Status of the Cryogenic Dark Matter Search

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October 6, 2003

What is CDMS?

Dark Matter Search

Goal is direct detection of WIMPs which may be what holds our galaxy together

Cryogenic

Cool very pure Ge and Si crystals to < 50 mK using dilution refrigerator

Active Background Rejection

Detect heat and charge

WIMPS, neutrons => nuclear recoils

Charge/Heat ~ 1/3

EM backgrounds => electron recoils

Charge/Heat = 1

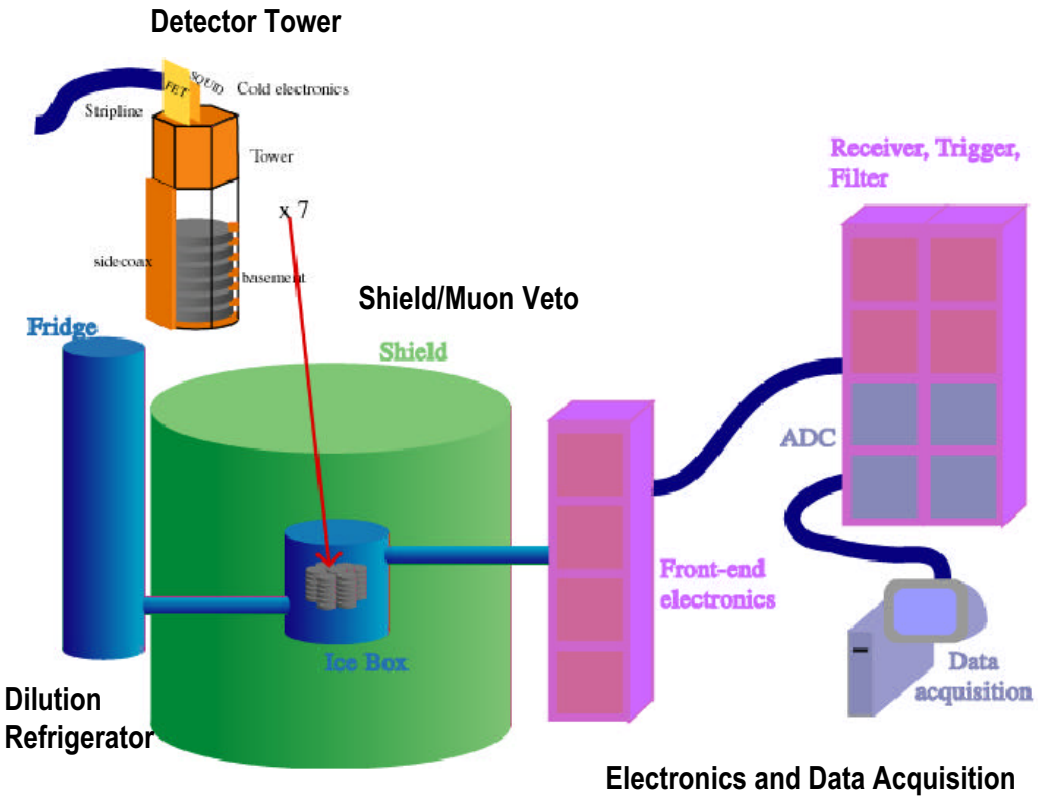
Reject neutrons using

multiple scattering

Neutrons do, WIMPS don't

comparison of Ge to Si rates

Neutron cross sections similar, but WIMPs x5 higher in Ge



Shielding

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

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ZIP Detectors

Z-sensitive Ionization and Phonon Detectors

Low-voltage ionization measurement

Athermal phonon measurement

low-noise SQUID readout

Measured background rejection:

> 99.9% for EM backgrounds using charge/heat

> 98% for β's using pulse risetime as well

Better than expected in CDMS II proposal!

Tower of 6 ZIPs

Tower 1

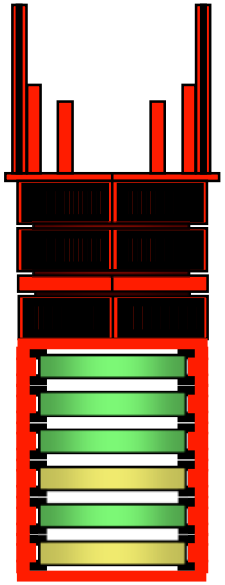
4 Ge

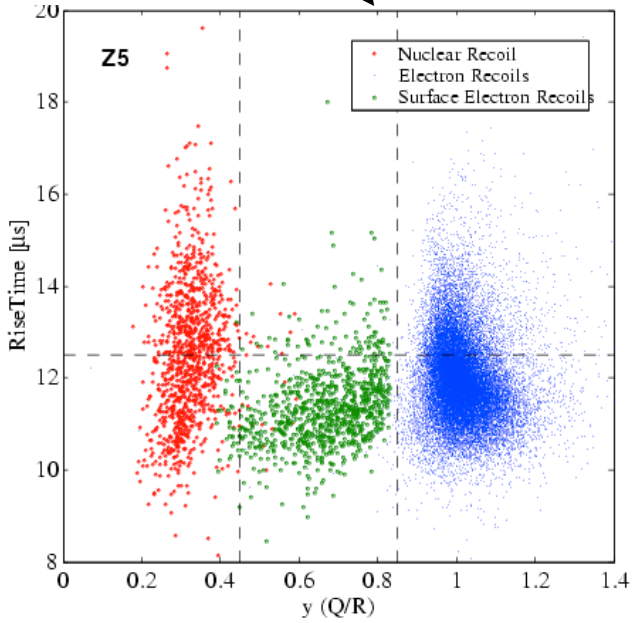
2 Si

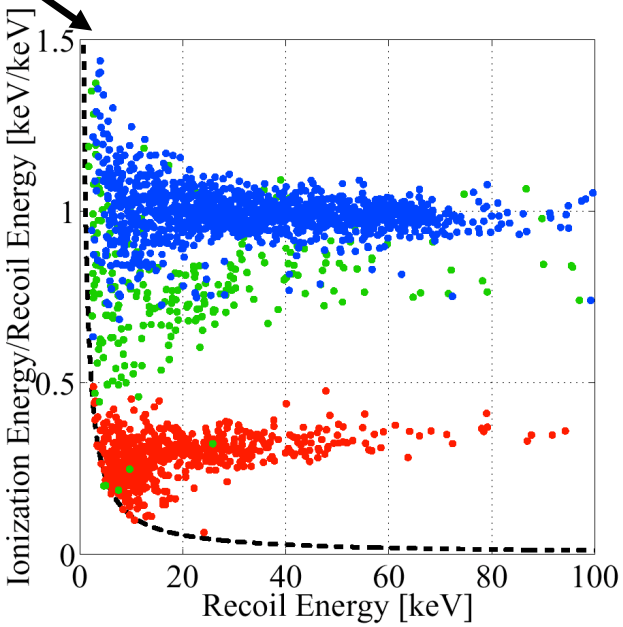
Tower 2

2 Ge

4 Si







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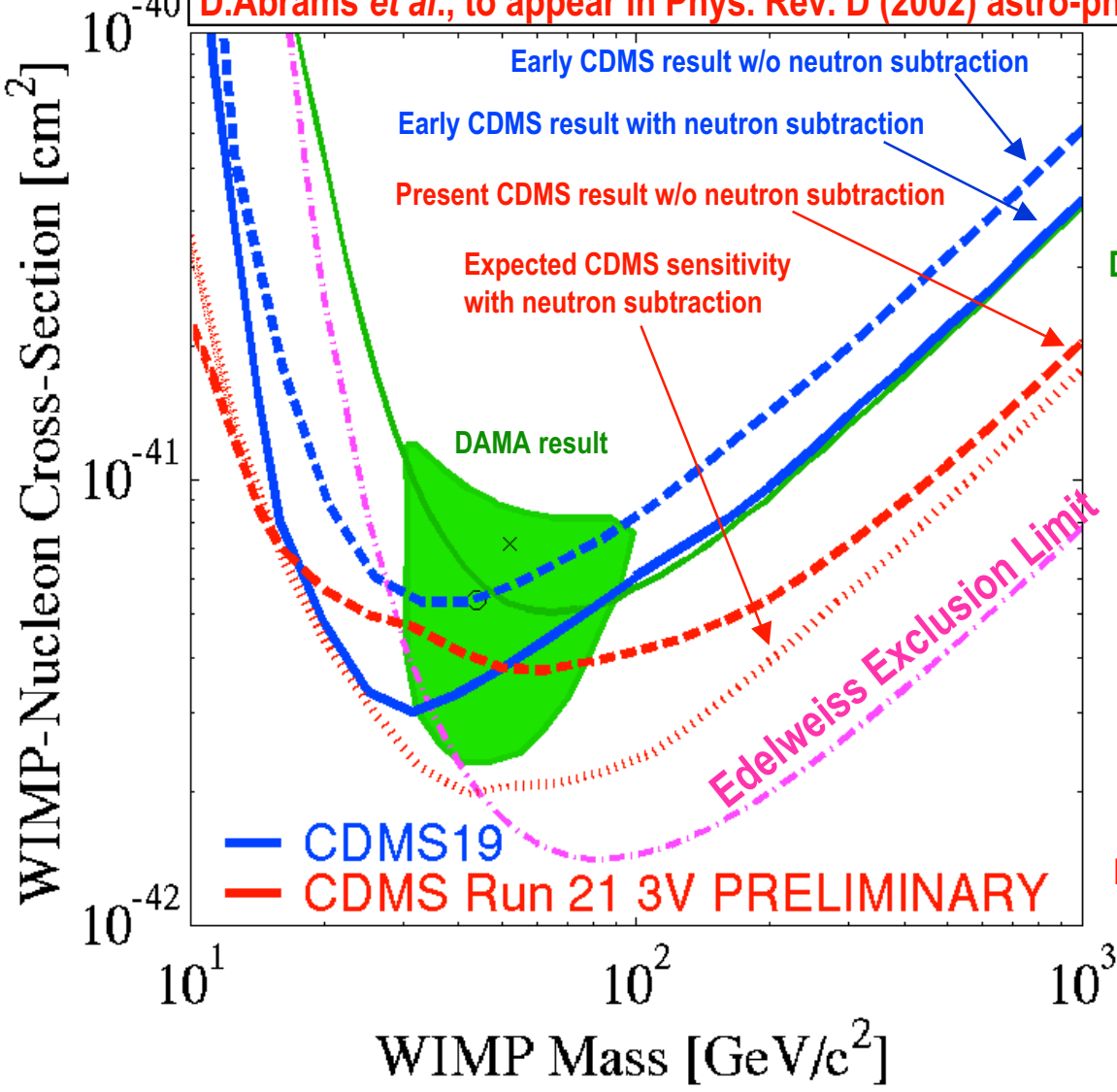
CDMS 2001-2002 Data Run at Stanford

R. Abusaidi *et al.*, Phys. Rev. Lett. 84, 5699 (2000).
D.Abrams *et al.*, to appear in Phys. Rev. D (2002) astro-ph/0203500 v3



DAMA signal essentially excluded
For standard halo and
spin-independent interactions

Edelweiss at deep site
Higher energy threshold
Worse limits at low mass
No neutron background
Better limits at high mass

Priority for CDMS-II to "go deep"

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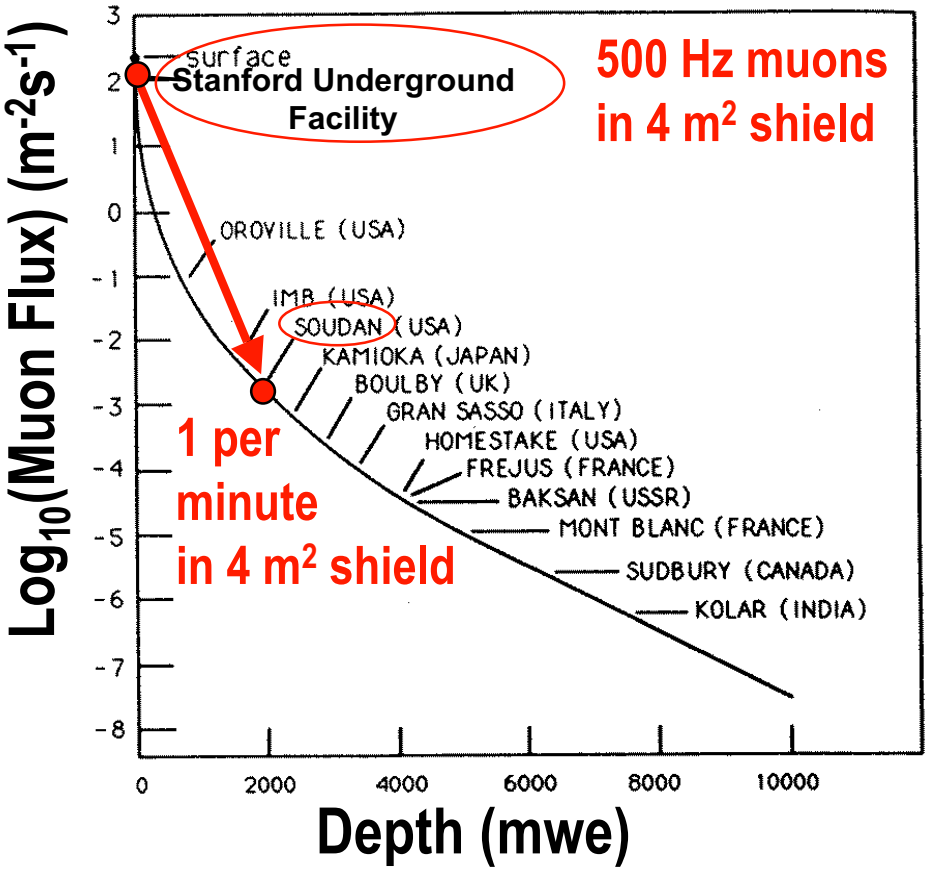
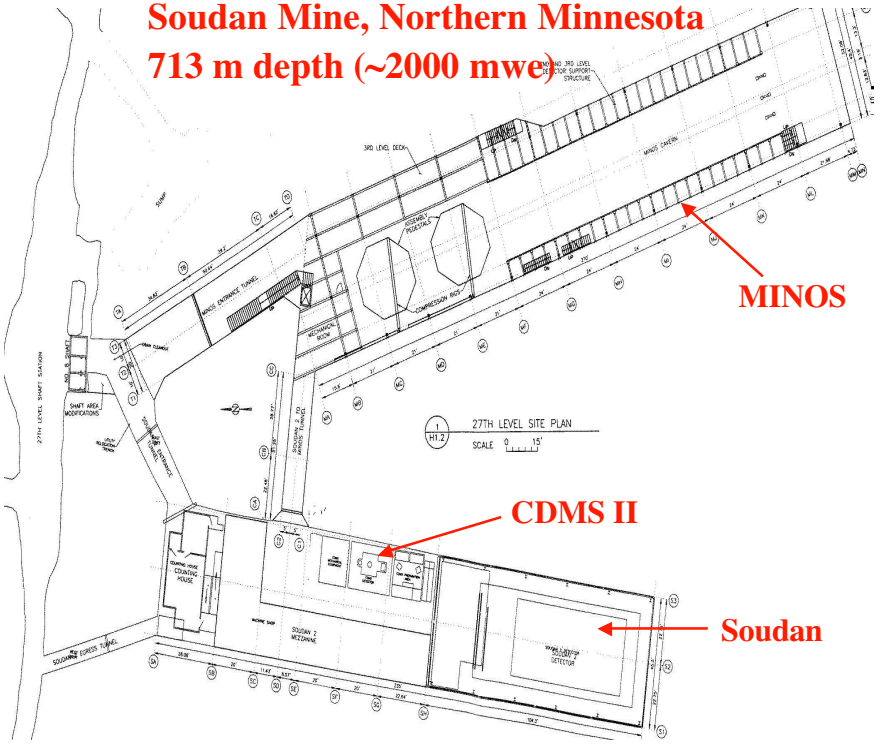
CDMS II at Soudan

Increased depth reduces neutron background from ~1 / kg / day at Stanford to ~1 / kg / year at Soudan

Expect WIMP sensitivity of 0.01 / kg / kev /day





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State of CDMS II in a nutshell

Commissioning nearly finished

All systems fully-installed and functioning

- Two towers of detectors installed
  - only Tower 1 turned on so far
- Icebox steady at 50 mK
  - cold enough to operate detectors, but not as cold as it should be
- Cryogenics operation for last month has been stable
  - Still some problems to sort out but lower priority
- Warm electronics revisions essentially complete
  - Haven't completely understood the noise but good enough for now
- New data acquisition functioning well
  - But not all software tools available yet
- Analysis system installed and functioning
  - Need to debug further before routine data taking is possible
- Calibration and some initial low-background data sets taken
  - Plan to intermix data (nights, weekends) with testing and fixing (day)

Expect to be taking data most of the time by October 15

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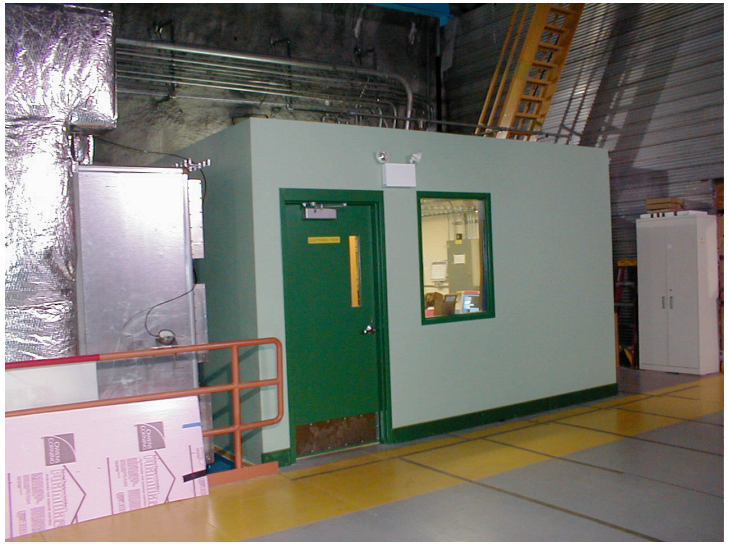
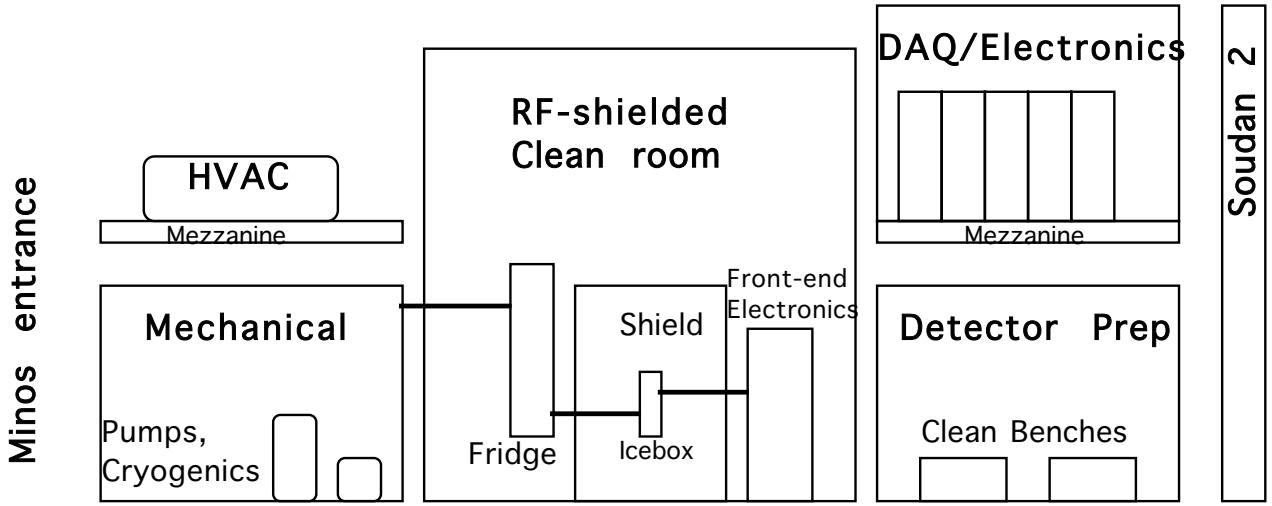
Soudan Facility

CDMS II Experimental Enclosures (Fermilab, Minnesota)





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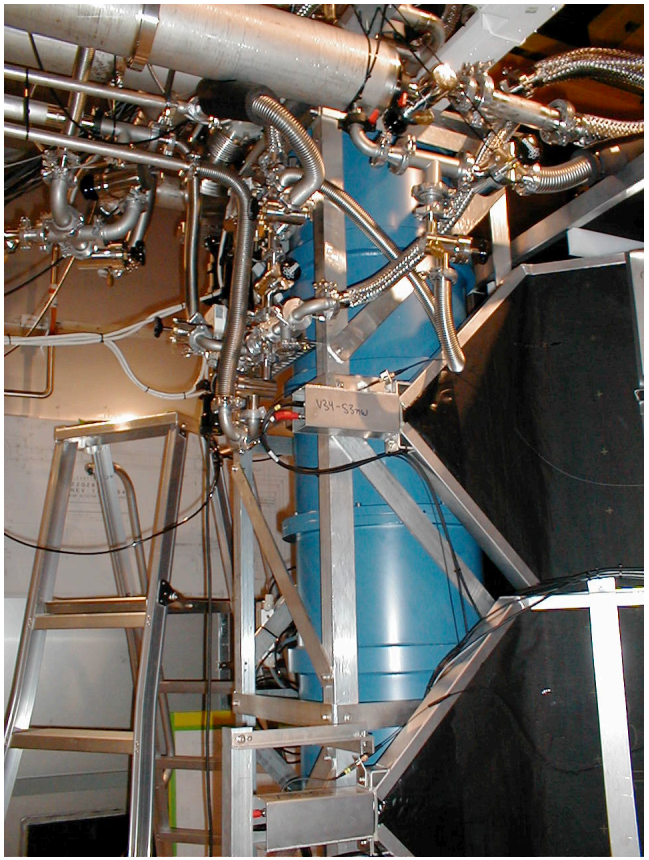
Cryogenics

CDMS II Icebox, Fridge (Fermilab)

- Oxford 400 dilution refrigerator (identical to one we use at SUF)
  - Only one major problem in 6 years at SUF (2 months downtime to fix)
  - The Soudan fridge has been considerably more problematic
    - Superfluid leak in dilution unit (now fixed)
    - Leak from LHe bath to vacuum (manageable but high He consumption)
- Offset "icebox" is cold volume for detectors
- Modern cryogenic control and monitoring system
  - But reliability, electrical noise have been issues



CDMS II Installation at Soudan

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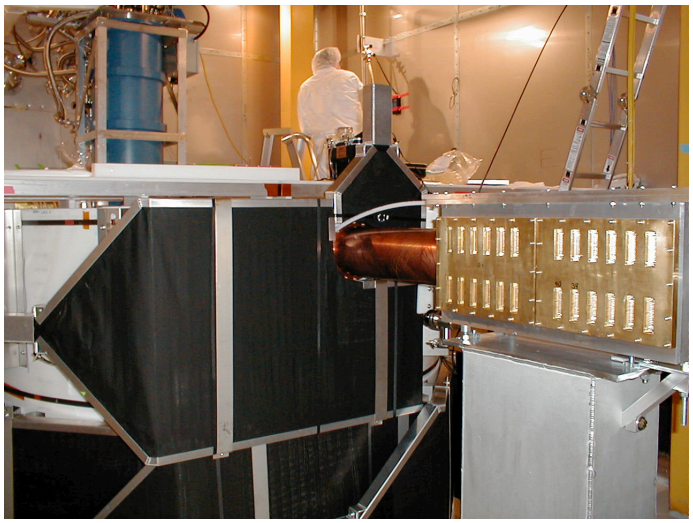
Layered shielding and efficient veto vital for background reduction
Robust DAQ/analysis with remote control and monitoring



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Detectors

Tower-1 for Soudan thoroughly tested in Run 21 at SUF

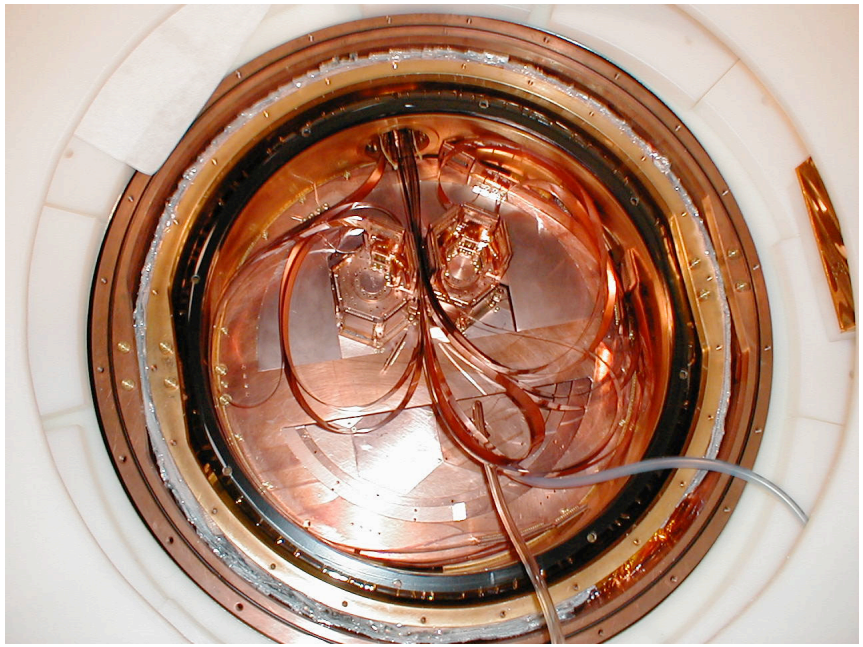
- 4 Ge and 2 Si ZIPs - background rejection better than expected; beta background on bottom Si detector

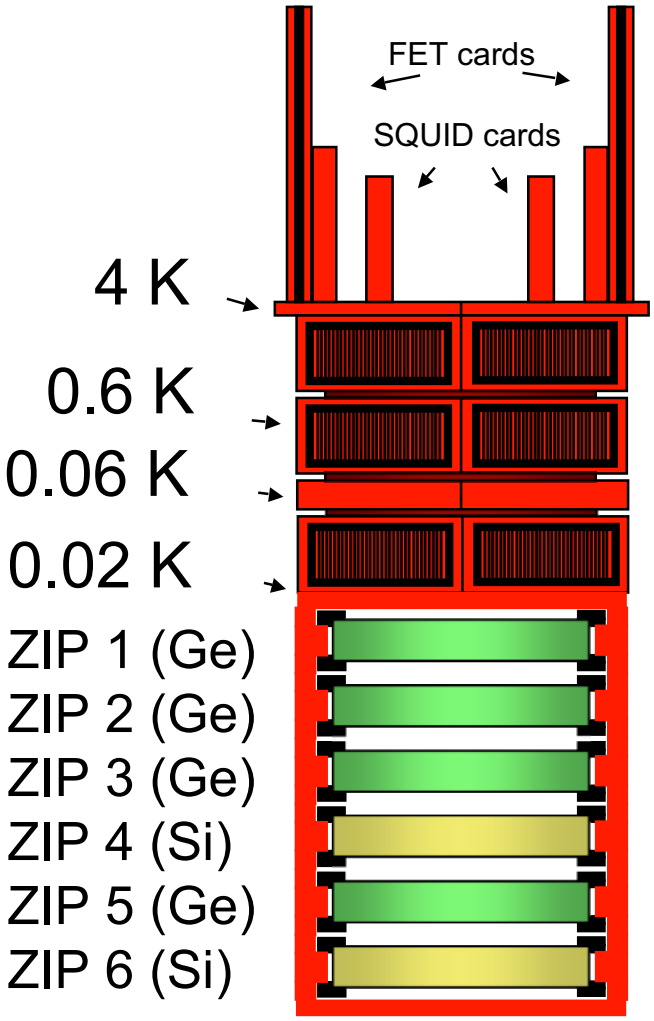
Tower-2 for Soudan; detectors tested in final run at UCB

- 2 Ge and 4 Si ZIPs - backgrounds unknown, but expected to be lower due to better handling

Two towers successfully installed in Soudan icebox

- Transport issues (shipping delicate towers)
- Installation issues (especially Radon)





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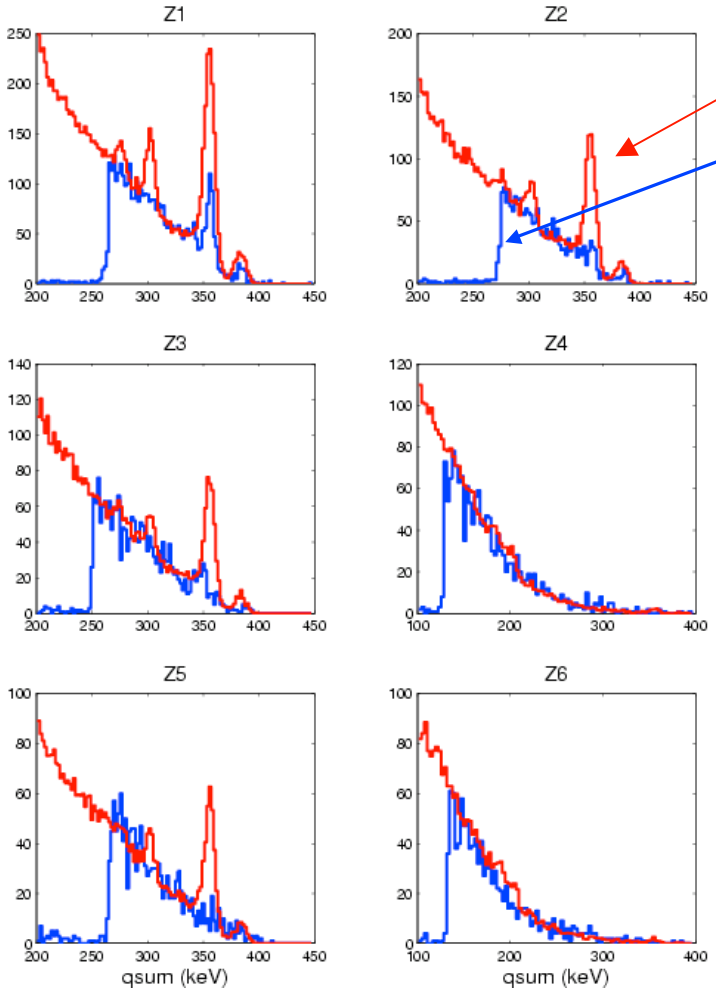
Early Results from CDMS II at Soudan

Energy calibration: Data versus Monte Carlo



Good resolution of lines from 133Ba source
Agreement will get better when
- Data analyzed using new fit templates
- Higher statistics

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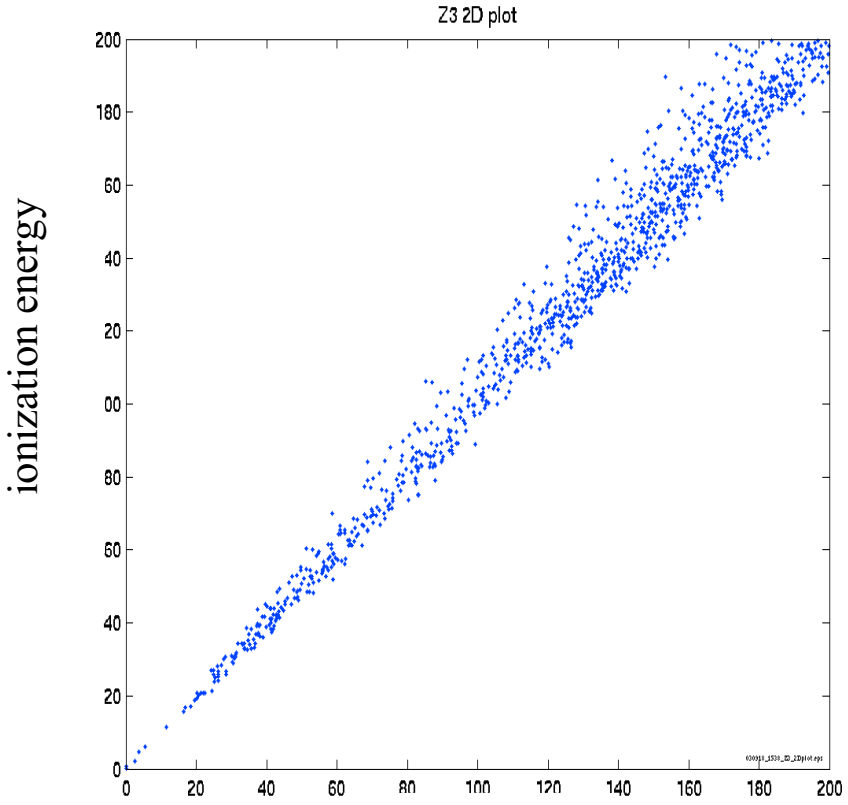
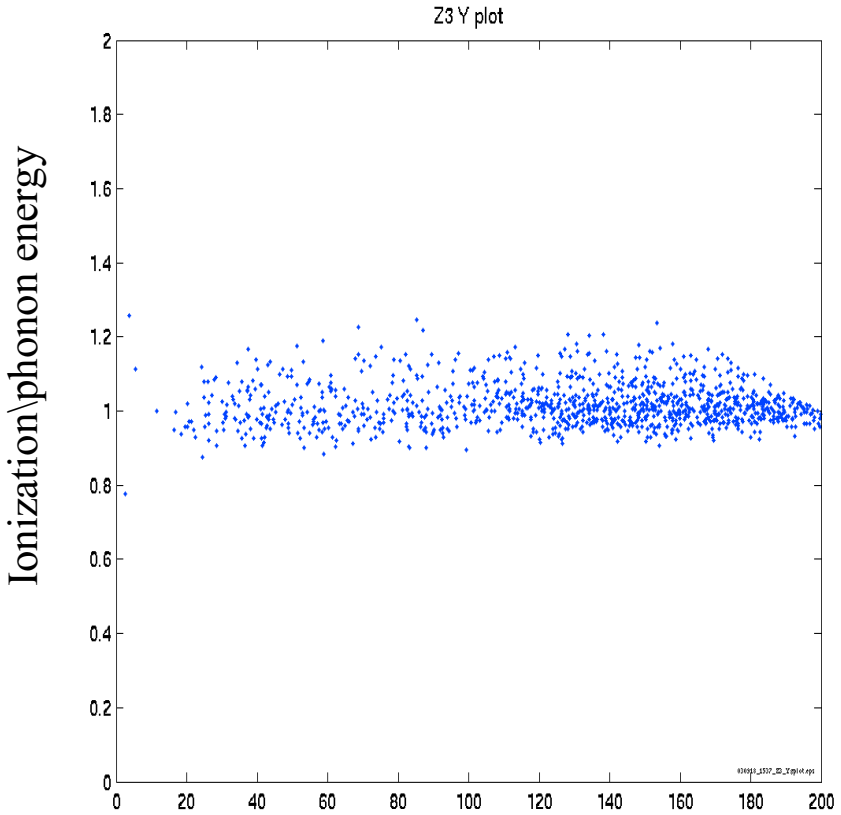
Early Results from CDMS II at Soudan

First look at γ's from calibration source
(neutron calibration coming soon)





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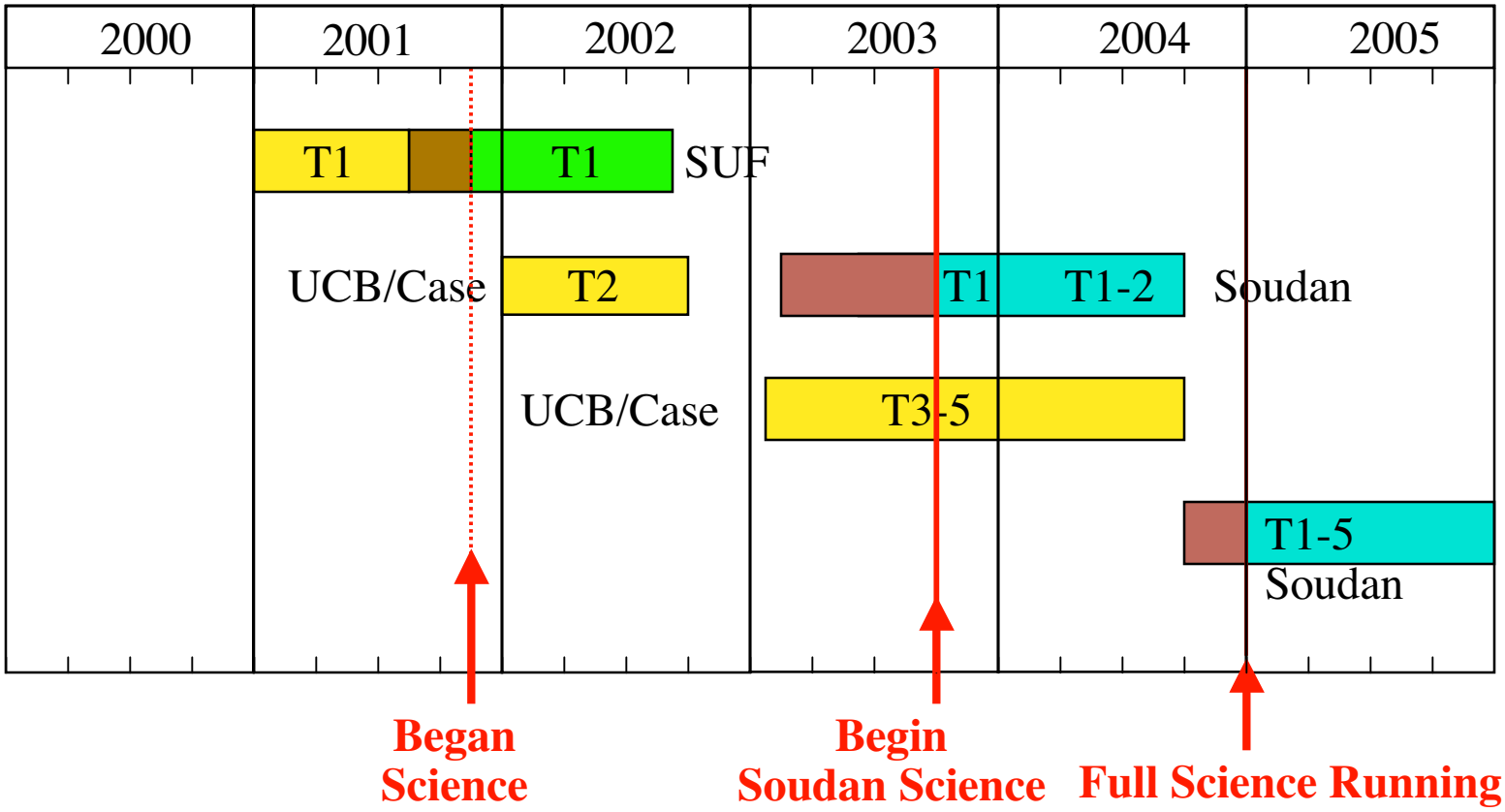
Soudan CDMS-II Plan with 5 Towers



This plan achieves science goals from CDMS II proposal. Nevertheless, delays encountered with cryogenics, detectors make this non-optimal for science.

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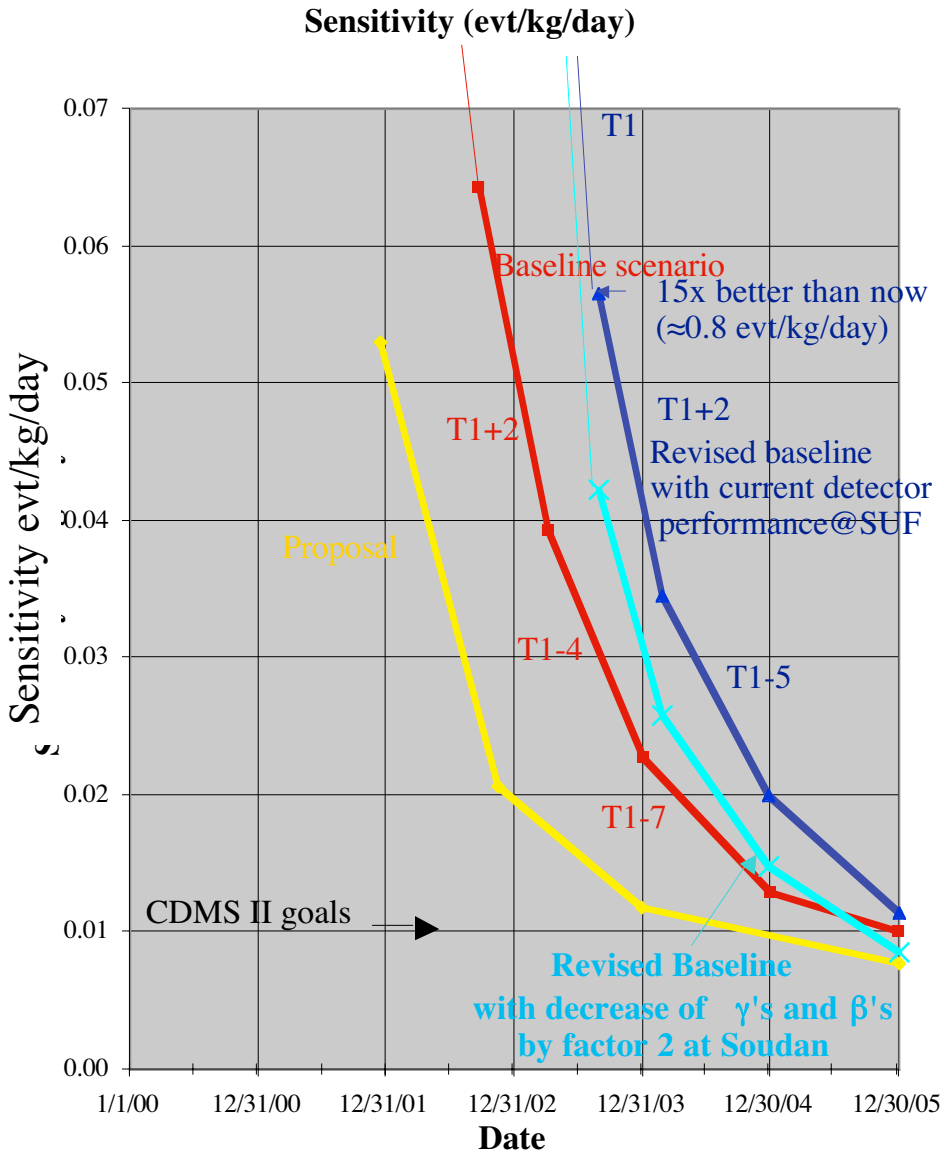
CDMS II Expected Sensitivity



Deep site => reduced backgrounds => linear sensitivity improvement

Expect factor of 10 improvement over current CDMS results by end of 2003.

Detector performance improvements mean we should still reach original CDMS II goals

Crucial issue: where do backgrounds start to appear?

- **Marks change from linear to √ MT improvement**
- **1/√MT extrapolation assumes that background can be subtracted statistically with negligible systematic errors.**
- **Lack of detailed knowledge may halt sensitivity improvement prematurely**

Cleaner detectors or better background rejection extend linear improvement range.

CDMS II Reach

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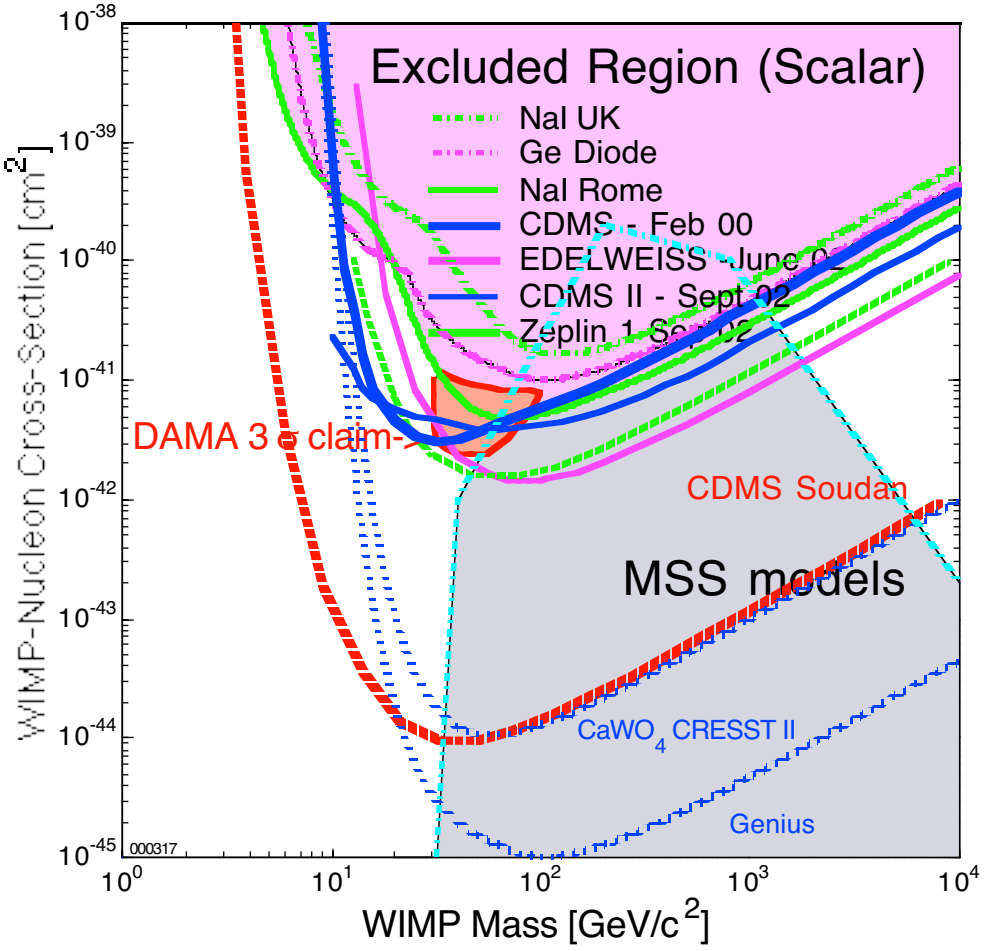
Current CDMS result from Stanford site (blue curves)
Best WIMP limits at low mass

CDMS II should begin taking data in October 2003
Expect x10 improvement in limits by end of 2003
(or maybe hint of a signal?)

No other running experiment will make such rapid progress
Power of active background rejection.



CDMS II