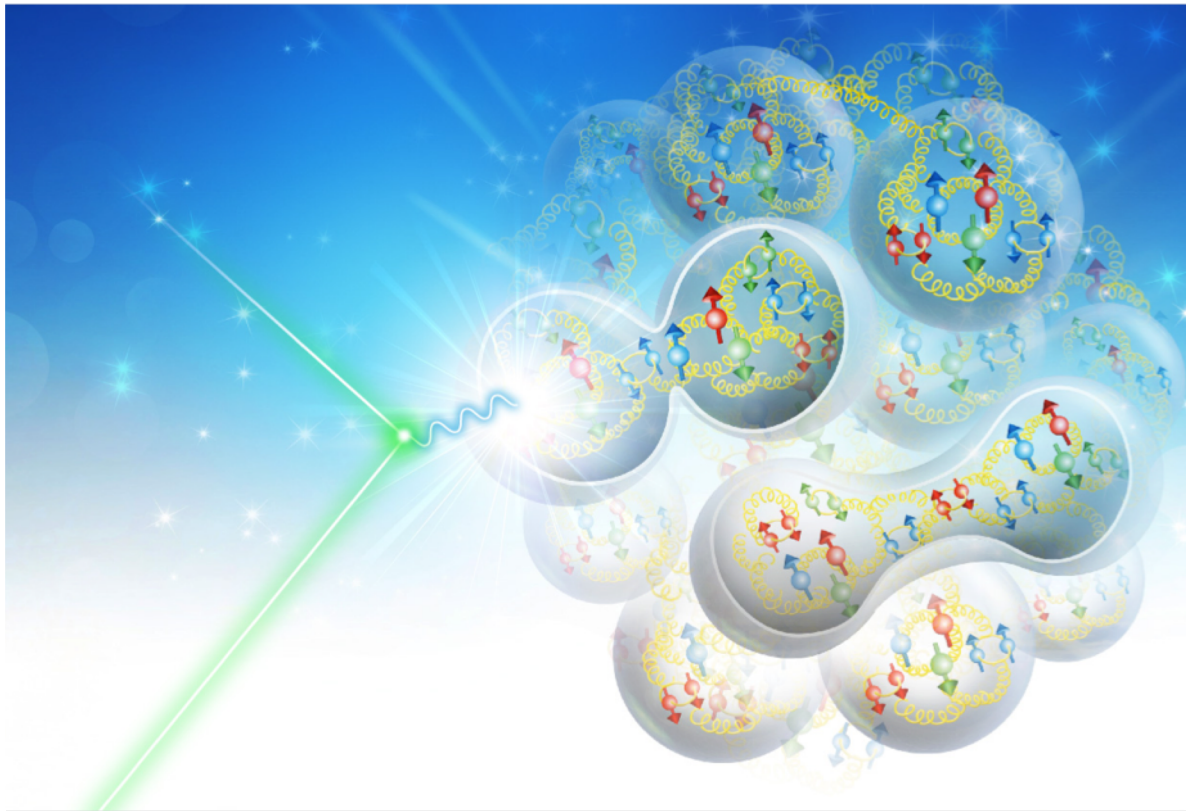
Introduction to Electron-Ion Collider

EIC Science Overview

EIC User Group Status

Open Science Grid

- Role in EIC project
- Support of EICUG initiative



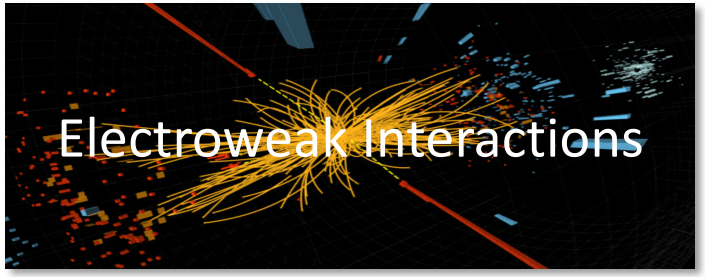
Markus Diefenthaler (Jefferson Lab)
on behalf of EICUG Software Working Group

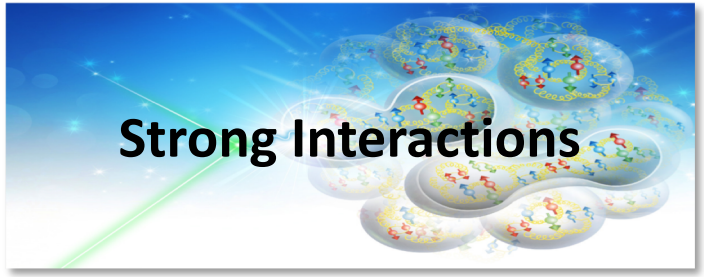
Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

The Standard Model of Physics



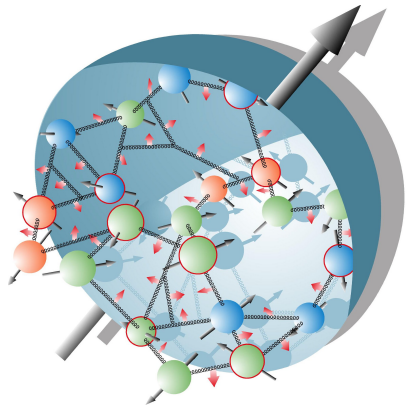


Further exploration of the Standard Model

Dark matter searches

Electroweak symmetry breaking

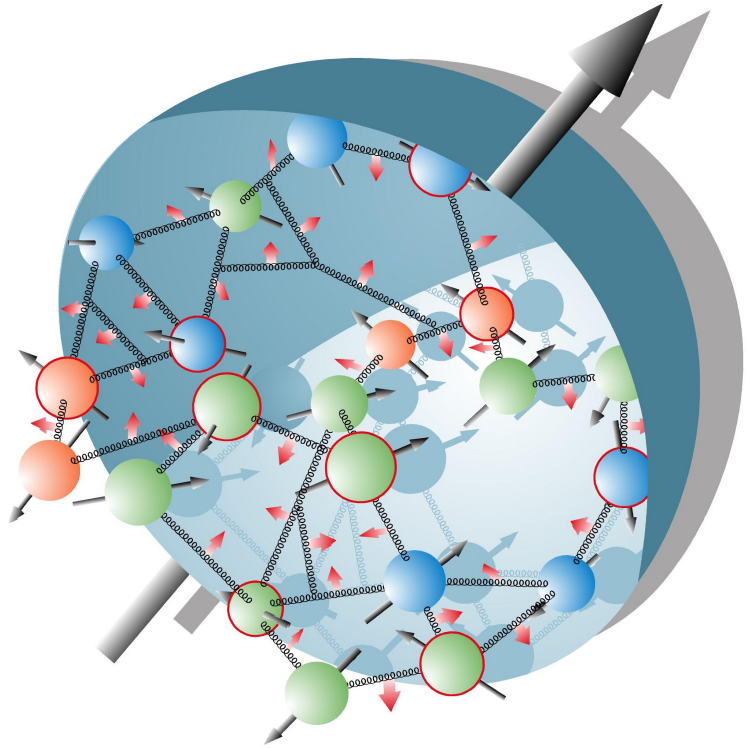
Deeper understanding of QCD:



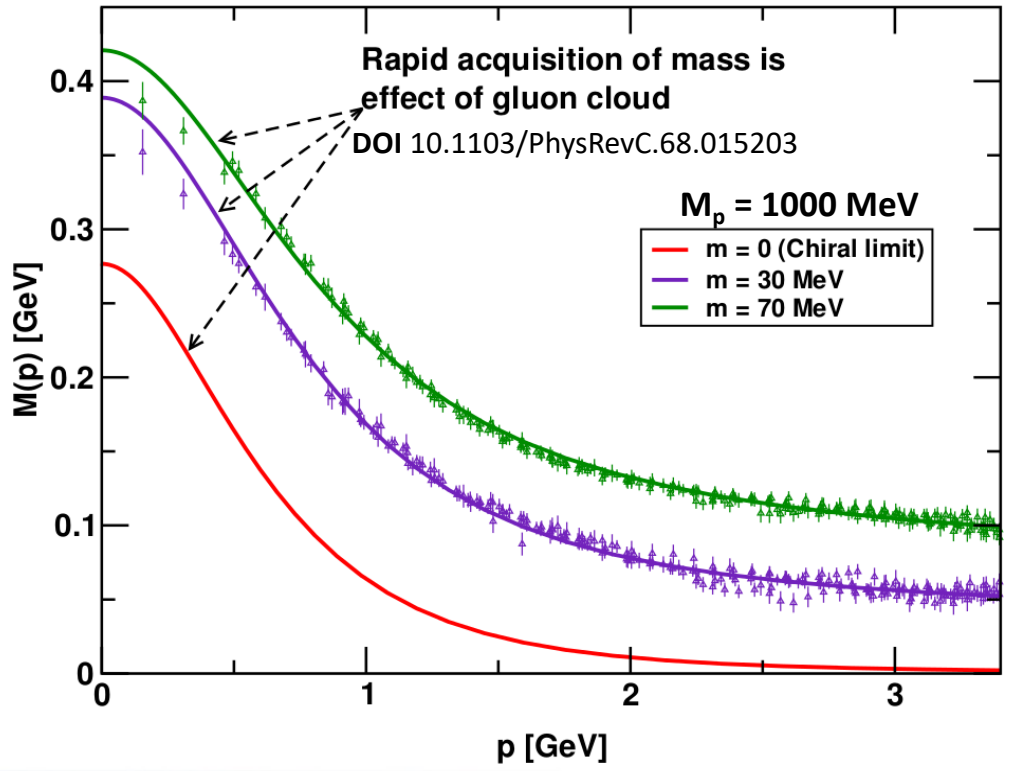
Study of nuclear matter

The dynamical nature of nuclear matter

Nuclear Matter Interactions and structures are inextricably mixed up



Observed properties such as mass and spin emerge out of the complex system



Ultimate goal Understand how matter at its most fundamental level is made

To reach goal precisely image quarks and gluons and their interactions

Nobel Prizes of Physics and EIC Science

Hideki Yukawa (1949) "for his prediction of the existence of mesons on the basis of theoretical work on nuclear forces"
But the quark-gluon origin of the nuclear binding force remains an unknown.

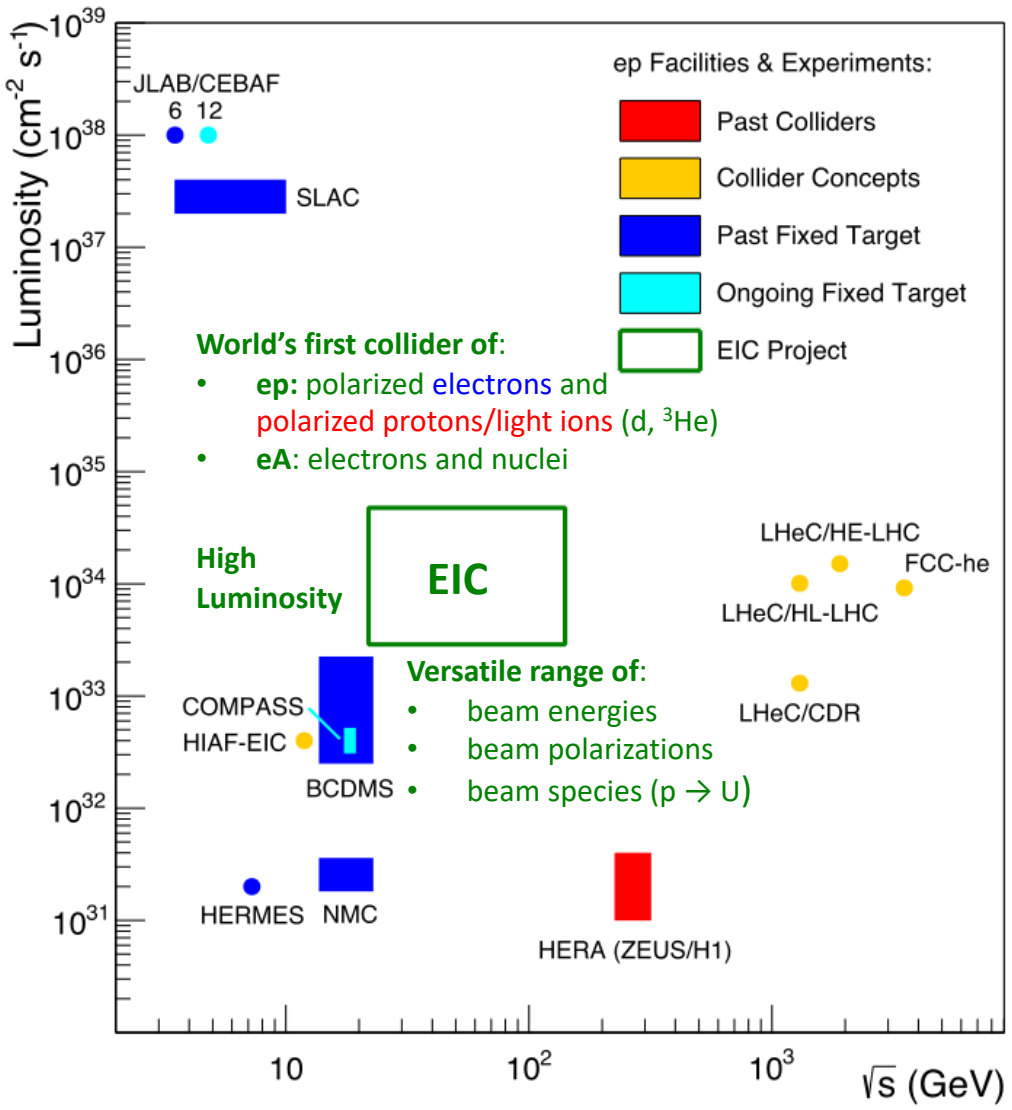
Robert Hofstadter (1961) "for his pioneering studies of electron scattering in atomic nuclei and for his thereby achieved discoveries concerning the structure of the nucleons"
But the 3D quark-gluon structure of nucleons remains an unknown.

Jerome Friedman, Henry Kendall, Richard Taylor (1990) "for their pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons, which have been of essential importance for the development of the quark model in particle physics"
But the role of gluons in protons and bound neutrons remains unknown.

David Gross, David Politzer, Frank Wilczek (2004) "for the discovery of asymptotic freedom in the theory of the strong interaction"
But the confinement aspect of the theory remains unknown.

Yoichiro Nambu (2008) "for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics "
But how dynamical chiral symmetry breaking shapes the mass and structure of quark-gluon systems remains unknown.

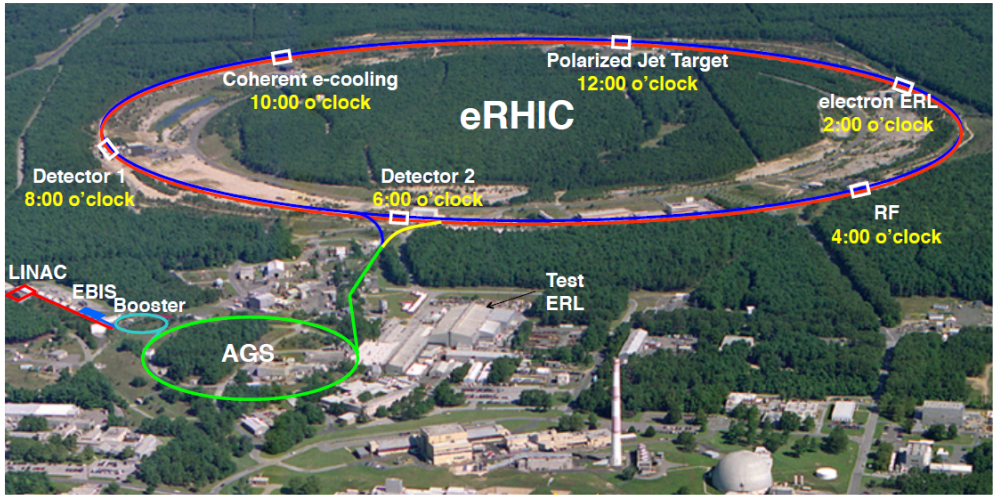
The Electron-Ion Collider: Frontier accelerator facility in the U.S.



Department of Energy

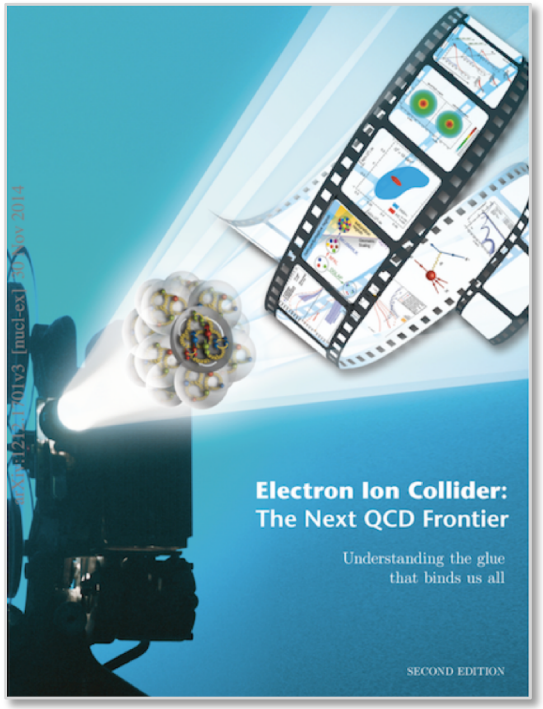
U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

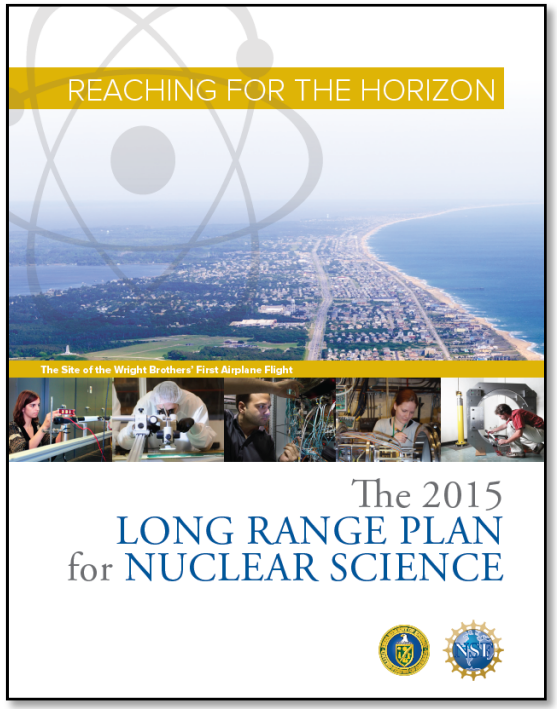
JANUARY 9, 2020

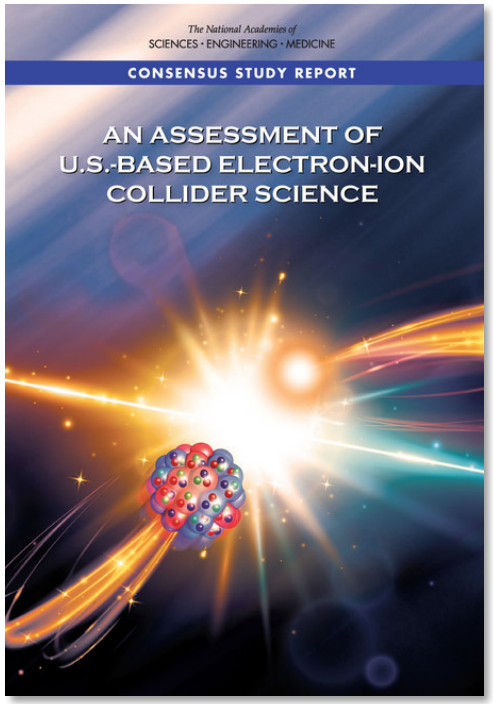


Thomas Jefferson National Accelerator Facility in Newport News, VA will be a major partner in realizing the EIC, and several other DOE laboratories are expected to contribute to EIC construction and to the groundbreaking nuclear physics research program that will be accomplished there.

Why an Electron-Ion Collider?







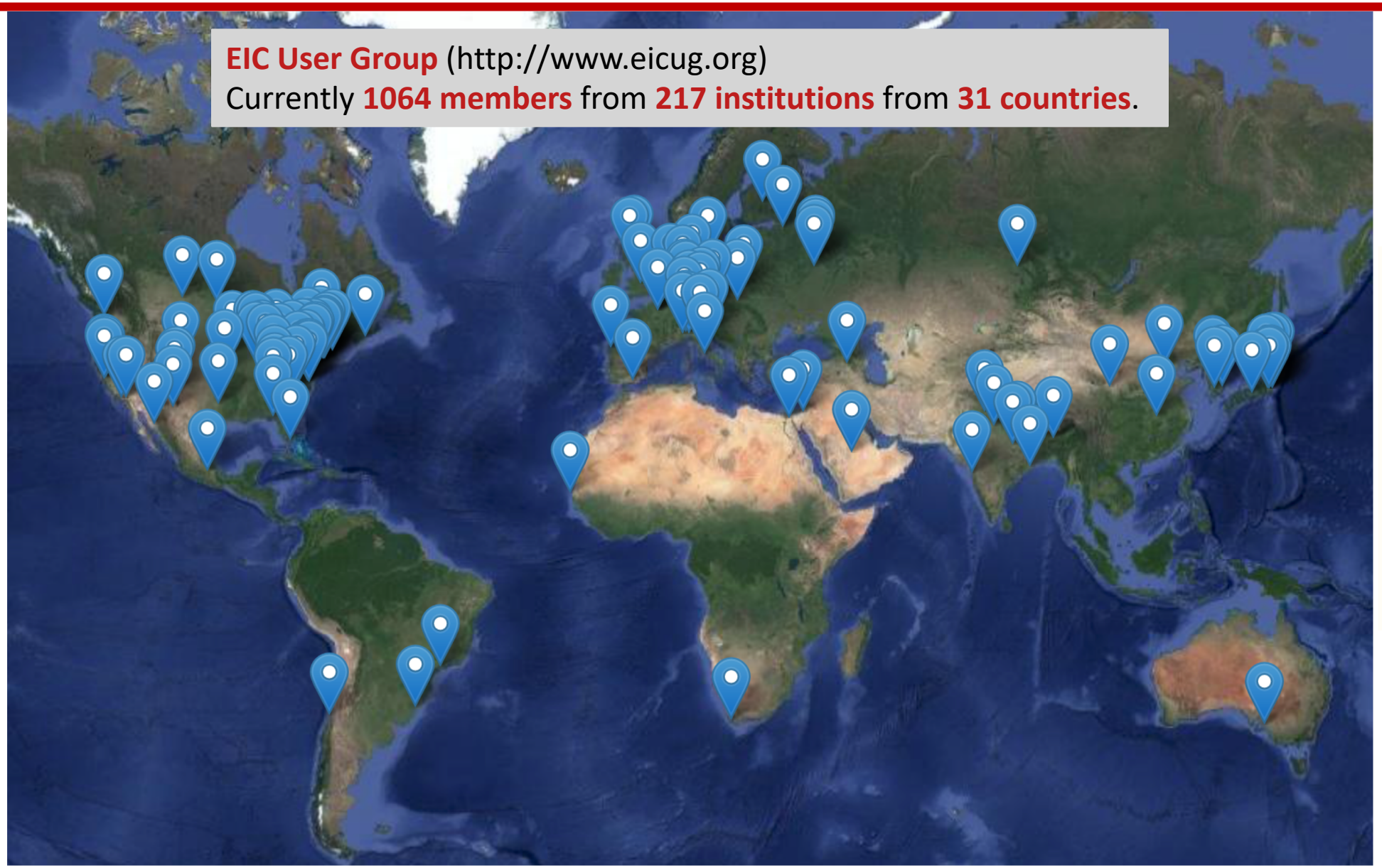
Right tool

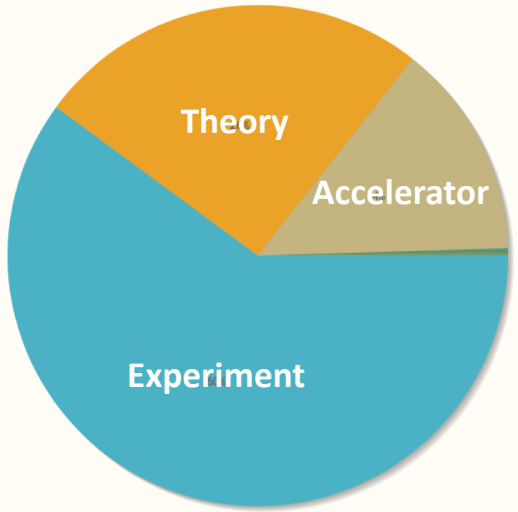
- to precisely **image quarks and gluons** and their interactions
- to explore the new **QCD frontier of strong color fields in nuclei**
- to understand **how matter at its most fundamental level is made**.

Understanding of nuclear matter is **transformational**,
perhaps in an even more dramatic way than how the understanding of the atomic and molecular structure of matter led to new frontiers, new sciences and new technologies.

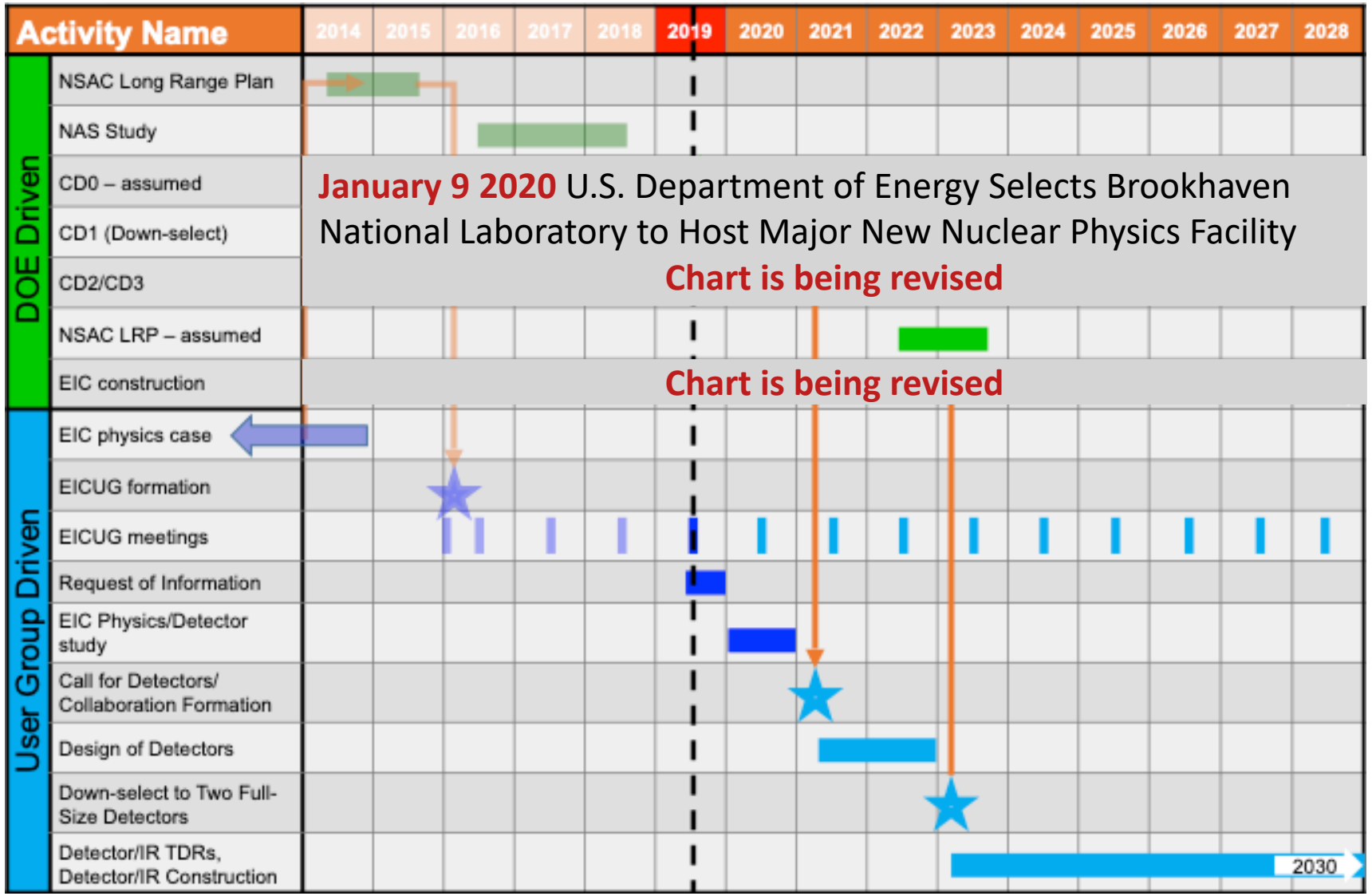
The worldwide EIC community

EIC User Group (http://www.eicug.org)
Currently **1064 members** from **217 institutions** from **31 countries**.





Timeline (currently being revised)



Yellow Reports Initiative

The purpose of the **Yellow Report Initiative** is to advance the state and detail of the documented physics studies (White Paper, INT program proceedings) and detector concepts (Detector and R&D Handbook) in preparation for the realization of the EIC. The effort aims to provide the basis for further development of concepts for experimental equipment best suited for science needs, including complementarity of two detectors towards future Technical Design Reports (TDRs).

Survey of computing needs (ongoing)

Please select your working group below for which you are submitting this request:	What is your estimated amount of remotely-accessible backed-up storage space for your working group in units of TB?	What CPU needs do you have?	Which CPU computing resources do you plan to use?
Physics WG: Exclusive Reactions	1	Only small amount of CPU power is required for our fast simulations. Each collaborator usually runs simulation on his Institution's nodes or personal computer. Therefore our major need is to have shared disk space rather than CPU.	both JLAB cluster, BNL cluster and locally available resources
Detector WG: Forward Detector / IR Integration	10	farm and jupyter notebook server	JLAB ifarm, RACF at BNL
Detector WG: Tracking	10	order of 100 core	expect HTC-like cpu
Detector WG: DAQ/Electronics	0.2	See next answer	400k CPU-hour for a total 10M events in full detector simulation
Physics WG: Semi-Inclusive Reactions	2	interactive nodes batch system at JLab and BNL.	50 cores continuous average
Physics WG: Jets and HQ	6	Heavy flavor estimates ~100,000 CPU hours for all simulation but may increase to ~600,000 or more if full Geant simu is needed	RCF or personal resources
Physics WG: Inclusive Reactions	100	It is hard to know right now as we haven't started to run our samples. But we will be producing several large Djangoh/Pythia samples so these are the primary CPU consumers.	It would be nice to use any job and batch submission infrastructure if possible
Physics WG: Diffractive Reactions and Tagging	2	20,000 cpu hours for yellow report work	split between BNL and JLab farms for manager simulations; smaller tasks will be done by individuals.

The role of the OSG in the Yellow Report Initiative

- The EIC User Group is international and so will the EIC Collaboration(s) be.
- The OSG with its strong support of NP science and experiments should be a part of the EIC.

- Discussion about OSG setup:
  - CVMFS:
    - Stratum 0 repository hosted by the OSG (currently at BNL and might remain there)
    - Stratum 1 repositories hosted by the BNL, JLAB, and other labs
    - Managed by EICUG
  - EIC VO:
    - Managed by the EICUG

- What could be setup? What timescale could be feasible?

Summary

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- Outstanding questions raised both by the science at HERMES/COMPASS/JLAB and RHIC/LHC, have naturally led to the science and design parameters of the EIC.
- EIC will enable us to embark on a **precision study of the nucleon and the nucleus at the scale of sea quarks and gluons**, over all of the kinematic range that are relevant.
- What we learn at JLAB 12 and later EIC, together with advances enabled by FRIB and LQCD studies, will open the door to **a transformation of Nuclear Physics**.
- The **Open Science Grid** can be a strong partner in realizing the EIC science.