LHCb Highlights

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Light ion collisions at the LHC
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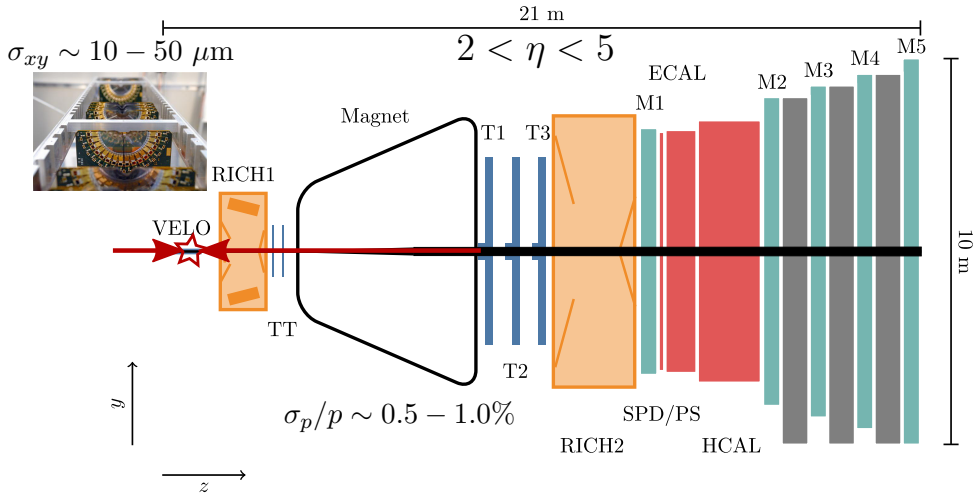
What happens when we vary A?

- **The gluon density changes.** Varying A lets us probe different gluon densities without changing kinematics.
- **The energy density and final-state multiplicity changes.** Varying A can help us find the onset of QGP production.
- **The geometry of the collision changes.** Changing the nuclear geometry could reveal links between the initial state of high-energy nuclear collisions and collective flow.

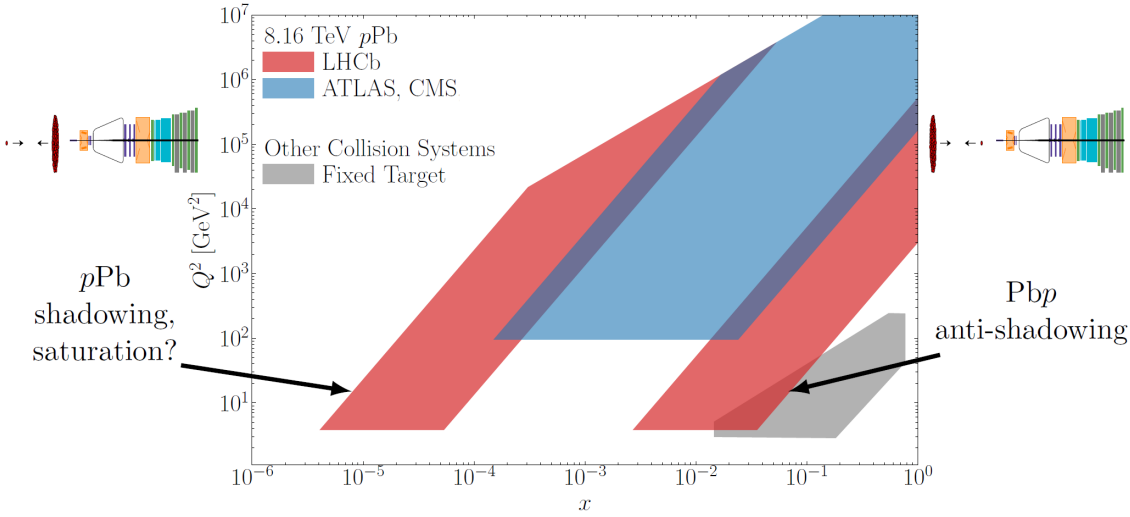
The LHCb detector (Int. J. Mod. Phys. A 30, 1530022 (2015))



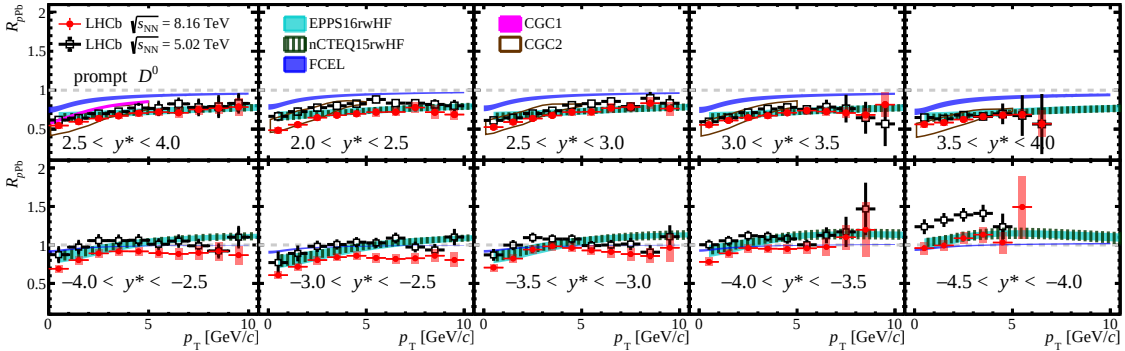
tracking, **calorimetry**, **RICH**, **muon** systems

Can reconstruct and identify: γ, $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, $K^{\pm}$, p, d, ^{3}He

LHCb kinematic coverage



Open charm production at LHCb (PRL 131 (2023) 102301)



LHCb open charm production data has had a major impact on nPDF uncertainties, although nPDF predictions fail to describe all LHCb D^0 production data.

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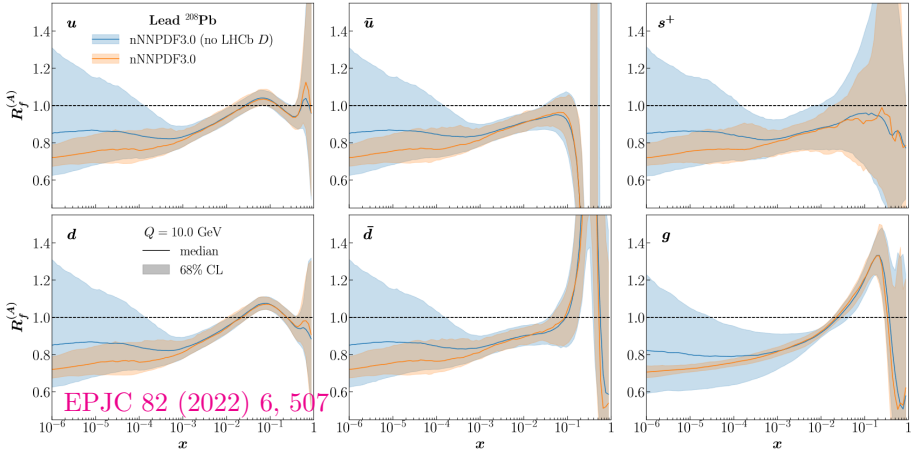

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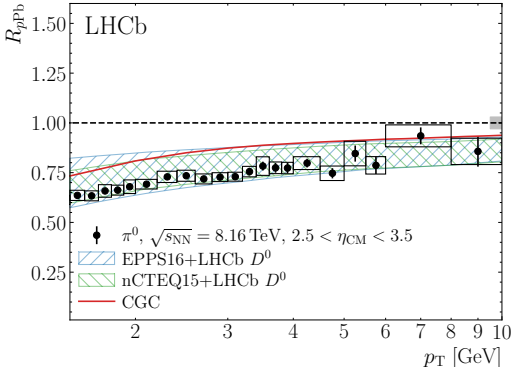
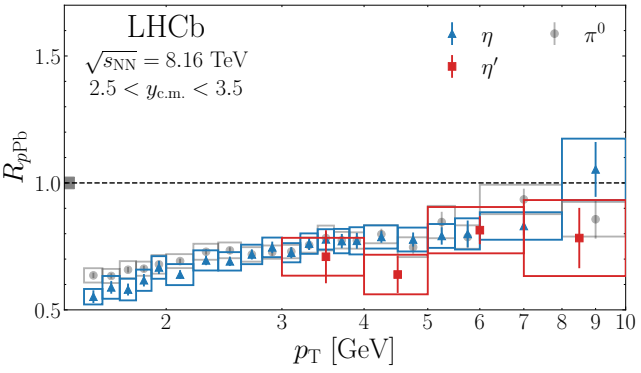
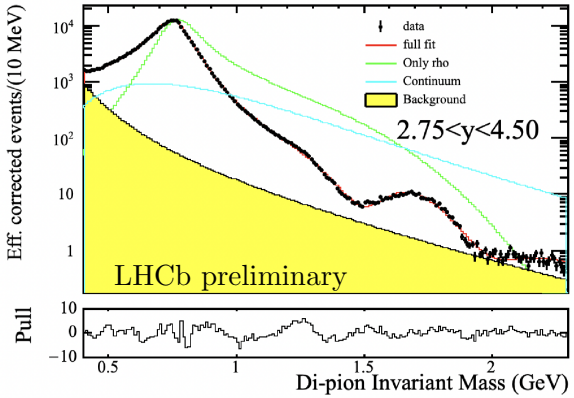
π^0, η, and η' production (PRL 131 (2023) 042302, PRC 109 (2024), 024907)

$$J^{PC} = 0^{-+},\ m(\pi^0) < m(\eta) < m(\eta') < m(D^0)$$





Light hadrons in ultraperipheral collisions (LHCb-PAPER-2024-042, in preparation)

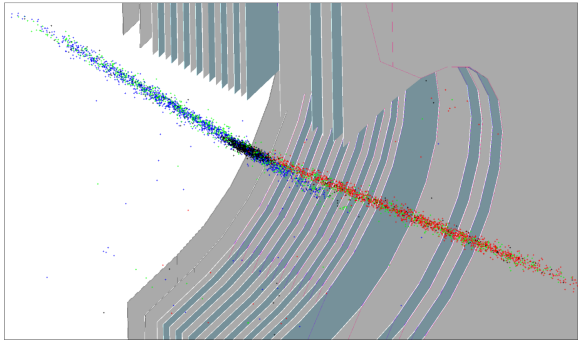


LHCb is uniquely well-suited to reconstruct light mesons, such as the ρ and ϕ, in ultraperipheral nuclear collisions.

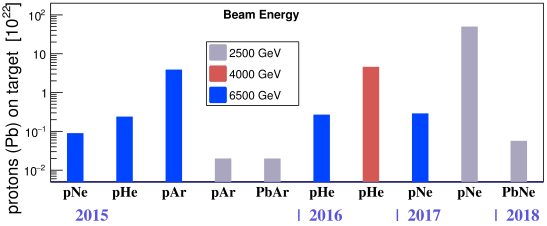
Prospects for low-x physics with light ions at LHCb

- LHCb can probe the gluon nPDF at low x with forward inclusive hadron production measurements.
- Constraining low-x nPDFs at various A (and gluon densities) will be important for finding nonlinear parton density evolution.
- Expected integrated luminosities for OO collisions in 2025 are small, so light probes like the ρ and ϕ at LHCb will be important for studying light ion UPCs.

Fixed-target physics at LHCb with SMOG



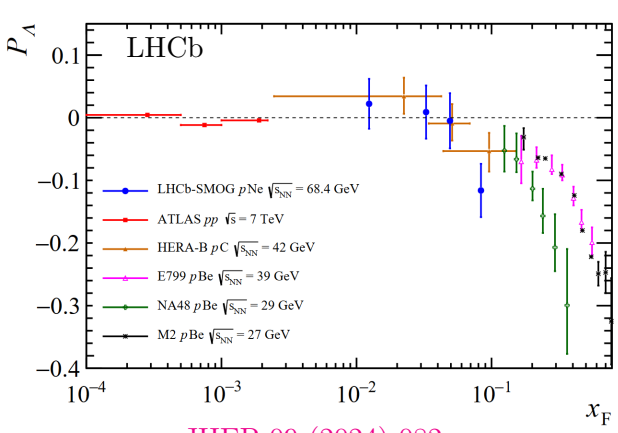
CERN-THESIS-2013-301



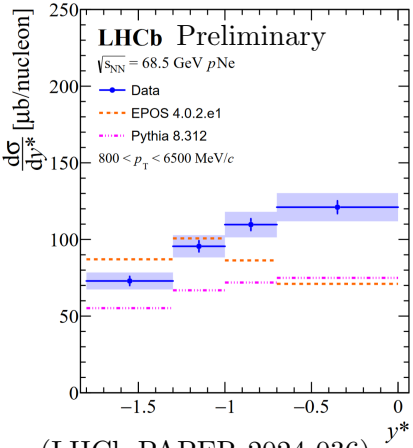
LHCb-PUB-2018-015

The **S**ystem for **M**easuring **O**verlap with **G**as was designed for precise luminosity measurements, but has since been used to study fixed-target collisions at LHCb.

Strangeness production in fixed-target collisions



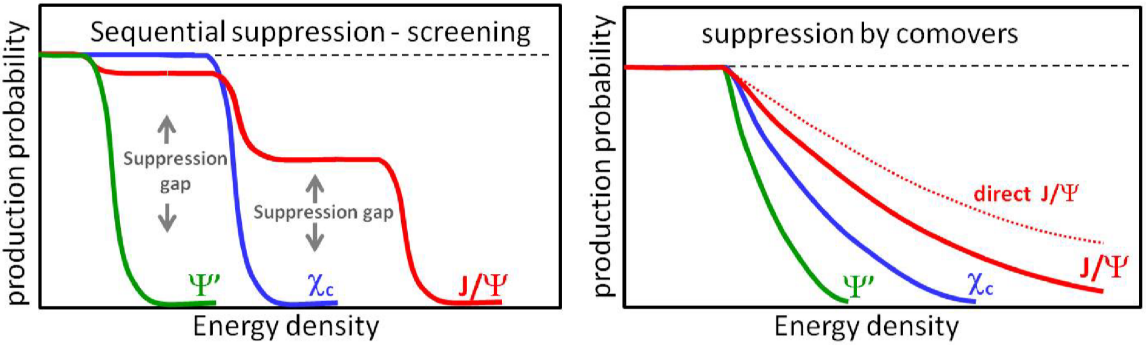
JHEP 09 (2024) 082



(LHCb-PAPER-2024-036)

First strangeness and polarization studies in light-ion collisions at the LHC. Probe cold nuclear matter effects and transverse momentum dependent fragmentation functions.

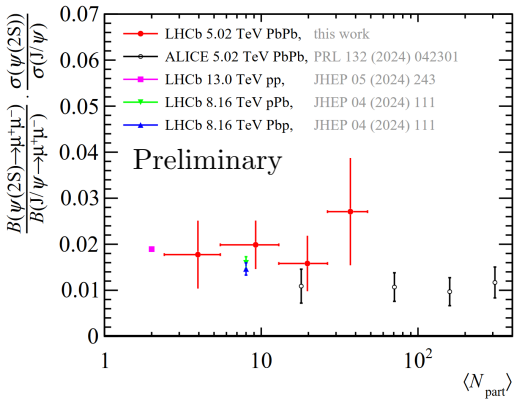
Sequential charmonium suppression and QGP

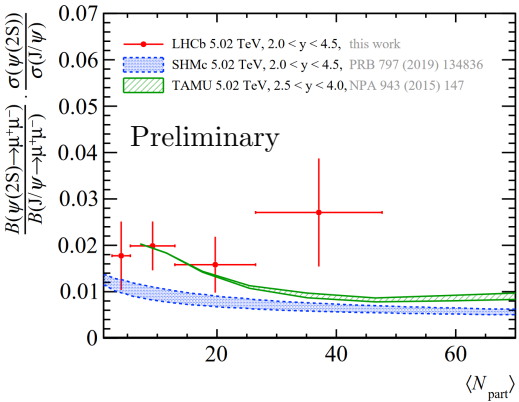


CERN-SPSC-2012-031

The pattern of charmonium suppression vs energy density can reveal the underlying physical mechanism. Measuring charmonium production with various collision systems lets us probe a wide range of energy densities.

Charmonium from small to large systems at LHCb

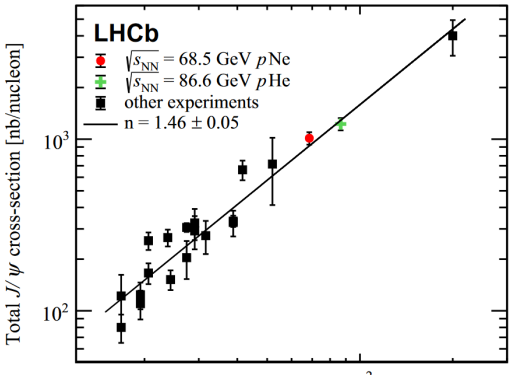




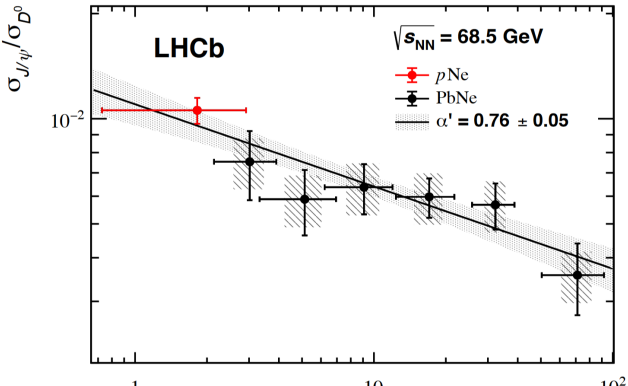
LHCb-PAPER-2024-041

New measurements of charmonium production ratios at LHCb can help disentangle nuclear effects such as statistical hadronization and regeneration.

Open and hidden charm production in fixed-target collisions



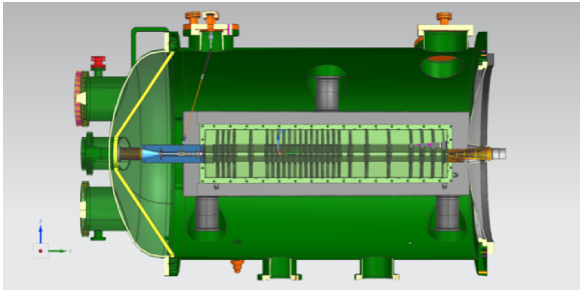
EPJC 83 (2023) 625

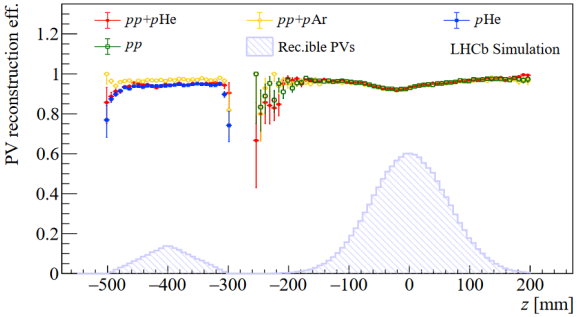


EPJC 83 (2023) 658

Fixed-target collisions at LHCb fill a gap between previous fixed-target experiments and RHIC. No evidence for anomalous J/ψ suppression in PbNe collisions at this energy.

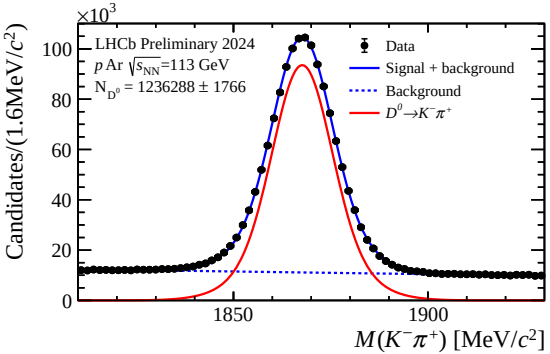
The SMOG2 system (LHCb-DP-2024-002)

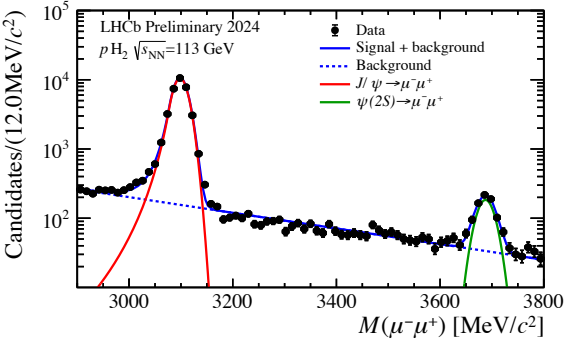




- Consists of a dedicated gas cell upstream of the the VELO.
- Up to two orders of magnitude increase in gas pressure vs the original system.
- Allows for the injection of non-noble gases (e.g. hydrogen and deuterium).
- Clean separation of beam-beam and beam-gas allows LHCb to collect collider and fixed-target data simultaneously.

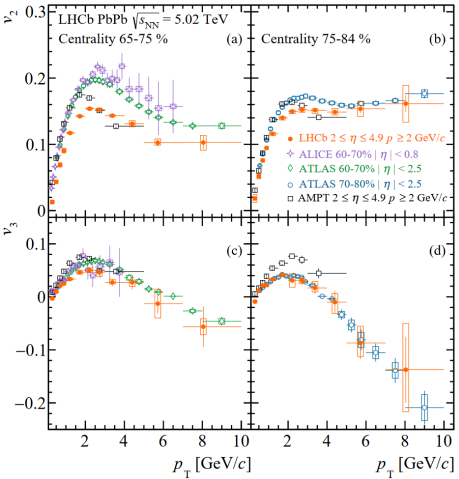
Heavy flavor with SMOG2 (LHCb-FIGURE-2024-023)





- Collected large samples of $p\mathrm{H}_2$, $p\mathrm{D}_2$, pHe, pNe, and pAr in 2024
- Plan to collect large PbNe and PbAr samples during the PbPb run this year

Collectivity studies with SMOG2



PRC 109 (2024) 054908

- LHCb recently performed the first measurement of flow harmonics of charged particles at forward rapidity at the LHC.
- SMOG2 will allow us to study the impact of nuclear geometry on flow measurements by studying collisions between Pb and light nuclei.
- See the talk by Giacomo Graziani later this week!

Final thoughts

- The LHCb detector has unique capabilities that will allow it to take particular advantage of light-ion collisions.
- LHCb has an ongoing light-ion physics program via its fixed-target system that has greatly expanded with new data in 2024.
- Light-ion beams would allow us to study a large variety of collisions systems in both fixed-target and collider modes.

Thank you!