SuperCDMS Research Program  
(Direct Detection of Dark Matter)

Eduardo do Couto e Silva  
SLAC/KIPAC  

SuperCDMS Dept Manager  

Sept 14, 2010
Comprehensive Dark Matter Searches at SLAC

Direct Detection

Indirect Detection
SuperCDMS @ Soudan/SNOLAB/DUSEL

SPACE
Fermi Gamma Ray Telescope

Direct Production

COLLIDER
ATLAS @ LHC

Adapted from J. Feng
SuperCDMS Discovery Potential

The origin of Dark Matter is a central question to particle physics, astrophysics, and cosmology.

The mass of a Dark Matter candidate (GeV):

- Dark Matter (mass \(\sim\) GeV – TeV)

Improvements in sensitivity by three decades (few \(10^{-44}\) to \(2.10^{-47}\)) in the next 10 years.

Graph showing the spin-independent cross-section versus the mass of a Dark Matter candidate (GeV).
SuperCDMS Systems for Future Experiment (preliminary)

Bring detector fabrication efforts currently done at Stanford University to a National Lab (SLAC) to enable large target mass experiments

(SLAC)
Ge Towers

(FNAL)
Cryostat & Veto/Shield

(FNAL)
Trigger & DAQ

(Queens)
SNOLAB Facilities

(SLAC/FNAL)
Systems Integration

(FNAL)
Project Management

(University leads)
Background Controls

(SLAC/FNAL)
Software/Computing

SLAC involvement is shown as red boxes

SLAC involvement is shown as red boxes

(SLAC)

(FNAL)

(Queens)

(SLAC/FNAL)
Management : Accomplishments (FY10)

• SLAC and Stanford were well integrated since SLAC joined (May 2009)
  – Synergistic relationship (detector R&D)
  – Joint weekly meetings at SLAC and at Stanford

• SLAC/FNAL are coordinating DoE funding requests within the Collaboration
  – Weekly teleconferences and face to face meetings between FNAL and SLAC

• SLAC has provided meaningful contributions to support university efforts and strengthened ties through multiple activities
  – Santa Clara (crystal procurement and detector testing)
  – Queens University in Canada (underground detector test facility)
  – UCB (cold hardware)
  – UMN (detector testing)
  – TAMU (preparation for DoE reviews)
Ge Tower R&D: Accomplishments (FY10)

- Evaluate technology for large diameter (100 mm) crystals
  - Purchased crystals of different lattice orientations, i.e.: [100] and [111]

- Fabricate detectors and assemble Ge modules
  - SLAC team is being trained by Stanford team
  - Expect first large diameter R&D detector to be fabricated soon

- Increase throughput of Ge detector fabrication
  - Streamline the process by implemented automated visual scan of detectors

- Develop underground test facility at SNOLAB for large diameter detectors
  - Acquire expertise with cryogenic operations at 40 mK
  - Designing new vessels for existing Stanford refrigerator and associated thermometry to monitor cool down process

- Experimental layouts for large diameter detector towers for SNOLAB
  - Initial sketches on future layouts (guided by UCB team)
Software Development : Accomplishments (FY10)

• SLAC has become the Monte Carlo production center for SuperCDMS
  – Processing pipeline and data catalog for Monte Carlo production
  – Distribution system for Monte Carlo simulated data

• Developed Monte Carlo Simulations to study phonon processes in Ge detectors using Geant4
  – Most of the measured energy is transported as phonons

• Developing a flexible and scalable Monte Carlo software framework
  – Support multiple sites, geometries and infrastructure
Planned Activities for SLAC (FY11)

- Data Analysis and Calibrations SuperCDMS Soudan (15kg)
  - Data Quality Monitoring and shifts
  - Support detector fabrication and commissioning

- Feasibility of large Ge detectors
  - Fabricate and test R&D detectors
  - Compare crystal technology choices
  - Characterize background rejection of new detector design

- Scalability of Ge detector fabrication
  - Pursue cost/risk reduction with crystal procurement
  - Increase detector fabrication throughput
  - Streamline detector functional testing with cryogenic set up

- Scalability of software systems
  - Establish SLAC as a Monte Carlo Production center
  - Implement examples of flexible and robust software infrastructure
  - Define requirements for scalability of data processing

Deploy advanced detector technology in Summer 2011 (approved experiment)

Strong R&D is needed to maintain leadership in the field
Concerns

- Dark Matter discovery may be imminent (next decade)
  - US could lose leadership in direct detection experiments

- Assuming CD0 for the next generation of direct detection experiments in FY11
  - Funding profile may not support required aggressive schedules
  - Currently we are in the middle of production for the SuperCDMS Soudan (15 kg) experiment
    - Time will be required to coordinate universities through the CD process and to perform a bottom-up cost assessment

- SLAC R&D program is strongly dependent on FY11 FWP requests
  - Currently working with minimal engineering/professional support
  - SLAC will manage the Ge Tower system and play leading roles in software/computing systems for future experiment at SNOLAB
Back up
FY10 - Activities and Accomplishments (1)

Pursue increase in fiducial target volume with crystals of different lattice orientation

Streamline production by identifying defects with automated visual scan

Characterize background rejection performance with underground detector testing

Develop mechanical concepts for future experiments
Flexible and scalable Monte Carlo software framework to handle multiple experimental configurations

Data processing pipeline and data catalog for Monte Carlo production and Monte Carlo data distribution

SLAC LDRD: Large Diameter Ge Detectors

Fabricate and Test Large Diameter Detectors

Develop Phonon Simulations (Geant4)
Large fraction of signal is collected as phonons
SuperCDMS Direct Detection Technique

- Low Temperatures (40mK)
  - Signal is mostly from vibrations of the lattice (phonons), but also charge

- Separate signal from background
  - Advanced detector design

- Reduce background
  - Shield/veto cosmic rays
  - Minimize traces of radioactivity in materials and environment
- **SuperCDMS Soudan** *(approved)*  
  Soudan Mine, USA  
  Data taking expected for 2011-2012

- **SuperCDMS SNOLAB** *(future proposal)*  
  Vale Inco Mine, Canada  
  Data taking expected for 2014-2016

- **GEODM DUSEL** *(future proposal)*  
  Homestake Mine, USA  
  Data taking expected for 2018-2020

- 75 mm  
  15 detectors  
  15 kg

- 100 mm  
  ~80 detectors  
  ~100 kg

- 150 mm  
  300 detectors  
  1500 kg