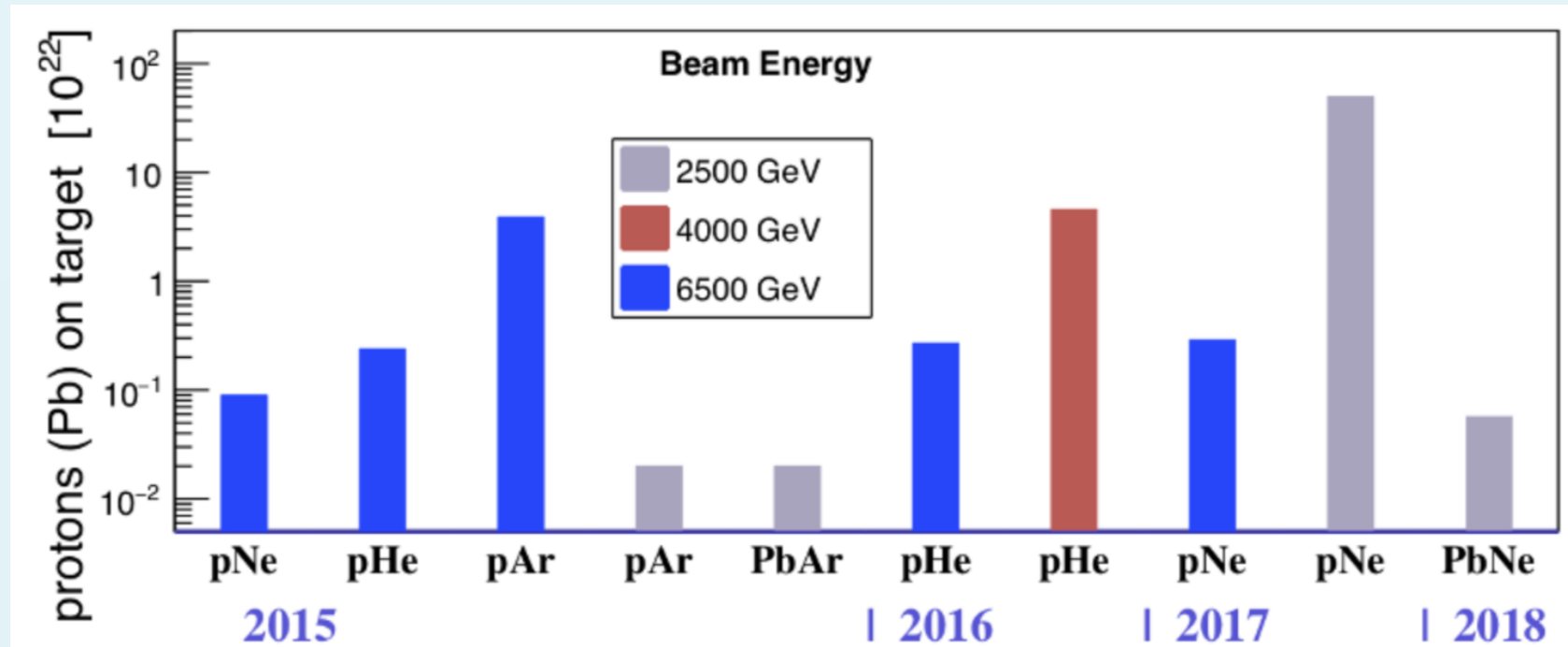
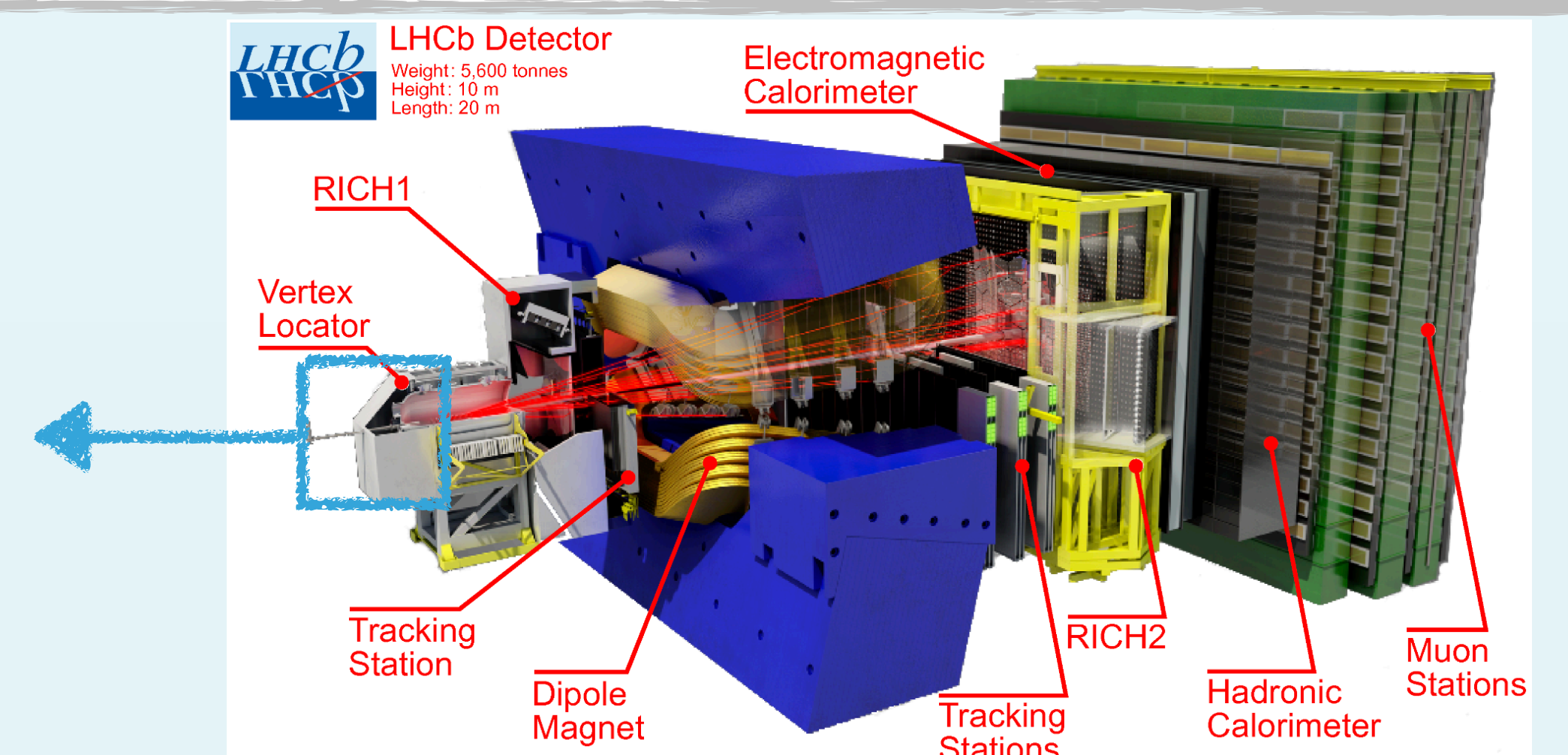
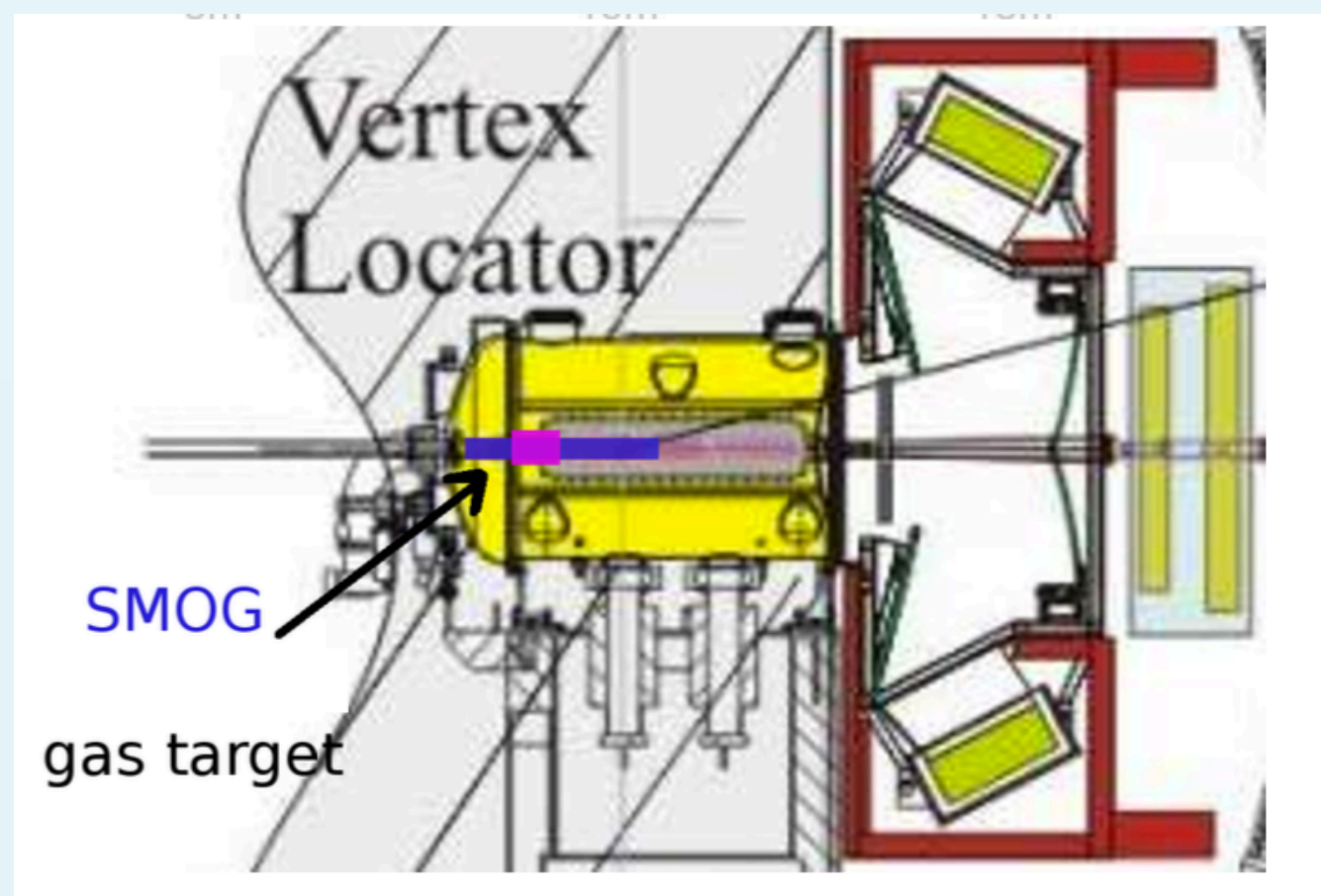
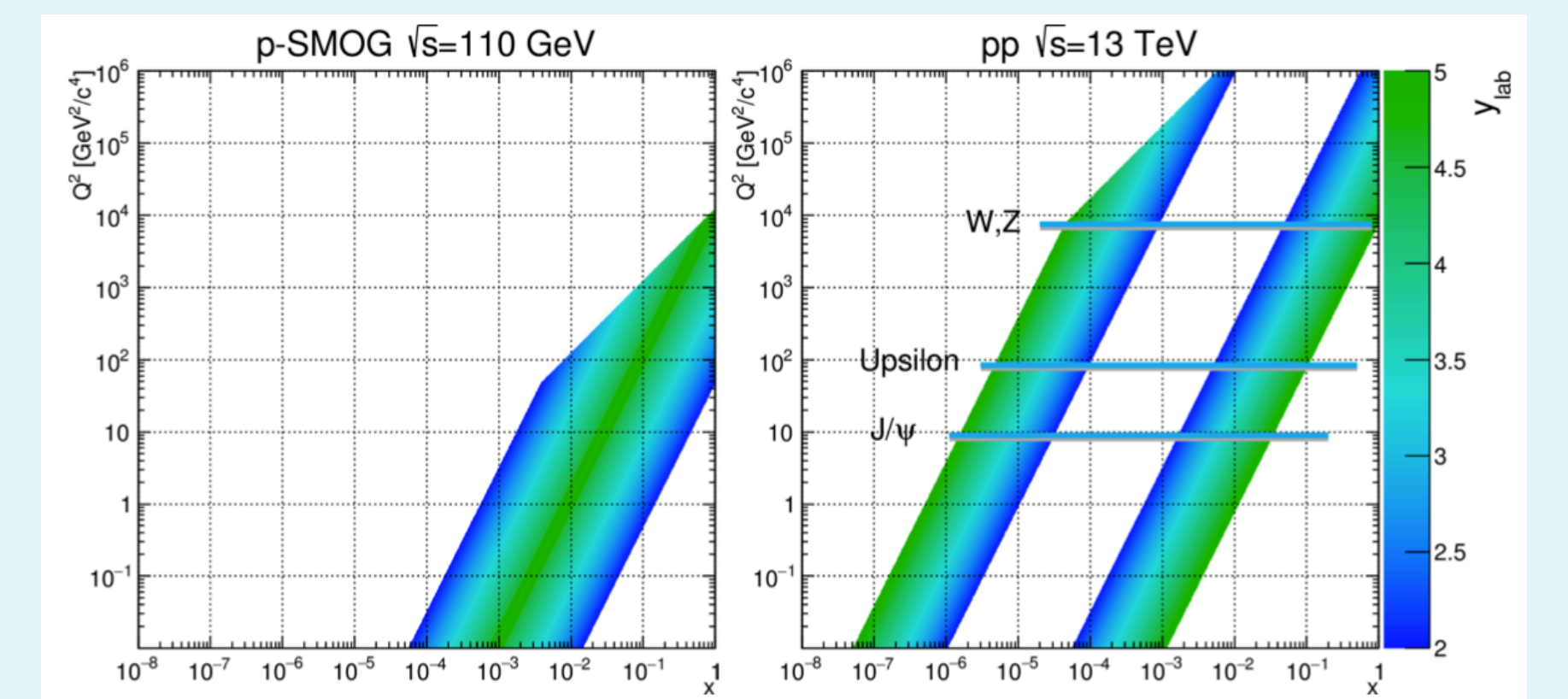


Fixed-target experiment at LHCb

- ▶ **LHCb**: one of the 4 main experiments at CERN
- ▶ **SMOG**: the LHCb fixed-target system
- ▶ **Noble gases (He, Ar, Ne)** injected into the LHC beam pipe ± 20 m from the Interaction Point (IP)
- ▶ **Highest-energy fixed-target experiment ever built!**

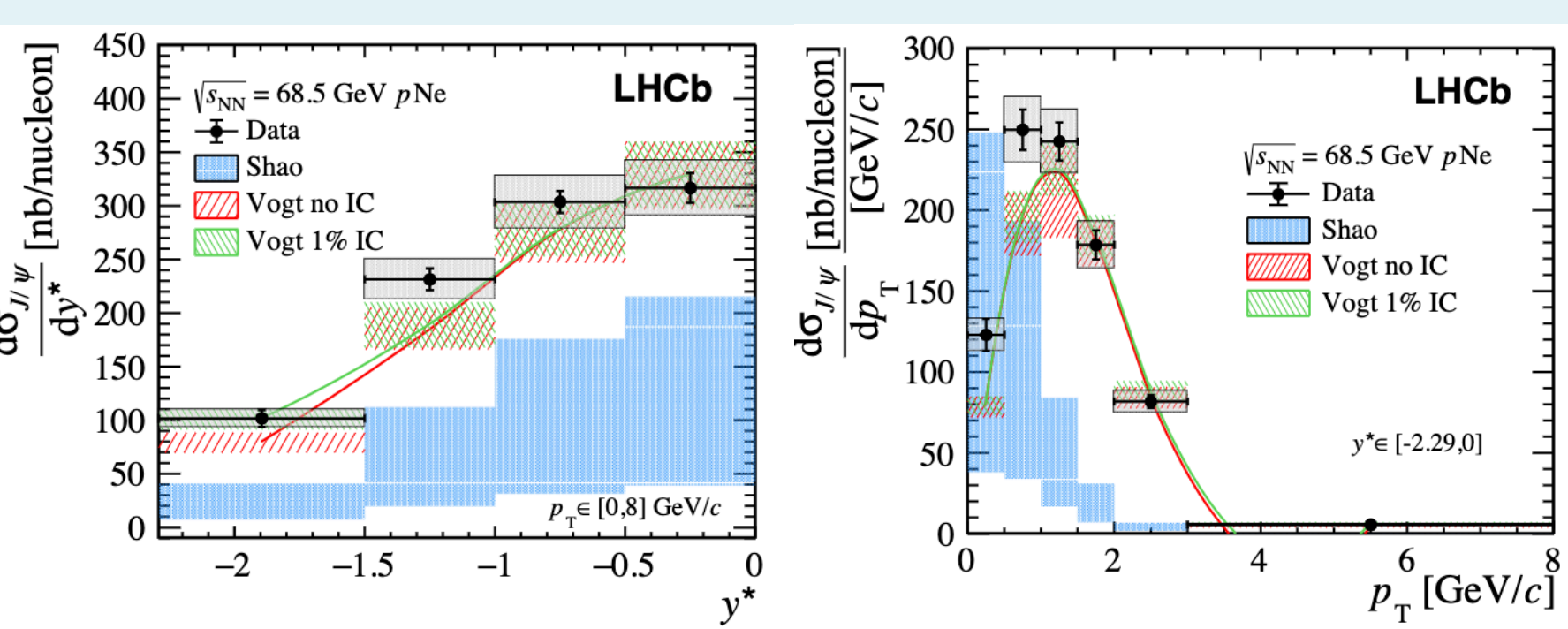


- ▶ **Unique kinematical region** accessible
- ▶ $\sqrt{s_{NN}} \sim \sqrt{2E_N M_N} = 41 - 115$ GeV
- ▶ Investigates the **high-x** of the nucleon target at **intermediate Q^2**



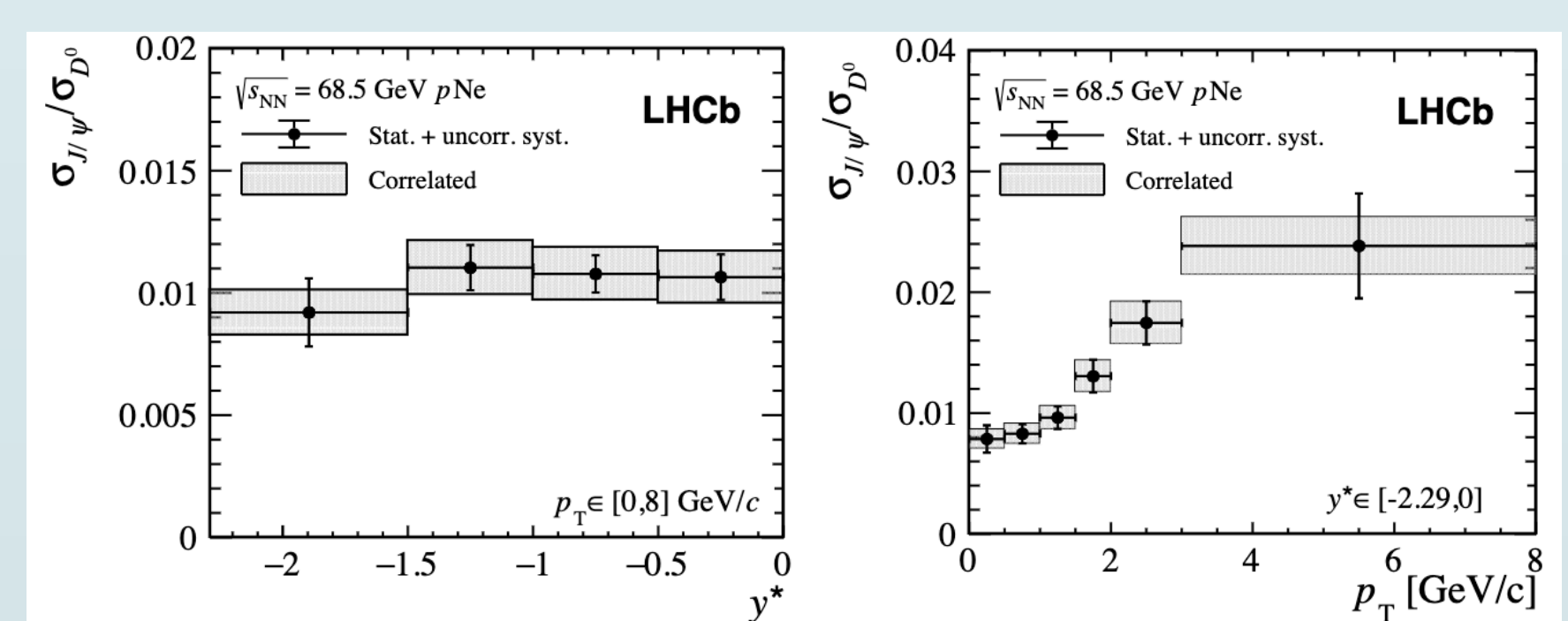
Charmonium in pNe at $\sqrt{s} = 68.5$ GeV

- ▶ **Charmonium production** is a good probe for QCD $\rightarrow c\bar{c}$ bound state suppression is a smoking gun of **QGP formation**
- ▶ $c\bar{c}$ production in pA collisions can be affected by different **CNM (cold nuclear matter)** effects to be investigated
- ▶ CNM effects depend on collision energy, p_T and y

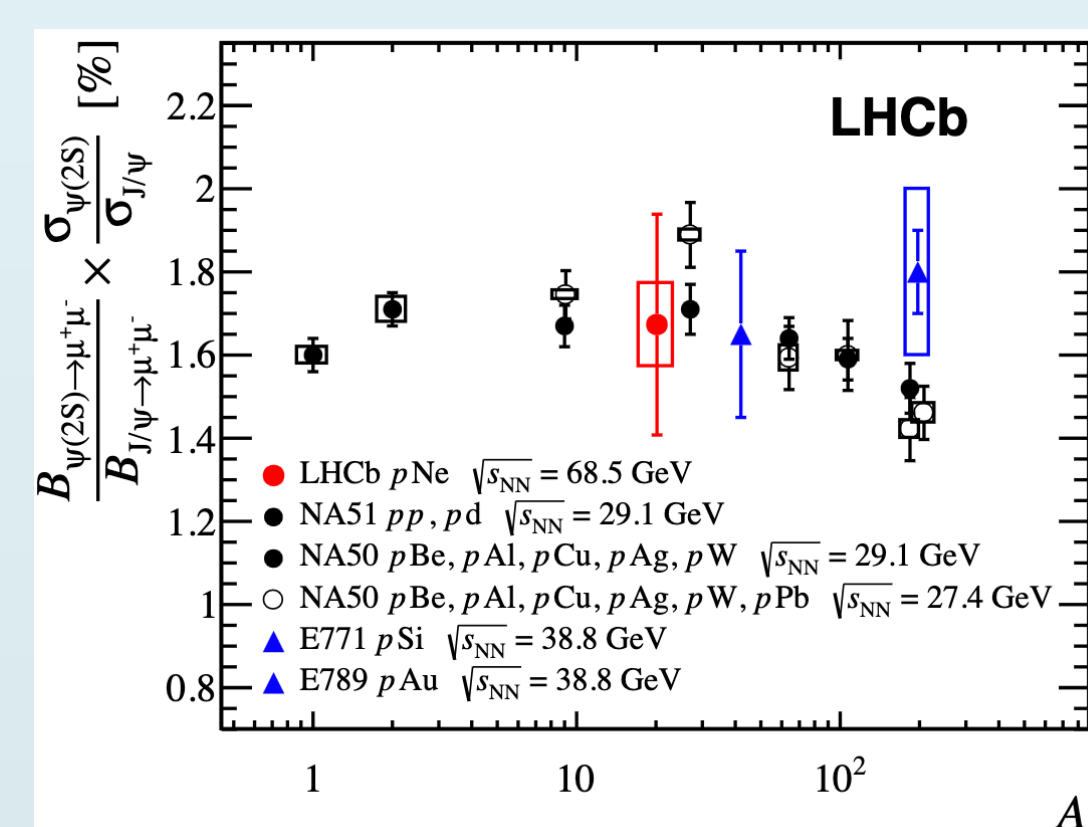


- ▶ J/ψ differential cross section [1]
- ▶ Data in **agreement with Vogt's predictions** [6]
- ▶ **HELAC-Onia simulations underestimate** the cross section

- ▶ $\psi(2S)$ to J/ψ production ratio as a function of the target nuclei [1]
- ▶ **Good agreement with other fixed-target experiments** at lower energies

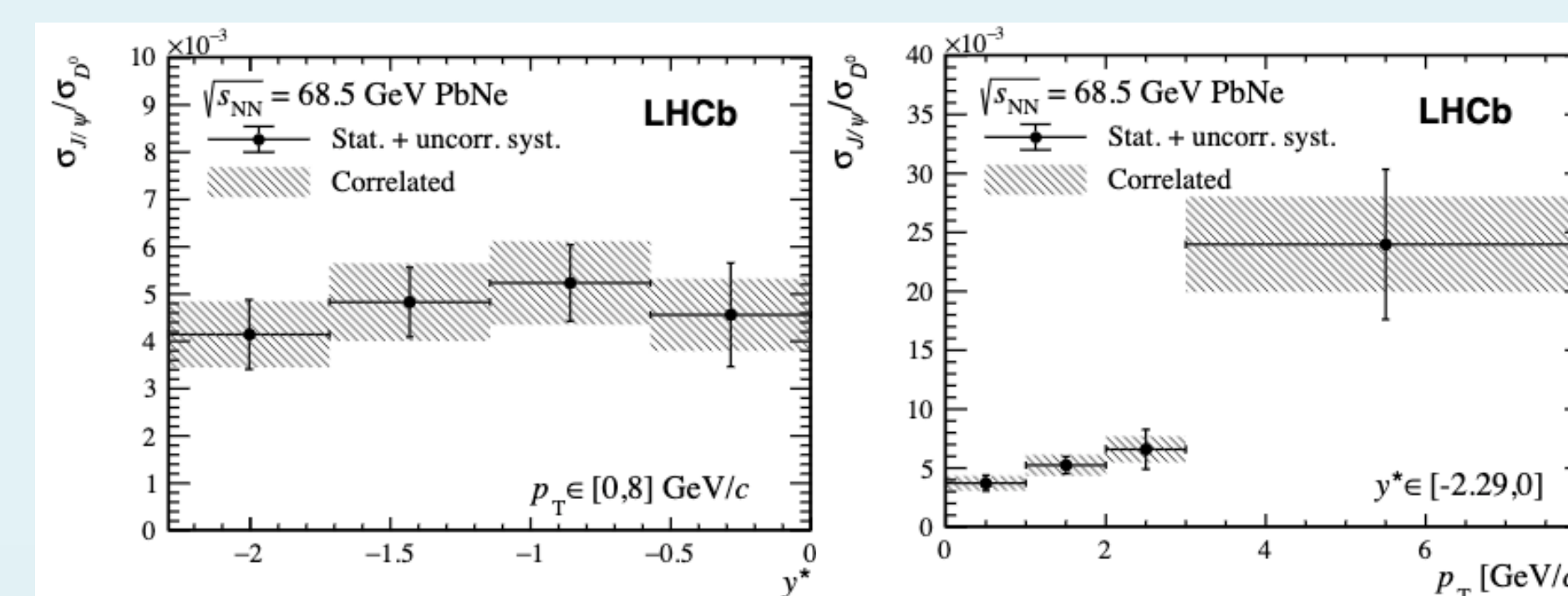


- ▶ **Ratio of J/ψ and D^0 cross section** [1]
- ▶ **No significant y dependence**
- ▶ **Strong dependence on p_T**



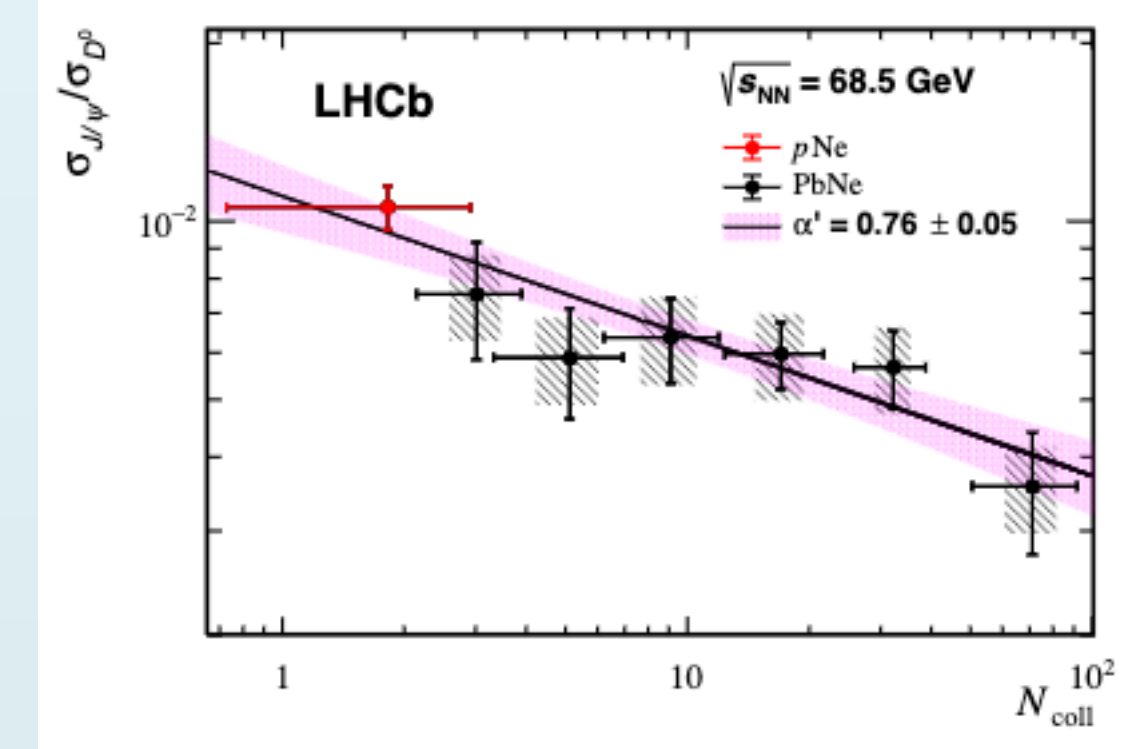
J/ψ and D^0 production in PbNe at $\sqrt{s} = 68.5$ GeV

- ▶ J/ψ **important probe for QGP** in PbA collisions
- ▶ D^0 **production yield** good reference for the total charm cross-section \rightarrow fundamental to quantify charmonia suppression



- ▶ **Ratio of J/ψ and D^0 cross section** [2]
- ▶ **No significant y dependence**
- ▶ **Strong dependence on p_T**

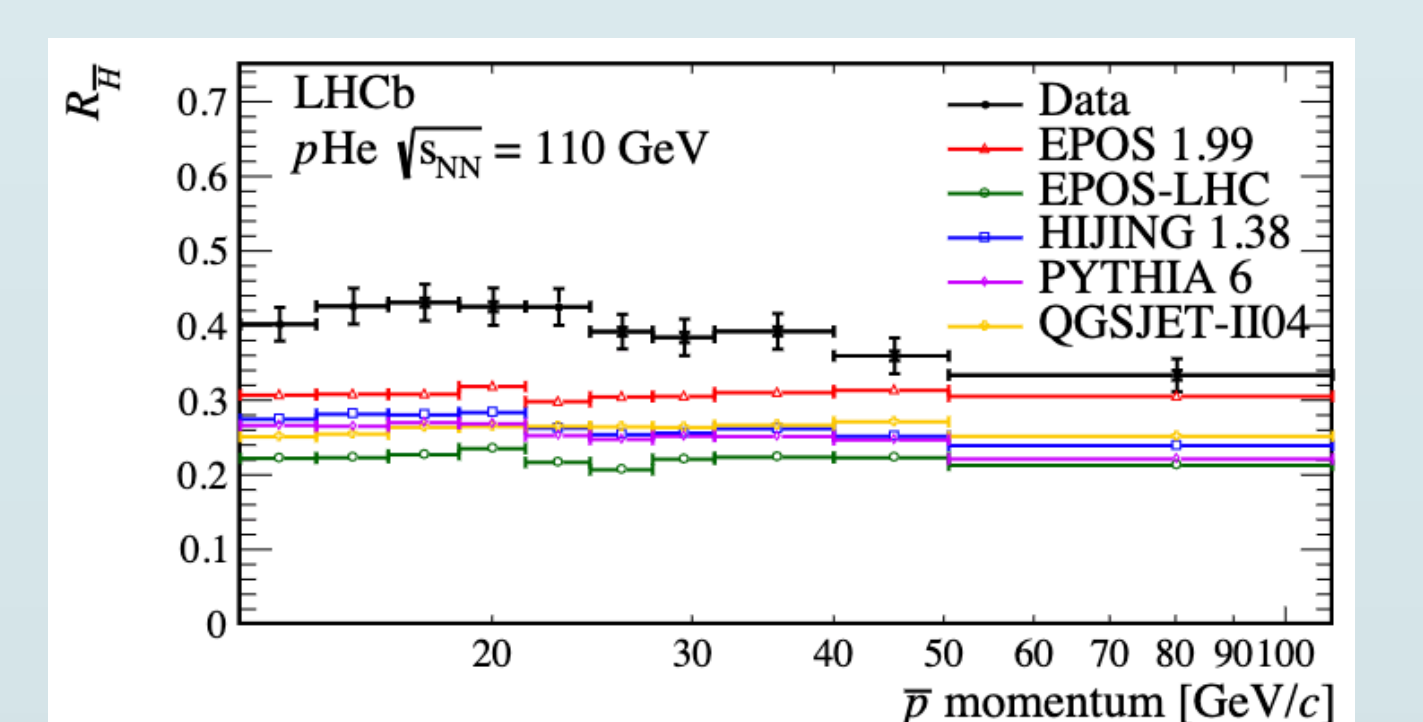
- ▶ **Comparison of the $J/\psi/D^0$ ratio between PbNe and pNe** [2]
- ▶ N_{coll} number of binary nucleon-nucleon collisions
- ▶ J/ψ is affected by additional nuclear effects with respect to D^0 , but the **suppression trend is identical from pNe to PbNe** in largest N_{coll} bin



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

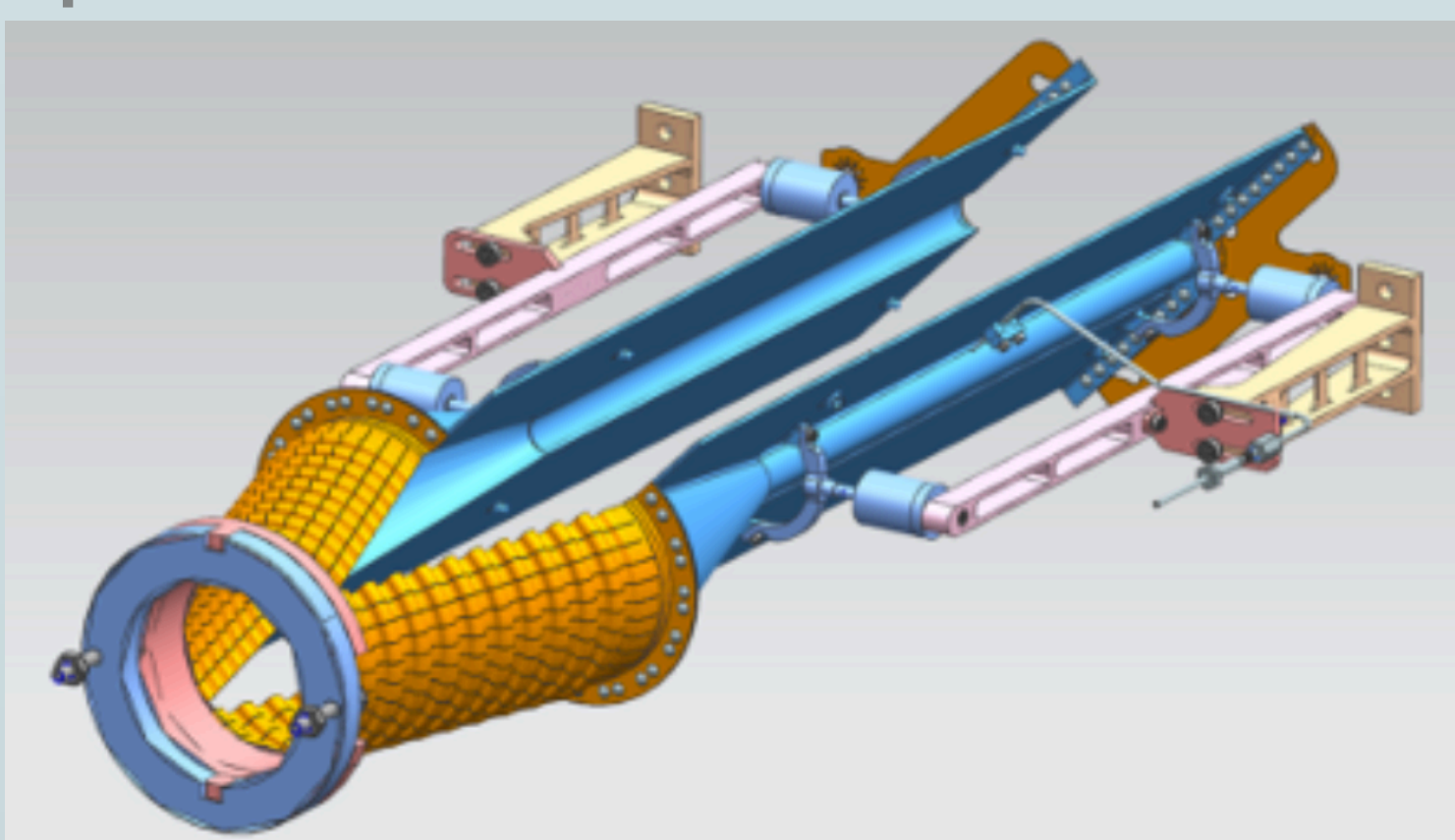
- ▶ **First measurement of \bar{p} production in pHe collisions** at $\sqrt{s} = 110$ GeV [3]

- ▶ Needed to explain the **flux of \bar{p} in cosmic ray data (AMS)**
- ▶ **Underestimation of detached contribution in cosmic ray models**

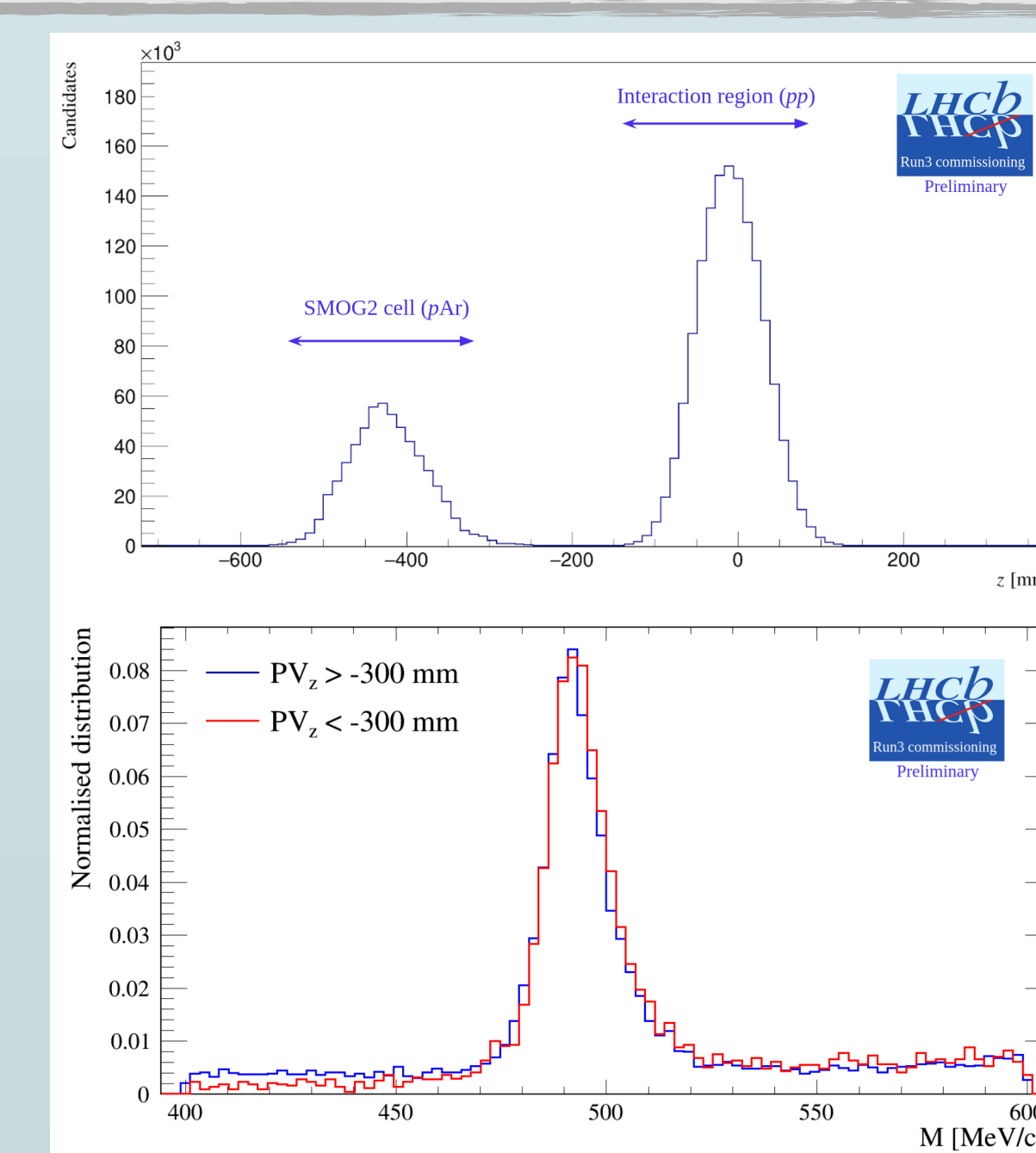


Prospects with the upgrade: SMOG2

- ▶ **SMOG2 [4]: gas confined in a storage cell** installed upstream of the IP



- ▶ **Higher areal density** than SMOG
- ▶ **Wider choice of gases to be injected:** $H_2, D_2, He, Ne, N_2, O_2, Ar, Kr, Xe$
- ▶ **Data taking simultaneous in pp and pA modes**



- ▶ **Physics perspective [5]:**
- ▶ Access to nucleon and nuclear **PDFs at large Bjorken-x**
- ▶ Studies of **nuclear matter effects**
- ▶ **Input for cosmic ray physics**

References

- [1] LHCb collaboration, "Charmonium production in $\sqrt{s} = 68.5$ GeV pNe collisions", LHCb-PAPER-2022-014, <https://cds.cern.ch/record/2841849>
- [2] LHCb collaboration, " J/ψ and D^0 production in $\sqrt{s} = 68.5$ GeV $PbNe$ collisions", LHCb-PAPER-2022-011, <https://cds.cern.ch/record/2841845>
- [3] LHCb collaboration, "Measurements of antiproton production from anti-hyperon decays in pHe collision at $\sqrt{s} = 110$ GeV", LHCb-PAPER-2022-006, <https://cds.cern.ch/record/2809797>
- [4] LHCb collaboration, "LHCb SMOG Upgrade", CERN-LHCC-2019-005, <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, <https://cds.cern.ch/record/2649878>
- [6] R.Vogt, "Limits on intrinsic charm production from the sea quest experiment", *Phys. Rev. C* **103** (2021) 035204