Diffractive vector meson production in ultraperipheral heavy ion collisions from the Color Glass Condensate

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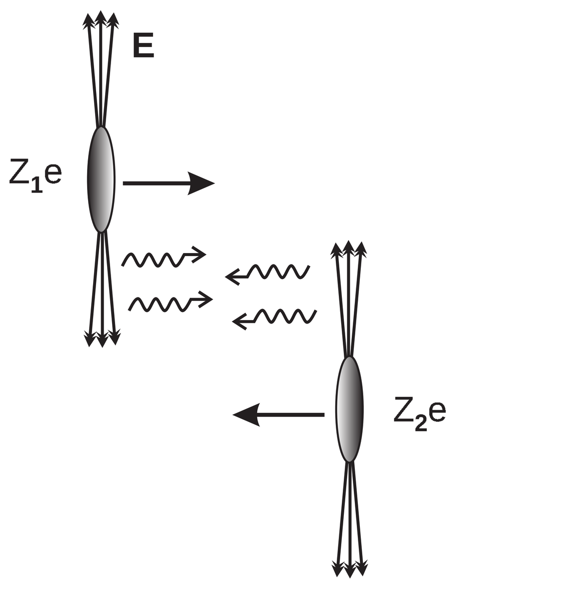
ABSTRACT

Ultraperipheral heavy ion collisions make it possible to study γA-scattering at high energy. We compute vector meson production in coherent and incoherent diffractive scattering using the IPsat model fitted to the HERA proton structure function measurements. The results are compared with the ALICE data.

1 Introduction



Heavy ion collision at large impact parameter: strong interactions are suppressed, but the colliding nuclei act as photon sources.

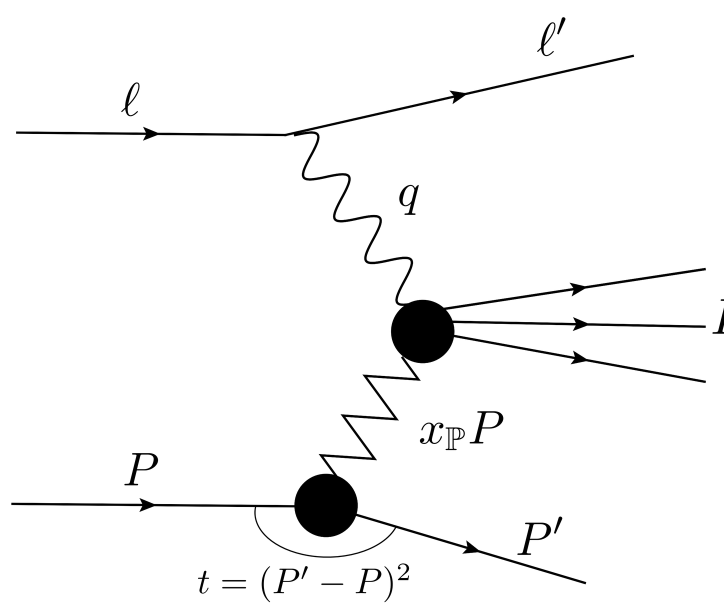
γA collision probes small-x structure of the nucleus: $x = M_V e^y/\sqrt{s}$

- LHC $y = 0$: $x \sim 10^{-3}$
- LHC $y = 2$: $x \sim 0.01$ and $x \sim 10^{-4}$

Results published in Ref. [1].

2 Diffractive DIS

$$e(\ell) + p(P) \to e(\ell') + p(P') + X(P_X)$$



$X = J/\Psi, \Psi(2S), \rho, \Upsilon, \ldots$

Diffractive scattering: no exchange of quantum numbers (color).

- Lepton emits a virtual photon which interacts with the target via pomeron exchange.
- Proton remains intact.
- Experimental signature: large rapidity gap between vector meson and the proton.

3 Diffraction off nuclei

Coherent diffraction: nucleus remains intact

$$d\sigma/dt \sim \langle|\mathcal{A}(x,Q^2,t)|^2\rangle_N,$$

dominates at $|t| \lesssim 1/R^2$.

Quasielastic diffraction: nucleus can also to break up

$$d\sigma/dt \sim |\langle\mathcal{A}(x,Q^2,t)\rangle_N|^2$$

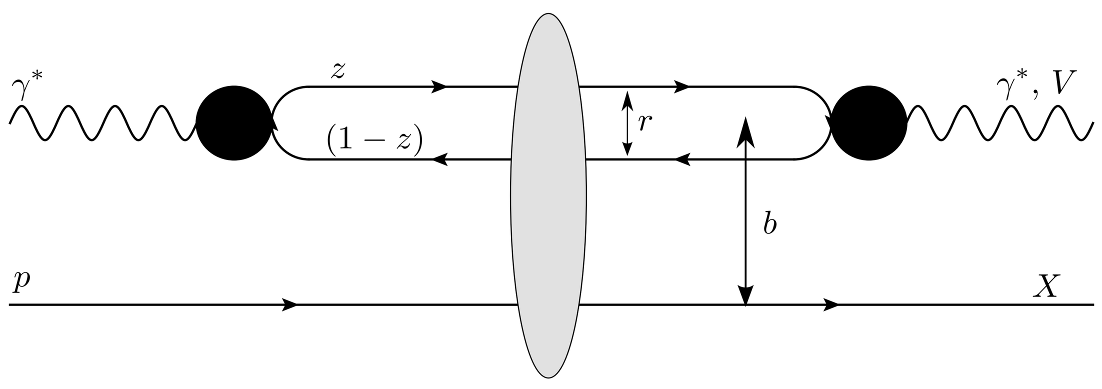
Incoherent diffraction: nucleus breaks up

$$d\sigma/dt \sim |\langle\mathcal{A}(x,Q^2,t)\rangle_N|^2 - \langle|\mathcal{A}(x,Q^2,t)|^2\rangle_N$$

Dominates at large $|t|$.

$\langle\rangle_N$: average over nucleon configurations.

4 Diffraction in dipole model



1. $\gamma^* \to q\bar{q}$ splitting: QED
2. Dipole-target scattering (QCD)
3. Dipole $\to \gamma^*$ or vector meson (QED+modeling)

Dipole-target cross section $\sigma_{\text{dip}} = 2\int d^2 b e^{ib\cdot\Delta} N(r,x,b)$.
Universal dipole amplitude N.

$$\mathcal{A}^{\gamma^* p \to Vp} = \int d^2 r dz [\Psi_V^* \Psi](r,z,Q) \frac{d\sigma_{\text{dip}}}{d^2 b}$$

$\Psi_V^*\Psi$: photon/vector meson wave function overlap.
Use factorized IPsat model:

$$N(r,x,b) = T_p(b)\left[1 - \exp\left(-\alpha_s x g(x,\mu^2) r^2 \frac{\pi^2}{2\pi B_p}\right)\right]$$

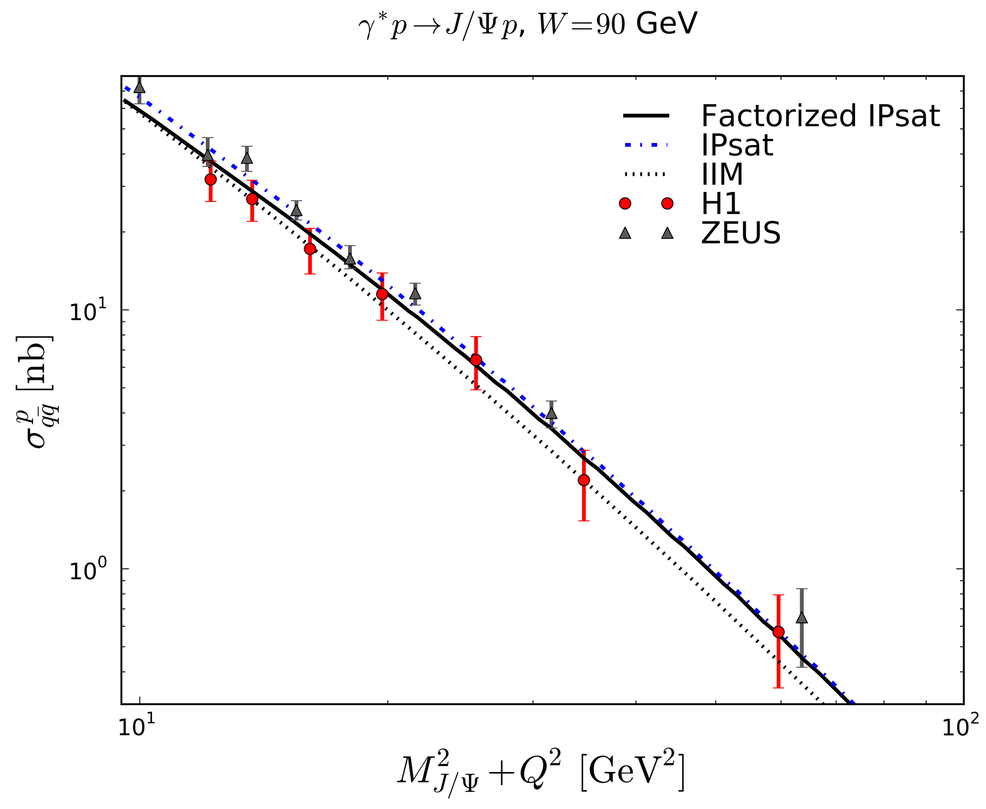
with Gaussian impact parameter profile T_p.

- Fit initial condition of the DGLAP-evolved gluon density xg and proton width to the HERA F_2 data [2].

Compare with the IIM model results.

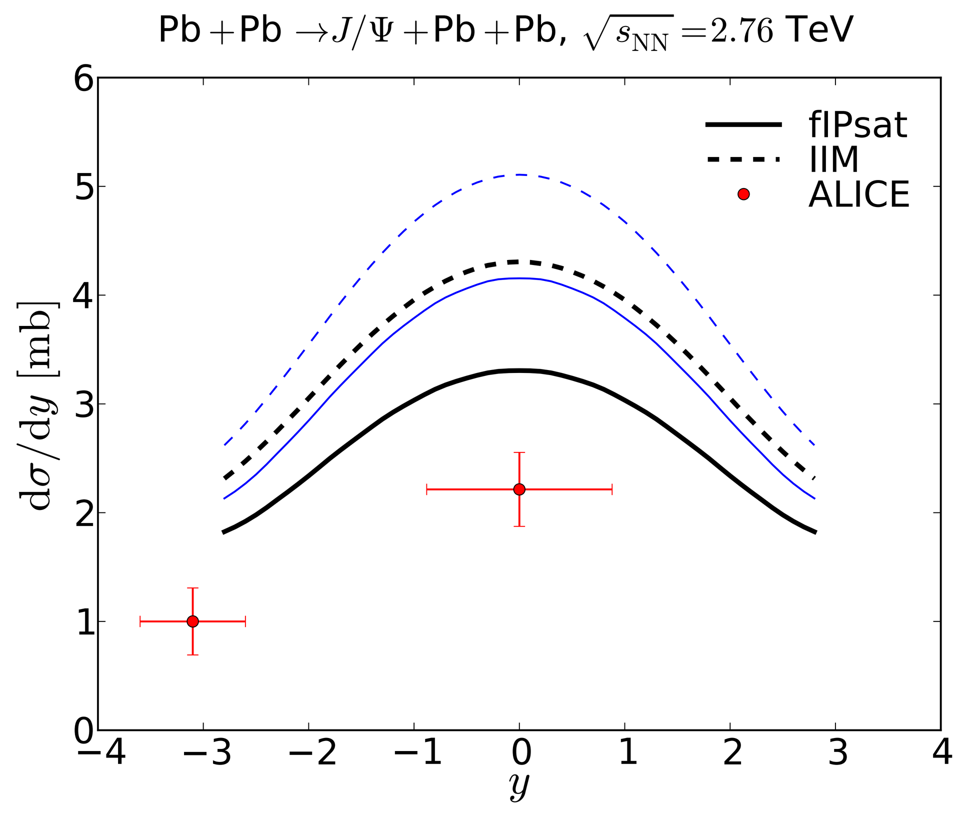
Generalization for nuclei: replace $T_p(b) \to \sum_{i=1}^{A} T_p(b - b_i)$. Incoherent cross section calculated in Ref. [3].

5 Check HERA data



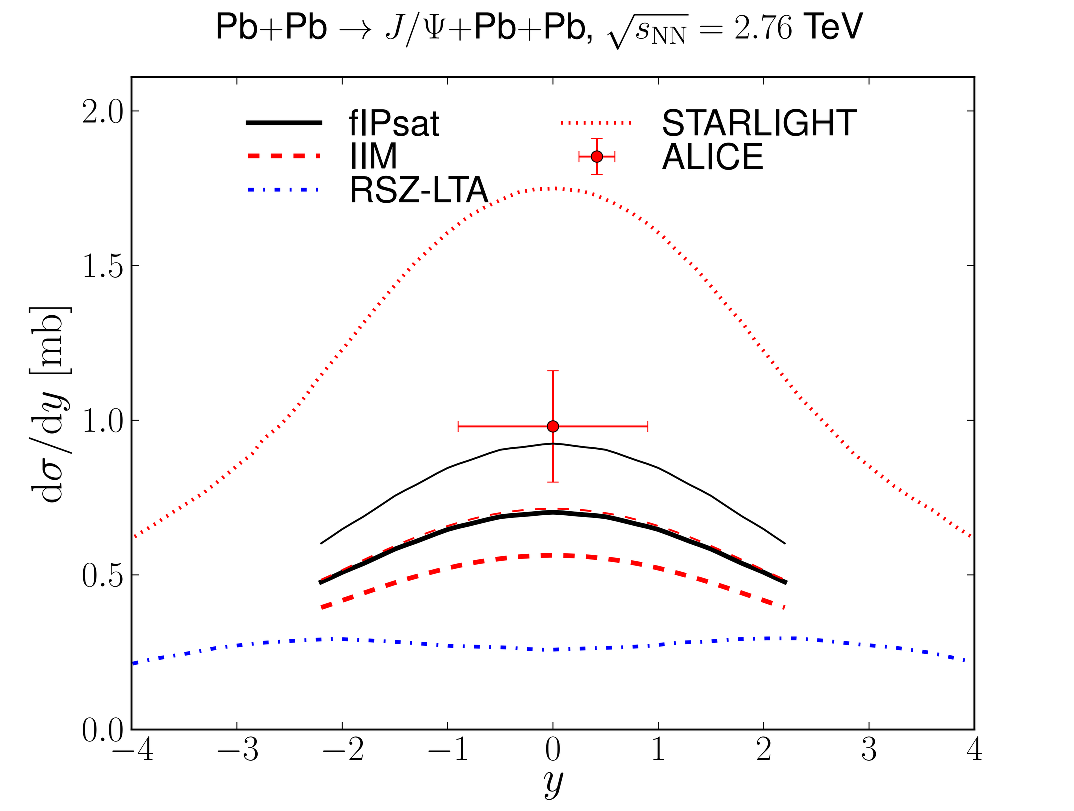
Large real part and skewedness corrections required.

6 Coherent J/Ψ production



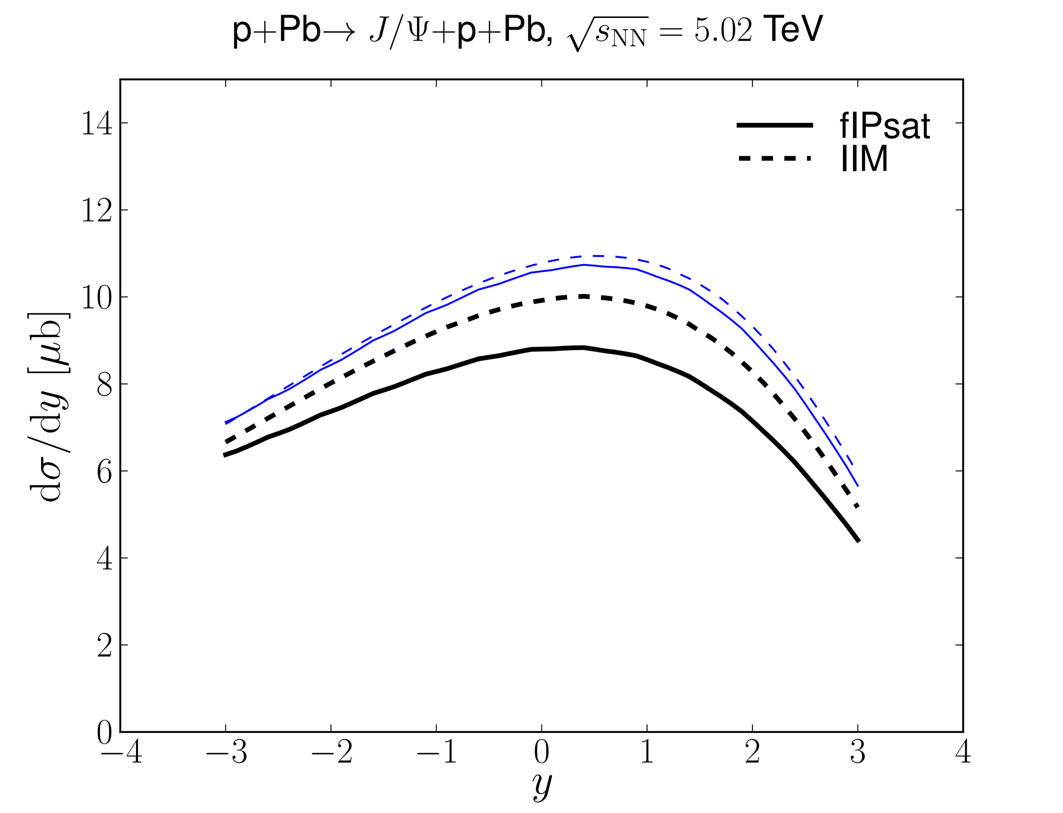
Different J/Ψ wave functions (thin lines: Boosted Gaussian, thick lines: Gaus-LC). Figure from Ref. [1], data from [4].
Absolute normalization has largish model dependence.
RHIC $y = 0$: $d\sigma/dy = 109\ \mu$b (exp: 76 ± 34 mb [5]).

7 Incoherent J/Ψ production



Thin lines: Boosted Gaussian, thick lines: Gaus-LC.
Data and other models (STARLIGHT, RSZ-LTA) from Ref. [4].

8 Proton-nucleus collisions



Photon flux $\sim Z^2$, dominant contribution from γp scattering.
γA event is required to be coherent.
Smaller model dependence as γp scattering is constrained by the HERA data.

9 Conclusions

- Ultraperipheral AA collisions make it possible to study diffractive γA scattering at high energy
- Simultaneous comparison with coherent and incoherent data can constrain model uncertainties in
  - dipole cross section
  - vector meson wave function

Work in progress:

- $\Psi(2S)$
- BK evolved dipole cross section

References

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