NLO Calculations of D-$\bar{D}$ Azimuthal Correlations with HERWIG

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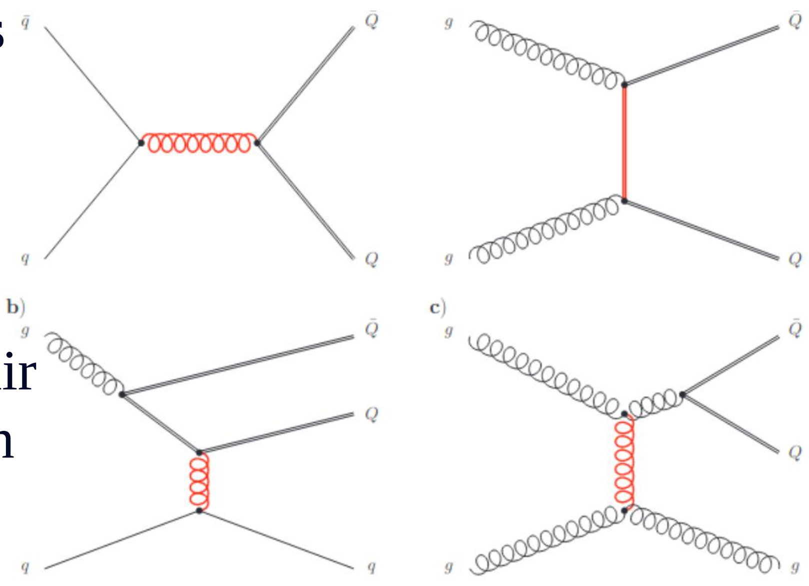
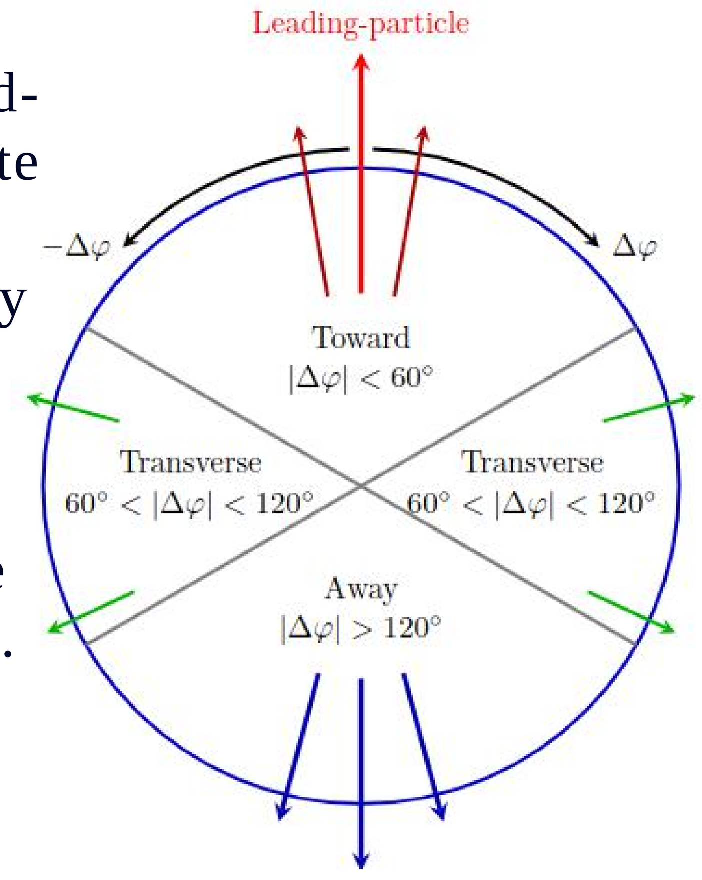
Physics motivation and goals

- Heavy-flavour quarks are produced in the initial hard scattering processes. In pp collisions heavy flavours are used for: testing perturbative QCD models; studying the fragmentation processes and the multiplicity dependent production.
- Azimuthal correlations of D-$\bar{D}$ pairs provide a **direct access to charm production mechanisms** in pp collisions [1].
- Heavy flavour generation can be separated into three processes: a) pair creation (FLC), b) flavour excitation (FEX), c) gluon splitting (GSP).



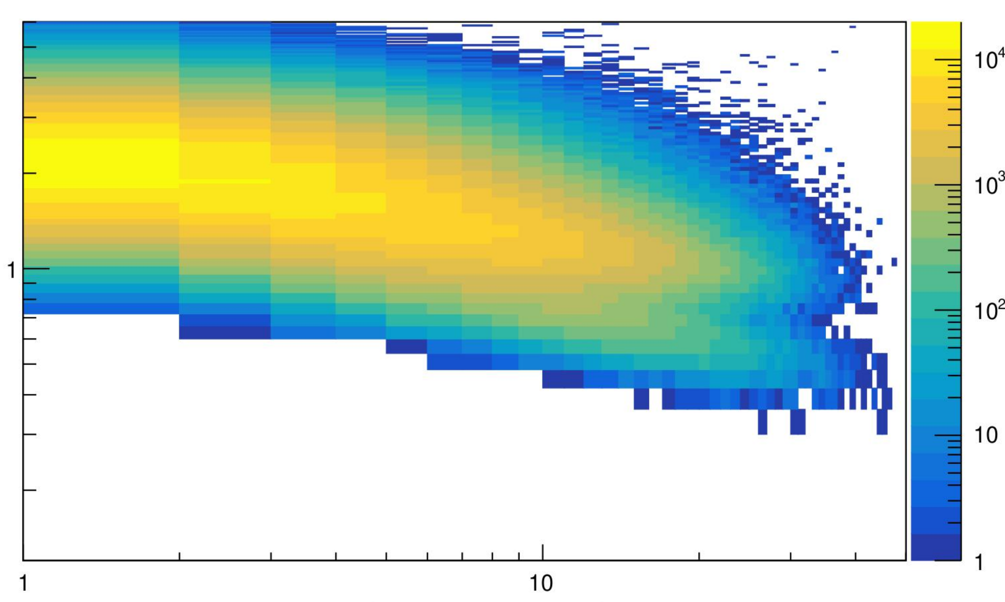
Event activity classifiers

- **Charged hadron multiplicity** at mid-rapidity ($|\eta| < 1$): number of final state charged particles.
- **Forward multiplicity** at forward rapidity ($2 < \eta < 5$).
- **R_T**: underlying event activity, $N_{CH}^{transverse} / \langle N_{CH}^{transverse} \rangle$.
- **Spherocity**: how spherical or jet-like the event is: $S_0 \rightarrow 0$: jet-like, $S_0 \rightarrow 1$: isotropic.
- **Flatenicity**: the relative standard deviation of the p_T^{cell} distribution [2].

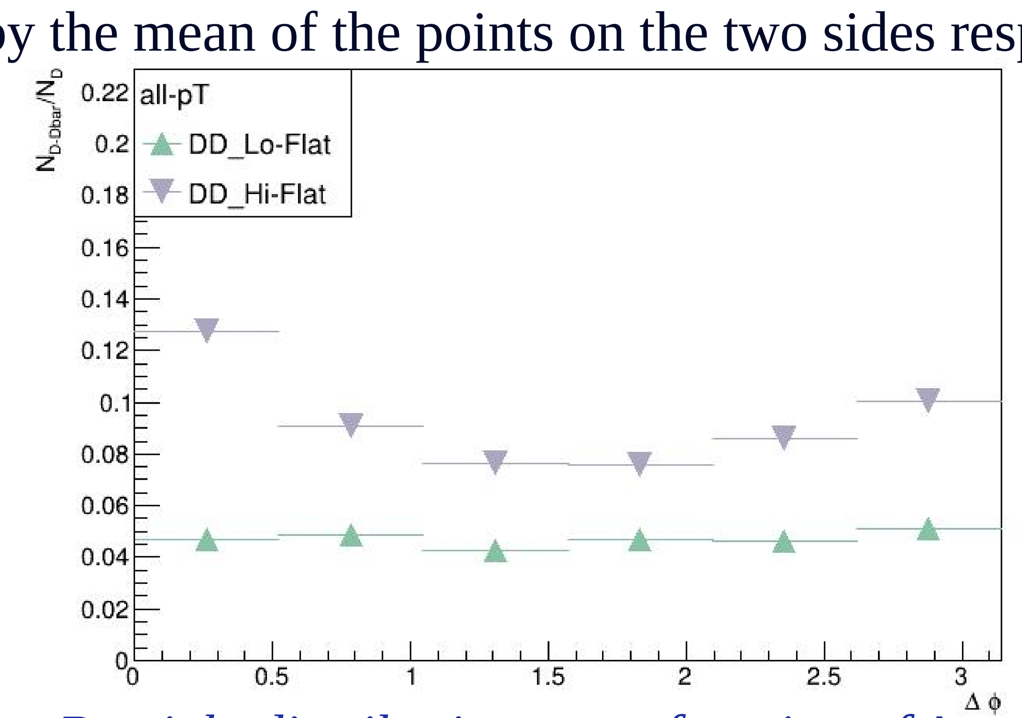


Analysis method

- 25 million MB event simulations from **HERWIG**. NLO calculations including heavy flavour, cluster hadronisation model, the showering ordering is different from PYTHIA (angular ordering with respect to p_T ordering).
- Due to statistical limitations, we estimated the baseline as the mean of the middle two points of particle distributions as a function of $\Delta\varphi$. The near-side and away-side peaks are represented by the mean of the points on the two sides respectively minus the baseline.



Flatenicity as a function of the transverse multiplicity.

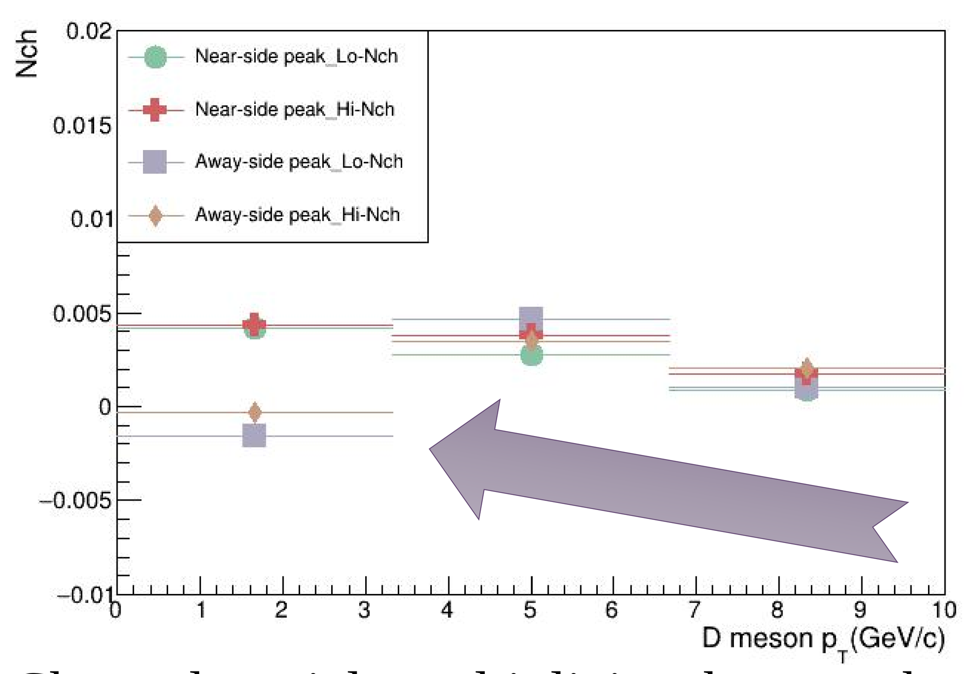


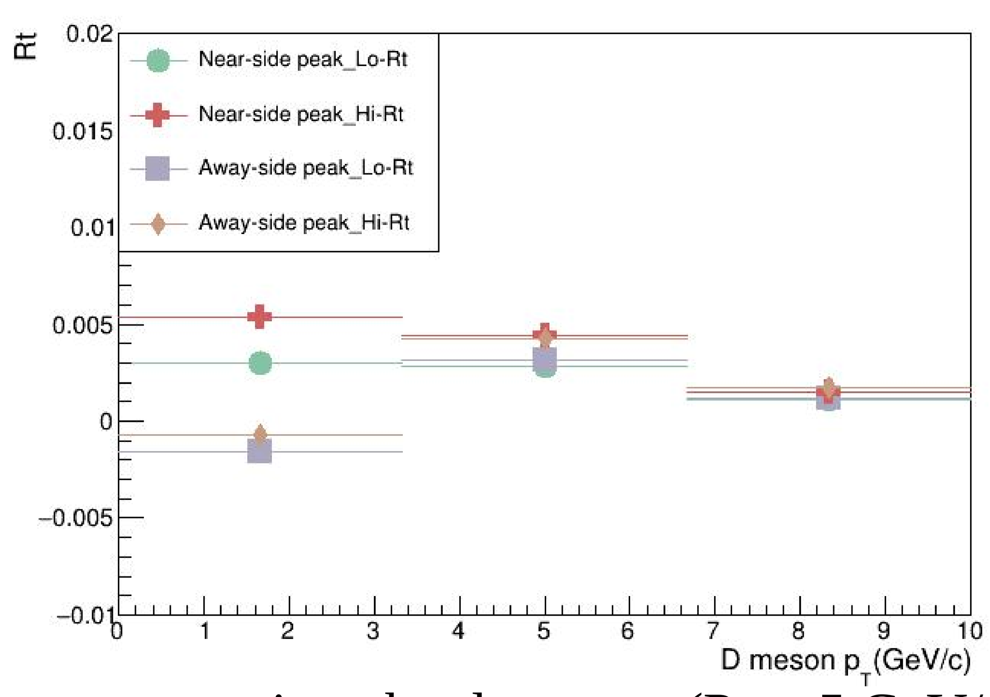
Particle distributions as a function of Δφ.

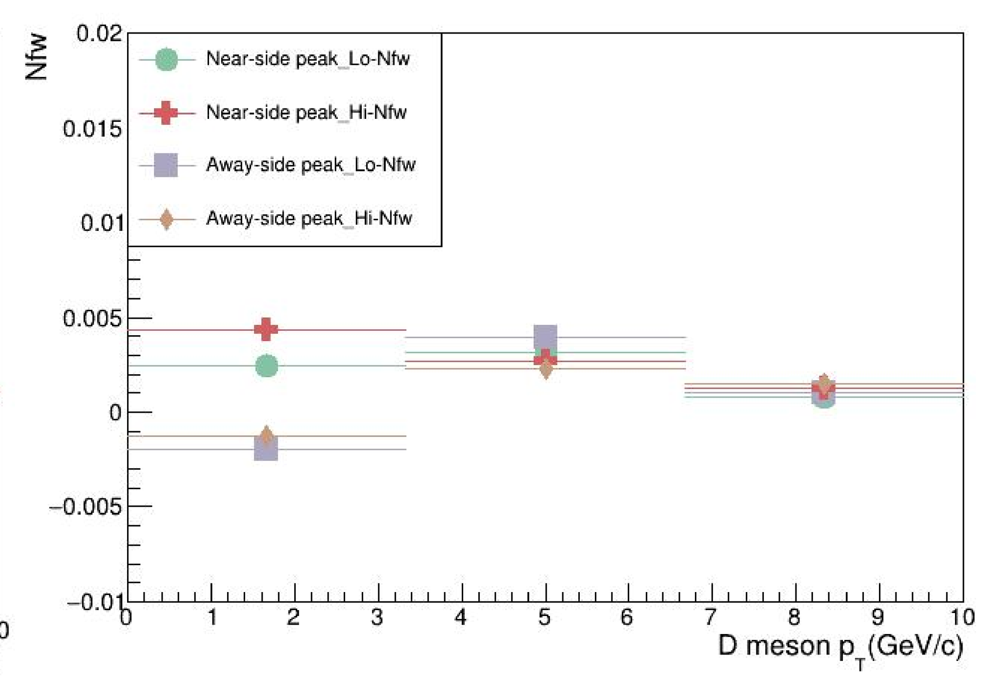
Stronger activity means stronger near-side and away-side correlation, which means that GSP and FLC are stronger as well. The effect is very clear in the case of flatenicity.

- The event activity classifiers were divided into two regions: low ($p_T^{trigger} < 2.5$) and high ($p_T^{trigger} > 2.5$) regions and we left a gap between the two region to separate the classifiers even more.
- The classifiers are shown in three p_T region: $p_T < 2.5$ GeV/c, $2.5 < p_T < 5$ GeV/c, $p_T > 5$GeV/c.

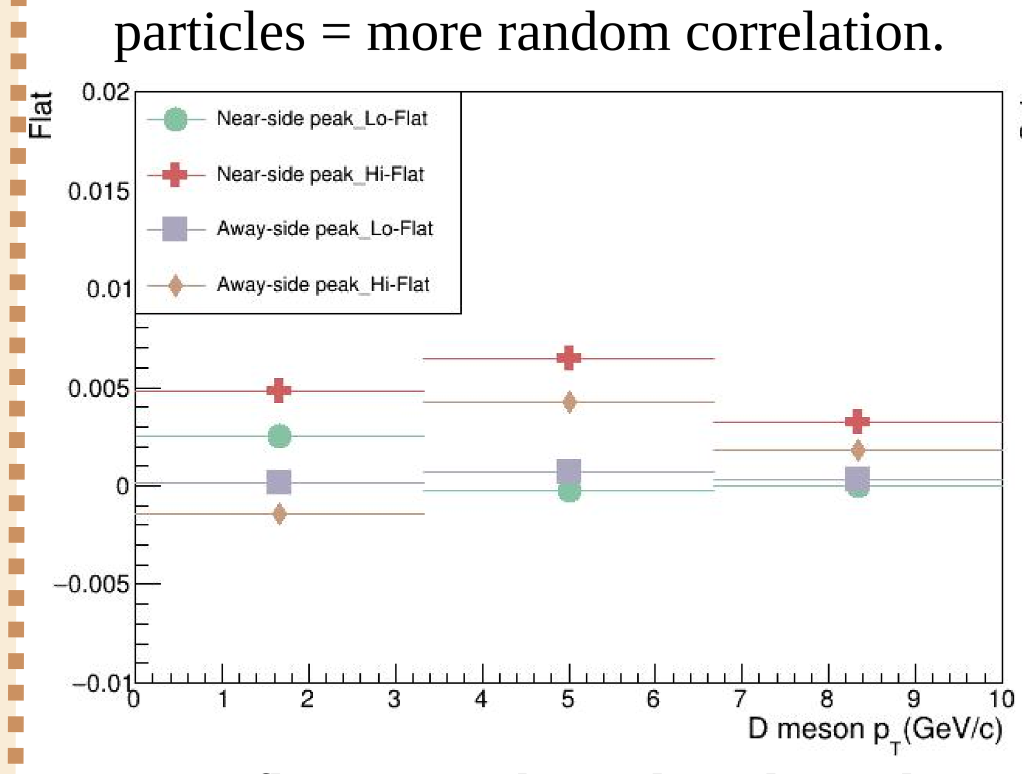
D meson azimuthal correlations vs. event activity classifiers

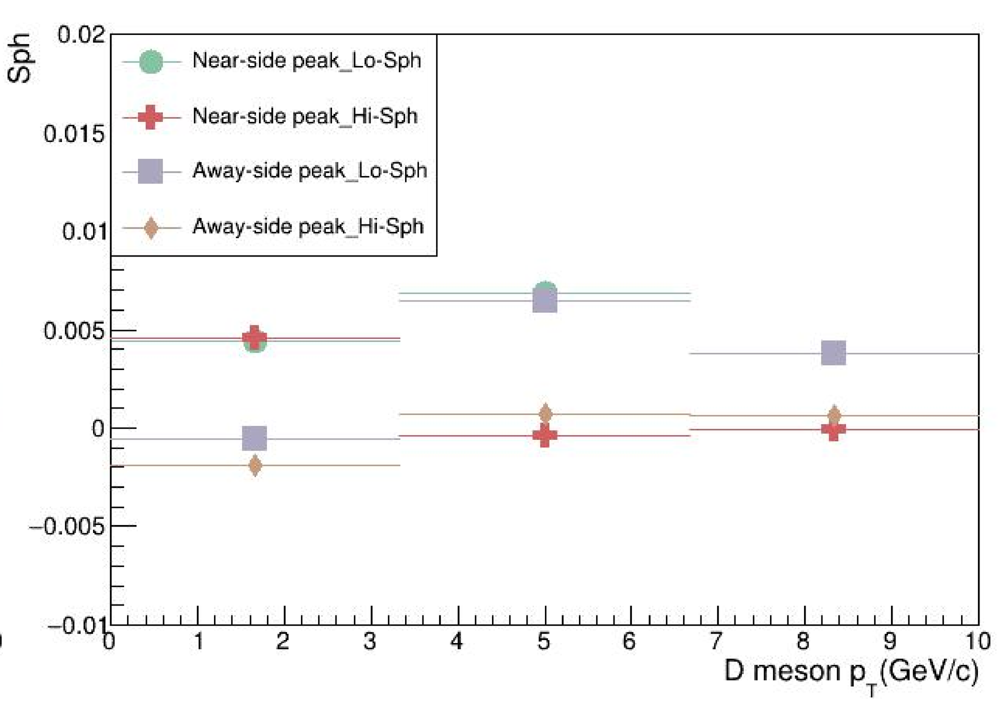






- Charged particle multiplicity shows a characteristic dependence of the p_T, especially at low p_T: more particles = more random correlation.
- In case we require a hard process ($P_T > 5$ GeV/c), no pronounced N_{fw} and R_T activity. In case of low p_T, there is stonger correlations. The away-side and the near-side points are better separated.





- Low flatenicity shows less dependence on the p_T than spherocity, the distribution is more isotropic. This show that flatenicity can be a great quantity to represent high-multiplicity pp collisions vs. low-multiplicity pp collisions.

Conclusions

- At low p_T, we can observe a soft background, which comes from random correlations. There is a strong dependence in the case of N_{ch} (more particles = more random correlation). In the case of the other event classifiers, there is a bias due to N_{ch}. Flatenicity is not prone to such bias.
- At high p_T the correlation is less sensitive to the background. In the case of flatenicity and spherocity, stronger activity is associated with stronger near-side and away-side correlation.

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References:

[1] S. Acharya *et al.* EPJC 80 (2020) 979.
[2] A. Ortiz, G. Paic [arXiv: 2204.13733 [hep-ph]].