U.S. DEPARTMENT OF ENERGY | Office of Science

NP Accelerator R&D Principal Investigators Exchange Meeting

DOE Office of Nuclear Physics

M. Farkhondeh

October 20, 2017
Room A-410

Germantown, MD

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Outline:

- This Meeting
- Office of Science Accelerator R&D categories
- 2016 NP Strategic Plan for accelerator R&D and EIC
- FY2016 Accelerator R&D FOA, applications and awards
- 2017 NP Community EIC R&D Panel Report (Jones Report)
  - NP Accelerator R&D Priority Table
- FY017 : Accelerator R&D Plans and evaluations
- Presentation Guidelines
- Meeting Agenda

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This Meeting

- Presentations on current status of work by all Principal Investigators (PIs) who received awards under funding opportunity announcements DE-FOA-0001556 and DOE: LAB 16-1556 (or under a similar FOA since FY2010) : **“Research and Development for Next Generation Nuclear Physics Accelerator Facilities.**

- 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 timely meeting on NP supported Accelerator R&D after the publication of the NP Community EIC Accelerator R&D panel report (Jones Report).

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SC Accelerator R&D Categories

Categories of Accelerator R&D at DOE Office of Science

- **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.

➢ Total annual NP investment in accelerator R&D through a) competitive funding opportunity announcement (FOA) and b) National Laboratory Accelerator R&D is on the order of $10-11M per year. This does not include project specific (FRIB and 12 GeV) R&D.

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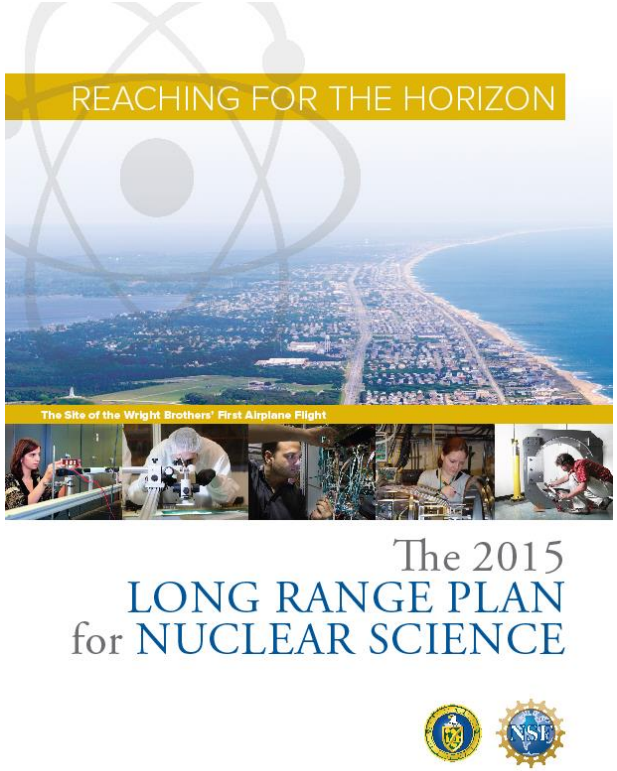
2015 LRP Reports



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.

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Planning for an Electron Ion Collider

2015 LRP Recommendation III: "We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB."

In view of this recommendation on the realization of an EIC, NP has developed a strategic plan in discussion with EIC stakeholders:

- A science assessment of a US-based EIC by National Academy of Sciences
- A major NP Community EIC Accelerator R&D Panel Review
- A mechanism for increased accelerator R&D funding for FY17 and beyond

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2016 NP Strategic Plan for Realization of an EIC

- **National Academy of Sciences (NAS) Study:** Initiated an eighteen-month NAS study entitled: "*US-BASED ELECTRON ION COLLIDER SCIENCE ASSESSMENT*" *Grant processed and funding started in July 2016.* ***(In Progress)***

- **FY16 FOA:** *Published a competitive FOA ("Accelerator R&D for Next Generation NP Facilities") this year. A review panel helped NP select university and Lab proposals for one year funding. NP has been funding competitive accelerator R&D since 2010 at ~$2M/year.* ***(Completed)***

- **NP Community Panel Review:** *Conduct an NP community EIC R&D panel review charged with generating a report as the basis for FY17-FY20+ EIC accelerator R&D funding. Dr. Kevin Jones of SNS is chairing this international panel. First face-to-face meeting scheduled for November 29-December 2. Panel Report published in February 2017.* ***(Completed)***

- **Bi-Annual FOA Starting FY17:** Publish bi-annual FOA for competitive accelerator R&D based on R&D priorities established in the EIC panel report.

  - **Funding level**: Aiming for $7M per year
  - **Funding sources:** Combination of NP competitive accelerator R&D funds (~1.9M) augmented with a percentage tax to RHIC and CEBAF Accelerator Operations budget (~2.6% in FY17 President's request for each Lab).

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FY16 FOA and Funding

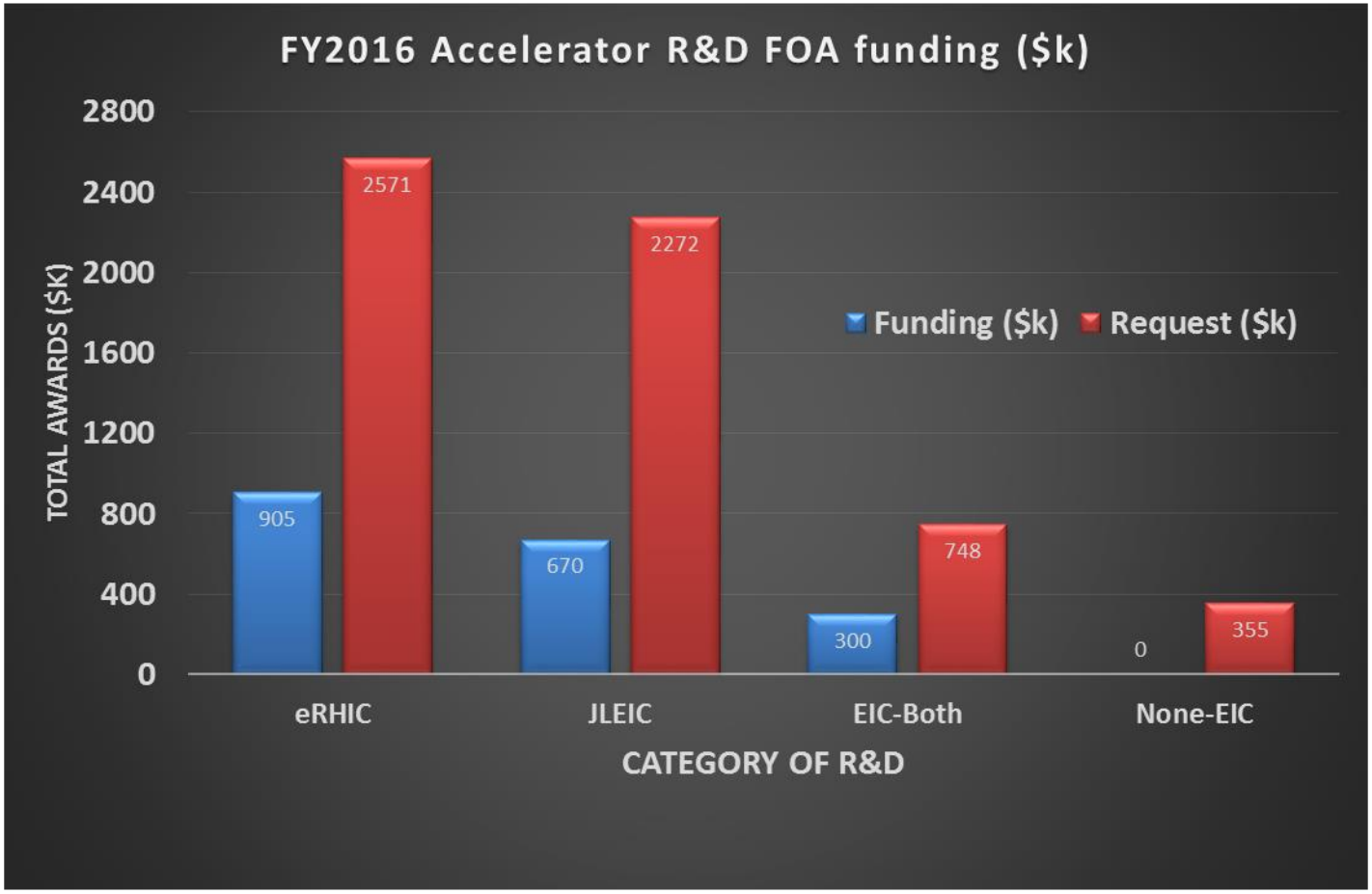
Proposals and Funding for FY16

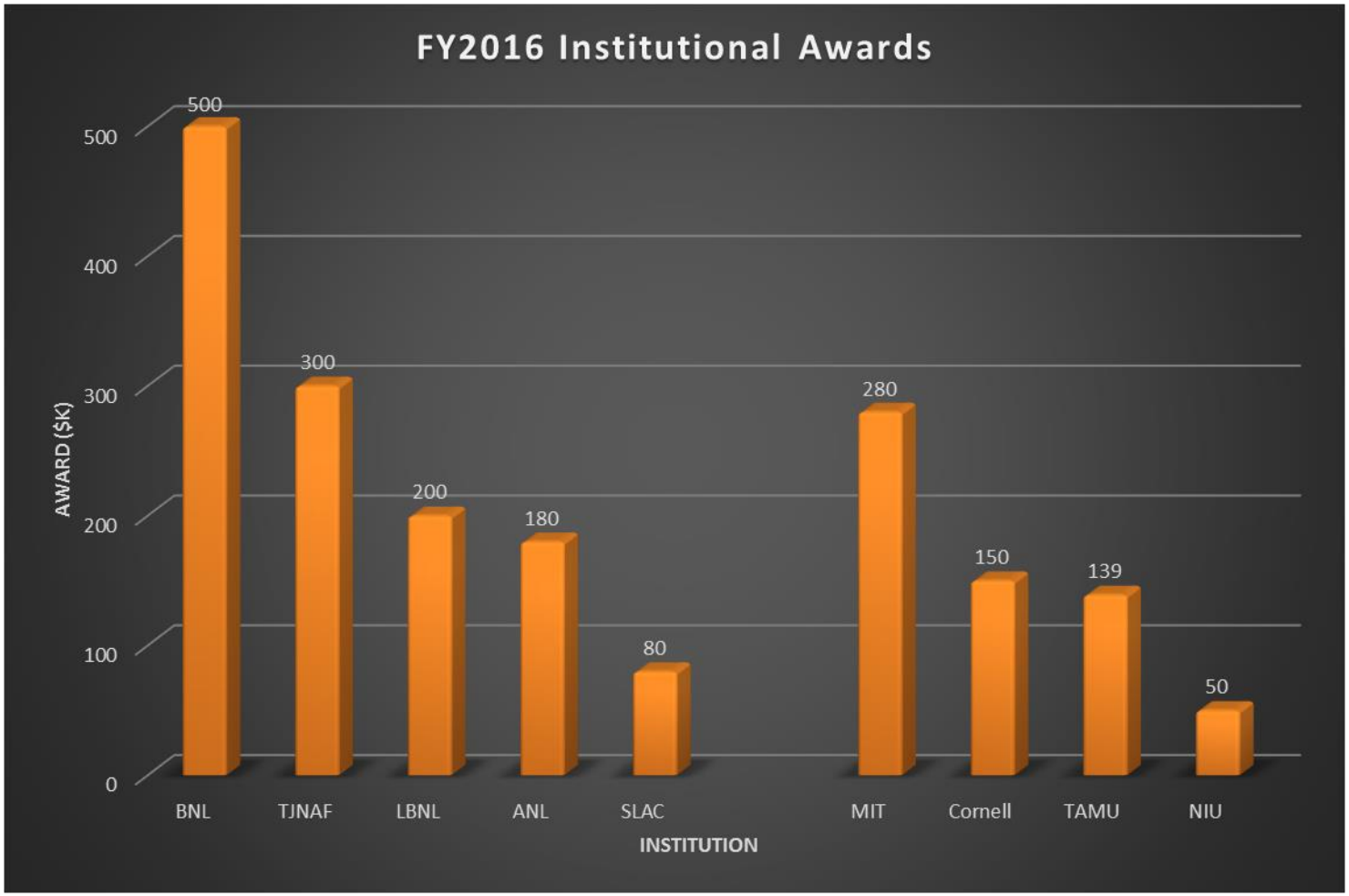
FY 2016 FOA	No of proposals	Categories	($k)
Total Lab Proposals	10	Total Lab Request	**3,487**
Total University Proposals	13	Total University Requ	**2,134**
Total Industry Proposals	3	Total Industry Reques	**324**
Total Proposals	**26**	**Total All Requests**	**5,945**

As a result of a panel Review in June 2016:

- ~$1870 K Appropriated FY 2016 funds was allocated and distributed.
- Awards are FOR ONE YEAR only with possibility of second year renewals. FOAs has been published every other year:2010-1016.

Today, you will be reporting your work based on this FY2016 funding


FY2016 Accelerator R&D FOA funding ($k)
TOTAL AWARDS ($K)
2800
2400
2000
1600
1200
800
400
0
2571
2272
905
670
748
300
355
0
Funding ($k)
Request ($k)
eRHIC
JLEIC
EIC-Both
None-EIC
CATEGORY OF R&D


FY2016 Institutional Awards
AWARD ($K)
0
100
200
300
400
500
500
300
200
180
80
280
150
139
50
BNL
TJNAF
LBNL
ANL
SLAC
MIT
Cornell
TAMU
NIU
INSTITUTION

Proposal Review Criteria (FY2016)

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: **(National Labs, Universities and Industry are competing)**

This FOA Supports:

- 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 scientific user facilities that will lead to new capabilities

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

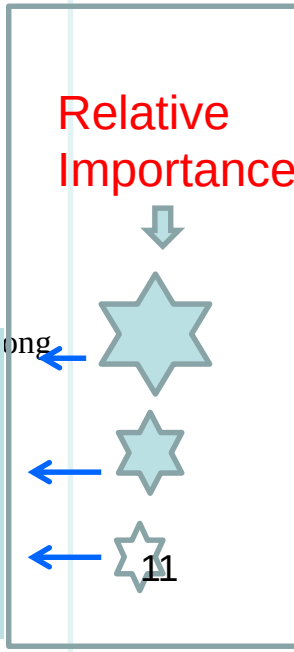
Merit Review Criteria

- Scientific and/or Technical Merit of the Project;
- Appropriateness of the Proposed Method or Approach;
- Competency of Applicant's Personnel and Adequacy of Proposed Resources; and
- Reasonableness and Appropriateness of the Proposed Budget

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

Program Policy Factors

For 2017 and beyond: This will be based on Jones Report priorities. A total of 7 Criteria all together (4: merit review criteria and 3 Priority criteria).



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Jones Panel Priority Table:

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

February 13, 2017

2017

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.

Table 1: Prioritized List of Proposed R&D Activities.

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
14	PANEL	RR	Necessity to triple the number of and shorten the bunches in the proton / ion ring	High	B
15	PANEL	RR	Beam pipe copper coating with plasma ion bombardment	High	B
16	PANEL	RR	Simulation of the effect of electron bunch removal on the hadron beam	High	B
17	PANEL	JLEIC	Complete and test a full scale suitable superferric magnet	High	B
18	PANEL	JLEIC	Develop a high current magnetized electron injector	High	B
19	PANEL	JLEIC	High power fast kickers for high bandwidth (2ns bunch spacing) feedback	High	B
20	PANEL	JLEIC	Complete the design of the gear change synchronizations and assess its impact on beam dynamics	High	B

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Jones Report R&D Priorities

Priority: "High", "Medium", or "Low", Sub-Priority: "A", "B", "C" or "None"
Proponent: "PANEL", "BNL" or "TJNAF"
Design Concept: "RR", "LR" or "JLEIC" (LR and RR were on equal footing)

- 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 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.

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Jones Panel Priority Table:

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

Sub-Priority-A

Sub-Priority-B

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

Jones Panel Priority Table Continued…

Row No.	Proponent	Concept / Proponent Identifier	Title of R&D Element	Panel Priority	Panel Sub-Priority
14	PANEL	RR	Necessity to triple the number of and shorten the bunches in the proton / ion ring	High	B
15	PANEL	RR	Beam pipe copper coating with plasma ion bombardment	High	B
16	PANEL	RR	Simulation of the effect of electron bunch removal on the hadron beam	High	B
17	PANEL	JLEIC	Complete and test a full scale suitable superferric magnet	High	B
18	PANEL	JLEIC	Develop a high current magnetized electron injector	High	B
19	PANEL	JLEIC	High power fast kickers for high bandwidth (2ns bunch spacing) feedback	High	B
20	PANEL	JLEIC	Complete the design of the gear change synchronizations and assess its impact on beam dynamics	High	B
21	PANEL	JLEIC	Integrated magnetized beam/kicker circulation test using the existing ERL infrastructure	High	B
22	PANEL	JLEIC	Operate the JLAB Continuous Electron Beam Accelerator Facility in the JLEIC injector mode	High	B
23	BNL	LR-A-1	R&D and Prototyping on the 6.2mA Polarized Electron Gun	High	C
24	BNL	LR-A-2	Study of Beam-Beam Effect with Crab Cavities	High	
25	BNL	LR-B-1	CBETA Project	High	C
26	BNL	LR-B-2	Waveguide HOM Couplers for the BNL (eRHIC) ERL	High	C
27	BNL	LR-C-2	Crab Cavity Prototype	High	C

Sub-Priority-C

Rows 23-75: LABS

Jones Panel Priority Table Continued…

Sub-Priority-None

Priority: Medium or Low

Row No.	Proponent	Concept / Proponent Identifier	Title of R&D Element	Panel Priority	Panel Sub-Priority
33	BNL	RR-A-4	Synchrotron Radiation Background Assessment	High	
34	BNL	RR-A-5	Electron-Cloud Study	High	
35	BNL	RR-C-5	Improved Cu coating of the stainless steel RHIC cold Beam Pipe	High	C
36	BNL	RR-C-6	Design and prototyping of actively shielded IR quadrupole magnet	High	C
37	JLAB	BDD1	Spin tracking in ion and electron rings	High	
38	JLAB	BDD2	Beam-beam simulation with gear changing	High	C
39	JLAB	ECL1	Electron cooling simulations	High	
40	JLAB	ECL3	ERL Cooler design for single and multi turn operations	High	C
41	JLAB	ECL4	Magnetized source for the e-cooler 36mA	High	C
42	JLAB	ECL5	Fast kicker prototype for multi turn cooler	High	C
43	JLAB	INJ6	Test of CEBAF electron injection mode	High	C
44	JLAB	IRS1	IR design and detector integration	High	
45	JLAB	MAG1	Super-ferric 3T fast ramping short prototype	High	C
46	JLAB	MAG4	IR compact large aperture, high radiation magnets	High	C
47	JLAB	SRF1	SRF cavity systems	High	
48	JLAB	SRF2	Crab cavity design, simulations, and prototype	High	C
49	BNL	LR-B-3	Study the use of 5-cell 647 MHz cavities in the BNL (eRHIC) electron storage ring	Medium	
50	BNL	LR-C-1	Development of an BNL (eRHIC) ERL cryomodule	Medium	
51	BNL	LR-C-3	BNL (eRHIC) Crab Cavity Prototype	Medium	
52	BNL	RR-C-3	Design of fast kickers for electron and Hadron Injection	Medium	

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EIC Machine Concepts

Current Machine Concepts for EIC:

eRHIC:

- Two concepts based on RHIC:
  - Ring-Ring collider based on existing technology
  - (Linac-Ring collider, high risk, lower cost)

In 2017, BNL adopted the Ring-Ring concept as the main option.

JLEIC:

- Ring-Ring collider using CEBAF and two figure-8 storage rings.

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Evaluation considerations for FY17

"Proposal Quality" (PQ): 1-10:
using Office Science 4 standard criteria

- Scientific and/or Technical
- Appropriateness…
- Competency of…
- Budget…

"Priority Factor" (PF) : 1-5:

5: Panel Priority: High, Sub-Priority-A,
4: Panel Priority: High, Sub-Priority-B
3: Panel Priority: High, Sub-Priority-C
2: Panel Priority: High, Sub-Priority-none
1: Panel Priority: Medium,
0: Panel Priority: Low

"EIC Concept Factor" (CF): 0-1:

1.0: Ring-Ring design concept: (R-R JLEIC and eRHIC)
0.70 Linac-Ring design Concept: (L-R eRHIC)

Ranking Score=PQ x PF x CF
A score between 0-50

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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

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FUNDING OPPORTUNITY ANNOUNCEMENT (FOA)

Research and Development for Next Generation Nuclear Physics Accelerator Facilities
Funding Opportunity Number : DE-DE-FOA-0001556
Announcement Type: Initial
CFDA Number: 81.049
ISSUE DATE: March4, 2016

Presentation Guidelines

- Each PI's presentation has been allotted a specific time depending on the size of their grant.

- 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 award.
  - A table showing annual budget and the total received to date;
  - A table showing major deliverables and schedule; and

  Relevance to the NP Accelerator R&D for EIC (eRHIC or MEIC/JLEIC).

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Friday, 10/20/2017

DOE Headquarters, Germantown, MD, Room A-410

Meeting Agenda

Time	Dur. (min)	Presentation Title	Speaker	Institution	Topic	Grant Status
8:30 AM	5	Welcome and Introductory Remarks	Gillo, Jehanne	NP	-	
8:35 AM	30	NP Accelerator R&D Program Overview	Farkhondeh, Manouchehr	NP	NP Accelerator R&D	
9:05 AM	30	High Intensity Polarized Electron Gun	Redwine, Robert / Tsentalovich, Evgeni	MIT	High current Pol source /eRHIC	Year 7, active
9:35 AM	30	Next generation robust polarization photocathodes for EIC, and High current Photoinjectors	Bazarov, Ivan/ Cultrera, Luca	Cornell	High current Photoinjector	Year 7, active
10:05 AM	15	Break				
10:20 AM	45	Coherent Electron Cooling Demonstration Experiment at RHIC	Litvinenko, Vladimir	BNL	CeC - cooling /eRHIC	Year 7, active
11:05 AM	30	Development of a Polarized ^{3}He Ion Source for RHIC	Milner, Richard/ Musgrave, Matthew	MIT	Pol ion source /eRHIC	Year 7, active
11:35 AM	45	Beam-dynamics study of the self-generating field with crab crossing scheme in the future electron-ion collider (LBNL and BNL Collaboration)	Qiang, Ji and Hao, Yue	LBNL/ BNL	Beam Dynamics/eHIC	Year 1, active
12:20 PM	60	Lunch Break				
1:20 PM	45	Critical Accelerator R&D for Achieving High Performance of a Polarized Medium Energy Electron Ion Collider (MEIC/JLEIC Collaboration)	Pilat, Fulvia/Vasiliy Morozov	TJNAF	MEIC/JLEIC design	Year 7, active
2:05 PM	25	(MEIC/JLEIC Collaboration)	Cai, Yunhai/Nosochkov Yuri	SLAC	MEIC/JLEIC design	Year 7, active
2:30 PM	35	(MEIC/JLEIC Collaboration)	Mustapha, Brahim/ Ostroumov, Peter	ANL	MEIC/JLEIC Design /ion injector	Year 7, active
3:05 PM	10	Break				
3:15 PM	35	Design Studies and Prototyping of Superferric Magnets for MEIC/JLEIC ((MEIC/JLEIC Collaboration))	McIntyre, Peter	TAMU	MEIC/JLEIC design	Year 2, active
3:50 PM	40	Design of HOM damping for high current SRF cavities for Electron Ion Collider (eRHIC) at BNL	Li, Derun and Ostoumov/Mustapha	LBNL/ANL	High current eRHIC	Year 1, active
4:30 PM	30	Studies of Conventional and ERL-Based Recirculator Electron Cooling for an Electron Ion Collider	Erdelyi, Bela	NIU	e cooling software /MEIC/JLEIC	Year 7, active
5:00 PM		Adjourn				

END
Presentation

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Electron Ion Collider

EIC Design Concepts: (2017)

- **BNL:** eRHIC staged approach (eRHIC) based on a Ring-Ring concept. LINAC-Ring concept is considered as a backup high-risk lower operation cost concept.
- **TNJAF:** MEIC/JLEIC**:** staged approach (MEIC) based on high repetition rate Ring-Ring concept.

EIC Accelerator R&D:

- First Accel R&D FOA in FY10-FY11 (~4M). Most funding went to “Highest priority EIC”. Small amount went to deuteron EDM. Last FOA was published in FY2016 and funds distributed.

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FY17 FOA and Funding (Original Plan)

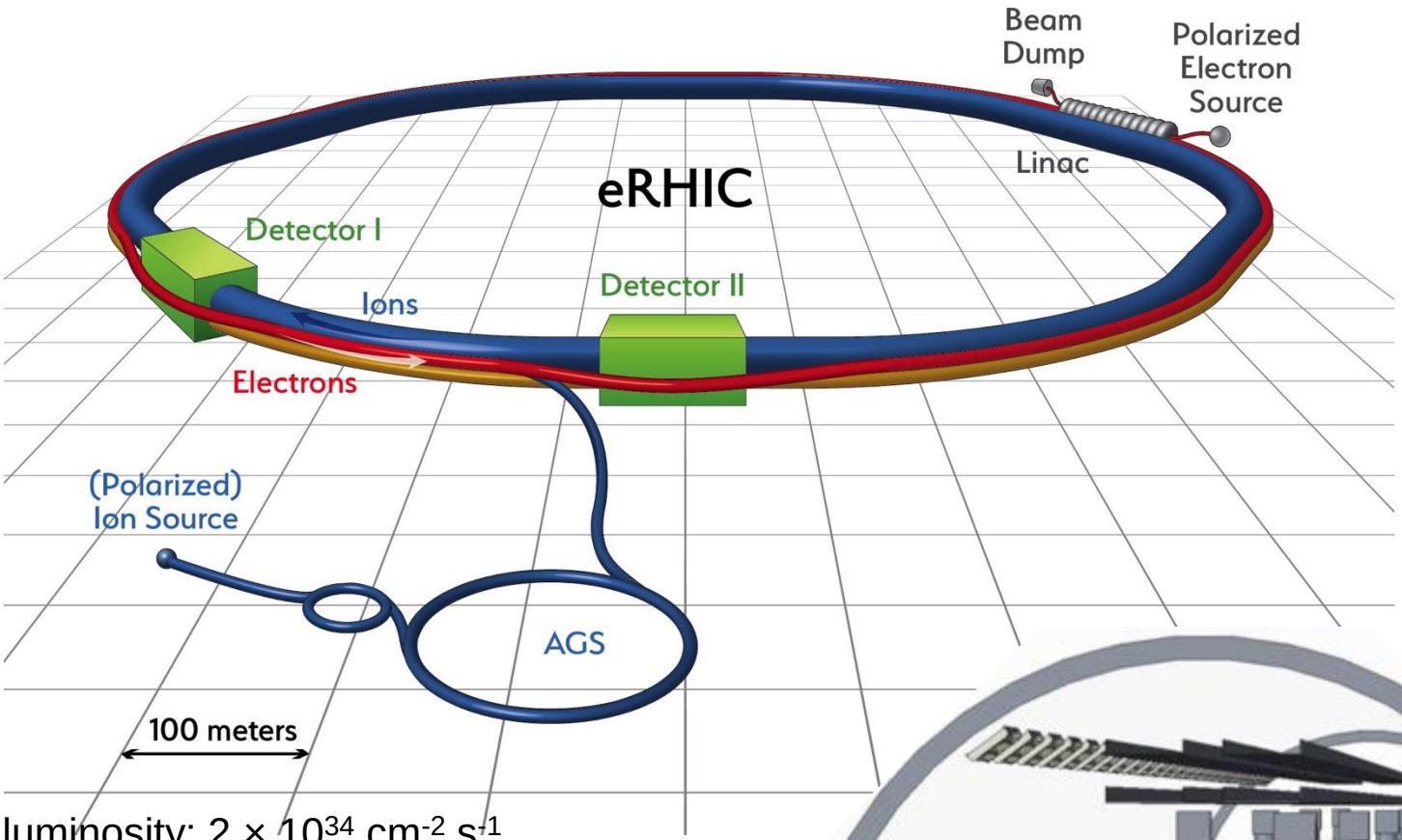
Current NP plan

- NP Community EIC R&D panel review to generate a report with EIC R&D priority list: January 2017.
- Subject to FY2017 funding constraints, NP to publish a new FOA based on EIC R&D priorities set by the Review Report above: March-April 2017
- Proposals to be reviewed by a new Review panel and awardees selected: May-June 2017.
- Planning for ~$7.0 total funding for FY17 and finalized after enactment of an appropriation.
- Considering publishing this FOA for 2-year funding. This would require dealing with upfront funding of university awards that are over $1M.

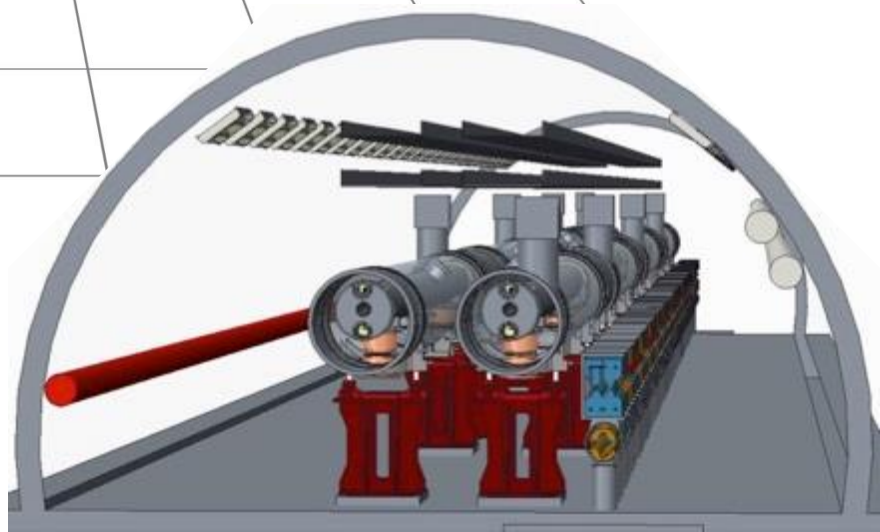
Ultimate eRHIC design

Highly advanced and energy efficient accelerator

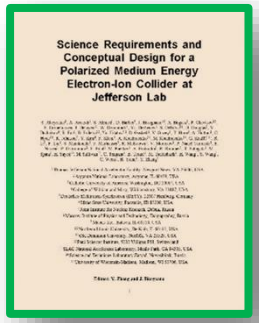
Thomas Roser
BNL

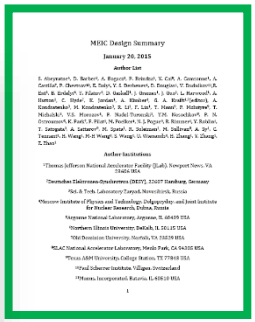


- Peak luminosity: 2×10^{34} cm^{-2} s^{-1}
- ERL and permanent magnet arcs greatly reduce electric power consumption to about 15 MW!



JLEIC Baseline

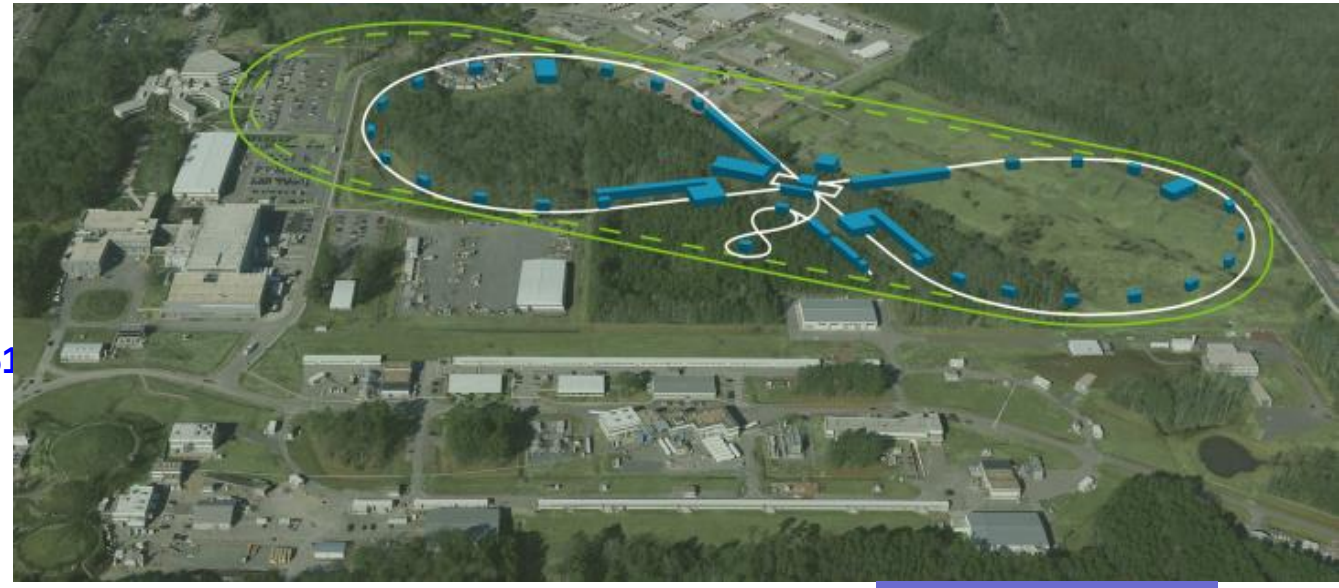


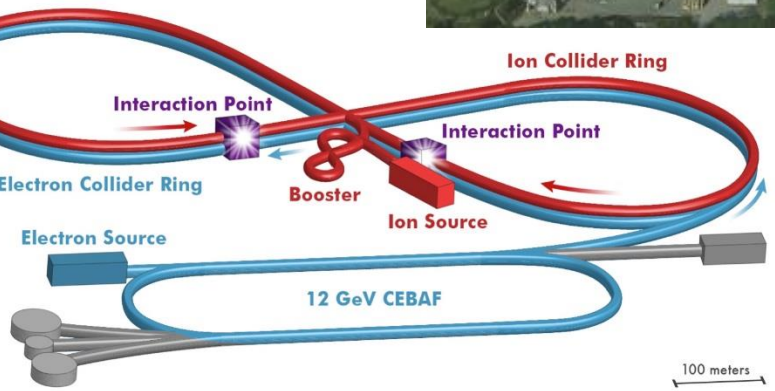


arXiv:1504.07961

arXiv:1209.0757

2012





energy range:
e^-: 3-10 GeV
p : 20-100 GeV

Cooling strategy:
- **DC cooler** in booster
- **Bunched beam cooler** in Ion collider ring

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