Status and Plans for SuperCDMS

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For the SuperCDMS Collaboration
Introduction

- Strong evidence for non-baryonic dark matter
- Weakly Interacting Massive Particles are well motivated candidates
- Search for nuclear recoils from WIMPs
- Main challenge: interaction rate much lower than background radiation
- Strategy to deal with background:
  - Reduce
  - Discriminate
  - Identify
Basics

- Conventional detectors (ionization, scintillation): signal reduction for nuclear recoils (*quenching*)
- Most energy converts to thermal energy (lattice vibrations – phonons)
- Measure thermal signal
- Combine with conventional technology: discrimination of BG
Detectors

- Cryogenic ionization detectors, Ge (Si)
- $\varnothing = 7$ cm, $h = 1$ cm, $m = 250$ g (100 g)
- Thermal readout: superconducting phase transition sensor (TES)
- Transition temperature: 50 – 100 mK
- 4 sensors/detector, fast signal (< ms)
- Charge readout: Al electrode, divided
Detector Performance

Discrimination

Detector with Collimator

Position/Timing

Ionization/Recoil energy

Recoil energy [keV]

γ-band

β-band

n-band

Surface effect

Z-sensitive

Ionization

Phonon detector

use timing

γ’s

β’s

neutrons
Soudan Setup

“Tower” (6 Detectors)

Cryostat, Coldbox, Shielding

Soudan Underground lab
Soudan Data 2003/04

2 Towers in Ice-box

Soudan Underground lab: 2090 m w.e.
2 runs in 2003/04:
• 1 Tower Run: 20 kg d Ge
• 2 Tower Run: 34 kg d Ge
  12 kg d Si

One event in each data set (Ge)
(consistent with expected BG)
Soudan 2005-08

- 5 Towers installed (ca. 4.8 kg Ge, 1.1 kg Si)
- Data taking since October 2006
  First data release (October – June, ~ 400 kg d raw data) February 08
Soudan Data 2006/07

Blind analysis:
Define cuts based on calibration, events outside signal region

- Remove blinding
- Data before application of timing cut
- Apply timing cut

Background free:
No event present in signal region
Soudan Data 2006/07

Timing parameter distribution for all events.

Neutron calibration data in yellow

Red box indicates approximate signal region defined before unblinding
Soudan Data 2006/07

![Graph showing WIMP-Nucleon Cross Section vs. WIMP Mass]
Results – 'Big Picture'

- Expected 2008 ($\sim 5 - 10$ kg)
- Need about 1 t to get here
Present Status - Soudan

- Data collected so far: ~2.5 times as much as included in latest publication
- Regular partial warm-ups to remove frozen air from system
- As we speak: full warm-up to remove air leak and for maintenance of cryo-cooler
- Cooldown mid October, measurement in present configuration planned to continue until early 2009
- Expected sensitivity: $O(10^{-8} \text{ pb})$
SuperCDMS - New Detectors

• Increase thickness / mass of single module
  (1 cm → 1 inch = 250 g → ~ 650 g per module)
  - Reduce number of readout channels per mass
  - Increase volume-to-surface ratio (surface events)

• Ionization sensor design
  - Electrode: improved diffusion barrier for surface events
  - Larger outer ionization readout channel

• Thermal sensor design
  - increased surface coverage (better timing)
  - New arrangement of phonon sensors (outer ring and a threelfold “Mercedes” like inner disk)
New Detector Performance

- Excellent energy resolution in charge signal (phonon signal somewhat worse)
- Promising data for surface event rejection.
- Extensive measurements underway to study position dependence in new 3-fold design with improved surface coverage
Soudan in 2009

- Funding exists for 2 Towers of new detectors (*SuperTowers*)
- Replace old towers by new ones
- Funding is being applied for to add 2-3 more SuperTowers (total target mass of ~ 15 kg)

Limiting background at Soudan:
- Unknown contamination of shielding material (e.g. U in Pb) and cryo-setup
- Cosmic radiation
SuperCDMS at SNOLAB

- Sensitivity (pb):
  - $10^{-6}$
  - $10^{-7}$
  - $10^{-8}$
  - $10^{-9}$
  - $10^{-10}$

- Exposure (kg d):
  - $10^1$
  - $10^2$
  - $10^3$
  - $10^4$
  - $10^5$
  - $10^6$

- Background free:
  - 1 event /kg/d

- 5 events/t/y

- 10 kg y

- 1 t/y

WIMP mass = 60 GeV/c^2

- Cross section on nucleon (cm^2) 90% CL
- Number of events/kg/day
- Raw Exposure MT kg days

- SuperCDMS @ SNOLAB
- SuperCDMS @ Soudain
- CDMS II
- CDMS II Feb 2008
- Tower 1
- Tower 1-2
- No background subtraction
- Background subtraction
- No background
### SuperCDMS Schedule

**CFI Proposal SNOLAB infrastructure**

- **DOE/NSF proposal** – additional SuperTowers @ Soudan
- **DOE/NSF proposal** – increased detector mass, SNOLAB operations

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SuperCDMS at SNOLAB
SuperCDMS at SNOLAB

- Detector volume holds ~ 150 kg of active target
- Cryostat in standard mode operated without liquid cryogens
- Pb/Cu shielding against external gammas
- PE shielding against external neutrons
- Incorporate neutron detector into shield (not shown)
SuperCDMS - Conclusion

- CDMS is presently the most sensitive dark matter experiment (spin-independent WIMP-nucleon cross-section above 45 GeV/c²)
- Only background free experiment to date!!
- 2-3 times as much data in hand, analysis underway
- Continue to collect data with present setup until early 2009
- New improved detectors under construction, first set will be deployed first half of 2009
- Funds for additional detectors and for new infrastructure at SNOLAB are applied for
- In the best of all worlds we could start underground activity at SNOLAB in mid to end 2009