FERMILAB-CRADA-FRA-2017-0035

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SENSEI Dark Matter Discovery Project
Cooperative Research and Development Agreement
Final Report

CRADA Number: FRA-2017-0035

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Summary Report
14 October 2021

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NOTICE

In accordance with Requirements set forth in Article XII of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

CRADA number: FRA-2017-0035

CRADA Title: SENSEI Dark Matter Discovery Project

Parties to the Agreement: The Research Foundation for the State University of New York/Stony Brook University and Fermi Research Alliance, LLC.

Sponsoring DOE Program Office(s): Office of Science, High Energy Physics

DOE Funding Commitment Table:

(a)	*(d)*	*(f)*	*(h)*
Category	Year 1 Cost	Year 2 Cost	Total Project Cost
Total Labor	**293,863**	**335,779**	**$629,642**

Abstract of CRADA work:

Researchers at Stony Brook University (Stony Brook) and the Fermi National Accelerator Laboratory (Fermilab) have proposed a new experiment called the Sub-Electron Noise Skipper-CCD Experimental Instrument (SENSEI). Uncovering the identity of dark matter (DM), which makes up about 85% of the matter in the Universe, is among the most important goals of particle physics today. Laboratory-based experimental searches, which have mostly focused on Weakly Interacting Massive Particles (WIMPs) with masses above the GeV-scale (proton mass), have turned up empty thus far. Stony Brook and Fermilab have agreed to provide most of the infrastructure and technical support that will be needed by the collaboration to construct and operate two detectors for the experiment -- SENSEI-10 and SENSEI-100. The Heising-Simons Foundation is providing partial support for the experiment, through a grant to Stony Brook University, which will be used to procure the detector components, support a graduate student to work full-time on the SENSEI experiment, and support travel for collaborators to work on the experiment.

Summary of Research Results:

Within the scope of this CRADA, a new generation of silicon Charged Coupled Devices was designed and fabricated implementing an ultralow-noise readout technology ("Skipper CCDs"), designed in collaboration with the Lawrence Berkeley National Laboratory Micro Systems Lab (separate from this CRADA). The new science-grade SENSEI sensors were delivered to Fermilab in May 2019. Fermilab has validated the packaging procedure of the sensors and evaluated and characterized their performance. Two sensors are installed in the MINOS cavern and led to world-leading results published in PRL and highlighted by the magazine as Editors Selection. A large fraction of the sensors, adding to 30 grams of target material, are currently installed in SNOLAB in Sudbury, Canada to perform a dark matter search in a well-shielded environment. Using data taken at Fermilab, the SENSEI collaboration presented in 2020 a detailed characterization of the single-electron events observed with the Skipper-CCD sensors. Three Stony Brook University students have graduated with a Master's degree with a thesis based exclusively on SENSEI. A fourth Master's student has been working on SENSEI since spring 2021, and three more students are contributing to the analysis tasks.

Related Reports, Publications, and Presentations:

1. SENSEI Collaboration. ``SENSEI: Direct-Detection Results on sub-GeV Dark Matter from a New Skipper-CCD'', Phys.Rev.Lett. 125, 171802, arXiv:2004.11378 (2020)
2. SENSEI Collaboration. ``SENSEI: Direct-Detection Constraints on Sub-GeV Dark Matter from a Shallow Underground Run Using a Prototype Skipper-CCD'', submitted for publication Phys. Rev. Lett., arXiv:1901.10478 (2019)
3. SENSEI Collaboration. ``SENSEI: First Direct-Detection Constraints on sub-GeV Dark Matter from a Surface Run'', Phys. Rev. Lett. 121, 061803, arXiv:1804.00088 (2018)

Subject Inventions listing:

None

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