Azimuthal anisotropy measurements from cumulants in PHENIX

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Outline

- Introduction to the cumulant method
- Simulation results
- Experimental results: Au+Au and p+p
- Conclusions and outlook

Measuring azimuthal anisotropy using cumulants

- Cumulants of multiparticle correlations are related to azimuthal anisotropy (**N.Borghini, P.M. Dinh, J.-Y Ollitrault Phys.Rev.C 63, 054906 (2001); Phys.Rev.C 64 054901 (2001)**)
- Second order cumulant

$$\langle\langle e^{2i(\phi_1-\phi_2)}\rangle\rangle \equiv c_2\{2\} = v_2^2$$

harmonic order

- Cumulants for the integral and differential anisotropy generated by generating functions

- Expansion of the average of the generating function over events defines the cumulants, which are related to azimuthal anisotropy

Acceptance corrections

- Acceptance/efficiency corrections implemented by a Fourier fit of particle distributions

$$A(\phi) = \sum_{k=-\infty}^{k=+\infty} a_k e^{ik\phi}$$

- Non-isotropic acceptance

  => mixing of different harmonics

  => modified relations between cumulants and v_2

- 2nd order cumulant $c_2\{2\} = v_2^2$ (for perfect acceptance)

  becomes

$$c_2\{2\} = k_1 v_1^2 + k_2 v_2^2$$ (for non-isotropic acceptance)

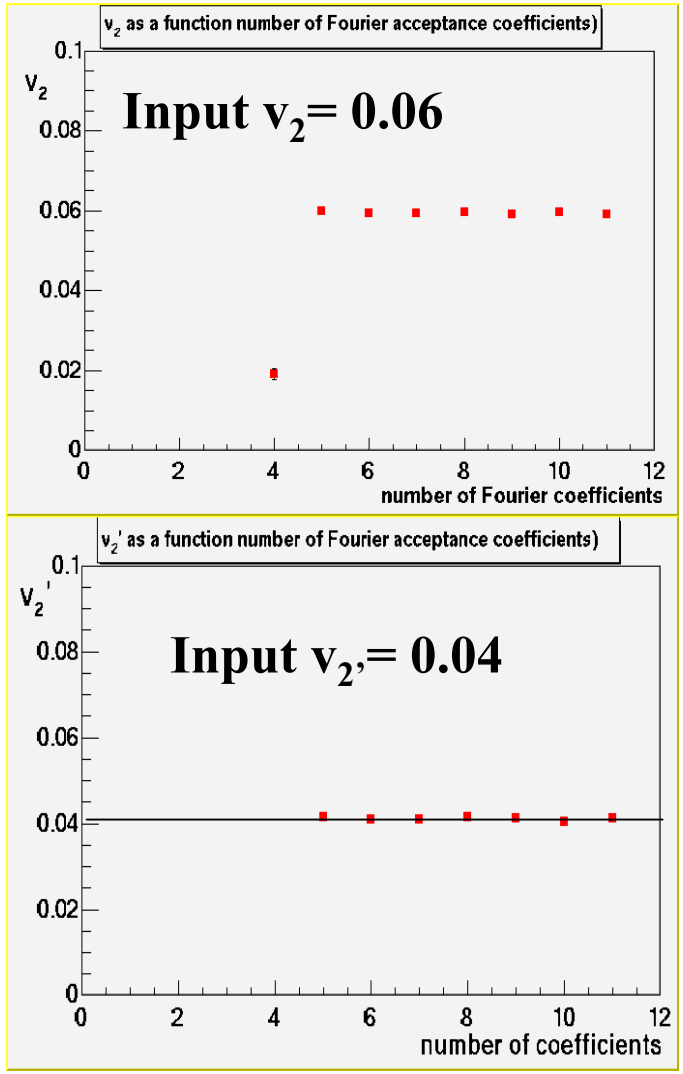
where k_1 and k_2 are functions of the extracted Fourier coefficients a_k

- Similarly $c_1\{2\} = k_1' v_1^2 + k_2' v_2^2$

- Combining the equations above gives v_2 in terms of $c_1\{2\}$ and $c_2\{2\}$

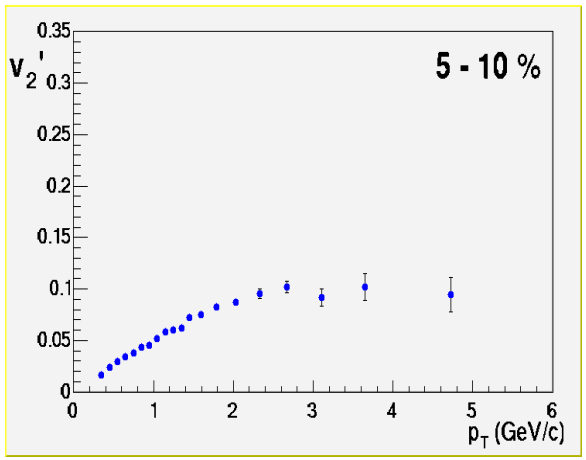
Simulations

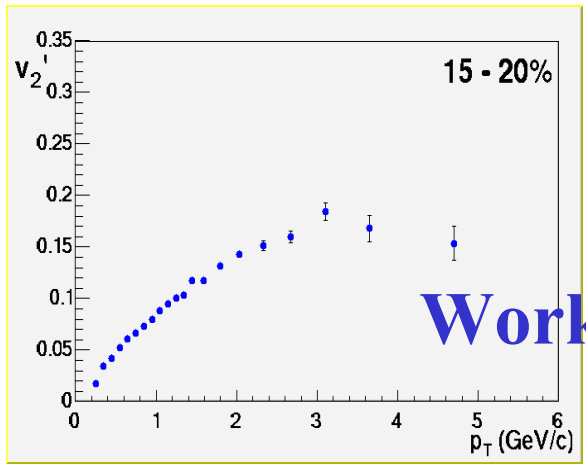
- Monte Carlo simulations performed
- Events were generated in which particles were sampled at random with given v_2
- Sampling weighted by a probability function extracted from measured azimuthal distributions
- Results show the reliability of the method when applied to PHENIX

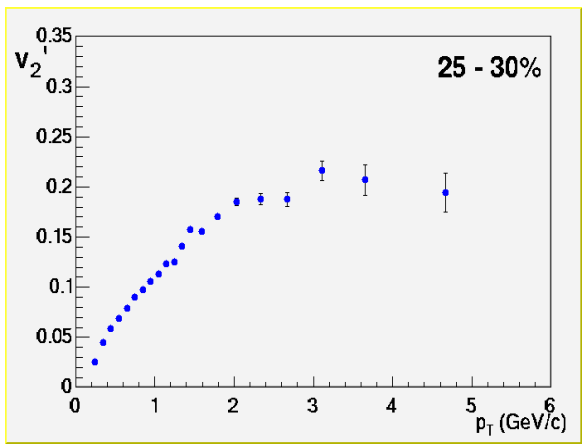


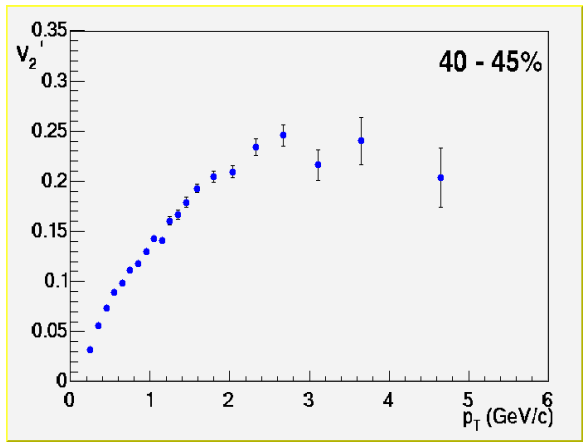
v_2 extracted as a function of number of Fourier correction coefficients

p_T dependence of v_2





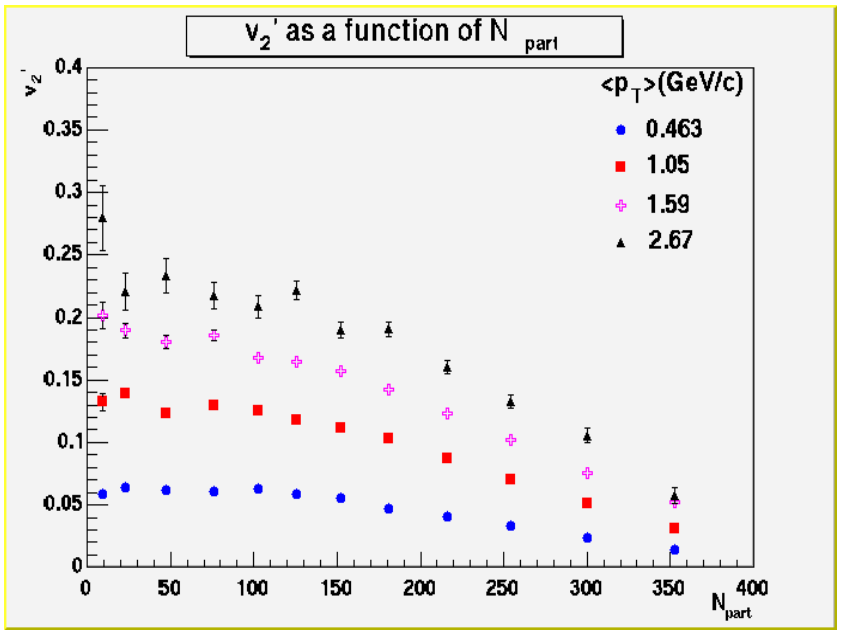




Work in progress

- Analysis performed with 5% centrality bins
- Results compare favorably with other analysis methods

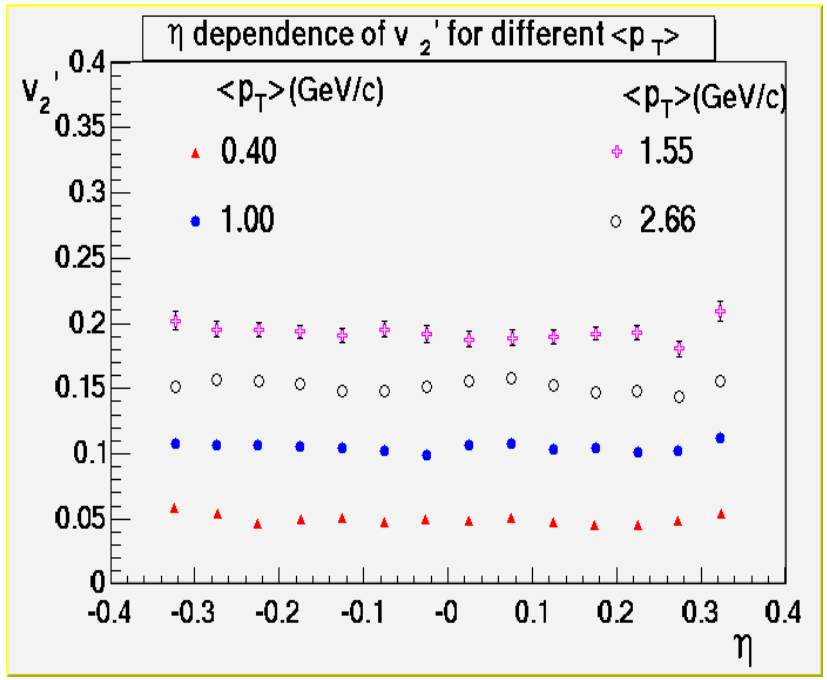
Centrality and pseudo-rapidity dependence of v_2



v_2 as a function of N_{part} for different $\langle p_T \rangle$

- Trend appears to be different at high $\langle p_T \rangle$ for peripheral collisions

Work in progress

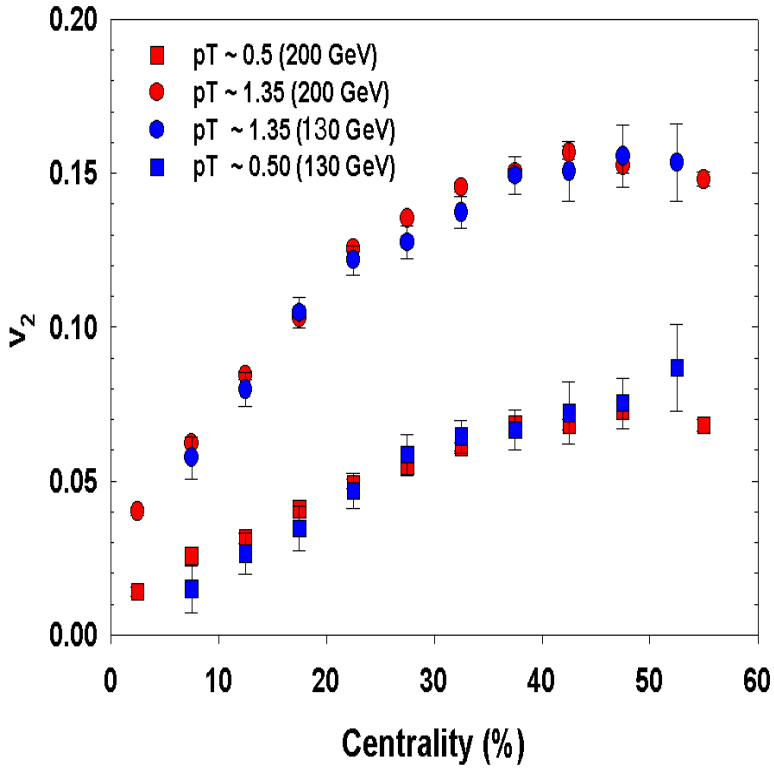


v_2' does not vary over the η range of the detector

Comparison between v_2 at $\sqrt{s_{NN}}$ =130 GeV and 200 GeV

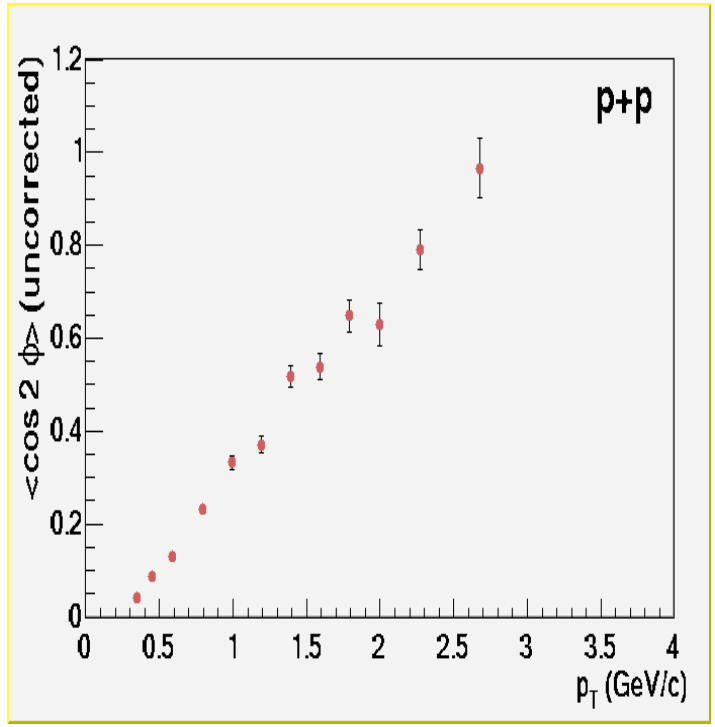
Work in progress

- v_2 similar over a broad range of centralities at 130 GeV and 200 GeV
- Energy dependence of v_2 can be studied in detail
- Results indicate no significant cahnge of v_2 with beam energy/initial energy density



Azimuthal anisotropy from p+p at $\sqrt{\ }$ =200 GeV

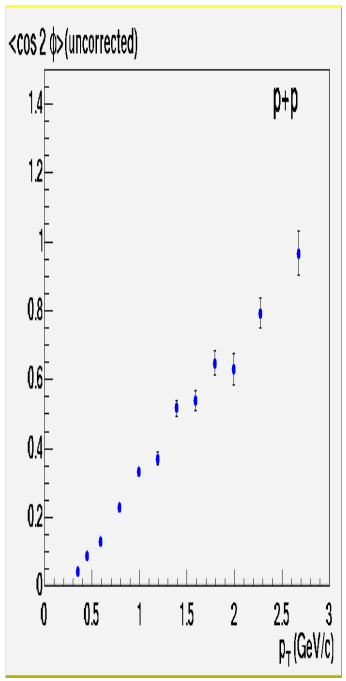
- ~44 million p+p events analyzed
- Azimuthal anisotropy increases with p_T to large values
- Analysis on Pythia events indicates similar trend

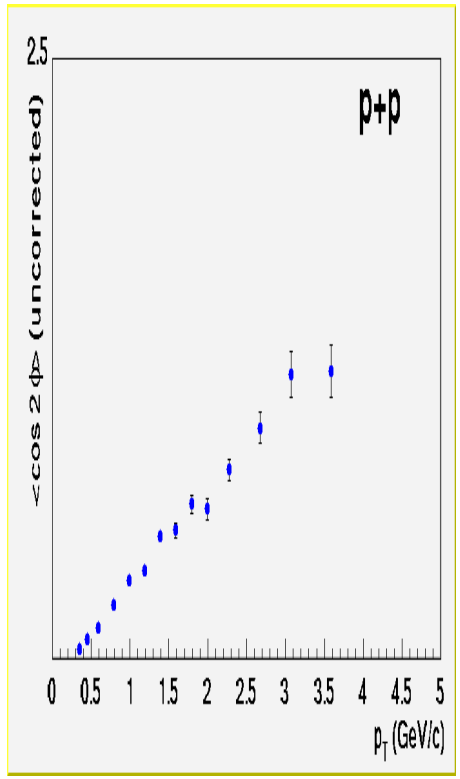


Work in progress

Conclusions and outlook

- Cumulant method: alternative way to measure azimuthal anisotropy
- Method has been successfully applied in PHENIX
- ➢ Acceptance/efficiency corrections implemented easily and are under control
- ➢ Enables a detailed analysis of v_2 as a function of $p_{T,}$, centrality and pseudo-rapidity
- ➢ Results compare well with other methods
- Fourth-order cumulants lead to a removal of direct (non-flow) correlations=>dependent on statistics (are being studied, especially in cases where statistics are not a limitation (HIJING, Pythia)


<cos 2 φ>(uncorrected)
p+p
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.5 1 1.5 2 2.5 3
p_T (GeV/c)


2.5
p+p
<cos 2 φ> (uncorrected)
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
p_T (GeV/c)