Heavy flavour jet production vs event activity in simulations

Szende Sándor

ELTE and Wigner FK

In collaboration with Róbert Vértesi

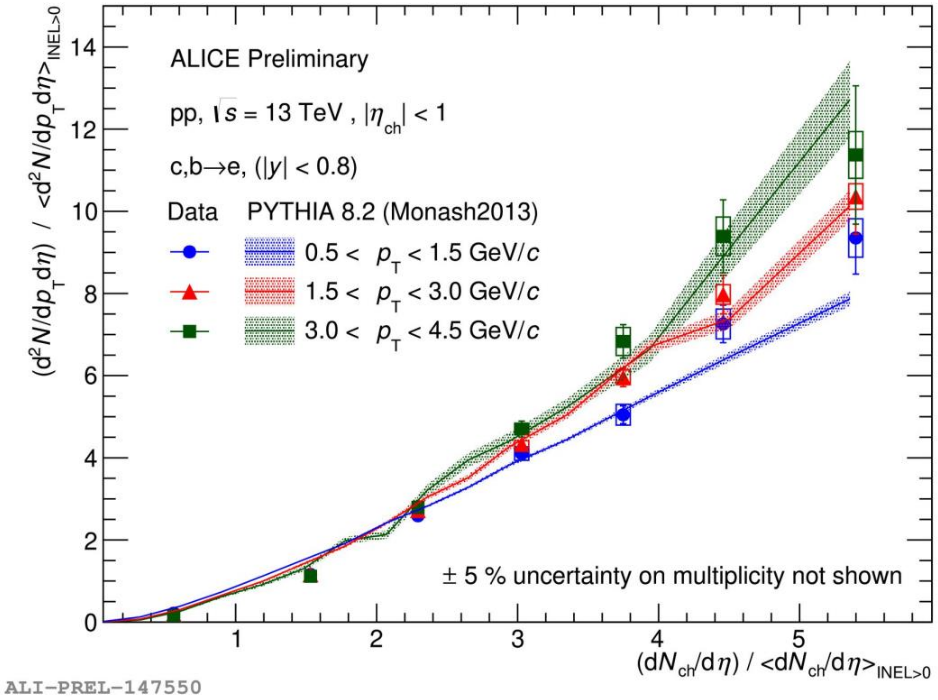
Motivation

Small systems with high-multiplicity (pp collisions)

- Collectivity of particles observed
- Likely caused by multiple-parton interactions (MPI)

Heavy quarks:

- Heavy quarks produced in initial hard processes
- Long lifetime: weak decays into heavy-flavour hadrons ($c\tau$ ~ 100-400 μm)
- Yield increases strongly with multiplicity: effect of MPI



Source: arXiv:2011.12686

We can study the relationship between the hard process and the underlying event in high-multiplicity pp collisions.

Definitions

Multi-Parton Interaction (MPI)

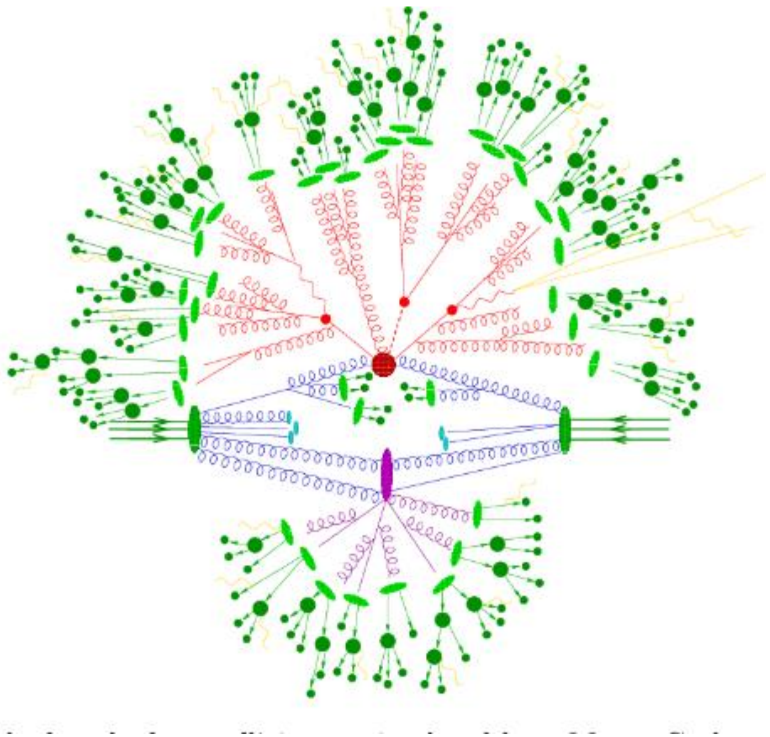
- Semi-soft QCD multi-step processes involving several partons
- Increasing with event activity

Leading process

- The parton scattering with the highest momentum exchange

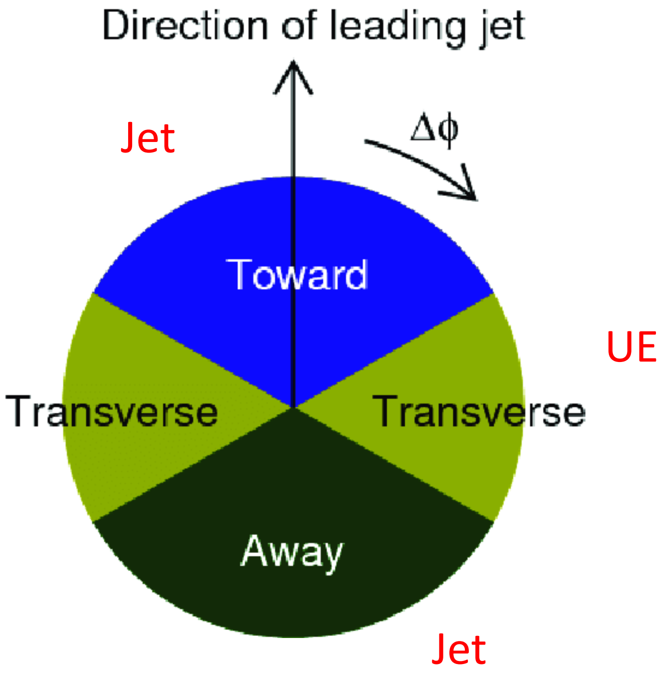
Underlying Event (UE)

- Everything else: secondary hard processes, beam remnants, soft particles from MPI
- Generally considered independent from leading process

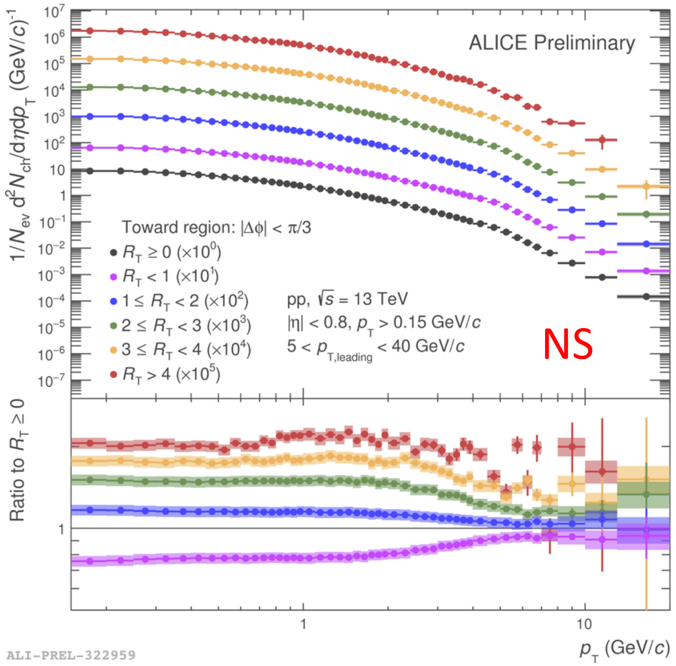


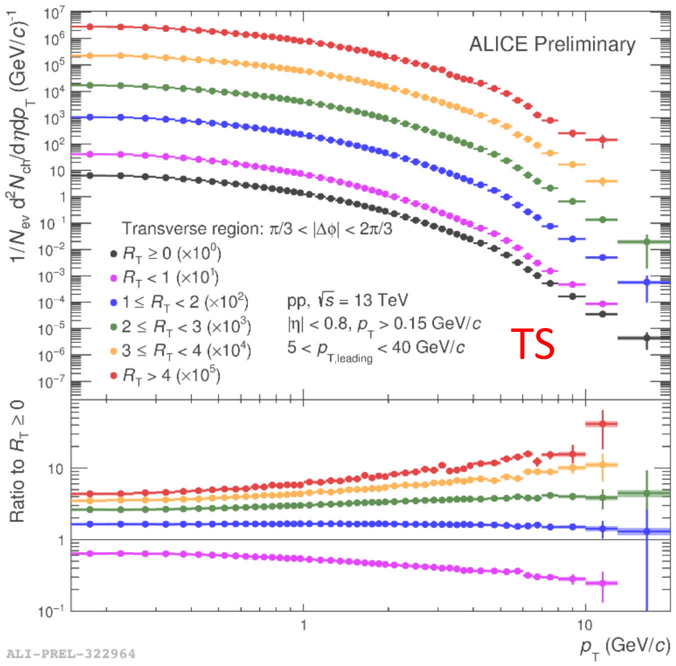
Is there connection between the leading process and the UE through MPI?

ALICE: yield of charged particles in pp collisions



Categorize the events by UE activity ~ MPI : $R_T = N_{trans} / \langle N_{trans} \rangle$



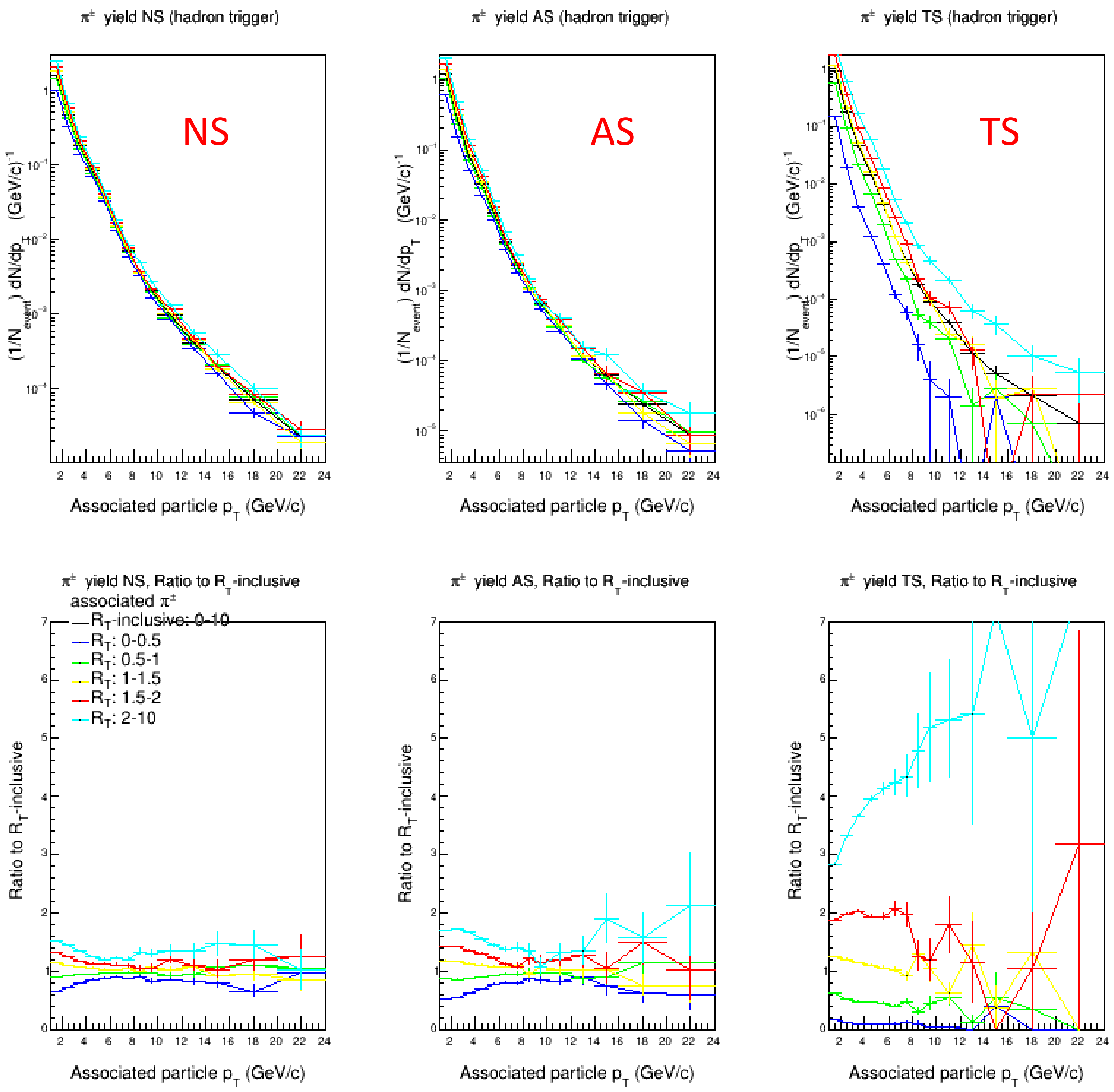


Source: arXiv:1910.04457

The yield of charged particles **depends a lot of multiplicity**: low p_T on Near Side (NS), high p_T on Transverse Side (TS).

The dependece of multiplicity in high p_T on NS shows the connection between the hard process and UE.

Yield of charged pions (hadron trigger)



Simulations settings:

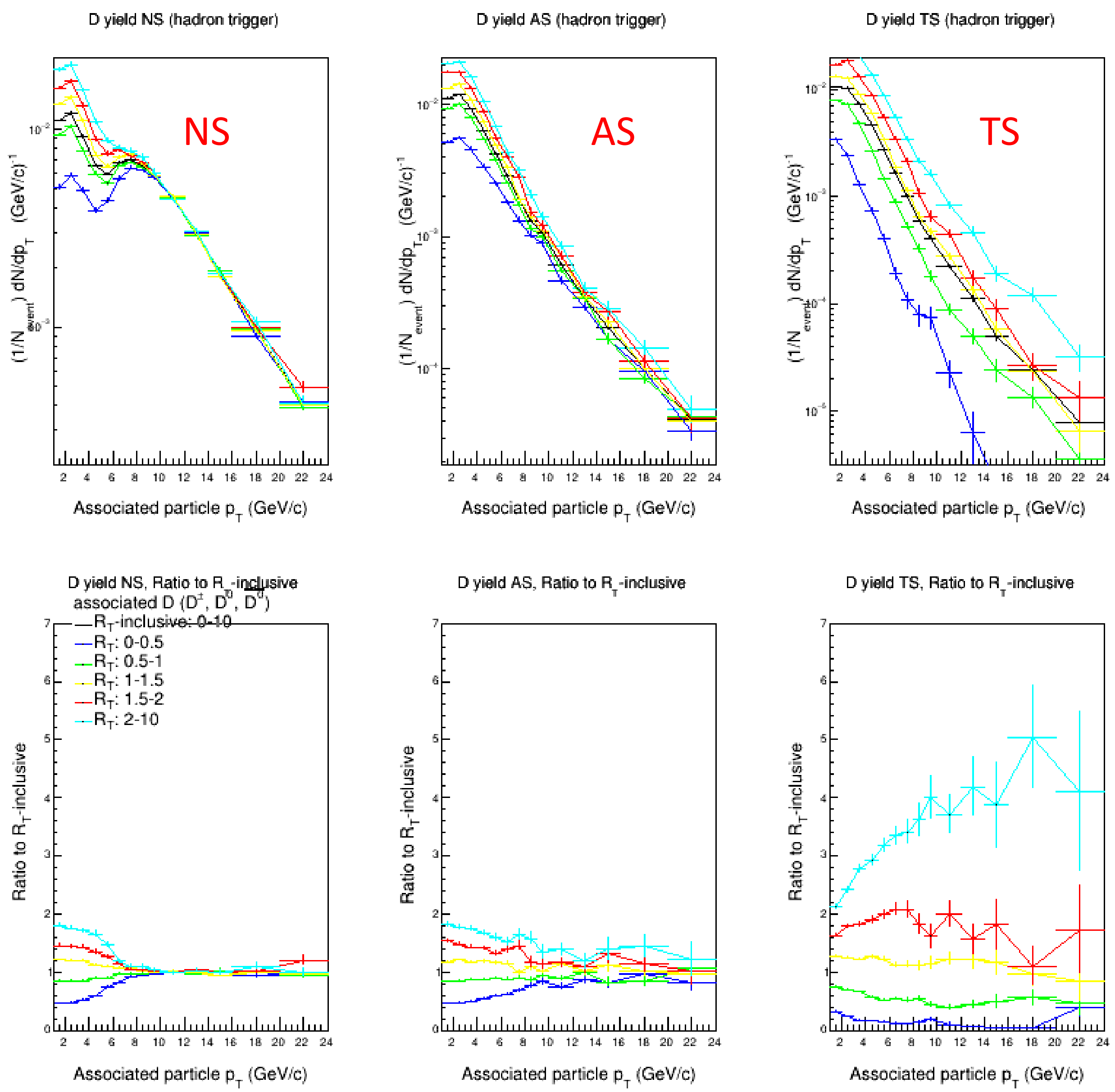
- Pythia 8 SoftQCD (MinBias)
- pp collisions at $\sqrt{s}$ =13 TeV,
- 100 million events
- Trigger particle: π^{+-},K^{+-},p/pbar,

$|\eta| < 0.5$, $p_{T,trigger} > 5$ GeV/c

- Associated particles: $|\eta| > 0.8$, $p_T > 0.5$ GeV/c

ALICE results qualitatively reproduced.

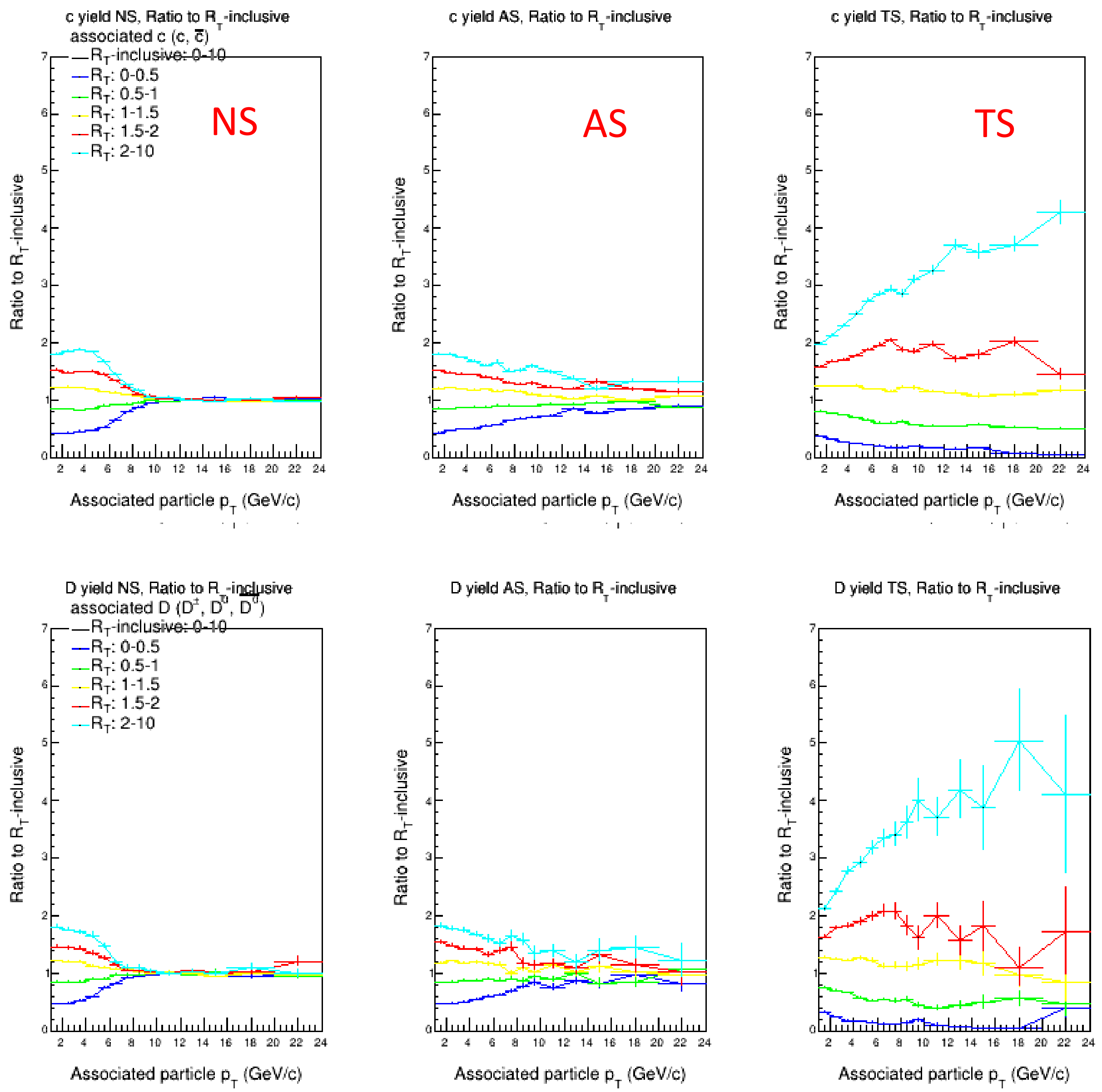
Yield of D-mesons (hadron trigger)



- The c quark decays to D^{+-},D^0,D^{0bar}
- The yield of D-mesons **independent of the activity** of UE at high p_T.
- D-mesons from low p_T came from UE, because the $p_{T,trigger}$ > 5 GeV/c

The production of D-mesons in leading processes are independent of UE at high pT.

Yield of heavy charm particles (hadron-trigger)

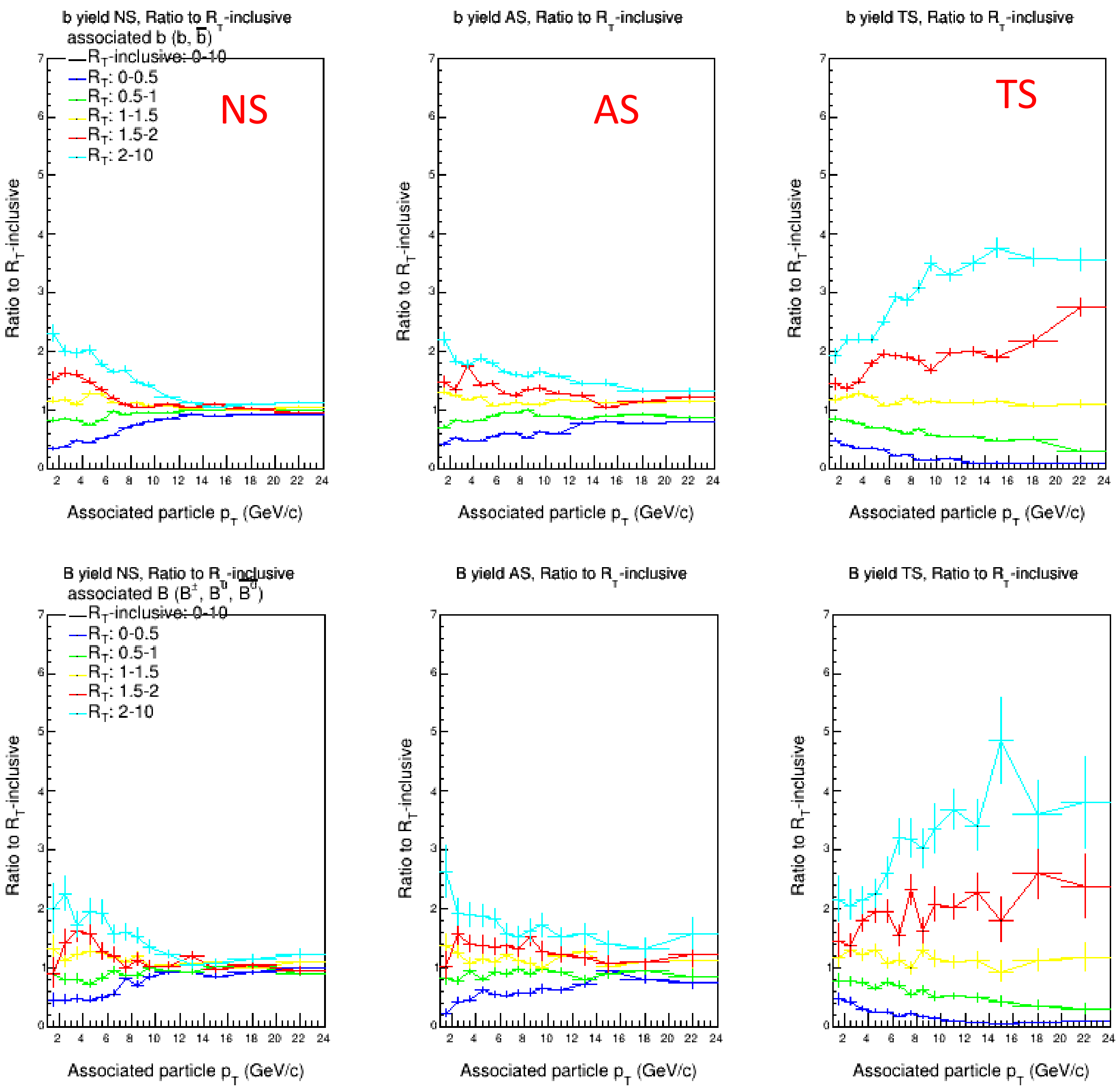


	Average (NS)	St Deviation (NS)
c-quark	9.086	5.94
D-meson	7.173	4.485

- The c quark hadronises mostly to D-mesons
- The differens between distribution of c quark and D-meson is 20-25%

The difference between charm particles is not negligible based on my simulations.

Yield of heavy beauty particles (hadron-trigger)

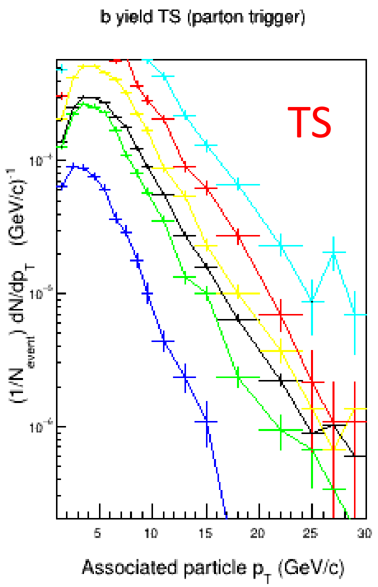


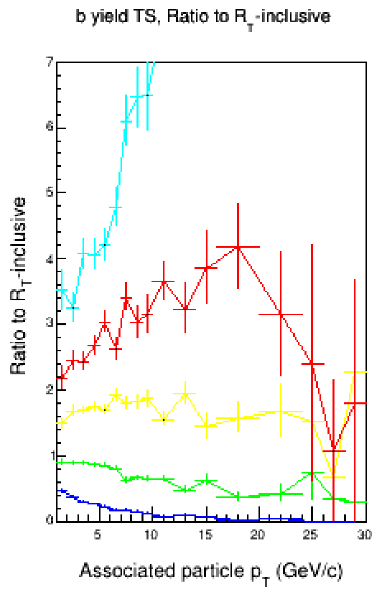
	Average (NS)	St Deviation (NS)
b-quark	13.00	5.457
B-meson	12.55	5.318

- The b quark hadronises mostly to B-mesons
- The differens between distribution of b quark and B-meson is 2-4%

The difference between beauty particles is negligible, so we can focus on B-mesons.

Yield of beauty quarks (inclusive trigger)

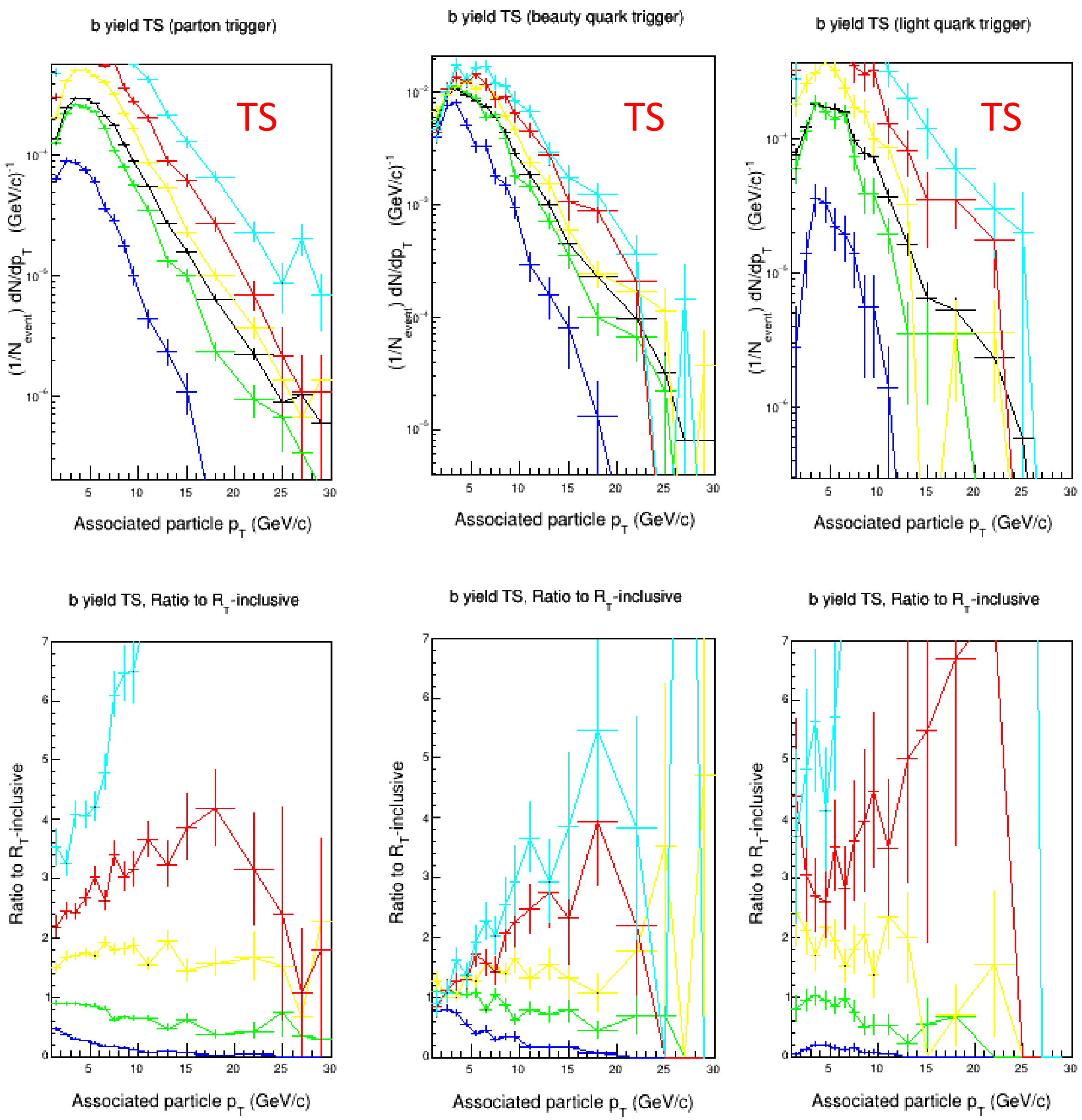




- Using **parton trigger**: represents the momentum and angle of the jets more precisely than leading hadrons
- Identifying **jet types** can select particular hard processes
- On TS the formation of heavy-flavour shows the connection between the hard processes

The jet-trigger method is suitable for studying the secondary processes, like gluon-splitting.

Yield of beauty quarks (p,q trigger vs b trigger vs u,d,s trigger)



Beauty jet-triggers ensure that b in the TS is from secondary processes:

- It is either an independent, softer b-bbar pair
- Or part of leading b-bbar process in a higher-order 3-jet event

Light jet isolates higher-order b-bbar production from eg gluon-splitting (statistics is a problem here though)

Identified full-jet triggers can isolate soft b-bbar (eg. Gluon-splitting) contribution.

Summary and outlook

- The yield of heavy quarks is independent of UE at high p_T
- The yield of reconstructed B-mesons are a good proxy for b-quarks
- Identified quark-jet triggers reveals the dependence of higher-order heavy-flavor production (eg. gluon splitting) on MPI.

Future:

- Looking forward to ALICE Run-3, where statistics will allow for the detailed study of b-production w.r.t UE

Thank you for your attention!

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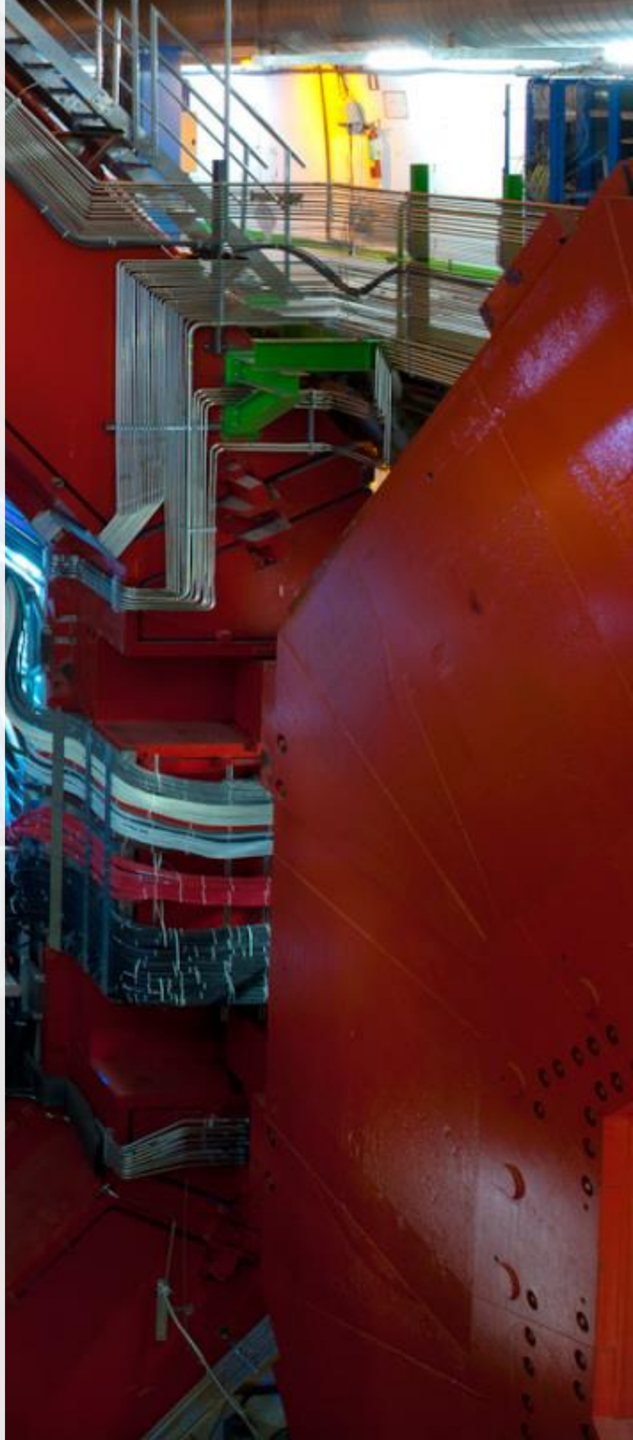
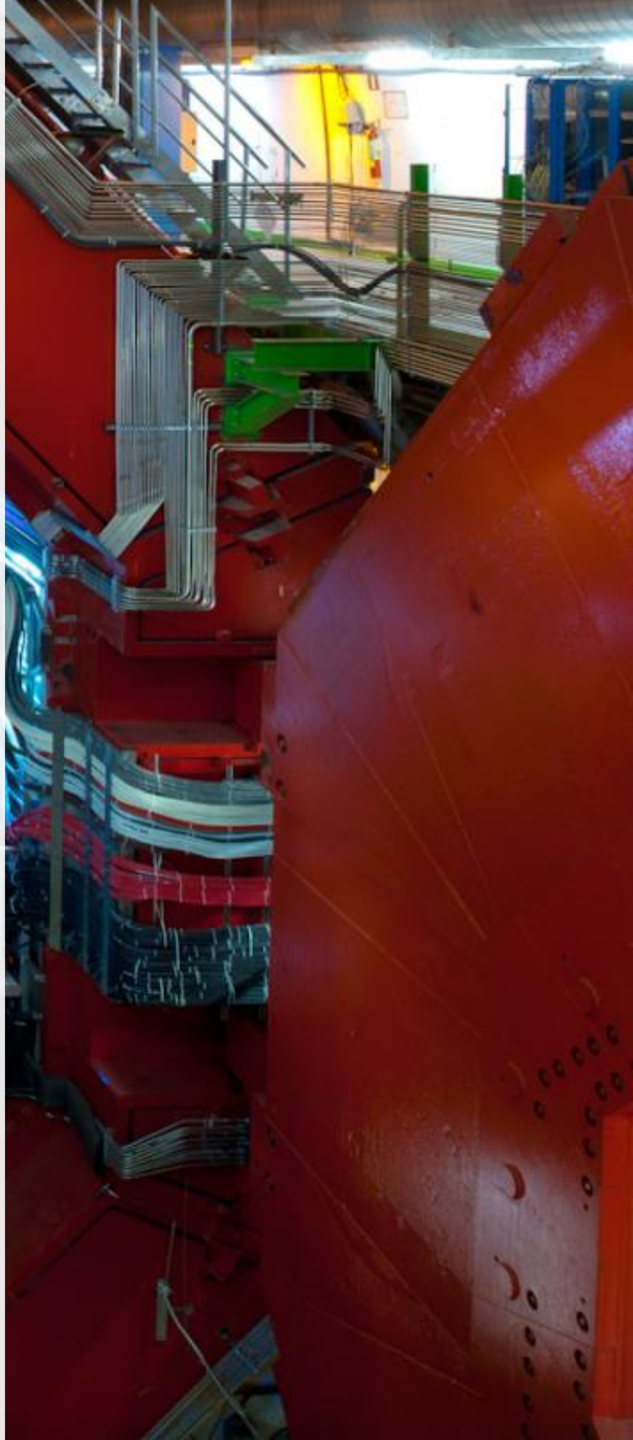
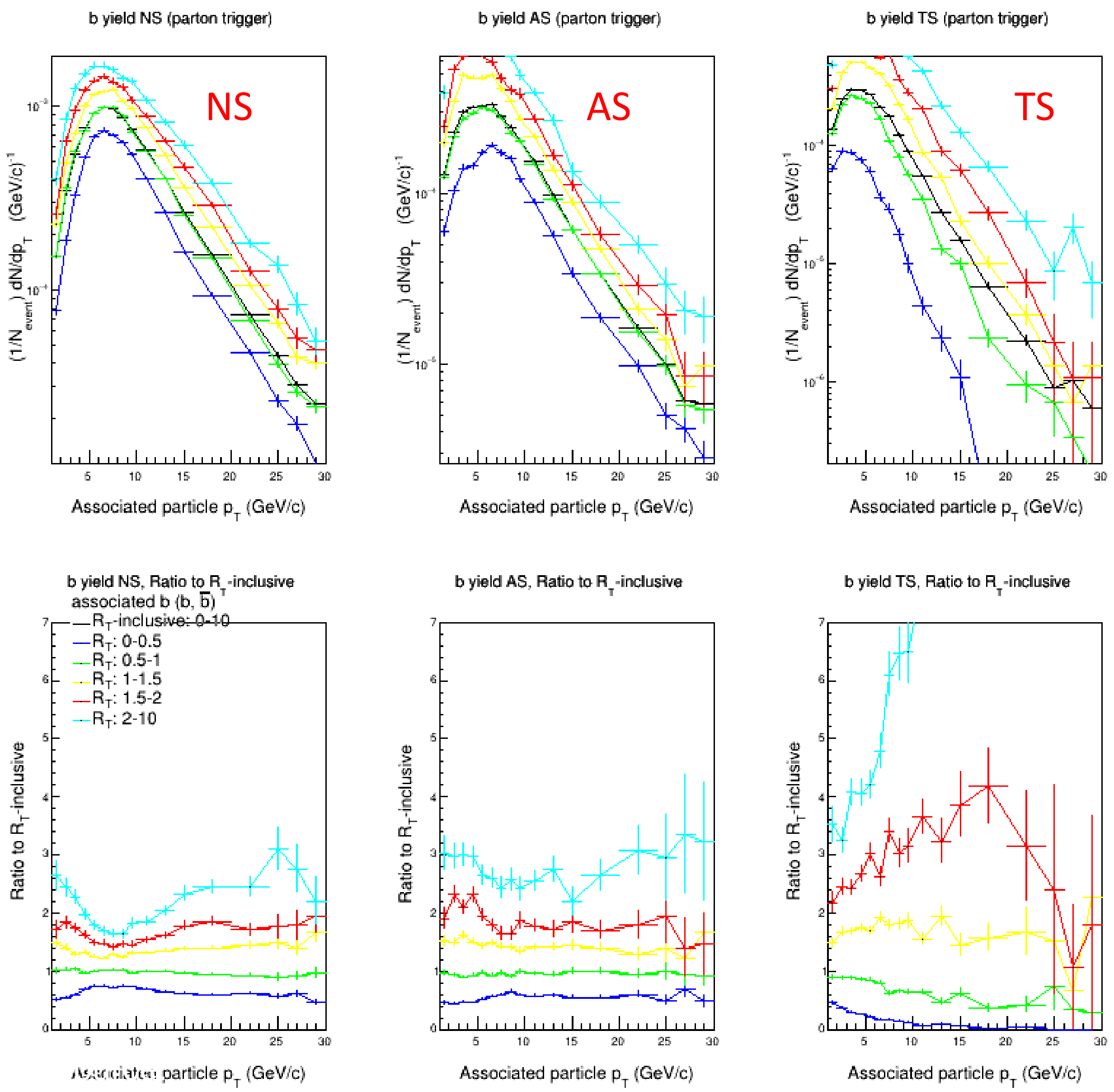


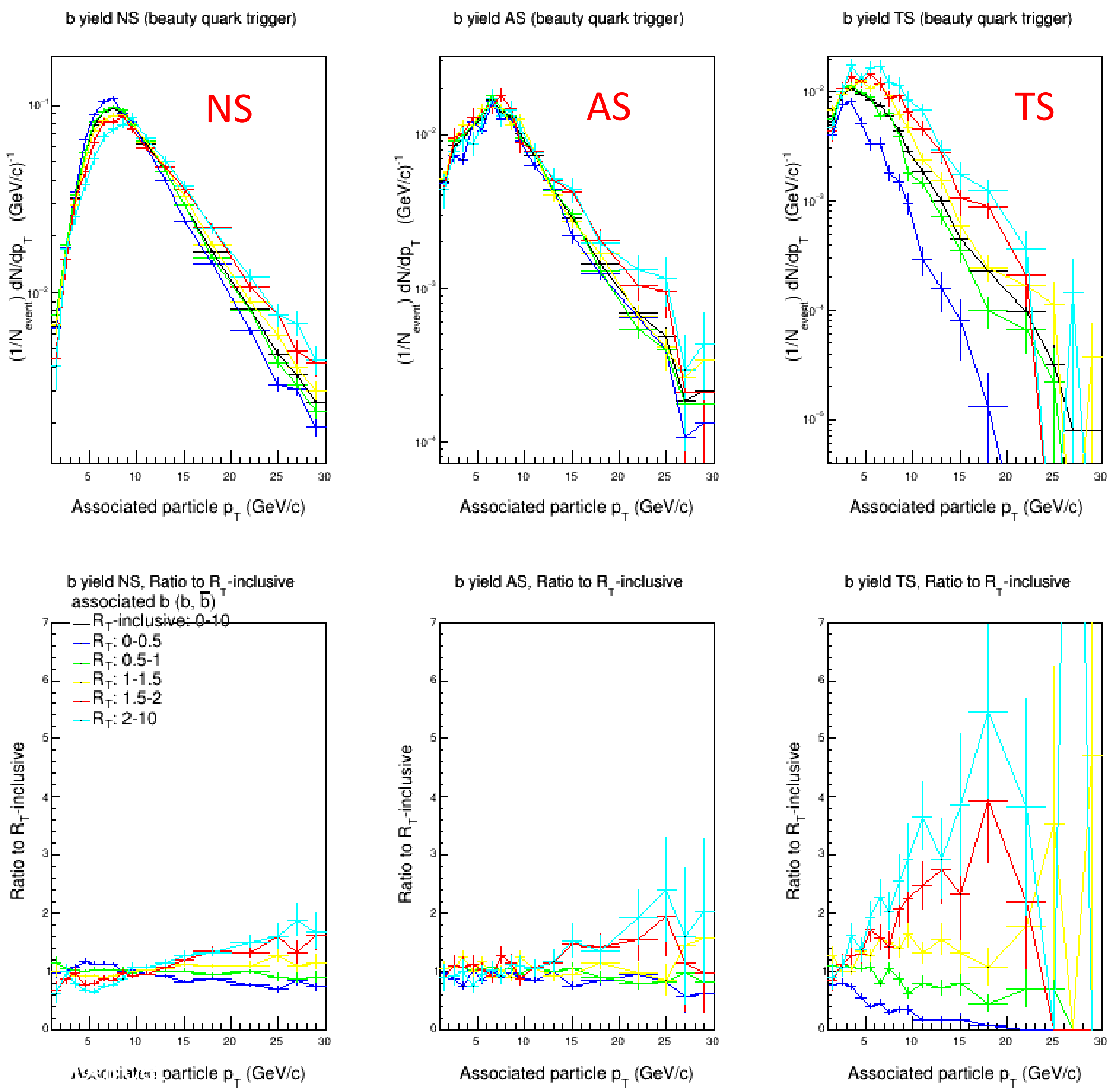
Backup



Inclusive trigger



Beauty-quark trigger



Lightquark trigger