Highlights from the 12 GeV JLab program towards EIC

Tanja Horn

THE CATHOLIC UNIVERSITY OF AMERICA

Jefferson Lab
Thomas Jefferson National Accelerator Facility

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EIC User Group Annual Meeting

Lehigh U., 23-24 July, 2024

EIC NAS Science Highlights

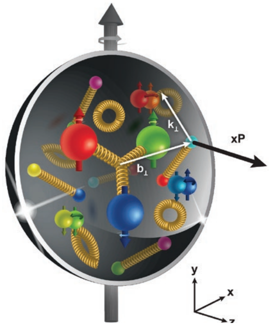
SPIN is one of the fundamental properties of matter.
All elementary particles, but the Higgs carry spin.
Spin cannot be explained by a static picture of the proton
It is the interplay between the intrinsic properties and interactions of quarks and gluons

The EIC will unravel the different contribution from the quarks, gluons and orbital angular momentum.

Does the mass of visible matter emerge from quark-gluon interactions?

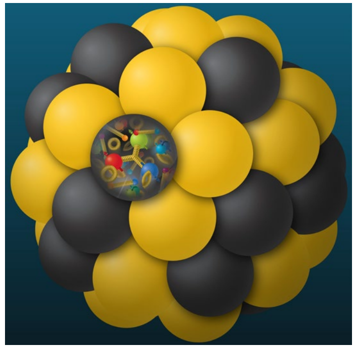
Atom: Binding/Mass = 0.00000001
Nucleus: Binding/Mass = 0.01
Proton: Binding/Mass = 100

proton
determine an important term contributing to the proton mass, the so-called “QCD trace anomaly



How are the quarks gluon distributed in space and momentum inside the nucleon & nuclei?

nucleon properties emerge from them and their interactions?
How can we understand their dynamical origin in QCD?
What is the relation to Confinement

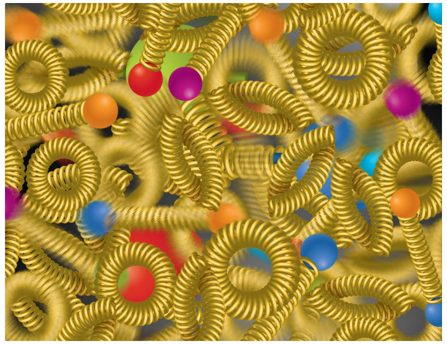


Is the structure of a free and bound nucleon the same?

How do quarks and gluons, interact with a nuclear medium?

How do the confined hadronic states emerge from these quarks and gluons?

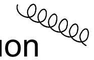
How do the quark-gluon interactions create nuclear binding?



How many gluons can fit in a proton?

How does a dense nuclear environment affect the quarks and gluons, their correlations, and their interactions?

What happens to the gluon density in nuclei? Does it saturate at high energy?

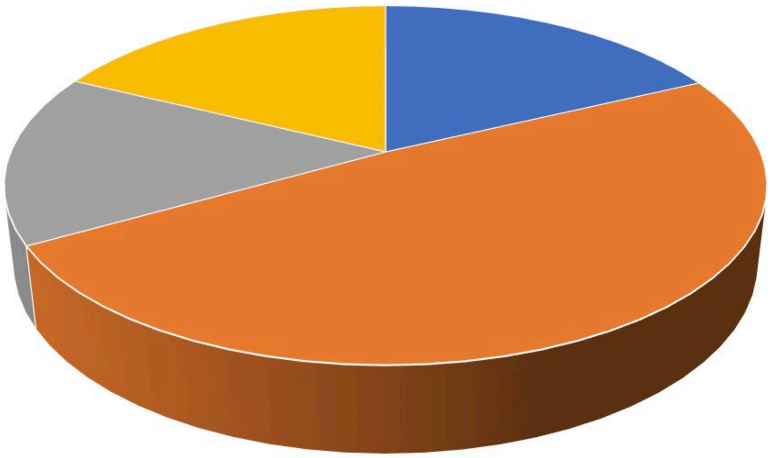


gluon splitting ? = gluon recombination

1D - 3D Nucleon Structure **Hadrons & Cold Nuclear Matter**

Jefferson Lab and CEBAF

Approved 12 GeV program by PAC days



Hadron Spectra

1D-3D Nucleon Structure

Hadrons & Cold Nuclear Matter

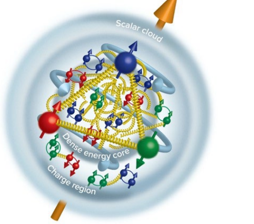
Test of SM & Fundamental Sym.

- ❑ Probe the structure of matter

  Complex **non-pQCD** problem which demands different approaches and measurements to access multiple observables

- ❑ Discover evidence for physics beyond the standard model

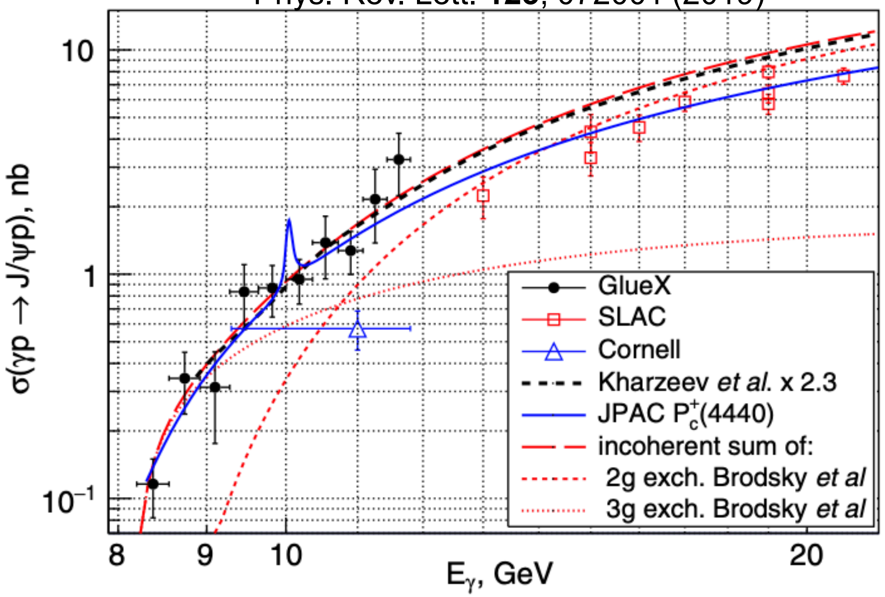
Near threshold J/ψ Photoproduction – *gluon mass*



Hall D - GlueX

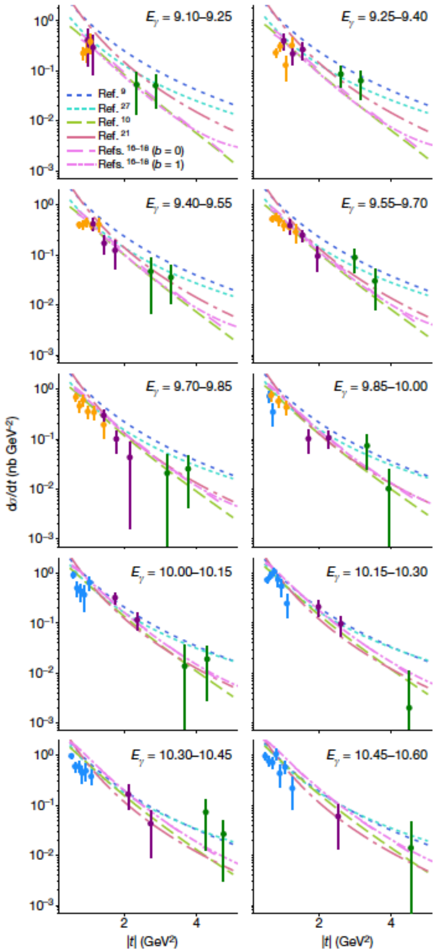
- Two-gluon exchange model doesn't reproduce σ
- **no evidence of 5quark** → model-dependent U.L. on on the branching fraction of the LHCb P_c^+ states

Phys. Rev. Lett. **123**, 072001 (2019)

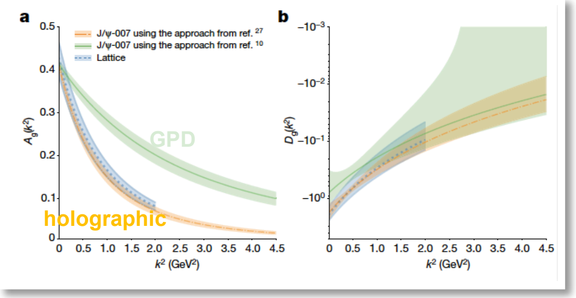


Hall C (E12-16-007)

- measured 5x more statistics → set more stringent limit on $\sigma(\gamma p \to P_c \to J/\psi p)$
- Data used to determine the **gluonic gravitational form factors of the proton**



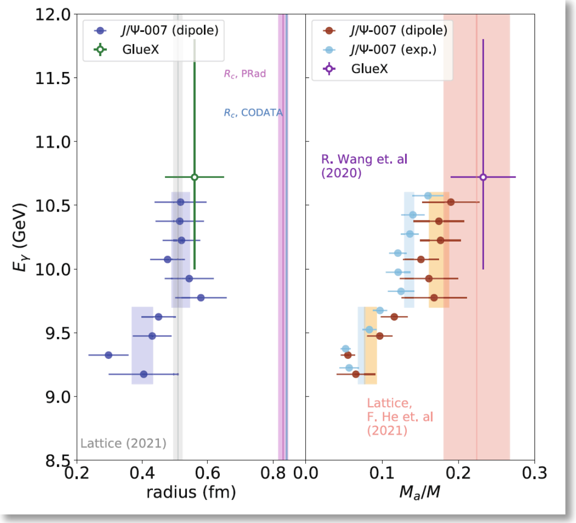
- Simultaneously fit of the **J/ψ dσ/dt** with the holographic and the GPD approaches to extract the gluonic gravitation form factors A(k) and D(k).



$$\langle r_m^2 \rangle_g = 6\frac{1}{A_g(0)}\frac{dA_g(t)}{dt}\Big|_{t=0} - 6\frac{1}{A_g(0)}\frac{C_g(0)}{M_N^2}$$

$$\langle r_s^2 \rangle_g = 6\frac{1}{A_g(0)}\frac{dA_g(t)}{dt}\Big|_{t=0} - 18\frac{1}{A_g(0)}\frac{C_g(0)}{M_N^2}$$

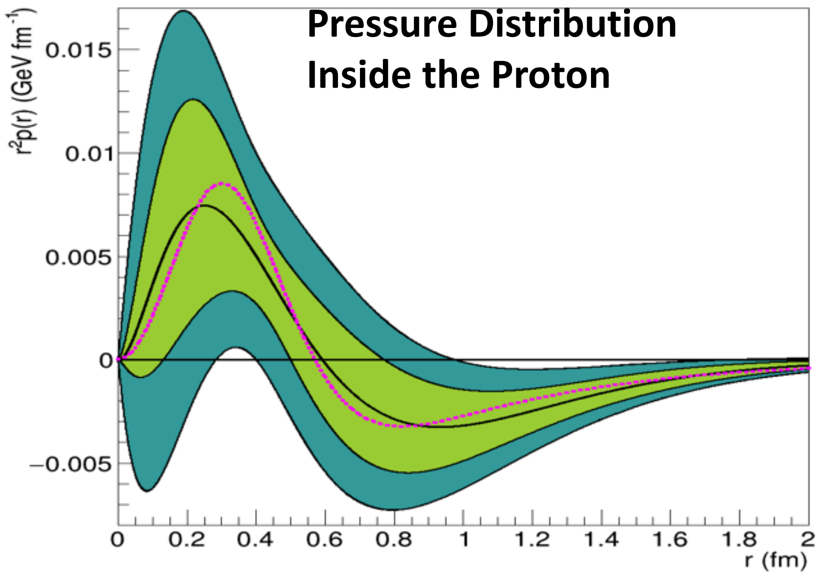
- Inner Gluon radius: 0.52 +/- 0.03 fm
- Charge radius: ~0.84-0.88 fm
- Scalar gluon rad: 1.069+/- 0.056 fm



CEBAF Experiment Locates Gluon Mass in the Proton

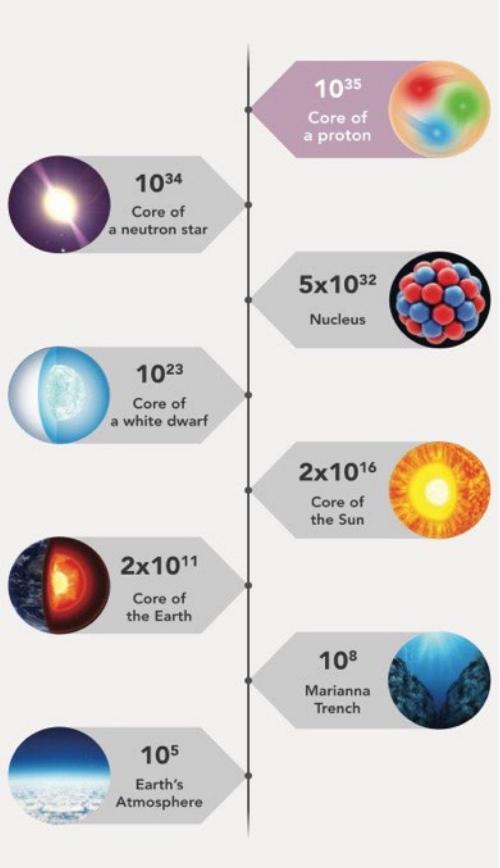
"Determining the gluonic gravitational form factors of the proton," Duran et al, Nature **615**, 813 (2023)

Mechanical *Structure of the Proton*: Pressure and Sheer Forces

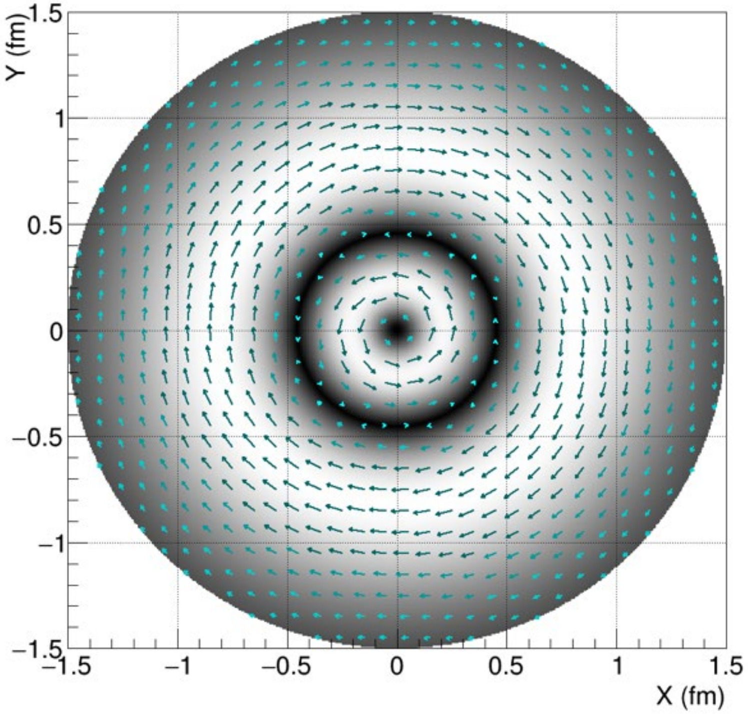


V.Burkert, L. Elouadrhiri, F.X. Girod, Nature **557** (2018) 7705, 396

Peak pressure in objects on earth, the sun, and the universe



Tangential stress force inside the proton changes direction near r ~ 0.45 fm
Peak : 38,000 N (4 metric tons)



Burkert, V.D., *et al.*, Colloquium: Gravitational form factors of the proton. *Reviews of Modern Physics* **95**, 041002 (2023)

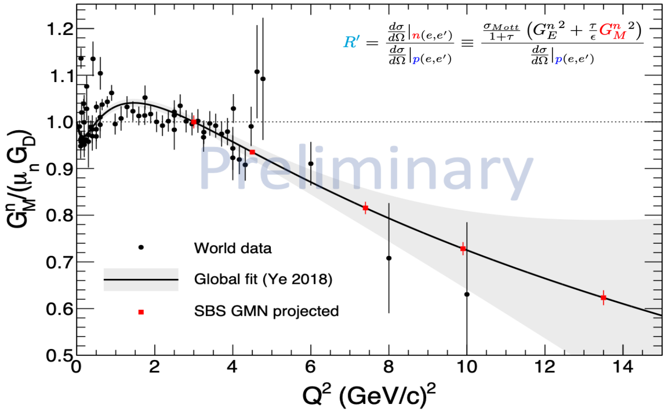
Pierre Chatagnon
JLab – Post-doc

NATIONAL LAB RESEARCH SLAM

This breakthrough has paved the way for a novel approach to unraveling the intricate structure of the proton.

Hall A SBS Program: unprecedented access to **all nucleon FFs** at high Q^2

SBS-G_M^n exp. successfully completed in 2022 (E12-09-019)



Precision of the highest Q^2 data point (13.5 (GeV/c)^2) is expected to stay unmatched for years to come

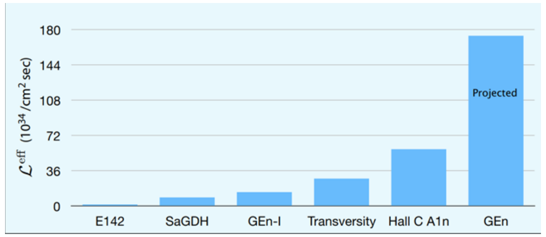
Neutron two-photon exchange (nTPE) (E12-20-010)

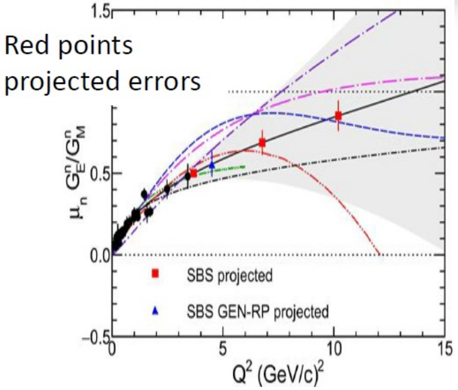
SBS-G_E^n exp. Completed in 2023 (E12-09-016)

- use double polarization to measure $\frac{G_E^n}{G_M^n}$
- Polarized ^{3}He target – highest L to date!
  - First time 60 cm long target
  - 42 – 50% target polarization

$$A_N = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} = \frac{\Delta}{\Sigma}$$

$$A_N = -\frac{2\sqrt{\tau(\tau+1)}\tan(\theta/2)\frac{G_E^n}{G_M^n}\sin\theta^*\cos\phi^*}{\left(\frac{G_E^n}{G_M^n}\right)^2 + \tau + 2\tau(1+\tau)\tan^2(\theta/2)} - \frac{2\tau\sqrt{1+\tau+(1+\tau)^2\tan^2(\theta/2)}\tan(\theta/2)\cos\theta^*}{\left(\frac{G_E^n}{G_M^n}\right)^2 + \tau + 2\tau(1+\tau)\tan^2(\theta/2)}$$

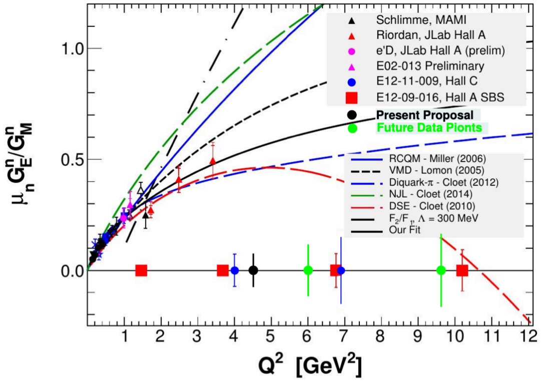




SBS G_E^n / G_M^n ran in 2024 with K_LL (E12-17-004)

Measurement of the ratio G_E^n / G_M^n using the **two-recoil polarization technique** of a polarized beam on an unpolarized LD_2 target

- Change-exchange np→pn (copper analyzer)
- Conventional np-np (plastic analyzer)

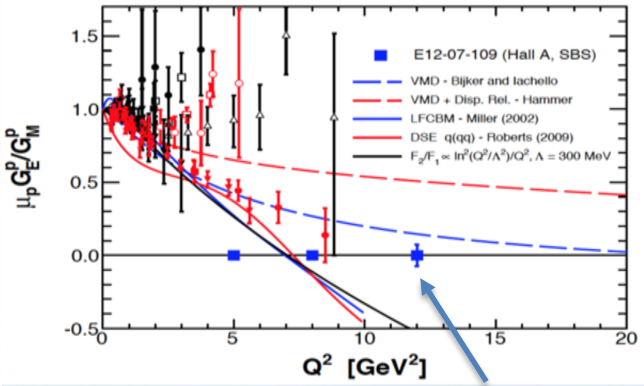


SBS G_E^p / G_M^p exp. currently being installed (E12-07-109)

- Measurement of the ratio G_E^p / G_M^p in a wide range of momentum transfer Q^2 using the **polarization transfer method**

ECal Front view.
All Supermodules
(1700 blocks) installed.

ECal Rear view.
Cooling system is installed.



Measure to Q^2 = 12 GeV^2

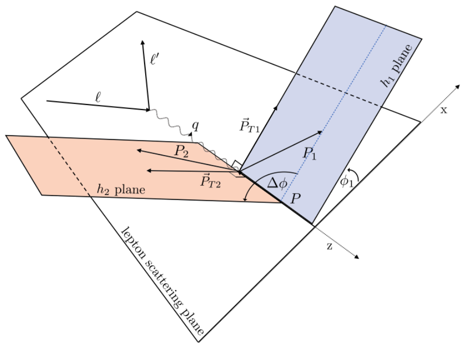
Hall B provides **First-ever** Measurements

Observation of *Correlations between Spin and Transverse Momenta* in Back-to-Back Dihadron production at CLAS12

H. Avakian et al. (CLAS Collaboration)

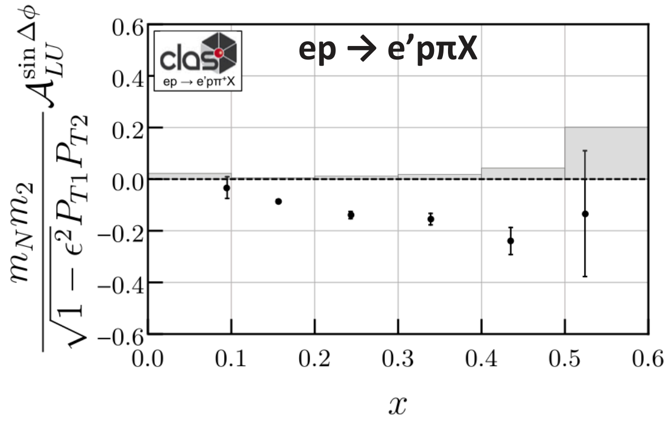
Phys. Rev. Lett. **130**, 022501 (2023)

Two hadrons in opposite hemispheres (current and target-fragm. regions)



- Direct access to leading twist **Fracture Functions** which gives conditional probability to eject a longitudinally polarized quark with the additional hadron in the target fragment

$$\mathcal{A}_{LU} = -\sqrt{1-\epsilon^2}\,\frac{|\vec{P}_{T1}||\vec{P}_{T2}|}{m_N m_2}\,\frac{\mathcal{C}[w_5 \hat{l}_1^{\perp h} D_1]}{\mathcal{C}[\hat{u}_1 D_1]}\sin\Delta\phi$$

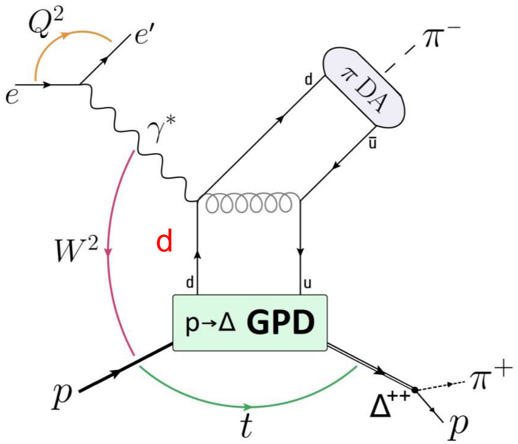


A_{LU} increases with x → correlation of final-state hadrons most significant in the valence quark region

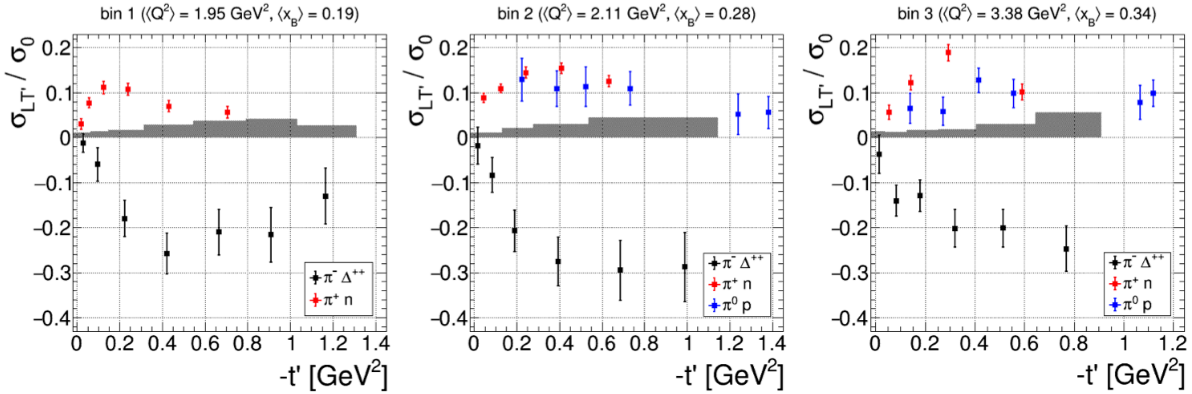
First measurement of hard exclusive $\pi^-\Delta^{++}$ electro-production BSA off protons

S.. Diehl et al. (CLAS Collaboration)

Phys.Rev.Lett. **131** (2023) 2, 021901



- Provides access to p-Δ transition GPDs
- Provides access to the d-quark content of the nucleon

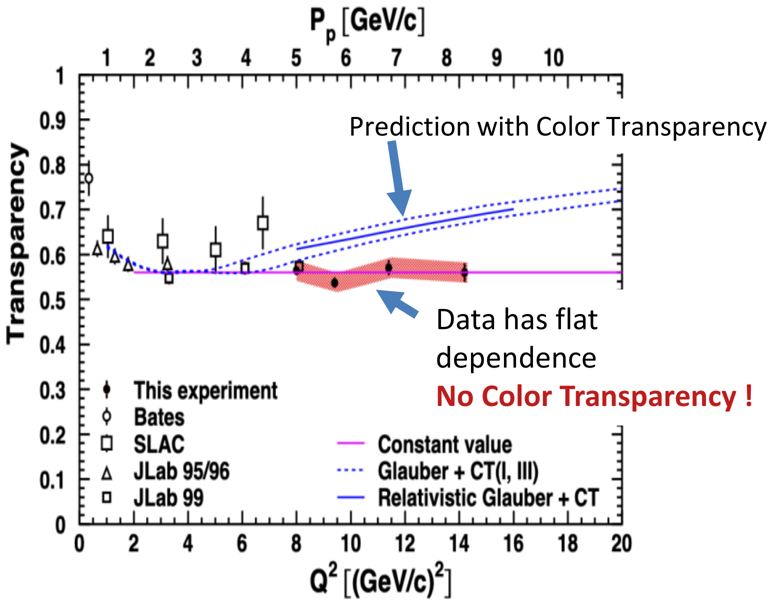


BSA clearly negative and ~ 2 times larger than for the hard exclusive π^+/π^0 production → Polarized u quarks (π^+n, π^0p) has positive asymmetry, d quarks ($\pi^-\Delta^{++}$) negative asymmetry

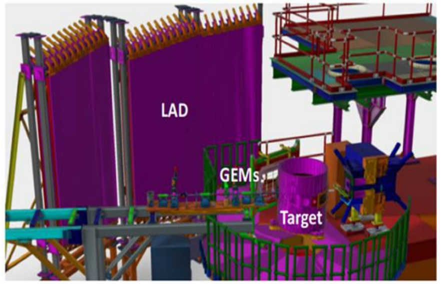
Hall C - **New** nuclear data challenge theory

Ruling out color transparency in quasi-elastic $^{12}C(e,e'\,p)$ up to Q^2 of 14.2 $(GeV/c)^2$

Phys. Rev. Lett. **126**, 082301



Spectator tagged DIS $d(e,e'p_s)$ – next run period (E12-11-107)

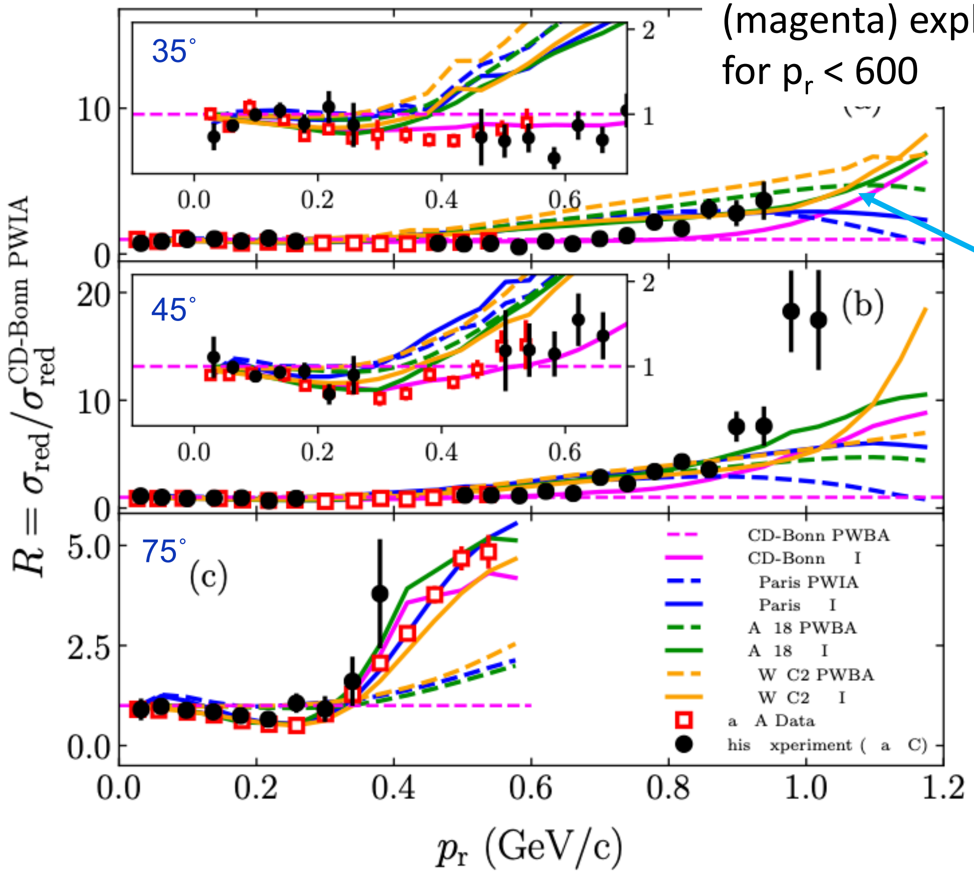


Does the EMC effect depend on nucleon virtuality?
Measure bound F2 by tagging the SRC proton in D(ee'p) DIS and look for nuclear effects
Will provide crucial information needed for identifying the origin of the EMC effect

Probing the Deuteron at Very Large Internal Momenta

Phys. Rev. Lett. **125**, 262501 (2020)

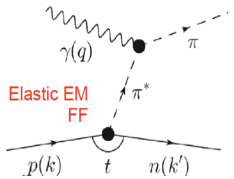
CD-BONN theory (magenta) explains data for p_r < 600



- None of the calculations, including the CD-BONN theory, can explain data for p_r > 0.6
- Completed experiment to explore if trend continues to p_r > 1.1

Hall C - **Upcoming** Results

Home of the precision cross section measurements through L/T and tagged DIS (TDIS)

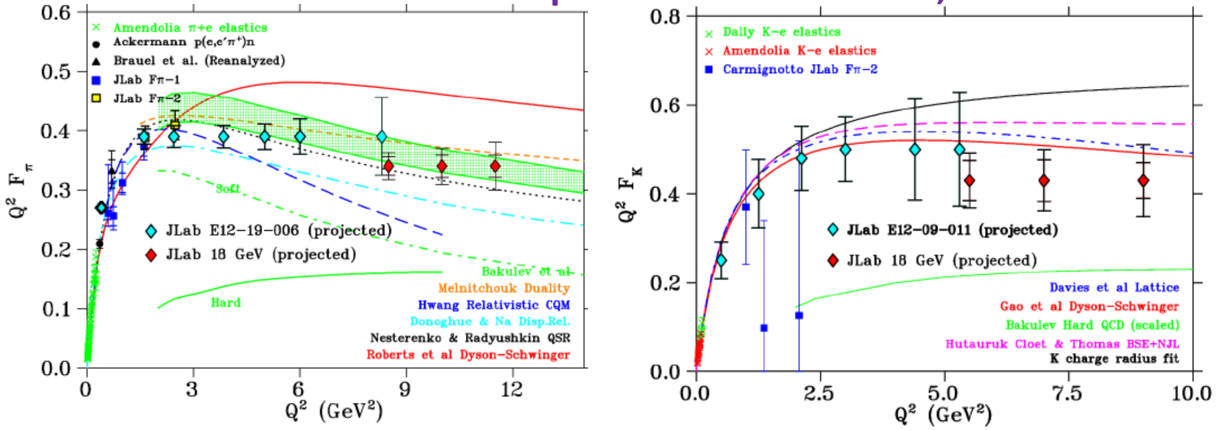


Sullivan process

Pion/Kaon elastic EM Form Factor

- Informs how EHM manifests in the wave function
- Decades of precision F_π studies at JLab and recently completed measurement in Hall C for F_π and also F_K

Jefferson Lab 12 GeV – experiments E12-19-006, E12-09-011

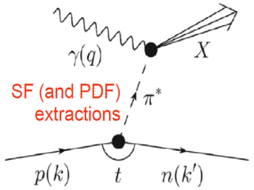


PionLT experiment with SHMS+HMS (<u>completed in 2022</u>):

- ➢ **L/T cross sections** at fixed x=0.3, 0.4, 0.55 up to Q^2=8.5 GeV^2
- ➢ Pion form factor at Q^2 values up to 8.5 GeV^2

KaonLT experiment with SHMS+HMS (completed in 2018/19):

- ➢ Highest Q^2 for **L/T separated kaon electroproduction cross section**; separated cross sections have been extracted – anticipate publication as soon as later this year; KaonFF will follow if warranted

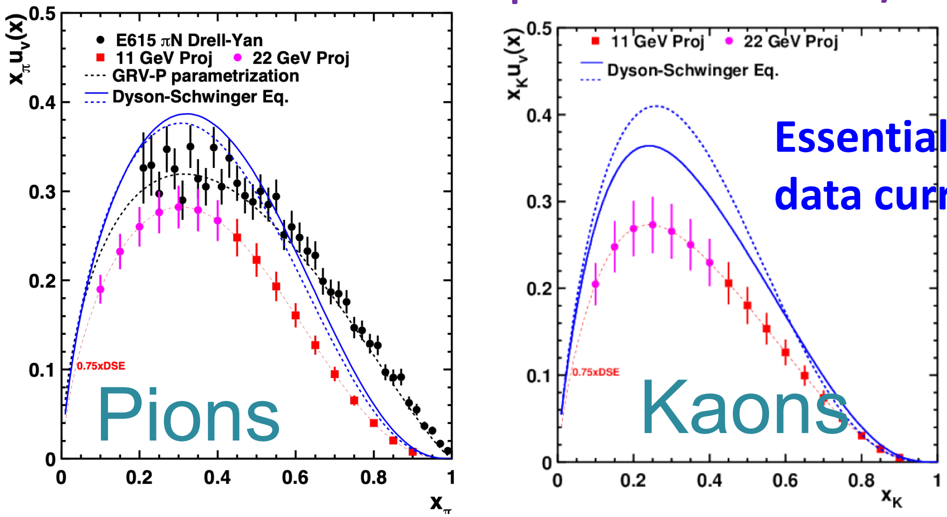


Sullivan process

Pion/Kaon Structure Functions

- Informs about the quark-gluon momentum fractions

Jefferson Lab 12 GeV – experiment C12-15-006/006A



Essentially no kaon data currently

<u>TDIS with SBS:</u>

✓High luminosity,
50 µAmp,
$\mathcal{L}$ = 3x10^{36}/cm^2 s

✓Large acceptance
~70 msr

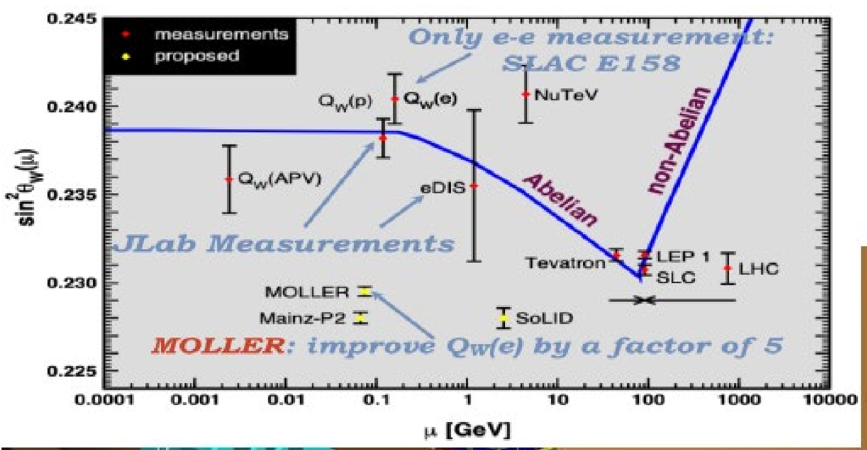
Important for small cross sections

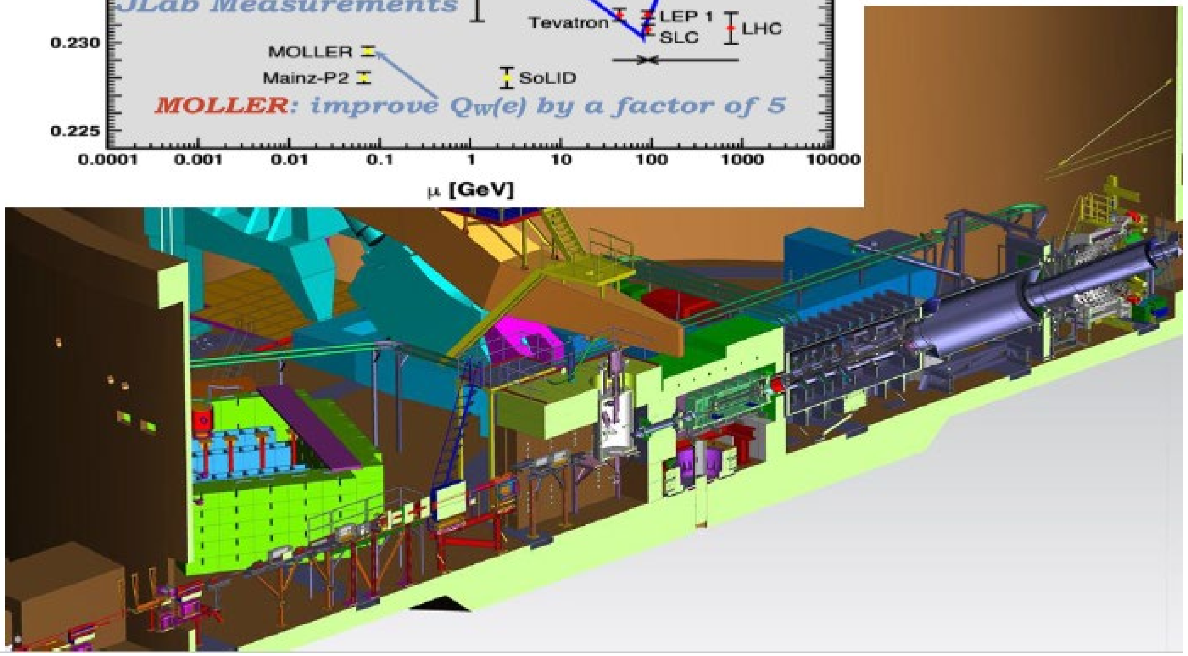
Pion and Kaon F2 SF extractions in valence regime

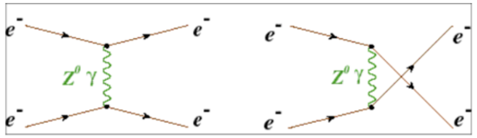
- Independent charged pion SF
- First kaon SF
- First neutral pion SF

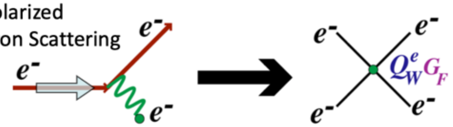
MOLLER: World-leading Measurement of e-e PV

$(Q^e_W) = \pm 2.1\%$ (stat) $\pm$ 1.1% (syst.)



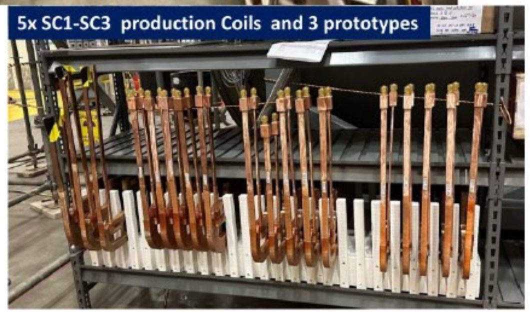






$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = -mE\frac{G_F}{\sqrt{2}\pi\alpha}\frac{16\sin^2\Theta}{(3+\cos^2\Theta)^2}Q^e_W$$

$$Q^e_W = 1 - 4\sin^2\theta_W \sim 0.075$$

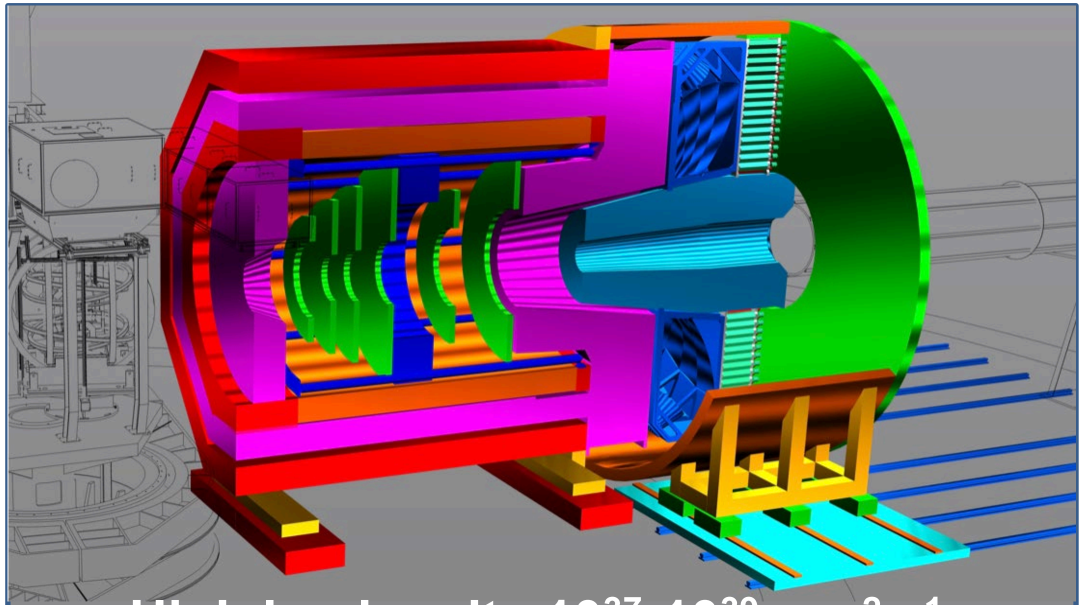


- ❑ IRA provided full funding
- ❑ Passed CD-3A review and spending CD-3A funds
- ❑ In May 2024, ESAAB Approval: MOLLER project CD-2/3
- ❑ Installation after Gep run ends

Solenoidal Large Intensity Device (SoLID)

SoLID Whitepaper : *J.Phys.G* 50 (2023)
Highlights of SoLID scientific programs and instrumentation

Fully Enables CEBAF 12 GeV at the Intensity Frontier



High luminosity 10^{37}-10^{39} cm^{-2}s^{-1}
+
large acceptance detector

- Nucleon spin, origin of proton mass and gluonic force, BSM experiments require precision measurements of small cross sections and asymmetries, combined with multiple particle detection
- There is a critical need for a high luminosity 10^{37}-10^{39} cm^{-2}s^{-1} and large acceptance working in tandem – takes full advantage of Jefferson Lab capabilities

SoLID Awaiting Science Review Report

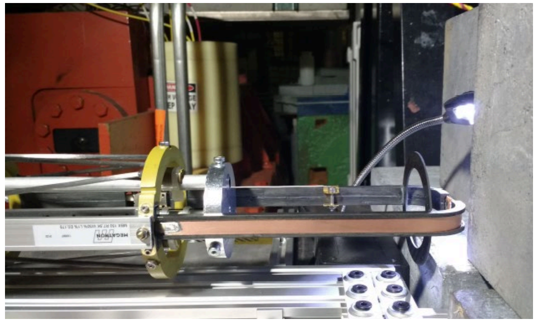
Hall B: Nuclear Experiments

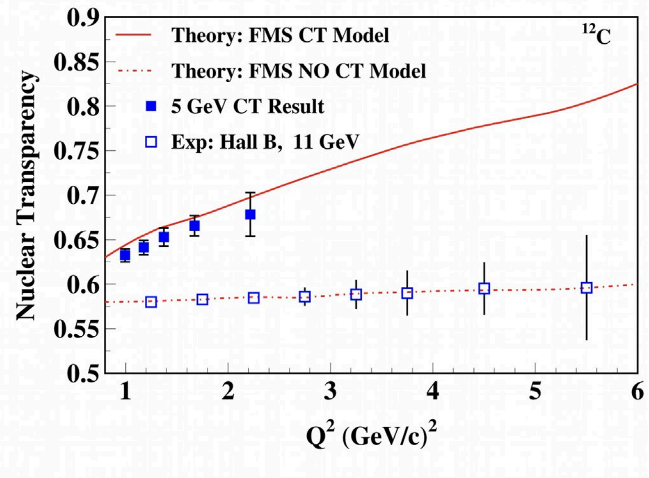
Suite of experiments using nuclear targets: D, C, Al, Sn, Cu, Pb

July 2023-Nov 2024

- Study of Color Transparency in Exclusive Vector Meson Electro-production off Nuclei
- Quark Propagation and Hadron Formation
- A Low Energy Recoil Tracker (ALERT): A comprehensive program to study the partonic nuclei & nuclear effects

new Double-Target system

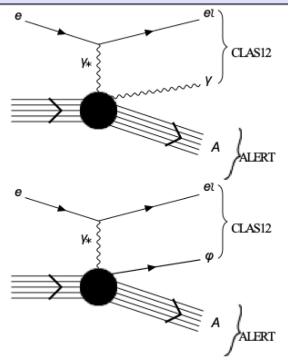




Coherent Processes on ^4He

- $^4He(e, e' \, ^4He \; \gamma)$
- $^4He(e, e' \, ^4He \; \varphi)$

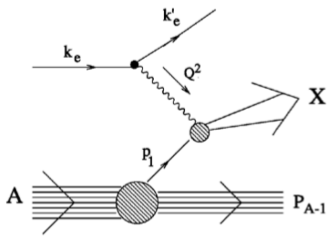
Explores the partonic structure of ^4He



DIS on ^4He and ^2H : Tagged EMC Effect

- $^4He(e, e' + ^3H)X$ (proton DIS)
- $^4He(e, e' + ^3He)X$ (neutron DIS)
- $^2H(e, e' + p)X$ (neutron DIS)

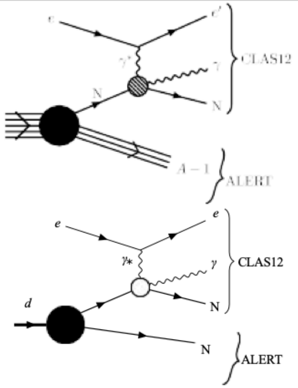
Test FSI and rescaling models



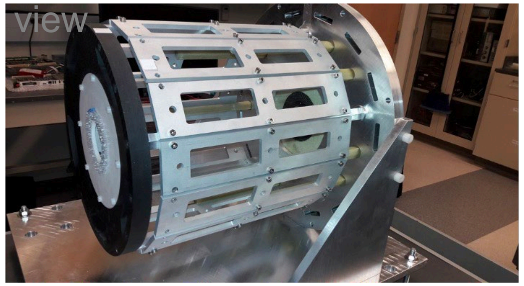
Incoherent processes on ^4He and ^2H

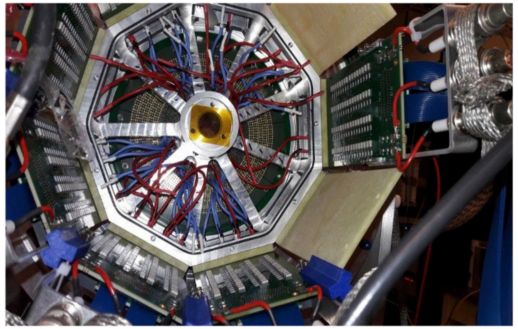
- $^4He(e, e'\gamma \; p + ^3H)$
- $^4He(e, e'\gamma + ^3He)n$
- $^2H(e, e'\gamma \; + \; p)n$

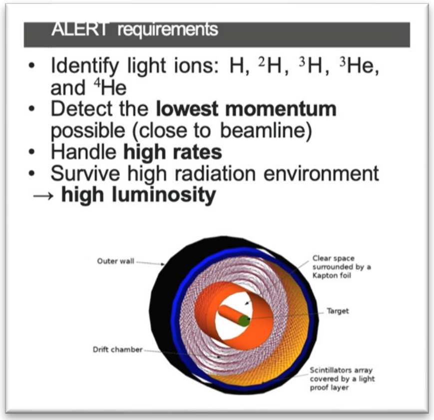
Identify medium modified nucleons



Upstream with electronics view







Hall C Neutral Particle Spectrometer (NPS) Program

Relevant technologies for EIC (backward EMCal, B0 calorimeter)

e^- beam – small angle configuration

E12-13-010 - E12-06-114 - E12-13-007 – E12-23-014
- Exclusive Deeply Virtual Compton **on proton**
- SIDIS $p(e,e',p^0)$ cross section.

  Map the transverse momentum dependence.

E12-22-006
- Exclusive Deeply Virtual Compton **on deuteron**

  Subtract the proton data from deuteron data to get neutron

Completed Run Group 1A in 2023/24

Large angle and other configuration

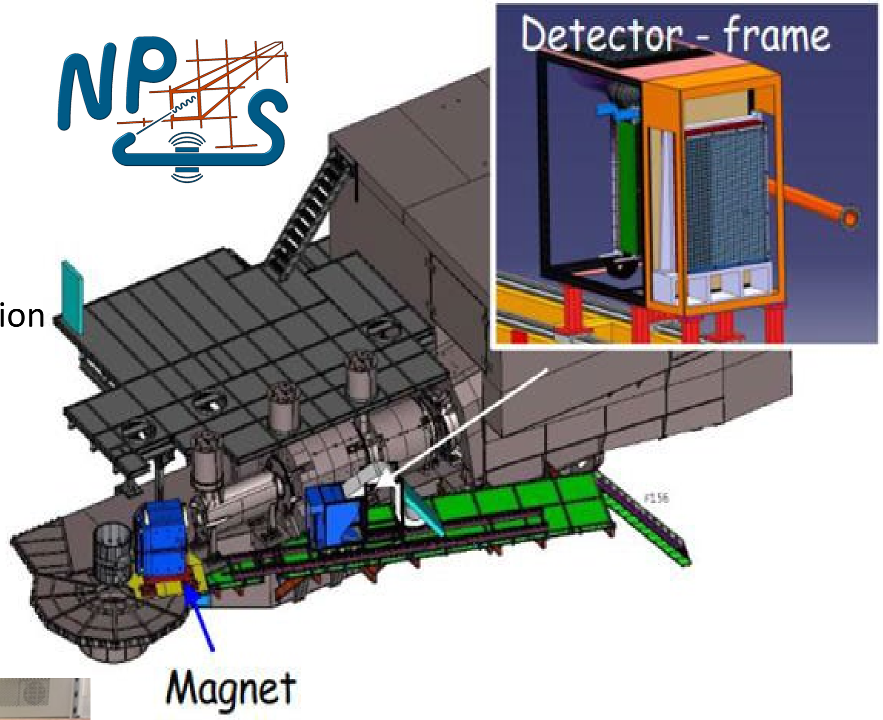
E12-14-003
- Wide-angle Compton Scattering

E12-14-005
- Wide Angle Exclusive π^0 Photoproduction

E12-17-008
- Polarization observables in WACS

E12-23-004
- Search for nonzero strange proton FF

C12-20-012 (standard + positron beam)
- DVCS using a positron beam

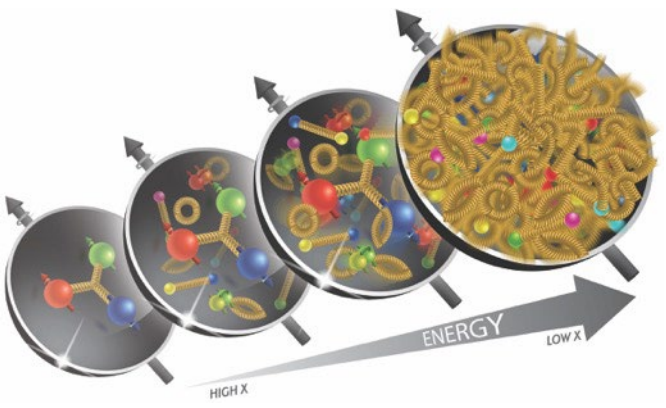


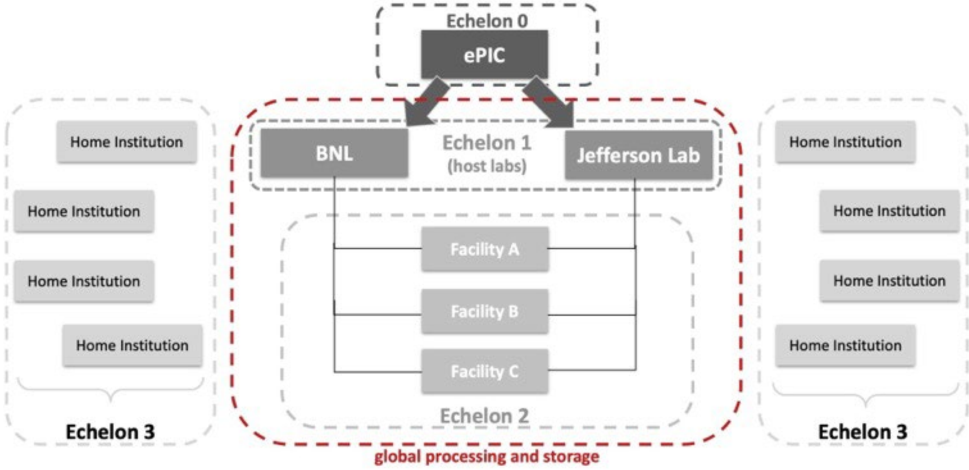
Nucl.Instrum.Meth.A **956** (2020) 163375

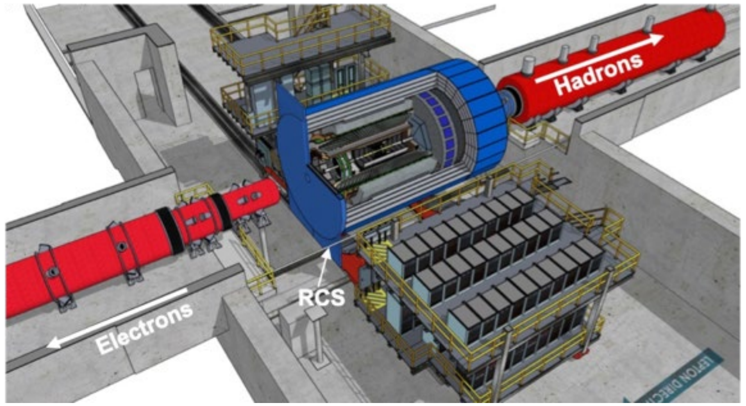
Neutral Particle Spectrometer (NPS) : Magnet with calorimeter
- **1080 Lead-Tungstate blocks** in Calorimeter to detect γ & π^0
- fADC250 with **streaming triggers**
- NPS attached to SHMS carriage to allow easy angle change. The calorimeter is on rails.

Miktat Imre and Carlos Domingues installing PMT/bases assemblies

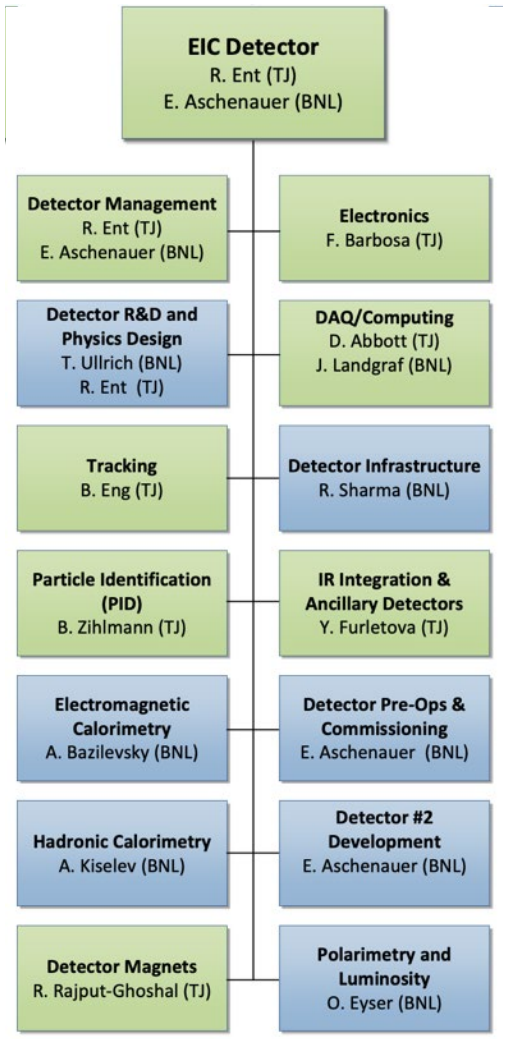
JLab – EIC Science and the Interaction Region







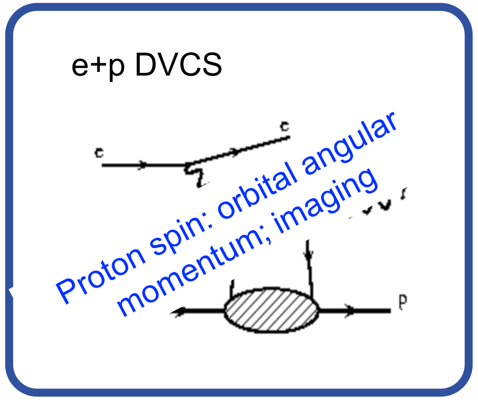
- JLab is a partner in the EIC Project
- Working on the science and designing the detector to accomplish the physics goals of ePIC collaboration.
- Computing for ePIC is also being developed
- Project management

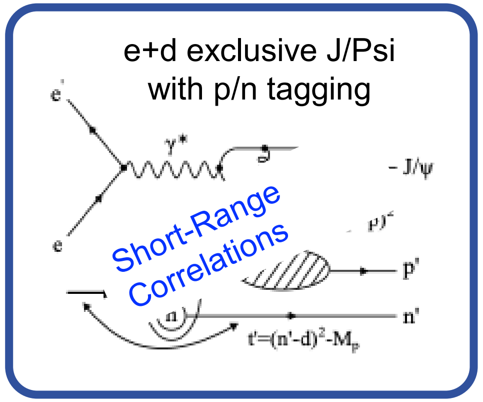


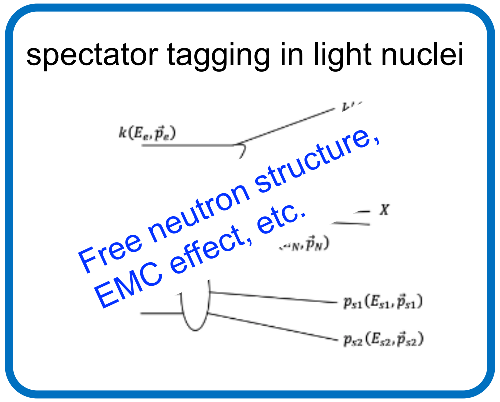
Jefferson Lab

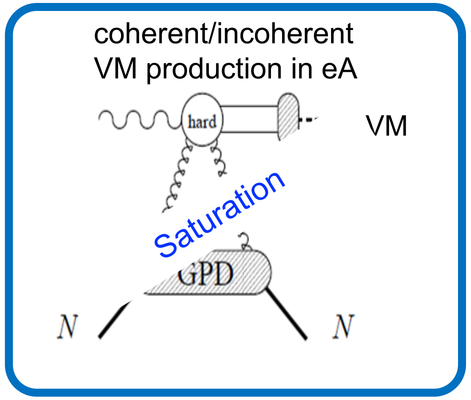
Far-Forward Physics at EIC

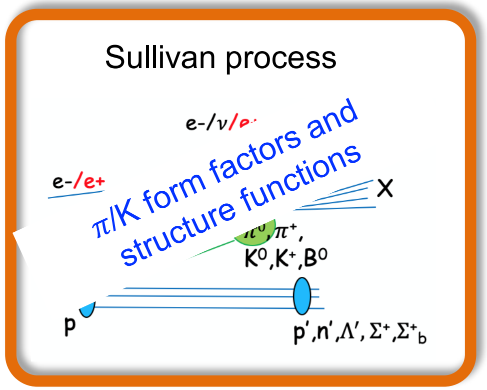
All these processes require the detection of protons, neutrons, photons and hadrons at small scattering angles → *MAJOR EIC science and detector emphasis*

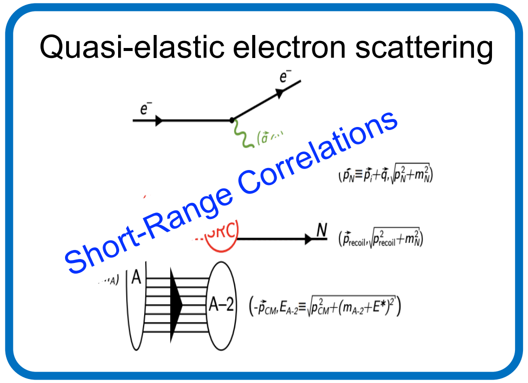


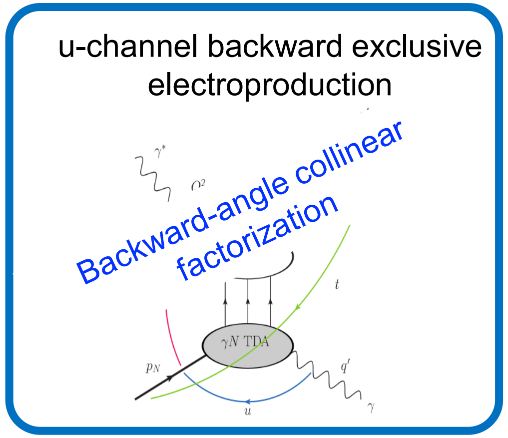


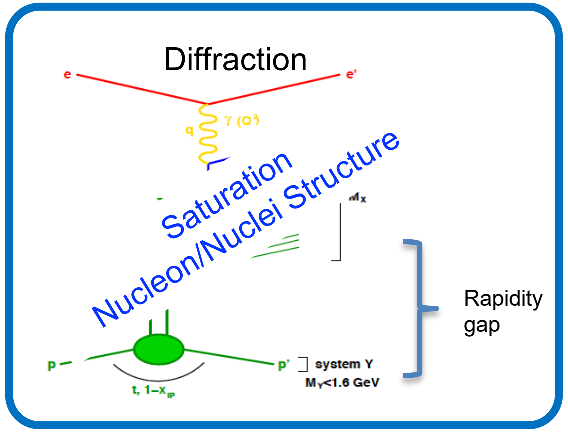






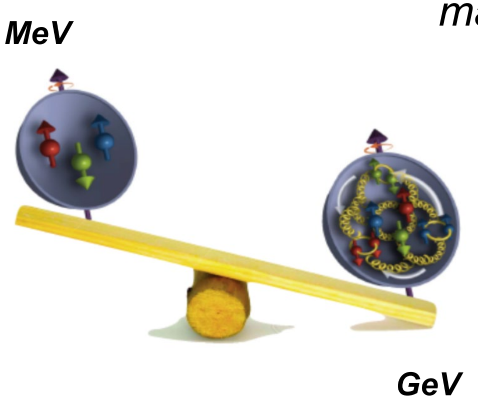






Look at this process in more detail as example of science from JLab to EIC

What Do We Know: Mass of the Proton, Pion, Kaon

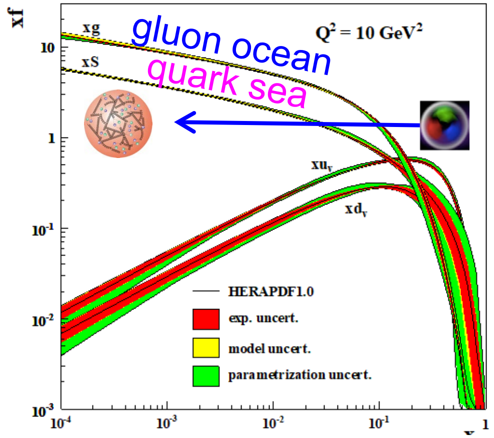


Visible world: mainly made of light quarks – its mass emerges from quark-gluon interactions.

Proton

Quark structure: uud
Mass ~ 940 MeV (~1 GeV)
Most of mass generated by dynamics.

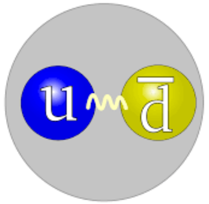
Gluon rise discovered by HERA e-p



Fraction of overall proton momentum carried by quark or gluons

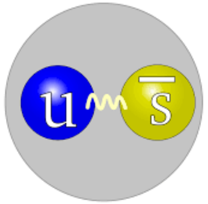
Pion

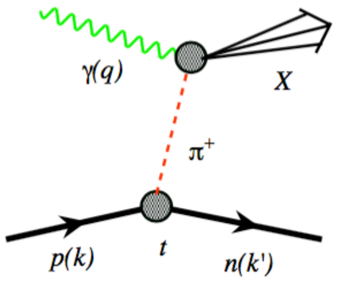
Quark structure: ud
Mass ~ 140 MeV
Exists only if mass is dynamically generated.
Empty or full of gluons?



Kaon

Quark structure: us
Mass ~ 490 MeV
Boundary between emergent- and Higgs-mass mechanisms.
More or less gluons than in pion?





proton the EIC will allow determination of an important term contributing to the proton mass, the so-called "QCD trace anomaly"

pion and the kaon the EIC will allow determination of the quark and gluon momentum contributions with the Sullivan process.

*C. Aguilar et al., Pion and Kaon structure at the EIC, arXiv:1907.08218, EPJA **55** (2019) 190.*
*Arrington et al., Revealing the structure of light pseudoscalar mesons at the EIC, arXiv:2102.11788, J. Phys. G **48** (2021) 7, 075106.*

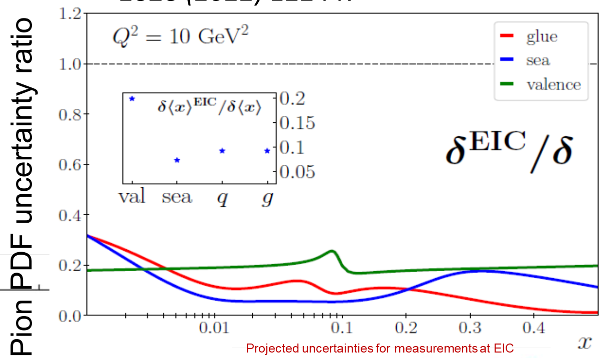
Light Meson Structure Programs at JLab and EIC

Beyond protons and neutrons, pions and kaons are the necessary main building blocks of nuclear matter.
If we really want to claim we understand QCD dynamics, we have to understand their structure.

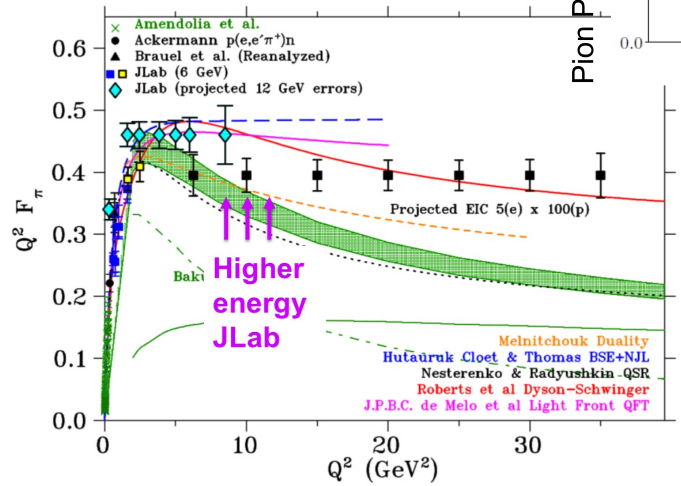
Proton Mass ~ 940 MeV versus Pion Mass ~140 MeV

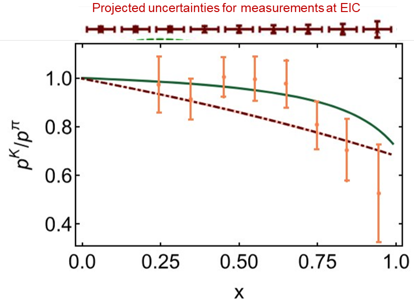
Paradoxically, the lightest pseudoscalar mesons– the pions and kaons – appear to be key to the further understanding of the emergent mass and structure mechanisms.

R. Abdul Khalek et al., Nucl. Phys. A ***1026*** *(2022) 122447*



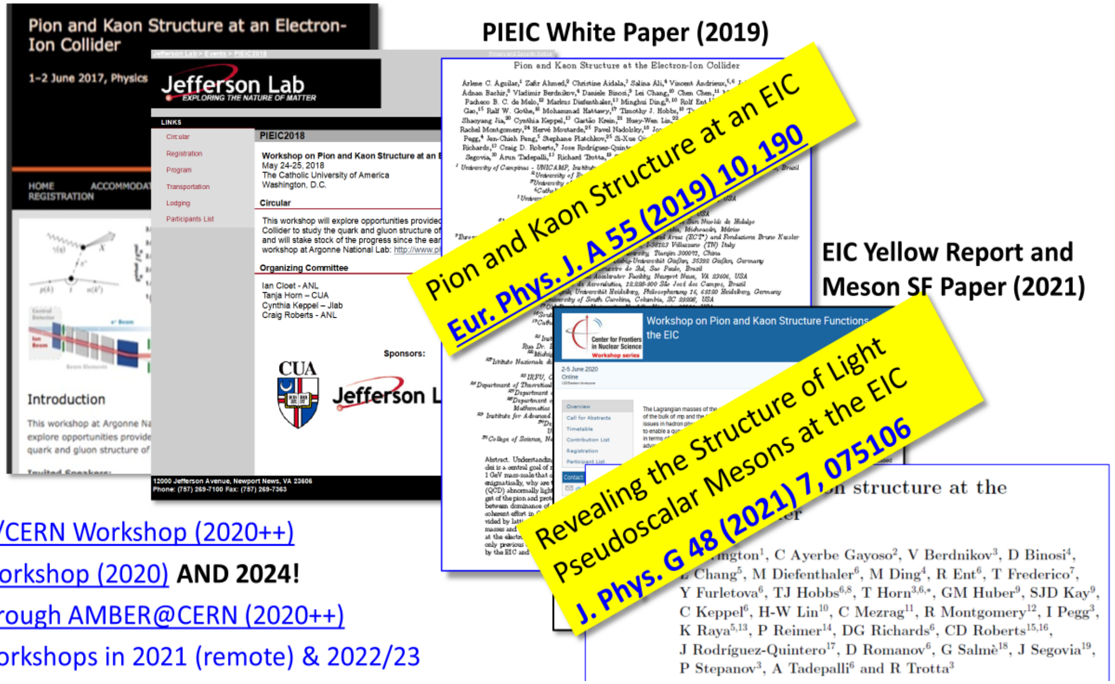
Jefferson Lab and EIC meson FF and SF measurements





Pion and Kaon Structure at the EIC – History

- PIEIC Workshops hosted at ANL (2017) and CUA (2018)
- ECT* Workshop: Emergent Mass and its Consequences (2018)

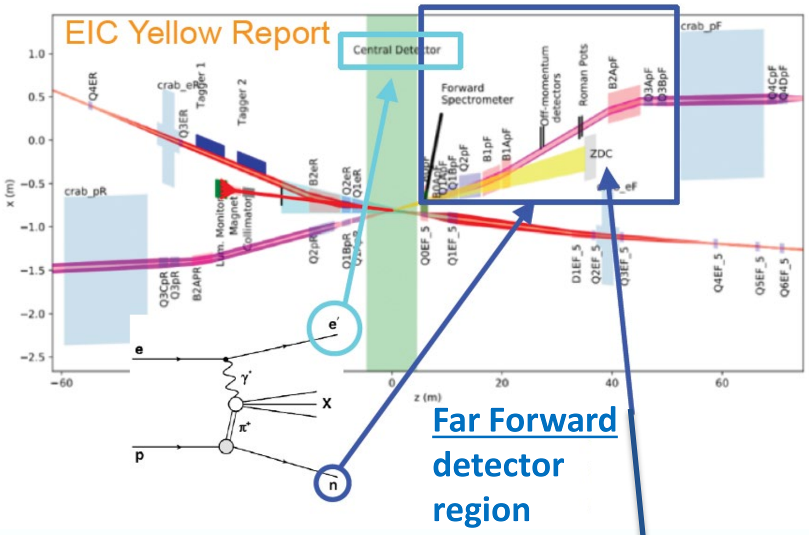


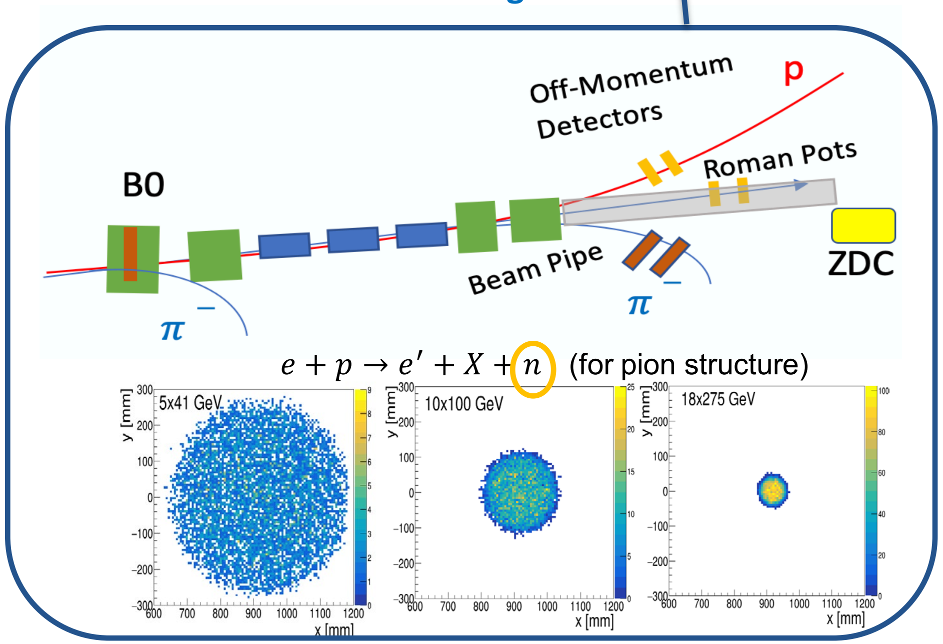
- AMBER/CERN Workshop (2020++)
- CFNS Workshop (2020) AND 2024!
- EHM through AMBER@CERN (2020++)
- ECT* Workshops in 2021 (remote) & 2022/23

Understanding pion/kaon is vital to our understanding of hadron structure and dynamic generation of hadron mass

EIC and Light Meson Structure Measurements

Good Acceptance for TDIS-type Forward Physics! Low momentum nucleons ***easier*** to measure!



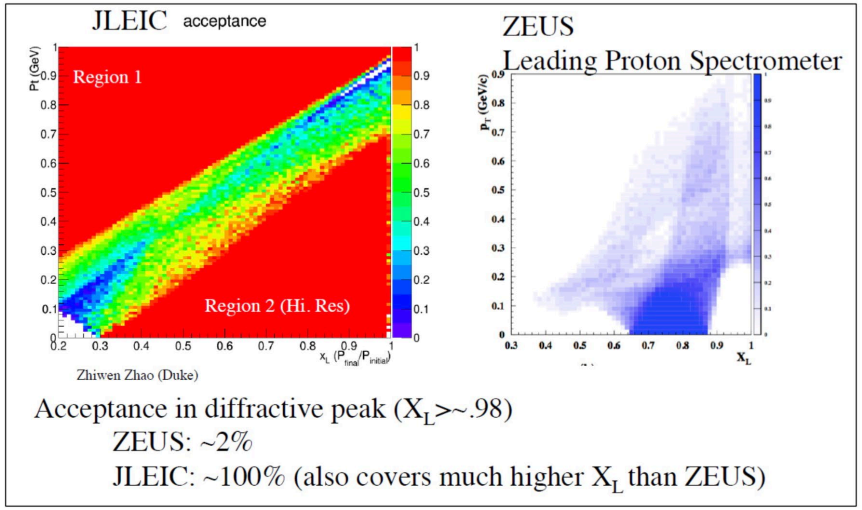


- ❑ EIC design well suited for HERA-style (Sullivan process/leading hadron) pion/kaon SF measurements
- ❑ Scattered electron detected in the central detector
- ❑ Leading hadrons → large fraction of initial beam energy → far forward detector region
  - ○ ZDC particularly important (reaction kinematics and 4 momenta)

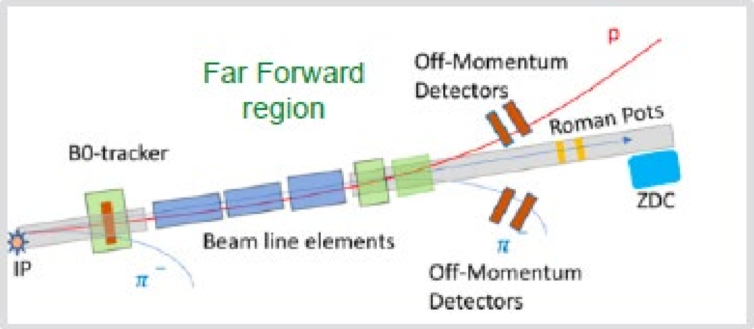
Huge gain in acceptance for forward tagging….

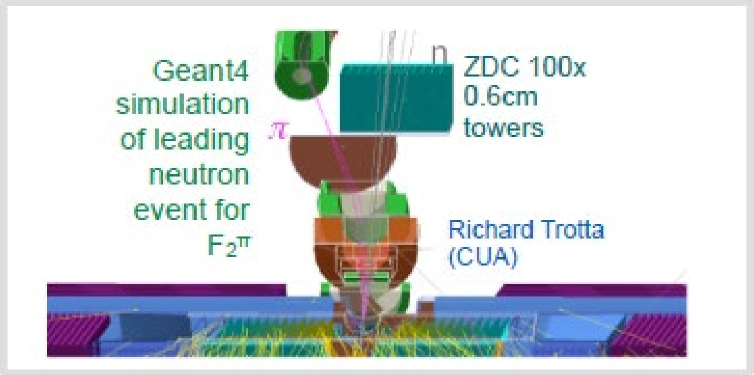
*R. Abdul Khalek et al., Nucl. Phys. A **1026** (2022) 122447*

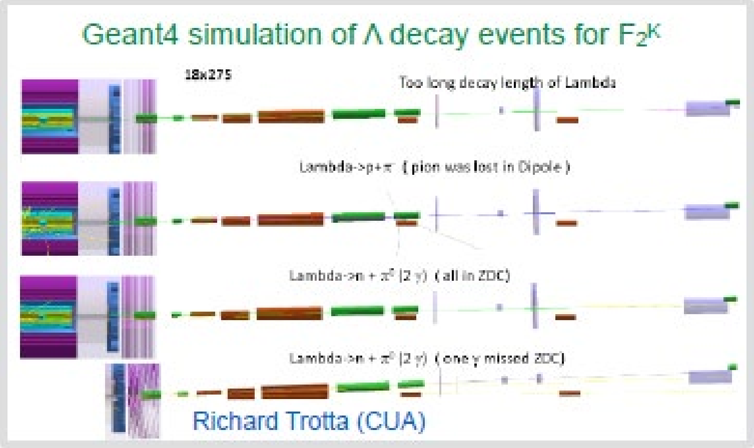
Example: acceptance for p' in e + p → e' + p' + X

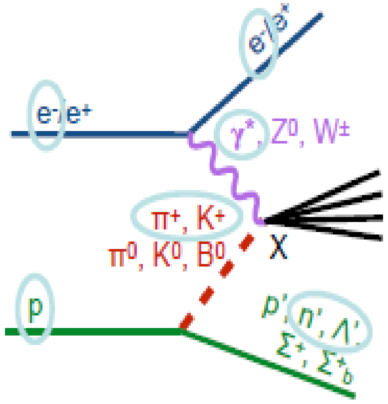


EIC Pion/Kaon SF Measurements









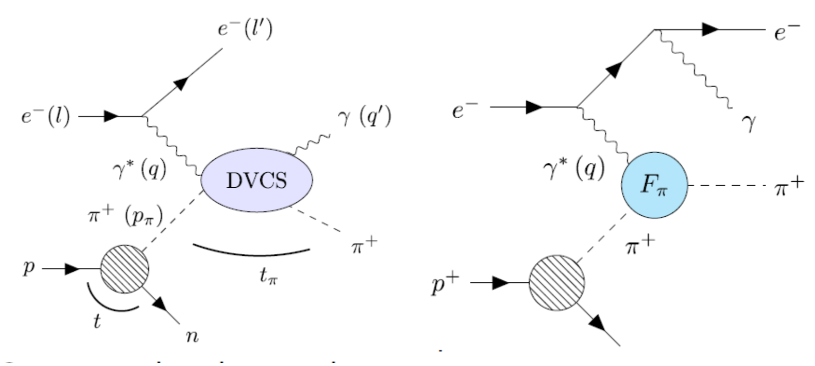
- ❑ Custom fast MC event generator (R. Trotta, A. Singh, CUA) G4 for detector acceptance/response
- ❑ Focus so far: ep and measuring cross section at small-t for
  - ○ F_2^{π} (π^+) tagged by n
  - ○ F_2^{K} (K^+) tagged by Λ^0 decay
- ❑ Settings e x p(GeV): 5x41, 5x100, 10x100, 10x135, 18x275

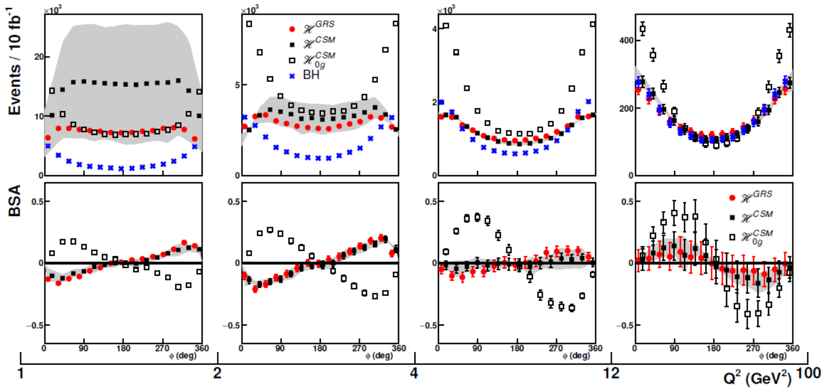
Detector requirements:

- ○ **For π-n:**
  - ➢ Lower energies (5 on 41, 5 on 100) require at least 60 x 60 cm^2
  - ➢ For all energies, the neutron detection efficiency is 100% with the planned ZDC
- ○ **For π-n and K^+/Λ:**
  - ➢ All energies need good ZDC angular resolution for the required -t resolution
  - ➢ High energies (10 on 100, 10 on 135, 18 on 275) require resolution of 1cm or better
- ○ **K^+/Λ benefits from low energies (5 on 41, 5 on 100) and also need:**
  - ➢ $\Lambda \rightarrow n+\pi^0$: additional high-res/granularity EMCal+tracking before ZDC – seems doable
  - ➢ $\Lambda \rightarrow p+\pi^-$: additional trackers in opposite direction on path to ZDC – more challenging
- ○ Standard electron detection requirements
- ○ Good hadron calorimetry for good x resolution at large x

The Pion in 3D – Spatial Imaging

Lot of recent theory interest in the Sullivan process and calculations of meson structure



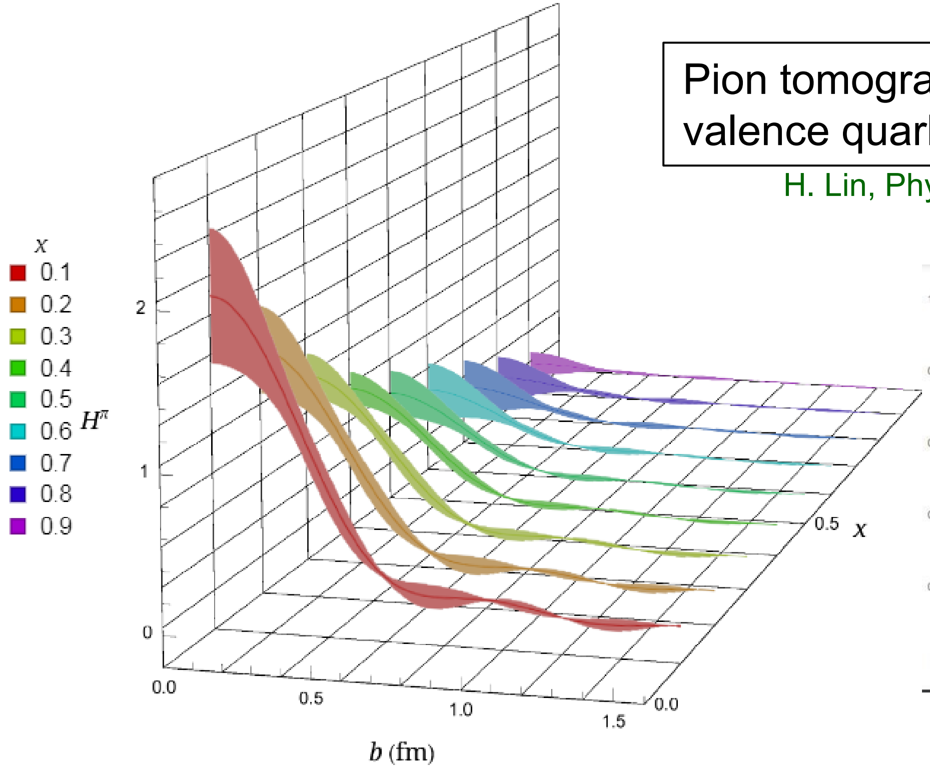


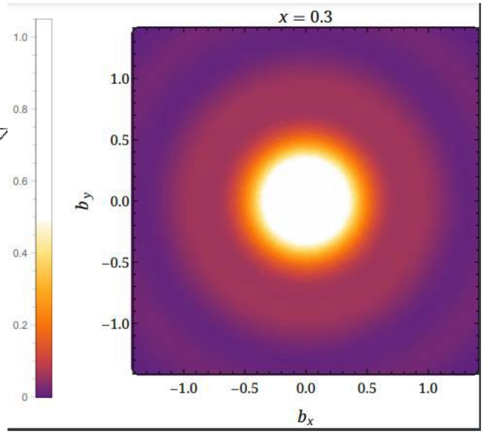
Sullivan DVCS seems measurable at the EIC

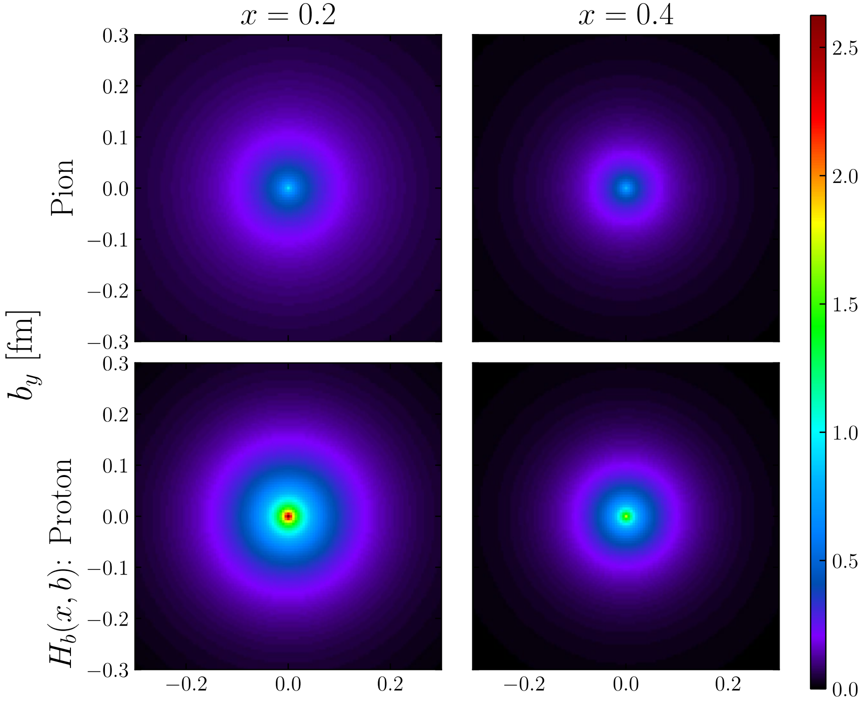
J.M.M. Chavez et al. Rev.Mex.Fis.Suppl. **3** (2022) 3, 0308099; Phys.Rev.Lett. **128** (2022) 20, 202501;Phys.Rev.D **105** (2022) 9, 094012

Pion tomography using the lattice – valence quark GPD results

H. Lin, Phys. Lett. B **846** (2023) 138181







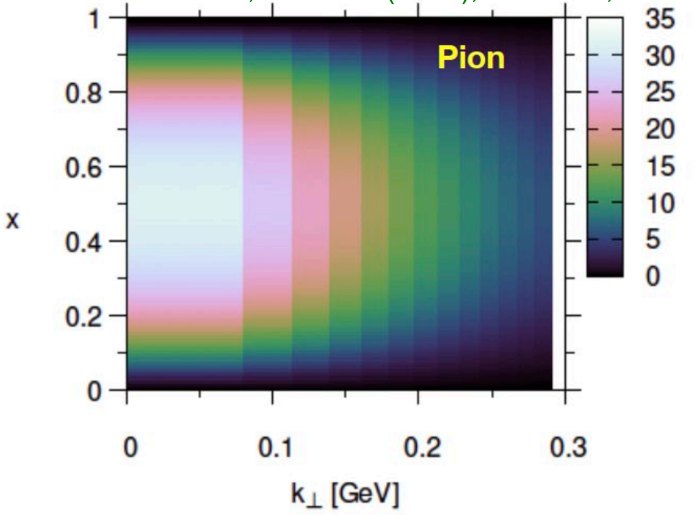
b_x [fm]

P. Petreczky, CFNS 2024 talk

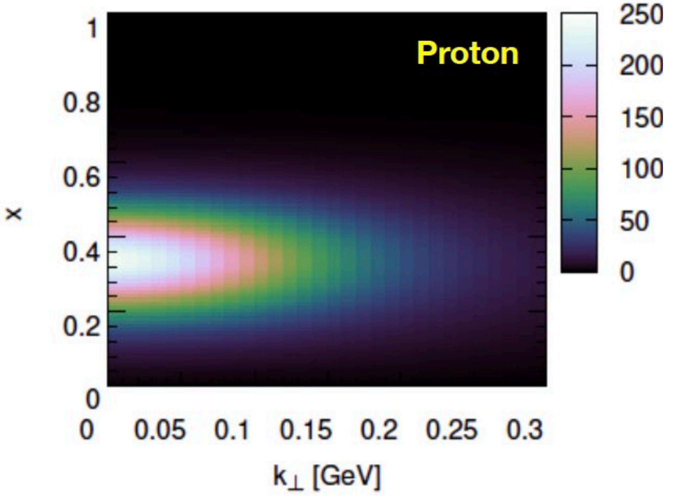
The Pion in 3D – Momentum Imaging

Lot of recent theory interest in the Sullivan process and calculations of meson structure

PRD **105**, L071505 (2022); PRD **104**, 114012 (2021) E. Ydrefore & T. Frederico

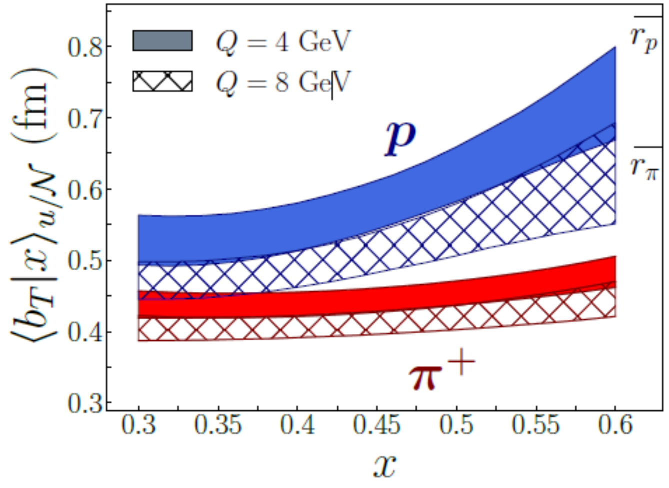


Pion TMDs from
Bethe-Saltpeter equation



Proton TMDs from
Light-Front Model

Significant x-broadening of Pion TMDs compared to proton TMDs



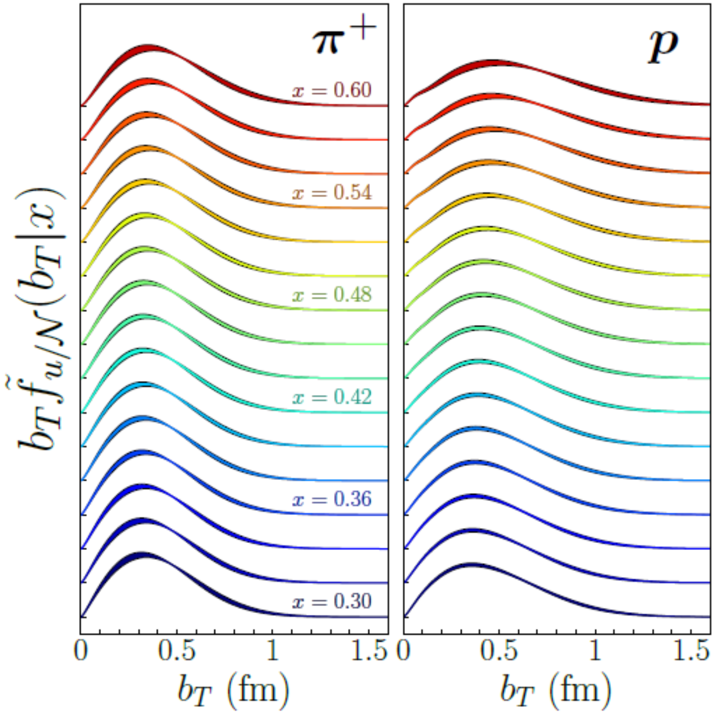
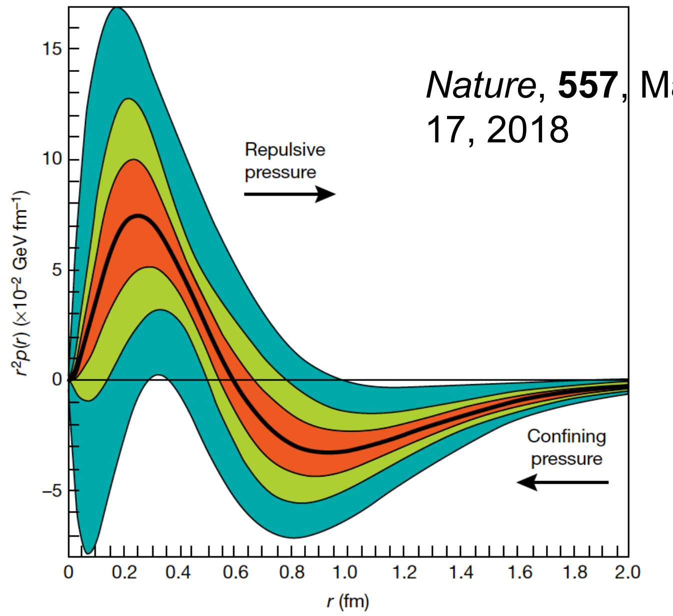


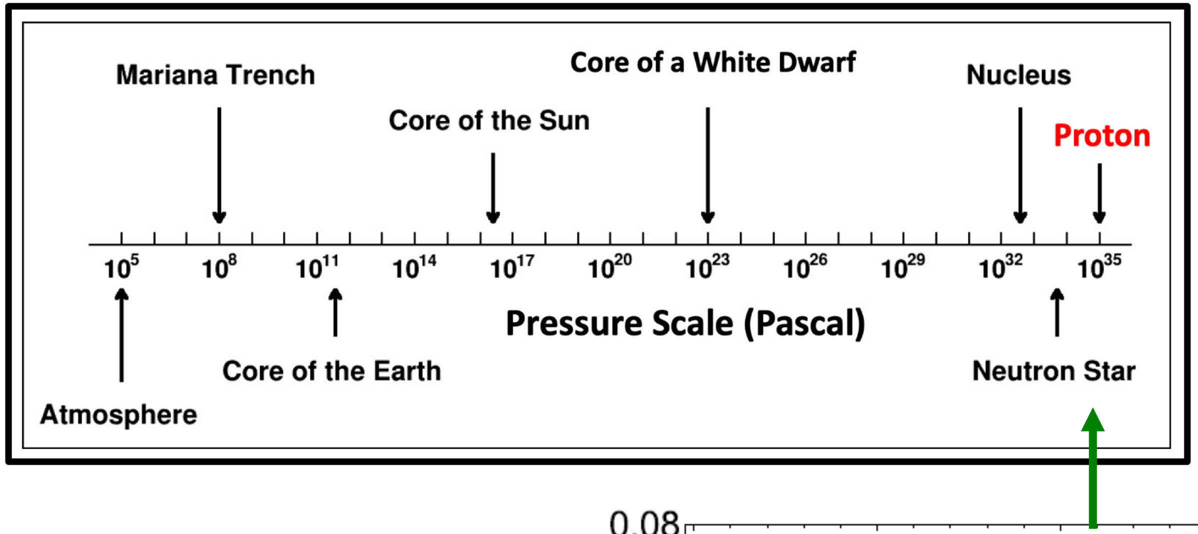
FIG. 1. The conditional TMD PDFs for the pion (**left**) and proton (**right**) as a function of b_T for various x values (indicated by color) evaluated at a characteristic experimental scale $Q = 6$ GeV. Each of the TMD PDFs are offset for visual purposes.

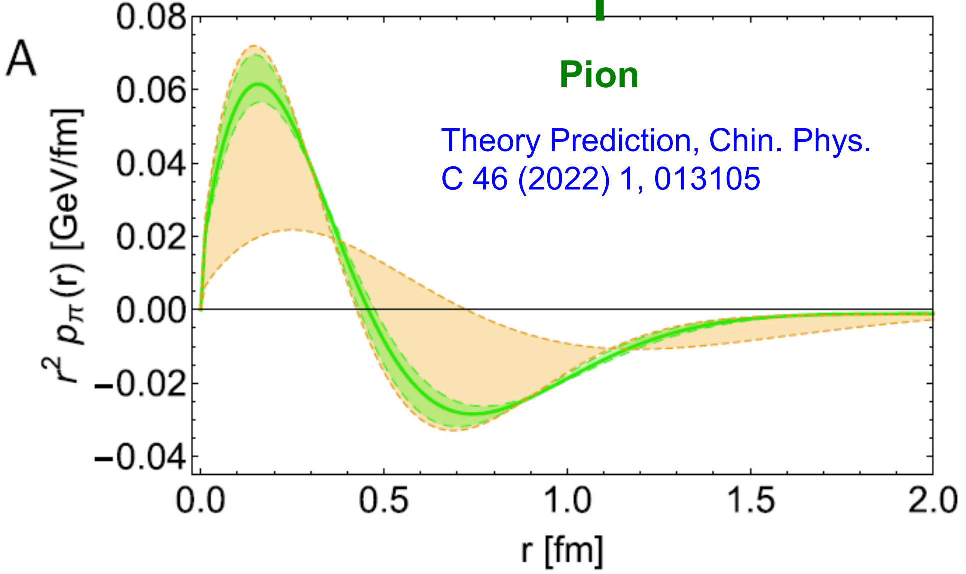
P. Barry, L. Gamberg, W. Melnitchouk, Moffat, Pitonyak, A. Prokudin, Phys. Rev. D **108** (2023) L0911504

Steps towards pressure distribution



Nature, **557**, May 17, 2018

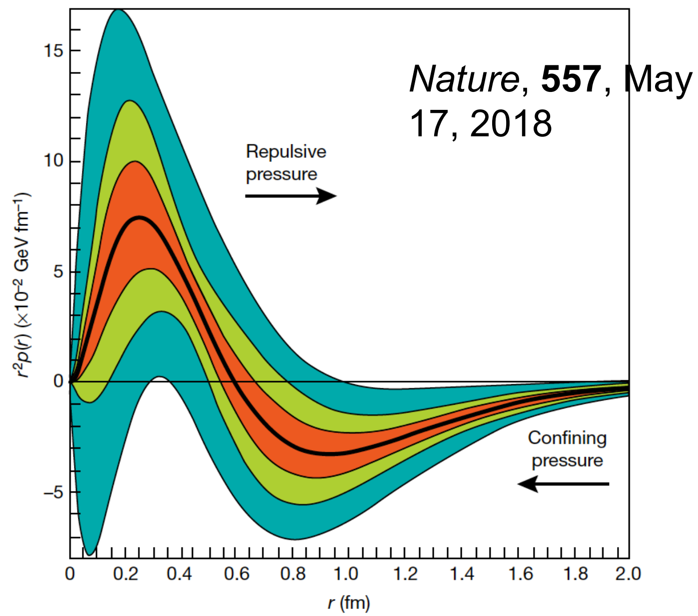


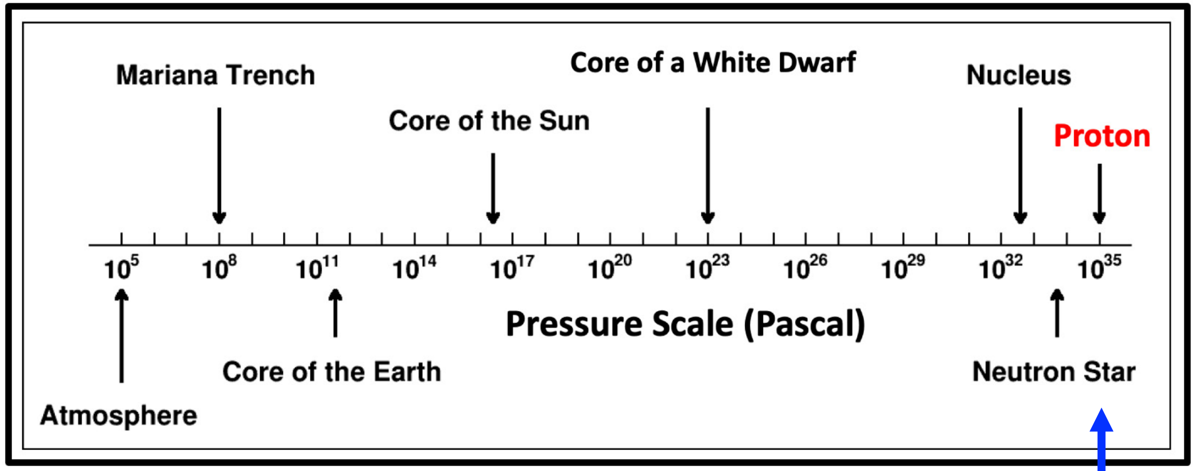


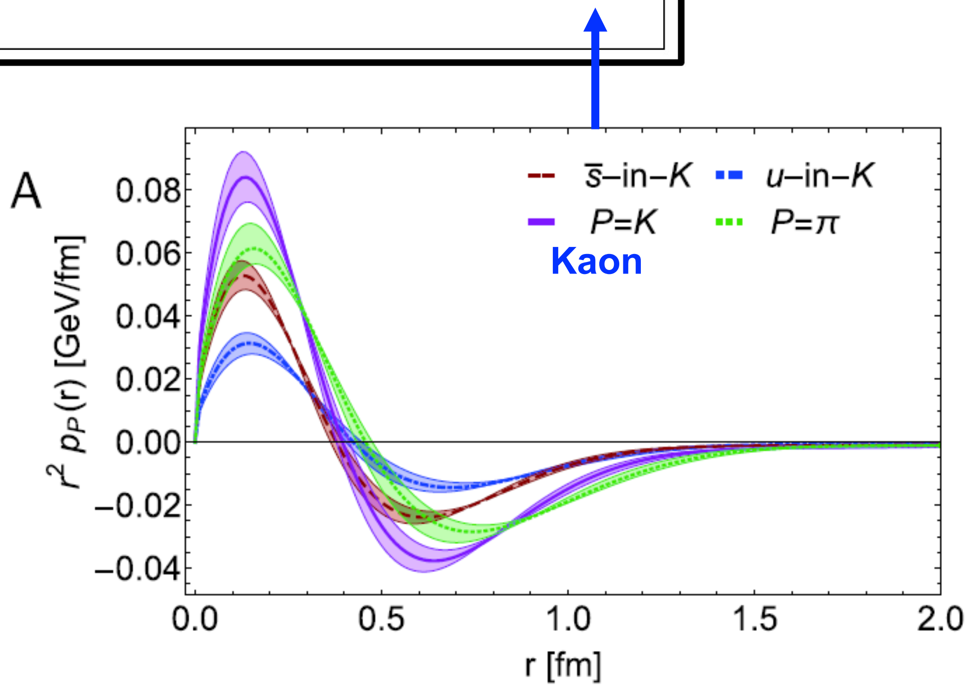
- **Pressure in the Proton**
  - First determination using DVCS (Deeply Virtual Compton Scattering) data
  - Interior pressure in proton is > pressure inside a neutron star! ***Who knew that!***
  - Lattice calculation motivates determination of gluon GPDs at EIC

Experimental prospects at EIC first discussed in J. Phys. G 48 (2021) 7, 075106 – further work ongoing

Steps towards pressure distribution





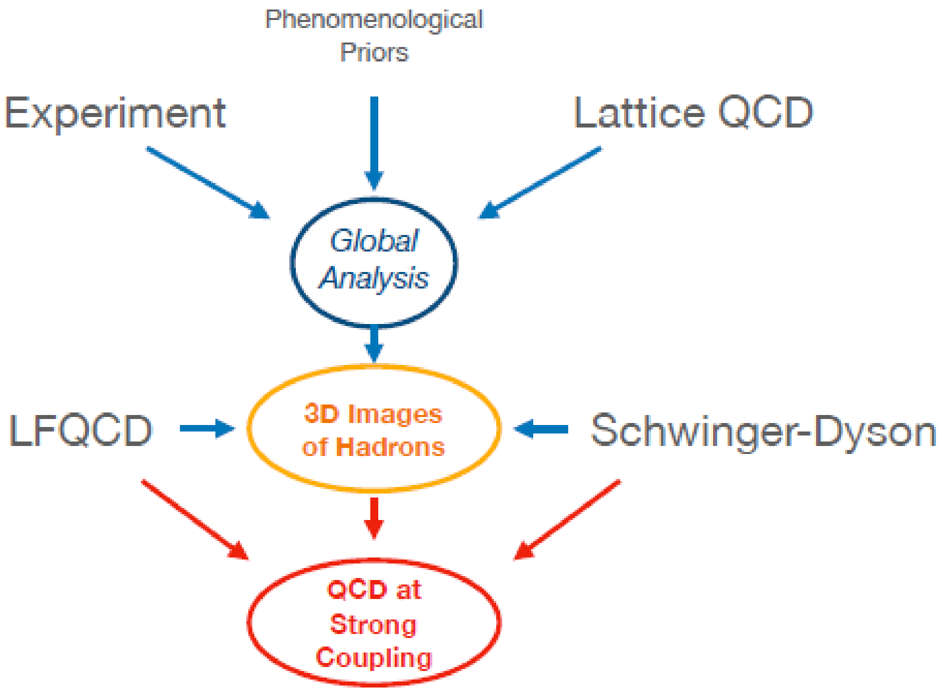


- **Pressure in the Proton**
  - First determination using DVCS (Deeply Virtual Compton Scattering) data
  - Interior pressure in proton is > pressure inside a neutron star! ***Who knew that!***
  - Lattice calculation motivates determination of gluon GPDs at EIC

Meson Structure – a Synergy of Experiment, QCD Phenomenology and Lattice QCD

This plot was made in the context of a large group of theorists and experimentalists working together on pion and kaon structure in a series of EIC-related workshops ("Pion and Kaon Structure at the EIC").This group continues to meet, with emphasis on the synergy of experiment, QCD theory and LQCD.

J. Phys. G 48 (2021) 7, 075106; arXiv:2102.11788



This will remain the theme, the mesons provide an excellent area to make progress in understanding and gaining intuition of how QCD works. The two-quark systems lend themselves for advanced QCD theory calculations of the QCD dynamics. The Sullivan process may (should!) provide the key data required for experimental validation.

Summary

- The 12 GeV era is going strong
  - More than 1/3 of experiments have been completed
  - High-profile results are emerging from the program
- CEBAF's approved program extends into 2030s (assuming ~30 weeks OPS/year)
  - 86% complete in FY29 without SoLID
  - 70% complete with SoLID
- CEBAF will remain a critical facility for fixed target electron scattering at high luminosity
  - Laying the groundwork for an exciting role for CEBAF in the EIC era
- Example of science from JLab to EIC: Meson structure is one of the Far Forward processes with major EIC Science and Detector Emphasis and is essential for understanding EHM and our visible Universe
  - Meson structure is non-trivial and experimental data for pion and kaon structure functions is extremely sparse
  - JLab 12 GeV will dramatically improve the $\pi^+/K^+/\pi^0$ electroproduction data set
  - EIC - Potential game-changer for this topic due to large CM range (20-140 GeV); Large x/Q2 landscape for pion/kaon SF; Potential to provide definite answers on different gluon distributions in pion/kaon