Heavy Ion results in fixed target mode at LHCb

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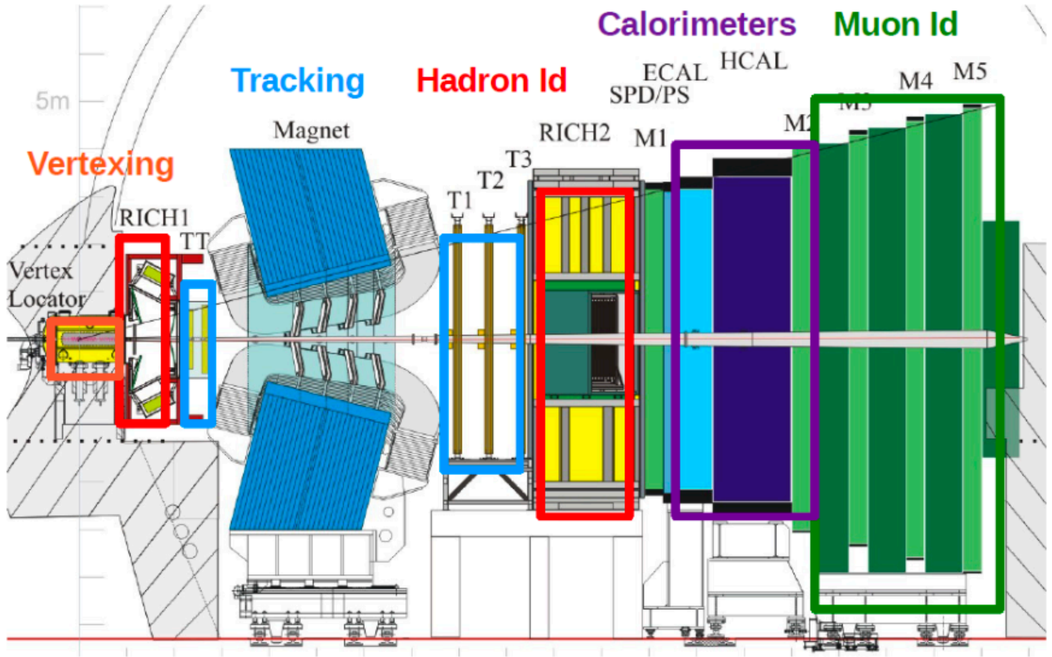
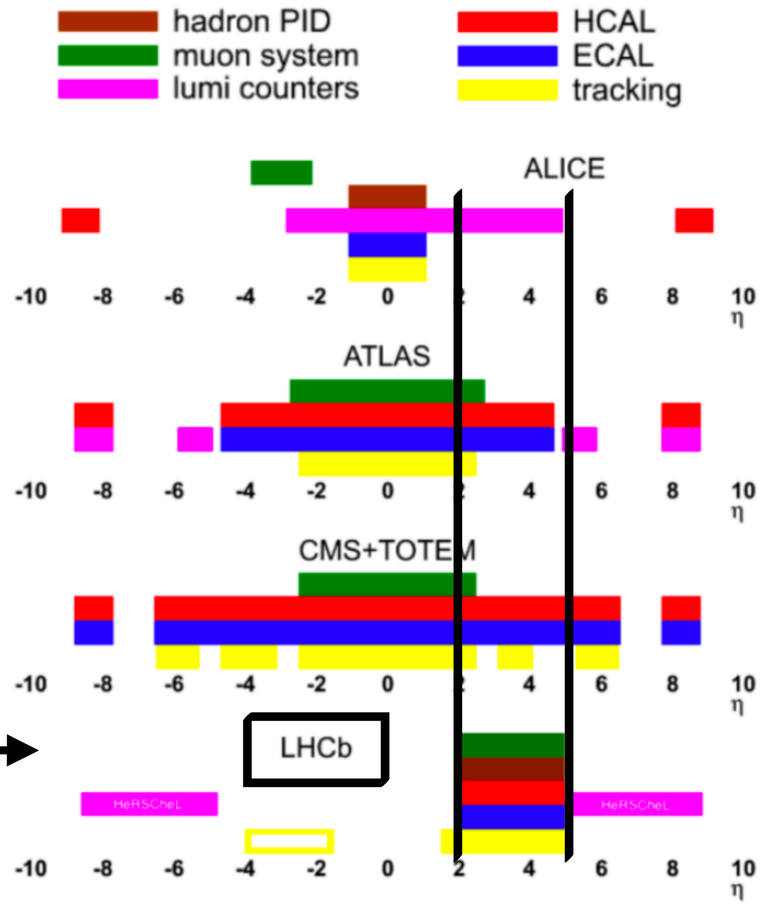
FTE@LHC workshops

LHCb Detector

- From heavy flavour physics to a general-purpose detector in the forward region.
- Forward detector fully instrumented in $2 < \eta < 5$.
- Excellent tracking, momentum resolution, and particle identification.



JINST 3 (2008)S08005



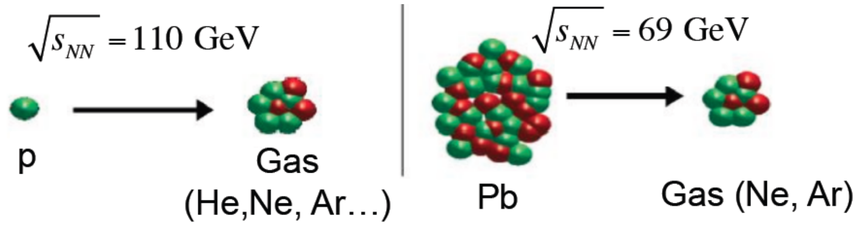
IJMPA 30 (2015) 1530022

SMOG:fixed-target program

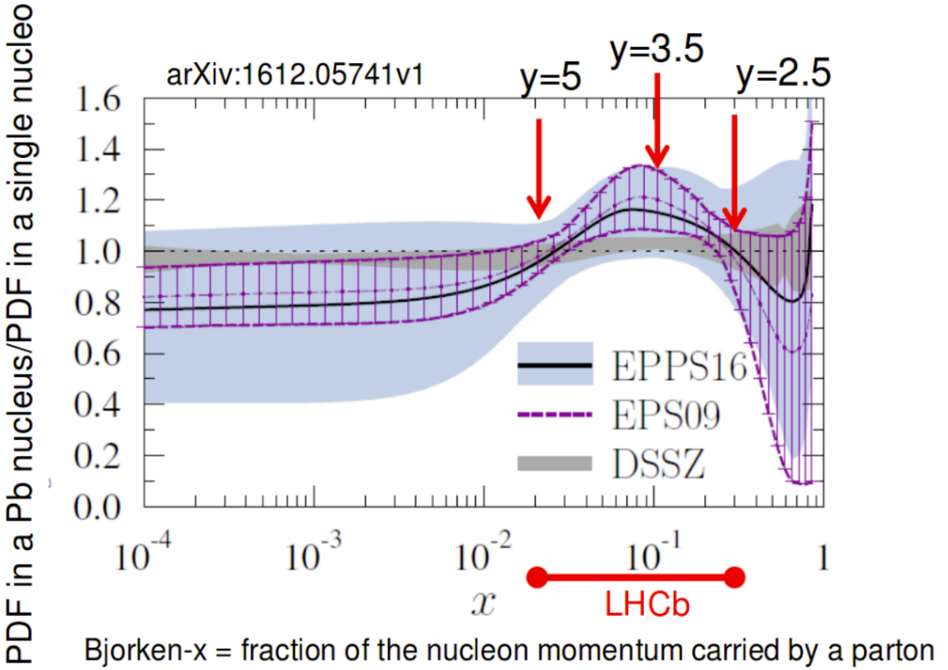
SMOG: System for Measuring Overlap with Gas.

Noble gases at a pressure of $O(10^{-7})$mbar are injected into the VELO.

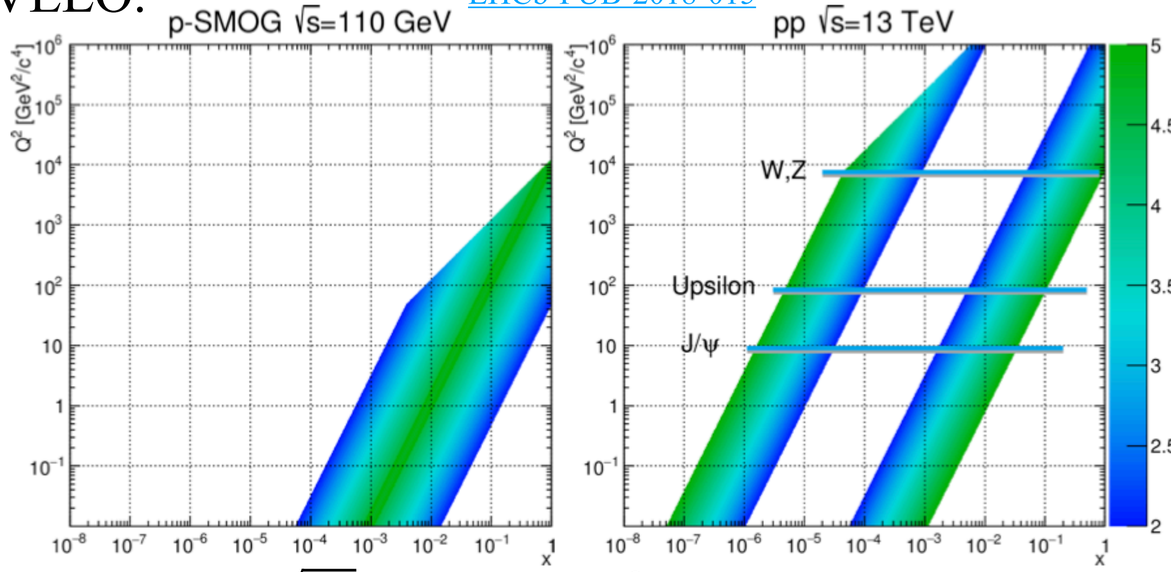
Fixed target mode



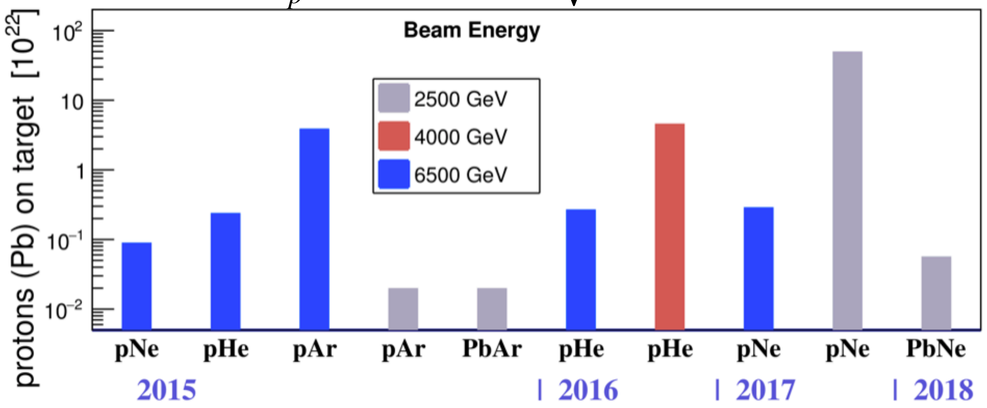
- Access nPDF anti-shadowing region
- Can probe intrinsic charm content of nucleon.



LHCb-PUB-2018-015



$$y = y^* + ln(\frac{\sqrt{s_{NN}}}{m_p}) \qquad x_F \simeq \frac{2}{\sqrt{s_{NN}}}\sqrt{M^2 + p_T^2}\ sinh(y^*)$$



Talk Outline

- D^0 production and asymmetry in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

  arXiv:2211.11633

- J/ψ and $\psi(2S)$ production in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

  arXiv:2211.11645

- J/ψ and D^0 production in PbNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

  arXiv:2211.11652

D^0 production and asymmetry in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV

arXiv:2211.11633

Motivation:

- D^0 can serve as a reference for the study of the modification of hidden charm production.
- Can bring new insight on the intrinsic charm content of the nucleon.

Event selection:

- Primary vertex along the beam line in [-200, -100]mm or [100, 150]mm to avoid residual pp collisions.
- Pions and Kaons are required to have a transverse momentum greater than 250 MeV/c.
- D^0 candidate $p_T < 8$ GeV/c.
- D^0 candidate rapidity $y \in [2.0,4.49]$ in the lab frame ($y^* \in [-2.29,0]$ in the centre of mass frame).

D^0 production and asymmetry in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV

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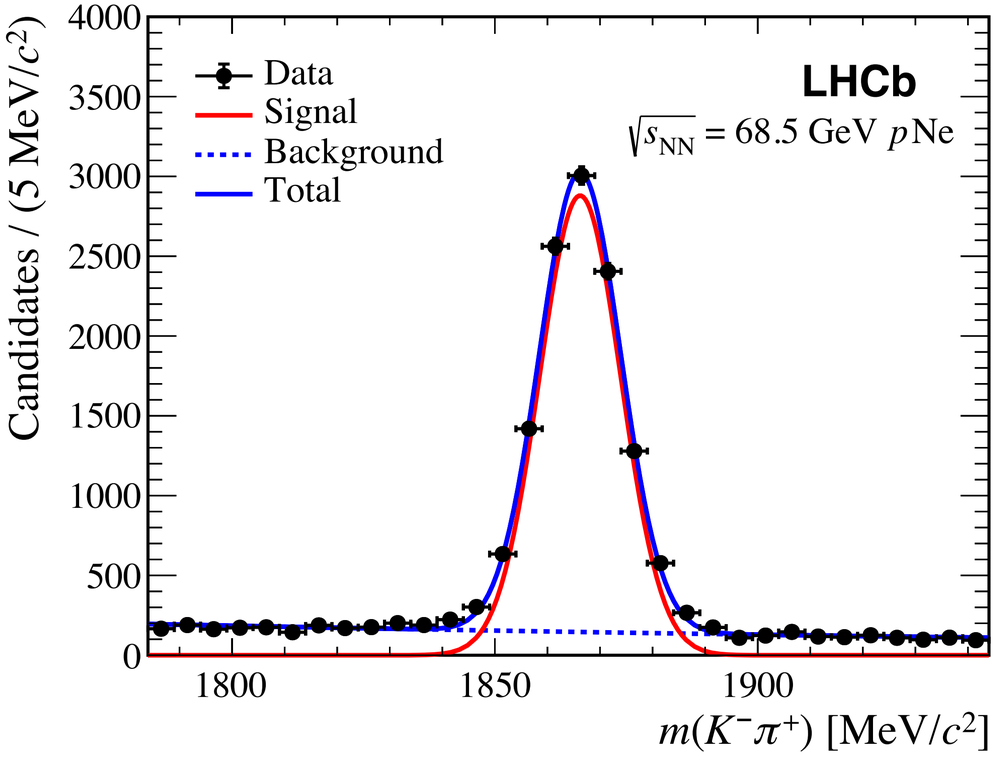
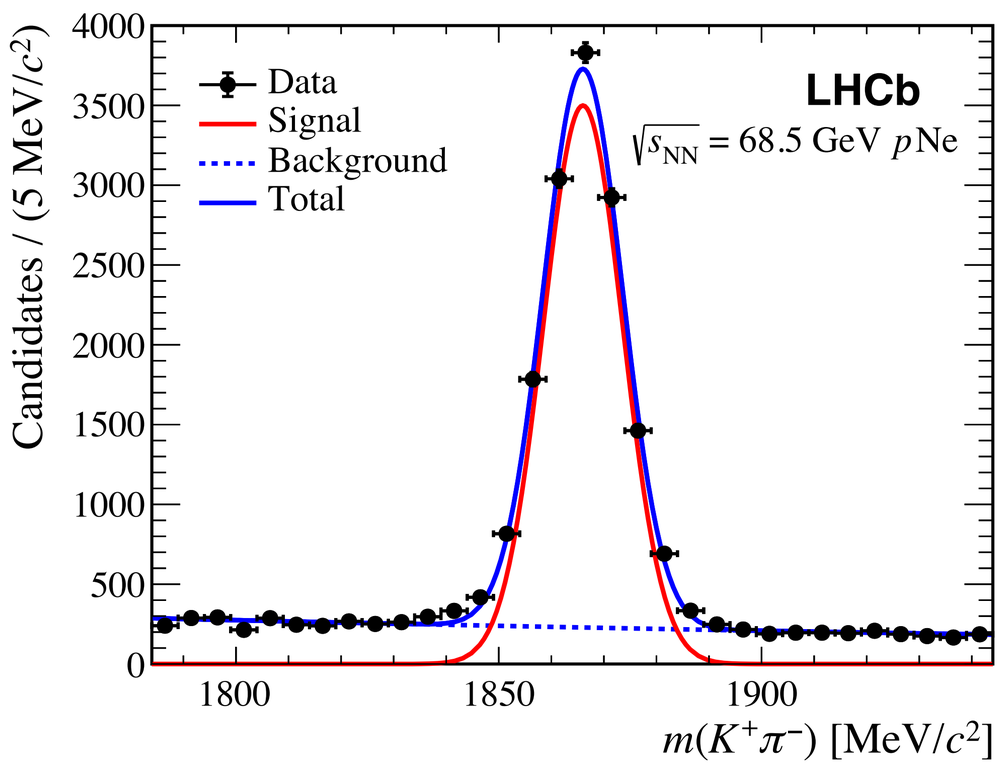
D^0



$\overline{D^0}$



D^0 production and asymmetry in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV

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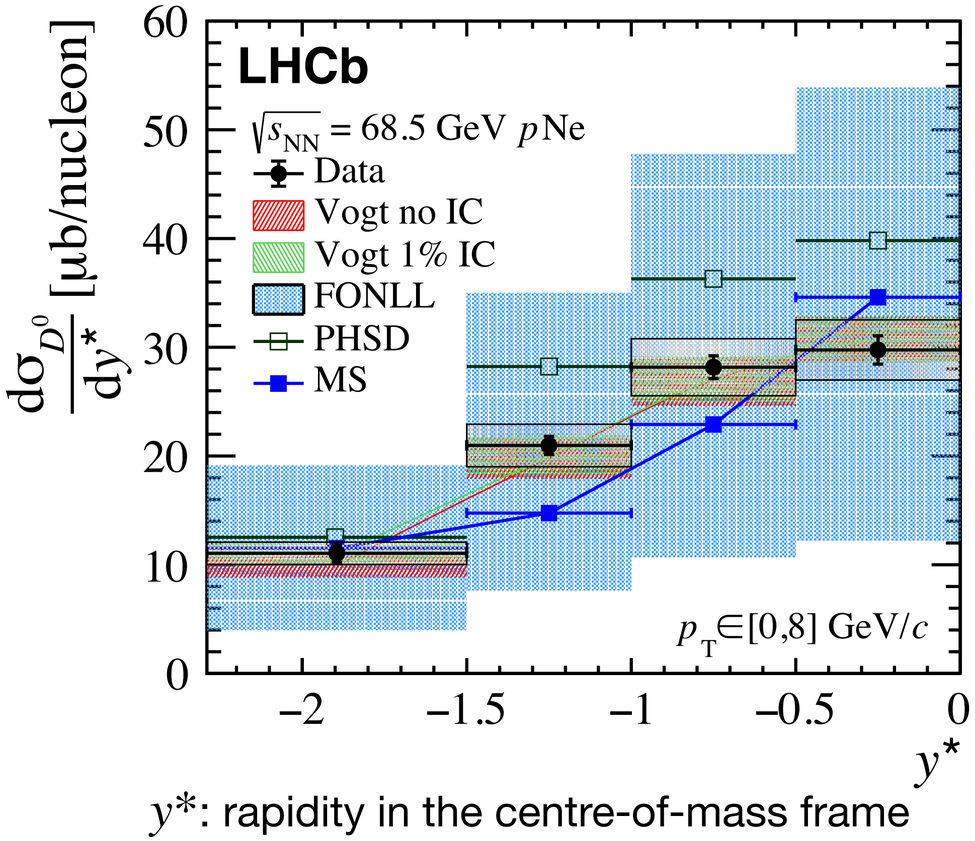
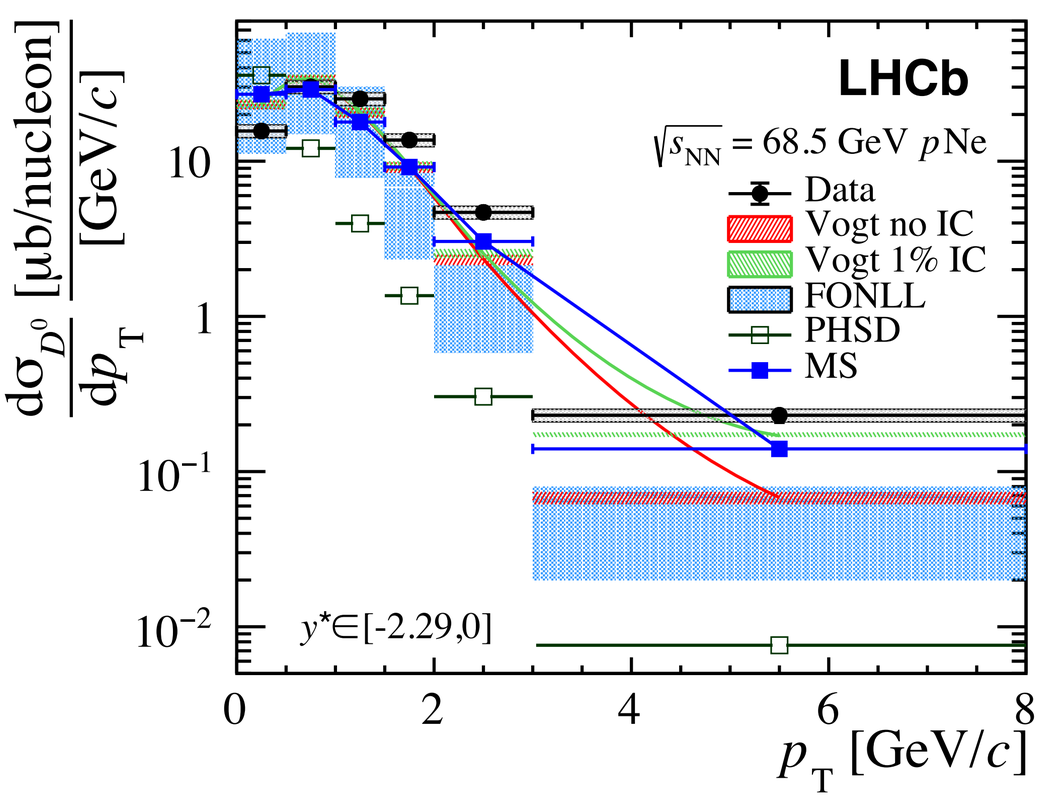


y^*: rapidity in the centre-of-mass frame



- Data well described by (Vogt 1% IC) or without (Vogt no IC) intrinsic charm contributions.
- The p_T distribution is not well reproduced by the theoretical predictions.

D^0 production and asymmetry in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV

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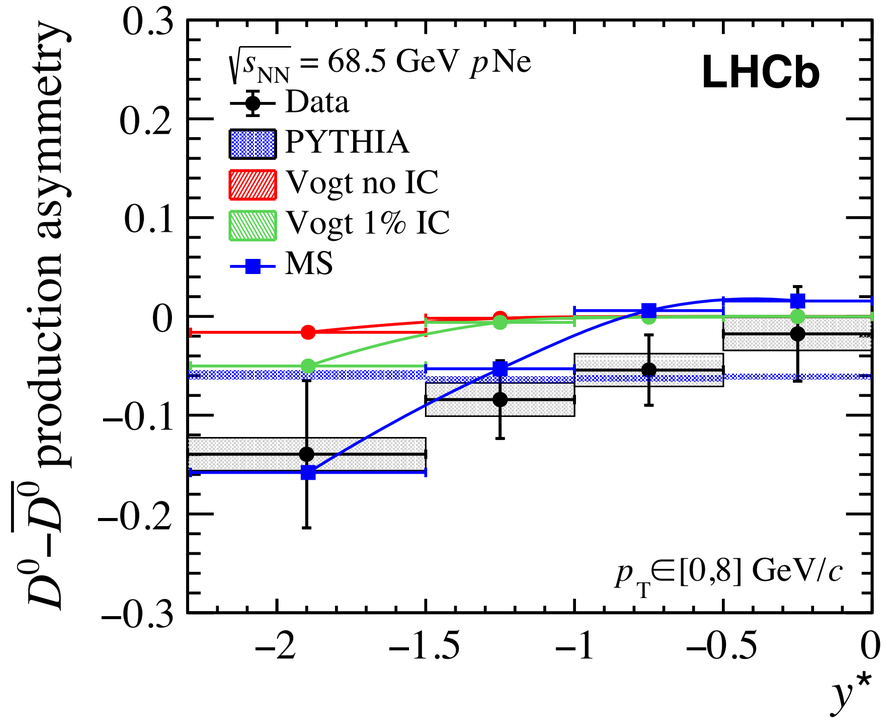
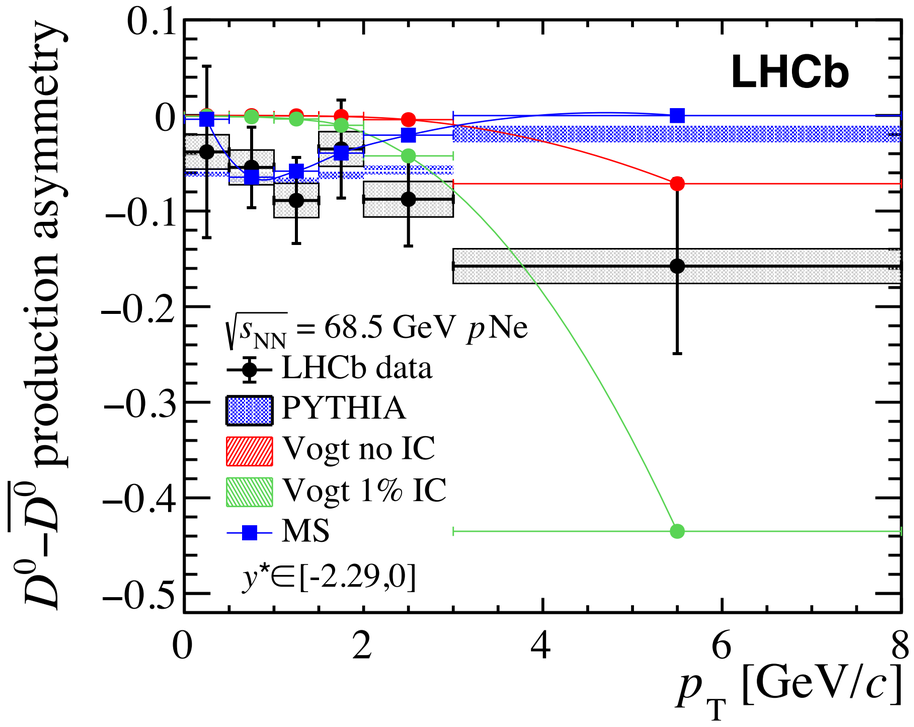
The production asymmetry is quantified as : $\mathcal{A}_{\rm prod} = \dfrac{Y_{\rm corr}(D^0) - Y_{\rm corr}(\overline{D}^0)}{Y_{\rm corr}(D^0) + Y_{\rm corr}(\overline{D}^0)},$





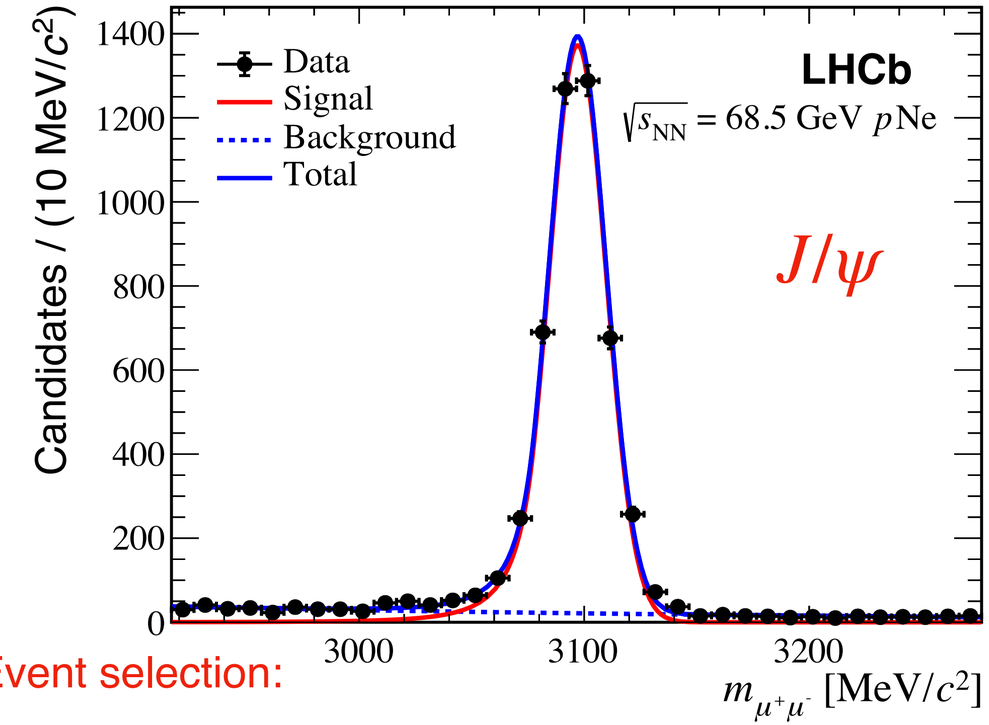
- An asymmetry of ~-15% is observed in the most negative y^* bin where the valence quark contribution of the neon target is more significant than at y^*~ 0

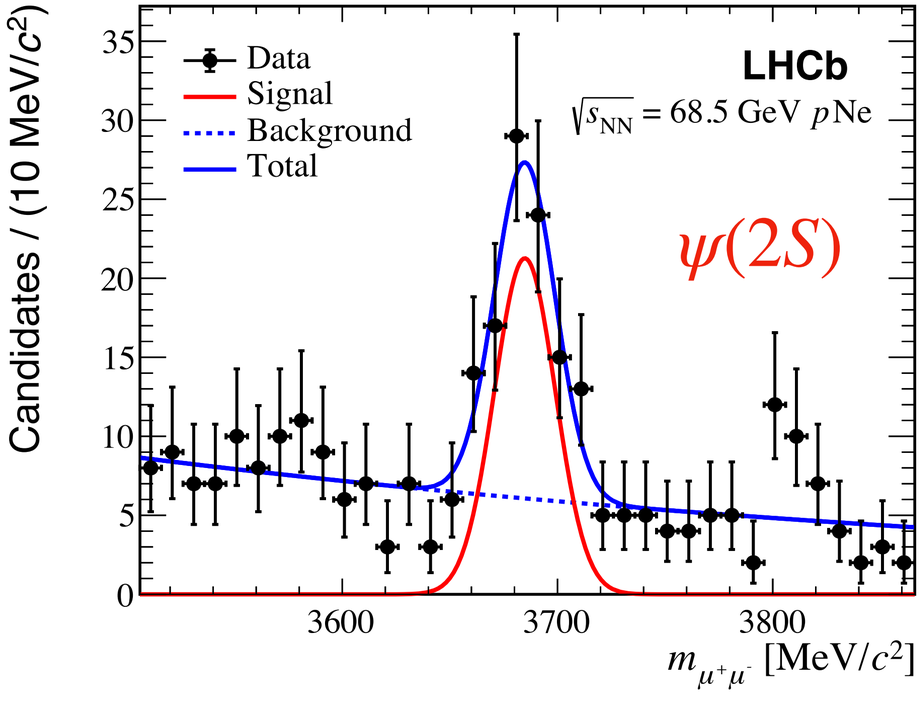
J/ψ and $\psi(2S)$ production in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

arXiv:2211.11645

Motivation:

- Understanding of charmonium production and hadronization mechanisms.





Event selection:

- Primary vertex along the beam axes in [-200, -100]mm or [100, 150]mm to avoid residual pp collisions.
- J/ψ candidate p_T < 8 GeV/c.
- J/ψ candidate rapidity $y \in [2.0,4.49]$.

J/ψ and $\psi(2S)$ production in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

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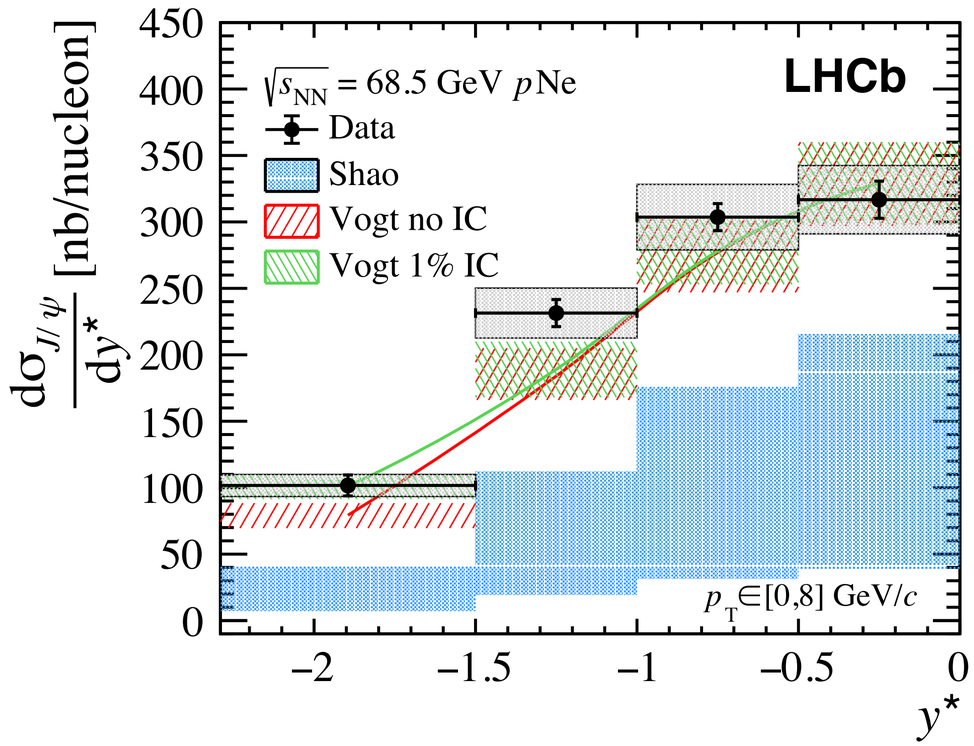

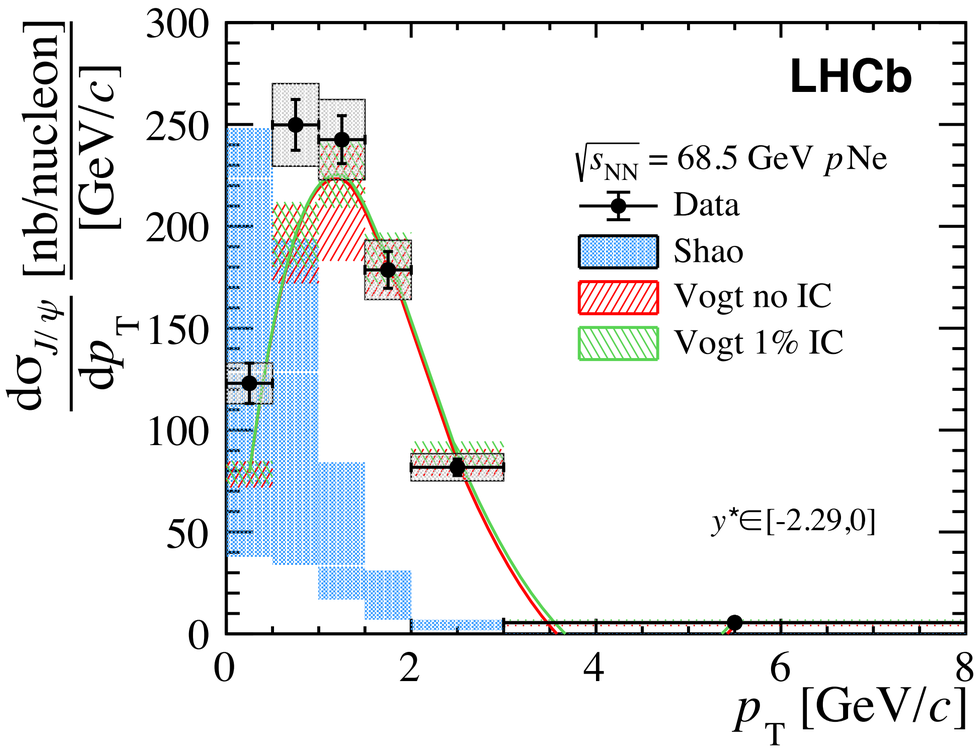

- Data are better described by Vogt with or without a 1% intrinsic charm (IC) contribution.

J/ψ and $\psi(2S)$ production in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

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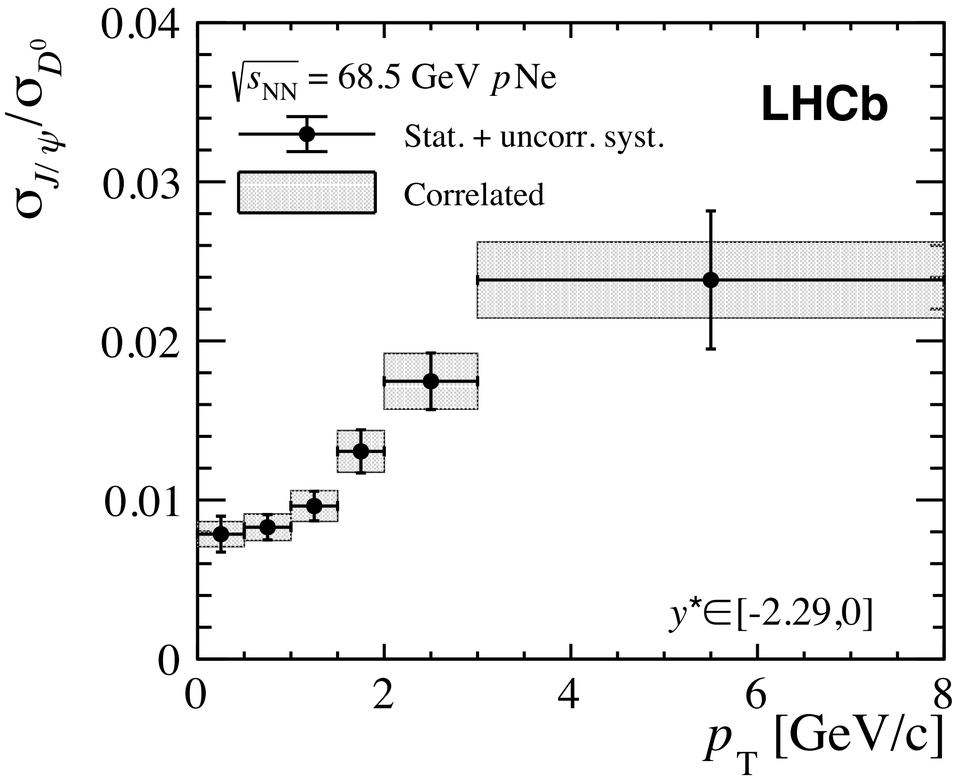

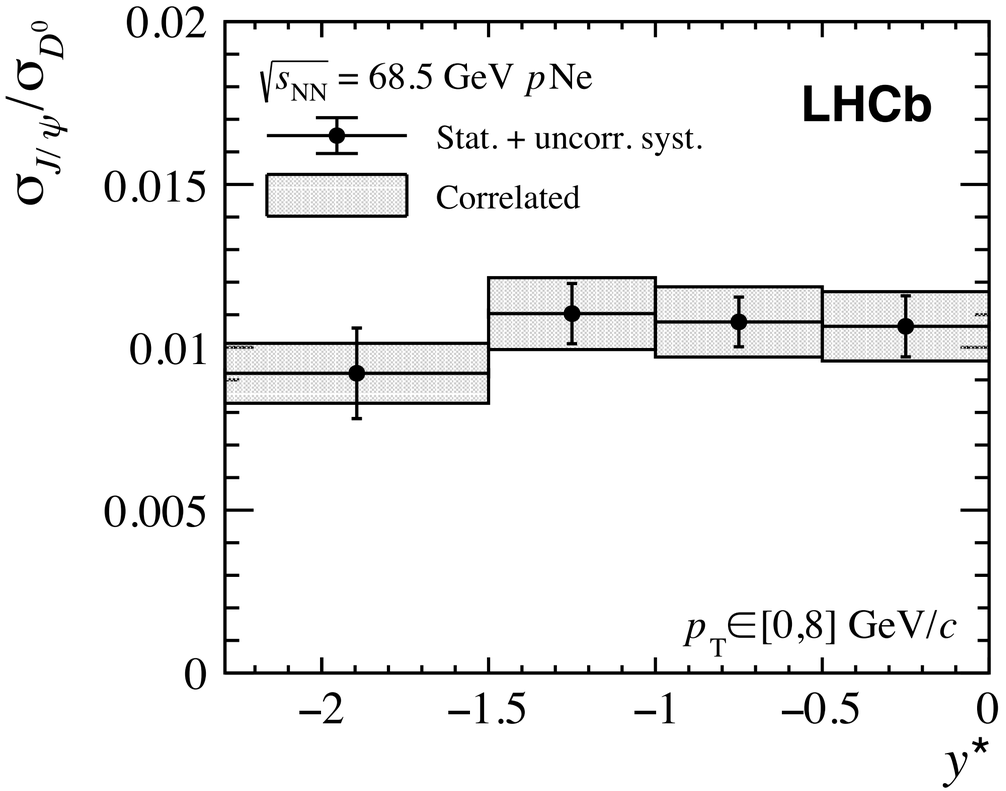

- The D^0cross-section serves as a proxy for the total charm cross-section.
- The ratio of J/ψ over D^0 can shed light on differences between hidden and open charm hadronization in nuclear media.

J/ψ and $\psi(2S)$ production in pNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

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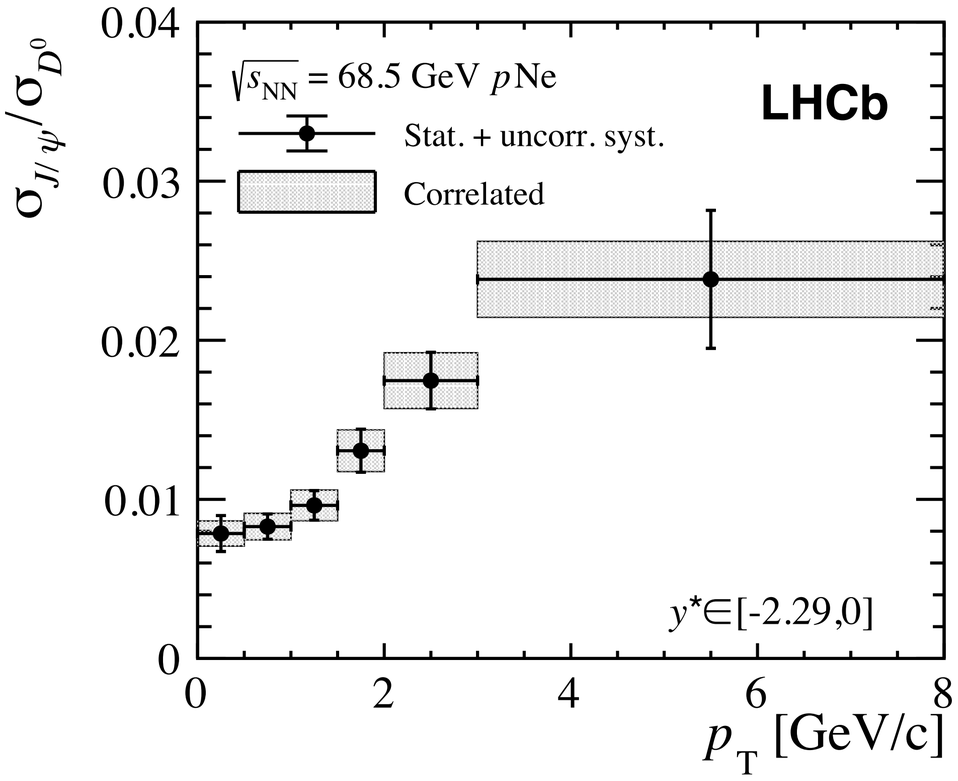
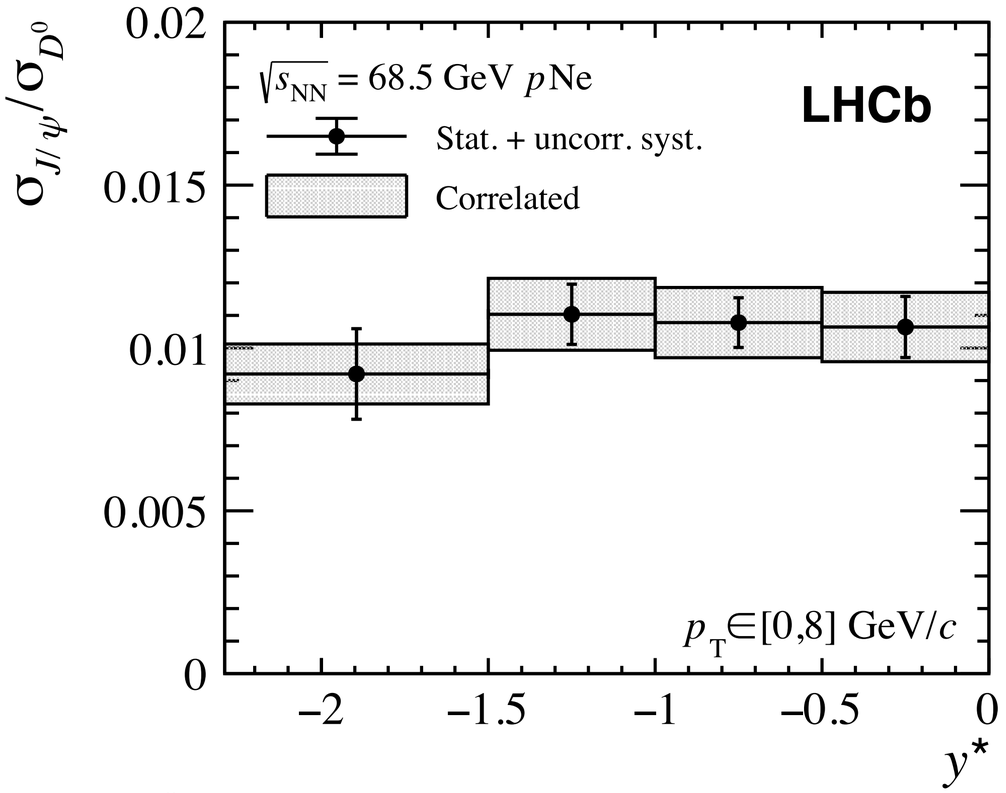


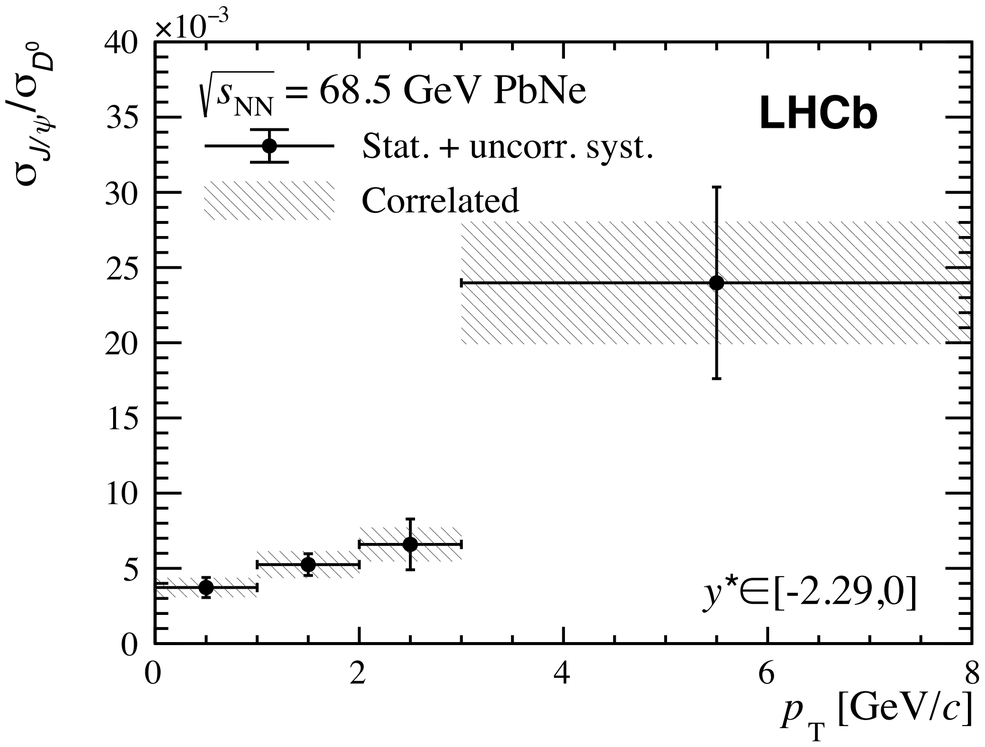
- The cross-section ratio shows a strong dependence on p_T.

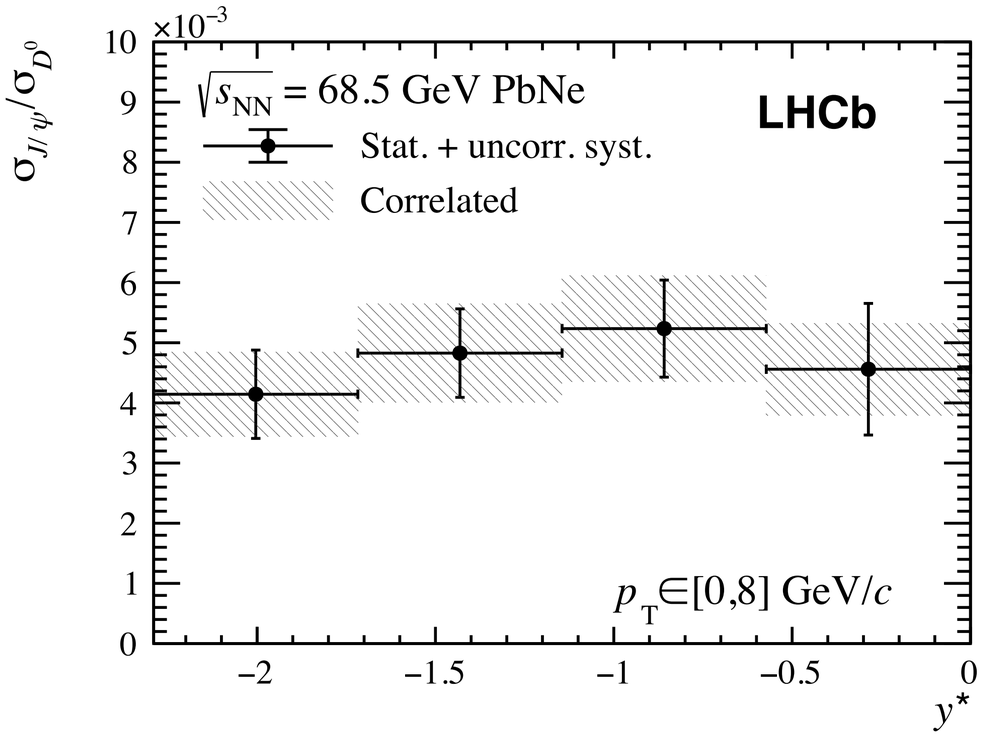


- $D^0/J/\psi$ shows no dependence on y^*.

J/ψ and D^0 production in PbNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

arXiv:2211.11652





- The ratio of $D^0/J/\psi$ cross-sections in PbNe follows similar trends in both p_T and y^* as observed in pNe.

J/ψ and D^0 production in PbNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

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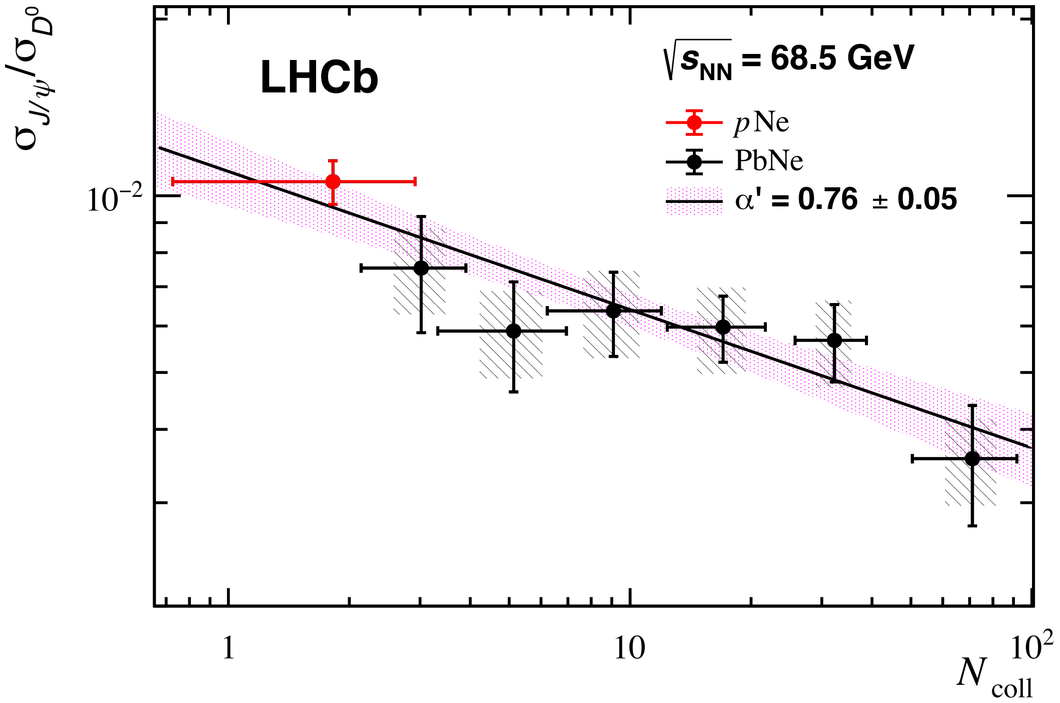
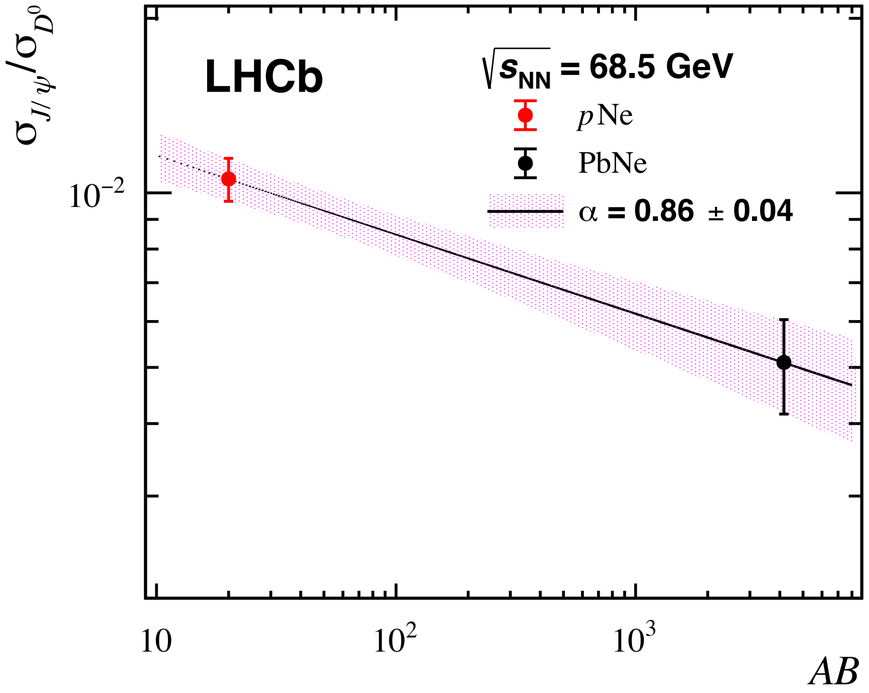
- To compare with previous results obtained in different beam and target combinations we assume that $\sigma_{D^0}^{AB} = \sigma_{D0}^{pp} \times AB$ and $\sigma_{J/\psi}^{AB} = \sigma_{J/\psi}^{pp} \times (AB)^{\alpha}$

$$\frac{\sigma_{J/\psi}^{AB}}{\sigma_{D^0}^{AB}} = \frac{\sigma_{J/\psi}^{pp}}{\sigma_{D^0}^{pp}} \times (AB)^{\alpha-1}$$

Where AB are The projectile and target atomic mass numbers





J/ψ and D^0 production in PbNe collisions at $\sqrt{S_{NN}} = 68.5$ GeV.

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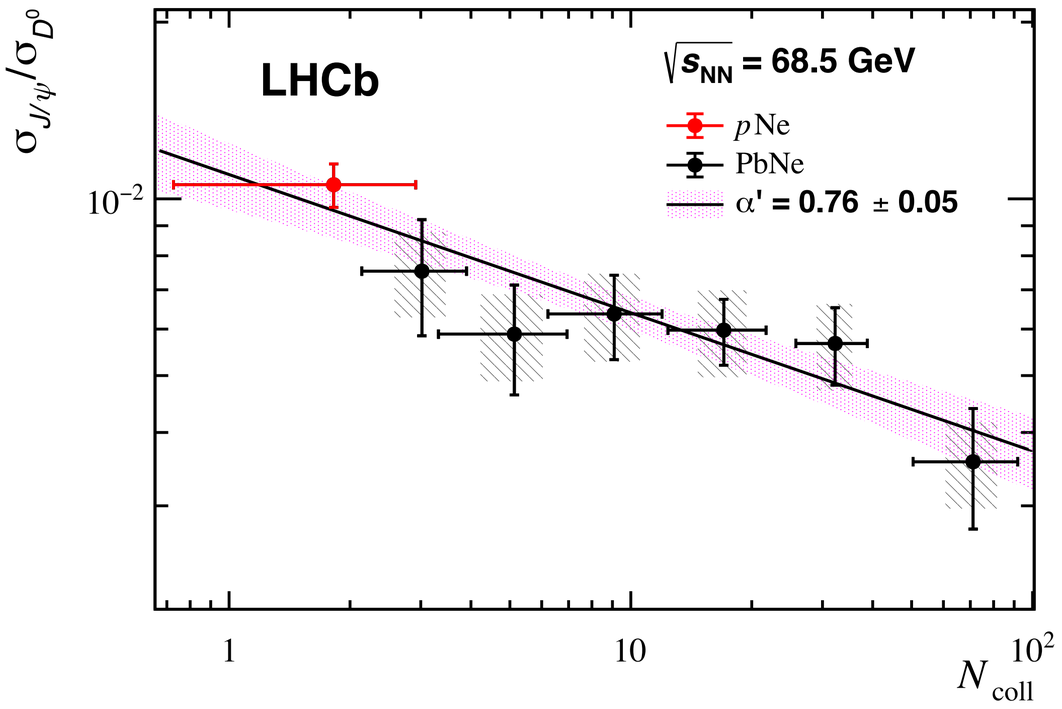

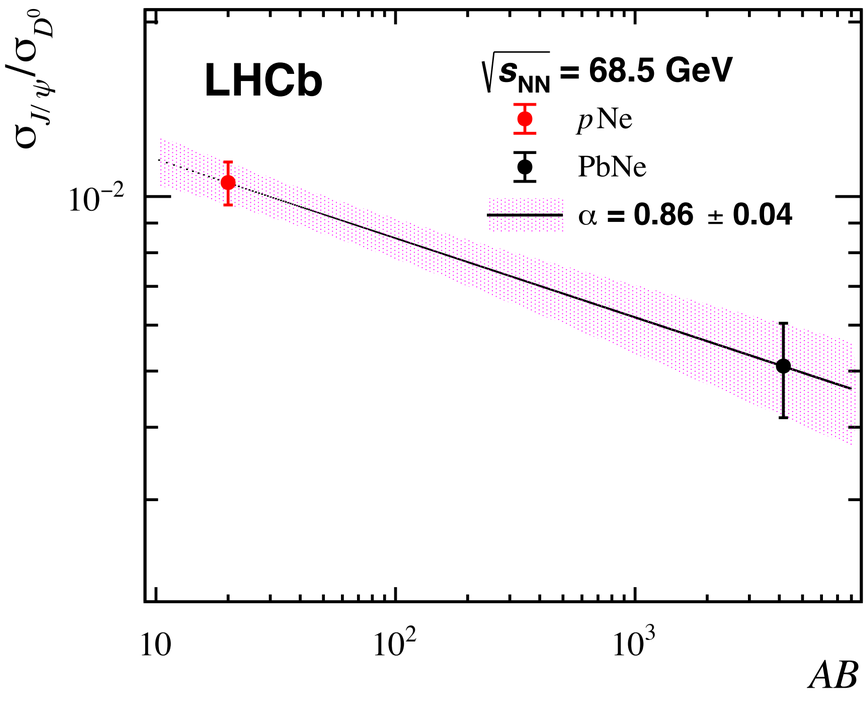

- $\alpha < 1$: indicates that J/ψ mesons experience additional nuclear effects than D^0 mesons.
- The α values are consistent with those previously measured in pA collisions.

Conclusion

- The $D^0 - \bar{D}^0$ production asymmetry tends toward a negative value of roughly –15% which could indicate more anti-charm quark hadronization with valence quarks from the high-energy proton beam.

- The cross-section of J/ψ and D^0 is found to be independent of rapidity and the data are well described by theoretical predictions with and without an intrinsic charm component included.

- The α value suggests that no anomalous suppression is observed nor is the formation of a hot nuclear medium.