Measurements of p_T-differential v_2 and v_3 using multi-particle cumulants in Pb-Pb and Xe-Xe collisions

Vytautas Vislavicius for the ALICE Collaboration

ALICE

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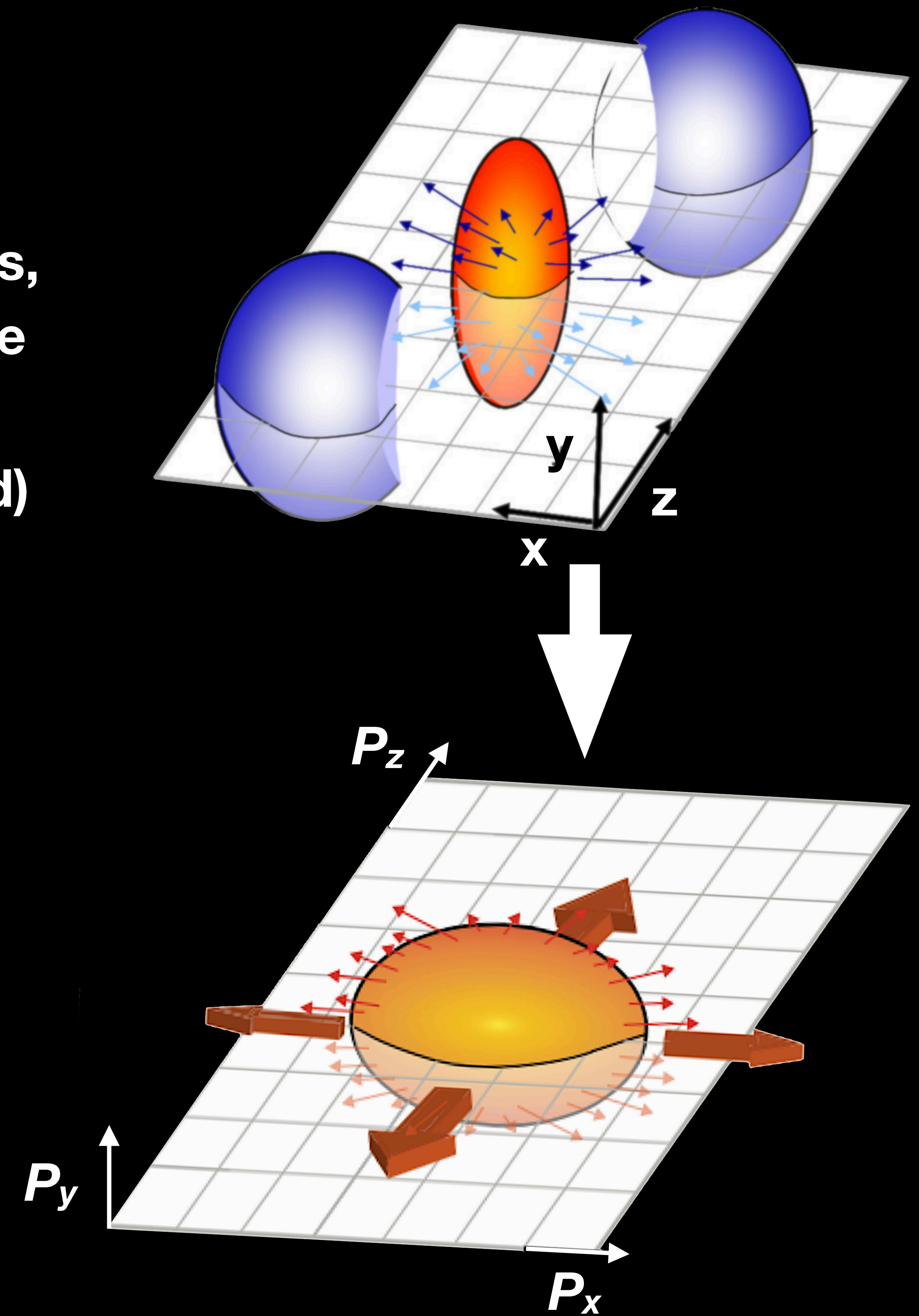
Hydrodynamical flow in heavy-ion collisions

Heavy-ion collision geometry

- Partial overlap between colliding projectiles, spatial anisotropy of colliding nucleons give rise to pressure gradients…
- … which result in anisotropies in (produced) particle azimuthal angular distributions
  -> Particles “flow”



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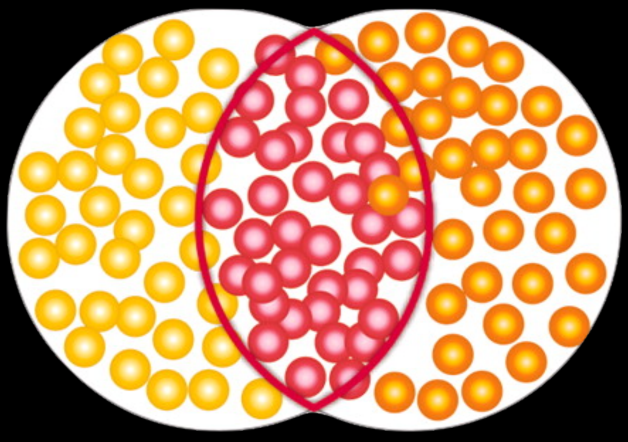
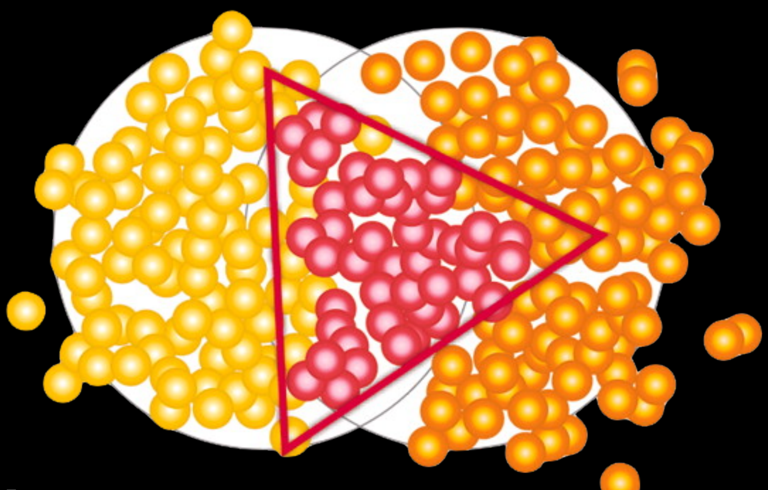
  — Elliptic flow (v_2), triangular flow (v_3), etc…





Studying the flow of final state hadrons we can learn about medium properties and initial conditions in heavy-ion collisions

Hydrodynamical flow in heavy-ion collisions

How do we measure flow?

Several techniques: Fourier decomposition, Q-cumulants…

From 2-particle correlations:

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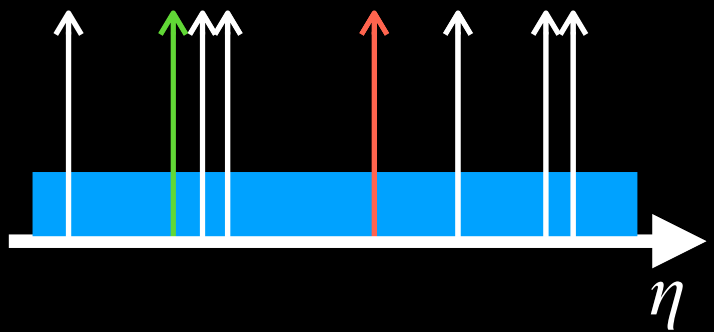

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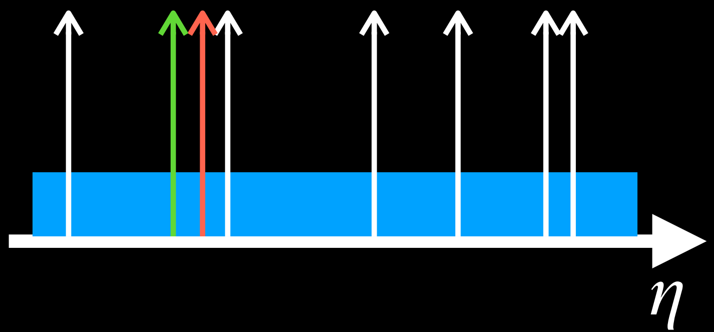

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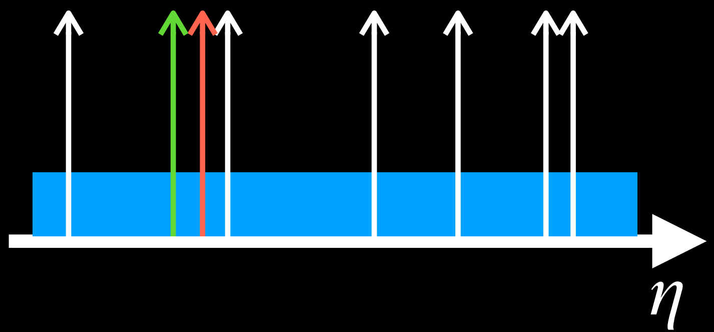

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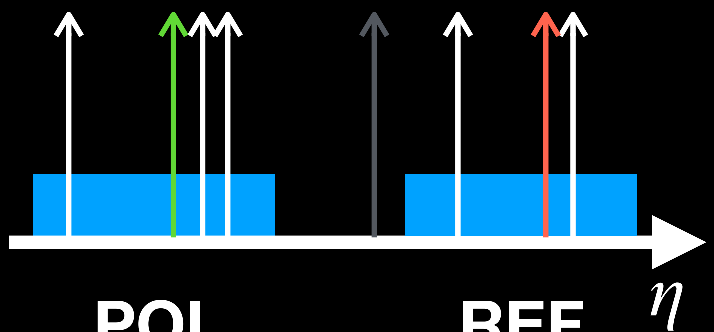

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Can also calculate from 4-particle correlation:

$$c_n\{4\} = \langle\langle 4\rangle\rangle_n - 2\langle\langle 2\rangle\rangle_n^2$$

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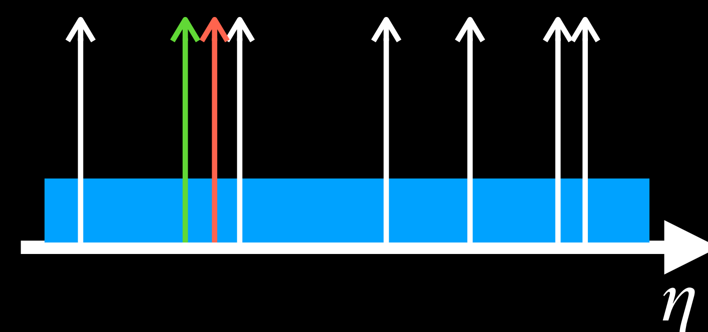

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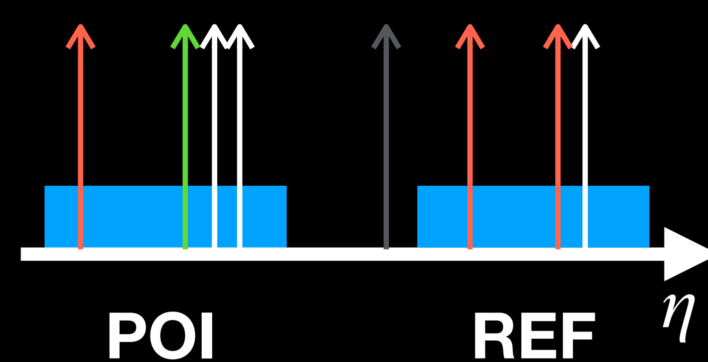
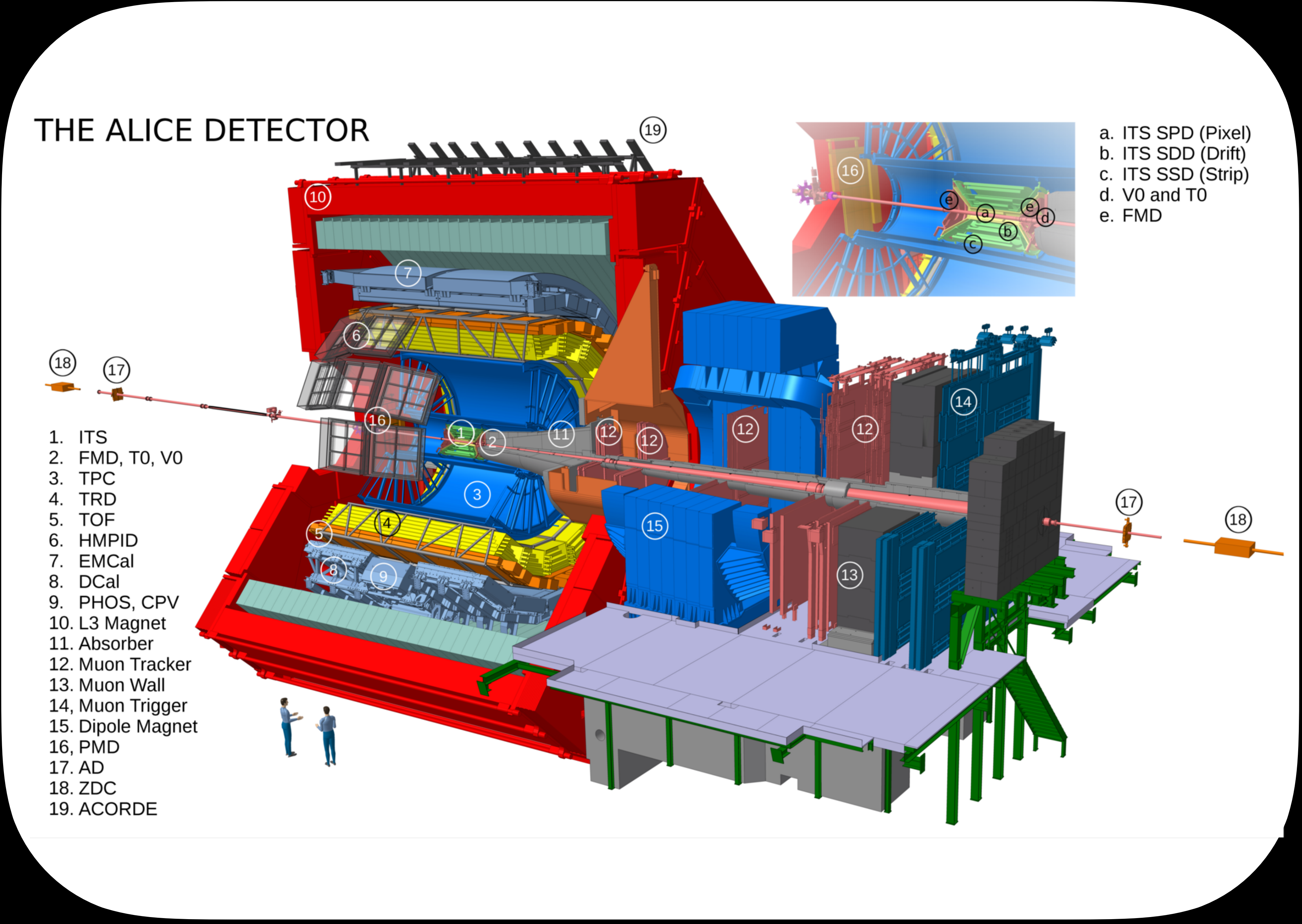


The ALICE detector

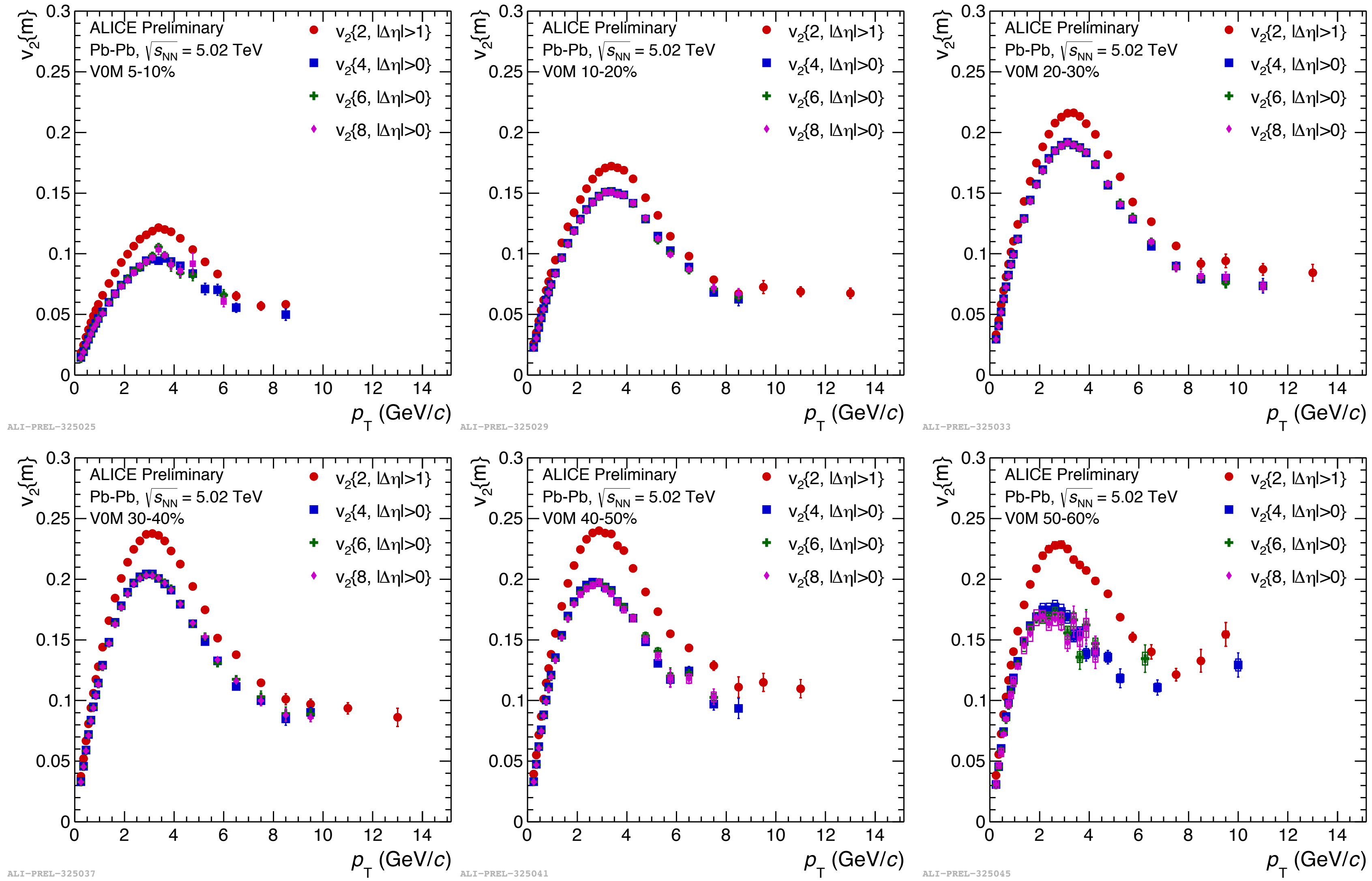
A Large Ion Collider Experiment: multi-purpose detector at the LHC with excellent tracking & particle identification capabilities in a wide p_{T} range (0.1 GeV/c to ~20 GeV/c for PID, up to 50 GeV/c for unidentified)

- **Inner Tracking System (ITS)**
  - **Tracking**
  - **Triggering**
  - **PID**
- **Time-Projection Chamber**
  - **Tracking**
  - **PID**
- **V0 detector**
  - **V0A ($2.8 < \eta < 5.1$)**
  - **V0C ($-3.7 < \eta < -1.7$)**
  - **Triggering**
  - **Multiplicity estimation**



p_T-differential $v_n\{m\}$ in Pb-Pb collisions

Plethora of $v_2\{2,4,6,8\}$ measurements in ALICE, with different η gaps,



New!

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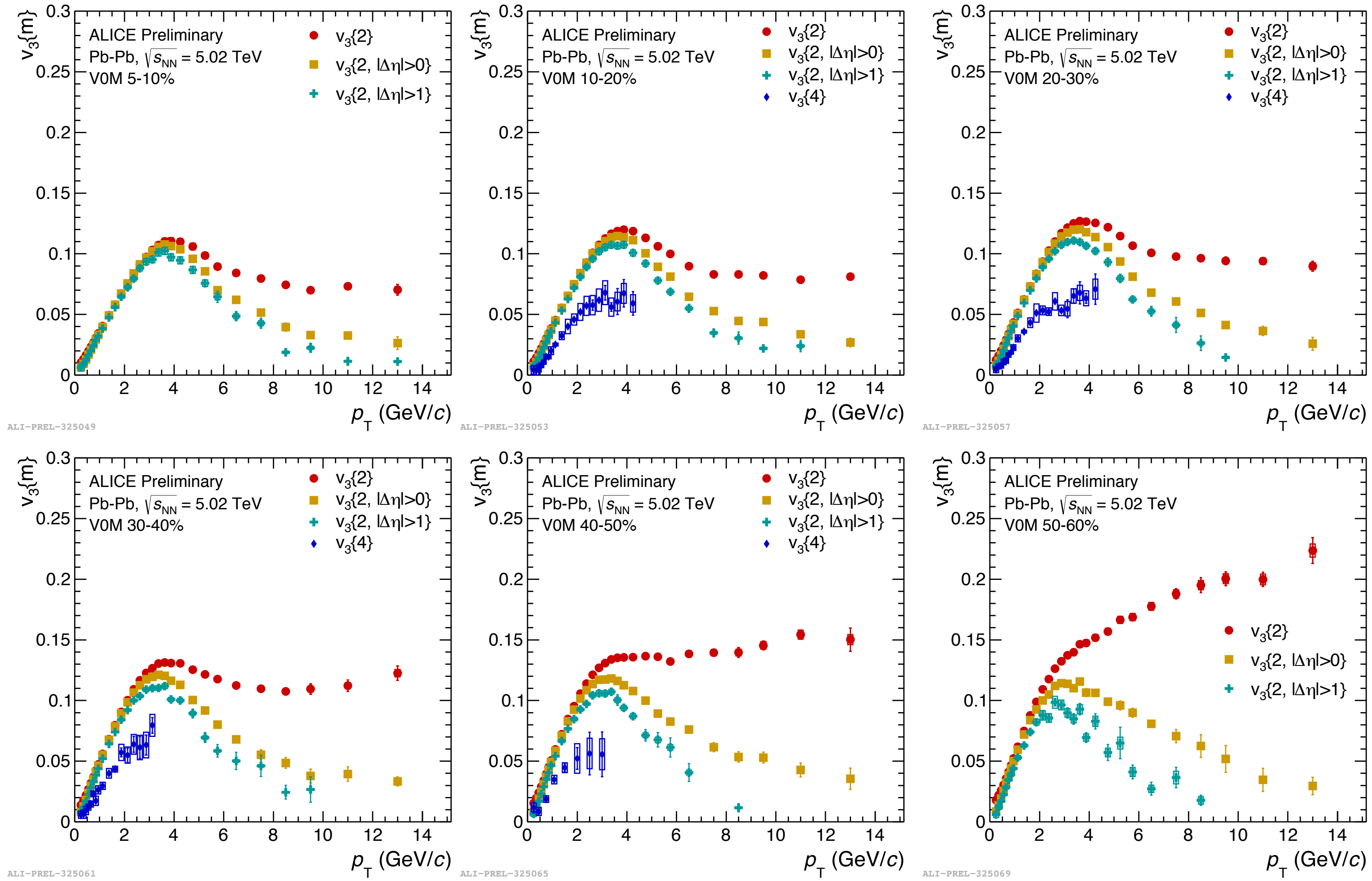

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$v_2\{\mathrm{m}\}$ in central Pb—Pb collisions:

- **$v_2\{2\}$ larger than $v_2\{4,6,8\}$: fluctuations and non-flow**
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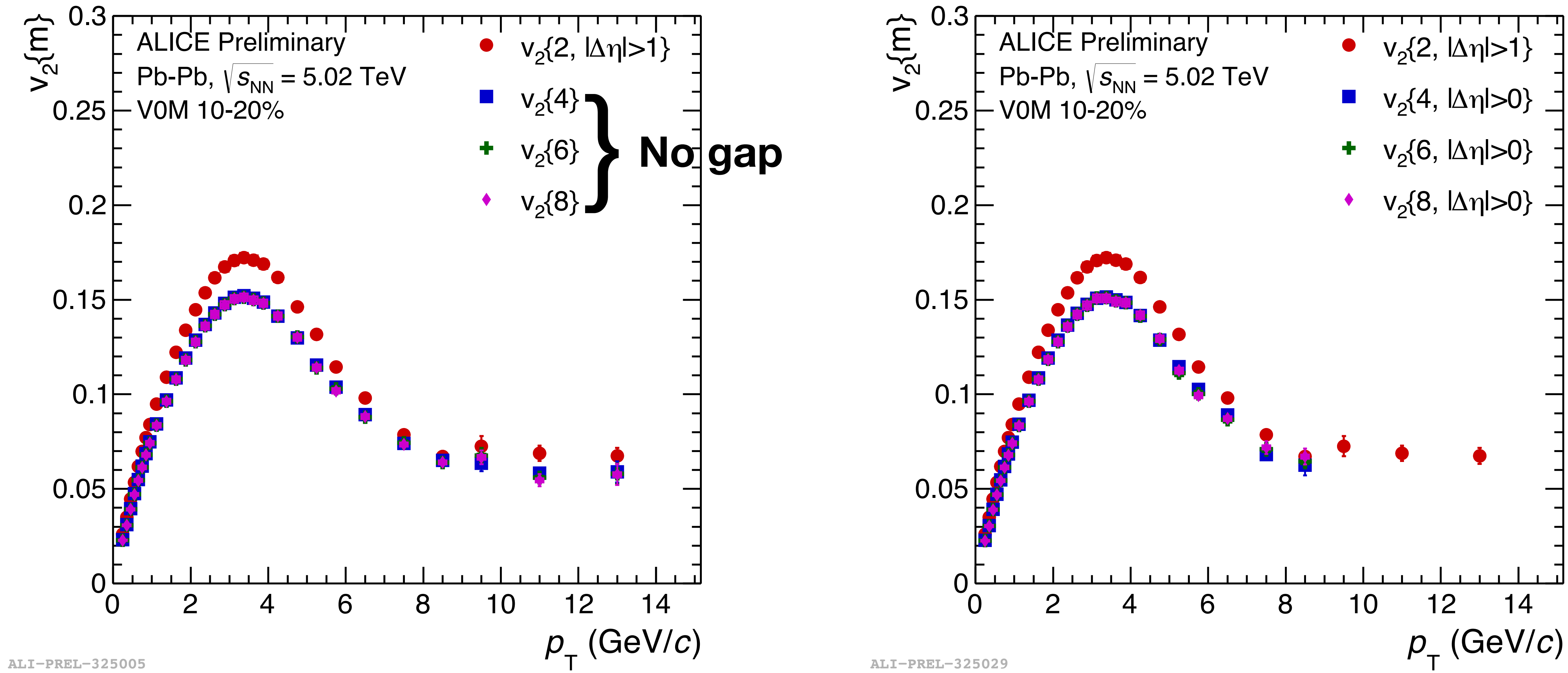

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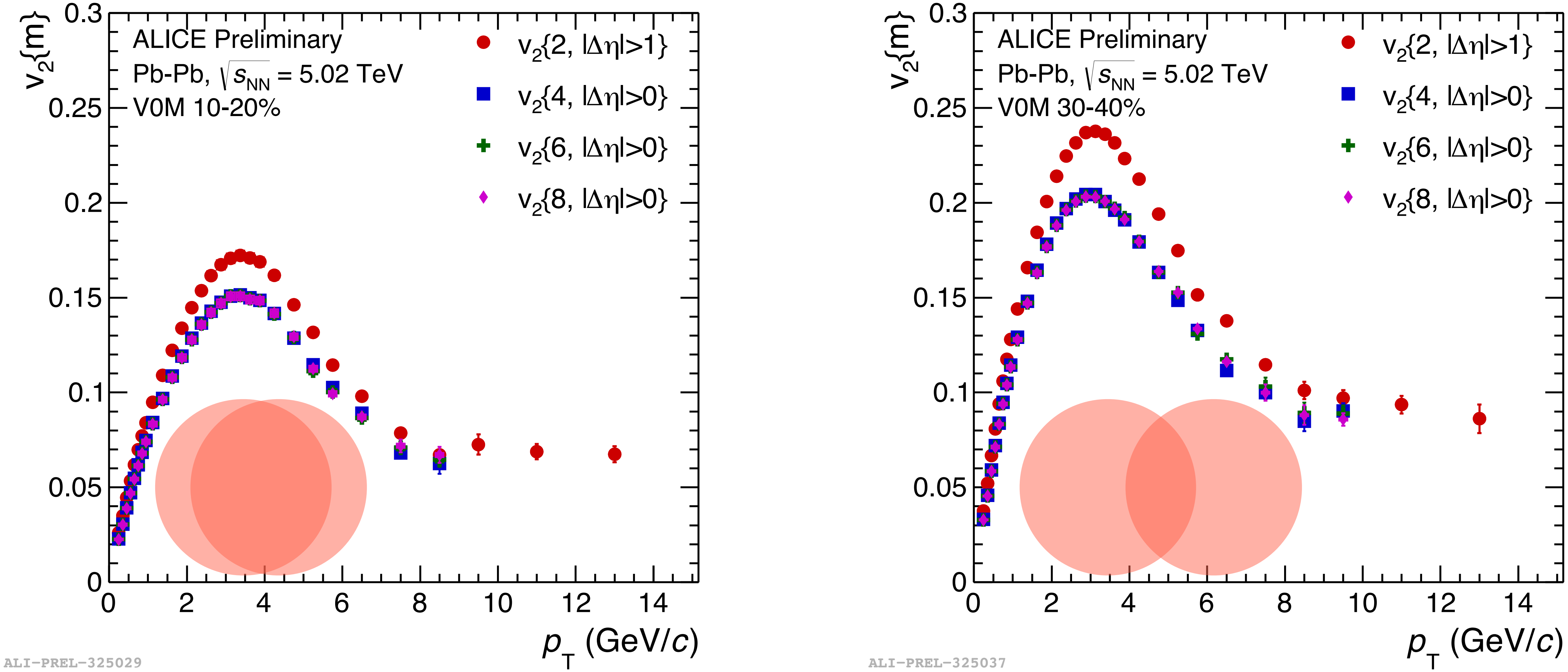

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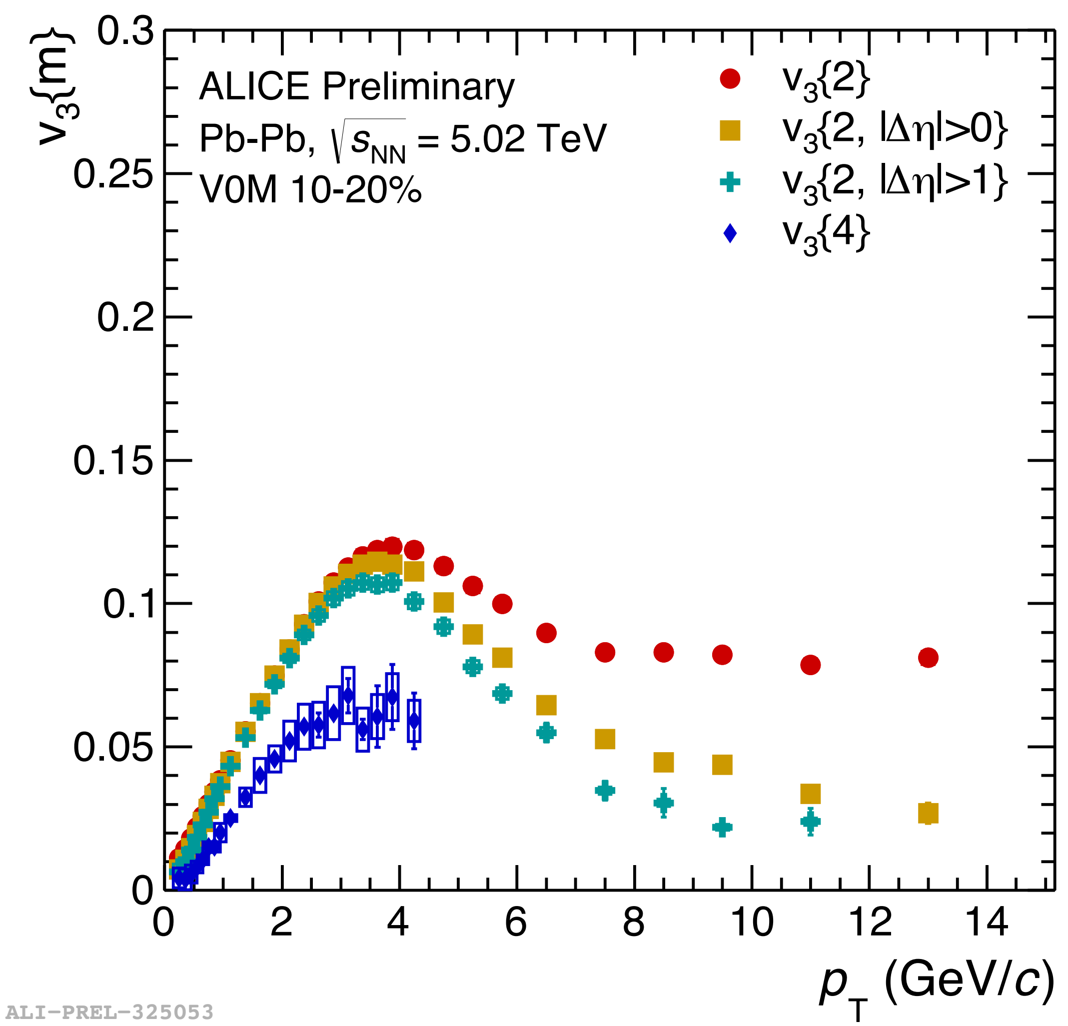

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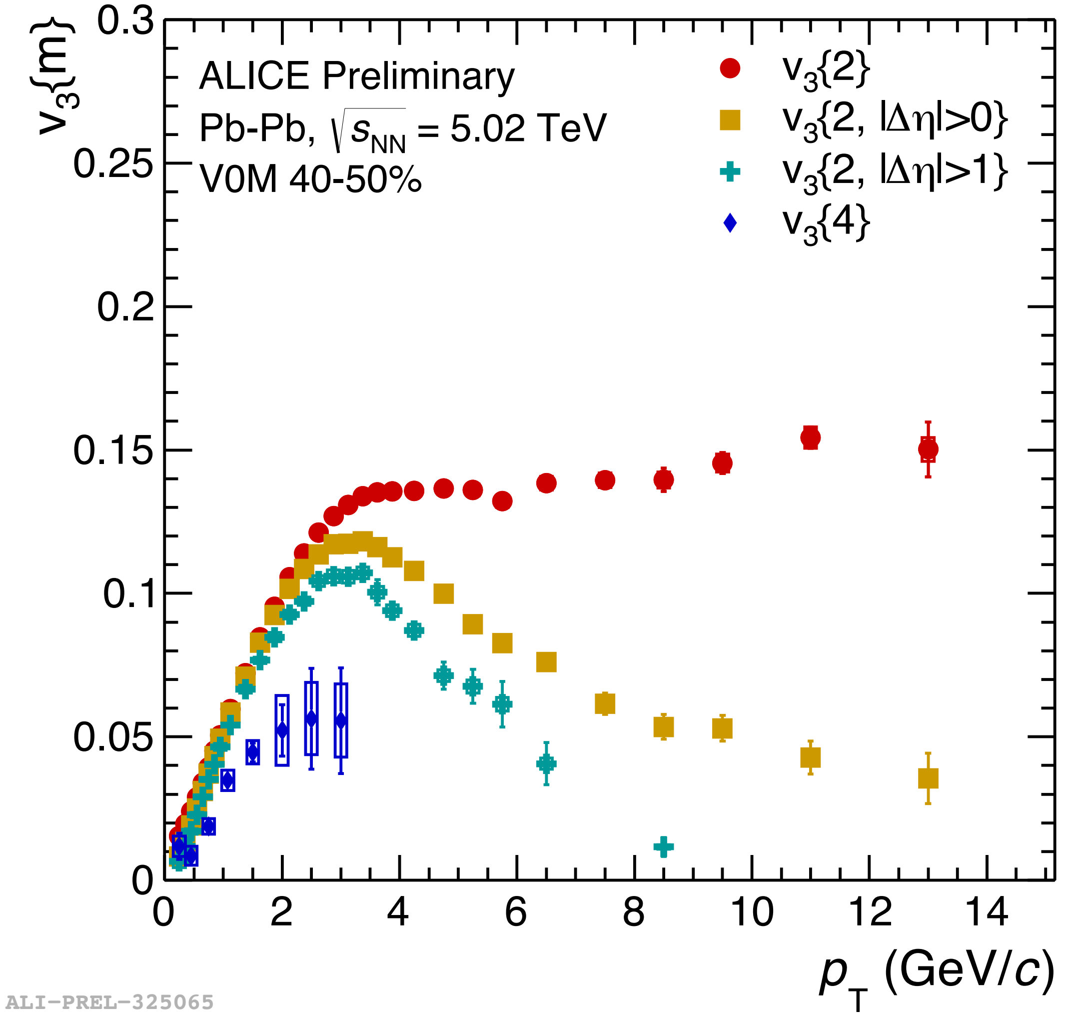

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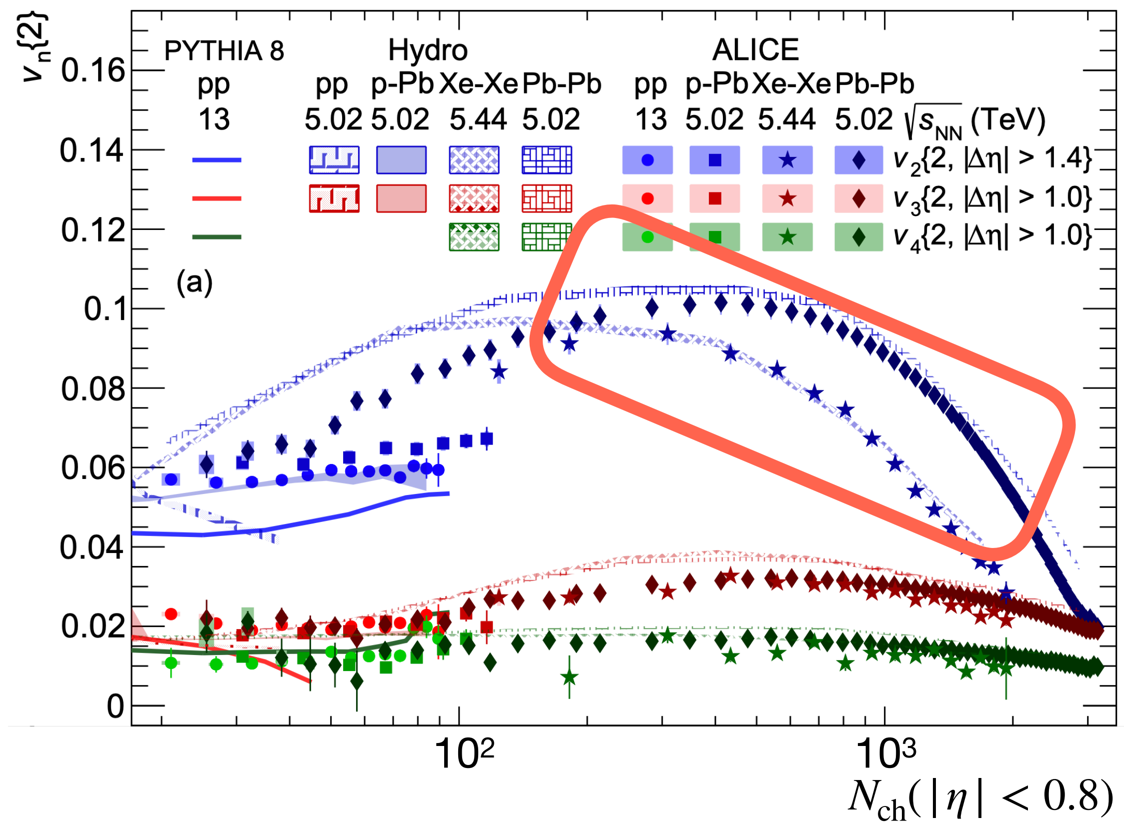
What about smaller systems, eg Xe—Xe?

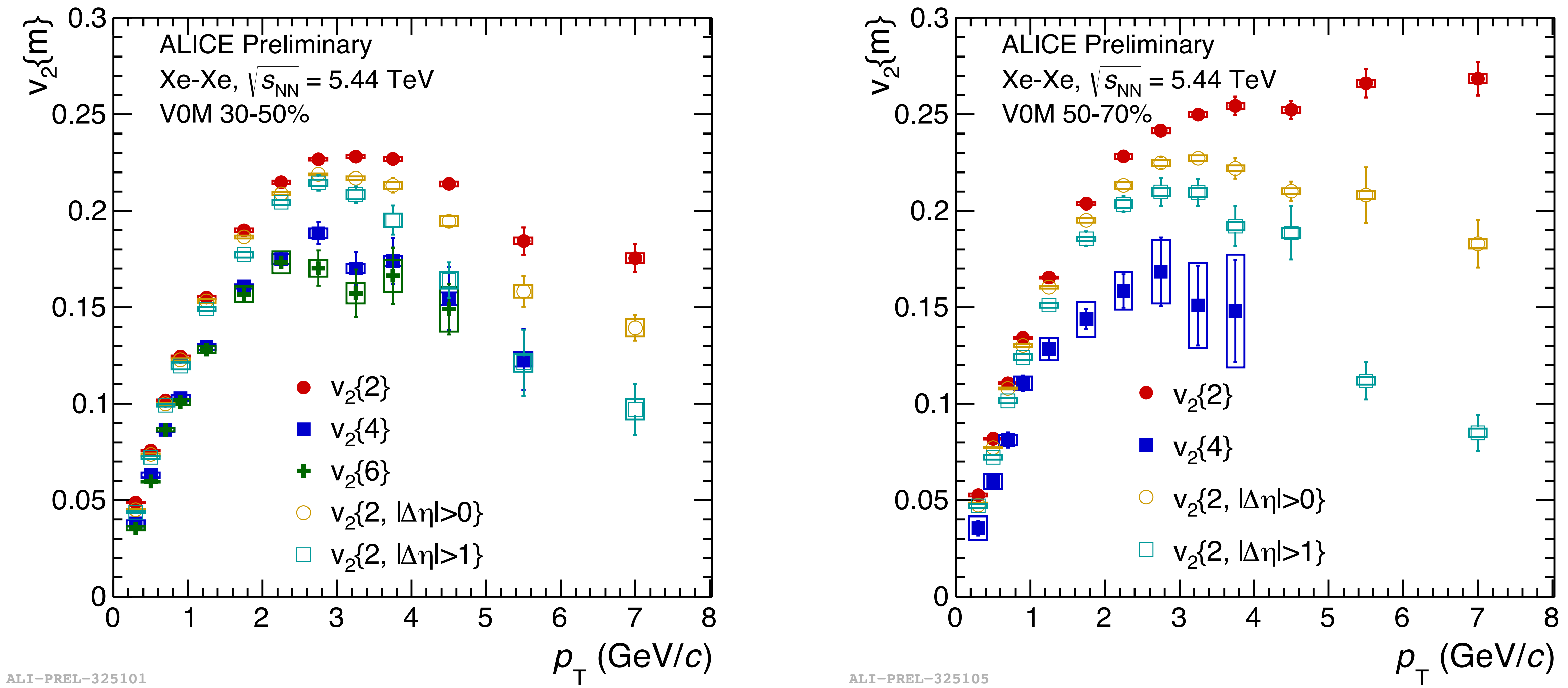


arXiv:1903.01790 [nucl-ex]

p_T-differential $v_n\{m\}$ in Xe-Xe collisions

v_2 in Xe—Xe: similar trends to those seen in Pb—Pb collisions

- $v_2\{4,6\} < v_2\{2\}$, fluctuations and non-flow
- η-gap suppresses non-flow, larger gap required
- In peripheral collisions, $v_2\{2\}$ is dominated by non-flow



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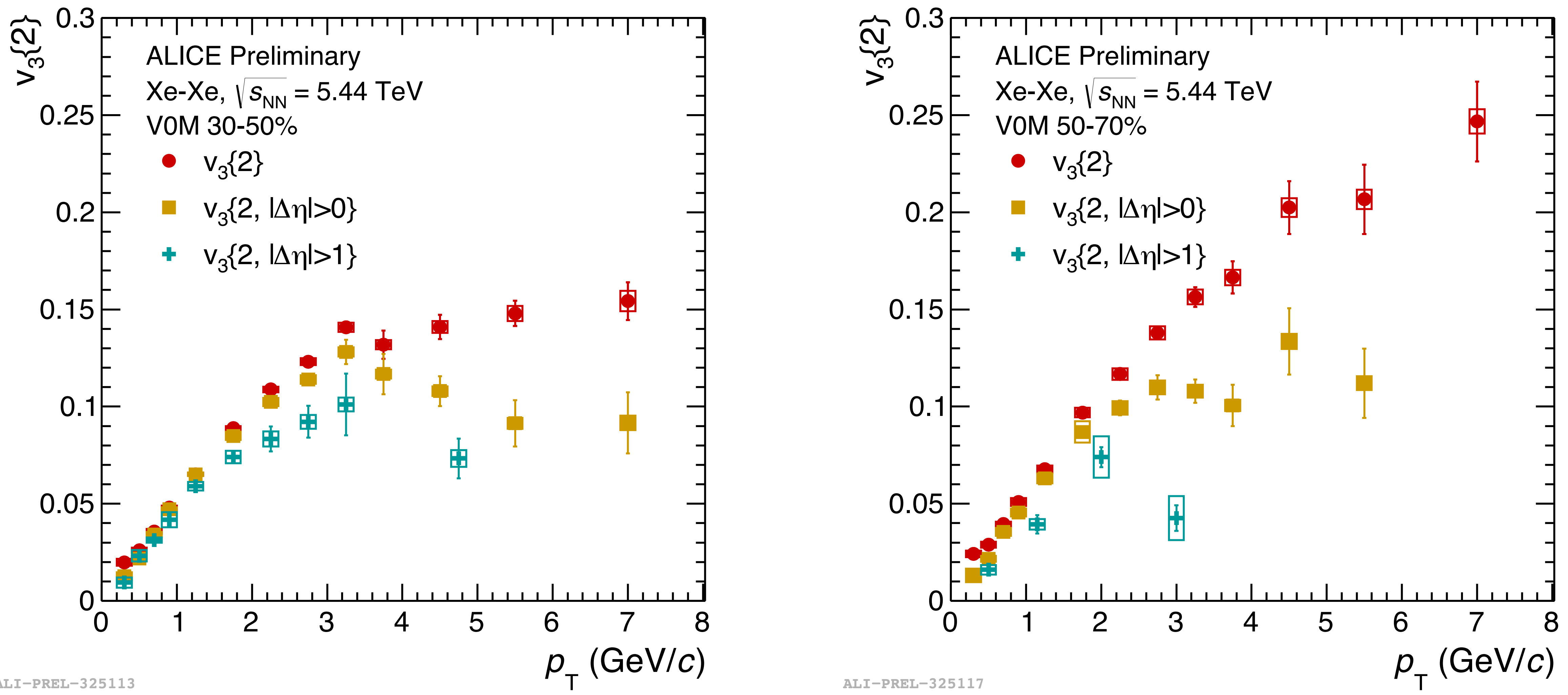
And similar for v_3**...**



p_T-differential v_2 PDFs

What can we learn from these measurements?

- **If $v_2\{m\} \propto \varepsilon_2$, then $\dfrac{v_2\{4\}}{v_2\{6{,}8\}} = const$, independent of p_T**
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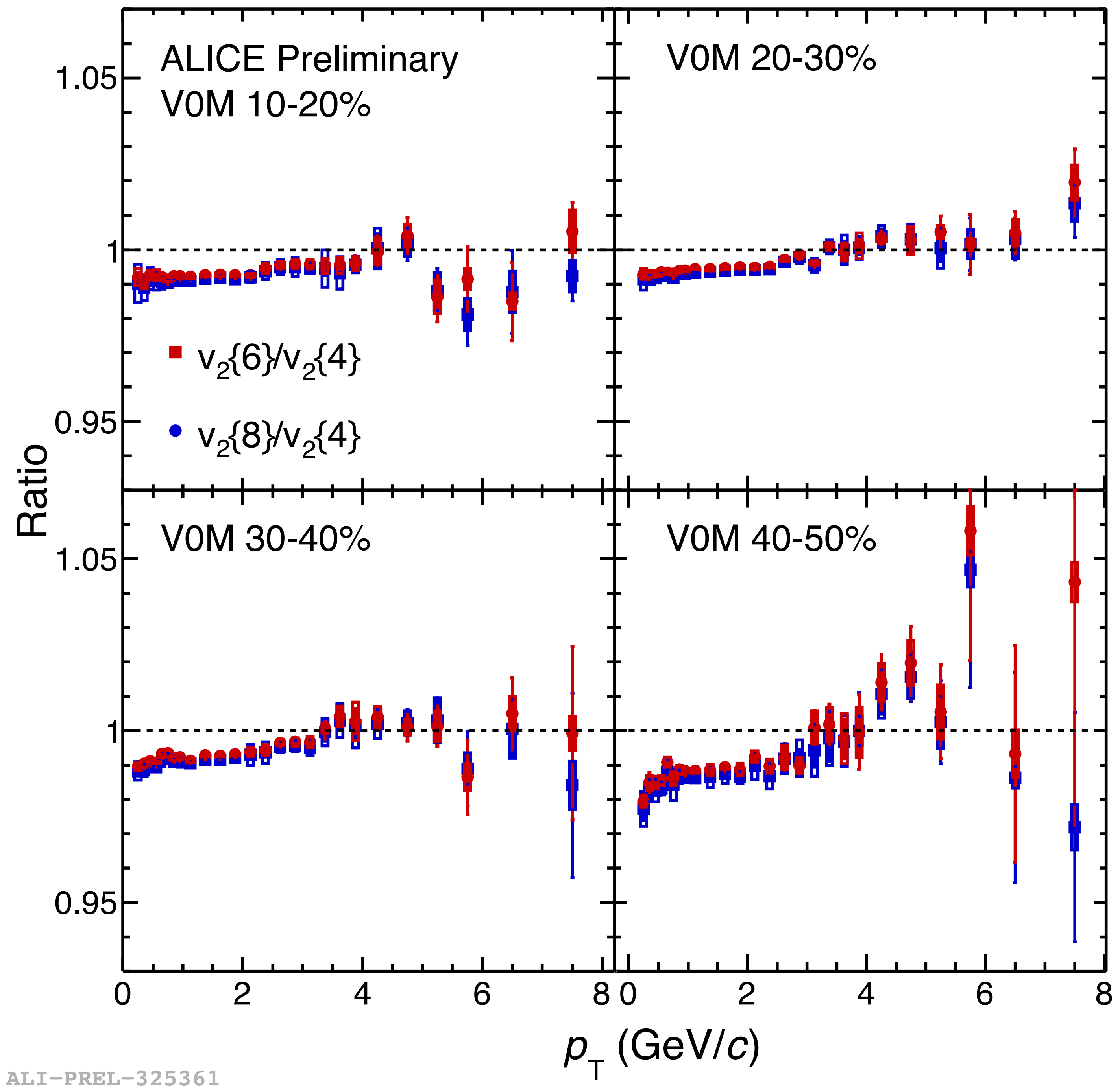
But we find:

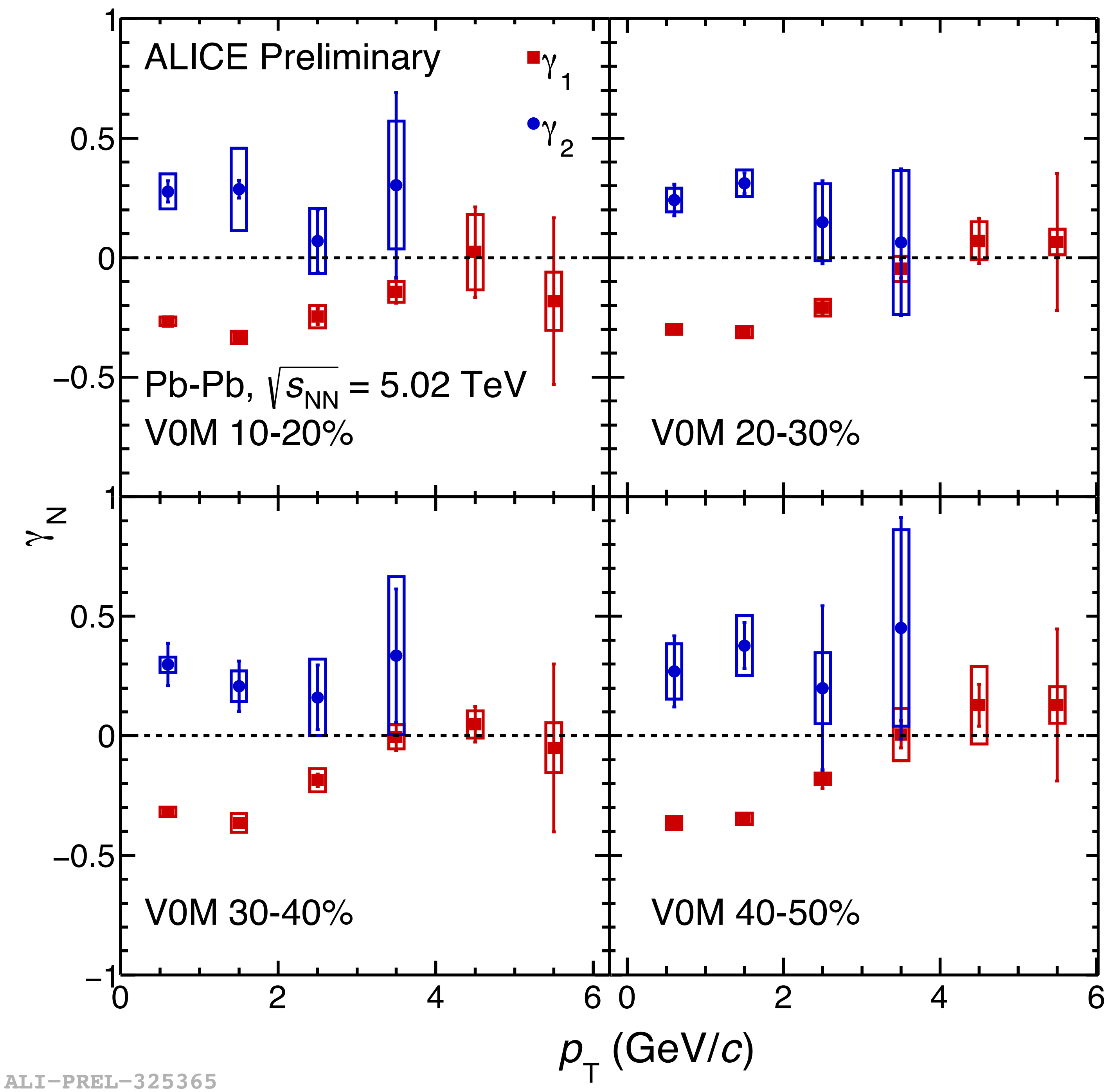
- **v_2 distribution not described by the Bessel-Gaussian distribution**
- **Non-trivial evolution with p_T, -> Sensitive to medium transport parameters?**



p_T-differential v_2 PDFs

v_2 **PDF: sensitive to geometry and evolution of the system. How does it look?**
— Can calculate different moments of the distribution from $v_2\{m\}$[1]:

- **Skewness (γ_1) ~ -0.3 at low p_T (cf hydro [2])**
- **Kurtosis (γ_2) small, positive at low p_T, tails larger than Gaussian**
- **Higher p_T ($\gtrsim 3$): γ_1 and γ_2 consistent with 0, v_2 PDF approaches normal distribution**



[1] Phys. Rev. C 95, 014913
[2] JHEP 1807, 103 (2018)

Summary

- p_T-differential measurements of flow coefficients using 6- and 8-particle correlations done for the first time in ALICE
- $v_2\{6\}$ and $v_2\{8\}$ show deviations from $v_2\{4\}$, indicating that the underlying PDF is not described by the Bessel-Gaussian distribution
- $v_2\{6\}/v_2\{4\}$ and $v_2\{8\}/v_2\{4\}$ ratios show non-trivial evolution with p_T
  -> Might point to needed refinement of the traditional linear relation between v_n and ε_n
- Probability density function of v_2 is not constant in p_T (large left tail at low p_T, approaching normal distribution at ~3 GeV/*c*)

Backup

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