Analysis of Midrapidity p_t Distributions of Identified Charged Particles in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV using non-extensive Tsallis Statistics with included Transverse Flow

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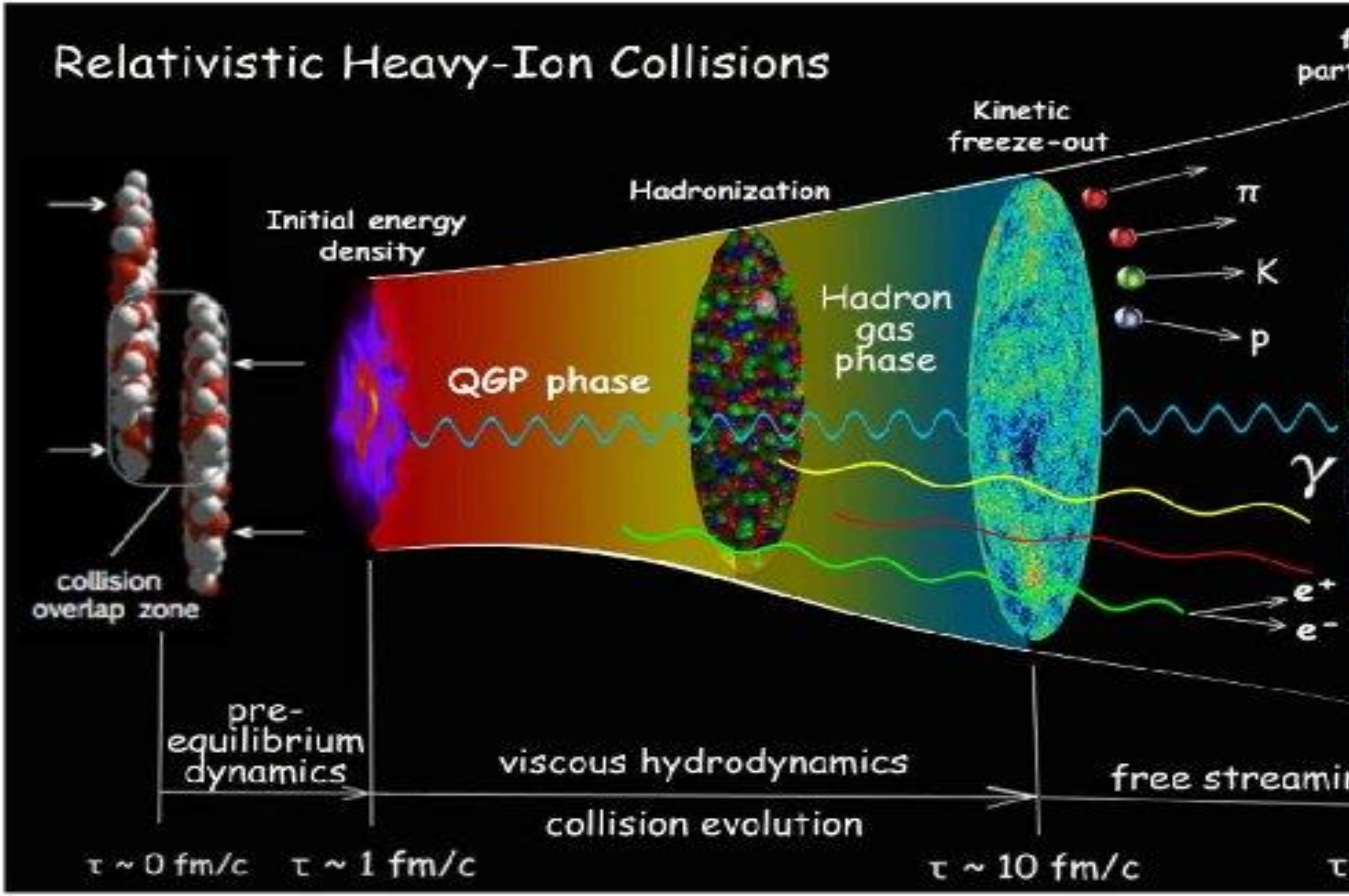

Relativistic Heavy-Ion Collisions
Kinetic freeze-out
Hadronization
Initial energy density
Hadron gas phase
QGP phase
π
K
p
γ
e+
e-
collision overlap zone
pre-equilibrium dynamics
viscous hydrodynamics
free streamin
collision evolution
τ ~ 0 fm/c
τ ~ 1 fm/c
τ ~ 10 fm/c

INTRODUCTION

- *Investigation of the Properties of Quark-Gluon Plasma (QGP) is of high importance - According to Big Bang Theory – The Matter of the Early Universe was in a State of QGP just a few microseconds after the Big Bang.*

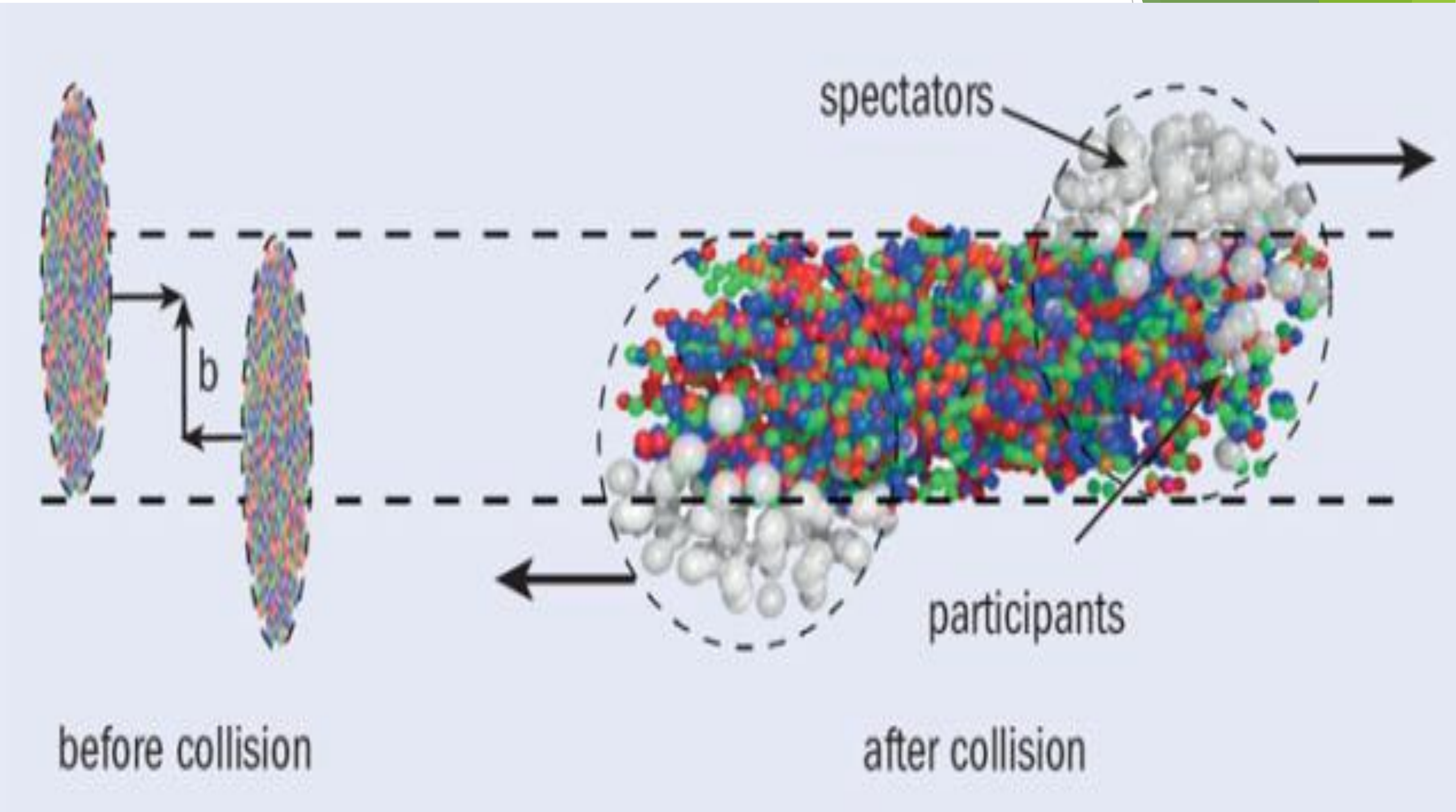
- *The lattice QCD estimations have yielded $T_c \approx$150-170 MeV (critical temperature) and $\varepsilon_c \approx$1 GeV/fm^3 (critical energy density) for a transition from a nucleon to QGP state of matter.*
-
- *Nucleus-Nucleus collisions at High Energies are Key for discovery of new (heavy) particles (resonances), allowing also To Probe the Matter at Record Small Distances about 10^{-13} cm and less.*

- ***QGP has been discovered in collisions of heavy ions at high energies at the RHIC and LHC. The obtained QGP matter has shown fluid-like behavior with low viscosity.***

- ***The parameters of the chemical freeze-out – the chemical freeze-out temperature (T_{ch}) and the baryochemical potential (μ_b) are commonly obtained from fitting the particle yields (abundancies) with the statistical hadronization or thermal models.***

- ***The parameters of the kinetic freeze-out – the kinetic freeze-out temperature (T_0) and the transverse expansion velocity (β_t) of particles at the time of decoupling of an expanding fireball are estimated from analysis of transverse momentum distributions of particles with the help of various theoretical and phenomenological models - hydrodynamics based blast-wave models, the blast-wave model with Boltzmann-Gibbs (BGBW model) as well as Tsallis (TBW model) statistics, QCD-inspired Hagedorn (power law) function with embedded transverse flow and others.***

- ***Pions, kaons, and (anti)protons account for the predominantly largest part of the final particles produced in high-energy collisions at the RHIC and LHC.***


spectators
b
participants
before collision
after collision

ANALYZED ALICE TRANSVERSE MOMENTUM DATA ON Pb+Pb Collisions at $(s_{nn})^{1/2}$=5.02 TeV (MIDRAPIDITY)*

The average number of participant nucleons and mean charged-particle multiplicity densities in the analyzed groups of centralities of Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV*.

Centr.	$\langle N_{part} \rangle$	$\langle dN_{ch}/d\eta \rangle$
0-5%	383±11	1943±56
5-10%	331±10	1587±47
10-20%	262±7	1180±31
20-30%	188±5	786±20
30-40%	131±4	512±15
40-50%	87±4	318±12
50-60%	54±3	183±8
60-70%	31±2	96±6
70-80%	16±2	45±3
80-90%	7±1	18±2

**ALICE Collaboration, Acharya, S.; et al. Production of charged pions, kaons and (anti-)protons in Pb-Pb and inelastic pp collisions at $(s)^{1/2}$=5.02 TeV. Phys. Rev. C 2020, 101, 044907. arXiv: 1910.07678v1 [nucl-ex].*

ANALYZED ALICE TRANSVERSE MOMENTUM DATA ON Xe+Xe Collisions at $(s_{nn})^{1/2}$=5.44 TeV (MIDRAPIDITY)*

The average number of participant nucleons and mean charged particle multiplicity densities for the analyzed centralities of Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV*.

Centr.	$\langle N_{part} \rangle$	$\langle dN_{ch}/d\eta \rangle$
0-5%	236±2	1167±26
5-10%	207±2	939±24
10-20%	165±2	706±17
20-30%	118±3	478±11
30-40%	82±3	315±8
40-50%	55±3	198±5
50-60%	34±2	118±3
60-70%	20±2	65±2
70-90%	8±1	24±2

**ALICE Collaboration, S. Acharya et al., Production of pions, kaons, (anti-)protons and φ mesons in Xe–Xe collisions at $(s_{nn})^{1/2}$ = 5.44 TeV, Eur. Phys. J. C 81, 584 (2021), arXiv:2101.03100 [nucl-ex].*

TSALLIS DISTRIBUTION FUNCTION

- *Various types of Tsallis distribution function, based on non-extensive Tsallis statistics, have demonstrated quite high efficiencies, becoming standard for describing the p_t spectra of final hadrons in high-energy proton+proton collisions. Tsallis distribution function has the advantage of being connected via the entropy to thermodynamics, which is not the case with other power law distributions.*

- Simple (thermodynamically non-consistent) Tsallis distribution function (at midrapidity <y> = 0)

$$\frac{d^2N}{2\pi N_{ev} p_t dp_t dy} = C\left(1 + (q-1)\frac{m_t}{T}\right)^{-q/(q-1)}, \qquad (1)$$

- Thermodynamically consistent Tsallis distribution function (at midrapidity <y> = 0)

$$\frac{d^2N}{2\pi N_{ev} p_t dp_t dy} = C_q m_t \left(1 + (q-1)\frac{m_t}{T}\right)^{-q/(q-1)}, \qquad (2)$$

- $m_t = \sqrt{p_t^2 + m_0^2}$ **is the transverse mass (energy), and m_0 - the rest mass of a hadron, T is the effective temperature**

- **q − non-extensivity parameter, which characterizes the deviation of p_t distribution from the exponential Boltzmann-Gibbs distribution and is thought to measure the degree of non-equilibrium or non-thermalization.**

- **As q tends to one (1), the Tsallis function approaches the exponential (equilibrated) Boltzmann-Gibbs distribution.**

- **The closer is the parameter q to one, the larger is the thermalization level of a system.**

SIMPLE TSALLIS FUNCTION WITH TRANSVERSE FLOW

- The values of T, obtained from Tsallis function (Eqs. (1) and (2)) fits are actually the effective temperatures, which include contributions of both the thermal motion and collective expansion (collective flow) effects. To separate these two effects, the transverse flow velocity should be incorporated into the Tsallis distribution function.

- For description of midrapidity (mid-y) p_t distributions, $d^2N/(N_{ev}dp_tdy)$, of identified charged particles in different centrality classes of Pb+Pb and Xe+Xe collisions at the LHC, we embed the transverse flow effect into simple Tsallis function in Eq. (1) by substituting (simple Lorentz transformation) $m_t \to \langle\gamma_t\rangle\,(m_t - p_t\langle\beta_t\rangle)$:

- $$\frac{d^2N}{N_{ev}dp_tdy} = 2\pi C\, p_t\left(1 + \langle\gamma_t\rangle\frac{(q-1)(m_t-p_t\langle\beta_t\rangle)}{T_0}\right)^{-q/(q-1)}, \qquad (4)$$

- which is called simple (or non-consistent) Tsallis function with transverse flow in present work. Here $\langle\beta_t\rangle$ is the average transverse flow velocity in c units.

- $<\gamma_t>=1/\sqrt{1-<\beta_t>^2}$ is the Lorentz factor.

THERMODYNAMICALLY CONSISTENT TSALLIS FUNCTION WITH TRANSVERSE FLOW

- Similarly, we incorporate the transverse flow into Tsallis function with thermodynamical consistence in Eq. (2) by applying simple Lorentz transformation $m_t \rightarrow \langle\gamma_t\rangle\,(m_t - p_t\langle\beta_t\rangle)$ transformation to obtain

- $$\frac{d^2N}{N_{ev}dp_tdy} = 2\pi\, C_q p_t\langle\gamma_t\rangle(m_t - p_t\langle\beta_t\rangle)\left(1 + \langle\gamma_t\rangle\frac{(q-1)(m_t-p_t\langle\beta_t\rangle)}{T_0}\right)^{-q/(q-1)}, \quad (5)$$

- which is called thermodynamically consistent Tsallis function with transverse flow in present work.

$$\frac{d^2N}{N_{ev}dp_tdy} = 2\pi\, C_q p_t \langle\gamma_t\rangle (m_t - p_t\langle\beta_t\rangle)\left(1 + \langle\gamma_t\rangle \frac{(q-1)(m_t - p_t\langle\beta_t\rangle)}{T_0}\right)^{-q/(q-1)},$$

Thermodynamically consistent Tsallis function (for <y>=0) with transverse flow

Fitted p_t ranges: [0.5-5.0] GeV/c for $\pi^+ + \pi^-$; [0.2-5.0] GeV/c for $K^+ + K^-$;

[0.3-5.0] GeV/c for $p+\bar{p}$.

The results of combined minimum $\chi 2$ fits with thermodynamically consistent Tsallis function with transverse flow (Eq.(5)) of p_t spectra of particles in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV. *n.d.f.* denotes the number of degrees of freedom. T_0 and $\langle\beta_t\rangle$ are shared (global) parameters during combined fits.

Centrality	q $(\pi^+ + \pi^-)$	q $(K^+ + K^-)$	q $(p+\bar{p})$	T_0 (MeV)	$\langle\beta_t\rangle$	$\chi^2/n.d.f.$
0-5%	1.088±0.002	1.086±0.002	1.088±0.002	80±3	0.60±0.01	296/98
5-10%	1.093±0.002	1.088± 0.002	1.090±0.002	79±3	0.59±0.01	301/98
10-20%	1.096±0.002	1.093±0.002	1.092±0.002	79±3	0.58±0.01	270/98
20-30%	1.102±0.002	1.098±0.002	1.095±0.002	77±2	0.57±0.01	216/98
30-40%	1.108±0.002	1.106±0.002	1.098±0.002	77±2	0.53±0.01	167/98
40-50%	1.117±0.002	1.114±0.002	1.100±0.001	76±2	0.49±0.01	116/98
50-60%	1.124±0.001	1.121±0.001	1.107±0.001	78±2	0.43±0.01	72/98
60-70%	1.131±0.001	1.131±0.001	1.112±0.001	82±2	0.33±0.01	31/98
70-80%	1.136±0.001	1.139±0.001	1.116±0.001	87±2	0.22±0.01	20/98
80-90%	1.142±0.001	1.146±0.001	1.118±0.001	86±3	0.14±0.02	21/98

$$\frac{d^2N}{N_{ev}dp_tdy} = 2\pi\, C_q p_t \langle\gamma_t\rangle (m_t - p_t\langle\beta_t\rangle)\left(1 + \langle\gamma_t\rangle \frac{(q-1)(m_t - p_t\langle\beta_t\rangle)}{T_0}\right)^{-q/(q-1)},$$

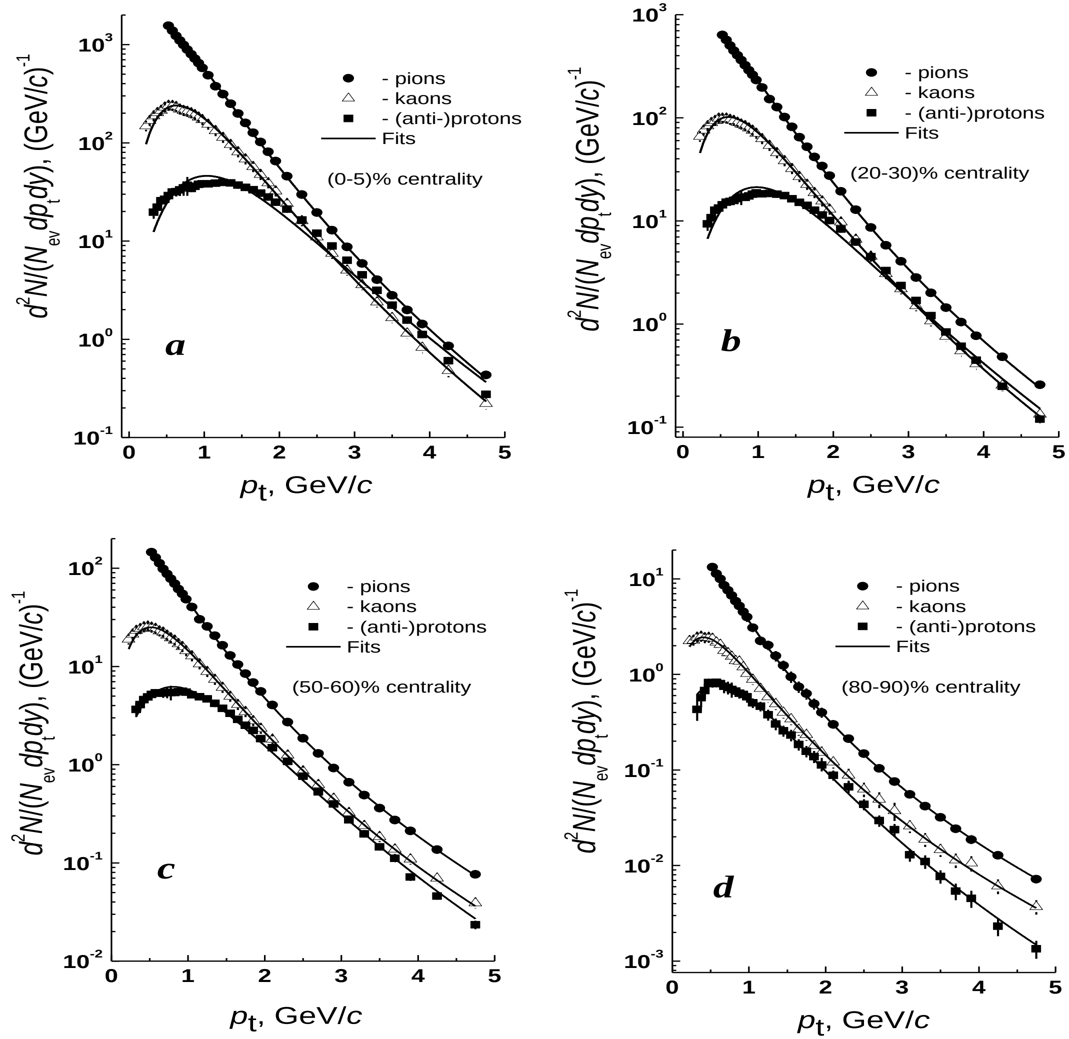
Thermodynamically consistent Tsallis function (for <y>=0) with transverse flow

Fitted p_t ranges: [0.5-5.0] GeV/c for $\pi^+ + \pi^-$; [0.2-5.0] GeV/c for $K^+ + K^-$;

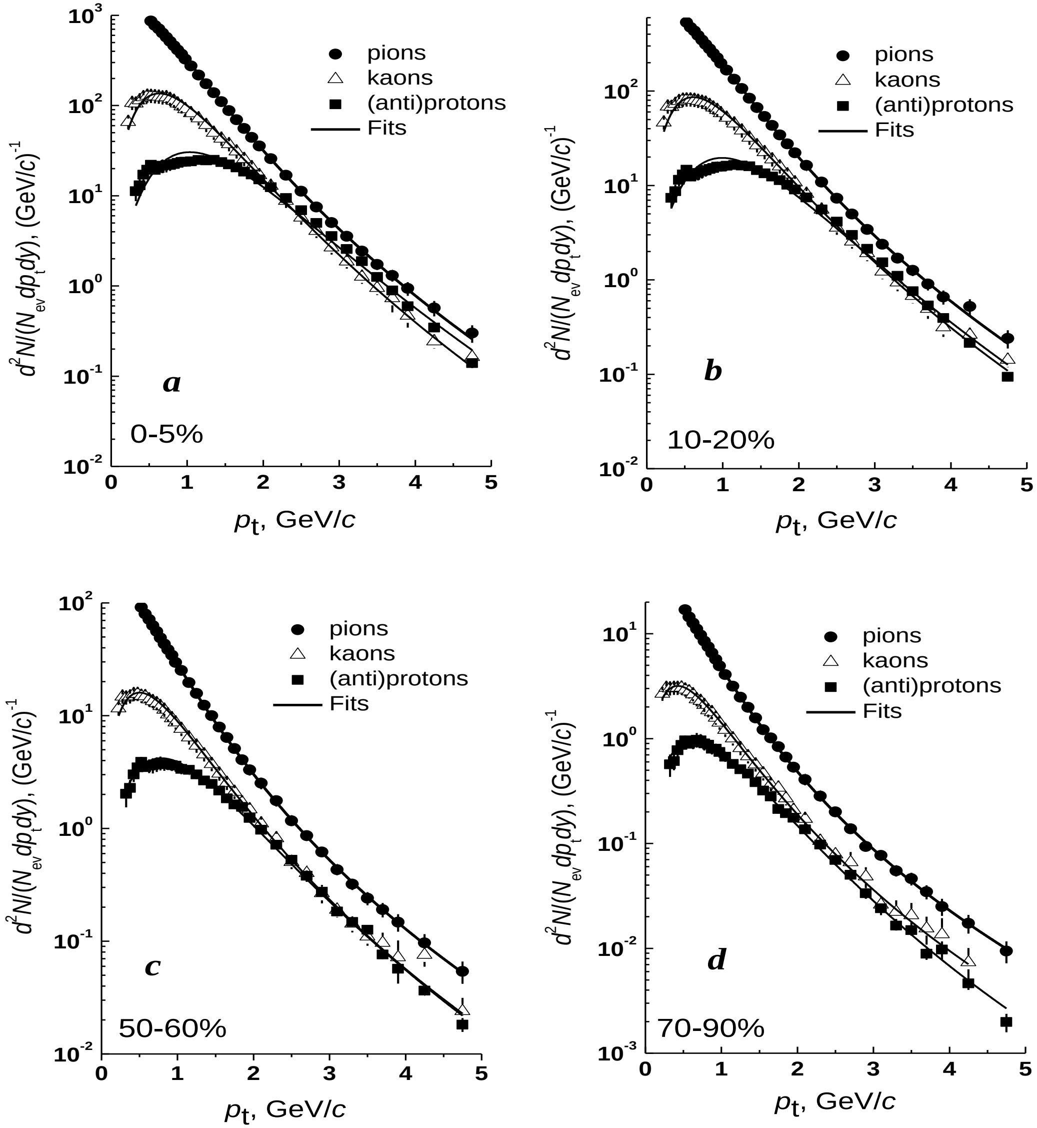
[0.3-5.0] GeV/c for $p+\bar{p}$.

The results of combined minimum $\chi 2$ fits with thermodynamically consistent Tsallis function with transverse flow (Eq.(5)) of p_t spectra of particles in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV. T_0 and $\langle\beta_t\rangle$ are shared (global) parameters during combined fits. *n.d.f.* denotes the number of degrees of freedom.

Centr.	q ($\pi^+ + \pi^-$)	q ($K^+ + K^-$)	q ($p+\bar{p}$)	T_0 (MeV)	$\langle\beta_t\rangle$	χ^2/*n.d.f.* (*n.d.f.*)
0-5%	1.093±0.004	1.087±0.003	1.085±0.002	76±3	0.61±0.01	1.69 (98)
5-10%	1.098±0.004	1.093±0.003	1.086±0.002	74±3	0.60±0.01	1.71 (98)
10-20%	1.104±0.004	1.099±0.003	1.092±0.002	75±3	0.58±0.01	1.49 (98)
20-30%	1.109±0.003	1.104±0.003	1.096±0.002	75±3	0.55±0.01	1.14 (98)
30-40%	1.115±0.003	1.109±0.003	1.099±0.002	76±3	0.52±0.01	1.03 (98)
40-50%	1.121±0.003	1.114±0.003	1.103±0.002	75±3	0.48±0.01	0.86 (98)
50-60%	1.130±0.003	1.124±0.002	1.114±0.002	77±3	0.40±0.01	0.71 (98)
60-70%	1.134±0.002	1.130±0.002	1.119±0.001	81±3	0.33±0.02	0.45 (97)
70-90%	1.142±0.002	1.138±0.002	1.120±0.001	82±3	0.22±0.02	0.38 (97)



The obtained fit curves by the thermodynamically consistent Tsallis function with transverse flow of the experimental midrapidity transverse momentum spectra of the charged pions (●) and kaons (Δ), protons and antiprotons (■) in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV at various centralities: 0-5% (a), 20-30% (b), 50-60% (c), and 80-90% (d).



The resulting combined minimum $\chi 2$ fit curves by the thermodynamically consistent Tsallis function with transverse flow of the experimental mid-y p_t distributions of the charged pions (●) and kaons (Δ), protons and antiprotons (■) in Xe-Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV at different collision centralities: 0-5% (a), 10-20% (b), 50-60% (c), and 70-90% (d). The error bars are combined (added in quadrature) statistical and systematic errors, dominated by the systematic ones.

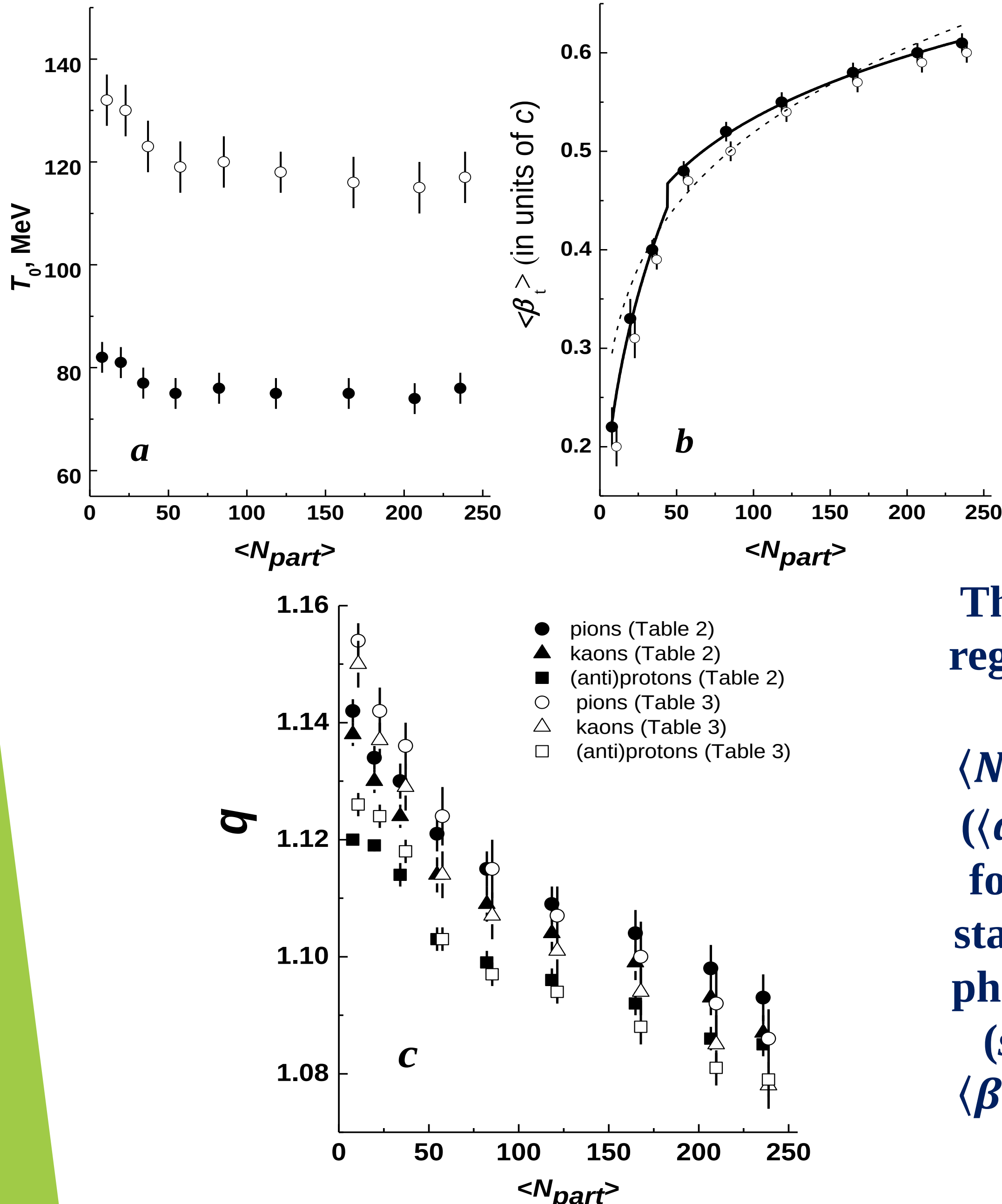


Figure. The $\langle N_{part}\rangle$ dependencies of the obtained T_0 (*a*) and $\langle\beta_t\rangle$ (*b*) parameters (●) of consistent Tsallis function with transverse flow in Xe-Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV; (*c*) – the same for the obtained *q* values of consistent Tsallis function with transverse flow for the charged pions (●) and kaons (▲), protons and antiprotons (■). The corresponding results extracted for the respective particles in Xe-Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV using non-consistent Tsallis function with transverse flow are shown by the corresponding open symbols.

The significantly different growth rates of $\langle\beta_t\rangle$ in regions $\langle N_{part}\rangle$ < 44±5 and $\langle N_{part}\rangle$ > 44±5, with T_0 becoming practically constant in range $\langle N_{part}\rangle$ > 44±5, could indicate that $\langle N_{part}\rangle \approx$ 44±5 ($\langle dN_{ch}/d\eta\rangle \approx$ 158±20) is a threshold border value for a crossover transition from a dense hadronic state to the Quark-Gluon Plasma phase (or mixed phase of QGP and hadrons) in Xe+Xe collisions at $(s_{\rm nn})^{1/2}$=5.44 TeV. The threshold border value is $\langle\beta_t\rangle \approx$ 0.44±0.02 (corresponding to $\langle N_{part}\rangle \approx$ 44±5 and $\langle dN_{ch}/d\eta\rangle \approx$ 158±20).

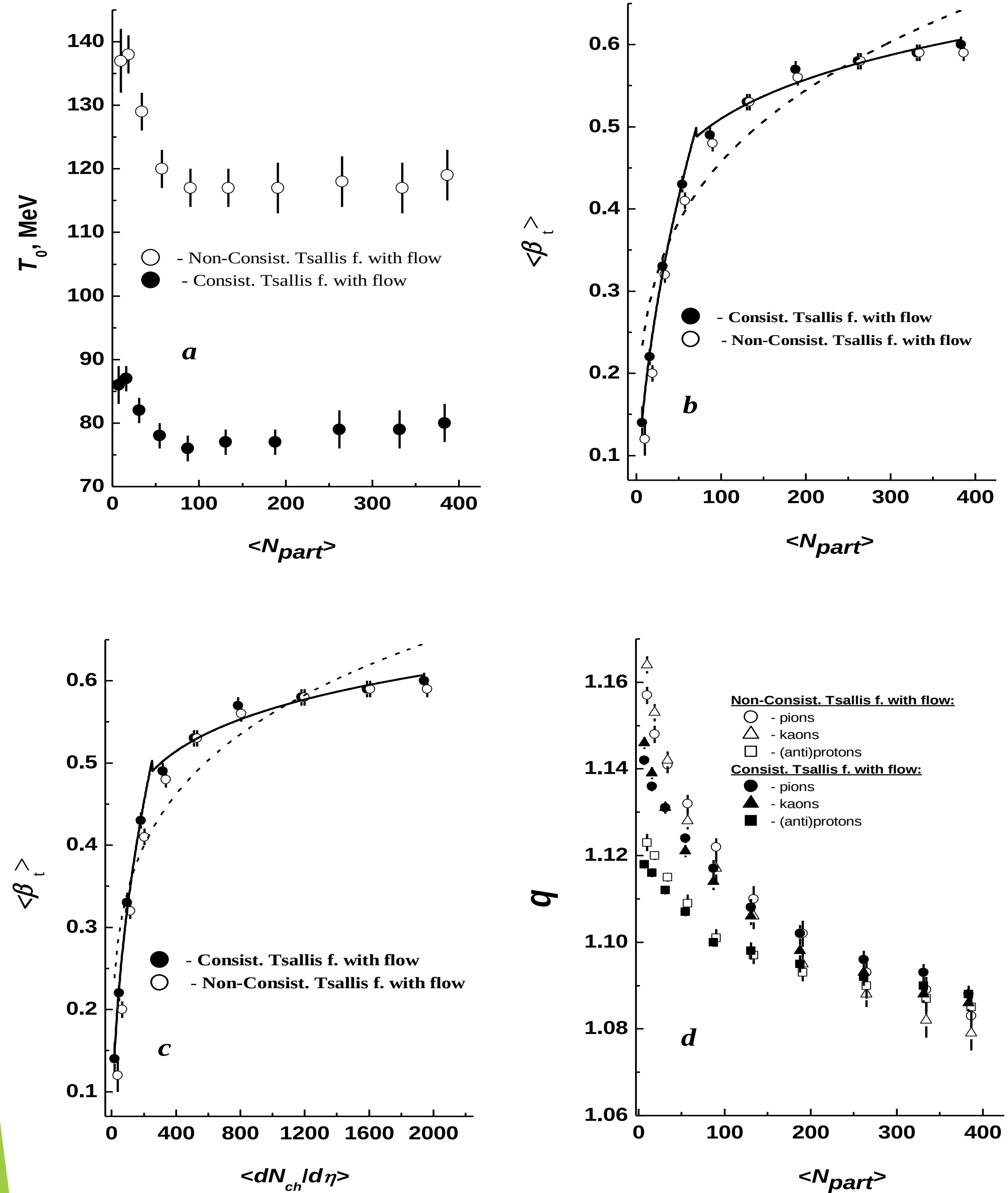


Figure. The $\langle N_{part}\rangle$ dependencies of the obtained T_0 (*a*) and $\langle\beta_t\rangle$ (*b*) parameters (●) of consistent Tsallis function with transverse flow in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV; (*c*) – the $\langle\beta_t\rangle$ versus $\langle dN_{ch}/d\eta\rangle$ dependence; (*d*) – The $\langle N_{part}\rangle$ dependence for the extracted *q* values of consistent Tsallis function with transverse flow for the charged pions (●) and kaons (▲), protons and antiprotons (■). The results extracted for the respective particles in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV using non-consistent Tsallis function with transverse flow are plotted by the corresponding open symbols.

Significantly differing growth rates of $\langle\beta_t\rangle$ in regions $\langle N_{part}\rangle$ < 71±7 ($\langle dN_{ch}/d\eta\rangle$ < 251±20) and $\langle N_{part}\rangle$ > 71±7 ($\langle dN_{ch}/d\eta\rangle$ > 251±20) with T_0 staying constant within uncertainties in region $\langle N_{part}\rangle$ > 71±7 ($\langle dN_{ch}/d\eta\rangle$ > 251±20) probably indicates that $\langle N_{part}\rangle \approx$ 71±7 ($\langle dN_{ch}/d\eta\rangle \approx$ 251±20) is a threshold border value for a crossover transition from a dense hadronic state to the QGP phase (or mixed phase of QGP and hadrons) in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV.

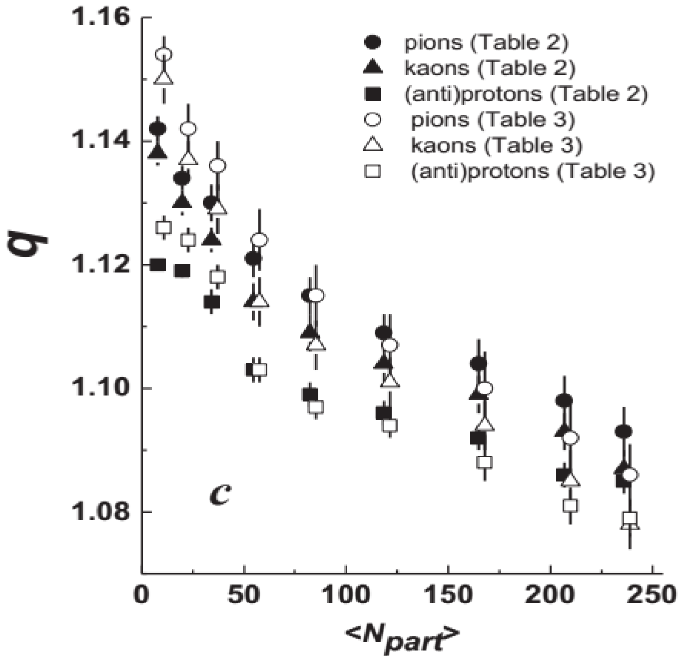
The threshold border value $\langle\beta_t\rangle \approx$ 0.46±0.03 (corresponding to $\langle N_{part}\rangle \approx$ 71±7 and $\langle dN_{ch}/d\eta\rangle \approx$ 251±20) in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV has agreed well with the corresponding border value $\langle\beta_t\rangle \approx$ 0.44±0.02, obtained by us in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV.

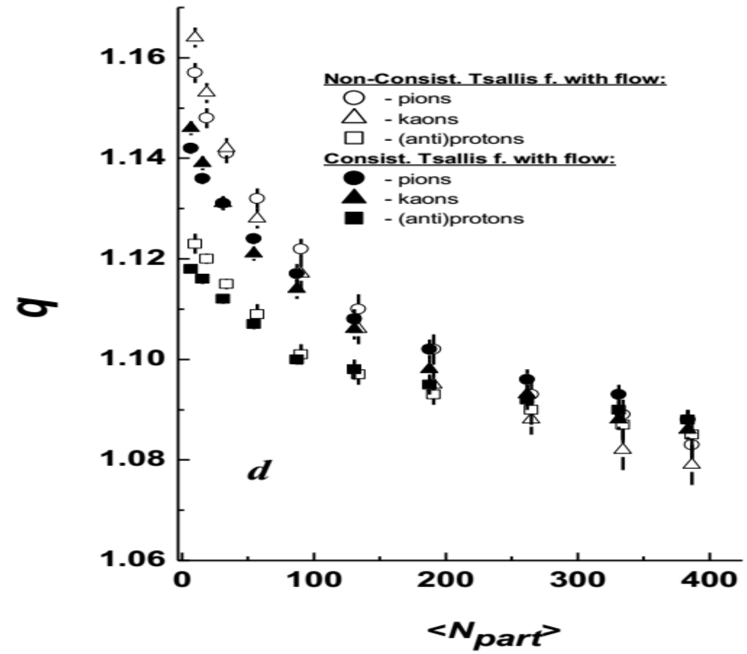
- The threshold border value $\langle \beta_t \rangle \approx 0.46 \pm 0.03$ (corresponding to $\langle N_{part} \rangle \approx 71 \pm 7$ and $\langle dN_{ch}/d\eta \rangle \approx 251 \pm 20$), estimated in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV in Ref. [1] has agreed well with the corresponding border value $\langle \beta_t \rangle \approx 0.44 \pm 0.02$, obtained in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV in Ref. [2], and with almost constant $\langle \beta_t \rangle$ values extracted in Ref. [3] in the BES program at the RHIC in central Au+Au collisions in $(s_{nn})^{1/2}$ = 7.7–39 GeV energy range, where the threshold for QGP production has been reached.

[1.] Kh. K Olimov *et al.*, Midrapidity p_T Distributions of Identified Charged Particles in Pb + Pb Collisions at $(s_{nn})^{1/2}$= 5.02 TeV Using Tsallis Distribution with Embedded Transverse Flow, ***Universe*** **8**, 401 (2022). https://doi.org/10.3390/universe8080401

[2.] Kh. K Olimov *et al.*, Study of midrapidity p_t distributions of identified charged particles in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV using non-extensive Tsallis statistics with transverse flow, ***Modern Physics Letters A 37***, 2250095 (2022). https://doi.org/10.1142/S021773232250095X

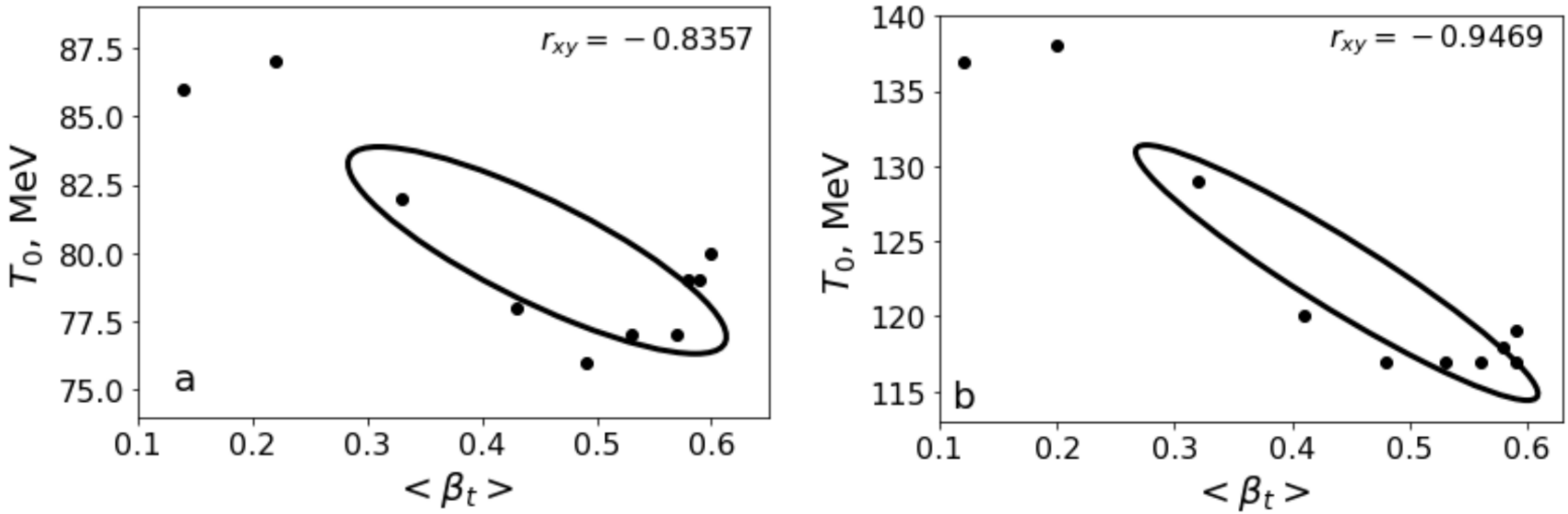
[3.] STAR Collaboration, Adamczyk, L.; *et al*. Bulk Properties of the Medium Produced in Relativistic Heavy-Ion Collisions from the Beam Energy Scan Program. *Phys. Rev. C* 2017, *96*, 044904. arXiv:1701.07065 [nucl-ex].





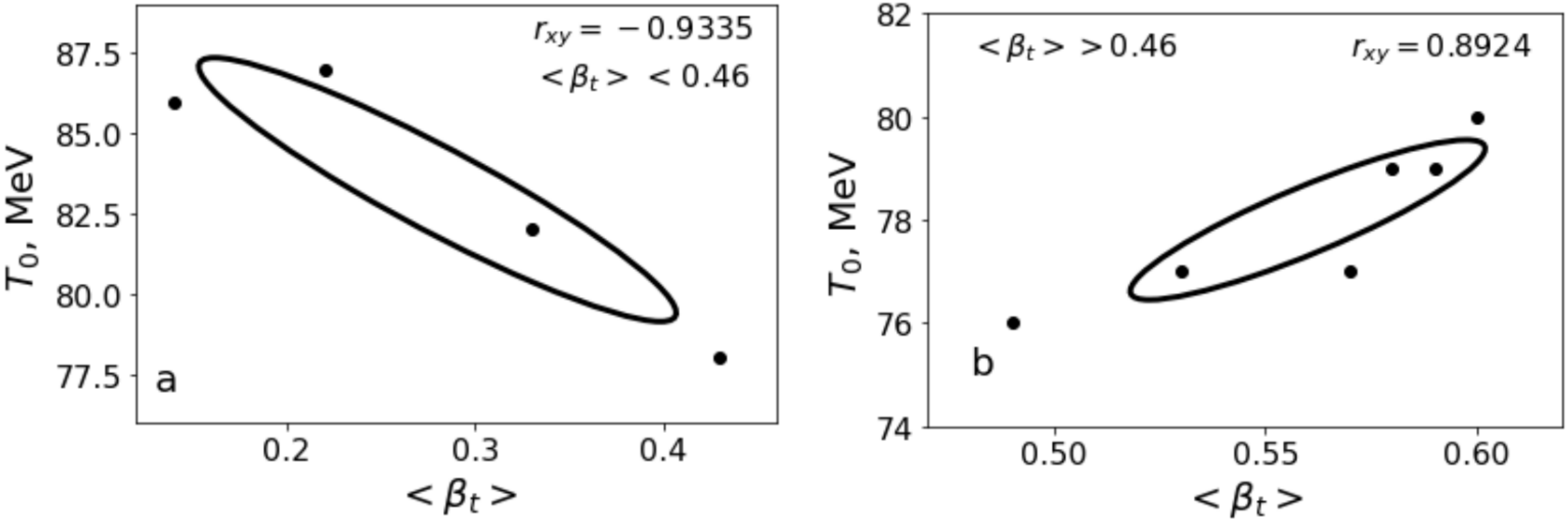
The non-extensivity parameter q demonstrates a systematic decrease with increasing $\langle N_{part} \rangle$ (collision centrality) for all studied particle species in both Xe+Xe (left figure) and Pb+Pb (right figure) collisions at the LHC. This observation is in agreement with the known fact that the degree of thermalization of the system grows with increasing centrality of heavy-ion collisions at high energies.

The gap between q(mesons) and q(baryons) decreases with an increase in collision centrality, and q(mesons) practically coincides within uncertainties with q(baryons) in central Xe+Xe (left figure) and Pb+Pb (right figure) collisions with large $\langle N_{part} \rangle$ values at the LHC. This could indicate quite large degree of equilibrium and thermalization of QGP produced in central Xe+Xe and Pb+Pb collisions with large $\langle N_{part} \rangle$ values at the LHC.



The 1-sigma confidence ellipse (corresponding to 68% confidence interval) of the covariance of the parameters T_0 and $\langle\beta_t\rangle$ and the calculated Pearson correlation coefficient, r_{xy}, between T_0 and $\langle\beta_t\rangle$ in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV are shown in the figures.

The orientations and shapes of the confidence ellipses and values of Pearson correlation coefficient r_{xy} on Left (a) and Right (b) Figures show the high degree of anticorrelation (negative correlation) between parameters T_0 and $\langle\beta_t\rangle$ extracted from fits by both consistent and non-consistent Tsallis functions with transverse flow.



It is observed that not only the parameter $\langle\beta_t\rangle$ shows significantly differing growth rates in regions $\langle N_{part}\rangle$ < 71±7 ($\langle dN_{ch}/d\eta\rangle$ < 251±20) and $\langle N_{part}\rangle$ > 71±7 ($\langle dN_{ch}/d\eta\rangle$ > 251±20), but also the character of correlation between parameters T_0 and $\langle\beta_t\rangle$ differs much in the corresponding intervals $\langle\beta_t\rangle$ < 0.46 and $\langle\beta_t\rangle$ > 0.46 in Pb+Pb collisions at the LHC.

This supports further our conjecture that $\langle N_{part}\rangle \approx$ 71±7 ($\langle dN_{ch}/d\eta\rangle \approx$ 251±20) is probably a threshold border value for a crossover transition from a dense hadronic (nucleon) state to the QGP phase (or mixed phase of QGP and hadrons) in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV.

Also in Xe+Xe collisions at the LHC - the degree of correlation between parameters T_0 and $\langle\beta_t\rangle$ differs much in the corresponding intervals $\langle\beta_t\rangle$ < 0.44 and $\langle\beta_t\rangle$ > 0.44.

The threshold border values of $\langle N_{part}\rangle$, $\langle dN_{ch}/d\eta\rangle$, and $\langle \beta_t\rangle$ estimated in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV and compared with those extracted in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV. The ratios of the corresponding quantities for two collision types are given in the last column.

Quantity	Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV [24]	Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV	$\frac{Pb+Pb}{Xe+Xe}$
$\langle N_{part}\rangle$	44±5	71±7	1.61±0.24
$\langle dN_{ch}/d\eta\rangle$	158±20	251±20	1.59±0.24
$\langle \beta_t\rangle$	0.44±0.02	0.46±0.03	1.07±0.08

It is interesting to compare these ratios for border values of $\langle N_{part}\rangle$ as well as $\langle dN_{ch}/d\eta\rangle$ with the ratio of the mass numbers of the corresponding ^{208}Pb and ^{132}Xe nuclei equal to $\frac{A(208_{Pb})}{A(132_{Xe})} \approx 1.58$.

All three ratios practically coincide with each other satisfying the relation

$$\frac{\langle N_{part}\rangle_{Pb+Pb}}{\langle N_{part}\rangle_{Xe+Xe}} \approx \frac{\langle dN_{ch}/d\eta\rangle_{Pb+Pb}}{\langle dN_{ch}/d\eta\rangle_{Xe+Xe}} \approx \frac{A(208_{Pb})}{A(132_{Xe})} \approx 1.6$$

SUMMARY AND CONCLUSIONS

- *We have analyzed successfully the midrapidity p_t distributions of the charged pions and kaons, protons and antiprotons, measured by ALICE Collaboration at various centrality classes of Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV and Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV, applying combined minimum χ^2 fits with the thermodynamically non-consistent as well as thermodynamically consistent Tsallis function with transverse flow.*

- *We have estimated the threshold border values of $\langle N_{part} \rangle$, $\langle dN_{ch}/d\eta \rangle$, and $\langle \beta_t \rangle$ for a crossover transition from a dense hadronic state to the QGP phase (or mixed phase of QGP and hadrons) in Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV and Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV.*

- *The ratio (1.61±0.24) of the estimated border values of $\langle N_{part} \rangle$ in Pb+Pb collisions at $(s_{nn})^{1/2}$=5.02 TeV and Xe+Xe collisions at $(s_{nn})^{1/2}$=5.44 TeV has coincided with the ratio (1.59±0.24) of the corresponding $\langle dN_{ch}/d\eta \rangle$ in these two collision types, and with the ratio of the mass numbers of the corresponding ^{208}Pb and ^{132}Xe nuclei equal to $\frac{A(208_{Pb})}{A(132_{Xe})} \approx 1.58$.*

- *The non-extensivity parameter q demonstrates a systematic decrease with increasing $\langle N_{part} \rangle$ (collision centrality) for all studied particle species in both Xe+Xe and Pb+Pb collisions at the LHC, implying an increase in system thermalization with increasing centrality of heavy-ion collisions at high energies.*

- *The gap between q(mesons) and q(baryons) decreases with an increase in collision centrality, and q(mesons) practically coincides within uncertainties with q(baryons) in central Xe+Xe and Pb+Pb collisions with large $\langle N_{part} \rangle$ values at the LHC. This could indicate quite large degree of equilibrium and thermalization of QGP produced in central Xe+Xe and Pb+Pb collisions with large $\langle N_{part} \rangle$ values.*

- ***THANK YOU VERY MUCH***