DE-FOA-0002875: Artificial intelligence and machine learning for autonomous optimization and control of accelerators and detectors

David J. Dean
Deputy Director

Presented To:
Kick-off meeting

November 14, 2022

NP Program manager and documents

Program Manager	Dr. Manouchehr Farkhondeh
Scientific Contact	301-903-4398
	Manouchehr.farkhondeh@science.doe.gov

Web documents

- https://www.grants.gov/web/grants/view-opportunity.html?oppId=344408
- Click ‘related documents’ tab to get to pdf file

DUE: 11 January 2023

Background documents

- Report of 2015 DOE/National Science Foundation (NSF) Nuclear Science Advisory Committee (NSAC) Long Range Plan. NSAC's report can be found at https://science.osti.gov/-/media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf
- 2014 NP community White paper on Electron Ion Collider: The Next QCD Frontier, Understanding the glue that binds us all (second edition) https://arxiv.org/pdf/1212.1701
- 2019 FRIB Theory Alliance Summer School on machine learning in physics applications https://indico.frib.msu.edu/event/16/
- 2020 Roundtable meeting on Machine Learning and Artificial Intelligence (ML/AI) for NP Accelerator Facilities: https://science.osti.gov/np/Research/ai
- TJNAF A.I. For Nuclear Physics Workshop, March 2020: https://www.jlab.org/conference/AI2020
- Computational Nuclear Physics and AI/ML Workshop, September 2022: https://www.jlab.org/computational-nuclear-physics-and-aiml-workshop

Research priorities

Efficiently extract critical and strategic information from large complex data sets: Address how AI and data analytics can extract robust and meaningful information from the increasingly vast and complex data now being produced at the NP user facilities and by major experimental groups.

Address the challenges of autonomous control and experimentation: Incorporate use of AI to address the challenges in the real-time operation of large, complex NP user facilities and scientific instrumentation.

Efficiency of operation of accelerators and scientific instruments: Increase particle beam availability to users through the optimization of beam tuning, as well as the risk reduction in machine protection, will provide users with more opportunities to perform discovery science.

AI for data reduction of large experimental data: NP physics experiments generate huge volumes of data that would take a long time to go through for data analysis for one pass.

In addition to the above topics, software development is needed for enabling data-driven discovery of new physics and exploration of new avenues in optimization, efficient surrogate models, data analytics, and inverse problems for accelerator and major detector operations and controls. The development of advanced design approaches using AI and machine learning to inform instrumentation development is also of interest. Finally, the integration of data-analytics-driven automated decision tree navigation capability into control systems is needed for existing NP-supported national user facilities, as well as into the design of the Electron-Ion Collider.

Some further notes

- **A note on applications and NP Major Projects:** Any proposed work that is not part of a current NP project including the approved Electron-Ion Collider (EIC) can be submitted to this FOA. AI/ML methods related to the EIC need to be carefully drafted to ensure they would not overlap with the approved EIC project scope. However, the methods can be related to enhancing scientific output of the EIC as a scientific user facility. 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.).
- Funding
  - Ceiling: $2M for 2 years (no more than $1M/year
  - Floor: $50k for 2 years
- Total of $16M in current and future fiscal year funds
- Number of proposals funded depends on quality
- Limits:
  - Unlimited from institution (but we will triage and we will not send in competing proposals, e.g., same topic different PIs).
  - Limited from PI or co-PI (no more than 3).
- Timeline: **Proposals due on January 11, 2023**

JLab Process

- The JLab proposals will be coordinated by relevant JLab ADs:
  - Andrei, Accelerator Areas
  - Thia in Detector Areas
  - Amber, Data Analysis
- Proposal submission to be done by Deborah Dowd.
- Proposals will be reviewed by Andrei, Thia, Amber, David and others as needed
- Final proposals should be red-teamed (and if we can, reviewed by a tech writer).

JLab Deadlines

Leading a proposal	DE-FOA-0002875 (AI/ML)
Notify JLab POC of intent to submit	November 18
Full proposal due to JLab POC (and David) for review	January 3
Red-team reviews and any technical writer input	January 5-9
Revised full proposal completed and entered in PAMS	January 9
Full proposal submitted in PAMS by Deborah Dowd	January 11
Partnering (not leading) with other lab or university	
Notify JLab POC (and David) of participation and role	November 18
Send copy of final proposal to JLab POC (and David)	January 11

POC:

- Andrei, Accelerators
- Thia, Detectors
- Amber, Data analysis

Review Criterion from the Call

- **Full proposal**
  - 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.
  - Quality and Efficacy of the Promoting Inclusive and Equitable Research (PIER) Plan. (NEW)
  - Relevance to compelling scientific opportunities identified in the 2015 NSAC Long Range Plan

- Review criteria are listed in decreasing order of significance, though their importance is comparable

Promoting Inclusive and Equitable Research (PIER) Plan

Appendix 5

- The PIER plan should describe the activities and strategies of the applicant to promote equity and inclusion as an intrinsic element to advancing scientific excellence in the research project within the context of the proposing institution and any associated research group(s). Plans may include, but are not limited to:
  - Strategies of your institution (and collaborating institutions, if applicable).
    - Rhonda Barbosa, Auroa Realin, and I will pull together from the annual DEI report information for this part.
  - Incorporate or built upon existing DEAI efforts of the project key personnel or applicant institution(s), but should not be a re-statement of standard institutional policies or broad principles.

Key components of Nuclear Physics Proposals

- **Goals**: science outcomes that drive the proposal
  - Must be high-reward, sometimes high-risk
  - Impact on Nuclear Physics Program (Heavy Ions, Medium Energy, Low Energy, Theory)
- **Milestones**: indicators that the project is on track
  - Derived from goals, intermediate tests
  - Provides oversight without micro-management
- **Publications, Demonstrations, and Highlights**
  - Ways of communicating results
  - Not explicitly part of the proposal, but expected for all funded projects
- **Artifacts**: side-effects of conducting the research
  - Typically software in the form of libraries and tools
  - NP does not (directly) fund the development of software

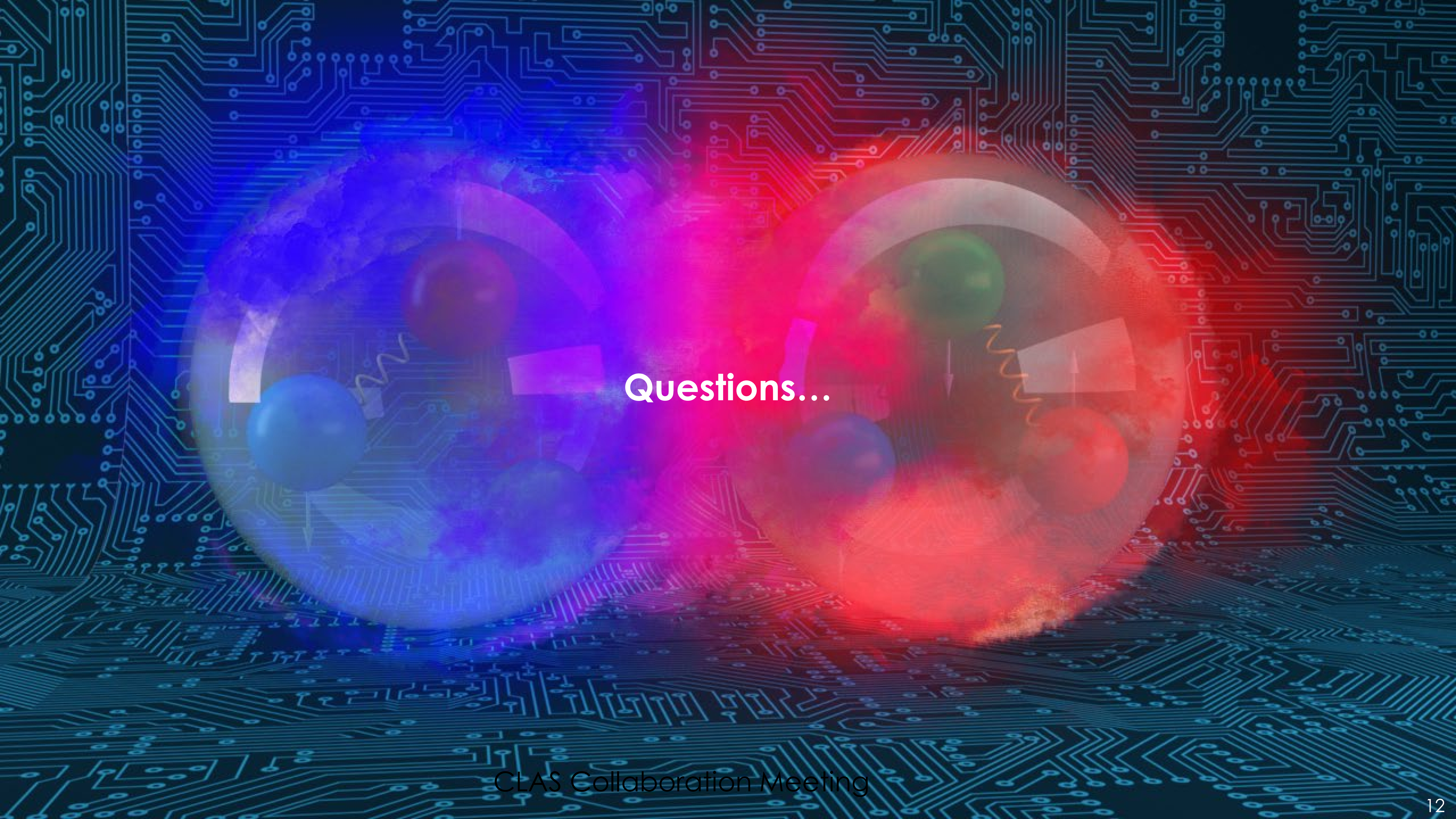
Heilmeier's Catechism

George H. Heilmeier

- What are you trying to do ? Articulate your objectives using no jargon.
- How is it done today, and what are the limits of current practice ?
- What's new in your approach and why do you think it will be successful ?
- Who cares ? If you're successful, what difference will it make ?
- What are the risks and the payoffs ?
- How much will it cost ?
- How long will it take ?
- What are the midterm and final "exams" to check for success ?

Prose, not poetry !

Must answer all of these questions in the pre-proposal and in the abstract of the final proposal. Also, this is a good order!



Questions…