Exclusive Υ and $\rho(770)^0$ photoproduction in pPb at $\sqrt{s_{NN}} = 5.02$ TeV

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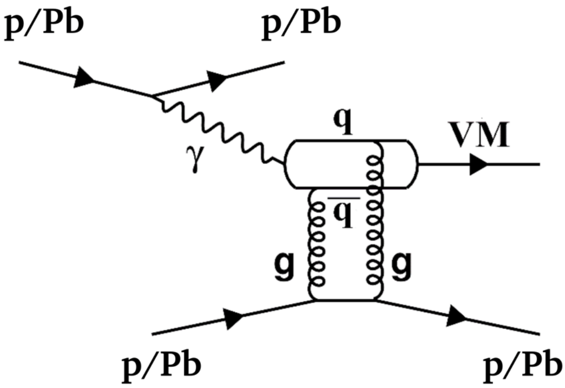
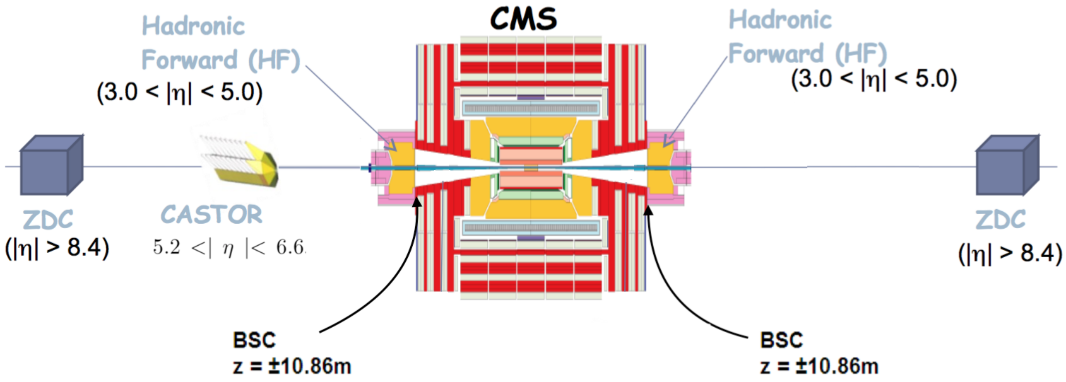
Ultra-Peripheral Collisions (UPC)



- The study of exclusive photoproduction offers a probe of target hadron structure, its generalized parton distributions

CMS Detector



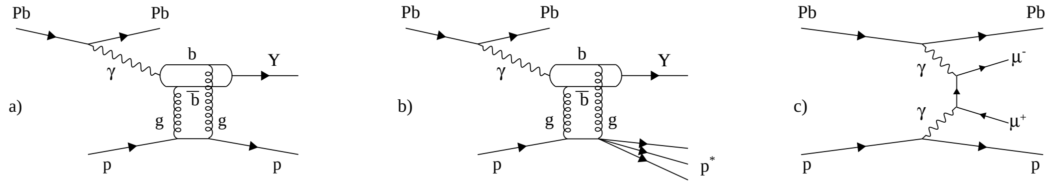
Exclusive Υ photoproduction in pPb

CMS collaboration,

Measurement of exclusive Υ photoproduction from protons in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

Eur. Phys. J. C 79 (2019) 277

Data and event topology



Exclusive production

Semi-exclusive production

Background

Data

- Data: CMS, pPb $\sqrt{s_{NN}} = 5.02$ TeV (2013)
- $\mathcal{L} = 32.6\text{nb}^{-1}$
- Υ meson rapidity range: $|y| < 2.2$
- Photon-proton centre-of-mass energy:
  $91 < W_{\gamma p} < 826$ GeV
  $W^2_{\gamma p} = 2E_p m_\Upsilon e^{\pm y}$

MC generator

STARLIGHT:

- Exclusive Υ(nS) photoproduction events
- Exclusive QED background

Event selections

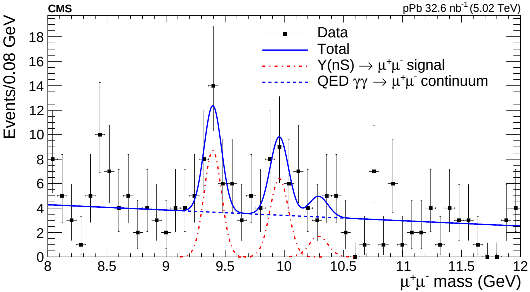
Event selection

Online selection:

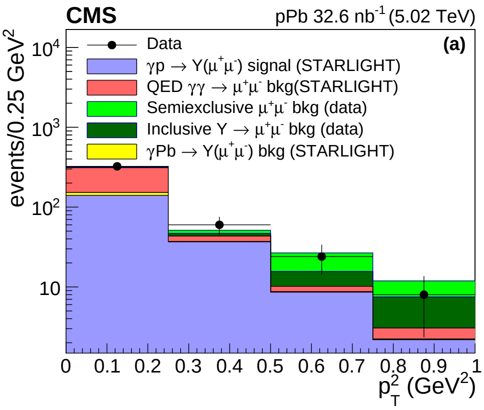
- At least one muon
- Number of tracks: $[1, 6]$

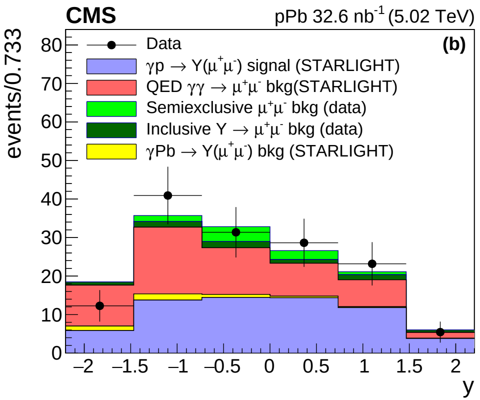
Offline selection:

- Two opposite-charge muons with: $p_T > 3.3$ GeV, $|\eta_\mu| < 2.2$
- Single vertex with no extra charged particles with $p_T > 0.1$ GeV
- HF tower energy deposit < 5 GeV
- For dimuon selection: $0.1 \text{ GeV} < p_T < 1$ GeV

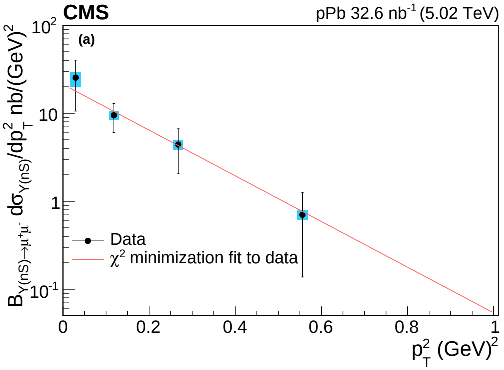


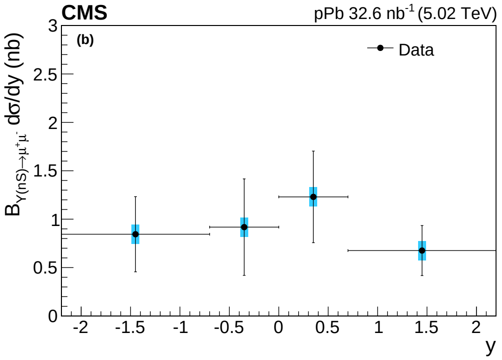
Comparison to background





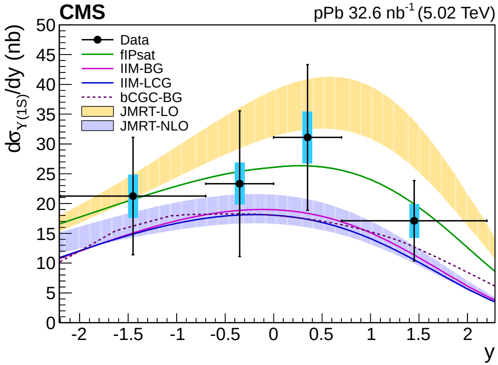
Result

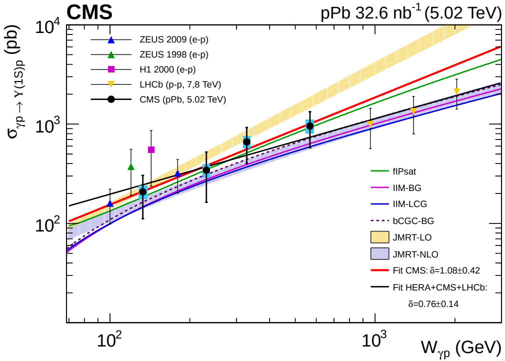




- Fitted as $\sigma \sim e^{-bp_T^2}$
- b $= 6.0 \pm 2.1$ (stat) $\pm\, 0.3$ (syst) GeV^{-2}
- Consistent with ZEUS results: b $= 4.3^{+2.0}_{-1.3}$ (stat)$^{+0.5}_{-0.6}$ (syst) GeV^{-2}

Result: comparison with predictions and other data





- CMS results between previous ZEUS and LHCb data.
- δ (CMS only) $= 1.08 \pm 0.42$
- δ (ZEUS) $= 1.2 \pm 0.8$
- $\sigma \sim W_{\gamma p}^{\delta}$
- δ (CMS + ZEUS + H1) $= 0.99 \pm 0.27$
- δ (CMS + ZEUS + H1 + LHCb) $= 0.77 \pm 0.14$

Exclusive $\rho(770)^0$ photoproduction in pPb

CMS collaboration,
Measurement of exclusive $\rho(770)^0$ photoproduction in ultraperipheral pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
Eur. Phys. J. C 79 (2019) 702

$\rho(770)^0$ photoproduction

Data

- Decay mode: $\rho(770)^0 \to \pi^+\pi^-$
- Data: CMS, pPb $\sqrt{s_{NN}} = 5.02$ TeV (2013)
- $\mathcal{L} = 16.9\mu\text{b}^{-1}$
- Photon-proton centre-of-mass energy:
  $29 < W_{\gamma p} < 213$ GeV
- $0.025 < |t| < 1.000$ GeV^2

MC generator

STARLIGHT:

- Exclusive $\rho(770)^0$ (resonant and non-resonant)
- Exclusive $\rho(1700)^0$

Event selections

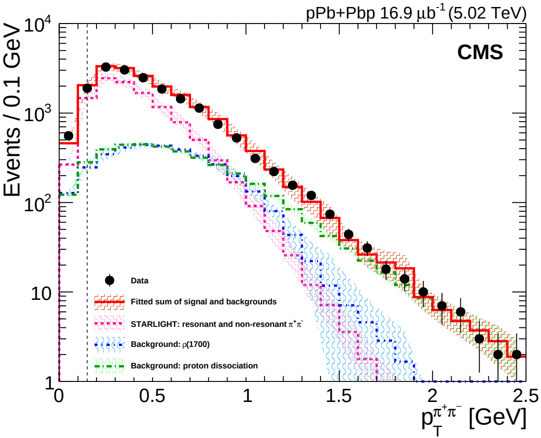
Event selection

Online selection:

- At least one track

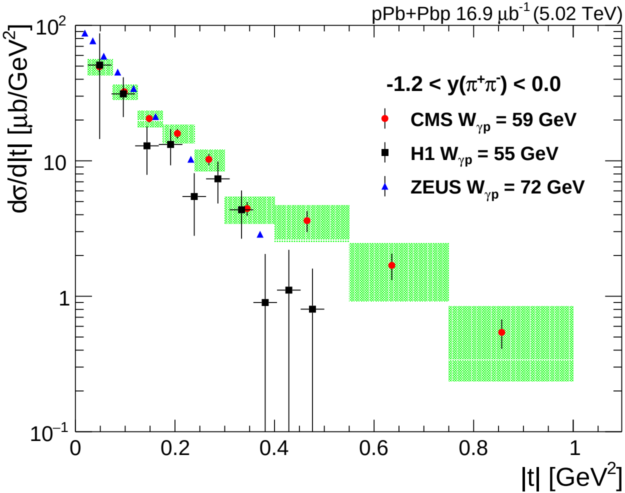
Offline selection:

- Leading HF tower < 3 GeV
- Exactly two tracks from the same PV with $|\eta_{track}| < 2.0$, $p_T^{lead} > 0.4$ GeV, $p_T^{sublead} > 0.2$ GeV
- $|y_{\pi^+\pi^-}| < 2.0$
- Leading HE tower < 1.95 GeV
- CASTOR energy < 9 GeV
- ZDC$^+$ energy < 500 GeV
- ZDC$^-$ energy < 2000 GeV



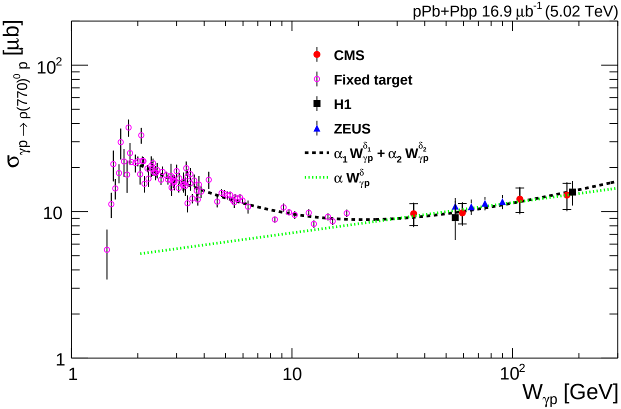
Results for $d\sigma/d|t|$

- Fitted as: Ae^{-bt+ct^2}
- $b = 9.2 \pm 0.7$ (stat) GeV^{-2},
  $c = 4.6 \pm 1.6$ (stat) GeV^{-4}
- Regge formula: $b = b_0 + 2\alpha' ln(W_{\gamma p}/W_0)^2$
- $W_0 = 92.6$ GeV
- $\alpha' = 0.28 \pm 0.11$ (stat) ± 0.12 (syst) GeV^{-2}, consistent with ZEUS data and Regge expectations



Results for σ

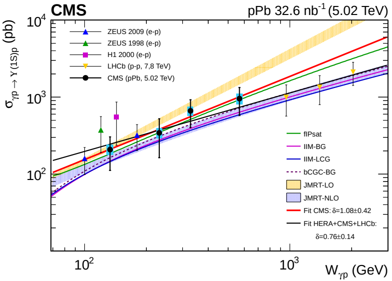
- Fitted with: $\alpha_1 W_{\gamma p}^{\delta_1} + \alpha_2 W_{\gamma p}^{\delta_2}$ (full range)
- Fitted with: $\alpha W_{\gamma p}^{\delta}$ (CMS and HERA combined)
- $\delta_1 = -0.81 \pm 0.04$ (stat) ± 0.09 (syst)
- $\delta_2 = 0.36 \pm 0.07$ (stat) ± 0.05 (syst)
- $\delta = 0.24 \pm 0.13$ (stat) ± 0.04 (syst)

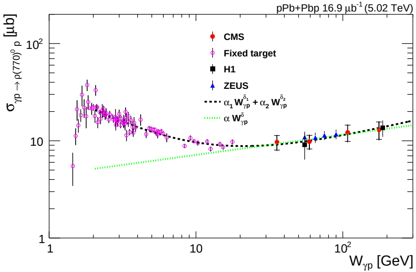


Summary:

- The first measurement of the exclusive photoproduction of Υ in UPC pPb at $\sqrt{s_{NN}} = 5.02$ TeV is performed by CMS
- The data are consistent with available pQCD approaches of the low-x gluon proton density
- The new insights on the gluon proton distribution in this poorly explored region between ZEUS and LHCb data

- The first measurement of the exclusive photoproduction of $\rho(770)^0$ in pPb at $\sqrt{s_{NN}} = 5.02$ TeV is performed by CMS
- The results are consistent with electron-proton DIS at HERA, i.e. lead ions can act as a source of quasi-real photons
- Measured $d\sigma/d|t|$ systematically lower than STARLIGHT generator predictions in the high-$|t|$ region





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Data and STARLIGHT comparison for $\rho(1700)^0$