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

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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)

ZDC ($|\eta| > 8.4$)

CASTOR ($5.2 < |\eta| < 6.6$)

BSC $z = \pm 10.86 \text{m}$

Hadronic Forward (HF) ($3.0 < |\eta| < 5.0$)

Events are very clean with two muon Tracks and no activity in the entire detector UPC trigger: low-multiplicity (< 6 tracks) in tracker
Measurement of exclusive $\rho(770)^0$ photoproduction in ultraperipheral pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

arXiv:1902.01339

• 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 $\rho(770)^0 \rightarrow \pi^+ \pi^-$
• 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
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
\[ \sigma(\gamma p \rightarrow \rho(770)^0) = 11.0 \pm 1.4\text{(stat)} \pm 1.0\text{(syst)} \mu b \]

- for \( 29 < W_{\gamma p} < 213 \text{ GeV} \)

\[ \delta = 0.24 \pm 0.13\text{(stat)} \pm 0.04\text{(syst)} \]

- both CMS and HERA data

Consistent with H1 and ZEUS Collaborations at HERA

Ion-proton collisions can be used similarly to electron-proton
First measurement of the energy dependence of the $d\sigma/dt$
Sensitive to the onset of the gluon saturation
Exclusive γ photoproduction in Run2 PbPb data from CMS
Motivation [3] [4]

\[ R_{i}^{A}(x, Q^{2}) = \frac{f_{i}^{A}(x, Q^{2})}{A f_{i}^{P}(x, Q^{2})} \]

Done for \( J/\psi \). Now with a new kinematic range with \( \Upsilon \).
Exclusive $\Upsilon$ photoproduction in Run2 PbPb data

- **2015 PbPb data in CMS**
  - $\sqrt{s_{NN}} = 5.02$ TeV
  - integrated luminosity recorded by CMS: 550 $\mu$b$^{-1}$
  - hundreds of $\Upsilon$ candidates

- **2018 PbPb data in CMS**
  - $\sqrt{s_{NN}} = 5.02$ TeV
  - integrated luminosity recorded by CMS: 1700 $\mu$b$^{-1}$
  - very good performance of the ZDC
  - expected order of thousand of $\Upsilon$ candidates
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 agreement with the power law dependence of $W_{\gamma p}$ observed at HERA
- Upcoming measurement at 8 TeV with much larger statistics

Exclusive $\Upsilon$ photoproduction in PbPb (ongoing)
- New kinematic range
- Improve our understanding of the initial state of relativistic nuclei

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[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


[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 $\rho$ in pPb collisions

<table>
<thead>
<tr>
<th>$y_{\pi^+\pi^-}$ interval</th>
<th>(−2.0, 2.0)</th>
<th>(−2.0, −1.2)</th>
<th>(−1.2, 0.0)</th>
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<td>Integrated luminosity</td>
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Results

arXiv:1902.01339, Submitted to EPJC

- Fit with the form $A e^{-bt + ct^2}$ 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$^{-4}$
Constraining nuclear parton distributions with heavy ion collisions at the HL-LHC with the CMS experiment