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Response to Reviewer Question: Cosmic Program

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Fermilab Institutional Review

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Question from the reviewers

Please describe the specific contributions Fermilab brings to the various dark matter direct detection experiments in which laboratory staff currently participate, the likely evolution of staffing across direct detection projects, and the basis for this management plan.

Fermilab Dark Matter Experiments

Experiment	Location	Status	Technique	Physics Focus
G1 experiments (2012-2017)				
SuperCDMS	Soudan	Operating	Cryogenic Solid-State	Background-free WIMP search
COUPP/PICO	SNOLAB	Operating	Bubble Chamber	Spin-dependent dark matter
Darkside 50	LNGS	Operating	Liquid Argon TPC	WIMPS $> 1 \text{ TeV}/c^2$
DAMIC	SNOLAB	Operating	CCDs	WIMPS $< 1 \text{ GeV}/c^2$
G2 experiments (2018-2023)				
SuperCDMS	SNOLAB	Design	Cryogenic Ge/Si target	Low-mass WIMPs to neutrino floor
LZ	SURF	Design	Liquid Xenon TPC	High-mass WIMPs
ADMX	U. Wash	Fabrication	Cryogenic resonant cavity	Axion dark matter

Fermilab Roles in Dark Matter Experiments (highlighting Wilson Fellows, Early Career awardees)

Experiment	Fermilab roles	Fermilab scientist/ postdocs FTEs (Leader)
SuperCDMS	Project/Operations management, Cryogenics/shielding/electronics, Data analysis/Science	3/1 (Bauer)
COUPP/ PICO	Project/Operations management, Fabrication Data Analysis/Science	3/1 (Sonnenschein)
Darkside 50	LAr expertise, data acquisition	1/1 (Pordes)
DAMIC	CCDs, management	1/1 (Estrada)
LZ	TPC, process control, science	1/1 (Lippincott, Dahl)
ADMX	RF cavity R&D, analysis, science	1/0 (Chou)

Specific Fermilab Contributions (page 1 of 2)

- CDMS/SuperCDMS – Experienced leadership, project management, cryogenics expertise, shielding, electronics
 - Staffing: 3 scientists, 1 postdoc. Plan to add another scientist.
- COUPP/PICO –Fermilab scientists led development of large scale systems, and fill critical roles in operations.
 - Collaboration now has strong Canadian presence.
 - Potential as a G3 detector depends on outcome of G1 operations.
 - Staffing: 3 scientists now, two transitioning now to LZ and ADMX.
- LZ – Fermilab recently joined. Invited to take a leading role on process controls and simulations.
 - Small effort now (2 x 0.5 scientists, 1 postdoc), will grow
- ADMX – Small collaboration; Fermilab is invited to provide expertise in RF cavity design, axion science, and analysis
 - A small fraction of 3 scientists now, will grow those fractions as other efforts wind down.

Specific Fermilab Contributions (continued)

- Darkside – Fermilab designed and built the distillation column for LAr purification, and the DAQ system.
 - Will provide technical support for the current run as needed.
 - Potential for G3 will depend on outcome of G1 operations
 - Staffing: <1 scientist, 1 postdoc; will transition to other projects
 - Bulk of funding is from NSF and from overseas
- DAMIC - Leadership and CCD packaging, testing and operational experience grew from Fermilab role in DECam
 - Growing collaboration with Chicago/KICP and others
 - <1 scientist and 1 postdoc, expect to stay roughly this level through DAMIC 100 deployment and operations, next year.
 - Supported by Presidential Early Career Award

Likely Evolution of Fermilab Dark Matter program

- We are in a unique period of transition from G1 to G2
 - Driven at a high level by the timing of P5 and the G2 selection
 - Plan shaped by community, collaborations, lab capabilities, science opportunities
- Fermilab G1 operating experiments are still doing world-leading science and capitalizing on early investments.
 - SuperCDMS Soudan, DAMIC for low-mass WIMPs
 - PICO for spin-dependent interactions
 - Darkside-50 is demonstrating a possible path towards a very large G3 experiment to explore high-mass WIMPs
- G1 efforts will wind down as G2 experiments ramp up over the next 1-2 years
- G2 dark matter program focuses on selected technologies that have proven capable of probing the whole parameter space and cross checking each other
 - SuperCDMS SNOLAB for low-mass WIMPS
 - LZ for high-mass WIMPS
 - ADMX for axions
- Need for R&D towards G3 experiment(s) to reach neutrino floor

Basis for this plan

- Science-driven strategy
 - G1 experiments are still on the forefront of WIMP and axion sensitivity until G2 experiments come online
 - G1 experiments are informing design of G2, R&D for G3
- Influenced by limited manpower and resources
 - Need to shift effort to make G2 experiments happen
- Influenced by DOE support
 - Duration of G1 operations funding depends on outcome of December 2014 cosmic operations review
- Influenced by the US and international community
 - Strong Canadian interest in PICO, Italian interest in Darkside
 - Maintaining US lead towards G3 experiments