Systematic investigation of the particle spectra in heavy-ion collisions at the Large Hadron Collider

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We investigate the charged particle spectra produced in the heavy-ion collisions at nine centralities from different systems, i.e., Pb+Pb at $\sqrt{s_{NN}} = 2.76$TeV and 5.02 TeV as well as Xe+Xe at $\sqrt{s_{NN}} = 5.44$ TeV, at Large Hadron Collider (LHC) using one empirical formula inspired by the stationary solution of the Fokker-Planck equation, dubbed as the generalized Fokker-Planck solution (GFPS) [1]. Our results show that the GFPS can reproduce the experimental particle spectrum up to transverse momentum p_T about 45 GeV/c with the maximum discrepancy 30% covering 10 orders of magnitude. The discrepancy between the data and the results from the GFPS decreases to 15% when the maximum of the charged particle transverse momentum is cut to 20 GeV/c. We confirmed that the Tsallis distribution derived from the non-extensive statistics, which can reproduce the particle spectra produced in small collision systems, such as p+p, up to few hundreds GeV/c, can only apply to systematically study the particle spectra up to 8 GeV/c in A+A collisions at LHC, as pointed out in the study of identified particle spectra in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$TeV [2]. A brief discussion on GFPS is also given.

Recently, the experimental data of charged particle spectra at different centralities in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$TeV and 5.02 TeV as well as Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$TeV with a wide p_T range up to 45 GeV/c, which is twice larger than the previous experimental measurements [3], have been released by the ALICE Collaboration at LHC [4, 5]. More systems and more colliding energies with particle spectra in wider p_T range will be the new challenges to all the models. Therefore, we investigate whether the GFPS proposed by us can reproduce the new experimental data, which can shed the light on understanding the particle production mechanism at LHC.

The generalized Fokker-Planck solution (GFPS) adopted is

$$(E\frac{d^3N}{dp^3})_{|\eta|<a} = A\frac{e^{-\frac{b}{T}\arctan\frac{E_T}{b}}}{[1+(\frac{E_T}{b})^d]^c}$$

It has five parameters A, b, c, d and the effective temperature T. $E_T$is the transverse energy of the particle. The asymptotic behavior of GFPS at high p_T is the power-law and at low p_T is the Boltzmann thermal distribution. A crossover from the exponential law at low p_T to the power law at high p_T takes place at $E_T \sim b$. In Fig. 1, we show the typical results for the charged particles produced in Pb+Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV using GFPS and Tsallis distribution.

By conducting detailed investigation of the transverse momentum spectra of charged particle spectra produced in Pb+Pb at $\sqrt{s_{NN}} = 2.76$TeV and 5.02 TeV as well as Xe+Xe at$\sqrt{s_{NN}} = 5.44$TeV using GFPS and the Tsallis distribution, our results show that the GFPS can nicely describe the charged particle spectra from central to peripheral collisions with p_T up to 45 GeV/c, while the Tsallis distribution

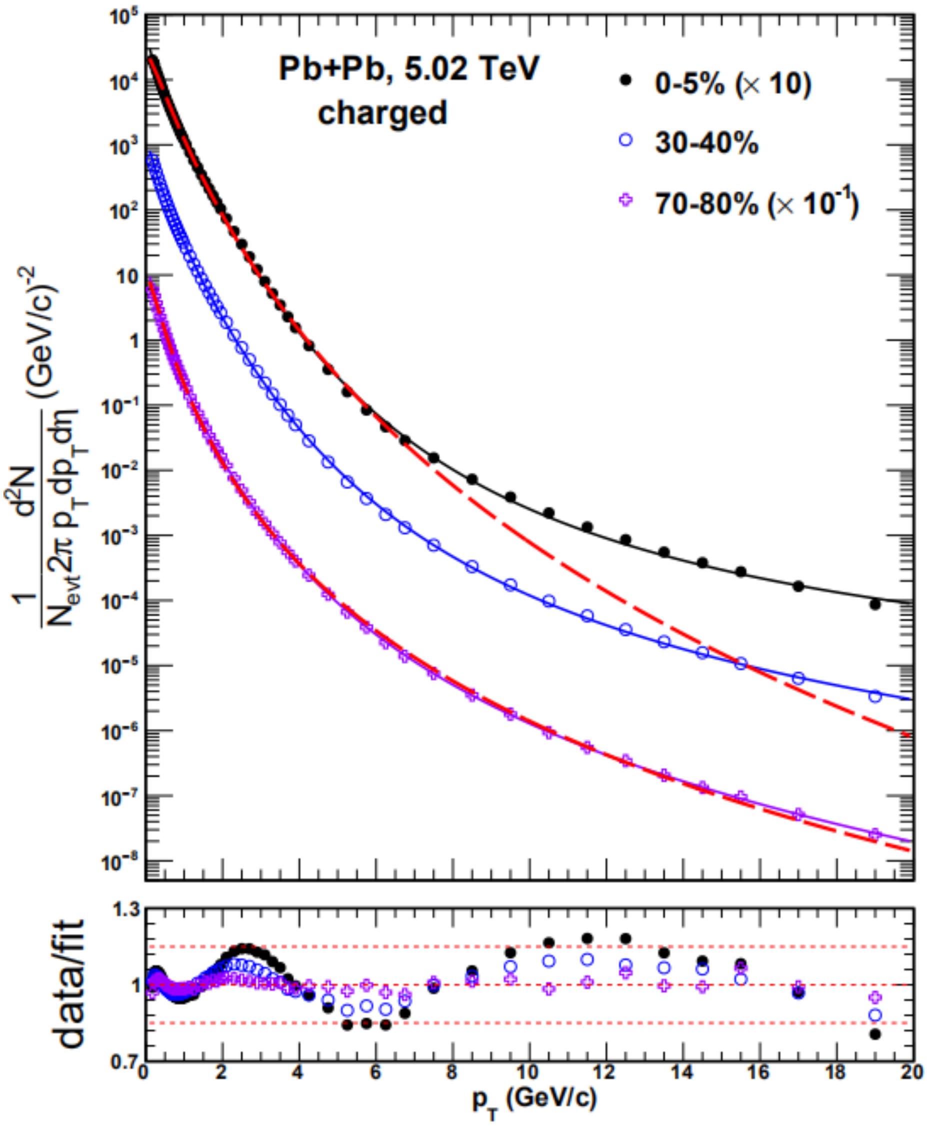

Fig. 1. (Color online) Fitting results showed by solid lines using the GFPS and dashed lines using Tsallis distribution for Pb+Pb collisions at 5.02 TeV.

can only fit the spectra at $p_T < 8$ GeV/c for central collisions and it has the same performance as the GFPS for the peripheral collisions.

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