



Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Detectors For Science Working Group

J. Estrada, A. Fava, P. Merkel, V. Rusu

All scientist retreat









26 April 2018

Overview

- 2 meetings:
 - 16 talks ~ 15 min each;
 - approx. 30 participants.
- Thu, April 12th
<https://indico.fnal.gov/event/16757/>
- Mon, April 23rd
<https://indico.fnal.gov/event/16890/>
- Valuable input from activities of the other working groups:
 - meeting after the other working groups had met;
 - summary reports of cosmic, energy frontier, neutrino and precision science.









First meeting

Thursday, 12 April 2018

- 14:00 - 14:10 **Introduction 10'**
Speakers: Dr. Petra Merkel (Fermi National Accelerator Laboratory), Dr. Juan Estrada (FNAL), Angela Fava, Dr. Vadim Rusu (FNAL)
Material: [Slides](#) 
- 14:10 - 14:25 **Highlights from CERN R&D Workshop 15'**
Speaker: Mr. Alan Prosser (Fermilab)
Material: [Slides](#) 
- 14:25 - 14:40 **Detector challenges for a Muon Collider 15'**
Speaker: Dr. Ron Lipton (Fermilab)
Material: [Slides](#) 
- 14:40 - 14:55 **Summary of Mu2e-II needs and plans 15'**
Speakers: Dr. Vadim Rusu (FNAL), Pavel Murat
Material: [Slides](#) 
- 14:55 - 15:10 **ASIC group considerations 15'**
Speaker: Dr. Gregory Deptuch (FERMILAB PPD/EED)
Material: [Slides](#) 
- 15:10 - 15:25 **Future test beam and irradiation needs 15'**
Speaker: Dr. Mandy Rominsky (Fermilab)
Material: [Slides](#) 
- 15:25 - 15:40 **High Speed Links for HEP @ Fermilab 15'**
Speaker: Mr. Alan Prosser (Fermilab)
Material: [Slides](#) 
- 15:40 - 15:55 **Liquid Nobel Dark Matter detectors 15'**
Speaker: Hugh Lippincott (Fermilab)
Material: [Slides](#) 

Second meeting

Monday, 23 April 2018

- | | | |
|---------------|--|---|
| 13:00 - 13:15 | R&D needs for CMB 15'
Speaker: Dr. Bradford Benson (Fermilab) | ▼ |
| 13:15 - 13:30 | Astrophysics instruments with Skipper CCDs 15'
<i>-- skipper for dark matter/neutrinos/quantum science</i>
<i>-- skipper for astronomy</i>
Speakers: Dr. Juan Estrada (FNAL), Dr. Javier Tiffenberg (Fermilab), Alex Drlica-Wagner (Fermilab)
Material: Slides  | ▼ |
| 13:30 - 13:45 | Fiber positioner R&D 15'
Speaker: Dr. Thomas Diehl (fnal)
Material: Slides  | ▼ |
| 13:45 - 14:00 | Alternative spectroscopy 15'
Speaker: Dr. Albert Stebbins (Fermilab)
Material: Slides  | ▼ |
| 14:05 - 14:10 | MKIDs for cosmic surveys 5'
Speaker: Dr. Juan Estrada (FNAL)
Material: Slides  | ▼ |
| 14:25 - 14:40 | R&D needs for neutrino detectors 15'
Speaker: Angela Fava
Material: Slides  | ▼ |
| 14:40 - 14:55 | Magnetized LAr TPCs 15'
Speaker: Thomas Strauss (FNAL)
Material: Slides  | ▼ |
| 15:00 - 15:10 | Summary from Energy Working Group 10'
Speaker: Dr. Anadi Canepa (Fermilab)
Material: Slides  | ▼ |
| 15:15 - 15:35 | Scintillation light in LAr 20'
Speaker: Flavio Cavanna (Fermilab)
Material: Slides  | ▼ |

Hot topics

- **Energy frontier science**
 - high granularity ($\sim 20 \mu\text{m}$)
 - fast timing (few ps);
 - high-speed/wireless readout links
 - radiation hardness.
- **Cosmic science**
 - ultra-low temperature (sub-K) superconducting, highly multiplexed readout;
 - low threshold and new nuclear targets;
 - high density fiber positioning and low noise sensors.
- **Precision science**
 - ultra-low mass rad hard tracker;
 - rad-hard crystals for calorimetry with fast readout;
 - high-efficiency cosmic ray veto system with low sensitivity to neutrons;
- **Neutrino science**
 - magnetization of large masses of liquid argon;
 - further exploitation of scintillation light in liquid argon;
 - high-granularity high-density tracker continuously active.

Broad interest R&D areas

- Very large data volume and reduction needs (everybody!)
→ front-end electronics (ASICs), high speed links, wireless data readout, computing, etc
- Radiation hardness (colliders, Mu2e, astrophysic experiment in space)
→ special materials and electronics (crystals, silicons, scintillators, glues, ASICs, etc)
- Development of noble liquid detectors (dark matter and neutrino)
→ cold electronics, high granularity, low noise, cold skipper CCDs
- New detection techniques (everybody!)
→ graphene, quantum dots

	R&D / CAPABILITY	microdetector assembly	sensor design/ simulations	sub-K lab	ASIC development	LAR test facility	Test Beam	Thin film/Special Materials/ Scintillator extrusion
Neutrinos	Lower Energy Detector for Supernovae					●		
	Improved Photon Detection Systems					●		
	R&D in HV Feedthrough					●		
	Improved charge readout				●	●	●	
	magnetization of LAr volume					●	●	
Energy	rad hard photodetector and scintillator	●					●	●
	smaller edgeless pixel sensors	●	●		●		●	
	new materials for Si det support structure	●					●	●
Cosmic	low threshold detectors (super, semiconductors, and	●	●	●		●		
	low energy nuclear recoil calibration					●	●	
	high density fiber positioner	●						
	superconductor detectors for VNIR		●	●				
	quantum detectors			●				
Precision	low mass, high-rate tracker	●					●	
	high-rate/dose photon sensors	●					●	

Facilities used by detector R&D (1)

- Fermilab Test Beam Facility (FTBF)
 - Highly sought after, demand likely to increase; needs modernization and possibly expansion
- Irradiation Test Area (ITA at MTA)
 - To be established this year; high demand for HL-LHC upgrades, future colliders, Mu2e-II, ASICs, space experiments
- Nobel liquids cryostats (PAB)
 - Highly sought after, being expanded now

Facilities used by detector R&D (2)

- ASIC group
 - Needs to stay up-to-date with modern tools and methods, linked into national and international collaborations; should be expanded
- Special materials, thin films, scintillators
 - Crucial in-house capabilities for R&D and mass production
- Silicon Detector Facility
 - sub kelvin refrigerators
 - micro detector assembly/packaging
 - sensor testing

Detector R&D budgets

- LDRD program (ldrd.fnal.gov)
 - Lab-directed R&D, shared with computing, technical and accelerator R&D
 - Highly competitive, many good ideas cannot be supported
 - Fixed budget as percentage of total lab budget; suggest to consider increase in coming years to support ambitious R&D program needed for future of lab
 - Would be good to link final reports of completed projects from webpage
- KA25 (detectors.fnal.gov)
 - DOE category of money to support detector R&D and facilities
 - More geared towards generic R&D, small, potentially high-risk efforts
- Early Career Award (directly from DOE)
 - Multi-year, multi-million dollar awards, which can have high impact on projects at the lab
 - Several very successful examples at the lab in recent years
 - Keep encouraging our early career colleagues to apply, including mentoring by seasoned awardees.

Next steps

- Brainstorming should be expanded further beyond the meetings in preparation for the retreat.
Example charge: update the R&D vs facility table with more specific items.
- Synergy with other working groups.
Example: participation in working groups proposed by neutrino science.
- Increase accessibility of Fermilab users (especially newcomers) to resources and facilities for detector R&D.
- Boost collaboration with other Labs and University.
 - Can collaborations on specific R&D topics, sharing infrastructure and know-how (ex: RD-51) be a model?
 - Can the awarding of grants specific for staff exchange, collaborative networks and infrastructures (ex. EU-ESI, Marie Curie RISE, ERC synergy grants) be a viable approach?

Communications

- How to get started with detector R&D at the lab, or if you need resources (technical expertise, equipment, facilities) contact: petra@fnal.gov
 - Will look for help via Detector Advisory Group
- More general questions can be addressed to: detectors@fnal.gov (need to be subscribed via listserv), also useful for detector R&D related announcements and seminars
- If you want to be part of this planning process, please subscribe to strategic-planning-detectors@fnal.gov



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Backup

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Detectors for Astrophysics

Flagship program focused in CMB-stage4 and next generation ADMX.

- This means going cold (sub-Kelvin), superconducting and highly multiplexed readout.
- FNAL is already investing in this area. We should keep healthy effort to be able to lead in the coming years.
- Good synergy with ongoing projects (superCDMS) and R&D efforts (MKIDs and quantum sensors)

Active R&D efforts are important to build the future program:

- Next generations cosmic surveys: fiber positioner R&D, low noise skipper-CCD, MKIDs)
- Dark matter:
 - Noble liquids (doped Xenon, liquid He detector)
 - Low threshold sensors (superCDMS++, skipperCCD)
 - Bubble chamber R&D
 - Spaced based instrumentation (growing fast due to cost)