
# EIC phi meeting

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Yongsun Kim (Sejong Univ)

# Pentaquark production

**High Energy Physics - Phenomenology**

*[Submitted on 23 Feb 2022]*

## Production of $P_c(4312)$ state in electron-proton collisions

In Woo Park, Su Houng Lee, Sungtae Cho, Yongsun Kim

We study the cross sections for the electro-production of $P_c(4312)$ particle, a recently discovered pentaquark state, in electron-proton collisions assuming possible quantum numbers to be $J^P = \frac{1}{2}^{\pm}, \frac{3}{2}^{\pm}$. $\sqrt{s}$ is set to the energy of the future Electron Ion Collider at Brookhaven National Laboratory, in order to asses the possibility of the measurement in this facility. One can discriminate the spin of $P_c(4312)$ by comparing the pseudorapidity distribution in two different polarization configurations for proton and electron beams. Furthermore, the parity of $P_c(4312)$ can be discerned by analyzing the decay angle in the $P_c \to p + J/\psi$ channel. As the multiplicity of $P_c$ production in our calculation is large, the EIC can be considered as a future facility for precision measurement of heavy pentaquarks.

**High Energy Physics - Phenomenology**

*[Submitted on 12 Feb 2024]*

## Study on the $\phi$-meson photoproduction off the proton target with the pentaquark-like $K^*\Sigma$ bound state $P_s$

Sang in Shim, Yongsun Kim, Seung-il Nam

We utilize the effective Lagrangian method within the tree-level Born approximation to explore $\phi$-meson photoproduction, i.e., $\gamma p \to \phi p$. Our analysis encompasses contributions from various sources, including the Pomeron, $f_1$-Regge, pseudoscalar particles ($\pi$, $\eta$), scalar particles ($a_0$, $f_0$), protons, and three-nucleon resonance states. In addition, we consider a possible pentaquark-like $K^*\Sigma$-bound state $P_s$. The findings indicate that, apart from the region near the threshold, contributions other than the Pomeron generally have a limited impact on the total cross section. However, at specific angles, alternative contributions become crucial, particularly at smaller values of $\cos\theta$. The incorporation of $P_s$ and other nucleon resonances proves

**High Energy Physics - Phenomenology**

*[Submitted on 4 Mar 2025]*

## The Electron-Ion Collider as A Prospective Facility for Pentaquark Measurements

In Woo Park, Sungtae Cho, Yongsun Kim, Su Houng Lee

The Electron-Ion Collider provides a groundbreaking opportunity to study heavy pentaquarks with unprecedented precision, leveraging its high collision energy and beam spin polarization capabilities. As a representative case, we analyze electroproduction cross sections of Pc (4312) under different spin-parity hypotheses using the vector meson dominance model. To ensure a parameter-free approach and minimize ambiguity, we incorporate results from the LHCb and GlueX experiments. To characterize the spin and the parity of Pc (4312), we propose measuring the beam spin asymmetry and decay kinematic polarization, quantities that can be accurately determined by the ePIC detector. Our approach can be extended to investigate other heavy pentaquarks produced in electron-proton and electron-deuteron collisions, as well as to study their interactions with nuclear matter in electron-heavy ion collisions. We strongly encourage the EIC community to explore this potential and integrate pentaquark studies as a critical element of the scientific mission.

- Pc(4312) cross section을 예시로 하여, 무거운 팬타쿼크를 많이 만들고, 스핀과 페리티를 측정할 수 있음

- JLab의 12 GeV photon beam에 비해 EIC가 어떤 점에서 우월한지에 대해 설명

# Pentaquark production

**Double polarization observables in pentaquark photoproduction** #4

JPAC Collaboration • Daniel Winney (Indiana U., CEEM and Indiana U.) et al. (Jul 22, 2019)

Published in: *Phys.Rev.D* 100 (2019) 3, 034019 • e-Print: 1907.09393 [hep-ph]

pdf links DOI cite claim reference search 40 citations

**Searching for strange hidden-charm pentaquark state Pcs(4459) in γp→K+Pcs(4459) reaction** #5

Cai Cheng (Chengdu Technol. U.), Feng Yang (Southwest Jiaotong U.), Yin Huang (Southwest Jiaotong U. and APCTP, Pohang) (Oct 10, 2021)

Published in: *Phys.Rev.D* 104 (2021) 11, 116007 • e-Print: 2110.04746 [hep-ph]

pdf DOI cite claim reference search 20 citations

**Production of hidden-charm and hidden-bottom pentaquark states in electron-proton collisions** #6

Ya-Ping Xie (Lanzhou, Inst. Modern Phys. and Beijing, GUCAS), Xu Cao (Lanzhou, Inst. Modern Phys. and Beijing, GUCAS), Yu-Tie Liang (Lanzhou, Inst. Modern Phys. and Beijing, GUCAS), Xurong Chen (Lanzhou, Inst. Modern Phys. and Beijing, GUCAS and South China Normal U.) (Mar 27, 2020)

Published in: *Chin.Phys.C* 45 (2021) 4, 043105 • e-Print: 2003.11729 [hep-ph]

pdf DOI cite claim reference search 18 citations

**Study of a possibility of observation of hidden-bott photoproduction on protons and nuclei near thresh**

E.Ya. Paryev (Moscow, INR and Moscow, ITEP) (Jul 1, 2020)

e-Print: 2007.01172 [nucl-th]

pdf cite claim

- JPAC collaboration 을 비롯해 비슷한 연구를 한 페이퍼가 꽤 있음. 다만 대부분은 photo-production에 촛점이 맞춰져 있어서 우리는 electro-production을 강조하면 될 것 같음

- 인하대 김현철 교수님 그룹에서도 Pc 및 Pcs 논문을 출판하심

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**Double-strangeness hidden-charm pentaquarks** #1

Samson Clymton (POSTECH and APCTP, Pohang), Hyun-Chul Kim (Inha U. and Korea Inst. Advanced Study, Seoul), Terry Mart (Indonesia U.) (Jun 30, 2025)

e-Print: 2506.23587 [hep-ph]

pdf cite claim reference search 0 citations

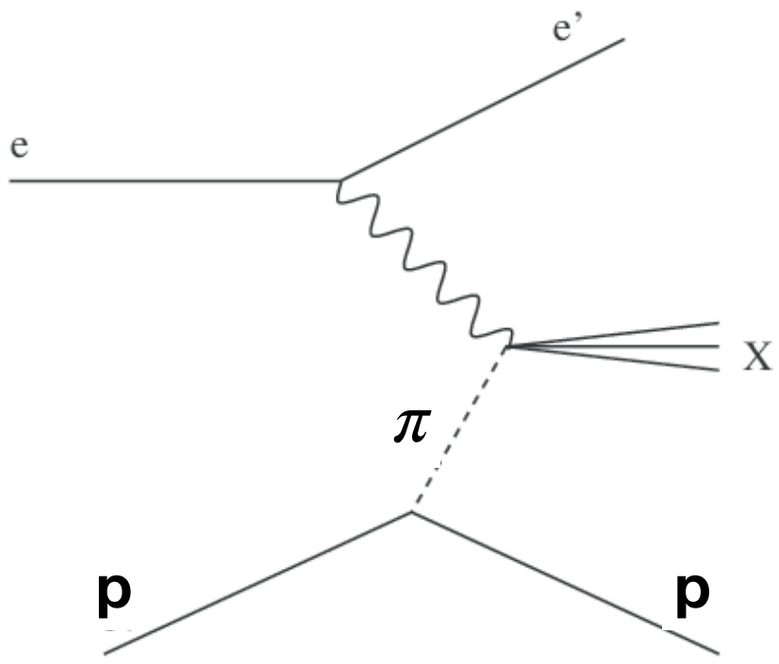
**Production mechanism of hidden-charm pentaquark states $P_{c\bar{c}s}$ with strangeness $S = -1$** #2

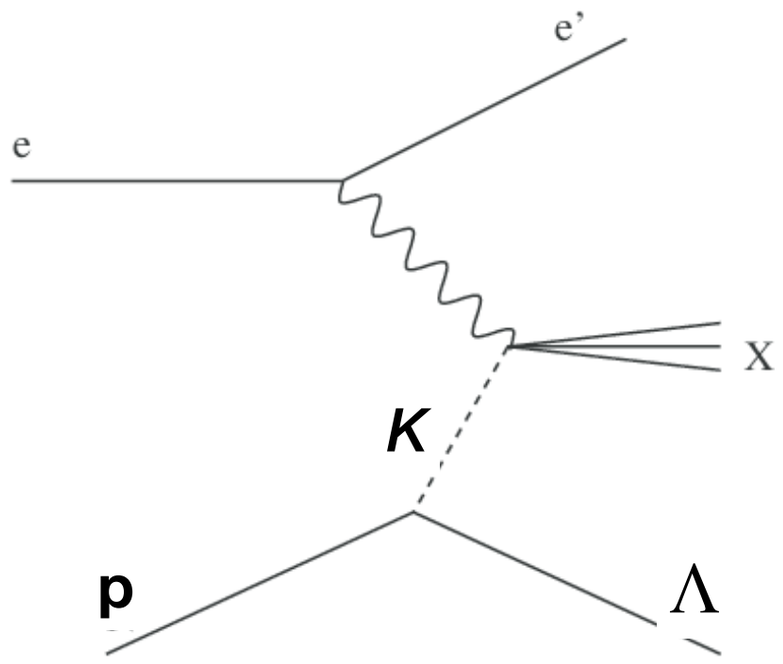
Samson Clymton (Inha U. and POSTECH and APCTP, Pohang), Hyun-Chul Kim (Inha U. and Korea Inst. Advanced Study, Seoul), Terry Mart (Indonesia U.) (Apr 10, 2025)

e-Print: 2504.07693 [hep-ph]

pdf cite claim reference search 2 citations

# Sullivan process



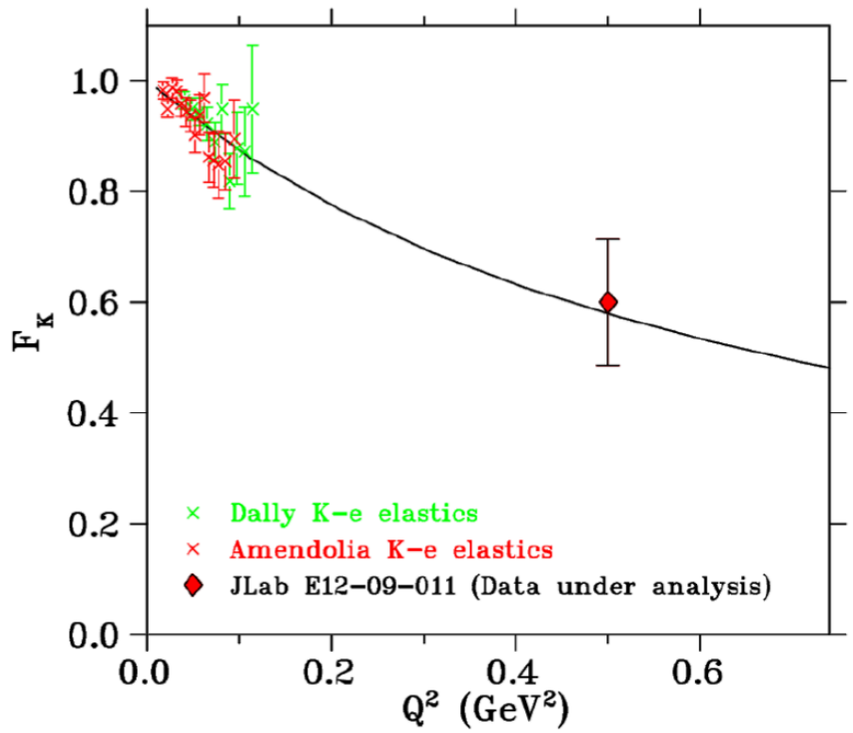

- Meson의 form factor를 측정할 수 있는 Sullivan process 가 EIC에서는 $\pi^0$, $\pi^{\pm}$, $K^0$ 입자에 활용할 수 있음
- 특히 strangeness sector는 데이터가 아주 부족하기에 EIC 의 강점을 여기서 부각시키면 좋을 듯.

*[Submitted on 17 Feb 2025 (v1), last revised 13 Jun 2025 (this version, v2)]*

**Sullivan process near threshold and the pion gravitational form factors**

Yoshitaka Hatta, Jakob Schoenleber

We propose a novel method to experimentally access the gravitational form factors (GFFs) of the charged pion $\pi^+$ through the Sullivan process in electron-proton scattering. We demonstrate that the cross sections of $J/\psi$-photoproduction and $\phi$-electroproduction near the respective thresholds are dominated by the gluon GFF of the pion to next-to-leading order in perturbative QCD. We predict cross sections for the Electron-Ion Collider and the Jefferson Lab experiments.



# Handbag process

*Arxiv. 2501.01582*
A Letter of Intent to Jefferson Lab PAC 52

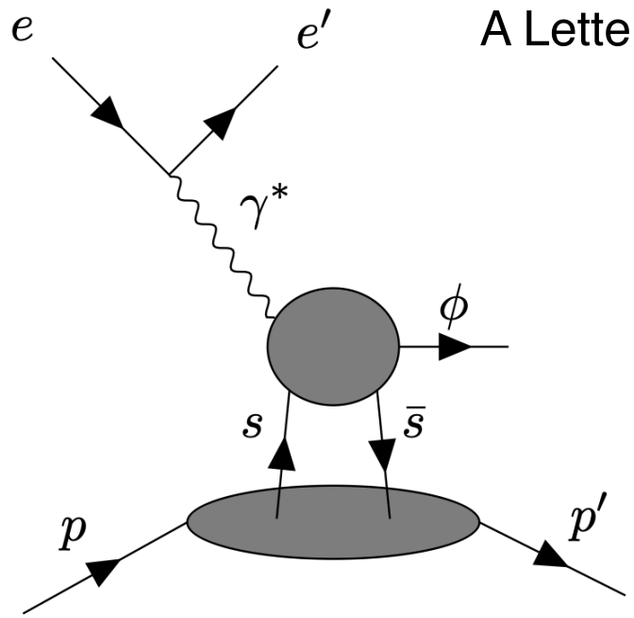



Figure 1: Example diagram contributing to deep exclusive $\phi$ production. This process is sensitive to the strangeness $D$-term.

- 남승일 교수님께서 말씀하셨던 핸드백 프로세스