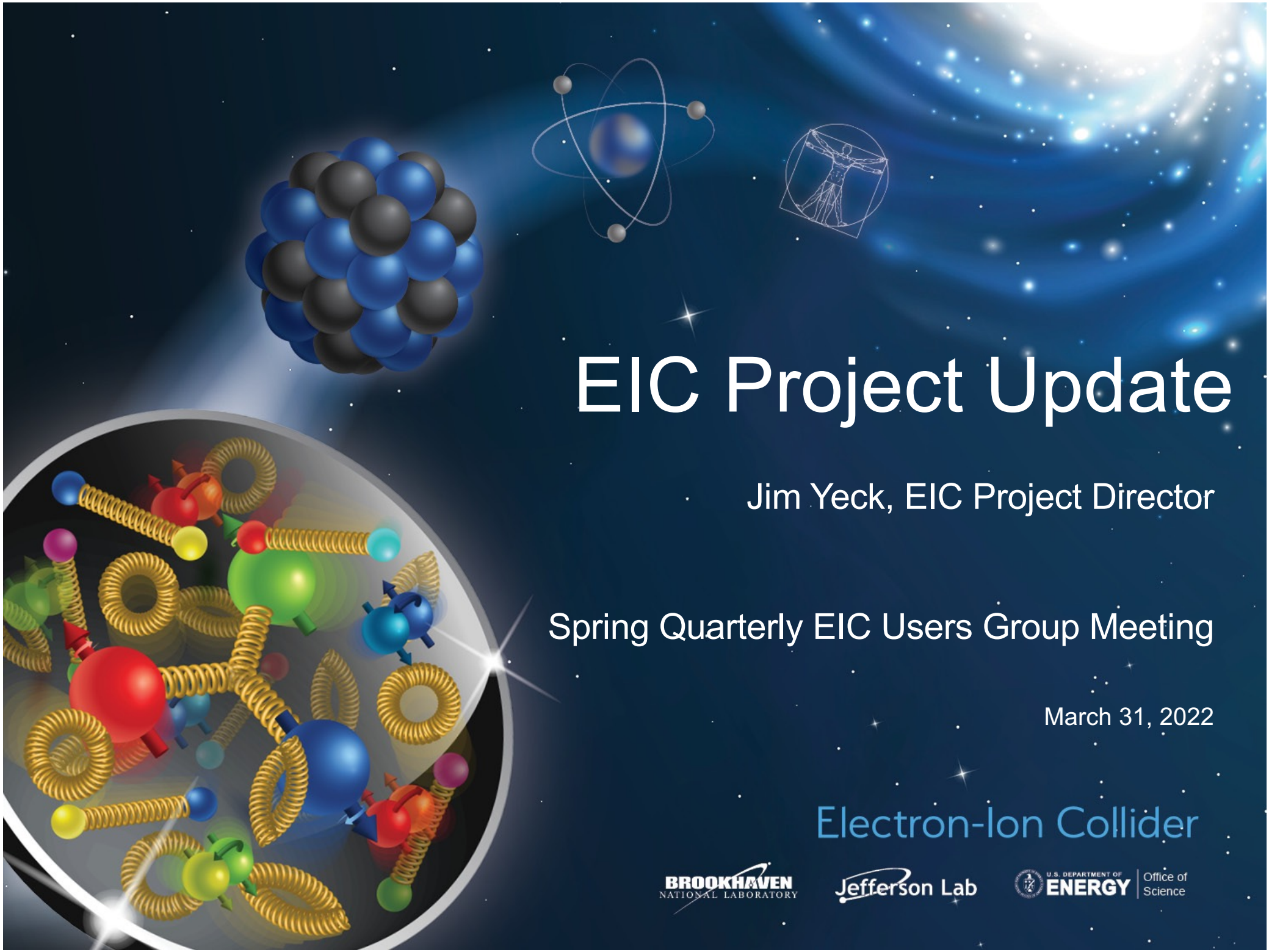


EIC Project Update

Jim Yeck, EIC Project Director

Spring Quarterly EIC Users Group Meeting

March 31, 2022

Electron-Ion Collider

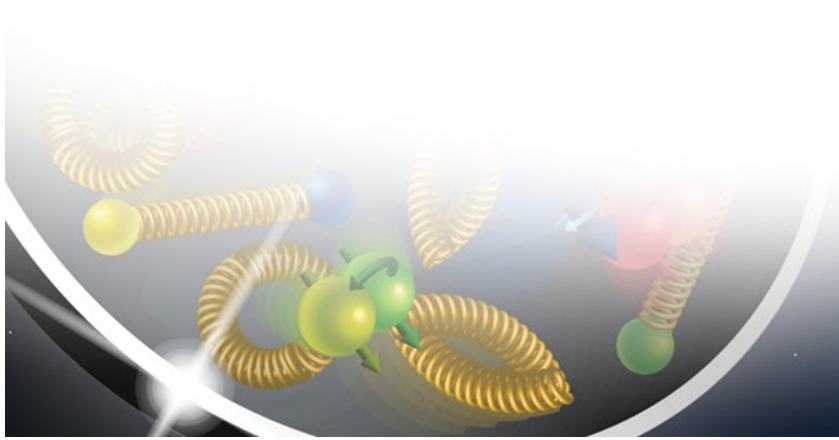
BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

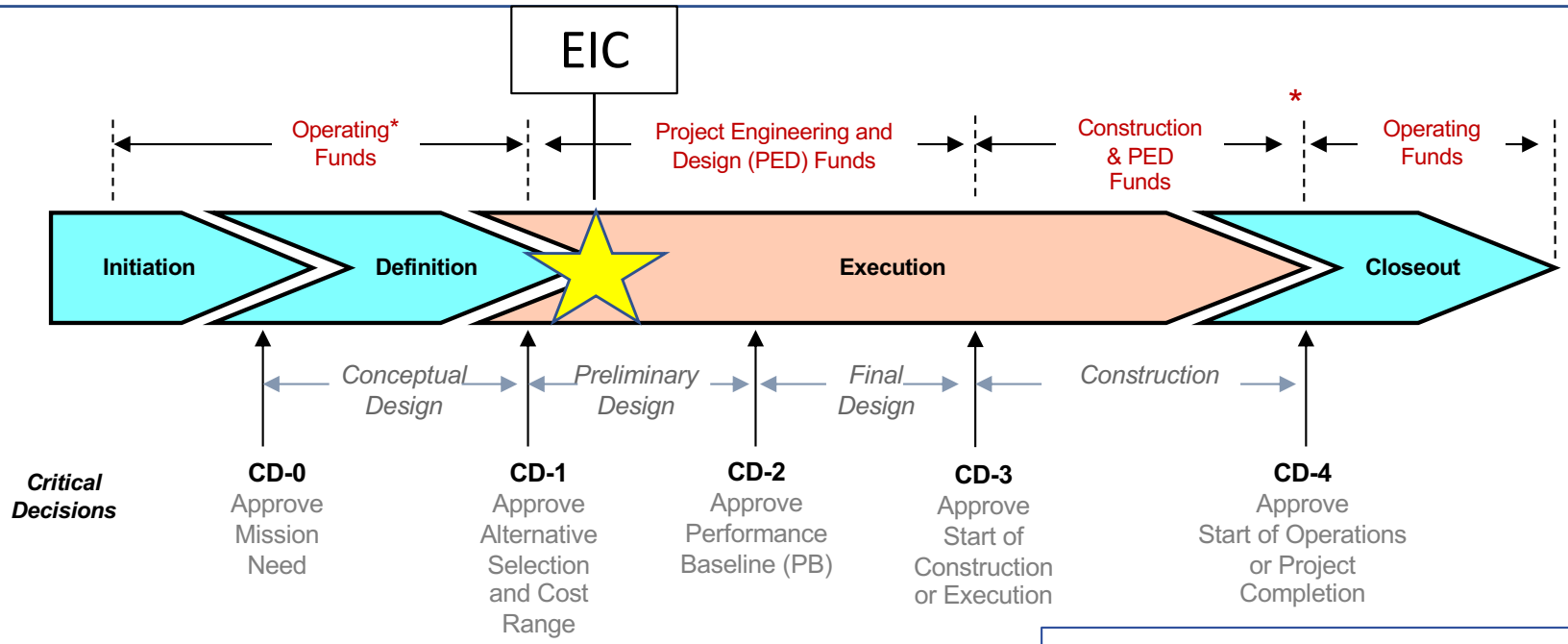
U.S. DEPARTMENT OF ENERGY | Office of Science

Outline

- U.S. Department of Energy (DOE) Project Decision Process
- Cost and Funding Plans
- CD-2/3A Preparation
- Governance and Key Challenges
- Summary



DOE Project Decision Process



Formal Process of Gateway Reviews

- CD-0, Mission Need
- CD-1, Alternative Selection and Cost Range
- CD-2, Performance Baseline
- CD-3a, Long Lead Procurement

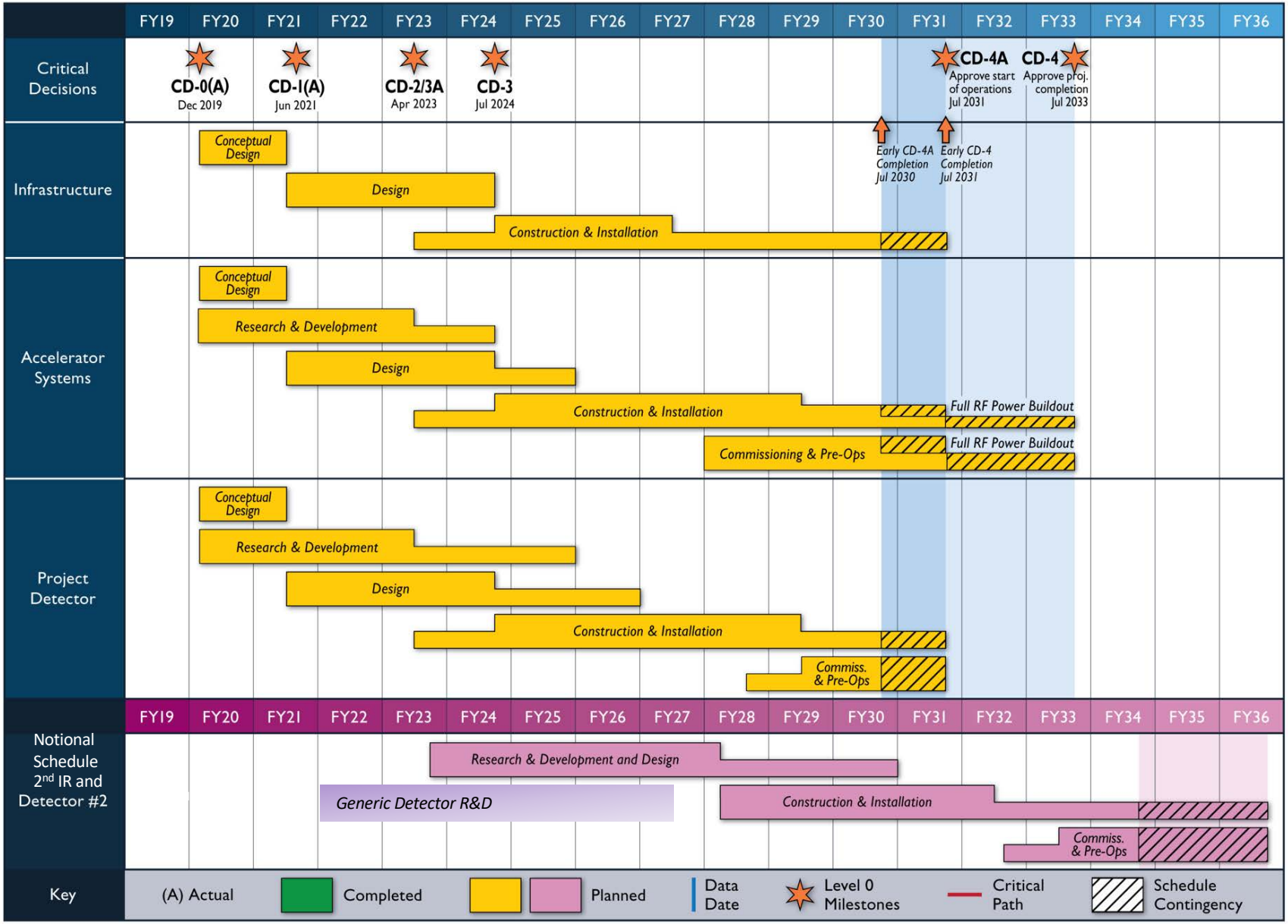
EIC Critical Decision Plan at CD-1

CD-2/3a	April 2023
CD-3	July 2024
CD-4a early finish	July 2030
CD-4a	July 2031
CD-4 early finish	July 2031
CD-4	July 2033

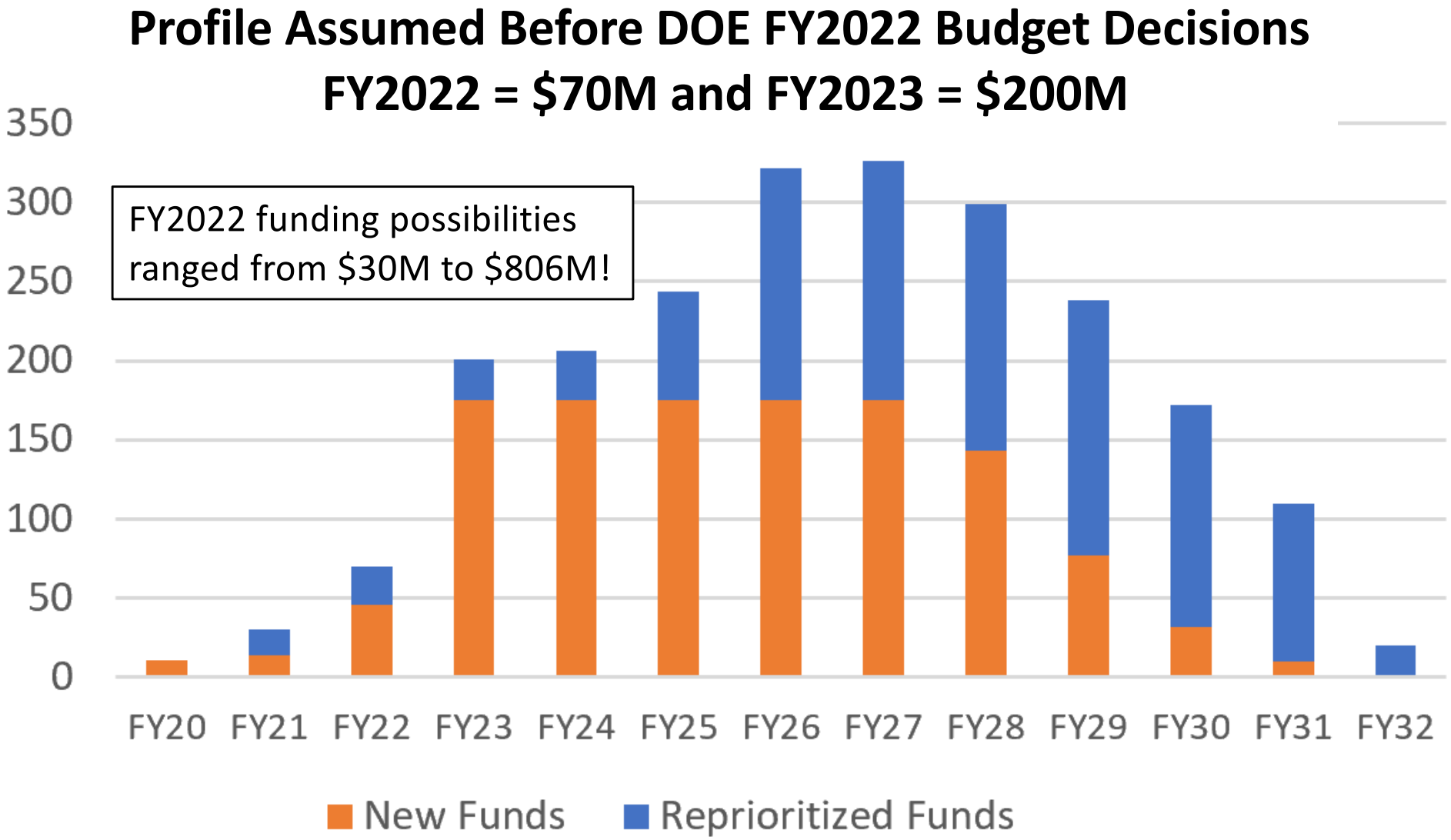
EIC Project Recent History

Event	Date
Mission Need Statement Approved	**January 22, 2019**
CD-0, Mission Need Approved	**December 19, 2019**
DOE Site Selection Announced	January 9, 2020
FY2020 Budget Includes EIC TEC and OPC Funding	1st Quarter FY2020
BNL - TJNAF Partnership Agreement Approved	May 2020
Conceptual Design Review	November 2020
DOE Independent Cost Review (ICR)	Jan. 4 – Feb. 4, 2021
CD-1, Alternative Selection and Cost Range, Approved	**June 29, 2021**
DOE Budget Uncertainties	
Detector Proposal Advisory Panel Report	March 21, 2022
CD-2/3A, Performance Baseline/Long Lead Procurement	**April 2022 (To be Revised)**

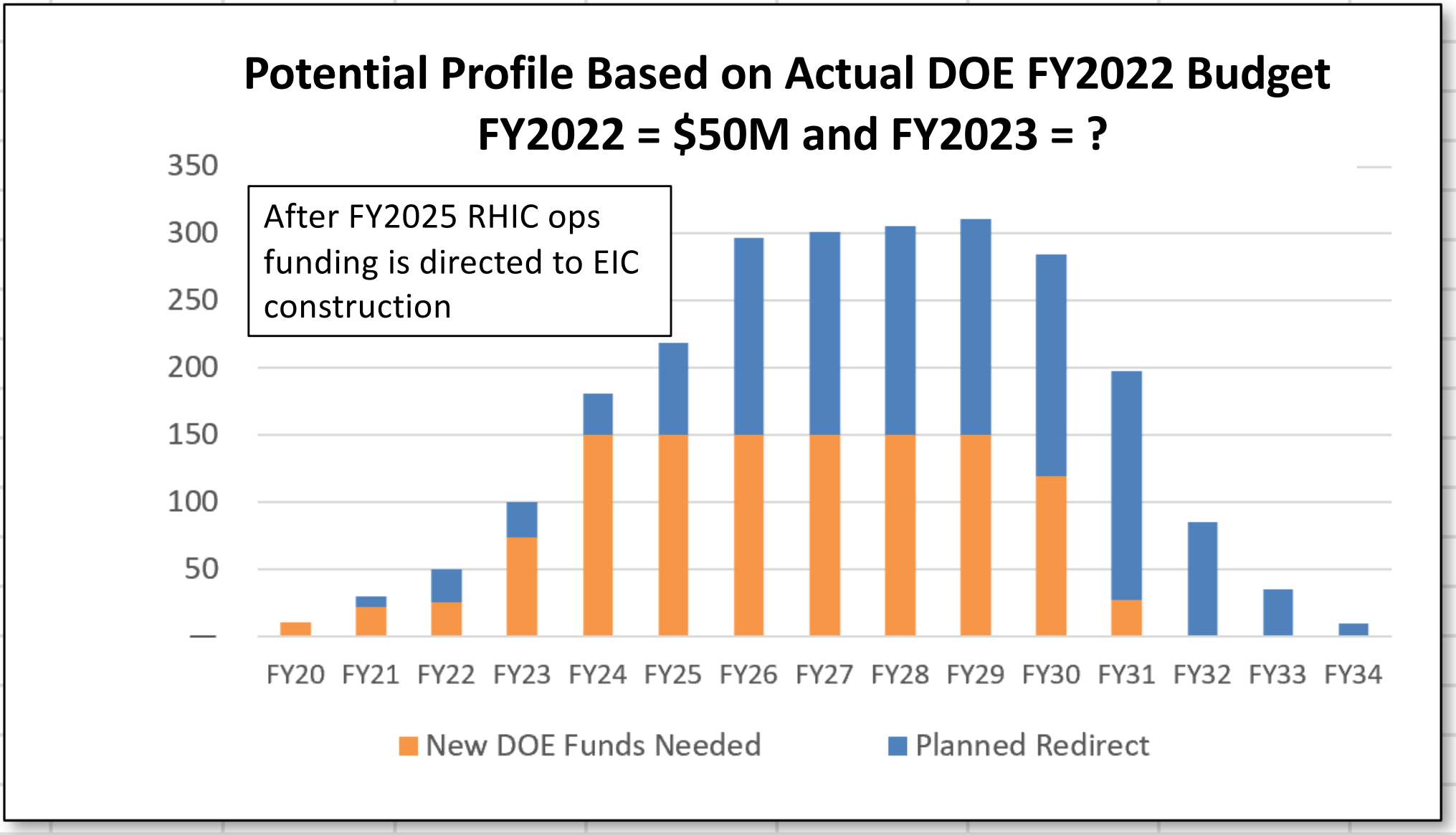
Reference Schedule at CD-1

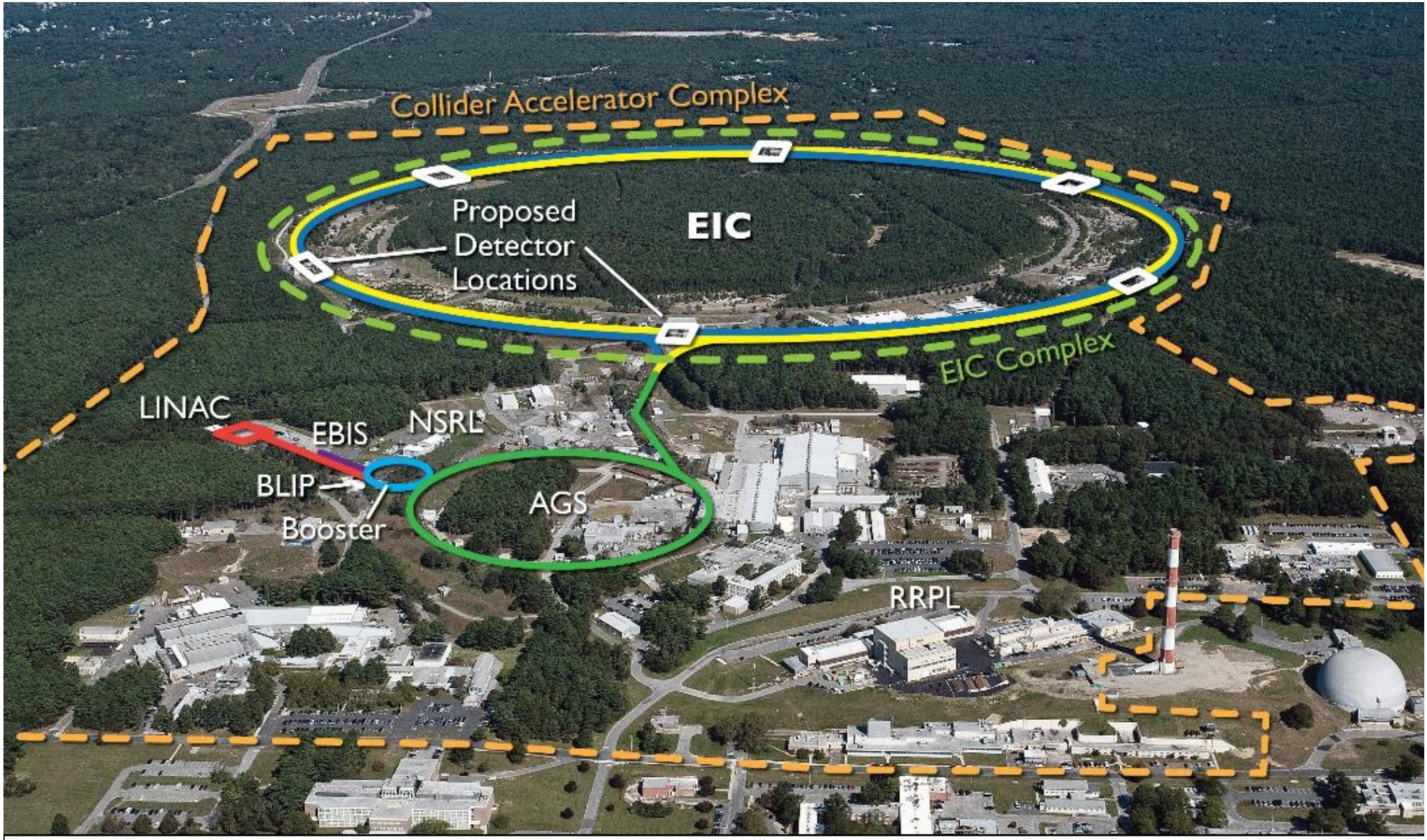


DOE Funding Profile at CD-1 (v2)



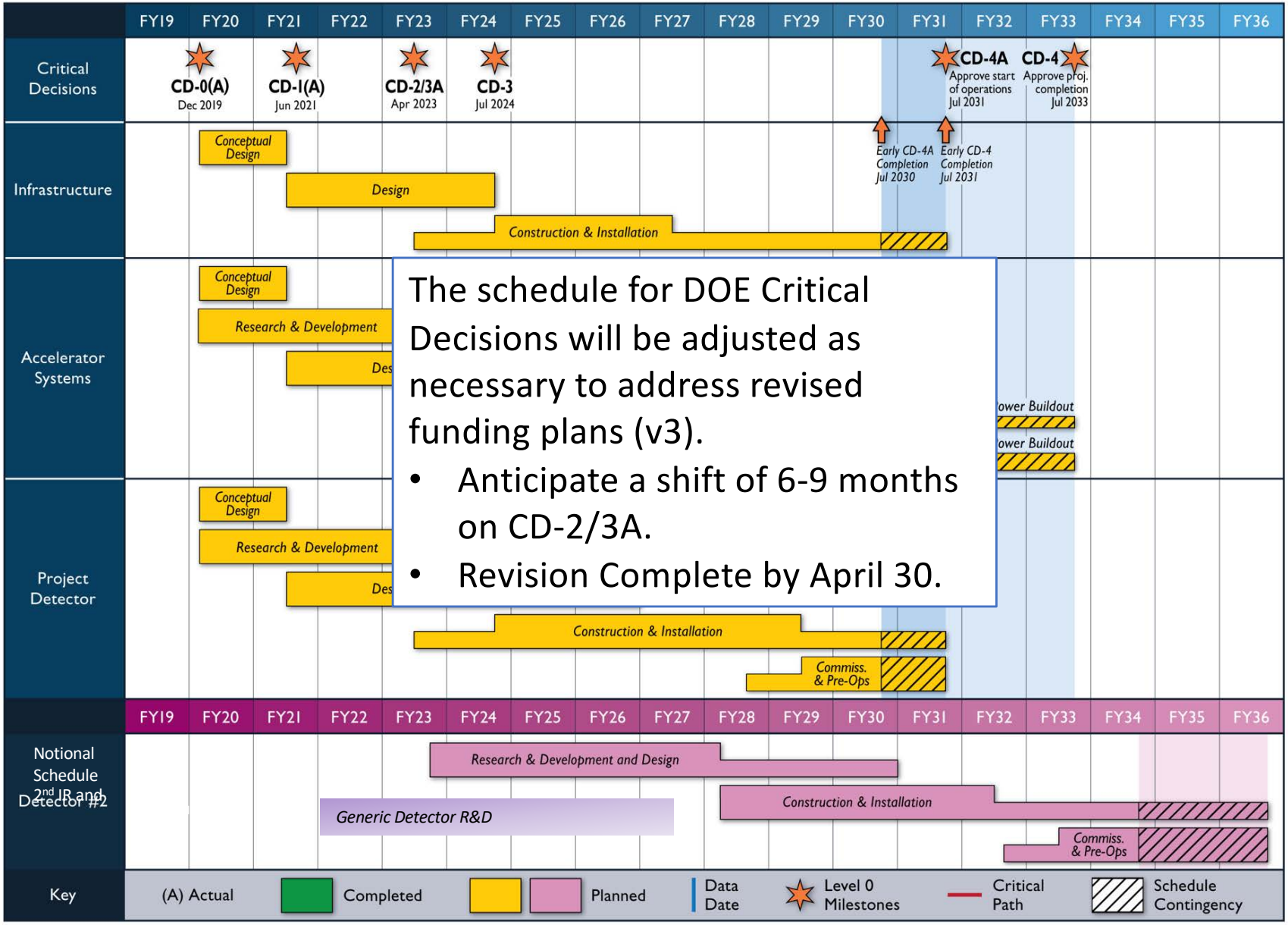
Revised DOE Funding Profile (v3?)





- EIC benefits from $B plus investments at BNL and the highly successful RHIC program.
- RHIC concludes operations in 2025. EIC installation begins after RHIC ops concludes.

Reference Schedule



The schedule for DOE Critical Decisions will be adjusted as necessary to address revised funding plans (v3).

- Anticipate a shift of 6-9 months on CD-2/3A.
- Revision Complete by April 30.

Perspective on DOE CD-2/3A

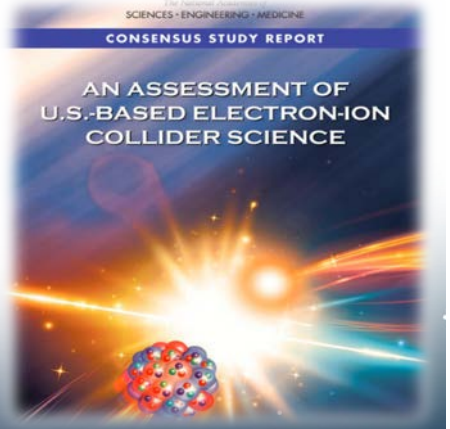
- Top priority is to secure DOE CD-2/3A (Project Performance Baseline and Long Lead Procurement Approvals) approvals as soon as possible. Major step in securing funding plans.
- We will proceed with the DOE approval reviews when we are ready, successfully passing both a preliminary design review and a “Director’s Review.”
- Substantial funding needed to make the necessary progress and to demonstrate the necessary level of design maturity (typically 10-15% of a total project cost).

Project Requirements

Project Design Goals

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

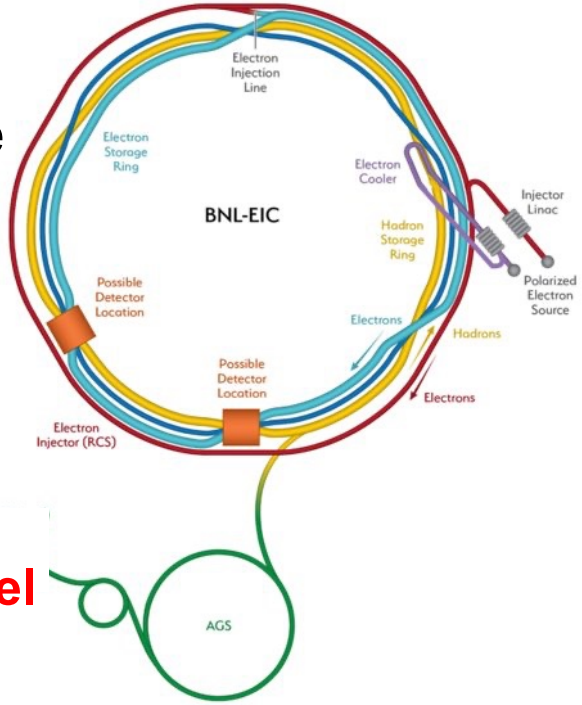
Conceptual design scope and expected performance meets or exceed NSAC Long Range Plan (2015) and the EIC White Paper requirements endorsed by NAS (2018)



Requirements Established at CD-0: No Change

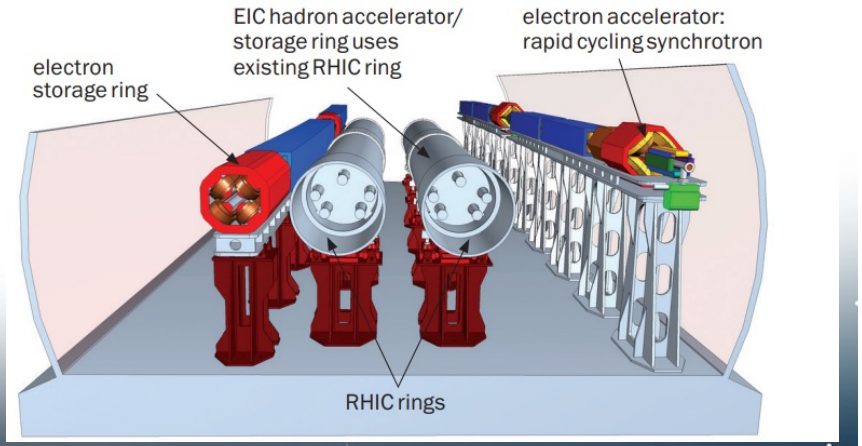
EIC Accelerator

Design based on **existing RHIC Complex**
RHIC is well-maintained, operating at peak performance



- **Hadron storage ring 40-275 GeV**

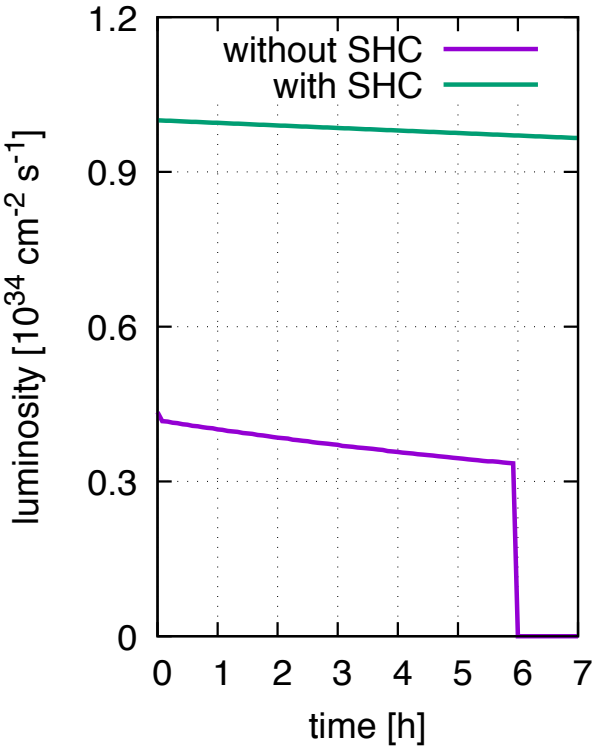
  based on existing RHIC
  - 1160 bunches, 1A beam current (3 x RHIC
  - Bright vertical beam emittance 1.5 nm
  - Strong hadron cooling (coherent electron cooling)
- **Electron storage ring 2.5–18 GeV new ring in RHIC tunnel**
  - 1160 bunches
  - Large beam current, 2.5 A ➔ 9 MW S.R. power
  - SRF cavities
- **Electron rapid cycling synchrotron 0.4- 18 GeV new ring in RHIC tunnel**
  - 2 x 28 nC bunches, 1 Hz cycle time
  - Use spin transparency for high polarization
- **High luminosity interaction region(s) new**
  - L = 10^{34} $cm^{-2}s^{-1}$, Superconducting magnets
  - 25 mrad crossing angle with crab cavities
  - Spin rotators (longitudinal electron spin)
  - Forward hadron instrumentation for tagging



EIC Requires Strong Hadron Cooling to Deliver Science Program

- Performance metric: **average luminosity**
  - Intrinsic ion **emittance growth** limits achievable initial and average luminosity
  - Reduces average luminosity by at least factor 2-3 unless **counteracted by strong hadron cooling** (SHC)
  - Ultimate performance peak luminosity of 10^{34} cm^{-2} s^{-1} requires hadron beam cooling

- SHC is **required to deliver the EIC physics program** in a reasonable time



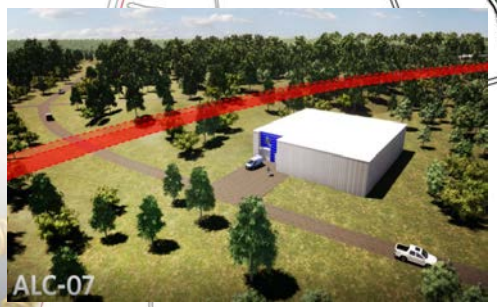
Assumption: electron collision beam size matches ion beam evolution

Preparing for Preliminary Design: Example

Accelerator Technical Reviews

Technical Review	Review Dates	Status
Beam-Beam Effect	5/10/21	Complete
Collective Effects	6/4/21	Complete
Beam Polarization	5/21/21	Complete
Dynamic Aperture	5/11/21	Complete
Forward Power Coupler	6/17/21	Complete
ESR/HSR Vacuum Systems and Impedance	11/8/21	Complete
Detector Machine Interface and IR Installation Logistics	Spring 2022	TBD
SC IR Magnets	TBD	TBD
Pulsed Devices	TBD	TBD
NC Magnets & Power Supplies	6/22	TBD
Strong Hadron Cooling	2/2/22 – 2/3/22	Review underway.
Control Systems	5/22	TBD
RF Design	5/22	TBD
Installation	4/22	Internal review.
Radiation Shielding	3/22	TBD
Design and Operation with Second IR	3/22	TBD
Cryogenics Satellite Plant and 2K Dist.	3/22	TBD

EIC Proposed Site Plan: Buildings



PROPOSED BUILDINGS FOR EIC

TUNNEL

BER

ALC11

ALC01

1010 RF

Cryo Facility

100' SETBACK

100' SETBACK

100' SETBACK

100' SETBACK

1002

ALC09

ALC03

1004

ALC07

1006 ALT

ALC05

Cryo Facility

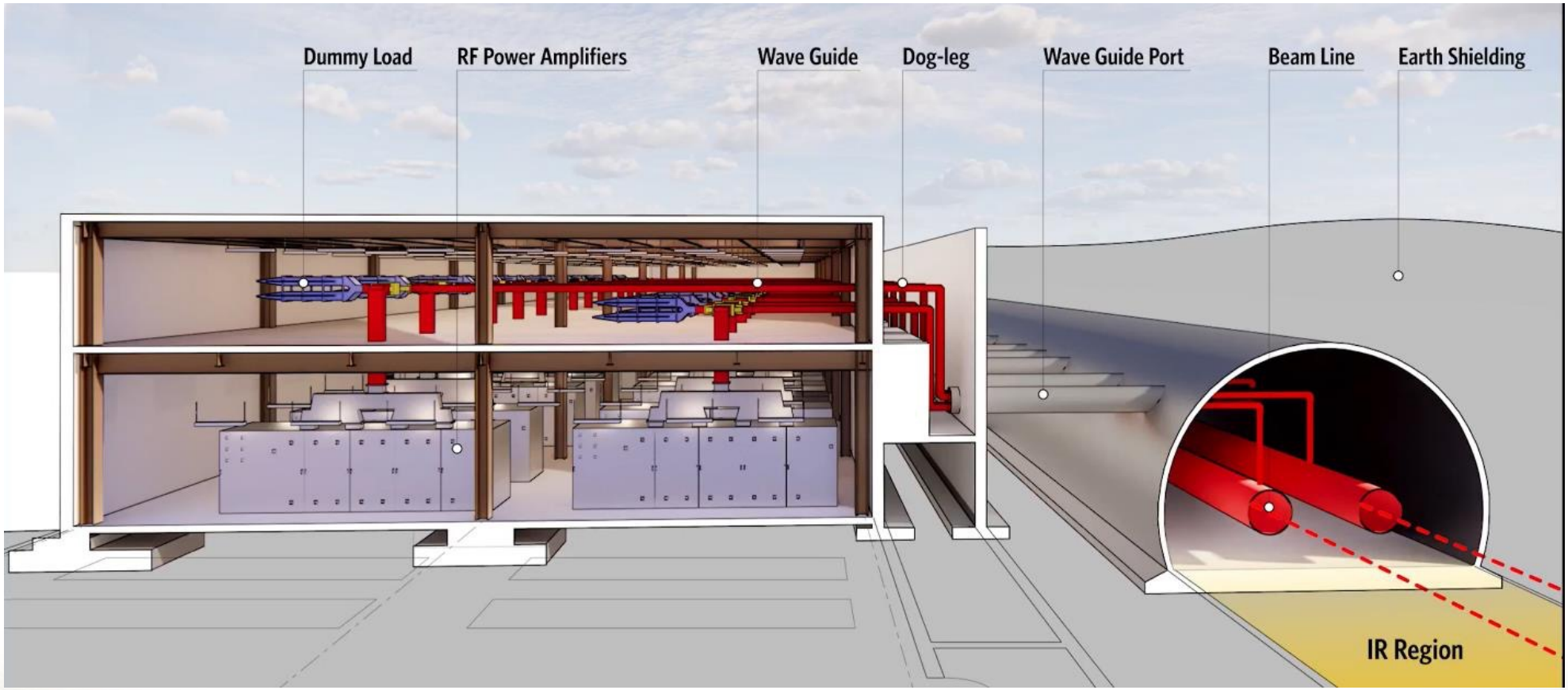
LEGEND

- Existing Buildings
- EIC Tunnel
- Existing Berm
- Accelerator Systems/RF Buildings
- Cooling Towers
- Power Supply Buildings
- Alcove Buildings
- Cryo Facility

Electron Injection Support Building

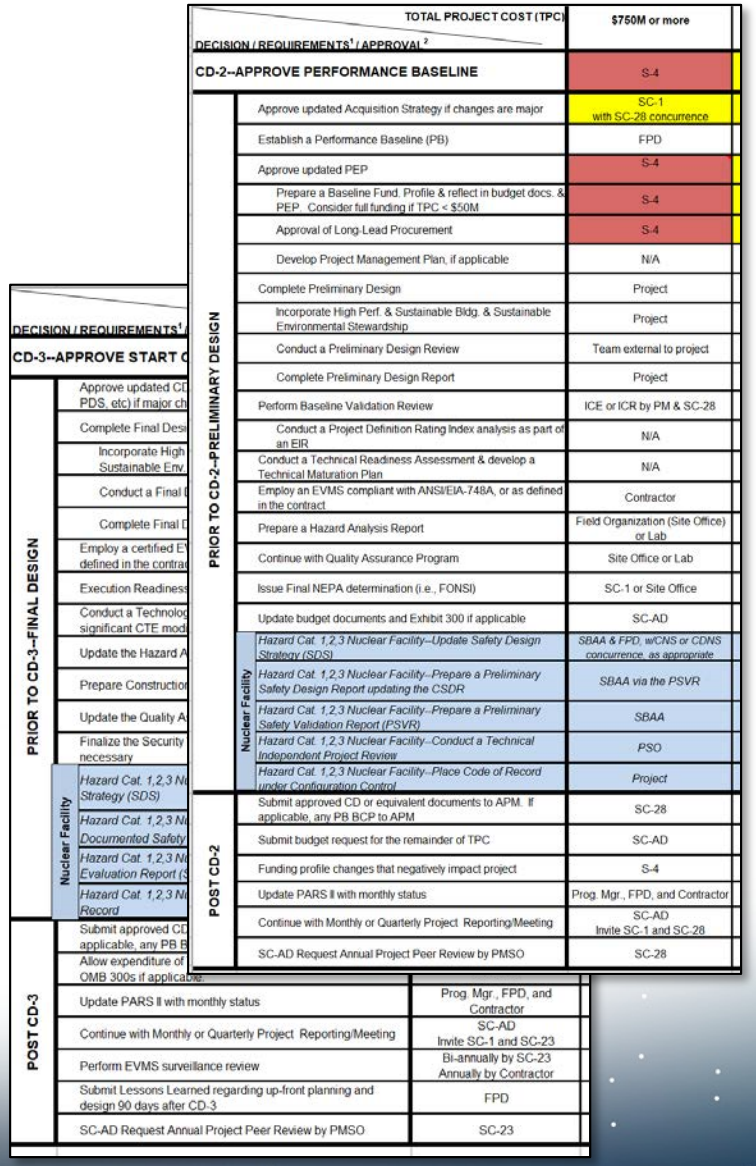
- 1002H EIC Injection LINAC Building ≈ 50,000 SF

RF Support Buildings



CD-2/3A Requirements

- Establish a Performance Baseline
- Complete Preliminary Design
  - Conduct a Preliminary Design Review
  - Complete a Preliminary Design Report
- For long lead items
  - Complete final design
  - Conduct a final design review
  - Complete a final design report

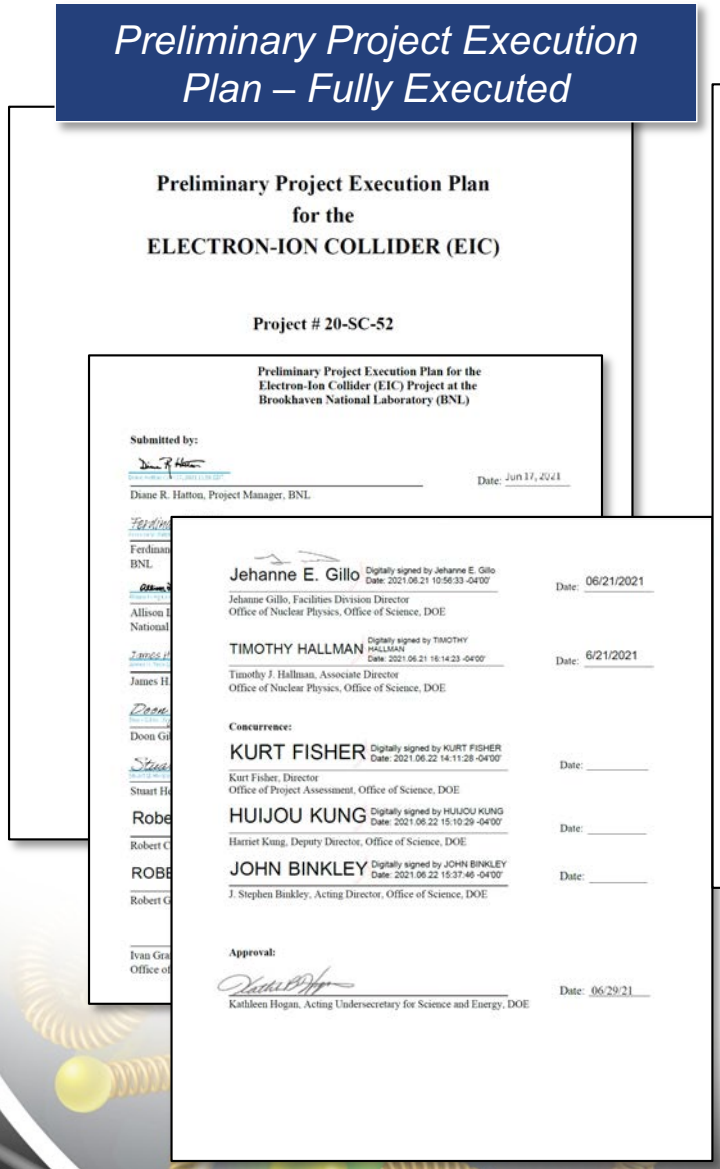


DECISION / REQUIREMENTS[1] / APPROVAL[2]	TOTAL PROJECT COST (TPC) $750M or more
CD-2--APPROVE PERFORMANCE BASELINE	S-4
PRIOR TO CD-2--PRELIMINARY DESIGN: Approve updated Acquisition Strategy if changes are major	SC-1 with SC-28 concurrence
Establish a Performance Baseline (PB)	FPD
Approve updated PEP	S-4
Prepare a Baseline Fund. Profile & reflect in budget docs. & PEP. Consider full funding if TPC < $50M	S-4
Approval of Long-Lead Procurement	S-4
Develop Project Management Plan, if applicable	N/A
Complete Preliminary Design	Project
Incorporate High Perf. & Sustainable Bldg. & Sustainable Environmental Stewardship	Project
Conduct a Preliminary Design Review	Team external to project
Complete Preliminary Design Report	Project
Perform Baseline Validation Review	ICE or ICR by PM & SC-28
Conduct a Project Definition Rating Index analysis as part of an EIR	N/A
Conduct a Technical Readiness Assessment & develop a Technical Maturation Plan	N/A
Employ an EVMS compliant with ANSI/EIA-748A, or as defined in the contract	Contractor
Prepare a Hazard Analysis Report	Field Organization (Site Office) or Lab
Continue with Quality Assurance Program	Site Office or Lab
Issue Final NEPA determination (i.e., FONSI)	SC-1 or Site Office
Update budget documents and Exhibit 300 if applicable	SC-AD
Nuclear Facility: *Hazard Cat. 1,2,3 Nuclear Facility--Update Safety Design Strategy (SDS)*	*SBAA & FPD; w/CNS or CDNS concurrence, as appropriate*
Nuclear Facility: *Hazard Cat. 1,2,3 Nuclear Facility--Prepare a Preliminary Safety Design Report updating the CSDR*	*SBAA via the PSVR*
Nuclear Facility: *Hazard Cat. 1,2,3 Nuclear Facility--Prepare a Preliminary Safety Validation Report (PSVR)*	*SBAA*
Nuclear Facility: *Hazard Cat. 1,2,3 Nuclear Facility--Conduct a Technical Independent Project Review*	*PSO*
Nuclear Facility: *Hazard Cat. 1,2,3 Nuclear Facility--Place Code of Record under Configuration Control*	*Project*
POST CD-2: Submit approved CD or equivalent documents to APM. If applicable, any PB BCP to APM	SC-28
Submit budget request for the remainder of TPC	SC-AD
Funding profile changes that negatively impact project	S-4
Update PARS II with monthly status	Prog. Mgr., FPD, and Contractor
Continue with Monthly or Quarterly Project Reporting/Meeting	SC-AD Invite SC-1 and SC-28
SC-AD Request Annual Project Peer Review by PMSO	SC-28

DECISION / REQUIREMENTS[1] /	
CD-3--APPROVE START C	
PRIOR TO CD-3--FINAL DESIGN: Approve updated CD PDS, etc) if major ch	
Complete Final Desi	
Incorporate High Sustainable Env	
Conduct a Final	
Complete Final D	
Employ a certified E defined in the contra	
Execution Readiness	
Conduct a Technolog significant CTE modi	
Update the Hazard A	
Prepare Constructio	
Update the Quality A	
Finalize the Security necessary	
Nuclear Facility: *Hazard Cat. 1,2,3 Nu Strategy (SDS)*	
Nuclear Facility: *Hazard Cat. 1,2,3 Nu Documented Safety*	
Nuclear Facility: *Hazard Cat. 1,2,3 Nu Evaluation Report (S*	
Nuclear Facility: *Hazard Cat. 1,2,3 Nu Record*	
POST CD-3: Submit approved CD applicable, any PB B	
Allow expenditure of OMB 300s if applicab	
Update PARS II with monthly status	Prog. Mgr., FPD, and Contractor
Continue with Monthly or Quarterly Project Reporting/Meeting	SC-AD Invite SC-1 and SC-23
Perform EVMS surveillance review	Bi-annually by SC-23 Annually by Contractor
Submit Lessons Learned regarding up-front planning and design 90 days after CD-3	FPD
SC-AD Request Annual Project Peer Review by PMSO	SC-23

DOE Project Management

Preliminary Project Execution Plan – Fully Executed



Preliminary Project Execution Plan
for the
ELECTRON-ION COLLIDER (EIC)

Project # 20-SC-52

Preliminary Project Execution Plan for the Electron-Ion Collider (EIC) Project at the Brookhaven National Laboratory (BNL)

Submitted by:

Diane R. Hatton, Project Manager, BNL

Date: Jun 17, 2021

Jehanne E. Gillo Digitally signed by Jehanne E. Gillo Date: 2021.06.21 10:56:33 -04'00'

Jehanne Gillo, Facilities Division Director
Office of Nuclear Physics, Office of Science, DOE

Date: 06/21/2021

TIMOTHY HALLMAN Digitally signed by TIMOTHY HALLMAN Date: 2021.06.21 16:14:23 -04'00'

Timothy J. Hallman, Associate Director
Office of Nuclear Physics, Office of Science, DOE

Date: 6/21/2021

Concurrence:

KURT FISHER Digitally signed by KURT FISHER Date: 2021.06.22 14:11:28 -04'00'

Kurt Fisher, Director
Office of Project Assessment, Office of Science, DOE

Date:

HUIJOU KUNG Digitally signed by HUIJOU KUNG Date: 2021.06.22 15:10:29 -04'00'

Harriet Kung, Deputy Director, Office of Science, DOE

Date:

JOHN BINKLEY Digitally signed by JOHN BINKLEY Date: 2021.06.22 15:37:46 -04'00'

J. Stephen Binkley, Acting Director, Office of Science, DOE

Date:

Approval:

Kathleen Hogan, Acting Undersecretary for Science and Energy, DOE

Date: 06/29/21

BROOKHAVEN NATIONAL LABORATORY — Jefferson Lab

PARTNERING AGREEMENT
In support of collaborative development of the Electron Ion Collider and its scientific programs

This PARTNERING AGREEMENT is effective as of the date of the final signature below (the "Effective Date") and is entered into by and among the Brookhaven National Laboratory (BNL), managed by Brookhaven Science Associates LLC (BSA) and the Thomas Jefferson National Accelerator Facility (JLAB), managed by Jefferson Science Associates Inc. (JSA). Each of the parties is referred to individually as a "Party" or

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Electron-Ion Collider, Brookhaven National Laboratory			
Doc No. [Insert here]	Author: Diane Hatton	Effective Date: 10/01/2021	Review Frequency: 1 years
Plan: Operating Plan			Version: 1

Electron-Ion Collider Plan

Operating Plan

October 1, 2021

Prepared by:
Diane Hatton, Project Manager
Allison Lung, Deputy Director for the TJNAF Partnership

Reviewed by:
Ferdinand Willeke, Deputy Director and Technical Director
Andre Seryi, Associate Director for Accelerator Systems and International Partnership
Elke Aschenauer, Co-Associate Director for the Experimental Systems
Rolf Ent, Co-Associate Director for the Experimental Systems

Approved by:
James Yeck, Project Director

TJNAF/BNL Partnership

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Electron-Ion Collider, Brookhaven National Laboratory			
Doc No.	Author: D. Hatton	Effective Date: 11/1/2020	Review Frequency: 5 years
Plan: Electron-Ion Collider Project Management Plan			Version: 01

Electron-Ion Collider
Project Management Plan

November 1, 2021

Submitted:
Diane Hatton, EIC Project Manager

Approval:
James Yec

Concurren
Ferdinand
Allison Lu
Associate D
Doon Gibb
Stuart Hen

CCs: All L2

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Electron-Ion Collider, Brookhaven National Laboratory			
Doc No. [Insert here]	Author: Diane Hatton	Effective Date: October 1, 2021	Review Frequency: 1 year
Plan: Institutional Memorandum of Understanding			Version: Initial

Electron-Ion Collider Plan

Memorandum of Understanding
between
Brookhaven National Laboratory
and the
Electron-Ion Collider Project

October 1, 2021

Prepared by:
Diane Hatton

Reviewed by:
Ferdinand Willeke
James Yeck
Jack Anderson
Bob Tribble
David Asner
Susan McKeon
Steven Coleman
Thomas Daniels
Haiyan Gao

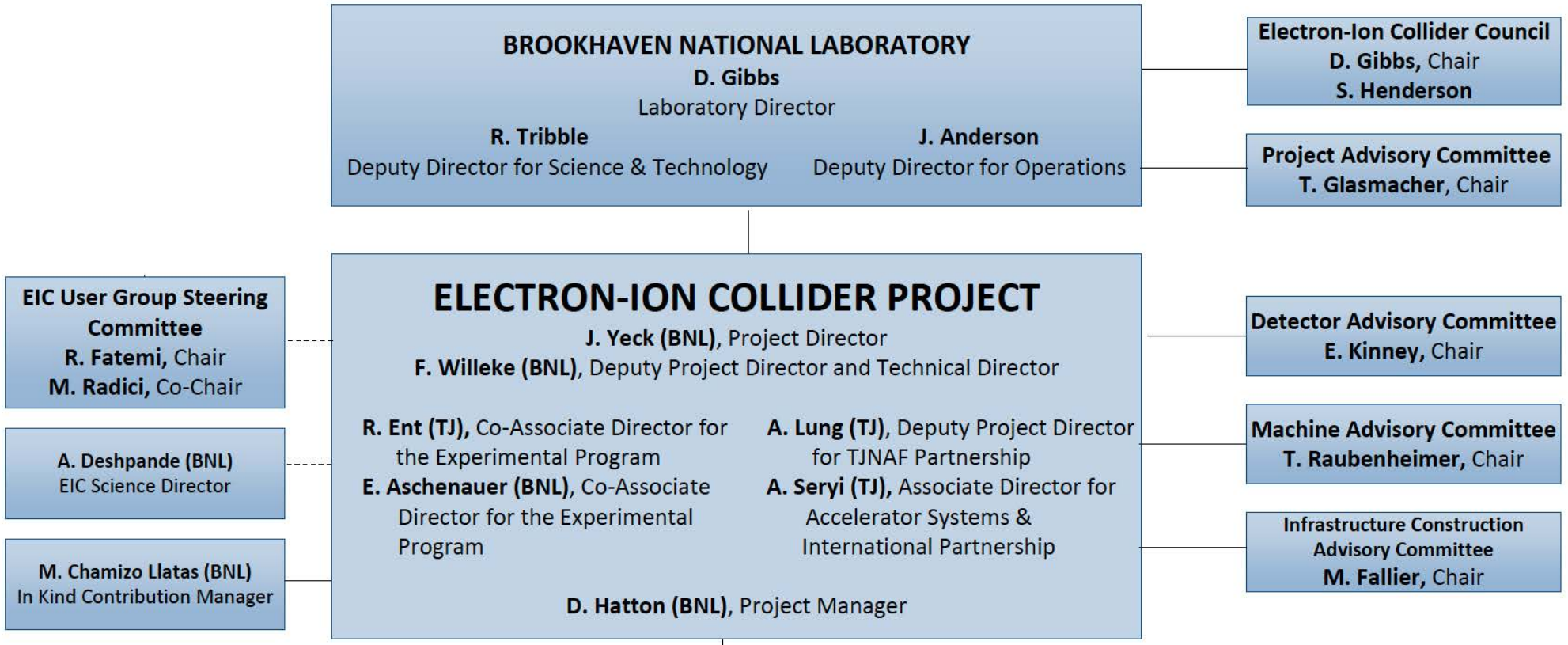
Approved by:
Doon Gibbs

Tactical Project Management

Planning Assumptions for Cost and Schedule Update

- Critical Decision Assumptions (+6-9 months)
  - CD-2/3A: ~End of 2023
  - CD-3: January 2025
  - CD-4A EF: January 2031
  - CD-4: January 2032
  - CD-4 EF: January 2032
  - CD-4: January 2034
- Dates are for initial planning purposes only
  - We will need to adjust based on cost and schedule updates and funding

EIC Project Organization



A few points:

- Host Lab
- Executive Management Team
- Council, Advisory Committees, Connections to User Group

EIC Governance

- EIC is a DOE project, with traditional DOE accountability structure (different than ITER, DUNE, and PIP-II).
- DOE, together with BNL and JLab, envision a facility for the world and “fully international in character.”
- DOE organizes meetings and discussion with international funding agencies on cooperation and collaboration and is establishing government to government agreements to enable collaboration
- BNL established EIC Council (BNL and JLab Directors as founding members) and ready to discuss evolution of the Council to include potential partners
- The governance of the experimental program requires input from the EIC Users Group, the detector collaborations, the host labs (BNL and Jlab), and the funding agencies. It could be similar to the CERN RRB model which has many benefits (ALICE, DUNE).
- Governance model will be defined this year.

Key Project Challenges

- Cost: affordability, funding profile, in-kind, escalation
  - Project cost control must remain a top priority
- Accelerator Science and Technology
  - Complex machine requiring a collaborative approach to identify and address the technical issues
  - BNL and JLab are working to engage international and domestic partners in these efforts
- Infrastructure Schedule
  - Initial pacing scope for the project with significant NYS funding
  - Requires EIC technical teams to deliver timely requirements
- Project Detector Plans
  - Starting from the DPAP recommendations, need clarity on the detector scope, cost, schedule, collaboration, and institutional responsibilities

Summary

- CD-1 approval was a major accomplishment!
- CD-2 and CD-3A approval will be an even bigger challenge, and dependent on funding, design progress, further development of the organization including in-kind partners, and effective implementation of risk mitigation strategies.
- Plans for the project detector must mature rapidly to support CD-2/3A goals.
- Need to make the maximum technical progress
  - EIC technical progress constrained by funding
  - Need to make the best technical progress in the most cost-effective way, this will continue to include contributed effort by the community and lab staff in many cases