CDMS II: Status and Future Plans

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Fermilab

What is CDMS?

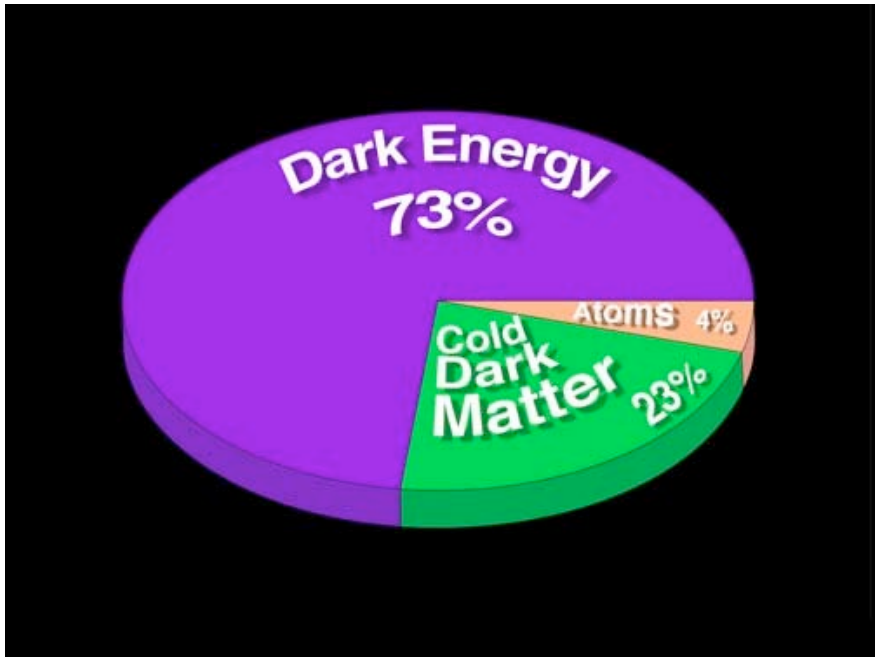
- Direct detection of cold dark matter

Status of CDMS II at Soudan

- Status of the experiment
- Current results
- Goals

Future Plans - SuperCDMS

- Continued running at Soudan
- More from Blas Cabrera



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CDMS in a nutshell

Dark Matter Search

Direct detection of WIMPs

Cryogenic

Ge and Si detectors, < 50 mK

Active Background Rejection

Distinguish between nuclear recoils (WIMPS, neutrons) and electron recoils (backgrounds)

Reject neutrons using

multiple scattering

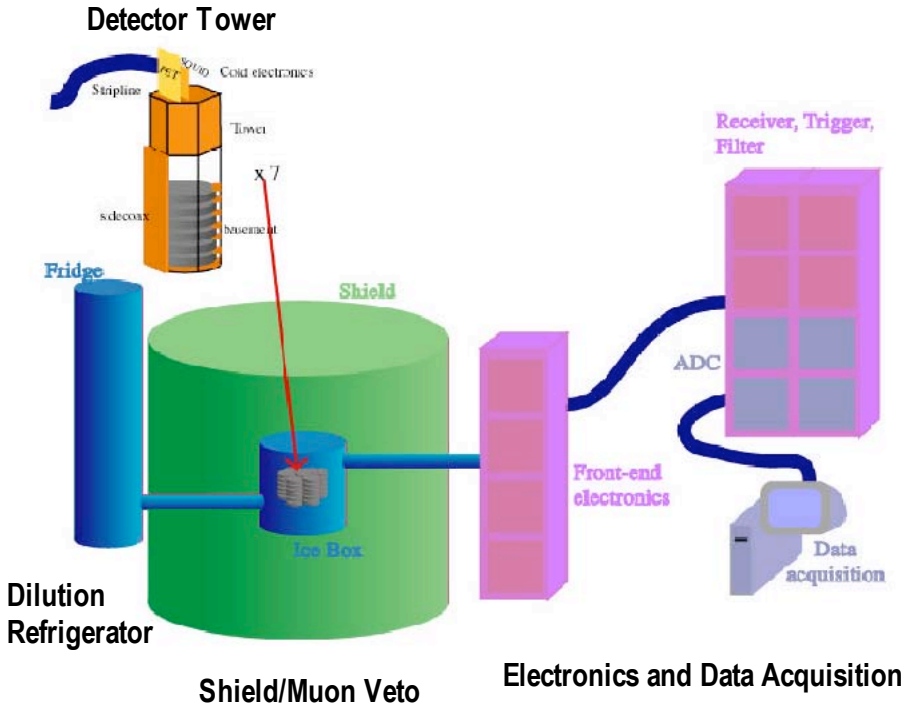
Neutrons do, WIMPS don't

comparison of Ge to Si rates

Neutron cross sections similar, but WIMP cross sections x5 higher in Ge

depth

Neutrons mainly from cosmic ray interactions



Shielding

Layered shielding (Pb, polyethylene, Cu) against radioactive backgrounds and active scintillator veto (>99.9% efficient against cosmic rays).

CDMS Active Background Rejection

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Detectors with excellent event-by-event background rejection

Measured background rejection:
99.995% for EM backgrounds using charge/heat
99.4% for β's using pulse risetime as well
Much better than expected in CDMS II proposal!

Tower of 6 ZIPs

Tower 1

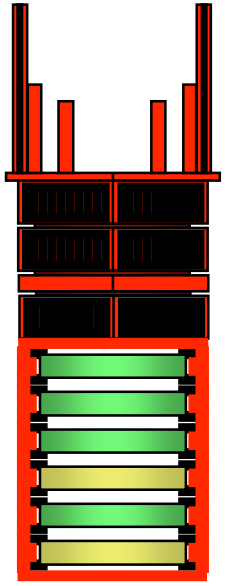
4 Ge

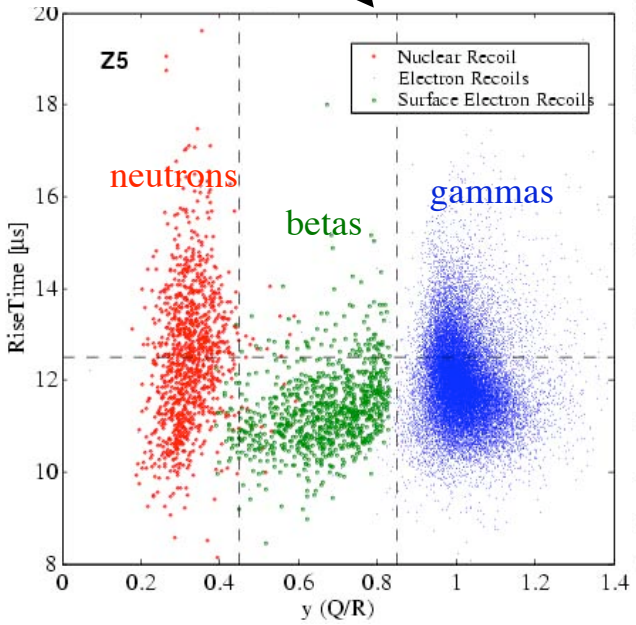
2 Si

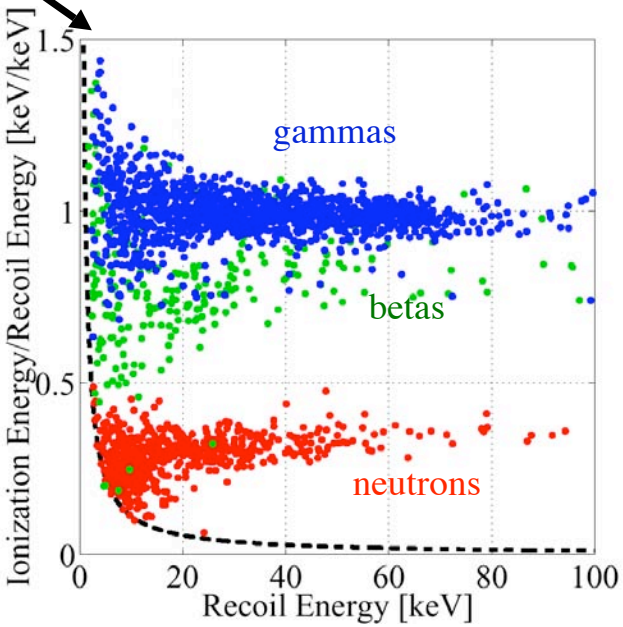
Tower 2

2 Ge

4 Si







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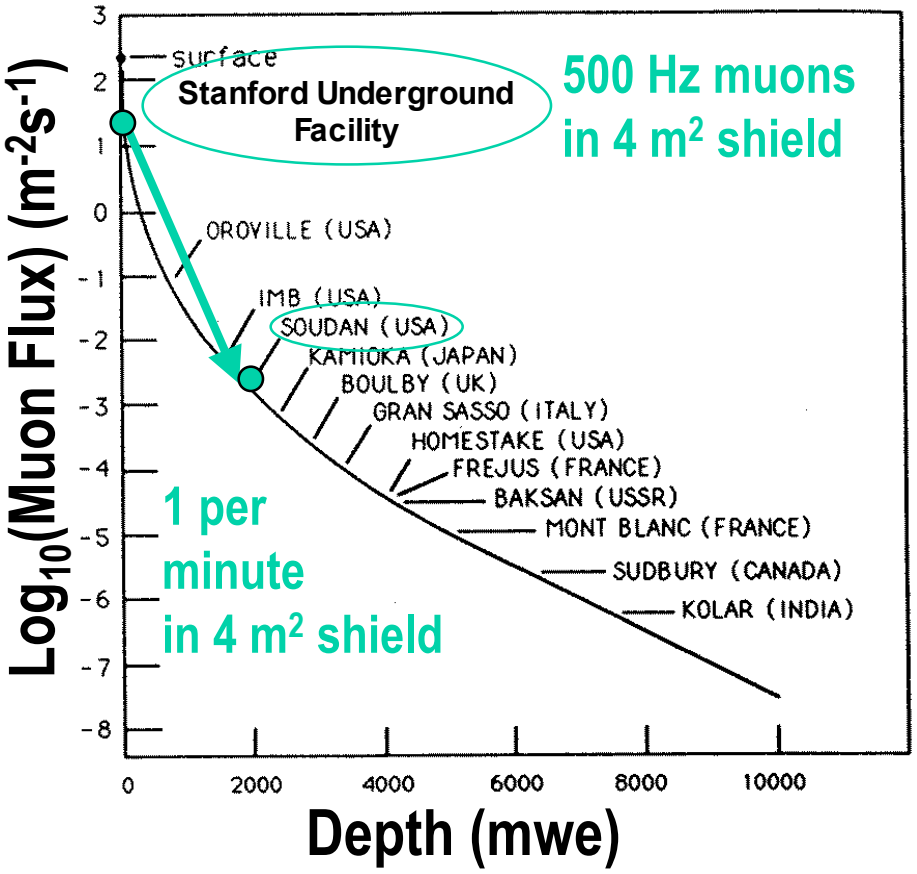
Status of CDMS II at Soudan

Depth of 2000 mwe reduces cosmic-ray-induced neutron background to ~1 / kg / year at Soudan

Construction of CDMS II begin 1999; operations began in 2003



First detectors arriving: winter 2003

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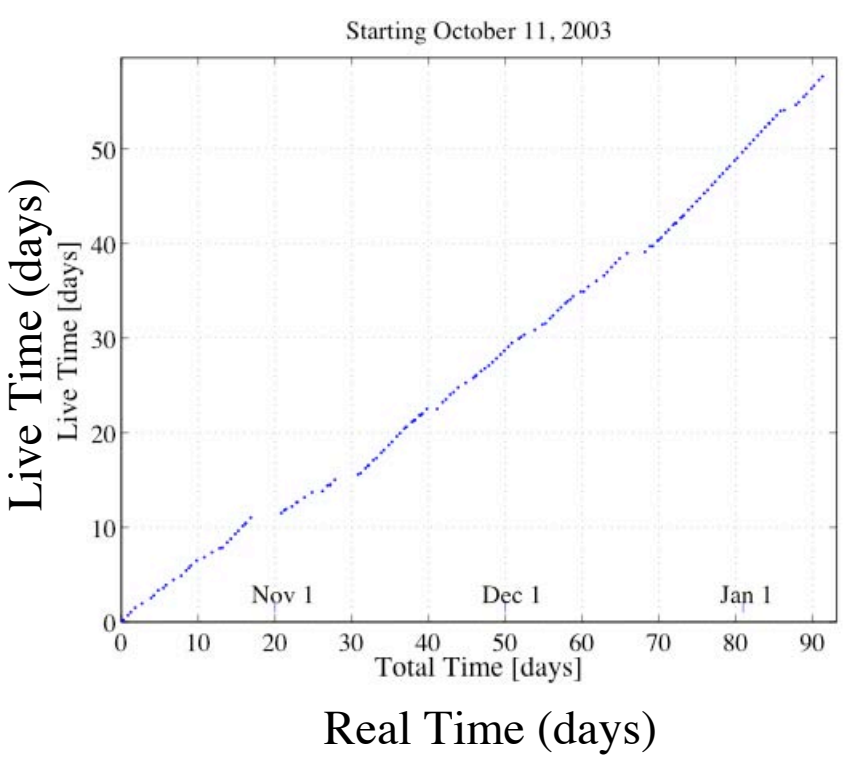
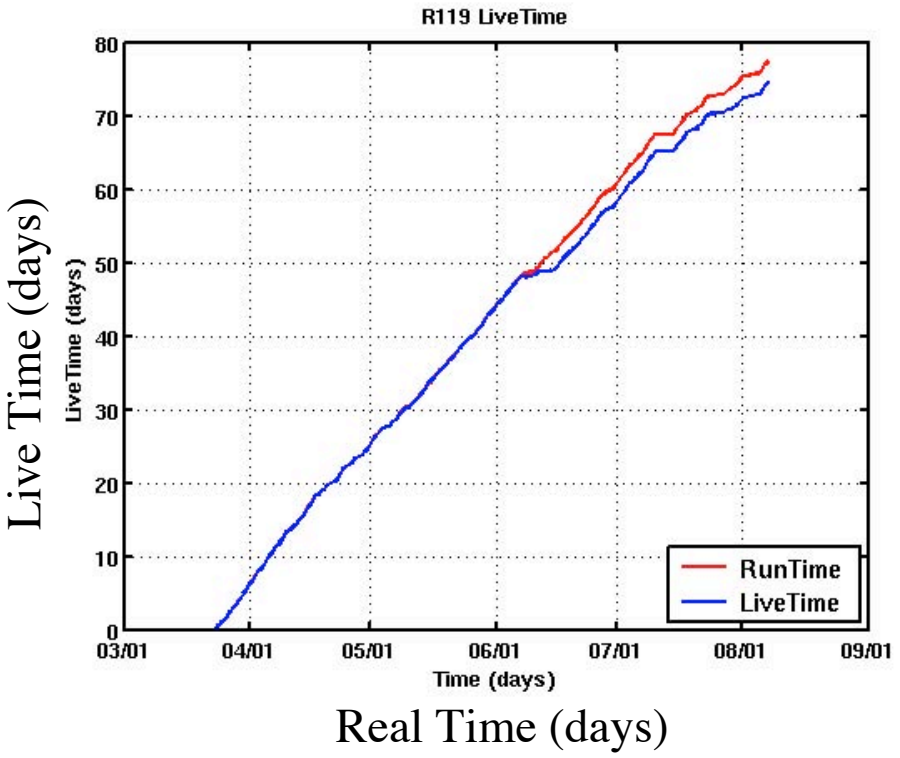
Soudan data sets

- **Tower 1 (Nov 2003 - Jan 2004)**
- **1 kg Ge, 0.2 kg Si**
- **52 live days, 22 kg-days Ge**



Tower 1 + Tower 2 (Mar - Aug 2004)
1.5 kg Ge, 0.6 kg Si
75 live days, ~56 kg-days Ge



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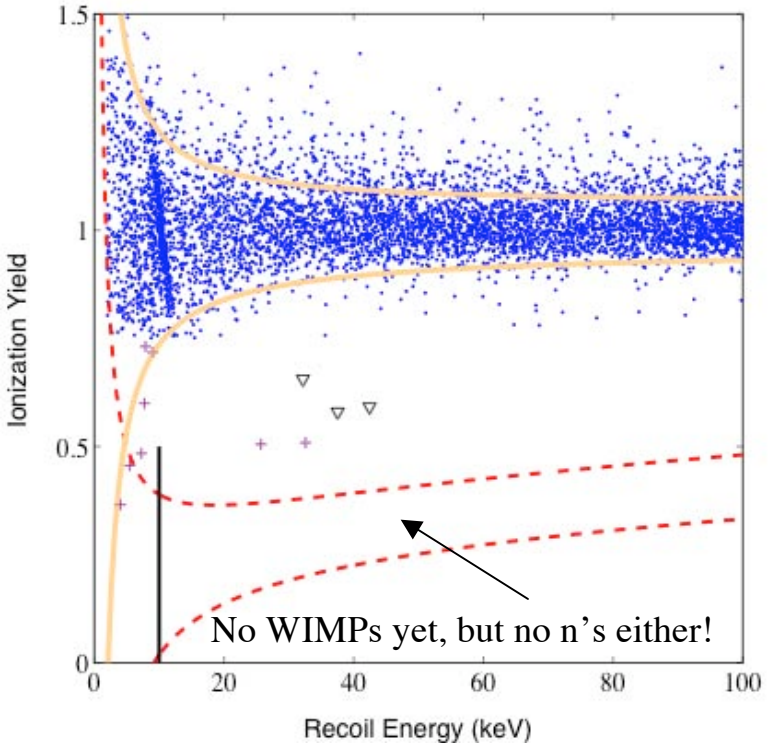
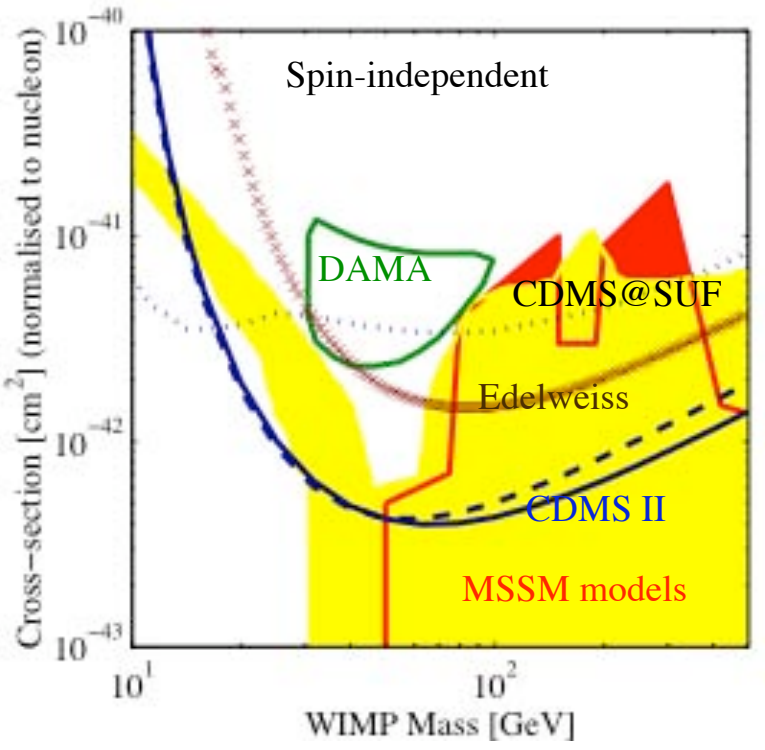
First WIMP limits from Tower 1 at Soudan

- Best in the world by a factor of 4
- DAMA 'signal' not due to spin-independent WIMP interactions
- Probing significant section of MSSM model space
- Accepted for publication in Physical Review Letters; PRD nearly finished





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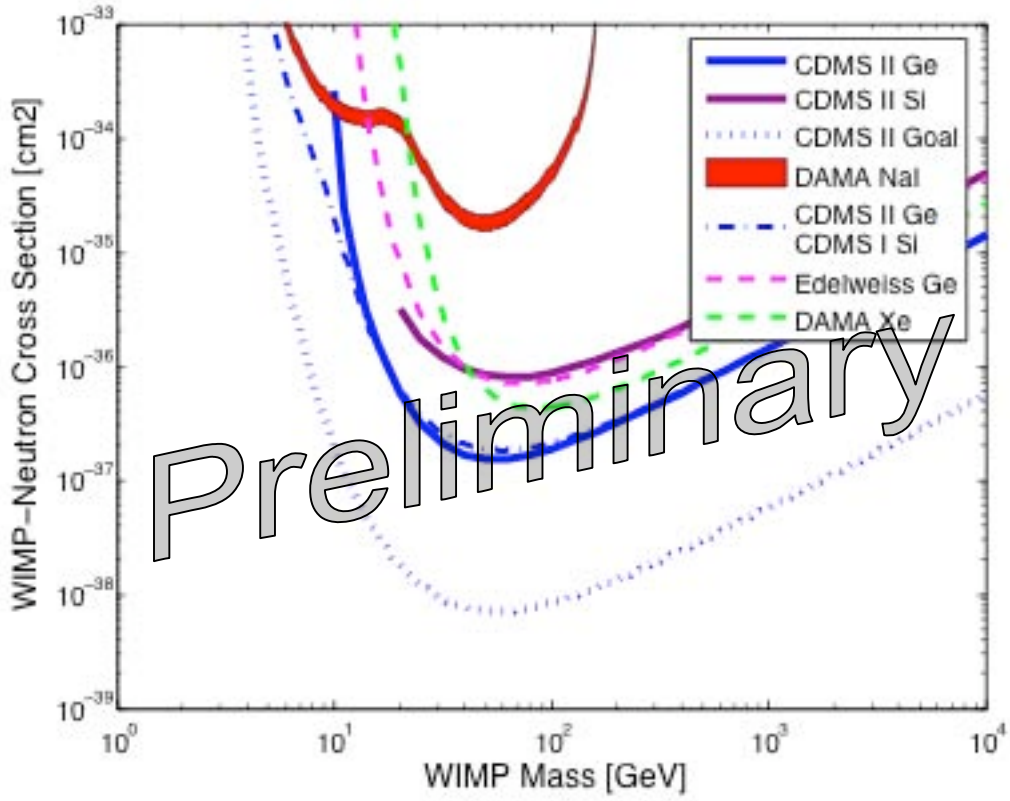
New Physics Result: Spin-dependent WIMP limits

- Recent realization that we can set best limits on WIMP-neutron spin-dependent cross sections (from 8% 73Ge with odd number of neutrons)
  - So DAMA probably not seeing spin-dependent WIMP interactions either!
- Paper will be submitted soon



How are we better than the competition?

We are taking data at a deep site!

- Edelweiss, CRESST are rebuilding (larger mass, better shielding)
- Xenon, bubble chamber experiments still doing R&D, prototypes

We have very low energy thresholds (< 10 keV recoil)

- Access to low mass WIMPs
- Big advantage with respect to Xenon (worth x10 in mass)

We have more information about events

- Ionization yield (ratio of charge to phonon signal)
- Timing (discrimination against surface events)
- Segmented charge electrode (fiducial cut against outer regions of crystal)
- Position resolution (mostly from phonon signals)
- Multiple detectors (multiple scattered events = neutrons)
- Si vs Ge (neutrons or WIMPs)

In a discovery, we will have many checks that events are WIMPs

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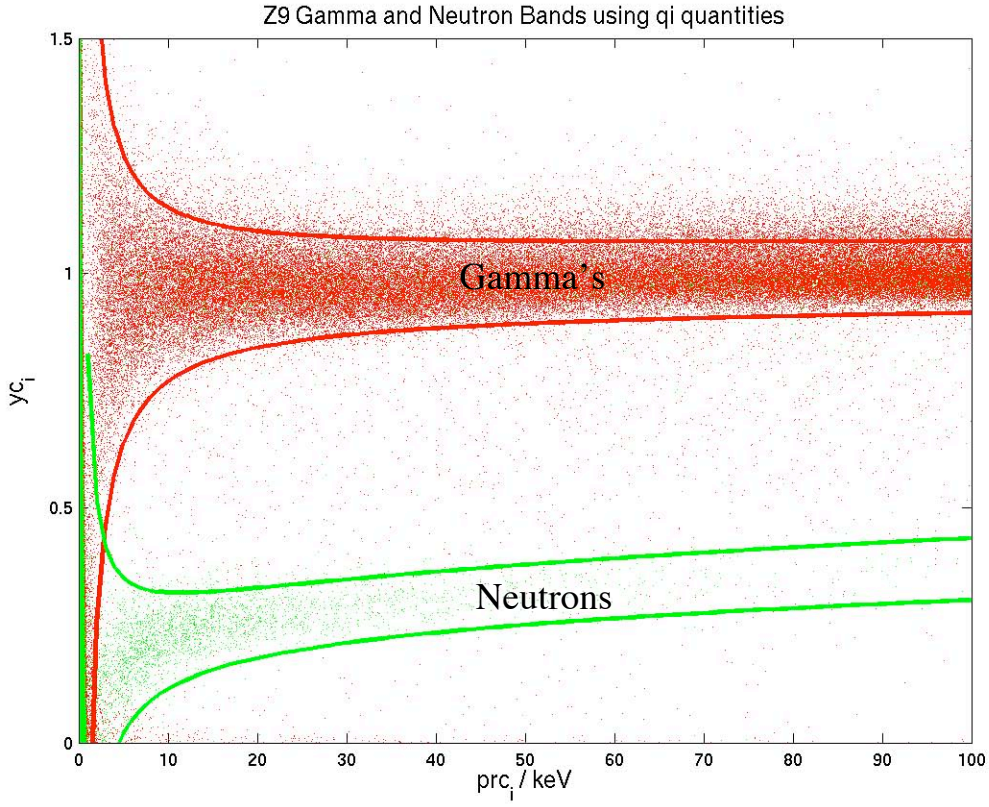
Analysis of Two-Tower Data nearly finished

- Blind analysis
  - Cuts set only on gamma, neutron calibration data
  - WIMP-search nuclear recoil region has just been opened, but still studying systematics
    - Not quite ready to release results :(
  - Should yield x3 improvement in sensitivity over Tower 1 result



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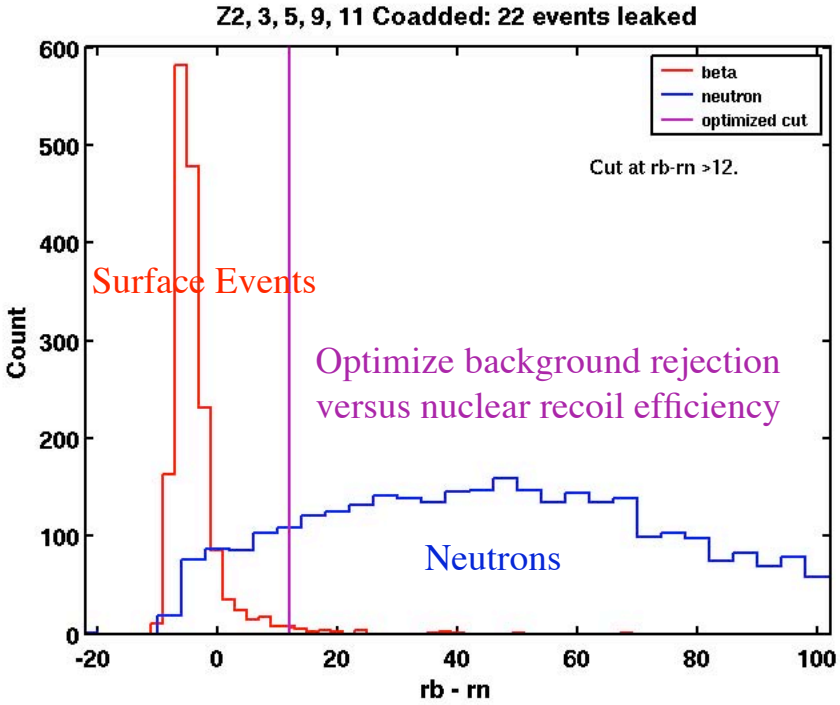
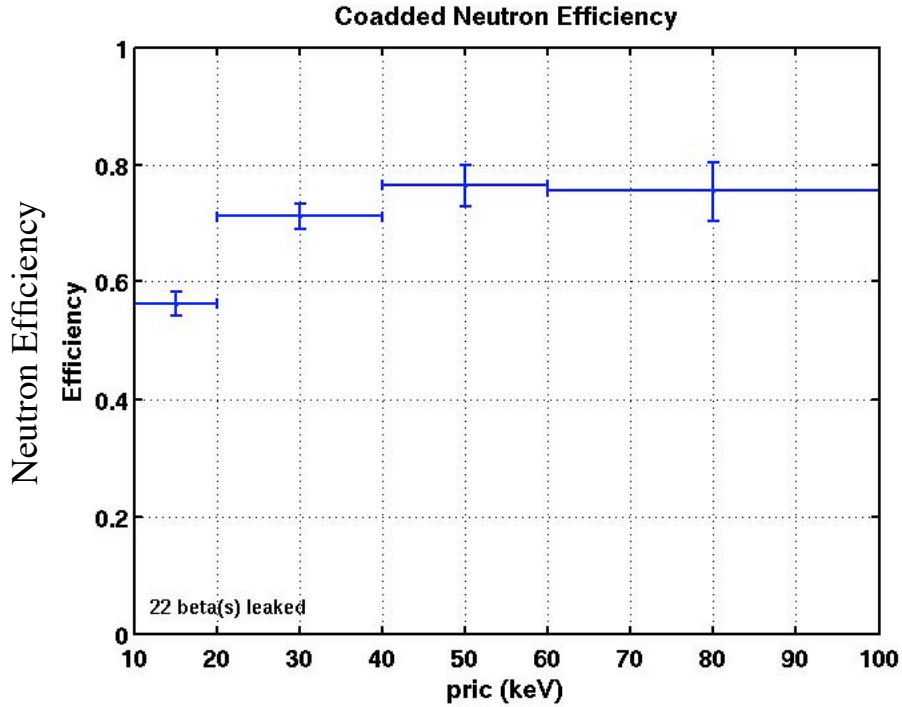
Improvements in Surface Event Rejection

- Significant improvements in our analysis of phonon timing information
  - Surface event rejection improved by x3; kept pace with exposure increase!
  - Nuclear recoil efficiency slightly improved
- We still have more discrimination power available as needed
  - Can continue to keep backgrounds < 1 event as more data accumulates
  - This is the real strength of CDMS detectors!



Chi-square (background pulse shape) - Chi-squared (neutron pulse shape)



Recoil Energy (keV)

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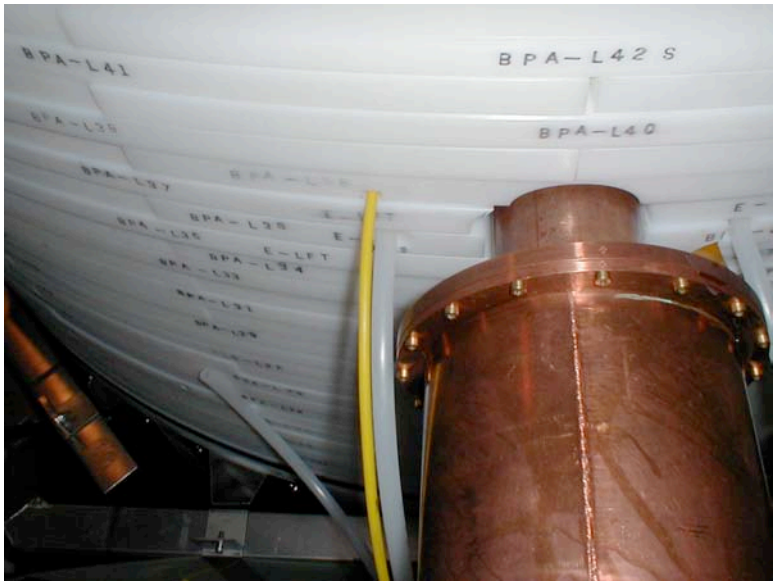
Improvements in Background Reduction

- Ambient Radon appears to dominate gamma background at Soudan
  - Radon purge during previous runs may not have been adequate
- Added 5 more Radon purge lines
  - Four of these can also accept radioactive sources for calibration



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DAQ and Computing Upgrades

- DAQ
  - 5 tower DAQ working
    - Improved data logging and tracking
    - More automated detector tune-up software
    - Better online diagnostics
- Offline computing
  - New onsite analysis cluster - 30 dual-cpu machines from FNAL
    - Very important for fast offline diagnostics to insure data quality
- Networking
  - Soudan is finally getting upgraded LAN (GigE) and WAN (T3)
    - Estimate completion by May
    - Should improve network bandwith to Soudan by at least x4

Cryogenic and Detector Upgrades

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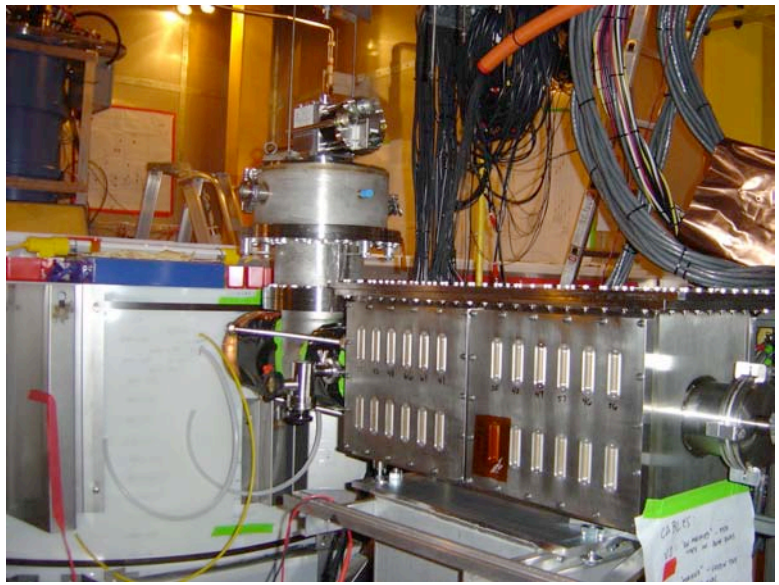
- Cryogenics
  - System has worked reliably for 1 year of running at 50 mK!
  - Upgrades installed to:
    - Improve vacuum, decrease maintenance
    - Better control and monitoring, more robust against power outages
    - Improve cooling at 4K with cryocooler; reduce Lhe consumption, costs
- Detectors
  - Three new towers installed; total of 4.5 kg Ge, 1 kg Si



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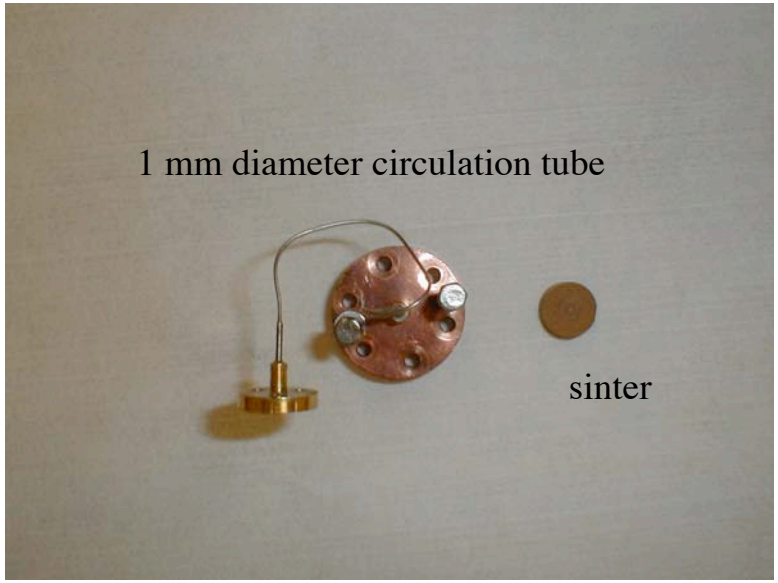
A Series of Unfortunate Events…

- Detector damage
  - Tower wires damaged by thermal shielding
  - Repaired on all good detectors in January
- Vacuum leak near the new cryocooler
  - Found and fixed in February
- Dilution refrigerator circulation blocked
  - Discovered 4 hours before cooldown in March!
  - Required tedious removal of refrigerator from icebox and disassembly
  - Found culprit 3 weeks ago; tiny bit of 'sinter' broke loose and plugged circulation tube
  - Fixed and fridge reassembled for test run
- More vacuum leaks
  - Helium bath
    - Difficult Indium seal not tightened sufficiently; fixed last week
  - Nitrogen Shield
    - Connectors to icebox cooling loop leak; fixed yesterday



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Path to Five Tower Operations

- Fridge 'stand-alone' run
  - Starting today, for the next week or two
- Reassembly of fridge to icebox
  - Completed by middle of May
- Cool down icebox with five towers
  - Should be at base temperature by end of May
- Commission and calibrate new towers
  - June
- Run the 5 towers
  - July-December 2005, and continue into 2006

Continuing Improvement in CDMS Sensitivity to WIMPs

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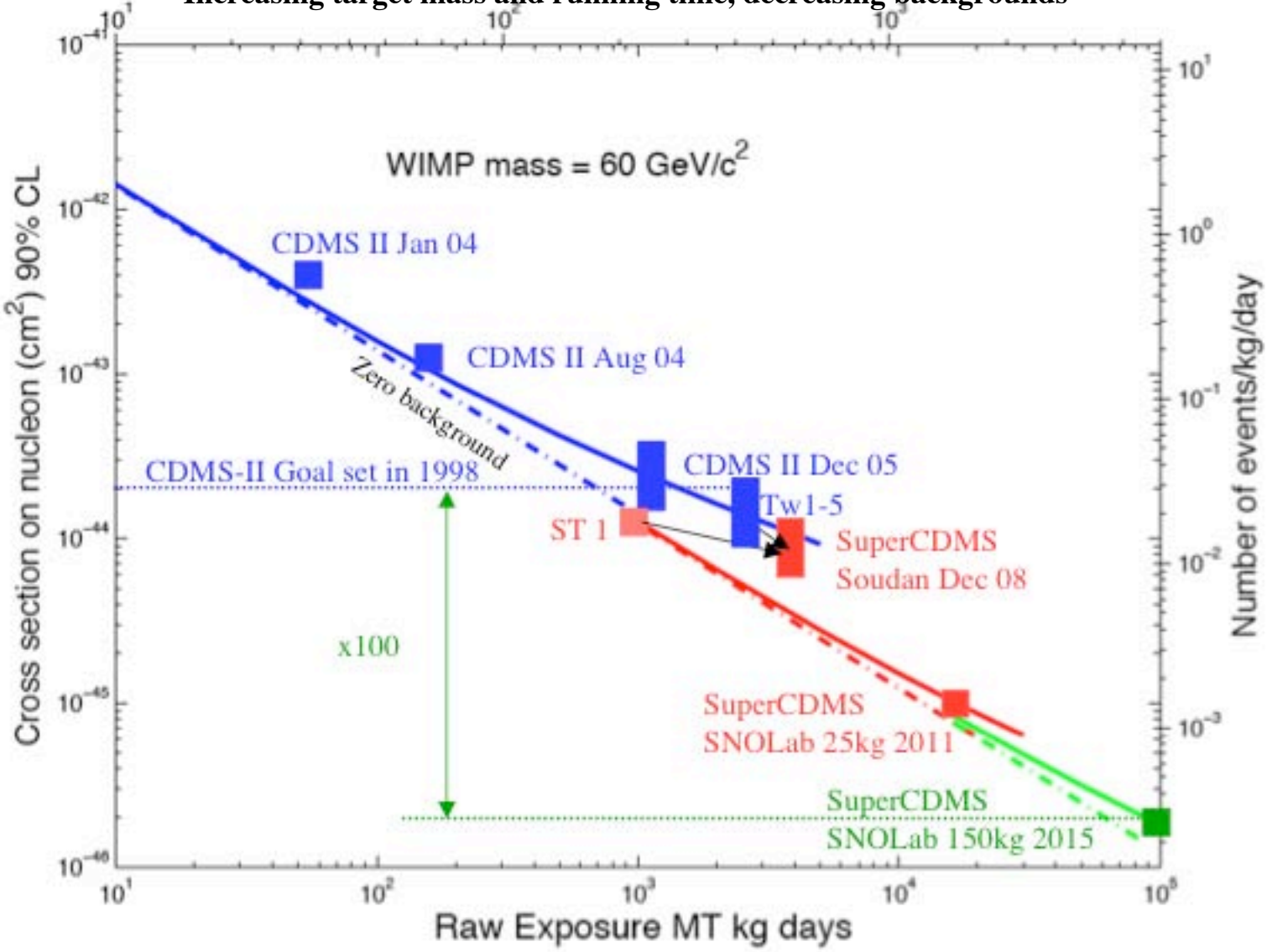
Increasing target mass and running time, decreasing backgrounds



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Cost of SuperCDMS Development Project

- This is NOT SuperCDMS itself, but a transition phase
  - Approval of development project ≠ approval of SuperCDMS
- Bottom line of $34M; comparable with CDMS II ($29M)
- Split almost evenly between DOE Lab, DOE University, and NSF
- DOE Lab is mostly Fermilab
  - Fermilab base = $1.7M/year fully-loaded salaries
    - Assumes 1 new associate scientist
  - Fermilab project = $0.6M/year operations costs
    - Dominated by cryogens, but significant travel, management costs
    - Modest increase from present level of $0.5M/year

Sum of Cost3 (w/contingency)	fund		
Agency	Base	Project	Grand Total
DOE Laboratory	6,727,047	3,751,233	10,478,280
DOE University	7,135,178	5,792,222	12,927,400
NSF	3,210,088	7,283,331	10,493,420
Grand Total	17,072,313	16,826,786	33,899,099

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Fermilab role - past, present & future

- Past and present responsibilities
  - Front end and RTF electronics boards
  - Soudan cryogenics and infrastructure
  - Computing support
  - Management - PROJECT MANAGER
- Future during SuperCDMS (similar level of resources)
  - Continue Soudan cryogenics and electronics upgrades
    - New Cryogenics design for larger experiment
    - New electronics design for bigger detectors with improved sensors
  - Continue project management and Soudan operations roles
- Future scientific leadership IF resources are increased
  - Possible role in detector characterization and testing
  - Additional senior research staff to lead analysis group
  - Major role in developing and maintaining analysis code
  - Will lead to success in postdoc hires

  Since August, we have had a CDMS postdoc at Fermilab!

Current Fermilab Presence in CDMS

- Scientific (3 FTE)
  - Dan Bauer (100%)
    - Project Manager, Soudan operations and infrastructure, cryogenics, electronics, analysis
  - Mike Crisler (25%)
    - Electronics, analysis (also participating in bubble chamber work)
  - Don Holmgren (25%)
    - DAQ, computing, analysis
  - Erik Ramberg (25%)
    - Analysis
  - Roger Dixon - On temporary loan to Accelerator Division!
  - **Jonghee Yoo (100%) - New Postdoc as of August!**
    - Much needed help in analysis
  - Andrew Sonnenschein - New Wilson Fellow
    - Mainly bubble chamber, but some level of effort on CDMS
- Technical (4 FTE)
  - 2 FTE Engineering (Schmitt, Orr, Kula, Kovlovsky, Grozis)
  - 2 FTE Technician (Lambin, B. Johnson, W. Johnson)
  - 0.25 FTE administrative and budget support (Maxine Hronek)


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Case Western Reserve U, FNAL, Santa Clara U,
NIST, U Colorado Denver, Brown U, U Minnesota