# SuperCDMS Research Program
# (Direct Detection of Dark Matter)

Eduardo do Couto e Silva

SLAC/KIPAC

*SuperCDMS Dept Manager*

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SLAC NATIONAL ACCELERATOR LABORATORY



LELAND STANFORD JUNIOR UNIVERSITY · DIE LUFT DER FREIHEIT WEHT · 1891

# Comprehensive Dark Matter Searches at SLAC

*Adapted from J. Feng*

## Direct Detection

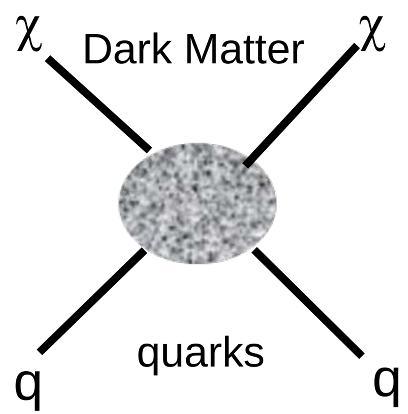
**UNDERGROUND**

**SuperCDMS @ Soudan/SNOLAB/DUSEL**

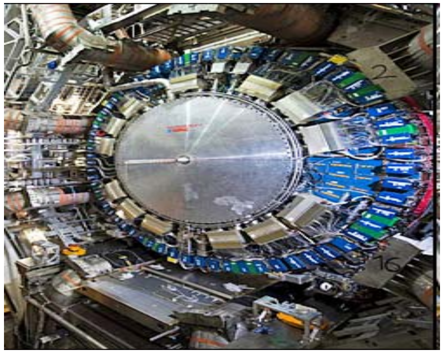
## Indirect Detection

**SPACE**

**Fermi Gamma Ray Telescope**




## Direct Production



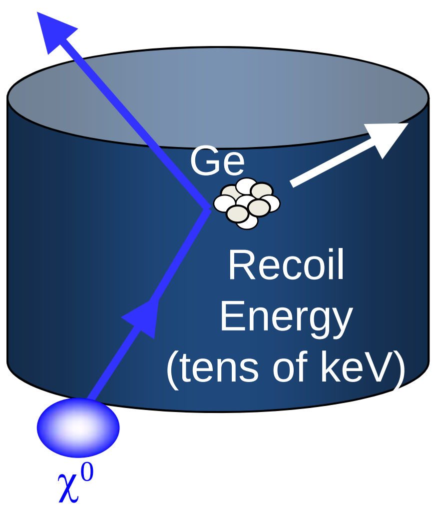
**COLLIDER**

**ATLAS @ LHC**

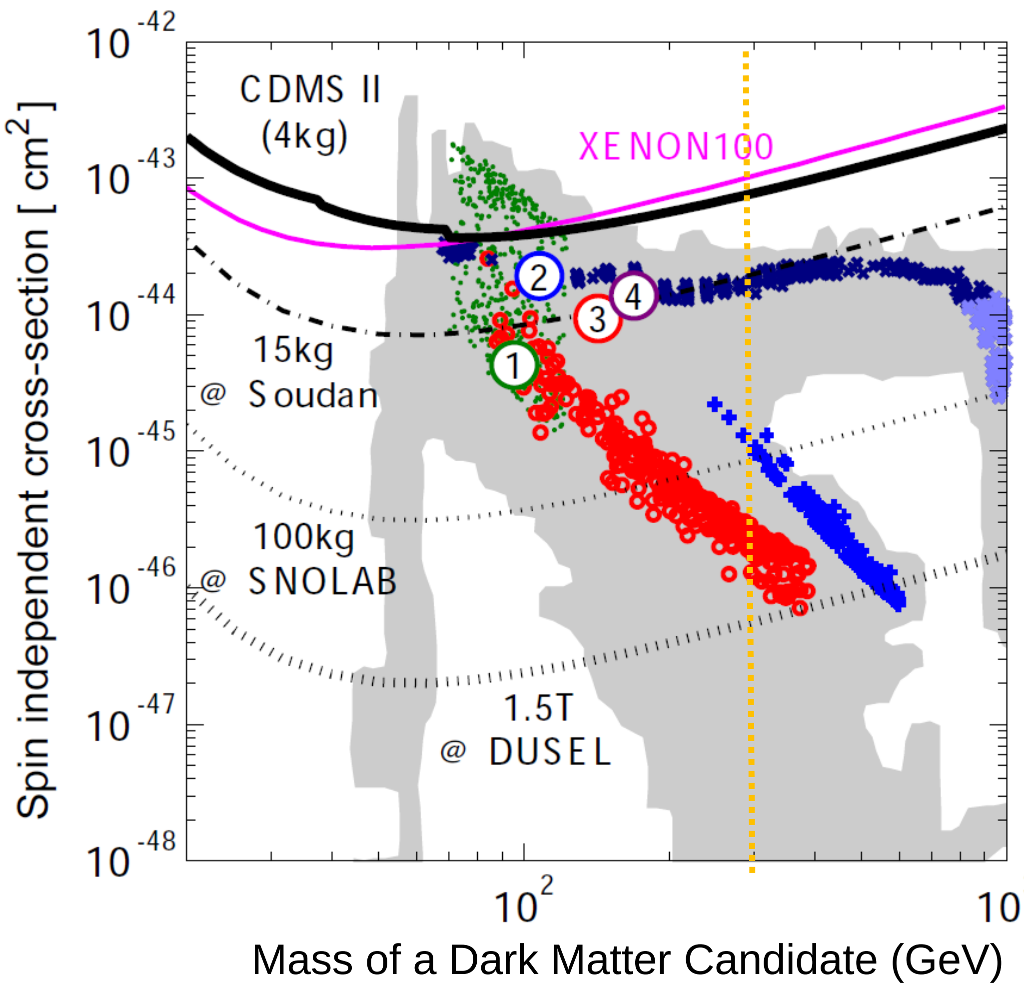
# SuperCDMS Discovery Potential

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

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




Dark Matter
(mass ~GeV – TeV)

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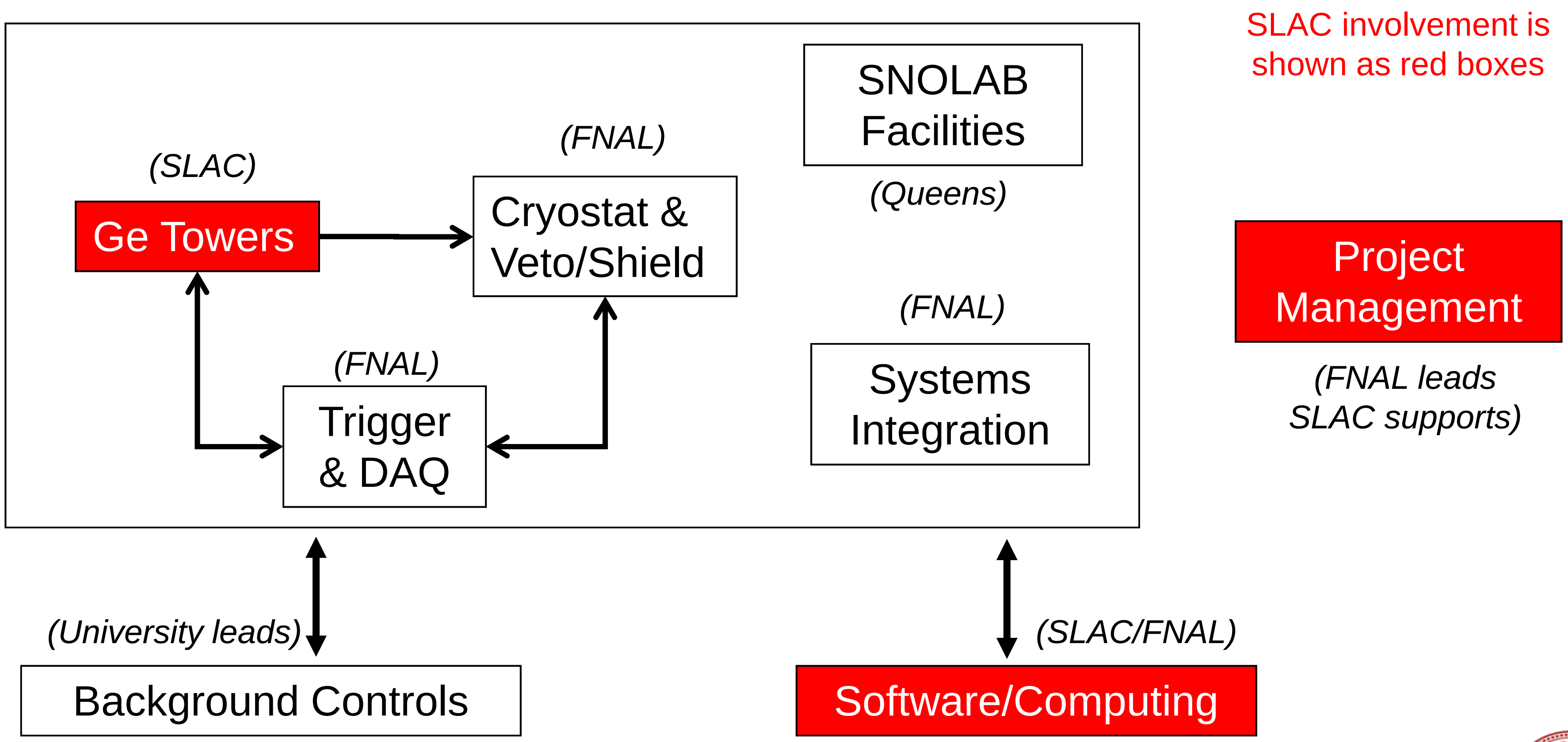
# SuperCDMS Systems for Future Experiment (preliminary)

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



# 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**

Deploy advanced detector technology in Summer 2011 *(approved experiment)*

- 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**

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

- 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**

# Concerns

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

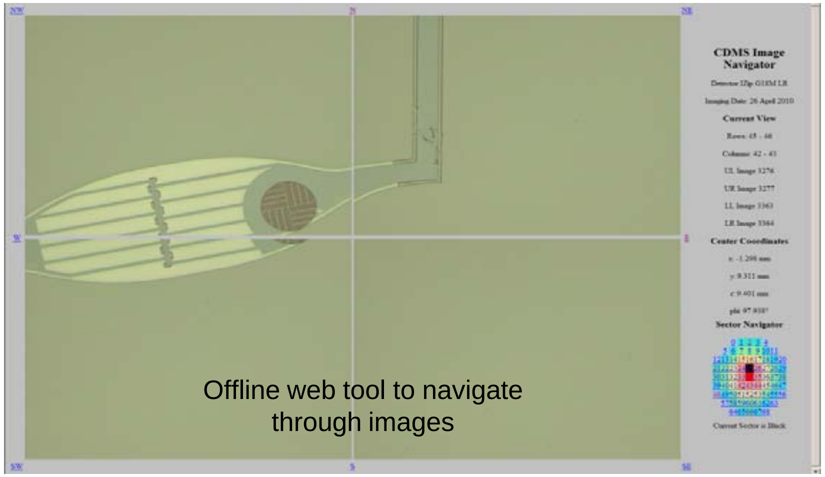
- Assuming CD0 for the next generation of direct detection experiments in FY11
  - **Funding profile may not support required aggressive schedules**
  - **Currently we are in the middle of production for the SuperCDMS Soudan (15 kg) experiment**
    - Time will be required to coordinate universities 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**

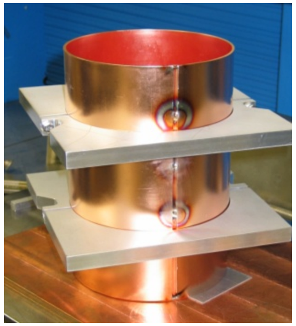
# Back up

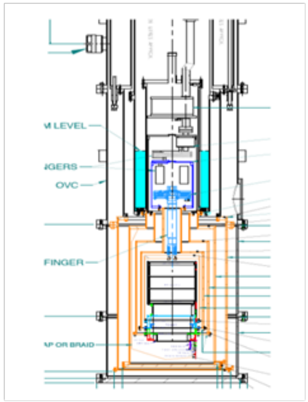
# FY10 - Activities and Accomplishments (1)

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

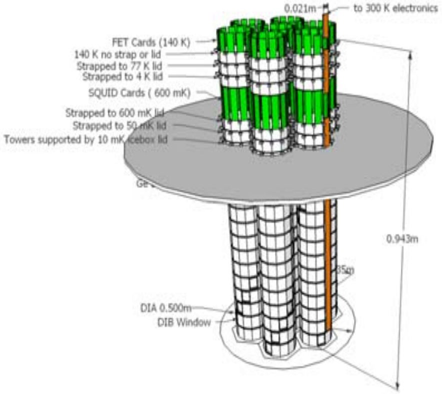



Streamline production by identifying defects with automated visual scan






Characterize background rejection performance with underground detector testing




Develop mechanical concepts for future experiments

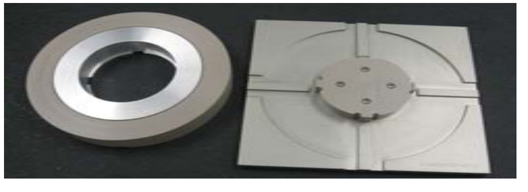
# FY10 - Activities and Accomplishments (2)

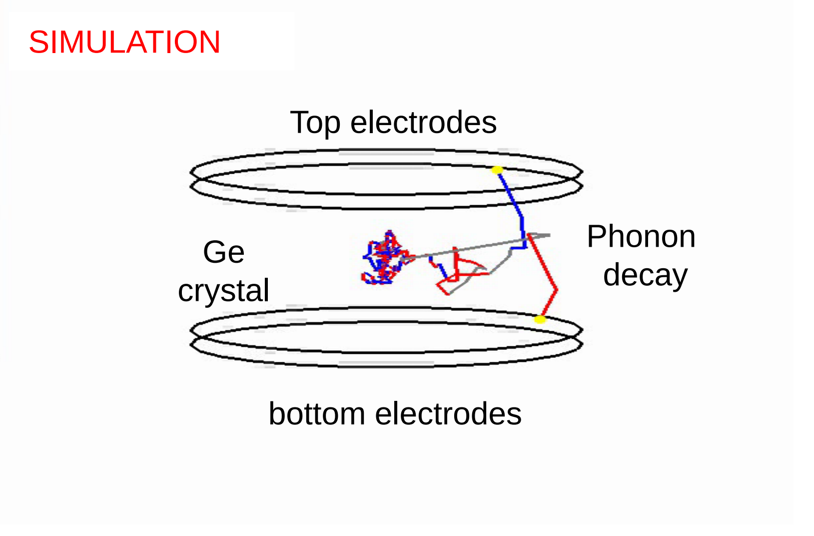
Leverage on computing and software infrastructure to reduce burden on Universities

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





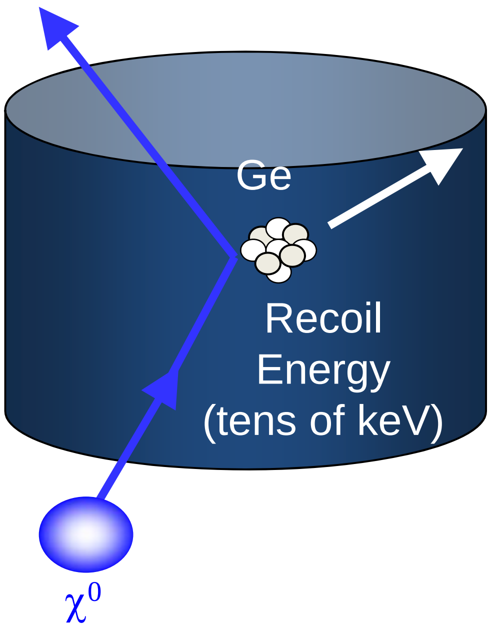

Fabricate and Test Large Diameter Detectors

Develop Phonon Simulations (Geant4)

*Large fraction of signal is collected as phonons*

# SuperCDMS Direct Detection Technique

Detection Technique
using Germanium Crystals



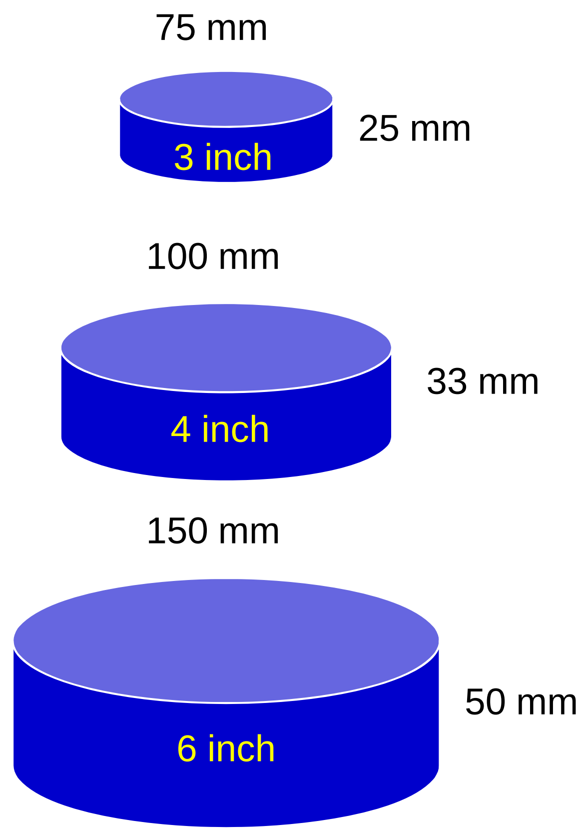

Dark Matter
(mass ~GeV – TeV)

- 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**




15 detectors
15 kg

~80 detectors
~100 kg

300 detectors
1500 kg