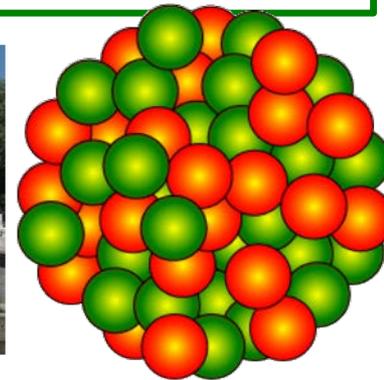
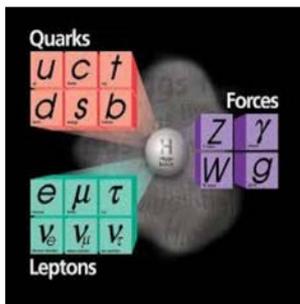


# Electron Ion Collider: The next QCD frontier

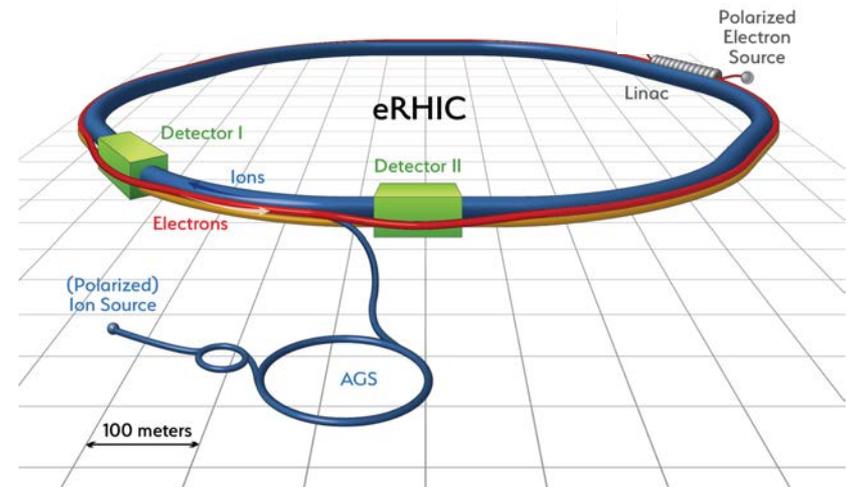
*Understanding the Glue that Binds Us All*

Why the EIC? → “Gluon Imaging”  
To understand the role of gluons in binding  
quarks & gluons into Nucleons and Nuclei

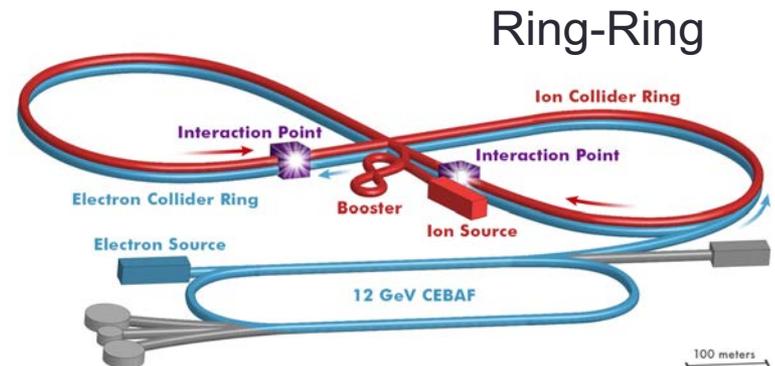


# The Electron Ion Collider

Two options of realization!



Not to scale



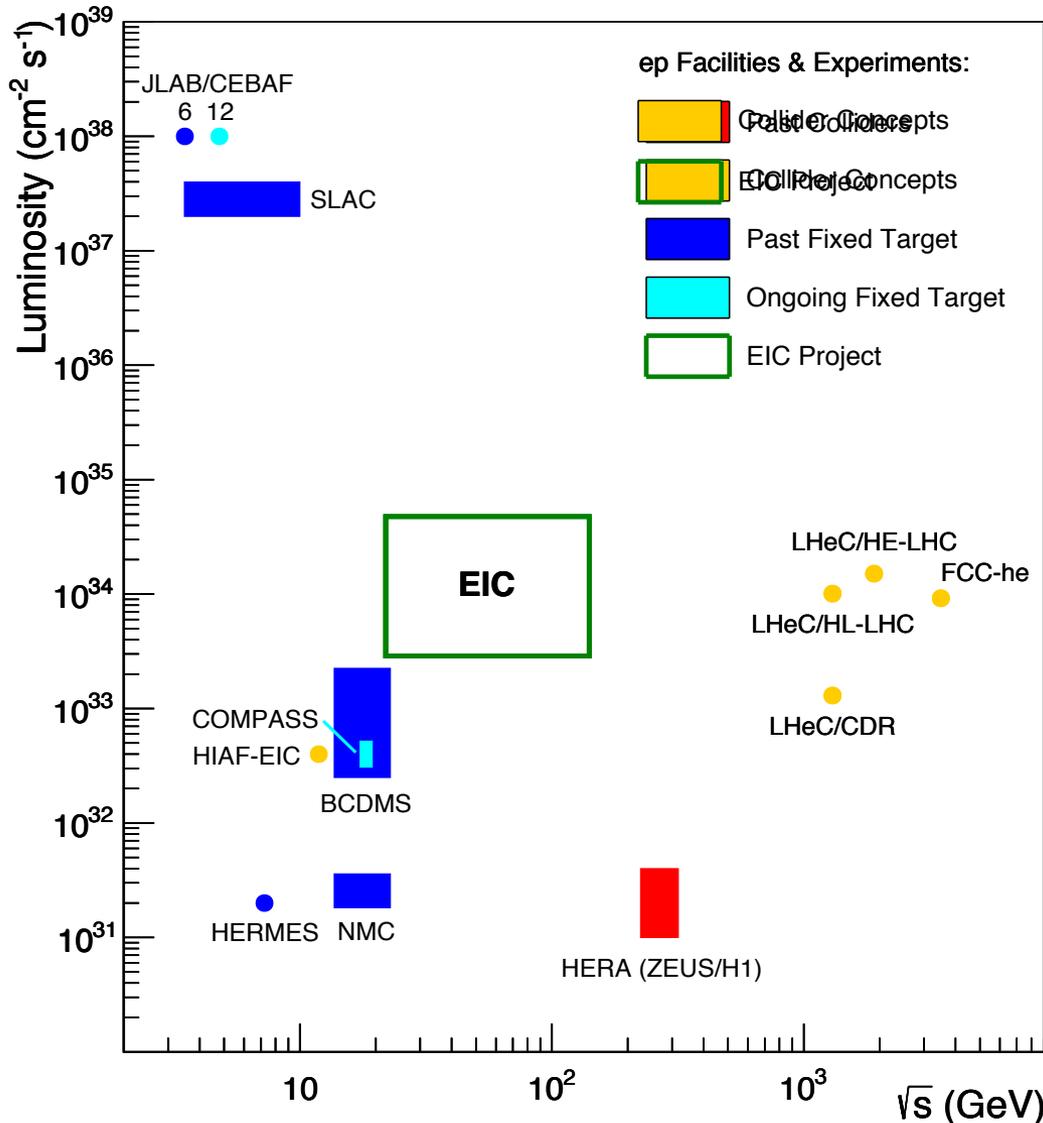
**Electron Ion Collider:  
The Next QCD Frontier**

Understanding the glue  
that binds us all

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

SECOND EDITION

# Uniqueness of EIC among all DIS Facilities



All DIS facilities in the world.

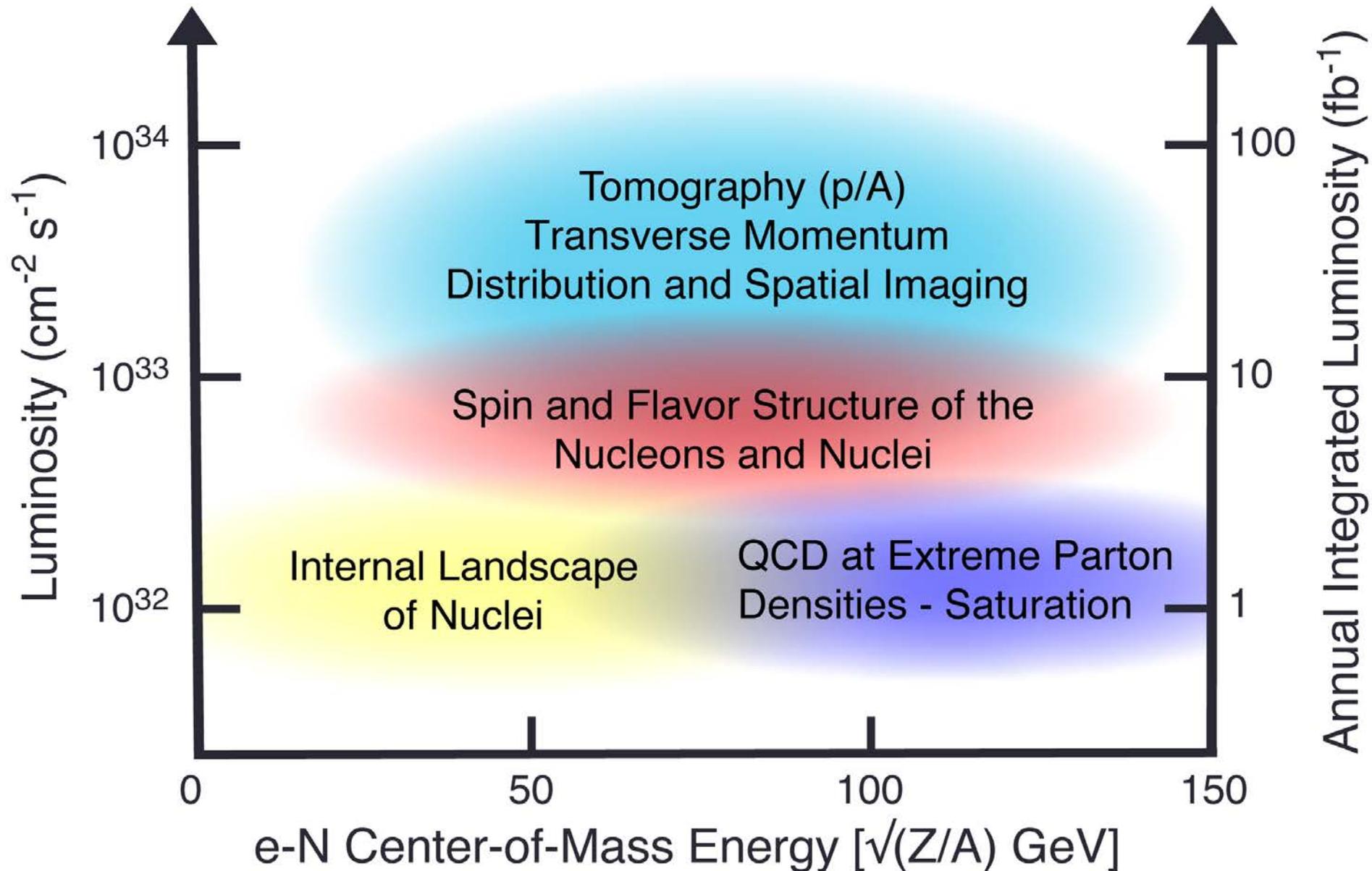
However,  
if we ask for:

- high luminosity & wide reach in  $\sqrt{s}$
- polarized lepton & hadron beams
- nuclear beams

**EIC stands out as unique facility ...**

# Summary: EIC Physics:

## CM vs. Luminosity vs. Integrated luminosity



## REACHING FOR THE HORIZON



The Site of the Wright Brothers' First Airplane Flight



# The 2015 LONG RANGE PLAN for NUCLEAR SCIENCE



### 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:**

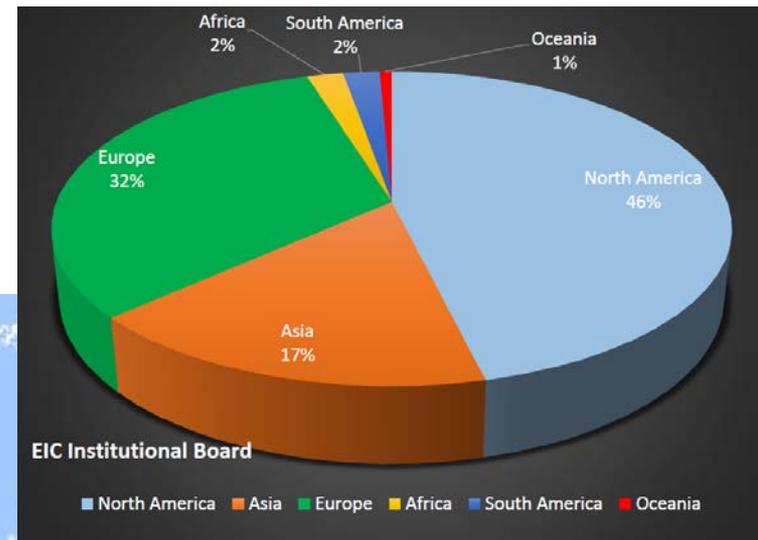
NEW Money for EIC Accelerator R&D already assigned \$7m/yr

# The EIC Users Group: [EICUG.ORG](http://EICUG.ORG)

(no students included as of yet)

**822 collaborators, 30 countries, 173 institutions... (October 2018)**

Map of institution's locations



## A very strong endorsement of the EIC

July 2018

Paved the way for the DOE to initiate the process of granting a CD0

**Finding 1:** An EIC can uniquely address three profound questions about nucleons—neutrons and protons—and how they are assembled to form the nuclei of atoms:

- How does the mass of the nucleon arise?
- How does the spin of the nucleon arise?
- What are the emergent properties of dense systems of gluons?

**Finding 2:** These three high-priority science questions can be answered by an EIC with highly polarized beams of electrons and ions, with sufficiently high luminosity and sufficient, and variable, center-of-mass energy.

**Finding 3:** An EIC would be a unique facility in the world and would maintain U.S. leadership in nuclear physics.

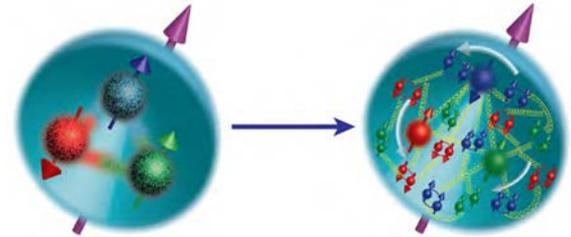
**Findings 4-9** go on to support the importance of accelerator research and science, societal impact, support for theory to fully benefit from the data expected from the EIC, and systematic approach of the US NP community in its planning process: EIC soon after FRIB....



# 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?

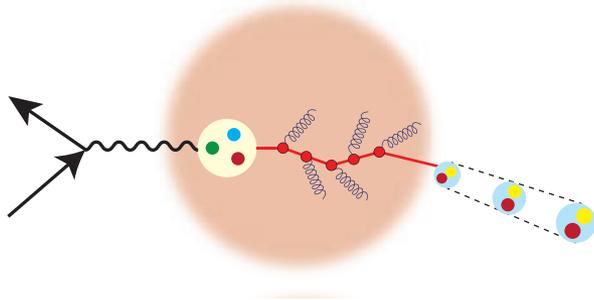
How do the **nucleon properties emerge** from them and their interactions?



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

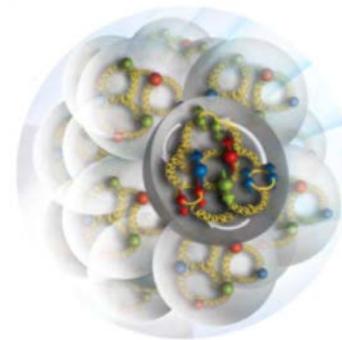
How do the **confined hadronic states emerge** from these quarks and gluons?

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?

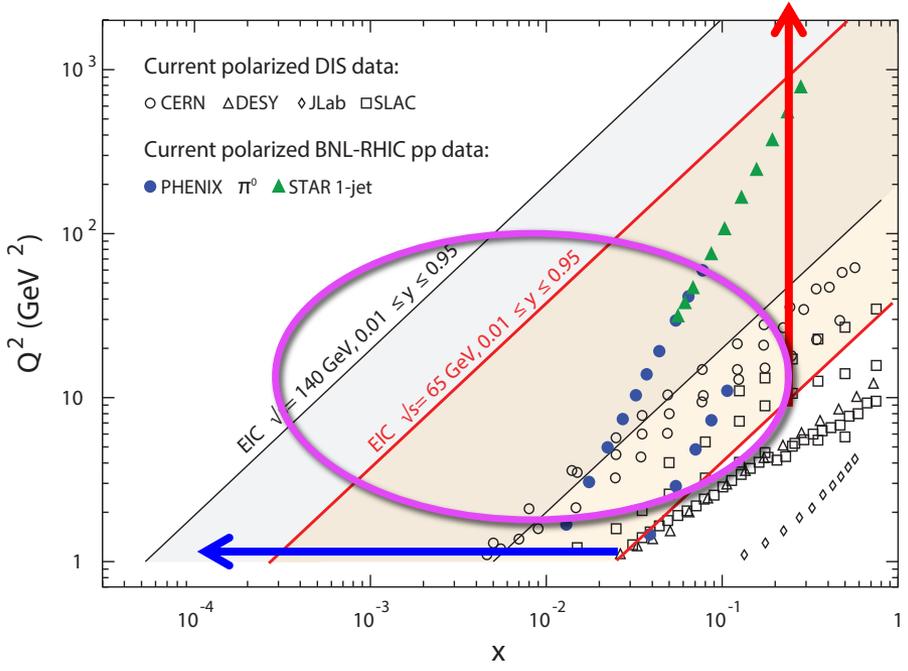


gluon  
emission

?

gluon  
recombination

# EIC: Kinematic reach & properties



- For e-N collisions at the EIC:**
- ✓ Polarized beams: e, p, d/<sup>3</sup>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)

