Measurement of coherent J/ ψ photoproduction in Pb-Pb collisions with ALICE

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Outline



- Motivation
- Photoproduction
- Ultra-peripheral collisions
- ALICE
- Results and data analysis

Motivation



- The structure of proton in DIS is described by the parton distribution functions $xf(x, Q^2)$
 - *x* fraction of momentum of proton carried by the parton
 - Q^2 four momentum transferred in the collision
- In leading order, distribution function $xf(x, Q^2)$ can be interpreted as the contribution of the given partons to the proton composition

Motivation



- The structure of proton in DIS is described by the parton distribution functions $xf(x, Q^2)$
 - *x* fraction of momentum of proton carried by the parton
 - Q^2 four momentum transferred in the collision
- In leading order, distribution function xf(x, Q²) can be interpreted as the contribution of the given partons to the proton composition
- At low *x* the main contribution is from gluons
- Nucleus is not a simple sum of nucleons

$$R_{F_2}^A(x,Q^2) = \frac{F_2^A(x,Q^2)}{AF_2^{\text{nucleon}}(x,Q^2)} \neq 1$$



Photoproduction



• Coherent photoproduction of J/ψ in Pb-Pb collisions





Photon emission - QED

- Lead ion at speed close to *c*
- Its electromagnetic field is contracted
 - It can be described as a flux of quasi-real photons
 - Maximum energy of the photons is given by the Lorentz boost of the ion
- The intensity of the photon flux is proportional to Z^2





Photoproduction







• High mass of the J/ψ

----- Perturbative calculations

 Small decay width and sizeable branching ratio to leptons
Clear experimental signal





$$\frac{d\sigma_{\gamma Pb}^{t=0}}{dt} = \frac{16 \Gamma_{ee} \pi^3}{3\alpha_{\rm em} M_{J/\psi}^5} \{\alpha_{\rm s}(Q^2) G_{\rm Pb}(x,Q^2)\}^2$$

Photon target interaction - QCD

- In LO QCD
 - The coherent J/ψ photoproduction cross section \propto gluon density squared
- Many models using various approaches to describe **nuclear shadowing**





M.G. Ryskin, Z.Phys. C57 (1993) 89-92





ALICE

- We have to distinguish between photoproduction and hadronic interactions
 - The strong interaction is short range
 - Lead nucleus breaks after interacting via the strong force



Ultra-peripheral collisions





- The strong interaction is short range
- Lead nucleus breaks after interacting via the strong force

• Interactions at impact parameter *b* larger than the sum of the radii of the colliding particles $R_1 + R_2$, which involve at least one photon are called

• ALICE can determine if the colliding nuclei broke or not with high efficiency







- We measure the J/ψ using its decay into pair of leptons in an otherwise empty detector:
 - e^+e^- and $\mu^+\mu^-$ in the central barrel
 - $\mu^+\mu^-$ in the muon spectrometer
- For triggering and background suppression
 - Detectors close to the beam line







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ALICE









• Integrated luminosity of about 55 μ b⁻¹

Phys. Lett. B 718 (2013) 1273-1283

- p_T fit to determine the coherent contribution
 - At low p_T coherent contribution is dominant

ALICE Pb-Pb UPC at mid rapidity at $\sqrt{s_{NN}} = 2.76$ TeV





- Integrated luminosity of about 23 μ b⁻¹
- p_T fit to determine the coherent contribution
 - At low p_T coherent contribution is dominant



$$\frac{\mathrm{d}\sigma_{\mathrm{J}/\psi}^{\mathrm{coh}}}{\mathrm{d}y} = \frac{N_{\mathrm{J}/\psi}^{\mathrm{coh}}}{(\mathrm{Acc} \times \varepsilon)_{\mathrm{J}/\psi} \cdot BR(\mathrm{J}/\psi \longrightarrow \mu^+\mu^-) \cdot \mathscr{L}_{\mathrm{int}} \cdot \Delta y}$$





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Number of produced J/ψ



























ALICE Pb-Pb UPC at $\sqrt{s_{NN}} = 2.76 \text{ TeV}$





- Measurement specially sensitive to nuclear shadowing
- Computation without shadowing rejected by data
- Models with moderate nuclear shadowing are favoured







- Larger data sample ~ 50 times more data than in Run 1 ALI-DER-143772
- Larger sample and higher collisions energy —> Better measurement —> Stronger constraints to models
- Analysis in progress Preliminary results again favor moderate nuclear shadowing

Measurement of coherent J/ ψ photoproduction in Pb-Pb collisions with ALICE





- Gluon structure of protons and nuclei at low Bjorken x (nuclear shadowing) can be studied by measuring the cross section of coherent J/ψ photoproduction
- Photoproduction cross section can be measured in UPC with ALICE
- Pb-Pb at $\sqrt{s_{NN}} = 2.76 \text{ TeV}$
 - Favours moderate nuclear shadowing
- Pb-Pb at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$
 - Larger data sample and higher energy
 - Preliminary results are available, work is being done on finalising them
 - New data collected during November 2018





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Thank you for your attention!