u-Channel Experiments a Hall C

Wenliang (Bill) Li

Hall A/C Summer Collaboration Meeting 2024

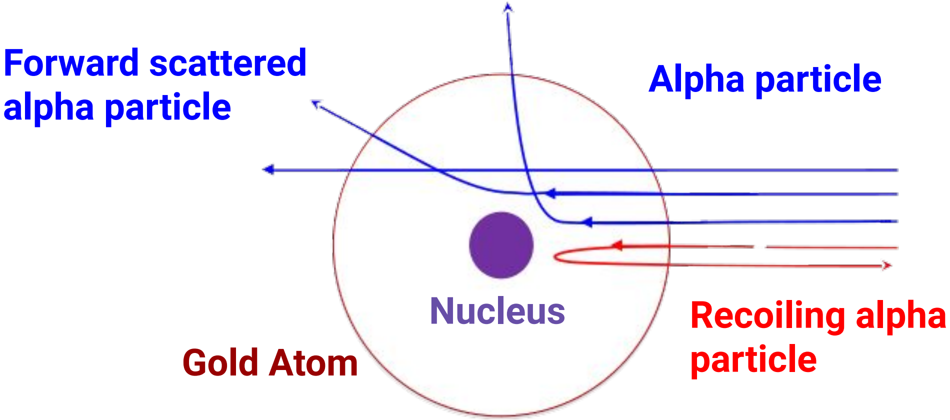
June/24/2024

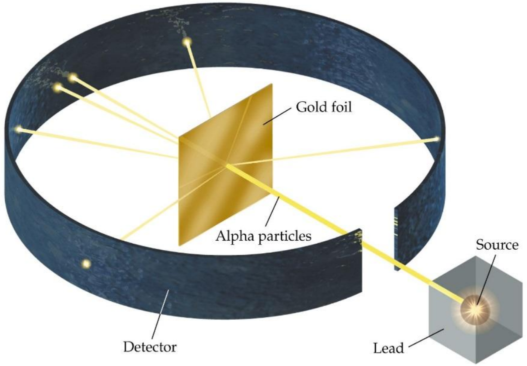
Center for Frontiers in Nuclear Science
Stony Brook University

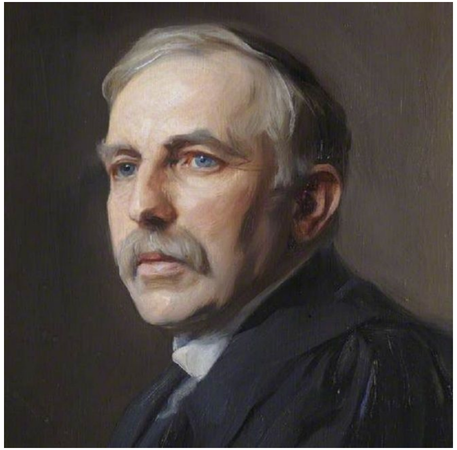
Outline

- **A introduction to the u-Channel processed**
- **A new set of theory perspectives**
- **Exclusive productions**
  - **E12-20-007 u-Channel**
- **Semi-inclusive production**
  - **Data mining effort with the existing data**

Forward and backward Scattering - Fundamental properties of nucleus







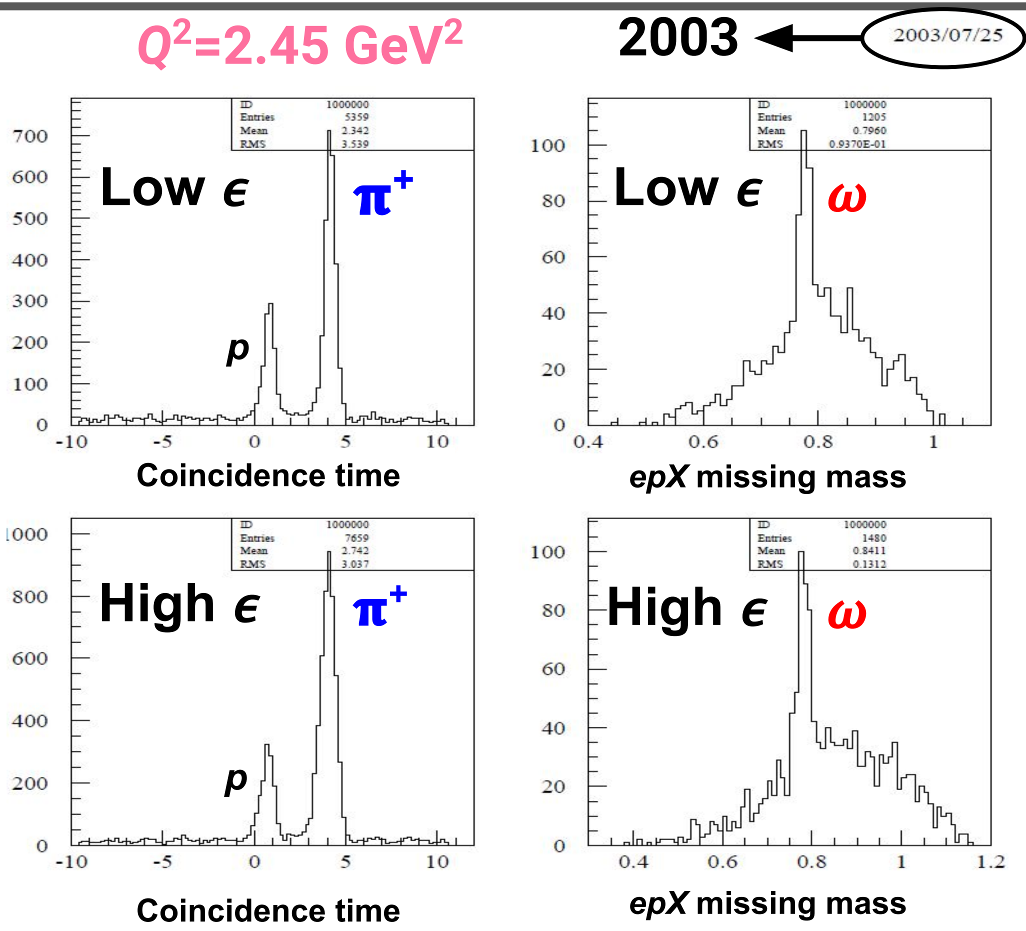
- Forward scattered alpha particle: extracting the interaction radius of the nucleus and mapping out the transverse structure of the atom (mostly empty)

- Recoiling alpha particle: stiffness of the "point-like" structure.

- Full structure = forward angle + backward angle observables.

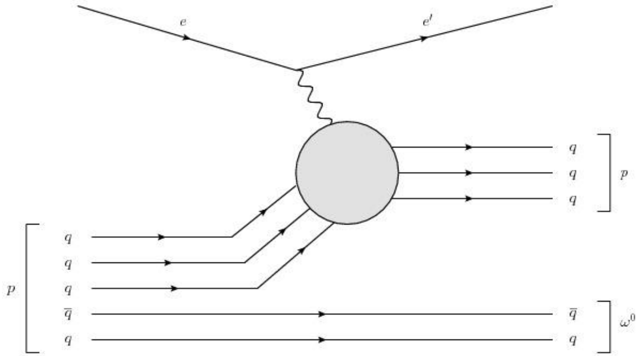
Gifted Backward-angle Observables

- **Fpi-2 (E01-004) 2003**
  - Spokesperson: **Garth Huber, Henk Blok**
  - Standard HMS and SOS (e) configuration
  - **Electric form factor of π^+** through exclusive π^+ production
- **Primary reaction for Fpi-2**
  - **H(*e, e'*π^+)*n***
- **In addition, the experiment fortuitously received**
  - **H(*e, e'p*)ω**
- **Kinematics coverage**
  - W= 2.21 GeV, Q^2=1.6 and 2.45 GeV^2
  - Two ϵ settings for each Q^2

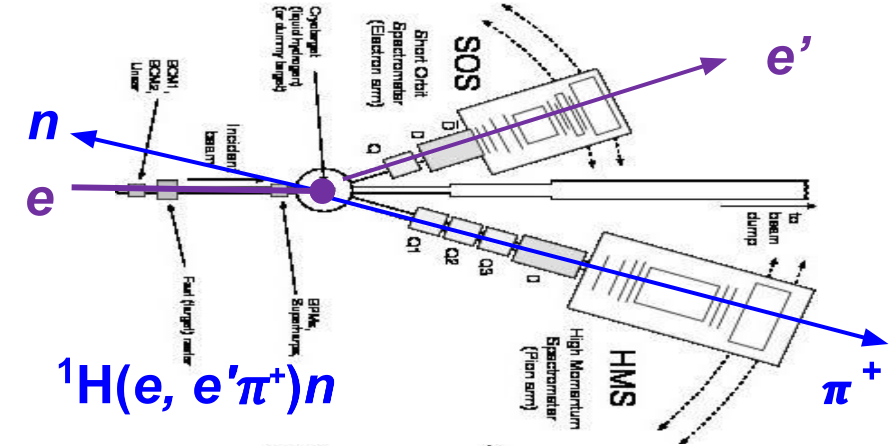


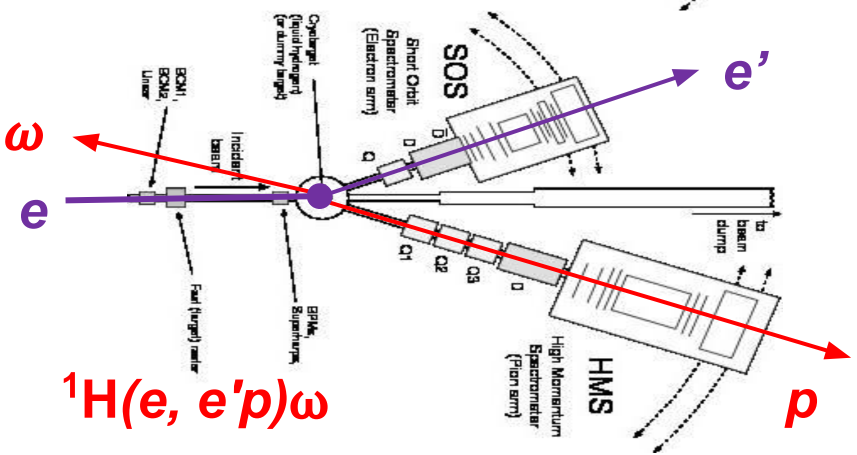
Forward (t-Channel) π^+ vs u-Channel ω Production

- **Primary reaction for Fpi-2**
  - **$^1H(e, e'\pi^+)n$**
  - **n (940 MeV)**
  - **π^+ (140 MeV)**
- **Unexpected reaction:**
  - **$H(e,e'p)\omega$**
  - **p (940 MeV)**
  - **ω (783 MeV)**



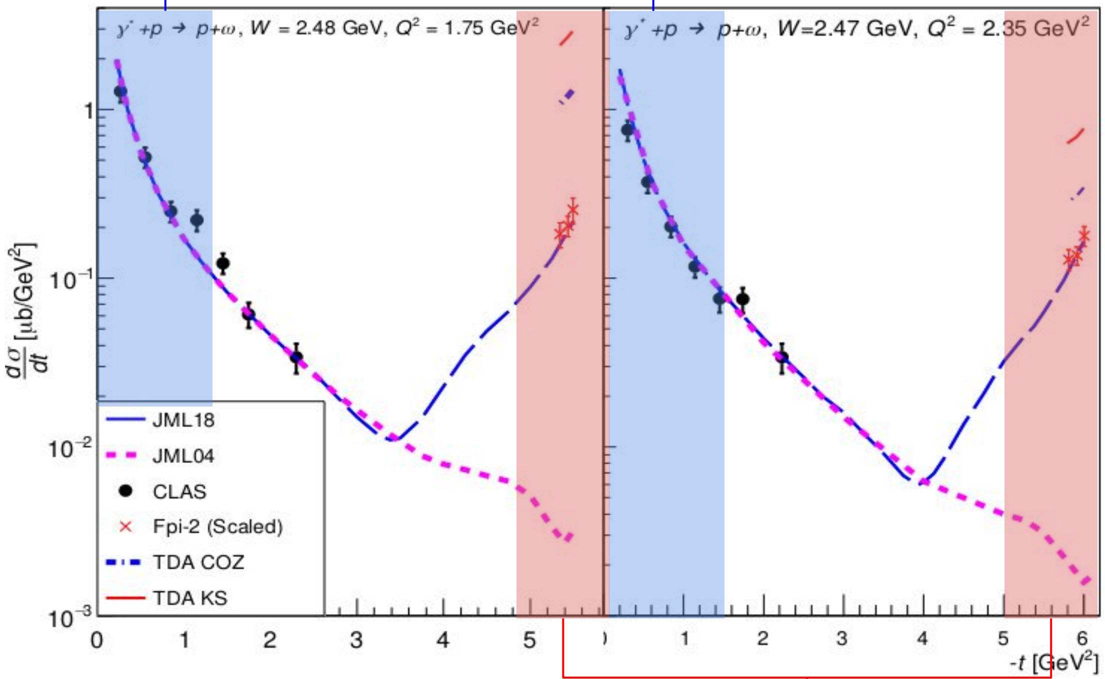
Mark Strikman & Christian Weiss: A proton being knocked out of a proton process





Results on Backward Angle Electroproduction

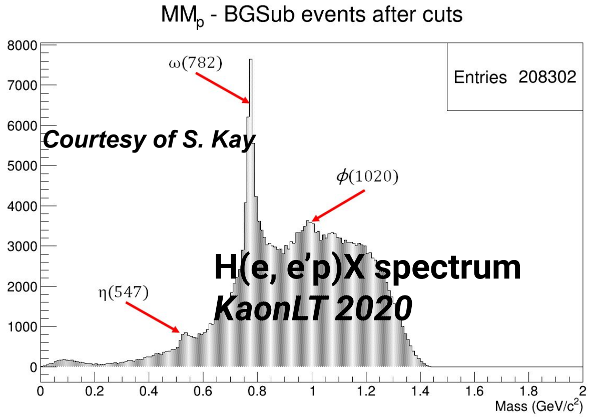
Forward ω electroproduction from CLAS 6 *(2004)*

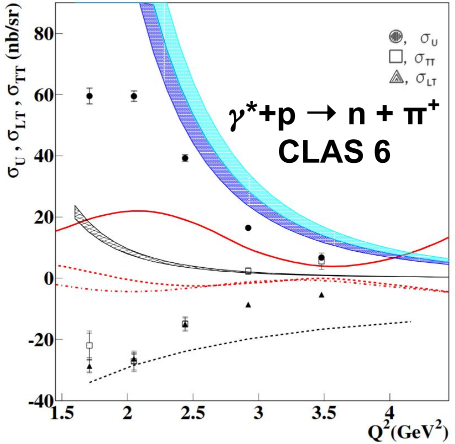


Backward angle ω electroproduction *(2017)*

- **Results published in *Phys. Rev. Let. (2019)***
- **The magnitude of *u*-Channel peak is surprisingly large !**
- **Rising cross section corresponds to a structure**
  - **What is it?**

Question: Are there *u*-channel peaks for other processes? Yes!





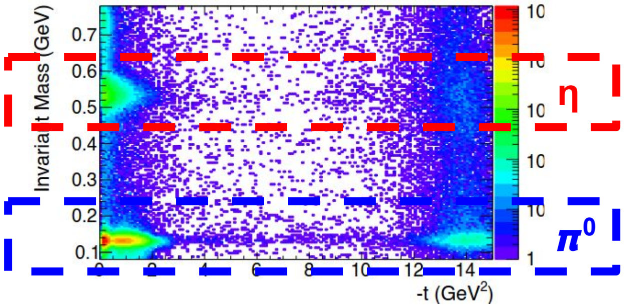
Approved proposal

	$\sigma_T > \sigma_L$	$1/Q^8$ Scaling
π^0	○	○
π^+		✓✓
π^-		
K^0		
$K^\pm$		
η	✓	✓
ρ		
ω	✓✓	✓
η'	✓	✓
ϕ	✓	✓
J/ψ		
DVCS		

Studied! By CLAS6

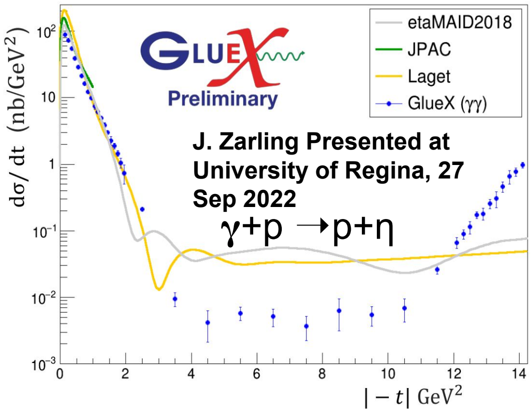
Studied!

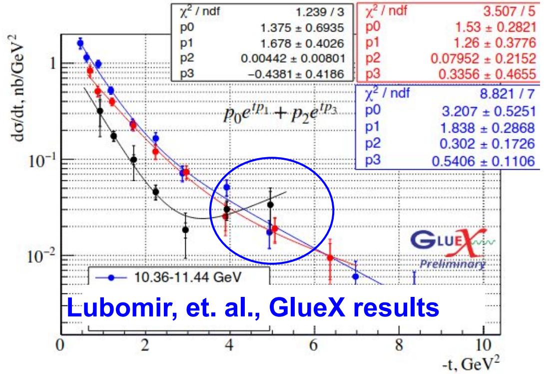
Hall C GlueX



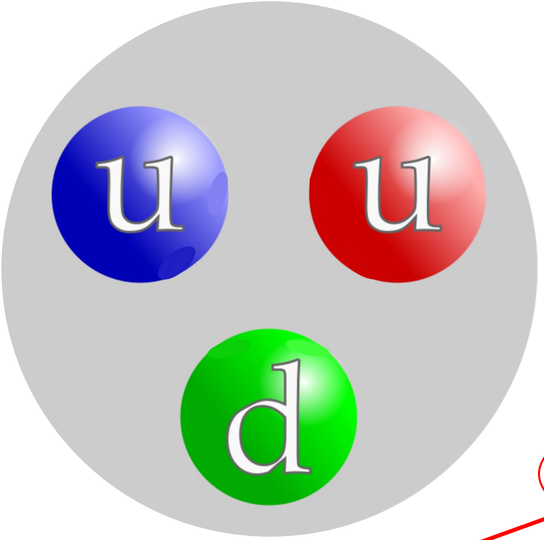
By J.R. Stevens, at u-channel Physics workshop, 2020

$E_\gamma = 8.25 \pm 0.25$ GeV





Fundamental Properties of Proton



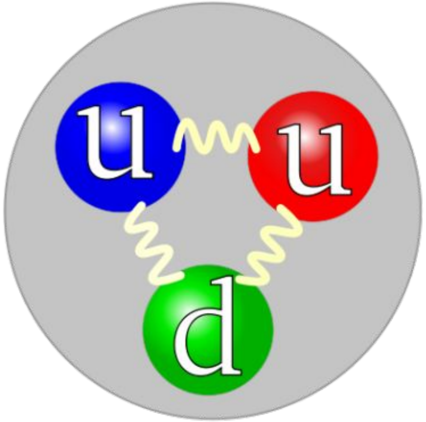
	Property	Structure
Mass	938.272 MeV	Fractionally carried by quarks
Spin	½	Fractionally carried by quarks and gluons
Charge	+1	Fractionally carried by quarks
Baryon number	1	?

Identity

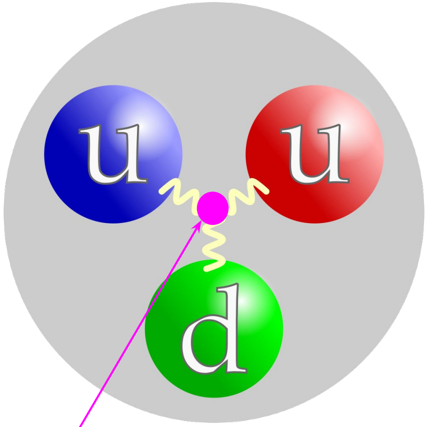
- **What is this number? Why conserved? How is it carried?**
- **Some facts:**
    - Lepton number conserved (point-like particle)
    - meson number conservation not conserved
    - No experiment evidence suggest baryon number violation: $p \rightarrow e^+\pi^0$ (Hyper-K)

Proton's Identity: Baryon Number, but who carries it?

- **Proton internal structure: which of the following picture is correct?**



A

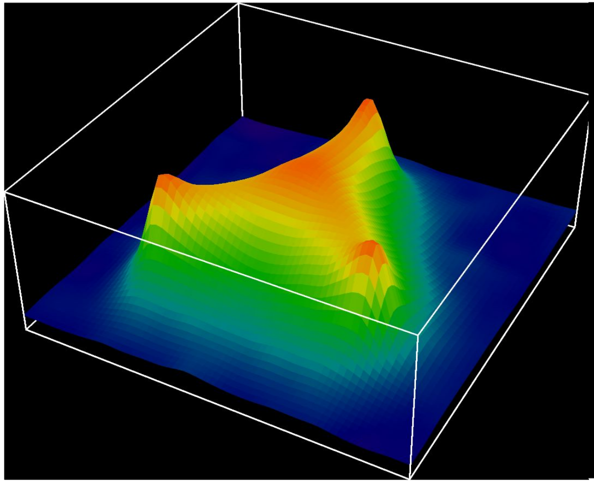


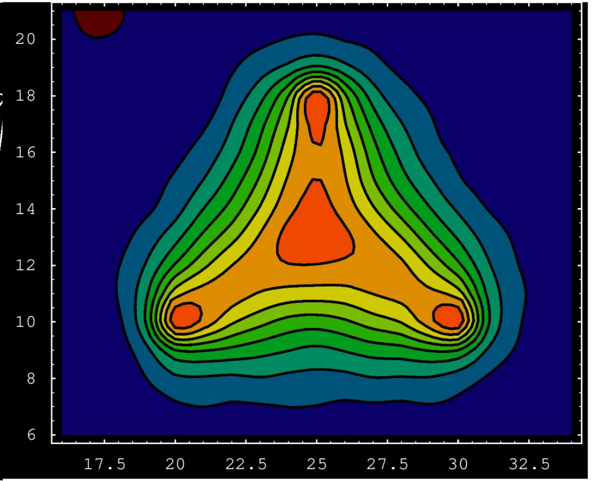
B

A: implies quark carries fractional baryon number

B: existence of a ***"Junction" like structure*** that potentially carries the baryon number.

Insights on baryon junction





Lattice QCD Study on proton wavefunction

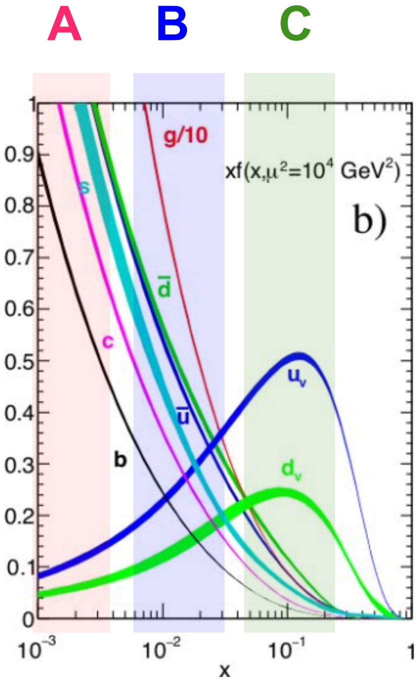
Hideo Suganuma, Toru T. Takahashi, Fumiko Okiharu, Hiroko Ichie, arXiv:hep-lat/0412026 , 2004

- **Baryon Junction was predicted by local gauge invariance of the baryon wave function (1977)**
  - **(G.C. Rossi, G. Veneziano, Nuclear Physics B, Volume 123, Issue 3, 1977)**
- **The lattice results of a "baryon junction" inside proton – a purely gluonic field configuration that represents entanglement among the quarks and carries baryon number! (2004)**
- **D. Kharzeev argued the transport of baryon number in high energy pp collision (1996)**
  - arXiv:nucl-th/9602027

Where could we find “bayron junction”?

- **What and where do we measure nucleon structure functions?**
  - **Gluon** and **quark sea**: **heavy-ion collisions** and **future EIC**
  - **Valence quark**: JLab

Junction ? or not ?



A: Ultra-high energy | **B: High Energy (EIC)** | **C: Medium Energy (JLab)**

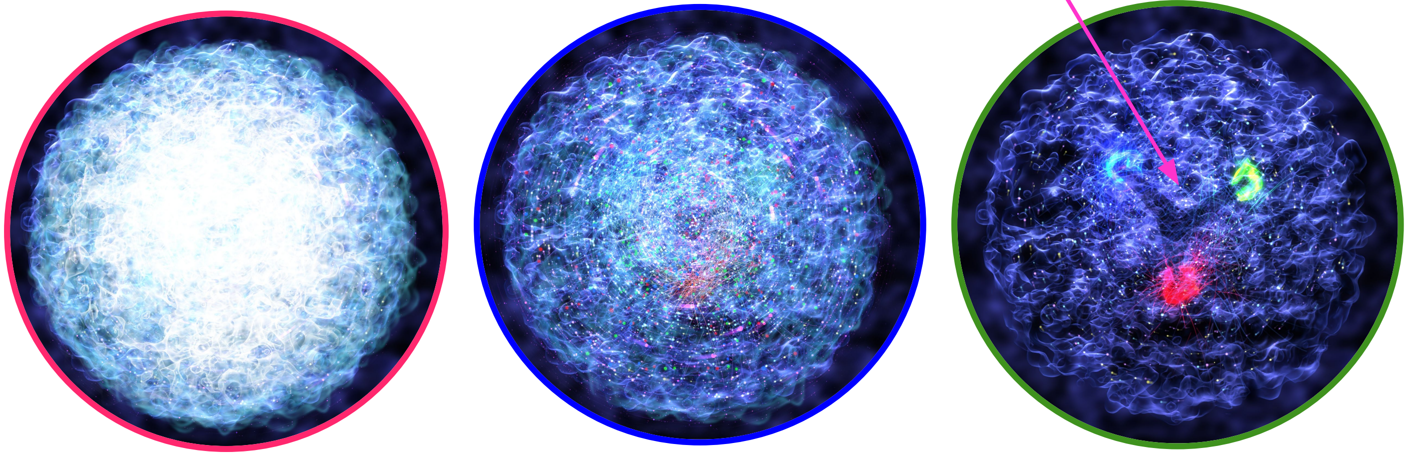
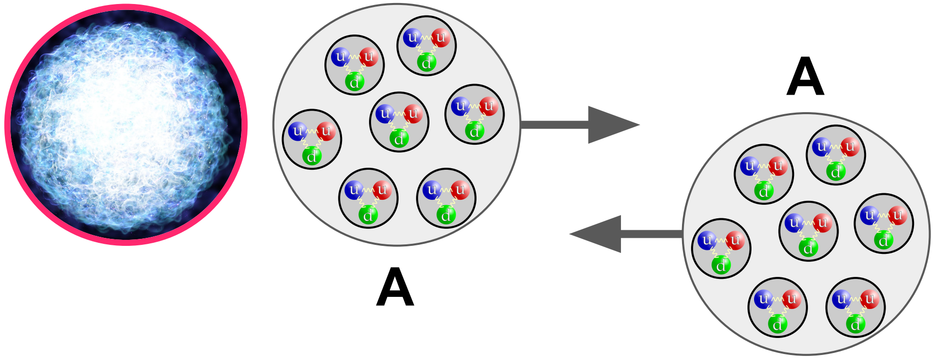


Image credit to JLab and MIT: Full video available on YouTube

Probing Baryon Junction with A-A at RHIC



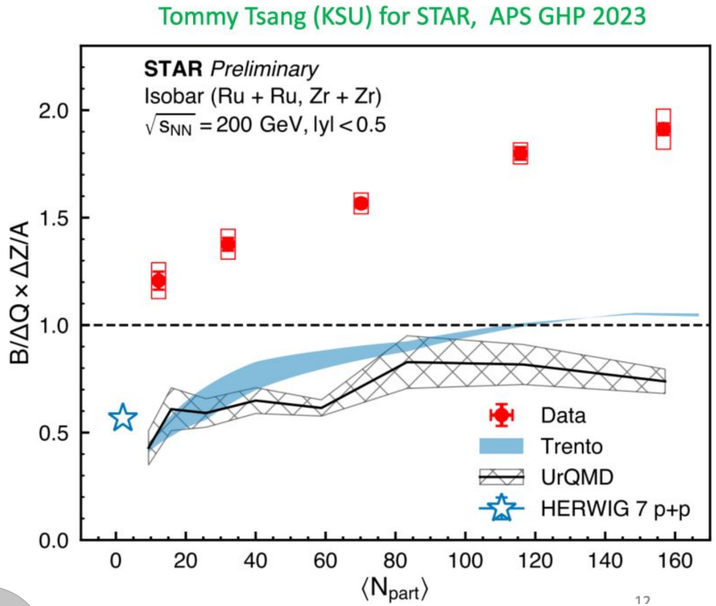
Charge vs. baryon transport in A+A collisions:

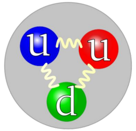
- If Valence quarks carry electric charge & baryon number:

$$\frac{Z}{\text{Charge Stoppoing}} \times \frac{\text{Baryon Stopping}}{A} \cong 1$$

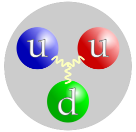
- If valence quarks carry electric charge & junctions cary baryon number

$$\frac{Z}{\text{Charge Stoppoing}} \times \frac{\text{Baryon Stopping}}{A} > 1$$



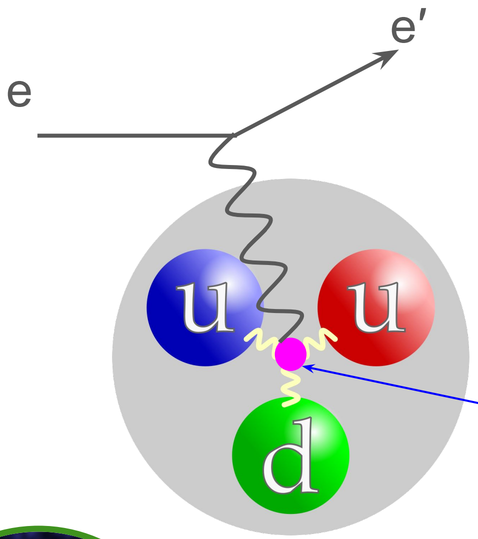


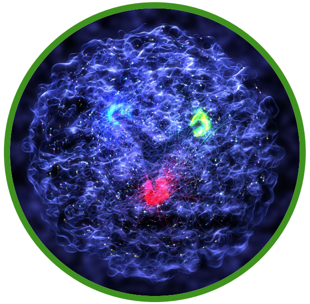
Theory: Quark Models: equal or less baryon compared to electric charge



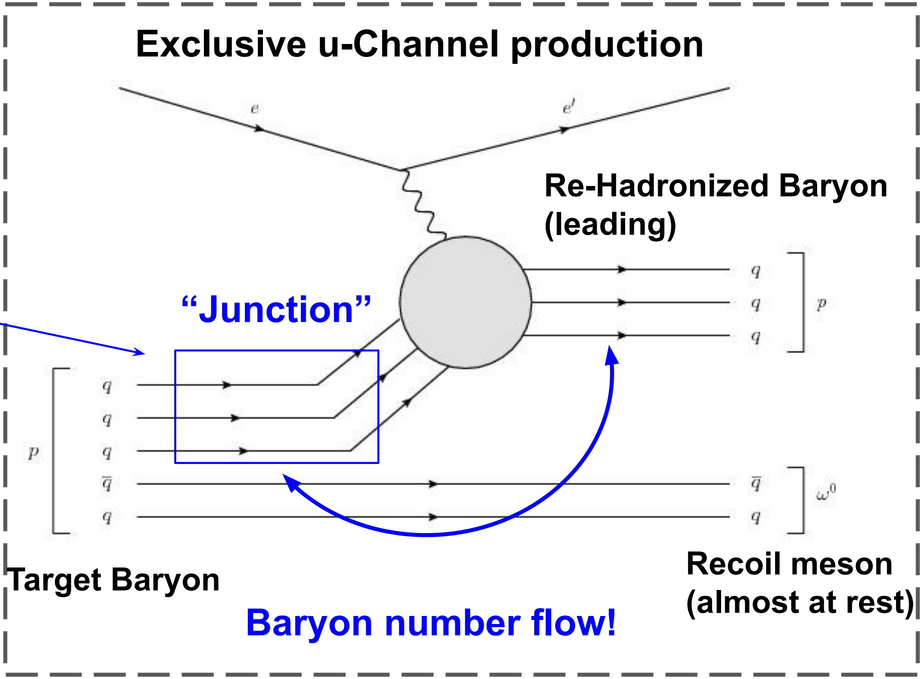
Data: More baryon transported to central rapidity than electric charge

Looking for Baryon Junction via Exclusive u-Channel Processes





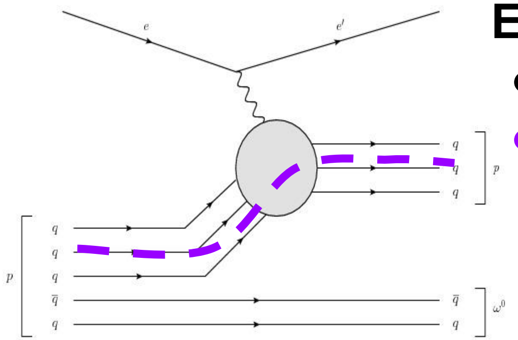
- **Probing baryon junction JLab 12 GeV?**
  - knocking a proton out of a proton process



u-Channel Experimental Observable

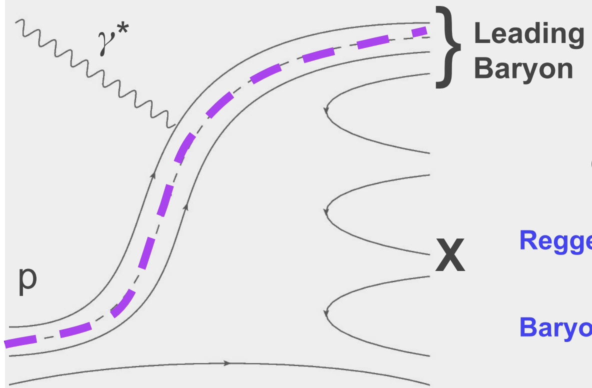
D. Frenklakh, Dmitri Kharzeev, W.B. Li
https://arxiv.org/abs/2312.15039

Case 0: Exclusive meson production

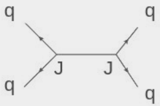


Exchanging:
- 3 q ?
- Junction (J) ?

Case 1: J+2q exchange



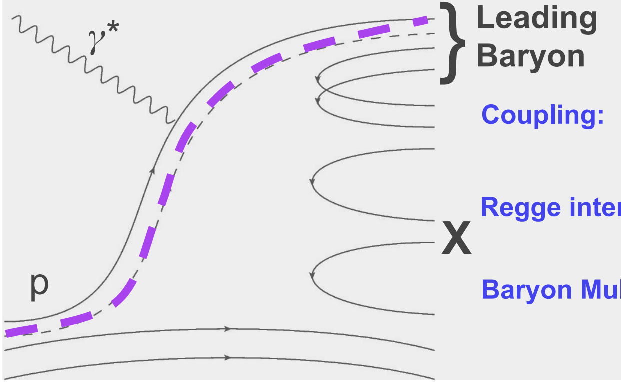
Coupling:



Regge interception: $\alpha(0) = -\frac{1}{2}$

Baryon Multiplicity: $n_x = 1n^{(1)}$

Case 2: J+q exchange

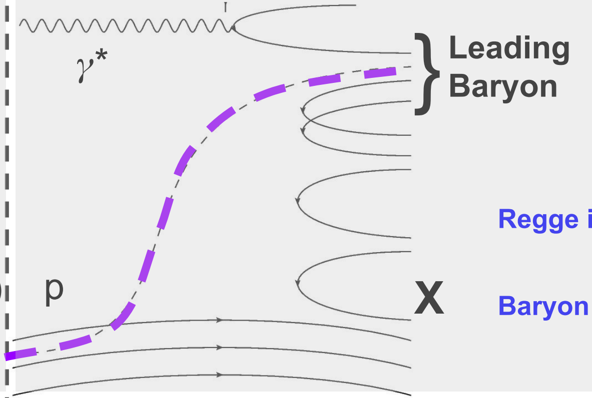


Coupling:

Regge interception: $\alpha(0) = 0$

Baryon Multiplicity: $n_x = 2n^{(1)}$

Case 3: J exchange



Coupling:

Regge interception: $\alpha(0) = +\frac{1}{2}$

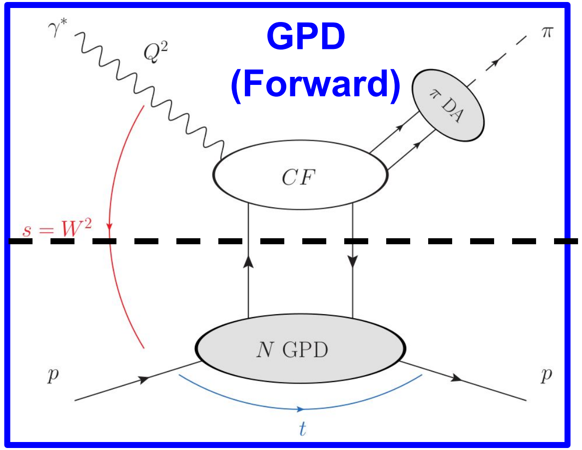
Baryon Multiplicity: $n_x = 3n^{(1)}$

Case 0: Exclusive meson production (quark exchange)

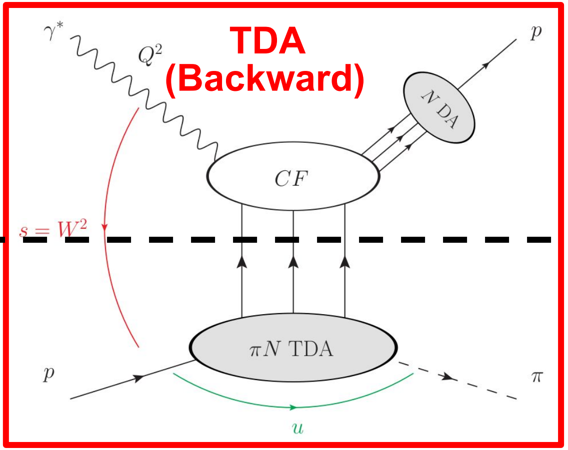
Hard structure

Soft structure

Collinear factorization



By **X. Ji et al.** in 1997

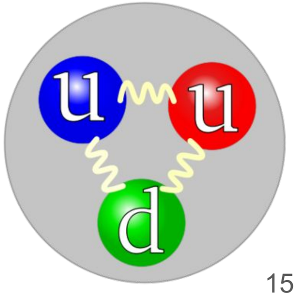


Developed by **B. Pire**, **L. Szymanowski** and **K Semenov-Tian-Shansky** in 2000

Description to the unseen side of proton

Complete description of Nucleon

- **GPD**: It is extracted predominantly based in the forward angle observables.
- **TDA**: meson-nucleon Transition Distribution Amplitude (TDA) only accessible through backward (u-channel) meson production.



E12-20-007 Collaborator List

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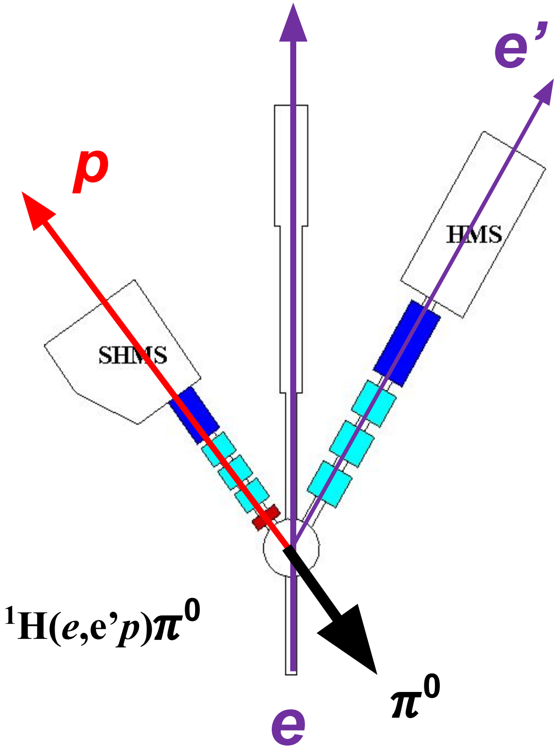
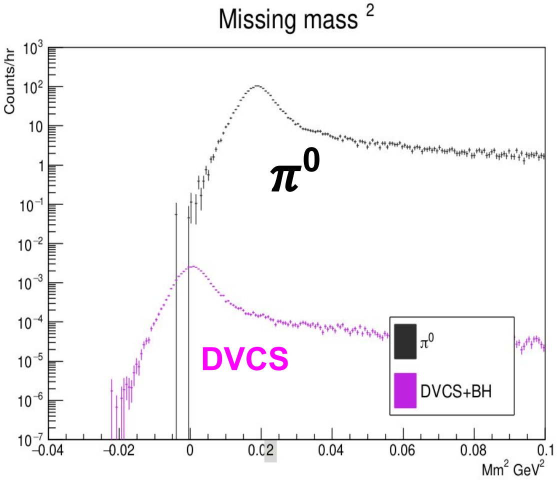
E12-20-007 Backward-angle $^1H(e,e'p)\pi^0$





Q^2 GeV²	W GeV	ϵ	x	θ_{pq} Degree
2.0	3.00	0.32	0.20	-3, 0
		0.79	0.20	-2.8, 0, +3
2.0	2.11	0.52	0.36	-3, 0, +3
		0.94	0.36	-3, 0, +3
3.0	2.49	0.54	0.36	-3, 0, +3
		0.86	0.36	-3, 0, +3
4.0	2.83	0.56	0.36	-3, 0, +3
		0.73	0.36	-3, 0, +3
5.0	3.13	0.26	0.36	-3, 0
		0.55	0.36	-3, 0, +3
6.25	3.46	0.27	0.36	0

First dedicated *u*-channel electroproduction study above the resonance region:

- **Q^2 coverage: $2.0 < Q^2 < 6.25$ GeV², at x=0.36 and W > 2 GeV L/T separated cross section @ Q^2= 2, 3, 4 and 5 GeV².**
- u coverage: $0 < -u' + 0.5 < 0.5$ GeV²
- **Additional W scaling check @ Q^2 = 2 GeV²**
- **Additional Q^2 scaling check @ Q^2 = 6.25 GeV²**

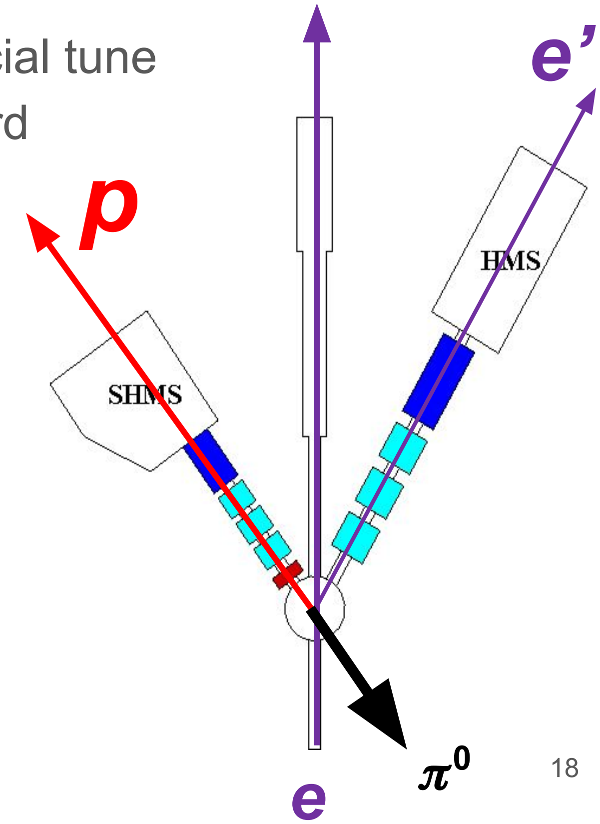
Requirements

- PAC has approved 29 days of beam (requested 29.4 days)

- Beam request: standard beam (2.2 GeV/pass) or special tune (1.1 GeV/pass) during the time of running with standard polarization

- **Special detector configuration:**
  - **Installing NGC for SHMS**
  - **SHMS aerogel tray n=1.0003**
  - **HMS aerogel tray n=1.0011**
  - **Using Moller polarimeter**

- **Equipment refurbishment for one setting:**
  - **HMS Aerogel PMT Replacement (new request)**
  - **SHMS Aerogel tray of n=1.0003 (already planned)**



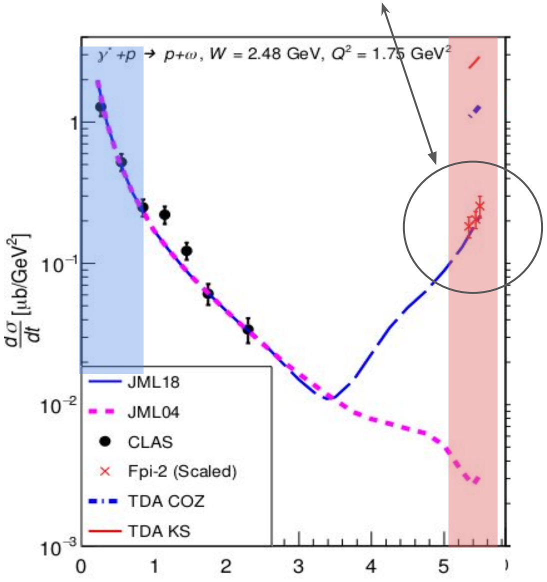
Experimental Objectives

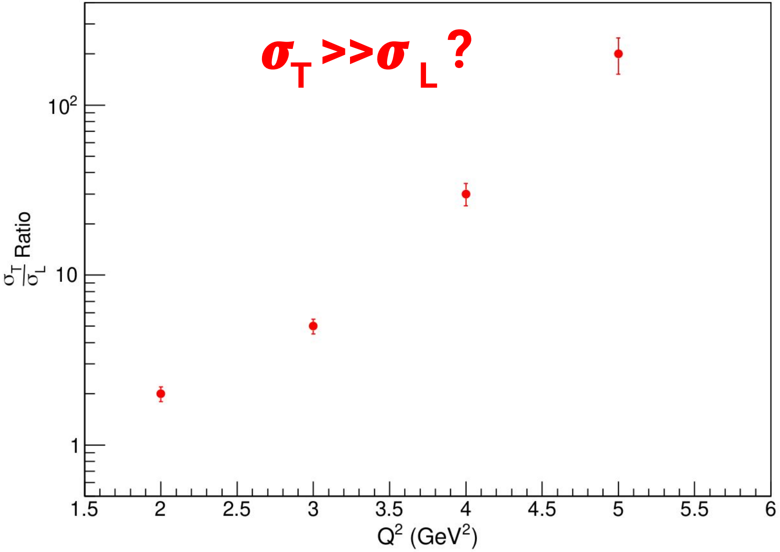
Objective 1: Demonstrating the existence of the *u*-channel peaks for H(e,e'p)π^0

Objective 2: Verify the prediction from the quark based model *TDA*

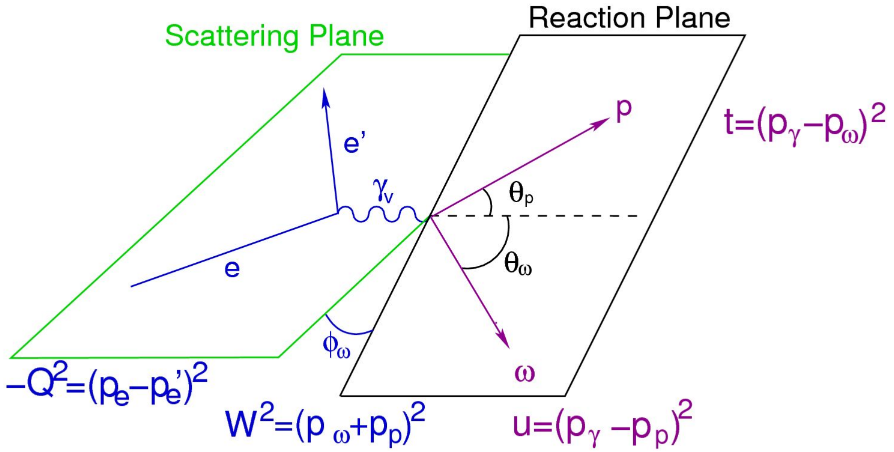
Objective 3: Looking for the signature for the baryon junction

Peak exist for π^0?





The Rosenbluth Separation



Virtual-photon polarization:

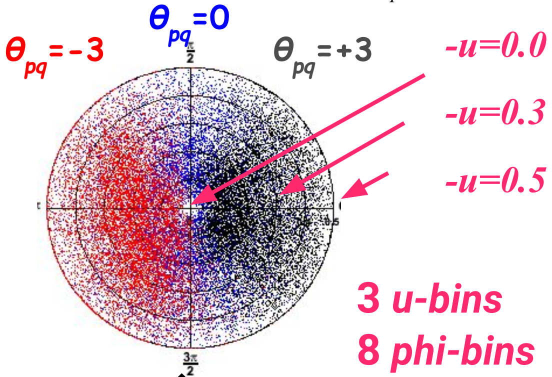
$$\varepsilon = \left(1 + 2\frac{(E_e - E_{e'})^2 + Q^2}{Q^2}\tan^2\frac{\theta_{e'}}{2}\right)^{-1}$$

$$2\pi \frac{d\sigma}{dt\,d\phi} = \varepsilon \frac{d\sigma_L}{dt} + \frac{d\sigma_T}{dt} + \sqrt{2\varepsilon(\varepsilon+1)}\frac{d\sigma_{LT}}{dt}\cos\phi + \varepsilon\frac{d\sigma_{TT}}{dt}\cos 2\phi$$

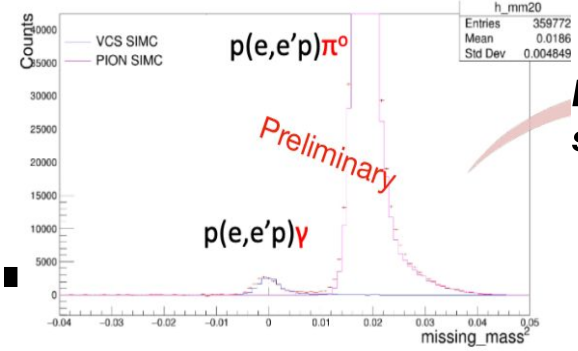
- **Rosenbluth Separation requirements:**
  - Separate measurements at different ε (virtual photon polarization)
  - All Lorentz invariant physics quantities: *Q^2, W, t, u,* remain constant
  - Beam energy, scattered e angle and virtual photon angle will change as the result, thus event rates are dramatically different

Iterative Procedure (Recipe) to a LT Separation

Improve ϕ coverage by taking data at multiple HMS angles, -3°< θ_p<+3°.

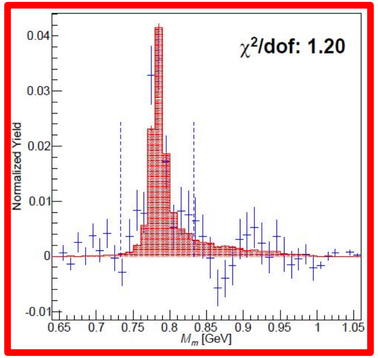


3 u-bins
8 phi-bins



H. Rahimtula,el. al., Hall C VCS experiment

Background subtraction

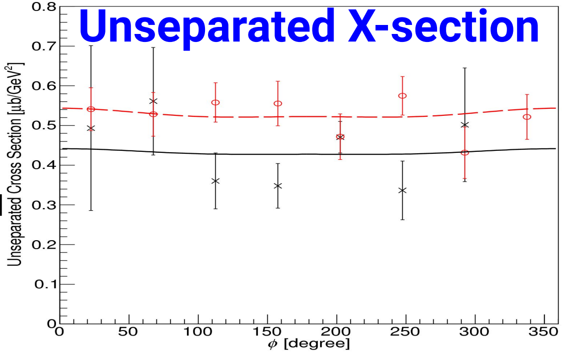


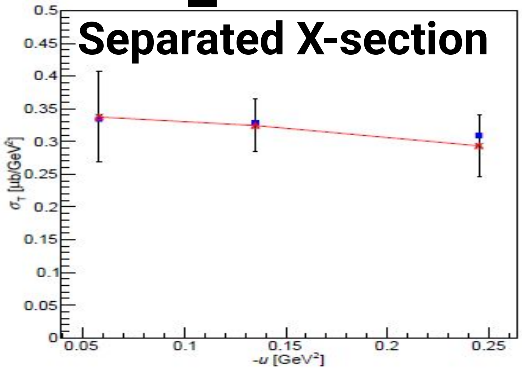
$$R = \frac{Y_{Exp} - Y_{\rho\ sim} - Y_{Xspace\ sim} - Y_{\eta\ sim}}{Y_{\omega\ sim}}$$

Combine ratios for settings together, propagating errors accordingly.

$$\frac{d^2\sigma}{dtd\varphi}_{EXP} = R\,\frac{d^2\sigma}{dtd\varphi}_{SIMC}$$

Empirical Model





Extracting T, L, LT, TT via simultaneous fit

$$2\pi\frac{d\sigma}{dtd\phi} = \frac{d\sigma_T}{dt} + \varepsilon\frac{d\sigma_L}{dt} + \sqrt{2\varepsilon(\varepsilon+1)}\frac{d\sigma_{LT}}{dt}\cos\phi + \varepsilon\frac{d\sigma_{TT}}{dt}\cos 2\phi$$

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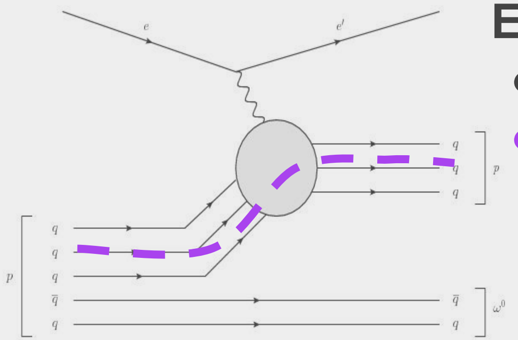
u-Channel Experimental Observable

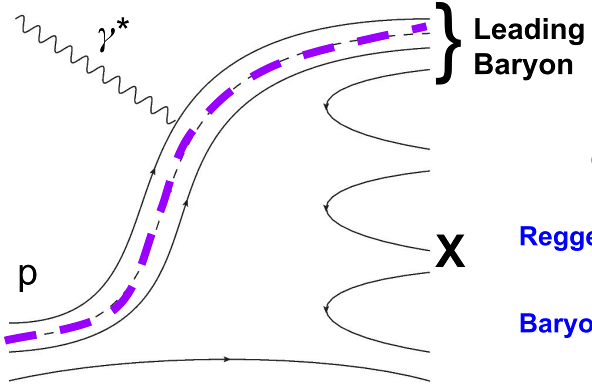
D. Frenklakh, Dmitri Kharzeev, W.B. Li
https://arxiv.org/abs/2312.15039

Case 0: Exclusive meson production

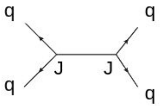


Exchanging:
- 3 q ?
- Junction (J) ?

Case 1: J+2q exchange



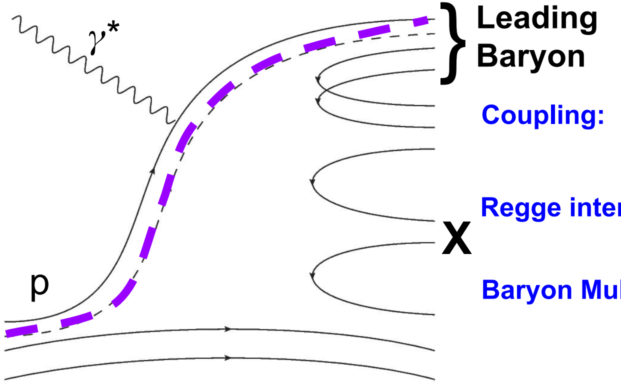
Coupling:



Regge interception: $\alpha(0) = -\frac{1}{2}$

Baryon Multiplicity: $n_x = 1n^{(1)}$

Case 2: J+q exchange

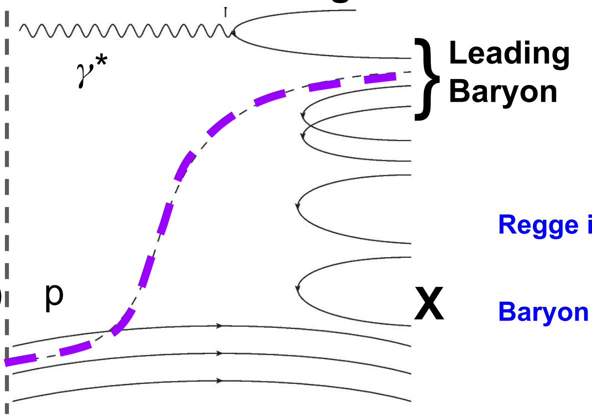


Coupling:

Regge interception: $\alpha(0) = 0$

Baryon Multiplicity: $n_x = 2n^{(1)}$

Case 3: J exchange



Coupling:

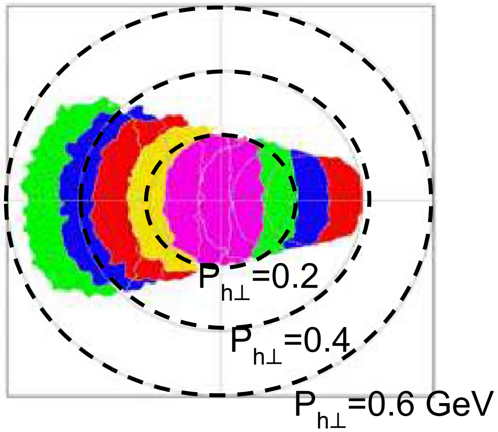
Regge interception: $\alpha(0) = +\frac{1}{2}$

Baryon Multiplicity: $n_x = 3n^{(1)}$

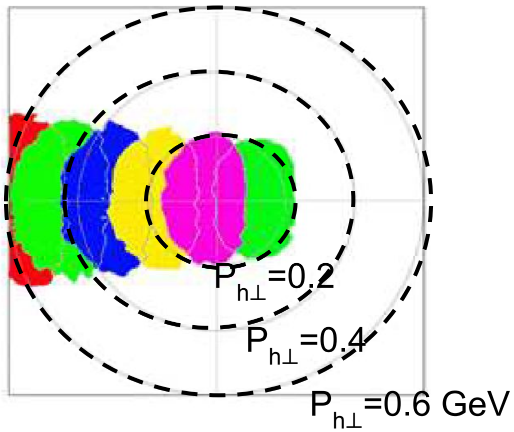
Recent Data from Hall C SIDIS Program

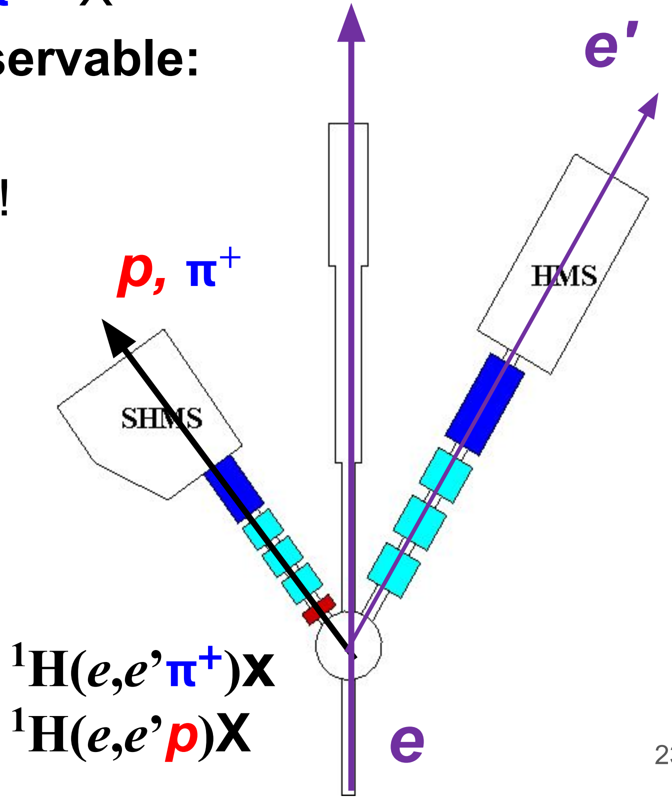
- **E12-09-017: Semi-Inclusive Pion and Kaon Production**
  - Primary experiment observable: e + p → e′ + π^+ + X
  - **Unexpected 2nd secondary experiment observable:**
    e + p → e′ + *p* + X
    - ep SIDIS data is 30% of the overall data set!

Q^2 = 3 GeV^2

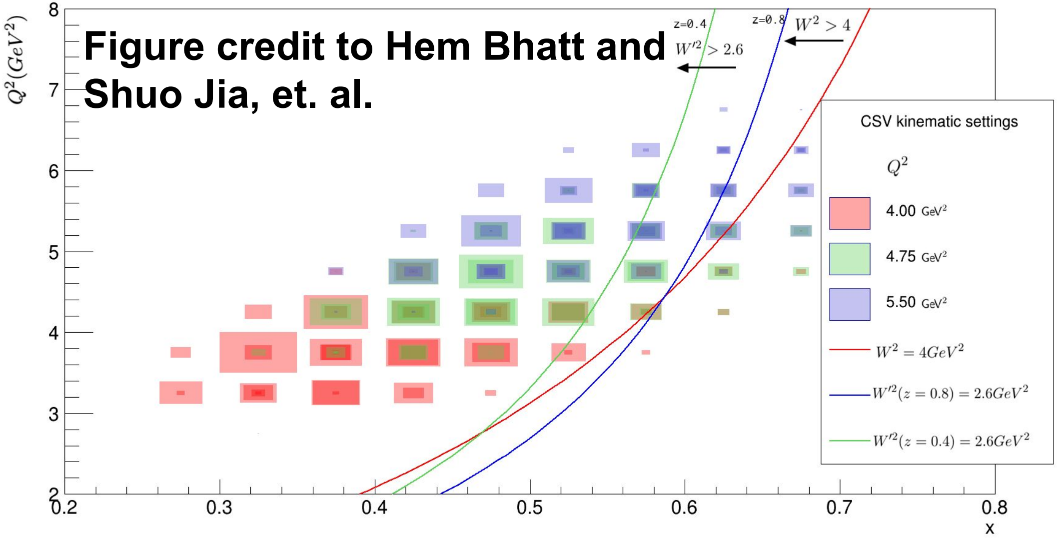


Q^2 = 6 GeV^2



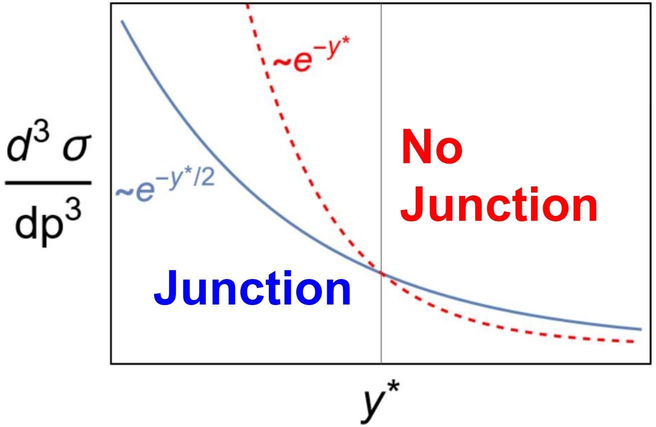


Recent Data from Hall C SIDIS Program



$$z = \frac{E_{\text{Proton}}}{E_{\gamma^*}}$$

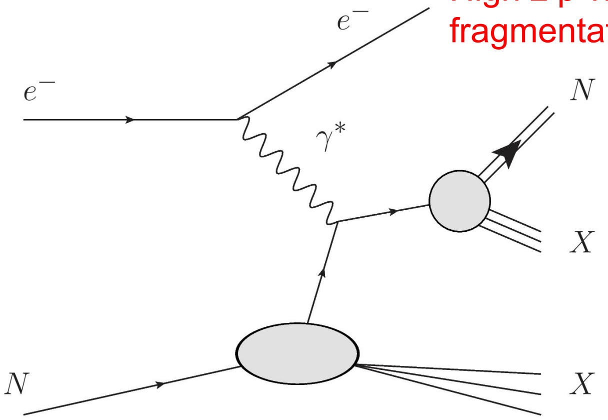
Plot credit to D.Frenklakh



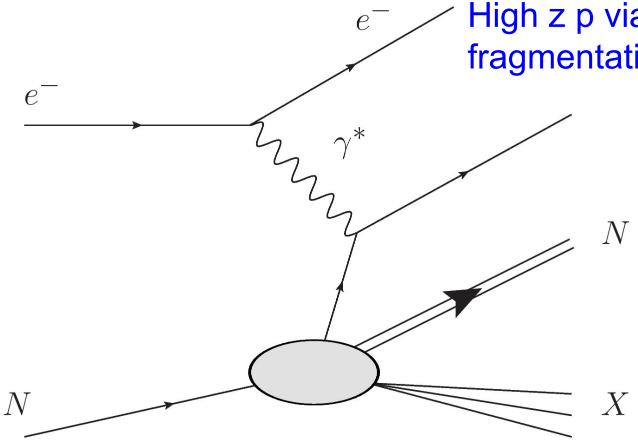
- **Kinematic of the ep data set on tape**
  - Q^2 Setting: 4.00, 4.75, 5.5 GeV^2
  - z coverage: $z < 0.8$
  - $P_{h\perp}$ coverage: $P_{h\perp} < 0.6$
- **Cross section extraction of the $P_{h\perp}$ dependence is under preparation!**

Semi-inclusive scattering (inspired by Alessandro Bacchetta)

High z p via parton fragmentation

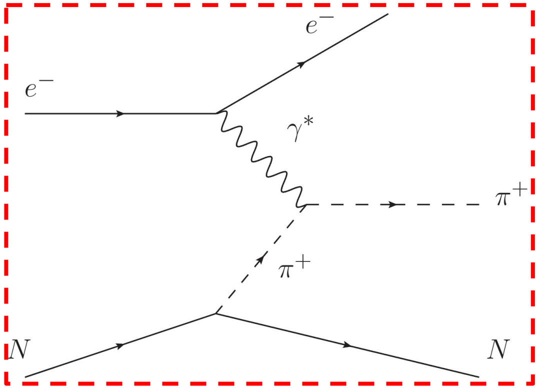


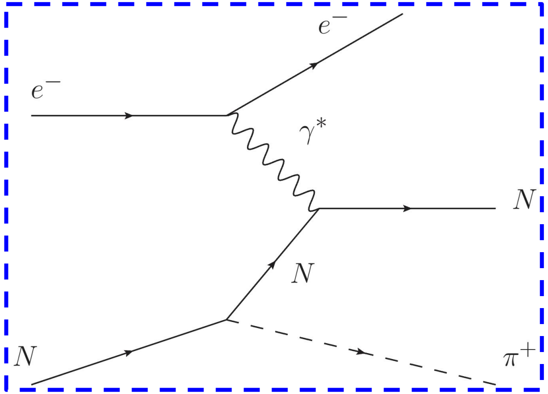
High z p via target fragmentation

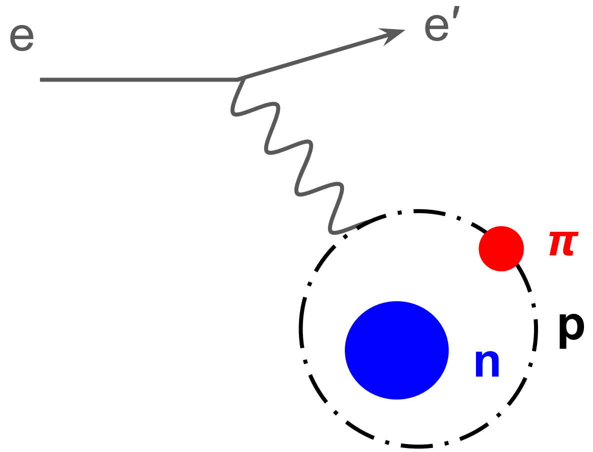


- **Where is the high-z proton coming from?**
- **Two possibilities**
  - From the fragmented parton region, which can be described by proton fragmentation function (can be integrated into the TMD formalism)
  - From the target fragmentation region, collinear factorization approach.
- **Analysis effort of the existing data is urgently needed to distinguish the production mechanism**
  - New postdoc will be tasked to lead this effort (with the endorsement of E12-09-017 and other relevant SIDIS experiments)

u-Channel Sullivan process (inspired by Tobias Federico)

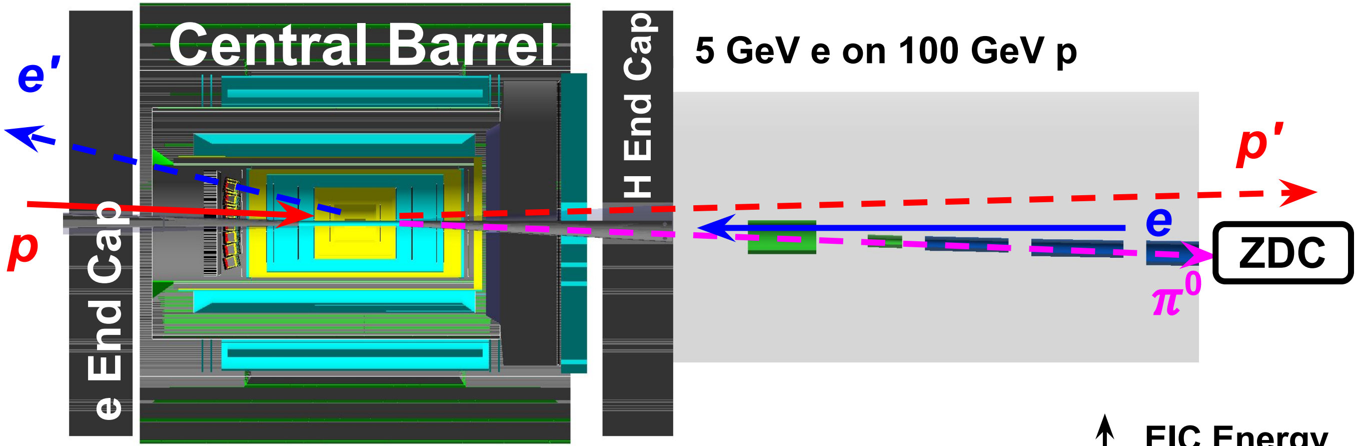






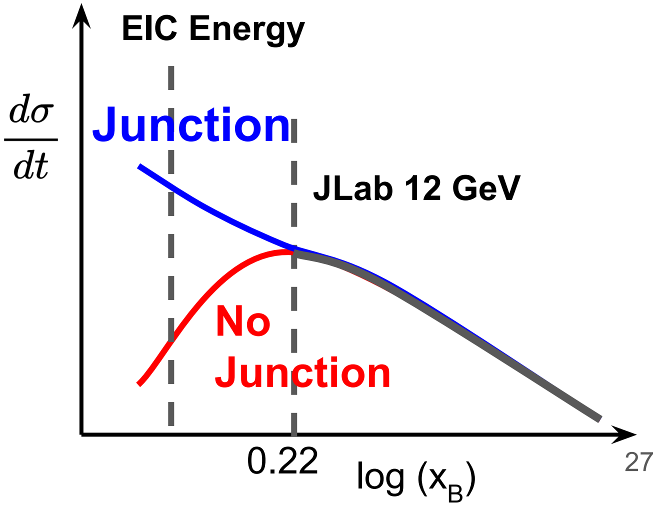
- ep→e′nπ^+ Standard Sullivan process
  - π^+ scatters forward
  - Probing the internal structure of pion
- ep→e′π^+n backward Sullivan process
  - Nuetron scatters forward
  - Probing the internal structure of neutron?

Further Studying the Proton Identity Electron Ion Collider



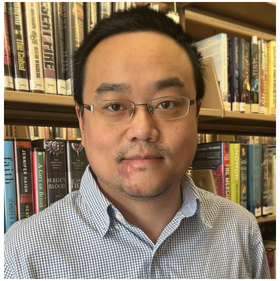
- **How do we conclude the "junction"**
  - **Junctions**: are construct of gluons: **Junction -> u-Channel cross section enhancement at low x_b**
  - **No junction: u-Channel cross section suppressed -> valence quark contribution**

- **The JLab and EIC data are equally critical to test the hyposased x_B**
- **Promise to Alex: a validation for exclusive π^0** is coming



A New Sub Group at Mississippi State

- PI: Bill Li

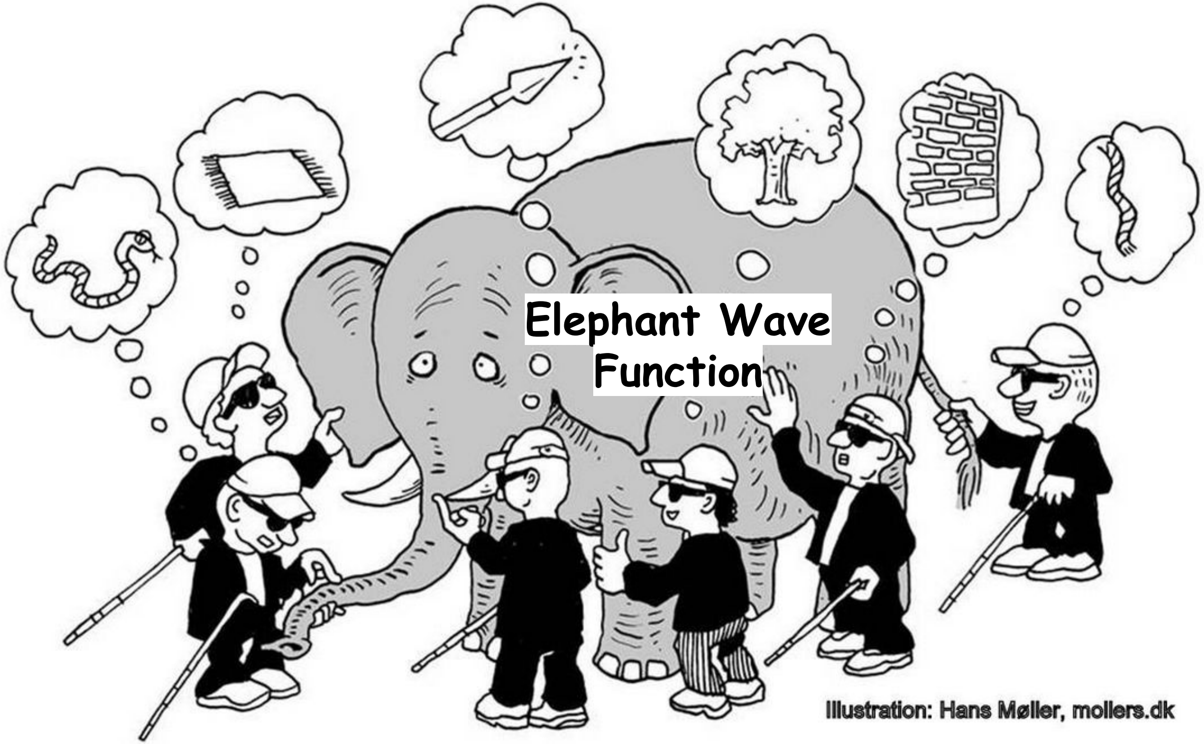


- Postdoc: to be advertised.

- Students: Zichen Yin + 1

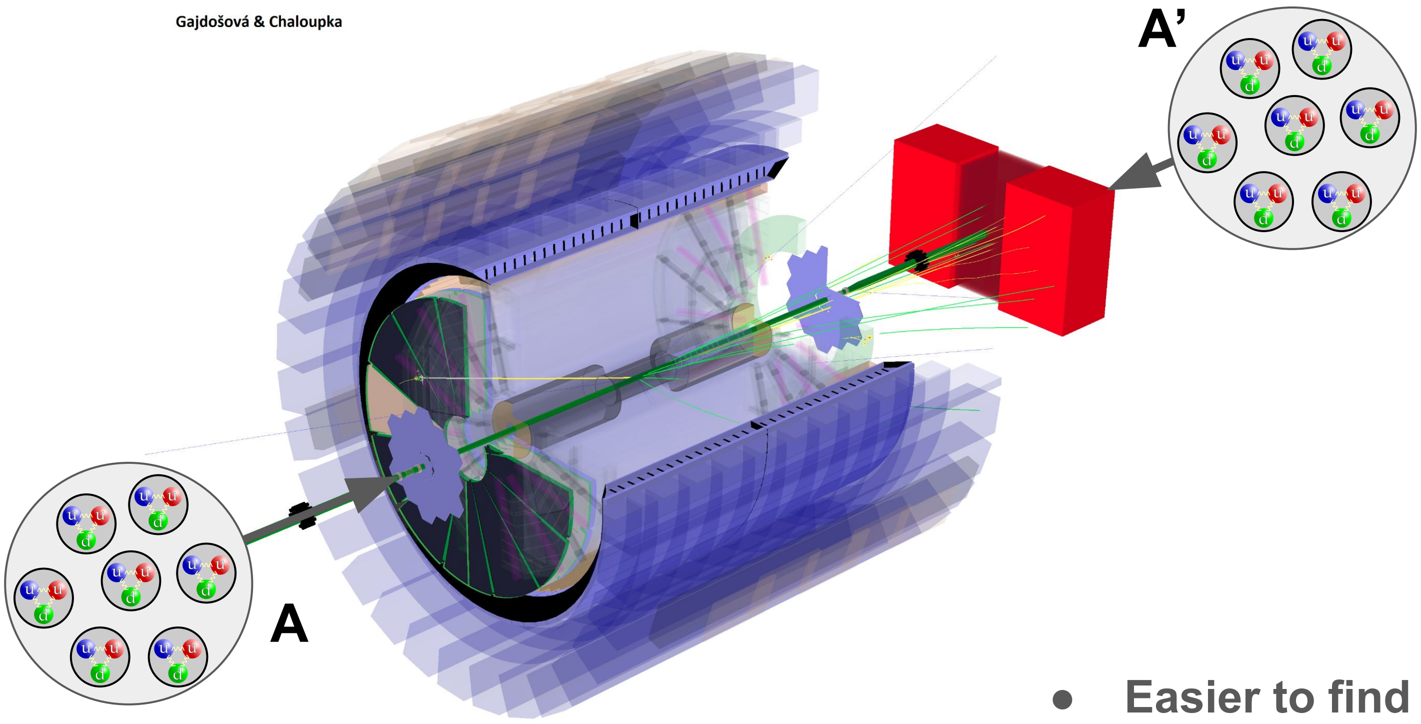
- Group objective
  - Completion of the E12-20-007
  - Analyze the Semi-Inclusive experiment
  - Assist currently scheduled Hall C experiment: Nuclear R. Band + others
  - Hall C detector refurbishment effort
  - New u-Channel observables and programs

Thank you!

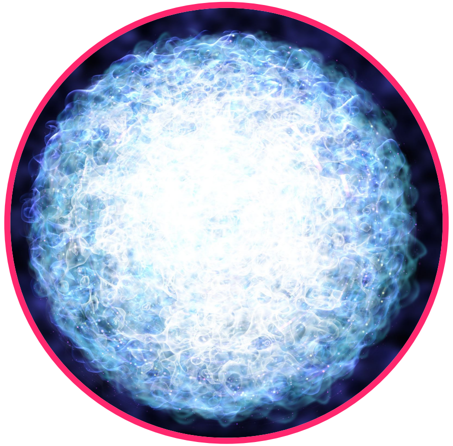


- **Hall C is in a unique position to lead in this newly evolved physics topic.**
- **Hall C u-Channel DVCS**
    - https://indico.phys.vt.edu/event/58/contributions/1265/attachments/997/1380/2023_u_Channel_DVCS.pdf

Probing Baryon Junction at high gluon density environment

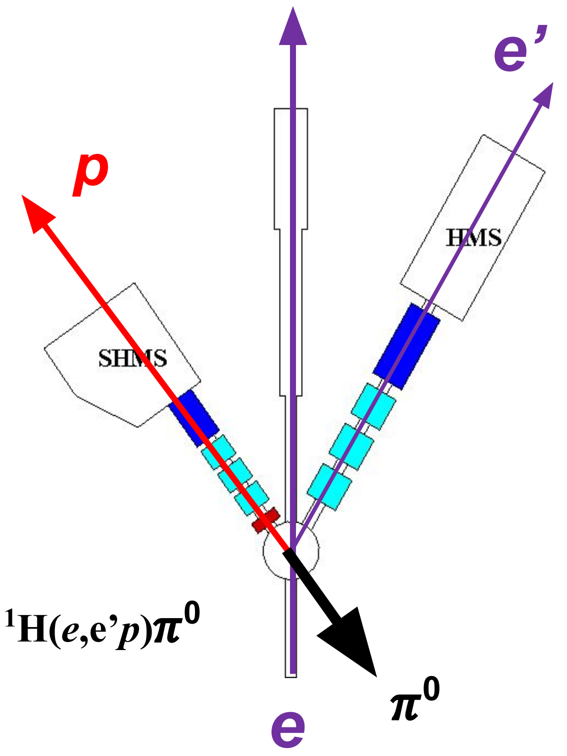


A: Ultra-high energy

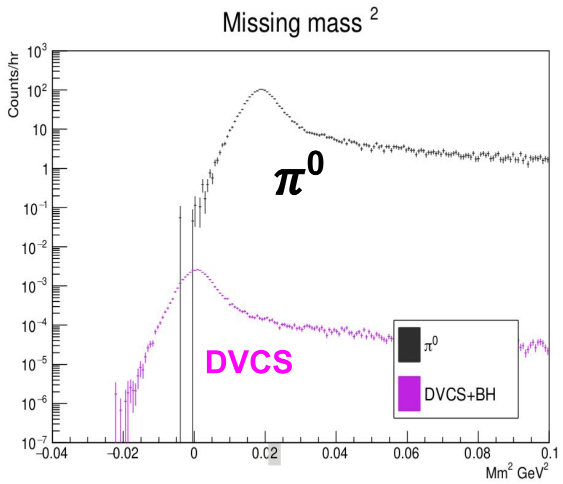


- Easier to find baryon junction at high gluon density “medium”.

E12-20-007 Backward-angle $^{1}H(e,e'p)\pi^0$



$^{1}H(e,e'p)\pi^0$



Q^2 GeV^2	W GeV	ϵ	x	θ_{pq} Degree
2.0	3.00	0.32	0.20	-3, 0
		0.79	0.20	-2.8, 0, +3
2.0	2.11	0.52	0.36	-3, 0, +3
		0.94	0.36	-3, 0, +3
3.0	2.49	0.54	0.36	-3, 0, +3
		0.86	0.36	-3, 0, +3
4.0	2.83	0.56	0.36	-3, 0, +3
		0.73	0.36	-3, 0, +3
5.0	3.13	0.26	0.36	-3, 0
		0.55	0.36	-3, 0, +3
6.25	3.46	0.27	0.36	0

First dedicated *u*-channel electroproduction study above the resonance region:

- **Q^2 coverage: $2.0 < Q^2 < 6.25$ GeV^2, at x=0.36 and $W > 2$ GeV L/T separated cross section @ Q^2= 2, 3, 4 and 5 GeV^2.**
- u coverage: $0 < -u' + 0.5 < 0.5$ GeV^2
- **Additional W scaling check @ Q^2 = 2 GeV^2**
- **Additional Q^2 scaling check @ Q^2 = 6.25 GeV^2**

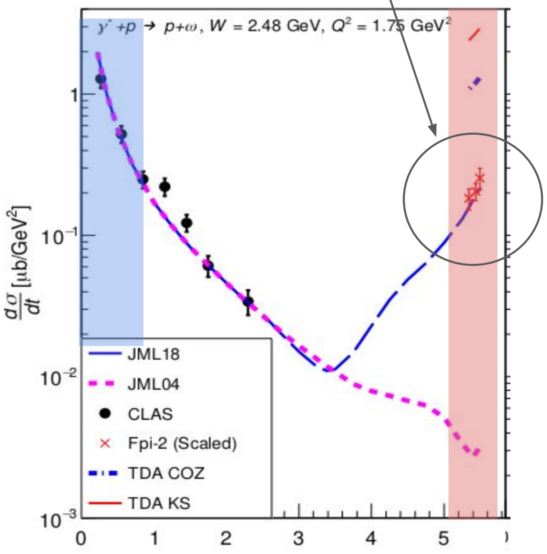
Experimental Objectives

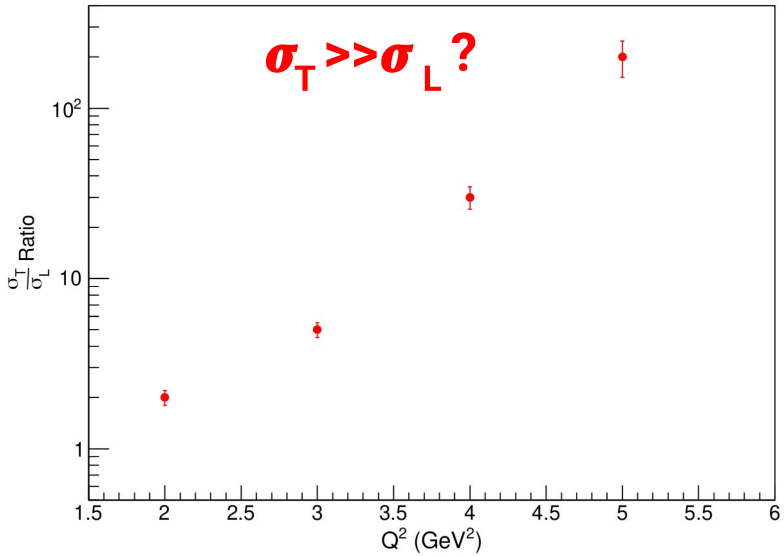
Objective 1: Demonstrating the existence of the *u*-channel peaks for H(e,e'p)π^0

Objective 2: Verify the prediction from the quark based model *TDA*

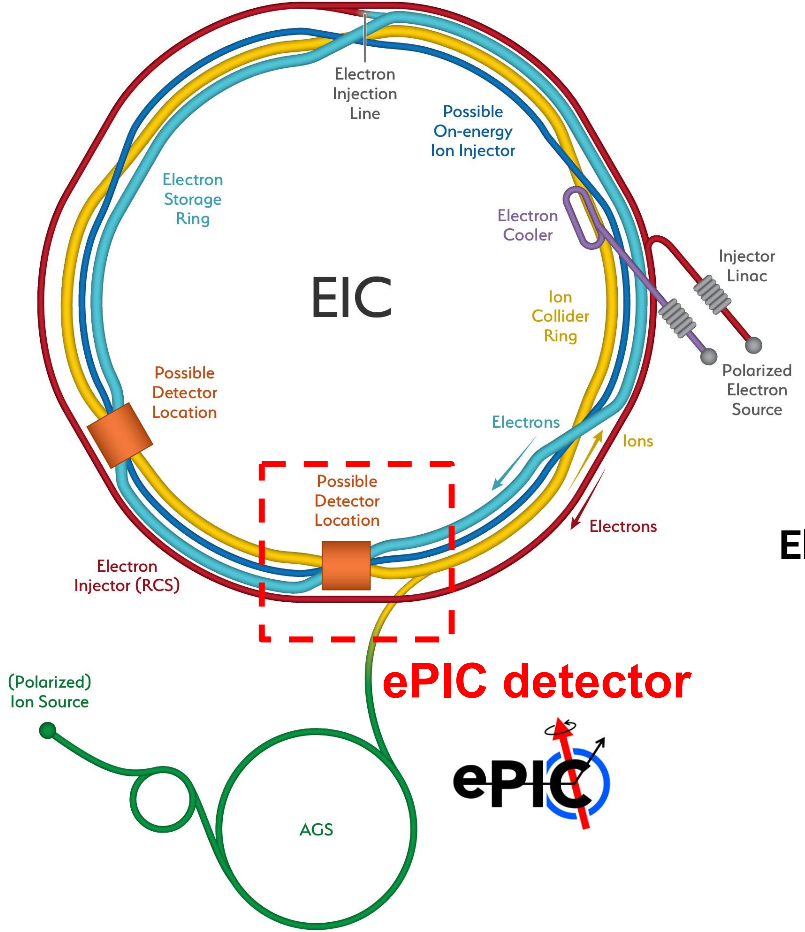
Objective 3: Looking for the signature for the baryon junction

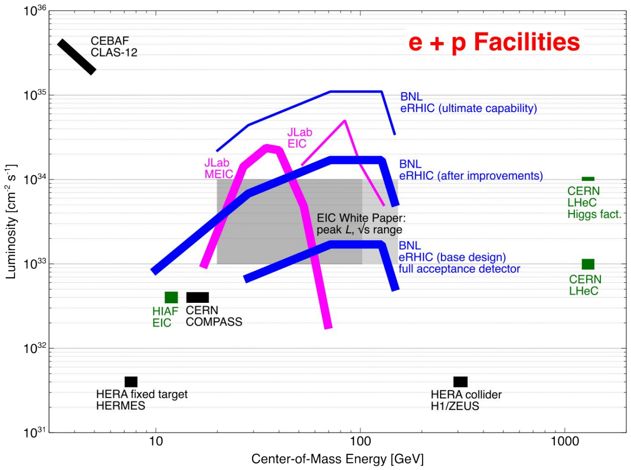
Peak exist for π^0?





Future dream Machine: Electron-Ion Collider



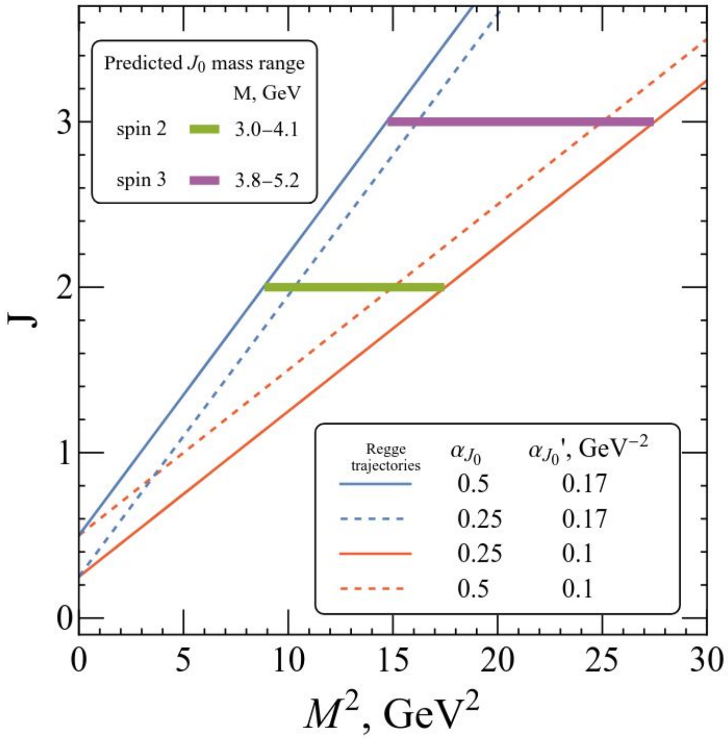


Electron-Ion Collider (EIC): next generation "Dream machine"

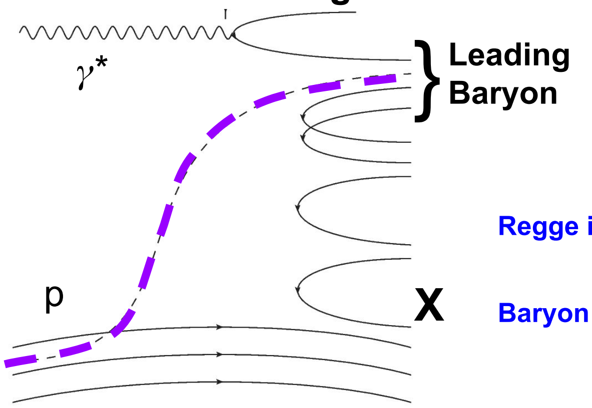
- Luminosity with 100 GeV p on 5 GeV e: 10 x10^{33} $cm^{-2}s^{-1}$ mi
- Project Location: BNL, NY.
- Additional Information:
  - CD-1 approved ~ \$2 B
  - Physics starts in 2033
- Project comes with 1 detector ePIC
- A second detector is being discussed

Hadron Spectroscopy: Searching for glue-ball structure

Baryon-number -flavor separation in the topological expansion of QCD,
David Frenklakh, Dmitri Kharzeev, Giancarlo Rossi, Gabriele Veneziano



Case 3: J exchange



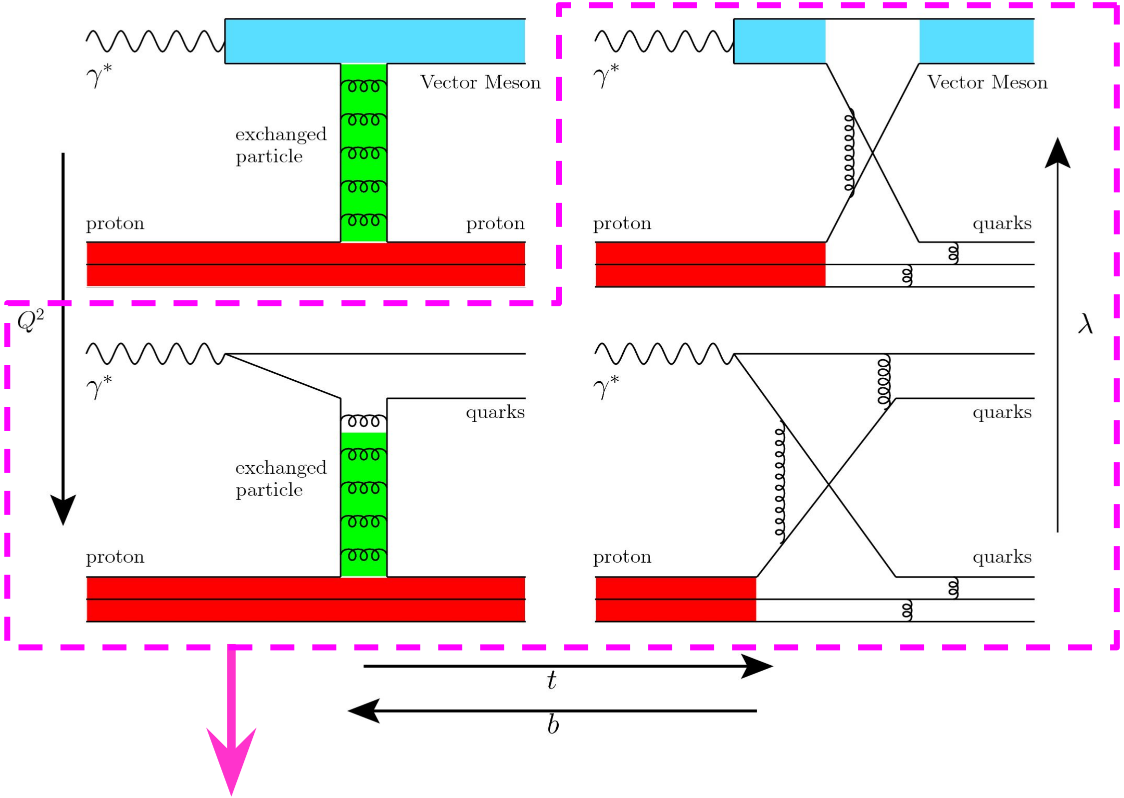
Coupling:

Regge interception: $\alpha(0) = +\frac{1}{2}$

Baryon Multiplicity: $n_x = 3n^{(1)}$

- **Searching for a signature of Glue Ball structure at 20 GeV JLab era.**
- **Input from lattice?**

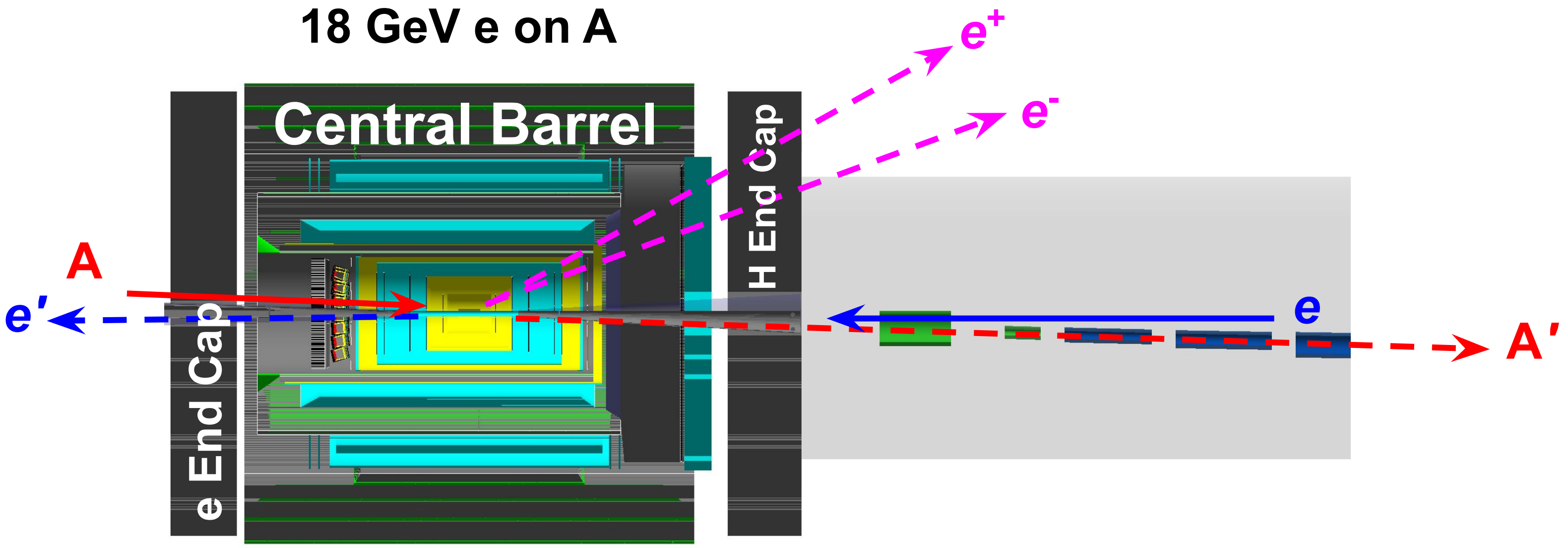
Hadronic Model: Transition (Evolution) of Proton Structure



Evolution of the Proton Structure

- Common physical parameters:
  - x_b, W (or s), Q^2, t, u
  - Lorentz Invariant quantities
- x_b: Parton momentum fraction:
  - 0.2< x<0.3 valence quark distribution is pronounced
- ***W***: Dictates if a process is in the resonance region
- Q^2: probe size or the resolving power
- ***t***: target momentum transfer squared
  - Inversely related to the Impact parameter b

Exclusive Vector Meson production



- **Scattered electron (e′):** $\eta \rightarrow -\infty$, far backward region, low Q^2 tagger
- **Decayed $J/\psi \rightarrow e^+e^-$:** $-1.5 < \eta < 3.5$, Central detector
- **Recoiled A (A′):** $\eta \sim 6$, far forward region

Why do we need a 2nd detector ?

Needed to unlock the full discovery potential of the EIC

- Implies a general-purpose collider detector able to support the full EIC program
- **Cross checks** of key results are essential!

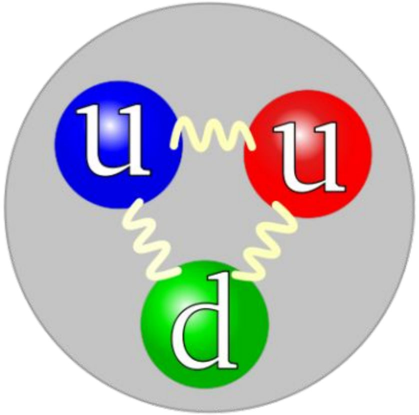
Complementary design features (to ePIC)

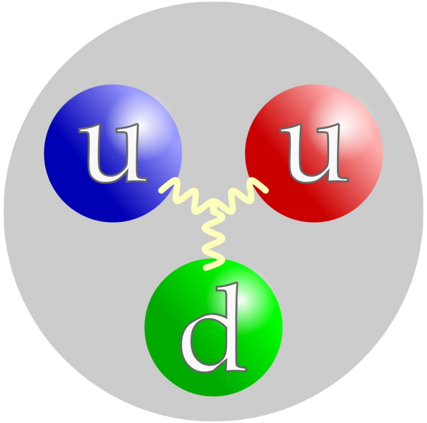
- Combined systematics (as for H1 and ZEUS)
- Phase-space coverage
- The EIC will high statistics, uncertainties for the envisioned measurements will be systematics limited.

New physics opportunities

- Take advantage of much-improved near-beam hadron detection enabled by a 2nd focus,
- Impacts, for instance, exclusive / diffractive physics; greatly expands the ability to measure recoiling nuclei and fragments from nuclear breakup.
- New ideas beyond the NAS and Yellow Report scope (EW and BSM)?

Summary and Thank You





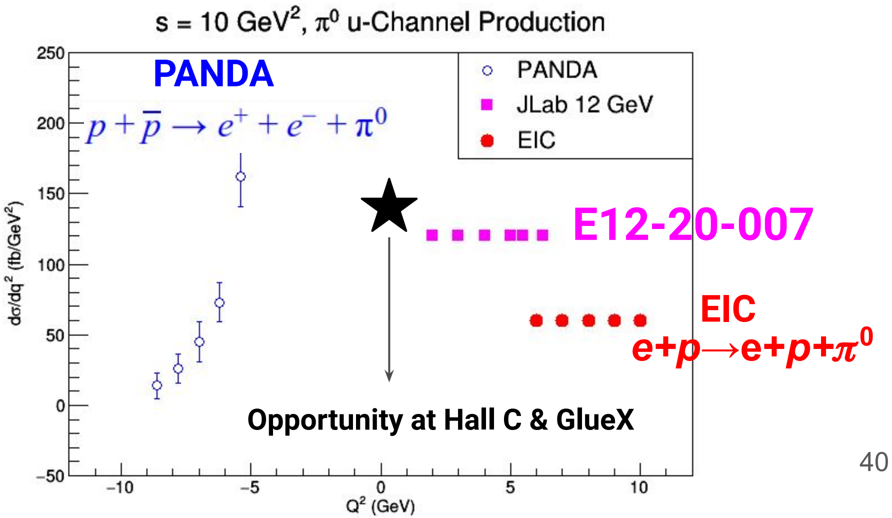
- **Identifying the "who" carries the identify of the proton and demonstrating the existence of baryon junction is at forefront of the current research**
- **Full conclusion is expected combining evidences from JLab and the future EIC.**
- ***u*-Channel scattering technique provides unique access to the baryon Junction observable, and will attract a new wave of early career physicists to uncover its full potential**
- **Our research plan: hardware + new physics ideas.**

u-Channel studies at EIC

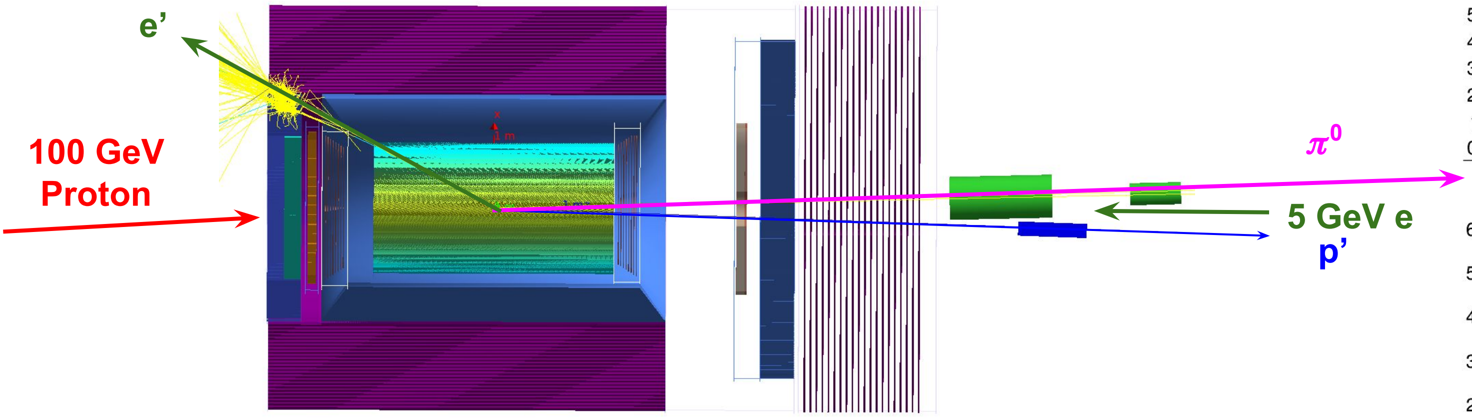

7.4 Understanding Hadronization

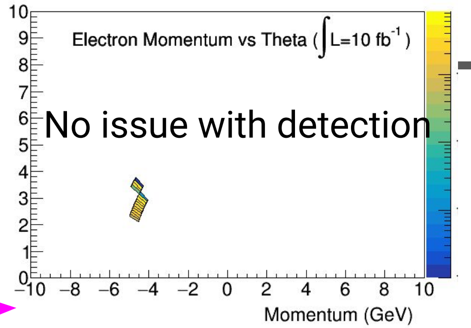
There is great potential also in studying **new particle production mechanisms** such as exclusive backward *u*-channel production. Given its high luminosity the EIC may be able to discover fundamental QCD particle production processes with low cross sections such as via hard (perturbative) *C*-odd three gluon exchange.

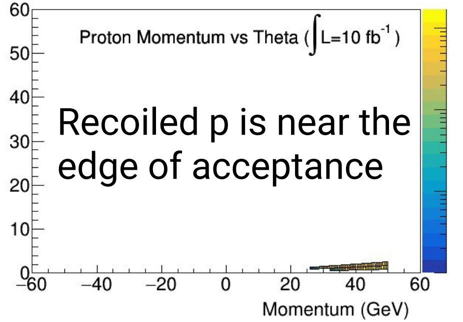
- **As postdoctoral fellow at JLab EIC Center: developed Backward π^0 program for EIC**
  - Offers synergy to other planned data set
  - Feasibility studies included as part of the EIC Yellow report (published last week)

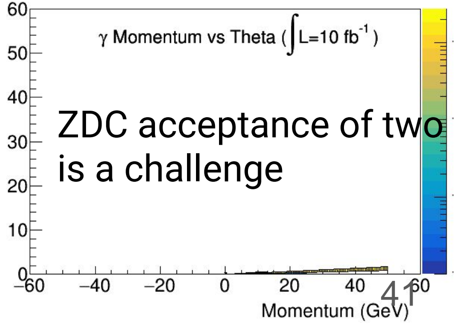


u-Channel Meson Production Setup



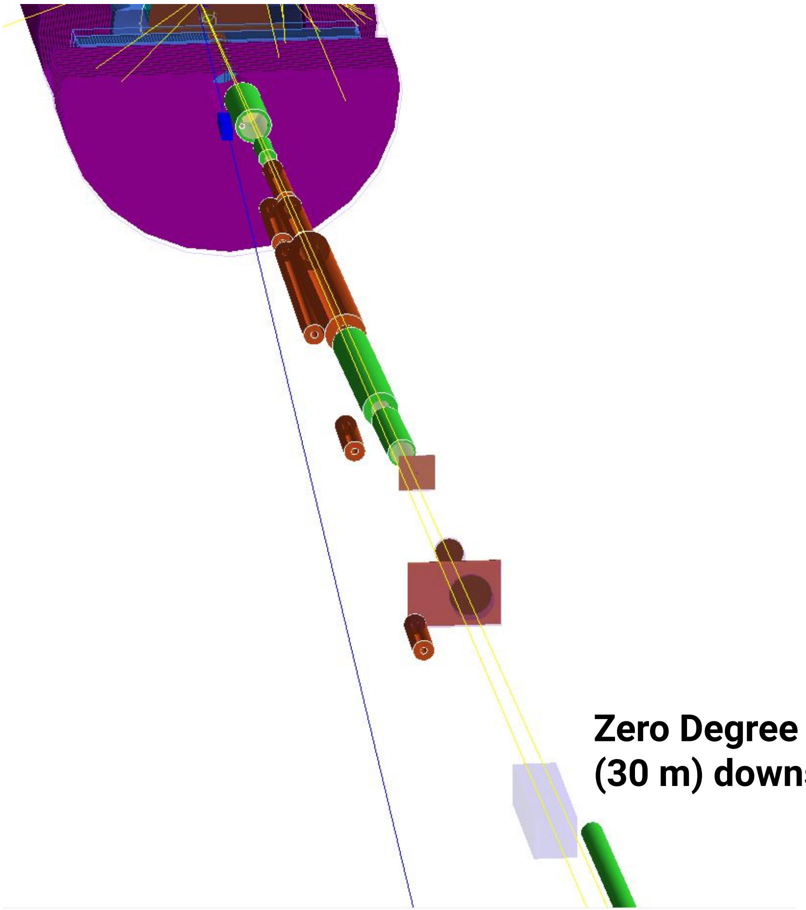




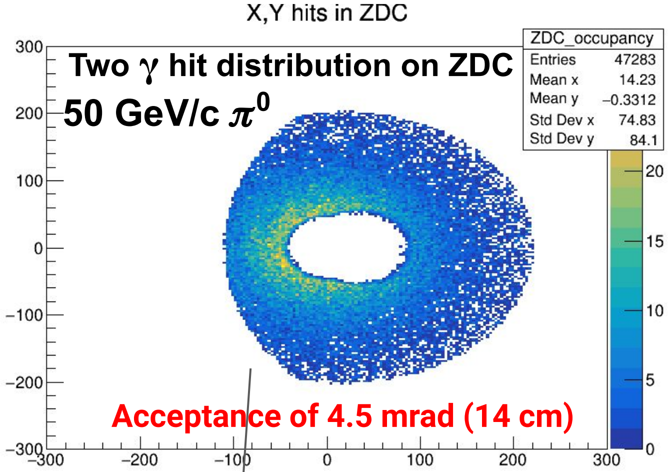


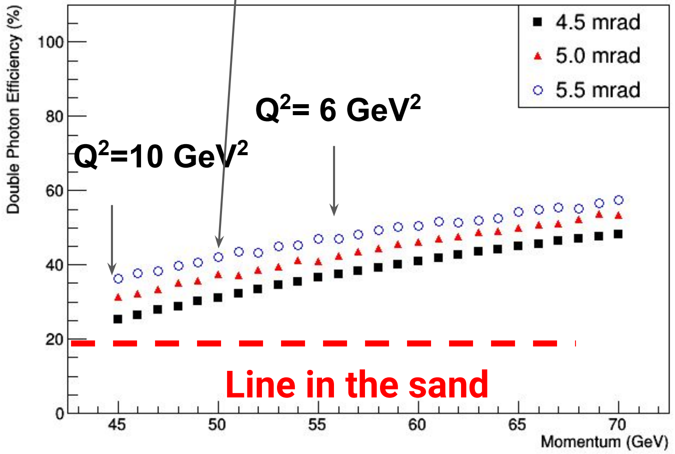
Q^2 (GeV^2)	W (GeV)	x_B	$\theta_{e'}$ (deg)	$\eta_{e'}$	$P_{e'}$ (GeV)	$\theta_{p'}$ (deg)	$\eta_{p'}$	$P_{p'}$ (GeV)	θ_{π^0} (deg)	η_{π^0}	P_{π^0} (GeV)	$-t$ (GeV^2)	$-u$ (GeV^2)
6.2	3.19		152	-1.39	5.31	-1.84	4.13	43.40	1.43	4.38	56.29	14.84	-0.37
7.0	3.19		150	-1.32	5.35	-1.92	4.09	45.50	1.43	4.38	54.12	16.19	-0.39
8.2	3.19		148	-1.24	5.40	-1.85	4.12	49.74	1.43	4.38	49.84	16.80	-0.42
9.3	3.19		146	-1.19	5.46	-1.92	4.09	51.90	1.43	4.38	47.60	18.19	-0.44
10.5	3.19		144	-1.12	5.52	-1.94	4.07	54.96	1.43	4.38	44.50	19.32	-0.47

Realistic ZDC Acceptance for π^0 Detection

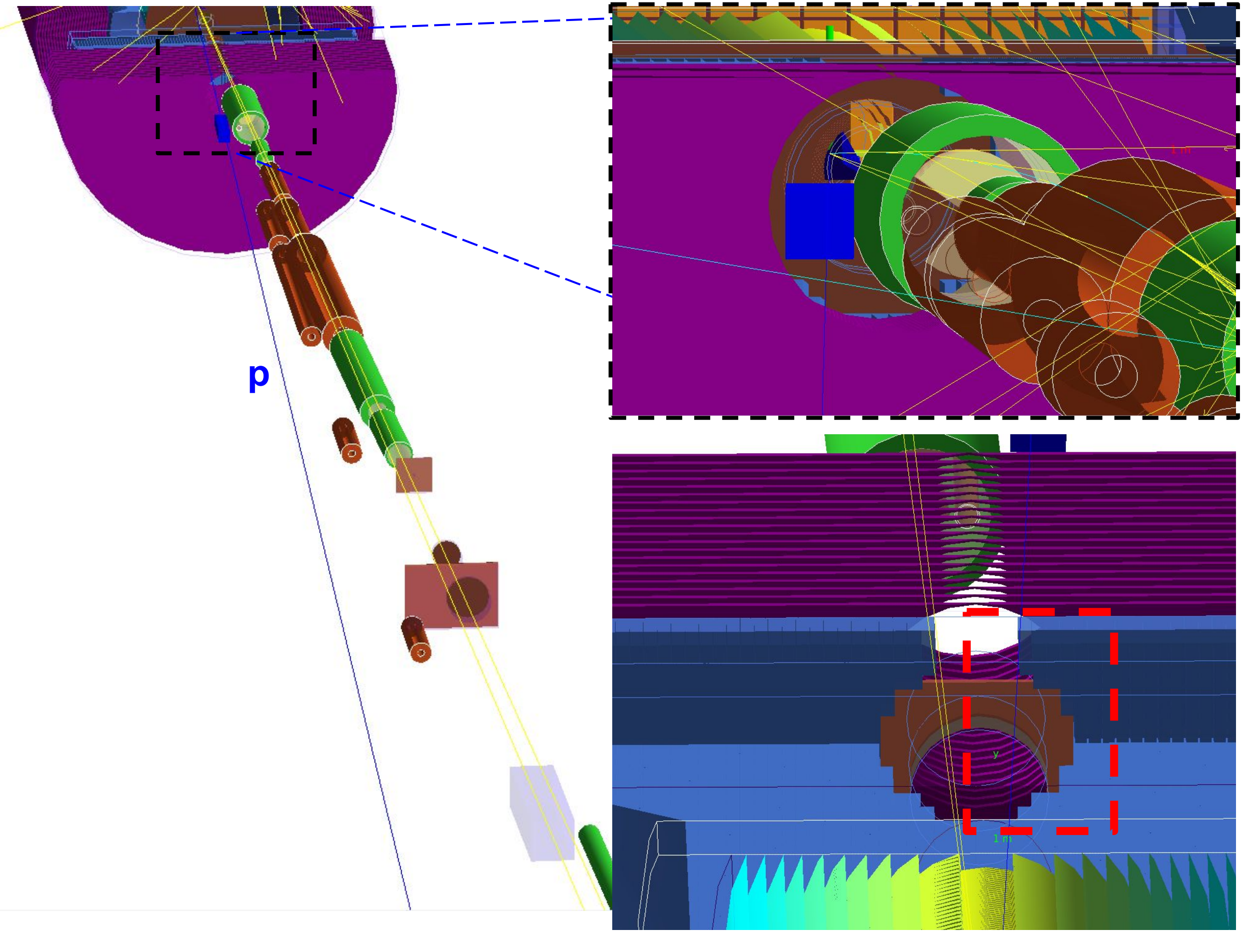


Zero Degree Calorimeter
(30 m) downstream of IR





A Proton Detection Problem



Proton detector issue!

- Proton will NOT be detector due to ventilation hole!
- Blue cube: new detector dropped in to help with acceptance study
- Completing feasibility study is critical now ! (designing stage)

First Dedicated Backward Angle Experiment

- **Probing backward-angle (*u*-channel) electroproduction of π^0 : E12-20-007**
  - First presented as Letter of Intent in 2018
  - Full proposal submitted in 2020
- **Received full approval by JLab Program Advisory Committee (PAC):**
  - Experiment fully approved for 29 PAC days
  - **Projected beam time: 48 days** (48 * $800k = $ 30M in electricity bill from tax payer)
- **PAC recognized the pioneering nature of the measurement**
  - The exploration of backward pion electroproduction is feasible, and JLab is an ideal venue at which to perform it.
- **Significant symbolic meaning: First approved dedicated u-channel experiment**

	$\sigma_T > \sigma_L$	$1/Q^8$ Scaling
π^0	○	○
π^+		✓✓
π^-		
K^0		
$K^\pm$		
η	✓	✓
ρ		
ω	✓✓	✓
η'	✓	✓
ϕ	✓	✓
VCS	△	△

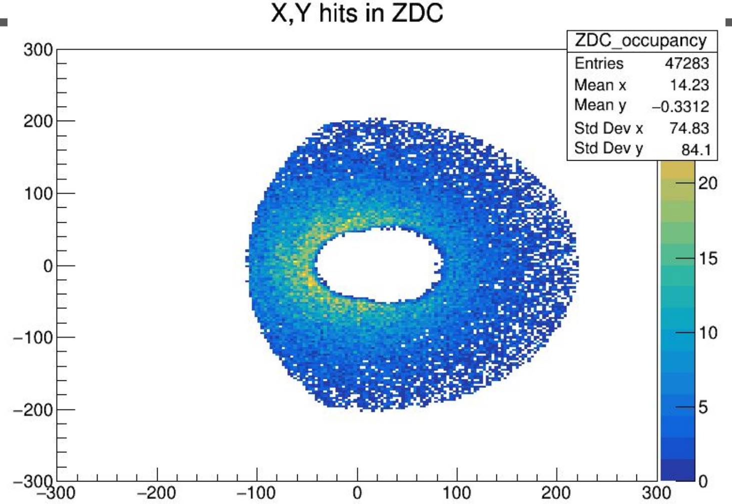
Confirmed! CLAS 6 π^+

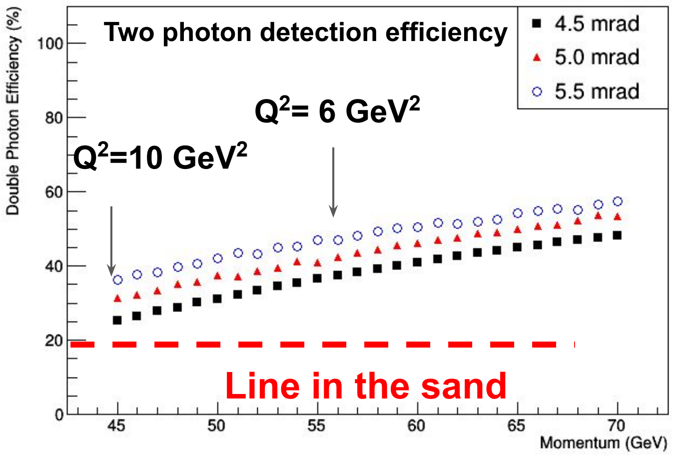
Parasitic Hall C Study

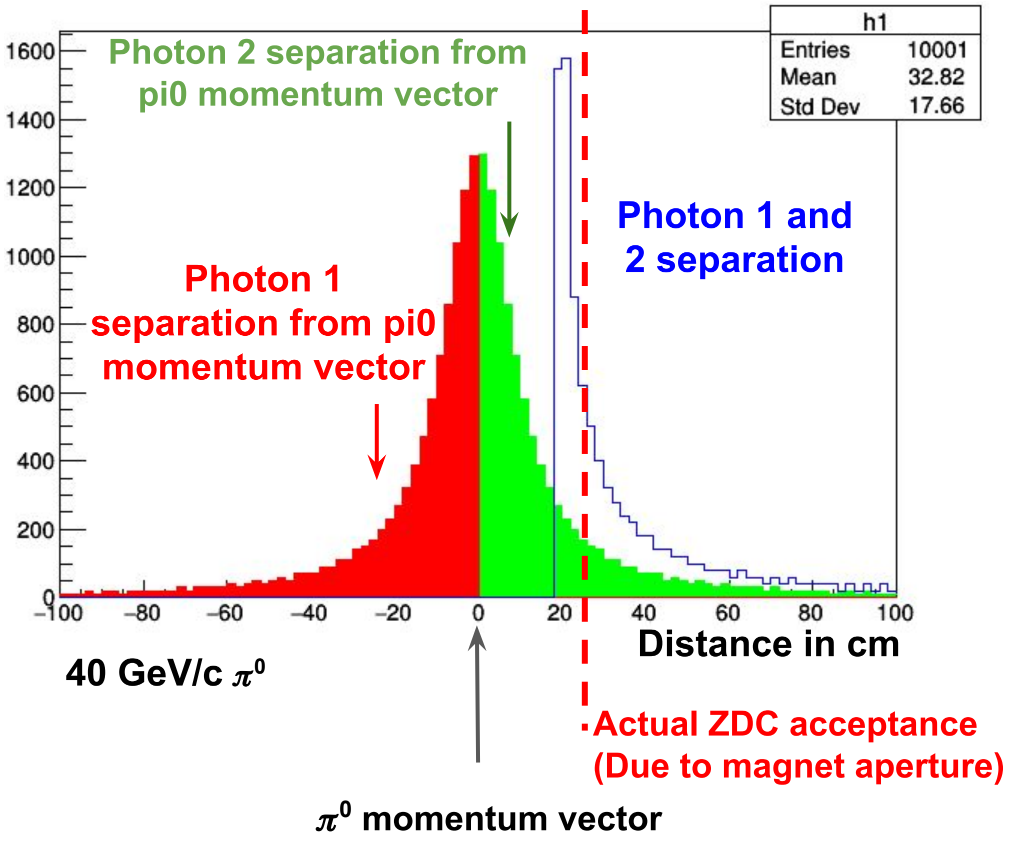
Confirmed! By Hall C 6 GeV ω

In the very early planning stage

Realistic ZDC Acceptance (through magnets Aperture)







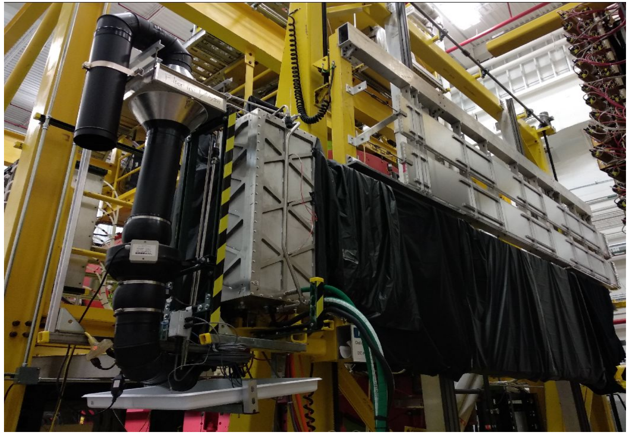
Two Cherenkov Detectors experiences and EIC R&D

Heavy Gas Cherenkov Detector Construction for JLab Hall C

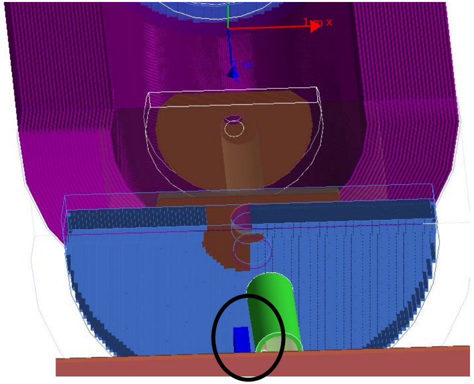
- 2009-2017
- Led by Dr. G. Huber
- My contribution: Design, prototyping, Geant4 simulation, final assembly

GlueX DIRC Detector

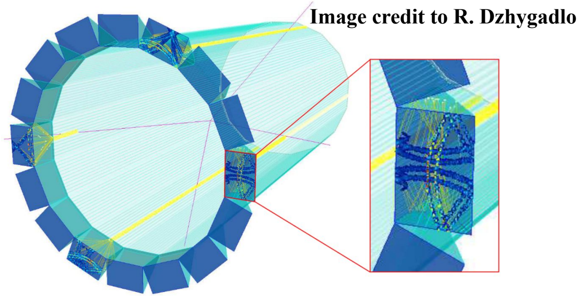
- 2017-Present
- Led by Dr. J. Stevens
- My contribution: Prototyping, final assembly, maintenance, data analysis



EIC Detector R&D



High Eta Counter for backward π^0



High-performance-DIRC: CUA,JLab, W&M, GSI (Germany), University of Hawaii, Indiana University

Requirements

- PAC has approved 29 days of beam (requested 29.4 days)

- Beam request: standard beam (2.2 GeV/pass) or special tune (1.1 GeV/pass) during the time of running with standard polarization

- **Equipment refurbishment:**
  - **HMS Aerogel PMT Replacement (new request)**
  - **SHMS Aerogel tray of n=1.0003 (already planned)**

- **Special detector configuration:**
  - **Installing NGC for SHMS**
  - **SHMS aerogel tray n=1.0003**
  - **HMS aerogel tray n=1.0011**
  - **Using Moller polarimeter**