Fermilab Lab Directed R&D

R. Tschirhart, LDRD Coordinator

Fermilab LDRD Program

February 22nd, 2021

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.

Fermilab

*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.

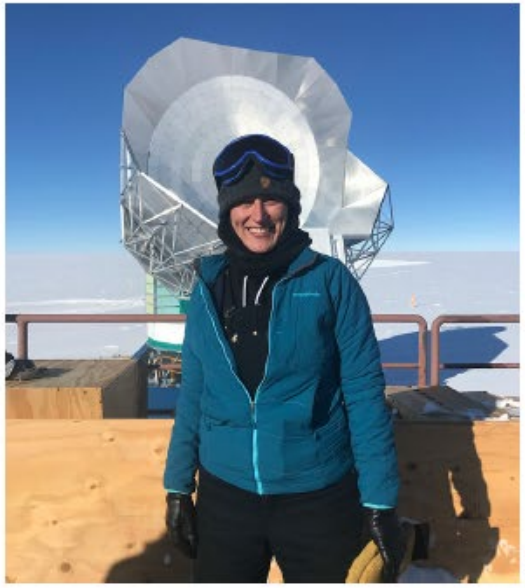
The program has an excellent track record in associated publications, patents, Records of Invention and attraction of new and additional funding (e.g. Early Career Awards).

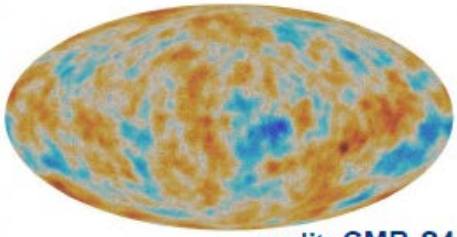
What about those Requirements and Restrictions?

- *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

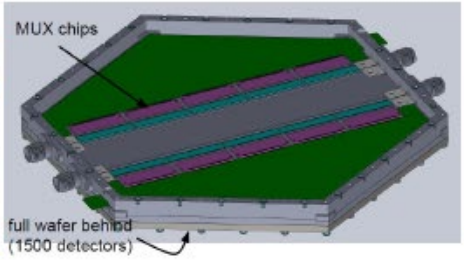
- *What LDRD is unable to support:*
  - R&D that is already part of programmatic activity or existing project
  - R&D that requires non-LDRD funds to complete

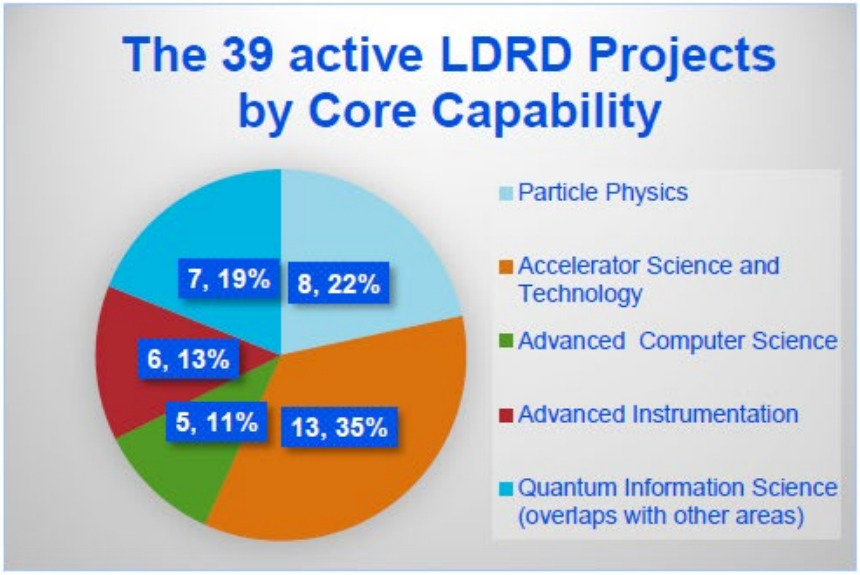
Aligning LDRD Investments with Lab Strategy





credit: CMB-S4



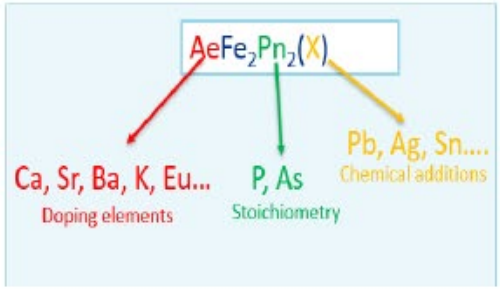


Alexandra Rahlin, "Development of Microwave Readout Electronics for Massively Multiplexed Arrays of Transition-Edge Sensors"

Adam Anderson, "SPT-SLIM: The South Pole Telescope Summertime Line Intensity Mapper" (pending FSO approval)

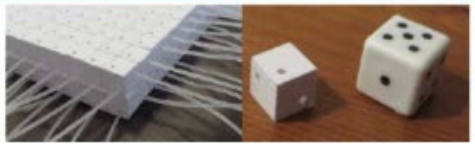
Connecting LDRD to Core Capabilities

Tiziana Spina: Iron Based Superconductors for next generation accelerator magnets

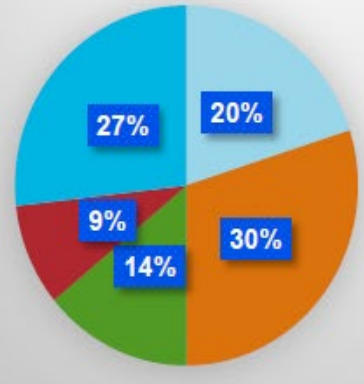


Anna Pla-Dalmau: Injection-molded plastic scintillator for next generation detectors

DUNE NEAR DETECTOR – 3DST DETECTOR



Funding for LDRD projects by Core Capability in FY2020 (using FY20 budgeted amounts)



- Particle Physics
- Accelerator Science and Technology
- Advanced Computer Science
- Advanced Instrumentation
- Quantum Information Science (overlaps with other areas)

Robert Ainsworth: Development of a dedicated wake-building feedback system to study beam bunch stability; led to recent DOE Early Career Award!

Fermilab LDRD Program 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, 7 completed
- FY18: 51 Preliminary, 20 Full Proposals, 12 funded, 2 completed
- FY19: 43 Preliminary, 17 Full Proposals, 10 funded
- FY20: 52 Preliminary, 23 Full Proposals, 14 funded
- FY21: 51 Preliminary, 25 Full Proposals, 12 approved*

- 353 proposals considered since inception
- 75 projects funded*
- 39 projects previously in-flight ; 12 new starts in FY21;
  51 projects*!
- 29 projects completed

*pending DOE FSO concurrence

DOE LDRD Funding Authority and Actual Fermilab Costs

	DOE Authority		Fermilab 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:	$6.4M	2.0%	$3.8M actual (Covid suppressed)
FY21:	~$9M	3.0%	

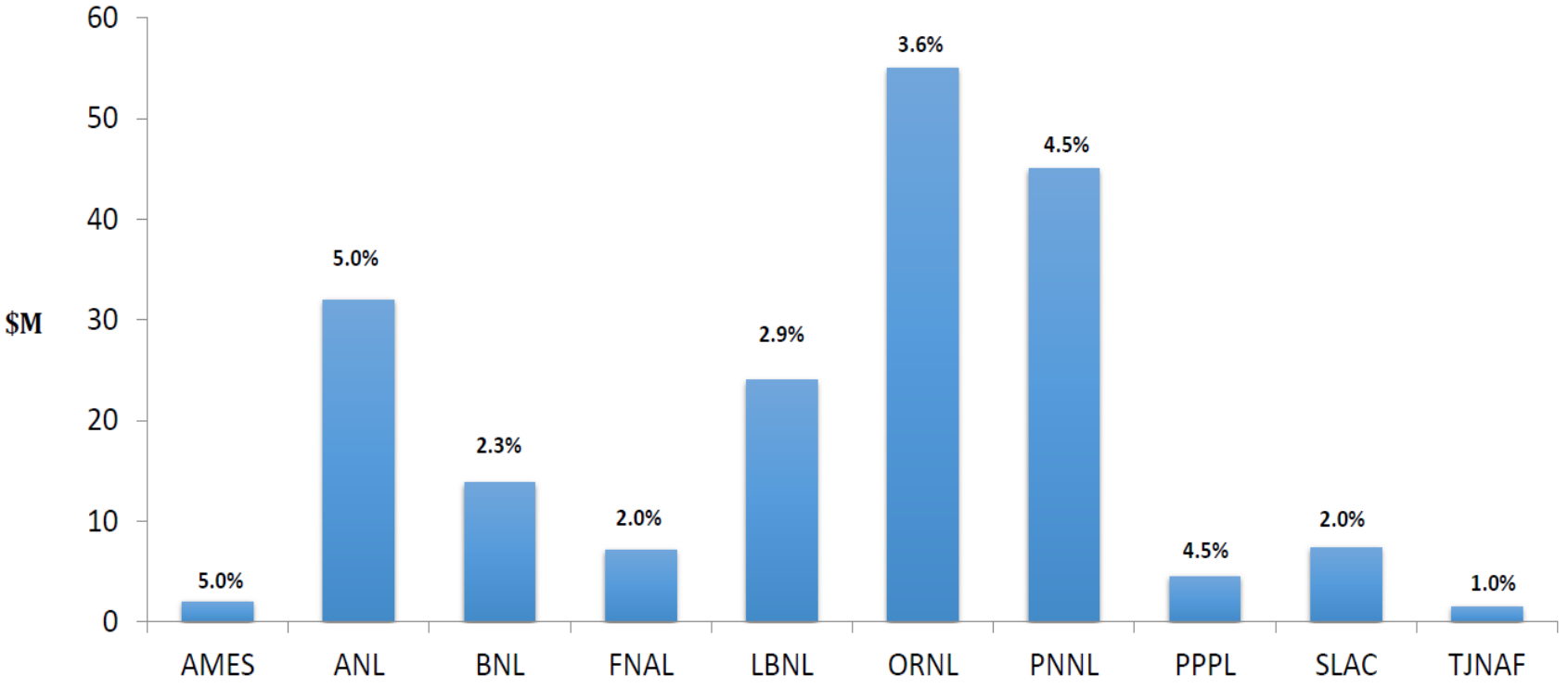
Actual LDRD burden to date (i.e. “LDRD Tax”) has been about 1.5%

New for FY21: Recognition of a directorate driven stripe for strategic and targeted infrastructure investments (e.g. dilution refrigerators) in parallel with the P.I. driven program.

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

Process

- The current in-flight program (FY18-FY20) of 39 projects was reviewed in September 2020, FSO concurrence of the in-flight program granted.
- Responsive to the June 2020 call for new proposals, 51 pre-proposals for new-starts received August 28th, 2020. Strategic guidance received.
- Following pre-proposal review, 28 P.I.s were invited to submit full proposals. 25 full proposals received.
- The committee invited remarks from each prospective new-start P.I. and deliberated on each of the 25 Full proposals in December.
- The committee identified 10 excellent projects in a new-start portfolio that caps FY21 P.I.-driven new-starts to the level of FY20 P.I. driven new-starts
- Directorate approved FY2021 new starts including two additional pilot projects in January.

Fermilab LDRD Selection Committee

Bob Tschirhart, Chair (ex officio)

Karie Badgley (APSTD, FY21 -)
Roni Harnik (SQMS/PPD, FY21 -)
Matt Hollister (APSTD, FY21 -)
Lauren Hsu (PPD, FY19 -)
Corrinne Mills (UIC-JA/PPD, FY21 -)
Jim Kowalkowski (FQI, FY19 -)
Howie Pfeffer (AD, FY21 -)
Sam Posen (APSTD, FY19 -)
Michelle Stancari (ND, FY20 -)
Matt Toups (ND, FY19 -)

Gary Drake (FY21 -) ;
Engineering Advisory Council (EAC) chair (ex officio)
Petra Merkel (FY21 -) ;
DPF Coordinating Panel for Advanced Detectors (CPAD) chair, Fermilab Detector R&D coordinator (ex officio)

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

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

APsTD (8): Boffo, Chao, Checchin, Kashikhin, Posen, Romanenko(2), Stoynev(2), Spina, Wu, Xu

IARC(1): Thangaraj

Engineer
Affiliated Technologist

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

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

SCD (10.5): Cancello, Chang, DeMar, Gray(½), Nord, Paterno(2), Peña, Purdue, Rivera, Spentzouris, Tran, Wang

*Prior to forming FQI/SQMS

New LDRD Project Starts for 2021

Approved* new-start project starts for 2021:					Total
LDRD Prop ID	PI- First	PI - Last	Lab Div/Org	Title	Project Budget ($)
FNAL-LDRD-2021-004	Brian/Yuanyuan	Nord/Zhang	SCD/PPD	Developing simulation-based Inference to enable next-generation cosmological discoveries	898723
FNAL-LDRD-2021-007	Michael	Wang	SCD	Breaking the Big Data Bottleneck and Meeting the Realtime Constraints of Multi-messenger	465366
				Astronomy in DUNE and LSST with Computational Storage and Machine Learning	
FNAL-LDRD-2021-011	Carlos	Escobar	ND	Metalenses as light concentrators in noble element detectors	395939
FNAL-LDRD-2021-013	Minerba	Betancourt	ND	Understanding neutrino-nucleus interactions with realistic nuclear models	584106
FNAL-LDRD-2021-024	Bill	Pellico	AD	Argonaut: A Robotic System for Cryogenic Environments	668153
FNAL-LDRD-2021-028	Carol	Johnstone	AD	High-Intensity Multi-slice Target Development	884000
FNAL-LDRD-2021-032	Maria	Baldini	APsTD	Novel quench detection system for High temperature superconducting magnets	479876
FNAL-LDRD-2021-035	Silvia	Zorzetti	SQMS	Preliminary study on microwave-to-optical transduction using high-Q SRF cavities	953547
FNAL-LDRD-2021-047	Rakshya	Khatiwada	FQI/IIT	Design and Engineering studies of a cryogenic weak-photon source	100000
				testbed for ultrasensitive dark matter detectors	
FNAL-LDRD-2021-048	Adam/Kirit	Anderson/Karkare	PPD	SPT-SLIM: The South Pole Telescope Summertime Line Intensity Mapper	683893
FNAL-LDRD-2021-049	Sara	Simon	PPD	Characterizing Microwave Coupling to Superconducting Detectors for the Cosmic Frontier	100846
FNAL-LDRD-2021-052	Andrew	Sonnenschein	PPD	Development of Coaxial Reflecting Optics for Axion and Hidden Photon Searches	415003
				Astronomy in DUNE and LSST with Computational Storage and Machine Learning	
	Engineer			**Total:**	**6629452**
	Under-represented				
***pending Fermilab Site Office concurrence**					

Bill Pellico's Project

Fermi National Accelerator Laboratory
LDRD Project Data Sheet – FY21

Project ID: ID FNAL-LDRD-2021-024
Project title: Argonaut: A Robotic System for Cryogenic Environments

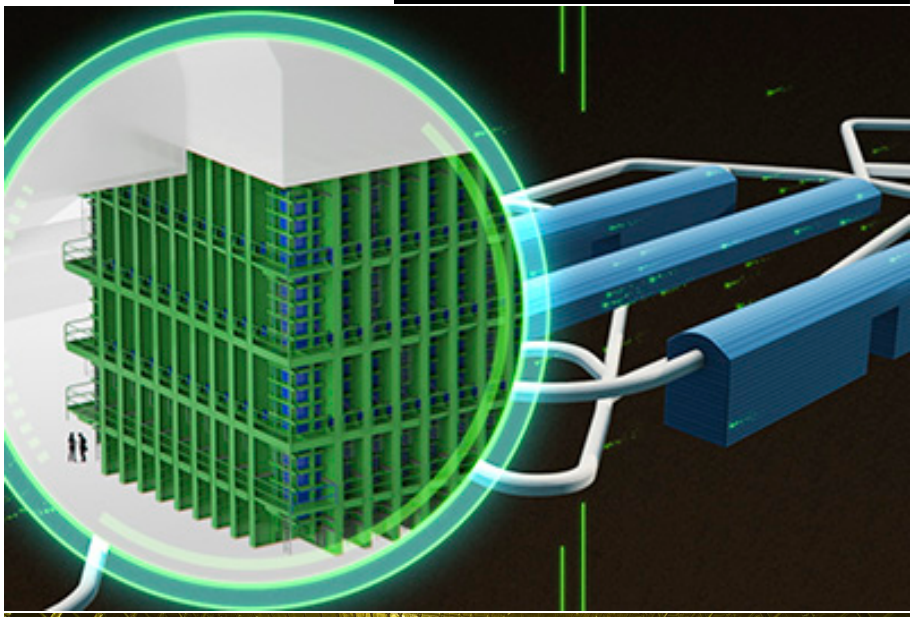
Principal investigator: William Pellico

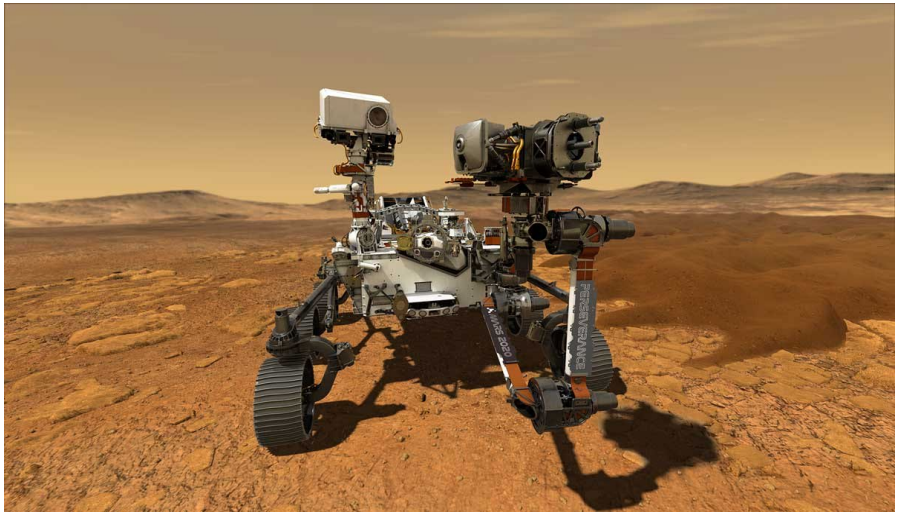
Project description: (short description and explanation of cutting edge, high-risk, high-potential science or engineering)

Fermilab and the HEP community invest significant resources into liquid argon detectors. The largest and most expensive of these detectors will be located in the Deep Underground Neutrino Experiment (DUNE). However, recent experiences have shown that there are limited avenues of monitoring, intervention and interaction in the internal liquid environment. This proposal shows a technological path that could provide a valuable tool to ensure or at least improve management of these HEP detectors. The development of a robotic system named Argonaut will demonstrate several technologies including: 1) demonstration of suitable mobility of a small robotic device at liquid argon temperatures, 2) demonstration of wireless communication, 3) demonstration of improved diagnostics capabilities – such as tunable optics with motion control, 4) demonstration of interconnectivity of a robotic system with hardware residing within the detector. We have received strong support from potential collaborators interested in similar capabilities. This work has many possible research avenues and benefits and we expect this LDRD to act as a seed for extended development in cold robotics and associated technologies. DUNE's success relies significantly upon contributions. This LDRD will allow FNAL to play a significant role in future diagnostic and detector operations management.

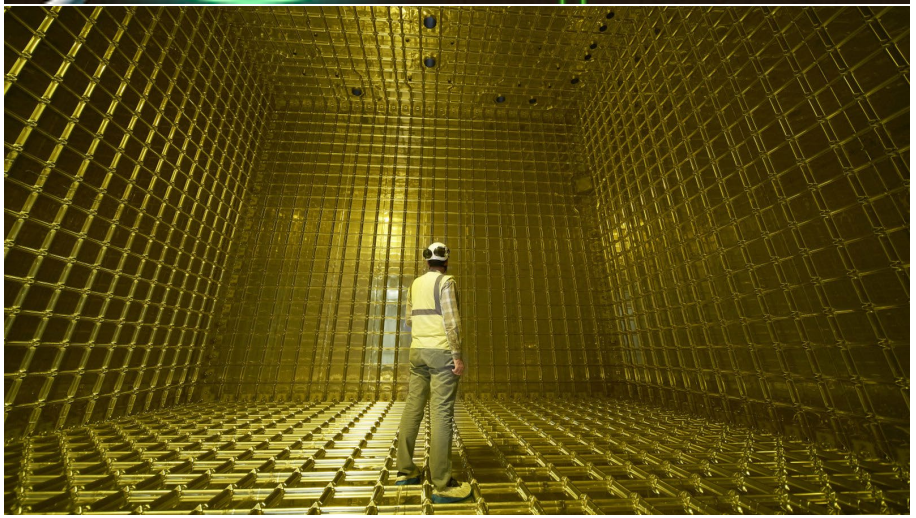
Present and Future Robots…

Courtesy MIT; searching for MH370





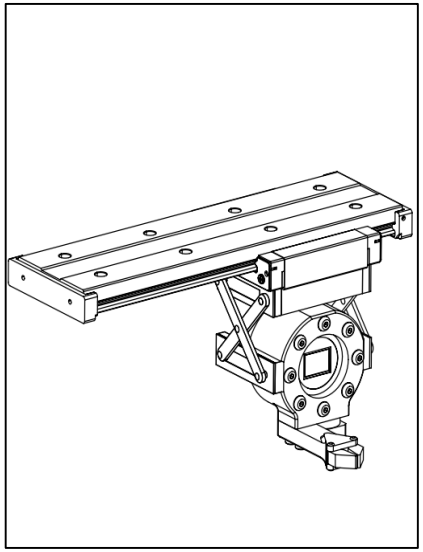
Perseverance; Courtesy NASA/JPL



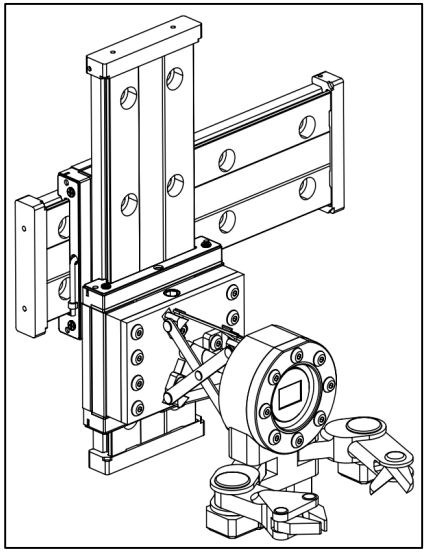
DUNE Courtesy FNAL

Argonaut Prototype Mechanical Design

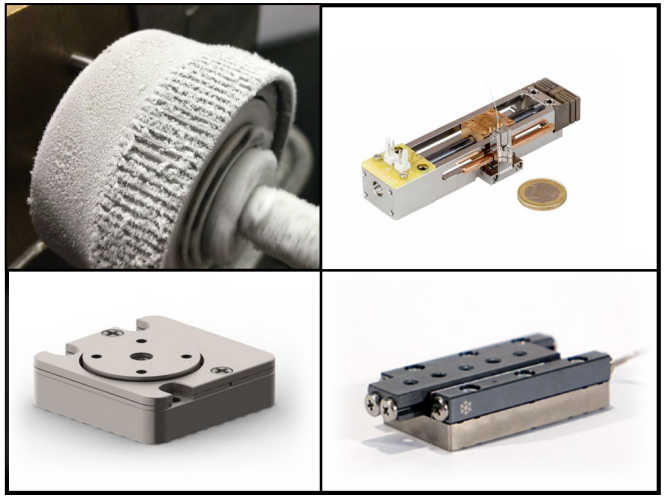
Possible Prototype Concept
- Swappable, fixed tool arm
- 2-axis motion
- Light-weight
- Power efficient
- Compact and simple to test



Future Development Concepts
- Multi-axis tool arms
- 3-axis motion
- Advanced extension mechanisms
- Detector repair capabilities
- Increased weight and power draw



5 Relevant key technologies:
- Cold gears (JPL)
- Cryo Linear Drive (CLD)
- Non-conductive linear guides
- Micro piezo stages
- Cryo compatible composites



Courtesy B. Pellico's LDRD Proposal presentation

Silvia Zorzetti's Project

Emerging Quantum Technologies

Enabling Technology discussed in the Retreat Plenary: **Manipulating the quantum state of microwave photons in multimode cavities**

Fermi National Accelerator Laboratory
LDRD Project Data Sheet – FY21

Project ID: FNAL-LDRD-2021-035

Project title: Preliminary study on microwave-to-optical transduction using high-Q SRF cavities

Principal investigator: Silvia Zorzetti

Project description:
An efficient quantum transducer that faithfully and reversibly converts optical quantum signals to microwave quantum signals could be used as an interface between superconducting-based quantum devices, such as transmon qubits, and optical photons. Despite the great potential for quantum sensors and heterogeneous quantum networks, and many theoretical studies dedicated to transduction protocols, there are relatively few demonstrations of microwave-to-optical transduction at the quantum level. Most demonstrations have demonstrated either low conversion efficiency or high noise, and thus are not suitable for quantum signals. One way to improve the efficiency of a transducer is to use high quality factor (Q) microwave cavities. Fermilab has developed bulk Nb superconducting cavities with record-high 2 second photon lifetime ($Q=10^{11}$), a significant improvement compared to previous efforts. Our interdisciplinary team will conduct an extensive study to develop a conceptual transducer design.

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 (~200 words): Project objectives, novelty, relation to mission, distinction from programmatic work.

Project Work Plan (~250 words): Overview description the work to be performed, timescale, and approximate financial/personnel resources required for each year of the proposal.

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.

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 HEP 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 (Covid!)
- Exploration of emergent technologies; e.g. Quantum Technologies, robot development, exploiting Artificial Intelligence and Machine Learning in design and operations

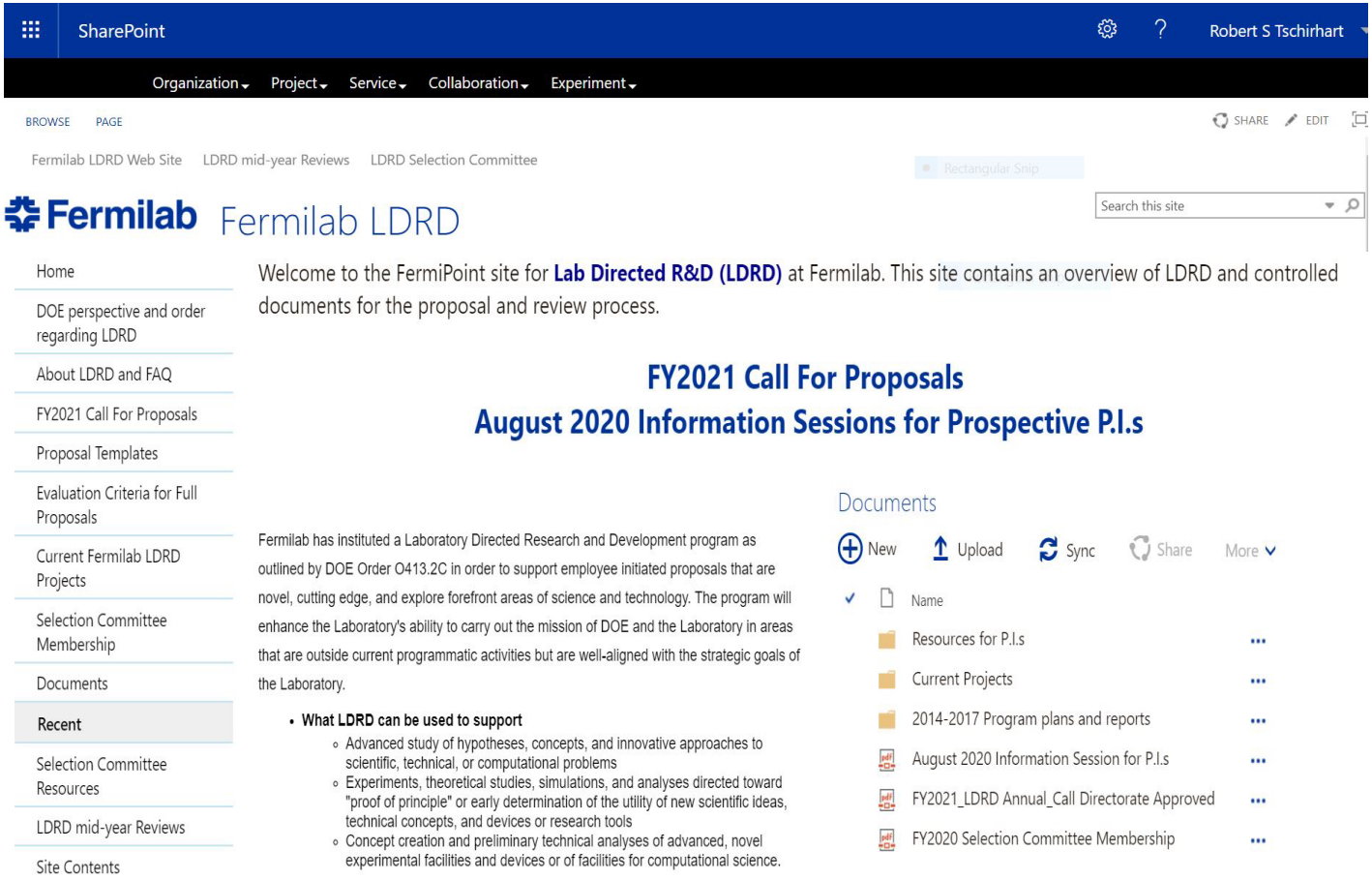
Timeline for FY-2022 Cycle

- Call for Proposals June 2021
- Preliminary Proposals due August 2021

  LDRD selection committee identifies proposals that are encouraged to advance to final proposal stage
- Final Proposals due November 2021

  LDRD selection committee identifies and recommends a suite of proposals for approval by the director
- P.I.s are notified in January 2022
- Funding available for projects to start in March 2022

Fermilab LDRD SharePoint Site



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