

Deciphering Azimuthal Correlations in Relativistic Heavy-Ion Collisions

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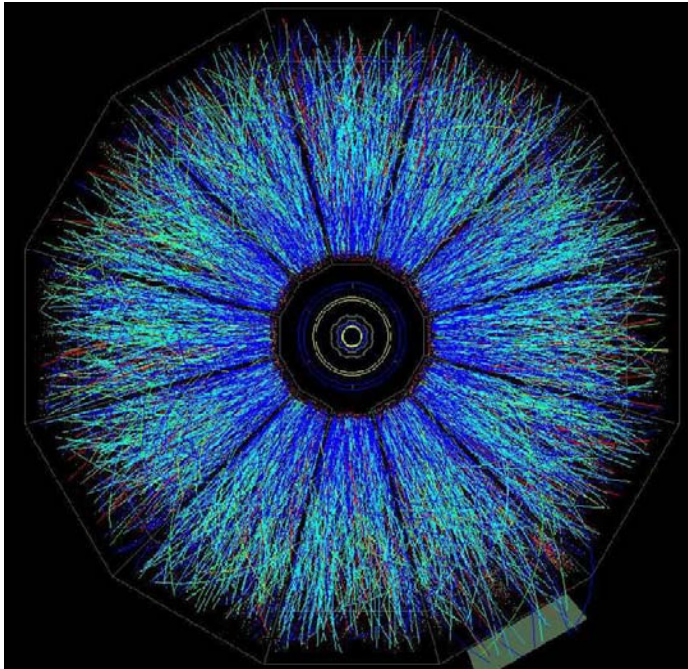
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Various sources of azimuthal correlations



- Jets
- collective flow
- collective flow fluctuations
- resonance decays
- p_T conservation
-

 **STAR experiment @ RHIC**

Au–Au @ $\sqrt{s_{NN}} = 200$ GeV

Integral fluctuation measure Φ

$$\Phi_{\varphi} = \sqrt{\frac{\langle Z \rangle^2}{\langle N \rangle}} - \sqrt{\overline{Z^2}}$$

$z \equiv \varphi - \overline{\varphi}$ one-particle variable

$\overline{\dots}$ inclusive average $\overline{z} = 0$

$Z \equiv \sum_{i=1}^N z_i = \sum_{i=1}^N (\varphi_i - \overline{\varphi})$ event variable

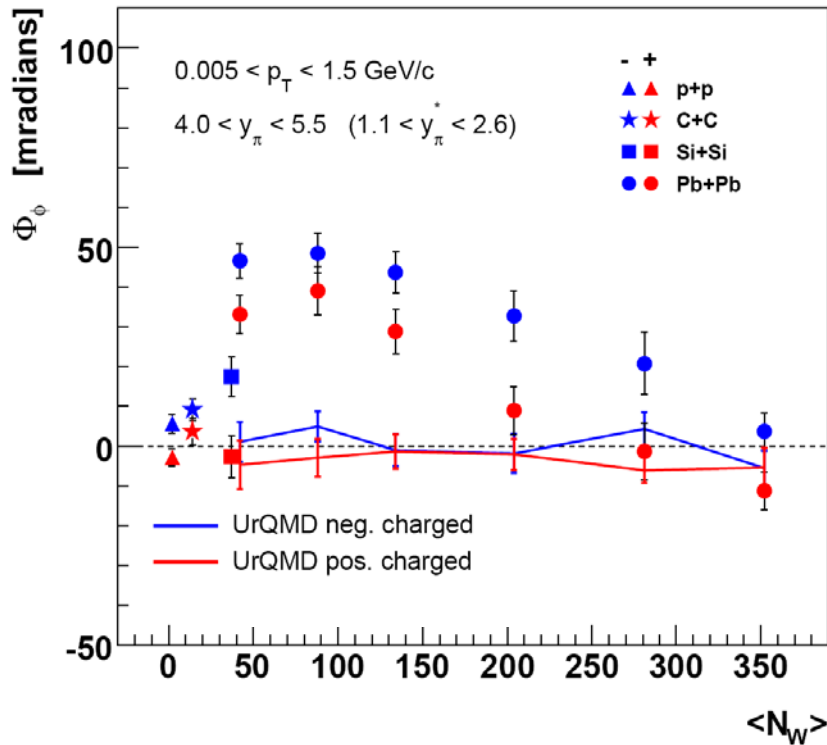
$\langle \dots \rangle$ average over events $\langle Z \rangle = 0$

✓ $\Phi_{\varphi} = 0$ for no correlations

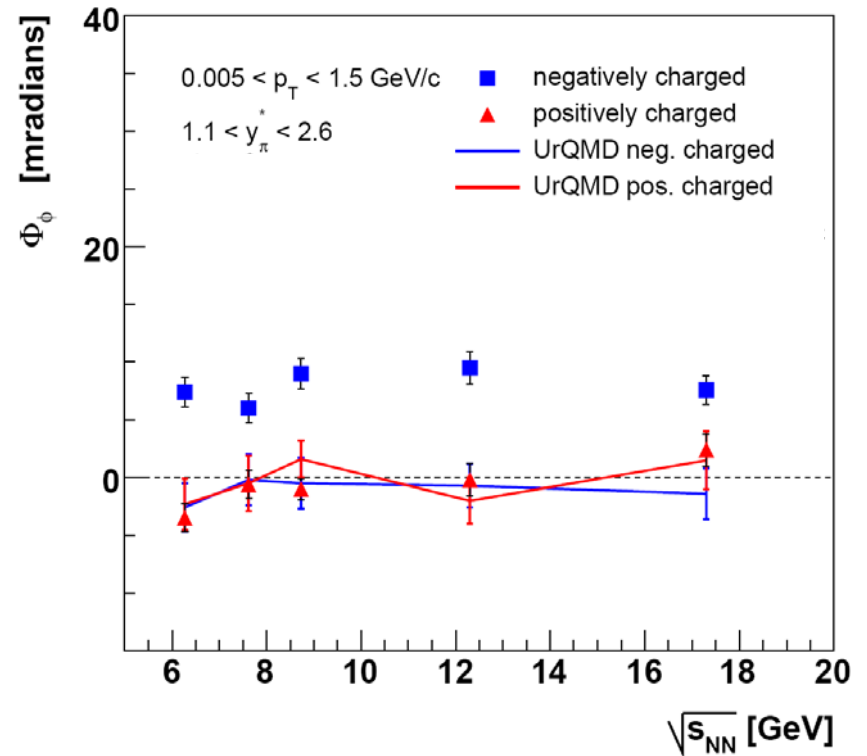
✓ Φ_{φ} strictly intensive

NA49 preliminary data

A-A @ 158 AGeV



Most central Pb-Pb



Modeling of azimuthal correlations

Sources of correlations which are modeled:

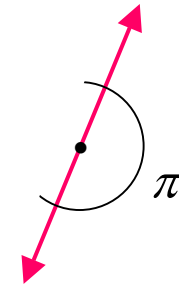
- resonance decays
- jets
- p_T conservation
- collective flow
- collective flow fluctuations

Resonance decays

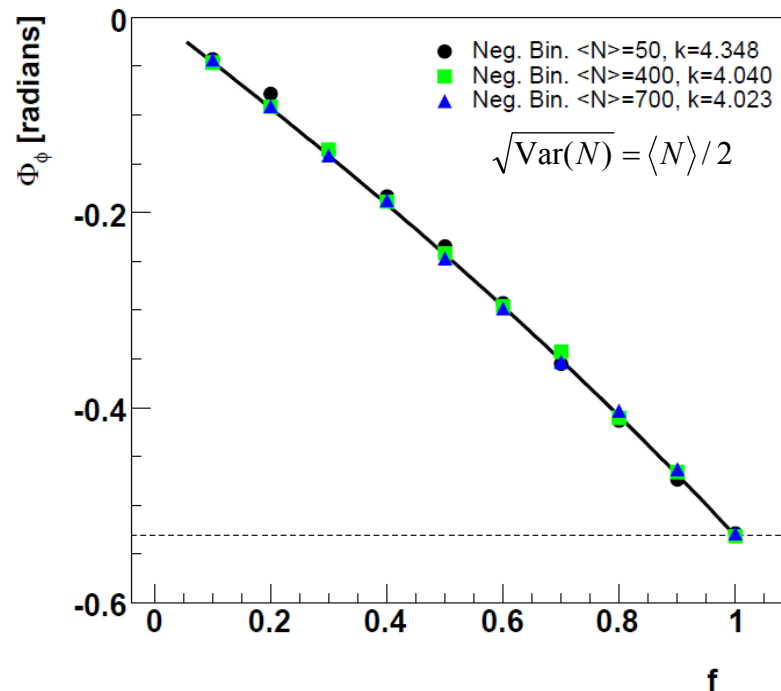
Toy Model

N_R heavy resonances decaying back to back and N_0 stable particles

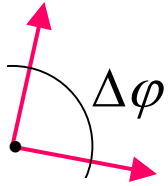
f – fraction of particles coming from resonance decays, $f = \frac{2N_R}{2N_R + N_0}$



$$\Phi_\varphi = \frac{\sqrt{2-f} - \sqrt{2}}{\sqrt{6}} \pi$$



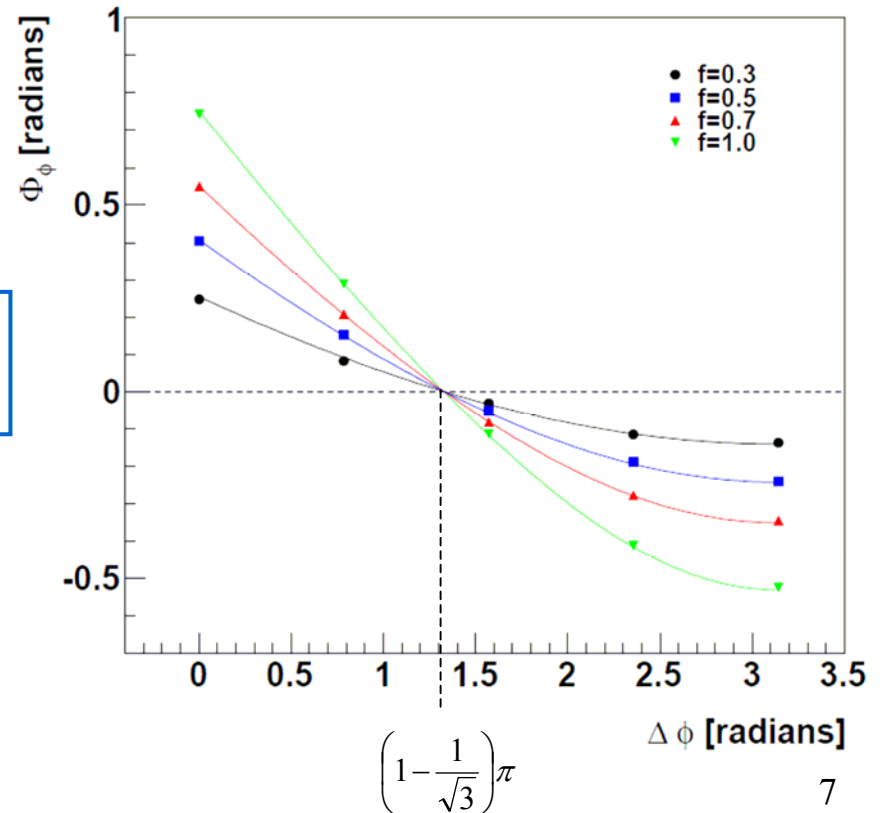
Resonance decays cont.



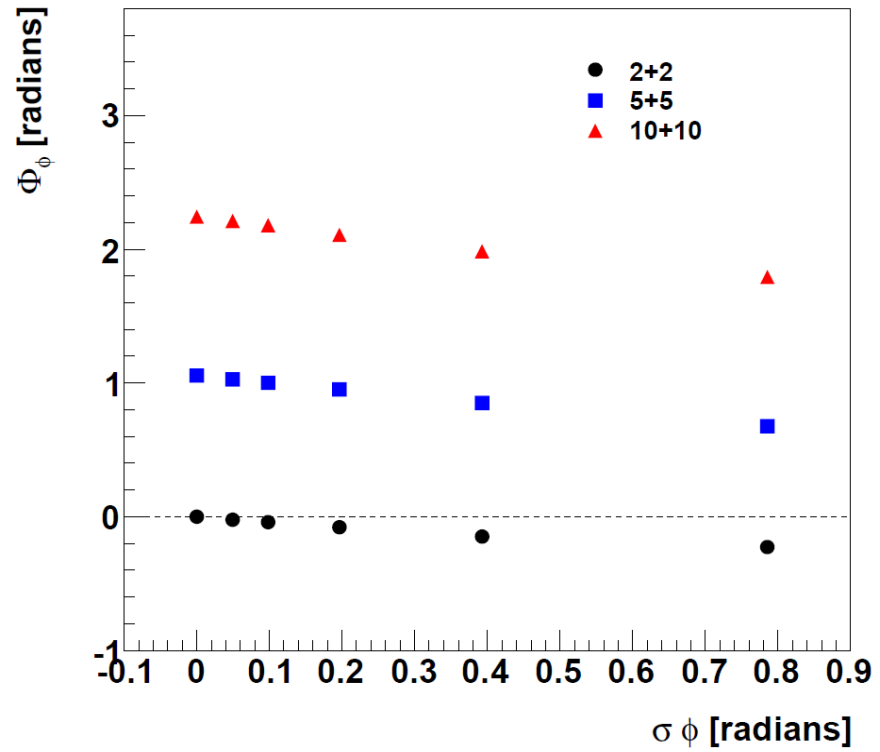
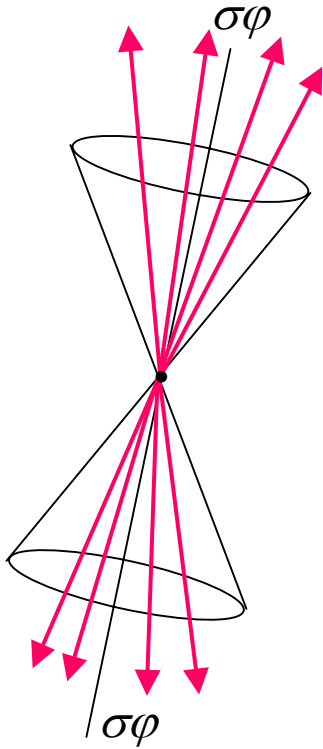
N_R resonance and N_0 stable particles

f – fraction of particles coming from resonance decays, $f = \frac{2N_R}{2N_R + N_0}$

$$\Phi_\phi = \sqrt{\frac{\pi^2}{3} + f \left(\frac{\pi^2}{3} - \pi\Delta\phi + \frac{1}{2}(\Delta\phi)^2 \right)} - \frac{\pi}{\sqrt{3}}$$



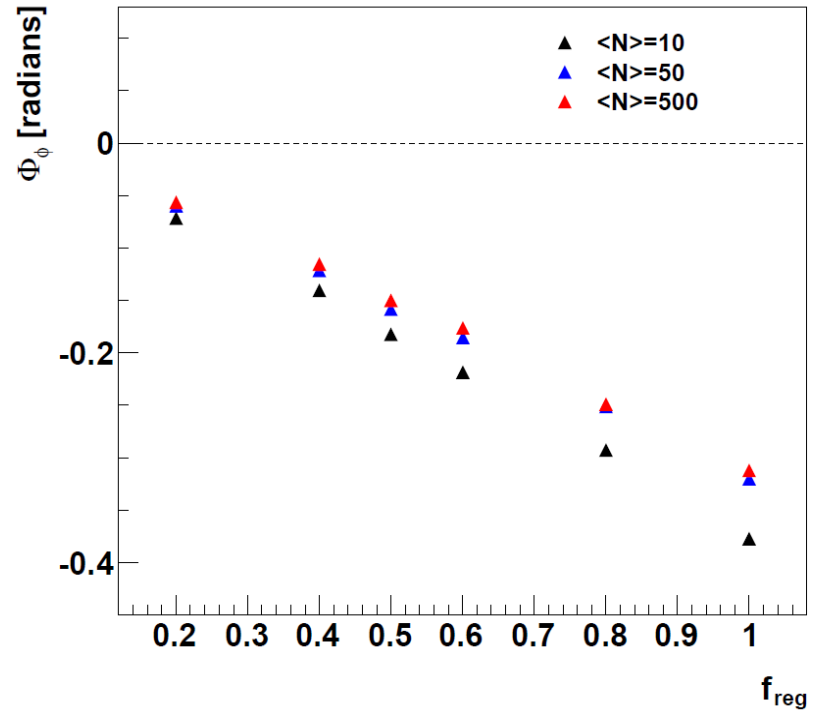
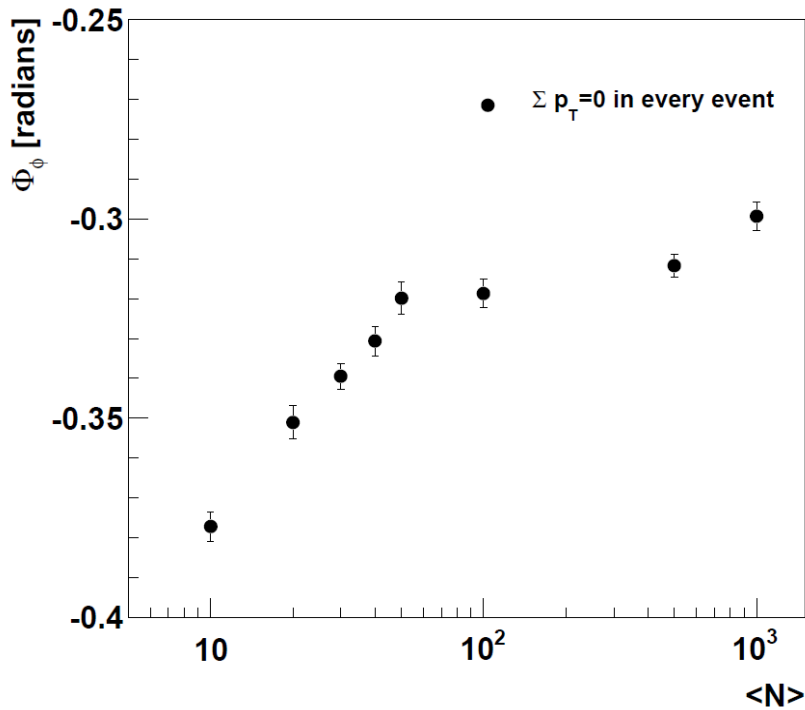
Jets



p_T conservation

Monte Carlo model:

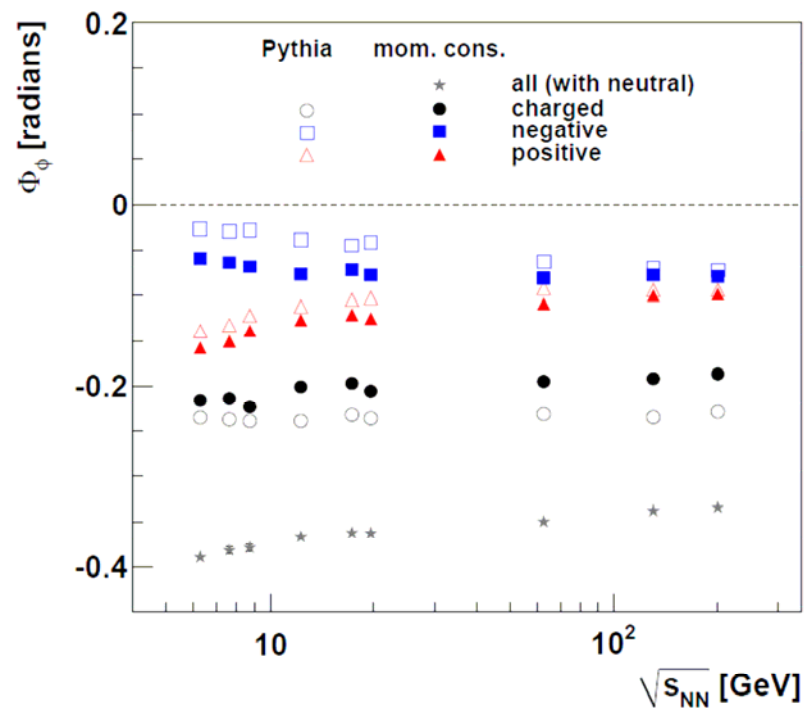
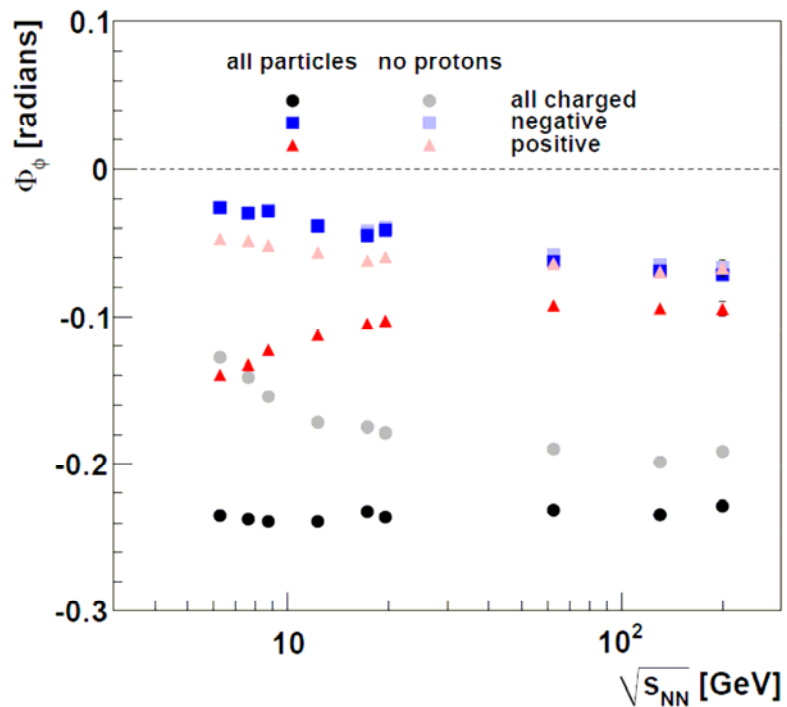
$$p_x \rightarrow p_x - \frac{1}{N} \sum_{i=1}^N p_x^i, \quad p_y \rightarrow p_y - \frac{1}{N} \sum_{i=1}^N p_y^i$$



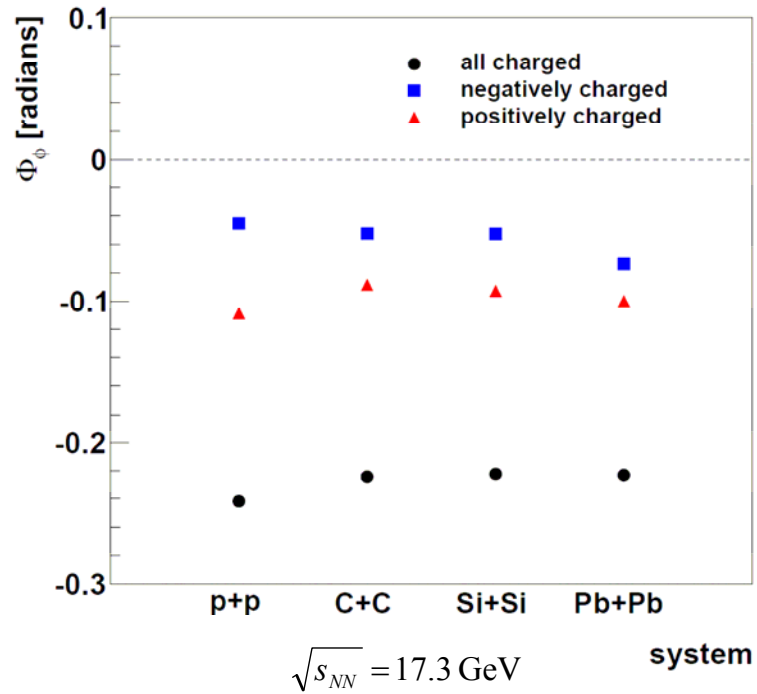
f_{reg} – fraction of registered particles

PYTHIA p-p data

PYTHIA vs. p_T conservation



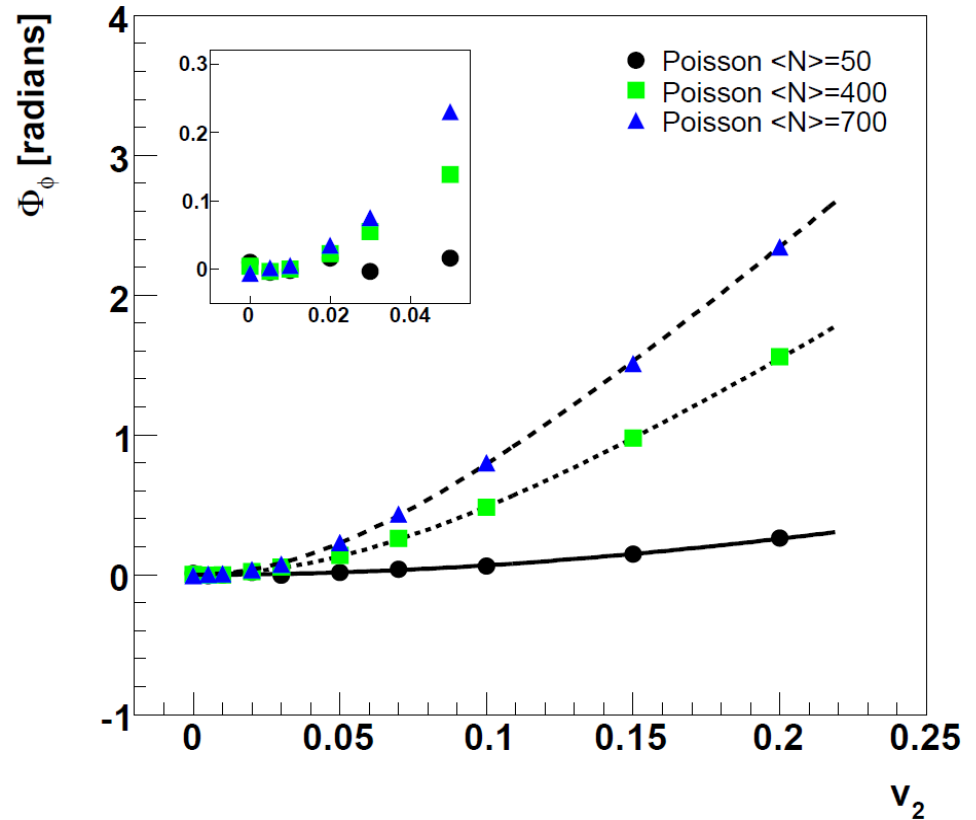
HIJING A-A data



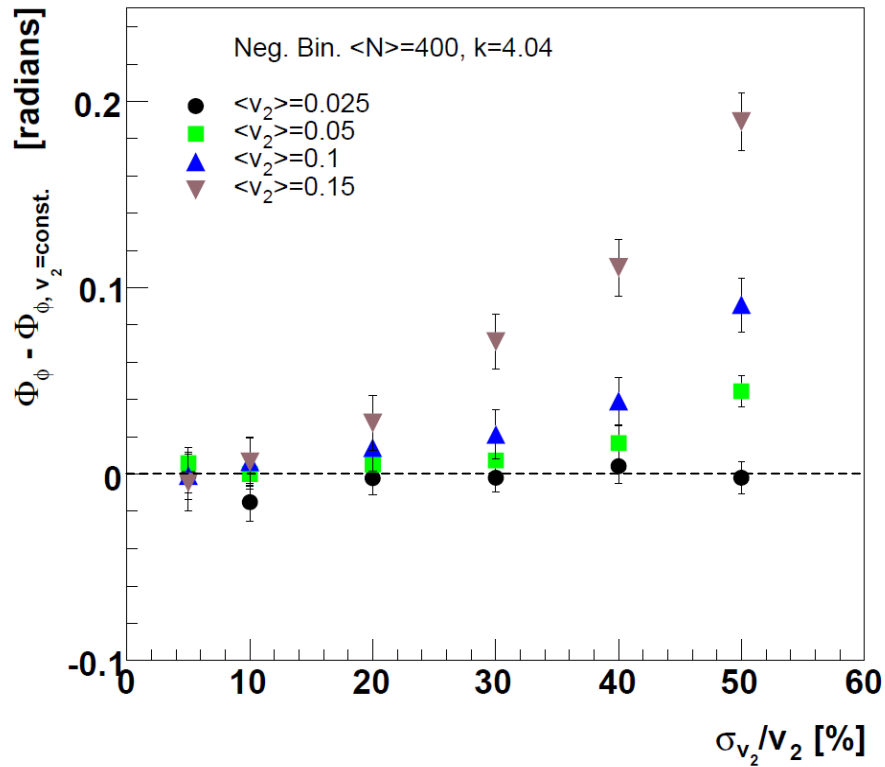
Collective flow

$$\Phi_\varphi = \sqrt{\frac{\pi^2}{3} + \frac{\langle N^2 \rangle - \langle N \rangle}{\langle N \rangle} S} - \frac{\pi}{\sqrt{3}}$$

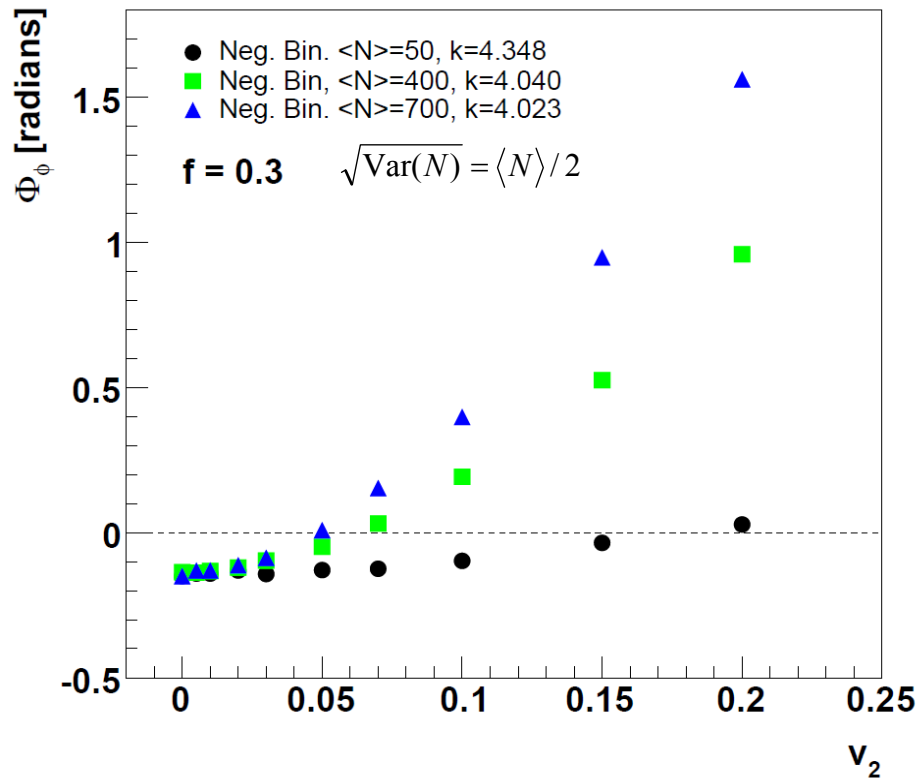
$$S \equiv 2 \left\langle \sum_{n=1}^{\infty} \left(\frac{v_n}{n} \right)^2 \right\rangle$$



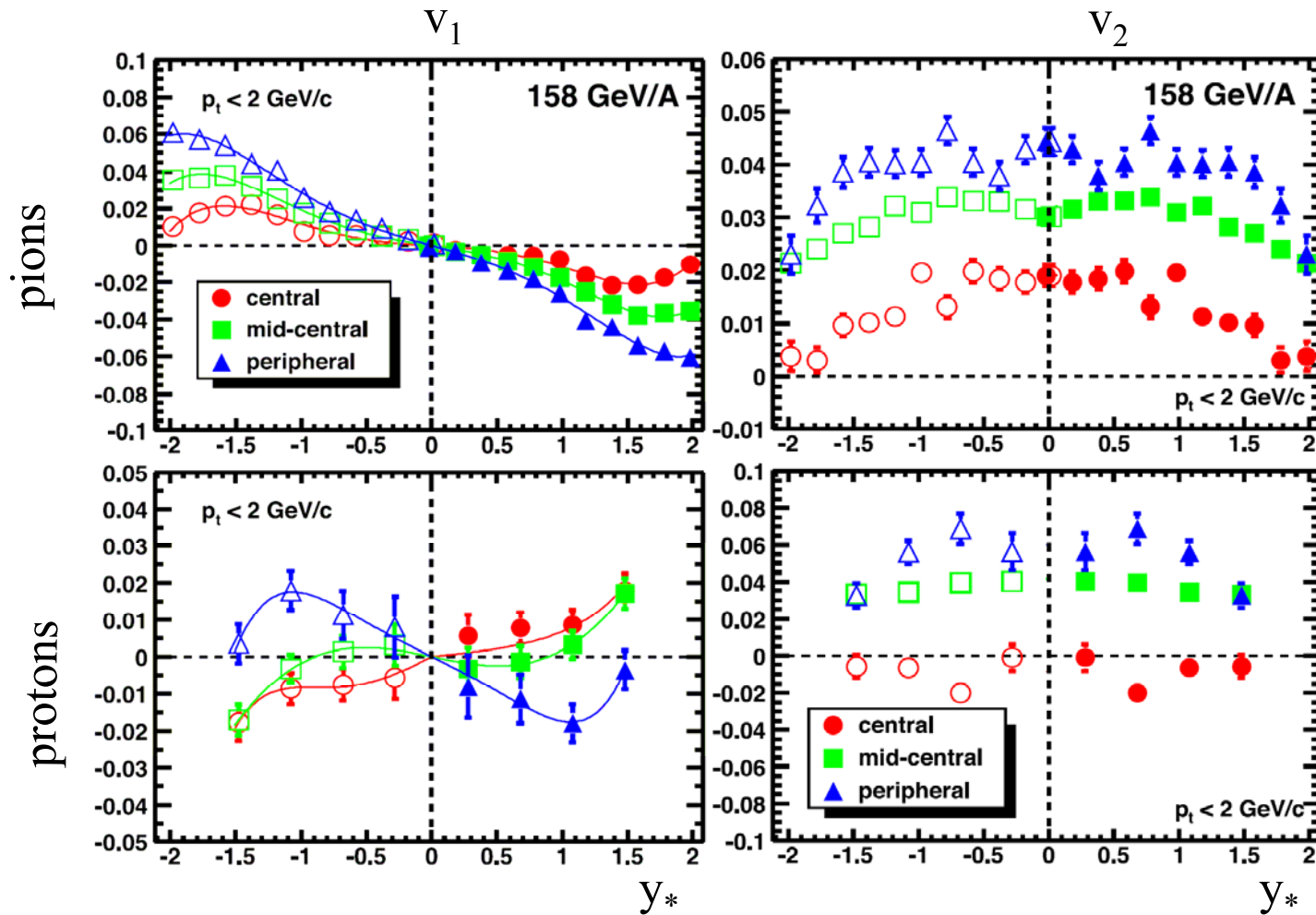
Collective flow fluctuations



Collective flow & resonance decays

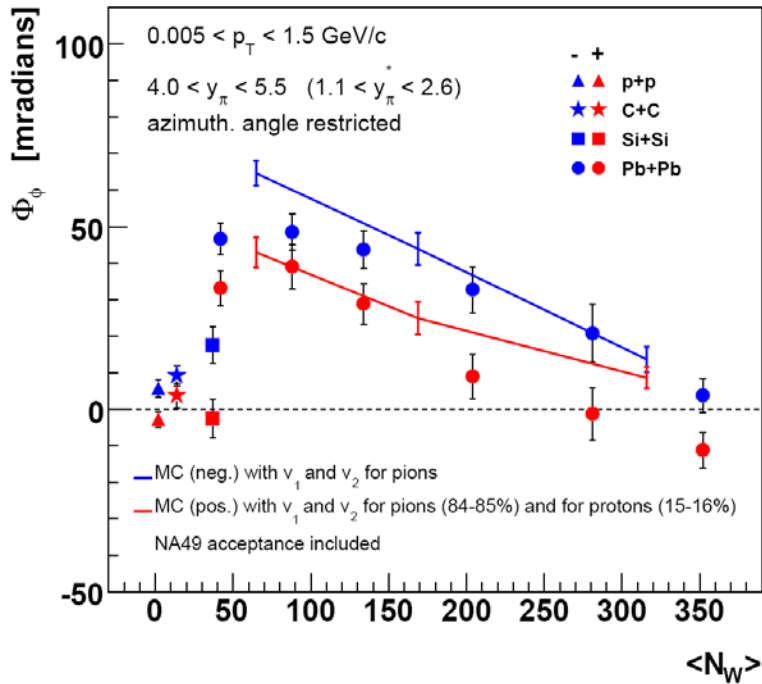


NA49 data on collective flow in Pb-Pb @ 158 GeV

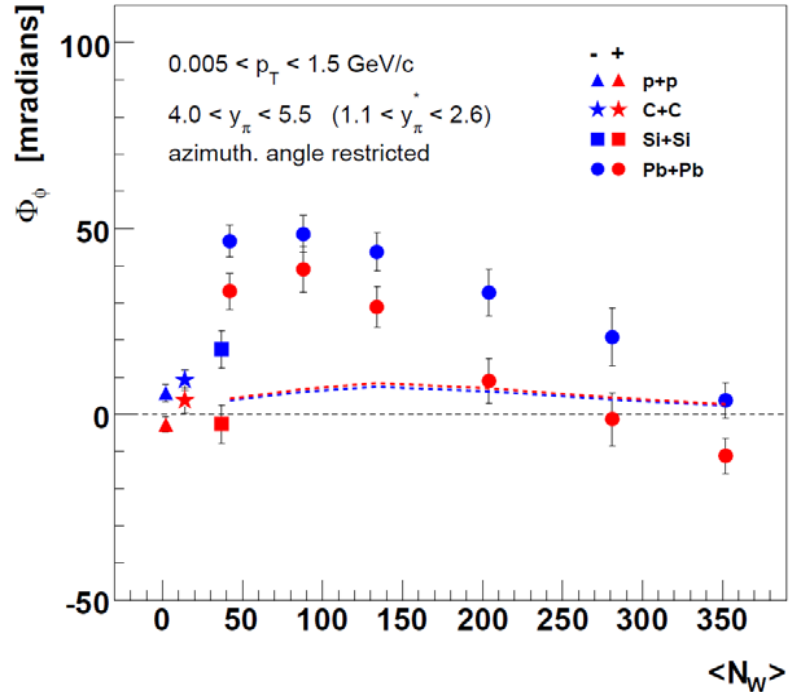


Measured v_1 & v_2 vs. NA49 data on Φ_ϕ

v_1 & v_2



v_2 only



$$\Phi_\phi = \sqrt{\frac{\pi^2}{3} + \frac{\langle N^2 \rangle - \langle N \rangle^2}{\langle N \rangle}} S - \frac{\pi}{\sqrt{3}}$$

$$S \equiv 2 \left\langle \sum_{n=1}^{\infty} \left(\frac{v_n}{n} \right)^2 \right\rangle$$

Thanks to Wojtek Broniowski!

Conclusions

- azimuthal correlations are dominated by collective flow
- no exotic source of strong correlations is seen