Elliptic Flow of charged particles in Au+Au collisions at 7.7, 11.5 and 39 GeV from STAR

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Abstract: *The study of elliptic flow and non-flow effects over a wide energy range can provide information on the onset of collective effects in heavy-ion collisions. In 2010, STAR collected high-statistics data samples at lower RHIC energies at $\sqrt{s_{NN}}$ = 7.7, 11.5 and 39 GeV. We will present measurements of charged particle elliptic flow using the event-plane ($v_2\{EP\}$) determined from detectors separated in η, 2-particle ($v_2\{2\}$) and 4-particle ($v_2\{4\}$) correlation methods integrated over p_t and η. The difference between $v_2\{2\}$ and $v_2\{4\}$ decreases with decreasing beam energy. We will present the difference between $v_2\{2\}^2$ and $v_2\{4\}^2$, which is related to v_2 fluctuations (σ_{v2}) and non-flow correlations (δ_2).*

Introduction

- In non-central collisions the coordinate space configuration is anisotropic, but the initial momentum distribution is isotropic.
- Interaction among constituents generates a pressure gradient that transforms the initial coordinate space anisotropy into the observed momentum space anisotropy
  → anisotropic flow
- Elliptic flow (v_2) is sensitive to the shape of the initial overlap zone, so v_2 fluctuations and correlations in the initial geometry will lead to a better understanding of the initial conditions of the collision evolution.
- v_2 is sensitive to the early stage of the collision dynamics
  ⇒ A unique hadronic probe of the early stage of the collision

$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_t dp_t dy}\left(1+\sum_{n=1}^{\infty} 2v_n cos(n(\phi-\Psi_R))\right)$$

The Q-Cumulant method and Non-Flow

- The advantage using the Q-Cumulants, is that it provides fast (one loop over the data) and exact non-biased (no approximations and no interference between different harmonics) estimating the correlator's compared to the Generating Function cumulants (GF-Cumulants).

$$\langle 2\rangle = \left\langle e^{in(\phi_1-\phi_2)}\right\rangle = 2\,\langle\langle 2\rangle\rangle_n^2$$
$$= v_2\{2\}^2 = v_2^2 + \delta_2 + \sigma_{v_2}^2$$
$$\langle 4\rangle = \left\langle e^{in(\phi_1+\phi_2-\phi_3-\phi_4)}\right\rangle = 2\,\langle\langle 2\rangle\rangle_n^2 - \langle\langle 4\rangle\rangle_n^4 = v_2\{4\}^4$$
$$v_2\{4\}^2 \simeq v_2^2 - \sigma_{v_2}^2$$
$$\sigma_{tot}^2 = v_2\{2\}^2 - v_2\{4\}^2 \approx \delta_2 + 2\sigma_{v_2}^2$$

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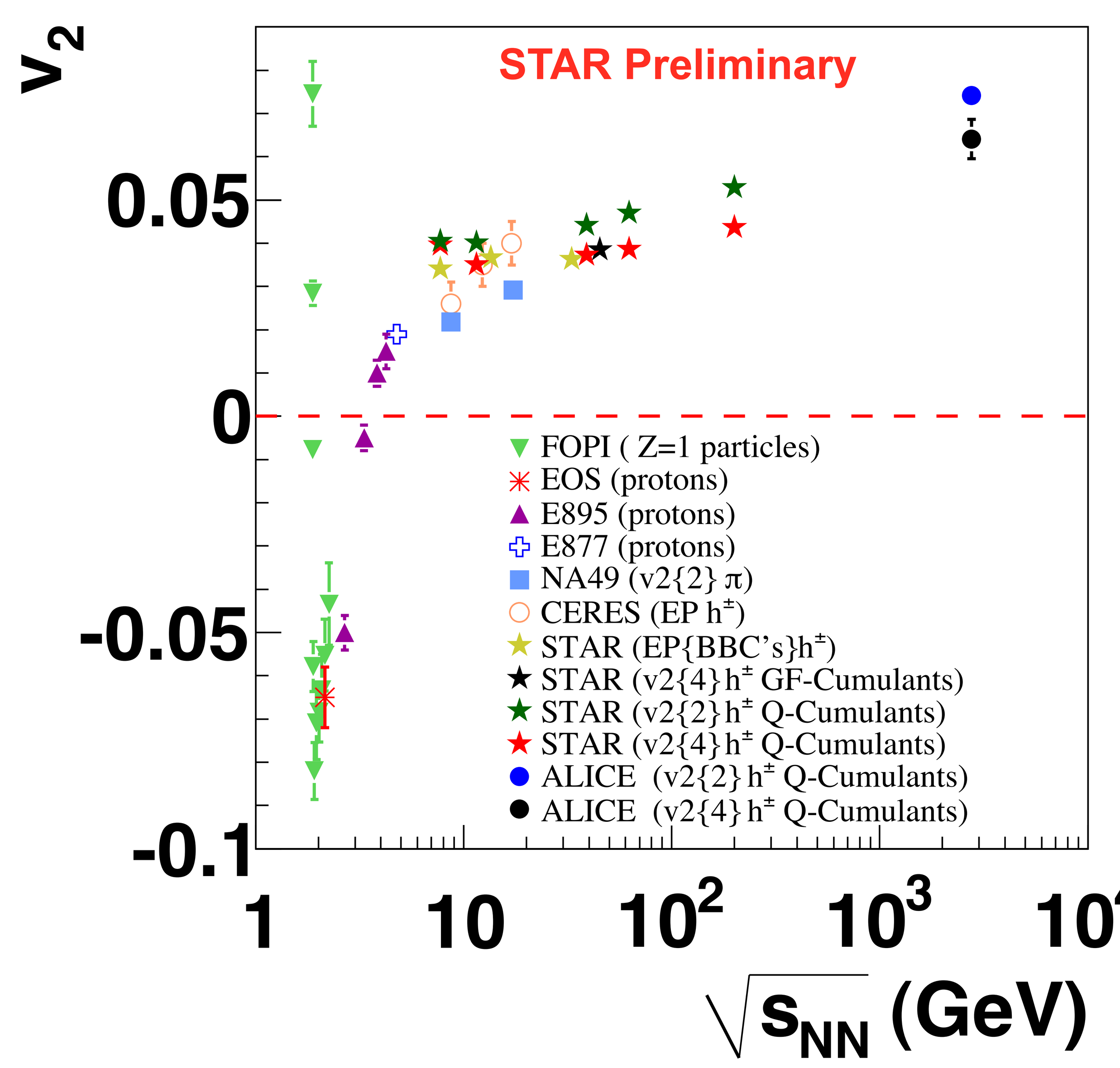
Energy Dependence of integrated charged hadron v_2



Integrated elliptic flow (v_2) of charged hadrons from 7.7 to 200 GeV in 20-30% most central collisions (|η| < 1.0, p_t < 2.0 GeV/c, stat. errors only) compared to measurements at lower and higher energy measurements at similar centralities (For the comparison we corrected the integrated elliptic for the p_t-cutoff of 0.2 GeV/c). (Results on GF-Cumulants see **S. Shi Poster 281, Board #16**)

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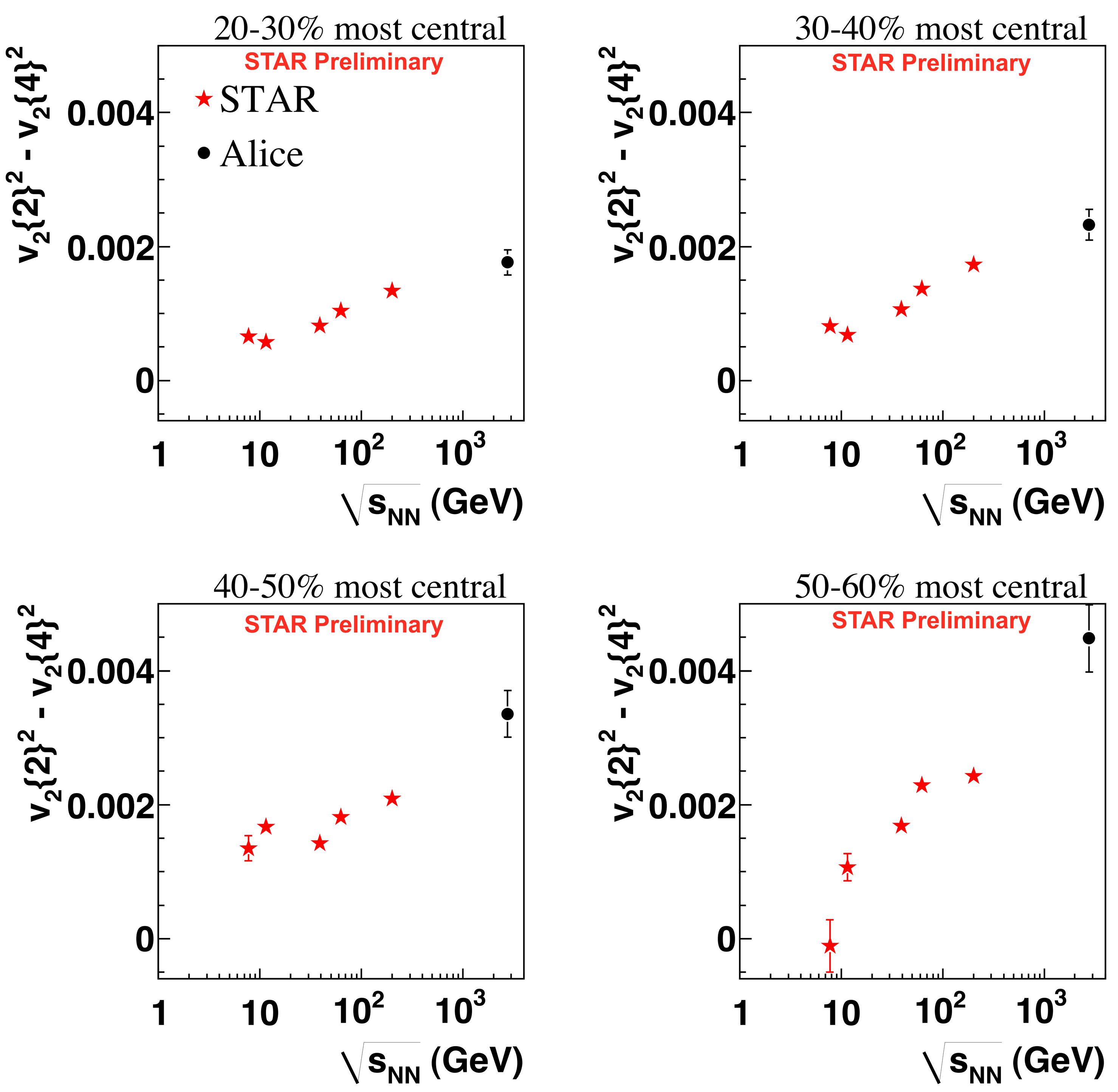
K. Aamodt et al. (ALICE Collaboration), Phys. Rev. Lett. **105**, 252302 (2010)

Energy Dependence of σ_{tot}^2



Energy dependence of $v_2\{2\}^2$ - $v_2\{4\}^2$ of charged hadrons from 7.7 to 200 GeV (|η| < 1.0 and p_t = 0.2-2.0 GeV/c, stat. errors only) for different centralities compared to measurements from ALICE.

K. Aamodt et al. (ALICE Collaboration), Phys. Rev. Lett. **105**, 252302 (2010)

Summary

- We presented new results on integrated v_2 and non-flow/fluctuations versus energy.
- Weak energy dependence of $v_2\{2\}$ and $v_2\{4\}$ from 7.7 - 39 GeV is observed.
- $v_2\{2\}$ and $v_2\{4\}$ is increase between 39 GeV and LHC energies.
- Weak energy dependence of $v_2\{2\}^2$ - $v_2\{4\}^2$ between 7.7 - 39 GeV for 20-30% 30-40% and 40-50% central collisions. Turn on of jets or increase in conversion of initial density fluctuations into momentum space?
- Possible sensitivity to EOS needs to be further investigated.
- STAR recently collected data at 19.6 GeV.
- Data at ~5 and 27 GeV is needed.