CDMS II Status
+ CDMS I / III / CryoArray
Direct Detection of SUSY
Cold Dark Matter

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see information at
http://cdms.brown.edu/
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STATUS: CDMS II - Cold & Running “First Dark” achieved

• 12 detectors - cold & checked out @ SOUDAN
  6 Ge+6 Si
  Cryo / DAQ / Electronics / Analysis operating

• Tower 1 - currently calib
  Prev. 1/2 year @ Stanford - b/g well understood
  • 120 live days (50 kg-days Ge)
  • Tower not changed -> Soudan
  • Will be some improvement at depth
    – Need stats to study b/g (Prelim looks good)

• Tower 2
  All New detectors
  • Some improvements made in b/g handling
  • Not yet measured b/g for this tower

• Initial Goal @ SOUDAN
  Similar run to Stanford: 50 Ge kg-days
  Looking for Zero background (ZBG) >10 keV
  • Expect very clean analysis
Direct Detection: History & Future
90% CL Limit on Cross section for 60 GeV WIMP (scalar coupling)

Limit Scalar Cross-section cm$^2$ [60 GeV WIMP]

Year


~1 event kg$^{-1}$ day$^{-1}$

~1 event kg$^{-1}$ yr$^{-1}$

~1 event 100 kg$^{-1}$ yr$^{-1}$

[\( m = \text{?? GeV} \text{ - if significantly better limit obtained at different mass} \)]

Not meant to be a complete list - see http://dmtools.brown.edu

CDMS Dark Matter - Aachen EPS - 17 July 2003

Rick Gaitskell
Latest & Greatest Limits on Scalar C-S for WIMPs

- Latest Edelweiss result (updated May 2003)
- ZEPLIN I result (announced Sept 2002)
- CDMS I result (updated June 2003)

http://dmtools.brown.edu

~1 event kg$^{-1}$ day$^{-1}$

http://dmtools.berkeley.edu

CDMS I Final

ZEPLIN I - Liq$^{nat^{130}}$Xe

Edelweiss - $^{nat^{72}}$Ge

http://dmtools.brown.edu
Ionization Yield (ionization energy per unit recoil energy) depends strongly on type of recoil.

Most background sources (photons, electrons, alphas) produce electron recoils.

Particles (electrons) that interact in surface “dead layer” of detector result in reduced ionization yield.

WIMPs (and neutrons) produce nuclear recoils.

Detectors provide near-perfect event-by-event discrimination against otherwise dominant bulk electron-recoil backgrounds, very good (>98%) against surface electron-recoil backgrounds.
CDMS II - Calibrations at Stanford

• ZIP Detector (250g Ge, or 100 g Si)
  20,400 gamma events (5-100 keV) ~ 1 week continuous calibration with $^{60}$Co source
  = ~one count in 12 years of gamma background
  (assuming project background level of 0.25 counts/keV/kg/day at CDMSII Soudan. Calibration still Poisson stats/neutron background limited)

Sensitivity better than 1 WIMP per year per detector
ZIP Detector Phonon Sensor Close-up

- Photolithographic patterning like CMOS but 1 big chip
- 37 cells per quadrant
- 7x4 array of W transition-edge sensors per cell, with Al “collector” fins covering only fraction of surface
Demonstration of xyZIP Position Sensitivity

Am$^{241}$:
14, 18, 20, 26, 60 kev

$Cd^{109}$:
22 kev
i.c. electr 63, 84 KeV

$Cd^{109}$ + Al foil:
22 kev

CDMS Dark Matter - Aachen EPS - 17 July 2003
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Working at Soudan
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Expected Backgrounds for CDMS II at Soudan

On track for 0.0003 events/kg/keV/day at 15 keV?

- Depth of 2000 mwe reduces neutron background from ~1 / kg / day to ~1 / kg / year
  - Also better neutron shielding
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• Photon background is already 0.7 events/(kg keV day) x 10^{-3} expected leakage, despite the shallow site (good enough with background subtraction)
Expected Backgrounds for CDMS II at Soudan

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• Depth of 2000 mwe reduces neutron background from ~1 / kg / day to ~1 / kg / year
  
  - Also better neutron shielding

• Photon background is already 0.7 events/(kg keV day) x <10^{-3} expected leakage, despite the shallow test site

• Electron background is 0.1 events/(kg keV day) x ~0.04 expected leakage, despite the shallow site (need ~2x improvement from depth, or better surface screening/cleaning)
Latest & Greatest Limits on Scalar C-S for WIMPs

- CDMS II
  Initial goal 20x improvement over CDMS I

ZeroBG 50 kg-days Ge

~1 event kg\(^{-1}\) day\(^{-1}\)  

Initial Goal 2003 CDMS II 20x ZBG 50 kg-days

http://dmtools.brown.edu
CDMS Conclusions

CDMS I (1995-2001)

- SI upper limits now eclipsed by EDELWEISS, Zeplin I except at low WIMP mass.
- CDMS data are incompatible with DAMA signal for standard WIMPs & halo.
- Sensitivity limited by neutrons from muons interacting in surrounding rock.

CDMS II (2000-2005)

- 12 detectors (1.5 kg Ge, 0.6 kg Si) cold @ Soudan
  - Stanford discrimination tests of 6 dets exceeded performance expectations.
  - Stanford b/g testing showed expected reduction of neutron background by factor of ~2.3 due to installation of internal moderator (agreement with MC predictions.)
  - “First Dark” achieved Apr 2003.
    - Initial Goal ~50 kg-days Ge (similar to previous run @ Stanford, but no neutrons!)

CryoArray (2006 - 2017 or so…)

- Sensitivity to study WIMP physics down to s~10^{-46} cm^2 (many events if higher s).
- Modest improvements over current results (shared):
  - Discrimination: already good enough, within factor few.
  - Backgrounds: x20 reductions vs CDMS II, 2-3x vs best current IGEX, H-M
Backup Slides Q&A
(Not Used in Talk)
CryoArray: A 3rd Generation Experiment

- Based on extrapolation of CDMS technology/strategy
- Basic parameters/goals
  - $1000 \text{ kg} \times 2 \text{ (live) years}$
  - $\sim 100 \text{ WIMPs at } 10^{-45}\text{cm}^2$
    - $\sim 10 \text{ WIMPs at } 10^{-46}\text{cm}^2$
    - $\sim 10$'s background events
  - $10^4 - 10^5 \text{ increase over present limits}$
  - $10^2 - 10^3 \text{ increase over expts under construction}$
- Excellent discrimination so need little background reduction
  - Internal (, ) and external (n)
- Main challenge:
  - Increase mass ($\sim 100x$) and manufacturability of detectors/cryo package
  - Maintain Performance
- Possible sites
  - Soudan (CDMS II) among shallower sites (n background problematic)
  - National Underground Facility
    - Depth
    - Shared resources (vetos, assembly, materials screening, fabrication???)
Background Projections - CryoArray (1 ton)

Energy Range 15-45 keV

<table>
<thead>
<tr>
<th></th>
<th>Site</th>
<th>Depth (mwe)</th>
<th>Event Rate (mdru)</th>
<th>Exposure (1000 kg day)</th>
<th>Raw Events (#)</th>
<th>Rejection Efficiency</th>
<th>After Reject (#)</th>
<th>After Subtraction (#) (mdru)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Photons</strong></td>
<td>CDMS I</td>
<td>SUF</td>
<td>16</td>
<td>800</td>
<td>0.016</td>
<td>384</td>
<td>99.96%</td>
<td>0.1</td>
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<tr>
<td></td>
<td>CDMS II</td>
<td>SUF</td>
<td>16</td>
<td>800</td>
<td>0.04</td>
<td>960</td>
<td>99.97%</td>
<td>0.3</td>
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<tr>
<td></td>
<td>CDMS II</td>
<td>Soudan</td>
<td>2080</td>
<td>260</td>
<td>2.50</td>
<td>19500</td>
<td>99.97%</td>
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<td>CryoArray</td>
<td></td>
<td></td>
<td>13</td>
<td>500</td>
<td>195000</td>
<td>99.97%</td>
<td>65</td>
</tr>
</tbody>
</table>

| **Electrons**       | CDMS I  | SUF         | 16                | 300                    | 0.016          | 145                  | 95.00%          | 7                          |
|                     | CDMS II | SUF         | 16                | 80                     | 0.04           | 96                   | 95.00%          | 5                          |
|                     | CDMS II | Soudan      | 2080              | 20                     | 2.50           | 1500                 | 95.00%          | 75                         |
|                     | CryoArray|            |                   | 1                      | 500            | 15000               | 99.50%          | 75                         |

- Photon background is very manageable
  - Current lower limit on discrimination already good enough if raw rate reduced to 13 mdru, ~2-3 times better than best levels reached so far (by IGEX, H-M)
    - achieve via materials selection and simplification of structures (little mounting material)
  - Screening to $10^{-10}$ g/g can reveal contamination source of such a background

- Electron background more worrisome, but certainly tractable
  - Need to screen & clean surfaces to $2.5 \times 10^{-2}$ counts/ (keV m² day), or to 10x better if rejection remains only 95% -- novel but appears to be doable

$dru = 1 \text{ event keV}^{-1} \text{ kg}^{-1} \text{ day}^{-1}$

see Schnee, Gaitskell & Akerib astro-ph/0208326