Directed Flow of Identified Particles in Au +Au Collisions at $\sqrt{s_{NN}}$ = 39,11.5 and 7.7 GeV from the STAR Experiment

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Abstract

Measurements of anisotropic flow in heavy-ion collisions provide insight into the early stage of the system's evolution. Directed flow, v_1, is imparted especially early. A change of sign in the slope of dv_1/dy for identified particles, particularly for protons, has been suggested as a possible signal of a first-order phase transition. In this poster, we present the STAR measurements of v_1 for $\pi^{\pm}$,$K^{\pm}$, protons and antiprotons, as well as for all detected charged particles in Au + Au collisions at $\sqrt{s_{NN}}$ = 39, 11.5 and 7.7 GeV as a function of transverse momentum, rapidity and centrality. At $\sqrt{s_{NN}}$ = 39 GeV, all measured $v_1$values follow the trend observed at higher RHIC energies. At $\sqrt{s_{NN}}$ = 11.5 and 7.7 GeV, the proton dv_1/dy near midrapidity changes sign between peripheral and central collisions. This behavior is not observed for antiprotons, $\pi^{\pm}$ and $K^{\pm}$.

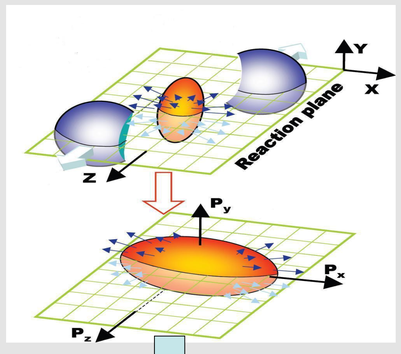
Motivation

Anisotropic flow:

$$E\frac{d^3N}{d^3p} \propto \left(1+\sum_{n=1}^{\infty} 2v_n \cos n(\phi-\Psi_r)\right)$$

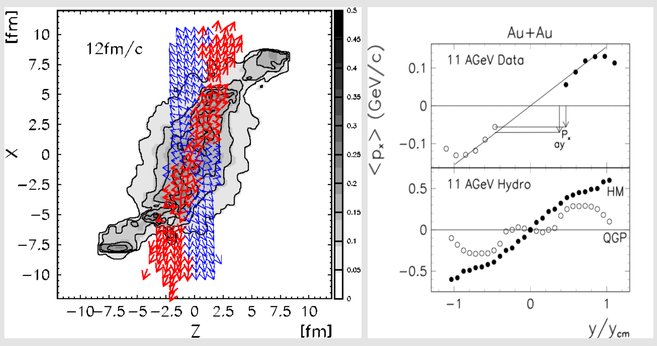
$$v_n = \langle \cos n(\phi-\Psi_r)\rangle$$

$$\phi = \tan^{-1}\left(\frac{p_y}{p_x}\right)$$



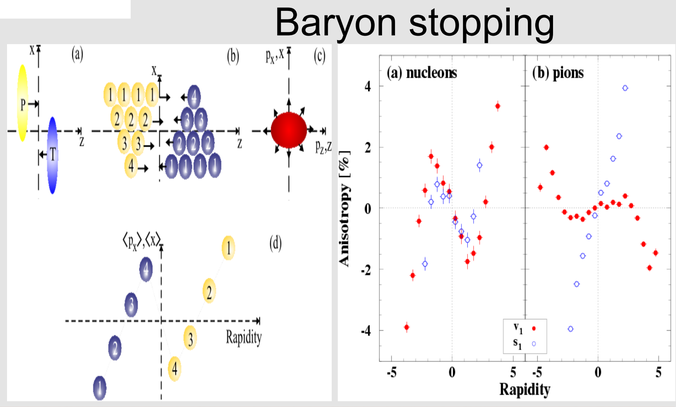
Directed flow ,v_1,describes the sideward motion of the particles in ultra-relativistic nuclear collisions, and it carries early information from the collision[1,2]

Anti-flow



Anti-flow/3rd flow component, with QGP ⇒ v_1 flat at midrapidity[3-5]

Baryon stopping

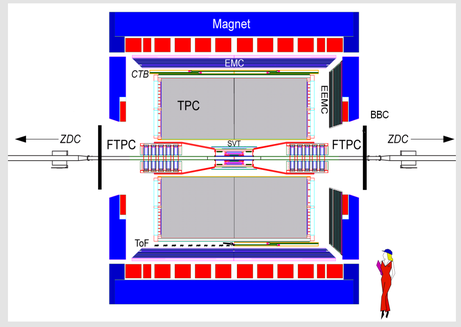


Positive space-momentum correlation, no QGP necessary ⇒ v_1 wiggle.[6]

To distinguish between baryon stopping and anti-flow associated with a phase transition, it is desirable to measure the *$v_1(y)$ for identified particles and compare the sign of their slopes at midrapidity.*

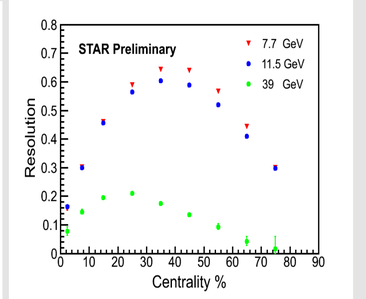
Experiment

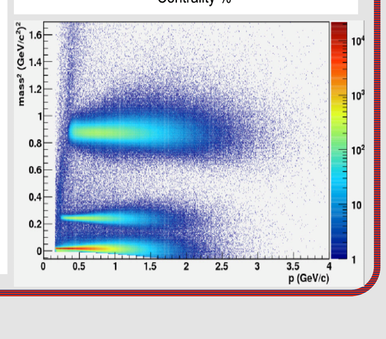
STAR Detector at RHIC:



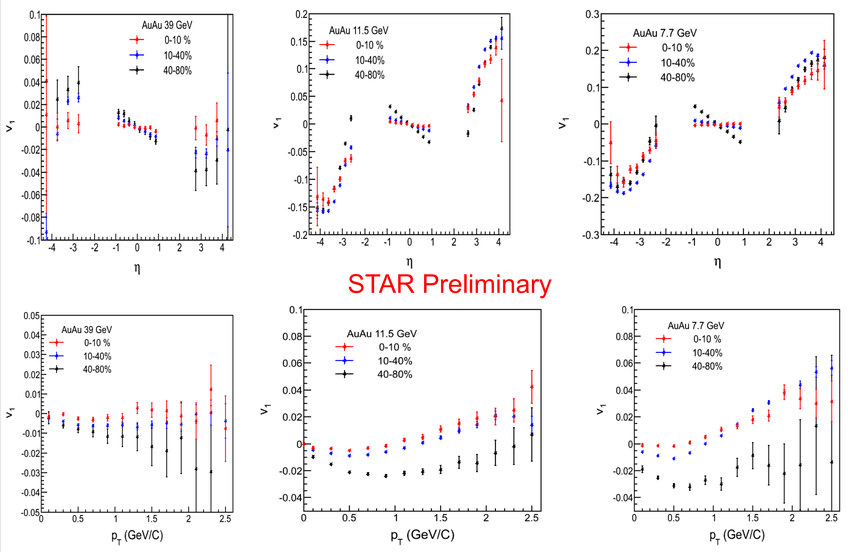
- Time Projection Chamber(TPC) is main tracking detector at STAR.
- Forward TPC also provides tracking at forward rigidities

- Beam Beam Counters(BBC) (3.3<|η|<5.0) are used to reconstruct the first-order event plane at 39 GeV and lower beam energies, provides very good event plane resolution
- Reduced non-flow effects in v_1 study because of eta gap between TPC and BBC
- Time of Flight(TOF) provides excellent particle identification p_T < 1.6 GeV for pions (-0.10<m^2<0.10) and kaons (0.20<m^2<0.35) and p_T<2.8 GeV for protons(0.8<m^2<1.0)

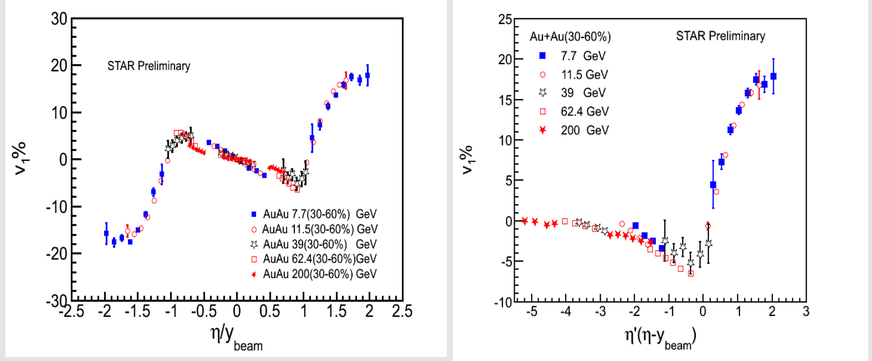




Result: Charged Particles

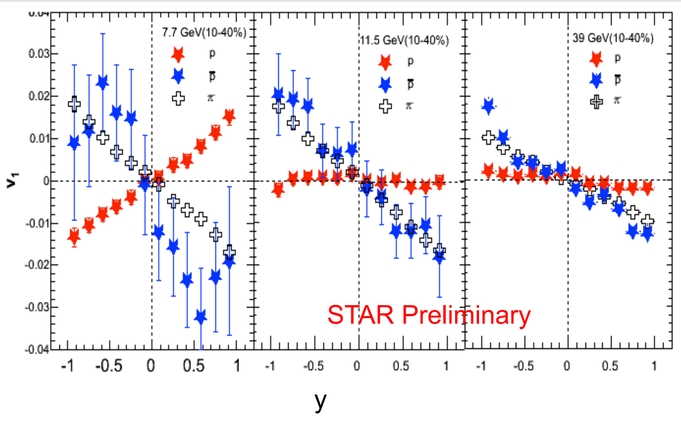


Beam Energy Dependence [9]:

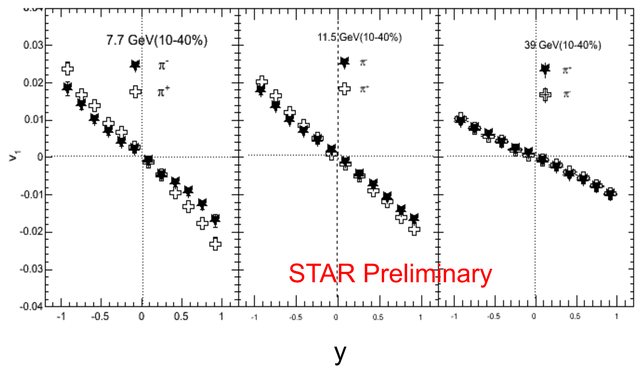


Identified Particles

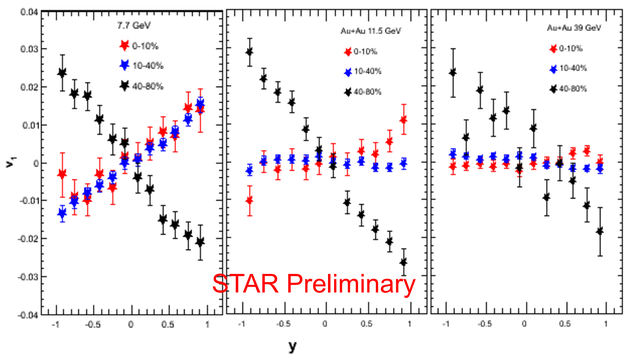
Directed flow of Identified Particles



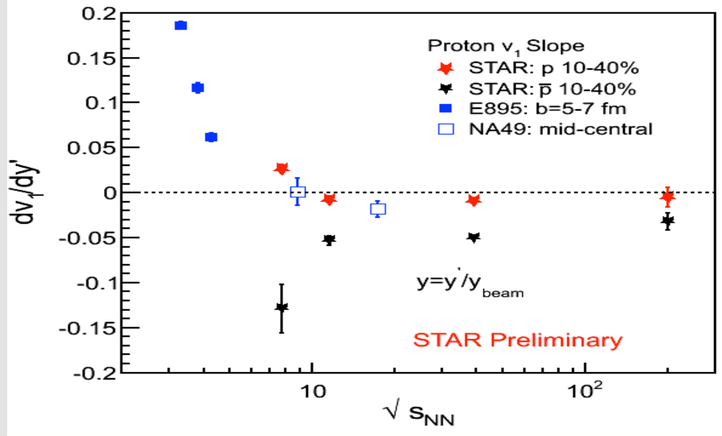
Directed flow of π^+ and π^-



Centrality Dependence of Proton v_1



Beam Energy Dependence : Proton v_1 slope[7,8]:



Summary

- Beam energy dependence of directed flow is observed for BES data, a similar observation shown by data at 62.4 & 200 GeV.
- Differences in Directed flow of h^+ and h^- decreases with increase in beam energy
- For mid central collisions (10-40%) the $\pi^{\pm}$,$K^{\pm}$ (not shown here) and anti protons have a negative dv_1/dy slope at mid rapidity but proton dv_1/dy slope at 7.7 GeV becomes positive .
- Proton v_1 slope changes sign from positive to negative going from central to peripheral collisions at mid central collision at 7.7 and 11.5 GeV. At 39 GeV and higher RHIC energies we do not observe such phenomena.
- The proton v_1(y') slope decreases rapidly with increasing energy, reaching zero around $\sqrt{s_{NN}}$=9GeV. Its sign changes to negative and remains close to zero at 11.5 ,17, 39 and 200GeV

Reference

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

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