Characterizing system dynamics with two-particle transverse momentum correlations in pp, p–Pb, and Pb–Pb collisions at ALICE

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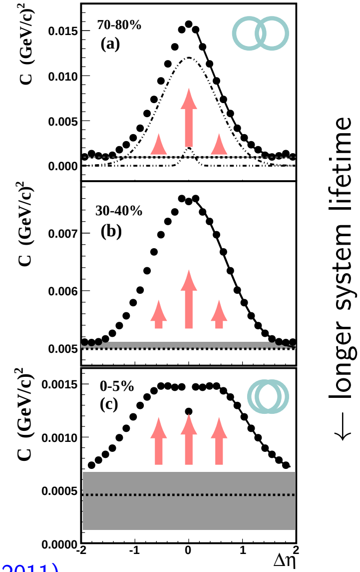
Two-particle transverse momentum correlation

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

- Sensitive to momentum currents transfer
- Longitudinal shape encodes viscous effects

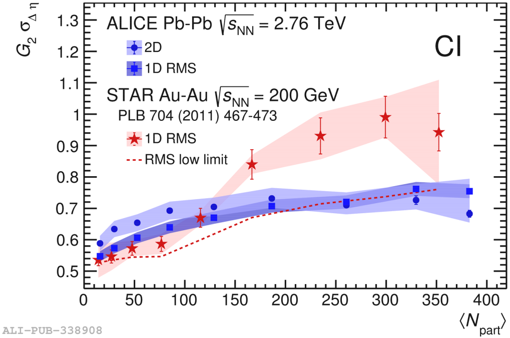
Drag between neighboring fluid cells broadens G_2 correlator

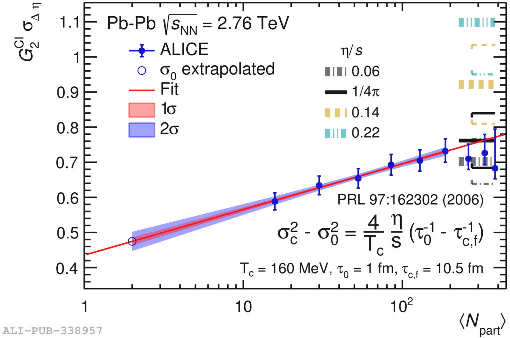
Gavin, Abdel-Aziz, PRL 97, 162302 (2006)
Gavin, Moschelli, Zin, PRC 94, 024921 (2016)



STAR, PLB 704, 467–473 (2011)

η/s from two-particle transverse momentum correlation function G_2





ALICE, PLB 804, 135375 (2020)

- STAR $\Rightarrow$ η/s in the range 0.06 - 0.21
- ALICE $\Rightarrow$ measured correlator widths favor values of η/s close to the KSS[1] limit $1/4\pi$

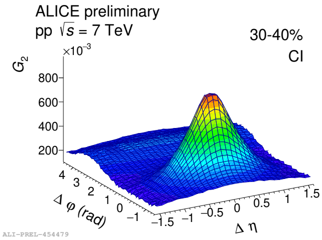
[1] Kovtun, Son, Starinets, PRL 94, 111601 (2005)

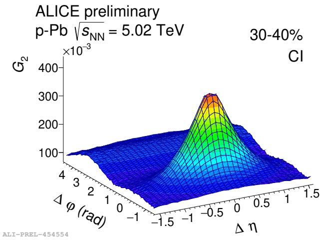
pp at $\sqrt{s} = 7$ TeV and p–Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, G_2^{CI} and G_2^{CD}

30–40% multiplicity class

Charge independent (CI)

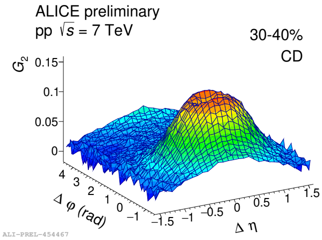
$$\text{CI} = \frac{1}{4}\{(+-) + (-+) + (--) + (++)\}$$

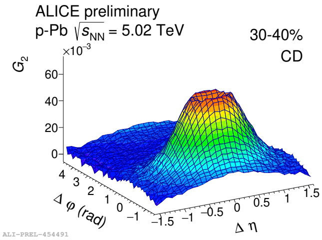




Charge dependent (CD)

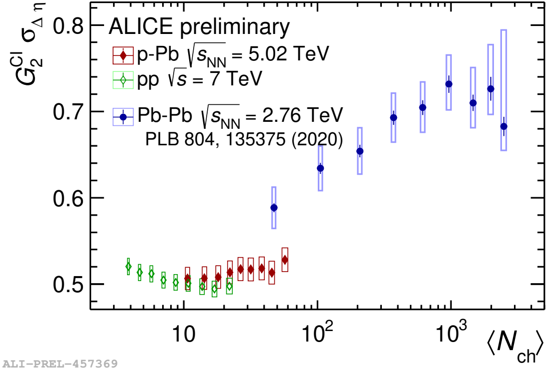
$$\text{CD} = \frac{1}{4}\{(+-) + (-+) - (--) - (++)\}$$

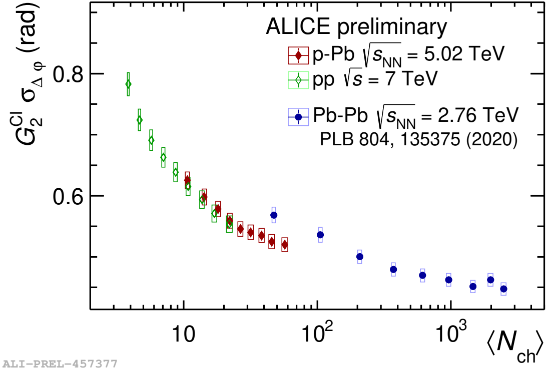




pp at $\sqrt{s} = 7$, p–Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02$, Pb–Pb at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV

G_2^{CI} widths evolution

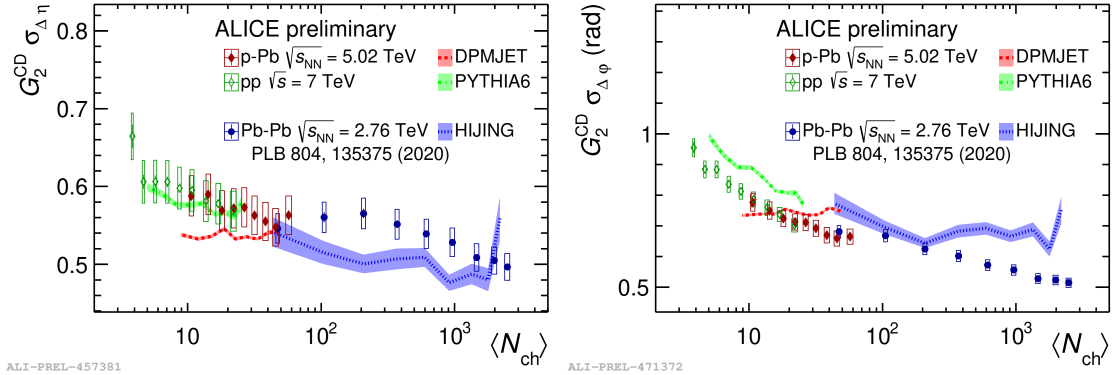




- **Trend breaks in both dimensions in the evolution from small to large systems**
- **Consistent azimuthal narrowing trend along the three systems**
- **Completely different longitudinal evolution**

Models comparison

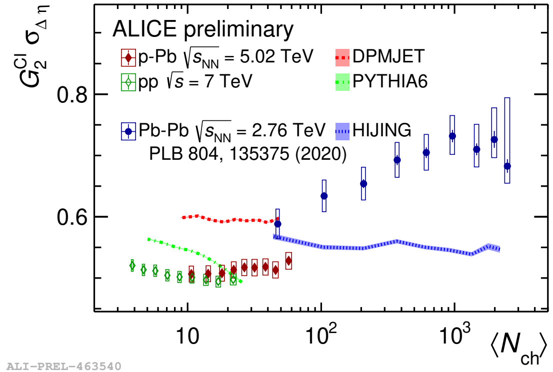
G_2^{CD} widths evolution

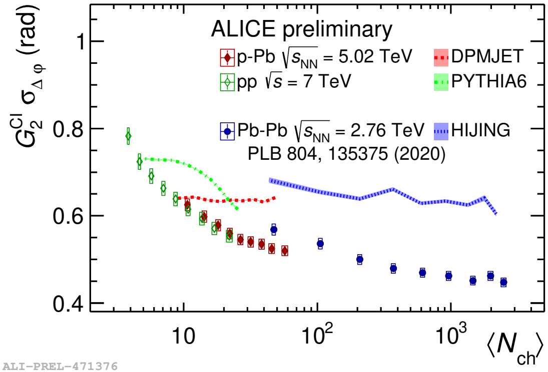


- **Correlator narrowing reproduced by Pythia6 Perugia-2011**
- **DPMJET not sensitive to multiplicity evolution**

Models comparison

G_2^{CI} widths evolution





- **Longitudinal narrowing captured by Pythia6 but misses the trend**
- **Flat evolution of DPMJET**

Conclusions

– The G_2^{CI} correlator, which potentially captures viscous effects, changes behavior in the longitudinal dimension from narrowing to broadening when going from pp to p–Pb and to Pb–Pb

– Azimuthal narrowing consistent in all three systems

– What is the origin of the interplay between narrowing and broadening trends observed when moving towards larger systems?

– Pythia6 Perugia-2011 qualitatively captures the narrowing in pp

- Reproduces G_2^{CD} narrowing trend
- Fails to reproduce G_2^{CI}