

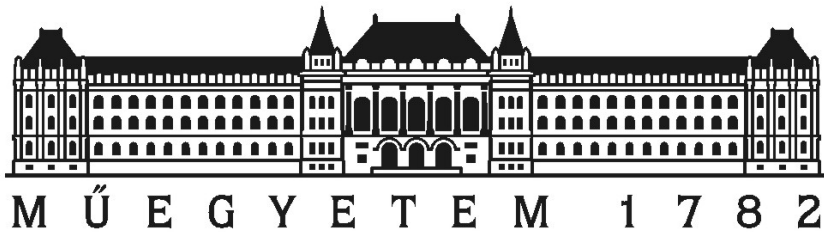
ISMD2022

The role of the underlying event in the charm-baryon enhancement observed in pp collisions at LHC energies

Zoltán Varga^{1,2}, Róbert Vértesi¹

1. Wigner Research Centre for Physics

2. Budapest University of Technology and Economics

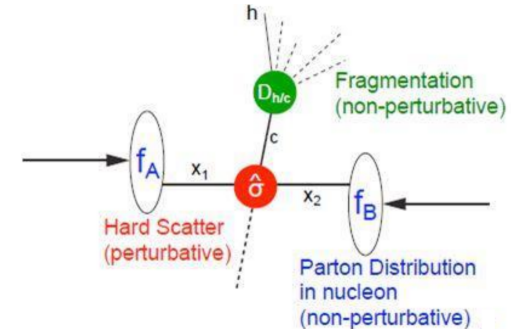


Production of heavy-flavor baryons

- Heavy-flavor production is usually described with the factorization approach: incoming hadron PDFs, hard parton-parton scattering and fragmentation are independent:

$$d\sigma_{AB \rightarrow C}^{\text{hard}} = \sum_{a,b} f_{a/A}(x_a, Q^2) \otimes f_{b/B}(x_b, Q^2) \otimes d\sigma_{ab \rightarrow c}^{\text{hard}}(x_a, x_b, Q^2) \otimes D_{c \rightarrow C}(z, Q^2)$$

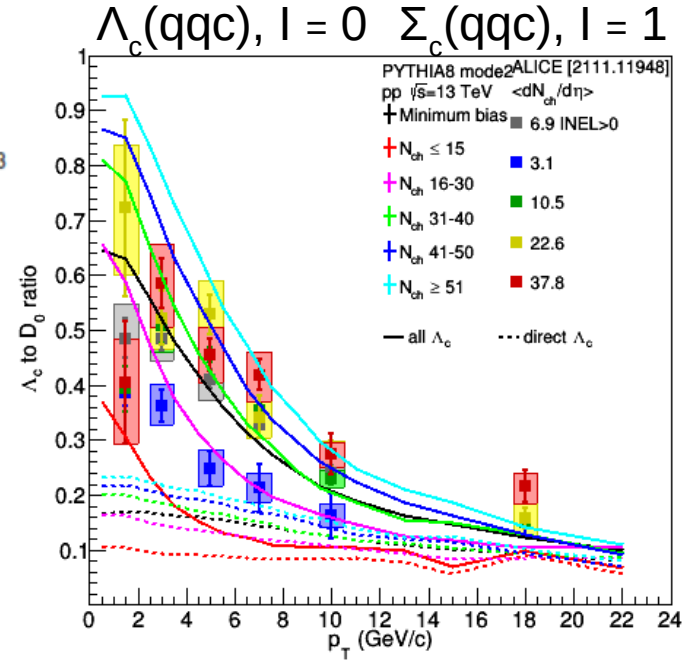
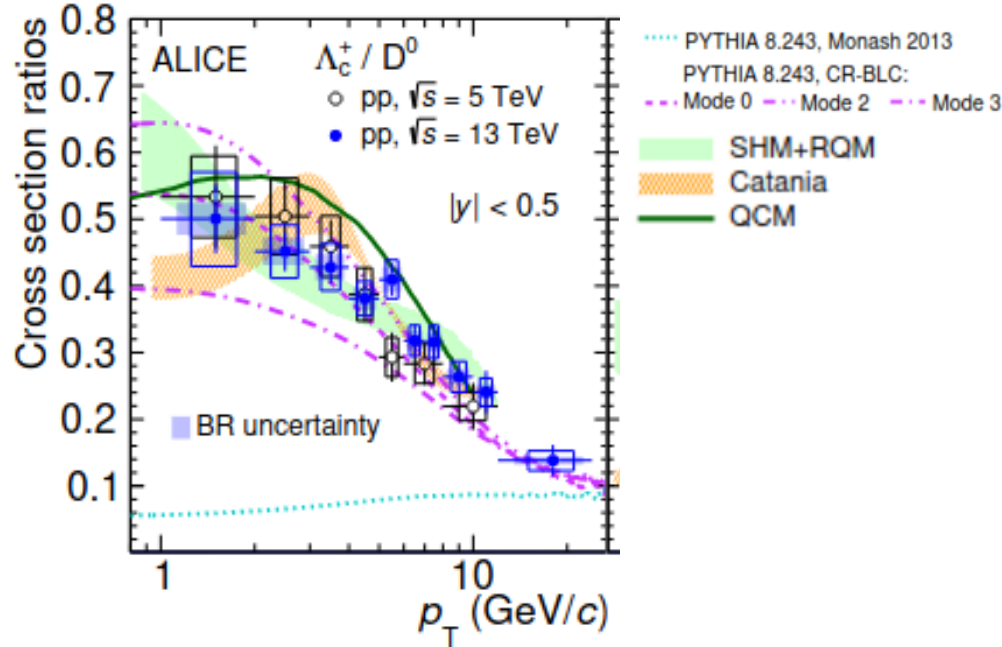
Parton Distribution Function (PDF)
Partonic hard scattering cross-section
Fragmentation Function (FF)



- Traditional assumption: fragmentation functions are **universal** for different collision systems
 - **FF** often determined from e-e⁺ (or e-p) collisions, where **PDF** plays no (or less important) role
- Recent experimental results (ALICE, CMS, LHCb) on charmed baryon production **do not support** this assumption!

Event activity dependence of Λ_c/D^0 enhancement

ALICE Coll., "Measurement of prompt D^0 , Λ_c , and Σ_c production in pp collisions at $\sqrt{s} = 13$ TeV" (arXiv:2106.08278)



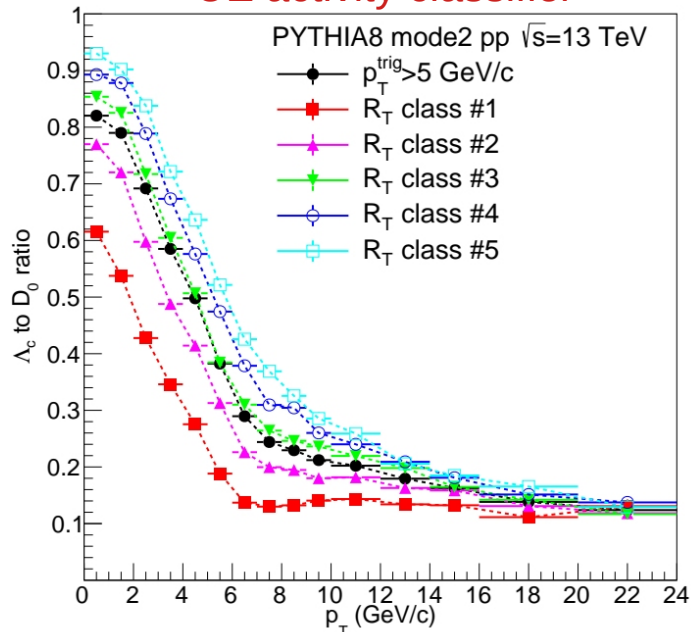
- Significant enhancement in the Λ_c/D^0 ratio in the low p_T (2-8 GeV/c) range compared to predictions from e^+e^- : **no universality!**
- **Color-reconnection beyond leading color (CR-BLC)**: describes the multiplicity dependence.
- **Multiplicity dependence**: connected to the event activity. Needs to be better understood!
- p_T dependence may be sensitive to baryon type: the trend differs for Σ_c although only **differs** from Λ_c in isospin.

Christiansen, J.R., Skands, P.Z. String formation beyond leading colour. J. High Energy. Phys. 2015, 3 (2015)

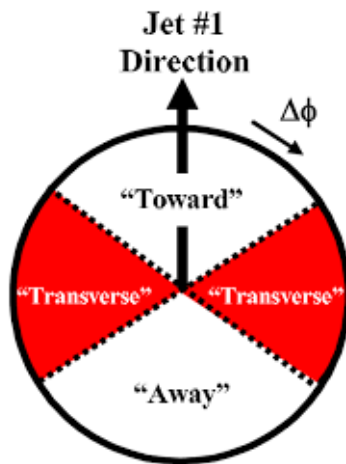
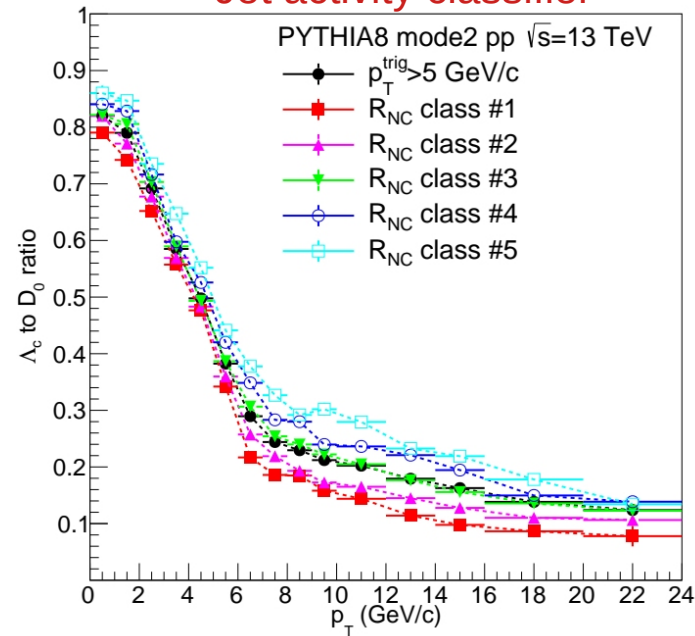
Λ_c/D^0 enhancement in events classified by jet and UE activity

Z.V., R.V., J. Phys. G: Nucl. Part. Phys. 49 (2022) 075005
(arXiv:2111.00060)

UE activity classifier



Jet activity classifier



$$R_T = N_{\text{CH}}^{\text{transverse}} / \langle N_{\text{CH}}^{\text{transverse}} \rangle$$

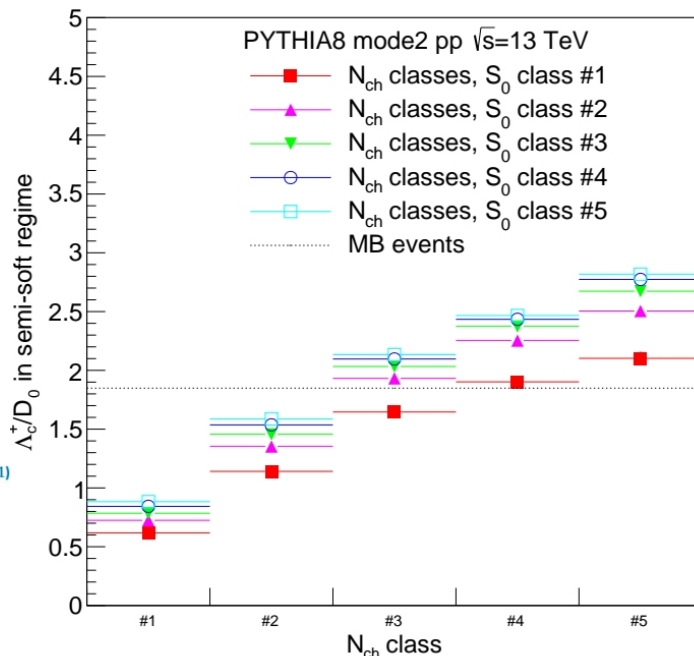
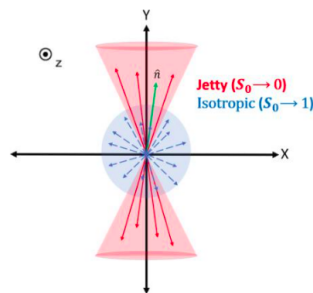
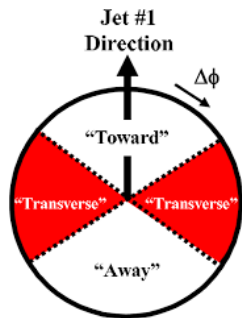
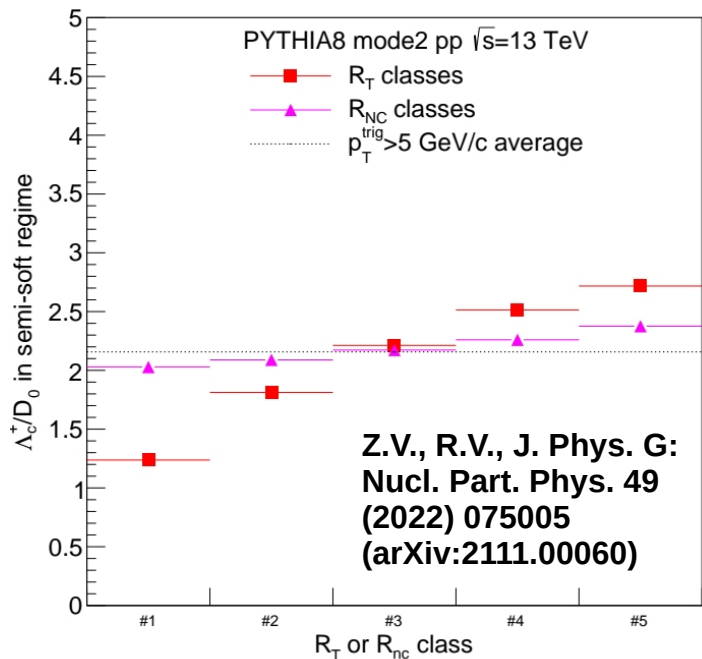
underlying event (UE) activity
 $\pi/3 < |\Delta\phi| < 2\pi/3$

$$R_{\text{NC}} = N_{\text{CH}}^{\text{near-side cone}} / \langle N_{\text{CH}}^{\text{near-side cone}} \rangle$$

jet region activity
 $\sqrt{(\Delta\phi^2 + \Delta\eta^2)} < 0.5$

- Events require $p_T > 5$ GeV/c hadron trigger.
- **Significant difference** is observable **in case of R_T** (UE classification).
- **No significant difference** when classified **by R_{NC}** classes (jet activity).

Λ_C/D^0 enhancement in jetty and isotropic events



- R_T vs. R_{NC} in **hadron triggered events** (hadron with $p_T > 5$ GeV/c):
 - Λ_C/D^0 enhancement depends on UE activity, almost independent on activity within jet

- Sphericity S_0 in **minimum-bias events**:
 - Λ_C/D^0 enhancement is more prominent in spherical (UE-dominated) than jetty events

$$S_0 = \frac{\pi^2}{4} \times \min_{\hat{n} = (n_x, n_y, 0)} \left(\frac{\sum_i |\vec{p}_{T_i} \times \hat{n}|}{\sum_i \vec{p}_{T_i}} \right)^2$$

- **CR-BLC model links the enhancement to the UE**:
 - discrimination power in data from the upcoming LHC Run3.

Summary

- Λ_c/D^0 ratios: universality of **fragmentation** functions is **broken**.
Does the factorization approach work?
- **Discrimination power** of differential measurements that focus on event activity in the jet and/or the underlying event region.
- Measurements with different heavy-flavor baryons: more **constraints on models**. Explore the **connection to strange-baryon enhancement**.

Thank you for your attention!

Backup

Binning used for the event classifiers:

class	#1	#2	#3	#4	#5
N_{ch}	≤ 15	16–30	31–40	41–50	≥ 51
N_{fw}	≤ 45	46–90	91–120	121–150	≥ 151
R_{T}	< 0.5	0.5–1	1–1.5	1.5–2	> 2
R_{NC}	< 0.5	0.5–1	1–1.5	1.5–2	> 2
S_0	0–0.25	0.25–0.45	0.45–0.55	0.55–0.75	0.75–1