中国科学技术大学

University of Science and Technology of China

Coherent J/ψ photoproduction at midrapidity in Pb–Pb collisions at ALICE

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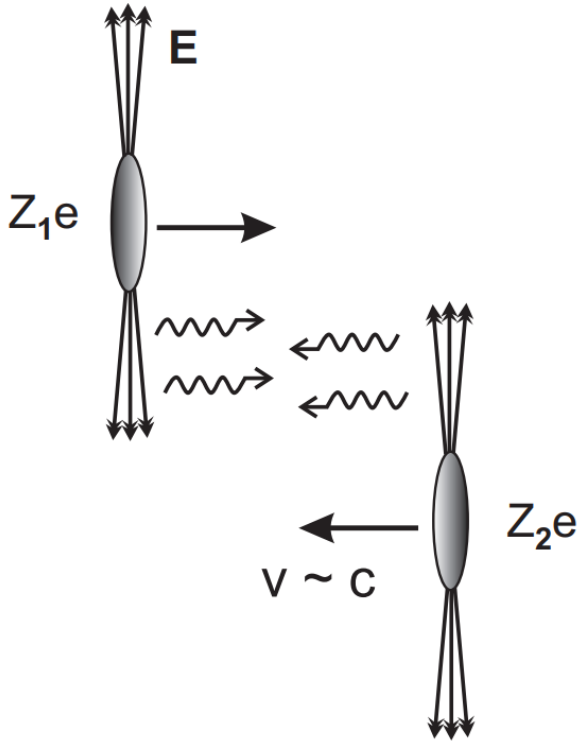
Photoproduction in PCs



Bertulani et al., Ann.Rev.Nucl.Part.Sci.55 (2005) 271

EM field of nuclei: beam of quasi-real photons

- Photons achieve a large boost at the LHC: photon-hadron and photon-photon collisions

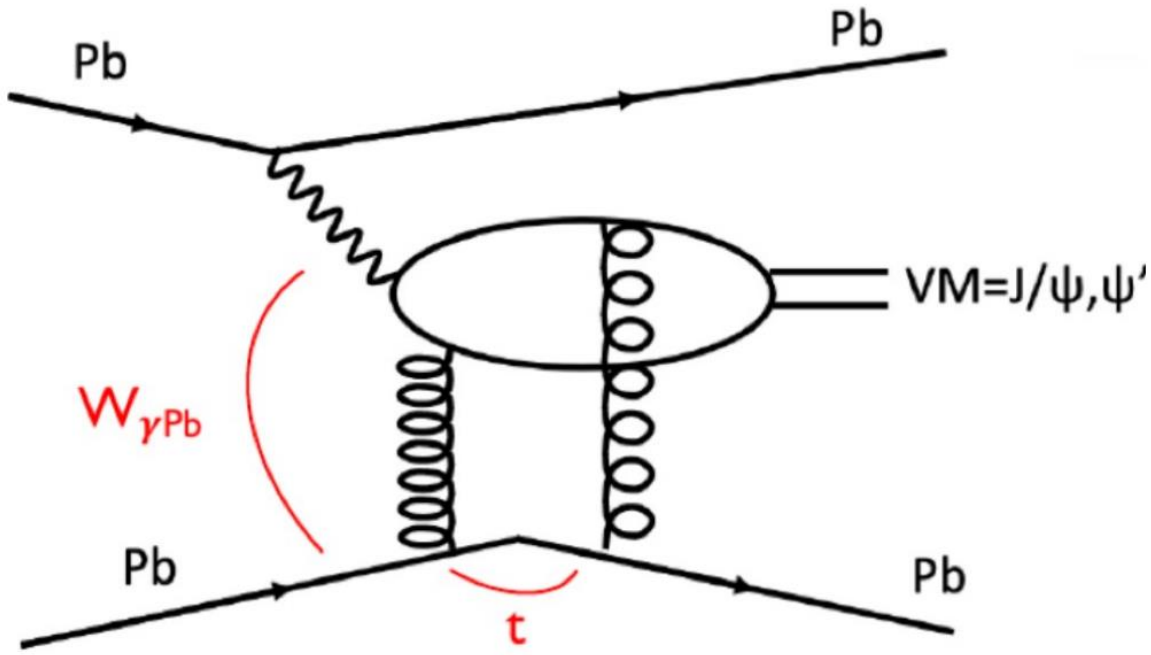
Ultraperipheral collisions (UPC): $b > R_1+R_2$

- Hadronic interactions suppressed
- Electromagnetic interactions are dominant
- Very small number of tracks produced, with large gaps in rapidity

Peripheral collisions (PC): $b < R_1+R_2$

- a larger nuclear overlap region
- Investigate the impact of the QGP

Vector meson photoproduction



$$\sigma(AA \to AAJ/\psi) = \int d\omega_\gamma \frac{dN_\gamma(\omega_\gamma)}{d\omega_\gamma} \sigma(\gamma A \to J/\psi A)$$

Bertulani et al., Ann.Rev.Nucl.Part.Sci.55 (2005) 271

- Many studies focused on the exclusive photoproduction of vector mesons, both at the LHC and RHIC
- Vector mesons production cross section constrain nuclear gluon PDFs in the range $10^{-5} < x < 10^{-2}$ at the LHC

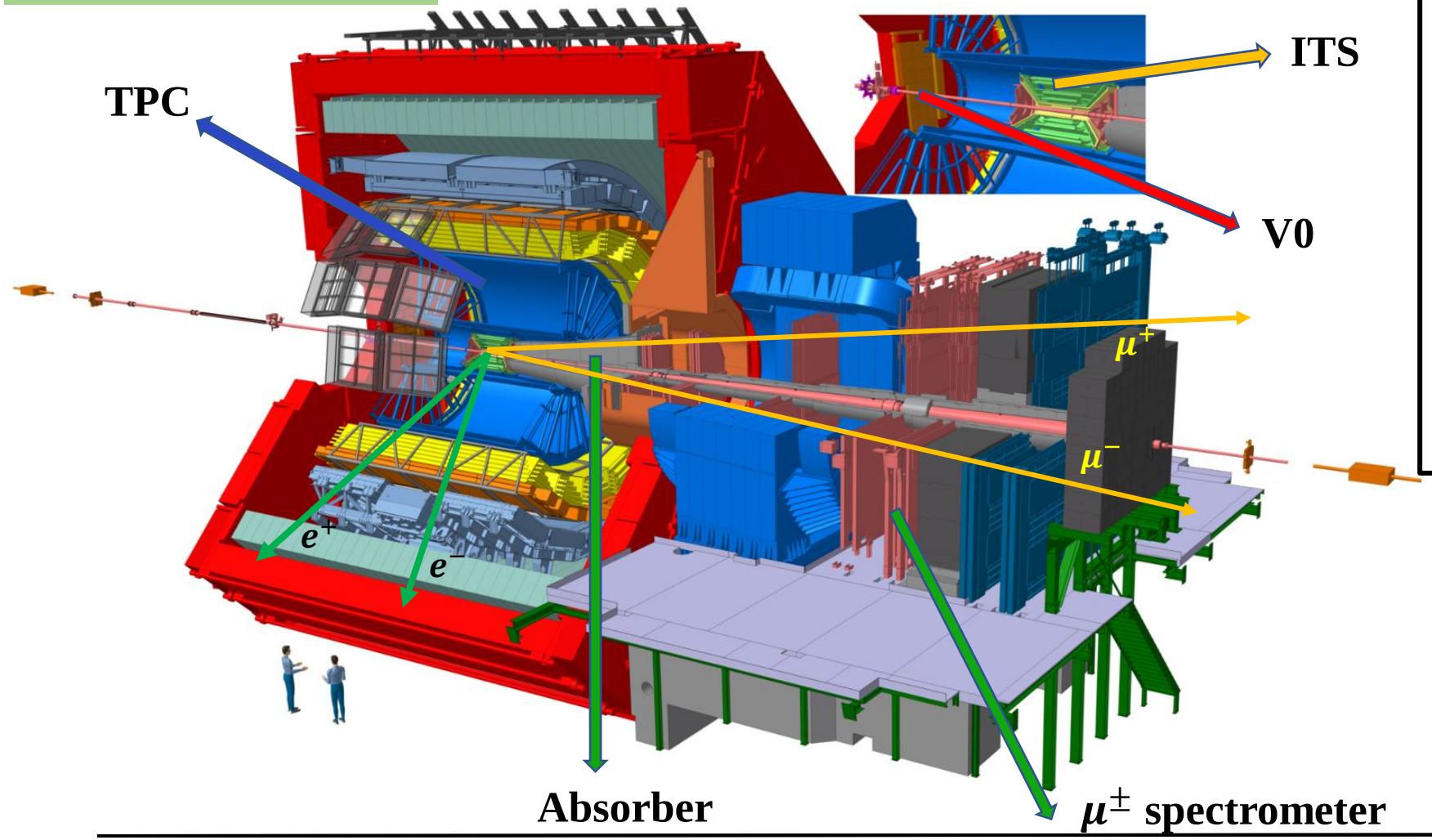
Coherent photoproduction
- Photon couples to the entire nucleus
- $\langle p_T \rangle (J/\psi) \sim 60$ MeV/c

Incoherent photoproduction
- Photon couples to one nucleon
- $\langle p_T \rangle (J/\psi) \sim 500$ MeV/c

ALICE Run 3 detector

Forward ($2.5 < y < 4.0$)

Central barrel ($|y| < 0.9$)



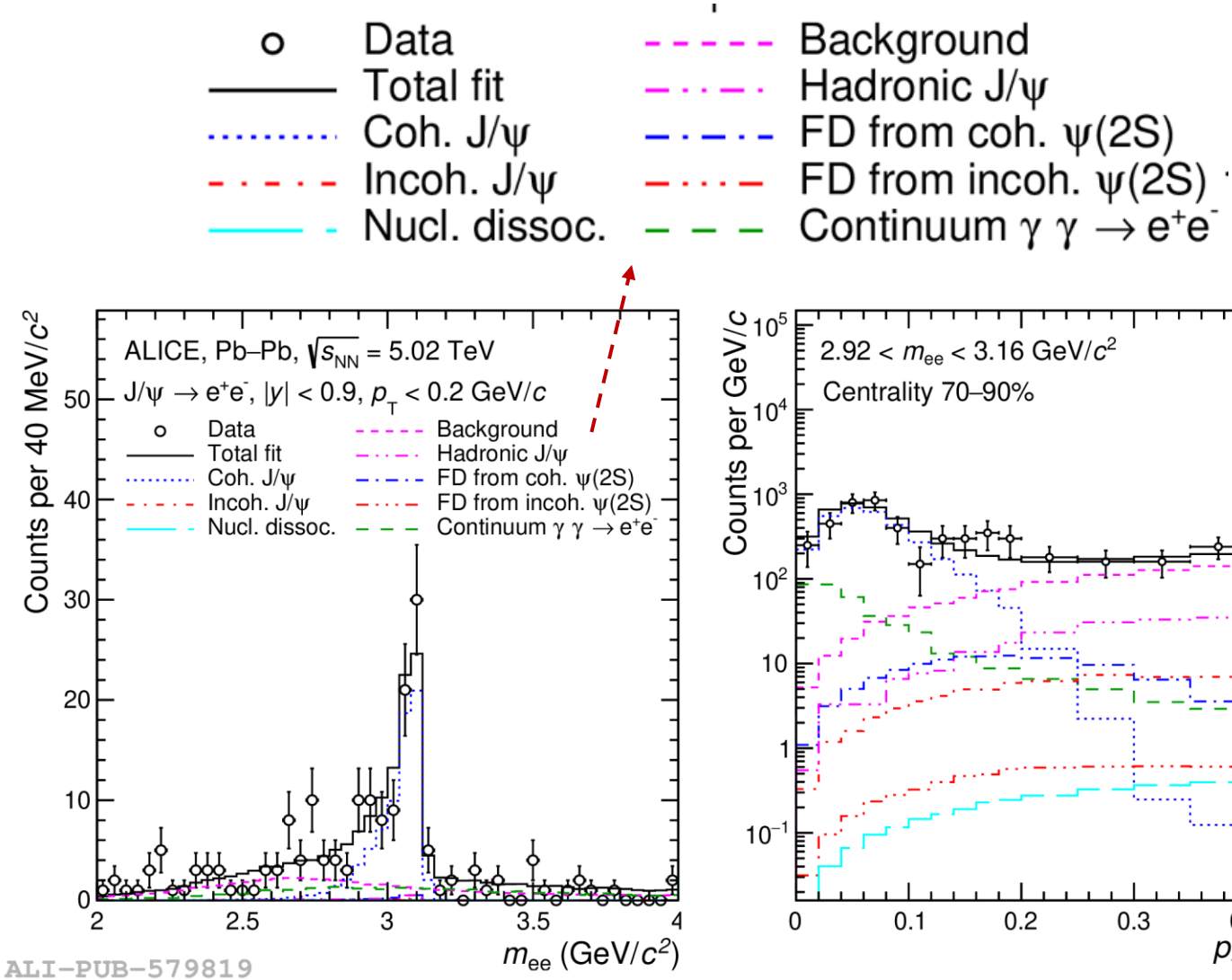
- **V0 detector**
  - ✓ Centrality determination
  - ✓ Trigger
  - ✓ Background rejection
- **$\mu^\pm$ spectrometer**
  - ✓ Trigger
  - ✓ $\mu^\pm$ tracking
- **Time Projection Chamber**
  - ✓ Tracking, Particle identification
- **Inner Tracking System**
  - ✓ Tracking, Vertex reconstruction

Run 3 updates:

Upgraded:
- TPC
- ITS

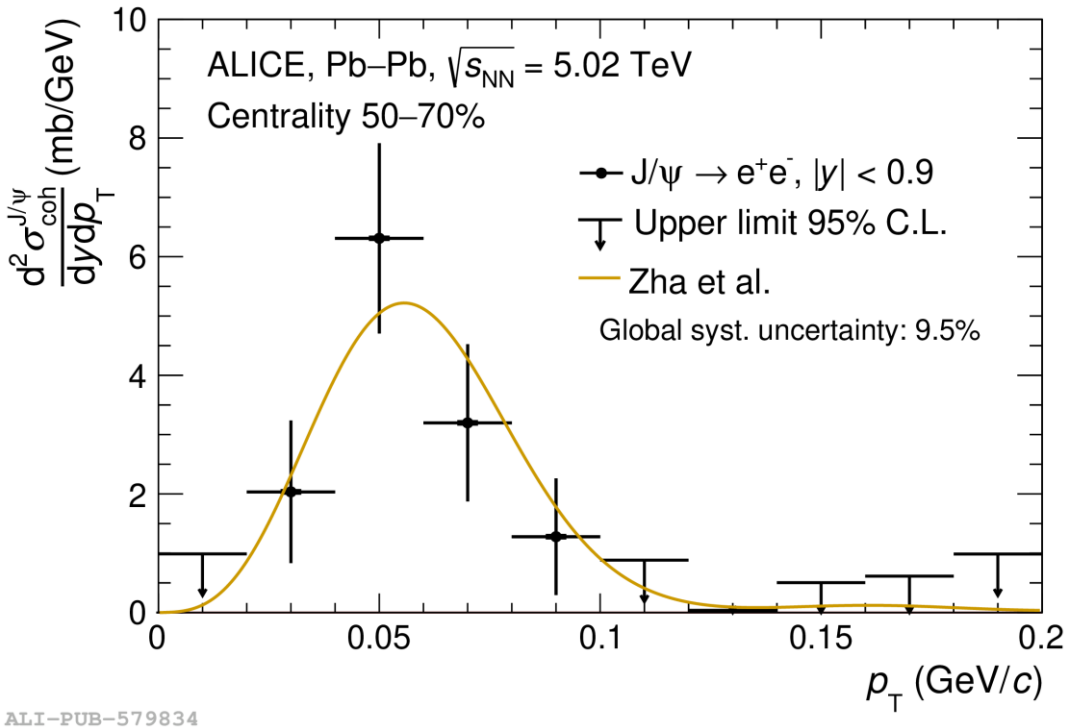
New:
- FIT
- MFT

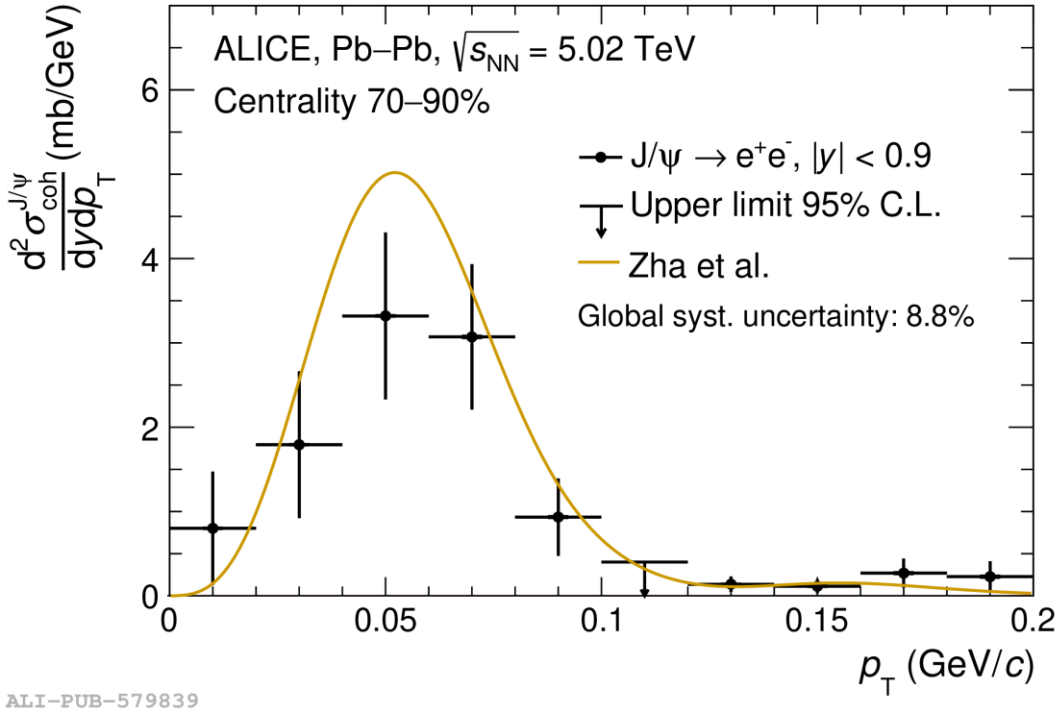
J/ψ photoproduction in peripheral collisions



- Recent measurement at midrapidity
- Coherent yield extracted via a template fit
- Photo-production components (STARlight)
  - Coherent J/ψ
  - Incoherent J/ψ
  - Feed-down from coherent and incoherent ψ(2S)
  - γγ continuum
- Hadronic J/ψ production (data driven)
- Combinatorial and correlated background (data driven)

p_T dependence of J/ψ photoproduction

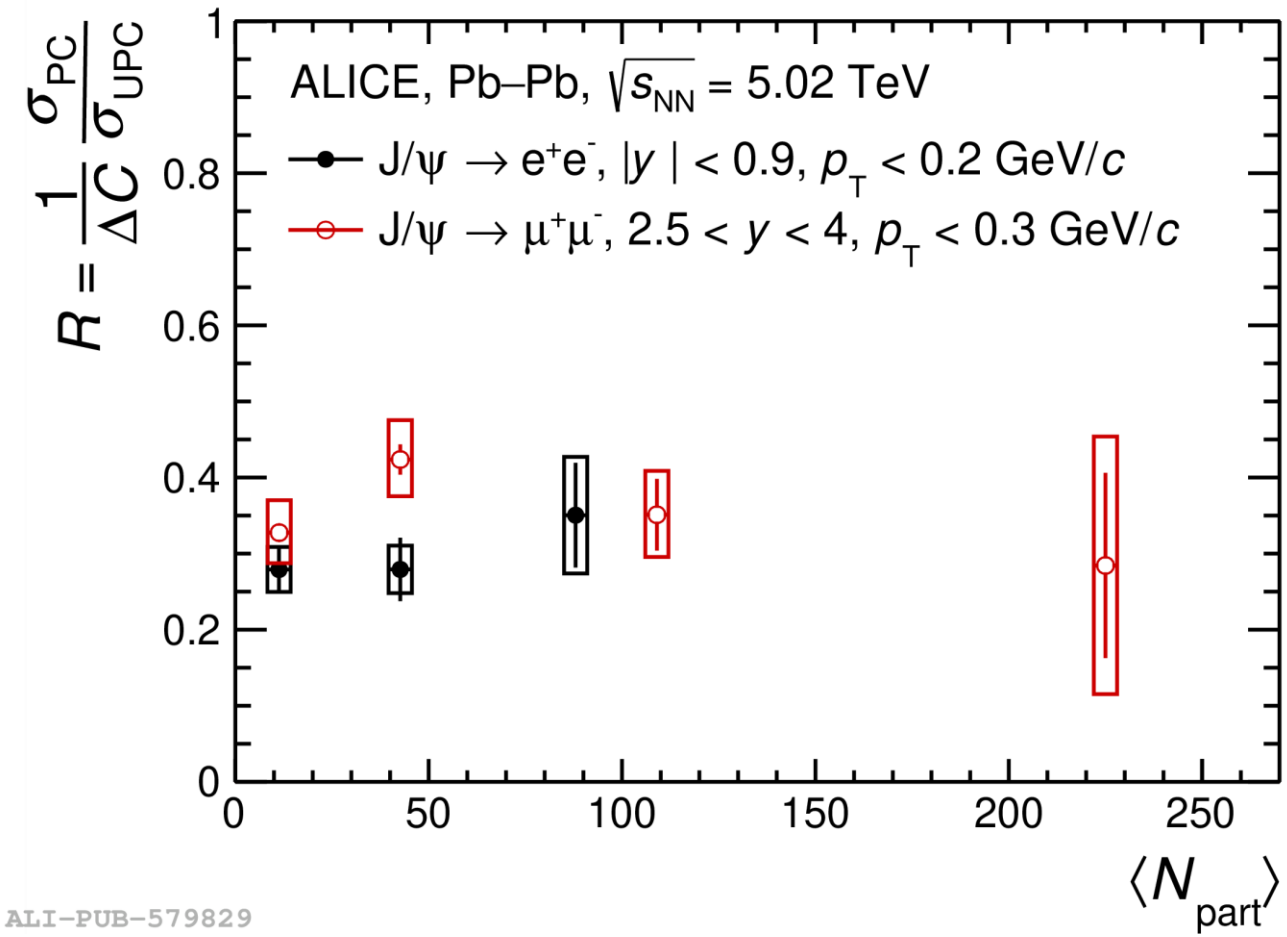




Zha et al., PRC 99 (2019) 061901

- Model calculations using destructive interference compatible with the data
- Modifications in the differential cross section with centrality still difficult to disentangle with the current datasets at mid-y

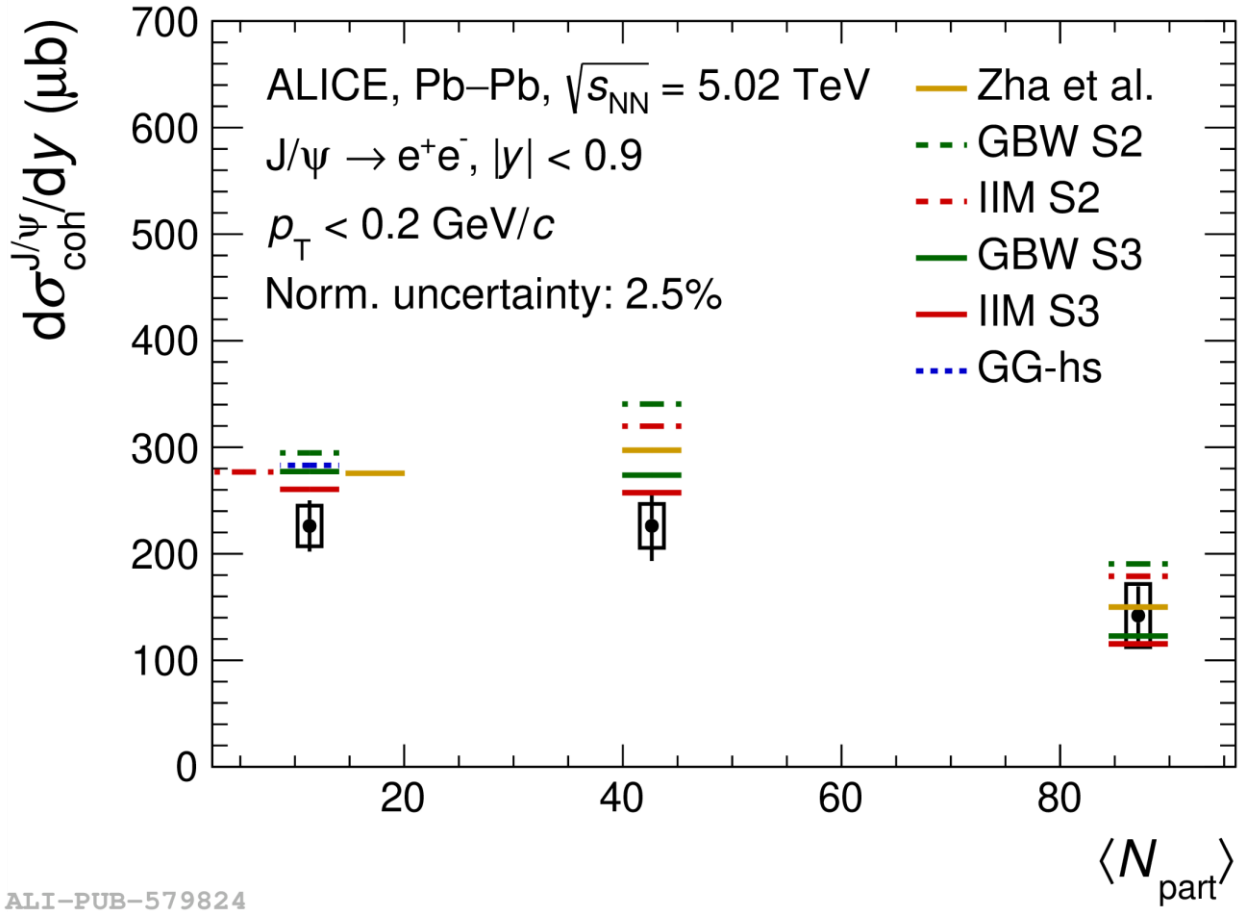
Coherent J/ψ production as a function of centrality



mid-y: ALICE, arxiv:2409.11940
fwd-y: ALICE, PLB846 (2023) 137467

- Cross section extracted up to nearly central (at forward) and semicentral collisions (at mid-y)
- No significant centrality dependence within uncertainties
- Good agreement between mid- and forward-y results in most peripheral collisions.

Coherent photoproduction, data vs models



Modifications of photon-flux only:
GBW S2, IIM S2, VDM, GG-hs

Modifications of both photon-flux and σ(γA):
GBW S3, IIM S3

Modifications of σ(γA):
Zha et al.

Zha et al. Phys. Rev. C 97, 044910 (2018)
Zha et al. Phys. Rev. C 99, 061901 (2019)
M. B. Gay Ducati et aal. Phys. Rev. D 97, 116013 (2018)
J. Cepila et al. Phys. Rev. C 97, 024901 (2018)

- Data tends to favor models where both the emitted photon flux and photonuclear cross section exclude the participant region

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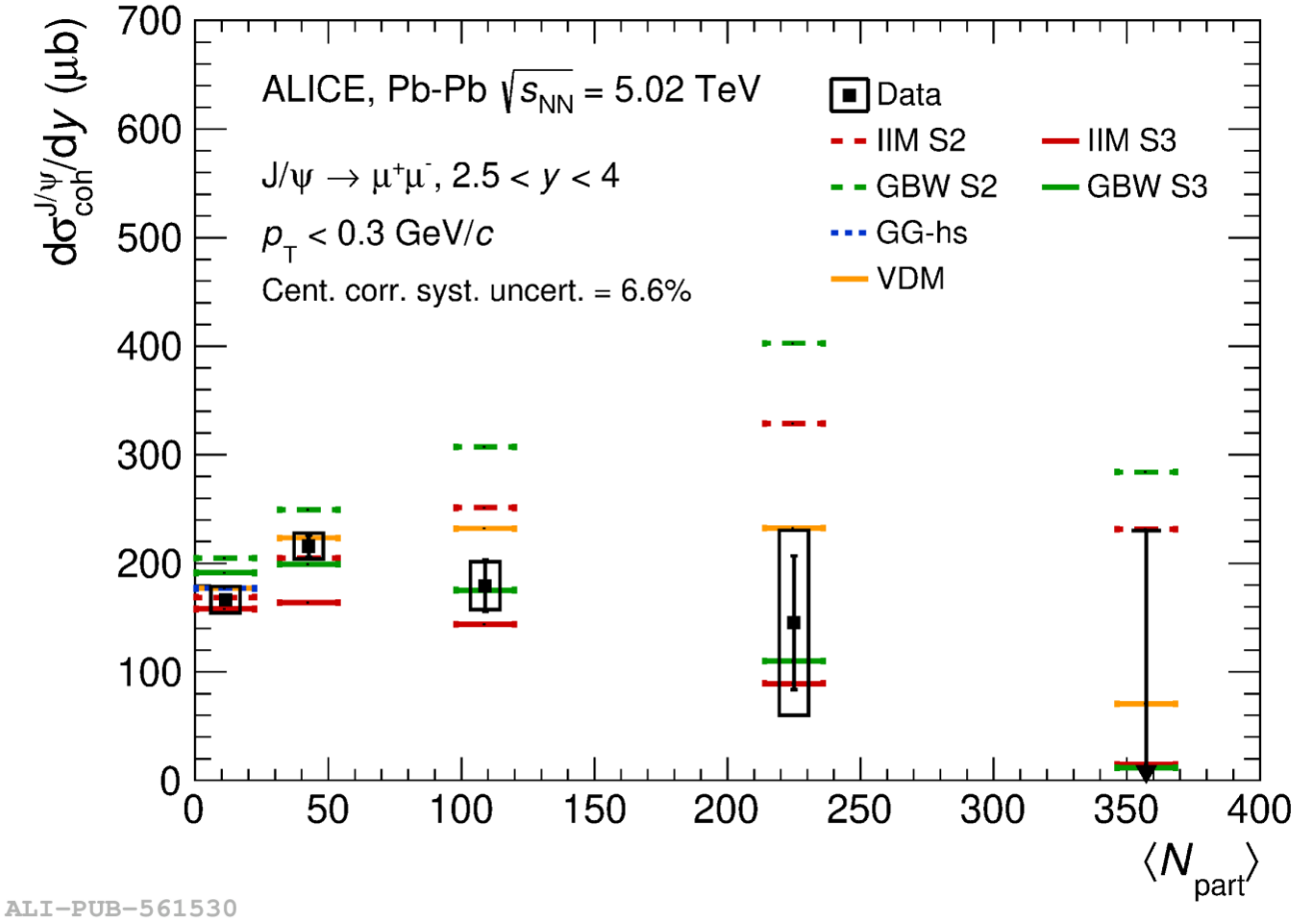

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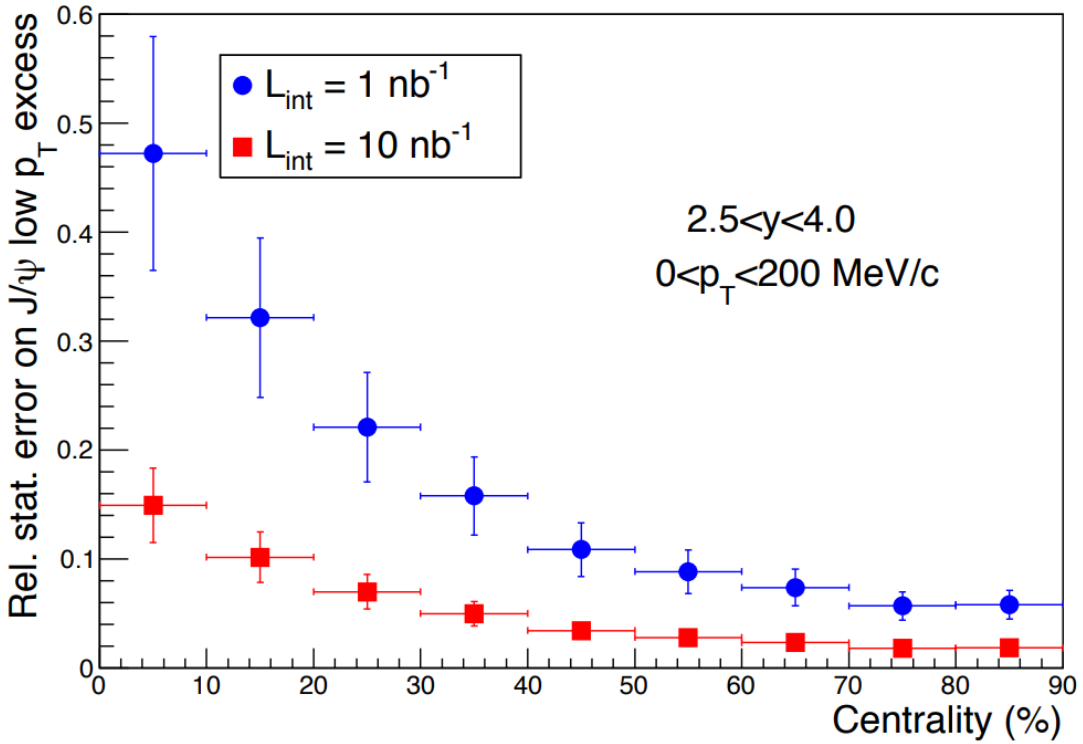
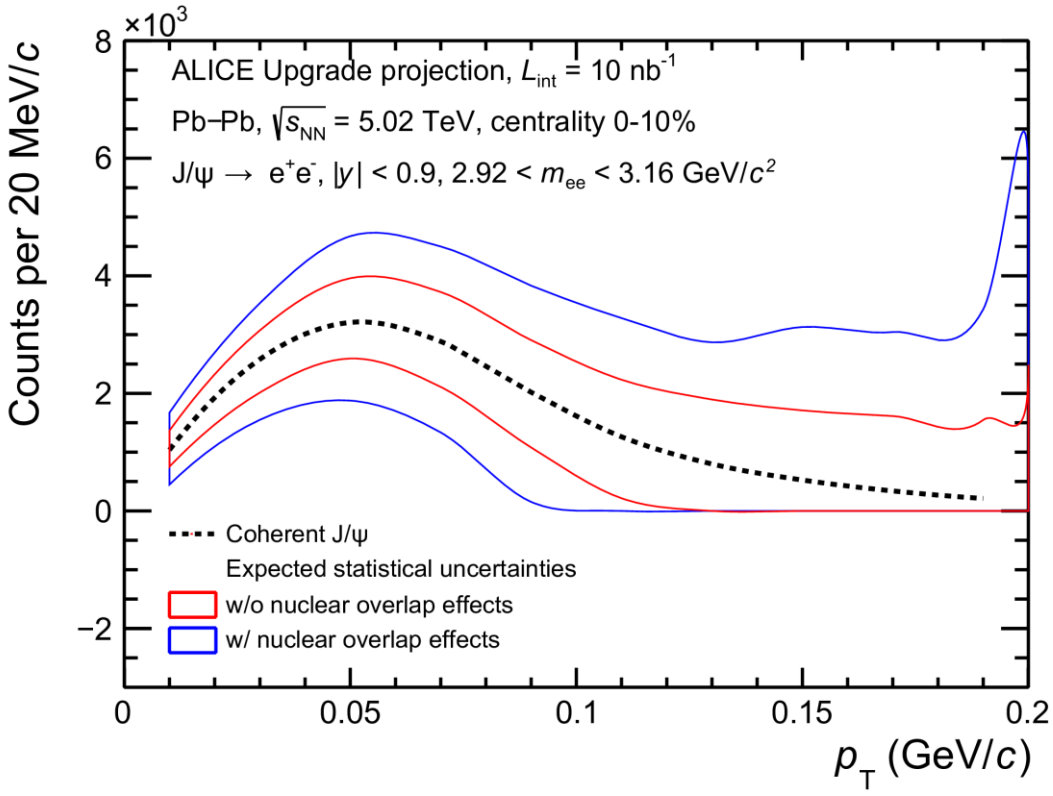
- Data tends to favor models where both the emitted photon flux and photonuclear cross section exclude the participant region
- VDM modifies only the photon flux but still gets a good agreement to data

Projections for Run 3 and Run 4



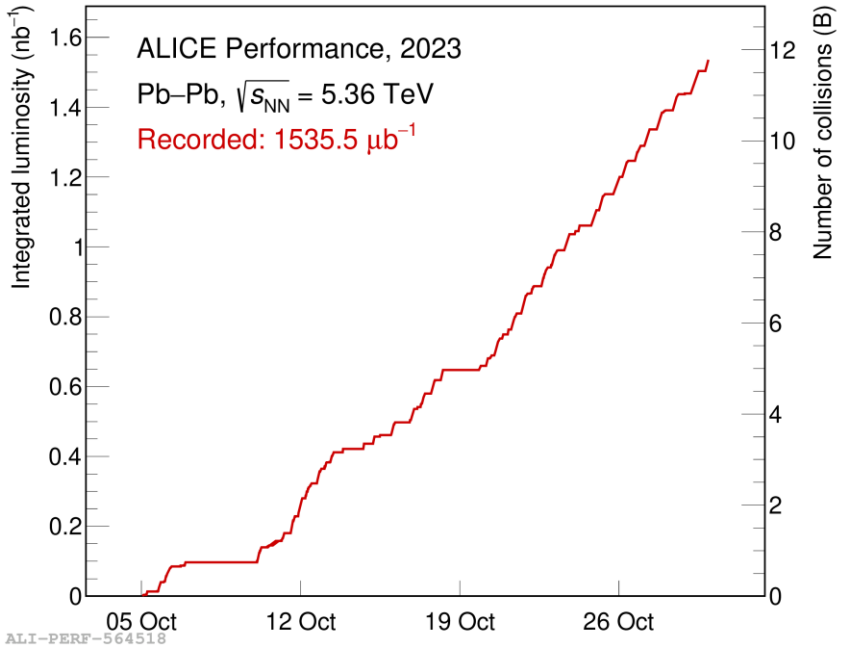


ALI-SIMUL-514006

- Expected integrated luminosity in Pb–Pb: ~10 nb^{-1} at both mid and fwd-y
- In central collisions (0-10%), expected significance of coherent yields of 5-10
- Below 10% centrality:
  - Precise measurements of p_T spectrum, azimuthal correlations, polarization

Summary and Conclusion

- p_T-differential cross sections at midrapidity
  - peak at ~60 MeV/c, as seen in UPC
  - compatible with hypothesis destructive interference



- p_T-integrated cross-sections
  - photon flux and σ(γA) sensitive to the participant region

- Projections for Run 3 and Run 4
  - Central collisions: coherent J/ψ cross-section feasible with a significance better than 5
  - Semicentral and peripheral: precise differential measurements

Thank You