(Super)CDMS

Anders W. Borgland
PPA SCA and SuperCDMS

(Super)CDMS

- **PPA SCA and SuperCDMS:**
  - **How can a small experiment leverage the PPA SCA resources and expertise?**
- **A very brief introduction to (Super)CDMS:**
  - **Physics**
  - **Detector**
- **The SLAC SuperCDMS group:**
  - **Scope: LDRD**
- **Current activities:**
  - **Monte Carlo simulations**

- **Many slides are from Jodi Cooley's SLAC December 17, 2009 talk (and one from P. Brinks recent DM2010 talk):**
  - **Did I say I have just started in (Super)CDMS? :-)**

PPA SCA And (Super)CDMS

- **(Super)CDMS is a small collaboration:**

The CDMS Collaboration

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SLAC, Dec. 17, 2009 17 Jodi Cooley, SMU, CDMS Collaboration

PPA SCA And (Super)CDMS

- **PPA SCA:**
  - Created so smaller experiments with limited manpower and resources can leverage the considerable experience, expertise and resources we have developed here at SLAC.
- **(Super)CDMS fits the bill!**
  - Small collaboration.
  - Planning major upgrades in the near future.
  - Can benefit from professional help with software and computing.
- **The following slides are meant to illustrate this particular aspect (only):**
  - They are in no way meant to be a detailed description of the experiment, nor of the physics!
  - In particular, for the recent '2 events' CDMS results, see Jodi's talk (it was even filmed).

Weakly Interacting Massive Particles (WIMP)

- **Won't go into Dark Matter and WIMPs here except for:**
  - **Stable, massive particle from the early universe**
  - **Also predicted by particle physics models**
- **Detection:**
  - **Direct production: LHC and Atlas**
  - **Annihilation in the universe: Fermi**
  - **Scattering here on Earth: (Super)CDMS**
- **The three dection methods are complementary and all three are covered by PPA programs!**

WIMP Scattering

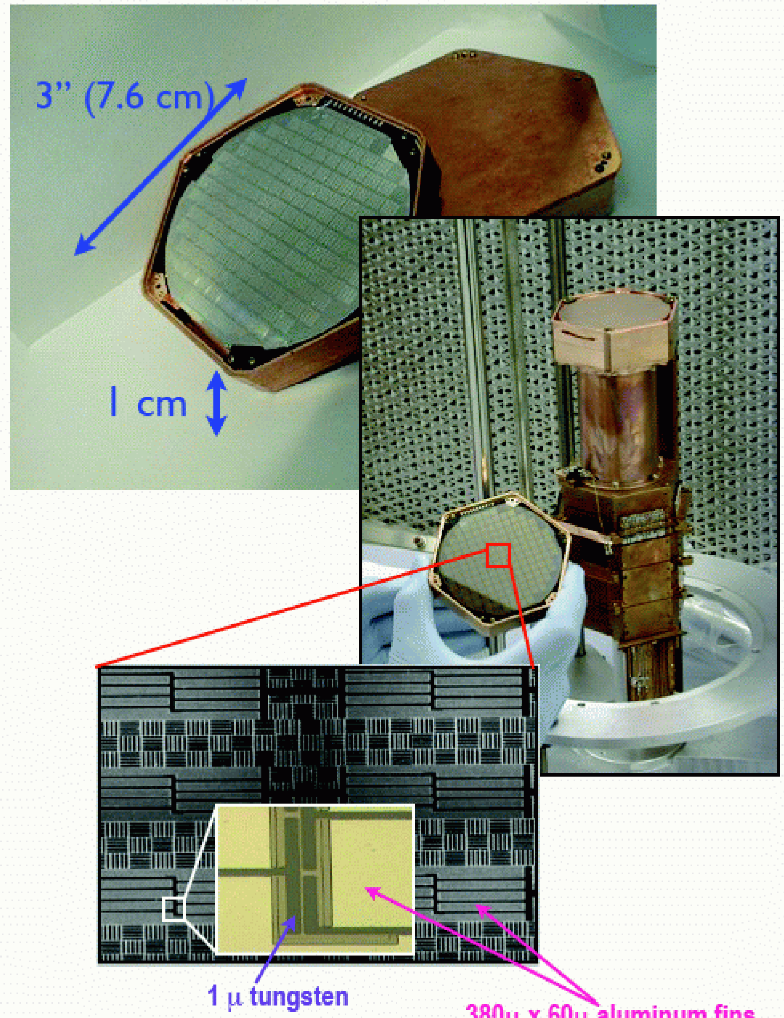
- WIMP scattering:
  - If we assume coherent (spin independent) scattering:
    - ~A^2 enhancement
    - You want massive detectors.
  - If you don't you don't:
    - Experiments in the direct detection field prefer the first alternative :-)
- Sensitive detectors:
  - WIMP scatters off nucleon:
    - Recoil energy is a few tens of keV.
    - Rate is low: <0.01 per kg-day
- "The Wind-Up Bird Chronicle" approach:
  - Underground to reduce cosmic ray background.
  - Shield the detector from radioactivity/backgrounds: (n,e)
  - Cool down the detector to remove thermal vibrations (mK).
  - Patience: Long exposures.

Detector And Detection Choices

- Two main directions you can go with the detector:
  - Liquids:
    - Scales well
    - Backgrounds are an issue
  - Crystals like Ge:
    - Backgrounds very low
    - Scaling to high mass is more challenging
- Three detection measurements:
  - Phonons
  - Ionization
  - Scintillation light
- "Two out of three ain't bad":
  - (Super)CDMS uses phonons and ionization.
  - Other experiments use different combinations.

CDMS Detector

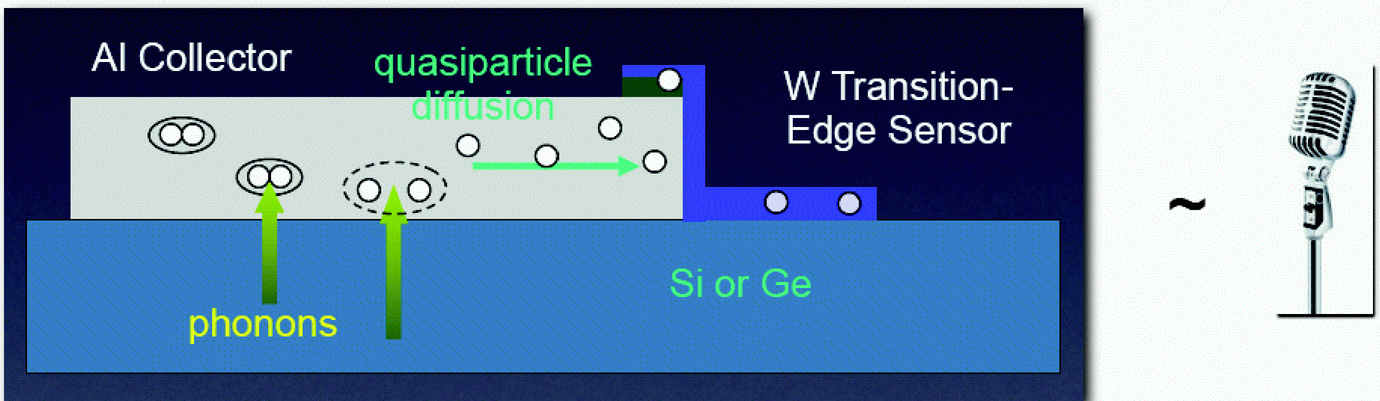
CDMS-II ZIP Detectors

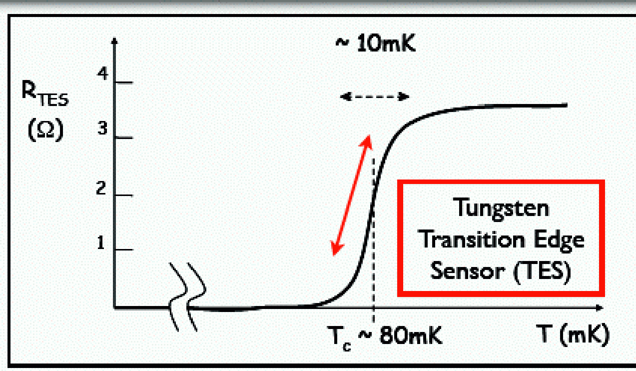


- **Z**-sensitive **I**onization and **P**honon mediated
- **230 g Ge** or **100 g Si** crystals (1 cm thick, 7.5 cm diameter)
- Photolithographically patterned to **collect athermal phonons** and **ionization signals**
  - xy-position imaging
  - Surface (z) event rejection from pulse shapes and timing
- **30 detectors** stacked into **5 towers** of 6 detectors

Phonon Detection

ZIP Detectors: Phonons





4 SQUID readout channels, each reads out 1036 TESs in parallel

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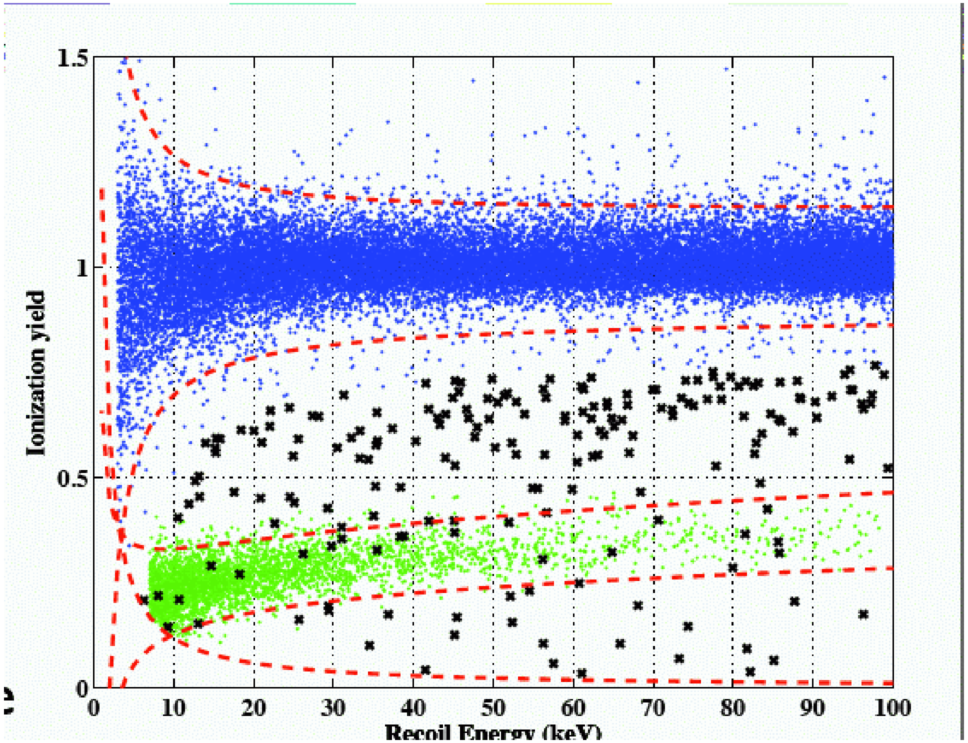
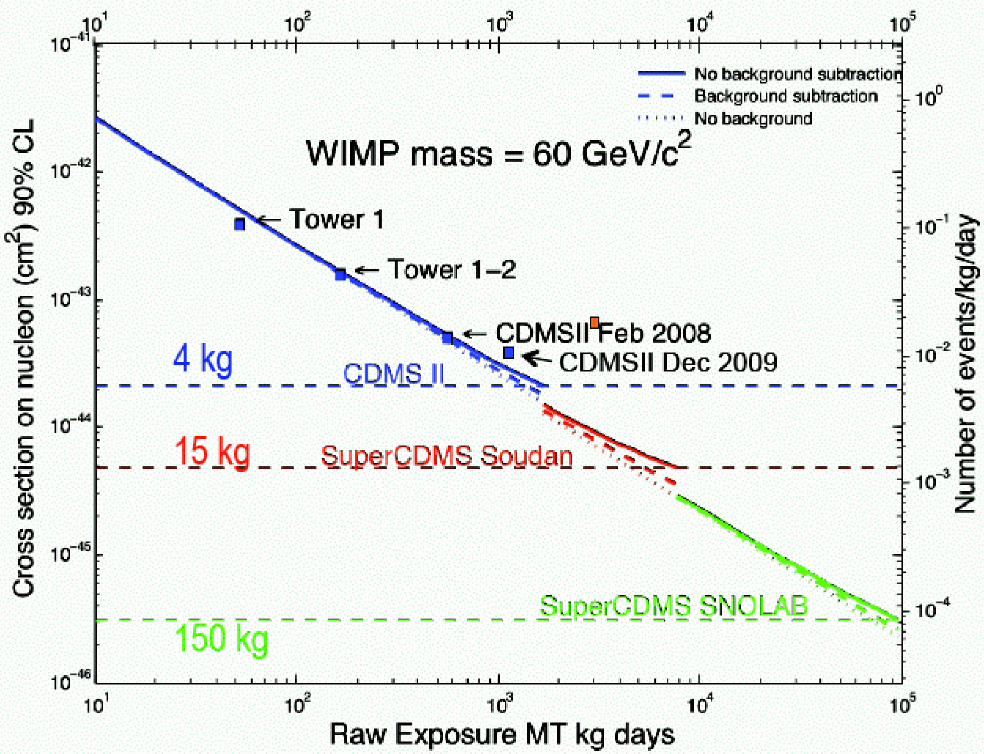
CDMS Detection Method

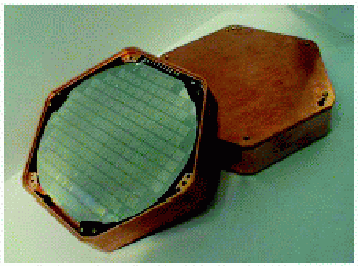
- **WIMP scattering produces phonons:**
  - **See previous page.**
- **Ionization:**
  - **CDMS also records ionization.**
- **Recoil energy and ionization define a 2D-plane (see below).**
- **Calibration data:**
  - **Vital for cut tuning.**

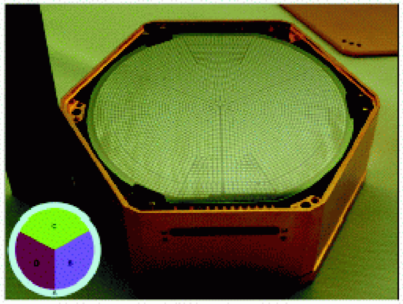


(Super)CDMS: Upgrades

SuperCDMS phases - Moore's Law if zero bkgd







GEODM

See e.g. 'Background Penalty Factor', Scott Dodelson arXiv 0812.0787v2

4 SuperCDMS & GEODM Feb 2010 Paul Brink

SuperCDMS And SLAC

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Accepted Proposals

Proof-of-Principle for Mass Production of Large Germanium Detectors for Large Scale Dark Matter Search Experiments

Proposal

Lead Scientist: Eduardo do Couto e Silva

Other Scientists: Paul Brink, Blas Cabrera, Helmut Marsiske

Proposal Term: From October 2008 through October 2011

Description of Project

The origin of Dark matter is a fundamental question in High Energy Physics. Future experiments aiming at detecting dark matter through scattering off target nuclei will demand improvements of two orders of magnitude in sensitivity. The main choices for the target material for such experiments are: noble liquids (e.g. Ar, Xe) or semiconductors (e.g. Ge). The former scales to large volumes, but future prototypes have to demonstrate their background rejection capabilities. Ge detectors already operate in a background-free environment, but have to demonstrate scalability of the technology to large volumes. The scientific community should invest in both approaches, so that discoveries can be corroborated by different experimental techniques. Our research focus on the main scalability issues for Ge experiments. We propose the development of a proof-of-principle for mass production of large Ge detectors, improving process control and developing new tools to further reduce background as the mass increases. We request ~$315k dollars per year over the next three years for the development, test and evaluation of 3 inch diameter test wafers, components for 6 inch photolithography and feasibility studies using Monte Carlo simulations. This effort will enhance KIPAC's (SLAC and Stanford University) participation in the field of non-accelerator high energy physics and astrophysics and will assert their technical and scientific leadership in this field. This proposal, with support from the SuperCDMS and GEODM collaborations (see attached letter at the end of this proposal), emphasizes technical and scientific synergies between Stanford University and SLAC National Accelerator Laboratory in the areas of semiconductor fabrication, testing and large scale integration of detectors for High Energy Physics and Astrophysics experiments.

Expected Results

Demonstrate readiness of Ge detector fabrication for large scale experiments and identify scalability issues. Fabricate test wafers, measure background levels from the fabrication process and develop new photolithography components necessary for 6 inch technology. Develop simulation of phonon signals for larger-diameter detectors in a GEANT framework. This can be used as a tool to reject backgrounds for large scale experiments. Provide a recommendation on the feasibility of scaling of Ge detectors for one ton experiments for future dark matter searches. This will have an immediate impact on experiments being designed for the next 5-10 years. We expect these results will lead to follow-up funding from NSF and DOE and foster collaborations between agencies.

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SLAC SuperCDMS Group

- **SLAC SuperCDMS:**
  - **Led by Eduardo.**
  - **Scope is directed by the LDRD: 2008-2011**
  - **Main goal:**
    - **How to scale up the current Ge detector:**
      - **From ~4 kg to 100-1000 kg**
      - **SuperCDMS, GEODM**
  - **Additional goals:**
    - **Implement the phonon simulation in G4.**
    - **Improve the MC simulations for better background rejection.**
- **Related to this:**
  - **More structured software organization.**
  - **Implement an offline framework for MC simulations.**
  - **Use cloned Fermi pipeline to produce MC.**
- **Note that it says 'MC' everywhere ....**

SLAC SuperCDMS: Current Activities

- Implementing the current MATLAB phonon simulations into Geant4:
  - Makoto, Dennis and Mike
- MC framework:
  - Mike
  - BaBar framework or Gaudi are candidates.
    - PPA SCA have expertise with both!
- MC has to support:
  - Phonon and background simulations
  - Multiple detector geometries:
    - Increasing the mass from 4kg to >100 kg
    - In physical different locations:
      - » Soudan, SNOLAB, ...
- Set up the MC production pipeline:
  - Tony
- Future overall software and computing organization/structure:
  - Anders

SuperCDMS' Future Looks Bright

Report of the HEPAP Particle Astrophysics Scientific Assessment Group (PASAG)

23 October 2009

The CDMS collaboration is addressing these issues and significant progress has been made. To advance the CDMS technology, **PASAG recommends a technical review of SuperCDMS in FY2010 to evaluate the performance of the new detectors currently in operation at Soudan. Funding for the 100-kg SuperCDMS-SNOLAB experiment should begin as soon as the detectors meet the design requirements.** Tests of the iZIP detectors in SuperCDMS-Soudan are also highly desirable.

And The Proof Is ....

Job Details

Printer friendly

Req Number: 35249 Apply for this job

Job Title: Staff Scientist

Directorate: P00000 - Particle Physics and Astro

Percent Time: 100%

Duration: Continuing

Open To: All

Responsibilities

One of the top scientific questions of our century is the origin of dark matter. The Cryogenic Dark Matter Search (CDMS) at SLAC is a recently created Department under the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) and the Particle and Particle Astrophysics (PPA) Directorate. SuperCDMS is an experiment designed for deep underground operations that will search for Dark Matter from nuclear recoils off germanium crystals. These interactions could be ascribed to hypothetical particles (WIMPs) predicted by extensions of the Standard Model. The detector consists of Ge crystals assembled in modules (Ge Towers) inside a cryostat, operating at cryogenic temperatures and surrounded by adequate veto and shielding. The SuperCDMS experiment at the Soudan Mine in Minnesota will deploy a germanium target mass of 15 kg. The projected sensitivity reached by the end of 2012 is expected to be a few times 10-45 cm2 for a WIMP mass around 60 GeV/c2. Sensor fabrication currently occurs at the Stanford Nanofabrication Facility and is led by the SuperCDMS group at Stanford. To extend the sensitivity even further, SLAC is participating in the R&D for the future SuperCDMS project with plans to build a new underground installation within the SNOLAB laboratory in Canada and to instrument more than 100 kg of Ge cryogenic detectors. Operating through 2015, SuperCDMS SNOLAB would improve the present sensitivity for dark matter WIMPs by more than two orders of magnitude. SLAC is partnering with Stanford University and will lead detector fabrication and testing. The main focus of the SLAC group is to address scalability issues of hardware and of software to enable future experiments with germanium target masses of order 100 to 1000 kg. In addition, the SLAC group plans to contribute to the deployment (in 2011) of five Ge Towers at the Soudan mine in Minnesota, and subsequent operations, as well as software development and data analysis for the following two years. The hardware R&D effort at SLAC includes designing, fabrication, simulation, testing of Ge detectors . In