Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY17

Project ID: FNAL-LDRD-2017-020
Project title: Development of next-generation Nb3Sn superconductors for accelerator magnets
Principal investigator: Xingchen Xu

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

This project seeks to develop a new generation of Nb_3Sn conductors with significantly enhanced performance for superconducting magnets. Such conductors cannot only increase the achievable field of accelerator magnets (to 16 T and above) and hence boost particle collision energy in search for new physics, but also greatly reduce their costs.

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

Nb_3Sn strands are the workhorse to fabricate magnets above 10 T; their critical current density (J_c) determines the achievable field, which further determines the particle beam energy and luminosity. The PI (Xu) recently invented a novel technique that doubled the high-field J_c in proof-of-principle strands by forming ZrO_2 artificial pinning centers in Nb_3Sn via internal oxidation of Nb-1%Zr. Tripling of J_c is projected by further optimization of strands. This project aims to further optimize this new technique and to transform it into practical magnet-grade conductors. The planned energy upgrade of Large Hadron Collider or building of Future Circular Collider will benefit from this technology as their costs will be reduced by billions of dollars if Nb3Sn Jc is doubled.

Previous year's accomplishments: (as applicable)

Four different designs have been attempted to fabricate wires with a maximum Nb3Sn fraction being the goal. Two of the designs show good results. The second task involving optimizing the doping has progressed in three stages. The research is deemed to be ahead of schedule compared with the original plan.

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

If design IV works well, it will become the standard for future wires (else Design I). The recipe will continue to be optimized with different ratio's of alloys and doping schemes. Optimization should continue to the later part of the year with candidate wires available for other tests such as Ic vs stress. Begin to optimize new high-Jc wires for cabling.

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

Prior year(s) costs	FY17	FY18	FY19	FY20 (6 mo)	Total
N/A	92,555	387,037	403,386	200,000	1,082,978

Project Start Data: 3/01/2017 Total Approved Project funds: $ 1,221,557