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ALICE

Characterizing system dynamics with two-particle transverse momentum correlations in pp collisions at $\sqrt{s} = 7$ TeV and p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

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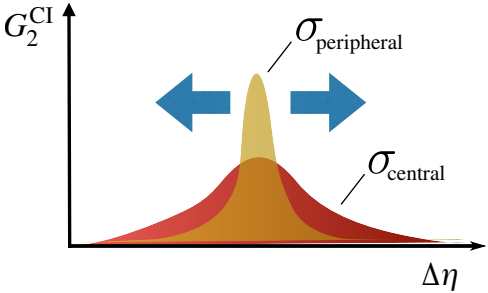
Motivations and goals

- Evidence of specific shear viscosity (η/s) effects in Pb–Pb collisions
  – Anisotropic flow vs. viscous hydro calculations
  – Transverse momentum (p_{T}) two-particle correlations G_2^{CI}[1]
- **Seek evidence for viscous (η/s) effects in pp and p–Pb collisions based on the longitudinal broadening of $G_2^{\mathrm{CI}}(\Delta\eta)$ vs. charged particle multiplicity N_{ch}**[2,3]



[1] ALICE, Phys. Lett. B 804, 135375 (2020)
[2] S. Gavin et al., Phys. Rev. Lett. 97 162302 (2006)
[3] M. Sharma, C.A. Pruneau, Phys. Rev. C79, 024905 (2009)

Measurement method

$$G_2(\Delta\eta, \Delta\varphi) = \langle p_{\mathrm{T}} \rangle^{-2} \langle N \rangle^{-2} \left\langle \sum_{\mathrm{i} \neq \mathrm{j}} p_{\mathrm{T,i}} p_{\mathrm{T,j}} \right\rangle - 1$$

CD : charge dependent

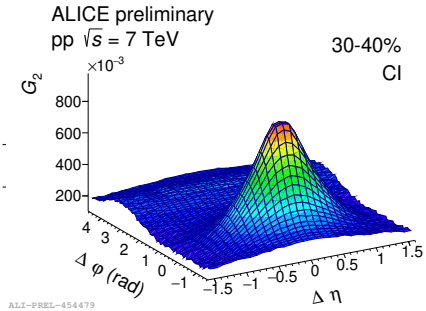
CI : charge independent

$$G_2^{\mathrm{CD}} = \left(G_2^{+-} + G_2^{-+} - G_2^{++} - G_2^{--}\right)/4$$
$$G_2^{\mathrm{CI}} = \left(G_2^{+-} + G_2^{-+} + G_2^{++} + G_2^{--}\right)/4$$

Measure the evolution of $\Delta\eta$ and $\Delta\varphi$ widths of near-side peak of G_2^{CD} and G_2^{CI} vs. charged-particle multiplicity, N_{ch}, from fit

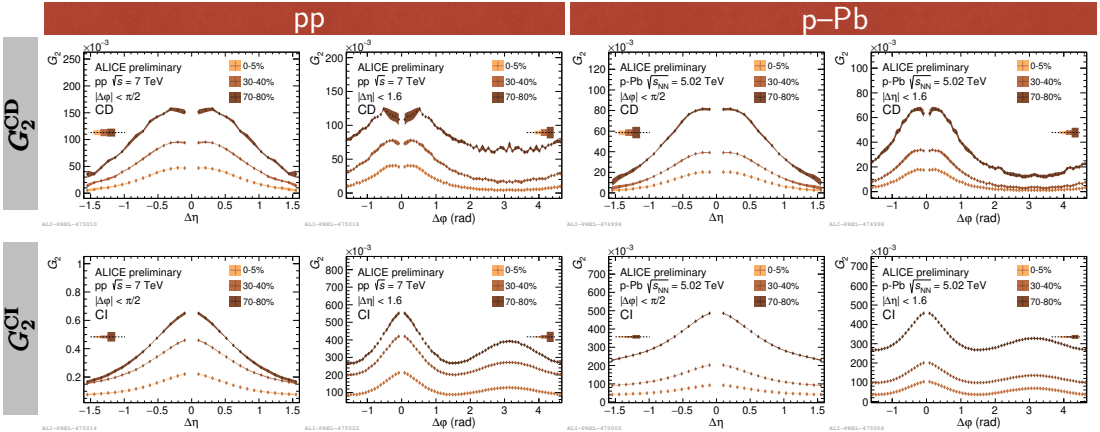
$$F = B + \sum_{\mathrm{n}=2}^{6} a_{\mathrm{n}} \cos(\mathrm{n}\,\Delta\varphi) + A \frac{\gamma_{\Delta\eta}\gamma_{\Delta\varphi}}{4\omega_{\Delta\eta}\omega_{\Delta\varphi}\Gamma\left(\frac{1}{\gamma_{\Delta\eta}}\right)\Gamma\left(\frac{1}{\gamma_{\Delta\varphi}}\right)} \exp\left[-\left|\frac{\Delta\eta}{\omega_{\Delta\eta}}\right|^{\gamma_{\Delta\eta}} - \left|\frac{\Delta\varphi}{\omega_{\Delta\varphi}}\right|^{\gamma_{\Delta\varphi}}\right]$$

$$\sigma_{\Delta\eta(\Delta\varphi)} = \sqrt{\frac{\omega^2_{\Delta\eta(\Delta\varphi)}\Gamma(3/\gamma_{\Delta\eta(\Delta\varphi)})}{\Gamma(1/\gamma_{\Delta\eta(\Delta\varphi)})}}$$



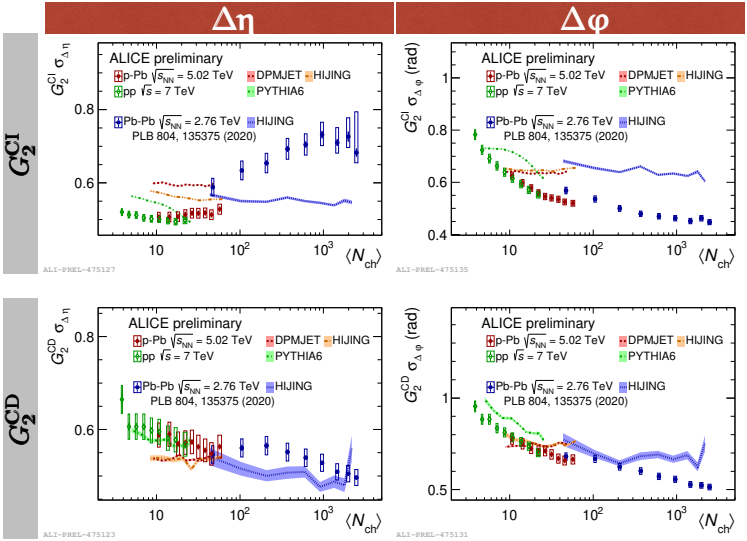
Evolution of projections

Along Δη & Δφ axes



G_2^{CI} and G_2^{CD} show different dependencies on fractional cross-section measured with different N_{ch}

Longitudinal & azimuthal widths vs. N_{ch}



- Narrowing of G_2^{CI} and G_2^{CD} vs. $\Delta\varphi$ in pp, p–Pb, and Pb–Pb
  - $\langle p_{\mathrm{T}} \rangle$ dependence
  - **Radial flow effects**
- Substantial broadening of G_2^{CI} vs. $\Delta\eta$ in Pb–Pb
  - Shear viscous effects
- **No broadening of G_2^{CI}** vs. $\Delta\eta$ in pp and p–Pb

Summary

- Significant narrowing of $G_2^{\mathrm{CD}}(\Delta\eta)$, $G_2^{\mathrm{CD}}(\Delta\varphi)$, and $G_2^{\mathrm{CI}}(\Delta\varphi)$ with increasing N_{ch} in pp & p–Pb
  - Possibly due to increasing $\langle p_{\mathrm{T}} \rangle$ with increasing N_{ch}
  - Consistent with radial flow (collective behavior)
- No significant broadening of $G_2^{\mathrm{CI}}(\Delta\eta)$ with increasing N_{ch} in pp & p–Pb
  - **At variance with broadening seen in Pb–Pb** collisions
  - **No evidence** for shear viscous effects in pp & p–Pb based on $G_2^{\mathrm{CI}}(\Delta\eta)$
  - **System lifetime too short for viscous forces to play a significant role?**