Brookhaven National Laboratory

Jefferson Lab

U.S. DEPARTMENT of ENERGY | Office of Science

The Electron-Ion Collider Project Status

Luisella Lari

EIC Project Manager transitioning to EIC Associate Director for Strategic Partnership

Sr. Scientist

May 20, 2026

What is the Electron-Ion Collider (EIC)?

What is the EIC?

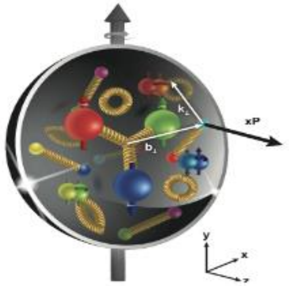
- A **next-generation particle collider** at **Brookhaven National Laboratory**
- Collides **electrons** with **atomic nuclei or protons**
- Acts as a **precision microscope** for **studying quarks and gluons**
- Designed to answer how **mass, spin, and nuclear structure** emerge from the **strong force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

Why electrons + ions?

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

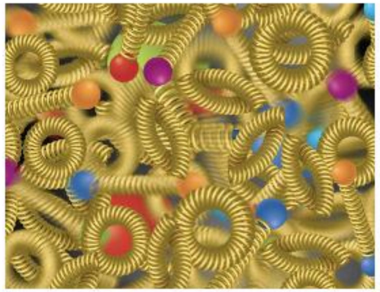
How do quarks, gluons, and orbital angular momentum contribute to proton spin?

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



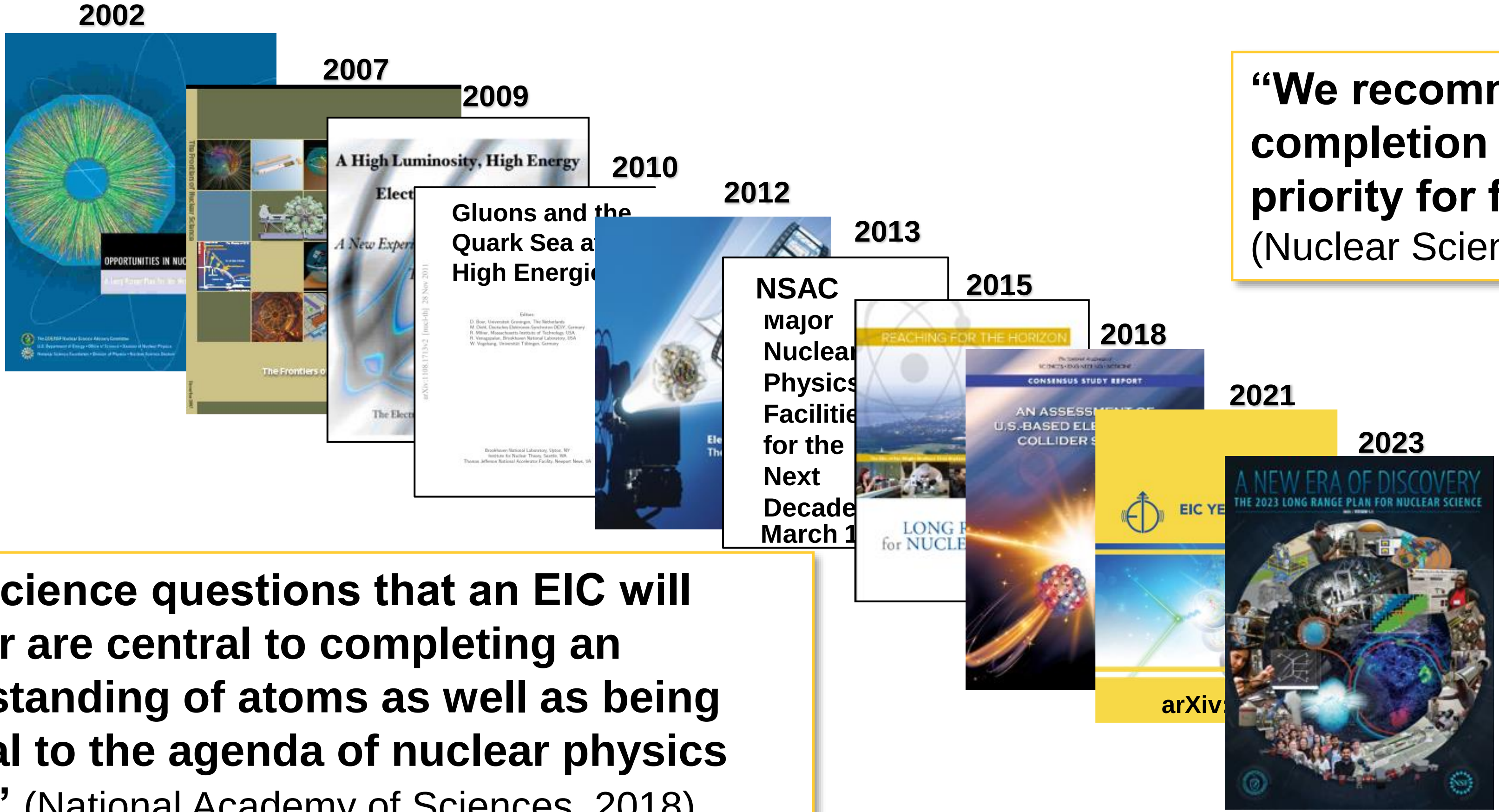
How can we understand QCD dynamics and the relation to confinement?

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)

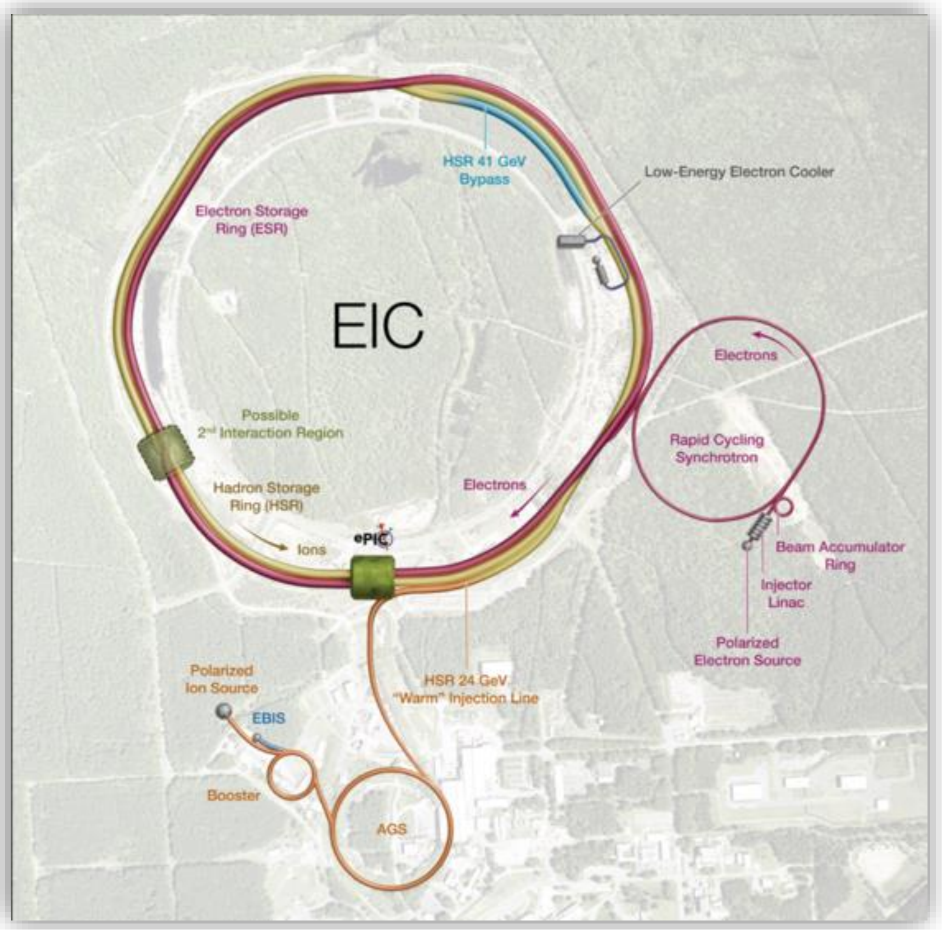
"The science questions that an EIC will answer are central to completing an understanding of atoms as well as being integral to the agenda of nuclear physics today." (National Academy of Sciences, 2018)

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

EIC Facility Requirements

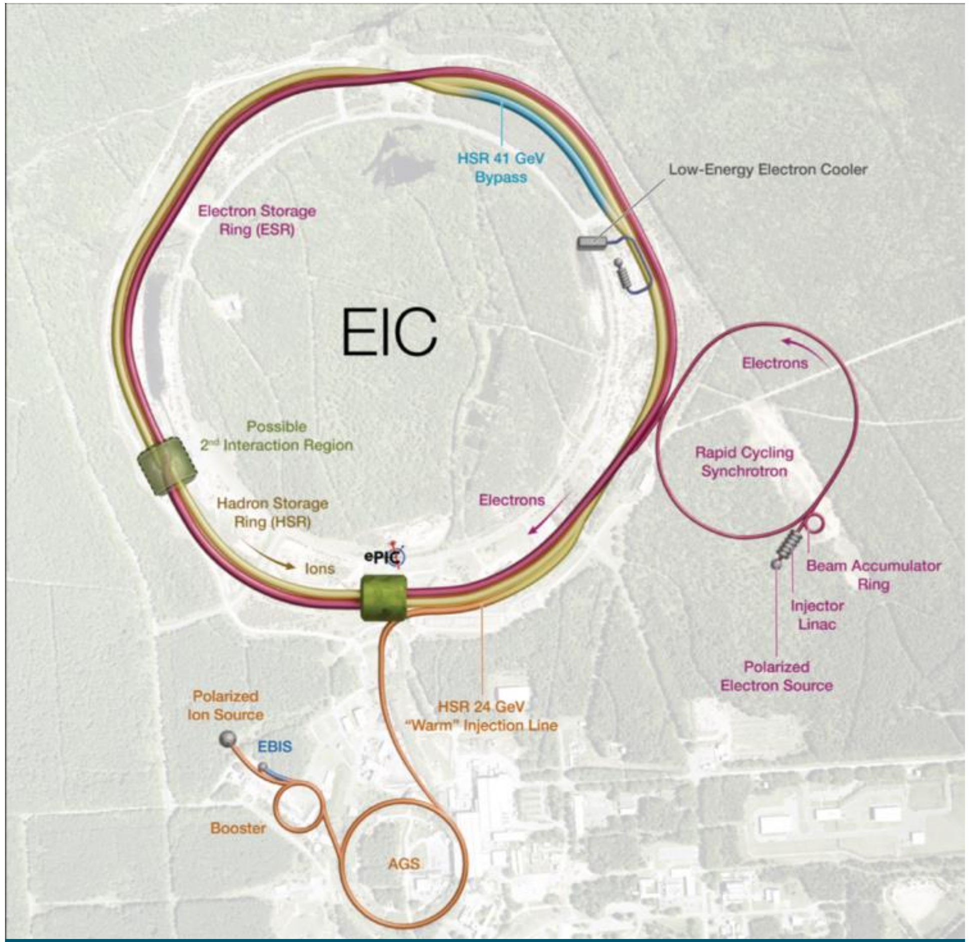
Ultimate Performance Parameters

- High Luminosity: $L = 10^{33} – 10^{34} cm^{-2} sec^{-1}$
- Highly Polarized Beams: 70%
- Large Center of Mass Energy Range: Ecm = 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)



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

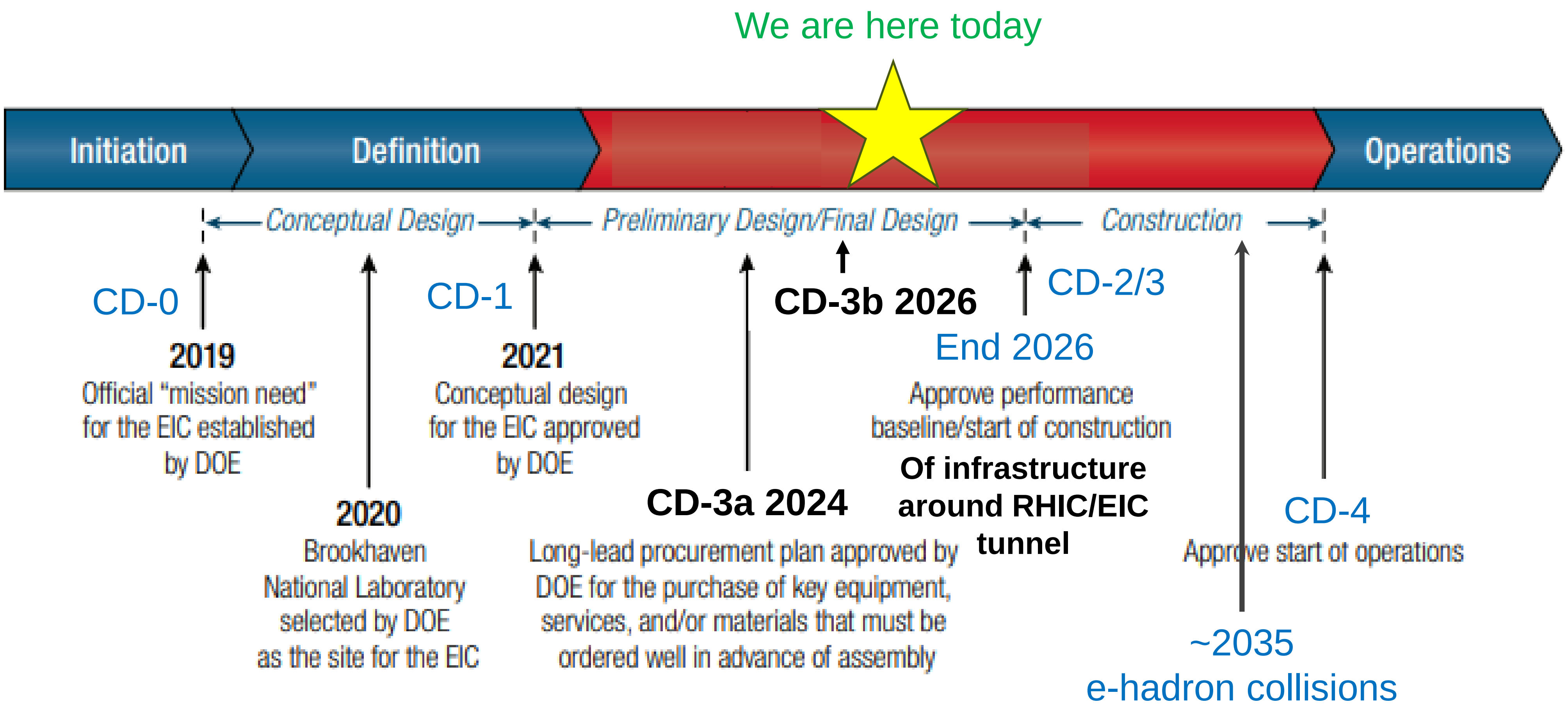


Reuse of RHIC Facility components
Valued at ~$2B

EIC Infrastructure Project Scope

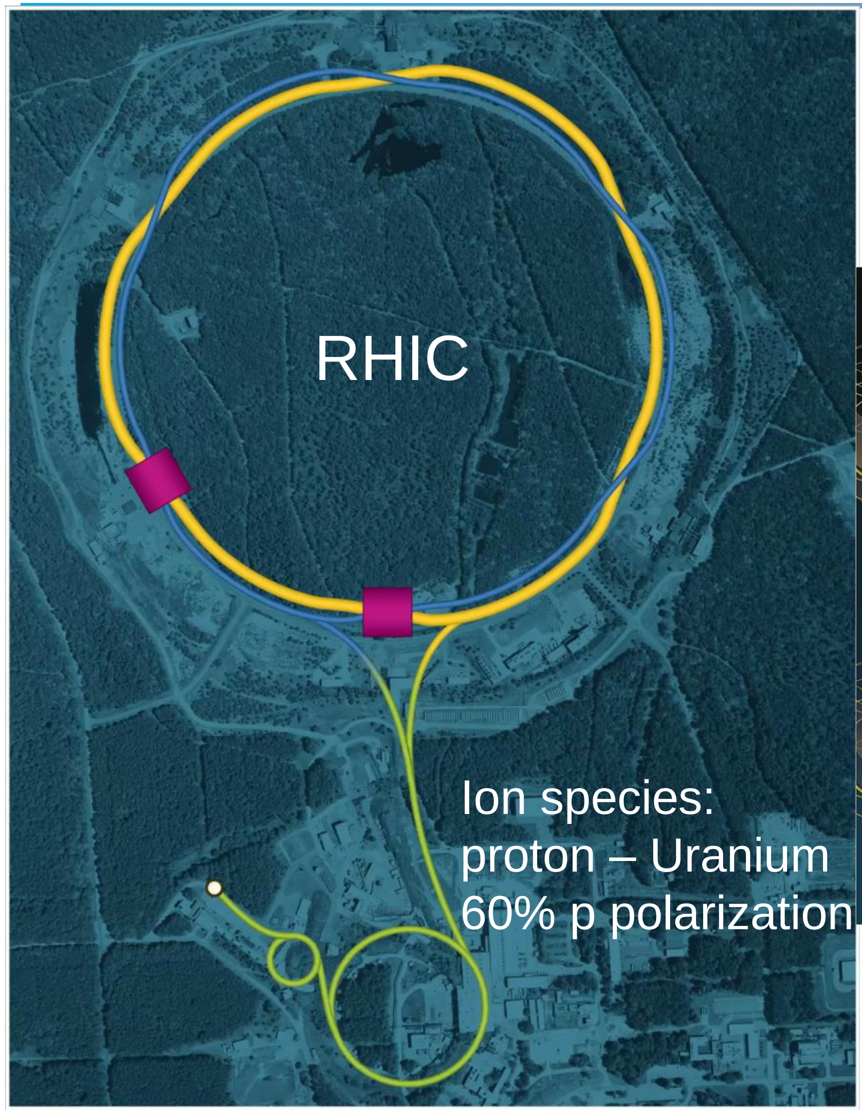
100% Design completed for the infrastructure around EIC/RHIC tunnel.

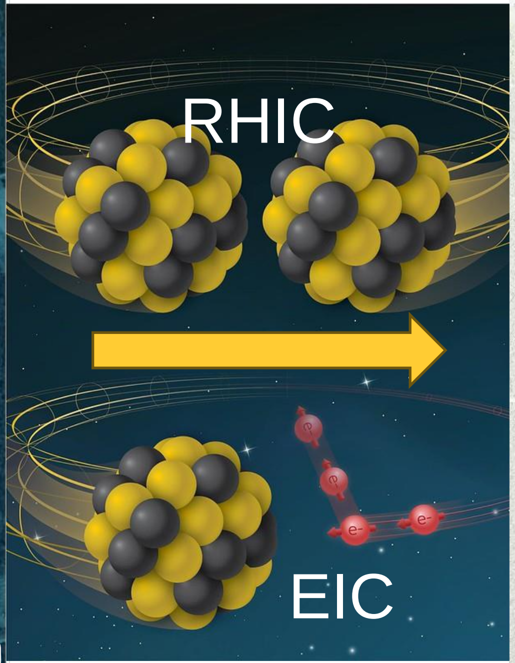
Project Milestones

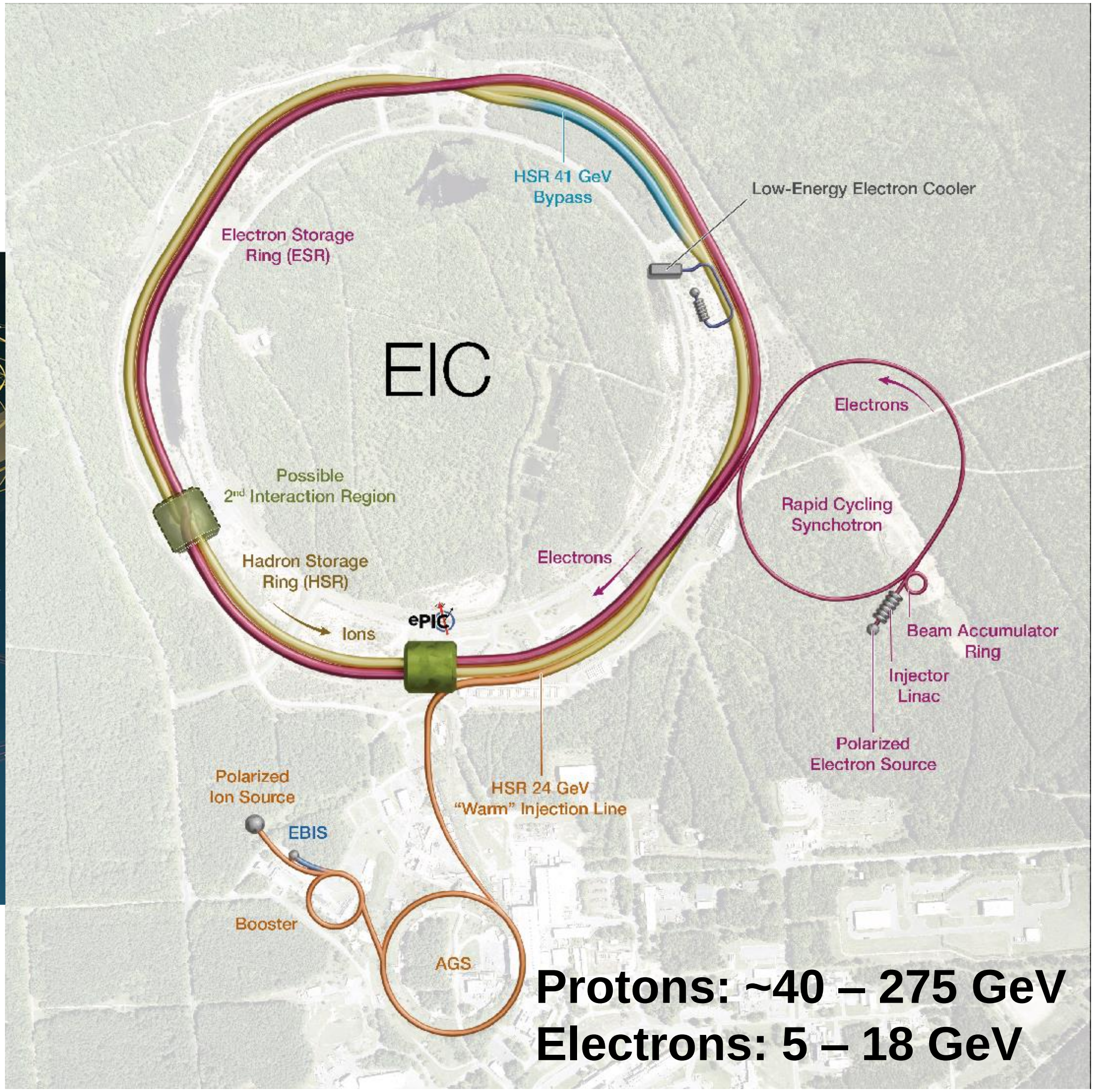


EIC Accelerator Challenges Overview

From RHIC to EIC





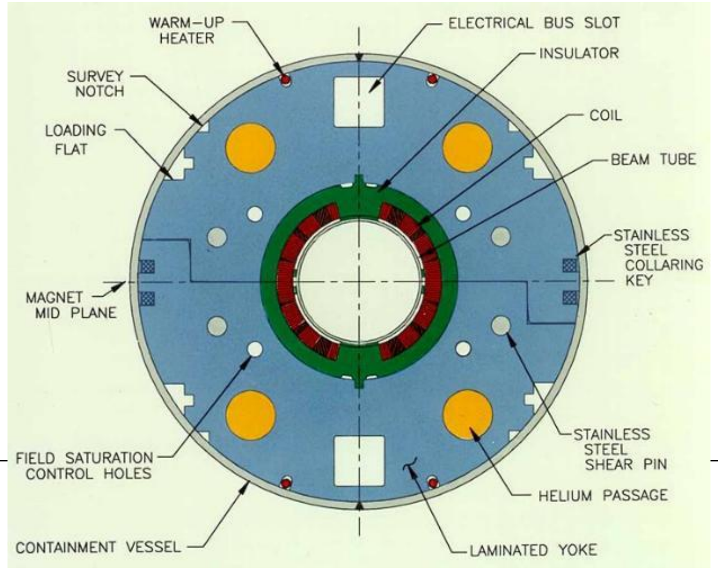


From RHIC (yellow ring) to EIC HSR

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

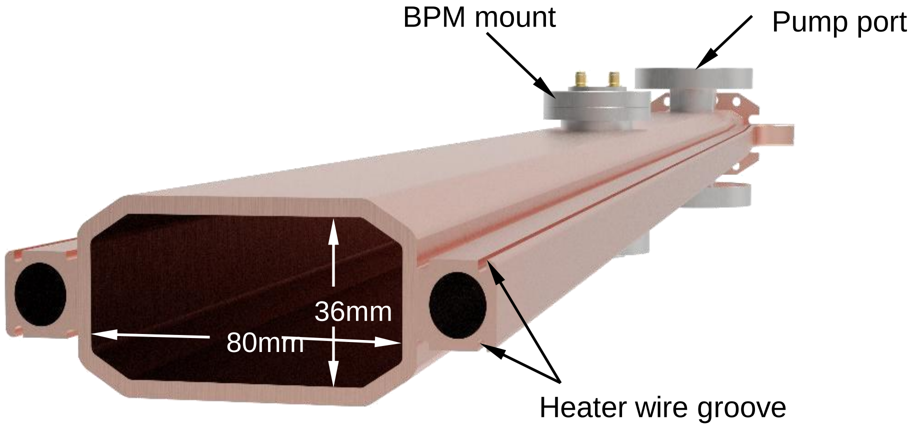
- EIC HSR to be composed of existing arcs of the Yellow RHIC ring (remove unused magnets)
- Insert sleeves coated with copper and amorphous carbon into superconducting magnet beam pipes to improve conductivity and reduce secondary electron yield (-> electron cloud)
- Add new RF cavities
- Add hadron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

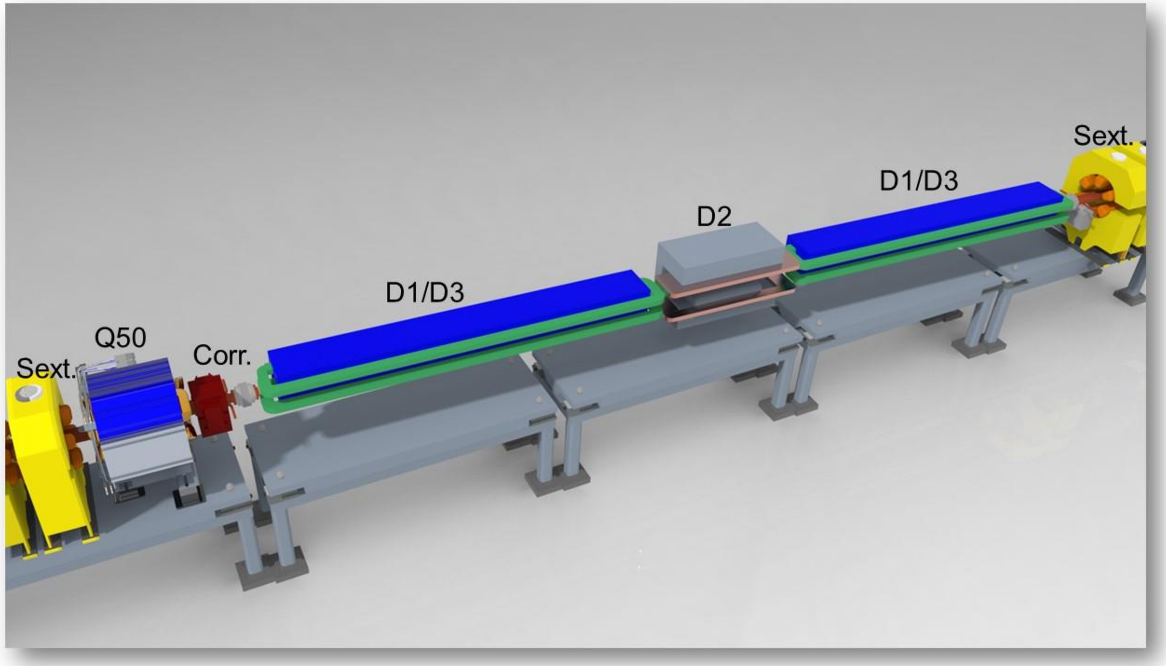
Actively Cooled Beam Screen Material procurement



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





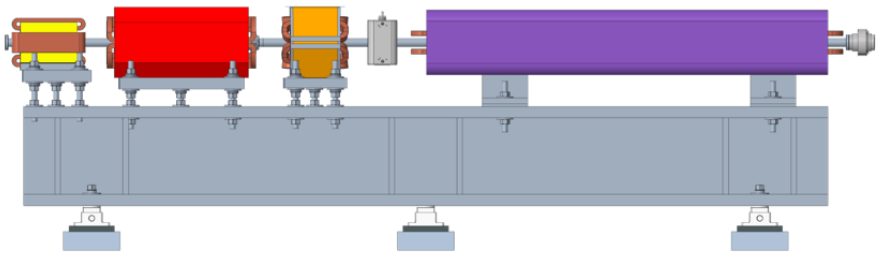
EIC needs nearly constant (20 to 24 nm) emittance from 5 to 18 GeV for optimum luminosity, but equilibrium emittance in an electron storage ring depends on beam energy.

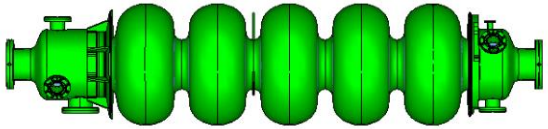
We will use ‘super bends’ (reverse bends) for emittance control below 10 GeV

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


RESEARCH ARTICLE | JUNE 17 2024

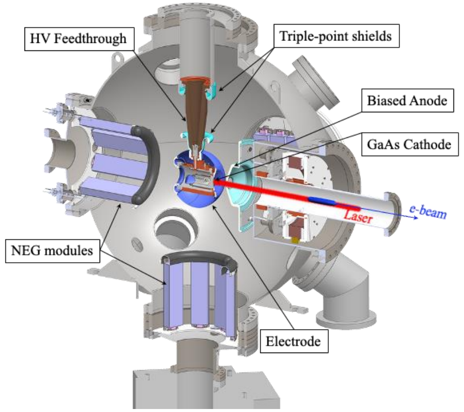
High-intensity polarized electron gun featuring distributed Bragg reflector GaAs photocathode

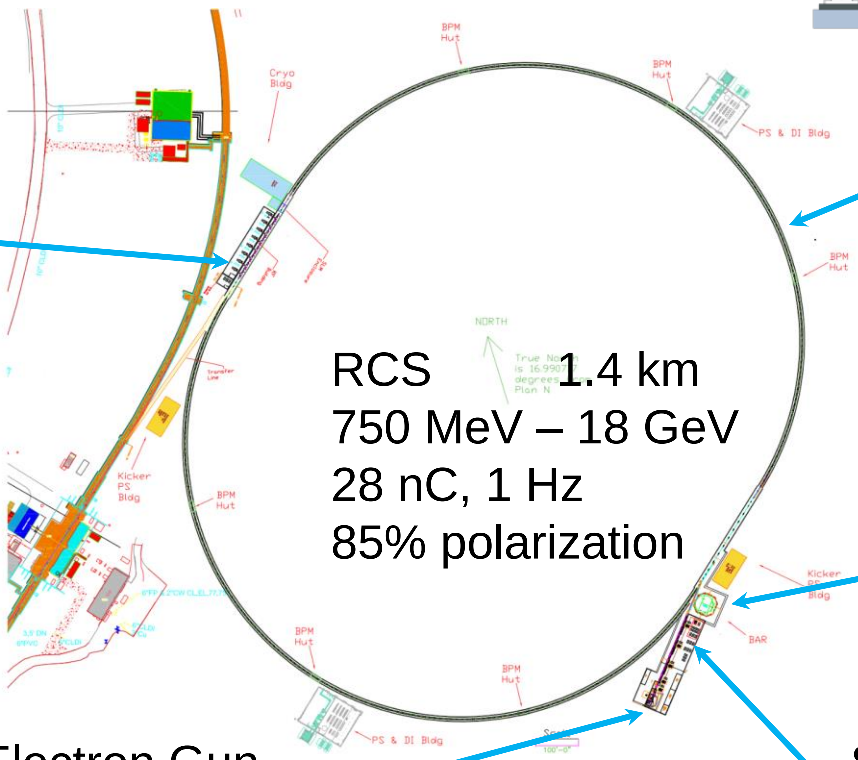
Erdong Wang; Omer Rahman; Jyoti Biswas; John Skaritka; Patrick Inacker; Wei Liu; Ronald Napoli; Matthew Paniccia

Check for updates

Appl. Phys. Lett. 124, 254101 (2024)

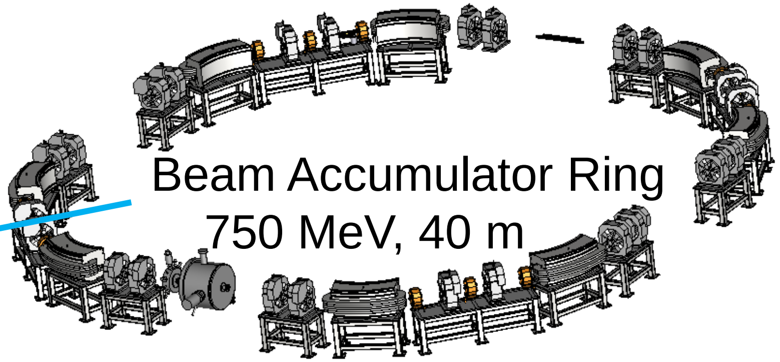
https://doi.org/10.1063/5.0216694





RCS 1.4 km
750 MeV – 18 GeV
28 nC, 1 Hz
85% polarization

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



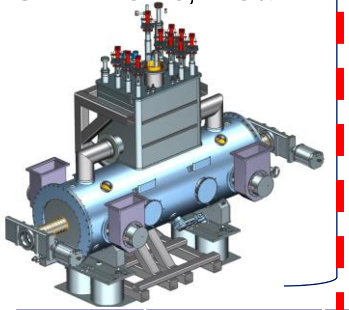
Beam Accumulator Ring
750 MeV, 40 m

Polarized Electron Gun
1-nC, 30 Hz

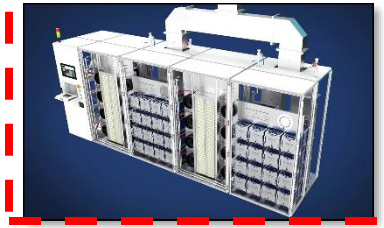
S-band linac, 750 MeV, 30 Hz, 1 nC single bunch

EIC - RF Systems

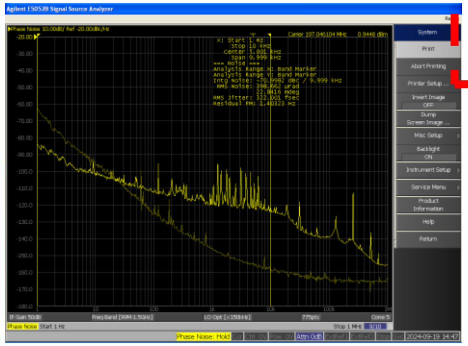
Electron Storage Ring & Hadron Storage Ring – IR10
591 MHz 800 kW 2 K
1-Cell Cavity Cryomodules
ESR = 8 CMs, 16 Cav
HSR = 2 CMs, 4 Cav



400 kW Solid State Amplifier

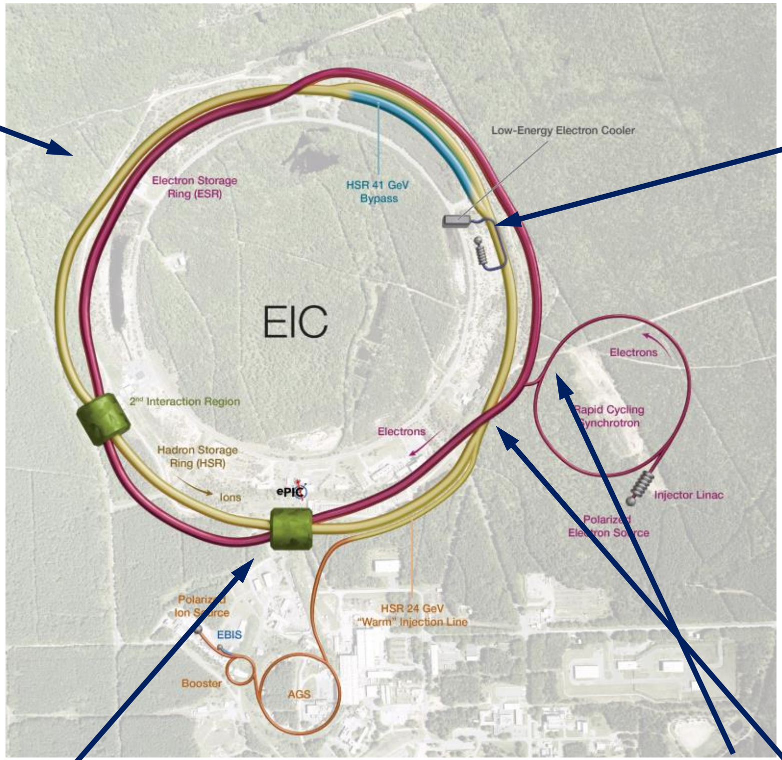


EIC LLRF DAC Clock for Crab Cavities

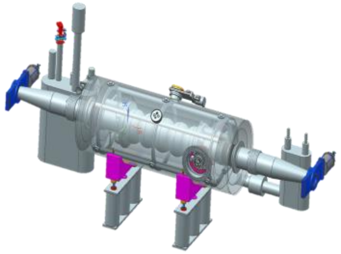


IR06

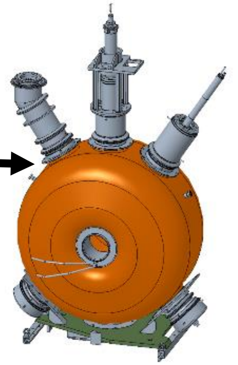
Crab Cavities (per IR)	HSR (Cavities/CMs)	ESR (Cavities/CMs)
197 MHz	8/4	–
394 MHz	4/4	2/2



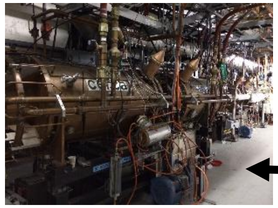
RCS
591 MHz 5-Cell Cavity Cryomodules
2 CMs



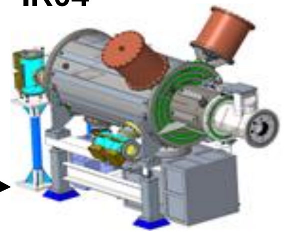
Low-Energy Cooler, IR02 -
16 197 QWR NCRF,
4 591 NCRF,
1 24 MHz NCRF,
And **1** 591 MHz Deflecting Cavity



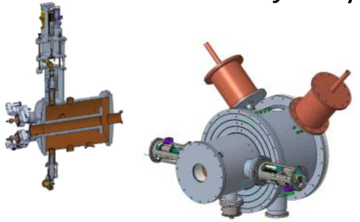
HSR NCRF – IR04



RHIC – 28 MHz acceleration cavity

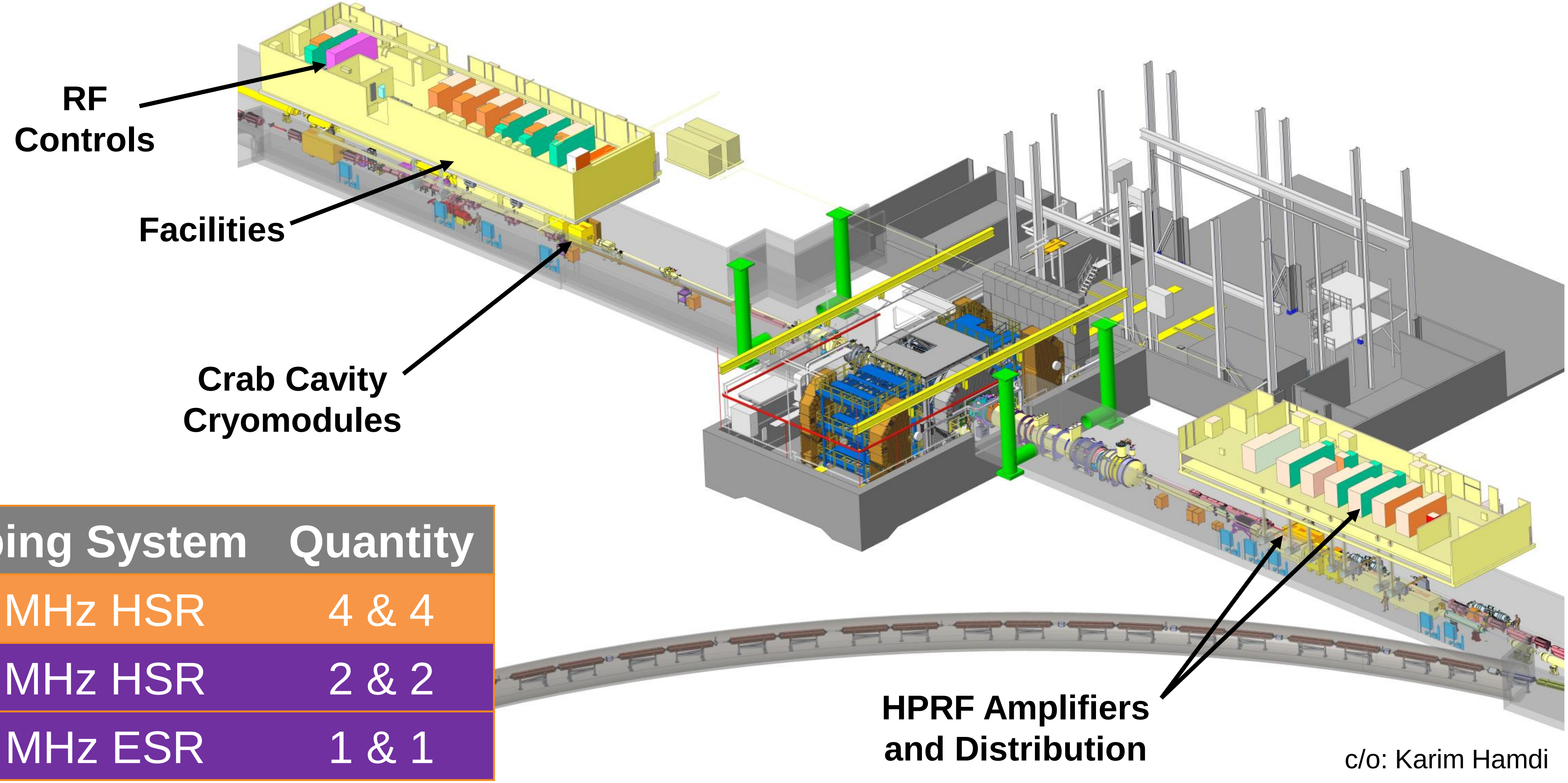


4 24.6 MHz Capture & Accel Cavity, IR04



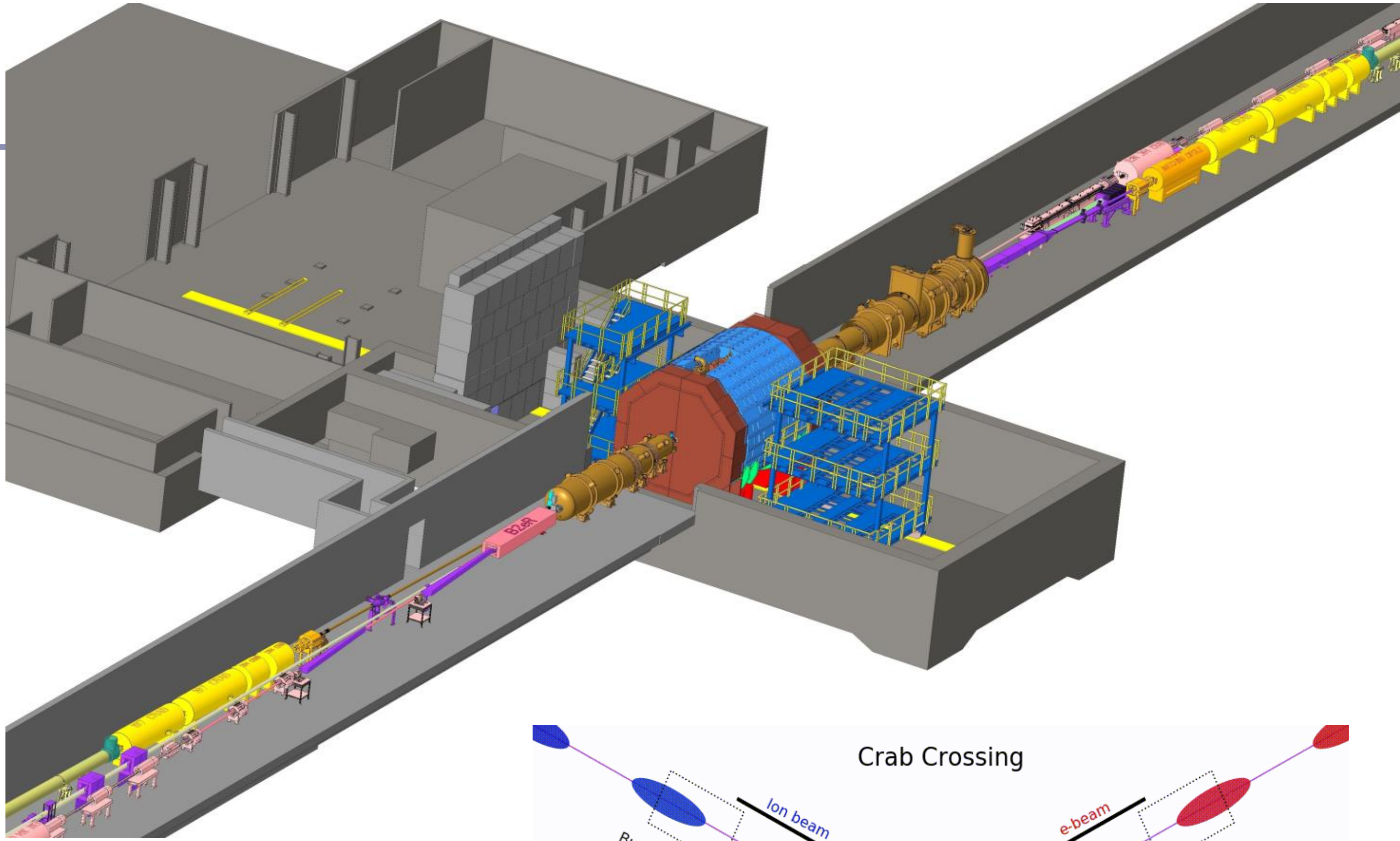
Bunch Splitting
3 49.2 MHz NCRF
4 98.5 MHz NCRF
Capture & Accel
8 197 MHz NCRF

IR6 (Crab Cavities)



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

EIC IR Layout

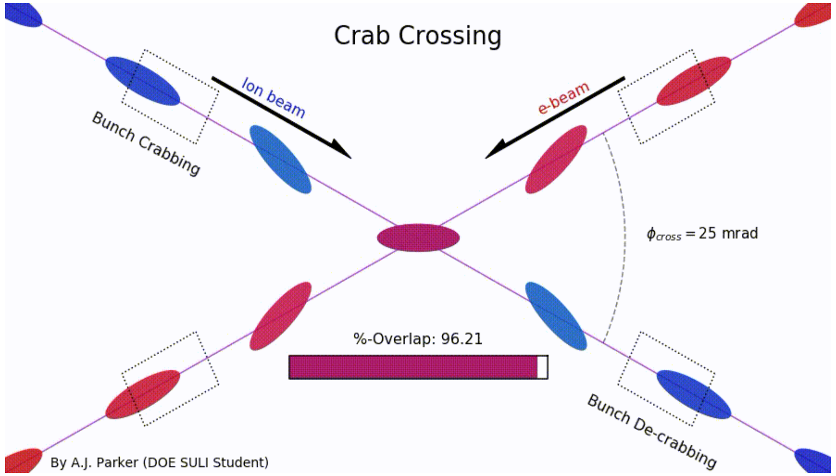


High Luminosity:

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

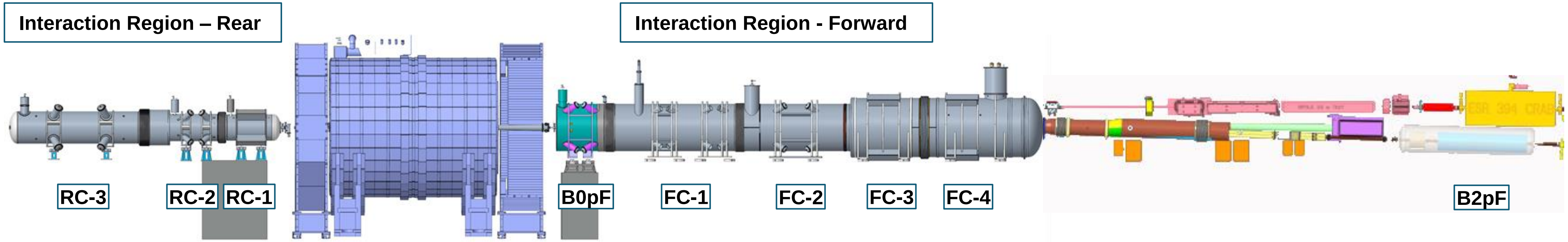
Machine Detector Interface

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

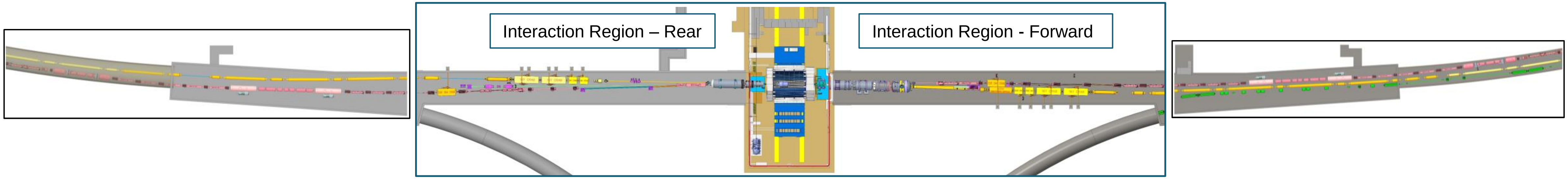


EIC IR layout

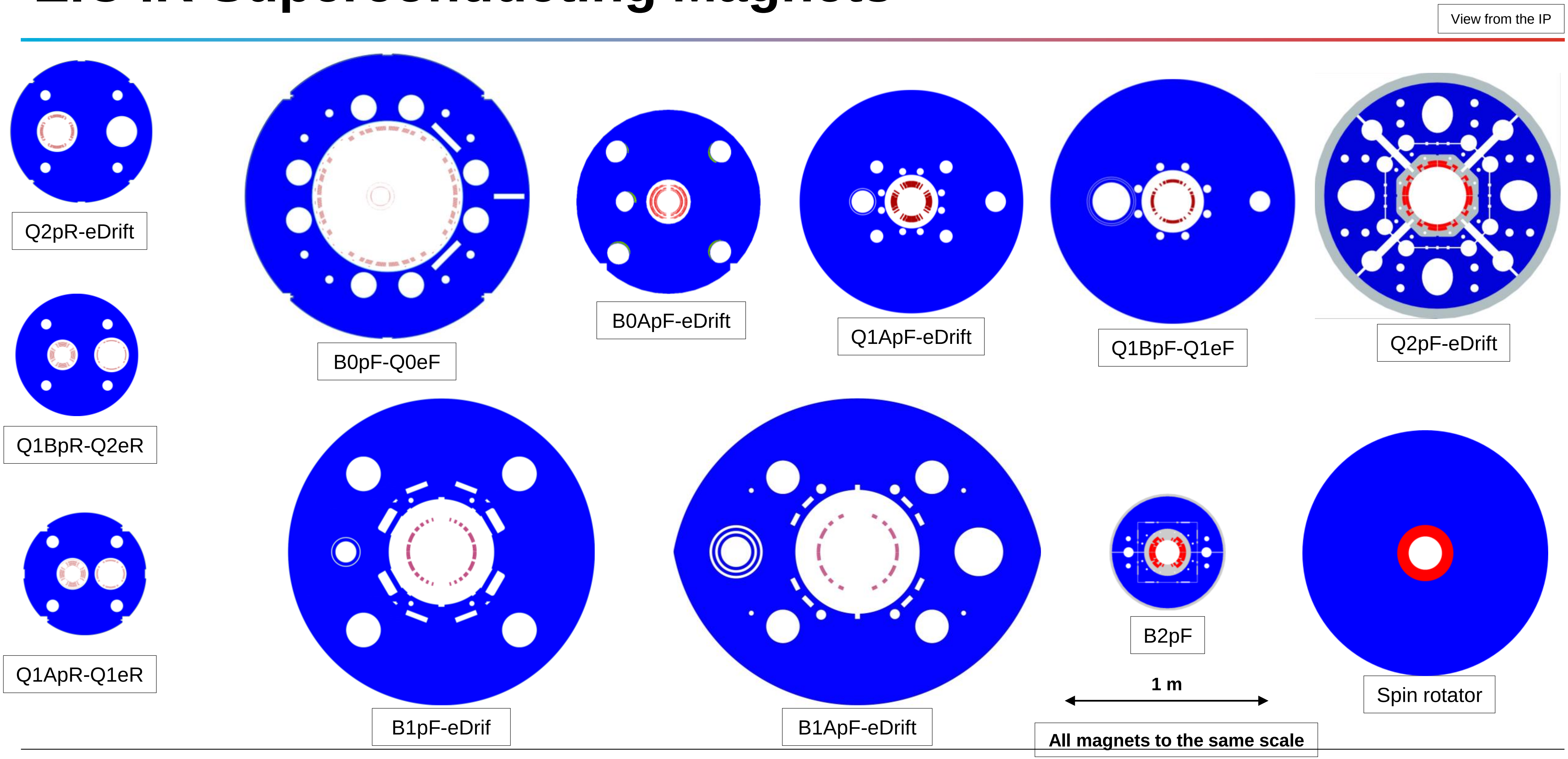
- **9 cryostats** housing **11 cold masses (2 K)**
  - **15 magnets** (dipole, quadrupole, and combined-function)
    - **6** “cos-theta” magnets with **Rutherford cables, 9** magnets fabricated with Direct Wind technique (**DW**)



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

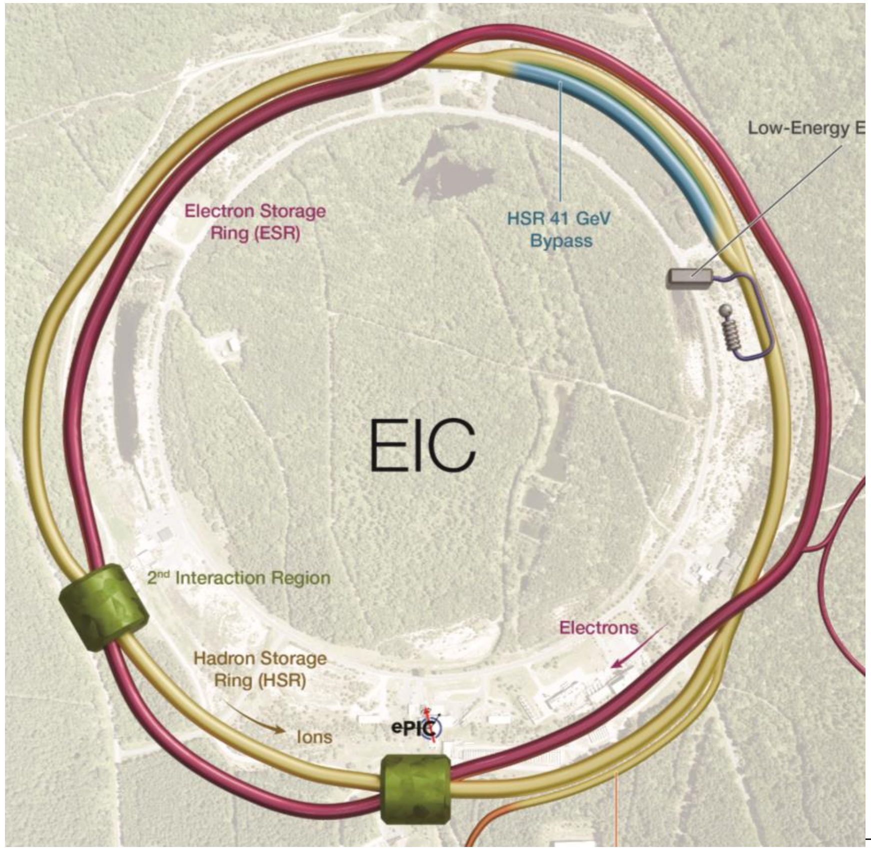


EIC IR Superconducting Magnets

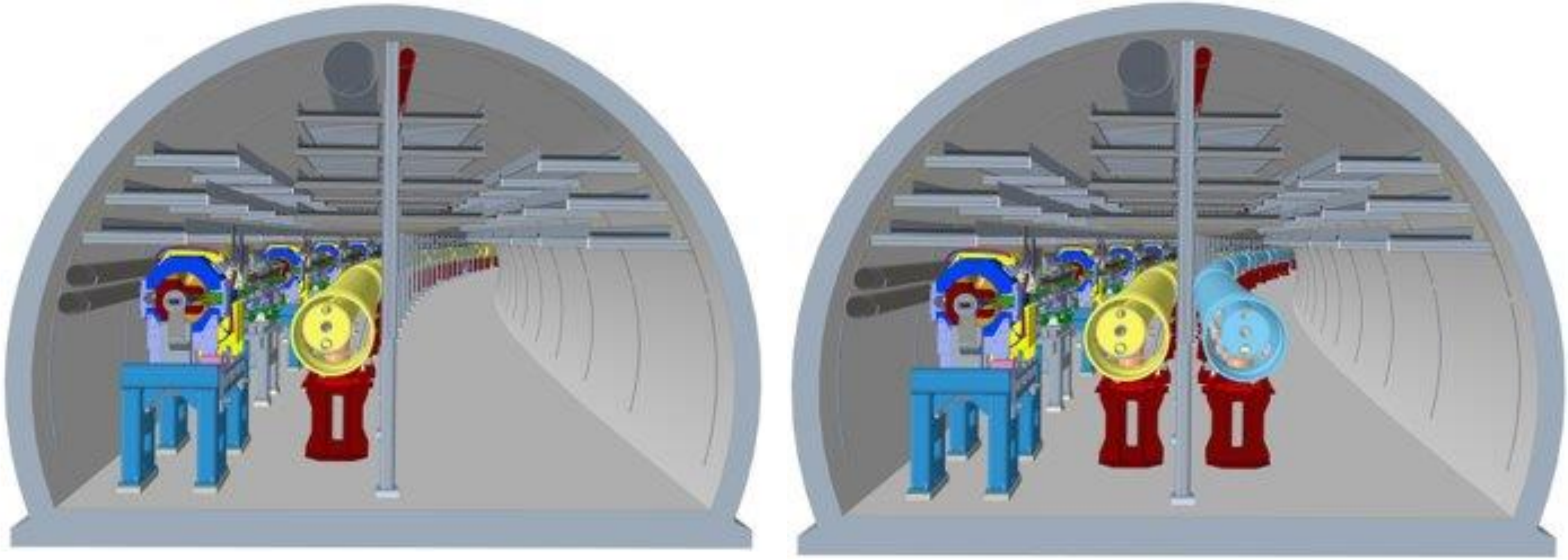


The 41-GeV 'bypass'

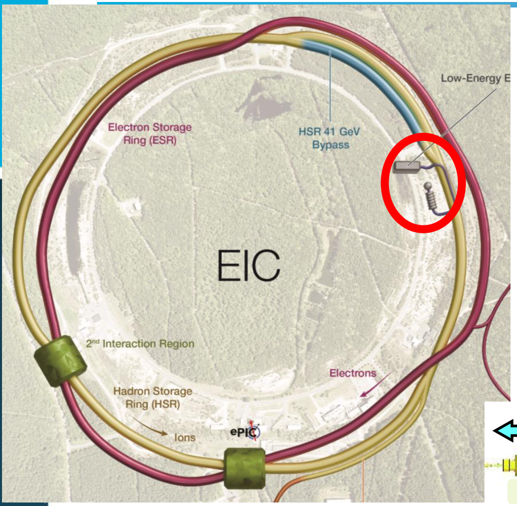
This bypass provides access to the lowest EIC CoM energy, 29 GeV



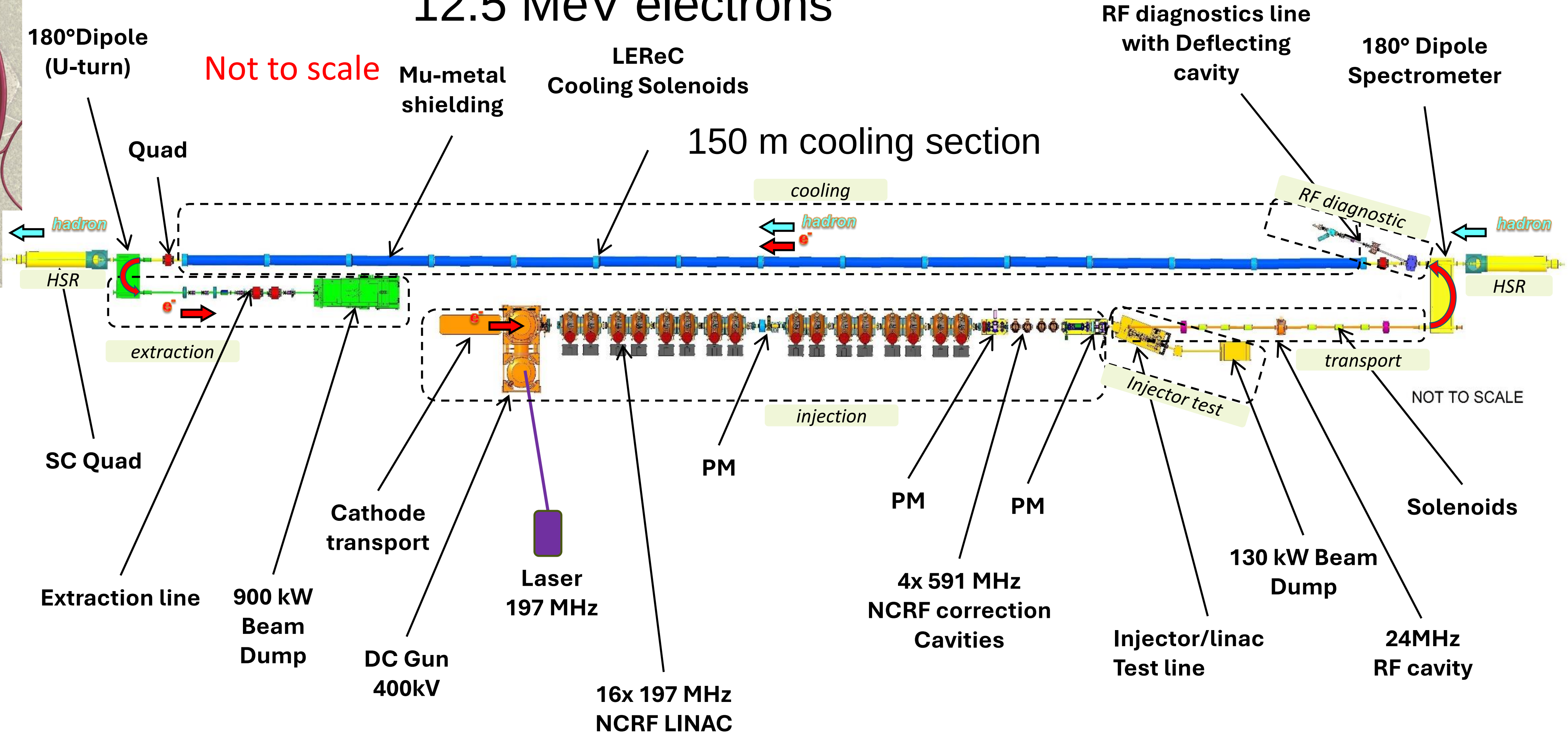
Sector 1 without and with the 41-GeV bypass line



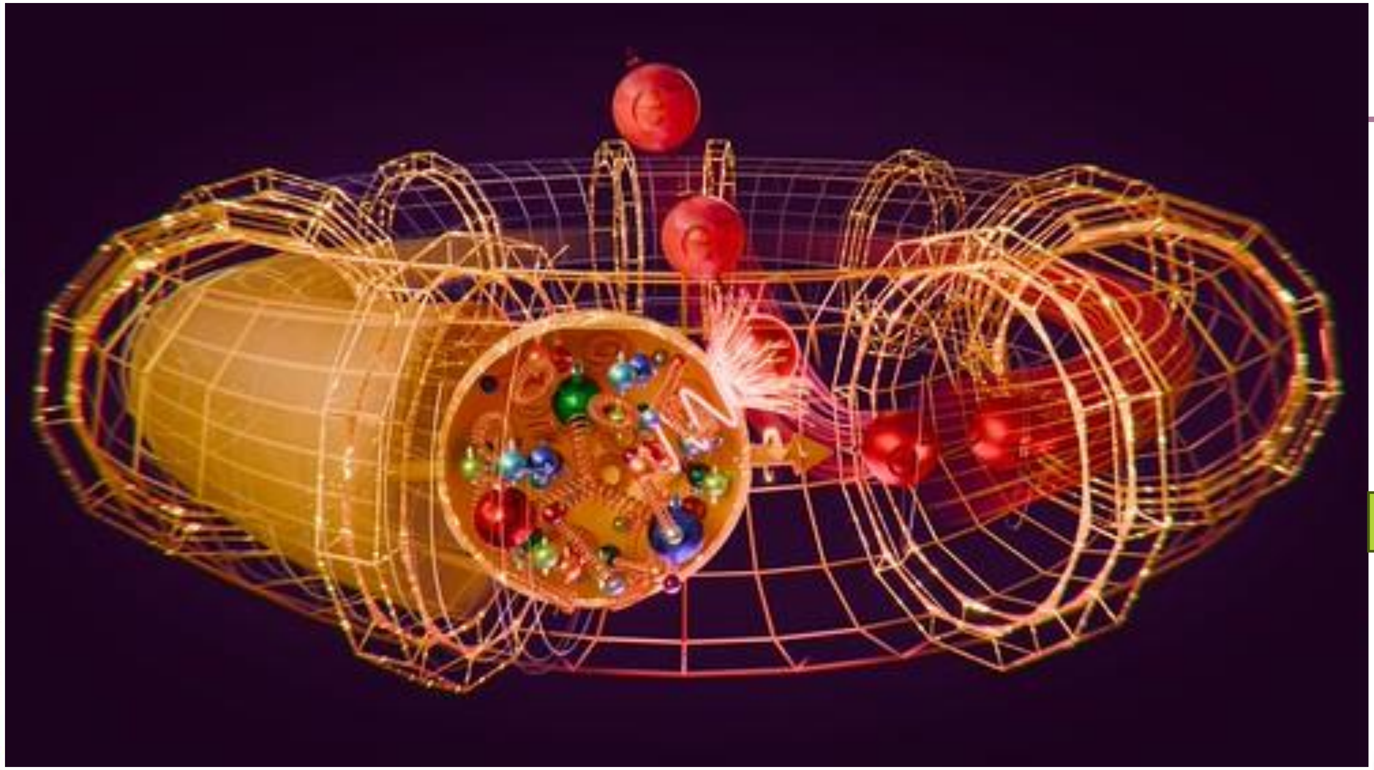
Low-energy Cooler Concept



24 GeV protons
12.5 MeV electrons



IR2 layout (all within the existing RHIC Tunnel)



The EIC facility is international in characters.

It will be built at BNL in Partnership with JLab, and collaborators around the world.

Wolfram Fischer has been named co-chair of the Electron-Ion Collider Accelerator Collaboration