Ultra-peripheral vector meson photoproduction in heavy-ion collisions in CMS

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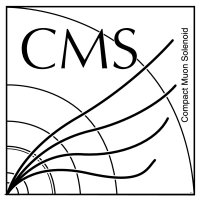
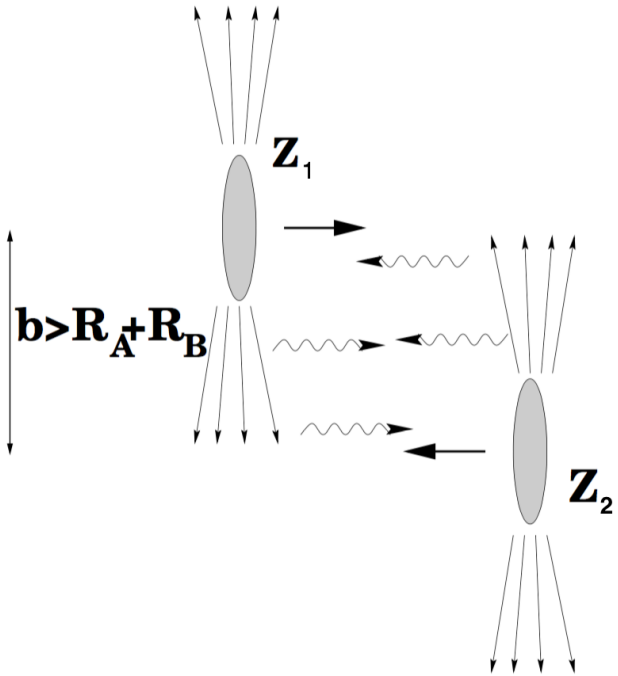
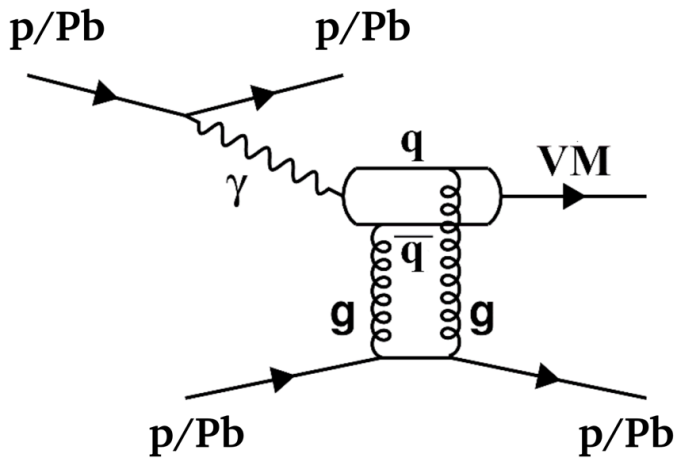


Contents

Ultra-Peripheral Collisions (UPCs)

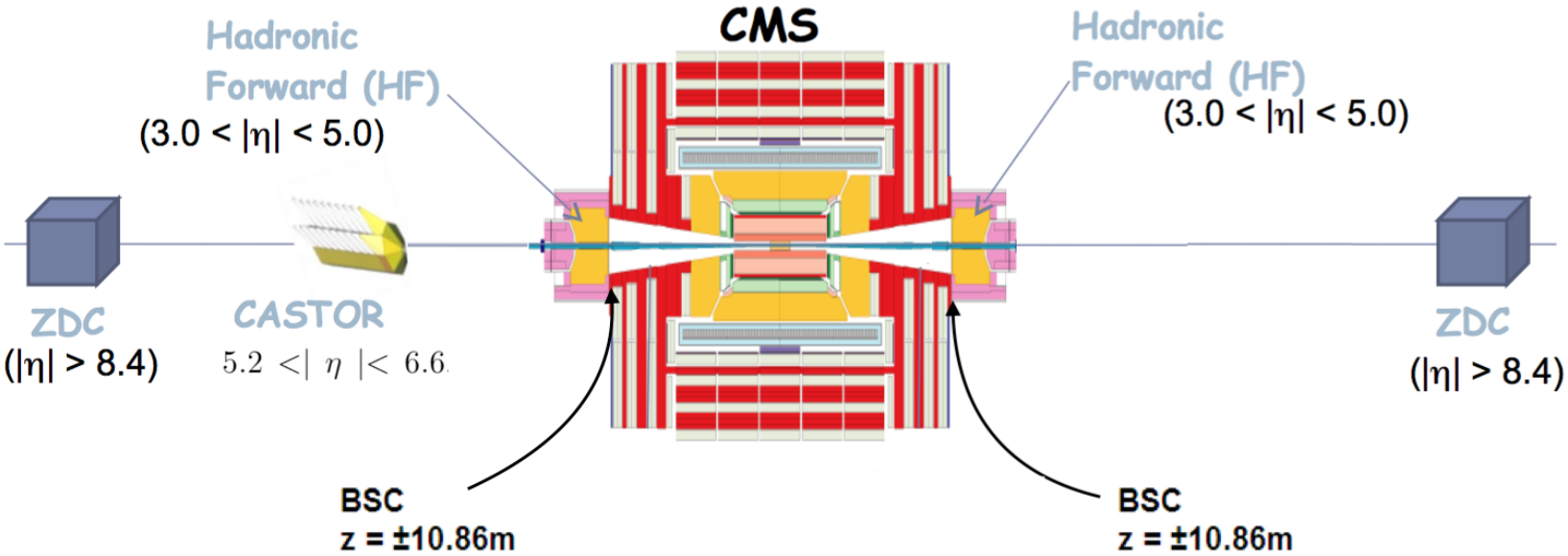


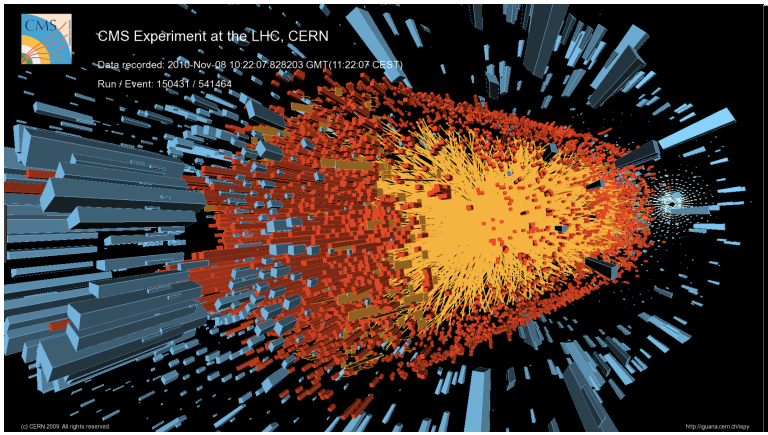


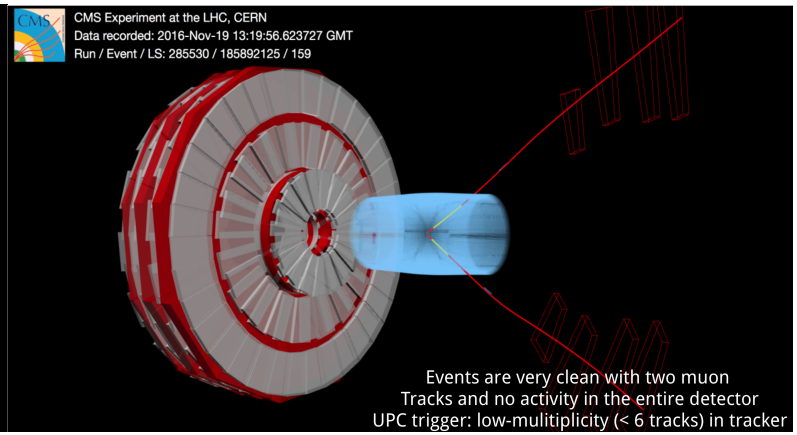
photon flux scales as Z^2

sensitive to the gluon density squared in the hadron at low x

Compact Muon Solenoid (CMS)







Exclusive $\rho(770)^0$ photoproduction [1]

Measurement of exclusive $\rho(770)^0$ photoproduction in ultraperipheral pPb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02\,\mathrm{TeV}$

arXiv:1902.01339

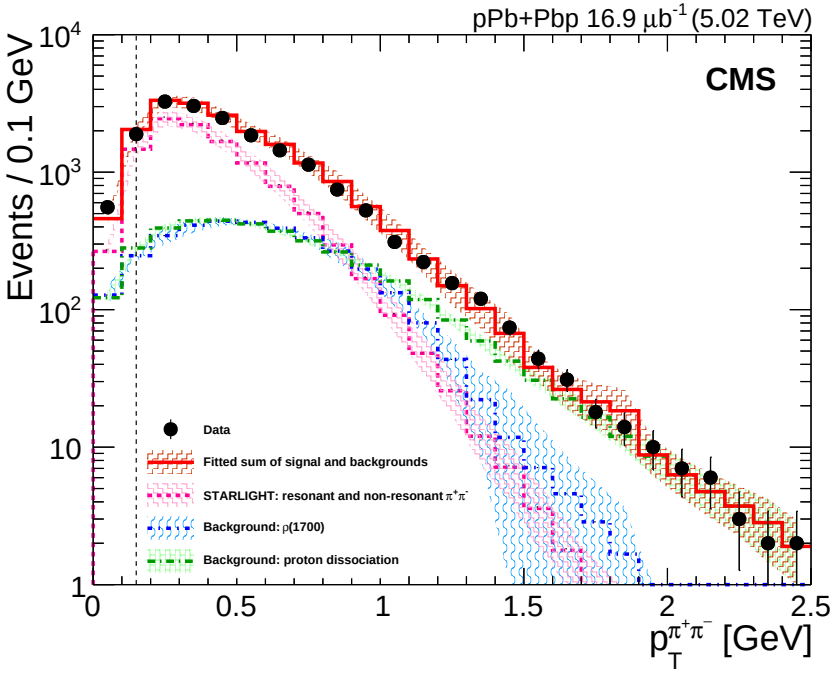
Eur. Phys. J. C 79 702, 2019

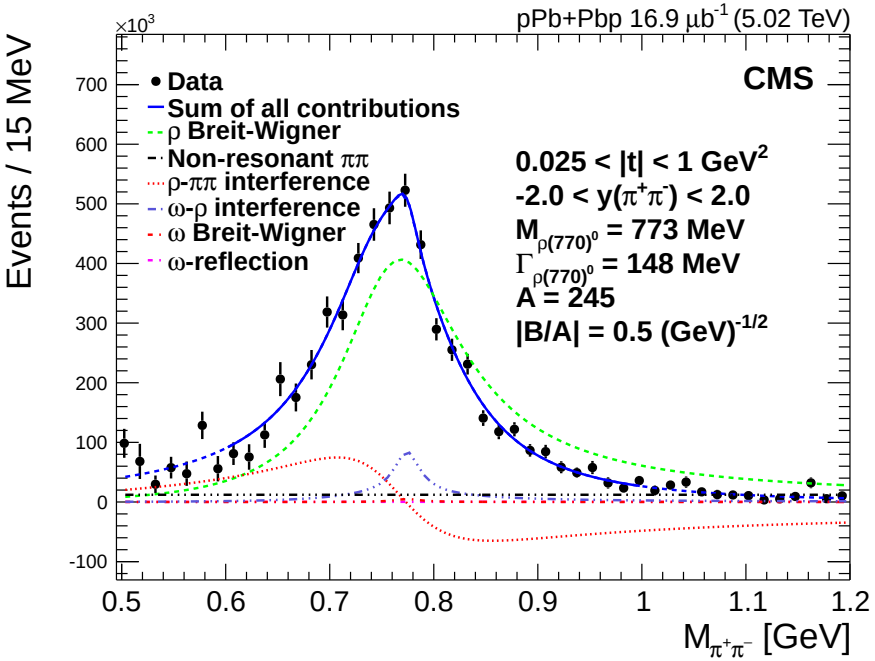
Analysis

- Run1 pPb data at $\sqrt{s_{NN}} = 5.02$ TeV collected with the CMS detector
- Luminosity: $L = 7.4 \mu b^{-1}$ for pPb and $L = 9.6 \mu b^{-1}$ for Pbp
- Process: exclusive $\rho(770)^0 \to \pi^+\pi^-$
- Photon-proton centre-of-mass energies, $W_{\gamma p}$, between 29 and 213 GeV
- $d\sigma/d|t|$ is measured in the $0.025 < |t| < 1$ GeV ^{2} interval as a function of $W_{\gamma p}$
- Here: $|t| = p_T^2$
- The STARLIGHT Monte Carlo event generator
  - exclusive resonant and nonresonant $\pi^+\pi^-$ production
  - exclusive $\rho(1700)$ events
  - acceptance and efficiency corrections
  - photon flux

Event selection and signal extraction

arXiv:1902.01339, Submitted to EPJC

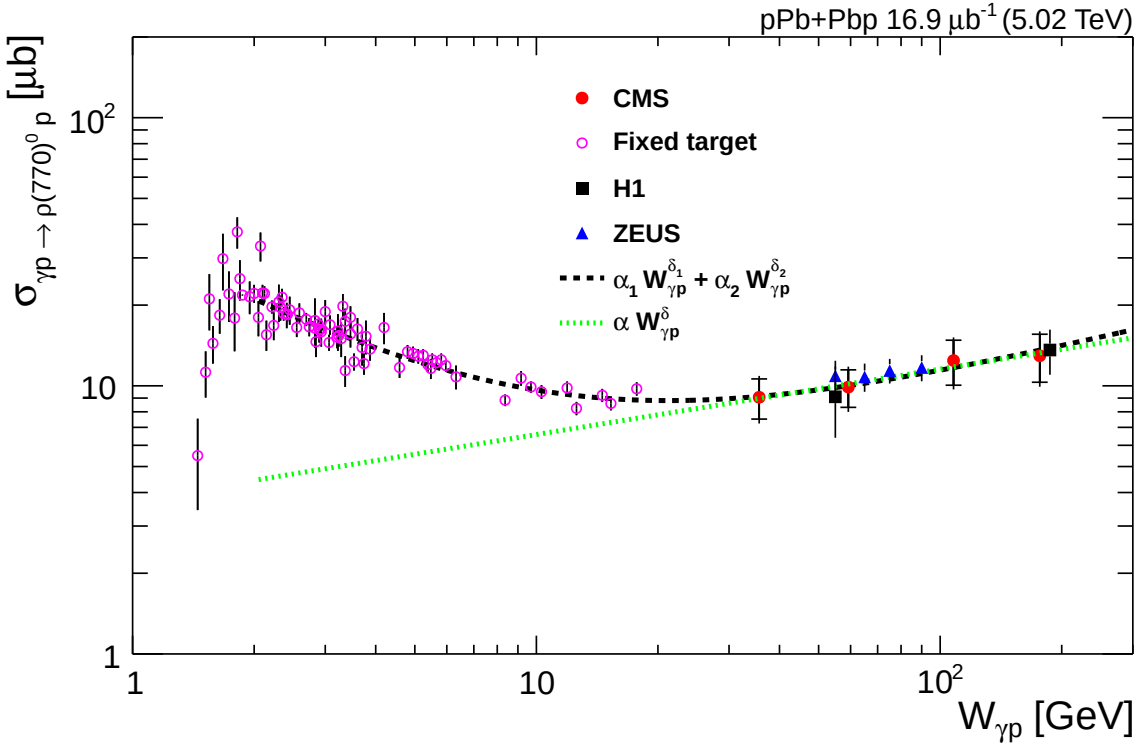




- Exactly two tracks, $|\eta_{\text{track}}| < 2.0$, $p_T^{\text{leading}} > 0.4$ GeV, $p_T^{\text{subleading}} > 0.2$ GeV
- Leading HF tower < 3.0 GeV
- CASTOR energy < 9.0 GeV
- ZDC$^+$ energy < 500 GeV, ZDC$^-$ energy < 2000 GeV

Results

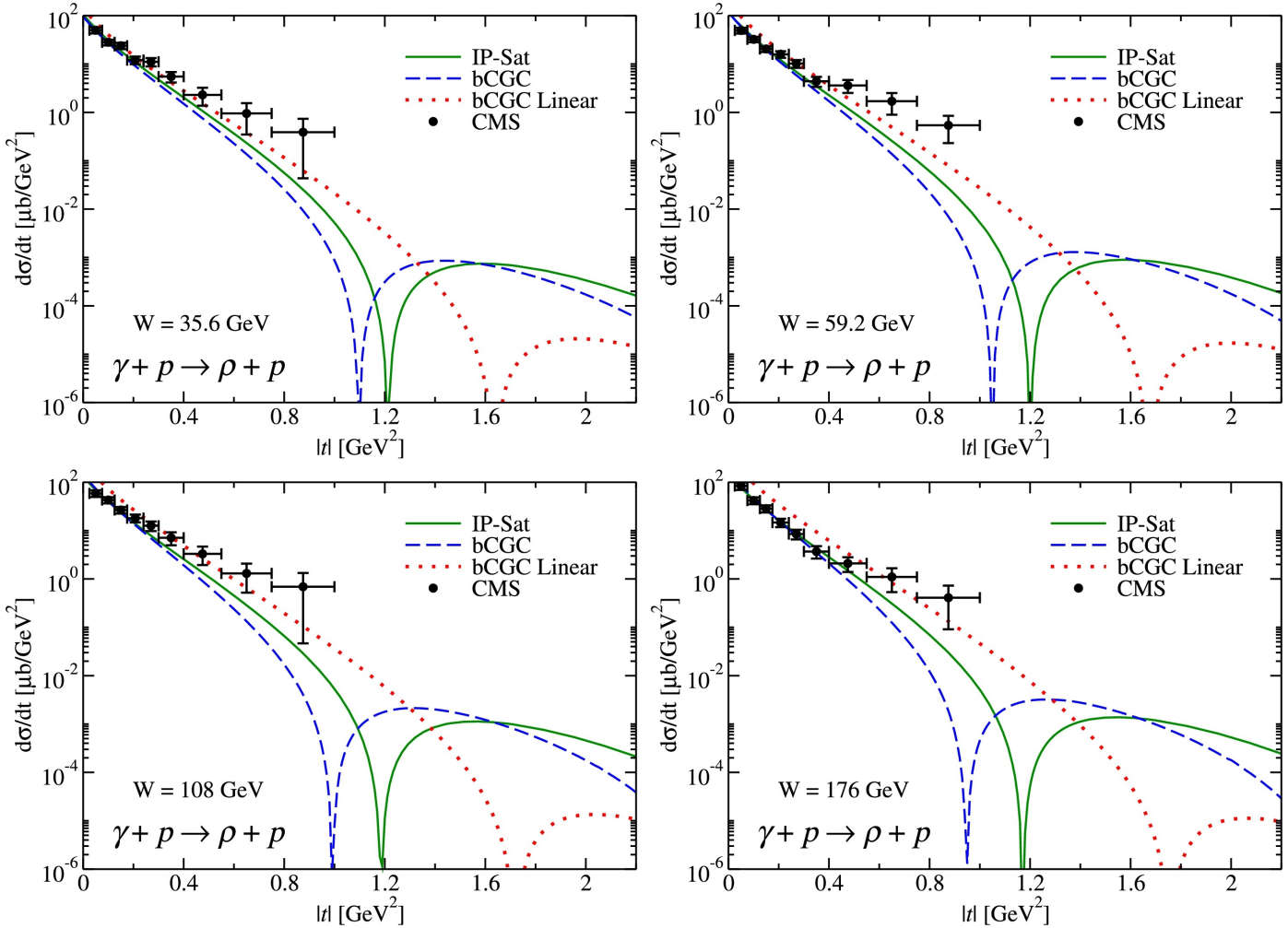
arXiv:1902.01339, Submitted to EPJC



- $\sigma(\gamma p \to \rho(770)^0) = 11.0 \pm 1.4(\text{stat}) \pm 1.0(\text{syst})\ \mu b$
  - for $29 < W_{\gamma p}$ 213 GeV
- $\delta = 0.24 \pm 0.13(\text{stat}) \pm 0.04(\text{syst})$
  - both CMS and HERA data
- Consistent with H1 and ZEUS Collaborations at HERA
- Ion-proton collisions can be used similarly to electron-proton

Results [2]

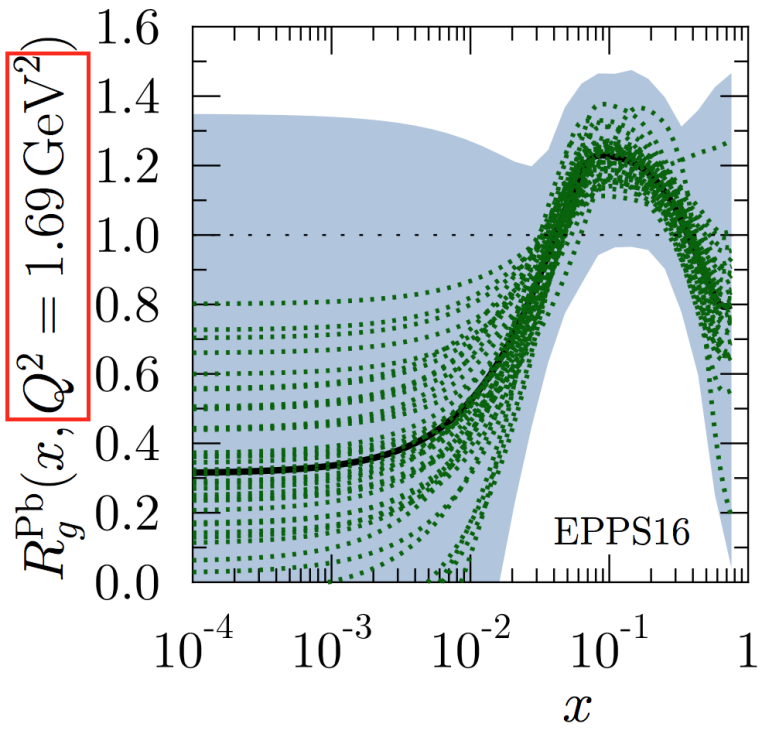
V. Goncalves, et al. Phys. Lett. B791 (2019) 299-304



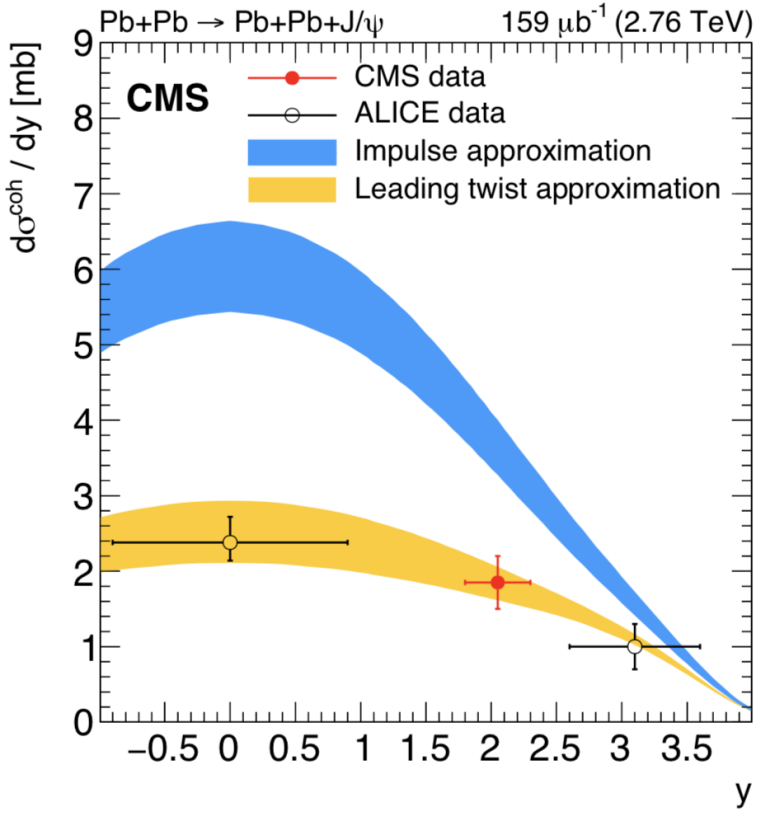
- First measurement of the energy dependence of the $d\sigma/dt$
- Sensitive to the onset of the gluon saturation

Exclusive Υ photoproduction in Run2 PbPb data from CMS

Motivation [3] [4]



$$R_i^A(x, Q^2) = \frac{f_i^A(x, Q^2)}{A f_i^p(x, Q^2)}$$

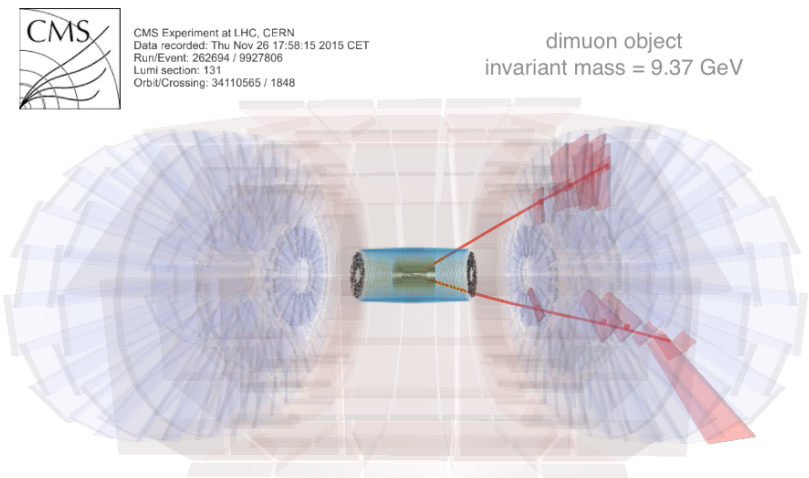


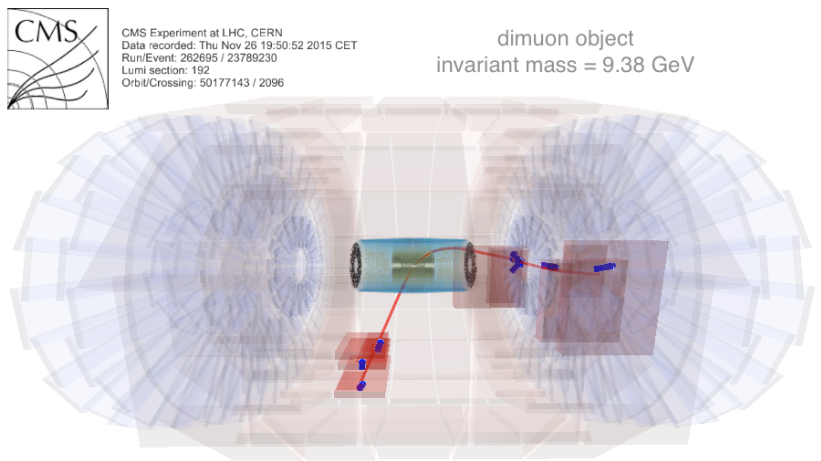
Coherent J/ψ photoproduction in ultra-peripheral PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the CMS experiment

Done for J/ψ. Now with a new kinematic range with Υ.

Exclusive Υ photoproduction in Run2 PbPb data

- 2015 PbPb data in CMS
  - $\sqrt{s_{NN}} = 5.02$ TeV
  - integrated luminosity recorded by CMS: 550 μb^{-1}
  - hundreds of Υ candidates
- 2018 PbPb data in CMS
  - $\sqrt{s_{NN}} = 5.02$ TeV
  - integrated luminosity recorded by CMS: 1700 μb^{-1}
  - very good performance of the ZDC
  - expected order of thousand of Υ candidates





Summary

- CMS is a perfect experiment for UPC studies
- Exclusive $\rho(770)^0$ photoproduction in pPb
  - Sensitive to gluon distribution in the proton at $x \sim 10^{-4} - 10^{-2}$
  - Extends HERA results
  - Cross-sections in agreemen with the power law dependence of $W_{\gamma p}$ observed at HERA
  - Upcoming measurement at 8 TeV with much larger statistics
- Exclusive Υ photoproduction in PbPb (ongoing)
  - New kinematic range
  - Improve our understanding of the initial state of relativistic nuclei

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References

[1] *CMS Collaboration, Exclusive $\rho(770)^0$ photoproduction in ultra-peripheral pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with the CMS experiment, Eur. Phys. J. C 79 702, 2019*

[2] *V.P. Gonçalves, F.S. Navarra, D. Spiering, Exclusive ρ and J/ψ photoproduction in ultraperipheral pA collisions: Predictions of the gluon saturation models for the momentum transfer distributions, Phys. Lett. B791 299-304, 2019*

[3] *Kari J. Eskola Petja Paakkinen, Hannu Paukkunen, Carlos A. Salgado, EPPS16: Nuclear parton distributions with LHC data, arXiv:1612.05741, 2016*

[4] *CMS Collaboration, Coherent J/ψ photoproduction in ultra-peripheral PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the CMS experiment, Phys. Lett. B 772 489, 2017*

[5] *CMS Collaboration, Constraining nuclear parton distributions with heavy ion collisions at the HL-LHC with the CMS experiment, CMS-PAS-FTR-18-027, 2018*

Systematic uncertainties – exclusive ρ in pPb collisions

$y_{\pi^+\pi^-}$ interval	$(-2.0, 2.0)$	$(-2.0, -1.2)$	$(-1.2, 0.0)$	$(0.0, 1.2)$	$(1.2, 2.0)$
Integrated luminosity	4.0	4.0	4.0	4.0	4.0
Track reconstruction	7.8	7.8	7.8	7.8	7.8
Unfolding	3.0	3.0	3.0	3.0	3.0
Photon flux calculation	5.0	2.0	4.0	6.0	9.0
Calorimeter exclusivity	1.4	1.4	1.4	1.4	1.4

Results

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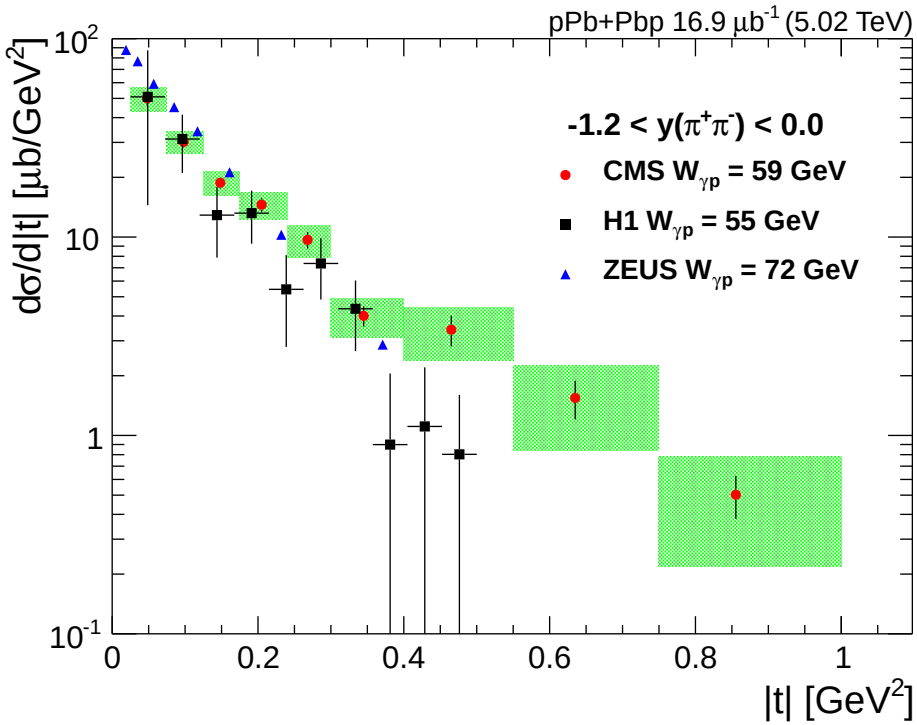
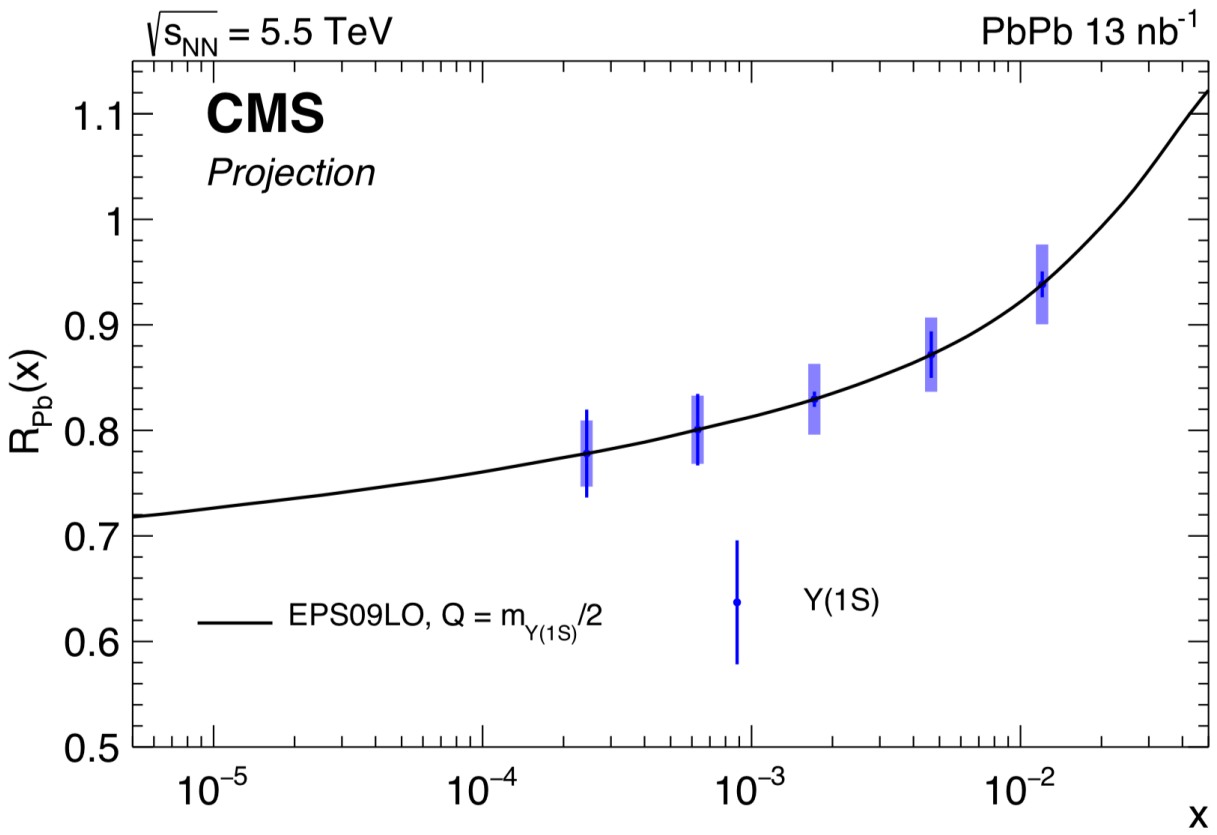


- Fit with the form Ae^{-bt+ct^2} for $0.025 < |t| < 0.5$ GeV^2
- b= 9.2 $\pm$ 0.7 (stat) GeV^{-2} and c = 4.6 $\pm$ 1.6 (stat) GeV^{-4}

Predictions for HL LHC [5]



Constraining nuclear parton distributions with heavy ion collisions at the HL-LHC with the CMS experiment