/κ_2	$1.3643 \pm 0.0029 \pm 0.042$	$0.9189 \pm 0.0020 \pm 0.054$	$0.9696 \pm 0.0020 \pm 0.025$	$0.3785 \pm 0.0026 \pm 0.044$
12.3	κ_3/κ_2	$1.6952 \pm 0.0051 \pm 0.049$	$1.0405 \pm 0.0032 \pm 0.032$	$1.0871 \pm 0.0031 \pm 0.028$	$0.3624 \pm 0.0042 \pm 0.028$
17.3	κ_3/κ_2	$2.1360 \pm 0.0061 \pm 0.14$	$1.2396 \pm 0.0039 \pm 0.071$	$1.2371 \pm 0.0036 \pm 0.065$	$0.3909 \pm 0.0051 \pm 0.033$
6.3	κ_4/κ_2	$1.217 \pm 0.045 \pm 0.023$	$0.510 \pm 0.024 \pm 0.092$	$0.757 \pm 0.024 \pm 0.013$	$0.668 \pm 0.022 \pm 0.098$
7.7	κ_4/κ_2	$1.454 \pm 0.028 \pm 0.24$	$0.562 \pm 0.013 \pm 0.089$	$0.837 \pm 0.013 \pm 0.079$	$0.769 \pm 0.013 \pm 0.048$
8.8	κ_4/κ_2	$1.722 \pm 0.019 \pm 0.27$	$0.6523 \pm 0.0087 \pm 0.15$	$0.9064 \pm 0.0087 \pm 0.090$	$0.8557 \pm 0.0082 \pm 0.060$
12.3	κ_4/κ_2	$2.498 \pm 0.040 \pm 0.35$	$0.862 \pm 0.015 \pm 0.11$	$1.162 \pm 0.015 \pm 0.14$	$1.165 \pm 0.014 \pm 0.027$
17.3	κ_4/κ_2	$3.382 \pm 0.058 \pm 0.79$	$1.078 \pm 0.022 \pm 0.21$	$1.433 \pm 0.020 \pm 0.24$	$1.426 \pm 0.018 \pm 0.062$

Table 5 Numerical values of factorial cumulants of h^+ and h^-

$\sqrt{s_{NN}}$ (GeV)	Quantity	h^+	h^-
6.3	$\hat{C}_2$	$-0.0363 \pm 0.0021 \pm 0.027$	$-0.01481 \pm 0.00090 \pm 0.0026$
7.7	$\hat{C}_2$	$-0.0277 \pm 0.0012 \pm 0.024$	$-0.01140 \pm 0.00056 \pm 0.0051$
8.8	$\hat{C}_2$	$-0.01496 \pm 0.00084 \pm 0.027$	$-0.00676 \pm 0.00042 \pm 0.0049$
12.3	$\hat{C}_2$	$0.0873 \pm 0.0017 \pm 0.018$	$0.0489 \pm 0.0010 \pm 0.0017$
17.3	$\hat{C}_2$	$0.4226 \pm 0.0026 \pm 0.060$	$0.2194 \pm 0.0015 \pm 0.027$
6.3	$\hat{C}_3$	$-0.0249 \pm 0.0028 \pm 0.020$	$0.00331 \pm 0.00075 \pm 0.0011$

Table 5 continued

$\sqrt{s_{NN}}$ (GeV)	Quantity	h^+	h^-
7.7	$\hat{C}_3$	$-0.0384 \pm 0.0018 \pm 0.014$	$0.00069 \pm 0.00072 \pm 0.00024$
8.8	$\hat{C}_3$	$-0.0429 \pm 0.0013 \pm 0.0031$	$-0.00089 \pm 0.00051 \pm 0.0026$
12.3	$\hat{C}_3$	$-0.1228 \pm 0.0028 \pm 0.021$	$-0.0280 \pm 0.0017 \pm 0.014$
17.3	$\hat{C}_3$	$-0.3658 \pm 0.0056 \pm 0.059$	$-0.1177 \pm 0.0033 \pm 0.030$
6.3	$\hat{C}_4$	$0.0304 \pm 0.0048 \pm 0.026$	$-0.00100 \pm 0.00076 \pm 0.0013$
7.7	$\hat{C}_4$	$0.0421 \pm 0.0027 \pm 0.018$	$0.00012 \pm 0.00082 \pm 0.00043$
8.8	$\hat{C}_4$	$0.0351 \pm 0.0021 \pm 0.0090$	$0.0014 \pm 0.0010 \pm 0.0014$
12.3	$\hat{C}_4$	$0.0361 \pm 0.0056 \pm 0.027$	$0.0045 \pm 0.0026 \pm 0.0028$
17.3	$\hat{C}_4$	$-0.185 \pm 0.015 \pm 0.074$	$-0.0231 \pm 0.0084 \pm 0.025$

Table 6 Numerical values of cumulant ratio combinations which are intensive for net-charge

$\sqrt{s_{NN}}$ (GeV)	Quantity	$h^+ - h^-$
6.3	$\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$	$0.7431 \pm 0.0032 \pm 0.017$
7.7	$\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$	$0.7072 \pm 0.0017 \pm 0.0088$
8.8	$\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$	$0.6771 \pm 0.0010 \pm 0.039$
12.3	$\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$	$0.5697 \pm 0.0017 \pm 0.014$
17.3	$\kappa_2[h^+ - h^-]/(\kappa_1[h^+] + \kappa_1[h^-])$	$0.4599 \pm 0.0020 \pm 0.010$
6.3	$\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$	$0.782 \pm 0.017 \pm 0.13$
7.7	$\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$	$0.8064 \pm 0.0085 \pm 0.098$
8.8	$\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$	$0.8264 \pm 0.0058 \pm 0.11$
12.3	$\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$	$0.893 \pm 0.011 \pm 0.065$
17.3	$\kappa_3[h^+ - h^-]/\kappa_1[h^+ - h^-]$	$1.025 \pm 0.012 \pm 0.11$

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