Open and hidden heavy-flavour production and medium interaction with ALICE

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on behalf of the ALICE Collaboration

The 18th International Conference on
Strangeness in Quark Matter (SQM 2019)
10-15 June 2019, Bari (Italy)

Outline

Heavy quarks are produced "perturbatively" (=high-Q^2 processes) over a short time scale with respect to QGP formation time

→ Heavy-flavour **signals are excellent probes to spot medium effects** and investigate local processes ongoing in the medium with the goal of painting a **microscopic picture of the medium evolution**

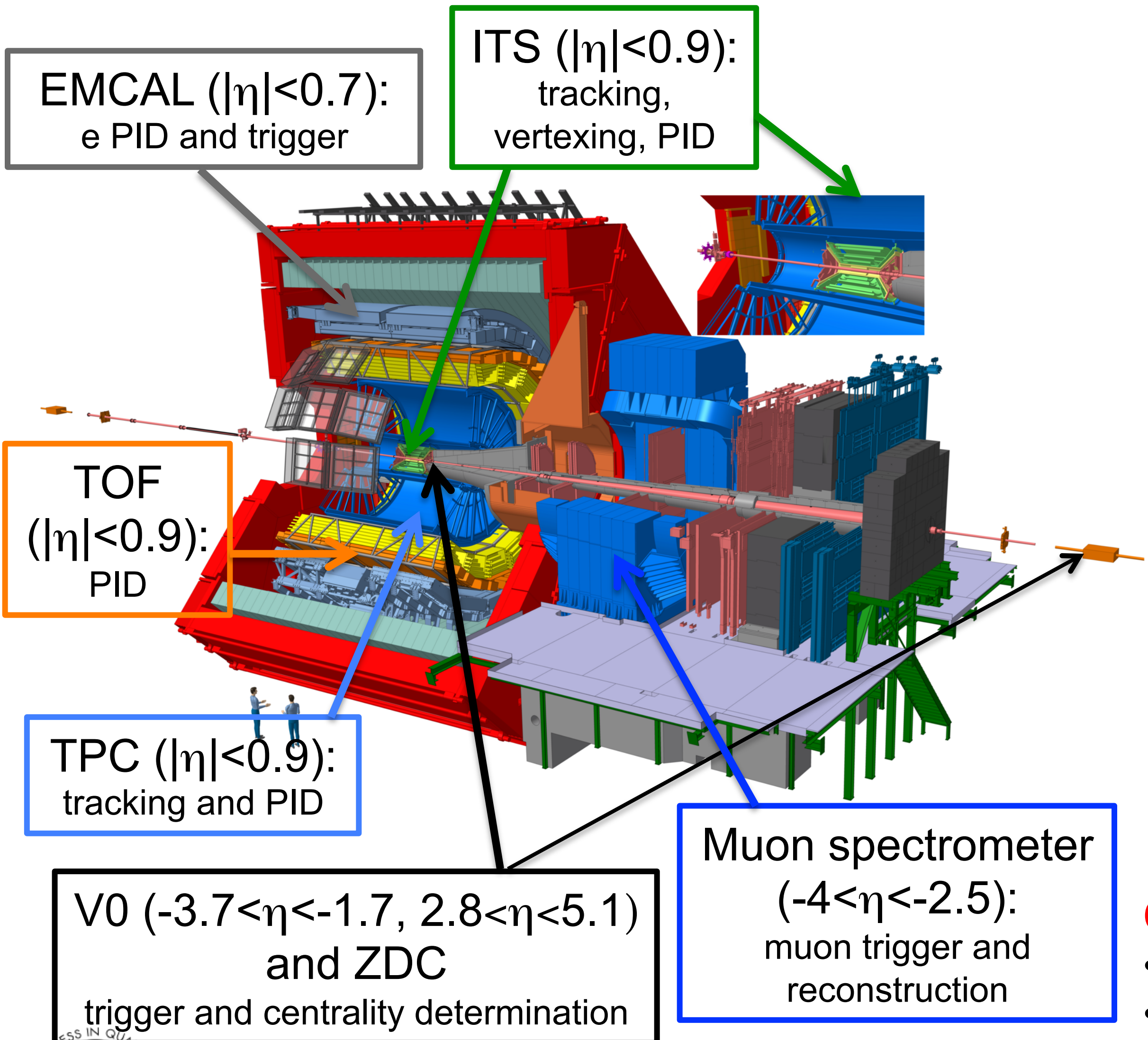
Many new results produced by ALICE on open-heavy flavour and quarkonia in

- pp collisions
- p-Pb collisions
- Pb-Pb collisions

Not all of them advertised here! You can find more in the related parallel talks:

1. Quarkonium measurements at forward rapidity with ALICE at the LHC→ W. Shaikh
2. J/ψ production measurements in pp, p-Pb, and Pb-Pb collisions at mid-rapidity using the ALICE detector at the LHC→ M. J. Kim
3. Study of open heavy-flavour hadron production in pp nad p-Pb collisions with ALICE→ P. Dhanker
4. Heavy-flavour jet production and charm fragmentation→ A. Mohanty
5. Latest results on D_s^+ and Λ_c^+ in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE at LHC→ C. Zampolli
6. Beauty production with ALICE at the LHC→ E. F. Gauger
7. Measurement of non-strange D-meson production and azimuthal anisotropy in Pb-Pb collisions with ALICE at the LHC → S. Jaelani

Heavy-flavour with ALICE



Open heavy-flavour

Charmed hadrons (|*y*|<0.5)

- $D^0 \rightarrow K^-\pi^+$
- $D^{*+} \rightarrow D^0\pi^+$
- $D^+ \rightarrow K^-\pi^+\pi^+$

} "non-strange" D mesons

- $D^+_s \rightarrow \phi\pi^+$, $\phi \rightarrow K^-K^+$
- $\Lambda_c^+ \rightarrow pK^0_s$, $K^0_s \rightarrow \pi^+\pi^-$
- $\Lambda_c^+ \rightarrow pK^-\pi^+$
- $\Lambda_c^+ \rightarrow e^+\Lambda\nu_e$
- $\Xi_c^0 \rightarrow e^+\Xi^-\nu_e$

HF –decay electrons (|*y*|<0.9)

- c,b hadrons → e X
- b hadrons → e X

HF-decay muons (2.5<*y*<4)

- c,b hadrons → μ X

Quarkonia

- $J/\psi \rightarrow e^+e^-$ **|*y*|<0.9**
- J/ψ, $\psi(2S)$, $\Upsilon(1S,2S,3S) \rightarrow \mu^+\mu^-$
  2.5<*y*<4

Charged-track jets

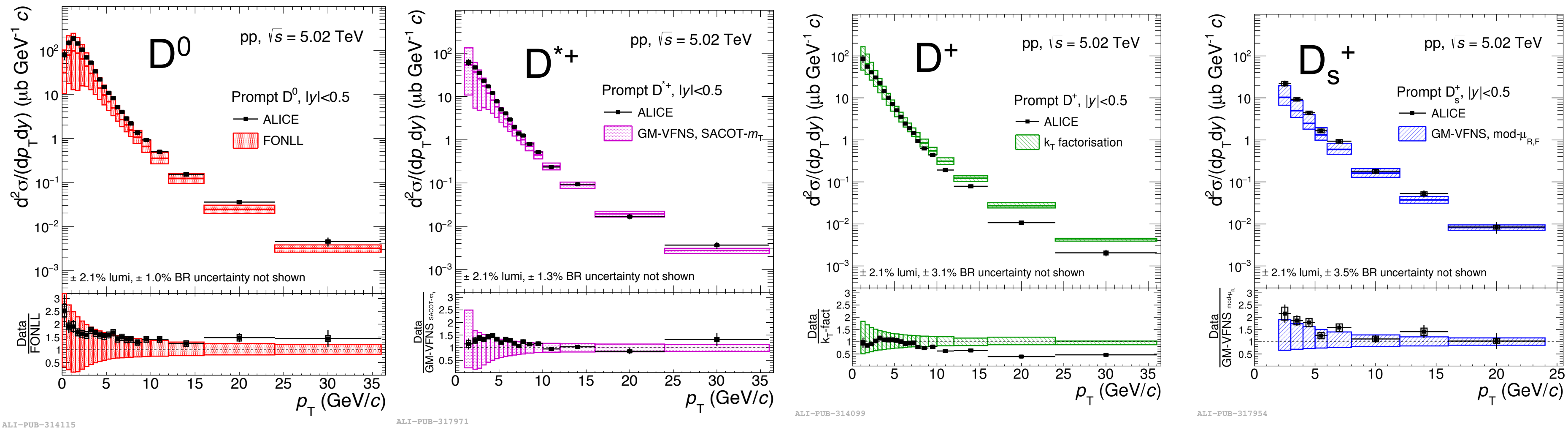
- Charged constituents
- Anti-k_T algorithm
- Various HF tagging techniques

pp collisions

Open-charm production

Eur.Phys.J. C79 (2019) no.5, 388

P. Dhanker



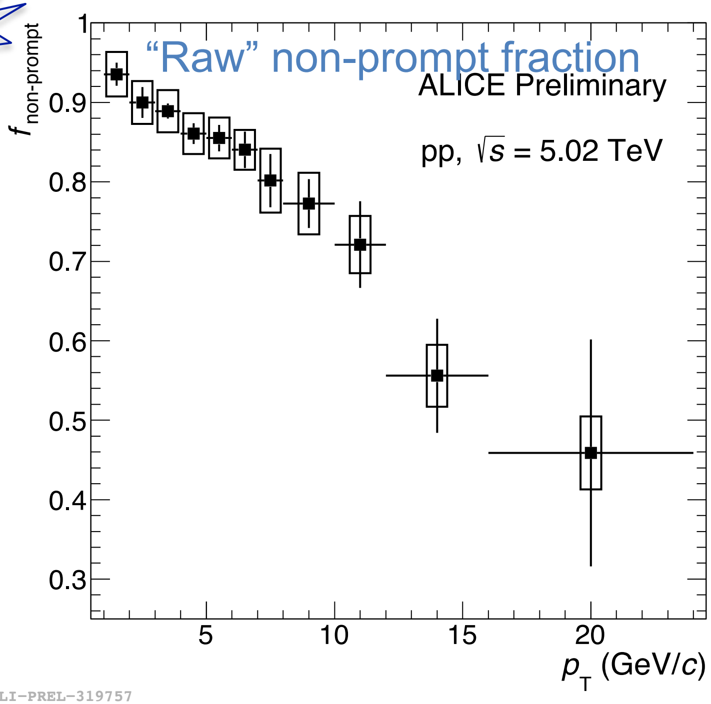
- Prompt **D^0,D^{*+},D$^+$,D$_s^+$-meson** cross section at mid-rapidity (**down to p_T=0 for D^0**) in pp collisions at $\sqrt{s}$ = 5.02 TeV → new pp reference

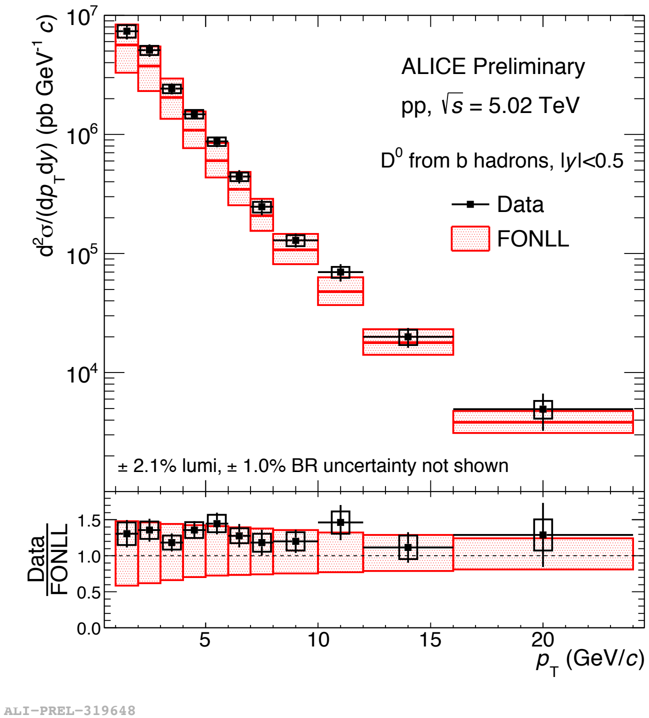
- Data **described by pQCD** calculations relying on factorisation approach

- Data uncertainties much smaller than theoretical ones

FONLL: JHEP 10 (2012) 137
GM-VFNS SACOT-m_T: JHEP 05 (2018)
GM-VFNS mod $\mu_{R,F}$: JHEP 12 (2017); Nucl. Phys. B925 (2017)
k_T-factorisation: PRD 98, no. 1 (2018)

Beauty with non-prompt D^0 mesons





E. Gauger, M. Cai poster

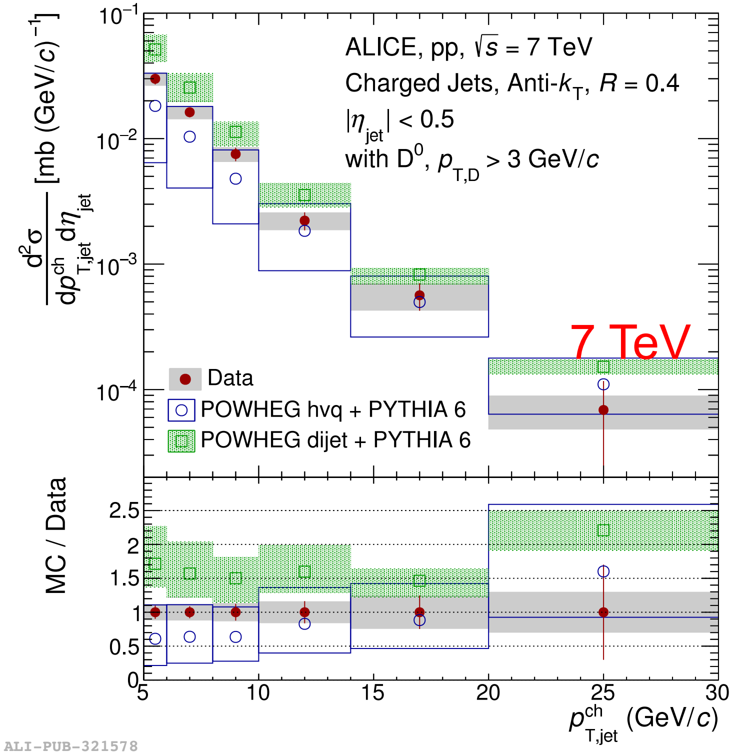
- **Novel analysis** based on
  - two-step machine learning (BDT) cut optimisation to single out non-prompt D-meson component from prompt one and combinatorial background
  - Data-driven determination of prompt D-meson contamination
- Cross section described by FONLL

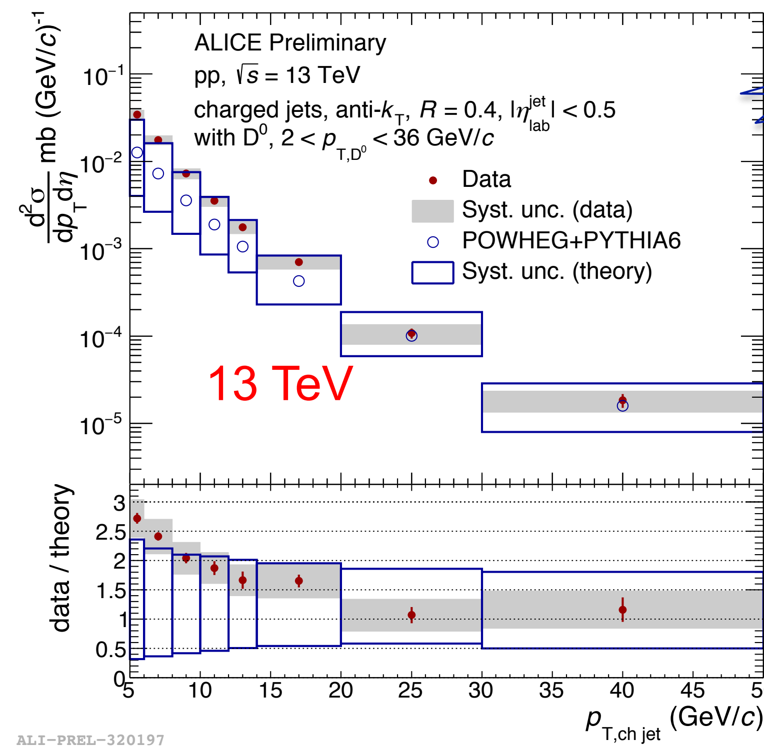
Charm and beauty production in pp collisions described reasonably by pQCD calculations

Study of charm-jet properties

arxiv 1905.02510

A. Mohanty





- Charm jets tagged by a fully reconstructed D^0 meson
- Ideal tool to investigate **charm fragmentation and jet kinematic properties**

- p_T-differential cross section described reasonably by POWHEG HVQ+PYTHIA6 down to low p_T in pp collisions at LHC energies

POWHEG: JHEP 0711 (2007) 070; POWHEG-HVQ: JHEP 0709 (2007) 126; POWHEG dijet JHEP 1104 (2011) 081; PYTHIA6: JHEP 05 (2006) 026

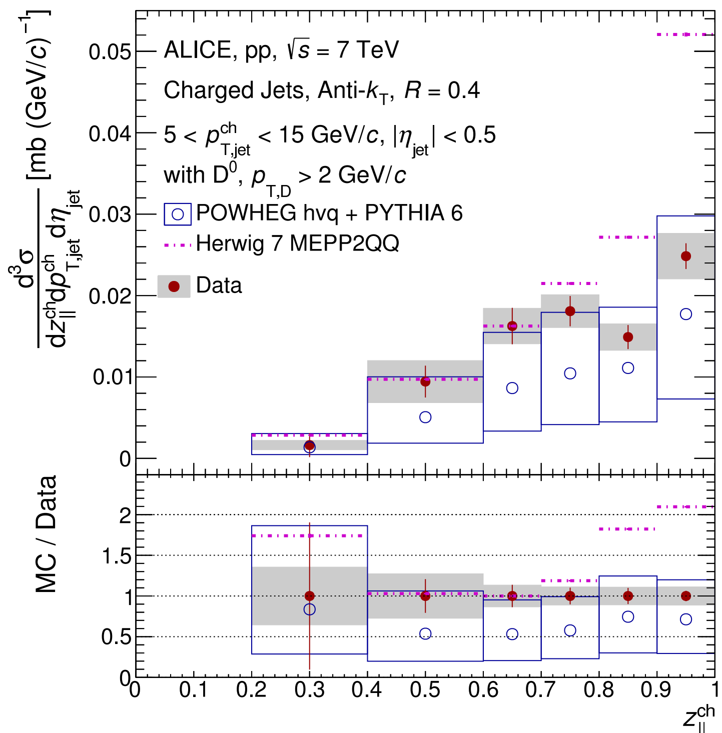
Study of charm-jet properties

ALICE

arxiv 1905.02510

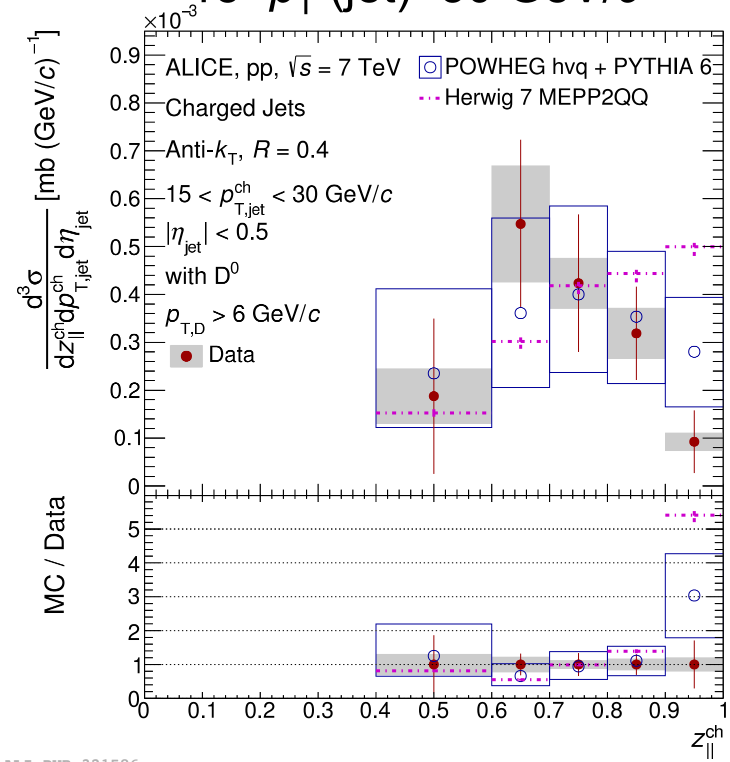
A. Mohanty

$5<p_T$ (jet)<15 GeV/c



ALI-PUB-321582

$15<p_T$ (jet)<30 GeV/c



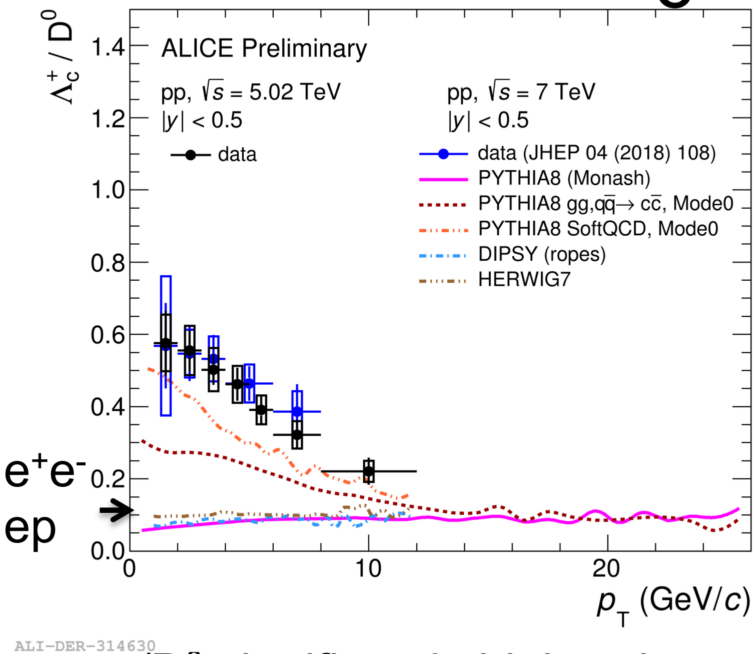
ALI-PUB-321586

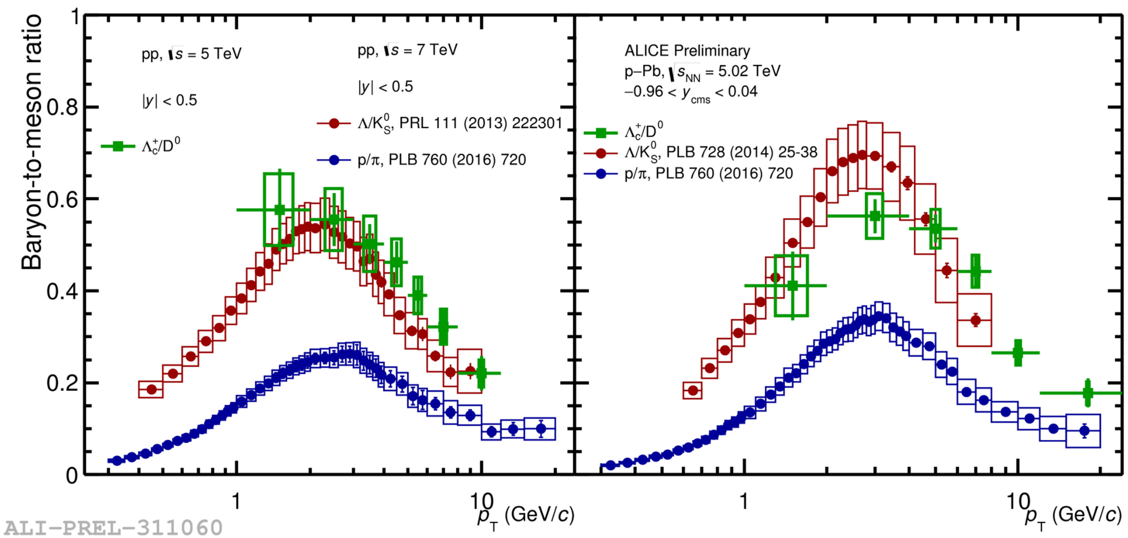
- Jet-momentum fraction $z_{//}^{ch} = \frac{\vec{p}_{\text{ch jet}} \cdot \vec{p}_{D}}{\vec{p}_{\text{ch jet}} \cdot \vec{p}_{\text{ch jet}}}$ carried by D^0 meson studied at low jet p_T
- z-differential cross section, along with softening of z distribution with p_T, reproduced by POWHEG hvq+PYTHIA6 (not so well by HERWIG7)

→ good starting point to address possible modifications in Pb-Pb

POWHEG-HVQ: JHEP 0709 (2007) 126; PYTHIA6: JHEP 05 (2006) 026; HERWIG7: EPJC76 (2016) no.4, 196

Λ_c^+ production





- Λ_c^+/D^0 significantly higher than expectation from e^+e^- collisions:
  Does charm hadronisation depend on the collision system?

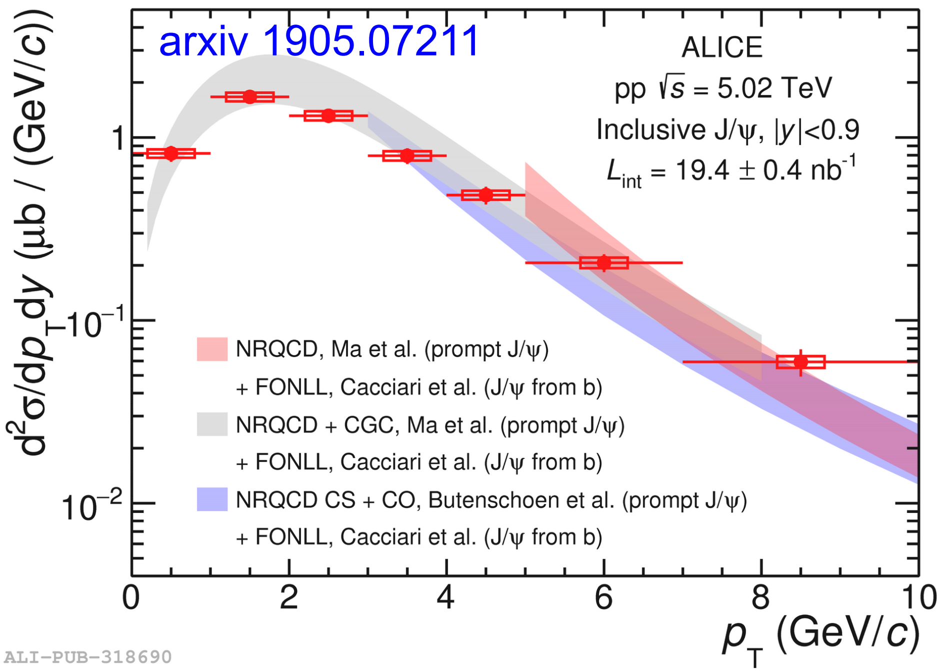
- PYTHIA8 with string formation beyond leading colour approximation close to data
  Christiansen, Skands, JHEP 1508 (2015) 003

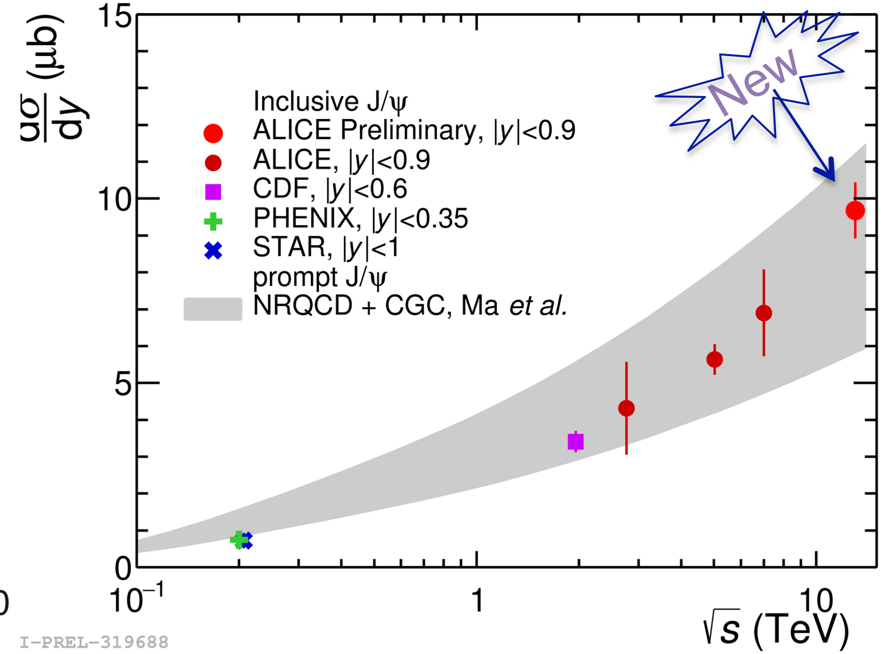
- Alternative explanation: feed-down from augmented set of charm-baryon states
  He, Rapp, arxiv 1902.08889

- Intriguing similarity with p_T trend of baryon-to-meson ratios in light-flavour sector in pp and p-Pb collisions

Charm hadronisation not fully understood

J/ψ production at mid rapidity





J/ψ p_T-differential cross section **down to p_T=0 at mid-rapidity at 5 and 13 TeV**
→ **New pp reference** + important constraints to understand J/ψ production mechanism

NRQCD+CGC describes data down to p_T=0, as well as the cross section vs. √s

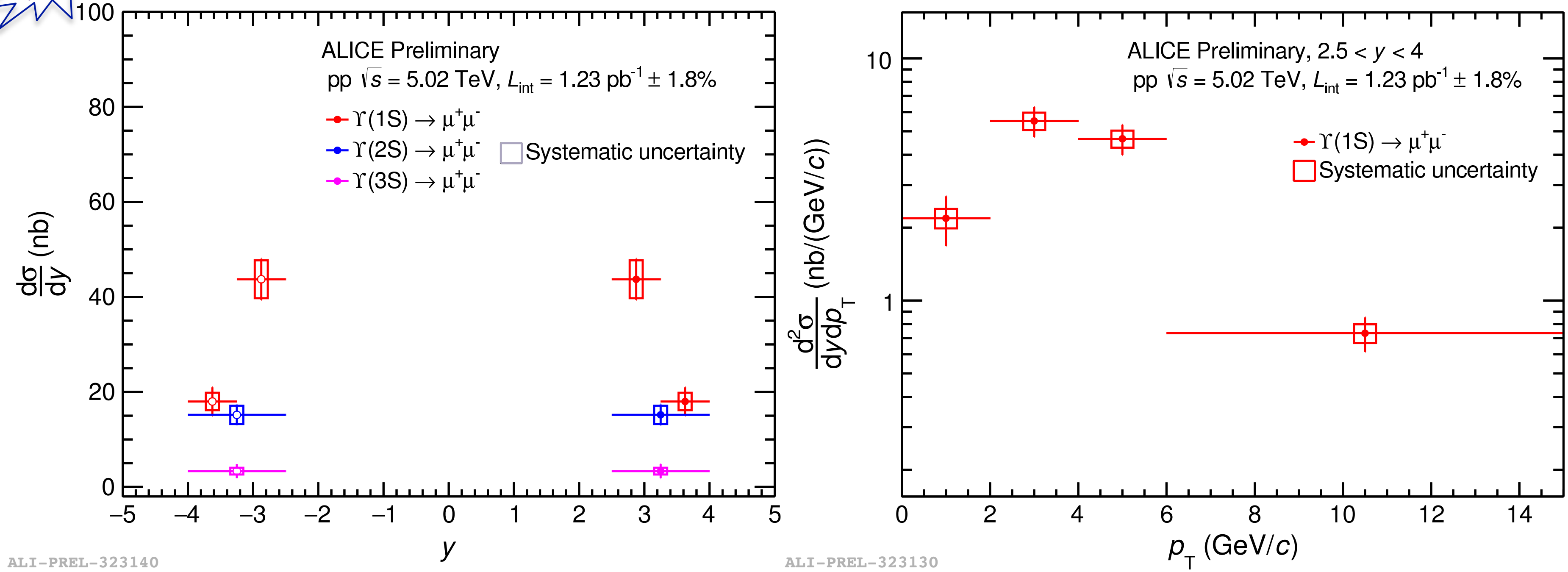
Run 1,2 ALICE legacy on charmonia: double p_T,y differential view on J/ψ (and forward ψ(2S)) production down to p_T=0 from √s = 2.76 to 13 TeV → **M. Kim, W. Shaikh**

LO-NRQCD+CGC: Y.-Q. Ma and R. Venugopalan: PRL. 113 (2014) 192301; **NLO-NRCQD**: Y.-Q. Ma *et al.*, PRL 106 (2011) 042002; **NLO-NRQCD CS+CO**: M. Butenschoen and B.A. Kniehl, PRL 106 (2011) 022003

Bottomonia in pp at 5 TeV

New

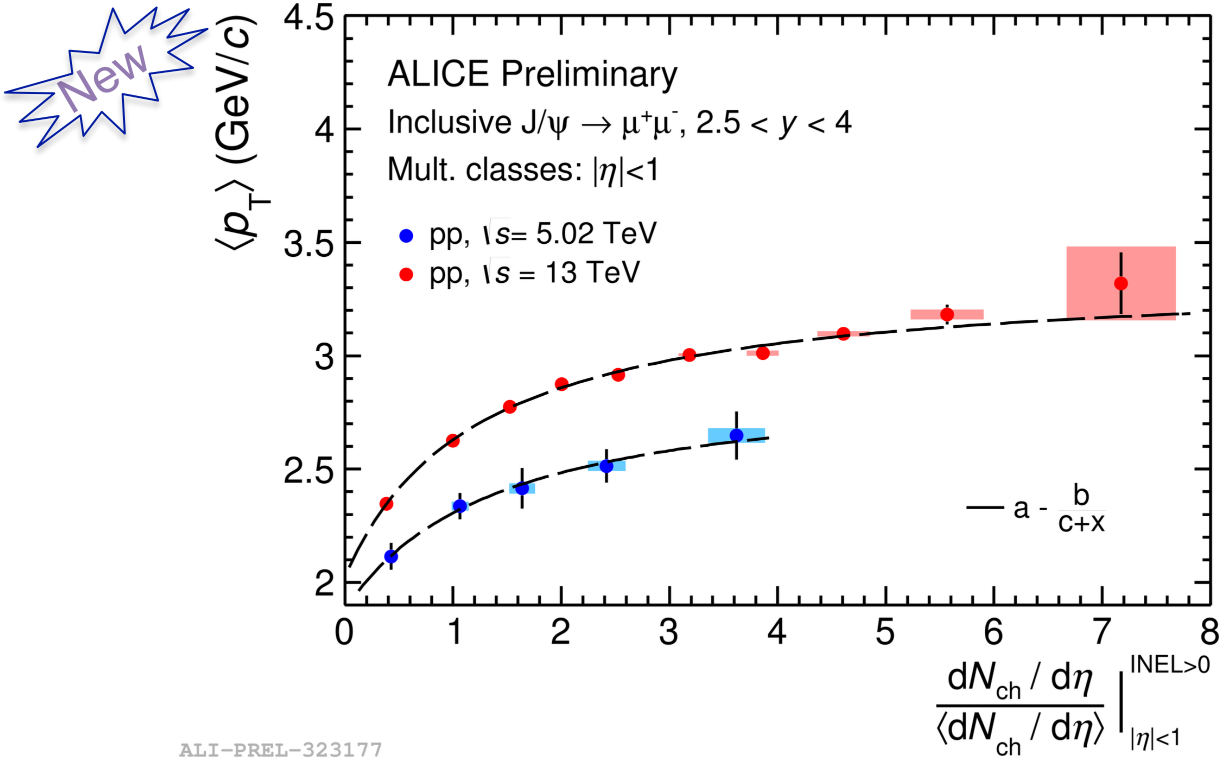
W. Shaikh



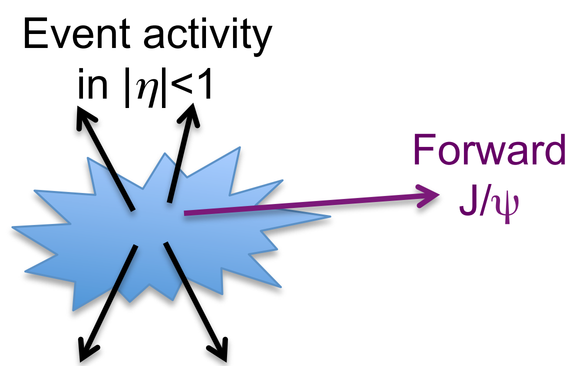
Y(1S), Y(2S), Y(3S) production measured at forward rapidity

→ **New pp reference** will improve interpretation of nuclear modification factors in p-Pb and Pb-Pb collisions

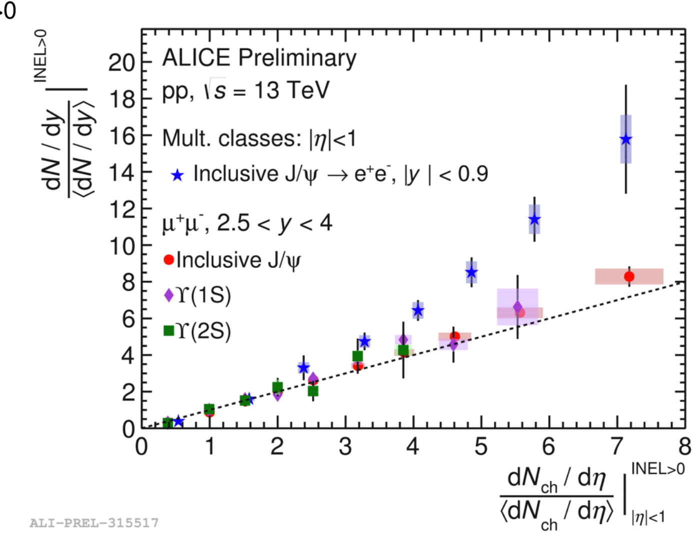
J/ψ ⟨p_T⟩ vs. multiplicity



W. Shaikh



- ⟨p_T⟩ of J/ψ at forward *y* increases with the event multiplicity measured at mid rapidity
- Similar trend at $\sqrt{s}$ = 5.02 and 13 TeV
- Complementary information to study of charmonium and bottomonium yields vs. multiplicity



p-Pb collisions

D mesons in p-Pb collisions

Tomorrow on arxiv, CERN-EP-2019-125

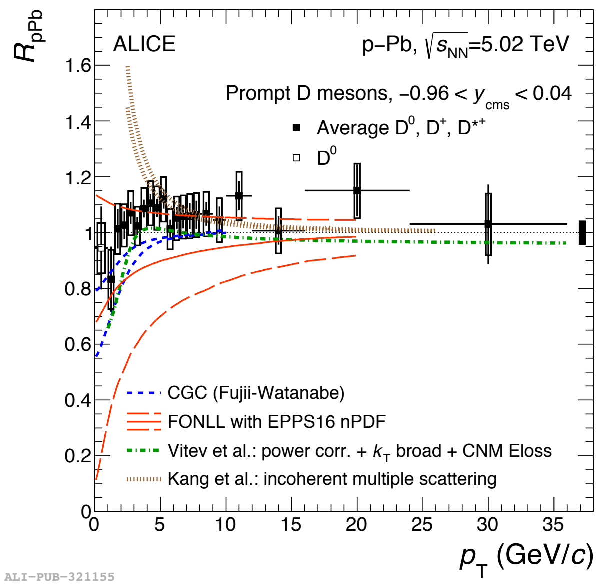
P. Dhanker

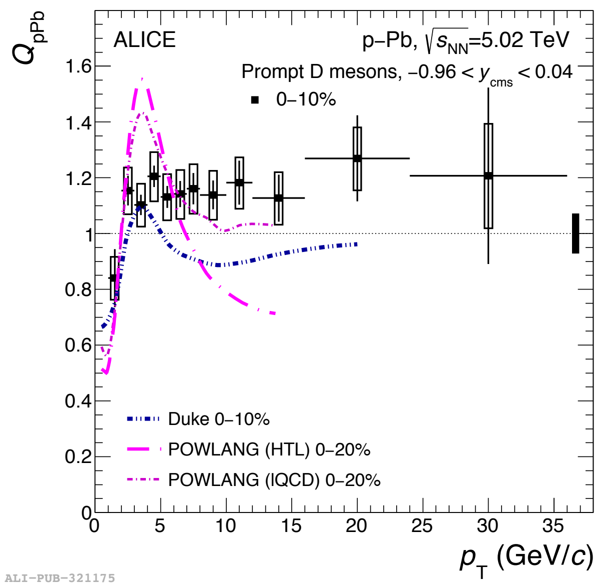
ALICE

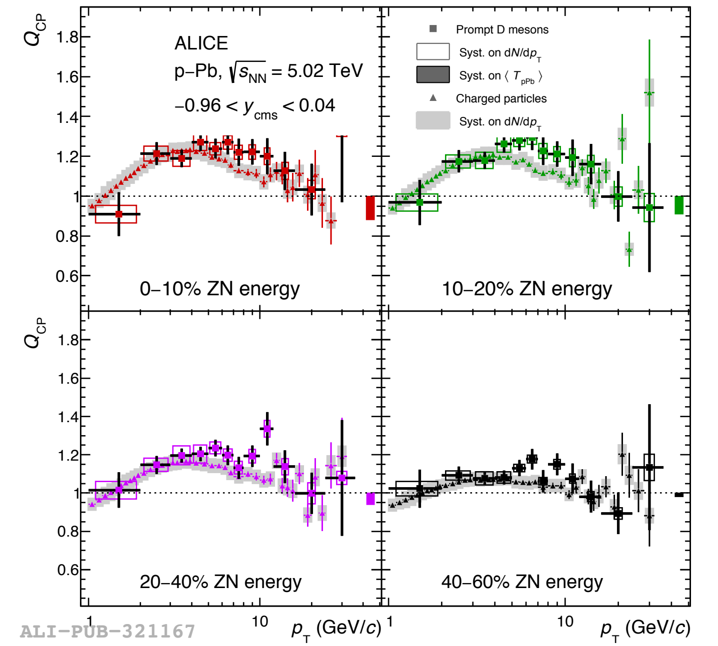
$$R_{\mathrm{pPb}} = \frac{\mathrm{d}\sigma_{\mathrm{pPb}} / \mathrm{d}p_{\mathrm{T}}}{A \times \mathrm{d}\sigma_{\mathrm{pp}} / \mathrm{d}p_{\mathrm{T}}}$$

$$Q_{\mathrm{pPb}}^{i} = \frac{\left(\mathrm{d}N_{\mathrm{pPb}} / \mathrm{d}p_{\mathrm{T}}\right)_i}{\left\langle T_{\mathrm{pPb}}\right\rangle_i \times \mathrm{d}\sigma_{\mathrm{pp}} / \mathrm{d}p_{\mathrm{T}}}$$

$$Q_{\mathrm{CP}}^{i} = \frac{\left(\mathrm{d}N_{\mathrm{pPb}} / \mathrm{d}p_{\mathrm{T}}\right)_i / \left\langle T_{\mathrm{pPb}}\right\rangle_i}{\left(\mathrm{d}N_{\mathrm{pPb}} / \mathrm{d}p_{\mathrm{T}}\right)_{60-100\%} / \left\langle T_{\mathrm{pPb}}\right\rangle_{60-100\%}}$$







- D-meson $\boldsymbol{R_{\mathrm{pPb}}}$ **compatible with unity** in $0<p_{\mathrm{T}}<36$ GeV/c
  - Described by models including Cold-Nuclear-Matter (CNM) effects
- Data do not favour "radial-flow"-like peak around 3-4 GeV/c, nor decreasing trend at higher p_{T}
- **Central-to-peripheral ratio around 1.2 at intermediate $\boldsymbol{p_{\mathrm{T}}}$** (larger than unity by ~3σ in $3<p_{\mathrm{T}}<7$ GeV/c in 20-40%): p_{T}-trend similar to that measured for charged particles

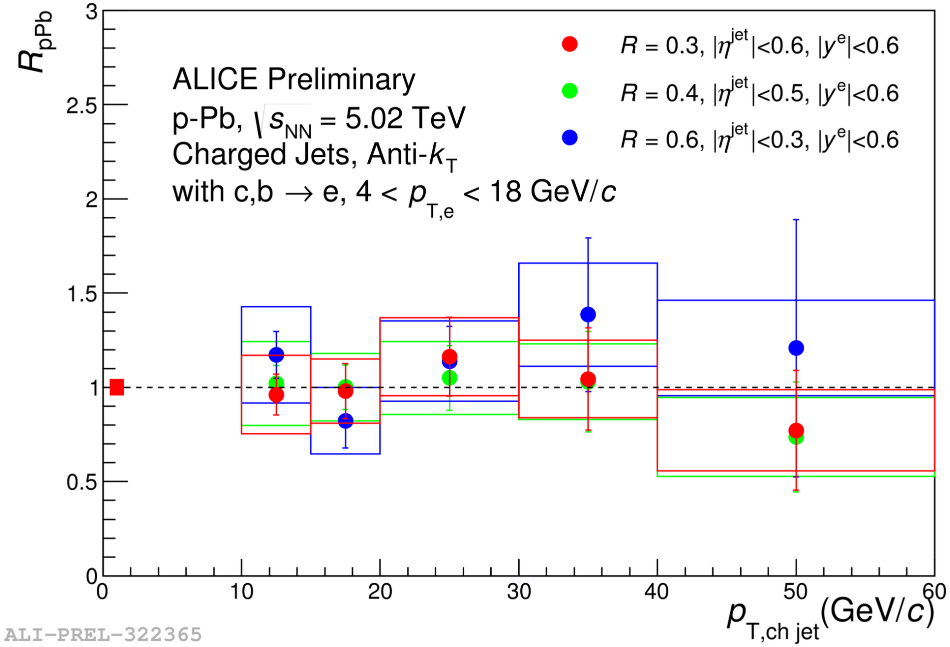
Heavy-Flavour jets in p-Pb

ALICE

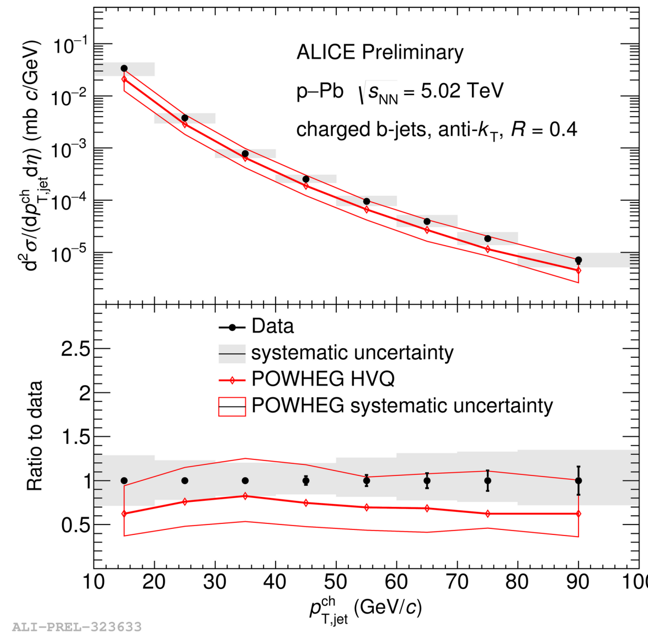
A. Mohanty,
E. Gauger

New

HF-electron tagged jets



b-tagged jets



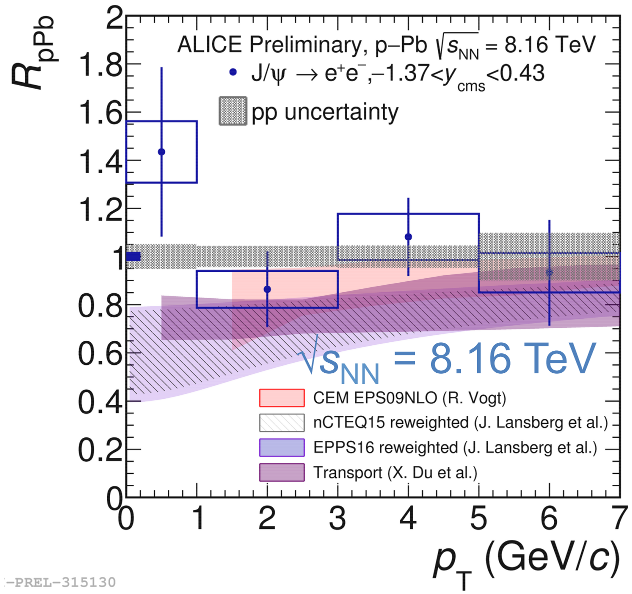
Heavy-flavour jets measured down to p_T = 10 GeV/c

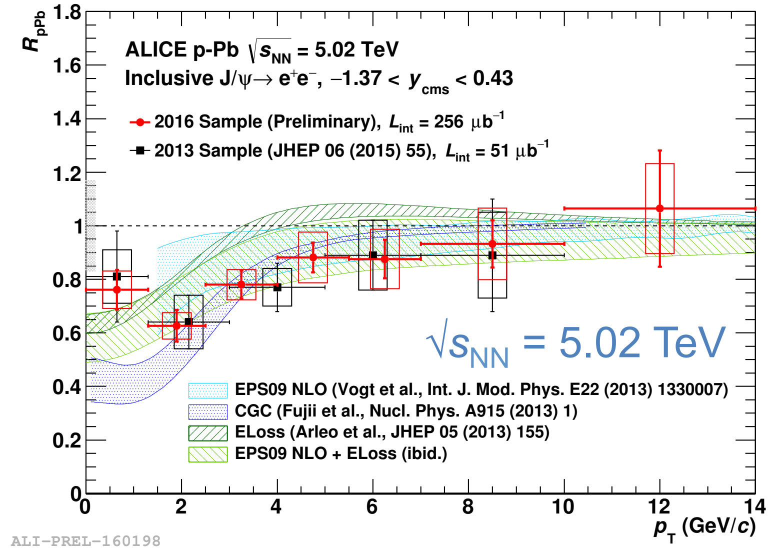
- R_{pPb} of charm + beauty jets with HF-electron tagging compatible with unity independently on jet radius

- Cross section of **beauty jets tagged with displaced vertices described by POWHEG HVQ x A** within uncertainty

Mid-rapidity J/ψ in p-Pb at $\sqrt{s_{NN}}$= 8.16 TeV

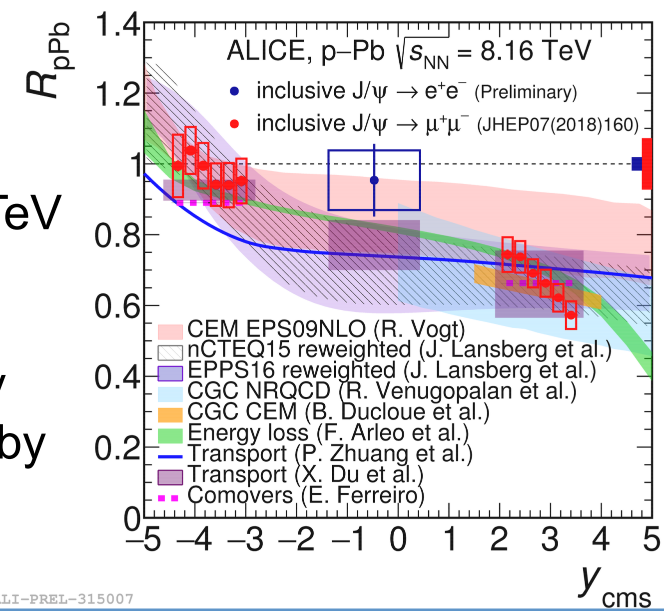
M. Kim





- R_{pPb} of inclusive J/ψ at $\sqrt{s_{NN}}$ = 8.16 TeV is compatible with unity for 0<p_T<7 GeV/c
  - Consistent, within uncertainties, with $\sqrt{s_{NN}}$ = 5.02 TeV data

- Within uncertainties, the p_T-dependence at mid-rapidity as well as rapidity dependence for p_T>0 are described by models including CNM effects



Pb-Pb collisions

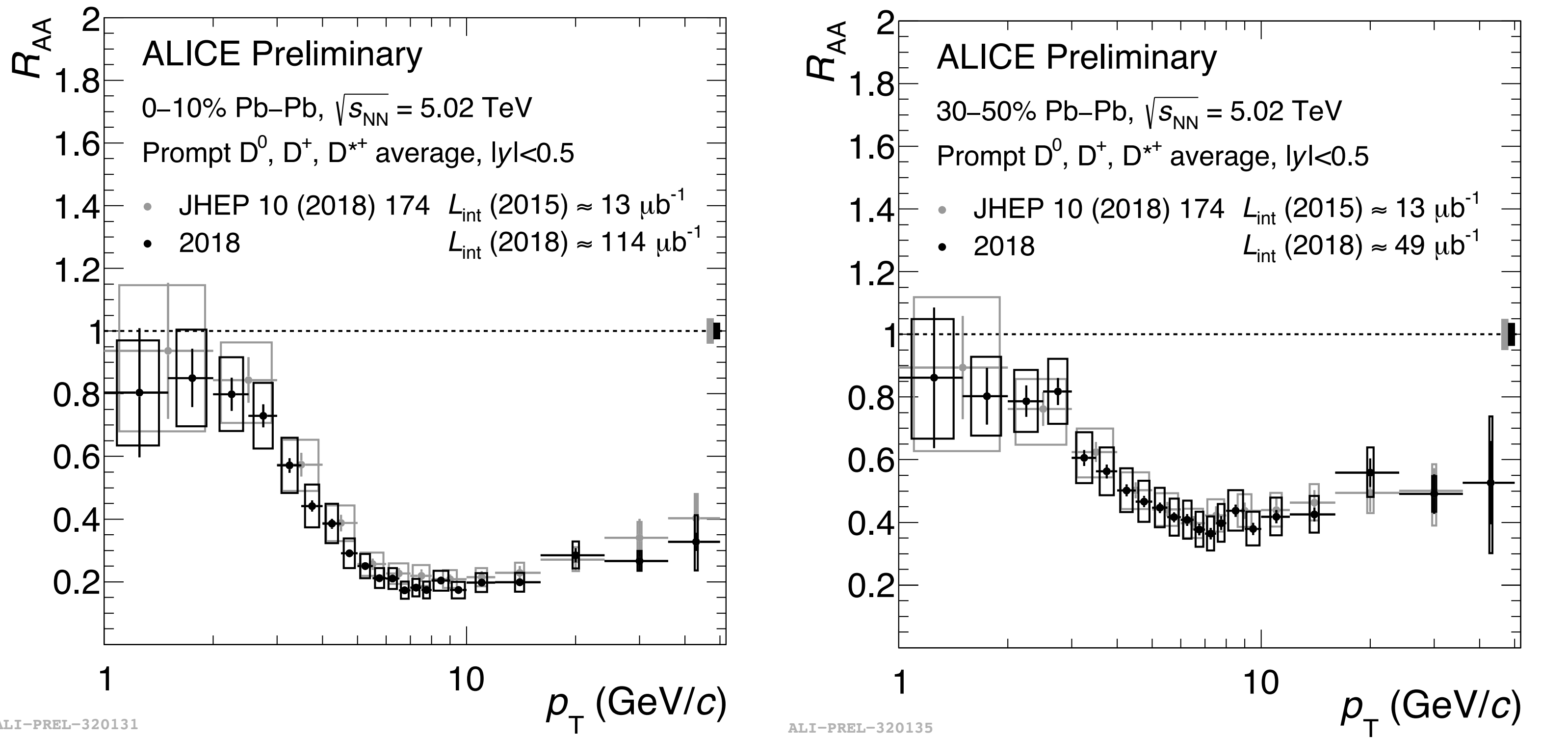
2018 data
Min. bias:
L_{int} ~20 μb^{-1} (similar to 2015)
Centrality triggers:
L_{int} ~ 114 μb^{-1} in 0-10% after selections (**x9 more** than 2015 data)
L_{int} ~ 49 μb^{-1} in 30-50% after selections (**x4 more** than 2015 data)
Di-muon triggers:
L_{int} ~ 540 μb^{-1} (**~x2.2 more** than 2015 data)

Non-strange D-meson R_{AA}

S. Jaelani

New

$$R_{AA} = \frac{dN_{AA}/dp_T}{\langle T_{AA}\rangle \times d\sigma_{pp}/dp_T}$$



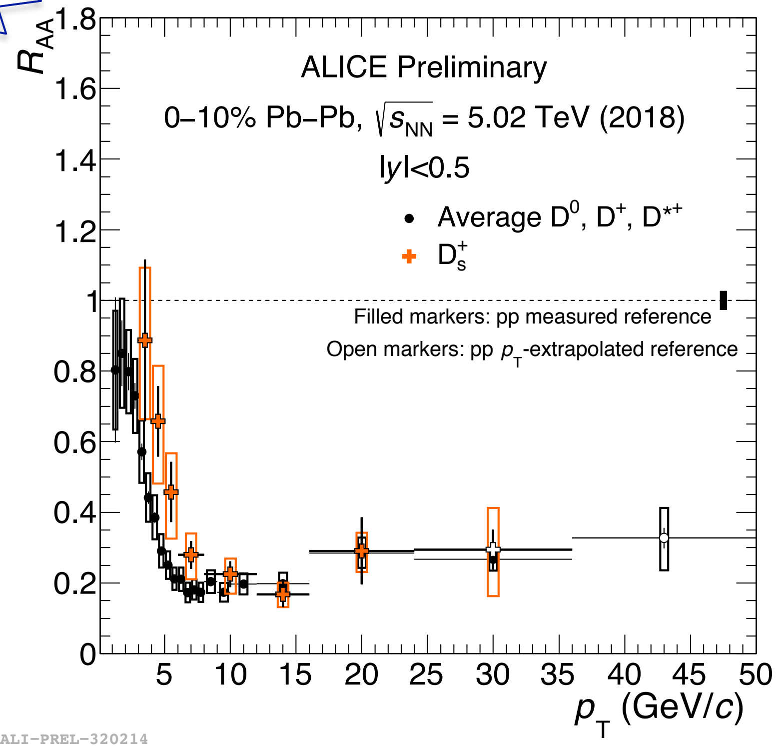
2018 data sample: reduced uncertainties, more p_T-differential

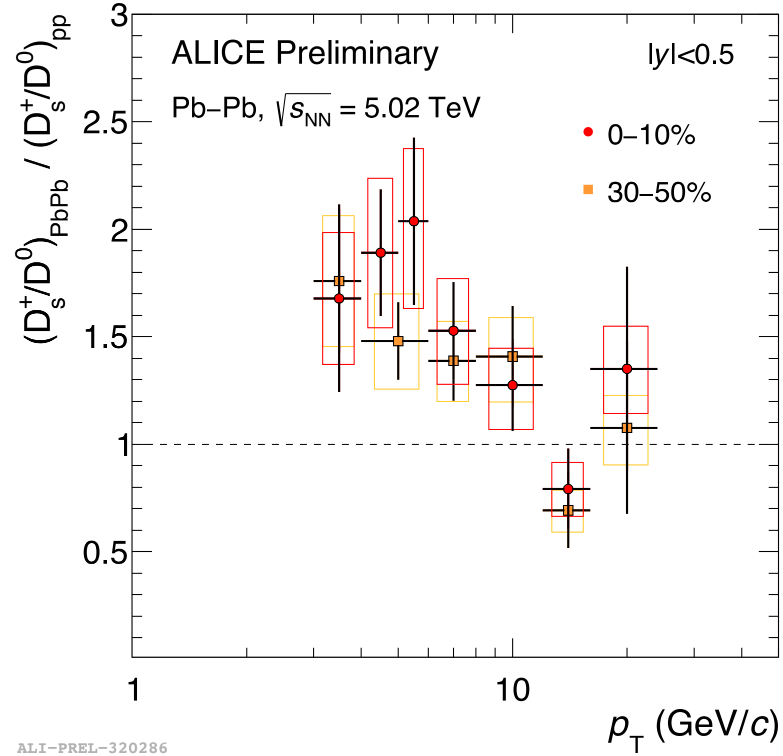
→ better constrain steeply decreasing R_{AA} trend at low p_T

→ important progress towards the measurement of total ccbar cross section

D_s^+ vs. non-strange D mesons

S. Jaelani

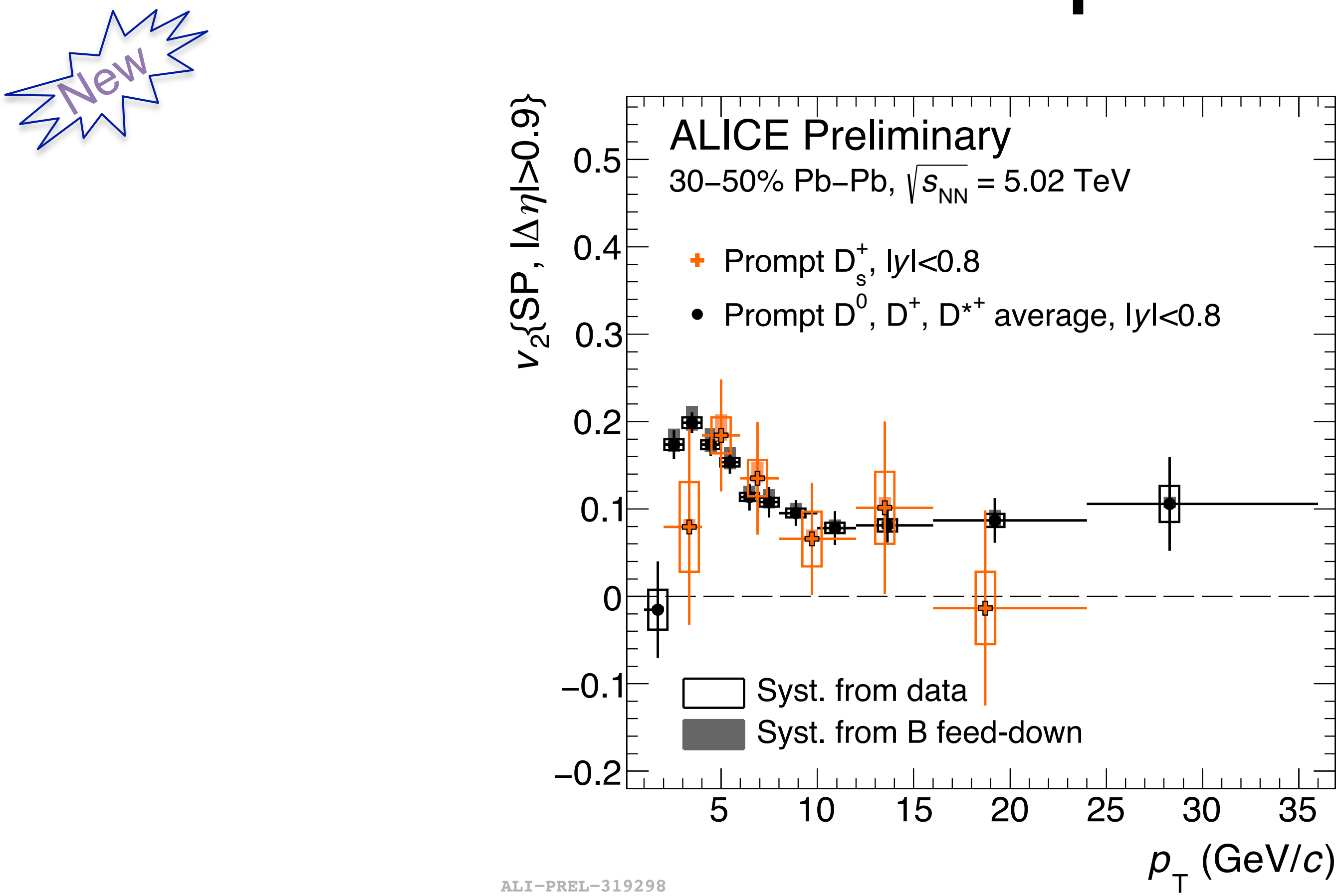




- D_s^+ meson measured down to p_T=3 GeV/c in 0-10% and 30-50% central collisions
- Indication of **enhancement of D_s^+/D^0 ratio in Pb-Pb with respect to pp** collisions
- No appreciable dependence on centrality within uncertainties
- Effort ongoing to push the measurement at lower p_T and improve its precision with Machine Learning techniques → poster by F. Catalano

D-meson elliptic flow

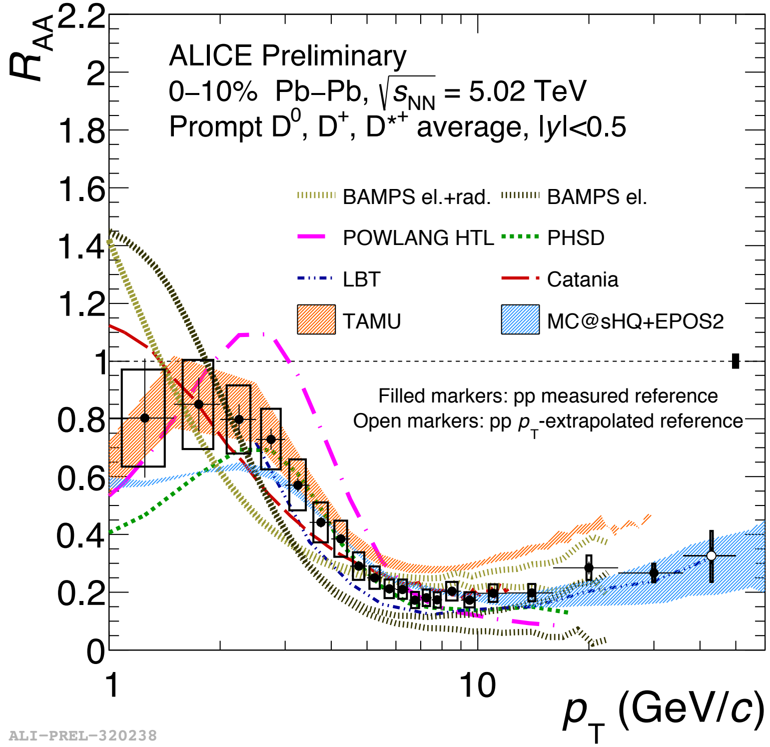
S. Jaelani,
C. Zampolli

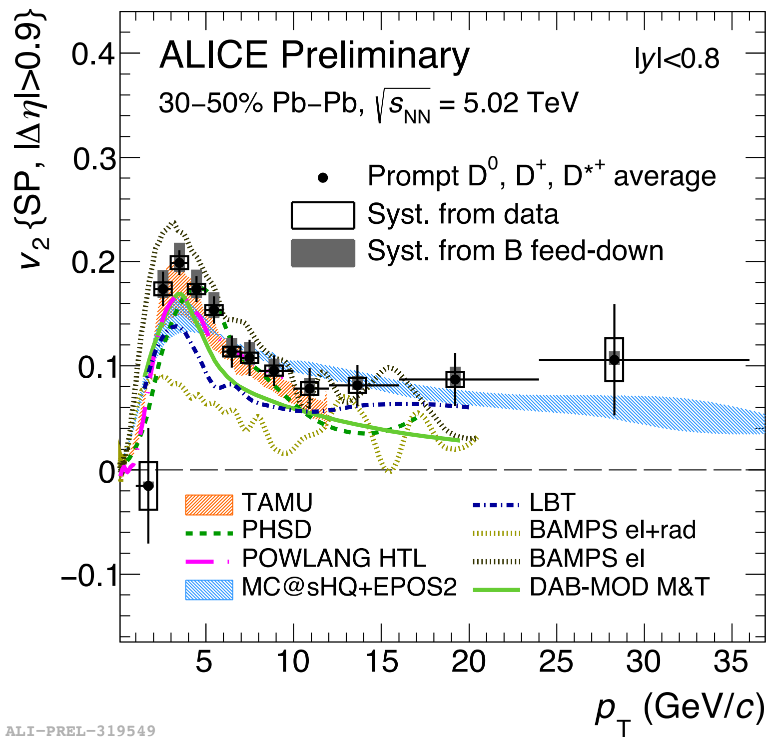


- New, more precise measurement of D meson v_2 in 30-50%
- Same v_2 for D_s^+ and non-strange D mesons, within uncertainties, down to 3 GeV/c

D-meson data vs. models

S. Jaelani



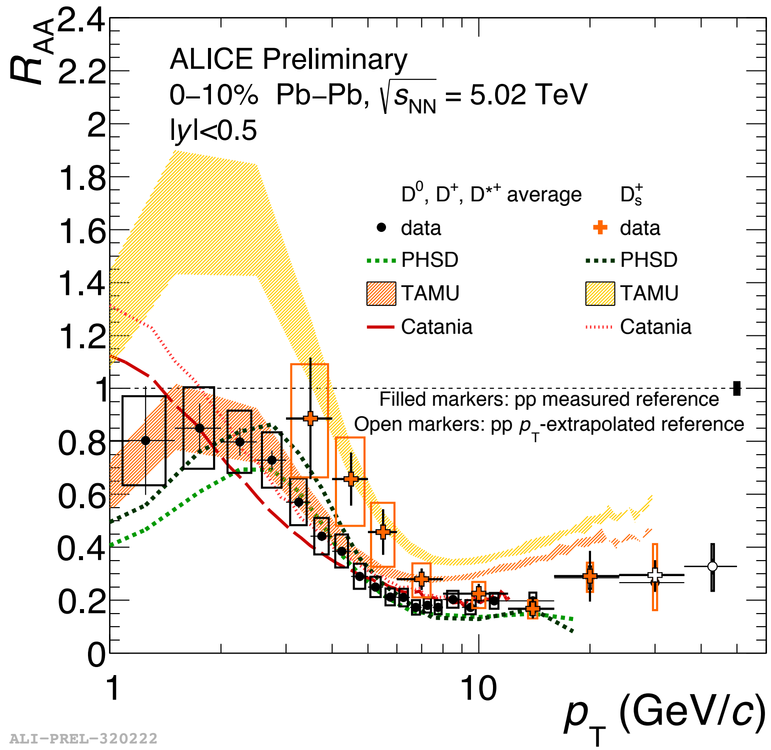


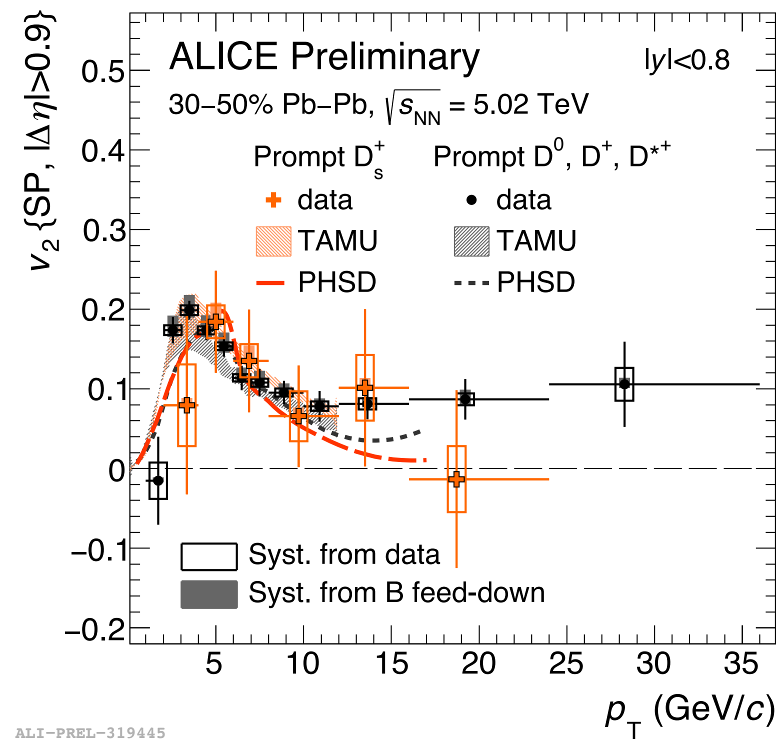
- Data precision nailing down description of charm-interaction and diffusion in the medium at low transverse momenta
- Interplay of CNM (shadowing), collisional and radiative energy loss, coalescence and realistic medium evolution required to describe data

BAMPS: JPG 42, 115106 (2016); **Catania**: EPJC (2018) 78: 348; **DAB-MOD**: PRC 96 064903 (2017); **LBT**: PLB 777 (2018) 255-259; **MC@sHQ+EPOS2**: PRC 89 014905 (2014); **TAMU**: PLB 735,445-450(2014); arXiv:1905.09216; **PHSD**: PRC 92, 014910 (2015); **POWLANG**: EPJC 75,121(2015);

D-meson data vs. models

S. Jaelani,
C. Zampolli



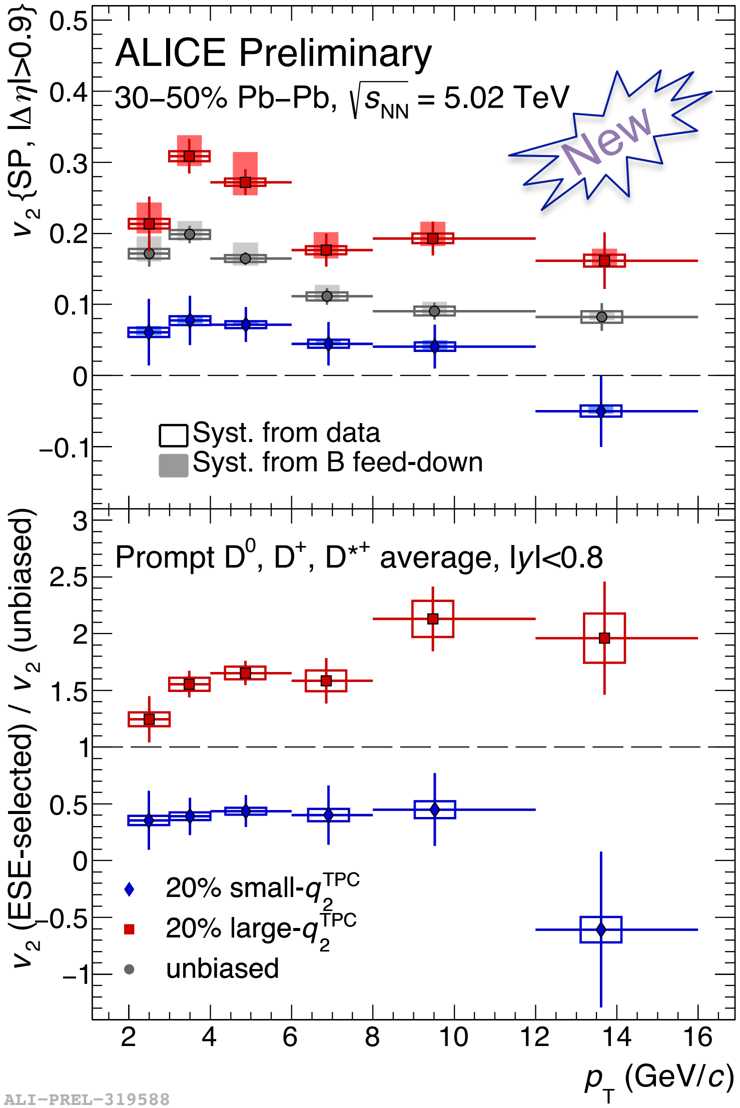


- Simulataneous description of D_s^+ and non-strange D-meson R_{AA} and v_2 → effective tool to constrain interplay of coalescence and collisional energy loss + medium flow on D-meson spectra
- Similar v_2 for non-strange D and D_s^+ mesons expected from TAMU and PHSD models

TAMU: PLB 735,445-450(2014); arXiv:1905.09216; **PHSD**: PRC 92, 014910 (2015); **Catania**: EPJC (2018) 78: 348

D-meson v_2 with Event-Shape Engineering

S. Jaelani



Initial-condition fluctuations and event eccentricity → event-by-event variation of the flow coefficients (v_n) at fixed centrality can be large

Clear difference of D-meson v_2 in events with small and large q_2 (2nd-order reduced q-vector)

- 2018 data clarifies effect reported in JHEP1902 (2019) 150

Suggest that **charm is sensitive to collectivity of light-hadron bulk and event-by-event initial-conditions fluctuations**

$$q_2 = \frac{|\vec{Q}_2|}{\sqrt{M}}, \quad Q_{2,x} = \sum_{i=1}^{M} \cos 2\varphi_i, \quad Q_{2,y} = \sum_{i=1}^{M} \sin 2\varphi_i$$

$$\langle q_2^2 \rangle \approx 1 + \langle M - 1 \rangle \langle v_2^2 - \delta_2 \rangle$$

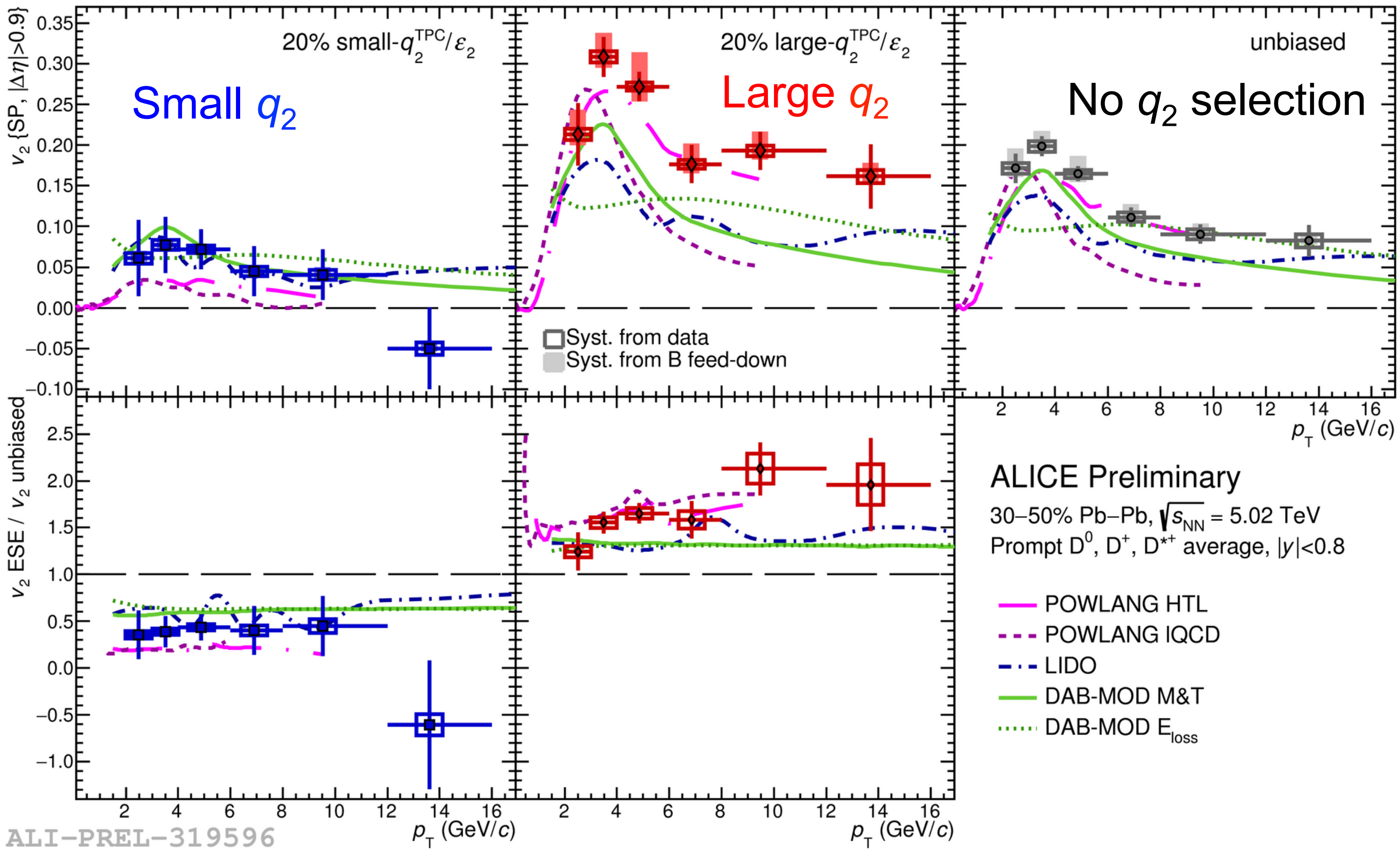
δ: non-flow effects

M: multiplicity v_2: flow strength

D-meson v_2 with Event-Shape Engineering

S. Jaelani

New

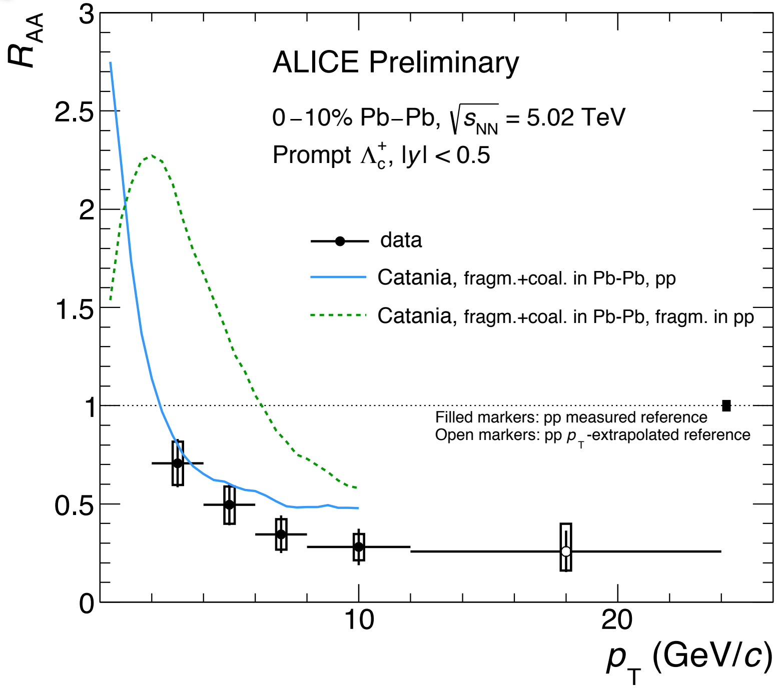


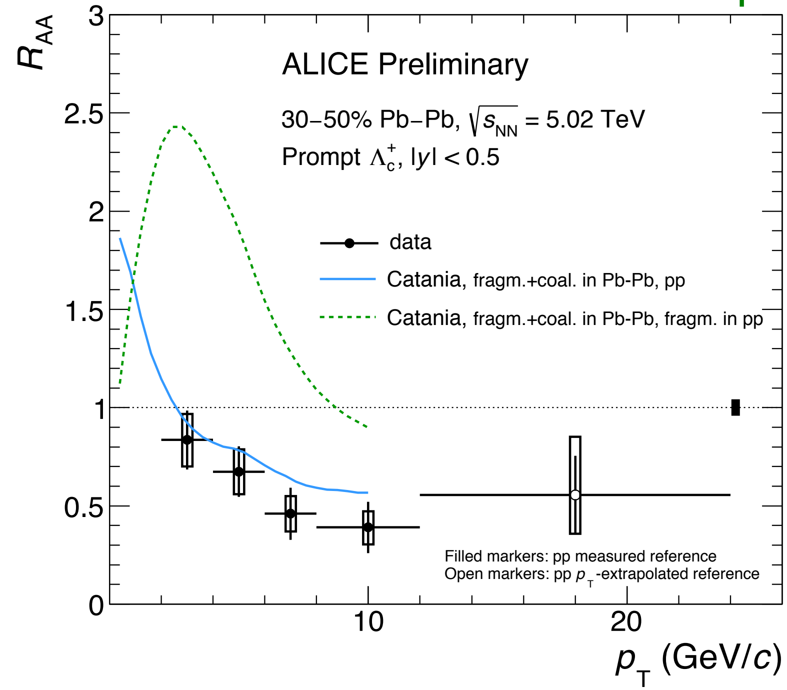
Transport models describe reasonably q_2 dependence of elliptic flow

POWLANG: EPJC 75,121(2015); **LIDO**: arxiv 1810.08177; **DAB-MOD**: PRC 96 064903 (2017)

Λ_c^+ in Pb-Pb collisions

C. Zampolli





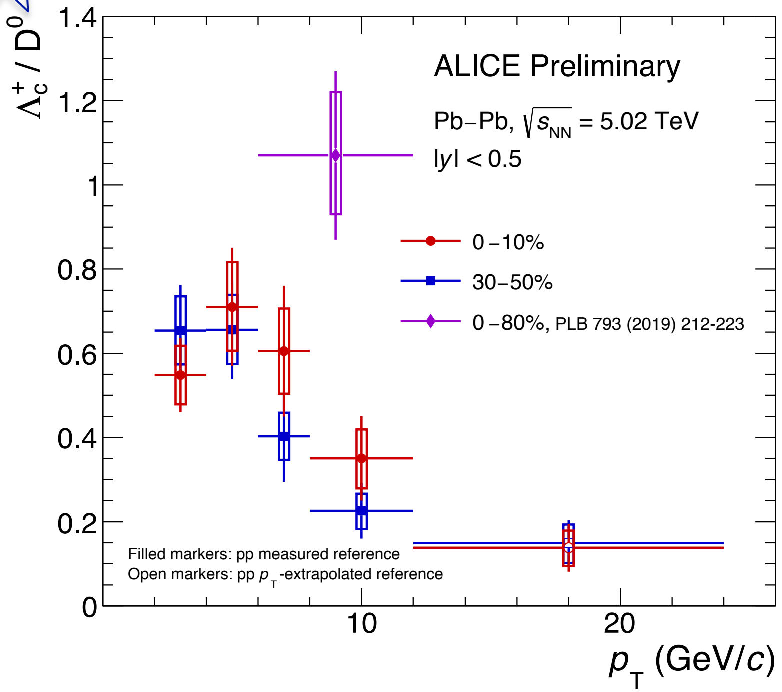
New Λ_c^+ R_{AA} measurements

- Improved precision, extended p_T-coverage ($2<p_T<24$ GeV/c), differential in centrality (0-10%, 30-50%)
  - Thanks to larger 2018 dataset and exploitation of Machine-Learning techniques
- Λ_c^+ suppression similar in 0-10% and 30-50%
- Described by Catania model including hadronisation via both fragmentation and coalescence Catania: S. Plumari *et al.*, EPJC (2018) 78: 348

Λ_c^+ in Pb-Pb collisions

C. Zampolli

New



ALI-PREL-321698

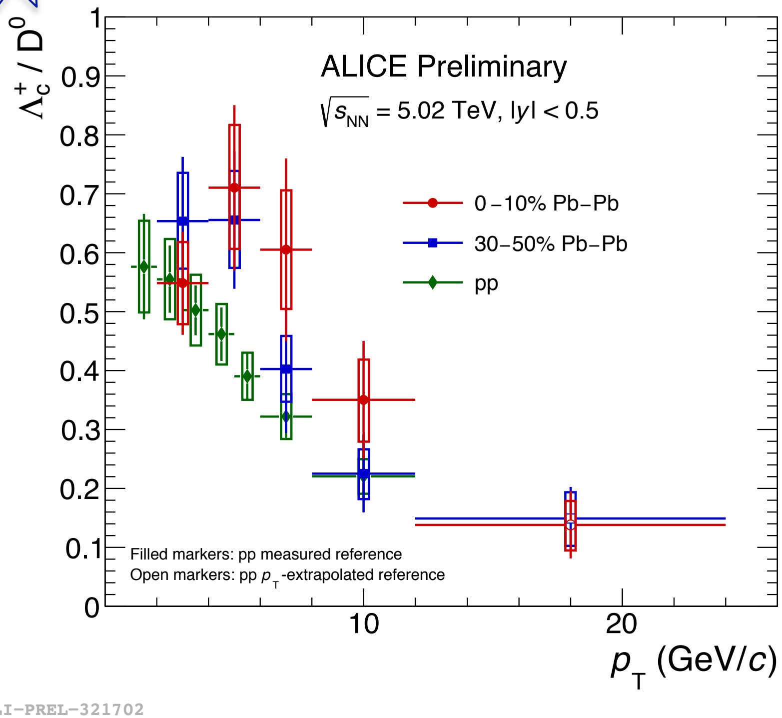
- Λ_c^+/D^0: 2015 result in 0-80% in $6<p_T<12$ GeV/c compatible at ~2σ with 0-10% result

Λ_c^+ in Pb-Pb collisions

C. Zampolli

New

pp, 30-50% Pb-Pb, 0-10% PbPb



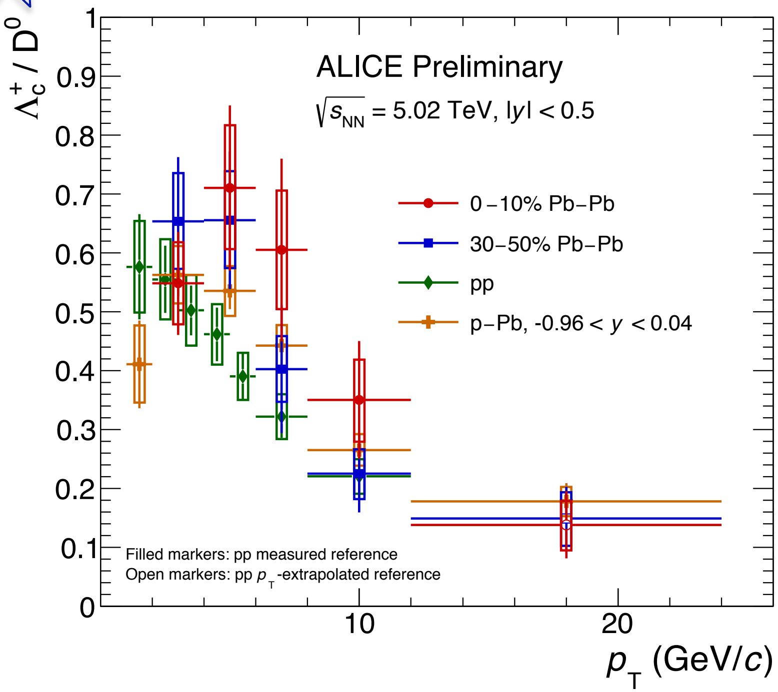
- Hint of higher Λ_c^+/D^0 ratio in 0-10% Pb-Pb collisions w.r.t. pp collisions

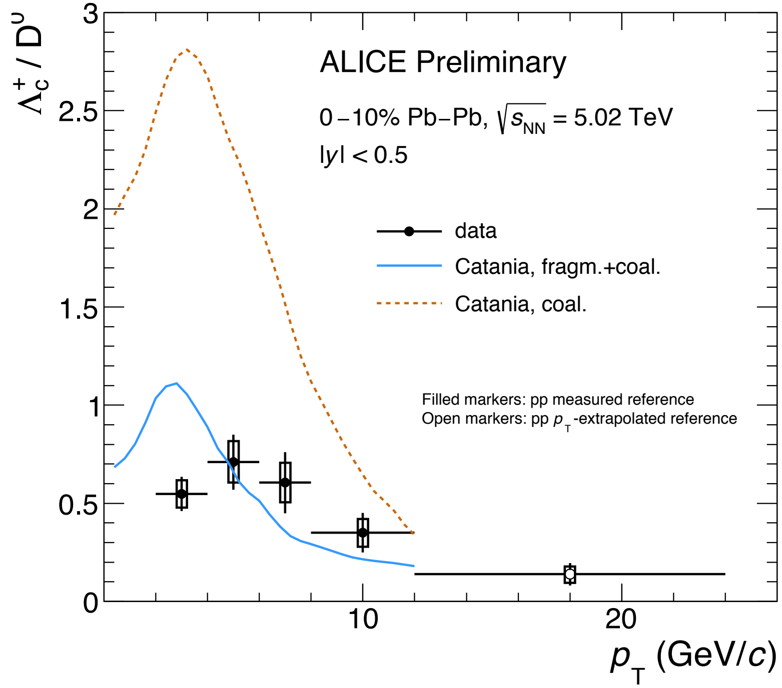
Λ_c^+ in Pb-Pb collisions

New

C. Zampolli

pp, p-Pb, 30-50% Pb-Pb, 0-10% PbPb

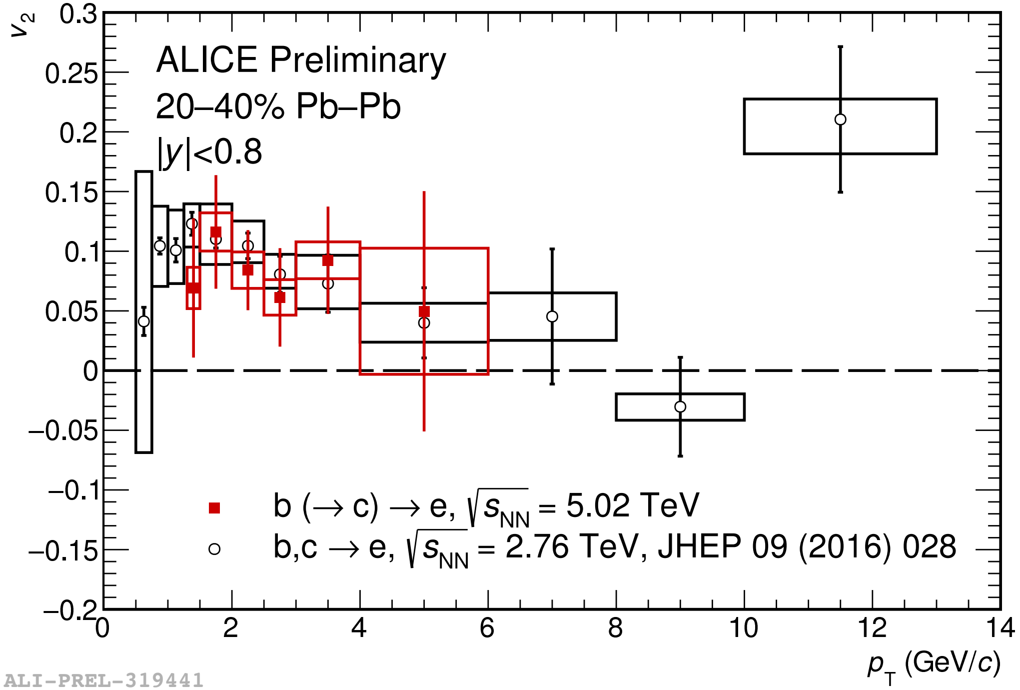




- **Hint of higher Λ_c^+/D^0 ratio in 0-10% Pb-Pb collisions w.r.t. pp collisions**
- More precision needed to imagine a trend from pp to p-Pb to Pb-Pb
  - Understanding of pp data is fundamental: not granted that Λ_c^+ is "enhanced" in the same way in Pb-Pb and pp (w.r.t. e^+e^-)
- **Λ_c^+/D^0 ratio in Pb-Pb collisions described by Catania model including both coalescence and fragmentation** Catania: S. Plumari *et al.,* EPJC (2018) 78: 348

Open-beauty elliptic flow

E. Gauger

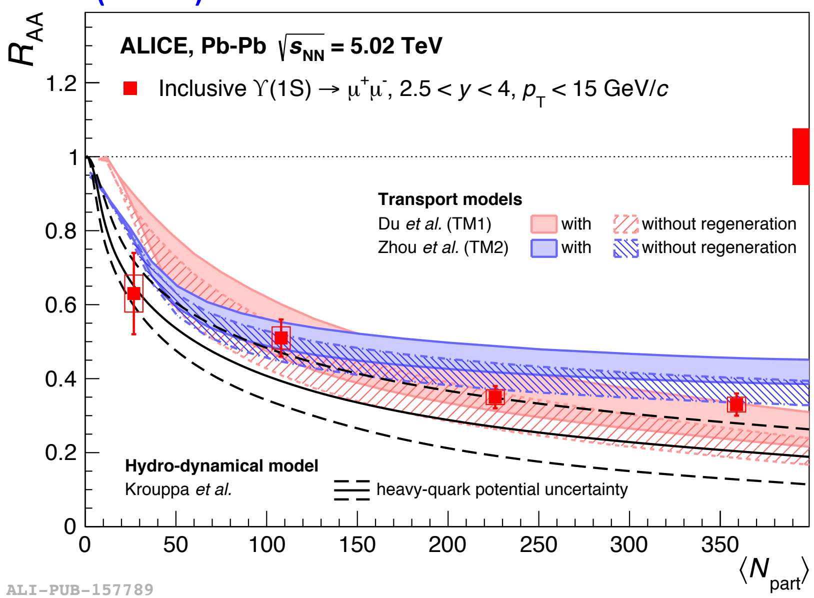


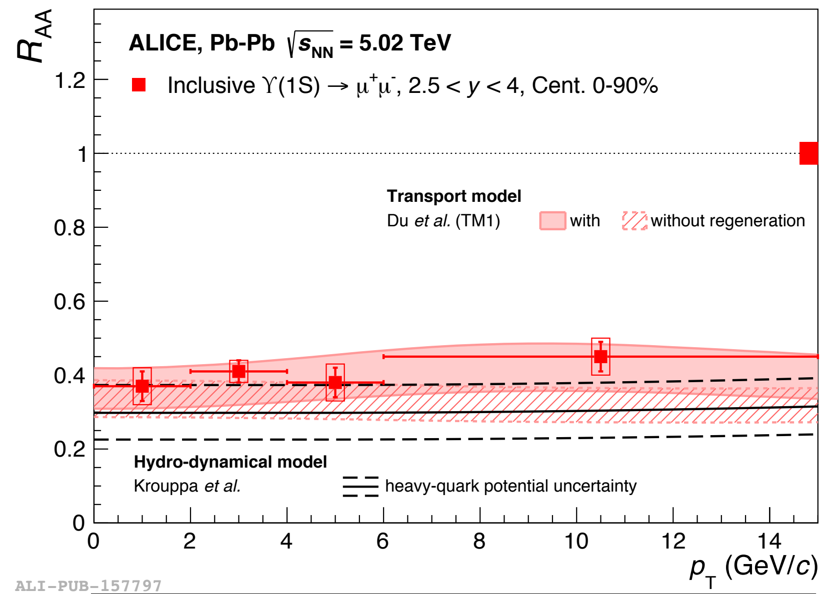
- ***v_2* >0** (~3.5σ effect) for **electrons from beauty-hadron decays** in 20-40% centrality
- **Similar** v_2 than for **charm(+beauty)** electrons
- From analysis of 2015 data → can reduce uncertainties with 2018 data

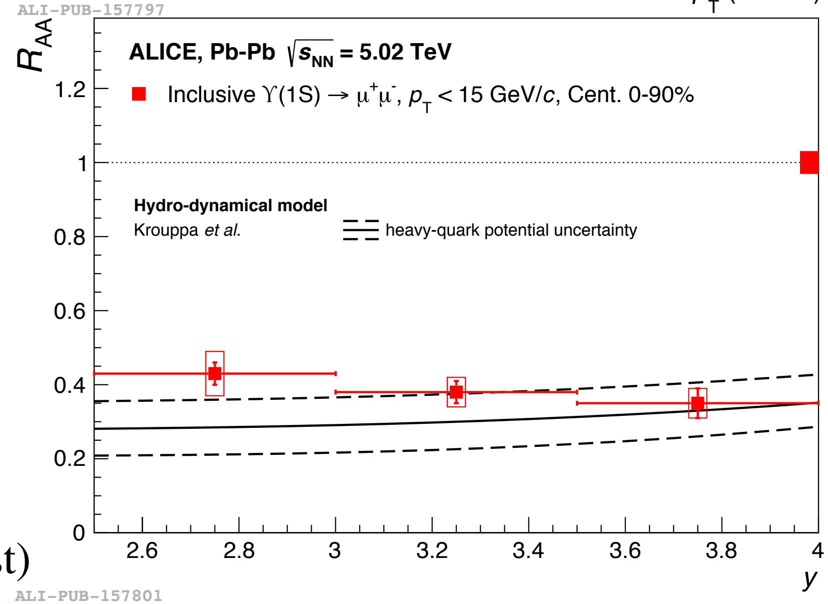
Υ(1S) nuclear-modification factor

PLB790 (2019) 89

W. Shaikh







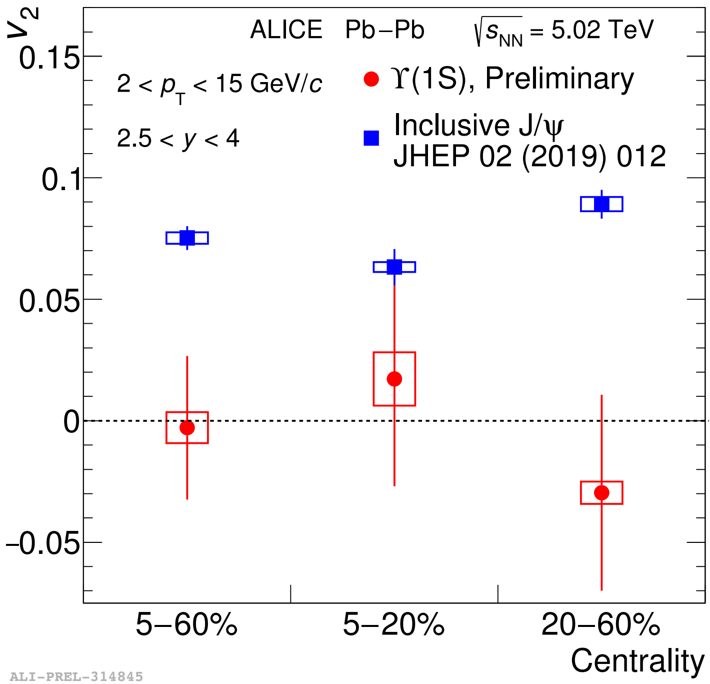
- Significant Υ(1S) suppression, increasing from peripheral to central collisions
- No significant variation observed as a function of p_T and rapidity
- Transport models reproduce data within uncertainties
  Zhou *et al.*, NPA931 (2014) 654-658
  Du *et al.*, PRC 96, no. 5, (2017) 054901
  - Hint of opposite *y* trend in Krouppa?
    PRD97, no1. (2017) 016017
- Stronger suppression measured for Υ(2S) in 0-90%: $R_{AA}^{\Upsilon(2S)} / R_{AA}^{\Upsilon(1S)} = 0.28 \pm 0.12(\mathrm{stat}) \pm 0.03(\mathrm{syst})$

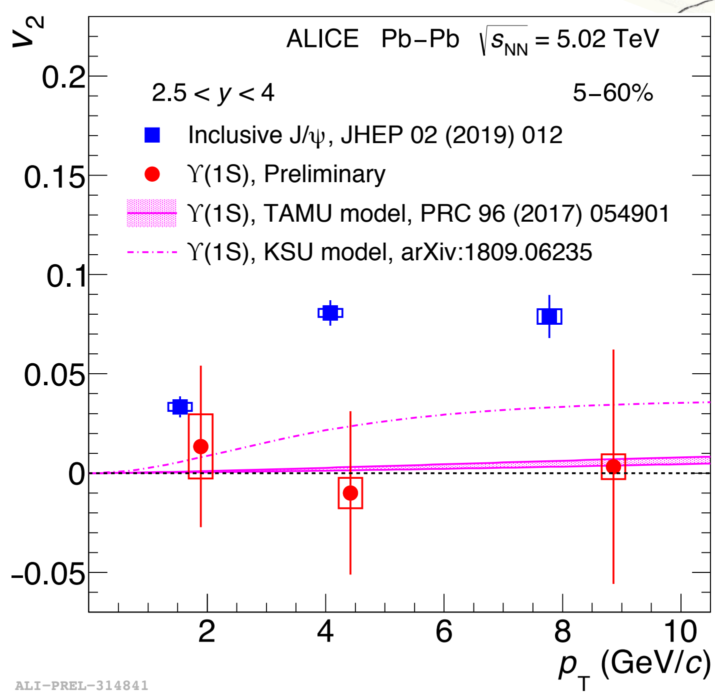
Υ(1S) (non?) elliptic flow

New

PANTA REI ?

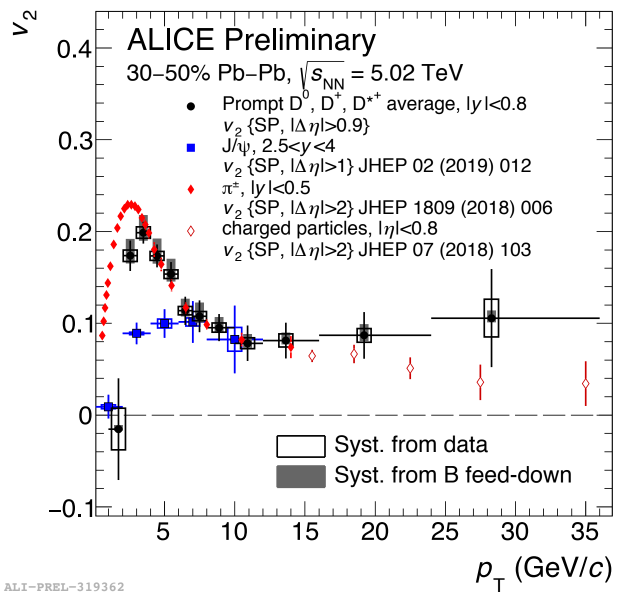
W. Shaikh

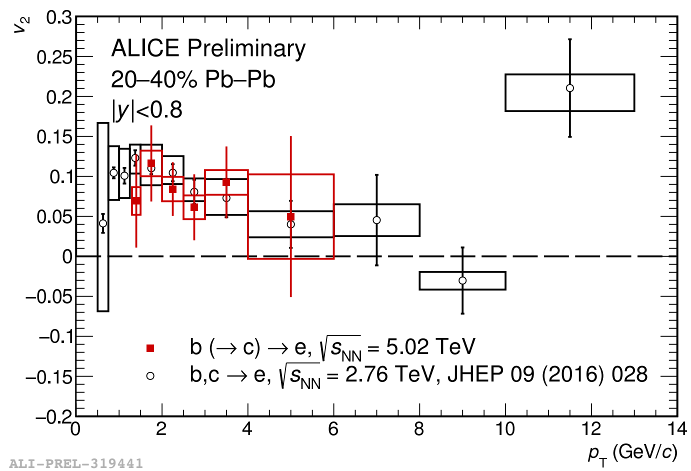


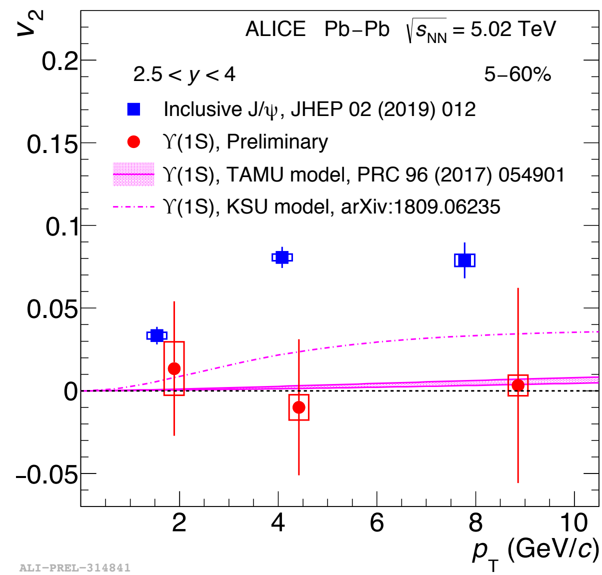


- **First measurement of Υ(1S) elliptic flow** at forward rapidity from analysis of 2015 and 2018 Pb-Pb datasets together.
- Υ(1S) v_2 **compatible with zero as well as with the small positive values predicted by available theoretical models**
  - KSU: path-length dependence of dissociation of initially created bottomonia
  - TAMU: includes also possible formation via recombination
- Indication of lower v_2 than inclusive J/ψ (2.6 σ) in $3 < p_T < 15$ GeV/c

Heavy-flavour elliptic flows







- **D-meson v_2 ≥ J/ψ v_2 > 0** → charm quarks flow + possible enhancement of open charm v_2 from hadronisation via coalescence with flowing light-flavour quarks

- **Open-beauty v_2 > 0, while bottomonia v_2 ~ 0**
→ what is the impact of collisional energy loss and coalescence on open-beauty v_2?

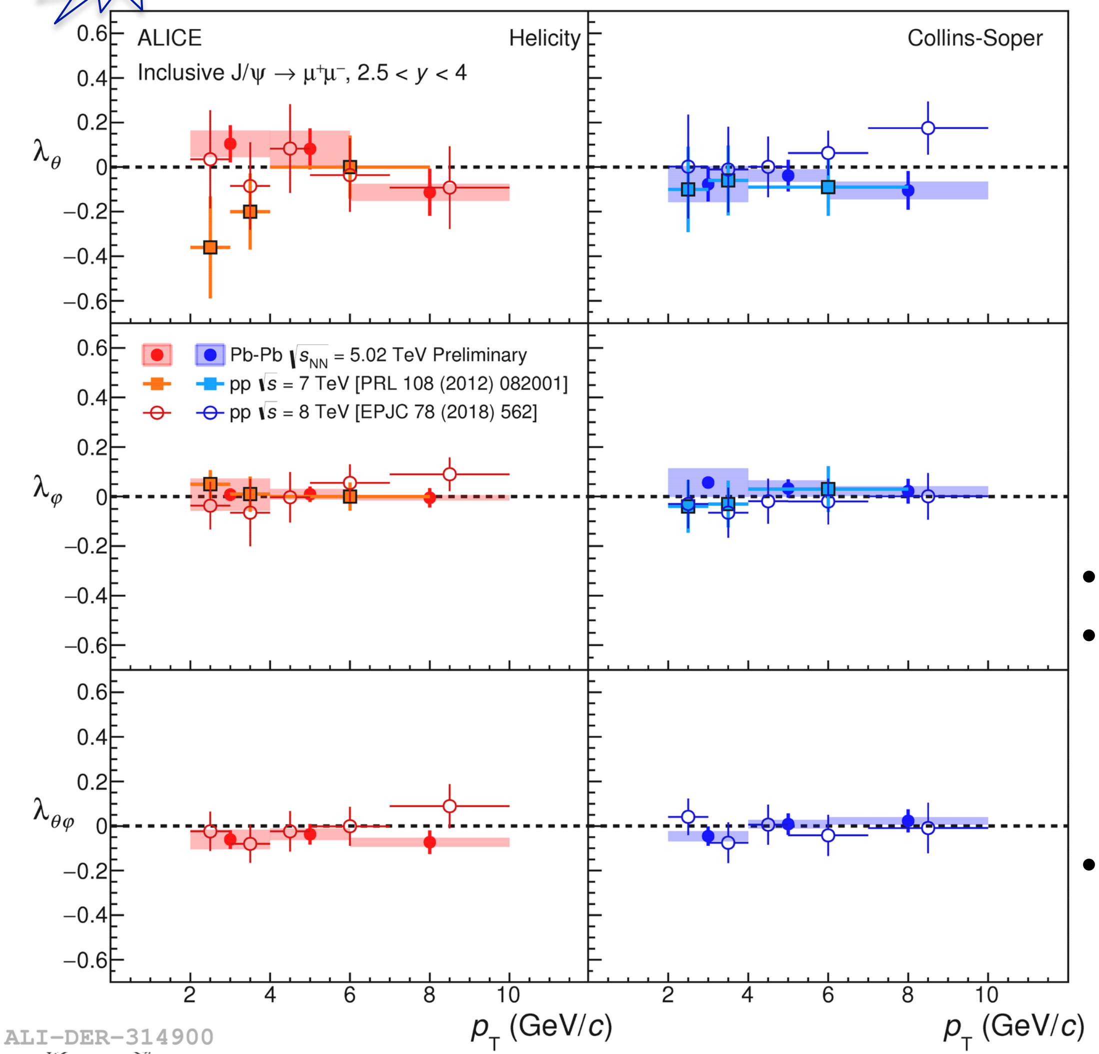
More precise measurements needed, as well as coherent interpretation of results via comparison with models

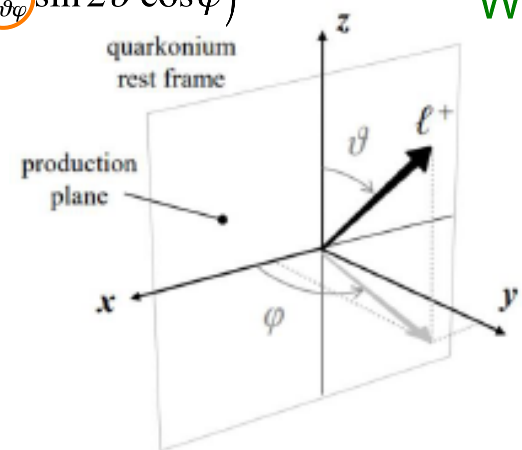
J/ψ polarisation in Pb-Pb collisions

New

$$W(\cos\vartheta,\varphi) \propto \frac{1}{3+\lambda_\vartheta}\cdot\left(1+\lambda_\vartheta\cos^2\vartheta+\lambda_\varphi\sin^2\vartheta\cos 2\varphi+\lambda_{\vartheta\varphi}\sin 2\vartheta\cos\varphi\right)$$

W. Shaikh





J/ψ polarisation measured for the first time in AA collisions at colliders

- Only 2015 data analysed
- **Compatible with zero and with pp-collision data** in both Helicity and Collin-Soper frames
- Outlook: possible future studies with different polarisation axes to probe potential effects from vorticity and EM field

Summary and outlook

at the end of run 2… after >9 years from first pp runs at the LHC

- **Reasonable theoretical description of open and hidden HF production in pp collisions** → key point for heavy-flavour physics in heavy-ion collisions
  - Main notable **exception: Λ_c^+ → charm hadronisation in pp differs from e^+e^-**

- CNM effects constrained with p-Pb collision data
  - Many (not all) effects observed can be described with nPDF
- But we observed medium-like (e.g. ψ(2S) suppression) and collective-like effects (HF flow at high multiplicity) also in p-Pb
  - Event activity "bridging" system properties from vacuum to QGP?

Pb-Pb collisions

- Interplay of CNM (shadowing), collisional and radiative energy loss, coalescence, radial flow required to describe (rather) precise D-meson flow and R_{AA} data
- **Intriguing results from charm-chemistry (Λ_c/D, D_s/D) → ALICE upgrade crucial**
  - Precise data needed to single out different effects and measure transport coefficients of HQ in the medium → talks by L. Musa, M. Weber
- **J/ψ flow and D-meson flow set together stringent constraints on cause of charm flow**
- **Beauty-electron v_2>0… but bottomonia v_2~0** → run 3 data needed to reduce uncertainties
- New observables and multi-differential studies (jet properties, ESE, v_1, J/ψ polarisation) very important to investigate medium properties

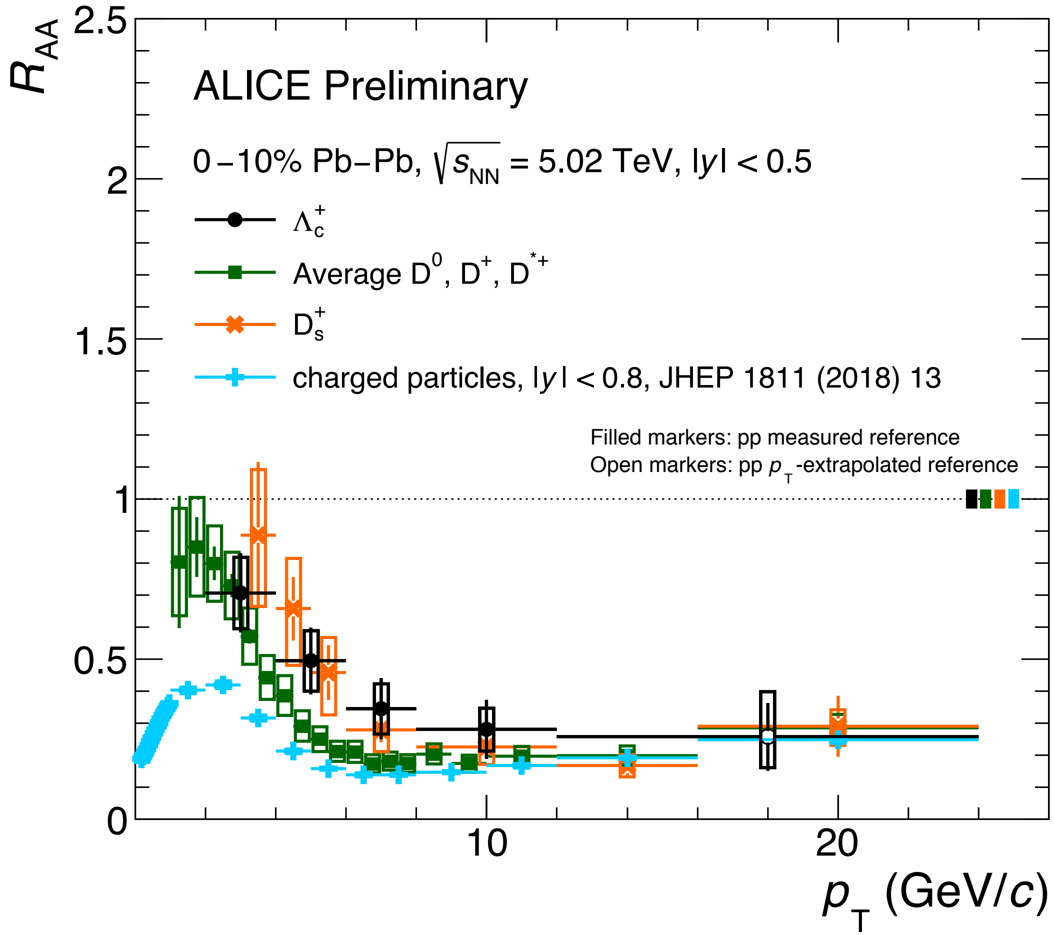
Related parallel talks

Quarkonium measurements at forward rapidity with ALICE at the LHC→ W. Shaikh, Thursday 15:20, session Heavy Flavour
J/ψ production measurements in pp, p-Pb, and Pb-Pb collisions at mid-rapidity using the ALICE detector at the LHC→ M. J. Kim, Thursday 14:40, session Heavy Flavour
Study of open heavy-flavour hadron production in pp nad p-Pb collisions with ALICE→ P. Dhanker, Tuesday 17:30, session Collectivity in small systems
Heavy-flavour jet production and charm fragmentation→ A. Mohanty, Thursday, 16:50, session Heavy Flavour
Latest results on Ds+ and Lc+ in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE at LHC→ C. Zampolli, Tuesday 15:20, session Hadronisation and coalescence
Beauty production with ALICE at the LHC→ E. F. Gauger, Tuesday 15:20, session Heavy Flavour
Measurement of non-strange D-meson prodcution and azimuthal anisotropy in Pb-Pb collisions with ALICE at the LHC → S. Jaelani, Tuesday 16:10, session Heavy Flavour

and posters:

Azimuthal anisotropy study of beauty-decay electrons in Pb-Pb collisions with ALICE → M. Volkl
Azimuthal correlations of D mesons with charged particles in pp collisions at $\sqrt{s}$=13 TeV with the ALICE experiment at the LHC → S. Sadhu
D-tagged jet production and fragmentation measurements in pp collisions with ALICE → B. Trzeciak
Electrons from heavy-flavour hadron decays in proton-proton collisions with ALICE at the LHC →S. P. Rode
Heavy-flavour correlations with charged particles and collective effects in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE at the LHC → M. Mazzilli
Measurement of D^0-meson R_{AA} and v_2 in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE → S. Trogolo
Measurement of D_s^+-meson production in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE at the LHC →F. Catalano
Measurement of electrons from heavy-flavour hadron decays in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV and in Xe-Xe collisions at $\sqrt{s_{NN}}$=5.44 TeV → M. Faggin
Measurement of open-heavy flavour hadron decay muons as a function of charged-particle multiplicity in pp and p-Pb collisions with ALICE → S. Mhlanga
Measurement of prompt and non-prompt J/ψ production at mid-rapidity in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE → G. Trombetta
Measurement of the Λ_c^+ production in pp, p-Pb, Pb-Pb collisions with ALICE Run-2 data → L. A. Vermunt
Non-prompt D^0-meson production in pp collisions at $\sqrt{s_{NN}}$=5.44 TeV → Cai Mengke
Reconstruction of bottom jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV with ALICE → K. Garner

The charm-family portrait 1 year after



ALI-PREL-321872

Did ageing clarify the picture? mmm…

… to be continued

Extra

D-meson v_2 with Event-Shape Engineering

Event-by-event variation of the flow coefficients (v_n) at fixed centrality can be large
Related to initial-condition fluctuations and event eccentricity

S. Jaelani

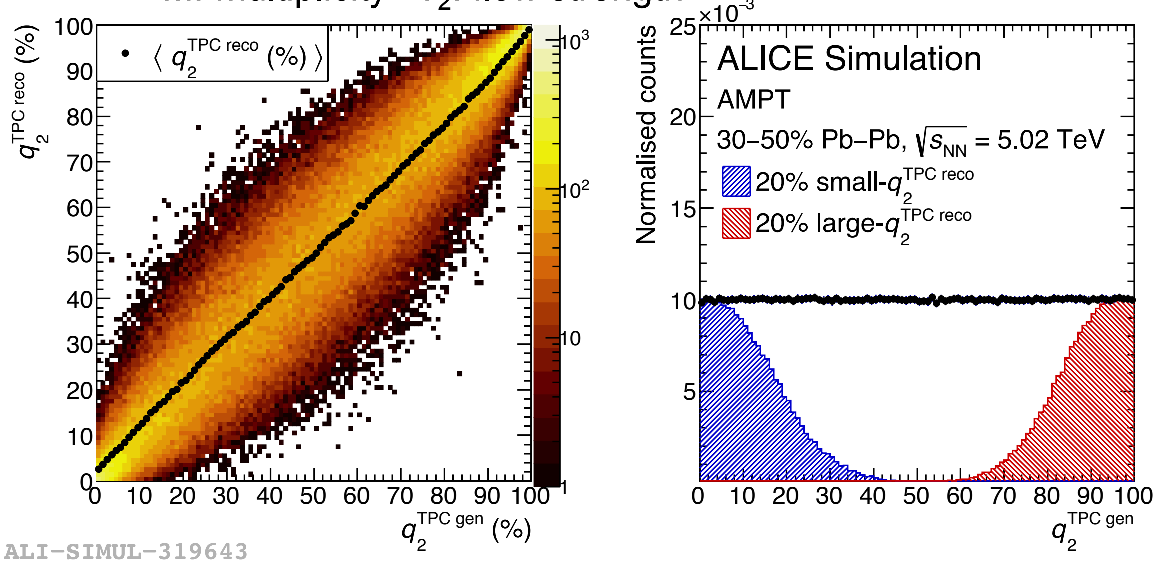
→ Investigate flow vs. 2nd order reduced q-vector

$$q_2 = \frac{|\vec{Q}_2|}{\sqrt{M}}, \quad Q_{2,x} = \sum_{i=1}^{M} \cos 2\varphi_i, \quad Q_{2,y} = \sum_{i=1}^{M} \sin 2\varphi_i$$

$$\langle q_2^2 \rangle \approx 1 + \langle M-1 \rangle \langle v_2^2 - \delta_2 \rangle$$

δ: non-flow effects

M: multiplicity v_2: flow strength

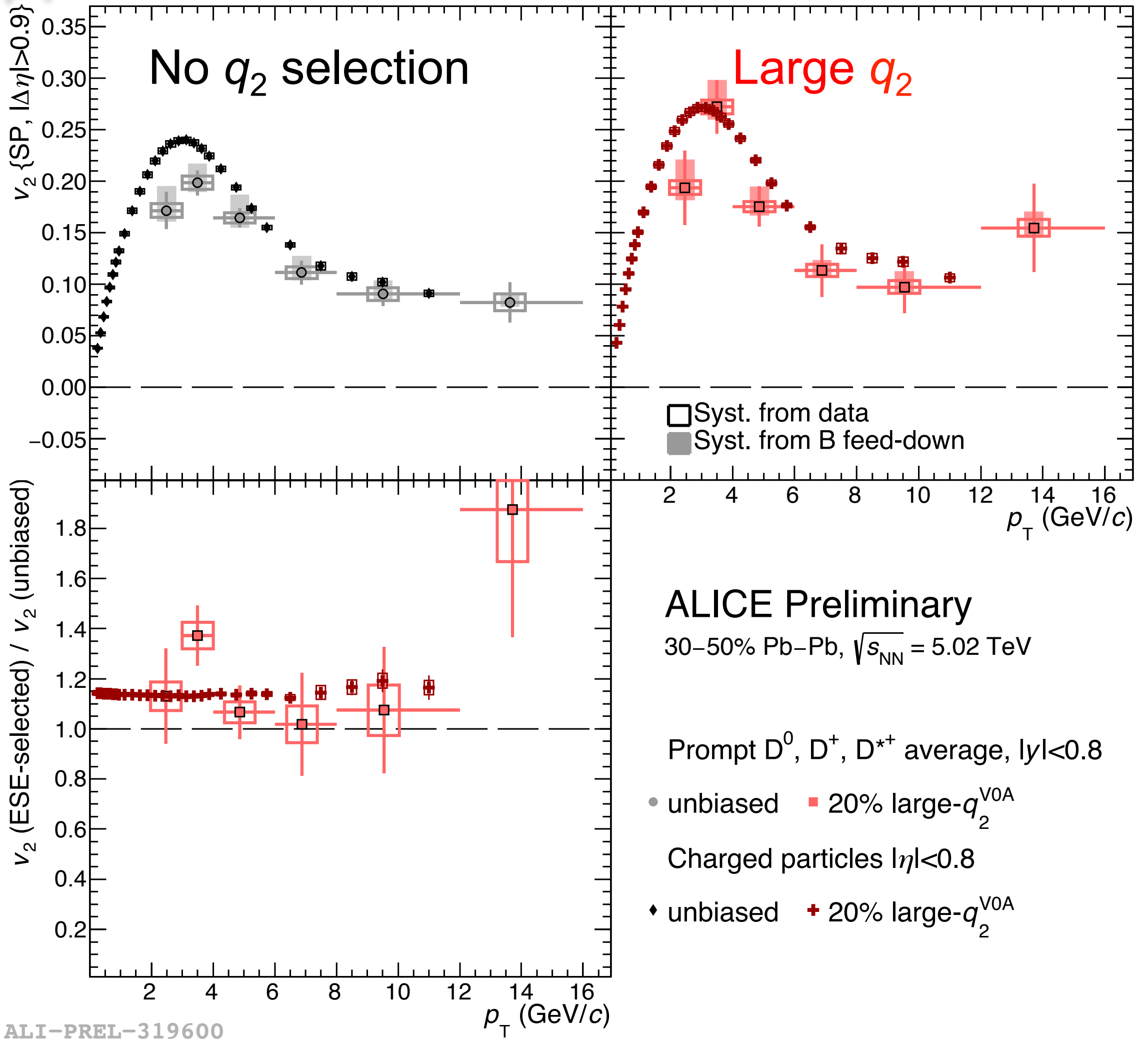


Study of D-meson v_2 as a function of q_2 → investigate charm sensitivity to collectivity of light-hadron bulk and event-by-event initial-conditions fluctuations

D-meson v_2 with Event-Shape Engineering

S. Jaelani

New



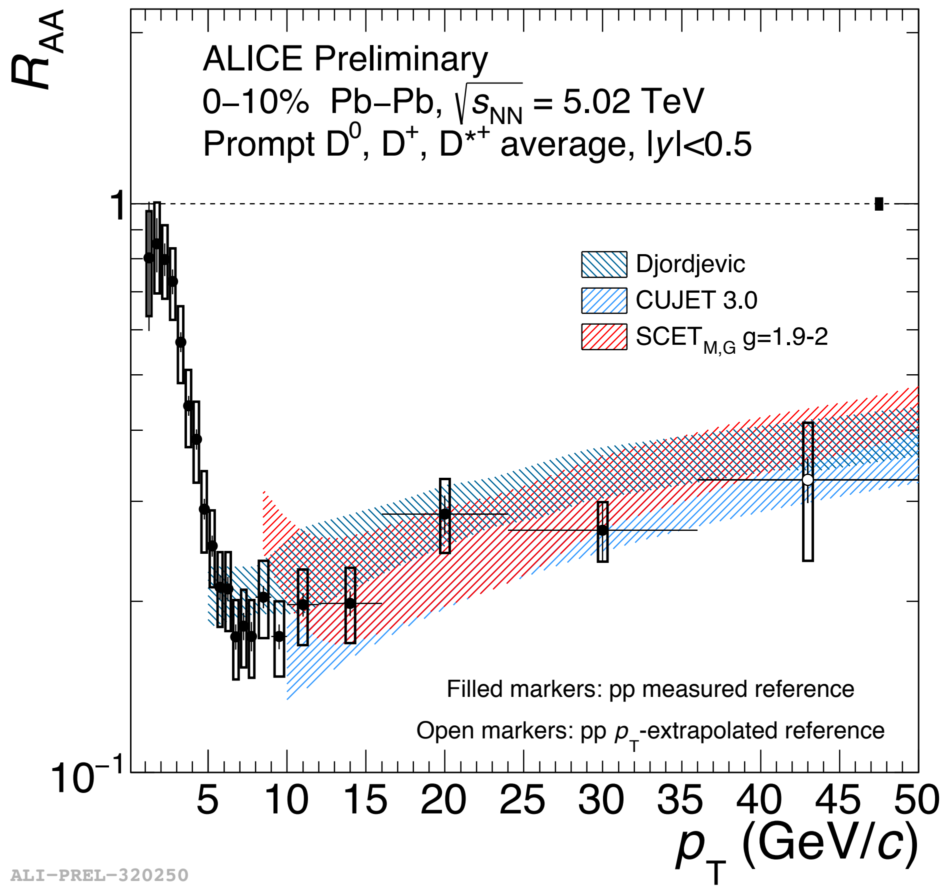
Similar effect for D-meson and charged particles

→ Confirm strong coupling of charm with medium constituents

D-meson data vs. models

S. Jaelani

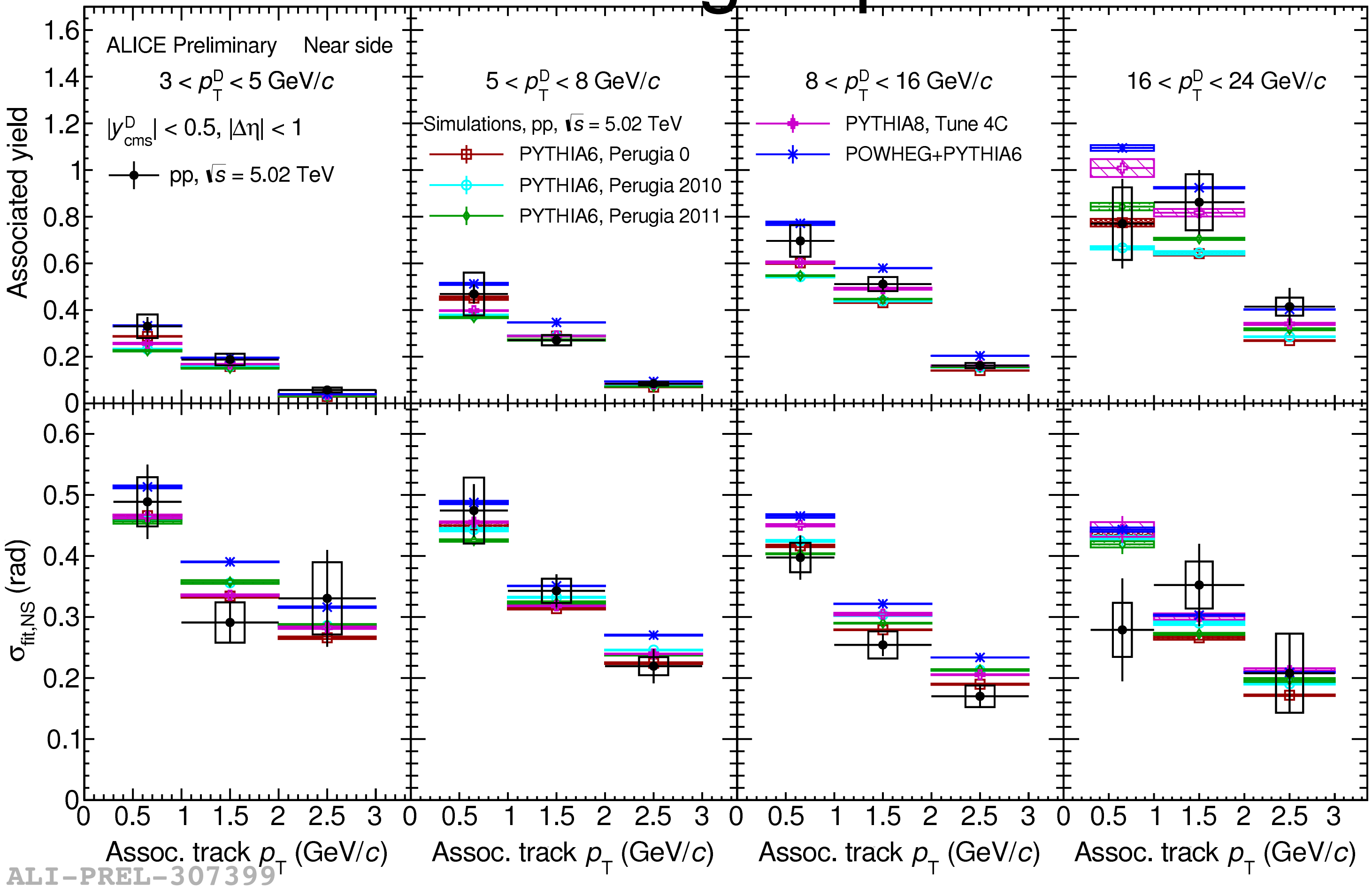
New



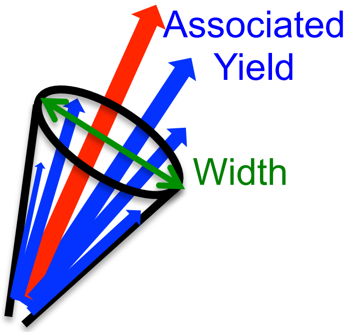
D-meson R_{AA} at high p_T described reasonably by pQCD-based models

Djordjevic, PRC 92 2 024918 (2015); CUJET3.0 JEHP 02 169 (2016); $SCET_{M,G}$ JHEP 03 146 (2017)

Azimuthal correlations of D mesons with charged particles



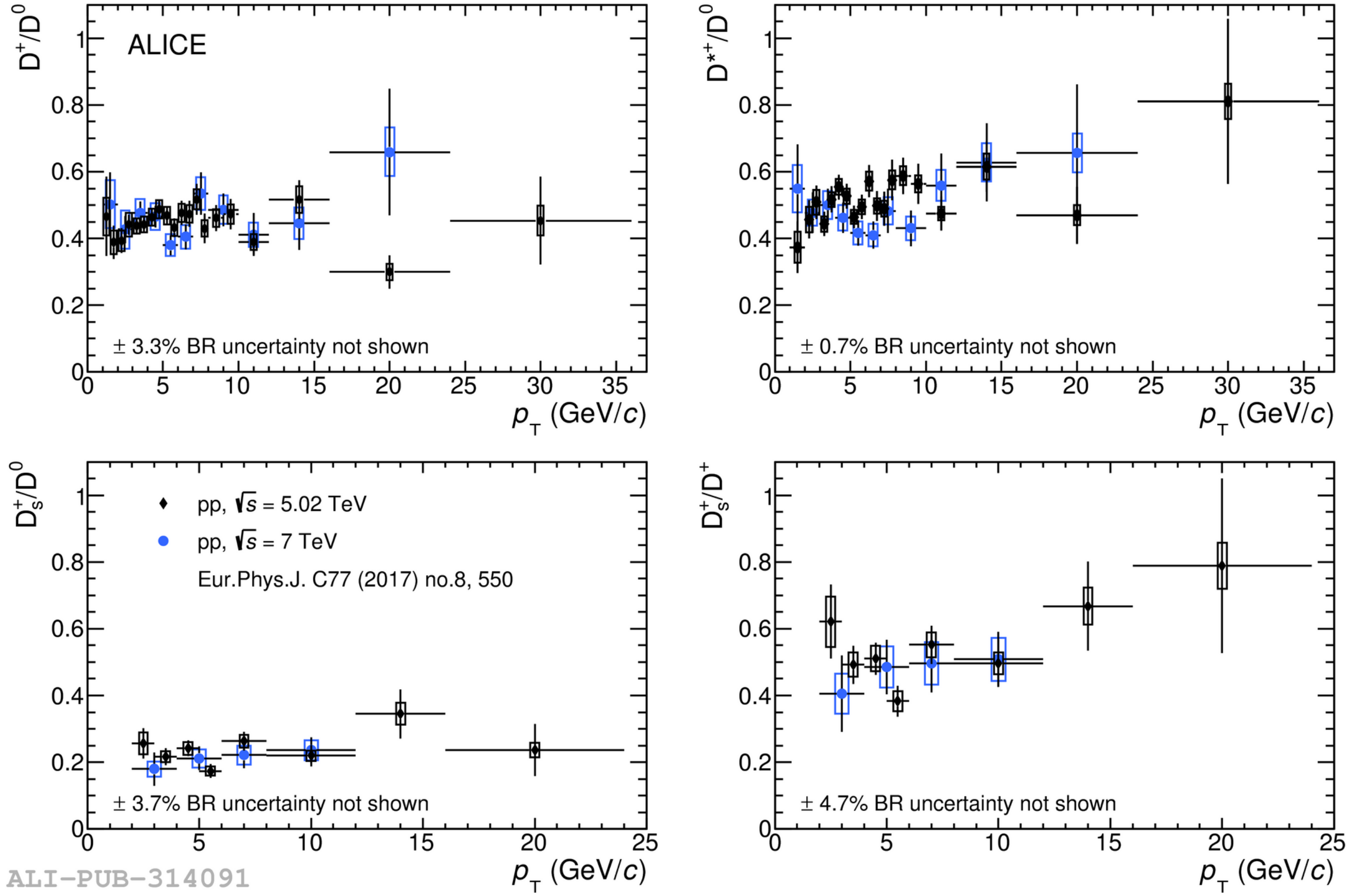
A. Mohanty



- Near-Side (NS) peak properties determined by charm-jet particle-multiplicity and internal kinematic jet structure.
- Expected angular-momentum ordering showing associated particles with higher-p_T closer in angle to "trigger" D meson, described reasonably by POWHEG+PYTHIA and PYTHIA

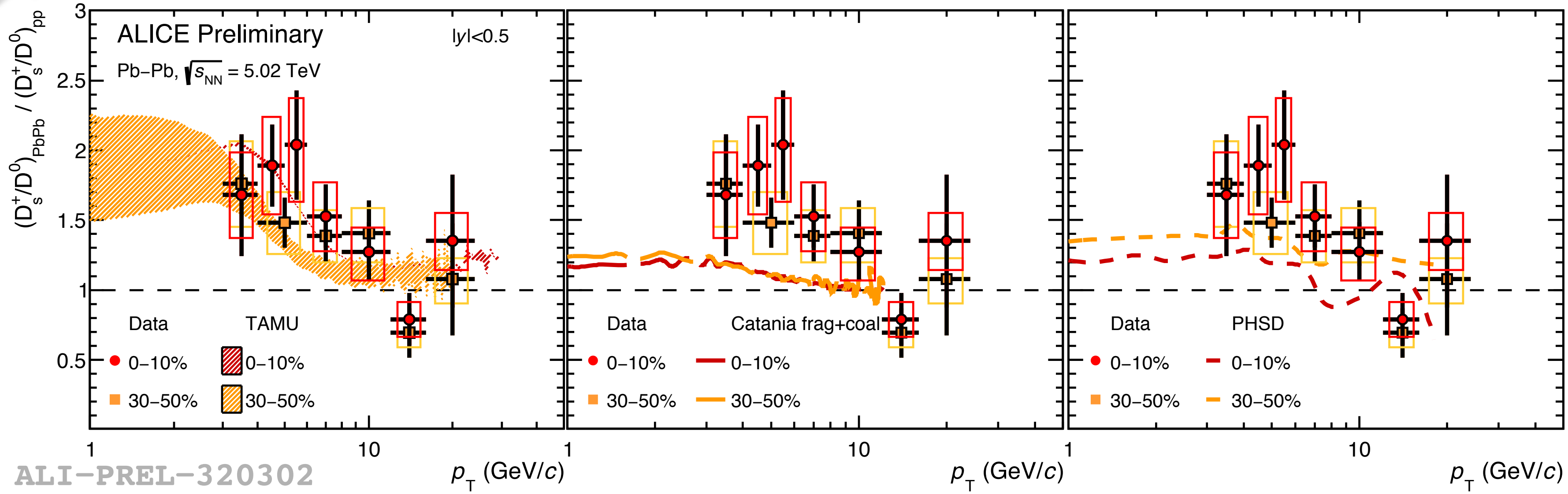
D-meson species

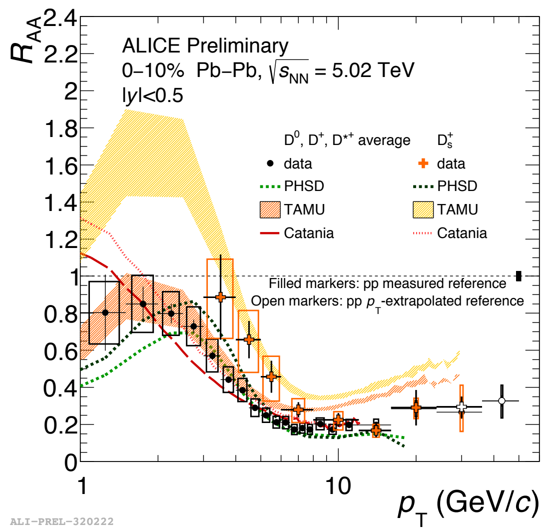
Eur.Phys.J. C79 (2019) no.5, 388

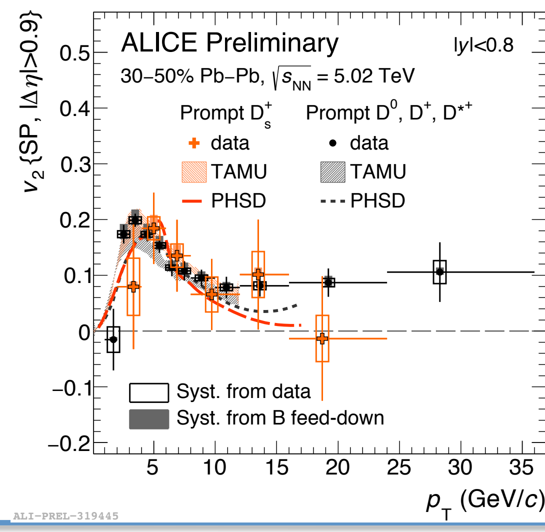


Non-strange D vs. D_s^+

New

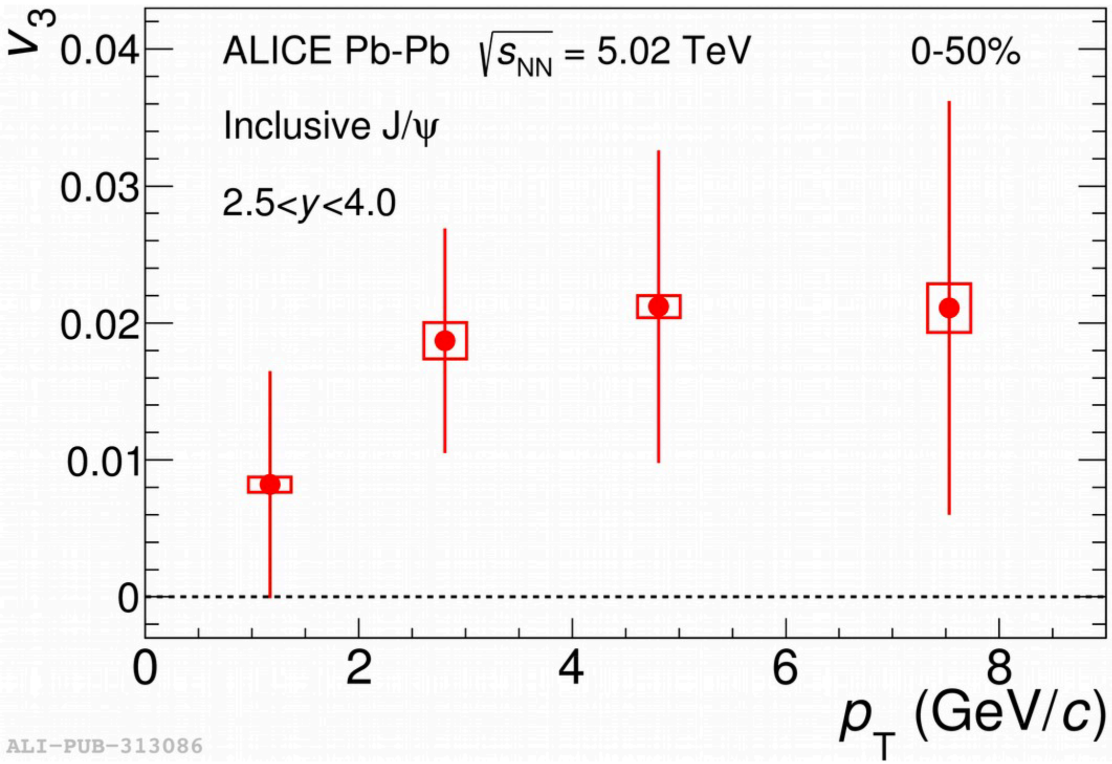






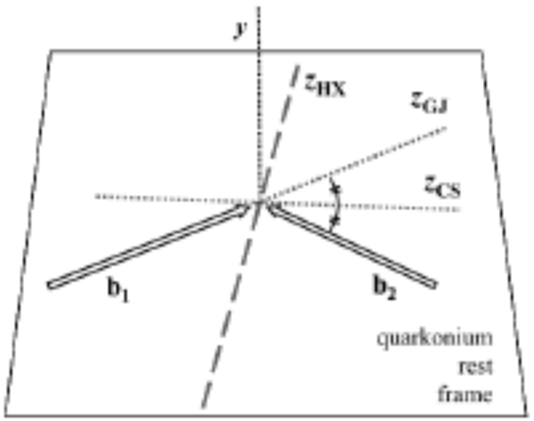
J/ψ v_3

JHEP 1902 (2019) 012

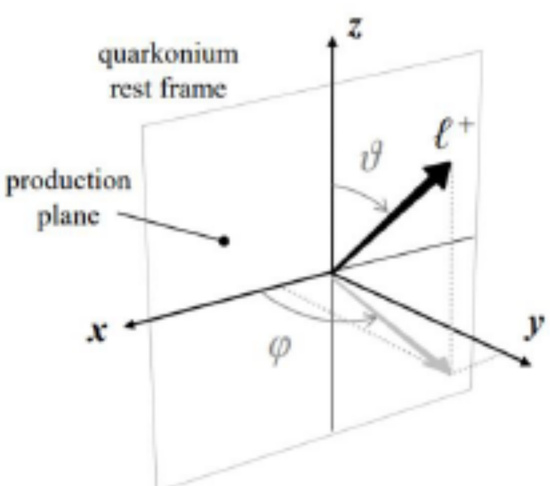


J/ψ polarisation

Helicity frame: z_{HX} along J/ψ momentum in collision center-of-mass frame
Collin-Soper: z_{CS} defined by bisector of the angle defined by a beam momentum vector and the opposite of the other beam momentum vector seen in the J/ψ rest frame



Figures from P.Faccioli et al. EPJ C69 (2010) 657-673



$$W(\cos\vartheta,\varphi) \propto \frac{1}{3+\lambda_\vartheta}\cdot\left(1+\lambda_\vartheta\cos^2\vartheta+\lambda_\varphi\sin^2\vartheta\cos2\varphi+\lambda_{\vartheta\varphi}\sin2\vartheta\cos\varphi\right)$$

$$(\lambda_\vartheta,\lambda_\varphi,\lambda_{\vartheta\varphi})=(0,0,0)\rightarrow \text{J}/\psi \text{ is not polarised}$$

$$(\lambda_\vartheta,\lambda_\varphi,\lambda_{\vartheta\varphi})=(-1,0,0)\rightarrow \text{J}/\psi \text{ is longitudinally polarised}$$

$$(\lambda_\vartheta,\lambda_\varphi,\lambda_{\vartheta\varphi})=(+1,0,0)\rightarrow \text{J}/\psi \text{ is transversally polarised}$$