Production of charm hadrons in pPb collisions with LHCb

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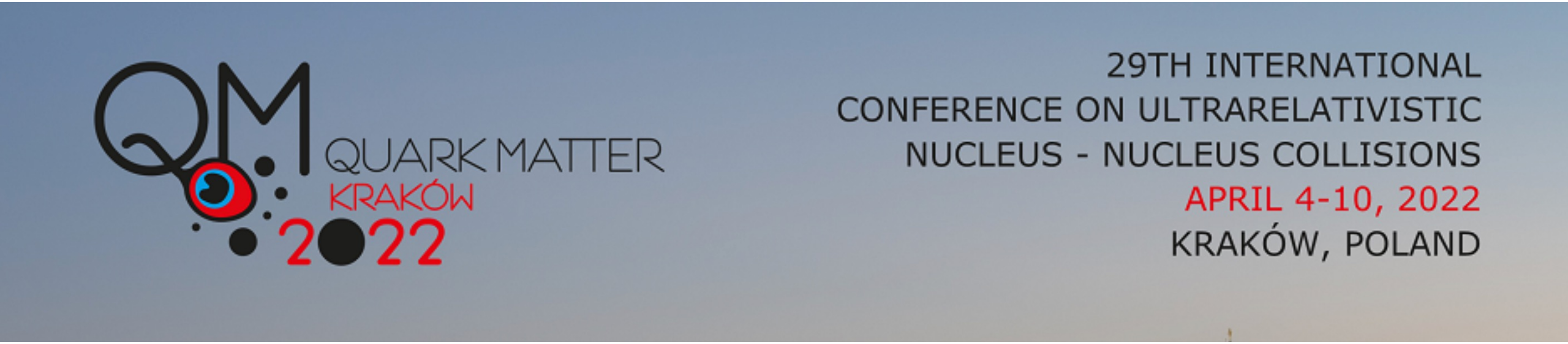
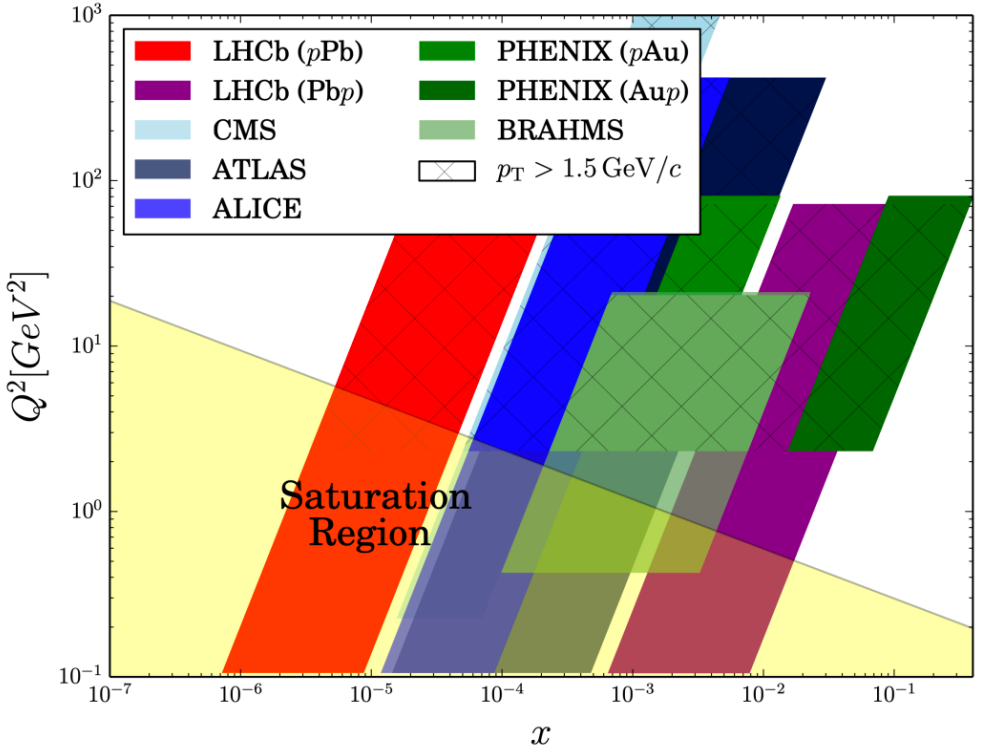
on behalf of LHCb collaboration



Introduction

- Cold nuclear matter effects (CNM) are assumed to be dominant in pPb collisions.
  - ➢ Modification of nuclear parton distribution functions (nPDFs).
  - ➢ Other initial/final state effects.
- Production cross-sections of open charm and charmonia are used to probe CNM and constrain nPDFs at small-x and mid-x region in pPb collisions at LHCb.



LHCb forward: small-x

Shadowing

LHCb backward: mid-x

Anti-Shadowing

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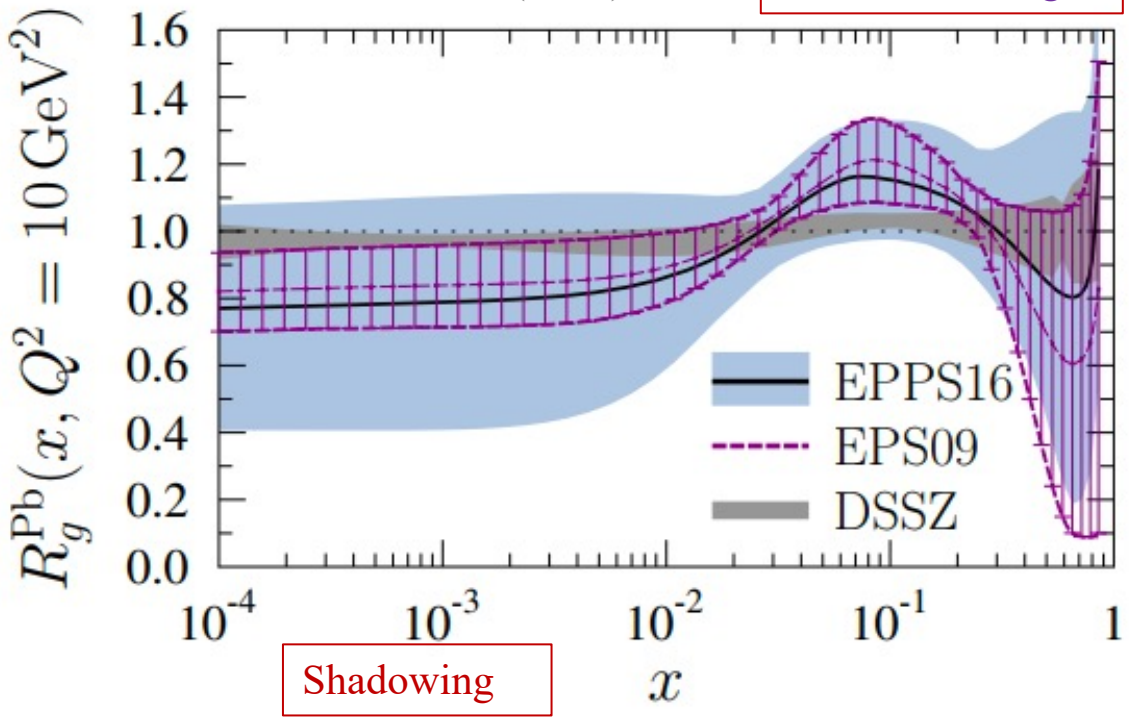
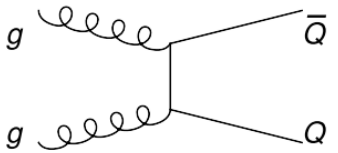
Anti-Shadowing



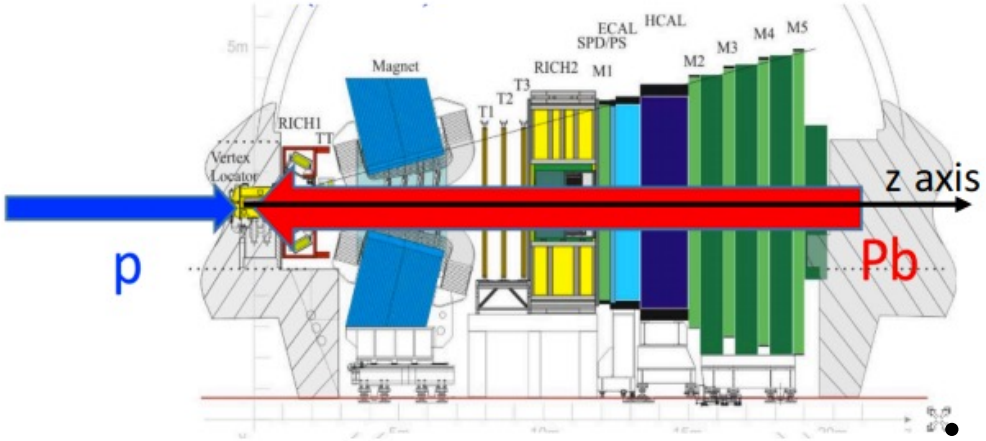
Shadowing

$$R_i^{\mathrm{Pb}}(x,Q^2) = \frac{f_i^{\mathrm{Pb}}(x,Q^2)}{A f_i^{p}(x,Q^2)}, i = g, q, \bar{q}$$



LHCb Detector and Datasets

Forward: pPb



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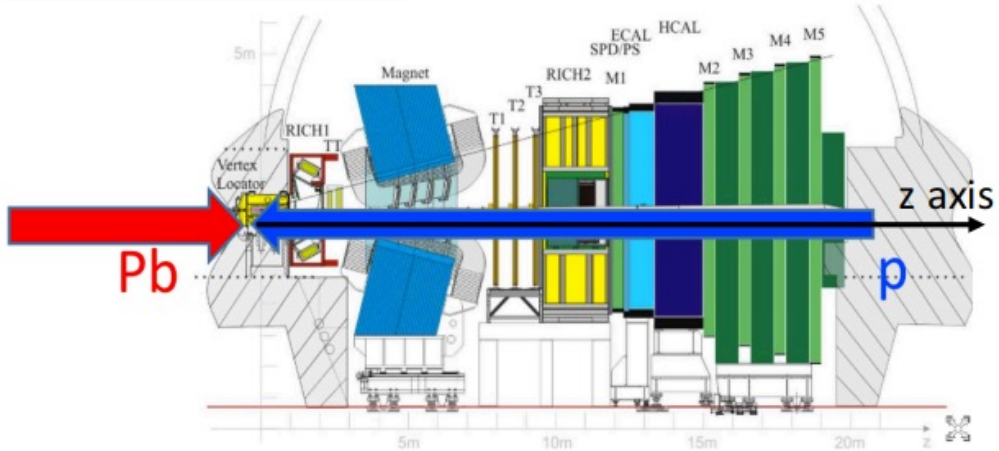
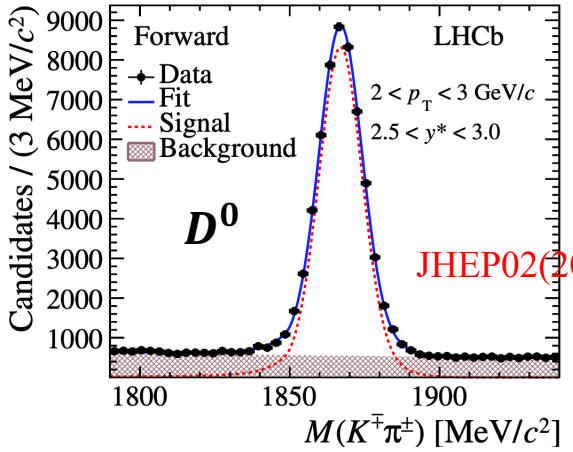
Backward: Pbp



- **A single-arm forward spectrometer, covering the pseudo-rapidity range of $2 < \eta < 5$; designed for studying particles containing b or c quarks down to low-p_T.**
  - Vertex detector: IP resolution $(15+29/p_{\mathrm{T}})\mu$m; time resolution 45fs
  - Tracking system: $\varepsilon(\text{tracking})\sim 96\%$; $\delta p/p \sim 0.5\sim 1\%(5-200\mathrm{GeV})$
  - Magnet: bending pow (4 Tm)
  - RICH ($K/\pi/p$ separation)

- **Datasets of D^0, Λ_c^+ and J/ψ collected in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV from LHCb.**
  - pPb system boosted in laboratory frame: $y^* = y_{lab} - 0.465$.
  - Rapidity acceptance:
    Forward (pPb): $1.5 < y^* < 4.0$
    Backward (Pbp): $-5.0 < y^* < -2.5$,
    common region: $2.5 < |y^*| < 4.0$
    pp reference: $2.0 < y < 4.5$
  - Luminosity:
    pPb: 1.06 nb^{-1} + Pbp: 0.52 nb^{-1}.

Analysis Strategy



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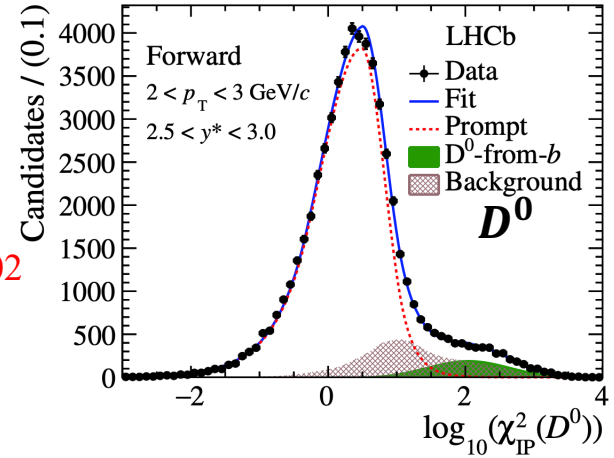

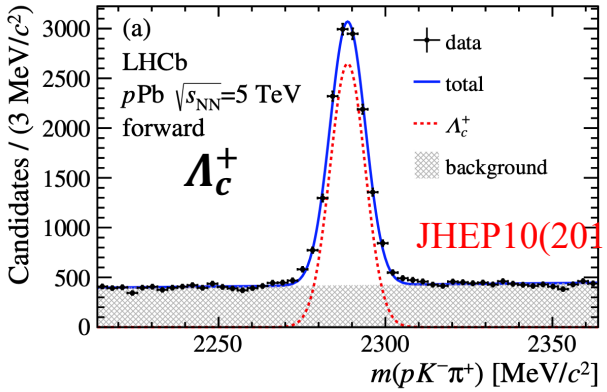

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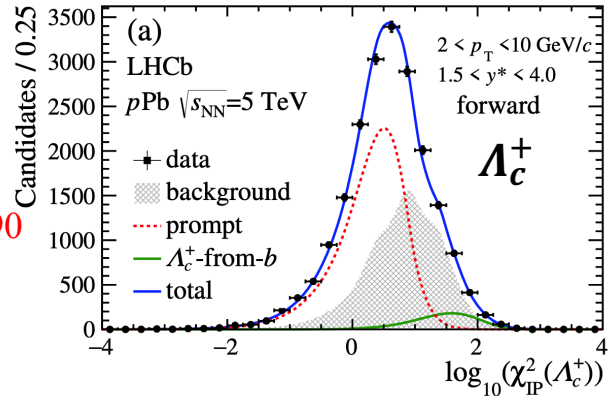

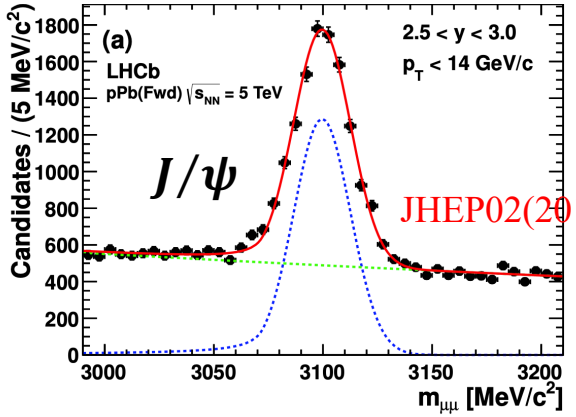

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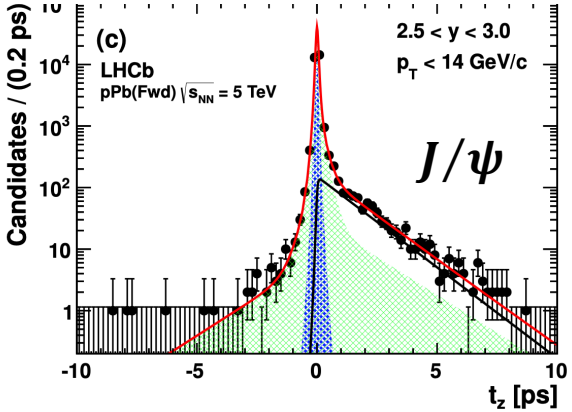
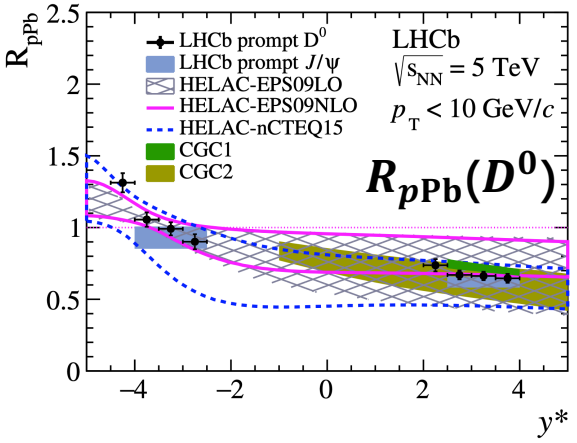
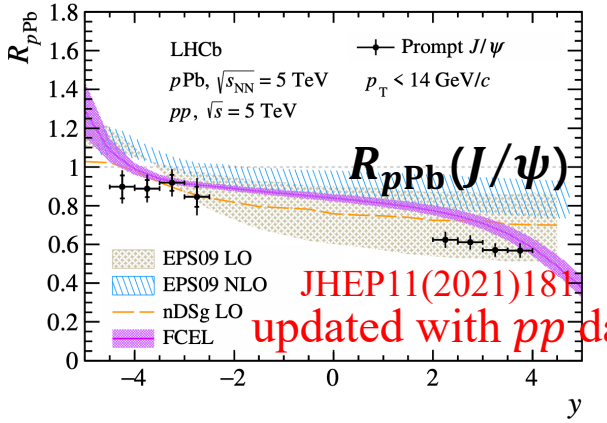


- D^0, Λ_c^+ and J/ψ are fully reconstructed through $D^0 \to K^-\pi^+$, $\Lambda_c^+ \to pK^-\pi^+$ and $J/\psi \to \mu^+\mu^-$ decays (charge conjugate).
- Background components are subtracted using invariant mass.
- Prompt and secondary yields separated using impact parameter ($D^0$and Λ_c^+) or pseudo-proper time (J/ψ).
- Nuclear modification factor and forward-backward ratio are measured to study CNM effects:
  - $R_{p\mathrm{Pb}} = \frac{\mathrm{d}^2\sigma_{p\mathrm{Pb}}/\mathrm{d}p_\mathrm{T}\mathrm{d}y^*}{A\times\sigma_{pp}/\mathrm{d}p_\mathrm{T}\mathrm{d}y^*}$, $A = 208$.
  - $R_{\mathrm{FB}}(p_\mathrm{T}, y^*) = \frac{\mathrm{d}^2\sigma_{p\mathrm{Pb}}(p_\mathrm{T},+|y^*|)/\mathrm{d}p_\mathrm{T}\mathrm{d}y^*}{\mathrm{d}^2\sigma_{\mathrm{Pb}p}(p_\mathrm{T},-|y^*|)/\mathrm{d}p_\mathrm{T}\mathrm{d}y^*}$.
- Baryon over meson ratio is sensitive to hadronization:
  - $R_{\Lambda_c^+/D^0} \equiv \frac{\mathrm{d}^2\sigma_{\Lambda_c^+}}{\mathrm{d}^2\sigma_{D^0}}$

Results: $R_{p\mathrm{Pb}}$, R_{FB} and $R_{\Lambda_c^+/D^0}$





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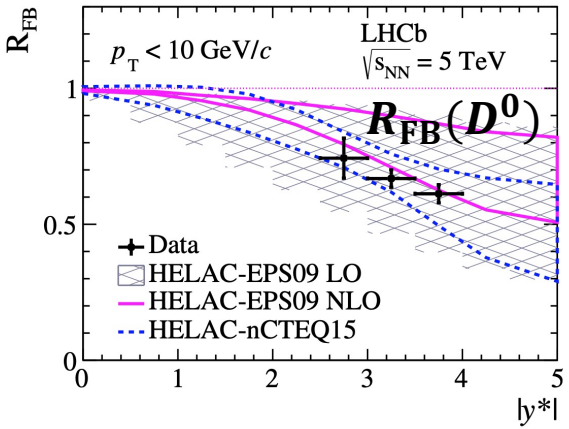
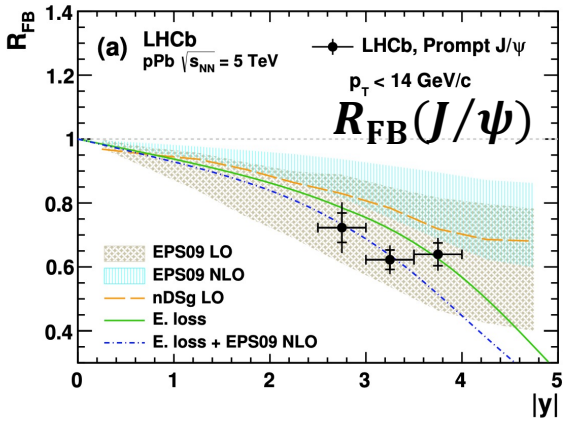
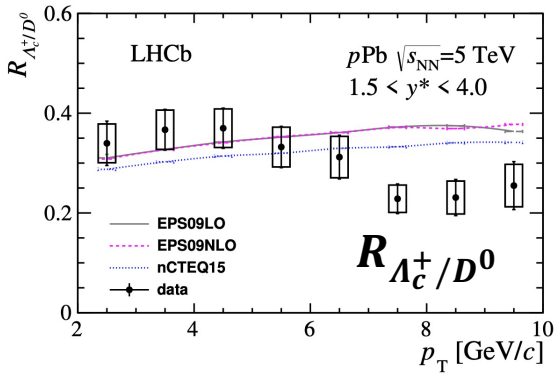
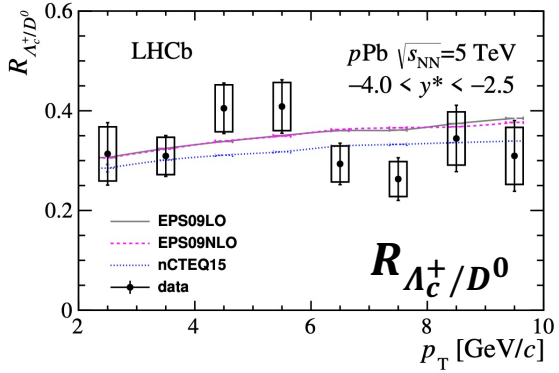
updated with *pp* data!





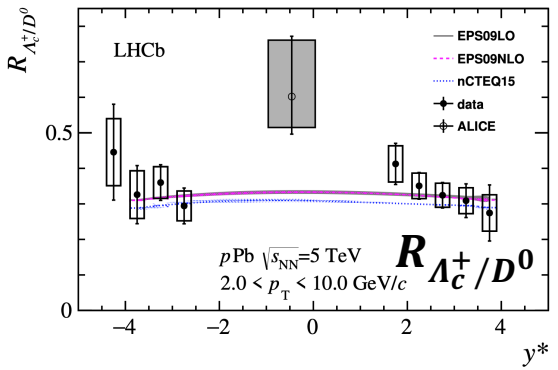




- $R_{p\mathrm{Pb}}(D^0, J/\psi)$ as a function of rapidity shows a strong suppression at positive rapidity, while it is compatible with no suppression at negative rapidity. At positive rapidity region $R_{p\mathrm{Pb}}(D^0)$ also consistent with CGC, with a proper saturation scale.

- R_{FB} consistent with calculations using nPDFs with less uncertainties.

- $R_{\Lambda_c^+/D^0}$ similar in p and Pb beam directions. Generally consistent with expectations from pp data, hint of discrepancy at high p_{T} for proton beam direction.



Summary and outlook

- **LHCb has strong capabilities to study heavy flavor in heavy-ion collisions.**

- **Studied charm production of open charm D^0, Λ_c^+ and charmonia J/ψ at LHCb:**
  - Precise data for prompt D^0 down to zero-p_T : strong suppression in proton beam direction. Moderate nuclear effect at lead beam direction, hint of enhancement for extreme rapidity
  - Nuclear modification factor $R_{p\mathrm{Pb}}$ of J/ψ is updated with pp data, consistent with nPDFs predictions.
  - Prompt $R_{\Lambda_c^+/D^0}$ cross-section ratio consistent with expectation at low, possible discrepancy at high at positive rapidity.

- **More production measurements in pPb collisions ($\sqrt{s_{NN}} = 5.02, 8.16$ TeV) at LHCb:**
  - Example:$D^+, D_s^+, D^{*+}, \Xi_c^+$ …, correlations, track multiplicity dependence.