Open heavy flavour: experiment

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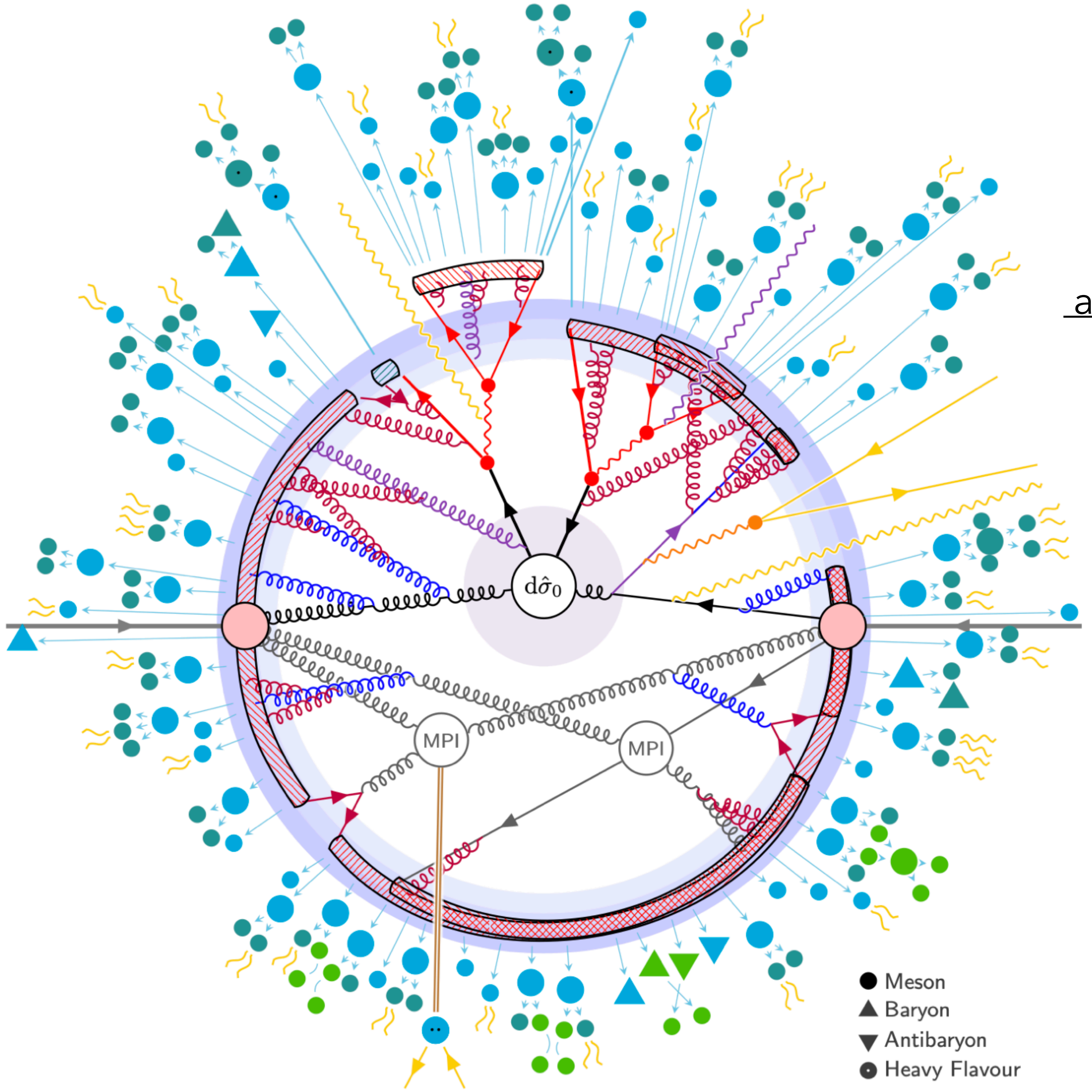
Disclaimer: only a selection of the results could be shown (time limit)

Hard Probes 2023, 27 March 2023, Aschaffenburg (Germany)

Why heavy flavours?



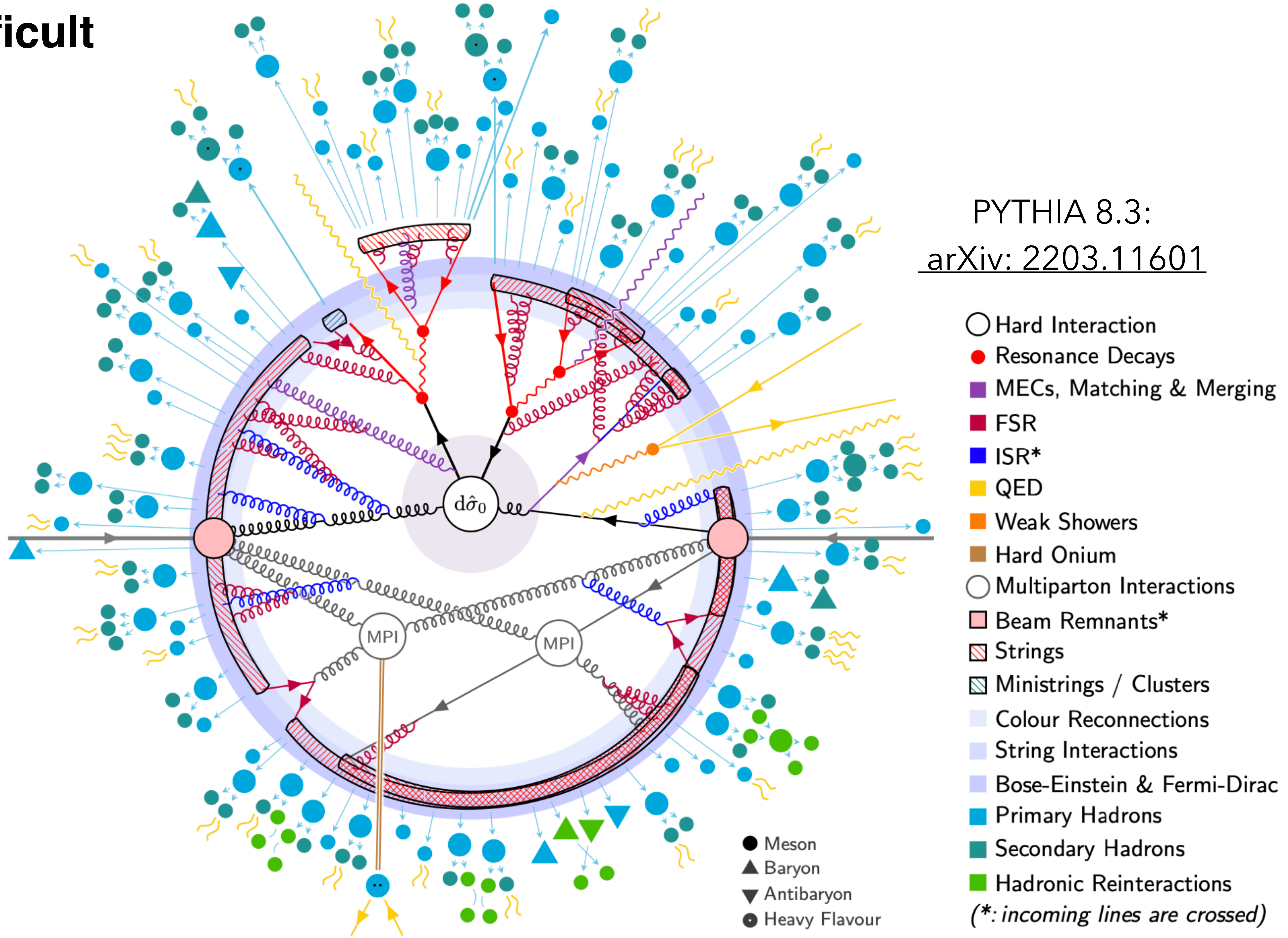
PYTHIA 8.3:
arXiv: 2203.11601

- Hard Interaction
- Resonance Decays
- MECs, Matching & Merging
- FSR
- ISR*
- QED
- Weak Showers
- Hard Onium
- Multiparton Interactions
- Beam Remnants*
- Strings
- Ministrings / Clusters
- Colour Reconnections
- String Interactions
- Bose-Einstein & Fermi-Dirac
- Primary Hadrons
- Secondary Hadrons
- Hadronic Reinteractions

(: incoming lines are crossed)*

Why heavy flavours?

- Heavy quarks are produced in initial hard scatterings with **large Q^2 → calculable with pQCD.**
- Large masses $m_b > m_c \gg \Lambda_{QCD}$ → short formation time → **experience whole medium evolution**
- Interactions with the medium don't change the flavour, but can modify the phase-space distribution. Thermal production rate in the QGP is expected to be 'small'.
  → destruction or creation in the medium is difficult



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- Factorization approach:

$$\frac{d^2\sigma}{dp_T dy}(AB \to CX) \propto \sum_{abcd} \int_0^1 dx_a \int_0^1 dx_b\, f_A^a(x_a, Q^2) f_B^b(x_b, Q^2) \frac{d\sigma}{dt}(ab \to cd)\, D_c^C(z_c, Q^2)$$

Parton distribution functions — Partonic cross section — Fragmentation function

- **Fragmentation functions assumed to be universal** across collision systems.
- For the quarkonium case, the binding of the quark pair involves soft scales, non-perturbative nature.

What can we learn?

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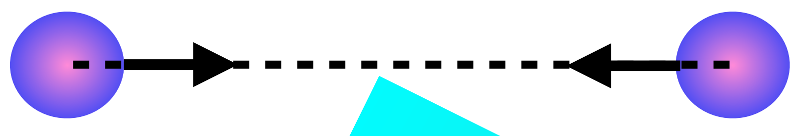
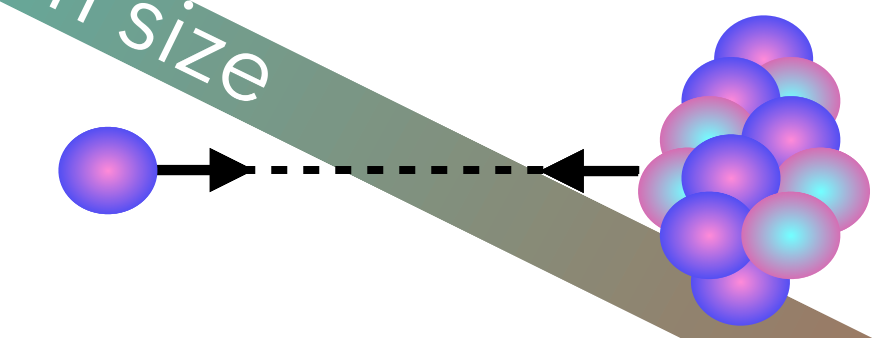


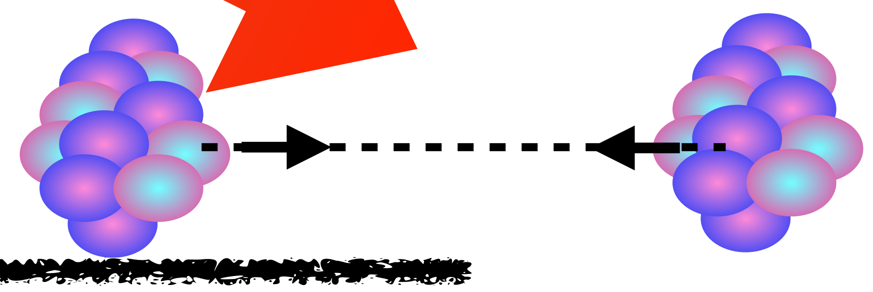
- Sensitive to **fragmentation / hadronisation**
  - Fragmentation fraction universality being questioned by recent LHC data.
  - Scrutinize hadron formation / nature

- **Underlying event / multiple parton interactions**
  - Interplay between soft/hard processes
  - Multiple parton interaction (MPI) contribution

- **Initial state effects**
  - saturation /
    modification of PDFs in nuclei
  - …



- **Final state effects**
  - energy loss
  - …



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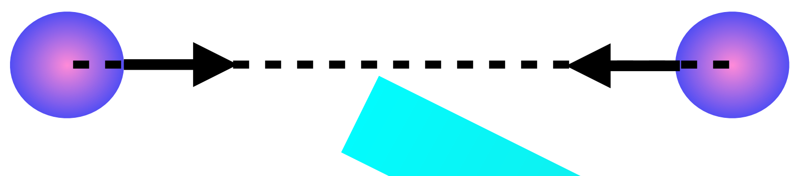

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system size

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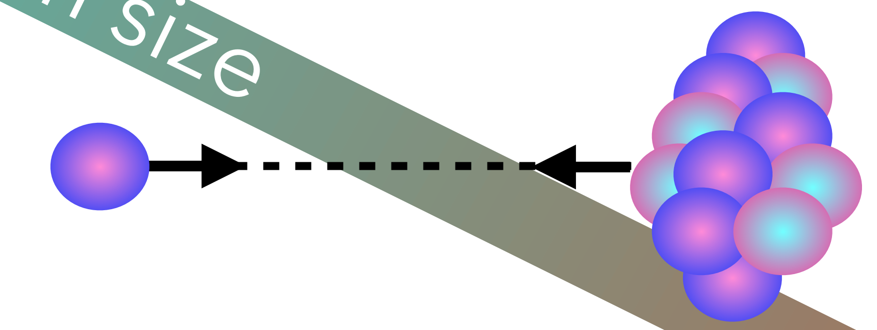
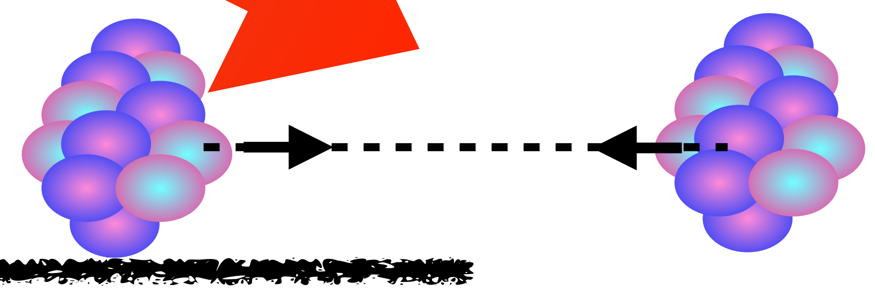
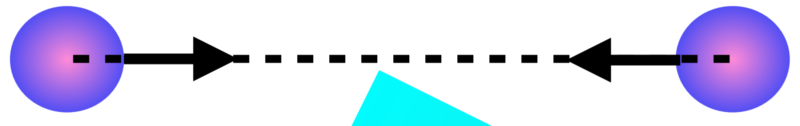


- **Final state effects**
  - energy loss
  - …

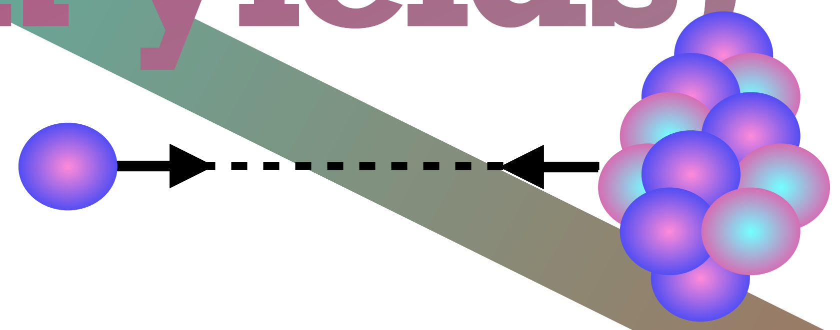
▹ **Understand particle production across collision system size.**

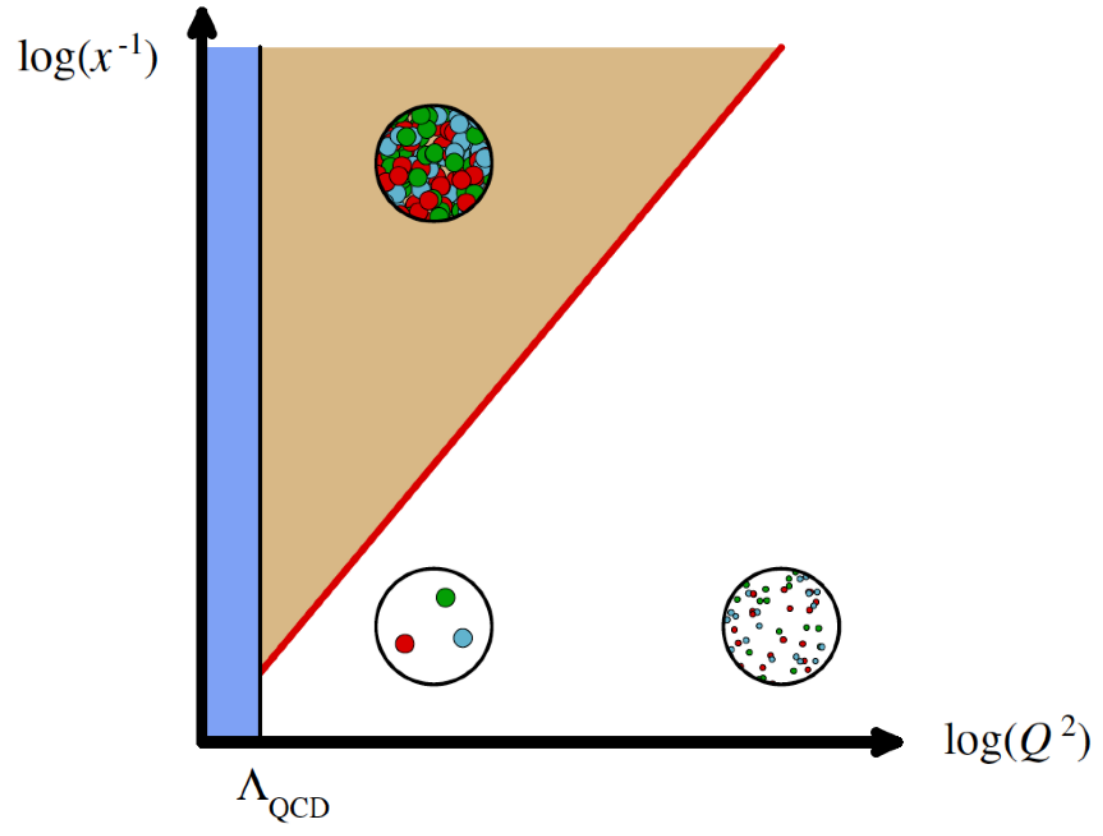
▹ **Investigate the source of collective effects.**



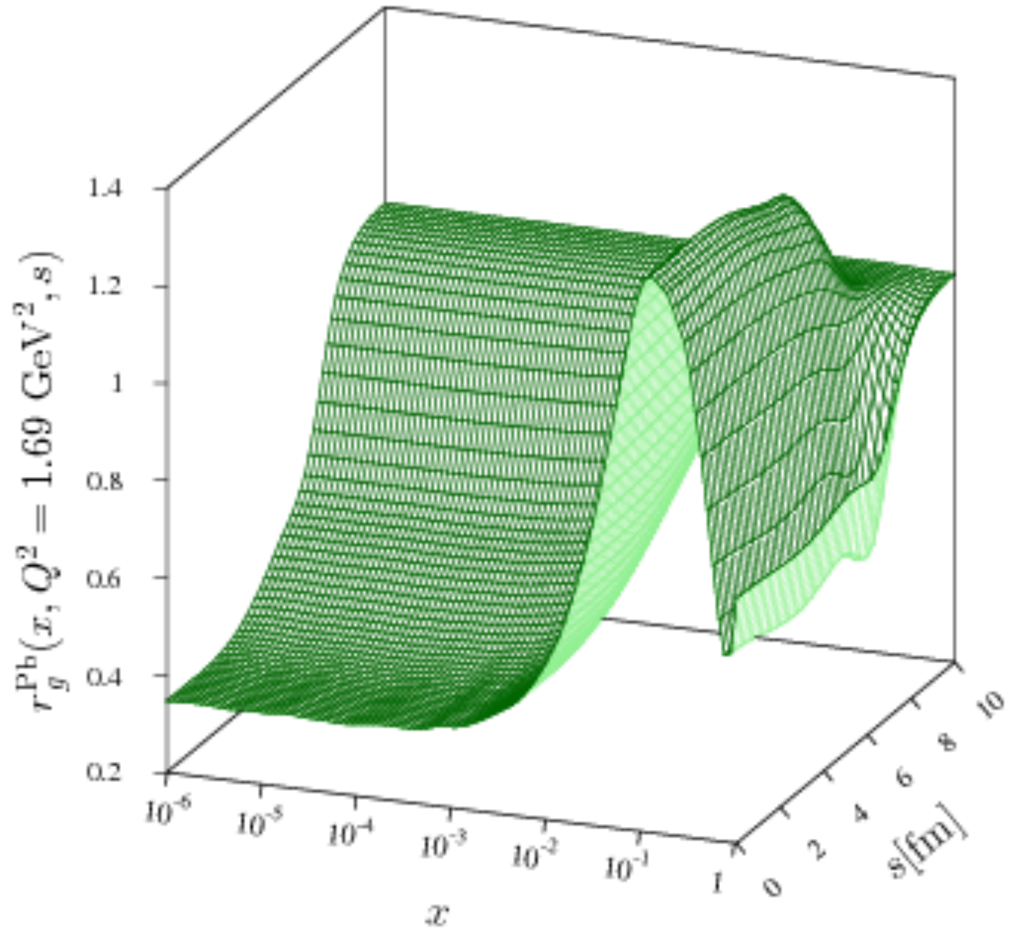


Initial state effects
(on yields)





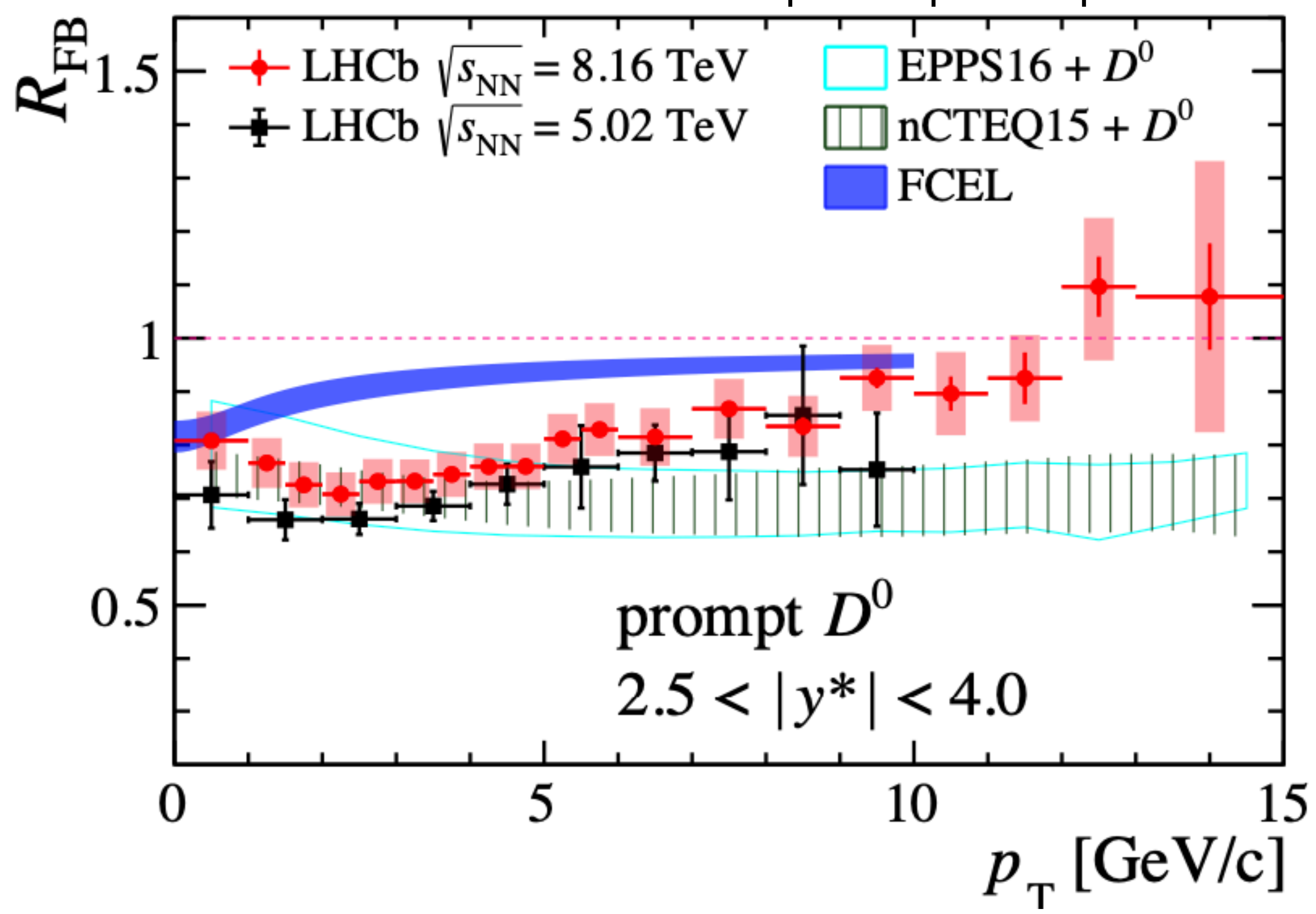
Saturation,
Modification of PDFs in nuclei



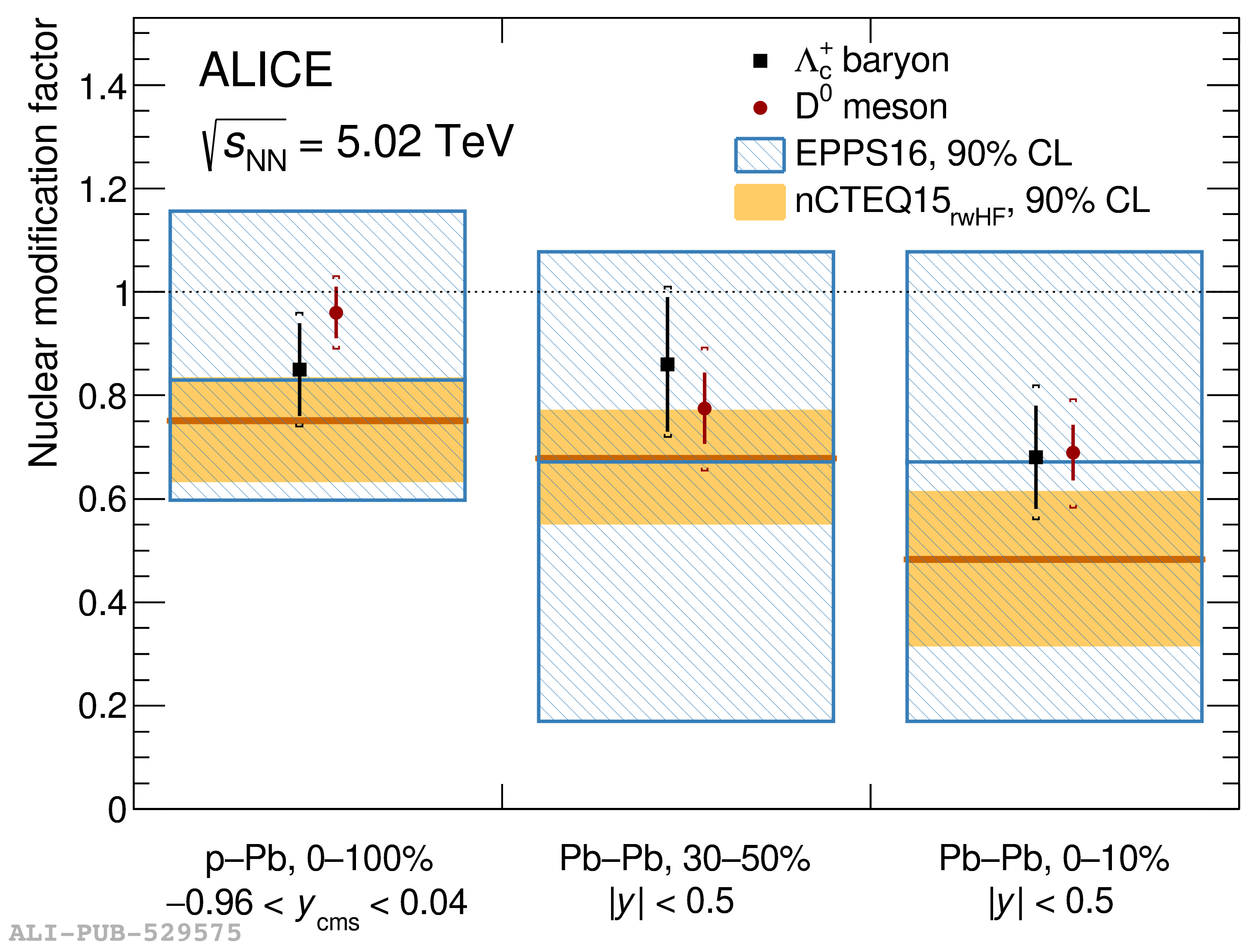
I. Helenius et al., Nucl.Phys.A 904-905 (2013) 999

Entering the precision era

Forward/backward prompt D^0 pPb



p_T-integrated R_{AA} prompt D^0, Λ_c pPb, PbPb



- Precise differential measurements (p_T, y) at the LHC
- **Constrain nuclear PDFs** down to small Bjorken-x (~10^{-5}), and possible final state effects

FCEL: Arleo et al, JHEP 01 (2022) 164
nCTEQ: Kovarik et al, Phys. Rev. D93 (2016) 085037
nCTEQnHFE: Kusina et al, Phys. Rev. D104 no. 1, (2021) 014010
EPPS16: Eskola et al., Eur. Phys. J. C77 (2017) 163

LHCb, D^0, arXiv:2205.03936
LHCb, B^0, B^+, Λ_b, PRD99 (2019) 052011
ALICE, JHEP 01 (2022) 174
ALICE, JHEP 12 (2019) 092
ALICE, Λ_c, arXiv: 2211.14032

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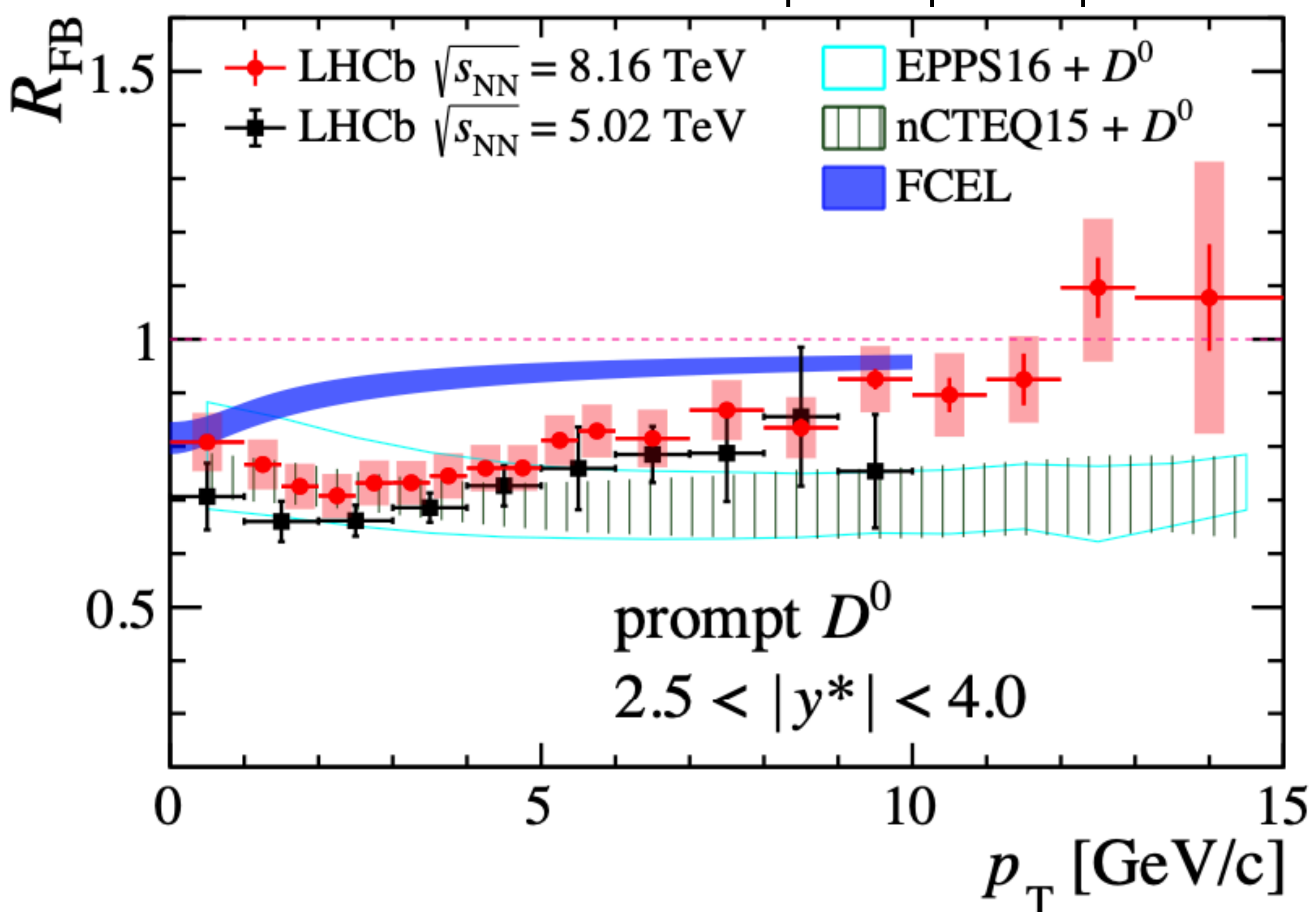

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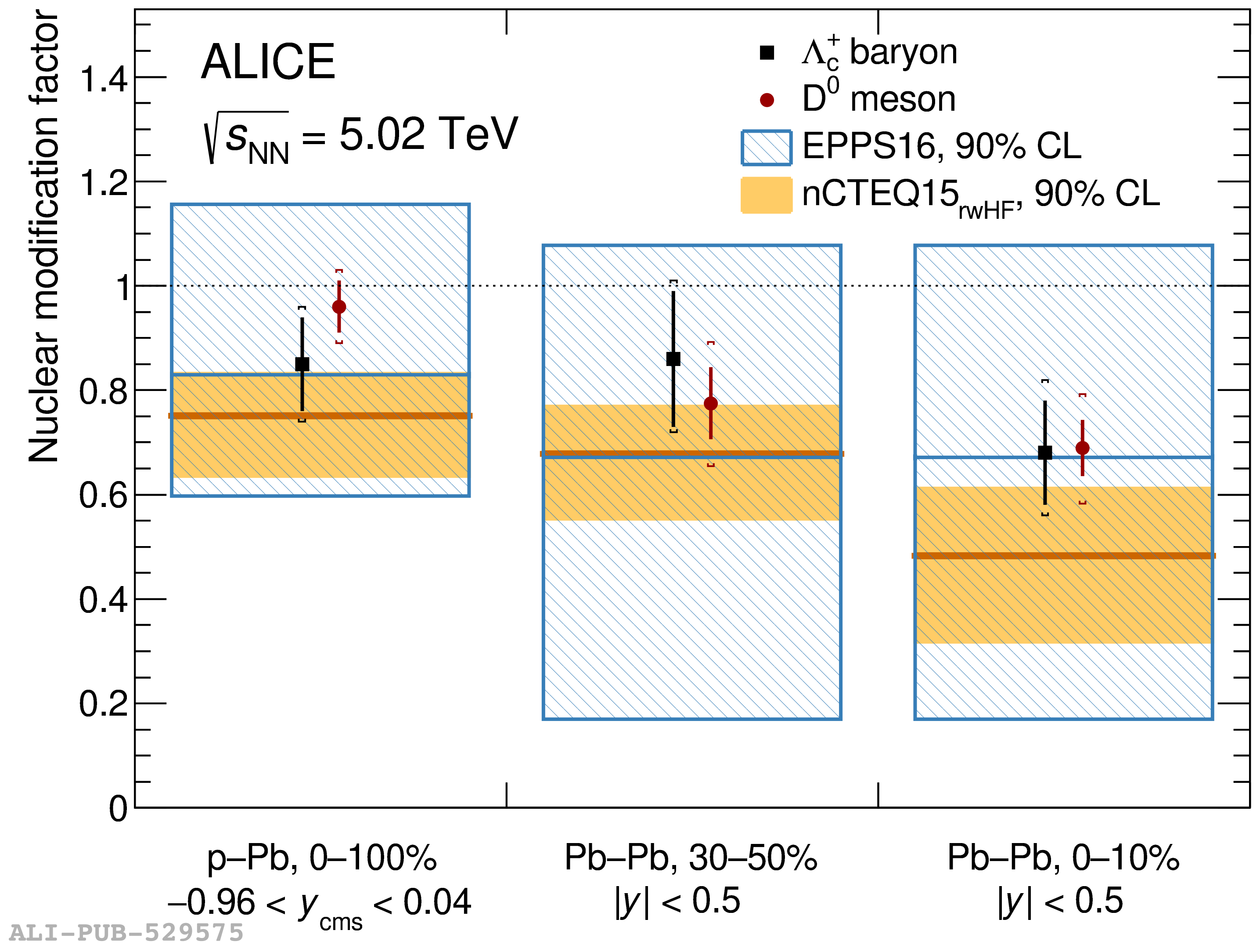
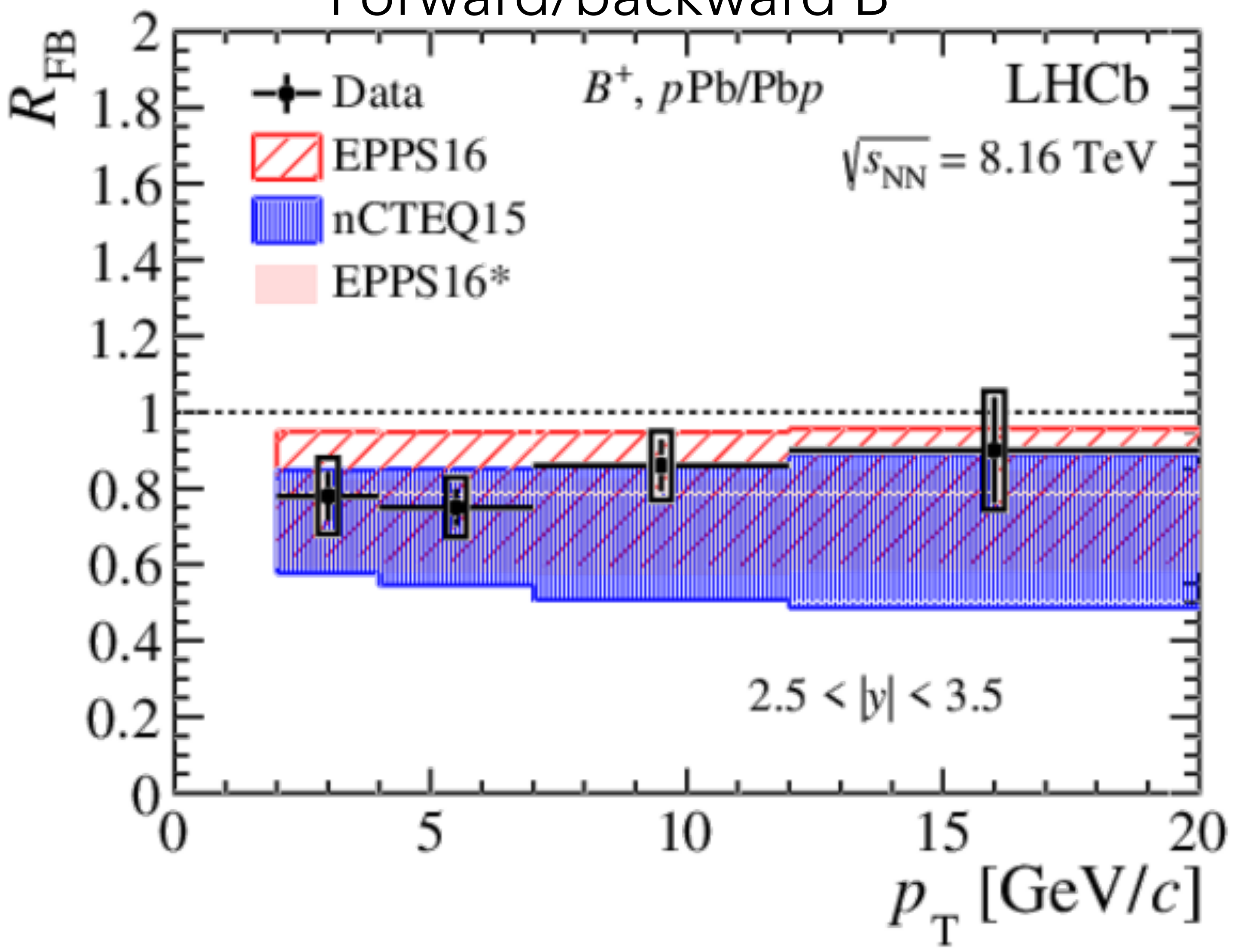


Forward/backward B^+



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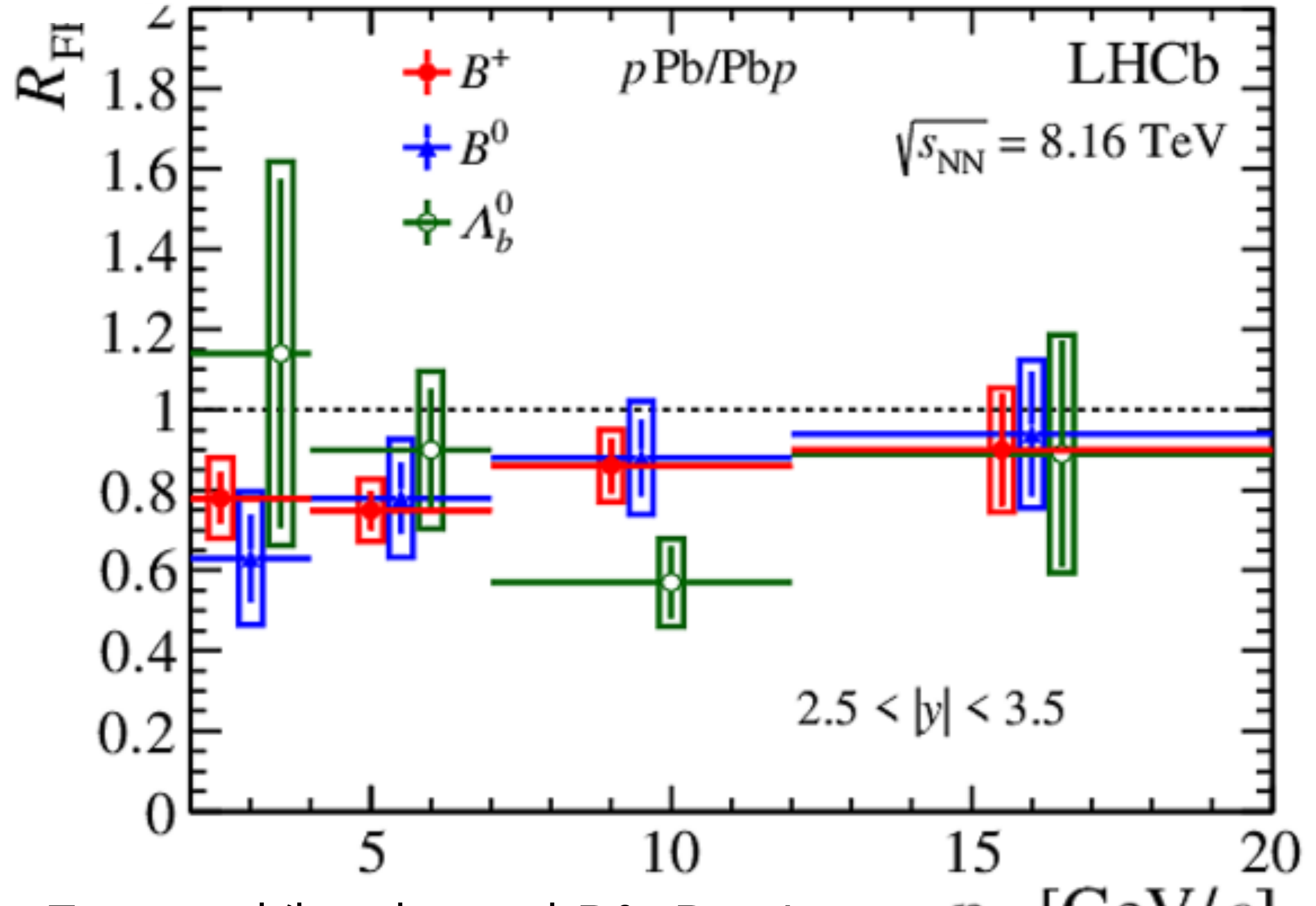

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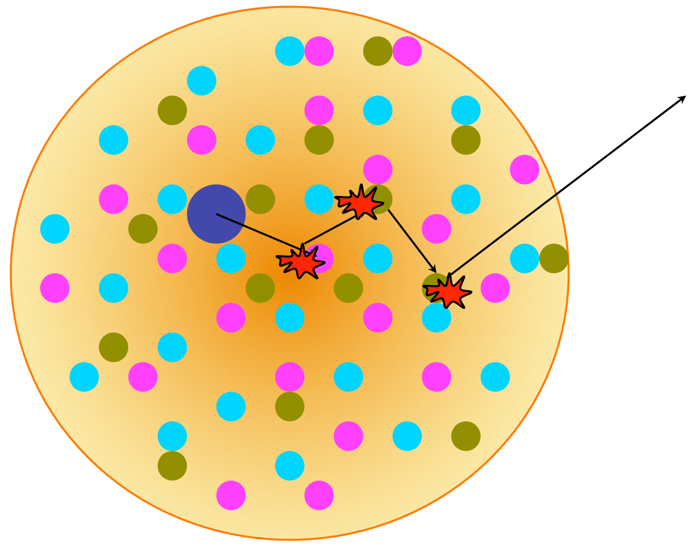
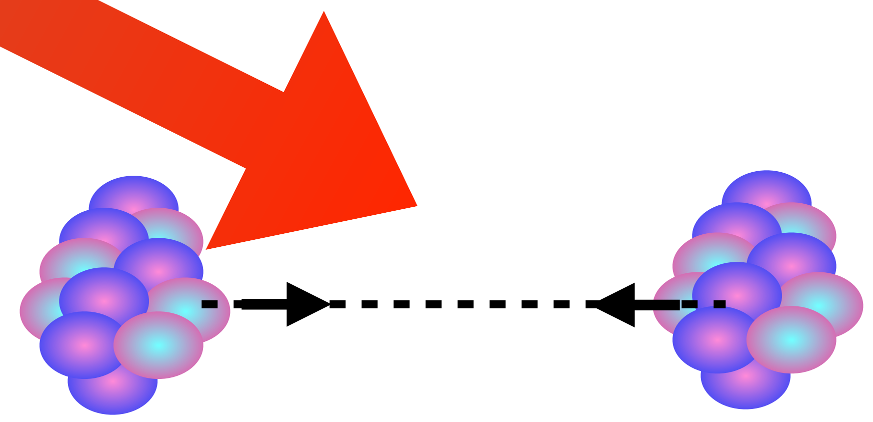
ALICE, Λ_c, arXiv: 2211.14032

Energy loss

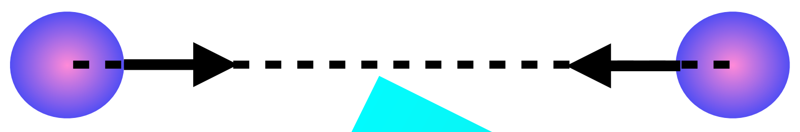
Energy loss: R_{AA}
Interaction of heavy quarks with the medium
Colour charge and parton mass dependence.

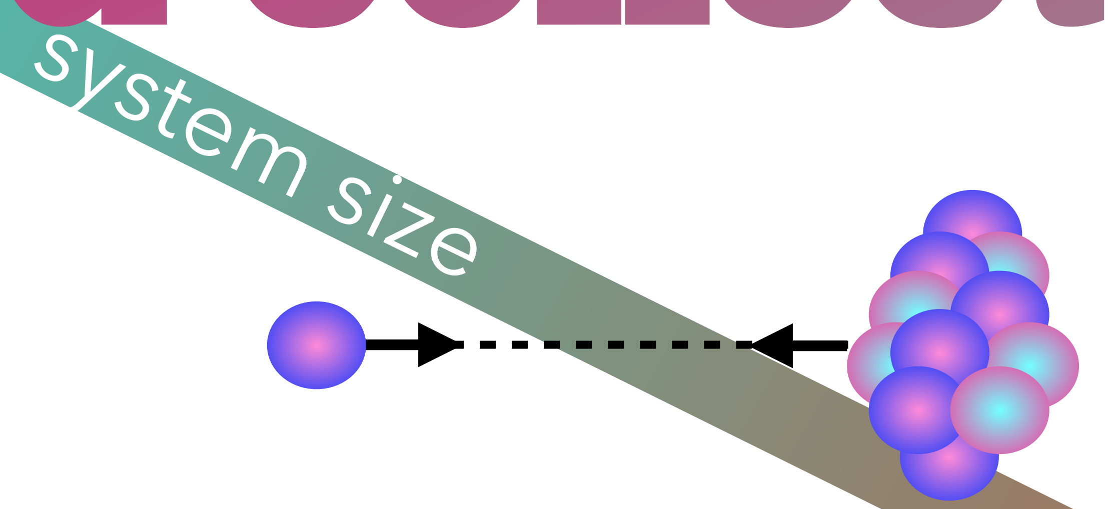


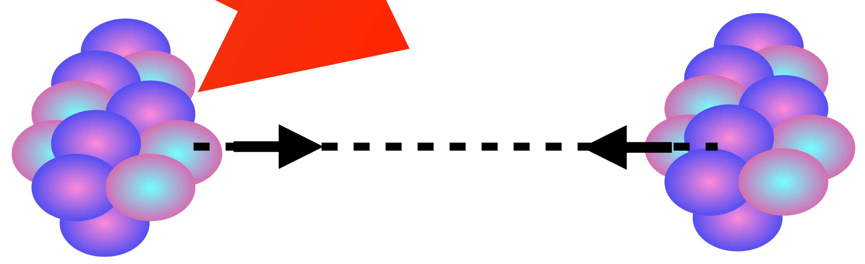
$$R_{\mathrm{AB}}^{\mathrm{probe,CC}} = \frac{\mathrm{d}N_{\mathrm{AB}}^{\mathrm{probe,CC}}}{\langle N_{\mathrm{coll}} \rangle^{\mathrm{CC}} \cdot \mathrm{d}N_{\mathrm{NN}}^{\mathrm{probe}}} \xrightarrow{\int b} R_{\mathrm{AB}}^{\mathrm{probe}} = \frac{\sigma_{\mathrm{AB}}^{\mathrm{probe}}}{\mathrm{AB} \cdot \sigma_{\mathrm{NN}}^{\mathrm{probe}}}$$

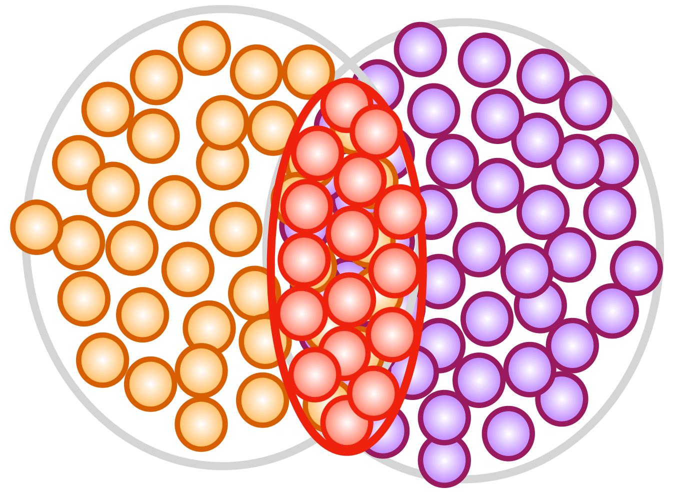


and collectivity

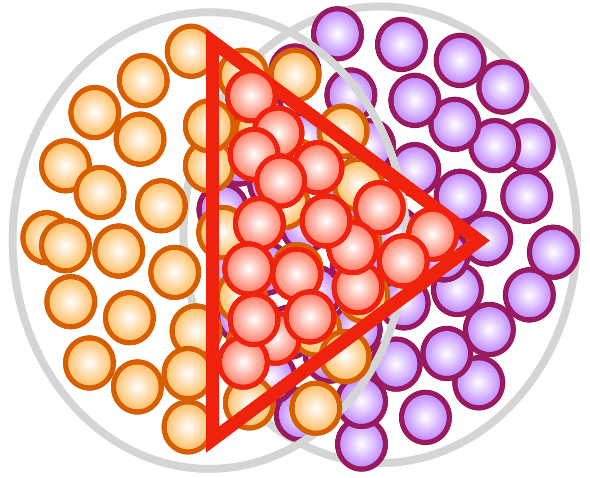




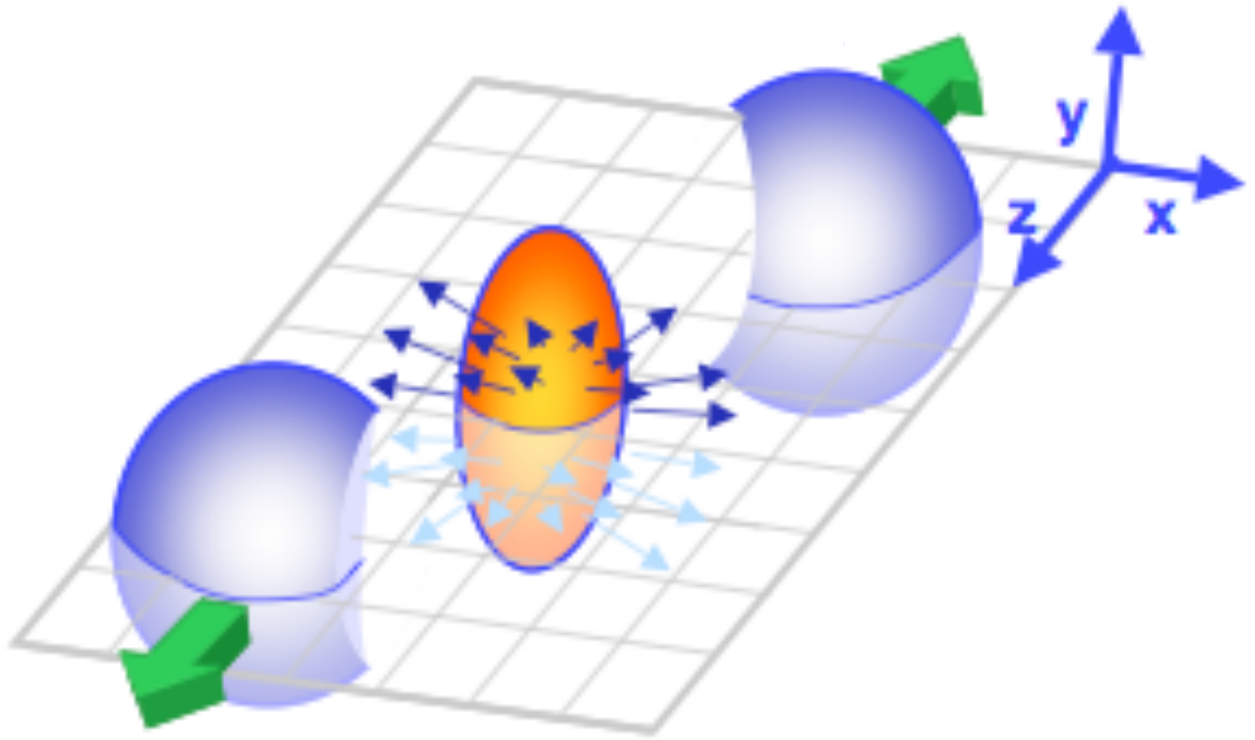




Elliptic flow v_2
Initial spatial anisotropy
and re-interactions

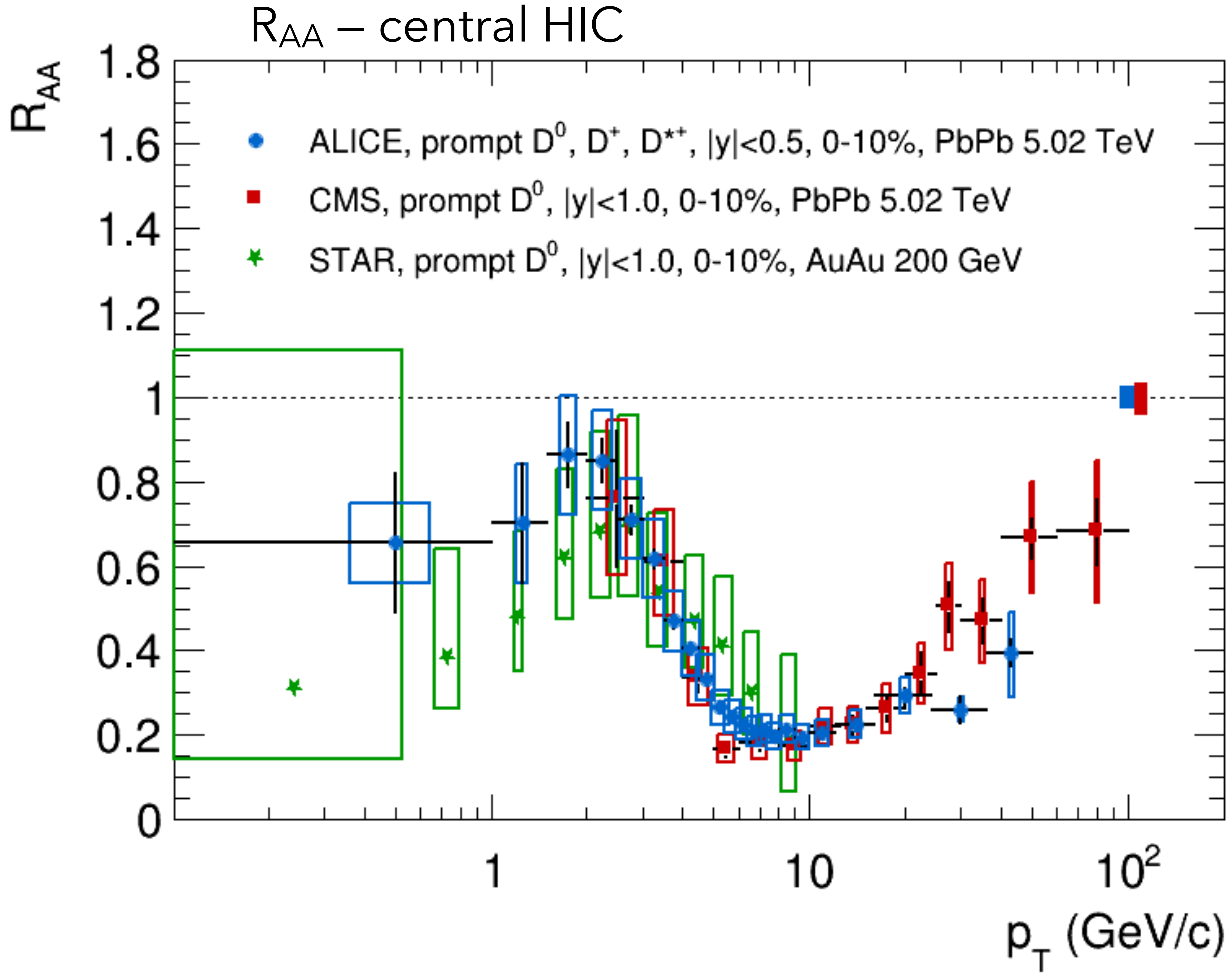


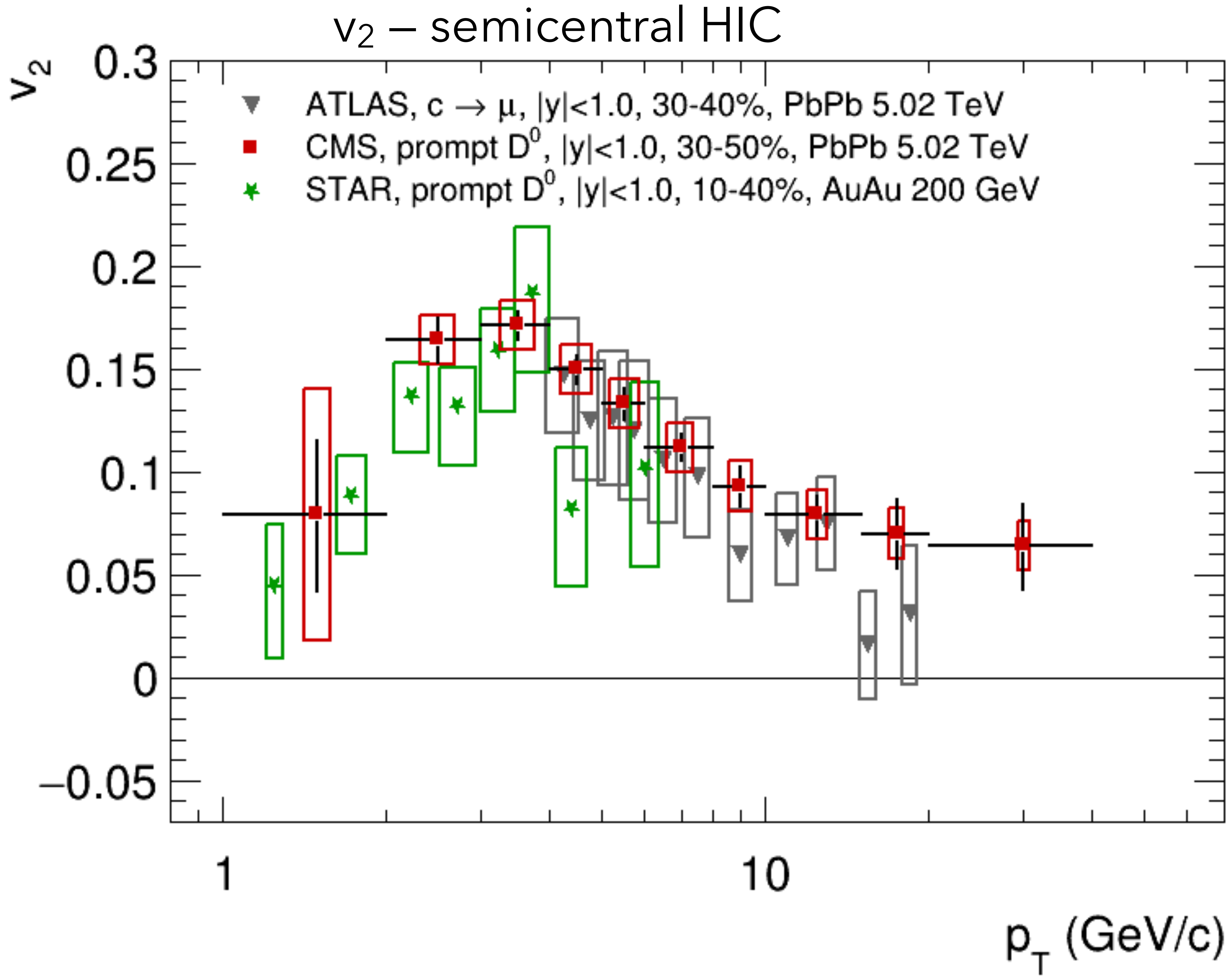
Triangular flow v_3
Fluctuations in the
initial state



$$\frac{d^3N}{d^3\vec{p}} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\left[1 + \sum_{n=1}^{\infty} 2v_n \cos\left(n(\phi - \Psi_R)\right)\right]$$

Charm hadrons in medium

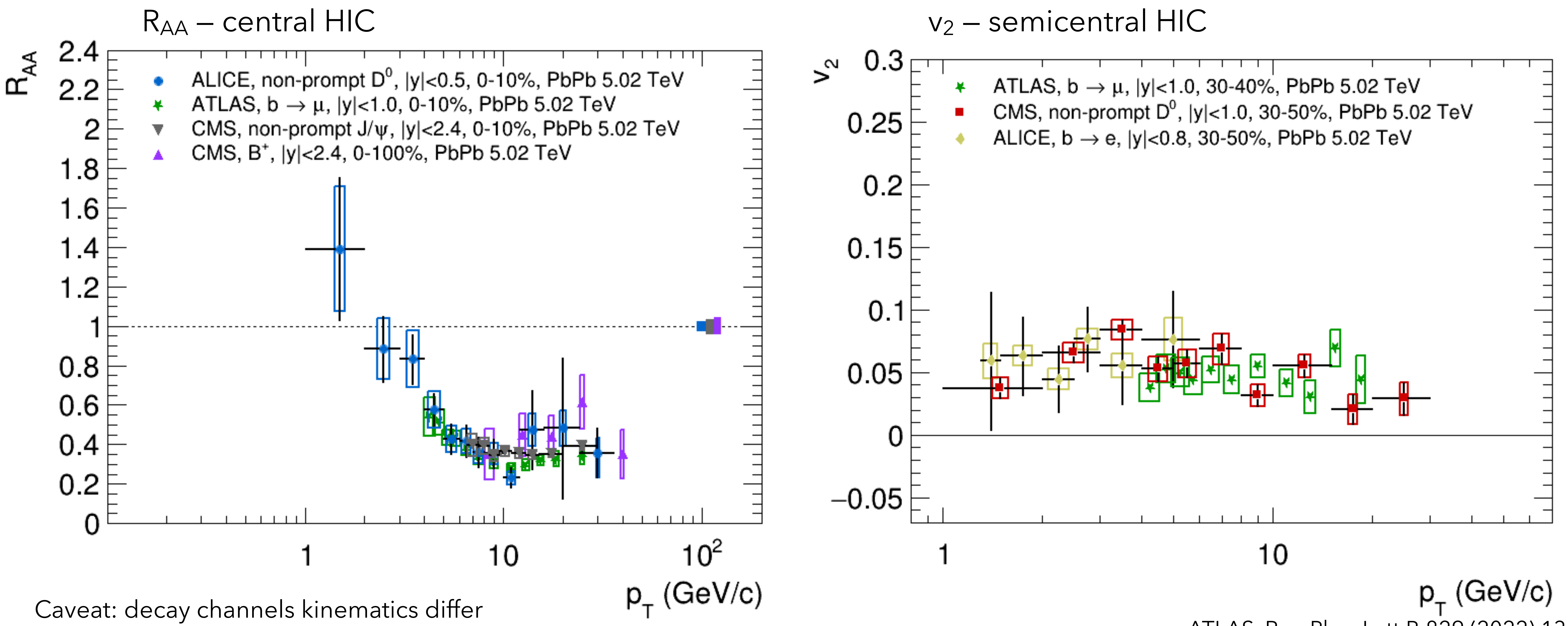




- Precise measurements of R_{AA} and v_2 in a wide p_T interval
- Similar results at RHIC and at the LHC despite different kinematics
- **Significant energy loss** of charm in medium
- **Positive v_2:** participation to the collective motion

ALICE, R_{AA}, JHEP 01 (2022) 174
CMS, R_{AA}, , PLB 782 (2018) 474
STAR, R_{AA}, Phys.Rev.C 99 (2019) 3, 034908
CMS, v_2, PRL 120 (2018) 202301
ATLAS, v_2, Phys.Lett.B 807 (2020) 135595
STAR, v_2, PRL 118 (2017) 21

Beauty hadrons in medium



Caveat: decay channels kinematics differ

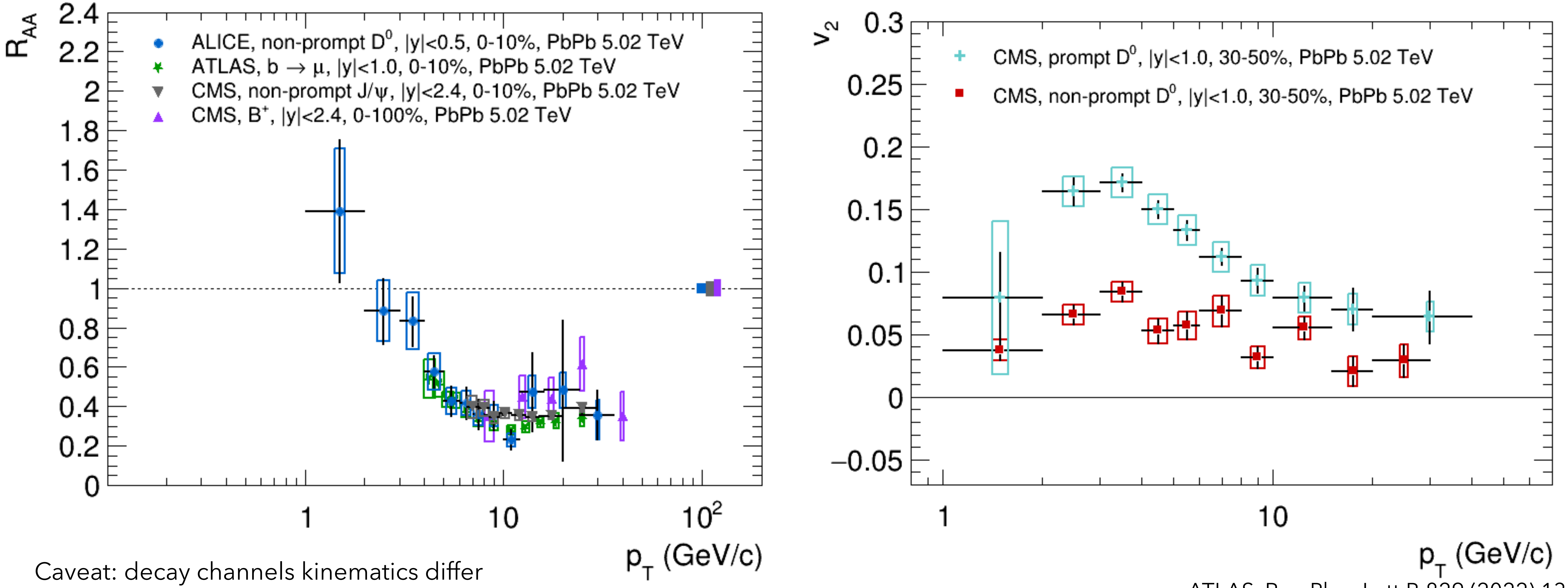
- Plenty of decay channels being investigated, increasing reach and precision
- **Significant energy loss** of beauty in medium
- **Positive v_2** for p_T > 2-3 GeV, **lower values for beauty than for charm hadrons**

ATLAS, R_{AA}, Phys.Lett.B 829 (2022) 137077
ALICE, R_{AA}, non-prompt D^0, JHEP 12 (2022) 126
ALICE, R_{AA}, b to e, arXiv: 2211.13985
CMS, R_{AA}, B+, PRL 119 (2017) 15, 152301
CMS, R_{AA}, non-prompt D^0, PRL 123 (2019) 022001
ATLAS, v_2, b to mu, Phys.Lett.B 807 (2020) 135595
ALICE, v_2, b to e, Phys.Rev.Lett. 126 (2021) 16, 162001
CMS, v_2, non-prompt D^0, arXiv: 2212.01636

Beauty hadrons in medium

R_{AA} – central HIC

v$_2$ – semicentral HIC



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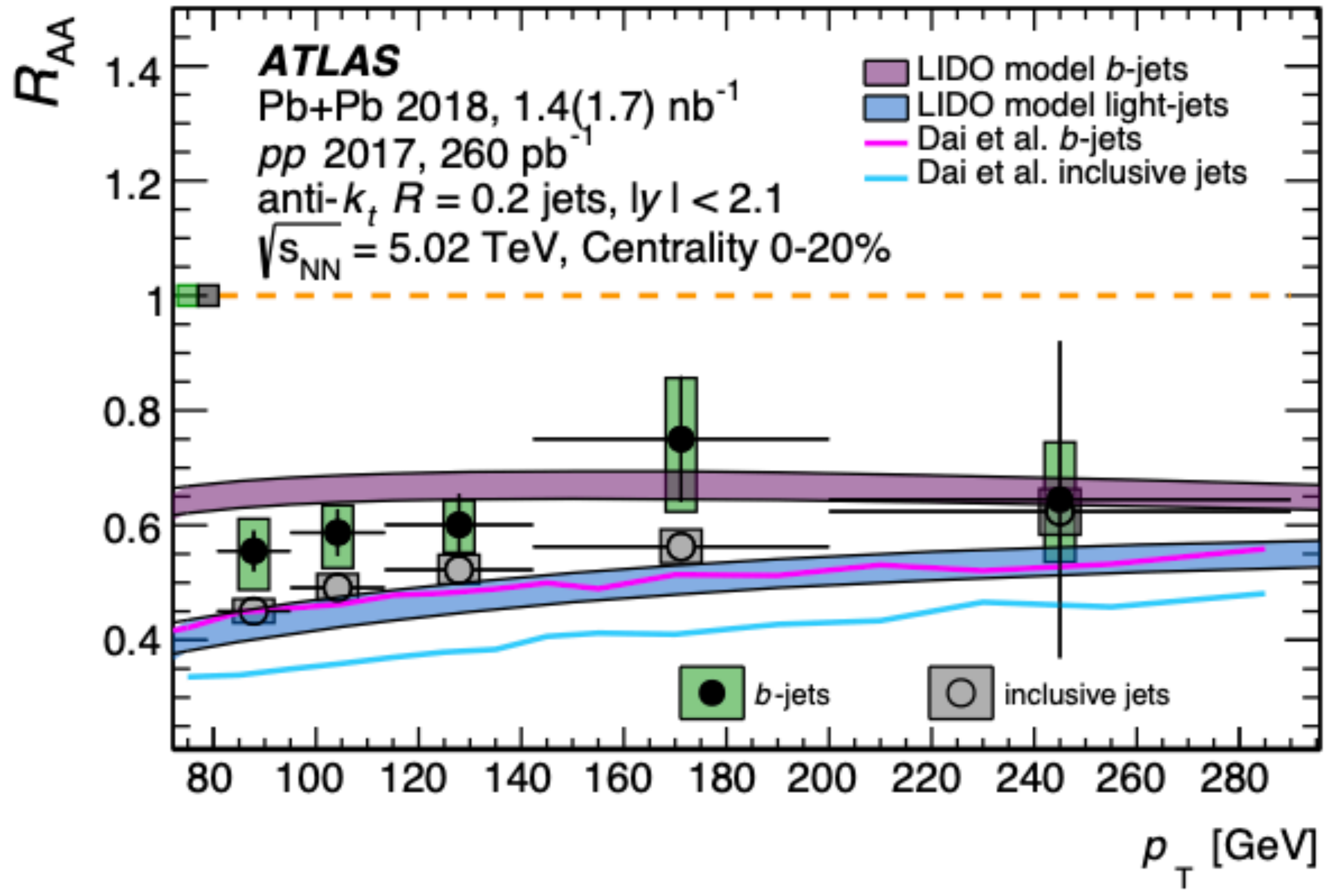
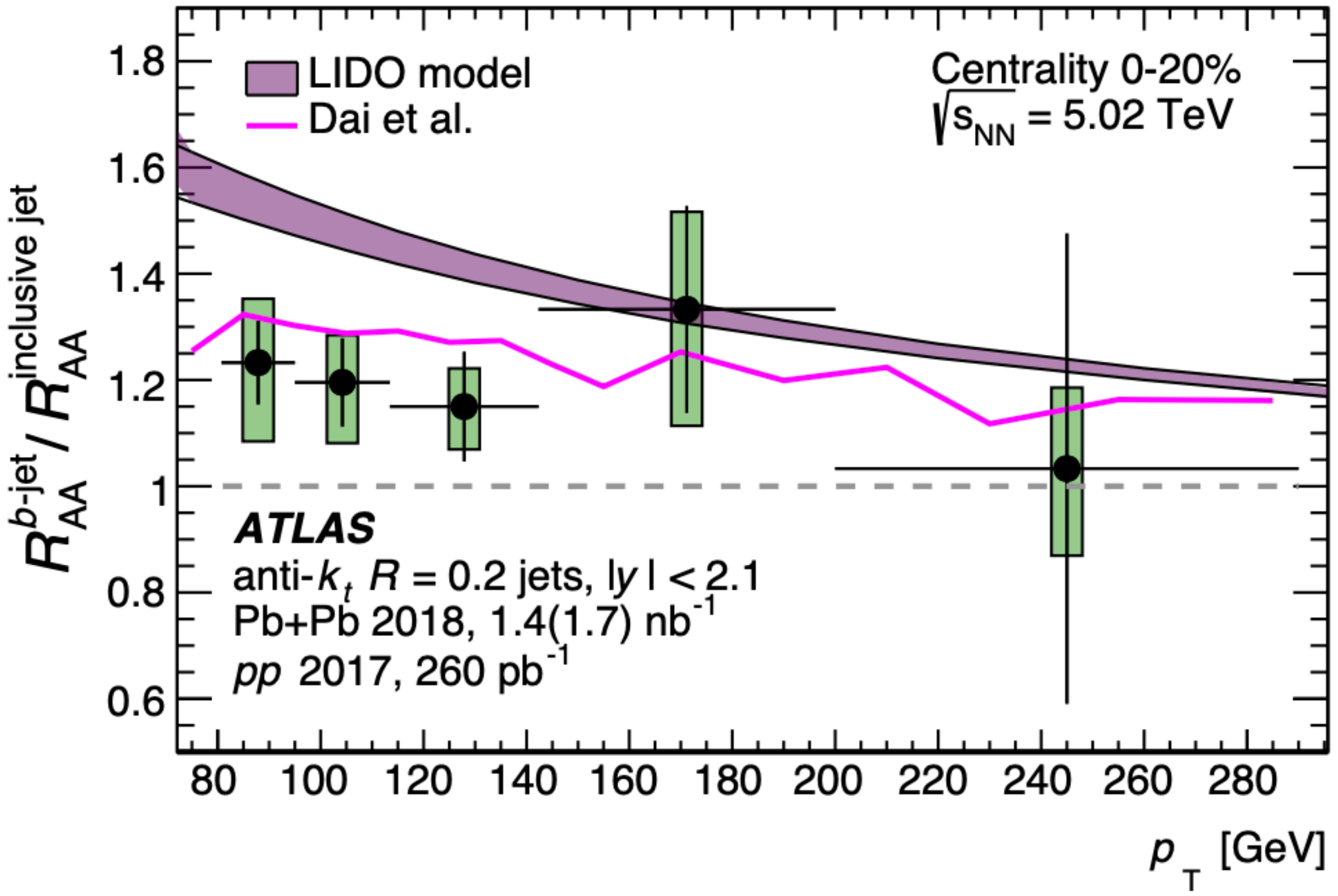
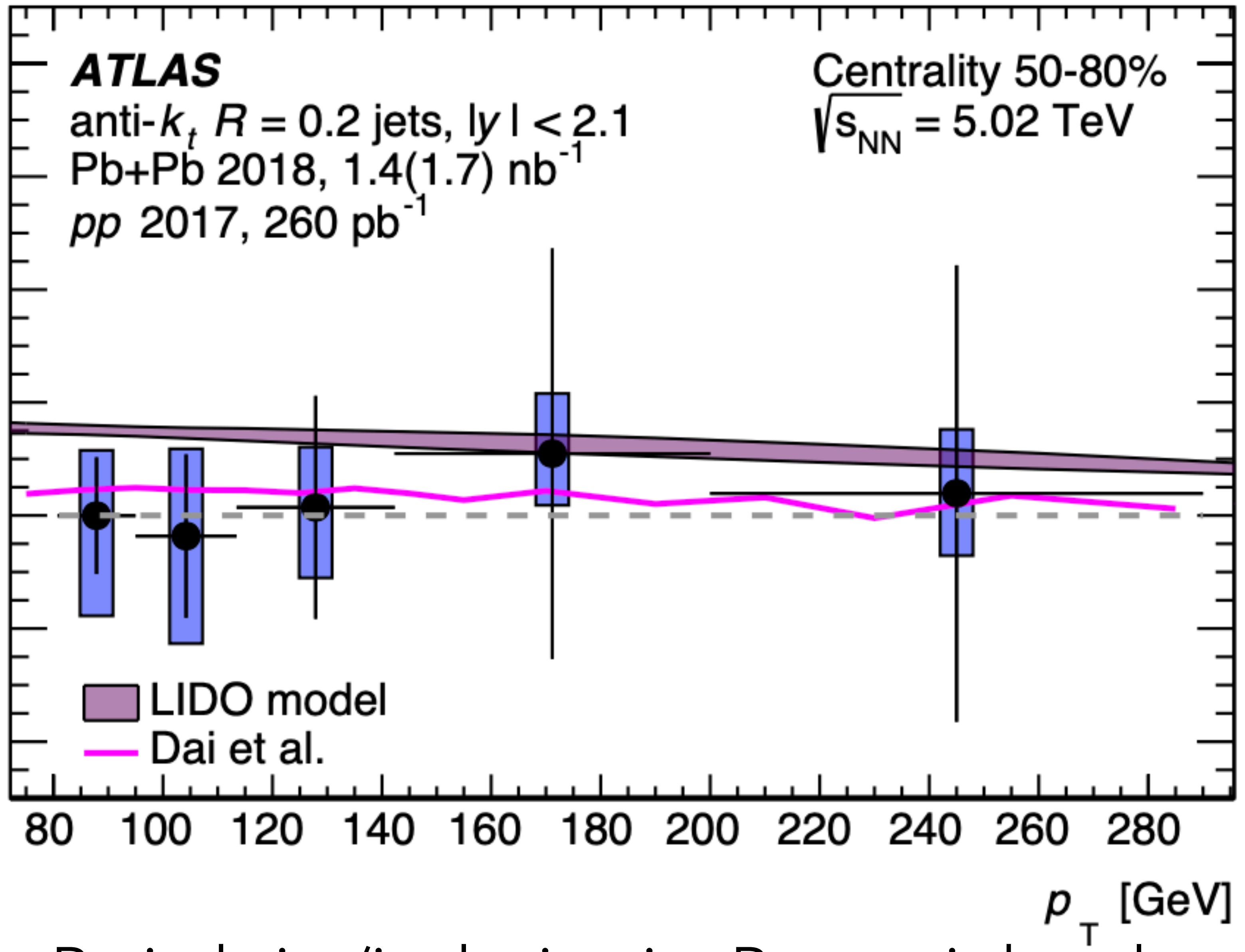
Moving to higher p_T? b-jets in medium



R_{AA} central collisions



Ratio b-jet/inclusive-jet R_{AA} central

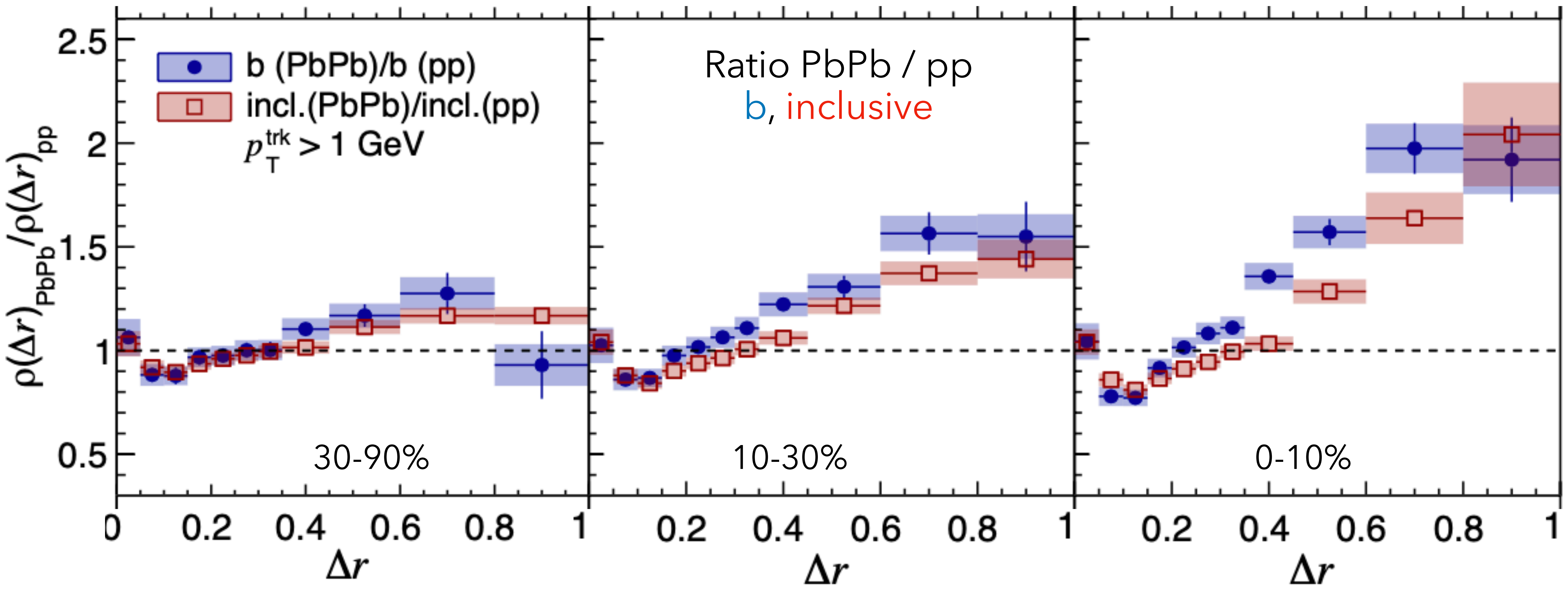


Ratio b-jet/inclusive-jet R_{AA} peripheral

- Suggest R_{AA} values for **b-jets higher than for inclusive jets** in central collisions
- Similar trend for peripheral collisions.
- Possible influence of b-jet fragmentation and/or
  mass effect on parton energy loss (expected to be small at large p_T)?

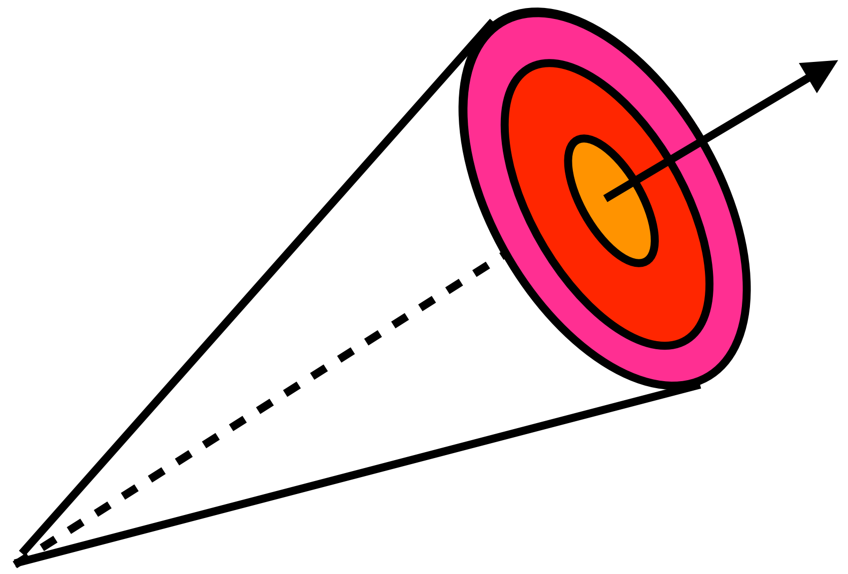
ATLAS, arXiv: 2204.13530
LIDO: W. Ke et al, Phys. Rev. C 98, 064901 (2018), Phys. Rev. C 100, 064911 (2019),
Dai et al: Chinese. Phys. C 2020, 44:104105

Looking at the energy distribution? b-jet shape



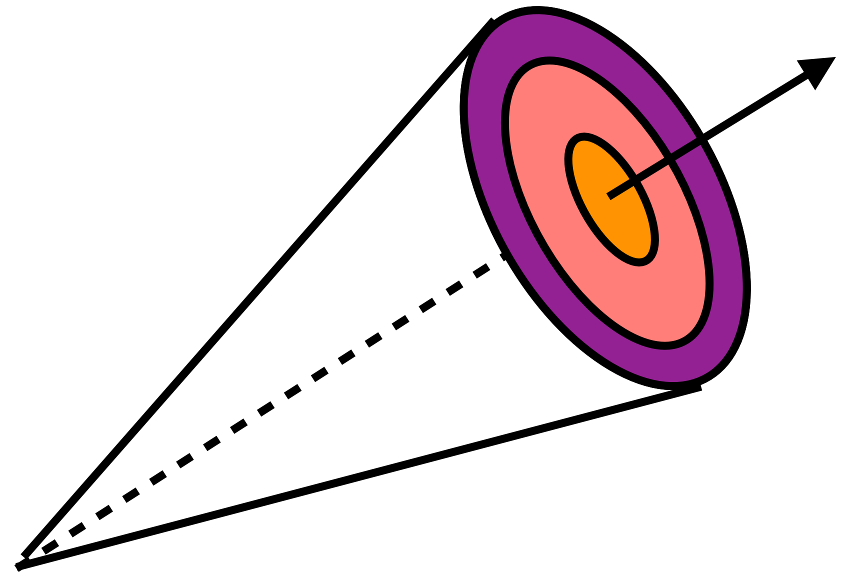
CMS, arXiv:2210.08547

Δr : radial distance between the track and the jet axis
ρ : normalised profile of charged particles in jets



Jet substructure: energetic component close to jet axis

- Jet-track correlation $p_T^{jet} > 120$ GeV, $p_T^{track} > 1$ GeV
- Energetic core (close to jet axis) stays intact, intermediate part is reduced, and enhancement of the activity on the surface/edges and far away from the jet.
- The **modification is more pronounced for b-jets** than for inclusive jets, and is already present in pp.
  b-jet fragmentation?
  Dead-cone effect (mass effect expected to be small at large p_T)?
  Increased medium response to heavy quark propagation?



Jet substructure modified:
core stays intact,
intermediate part is reduced,
larger activity in the border and far away

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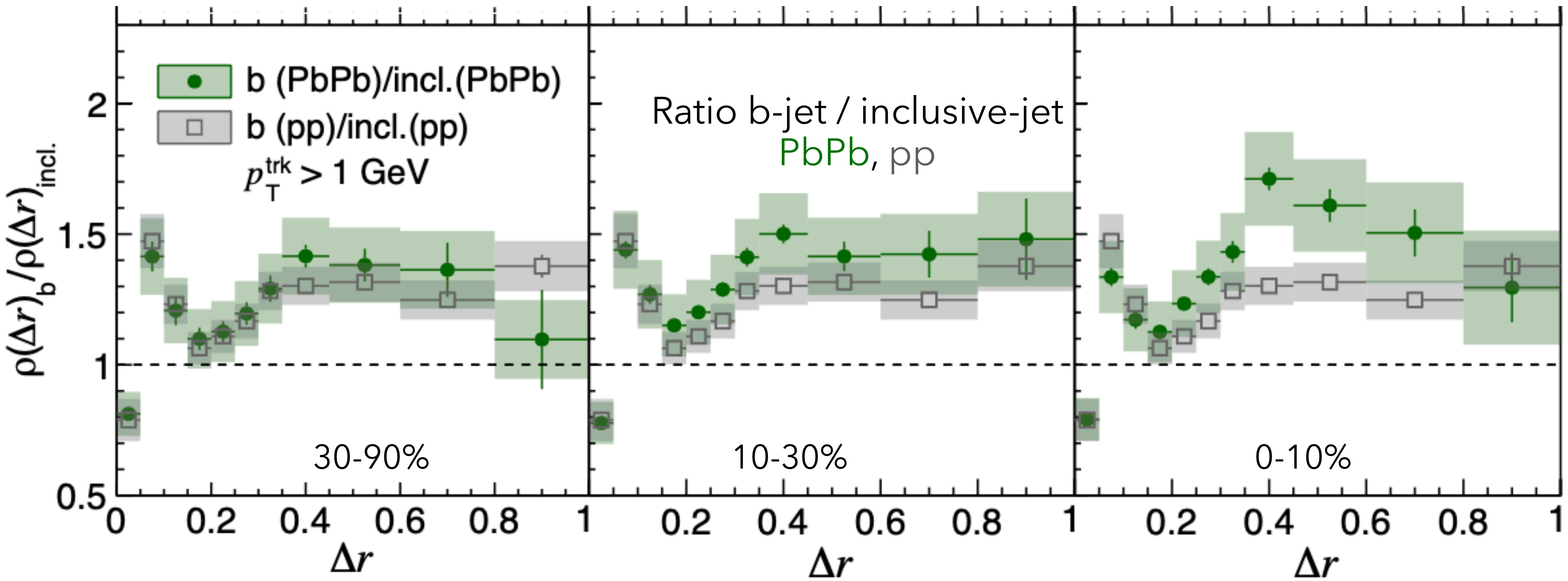
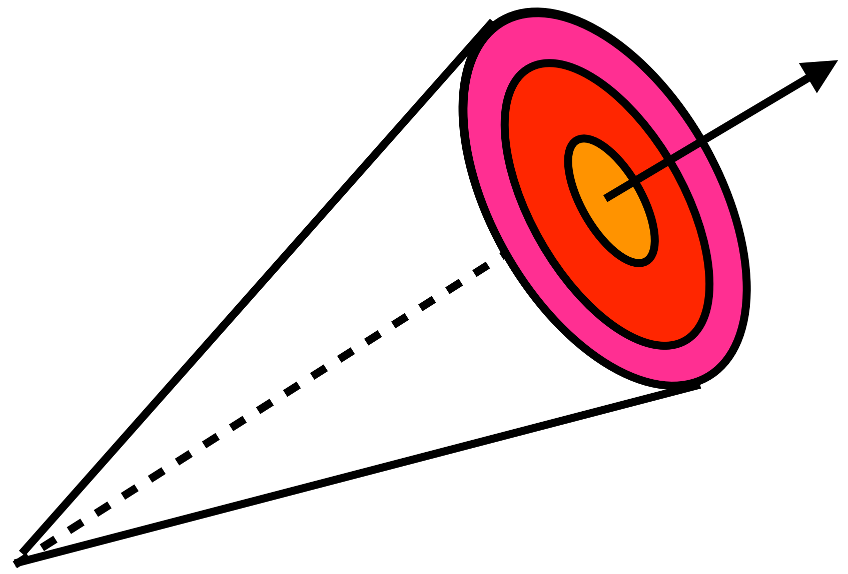


CMS, arXiv:2210.08547



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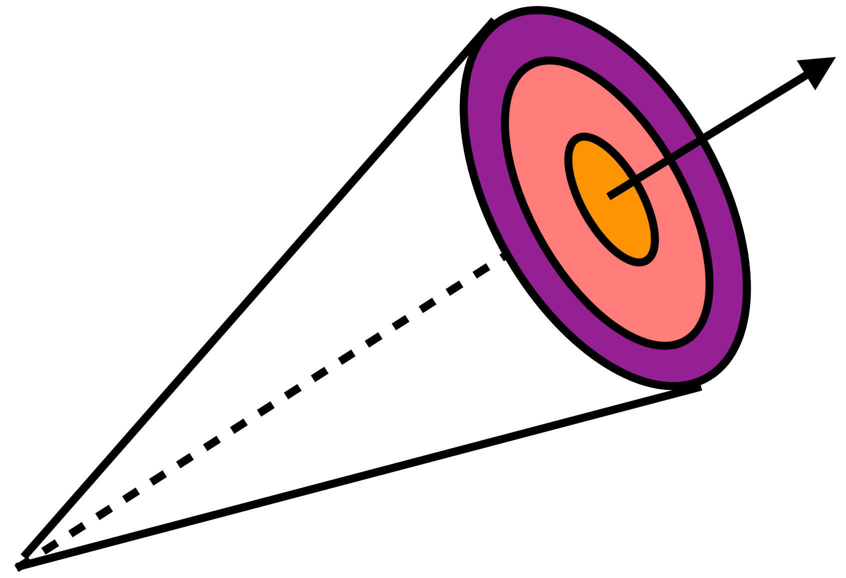

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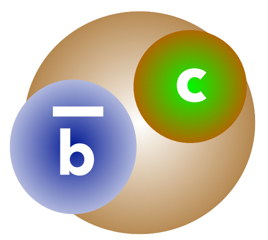
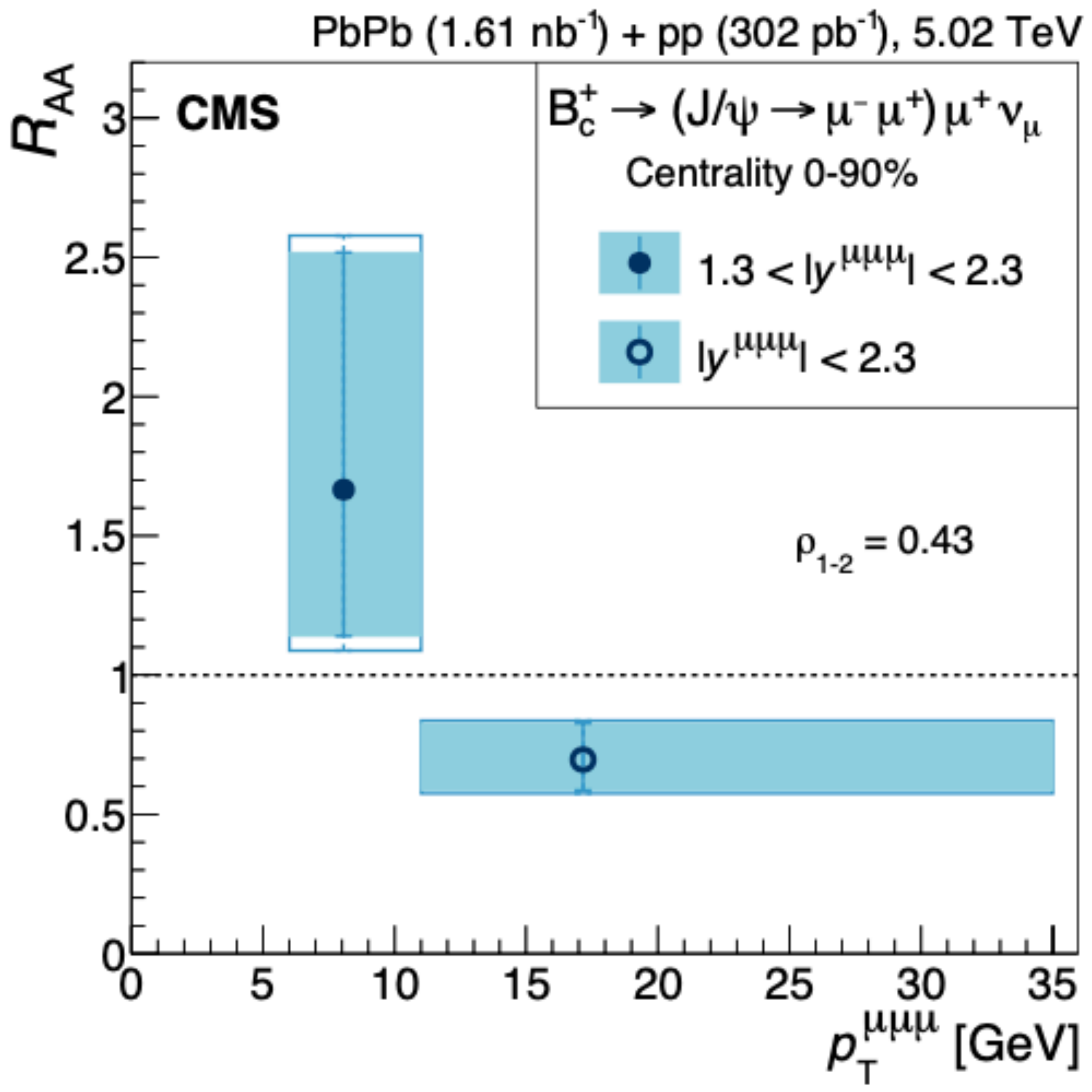
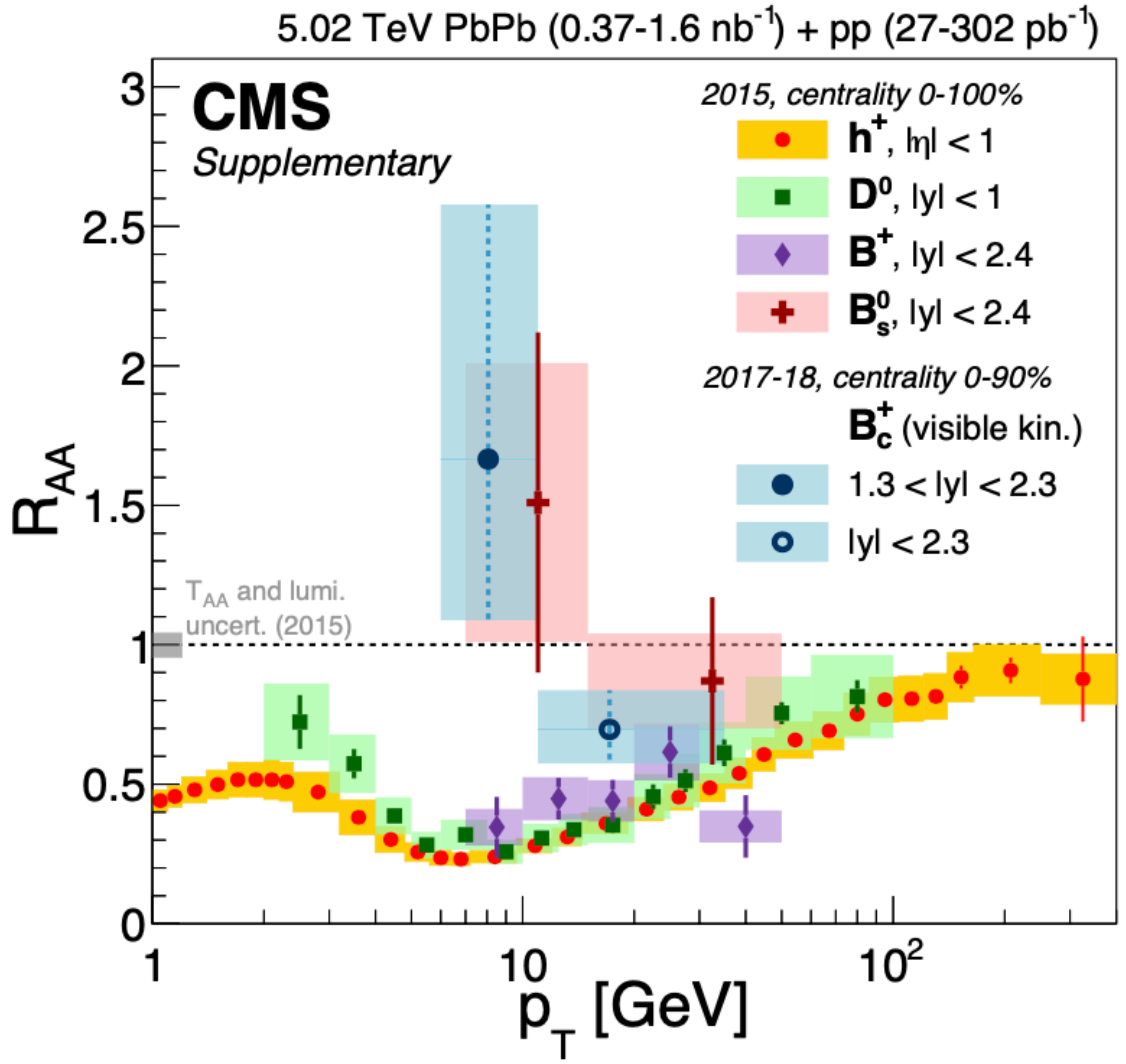
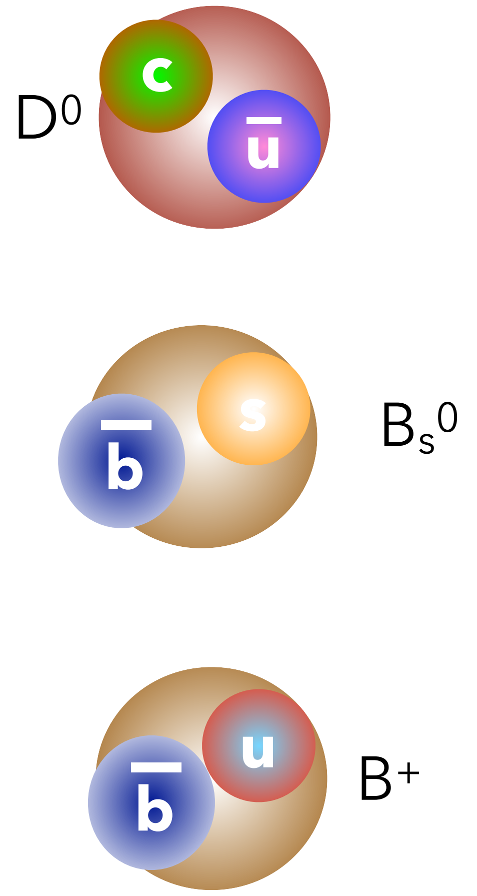
Going rarer? B_c^+ in PbPb



B_c^+



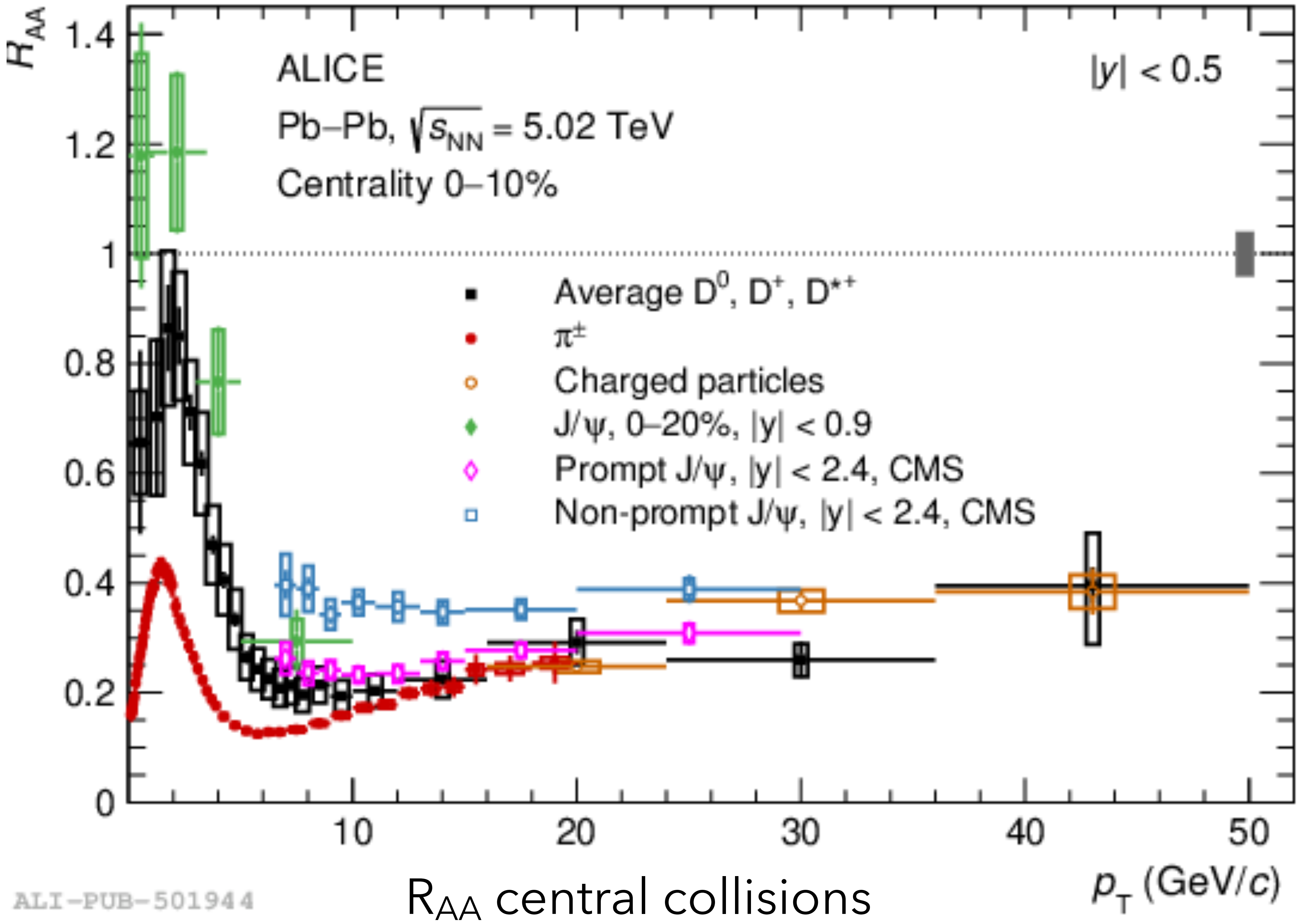




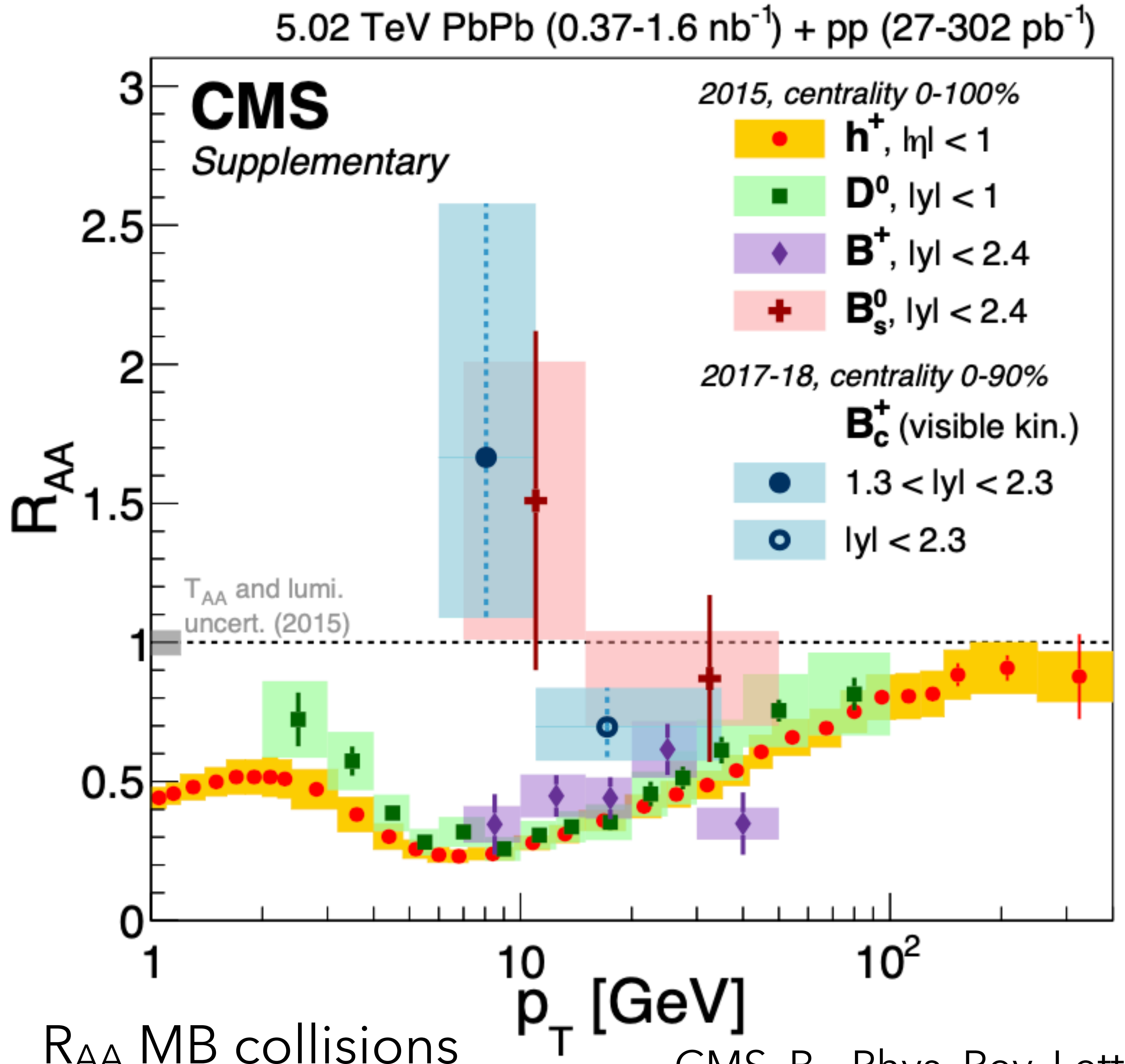
- **Unique charm-bottom state** → sensitive to both energy loss (suppression) and recombination
- Moderate suppression at high p_T.
- Less suppression than other heavy mesons (except for B_s^+).

CMS, Phys. Rev. Lett. 128, 252301 (2022)

What have we learned from data?



R_{AA} central collisions

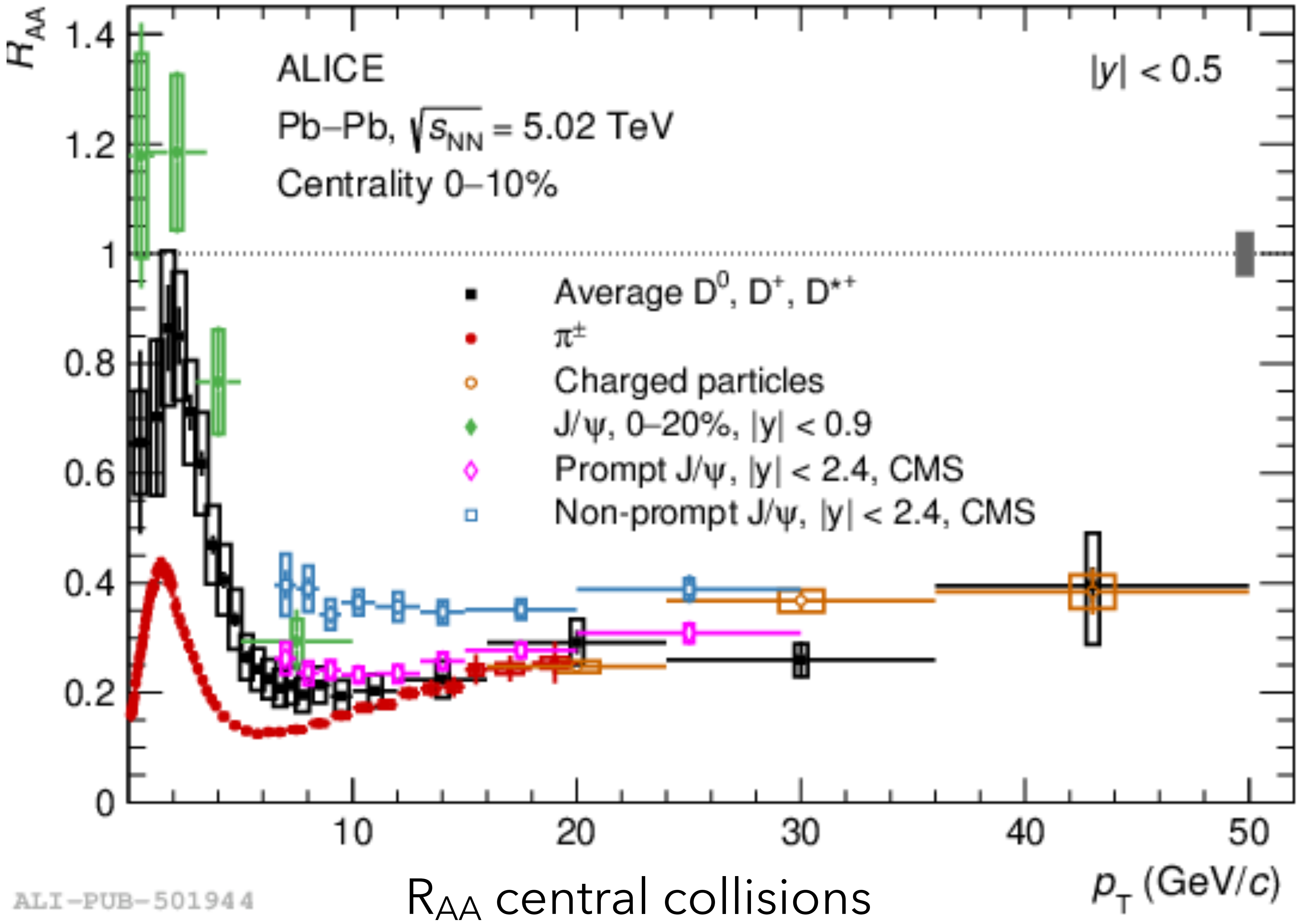


R_{AA} MB collisions

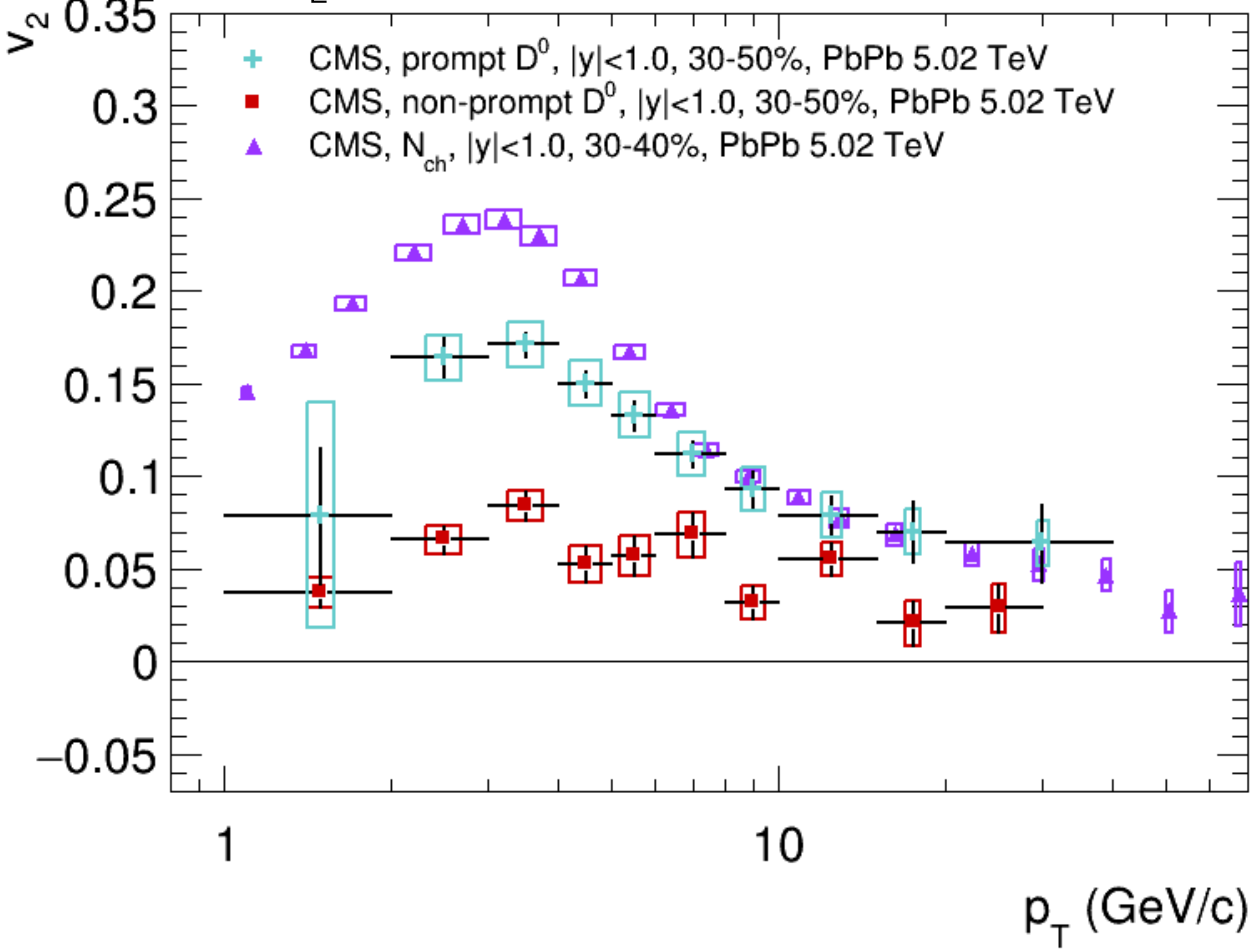
CMS, B_c, Phys. Rev. Lett. 128, 252301 (2022)
CMS, v_2, N_{ch}, PLB 776 (2018) 195-216
CMS, v_2, non-prompt D^0, arXiv: 2212.01636
ALICE prompt D^0, JHEP 01 (2022) 174

- R_{AA} **hierarchy** at intermediate p_T,
  $R_{AA}(ch/\pi) < R_{AA}$(prompt D) $< R_{AA}$(non-prompt D/J/ψ,B^+) $< R_{AA}(B_s)$
  consistent with **parton mass energy loss dependence**
- **Positive v_2:** $v_2(N_{ch}) > v_2$(prompt D^0) $> v_2$(non-prompt D^0) at intermediate p_T, similar at high p_T suggestive of participation of heavy quarks to the system collective motion and might thermalise

What have we learned from data?



R_{AA} central collisions



v_2 – semicentral HIC

CMS, B_c, Phys. Rev. Lett. 128, 252301 (2022)
CMS, v_2, N_{ch}, PLB 776 (2018) 195-216
CMS, v_2, non-prompt D^0, arXiv: 2212.01636
ALICE prompt D^0, JHEP 01 (2022) 174

- R_{AA} **hierarchy** at intermediate p_T, R_{AA}(ch/π) < R_{AA}(prompt D) < R_{AA}(non-prompt D/J/ψ,B^+) < R_{AA}(B_s) consistent with **parton mass energy loss dependence**
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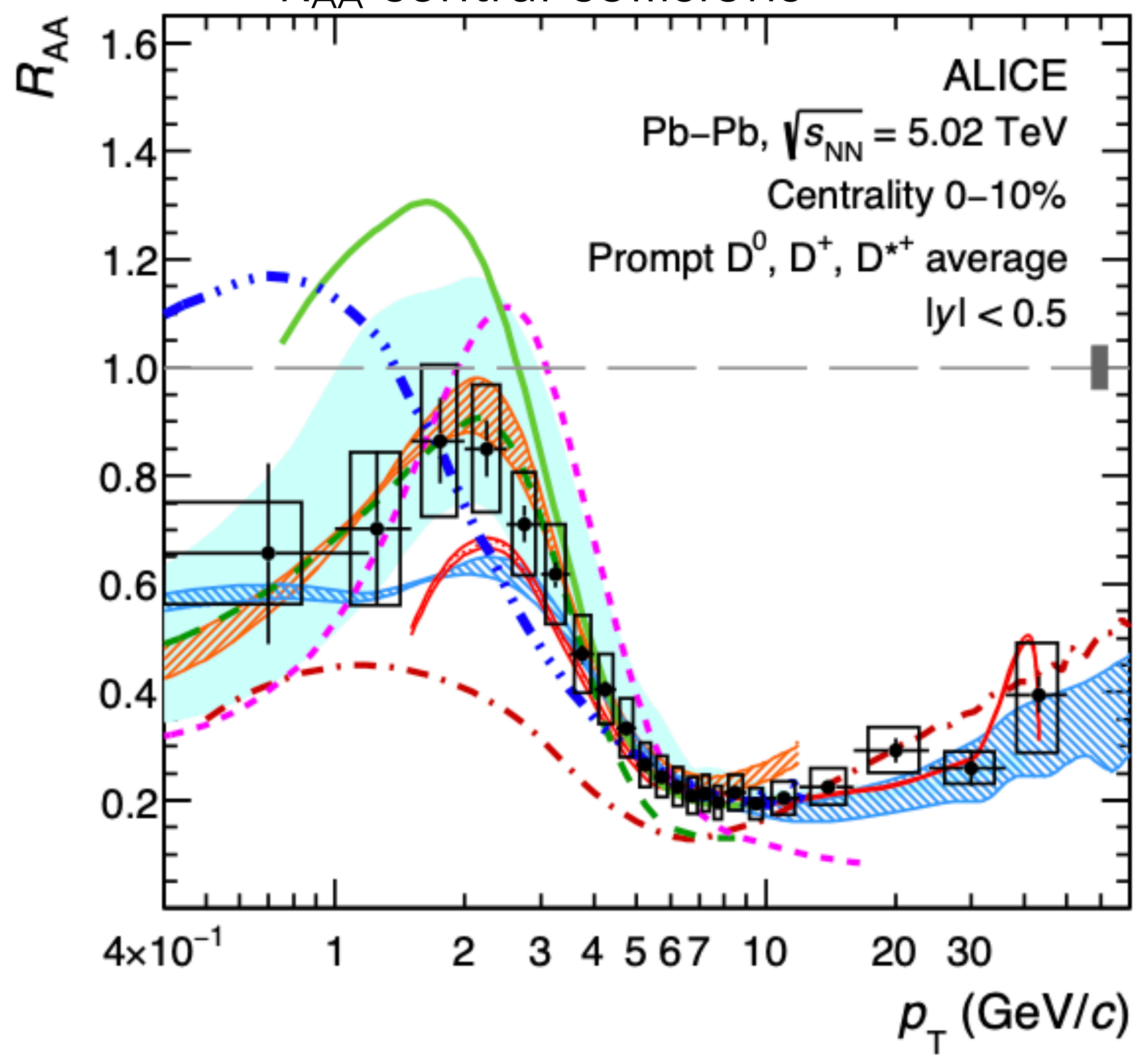
Going further, charm data-model comparison

R_{AA} central collisions



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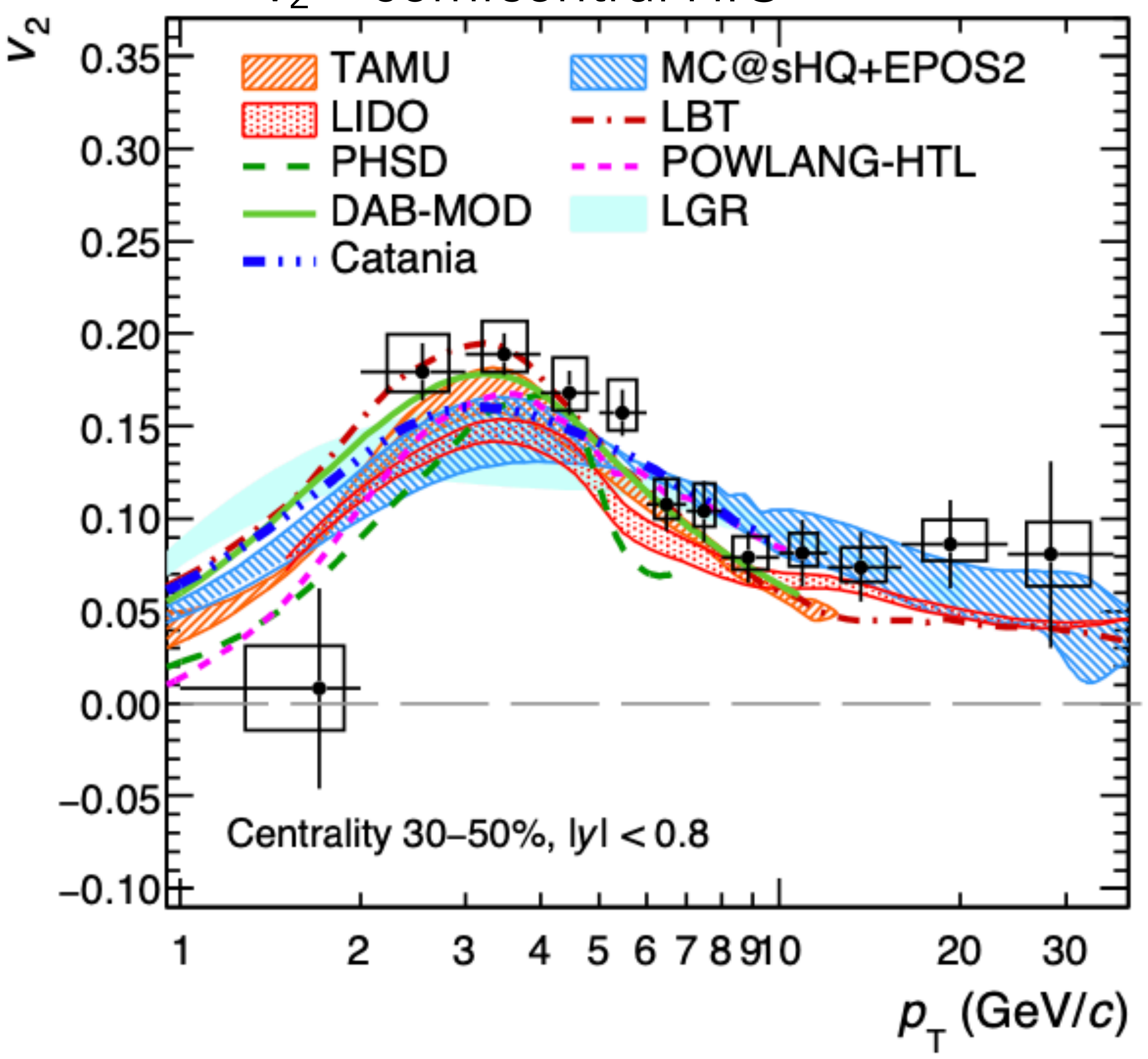


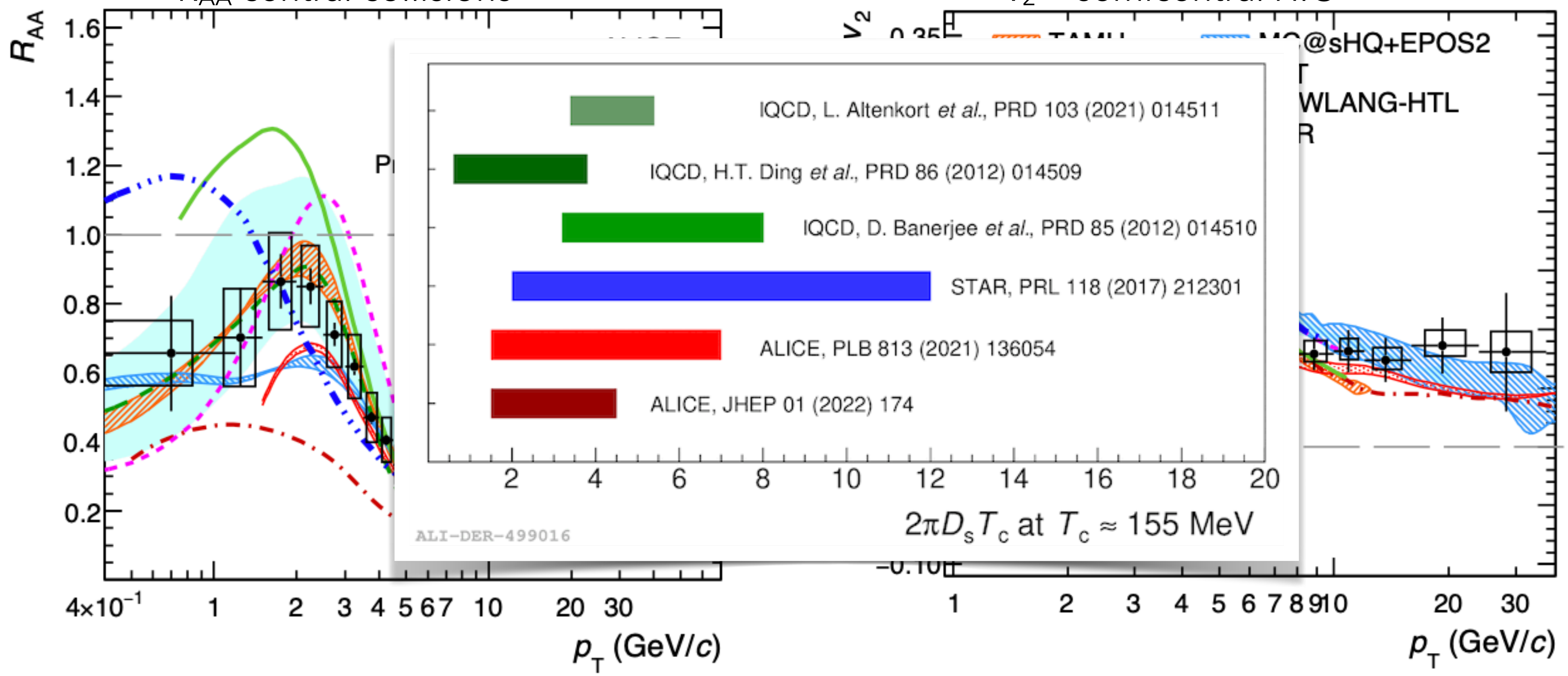
ALICE prompt D^0, JHEP 01 (2022) 174

ALICE, arXiv: 2211.04384

- Models shown here include: nPDF, collisional+radiative processes, hydrodynamic expansion, recombination
- Most models provide a **good description of both R_{AA} and v_2**
- **Data-model comparison set constraints on heavy quark spatial diffusion coefficient** $1.5 < 2\pi D_s T_c < 4.5$ at T_{pc} = 155 MeV
  → $\tau_{charm} = (m_{charm}/T) D_s(T) \approx$ 3-9 fm/c for m_c = 1.5 GeV

TAMU: He et al., PRL124 (2020) 042301
LIDO: Ke et al., PRC 100 n.6 (2019) 064911
PHSD: Song et al., Phys. Rev. C 92 (2015) 014910., Phys. Rev. C 96 (2017) 014905
DAB-MOD: Katz et al., PRC 102 n.2 (2020) 024906
LBT: Cao et al., PRC 94 n.1 (2016) 014909
POWLANG+HLT: EPJC 75 n.3 (2015) 121
LGR: Li et al., EPJC 80 (2020) 671, EPJC 80 (2020) 1113
MC@sHQ+EPOS2: Nahrgang et al., PRC 89 (2014) 014905
Catania: Scardina et al, PRC96 (2017) 044905

Going further, charm data-model comparison



ALICE prompt D^0, JHEP 01 (2022) 174

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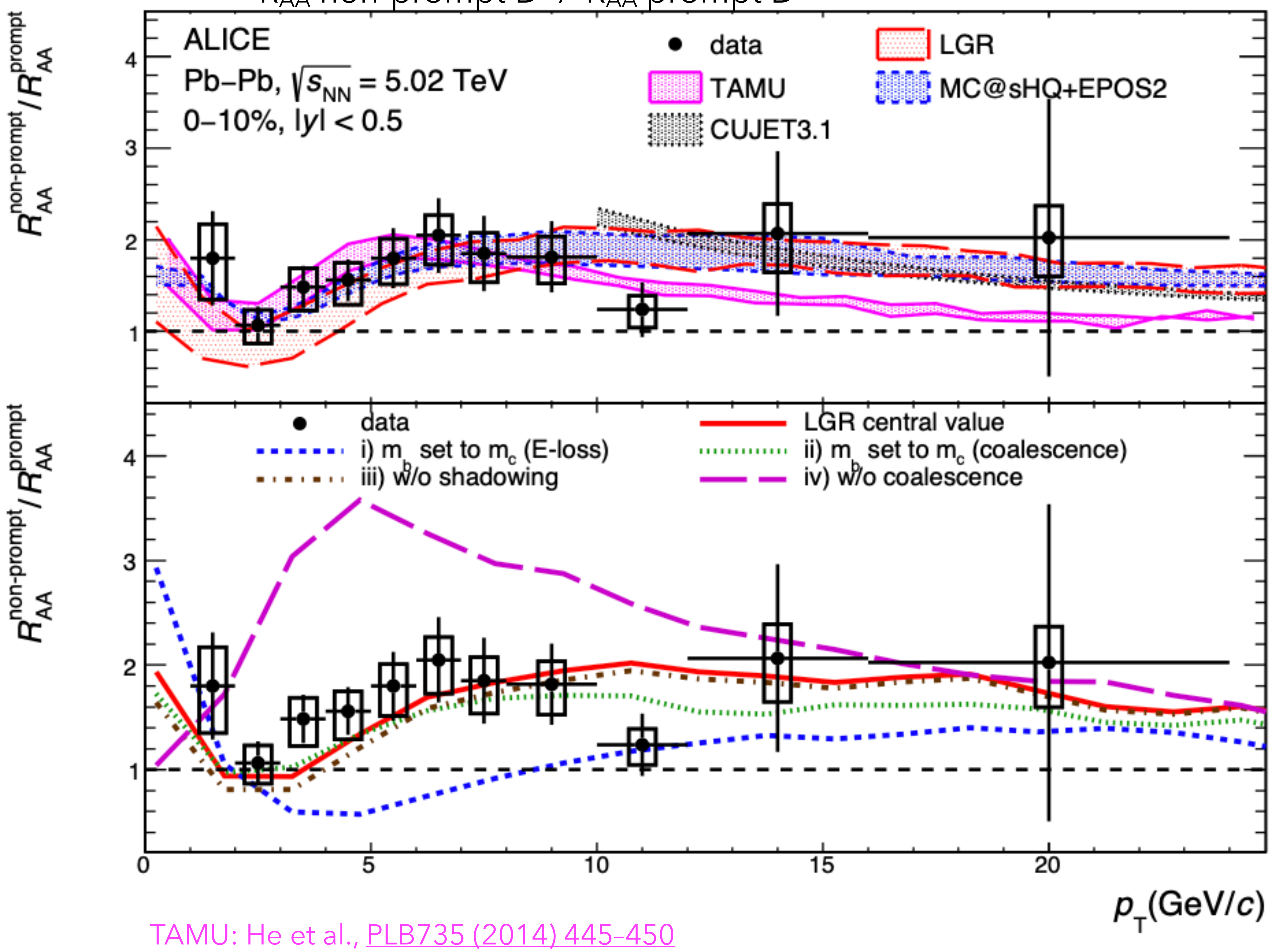
Catania: Scardina et al, PRC96 (2017) 044905

Going further, beauty/charm data-model comparison

R_{AA} non-prompt D^0 / R_{AA} prompt D^0



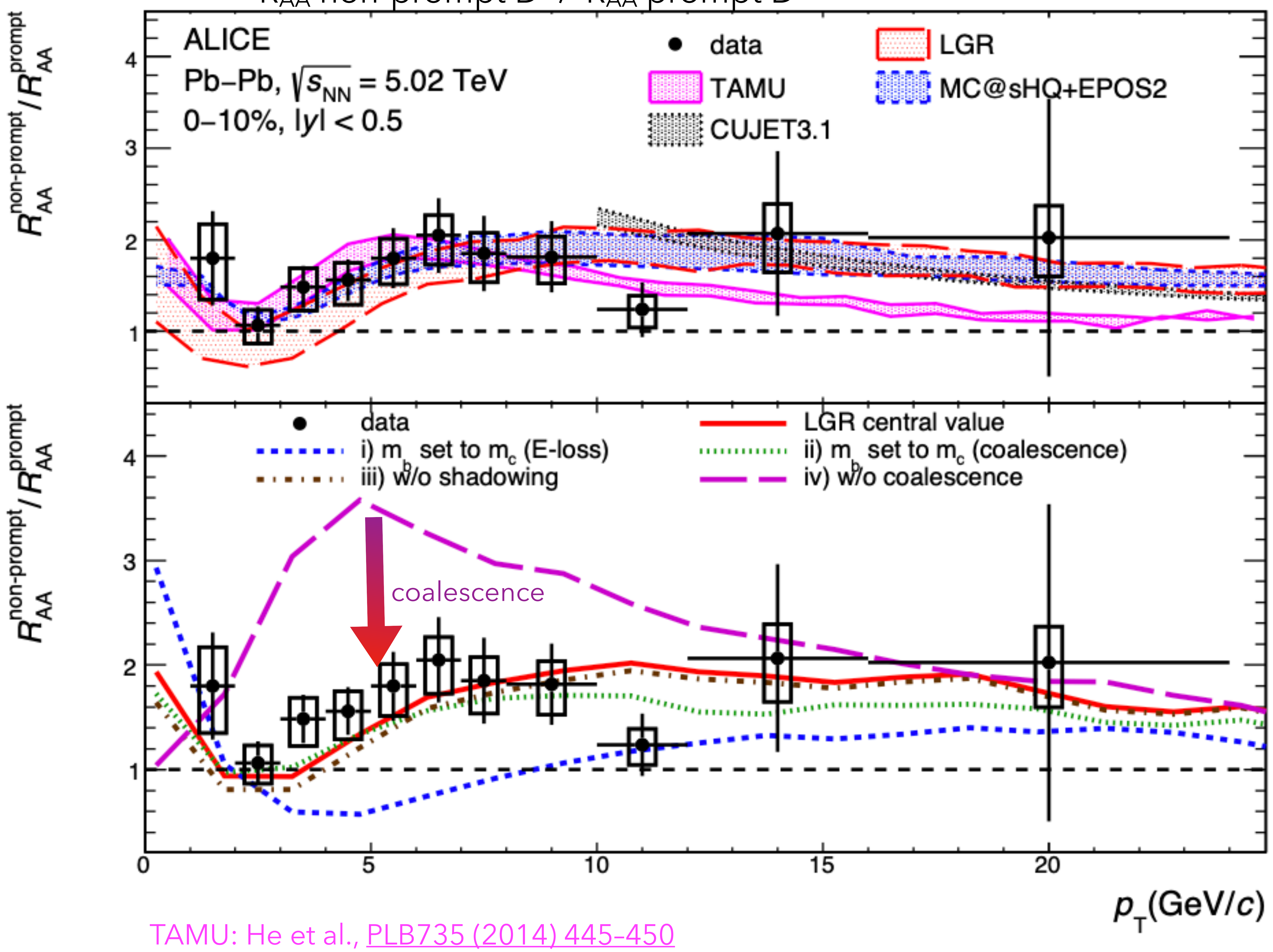
- R_{AA} (non-prompt D^0) for $p_T > 0$ is 1.00 ± 0.10 (stat.) ± 0.13 (syst.) $^{+0.08}_{-0.09}$ (extr.) ± 0.02 (norm.) in 0-10%
- For $p_T > 5$ GeV, the ratio is larger than unity → larger suppression of prompt D^0
- LGR model shows a strong influence of the **mass dependence** of parton energy loss and **coalescence**.

TAMU: He et al., PLB735 (2014) 445-450
CUJET: She et al., Chin. Phys. C 43 (2019) 044101
LGR: Li et al., EPJC 80 (2020) 671, EPJC 80 (2020) 1113
MC@sHQ+EPOS2: Nahrgang et al., PRC 89 (2014) 014905

ALICE prompt D^0, JHEP 01 (2022) 174
ALICE non-prompt D^0: JHEP 12 (2022) 126

Going further, beauty/charm data-model comparison

R_{AA} non-prompt D^0 / R_{AA} prompt D^0



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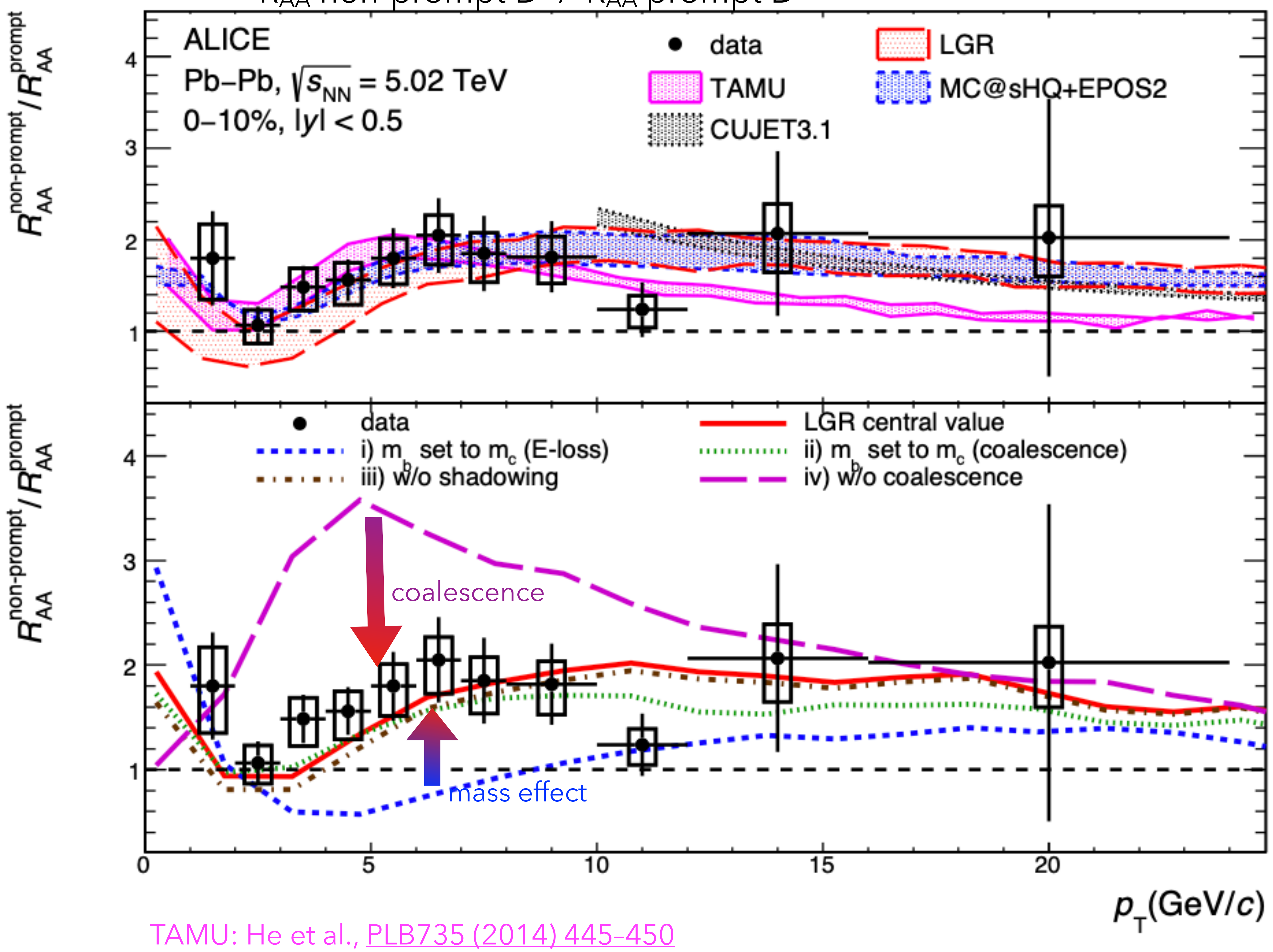
ALICE prompt D^0, JHEP 01 (2022) 174
ALICE non-prompt D^0: JHEP 12 (2022) 126

Going further, beauty/charm data-model comparison

R_{AA} non-prompt D^0 / R_{AA} prompt D^0



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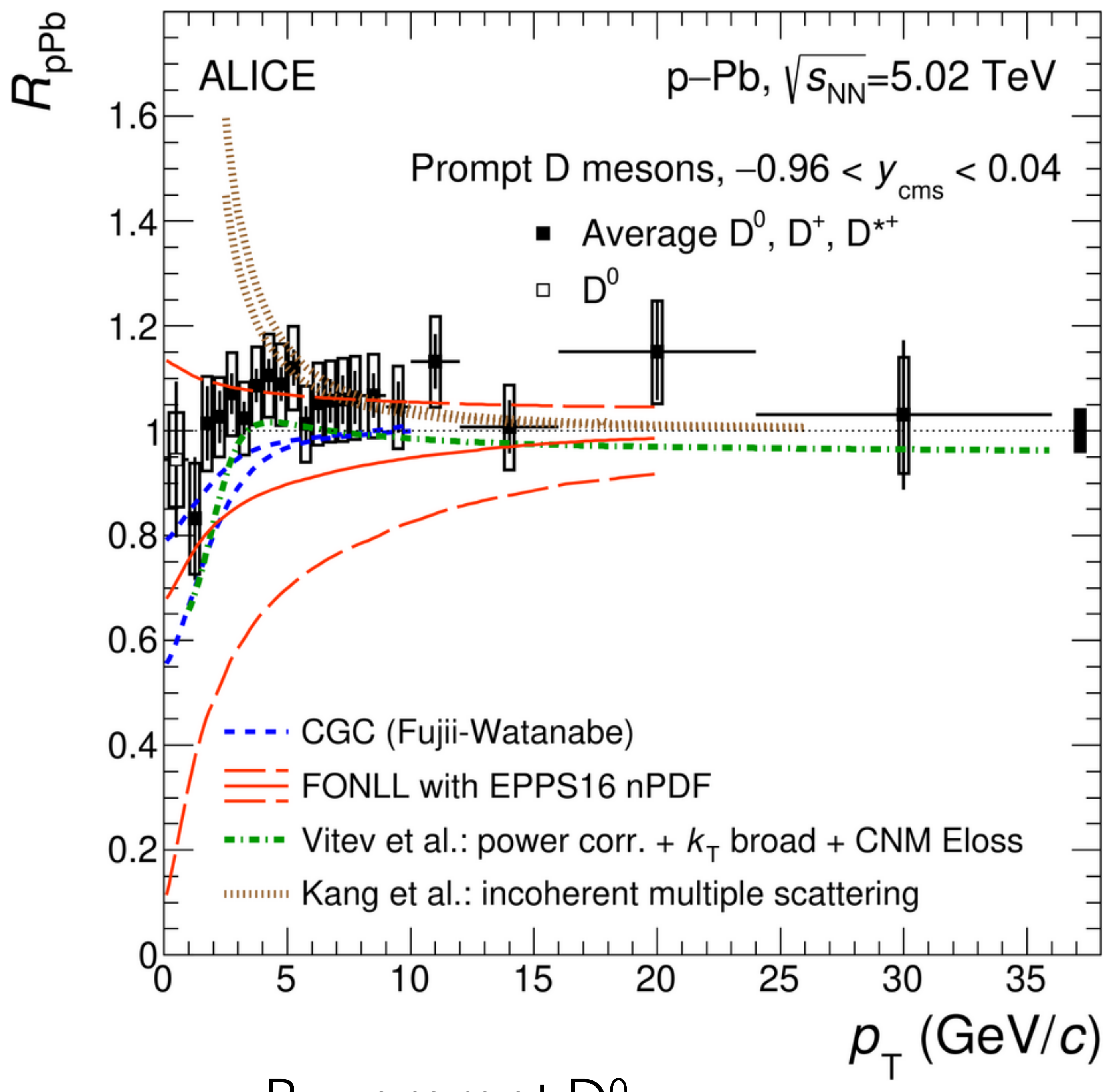
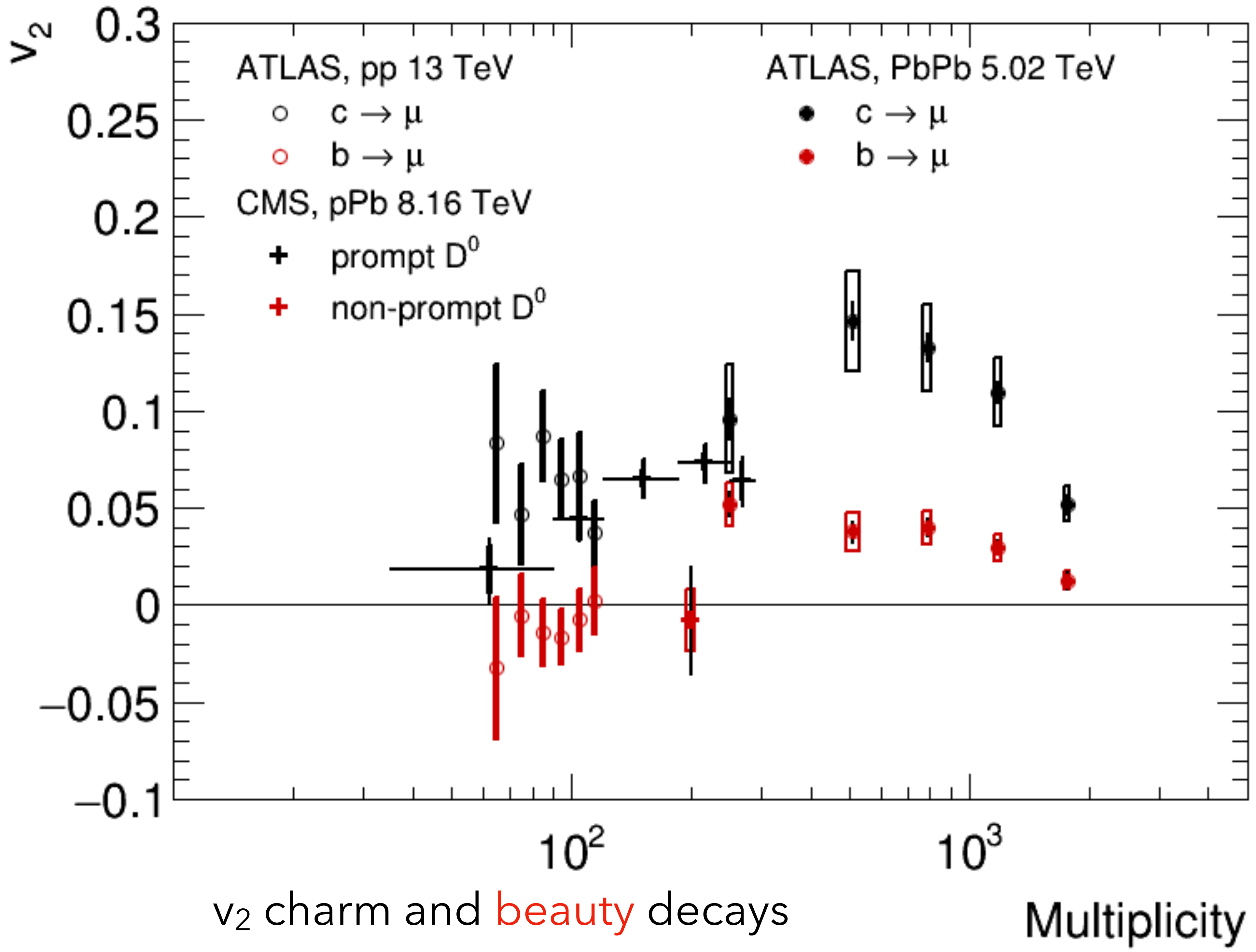
MC@sHQ+EPOS2: Nahrgang et al., PRC 89 (2014) 014905

ALICE prompt D^0, JHEP 01 (2022) 174
ALICE non-prompt D^0: JHEP 12 (2022) 126

Moving to smaller systems?



R_{AA} prompt D^0



v_2 charm and beauty decays

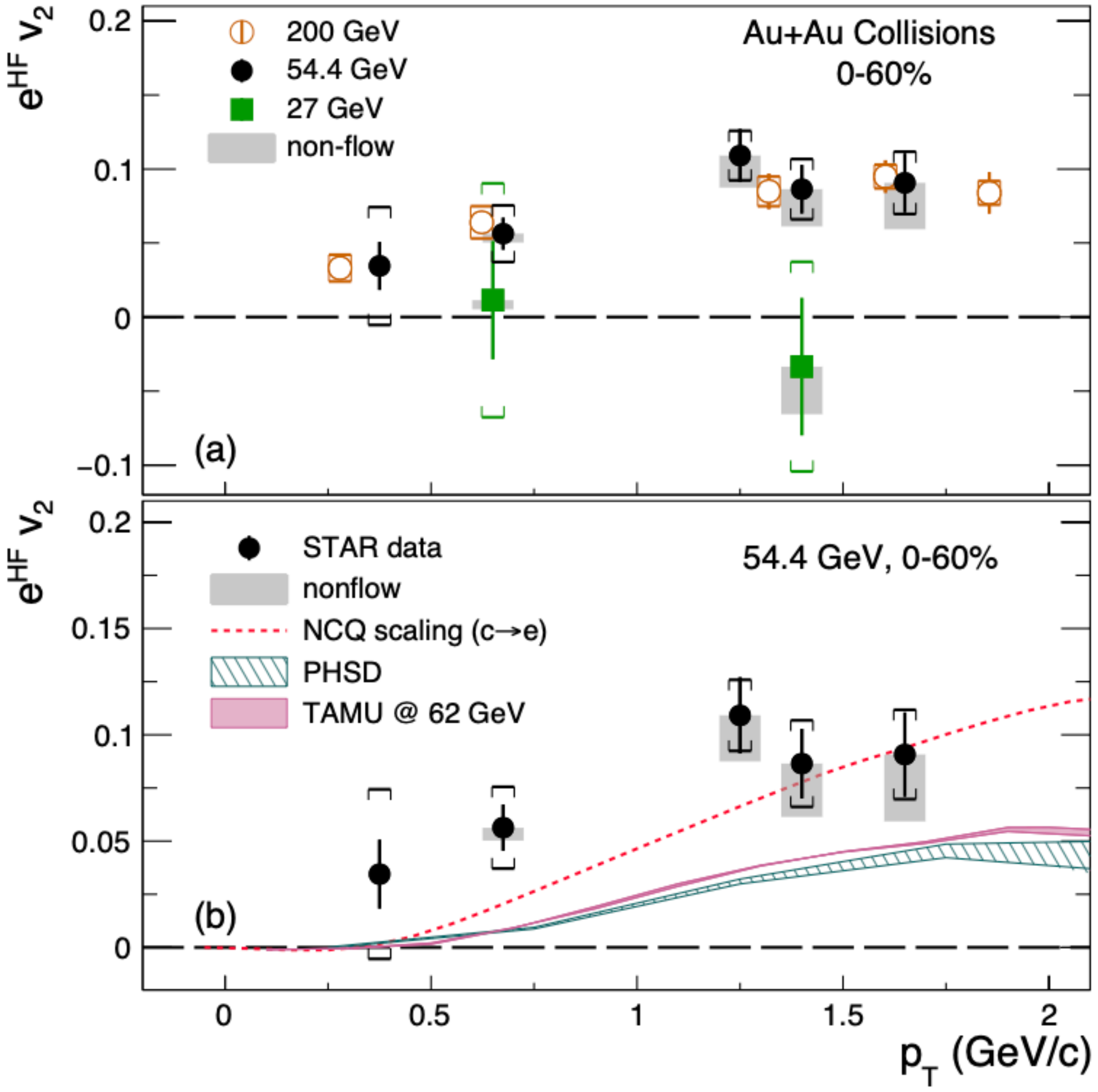
- Charm hadron spectra does not present strong modifications in pPb wrt pp, but those expected from nPDF/saturation.
- Heavy flavour **v_2 follows a smooth evolution** with charged-particle multiplicity
  - non-zero values for charm in pp and pPb collisions
  - important role of initial state effects and/or influence of final state effects?

ATLAS, pp, PRL 124 (2020) 082301
ATLAS, PbPb, PLB 807 (2020) 135595
CMS, pPb, prompt D^0, PRL 121 (2018) 8, 082301
CMS, pPb, non-prompt D^0, PRL 813 (2021) 136036
ALICE, pPb, JHEP 2019 (2019) 92
LHCb, D^0, arXiv:2205.03936

Moving to lower energy?

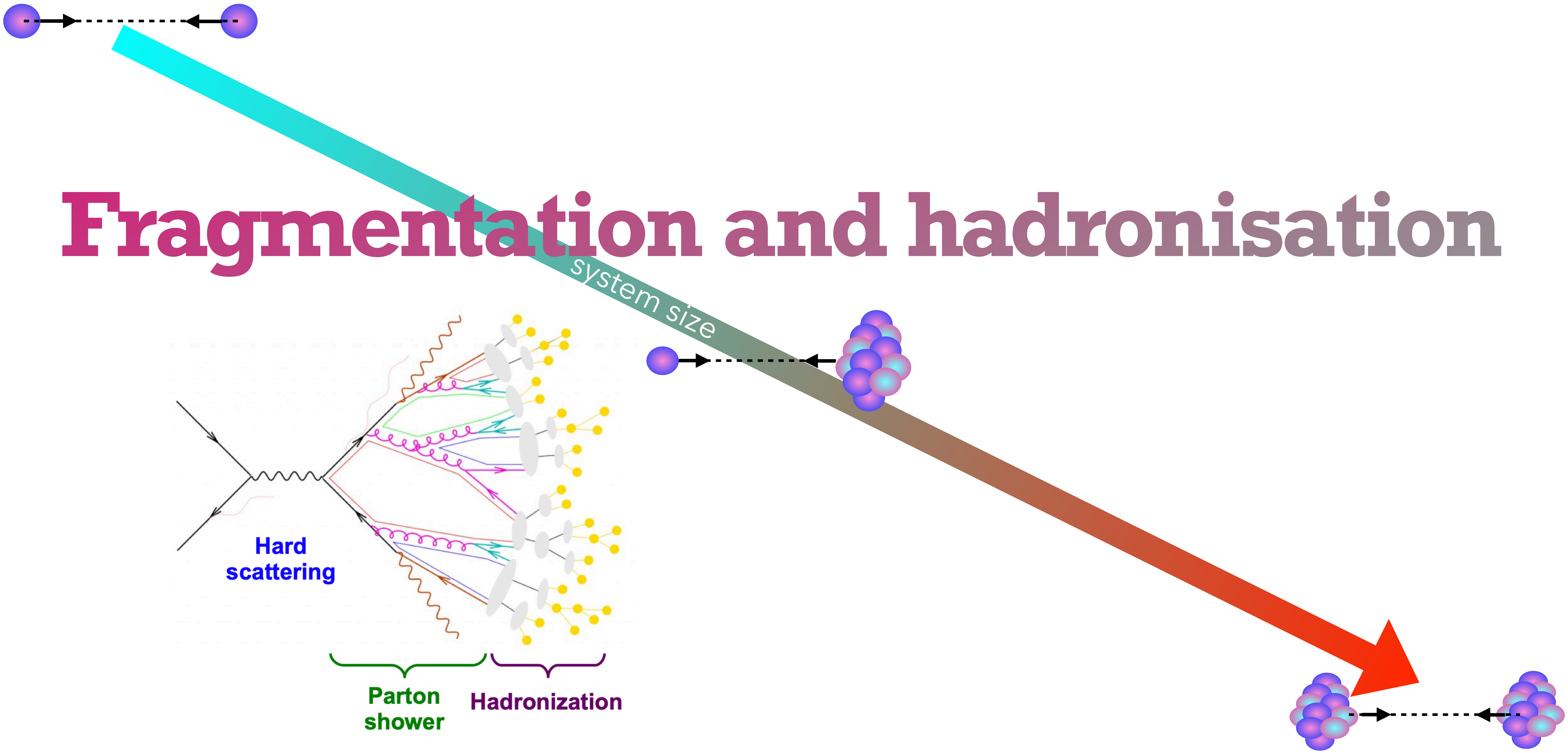
- Heavy-flavour decay electron v_2 is consistent with zero at 27 GeV, whereas **v_2 at 54.4 GeV is non-zero and consistent with that at 200 GeV**.
- TAMU and PHSD calculations underestimate it.
- Trend consistent with number of constituent quark scaling (NCQ) estimate.
- Suggest that charm quarks participate to the collective motion of the medium and might reach local thermal equilibrium.

STAR, arXiv:2303.03546



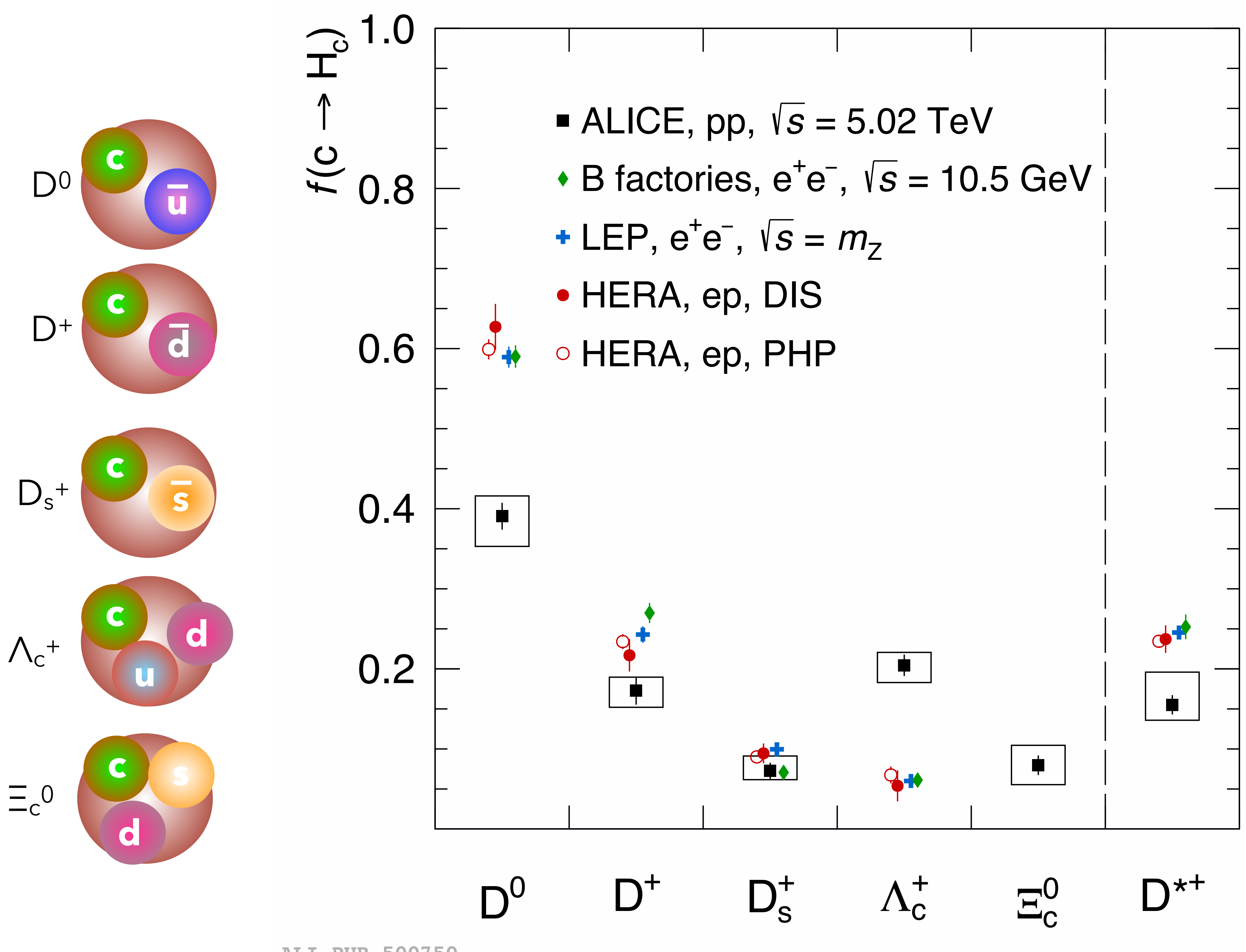
TAMU: He et al., Phys. Rev. C 91 (2015) 024904.
PHSD: Song et al., Phys. Rev. C 92 (2015) 014910., Phys. Rev. C 96 (2017) 014905

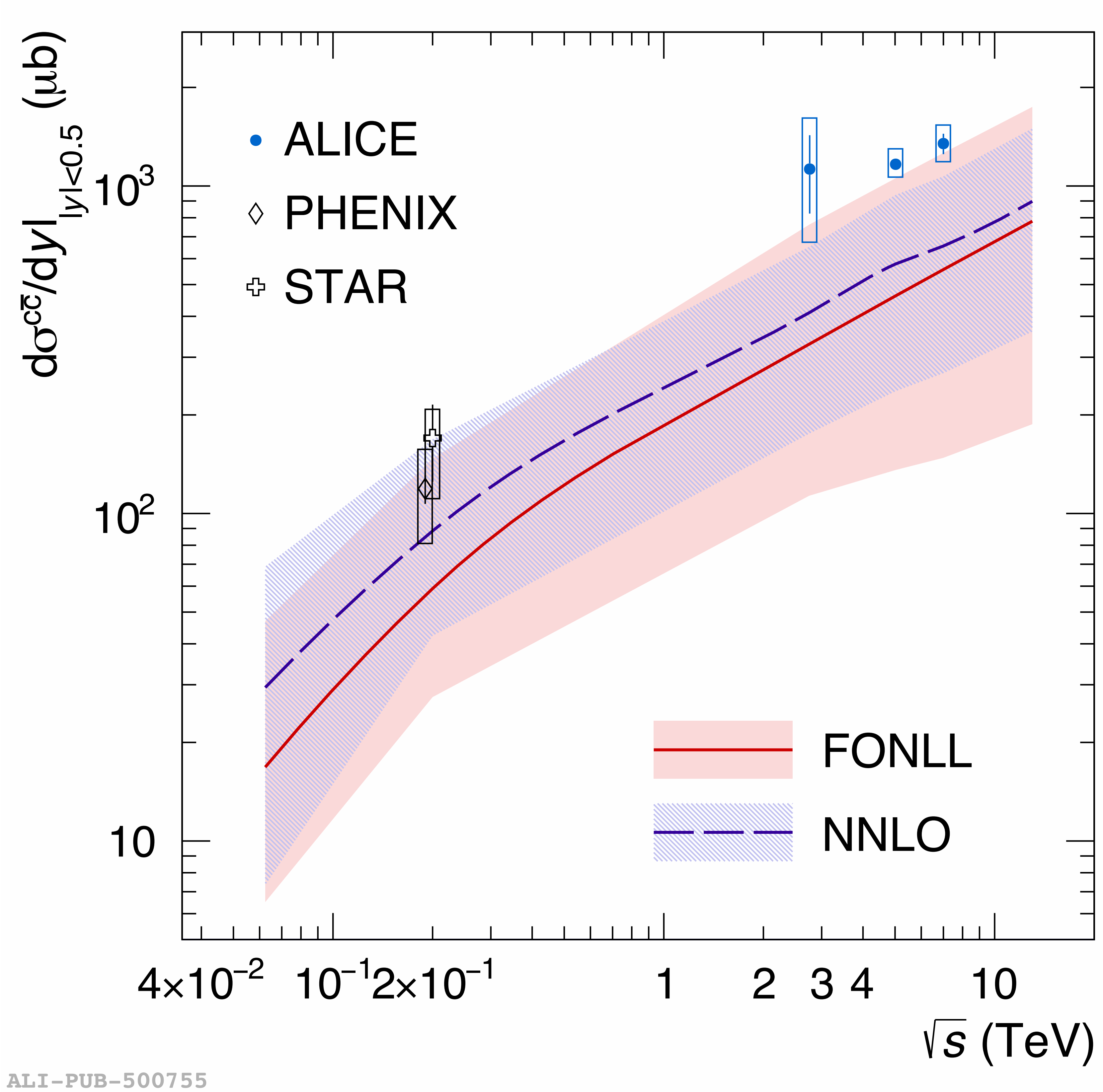
Fragmentation and hadronisation



Unexpected charm fragmentation fractions in pp

- **Significant difference of the charm fragmentation fractions in pp vs. e^+e^- and ep collisions**. Evidence of the dependence of the parton-to-hadron fragmentation fractions on the collision system. Universality?
- Updated total charm cross section calculation, ~40% higher than the previously published results. The data lie at the upper edge of the theoretical pQCD bands.





ALICE, Phys. Rev. D 105 (2022) L011103

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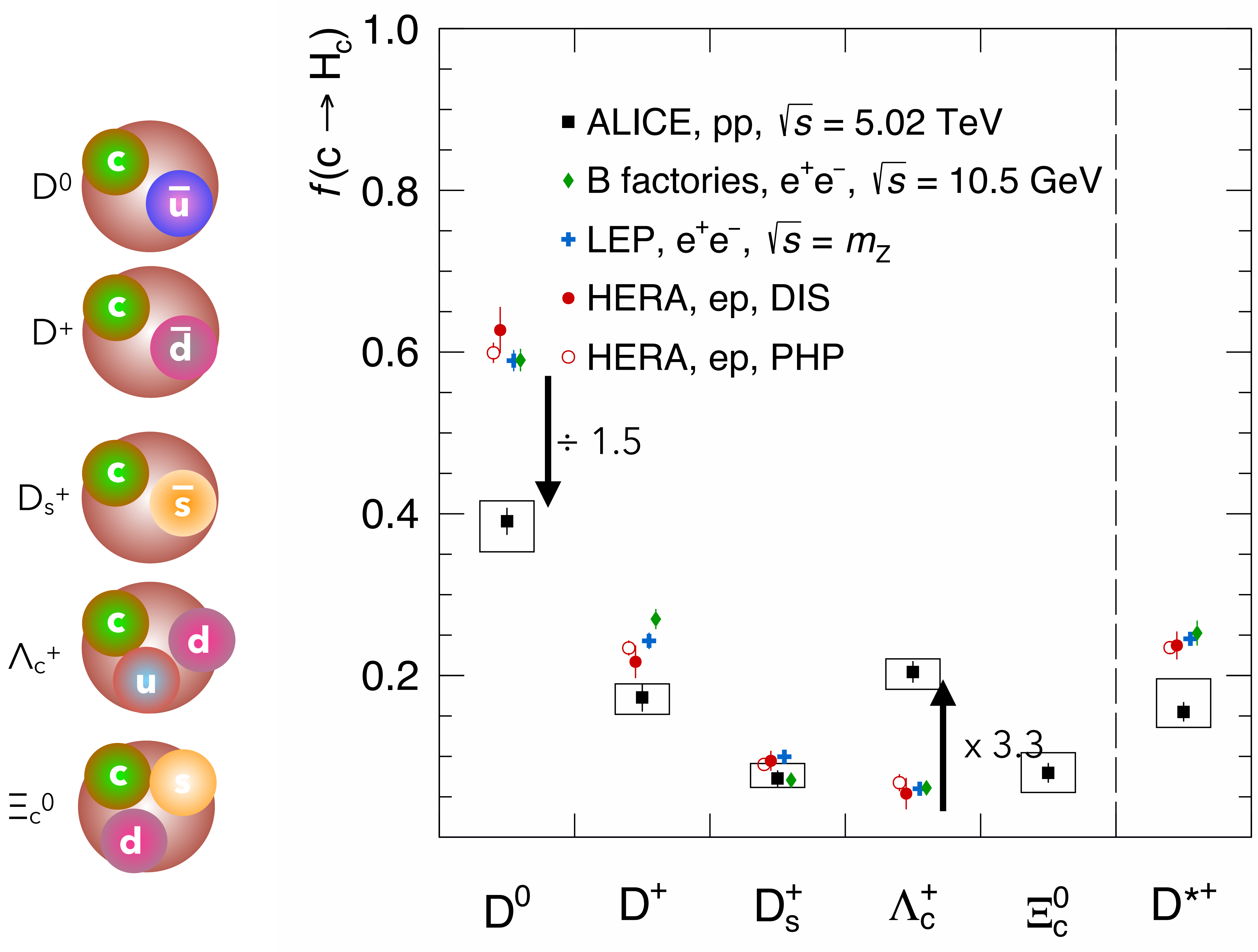
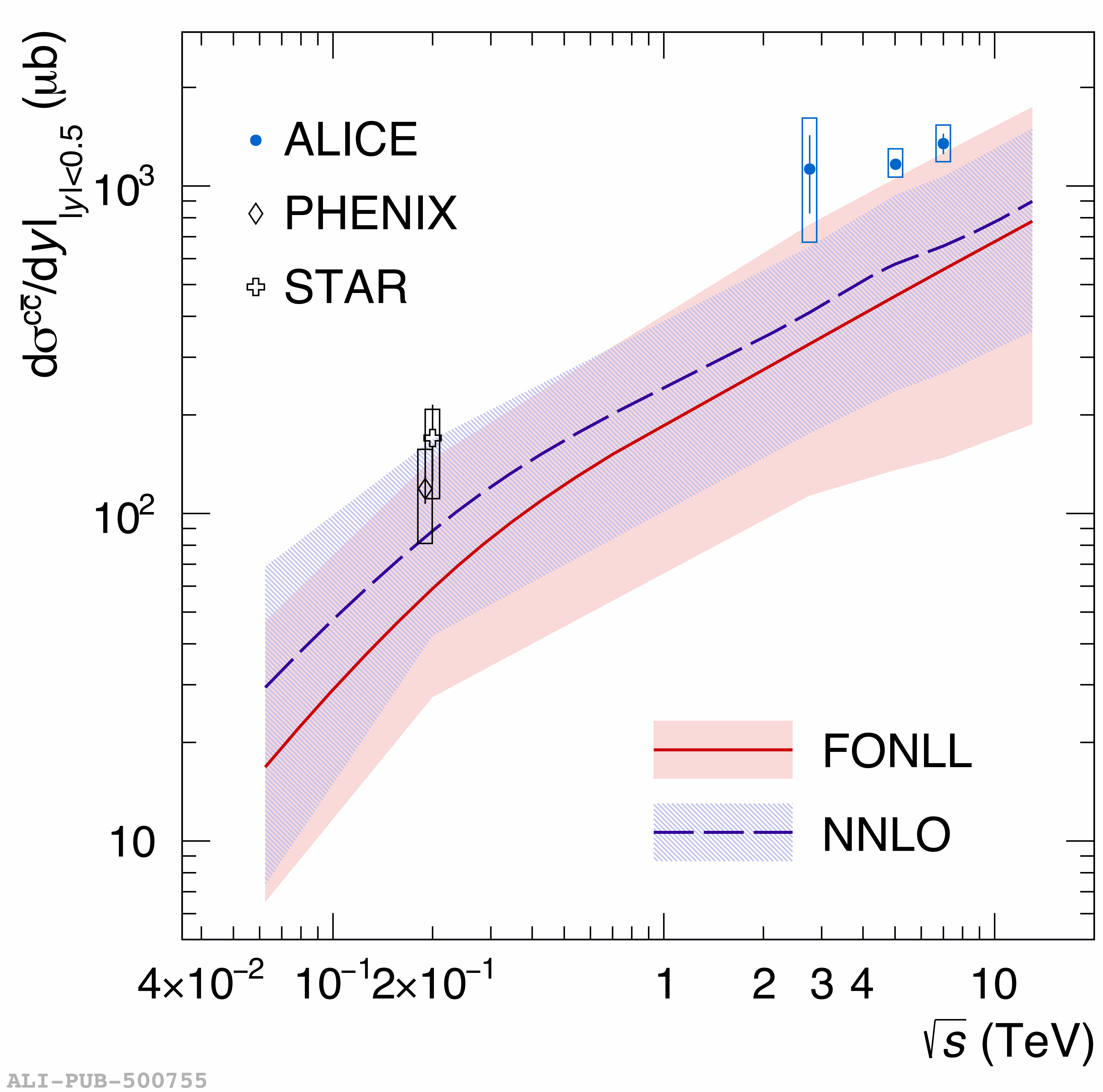
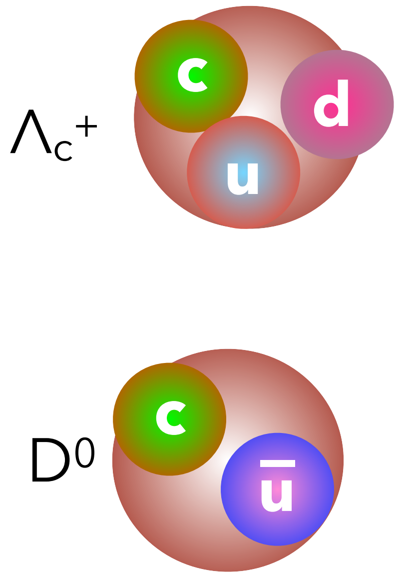


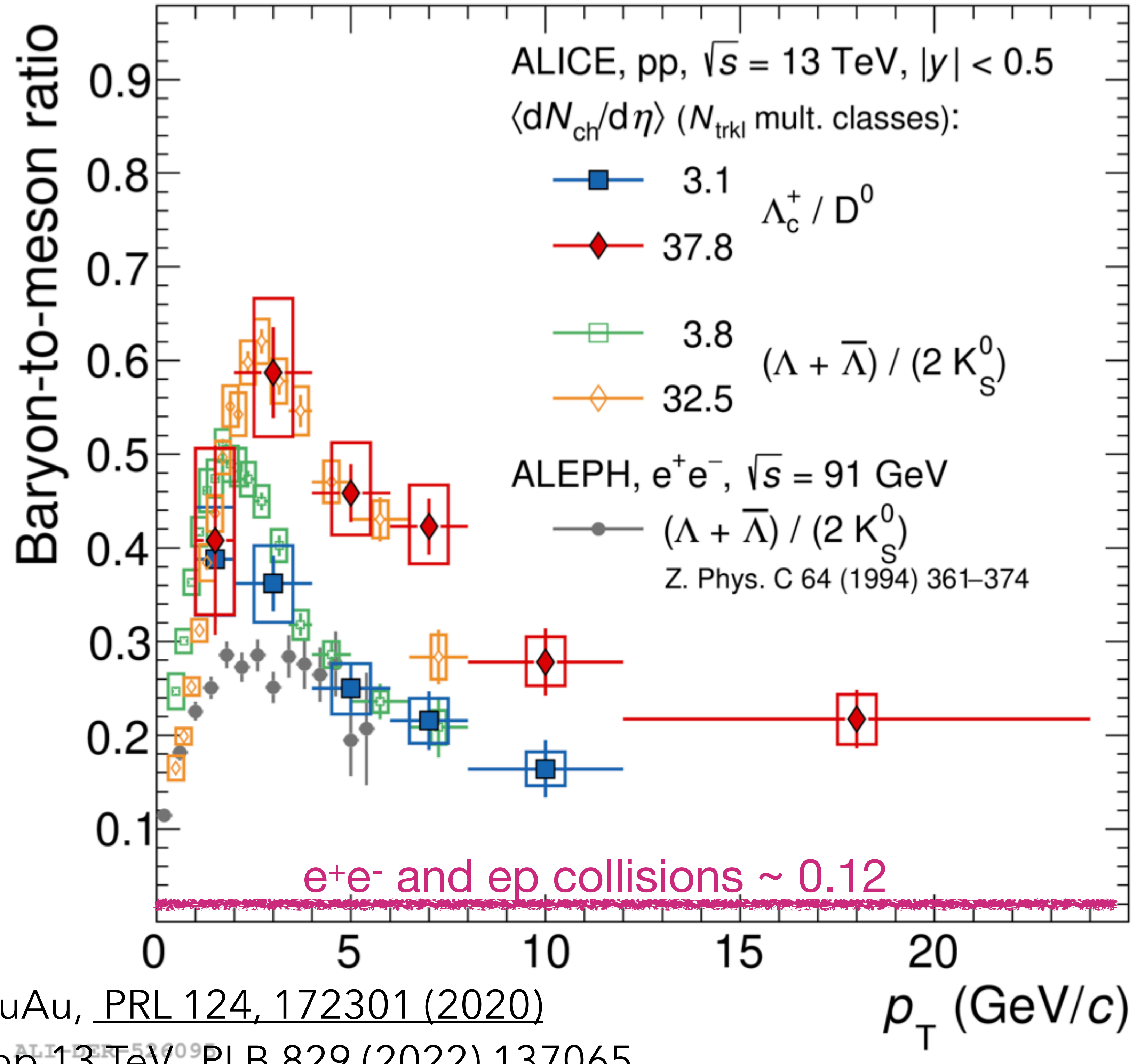


ALICE, Phys. Rev. D 105 (2022) L011103

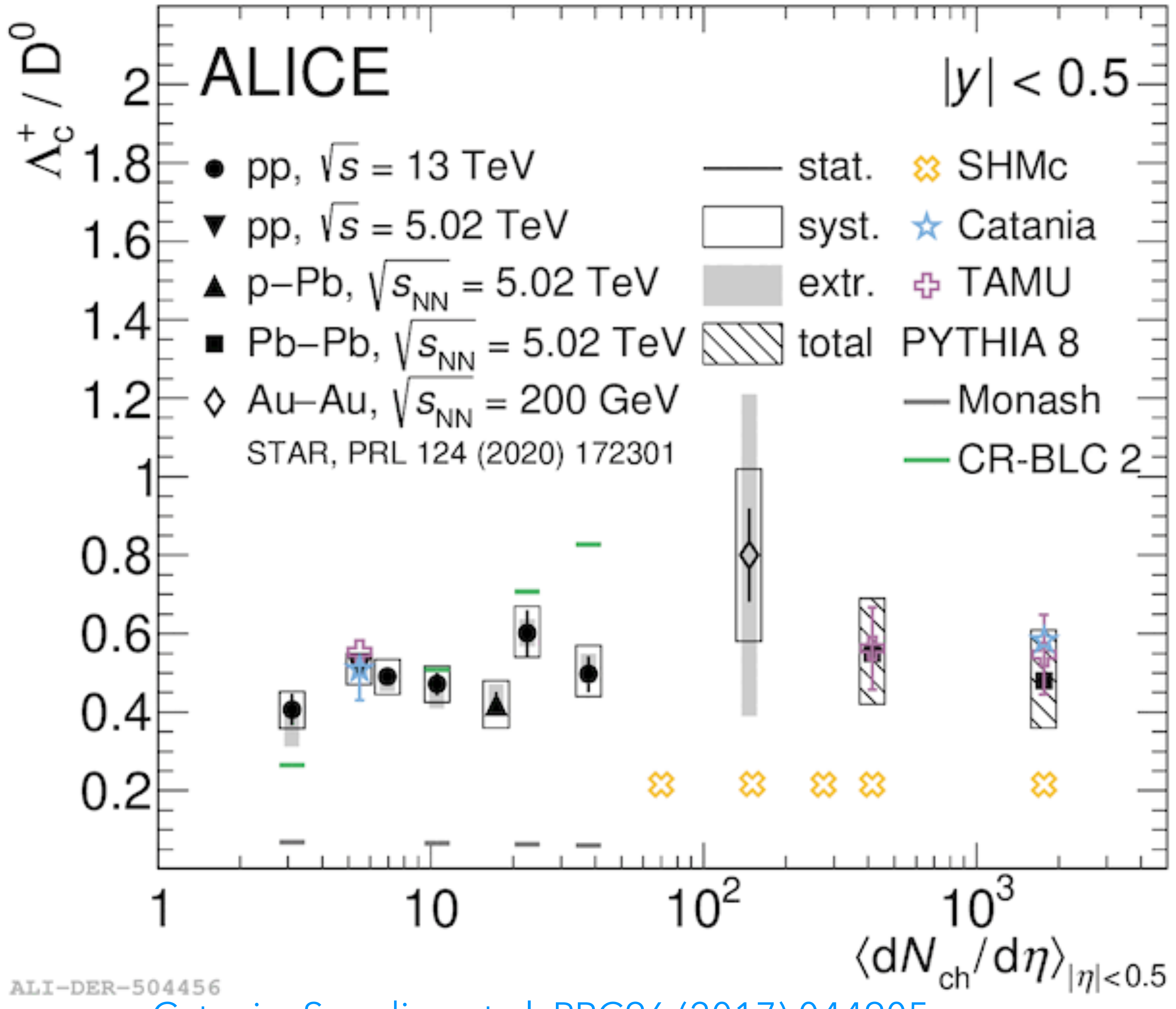
Similar influence for charm baryons and mesons (pp)?

- Observed a **strong p_T dependence of the baryon-to-meson ratios in the charm sector**, similar to that observed in the light-flavour sector.
- **Likely due to a redistribution of momentum**, rather than to an overall enhancement of baryon yield.



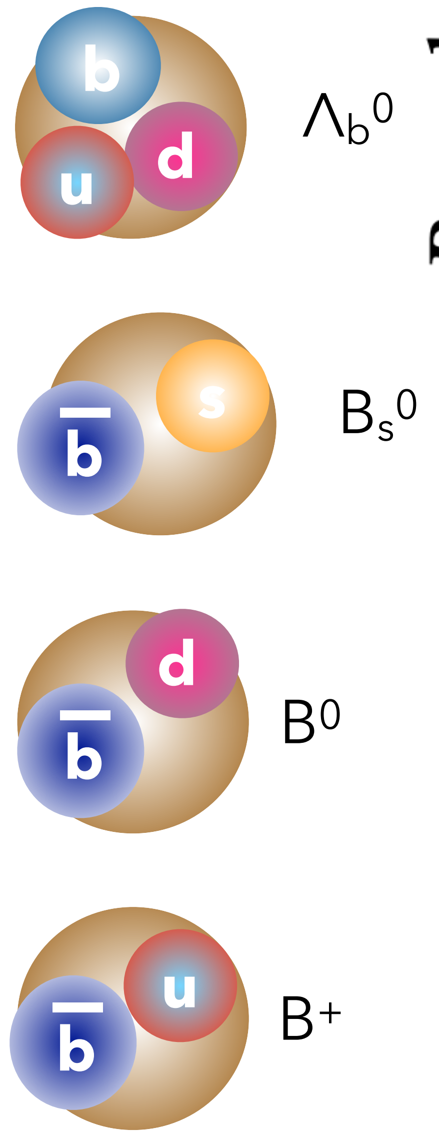


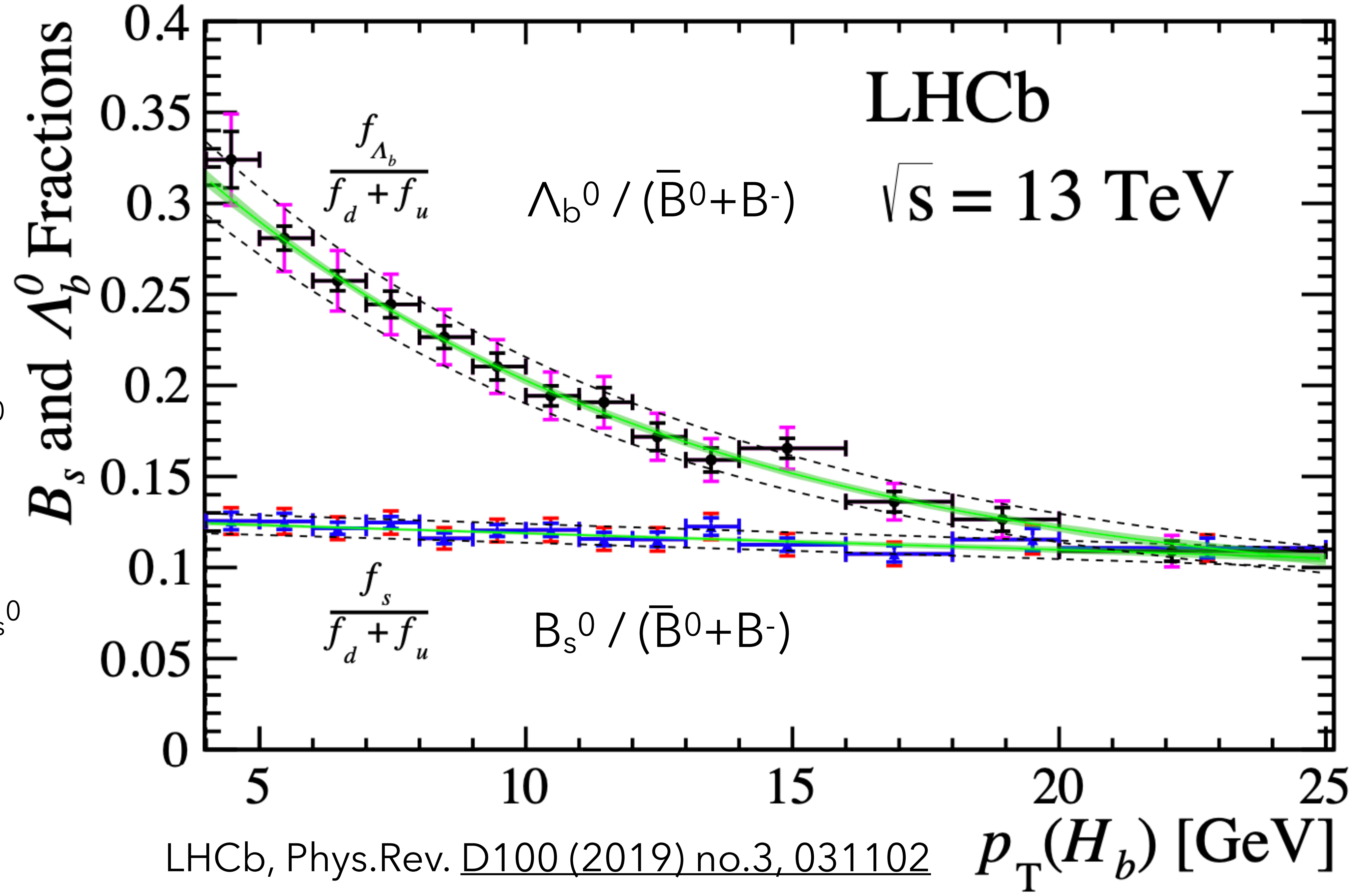
STAR, AuAu, PRL 124, 172301 (2020)
ALICE, pp 13 TeV, PLB 829 (2022) 137065
ALICE pp pPb 5 TeV, PRC 104 (2021) 054905
ALICE, PbPb, arXiv:2112.08156



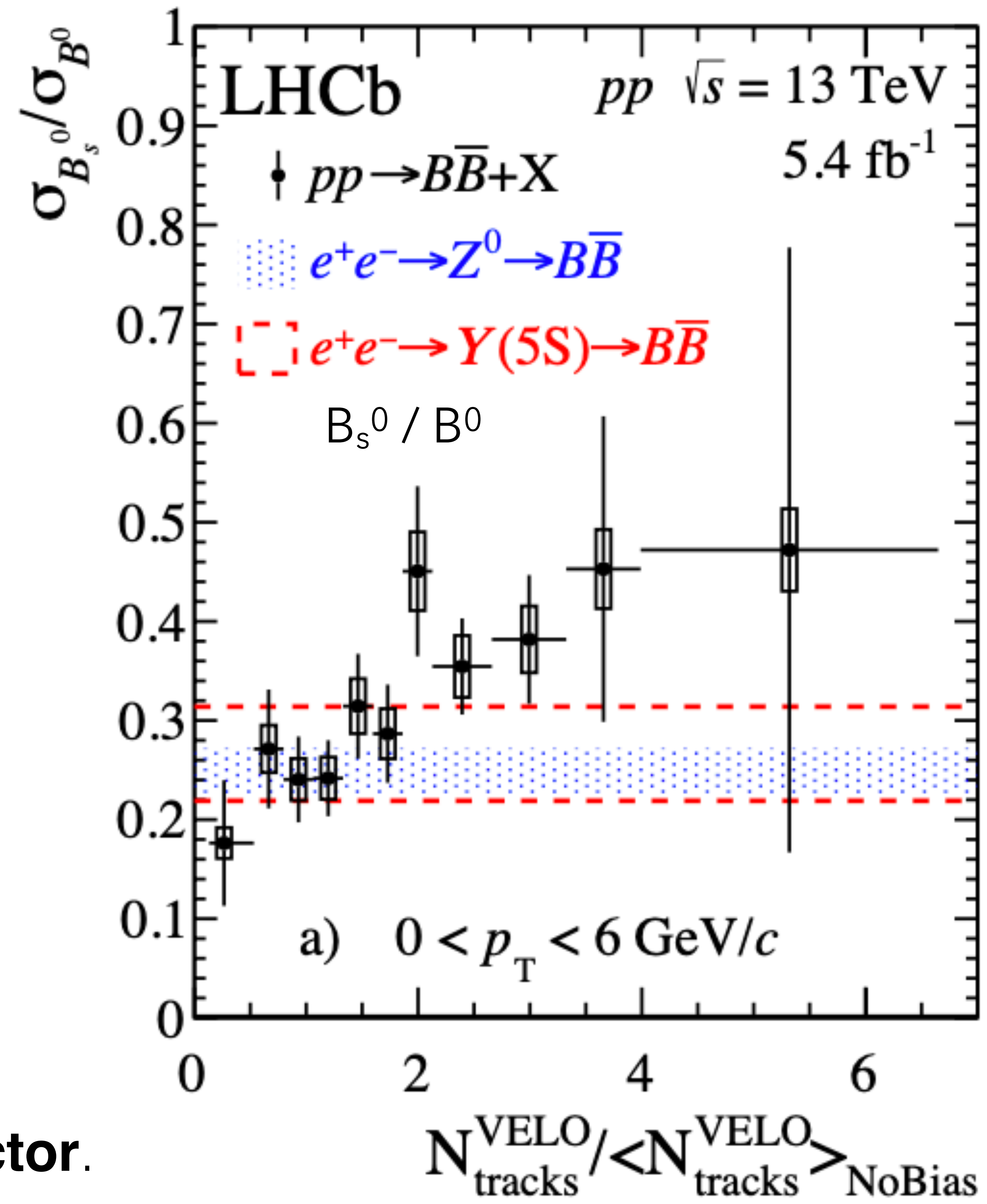
Catania: Scardina et al, PRC96 (2017) 044905
SHMc: Andronic et al. JHEP 07 (2021) 35
TAMU: He et al, PRL 124 (2020) 042301
Monash; P. Skands, et al, Eur.Phys.J.C74 n.8 (2014) 3024
CR-BLC; JR Christiansen, et al, JHEP 08 (2015) 003

Similar influence for beauty baryons and mesons (pp)?



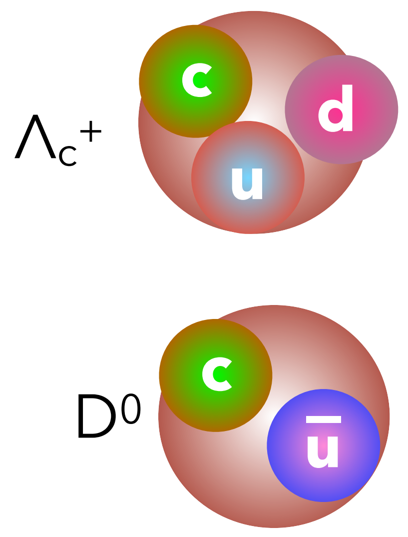


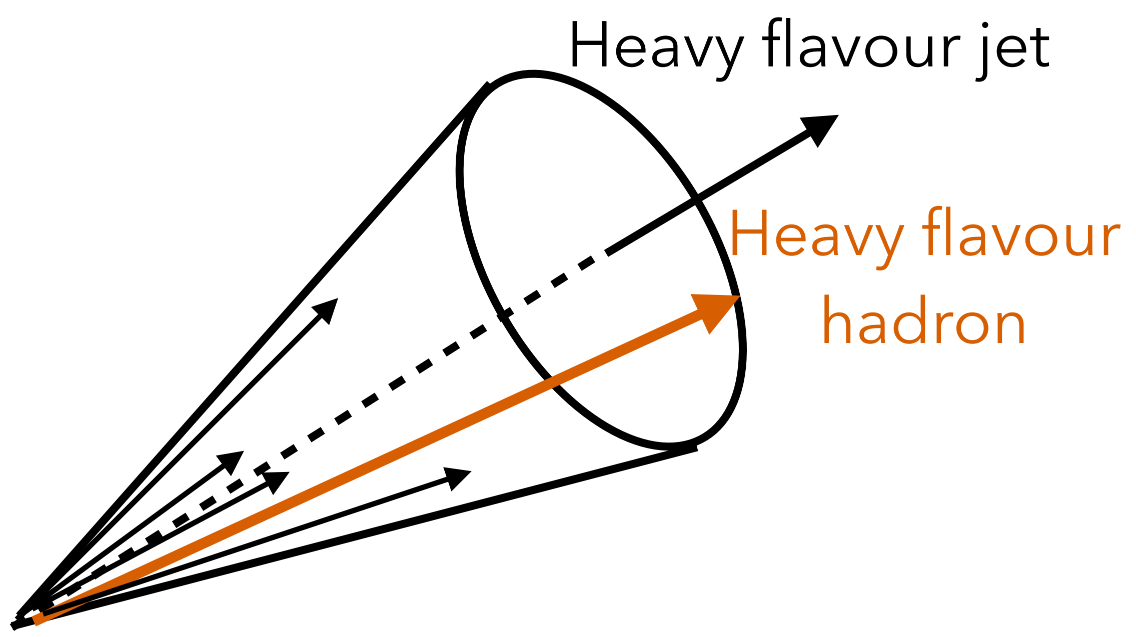
LHCb, Phys.Rev. D100 (2019) no.3, 031102
CDF, Phys.Rev.D77:072003,2008
LHCB-PAPER-2022-001, arXiv: 2204.13042



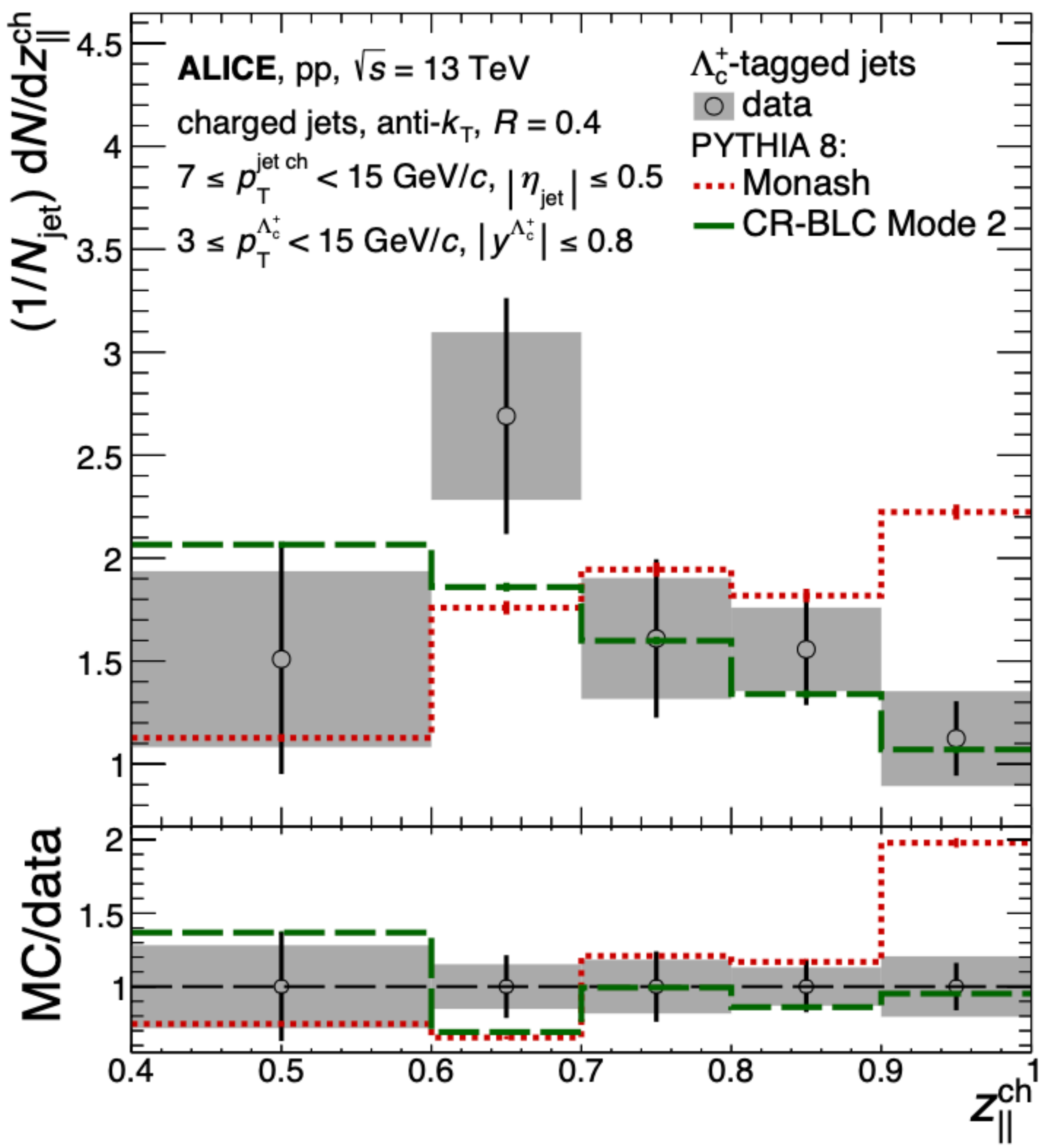
- Similar findings **observed by CDF and LHCb in the beauty sector**.
- Strong p_T dependence of the baryon-to-meson ratios.
- **Evolution of B_s^0/B^0 with charged-particle multiplicity at low p_T, no dependence at intermediate-to-large p_T.**
- Expected in a scenario where low-p_T production is affected by **coalescence**, whereas high p_T is dominated by vacuum **fragmentation**.

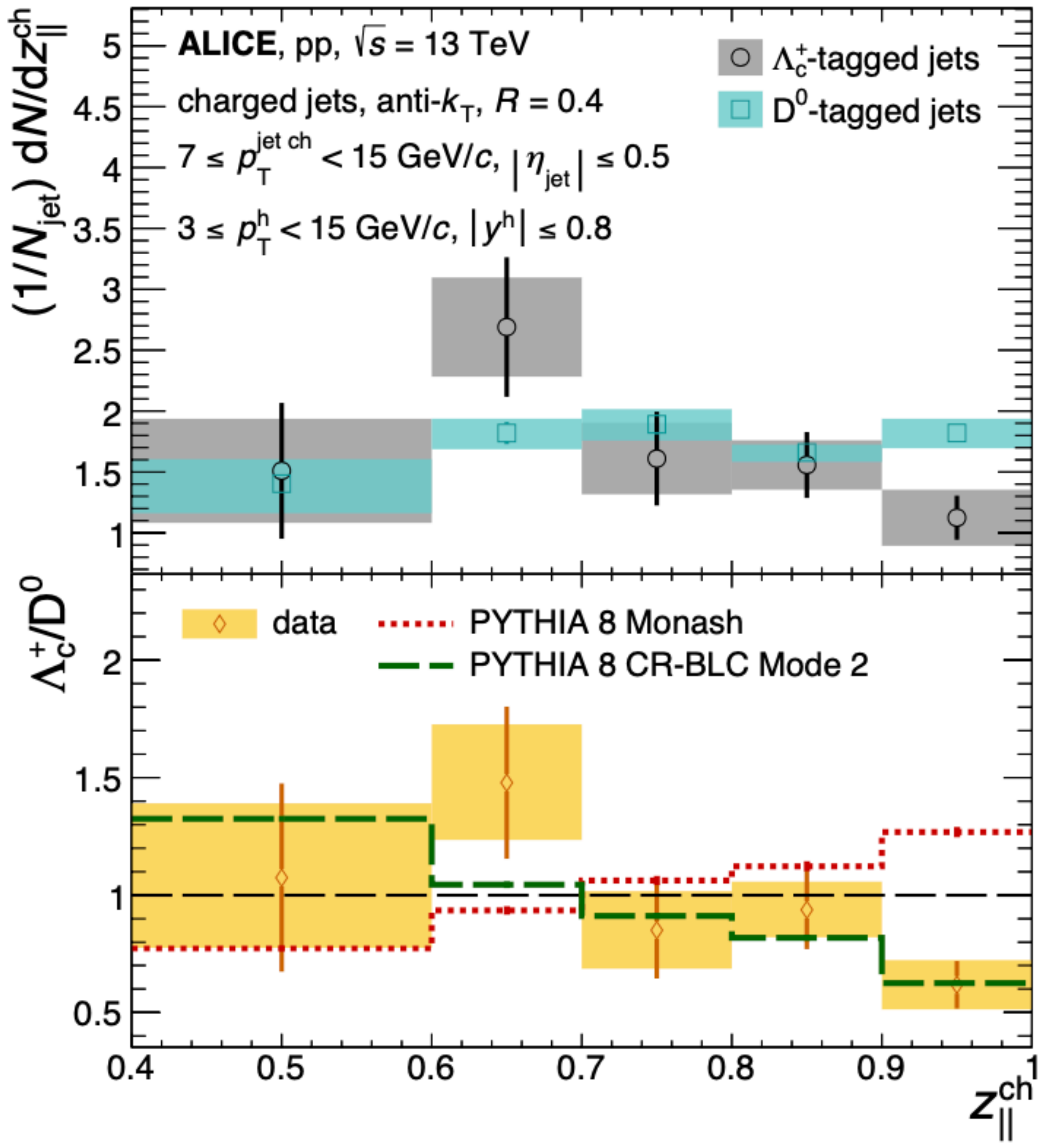
Can charm-jet studies help constrain hadronisation (pp)?





$$z_{||}^{ch} = \frac{\mathbf{p}_{jet} \cdot \mathbf{p}_{HF}}{\mathbf{p}_{jet} \cdot \mathbf{p}_{jet}}$$





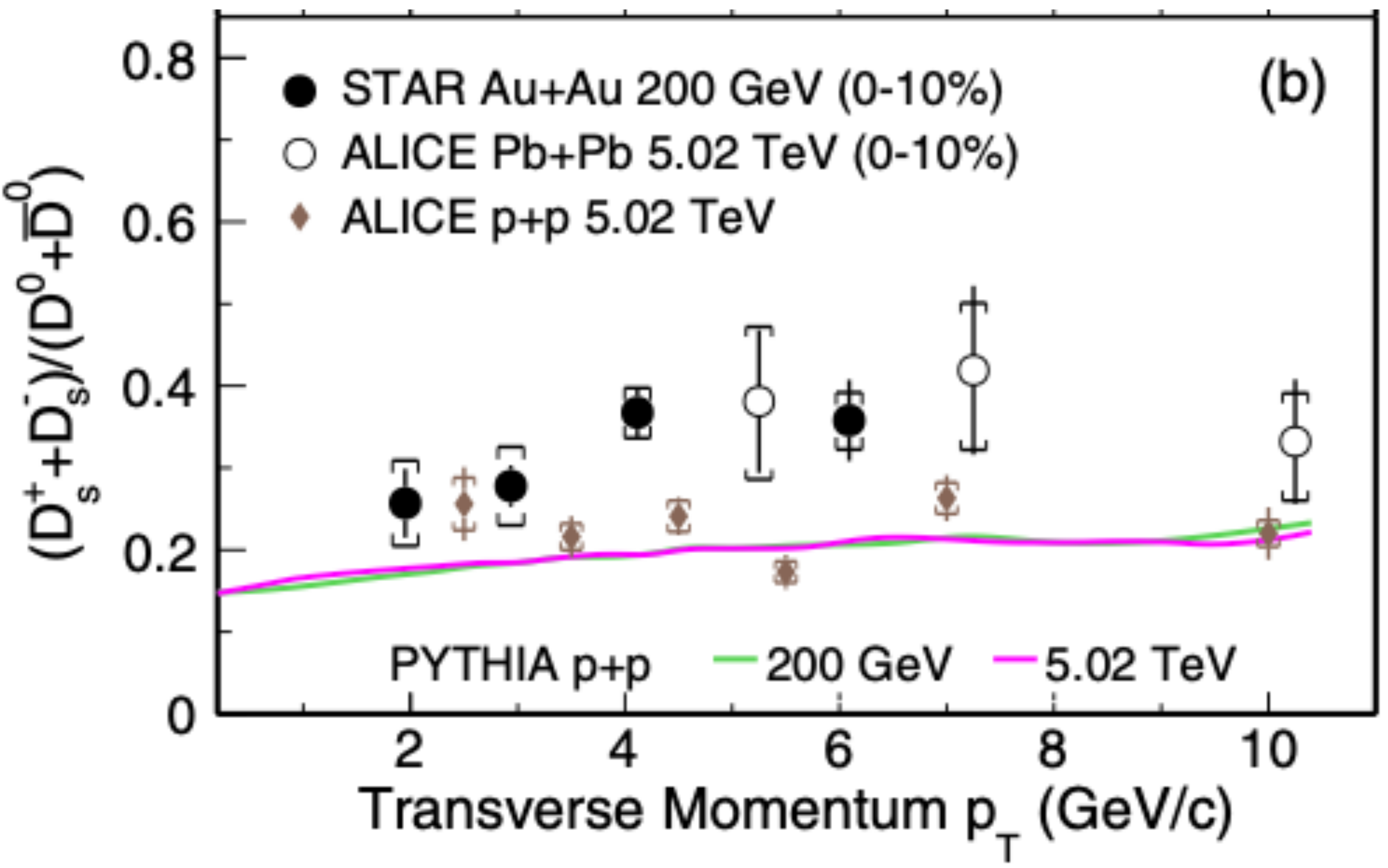
Fraction of the jet momentum carried by the particle along the direction of the jet axis

ALICE, arXiv: 2301.13798
ALICE, arXiv: 2204.10167

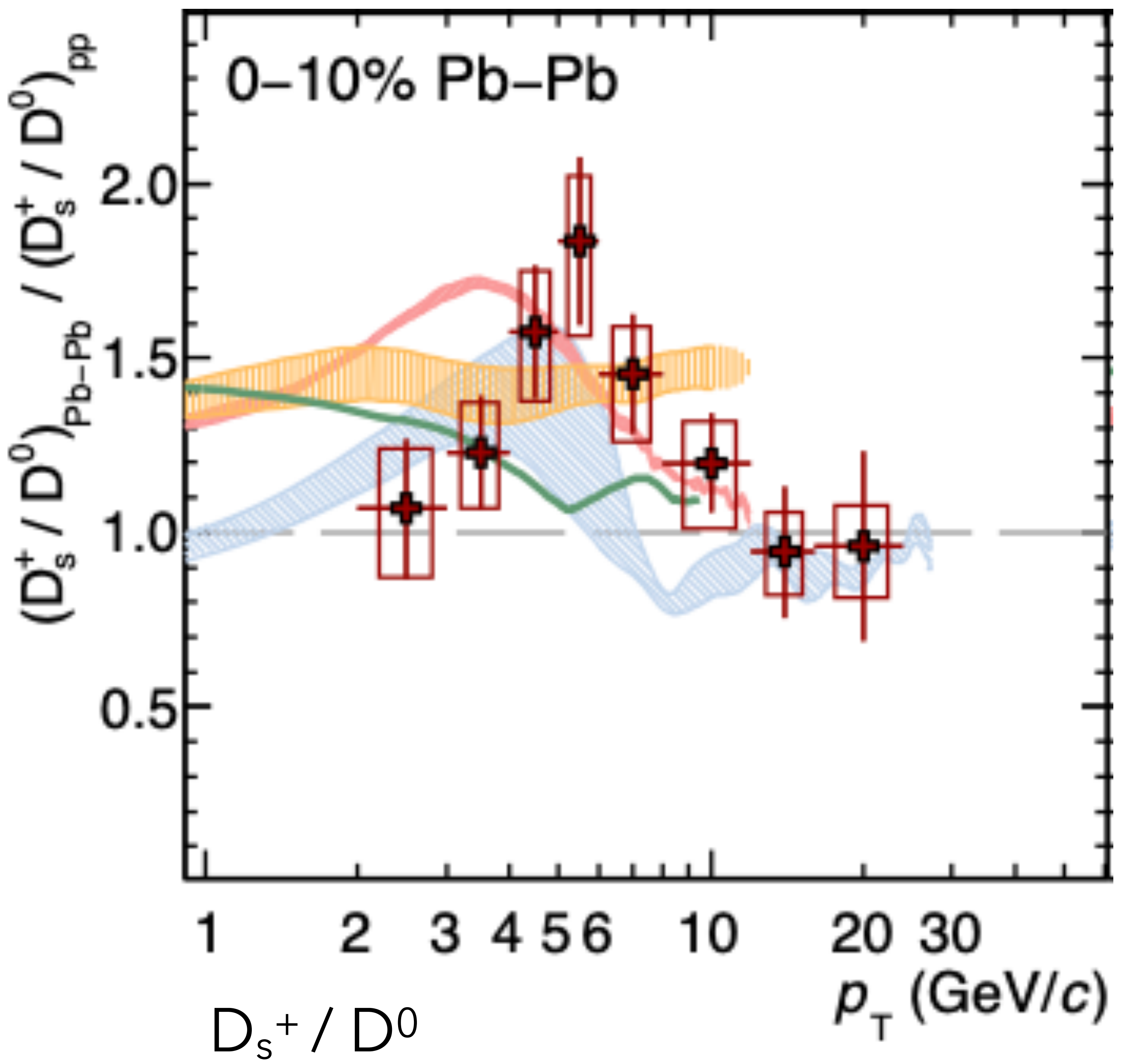
- Hint of different (softer) fragmentation for Λ_c than D^0
- PYTHIA 8 calculation with colour-reconnection seems to describe the trend

Monash; P. Skands, et al, Eur.Phys.J.C74 n.8 (2014) 3024
CR-BLC; JR Christiansen, et al, JHEP 08 (2015) 003

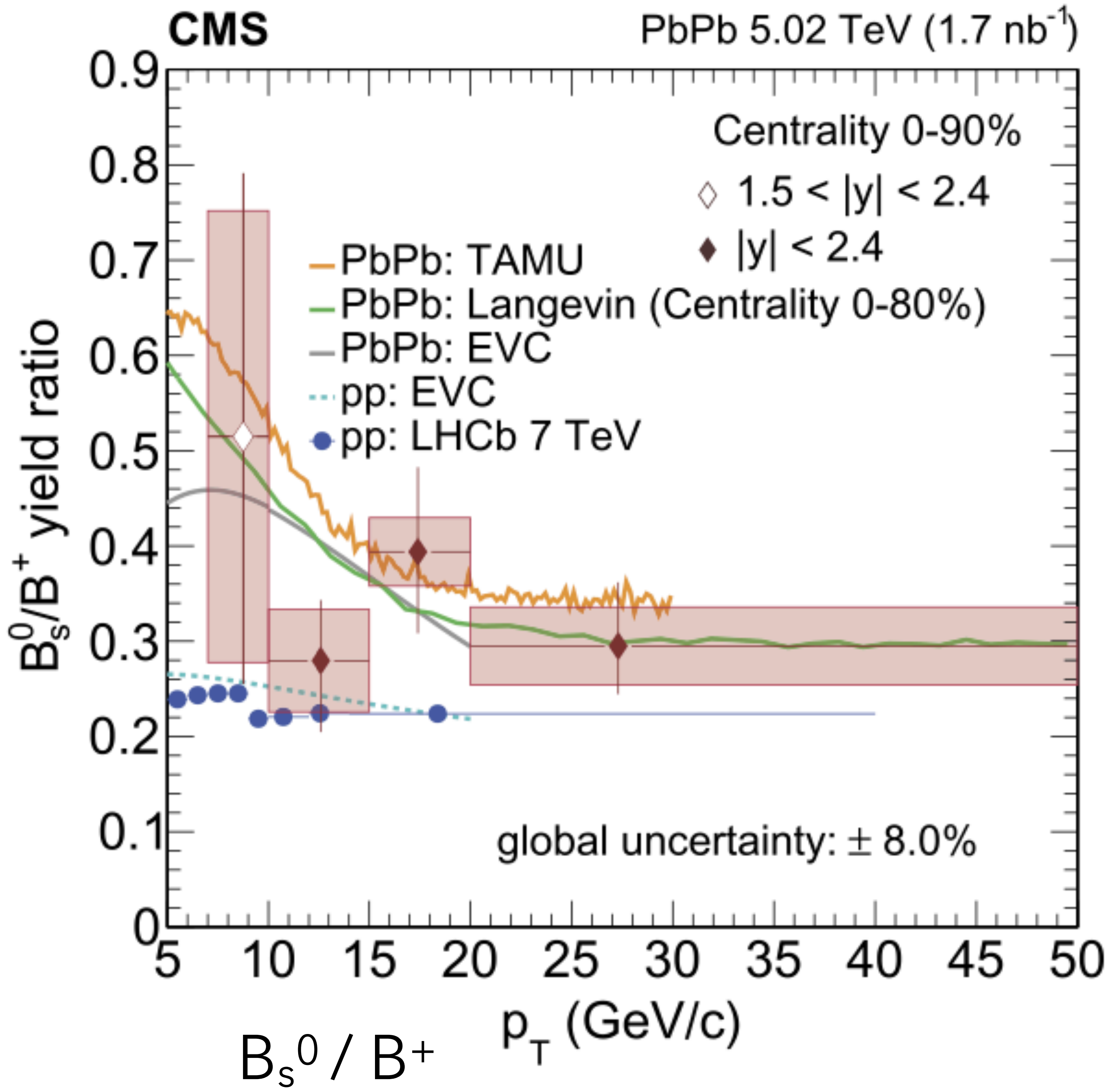
Are meson ratios affected in medium?



D_s^+ / D^0

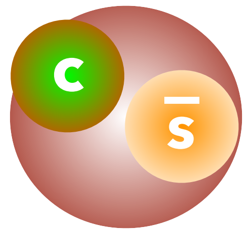


D_s^+ / D^0

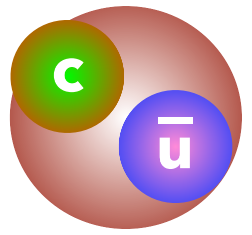


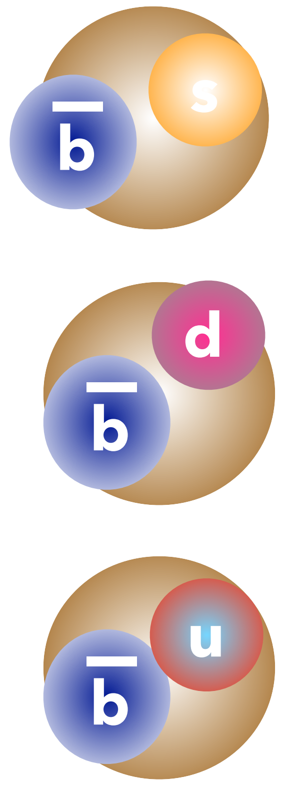
B_s^0 / B^+

D_s^+



D^0





B_s^0

B^0

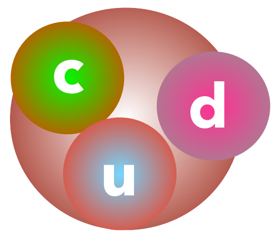
B^+

- Expected trend of the D_s^+ / D^0 and B_s^0 / B^+ ratios in pp
- **In central HIC, charm/beauty-strange mesons seem enhanced at intermediate p_T with respect to non-strange meson rates**
- Consistent with the **coalescence in-medium** picture (with enhanced strange quark production in medium)

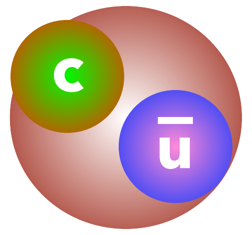
STAR, PRL 127 (2021) 092301 ALICE, arXiv:2204.10386
ALICE, PLB 827 (2022) 136986 CMS, PLB 829 (2022) 137062

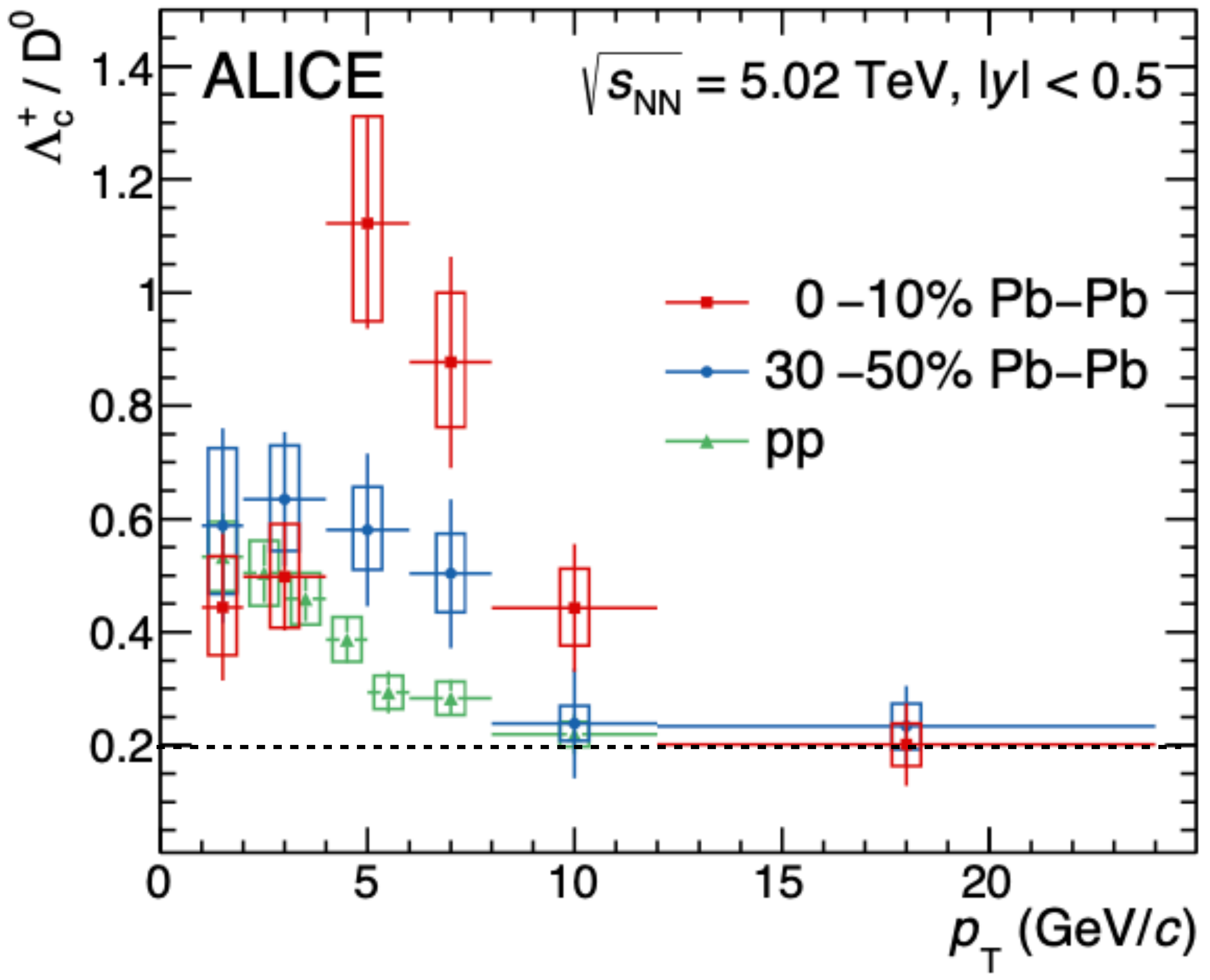
Are baryon ratios affected in medium?

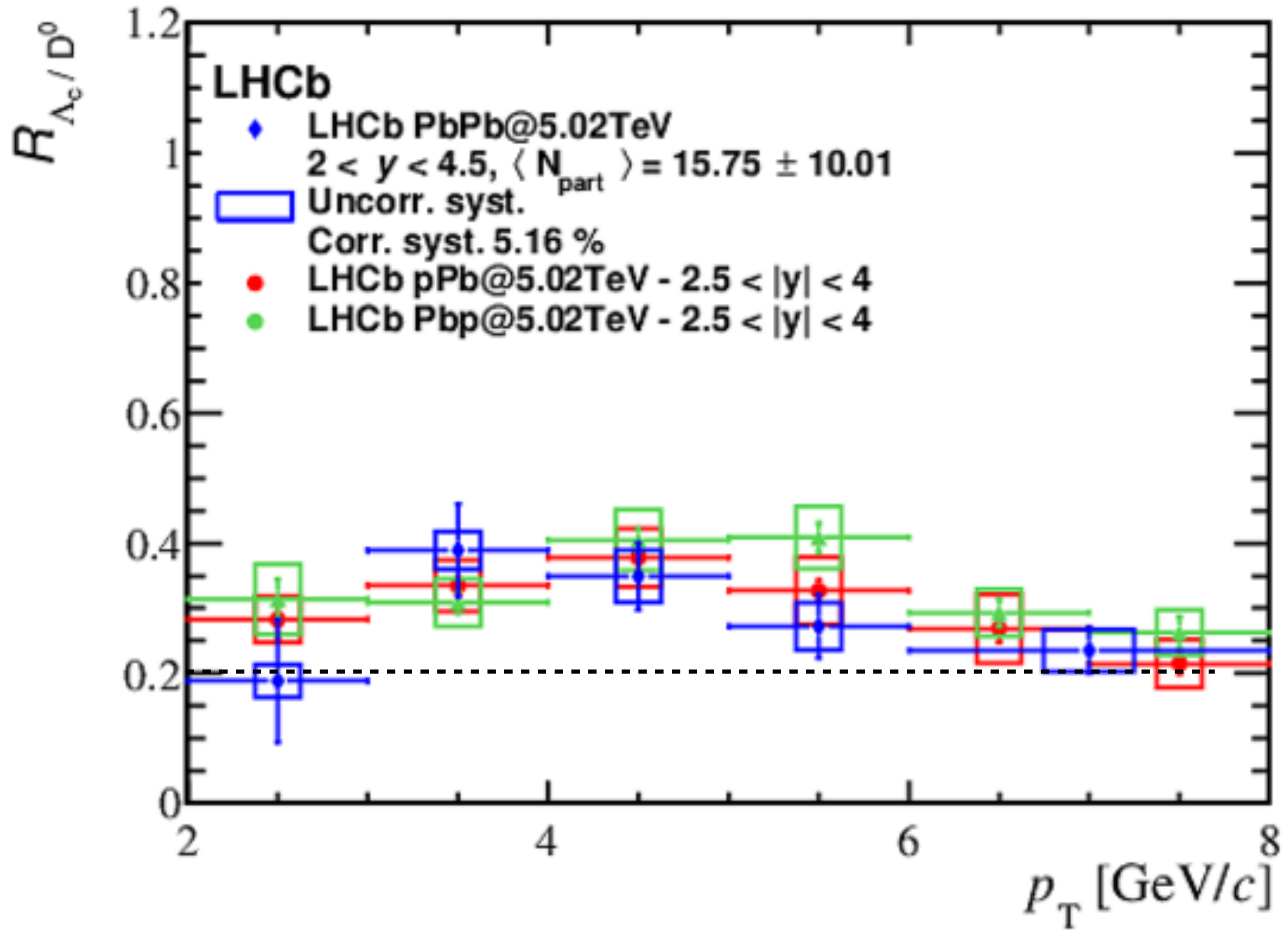
Λ_c^+



D^0





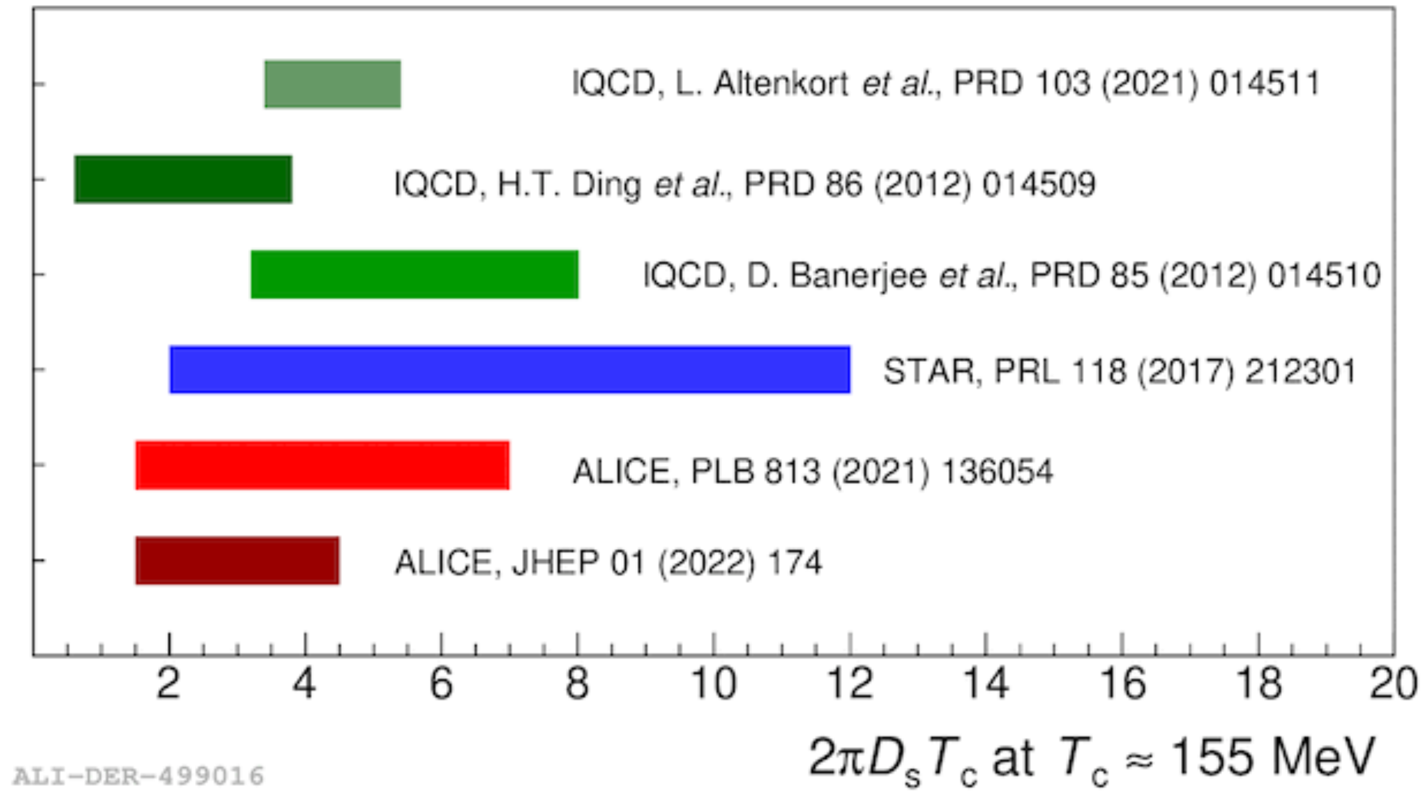


- ALICE observes a **larger modification of the p_T distribution with increasing charged-particle multiplicity**. No significant evolution observed by LHCb (in peripheral collisions)
- Consistent Λ_c/D^0 ratios at high p_T across collision systems (pp, pPb, PbPb)
- Interplay of (energy loss and) **fragmentation and coalescence** in medium?

LHCb, arXiv:2210.06939
ALICE, arXiv:2112.08156

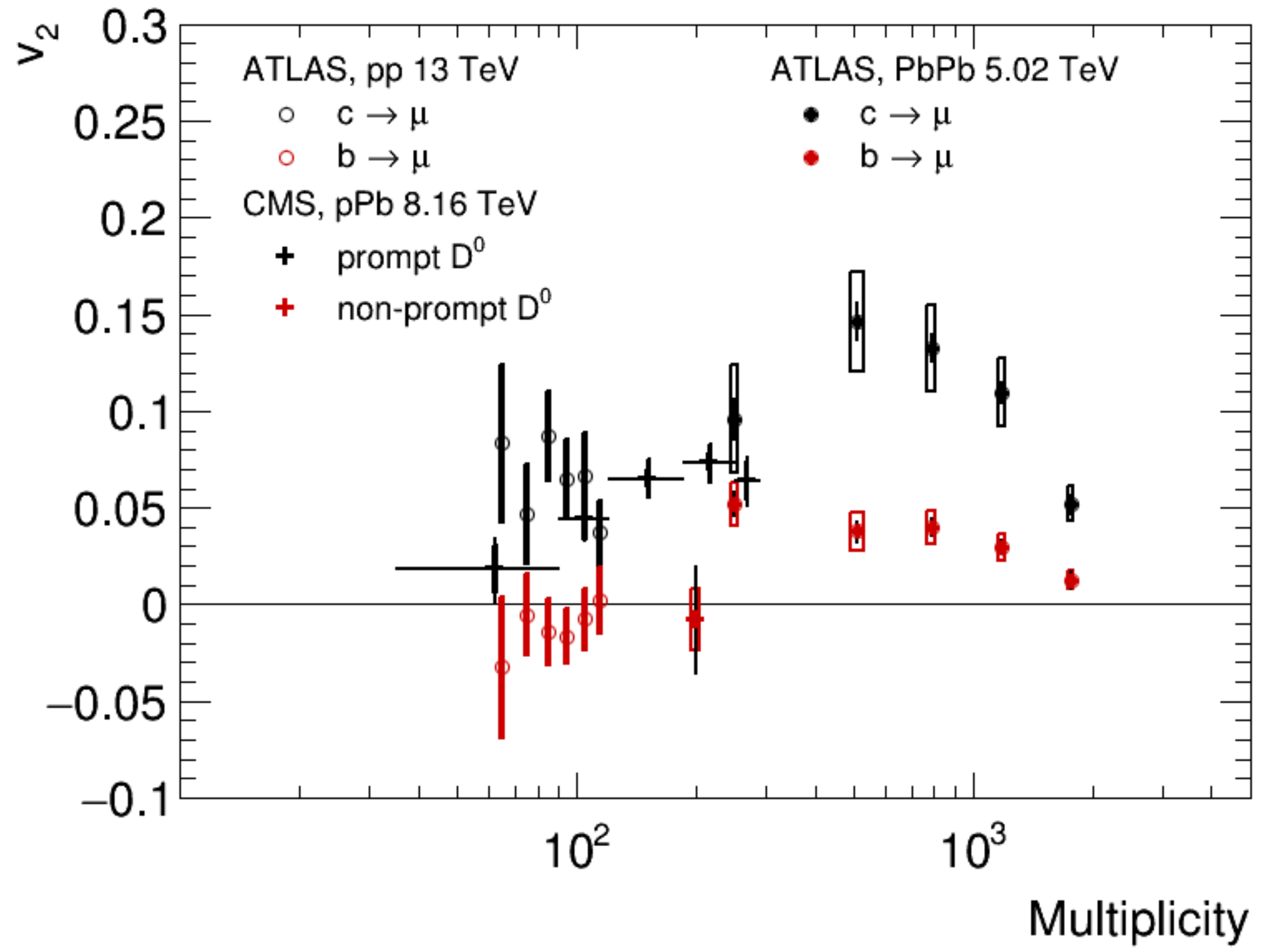
Summary

- Entering the heavy flavour precision era



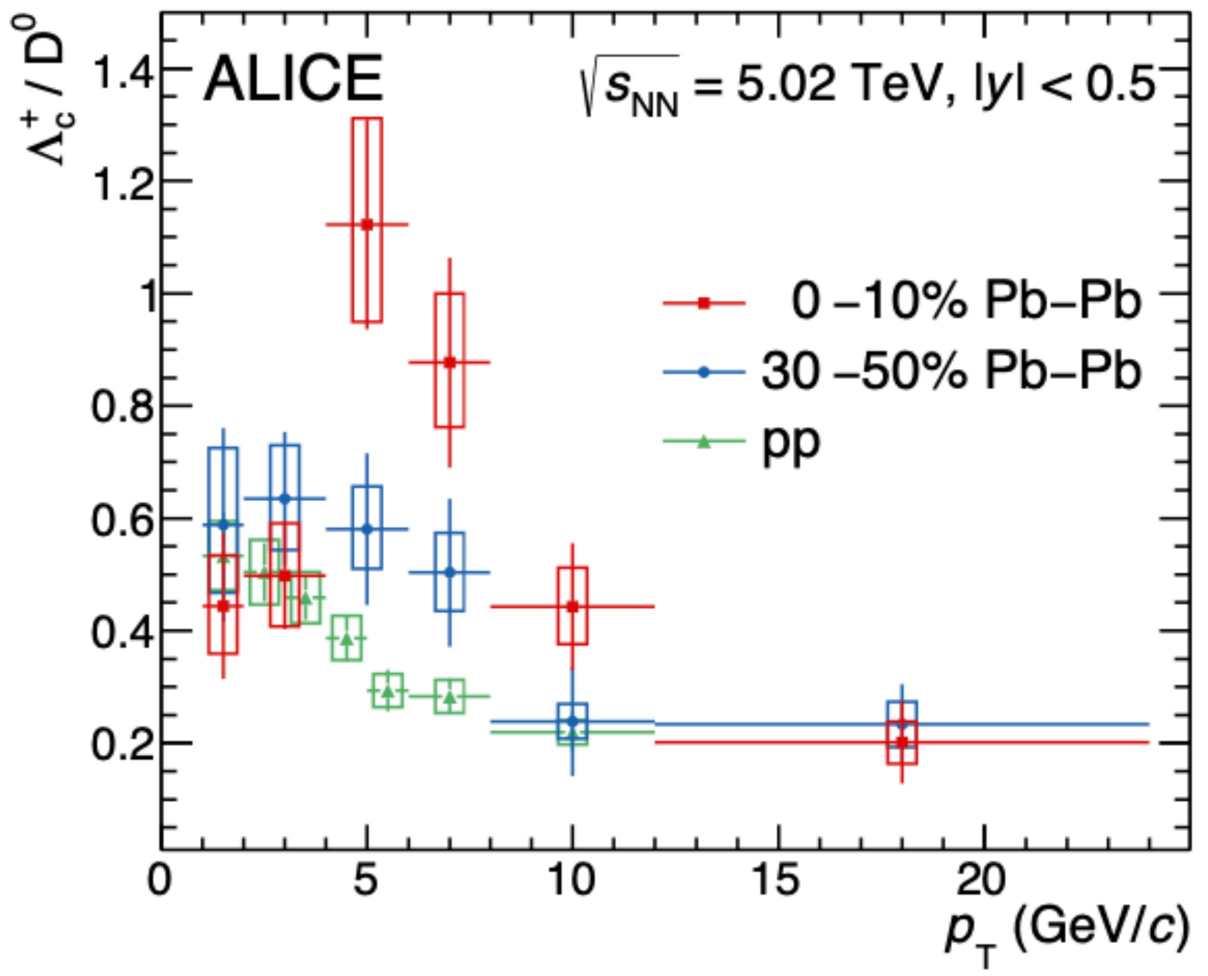
- Simultaneous comparison of (R_{AA}, v_n, jet shapes…) measurements with model calculations improves our understanding of heavy quark interaction with the medium

- The origin of the collective motion in small systems is still under debate. Important role of initial state effects and/or influence of final state effects ?



- Role of fragmentation and hadronisation is under scrutiny, both in medium and in vacuum.

Apologies for all those results I could not present, e.g. HF decay leptons (ALICE, STAR, PHENIX), non-prompt/prompt D^0 vs mult, correlations,….



Special thanks to A. Dainese for suggestions

Many interesting talks coming!

Tuesday, HF&Onia

- R. Litvinov LHCb, open HF pPb & PbPb
- K. Mattioli, LHCb, fixed target
- A. Kalteyer, ALICE, HF hadronisation
- S. Chandra, CMS, Λ_c & D^+ pp & PbPb
- Y. Zhang, CMS, HF flow pp & pP
- P. Lu, ALICE, prompt/non-prompt J/ψ

Wednesday, HF&Onia

- M. Völkl, ALICE, beauty pPb & PbPb
- S. Politano, ALICE, D_{s1}^* D_{s2}^* & D^{*+} spin pp
- M. Stojanovic, CMS, D^0 PbPb
- R. Arnaldi, NA60+, open HF & onia

Wednesday, Jet

- S. Tapia, ATLAS, b-jet PbPb
- P. Dhankher, ALICE, D^0-jet
- A. Palasciano, ALICE, D/Λ_c jet,HF correlations

Thursday, HF&Onia

- T. Sheng, CMS, B mesons pp & PbPb

Plenary

- **A. Rossi, hadronisation, Thursday**
- **A. Dubla, summary talk, Friday**

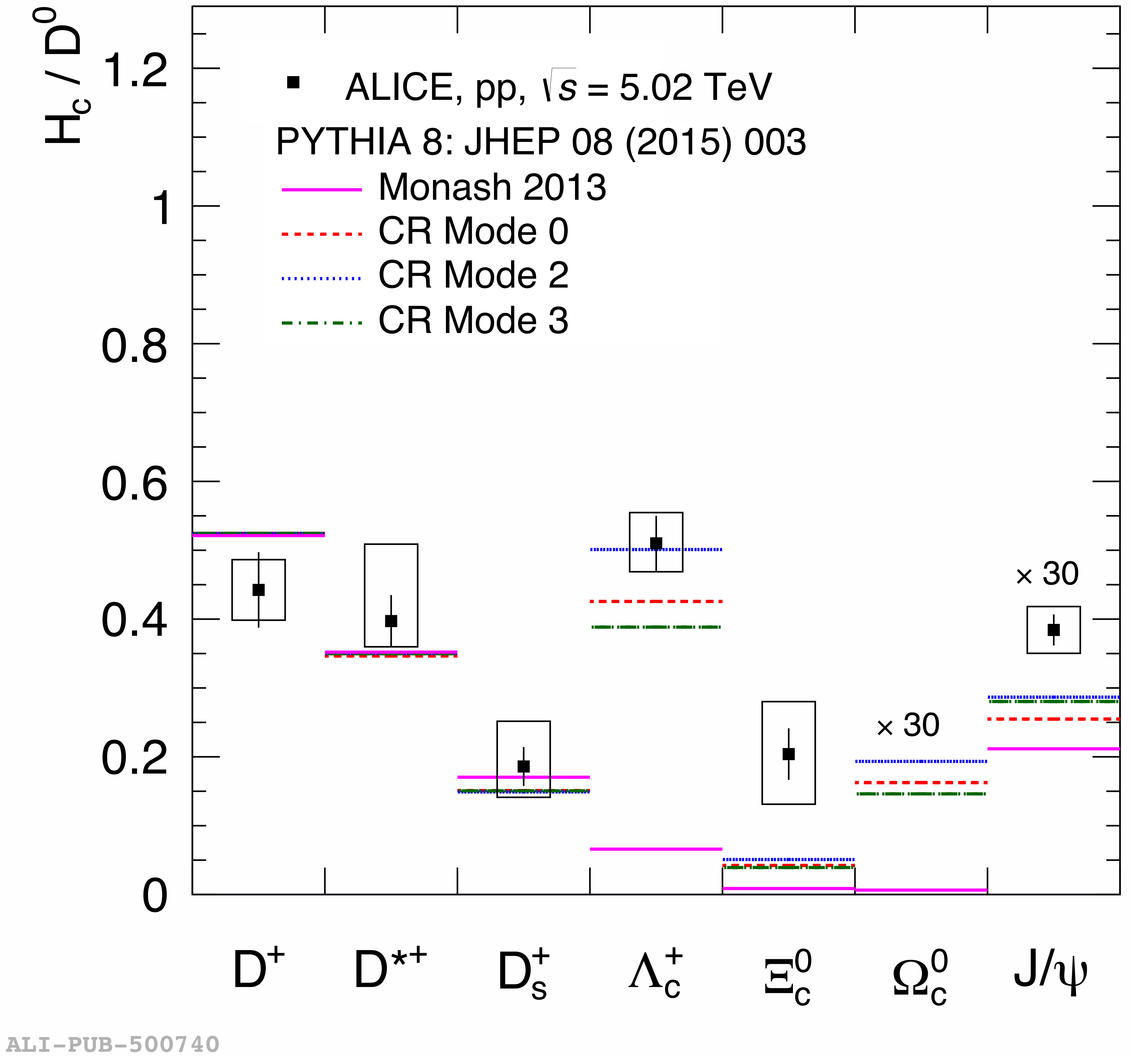
Big thank you to the organisers !

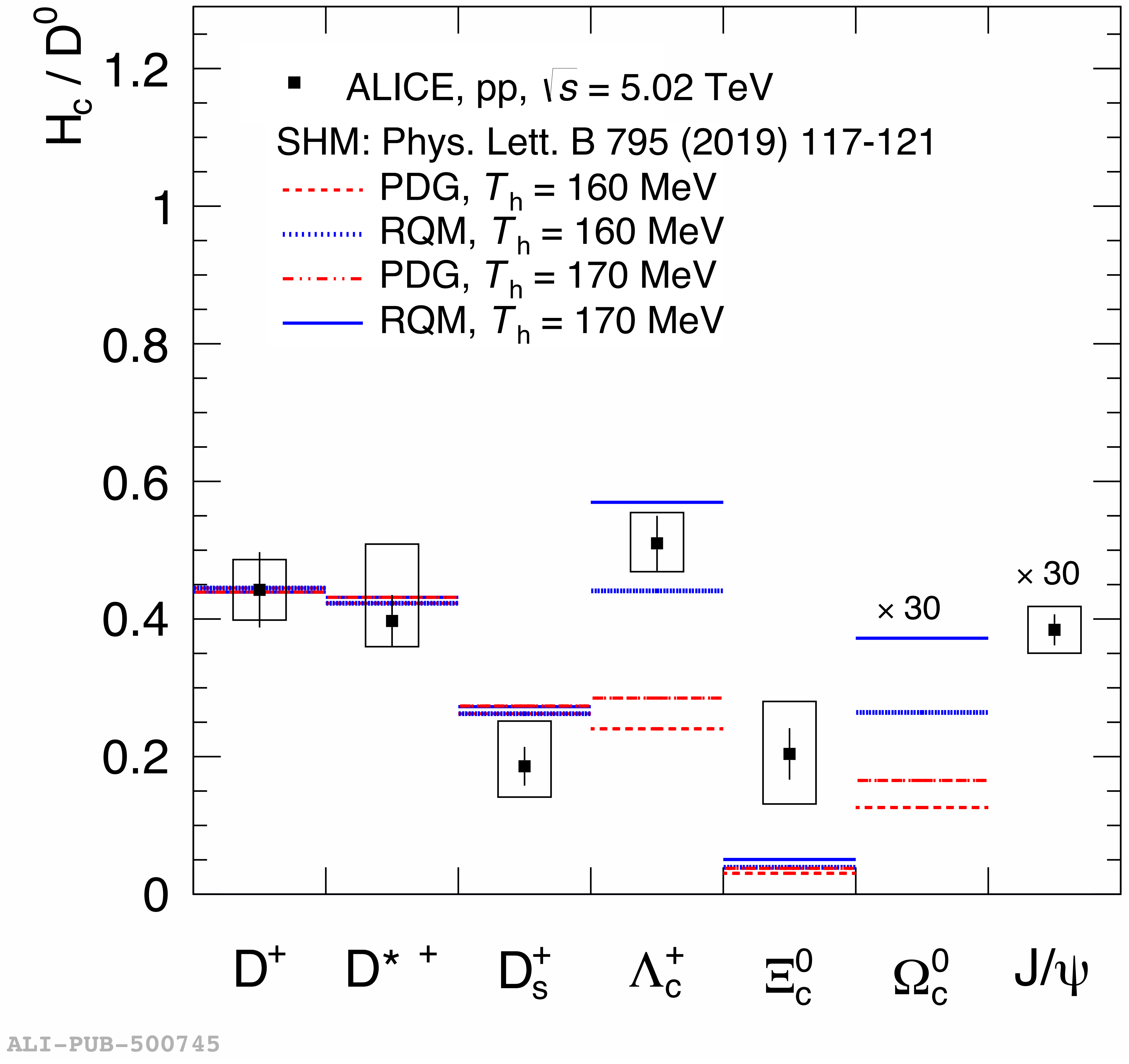
Thanks

Danke

Additional material

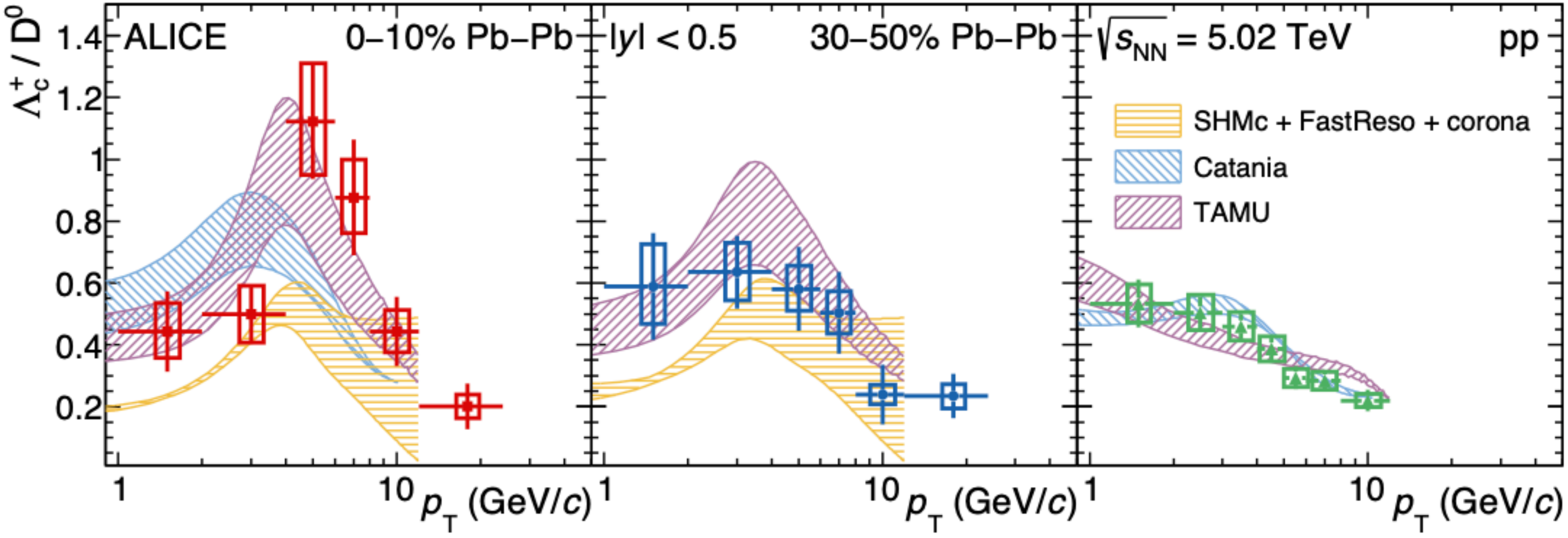
Charm fragmentation fractions in pp





ALICE, Phys. Rev. D 105 (2022) L011103

Λ_c/D^0 ratio in PbPb

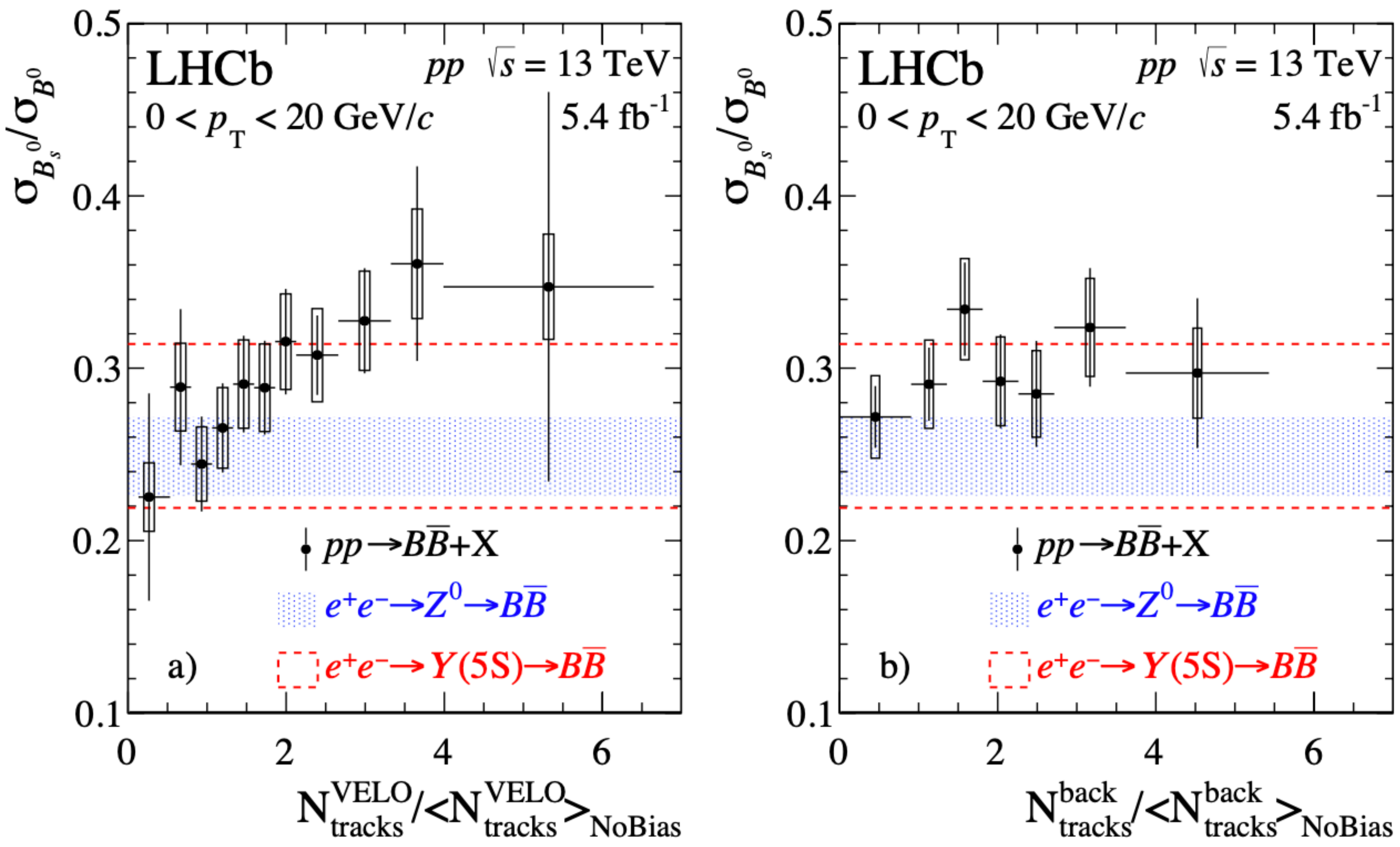


- Described by transport calculations that include both fragmentation and coalescence mechanisms in medium.

ALICE, arXiv:2112.08156

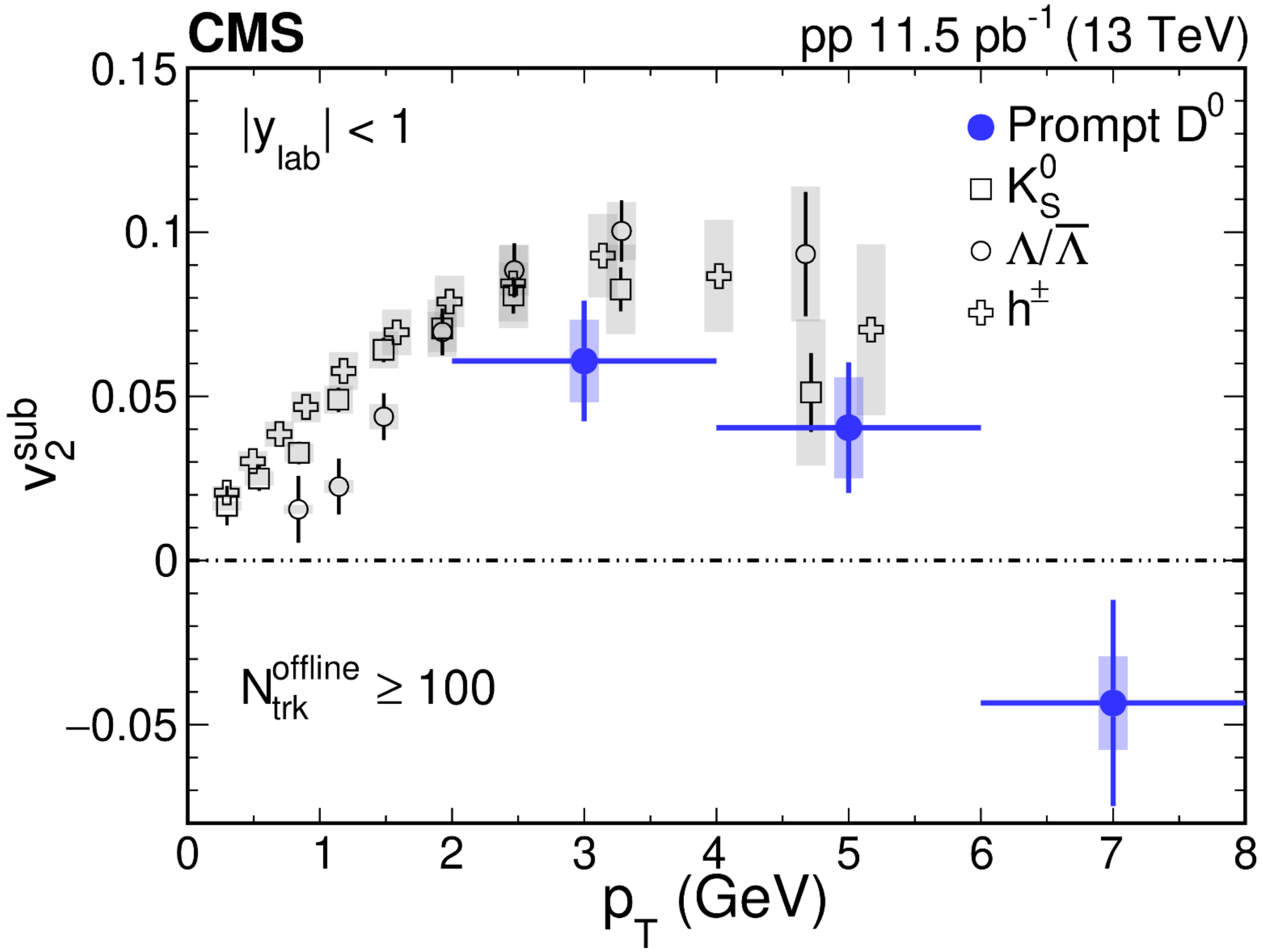
B^0_s/B^0 vs. multiplicity in pp

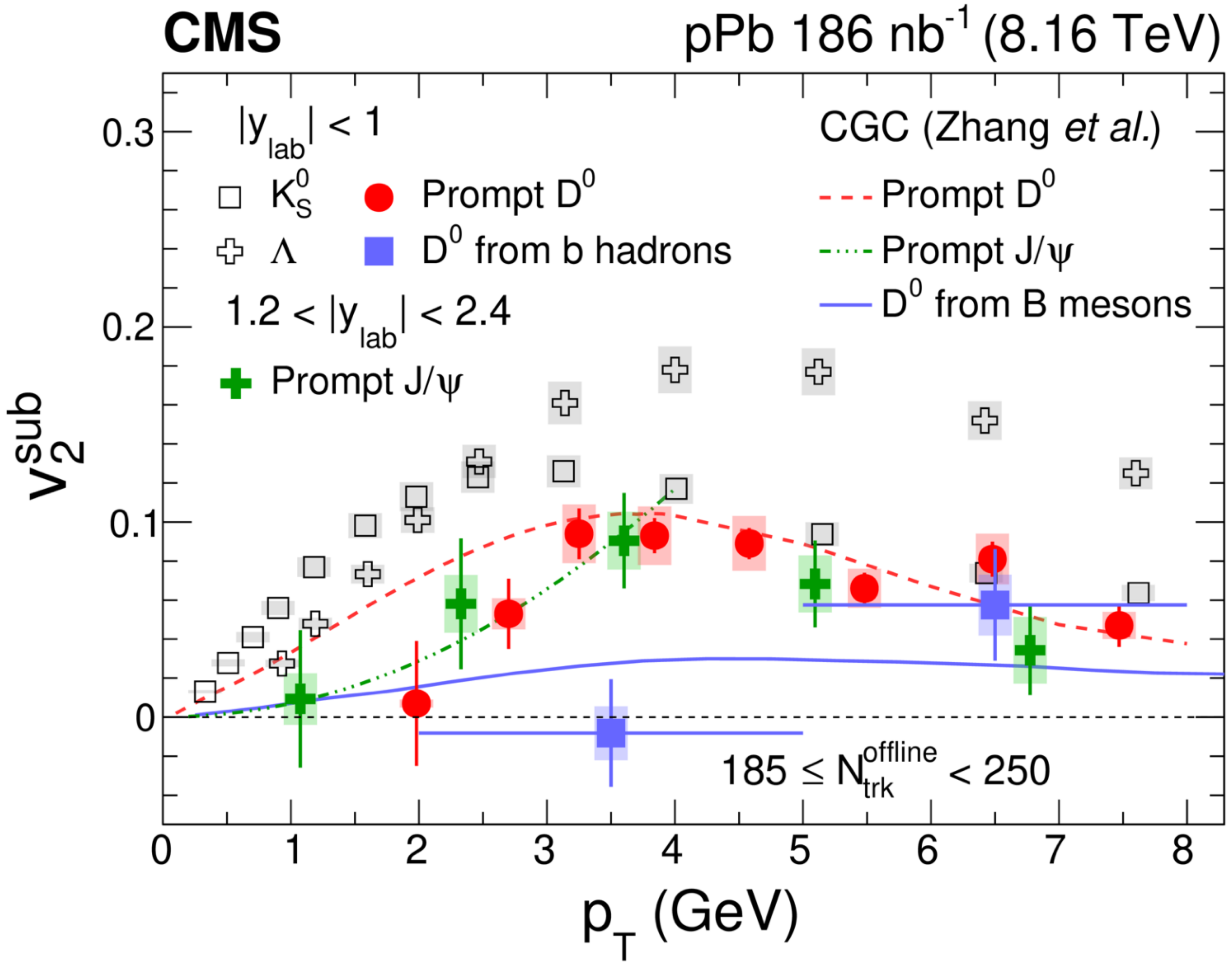
- Lack of dependence with multiplicity at backward rapidity.
- Mechanism possibly related to local particle density in a similar rapidity interval to that of the production of the B



LHCB-PAPER-2022-001, arXiv: 2204.13042

Azimuthal anisotropy of D^0 in small systems





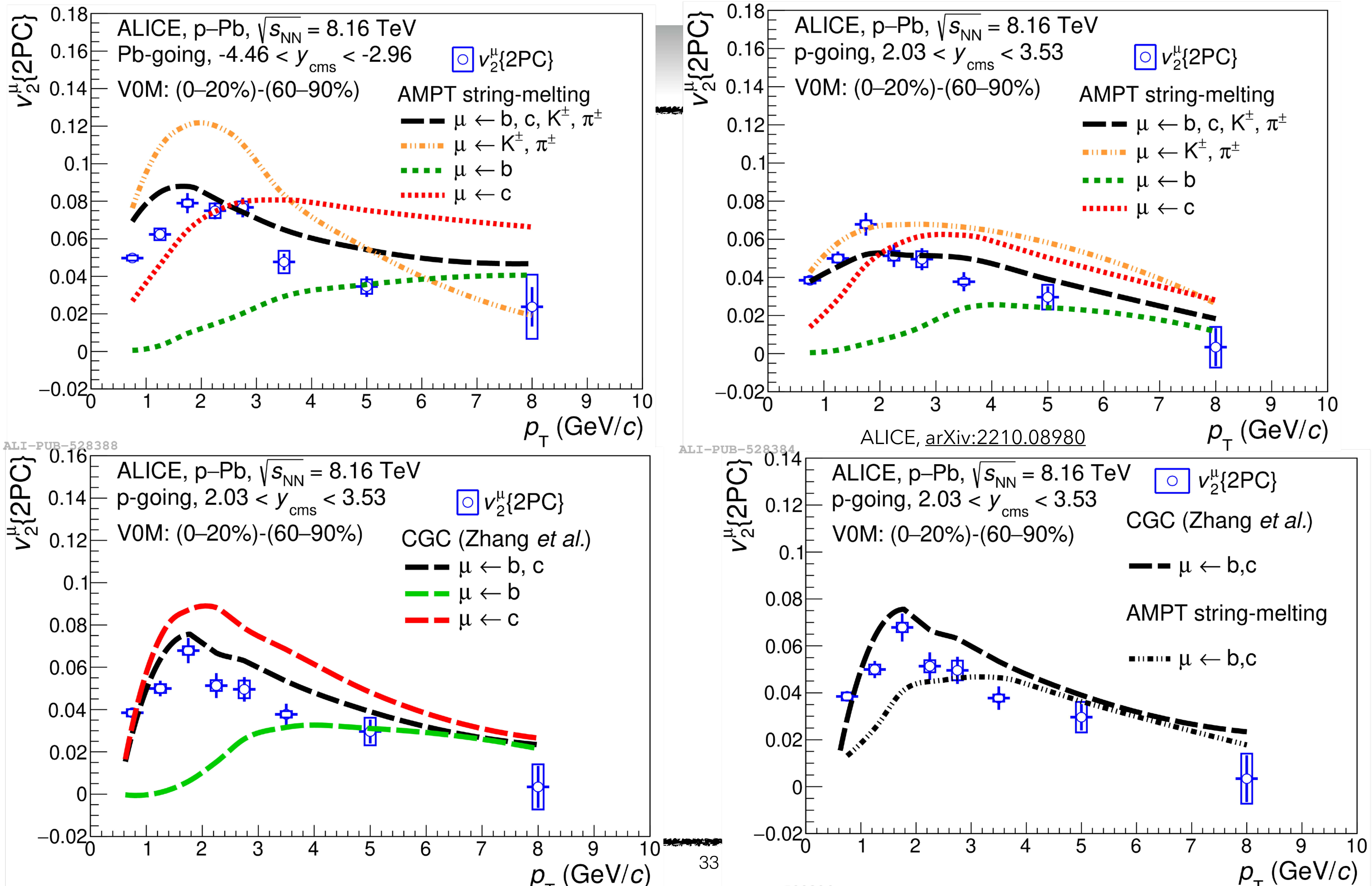
- **In pp**, positive prompt D^0 v_2^{sub} at high multiplicity → **collectivity being developed for charm** similar to that of light hadrons.

CMS, Phys. Rev. Lett. 121, 082301 (2018)
CMS, Phys. Lett. B 813 (2021) 136036

- **Comparable prompt D^0 v_2^{sub} values in pp and p–Pb at similar multiplicities.**

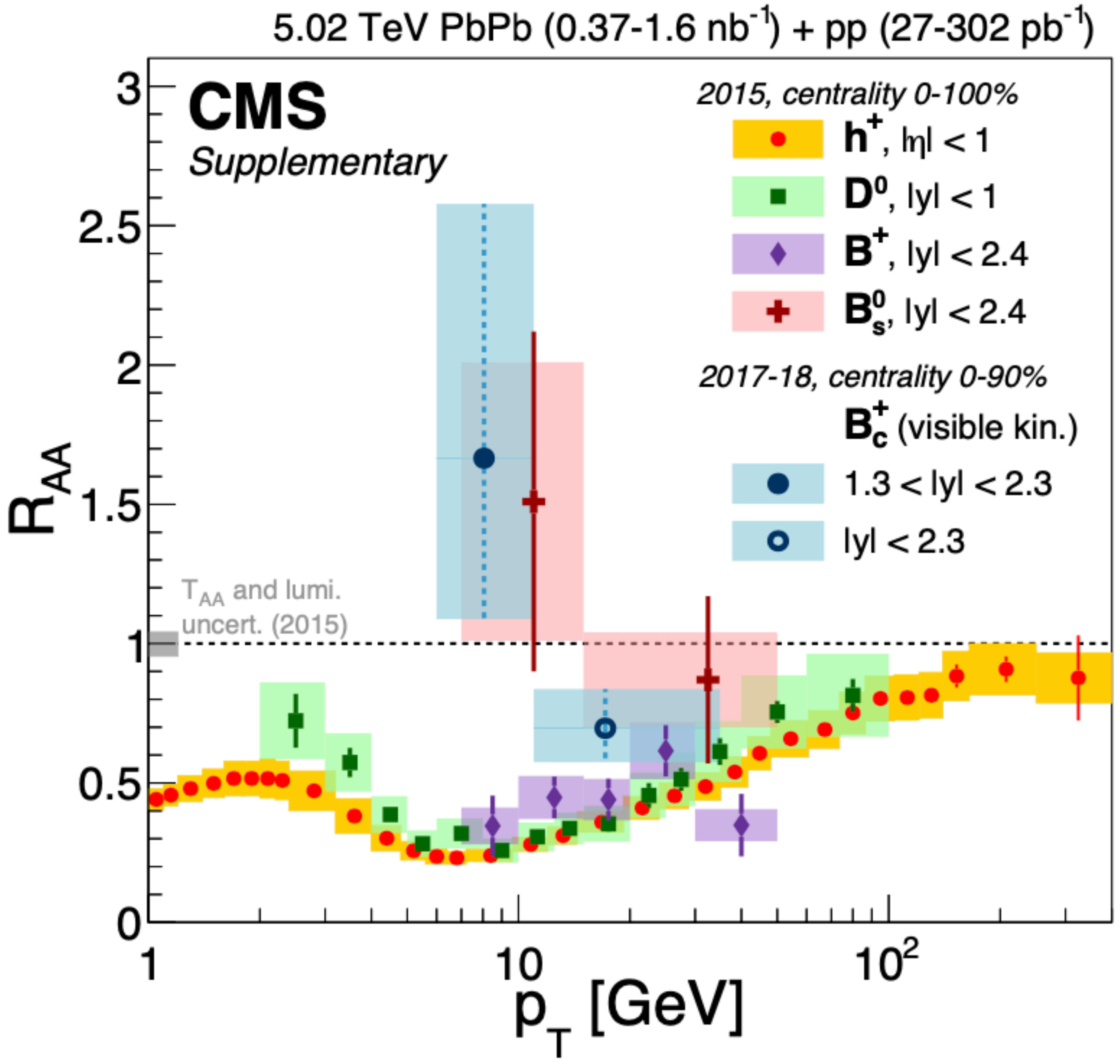
Dong et al, Ann. Rev. Nucl. Part. Sci. 69 (2019) 417-445
Zhang et al, Phys. Rev. D 102, 034010 (2020)

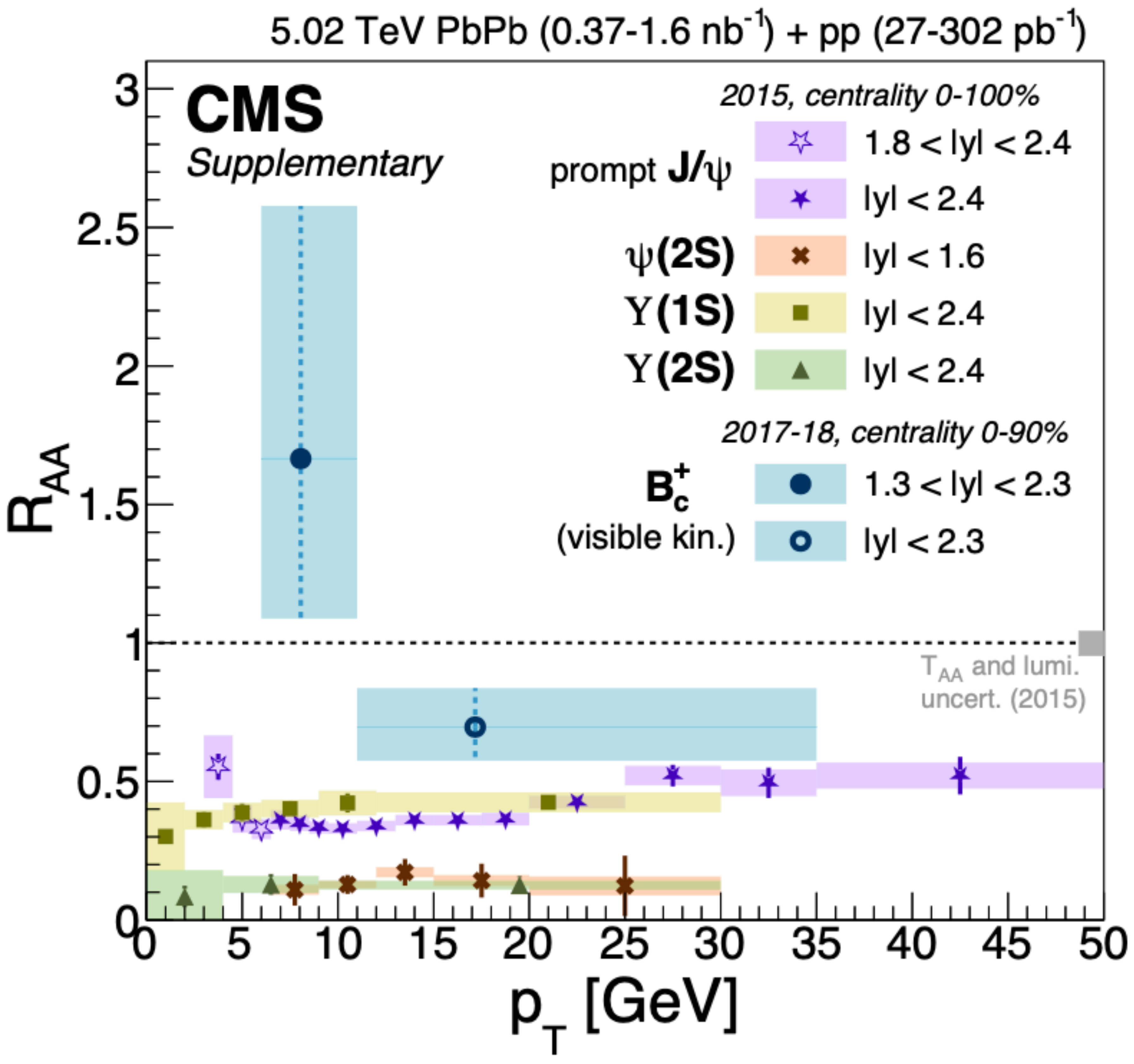
- Results consistent with ***v_2* flavour hierarchy** for $2 < p_T < 5$ GeV/*c* in p–Pb **v_2 (non-prompt D^0) < v_2 (prompt D^0)**. Compatible with scenarios where v_2 is generated either via final state scatterings or via a large impact of initial state effects.



ALICE, arXiv:2210.08980

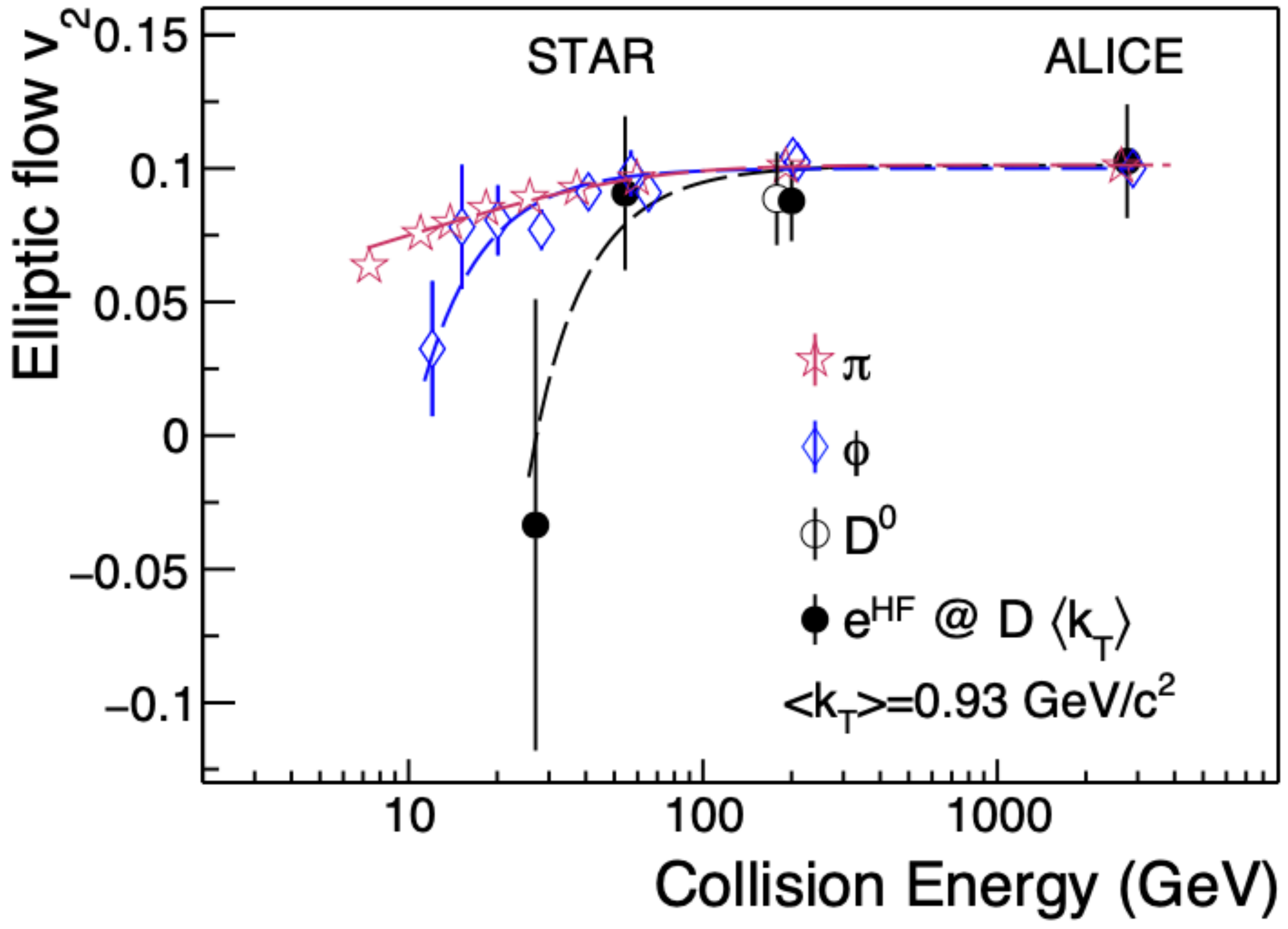
B_c^+ meson in PbPb



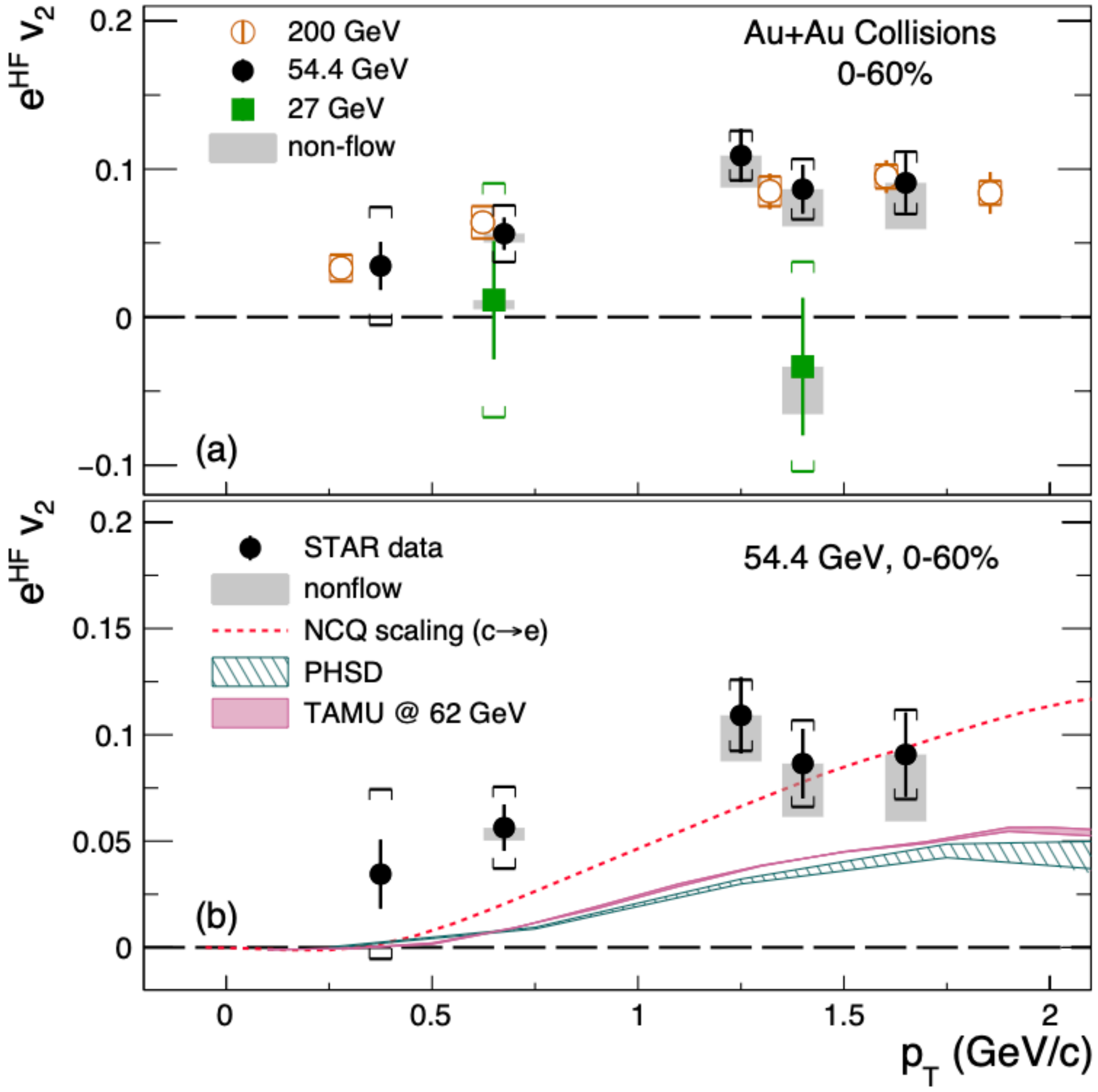


CMS, Phys. Rev. Lett. 128, 252301 (2022)

v_2 at RHIC

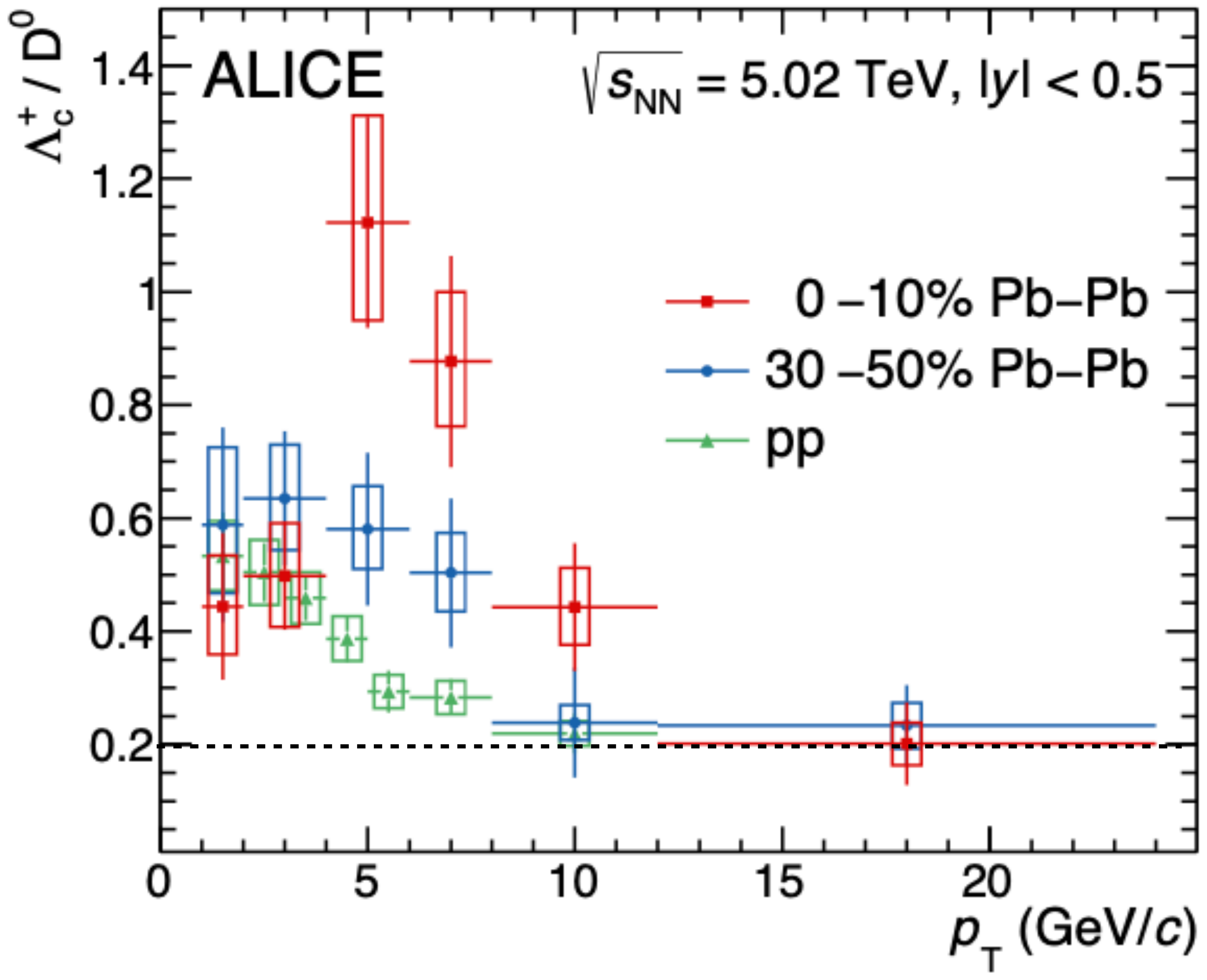


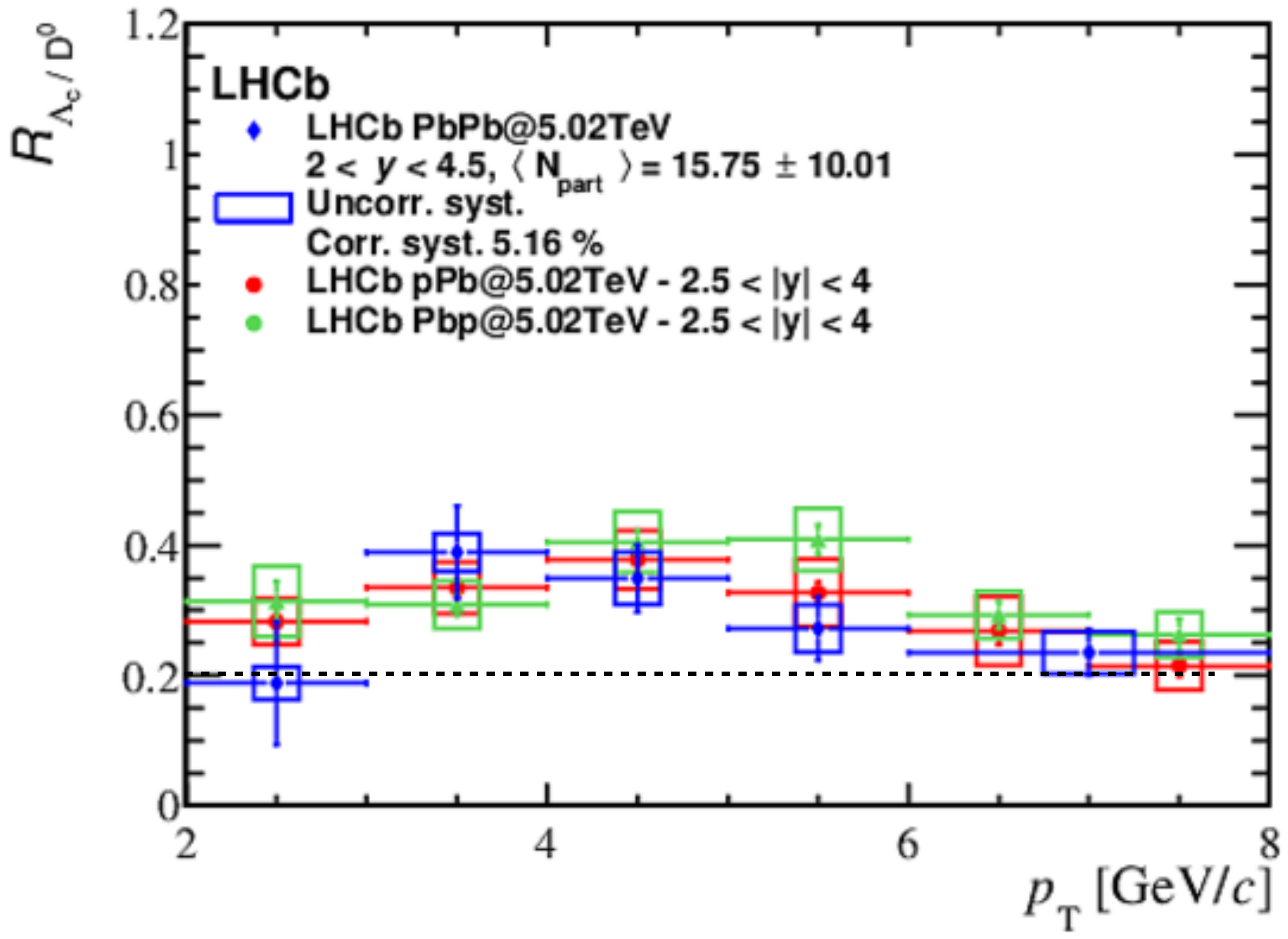
STAR, arXiv:2303.03546

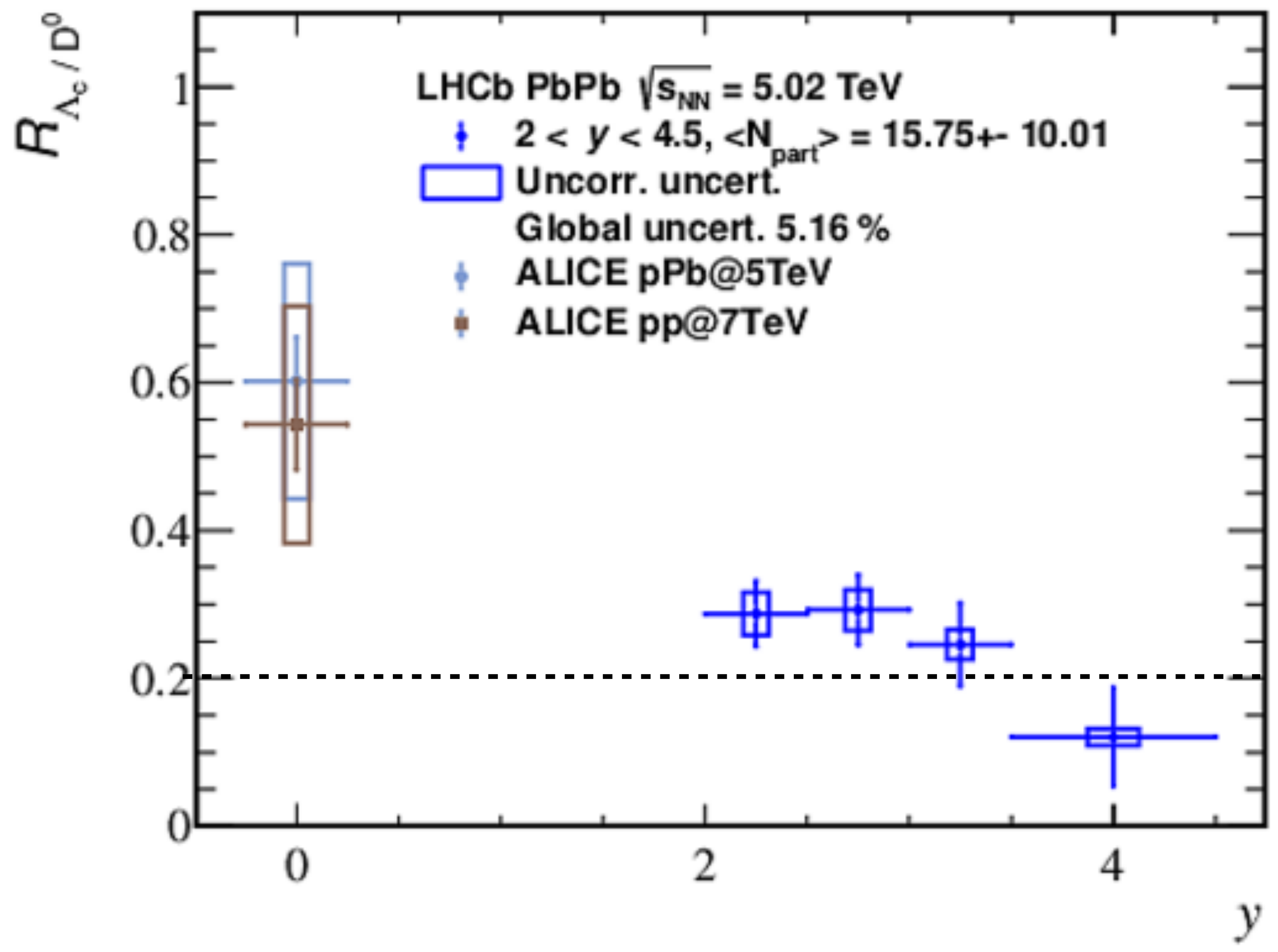


ATLAS, pp, PRL 124 (2020) 082301

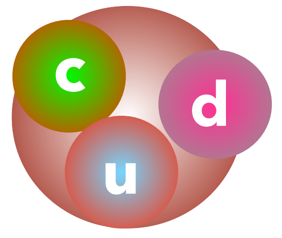
Are baryon ratios affected in medium?





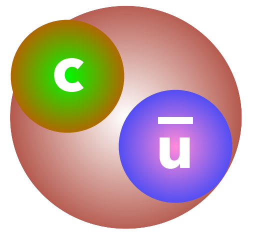


Λ_c^+



- ALICE observes a **larger modification of the p_T distribution with increasing charged-particle multiplicity**. No significant evolution observed by LHCb (in peripheral collisions)
- Consistent Λ_c/D^0 ratios at high p_T across collision systems (pp, pPb, PbPb)
- Interplay of (energy loss and) **fragmentation and coalescence** in medium?

D^0



LHCb, arXiv:2210.06939
ALICE, arXiv:2112.08156