

# Further WIMP results from the CDMS experiment

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# CDMS Collaboration



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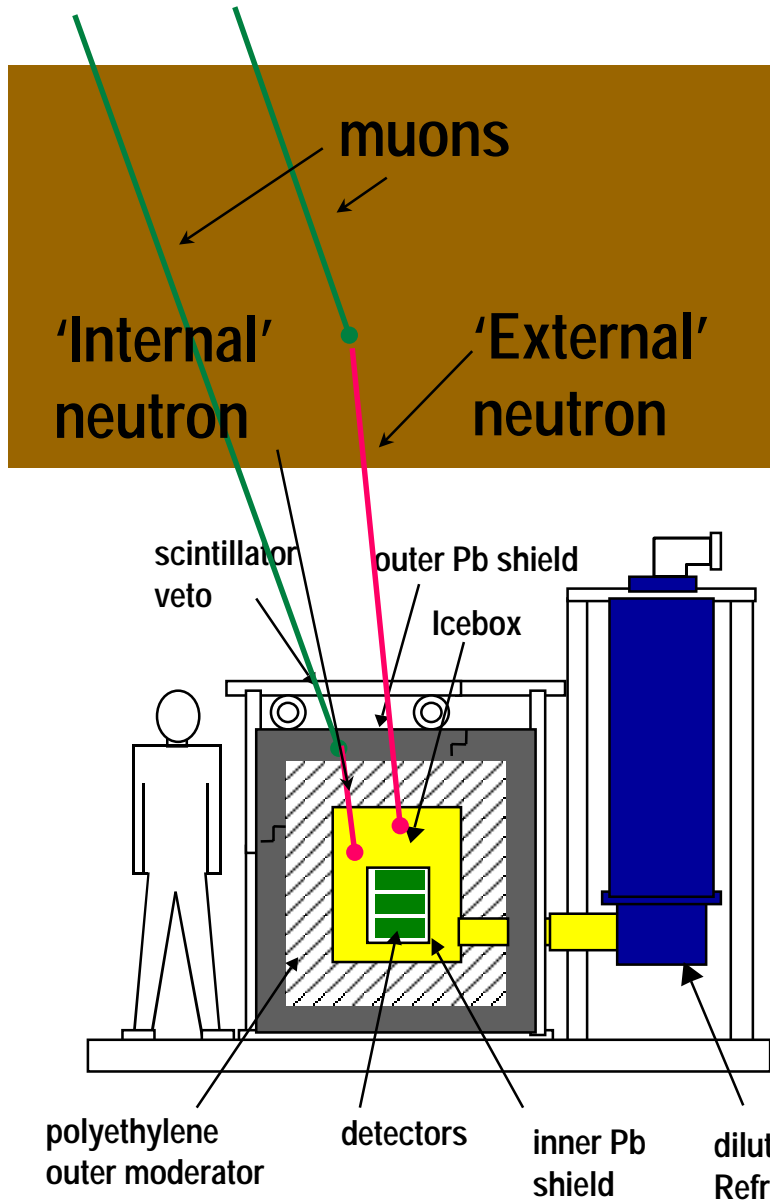
(Jul03 PLB)

# Overview



- **CDMS I: 1998-1999 run of 3 Ge BLIPs**
  - ◆ 15.8 kg days after cuts
  - ◆ 23 single-detector & 4 multiple-detector nuclear-recoil candidates, most (or all) are neutrons
  - ◆ Final results in 35-page paper in Phys. Rev. D66, 122003 (2002), astro-ph/0203500
  - ◆ Conflict with DAMA, agreement from Edelweiss and Zeplin I.
- **Preparations for CDMS II at deep site**
  - ◆ New athermal phonon technology
  - ◆ Run first tower at SUF
  - ◆ Confirmed CDMS I results, hep-ex/0306001
  - ◆ Towers 1 and 2 now installed at Deep site facility, Soudan, Minnesota.
  - ◆ Assembly of Deep site facility at Soudan, Minnesota.

# Stanford Underground Facility (SUF)



## •Stanford Underground Facility

- ◆ 17 mwe of rock
- ◆ Hadronic component down by 1000
- ◆ Muon flux down by ~5

## •Low Background Environment

- ◆ 15 cm Pb reduces photon flux by factor >1000
- ◆ 25 cm polyethylene reduces muon-induced neutron flux from rock and lead by factor >100
- ◆ Radiopure cold volume (10 kg)
- ◆ Additional internal (ancient) lead shielding

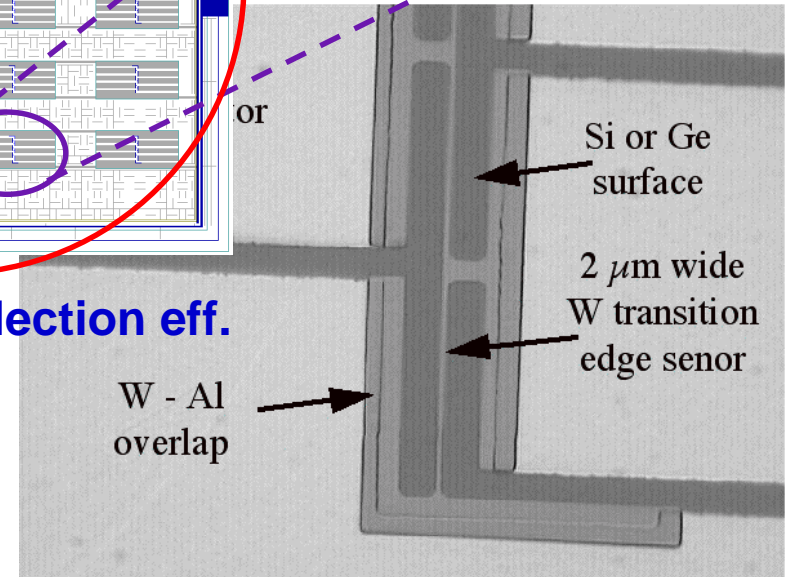
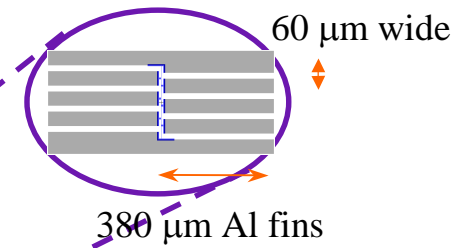
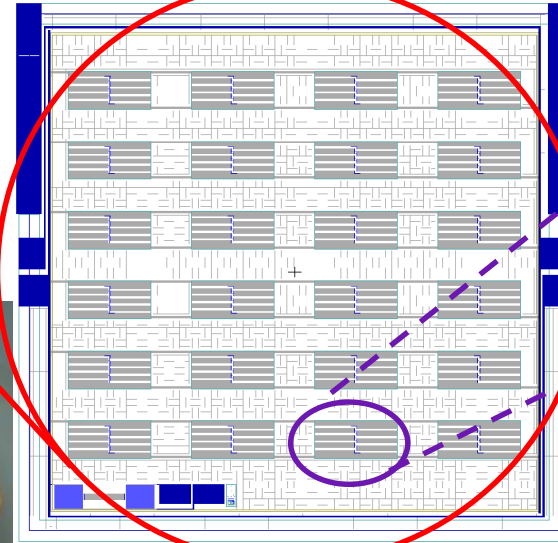
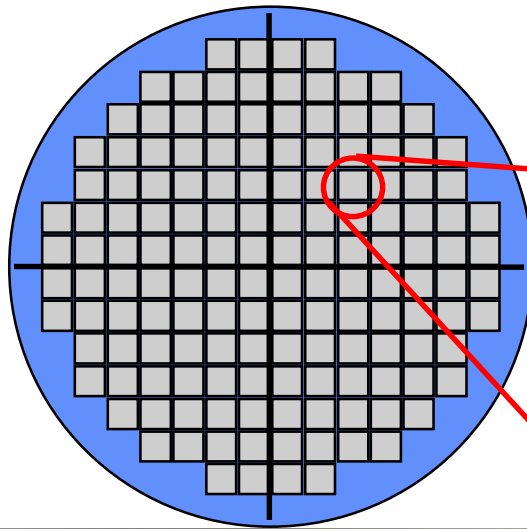
## •Active Scintillator Muon Veto

- ◆ Muon veto >99.9% efficient
- ◆ Reject ~22 "internal" neutrons/ day produced by muons within shield

# ZIP detector phonon sensor technology



- ◆ TES's patterned on the surface measure the full recoil energy of the interaction
- ◆ Phonon pulse shape allows for rejection of surface recoils (with suppressed charge)
- ◆ 4 phonon channels allow for event position reconstruction



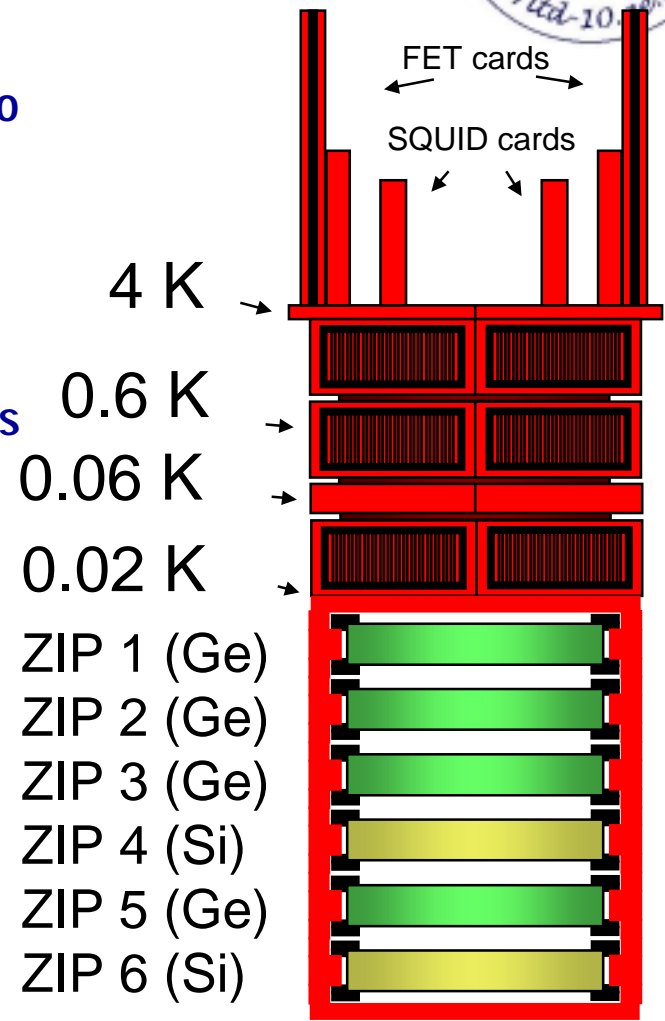
~25% QP collection eff.



# The SUF Run 21 Tower



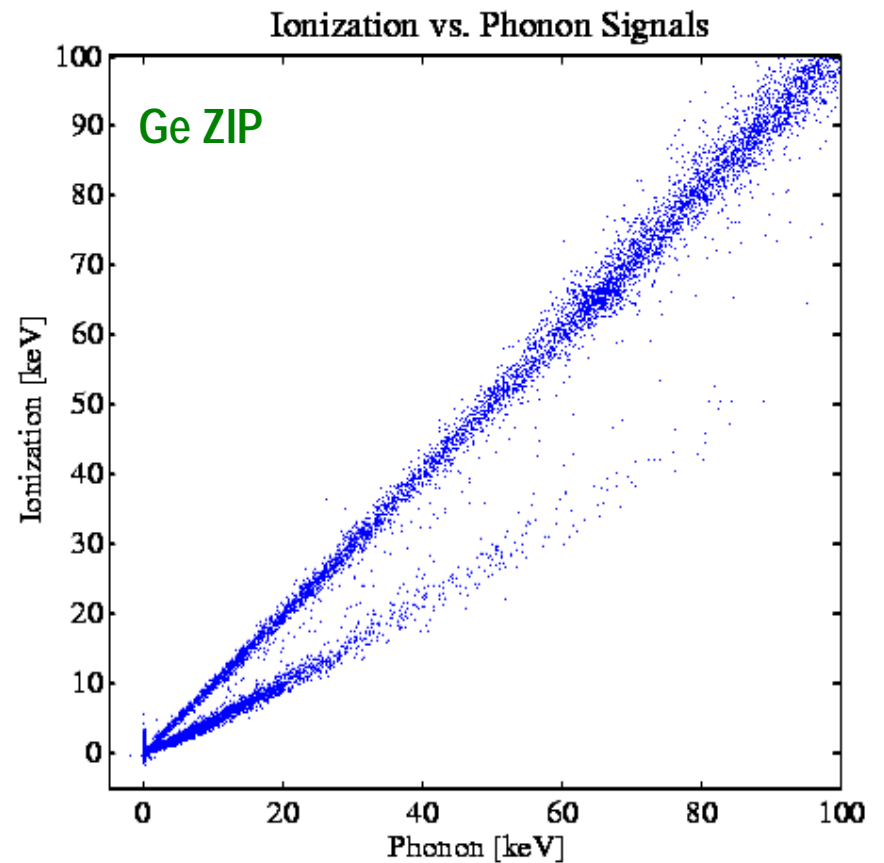
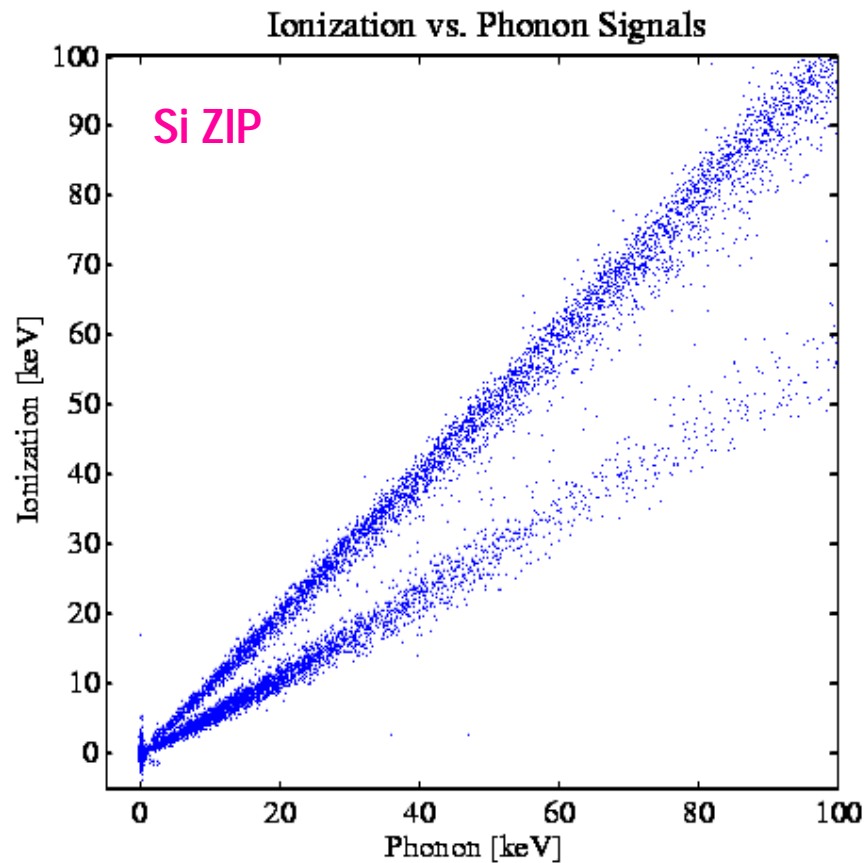
- Tower-1 for Soudan.
  - ◆ 4 Ge and 2 Si ZIPs - all worked well.
  - ◆ Run 'b' at SUF uninterrupted from November '01 to June '02.
  - ◆ 66 livedays at 3 V bias = 28 kg days after cuts.
  - ◆ 52 livedays at 6 V bias = 21 kg days after cuts.
- All Goals achieved
  - ◆ Establish the contamination levels of the detectors before their installation at Soudan: acceptable.
  - ◆ Measured gamma and beta rejection efficiencies: better than proposal.
  - ◆ Measure the muon anti-coincident flux at SUF simultaneously with Si & Ge ZIPs: achieved.
  - ◆ Test Monte Carlo predictions of neutron suppression rates due to addition of internal polyethylene: Monte Carlos correct.



# Photon and Neutron Calibration



The response of the detectors is best demonstrated with calibration photon and neutron sources



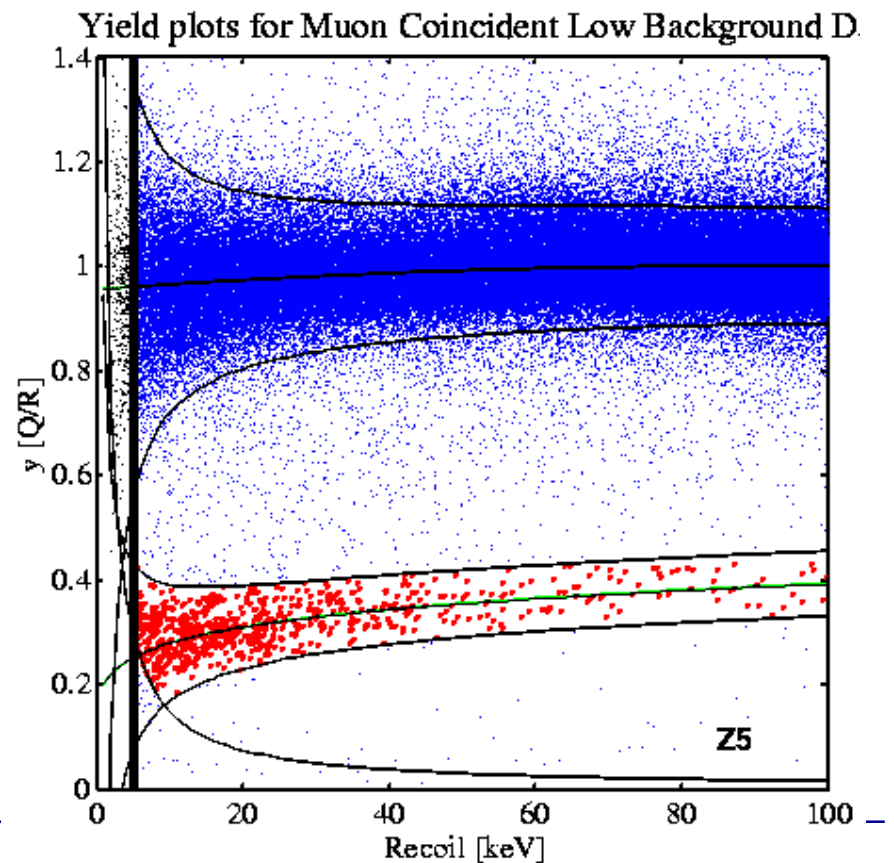
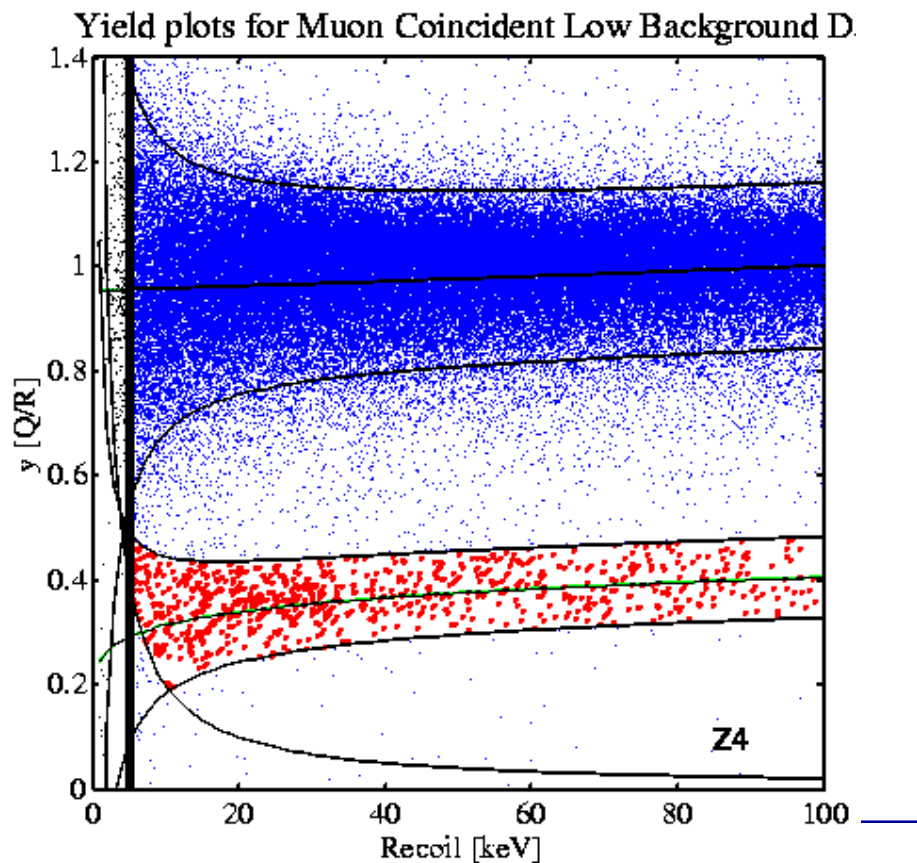
# SUF 21 - Background Data



Yield plots for background data from the current run

## – Muon Coincident Data

- Gamma background band is the dominant feature
- Muon coincident neutrons populate the nuclear recoil band
- A number of *'in between'* events





# SUF 21: internal muon-anticoincident neutrons



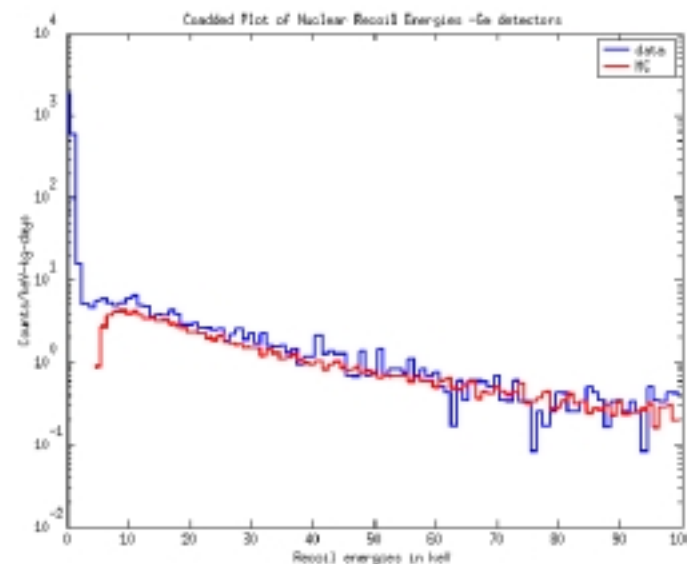
After Run 19, internal polyethylene added.

External, muon-coincident neutron rate dropped by a factor of 3.

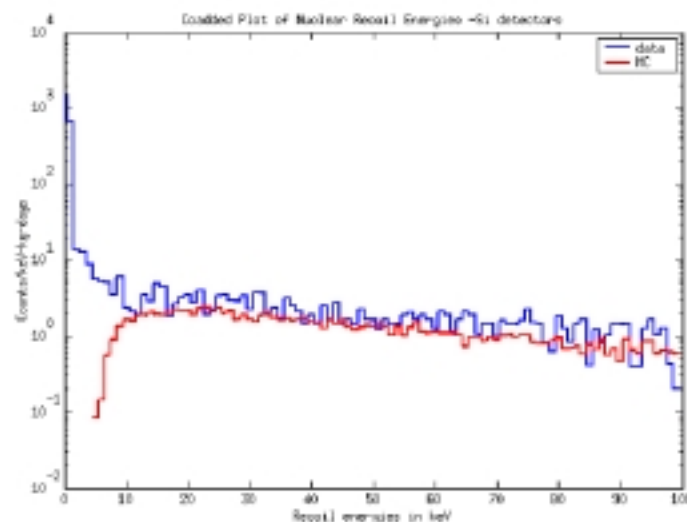
Internal, muon-anticoincident neutron rate dropped by a factor of 2.3 - as predicted by the Monte Carlos!

- ◆ Based on Run 19's 23 singles, 4 multiples in 15.8 kg days, expect ~17 Ge singles, ~3 Si Z4 singles, ~7 multiples in 28 kg days of Run 21.
- ◆ We see 20 Ge singles, 2 Si Z4 singles, 8 multiples in 28 kg days of 3 V bias data set of SUF Run 21.

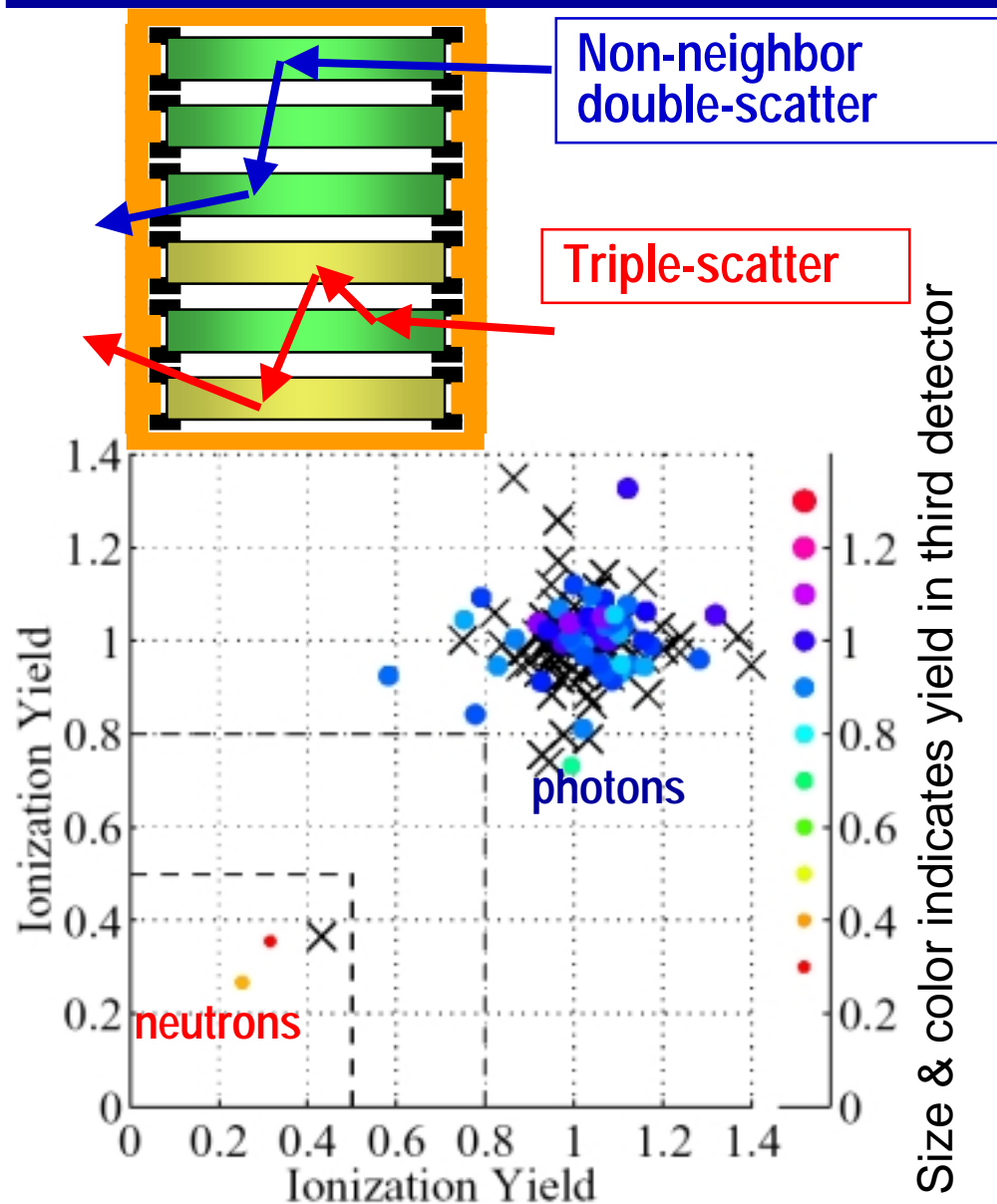
Coadded spectra for the Ge detectors – Data vs MC



Coadded spectra for the Si detectors – Data vs MC

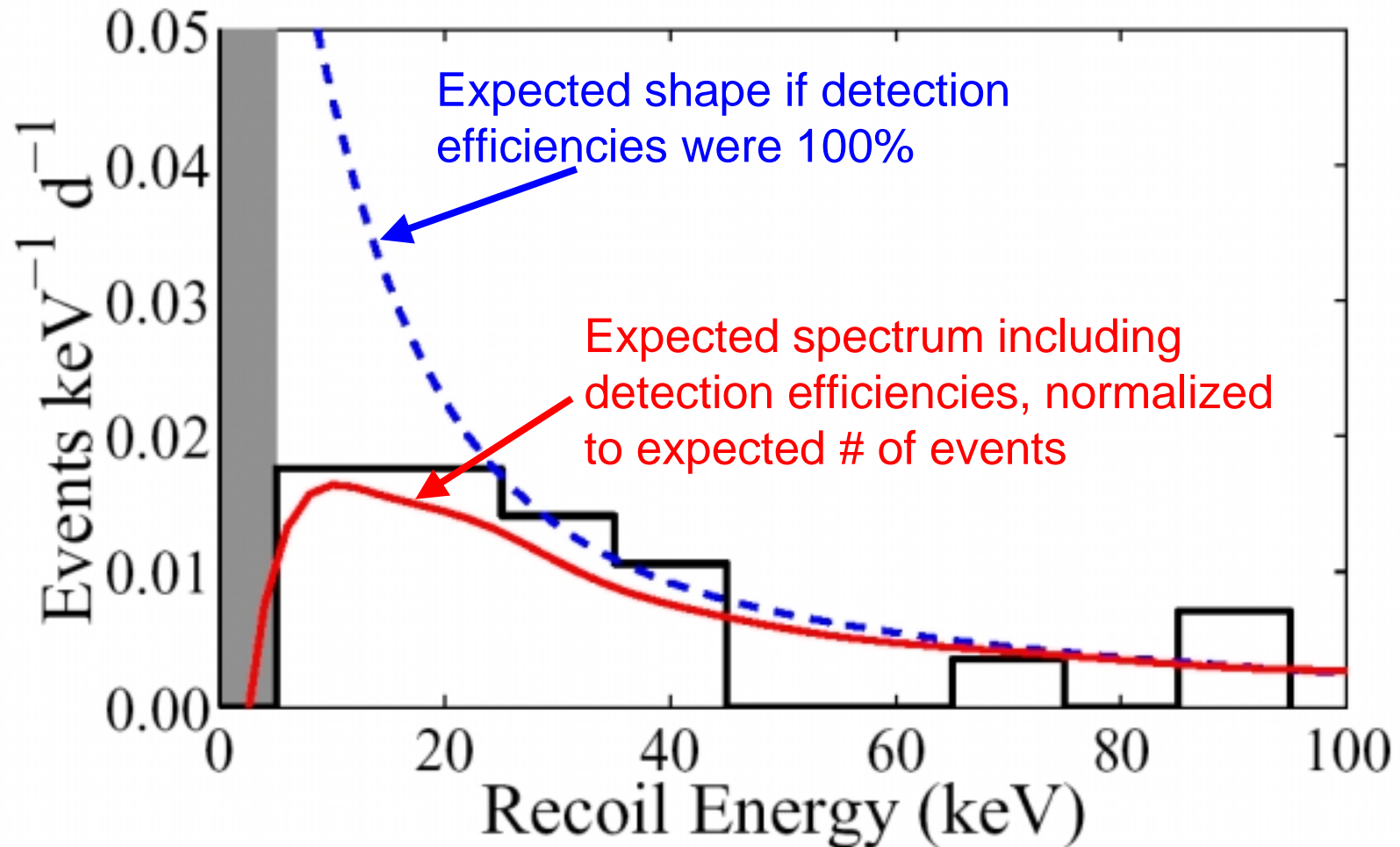


# Neutron Multiple Scatters



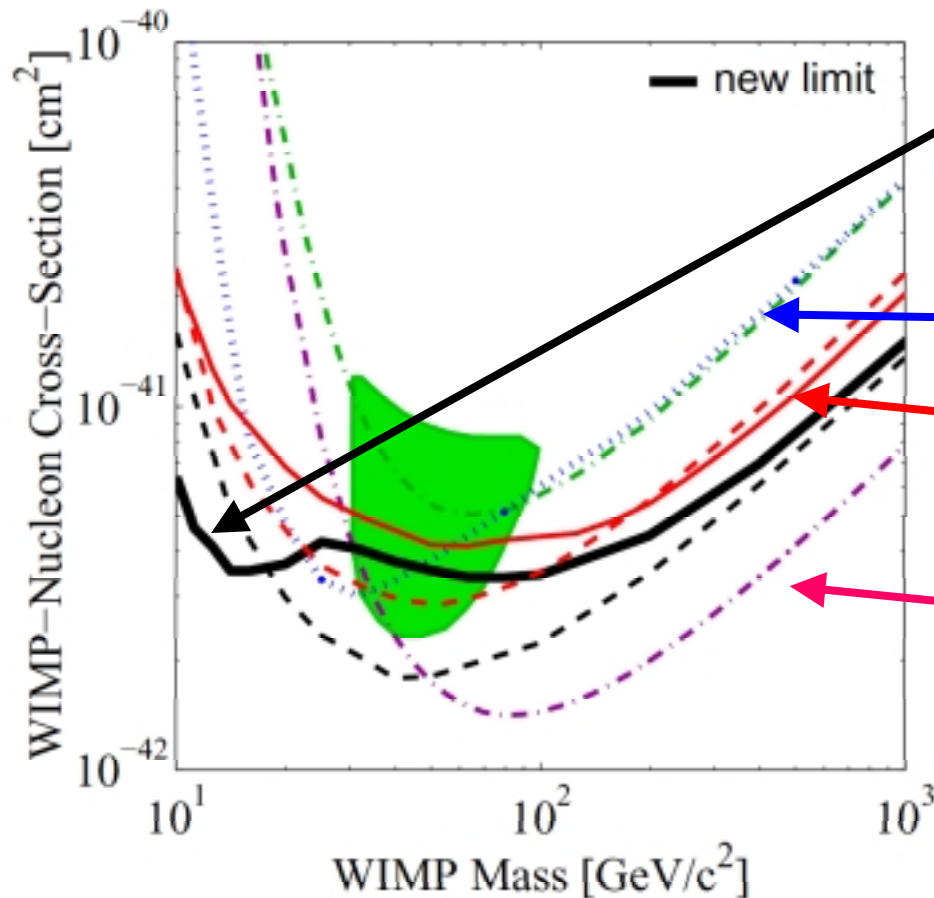
- **2 triple-scatter** (filled circles) and **1 non-nearest-neighbor double-scatter** NR candidates 5-100 keV
  - ◆ Ignore nearest-neighbor doubles because possible contamination by surface electrons
- Expect ~16 single-scatter neutrons per 3 multiple scatters
  - ◆ Implies many (or all) of 20 single-scatter WIMP candidates are neutrons

# Energy Spectrum



- Energy spectrum agrees with expected neutron spectrum
  - ◆ Kolmogorov-Smirnof test indicates we should expect worse agreement 32% of time

# 3 V bias SUF Run 21 WIMP limit



New CDMS II 3 V bias SUF Run 21 limit, with neutron subtraction

SUF Run 19 limit

SUF Run 21 no neutron subtraction

Edelweiss 2002

•Exclude DAMA most likely points (x,o) at >90% even without neutron subtraction.

Expected sensitivities calculated from expected neutron background of 3.3 multiple-scatters, 18 single scatters in Ge, and an expected background in Si of 0.8 electrons and 3.6 neutrons.

# Current and Projected CDMS Limits

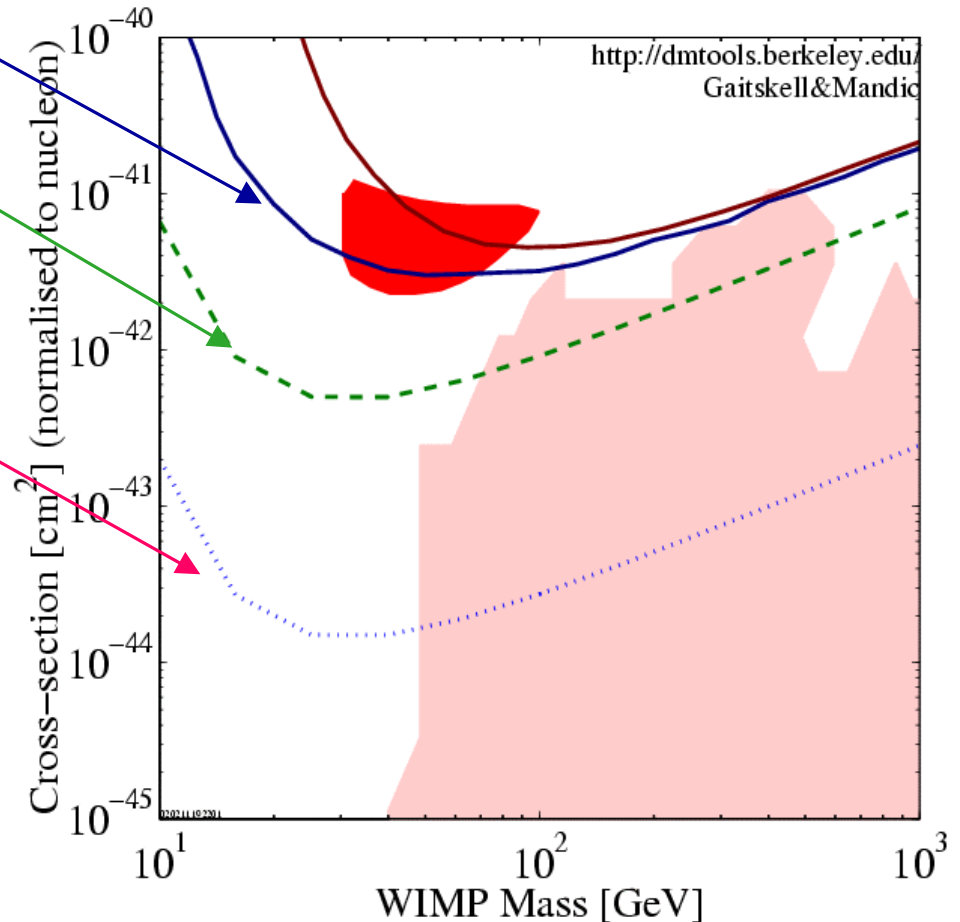


Current CDMS SUF R19 Limit

Projected CDMS SUF Limit

Projected CDMS Soudan Limit:  
x 100 than present limit at SUF  
(0.01 events/kg/keV/day).

- Increase detector mass by 10.
- Go deep, Cosmics down by 1000.
- Gamma leakage down by 2. (o.k.)
- Beta contamination down by 20. (?)



DATA listed top to bottom on plot  
 Edelweiss, 4.5 kg-days Ge(320g) June 2001 limit  
 CDMS Feb. 2000 ver. sub. to PRL  
 DAMA 2000 58k kg-days NaI Ann.Mod. 3sigma, w/o DAMA 1996 limit  
 CDMS, projected at SUF  
 CDMS, projected at Soudan mine  
 Baltz and Gondolo, spin indep. sigma in MSSM, without muon g-2 constraint  
 020211102201

# Soudan, Minnesota : The CDMS II Deep Site

See Poster D07 ...

QuickTime™ and a  
Photo - JPEG decompressor  
are needed to see this picture.

# Conclusions



## • CDMS I (1995-1999)

- ◆ Results for **scalar-interacting** ( $\sigma \sim A^2$ ) **WIMPs** probed are best upper limits of any experiment for the mass range 10 to 35 GeV.
- ◆ CDMS data are **incompatible** with DAMA signal at high confidence.
- ◆ Sensitivity limited by external neutron background from muons interacting in surrounding rock.

## • CDMS II (1999-2005)

- ◆ Construction completed at deep site: Soudan, Minnesota.
- ◆ First tower of 6 detectors exceed performance expectations.
- ◆ Reduction of neutron background by factor of 2.3 due to installation of internal moderator in agreement with Monte Carlo predictions.
- ◆ More work required on surface-beta rejection/identification/subtraction in order to fully utilize deep site?
- ◆ Towers 1 & 2 now installed at Soudan, first dark ....