Direct Photon Production at LHCb

Thomas Boettcher

Department of Physics and Laboratory for Nuclear Science
Massachusetts Institute of Technology

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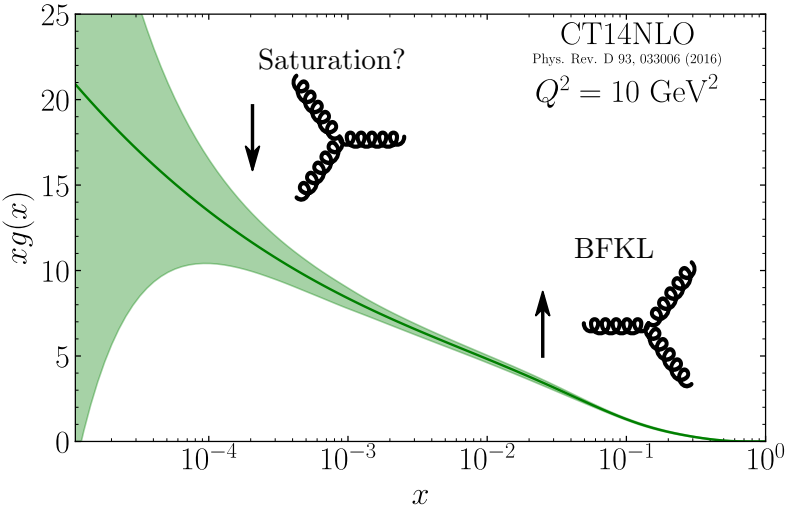
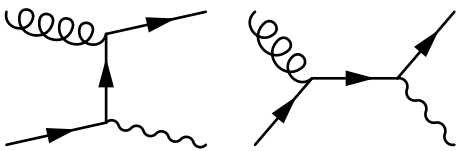
Gluon Saturation

At high number density, expect gluon recombination to compete with gluon splitting, leading to saturation of the gluon PDF



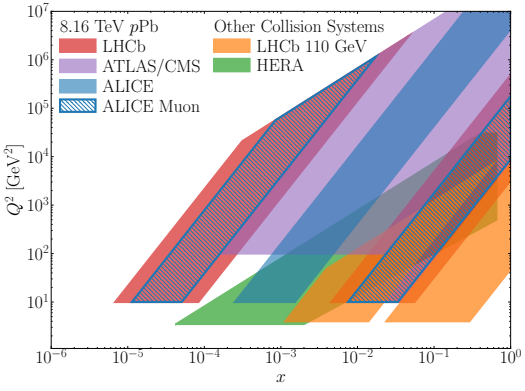
Gluon Saturation and Direct Photons



- Saturation is important when $1/Q \gtrsim$ distance between partons
- Characterized by the saturation scale

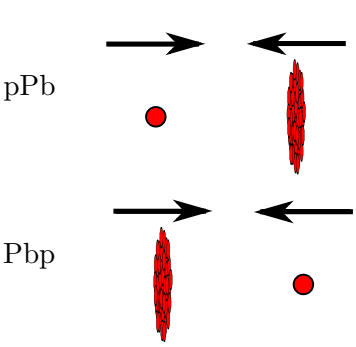
$$Q_s^2 \sim \frac{N(\text{partons})}{\text{transverse area}} \sim \frac{Ag(x)}{A^{2/3}} \sim \frac{A^{1/3}}{x^\lambda}$$

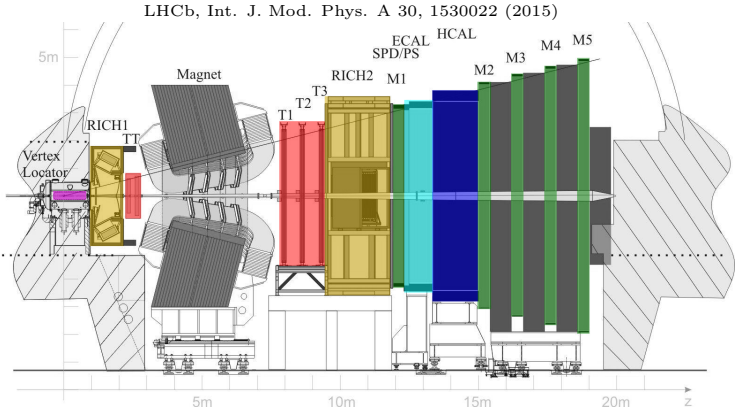
- Direct photons sensitive to gluon PDF



- LHCb has access to direct photon production at low x
- Low-p_T ($\lesssim 5$ GeV) direct photons are most sensitive

The LHCb Detector





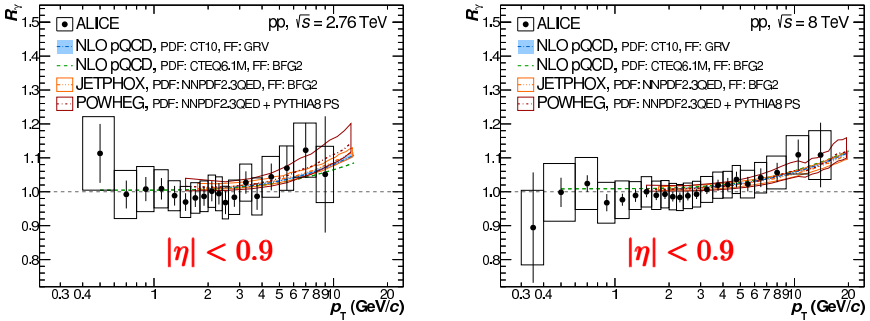
- Designed to study B decays in pp collisions
- Participated in 2013 and 2016 pPb runs
- Began participating in AA runs in 2015

- Fully instrumented for $2 < \eta < 5$
- Tracker, ECAL, HCAL, Muon
- High precision vertex locator (VELO)
- Ring imaging Cherenkov (RICH)

Double Ratio R_γ

Report results in terms of the double ratio $R_\gamma = (\gamma^{\text{inc}}/\gamma^{\pi^0})_{\text{Data}} \Big/ (\gamma^{\text{dec}}/\gamma^{\pi^0})_{\text{MC}}$

Similar to the strategy used in ALICE direct photon studies

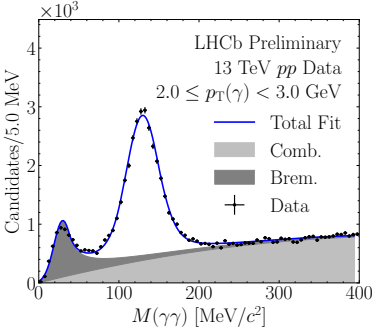


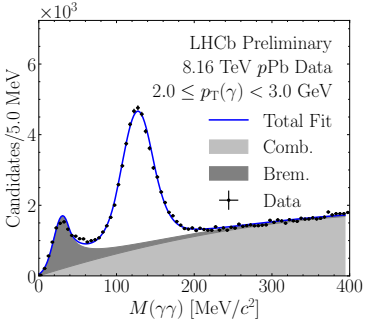
ALICE, arXiv:1803.09857

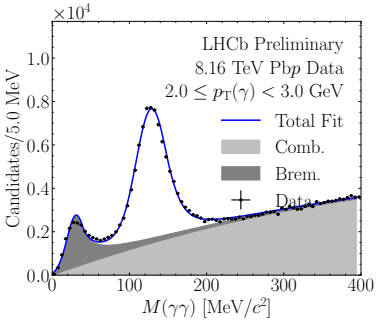
We can use inclusive *pp* data as a control sample to study systematic effects and perform the measurement on isolated photons.

Analysis Strategy

Perform the analysis using converted photons to avoid backgrounds from π^0s reconstructed in a single calorimeter cluster

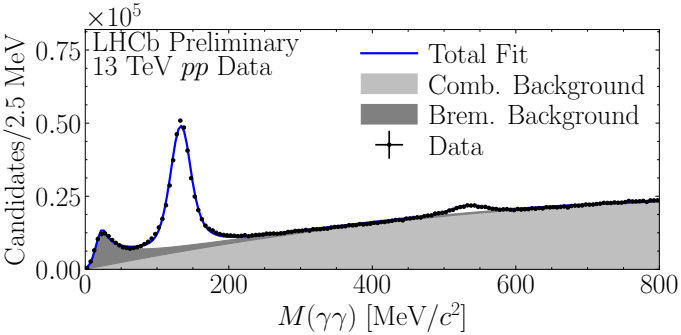


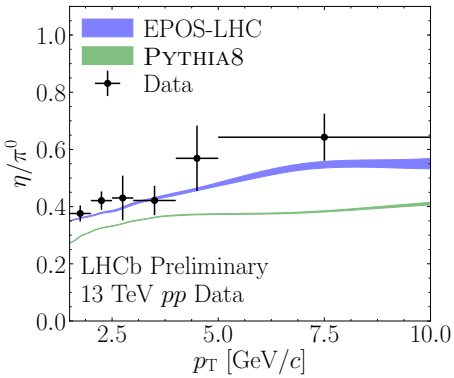




- Extract π^0 component by fitting the $\gamma^{\text{conv}} + \gamma^{\text{ECAL}}$ mass spectrum
- Must be corrected for ECAL photon efficiency differences between data and MC
- Data-driven studies show that MC is accurate to within an inherent 6% uncertainty
- Can use *pp* control samples for a more precise data-driven validation

η/π^0

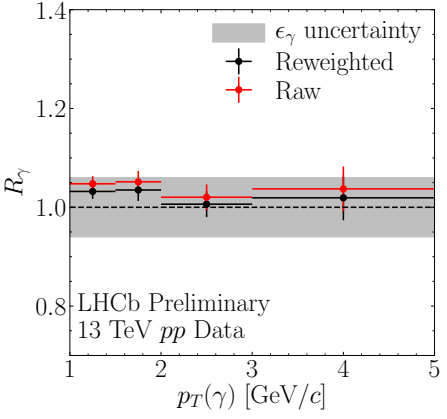


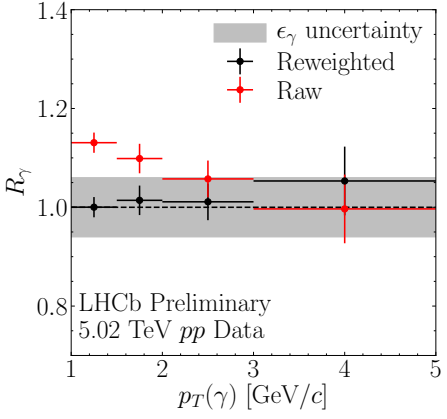


- Need to know the fraction of decay photons originating from π^0 decays
- Can check by measuring η/π^0
- Only $\sim 15\%$ of decay photons are from η decays, so this leads to percent level effects on R_γ

Control Results

- Use 13 TeV pp MC for the denominator in each double ratio
- Reweight to correct for differences in multiplicity and underlying π^0 p_{T} spectrum
- Consistency between 13 TeV and 5 TeV means we can use control studies to drive down uncertainties in photon efficiency





Summary

- Making progress towards measurements of direct photon production at LHCb
- Control studies show that we have a good understanding of systematic effects
- Observables such as R_{FB} allow for more precise but potentially interesting measurements
- LHCb has enormous potential to study saturation physics, and this is just the beginning!