

Electron-Ion Collider Project Status

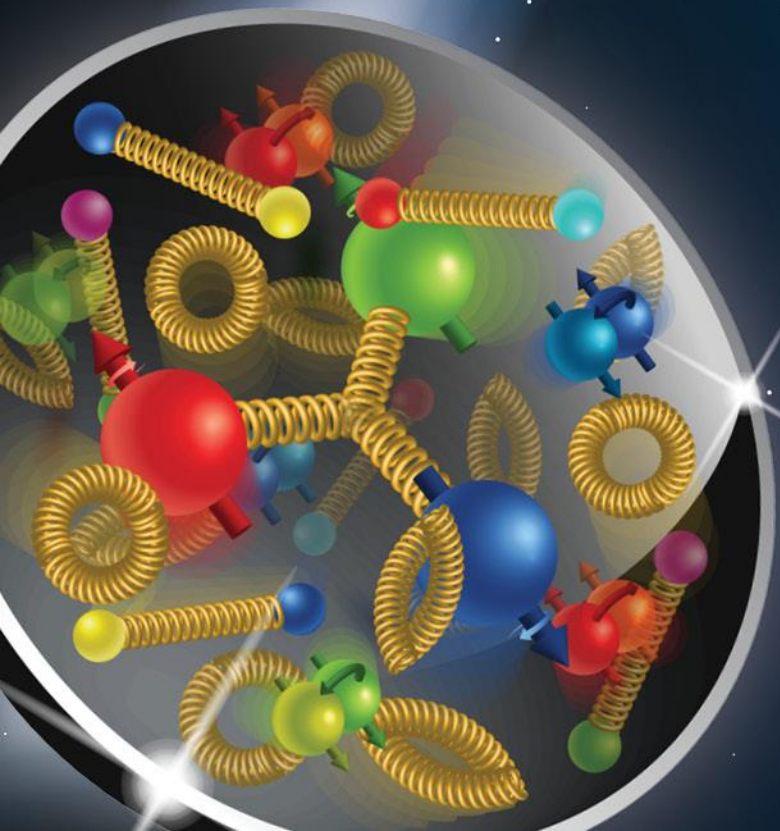
Jim Yeck

EIC Project Director

2021 RHIS/AGS Annual Users' Meeting

June 11, 2021

Electron-Ion Collider

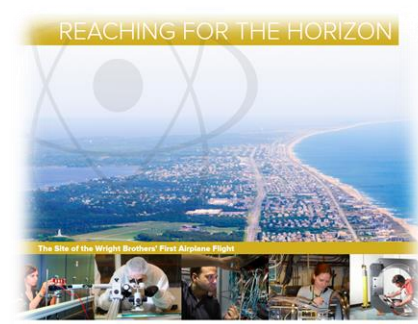


Project Requirements

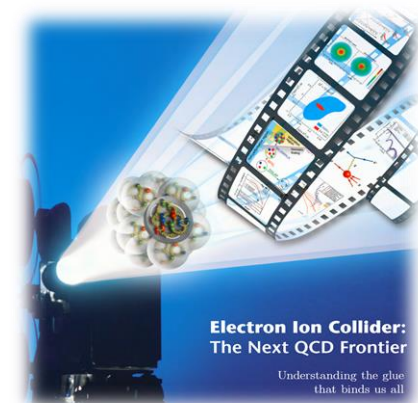
Project Design Goals

- High Luminosity: $L = 10^{33} - 10^{34} \text{cm}^{-2}\text{sec}^{-1}$, 10 – 100 fb⁻¹/year
- Highly Polarized Beams: 70%
- Large Center of Mass Energy Range: $E_{\text{cm}} = 20 - 140 \text{ GeV}$
- Large Ion Species Range: protons – Uranium
- Large Detector Acceptance and Good Background Conditions
- Accommodate a Second Interaction Region (IR)

Conceptual design scope and expected performance meets or exceed NSAC Long Range Plan (2015) and the EIC White Paper requirements endorsed by NAS (2018)

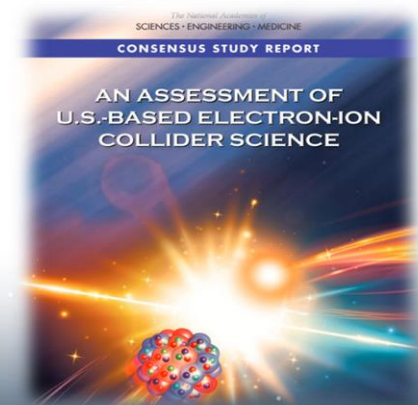


The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE



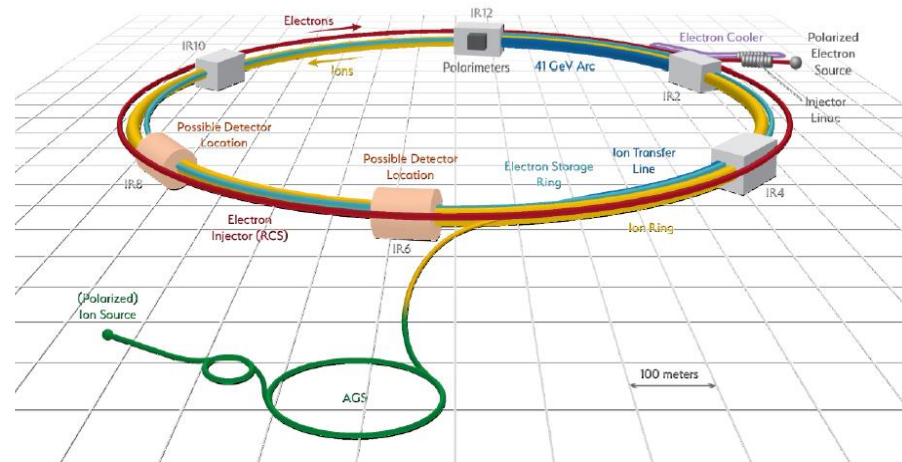
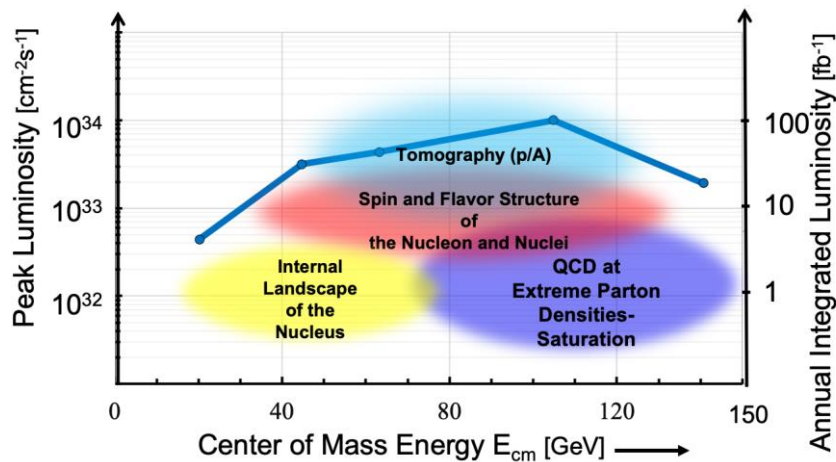
**Electron Ion Collider:
The Next QCD Frontier**

Understanding the glue
that binds us all



Electron-Ion Collider

EIC Machine Parameters



Double Ring Design Based on Existing RHIC Facilities

Hadron Storage Ring: 40 - 275 GeV

- RHIC Yellow Ring and Injector Complex
- Many Bunches, 1160 @ 1A Beam Current
- Bright Beam Emittance $\varepsilon_{xp} = 9 \text{ nm}$
- Flat Beam, Requires Strong Cooling

High Luminosity Interaction Region(s)

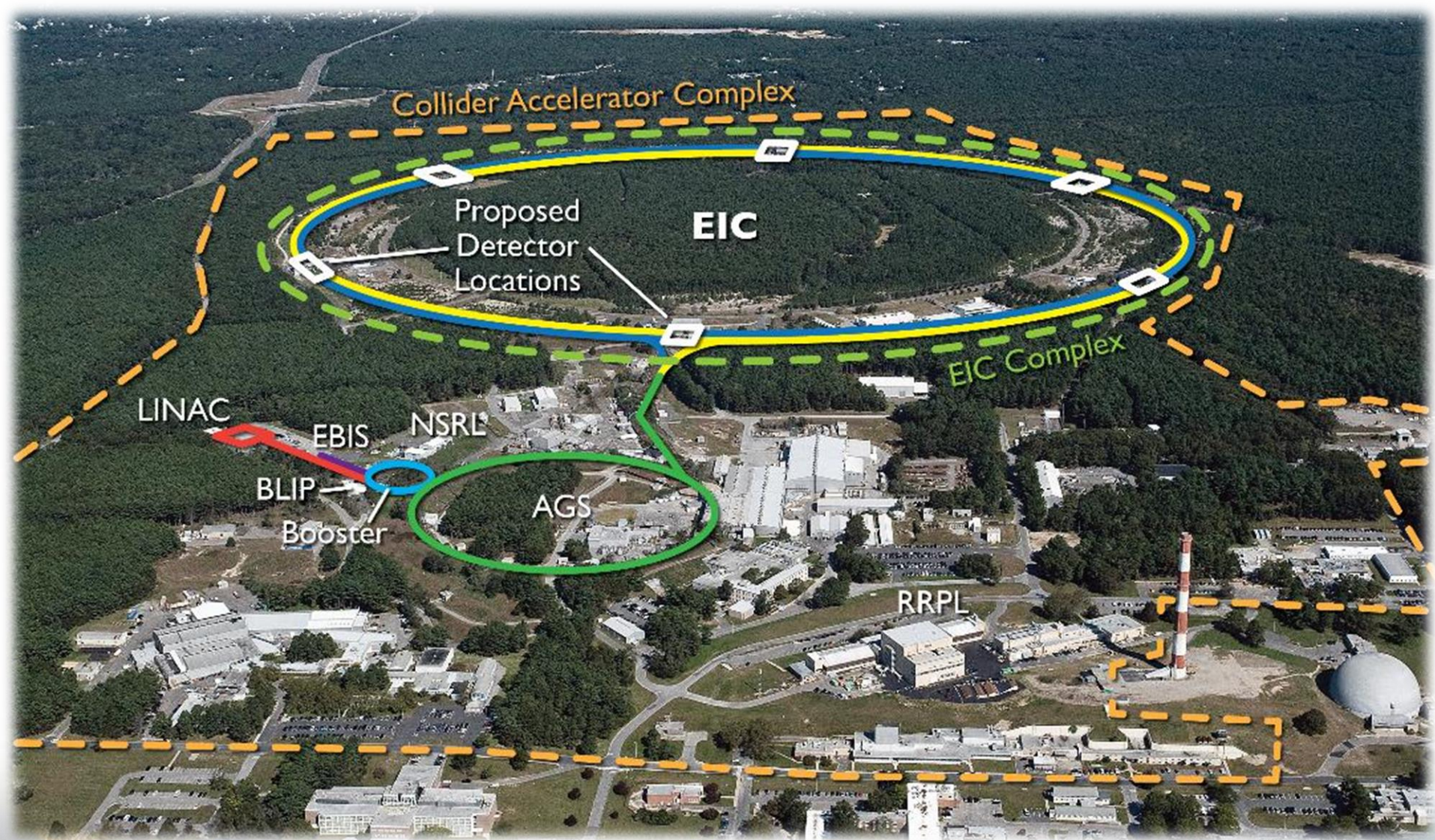
- 25 mrad Crossing Angle with Crab Cavities

Electron Storage Ring: 2.5 - 18 GeV

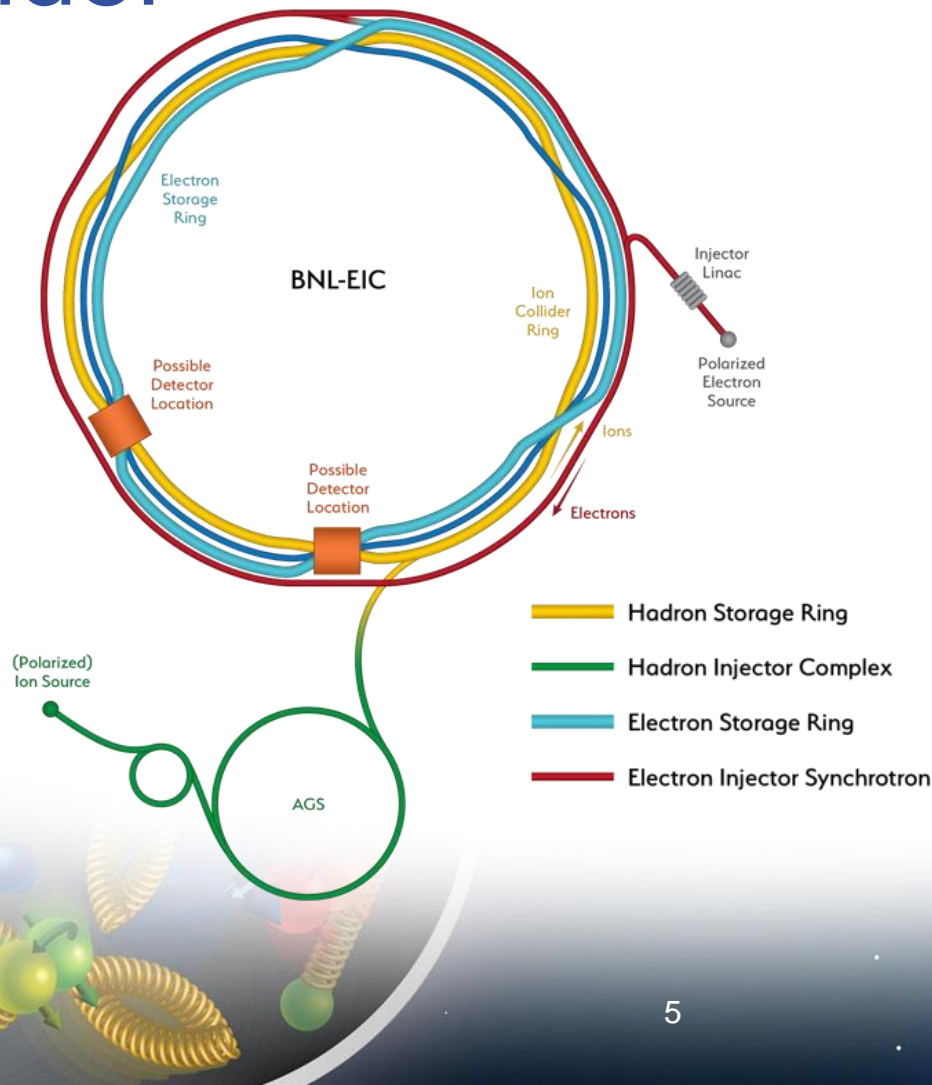
- Many Bunches, Large Beam Current - 2.5 A
- 9 MW Synchrotron Radiation
- Superconducting RF Cavities , 10MW Power

Electron Rapid Cycling Synchrotron

- Spin Transparent Due to High Periodicity



Relativistic Heavy Ion Collider (RHIC) Transformed into an Electron-Ion Collider



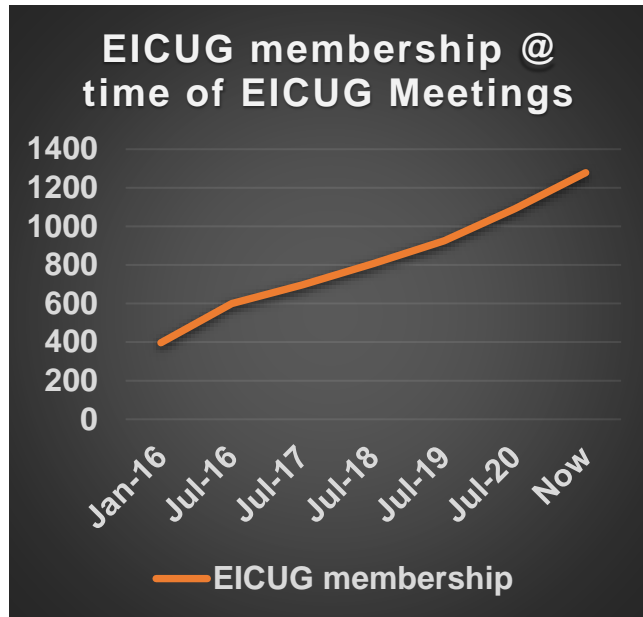
- Hadron Storage Ring
- Electron Injector Complex with Rapid Cycling Synchrotron
- Electron Storage Ring
- Strong hadron cooling completes the facility

Worldwide Interest in EIC Science

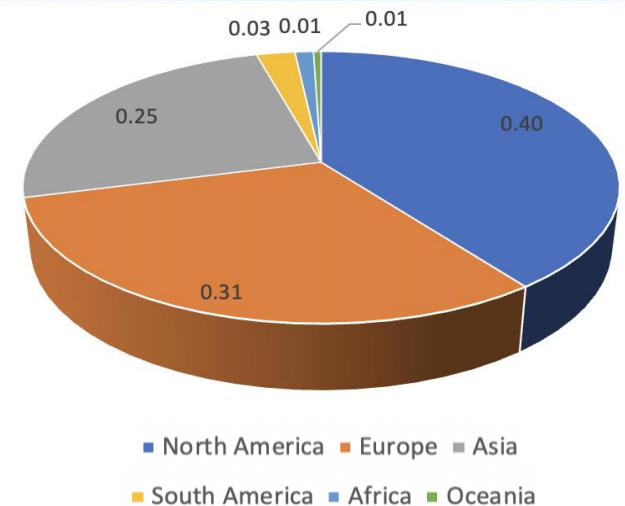
The EIC User Group:

EICUG.ORG, Formed 2016

**May 9, 2021: 1278 collaborators,
34 countries, 257 institutions**



- The EICUG membership has continuously grown since its formation
- Strong international representation



EIC Recent History

Event	Date
DOE Mission Need Statement Approved	January 22, 2019
DOE Independent Cost Review	July 2019
DOE Electron Ion Collider Site Assessment	October 2019
Critical Decision – 0 (CD-0) Approved	December 19, 2019
DOE Site Selection Announced	January 9, 2020
BNL TJNAF Partnership Agreement	May 7, 2020
DOE Office of Science Status Review	September 9-11, 2020
Independent EIC Conceptual Design Review	November 16-18, 2020
BNL Director's Review	December 8-10, 2020
DOE OPA CD-1 Review	January 26-29, 2021
<i>CD-1 Approval Target Date</i>	<i>June 28, 2021</i>

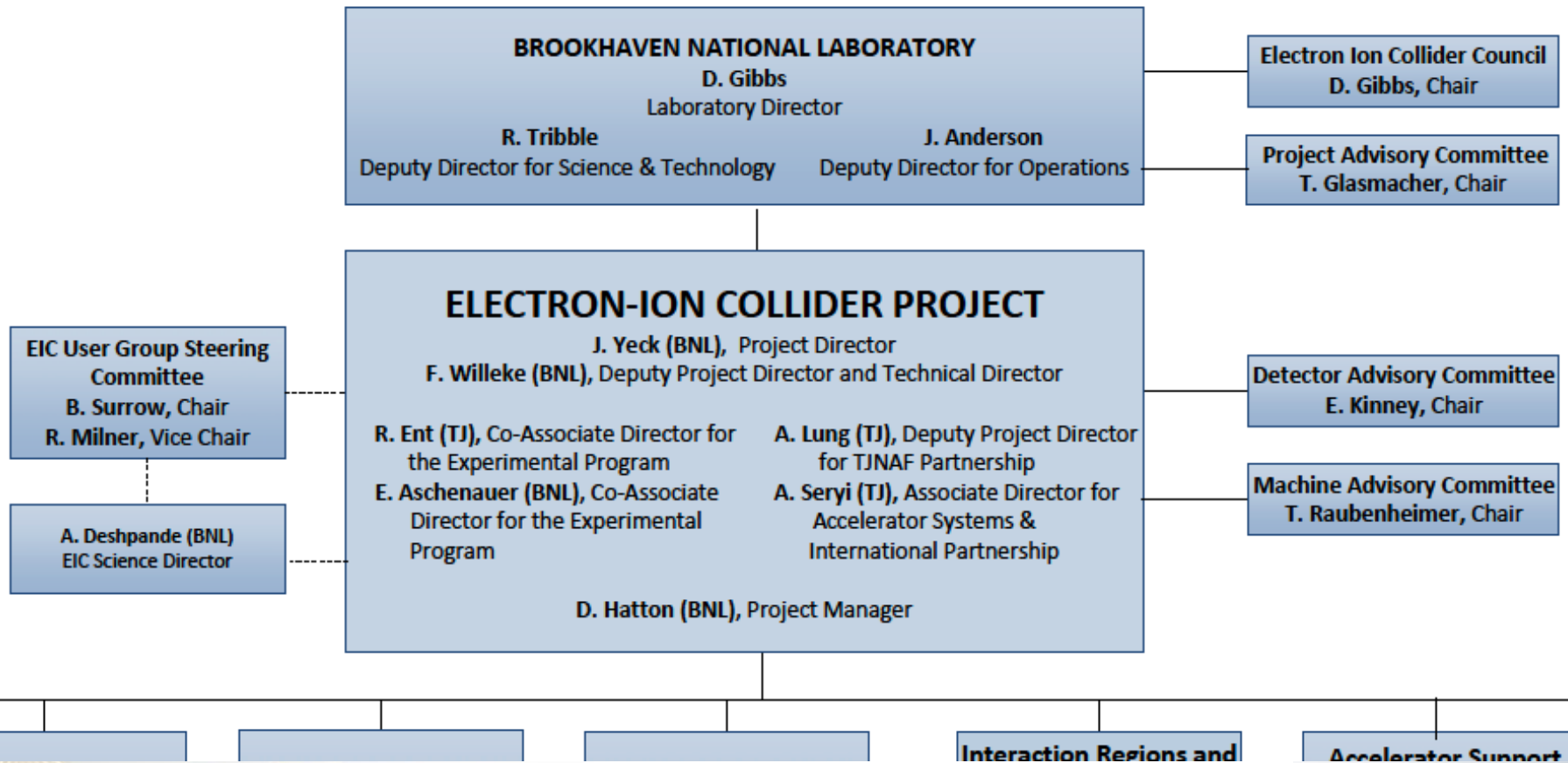
CD-1 Approval

- Successful Office of Project Assessment Review (January 26-29, 2021)
- Successful DOE Independent Cost Review (January 4 – February 4, 2021)
- Robert Caradonna, EIC Federal Project Director, to present for CD-1 Approval
 - DOE Project Management Risk Committee – June 1
 - ESAAB (Energy Systems Acquisition Advisory Board) – **June 28, 2021**
- Start Preliminary Design on June 29!

Project Organization

- BNL/TJNAF Partnership
 - BNL and TJNAF partnering agreement signed in May 2020.
 - Executive Management Team established that integrates BNL and TJNAF into project leadership roles.
 - EIC Council, chaired by BNL Director, established in June 2020. TJNAF Director is a founding member. Major international partners will also join the Council.
- Established standing advisory committees with international membership
 - Machine Advisory Committee: 08/26/20, 09/21-23/21
 - Project Advisory Committee: 08/27/20, 12/01/20, 04/29-30/21
 - Detector Advisory Committee: 09/28-29/20, 12/18/20, 03/24-26/21

Project Organization



EIC Partnership Goals

- Prospects for significant international and domestic partners considered in planning the project
- Promoting a culture of interdisciplinary and multi-institutional collaboration for both the accelerator and experimental program
- DOE Office of Nuclear Physics organizing regular meetings with international funding agencies
- Bi-lateral meetings with potential partners underway to discuss opportunities in the accelerator and experimental areas
- Accelerator Partnership Activities (~5-10%)
 - Workshop held October 2020 and another planned for this Fall
 - Possible contributions to the EIC accelerator could include the full range of accelerator design and hardware
- Detector Partnership Activities (~30%)
 - Detector Proposals due December 2021 with final decision on project detector planned for March 2022

EIC Scope

6.0 Electron-Ion Collider

6.01 Project Management	6.02 Accelerator Development & R&D	6.03 Electron Injector	6.04 Electron Storage Ring	6.05 Hadron Ring	6.06 Interaction Regions & Detector Interface	6.07 Accelerator Support Systems	6.08 Infrastructure	6.09 Pre-Ops	6.10 Detectors	
6.01.01 Project Management	6.02.01 Accel. Devel. & R&D Mgmt.	6.03.01 Electron Injector Mgmt.	6.04.01 Electron Storage Ring Mgmt.	6.05.01 Hadron Ring Management	6.06.01 IR & Detect. Interface Mgmt.	6.07.01 Accel. Supp. Syst. Mgmt. & Infra.	6.08.01 Infrastr. Mgmt. & Engrng.	6.09.01 Operations Transition Planning	6.10.01 Detector Management	6.10.08 Electronics
6.01.02 ESH&Q	6.02.02 Accel. Physics & Design	6.03.02 Rapid Cycling Synch. (RCS)	6.04.02 Electron Strg. Ring Magnets	6.05.02 Hadron Ring Strght. Sect. Modif.	6.06.02 Interaction Regions	6.07.02 Cryogenics	6.08.02 Civil Construction	6.09.02 Systems Commissioning	6.10.02 Detect. R&D & Physics Design	6.10.09 DAQ / Computing
6.01.03 Project Support	6.02.03 Accel. Systems R&D	6.03.03 Transf. Lines & Inj./Extr. Elements	6.04.03 Electron Strg. Ring Pwr. Sup.	6.05.03 Hadron Ring RF Systems	6.06.03 Detector Interface	6.07.03 Control System	6.08.03 Electrical Power Systems	6.09.03 Beam Commissioning	6.10.03 Tracking	6.10.10 Detector Infrastructure
6.01.04 Quality Assurance	6.02.04 Accelerator Integrated RF Design	6.03.04 Electron Pre-Injector	6.04.04 Electron Strg. Ring Vacuum	6.05.04 Injection System Upgrade	6.06.04 IR#2 Development*	6.07.04 RHIC Hadron Systems Removal	6.08.04 Cooling Systems	6.09.04 Spares	6.10.04 Particle Identification	6.10.11 IR Integration & Ancillary Detectors
			6.04.05 Electron Strg. Ring RF Syst.	6.05.05 HR SC Magn. Beam Pipe Upgrade		6.07.05 Accel. Strg. Ring Systems Install.		6.09.05 ESH	6.10.05 Electromagn. Calorimetry	6.10.12 Detector Pre-Ops & Commiss.
			6.04.06 Electron Strg. Ring Instrum.	6.05.06 Beam Instrum. Upgrade		6.07.06 SRF Fabrication*		6.09.06 Quality Assurance	6.10.06 Hadronic Calorimetry	6.10.13 Detector #2 Development
				6.05.07 Additional Snakes				6.09.07 IRR-ARR Preparation	6.10.07 Magnets	
				6.05.08 Strong Hadron Cooling						

* New WBS element (not yet in P6)

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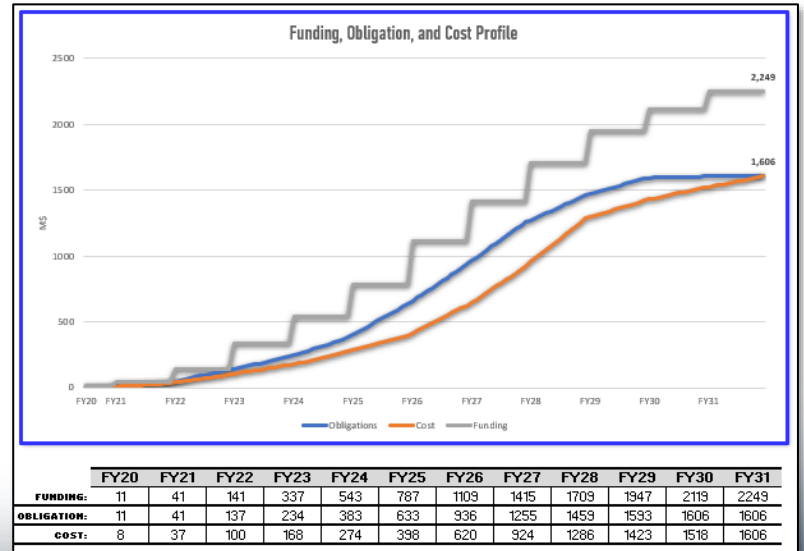
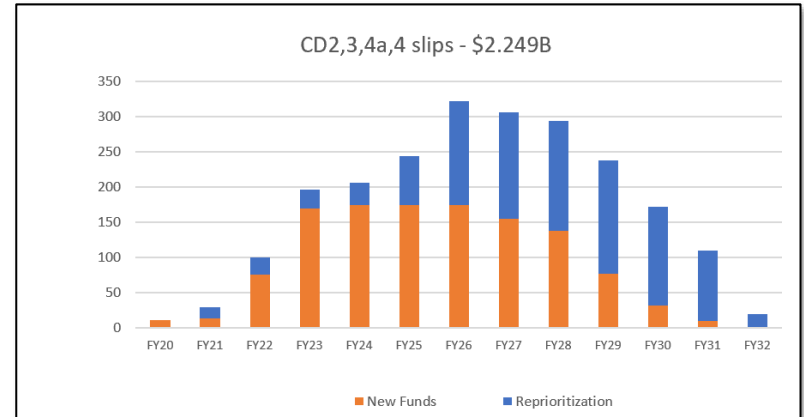
Total project cost (without contingency)

WBS	Description	WBS Manager	Total M\$	DOE M\$
6	Electron-Ion Collider	J. Yeck	\$ 1,848	\$ 1,606
6.01	Project Management	D. Hatton	\$ 103	\$ 103
6.02	Accelerator Dev & R&D	M. Blaskiewicz	\$ 70	\$ 70
6.03	Electron Injector	V. Ranjbar	\$ 195	\$ 171
6.04	Electron Storage Ring	C. Montag	\$ 310	\$ 285
6.05	Hadron Ring	V. Ptitsyn	\$ 199	\$ 199
6.06	Interaction Regions & Detector Interface	A. Drees	\$ 195	\$ 195
6.07	Accelerator Support Systems	J. Tuozzolo	\$ 230	\$ 230
6.08	Infrastructure	C. Folz	\$ 210	\$ 110
6.09	Pre-Operations	W. Fischer	\$ 80	\$ 80
6.10	EIC Detector	R. Ent	\$ 255	\$ 162

\$100M contribution from New York State
\$ ~93M anticipated detector in-kind
\$ ~49M anticipated accelerator in-kind

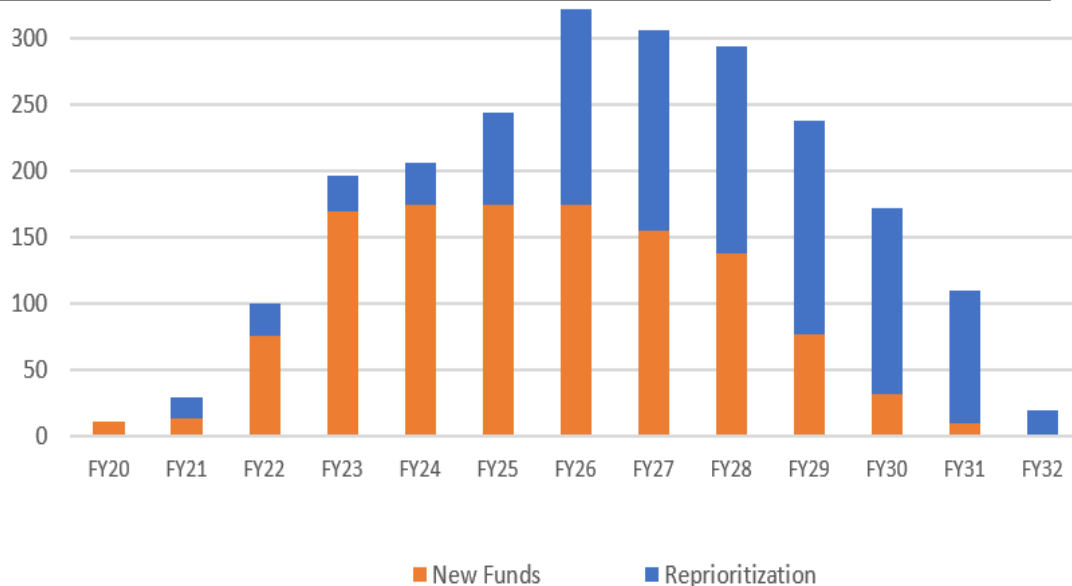
Reference Profile CD-1 Approval

- TPC \$2,249M
- Proposed DOE project management baseline at \$1,606M
- Contingency \$643M (40%)
- Milestones
 - CD-2 January 2023
 - CD-3 March 2024
 - CD-4a EF Jul 2030
 - CD-4a Jul 2031
 - CD-4 EF Jul 2031
 - CD-4 Jul 2033 (24 mos. sch contingency)

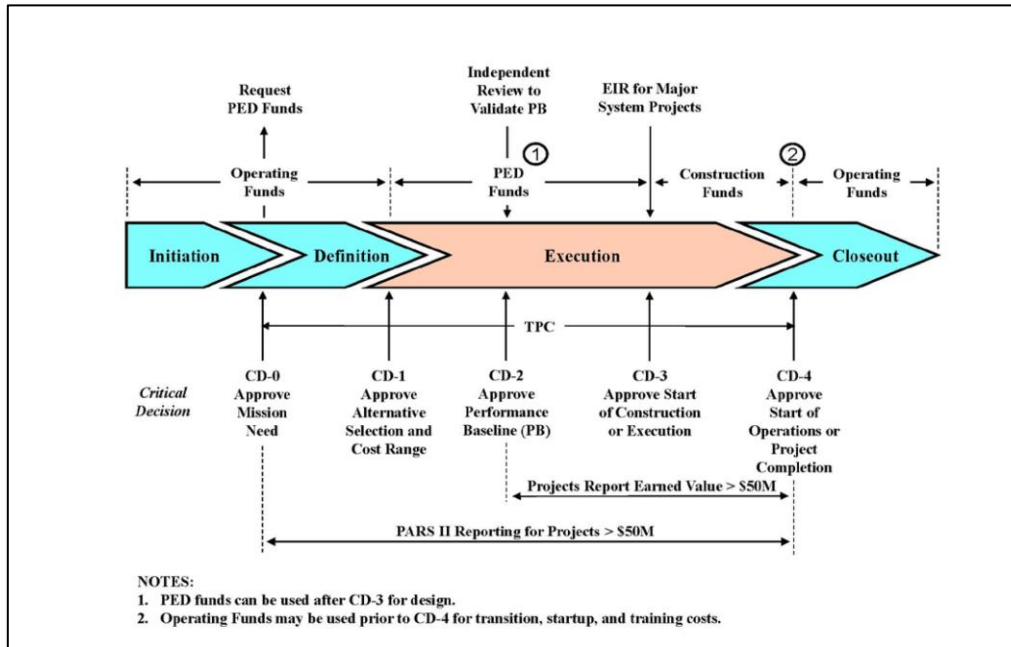


FY2022 Funding Status

- FY2022 plan at \$100M
- President's Budget Request at \$30M (\$10M OPC and \$20M TEC), plus possibility of Infrastructure bill with support for DOE projects. Final EIC budget likely in \$50-100M range.



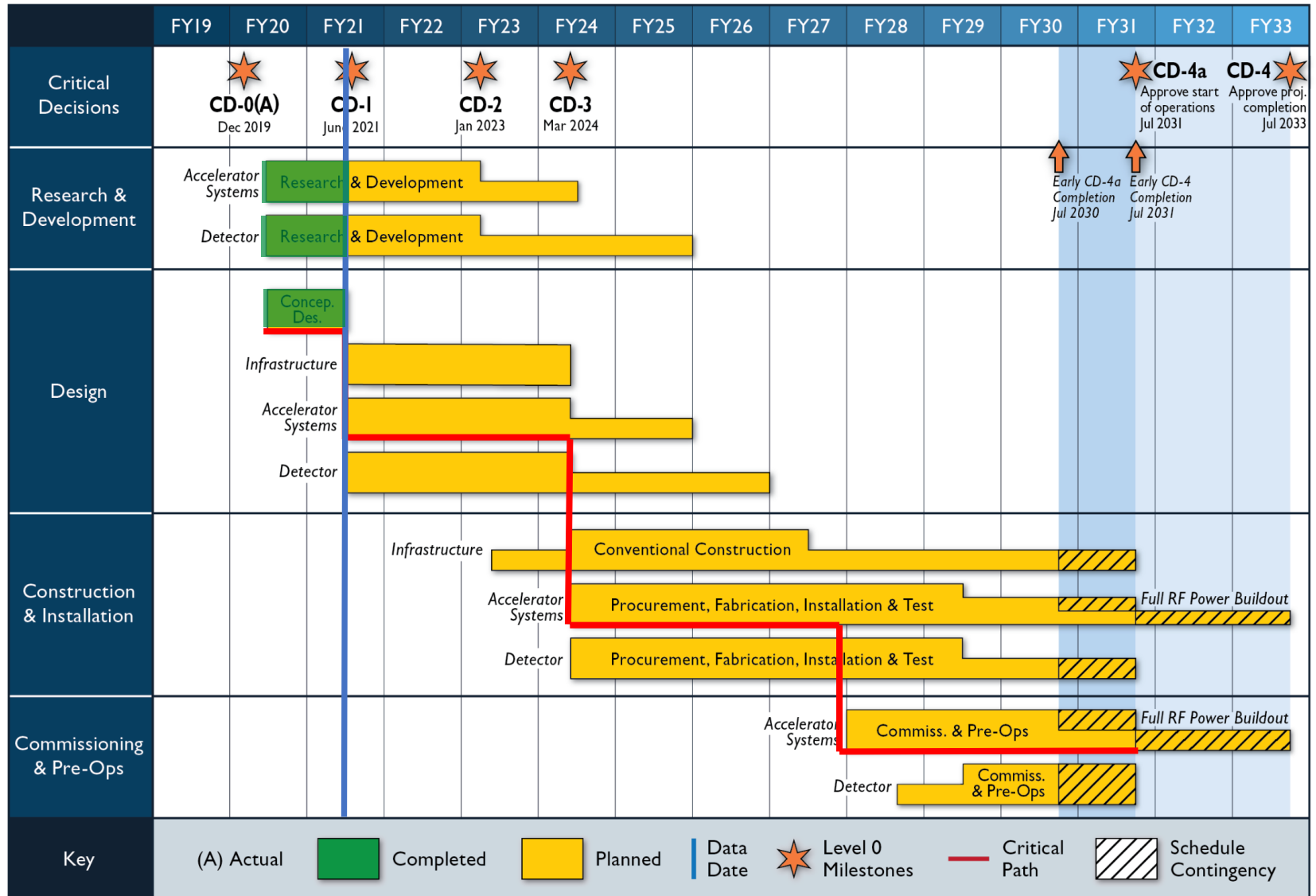
DOE Project Approval Process



- Formal decision process supported by comprehensive reviews.
- EIC schedule aligned with “Critical Decisions”

	Reportable Milestone Date
CD-0 Approve Mission Need	Q1FY20(A)
CD-1 Approve Alternative Selection and Cost Range	Q3FY21
CD-2 Approve Performance Baseline	Q2FY23
CD-3 Approve Start of Construction	Q3FY24
Early CD-4a Completion	Q4FY30
CD-4a Approve Start of Operations or Project Completion	Q4FY31
Early CD-4 Completion	Q4FY31
CD-4 Approve Start of Operations or Project Completion	Q4FY33

Schedule



Path To CD-2 – Technical Reviews

Date	Description
May 10, 2021	Beam-Beam Effect Technical Review
May 11, 2021	Dynamic Aperture Technical Review
May 21, 2021	Beam Polarization Technical Review
June 4, 2021	Collective Effects Technical Review
June 17, 2021	Superconducting RF Design Technical Review
June 2021	Superconducting IR Magnets Technical Review
July 2021	Interaction Region Design and Detector Machine Interface TR
October 2021	ESR/HSR Vacuum Systems and Impedance Technical Review
November 2021	Pulsed Devices Technical Review
December 2021	Strong Hadron Cooling Technical Review
January 2022	Controls Systems Technical Review
February 2022	Installation Workshop
March 2022	Radiation Shielding Review

Path To CD-2

Date	Description
Oct 5, 2021	Post Documentation for OPA Status Review
Oct 12, 2021	Post Presentations for OPA Status Review
Week of Oct 18, 2021	OPA Status Review
Dec 1, 2021	Detector Proposals Submitted
March 2022	Decision on Project Detector
March 2022	Start EVMS
~April 2022	OPA Status Review – Confirm schedule for CD-2 Reviews
April – June 2022	Preliminary Design Reviews
~July 2022	CD-2 Director's Review
~September 2022	CD-2 OPA/ICR Reviews
January 2023	CD-2 Approval

Experimental Program Preparation

[Yellow Report](#) and [EIC Conceptual Design Report](#) are both available and include the reference detector concept.

BNL and TJNAF Jointly Leading Process to Select Project Detector		
2020	Call for Expressions of Interest (EOI)	May 2020
	EOI Responses Submitted	November 2020
	Assessment of EOI Responses	On-going
2021	Call for Collaboration Proposals for Detectors	March 2021
	Proposal Evaluation Committee Established	Spring 2021
	Collaboration Proposals for Detectors Submitted	December 2021
✓	Decision on Project Detector	March 2022

EICUG Collaboration Activities

- ECCE Consortium: <https://www.ecce-eic.org>
 - Detector based on 1.5T solenoid investigating both EIC interaction regions as location
- ATHENA: <https://sites.temple.edu/eicatip6/>
 - New EIC experiment at IP6 based on a 3T magnet and Yellow Report Reference Detector
- CORE: <https://userweb.jlab.org/~hyde/EIC-CORE/>
 - Open collaboration for a new EIC detector based on a new 2-4T compact magnet at IP8
- 2nd IR Workshop Series on Detector and IR complementary: <https://indico.bnl.gov/event/10677/timetable/>
 - Initial workshops included several hundred attendees
 - Workshop organized by Korean collaborators planned for July 19-24
 - Plan to submit a draft white paper to the Proposal Advisory Panel

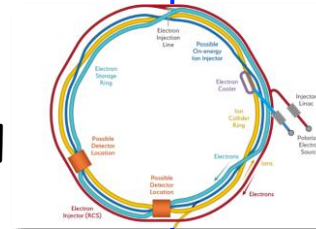
Strategy for Detector 1 and 2nd IR/Detector 2

- DOE-NP supported EIC Project includes one detector and one IR
- EIC with two interaction regions and detector ensures a robust physics program and enhances the science reach.
- IR2 and detector concepts needed now
 - Informs strategies for achieving IR2 and detector
 - Influences project decisions on IR1 and detector
 - Construction schedule and initial operations plans are important planning constraints
- Major effort needed to secure resources for IR2 (~\$500M)
 - Possibly a DOE Major Item of Equipment (MIE) project
 - Significant international engagement is expected
 - ~70% scope funded by the US-DOE EIC Project and ~30% funded by international or in-kind scope.
 - Many bi-lateral meetings with potential partners underway to discuss opportunities in accelerator and experimental areas

Complementarity for 1st-IR & 2nd-IR

Since CD-1 we made significant progress in the preliminary design for the 2nd IR with a focus on complementarity

	1 st IR (IP-6)	2 nd IR (IP-8)
Geometry:	<p>ring inside to outside</p> <p>tunnel and assembly hall are larger</p> <p>Tunnel: \varnothing 7m +/- 140m</p>	<p>ring outside to inside</p> <p>tunnel and assembly hall are smaller</p> <p>Tunnel: \varnothing 6.3m to 60m then 5.3m</p>
Crossing Angle:	<p>25 mrad</p> <p>different blind spots</p> <p>different forward detectors and acceptances</p> <p>different acceptance of central detector</p>	<p>35 mrad</p> <p>secondary focus</p>
Luminosity:	<p>more luminosity at lower E_{CM}</p> <p>optimize Doublet focusing FDD vs. FDF</p> <p>→ impact of far forward p_T acceptance</p>	
Experiment:	<p>1.5 Tesla or 3 Tesla</p> <p>different subdetector technologies</p>	



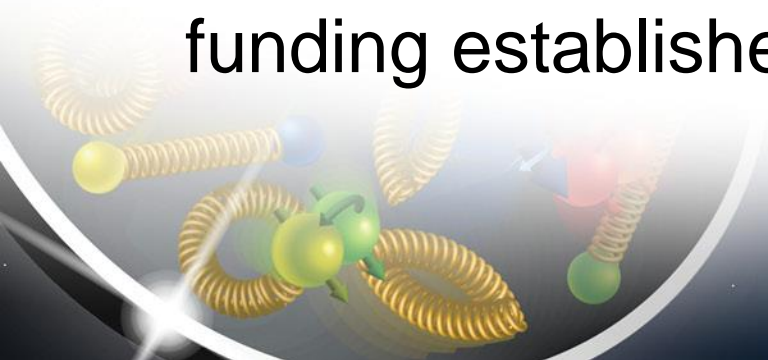
Summary

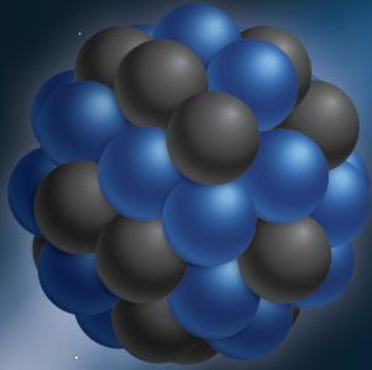
- **Excellent Progress**

- Solid foundation in place: organization, scope definition, conceptual design, preliminary performance parameters, cost & schedule range, and planning documentation
- CD-1 reviews and preparations complete
- BNL/TJNAF partnership and responsibilities defined, actively pursuing broader collaboration and partnership in the EIC

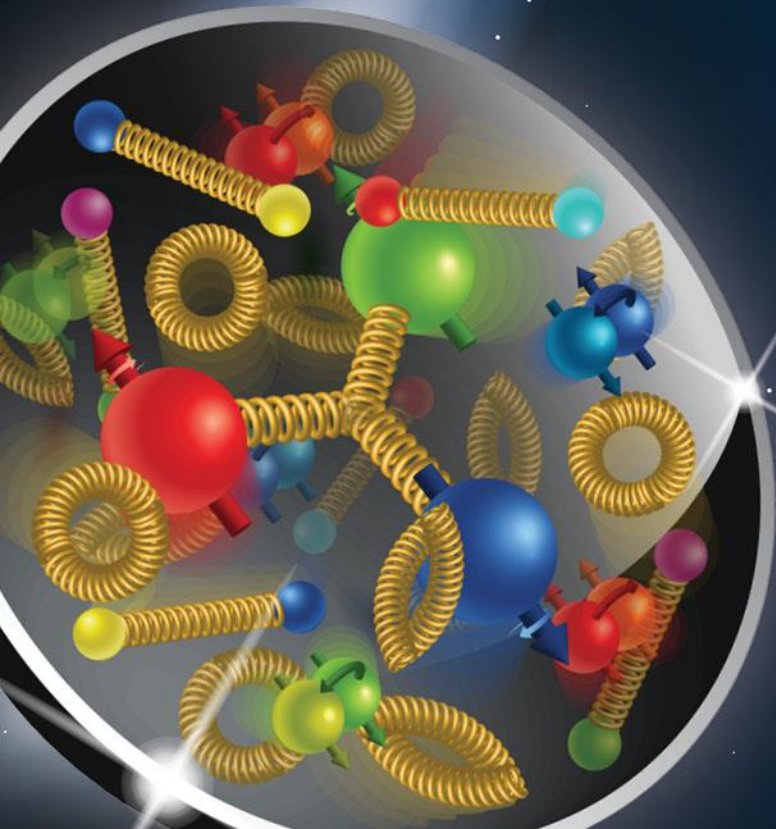
- **Awaiting CD-1 approval and preparing for CD-2!**

- **Strong case for substantial increase in project funding established and being pursued**





Thank You!



Electron-Ion Collider

BROOKHAVEN
NATIONAL LABORATORY

Jefferson Lab

U.S. DEPARTMENT OF
ENERGY

Office of
Science