EIC Spectroscopy
XYZ production

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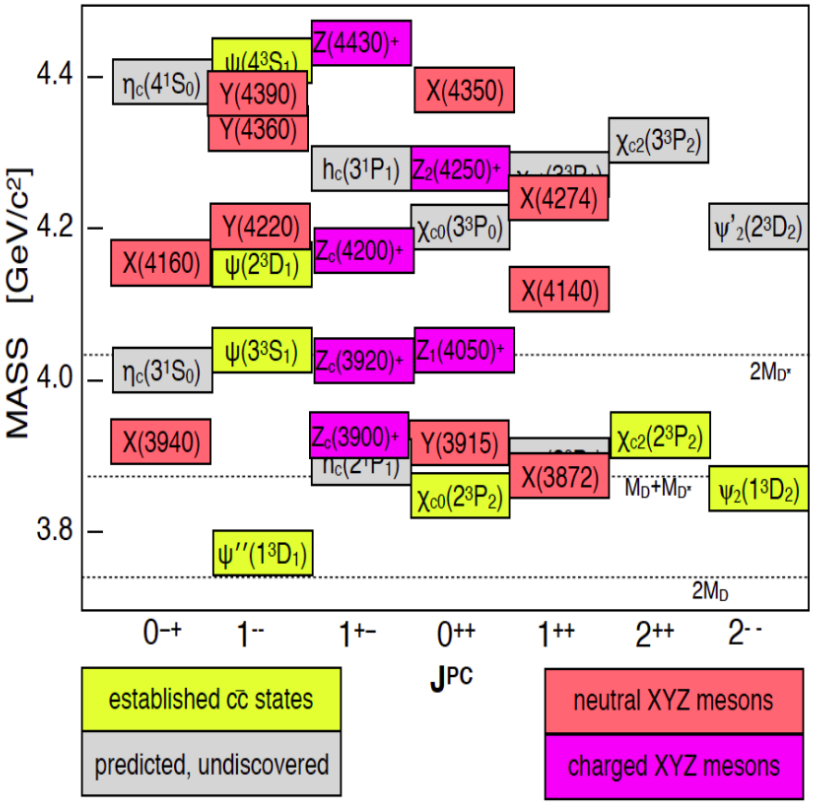
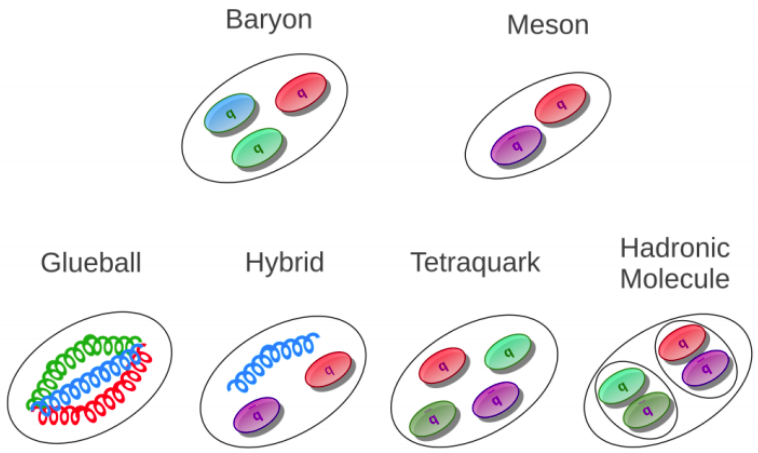
XYZ "exotic" mesons



Normal mesons consist quark-antiquark pair

"Exotic" => its something else



XYZ do not fit quark model expectations

Can be very narrow

$Z \rightarrow \pi^+ + J/\psi$ must contain 4 quarks

Exclusive Photoproduction (Quasi-real)

Observation of XYZ states in photoproduction
- independent confirmation,
- if they are real resonances they should be produced in photoproduction

Measurement of polarisation observables and photocouplings
- insights into production mechanisms and internal structure

Measurement of different decay branches

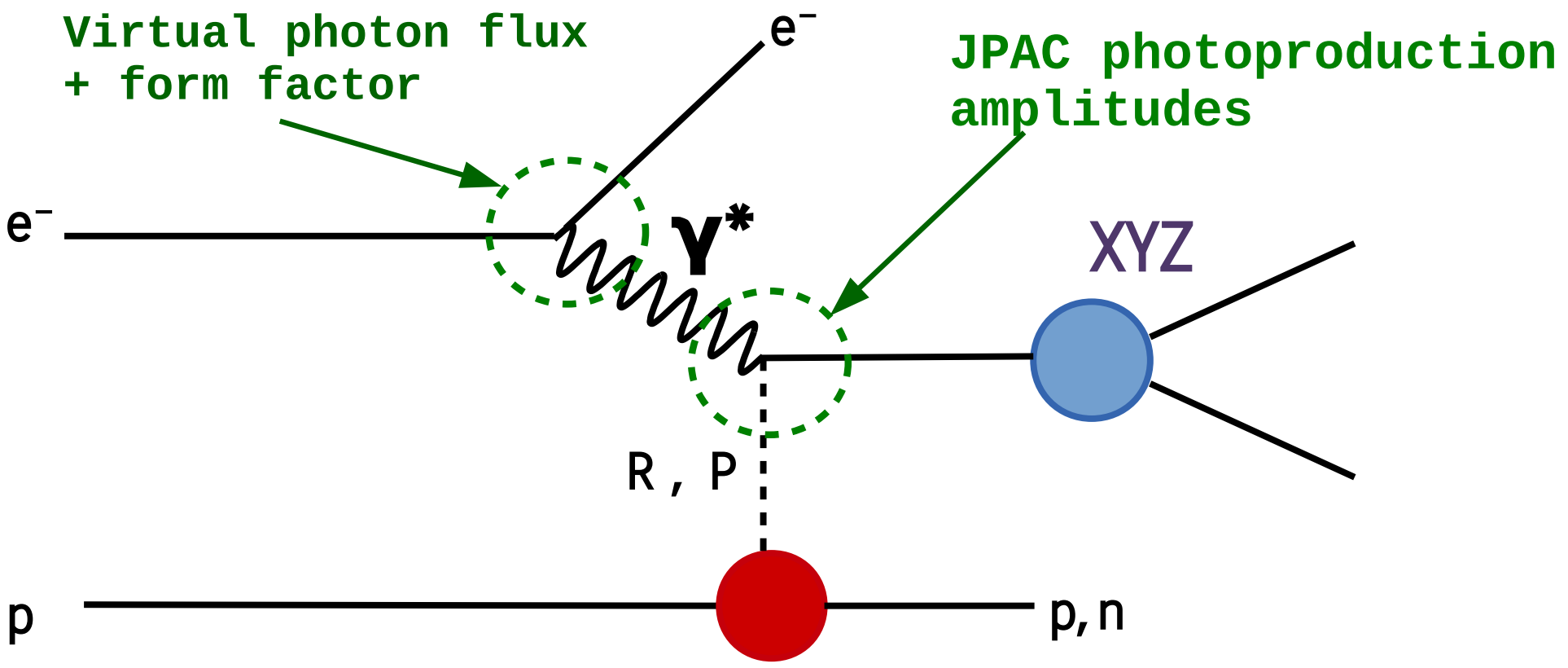
XYZ spectroscopy at electron-hadron facilities: Exclusive processes

M. Albaladejo, A. N. Hiller Blin, A. Pilloni, D. Winney, C. Fernández-Ramírez, V. Mathieu, and A. Szczepaniak
(Joint Physics Analysis Center)
Phys. Rev. D **102**, 114010 – Published 7 December 2020

- qualitative behaviour and order of magnitude estimates

Event Generator (Pictorial)

Factorise 2 photon vertices



https://github.com/dglazier/elSpectro

Event Generator (Formal)

$$\frac{d^4\sigma}{ds\,dQ^2\,d\phi\,dt} = \frac{d^2\sigma_{e,\gamma^* e'}}{ds\,dQ^2}\,\frac{d^2\sigma_{\gamma^*+p\to V+p}(s,Q^2)}{d\phi\,dt}$$

→ Integrate for event rate

$$\frac{d^2\sigma_{e,\gamma^* e'}}{ds\,dQ^2} = \frac{\alpha}{2\pi}\cdot\frac{K\,.\,L}{E}\cdot\frac{1}{Q^2}\cdot\frac{1}{(s-M^2+Q^2)}$$

$$Q^2 = 2\,E\,M\,x\,y$$

$$W^2 = M^2 + 2\,E\,M\,y - Q^2$$

$$L = \frac{1+(1-y)^2}{y} - \frac{2m_e^2\,y}{Q^2}$$

$$K = \frac{W^2-M^2}{2M} = \nu(1-x) = Ey(1-x) = \nu - \frac{Q^2}{2M}$$

$$\frac{d^2\sigma_{\gamma^*+p}}{d\phi\,dt} = \frac{d\sigma^T(Q^2,s)}{d\phi\,dt} + (\epsilon+\delta)\,\frac{d\sigma^L(Q^2,s)}{d\phi\,dt}$$

$$\frac{d^2\sigma^T(Q^2,s)}{d\phi\,dt} = \frac{d^2\sigma_{\gamma+p\to V+p}}{d\phi\,dt}\,F(Q^2)$$

$$\frac{d^2\sigma^L(Q^2,s)}{d\phi\,dt} = 0$$

$$\frac{d^2\sigma_{\gamma+p\to V+p}}{d\phi\,dt} = \frac{1}{128\,\pi^2\,s}\,\frac{1}{|\boldsymbol{p}_{\gamma^* cm}|^2}\,|M(s,t)|^2$$

→ |M(s,t)|² JPAC Photoproduction Amplitudes

Z(3900)

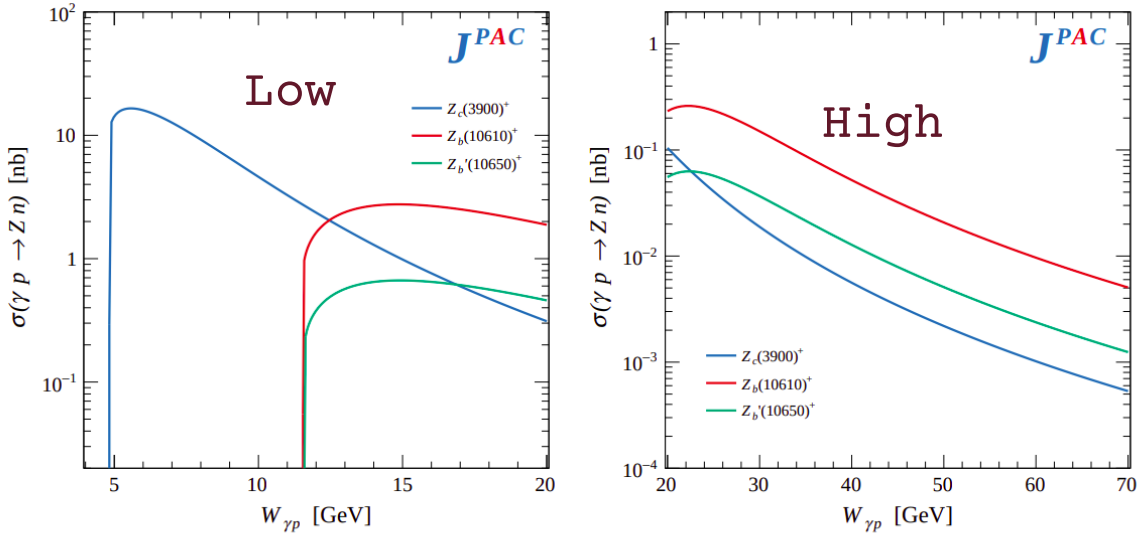
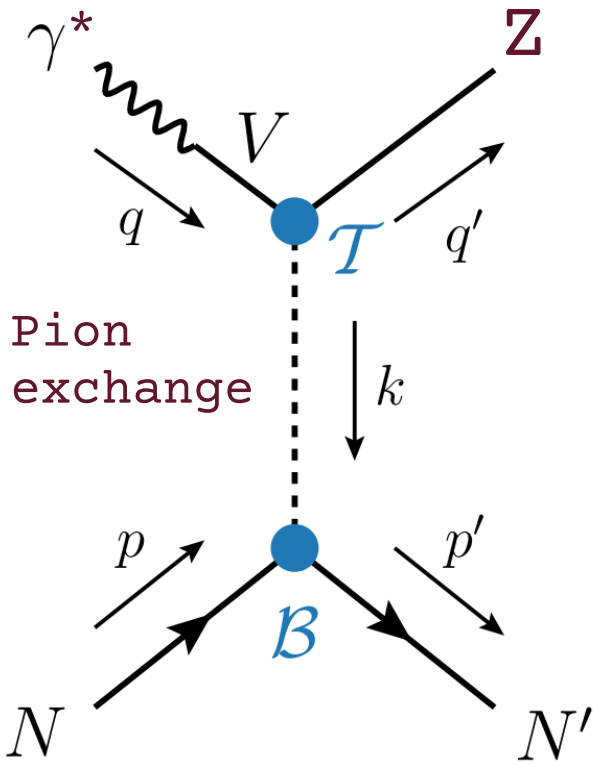


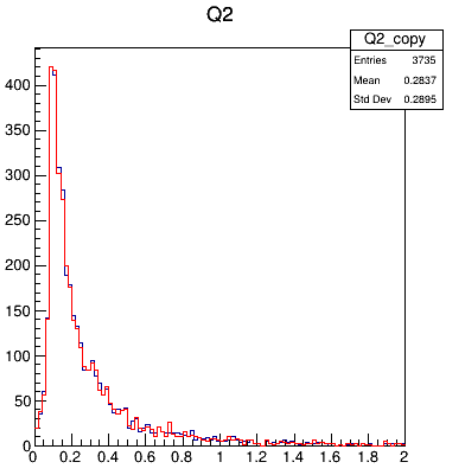
FIG. 2. Integrated cross sections for the three Z states considered. Left panel: predictions for fixed-spin exchange, which we expect to be valid up to approximately 10 GeV above each threshold. Right panel: predictions for Regge exchange, valid at high energies.

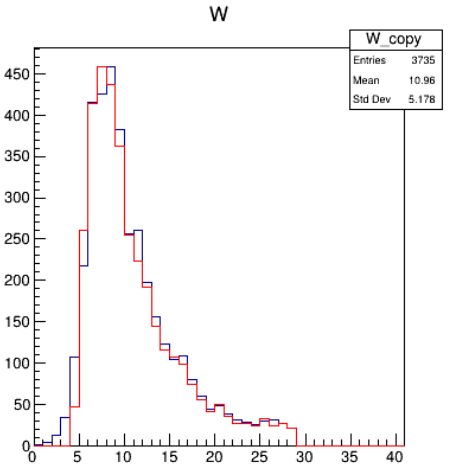


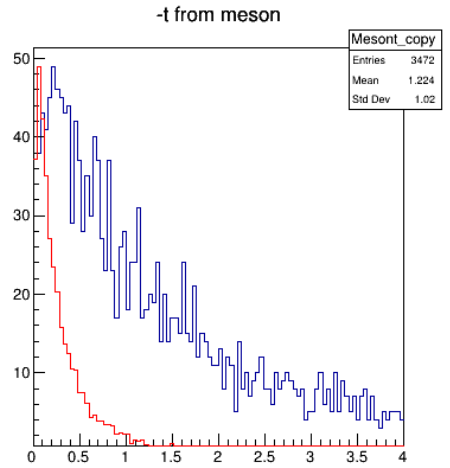
Larger at Low W,
Small at High W

$e^- + p \to e^{-'} + Z(3900) + n$
$Z \to J/\psi\, \pi^+$ (10%)
$J/\psi \to e^+e^-$ (6%)

Z 5-41 low MATRIXDETECTOR_0_2_B1_5T

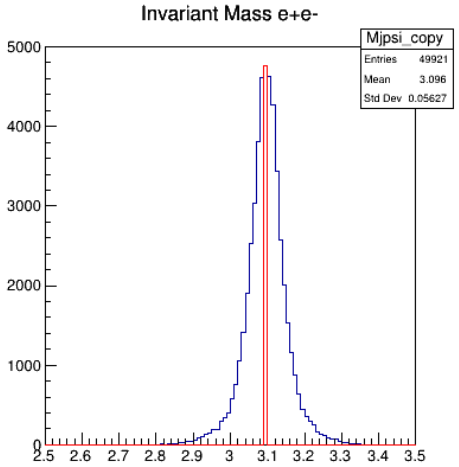


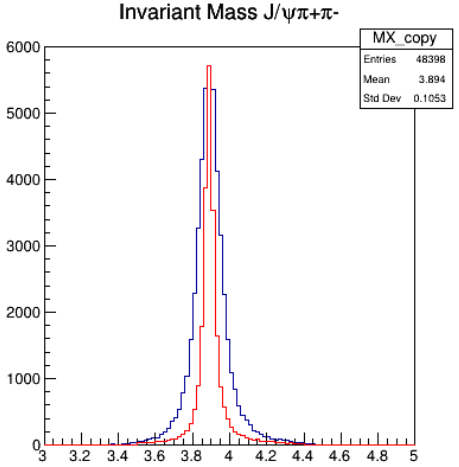




Generated
EIC-Smeared

Normalised to
Same max value





Summary Table

Take 1 month @ $10^{33}cm^{-2}s^{-1}$ → 1.5 fb^{-1}
6 months → 9 fb^{-1}

Take mean of "high" and "low" JPAC estimates

Take Luminosity(W) for low and high W optimisation

	L ($10^{33}cm^{-2}s^{-1}$)	N Z	N Z + e-	N Y	N Y + e-	N X *	N X +e- *
5-41	0.44 (1.2)	11k (30k)	770 (2k)	7.1k (19k)	1k (2.9k)	47k (129k)	6.5k (17k)
5-100	3.68 (10)	78k (213k)	5.1k (14k)	81k (220k)	11k (31k)	0.4M (1.1M)	57k (157k)
10-100	4.48 (12)	101k (272k)	1.6k (4.3k)	130k (350k)	8k (21k)	0.5M (1.6M)	26k (86k)
18-275	1.54	17k	83	45k	1k	194k	3.5k

Miscellaneous EIC related

Spectroscopy group meets every 2 weeks
    Theory and Experiment, currently mostly JLab related participants

Independent of detectors collaborations

Will perform simulations/present for different detectors
and working groups

Planning to contribute section for IR2 white paper

Planning CFNS workshop in 2022
"Exotic heavy meson spectroscopy and structure with EIC"