EIC 2nd Detector and Software and Computing

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Opportunity

2023 NSAC Long Range Plan for Nuclear Science: **We recommend the expeditious construction of the EIC as the highest priority for facility construction**

But EIC construction does not include

A second detector

Physics and detector simulations, along with related software and computing necessary to realize the science

Selected statements in the body of the Long Range Plan:

”A second detector would turn on several years after ePIC, and the EIC community will use this time to explore new and complementary detector technologies that may not have been employed in the project detector.”

“In particular, nuclear physics experimental programs face new computational challenges owing to increasing detector complexity and experiments with higher interaction rates than previously seen.”

Vision

The EIC will be a user facility that operates for multiple decades

To prepare for that, BNL needs to stand up:

The case for a second detector at the EIC: physics and technology

A modern framework for successful EIC software and computing operations

“EIC could be one of the first large-scale collider-based programs in which AI/ML is integrated from the start”

Background for the Vision

- The Electron Ion Collider will be a multi-decade facility. BNL as the site needs to plan for success beyond the initial construction project.

Words from the 2023 NSAC Long Range Plan:

- For a second detector at the EIC:
  - **Historically, projects of similar scientific impact and scope were designed to include two or more complementary detectors, and the EIC community has emphasized the need for at least two detectors for many years. Multiple detectors will expand scientific opportunities, draw a more vivid and complete picture of the science, provide independent confirmation for discovery measurements, and mitigate potential risks when entering uncharted territories.**

- For operation of the first detector:
  - **excitingly, cross-cutting development efforts with advanced computing are conceived to facilitate self-driving detector systems: ePIC at EIC [is a candidate] for initial large-scale deployment of such a concept. Here, a combination of heterogeneous computing, AI, ML, advanced computing, and streaming readout is anticipated to reduce the time from data collection to publication and improve efficiency of experimental operations.**

Why BNL?

BNL as the site for the EIC needs to take a leading role in making this happen

On physics case: history of intense involvement in white papers leading up to EIC
We are world experts both experimentally and theoretically,
esp. in the physics of gluon saturation and jet physics

On detector technology: experience with RHIC detectors, polarized hadron beams, limitations of ePIC, and cross-fertilization with HEP

On software and computing:
Experience with data analysis at scale with STAR, sPHENIX, and ATLAS

Why now?

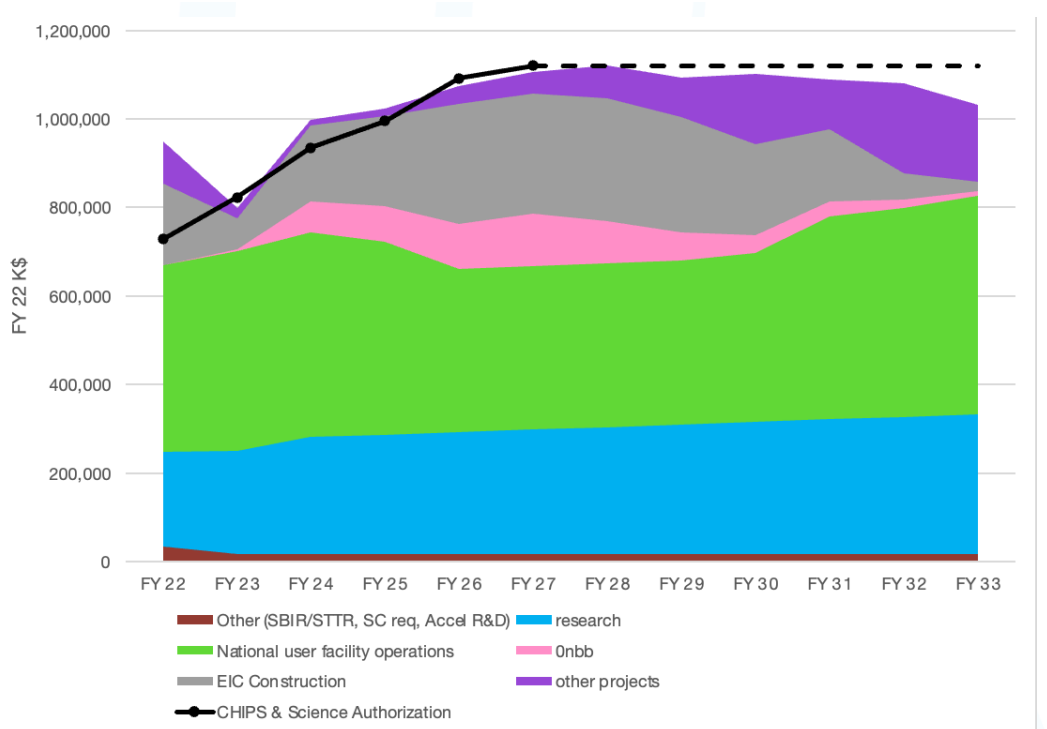
- In response to 2023 Long Range Plan for Nuclear Science and the imminent beginning of EIC construction with CD-3

- Case for second detector, while recognized in the community, not a “slam dunk”
  - While mentioned in LRP, only on p. 127, not in the executive summary
  - Driven partially by timing of EIC project itself, only at CD-1: too early for a strong push
  - Time is now to fully investigate the case for complementarity

- Time scale: position BNL for next Long Range Plan towards the end of 2020’s

- Capture operations and “other projects” funding as EIC project passes peak funding

From 2023 LRP: Projected DOE NP funding split under CHIPS & Science Authorization



BNL Current investments

LDRD-A under this initiative		PI	FY24	FY25	FY26
LDRD-23-048	Real-time Information Distillation on Novel AI Hardware	Huang	495	500	
LDRD-23-050	A Second EIC Detector: Physics Case and Conceptual Design	Ullrich	498	495	
LDRD-24-047	EIC simulation infrastructure	Kauder	500	500	500
LDRD-24-054	Galvanically Isolated, High Spatial and Temporal Resolution Silicon Vertex and Tracking Detector with Large-Area Monolithic Active Pixel Sensors	Deptuch	500	500	500
Related PD and LDRD B					
PD-24-007	Collaborative Scientific Computing for the Electron-Ion Collider	Lancon	366	346	342
PD-23-007	BNL EIC Theory Institute	Venugopalan	494	499	
PD-22-008	Data Storage and Access Infrastructure	Lauret	107		
LDRD-23-016	3-D Structure of the Proton	Mehtar-Tani	200		

Current LDRD investments include specific potential detector technology advancements, a broad investigation of physics case, and work on establishing new computational techniques
PD investments are complementary, focused on building community

Specific recent accomplishments are the mentions in the 2023 Long Range Plan

Who are we competing with in this initiative?

What are their strengths?

How can we mitigate that?

Competition

EIC not the only user facility for NP

- Major other operations: FRIB@MSU, CEBAF 12@JLAB
- Construction of Neutrinoless Double Beta Decay experiments has a prominent role
- Also ATLAS@ANL, university laboratories, and research

Many “other projects” mentioned beyond EIC 2nd detector

- Executive Summary mentions:
  - FRIB400, SoLID at JLAB, LHC heavy ion program, neutrino mass and electric dipole measurements
- Also mentioned in the body:
  - Upgrade of CEBAF to positrons and 24 GeV energy

Mitigation: strengthen complementarity case and community support

What are we missing at BNL to execute this strategy? Capabilities/expertise/political

What partnerships should we form to fill these gaps?
Individuals
Institutional
Domestic/international

Strategic partnerships

Second detector will necessarily be a multi-institutional collaboration

- Community needs to be behind it for success in next Long Range Plan
- International contributions also need to be a part of the portfolio, which require visible buy-in from the US community

Developing software and computing model multi-institutional

Primary partner in EIC is Jlab as co-host for the EIC

- Esp. in light of High Performance Data Facility to be located at Jlab
- Interaction with Generic Detector R&D program run by Jlab

Center for Frontiers in Nuclear Science (CFNS)
valuable forum for community-building activities

Long-term strategy

Target: capture operations/"other project" funds beyond EIC peak

Needs conceptual and technological progress and community support
to produce strong mention in late 2020's NSAC Long Range Plan

Milestones will become clearer as first detector design solidifies,
as its computing model becomes clearer,
and as limitations of both become apparent

Internal strategy

What is the roadmap to execute the long-term strategy
- Hires
- JAs
- Partnerships formed
- LDRDs to demonstrate/develop expertise/capabilities: what type (A or B), how many and when
- Program dev funds (what for and when)
- Other

Combination of driving specific technologies and broader physics case

4-5 associated LDRD A, focusing on specific detector technologies, specific computational advancements (including AI), and physics advances (including theoretical) beyond the initial physics case for the EIC

Some LDRD B for targeted opportunities

Program Development will remain critical for community engagement

Summary

Need: Sustained investment moderately above current level (~3-5 M$) through decade

Return on Investment:

A second detector is ~500 M$ or more, including the Interaction Region

A second detector enables opportunities to broaden user community

which is critical for a User Facility

Direct current RHIC operations funding for Software and Computing is ~$20M/year; similar levels will likely be necessary for the EIC

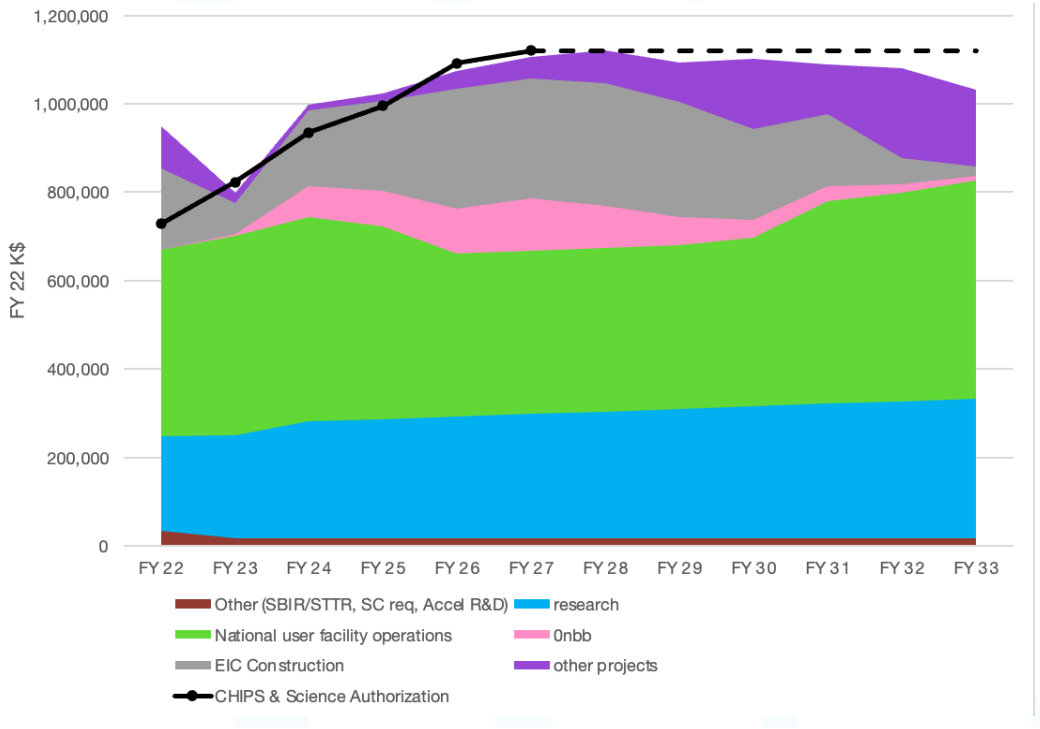
but more than that is critical to supporting the entire enterprise to produce the timely results DOE and our user community expect

Back up slides

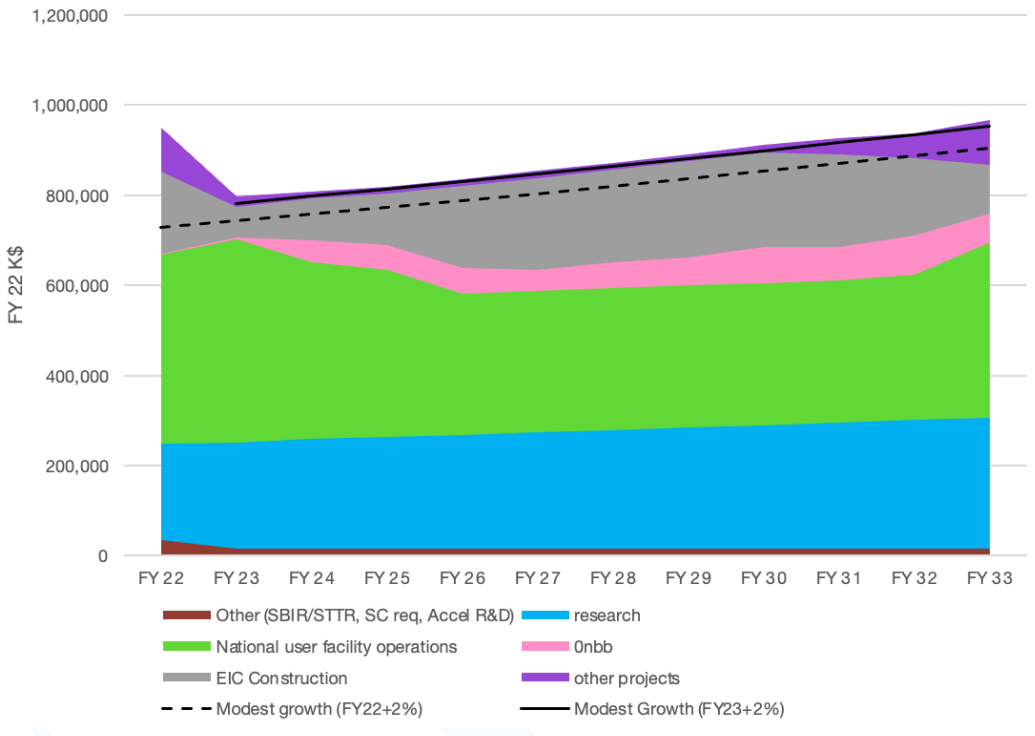
To be developed, but not shown

DOE NP Funding Profiles in 2023 LRP

CHIPS&Science



Modest Growth



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