



ALICE

Creighton
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U.S. DEPARTMENT OF
ENERGY

Office of Science

Recent results on ultra-peripheral heavy-ion collisions at ALICE

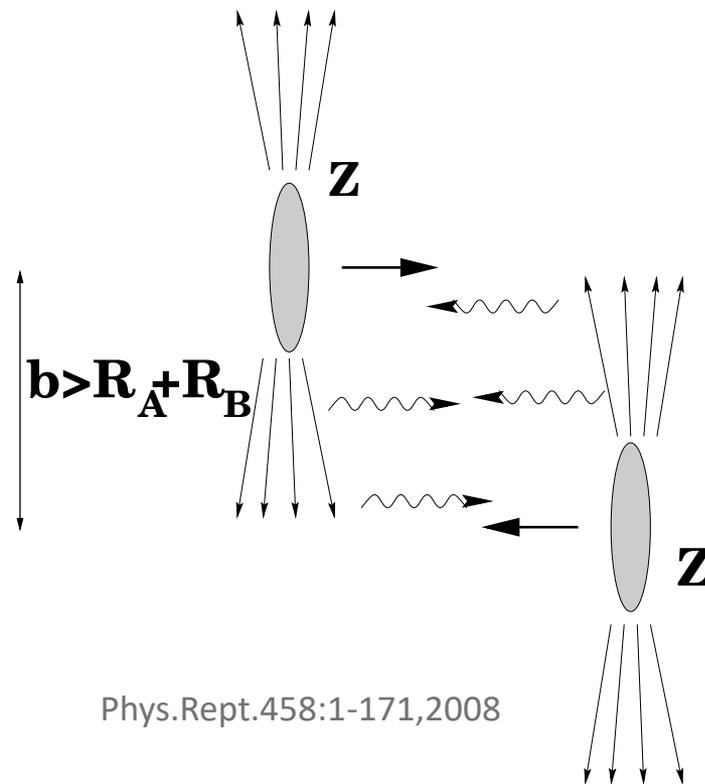
Ritsuya Hosokawa
for the ALICE Collaboration

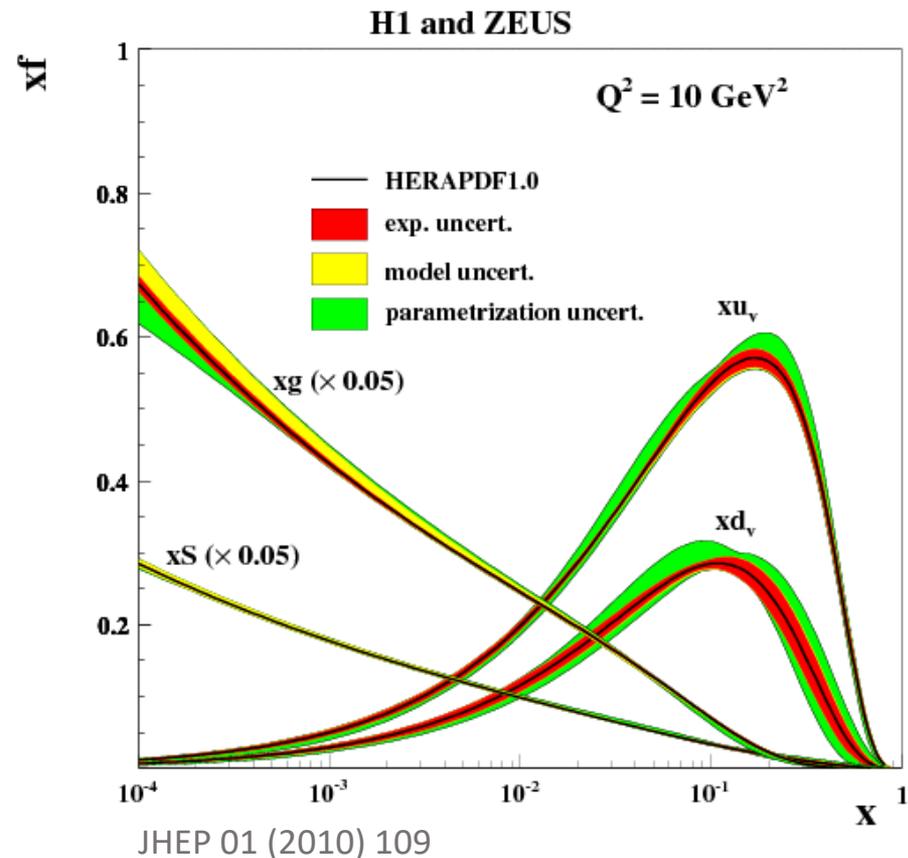
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The Annual US LHC Users Association Meeting
at Rice University, 15-17 Oct. 2019



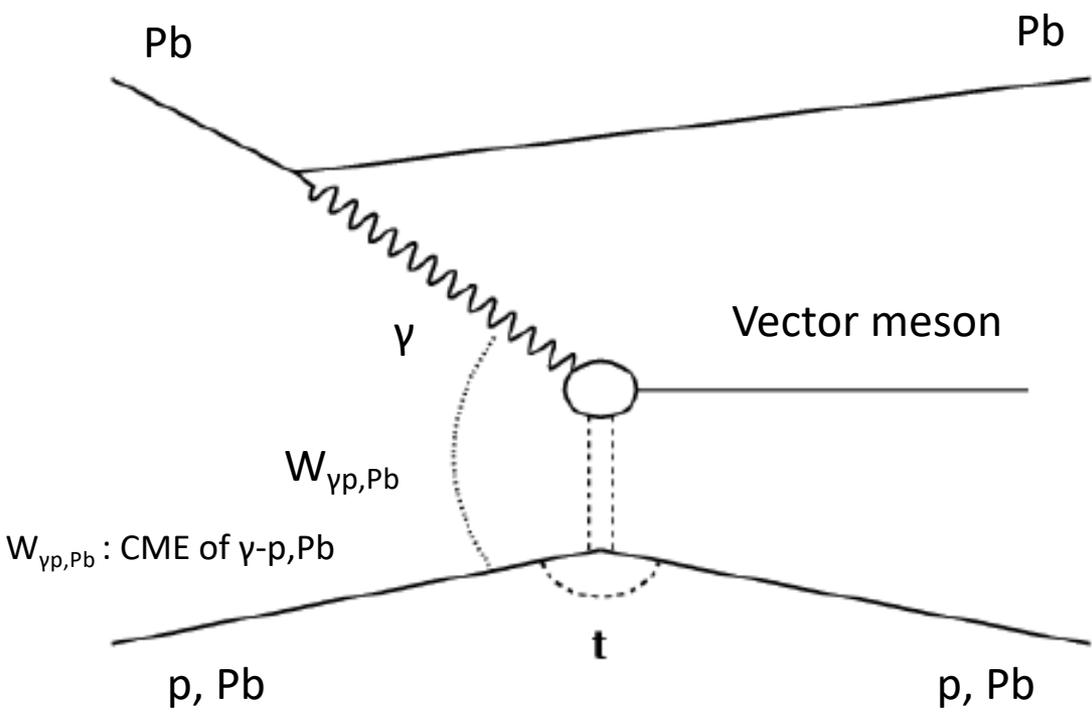
- The collisions with impact parameter $b > R_A + R_B$ where $R_{A,B}$ are the radii of nuclei A and B
 - EM induced processes are dominant
 - Photon-Photon
 - Photon-Nucleus (nucleon)
 - Hadronic interactions are largely suppressed
- The photon flux $\propto Z^2$ (Z: atomic number)





- The proton structure is dominated by gluons at low Bjorken- x ($x < 10^{-2}$)
- UPC at the LHC provides an excellent probe of the gluonic structure in nuclei (and nucleons) at low Bjorken- x
 - gluon saturation
 - shadowing

Typical picture of vector meson photoproduction



➤ The Bjorken- x is expressed as:

$$x = \frac{M_V}{\sqrt{s_{NN}}} \exp(-y)$$

➤ The relation between CME of the photon-target system and the rapidity

$$W_{\gamma p, Pb}^2 = 2E_{p, Pb} M_V e^{\pm y}$$

➤ The cross section is proportional to the square of gluon density in the target at LO

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

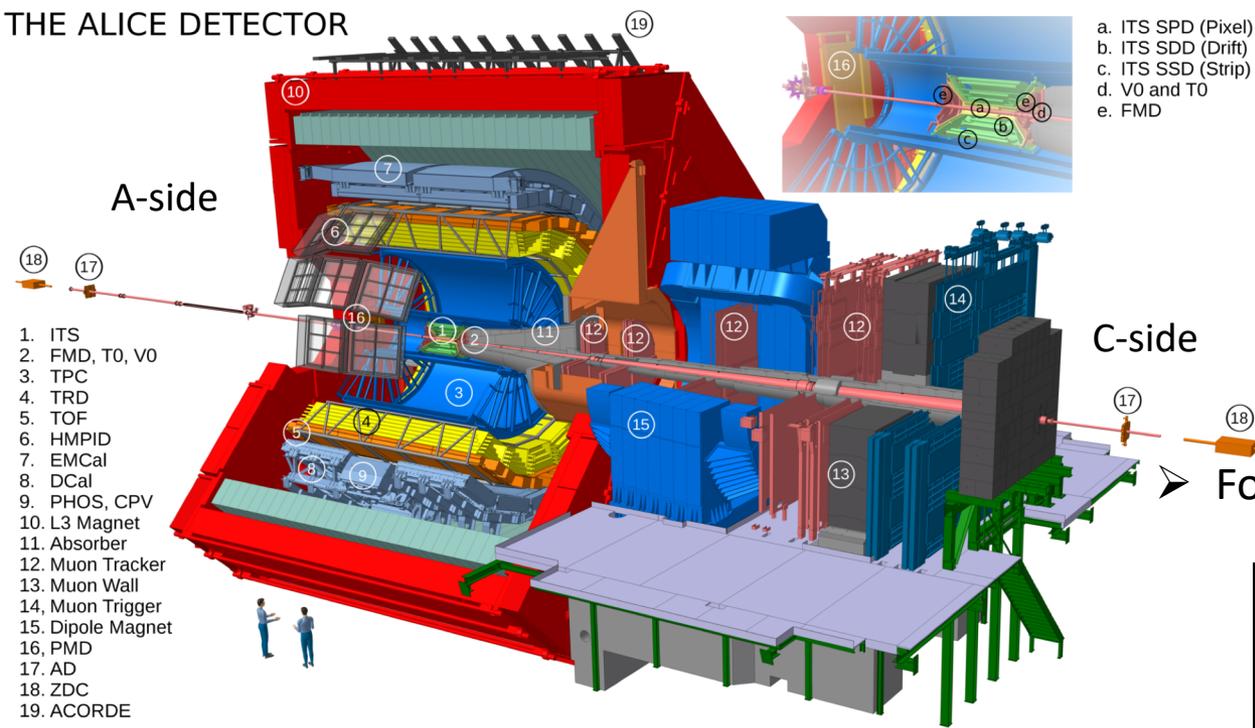
Z.Phys. C57 (1993) 89-92

ALICE detector : vector meson measurement using di-lepton decay channel

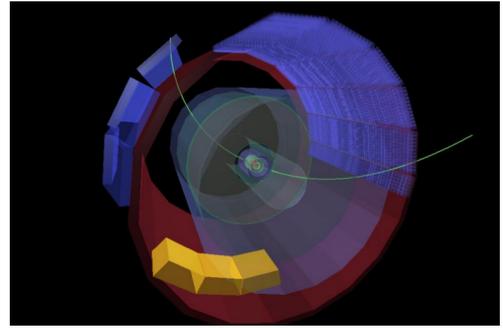


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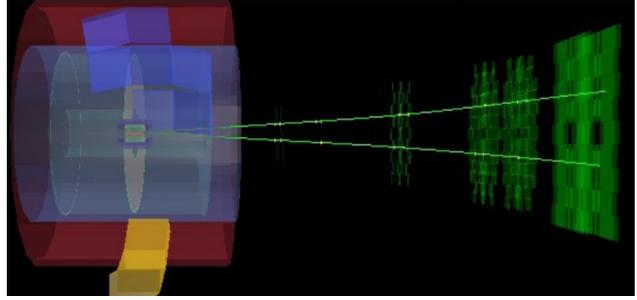
THE ALICE DETECTOR



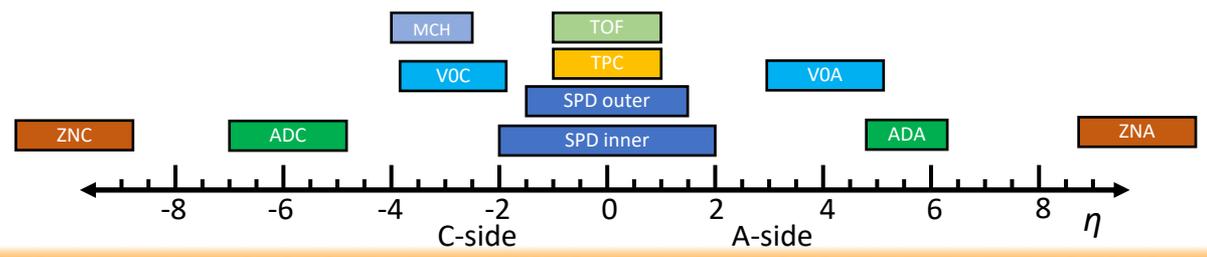
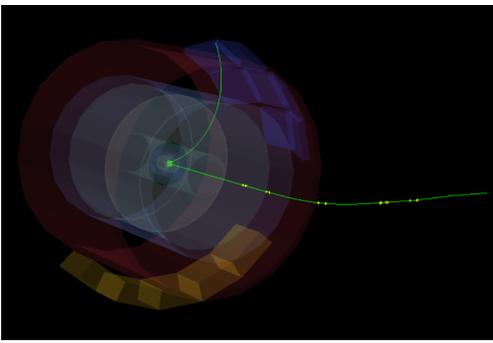
➤ Mid rapidity
➤ ITS + TPC + TOF



➤ Forward rapidity
➤ Muon tracker (MCH)

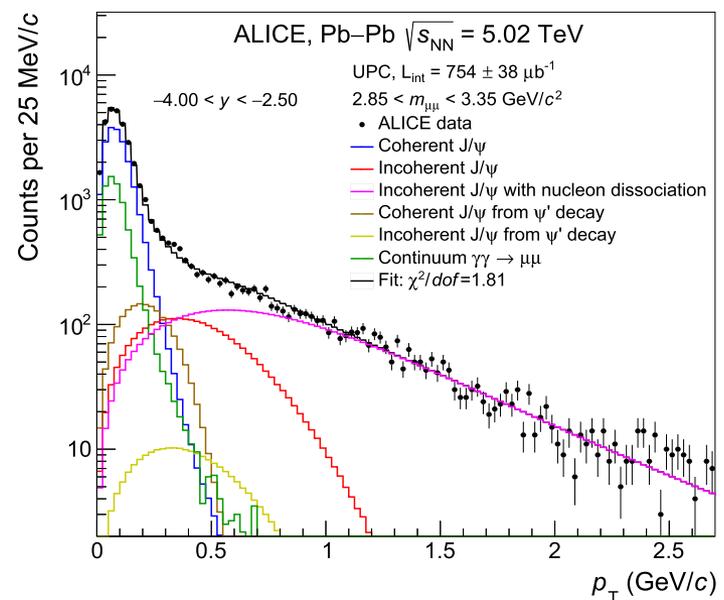
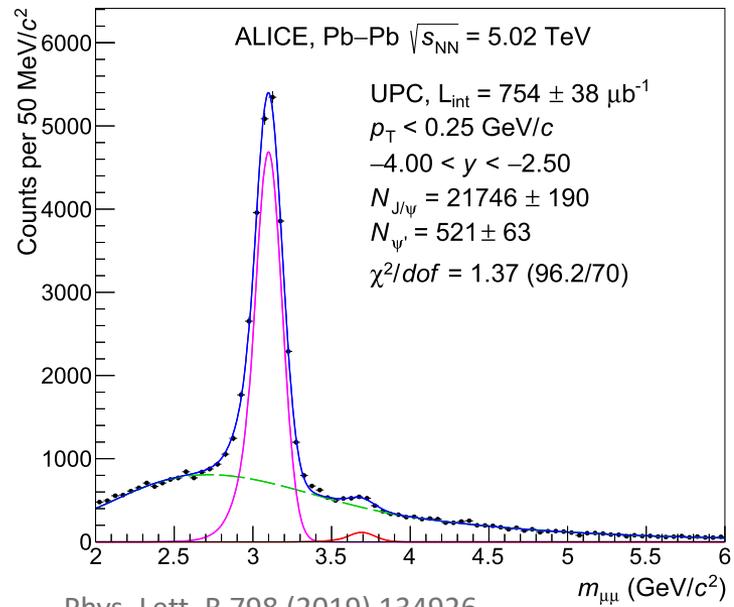


➤ Semi-forward rapidity
➤ ITS+TPC + Muon tracker





- Coherent condition
 - Photon couples coherently to all nucleons: $\langle p_T \rangle \sim 1/R_{Pb} \sim 60 \text{ MeV}/c$
 - Low p_T peak in the spectrum
- Incoherent condition
 - Photon couples to one nucleon: $\langle p_T \rangle \sim 1/R_p \sim 450 \text{ MeV}/c$
 - Higher and broader p_T peak compared to the coherent case



➤ Di-lepton mass spectra are fit by crystal-ball function (signal) + polynomial (background)

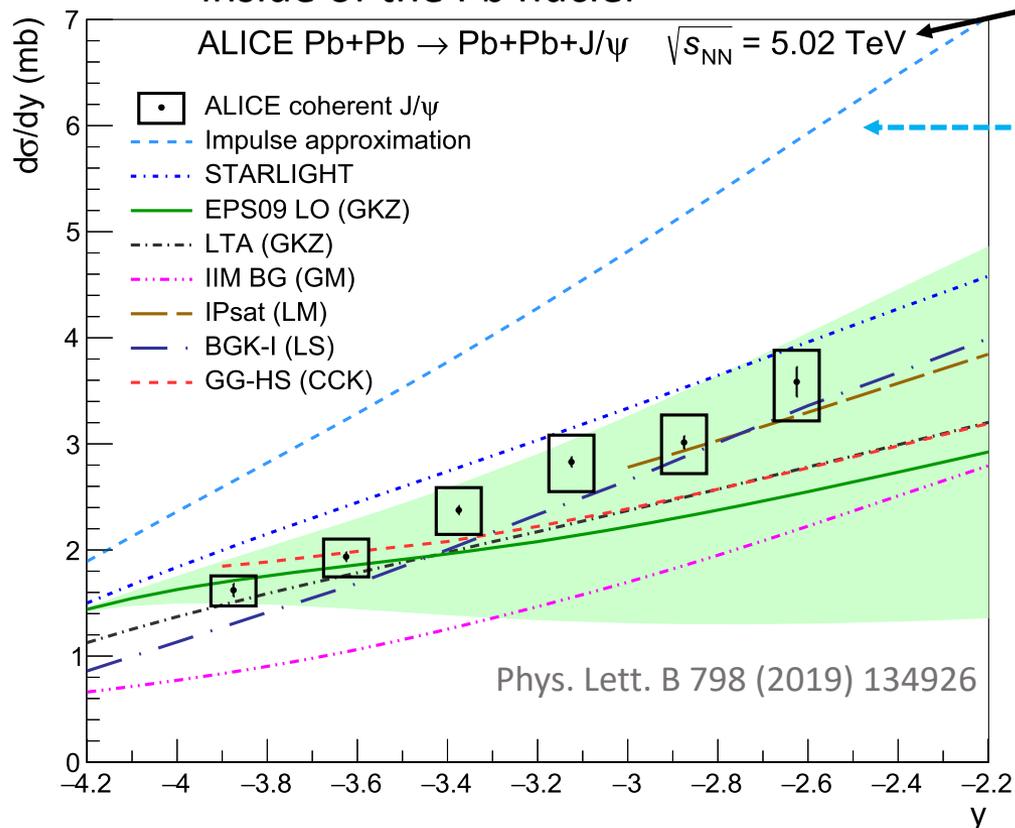
➤ Di-lepton p_T spectrum is fitted by a MC template corresponding to different production mechanisms

Coherent J/ψ at forward rapidity in Pb-Pb ultra-peripheral collisions



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- Studying the gluon distribution inside of the Pb nuclei



x200 statistics compared to Run1

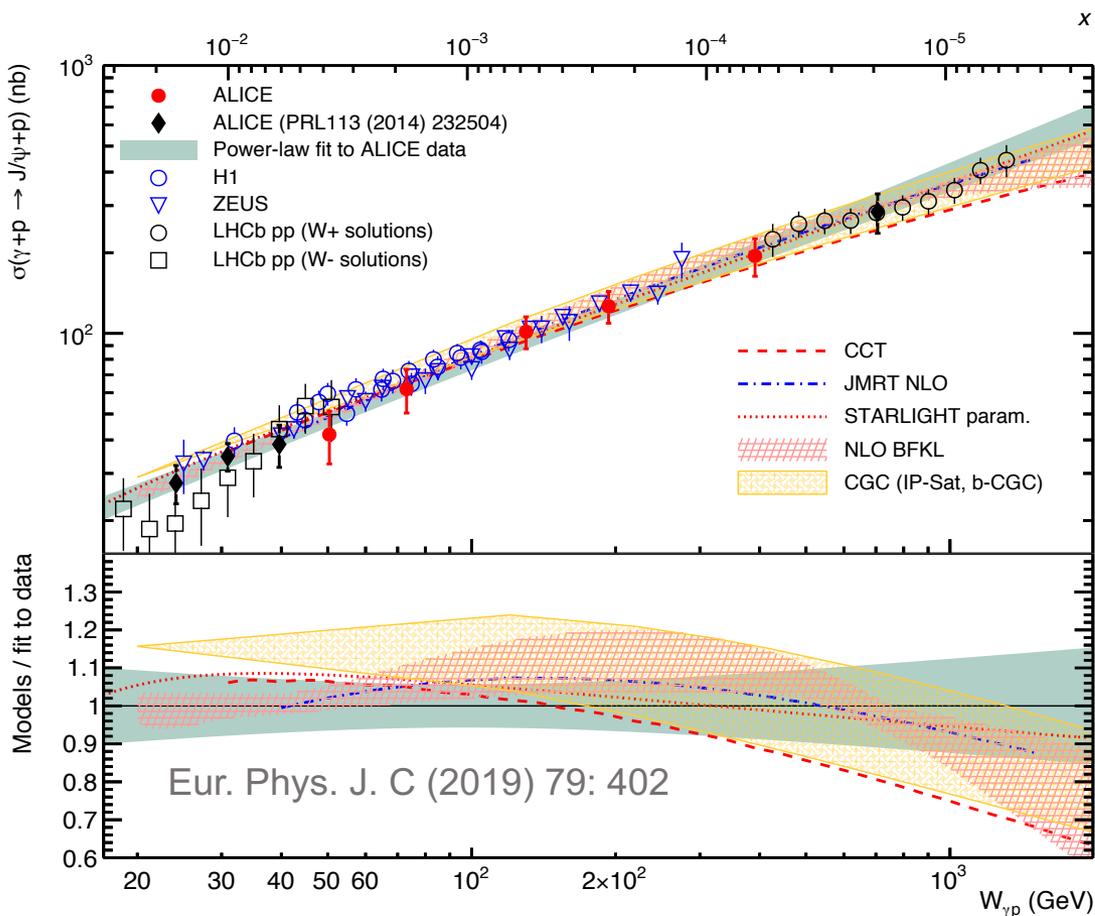
- The impulse approximation (without gluon shadowing effect) shows a significant difference from data
- The BGK-I (LS) and IPsat (LM) models give the best description
 - Based on a saturation prescription in the color-dipole model
- The upper range of the GKZ model based on EPS09 LO is consistent with data

Exclusive J/ψ photo-production in p -Pb ultra-peripheral collisions



ALICE

➤ Studying the gluon distribution inside of the protons



➤ Agreement with various theoretical predictions

➤ NLO pQCD, CGC...

➤ Agreement with other experiments

➤ H1 and ZEUS at HERA

➤ LHCb pp (W^\pm solutions)

➤ The results show the same trend and are on the power-law fit



➤ Other recent results

- Coherent J/ψ photoproduction in peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV (Phys. Rev. Lett. 116 (2016) 222301)
 - Excess of the yield of J/ψ at very low p_T in peripheral collisions
→ interpreted as coherent J/ψ photoproduction in UPC
- Coherent ρ^0 production in Pb-Pb
 - At $\sqrt{s_{NN}} = 5.02$ TeV (ALICE Preliminary, <https://alice-figure.web.cern.ch/node/10164>)
- Coherent $\psi(2S)$ photo-production in Pb-Pb at $\sqrt{s_{NN}} = 2.76$ TeV (Phys. Lett. B 751 (2015) 358-370)



- UPC measurements allow us detailed study of QCD
- The ALICE detector has excellent capability of UPC measurements
 - Vector mesons production are studied with LHC Run1 and Run2 dataset
 - J/ψ , $\psi(2S)$, ρ^0
 - J/ψ in p-Pb (γ -p interaction) :
 - The result shows agreement with the various predictions that are currently available
 - J/ψ in Pb-Pb (γ -Pb interaction) :
 - The result shows large discrepancy from the impulse approximation without gluon shadowing effects.
 - The IPsat (LM) and BGK-I (LS) models give the best description and the upper limit of the GKZ model based on EPS09 is consistent with data.
- Further measurements are also ongoing with current dataset
- Future prospects at Run3 and Run4 (arXiv:1812.06772 [hep-ph])
 - 13 nb^{-1} of Pb-Pb collisions (Run2 : 1 nb^{-1})
 - Access to the region of the Bjorken- $x \sim 10^{-5}$