Low-x physics at LHCb

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on behalf of the LHCb collaboration

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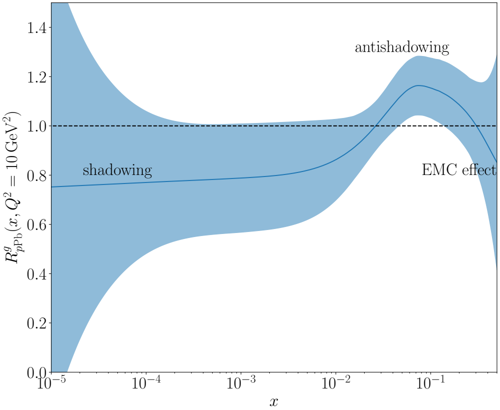
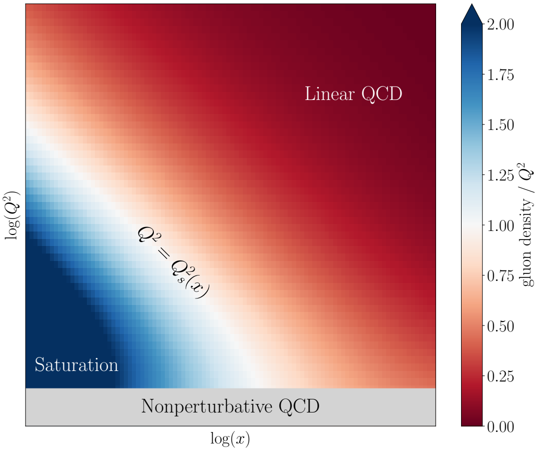
The goals of low-x physics

Describe nucleon structure at low x

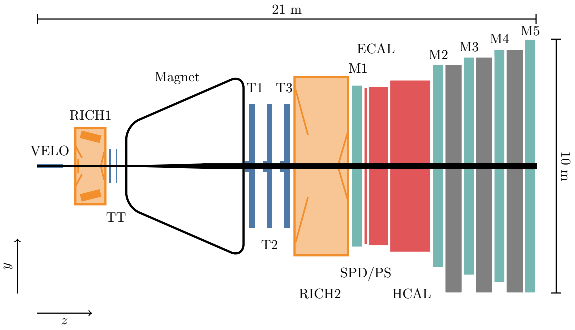


Understand QCD at high gluon densities

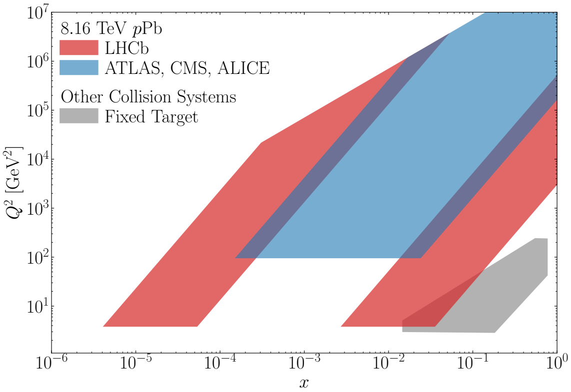


EPPS16, EPJC 77 (2017) 3, 163

LHCb detector and coverage (Int. J. Mod. Phys. A 30 (2015) 07, 1530022)

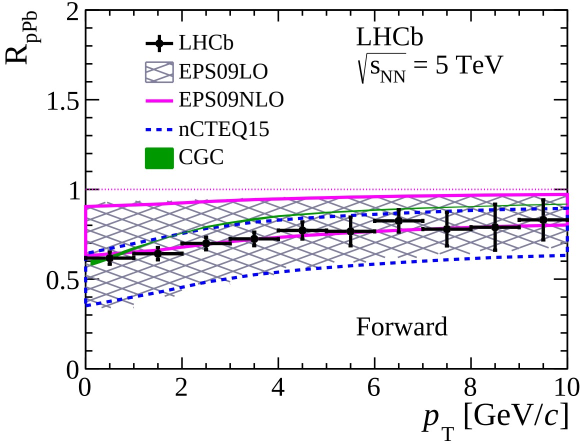


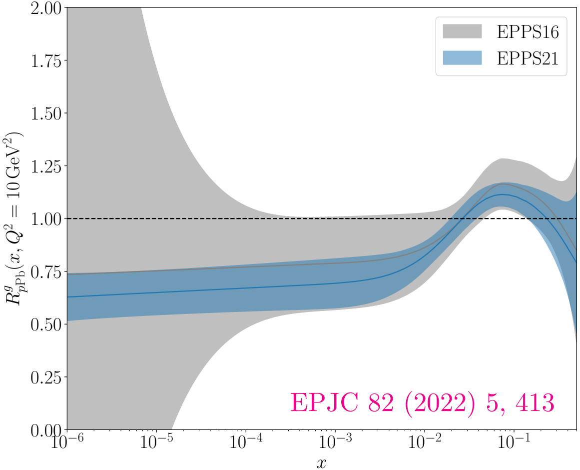
- Forward acceptance: $2 < \eta < 5$
- tracking, calorimetry, RICH, muon
- Excellent vertex resolution ($10 - 50\ \mu$m in x and y)



Collect data in the p-going (low-x nPDF) and Pb-going (high-x nPDF) configurations

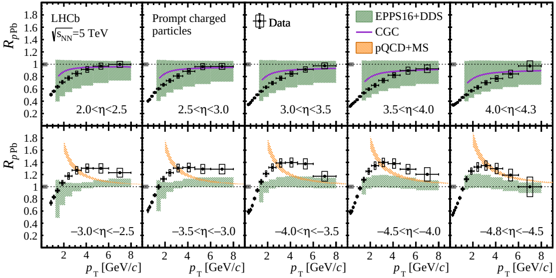
D^0 production at 5.02 TeV (JHEP 10 (2017) 090)



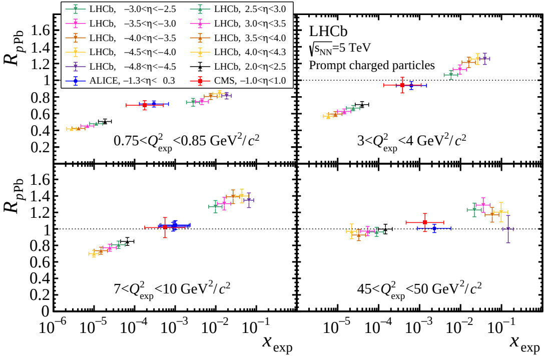


LHCb D^0 data now tightly constrains the gluon nPDF at low x. New data will overconstrain and could reveal non-linear QCD, breakdown of collinear factorization, etc.

Charged particle production at 5.02 TeV (PRL 128 (2022) 14, 142004)

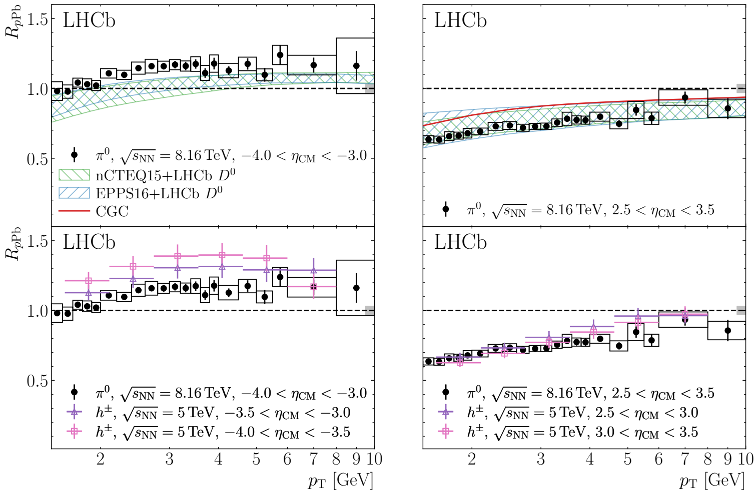


EPPS16+DDS, CGC, pQCD+MS



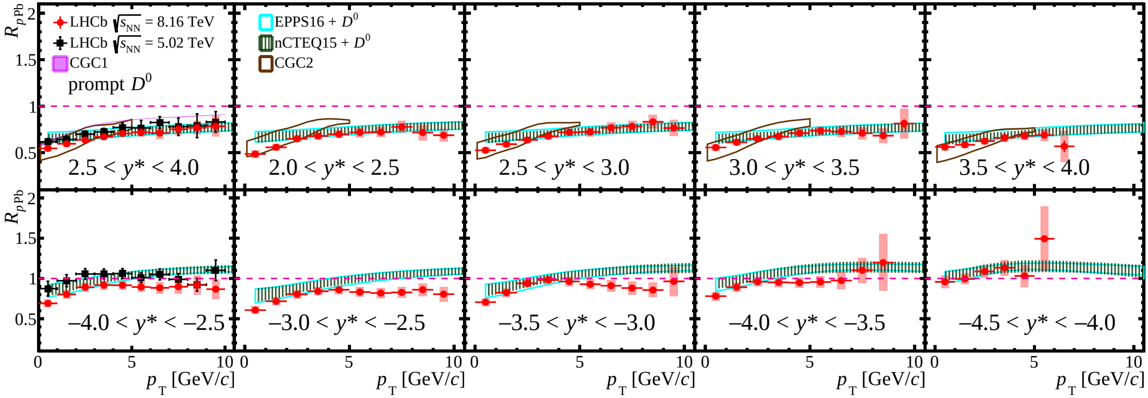
LHCb charged particle data probes gluon densities for $10^{-6} < x < 10^{-1}$ over a wide range in Q^2. Need to understand high-x enhancement (likely some final-state effect) in order to make sense of low-x data.

π^0 production at 8.16 TeV (arXiv:2204.10608, accepted by PRL)

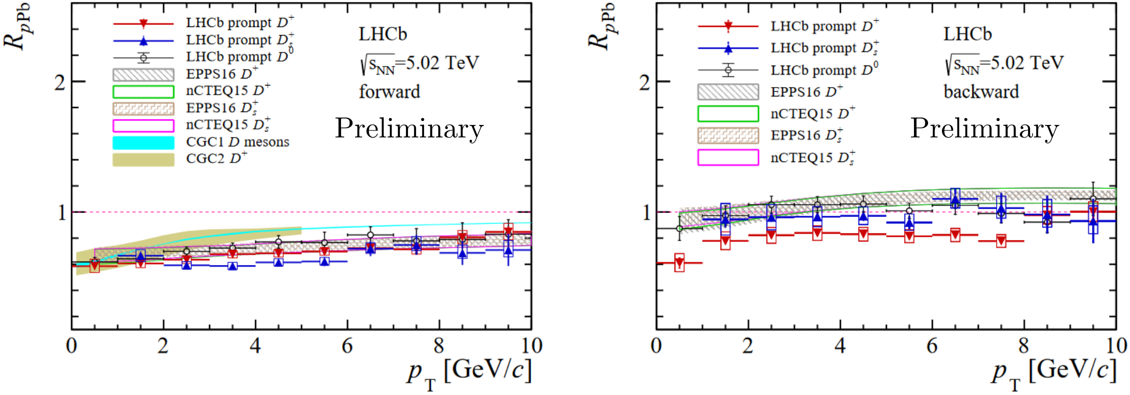


- Excellent agreement with nPDF predictions and charged-particle data at low x
- Small excess at high x
- Possible explanations
  - Radial flow leading to a mass-dependent enhancement
  - Quark coalescence leading to a larger baryon enhancement

D^0 production at 8.16 TeV (arXiv:2205.03936, accepted by PRL)

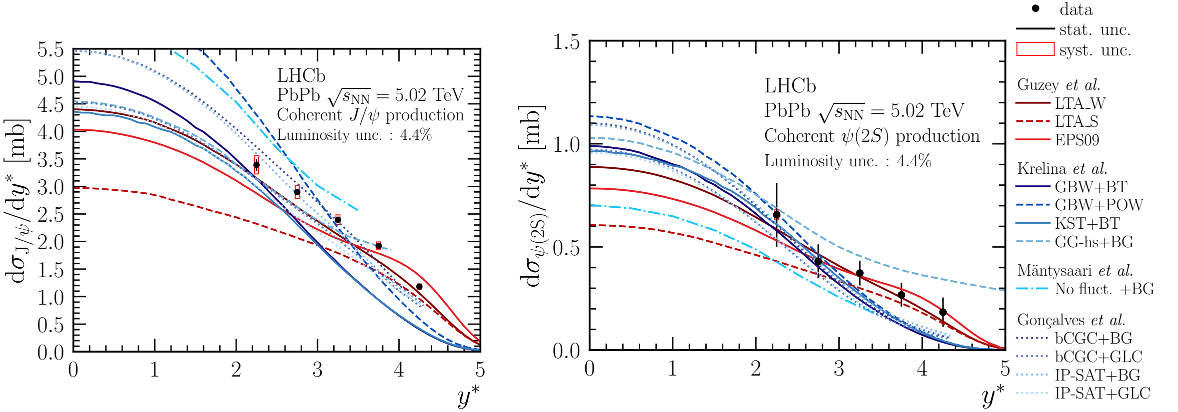


Recent study of D^0 production at 8.16 TeV shows a similar (but opposite) trend: agreement at forward rapidity and a deficit at backward rapidity.



New measurement of $D^{\pm}$ $R_{p\text{Pb}}$ shows a backward deficit, while $D_s^{\pm}$ agrees with nPDF predictions.

Use UPCs to study photoproduction: $\gamma\text{Pb} \to V\text{Pb}$. Cross section $\propto g(x, Q^2)^2$. But predictions suffer from huge scale uncertainties, and quark PDFs could play a large role.



Studying multiple final states with different masses can help constrain scale-dependence.

Final thoughts

- LHCb data has helped provide a successful description of the nucleon at low x, but understanding the underlying physics is much harder.

- LHCb has a lot of work to do:
  - Identified hadron production in pPb ($\pi^{\pm}$, $K^{\pm}$, p, η, η', etc.)
  - Additional photoproduction measurements in UPCs (e.g. $\phi \to K^+K^-$)
  - Direct photon production
  - Can we see the onset of low-x effects in the upcoming pO run?

- Low-x physics has entered a high-precision era.

Thank you!