Vector meson photoproduction in UPCs and EIC

CFNS postdoc monthly meeting

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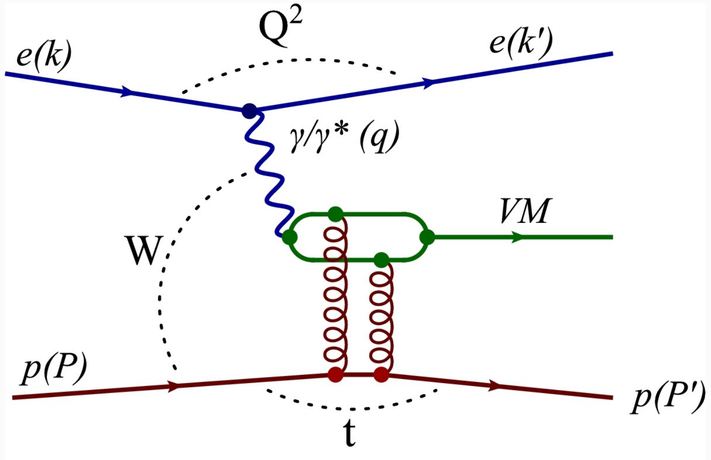
Vector meson photoproduction

- Vector meson photoproduction:
  γ fluctuate to a $q\bar{q}$ pair, has $J^{PC} = 1^{--}$

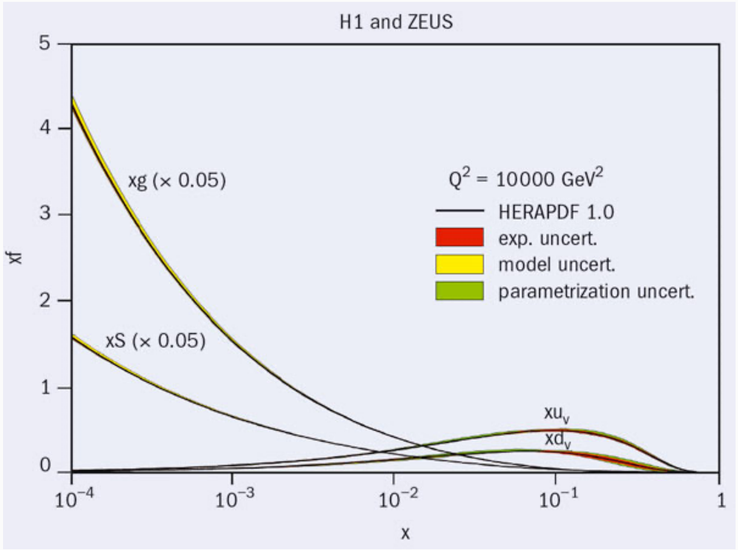


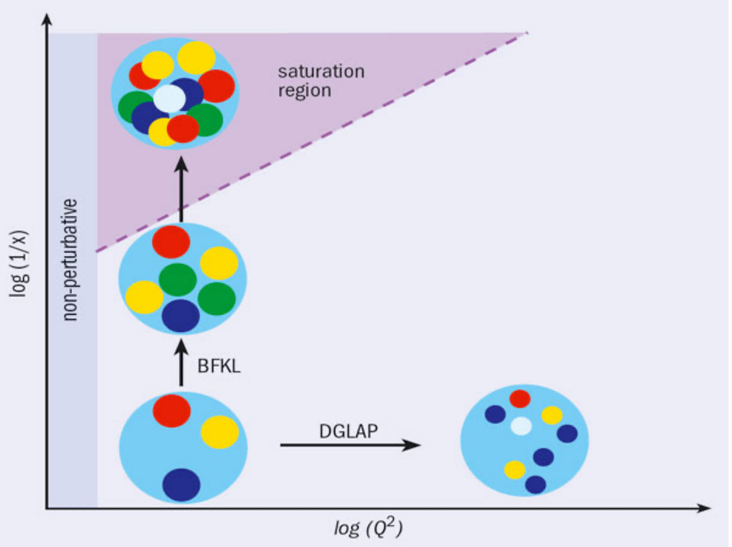
- The measured cross section is sensitive to gluon distribution

  - In LO collinear pQCD:

$$\left.\frac{d\sigma_{\gamma+A\to J/\psi+A}}{dt}\right|_{t=0} = \frac{M_{J/\psi}^3 \Gamma_{ee} \pi^3 \alpha_s(Q^2)}{48 \alpha_{em} Q^8} \left[x g_A(x, Q^2)\right]^2$$

M.G. Ryskin, Z.Phys. C57 (1993) 89-92

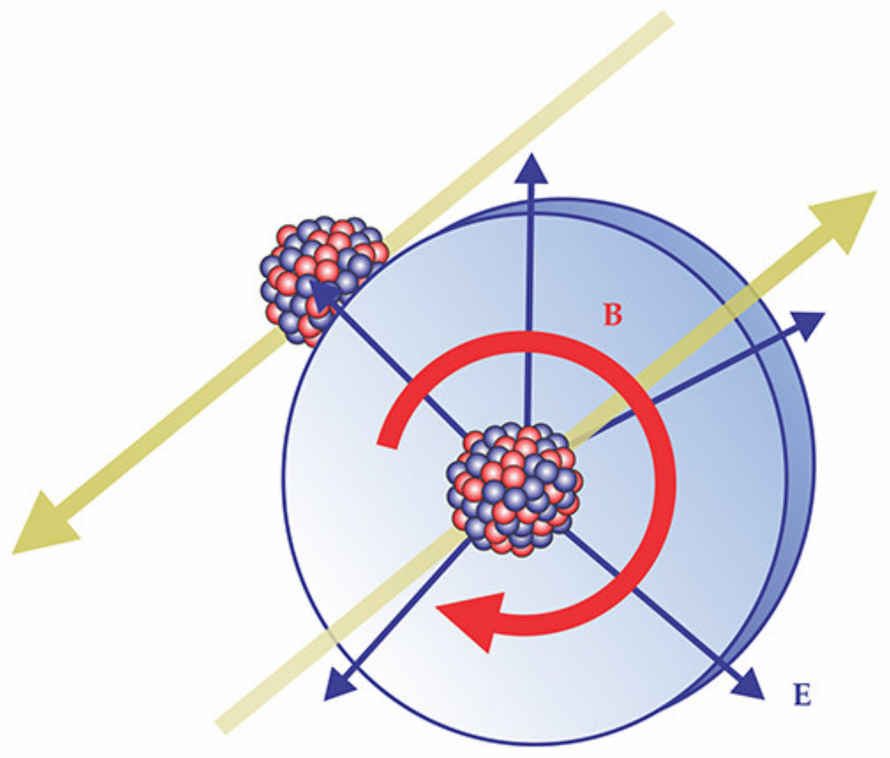




CERN Cour. 50N6 (2010) 24-26

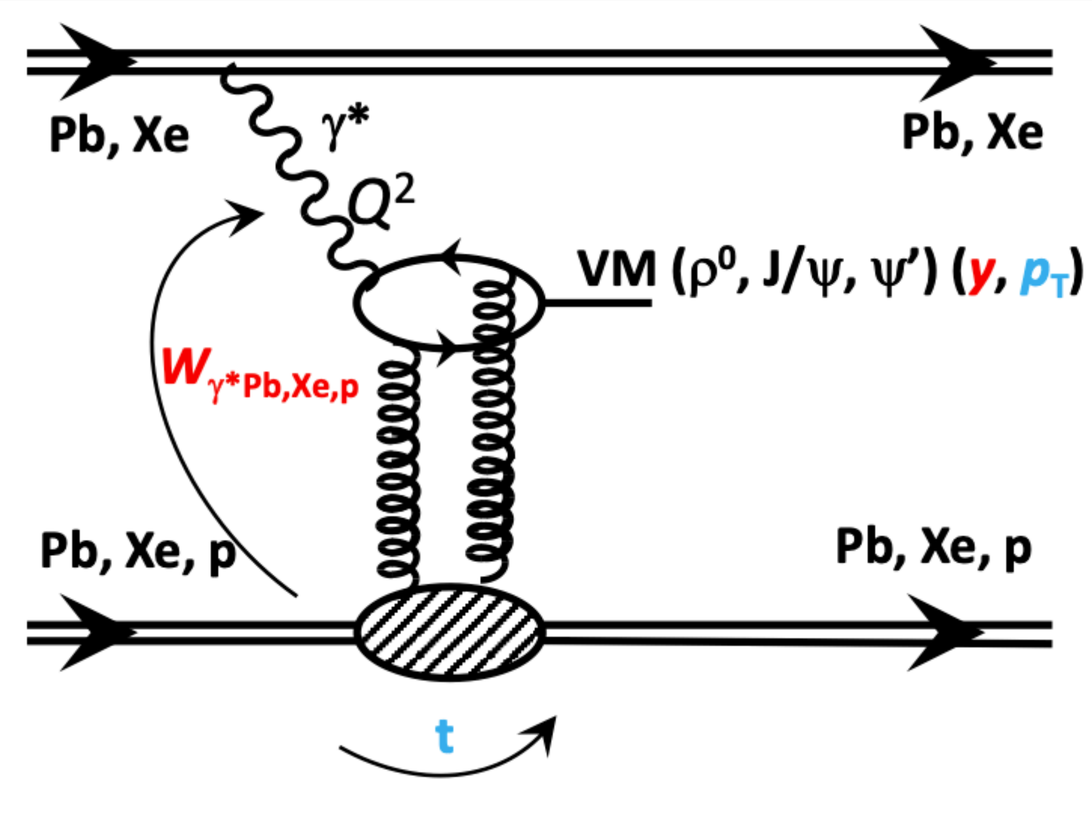
Ultra-peripheral heavy-ion collisions at the LHC

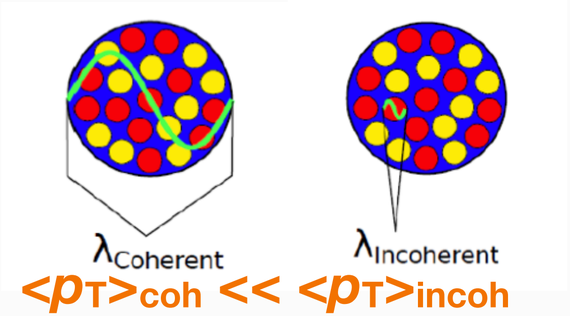
S. Klein, J. Nystrand, Physics Today 70, 10, 40 (2017)



- EM field of ultra-relativistic ions → a beam of quasi real photons (intensity ≈ Z^2)
- Ultra-Peripheral Collision (UPC): b > 2R
  hadronic interactions are strongly suppressed

Vector meson photoproduction in UPCs



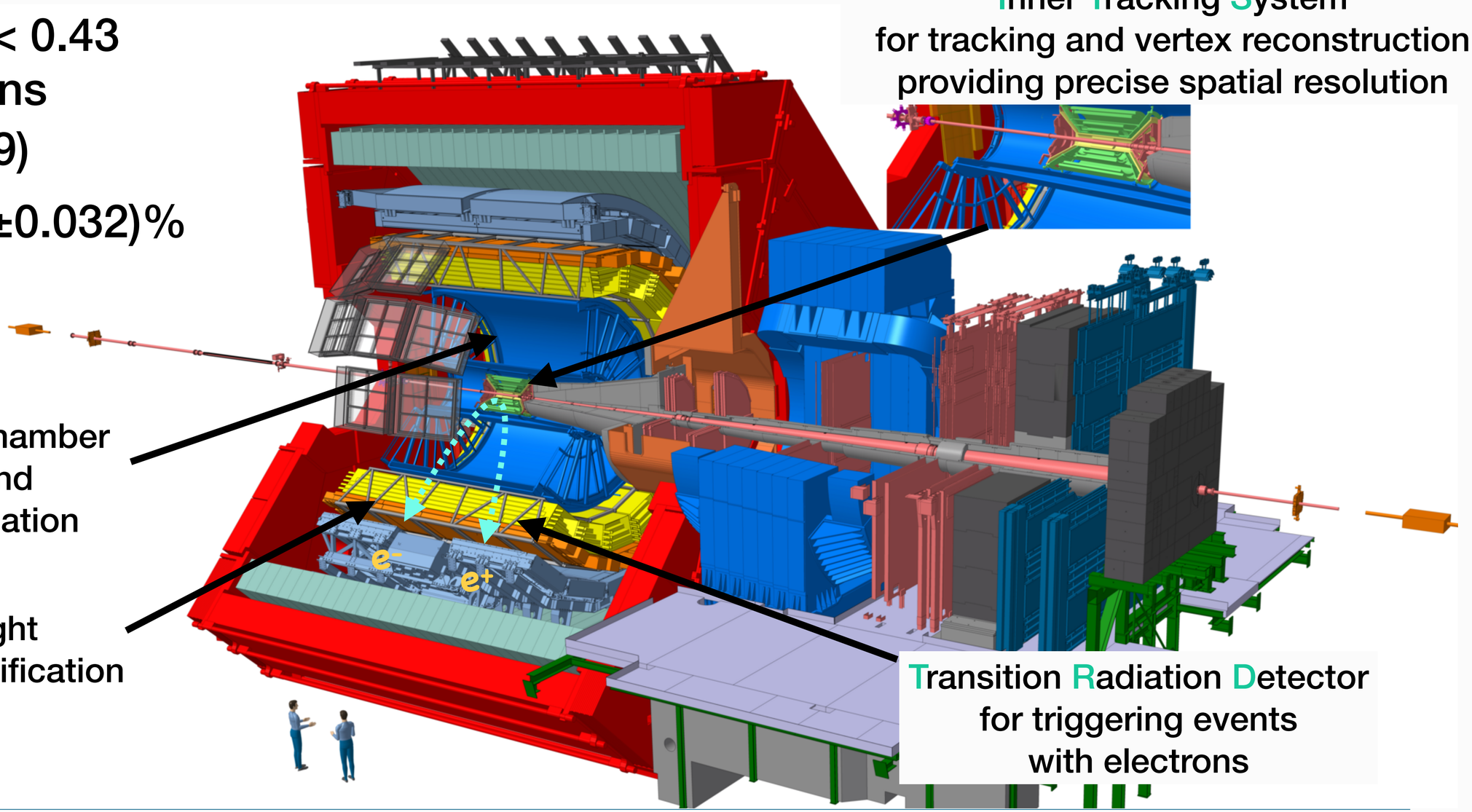
- Kinematic variables are accessible via measurement:
  - photon Virtuality: $Q^2 \sim (M_V/2)^2$
  - Bjorken-*x*: $x_B = \frac{M_V}{\sqrt{s_{NN}}} e^{\pm y_V}$
  - Photon-target center of mass energy: $W^2_{\gamma-\text{target}} = 2E_{\text{target}} M_V e^{\mp y}$
  - 4-momentum transfer: $|t| \sim p_T^2$
- Coherent and incoherent processes provide complementary informations on gluon density:
- 

Coherent production: average gluon densities

Incoherent production: event-by-event fluctuation in gluon densities

ALICE (A Large Ion Collider Experiment)

- $-1.37 < y_{\mathrm{C.M.S.}} < 0.43$ in p-Pb collisions ($-0.9 < y_{\mathrm{lab}} < 0.9$)
- $J/\psi \rightarrow ee$ (5.971±0.032)%



Inner Tracking System
for tracking and vertex reconstruction
providing precise spatial resolution

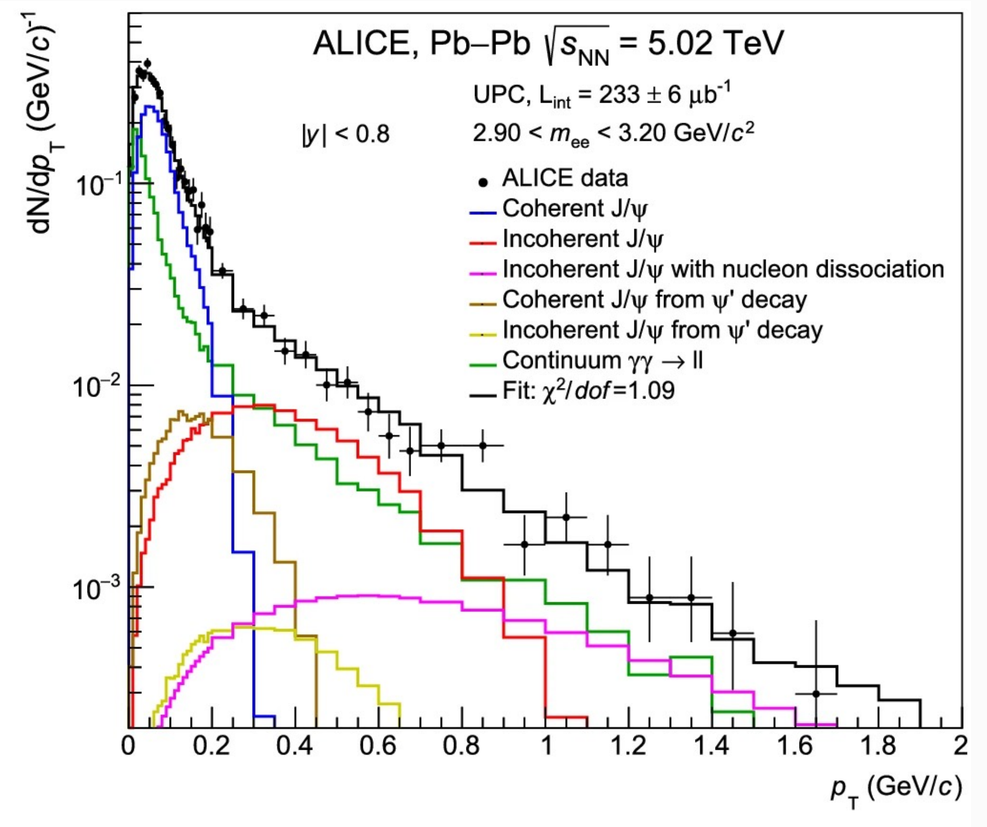
Time Projection Chamber
for tracking and
electron identification

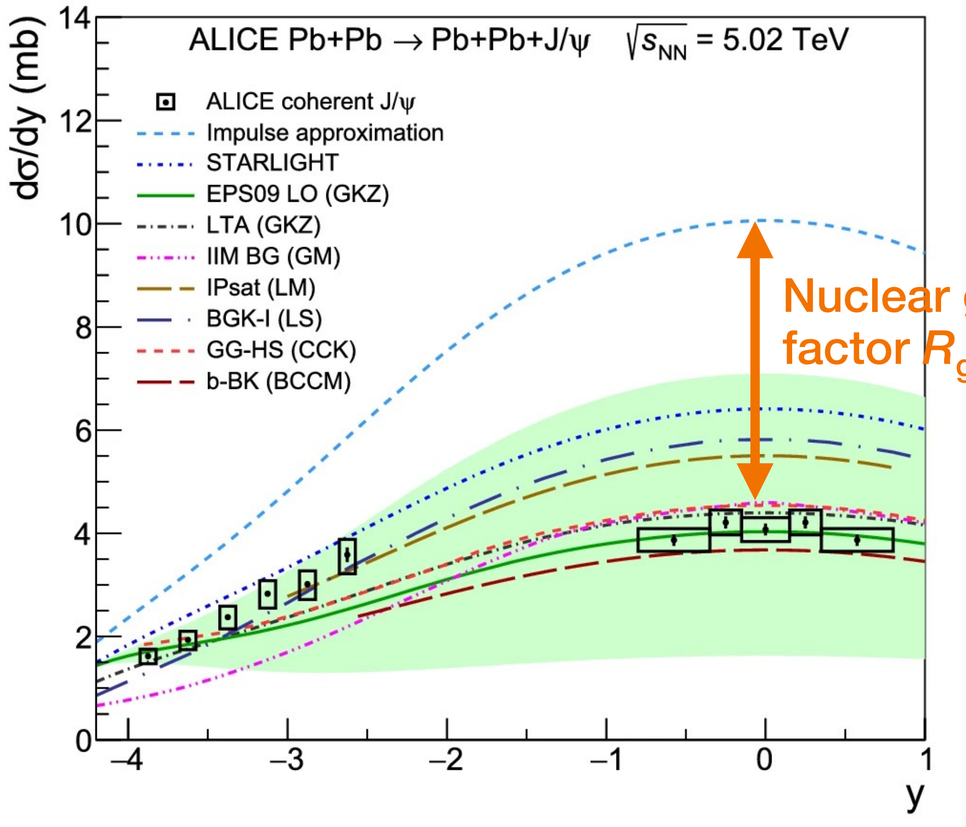
Time Of Flight
for electron identification

Transition Radiation Detector
for triggering events
with electrons

Coherent J/ψ photoproduction in UPCs

Eur. Phys. J. C 81 (2021) 712

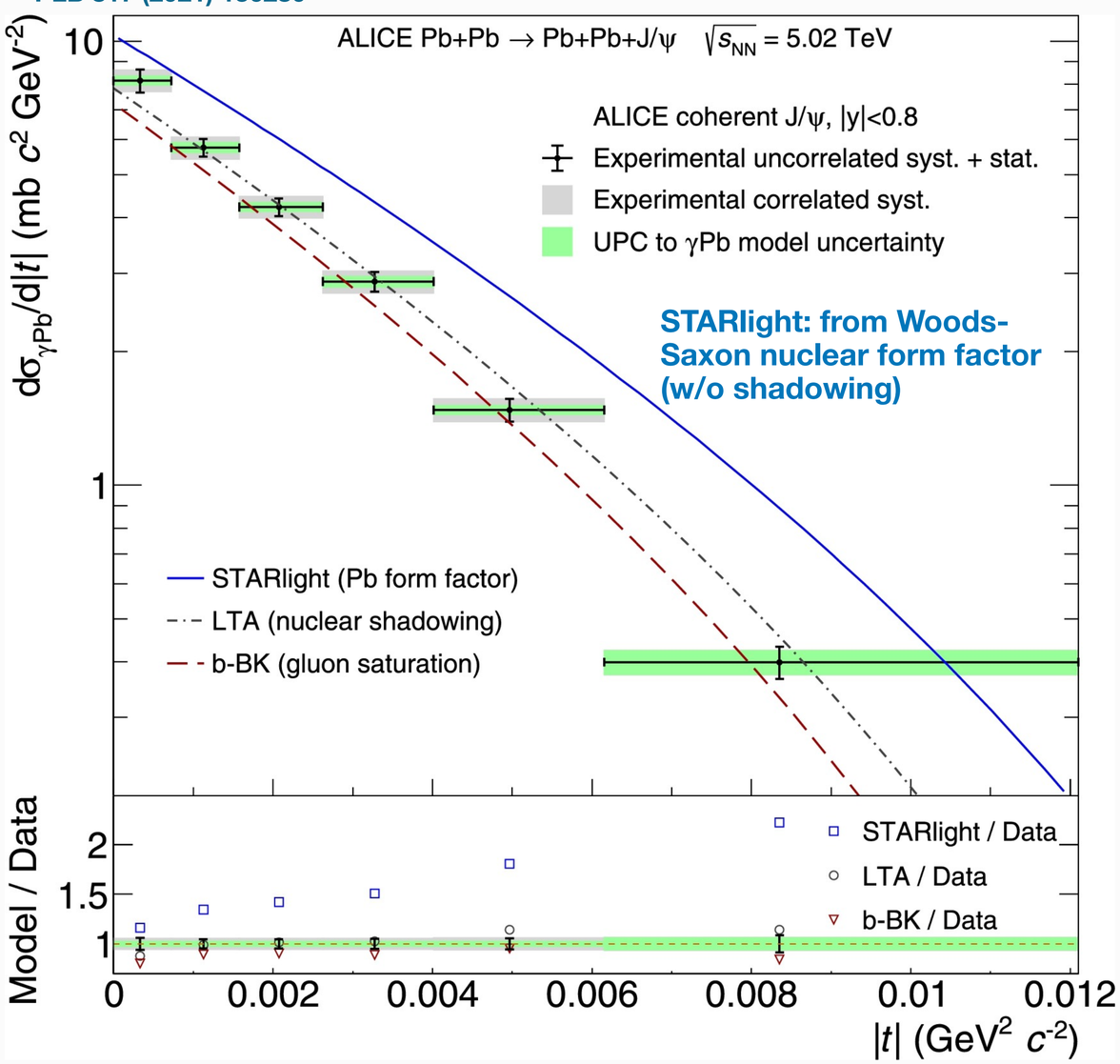




- Midrapidity: x ∈ (0.3, 1.4) × 10^{-3}, compatible with models predicting moderate shadowing
- 2-fold photon directional ambiguity in forward rapidity:
  x ∈ (1.1,5.1) × 10^{-5} or x ∈ (0.7,3.3) × 10^{-2}

Coherent J/ψ photoproduction in UPCs

PLB 817 (2021) 136280



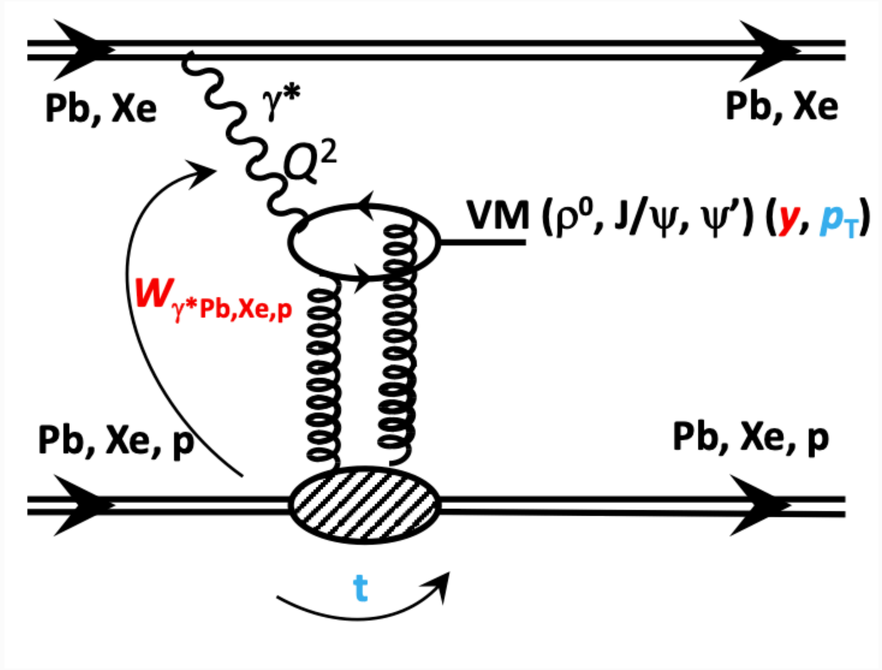
- x ~ 5*10^{-4}, Q^2 ~ 2.25 GeV^2
- The lowest-order pQCD coherent vector meson photoproduction:

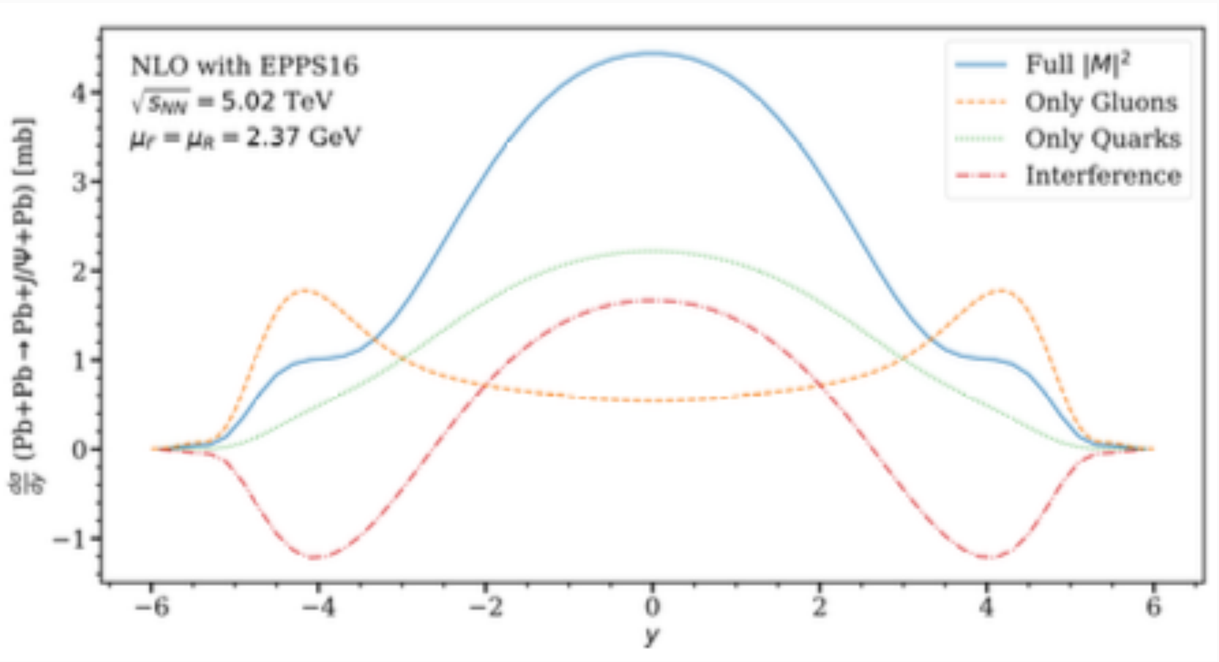
$$\frac{d\sigma_{coh}}{dt} = \frac{\pi^3 \alpha_s^2 M^3 \Gamma_{V\to e^+e^-}}{3\alpha_{em}} \left[\frac{1}{(2q^2)^2} xg(x,q^2)\right]^2 F_N^{2g}(t)^2$$

Phenomenological two-gluon form factor describing gluon distribution of nucleus in transverse plane

- Falls off more steeply than the Woods-Saxon nuclear form factor
- Consistent with dipole model calculations that include nuclear shadowing and/or gluon saturation

Towards next steps

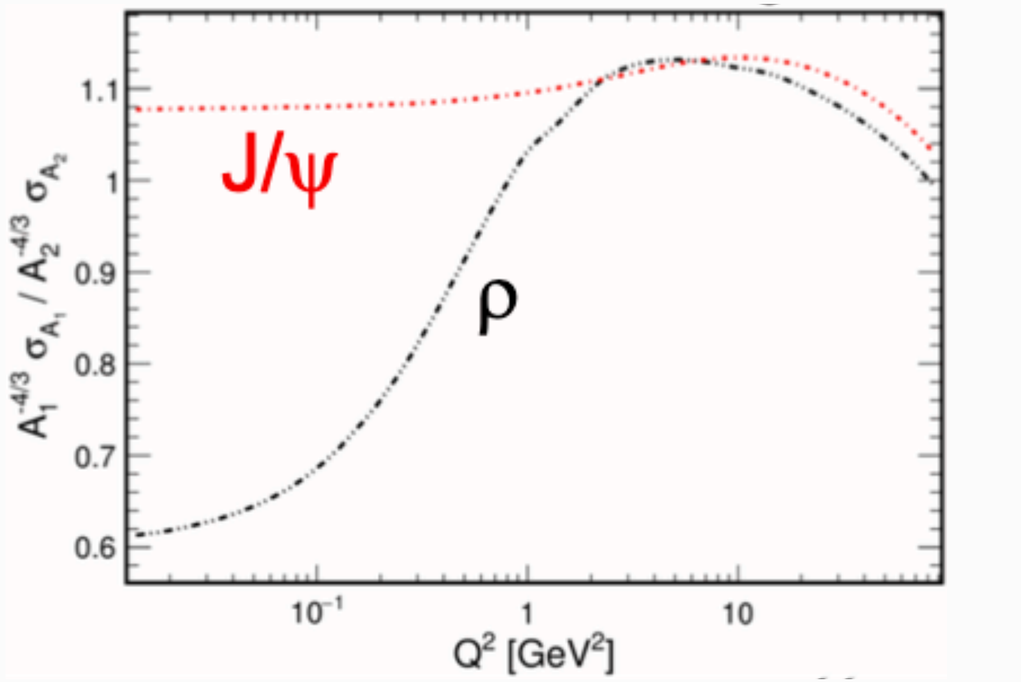


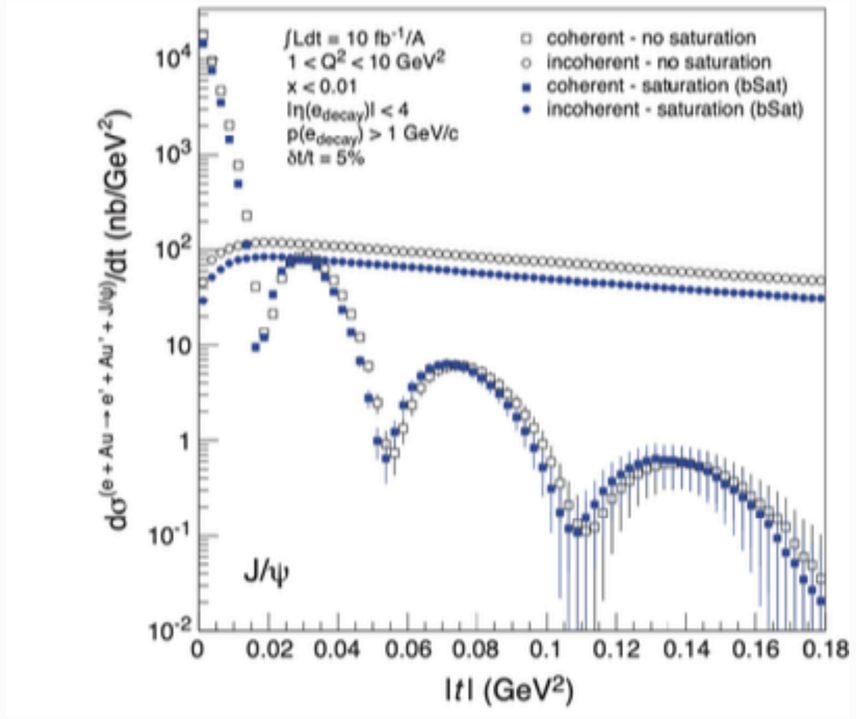


- For pp or AA, 2-fold photon directional ambiguity: Resolve using events with neutrons or peripheral collisions, at a statistical cost
- New NLO calculation: new next-to-leading order calculation brought many surprises: The quark contribution is significant due to NLO and LO gluon cancellations

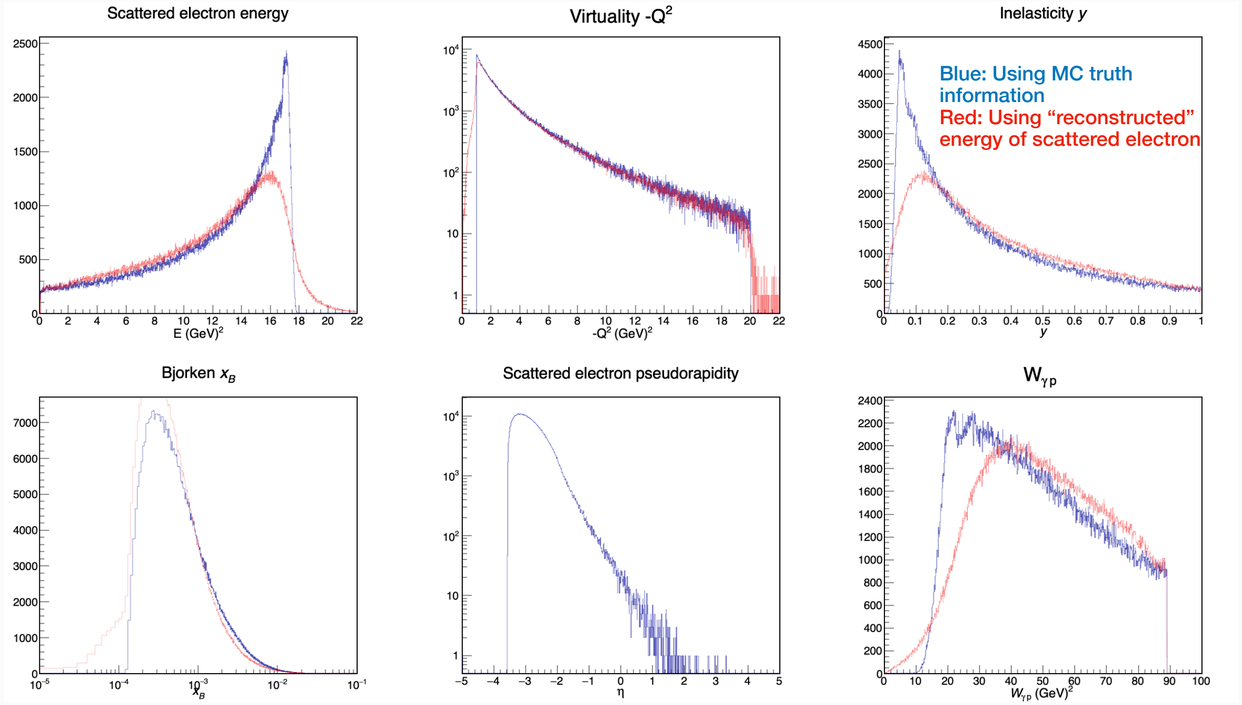
Vector meson photoproduction at the EIC

- High luminosity ep/eA collider coveting range of vector mesons in wide Q2 with high precision
- Possibility to measure other probes of gluons: open charm, dijets, …….





What I’m doing now….



- ALICE UPCs data analysis collected in RUN 2 and the MC production for upcoming RUN 3
- Feasibility study of quarkonium measurements in EPIC detector