Coherent J/ψ photoproduction in ultra-peripheral Pb-Pb collisions with ALICE at the LHC

IV International Conference on Particle Physics and Astrophysics

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FNSPE CTU in Prague

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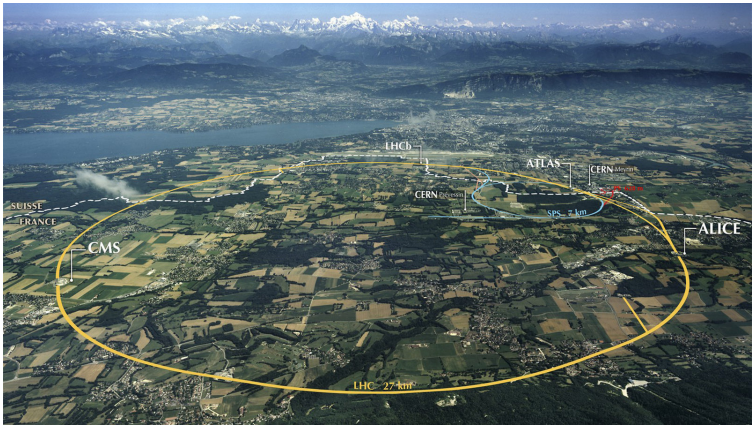
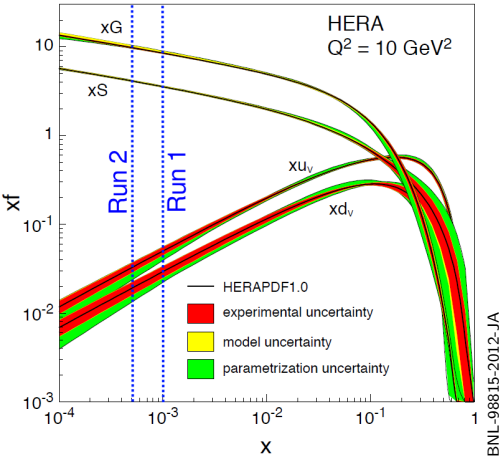
Content

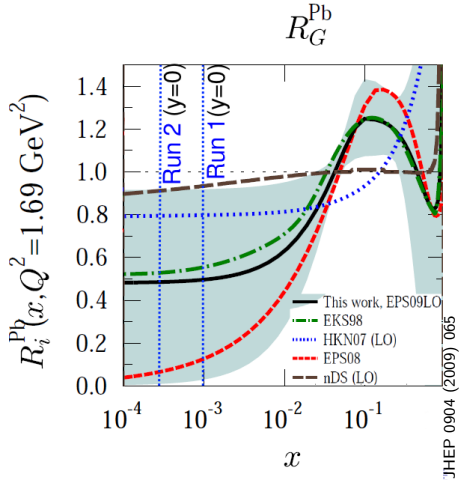


Motivation

Where QCD is now

- Proton is mainly gluons for Bjorken $x < 10^{-3}$ (HERA).
- LHC gives the possibility to study the gluonic structure of lead nuclei at small Bjorken x.

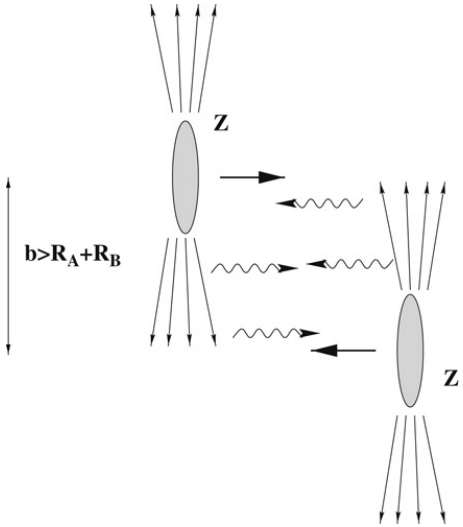




Ultra-peripheral collisions

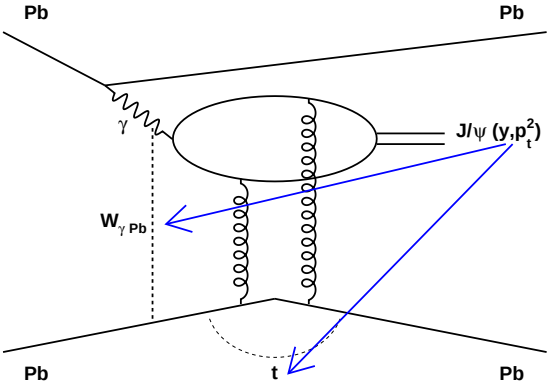
- Collisions with impact parameter $b > R_A + R_B$.
  - Strong interaction suppressed.
  - EM interaction remains.

- EM field of ultra-relativistic electrically charged particle $\sim$ flux of photons.
  - Flux intensity increasing with Z^2.



Phys.Rept. 458 (2008) 1-171

Tool to use light to study gluons

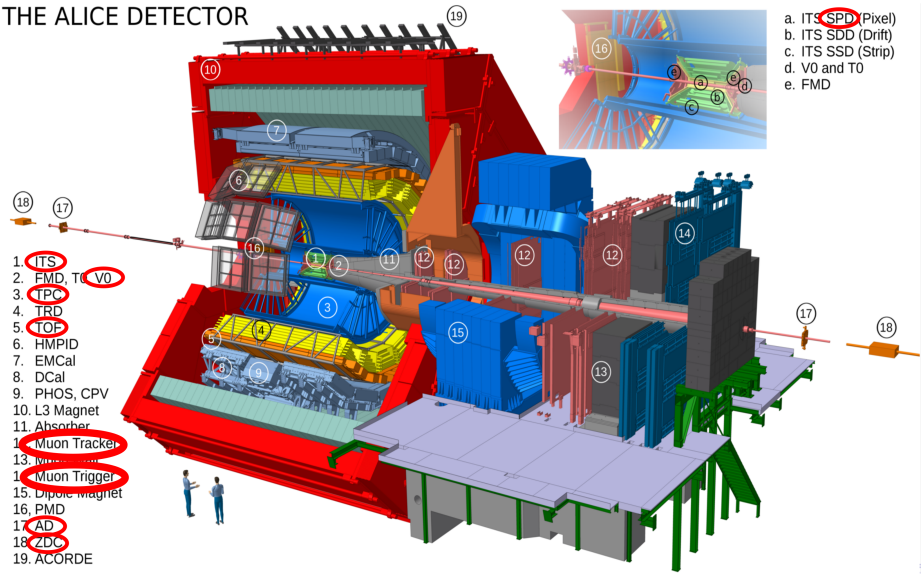


- Coherent photoproduction of J/ψ (hard scale).
- Provides information on gluon shadowing in nuclei at low-x.

$$\left.\frac{\mathrm{d}\sigma_{\gamma A\to J/\psi A}}{\mathrm{d}t}\right|_{t=0} = \frac{M_{J/\psi}^3 \Gamma_{ee}\pi^3\alpha_s^2(Q^2)}{48\alpha_{em}Q^8}\left[xg_{A(x,Q^2)}\right]^2$$

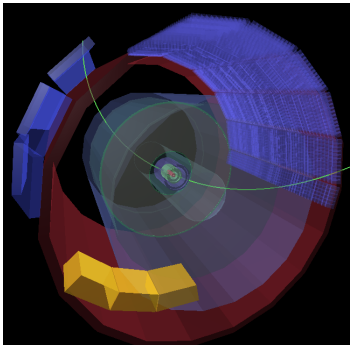
Ryskin: Z. Phys. C 57, 89 (1993)

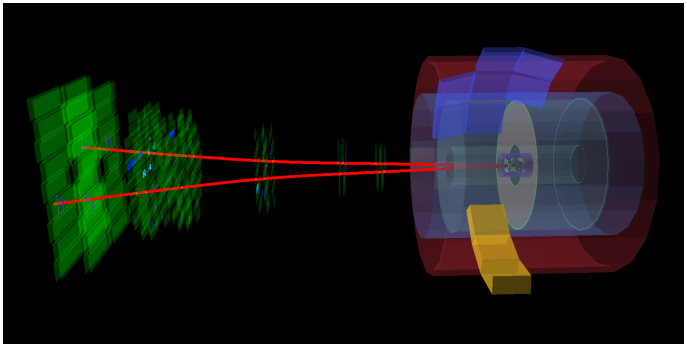
Experimental setup



What we look for in a collision

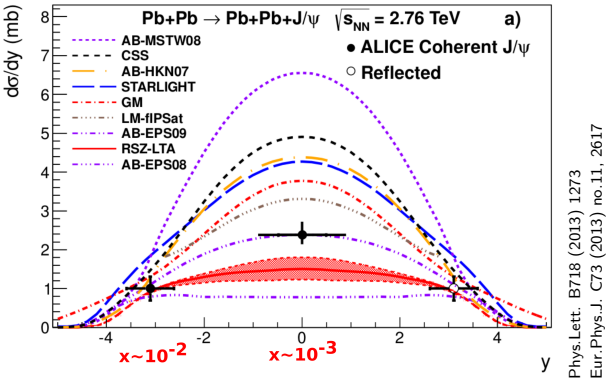
- Central rapidity events:
  - VETOs in forward detectors,
  - 2 back-to-back leptons (ITS/TPC/TOF).
- Forward rapidity events:
  - VETOs in forward/central detectors,
  - 2 muons (Muon chambers).





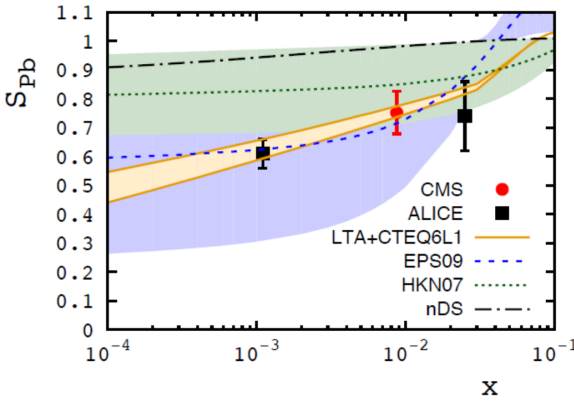
Results overview

Published results - Pb-Pb collisions at ALICE



- Forward and central rapidity region.
- Large spread of predictions before the measurement.
- Disfavour no and strong nuclear shadowing models.

Published results - What we have learnt



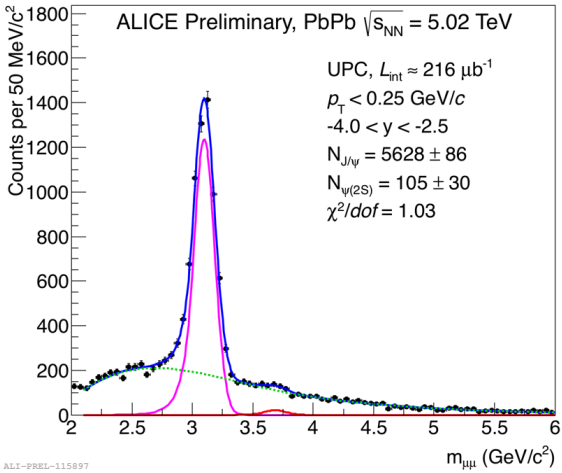
Phys. Lett. B 726 (2013) 290-295

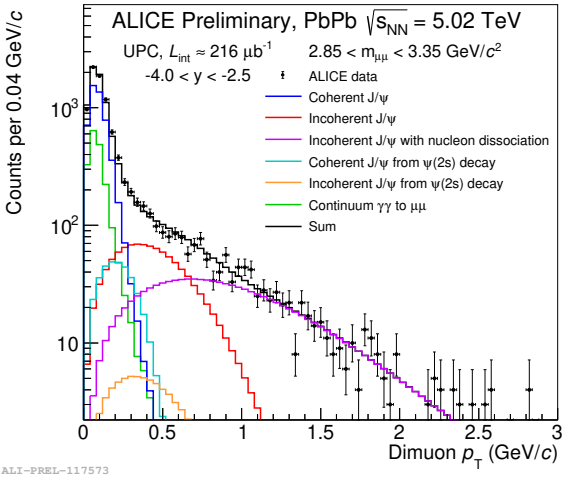
$$S_{Pb}(W_{\gamma p}) = \left[\frac{\sigma^{exp}_{\gamma Pb\to J/\psi Pb}(W_{\gamma p})}{\sigma^{IA}_{\gamma Pb\to J/\psi Pb}(W_{\gamma p})}\right]^{1/2}$$

$$x = \frac{M^2_{J/\psi}}{W^2_{\gamma p}}$$

- Based on experimental inputs:
- Pb-Pb UPC experimental cross section.
- Impulse approximation (γ-p data).
- Good agreement with EPS09 and LTA.

Preliminary results - Pb-Pb collisions at ALICE of Run 2





- Clear J/ψ signal, well understood p_T spectrum.

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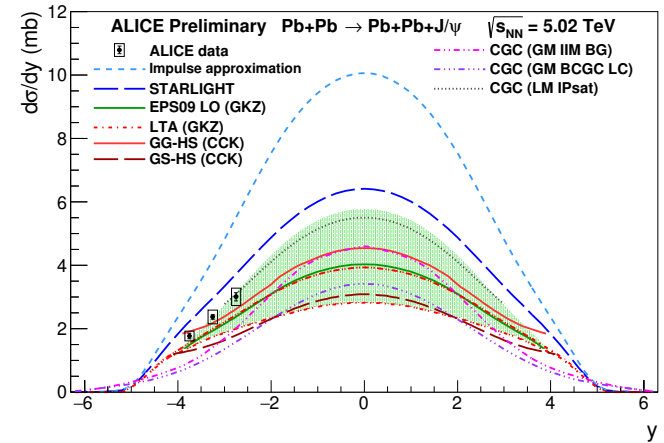
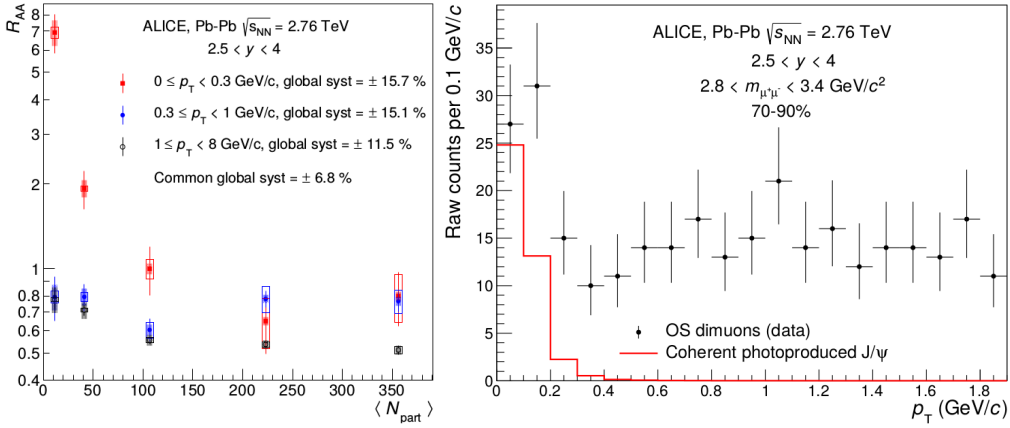


- New measurements at higher energies with higher luminosity are underway.
- These will tell more about the gluon content of nuclei and its Bjorken-x evolution.

Surprise

Excess in peripheral events

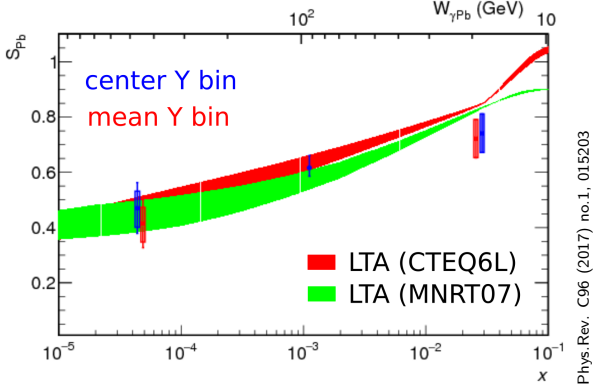
Published results - Pb-Pb collisions at ALICE



Phys.Rev.Lett. 116, 222301 (2016)

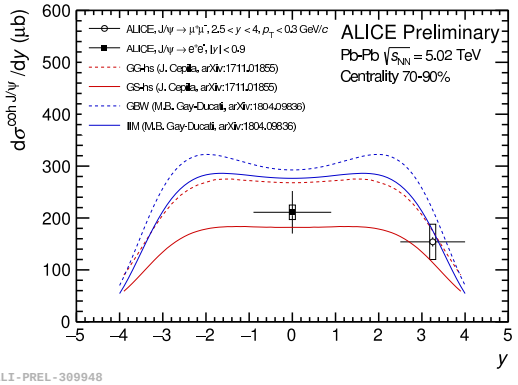
- Low-p_T excess in peripheral collisions, first visible in Run 1.
- Interpreted as coherent J/ψ photoproduction.

What we have learnt - Nuclear gluon shadowing in Lead



- Two contributions at forward rapidity: low and high-x.
- This measurement and the UPC one allow us to study $g(x)$ in lead down to $\sim 5x^{-5}$.

Preliminary results - Pb-Pb collisions at ALICE of Run 2



- New data at higher energies.
- Preliminary cross sections at mid and forward rapidities.
- The new UPC and peripheral data will allow us to put constraints on pQCD models.

Outlook

- 2015 Pb-Pb collisions:
  - Working to finalise the UPC and peripheral analysis.
- November 2018 new Pb-Pb collisions:
  - Higher interaction rate $\rightarrow$ even more statistics.
  - Better triggers.
- LHC Run 3 and Run 4:
  - Higher luminosity (Up to 13 nb^{-1} in comparison to expected in Run 2 $\sim$1 nb^{-1}).
  - ALICE will read-out data continuously.
  - No triggering $\rightarrow$ better efficiency.

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More interesting data are coming - stay tuned!

BACK UP

Preliminary invariant mass of Run 2 - central