Pseudorapidity dependence of the anisotropic flow with ALICE at the LHC

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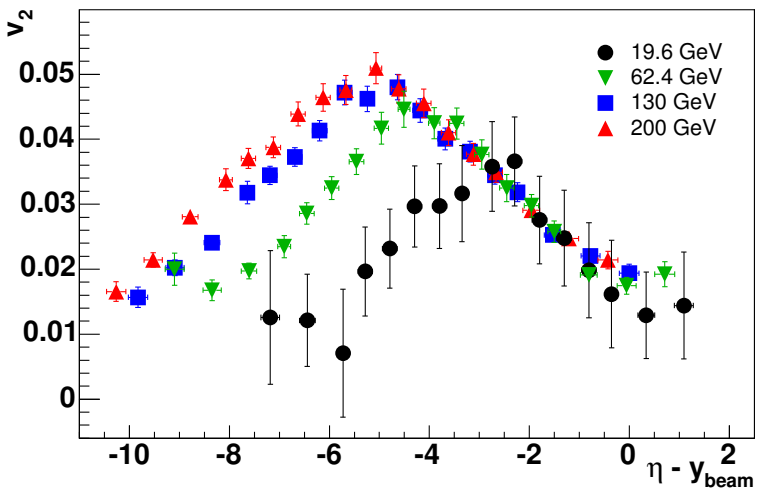
Outline

Motivation

- Study collision energy dependence of anisotropic flow at forward rapidity.
- Test longitudinal scaling of flow at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV.
- Test how fluctuations in the initial conditions affect flow at forward rapidity.
- Compare with model predictions.



PHOBOS - PRL 94, 122303 (2005)

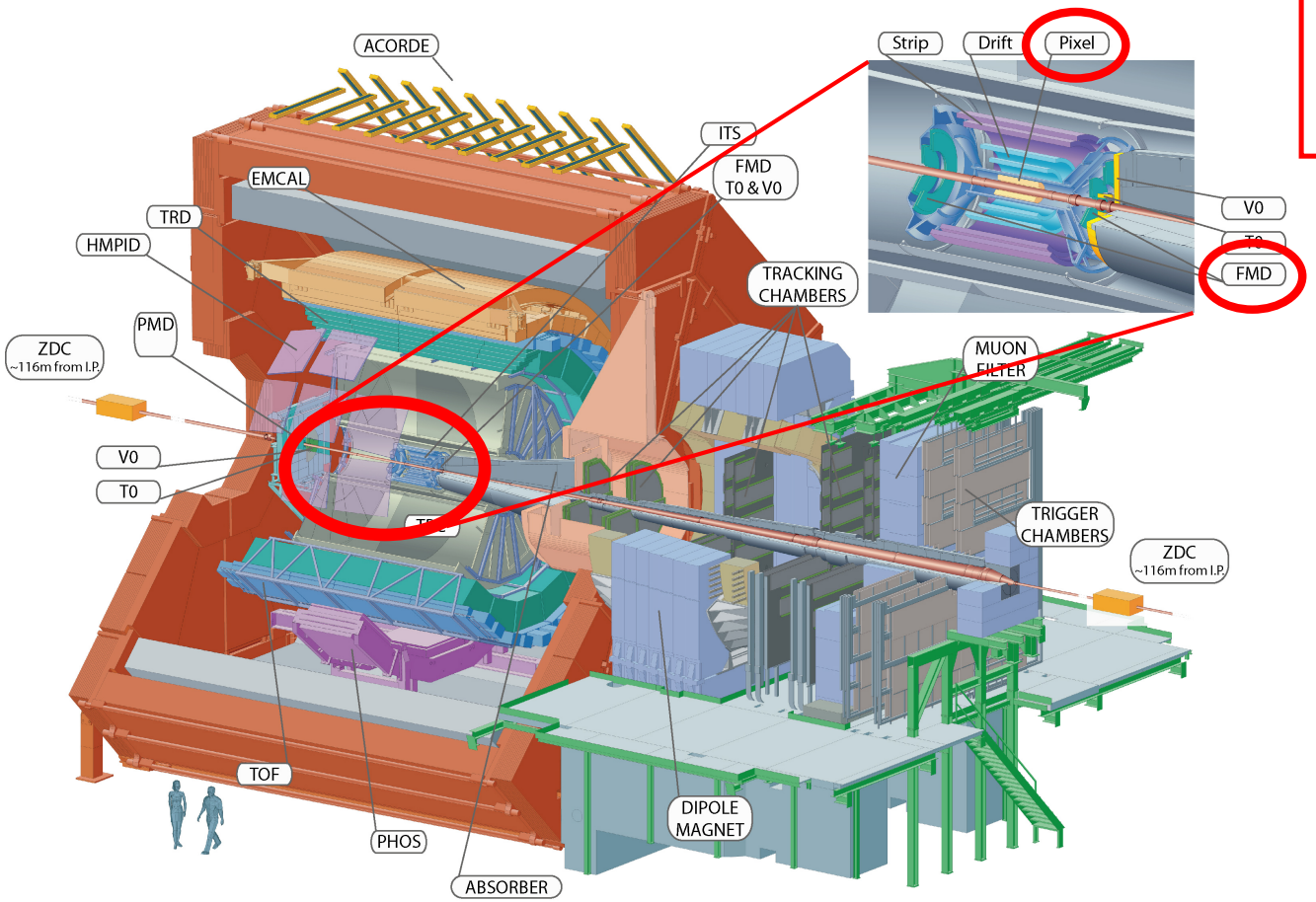
Flow measurement with cumulants

Measuring anisotropic flow with multi-particle cumulants, Borghini, Dihn and Ollitrault PRC 64, 054901 (2001).

- $v_n^2\{2\} = \langle v_n \rangle^2 + \sigma_{v_n}^2 + \delta_n$.
- Nonflow, δ_n, subtracted using pp at 2.76 TeV:
  - $\delta_n = v_n^2\{2\}^{pp} \cdot \frac{M^{pp}}{M^{cent}}$, where M is the multiplicity.
- $v_n^2\{4\} = \langle v_n \rangle^2 - \sigma_{v_n}^2$, $\sigma_{v_n} \ll \langle v_n \rangle$.
- Different sensitivity to σ_{v_n} between $v_n\{2\}$ and $v_n\{4\}$ gives an estimate of flow fluctuations:
  - $\frac{\sigma_{v_n}}{\langle v_n \rangle} \approx \sqrt{\frac{v_n^2\{2\} - v_n^2\{4\}}{v_n^2\{2\} + v_n^2\{4\}}}$.
- Analytical results: Bilandzic, Snellings and Voloshin PRC 83, 044913 (2011).

Results presented for $v_2\{2\}$, $v_2\{4\}$ and $v_3\{2\}$.

ALICE



Detectors

- Forward multiplicity detector
- Silicon pixel detector

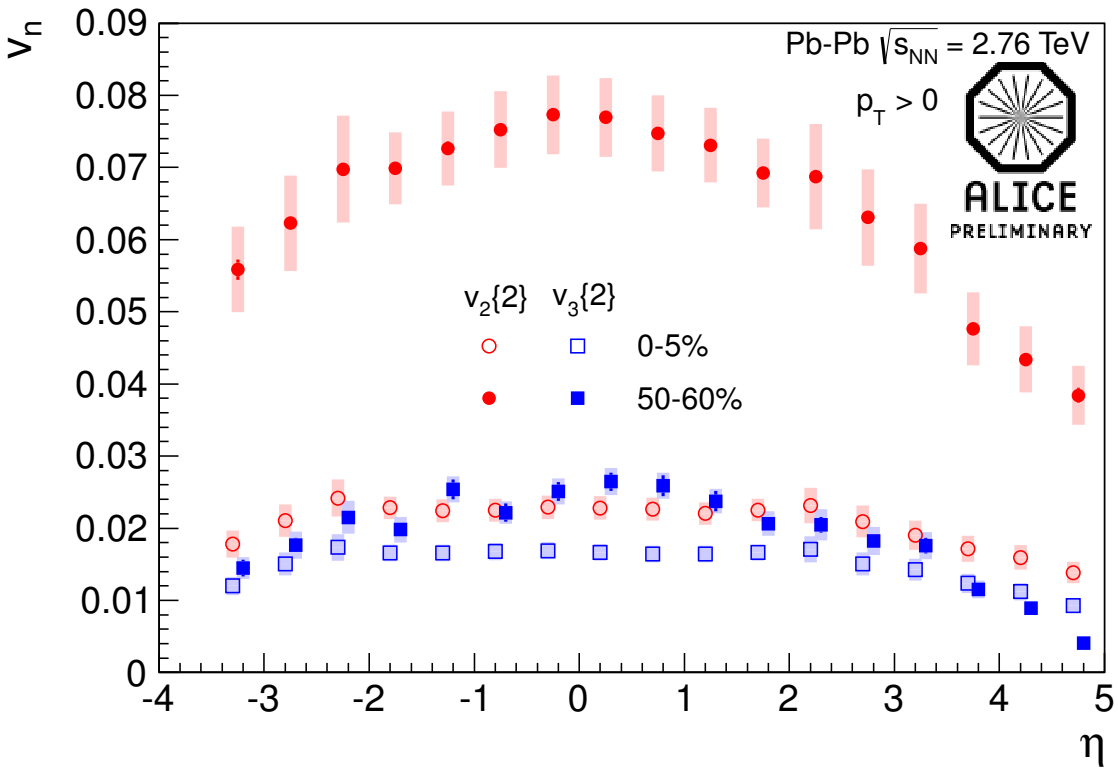
FMD

- $-3.4 < \eta < -1.7$, $1.7 < \eta < 5$
- $0 \leq \varphi < 2\pi$
- $p_{\mathrm{T}} > 0$

SPD inner layer

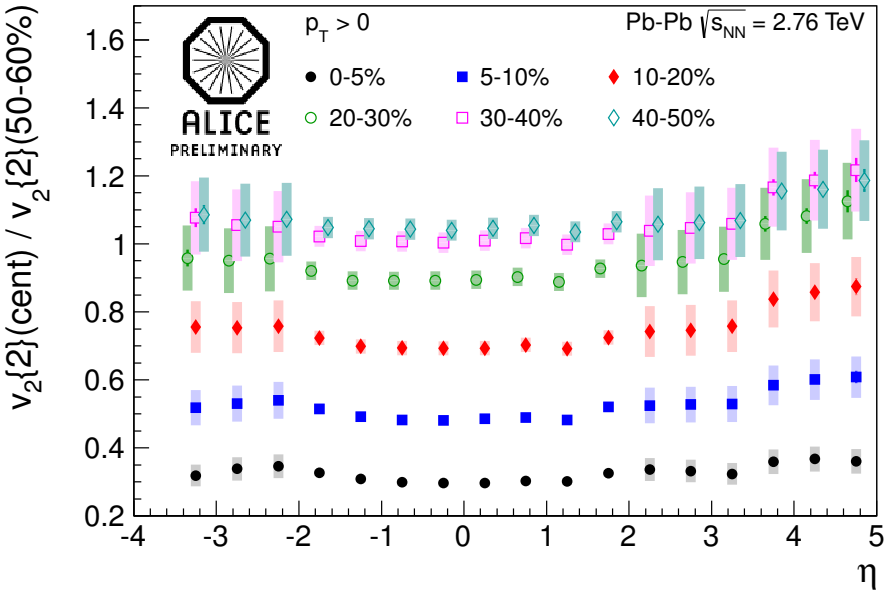
- $-2 < \eta < 2$
- $0 \leq \varphi < 2\pi$
- $p_{\mathrm{T}} > 0$

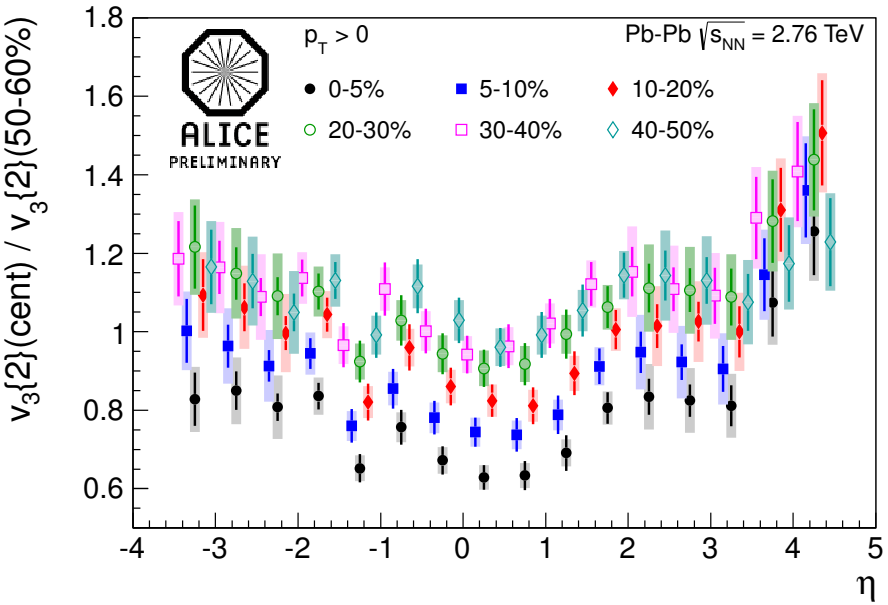
Elliptic and triangular flow with ALICE



- $v_2\{2\}$ and $v_3\{2\}$ measured over wide rapidity range: $-3.5 < \eta < 5$.
- v_2 has strong centrality dependence.
- v_3 has weaker centrality dependence (expected for flow fluctuations).

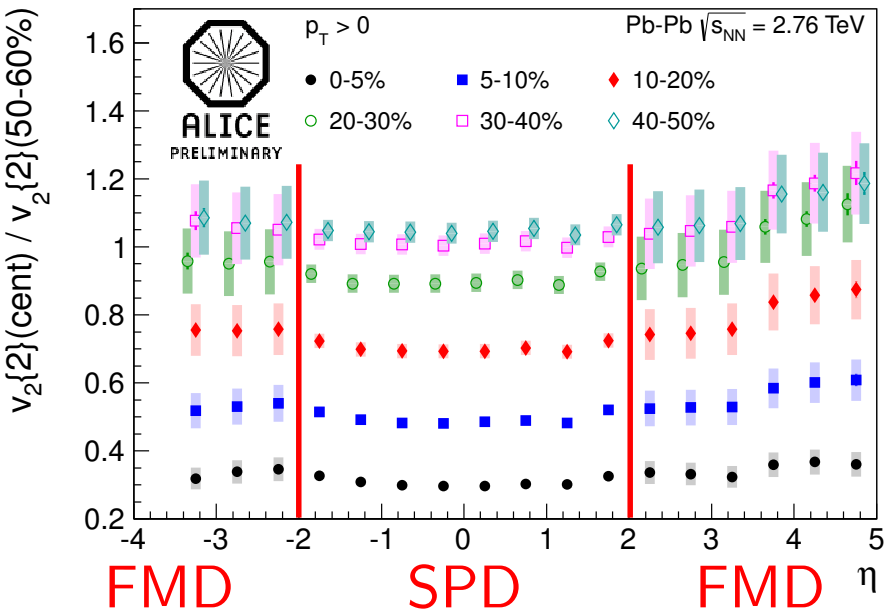
$v_n\{2\}$ centrality dependence: $v_n(cent)/v_n(50-60\%)$

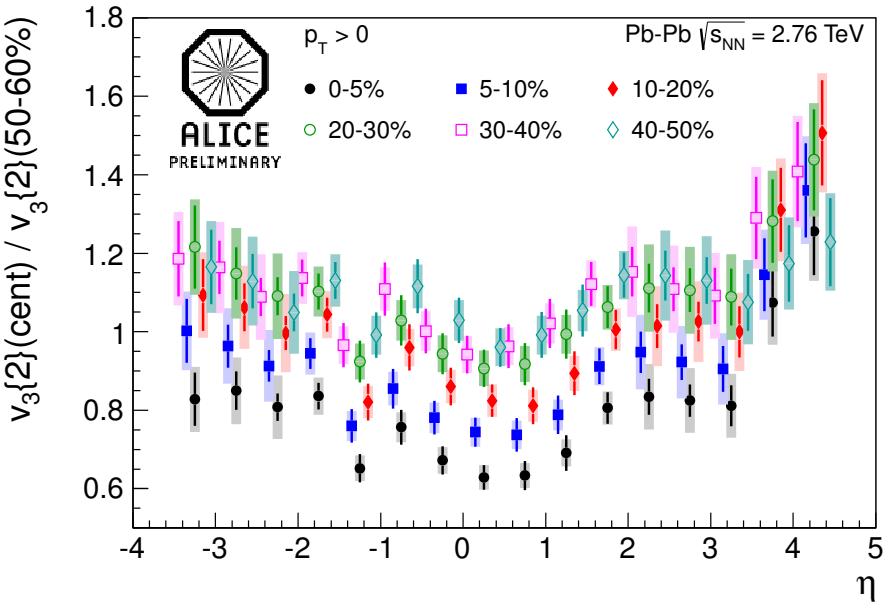




- The shape of elliptic flow vs. rapidity shows weak centrality dependence.
- The shape of triangular flow vs. rapidity changes strongly with centrality.

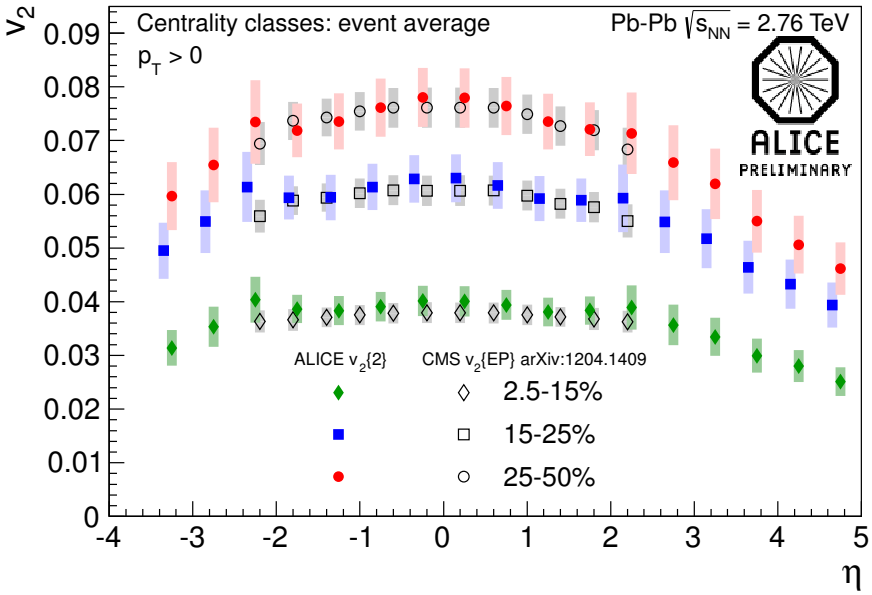
$v_n\{2\}$ centrality dependence: $v_n(cent)/v_n(50-60\%)$

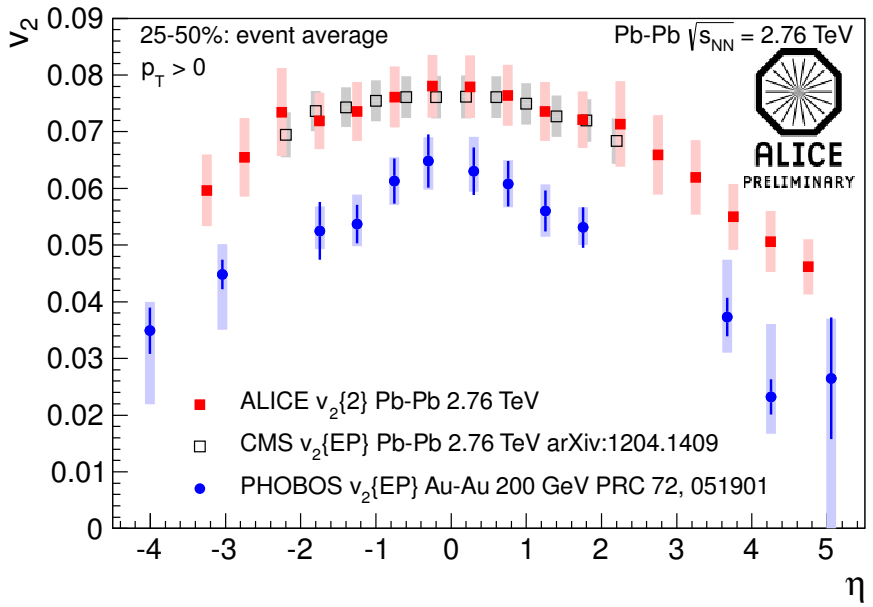




- The shape of elliptic flow vs. rapidity shows weak centrality dependence.
- The shape of triangular flow vs. rapidity changes strongly with centrality.
- Larger systematics at forward rapidity (additional material budget).

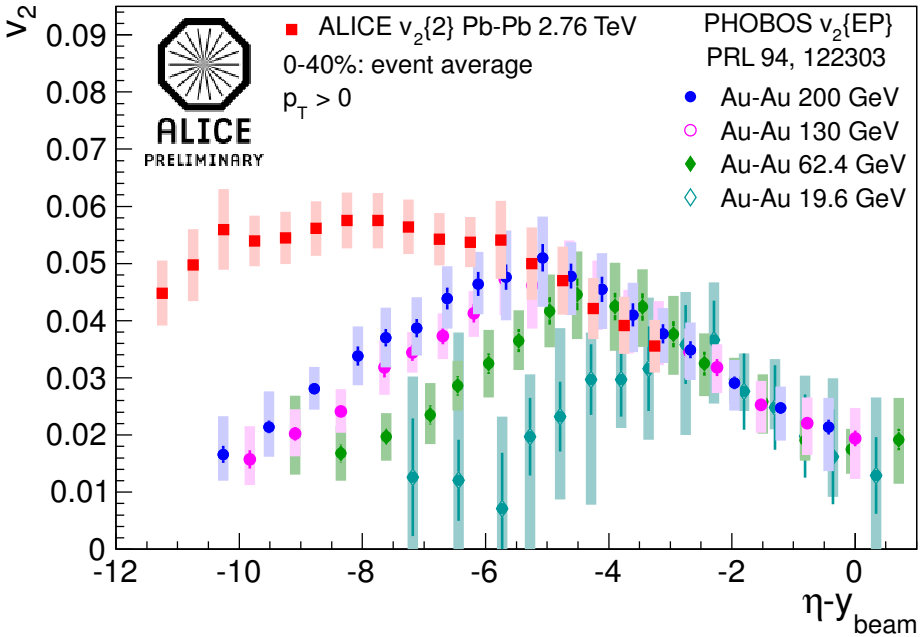
Comparison to RHIC and other experiments at LHC

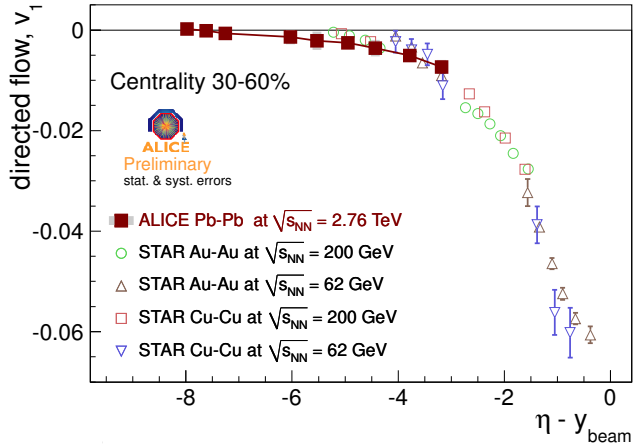




- Extended rapidity reach compared to CMS $|\eta| < 2.4$, arXiv:1204.1409.
  - Good agreement observed in the overlap region.
- Compared to measurements at RHIC:
  - At mid-rapidity increase from RHIC to LHC $20 - 30\%$.
  - Stronger energy dependence at forward rapidity.

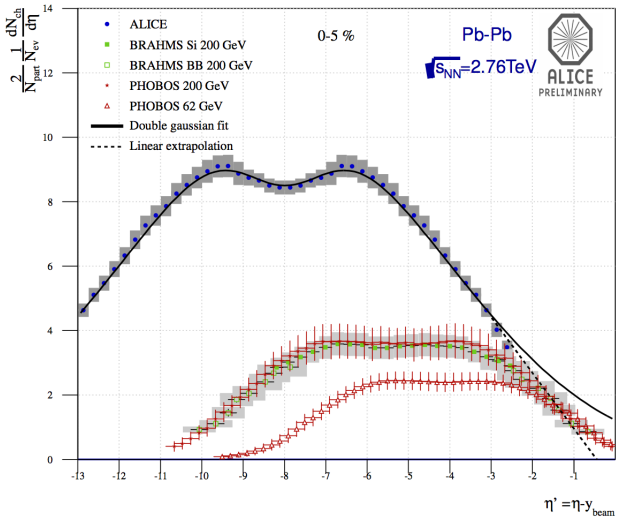
Longitudinal scaling of elliptic flow





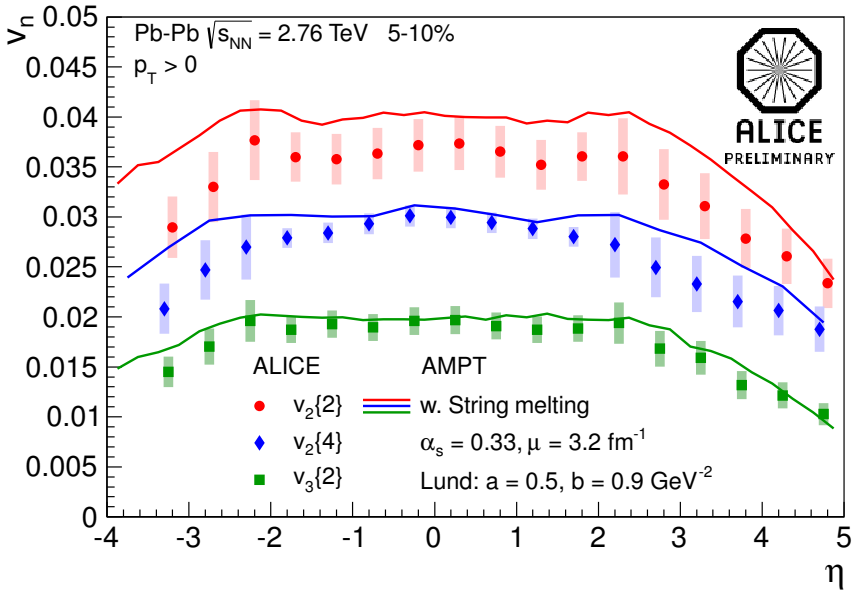
Selyuzhenkov - JPG 38, 124167 (2011).

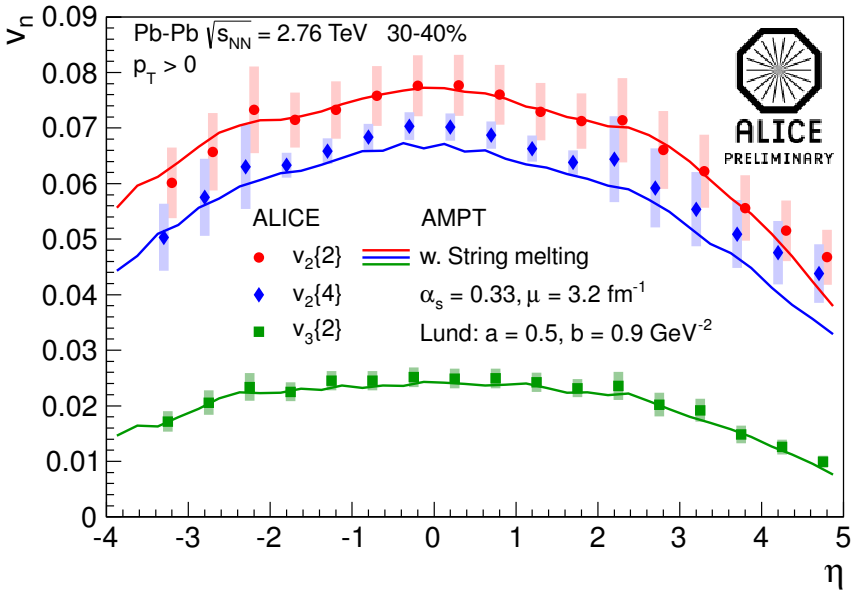
- Observe longitudinal scaling for elliptic flow.
- Longitudinal scaling also observed for:
  - Directed flow, v_1.
  - Multiplicity density, $\frac{dN_{ch}}{d\eta}$.



See talk #400 by M. Guilbaud.

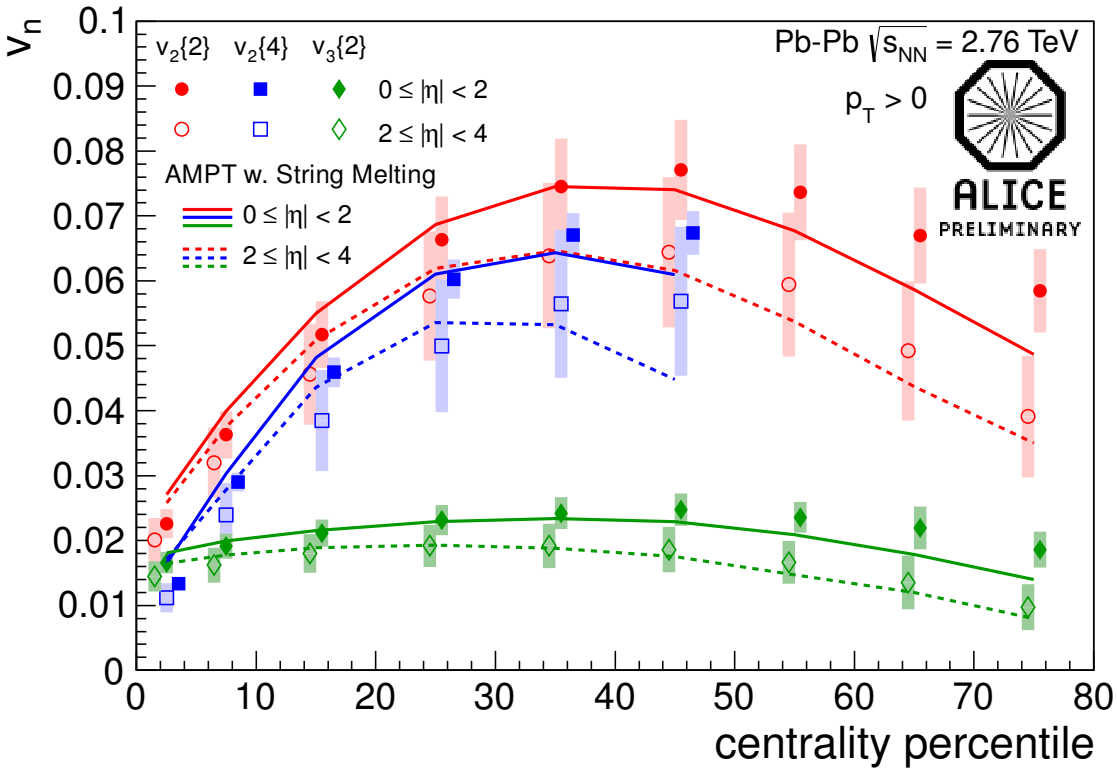
Model comparison





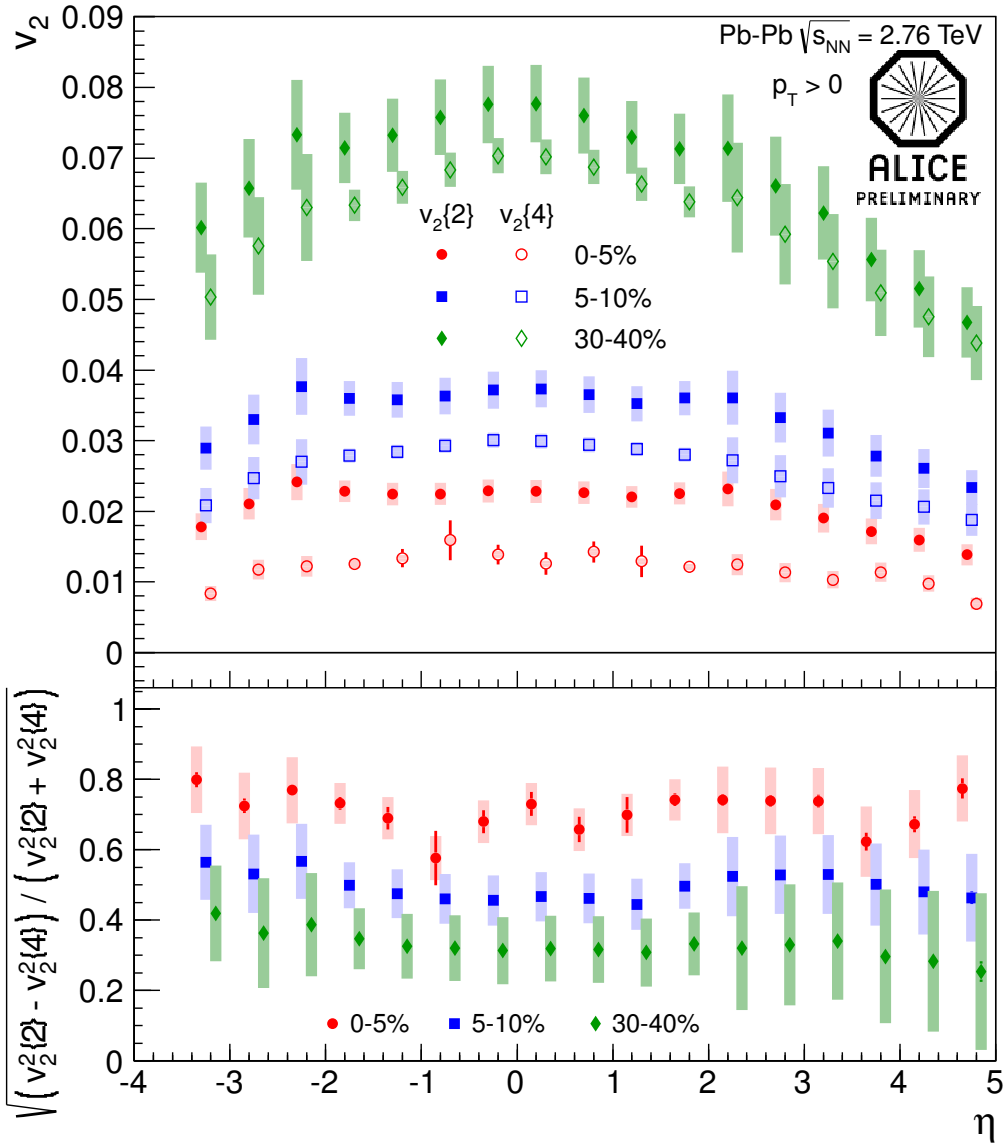
- AMPT (PRC 72, 064901) with configuration from (PRC 83, 034904):
  - String melting.
  - Strong coupling constant $\alpha_s = 0.33$, screening mass $\mu = 3.2$ fm^{-1}.
  - Lund string fragmentation function parameters: $a = 0.5$, $b = 0.9$ GeV^{-2}.
- Good agreement observed for centrality $30 - 40\%$, AMPT slightly overestimates v_2 for centrality $5 - 10\%$.

$v_2\{2\}$, $v_2\{4\}$ and $v_3\{2\}$ centrality dependence



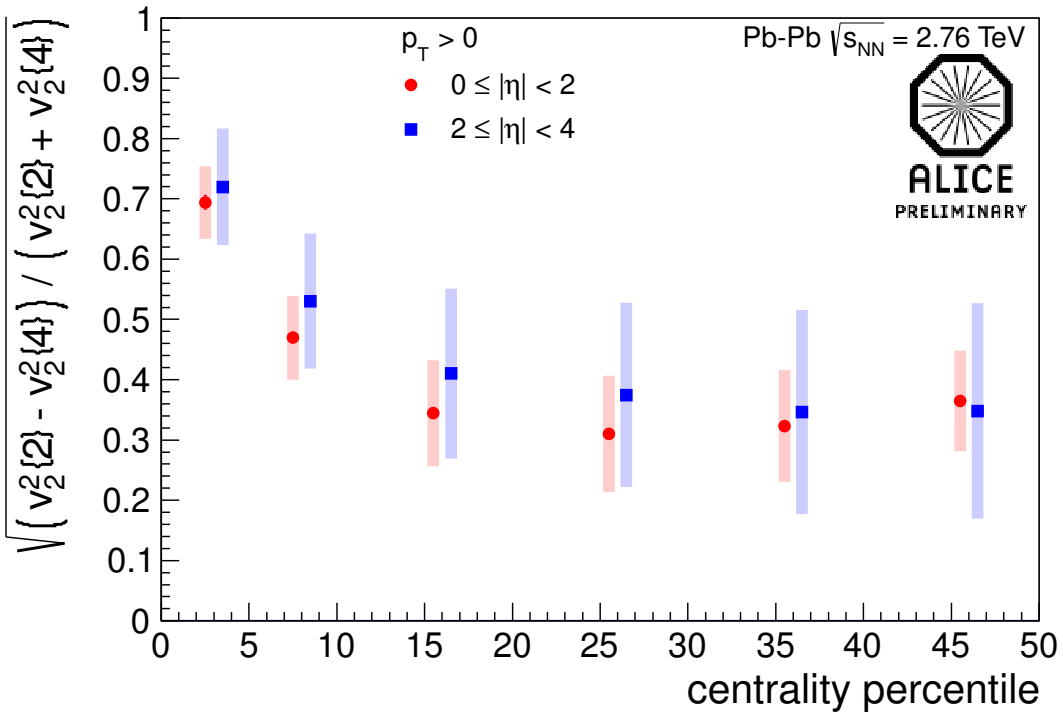
- AMPT model:
  - Slightly overestimates measured flow for most central collisions.
  - Slightly underestimates flow at mid-rapidity for peripheral collisions.

Elliptic flow fluctuations



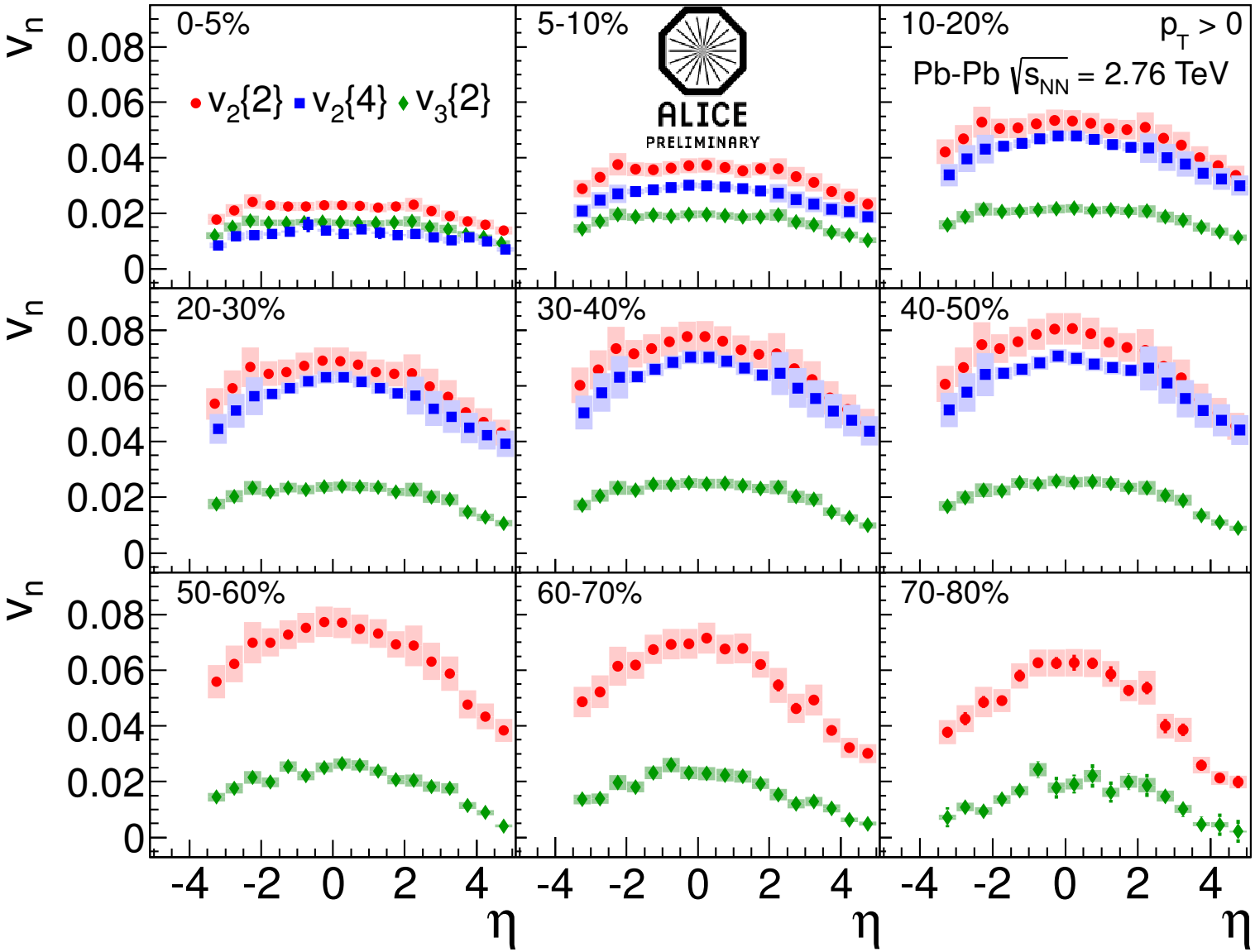
- Difference between $v_2\{2\}$ and $v_2\{4\}$ is used to estimate flow fluctuations:
  - $\frac{\sigma_{v_2}}{\langle v_2 \rangle} \approx \sqrt{\frac{v_2^2\{2\} - v_2^2\{4\}}{v_2^2\{2\} + v_2^2\{4\}}}$.
- Fluctuations at forward rapidity are similar to fluctuations at mid-rapidity.

Centrality dependence of flow fluctuations



- $\frac{\sigma_{v_2}}{\langle v_2 \rangle}$ at mid-rapidity and forward-rapidity have similar magnitude and centrality dependence.
- Fluctuations largest for most central collisions.
- At mid-rapidity fluctuations are consistent with previously reported results for $p_T > 0.2$ GeV/c, Snellings - JPG38, 124013 (2011).

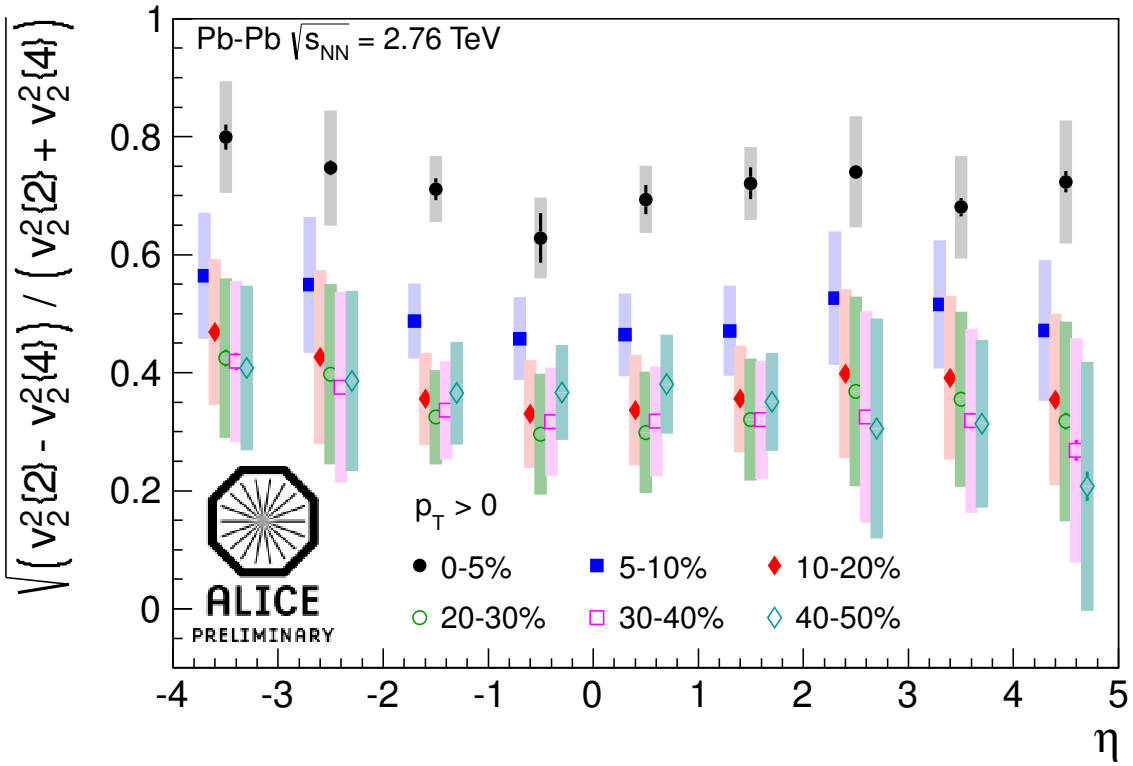
Centrality overview



Conclusions

- $v_2\{2\}$, $v_2\{4\}$ and $v_3\{2\}$ measured over a wide pseudorapidity range, $-3.5 < \eta < 5$.
- Measurements suggest that collision energy dependence from RHIC to LHC is stronger at forward rapidity than at mid-rapidity.
- Longitudinal scaling appears to hold for RHIC and LHC energies.
- Within stat. and sys. errors, the measured shape of $v_2\{2\}$ vs. rapidity is independent of centrality, while it changes for $v_3\{2\}$.
- Elliptic flow fluctuations, $\frac{\sigma_{v_2}}{\langle v_2 \rangle}$, measured over a wide range of rapidity have similar magnitude at forward and mid-rapidity.

Backup: Fluctuations overview



- Consistent with observations on slides 12 and 13: No η-dependence within systematic uncertainties.