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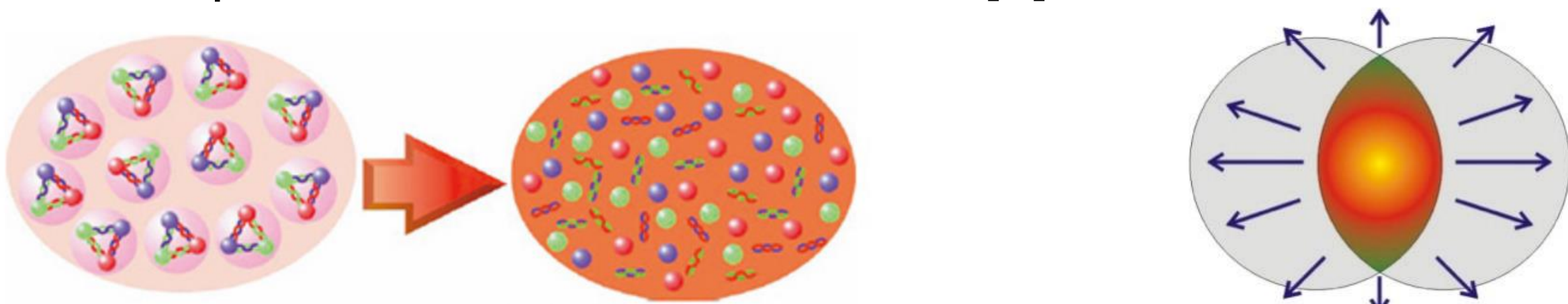
Differential studies of multiharmonic v_n correlations in heavy-ion collisions with ALICE

Heavy-ion collisions and anisotropic flow

❑ Results from heavy-ion collisions confirmed the scenario in which the deconfined state of nuclear matter, dubbed quark–gluon plasma (QGP), undergoes collective expansion.

❑ Collective anisotropic flow, quantified with Fourier harmonics v_n, is one of the most sensitive experimental probes to constrain QGP properties, as well as other stages in the heavy-ion collision [1].

❑ State-of-the-art analysis techniques to extract harmonics v_n from data are multiparticle azimuthal correlations [2].
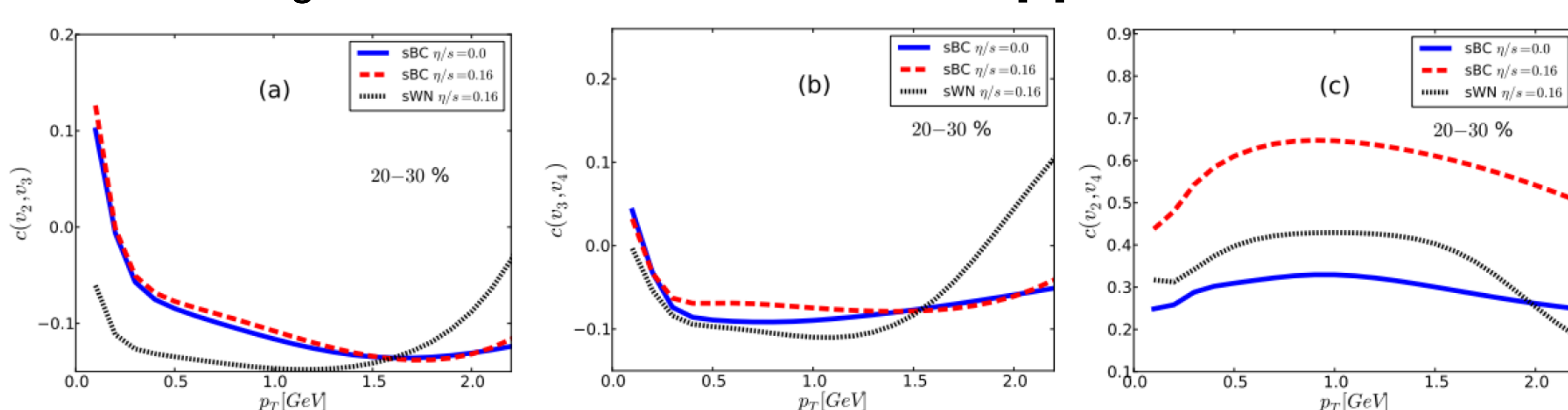

$$f(\varphi) = \frac{1}{2\pi}\left[1 + 2\sum_{n=1}^{\infty} v_n \cos[n(\varphi - \Psi_n)]\right]$$

$$\left\langle e^{i(n_1\varphi_1 + \cdots + n_k\varphi_k)}\right\rangle = v_{n_1}\cdots v_{n_k} e^{i(n_1\Psi_{n_1} + \cdots + n_k\Psi_{n_k})}$$

Multiharmonic correlations

❑ New and independent information about all stages in heavy-ion collision can be extracted from correlations of two or more different Fourier harmonics v_k, v_l, v_m, ... ⇔ **multiharmonic correlations.**

❑ Pioneering theoretical work from Niemi et al. [3]:

❑ First experimental results for correlations of v_2^2, v_3^2, and v_4^2 using Symmetric Cumulants (SC) [4,5]:
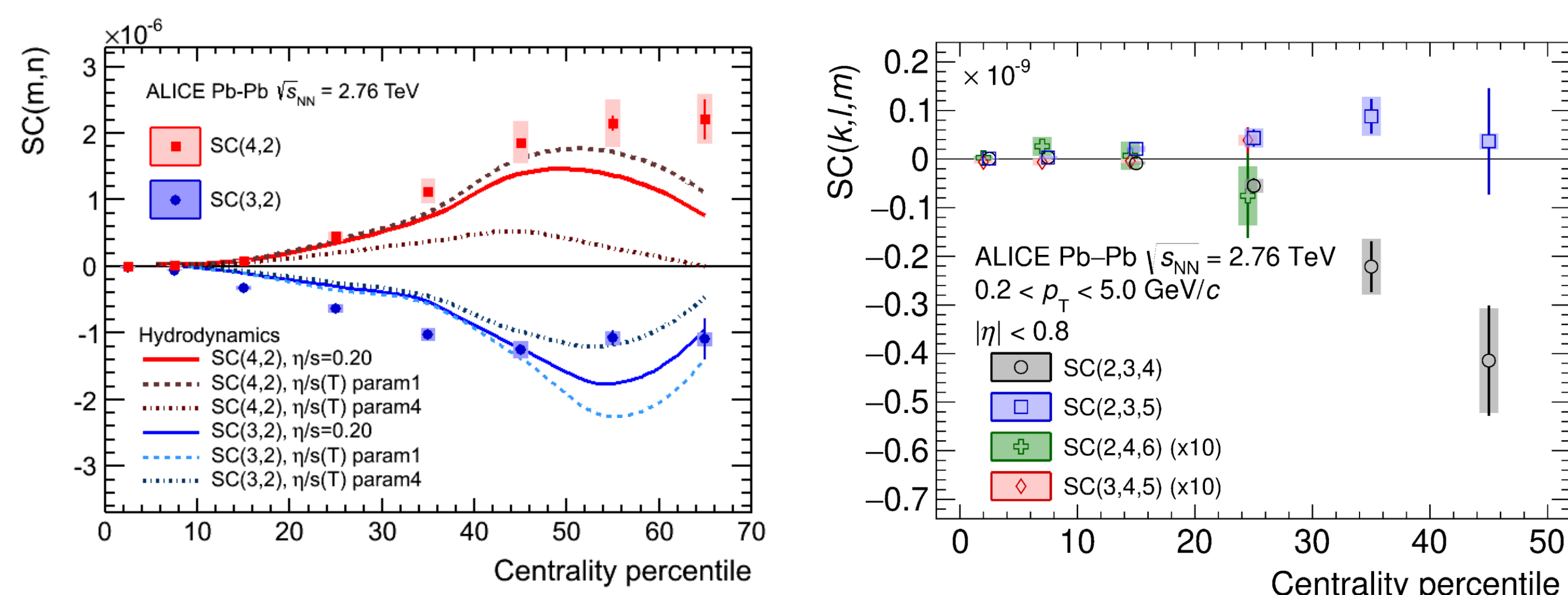

$$SC(m,n) \equiv \langle v_m^2 v_n^2\rangle - \langle v_m^2\rangle\langle v_n^2\rangle$$
$$= \langle\langle e^{i(m\varphi_1 + n\varphi_2 - m\varphi_3 - n\varphi_4)}\rangle\rangle - \langle\langle e^{im(\varphi_1-\varphi_2)}\rangle\rangle\langle\langle e^{in(\varphi_1-\varphi_2)}\rangle\rangle$$

$$SC(k,l,m) = \langle\left(v_k^2 - \langle v_k^2\rangle\right)\left(v_l^2 - \langle v_l^2\rangle\right)\left(v_m^2 - \langle v_m^2\rangle\right)\rangle$$

❑ Unlike individual harmonics v_n, which are sensitive only to average values of specific shear viscosity $\langle\eta/s\rangle$, SC observables are sensitive to the details of the temperature dependence of $\eta/s(T)$.

Differential multiharmonic correlations

❑ Further independent information can be extracted from differential measurements of multiharmonic correlations as a function of kinematic variables (transverse momentum p_T, pseudorapidity η, …).

THE ALICE DETECTOR
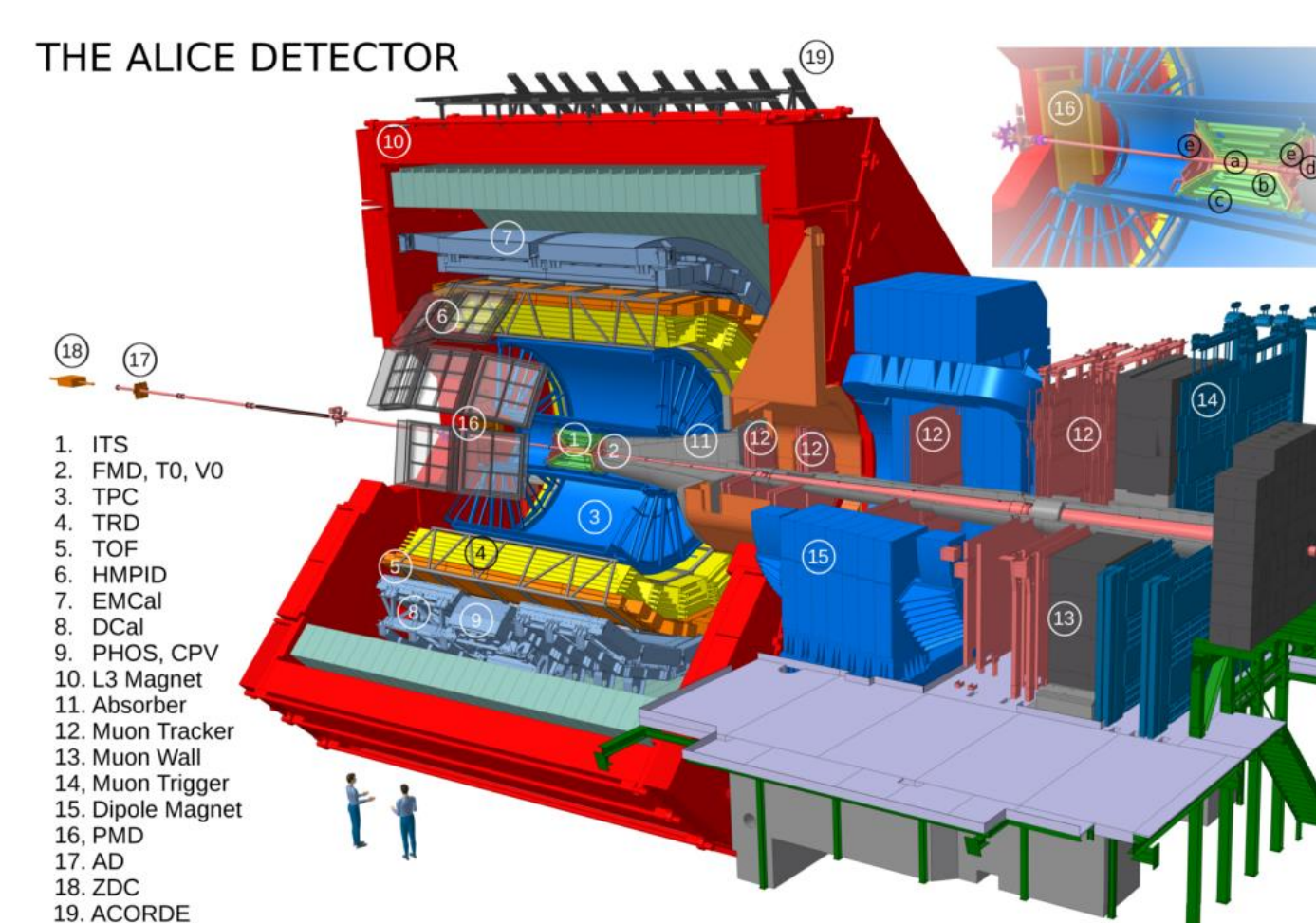
Dataset: Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV, centrality classes within 0–50%

❑ First differential measurements of multiharmonic correlations as a function of p_T, using SC(k,l) and SC(k,l,m) observables.

❑ Further independent input to Bayesian studies.

New
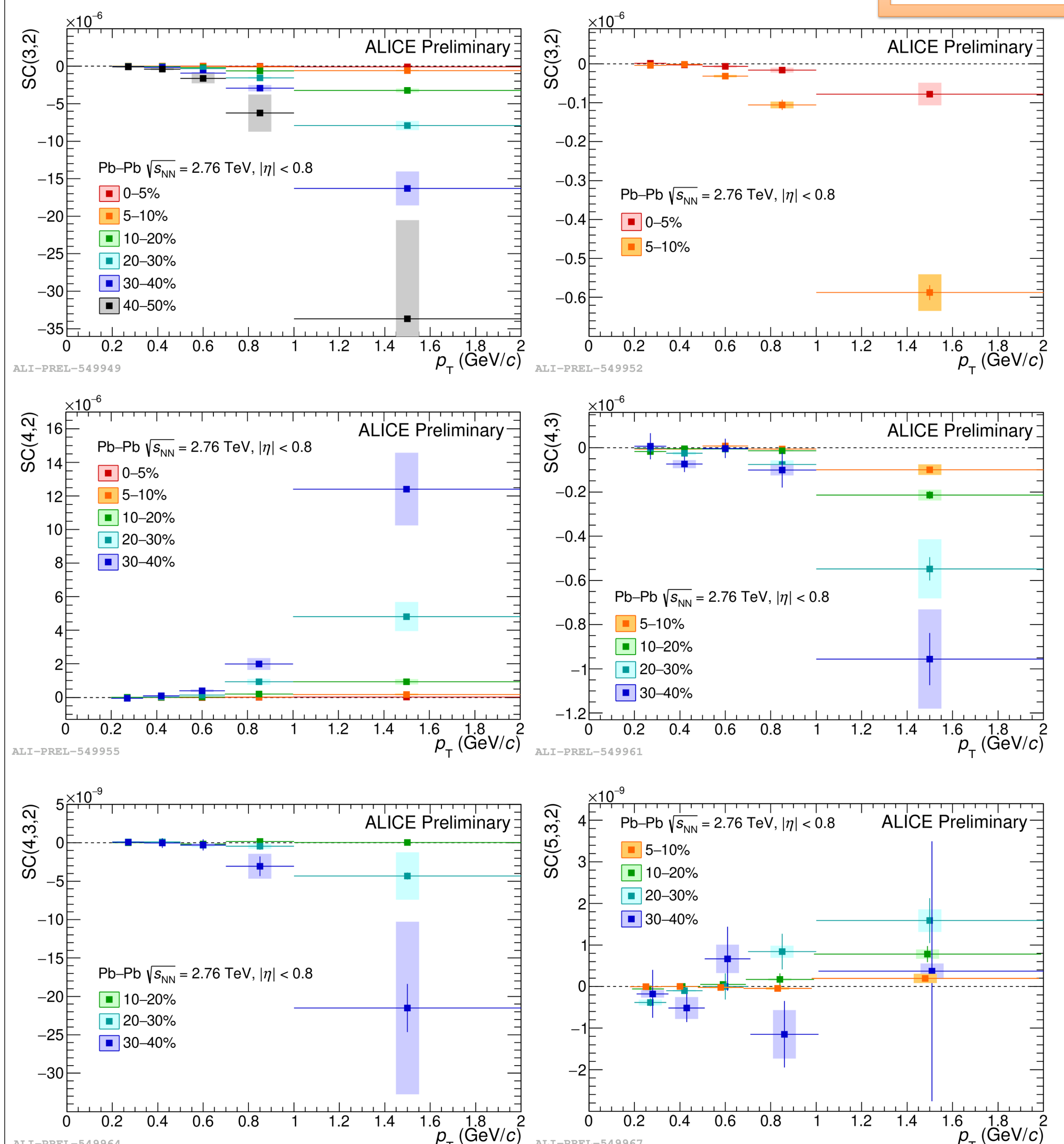
References

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[2] N. Borghini, P. M. Dinh, J-Y. Ollitrault, Phys.Rev.C 63 (2001) 054906
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[4] ALICE Collaboration, Phys.Rev.Lett. 117 (2016) 182301
[5] ALICE Collaboration, Phys.Rev.Lett. 127 (2021) 092302