



6450-01-P

DEPARTMENT OF ENERGY

Office of Science, Office of High Energy Physics

Request for Information: Impacts from and to Quantum Information Science in High Energy Physics

AGENCY: Office of High Energy Physics, Office of Science, Department of Energy.

ACTION: Notice of request for information (RFI).

SUMMARY: The Office of High Energy Physics (HEP) in the Department of Energy (DOE) invites interested parties to provide input on topical areas in which progress in quantum information science can inform high energy physics, and on contributions that the high energy physics community can make to advancing quantum information science.

DATES: Written comments and information are requested on or before **[INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

ADDRESSES: Interested persons may submit comments by email only. Comments must be sent to *QISandHEP-RFI@science.doe.gov* with the subject line “Quantum Information Science and HEP RFI”. Any attachments must be in one of the following formats: ASCII; Word; RTF; or PDF.

FOR FURTHER INFORMATION CONTACT: Requests for additional information may be submitted to Dr. Lali Chatterjee, (301) 903-0435, *QISandHEP-RFI@science.doe.gov* or Dr. Altaf H. Carim, (301) 903-9564, *QISandHEP-RFI@science.doe.gov*.

SUPPLEMENTARY INFORMATION: Quantum information science (QIS) encompasses novel approaches to fundamental science and to applications such as sensing, communications, simulation, and computing that are enabled by understanding and manipulation of the uniquely

quantum phenomena of superposition, entanglement, and squeezing. Within high energy physics, DOE's emphasis is on employing new perspectives and capabilities offered or enabled by QIS to address the science drivers identified by the community in the May 2014 "Building for Discovery" report of the Particle Physics Project Prioritization Panel (P5).¹ Focus areas include quantum computing and foundational QIS, quantum sensor technology, and novel experiments exploiting quantum entanglement. QIS methods and concepts are proving increasingly important in advancing fundamental understanding in, e.g., the search for dark matter, emergence of space-time, and the black hole information paradox. Likewise, these advances contribute to development of QIS including quantum error correction and thermalization. Because the field is interdisciplinary and progressing rapidly, effective research programs may require collaborative groups with appropriate combinations of knowledge, capabilities, and experience in quantum information, particle physics, and/or other related fields. Several DOE HEP reports provide additional information pertaining to QIS impacts on and from HEP.²³⁴

The U.S. Department of Energy's Office of High Energy Physics in the Office of Science seeks input from stakeholders regarding potential research and development in QIS that addresses scientific and technological needs in high energy physics, and regarding capabilities in the high energy physics community that could contribute to the advancement of QIS. The information received in response to this RFI will inform and be considered by the Office of High Energy Physics in program planning and development. Please note that this RFI *is not* a Funding

¹ https://science.energy.gov/~media/hep/hepap/pdf/May-2014/FINAL_P5_Report_Interactive_060214.pdf

² HEP-ASCR Study Group Report, Grand Challenges at the Interface of Quantum Information Science, Particle Physics, and Computing, 2015, https://science.energy.gov/~media/hep/pdf/files/Banner_PDFs/QIS_Study_Group_Report.pdf

³ HEP-BES roundtable report, "Common Problems in Condensed Matter and High Energy Physics", 2015, https://science.energy.gov/~media/hep/pdf/Reports/HEP-BES_Roundtable_Report.pdf

⁴ HEP-ASCR QIS roundtable report, "Quantum Sensors at the Intersections of Fundamental Science, QIS and Computing", 2016, http://science.energy.gov/~media/hep/pdf/Reports/DOE_Quantum_Sensors_Report.pdf

Opportunity Announcement, a Request for Proposal, or other form of solicitation or bid of DOE to fund potential research and development work in QIS.

Request for information: The objective of this request for information is to gather input about opportunities for research and development at the intersection of quantum information science and high energy physics, to inform Federal efforts in this area. The questions below are intended to assist in the formulation of comments, and should not be considered as a limitation on either the number or the issues that may be addressed in such comments.

The DOE Office of High Energy Physics is specifically interested in receiving input pertaining to any of the following questions:

(1) Fundamental Science

What are the key questions, opportunities, needs, and challenges for QIS to contribute to progress in the following topics? What kinds of experiments or calculations are needed to advance understanding? How can research in these areas contribute to the advancement of QIS?

- a. Quantum gravity and emergence of space-time
- b. Tensor networks, gauge symmetries, and field theories
- c. Holographic correspondence and black hole physics
- d. Dark matter, dark energy, and physics beyond the Standard Model
- e. Analog simulation and emulation of quantum systems of interest to particle physics

(2) Devices, Tools, Approaches, and Techniques

What developments are needed, are on the horizon, or can be envisioned in the following areas? How will they contribute to high energy physics? How can high energy physics expertise, resources, or capabilities in these or other areas contribute to broader advances

in quantum information science?

- a. Quantum sensors exploiting superposition, entanglement, and/or squeezing
- b. Supporting technologies (superconducting radio frequency cavities, cryogenics, fast feedback and control systems, etc.)
- c. Data analysis and background reduction
- d. Machine learning and optimization
- e. Algorithm development
- f. Error correction and measurement

(3) Organizational and Assessment Considerations

- a. What metrics could be applied to evaluate progress of the field and assess impacts of Federal investments?
- b. What are key obstacles, impediments, or bottlenecks to advancing research at the intersection of QIS and HEP?
- c. What mix of institutions (industrial, academic, lab) could best carry out the envisioned research and/or development, and who should drive the formulation of such efforts?
- d. What collaboration models would be most effective for pursuing joint R&D?
- e. What resources at DOE National Laboratories would be beneficial for and could accelerate or facilitate research in this topic?
- f. Are there other factors, not addressed by the questions above, which should be considered in planning DOE HEP activities in this subject area?

Comments containing references, studies, research, and other empirical data that are not widely published should include copies of the referenced materials. Note that comments will be made publicly available as submitted. Any information that may be confidential and exempt by law

from public disclosure should be submitted as described below.

Confidential Business Information: Pursuant to 10 CFR 1004.11, any person submitting information he or she believes to be confidential and exempt by law from public disclosure should submit via email: one copy of the document marked “confidential” including all the information believed to be confidential, and one copy of the document marked “non-confidential” with the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination. Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) a description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

Depending on the response to this RFI, subsequent workshops or other activities may be held to further explore and elaborate the opportunities.

Issued in Washington, DC, on December 18, 2017.

James Siegrist,
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for High Energy Physics.

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