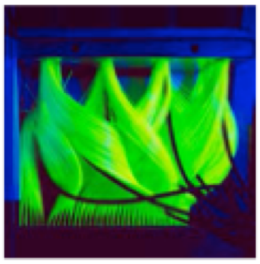
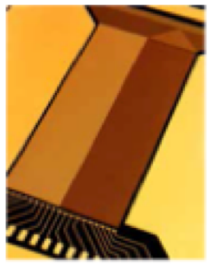
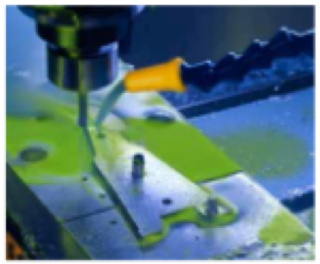
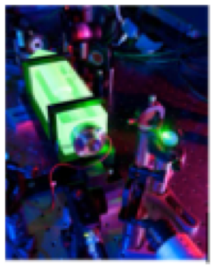
Laboratory Directed Research and Development (LDRD) at Fermilab

William Wester
LDRD Coordinator
PAC Meeting
18 Jul 2018

ldrd.fnal.gov



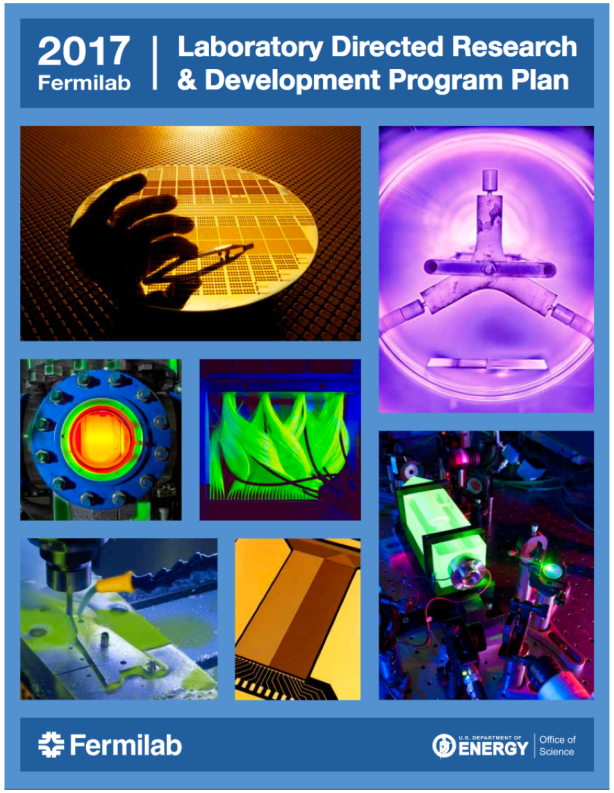






LDRD Overview

- DOE O 413.2C authorizes National Laboratories to establish a LDRD program. All DOE labs now have LDRD.
  - Maintain scientific and technical vitality
  - Encourage and act upon new ideas at forefront areas in science and technology that are aligned with the mission and strategic outlook of the Laboratory and the Department of Energy
  - Proposed projects are required:
    - To have a Fermilab employee PI (Joint App'ts OK, unpaid GS not)
    - To be outside current programmatic activities
    - To be stand-alone, i.e. cannot have other sources of funding
    - To be R&D, i.e. cannot be for construction
    - Maximum of 36 months
  - The PI manages the project in accordance with Laboratory best practices and policies.

LDRD Implementation at Fermilab

- An LDRD Advisory Committee (Fall 2013) resulted in an approved (by Director/DOE) Annual LDRD Program Plan. Since FY18, LDRD is renewed through Annual Lab Plan.
  - Call for Proposals: 1 page Preliminary / 5-6 pp. Full Proposal
  - LDRD Selection Committee evaluation
  - Lab Director approves projects
  - DOE concurs on projects through Project Data Sheets (on the web)
- Formal compliance with DOE O413.2C
  - DOE review with other National Labs
  - End of year costs / performance metrics
  - LDRD Annual Report sent to DOE
- LDRD Coordinator guides this process



LDRD Committees

LDRD Advisory Committee

William Wester (chair, LDRD Coordinator)
Ruben Carcagno
Dave Christian
Erik Gottschalk
Debbie Harris
Denise Keiner
Andreas Kronfeld
Nigel Lockyer (LDRD Champion)
Wyatt Merritt
Cherri Schmidt (LDRD Coordinator, Ass't)
Vladimir Shiltsev
Panagiotis Spentzouris

Excellent representation across Divisions and technical and managerial expertise and also reflecting laboratory diversity.

LDRD Selection Committee

William Wester, Chair (*ex officio*)
Lothar Bauerdick (FY15 -)
Estia Eichten (FY18 -)
Anna Grassellino (FY15 -)
Adam Lyon (FY14 -)
Robyn Madrak (FY18 -)
Petra Merkel (FY18 -)
Vaia Papadimitriou (FY17 -)
Bill Pellico (FY18 -)
Brian Rebel (FY16 -)
Nikolay Solyak (FY18 -)

Past Members:
John Campbell (FY14 - 17)
Lance Cooley (FY14 - 17)
Paul Derwent (FY14 - 17)
Vladimir Shiltsev (FY14 - 17)
Julie Whitmore (FY14 - 17)
Ruben Carcagno (FY14 - 16)
David Christian (FY14 - 15)
Wyatt Merritt (FY14)
Panagiotis Spentzouris (FY14)

LDRD Scoring Metric for Projects

- "Best portfolio of projects to recommend … "

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						

LDRD: Project Oversight

- PI's are responsible for managing their projects and communicating with their supervisors and management
- PI's are asked to provide short monthly status updates to the LDRD coordinator (best practice is to CC: this to their line management)
- LDRD Selection Committee also conducts mid-year reviews
  - Short presentations. Re-evaluate budgets.
  - Feedback to PI's
  - Recommendation to Director on continuation of funding
- DOE reviews updated Project Data Sheets at FY boundaries
- End-of-FY data (finances, some success metrics) to DOE
- Fermilab LDRD Annual Report with short PI Project Summaries.
- End of project reports get published and transmitted to OSTI

LDRD Projects

- FY14: 50 Preliminary, 26 Full Proposals, 7 funded, 7 completed
- FY15: 34 Preliminary, 10 Full Proposals, 6 funded, 5 completed
- FY16: 34 Preliminary, 15 Full Proposals, 7 funded, 2 completed
- FY17: 38 Preliminary, 15 Full Proposals, 9 funded
- FY18: 51 Preliminary, 20 Full Proposals, 10 funded

LDRD-2014-010	Brad Benson	Cosmic Microwave Background Detector Development at Fermilab
LDRD-2014-038	Phil DeMar	Application-Oriented Network Traffic Analysis based on GPUs
LDRD-2014-028	Juan Estrada	Deployment and operation of a prototype CCD array at Reactor Site for detection of Coherent Neutrino-Nucleus Interaction
LDRD-2014-027	Sarah Lockwitz	From Magic to Method: Characterizing High Voltage in Liquid Argon TPCs with Breakdown in liquid argon cryostat for high voltage experiments
LDRD-2014-012	Henryk Piekarz	Development of HTS Based Rapid-Cycling Accelerator Magnets
LDRD-2014-016	Greg Saewert	HF GaN Driver
LDRD-2014-025	Bob Zwaska	The Sinuous Target
LDRD-2015-020	Ryan Rivera	Off-the-Shelf Data Acquisition System
LDRD-2015-029	Sam Posen	Nb_3Sn superconducting RF cavities to reach gradients up to 90MV/m and enable 4.2K operation of accelerators
LDRD-2015-021	Victor Scarpine	Transverse and Longitudinal Profile Diagnostics for H- Beams using Fiber Lasers and Synchronous Detection
LDRD-2015-010	Marcelle Soares-Santos	Dark Energy Survey and Gravitational Waves
LDRD-2015-031	Alexander Valishev	A comprehensive investigation of a transformational integrable optics storage ring as a "smart" rapid cycling synchrotron for high-intensity beams
LDRD-2015-009	Michael Wang	High Energy Physics Pattern Recognition with an Automata Processor

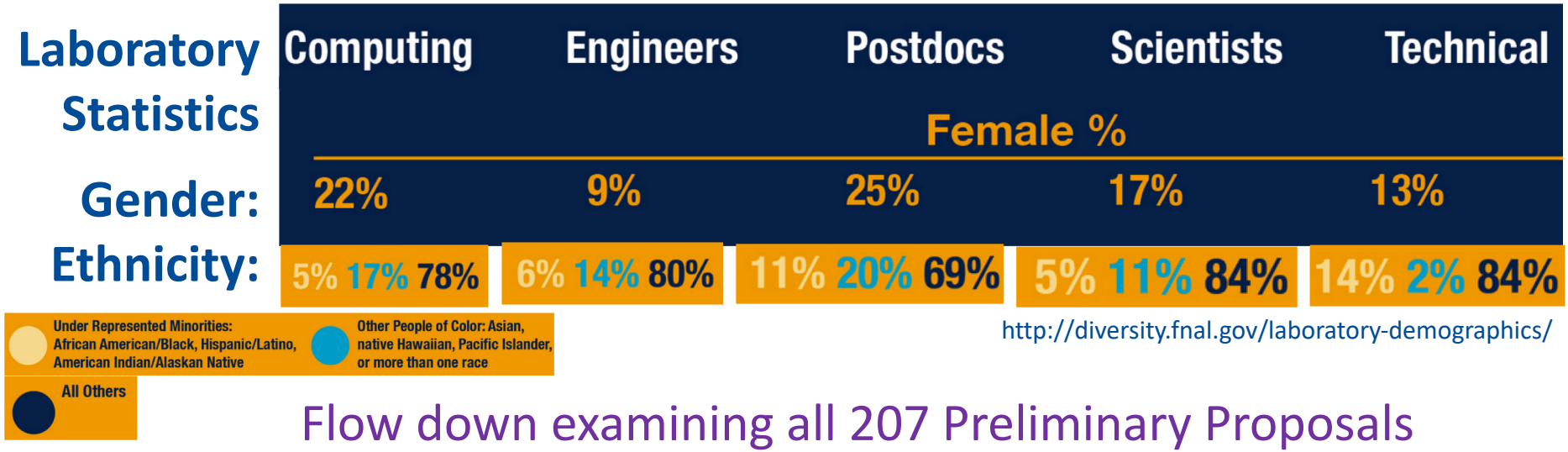
CMB at FNAL
Intel. property
Science paper
New hire + test stand
Work w/CERN
PIP2 use
Future targets
DAQ in use at TestBeam
Early Career Award
For FAST beam profile
Science result of 2017
Ongoing, postdoc hire
Work with Micron Semi.

LDRD Projects – FY16 through FY18

In use in Acc Division
Foundation supported

Prebys	Eric	Beam Precision Time Profile Monitor
Tiffenberg	Javier	Development of an ultra low energy threshold particle detector
Sonnenschein	Andrew	Tuning Axion Detectors with Non-Linear Dielectrics
Wu	Genfa	Novel Methods for High Performance Superconducting Coating on Copper
Paterno	Marc	Preparing HEP reconstruction and analysis software for exascale era computing
Chang	Jin	Implement open source HEP NoSQL database
Chattopadhyay	Swapan	Instrumentation for the Initial set of Critical Scientific Experiments in IOTA and the FAST Injector
Estrada	Juan	Optical Microwave Kinetic Inductance Detectors for future cosmic surveys
Niner	Evan	Training Deep Neural Networks for Neutrino Identification in the Cloud
Fava	Angela	LArCADe _ Liquid Argon Charge Amplification Devices
Chou	Aaron	Cryogenic photon sensors for the low mass frontier
Thangaraj	Jayakar	First demonstration of conduction cooled SRF Cavity
Xu	Xingchen	Development of next-generation Nb3Sn superconductors for accelerator magnets
Apresyan/Gray	Artur/Lindsey	Silicon precision timing detectors for minimum ionizing particles
Cancelo	Gustavo	R&D plan to increase the DUNE Photon Detector light efficiency an order of magnitude
Romanenko	Alexander	Quantum Computing using SRF Technology
Dahl	Eric	A scintillating liquid argon bubble chamber for WIMP and coherenet neutrino scattering detection
Nord	Brian	Modeling Physical Systems with Deep Learning Algorithms
Kashikhin	Vladimir	High Temperature Superconducting Magnet with Circular Coils
Rusu	Vadim	Broadband spectral sensitive graphene photodetector
Stratakis	Diktys	Increasing the intensity of muon based experiments using wedge absorbers
Spentzouris	Panagiotis	Towards a Quantum Computing Science Center at Fermilab
Estrada	Juan	Development of 10kg Skipper-CCD experiments
Timpone	Stephanie	Dark Matter as Sterile Neutrinos Search Satellite
Peña	Cristián	Quantum Networks Using Time-bin Photonic Qubits
Johnson	David	A Quasi-CW bunch-by-bunch H- Neutralization Laser System for Longitudinal Phase Collimation in Linacs and other Applications

LDRD Projects – Diversity Statistics



http://diversity.fnal.gov/laboratory-demographics/

Flow down examining all 207 Preliminary Proposals

Male PI	Female PI
182 (88%)	25 (12 ± 3%)
77 Full Proposals (42%)	11 Full Proposals (44 ± 13%)
35 Funded (45%)	4 Funded (36 ± 18%)

Funded proposals include 6 from under represented minorities (15%)
and 6 from other people of color (15%)
and 27 from all others (70%)

Note: capture of gender and ethnicity done as best effort

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LDRD Projects well-distributed across Divisions

PPD (10): Benson, Estrada(1½), Soares-Santos, Tiffenberg, Sonnenshien, Chou, Apresyan(½), Dahl, Rusu, Timpone

Neutrino (3.5): Lockwitz, Niner, Fava, Estrada(1½)

Accelerator (10): Piekarz, Saewert, Zwaska, Scarpine, Valishev, Prebys, Chattopadhyay, Kashikhin, Stratakis, Johnson D.

Technical (5): Posen, Wu, Xu, Romanenko, Thangaraj

Computing (9.5): DeMar, Rivera, Wang, Paterno, Chang, Cancello, Gray(½), Nord, Spentzouris, Peña

- Cross-divisional work enabled (many examples of cross Divisional activities especially with Computing.)
- Director initiated “projects” (Benson, Chattopadhyay, Romanenko, Nord, Spentzouris, Estrada, Peña)

LDRD: the money nationally (2017)

Laboratory	Total Lab Certified Cost Base ($M)	LDRD Costs ($M)	LDRD Rate (%)	Projects
Ames Lab	56.62	1.17	2.07%	9
Argonne National Lab	697.65	33.08	4.74%	146
Brookhaven National Lab	518.93	10.36	2.00%	47
Fermi National Accelerator Lab	315.12	3.77	1.20%	23
Idaho National Lab	987.24	22.69	2.30%	84
Los Alamos National Lab	1,977.99	115.76	5.85%	299
L. Berkeley National Lab	759.06	25.49	3.36%	90
L. Livermore National Lab	1,578.16	92.63	5.87%	215
National Renewable Energy Lab	350.64	14.36	4.10%	80
Oak Ridge National Lab	1,266.89	40.90	3.23%	186
Pacific Northwest National Lab	916.17	43.31	4.73%	211
Princeton Plasma Physics Lab	84.47	2.77	3.28%	25
SLAC National Accelerator Lab	252.93	3.51	1.39%	31
Sandia National Labs	2,885.12	154.74	5.36%	344
Savannah River National Lab	195.80	9.57	4.89%	57
Thomas Jefferson National Accelerator Facility	111.48	0.68	0.61%	4
TOTAL LDRD	$ 12,954.27	$ 574.79	4.44%	1,851

max approved actual

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%, in progress

FY19: ~5.7M 1.9%, current Call

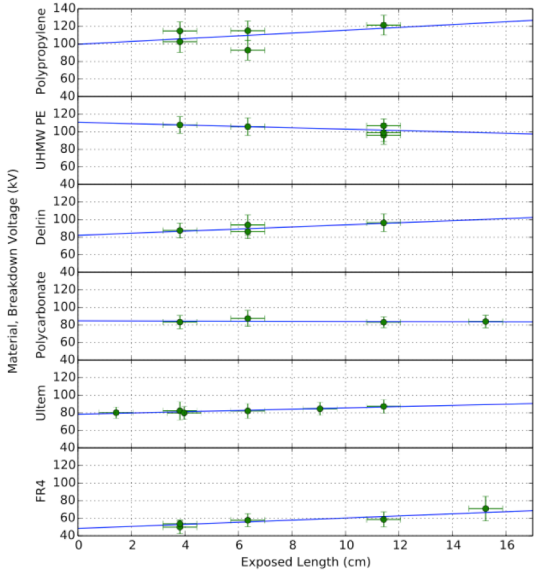
Actual amount spent (i.e. “LDRD Tax”) is about 1.6%.

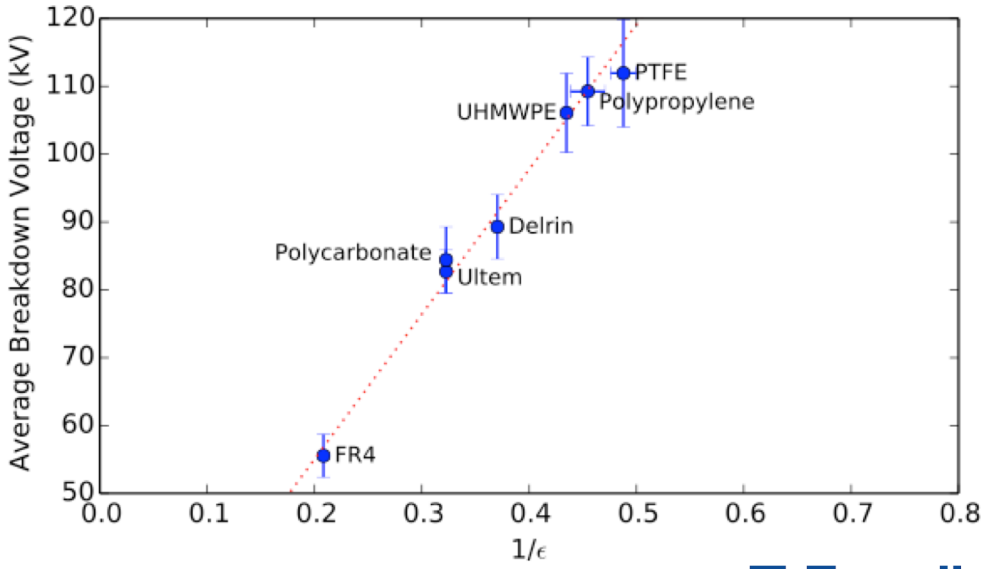
Some recent growth due to initiatives lead by the Directorate such as Quantum Information. Slow growth to perhaps 2.5% level is expected.

Note: LDRD pays back into the overhead pool as well.

Look at the Completed Projects

- Sarah Lockwitz, “Liquid Argon HV”
  - Demonstrated and quantified key features of HV breakdown in liquid argon relevant for future neutrino experiments
  - Publication accepted in JINST
  - All the positives of having a postdoc take charge of her 1st project
  - Left a viable liquid noble gas test stand that will be useful for future detector R&D with noble liquids.





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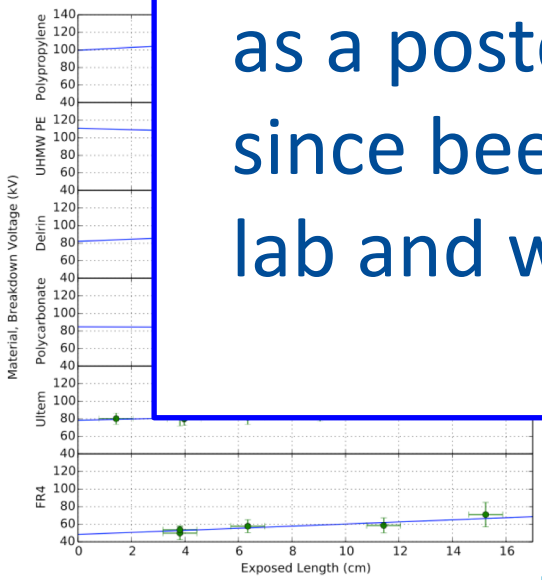
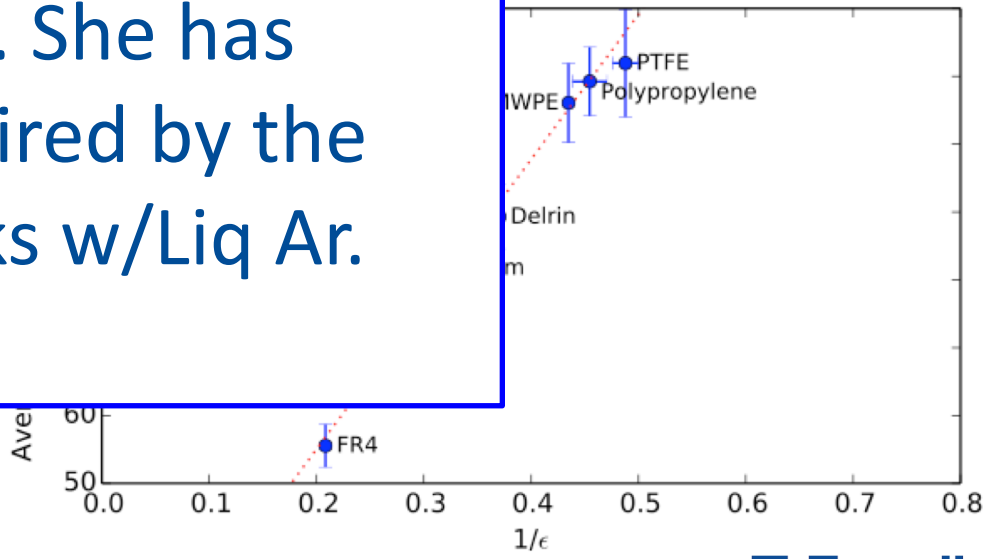
Look at the Completed Projects

- Sarah Lockwitz, “Liquid Argon HV”
  - Demonstrated and quantified key features of HV breakdown in liquid argon relevant for future neutrino experiments
  - Public
  - All the rge of her 1st project
  - Left a ill be useful for future

Nice success story as Sarah was the first PI as a postdoc. She has since been hired by the lab and works w/Liq Ar.





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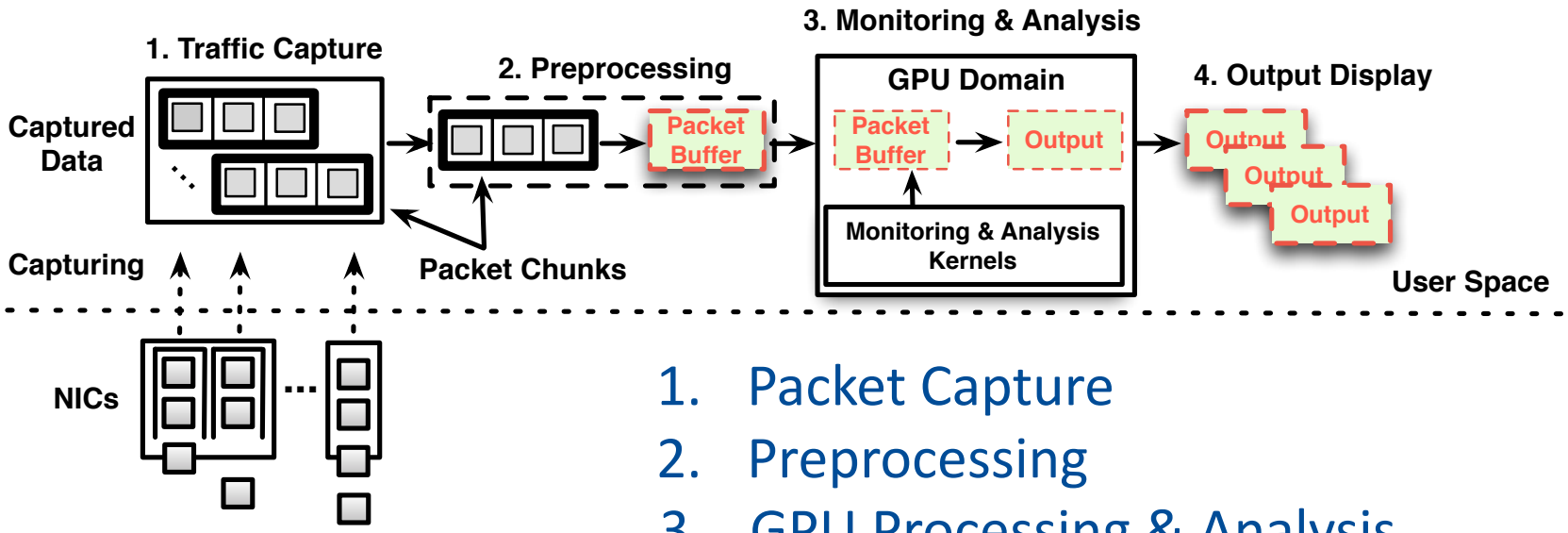
Look at the Completed Projects

- Phil DeMar, “Network Traffic Analysis on GPU”



1. Packet Capture
2. Preprocessing
3. GPU Processing & Analysis
4. Output (SDN controller configuration)

Successful demonstration at 40GE, provisional patent filed for the packet capture engine, WireCap. Publication accepted. Funding opportunity for further work under DOE (ASCR) IJC3 R&D activity pending availability of funds.

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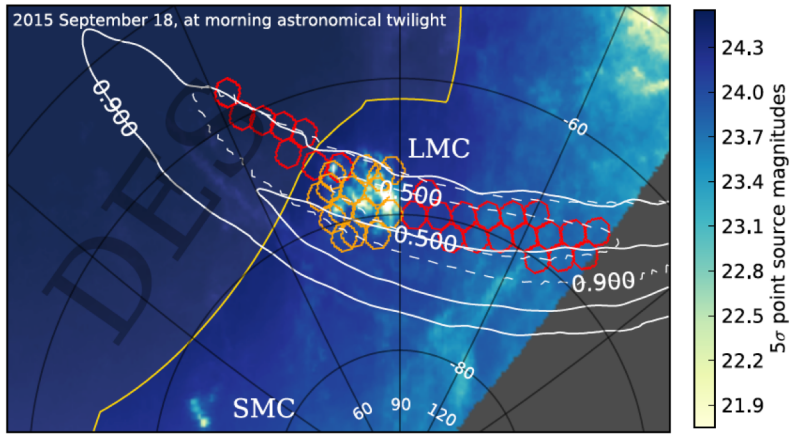
Look at the Completed Projects

- Marcelle Soares-Santos, "Dark Energy Survey and GWs"



In response to a GW trigger (esp. from neutron stars merging) perform wide area optical follow-up to find the source. Use multi-messenger and the "standard siren" to extract cosmology.

Timely project with the LIGO first GW observation. The LDRD project had started and a search was made triggered by 1st LIGO events.

Telescope time awarded, new image processing software, FermiGrid employed, pre-LSST transient sky program. 3 publications so far.

Initial follow-up funding received (U Chicago Strategic Seed Grant).
Then success in 2017 with the binary neutron star merger! Fame!

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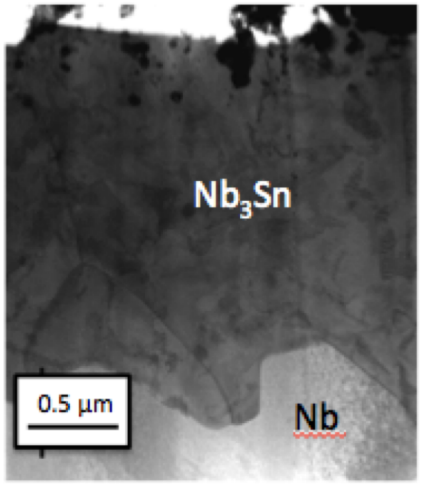
Look at the Completed Projects

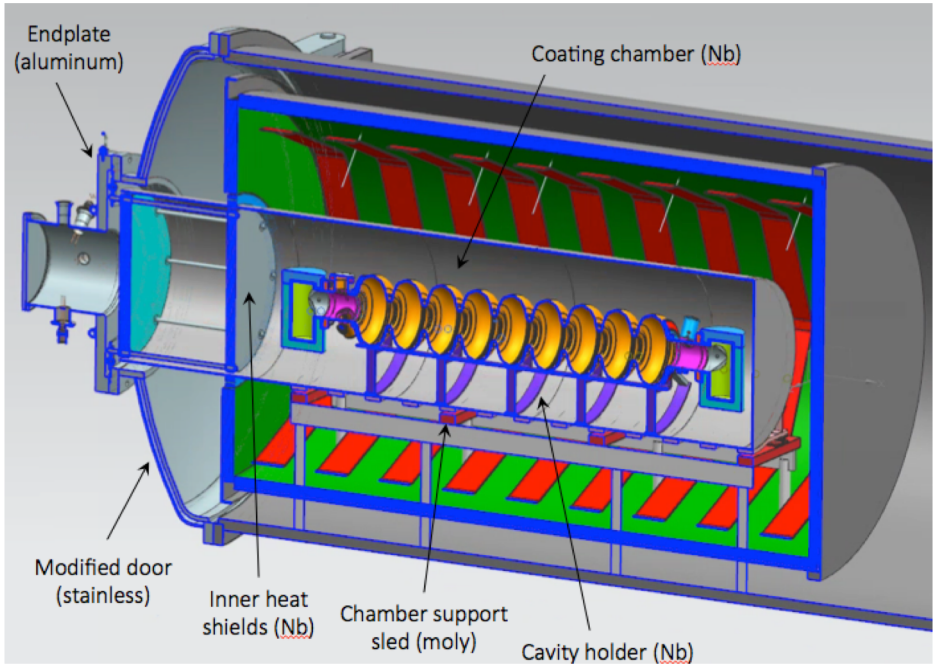
- Sam Posen, "Nb_3Sn superconducting RF Cavities"

Much higher Q, higher gradients, higher T operations (less cryo!)

Nb_3Sn coating chamber and analytics to develop best recipe



C. Becker et al., *App. Phys. Lett.*, 106, 082602 (2015)



LDRD Project objectives to be completed under Sam Posen's DOE Early Career Award!

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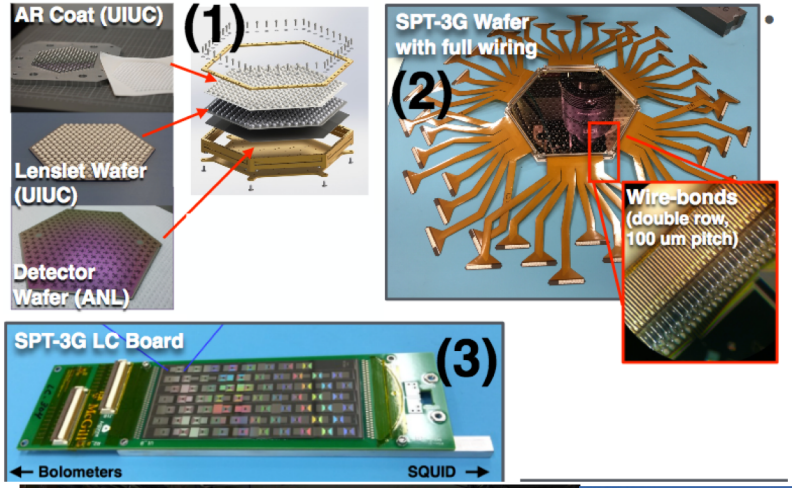
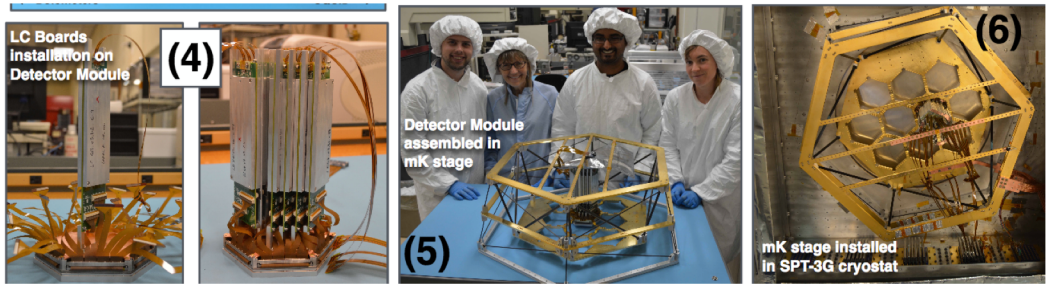
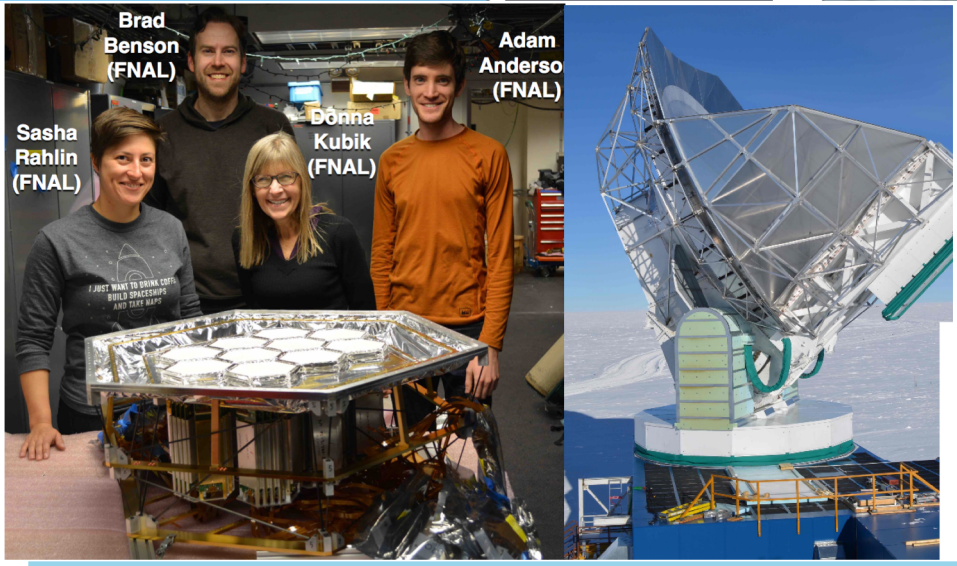
Look at the Completed Projects

- Brad Benson, “CMB Detector Development and test”



Large scale detector packaging for SPT-S3. Preparations for CMB-S4





LDRD successful in demonstration of development of large CMB focal plane. Ultimately this has lead to the installation at the South Pole.

Fermilab is well-positioned to contribute to CMB-S4

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Look at the Completed Projects

- Javier Tiffenberg, “Ultra low noise, low threshold CCD detector”

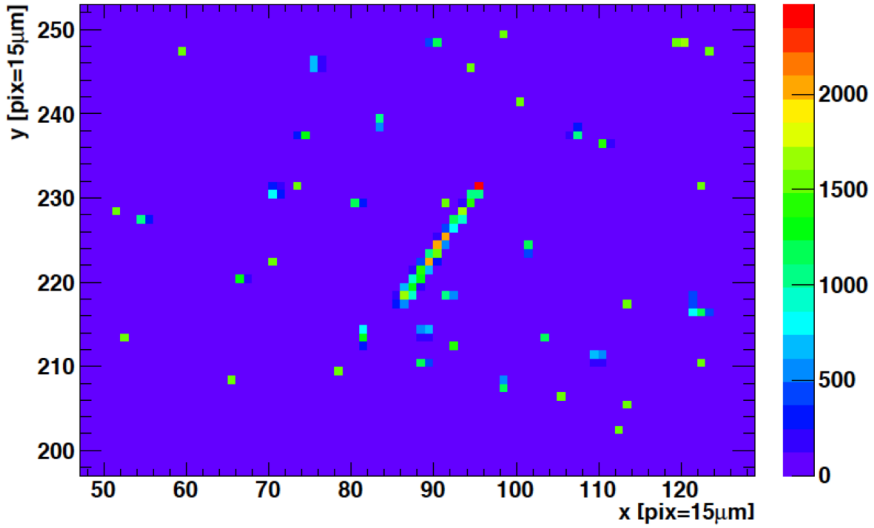
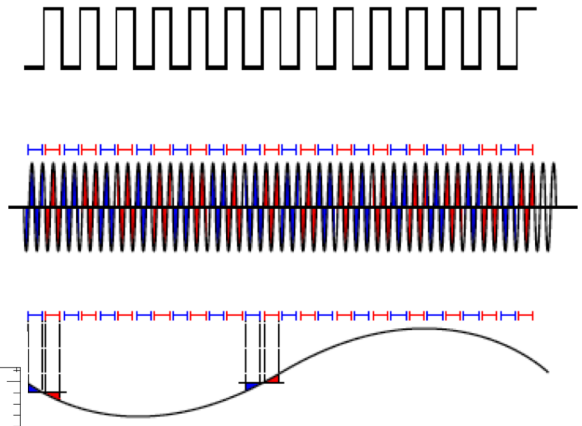
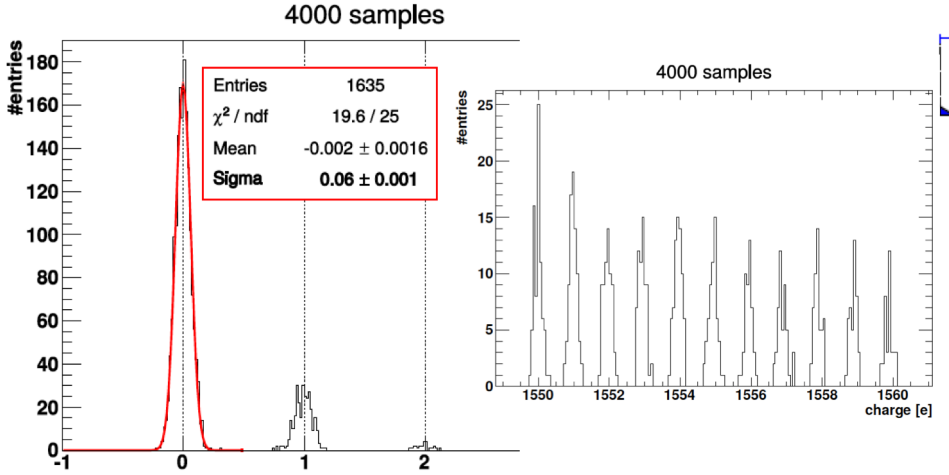


Image taken with a “Skipper CCD” showing a likely cosmic particle track and low energy x-rays.



“Skipper CCD” allows for N sampling of the same pixel



This has lead to a low mass dark matter search proposal and external foundation support- SENSEI !

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Look at a couple recent projects: Quantum Computing

- Alex Romanenko, “Quantum Computing using SRF cavities”
  - Qbit lifetime in high Q cavity might be a game-changer
- Aaron Chou, “Photon sensors for the low mass frontier”
  - Essentially noiseless detector might enable high mass axion search exp’t

	What:	Target R&D	Unique Capability	Funding source
	ADR (50 mK)	MKIDs for optical cosmo.	SiDet focal plane packaging	KA25 LDRD
	ADR (50 mK), He-3 fridges (1K)	SPT, CMB-S4	SiDet detector integration	LDRD
FY17-18	Dilution fridge (10 mK)	Qubit-based photon detectors for axions	High field magnet* (>14 T)	LDRD
FY17-18	Dilution fridge (10 mK)	Materials studies for high Q SRF cavities	SRF surface processing facility	LDRD
FY17-18	Dilution fridge (10 mK)	Active veto for WIMP detectors, low threshold calorimetry	Underground** in NUMI (30 m.w.e.)	Northwestern, KA25 (install) KA23 (G3 DM)

Strategy for the low temperature frontier to be mutually beneficial to HEP and future DOE areas such as quantum computing

LDRD at Fermilab: Conclusions

- LDRD now part of lab culture Fermilab
  - 25 current projects being supported
    - Some additional ideas funded programmatically
  - Very positive feedback from employees on LDRD opportunities
- Equilibrium established with starting / finishing projects
  - Slow growth to LDRD to further Director-lead initiatives and to continue to allow an open call
  - Initial successes on completed projects – some already with follow-up funding
- LDRD-fest! Seminars
  - Apr 3 2015, May 20 2016, Mar 31 2017, and Jun 22 2018
- As always, questions, concerns, follow-ups are welcome
  - wester@fnal.gov http://ldrd.fnal.gov