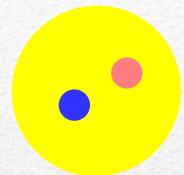
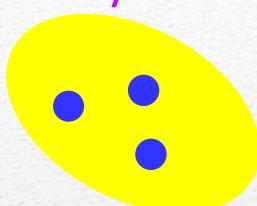


# Hadron Spectroscopy

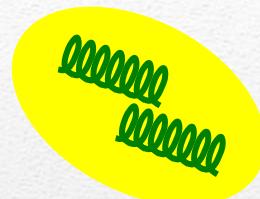
Meson



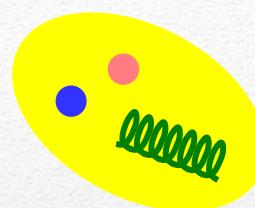
Baryon



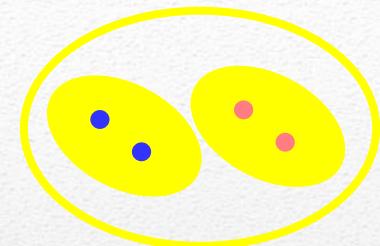
Glueball



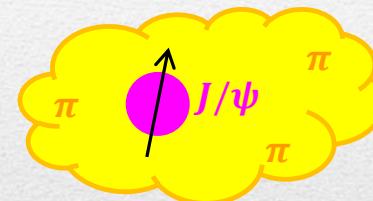
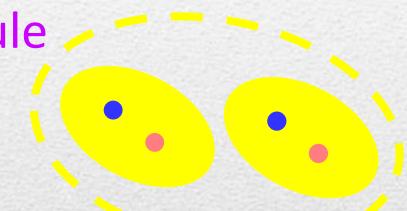
Hybrids



Tetraquark



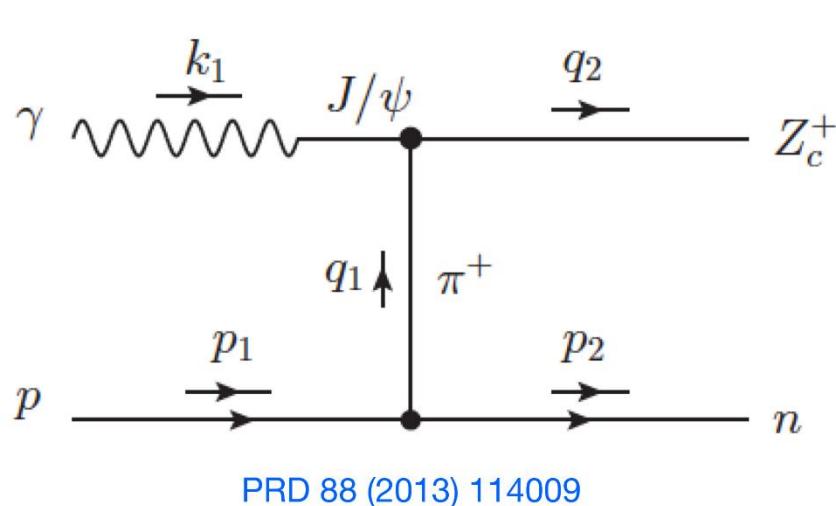
Molecule



Hadroquarkonium



# XYZ states in photoproduction



$$\mathcal{L}_{V\gamma} = -\frac{eM_V^2}{f_V} V_\mu A^\mu$$

$$\mathcal{L}_{Z\psi\pi} = \frac{g_{Z\psi\pi}}{M_Z} (\partial^\mu \psi^\nu \partial_\mu \pi^\lambda Z_\nu - \partial^\mu \psi^\nu \partial_\nu \pi^\lambda Z_\mu)$$

$$\mathcal{L}_{\pi NN} = -\frac{g_{\pi NN}}{2m_N} \bar{N} \gamma_5 \gamma_\mu (\vec{\tau} \cdot \partial^\mu \vec{\pi}) N$$

- \* Several proposals to study XYZ states in photoproduction
  - \*  $\gamma p \rightarrow Z_c^+(3900)n, Z_c^+ \rightarrow J/\psi \pi^+$  PRD 88 (2013) 114009
  - \*  $\gamma p \rightarrow Z_c^+(4430)n, Z_c^+ \rightarrow \psi' \pi^+$  PRD 77 (2008) 094005, PRC 83 (2011) 065203
  - \*  $\gamma p \rightarrow Z_c^+(4200)n, Z_c^+ \rightarrow J/\psi \pi^+$  arXiv:1503:02125 (incl. Regge trajectories in model)
  - \*  $\gamma p \rightarrow Y(3940)p, Y(3940) \rightarrow J/\psi \omega$  PRD 80 (2009) 114007
- \* Use an Effective Lagrangian approach with Vector Meson Dominance

# Comparison: EIC vs. others

Too late (?) for charm physics ✗



Flexibility in the production mechanism ✓

Flexibility in energy (no  $\Lambda_b$ ) ✓

Less clean environment ✗



Same luminosity ✓

Lower cross sections ✗

Better efficiencies for neutrals (?) ✓



Polarized electron & ion beams ✓

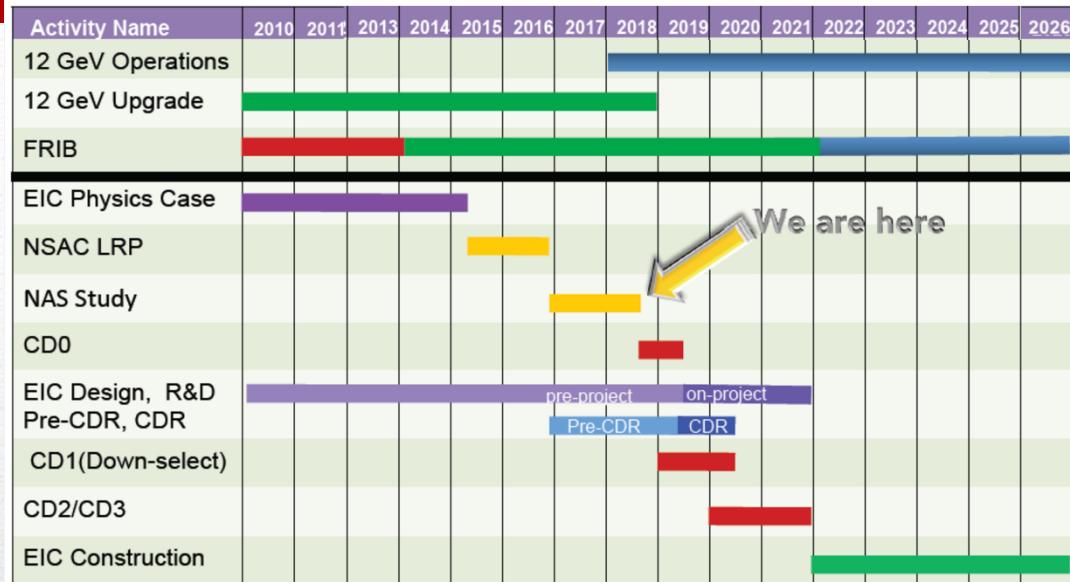
# What for?

- High energy in the COM, possibility to study heavy flavors
  - Meson(-like) spectroscopy:  $X_b, Z_b, (?)_b$
  - Baryon(-like) spectroscopy:  $P_b, (?)_b$
  - Doubly heavy:  $\Xi_{cc}, \Xi_{bc}; T_{bb}$
  - Gluon-rich (small-x): heavy hybrids production?
- Diffractive production (photon-pomeron fusion, Primakoff)
- .....

Need for cross section estimates  
(NRQCD? Regge models?)

# Timeline

- **July 2018:**  
presentation of the project  
at the EIC User group
- **December 2018:**  
Workshop in Trento
- **Spring 2019:**  
White book



CD0 = DOE "Mission Need" statement; CD1 = design choice and site selection (VA/NY)

CD2/CD3 = establish project baseline cost and schedule



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**2018 Workshops and collaboration meetings**

[The spectroscopy program at EIC and future accelerators](#)

19 Dec 2018 to 21 Dec 2018

**Organizers**

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# Working group

- **Theorists:**  
F.K. Guo (CAS), T. Mehen (Duke), A. Pilloni (JLab), A. Szcepaniak (IU/JLab)
- **Experimentalists:**  
M. Battaglieri (INFN-GE), Y. Furletova (JLab), J. Stevens (W&M)