New measurements in fixed-target collisions at LHCb

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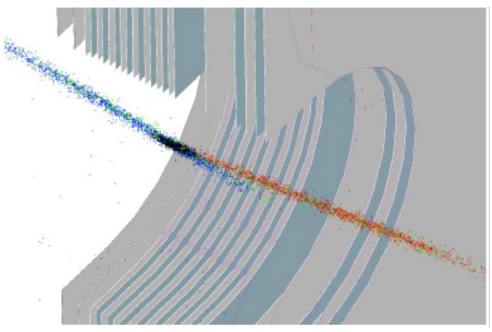
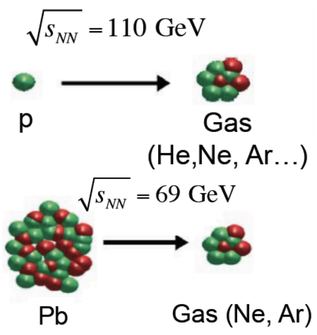
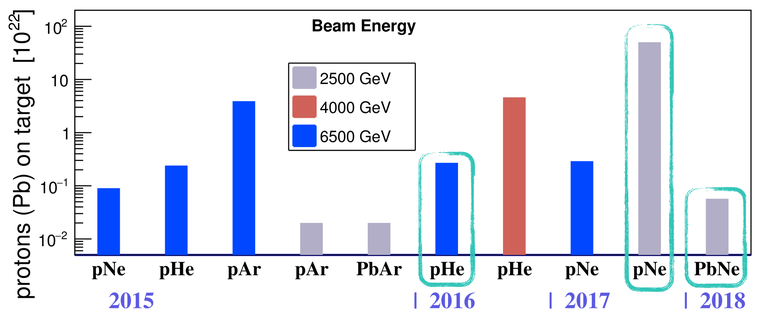
Fixed-target programme at LHCb: SMOG

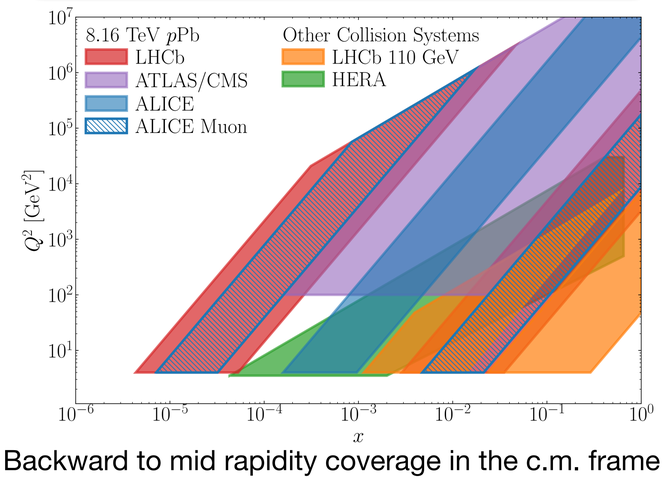




- Fixed-target measurements at LHCb are possible thanks to the **SMOG device** (System for Measuring the Overlap with Gas)
- **Injection of noble gases** at a pressure of $O(10^{-7})$ mbar in the VELO
- Conceived for precise **luminosity measurements** based on the beam-imaging technique
- Rich and unique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



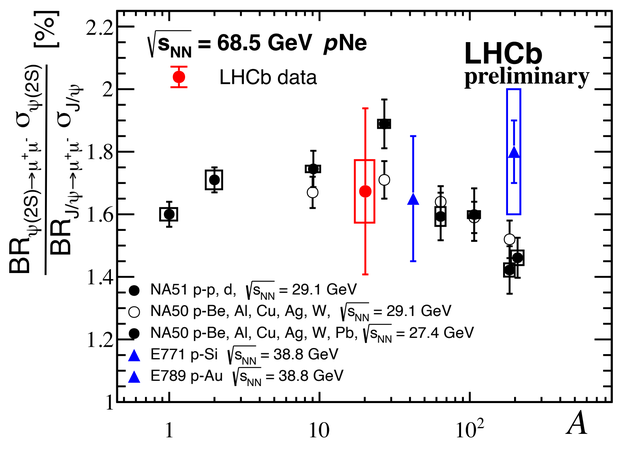
Fixed-target kinematics

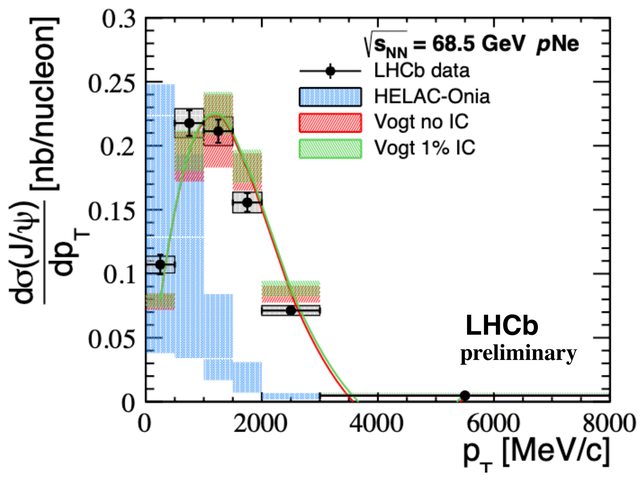


- Backward to mid rapidity coverage in the c.m. frame
- **High-x** of the nucleon target at **intermediate** Q^2 corresponding to **large and negative** x_F
- **Poorly explored** kinematic region

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/ψ differential cross-section, as a function of y^* and p_T [1]

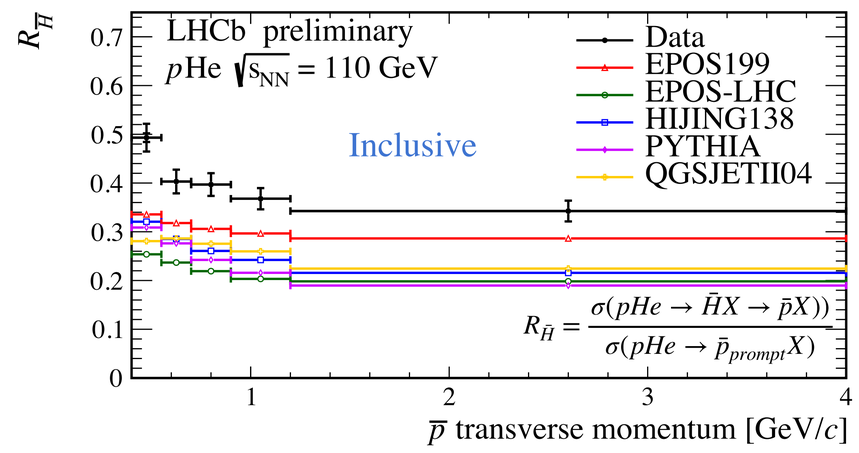




- **Good agreement** with R. Vogt's predictions with (1%) or without Intrinsic Charm contribution
- The **first measurement** at SMOG of the $\psi(2S)$ **to** J/ψ **ratio** is in agreement with other results at small A

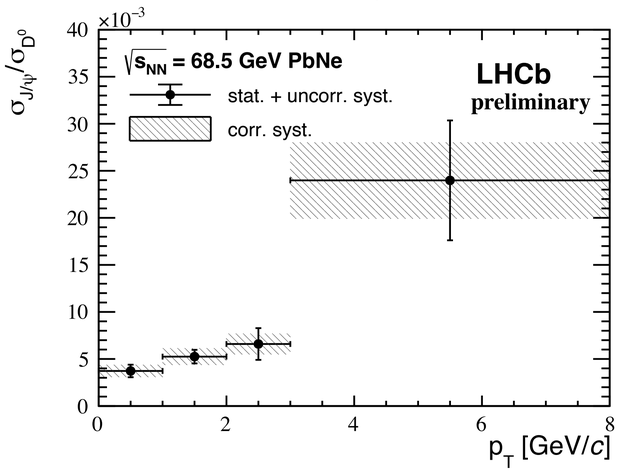
Detached $\bar{p}$ in pHe at $\sqrt{s_{NN}} = 110$ GeV

- 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

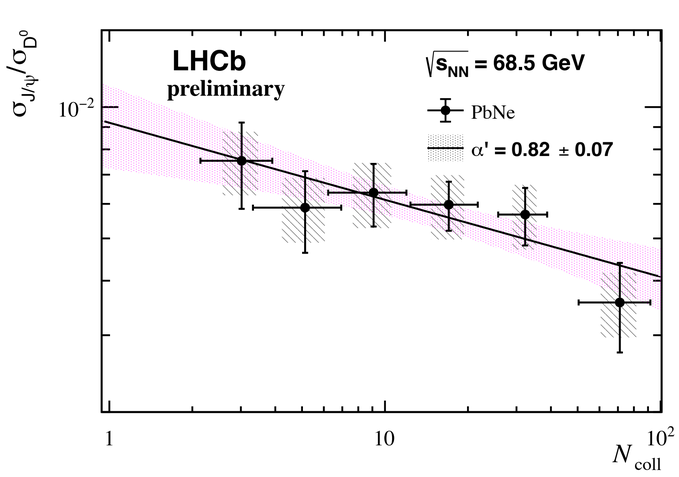


J/ψ and D_0 in PbNe at $\sqrt{s_{NN}} = 68.5$ GeV

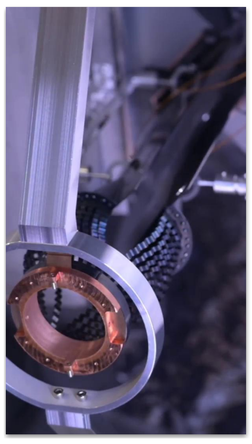
- Improve the **interpretation of** $c\bar{c}$ **suppression** by measuring charmonium yields together with the D_0 production
- $\sigma_{J/\psi}/\sigma_{D^0}$ ratio strongly depends on p_T and no significant dependence on y^* [2]



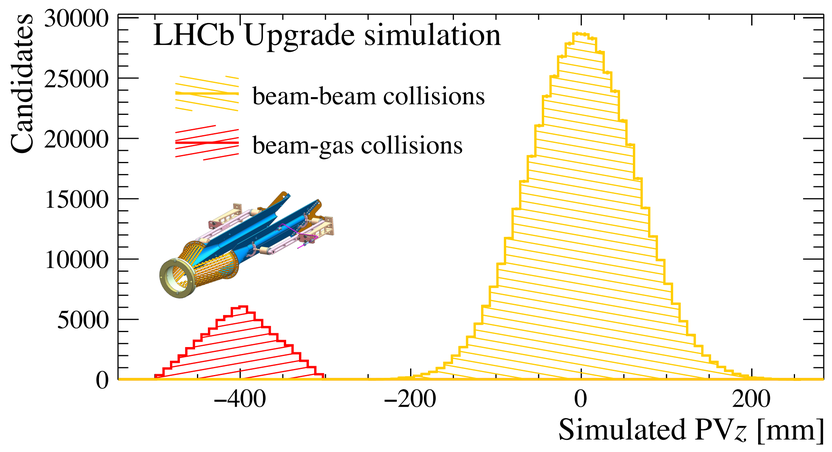
- The energy deposited in the EM calorimeter is used to determine the centrality classes N_{coll}
- **No anomalous suppression** that could indicate the formation of a deconfined medium



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/ψ 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/