Brookhaven National Laboratory | Jefferson Lab | U.S. DEPARTMENT of ENERGY | Office of Science

The Electron-Ion Collider Accelerator Collaboration

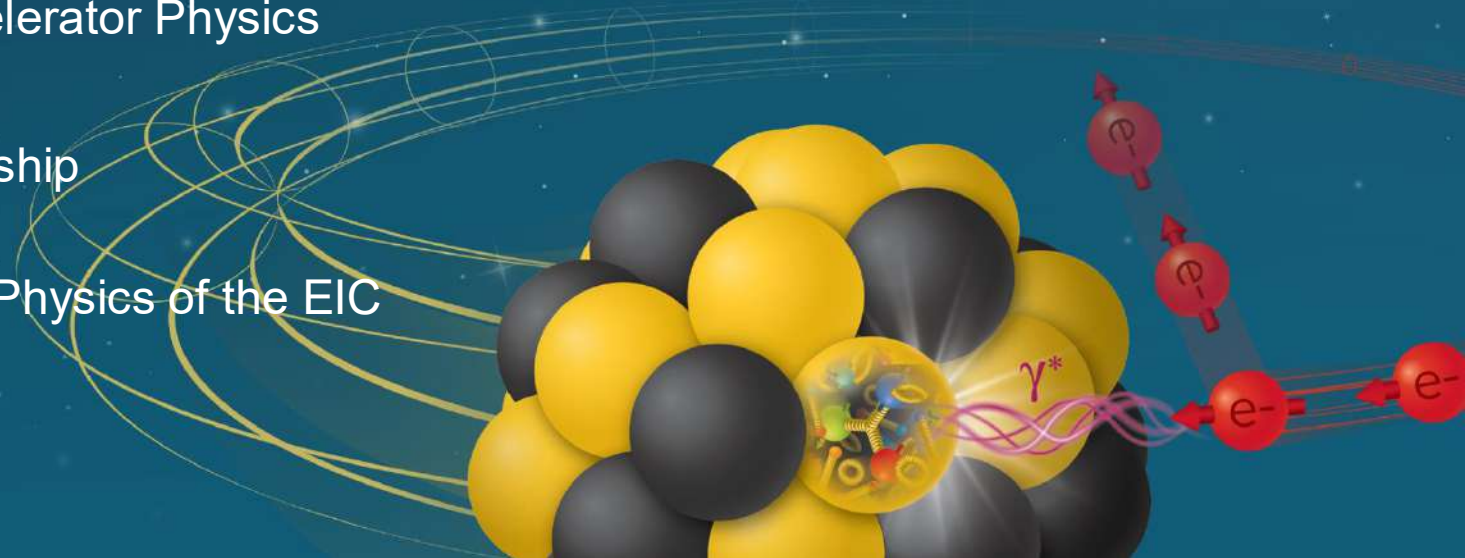
Wolfram Fischer (BNL), Co-Chair
Deputy Associate Lab Director for Accelerators in Nuclear and Particle Physics
Collider-Accelerator Department Chair

Tatiana Pieloni (EPFL), Co-Chair
Accelerator Physicist at Lab of Particle Accelerator Physics

Luisella Lari (BNL)
EIC Associate Director for Strategic Partnership

Stony Brook CFNS Summer School on the Physics of the EIC
10 June 2026

Electron-Ion Collider



Why is there an EIC Accelerator Collaboration?

- EIC will be the next large collider in the world
  (hopefully followed by the FCC-ee at CERN)

- EIC complexity and challenges require the world-wide knowledge
  in accelerator science and technology

- Detectors have a similar model (for longer and accelerators)

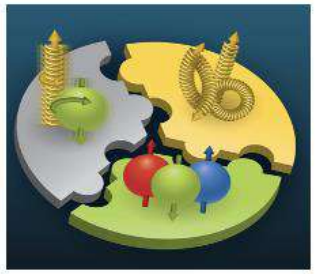
What is the Electron-Ion Collider (EIC)?

What is the EIC?

- A **next-generation particle collider** at **Brookhaven National Laboratory**
- Collides **electrons** with **atomic nuclei or protons**
- Acts as a **precision microscope** for **studying quarks and gluons**
- Designed to answer how **mass, spin, and nuclear structure** emerge from the **strong force (QCD)**

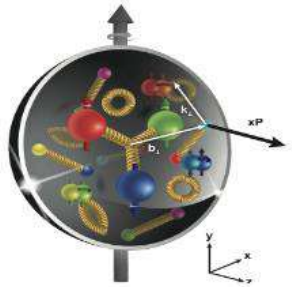
Why electrons + ions?

- **Electrons** probe structure cleanly and precisely
- **Protons/nuclei** contain quarks and gluons
- **Polarized beams** reveal spin and motion in 3D



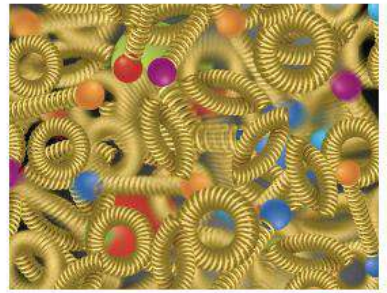
How do quarks, gluons, and orbital angular momentum contribute to proton spin?

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



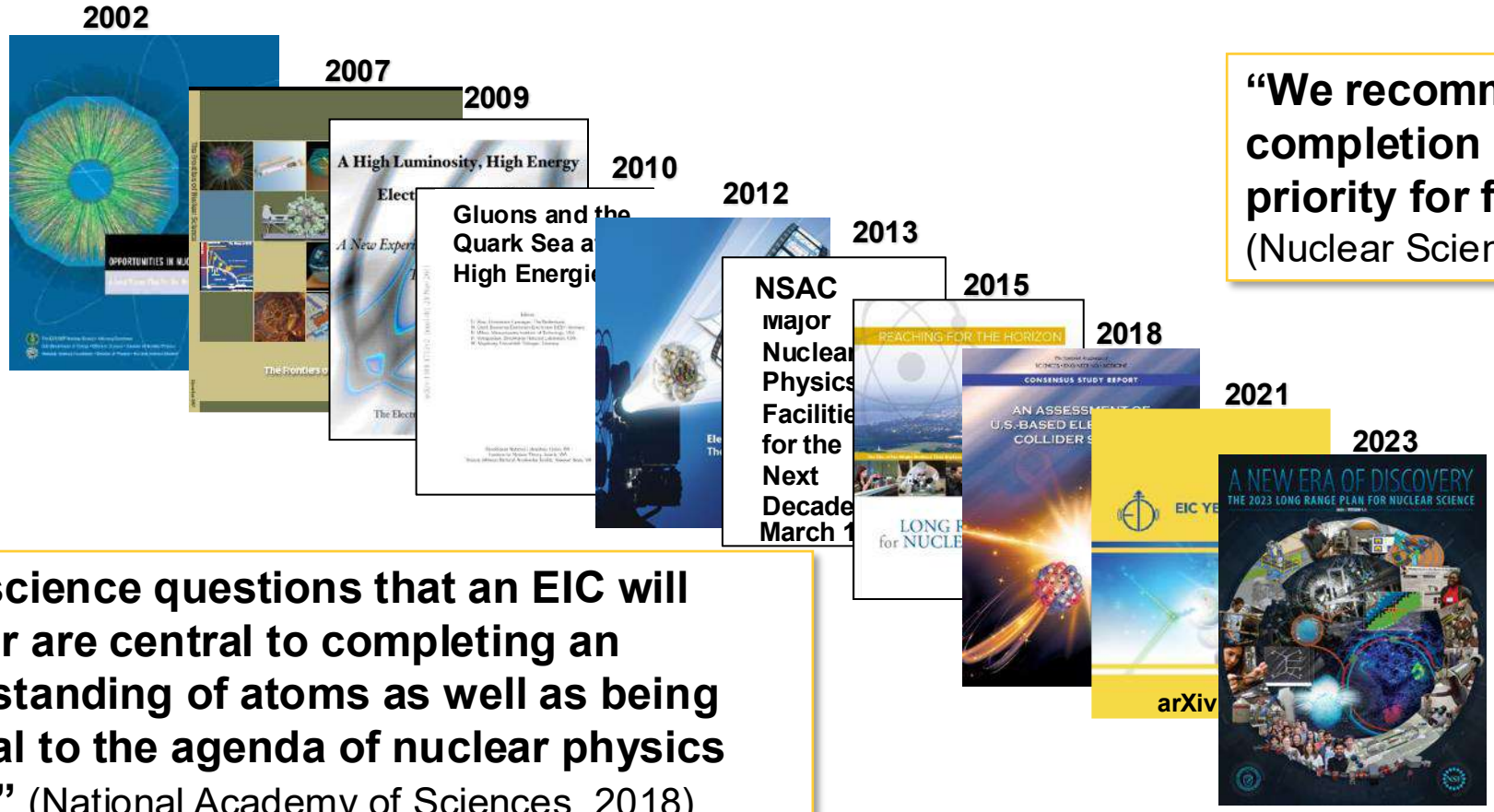
How can we understand QCD dynamics and the relation to confinement?

How do quark-gluon interactions create nuclear binding?



Does gluon density in nuclei saturate at high energy?

EIC Scientific Case Built Over Decades



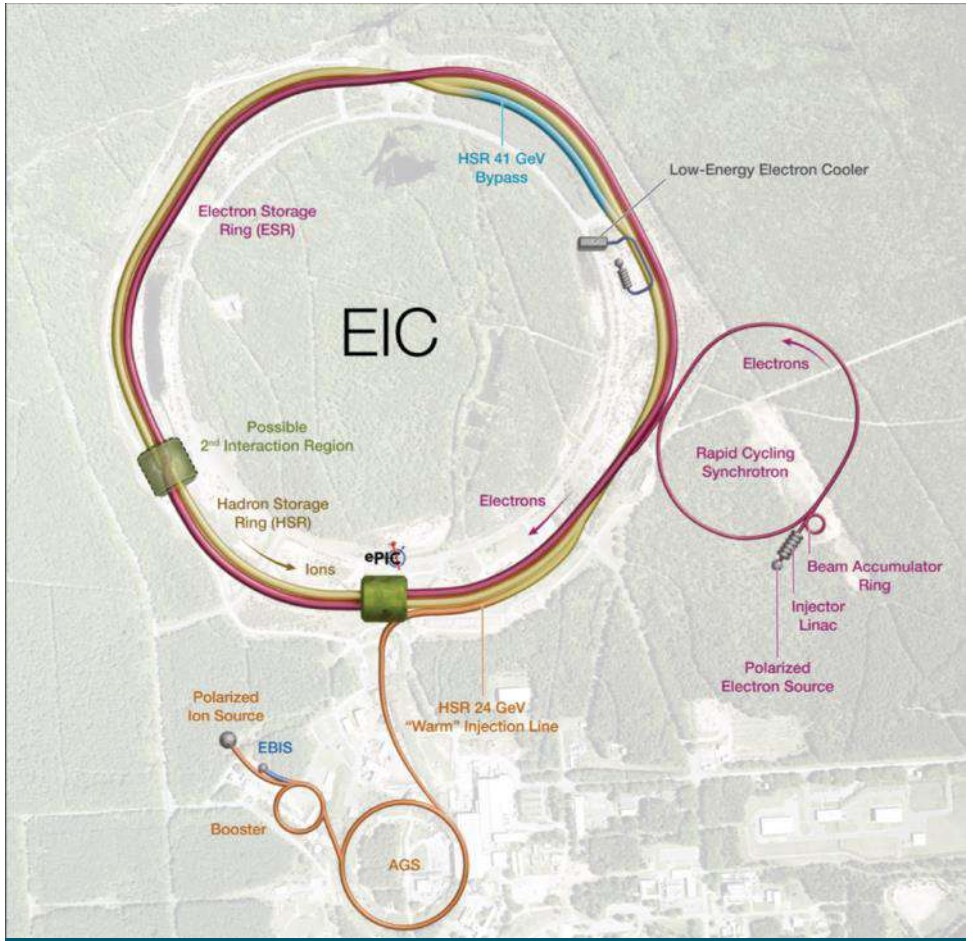
"We recommend the expeditious completion of the EIC as the highest priority for facility construction." (Nuclear Science Advisory Committee, 2023)

"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." (National Academy of Sciences, 2018)

EIC will be the only operating particle collider in the U.S. in the next decade/s.

Accelerator Status at a glance

- ✓ Polarized ion/proton source
- ✓ Ion injection and initial acceleration systems – Linac (200 MeV), Booster (1.5 GeV), AGS (25 GeV)
- UPGRADE Hadron Storage Ring (40-275 GeV) – HSR
- NEW Electron Pre-Injector (750 MeV linac)
- NEW Beam Accumulation Ring (750 MeV) – BAR
- NEW Electron Rapid Cycling Synchrotron (0.75 GeV – top energy) – RCS
- NEW Electron Storage Ring (5 GeV – 10 GeV) – ESR
- NEW Interaction Region(s) – IR
- NEW Hadron Cooling System

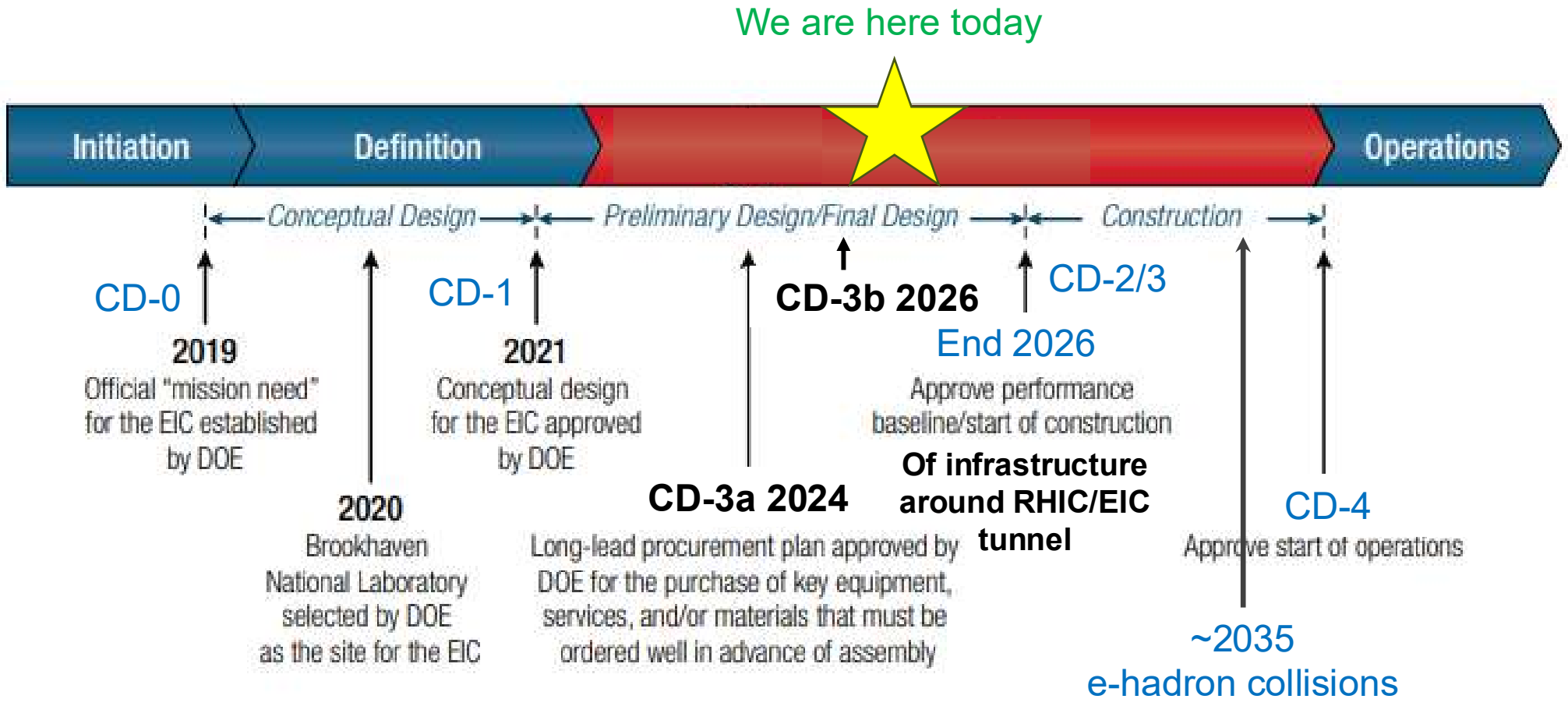


Reuse of RHIC Facility components
Valued at ~$2B

EIC Infrastructure Project Scope

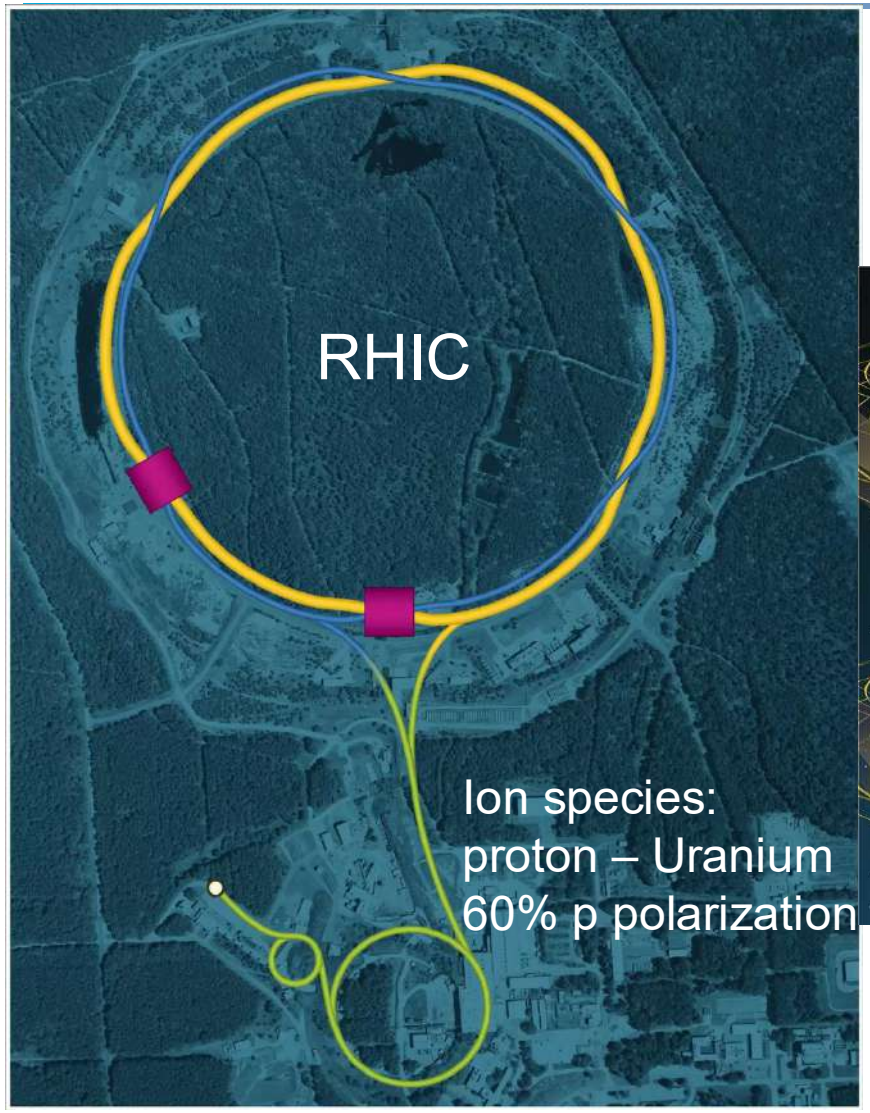
100% Design completed for the infrastructure around EIC/RHIC tunnel.

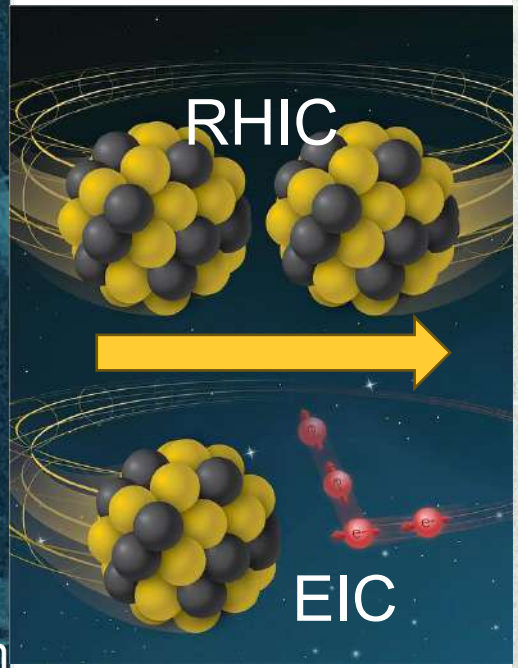
Project Milestones

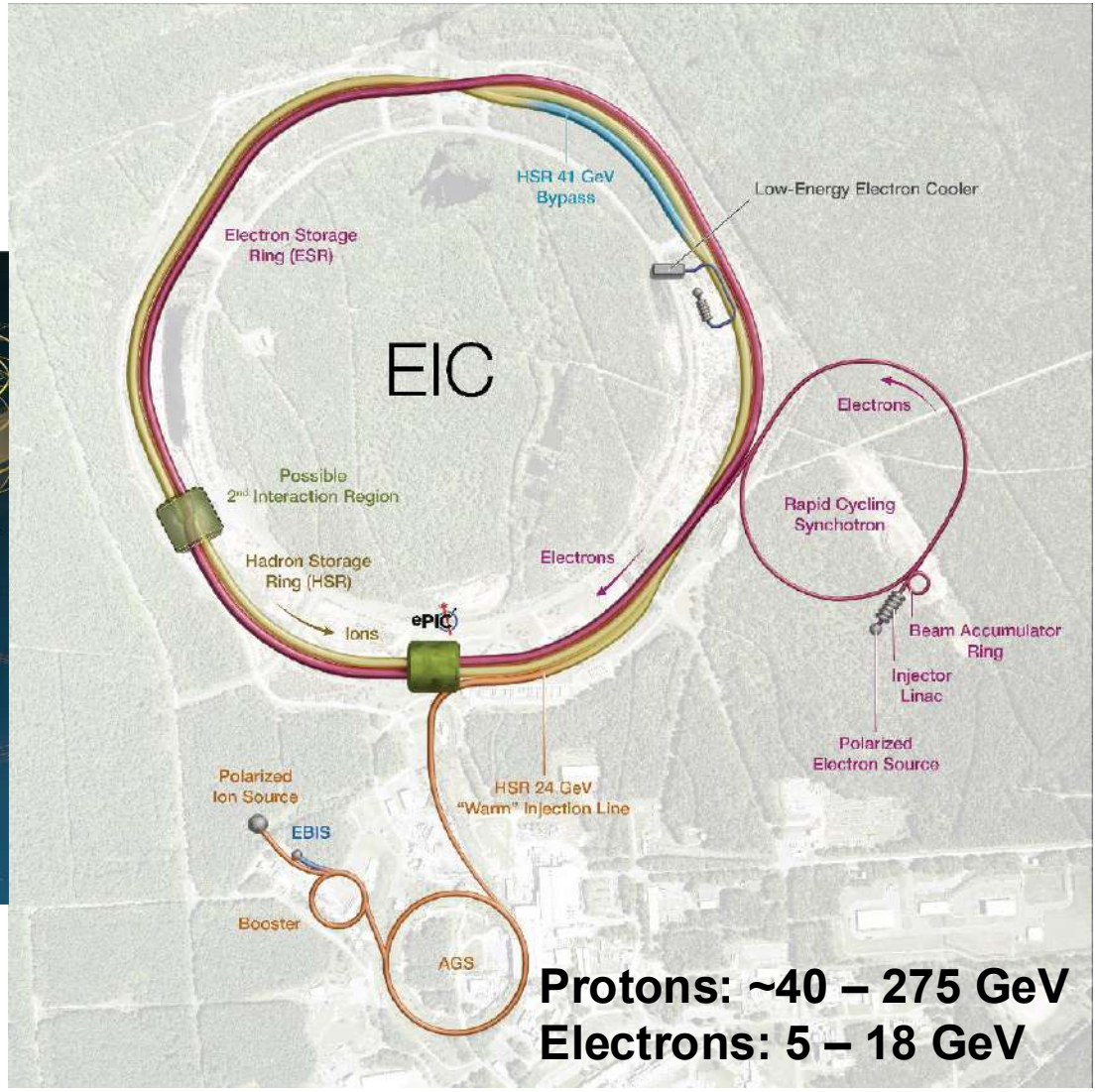


EIC Accelerator Challenges Overview

From RHIC to EIC



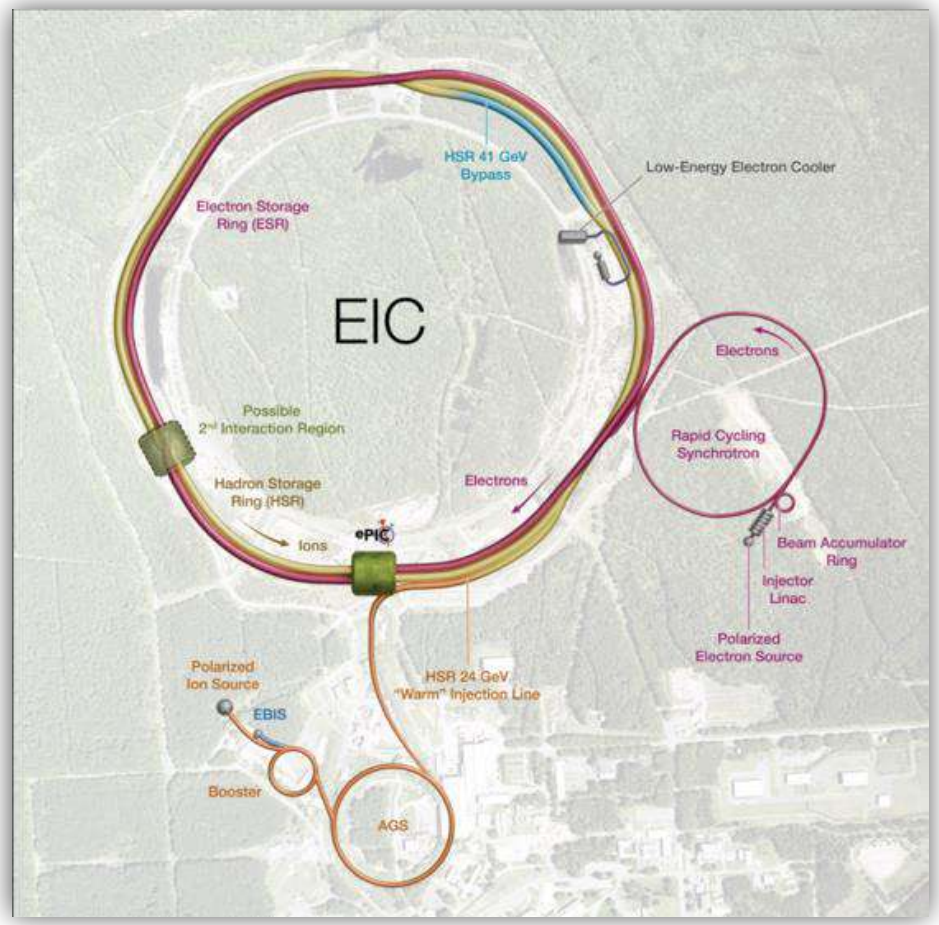




EIC Facility Requirements

Ultimate Performance Parameters

- High Luminosity: L= 10^{33} – 10^{34}cm^{-2}sec^{-1}
- Highly Polarized Beams: 70%
- Large Center of Mass Energy Range: E_{cm} = 28 – 140 GeV
- Large Ion Species Range: protons – Uranium
- Large Detector Forward Acceptance and Low-Background Conditions
- Possibility to Implement a Second Interaction Region (IR)

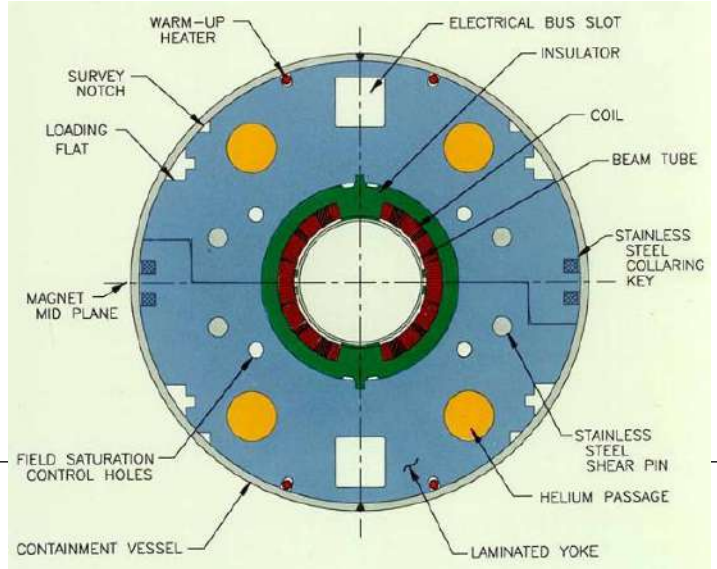


From RHIC (yellow ring) to EIC HSR

Tripled beam current, shorter bunch length, shorter bunch distance, ‘flat’ beams with small vertical emittance

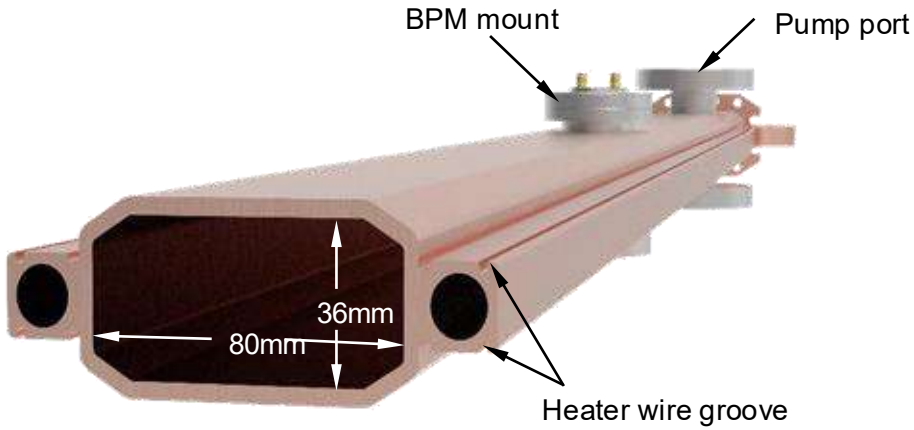
- EIC HSR to be composed of existing arcs of the Yellow RHIC ring (remove unused magnets)
- Insert sleeves coated with copper and amorphous carbon into superconducting magnet beam pipes to improve conductivity and reduce secondary electron yield (-> electron cloud)
- Add new RF cavities
- Add hadron cooling to create flat beam
- Add crab cavities, new IR SC magnets
- Add a collimation system
- Add extra ‘snakes’

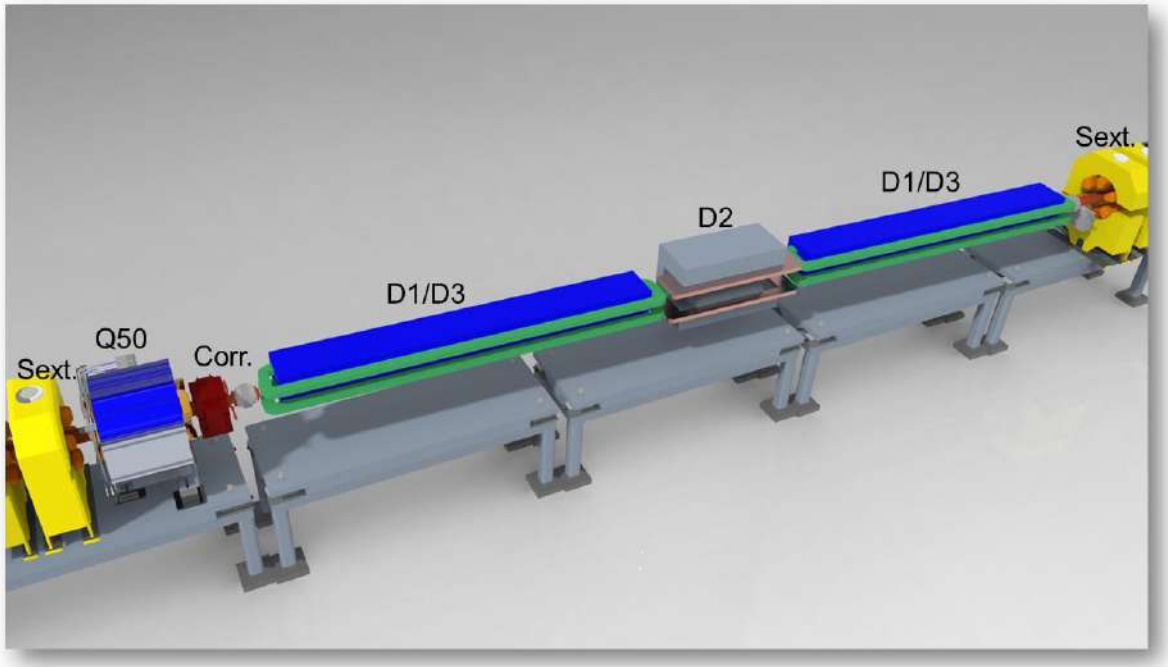
Actively Cooled Beam Screen Material procurement



EIC Electron Storage Ring

- Electron Storage Ring (ESR) consists of six FODO-cell arcs, and six straight sections (IRs)
- High-intensity (28 nC), short (7 mm) bunches add many interesting accelerator challenges
- Circulating beam current ~2.5 A and the synchrotron radiation power of ~10MW





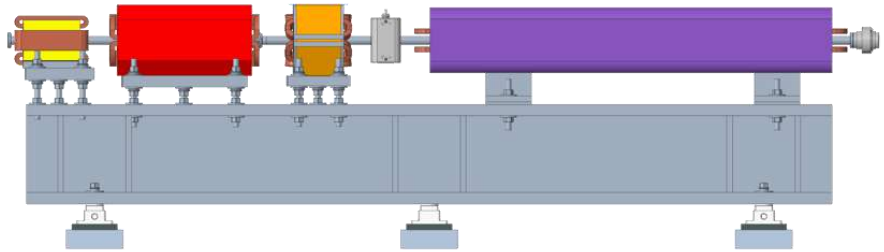
EIC needs nearly constant (20 to 24 nm) emittance from 5 to 18 GeV for optimum luminosity, but equilibrium emittance in an electron storage ring depends on beam energy.

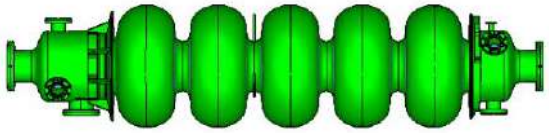
We will use ‘super bends’ (reverse bends) for emittance control below 10 GeV

Electron Injector

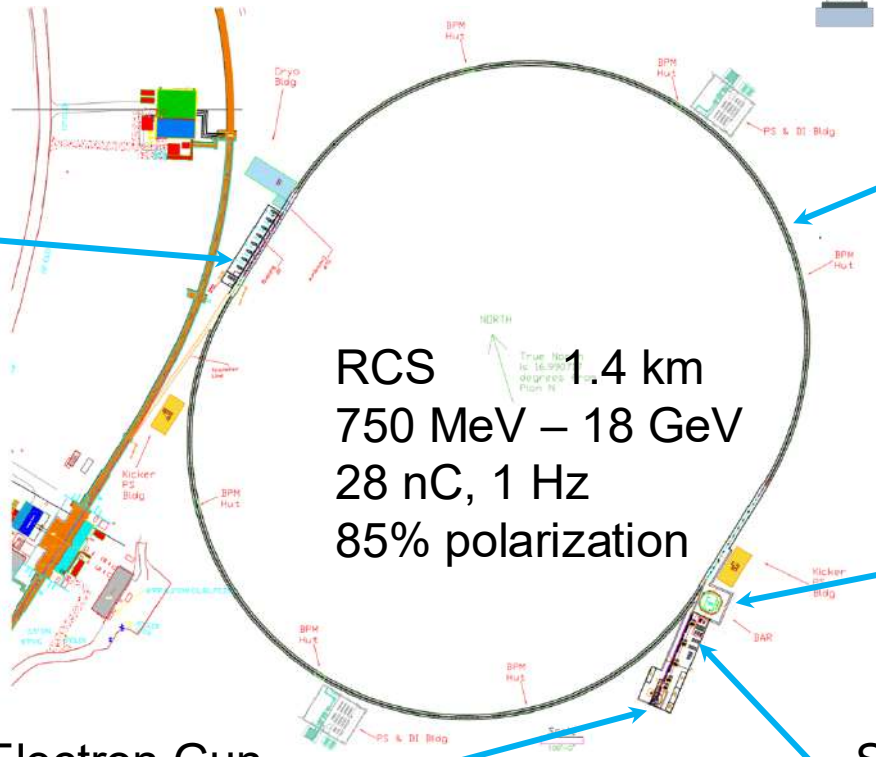
Concept modeled after the ANL APS-U injector

Function: Deliver electron bunches of up to 28 nC at a 1 Hz repetition rate for injection into the ESR at various energies of 5 – 10 GeV (upgradeable to 18 GeV).





RCS SRF Cavity, 591 MHz



RCS magnet assembly
Vacuum chamber: stainless steel, copper coated (50 um)

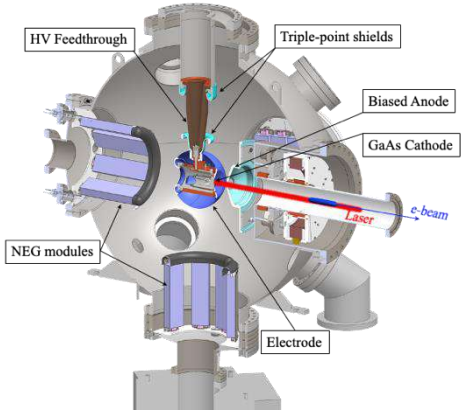

RESEARCH ARTICLE | JUNE 17 2024

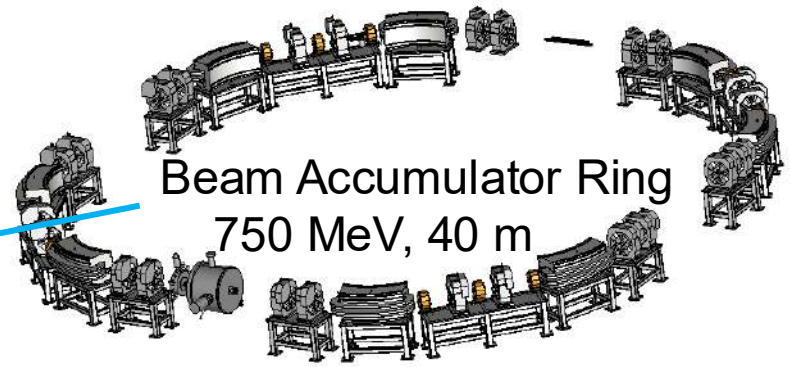
High-intensity polarized electron gun featuring distributed Bragg reflector GaAs photocathode

Erdong Wang; Omer Rahman; Jyoti Biswas; John Skaritka; Patrick Inacker; Wei Liu; Ronald Napoli; Matthew Paniccia

Check for updates

Appl. Phys. Lett. 124, 264101 (2024)





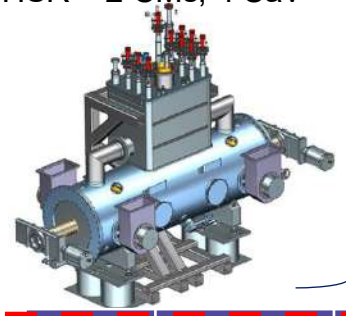
Beam Accumulator Ring
750 MeV, 40 m

Polarized Electron Gun
1-nC, 30 Hz

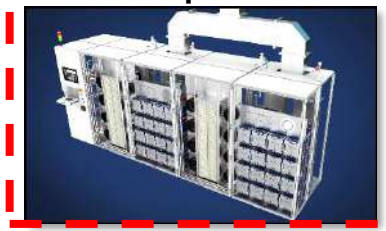
S-band linac, 750 MeV, 30 Hz, 1 nC single bunch

EIC - RF Systems

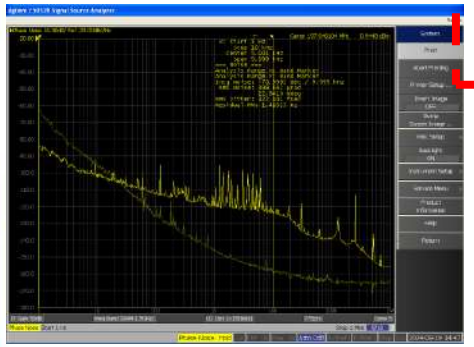
Electron Storage Ring & Hadron Storage Ring – IR10
591 MHz 800 kW 2 K
1-Cell Cavity Cryomodules
ESR = 8 CMs, 16 Cav
HSR = 2 CMs, 4 Cav

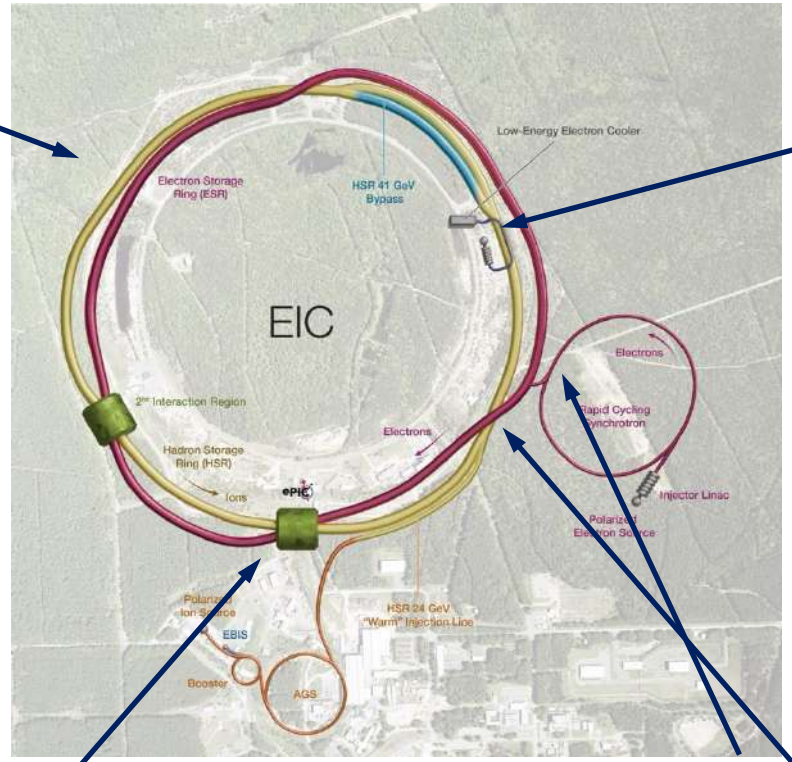


400 kW Solid State Amplifier



EIC LLRF DAC Clock for Crab Cavities

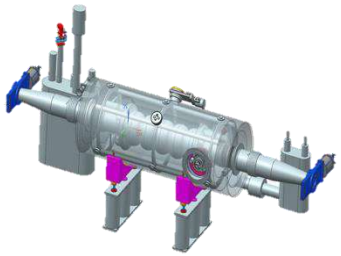




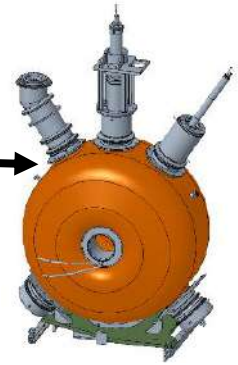
IR06

Crab Cavities (per IR)	HSR (Cavities/CMs)	ESR (Cavities/CMs)
197 MHz	8/4	–
394 MHz	4/4	2/2

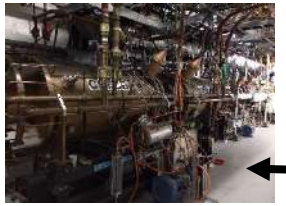
RCS
591 MHz 5-Cell Cavity
Cryomodules
2 CMs

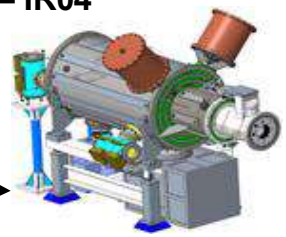


Low-Energy Cooler, IR02 -
16 197 QWR NCRF,
4 591 NCRF,
1 24 MHz NCRF,
And **1** 591 MHz
Deflecting Cavity



HSR NCRF – IR04



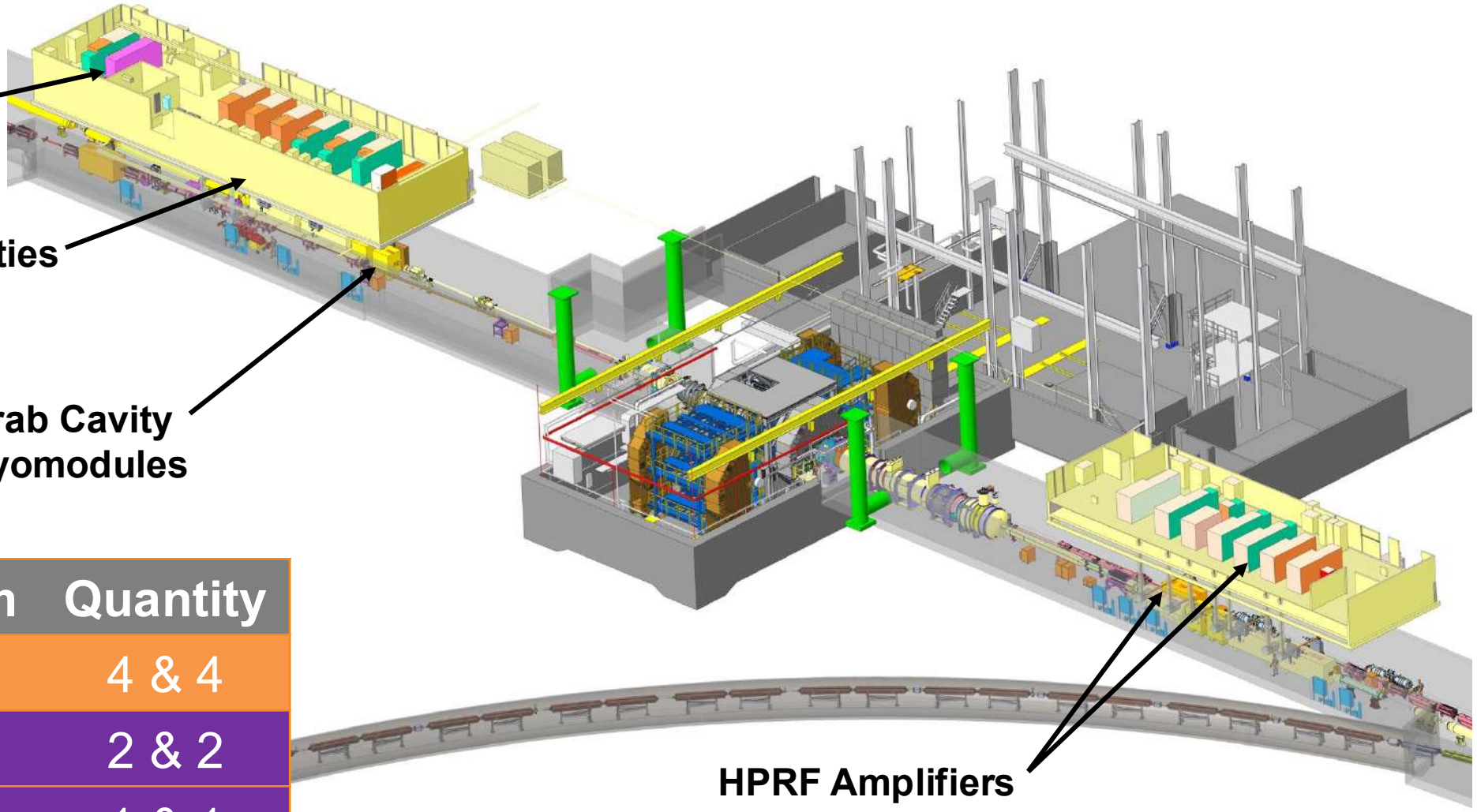


RHIC – 28 MHz
acceleration cavity

4 24.6 MHz Capture &
Accel Cavity, IR04

Bunch Splitting
3 49.2 MHz NCRF
4 98.5 MHz NCRF
Capture & Accel
8 197 MHz NCRF

IR6 (Crab Cavities)



Crabbing System	Quantity
197 MHz HSR	4 & 4
394 MHz HSR	2 & 2
394 MHz ESR	1 & 1

c/o: Karim Hamdi

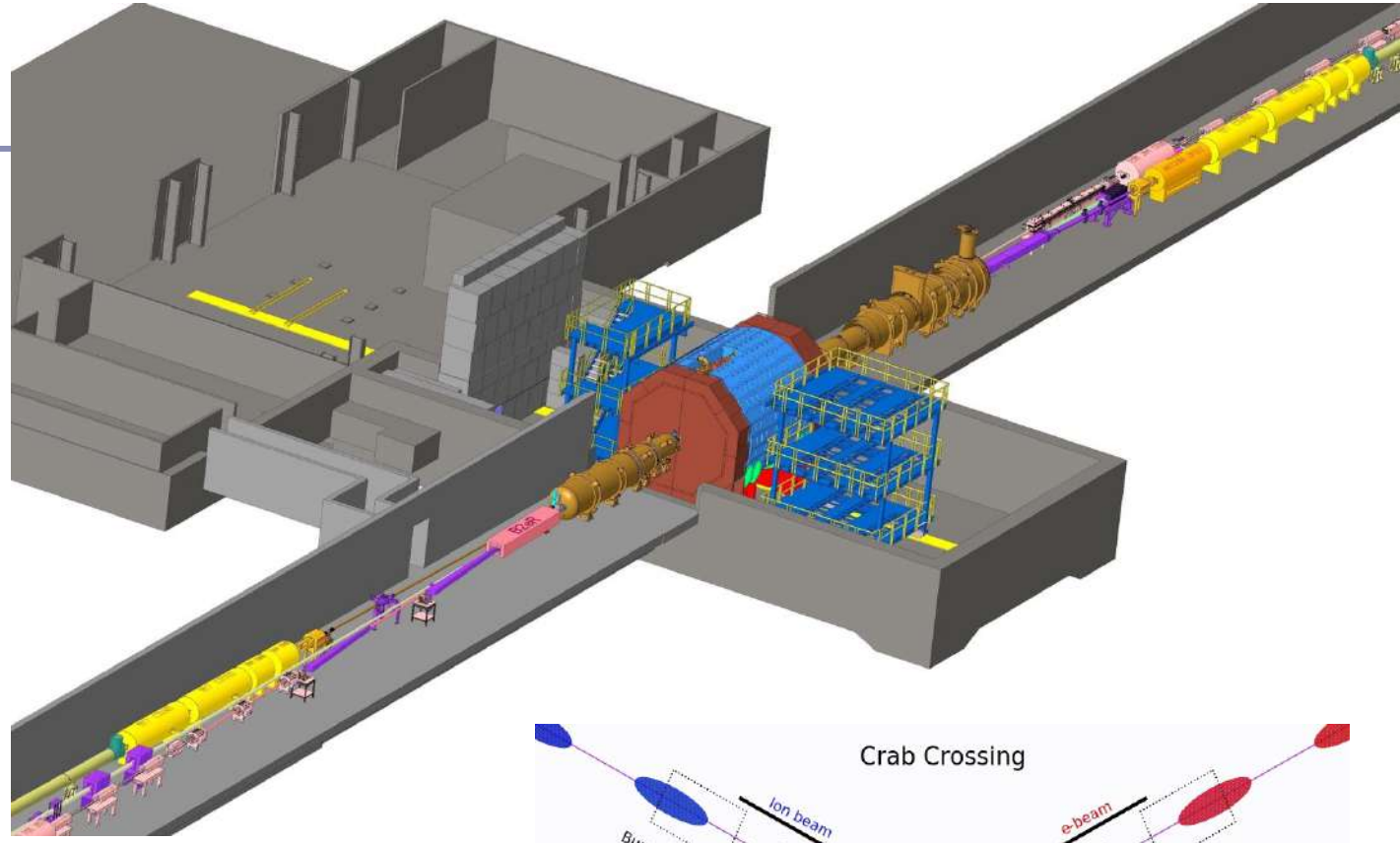
EIC IR Layout

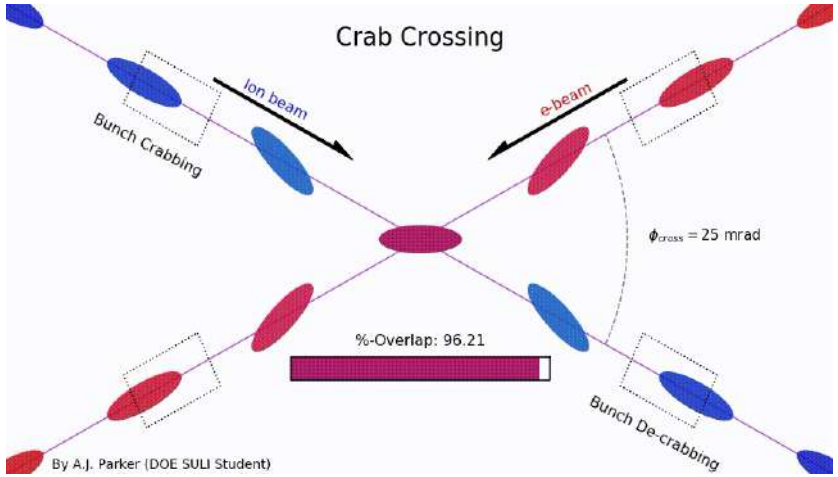
High Luminosity:

- 25 mrad crossing angle
- Small β* for high luminosity
  with limited IR chromaticity
  contributions
- Large final focus quadrupole aperture

Machine Detector Interface

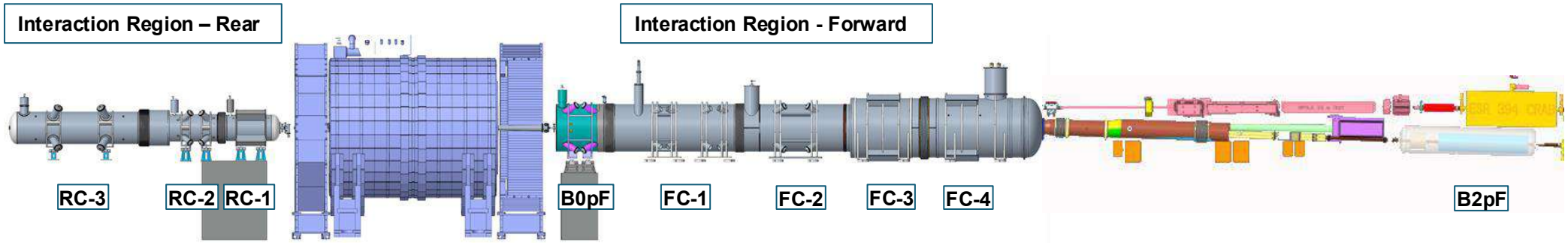
- Large detector acceptance
- Forward spectrometer
- No magnets within - 4.5 / +5 m from IP
- Space for luminosity detector, neutron detector, “Roman Pots”



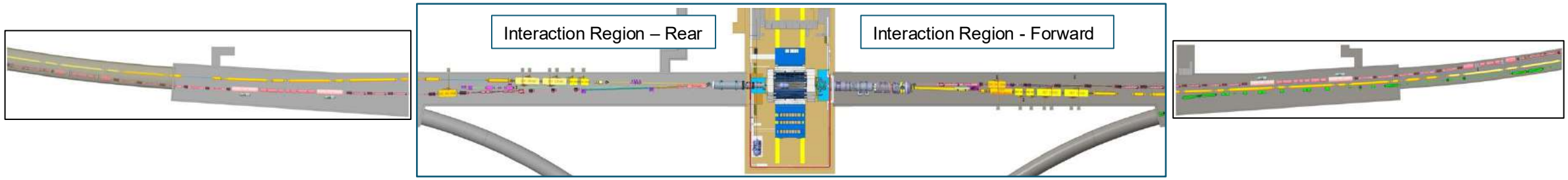


EIC IR layout

- **9 cryostats** housing **11 cold masses (2 K)**
  - **15 magnets** (dipole, quadrupole, and combined-function)
    - **6** “cos-theta” magnets with **Rutherford cables, 9** magnets fabricated with Direct Wind technique (**DW**)



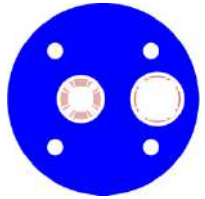
- **8 cryostats** (4 per side) which contain the **spin rotators** (solenoids 8.5 T, 2K)
  - 2 long and 2 short per side



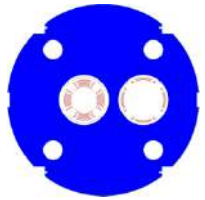
EIC IR Superconducting Magnets

View from the IP

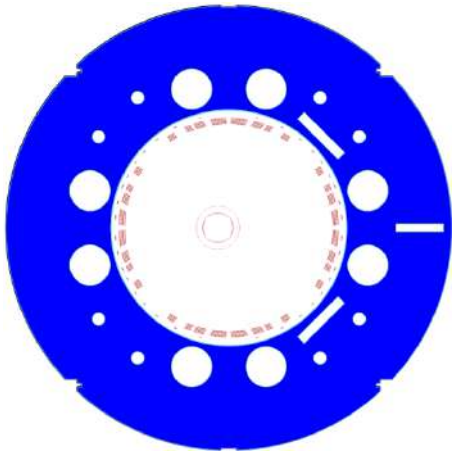
Q2pR-eDrift



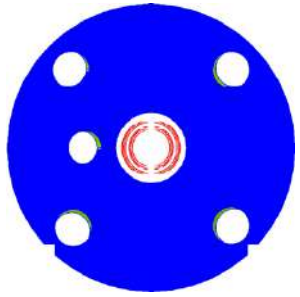
Q1BpR-Q2eR



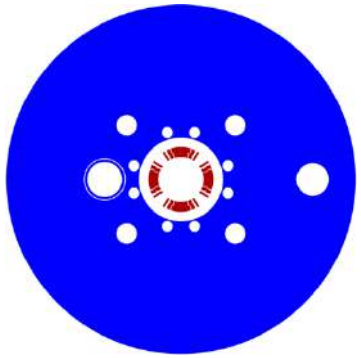
Q1ApR-Q1eR



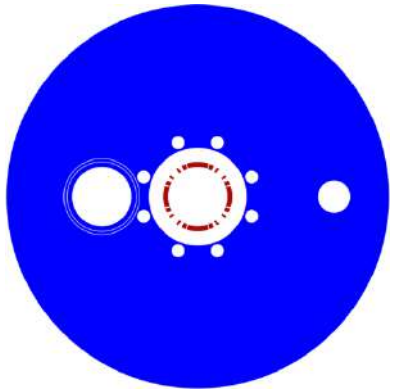
B0pF-Q0eF



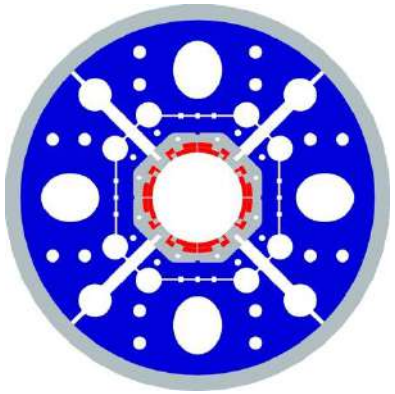
B0ApF-eDrift



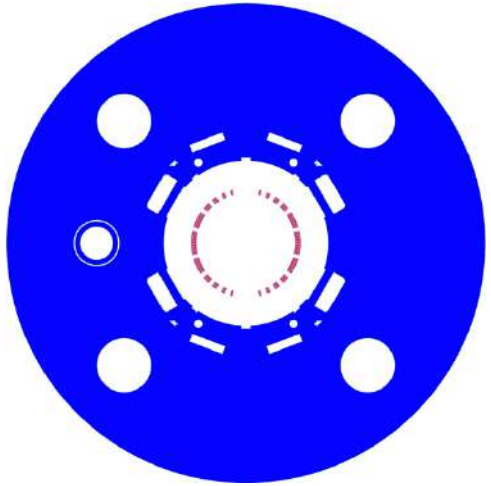
Q1ApF-eDrift



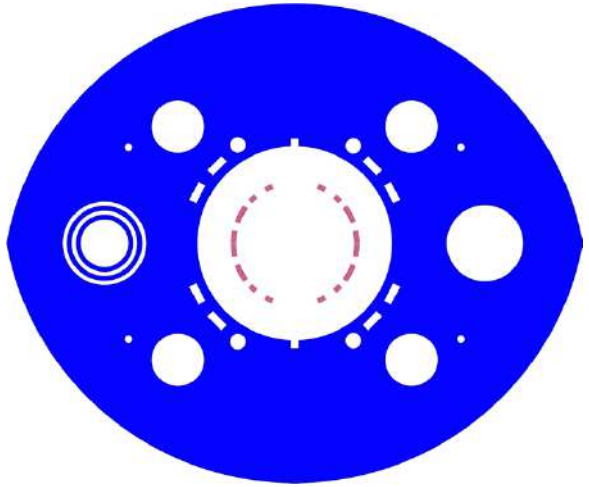
Q1BpF-Q1eF



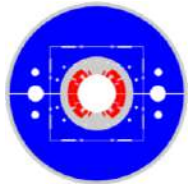
Q2pF-eDrift



B1pF-eDrif



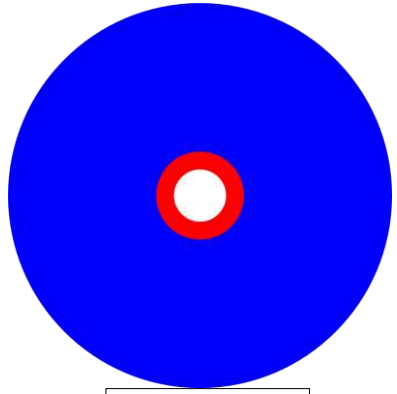
B1ApF-eDrift



B2pF

1 m

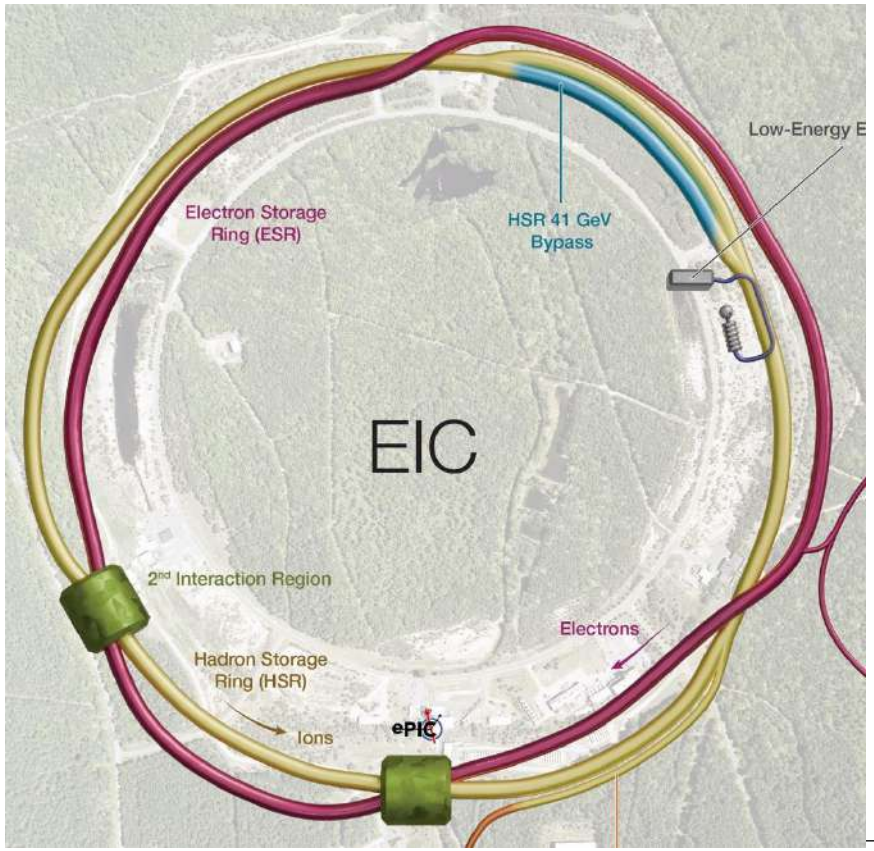
All magnets to the same scale



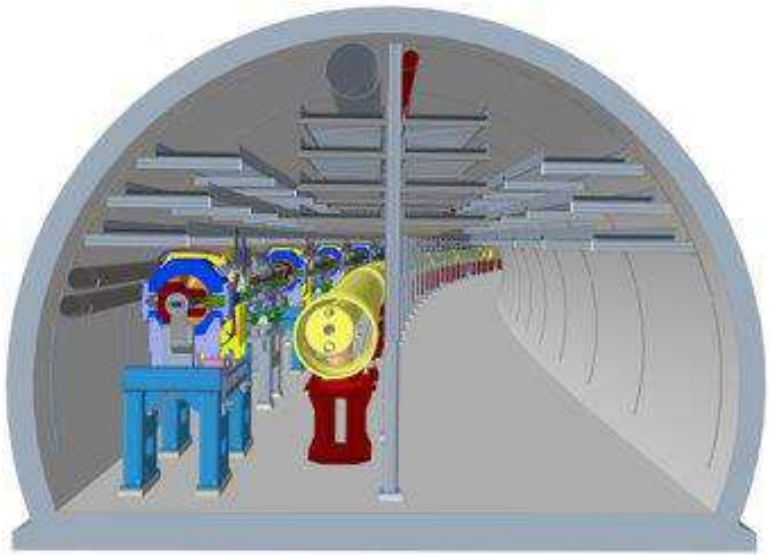
Spin rotator

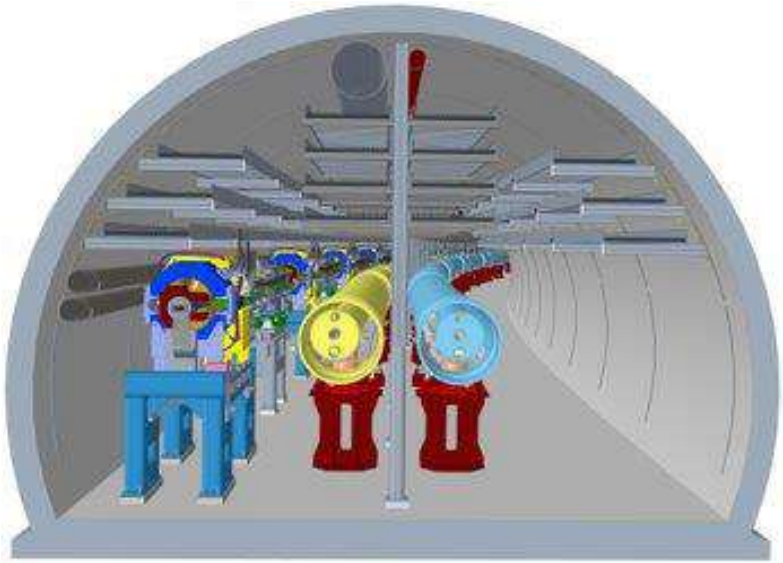
The 41-GeV ‘bypass’

This bypass provides access to the lowest EIC CoM energy, 29 GeV



Sector 1 without and with the 41-GeV bypass line





Low-energy Cooler Concept

IR2 layout (all within the existing RHIC Tunnel)

24 GeV protons
12.5 MeV electrons

Not to scale

150 m cooling section

180°Dipole (U-turn)
Quad
Mu-metal shielding
LEReC Cooling Solenoids
RF diagnostics line with Deflecting cavity
180° Dipole Spectrometer
cooling
RF diagnostic
hadron
HSR
extraction
transport
injection
Injector test
NOT TO SCALE
SC Quad
Extraction line
900 kW Beam Dump
Cathode transport
DC Gun 400kV
Laser 197 MHz
16x 197 MHz NCRF LINAC
PM
PM
PM
4x 591 MHz NCRF correction Cavities
Injector/linac Test line
130 kW Beam Dump
24MHz RF cavity
Solenoids

What is the EIC Accelerator Collaboration

- We would like to collaborate with other labs in the world
  - to realize the EIC, and
  - work for mutual benefit

- On topics of common interest in
  - Beam dynamics
  - Technology

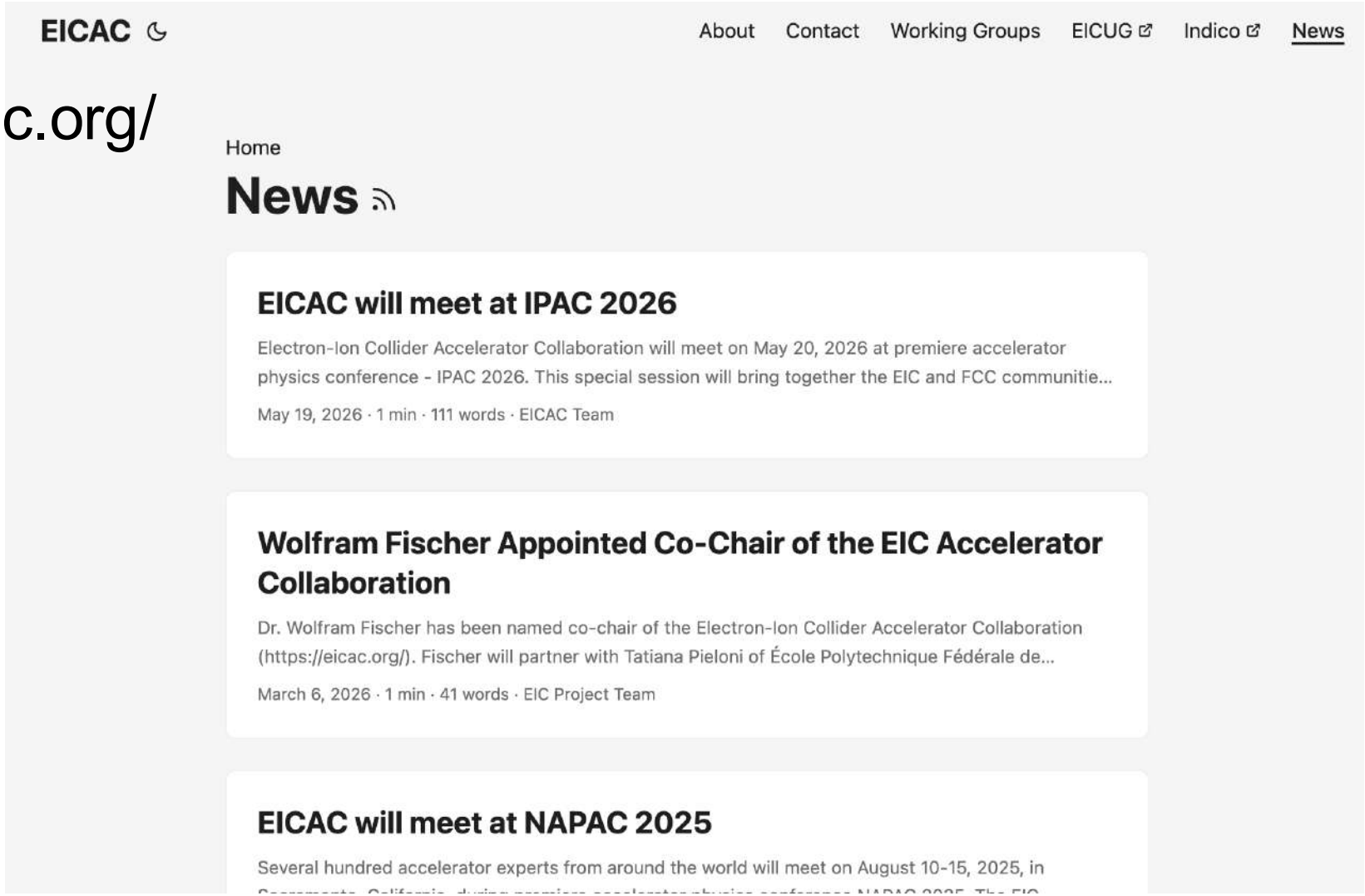
EIC Accelerator Collaboration

Main Elements of the EIC Accelerator Collaboration:

- Institutional Board (27 members from around the world)
- Co-Chairs
- Working Groups
  - Beam-beam
  - Polarization and Polarimetry
- Collaboration Meetings (at IPAC, NAPAC)
- Fellowships (yet to be established)

What is the EIC Accelerator Collaboration

https://eicac.org/

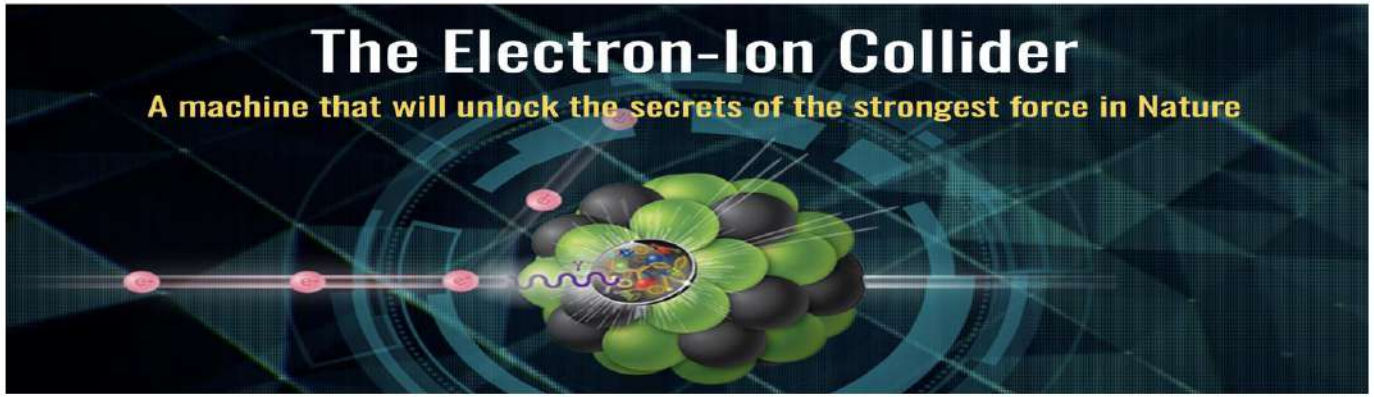


EIC Accelerator Collaboration and synergies with FCC studies

May 20, 2026
Europe/Paris timezone

Enter your search term

- Overview
- Timetable
- Contribution List
- Registration
- Participant List



The Electron-Ion Collider (EIC) will be a world-leading facility for exploring the strong nuclear force—the fundamental interaction that binds quarks and gluons into protons, neutrons, and nuclei. Hosted at Brookhaven National Laboratory and built on the existing RHIC infrastructure, the EIC will bring high-energy electron beams into collision with protons and heavy ions to unlock deep insights into the structure of matter.

The realization of the EIC presents an array of scientific and technical challenges, offering a unique opportunity for the global accelerator community to engage in a major international project.

To support this, the EIC Accelerator Collaboration was officially launched in December 2023. Since its inception, the collaboration has taken flight, with growing international engagement and ongoing contributions to key areas of EIC design, R&D, and long-term performance planning.


17th International Particle Accelerator Conference
IPAC26
May 17 - 22, 2026
Luisella Lari (BNL)
Frank Zimmermann (CERN)
Wolfram Fischer (BNL)
Tatiana Pieloni (EPFL)

EIC Accelerator Collaboration Working Groups

- Beam-beam - Christoph Montag & Xavier Buffat
- Polarized Beams & Polarimetry - Frank Rathmann & Georg Hoffstaetter
- Commissioning Tools - Yue Hao and Jean-Luc Vay

Possible additional working group

- Second Interaction Region
- Electron injectors
- High Energy Beam Cooling
- FCC-EIC Forum
- More WGs are coming

EIC AC Institutional Board

Lin Liu	LNLS	Brazil
Oliver Kester	TRIUMF	Canada
Guillaume Olry	IJCLab	France
Pierre Vedrine	CEA Saclay	France
Qing Qin	ESRF	France
Ralph Assmann	GSI/FAIR	Germany
Lucio Rossi	INFN Milano	Italy
Roberto Cimino	INFN-LNF	Italy
Moses Chung	Pohang Accelerator Lab	South Korea
Amalia Ballarino	CERN	Switzerland
Paolo Craievich	PSI	Switzerland
Graeme Burt	Lancaster University	UK
Carsten Welsch	University of Liverpool	UK
Nik Templeton	STFC	UK
Phil Burrows	John Adams Institute	UK
Stewart Boogert	Cockcroft Institute	UK
Georg Hoffstaetter	Cornell University	United States
Jean Delayen	Old Dominion University	United States
John Power	ANL	United States
Mei Bai	SLAC	United States
Sam Posen	Fermilab	United States
Sarah Cousineau	ORNL	United States
Soren Prestemon	LBNL	United States
Young-Kee Kim	University of Chicago	United States
Yue Hao	FRIB	United States
Sergei Nagaitsev (ex-officio)	BNL	United States
Todd Satogata (ex-officio)	JLab	United States

First meeting
on 29 May 2026

Planned Fellowships for EIC-FCC collaboration

- Working on setting up 2 Fellowships (post-doc level)

- 1 based in US (BNL or JLab)
- 1 based in Europe (CERN)

- Focus on topics common to EIC and FCC
- With significant stay period (>= 3 months/year) on other side of pond

EIC Accelerator Collaboration

- EIC and FCC are the next generation of colliders
- World-wide collaboration and ideas are essential
- We need the collaboration to realize the EIC