Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY16

Project ID: FNAL-LDRD-2016-007
Project title: Tuning Axion Detectors with Non-Linear Dielectrics
Principal investigator: Andrew Sonnenschein

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

The project seeks to characterize dielectric materials that can be used to tune resonant microwave cavities through an DC electric field. A novel aspect is that for the application of axion detectors, these materials will require characterization at low-temperatures and high magnetic fields. The "tunability" and "loss tangent" are two parameters that describe this use of dielectrics. This project will also study how to implement (i.e. mechanical aspects) using these dielectrics to control an array of cavities, which are required to be kept matched in phase using the tunable dielectrics for the axion experiment.

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

axion, which can leave a signal in a resonant microwave cavity, is a promising candidate and has been selected by DOE as the subject one of the three generation 2 dark matter programs. Specifically, Fermilab has joined the Axion Dark Matter eXperiment (ADMX) to contribute laboratory expertise and capabilities to achieve the scientific goals of the experiment. These goals may include eventually hosting a future generation of the experiment at Fermilab. In addition, the techniques developed under the LDRD may have application to accelerator-based cavities as well.

Previous year's accomplishments: (as applicable) A 4K cryostat was commissioned and a coplanar resonator test cell was developed to measure the frequency shifts due to the SrTiO3 films from 10-300K. The results have been matched to simulations. The films do have lower than expected dielectric constants and little increase at lower temperature. The 3D resonator has been mostly designed.

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

With higher quality films, the goal is to demonstrate electric field tuning and explore magnetic effects. Measurements will be improved to allow for 5% or better uncertainties on the dielectric constant and loss tangent. The 3D resonator will be commissioned and used to demonstrate combined mechanical and electronic tuning.

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

Prior year(s) costs	FY16	FY17	FY18	Total
N/A	123,406	132,651	144,000	400,057

Project Start Data: 12/15/2015 Total Approved Project funds: $ 445,000