Incident Energy Dependence of Transverse Momentum Correlations in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 200 GeV in STAR

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Abstract

It has been proposed that one signal of the critical point could be a non-monotonic change in the value of transverse momentum (p_t) correlations as a function of centrality and/or incident energy [1]. Accordingly, we present results for two-particle p_t correlations as a function of event centrality for Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 39, 62.4 and 200 GeV at RHIC, extending our previous work [2] to lower incident energies. The p_t correlations are calculated as a function of centrality and collision energy. We have studied the energy dependence of the square root of the correlations ($\langle \Delta p_{t,i} \Delta p_{t,j} \rangle$) divided by the event-wise average transverse momentum ($\langle\langle p_t \rangle\rangle$). These results are compared to measurements from other experiments as well as UrQMD model calculations.

[1] H. Heiselberg, Phy. Rep. 351, 161 (2001); [2] STAR: Phys. Rev. C **72,** 044902 (2005); [3] S. Heckel et al. [ALICE Collaboration], J. Phys.G: Nucl. Part. Phys. 38 (2011) 124095; [4] D. Adamova et al. [CERES Collaboration], Nucl. Phys. A727, 97 (2003)

Motivation

This is a critical point search

We are looking for "a nonmonotonic change in p_t correlations as a function of centrality and/or as the incident energy is raised"

Phys. Rev. C 72, 044902 (2005)

Nonmonotonic behavior of any fluctuation observable could be indicative of the critical point.

Definitions

Two-particle p_t correlation:

$$\left\langle \Delta p_{t,i} \Delta p_{t,j} \right\rangle = \frac{1}{N_{event}} \sum_{k=1}^{N_{event}} \frac{C_k}{N_K (N_k - 1)}$$

$$C_k = \sum_{i=1}^{N_k} \sum_{j=1, i \neq j}^{N_k} \left(p_{t,i} - \left\langle \left\langle p_t \right\rangle \right\rangle \right) \left(p_{t,j} - \left\langle \left\langle p_t \right\rangle \right\rangle \right)$$

$$\left\langle \left\langle p_t \right\rangle \right\rangle = \left(\sum_{k=1}^{N_{event}} \left\langle p_t \right\rangle_k \right) \Big/ N_{event} \qquad \left\langle p_t \right\rangle_k = \left(\sum_{i=1}^{N_k} p_{t,i} \right) \Big/ N_k$$

To remove non-statistical fluctuations in $\langle\langle p_t \rangle\rangle$ arising from variations in centrality, $\langle\langle p_t \rangle\rangle$ was calculated as a function of event multiplicity.

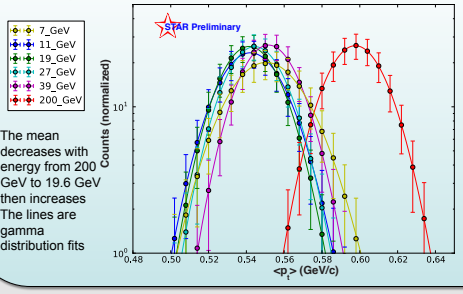
Methodology

The average p_t per event is calculated as a function of the multiplicity and the correlation parameter is calculated with respect to the average p_t.

Analysis Cuts

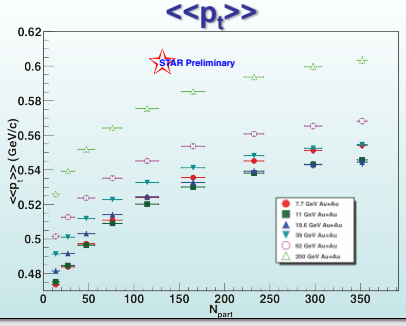
p_t range: 0.15 GeV/c < p_t < 2.0 GeV/c
|DCA| < 1 cm
V_R < 2 cm
|η| < 1
Required at least one TOF hit

$\langle p_t \rangle$ Spectra – Central Bin

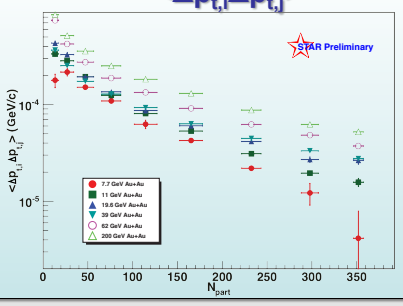


- The mean decreases with energy from 200 GeV to 19.6 GeV then increases
- The lines are gamma distribution fits

$\langle\langle p_t \rangle\rangle$



$\langle \Delta p_{t,i} \Delta p_{t,j} \rangle$



Motivation for Scaling

$\langle \Delta p_{t,i} \Delta p_{t,j} \rangle$ is a parameter which is sensitive to energy and centrality. It may also be sensitive to other event parameters. Scaling isolates non-trivial signals.

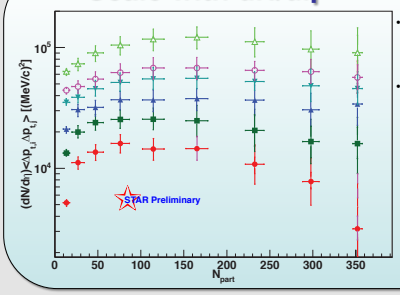
Scaling observable with multiplicity to remove 1/N scaling

$$\frac{dN}{d\eta} \left\langle \Delta p_{t,i} \Delta p_{t,j} \right\rangle$$

Scaling with average transverse momentum to remove energy and centrality dependence of p_t

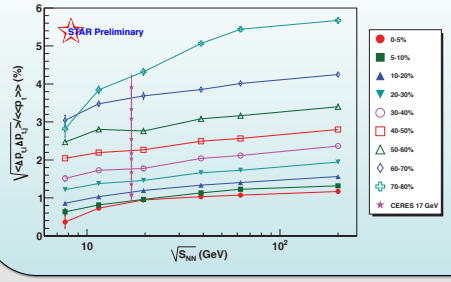
$$\sqrt{\left\langle \Delta p_{t,i} \Delta p_{t,j} \right\rangle} \Big/ \left\langle \left\langle p_t \right\rangle \right\rangle$$

Scale with dN/dη

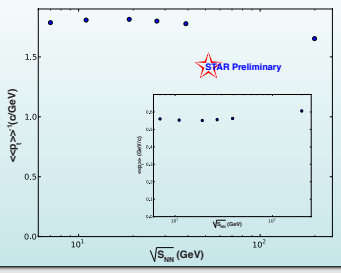


- Correlation observable scaled with multiplicity
- The multiplicity values used in this calculation are uncorrected

Scaled with $\langle\langle p_t \rangle\rangle$

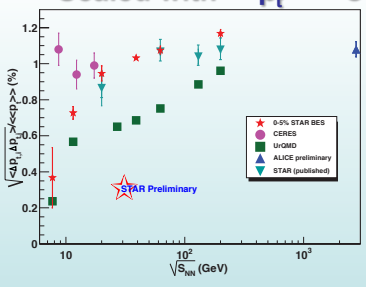


$\langle\langle p_t \rangle\rangle^{-1}$ - Central Bin



- Below 19.6 GeV $\langle\langle p_t \rangle\rangle$ increases with decreasing energy
- the scale of variation is much smaller than that seen in $\sqrt{\langle \Delta p_{t,i} \Delta p_{t,j} \rangle} / \langle\langle p_t \rangle\rangle$
- The inset shows $\langle\langle p_t \rangle\rangle$ for the central bin as a function of $\sqrt{s_{NN}}$

Scaled with $\langle\langle p_t \rangle\rangle$ - Central Bin



- Scaled correlations strongly decrease with decreasing energy below 39 GeV
- We agree with previous STAR results
- UrQMD reproduces the trend of these data.
- We are in disagreement with CERES
- Our disagreement with CERES may be due to acceptance effects or differences in the p_t cut
- CERES used: 0.1GeV/c < p_t < 1.5 GeV/c

Summary

- **The quantity $\sqrt{\langle \Delta p_{t,i} \Delta p_{t,j} \rangle} / \langle\langle p_t \rangle\rangle$ decreases strongly with incident energy below 39 GeV**
- **No non-monotonic behavior is observed in $\langle \Delta p_{t,i} \Delta p_{t,j} \rangle$**

CERES Data points: D. Adamova et al. [CERES Collaboration], Nucl. Phys. A727, 97 (2003)
ALICE Data point: S. Heckel et al. [ALICE Collaboration], J. Phys.G: Nucl. Part. Phys. 38 (2011) 124095

The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations