

Fermi National Accelerator Laboratory LDRD Project Data Sheet - FY18

Project ID: FNAL-LDRD-2018-054

Project title: Single-electron experiments in the Fermilab IOTA ring

Principal investigator: Sergei Nagaitsev

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

A small storage ring, the Integrable Optics Test Accelerator (IOTA) is a 40-meter machine specifically designed to conduct accelerator physics research and will be capable of circulating electrons with energy of up to 150 MeV. However, a single-electron mode of operation is NOT part of the IOTA commissioning plan, which focuses on bunches of $\sim 10^9$ electrons. This project would allow us to develop and commission a single-electron storage and detection capability.

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

The specific objective of this proposal is to develop a new capability in the Fermilab IOTA ring to store and detect a single electron. Such a capability would open research and funding opportunities for various quantum radiation experiments. Having well-defined initial conditions and time structure, single- and multi-photon radiation of a single electron in a storage ring may become a "standard candle" source for various kinds of quantum correlation and quantum optics experiments with the high-order field correlation function, such as, for example, quantum cryptography and teleportation.

Previous year's accomplishments: not applicable

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

To attain a single circulating electron in the IOTA ring, we will inject into the ring a minimum possible number of electrons (probably $\sim 10^6$) in a single bunch from the FAST injector. Then, we will develop and perfect techniques to reduce this number to "few" and, ultimately, to one, by continuously observing the PMT photon rates while removing the electrons. The electron removal will be accomplished by a combination of transverse scraping and the rf cavity voltage reduction. We would then increase the rf voltage in order to contain this electron longitudinally. In FY18 we are planning to design, procure and install the photon diagnostics. In FY19, we are anticipating the commissioning and beam studies. Results of these experiments will be submitted to peer-reviewed journals.

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

Prior year(s) costs	FY18	FY19	FY20	Total
N/A	23,000	25,000	--	48,000

Project Start Date: 8/1/2018 (est) Total Approved Project funds: \$ 57,000