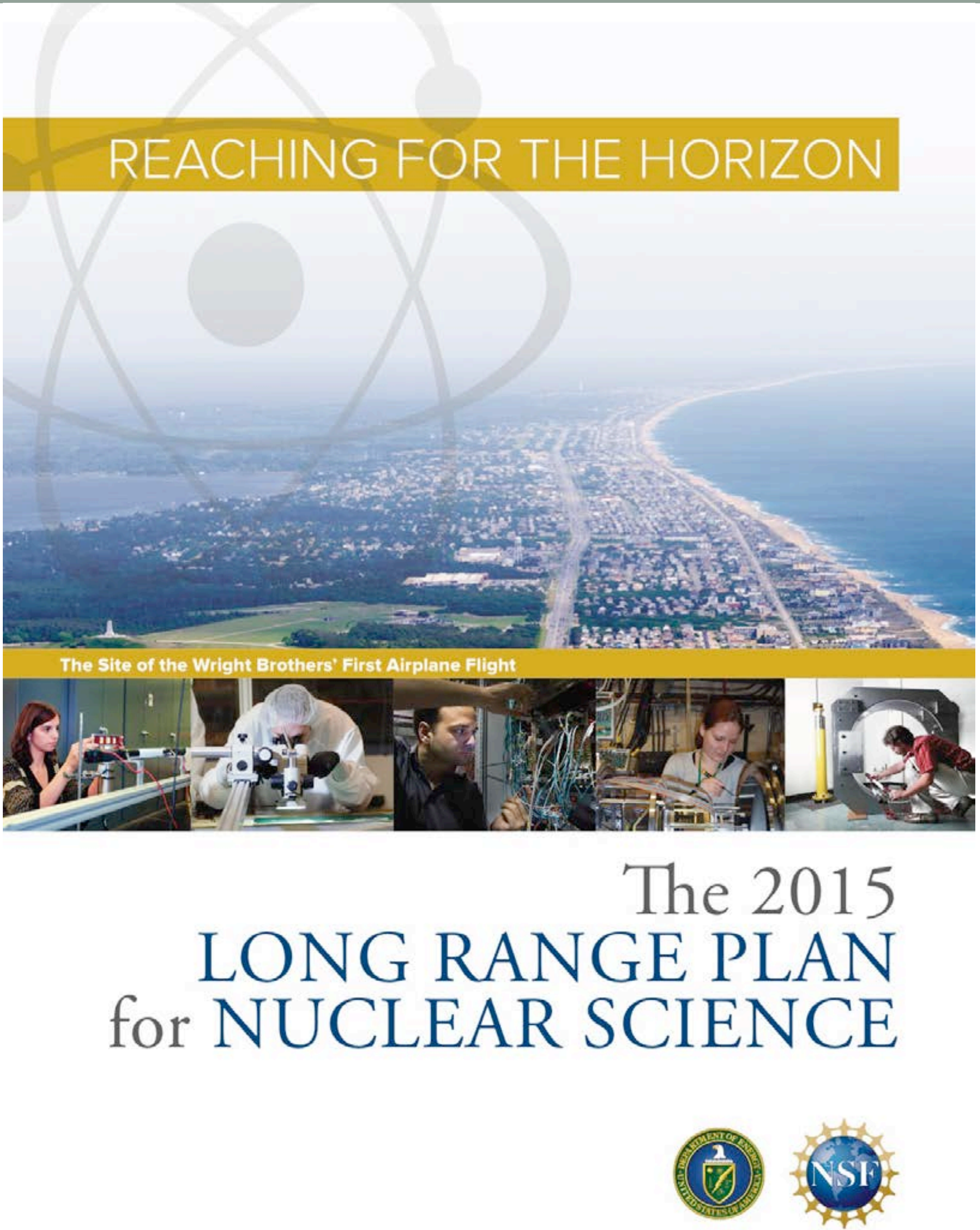


REACHING FOR THE HORIZON

The Site of the Wright Brothers' First Airplane Flight

The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE

http://science.energy.gov/np/reports

RECOMMENDATION:

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.

Initiatives:

Theory
Detector & Accelerator R&D

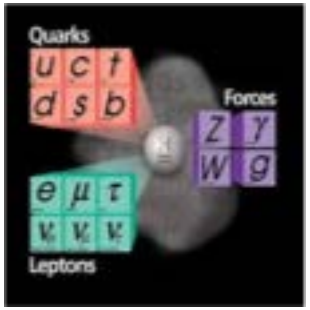
Detector R&D money ~1.3M/yr since 2011; significant increase anticipated soon.

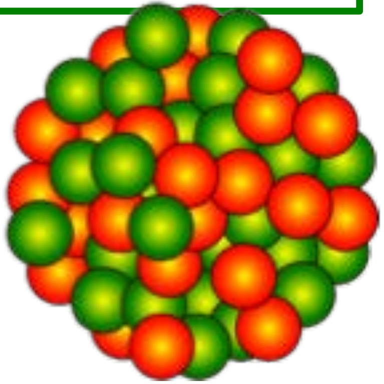
Anticipated Now:
NEW Money for EIC Accelerator R&D already assigned $7m/yr

Electron Ion Collider:
The next QCD frontier

Understanding the Glue that Binds Us All

Why the EIC? ➔ "Gluon Imaging"
To understand the role of gluons in binding quarks & gluons into Nucleons and Nuclei



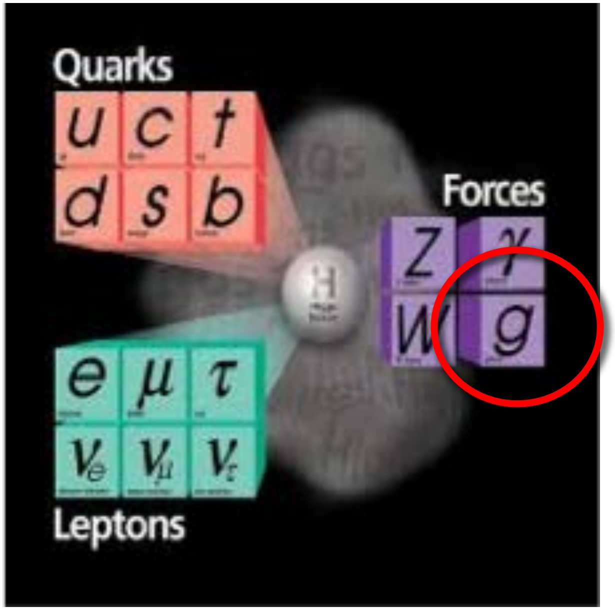


Stony Brook University

BROOKHAVEN NATIONAL LABORATORY

Abhay Deshpande

Gluon in the Standard Model of Physics



Gluon: carrier of strong force (QCD)

Charge-less, massless, but carries color-charge

Binds the quarks and gluons inside the hadrons with tremendous force! (Strong force)

At the heart of many un/(ill)-understood phenomena:

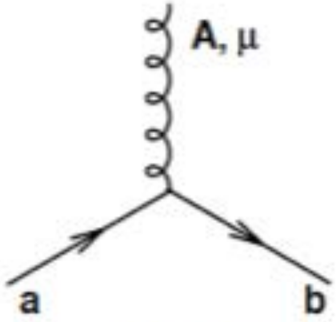
Color Confinement, composition of nucleon spin, quark-gluon plasma at RHIC & LHC…

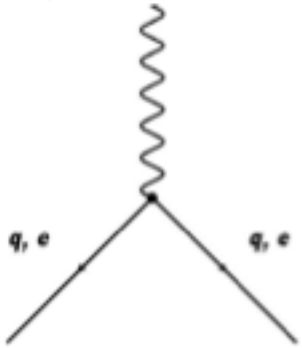
What distinguishes QCD from QED?

QED is mediated by photons (γ) which are charge-less

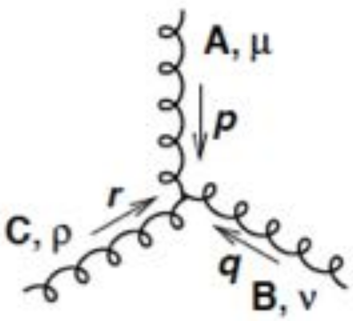
QCD is mediated by gluons (g), also charge-less but *are* colored!

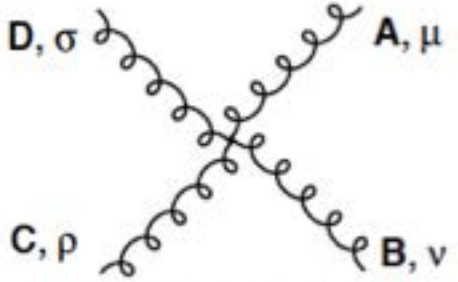
In QCD &
g → γ in QED





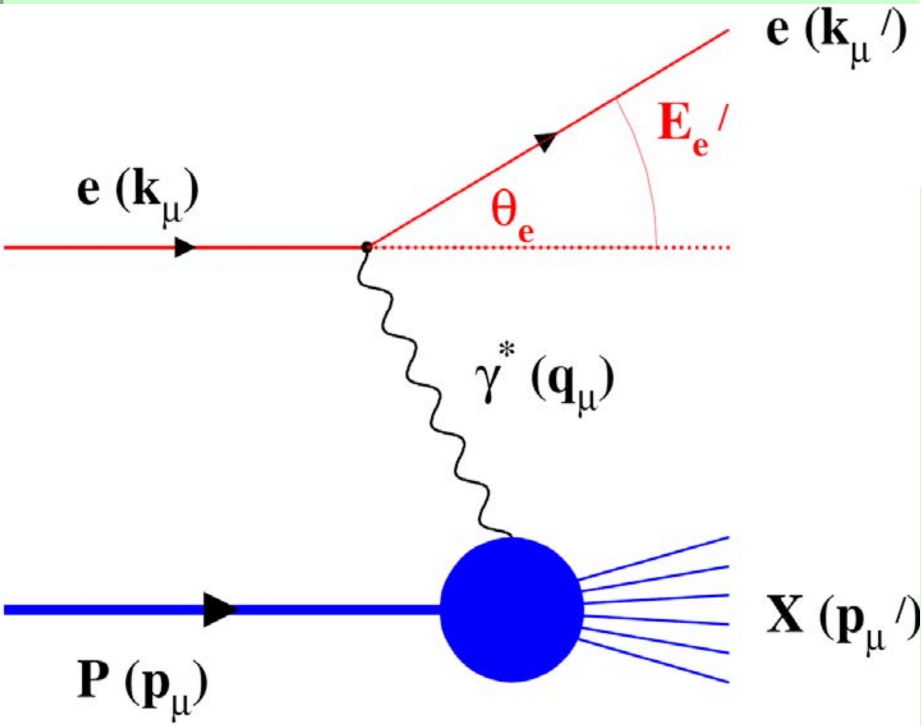
Only in QCD





Deep Inelastic Scattering: Precision & Control

Kinematics:



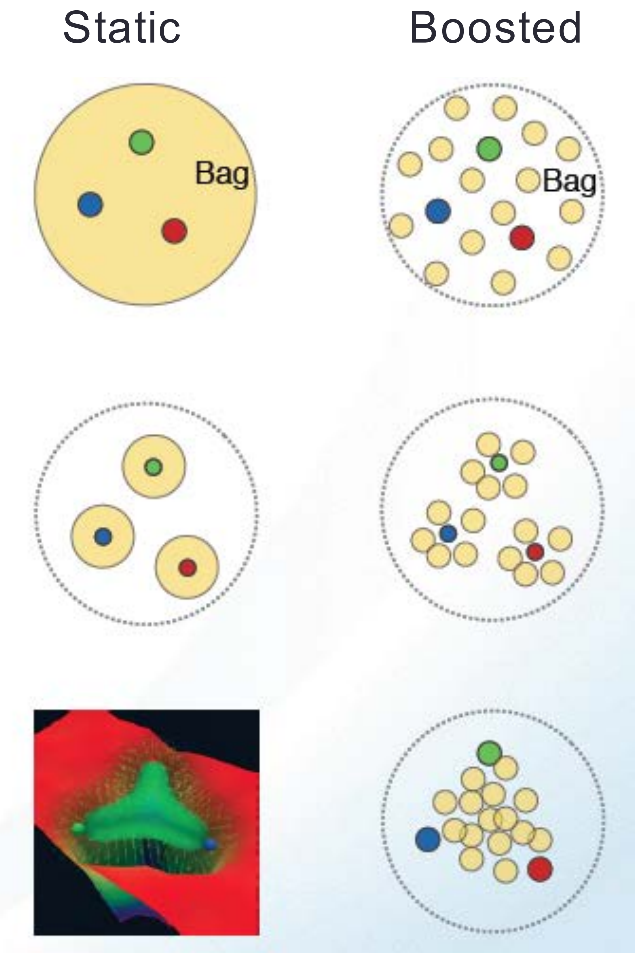
$$\frac{d^2\sigma^{eh\to eX}}{dxdQ^2} = \frac{4\pi\alpha_{em}^2}{xQ^4}\left[\left(1-y+\frac{y^2}{2}\right)F_2(x,Q^2) - \frac{y^2}{2}F_L(x,Q^2)\right]$$

quark+anti-quark momentum distributions

gluon momentum distribution

Exclusive A’+ h(π,

What does a proton look like?



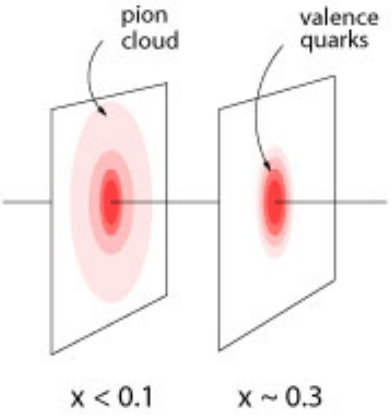
Bag Model: Gluon field distribution is wider than the fast moving quarks.
Gluon radius > Charge (quark) Radius

Constituent Quark Model: Gluons and sea quarks hide inside massive quarks.
Gluon radius ~ Charge (quark) Radius

Lattice Gauge theory (with slow moving quarks), gluons more concentrated inside the quarks:
Gluon radius < Charge (quark) Radius

Need *transverse* images of the quarks *and gluons* in protons

What does a proton look like with increasing energy?



One of several possible scenarios: a pion cloud model

A parton core in the proton gets increasingly surrounded by a meson cloud with decreasing x
→ large impact on gluon and sea-quark observables

What do we expect to see:

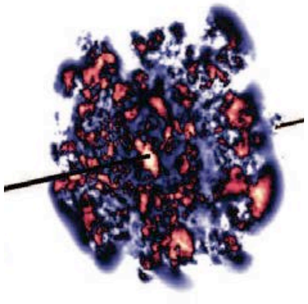
- ❑ $q\bar{q}$ pairs (sea quarks) generated at small(ish)-x are predicted to be unpolarized
- ❑ gluons generated from sea quarks are unpolarized

→ needed:

  - ➢ high precision measurement of flavor separated polarized quark and gluon distributions as functions of x
  - ➢ high precision spatial imaging: Gluon radius ~ sea-quark radius ?

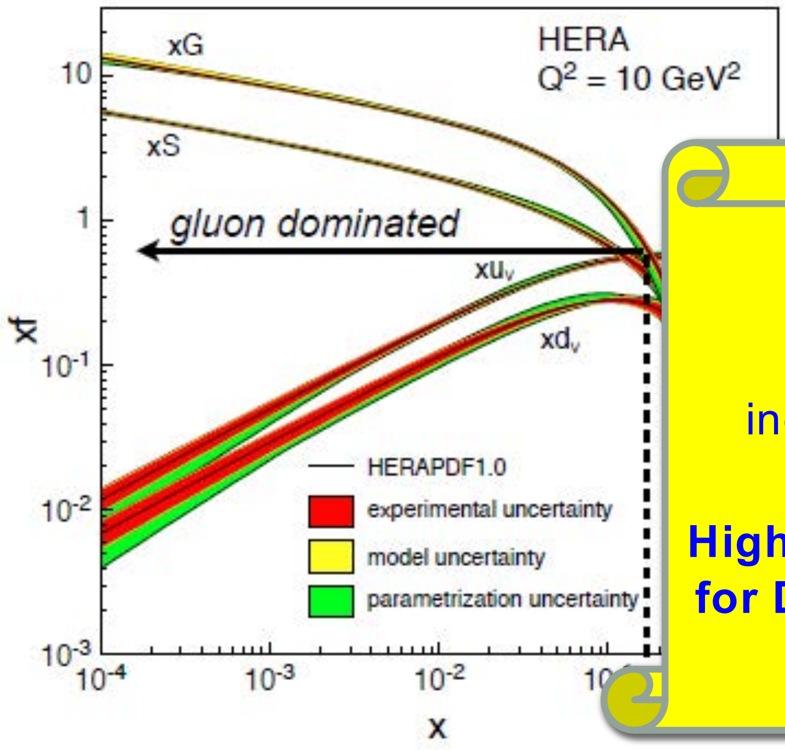
What happens in the gluon dominated small-x regime?

  - ➢ possible scenario: lumpy glue



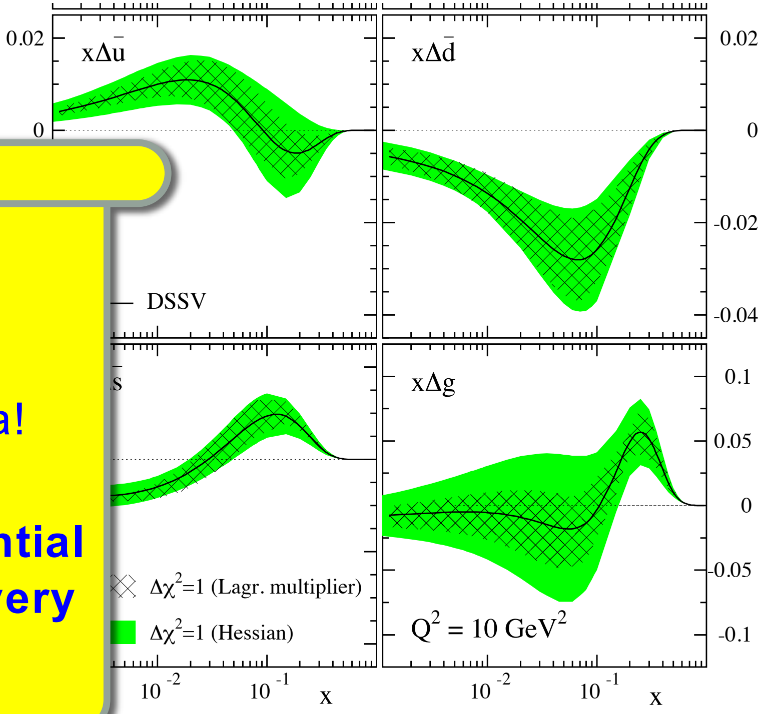
EIC needs to and will explore the dynamical spatial structure of hadrons

What do ***gluons*** in protons look like?
Unpolarized & polarized parton distribution functions



QCD
Terra-
incognita!

High Potential for Discovery



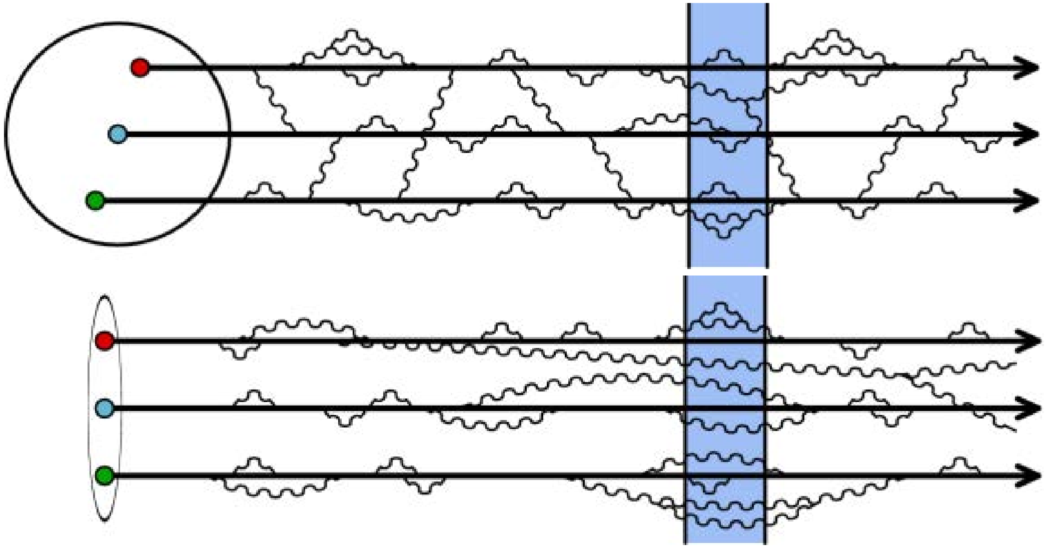
Need to go beyond 1-dimension!

Need (2+1)D image of gluons in a nucleon in position & momentum space

How does a Proton look at low and very high energy?

Low energy
High x
Regime of fixed target exp.

High energy
Low- x
Regime of a Collider



At high energy:

- Wee partons fluctuations are time dilated in strong interaction time scales
- Long lived gluons radiate further smaller x gluons ➔ which intern radiate more……. Leading to a **runaway growth?**

Gluon and the consequences of its interesting properties:

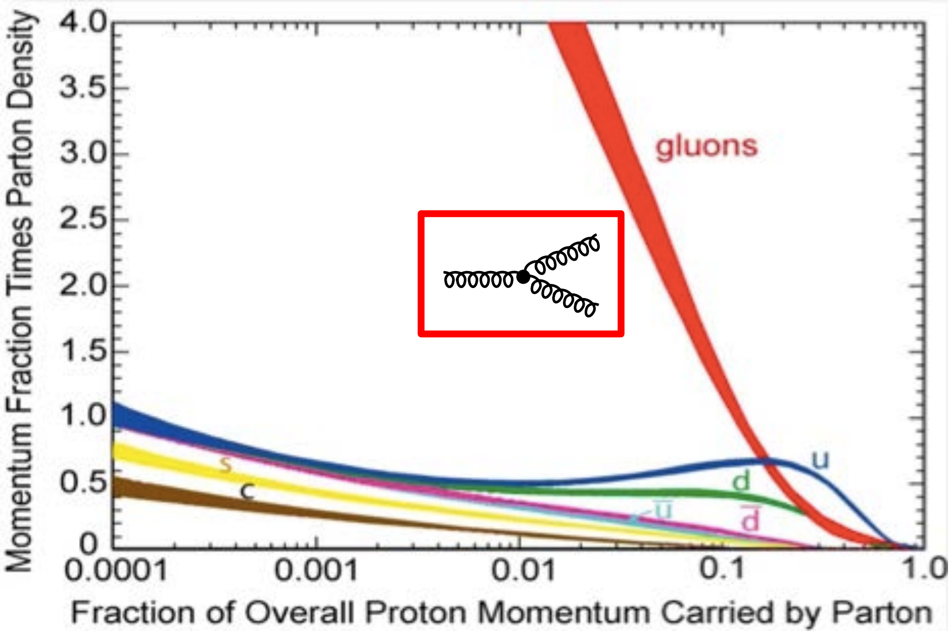
Gluons carry color charge ➔ Can interact with other gluons!

> "…The result is a self catalyzing enhancement that leads to a runaway growth. A small color charge in isolation builds up a big color thundercloud…."

F. Wilczek, in "Origin of Mass"
Nobel Prize, 2004

Gluon and the consequences of its interesting properties:

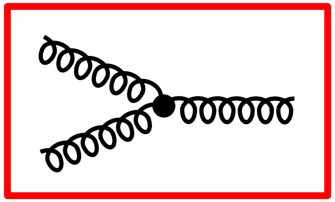
Gluons carry color charge ➔ Can interact with other gluons!



Apparent “indefinite rise” in gluon distribution in proton!

What could **limit this indefinite rise?** → saturation of soft gluon densities via gg→g recombination must be responsible.

recombination



Where? No one has unambiguously seen this before!

If true, effective theory of this →“Color Glass Condensate”

Non-linear Structure of QCD: Fundamental Consequences

- Quark (Color) confinement:
  - Consequence of nonlinear gluon self-interactions
  - Unique property of the strong interaction

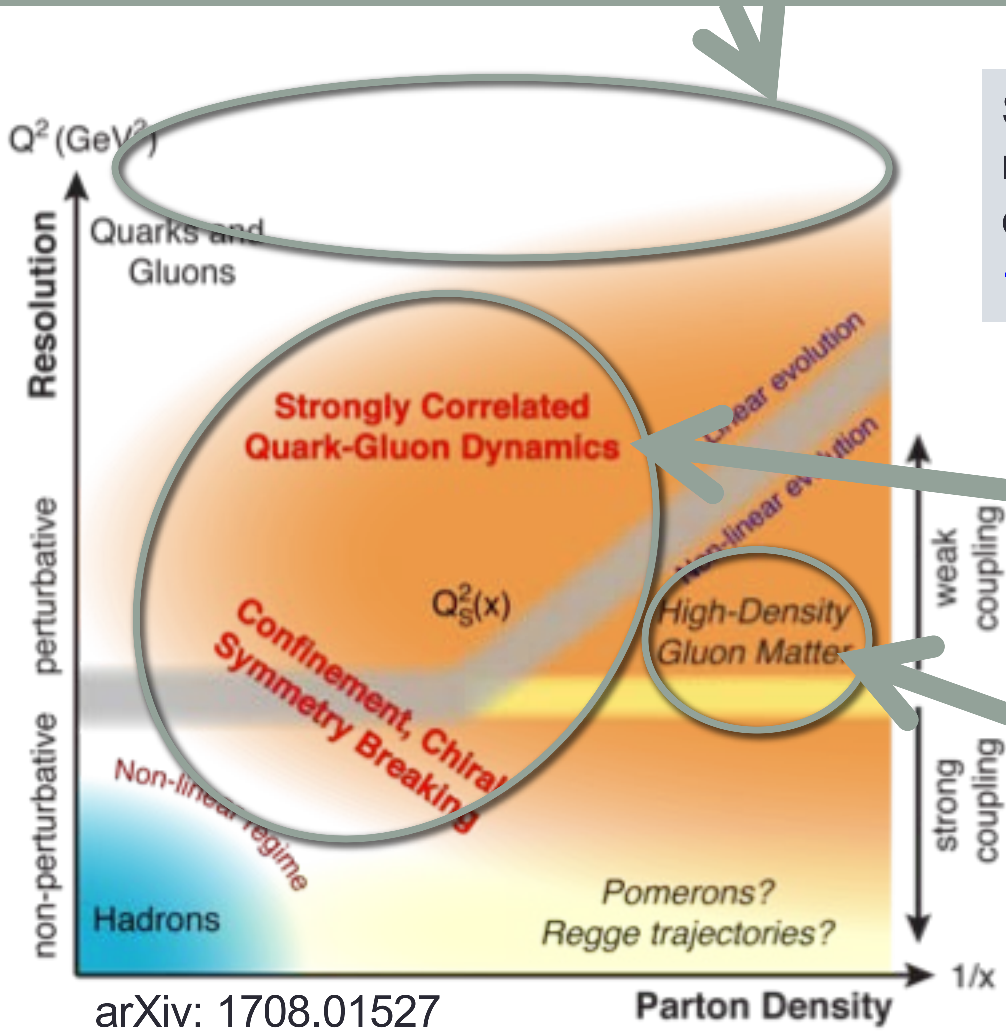
- Strong Quark-Gluon Interactions:
  - Confined motion of quarks and gluons – Transverse Momentum Dependent Parton Distributions (TMDs)
  - Confined spatial correlations of quark and gluon distributions – Generalized Parton Distributions (GPDs)

- Ultra-dense color (gluon) fields:
  - Is there a universal many-body structure due to ultra-dense color fields at the core of **all** hadrons and nuclei?

All expected to be under the "femtoscope" called the EIC

QCD Landscape to be explored by EIC

QCD at high resolution (Q^2) —weakly correlated quarks and gluons are well-described



arXiv: 1708.01527

Strong QCD dynamics creates many-body correlations between quarks and gluons
→ hadron structure emerges

EIC will systematically explore correlations in this region.

An exciting opportunity: Observation by EIC of a new regime in QCD of weakly coupled high density matter

Emergent Dynamics in QCD

Without gluons, there would be no nucleons,

no atomic nuclei… no visible world!

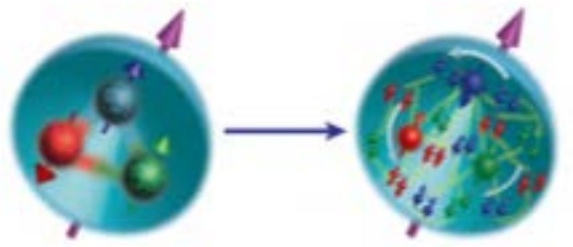
- Massless gluons & almost massless quarks, *through their interactions,* generate most of the mass of the nucleons
- Gluons carry ~50% of the proton's momentum, a significant fraction of the **nucleon's spin**, and are essential for the dynamics of confined partons
- Properties of hadrons are emergent phenomena resulting not only from the equation of motion but are also inextricably tied to the properties of the QCD vacuum. Striking examples besides confinement are spontaneous symmetry breaking and anomalies
- The nucleon-nucleon forces emerge from quark-gluon interactions: how this happens remains a mystery

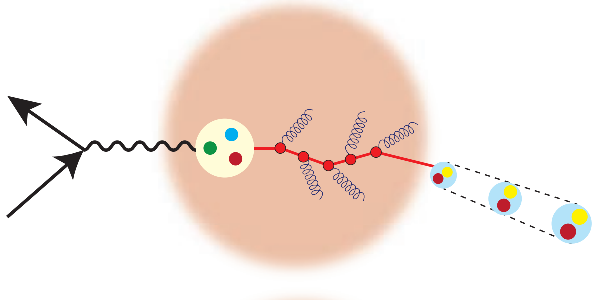
Experimental insight and guidance crucial for complete understanding of *how* hadrons & nuclei emerge from quarks and gluons

A new facility is needed to investigate, with precision, the dynamics of gluons & sea quarks and their role in the structure of visible matter

How are the sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon?

How do the nucleon properties emerge from them and their interactions?





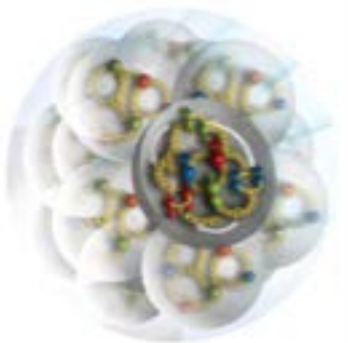
How do color-charged quarks and gluons, and colorless jets, interact with a nuclear medium?

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

How do the quark-gluon interactions create nuclear binding?

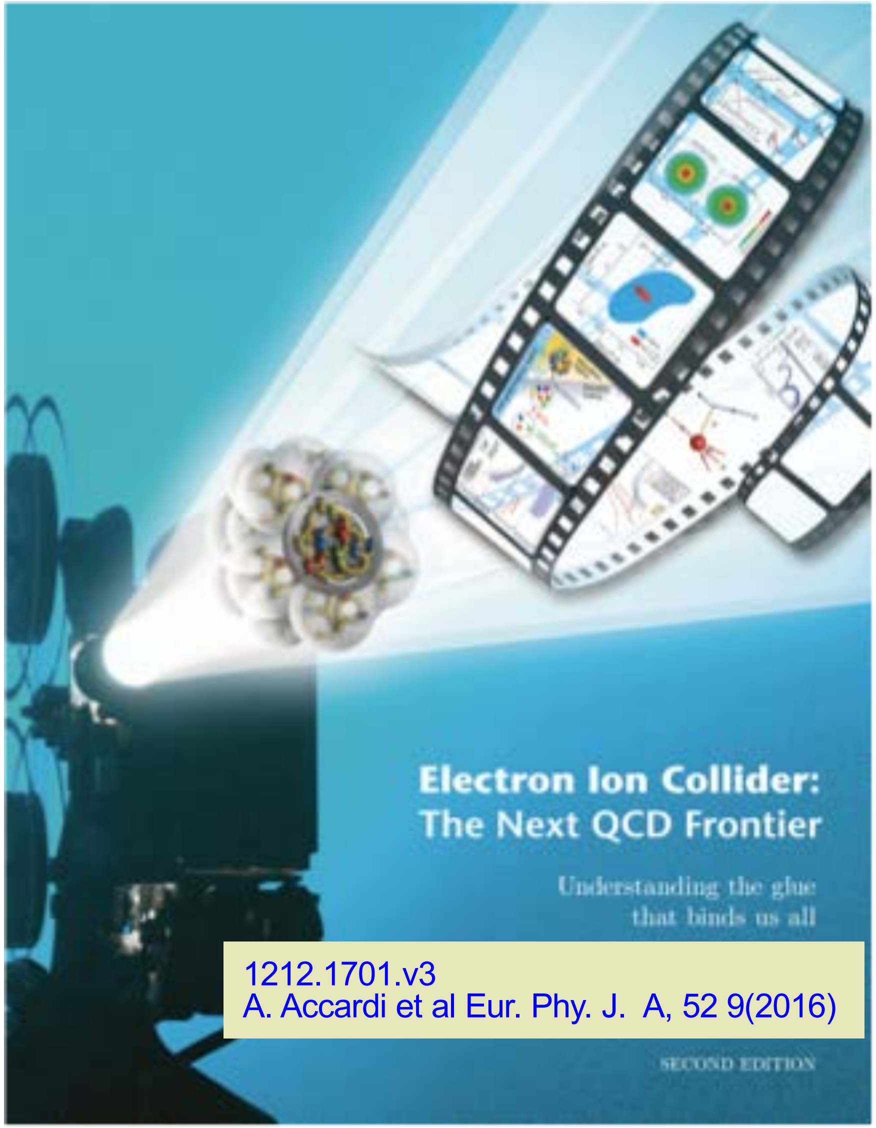
How does a dense nuclear environment affect the quarks and gluons, their correlations, and their interactions?

What happens to the gluon density in nuclei? Does it saturate at high energy, giving rise to a gluonic matter with universal properties in all nuclei, even the proton?



The Electron Ion Collider

Two options of realization!

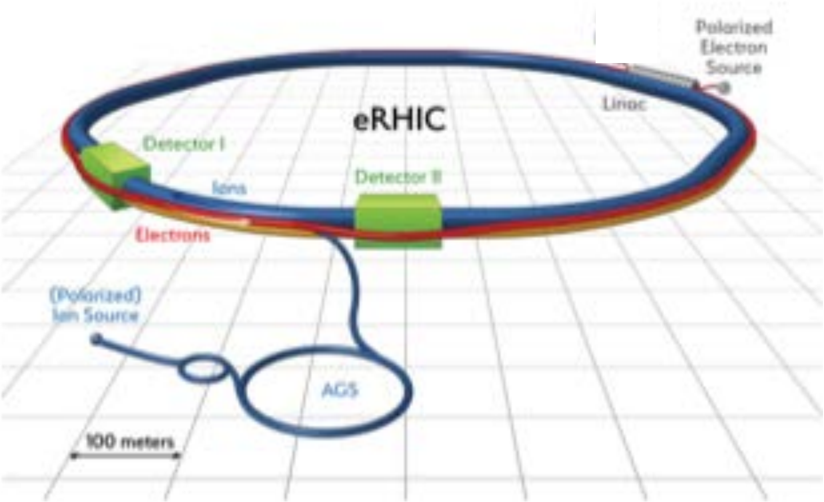


Electron Ion Collider:
The Next QCD Frontier

Understanding the glue
that binds us all

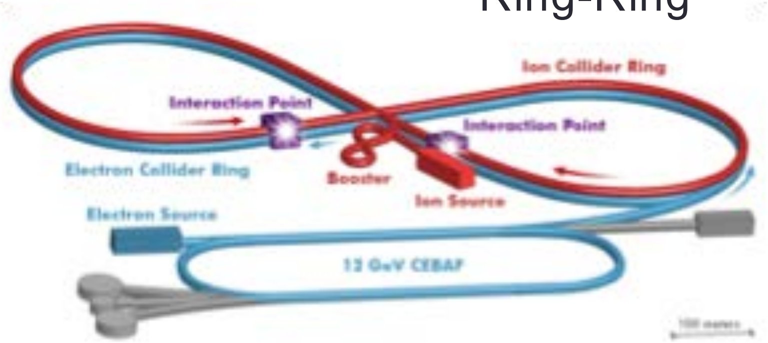
SECOND EDITION

1212.1701.v3
A. Accardi et al Eur. Phy. J. A, 52 9(2016)

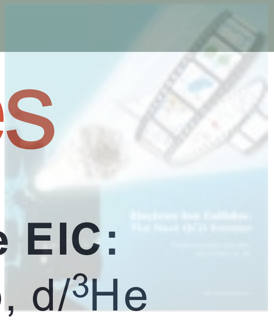


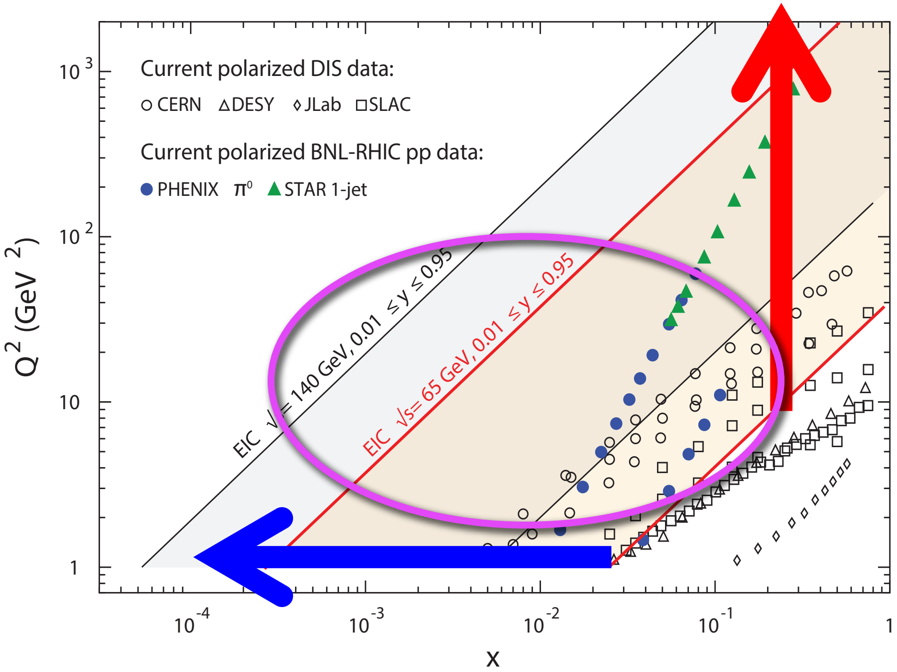
Not to scale

Ring-Ring



EIC: Kinematic reach & properties



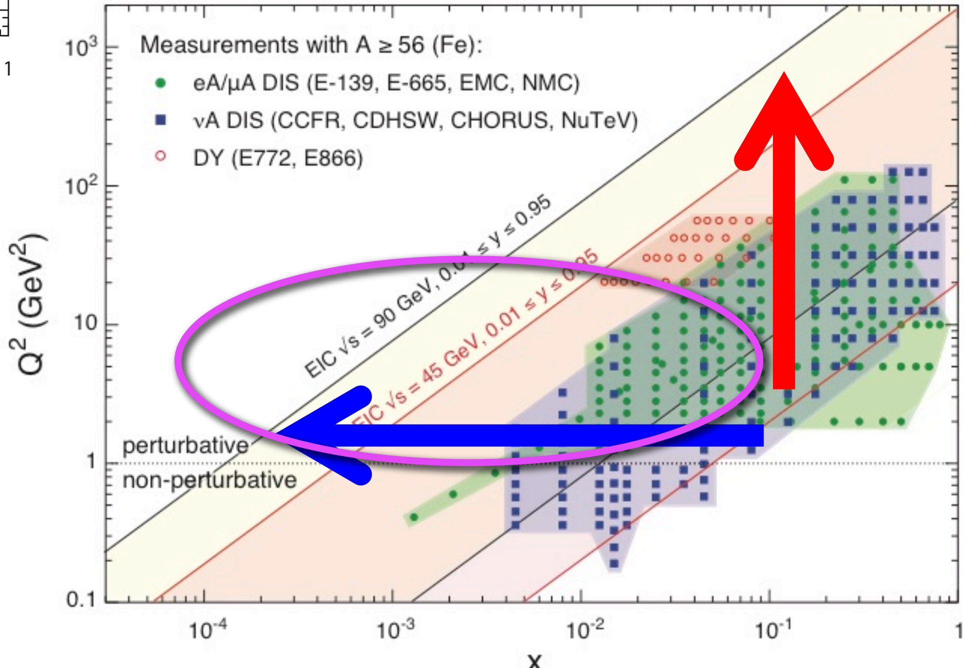


For e-N collisions at the EIC:

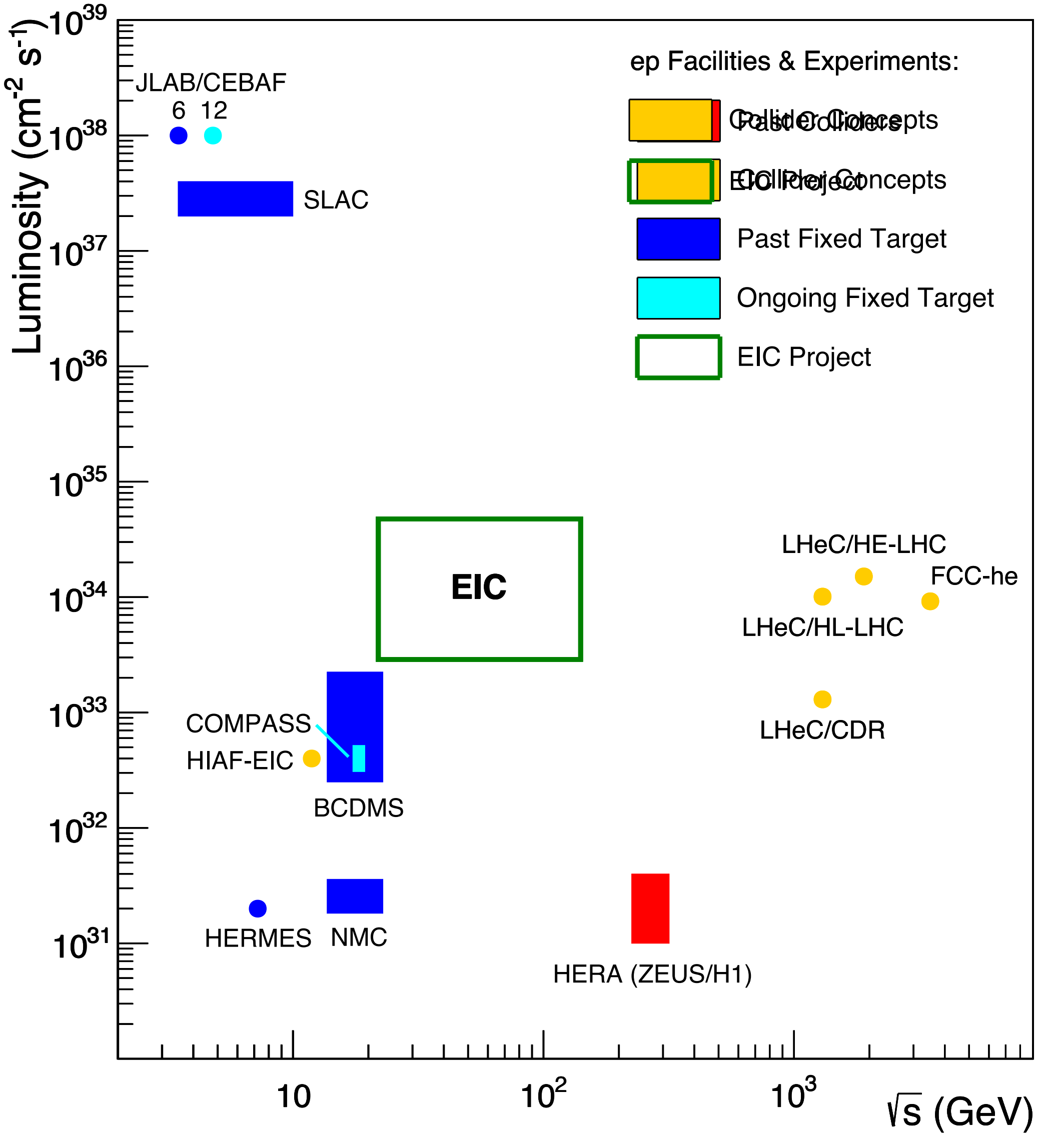
- ✓ **Polarized** beams: e, p, d/^{3}He
- ✓ Variable center of mass energy
- ✓ Wide Q^2 range → evolution
- ✓ Wide x range → spanning valence to low-x physics

For e-A collisions at the EIC:

- ✓ **Wide range in nuclei**
- ✓ Lum. per nucleon same as e-p
- ✓ Variable center of mass energy
- ✓ Wide x range (evolution)
- ✓ Wide x region (reach high gluon densities)



Uniqueness of EIC among all DIS Facilities



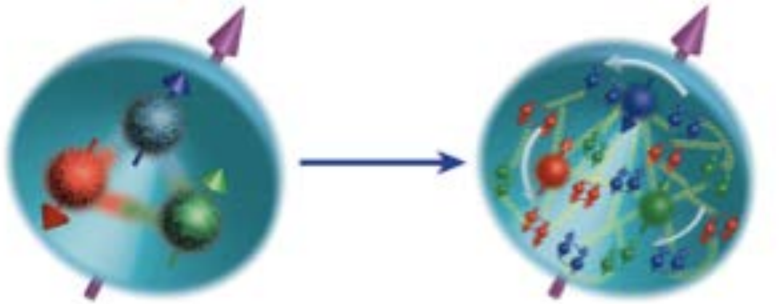
All DIS facilities in the world.

However,
if we ask for:

- high luminosity & wide reach in √s
- polarized lepton & hadron beams
- nuclear beams

EIC stands out as unique facility …

Nucleon Spin: An emergent phenomena



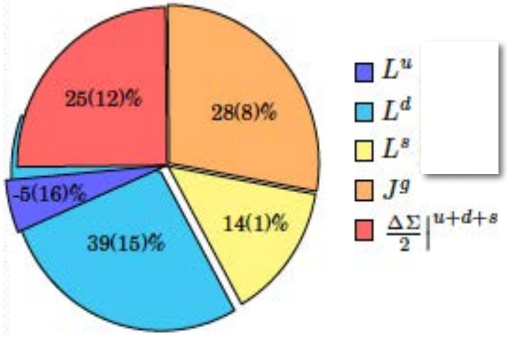
"Helicity sum rule"

$$\frac{1}{2}\hbar = \frac{1}{2}\underbrace{\Delta\Sigma}_{\text{quark contribution}} + \underbrace{\Delta G}_{\text{gluon contribution}} + \underbrace{\sum_q L_q^z + L_g^z}_{\text{orbital angular momentum}}$$

(25 +/- 3%) + (25+/-25%) + ????

RECENT: Spin on the Lattice:

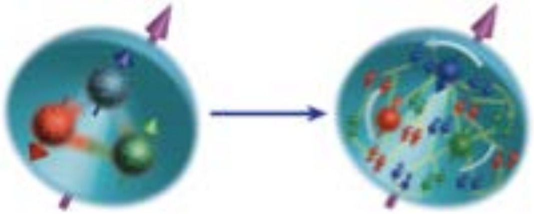
- ☐ **Gluon's spin contribution on Lattice: $S_G = 0.5(0.1)$**
  Yi-Bo Yang et al. PRL **118**, 102001 (2017)
- ☐ **J_q calculated on Lattice QCD:**
  χQCD Collaboration, PRD91, 014505, 2015



Proton as a laboratory for QCD

3D structure of hadrons in momentum and position space….

Our Understanding of Nucleon Spin



$$\frac{1}{2} = \left[\frac{1}{2}\Delta\Sigma + L_Q\right] + [\Delta g + L_G]$$

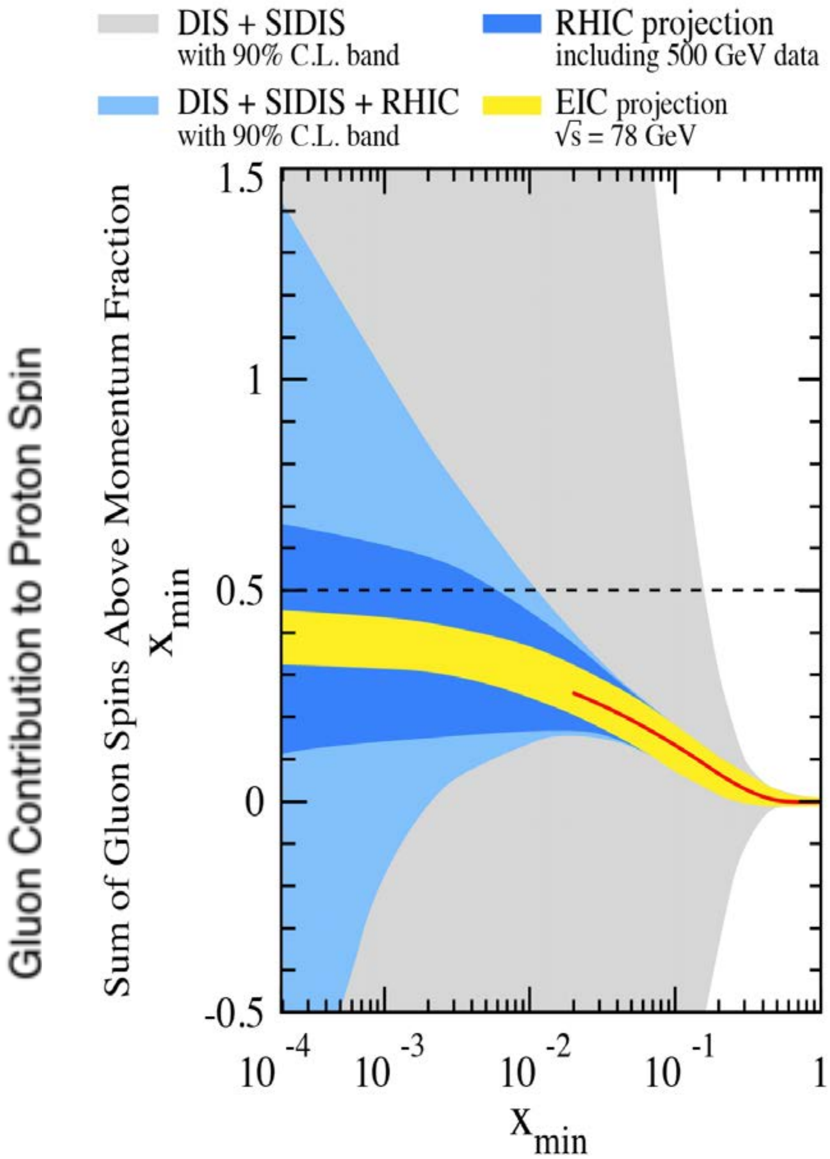
$\Delta\Sigma/2$ = Quark contribution to Proton Spin

L_Q = Quark Orbital Ang. Mom

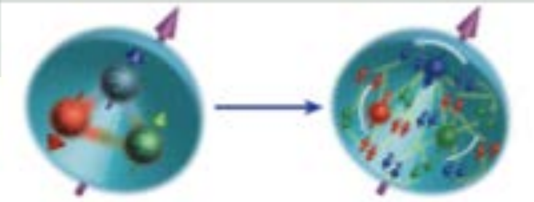
Δg = Gluon contribution to Proton Spin

L_G = Gluon Orbital Ang. Mom

Precision in $\Delta\Sigma$ and Δg ➔ A clear idea Of the magnitude of L_Q+L_G



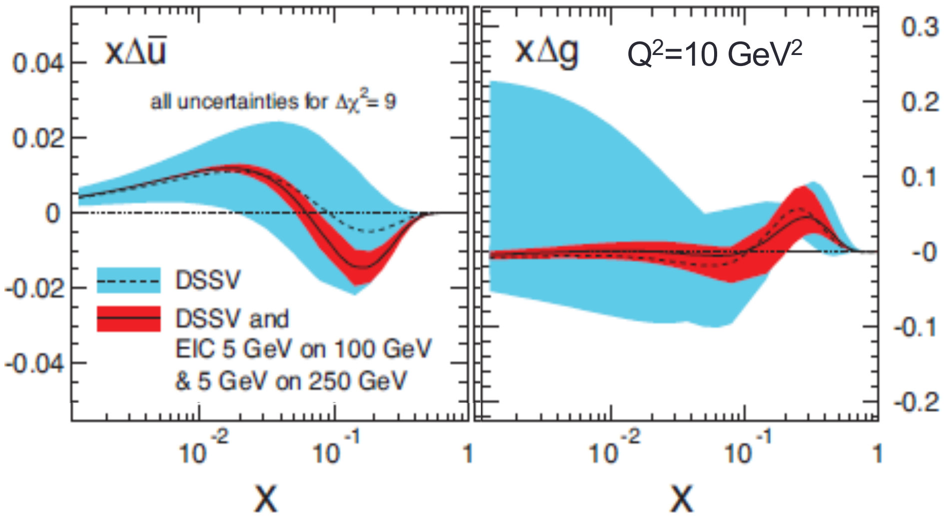
Understanding Nucleon Spin

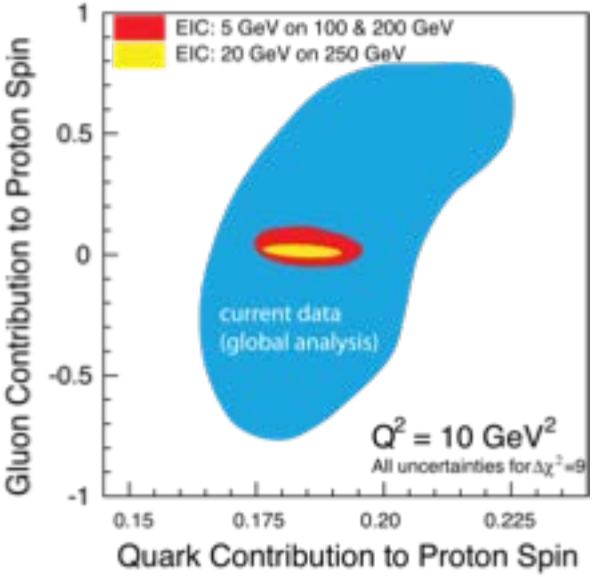


"Helicity sum rule"

$$\frac{1}{2}\hbar = \underbrace{\frac{1}{2}\Delta\Sigma}_{\text{quark contribution}} + \underbrace{\Delta G}_{\text{gluon contribution}} + \underbrace{\sum_q L_q^z + L_g^z}_{\text{orbital angular momentum}}$$

EIC projected measurements:
precise determination of polarized PDFs of quark sea and gluons ➔ precision ΔG and ΔΣ
→ A clear idea of the magnitude of ∑Lq+Lg





Spin and Lattice: Recent Activities

- ☐ **Gluon's spin contribution on Lattice: S_G = 0.5(0.1)**
  Yi-Bo Yang et al. PRL **118**, 102001 (2017)
- ☐ **J_q calculated on Lattice QCD:**
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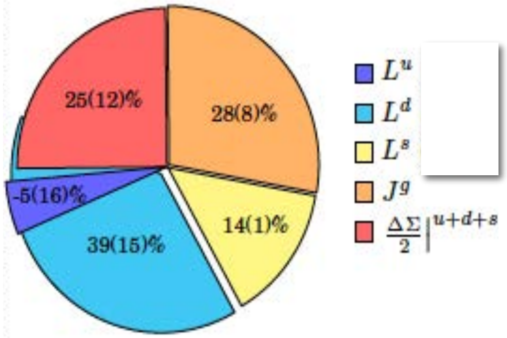
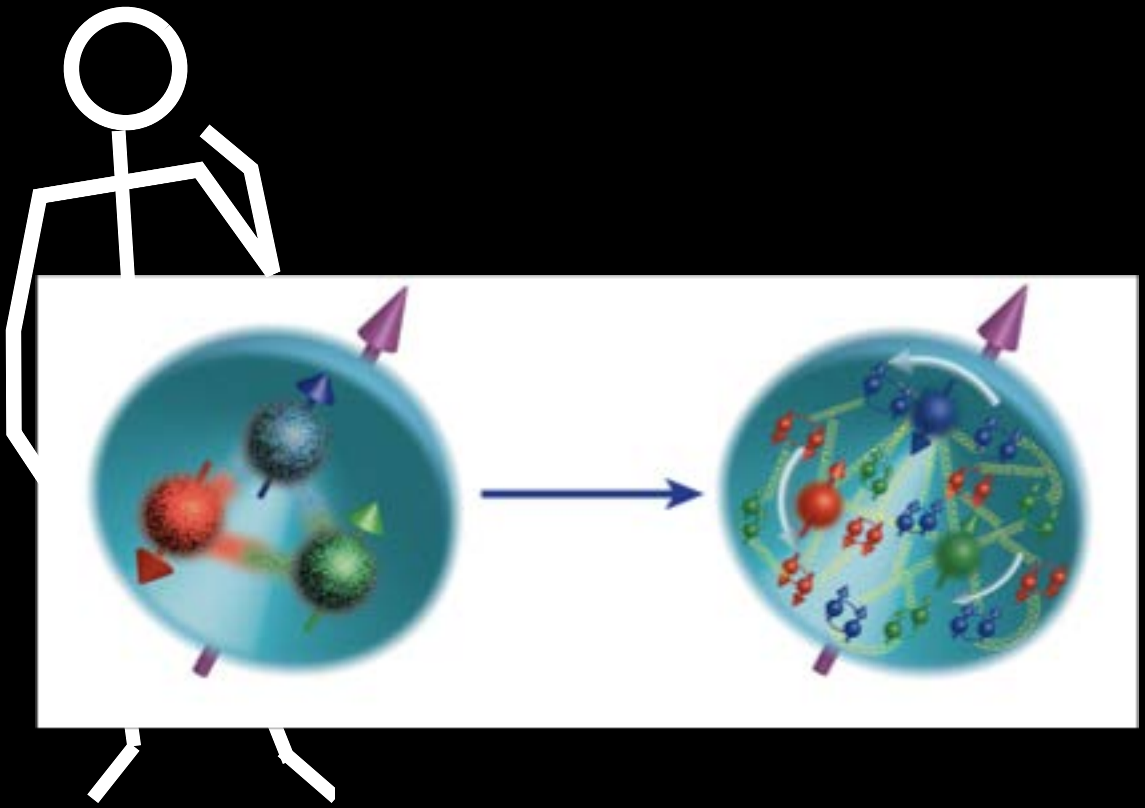


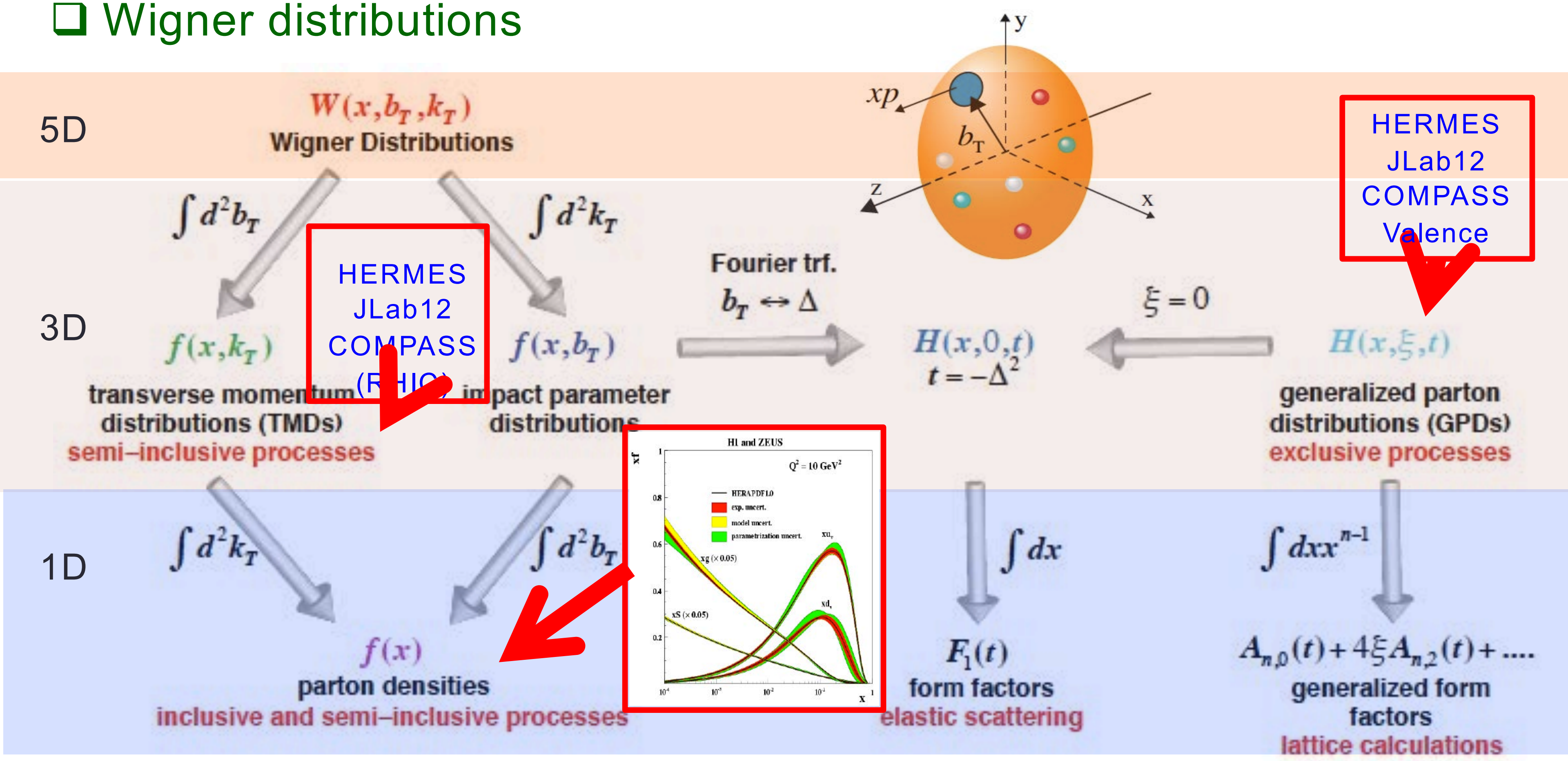
1D



Courtesy: Alssandro Bacchetta

Unified view of the Nucleon Structure

- ❑ Wigner distributions

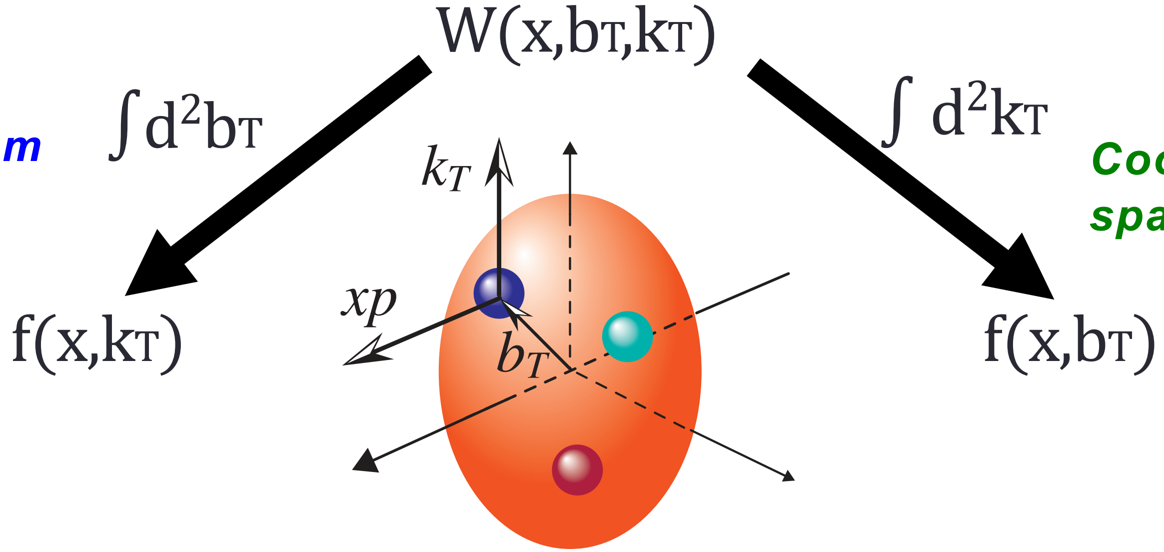


- ❑ (2+1)D imaging Quarks (Jlab/COMPASS) , **Gluons (EIC)**
  - ✧ TMDs – confined motion in a nucleon (semi-inclusive DIS)
  - ✧ GPDs – Spatial imaging of quarks and gluons (exclusive DIS & diffraction)

3-Dimensional Imaging Quarks and Gluons

Wigner functions $W(x,b_T,k_T)$

offer unprecedented insight into confinement and chiral symmetry breaking.



$W(x,b_T,k_T)$

Momentum space $\int d^2b_T$

$f(x,k_T)$

$\int d^2k_T$ ***Coordinate space***

$f(x,b_T)$

Spin-dependent 3D momentum space images from semi-inclusive scattering
→ **TMDs**

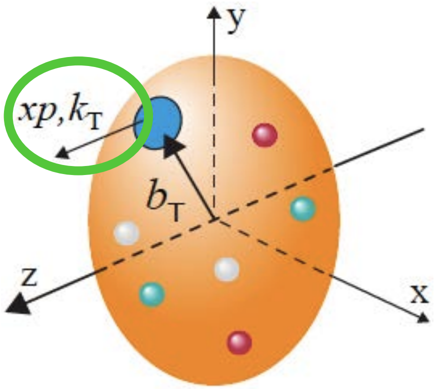
Spin-dependent 2D coordinate space (transverse) + 1D (longitudinal momentum) images from exclusive scattering
→ **GPDs**

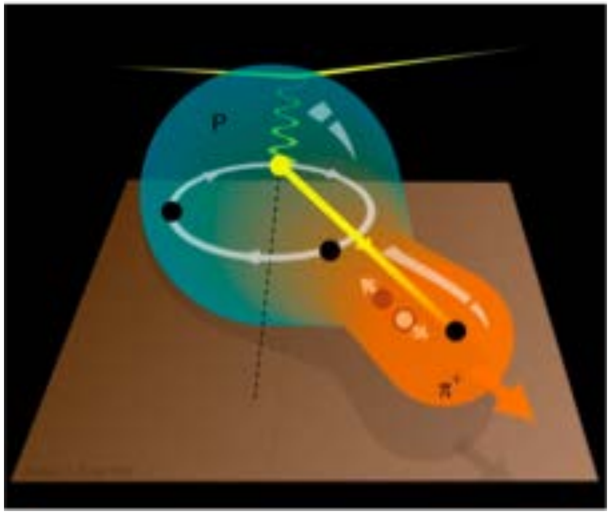
Position and momentum → Orbital motion of quarks and gluons

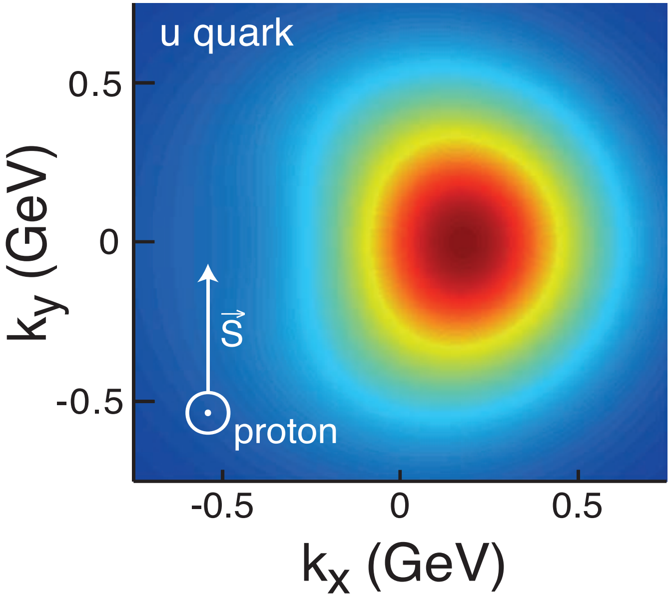
Possible direct access to gluon Wigner function through diffractive di-jet measurements at an EIC: Y. Hatta et al. PRL 16, 022301 (2016

Measurement of Transverse Momentum Distribution

Semi-Inclusive Deep Inelastic Scattering



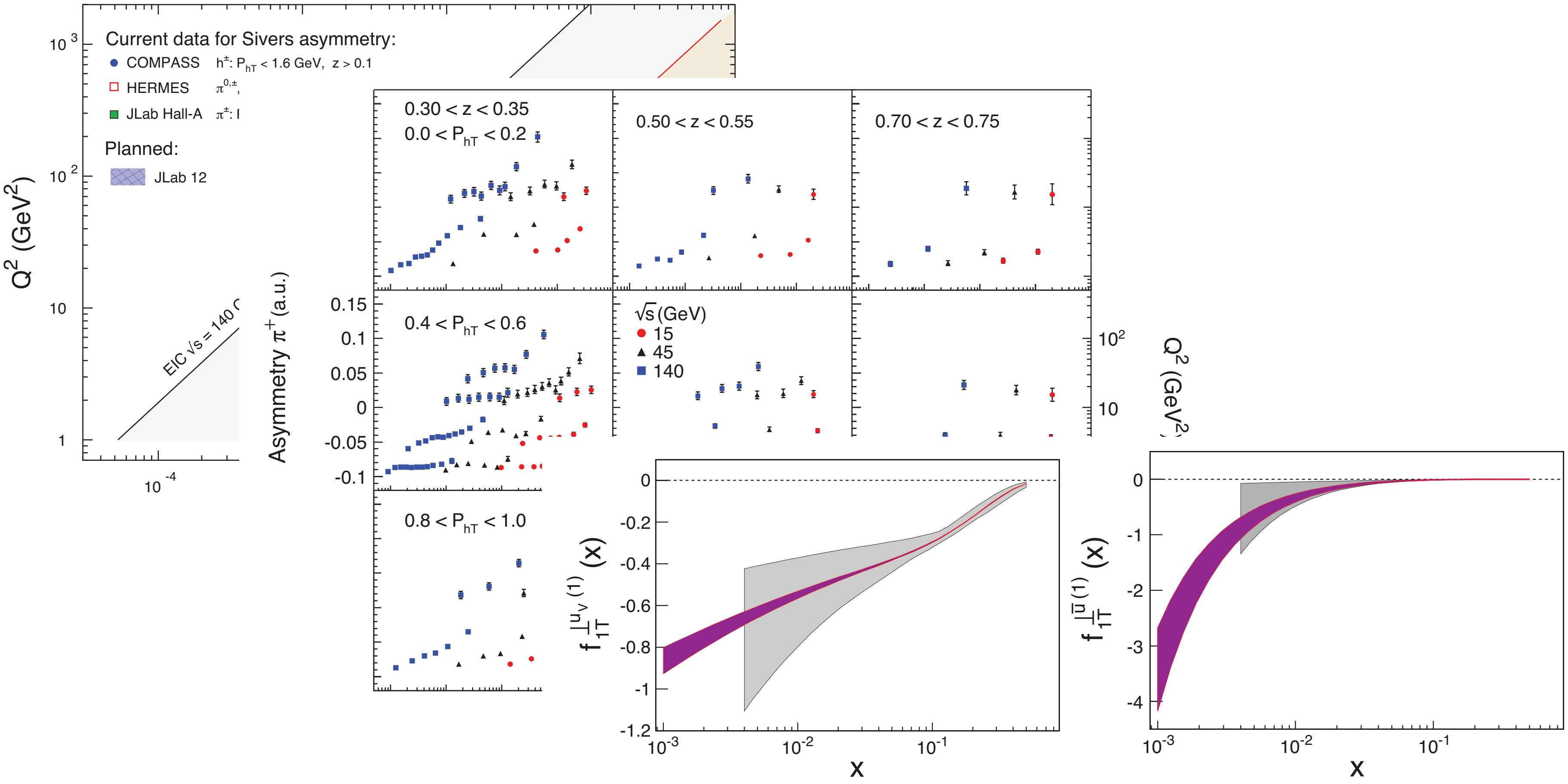




❑ Naturally, two scales:

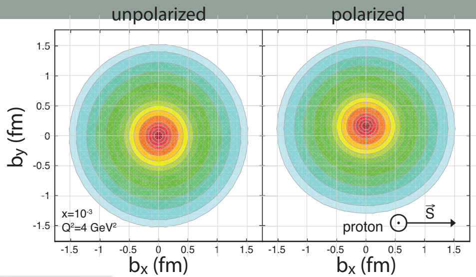
- ✧ high Q – localized probe
  To “see” quarks and gluons
- ✧ Low p_T – sensitive to confining scale
  To “see” their confined motion
- ✧ *Theory – QCD TMD factorization*

Scope & possible impact of EIC on Sivers Function measurements…. Quark TMDs



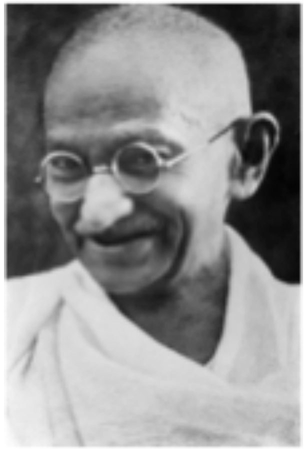
Spatial Imaging of quarks & gluons

Generalized Parton Distributions

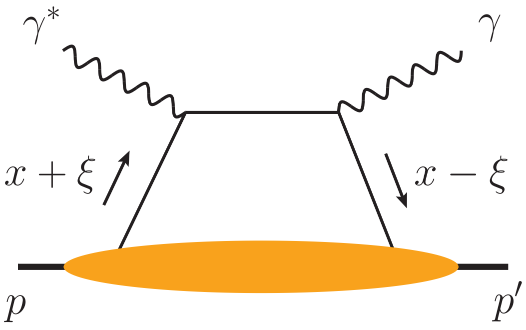


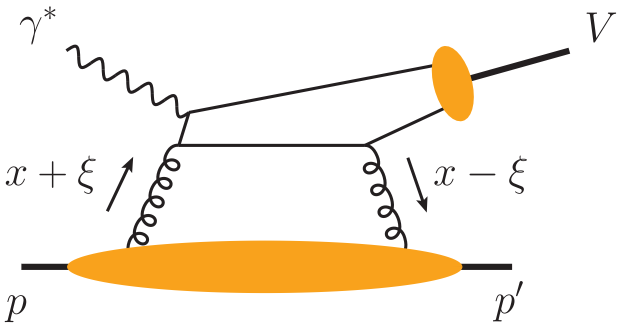
Historically, investigations of nucleon structure and dynamics involved breaking the nucleon…. (exploration of internal structure!)

To get to the **orbital motion** of quarks and gluons we need **non-violent collisions**



Quarks Motion





Gluons: Only @ Collider

Deeply Virtual Compton Scattering

Measure all three final states

e + **p** → e’+ **p’**+ γ

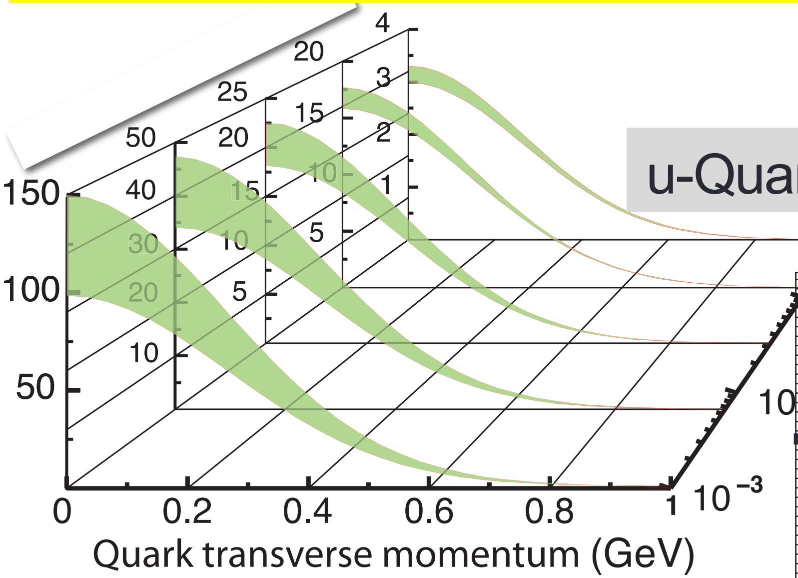
Fourier transform of momentum transferred=(p-p’) → Spatial distribution

Exclusive measurements → measure “everything”

2+1 D partonic image of the proton with the EIC

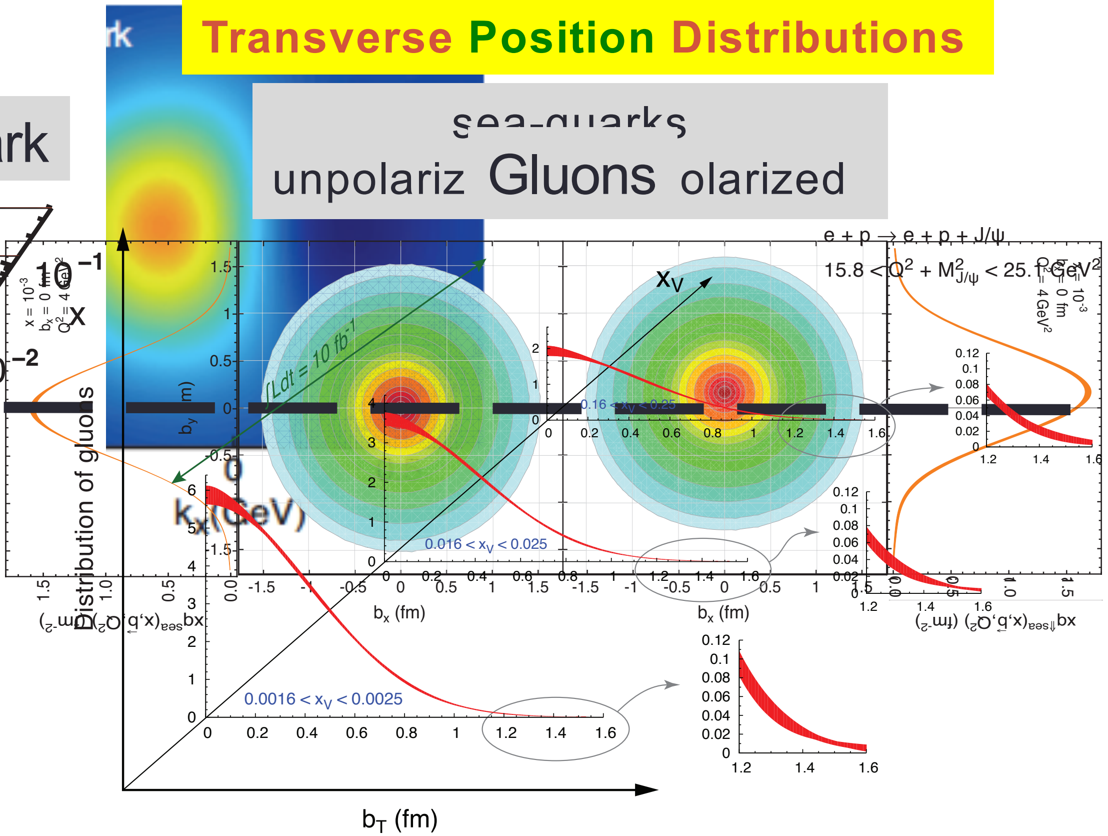
Spin-dependent 3D momentum space images from semi-inclusive scattering

Transverse Momentum Distributions



Spin-dependent 2D coordinate space (transverse) + 1D (longitudinal momentum) images from exclusive scattering

Transverse Position Distributions



Study of internal structure of a watermelon:

A-A (RHIC)

1) Violent collision of melons

2) Cutting the watermelon with a knife

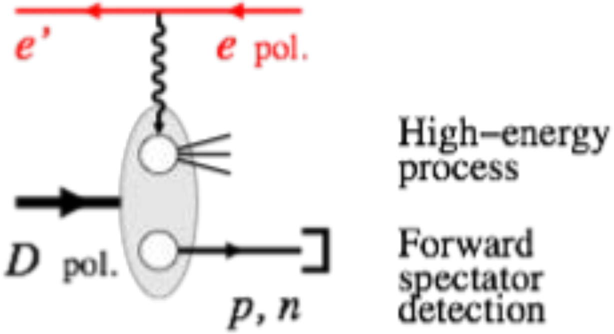
Violent DIS e-A (EIC)

3) MRI of a watermelon

Non-Violent e-A (EIC)

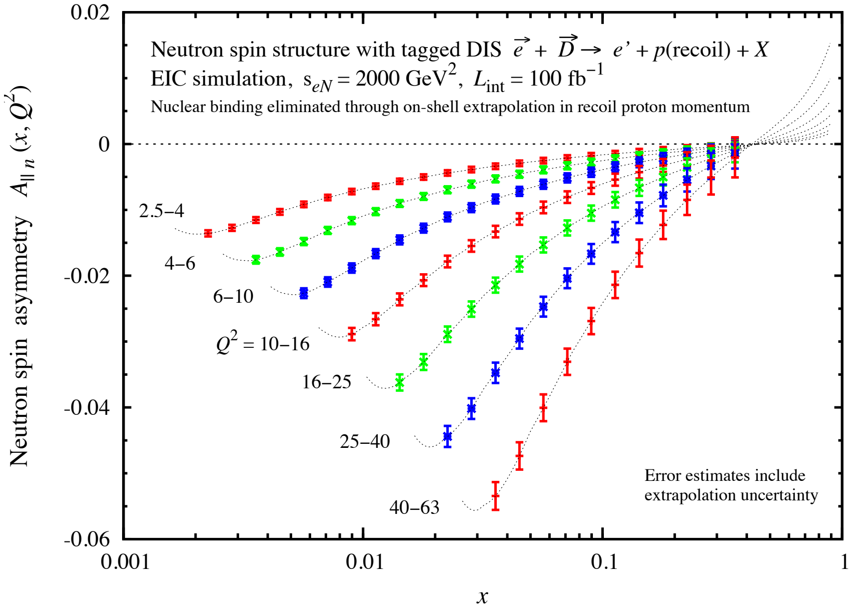
Use of Nuclei as a Laboratory for QCD :

Nuclear binding



- Measurement of the kinematics of the spectator nucleon indicator of the strength and (hence) the nature of its *binding* with the in-play nucleon(s):

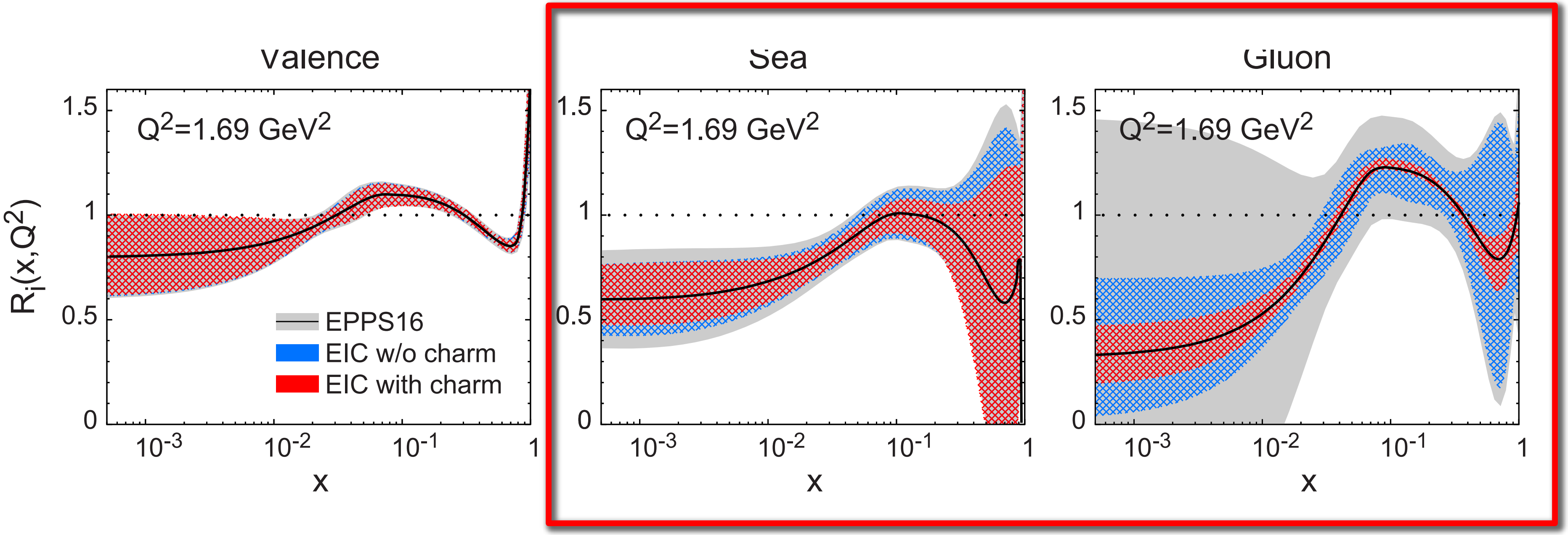
→ quark-gluon origin of the nuclear binding



Tag the recoil proton:
Study the neutron's q-g spin structure function.
Also for other few body nuclei

Neutron Spin Structure

EIC: impact on the knowledge of 1D Nuclear PDFs

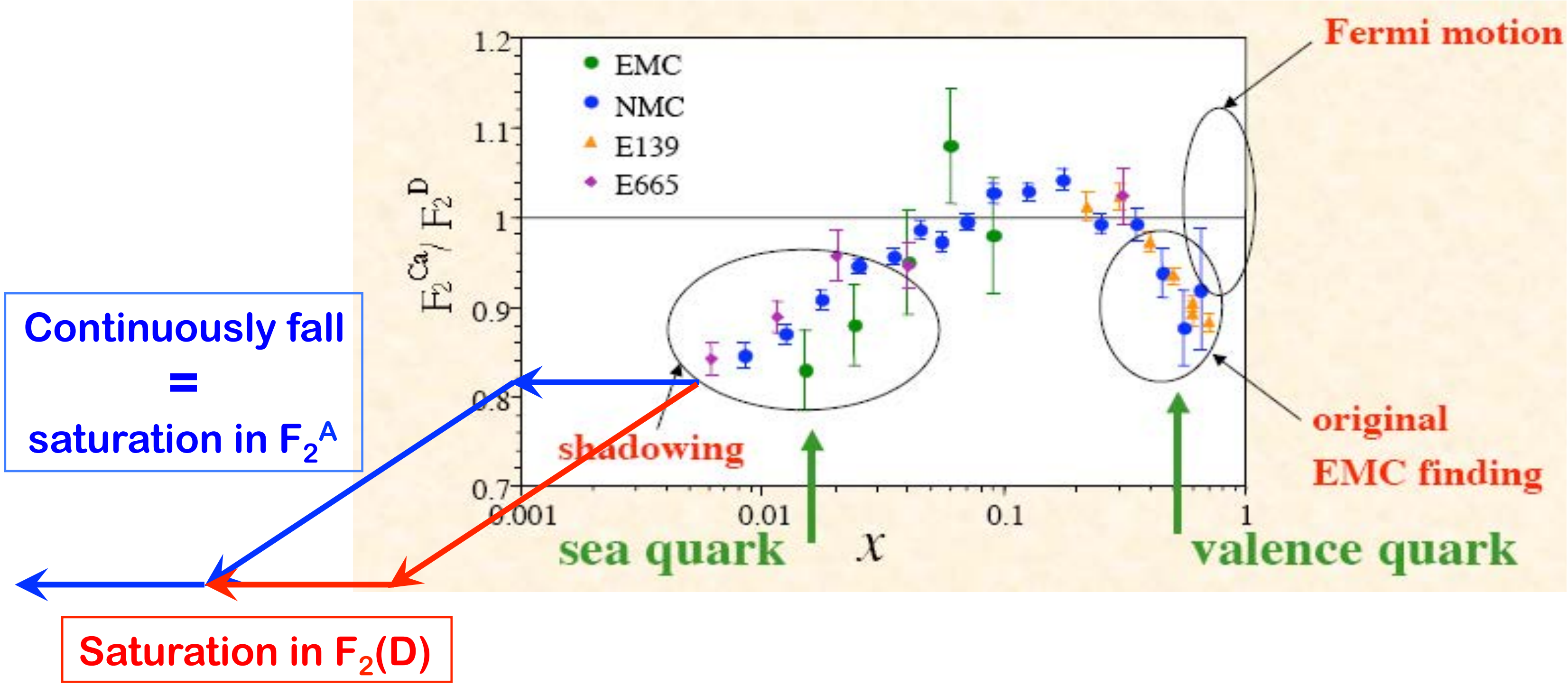


Ratio of Parton Distribution Functions of Pb over Proton:

- Without EIC, large uncertainties in **nuclear sea quarks and gluons**
  ➔With EIC significantly reduced uncertainties
- Complementary to RHIC and LHC pA data. Provides information on initial state for heavy ion collisions.
- Does the nucleus behave like a proton at low-x? ➔ such color correlations relevant to the understanding of astronomical objects

An easy measurement (early program)

- ❑ **Ratio of F_2: EMC effect, Shadowing and Saturation:**



Continuously fall = saturation in F_2^A

Saturation in $F_2(D)$

- ❑ **Questions:**

Will the suppression/shadowing continue fall as x decreases?

Could nucleus behaves as a large proton at small-x?

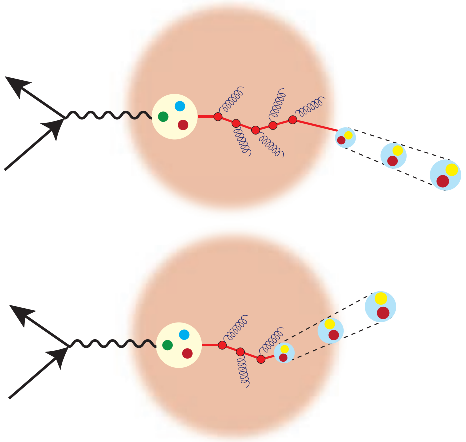
Range of color correlation – could impact the center of neutron stars!

Emergence of Hadrons from Partons

Nucleus as a Femtometer sized filter

Unprecedented ν, the virtual photon energy range @ EIC : *precision & control*

$$\nu = \frac{Q^2}{2mx}$$

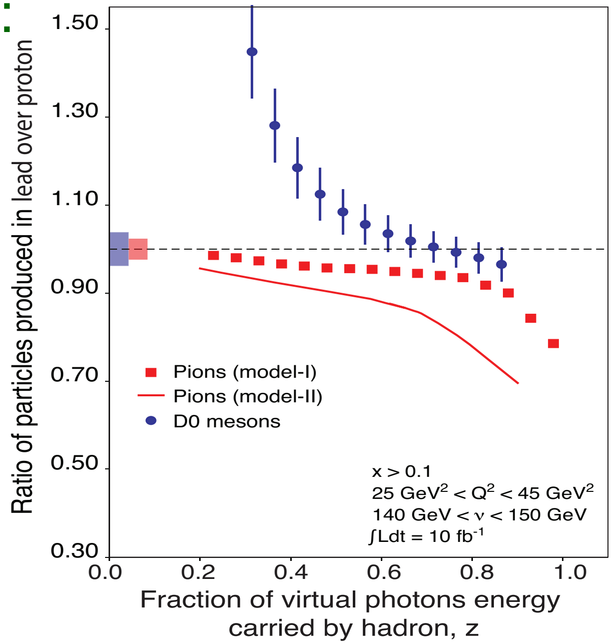


Control of ν by selecting kinematics;

Also under control the nuclear size.

(colored) Quark passing through cold QCD matter emerges as color-neutral hadron ➔ Clues to color-confinement?

Energy loss by light vs. heavy quarks:

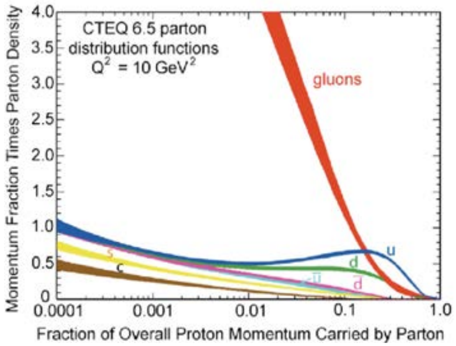


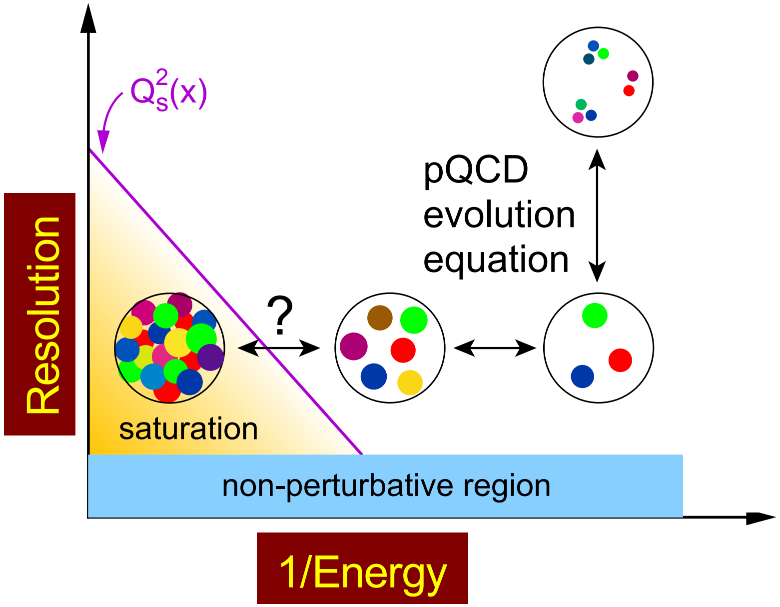
Identify π vs. D^0 **(charm)** mesons in e-A collisions: Understand energy loss of light vs. heavy quarks traversing the cold nuclear matter:

Connect to energy loss in Hot QCD

Need the collider energy of EIC and its control on parton kinematics

What do we learn from low-x studies?





What tames the low-x rise?

- New evolution eqn.s @ low x & moderate Q^2
- Saturation Scale Qs(x) where gluon emission and recombination comparable

gluon emission = gluon recombination **At Qs**

First observation of gluon recombination effects in nuclei:
➔leading to a *collective* gluonic system!
First observation of g-g recombination in *different* nuclei
→ Is this a universal property?

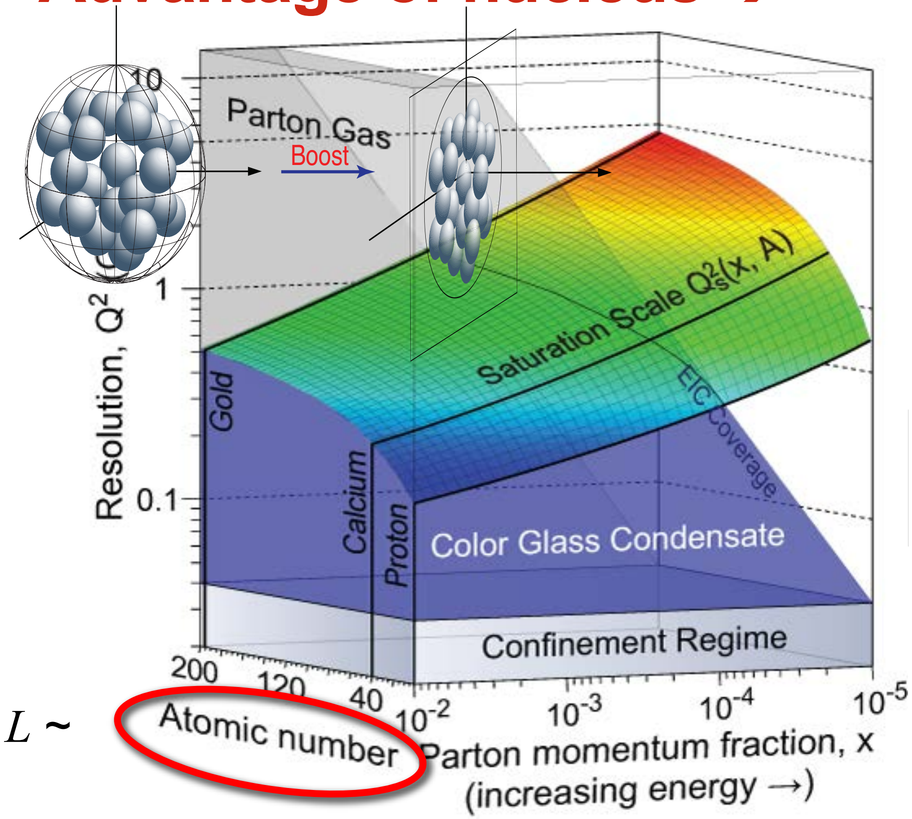
→ Is the Color Glass Condensate the correct effective theory?

How to explore/study this new phase of matter?

(multi-TeV) e-p collider OR **a (multi-10s GeV) e-A collider**

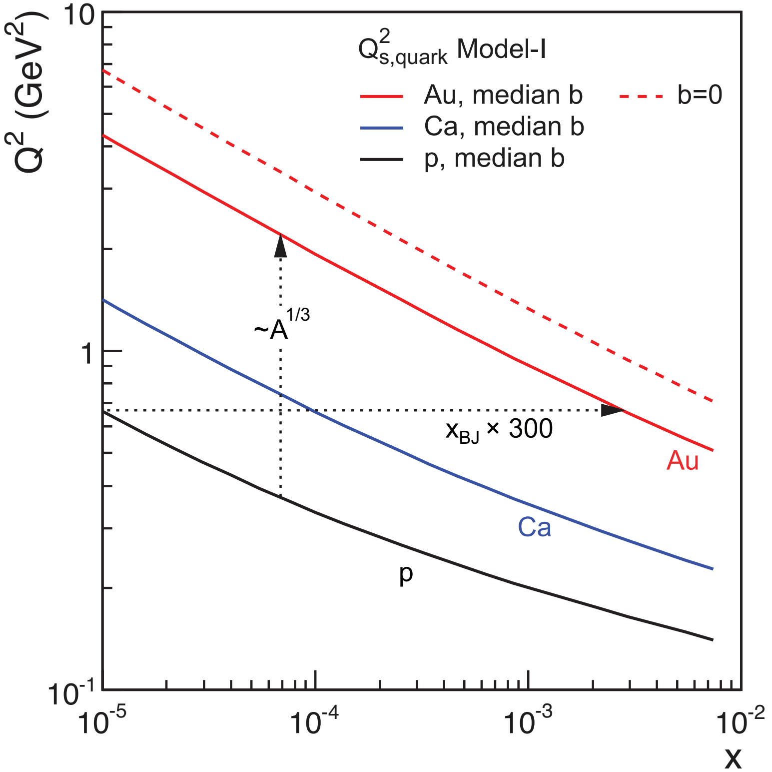
Teaney, Kowalski
Kovchegov et al.

Advantage of nucleus →



$L \sim$

$1/3$

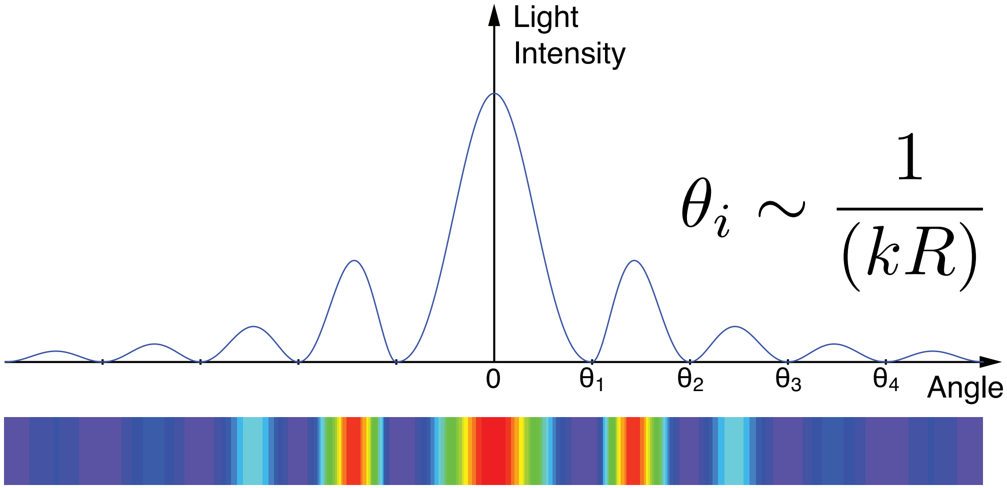


Enhancement of Qs with A:
Saturation regime reached at significantly lower energy (read: "cost") in nuclei

Diffraction in Optics and high energy scattering

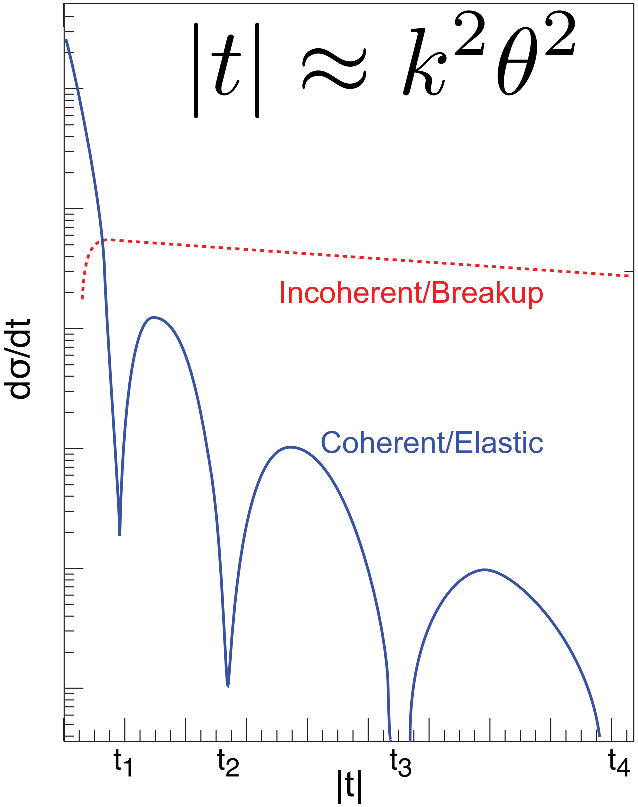
Light with wavelength λ obstructed by an opaque disk of radius R suffers diffraction:

k → wave number



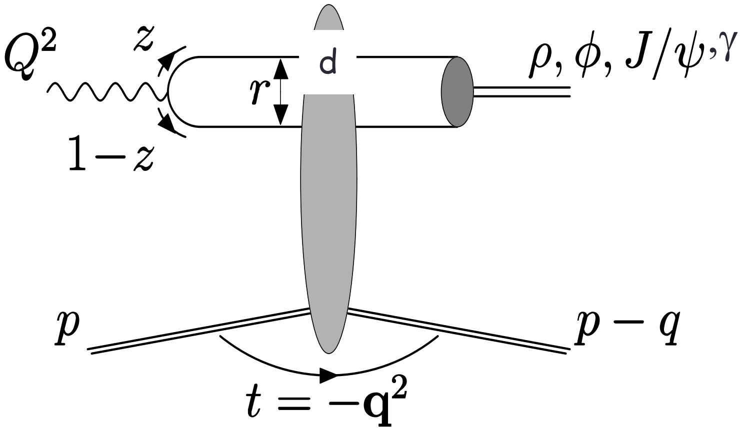
$$\theta_i \sim \frac{1}{(kR)}$$

Calculation of e-A diffraction



$$|t| \approx k^2\theta^2$$

Transverse imaging of the gluons nuclei

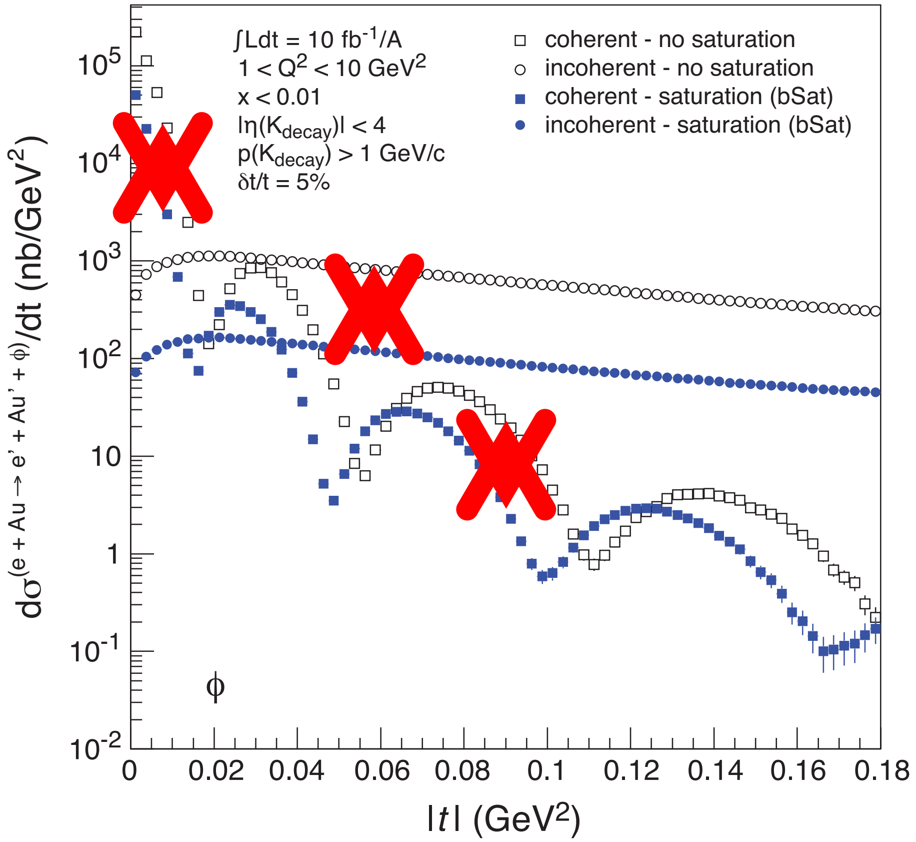


➔Does low x dynamics (Saturation) modify the transverse gluon distribution?

Experimental challenges being Studied.

Diffractive vector meson production in **e-Au**

Diff. MC: “Sartre”

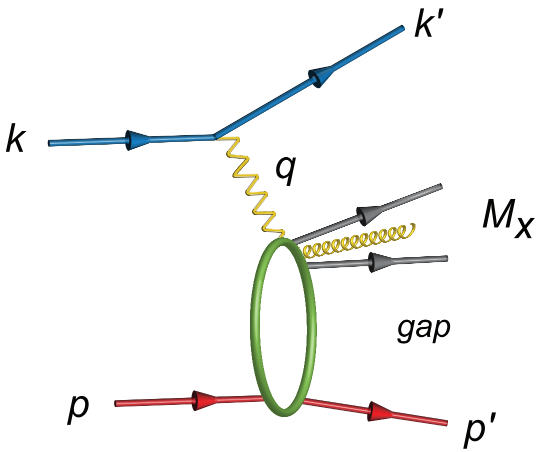


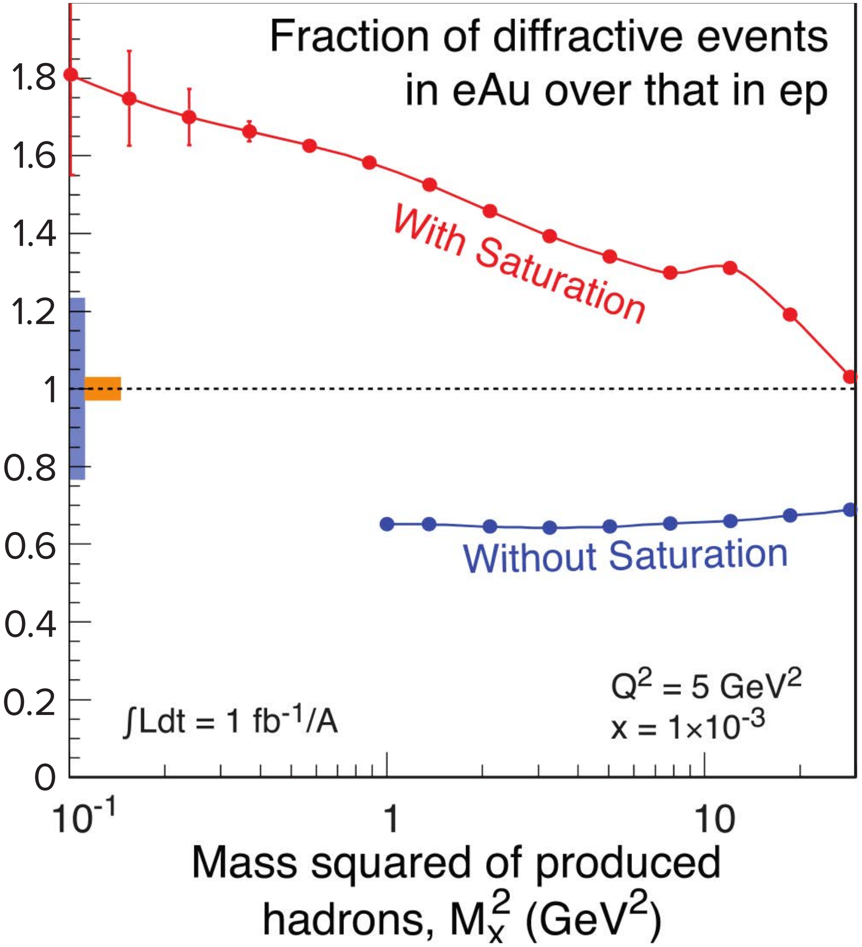
Simulation study by Toll & Ullrich

Saturation/CGC: What to measure?

Many ways to get to gluon distribution in nuclei, but diffraction most sensitive:

$$\sigma_{\mathrm{diff}} \propto [g(x, Q^2)]^2$$





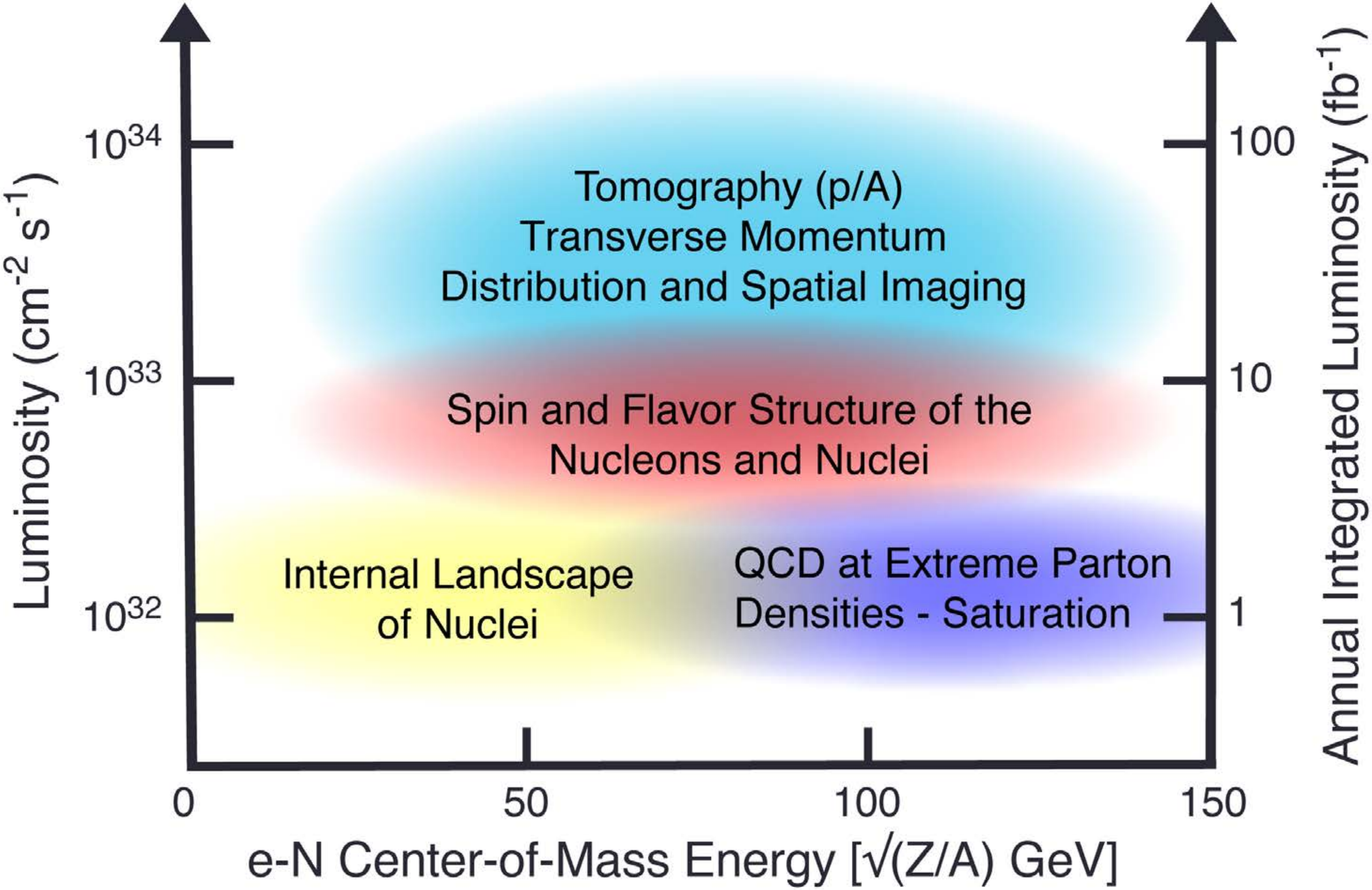
At HERA

ep: 10-15% diffractive

At EIC eA, if Saturation/CGC

eA: 25-30% diffractive

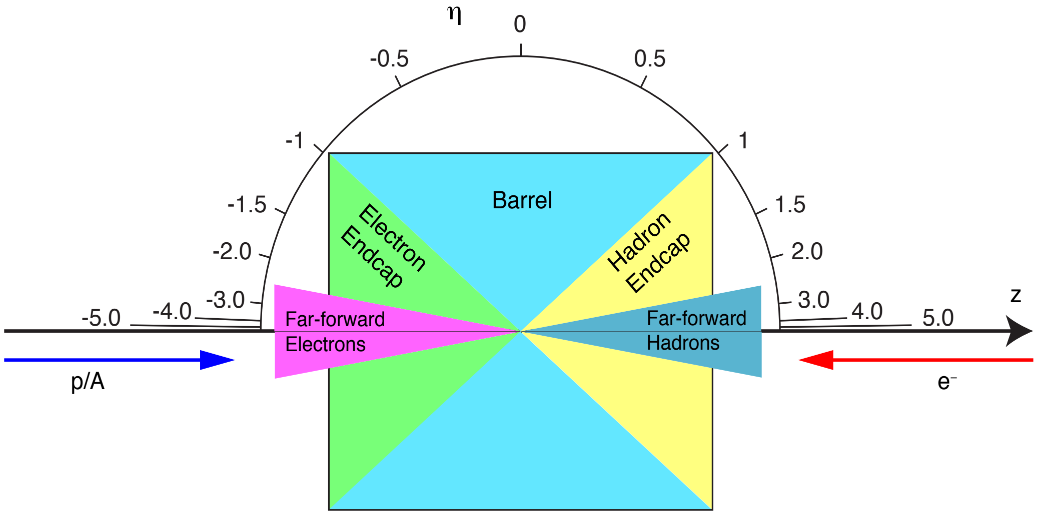
Summary: EIC Physics: CM vs. Luminosity vs. Integrated luminosity

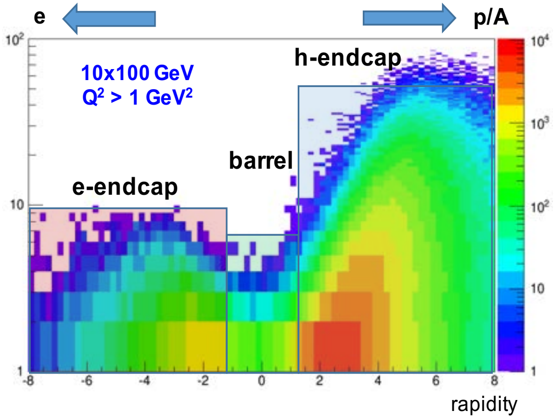


Requirement are mostly site-independent with some slight differences in the forward region (IR integration)

In Short:

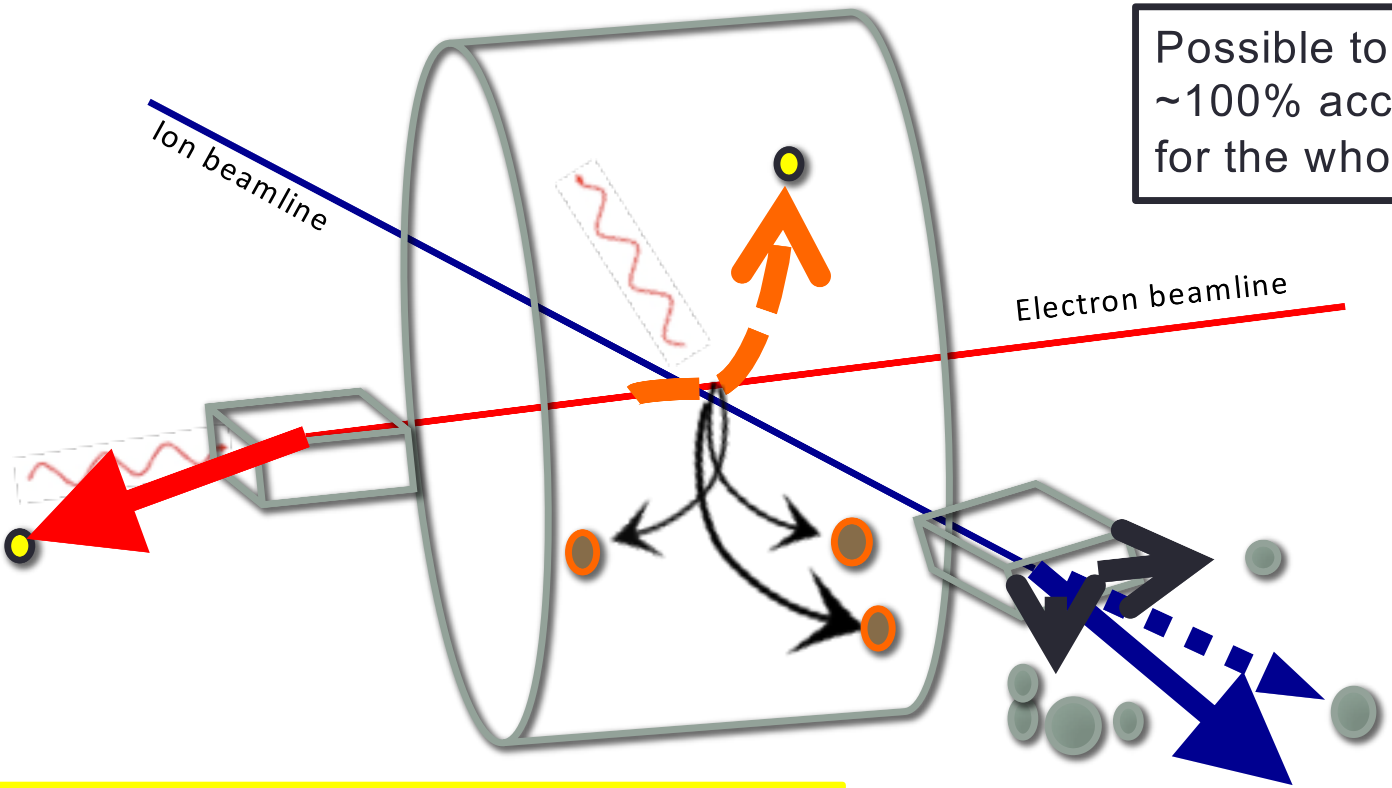
- Hermetic detector, low mass inner tracking, good PID (e and π/K/p) in wide range, calorimetry
- Moderate radiation hardness requirements, low pile-up, low multiplicity





Curtsey of Thomas Ullrich

Detector integration with the Interaction Region accelerator components:



Possible to get ~100% acceptance for the whole event

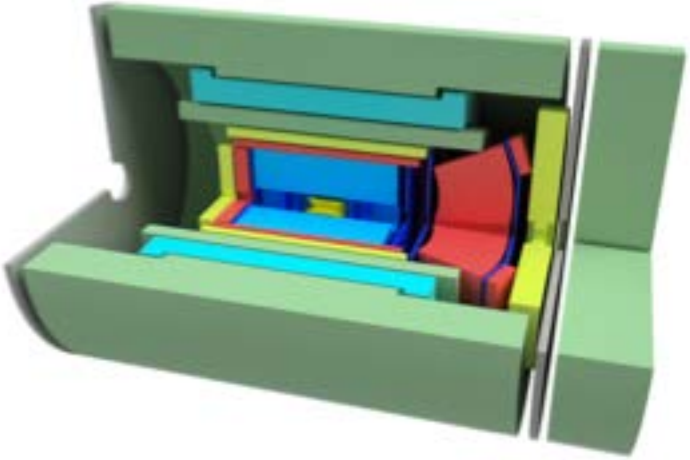
Total acceptance detector (and IR)

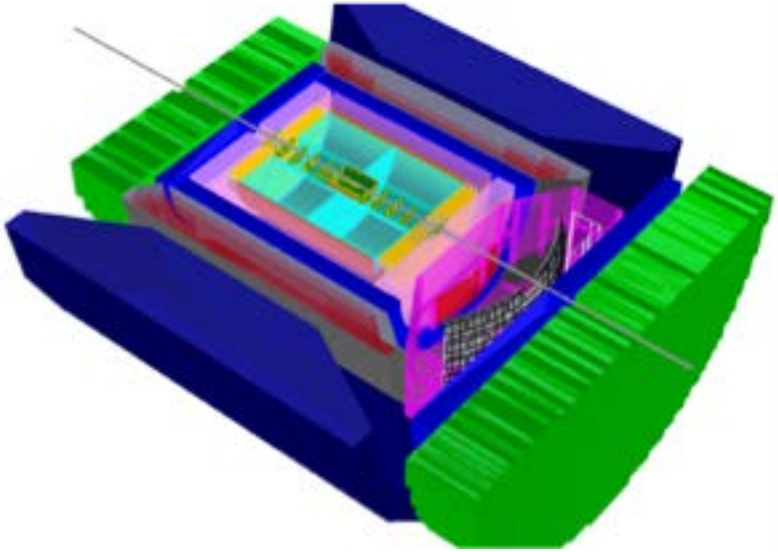
Crossing angles:
eRHIC: 10-22 mrad
JLEIC : 40-50 mrad

Figure Courtesey: Rik Yoshida

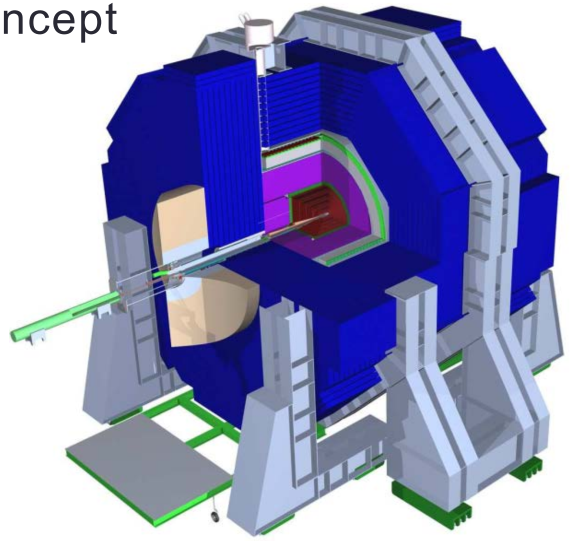
EIC Detector Concepts

EIC Day 1 detector

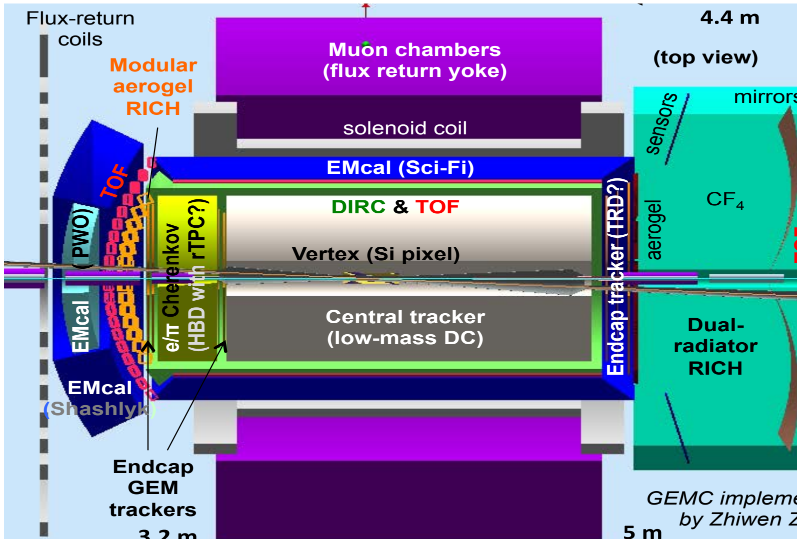




ANL's: "SiEIC Detector" Si-tracker & Precision calorimetry: particle flow detecor concept



JLEIC Det



REALIZATION….

Detector R&D program + EIC User Group formation ➔ Seeds for future experimental collaboration

Current Detector Design Ideas

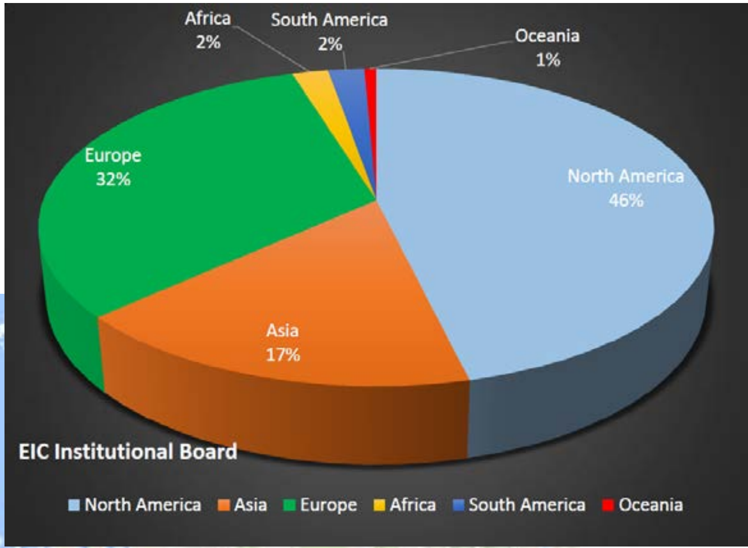
The National Academy of Science (NAS- NRC) Review

The EIC Users Group: EICUG.ORG

(no students included as of yet)

788 collaborators, 29 countries, 169 institutions... (June 2018)

Map of institution's locations



New physics for EIC beyond the White Paper:

- Impact of super-precise PDFs in $x > 0.0$, $1 < Q^2 < 100$ GeV^2 for future Higgs studies (some insight through LHeC studies, but serious effort on EIC beginning now).
- What role would TMDs in e-p play in W-Production at LHC?

- Heavy quark and quarkonia (c, b quarks) studies beyond HERA, with 100-1000 times luminosities (??) Does polarization of hadron play any role?

- Quark Exotica: 4,5,6 quark systems…?

- Internal structure of jets with variability of CM 50-140 GeV^2, in comparison with HERA, Tevatron & LHC energies, and with controlled electron & proton polarizations (jet fragmentation studies) aided by knowledge from e+e- physics at BaBar/Belle & in future Super-Belle ("Collins Functions")
- Jet propagation in nuclei… energy loss in cold QCD medium: a topic interest

- Initial state affects QGP formation!….. p-A, d-A, A-A at RHIC and LHC: many puzzles

- Gluon TMDs at low-x!

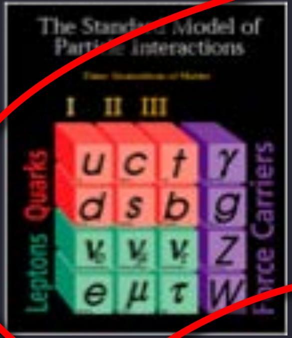
  See: http://www.lnf.infn.it/conference/2016/3DPDF/scientific-topics.php

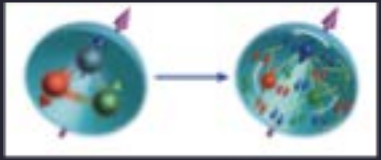
Path forward for the EIC:

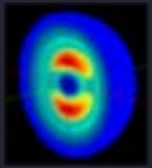
- DOE sanctioned a science Review by National Academy of Science of EIC
  - Expect report **by April/May 2018**

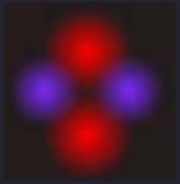
- Positive NAS review will trigger the DOE's CD process
  - CD0 (acceptance of the critical need for science by DOE) FY19
  - EIC-Proposal's Technical & Cost review → FY20 (site selection)(/)
  - CD1 requires site selection
  - **Major Construction funds ("CD3") by 2022/23"**
    - Assuming 1.6% sustained increase over inflation of the next several years (Long Range Plan)
    - Consistent with the past 10 years of NP funding increases in the US

21st Century Nuclear Science: Probing nuclear matter in all Its forms & exploring their potential for applications



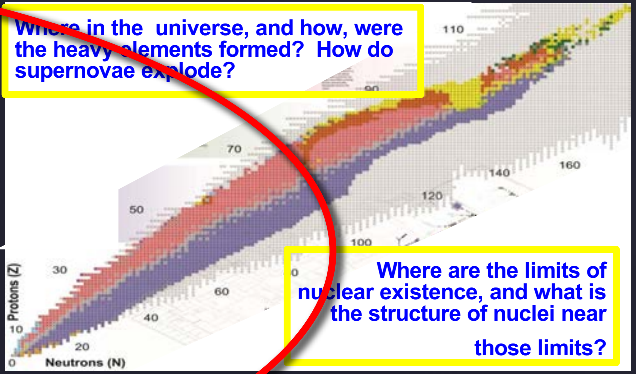




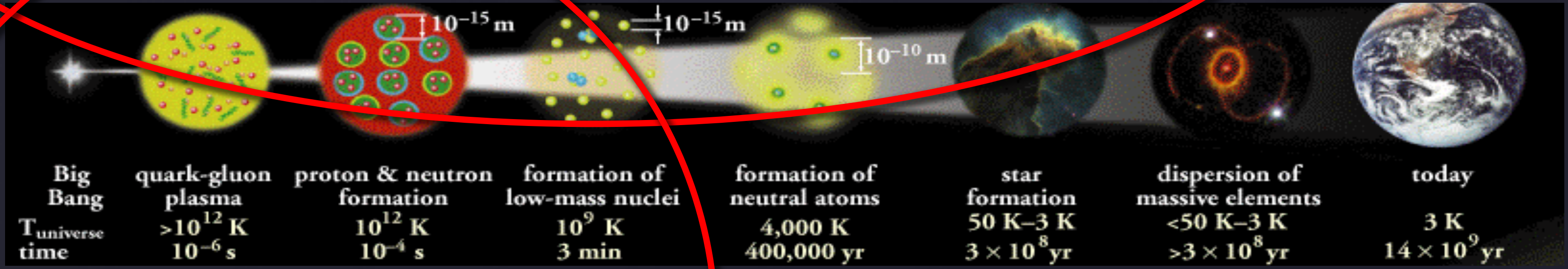


How are the properties of protons and neutrons, and the force between them, built up from quarks, antiquarks and gluons? What is the mechanism by which these fundamental particles materialize as hadrons?

Where in the universe, and how, were the heavy elements formed? How do supernovae explode?

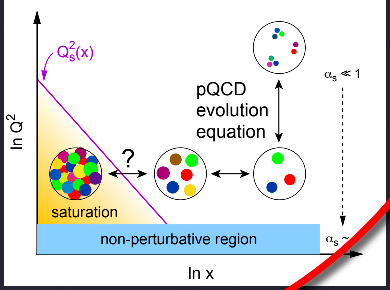


Where are the limits of nuclear existence, and what is the structure of nuclei near those limits?

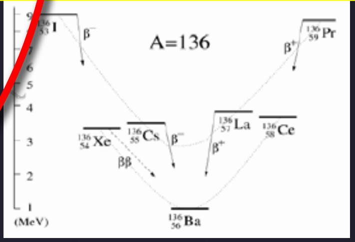


What is the nature of the different phases of nuclear matter through which the universe has evolved?

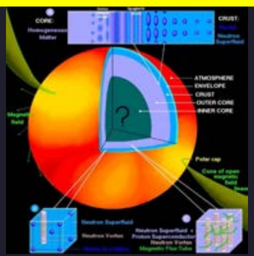
Do nucleons and all nuclei, viewed at near light speed, appear as walls of gluons with universal properties?



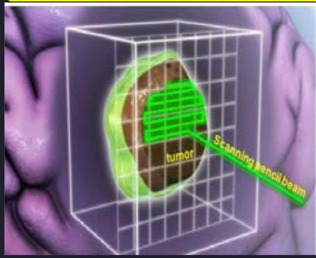
How can the properties of nuclei be used to reveal the fundamental processes that produced an imbalance between matter and antimatter in our universe?



How are the nuclear building blocks manifested in the internal structure of compact stellar objects, like neutron stars?



How can technologies developed for basic nuclear physics research be adapted to address society's needs?



Concluding thoughts & perspective:

The EIC (with its precision and control) will profoundly impact our understanding of the many body structure of nucleons and nuclei in terms of sea quarks & gluons → *The bridge between sea quark/gluons to Nuclei*

The EIC will enable IMAGES of yet unexplored regions of phase spaces in QCD with its high luminosity/energy, nuclei & beam polarization

→ *High potential for discovery*

Challenging accelerator and detector design and construction problems. Exciting opportunities for young people to get involved!

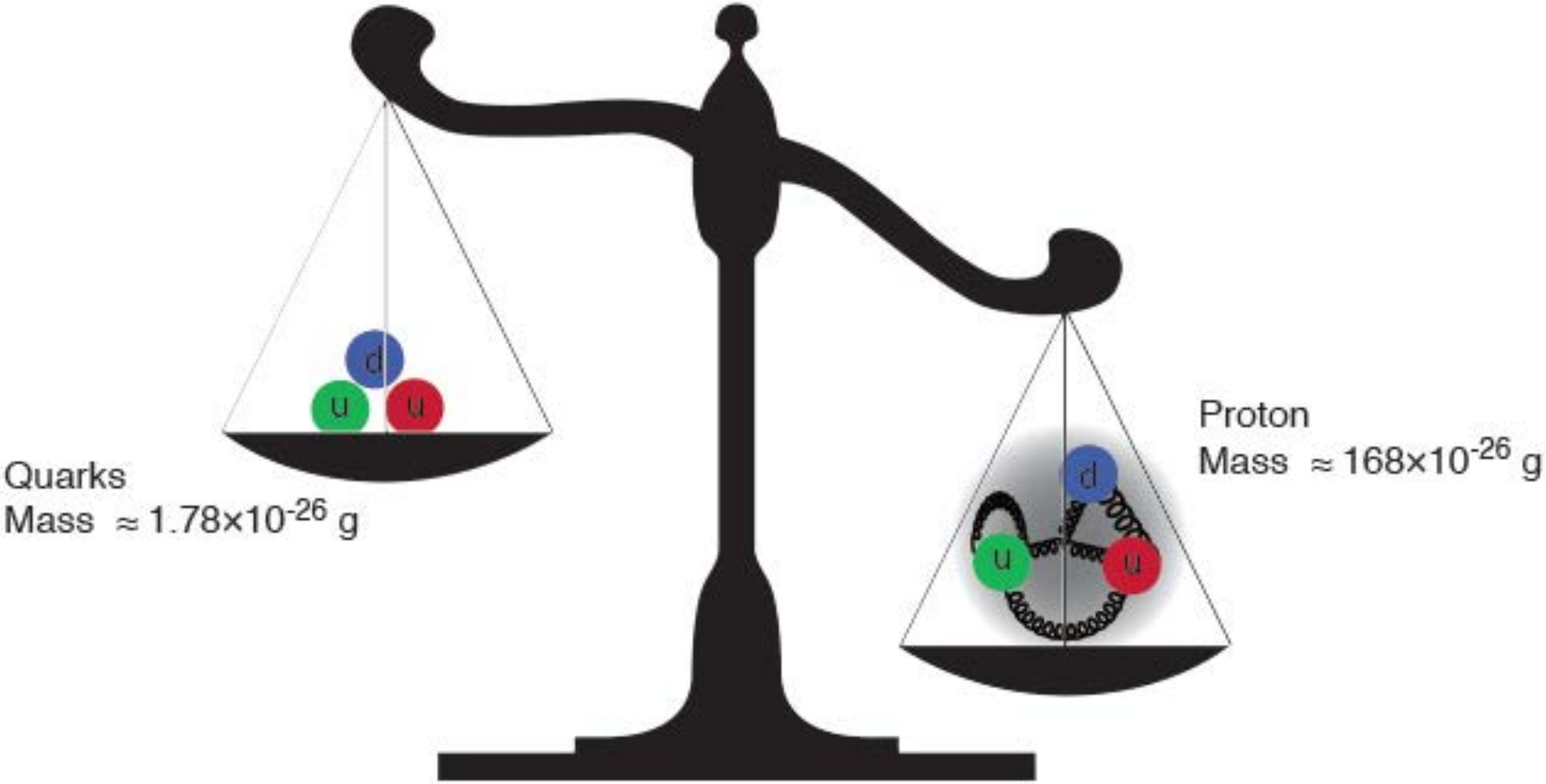
Project status: Positive National academy report → critical decision process at the DOE. Expect collisions in the later in 2020's

Now is the time to explore, get involved and influence the physics program, detector design or accelerator deliverables according to your intellectual interests!

EIC Users Group has been formed: eicug.org

Please register yourself as a user of this group
Next July 31-Aug 4, 2018 at Catholic American University, Washington DC

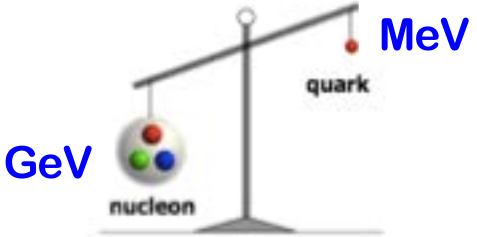
Thank you.

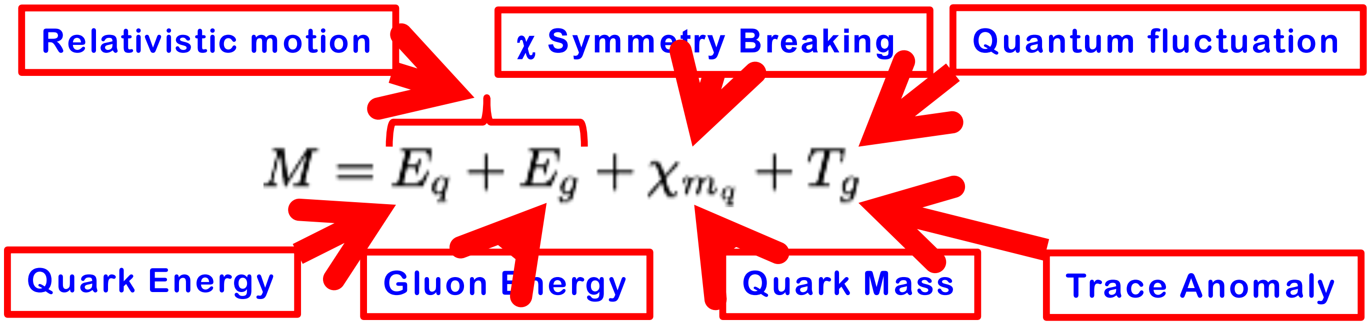


Gluons are massless…yet their dynamics is responsible for (nearly all) the mass of visible matter

The Higgs “God particle” is responsible for quark masses ~ 1-2% of the proton mass.

Understanding Nucleon Mass





Relativistic motion

χ Symmetry Breaking

Quantum fluctuation

$$M = \overbrace{E_q + E_g} + \chi_{m_q} + T_g$$

Quark Energy

Gluon Energy

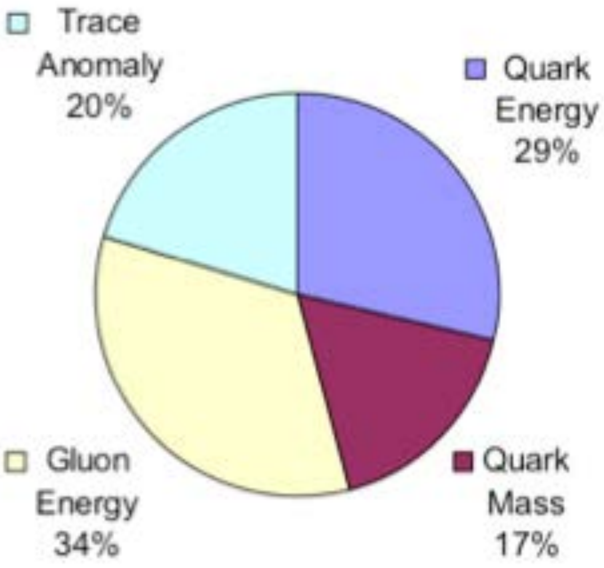
Quark Mass

Trace Anomaly

> "… The vast majority of the nucleon's mass is due to quantum fluctuations of quark-antiquark pairs, the gluons, and the energy associated with quarks moving around at close to the speed of light. …"

The 2015 Long Range Plan for Nuclear Science

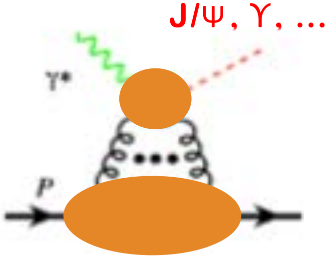
❑ Preliminary Lattice QCD results:



❑ EIC's expected contribution in:

- ✧ Trace anomaly:

  Upsilon production near the threshold

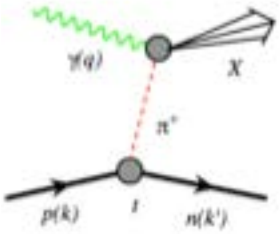


- ✧ Quark-gluon energy:

  $\propto$ *quark-gluon momentum fractions*

  In nucleon with DIS and SIDIS

  In pions and kaons with Sullivan process



THANK YOU

Thanks to many of my EIC Collaborators and Enthusiasts who led many of the studies presented in this talk

See: arXiv:1108.1713, D. Boer et al.

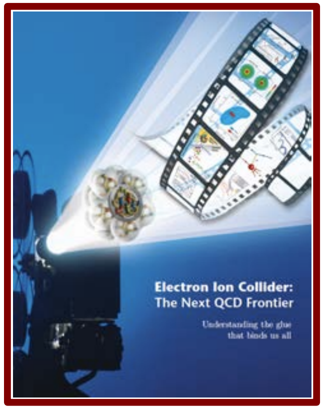
Without the EIC White Paper Writing Group the EIC White Paper would not have existed.
Special thanks to Dr. Jianwei Qiu and Prof. Zein-Eddine Meziani, my Co-Editors for the EIC White Paper
See: arXiv:1212.1701.v3 , A. Accardi et al.
Eur. Phy. J. A 52, 9 (2016)

The eRHIC and JLEIC machine design teams

Also gratefully acknowledge recent input from: M. Diefenthaler, R. Ent, R. Milner, R. Yoshida

Gluons and the quark sea at high energies: distributions, polarization, tomography

Institute for Nuclear Theory • University of Washington, USA
September 13 to November 19, 2010

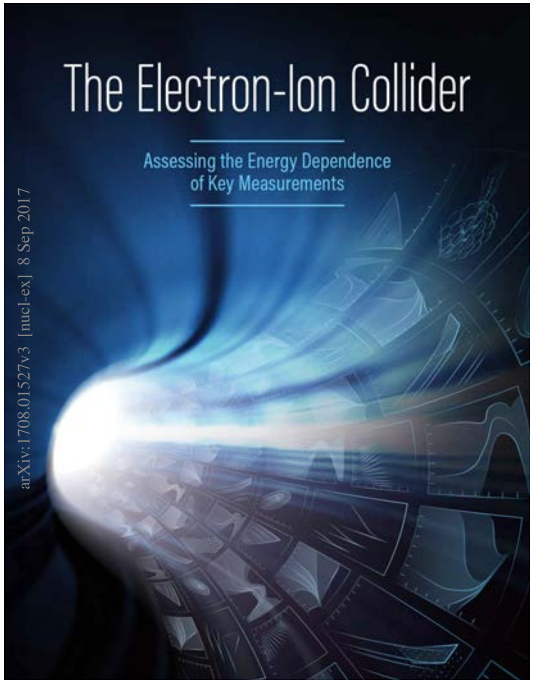


Electron Ion Collider:
The Next QCD Frontier

Understanding the glue
that binds us all

Advantages of (high) energy:

- Precision measurement of proton spin
- Spatial imaging of quarks and gluons
- Charged current interactions as probe of nucleon structure
- Nuclear Structure function
- Gluon saturation studies in nuclei
    - Di-hadron suppression
    - Diffraction
- Physics with Jets:
    - Hadronization, parton shower evolution in strong color fields, dijets, diffractive dijets, photon structure, gluon helicity….



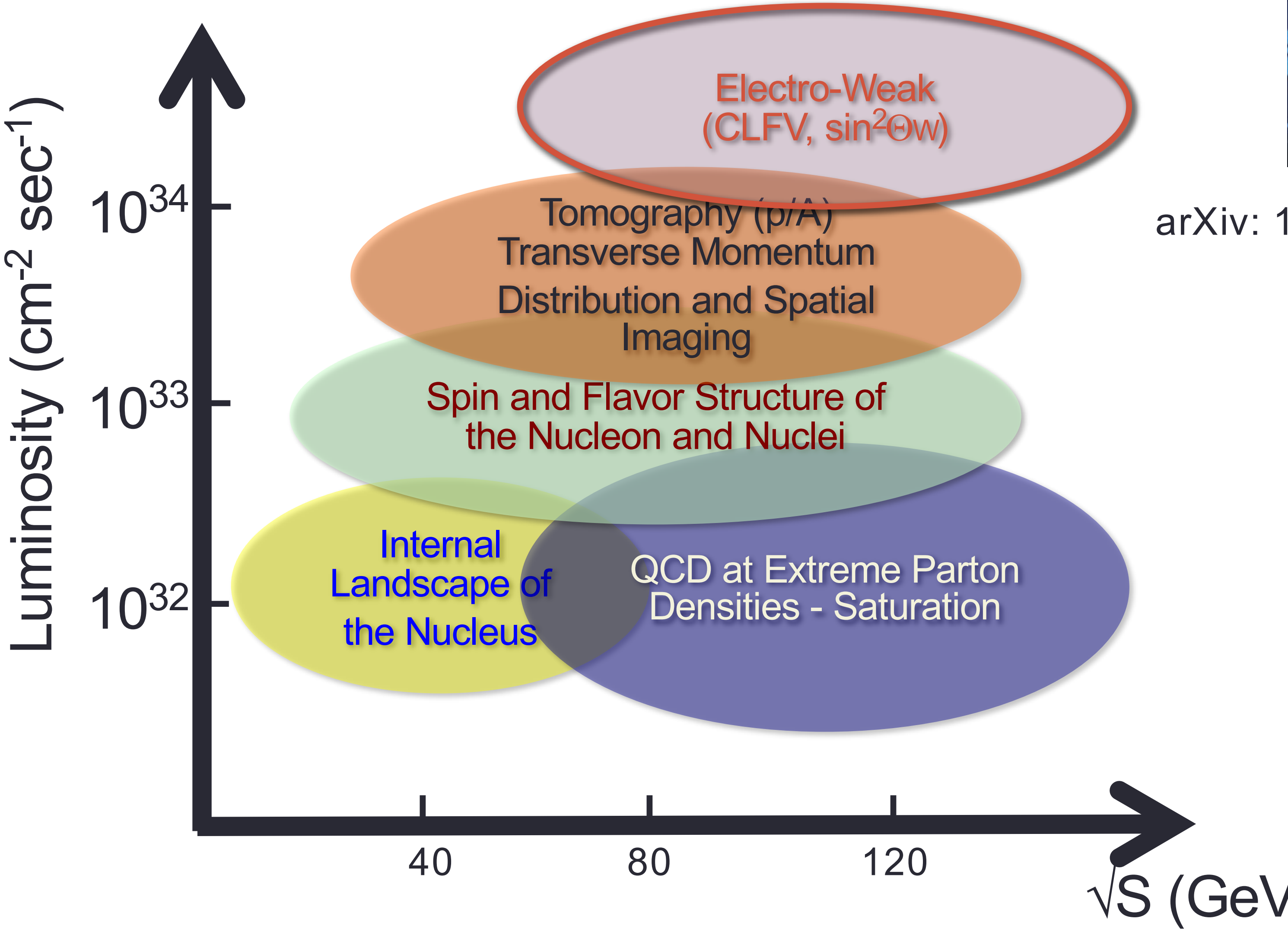
The Electron-Ion Collider

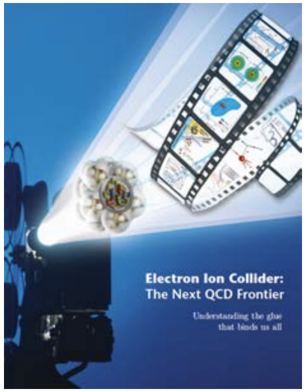
Assessing the Energy Dependence of Key Measurements

arXiv:1708.01527v3 [nucl-ex] 8 Sep 2017

arXiv:1708.01527
E. Aschenauer et al.

Physics vs. Luminosity & Energy





arXiv: 1212.1701.v3