

# New measurements in fixed-target collisions at LHCb

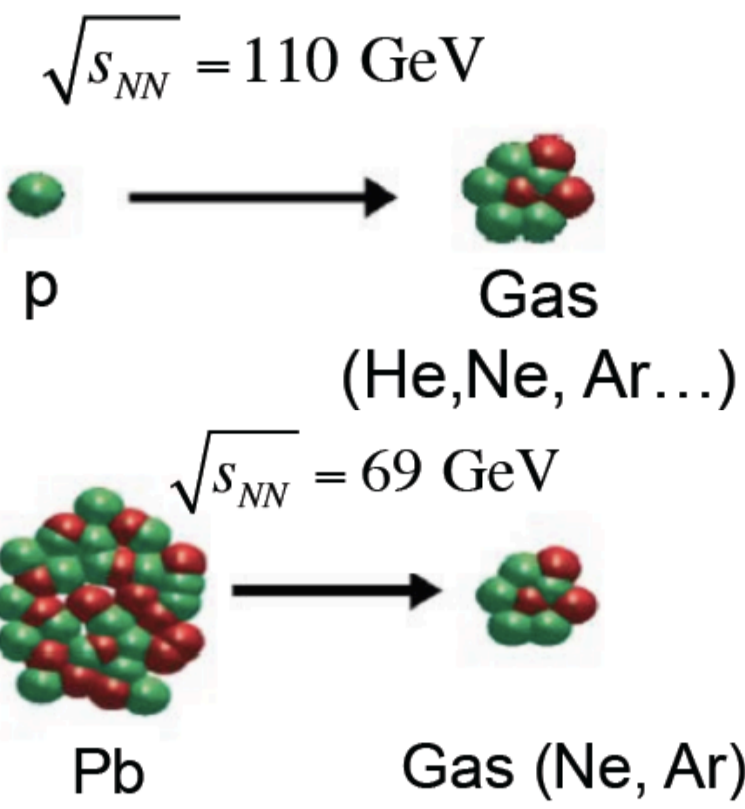
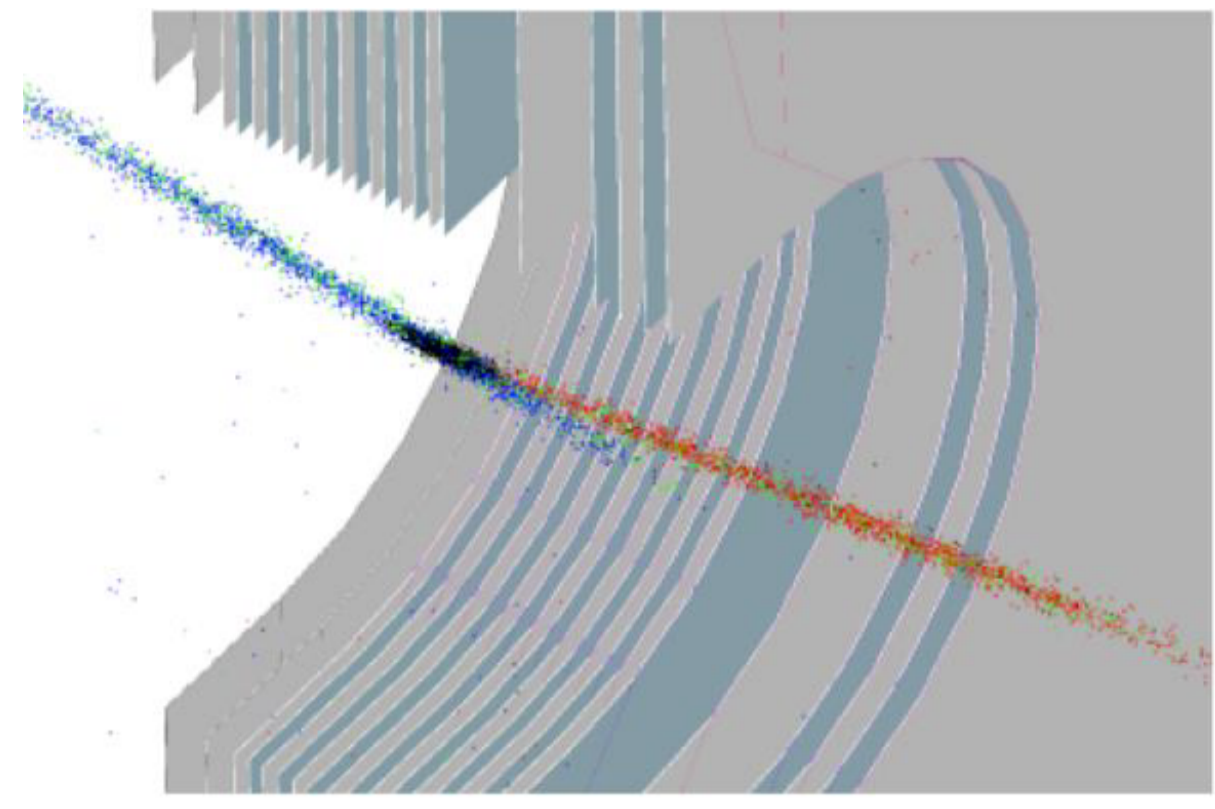
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On behalf of the LHCb collaboration

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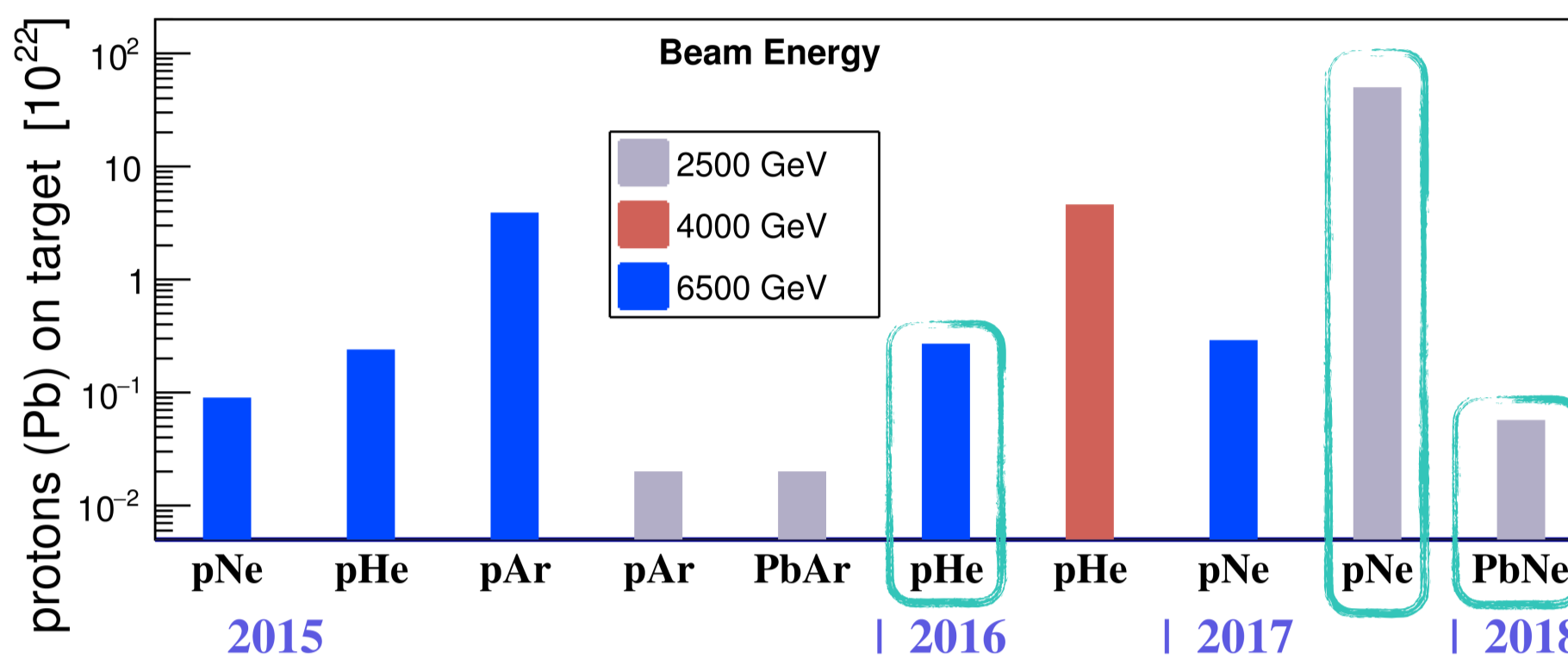
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## Fixed-target programme at LHCb: SMOG

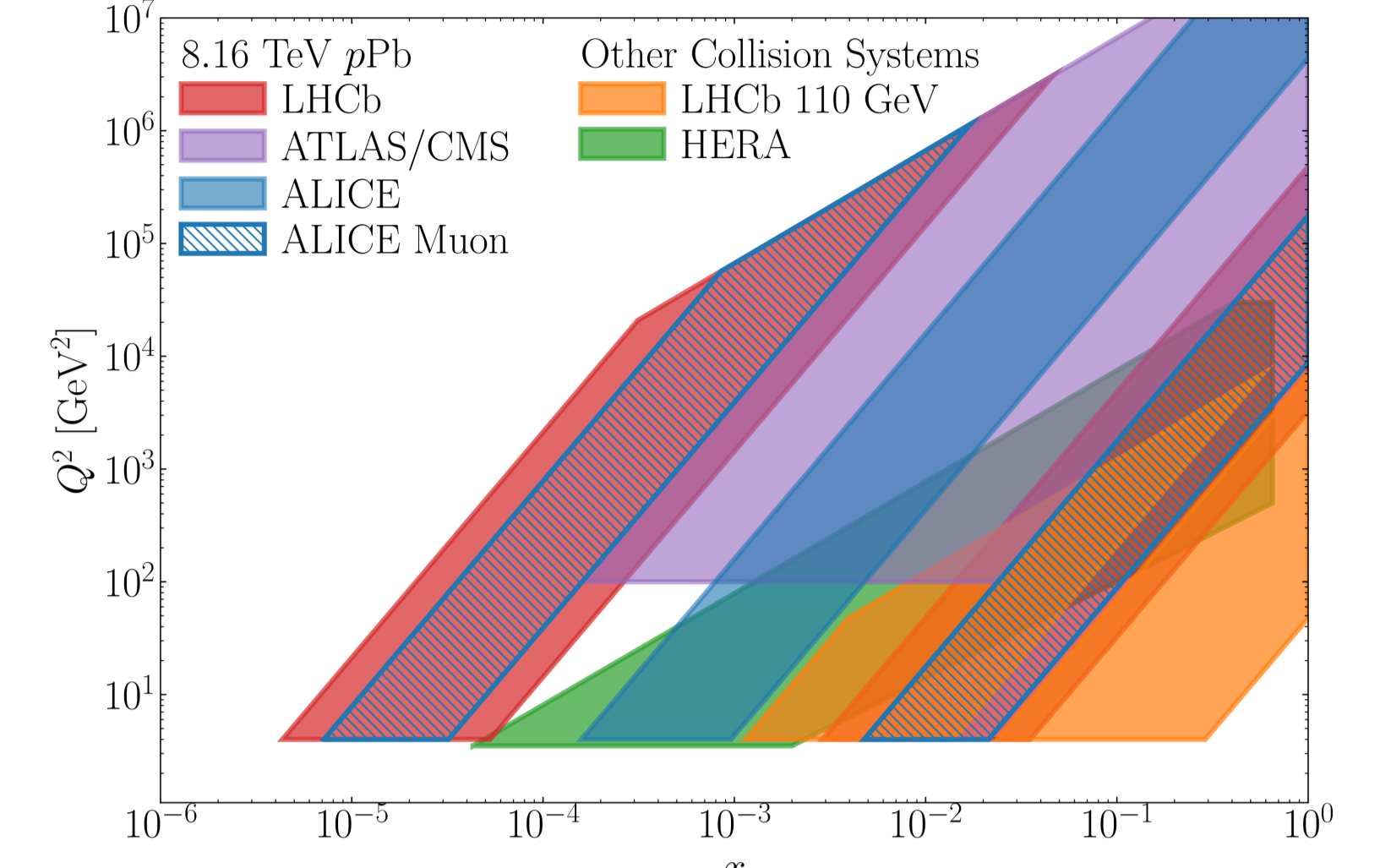


- Fixed-target measurements at LHCb are possible thanks to the **SMOG device** (System for Measuring the Overlap with Gas)
- Injection of noble gases** at a pressure of  $O(10^{-7})$  mbar in the VELO
- Conceived for precise **luminosity measurements** based on the beam-imaging technique

- Rich and unique **fixed-target research programme** became possible during the LHC Run 2
- Dedicated SMOG runs** at LHCb, exploiting only the LHC non-colliding bunches
- Previous SMOG results: first measurements of charm production in pNe and measurements of antiproton production in pHe



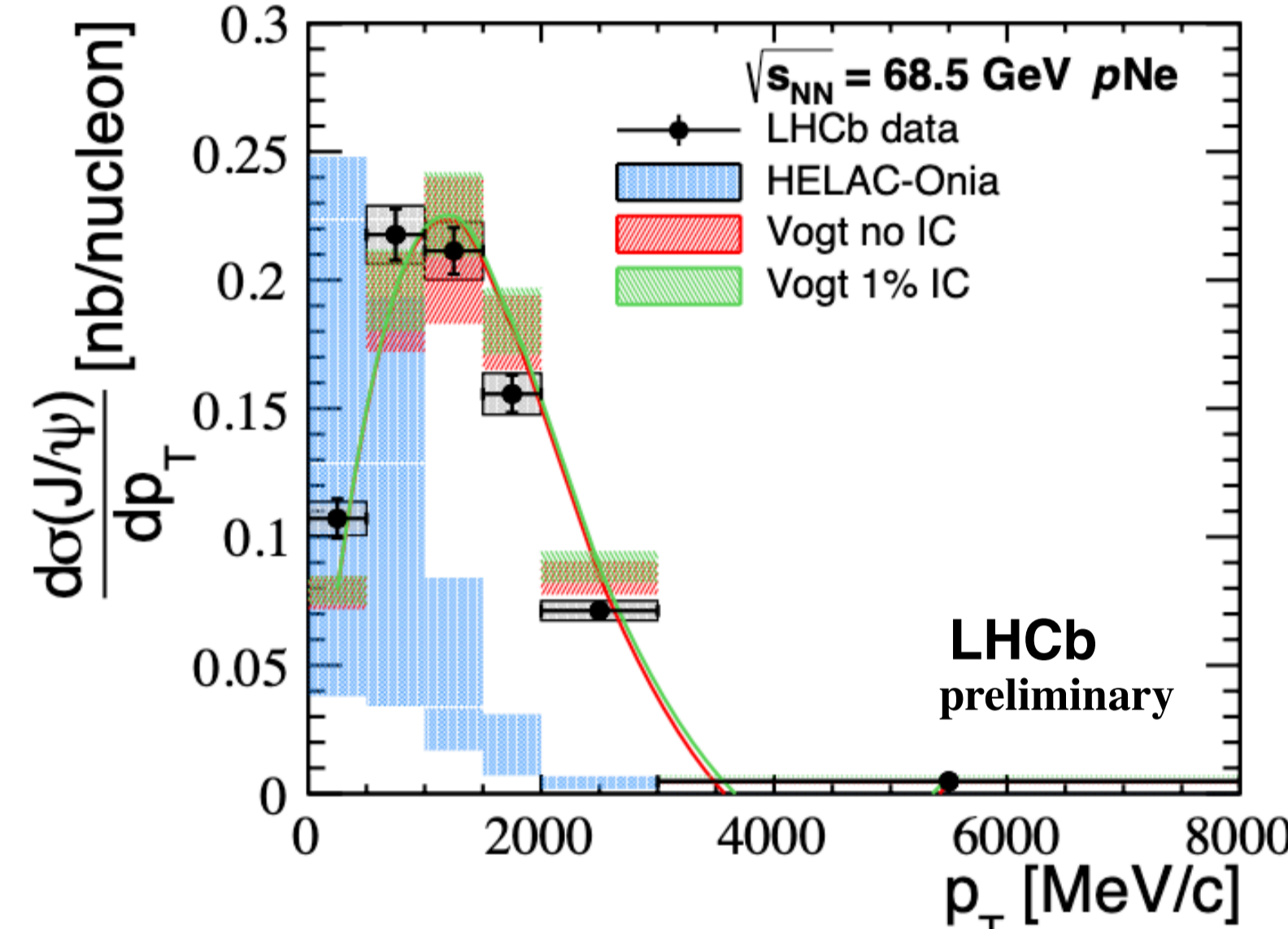
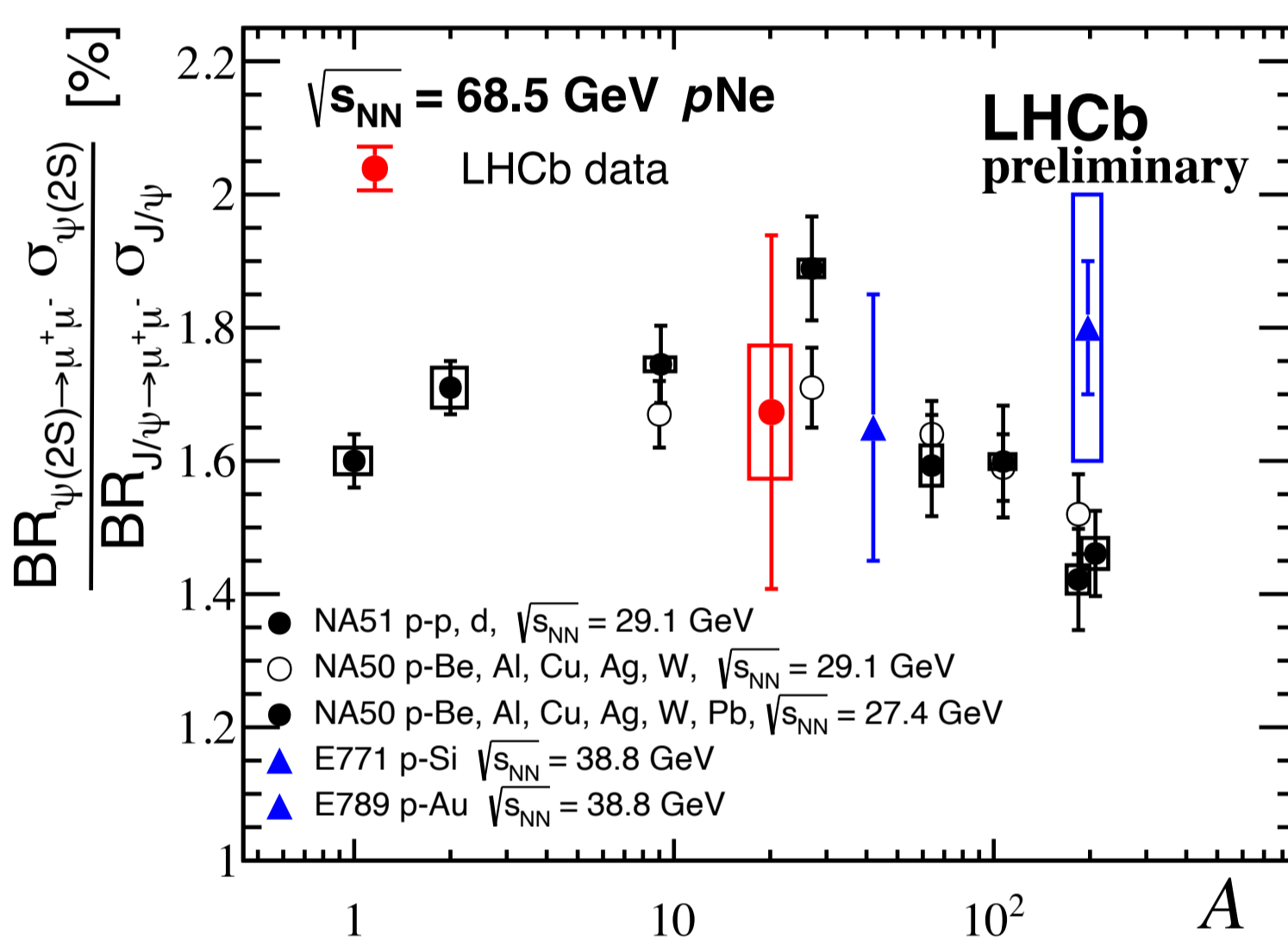
## Fixed-target kinematics



- Backward to mid rapidity coverage in the c.m. frame
- High-x** of the nucleon target at **intermediate  $Q^2$**  corresponding to **large and negative  $x_F$**
- Poorly explored** kinematic region

## Charmonium in pNe at $\sqrt{s_{NN}} = 68.5$ GeV

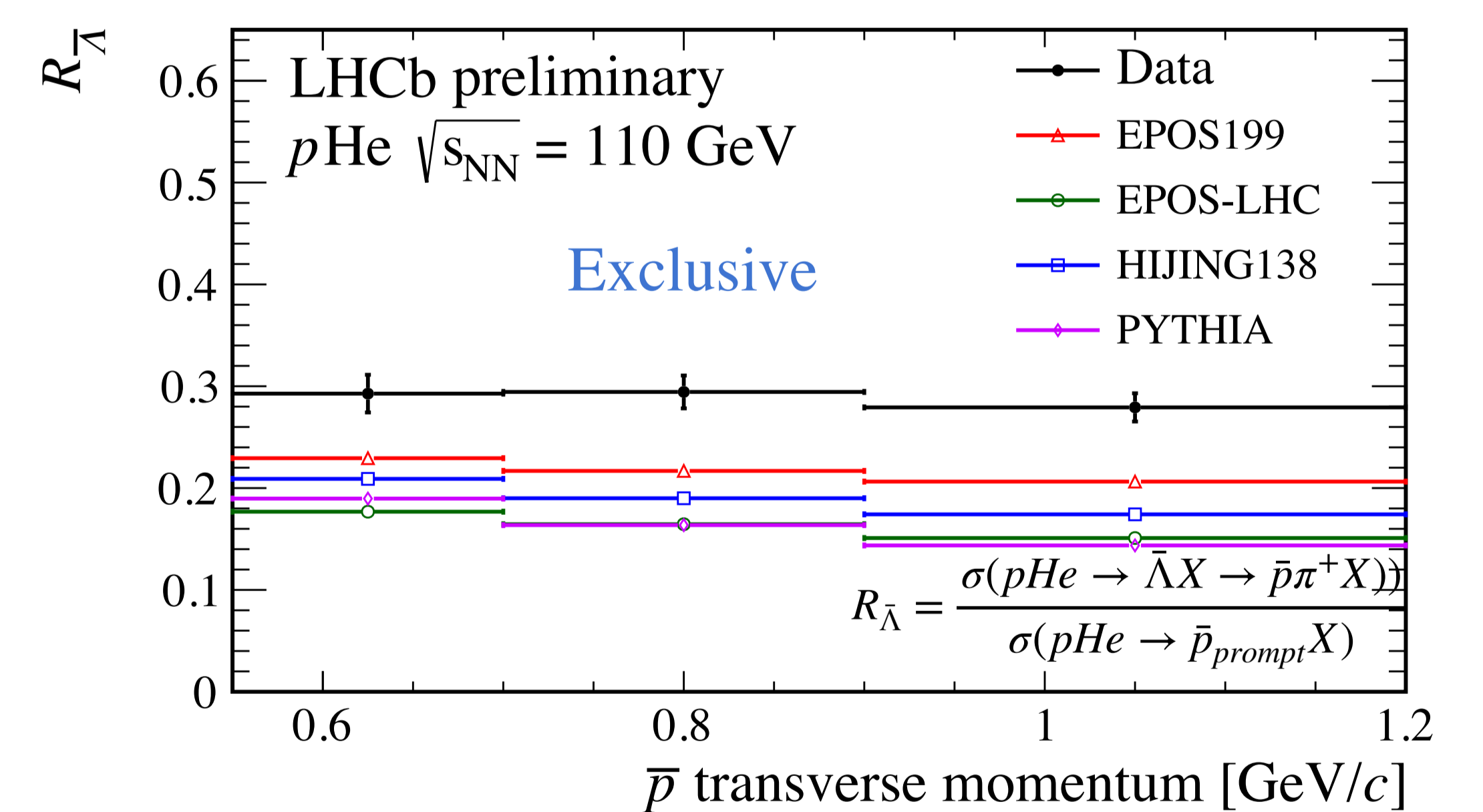
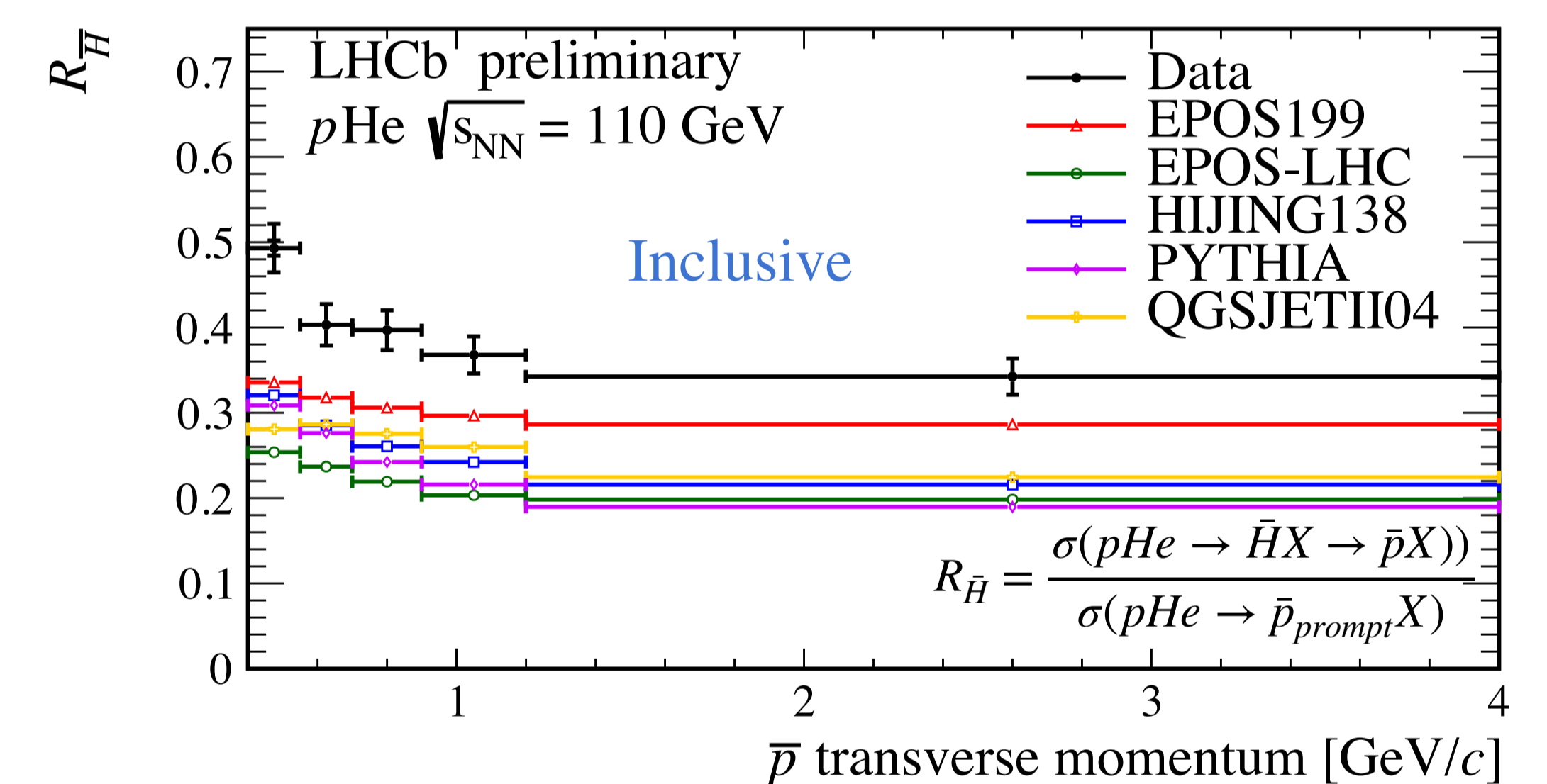
- Cold Nuclear Matter effects** (CNM) that can suppress charmonium production: nuclear absorption, comover scattering, and modification of the parton flux
- HELAC-ONIA parametrisation **underestimates** the  $J/\psi$  differential cross-section, as a function of  $y^*$  and  $p_T$  [1]



- Good agreement** with R. Vogt's predictions with (1%) or without Intrinsic Charm contribution
- The **first measurement** at SMOG of the  $\psi(2S)$  to  $J/\psi$  ratio is in agreement with other results at small A

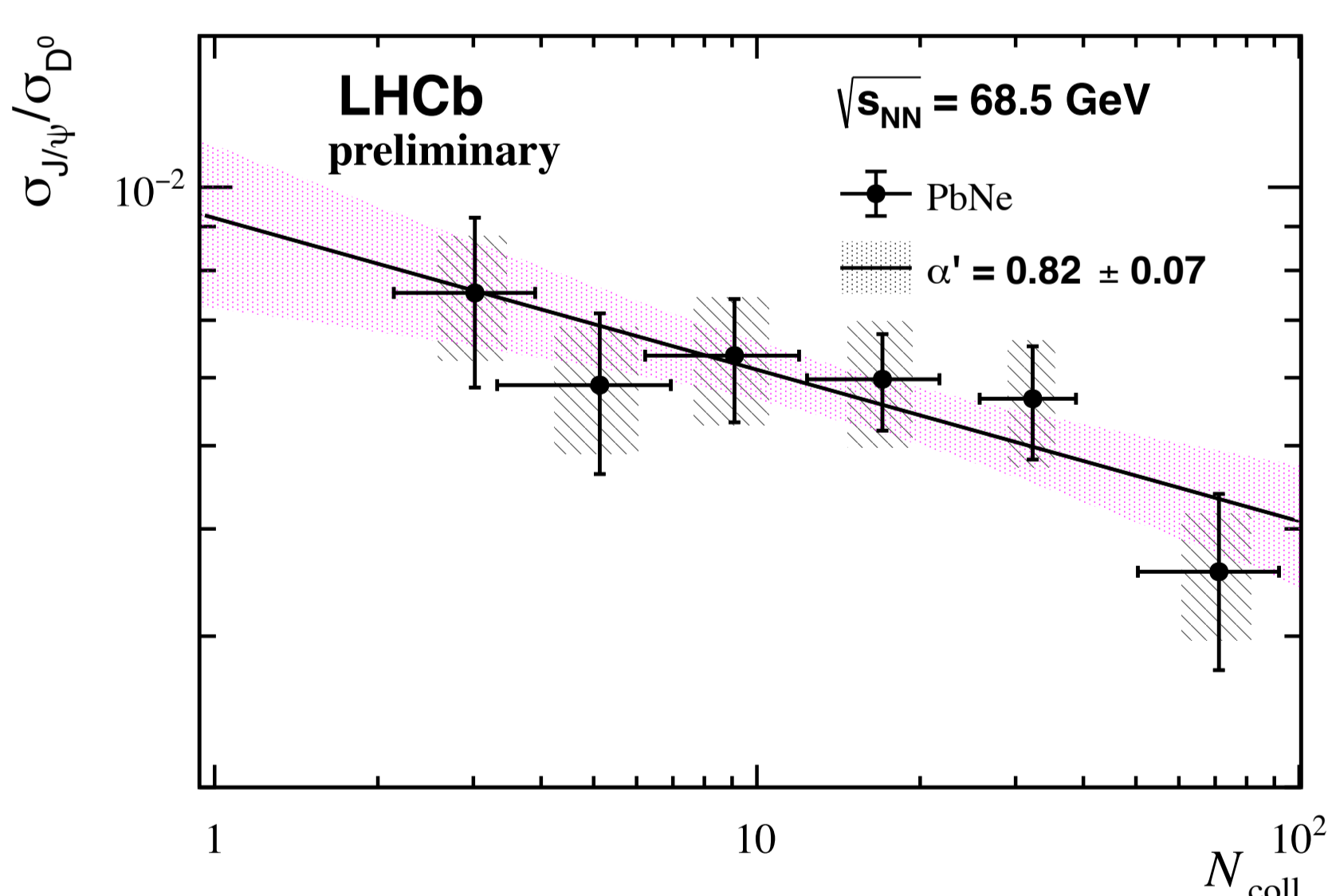
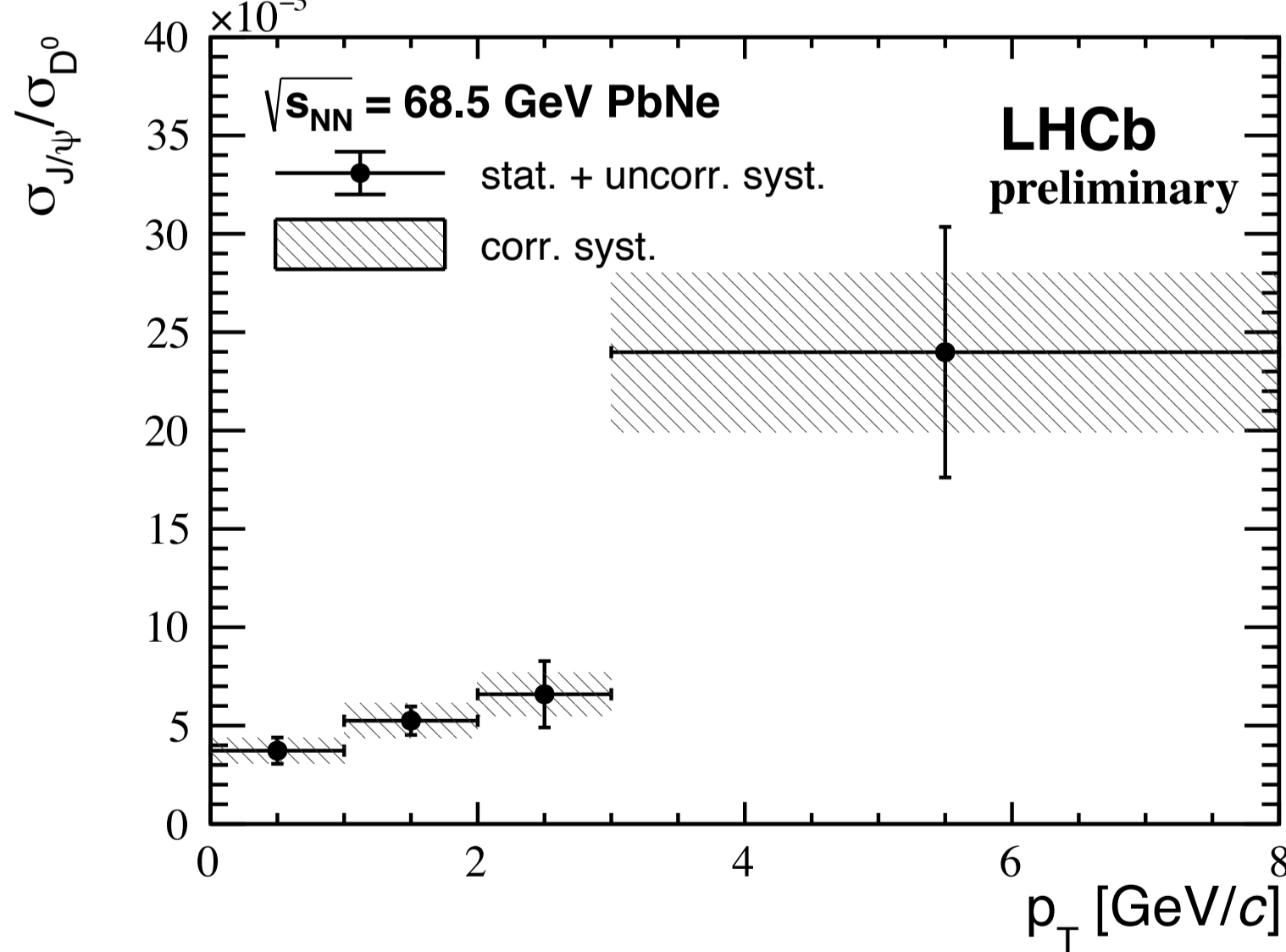
## Detached $\bar{p}$ in pHe at $\sqrt{s_{NN}} = 110$ GeV

- The uncertainties on the  $\bar{p}$  production limit the **interpretation of cosmic  $\bar{p}$  data** (AMS, PAMELA)
- Extend the first measurement of prompt  $\bar{p}$  in pHe collisions at  $\sqrt{s_{NN}} = 110$  GeV including contributions from detached  $\bar{p}$  [3]
- The generators **underestimate** the  $\bar{\Lambda}$  (anti-hyperon) contribution to the overall  $\bar{p}$  production
- Increased  $\bar{H}$  contributions** compared to data at  $\sqrt{s_{NN}} = 10$  GeV
- Underestimation** of detached  $\bar{p}$  contribution in cosmic ray models

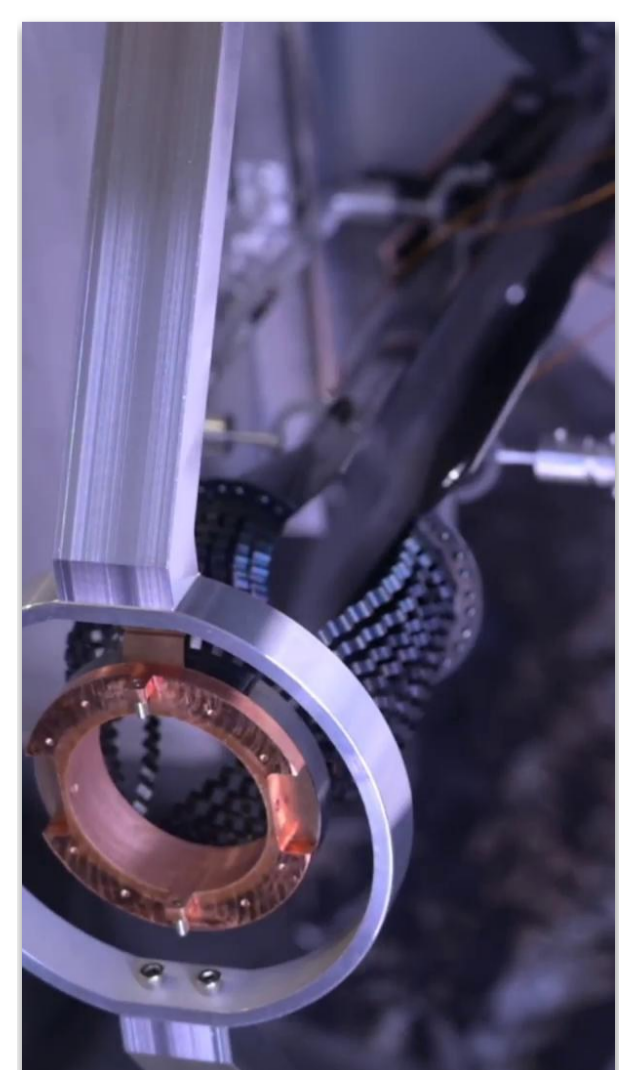


## $J/\psi$ and $D_0$ in PbNe at $\sqrt{s_{NN}} = 68.5$ GeV

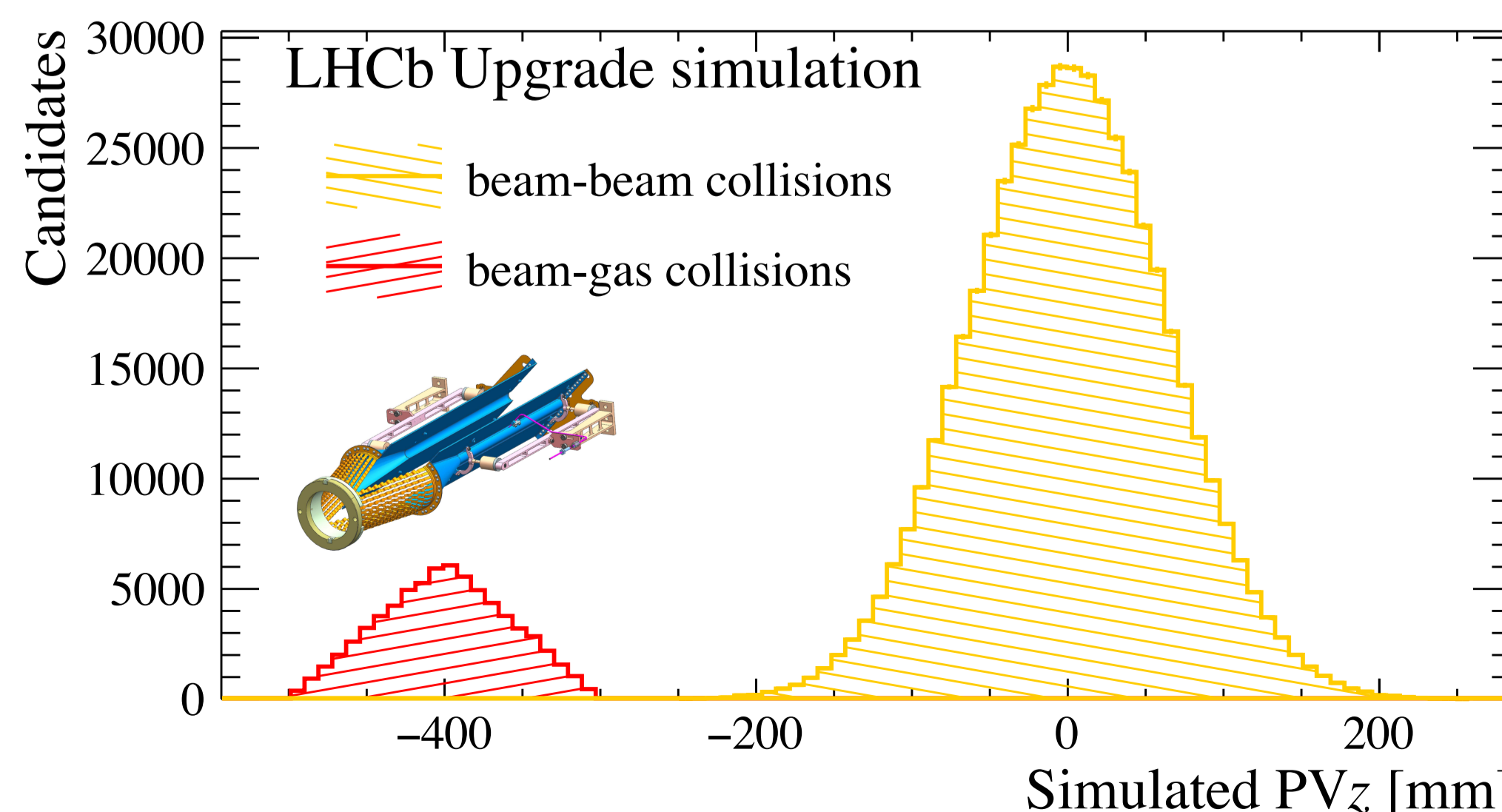
- Improve the **interpretation of  $c\bar{c}$  suppression** by measuring charmonium yields together with the  $D_0$  production
- $\sigma_{J/\psi}/\sigma_{D_0}$  ratio strongly depends on  $p_T$  and no significant dependence on  $y^*$  [2]
- The energy deposited in the EM calorimeter is used to determine the centrality classes  $N_{coll}$
- No anomalous suppression** that could indicate the formation of a deconfined medium



## The upgraded fixed-target: SMOG2



- SMOG2: a **storage cell**, installed upstream of the VELO, and a **new gas feed system** (GFS) [4]
- Precise determination of the **target density** (luminosity) and **increment of the gas density** by up to two order of magnitude
- More gas species** including  $H_2$  and  $D_2$ ,  $N$  and  $O_2$  in addition to noble gases
- Run in parallel with collider mode**, thanks to well displaced interaction regions and high tracking efficiency



## Physics opportunities [5]

- Intrinsic heavy-quark
- p-Gas collisions: nPDFs, gluon anti-shadowing at large x, CNM effects
- Pb-Gas collisions: QGP formation, rapidity scan at lower energy, quarkonium sequential suppression
- Input to astrophysics

## References

[1] LHCb collaboration, "Charmonium production in  $\sqrt{s_{NN}} = 68.5$  GeV pNe collisions", LHCb-PAPER-2022-014, in preparation  
[2] LHCb collaboration, " $J/\psi$  and  $D_0$  production in  $\sqrt{s_{NN}} = 68.5$  GeV PbNe collisions", LHCb-PAPER-2022-011, in preparation  
[3] LHCb collaboration, "Measurements of antiproton production from anti-hyperon decays in pHe collision at  $\sqrt{s_{NN}} = 110$  GeV", LHCb-PAPER-2022-006, in preparation

[4] LHCb collaboration, "LHCb SMOG Upgrade", CERN-LHCC-2019-005, May 2019, <https://cds.cern.ch/record/2673690/>  
[5] A. Bursche et al., "Physics opportunities with the fixed-target program of the LHCb experiment using an unpolarized gas target", LHCb-PUB-2018-015, Feb 2019, <https://cds.cern.ch/record/2649878/>