

# J/ $\Psi$ photo-production in ultra-peripheral Pb-Pb collisions

Christoph Mayer for the ALICE Collaboration

Henryk Niewodniczański Institute of Nuclear Physics  
Polish Academy of Sciences (PAN)  
31-342 Kraków

LHC on the March, 20–22.11.2012, Protvino

# Outline

- 1 Motivation
- 2 The ALICE Experiment
- 3 Measurement of J/Psi photo-production in Pb-Pb
  - Forward Rapidity
  - Central Rapidity
- 4 Comparison to models
- 5 Conclusions/Outlook

- Ultra-peripheral collisions (UPC): impact parameter  $b > 2R_A$ 
  - hadronic interactions are strongly suppressed
  - electro-magnetic interactions
- UPC interactions:
  - ▶ Photon-Nucleus, e.g. PbPb → PbPb + J/ψ
  - ▶ Photon-Photon, e.g.  $\gamma\gamma \rightarrow e^+e^-$
- Strong electromagnetic field around lead ions:  
number of photons  $\sim Z^2$
- Allows to study the gluon-distribution  $g(x, q)$  inside the Pb nucleus
  - ▶ Partonic momentum fraction  $x \sim 10^{-2}-10^{-5}$
  - ▶ Gluon shadowing

# Exclusive Vector Meson Production

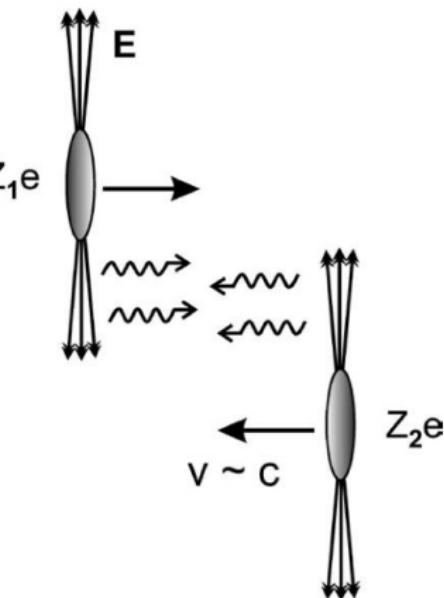


- Coherent

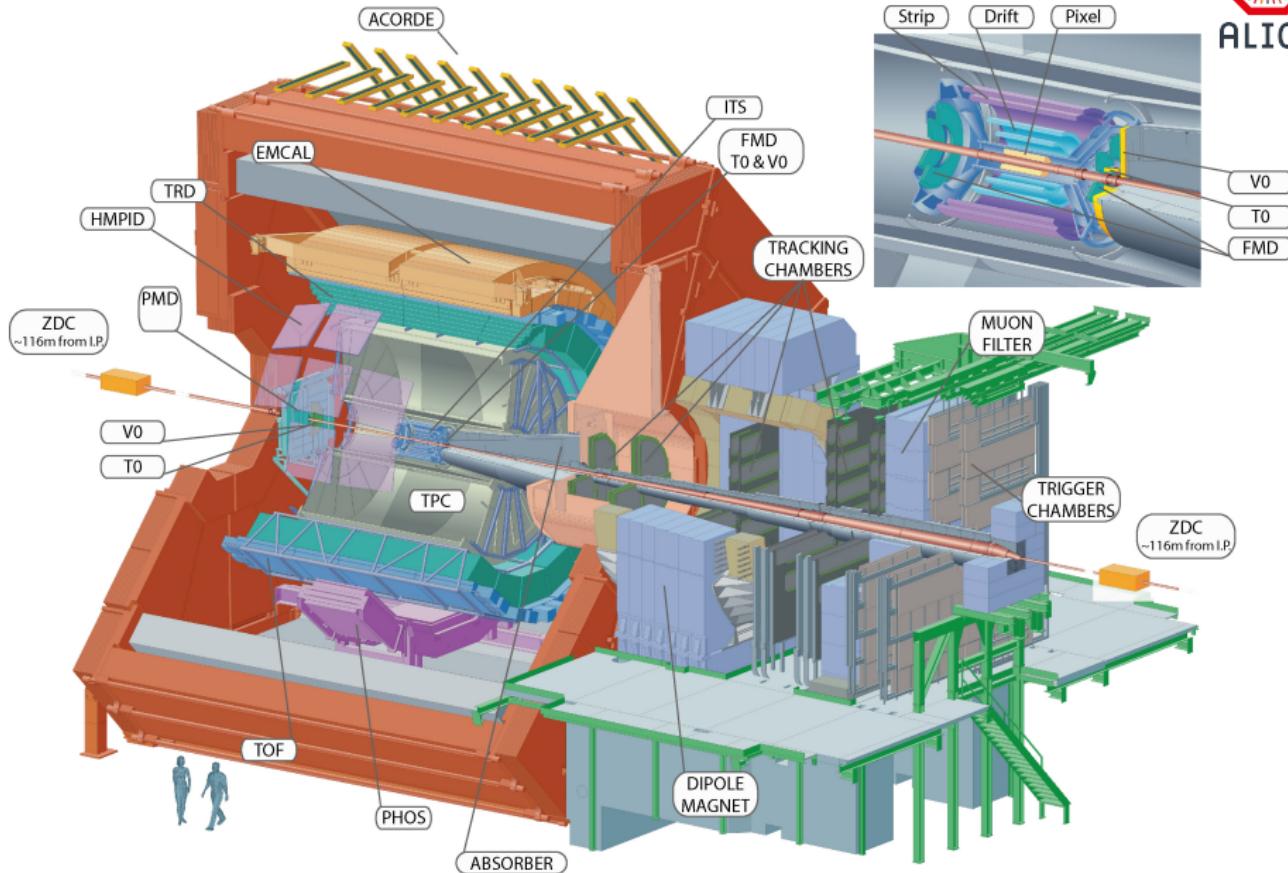
- ▶ Photon couples coherently to all nucleons
- ▶  $\langle p_T \rangle \sim 60 \text{ MeV}/c$
- ▶ target nucleus normally does not break up

- Incoherent

- ▶ Photon couples to a single nucleon
- ▶  $\langle p_T \rangle \sim 500 \text{ MeV}/c$
- ▶ target nucleus normally does break up



# The ALICE Experiment



# J/ψ photo-production in Pb-Pb

Forward Rapidity

Data sample: 2011 Pb-Pb 2.76 TeV,  $\mathcal{L}^{\text{int.}} \sim 55 \mu\text{b}^{-1}$

Trigger:

- Single muon trigger with  $p_T > 1 \text{ GeV}/c$
- At least one hit in VZERO-C ( $2.8 < \eta < 5.1$ )
- No hits in VZERO-A ( $-3.7 < \eta < -1.7$ )

Beam gas and hadronic rejection:

- $< 6$  neutrons in both zero-degree calorimeters ( $\pm 116 \text{ m}$  distance to IP)
- Veto on SPD activity at central rapidity

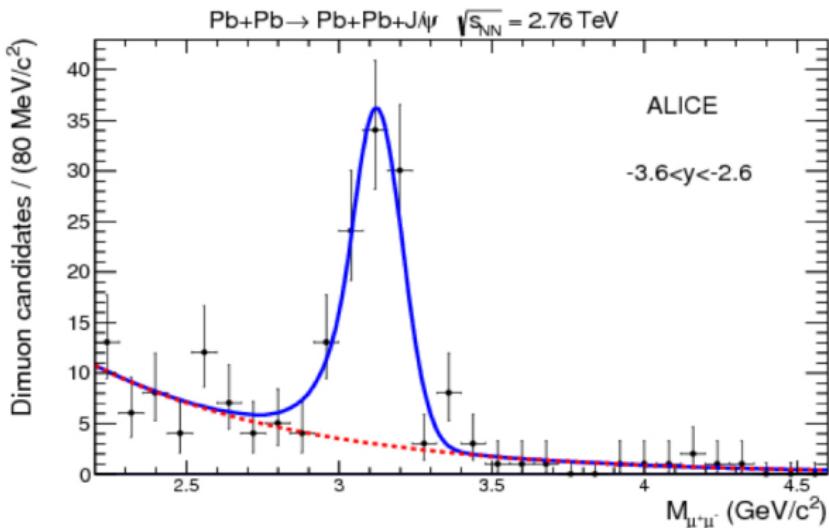
Offline event selection:

- Two reconstructed muon tracks with opposite charges
- $p_T$ -dependent DCA cut
- Matching of one muon track with track of triggered muon
- Acceptance selection (dimuon) :  
 $-3.6 < y < -2.6, \quad 2.8 < M_{\text{inv}} < 3.4 \text{ GeV}/c^2, \quad p_T < 0.3 \text{ GeV}/c$

Number of remaining J/ψ candidates: 117

# J/ $\psi$ photo-production in Pb-Pb

Forward Rapidity



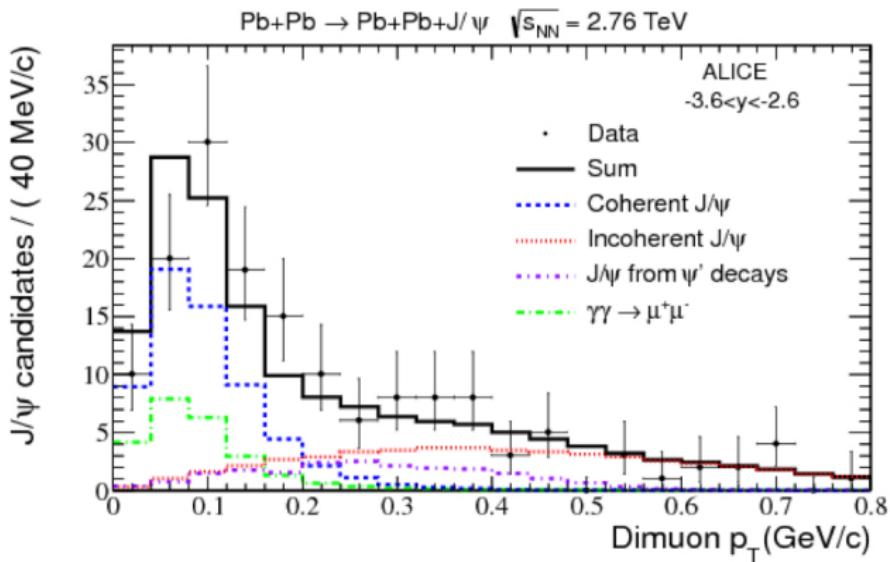
B. Abelev *et al.* (ALICE Collaboration) arXiv:1209.3715, submitted to *Phys. Lett. B.*

- Background from like-sign contribution: 2 events
- Fitting functions: Crystal Ball and exponential
- Exponential slope parameters

data:  $(-1.4 \pm 0.2) \text{ GeV}^{-1}c^2$ , MC:  $(-1.39 \pm 0.01) \text{ GeV}^{-1}c^2$

# J/ $\psi$ photo-production in Pb-Pb

Forward Rapidity



B. Abelev *et al.* (ALICE Collaboration) arXiv:1209.3715, submitted to *Phys. Lett. B.*

Four physics processes:

coherent+incoh. J/ $\psi$ , feed-down from  $\psi'$  decays,  $\gamma\gamma \rightarrow \mu^+\mu^-$

# J/ψ photo-production in Pb-Pb

Forward Rapidity

$$\frac{d\sigma_{J/\psi}^{\text{coh}}}{dy} = \frac{1}{\text{BR}(J/\psi \rightarrow \mu^+\mu^-)} \cdot \frac{N_{J/\psi}^{\text{coh}}}{N_{\gamma\gamma}} \cdot \frac{(\text{Acc} \times \epsilon)_{\gamma\gamma}}{(\text{Acc} \times \epsilon)_{J/\psi}} \cdot \frac{\sigma_{\gamma\gamma}}{\Delta y}$$

The QED process  $\gamma\gamma \rightarrow \mu^+\mu^-$  is used for cross section normalization:

- uncertainties from minimum momentum transfer and nuclear form factor
- higher order terms: coupling is  $Z\sqrt{\alpha}$

Theoretical uncertainty of  $\gamma\gamma \rightarrow \mu^+\mu^-$ : 20%

## Result:

$$\frac{d\sigma_{J/\psi}^{\text{coh}}}{dy} = (1.00 \pm 0.18(\text{stat})^{+0.24}_{-0.26}(\text{syst})) \text{ mb ,}$$

$$-3.6 < y < -2.6 , \quad p_T^{\mu^+\mu^-} < 0.3 \text{ GeV}/c$$

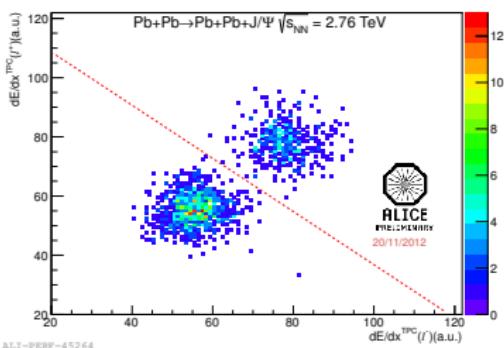
# J/ $\psi$ photo-production in Pb-Pb

Central Rapidity

Data set: 2011 PbPb data,  $\mathcal{L}^{\text{int}} \sim 20 \mu\text{b}^{-1}$

## Trigger:

- Veto on VZERO-A and VZERO-C
- $\geq 2$  hits in SPD
- $2 \leq N \leq 6$  hits in TOF and topology  $150^\circ \leq \Delta\phi \leq 180^\circ$



## Beam gas suppression:

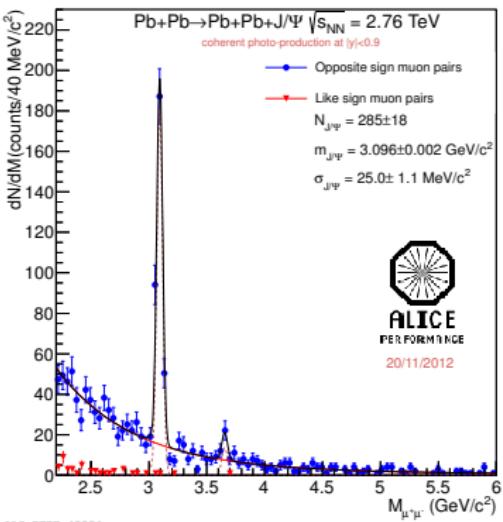
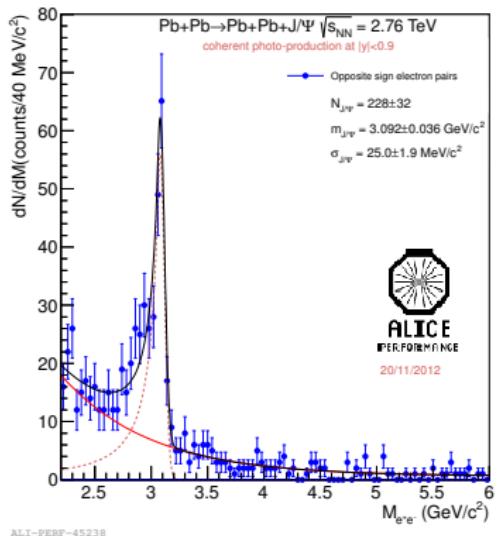
- Absence of V0 signal in offline time window
- $p_T$ -dependent DCA cut

## Event Selection:

- Exactly two tracks passing track quality cuts
- $dE/dx$  for the two tracks compatible with muon/electron  $dE/dx$

# J/ $\psi$ photo-production in Pb-Pb

## Central Rapidity – coherent

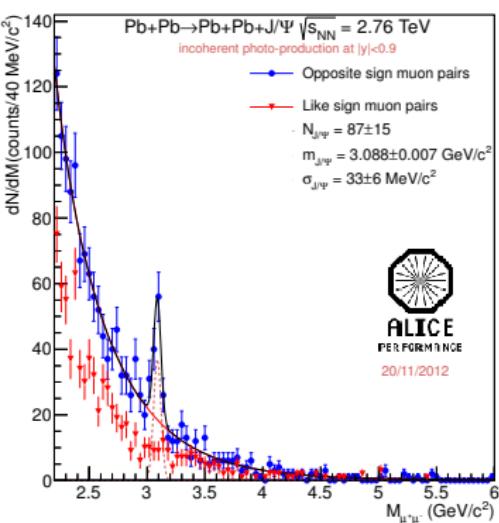
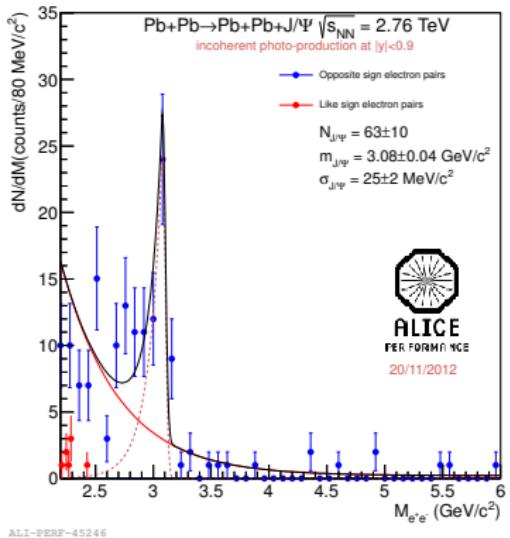


Left: di-electron channel, Right: dimuon channel.

- Fit: Crystal Ball + exponential
- Coherent: pair- $p_T(J/\psi) < 300$  MeV/c

# J/ $\psi$ photo-production in Pb-Pb

## Central Rapidity – incoherent

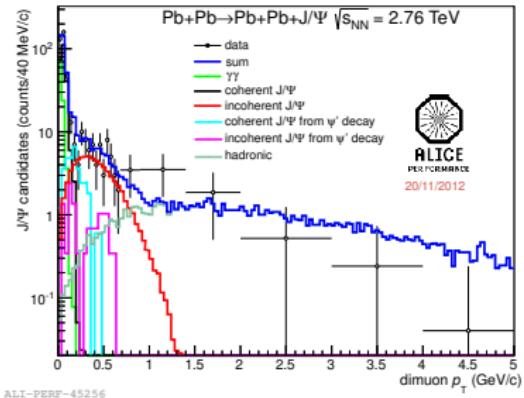
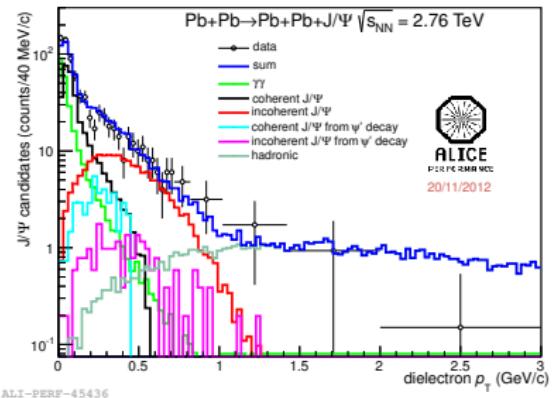


Left: di-electron channel, Right: dimuon channel.

- Fit: Crystal Ball + exponential
- Incoherent: pair- $p_T(J/\psi) > 300$  MeV/c

# J/ $\psi$ photo-production in Pb-Pb

Central Rapidity - pair- $p_T$



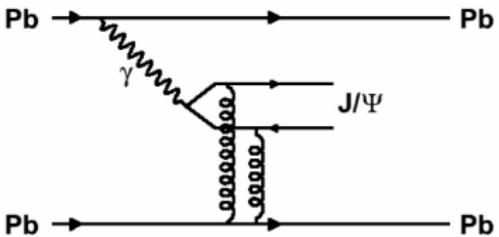
Left: di-electron channel, Right: dimuon channel.

## 6 Components:

- coherent+incoherent J/ $\psi$
- feed-down from coherent+incoherent  $\psi'$ -decay
- hadronic J/ $\psi$  events, and continuum  $\gamma\gamma \rightarrow e^+e^- (\mu^+\mu^-)$

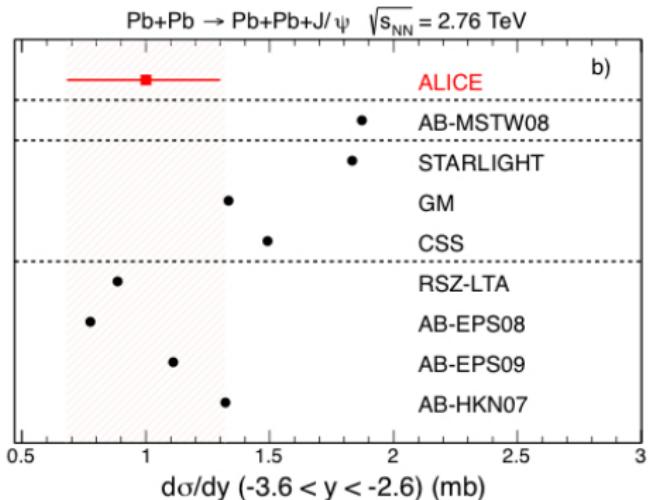
# Comparison to models

Predictions for exclusive  $J/\Psi$  production at LHC



- S. Klein, J. Nystrand (STARLIGHT), *Phys. Rev.* C60 (1999) 014903.
- Adeluyi and Bertulani (AB), *Phys. Rev.* C85 (2012) 044904.
- Gonçalves and Machado (GM), *Phys. Rev.* C84 (2011) 011902.
- Cisek, Szczerba, Schäfer (CSS), *Phys. Rev.* C86 (2012) 014905.
- Rebyakova, Strikman, Zhalov (RSZ), *Phys. Lett.* B 710 (2012) 252.

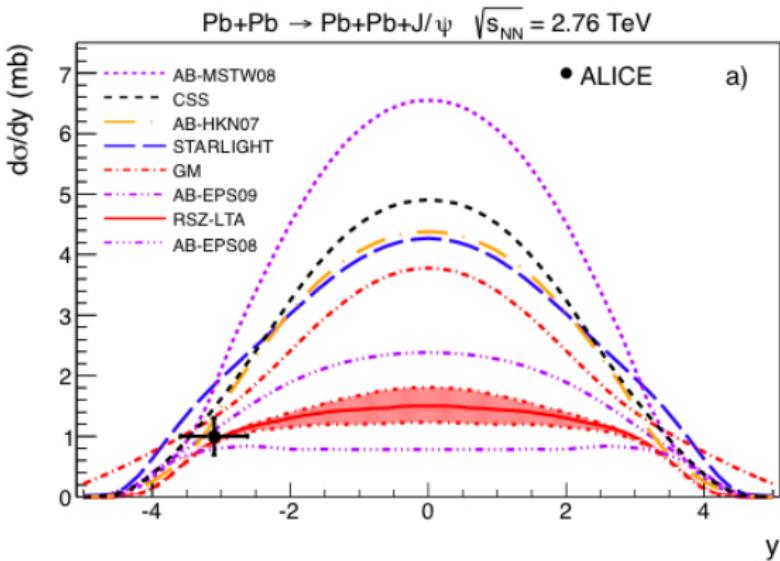
# Comparison to models / 1



B. Abelev *et al.* (ALICE Collaboration) arXiv:1209.3715, submitted to *Phys. Lett. B.*

- No nuclear effects: AB-MSTW08
- Glauber approach: STARLIGHT, GM, CSS
- Partonic models: RSZ-LTA, AB-EPS08,09, AB-HKN07

# Comparison to models / 2



B. Abelev *et al.* (ALICE Collaboration) arXiv:1209.3715, submitted to *Phys. Lett. B.*

- Differences between models: gluon shadowing, use of Glauber models
- Central rapidity: better discrimination power; analysis is ongoing

## Conclusions

- We have measured the cross section for coherent photo-production J/ $\Psi$  in UPC
- Comparison to several models
- Gluon shadowing

## Outlook

- Ultra-peripheral J/ $\Psi$  cross section at central rapidity
- Ultra-peripheral cross section of PbPb  $\rightarrow$  PbPb +  $\rho^0$
- Measurement of  $\gamma\gamma \rightarrow e^+e^-$  cross section
- Vector-meson production in coincidence with nuclear breakup

Thank you for your attention