Simulation studies of $R_2(\Delta\eta, \Delta\varphi)$ and $P_2(\Delta\eta, \Delta\varphi)$ correlation functions in p–p collisions with the PYTHIA and HERWIG models

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Introduction

- Two- and multi- particle azimuthal correlation functions have provided evidence for the existence of anisotropic flow and quark scaling (approximate) of flow coefficients in A–A collisions at RHIC and LHC as well as reveals the presence of flow in smaller systems (e.g., p–A and high multiplicity p–p collisions).
- Measurements of two particle differential- number correlations, R_2, and transverse momentum correlations, P_2, have confirmed the collective nature of the azimuthal correlations observed in Pb–Pb collisions[3] .
- Centrality study in A–A collisions show that near-side peak of both CI and CD correlations are narrower for P_2 than in R_2 [2].
- P_2 provides a more discriminating probe of the correlation structure of jets and their underlying events than the R_2 .

Correlation Observable

Particle Densities:

$$\rho_1(\vec{p_1}) \equiv \rho_1(\eta_1, \varphi_1, p_{T,1}) \qquad \rho_2(\vec{p_1}, \vec{p_2}) \equiv \rho_2(\eta_1, \varphi_1, p_{T,1}; \eta_2, \varphi_2, p_{T,2})$$

1st Observable:

Two-particle differential number Correlation [3,4]:

$$\boxed{R_2(\Delta\eta, \Delta\varphi) = \frac{\rho_2(\Delta\eta, \Delta\varphi)}{\rho_1(\eta_1, \varphi_1) * \rho_1(\eta_2, \varphi_2)} - 1}$$

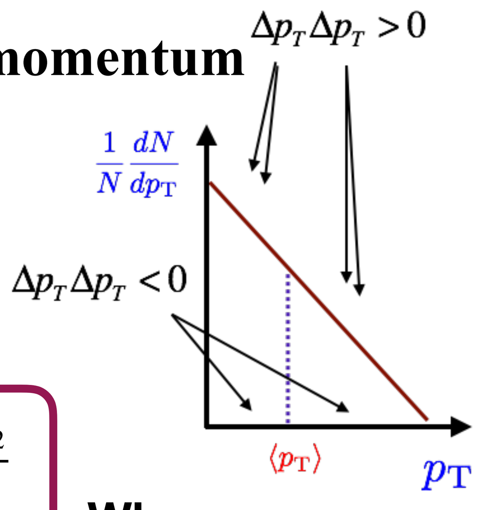
✓Sensitive to particle production mechanisms.

2nd Observable:

Two-particle differential transverse momentum Correlation [3,4]:

$$\boxed{P_2(\Delta\eta, \Delta\varphi) = \frac{\left\langle \Delta p_{T,1} \Delta p_{T,2} \right\rangle (\Delta\eta, \Delta\varphi)}{\langle p_T \rangle^2}}$$

$$\boxed{= \frac{1}{\langle p_T \rangle^2} \frac{\int \rho_2(\vec{p_1}, \vec{p_2}) \Delta p_{T,1} \Delta p_{T,2} dp_{T,1} dp_{T,2}}{\rho_2(\Delta\eta, \Delta\varphi)}}$$



Where $\Delta p_{T,i} = p_{T,i} - \langle p_T \rangle$

✓Sensitive to transverse momentum fluctuations.

Why we used R_2 and P_2 ?:

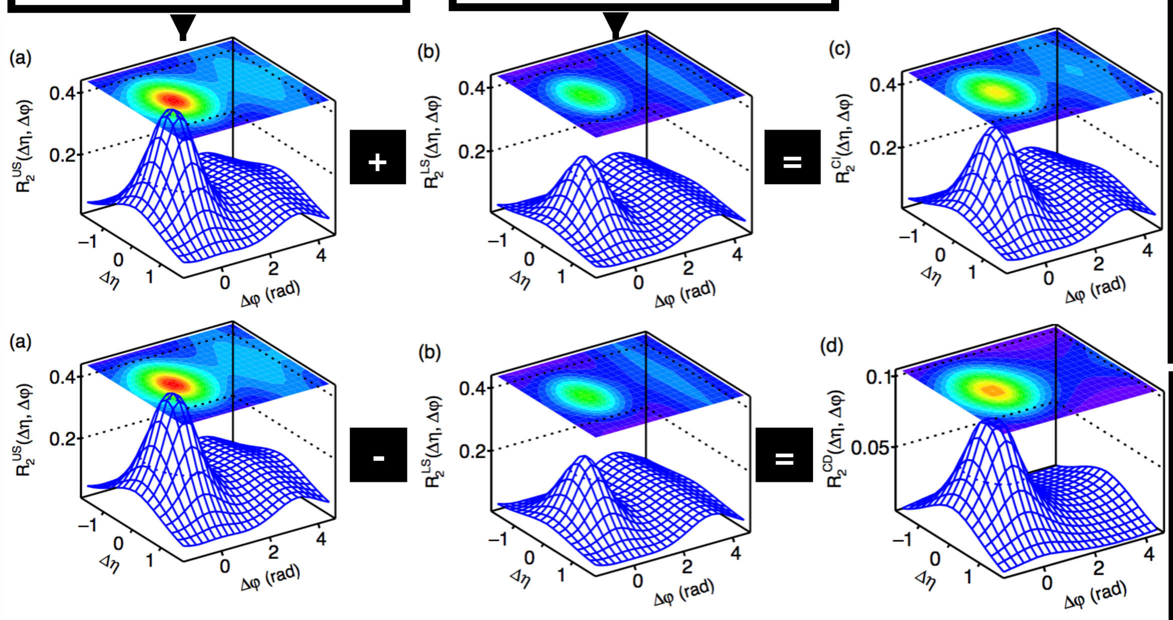
✓ Dimensionless quantity ✓ Robust observable[1]

4 different charge combinations: (+ -), (- +), (+ +), (- -)

- Unlike Sign(US): $O^{US} = \frac{1}{2}(O^{(+,-)} + O^{(-,+)})$
- Like Sign(LS): $O^{LS} = \frac{1}{2}(O^{(+,+)} + O^{(-,-)})$
- Charge Independent(CI): $O^{CI} = \frac{1}{2}(O^{US} + O^{LS})$
- Charge Dependent(CD): $O^{CD} = \frac{1}{2}(O^{US} - O^{LS})$

Coulomb Int., Jet, Resonance, flow(In Heavy Ion) etc

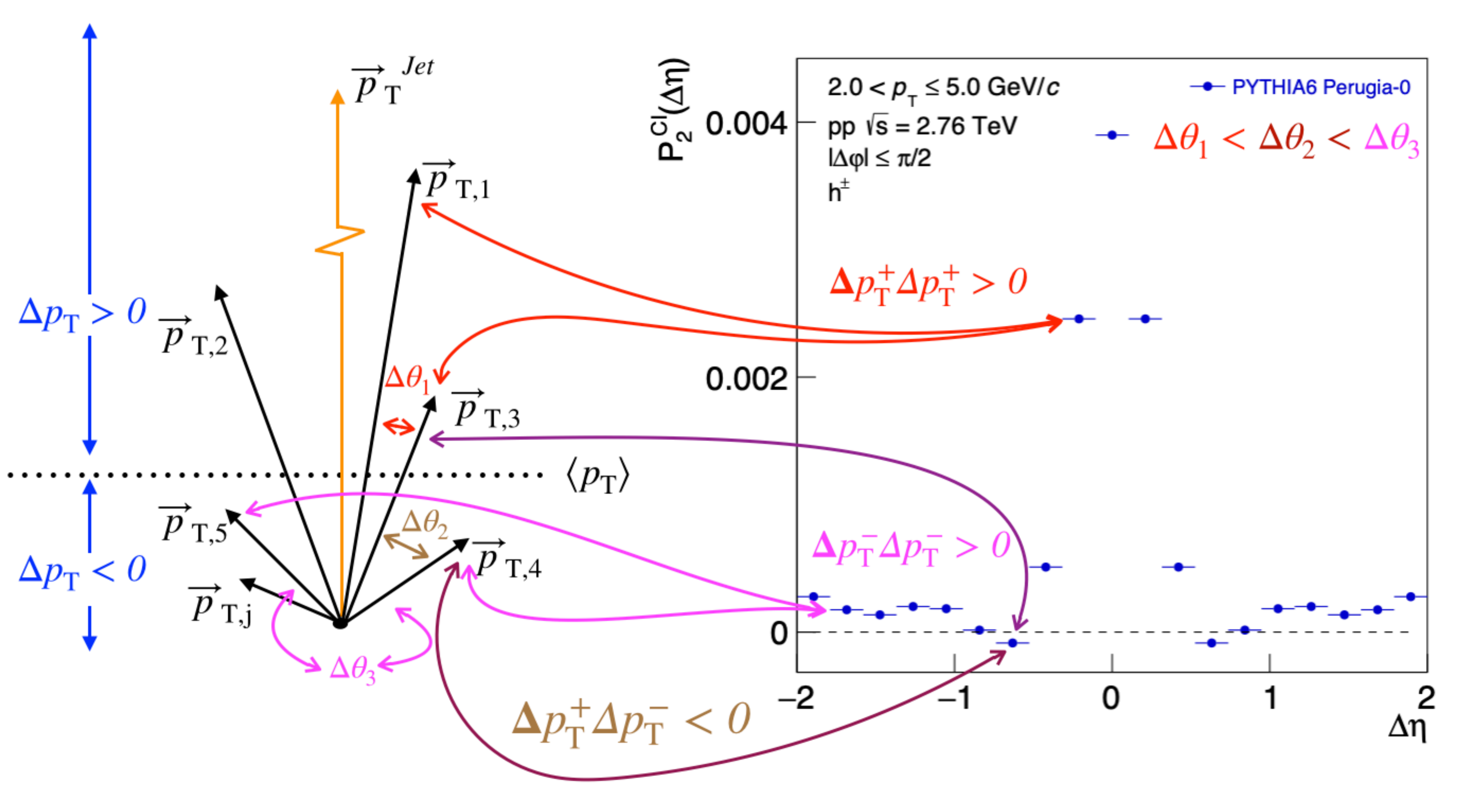
Coulomb Int., Jet, B-E corr., flow(In Heavy Ion) etc



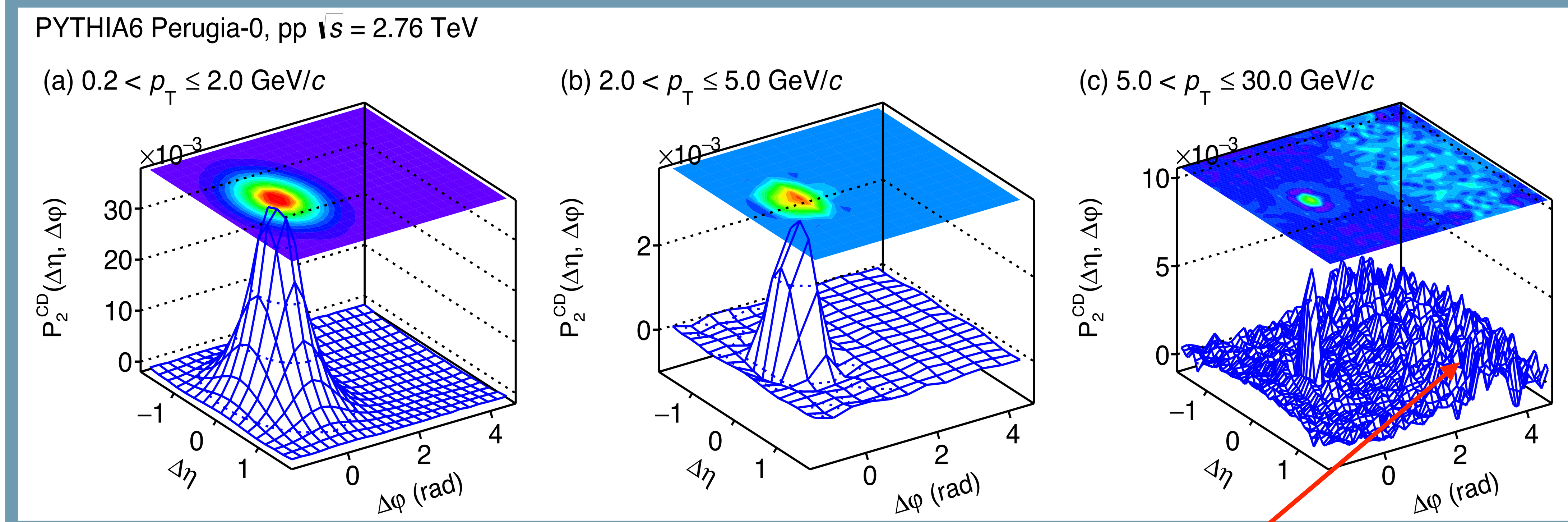
Measures the average correlation strength between all charge particles.

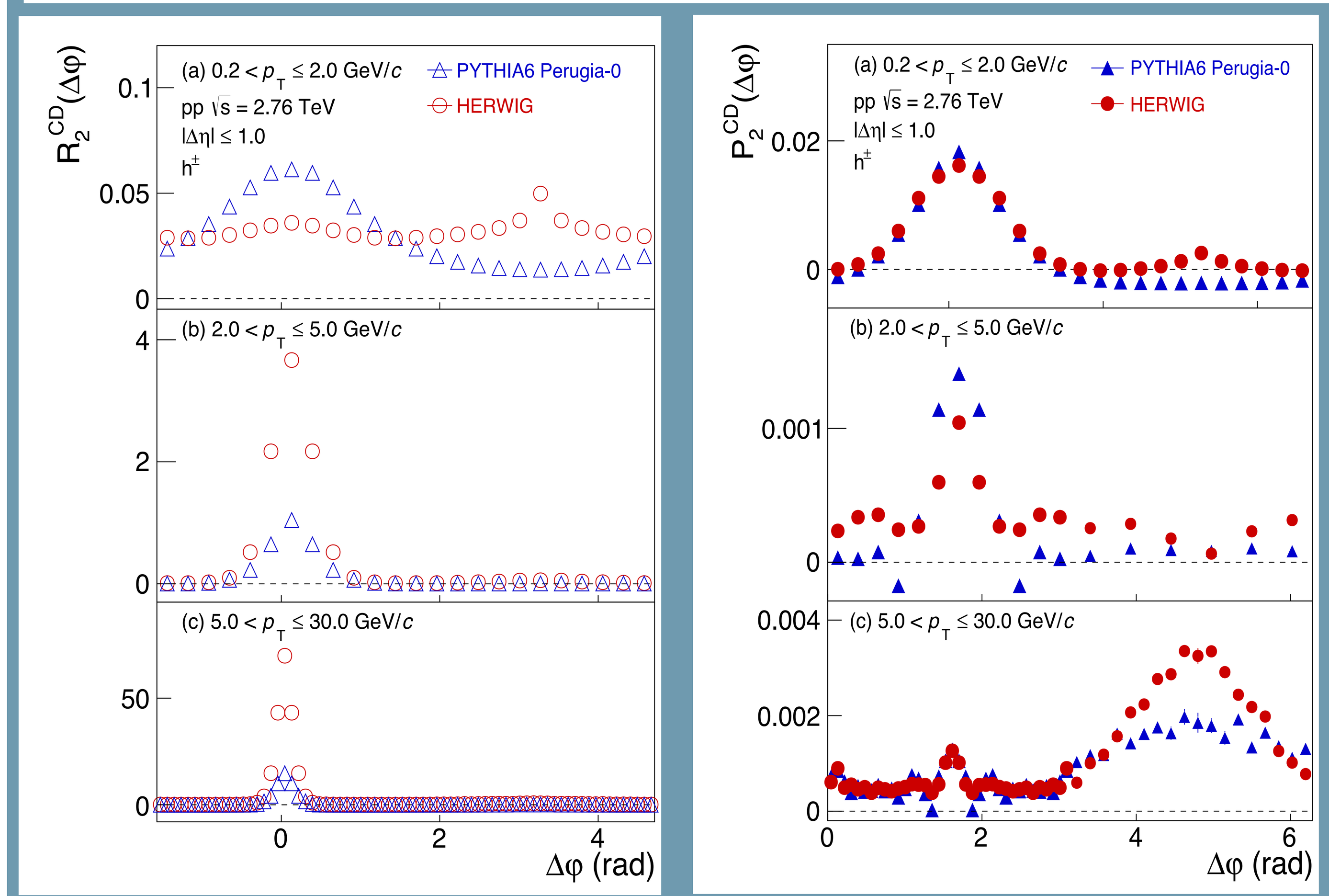
effects related to balancing pairs

Angular Ordering: probes the internal structure of jets



Results





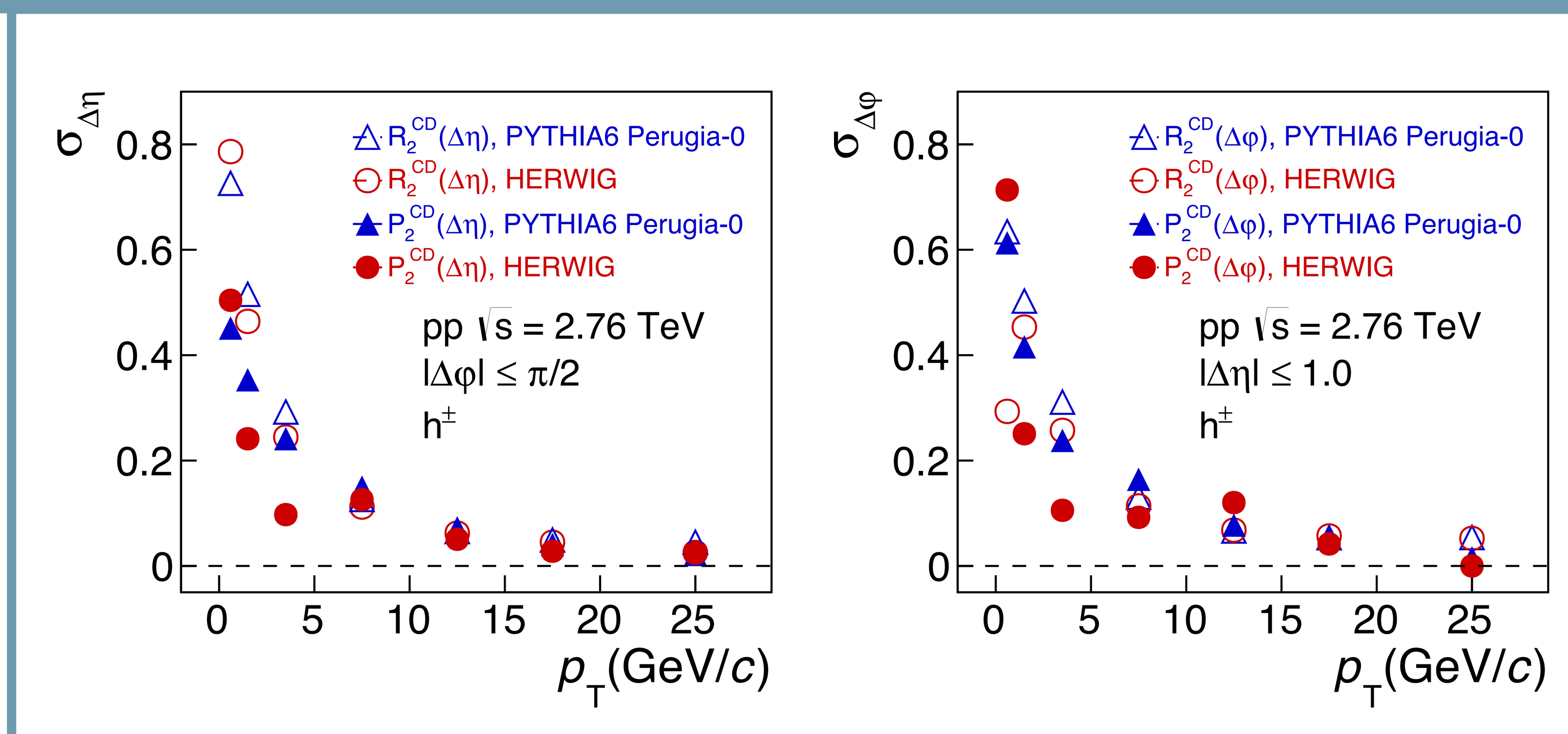
☑ **Quark-jets contribute away-side shape as it possesses charge.**

Narrowing of the near-side peak with increasing p_T for CD with PYTHIA and HERWIG .

$P_2^{CD}(\Delta\eta)$ is narrower than $R_2^{CD}(\Delta\eta)$: angular ordering

Widths decrease with increasing p_T .

P_2 width is broader than R_2 in some p_T ranges which is reverse in nature as stated in Ref. [3] .



Summary

✓ p_T -dependance study of CI and CD with R_2 and P_2 in p–p collisions at $\sqrt{s}$ = 2.76 TeV with the PYTHIA and HERWIG Monte Carlo models are performed for both identified and non-identified species.

✓ Narrower shape of the P_2 near-side peak, as compared to R_2 is because of p_T dependent angular ordering of hadrons produced in jets.

References

1. B. Sahoo et al. , Phys. Rev. C 100, 024909
2. J. Adam et al. (ALICE Collaboration), Phys. Rev. Lett. 118, 162302 (2017).
3. J. Adam et al. (ALICE Collaboration), Phys. Rev. C 100, 044903 (2019)
4. M. Sharma and C. A. Pruneau, PRC 79, 024905 (2009).
5. S. Bass, P. Danielewicz and S. Pratt, PRL 85, 2689 (2000).

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