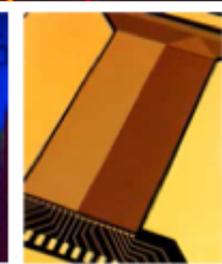
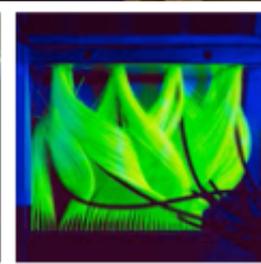
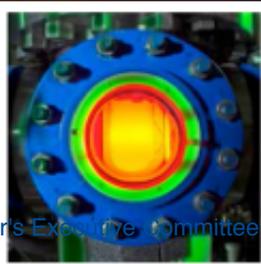


R&D possibilities at Fermilab



William Wester
Users Meeting
12 Jun 2019

ldrd.fnal.gov



Introduction

- **Fermilab** is focused on LBNF/DUNE and PIP-II and executing other projects in energy, intensity, and cosmic frontiers. There are also R&D opportunities in which the community can participate.
- I am presenting as the Laboratory Directed Research and Development (LDRD) Coordinator (rotating off to Bob Tschirhart (tsch@fnal.gov)). Web site: ldrd.fnal.gov
- There are opportunities in individual subject areas and opportunities supported by a variety of organizations.
- LDRD is a DOE program for national laboratories and its employees. There are opportunities for the larger Fermilab community to participate in LDRD and it's encouraged.

Test Beam and Detector R&D

- On the Fermilab Test Beam facility, see [slides](#) from Evan Niner earlier today
- see [slides](#) from Petra Merkel 51st Users Meeting
- Research Facilities:
 - Silicon Detector Facility (SiDet)
 - Precision Metrology
 - Common Detector Facility (Scintillators, thin films, photo detectors)
 - Noble Liquid Detector Development
 - Rapid Prototyping and Special Materials
 - ASIC Development Group / electronics



Instrumentation schools and seminar series

Partnerships with universities and other labs benefit all

Quantum and Computing R&D

- On Quantum Information Science, see talk by Joe Lykken at the end of the users meeting
 - On computing R&D, see [slides](#) from Adam Lyon
- And also see earlier talks today by Knoepfel and Goncalves

Broad program with many different funding sources such as DOE-ASCR, exascale computing project, etc.

- Physics and detector simulations with advanced architectures and techniques
- Accelerator Modeling on HPC
- Evolution of Infrastructure Frameworks (CMS, DUNE) and Root
- HPC, Advanced architectures/accelerators, multithreading
 - Containerization
 - HEP Data Analytics
 - Reconstruction
 - Spack & SpackDev [HPC compatible packaging]
- Machine Intelligence
- Data Acquisition
- Advanced networking (BigData Express)
- Workflow (HEPCloud)
- Certainly there is a healthy accelerator R&D program
- Note: some efforts are being funded by foundations and other non-traditional sources

LDRD Introduction

- Think of LDRD as the Fermilab internal small grants program for cutting edge research
- The Department of Energy allows national labs to have and administer a “Laboratory Directed Research and Development,” LDRD, Program under DOE Order 413.2C
 - Maintain scientific vitality at the laboratory
 - Novel, cutting edge, demonstration, high risk/high reward projects at the forefront of science and technology.
 - Projects must be outside current programmatic activities and relevant to the missions of FNAL and DOE.
 - Maximum duration is 36 months.

FNAL LDRD Projects – now with 7th Call for Proposals

- Inception for LDRD at FNAL was 2014
- 251 new ideas generated, 52 projects funded with about 30% having university involvement

LDRD program at Fermilab continues to grow. Eventually, to perhaps 2.5%.

FY14: \$0.2M actual

FY15: \$2.2M actual

FY16: \$3.3M actual

FY17: \$3.8M actual

FY18: \$4.6M actual

FY19: current year (1.9%)

About 25-30 active projects

LDRD activities exist across all major scientific and technical Divisions at Fermilab.

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

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

Accelerator (13): Piekarz, Saewert, Zwaska, Scarpine, Valishev, Prebys, Chattopadhyay, Stratakis, Johnson D., Nagaitsev (2), Stoynev, Madrak

Technical (8): Posen, Wu, Xu, Kashikhin, Romanenko, Thangaraj, Checcin, Chao

Computing (11.5): DeMar, Rivera, Wang, Paterno, Chang, Canello, Gray(1½), Nord, Spentzouris, Peña, Purdue

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

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

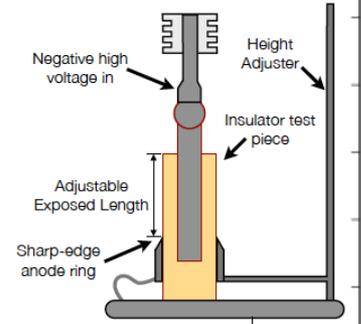
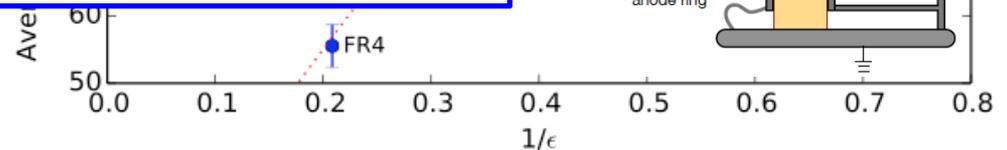
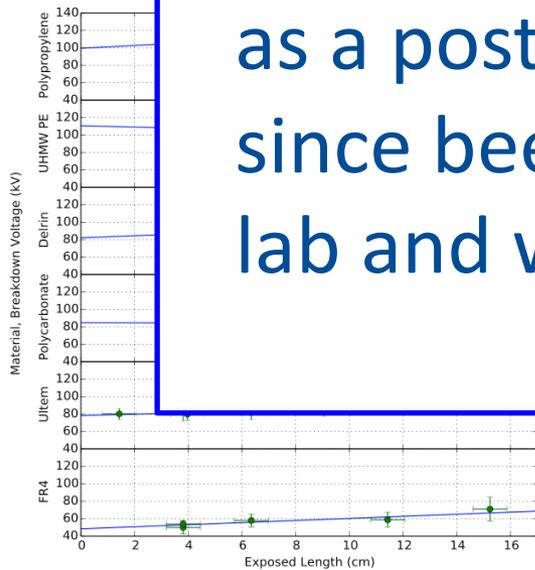
- Sarah Lockwitz, “Liquid Argon HV”
 - Demonstrated and quantified key features of HV breakdown in liquid argon relevant for future neutrino experiments

- Public
- All the
- Left a 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.

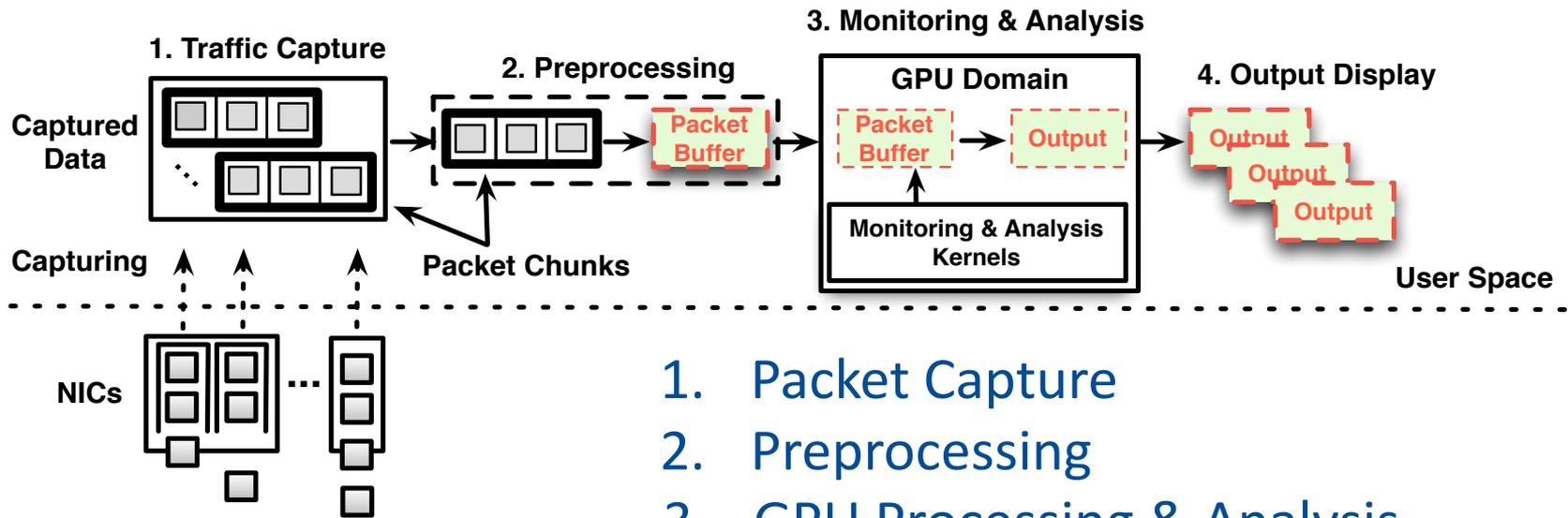


... of her 1st project
... be useful for



Look at the Completed Projects

- Phil DeMar, “Network Traffic Analysis on GPU”

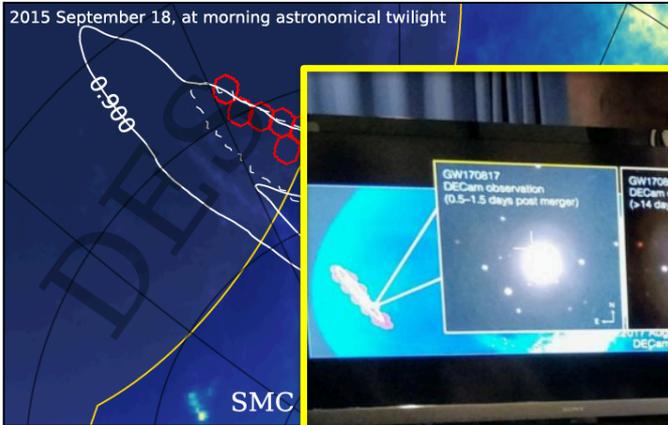


1. Packet Capture
2. Preprocessing
3. GPU Processing & Analysis
4. Output (SDN controller configuration)

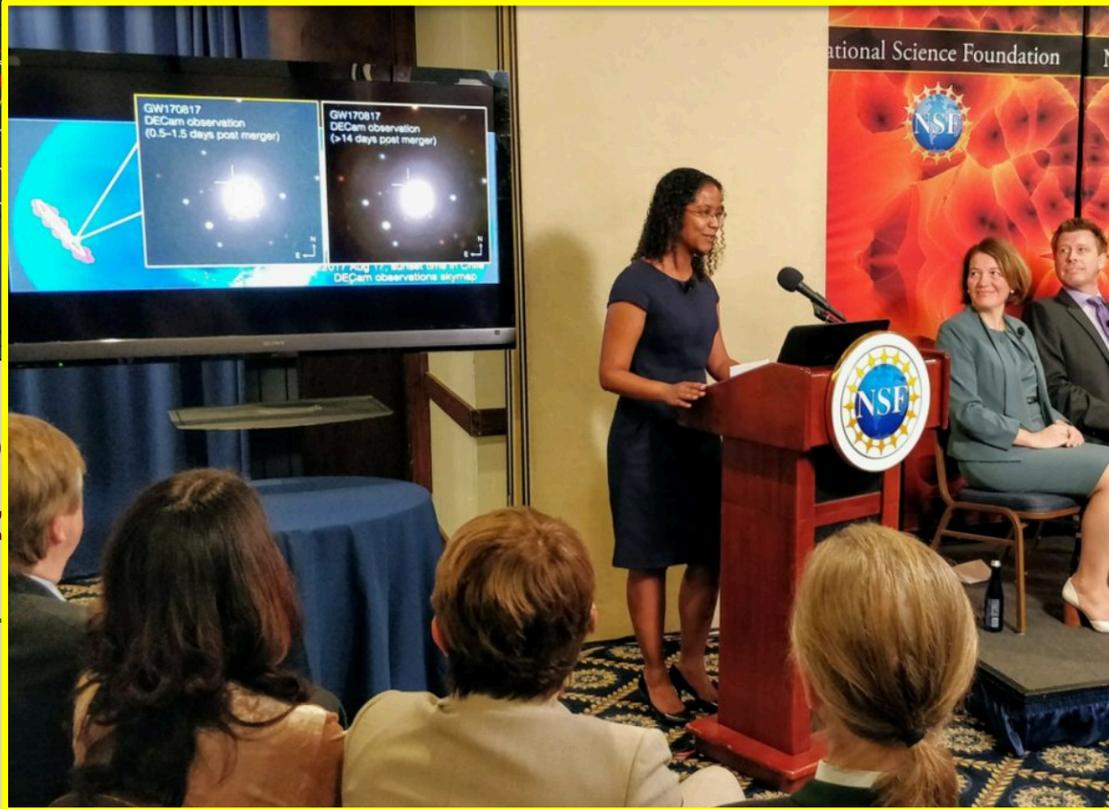
Successful demonstration at 40GE, provisional patent filed for the packet capture engine, WireCap. Publication accepted. On track for issuance of patent and another record of invention is in process for the GPU component.

Look at the Completed Projects

- Marcelle Soares-Santos, “Dark Energy Survey and GWs”



24.3



In response to a GW trigger (esp. from perform wide to find the messenger and the tract cosmology.

Timely project had started

Telescope employed,

the LDRD project GO events.

are, FermiGrid ons so far.

Initial follow-up funding received (U Chicago Strategic Seed Grant).

Then success in 2017 with the binary neutron star merger! Fame!

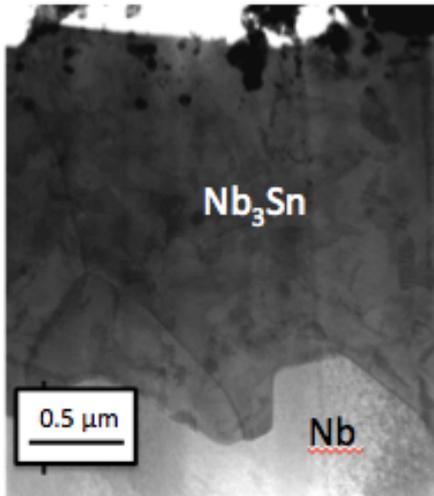
Look at the Completed Projects

- Sam Posen, “Nb₃Sn superconducting RF Cavities”

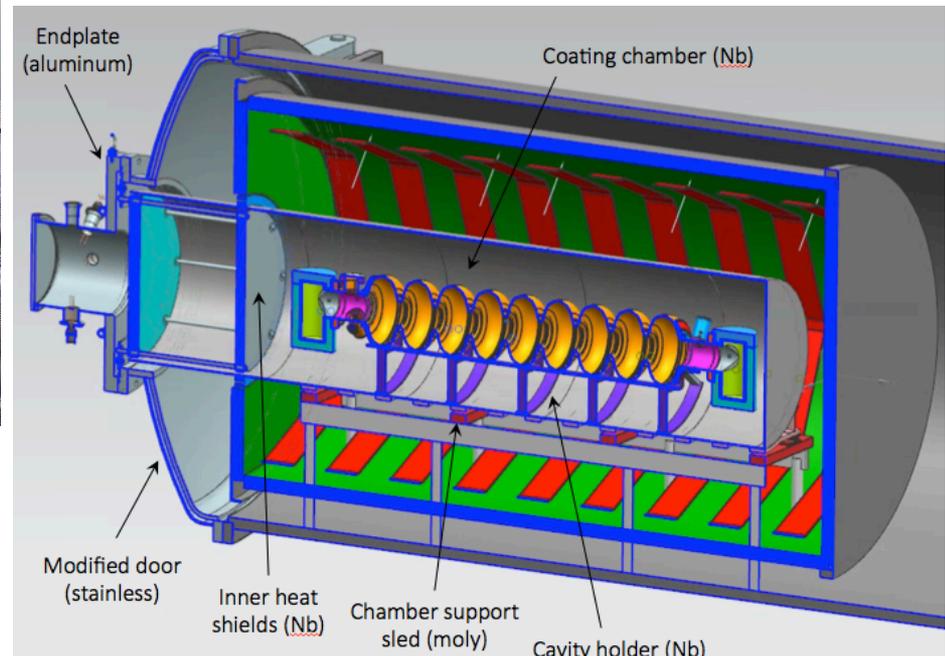
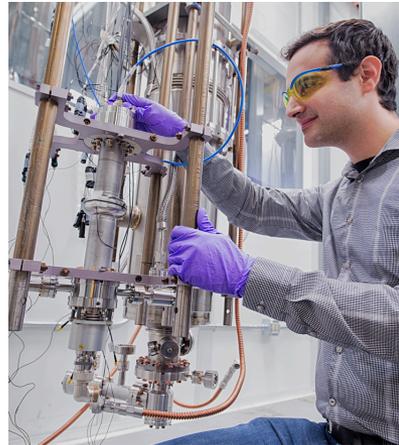
Much higher Q, higher gradients,
higher T operations (less cryo!)



Nb₃Sn coating chamber and analytics
to develop best recipe



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

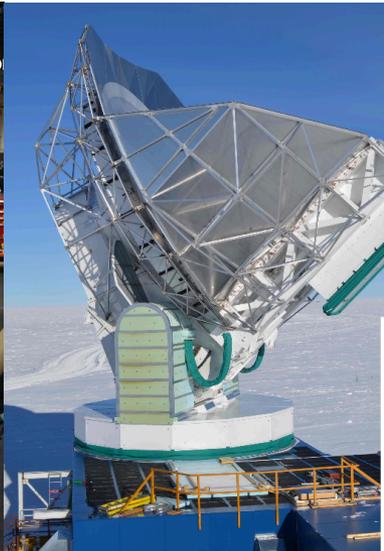
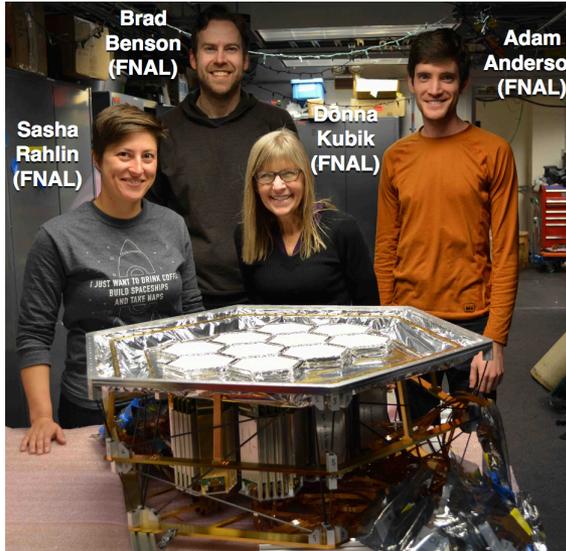
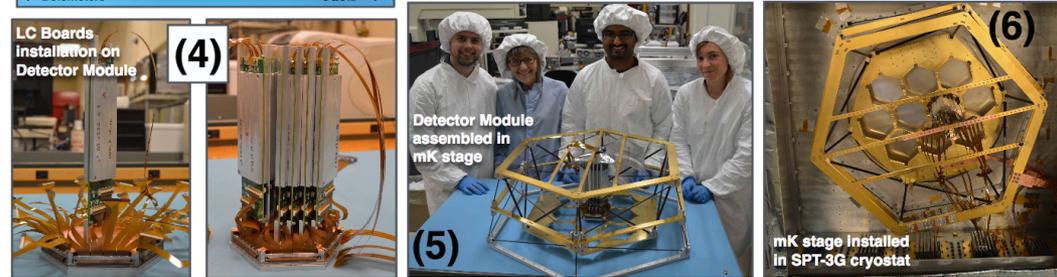
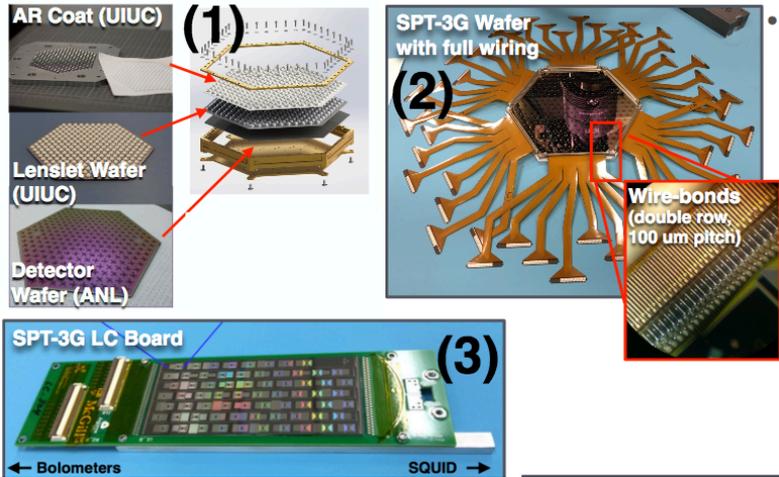


LDRD Project objectives to be
completed under Sam Posen's
DOE Early Career Award!

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



Look at the Completed Projects

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

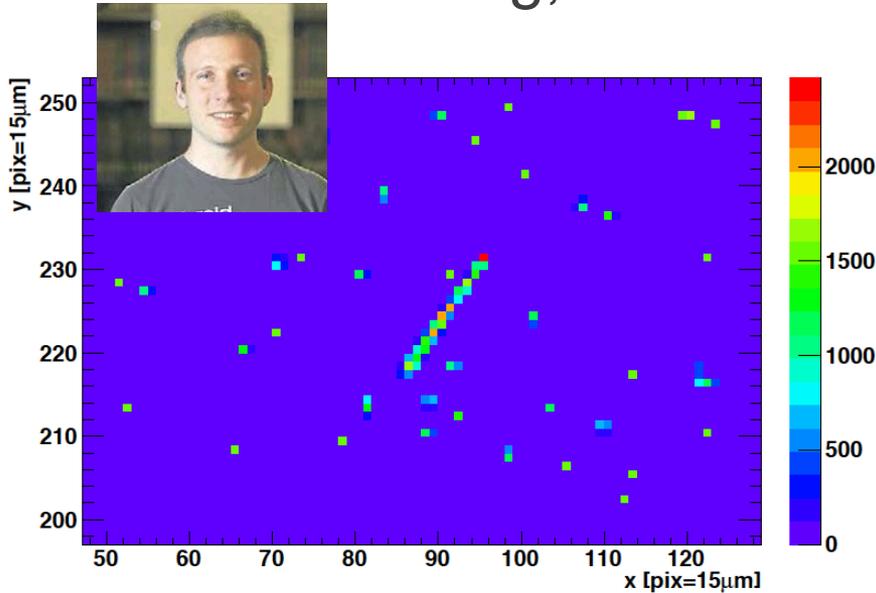
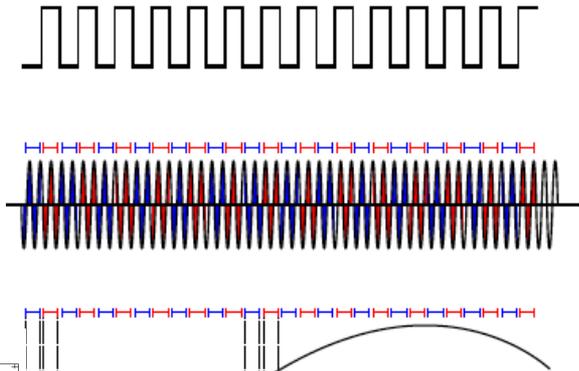
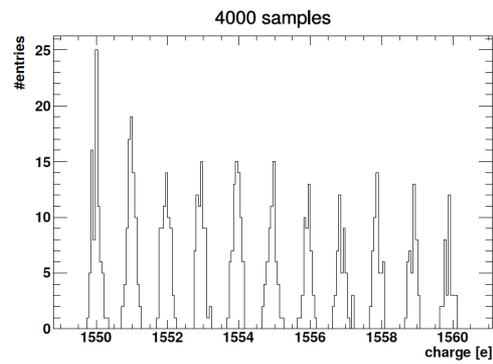
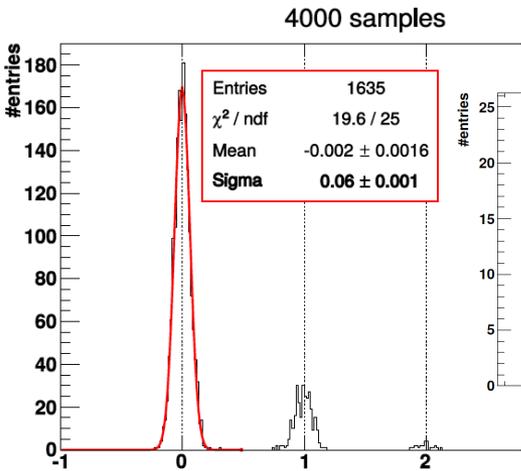


Image taken with a “Skipper CCD” showing a likely cosmic particle track and low energy x-rays.



“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 ! Early Career Award!



Look at a couple recent projects: Quantum Computing

- FY17 Alex Romanenko, “Quantum Computing using SRF cavities”
 - Qbit lifetime in high Q cavity might be a game-changer
- FY 17 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 <u>cosmo.</u>	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 <u>axions</u>	LDRD
	Dilution fridge (10 mK)	Materials studies for high Q SRF cavities	LDRD
	Dilution fridge (10 mK)	Active veto for WIMP detectors, low threshold <u>calorimetry</u>	Underground** in NUMI (30 <u>m.w.e.</u>)
			Northwestern, KA25 (install) KA23 (G3 DM)

- FY 18 Panagiotis Spenzouris, “Quantum Computing Science Center”
 - Support for performing HEP calculations on Quantum Computers
- FY 18 Cristián Peña, “Quantum networks”
 - Looking to advance quantum communication (entanglement) by 20%

To be decided ... the extent that these initiatives become programmatic

LDRD and Universities

- LDRD is for the Laboratory and requires a laboratory employee or joint appointment to serve as the PI
- Collaborations w/Universities are welcome and encouraged to participate
 - LDRD can provide funding as any other laboratory project
 - University members may participate as with other projects
 - A project DOES need to be stand alone with the laboratory providing the sole funding. With that said, there are often related opportunities
 - Universities should be mindful of the expectations of their sponsors
- The most successful projects will have a strategically impactful lasting impact and that includes collaborations with university scientists and groups