FNSPE CTU in Prague

Ultra-peripheral collisions at ALICE

SM & QCD miniworkshop

Roman Lavička

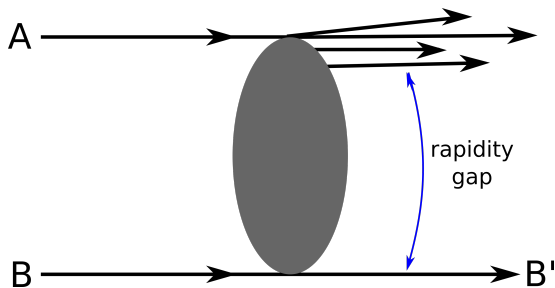Oct 8, 2018, Prague
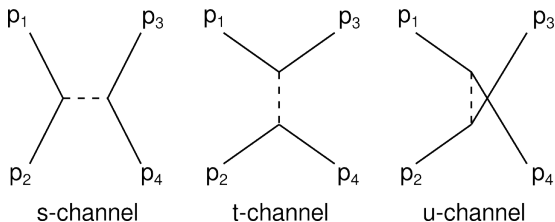
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Content

Introduction

Diffractive physics - definition

- No quantum number exchange.
- High energy.
- Rapidity gap.

Diffractive physics - kinematics

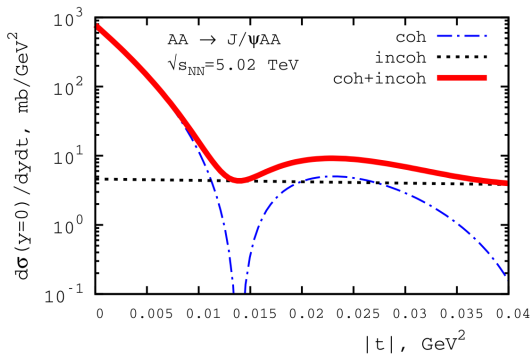s-channel   t-channel   u-channel

- t - transferred momentum (Mandentelstam variable).

$$t = (p_1 - p_3)^2 = (p_2 - p_4)^2$$

- y - rapidity.

$$y = \frac{1}{2} \ln \frac{E + p_z}{E - p_z}$$
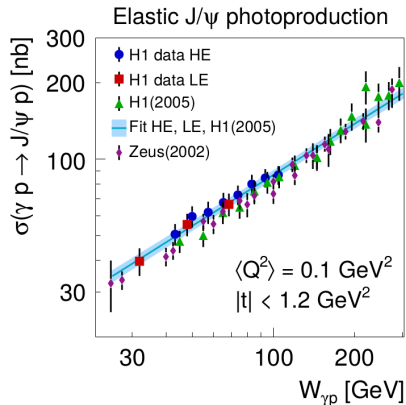
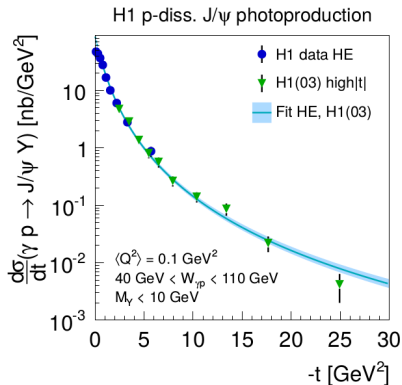# Diffractive physics - what can be studied

Phys. Rev. C 95, 025204 (2017)

- Nuclear shadowing effects, gluon saturation, distribution functions...
- Cross section t-dependence.

$$\frac{\mathrm{d}\sigma}{\mathrm{d}t} = \left.\frac{\mathrm{d}\sigma}{\mathrm{d}t}\right|_{t=0} |F(t)|^2$$

Results overview

Published results - ep collisions at HERA
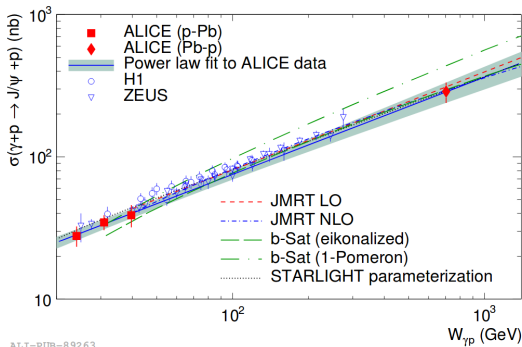

High precision data covering a large part of the phase space is available from HERA.
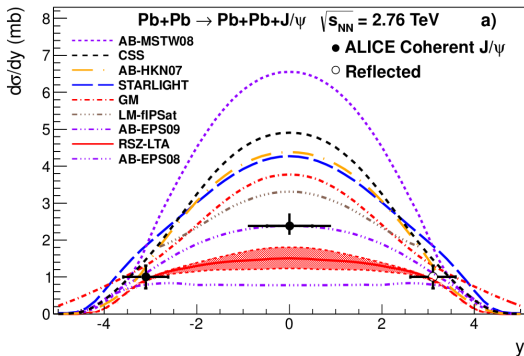
Published results - p-Pb/Pb-p collisions at ALICE

- Consistency with HERA results and its extention by factor of 2.
- Recent collisions at higher energies will allow to reach over 1 TeV.

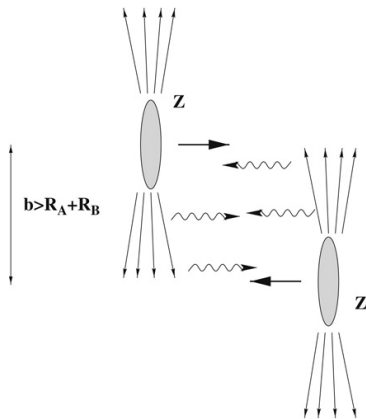# Published results - Pb-Pb collisions at ALICE

- Forward and central rapidity region.
- Large difference between of measurement and no nuclear shadowing models.

Ultra-peripheral collisions at ALICE

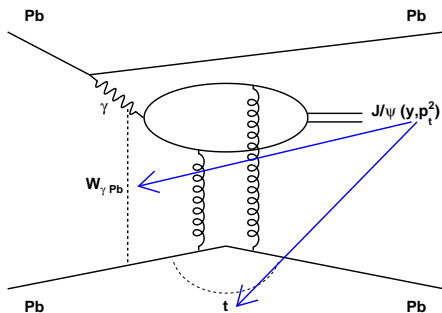# Ultra-peripheral collisions

- 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.
  - Interaction intensity increasing with Z^2.

Phys.Rept. 458 (2008) 1-171

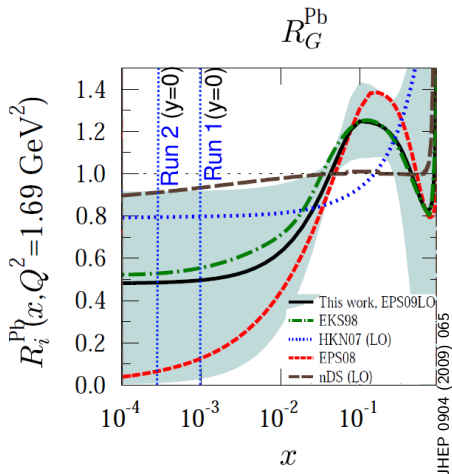# Tool to use light to study gluons

- Coherent photoproduction of J/ψ.
- Probe to QCD.

Where is QCD now

- Proton is mainly gluons at Bjorken $x \sim 10^{-3}$ (HERA).
- LHC provides possibility to study lead nuclei at small Bjorken x.

What we are going to study

- Coherent production of J/ψ in Pb-Pb UPC at mid rapidity at ALICE.
    - Run 1: $x \sim 10^{-3}$; Run 2: $x \sim 0.5 \cdot 10^{-3}$.

- t-Dependence of the cross section.

- Sensitive to the gluon distribution of the target in the impact parameter plane.

Measurement

Experiment

ALICE detector

THE ALICE DETECTOR

a. ITS SPD (Pixel)
b. ITS SDD (Drift)
c. ITS SSD (Strip)
d. V0 and T0
e. FMD

1. ITS
2. FMD, T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCal
8. DCal
9. PHOS, CPV
10. L3 Magnet
11. Absorber
12. Muon Tracker
13. Muon Wall
14. Muon Trigger
15. Dipole Magnet
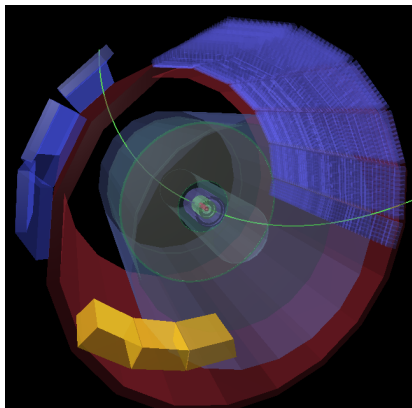16. PMD
17. AD
18. ZDC
19. ACORDE

What we look for in a collision

- Events with exactly two reconstructed tracks:
  - these are leptons,
  - these are back-to-back (TOF/ITS).
- VETO:
  - nothing in forward regions (V0, AD),
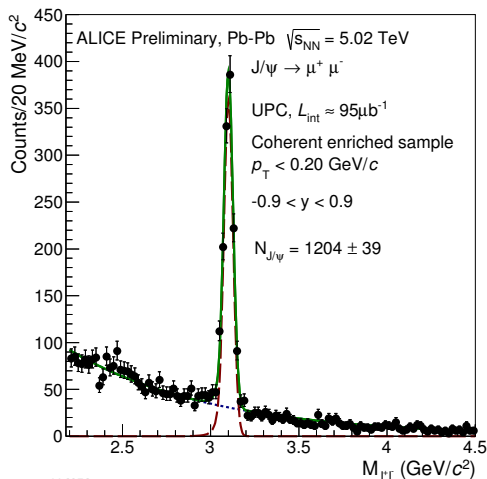 - no more than 6 hits in SPD (inner layers of ITS).

Measurement

Analysis

Measurement - theory

$$\frac{\partial^2 \sigma_{J/\psi}^{\text{coh}}}{\partial y \partial t} = \frac{N_{J/\psi}^{\text{coh}}}{(\text{Acc} \times \epsilon)_{J/\psi}^{\text{coh}} \cdot BR(J/\psi \to l^+ l^-) \cdot \mathscr{L}_{int} \cdot \Delta t \cdot \Delta y},$$

- $N_{J/\psi}^{\text{coh}}$ - number of coherently produced J/ψ
- $(\text{Acc} \times \epsilon)_{J/\psi}^{\text{coh}}$ - correction on detector effects
- $BR(J/\psi \to l^+ l^-)$ - branching ratio
- $\mathscr{L}_{int}$ - integrated luminosity of UPC triggers
- Δt - bin size
- Δy - rapidity region

Yield of coherently produced J/ψ

ALI-PREL-116079

- Crystal Ball function fit.
- Additional corrections on other processes generating J/ψ.

Work in progress

- Evaluating unfolding of the *t*-spectrum using different methods.
    - Regularization method (TUnfold).
    - Bayes method (D'Agostiny).
    - Singular Value Decomposition (RooUnfold).
- Evaluating with data the trigger efficiencies.
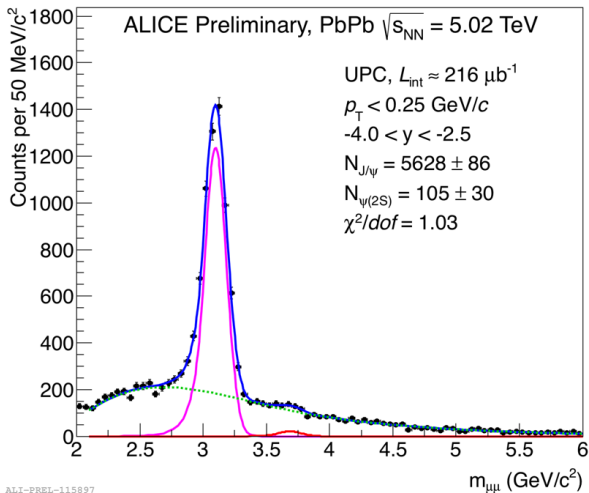- Evaluation systematic uncertanities.

Summary

- ALICE can study the QCD evolution in x-Bjorken of the gluon distribution in Pb for scales of the order of the charm mass using J/ψ coherent photonuclear production.
- Studying the t-dependence of this process, we can study the transverse distribution of gluons in Pb at small x.
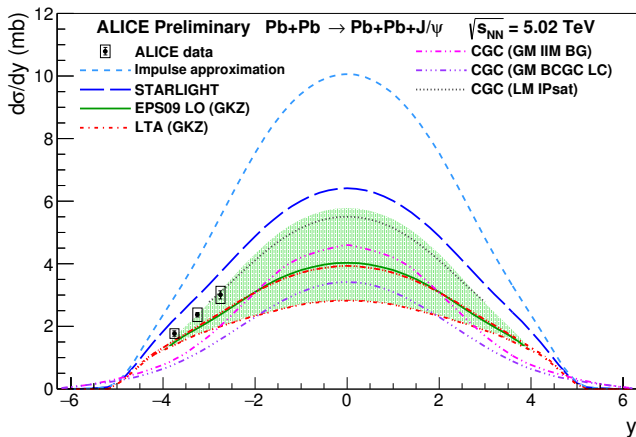- This is work in progress and we are planning to have final results in a few months.

BACK UP

Preliminary invariant mass of Run 2

ALICE Preliminary, PbPb $\sqrt{s_{NN}}$ = 5.02 TeV

UPC, $L_{int} \approx 216 \, \mu b^{-1}$
$p_T < 0.25$ GeV/c
$-4.0 < y < -2.5$
$N_{J/\psi} = 5628 \pm 86$
$N_{\psi(2S)} = 105 \pm 30$
$\chi^2/dof = 1.03$

ALI-PREL-115897

- Muons and electrons combined.

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

ALI-PREL-117502

- Forward region.

Template title

- Template item.