

Probing partonic collectivity in pp and p—Pb collisions with ALICE

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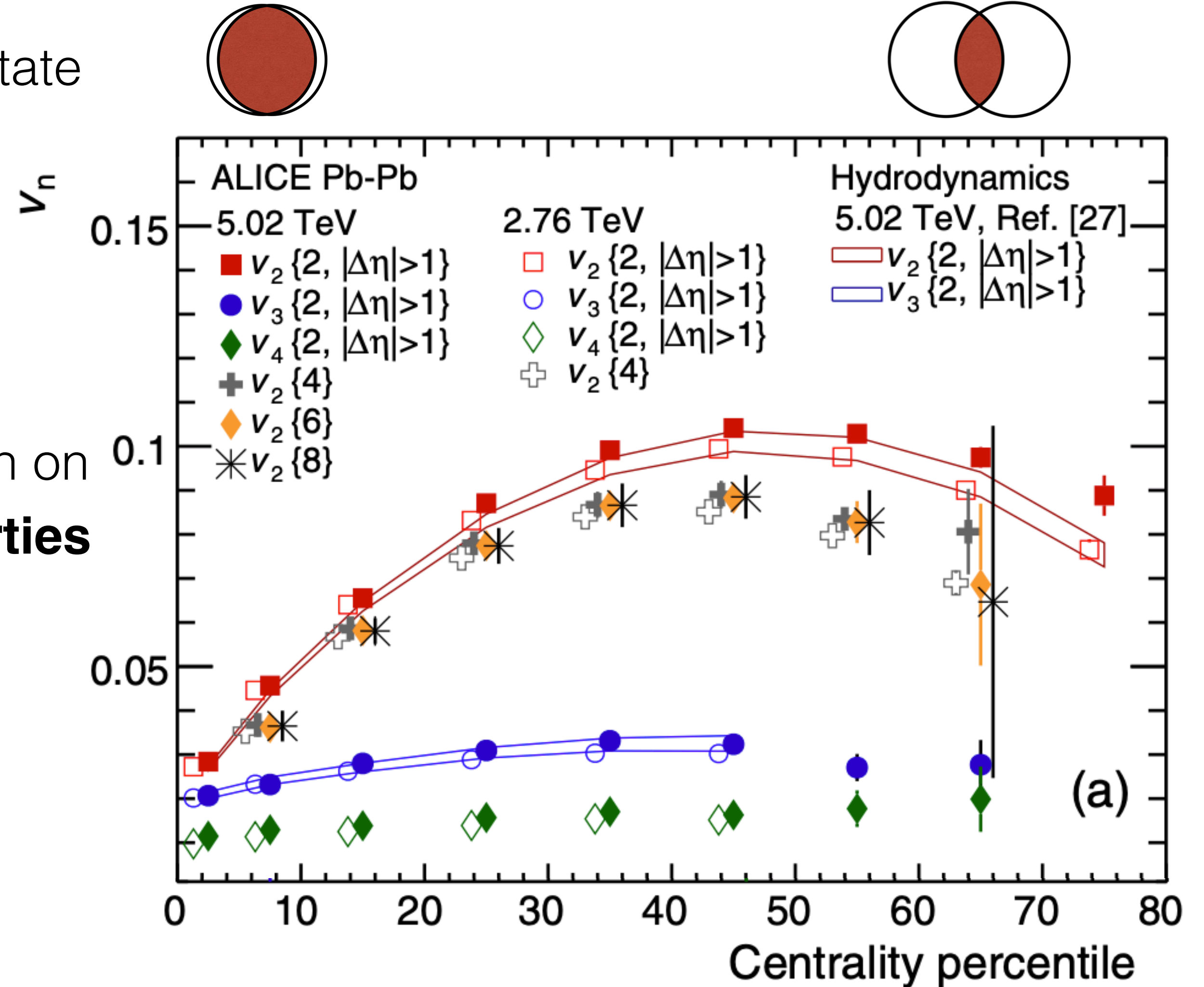
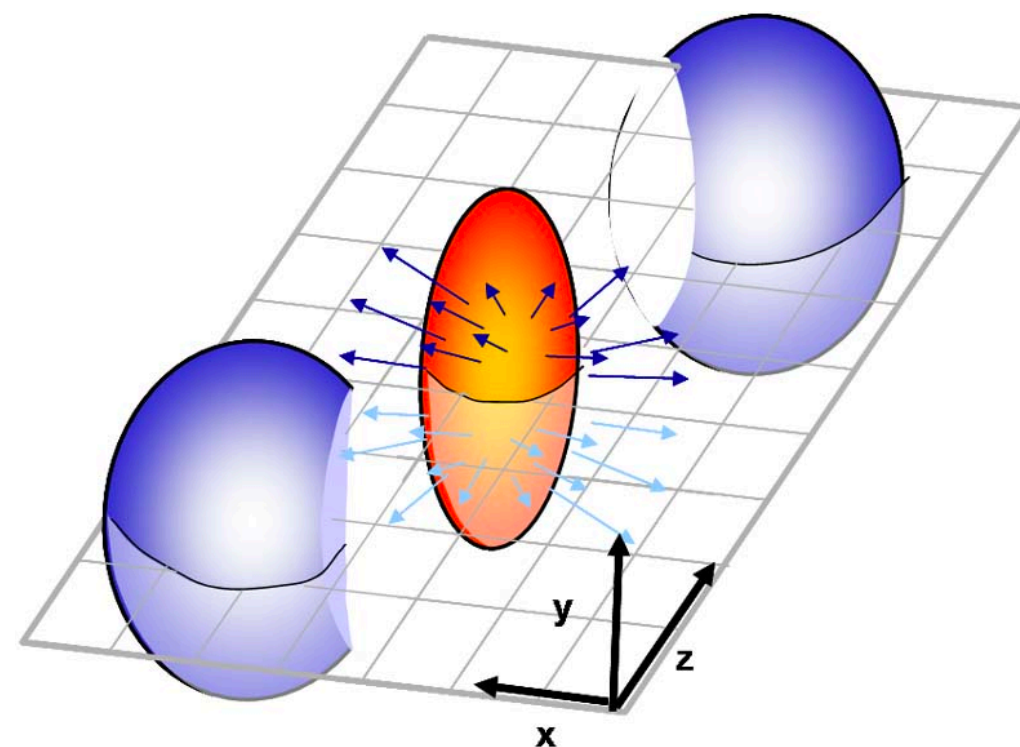


Flow measurements in heavy-ion collisions

- Anisotropy in azimuthal distribution of final-state particles with respect to the reaction plane:

$$\frac{dN}{d\phi} \approx 1 + 2 \sum_{n=1}^{\infty} v_n \cos(n(\phi - \psi_n))$$

- Flow coefficients $v_n \rightarrow$ their correlation to the initial geometry provides detailed information on the **initial conditions and transport properties of the created medium**
- Well described by hydrodynamic models

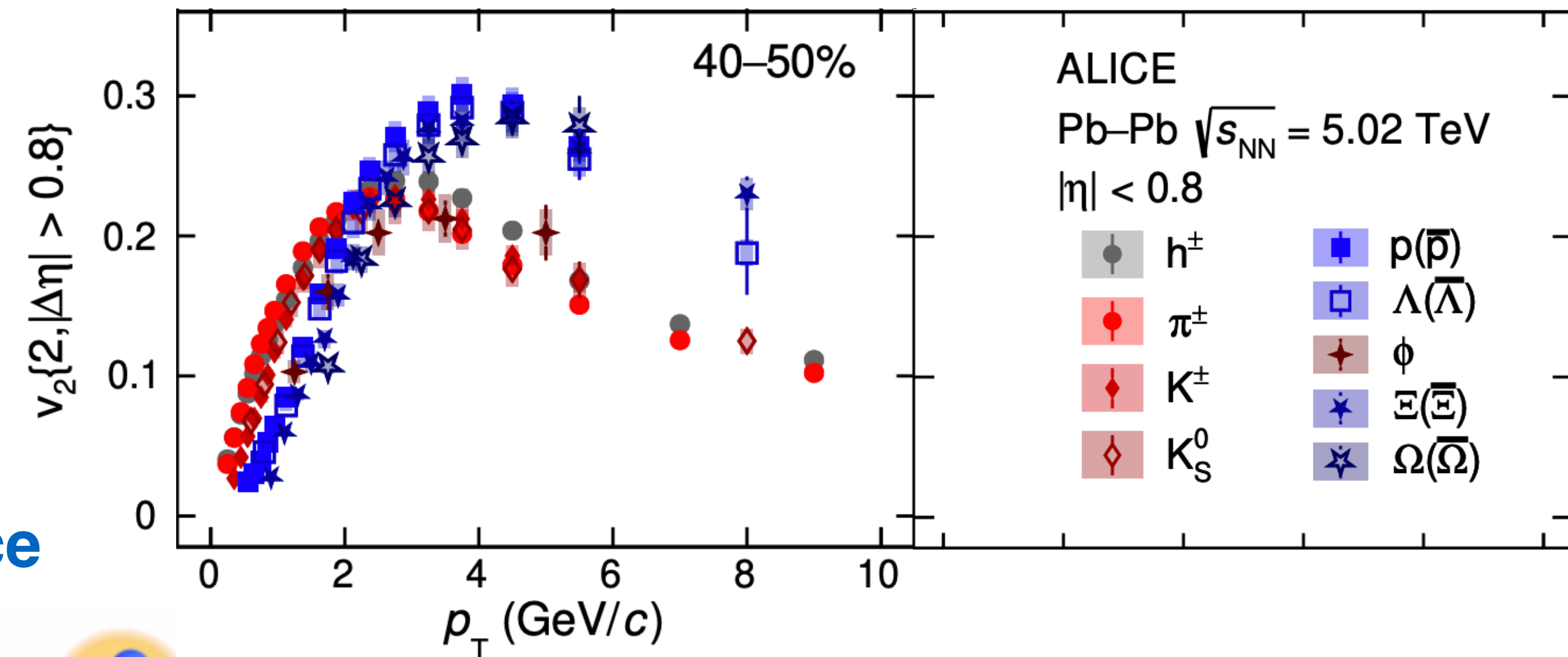


ALICE, PRL 116, 132302 (2016)

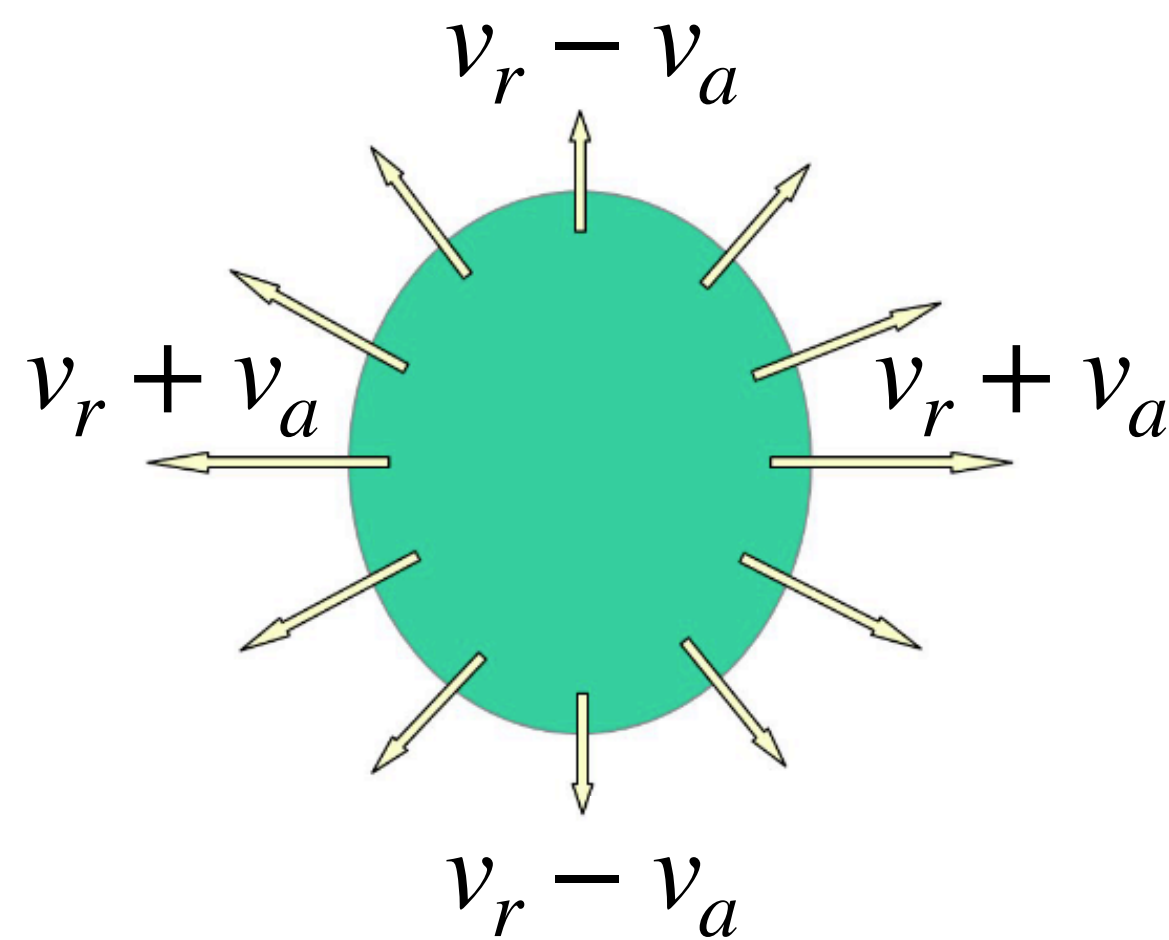
Flow of identified particles in Pb—Pb collisions

ALICE, JHEP 05 (2023) 243

- Low- p_T region: **mass ordering** (anisotropic boost from the medium, described by hydrodynamics)
- Intermediate- p_T region: **baryon-meson grouping** (partonic collectivity, transport effect)

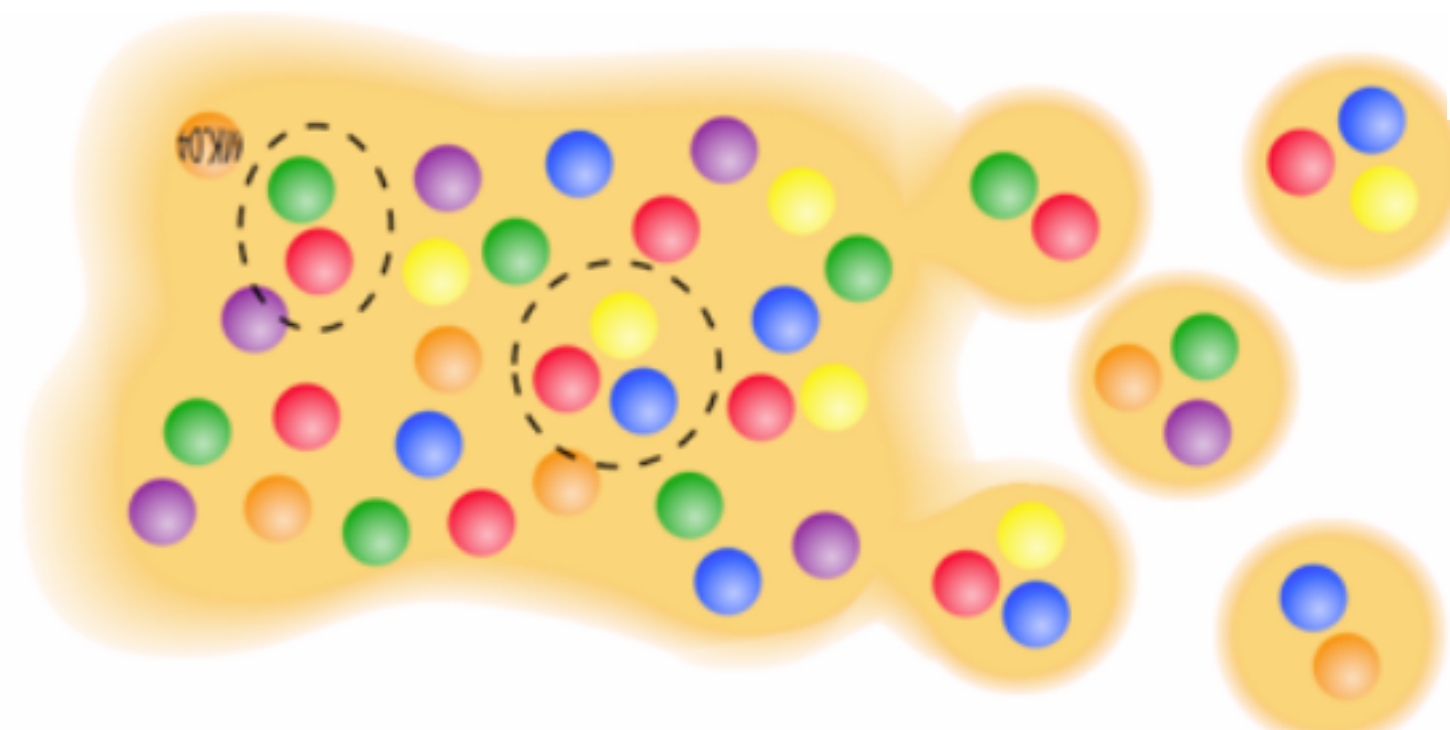


Hydrodynamics

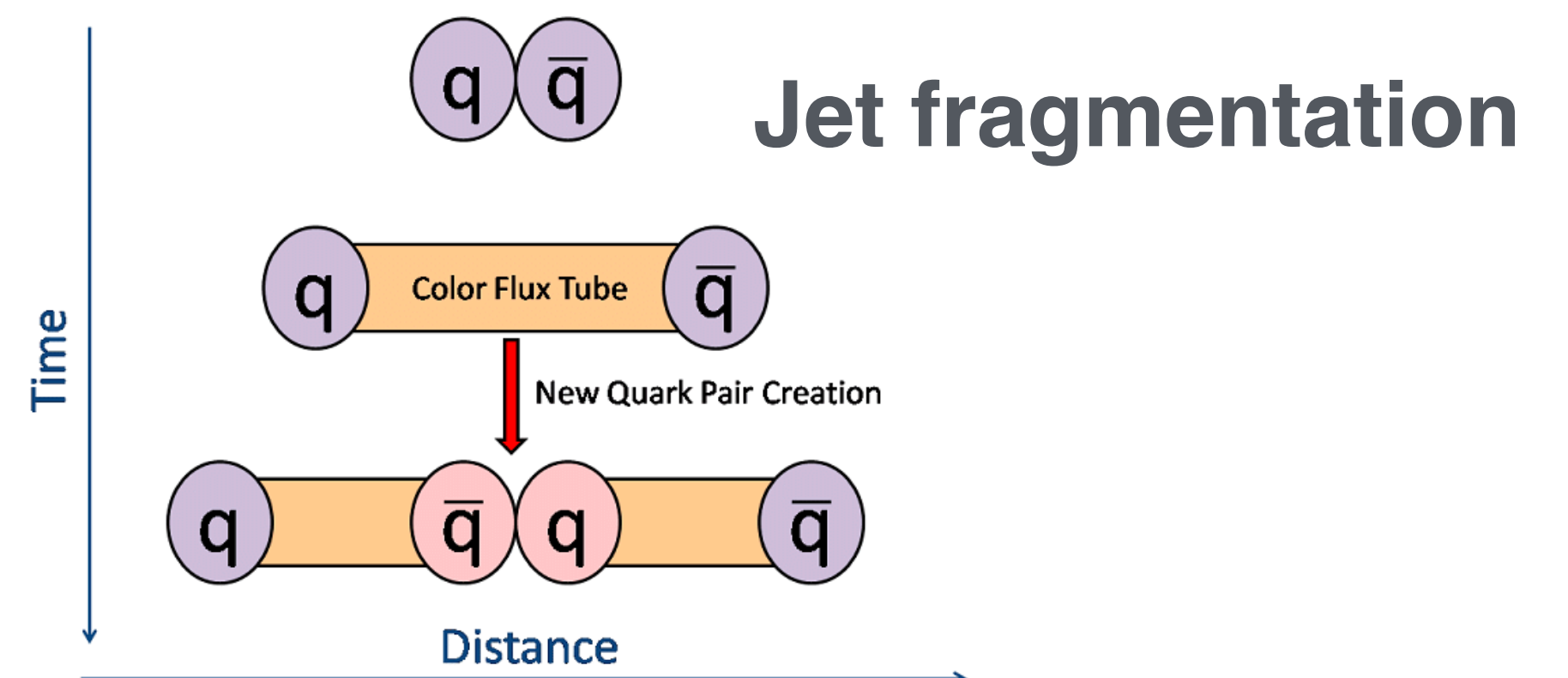


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Quark coalescence



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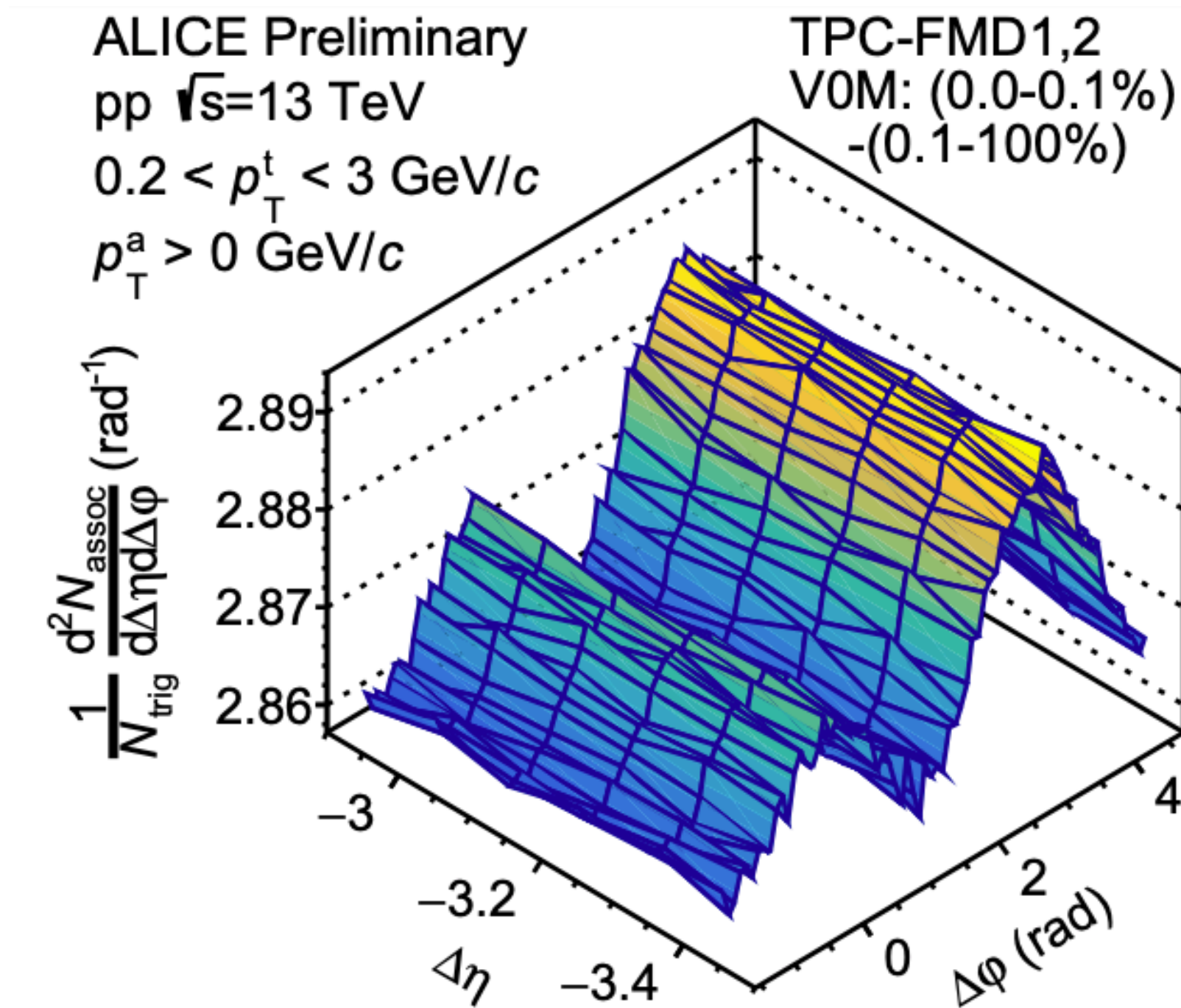


Collectivity in small systems

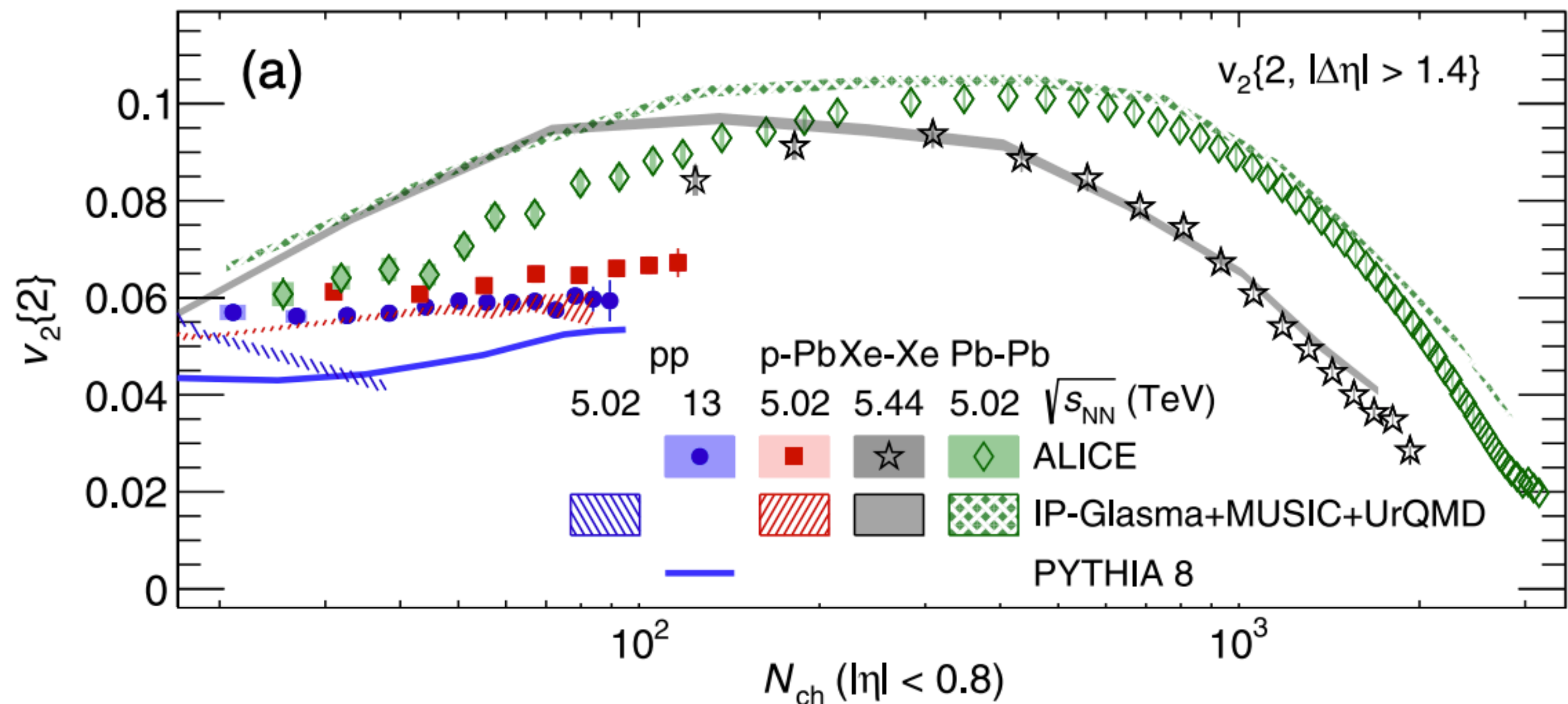
- Double ridge structure, a sign of collectivity in heavy-ion collisions, also observed in **pp** and **p—Pb collisions**

- Sizable flow observed across all collision systems (pp, p—Pb, Xe—Xe, Pb—Pb)
- Multiparticle long-range correlations confirmed **collectivity in small systems**

ALICE, PRL 123, 142301 (2019)



ALI-PREL-345489

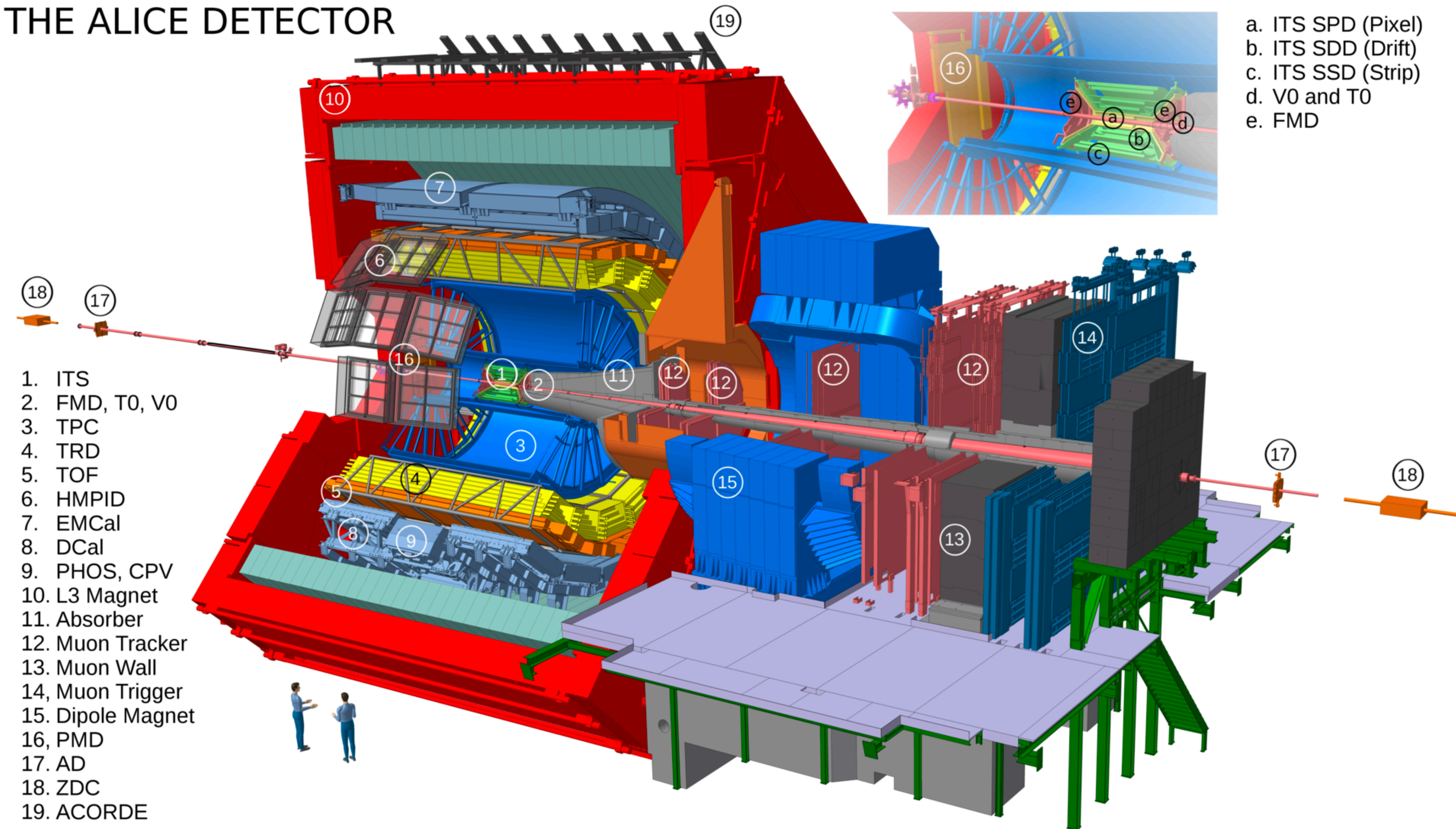


ALICE detector → A Large Ion Collider Experiment



- **Inner Tracking System (ITS)**
Tracking and triggering
- **V0 Detector**
Triggering and event classification
- **Forward Multiplicity Detector (FMD)**
Unique pseudorapidity coverage
 $-3.4 < \eta < -1.7$
 $1.7 < \eta < 5.0$
- **Time Projection Chamber (TPC)**
Tracking and particle identification
- **Time-of-Flight detector (TOF)**
Particle identification

THE ALICE DETECTOR



Non-flow treatment

- Two particle correlation function (same/mixed events)

$$C(\Delta\phi, \Delta\eta) = \frac{1}{N_{trig}} \sum_{P_{vZ}} \frac{SE(\Delta\phi, \Delta\eta)}{\alpha ME(\Delta\phi, \Delta\eta)}$$

- Non-flow suppression (combined):
 - Long-range correlation (large $|\Delta\eta|$ gap between particles)
 - Template fit \rightarrow correlation function can be described as **a superposition of non-flow and flow**:

$$Y(\Delta\phi) = \underset{\substack{\swarrow \\ \text{Peripheral events,} \\ \text{non-flow dominated}}}{FY(\Delta\phi)^{peri}} + G[1 + \sum_{n=2}^{\infty} \underset{\substack{\swarrow \\ \text{Flow signal}}}{2V_{n\Delta} \cos(n\Delta\phi)}]$$

Peripheral events,
non-flow dominated

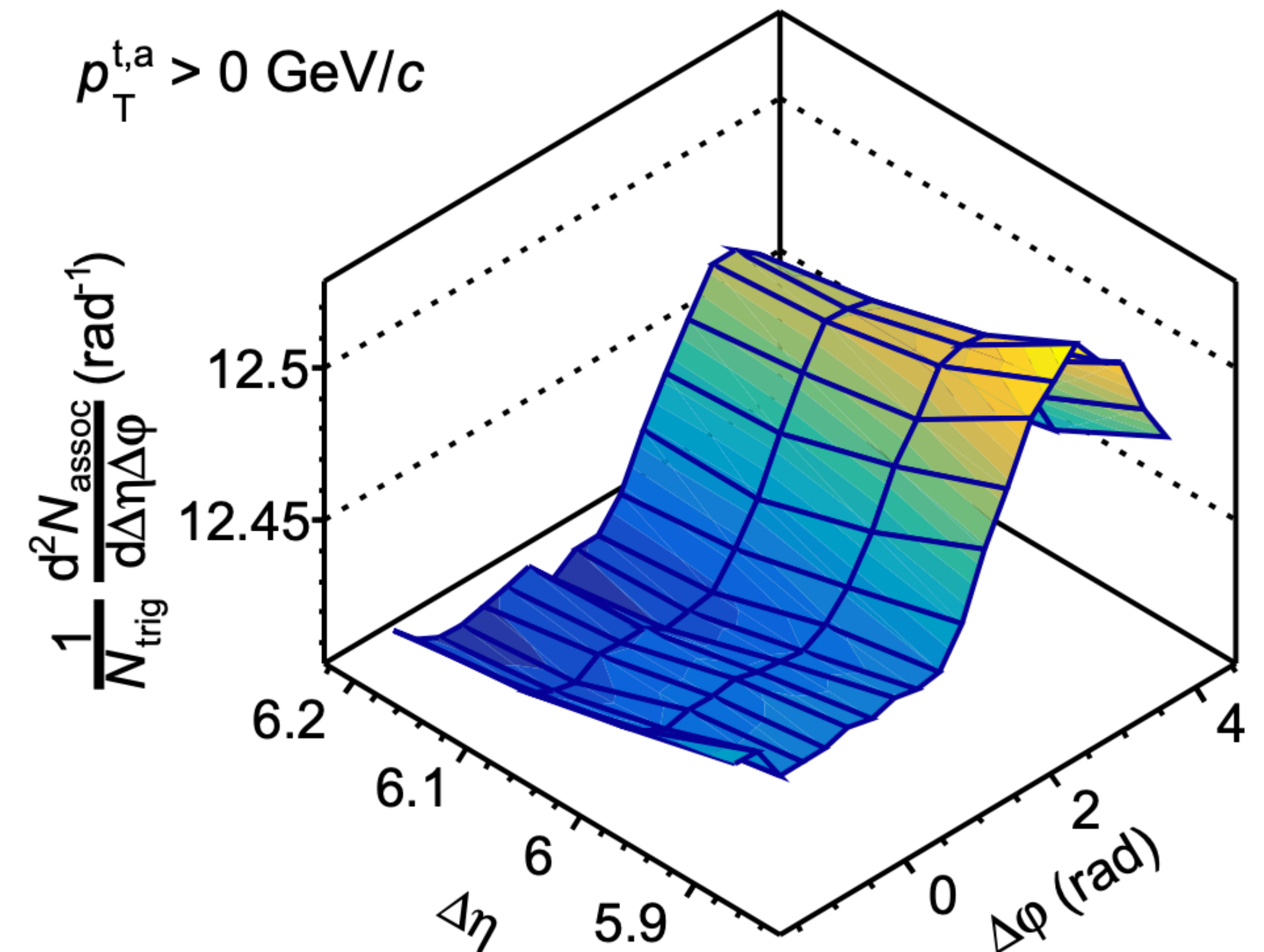
Flow signal

(TF is the best way rather than ITF and subtraction methods)

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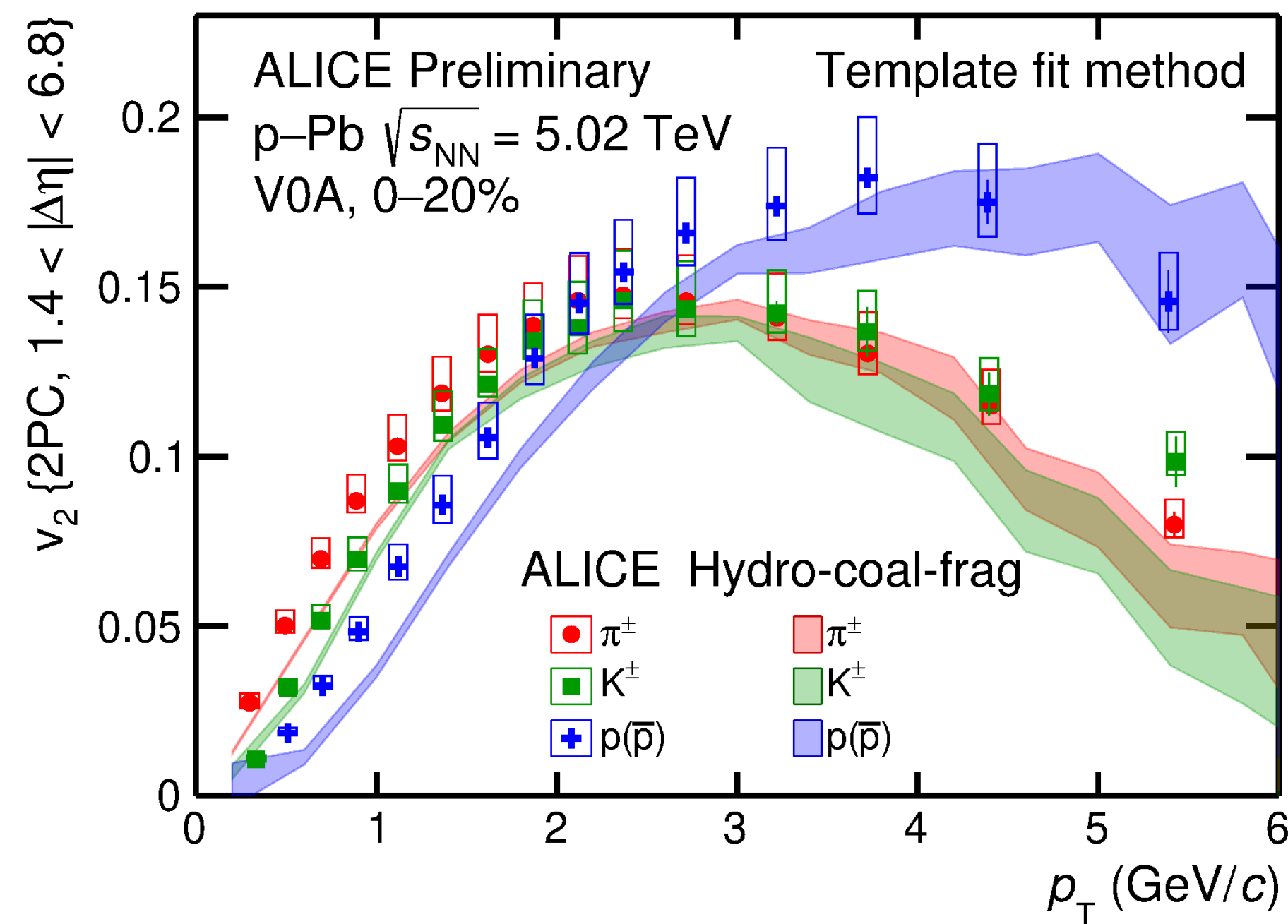
FMDA-FMDC (long range) correlation



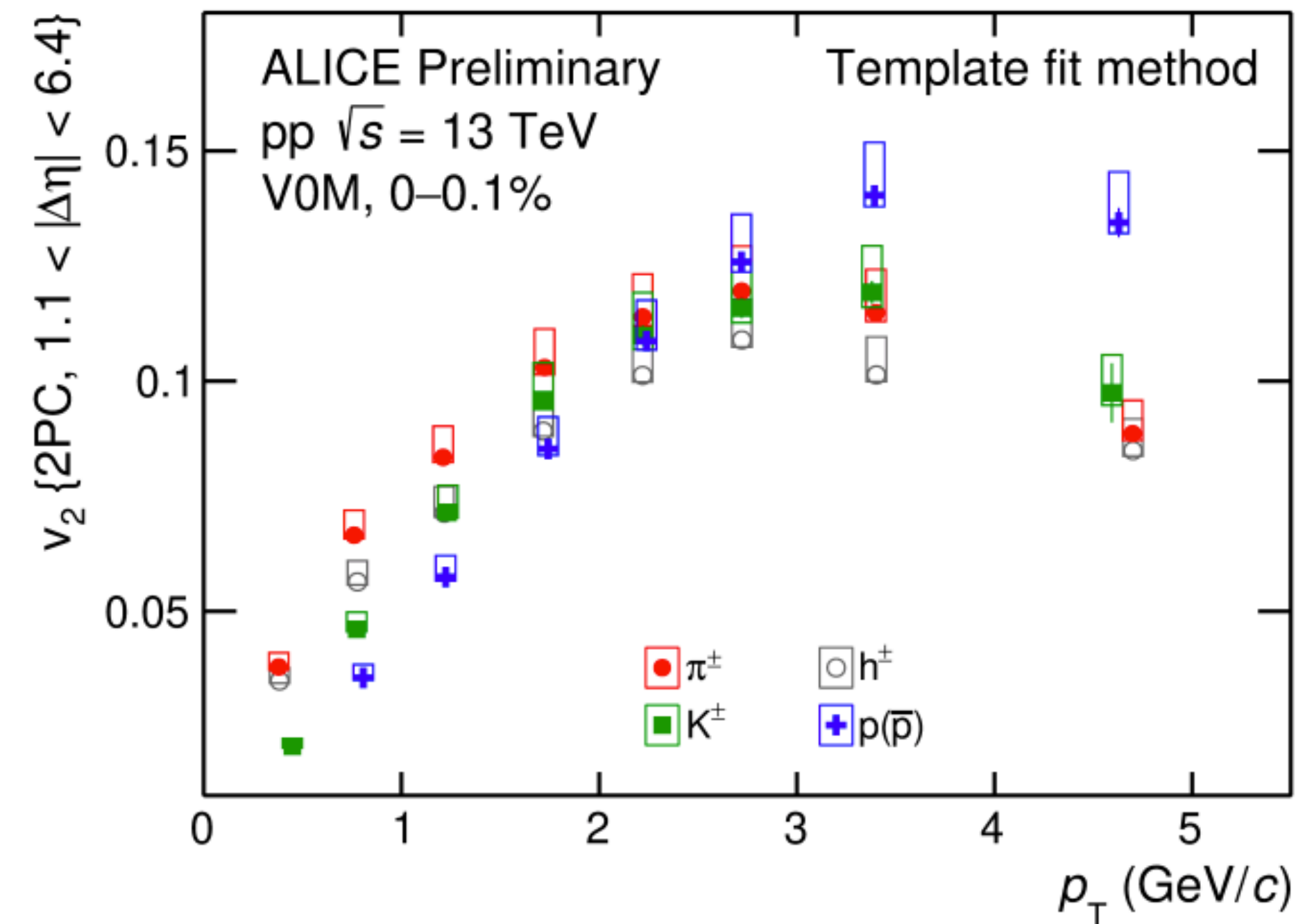
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p_T -differential flow of identified particles in small systems

- **Mass ordering (low- p_T region)** and **baryon-meson grouping (intermediate- p_T region)** are observed **at high multiplicity ranges in p–Pb and pp**
- Probing the **partonic collectivity in small systems**



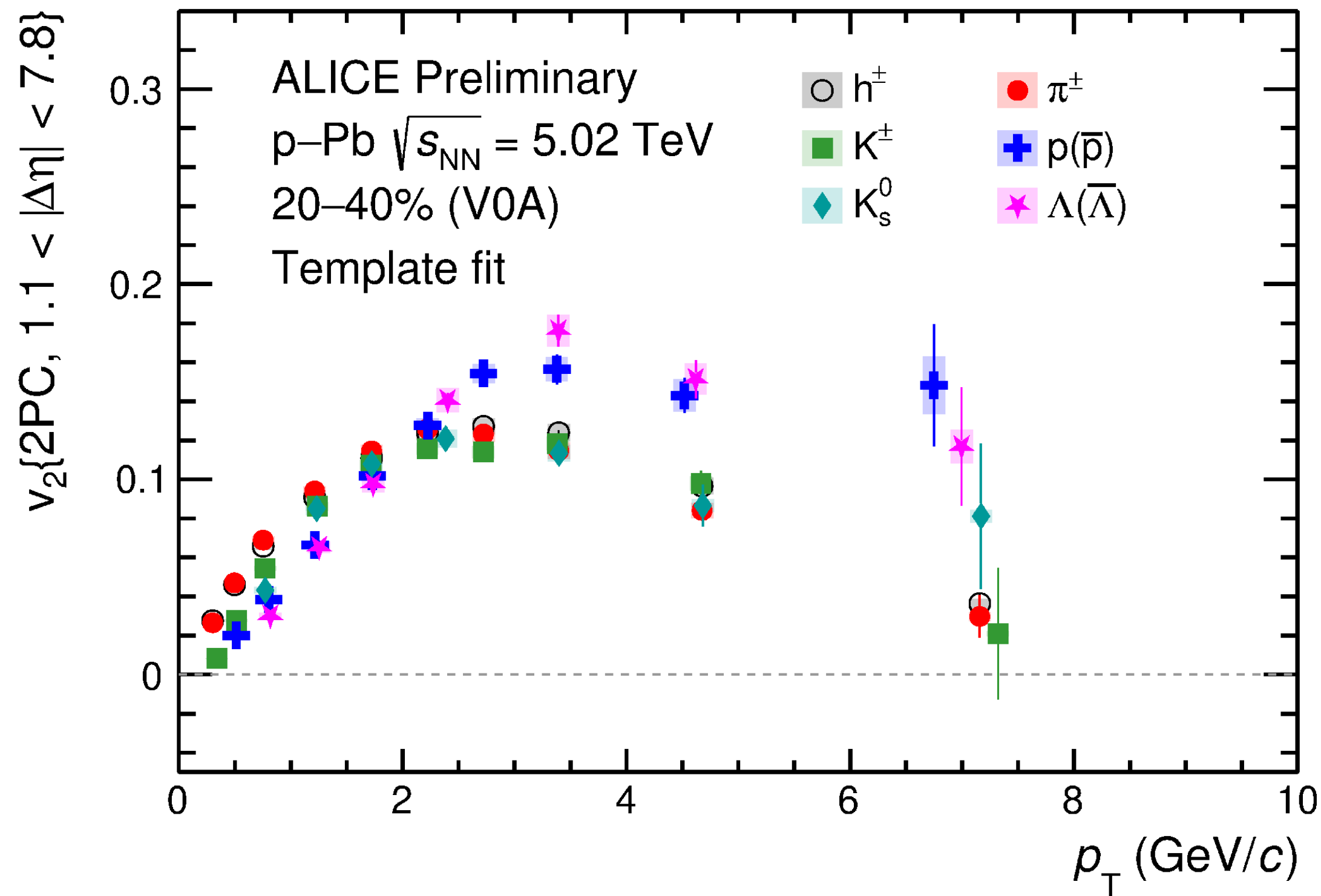
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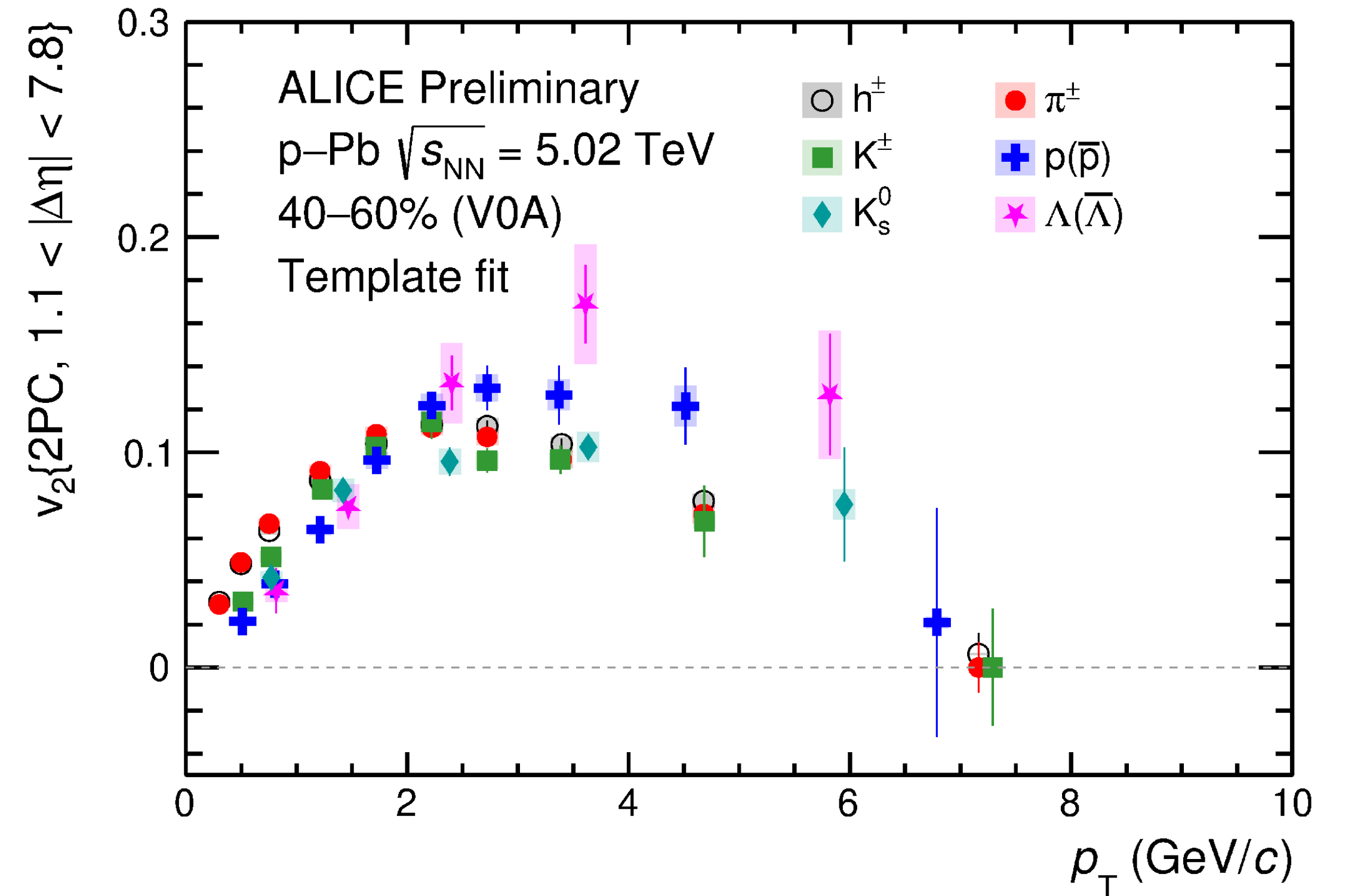
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The minimum requirements for observing partonic collectivity in a small system?
A comprehensive understanding of the **centrality/ N_{ch} dependence of PID differential-flow**

Centrality dependence of $v_2(p_T)$ with identified particles in p–Pb



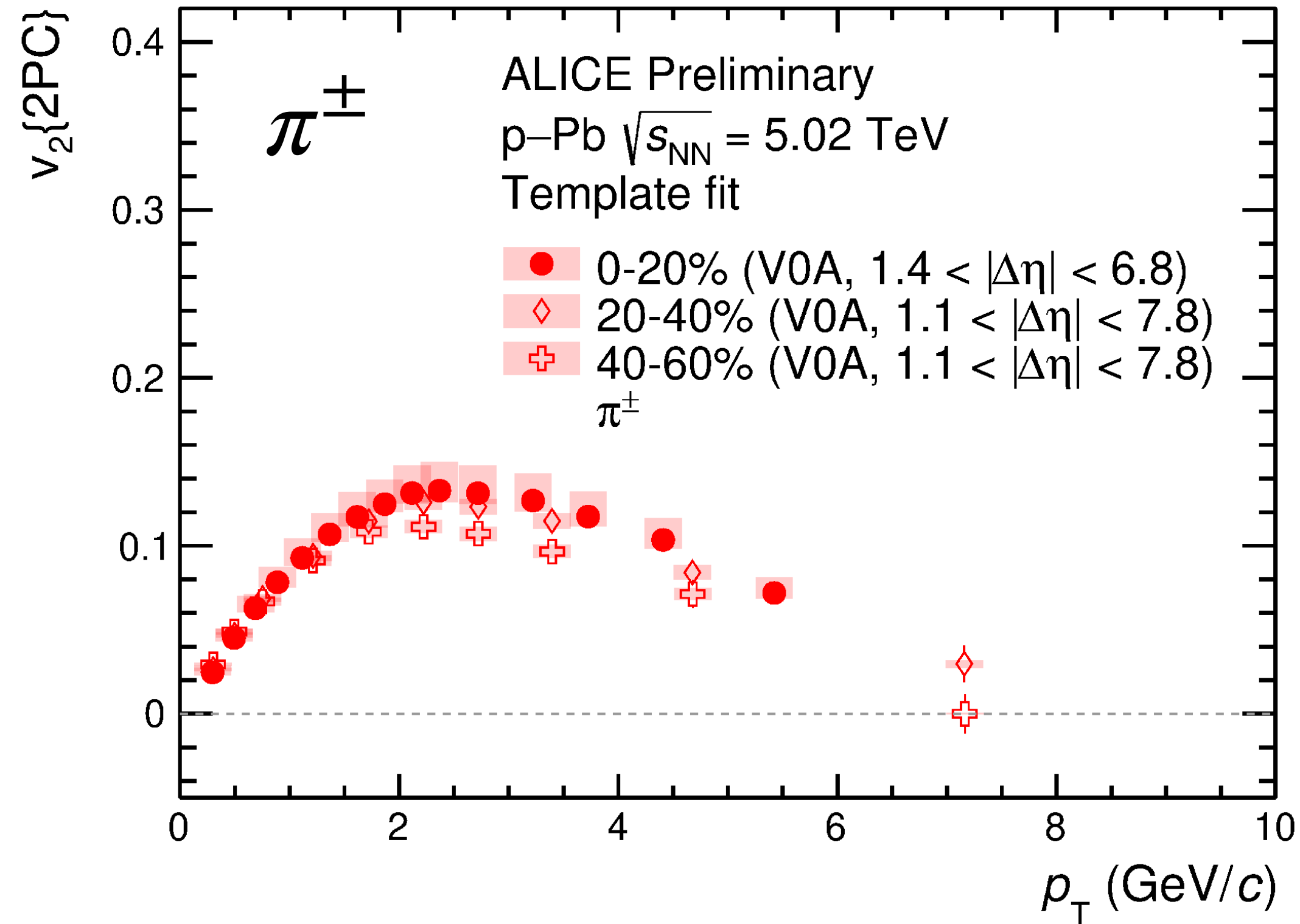
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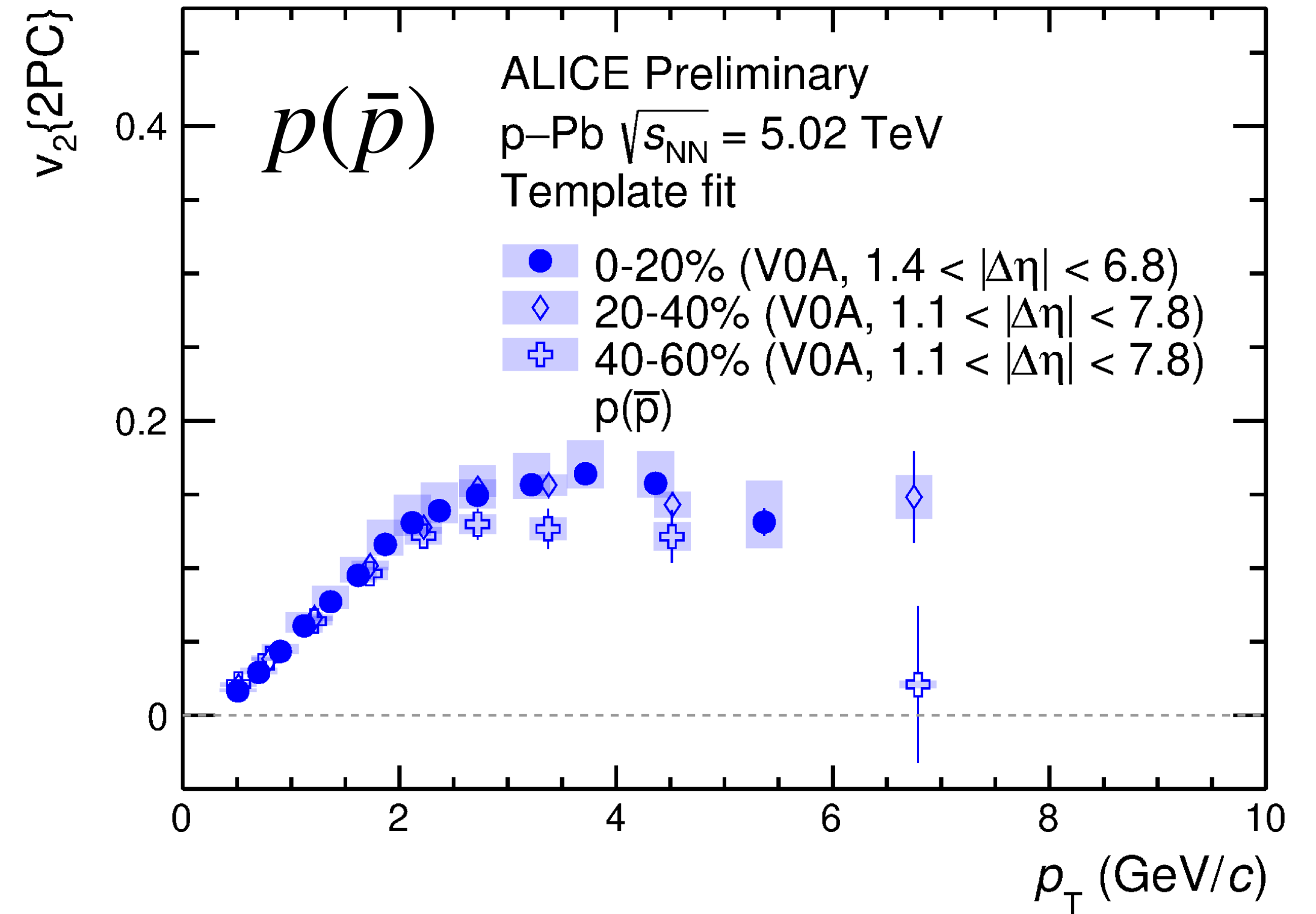
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- Hydro-dominated **mass ordering effect** observed in the low p_T region
- **Baryon-meson grouping** at intermediate p_T region presents at all centrality classes
- The “crossing” of baryons and mesons occurs at $p_T \sim 2.5$ GeV/c for both 20-40% and 40-60% (p–Pb), similar to 0-20% (p–Pb), pp and Pb–Pb

Comparison between centralities in p–Pb



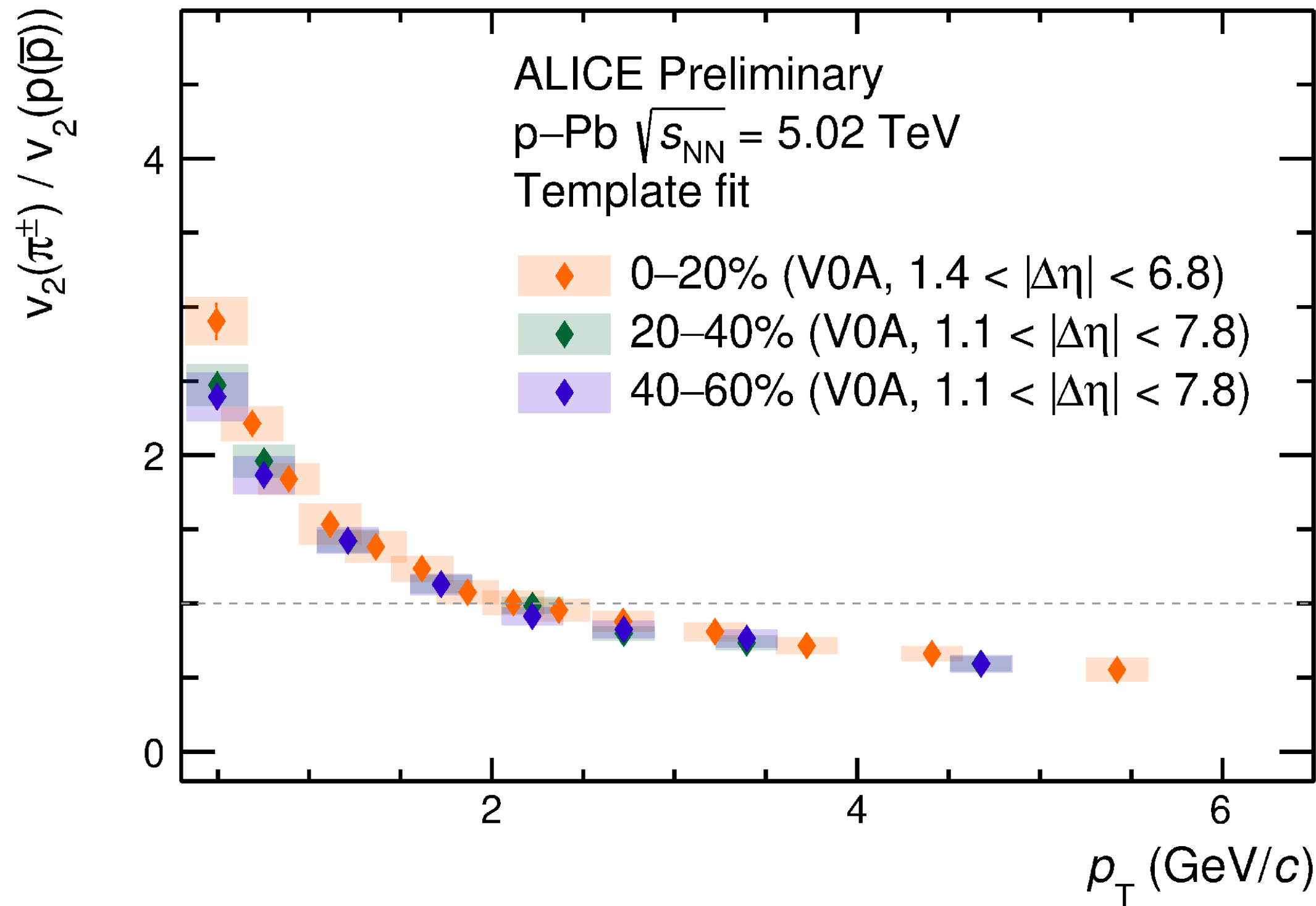
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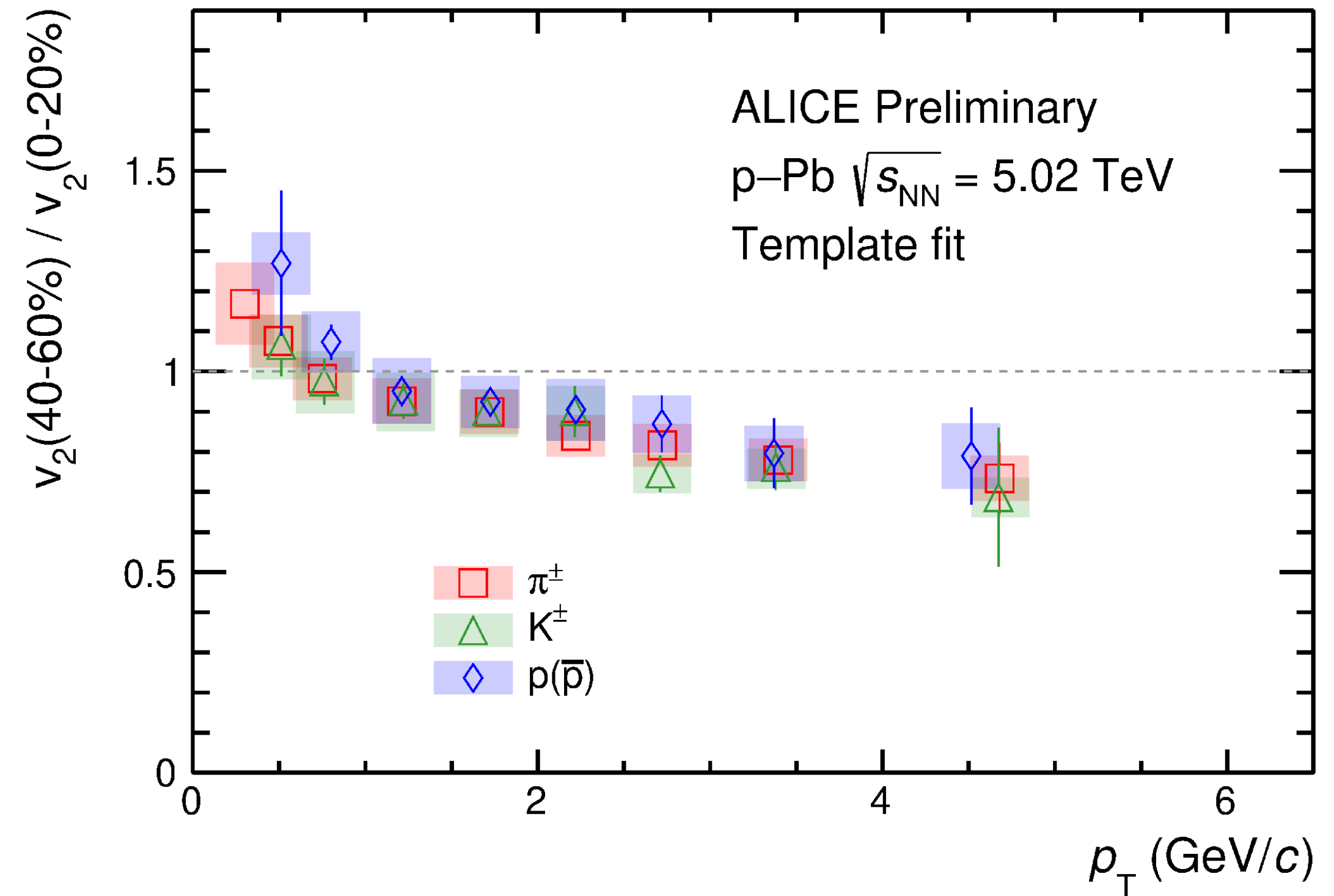
ALI-PREL-543492

- The absolute value of $v_2(p_T)$ decreases as centrality increases (other species see back up)
- Consistent with the multiplicity-dependent integrated $v_2\{2\}$ results published by ALICE, PRL 123, 142301 (2019) (see slide 4)

Ratio between meson/baryon and centralities in p–Pb



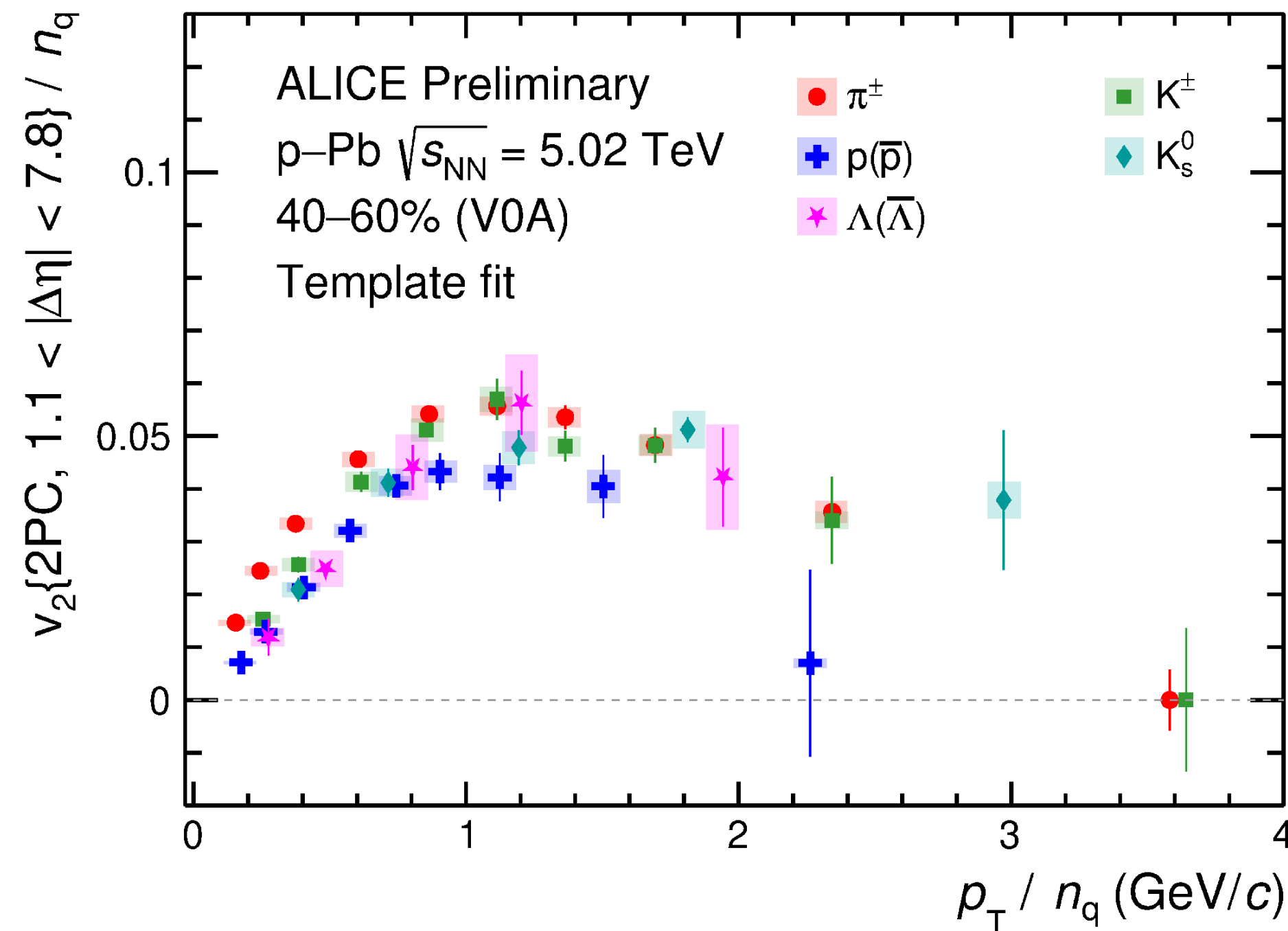
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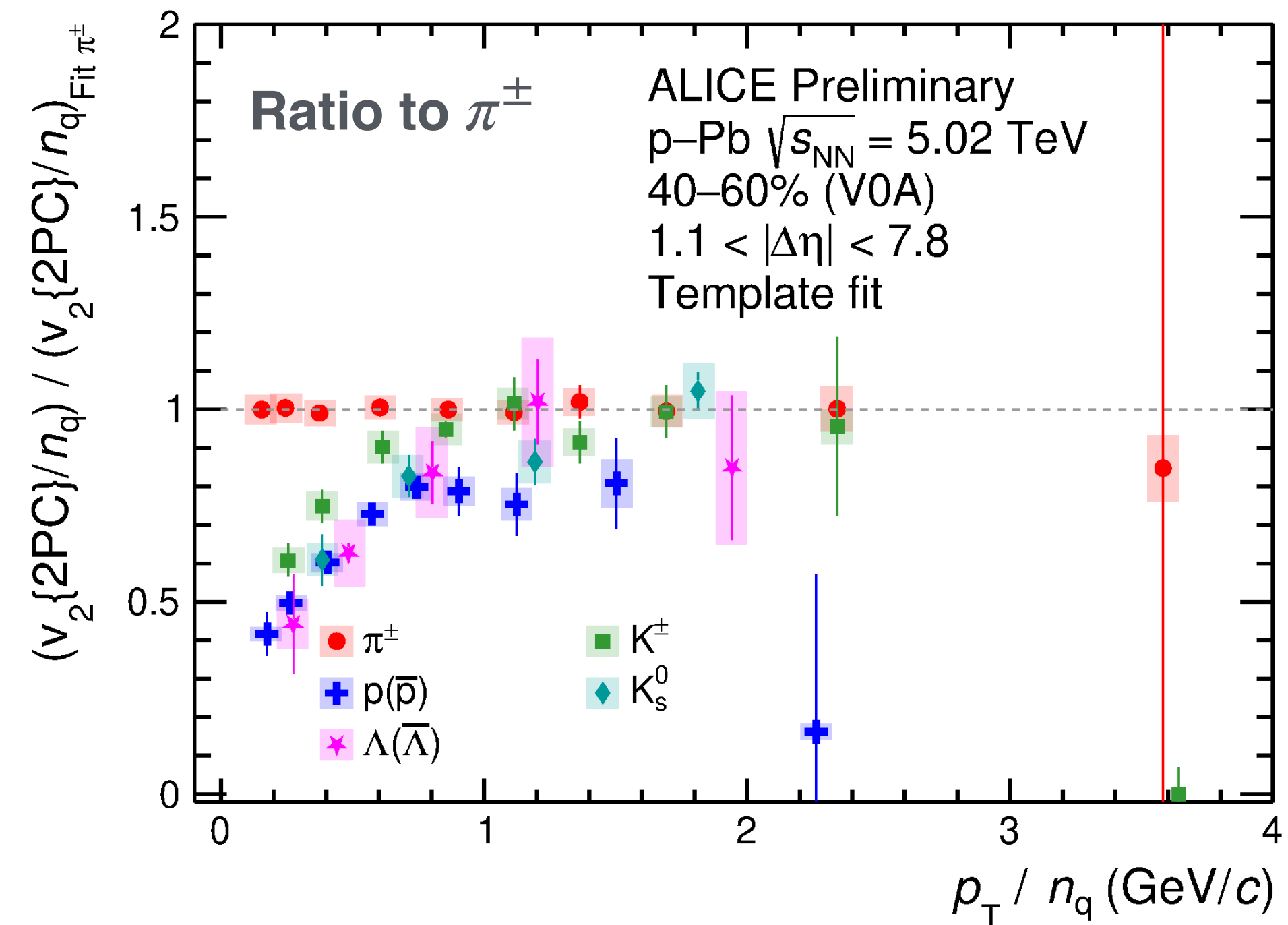
ALI-PREL-543555

- No centrality dependence was observed for the $v_2(\text{meson})/v_2(\text{baryon})$ ratio (left)
 - No significant $v_2(\text{PID})$ dependence observed with variation in centrality/multiplicity (right)
- The grouping effect does not show significant changes from 0-20% to 40-60% in p–Pb collisions. (The partonic collectivity does not change a lot to peripheral collisions in p–Pb?)**

Number of Constituent Quarks (NCQ) scaling

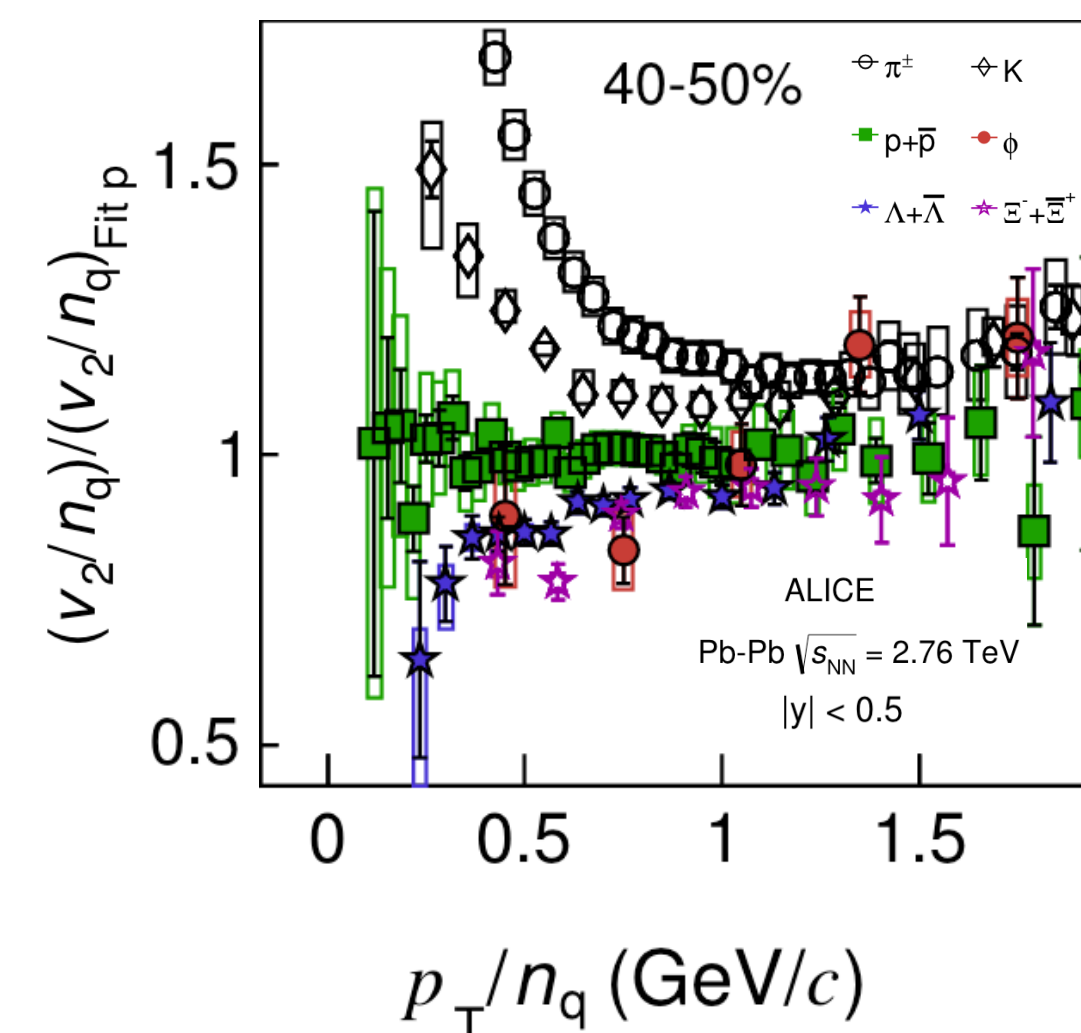


ALI-PREL-543530



ALI-PREL-543800

- Baryon-meson grouping doesn't follow perfect NCQ scaling
- Similar pattern observed in Pb—Pb collisions (right bottom)



ALICE, JHEP 06 (2015) 190

Ratio to $p(\bar{p})$

- Many similar observations for small and large systems;
- **Partonic collectivity** is observed in both pp and p—Pb collisions;
- p_T -differential flow shows **slight centrality dependence** in p—Pb collisions.
- **Mass ordering** and **baryon-meson grouping effect** observed from the 0-20% to the 40-60% in p—Pb → **The characteristics of behavior for partonic collectivity in p-Pb collisions are similar across different centrality ranges;**

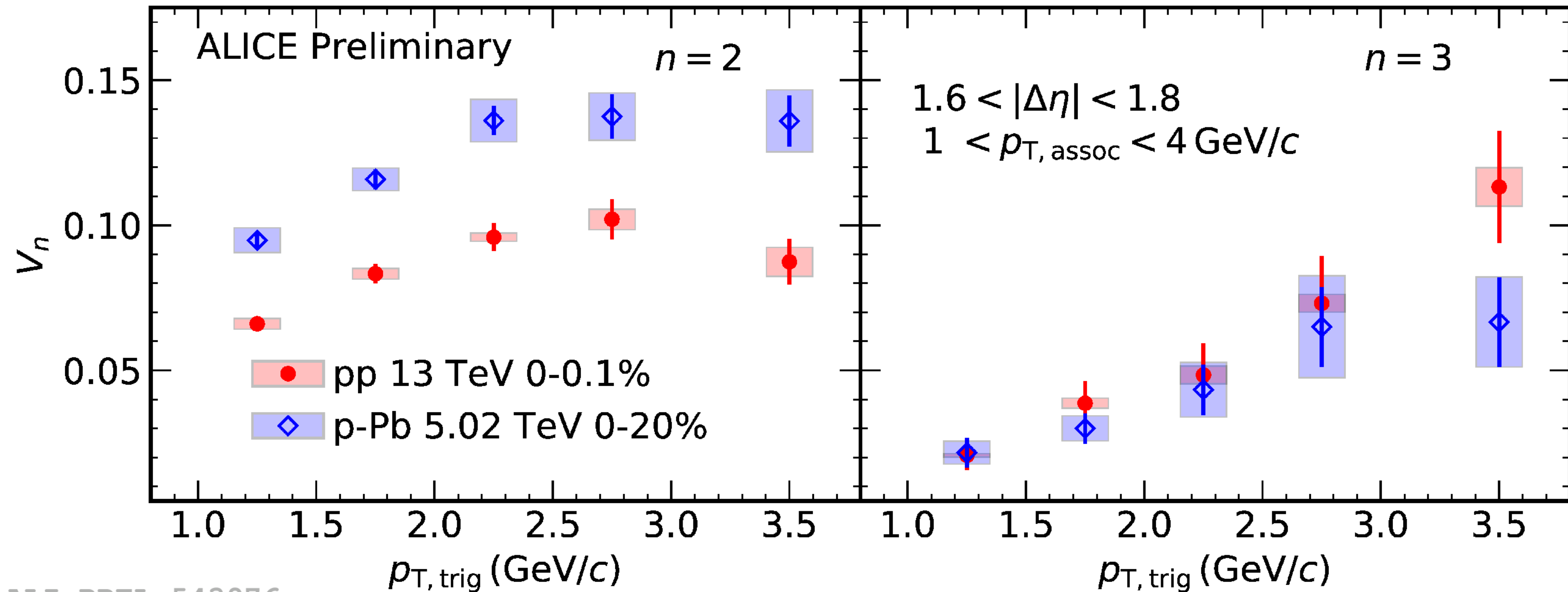
Outlooks:

- N_{ch} /centrality dependence of $v_2(p_T)$ in pp collisions;
- System comparisons in same N_{ch} region;

Thanks for your attention!

Backup

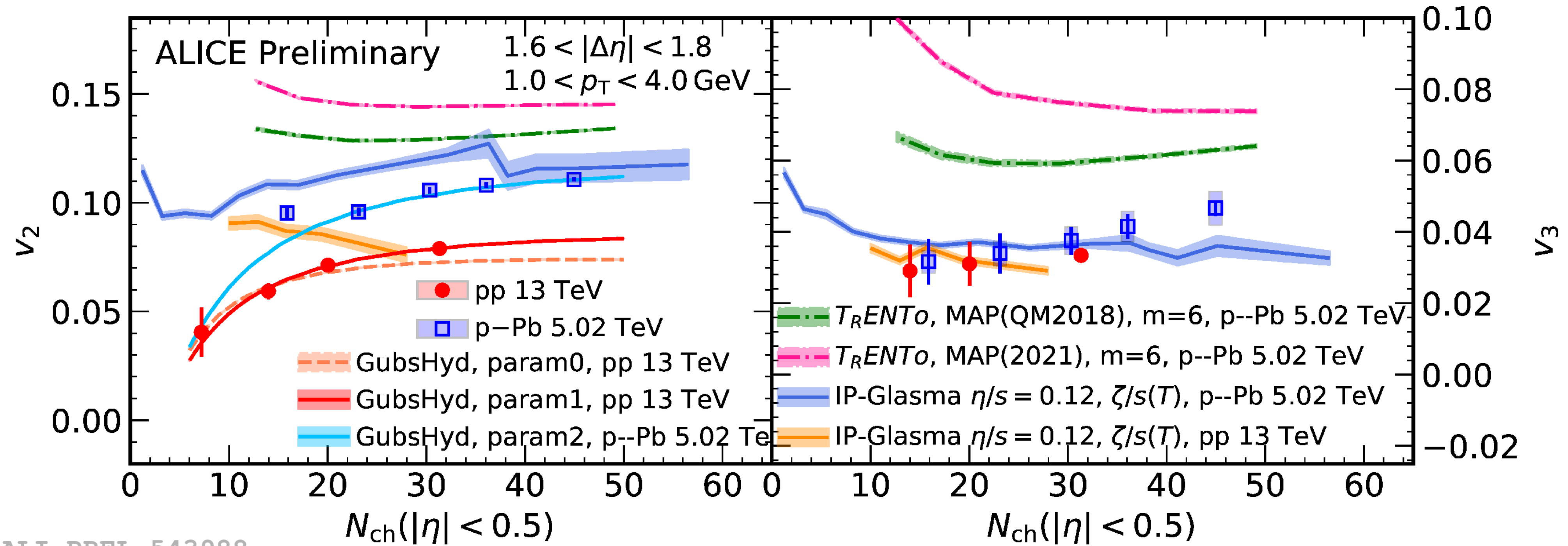
System comparison



ALI-PREL-543976

- The v_2 magnitude in p—Pb collisions is larger than the one in pp collisions
 - The larger system size and longer-lived medium in p—Pb collisions
- The v_3 magnitudes are similar in both collisions
 - Less sensitive to the collision systems

Comparison to models for hadron v_n

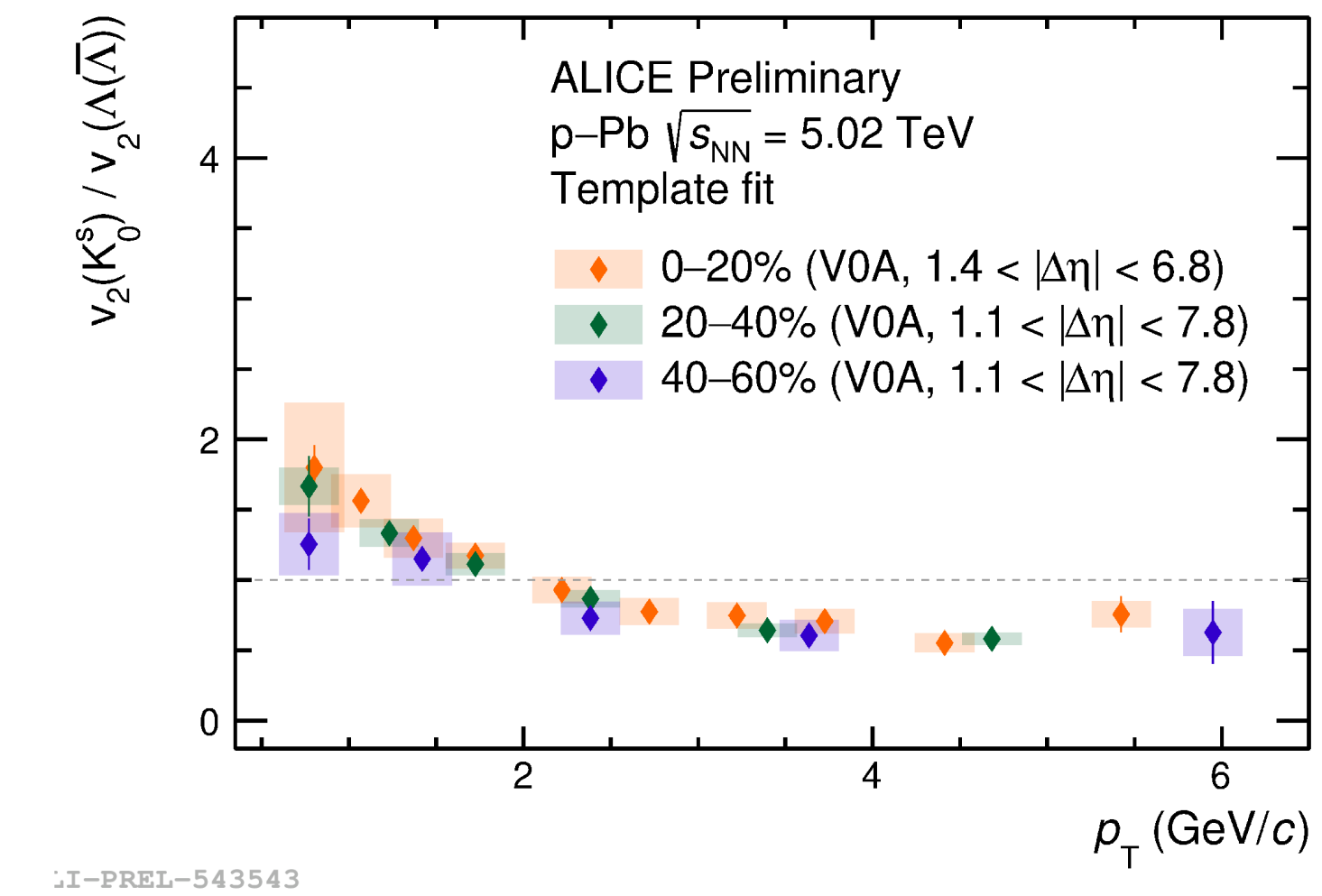
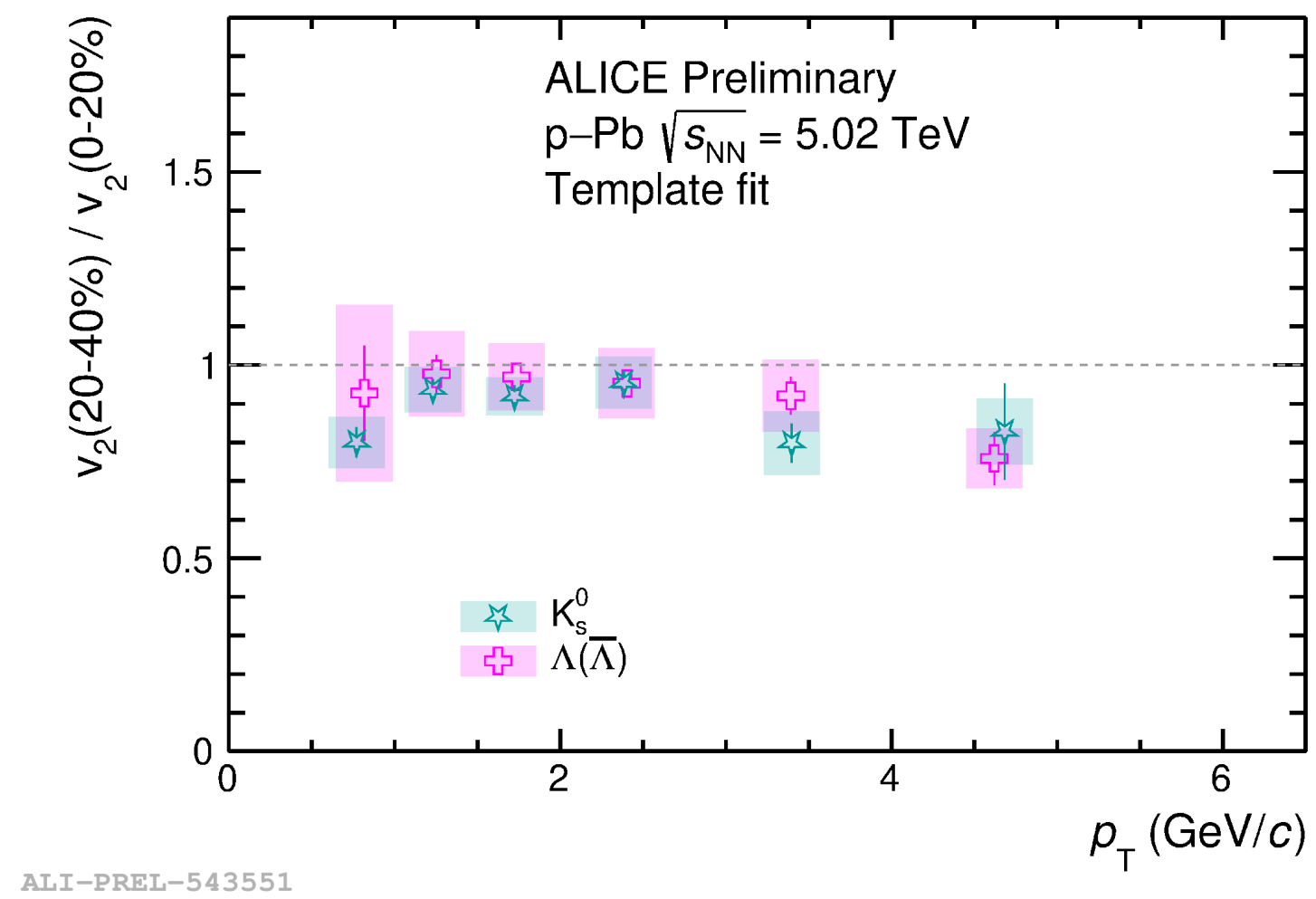
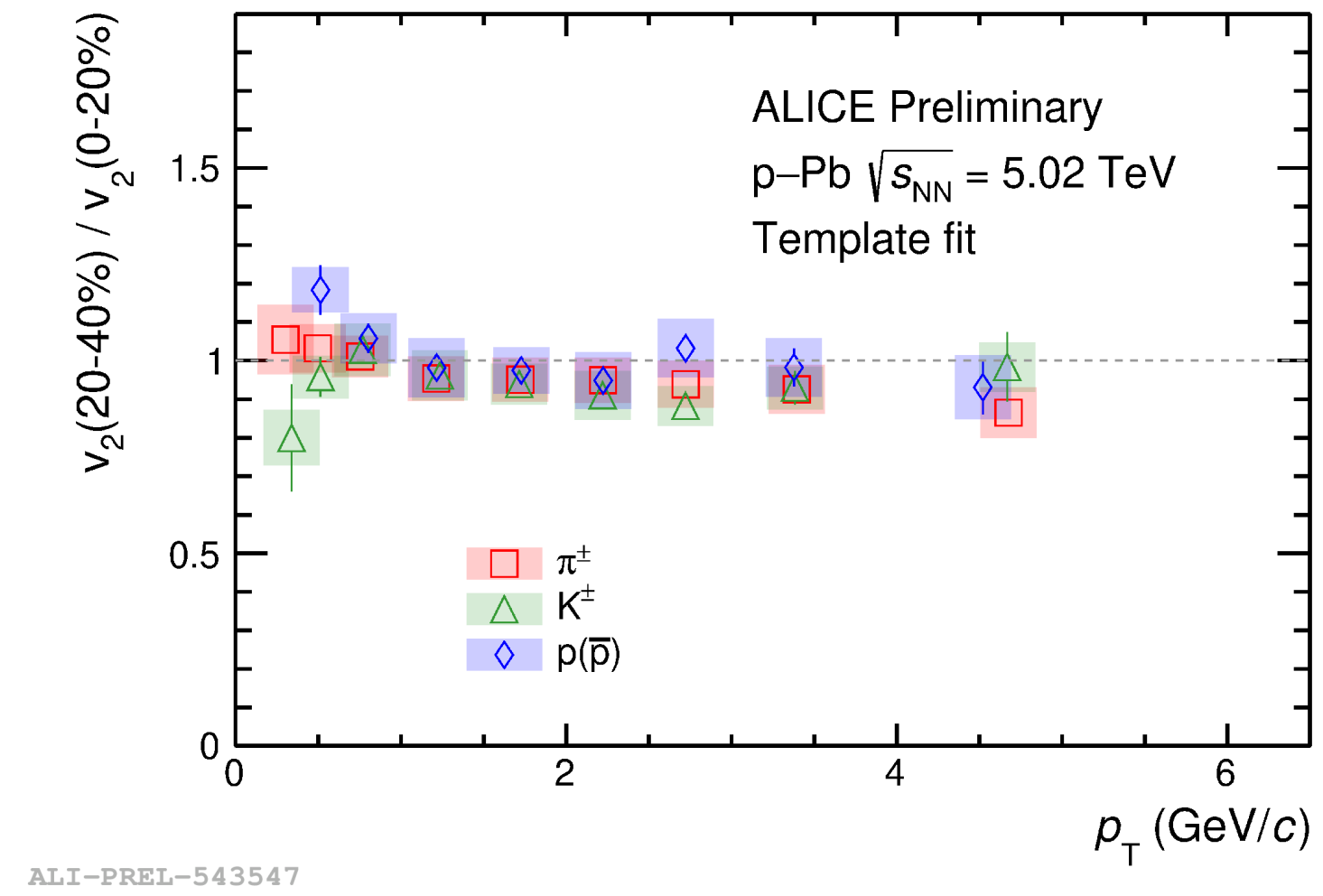
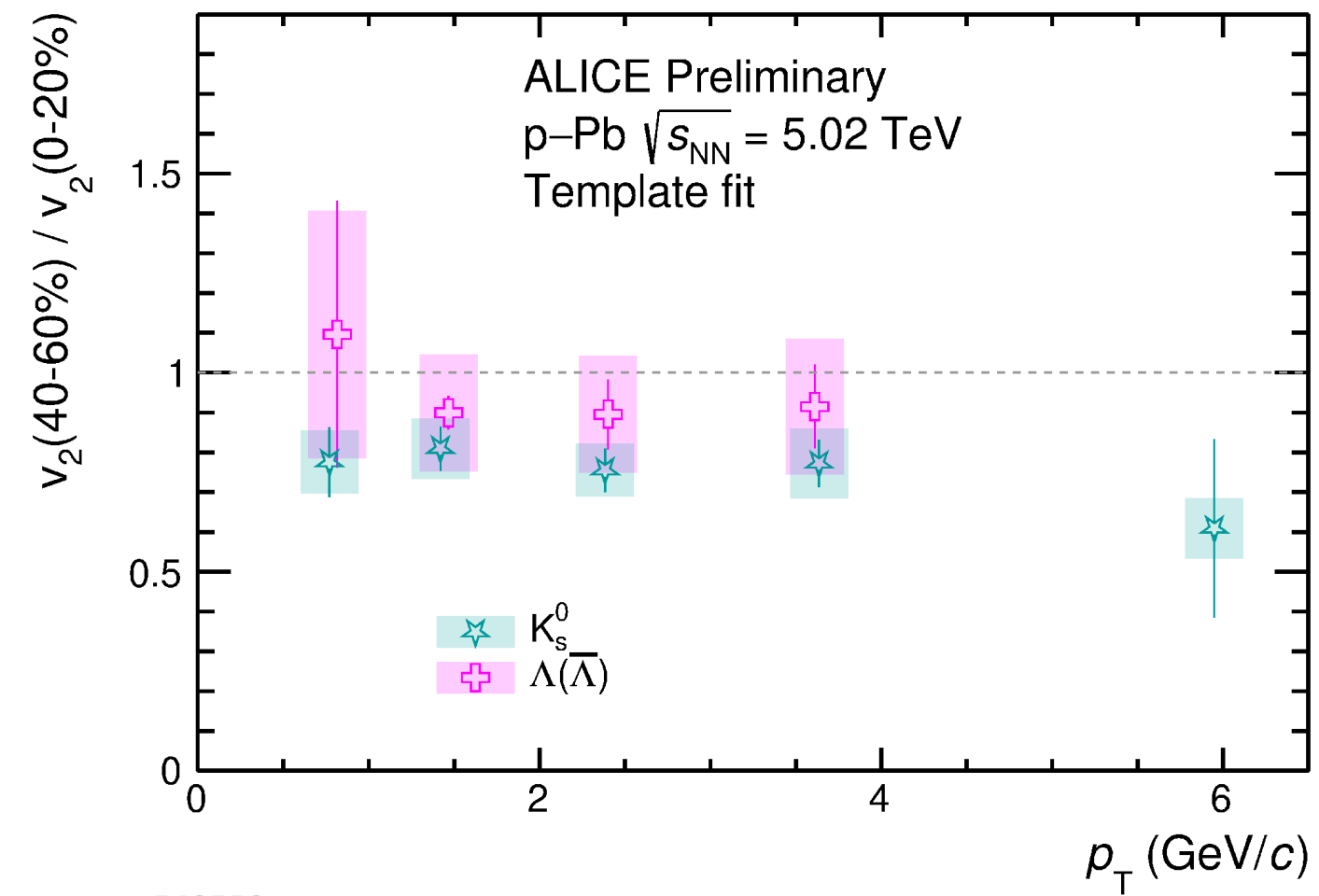


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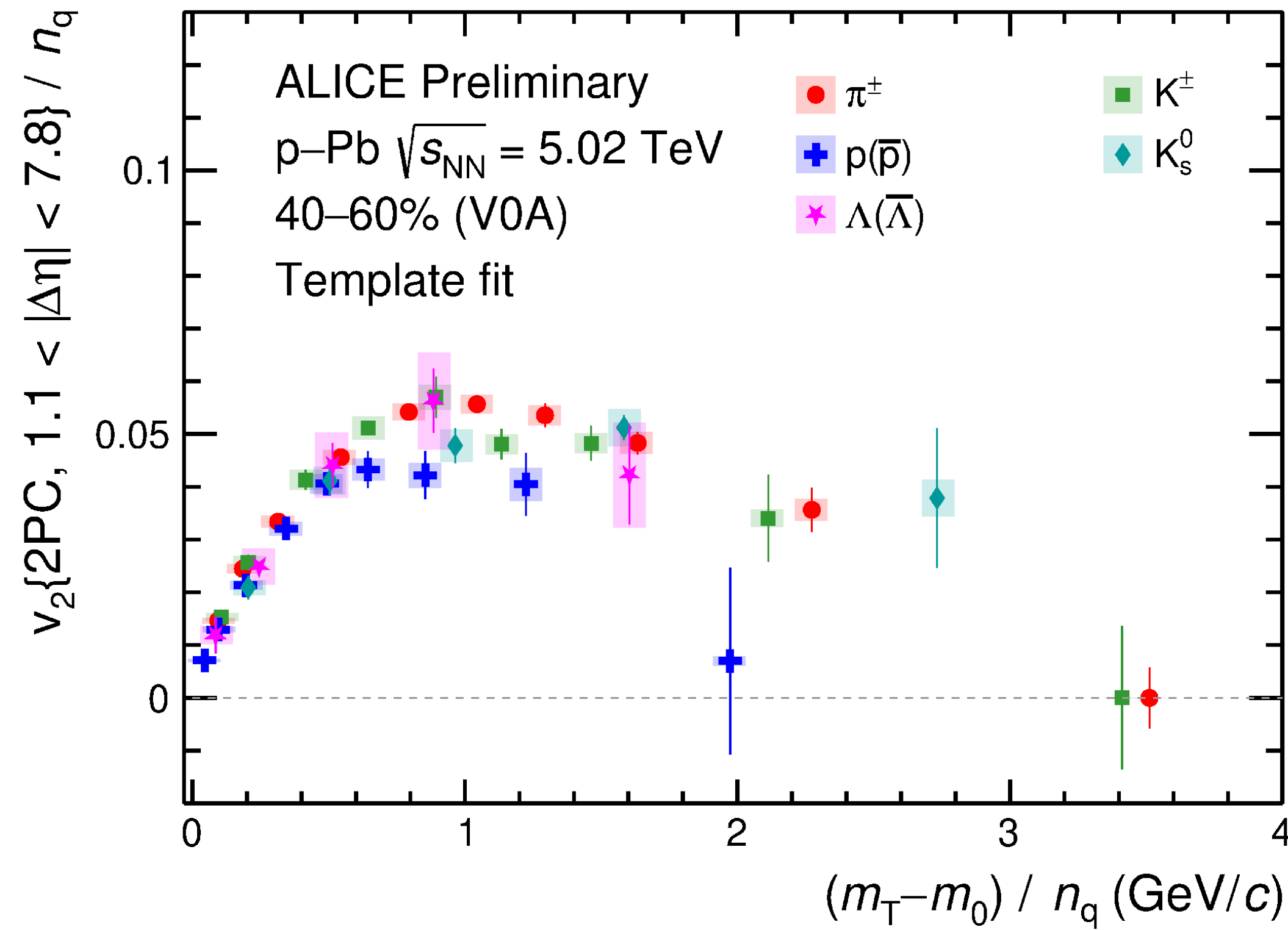
- **IP-Glasma** + hydro^[1]: captures p—Pb multiplicity dep. but **the opposite trend for pp**
- **TRENTo**+Hydro^[2]: **the opposite trend** for both systems and **overestimating**.
- **GubHyd**^[3]: capture the multiplicity dep. and magnitudes with tuned model parameters.
- Need more insights from the theories(eg. PRC 106, 054908, necessity of non-equilibrium components?)

[1] B. Shenke et al., PRC 102, 044905 (2020), [2] J.E. Parkkila et al., PLB 835 (2022) 137485, [3] S.F. Taghavi, PShys.Rev.C 104 (2021) 5, 054906

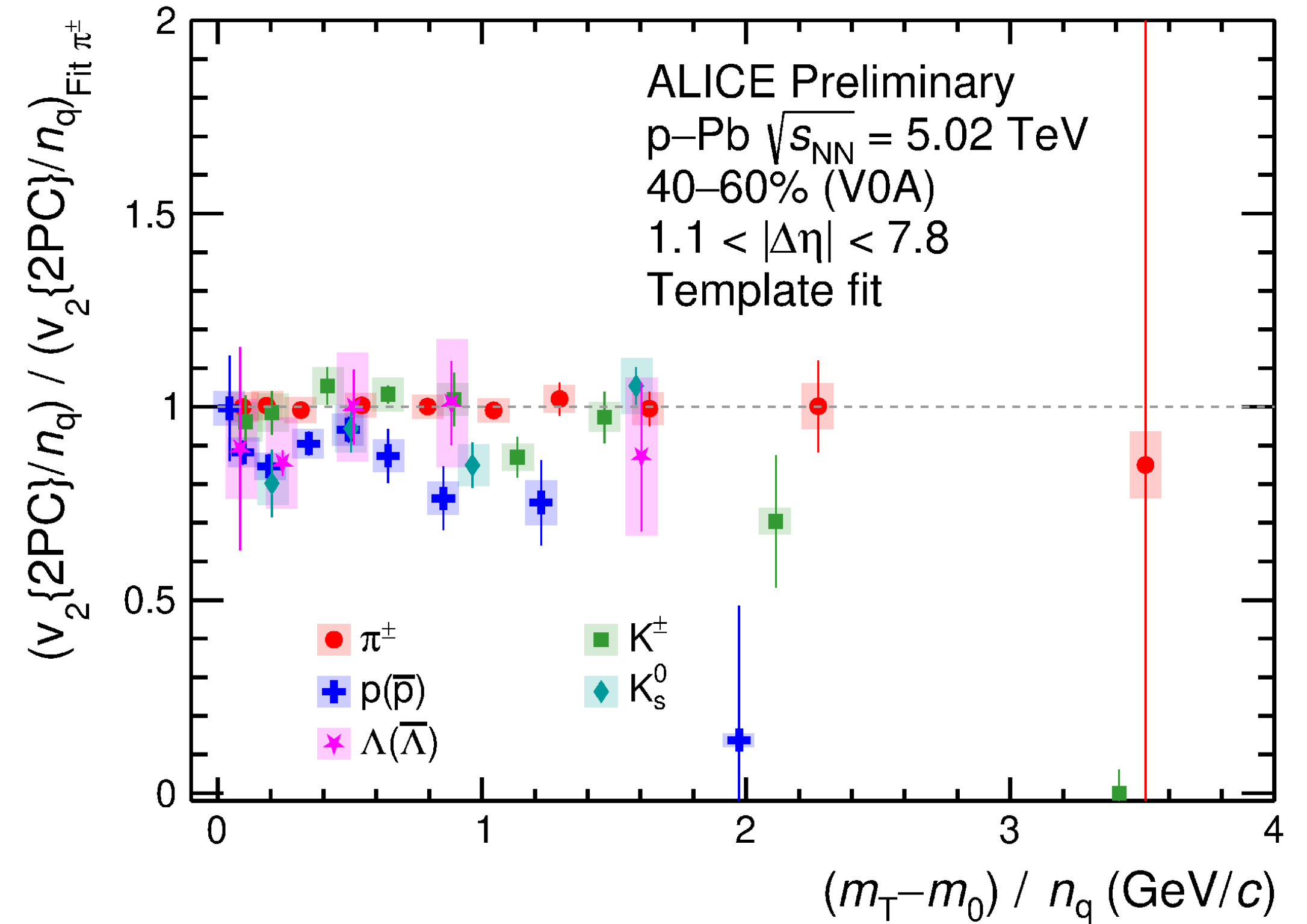
Ratio between meson/baryon and centralities in p-Pb



NCQ scaling and broken (40-60% p-Pb as function of K_{ET}/n_q)

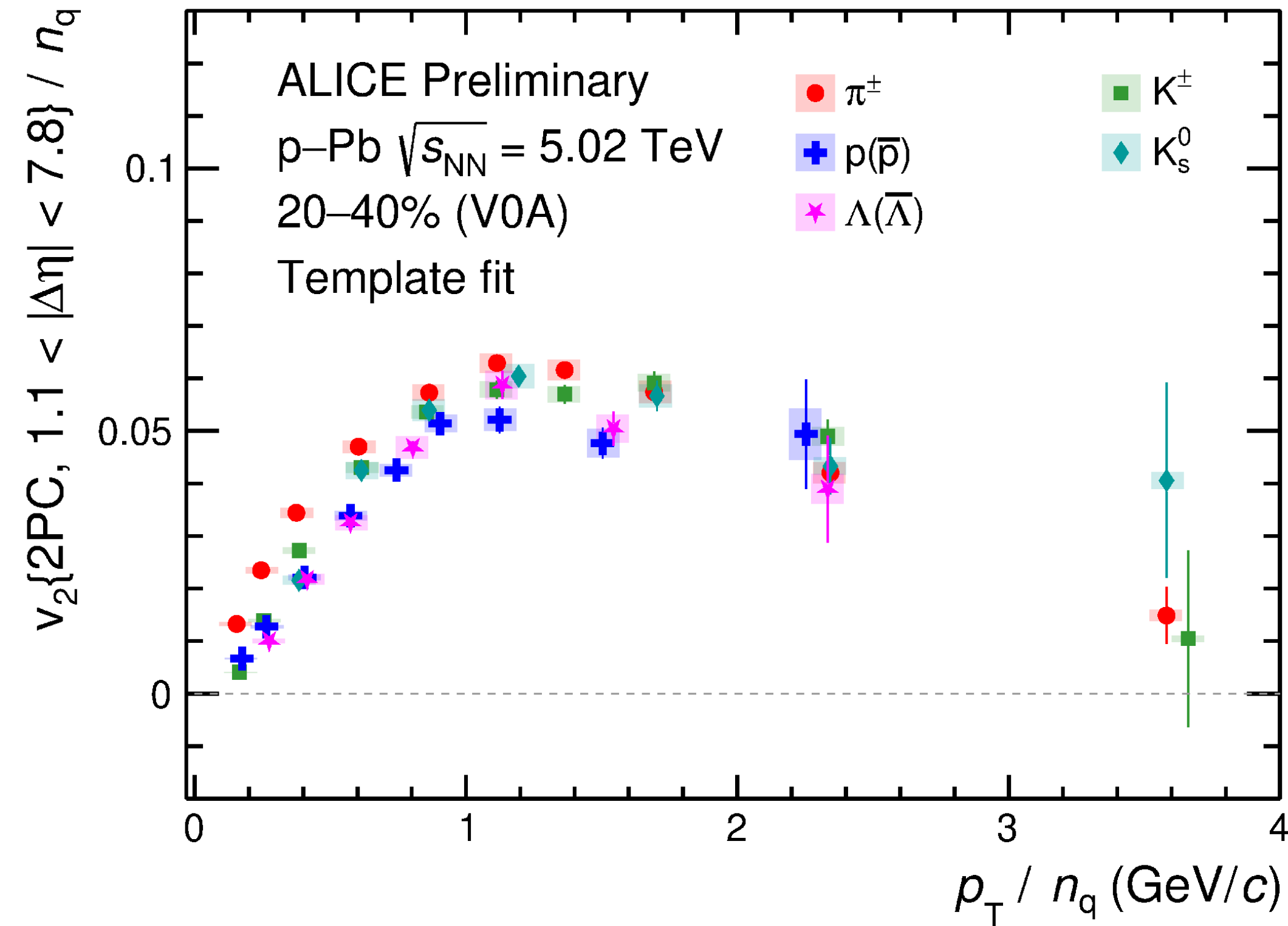


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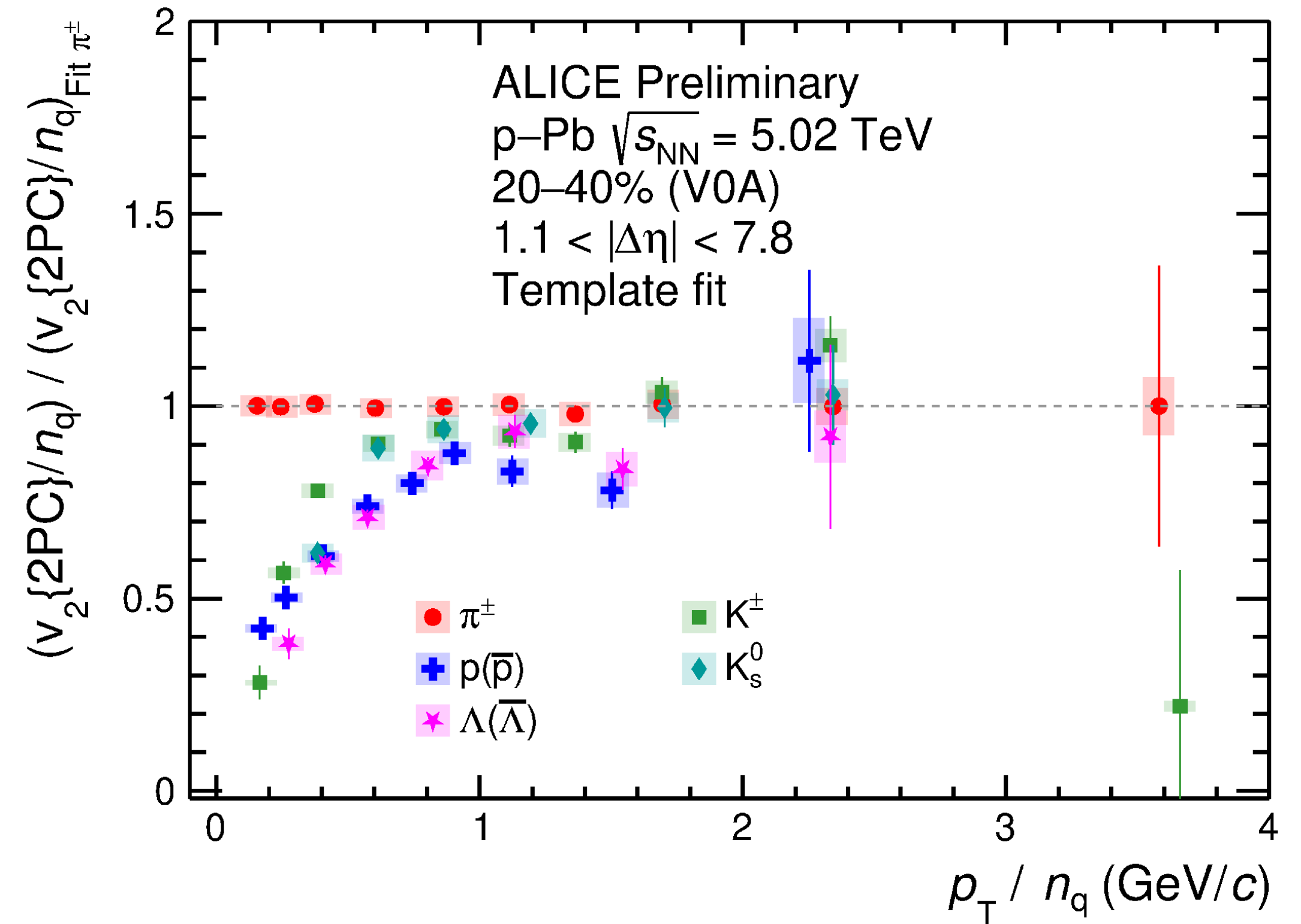


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NCQ scaling and broken (20-40% p-Pb as function of p_T/n_q)

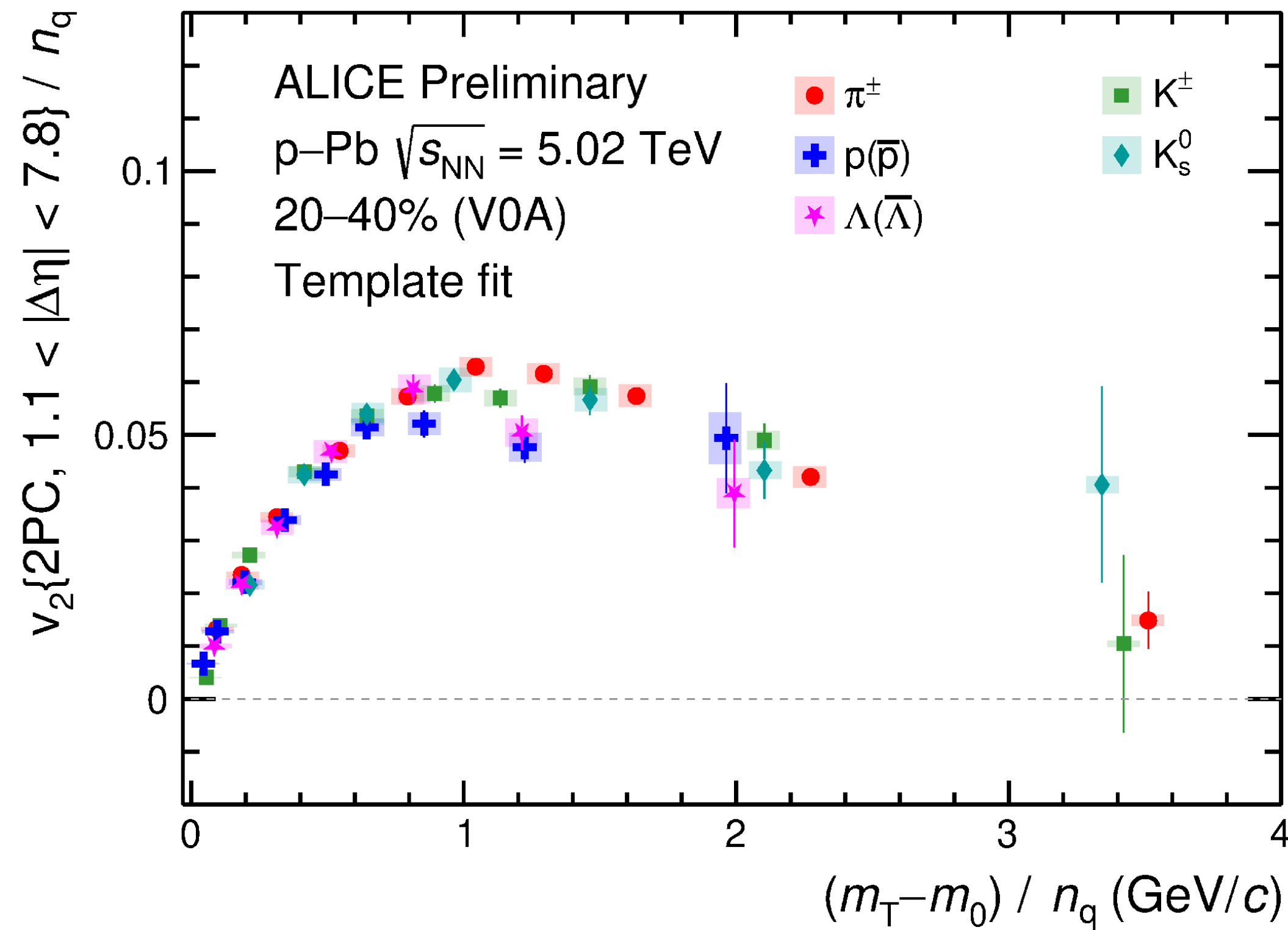


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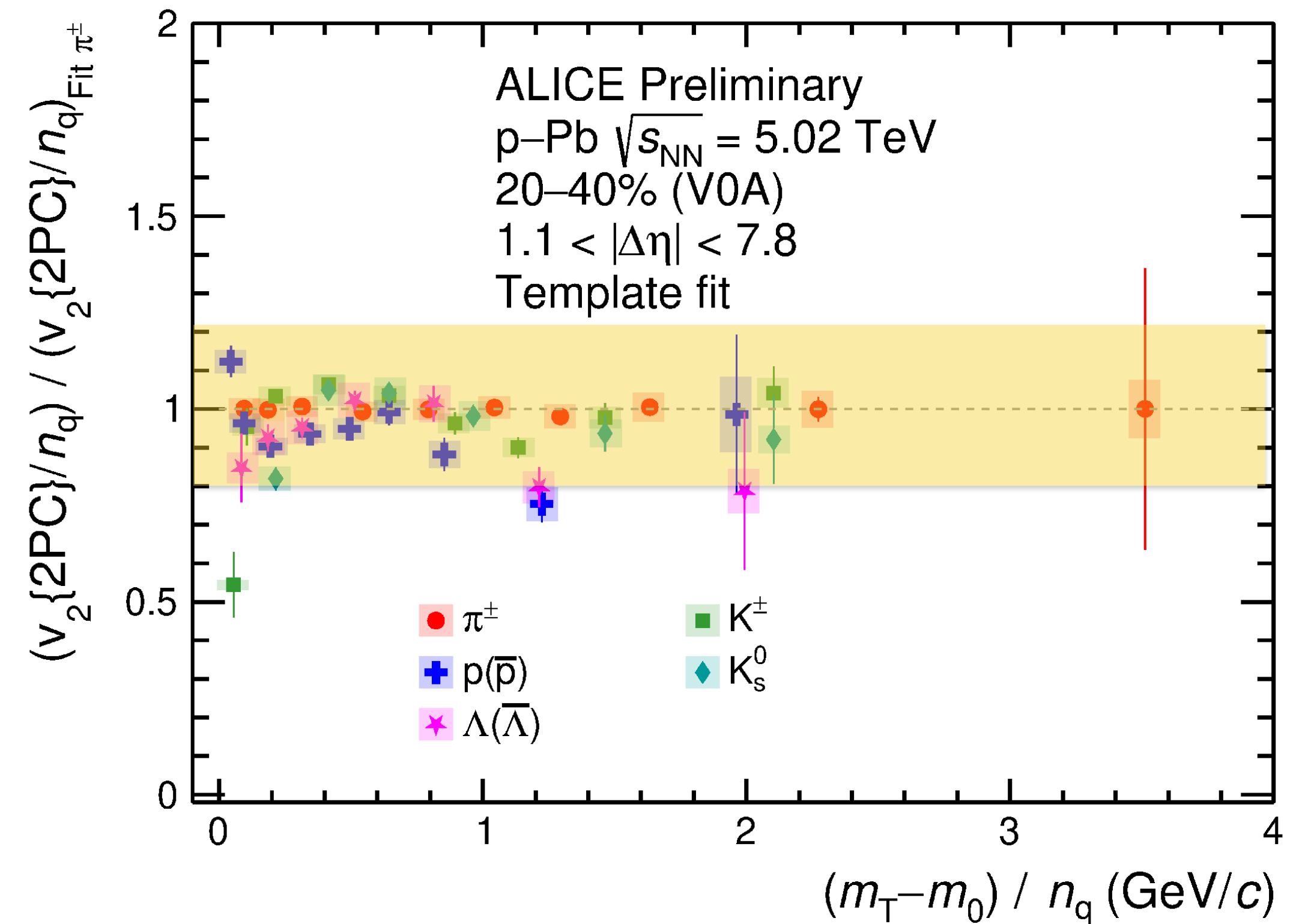


ALI-PREL-543790

NCQ scaling and broken (20-40% p-Pb as function of KET/n_q)



ALI-PREL-543525



ALI-PREL-543786

Comparison between centralities in p-Pb

