Probing small-x gluons with γ+hadron correlations in the forward rapidity with the LHCb detector

Maitreyee Mukherjee on behalf of the LHCb Collaboration

Central China Normal University, Wuhan, China

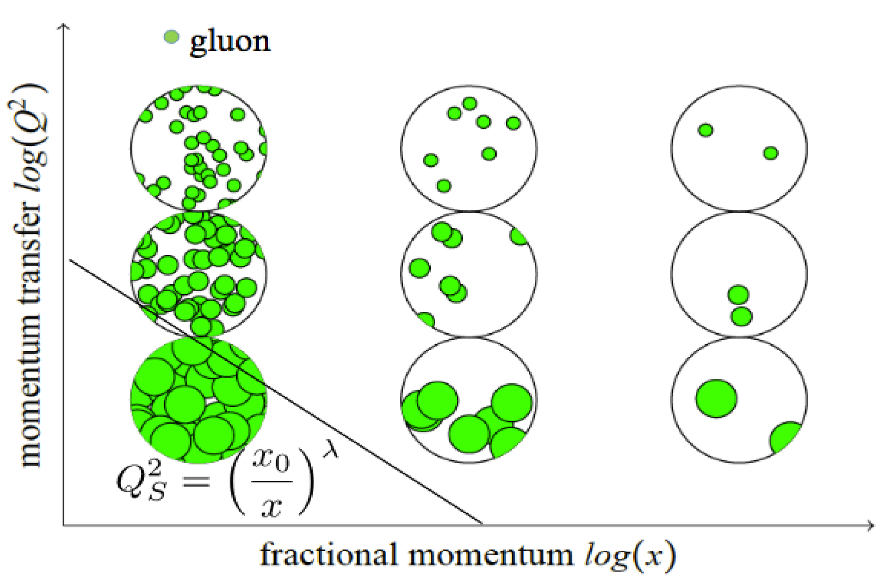
e-mail : maitreyee.mukherjee@cern.ch

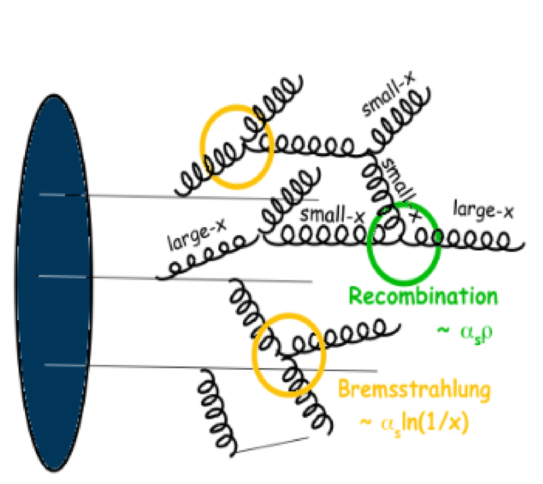
Abstract

Gluon nuclear PDFs still have large uncertainties in the small-x ($x<10^{-3}$) and small virtuality $Q^2<50$ (GeV/c)^2 region. Yields from particles coming from these gluons obtained in nuclear collisions are suppressed relative to p+p collisions because of initial-state effects such as shadowing, energy loss and gluon saturation. Precise measurement of yields coming from small-x, small-Q^2 gluons are essential to understand these effects which have a significant contribution to the suppressions observed in A+A collisions at RHIC and LHC. The inverse Compton process g+q -> γ+q -> γ+h is one of the few which can access and provide information on the gluon-x and Q^2 in the region where nPDFs are not well constrained. The LHCb detector can measure photons through the Electromagnetic Calorimeter or photon conversion to dielectrons in the pseudorapidity range $2<\eta<5$, covering $x>5\times10^{-6}$ and $Q^2>2$ GeV^2 in the case of inverse Compton processes. This unique coverage allows us to search for the gluon saturation scale, the transition between dilute and saturated gluons, predicted by the Color-Glass Condensate effective theory. This presentation will show the status of the isolated γ+hadron correlation analysis using data collected in p+Pb and Pb+p collisions at 8.16 TeV and p+p collisions at 8 TeV. New techniques will also be presented to identify isolated photons and subtract the large background from neutral meson decays.

Introduction

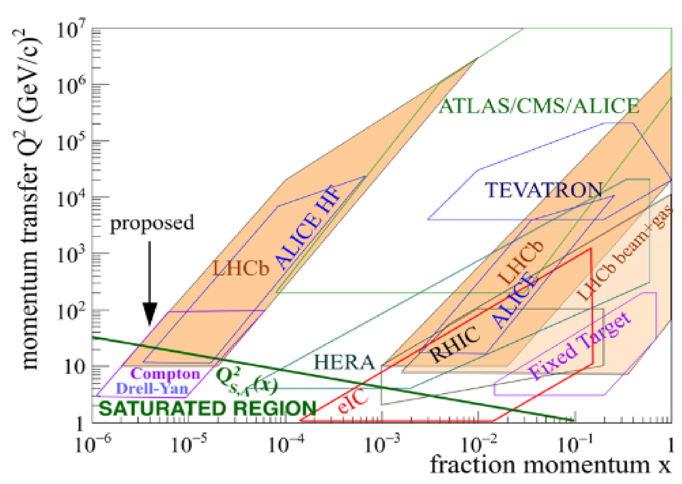
At some point after the Big Bang, there was a gluon saturated regime that defined the fate of the Universe.





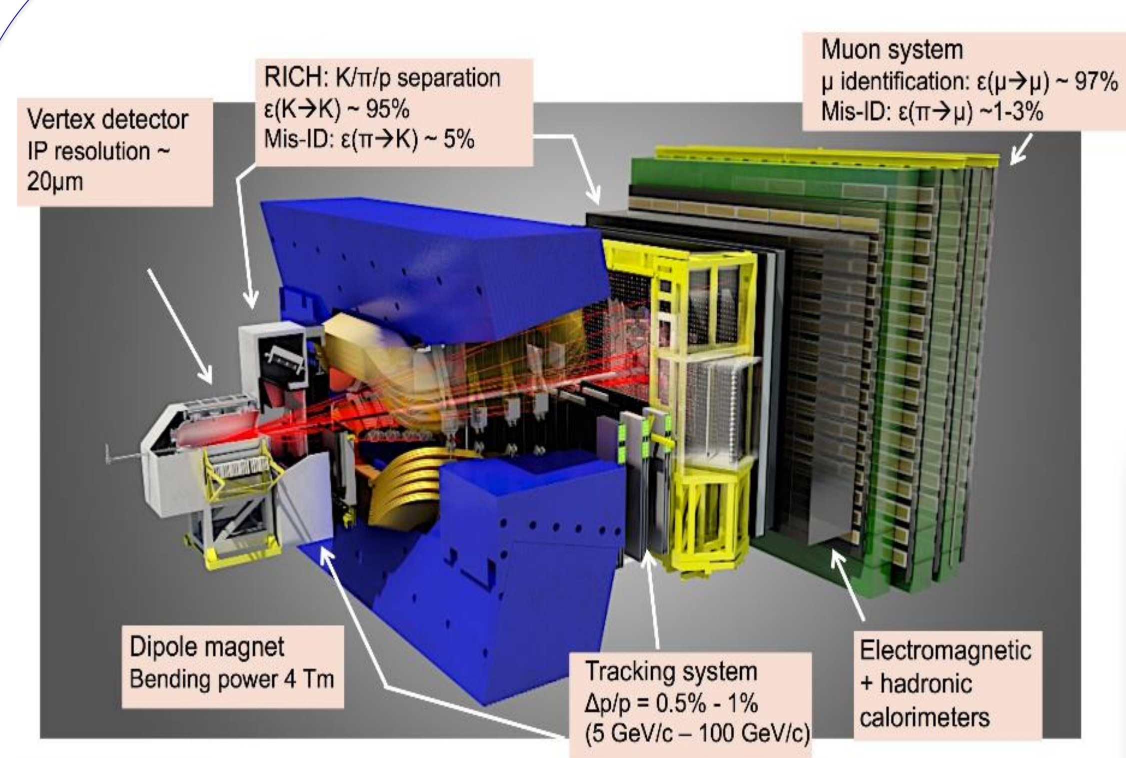
- Glasma and saturated physics may dominate the initial stages of high-energy nuclear collisions.
- In the saturated region, the recombination of small-x gluons dominates causing the reduction of the number of gluons and suppressed yields.
- Gluon saturation in p+A collisions :

$$Q^2_{S,A} = A^{1/3} Q^2_{S,p} \quad [1]$$

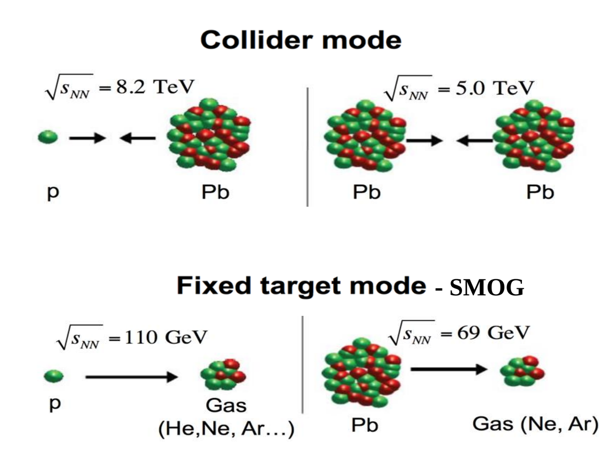


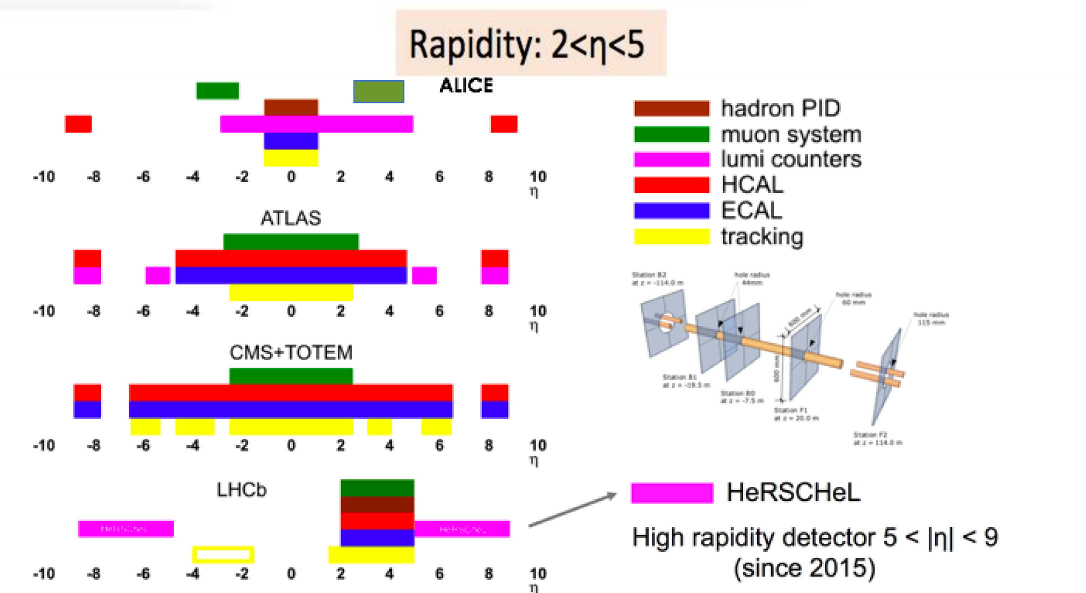
- Color Glass Condensate (CGC) effective theory calculates non-perturbative QCD using the saturation scale.
- **LHCb is the best place to find the transition between dilute and saturated gluon regime today -> A great bridge to future measurements in EIC.**

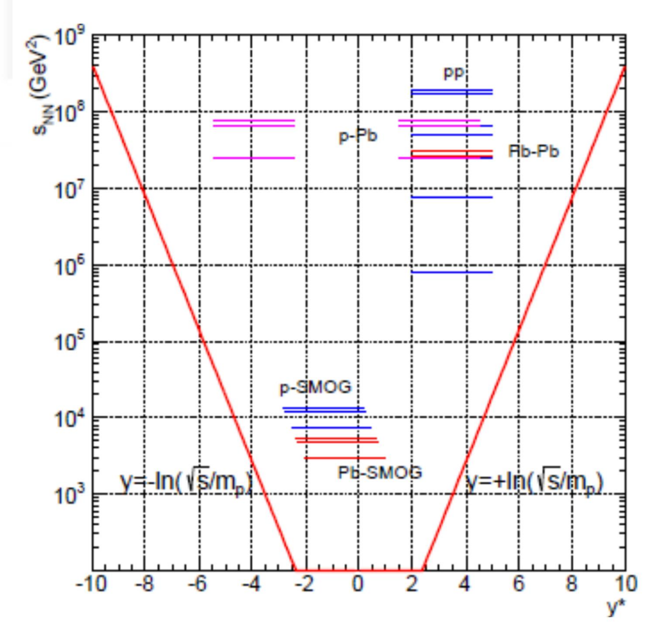
LHCb Detector



Heavy Ion Program

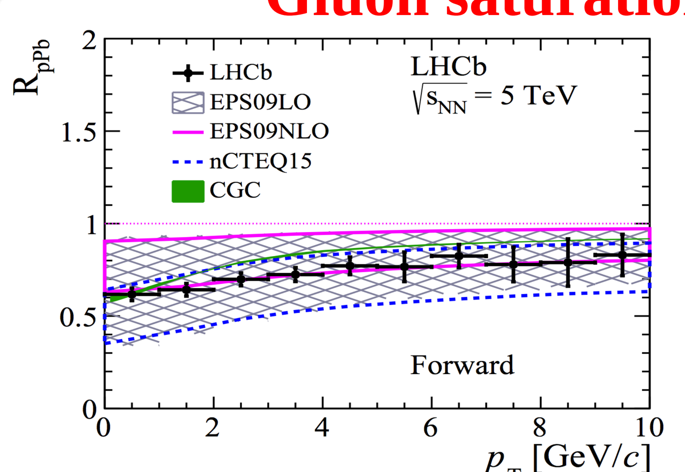




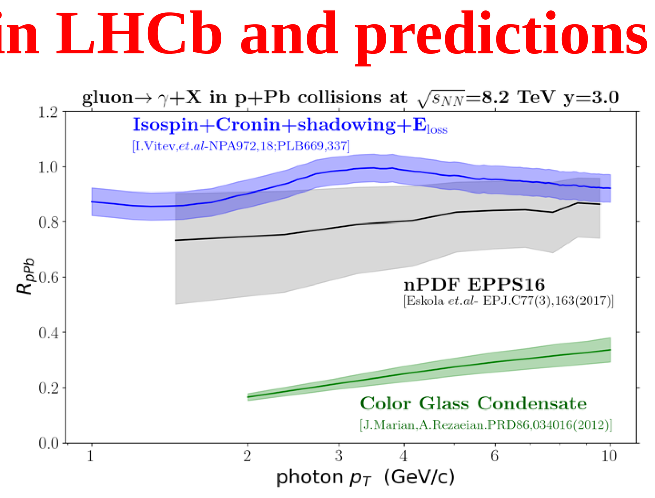


- **LHCb is the only fully instrumented detector in the forward direction at LHC.**
- Forward region : 1.5 < y* < 4.0 (pPb) ; Backward region : -5.0 < y* < -2.5 (Pbp).
- 2013 data taking : $\sqrt{s_{NN}}$=5.02 TeV; 1.1 nb^{-1} (Fwd), 0.5 nb^{-1} (Bwd).
- 2016 data taking : $\sqrt{s_{NN}}$=8.16 TeV; 13.6 nb^{-1} (Fwd), 20.8 nb^{-1} (Bwd).

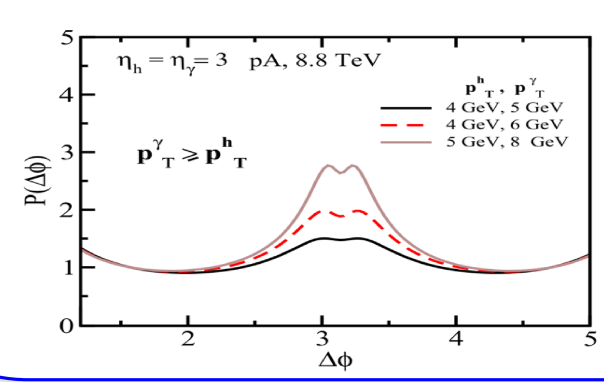
Gluon saturation in LHCb and predictions



- D-meson suppression agrees with CGC and nPDFs [2]



- In direct photon measurements, competing effects will be small compared to saturation [3].



- In photon+hadron angular distribution, double-peak structure is observed due to gluon wavefunction interference [3].

Conclusions and Outlook

❖Opening a new line of research in small-x physics with the LHCb Experiment.
❖Presented first observation of candidate direct photons from gluons in Pb nucleus in the potential gluon saturated region.
❖Good chance to map $Q_s^2(x)$.
❖The nuclear modification of the away-side peak yield vs p_T rapidity and x_{Pb} will be provided soon.
❖ Work is ongoing on the validation of the photon efficiencies in simulation and other systematics in the measurements.
❖ A result can be publicly available in the next few months.

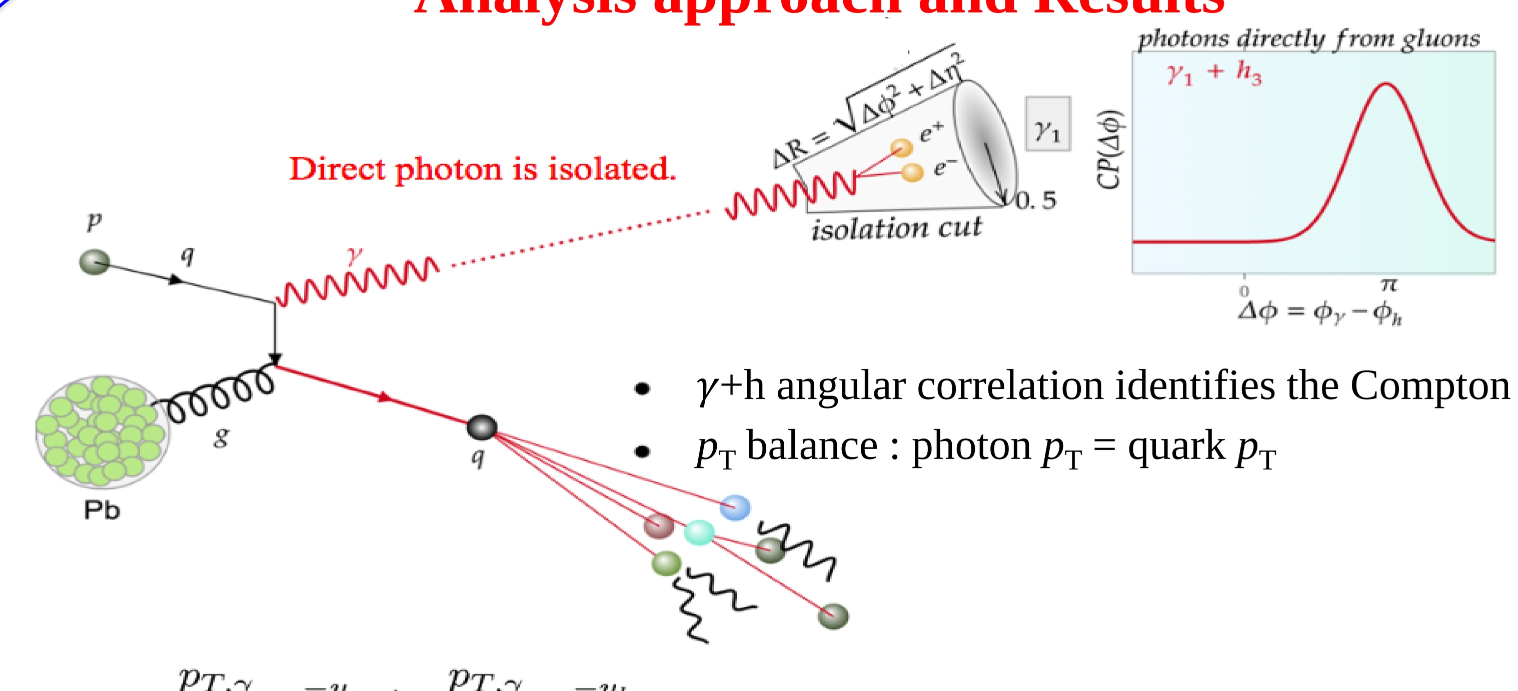
References

[1] H. Kowalski, T. Lappi, and R. Venugopalan, Phys. Rev. Lett.100:022303, 2008
[2] LHCb Collaboration, JHEP 1710 (2017) 090
[3] A. Rezaeian, Physical Review D86, 094016 (2012).
[4] Talk by Cesar Luiz Da Silva, APS/Division of Nuclear Physics 2018-Hawaii

Acknowledgement

- College of Physical Science and Technology, CCNU, Wuhan, P R China
- US DOE/OS NP

Analysis approach and Results

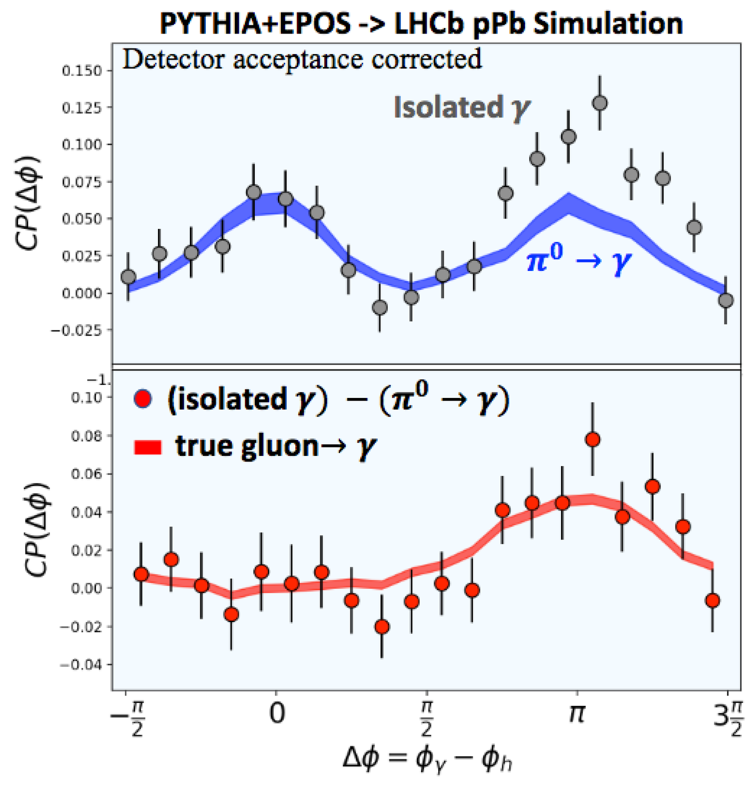


- γ+h angular correlation identifies the Compton signal.
- p_T balance : photon p_T = quark p_T

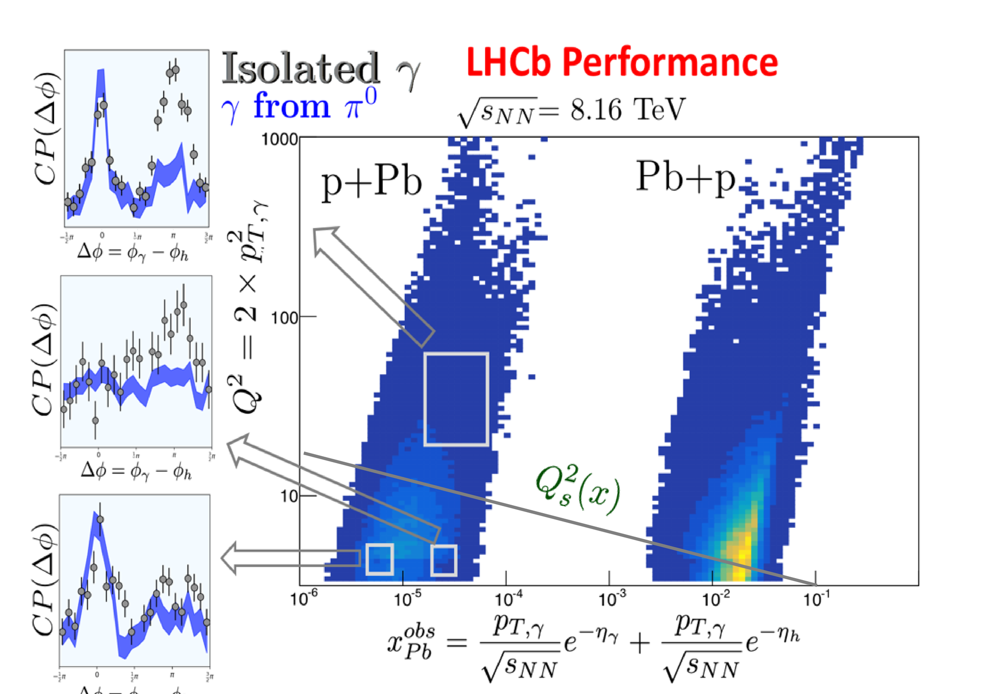
$$x_{Pb} \approx \frac{p_{T,\gamma}}{\sqrt{s_{NN}}} e^{-y_\gamma} + \frac{p_{T,\gamma}}{\sqrt{s_{NN}}} e^{-y_h}$$

$$Q^2 \approx 2 p^2_{T,\gamma}$$

Gluons are accessed via Inverse Compton Process.



Proof of principle measurement



- Di-jet contribution can be measured with identified π^0->γ in data.
- Near-side peak contains only di-jets, it is used to normalize the di-jet component.
- Techniques can reproduce the truth inverse Compton angular distribution in simulation.

First evidence of direct measurements of direct photons from gluons in the potential saturated region.