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Collective expansion in p-p collisions using the Tsallis statistics

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Introduction

- Quantum-Chromodynamics (QCD) predicts that at high temperature and energy density there exists a hot and dense strongly interacting matter.
- This matter is commonly denoted as quark-gluon plasma (QGP), where partons (quarks and gluons) are the dominant degrees of freedom.
- QGP is expected to be produced in ultrarelativistic heavy-ion collisions or high energy p-p collisions with large multiplicity.
- Understanding the nature of collective flows is one of the main goals in high energy collision experiments.
- The collective expansion can be investigated via the study of the transverse momentum (p_{T}) spectra of identified in heavy-ion or p-p collisions.

Results

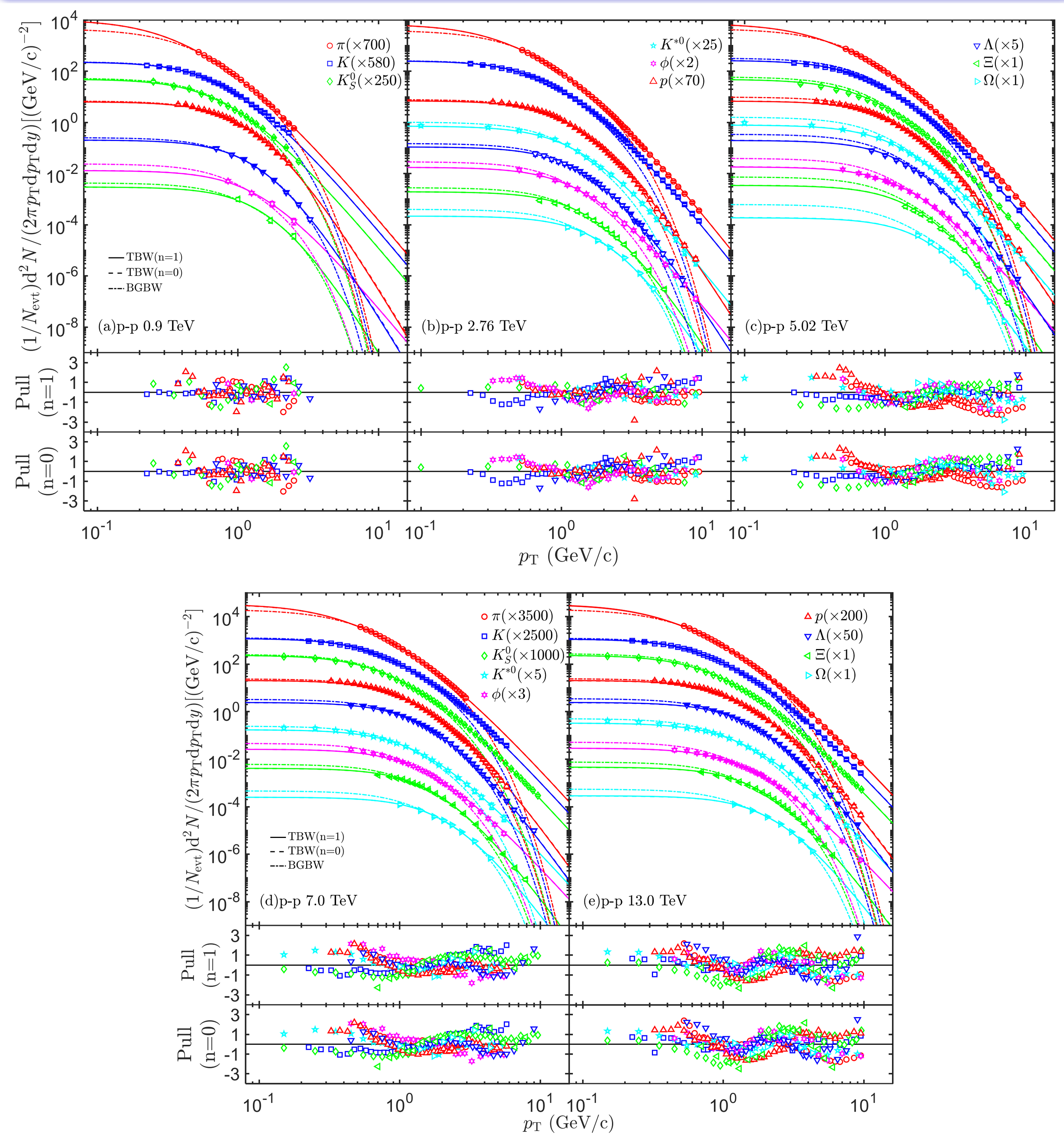

Fig.1 Identified particle p_{T} spectra in p-p collisions at $\sqrt{s_{NN}}$ = 0.9 TeV(a), 2.76 TeV(b), 5.02 TeV(c), 7.0 TeV(d) and 13.0 TeV(e). The solid(dash) curves represent the results from the TBW model with $n=1$ ($n=0$). The dash-dotted curves represent the results from the global BGBW fit.

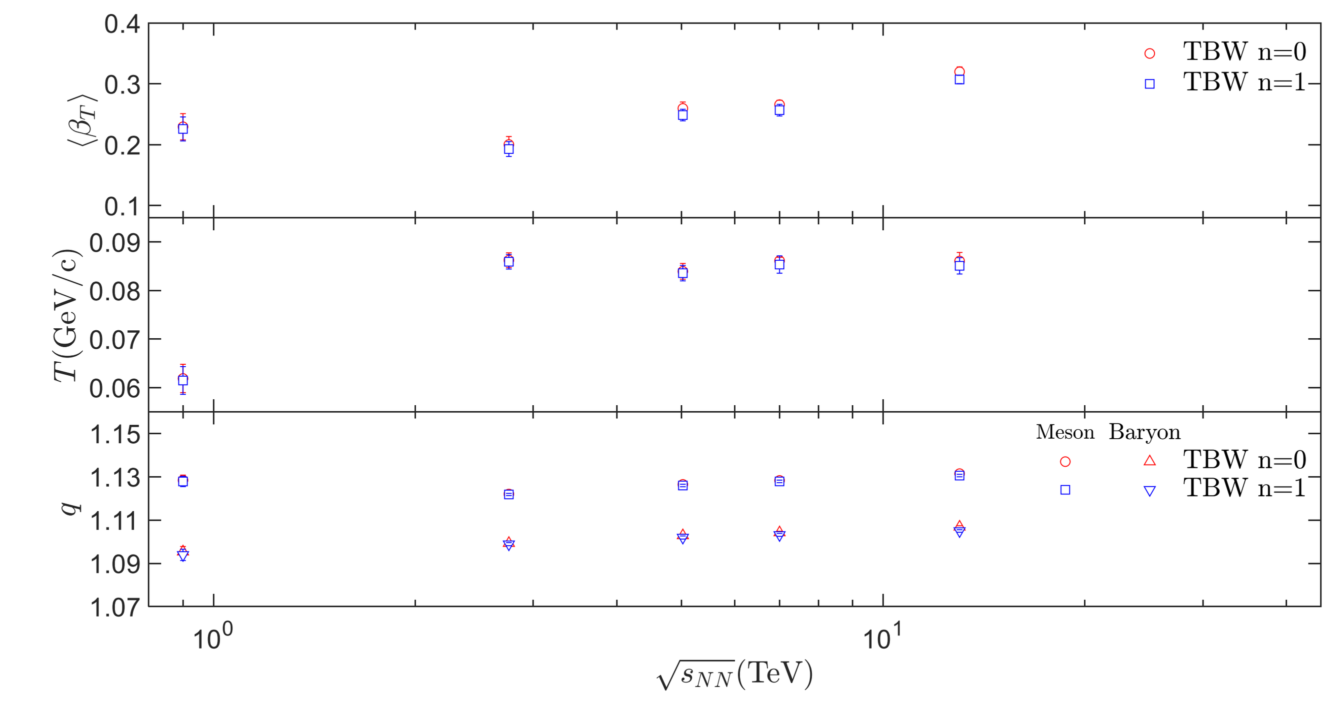

Fig.2 $\langle\beta\rangle$, T and $q_M(q_B)$ from the TBW fit as a function of beam energy in p-p collisions.

Model

- The TBW model:

$$\frac{d^2N}{2\pi p_{\mathrm{T}} dp_{\mathrm{T}} dy} \propto m_{\mathrm{T}} \int_{-y_b}^{+y_b} \exp\sqrt{y_b^2 - y_s^2}\cosh(y_s)dy_s \int_{-\pi}^{+\pi} d\phi_b \int_0^R rdr \int_{-\pi}^{+\pi} d\phi_p \left(1 + \frac{q-1}{T}(m_{\mathrm{T}}\cosh(y_s)\cosh(\rho) - p_{\mathrm{T}}\sinh(\rho)\cos(\phi_p - \phi_b))\right)^{-1/(q-1)},$$

where,

$$m_{\mathrm{T}} = \sqrt{p_{\mathrm{T}}^2 + m^2},\ y_b = \ln(\sqrt{s_{NN}}/m_N),$$

$$\rho = \tanh^{-1}\left(\beta_s\left(\frac{r}{R}\right)^n\right).$$

- $\langle\beta\rangle$ and T are common for all particles, while q_M (q_B) are the same for all of the mesons (baryons).
- Consider two kinds of velocity profiles for TBW model: the linear profile ($n=1$) and the constant profile ($n=0$).

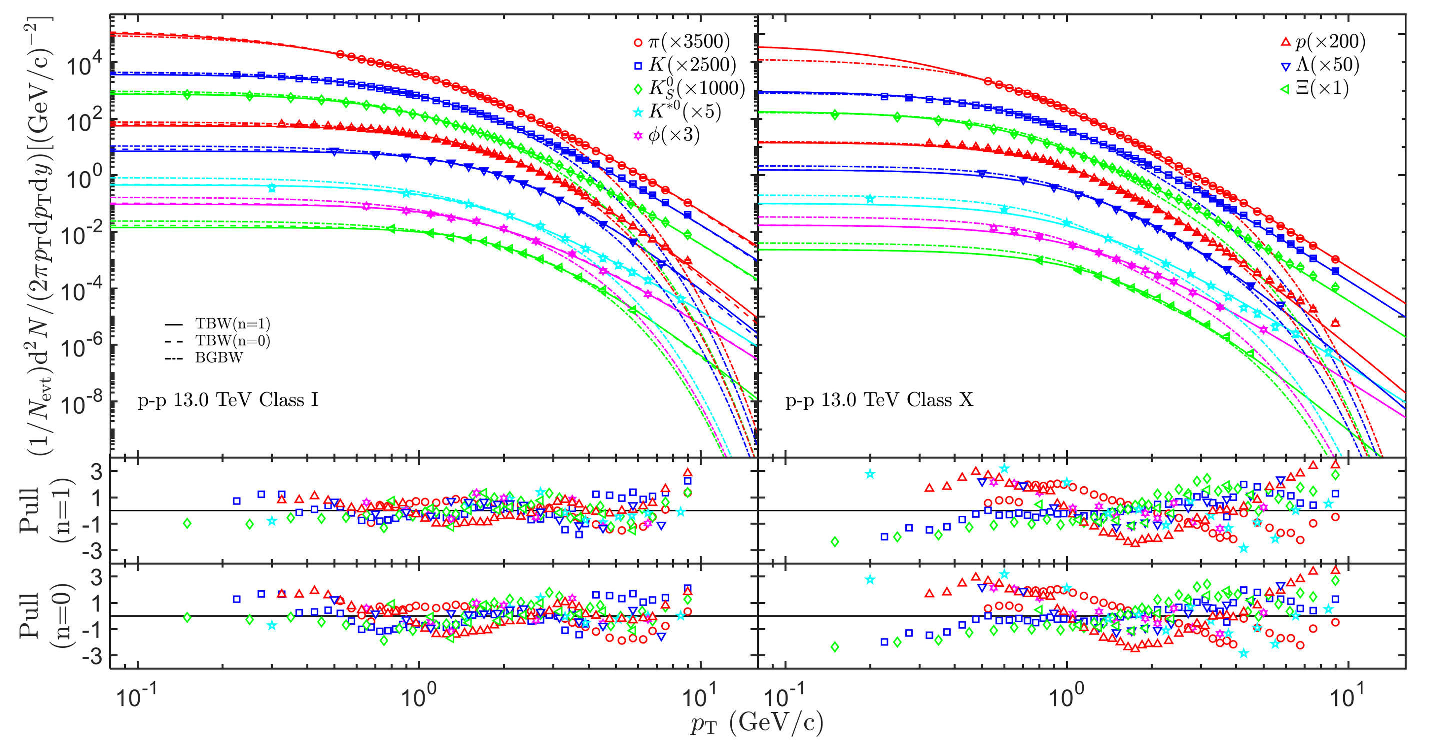

Fig.3 Identified particle p_{T} spectra at the multiplicity class I and X in p-p collisions at $\sqrt{s_{NN}}$ = 13.0 TeV. The solid(dash) curves represent the results from the TBW model with $n=1$ ($n=0$). The dash-dotted curves represent the results from the global BGBW fit.

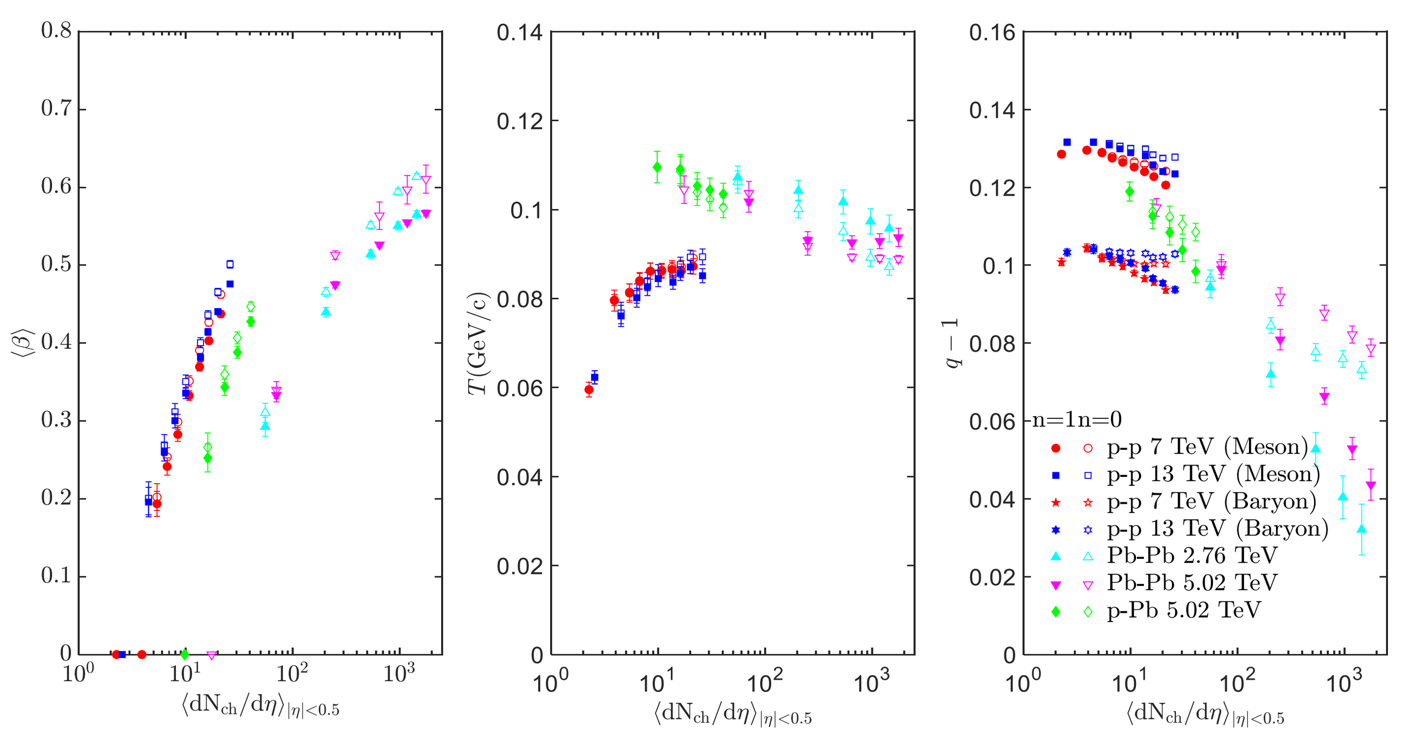

Fig.4 Evolution of $\langle\beta\rangle$, T and q with $\langle dN_{\mathrm{ch}}/d\eta\rangle$. $\langle\beta\rangle$, $T$and q are extracted from TBW fits to identified particle p_{T} spectra measured in p-p, p-Pb and Pb-Pb collisions at different $\sqrt{s_{NN}}$.

Conclusions

- The average transverse radial flow velocity $\langle\beta\rangle$ and non-extensive parameter q both grow with the collision energy, indicating he system at high energy has more obvious collective expansion and greater deviation from the thermal equilibrium than that at low energy.
- $\langle\beta\rangle$ grows with the increase of the charged-particle multiplicity $\langle dN_{\mathrm{ch}}/d\eta\rangle$, while q shows an opposite trend. The Tsallis temperature T first increases and then gradually saturates with $\langle dN_{\mathrm{ch}}/d\eta\rangle$.
- The larger the size of the system is, the smaller the radial flow velocity is, which suggests that the smaller system with the same multiplicity has a higher energy density and a larger radial flow velocity than the large system..
- In p-p collisions, the results from the TBW model with $n = 0$ and $n = 1$ are constant with each other at the low multiplicity. However, at the high multiplicity, large discrepancy is observed for the values of q for these two velocity profiles.

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Acknowledgements

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