U.S. DEPARTMENT OF ENERGY | Office of Science

NP Accelerator R&D Principal Investigators Exchange Meeting

DOE Office of Nuclear Physics

M. Farkhondeh

November 13-14, 2018

Gaithersburg, MD

U.S. DEPARTMENT OF ENERGY | Office of Science

Outline:

- This Meeting
- Office of Science Accelerator R&D categories
- EIC Concepts
- NP Near Term Strategic Plan for Accelerator R&D and EIC
- 2017 NP Community EIC R&D Panel Report (Jones Report)
- FY017: Accelerator R&D Plans and funding
- Presentation Guidelines
- FY18 FOA and funding
- Summary Remarks

This Meeting

- Presentations on current status of work by all Principal Investigators (PIs) who received awards under FY2017 Lab R&D Plans**.** Cover the continued work under the FY 2016 funding opportunity announcements DE-FOA-0001556 and LAB 16-1556.

- This is not a review and no review panel is involved. Presentations will be made to NP Office Program Managers and Division Directors, and possibly a few PMs from HEP and BES Program Offices.

- To facilitate exchange of information between PIs and the NP Office and among PIs and institutions on all current and past EIC-related Accelerator R&D funded efforts.

- A continuation of yearly meetings on NP supported Accelerator R&D for next generation NP facilities.

- For the next year's meeting (2019) will invite all PIs who received funding for NP in response to the FY18 FOA DE-FOA-0001848.

U.S. DEPARTMENT OF ENERGY | Office of Science

DOE Office of Science Accelerator R&D Categories

- **Short Term Accelerator R&D-** Accelerator R&D with the potential for improved performance and/or new capabilities to existing NP scientific user facilities that will lead to new capabilities or improved operations. This is supported by NP and other program offices.

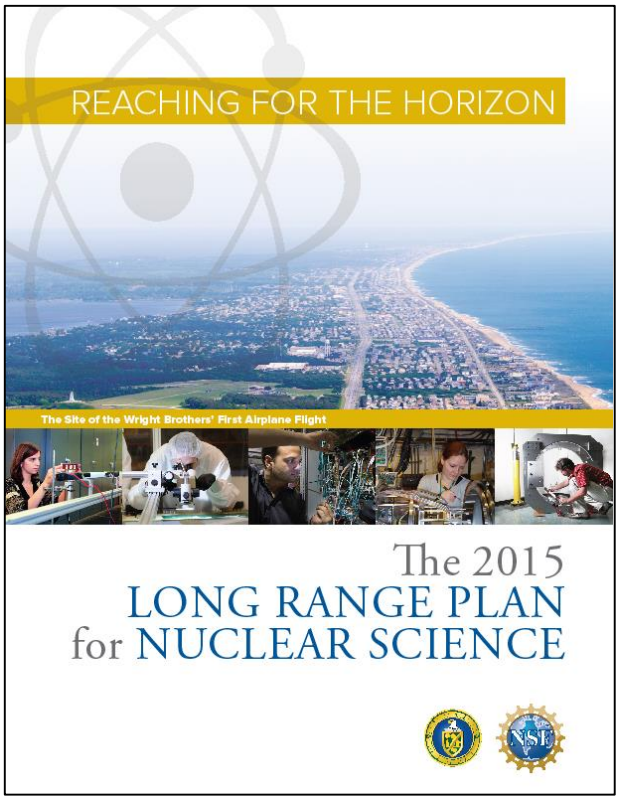
- **Mid-Term Accelerator R&D**: Accelerator R&D with the potential for the development of the future generation of NP accelerators not under construction. This is supported by NP and other program offices.

- **Long-Term or generic Accelerator R&D**: This is directly supported by the Office of High Energy Physics (HEP) although NP work often relevant.

➢ **Funding Level:** Total annual direct NP investment in EIC-related accelerator R&D through competitive funding opportunity announcement (FOA) and National Laboratory Accelerator R&D is on the order of $13.5 M per year and increasing.

U.S. DEPARTMENT OF ENERGY | Office of Science

2015 NSAC LRP Report



RECOMMENDATION III (Page 4)

Gluons, the carriers of the strong force, bind ……

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.

INITIATIVES : (Page 5)

B: *Initiative for Detector and Accelerator Research and Development*

……

We recommend vigorous detector and accelerator R&D in support of the neutrinoless double beta decay program ***and the EIC.***

The **key EIC machine parameters** identified in the LRP were:

- Polarized (~70%) electrons, protons, and light nuclei,
- Ion beams from deuterons to the heaviest stable nuclei,
- Variable center of mass energies ~20-100 GeV, upgradable to ~140 GeV,
- High collision luminosity ~10^{33}-10^{34} $cm^{-2}sec^{-1}$, and
- Possibly have more than one interaction region.

EIC Concepts

Current EIC concepts have emerged from national labs.

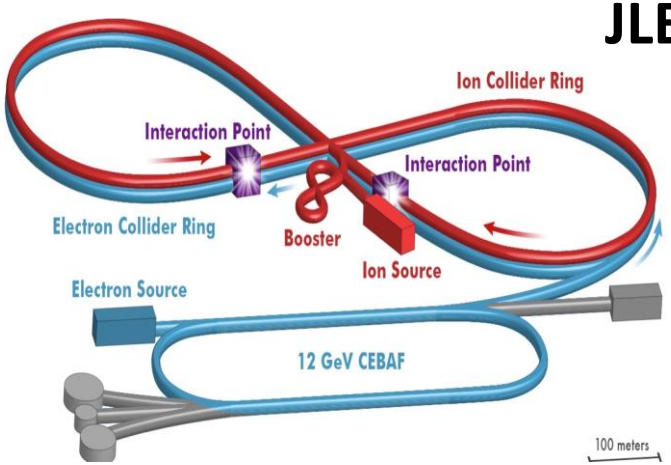
Strong collaborations at the labs and with universities to advance different concepts and common R&D relevant to all concepts:

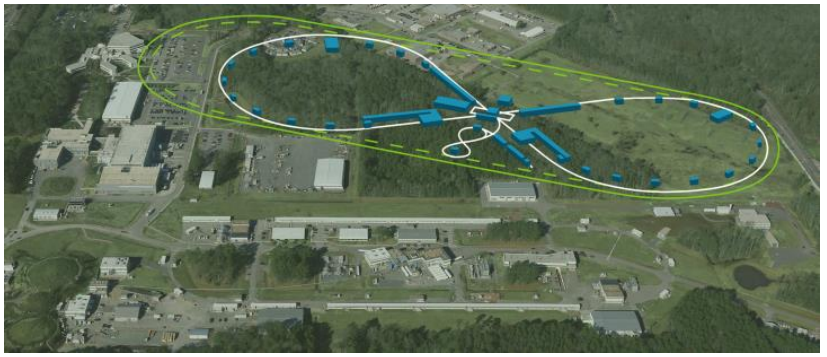
- **BNL:** eRHIC based on a Ring-Ring concept
- **TNJAF:** JLEIC based on a high repetition rate figure-8 Ring-Ring concept

Note: At the time of the Jones panel review, BNL developing two different eRHIC concepts R-R and L-R. In April 2017, after the Jones report was published, BNL announced the R-R as the primary concept for eRHIC.

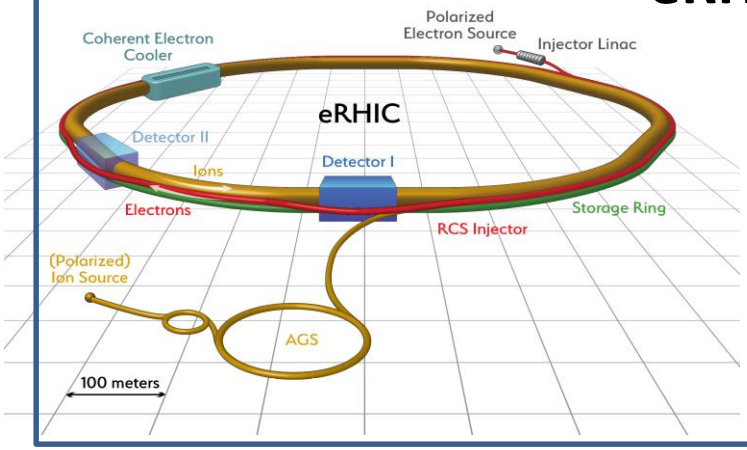
EIC Ring-Ring Design Concepts

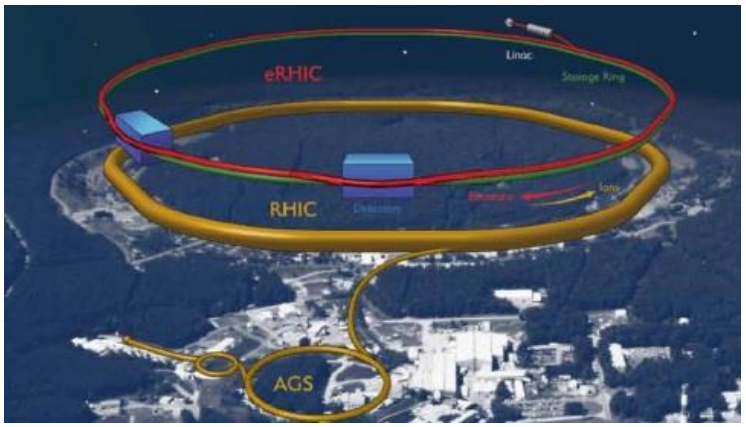
JLEIC





eRHIC





Planning Towards an EIC

- **National Academy of Sciences (NAS) Study:** Initiated an 18 month NAS study entitled: *"US-BASED ELECTRON ION COLLIDER SCIENCE ASSESSMENT"* Started in July 2016. **(Report: July 24, 2018)**

- **FY16 FOA:** Published competitive FOA ("Accelerator R&D for Next Generation NP Facilities") focused on EIC-related R&D. NP has been funding competitive accelerator R&D since 2010 at ~$2M/year.

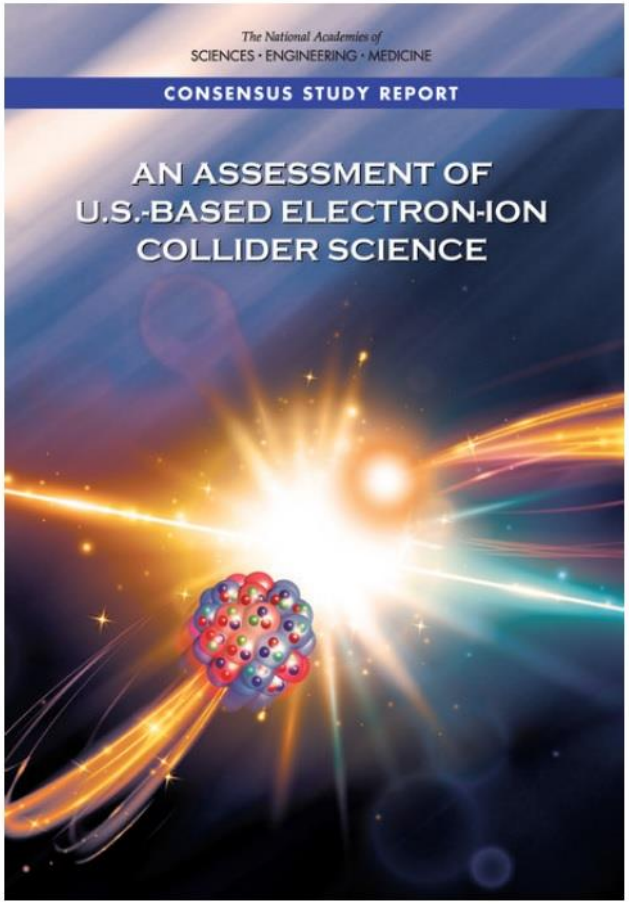
- **NP Community Panel Review:** Conducted NP community EIC R&D panel review charged with identifying high priority R&D aimed at technical risk reduction. Dr. Kevin Jones of SNS chaired this international panel. First face-to-face meeting was held November 29-December 2, 2016. Panel Report published in February 2017 (https://science.energy.gov/np/community-resources/reports/)

- **FY17:** EIC-related Accelerator R&D plans received from Labs and universities and high priority R&D in the context of Jones report is supported.

- **Bi-Annual FOA starting FY18:** Published bi-annual FOA for competitive accelerator R&D based on R&D priorities established in the EIC panel report. **(Awards selected for FY 18)**
  - **Funding level**: ~$8.8 M per year for FY18 and FY19.
  - **Funding sources:** Combination of NP competitive accelerator R&D funds augmented with RHIC and CEBAF Accelerator Operations budget funding.

U.S. DEPARTMENT OF ENERGY | Office of Science

NAS Report on Merit of a US based EIC



The short version:

The National Academies of Sciences, Engineering, and Medicine was asked by the U.S. Department of Energy to assess the scientific justification for building an Electron-Ion Collider (EIC) facility.

The *unanimous* conclusion of the Committee is that an EIC, as envisioned in this report, would be…

… a unique facility in the world that would answer science questions that are compelling, fundamental, and timely, and help maintain U.S. scientific leadership in nuclear physics.

Slide- courtesy of Ernst Sichtermann of LBNL

A unanimous conclusion in support of a US based EIC

U.S. DEPARTMENT OF ENERGY | Office of Science

Jones Panel Priority Table:

Report of the Community Review of EIC Accelerator R&D for the Office of Nuclear Physics

February 13, 2017

2017

Rows 1-22: "PANEL", "A" or "B"

Sub-Priority-A Rows 1-6

Row No.	Proponent	Concept / Proponent Identifier	Title of R&D Element	Panel Priority	Panel Sub-Priority
1	PANEL	ALL	Crab cavity operation in a hadron ring	High	A
2	PANEL	ALL	High current single-pass ERL for hadron cooling	High	A
3	PANEL	ALL	Strong hadron cooling	High	A
4	PANEL	ALL	Benchmarking of realist EIC simulation tools against available data	High	A
5	PANEL	ALL	Validation of magnet designs associated with high-acceptance interaction points by prototyping	High	A
6	PANEL	ALL	Polarized ^{3}He Source	High	A
7	PANEL	LR	High current polarized and unpolarized electron sources	High	B

U.S. DEPARTMENT OF ENERGY | Office of Science

Jones Report R&D Priorities

Priority: "High", "Medium", or "Low", Sub-Priority: "A", "B", "C" or "None"

Proponent: "PANEL", "BNL" or "JLAB"

Design Concept: "RR", "LR" or "JLEIC"

- Sub-Priority-A: The R&D elements that the panel judged to be applicable to **all** concepts presented are identified by "ALL" in the concept/proponent identifier column and are assigned sub-priority A. **These are considered the most important to be addressed to reduce overall design risk.**
- Sub-Priority-B: The R&D elements that the panel judged to be applicable to individual concepts presented are identified by the appropriate concept identifier in the concept/proponent identifier column (e.g., LR, RR or JLEIC) and are assigned sub-priority B. **These are considered to be second in importance to reduce overall design risk, but important to reduce the risk associated with a specific concept.**
- Sub-Priority-C: The R&D elements self-identified by the proponents are tabulated in lines 23-75 with the priority as deemed by the panel. Specific self-identified high priority R&D elements that have substantial correlation with the high priority global and concept-specific sub-priority A and B elements identified by the panel are denoted as sub-priority C to permit ready cross-reference when evaluating future R&D proposals.

U.S. DEPARTMENT OF ENERGY | Office of Science

Technical Challenges for EIC

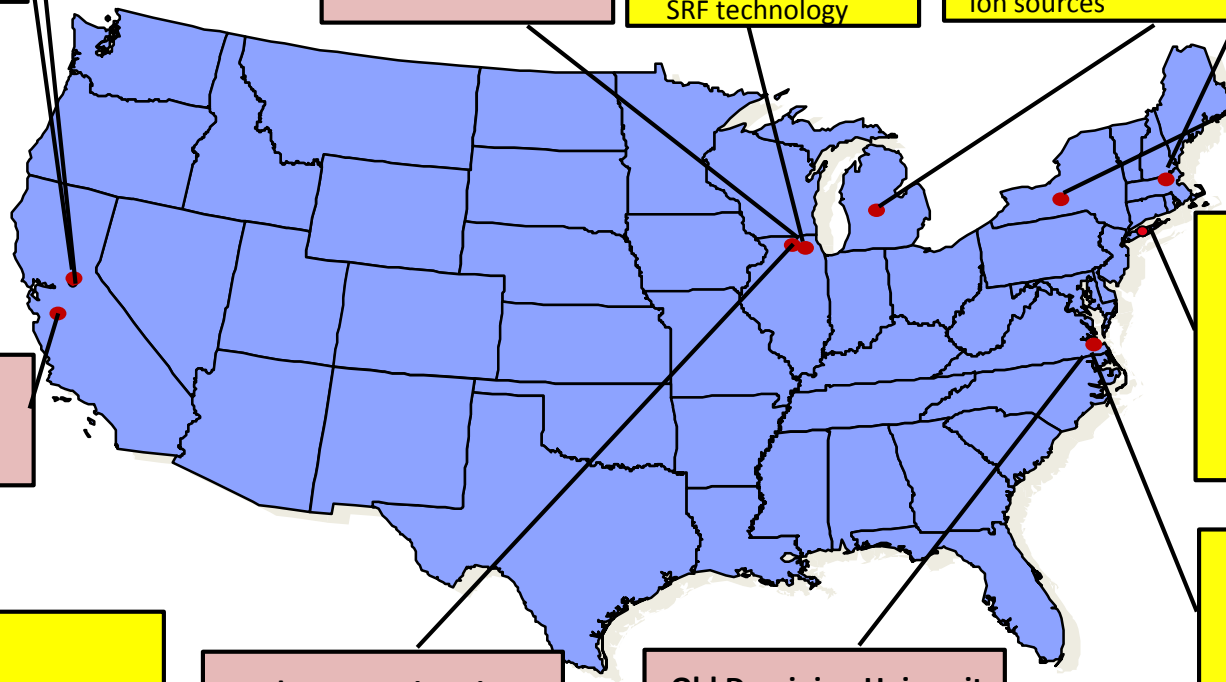
EIC will be one of the most complex collider accelerators ever to be built. It will push the envelope in many fronts including high degrees of beam polarizations, high luminosity, beam cooling, beam dynamics, crab cavities for both beams, and an interaction region with complex magnets.

Required Accelerator R&D Advances for EIC (list from the Jones panel report)

- Hadron cooling techniques
- Polarized electron sources
- Ring magnet demonstrations
- Interaction region magnet design and prototyping
- Machine-detector interfaces
- Superconducting RF technology
- Large scale cryogenics technology
- High current ERL Linacs
- Crab cavity design, fabrication and testing (with beam)
- Beam and spin dynamics and benchmarking of simulation tools
- Electron cloud mitigation techniques

Core competencies in these areas exist at NP and SC Labs and universities. Collaborations have formed to address these technical challenges.

Core Competencies for EIC at NP Labs and Universities



LBNL
Next Gen. ion source

LBNL
Beam simulation

FNAL
Beam Cooling

ANL
Beam simulation
SRF technology

Michigan State Univ. (FRIB)
SRF technology
Ion sources

MIT
High current polarized electron sources
Polarized ^{3}He target

Cornell University
High current e. sources
SRF technology

BNL (RHIC)
Beam cooling
Crab Cavity design
Beam simulations
Colliders
Polarized ion sources
SC magnet design

SLAC
Beam simulation

TJNAF
SRF technology
ERL
Polarized electron sources
Beam simulations
SC magnet design

Northern IL University
Beam simulation

Old Dominion University
Crab cavity design

NP core competency

With NP EIC awards

U.S. DEPARTMENT OF ENERGY | Office of Science

FY017 : Accelerator R&D Plans

- Due to delays in planned FOA we have asked TJNAF and BNL for their FY2017 R&D Plans (Base R&D and Additional-NP funds R&D if funding were available.)
- Also requested R&D Plan from Labs and universities that had received funding from NP in FY2016. Collaborations with lead labs were encouraged.
- Plans were received by June1, 2017. Evaluation of plans were completed by end of June and funding recommendations proceeded.
- "Base fund (Taxed)": BNL: $3.5M, TJNAF: $1.5M Total: $5.0M
- "NP Accelerator R&D Funds": $1.879M

FY2017 Accelerator R&D Funding distributions

-	BNL	Base and NP funds
-	TJNAF	Base and NP funds
-	ANL, FNAL	NP funds
-	MIT, Cornell	NP funds
-	TAMU, NIU	NP funds

U.S. DEPARTMENT OF ENERGY | Office of Science

FY2017 R&D Plans

Page 1			FY 2017 EIC R&D Plan Awards	
Proposal ID	**Institution**	**R&D Area**	**Proposal Title**	**Principal Investigator**
232006	Cornell	Polarized e Source	Next generation robust pol. photocathodes for EIC	Ivan Bazarov
FY17 Add Collab. BNL	MIT/subc		High Current, High Charge Polarized Electron Sources	Bob Redwine /Evgeni Sentalovich
FY17 Additional	BNL		complete procurement of components for inverted gun	John Skaritka
FY17 Base	BNL		Gatling gun, laser system and design of new inverted gun	John Skaritka
FY17 Additional BNL	BNL	Polarized 3He Source	Development of a Polarized 3He Ion Source for RHIC	Anatoly Zelenski
FY17 Add Collab. BNL	MIT/subc		Development of a Polarized 3He Ion Source for RHIC	Richard Milner
FY17 Base	TJNAF	Beam Cooling	Magnetized Electron Source	Riad Suleiman
FY17 R&D	TJNAF		Electron Cooling Simulation Development	Yves Roblin
FY17 Base	BNL		Coherent Electron Cooling PoP experiment	Vladimir Litvinenko
FY17 Base	TJNAF		Electron Cooler Design	Steve Benson
FY17 Base	TJNAF		Bunched Beam Electron Cooling Experiment	Yuhong Zhang
232015	NIU		Studies of Conventional and ERL-Based Re-circulator Electron Cooling for an Electron Ion Collider	Bela Erdelyi
FY17 Add Collab. BNL	FNAL	Spin Dynamics	Study of Electron Spin Polarization in the EIC	Eliana Gianfelice-Wendt
FY17 Additional BNL	BNL		Study of Electron Spin Polarization in the EIC	Mike Blaskiewicz
FY17 Base	TJNAF		Spin Tracking in Ion and Electron Rings	Vasiliy Morozov
FY17 R&D	TJNAF	Magnet R&D	IR FFQ Prototype Definition	Tim Michalski
FY17 Additional BNL	BNL		Design and Prototyping of SC EIC – IR Magnets	Peter Wanderer
FY17 Base	TJNAF		Interaction Region (IR) Magnet Design Verification	Tim Michalski
FY17 R&D	TAMU/Subc		Complete and Test a Full Scale Suitable Superferric Magnet	Peter McIntyre/Tim Michalski

FY2017 R&D Plans

Page 2			FY 2017 EIC R&D Plan Awards	
Proposal ID	**Institution**	**R&D Area**	**Proposal Title**	**Prinicipal Investigator**
113	ANL	Beam Dynamics	Beam Simulation and Benchmarking	Brahim Mustapha
FY17 Base	BNL		Beam-Beam Effects, Collective Effects Study, Dynamic Aperture	Mike Blaskiewicz
FY17 Base	BNL		eRHIC Electron Storage Ring Concept Development	Christoph Montag
FY17 Base	TJNAF		Beam-Beam Dynamics with Gear Changing	Yves Roblin
FY17 R&D	TJNAF	SRF R&D	Fast Feedback System and Kicker Design	Bob Rimmer
FY17 R&D	TJNAF		Test of CEBAF Electron Injection Mode	Jiquan Guo
111	ANL		ANL Plan for EIC R&D: HOM damping	Michael Kelly
FY17 Base	BNL		Design of state of the art RF systems for eRHIC	Kevin Smith
FY17 Base	TJNAF		Development of SRF Systems for an EIC	Bob Rimmer

- Areas of R&D: The majority included highest rated R&D priority areas identified in the Jones panel report. Also included a few areas TJNAF and BNL were doing R&D prior to the Community report.
- This two day Principal Investigator meeting is organized for all PIs listed above to present their work to NP and other PIs in order to promote communication and collaboration amongst national labs and universities.

16

Communications between NP and PI for Accelerator R&D work

There are two modes of communications between PIs and NP office: Quarterly reports and an annual face to face meeting with all PI in one place.

- Quarterly Reports
  - PIs are asked to submit quarterly reports to NP in a “Small Project” format. The first one for FY 2017 funds was requested for a 6 months period. The 3rd quarter request was sent by Cassie on June 22, 2018. The 4th quarter request was sent on September 28, 2018.

- PI Exchange Meeting
  - For Accelerator R&D efforts NP conducts annual “PI Exchange” meetings with presentations on current status of work by all Principal Investigators who received awards under previous fiscal year funds. The 2018 PI meeting will take place in November for all FY 2017 R&D Plans.

PI Meeting Presentation Guidelines:

- Each presentation should include the following information:
  - Description of the project and the current status;
  - The main goal of the project for which you received the FY 2017 Accelerator R&D Plan funds. Specify if the award is part of the Lab Base R&D at BNL or TJNAF.
  - Is the funding for this work continued by the FY 2018 NP Accelerator R&D FOA?
  - A table showing annual budget and the total received to date (see below);
  - A table showing major deliverables and schedule; and
  - **For each R&D task identify the priority and sub-priority designation(s) listed in the priority table of the 2017 Jones EIC R&D report.** Also list the row number in the Jones report Priority table that corresponds to each of your task (Rows 1-75).

PI Meeting Presentation Guidelines (P. 2):

- It is essential that Mrs. Brenda May has a copy of your final presentation by 8:00 am for the morning sessions and by 12:00 pm for the afternoon sessions on the day of your presentation.

- There will be no written report or follow up actions required for this meeting.

- <u>Summary of expenditures by fiscal year (FY):</u>

	FY10+ FY11	FY12+FY13	FY14+ FY15	FY16 +FY17	Totals
a) Funds allocated					
b) Actual costs to date					

FY018 : Accelerator R&D Funding

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA)

Research and Development for Next Generation Nuclear Physics Accelerator Facilities

Funding Opportunity Number : DE-DE-FOA-0001848
Announcement Type: Initial
CFDA Number: 81.049
ISSUE DATE: 12/01/2018
Application Due Date: 1/19/2018

• A panel of experts helped NP select for funding the most suitable proposal(s) submitted to this FOA based on the SC merit review criteria and NP Program Criteria (Jones panel priority list and 2015 NSAC LRP) for the appropriated FY18 funds and a similar amount is planned for FY2019.

•This was for ~~a~~ two-year funding. The next NP Accelerator R&D FOA is expected to be published for FY20-21 funding.

Review Criteria for FY2018 FOA

This FOA Supports:

This FOA is in support of pre-conceptual accelerator R&D aimed at technological challenges for the next generation NP facilities. Accelerator R&D intended for this announcement should fall in the following general categories:

- Accelerator R&D with the potential for the development of future generation of NP accelerators not under construction or design.
- Accelerator R&D with the potential for improved performance and/or upgrades to existing NP national user facilities that will lead to new capabilities

Merit Review Criteria

Reviewers are requested to evaluate proposals and comment on: **(Criteria)**

1. Scientific and/or Technical Merit of the Project;
2. Appropriateness of the Proposed Method or Approach;
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources; and
4. Reasonableness and Appropriateness of the Proposed Budget

NP Program Criteria

In addition, each application should also address these **program criteria**:

5. Relevance to compelling scientific opportunities identified in the 2015 NSAC Long Range Plan.(LRP)
6. If appropriate, relevance of proposed electron-ion collider efforts to the R&D priorities identified in the Jones Report.
7. The opportunity for training junior accelerator physicists in accelerator science and Technology.

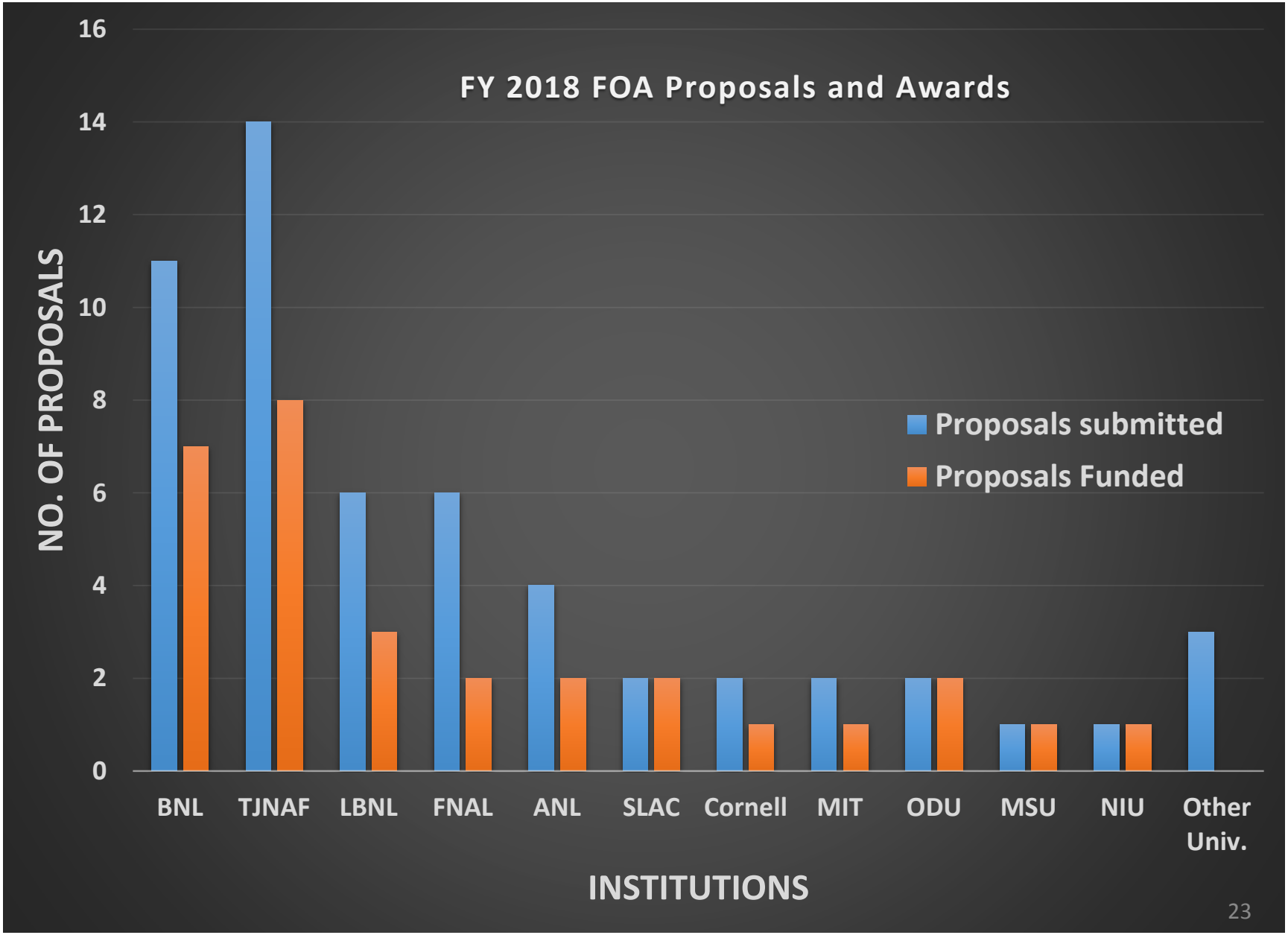
U.S. DEPARTMENT OF ENERGY | Office of Science

Proposals submitted to FY 2018 FOA

Institutions	Number of Proposals	Budget Request Y-1 ($k)	Budget Request y1+y2 ($k)
National Labs	43	17,526	34,481
Universities	12	3,966	7,931
Industry	1	107	213
Totals	**56**	**21,599**	**42,625**

Collaboration Proposals

Type of Proposals	No. of Proposals	Total Individual proposals
Collaborative	16	43
Non-collaborative	13	13
Totals	**29**	**56**


FY 2018 FOA Proposals and Awards
NO. OF PROPOSALS
16
14
12
10
8
6
4
2
0
Proposals submitted
Proposals Funded
BNL
TJNAF
LBNL
FNAL
ANL
SLAC
Cornell
MIT
ODU
MSU
NIU
Other Univ.
INSTITUTIONS

U.S. DEPARTMENT OF ENERGY | Office of Science

List of FY2018 FOA Awards Page 1

Proposal ID	Institution	Collab. num.	Proposal Title	PI
235278	FNAL		Ring-based high-energy electron cooler	Nagaitsev, Sergei
235263	BNL	Lead	Development and test of simulation tools for EIC beam	Luo, Yun
235254	LBNL		Collaboration	Qiang, Ji
235377	MSU		Collaboration	Hao, Yue
235315	TJNAF		Collaboration	Roblin, Yves
235309	TJNAF	Lead	Theoretical and experimental study of spin transparenc	Morozov, Vasiliy
235264	BNL		Figure-8 Ring (Collaboration)	Huang, Haixin
235325	TJNAF	Lead	Validation of EIC IR Magnet Parameters and Requirements Using Existing Magnet Results	Michalski, Timothy
235265	LBNL		Collaboration	Sabbi, GianLuca
235344	SLAC		Collaboration	Sullivan, Michael
235374	ODU	Lead	Crab Cavity Operation in a Hadron Ring	Delayen, Jean
235261	BNL		Collaboration	Wu, Qiong
235311	TJNAF		Collaboration	Krafft, Geoffrey
235335	BNL	Lead	Strong hadron cooling with micro-bunched electron bea	Willeke, Ferdi
235339	ANL		Collaboration	Zholents, Alexander
235343	SLAC		Collaboration	Stupakov, Gennady
235352	TJNAF		Collaboration	Zhang, Yuhong

Most awards going to collaborative proposals

U.S. DEPARTMENT OF ENERGY | Office of Science

List of FY2018 FOA Awards

Proposal ID	Institution	Collab. num.	Proposal Title	PI
235372	Cornell		High current electron sources for strong hadron cooling and polarized sources for EIC	Bazarov, Ivan
235236	BNL	Lead	High Gradient Actively Shielded Quadrupole	Wanderer, Peter
235273	LBNL		Collaboration	Sabbi, GianLuca
235324	TJNAF		Collaboration	Michalski, Timothy
235258	BNL	Lead	Development of an absolute polarimeter and spin-rotat	Raparia, Deepak
235336	MIT		Collaboration	Milner, Richard
235251	ANL	Lead	High Bandwidth Beam Feedback Systems for a High L	Conway, Zachary
235345	TJNAF		Collaboration	Rimmer, Bob
235303	TJNAF	Lead	Development of innovative high-energy magnetized electron cooling for an EIC	Benson, Stephen
235373	ODU		Collaboration	Krafft, Geoff
235277	FNAL		Collaboration	Piot, Philippe
235259	BNL		Collaboration	Blaskiewicz, Michae
235371	NIU		Studies of Conventional and ERL-Based Re-circulator Electron Cooling for an Electron Ion Collider	Erdelyi, Bela
	628	**Total**	**8802**	

- **Funding level**: FY 18 Enacted: $8.8M

U.S. DEPARTMENT OF ENERGY | Office of Science

FY019 : Accelerator R&D Funding

- **No new FOA for FY19 funding.**

FY2018 FUNDING OPPORTUNITY ANNOUNCEMENT (FOA)
Research and Development for Next Generation Nuclear Physics Accelerator Facilities
Funding Opportunity Number : DE-DE-FOA-0001848
Announcement Type: Initial
CFDA Number: 81.049
ISSUE DATE: 12/01/2018
Application Due Date: 1/19/2018

- This was for ~~a~~ two-year funding. The next NP Accelerator R&D FOA is expected to be published for FY20-21 funding.

- FY 19 appropriated fund should enable us to fund all FY18 awards for year 2. We will Contact PIs as what is needed to proceed to Year 2 funding.

Summary Remarks

- With the 2015 NSAC LRP recommendation for an EIC, NP has developed a near-term plan for moving forward:
  - A NAS study of the merits of US-based EIC
  - An NP community panel review for setting priorities for EIC accelerator R&D
  - Increased accelerator R&D funding

- The realization of an EIC will require development of many cutting-edge accelerator technologies, securing U.S. leadership in accelerator R&D in the long-term.

- NP will continue to support and nurture the core competencies needed to implement an EIC and will continue EIC R&D.

- All NP funded accelerator R&D are tracked through quarterly reports by PIs and annual PI meetings. Today's meeting will cover all FY 2017 awards to Labs and universities.

Backup

Rows 1-22: "PANEL", "A" or "B"

Sub-Priority-A Rows 1-6

Sub-Priority-B Rows 7-22

Row No.	Proponent	Concept / Proponent Identifier	Title of R&D Element	Panel Priority	Panel Sub-Priority
1	PANEL	ALL	Crab cavity operation in a hadron ring	High	A
2	PANEL	ALL	High current single-pass ERL for hadron cooling	High	A
3	PANEL	ALL	Strong hadron cooling	High	A
4	PANEL	ALL	Benchmarking of realist EIC simulation tools against available data	High	A
5	PANEL	ALL	Validation of magnet designs associated with high-acceptance interaction points by prototyping	High	A
6	PANEL	ALL	Polarized ^{3}He Source	High	A
7	PANEL	LR	High current polarized and unpolarized electron sources	High	B
8	PANEL	LR	Completion of the ongoing CeC demonstration (proof of principle) experiment	High	B
9	PANEL	LR	High-current multi-pass ERL	High	B
10	PANEL	LR	Concept for 3D hadron CeC beyond proof of principle	High	B
11	PANEL	LR	SRF high power HOM damping	High	B
12	PANEL	RR	Complete design of an electron lattice with a good dynamic aperture and a synchronization scheme and complete a comprehensive instability threshold study for this design	High	B
13	PANEL	RR	High peak current multi-turn electron linac	High	B