



Production of heavy-flavoured mesons and jets in dependence on Underlying Event activity

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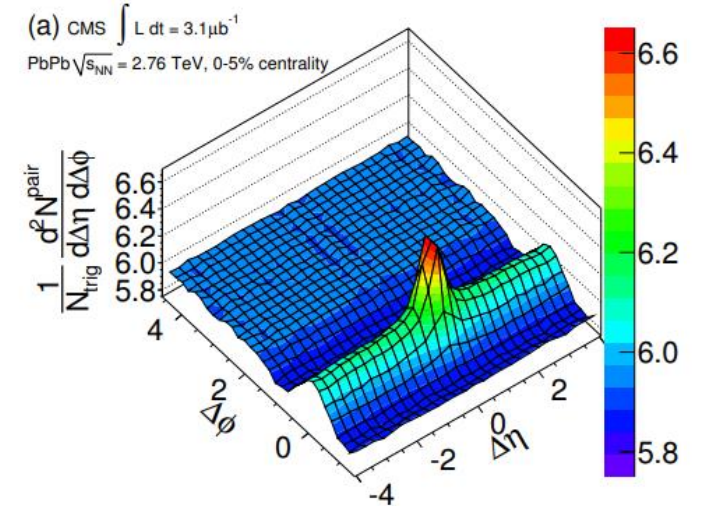
with Szende Sándor and Róbert Vértési

Collectivity in high-energy collisions

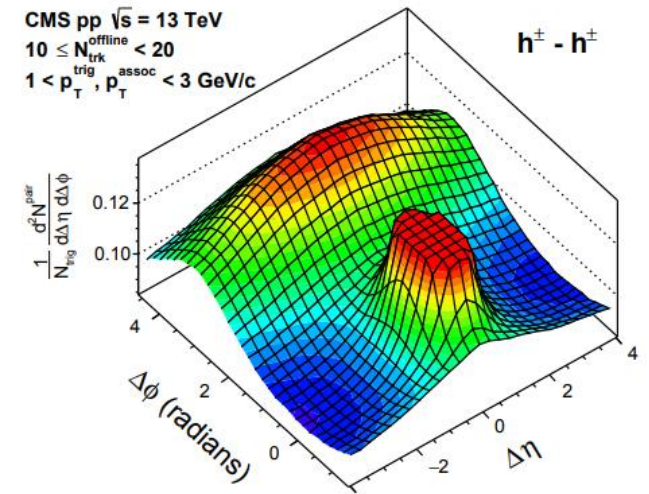
Collective phenomena arise in high-energy heavy-ion collisions. This is due to the Quark-Gluon Plasma (QGP), which is created in the primary vertex.

Such collective-like behaviour is also observed in small systems (pp, p-Pb) with high final-state multiplicity. Energy densities are insufficient to form QGP in substantial volumes in these collisions.

Another possibility: vacuum-QCD effects such as multiple parton interaction (MPI).



Two-particle correlation in Pb-Pb collisions



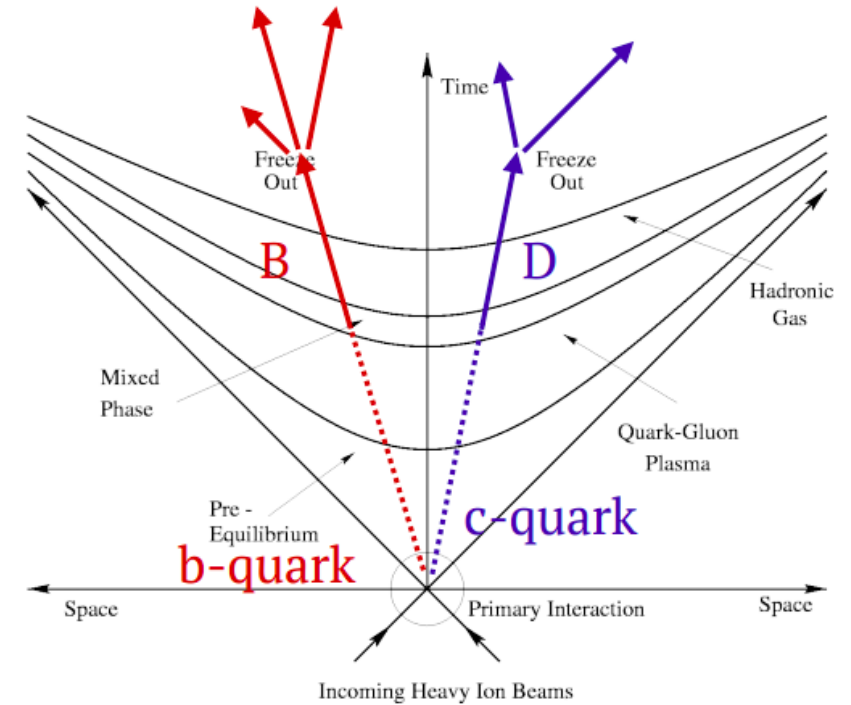
Two-particle correlation in pp collisions

Heavy-flavour probes

Heavy-flavour (c and b) 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;
- studying the multiplicity dependent production.



Evolution of heavy flavour

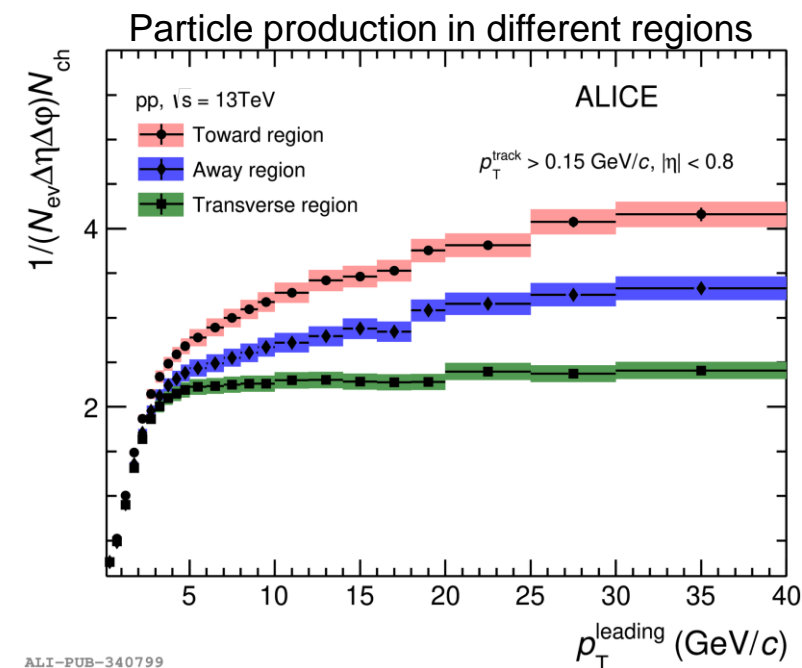
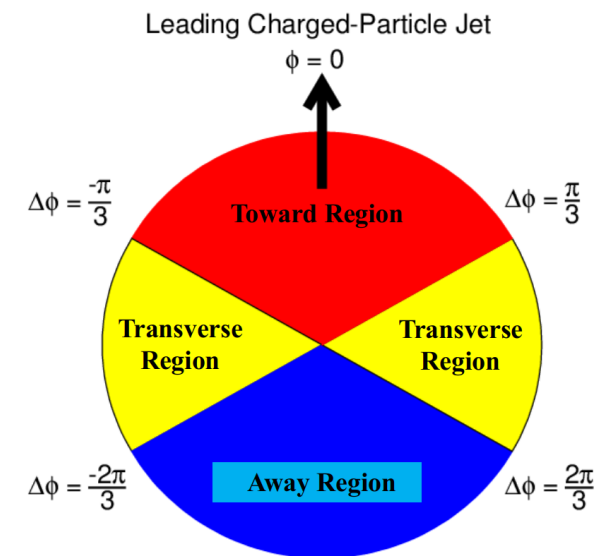
Transverse activity classifier

In events with a **high-energy trigger particle**, processes in the transverse region exhibit a behaviour which is independent of the hard scattering. Particle production there is mainly determined by the **underlying event**.

To classify the activity of underlying event, the transverse activity classifier R_T can be used:

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

Simulations show a strong correlation between the R_T and MPI.
(<https://inspirehep.net/literature/1429670>)



Simulation study of heavy flavour production vs R_T

PYTHIA 8 with SoftQCD.

FastJet for jet reconstruction.

Jet-tagging: c-, b-, and light-jets.

Total of 100 million events generated.

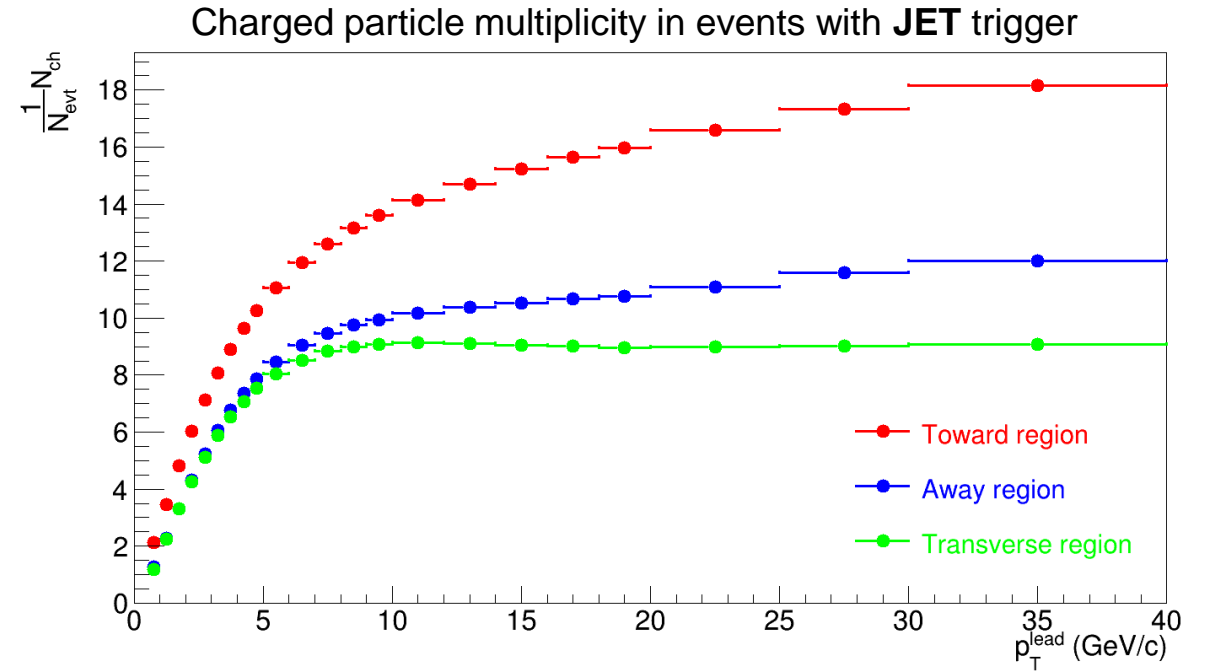
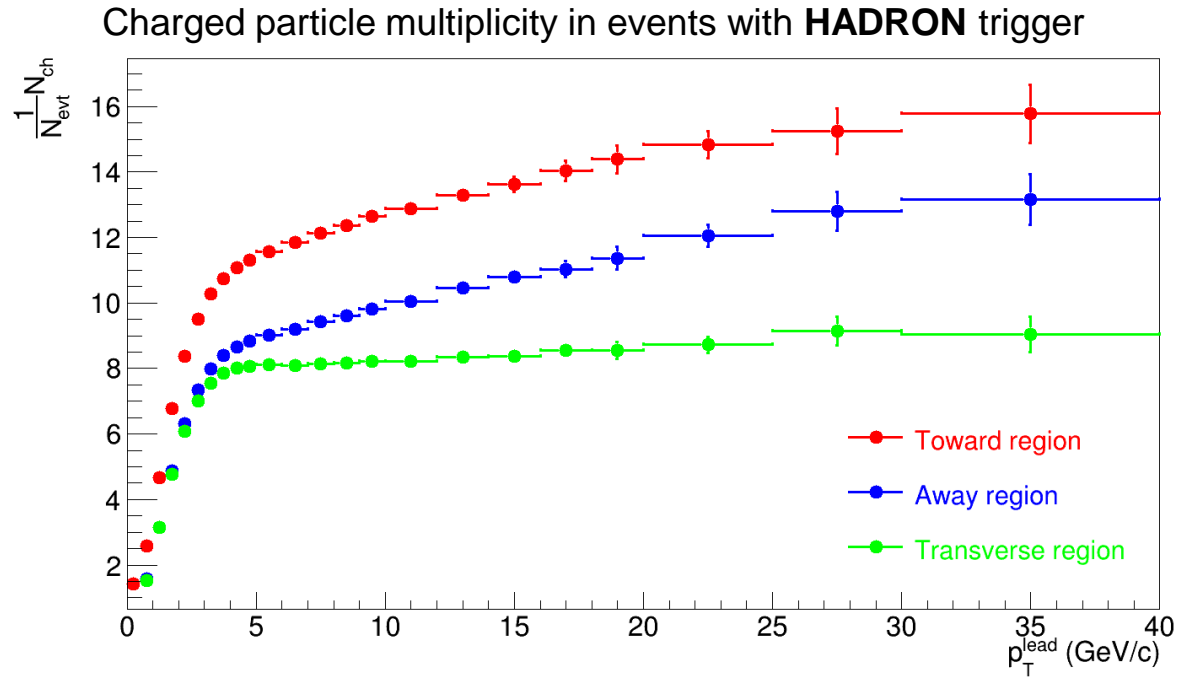
Number of events with hadron triggers: ~1 million.

Number of events with jet triggers: ~1 million.

Studied particles:

- D mesons (D^0 , D^+ , D^* and their antiparticles);
- B mesons (B^0 , B^+ , B^* and their antiparticles);
- c quarks;
- b quarks.

Charged particle multiplicity in events with hadron and jet triggers



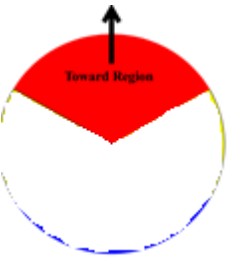
Similar behaviour in both cases.

Distinct plateau from:

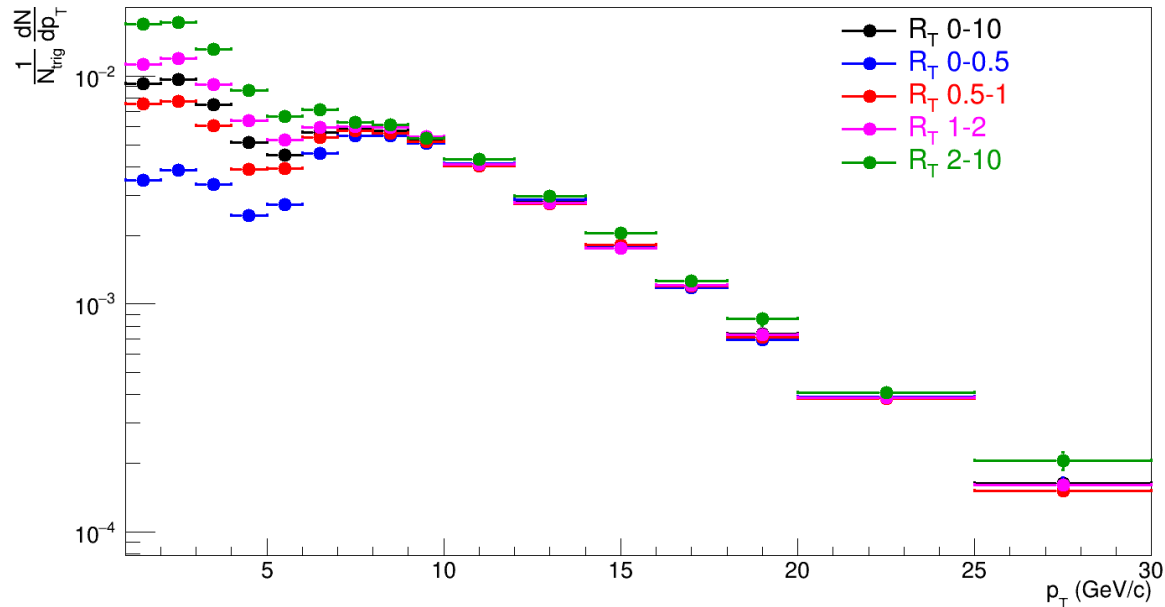
- ≈ 5 GeV/c for hadron triggers;
- ≈ 10 GeV/c for jet triggers.

Event activity in transverse region is independent of the leading hard process above the trigger threshold.

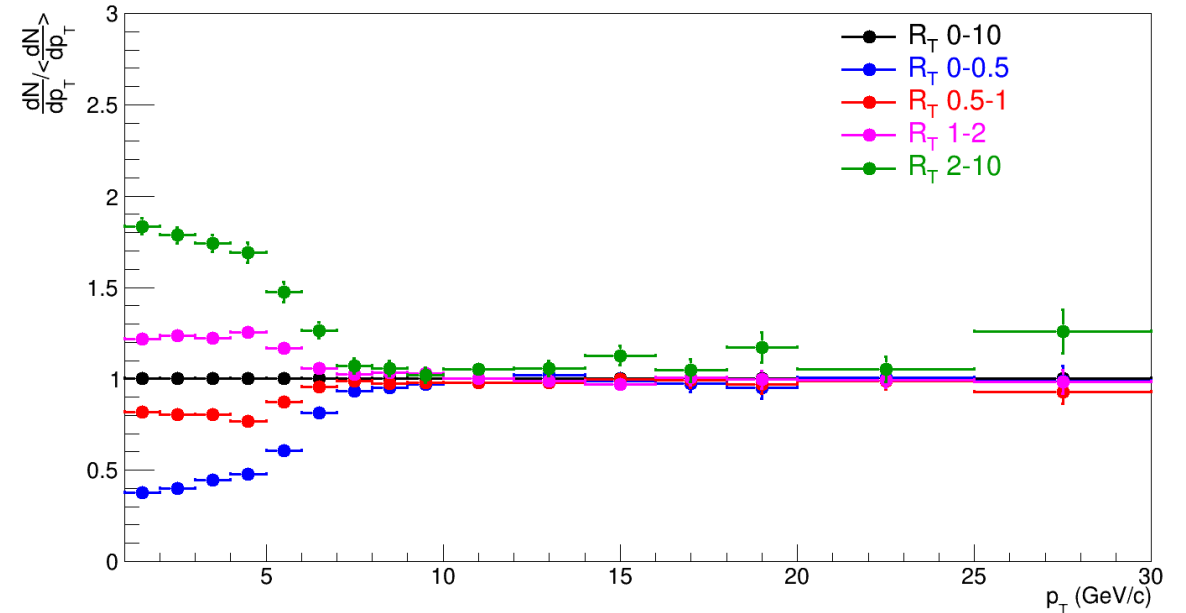
Production of D mesons in the Toward region, hadron trigger



D meson production in events with hadron trigger

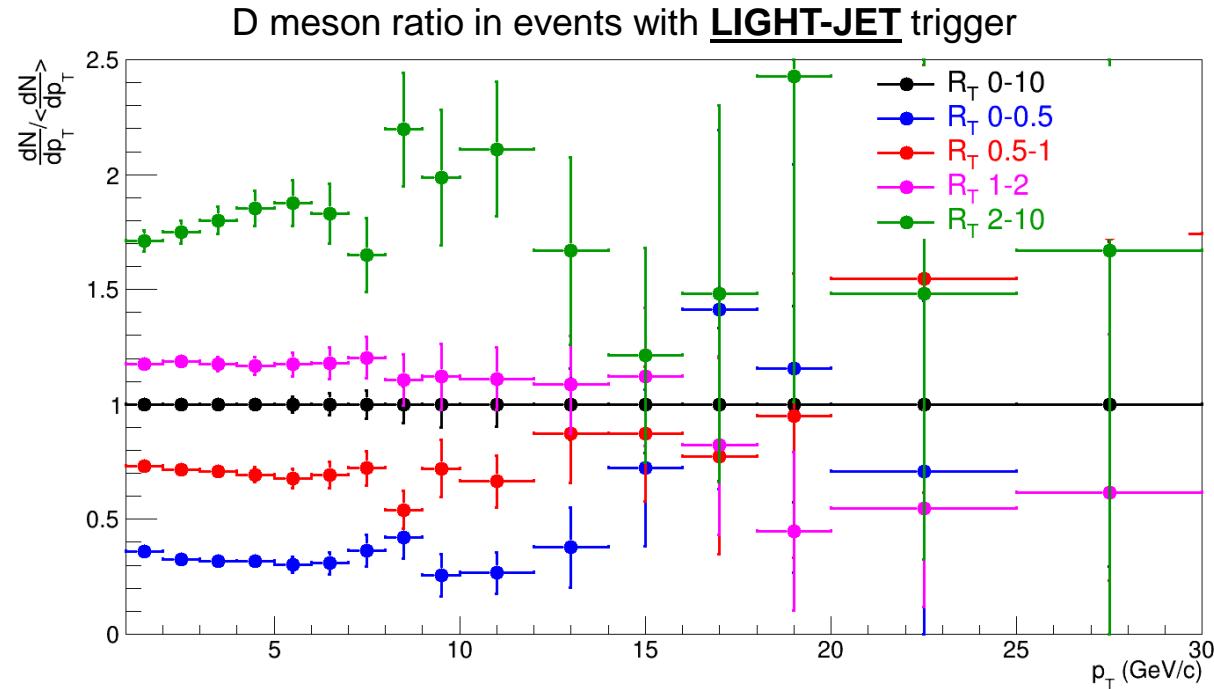
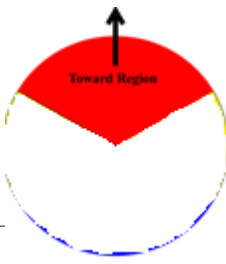


D meson ratio in events with hadron trigger

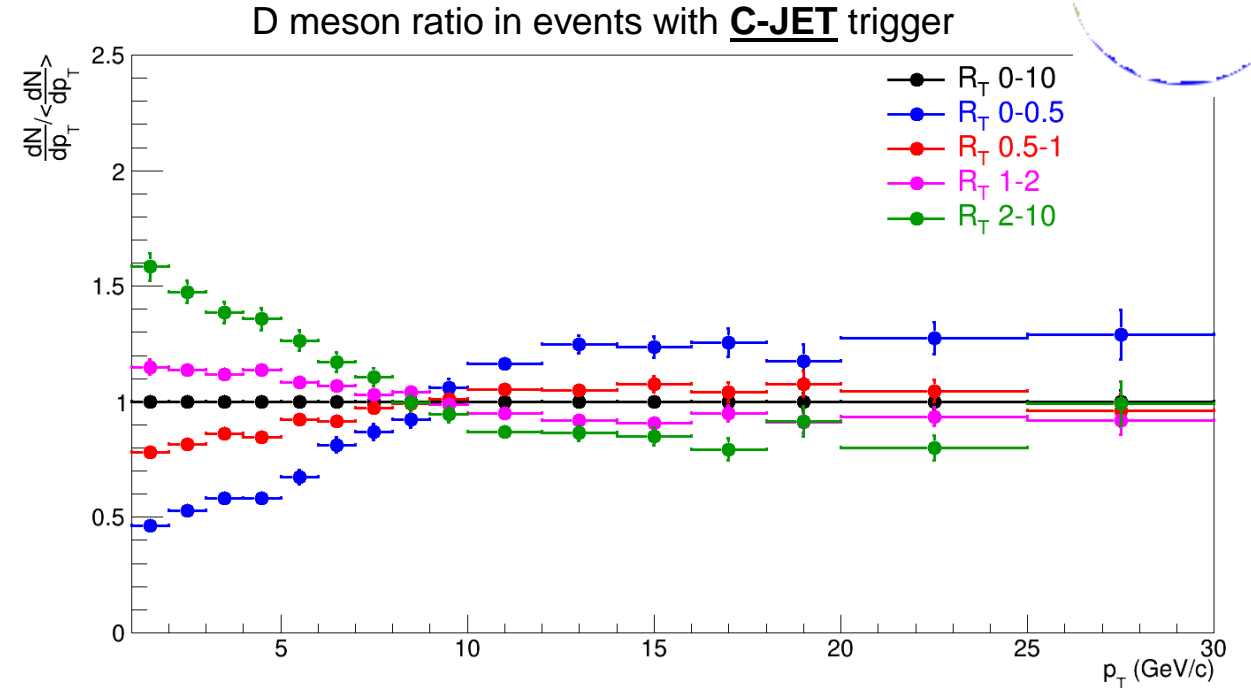


- Over $p_T \approx 7$ GeV/c D meson production is independent of the transverse activity.
→ Particles are produced mostly in the hard scattering.
- Between $p_T \approx 5$ and $p_T \approx 7$ GeV/c a “trigger turn-on” effect is observed.
- Below $p_T \approx 5$ GeV/c D meson production is heavily dependent on the R_T .
→ These particles come from the underlying event.

Production of D mesons in the Toward region, tagged jet trigger

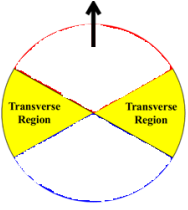


- D-meson production increases with higher R_T , trends are separated in the whole p_T range.
→ We find D mesons that mostly come from a process that is distinct from the leading jet production.

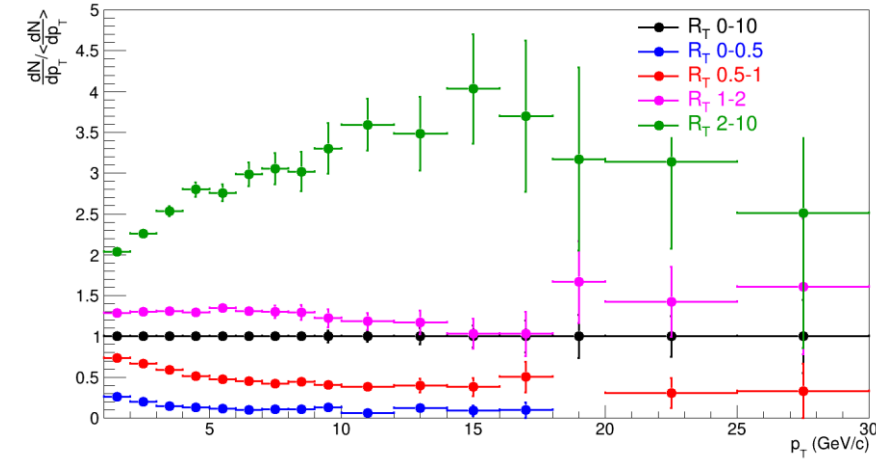


- Below the transition p_T , a similar behaviour to the hadron triggered events is observed.
- Above the transition p_T , D meson production shows a reversed dependence on R_T .
- Possible explanation is the autocorrelation from the wide-angle gluon-splitting process.

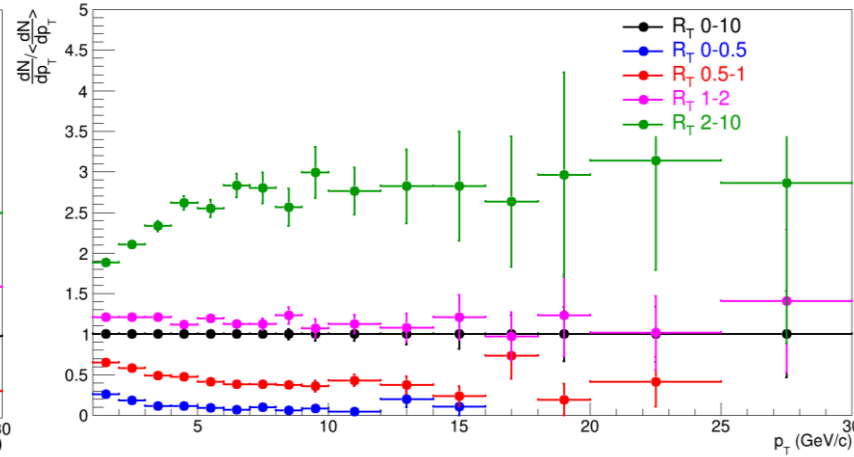
Production of D mesons in the Transverse region



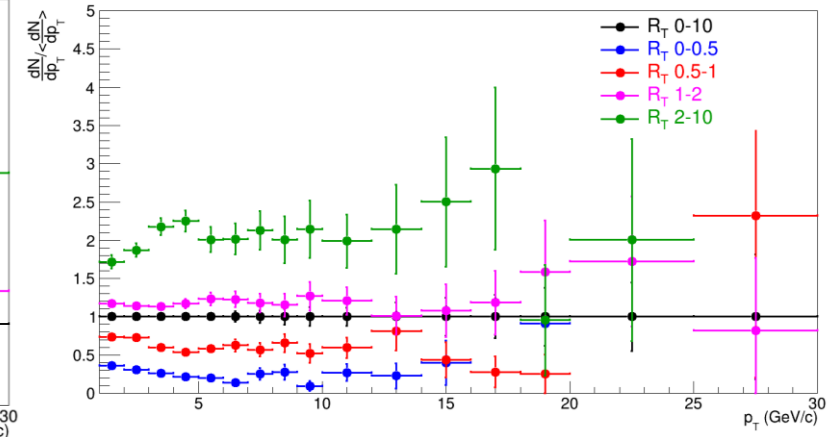
D meson ratio in events with **HADRON** trigger



D meson ratio in events with **LIGHT-JET** trigger

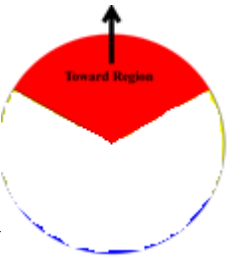


D meson ratio in events with **C-JET** trigger

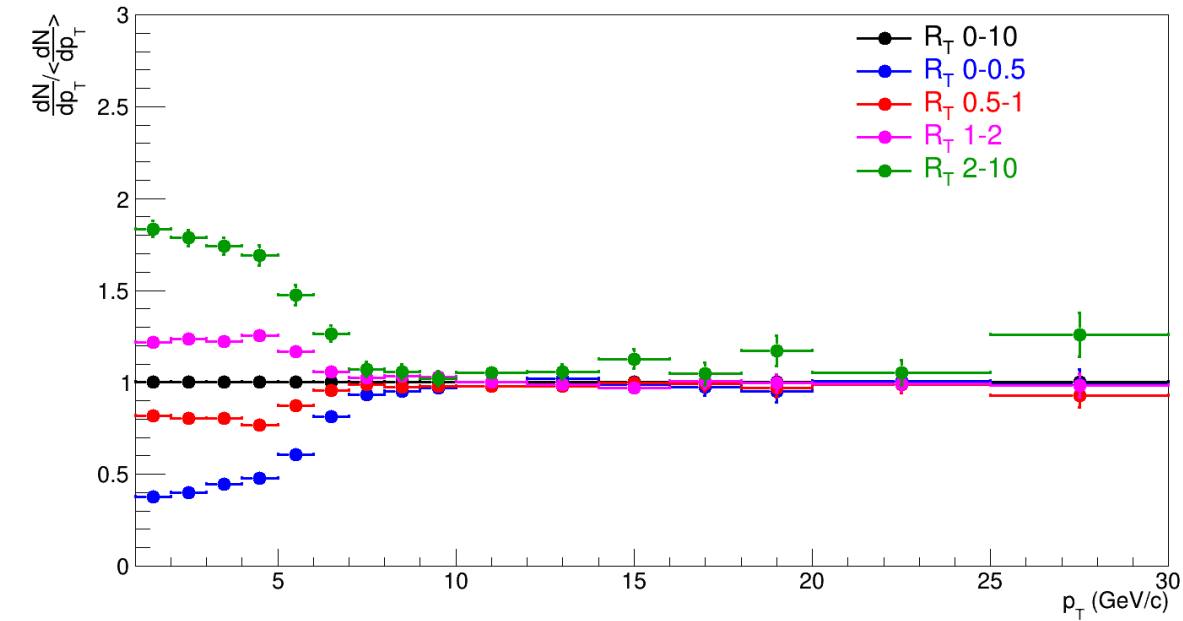


- D meson production increases with higher R_T , trends are separated in the whole p_T range.
→ Particles come from the underlying event.

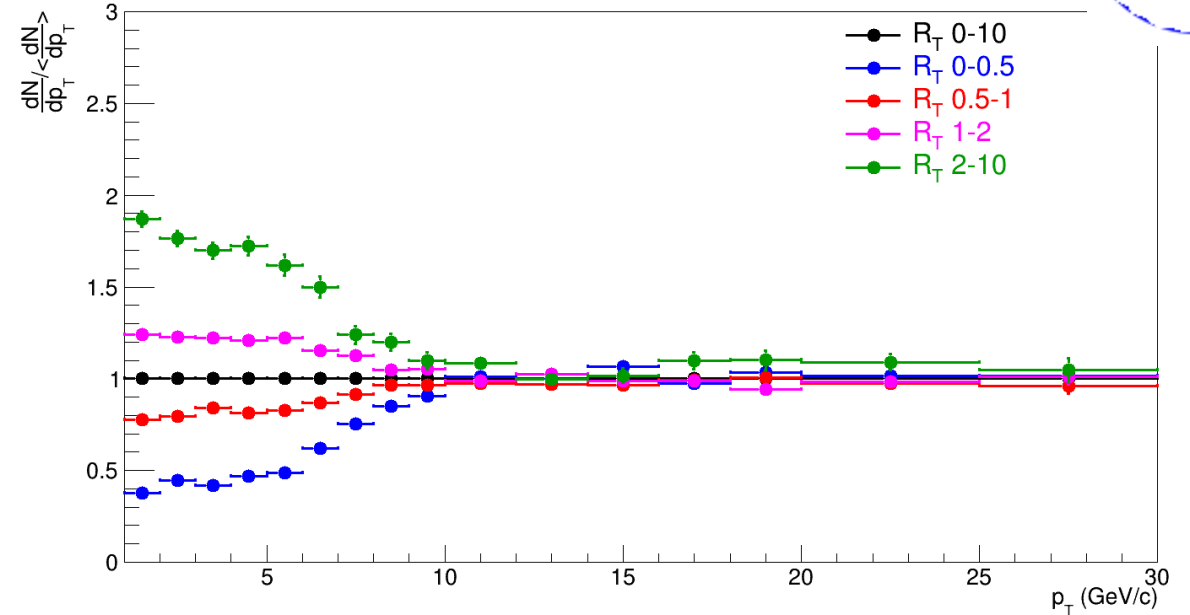
D mesons vs c quarks in the Toward region – hadron trigger



D meson ratio in events with HADRON trigger

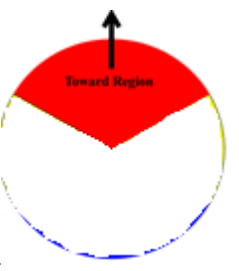


c quark ratio in events with HADRON trigger

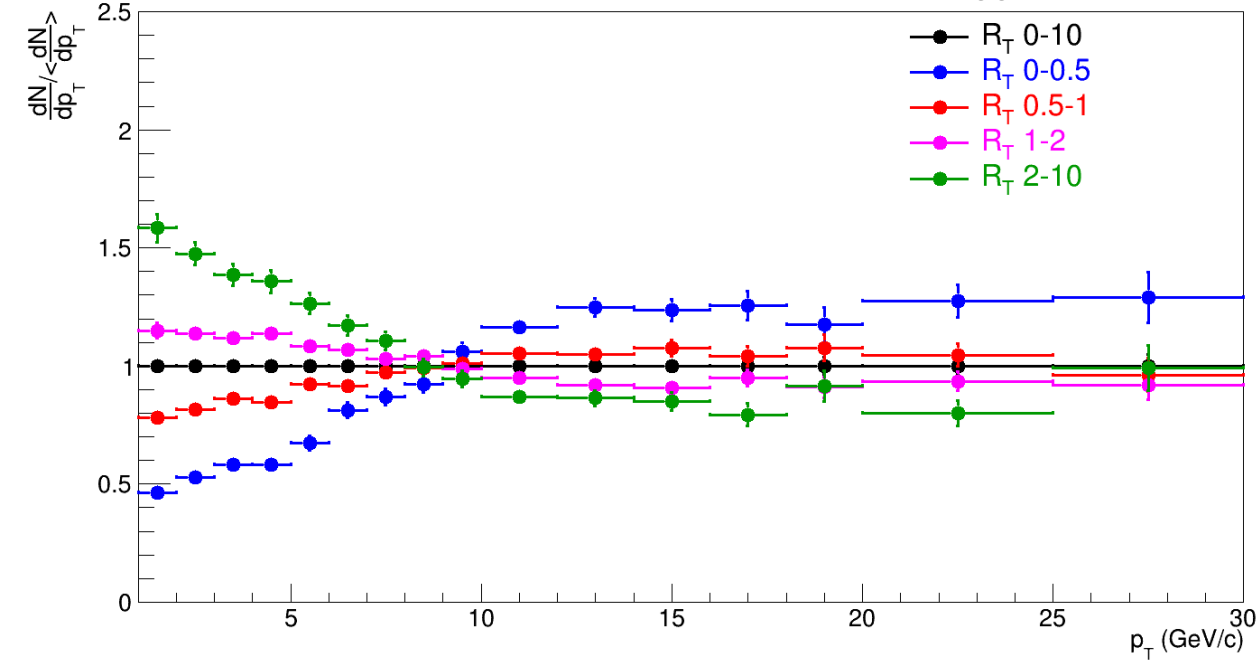


- The observed behaviour is similar for parton and hadron level charm.
- The transition p_T for c quarks is at higher p_T value.
 - This is due to the fragmentation function (momentum loss of charm during fragmentation).

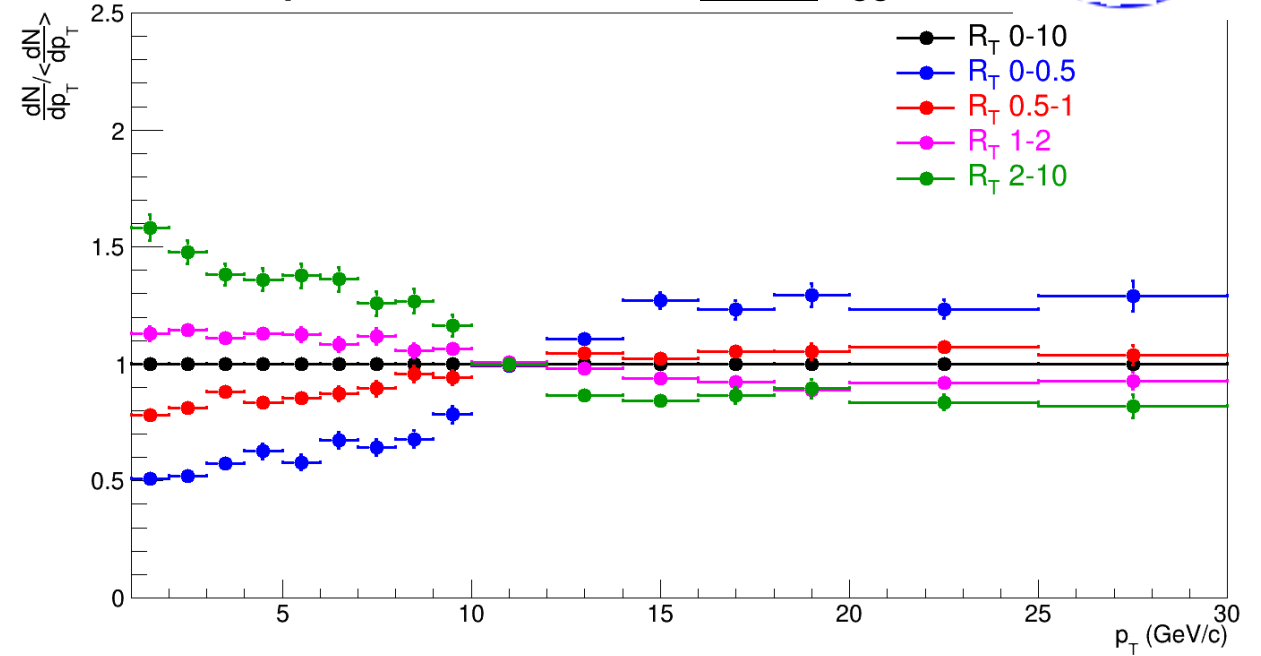
D mesons vs c quarks in the Toward region – c-jet trigger



D meson ratio in events with **C-JET** trigger

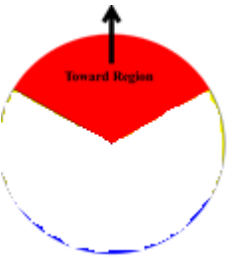


c quark ratio in events with **C-JET** trigger

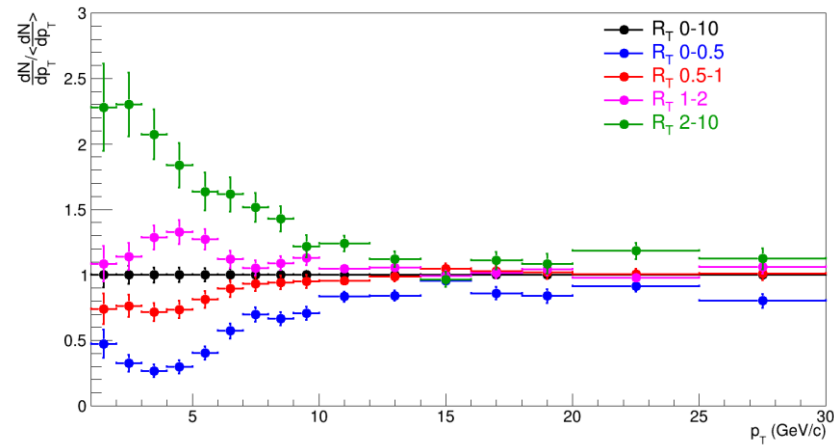


- The observed behaviour for this case is also similar for both particles.
- The transition p_T for c quarks is similarly at higher p_T value.

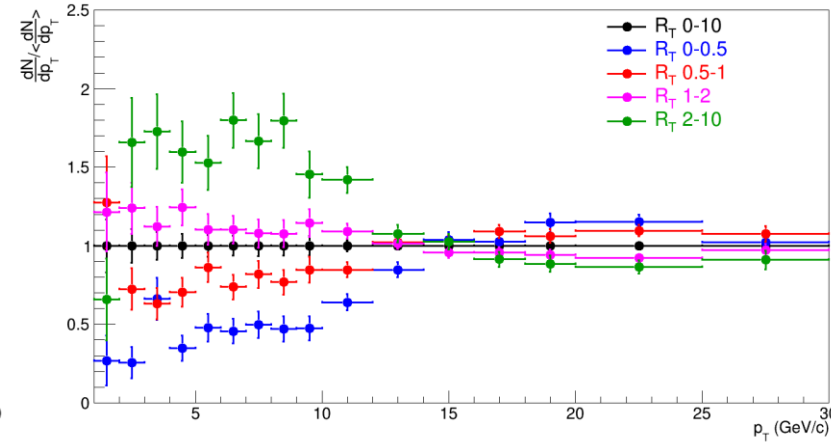
Production of B mesons in the Toward region



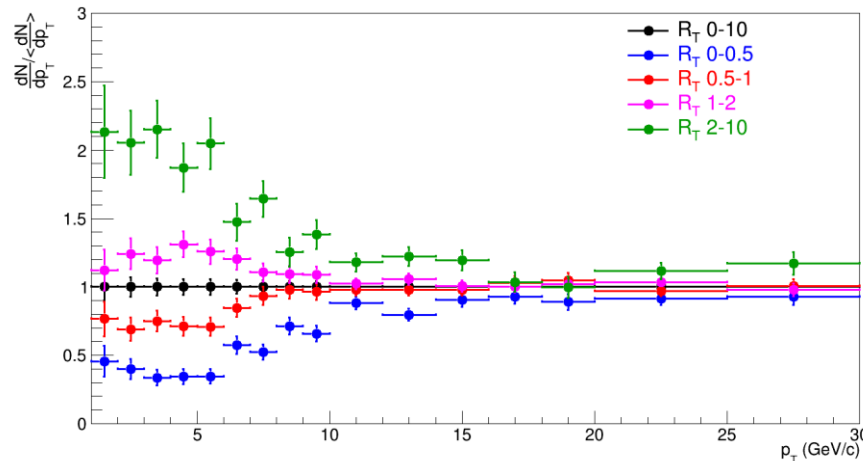
B meson ratio in events with **HADRON** trigger



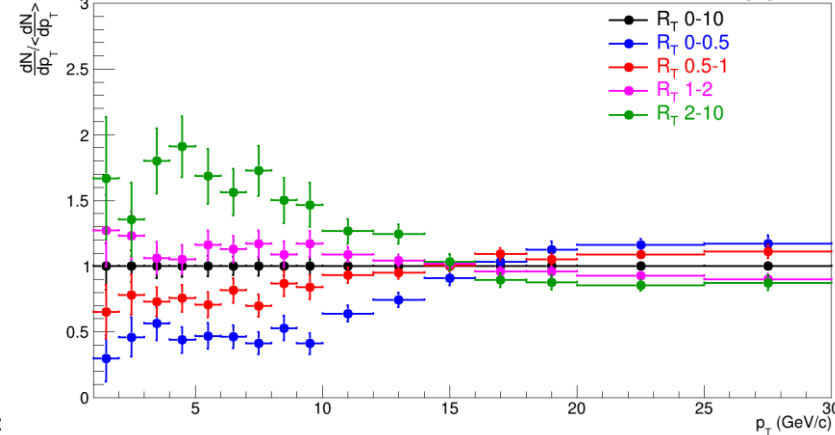
B meson ratio in events with **B-JET** trigger



b quarks ratio in events with **HADRON** trigger



b quarks ratio in events with **B-JET** trigger



- B mesons resemble similar behaviours to the D mesons. The transition p_T is observed at $p_T \approx 15$ GeV/c. The gluon-splitting effect is seen in events with b-jet trigger.

- No remarkable difference between parton and hadron level due to hard beauty fragmentation.

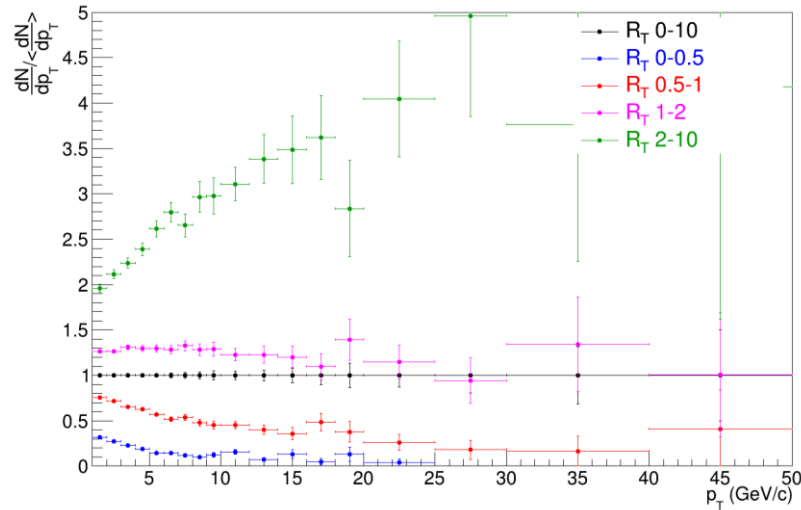
Summary

- Our studies serve as a basis for interpreting future measurements of R_T dependent heavy flavour production.
- Production of a **low momentum heavy flavour** is mostly determined by the **underlying event**.
- In the events with hadron triggers most of the **high-energy heavy flavour** is produced in the **initial hard scattering**.
- In the events triggered by **light-jets** production of heavy flavour depends heavily on the transverse activity. **Heavy flavour** in these events comes mostly from the **underlying event**.
- **Autocorrelation effects** are observed for D meson - c-jet trigger, and B meson - b-jet trigger pairs. Possible explanation is **gluon-splitting**.
- Difference in D meson and c quark spectrum is observed due to the **fragmentation effect**. Such behaviour is not observed for B mesons-b quarks because of larger masses.

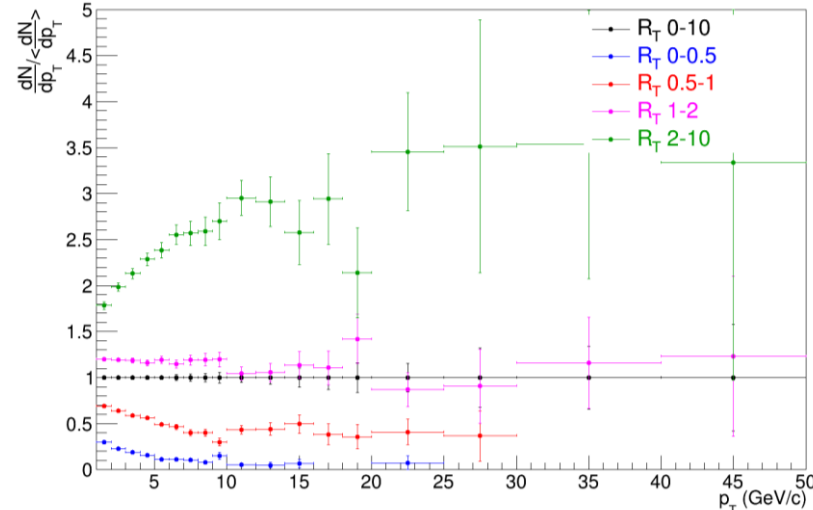
Thank you for attention!

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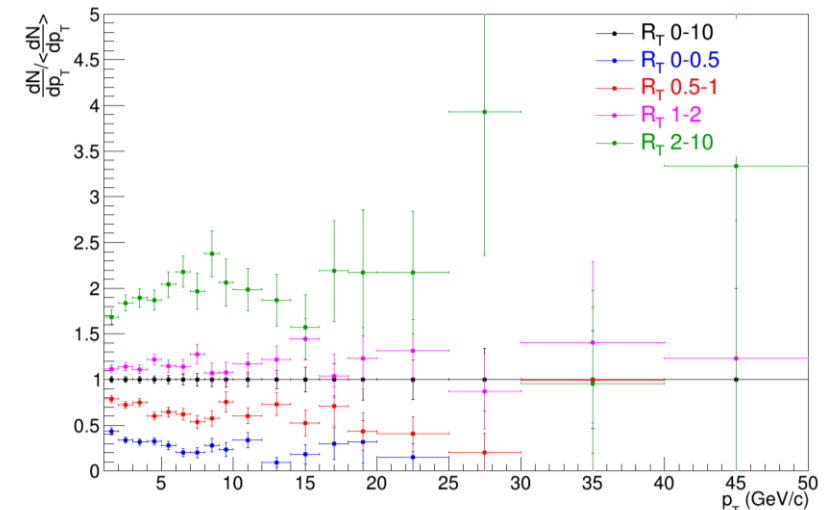
Production of c quarks in the Transverse region



c quark ratio in events with hadron trigger



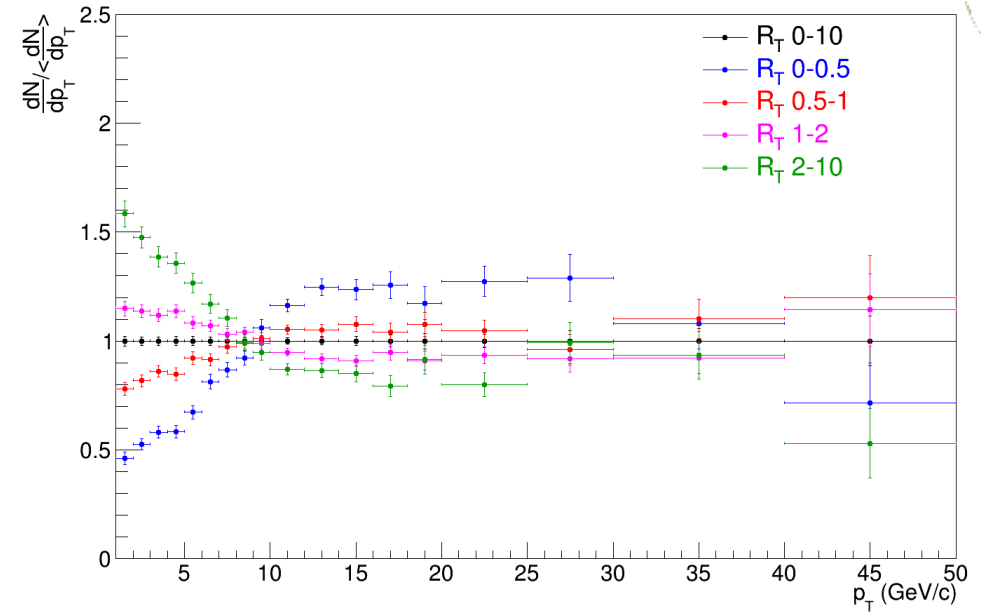
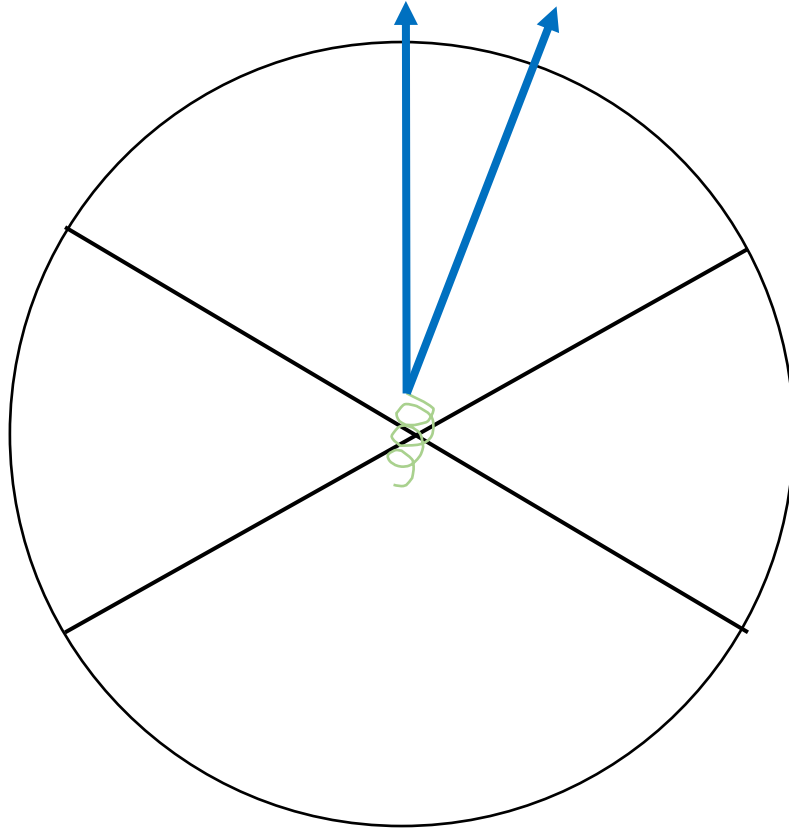
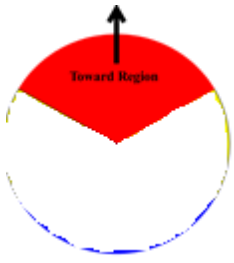
c quark ratio in events with light-jet trigger



c quark ratio in events with c-jet trigger

- In the Transverse region c quark production is independent of the hard scattering and is mainly influenced by the underlying event.

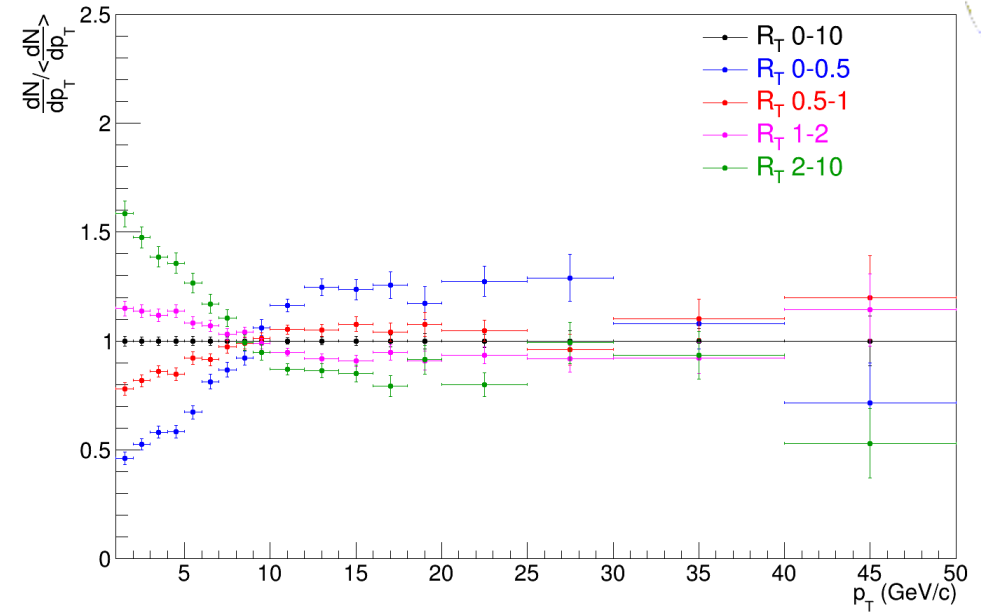
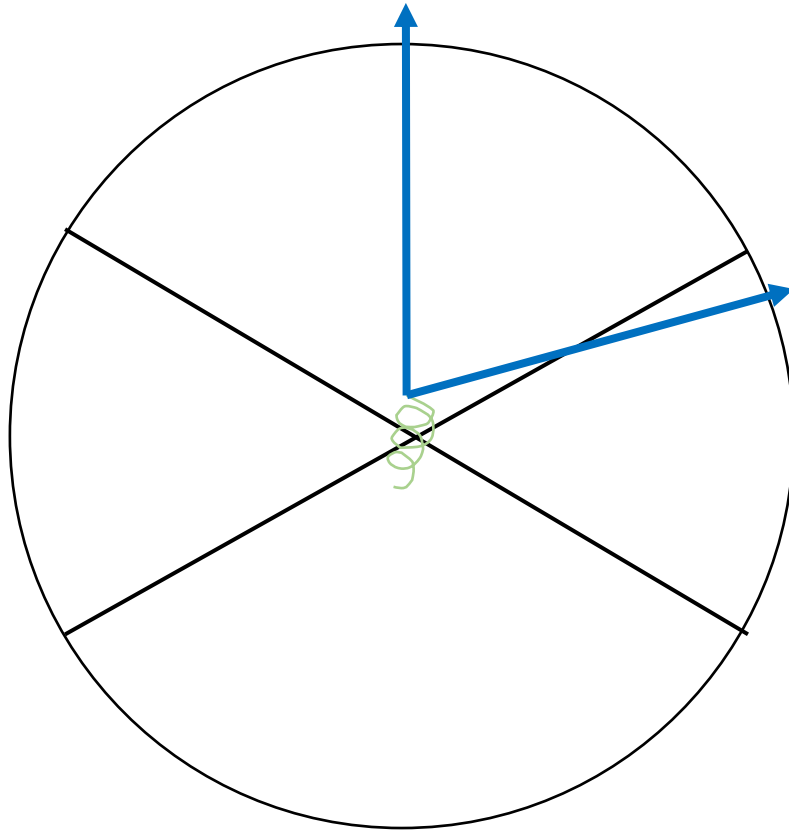
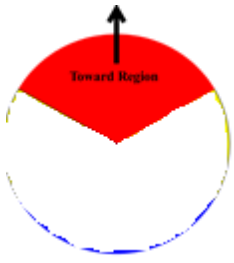
Production of D mesons in the Toward region, jet trigger



D meson ratio in events with c-jet trigger

- Below the transition, a similar behaviour to the hadron triggered events is observed.
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- Possible explanation is the autocorrelation from the wide-angle gluon-splitting process.

Production of D mesons in the Toward region, jet trigger



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