D-meson production in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02\ \mathrm{TeV}$ with ALICE

Xinye Peng

on the behalf of the ALICE Collaboration

Central China Normal University, China

Padova University & INFN, Italy

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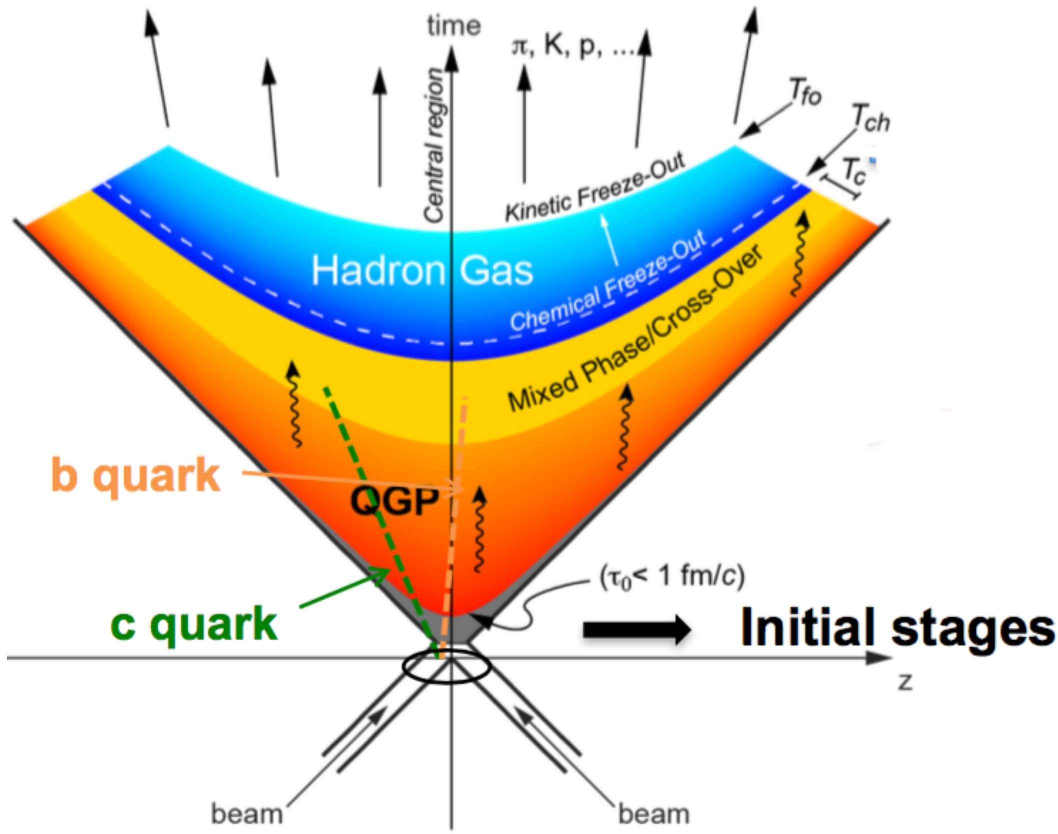
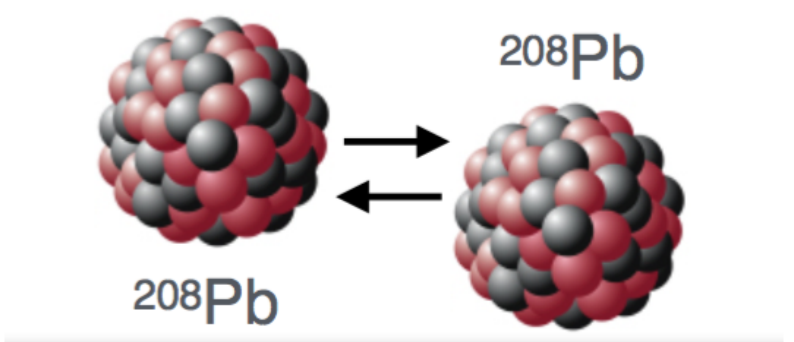
Outline

- Physics Motivation
- The ALICE detector
- Analysis strategy for D-meson reconstruction in ALICE
- Results
  - D meson nuclear modification factor in 0-10%, 30-50% and 60-80% centrality classes in Pb-Pb collisions at 5.02 TeV
- Conclusion and Outlook

Physics motivation

- In heavy-ion collisions, heavy flavors (i.e c, b quarks) produced mainly in hard-scattering processes
  - HF(heavy flavor) production:
    $t_{\mathrm{HF}} \lesssim \hbar/m_{c,b} \sim 0.1(0.04)\mathrm{fm/c}$
  - QGP formation:
    $t_{\mathrm{QGP}} \sim 0.3\ \mathrm{fm/c}$ (LHC) [1]





HF experience the whole system evolution interacting strongly with the constituents of the medium, and lose their energy

Effective probes of the Quark-Gluon Plasma!

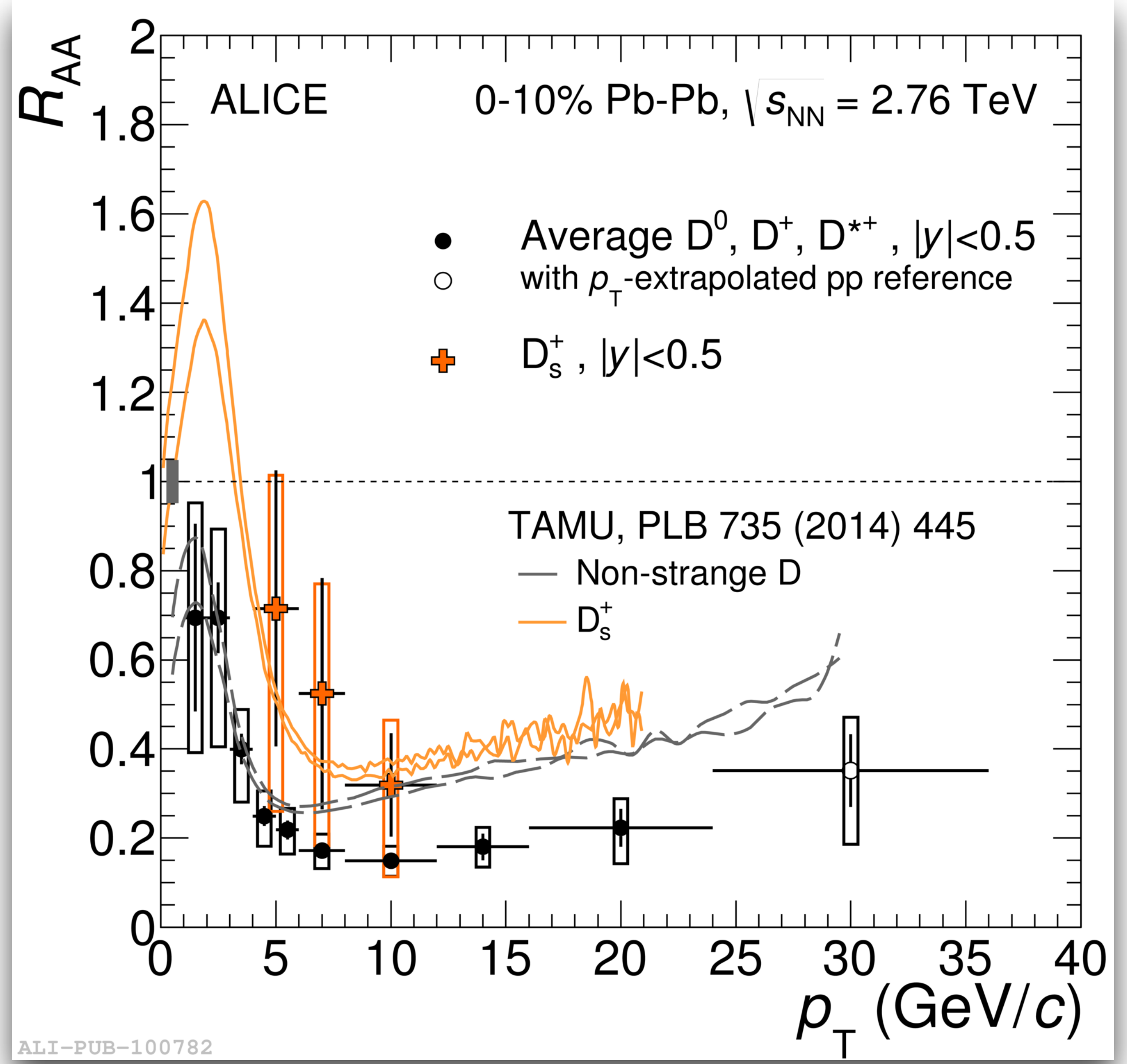
[1] F. M. Liu, S. X. Liu, Phys. Rev. C 89, 034906 (2014)

Physics motivation

- One of the main observable: nuclear modification factor

$$R_{\mathrm{AA}} = \frac{1}{\langle T_{\mathrm{AA}} \rangle} \frac{\mathrm{d}N_{\mathrm{AA}}/\mathrm{d}p_{\mathrm{T}}}{\mathrm{d}\sigma_{\mathrm{pp}}/\mathrm{d}p_{\mathrm{T}}}$$

- Study in-medium energy loss
  - path-length dependence and medium density
  - color-charge and quark-mass dependence
- Modification of hadronisation mechanism in the medium
  - coalescence mechanism?



JHEP, 1603, 082(2016)

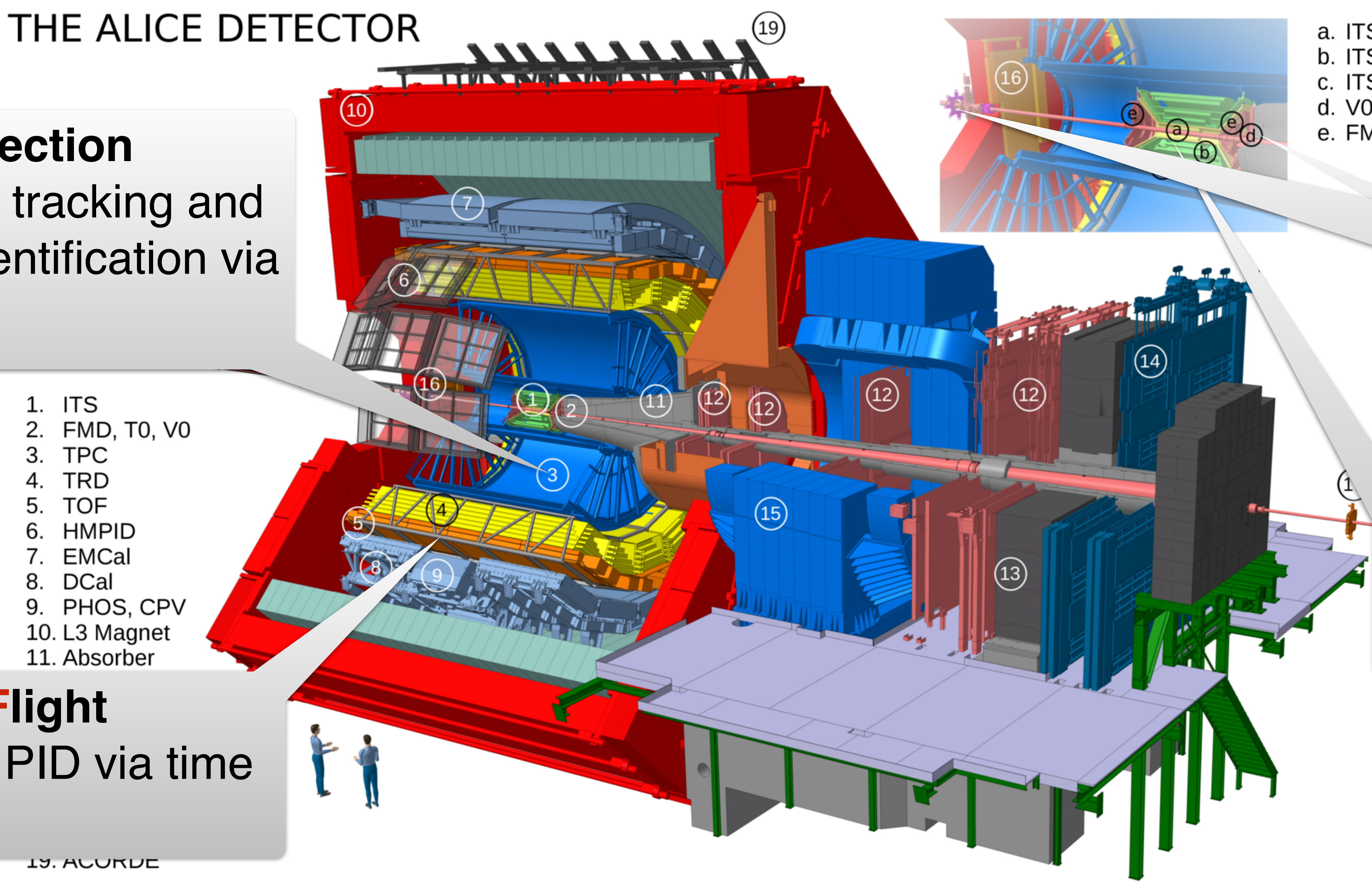
ALICE detector

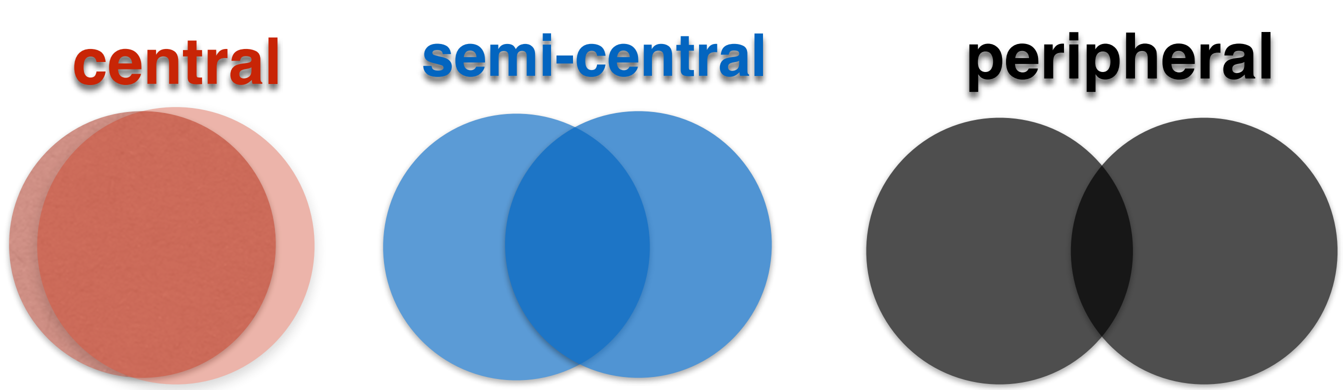
Time Projection Chamber: tracking and Particle identification via dE/dx

Time Of Flight detector: PID via time of flight

V0 detector: triggering and centrality

Inner Tracking System: tracking and vertexing





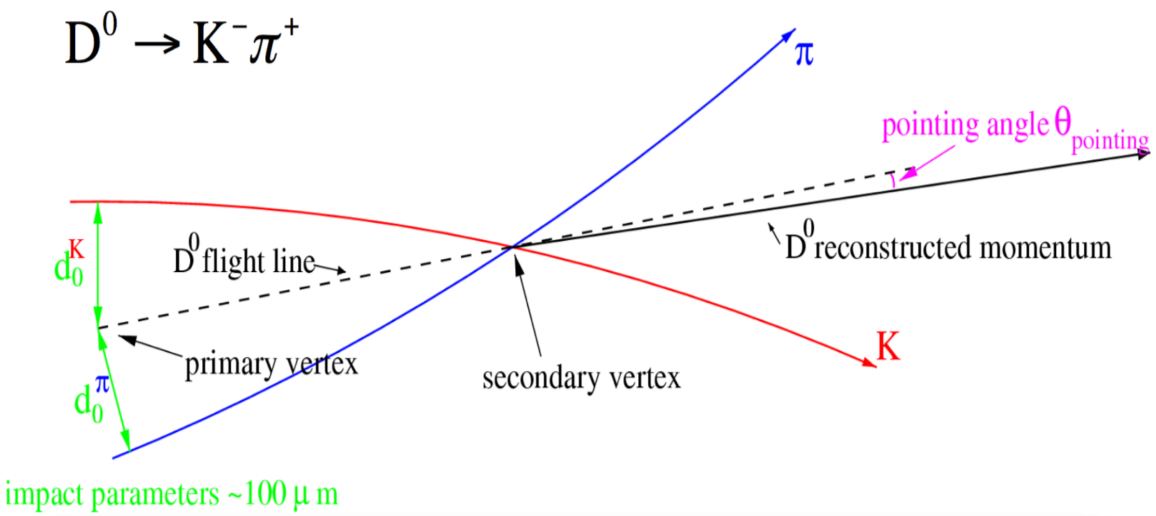
Data collected with min.bias trigger used for this analysis

Pb-Pb data sample 2015 at 5.02 TeV	
centrality class(%)	Events
0-10	~10M
30-50	~20M
60-80	~20M

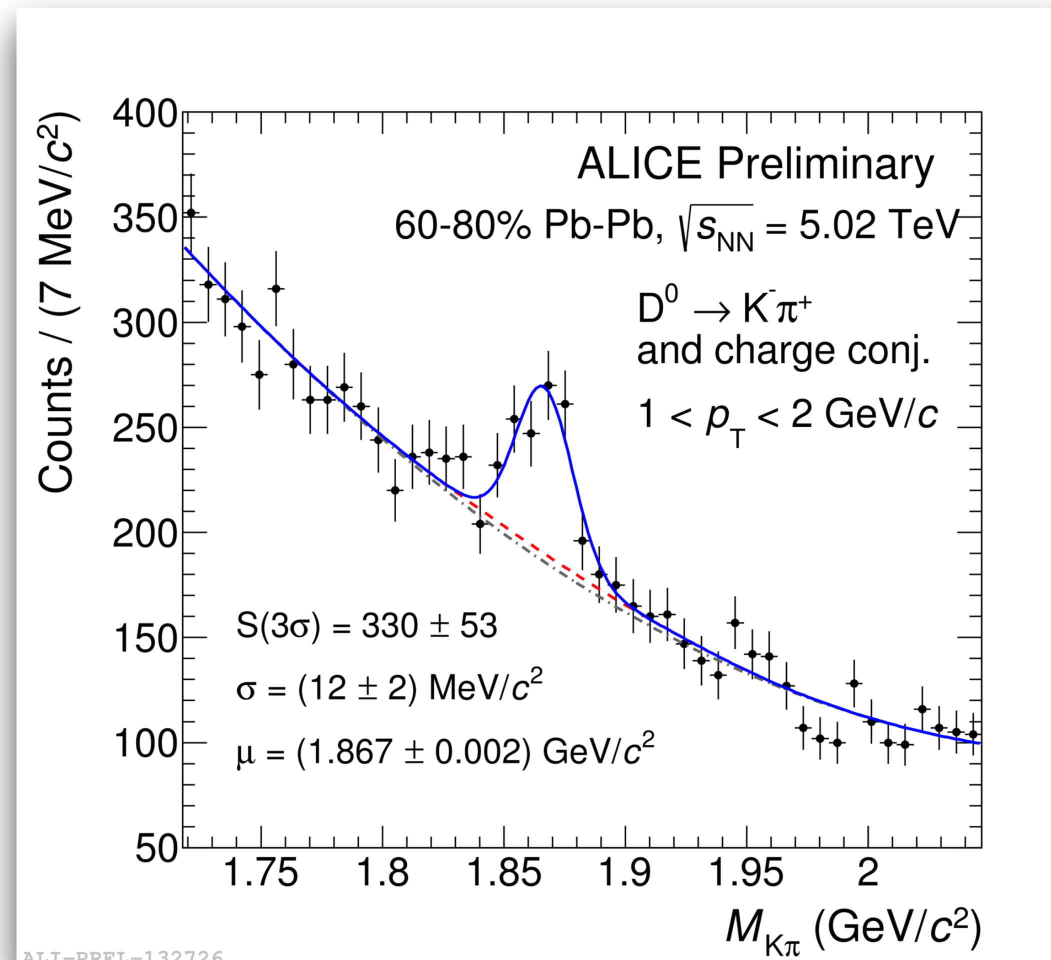
D-meson reconstruction

- D mesons are reconstructed at mid-rapidity via their hadronic decays

Meson	Mass (GeV/c^2)	decay channel	$c\tau$ (μm)	BR (%)
D^0 ($c\bar{u}$)	1.865	$K^-\pi^+$	123	3.93
D^+ ($c\bar{d}$)	1.870	$K^-\pi^+\pi^+$	312	9.46
D^{*+} ($c\bar{d}$)	2.010	$D^0(\rightarrow K^-\pi^+)\,\pi^+$	strong decay	67.7 (x 3.93)
D_s^+ ($c\bar{s}$)	1.968	$\phi\,(\rightarrow K^-K^+)\,\pi^+$	150	2.27

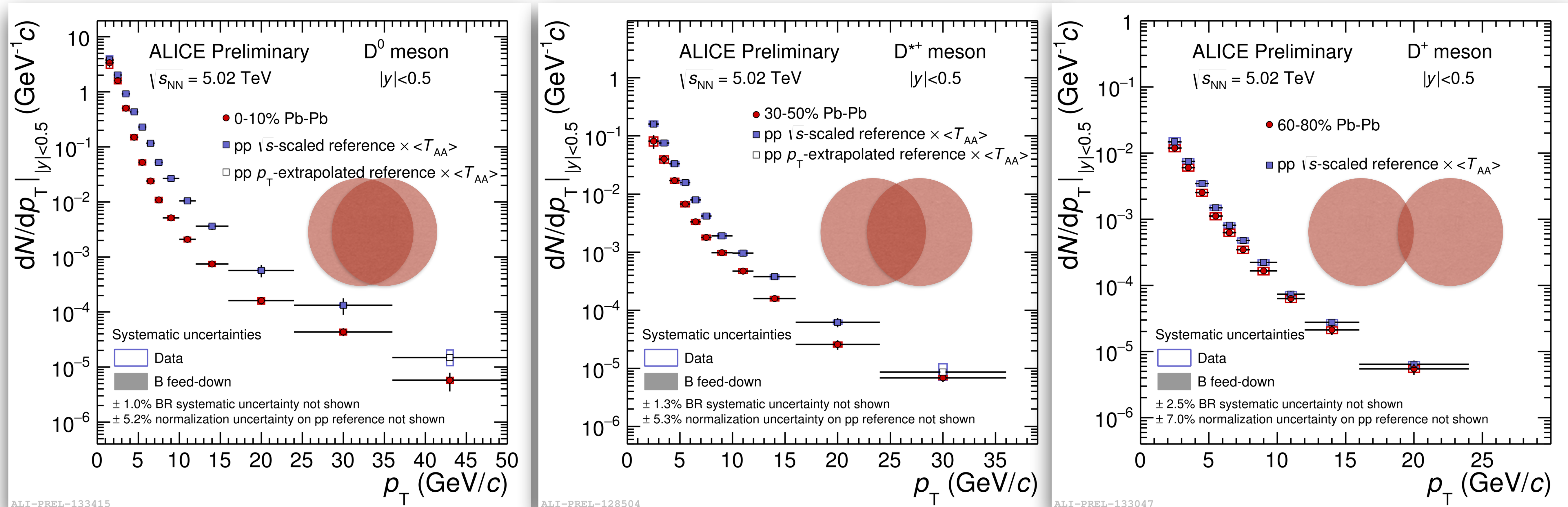


- Reconstruction of decay topologies
  - **Topological selection** and **particle identification** of pions and kaons applied to reduce combinatorial background
- Signal extracted via an **invariant-mass analysis**
- FONLL-based approach to subtract **feed-down from beauty-hadron decays**



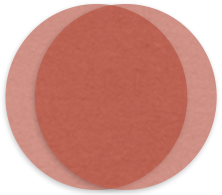
D-meson cross section compared with pp-scaled reference

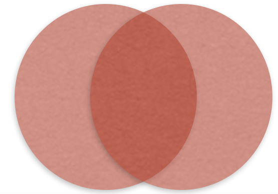
D^0, D^+, D^{*+} cross section in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

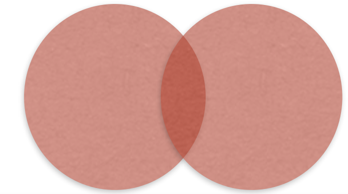


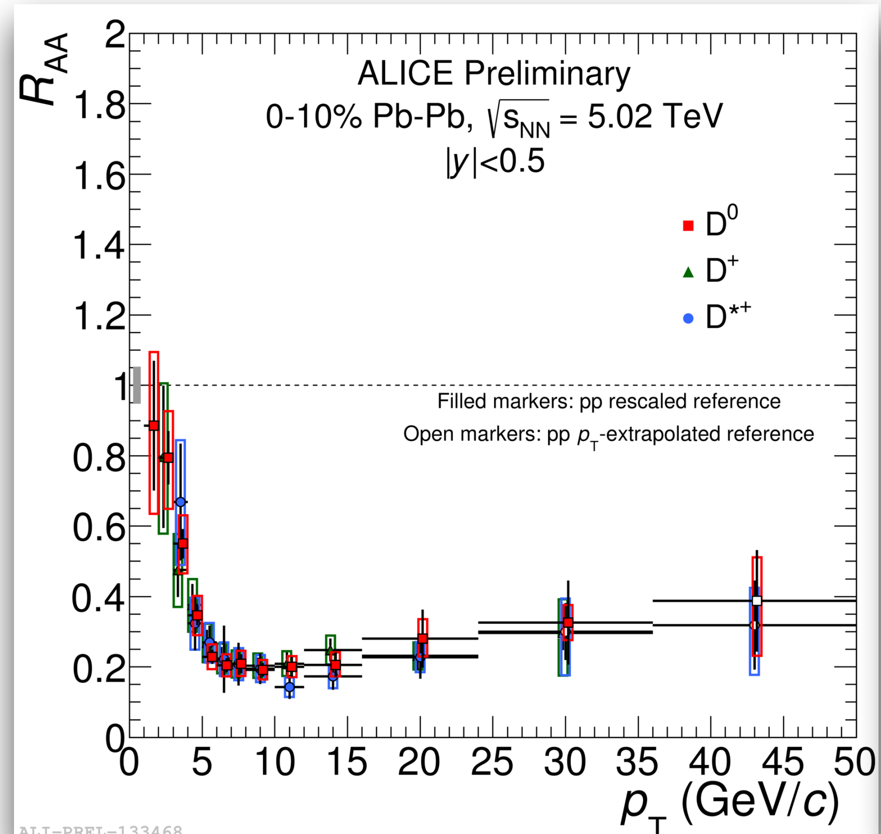
- pp reference from energy-scaled and p_{T}-extrapolated ALICE pp data at $\sqrt{s_{NN}} = 7$ TeV
- p_{T}-differential cross sections in central Pb-Pb collisions show large suppression at intermediate/high p_{T} compared with binary-scaled pp collisions

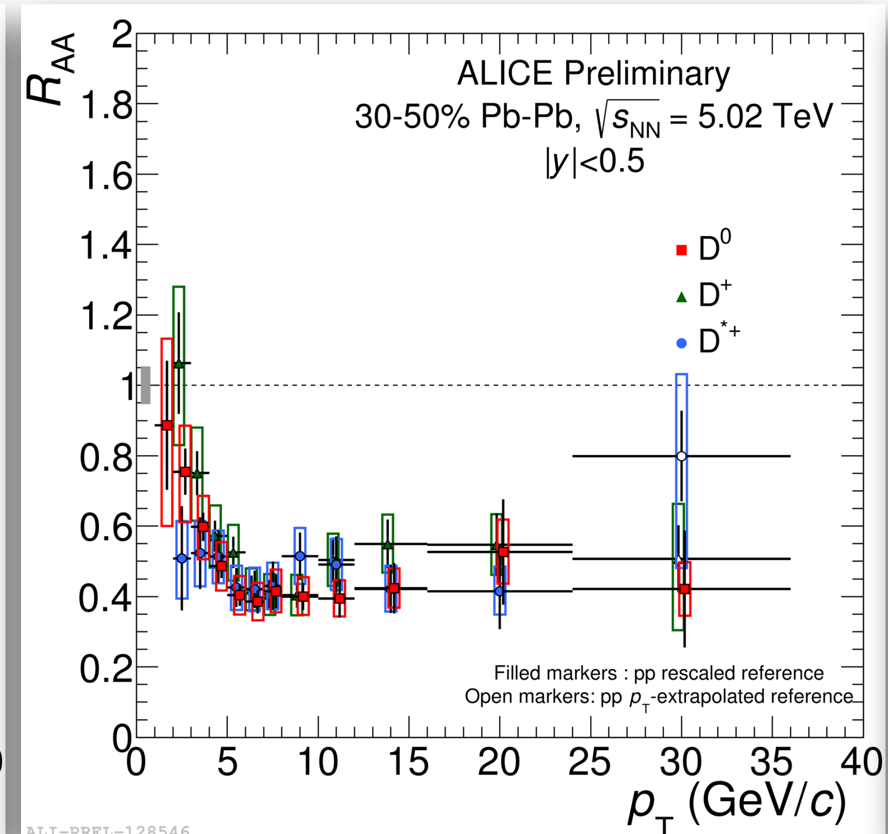
Results: D-meson R_{AA}

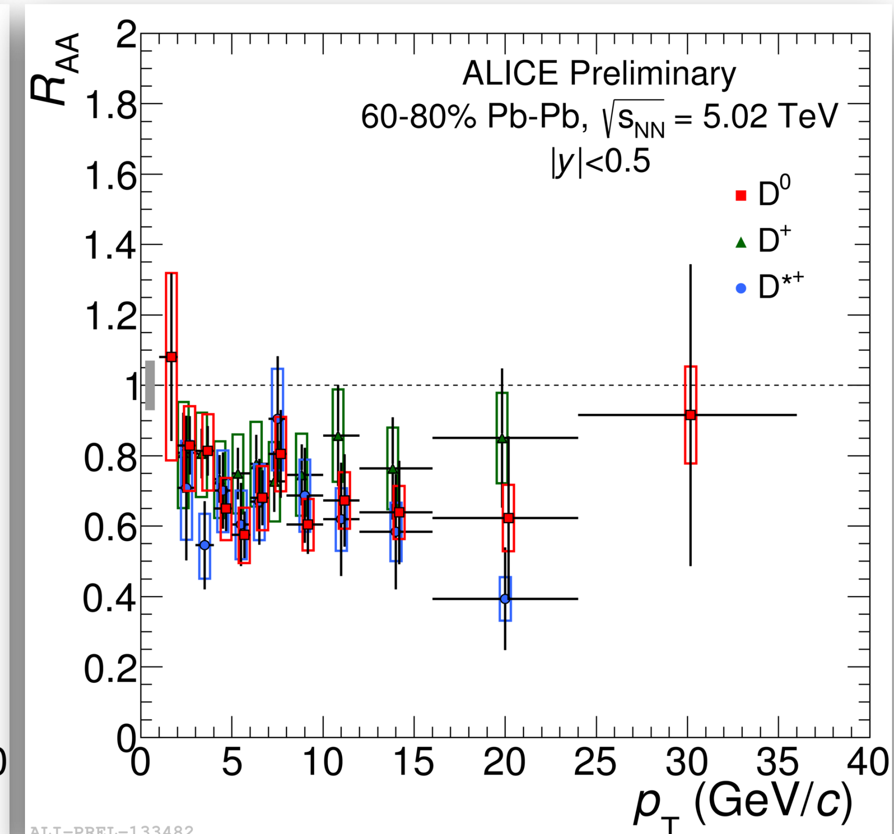






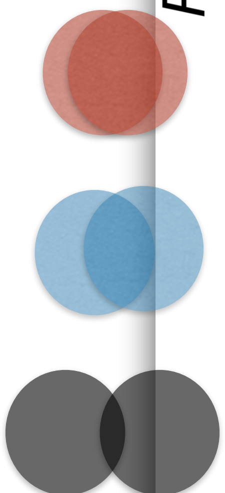


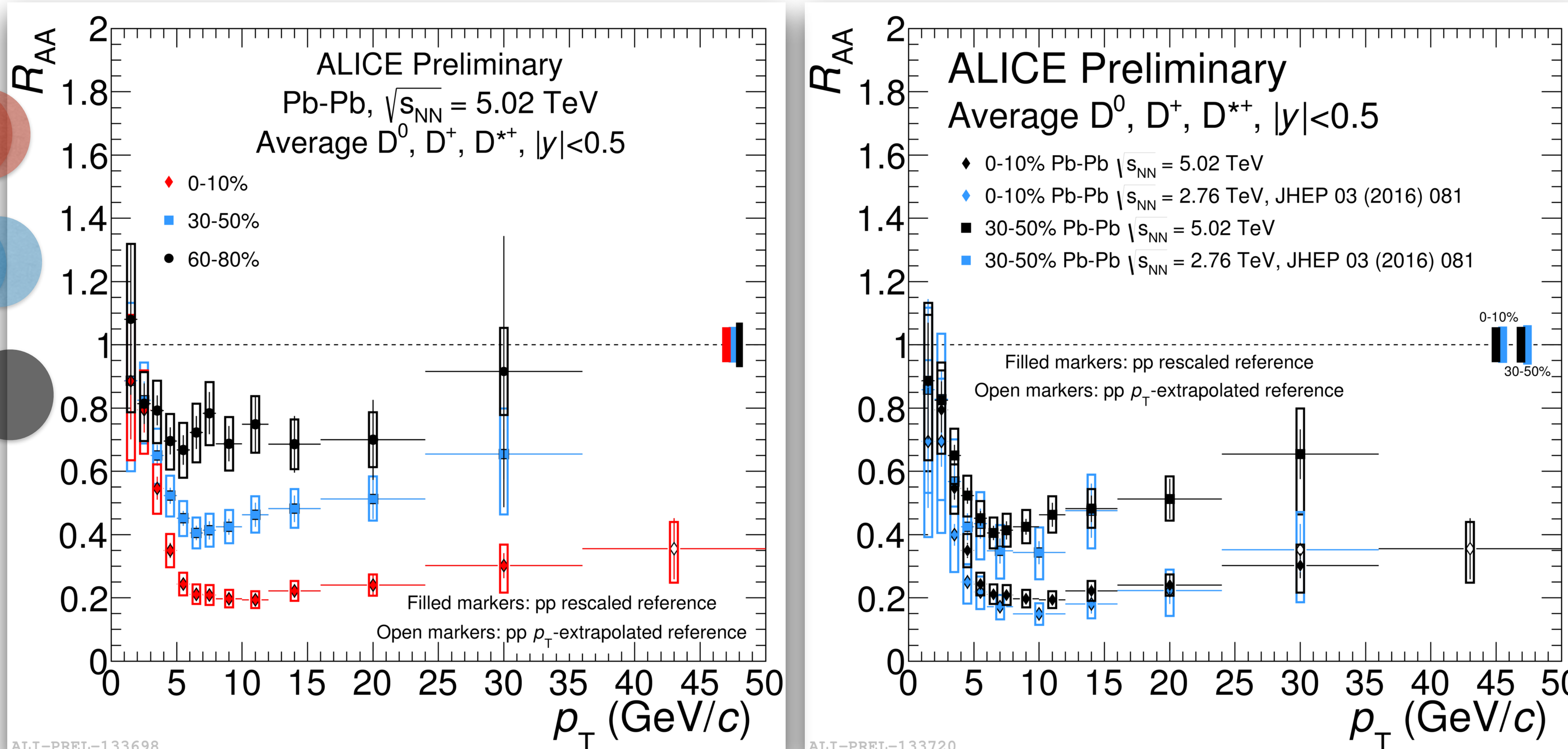




- Non-strange D meson R_{AA} compatible within uncertainties

Results: D-meson R_{AA}



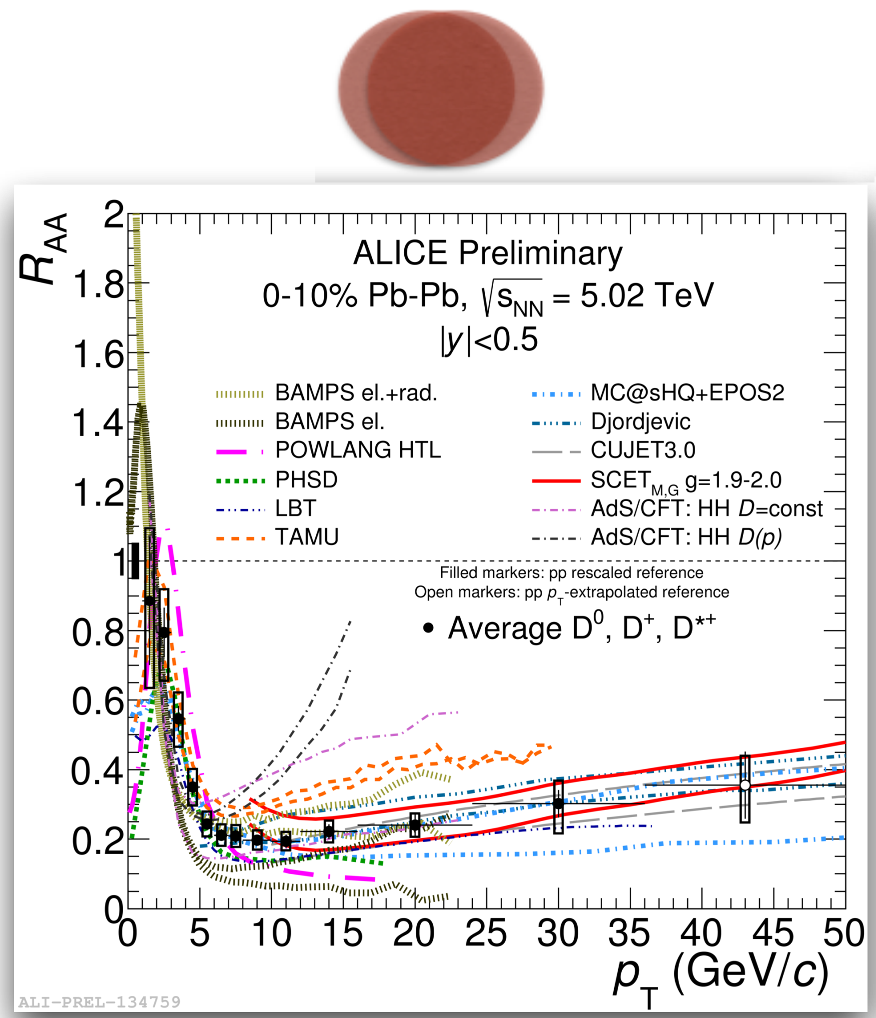


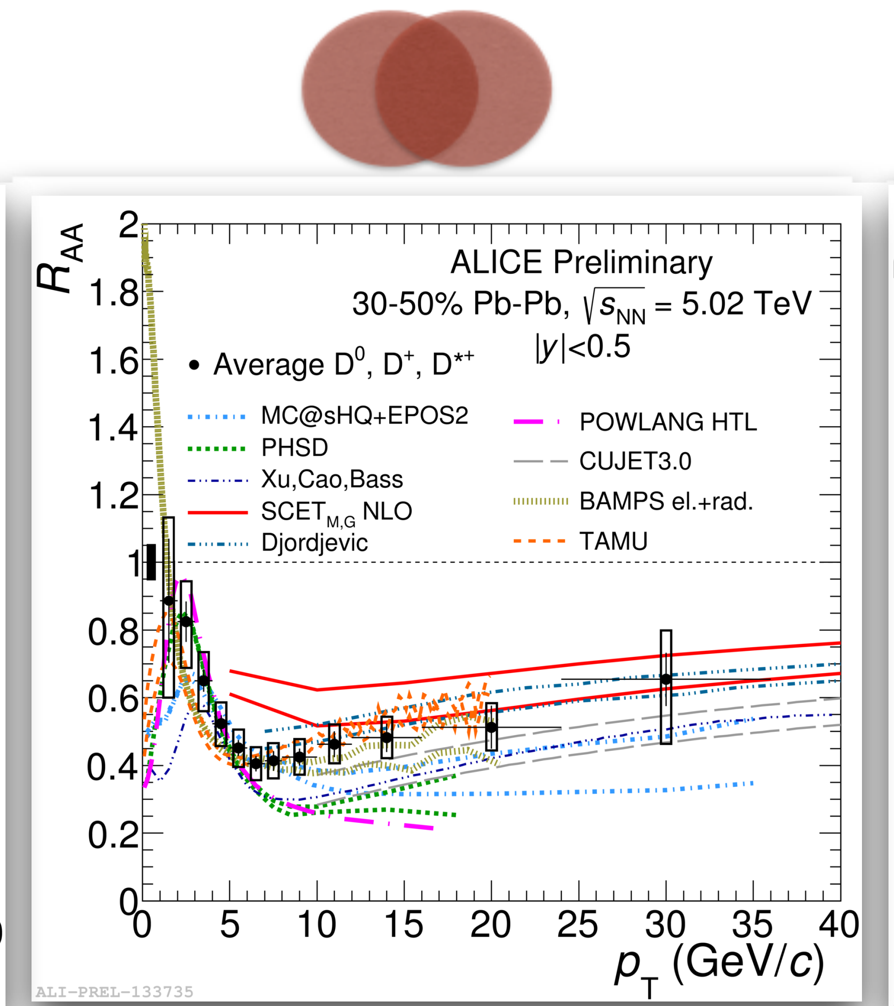
2.76 TeV

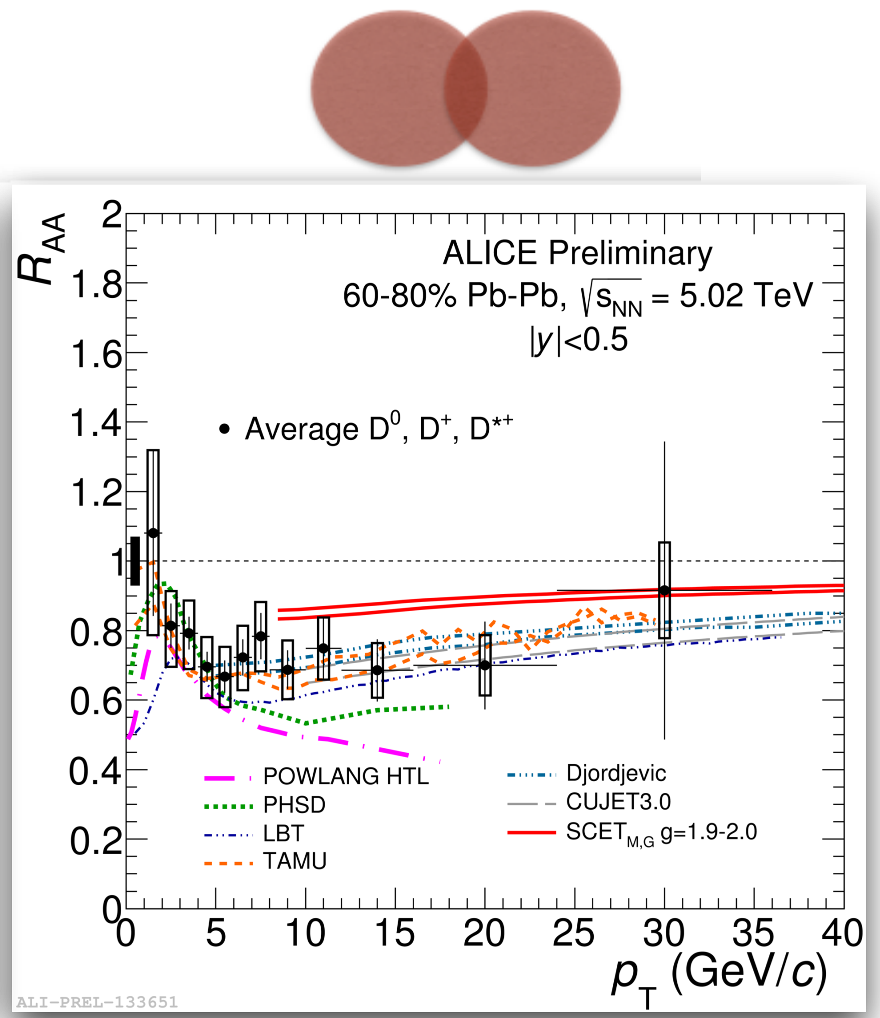
5.02 TeV

- Increasing suppression from peripheral (60-80%) to central (0-10%) Pb-Pb collisions
- Similar suppression, extended p_{T} coverage and better precision compared w.r.t Run-1 measurement at $\sqrt{S_{\mathrm{NN}}} = 2.76$ TeV

Results: D-meson R_{AA} compared with models







- With the improved precision non-strange D-meson R_{AA} provide important constraints to models

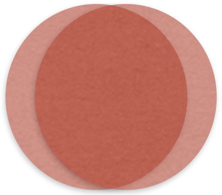
Heavy-quark transport models

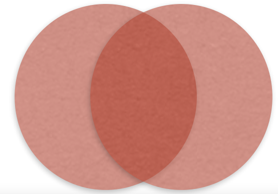
- TAMU: PLB 735, 445-450 (2014)
- LBT: arXiv:1703.00822
- PHSD: PRC 92, 014910 (2015)
- BAMPS: JPG 42, 115106 (2015)
- POWLANG: EPJC 75, 121 (2015)
- Xu,Cao,Bass: PRC 88, 044907 (2013)

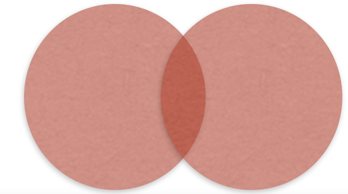
pQCD - AdS/CFT energy loss based models

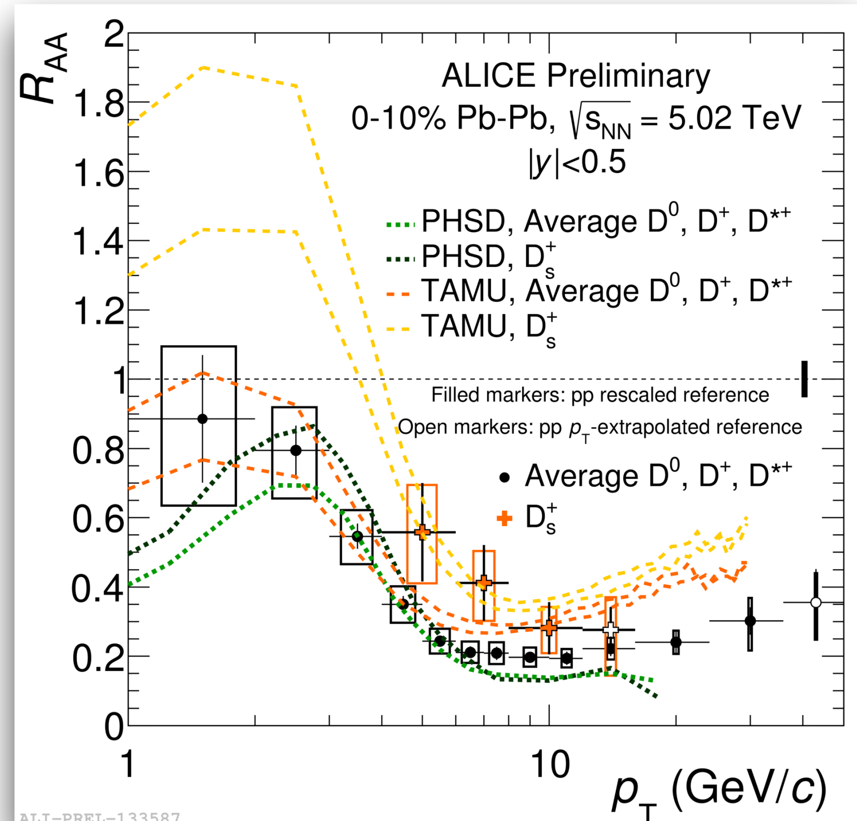
- Djordevic: PRC 92, 024918 (2015)
- CUJET: JHEP 02, 169 (2016)
- SCET: JHEP 03, 146 (2017)
- AdS/CFT: JHEP 1411, 017 (2014)
- MC@sHQ+EPOS: PRC 89, 014905 (2014)

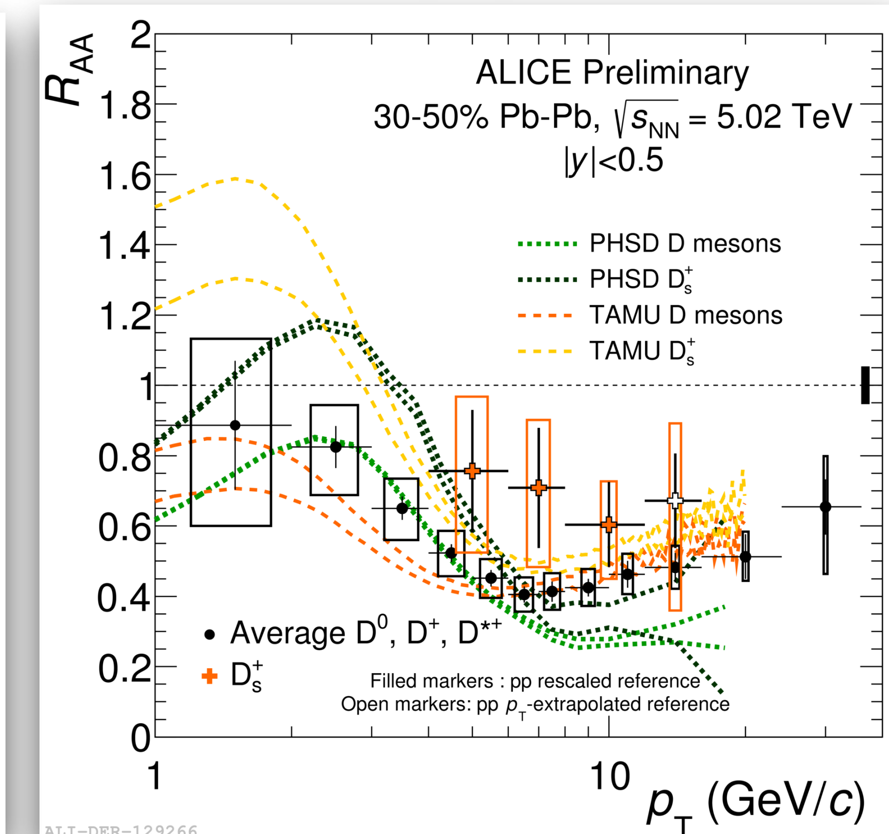
Results: strange and non-strange D-meson R_{AA}

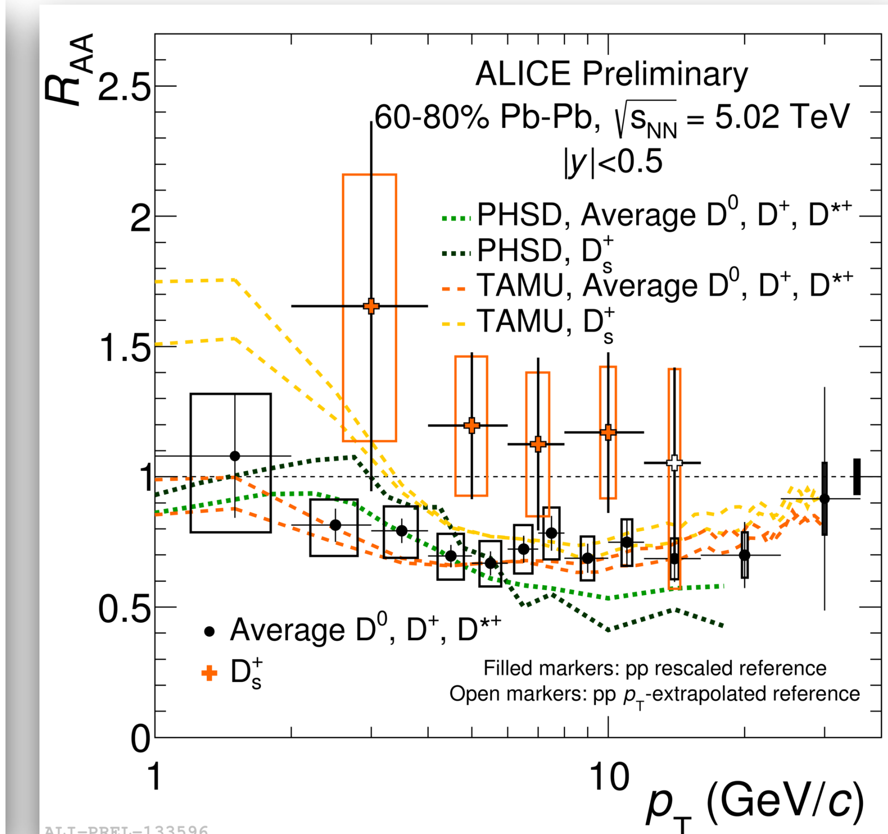








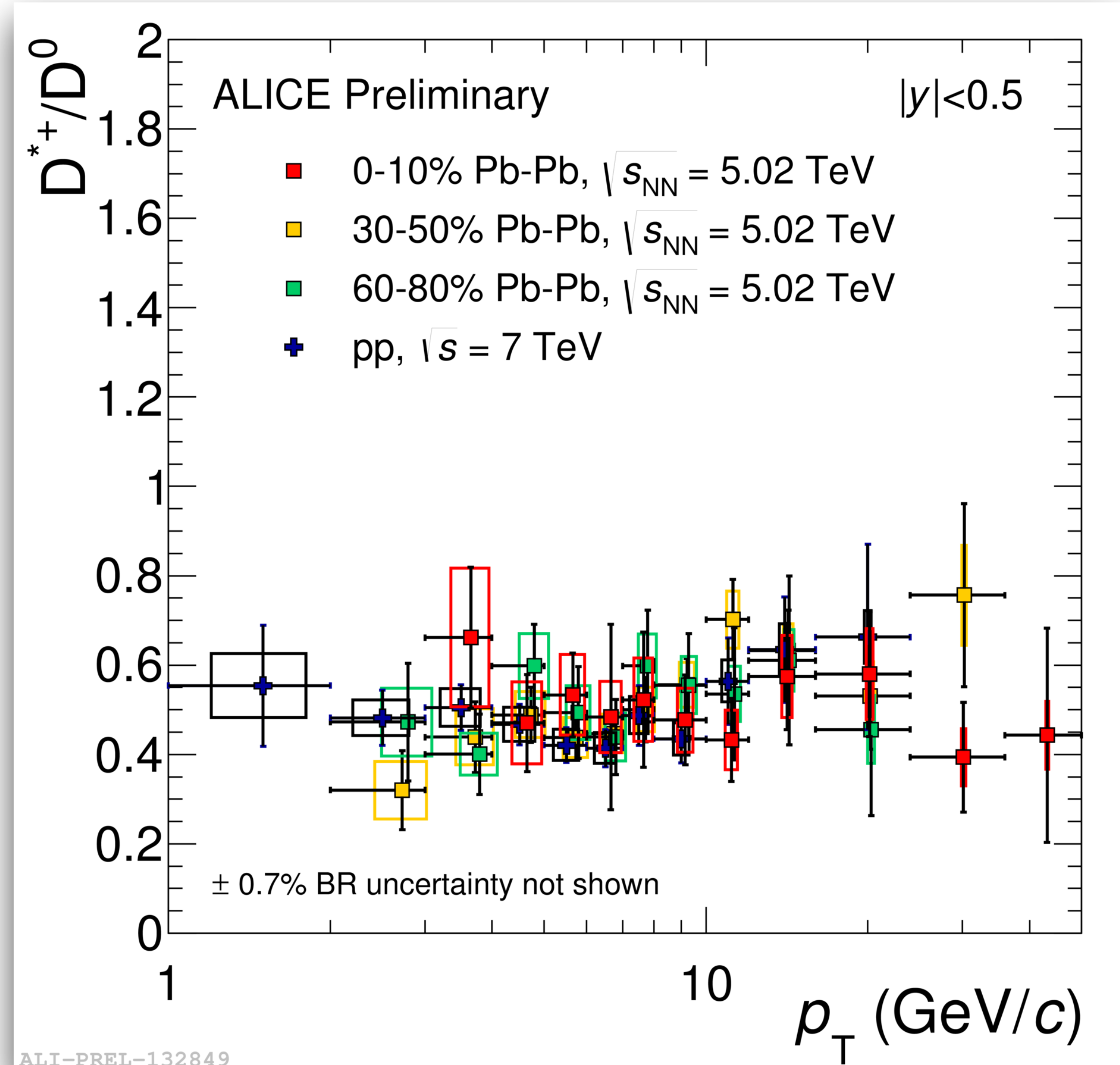


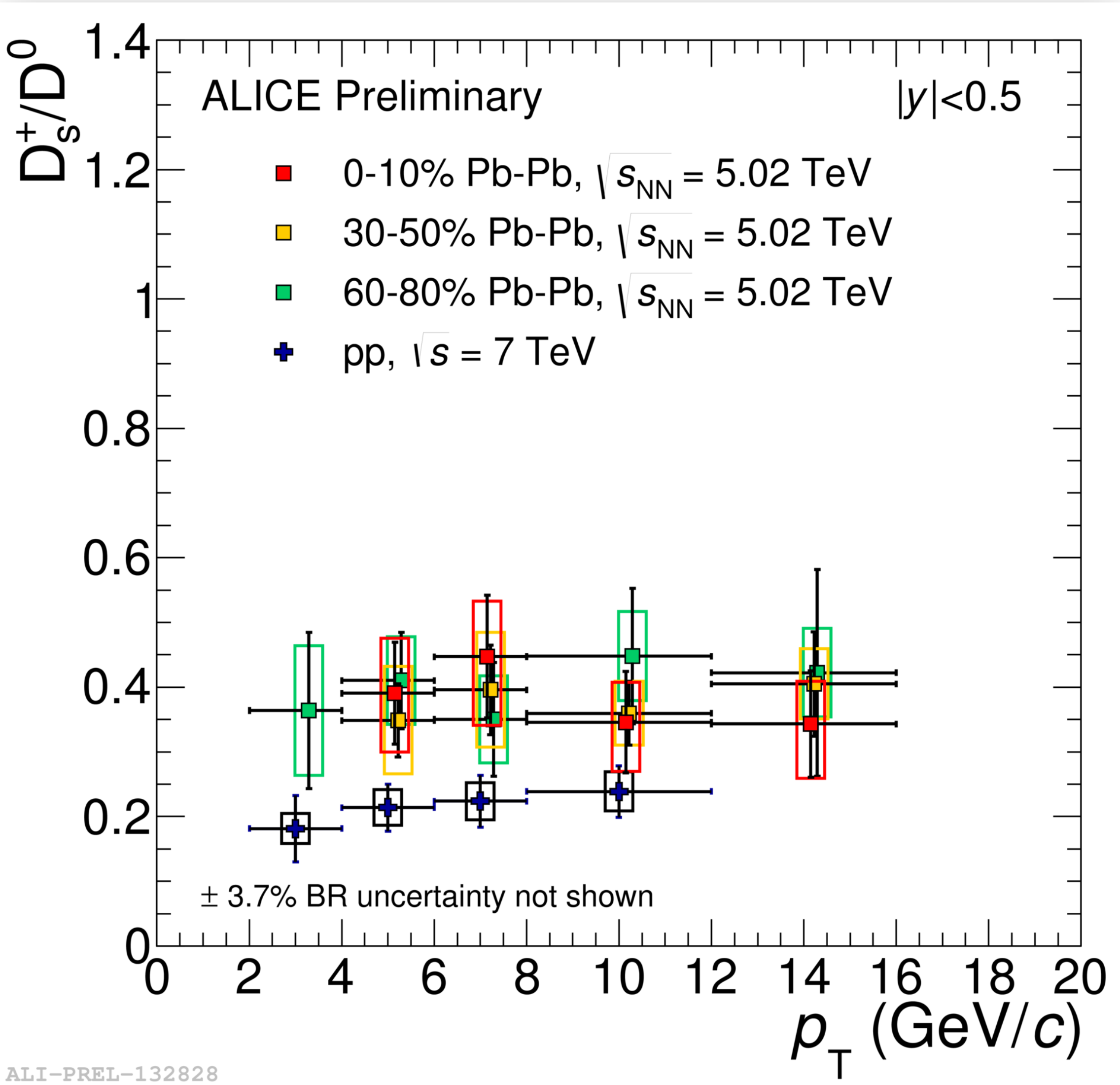


- Hint of $D_s^+ R_{AA}$ larger than non-strange D-meson R_{AA}
  - Coalescence + strangeness enhancement ?
- Still too large uncertainty to draw a conclusion

TAMU: Phys. Lett. B 735, 445-450 (2014)
PHSD: Phys. Rev. C 92, 014910 (2015)

Results: strange and non-strange D-meson ratio





- Similar D^{*+}/D^0 ratio in pp and Pb-Pb collisions in different centrality classes
- Hint of larger D_s^+ production in Pb-Pb than pp collisions compared with non-strange D mesons
  - Coalescence + strangeness enhancement ?
- D_s^+/D^0 ratio similar in different centrality classes in Pb-Pb collisions

Conclusion

- D^0, D^+, D^{*+}, D_s^+ nuclear modification factor measured for central, semi-central and peripheral centrality classes in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
  - Reduced statistical and systematic uncertainties of Run II w.r.t Run I measurements
    - Systematic uncertainty reduced by a factor two
  - **Increasing suppression** from peripheral to central collisions
  - The data set **stringent constraints** to theoretical models
- Ratio of D_s^+ and non-strange D mesons
  - hint of larger production in Pb-Pb collisions: from **coalescence in a strange-quark rich environment?**

BACK UP