

Fermi National Accelerator Laboratory LDRD Project Data Sheet - FY17

Project ID: FNAL-LDRD-2017-014

Project title: Cryogenic photon sensors for the low mass frontier

Principal investigator: Aaron Chou

Project description: (short description and explanation of cutting edge, high-risk, high-potential science or engineering)

Develop low threshold calorimeters and single photon detectors to enable future experiments to probe the low mass frontier. This program would expand on initial design work taking superconducting qubits developed for quantum computing and transferring this fairly mature technology to HEP applications. This project seeks to integrate these qubit-based detectors into systems incorporating 14-25T magnets for application to dark matter axion searches.

Tie to Mission: (explain the project's relevance or anticipated benefits to Fermilab's and DOE's missions)

When these solid-state qubits are used as single microwave photon detectors for ultralow threshold signal detection, the high fidelity design required for quantum computing translates into nearly 100% quantum efficiency and low dark rate – orders of magnitude below the standard quantum limit for linear amplifiers. If the qubit sensors can be demonstrated to maintain their high performance even in this extreme environment, including field cancellation to the mG level, then this R&D will provide the proof of principle enabling the next generation of dark matter experiments to reach sensitivity to the cosmologically-preferred axion mass range of 40-80 micro-eV.

Previous year's accomplishments: (as applicable)

N/A Some efforts have made to specify the dilution refrigerator and associated magnet. When those procurements are under way, the project will formally start. Facility preparations (non-LDRD) have been made to accommodate the refrigerator.

Work proposed for current fiscal year and anticipated / desired results:

In Year 1, the goal is to design and test prototypes for a waveguide or transmission line coupled qubit sensor. Various readout protocols will also be validated. The testing can be done in the Schuster Lab test stands on an as-available basis. Meanwhile, at Fermilab the installation site preparations can begin, with considerations being cryogenic and magnet safety, ergonomics, and potential for upgrade to the next generation experiment.

Project funding profile: (costs, budgets, projected budgets, and total)

Prior year(s) costs	FY18	FY19	FY20	FY21 (6 mo)	Total
N/A	794,000	762,000	418,000	300,000	2,274,000

Est Project Start Date: 2/01/2018

Total Approved Project funds: \$ 2,274,000