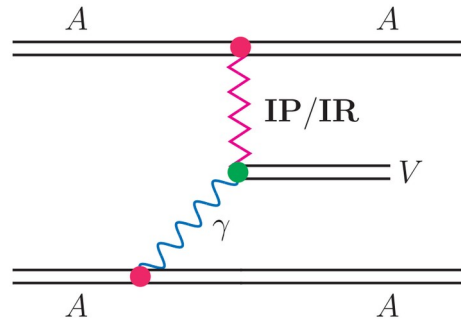
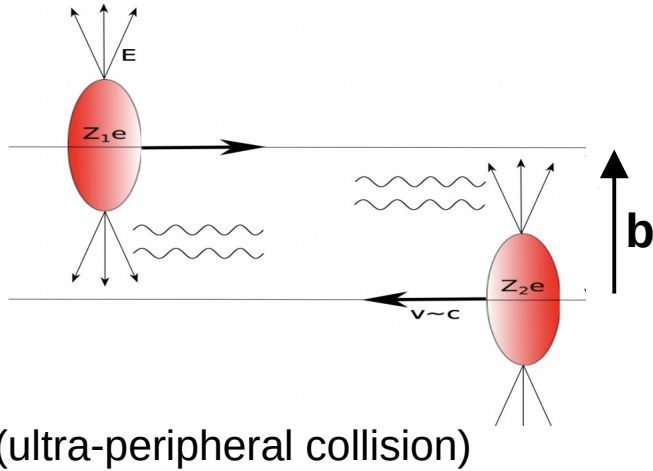


J/ψ photoproduction in Pb-Pb collisions with nuclear overlap at ALICE

Ionut-Cristian Arsene
on behalf of the ALICE Collaboration
University of Oslo

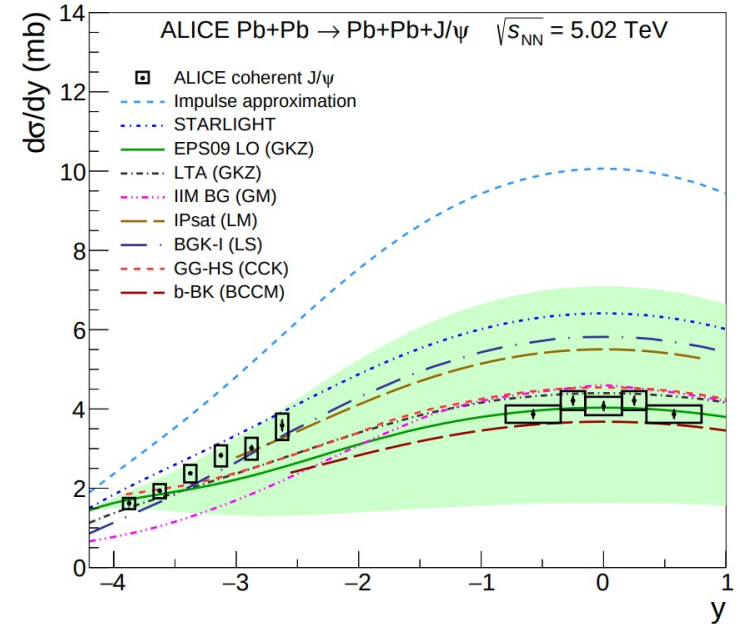


J/ψ photoproduction in UPCs ($b > R_1 + R_2$)



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

ALICE EPJC81 (2021) 712

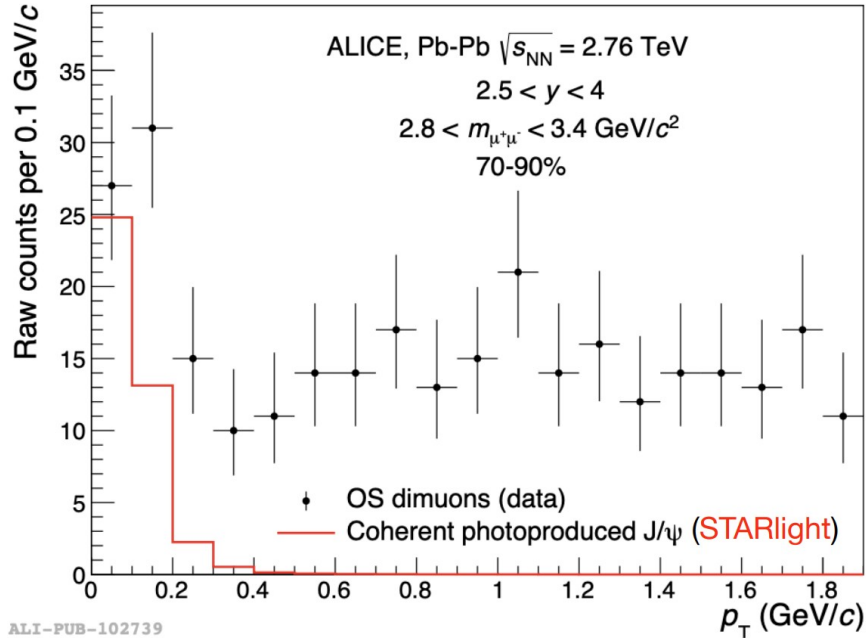


- Photon flux, $N_\gamma(\omega_\gamma)$, is relatively well known, depends on nucleus electric charge and EM form factor
- Photon-nucleus cross-section (σ) is sensitive to the parton distributions inside the nucleus
 - Gluon shadowing, gluon saturation

J/ψ photoproduction in hadronic AA collisions ($b < R_1 + R_2$)



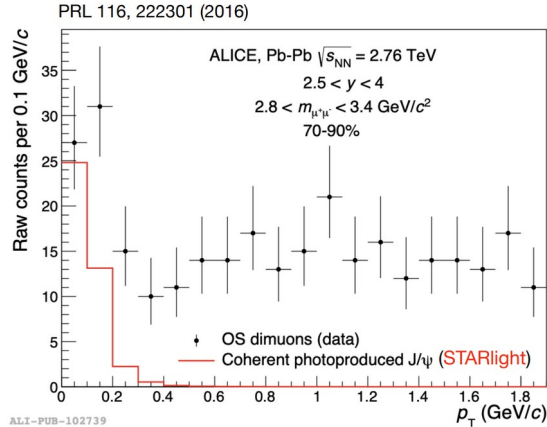
PRL 116, 222301 (2016)



- In Run 1, ALICE reported an excess of J/ψ wrt expectations from hadro-production in peripheral collisions at very low p_T
 - Good agreement with STARlight simulations

ALI-PUB-102739

J/ψ photoproduction in hadronic AA collisions ($b < R_1 + R_2$)

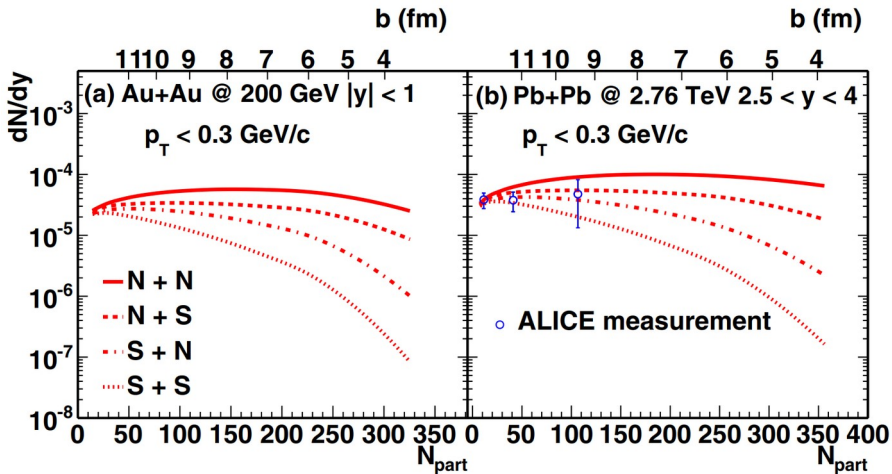


- In Run 1, ALICE reported an excess of J/ψ wrt expectations from hadro-production in peripheral collisions at very low p_T
 - Good agreement with STARlight simulations

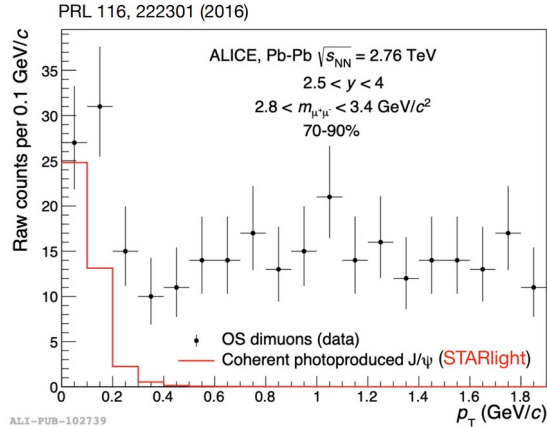
- Phenomenological understanding of the production cross-section ongoing

- Bracket scenarios:

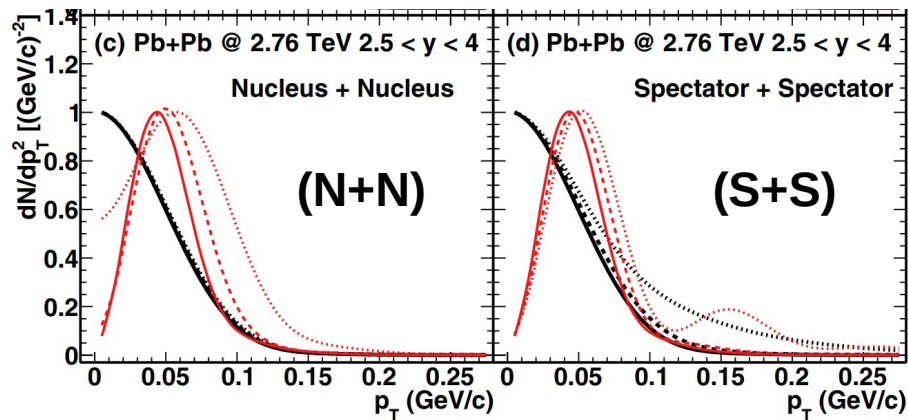
- Emitting photon source: whole nucleus (**N**) or spectator region only (**S**)
- Target: whole nucleus (**N**) or spectator region (**S**)



J/ψ photoproduction in hadronic AA collisions ($b < R_1 + R_2$)



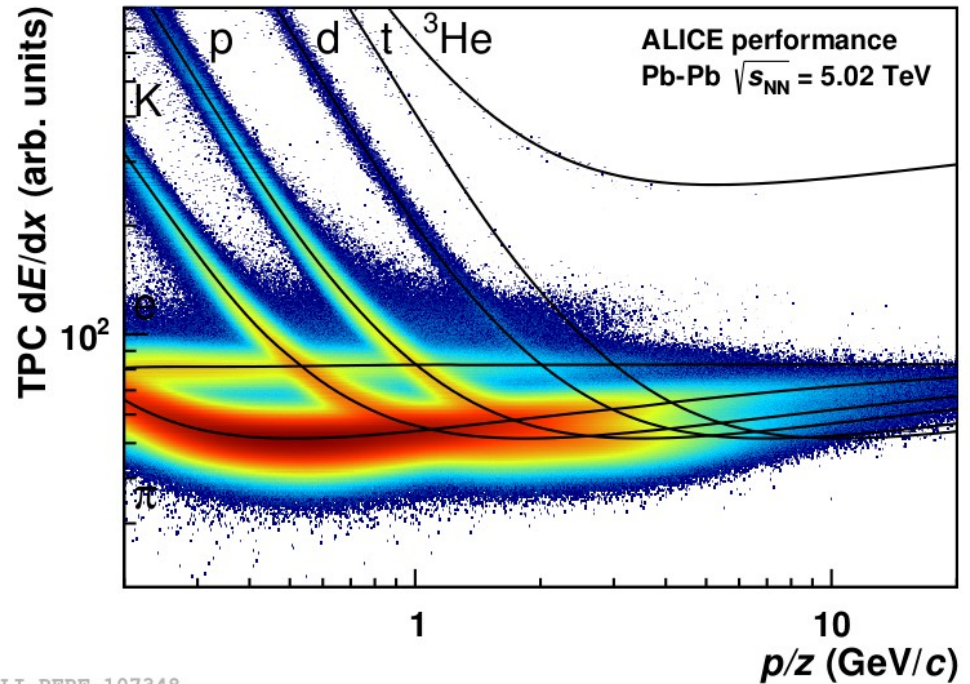
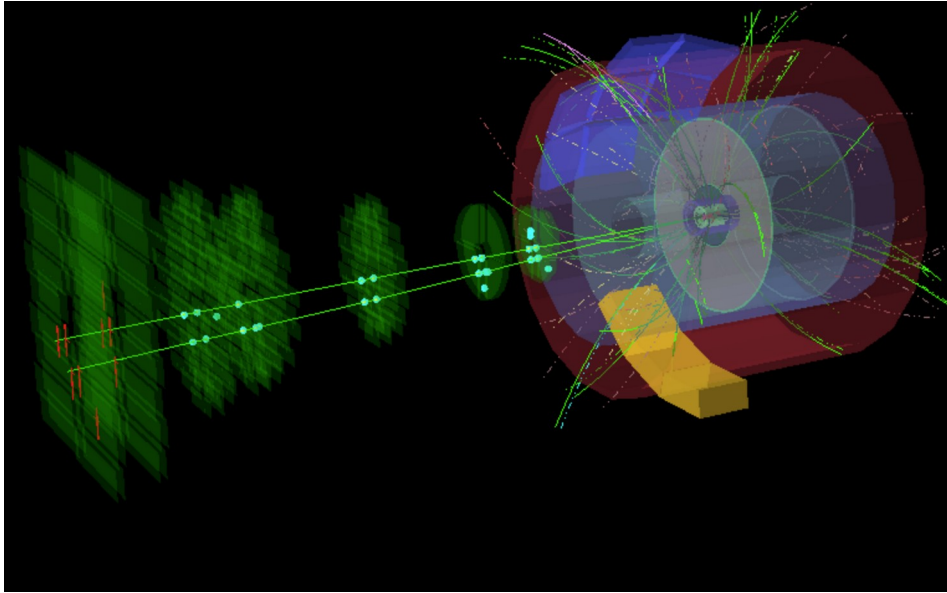
- In Run 1, ALICE reported an excess of J/ψ wrt expectations from hadro-production in peripheral collisions at very low p_T
 - Good agreement with STARlight simulations



- J/ψ has negative parity: destructive interference due to the possibility of switching the role of the two nuclei: Klein and Nystrand PRL84(2000)11, STAR Collaboration PRL102 (2009) 112301

w/o interference
 w/ interference

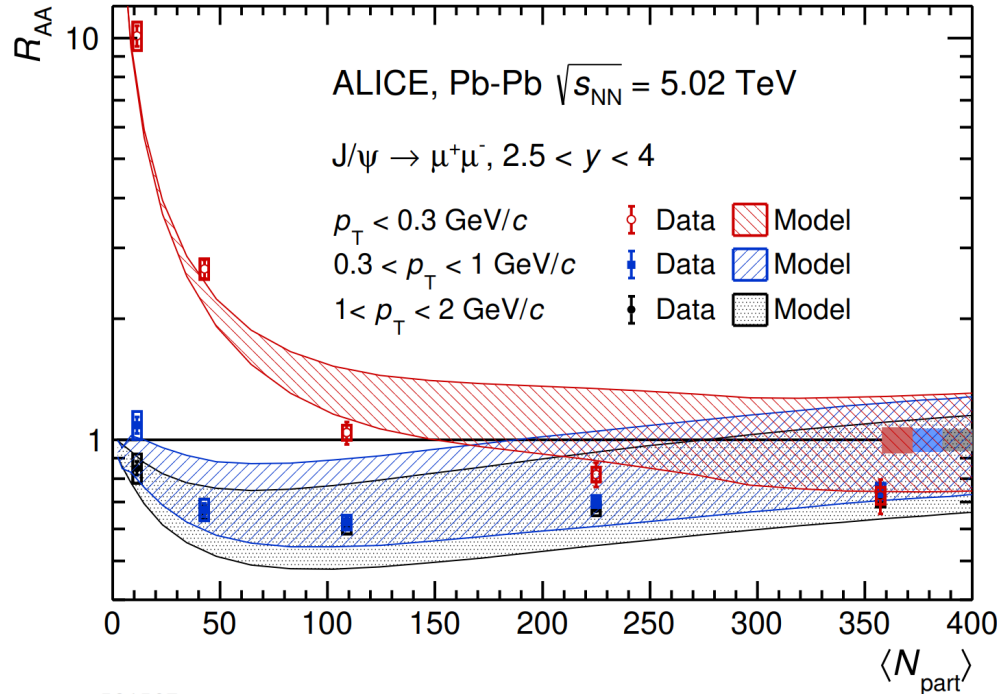
The ALICE detector and kinematics



- J/ψ reconstructed using
 - muon spectrometer: di-muons in $2.5 < y < 4.0$
 - central barrel: di-electrons in $|y| < 0.9$
- Coverage down to zero J/ψ p_T

J/ψ excess at forward rapidity in Run 2

ALICE, arxiv:2204.10684, PLB
Model: Shi et al., PLB777 (2018) 399

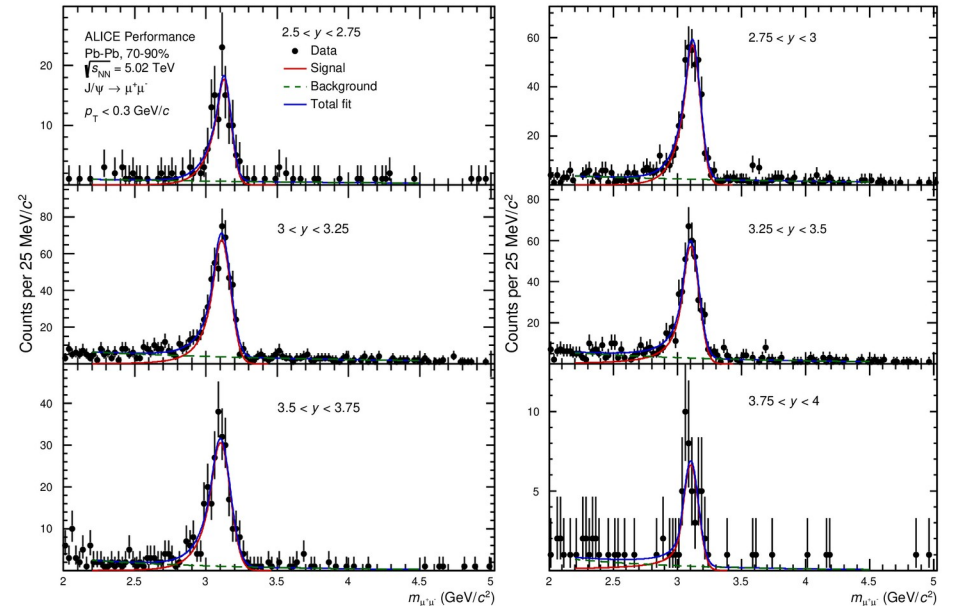
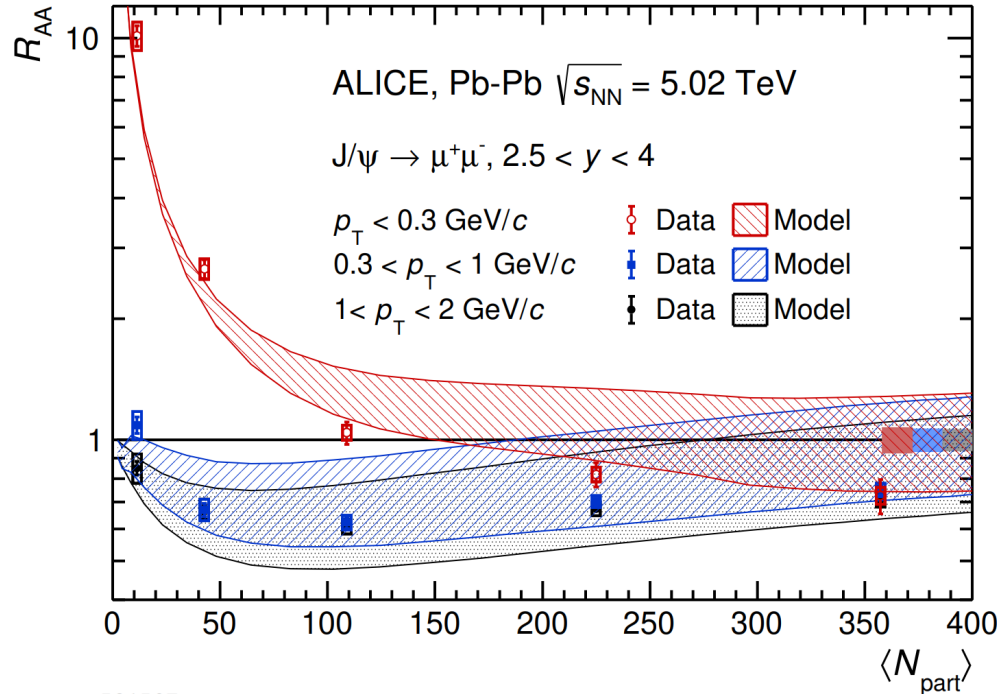


ALI-PUB-521507

- Run 2 Pb-Pb dataset allowed for the low- p_T J/ψ to be measured up to central collisions
- Clear excess indicated by the data up to semi-central collisions

J/ψ excess at forward rapidity in Run 2

ALICE, arxiv:2204.10684, PLB
 Model: Shi et al., PLB777 (2018) 399

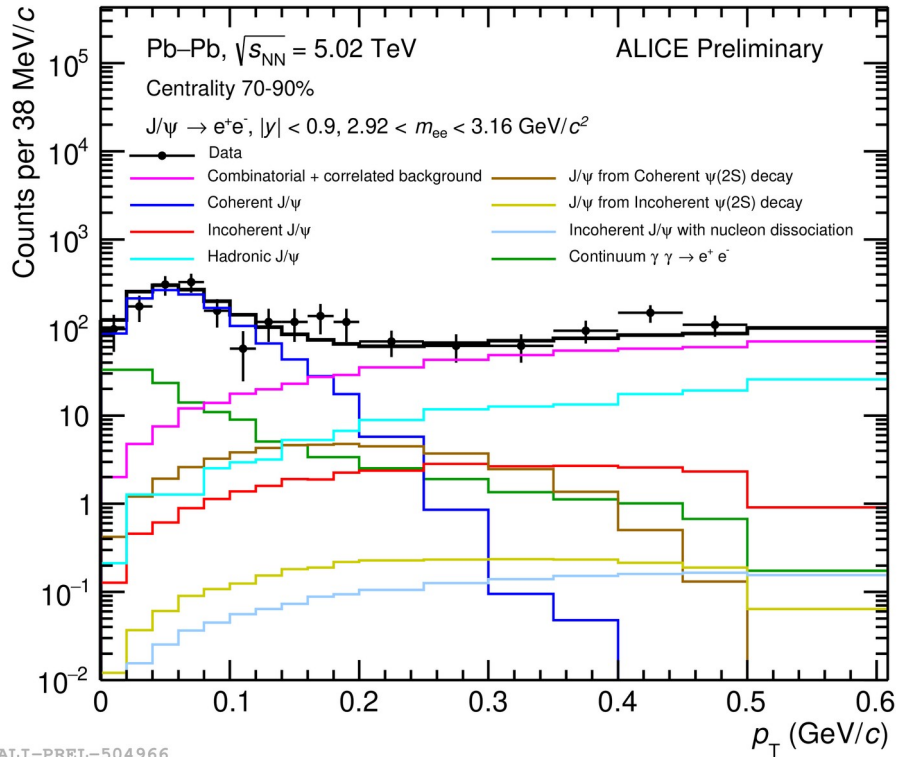


ALI-PUB-521507

ALI-PERF-538924

- Run 2 Pb-Pb dataset allowed for the low- p_T J/ψ to be measured up to central collisions
- Clear excess indicated by the data up to semi-central collisions
- Study on rapidity dependence of low p_T excess ongoing

J/ψ photoproduction in peripheral collisions at mid-y

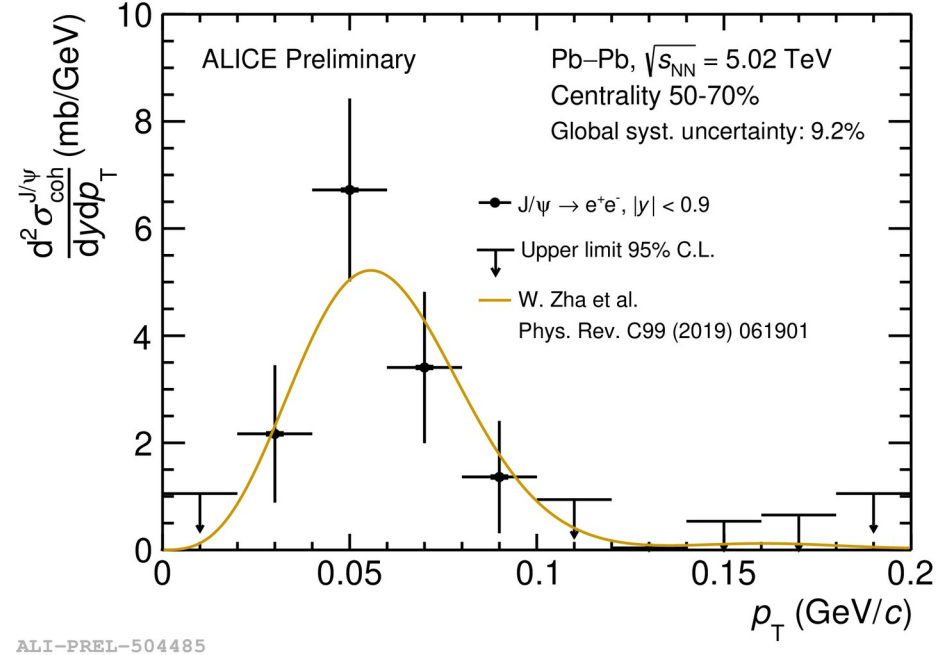
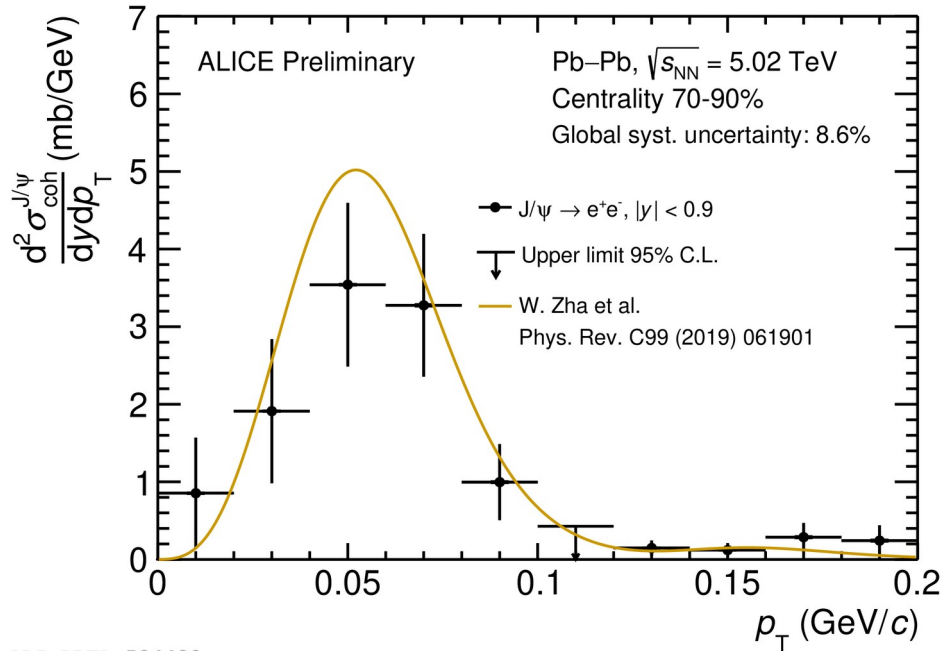


- Very recent measurement at mid-rapidity
- Coherent yield extracted via a template fit
- Photo-production components (STARlight)
 - Coherent J/ψ
 - Incoherent J/ψ
 - Feed-down from coherent and incoherent ψ(2S)
 - $\gamma\gamma$ continuum
- Hadronic J/ψ production (data driven)
- Combinatorial and correlated background (data driven)

*Hadronic J/ψ production:
Pengzhong Lu, Tuesday 11:10*

p_T dependence of J/ψ photoproduction at mid-y

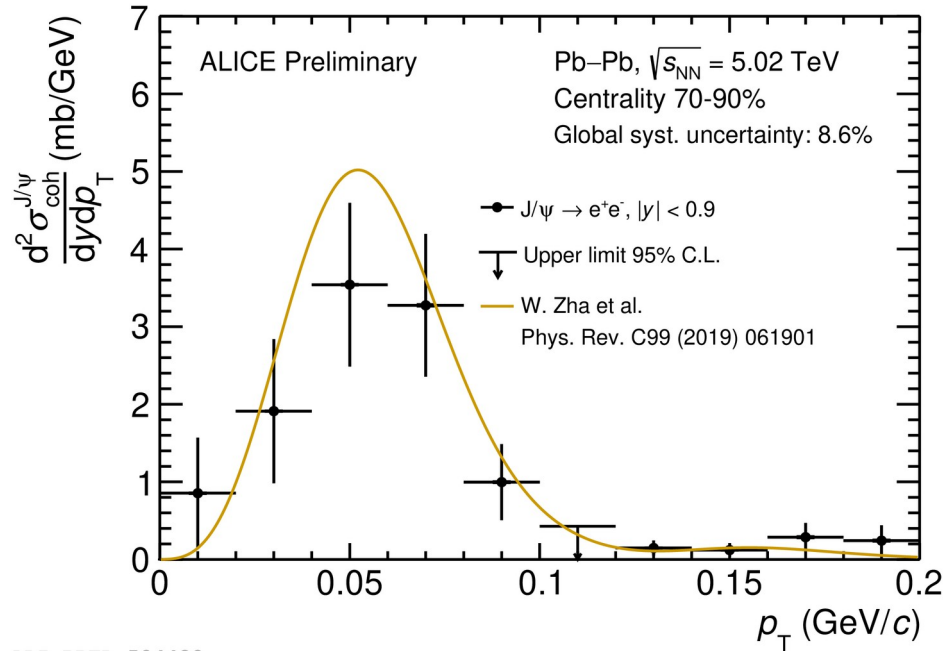
Zha et al., PRC 99 (2019) 061901



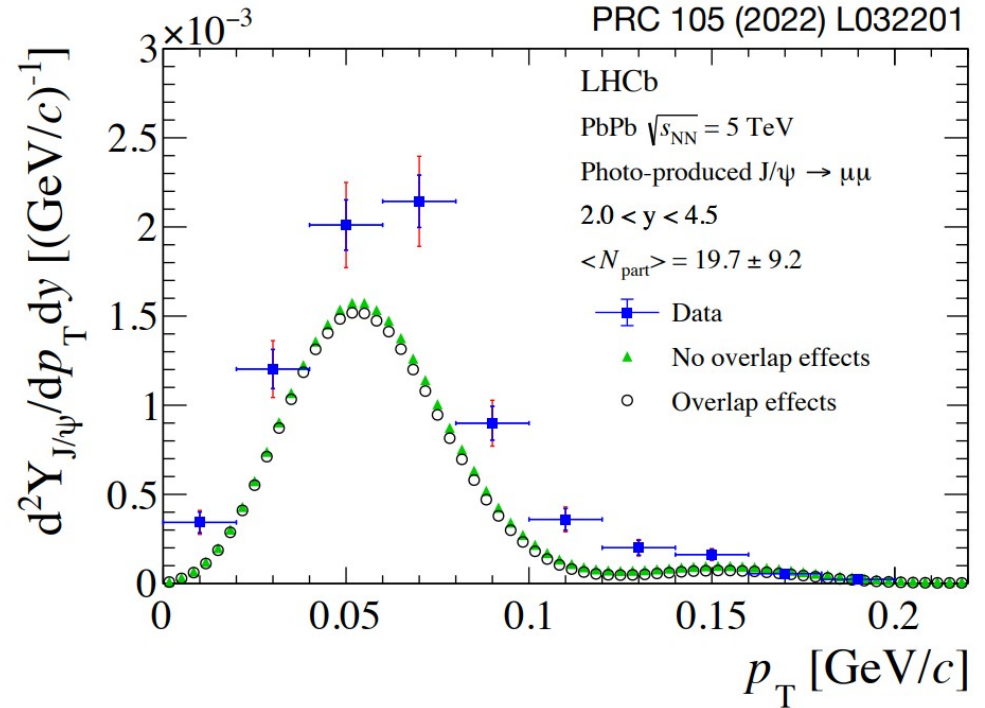
- Model calculations using destructive interference compatible with the data
- Modifications in the differential cross-section with centrality still difficult to disentangle with the current datasets at mid-y

p_T dependence of J/ψ photoproduction at mid-y

Zha et al., PRC 99 (2019) 061901



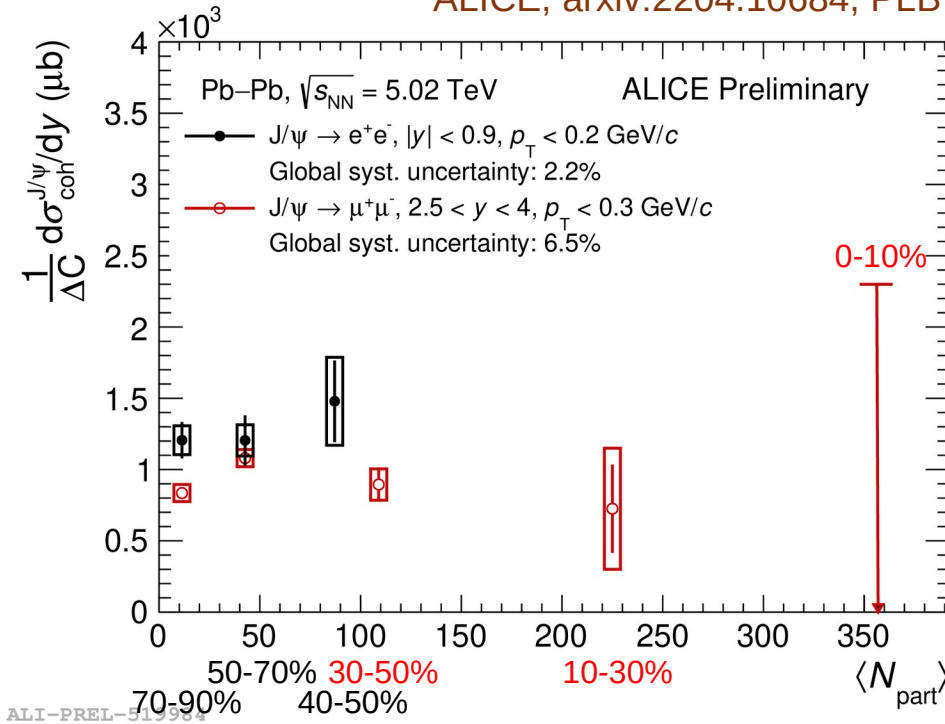
ALI-PREL-504480



- 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
- Similar observations reported by LHCb

Coherent J/ψ production as a function of centrality

ALICE, arxiv:2204.10684, PLB

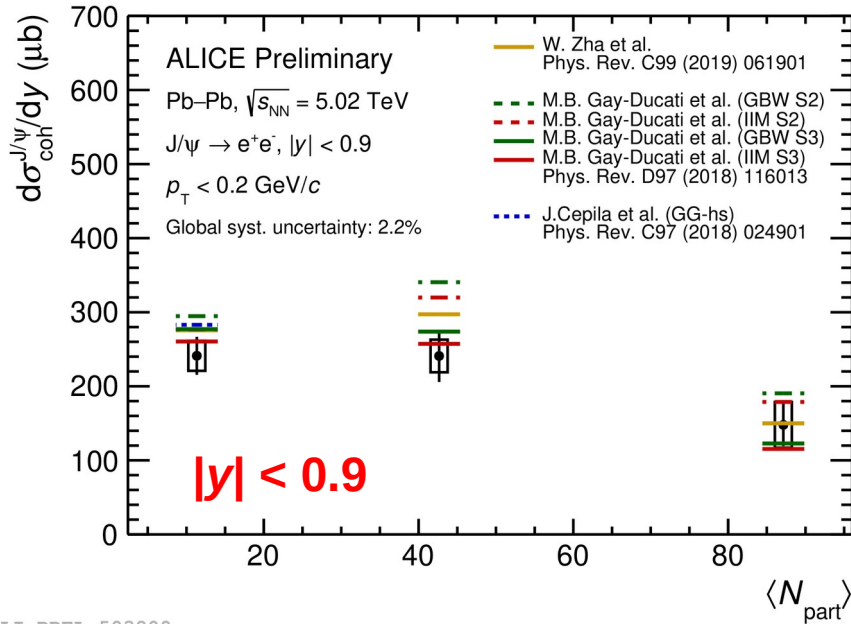


Cross-sections are normalized to the width of the centrality interval (ΔC)

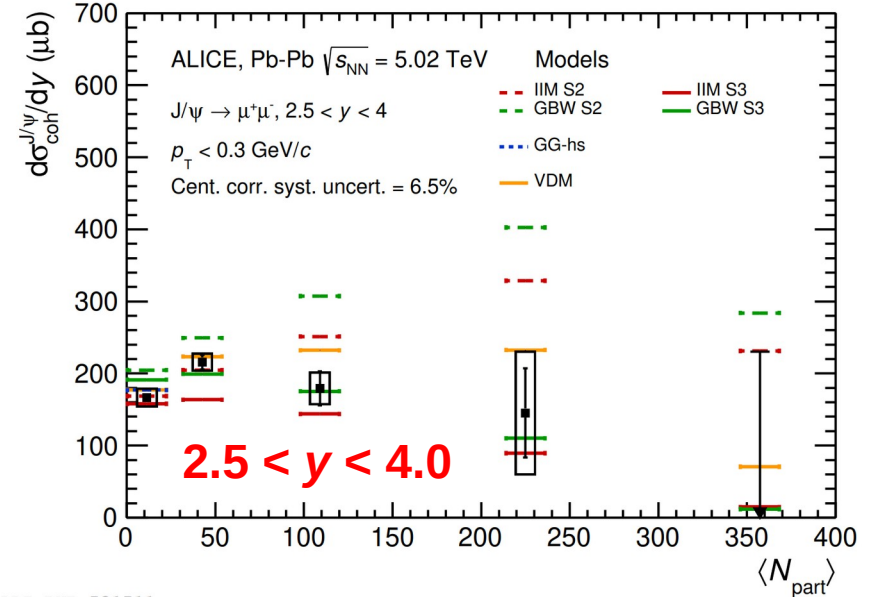
- Cross-sections extracted up to nearly central (at forward) and semi-central collisions (at mid-y)
- No significant centrality dependence within uncertainties

Coherent photo-production, data vs models

VDM: Klusek-Gavenda et al., PLB 790 (2019) 339



ALI-PREL-503800



ALI-PUB-521511

Modifications of photon-flux only:

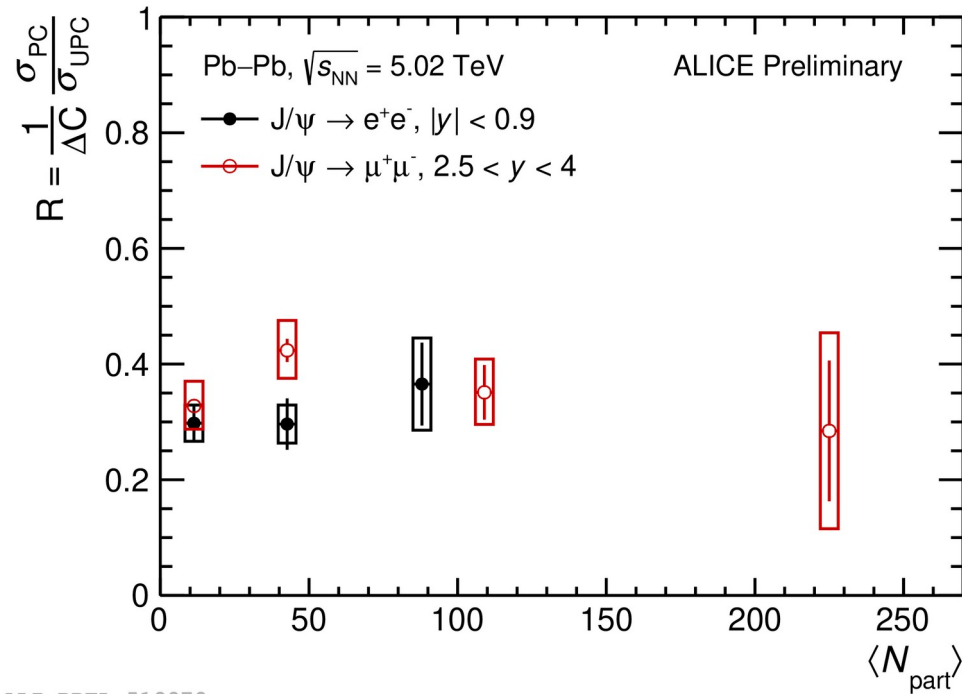
GBW S2, IIM S2, VDM, GG-hs

Modifications of both photon-flux and $\sigma(\gamma A)$:

GBW S3, IIM S3, Zha et al.

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

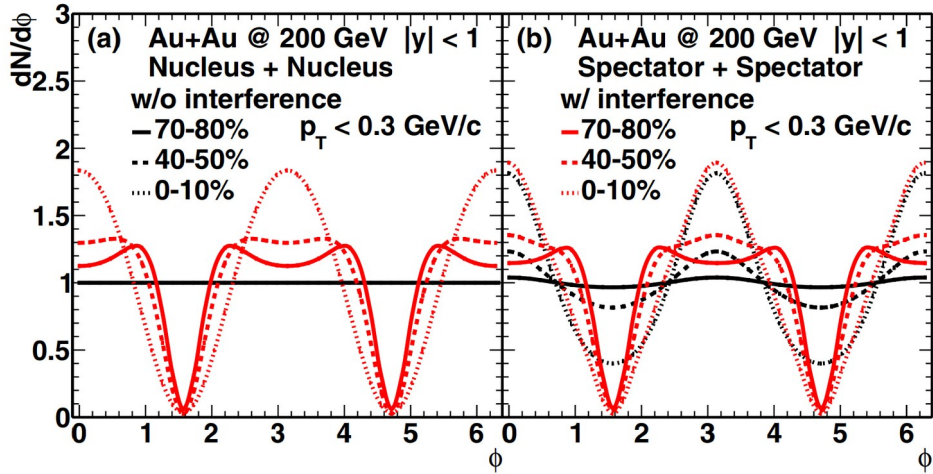
Coherent production in PC, normalized to UPC



ALI-PREL-519979

- Possible rapidity dependent effects can be studied using $\sigma(PC) / \sigma(UPC)$
- Good agreement between mid- and forward-y results in most peripheral collisions (70-90%)

Outlook: azimuthally dependent coherent J/ψ production

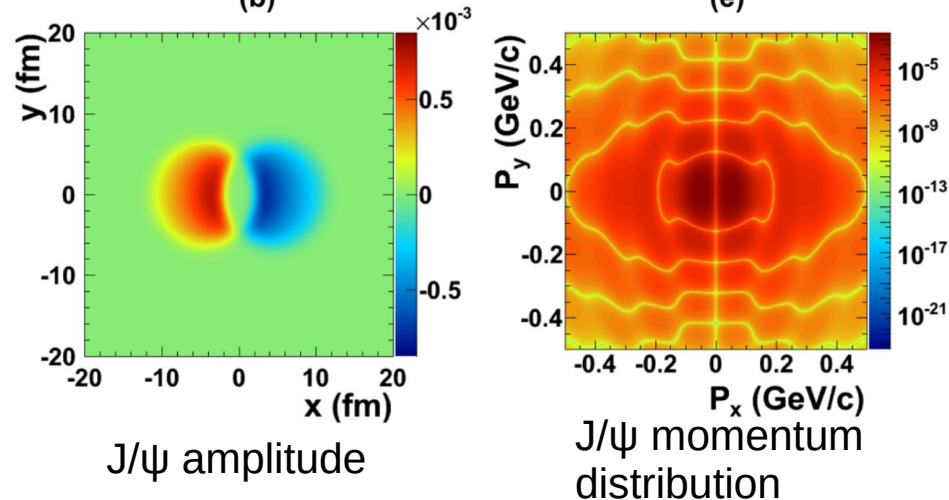


- Very strong azimuthal dependence predicted by models considering interference
 - Patterns are very different wrt hadronic production

Zha et al., PRC97 (2018) 044910

(b)

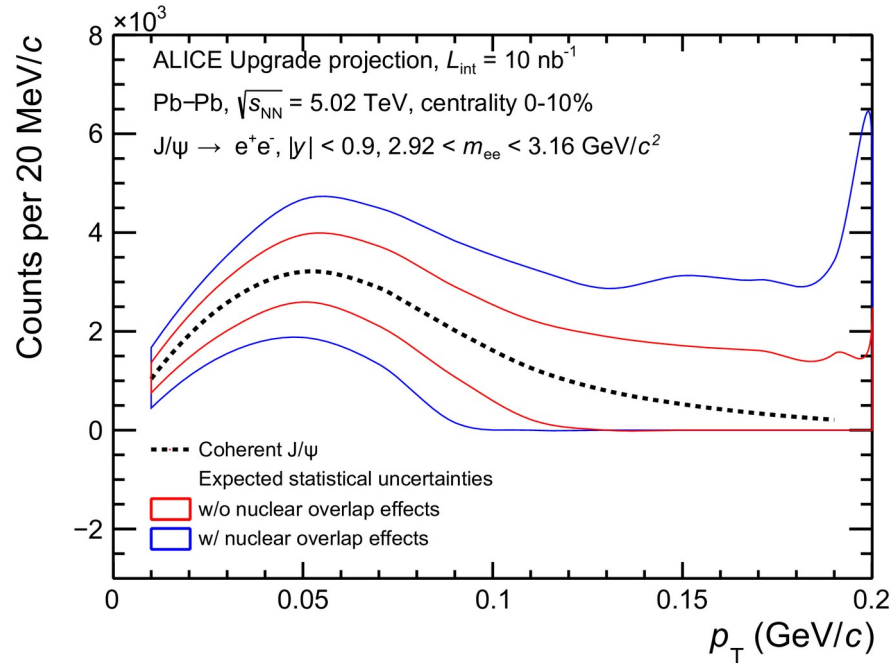
(e)



- Photoproduction modeled as a double slit experiment: interference patterns in the J/ψ (p_x, p_y) space

Zha et al., PRC99 (2019) 061901(R)

Projections for Run 3 and Run 4



ALI-SIMUL-514006

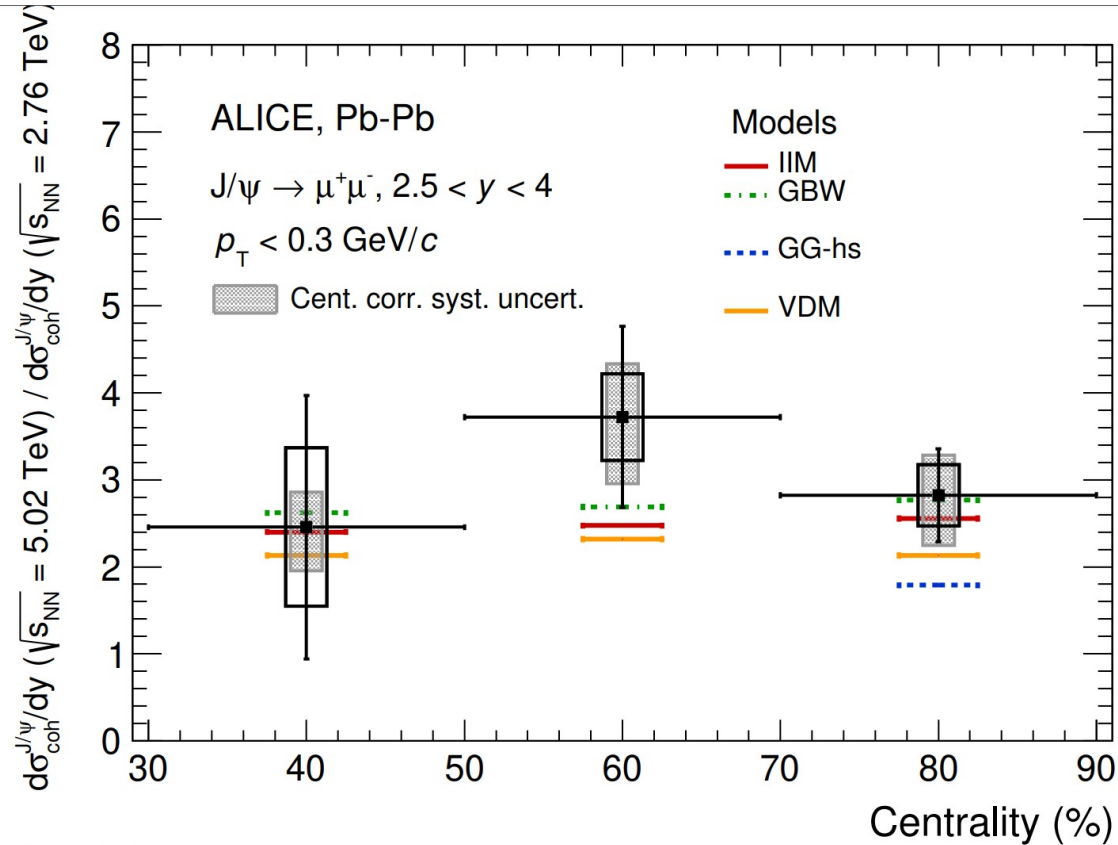
- Expected integrated luminosity in Pb-Pb: $\sim 10 \text{ nb}^{-1}$ at both mid and fwd-y
- In central collisions (0-10%), expected significance of coherent yields of 5-10
- Below 10% centrality:
 - Precise measurements of p_T spectrum, azimuthal correlations, polarization

Summary and conclusions

- Recent measurement of p_T -differential cross-sections at mid-rapidity
 - peak at 50-60 MeV/c
 - compatible with model assumptions of destructive interference
- p_T -integrated cross-sections at forward- and mid-y using the entire Run 2 Pb-Pb dataset
 - Models suggest that photon flux and $\sigma(\gamma A)$ may be affected by the participant region
- Projections for Run 3 and Run 4
 - Central collisions: coherent J/ψ cross-section feasible with a significance better than 5
 - Semi-central and peripheral: precise differential measurements

Backup

Sigma(5.02 TeV) / sigma (2.76 TeV)



ALI-PUB-521515