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Cosmic Program and Users: SuperCDMS

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Fermilab Institutional Review

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SuperCDMS Program

- Building off longtime success of CDMS in direct detection searches for dark matter using cryogenically operated solid-state detectors; In the process of transitioning to next-generation phase, SuperCDMS SNOLAB.
  - Current focus is designing the experiment (anticipated construction period 2016-2018)

- Current experiment, SuperCDMS Soudan, is winding down. Soudan operations to end in late 2015. Data analysis continuing for a few more years. Priorities:
  - Exploration of low-mass WIMP search techniques with CDMSlite; possible additional publication in this area.
  - Completion of high-mass dark matter search.
  - Technical studies to inform design for SNOLAB phase.
  - Nuclear recoil energy scale studies w/ photo-neutron sources.

SuperCDMS at Fermilab

- *Fermilab a leading institution in CDMS/SuperCDMS for nearly two decades (since 1997).*
- Group members and affiliates:
  - Scientific staff: D. Bauer (PI), L. Hsu (associate scientist), B. Loer (postdoc), P. Lukens (scientist)
  - Part-time technical staff: E. Chi (mech. eng.), S. Hansen (elec. eng.), D. Holmgren (computing), M. Ruschman (cryo tech), R. Schmitt (mech. Eng.), G. Tatkowski (mech. eng.).
- Responsibilities & Expertise:
  - Soudan: operations, data processing and storage, data analysis and science, project management
  - SNOLAB: cryogenics, shielding (including neutron veto R&D), warm electronics, calibrations, data acquisition, project management

The Collaboration

California Inst. of Tech.
CNRS-LPN
FNAL
Mass. Inst. of Tech.
NIST Inst. of Tech.
PNNL
Queen's University
SLAC
Southern Methodist U.
Santa Clara University
South Dakota SM&T
Stanford University
Texas A&M University
U. Autónoma de Madrid
U. British Columbia
U. California, Berkeley
U. Colorado Denver
U. Evansville
U. Florida
U. Minnesota
U. South Dakota

URA Visiting Scholar's Program

- Financial support for visitors from URA institutions to work at Fermilab. Successful proposals involved close collaboration with Fermilab SuperCDMS group members.
- Awards made to date sponsored visits that ranged from several weeks up to 7 months
- 6 SuperCDMS awards since program inception in 2007:
  - CDMSlite: electronics, operations, data analysis (R. Basu Thakur, U. of Illinois UC) – *more on next slides about this*
  - SuperCDMS neutron veto R&D: Y. Chen (Syracuse U), R. Calkins (SMU), S. Scorza (SMU) – *more on next slides about this*
  - Low-radioactivity cleaning techniques (S. Scorza)
  - Reconstruction software development: M. Kos (Syracuse U), A. Villano (U. of Minnesota)

URA = Universities Research Association

Additional Collaborative Efforts

- DOE Visiting Faculty Program: A. Kryemahdi (faculty) w/ 5 undergrads from Messiah College performed R&D on SuperCDMS neutron veto prototype (summers 2011-2014), supervised by B. Loer

- Additional student interns: *R. Fitzpatrick* (SULI, 2014), *M. Perego* (Italian Summer Students Program, 2013), *J. Li* (IMSA mentorship, 2012), *J. Fischer* (SULI, 2011), *R. Srirham* (Quarknet 2011), *S. Aujla* (Quarknet 2011), *R. Co* (SULI, 2010), *G. Caceres* (SIST, 2007), *R. Caputo* (SULI, 2006); Research topics: SuperCDMS/CDMS analysis, neutron veto R&D, PMT characterization, annual modulation search sensitivities

- SuperCDMS analysis workshops: hosted and supported 7 week-long workshops in 2012-2014; ~20 students, postdocs and analysis coordinator to spend focused time on SuperCDMS analysis. Made possible by affordable housing in the Fermilab village and availability of large meeting rooms in Wilson Hall.

Example I: CDMSlite

CDMSlite: novel use of CDMS detectors to search for low-mass WIMPs, yielded world-leading limit with 10 day exposure

- Begun as R&D by J. Hall as a FNAL postdoc (now at PNNL)
- First WIMP search completed by R. Basu Thakur, URA grant recipient; part of extended stay with FNAL SuperCDMS group and Rito's thesis topic
- Implemented, operated and analyzed data from CDMSlite in conjunction w/ FNAL staff
- Yielded first science result for CDMSlite and a world-leading limit; now a major component of SuperCDMS SNOLAB program

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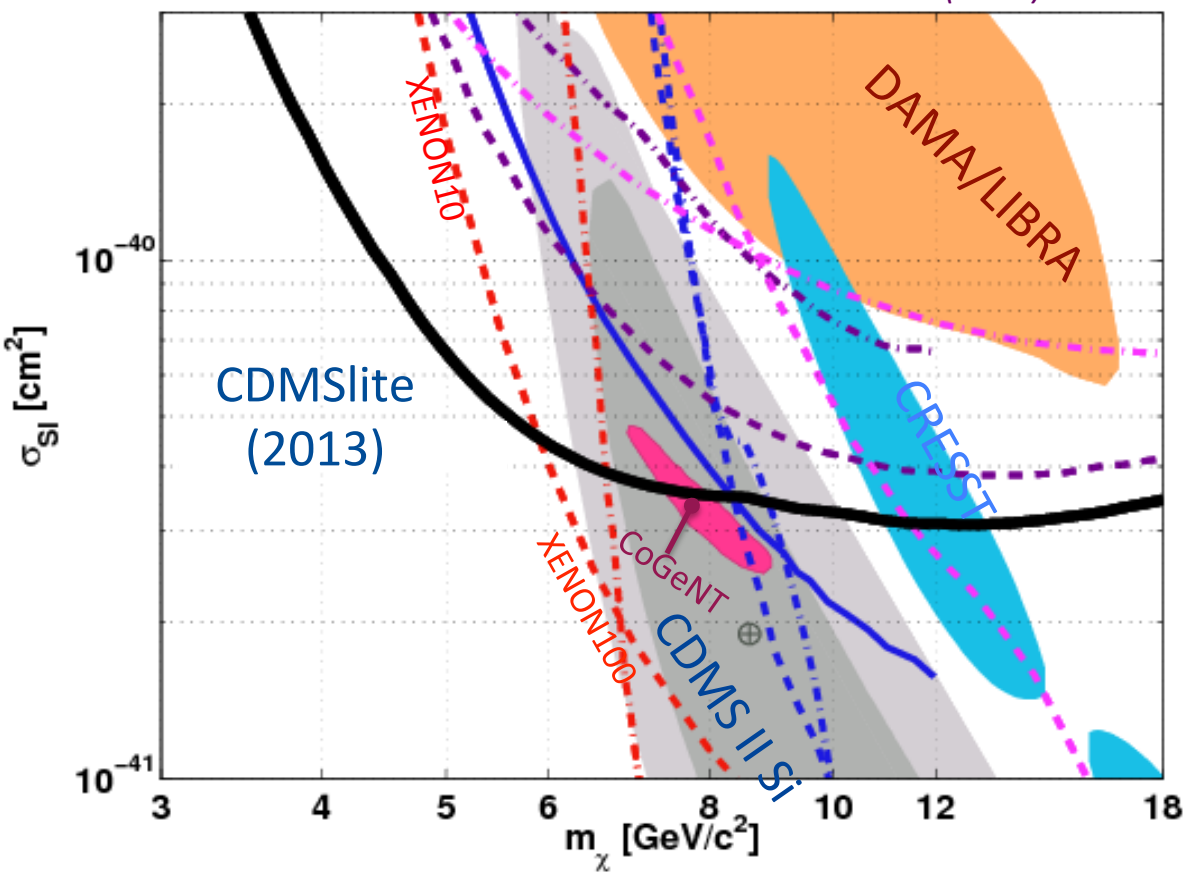
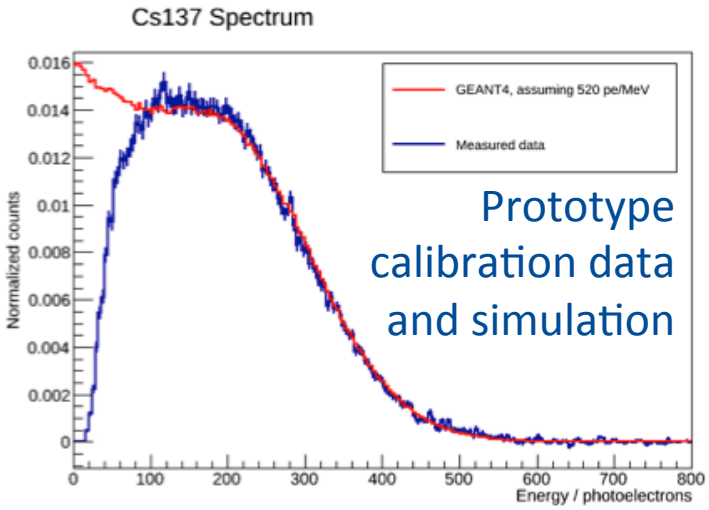


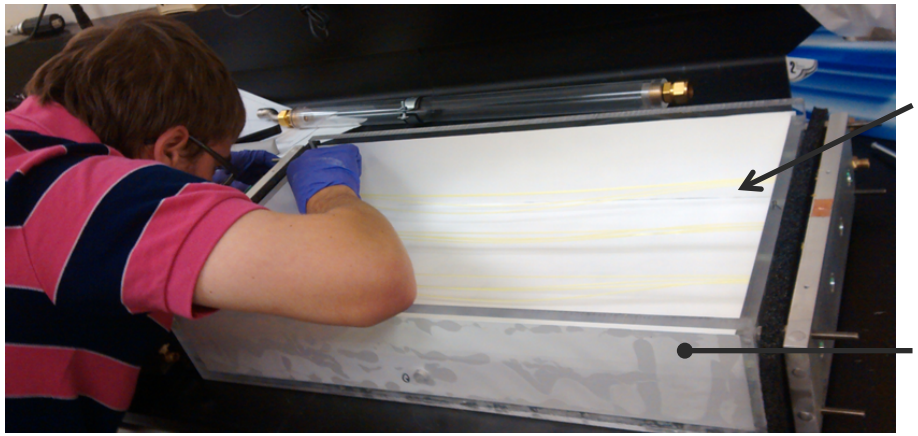
Example II: Neutron Veto R&D

- multi-year R&D program initiated at Fermilab for SuperCDMS SNOLAB (2012-present); progressed from design to functioning prototype (lead by B. Loer)
- Many university collaborators participated directly through URA, DOE visiting faculty grants and italian summer student program (overall, hosted 10 researchers, students and postdocs)



Prototype calibration data and simulation

neutron veto prototype (at FNAL Lab 6) w/ undergraduate intern M. Bressler



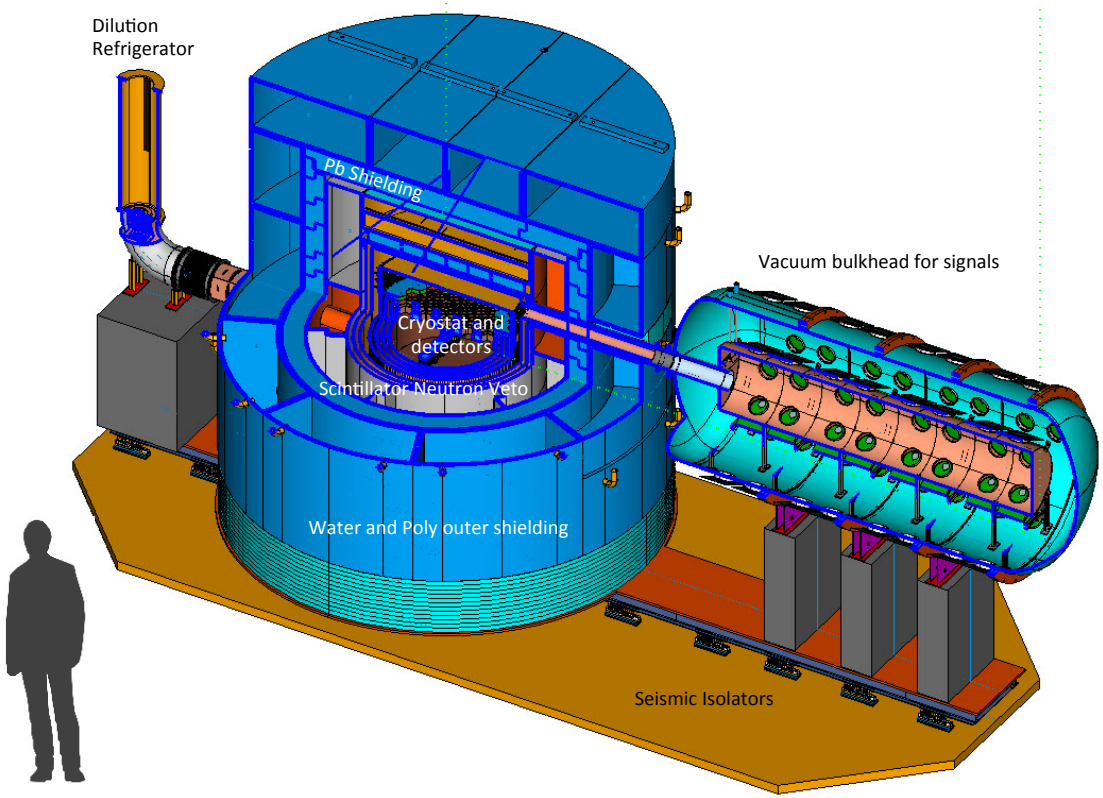
Scintillating optical fibers readout by 3mm SiPMs

Acrylic box, with reflector; filled with 17 L of LAB scintillator

Fermilab

SNOLAB System Integration Test

Planned 2016-2018: will perform full-scale test of experimental setup at Fermilab, with all major components assembled and integrated (cryogenics, shielding, electronics and detectors). Essentially this is full construction of the experiment at Fermilab before moving it to SNOLAB.



Will run shifts for the testing phase, with most members of the collaboration traveling to Fermilab on a rotating basis over a period of six months to 1 year.

Shifts will provide direct hardware experience that will be invaluable for installation and operation at SNOLAB.