

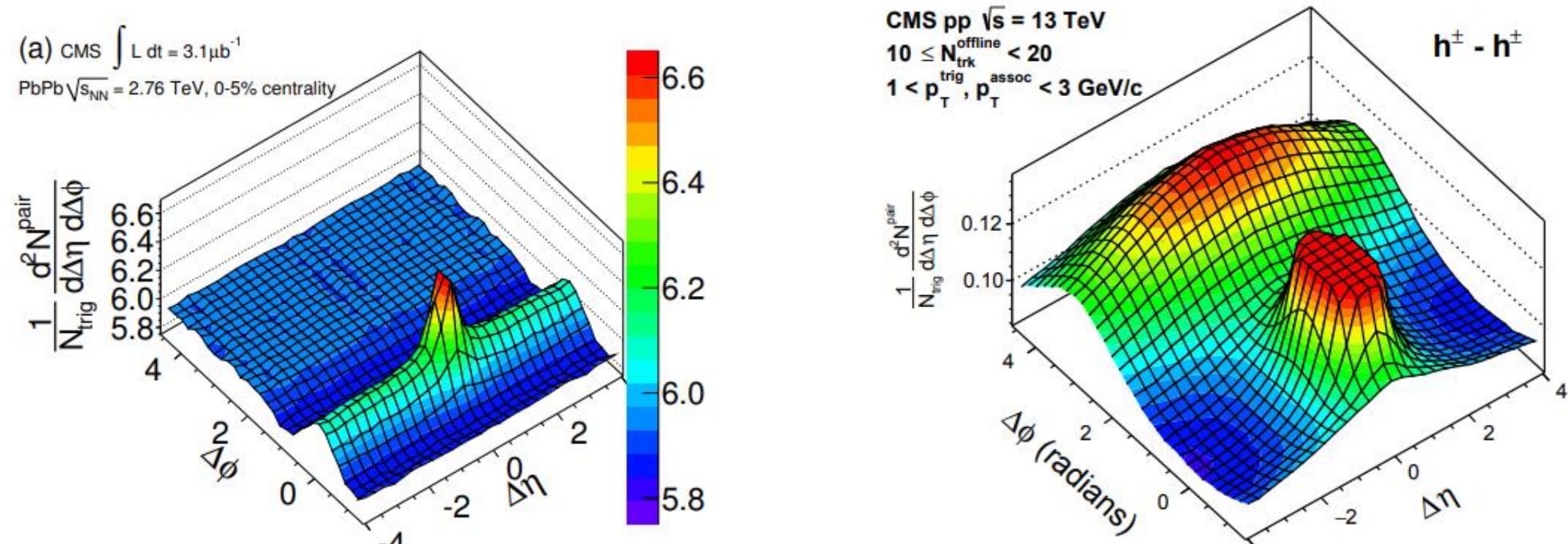
Defining the Underlying-Event Activity in the Presence of Heavy-Flavour Processes in Proton-Proton Collisions at LHC Energies

László Gyulai^{1,2}, Szende Sándor^{1,3} and Róbert Vértesi¹

Motivation

Collective phenomena arise in heavy ion collisions at the LHC. This is due to the presence of QGP at the primary vertex. Such collective-like behaviour is also observed in small systems (pp, p-Pb) with high final-state multiplicity.

Energy densities are insufficient for the QGP to be formed in substantial volumes in small systems. Another possibility for collectivity are vacuum-QCD effects such as multiple parton interactions (MPI).



Two-particle correlation in Pb-Pb collisions [1] Two-particle correlation in pp collisions [2]

Analysis method

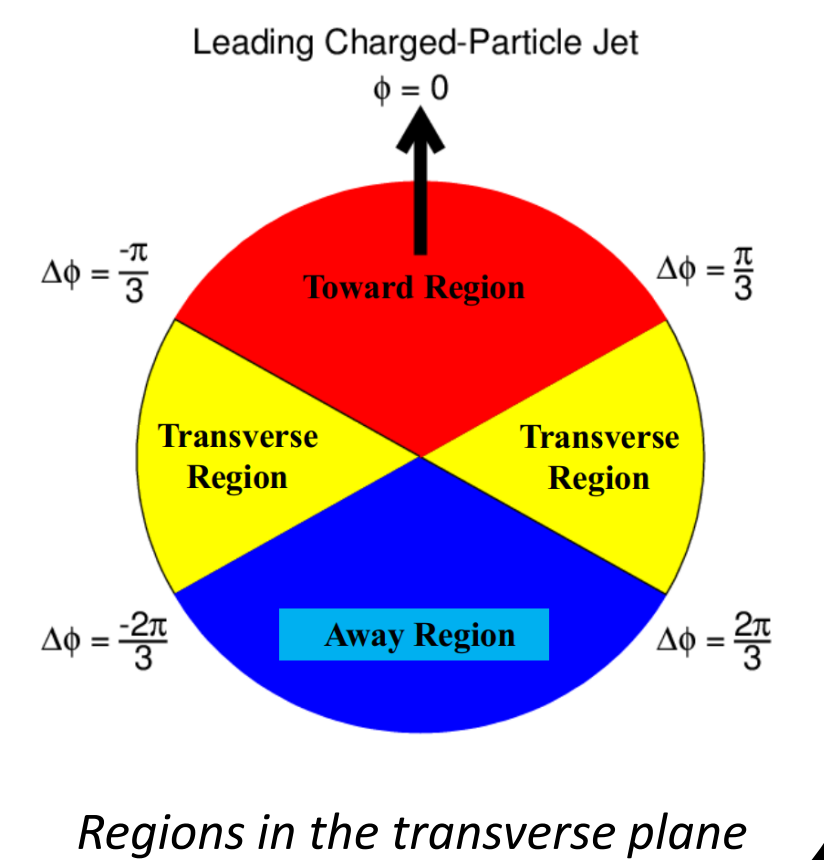
Experiments show a saturation of particle production in the transverse region if a high- p_T leading process is present [3]. In such events, processes in the transverse region are assumed to be independent of the hard scattering. Particle production in the transverse region is mainly determined by the underlying event.

To classify the activity of underlying event, the R_T parameter is used:

$$R_T = \frac{N_{ch,transverse}}{\langle N_{ch,transverse} \rangle}$$

Simulations show a strong correlation between the R_T and MPI.

In our study, we generated 1 billion pp collisions at $\sqrt{s}=13$ TeV with PYTHIA 8 Monash tune. Additionally, we applied soft QCD settings and the MPI-based colour-reconnection scheme.



Regions in the transverse plane

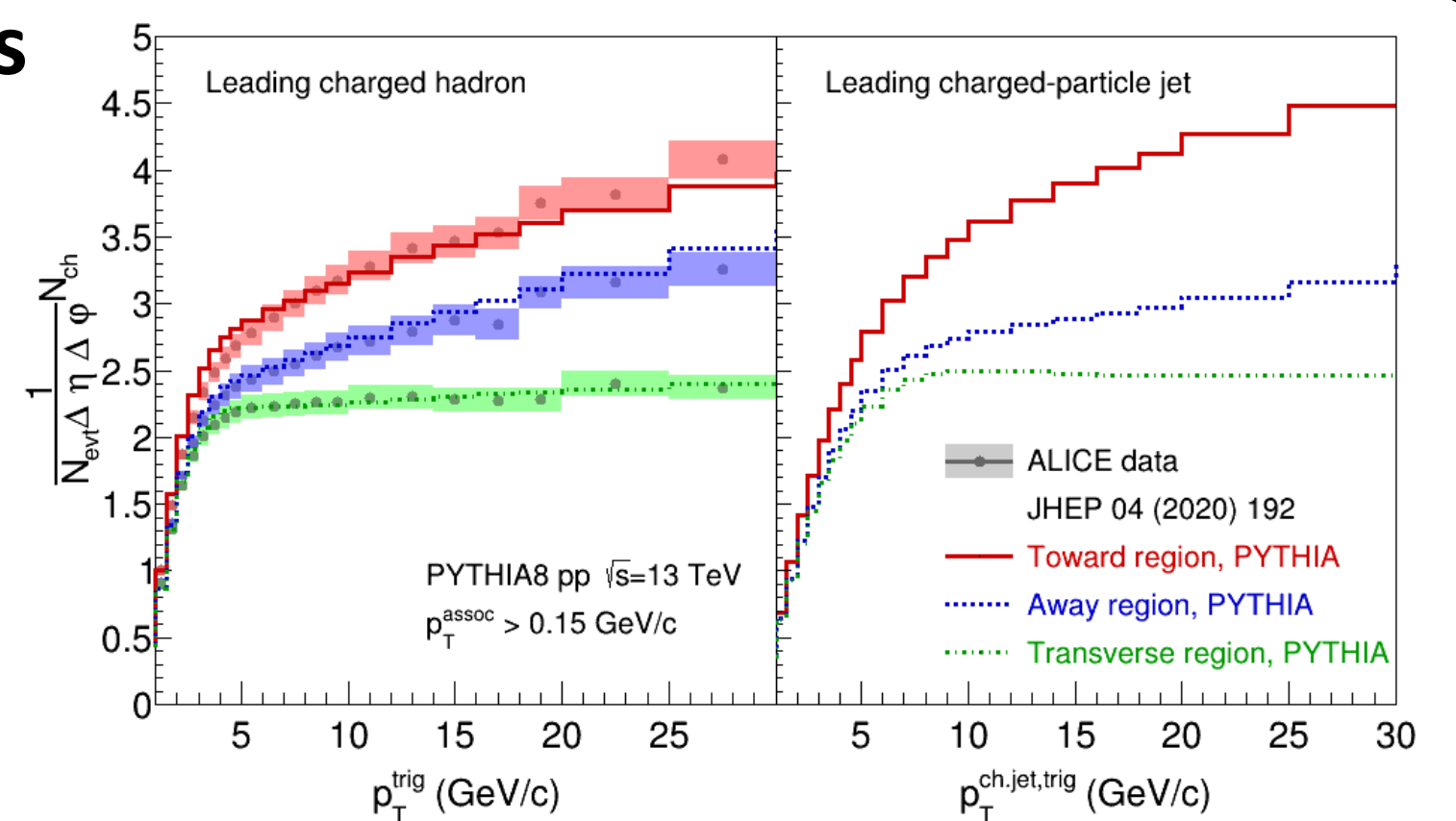
Charged particle production with hadron and jet triggers

- The number of charged hadrons in the **toward** and **away** regions increases with p_T^{trig}
- The number of charged hadrons in the **transverse** region forms a plateau above $p_T^{\text{trig}} \approx 5$ GeV/c and $p_T^{\text{ch,jet,trig}} \approx 10$ GeV/c
- For hadron triggers this behaviour is observed not only in simulations, but also in experiments

Our motivation for introducing jet triggering for event selection:

- Similar trends for hadron and jet triggers
- A hadron trigger may come from fragments of either light or heavy-flavour jets
- The fragmentation functions are different in both cases and heavy-flavour decay kinematics play a role, so the sensitivity of heavy flavour and light flavour for the trigger will be different.

Idea: look separately at events that are triggered with identified heavy-quark and light-flavour jets in order to connect heavy-flavour production to the underlying event.



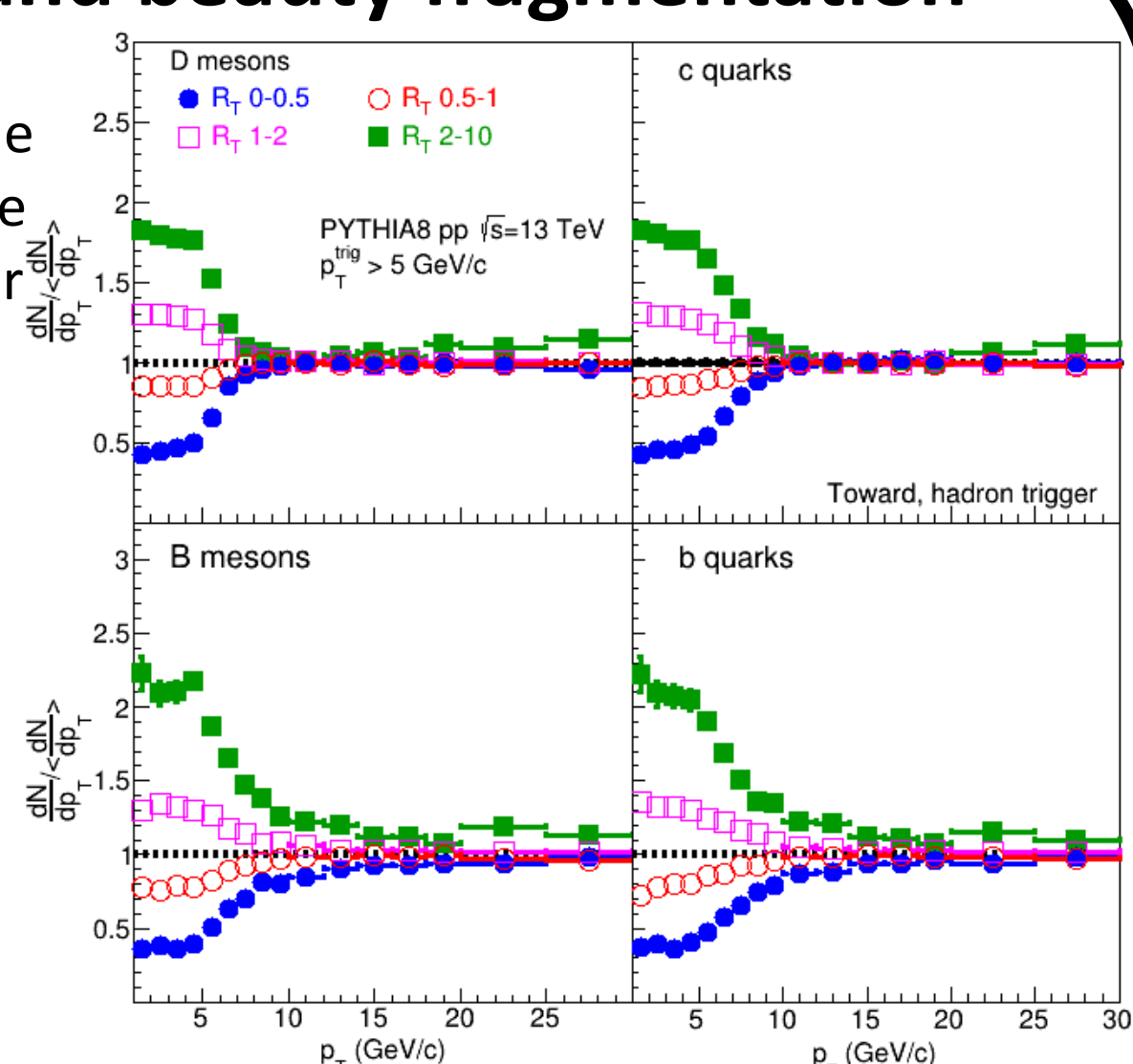
Charged-particle multiplicity in the azimuthal regions as a function of the leading charged hadron and charged-particle jet.

Effects of charm and beauty fragmentation

The transition from the soft to the hard production dominated range of c quarks is at about 40% higher p_T than in the hadronic case.

This is due to the change in momentum scale during the fragmentation of c quarks into D mesons.

Due to the much harder fragmentation of the b quarks, no significant difference in the transition is seen between b quarks and B mesons.



Production ratios of D mesons, c quarks, B mesons and b quarks with charged-hadron triggers as a function of p_T for different R_T classes in the toward region, over the R_T -integrated yield.

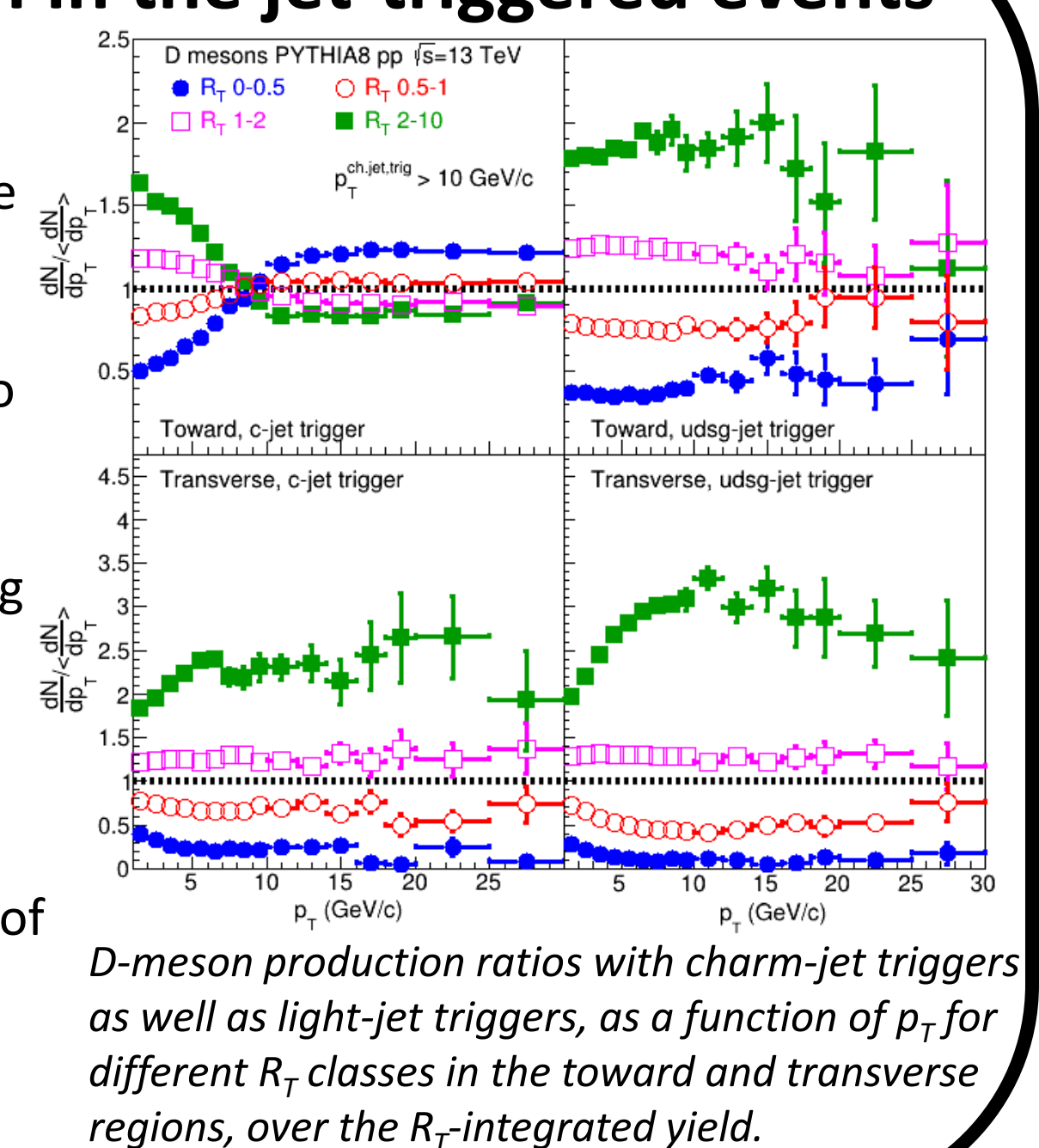
D-meson production in the jet-triggered events

D-meson yields depend on R_T in c-jet triggered events even above the trigger threshold.

This behaviour is probably due to the wide-angle gluon splitting.

In case of light-jet trigger a strong dependence on the R_T is present in the toward region.

In the transverse region the behaviour is similar for any type of trigger (as expected).



D-meson production ratios with charm-jet triggers as well as light-jet triggers, as a function of p_T for different R_T classes in the toward and transverse regions, over the R_T -integrated yield.

Conclusion

- Analysis of heavy-flavour production in connection to a leading hard process in pp collisions at $\sqrt{s} = 13$ TeV, using R_T -differential simulations from PYTHIA 8
- Production of low-momentum heavy flavour in toward region in the events with hadron trigger is mostly determined by the underlying event
- Jet-triggers bring more direct information on the initial heavy-flavour production process
- Investigation of fragmentation by comparing the UE-differential production of c and b quarks to D and B mesons respectively
- The production of heavy flavour is R_T -dependent over the whole p_T range, which is likely an effect of gluon radiation