



U.S. DEPARTMENT OF  
**ENERGY**

OFFICE OF  
**SCIENCE**

# **NP Artificial Intelligence Principal Investigators Exchange Meeting**

**November 30, 2022**

**Manouchehr Farkhondeh  
DOE Office of Science, Nuclear Physics Program**



## *Outline:*

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- This Meeting
- Overview of DOE-SC and NP AI/ML initiative
- FY2020 Data, AI and ML Lab call and awards
- FY2021 Data Analytics AI/ML FOA and awards
- FY2023 Data, AI and ML FOA and Lab call
- A new Requirement for all FY2023 and beyond FOAs
- Communications and Presentation Guidelines



## DOE SC Statement of Commitment

- *The DOE SC Diversity, Equity and Inclusion webpage:*
- *<https://science.energy.gov/sc-2/research-and-conduct-policies/diversity-equity-and-inclusion/>*
- *“The DOE Office of Science (SC) is fully committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity. Effective stewardship and promotion of diverse and inclusive workplaces that value and celebrate a diversity of people, ideas, cultures, and educational backgrounds is foundational to delivering on the SC [mission](#). The scientific community engaged in SC-sponsored activities is expected to be respectful, ethical, and professional.*
- *The DOE SC does not tolerate discrimination or harassment of any kind, including [sexual or non-sexual harassment](#), bullying, intimidation, violence, threats of violence, retaliation, or other disruptive behavior in the federal workplace, including DOE field site offices, or at national laboratories, scientific user facilities, academic institutions, other institutions that we fund, or other locations where activities that we support are carried out...”*

- **AI for User Facilities and Advanced Technology**

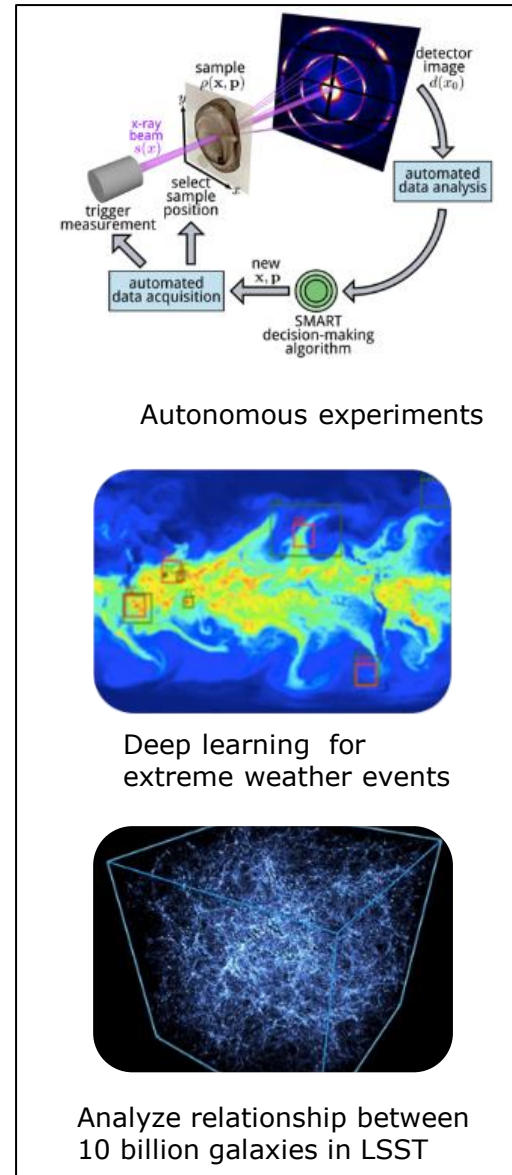
- Optimize design of experiments and operations
- Enable real-time analysis and integrated workflows
- Predict and mitigate instrument and facility down time
- **Increase particle beam availability to users through optimization of beam tuning and risk reduction in accelerator machine protection**
- Create Self-driving instruments and experiments

- **AI for Science**

- Accelerate scientific discovery through federated learning to gather broader insight via shared datasets
- Develop surrogate models for expensive or time constrained experiments
- Make sense of multi-modal, noisy data
- **Reduce time for complex scientific instrument calibration**

- **AI Tools**

- Incorporate uncertainty quantification and domain-knowledge
- Increase robustness, interpretability and repeatability
- Develop new storage and archival tools to make data FAIR (Findable, Accessible, Interoperable, and Reusable)
- Develop privacy-preserving algorithms for use of AI in edge devices and to support biopreparedness research efforts



# Overview of AI/ML initiative

- Artificial Intelligence (AI) represents a paradigm shift for scientific high-performance computing. DOE and the Office of Science (SC) recognize the power that AI will have to accelerate progress in scientific research and missions by developing new data analysis tools and integrating data focused approaches with our physics-based computer simulations.
- AI is one of the **current initiatives for SC** with focused efforts and fundings.
- Nuclear Physics (NP) — NP has been supporting applications of artificial neural networks in the analysis of nuclear physics data for decades. Current and planned NP facilities and scientific instrumentation face a variety of technical challenges in simulations, control, data acquisition, and analysis.
  - *January 2020: A roundtable NP meeting of experts was convened to discuss AI/ML techniques focused on improving efficiencies of accelerator and detector operations.*
  - *March 2020: An NP community workshop at TJNAF considered priority research opportunities in AI/ML.*
- In FY2020 NP participated in a three SC program offices (BES, HEP and NP) Lab only funding opportunity call in Data science and AI/ML for SC accelerator and detector facilities.
- NP has published an NP only funding opportunity (FOA) in FY2021 and just published a new one for FY2023-24 funding.
- An SC AI/ML working group with representation from all five SC Programs meets bi-weekly to discuss developments and coordination.



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# SC AI Lab Call Lab-20-2261 (Also, topic of this Exchange meeting)

DEPARTMENT OF ENERGY  
OFFICE OF SCIENCE  
BASIC ENERGY SCIENCES  
HIGH ENERGY PHYSICS  
NUCLEAR PHYSICS



**DATA, ARTIFICIAL INTELLIGENCE, AND MACHINE LEARNING  
AT DOE SCIENTIFIC USER FACILITIES**

**DOE NATIONAL LABORATORY PROGRAM ANNOUNCEMENT NUMBER:  
LAB 20-2261**

**ANNOUNCEMENT TYPE: INITIAL**

<b>Announcement Issue Date:</b>	<b>March 9, 2020</b>
<b>Submission Deadline for Proposals:</b>	<b>May 1, 2020, at 5 PM Eastern Time</b>



# NP Lab AI-ML proposals Lab-20-2261

- *This was a SC Laboratory call from BES, HEP and NP allowing 2 proposals per user facilities.*
- *NP received 3 proposals in accelerators and 2 in experiments and detectors, a total of 5 Proposals*

PI Name	SC Lab	Proposal Title	FY 2020 Award (\$K)	Total Award (\$K)
David Lawrence	TJNAF	A.I. Assisted Experiment Control and Calibration		
Christopher Tennant	TJNAF	AI for Improved SRF Operation at CEBAF		
Brahim Mustapha	ANL	Use of Artificial Intelligence to Optimize Accelerator Operations and Improve Machine Performance		
		<b>Total (\$K)</b>	<b>1,000</b>	<b>3,000</b>

- *Each proposal was mail reviewed by 4 reviewers:*
- *Funding in Year-1 came from accelerator R&D base funds (total of \$1M / year).*
- *These were 3 –year awards, FY20-22 funding*





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DEPARTMENT OF ENERGY  
OFFICE OF SCIENCE  
NUCLEAR PHYSICS



**DATA ANALYTICS FOR AUTONOMOUS OPTIMIZATION AND  
CONTROL OF ACCELERATORS AND DETECTORS**

**FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) NUMBER:  
DE-FOA-0002490**

**ANNOUNCEMENT TYPE: INITIAL  
CFDA NUMBER: 81.049**

<b>FOA Issue Date:</b>	<b>DATE: March 16, 2021</b>
<b>Submission Deadline for Applications:</b>	<b>DATE: April 30, 2021, 11:59 PM Eastern Time</b>



**Solicitation S&T Scope:** *DE-FOA-0002490*; *issue date: March 16, 2021*

**Scope:** The AI/ML for autonomous optimization and control of nuclear physics accelerators and detectors described in this FOA support efforts essential to developing leading core competencies and transformative technologies that significantly advance the state-of-the-art AI and data analytics capabilities in accelerator science and nuclear physics research:

- Efficiently extract critical and strategic information from large complex data sets,
- Address the challenges of autonomous control and experimentation,
- Efficiency of operation of accelerators and scientific instruments,
- AI for data reduction of large experimental data.

**Eligible Institutions:** Universities/colleges, non-profit and small business as collaborators, DOE/NNSA laboratories only; New single- or multi-PI proposals.

## **Outcome of the FOA:**

- Received 32 individual applications : 22 collaborative and single PI proposals
- A review panel helped NP **to select 6 R&D projects** ( 11 proposals)
- Total funding of \$5.68M over 2 years.



# NP AI/ML FY2021 DE-FOA-0002490 Statistics

*Applications and Awards*

*A total of 6 independent awards*

Institutions	# of Applications	# of Awards	Fraction (#)	Requests (K\$)	Award (K\$)	Fraction (%)
Laboratories	17	7	41%	12,117	4,200	34%
Universities	14	4	29%	8,339	1,480	18%
Industry	1	0	0	300	0	0%
<b>Totals</b>	<b>32</b>	<b>11</b>	<b>34%</b>	<b>20,816</b>	<b>5,680</b>	<b>27%</b>

*Application Types and Topics*

Type of Proposal	Submitted	Awarded	Fraction (%)
Collaborative	5	2	40
Single PI	17	4	24
Application Topic			
Accelerator Topic	8	2	25
Detector/Experiment Topic	12	3	25
Both	2	1	50



# Awards: NP AI/ML FY2021 DE-FOA-0002490 (subject of this meeting)

Awards for NP FY2021 FOA on Data Analytics and ... SC_FOA_0002490			
Award #	Institution	Proposal Title	Principal Investigator
1	MIT	Intelligent experiments through real-time AI: Fast Data Processing and Autonomous Detector Control for sPHENIX and future EIC detectors  <i>Lead Institution</i>	Roland, Gunther
	NJIT		Yu, Dantong
	FNAL		Tran, Nhan
	LANL		Liu, Ming Xiong
2	UNC	Deep Learning for Germanium-Based Neutrinoless Double Beta Decay Searches	Gruszko, Julieta
3	LBNL	Machine Learning Optimization Upstream and Downstream of the Accelerator: The Cases of VENUS and GRETA	Crawford, Heather
4	LLNL	AI-driven detector design for the EIC  <i>Lead Institution</i>	Angerami, Aaron
	UC, Riverside		Arratia, Miguel
	LBNL		Nachman, Benjamin
5	ANL- ATLAS	Autonomous Optimization of the Secondary Beam Production and Delivery at the ATLAS In-Flight Facility	Hoffman, Calem
6	ANL-ATLAS	Modern Data Analytics for the Large Gamma-Ray Spectrometers: GRETINA/GRETA and Gammasphere via Machine Learning and Optimization	Carpenter, Michael
<b>Total 2-year Awards (\$k)</b>			<b>5,680</b>



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- *FOA: DE-FOA-0002875*
- *Issue Date: Nov 9, 2022*
- *Proposals due: Jan 11, 2023*
- *No LOIs or preapplications*

DEPARTMENT OF ENERGY (DOE)  
OFFICE OF SCIENCE (SC)  
NUCLEAR PHYSICS (NP)



ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR  
AUTONOMOUS OPTIMIZATION AND CONTROL OF  
ACCELERATORS AND DETECTORS

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) NUMBER:  
DE-FOA-0002875

FOA TYPE: INITIAL  
CFDA NUMBER: 81.049

FOA Issue Date:	November 9, 2022
Submission Deadline for Applications:	January 11, 2023, at 11:59 PM Eastern Time



**General approach:** Use of AI/ML tools and methods for **experiments, simulation, theory and accelerator operation to expand scientific outreach**

## **Technical areas and scope for FY2023 FOA**

- Efficiently extract critical and strategic information from large complex data sets,
- Address the challenges of autonomous control and experimentation,
- Efficiency of operation of accelerators and scientific instruments,
- AI for data reduction of large experimental data.

## **Application context and NP Major Projects**

- Any proposed work that is not part of a current NP project including EIC can be submitted to this FOA.
- AI/ML for EIC application can be carefully drafted to ensure they would not overlap with approved EIC project scope. However, they can be related to enhancing scientific output of the EIC project.
- The above is also true about other major NP projects in Fundamental Symmetry or any other programmatic research areas of NP (Medium Energy, Heavy Ion, Nuclear Structure and nuclear astrophysics, etc.).





- **Solicitation S&T Scope:**
  - *Research focused on data for autonomous optimization and control of accelerators and detectors relevant to current- or next-generation NP accelerator facilities.*
  - *Research on technical developments at the intersections between real-time machine learning and the control and optimization of accelerator systems operation and detector design using AI models*
- **Program Planning/Context:**
  - *Impart an acceleration of experimental and computational discovery by applying AI methods and techniques to address technical challenges in simulations, theory, control, data acquisition and analysis for NP accelerators and scientific instruments.*
  - *Provides support consistent with FY 2023 budget language for targeted investments to develop cutting-edge techniques based on AI of relevance to nuclear science research and accelerator facility operations.*
- **Application Requirements:**
  - **Eligibility:** Universities/colleges, non-profit/ small business as collaborators, DOE/NNSA laboratories only;
  - **Award size/duration:** Up to \$1M/year; up to 2-year awards
  - **Funding by Fiscal Year:** FY 2023 ~\$8M, FY 2024 up to \$8M - subject to budget appropriation
  - **Preproposals:** No Preproposals or Letters of Intent are required



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➤ ***A new Requirement for all FY2023 SC FOA applications:***

- *All new and renewal applications must provide a Promoting Inclusive and Equitable Research (PIER) Plan as an appendix to the research narrative.*

➤ As a result, a new criteria (PIER) is added to the four existing SC 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;*
- *Reasonableness and Appropriateness of the Proposed Budget; and*



- ***Quality and Efficacy of the Promoting Inclusive and Equitable Research (PIER) Plan.***

Link to SC website <https://science.osti.gov/grants/Applicant-and-Awardee-Resources/PIER-Plans>

➤ ***PIER Criterion Questions:***

- *Is the proposed Promoting Inclusive and Equitable Research (PIER) Plan suitable for the size and complexity of the proposed project and an integral component of the proposed project?*
- *To what extent is the PIER plan likely to lead to participation of individuals from diverse backgrounds, including individuals historically underrepresented in the research community?*
- *What aspects of the PIER plan are likely to contribute...*



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# Communications between NP and PI for AI/ML work

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 FY2022 4<sup>th</sup> quarter request was sent on **October 4, 2022** for the FY2020 Lab call awards. Quarterly reports are reviewed by the Division (they are not just filed away). For FY2021 FOA awards Ms. Saryna Cameron has requested the initial package in June. You were asked to provide your Q1 report in January 2023. **We will update our request to provide a combined quarterly Q1-Q3 in January 2023.**

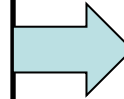
## ➤ PI Exchange Meetings:

- **Accelerator R&D:** Since 2015, 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.
- **AI/ML:** This is the first standalone annual NP AI/ML PI Exchange meeting, and we plan to have one yearly.

# NP Matrix for Quarterly Report Review and Assessment.

*Include brief and clear responses to these NP Matrix questions in your quarterly reports.*

- *NP matrix for Quarterly Report and progress assessment.*
- *Make sure your quarterly reports addresses elements of this matrix for our evaluation*
- *Continue to use the NP “small Project” template Ms. Saryna Camron sends you.*



<b>1-</b>	<b>PI’s performance during the quarter</b>
a	Progress made
b	Milestones met
c	Any breakthrough
<b>2-</b>	<b>Assessment of risk mitigation</b>
a	Issue communicated?
b	appropriate mitigation strategies
<b>3-</b>	<b>Likelihood of achieving project goals</b>
a	Will they meet cost and schedule
b	Will they deliver the promised scope
<b>4-</b>	<b>Recommendation on need for action</b>
a	Are there any actions you need to take in response to points above



- Presentations on current status of work by all Principal Investigators (PIs) who received awards
  - under FY 2021 FOA [DE-FOA-0002490](#) for AI and Data Analytics
  - Under FY 2020 Lab call [Lab-20-2261](#)
- 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 NP AI/ML awards activities.



# 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 2020- 22 AI/ML awards,**
- A table showing annual budget and the total received to date (see below);
- A table showing major deliverables and schedule; and
- There will be no written report or follow up actions required for this meeting.
- Summary of expenditures by fiscal year (FY):
- All talks will be posted on PI Exchange meeting page on NP website.
- **35 min talks should allow 7 min for Q/A and 30 min talks 5 min for Q/A**

	FY20	FY21	Totals
<b>a) Funds allocated</b>			
<b>b) Actual costs to date</b>			





# FY2022 PI Meeting Agenda

AGENDA : NP AI-ML PI Exchange Meeting, <b>Wednesday</b> November 30, Via Zoom							
#	Time (E.S.T)	Dur. (min)	Principal Investigator	Institution	R&D Area	Presentation Title	Speaker(s)
	10:00	5	-	DOE NP	-	Introductory Remarks	Mantica
	10:05 AM	35	-	DOE NP	-	NP supported Accelerator R&D and	Farkhondeh
<b>FY2020 Lab call awards in LAB 20-2261: "Data, Artificial Intelligence and Machine Learning at DOE Scientific User Facilities"</b>							
1	10:40 AM	30	Lawrence, David	TJNAF	Detectors	A.I. Assisted Experiment Control and Calibration	Lawrence
2	11:10 AM	30	Tennant, Christopher	TJNAF	Accelerators	AI for Improved SRF Operation at CEBAF	Tennant
	11:40 AM	15	<b>Break</b>				
3	11:55 AM	30	Mustapha, Brahim	ANL	Accelerator	Use of Artificial Intelligence to Optimize Accelerator Operation	Mustapha
<b>FY2021 FOA and Lab call awards: DE-FOA-0002490 "Data Analytics for Autonomous Optimization and Control....."</b>							
1	12:25 PM	35	Liu, Ming Xiong Roland, Gunther Yu, Dantong Tran, Nhan	LANL MIT NJIT FNAL	Detectors	Intelligent experiments through real-time AI: Fast Data Processing and Autonomous Detector Control for sPHENIX and future EIC	Liu
2	1:00 PM	35	Gruszko, Julieta	UNC	Detectors	Deep Learning for Germanium-Based Neutrinoless Double Beta Decay Searches	Gruszko
	1:35 PM	50	<b>Lunch</b>				
3	2:25 PM	35	Crawford, Heather	LBNL-88 inch	Accelerator	Machine Learning Optimization Upstream and Downstream of the Accelerator: The Cases of VENUS and GRETA	Crawford
4	3:00 PM	35	Arratia, Miguel Nachman, Benjamin Angerami, Aaron	UC, Riverside LBNL LLNL	Detectors	AI-driven detector design for the EIC	Arratia
	3:35 PM	10	<b>Break</b>				
5	3:45 PM	35	Hoffman, Calem	ANL- ATLAS	Accelerator	Autonomous Optimization of the Secondary Beam Production and Delivery at the ATLAS In-Flight Facility	Hoffman
6	4:20 PM	35	Carpenter, Michael	ANL-ATLAS	Detectors	Modern Data Analytics for the Large Gamma-Ray Spectrometers: GRETINA/GRETA and Gammasphere via Machine Learning and Optimization	Carpenter
	4:55 PM	5	Closing Remarks				
	5:00 PM		<b>Adjourn</b>				



# *BACKUP Slides*



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## **Solicitation S&T Scope: DE-FOA-0002490; issue date: March 16, 2021**

- *Research focused on data analytics for autonomous optimization and control of accelerators and detectors relevant to current- or next-generation Office of Nuclear Physics (NP) accelerator facilities.*
- *Research on technical developments at the intersections between real-time machine learning and the control and optimization of accelerator systems operation and detector design using artificial intelligence (A.I.) models*

## **Program Planning/Context:**

- *Impart a drastic acceleration of experimental and computational discovery by applying data analytics and autonomous optimization methods and techniques to address a variety of technical challenges in simulations, control, data acquisition, and analysis faced by NP accelerators and scientific instruments.*
- *Targeted investments to develop cutting-edge techniques based on data analytics and artificial intelligence of relevance to nuclear science research and accelerator facility operations.*
- *This FOA followed the FY 2020 DOE Lab Announcement with 3 NP awards*

## **Application Requirements:**

- **Eligible Institutions:** *Universities/colleges, non-profit and small business as collaborators, DOE/NNSA laboratories only; New single- or multi-PI proposals.*
- **Estimated award size/duration:** *Up to \$1.0M/year for universities and DOE Laboratories; Award duration: 2 years*
- **Estimated total funding:** *up to \$7M over two years (\$3M in FY 2021).*