The Inter-American network of networks of QCD challenges

AccelNet: ***Accelerating Research through International Network-to-Network Collaborations***

Design phase: *2021 – 2026*
Implementation phase 1: *2025 – 2029*

Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Daniel Tapia Takaki
Ottawa, Canada June 22, 2026

I·AN Inter-American Network of Networks QCD

Program goals

(1) Develop strategic partnerships across the various physics research networks in the Americas to tackle QCD challenges;

(2) Identify the needs, strengths and synergies of network partners for developing large scale science projects in the US;

(3) Design activities for researchers in the U.S., Canada, and Latin America that will facilitate leveraging complementary resources for QCD research, and

(4) Enhance the training of the next generation of researchers in a novel set of skills that include international multi-team experience.

I·AN Inter-American Network of Networks QCD

Research areas related to QCD

- Accelerator technologies
- Theory
- High performance computing
- Particle detectors, instrumentation and electronics
- Real-time event selection
- Software development, and development of Monte Carlo simulation
- AI and QIS tools

Leveraging resources to support the community of communities

Kick-off meeting at CFNS on Dec 16, 2021
120 participants
https://indico.bnl.gov/event/13562/

I·AN Inter-American Network of Networks QCD

List of invited networks

We are an open network: future networks can also participate

- Electron-Ion Collider User Group
- Jefferson Lab Users Association
- RHIC and AGS User's Group
- US LHC Users Association
- Association of Latin American Nuclear Physics and Applications (ALAFNA),
- Southeastern Universities Research Association (SURA)
- Latin American Association for High Energy, Cosmology and AstroParticle Physics
- Nuclear Physics and Applications (INCT-FNA)
- Rede Nacional de Física de Altas Energias (RENAFAE)
- Mexican Particle Accelerator Community (CMAP)
- EIC-Canada Collaboration
- California EIC Consortium

I·AN Inter-American Network of Networks QCD

List of invited network partners

We are an open network: future networks can also participate

- Center for Frontiers in Nuclear Physics (CFNS) at Stony Brook University & Brookhaven National Laboratory
- The Electron-Ion Collider Center at Jefferson Lab
- Center for Accelerator Science at Old Dominion University
- The ICTP South American Institute for Fundamental Research (ICTP-SAIFR)
- Canadian Institute of Nuclear Physics
- TRIUMF. Canada's Particle Accelerator Center
- The Institute of Nuclear Theory
- Center for Nuclear Femtography
- EIC Theory Institute at BNL

I·ANNQCD Inter-American Network of Networks

New phase of the program from September 2025

Track 1:

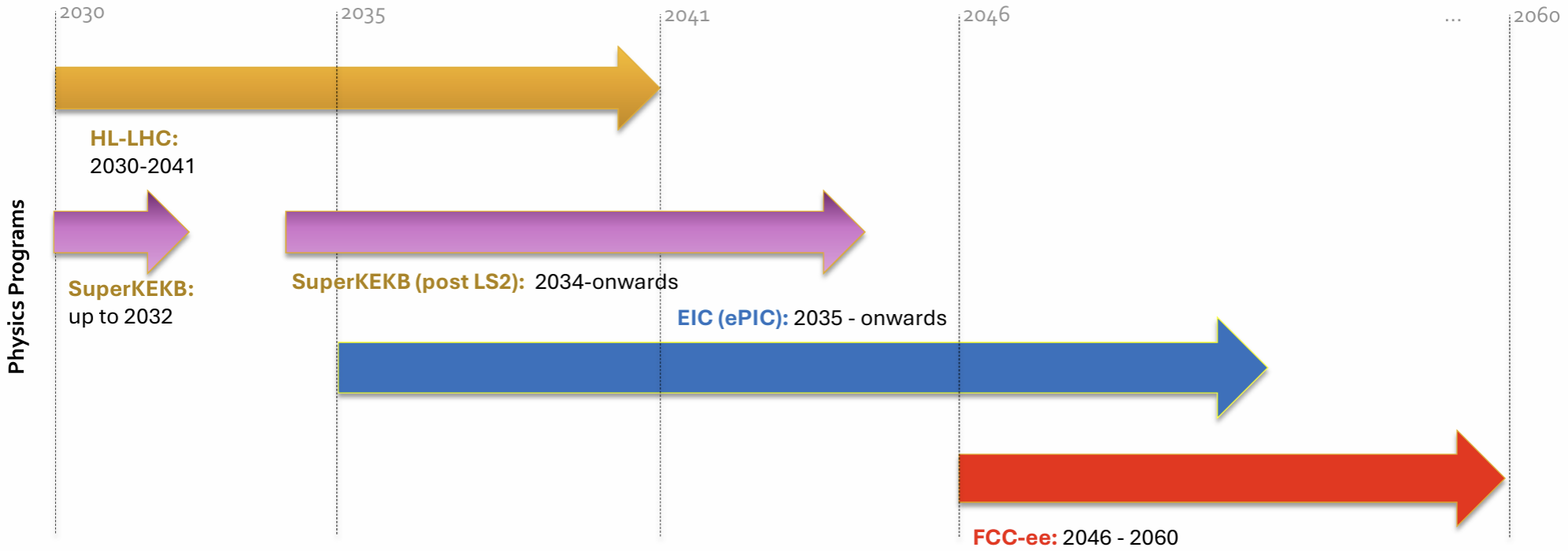
- Early career researchers workshop
- Bi-national or international meetings aligned to I.ANNQ QCD objectives
- Use case workshops (AI/QIS, detector R&D, theory-focused, etc)
- Short courses and mentoring sessions
- I.ANN QCD Summit, including science diplomacy

Track 2:

- Visiting and exchange programs
- QCD ambassadors program

New activities from 2025 based on community inputs from the initial phase!

Timelines for New Colliders



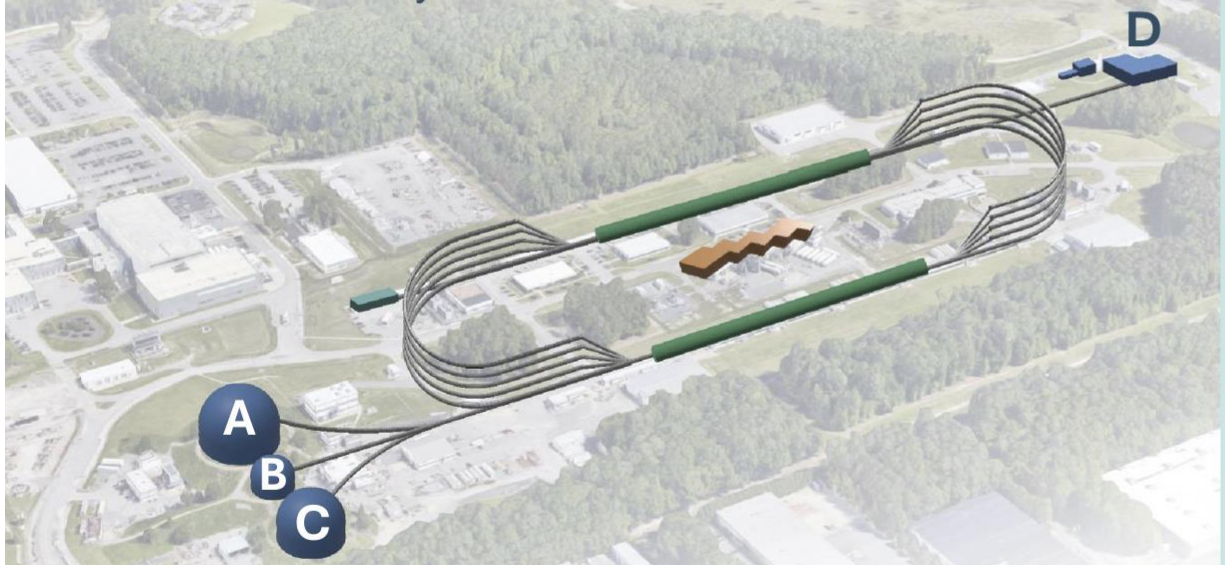
- **Phasing of different colliders allows for global R&D with current experiments/machines driving the deployment of technology**
  - HL-LHC, SuperKEKB (HEP) →EIC (NP) → FCC (HEP)
- **Partial overlapping and staggered start-up times allow for cross-fertilization of physics results**
- **Gap in time between in HEP/NP colliders allows for a balanced effort between communities**
  - For example, scientists can analyze LHC data while preparing for EIC
  - Scientists (especially early career) will be able to do research at EIC while preparing for FCC
  - Provides continuous opportunities for training the next generation HENP technical workforce

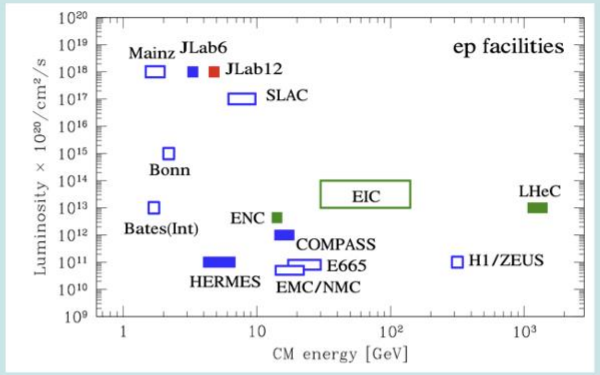
From J. Lajoie Joint APS DPF/DNP Meeting
https://indico.global/event/17474

Continuous Electron Beam Accelerator Facility (CEBAF)

FY26 CEBAF Operations Plan

- 24 weeks of Physics
- E = 11.7 GeV (energy gain per linac 1,060 MeV)
- Beam power up to 900 kW
- 86.7% reliability in FY25





CEBAF is the ***only*** electron accelerator in the world capable of probing nucleon and nuclear structure at the fundamental quark and gluon level.

World leadership:

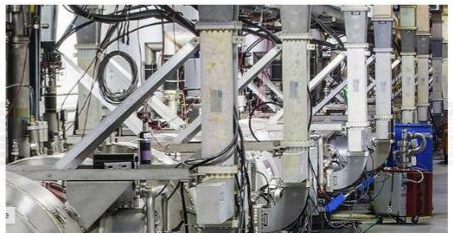
luminosity (up to 1039 e/cm2/s),
polarization (up to 95%)
with energy up to 12 GeV

Experiments in four halls – A, B, C and D

2 high current, spectrometers, multipurpose
1 low current, nearly full acceptance
1 for direct photon interactions (exotic spectroscopy, J/Ψ, etc.)








CEBAF: High-Impact Science Programs

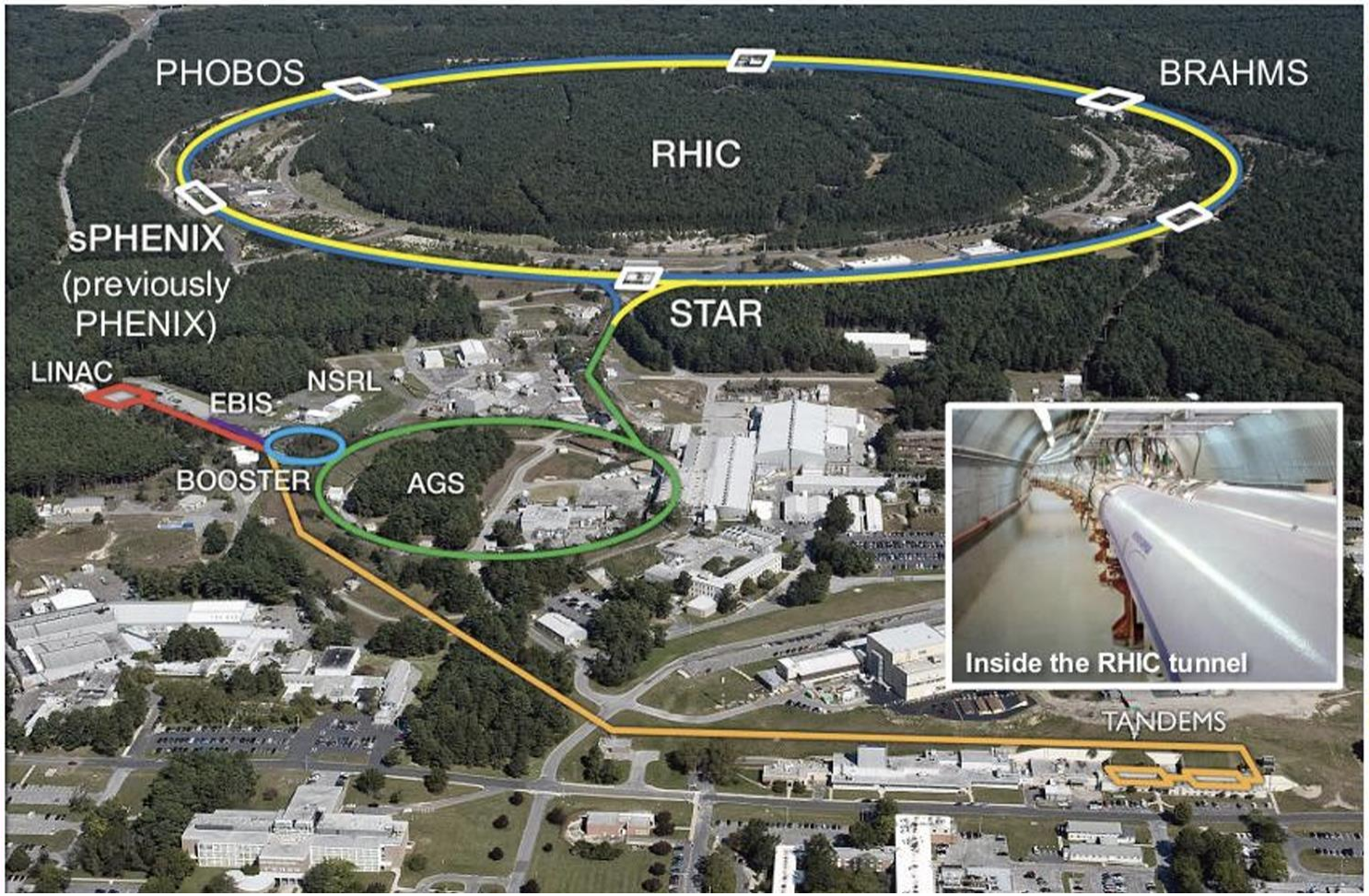
The CEBAF user facility runs up to four experimental halls simultaneously provided polarized electrons and total beam power of over 1MW. The scientific program, which completes several experiments a year, has six main categories:

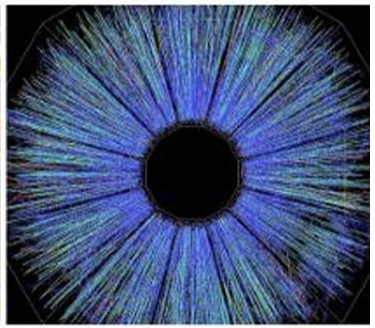
- **Nucleon structure:** Precision measurements of form factors and parton distributions reveal how quarks and gluons are arranged and bound.
- **Excited states & resonances:** Mapping the baryon spectrum tests how QCD confinement generates mass and structure.
- **3D imaging of quarks:** Generalized Parton Distributions (GPDs) from Deeply Virtual Compton Scattering and meson production give a “tomographic” picture of the nucleon.
- **Short-range nuclear forces:** Studies of correlated nucleon pairs show how QCD at the quark level translates into the nuclear force.
- **Exotic matter:** Searches for hybrid mesons and gluonic excitations test predictions of QCD beyond the simple quark model.
- **Tests of the Standard Model and Fundamental Symmetries**: Precision measurement such as MOLLER making ultra-precise measurements of the electron's weak charge and the weak mixing angle to search for physics beyond the standard model.

A glorious run from 2000-2026 : unparalleled scientific output: Quark Gluon Plasma and Nucleon Spin

The Relativistic Heavy Ion Collider

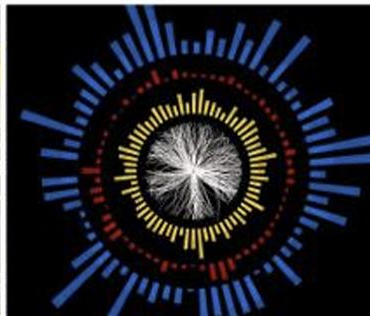
A machine built to explore fundamental matter at the dawn of time





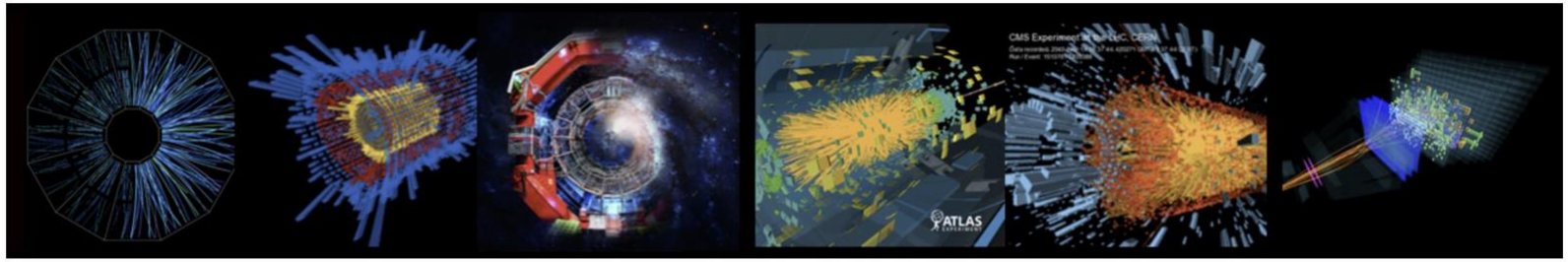
Collaborations, experiments

- PHOBOS: 2000 – 2005
- BRAHMS: 2000 – 2006
- PHENIX: 2000 – 2016
- STAR: 2000 – 2026
- sPHENIX: 2023 – 2026



Discovery Science at RHIC and the LHC

Combined complementary programs have demonstrated that the quark gluon plasma (QGP) is a strongly coupled, near perfect, highly vortical, fluid of deconfined quarks and gluons



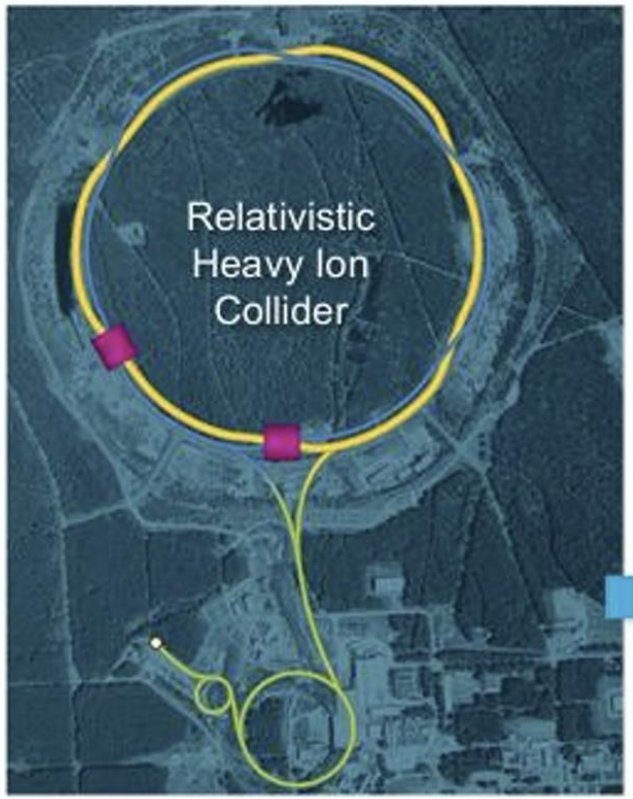
Open questions remain:

- What are the QGP's microscopic properties?
- How does this strongly interacting matter thermalize and exhibit collective fluid-like behavior?
- Is there a Critical Point in the QCD phase diagram?
- How do quarks and gluons lose energy and propagate through hot nuclear matter?
- Can we understand the emergence of hadrons, confinement, and the structure of matter?
- What are the connections between heavy-ions collisions and neutron stars?

RHIC : 7-10 years of analyses and publications necessary to complete science mission
LHC : Final HI collisions of Run-3 starting soon. Preparing for HL Run-4 and beyond

Slide: Helen Caines

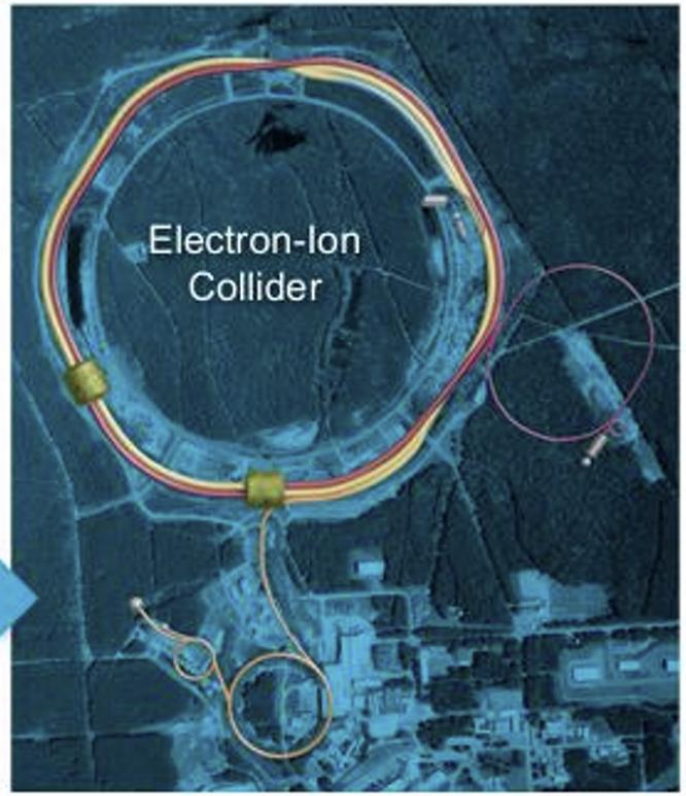
A New Era of Discovery:
From RHIC to the Electron-Ion Collider (EIC)



Building on the ~$2 billion+ investment in RHIC:

- Re-use existing tunnel
- Minimal modification to ion beam complex (yellow)
- New electron beam facility

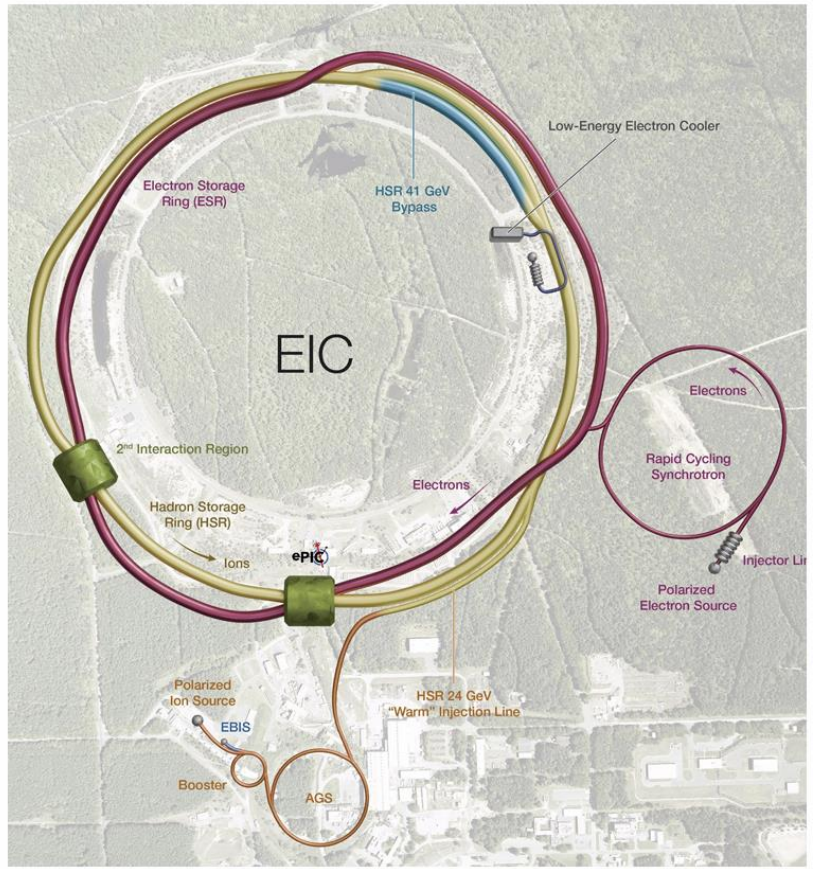
Partnership between U.S. Department of Energy, Brookhaven Lab, Thomas Jefferson National Accelerator Facility, New York State, and collaborators around the world.



Brookhaven National Laboratory

Electron-Ion Collider: Top Priority for New Facility Construction in the Nuclear Science Long Range Plan

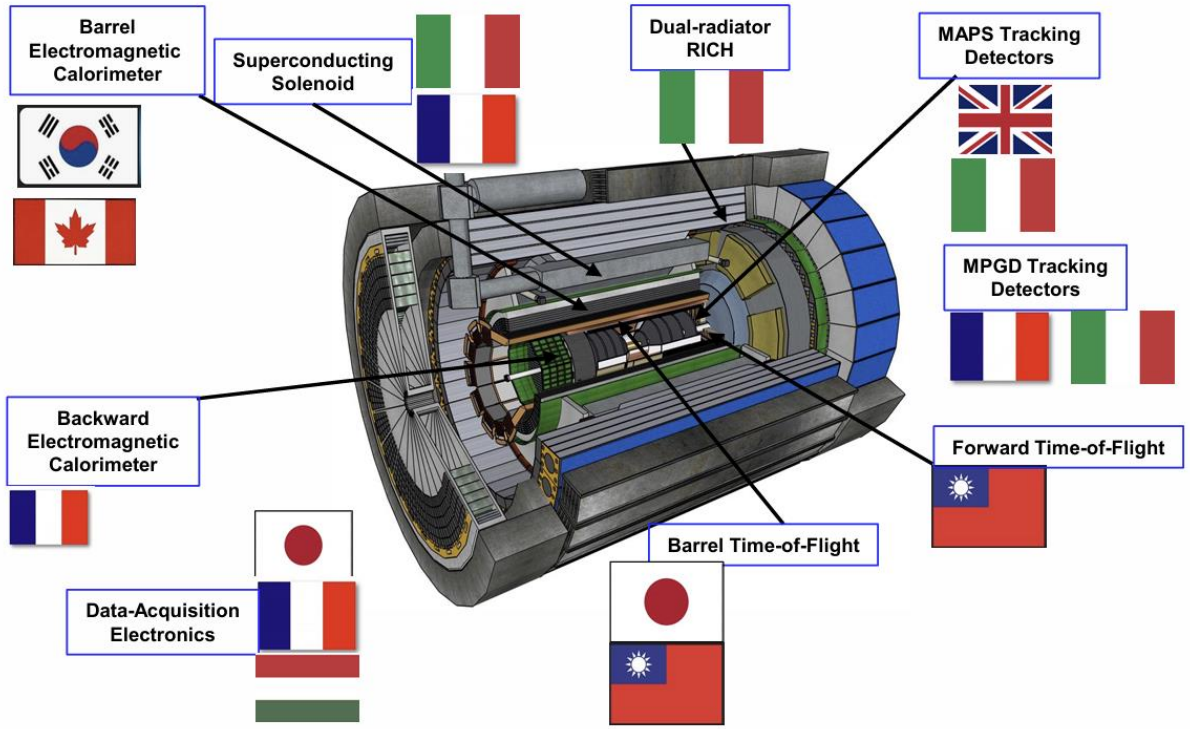
- Located at BNL, using existing RHIC assets, with TJNAF as a major partner
- Estimated cost rage of $1.7 billion to $2.8 billion.
- In-kind contributions: New York State and International partners
  - $100M grant from New York supports civil construction
  - ~$90M anticipated for the detector ePIC (~30%)
  - ~$50M anticipated accelerator scope (~5%)
- Critical Decision-3A (long lead procurement): March 2024
- Critical Decision CD-3B (second long lead procurement request) approved January 2026
- Project elaborating its subproject strategy



Regina Rameika. From Joint APS DPF/DNP Meeting https://indico.global/event/17474

NP International Engagement Continues to Grow

- Topics of mutual interest:
  - Alignment with NP mission and scope.
  - Alignment with mission and scope of international partners.
  - Capabilities of the participating international partners.
- EIC User Group: 1,562 members from 310 Institutions in 41 countries (March 2026)



- Expressed interests in the ePIC central detector subsystems labeled by country

Regina Rameika. From Joint APS DPF/DNP Meeting https://indico.global/event/17474

EIC NAS Science Pillars

From John Lajoie

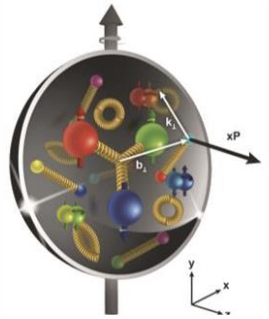
The EIC will unravel the different contribution from the quarks, gluons and orbital angular momentum

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

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

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



How can we understand their dynamical origin in QCD?
What is the relation to Confinement

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

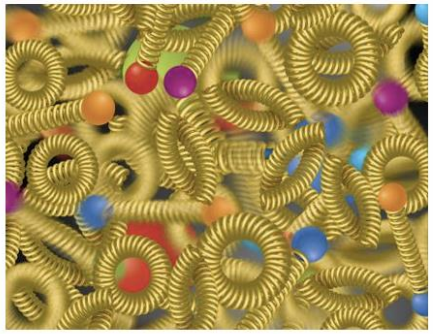
How do the nucleon properties emerge from them and their interactions?

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

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

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

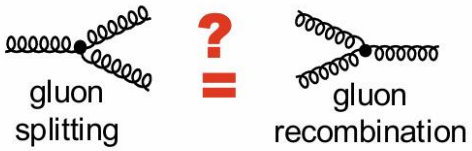
How do the quark-gluon interactions create nuclear binding?



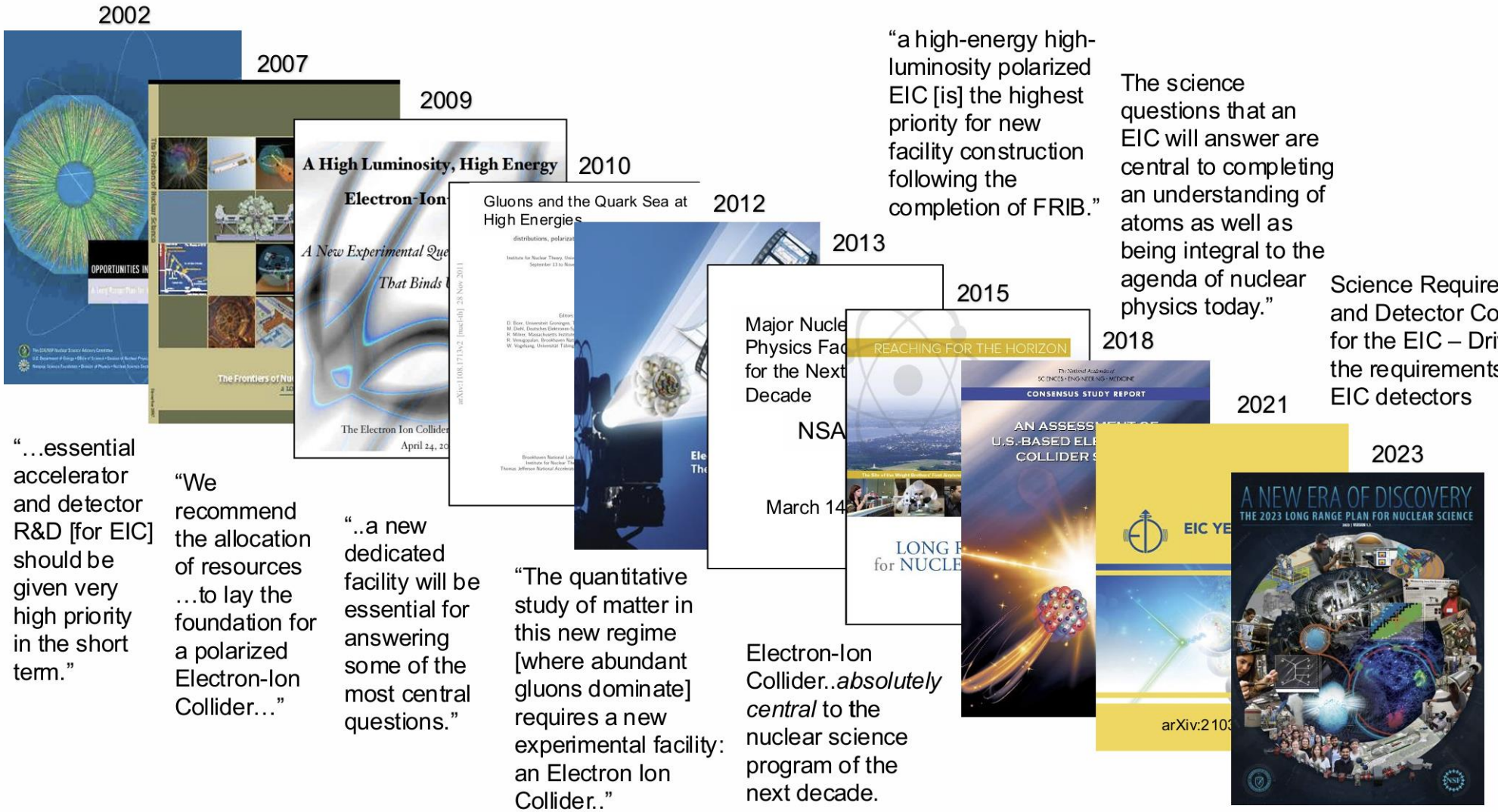
What happens to the gluon density in nuclei? Does it saturate at high energy?

How many gluons can fit in a proton?

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



The Scientific Foundation for an EIC was Built Over Two Decades



"…essential accelerator and detector R&D [for EIC] should be given very high priority in the short term."

"We recommend the allocation of resources …to lay the foundation for a polarized Electron-Ion Collider…"

"..a new dedicated facility will be essential for answering some of the most central questions."

"The quantitative study of matter in this new regime [where abundant gluons dominate] requires a new experimental facility: an Electron Ion Collider.."

Electron-Ion Collider..*absolutely central* to the nuclear science program of the next decade.

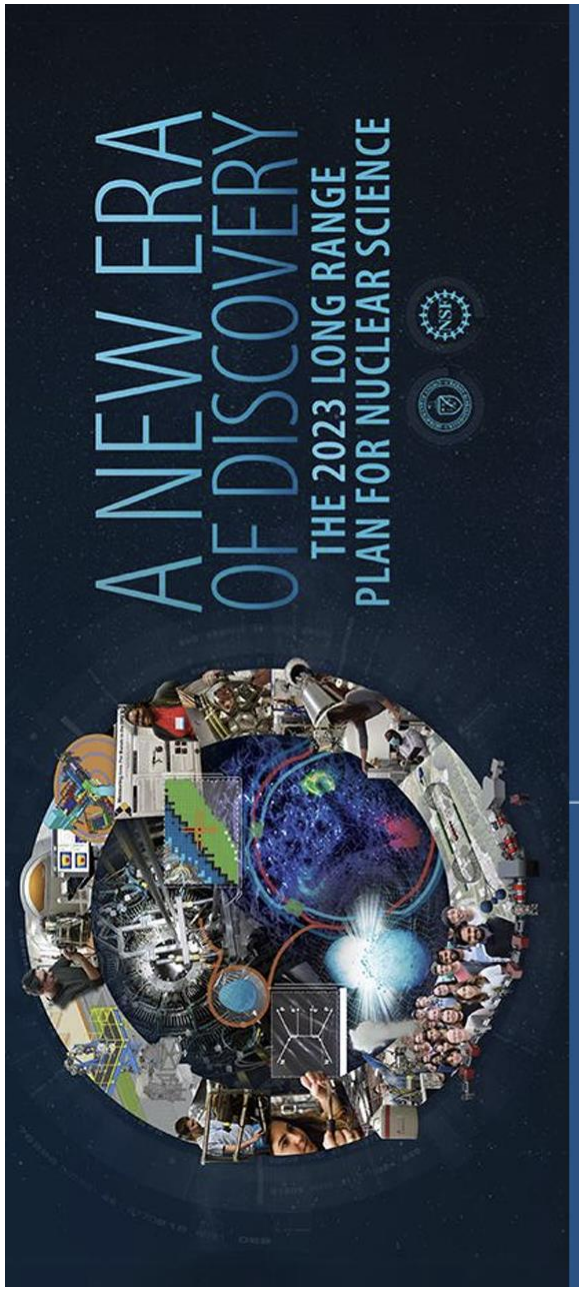
"a high-energy high-luminosity polarized EIC [is] the highest priority for new facility construction following the completion of FRIB."

The science questions that an EIC will answer are central to completing an understanding of atoms as well as being integral to the agenda of nuclear physics today."

Science Requirements and Detector Concepts for the EIC – Drives the requirements of EIC detectors

We recommend the expeditious completion of the EIC as the highest priority for facility construction.

From John Lajoie



RECOMMENDATION 1

The highest priority of the nuclear science community is to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal.

RECOMMENDATION 2

As the highest priority for new experiment construction, we recommend that the United States lead an international consortium that will undertake a neutrinoless double beta decay campaign, featuring the expeditious construction of ton-scale experiments, using different isotopes and complementary techniques.

RECOMMENDATION 3

We recommend the expeditious completion of the EIC as the highest priority for facility construction.

RECOMMENDATION 4

We recommend capitalizing on the unique ways in which nuclear physics can advance discovery science and applications for society by investing in additional projects and new strategic opportunities.

Complete initiated scientific programs

International Collaboration

New Construction

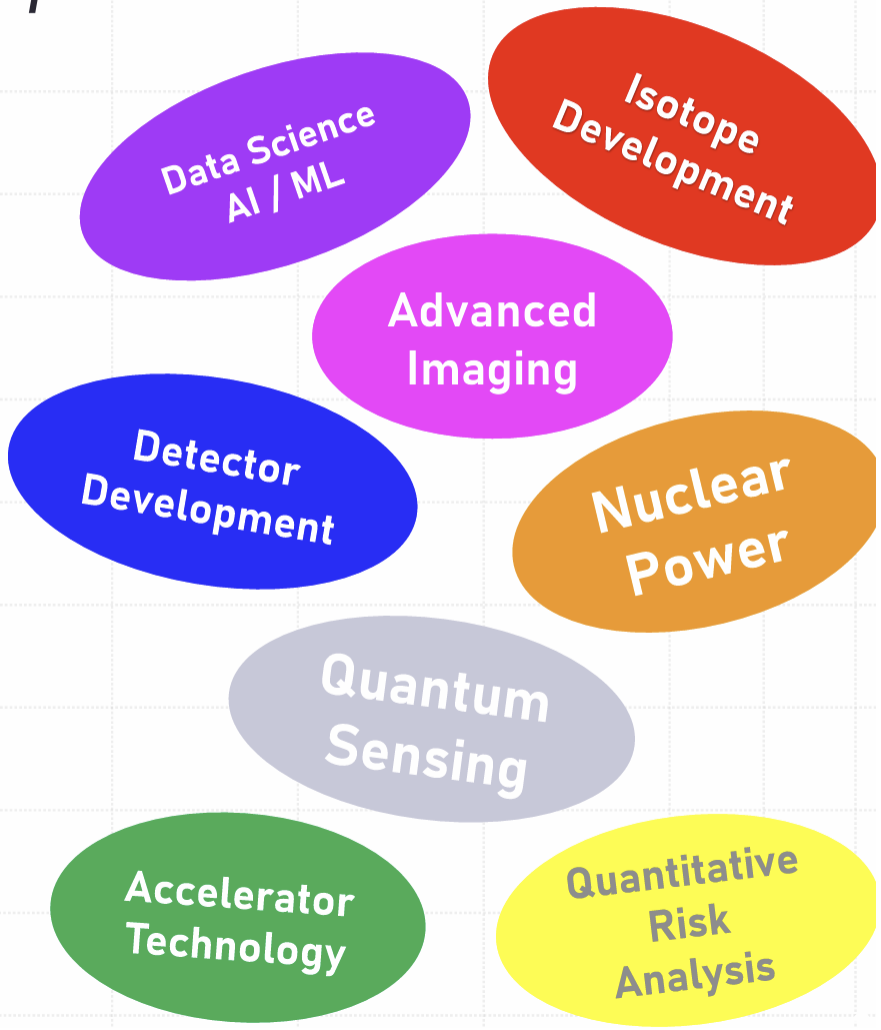
Applications

Nuclear Science Workforce

People are central to the scientific enterprise

- **Analysis of CEU participants (2011 - 2021)**
- Traceable NP PhD Recipients: Industry, National Labs, Academia
- Using skills developed in PhD to support:

✓ National Security
✓ Non-proliferation
✓ Healthcare Improvement
✓ Financial / Health / Security Risk Analysis
✓ Energy Security / Nuclear Power
✓ Advanced Detectors / Accelerator Development
✓ Crucial role in driving physics at FRIB, JLab, EIC, Theory etc.



From Nadia Fomin DNP Chair
https://indico.global/event/17474

NP in Quantum Information Science

Supports one of SC's National QIS Research Centers

- Led by BNL, partners with IBM, PNNL, and 25 other institutions to build tools for scalable fault-tolerant quantum systems
- >350 team members, 5 subject inventions, 11 open-source packages, 173 publications

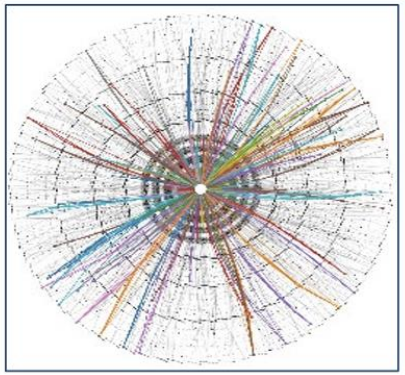
NP QIS Highlights:

- **Quantifying background radiation on qubits**. Scientists used a thermal kinetic inductance detector to measure disruptive events that were consistent with known terrestrial and cosmic sources of radiation. Such measurements are crucial to deduce the impact on coherence times of qubits that are subject to naturally occurring radiations.
- **Scalable quantum circuits**. Scientists at the InQubator for Quantum Simulations performed the one of the largest quantum simulations to date (more than 100 qubits) using IBM's quantum computers. The results from the quantum computer address the need for complex simulations of pre-collisional protons and heavy nuclei.
- **Detecting the decay of individual nuclei**. Scientists detected the decay of radioactive lead-212 embedded in helium by measuring the recoil of the helium atom. This was identified as a 2024 top 10 breakthrough by Physics World and demonstrates that very small forces (10^{-20} N) and accelerations (10^{-7} g) are in the realm of detection.

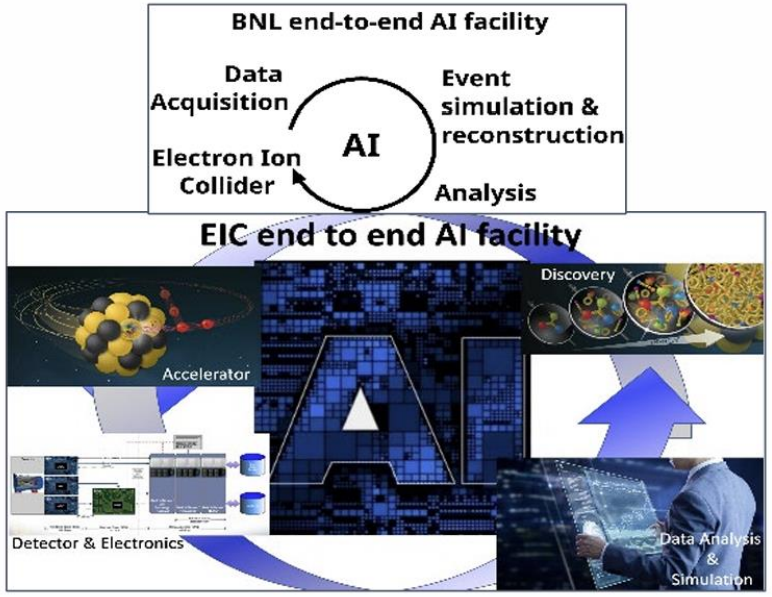
Regina Rameika. From Joint APS DPF/DNP Meeting https://indico.global/event/17474

Genesis Mission and Nuclear Physics

- Coordinating with ASCR, HEP, and other SC programs, **NP is advancing its mission through the development of AI-ready datasets and AI models that can take advantage of them.**
- Two discovery science national challenges targeted:
  - Unifying Physics from Quarks to the Cosmos
  - Enhancing Particle Accelerators for Discovery
- While the NP community has actively employed AI methods, the Genesis Mission offers a unique opportunity to overcome workflow pinch points and synthesize data from disparate domains.
- The development of domain-specific data standards and metadata for multi-modal data, including expert knowledge documentation, **will feed the American Science Cloud (AmSC)**, using the power of AI to accelerate **discovery of new physics** and progress on the fundamental questions on the nature of nuclear matter.



Event Reconstruction with Geometric Deep Learning



Regina Rameika. From Joint APS DPF/DNP Meeting https://indico.global/event/17474

EIC Users Group

https://www.eicug.org

While Paper on the EIC Latin America (2024), mainly theory

https://arxiv.org/abs/2409.18407

Nuclear Experiment

[Submitted on 27 Sep 2024 (v1), last revised 29 Apr 2025 (this version, v2)]

The glue that binds us all -- Latin America and the Electron-Ion Collider

A. C. Aguilar, A. Bashir, J. J. Cobos-Martínez, A. Courtoy, B. El-Bennich, D. de Florian, T. Frederico, V. P. Gonçalves, M. Hentschinski, R. J. Hernández-Pinto, G. Krein, M. V. T. Machado, J. P. B. C. de Melo, W. de Paula, R. Sassot, F. E. Serna, L. Albino I. Borsa, L. Cieri, I. M. Higuera-Angulo, J. Mazzitelli, Á. Miramontes, K. Raya, F. Salazar, G. Sborlini, P. Zurita

The Electron-Ion Collider, a next generation electron-hadron and electron-nuclei scattering facility, will be built at Brookhaven National Laboratory. The wealth of new data will shape research in hadron physics, from nonperturbative QCD techniques to perturbative QCD improvements and global QCD analyses, for the decades to come. With the present proposal, Latin America based physicists, whose expertise lies on the theory and phenomenology side, make the case for the past and future efforts of a growing community, working hand-in-hand towards developing theoretical tools and predictions to analyze, interpret and optimize the results that will be obtained at the EIC, unveiling the role of the glue that binds us all. This effort is along the lines of various initiatives taken in the U.S., and supported by colleagues worldwide, such as the ones by the EIC User Group which were highlighted during the Snowmass Process and the Particle Physics Project Prioritization Panel (P5).

Comments: White Paper contribution to the Latin American Strategy Forum for Research Infrastructure (III LASF4RI). Updated version includes an extended discussion of the

Forum for Research Infrastructure (LASF4RI) for High Energy, Cosmology and Astropar Physics (HECAP): Update of the Strategic Plan 2024

I·AN Inter-American Network of Networks QCD

Some examples

I·AN Inter-American Network of Networks QCD

Some examples

Advances in QCD at the LHC and the EIC

9–15 Nov 2025
CBPF, Rio de Janeiro
America/Sao_Paulo timezone

Enter your search term

- Overview
- Call for Abstracts
- Timetable
- Registration
- Accommodation
- Fees and financial support
- How to get to CBPF

Jointly with the CLAF Symposium on Opportunities for Latin-American Cooperation in High Energy Physics with CERN

EIC Latin America

Thanks to the **Universidad Autónoma del Estado de Hidalgo** and SMF DPyC leadership team, and the scientific program committee

I·AN Inter-American Network of Networks QCD

Three different meetings

Monday, May 19:
Report from the coordination and from countries. We expect Network reports at future meetings

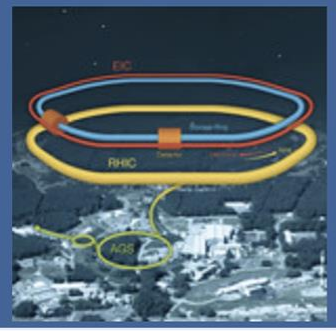
Tuesday, May 20:
EIC Latin America meeting

Wednesday, May 21:
Joint EIC Latin America with annual meeting of SMF DPyC: RADPYC 2025

https://indico.ku.edu/event/478

I·AN Inter-American Network of Networks QCD

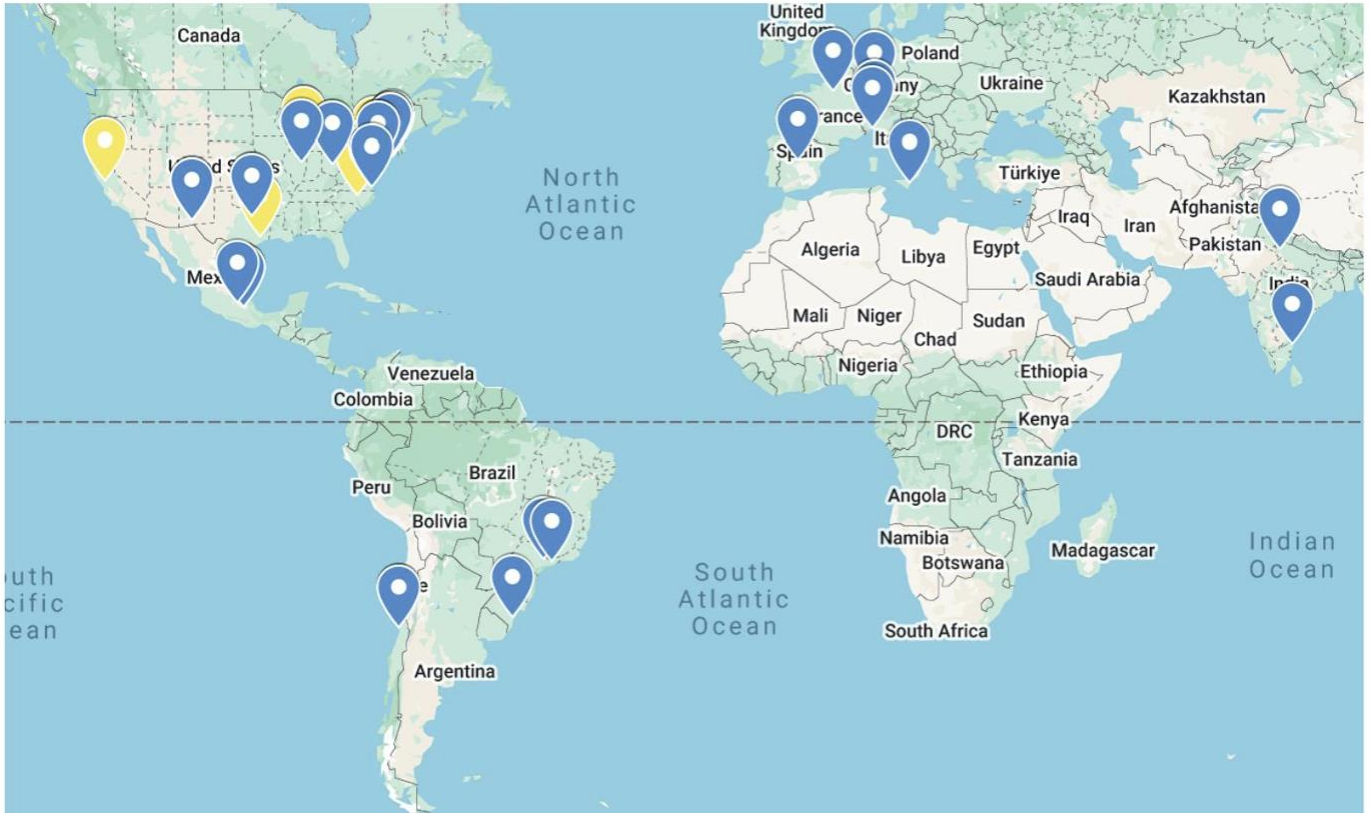
Some examples



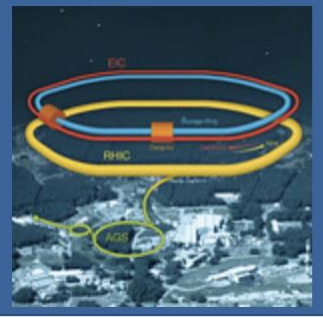
The 2025 CFNS-SURGE Summer Workshop on the Physics of the Electron-Ion Collider

Jun 2 – 13, 2025
Physics Building; CFNS
America/New_York timezone

This year we have 30 students from 9 countries from North and South Americas, Europe, and Asia.

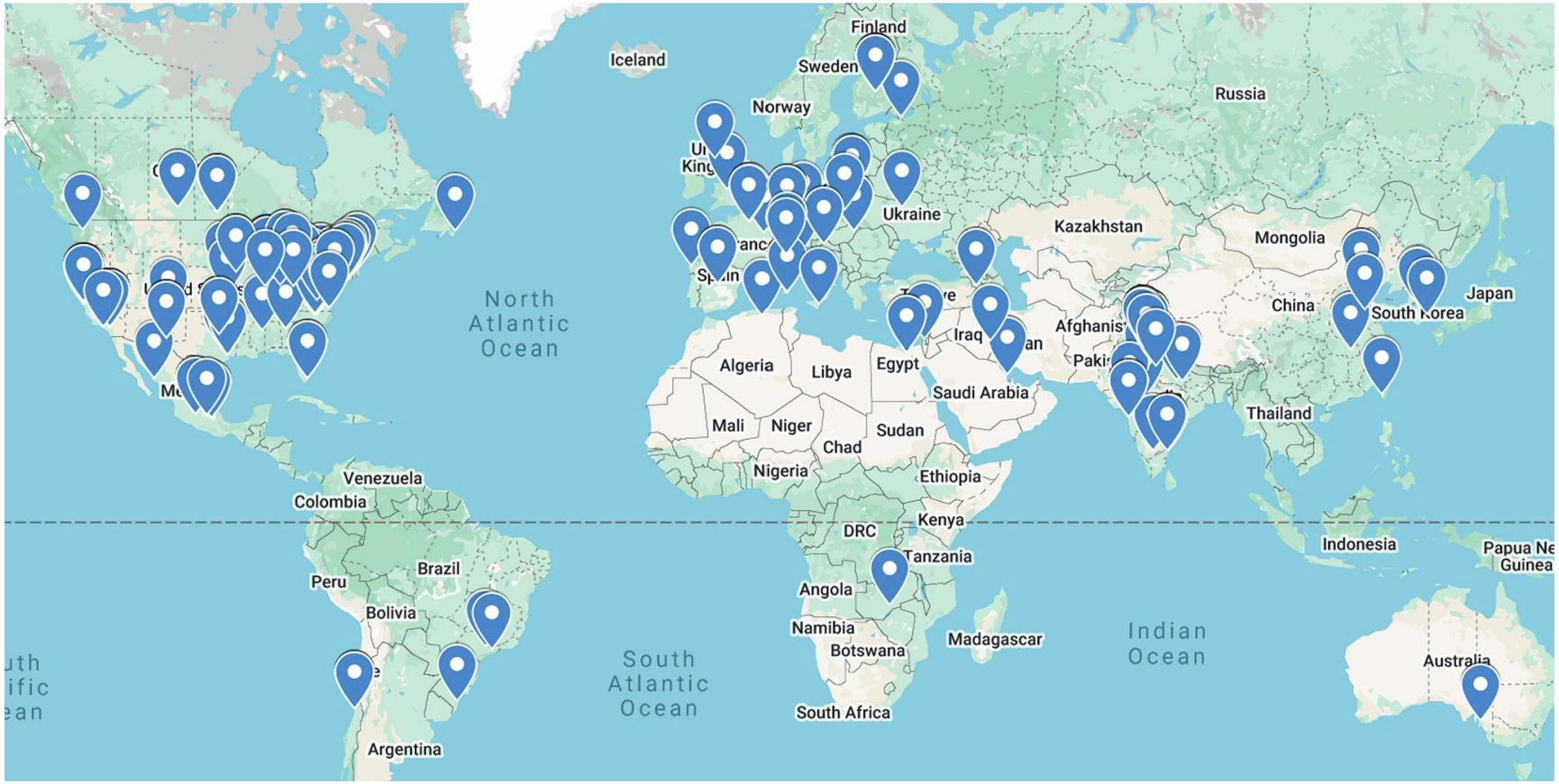


The CFNS EIC school is next week



The 2026 CFNS Summer School on the Physics of the Electron-Ion Collider

GEOGRAPHY OF THE SCHOOL 2019–2025



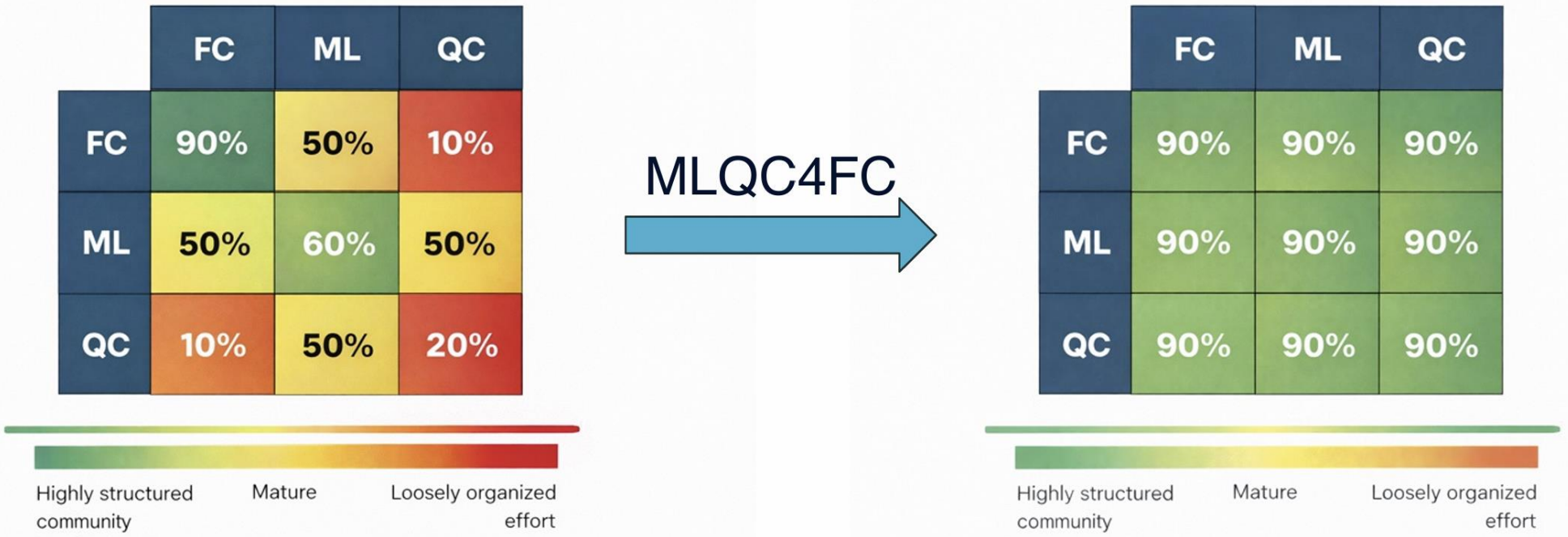
- Science diplomacy activities
  I.ANN QCD Summit 2024: Empowerin
  Global Networks (13-14 June 2024): O

Recent activities

https://indico.ku.edu/event/495

Why a COST Action?

To organise the community and structure the effort:
a challenging networking endeavour



Many communities involved:

hep-ex, hep-ph, hep-th, hep-lat, physics.acc-ph, physics.data-an, quantum-ph, cs.AI, stat.AP, stat.ML, …

Example of EU COST Action: Machine Learning & Quantum Computing for Future Colliders
https://indico.ku.edu/event/495

I·ANN Inter-American Network of Networks QCD

Some upcoming meetings partly supported by I.ANN QCD

- XV Latin American Symposium on Nuclear Physics and Applications. Sao Paulo, Brazil. December 7-10, 2026
- 2026 International Workshop on the Physics of Ultra Peripheral Heavy Ion Collisions. Playa del Carmen, Mexico. December 7-12, 2026
- ICTP-SAIFR School and Workshop "Electron-Ion Collider as a Probe of Quantum Chromodynamics" during the week of May 17-22, 2027 at the ICTP-SAIFR, São Paulo, Brazil.

Ongoing conversations

- While the program is centered in the Americas, we have been encouraged to have partnership with other regions
- Currently exploring a joint application between I.ANN QCD and a EU program Promoting activities with EU COST networks
- Contacted by groups in Asia that would like to joint I.ANN QCD as associate members

I·ANNQ Inter-American Network of Networks QCD

New phase of the program from September 2025

Track 1:

- Early career researchers workshop
- Bi-national or international meetings aligned to I.ANNQ QCD objectives
- Use case workshops
- Short courses and mentoring sessions
- I.ANN QCD Summit, including science diplomacy

Track 2:

- Visiting and exchange programs
- QCD ambassadors program

I·ANN QCD Inter-American Network of Networks

Contacts

- **Coordination team:**
  Daniel Tapia Takaki, Director
  Christine Aidala, co-PI
  Carlos Bertulani, co-PI
  Abhay Deshpande, co-PI

- Currently working on preparing a new structure for the National contacts and network representatives

I·AN Inter-American Network of Networks QCD

Join us for accelerating discoveries in fundamental physics

Please help us advertising this program and get engaged !

Website:
https://www.iann-qcd.org

Join the IANN-QCD Mailing list
https://www.iann-qcd.org/mailing-list

Find us also on LinkedIn