Fermilab Lab Directed R&D

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Fermilab LDRD Lab Strategy

February 17th , 2020

The DOE Recognizes* the Importance of Lab Directed R&D to:

- maintain the scientific and technical vitality of the laboratories;
- enhance the laboratories' ability to address current and future DOE/NNSA missions;
- foster creativity and stimulate exploration of forefront areas of science and technology;
- serve as a proving ground for new concepts in R&D;
- support high-risk, potentially high-value R&D.

*DOE Order 413.2C

For Fermilab Personnel with Great Ideas …

LDRD represents a great opportunity for staff to think creatively, to explore a new idea, a new concept, try out a new technique … work at the forefront of science and technology.

While there are requirements and restrictions, the proposal and award oversight process aims to minimize burden of Principal Investigators.

The program has an excellent track record in associated publications, patents, Records of Invention and attraction of new and additional funding (e.g. Early Career Awards).

What about those Requirements and Restrictions?

- *What LDRD can be used to support:*
  - Advanced study of hypotheses, concepts, and innovative approaches to scientific, technical, or computational problems
  - Experiments, theoretical studies, simulations, and analyses directed toward "proof of principle" or early determination of the utility of new scientific ideas, technical concepts, and devices or research tools
  - Concept creation and preliminary technical analyses of advanced, novel experimental facilities and devices or of facilities for computational science

- *What LDRD is unable to support:*
  - R&D that is already part of programmatic activity or existing project
  - R&D that requires non-LDRD funds to complete

Fermilab LDRD Program Proposals Since Inception

- FY14: 50 Preliminary, 26 Full Proposals, 7 funded, 7 completed
- FY15: 34 Preliminary, 10 Full Proposals, 6 funded, 6 completed
- FY16: 34 Preliminary, 15 Full Proposals, 7 funded, 7 completed
- FY17: 38 Preliminary, 15 Full Proposals, 9 funded, 5 completed
- FY18: 51 Preliminary, 20 Full Proposals, 12 funded
- FY19: 43 Preliminary, 17 Full Proposals, 10 funded
- FY20: 52 Preliminary, 23 Full Proposals, [in process]

- 302 proposals considered since inception
- 51+ projects funded
- 26 projects currently in-flight
- 25 projects completed

Program Span Across the Laboratory (P.I.s)

AD (12): Chattopadhyay, Johnson D., Madrak, Nagaitsev(2), Piekarz, Prebys, Saewert, Scarpine, Stratakis, Valishev, Zwaska

APsTD (8): Chao, Checchin, Kashikhin, Posen, Romanenko, Stoynev, Wu, Xu

IARC(1): Thangaraj

ND (4): Estrada, Fava, Lockwitz, Niner

PPD (15.5): Apresyan(½), Benson, Braga, Chou, Dahl, Drlica-Wagner(2), Estrada(2), Hogan, Rahlin, Rusu, Soares-Santos, Sonnenschein, Tiffenberg, Timpone

SCD (10.5): Cancello, Chang, DeMar, Gray(½), Nord, Paterno, Peña, Purdue, Rivera, Spentzouris, Wang

Engineer
Affiliated Technologist

Span of In-Flight Program

- Across Core Capabilities:

  8 projects in **Accelerator Science and Technology**
  8 projects in **Advanced Computer Science [including QIS]**
  6 projects in **Particle Physics**
  4 projects in **Advanced Instrumentation**

- Well represented across strategic themes

- Program is primarily grass-roots, P.I. inspired

- Includes a component of strategic direction that has been important to seeding new directions for the lab and the field, such as Cosmic Microwave Background (CMB) research and Quantum Information Science (QIS) research.

In-flight Program…

P.I.		Project
Davide	Braga	Characterization and Development of Nanoscale Integrated Circuits for Quantum Systems and Deep Cryogenic Detectors
Yu-Chiu	Chao	Demonstration of the microwave quantum communication via "warm" channel between two ultracold quantum systems
Mattia	Checchin	Charge and Flux-insensitive Superconducting Qubit Prototype
Aaron	Chou	Cryogenic photon sensors for the low mass frontier
Eric	Dahl	A scintillating liquid argon bubble chamber for WIMP and CEvNS A scintillating liquid argon bubble chamber for WIMP and coherenet neutrino scattering detection
Alex	Drlica-Wagner	Pixel-Configurable Skipper CCDs for Cosmological Applications
Juan	Estrada	Optical Microwave Kinetic Inductance Detectors for future cosmic surveys
Juan	Estrada	Development of 10kg Skipper-CCD experiments
Angela	Fava	LArCADe _ Liquid Argon Charge Amplification Devices
Lindsey	Gray	Graph Neural Networks for Accelerating Calorimetry and Event Reconstruction
Craig	Hogan	Verification of Planck Scale Correlations in the Reconfigured Fermilab Holometer
David	Johnson	A Quasi-CW bunch-by-bunch H- Neutralization Laser System for Longitudinal Phase Collimation in Linacs and other Applications
Vladimir	Kashikhin	High Temperature Superconducting Magnet with Circular Coils
Robyn	Madrak	Improving magnetic materials for RCS cavity tuners
Sergei	Nagaitsev	Single-electron experiments in the Fermilab IOTA ring
Sergei	Nagaitsev	Quantum effects in undulator radiation
Brian	Nord	Modeling Physical Systems with Deep Learning Algorithms
Cristián	Peña	Quantum Networks Using Time-bin Photonic Qubits
Gabriel	Perdue	Accelerator Control with Artificial Intelligence
Alexandra	Rahlin	Development of Microwave Readout Electronics for Massively Multiplexed Arrays of Transition-Edge Sensors
Vadim	Rusu	Broadband spectral sensitive graphene photodetector
Panagiotis	Spentzouris	Towards a Quantum Computing Science Center at Fermilab
Stoyan	Stoynev	Accelerated superconducting magnet training by a quench current-boosting device (QSD) at quench current
Diktys	Stratakis	Increasing the intensity of muon based experiments using wedge absorbers
Stephanie	Timpone	Dark Matter as Sterile Neutrinos Search Satellite
Xingchen	Xu	Development of next-generation Nb3Sn superconductors for accelerator magnets

Davide Braga's (SE) Project

Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY19

Project ID: FNAL-LDRD-2019-010
Project title: Characterization and Development of Nanoscale Integrated Circuits for Quantum Systems and Deep Cryogenic Detectors
Principal investigator: Davide Braga

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

We propose to develop transistor models for the cryogenic operation of an advanced 28nm commercial CMOS process. This will provide a toolkit for designing application specific integrated circuits (ASICs) that operates at cryogenic temperatures, down to 4K. The project will include the fabrication of a test structure and its subsequent testing that will allow comparison with simulation and the development of models.

Dave Johnson's (SEP) project

Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY18

Project ID: FNAL-LDRD-2018-049
Project title: A Quasi-Continuous Wave (CW) bunch-by-bunch H- Neutralization Laser System for Longitudinal Phase Collimation in Linacs and other Applications
Principal investigator: Dave Johnson

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

Two major aspects for this R&D program are 1) the reduction in required laser energy for bunch photoneutralization, and 2) the development of high peak and average power burst-mode pulsed laser system. With the completion of these two goals we will demonstrate the ability to reduce the longitudinal emittance presented to the downstream accelerating structures.

Vladimir Kashikhin's (SPE) project

Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY18

Project ID: FNAL-LDRD-2018-009
Project title: High Temperature Superconducting Magnet with Circular Coils
Principal investigator: Vladimir Kashikhin

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

The main goal of proposed research and development is to design, build, and test a high temperature superconducting (HTS) magnet which has a novel design most suitable for HTS configuration Two circular HTS coils will be assembled within a iron yoke forming a quadrupole field. After initial testing, the HTS magnet will have a HTS superconducting switch where the magnet could work in a persistent current mode, disconnected from a power source.

Stephanie Timpone's (EP-II) project

Fermi National Accelerator Laboratory
LDRD Project Data Sheet - FY18

Project ID: FNAL-LDRD-2018-040
Project title: Dark Matter as Sterile Neutrinos Search Satellite
Principal investigator: Stephanie Timpone

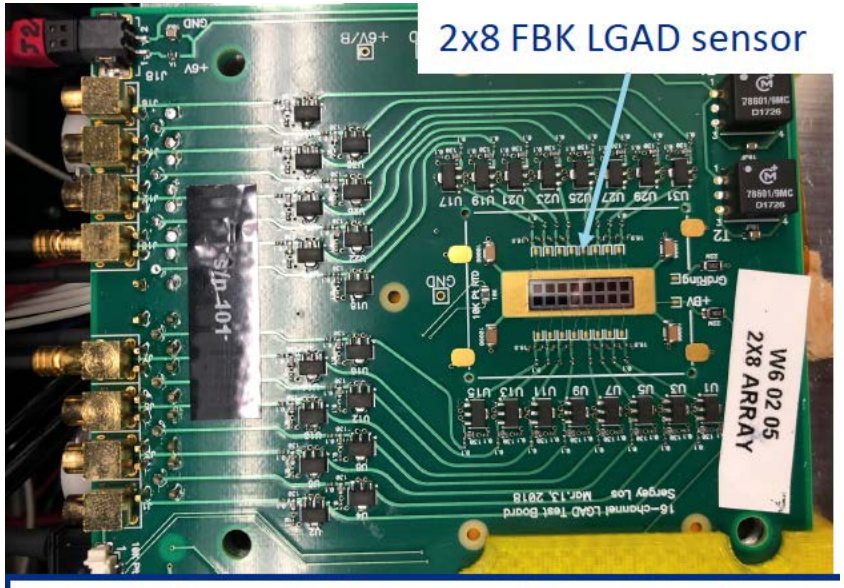
Project description: (short description and explanation of cutting edge, high-risk, high-potential science or engineering)

The goal of this project is to design a scientific experiment consisting of charge coupled detectors (CCDs) that could fit on a low cost, available, small satellite program (CubeSat).

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

The work proposed here has the overarching goal of detecting the 3.55 keV line from radiative decay of dark matter in our own galaxy using a small satellite (CubeSat) instrumented with CCD silicon detectors. This instrument would have a field of view similar to the proposed sounding rocket experiment, with a factor of 4000 larger X-ray collecting area, and a 100 longer exposure time.

Aligning LDRD Investments with Lab Strategy



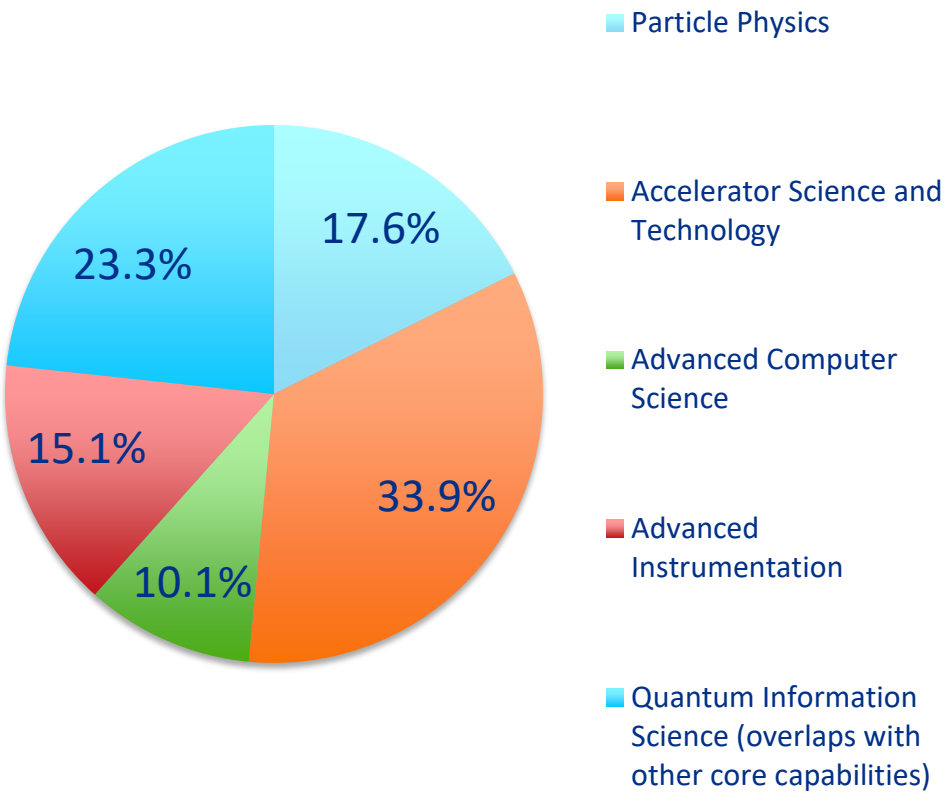
16-ch FBK sensor LGAD on Fermilab readout board

A. Apresyan, L. Gray P.I.s

LGAD (Low gain avalanche diodes) detectors for high luminosity CMS as silicon precision timing detectors for minimum ionizing particles.

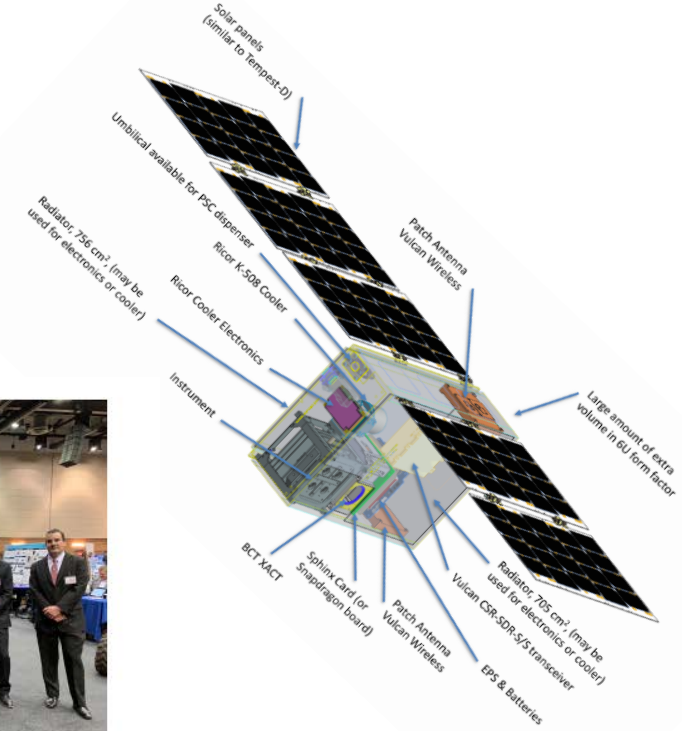
This project is now supported under an early career award!

Funding for LDRD projects by core capability in FY 2019 (using FY19 budgeted amounts)



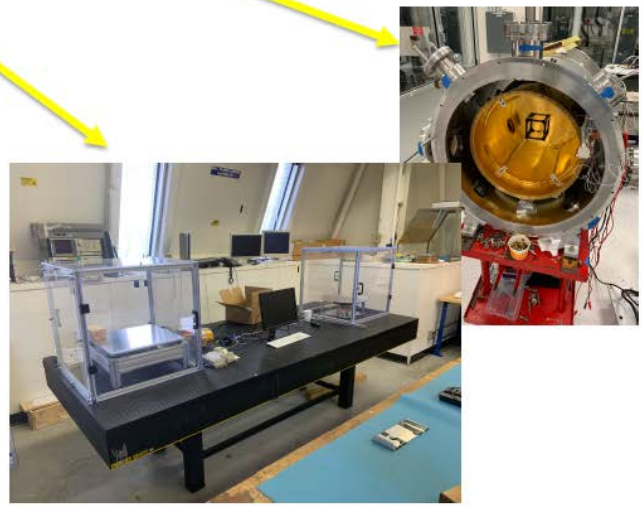
Engaging Engineer P.I.s & the University Community

DarkNess: Dark matter as sterile Neutrino Search Satellite, S. Timpone P.I.



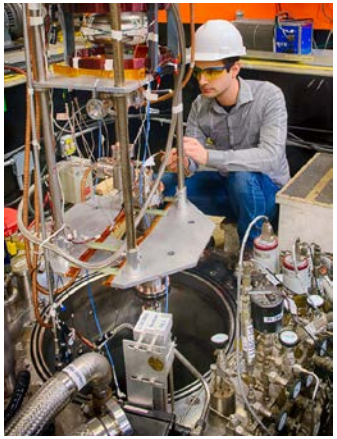
University Collaborations

- Four mechanical engineering teams from UIC – senior design projects:
  - Thermal Vacuum Chamber
  - Moment of Inertia Table
  - Center of Gravity Table
  - HUB
- SmallSat Lab at UIUC lead by Dr. Michael Lembeck
  - Conducting mission studies, potential for use of their local ground station for receiving data post-LDRD

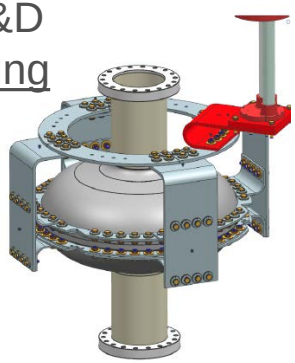


Program Focused on HEP and Relevant Across DOE/SC

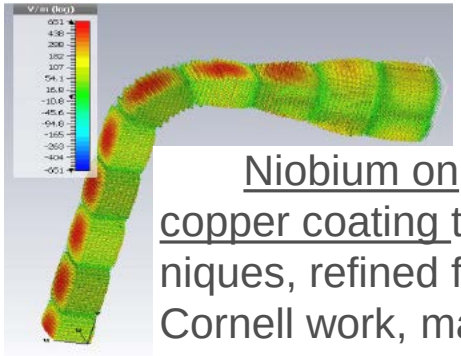
FNAL LDRD has supported R&D in Superconducting Technologies



Sam Posen's R&D in superconducting RF cavity R&D has led to Improvements in the design of SLAC's LCLS-II. LDRD funding is now followed by an Early Career Award.



Conduction-cooled SRF cavity with 50-fold reduction in thermal resistance may enable small accelerators for a variety of DOE- related applications



Niobium on copper coating techniques, refined from Cornell work, may greatly reduce the cost of SRF cavities for future accelerators.

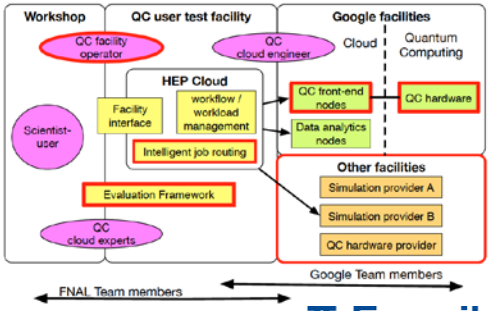
FNAL LDRD has supported R&D in Advanced Computing

Preparing HEP for exascale-era high performance computing will require new architectures. LDRD puts the team at FNAL in a strong position to apply for ASCR grants.

credit: NERSC

Brian Nord's R&D in deep learning techniques may allow for new information to be extracted from astrophysical data.

A LDRD project is transforming real problems into quantum computing code that will leverage Google early adopters of quantum computing.



Fermilab LDRD Funding Authority and Actual Costs

	Authority		Actuals
FY14:	$1.5M	0.6%,	$0.2M actual
FY15:	$3.5M	1.0%,	$2.2M actual
FY16:	$4.5M	1.4%,	$3.3M actual
FY17:	$4.5M	1.5%,	$3.8M actual
FY18:	$5.1M	1.7%,	$4.6M actual
FY19:	$6.1M	1.9%,	$3.9M actual
FY20:	~$6.5M	2.0%	

Actual LDRD burden to date (i.e. “LDRD Tax”) is about 1.5%

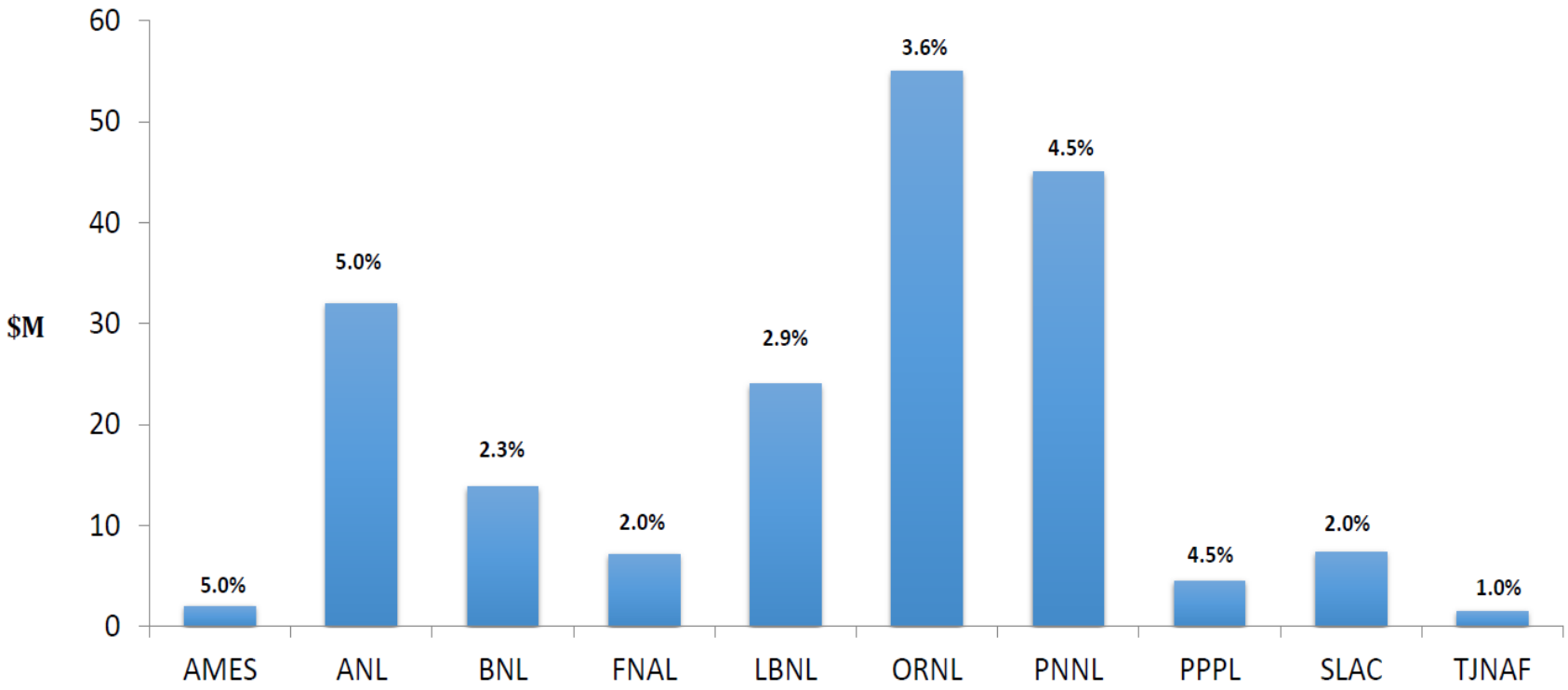
Some recent growth due to strategic initiatives led by the Directorate such as Quantum Information Systems

Note: LDRD pays back into most of the overhead pool as well

Office of Science 2020 LDRD Program

FY 2020 Requested Levels

U.S. DEPARTMENT OF ENERGY | Office of Science



LDRD Review 2019 – LDRD Stats Presentation 6

Preliminary Proposal:

-Less than 2 pages
-Supervisor Approval

Fermilab Laboratory Directed Research and Development, LDRD
Preliminary Proposal

Project Title:
Principal Investigator:
Co-Investigators (w/institutions):

Supervisor/Line Management Approval: _____ _____
Date

Lead Division/Sector/Center Approval: _____ _____
Date

Project Summary (~150 words): Project objectives, novelty, relation to mission.

Project Work Plan (~200 words): Overview description the work to be performed, timescale, and approximate financial/personnel resources required.

Comments or Questions (optional). Short description of anything else relevant or if you have any initial questions of the LDRD Selection Committee.

https://ldrd.fnal.gov/

Full Proposal: 6 pages + Budget Pages + Bios..

Fermilab LDRD Proposal

Project Title:

Principal Investigator:
Lead Division/Sector/Section:
Co-Investigators (w/institutions): (if applicable)

Proposed FY and Total Budgets: (summary of budget page (in dollars))

	SWF	SWF OH	M&S	M&S OH	Contingency	Total
½ yr FY20						
FY21						
FY22						
½ yr FY23						
Total						

SWF: Salary, Wages, Fringe SWF OH: overhead on SWF
M&S: Material and Supplies M&S OH: overhead on M&S
Contingency (estimate of additional funds that might be required with justification)

Initiative: 2020 Broad Scope

Project Description (150-200 words): Summarize in 150-200 words the scientific/technical objectives of the proposal, methods that will be used, and expected deliverables and their expected impact. This description should be understandable to a technically literate lay reader.

https://ldrd.fnal.gov/

Criteria for Evaluating LDRD Proposals

Technical Merit Criteria

1. **Scientific/Technical Significance:** How important is the proposed activity to advancing knowledge and understanding within its own field and across different fields?
2. **Innovativeness/Novelty:** To what extent does the proposed activity explore original, innovative or novel concepts?
3. **Proposer Qualifications:** How well qualified are the proposers to conduct the project? Is there sufficient expertise to address all the technical requirements of the proposed research plan?
4. **Proposal Quality:** How well conceived and organized is the proposed activity? Are the estimates of time and effort reasonable? Is the requested level of funding, overhead charges, and level of contingency appropriate?
5. **Likelihood of Success:** Can the project be completed within the proposed funding levels and duration?

Strategic Merit Criteria

6. **Mission Relevance:** Is the proposal relevant to the missions of DOE and of the Laboratory?
7. **Initiative Relevance:** Does the proposed activity address the specific objectives and research priorities of the LDRD Annual Call for Proposals?
8. **Strategic Fit:** Does the proposed activity match well with the Laboratory's distinctive capabilities and core competencies?
9. **Enduring Capability:** Will the proposed new capabilities bring enduring benefit to the Laboratory? How likely will the project initiate a new program and funding?
10. **Laboratory Reputation:** If successful, will the project enhance the Laboratory's reputation in the scientific and technical community.

Scoring Rubrics

WORKSHEET FOR SCORING LDRD PROPOSAL

Proposal Name and/or ID Number	Principal Investigator's Name

Scoring Criteria	Rating (Check One Per Criteria)					Comments/Notes
	1 = Poor	2 = Fair	3 = Good	4 = Very Good	5 = Excellent	
Scientific/Technical Significance						
Innovativeness/Novelty						
Proposer Qualifications						
Proposal Quality						
Likelihood of Success						
Mission Relevance						
Initiative Relevance						
Strategic Fit						
Enduring Capability						
Laboratory Reputation						

Engineer Principal Investigator Challenges

- Finding the niche between programmatic activities and proposals that may be programmatic one-day

- Finding/Making time for the project!
  Work with your team on this

- Right-scoping the project. Cost sweet-spot is $200K-$800K/project, *fully burdened* costs

- Identifying the glide-path out…remember this is R&D
  Papers, patents, ROIs are important deliverables. Evolution into programmatic support can happen but is *not* the rule.

Engineer Principal Investigator Opportunities

- Engineering breakthroughs drive the field forward
- Unique collaboration opportunities with university engineering departments; e.g. undergraduate senior projects
- Exploration and development of future collaborations and development of collaborative models;
  e.g. distributed design teams
- Exploration of emergent technologies; e.g. “tests” of 3D-model only for mechanical procurements, robot development, exploiting leadership-class computing and A.I. in design

Timeline for FY-2021 Cycle

- Call for Proposals in June 2020
- Preliminary Proposals due August 2020

  LDRD selection committee identifies proposals that are encouraged to advance to final proposal stage
- Final Proposals due November 2020

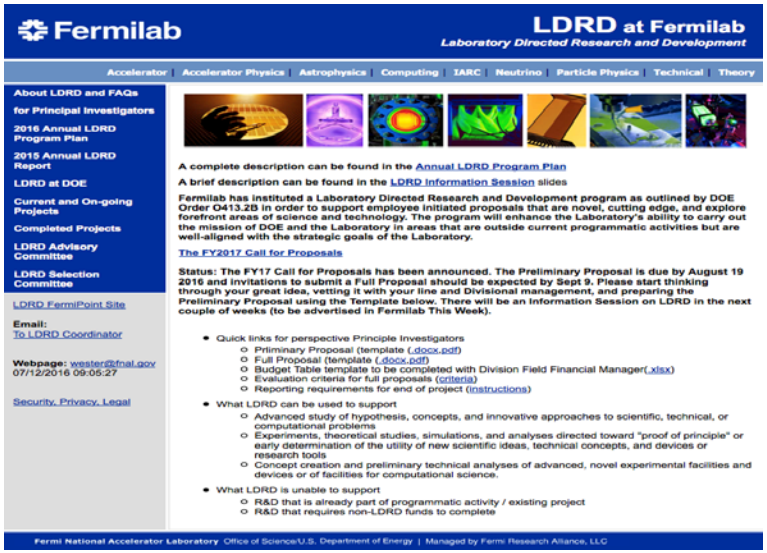
  LDRD selection committee identifies and recommends a suite of proposals for approval by the director
- P.I.s are notified in January 2021
- Funding available for projects to start in March 2021

Summary

- The Fermilab LDRD program has been an important partner with programmatic support in developing future directions for the laboratory and the field

- Working closely with the Fermilab Site Office, the program is vibrantly delivering on the goals of the DOE LDRD mission

- The program continues as an excellent opportunity to enable the creativity of scientists and technologists to advance the field



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