

Probing nucleon structure with fixed-target collisions at LHCb ¹

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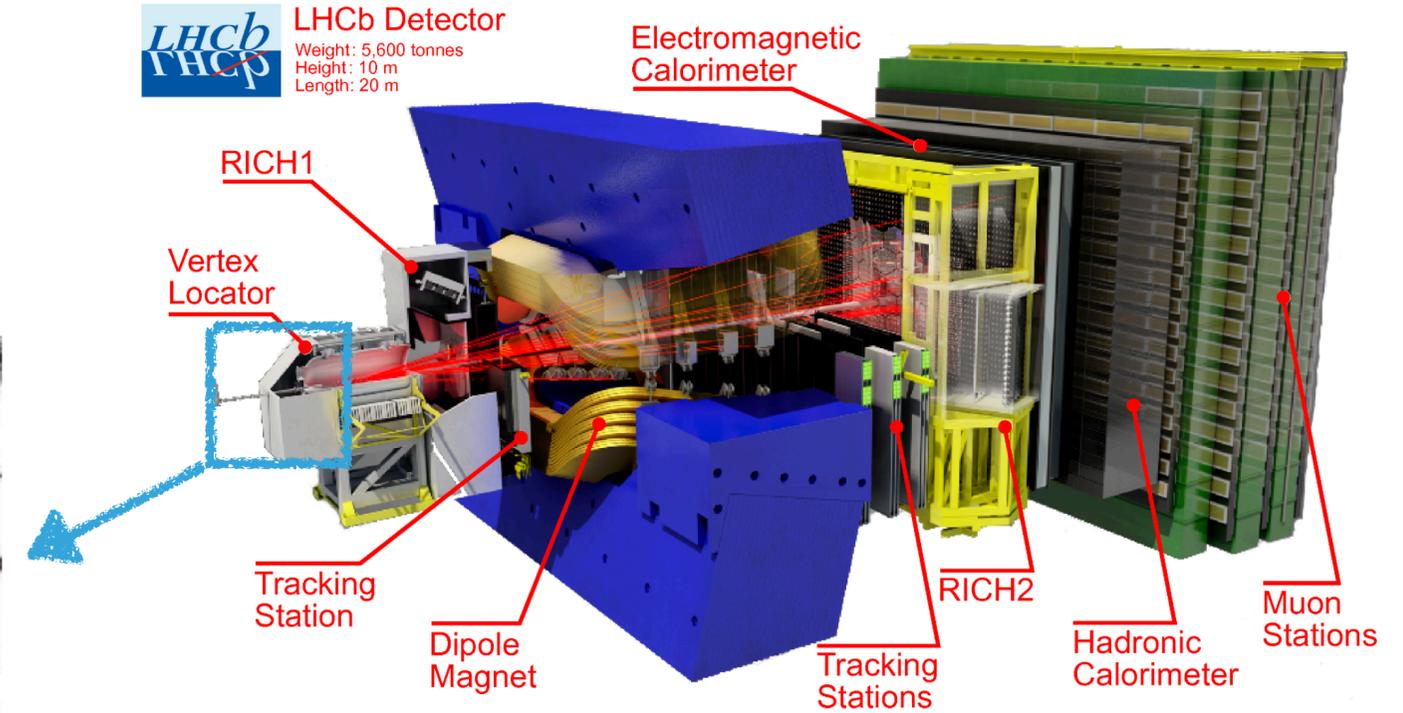
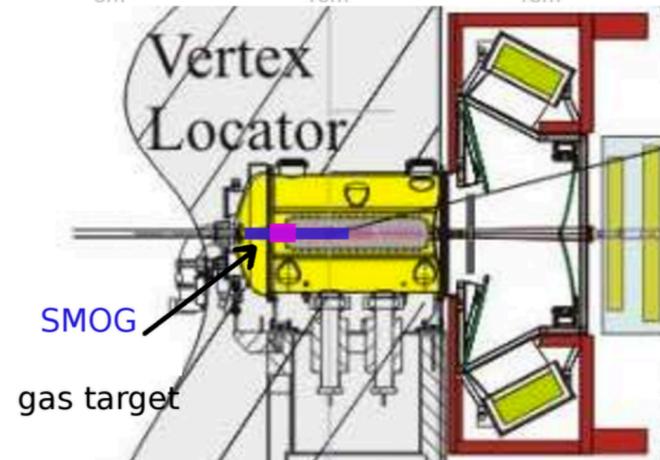
FIXED TARGET EXPERIMENT AT LHCb

▶ **LHCb**: one of the 4 main experiments at **CERN**

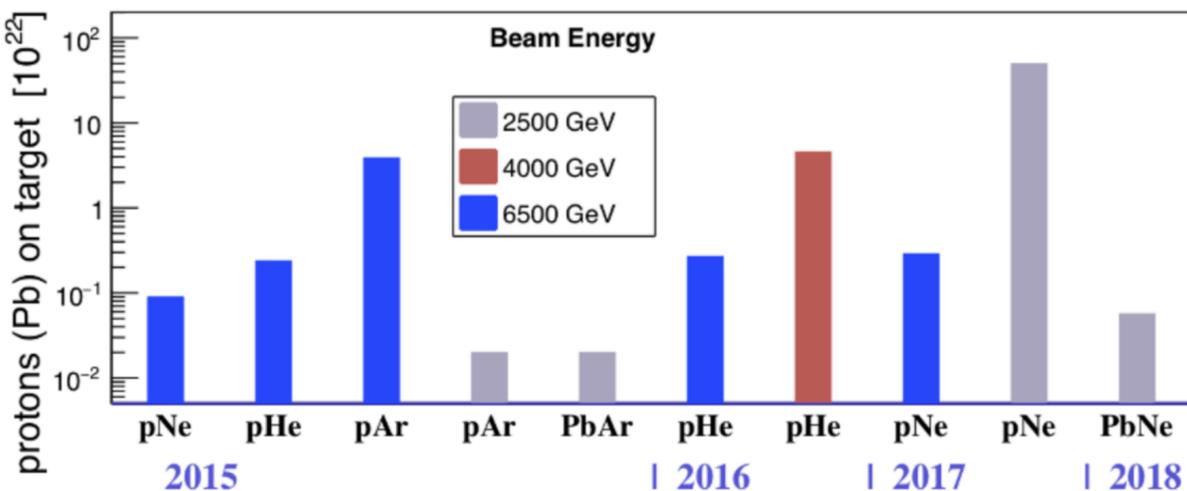
▶ **SMOG**: the **LHCb fixed-target system**

▶ **Noble gases (He, Ar, Ne) injected** into the LHC beam pipe around the Interaction Point (IP), $P \sim 10^{-7}$ mbar

▶ **Highest-energy** fixed-target experiment ever built!



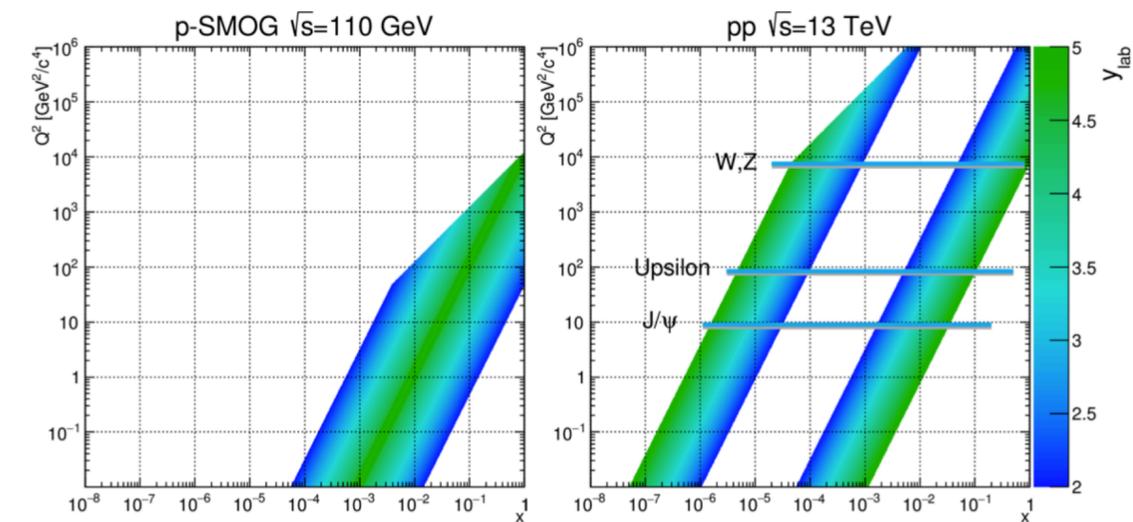
LHCb Run2



▶ **Unique kinematical region** accessible

▶ $\sqrt{s_{NN}} \sim \sqrt{2E_N M_N} = 41 - 115$ GeV

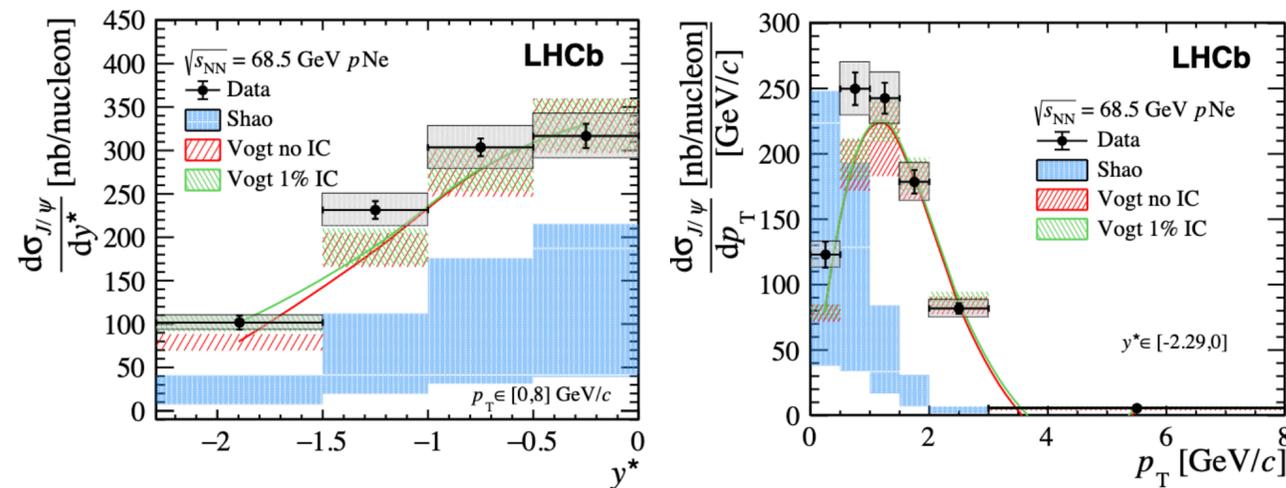
▶ Investigates the **high-x** of the nucleon target at **intermediate Q^2**



CHARMONIUM IN $p\text{Ne}$ COLLISIONS AT $\sqrt{s} = 68.5$ GeV

3

- ▶ **Charmonium production** is a good probe for QCD $\rightarrow c\bar{c}$ bound state suppression is one of the smoking guns of **QGP formation**
- ▶ **pA collisions** are crucial to study **CNM (Cold Nuclear Matter)** effects which **can mimic QGP presence in AA**
- ▶ J/ψ excellent probe to investigate them.

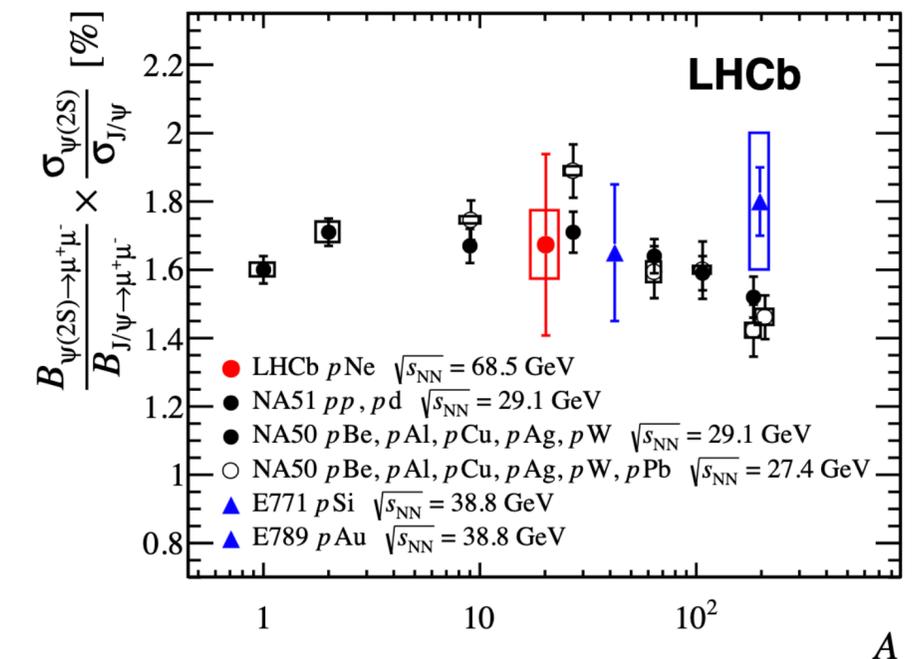


▶ J/ψ differential cross section

- Data in **agreement with Vogt's predictions** but **non sensitive to Intrinsic Charm (IC)**.
- **HELAC-Onia simulations underestimate** the cross section

▶ $\psi(2S)$ to J/ψ production ratio as a function of the target nuclei

- **Good agreement with other fixed-target experiments** at lower energies and different atomic mass number A



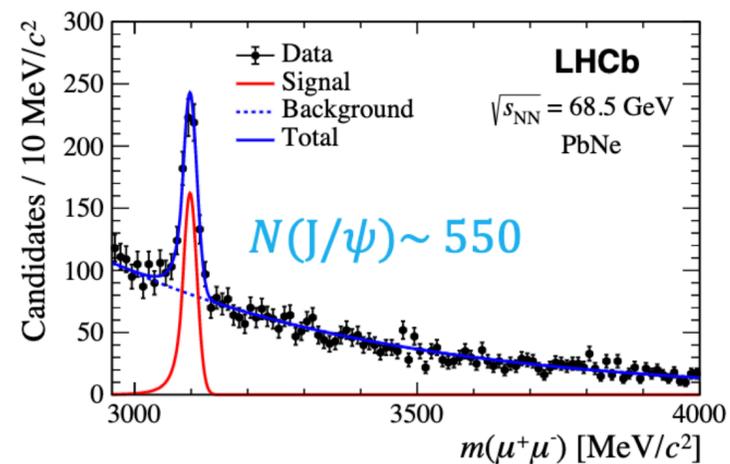
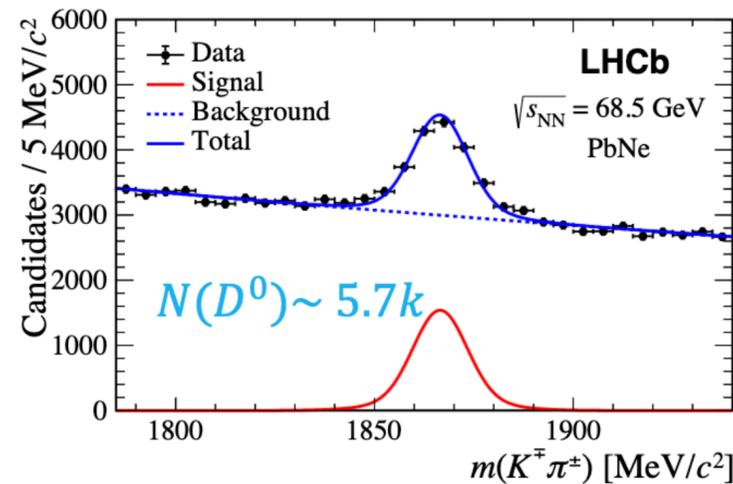
J/ψ AND D^0 PRODUCTION IN PbNe COLLISIONS AT $\sqrt{s} = 68.5$ GeV 4

▶ J/ψ and D^0 behave differently in the medium

▶ D^0 production

- fundamental to quantify charmonia suppression
- good reference for the total charm cross-section

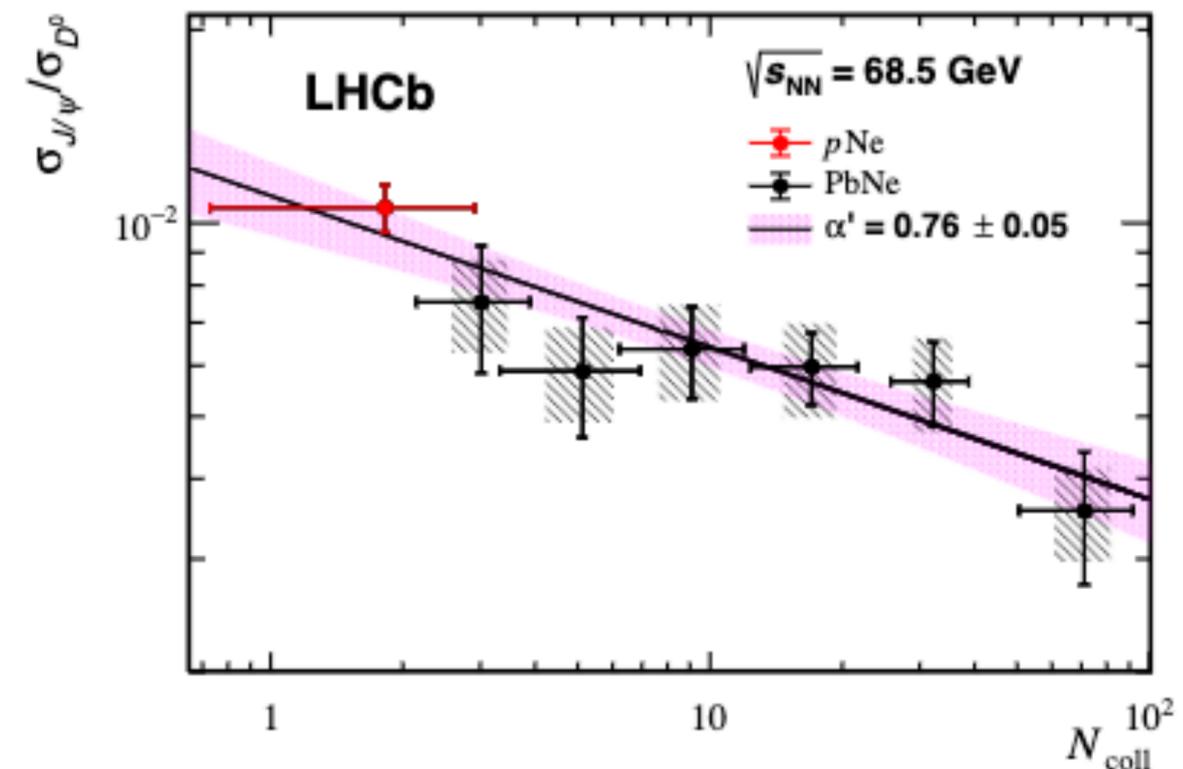
▶ J/ψ and D^0 invariant mass distributions



- **First measurement** in fixed-target nucleus-nucleus collisions

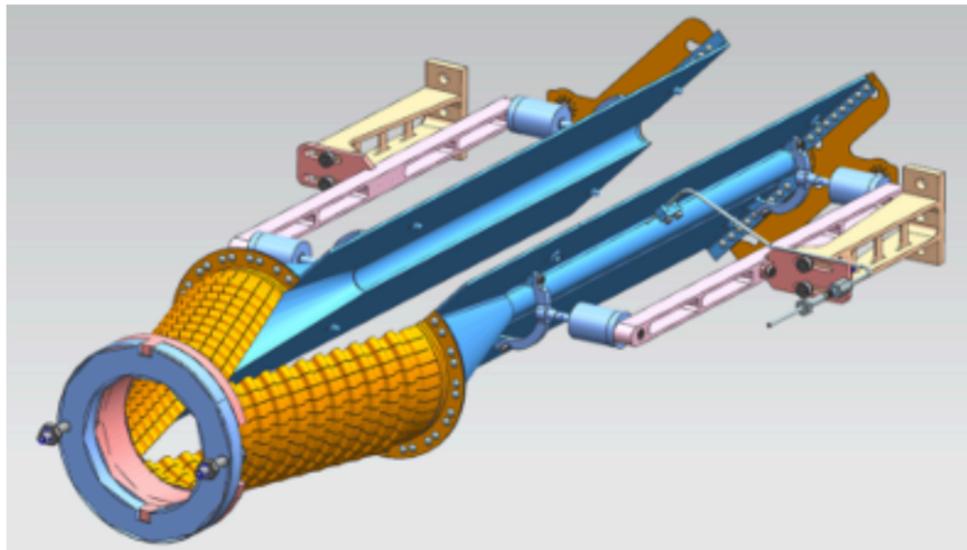
▶ Comparison of the $J/\psi/D^0$ ratio between PbNe and pNe

- 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 similar from pNe to PbNe** in largest N_{coll} bin

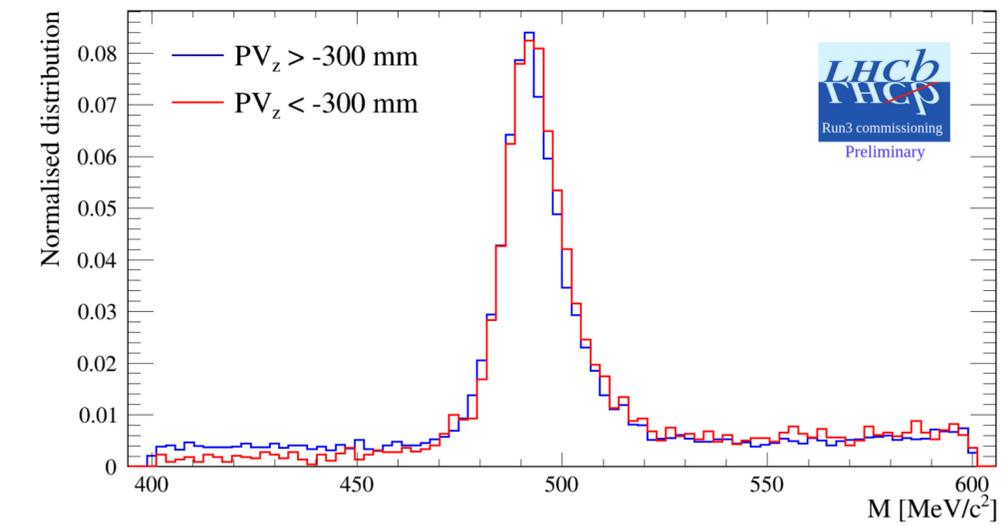
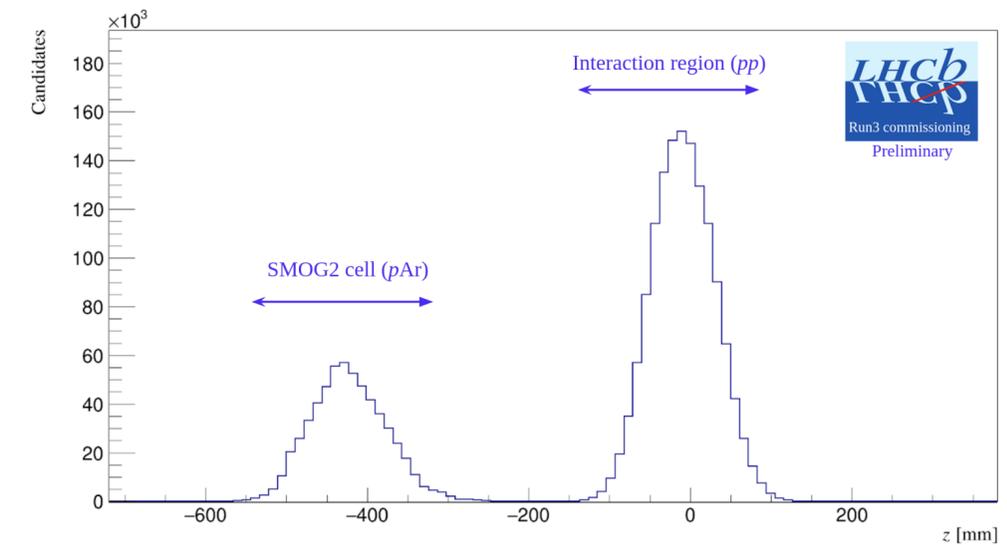


PROSPECTS WITH THE UPGRADE: SMOG2

- ▶ **SMOG2**: gas confined in a 20 cm long **storage cell** installed upstream of the IP coaxial with the beam



- ▶ **Higher areal density** than SMOG (luminosity increased up to two orders of magnitude)
- ▶ **Wider choice of gases to be injected**: H₂, D₂, He, Ne, N₂, O₂, Ar, Kr, Xe
- ▶ **Data taken simultaneously in *pp* and *pA* modes**



[LHCb-FIGURE-2023-001](#)

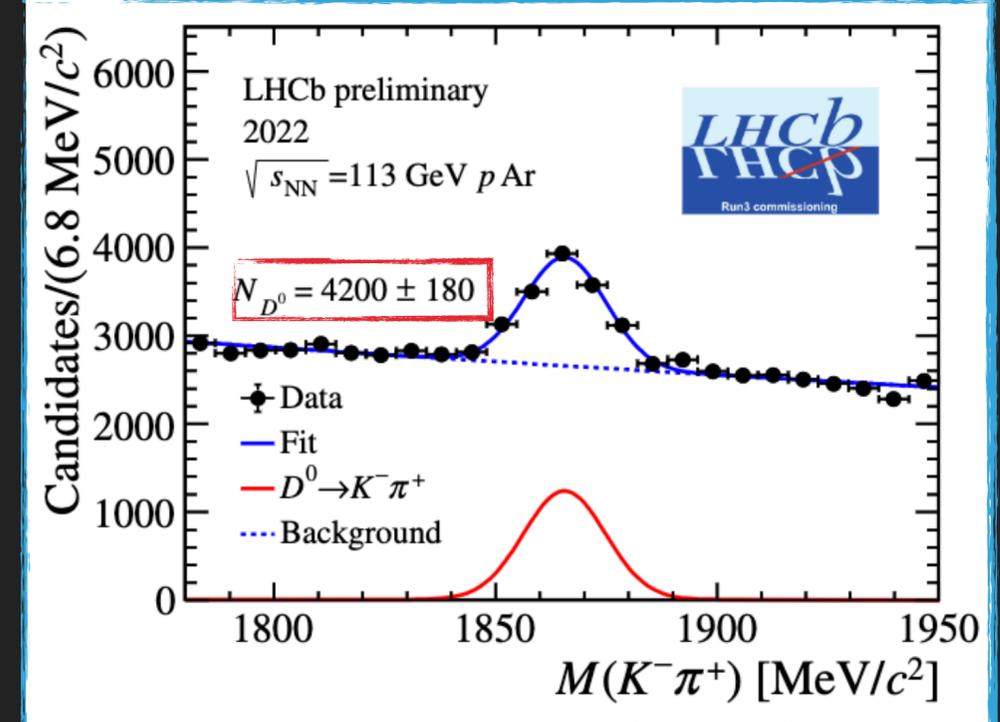
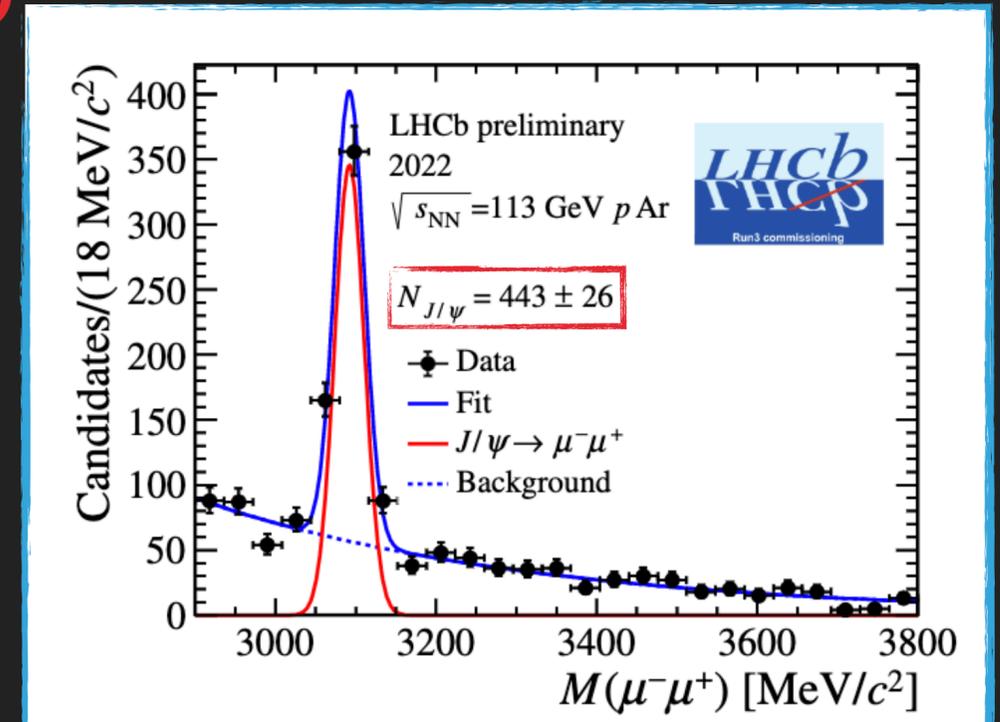
- ▶ Physics perspective:
 - Access to nucleon and nuclear **PDFs at wide Bjorken-x range** ($10^{-4} < x < 10^{-1}$)
 - Studies of **nuclear matter effects**
 - Input for **cosmic ray physics and Dark Matter** studies

- ▶ **First data collected in November 2022** in simultaneous data taking beam-gas and beam-beam
 - **Independent interaction point** between *pp* and *pA*
 - **Same resolution** of the spectrometer for the two collision modes

CONCLUSIONS

- ▶ Highest **fixed target experiment** ever built, the only one **at the LHC**
- ▶ Possibility to rich unique kinematical region, covering energies between RHIC and *usual* LHC and high-x region
- ▶ SMOG: prototype which gave us promising result in **different fields of QCD** and not only (nucleon structure, heavy-ion, cosmic ray physics..)
- ▶ SMOG2: upgrade which allow us to **dramatically increase statistics and vary the targets** during LHC Run3
- ▶ **Stay tuned**, interesting news are coming!

SMOG2



18 mins of data taking!