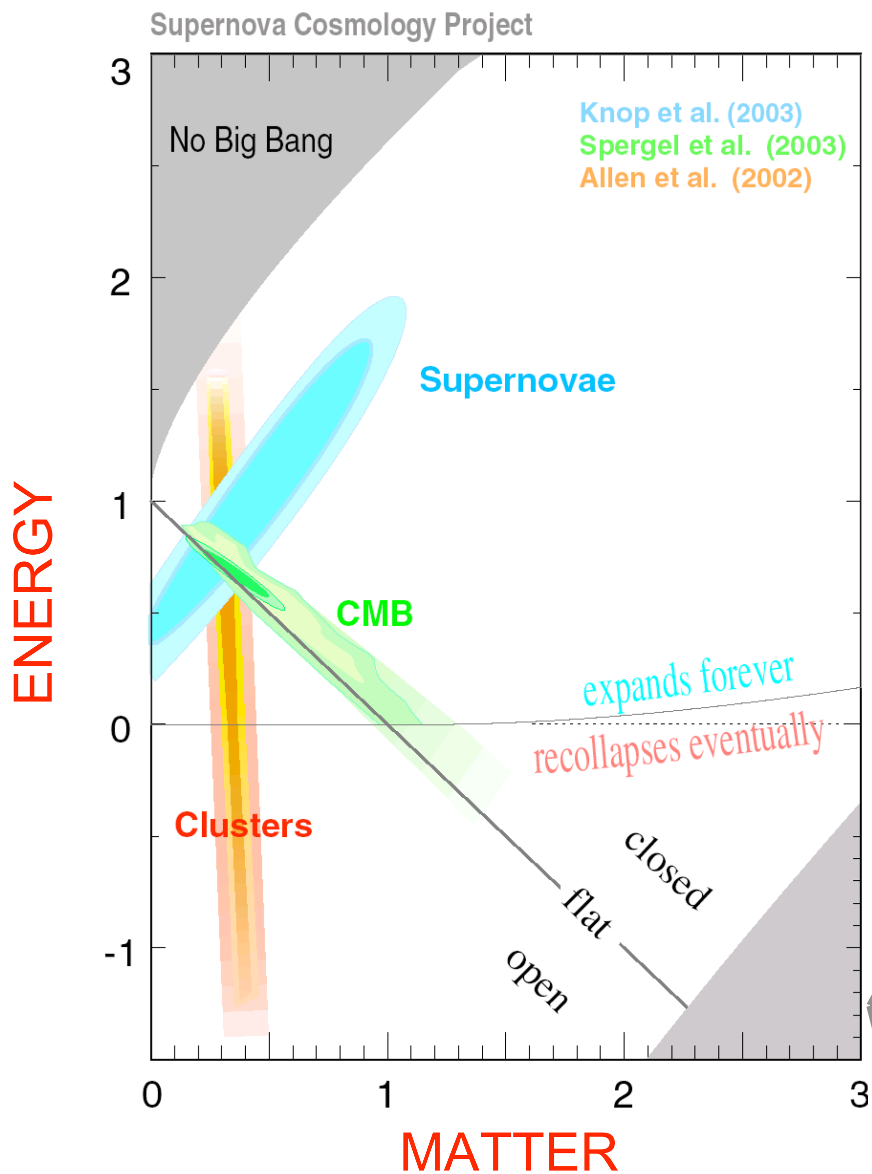
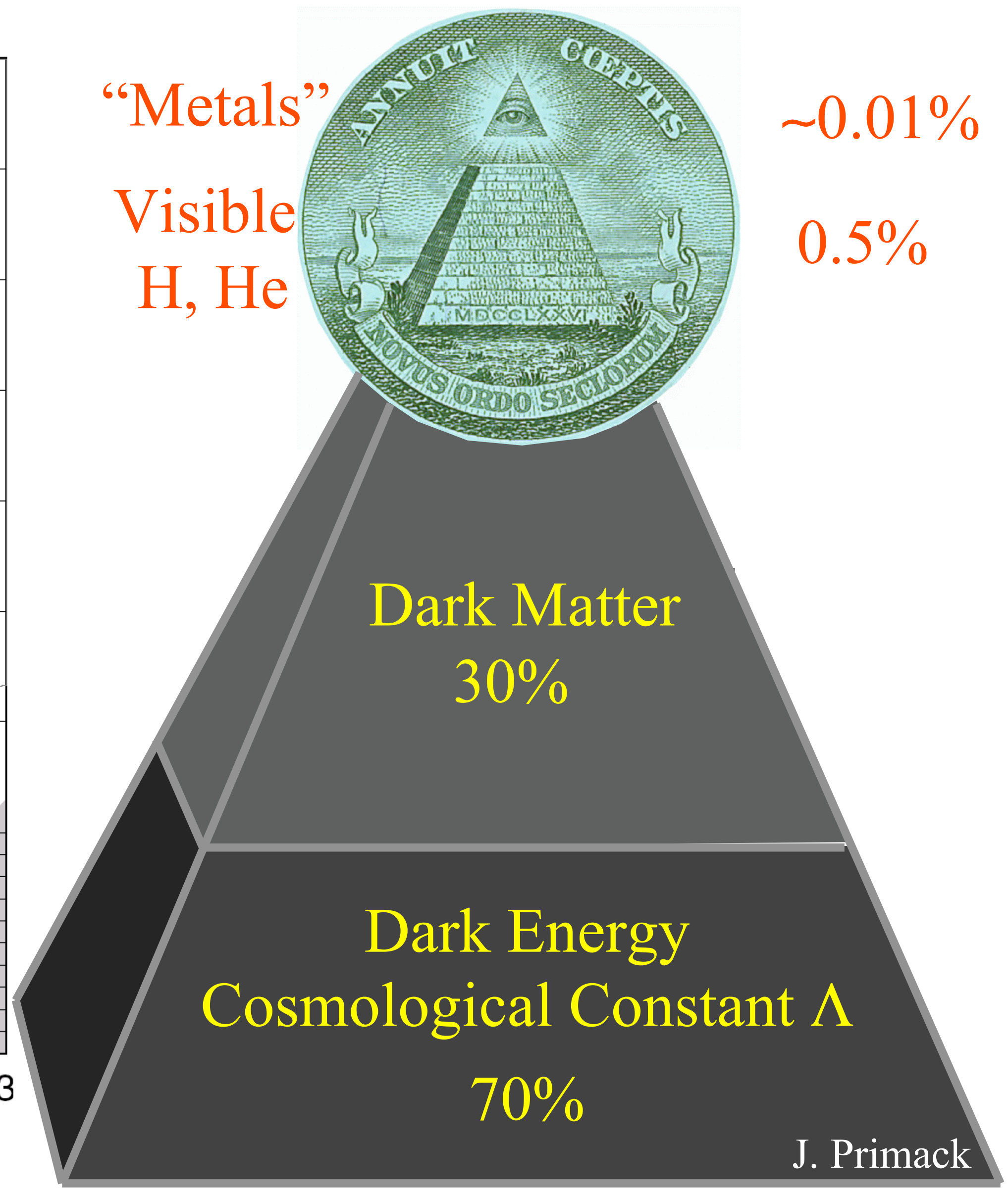
Recent Results and Future Prospects of the Cryogenic Dark Matter Search

Richard Schnee
Case Western Reserve University

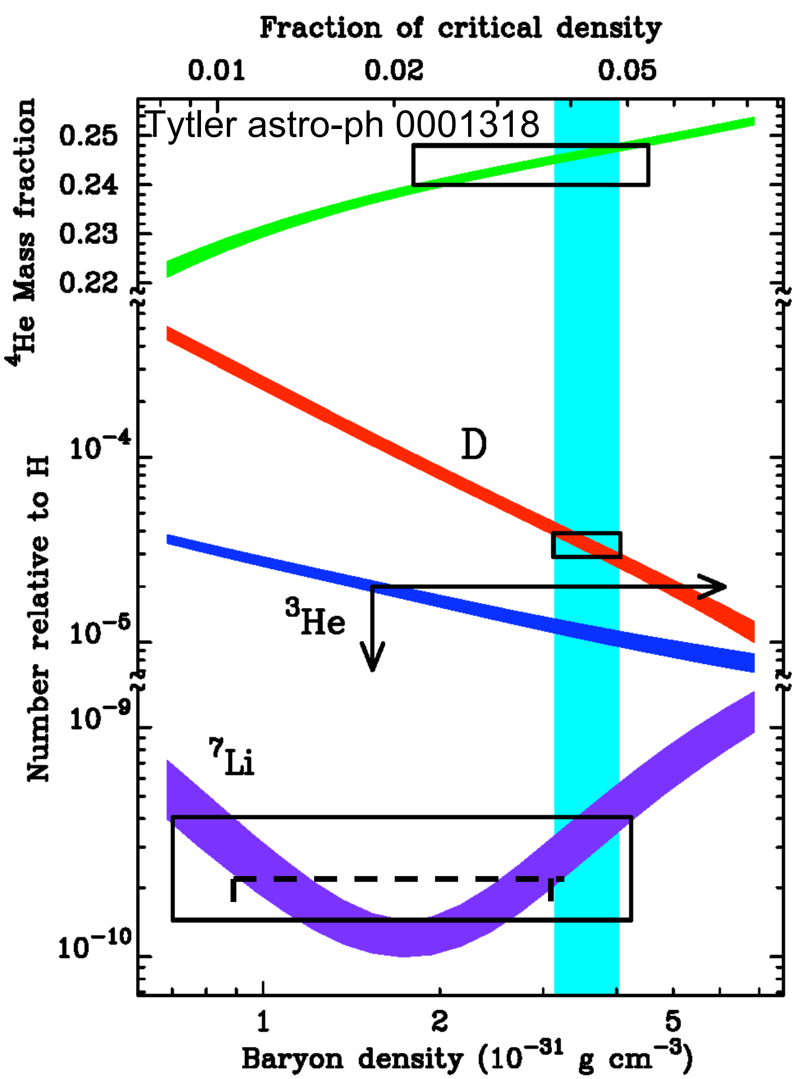
SCIPP Seminar, February 9, 2007

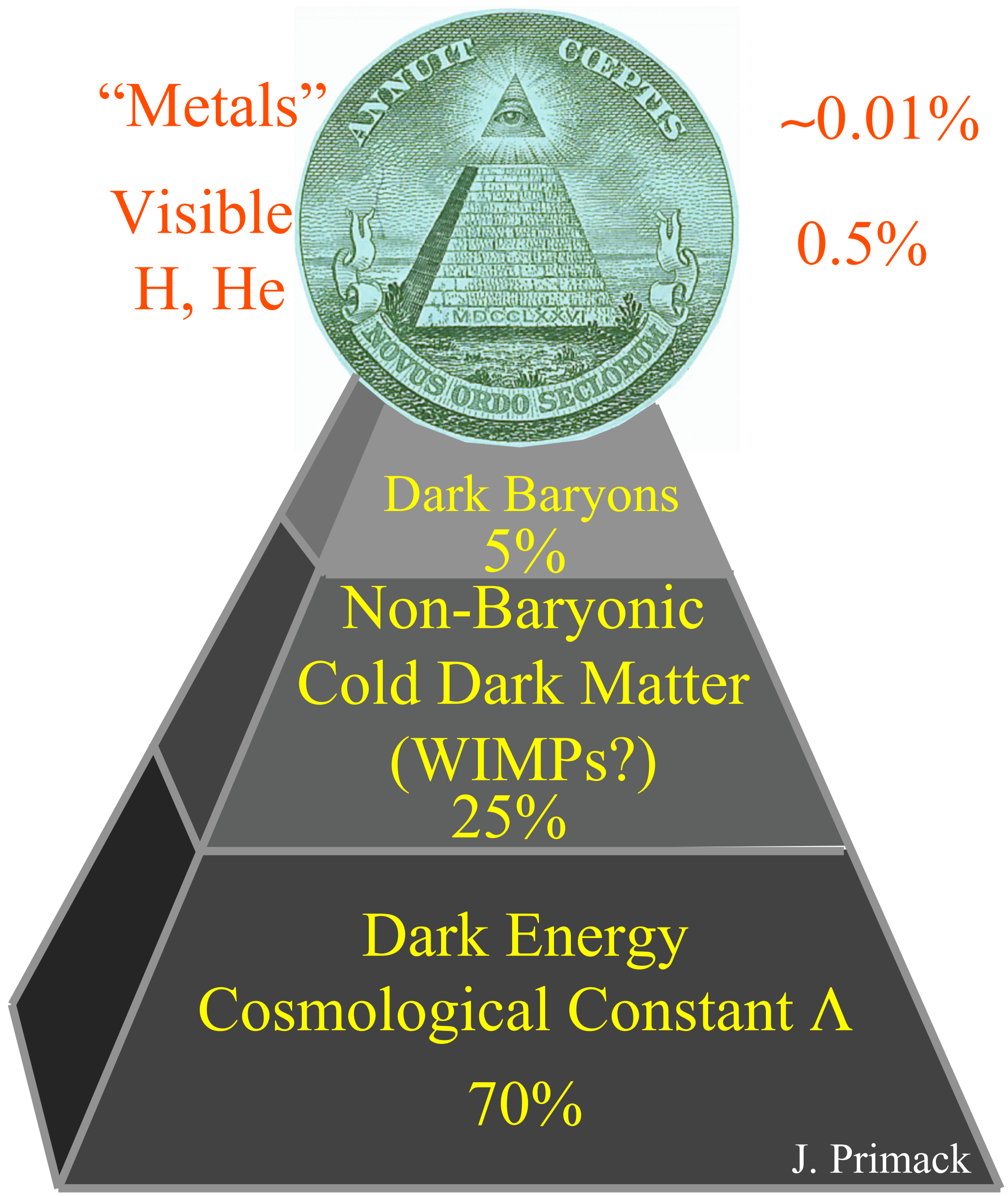
A New Order


Supernova Cosmology Project
No Big Bang
Knop et al. (2003)
Spergel et al. (2003)
Allen et al. (2002)
Supernovae
CMB
Clusters
expands forever
recollapses eventually
closed
flat
open
ENERGY
MATTER
3
2
1
0
-1
0
1
2
3


“Metals”
~0.01%
Visible
H, He
0.5%
ANNUIT COEPTIS
MDCCLXXVI
NOVUS ORDO SECLORUM
Dark Matter
30%
Dark Energy
Cosmological Constant Λ
70%
J. Primack

A New Order


Fraction of critical density
0.01
0.02
0.05
Tytler astro-ph 0001318
0.25
0.24
0.23
0.22
^{4}He Mass fraction
D
10^{-4}
^{3}He
10^{-5}
10^{-9}
^{7}Li
10^{-10}
Number relative to H
1
2
5
Baryon density (10^{-31} g cm^{-3})


"Metals"
~0.01%
Visible
H, He
0.5%
Dark Baryons
5%
Non-Baryonic
Cold Dark Matter
(WIMPs?)
25%
Dark Energy
Cosmological Constant Λ
70%
J. Primack

The CDMS Collaboration

Brown University

M.J. Attisha, **R.J. Gaitskell**, J-P. F. Thompson

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Lawrence Berkeley National Laboratory

R. McDonald, R.R. Ross, A. Smith

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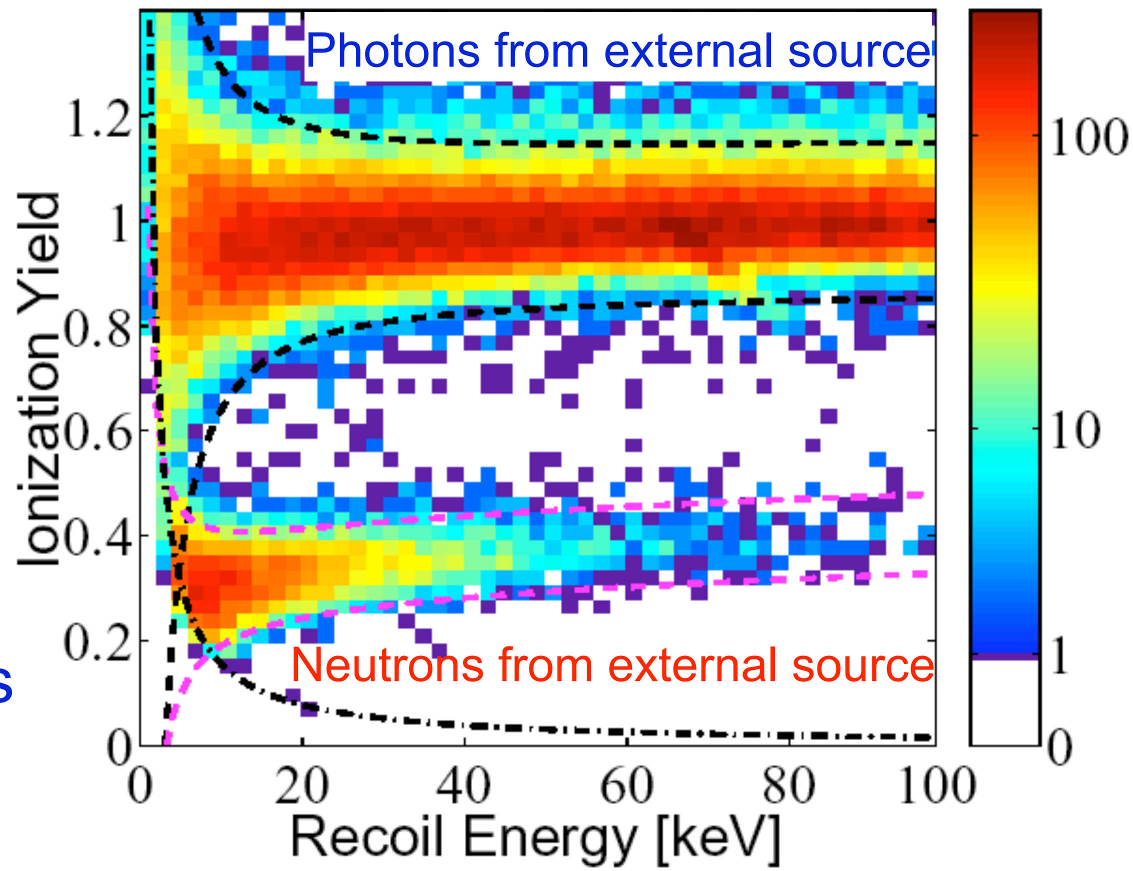
Cryogenic
Dark
Matter
Search

CDMS II Background Discrimination

- Ionization Yield (ionization energy per unit recoil energy) depends strongly on type of recoil
- Most background sources (photons, electrons, alphas) produce electron recoils
- WIMPs (and neutrons) produce nuclear recoils



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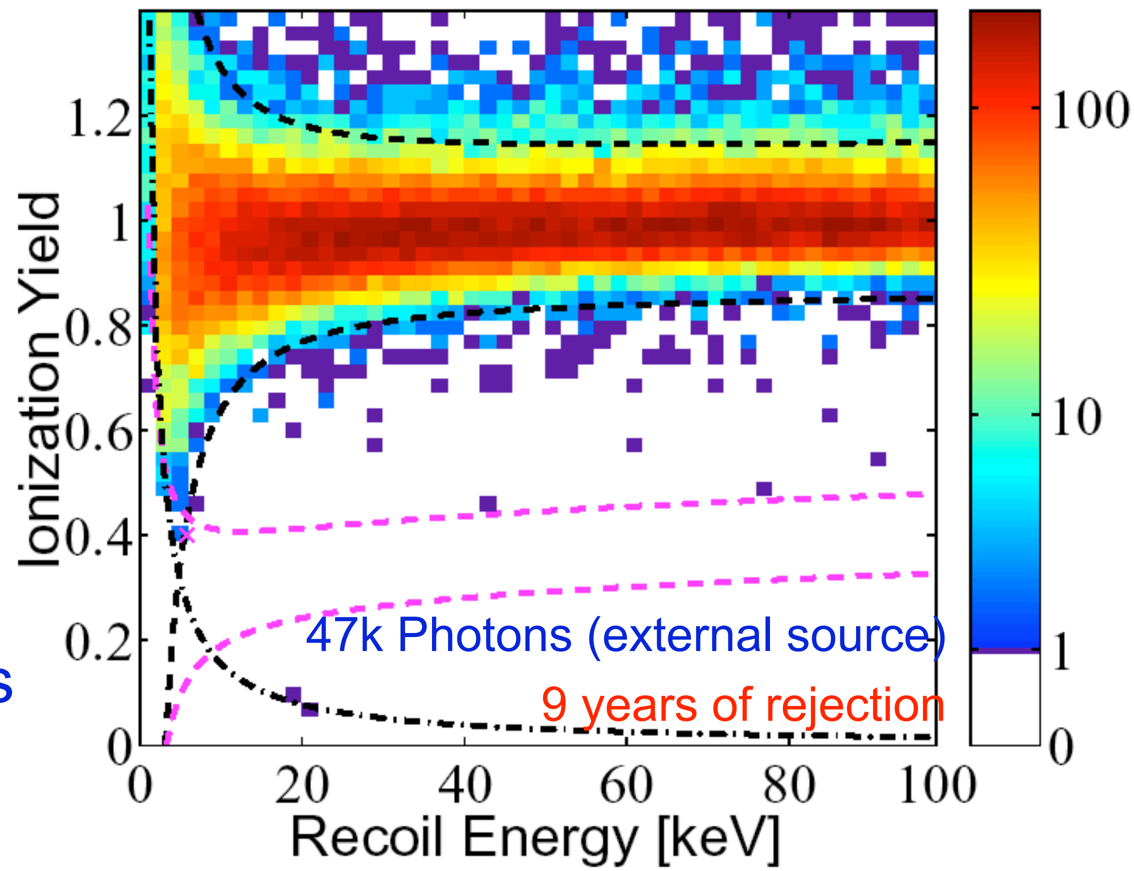
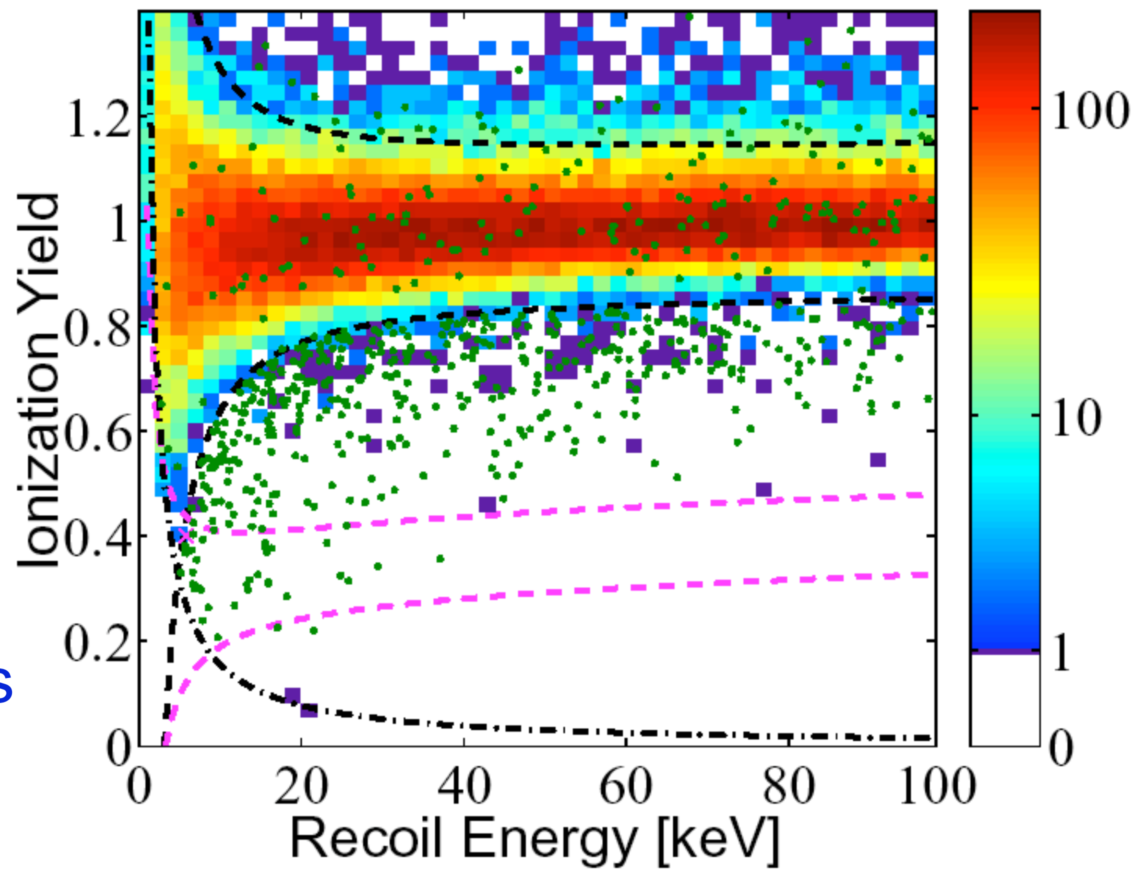


- Detectors provide near-perfect event-by-event discrimination against otherwise dominant bulk electron-recoil backgrounds

CDMS II Background Discrimination



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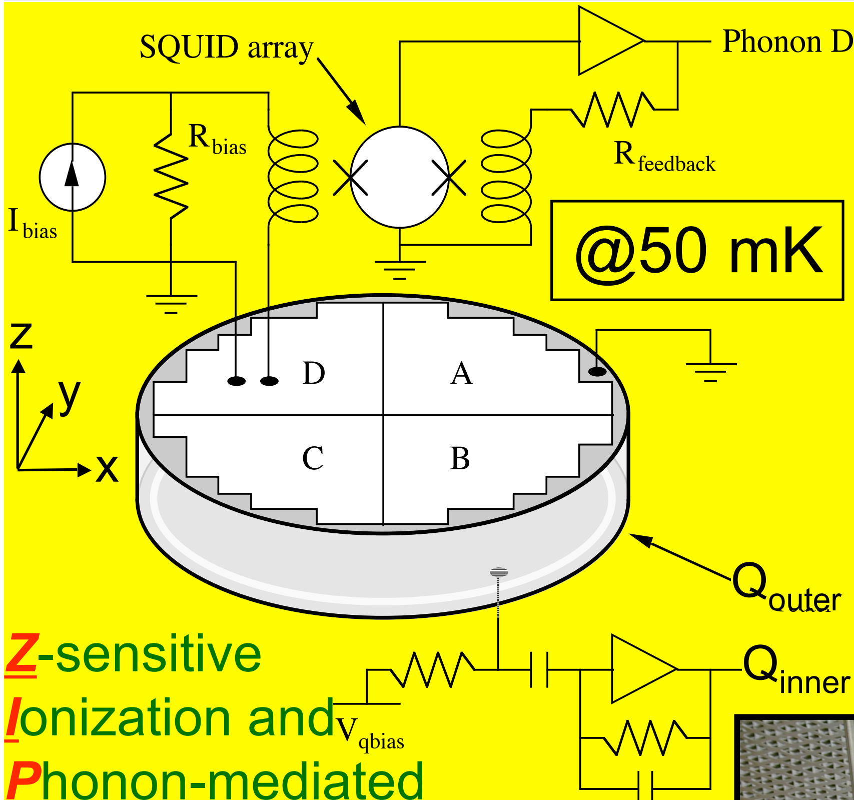
- WIMPs (and neutrons) produce nuclear recoils
- Detectors provide near-perfect event-by-event discrimination against otherwise dominant bulk electron-recoil backgrounds
- Particles (electrons) that interact in surface “dead layer” of detector result in reduced ionization yield

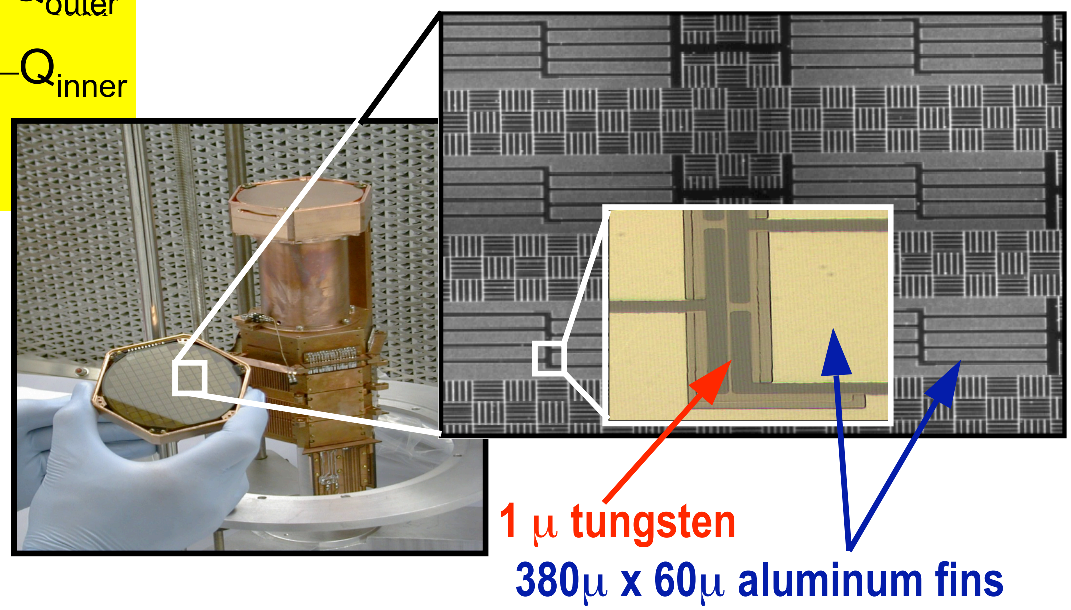
Really Cool Detectors: ZIPs



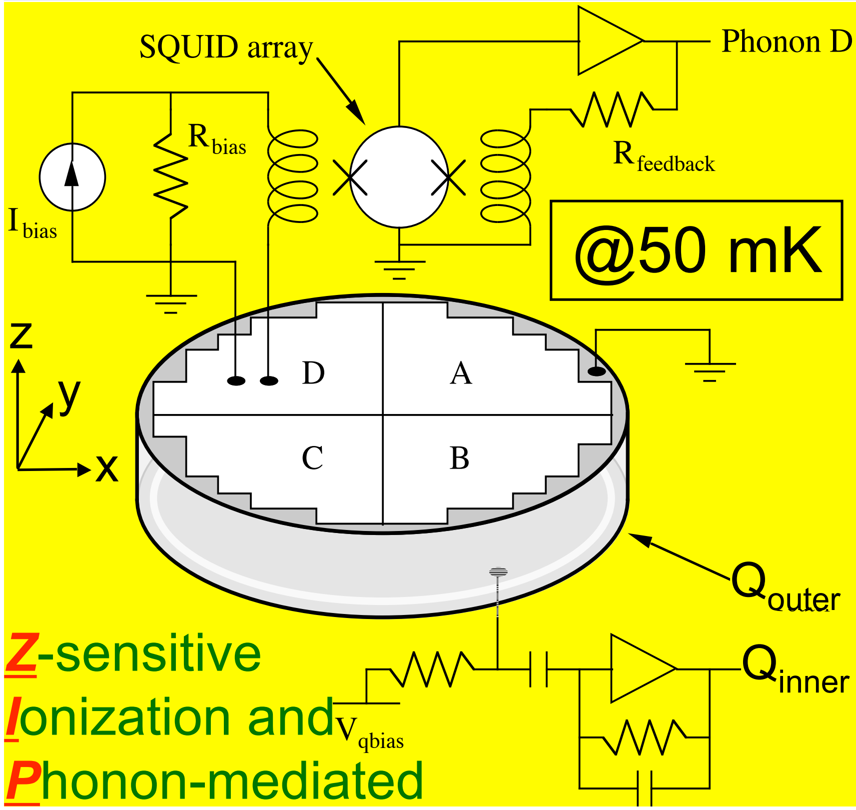
Z-sensitive
Ionization and
Phonon-mediated

- 250 g Ge or 100 g Si crystal
- 1 cm thick x 7.5 cm diameter
- Photolithographic patterning
- Collect athermal phonons:
  - XY position imaging
  - Surface (Z) event veto based on pulse shapes, timing, and energy partition in sensors

Measure ionization in low-field (~volts/cm) with segmented contacts to allow rejection of events near outer edge



Really Cool Detectors: ZIPs



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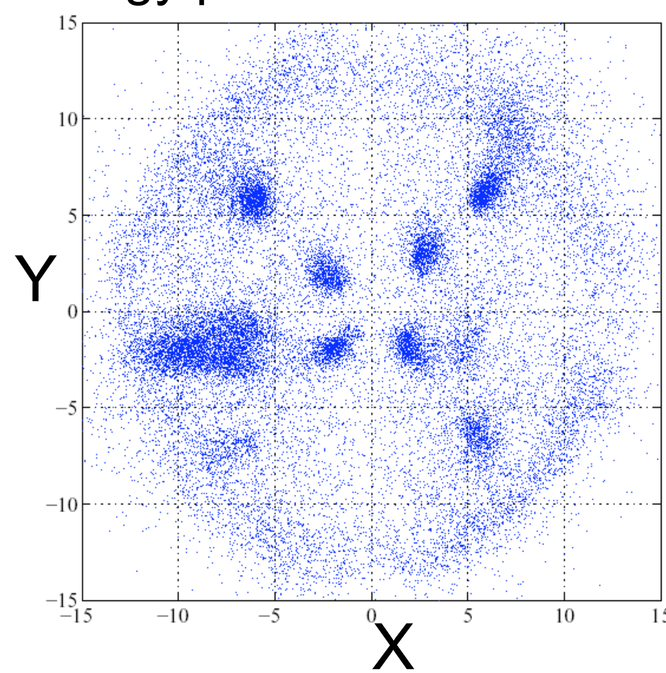

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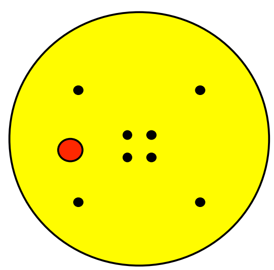
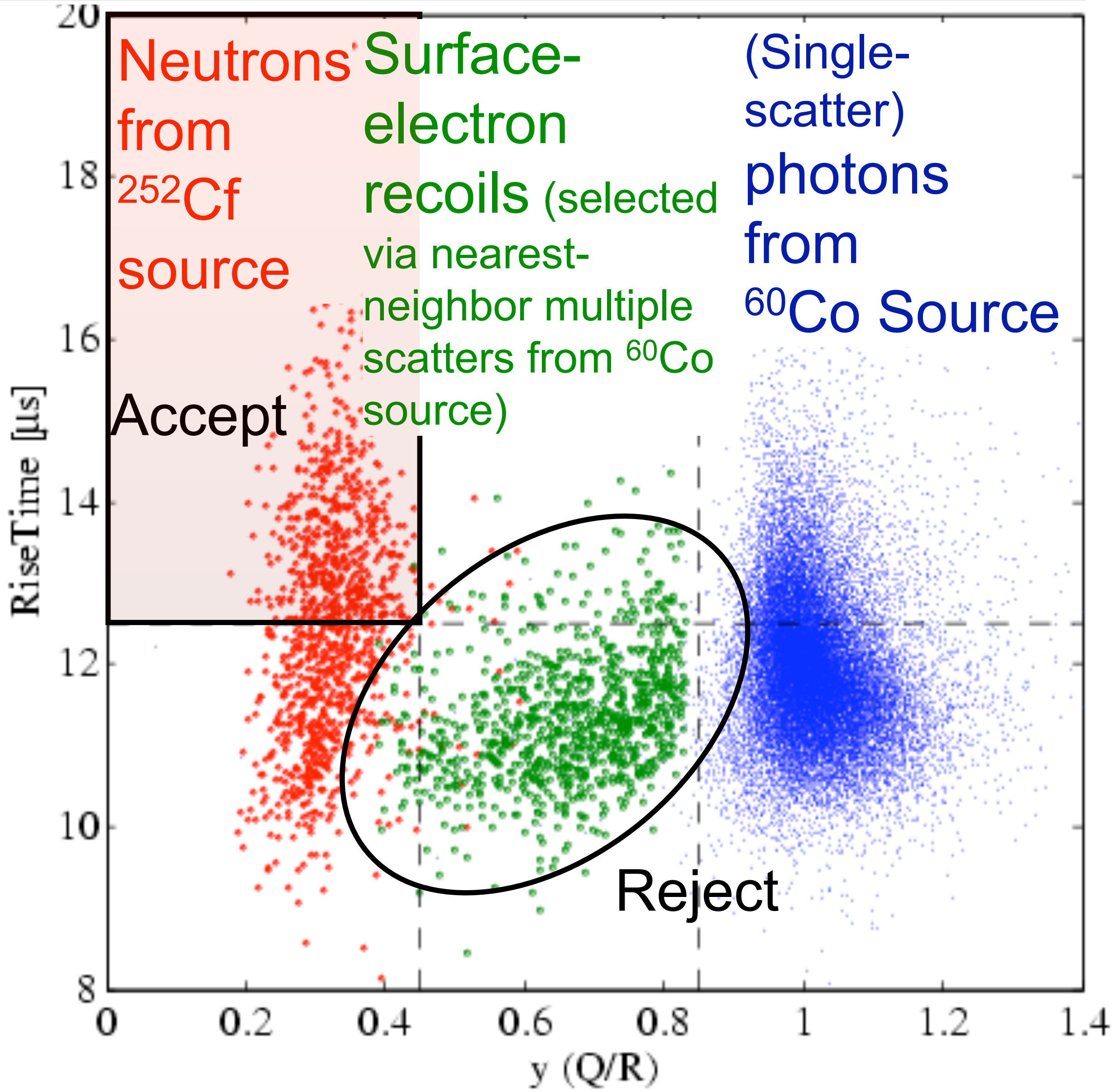


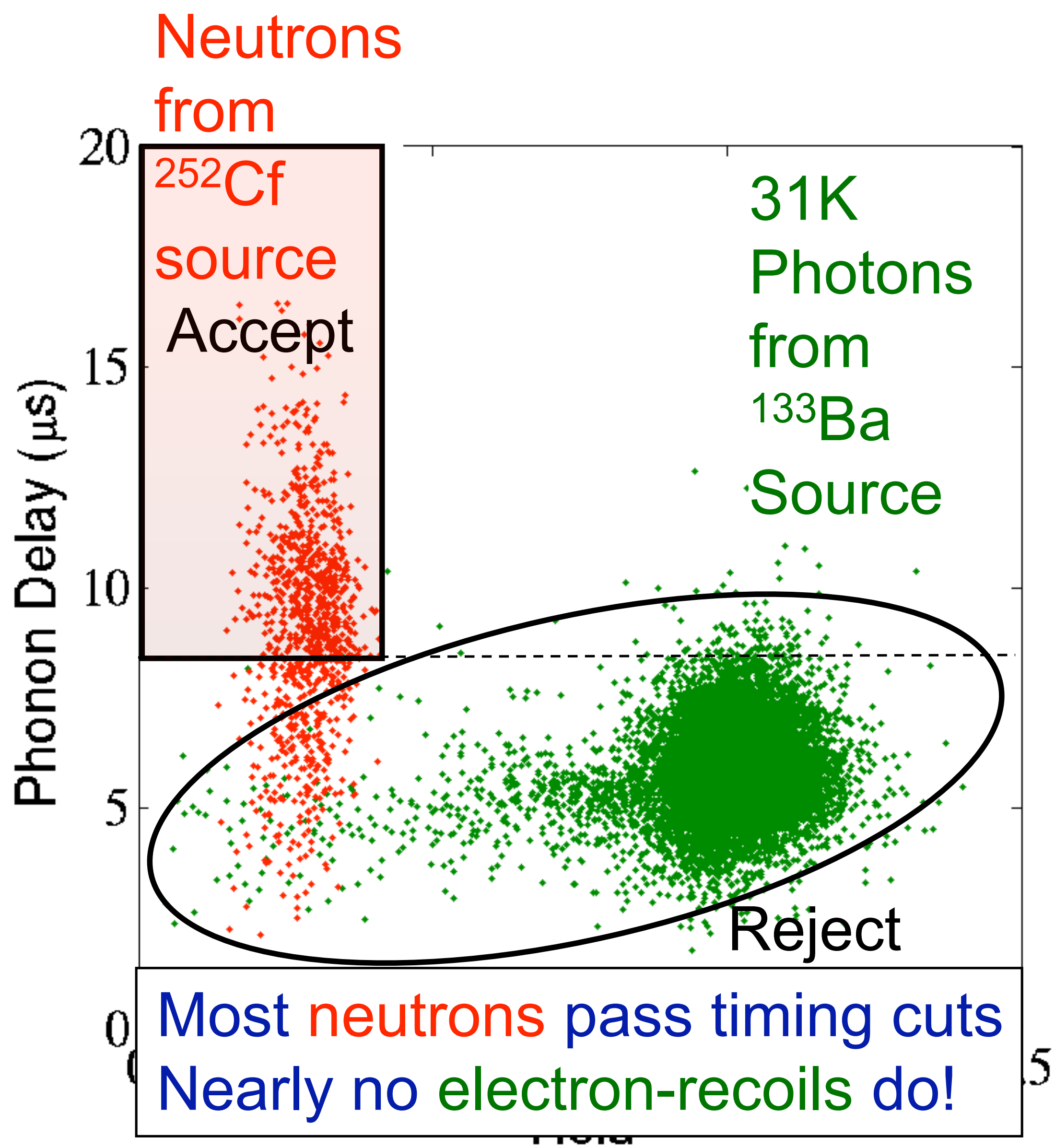
ZIP Z-Position Sensitivity Rejects Electrons

- Cut based on phonon-pulse risetime eliminates the otherwise troublesome background surface events
- >99% above 10 keV



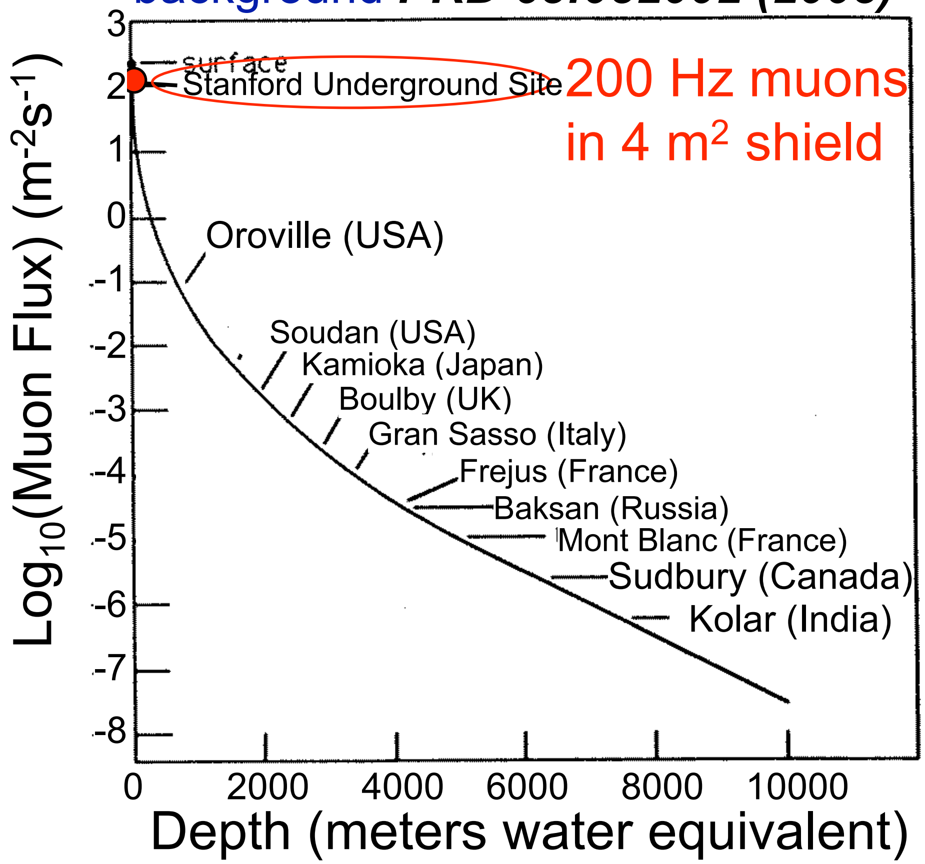
More ZIP Z-Position Sensitivity

- We are only beginning to take full advantage of the information from the athermal phonon sensors!
  - Improving modeling of phonon physics
  - Extracting better discrimination parameters (timing and energy partition)
- Towards a full event reconstruction, near-perfect rejection of surface events



CDMS II at Stanford and at Soudan

- 2001-2002 run at shallow site
  - 28 kg day exposure of 4x 250g Ge detectors (and 2x 100g Si detectors)
  - 20 nuclear-recoil candidates consistent with expected neutron background ***PRD 68:082002 (2003)***



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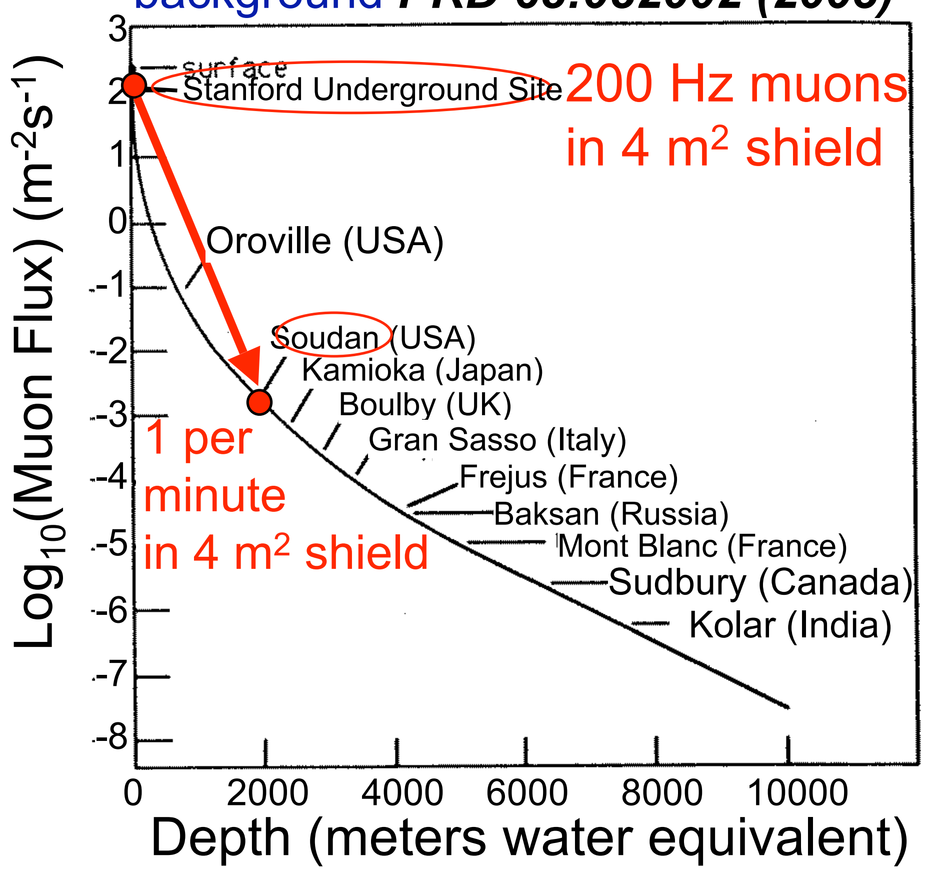
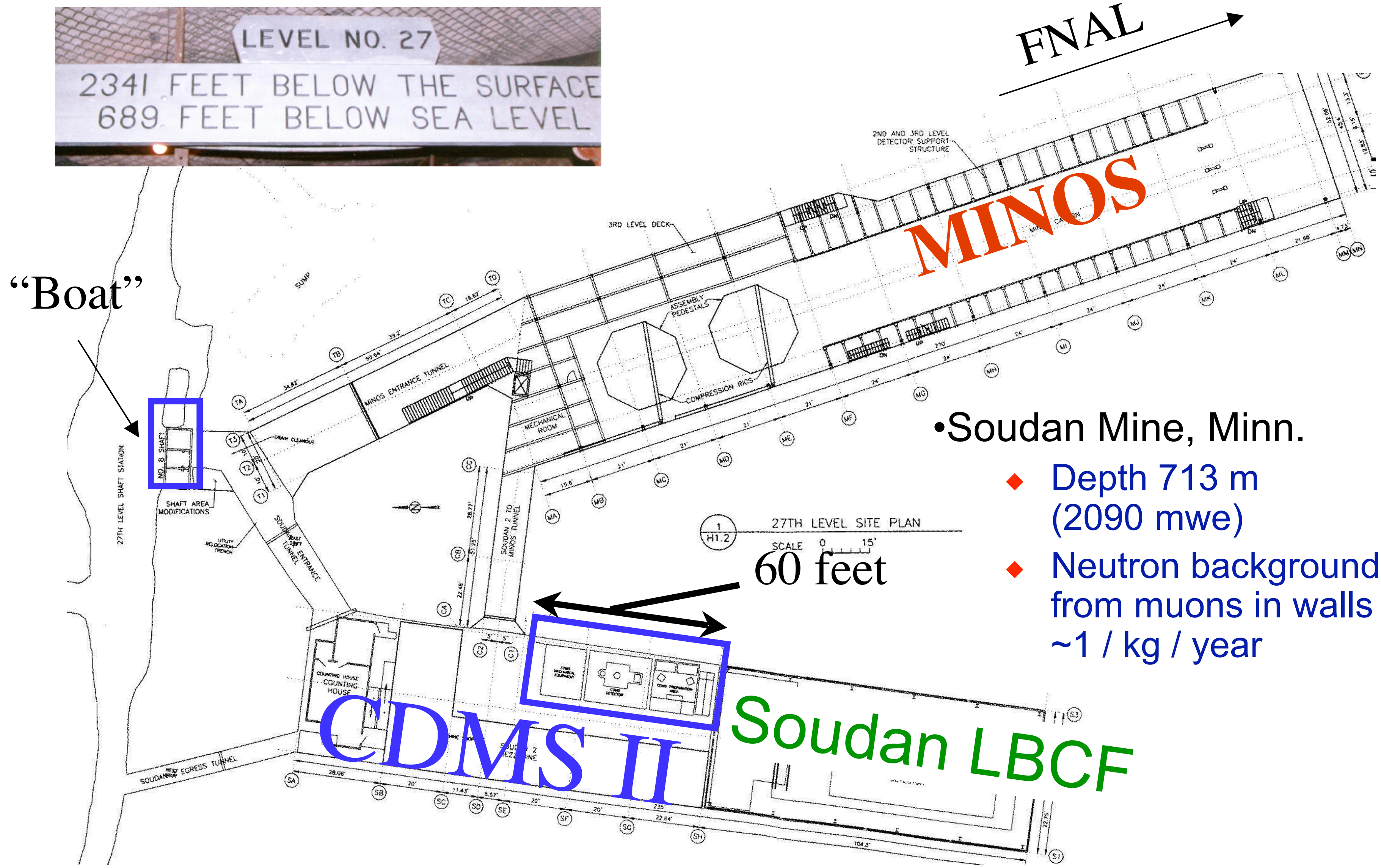


- 2003-2007 in Soudan Mine, Minn.
  - Depth 713 m (2090 mwe)
  - Reduce neutron background from ~1 / kg / day to ~1 / kg / year

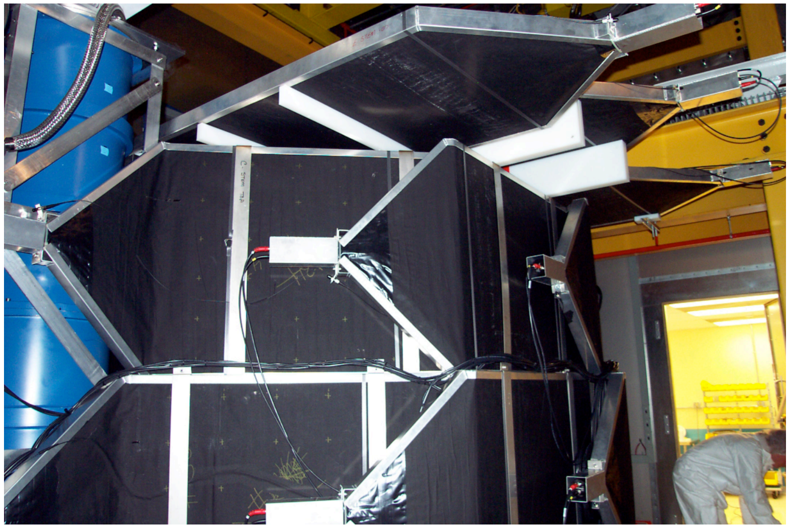
Experimental Setup in the Soudan Mine



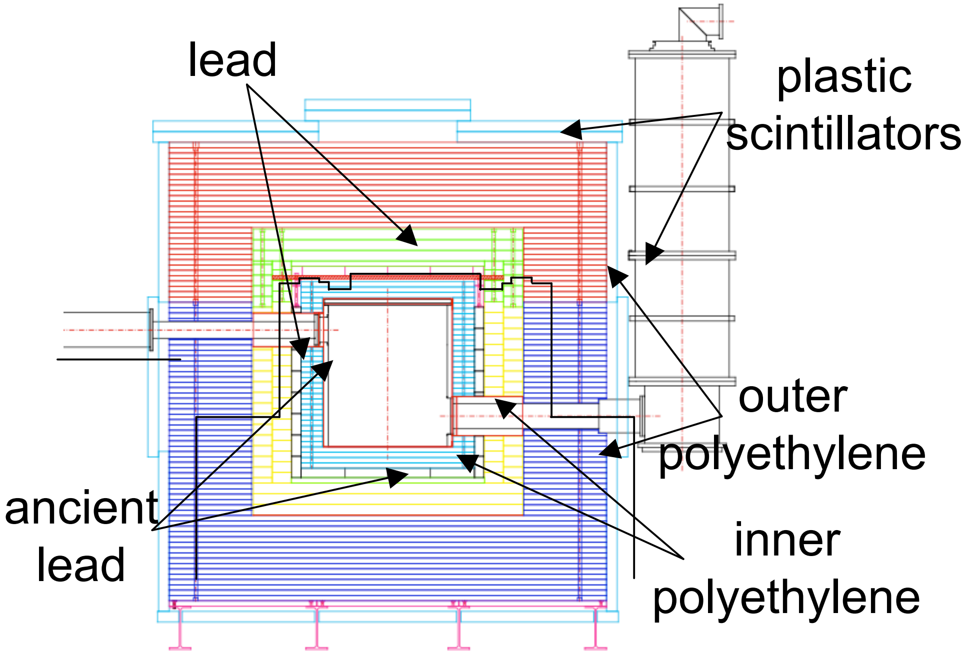
•Soudan Mine, Minn.

- Depth 713 m (2090 mwe)
- Neutron background from muons in walls ~1 / kg / year

CDMS II Shielding

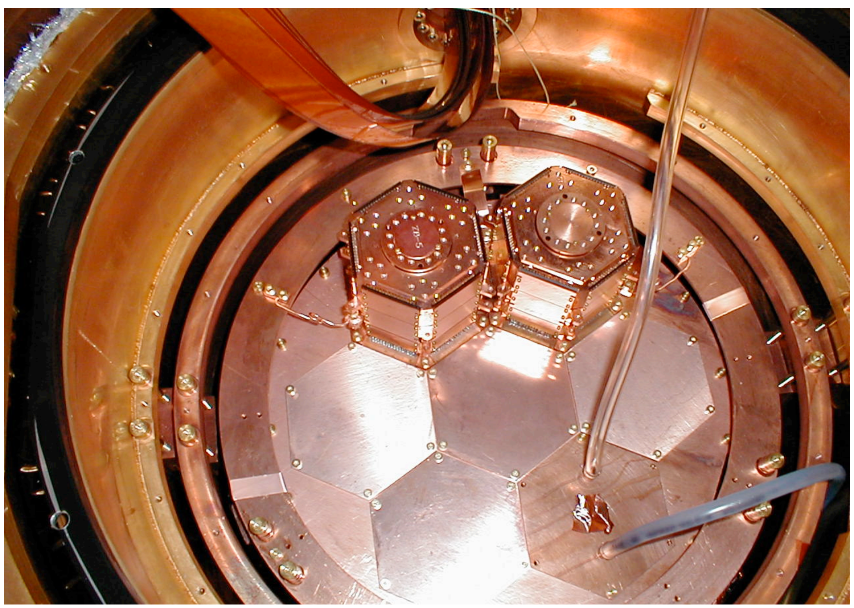


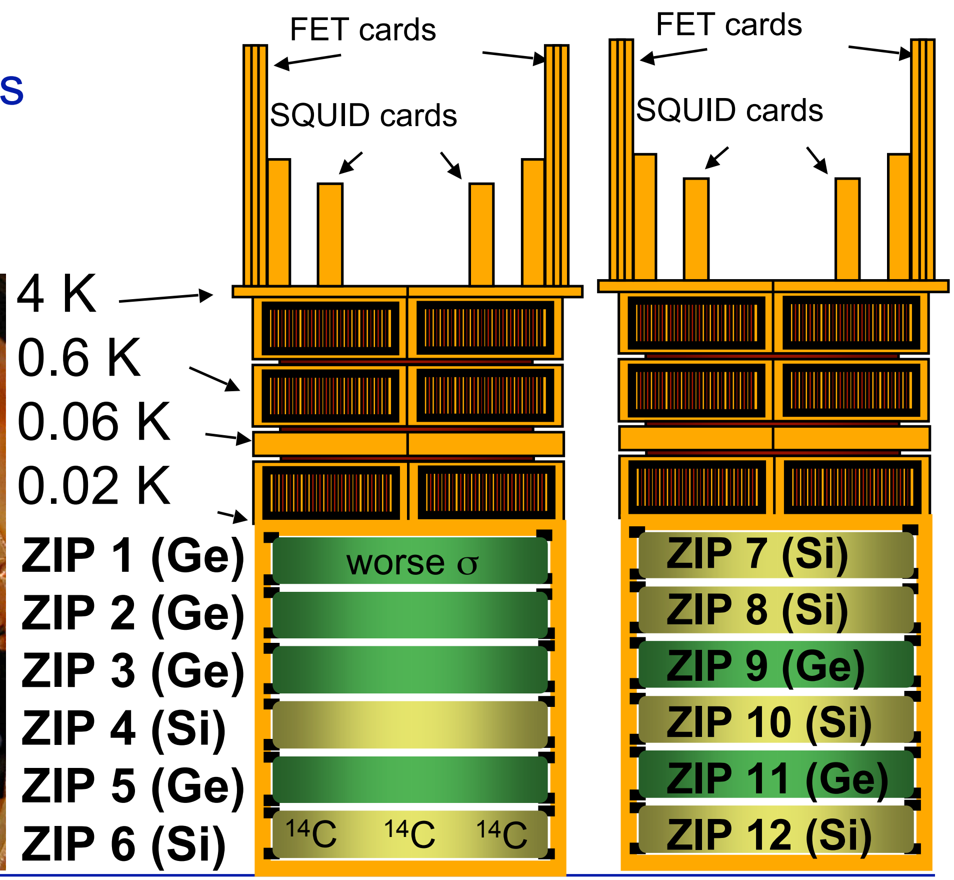
- Active muon veto
- 40 cm outer polyethylene
  - Removes neutrons from (α,*n*)
- 22.5 cm lead shielding
- 10 cm inner polyethylene
  - Reduces neutrons from muons
- Copper cryostat



First Year of Running CDMS II at Soudan

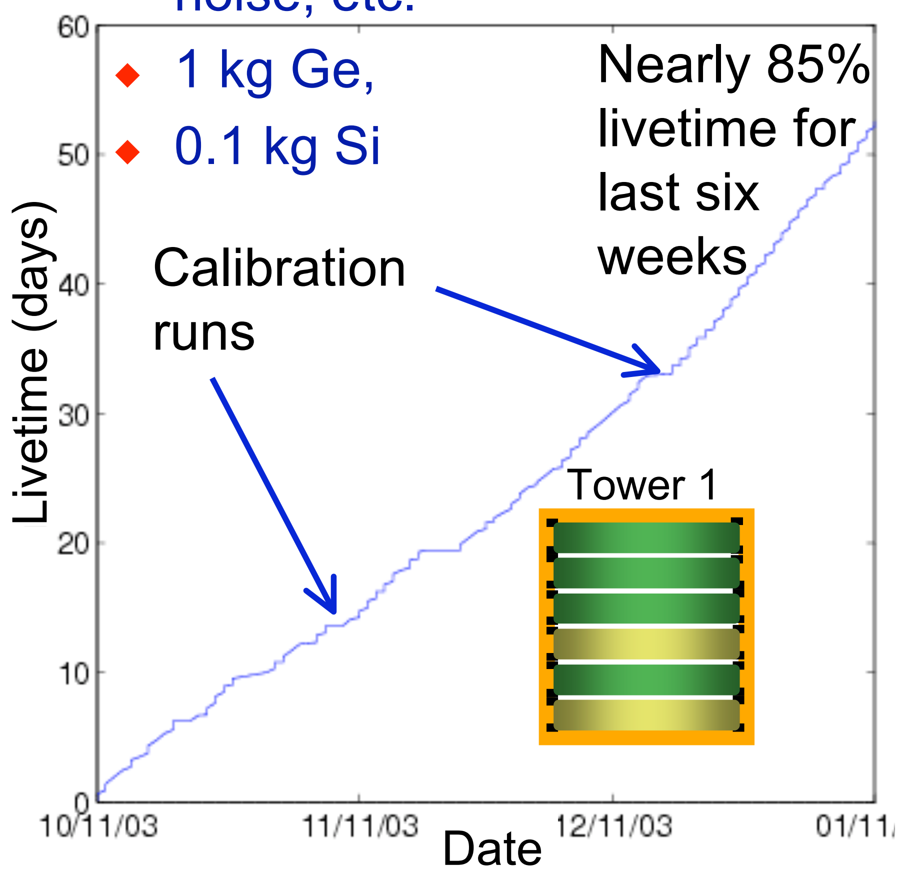
- Installed two towers of 6 detectors each in 2003
  - "Tower 1" same 4 Ge (1 kg) and 2 Si (0.2 kg) ZIPs run at Stanford
  - "Tower 2" with 2 Ge and 4 Si
  - Ge more sensitive to WIMPs since $\sigma_{n\chi} \propto A^2$
  - Si more sensitive to neutrons
  - Si sensitive to lower-mass WIMP



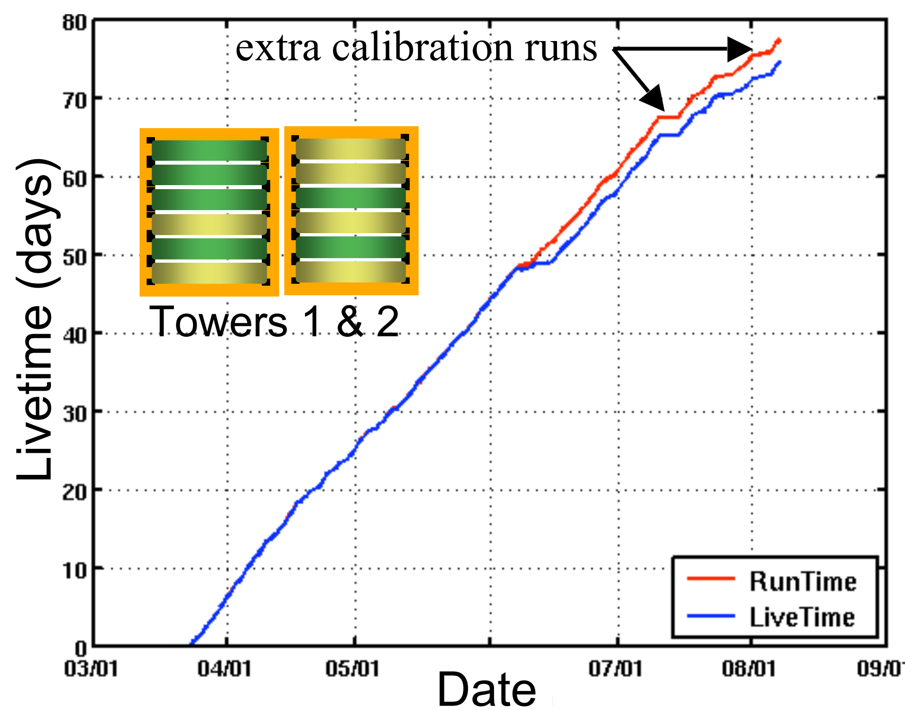


First Year of Running CDMS II at Soudan

- October 2003- January 2004 run of "Tower 1"
  - 62 "raw" livedays, 53 livedays after cutting times of poor noise, etc.
  - 1 kg Ge,
  - 0.1 kg Si



- March-August 2004 "The Two Towers"
  - 1.25 kg (of 1.5 kg total) of Ge, 0.4 kg (of 0.6 kg total) of Si
  - 76 "raw" livedays, 74 livedays
  - Nearly 2x exposure, expected sensitivity, and calibration data



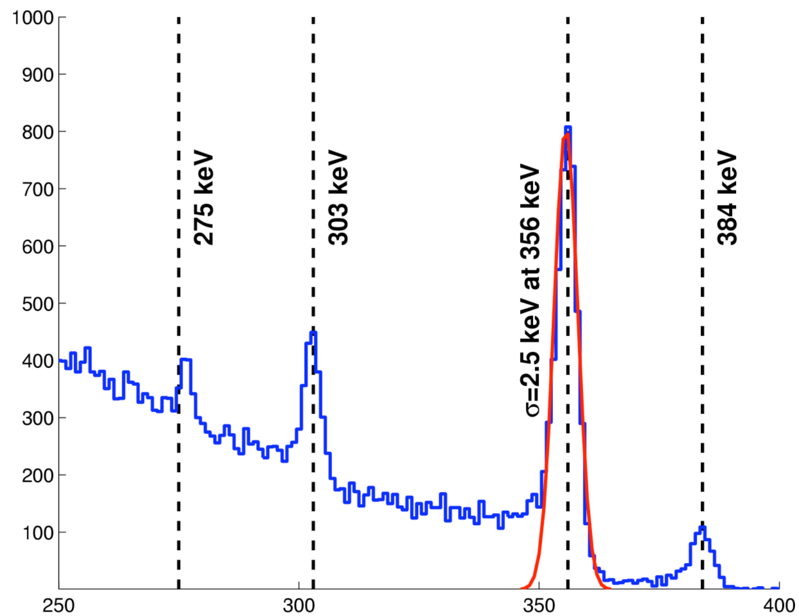
In Situ Energy Calibrations

Ionization Energy resolution

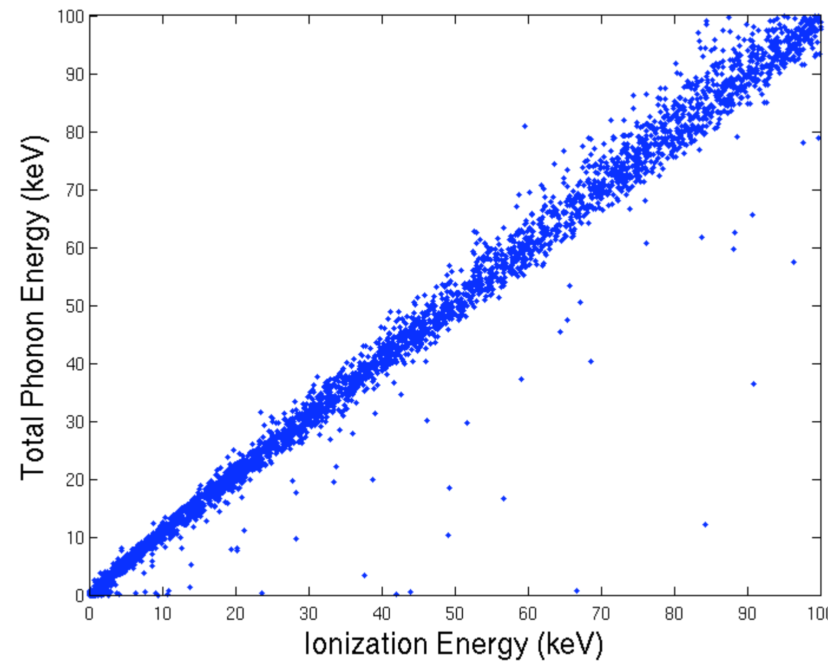
8-10 keV (at 356 keV)

0.3 keV (at 10 keV)

^{133}Ba peaks in a Ge ZIP

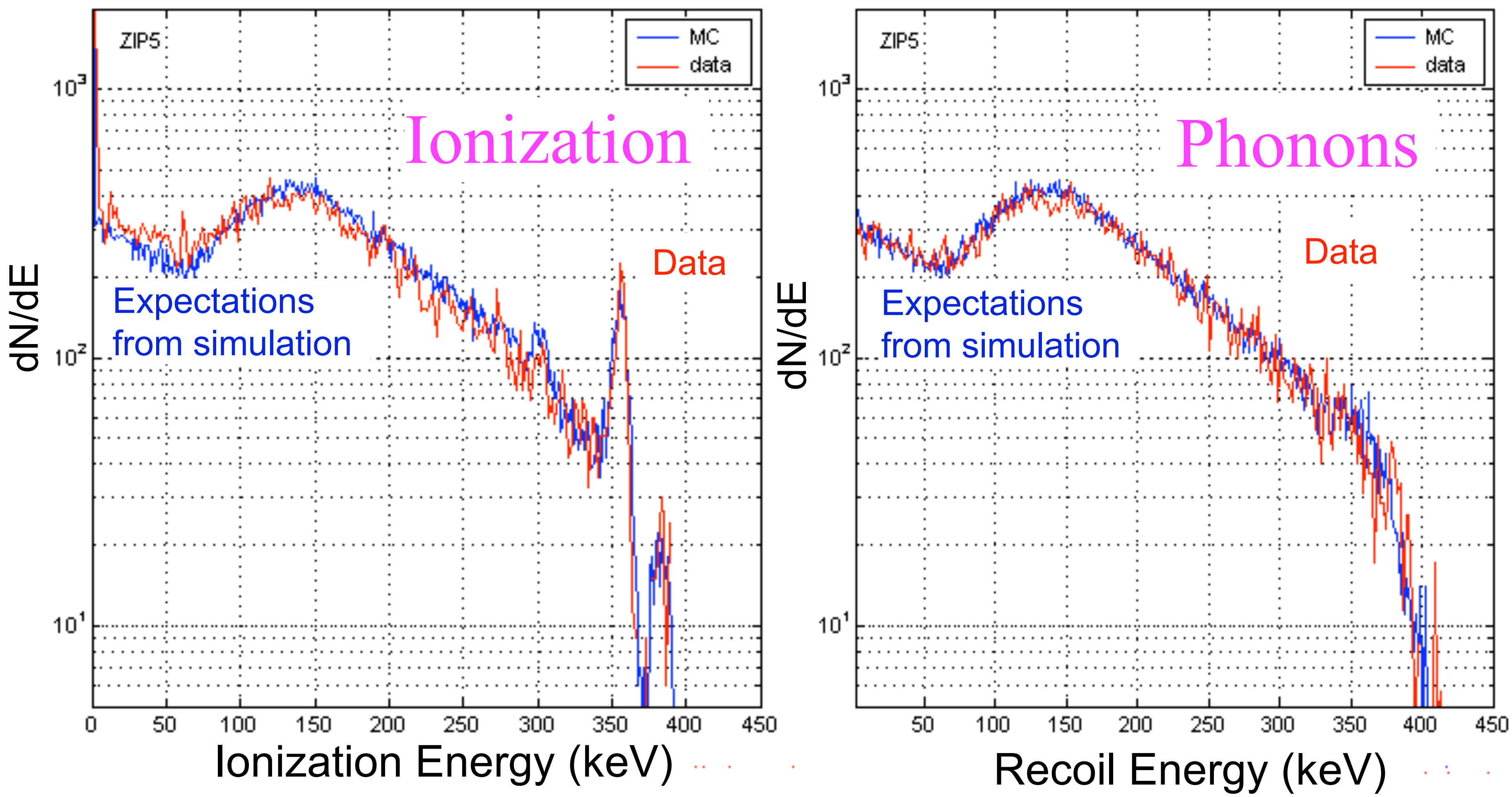


Ionization energy (keV-ee)



Normalize phonon recoil energy to ionization energy for photons from ^{133}Ba.

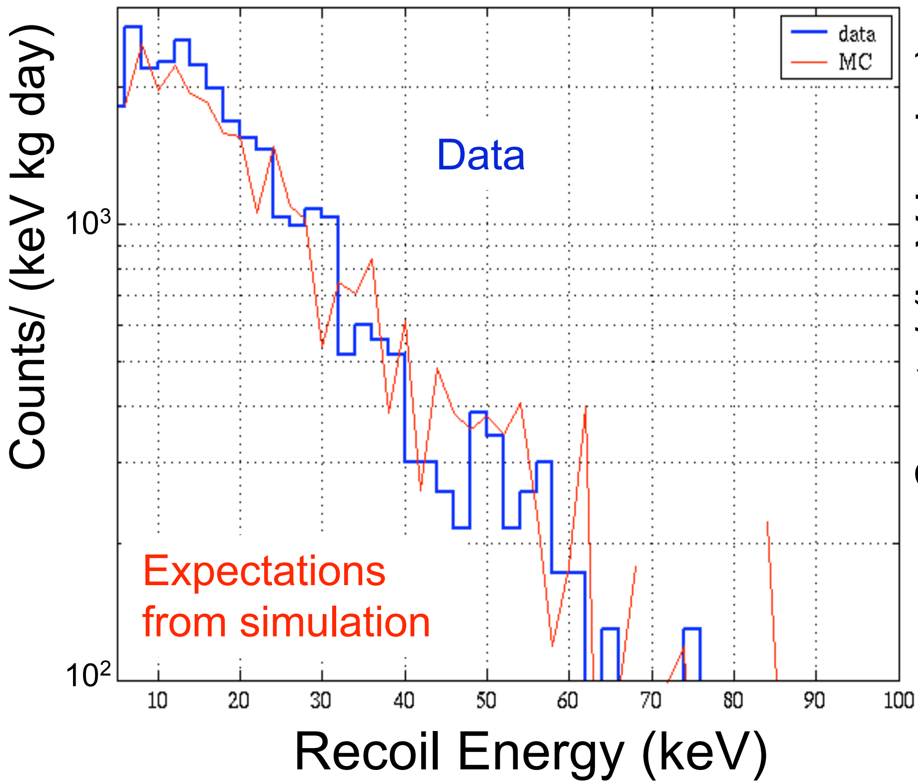
In Situ Photon Calibration with ^{133}Barium



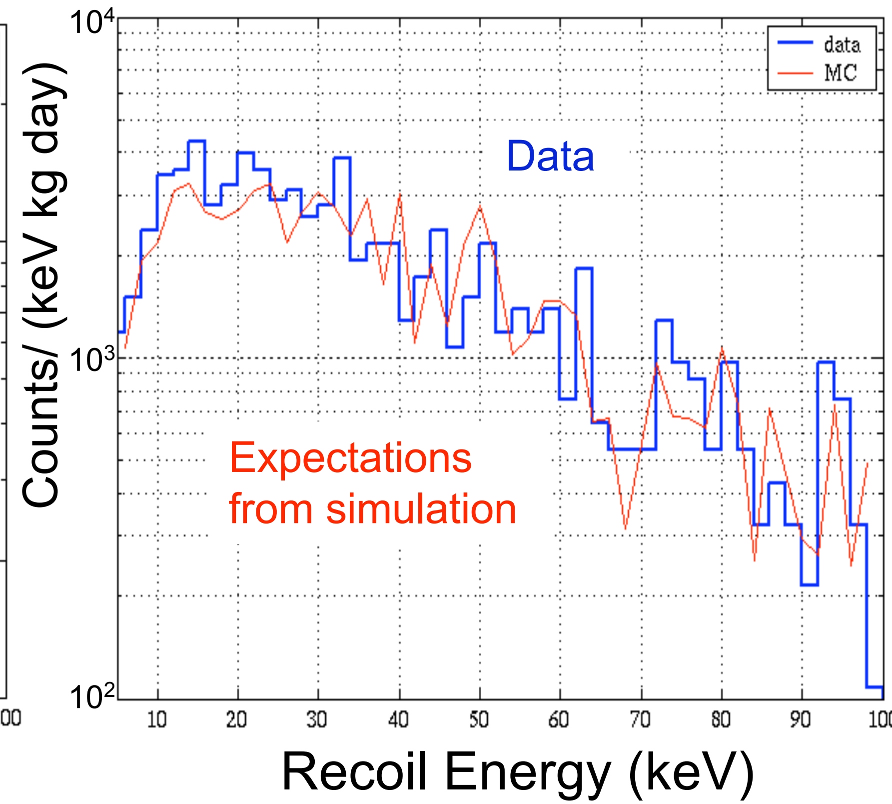
L. Baudis

In Situ Nuclear-recoil calibration with ^{252}Cf

Nuclear recoils in Ge ZIP



Nuclear recoils in Si ZIP



Excellent agreement between data and Monte Carlo
⇒Understand cut efficiencies, energy scale for nuclear recoils

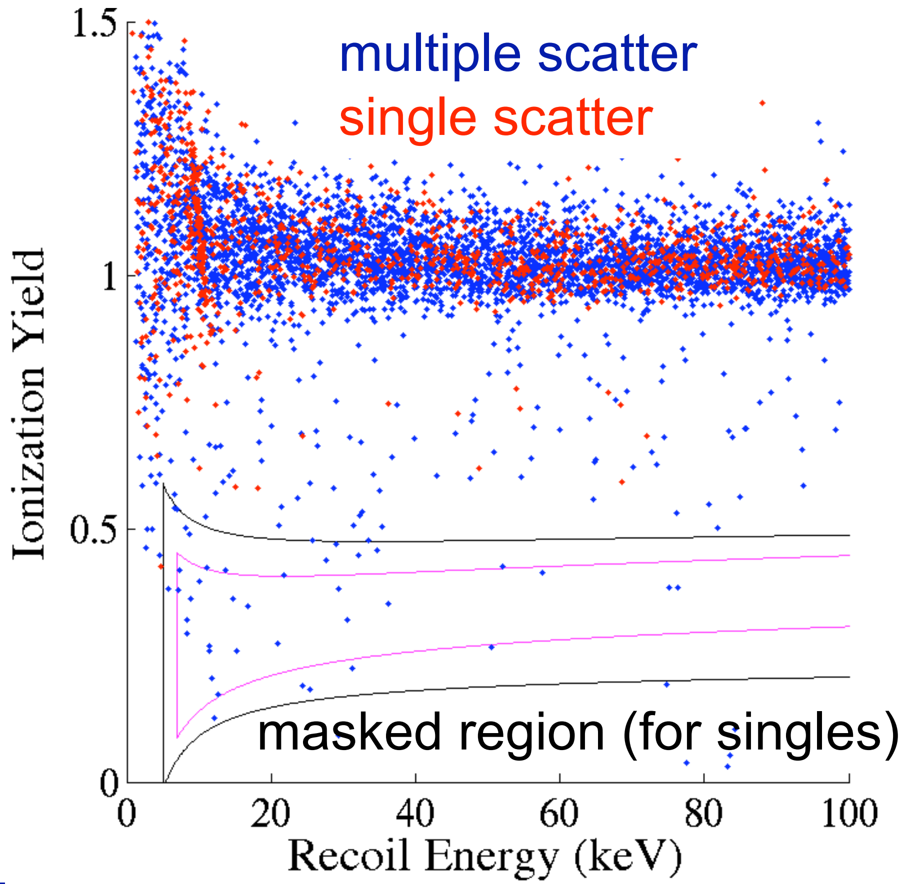
S. Kamat

CDMS “Blind” Analysis

•In a rare event search, it is critical to remove any possibility of human bias affecting results

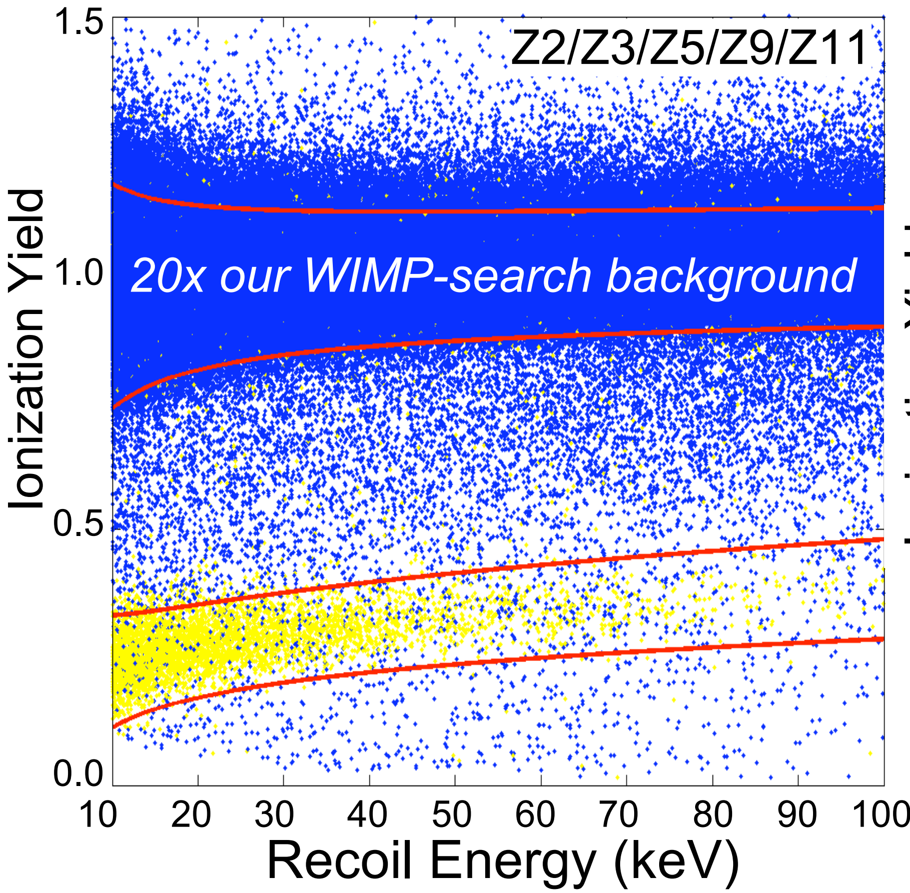
•Prevent possibility of bias by setting all data-selection cuts “blind,” before being aware of any candidate WIMP events

- Set nearly all cuts based on data taken with external calibration sources
- Set few cuts based on WIMP-search data (e.g. periods of poor electronics noise) after automated procedure removes all single-detector events in or near signal region
- Optimize cuts for greatest sensitivity, which occurs when expected background <1 event

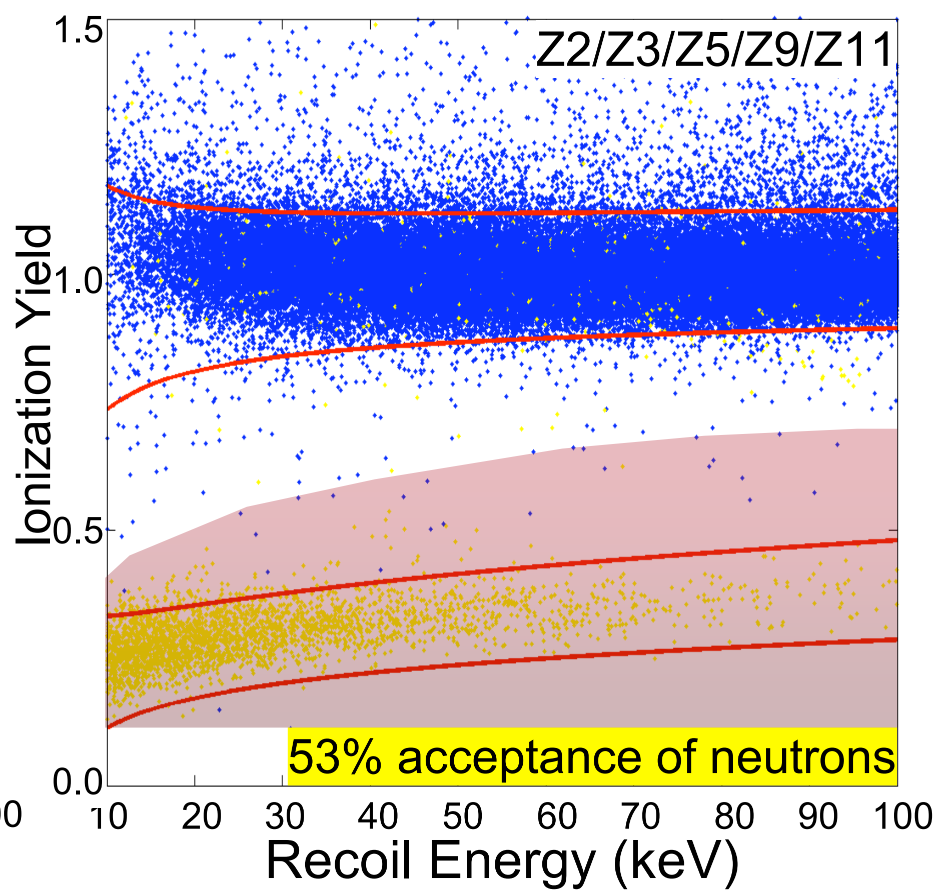


In Situ Calibrations for Setting Cuts "Blind"

Two-tower Ge calibration data, prior to timing cuts



After timing cuts, set to reject ~99% of low-yield electron recoils

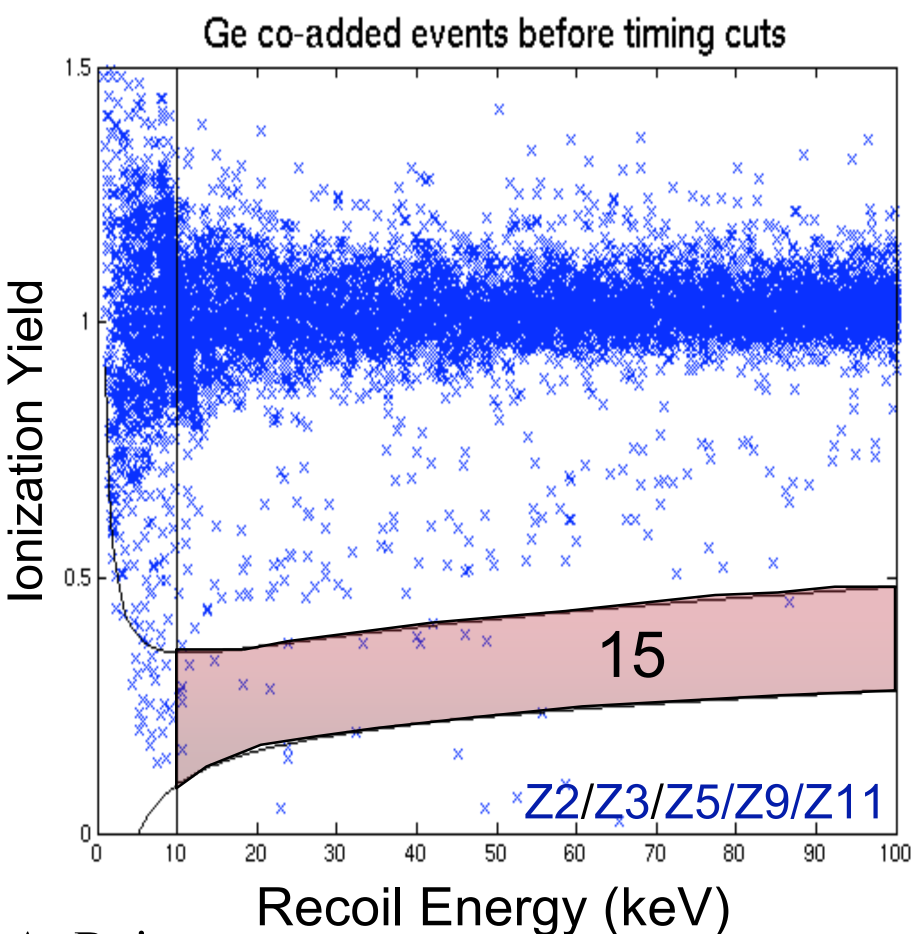


Blue points: electron recoils induced by a ^{133}Ba γ source

Yellow points: nuclear recoils induced by a ^{252}Cf neutron source

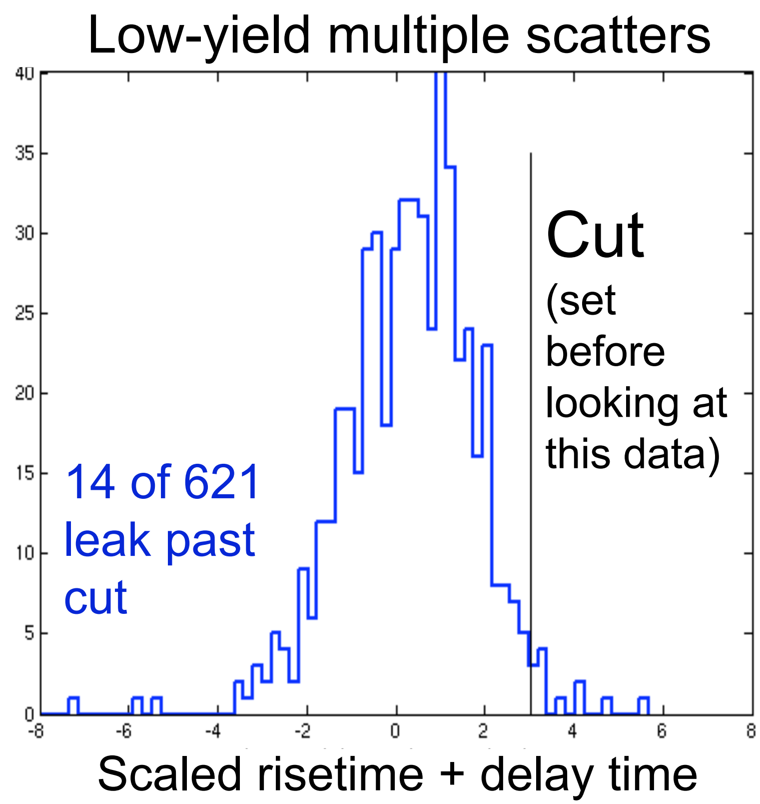
Estimating Expected Background

- Count number of events in signal region prior to timing cuts



A. Reisetter

- Multiply by leakage fraction of low-yield multiple scatters
  - Varies from 1% to 3% depending on detector and data sample



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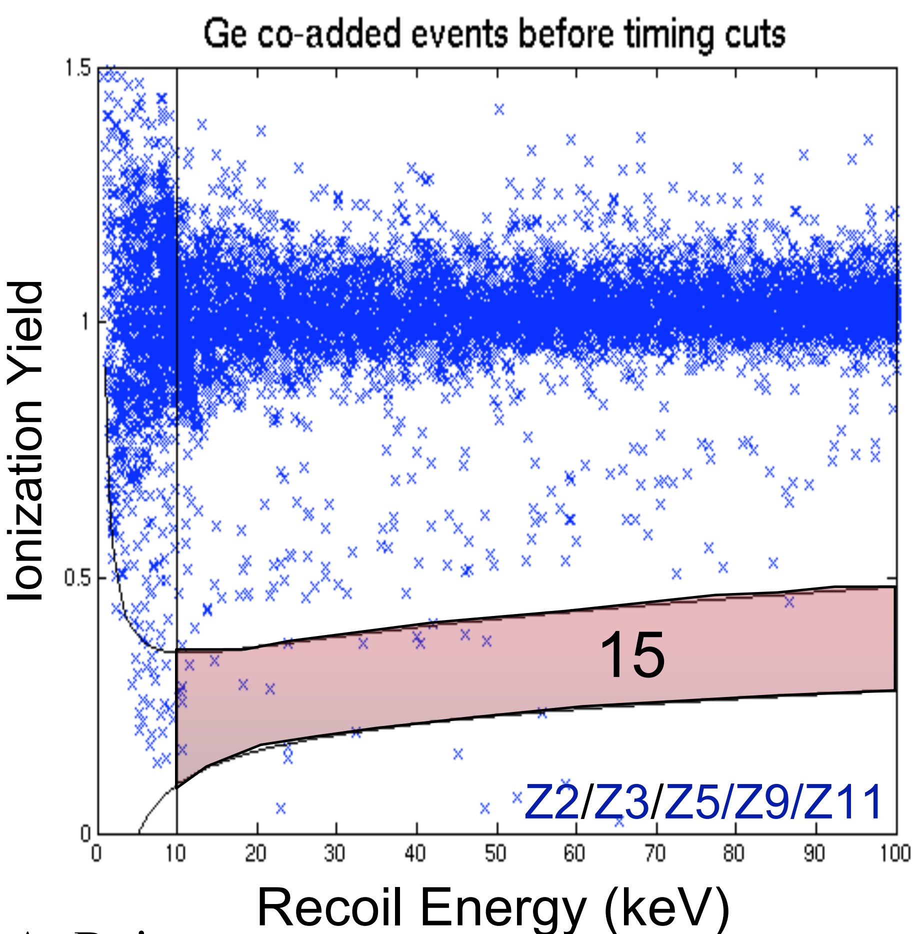


A. Reisetter

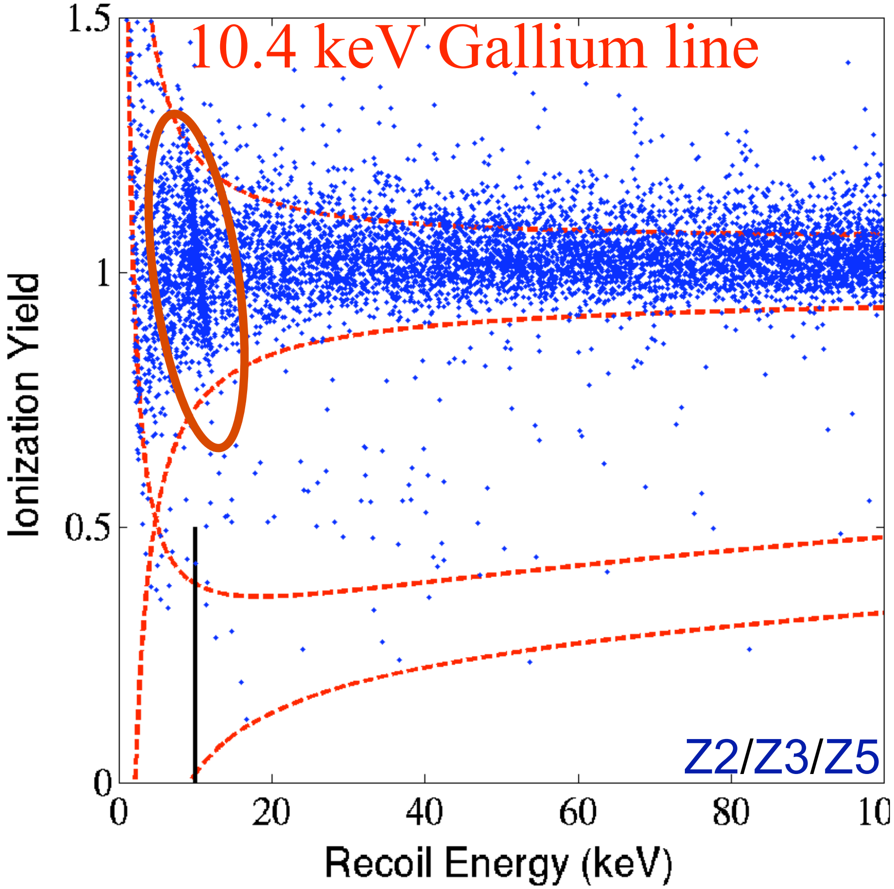
- Multiply by leakage fraction of low-yield multiple scatters
  - Varies from 1% to 3% depending on detector and data sample

ESTIMATE: 0.4 ± 0.2 (sys.) ± 0.2 (stat.) misidentified electron recoils

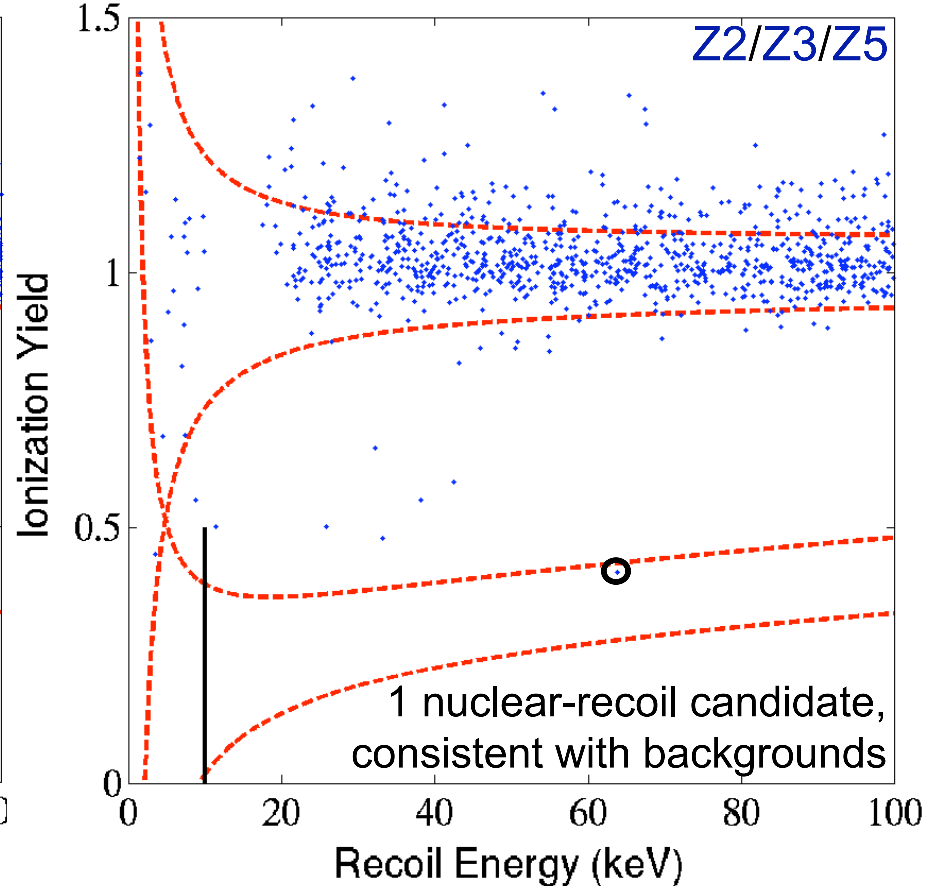
<0.05 recoils from neutrons expected after veto

First Ge WIMP-search data

Prior to timing cuts



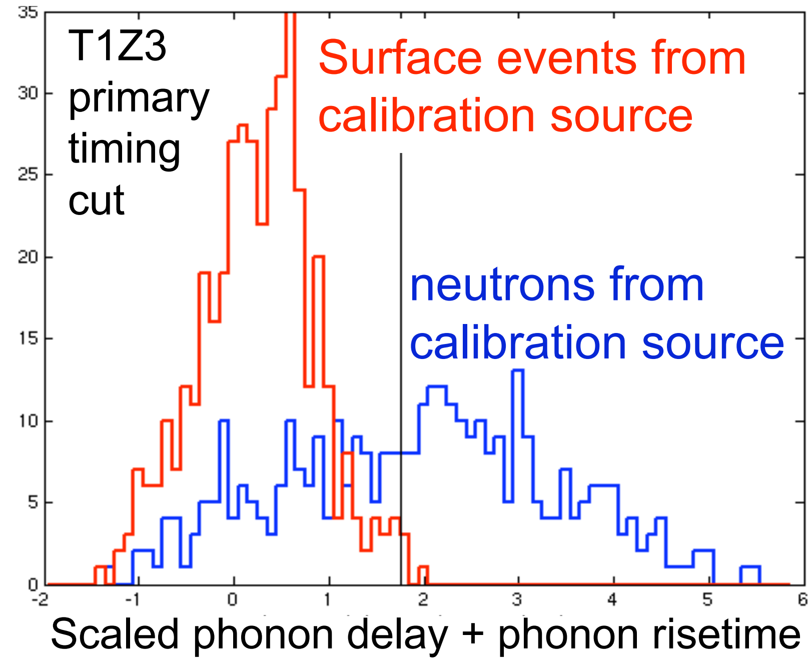
After timing cuts, which reject most electron recoils

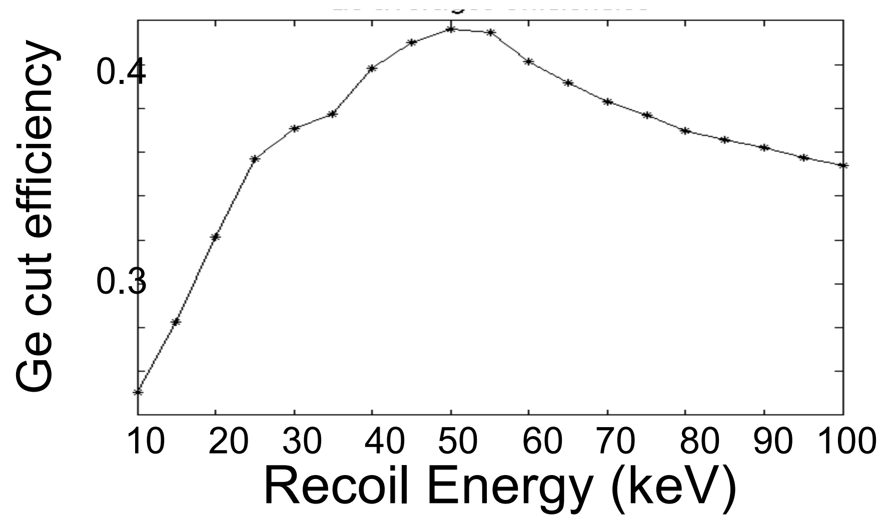


0.7 ± 0.35 misidentified electrons (w/Z1),
<0.05 recoils from neutrons expected (w/ Z1)

Analysis of 2nd Soudan Run of CDMS II

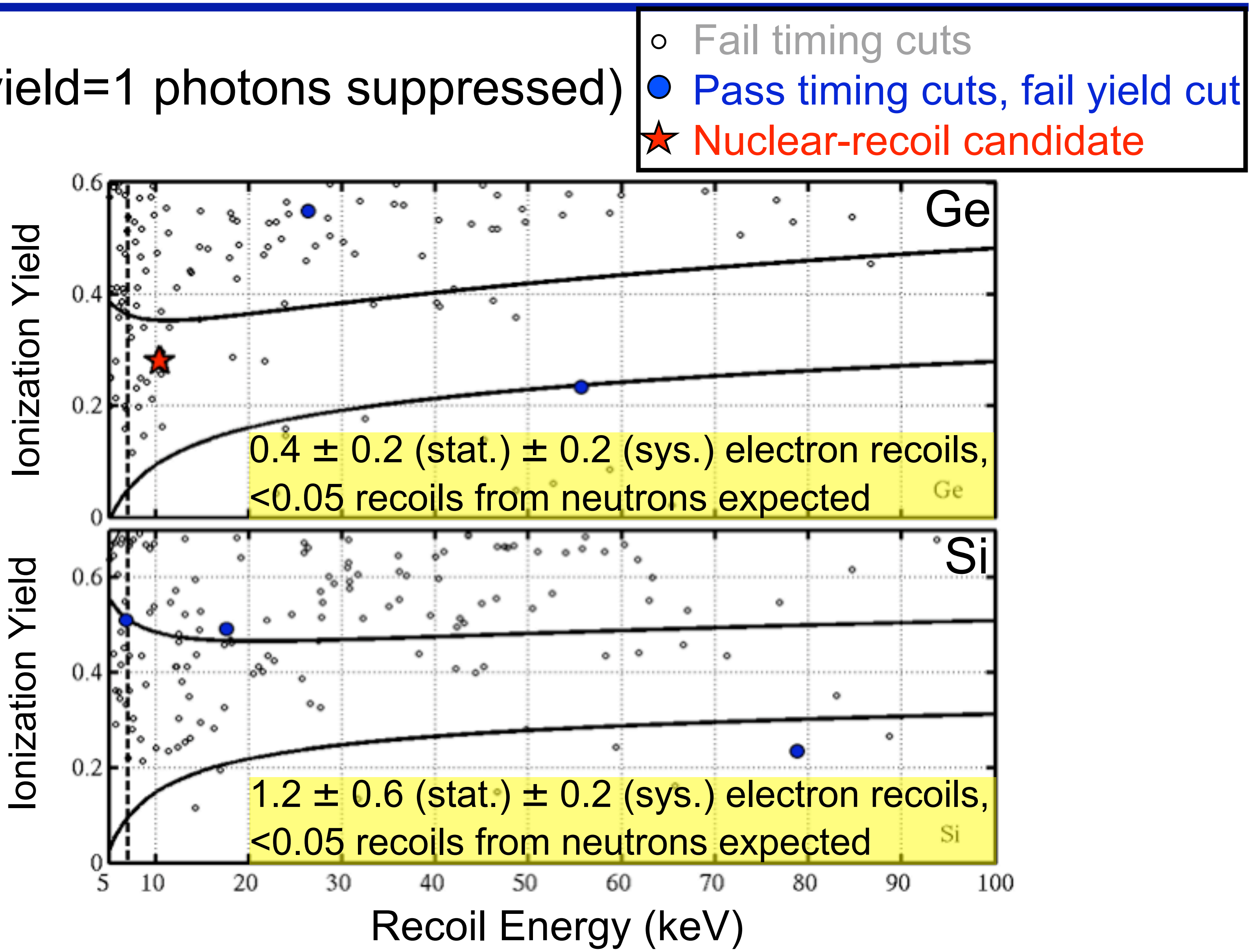
- Included 5 of 6 Ge and 4 of 6 Si detectors (others still blinded)
  - 1.25 kg of Ge, 0.4 kg of Si
  - 74 live-days WIMP-search data
- "Opened the box" on March 31, 2005
- Pre-designated "primary" analysis
  - Similar to timing cut used previously, but better rejection
- 4 "secondary" blind analyses with more sophisticated techniques
  - Higher efficiency at low energy
  - Better rejection of backgrounds





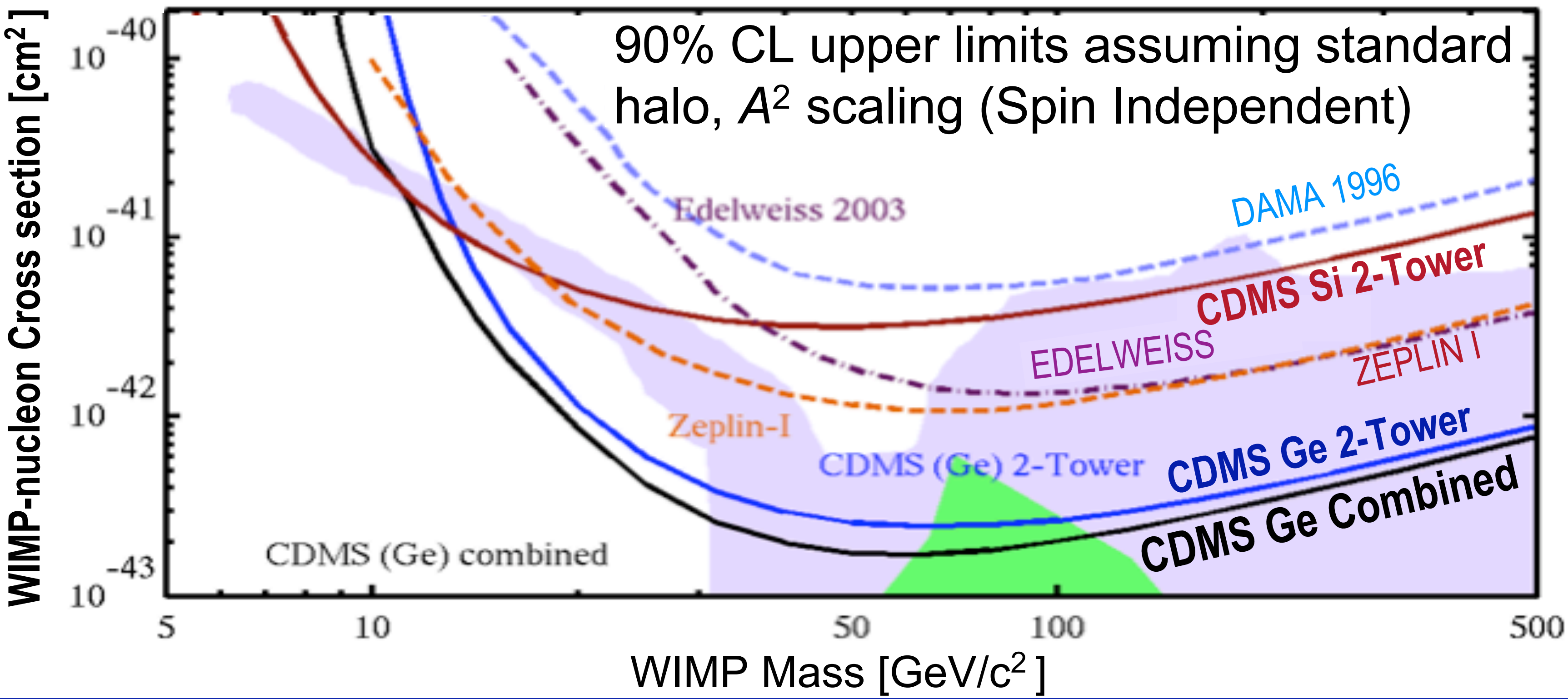
Two-Tower WIMP-search Data

(with yield=1 photons suppressed)



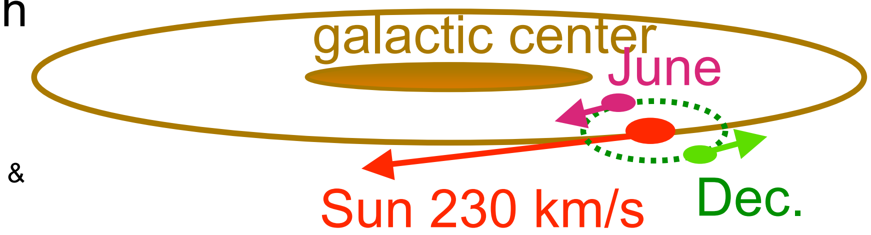
1st Year CDMS Soudan Combined Limits

- CDMS Upper limits on the WIMP- nucleon cross section are 1.7×10^{-43} cm^2 for a WIMP with mass of 60 GeV/c^2
  - Factor 6 lower than any other experiment
- Excludes regions of SUSY parameter space under some frameworks
  - Bottino et al. 2004 in light blue (MSSM with relaxed GUT Unification)
- Starting to probe constrained MSSM (Ellis et al. 2005 in green)

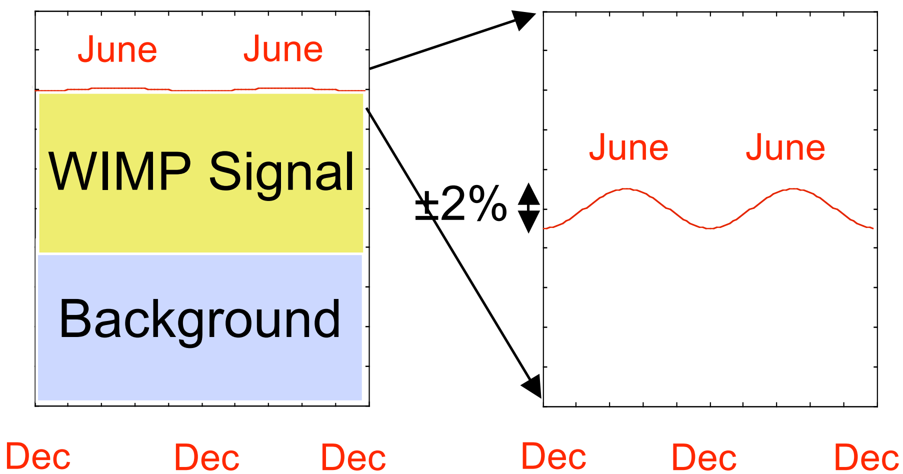


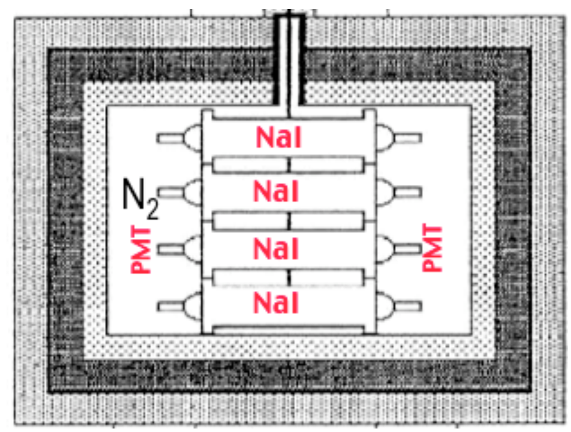
DAMA Search for Annual Modulation

- •DAMA experiment depends upon exploiting movements of Earth/Sun through WIMP halo
  - Annual modulation -- harder spectrum when Earth travels with sun (Drukier, Freese, & Spergel 1986)



- •Do not distinguish between WIMP signal and background directly
  - Infer the WIMP interaction rate from the amplitude of the modulation

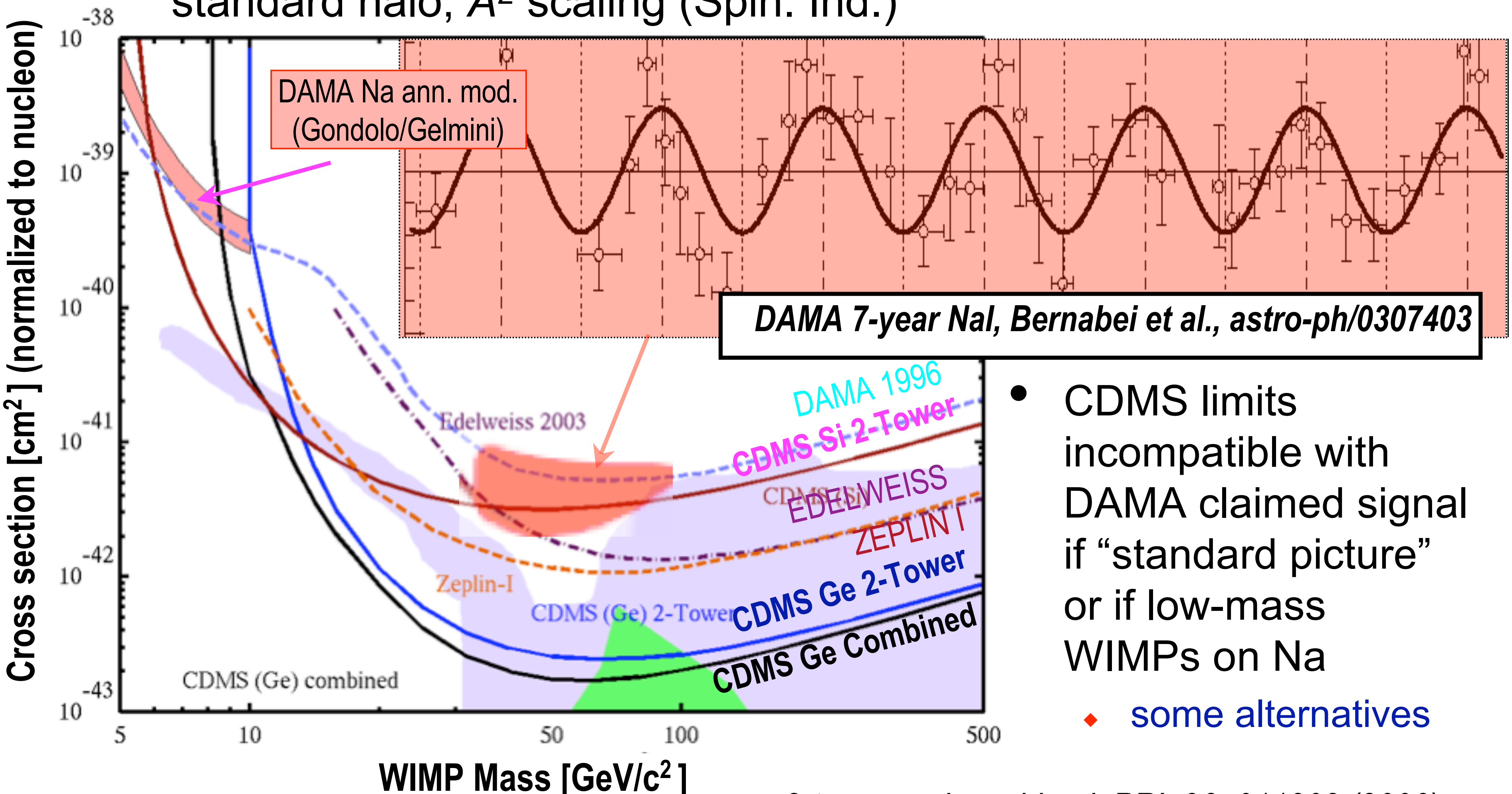




•See annual modulation signal (significant at 6.3σ!) in 107,731 kg-days total exposure of 100 kg of NaI scintillators from 1996-2002

1st Year CDMS Soudan Combined Limits

90% CL upper limits assuming standard halo, A^2 scaling (Spin. Ind.)

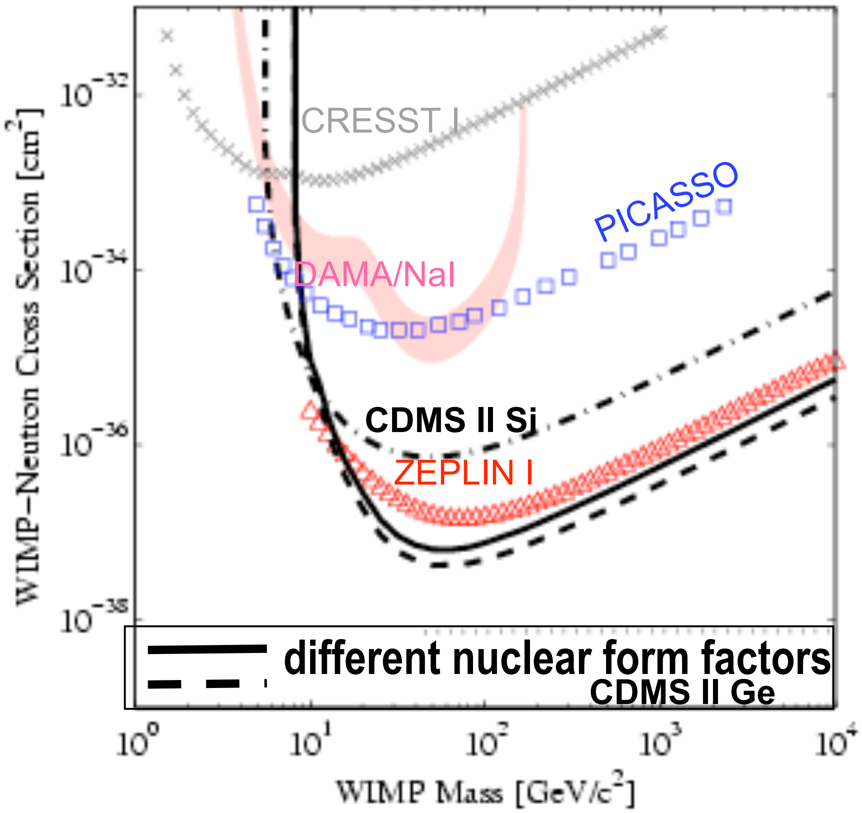


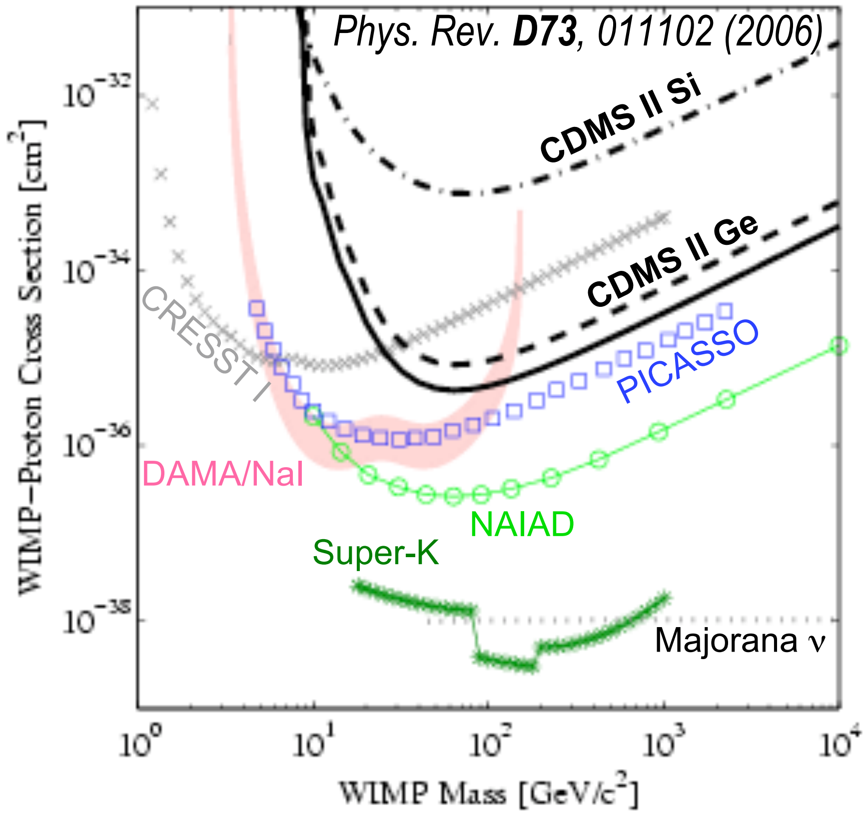
- CDMS limits incompatible with DAMA claimed signal if "standard picture" or if low-mass WIMPs on Na
  - some alternatives

*2-tower and combined: PRL **96**, 011302 (2006)*

*1-tower: PRL **93**, 211301 (2004); PRD **72**, 052009 (2005)*

CDMS Spin-Dependent Limits



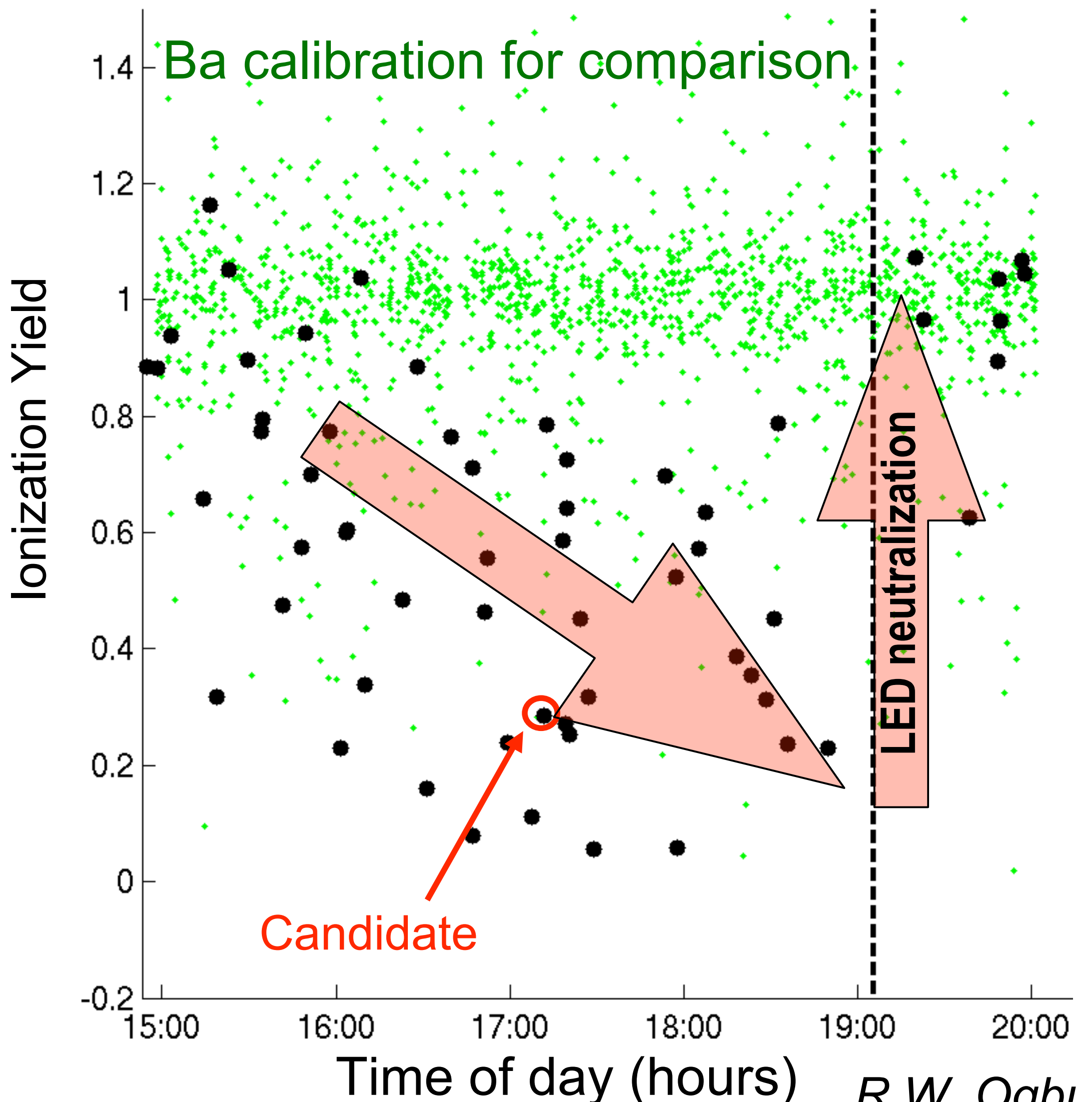


J. Filippini, UCB

- ^{73}Ge is odd-n, even-p nucleus (as is ^{27}Si)
  - Sensitive primarily to WIMP-neutron spin-dependent coupling
  - Rules out WIMP-neutron spin-dependent coupling to explain DAMA
- DAMA's Iodine is odd-p, so WIMP-proton spin-dependent coupling is allowed for small WIMP masses (ruled out by SuperK at higher masses)

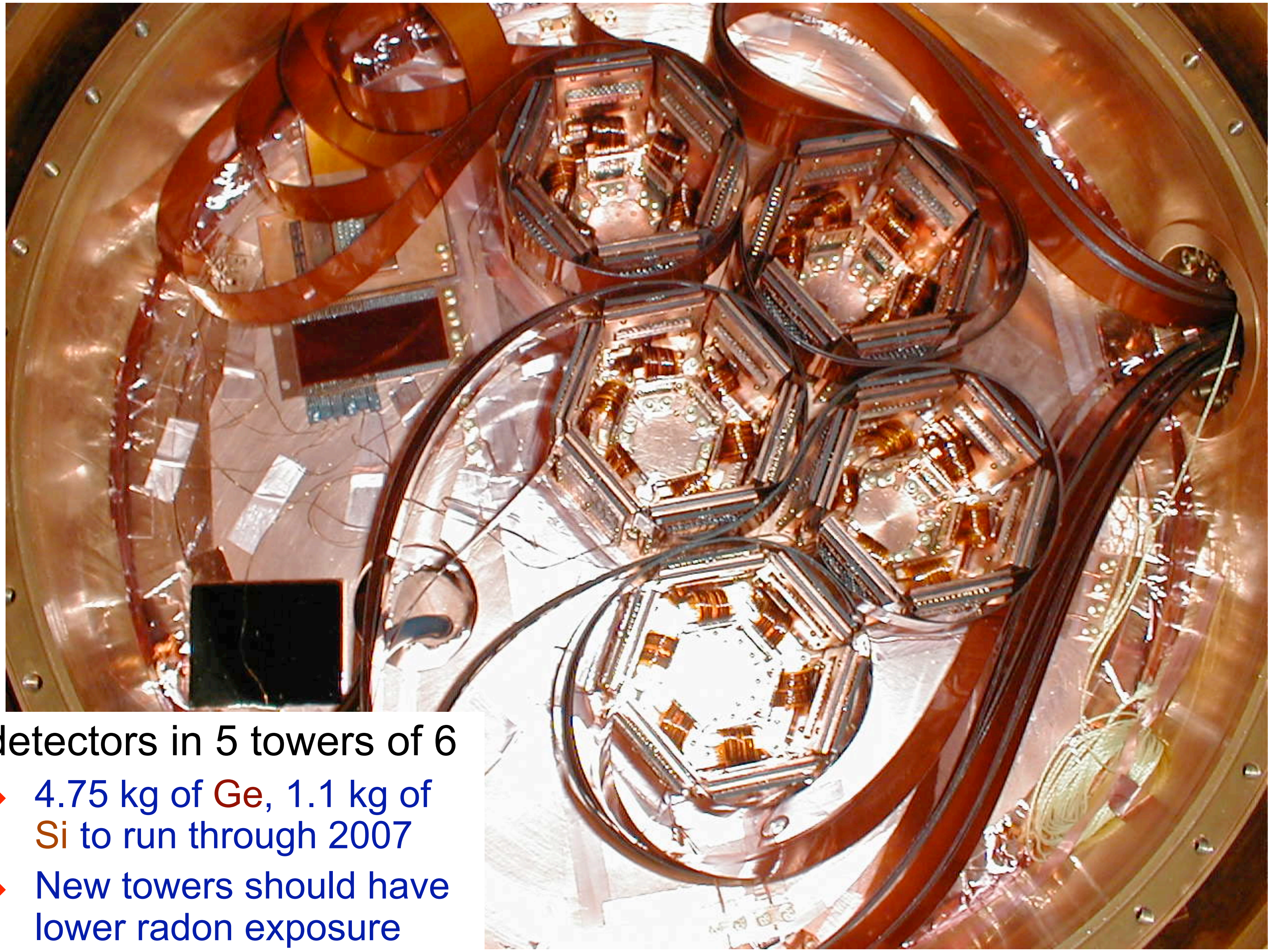
Is the Candidate Event Just Background?

- Very likely so!
- Automatic LED flash every 4 hours to discharge trapping sites
- The one candidate event occurred during run when its detector, was poorly neutralized!
    - Worst run for this detector
- Still include event in computing limits (so makes them worse)
- Improved screening for future analyses and runs

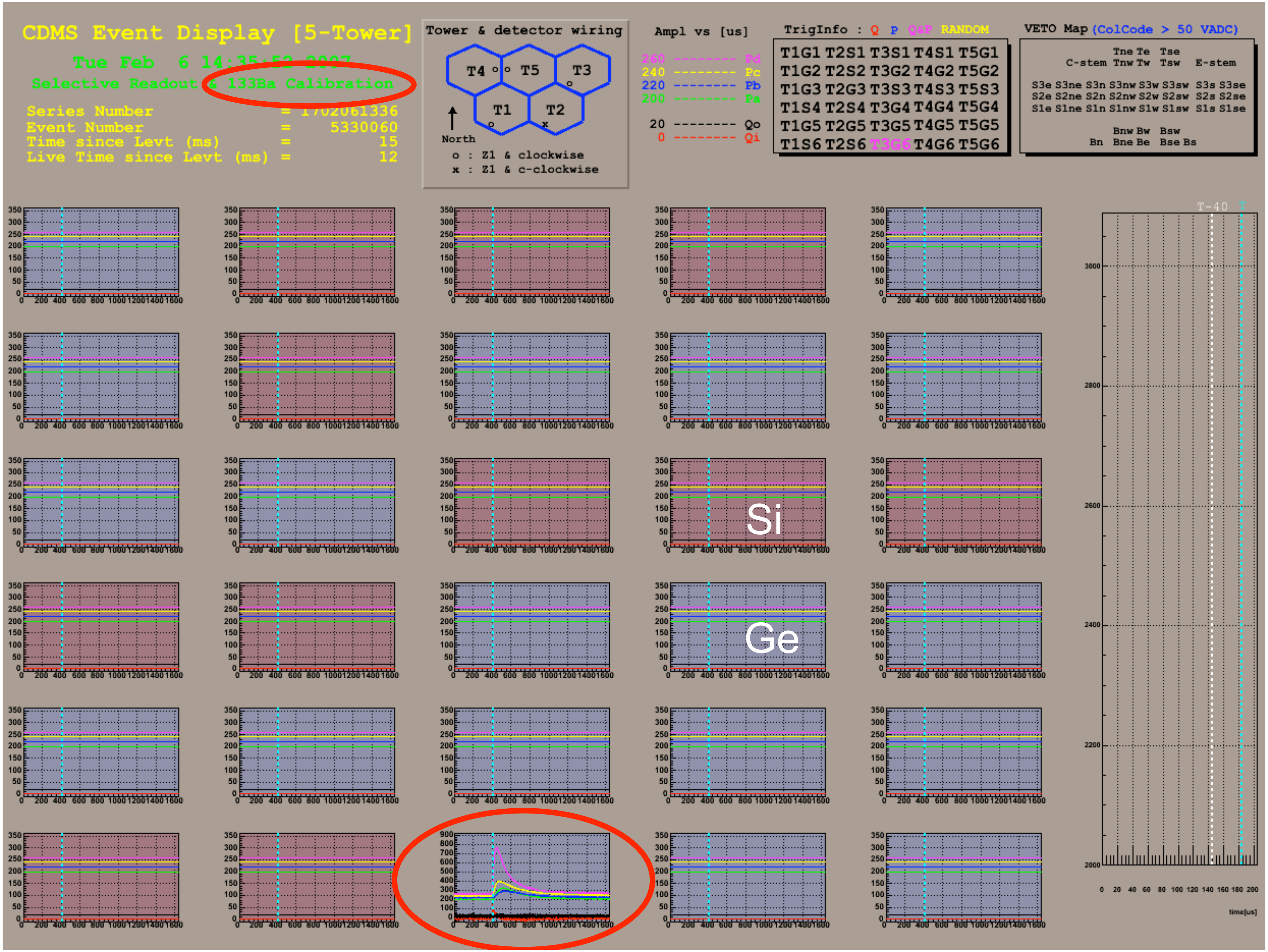


R.W. Ogburn

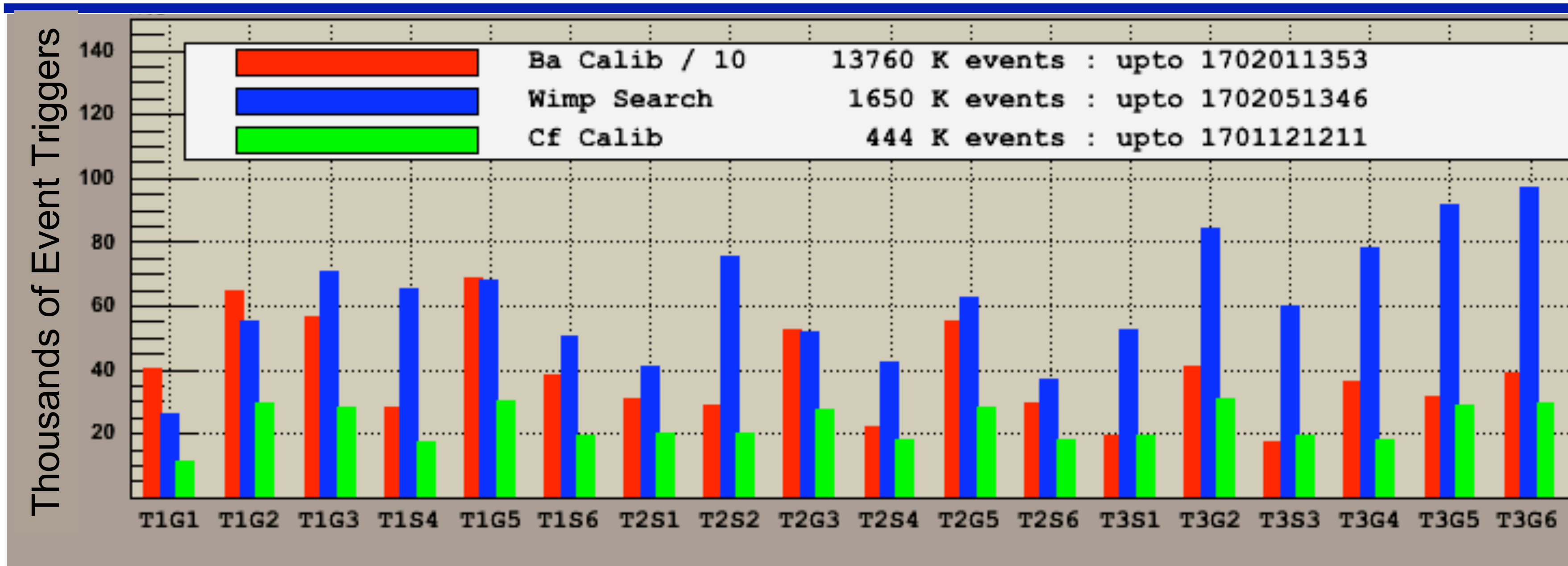
CDMS 5-Tower Run



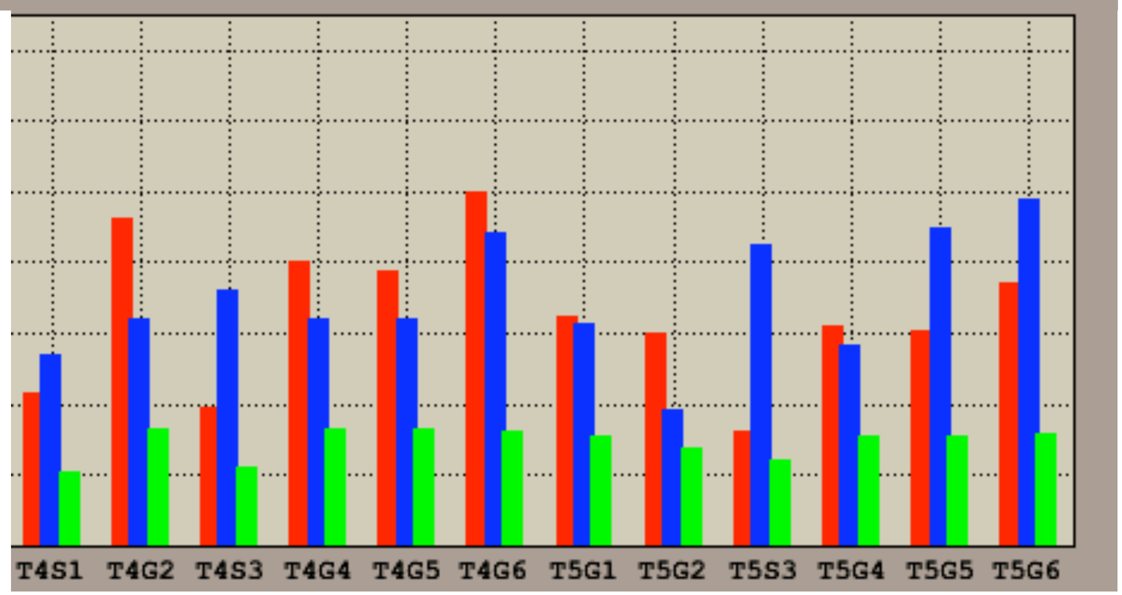
- 30 detectors in 5 towers of 6
  - 4.75 kg of Ge, 1.1 kg of Si to run through 2007
  - New towers should have lower radon exposure


CDMS Event Display [5-Tower]
Selective Readout & 133Ba Calibration
Series Number = 1702061336
Event Number = 5330060
Time since Levt (ms) = 15
Live Time since Levt (ms) = 12
Tower & detector wiring
T4 T5 T3 T1 T2
North
o : Z1 & clockwise
x : Z1 & c-clockwise
Ampl vs [us]
260 Pd
240 Pc
220 Pb
200 Pa
20 Qo
0 Qi
TrigInfo : Q P Q&P RANDOM
T1G1 T2S1 T3S1 T4S1 T5G1
T1G2 T2S2 T3G2 T4G2 T5G2
T1G3 T2G3 T3S3 T4S3 T5S3
T1S4 T2S4 T3G4 T4G4 T5G4
T1G5 T2G5 T3G5 T4G5 T5G5
T1S6 T2S6 T3G6 T4G6 T5G6
VETO Map (ColCode > 50 VADC)
Si
Ge
T-40
time[us]

CDMS 5-Tower Run



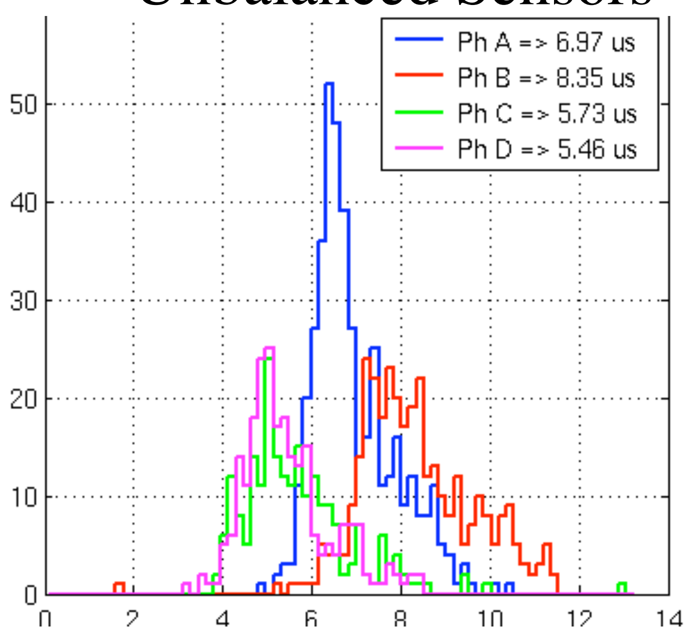
- 30 detectors operating
  - (WIMP-search triggers dominated by noise)
  - Nearly 2x previous calibration data already
  - 2 Ge, 2 Si not WIMP-search detectors



Improvements for CDMS 5-Tower Run

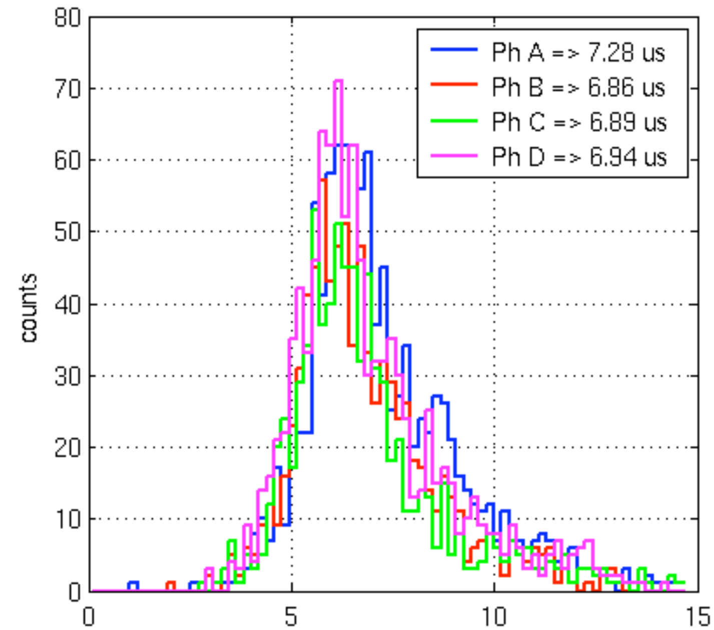
- "Biasing of detectors determines how "fast" each quadrant responds to the recoil signal
  - Critical for rejection based on phonon timing
- Performed much more careful "balancing" of detector bias

Unbalanced Sensors



Phonon delay

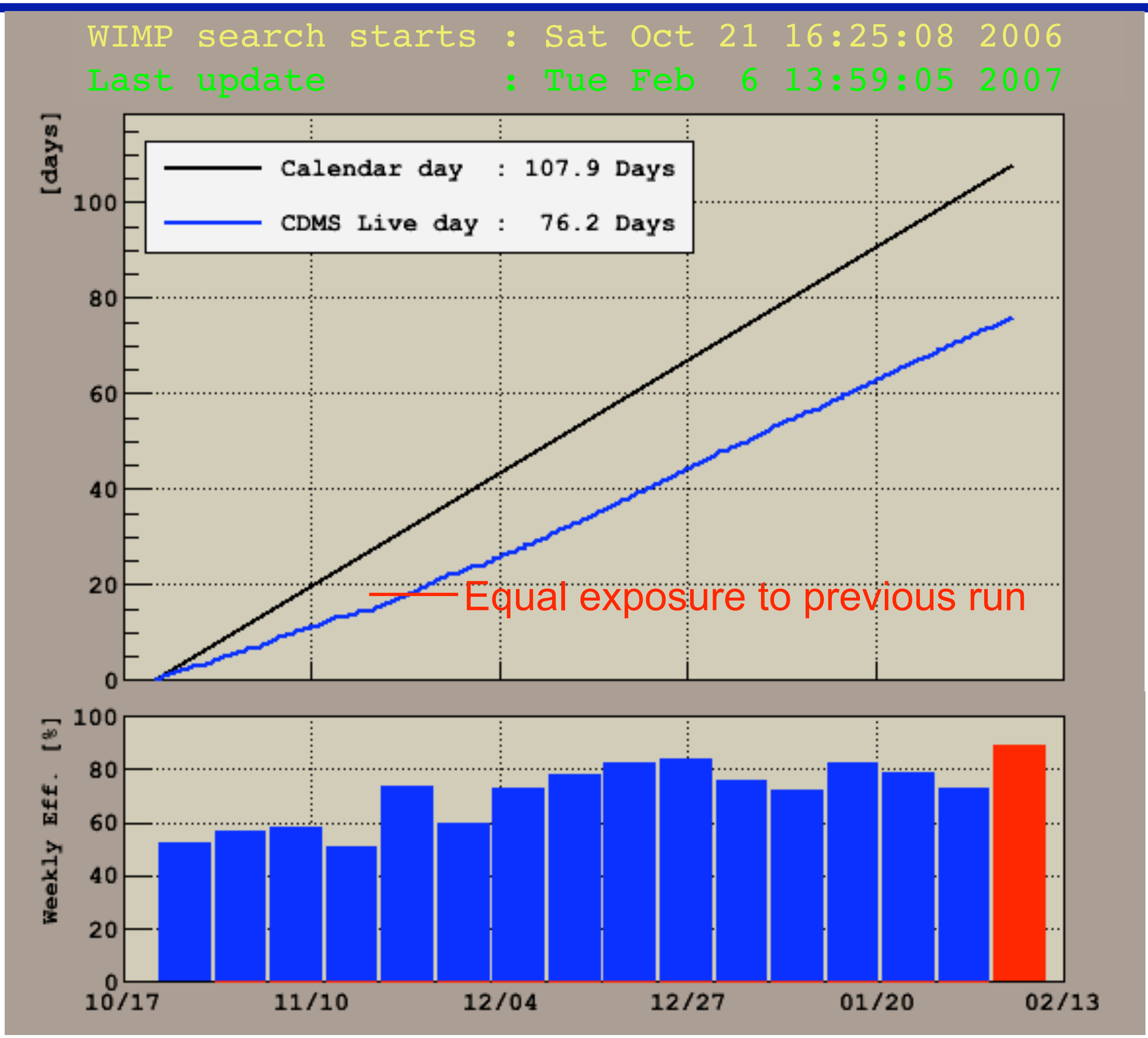
Well balanced detector



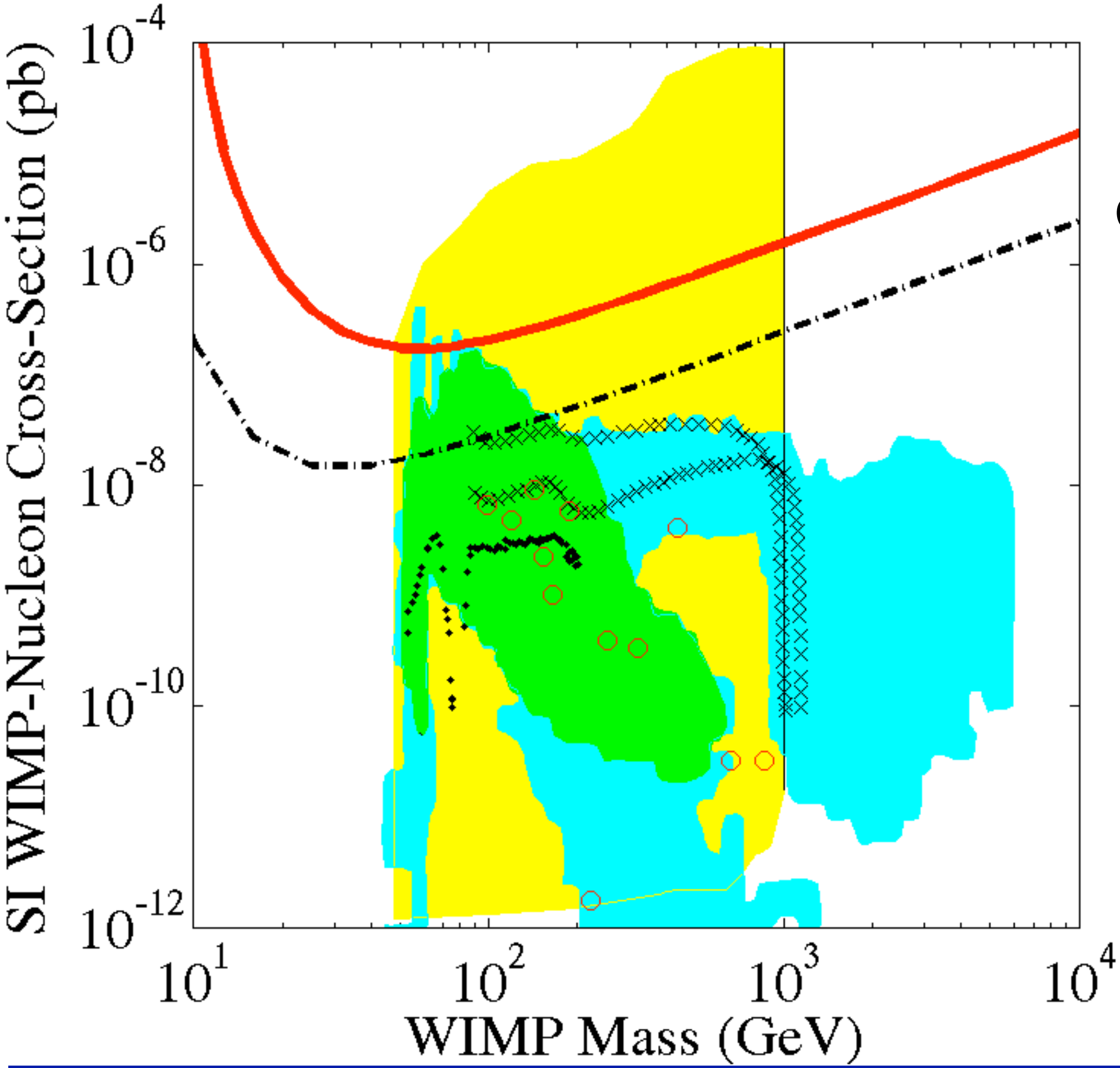
Phonon delay

A. Reisetter

CDMS 5-Tower Run LiveTime



CDMS 5-Tower Reach



Current CDMS II limit
PRL 96, 011302 (2006)

CDMS II goal (end 2007)

Kim et al. 2002 in yellow (MSSM scan)

Baltz & Gondolo 2004 in cyan (mSUGRA), in green ("" w/WMAP constraints)

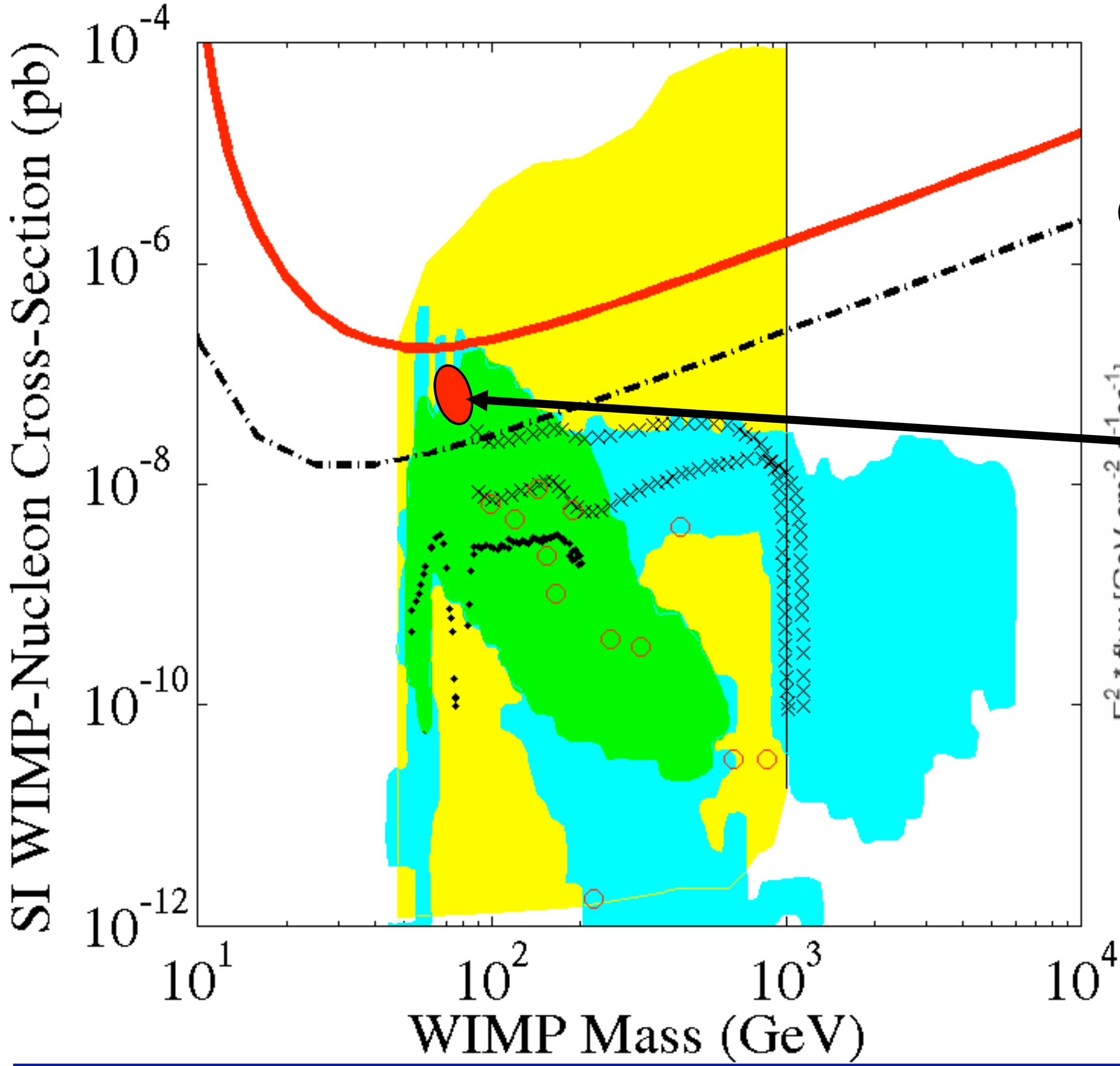
Battaglia et al. 2004 in red o (post-LEP benchmark points)

Guidice & Romanino 2004 x (split SUSY)

Pierce 2004 dots (split SUSY)

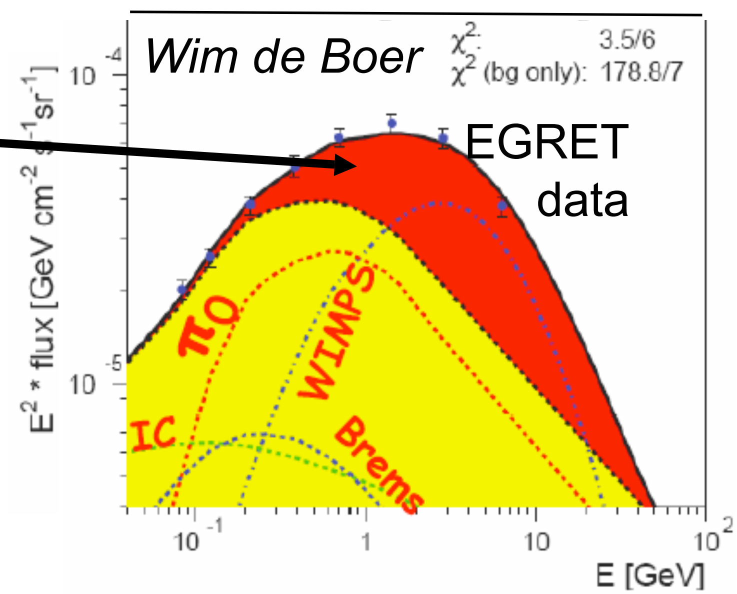
- Many model frameworks 10^{-8} - 10^{-10} pb

CDMS 5-Tower Reach



Current CDMS II limit
PRL 96, 011302 (2006)

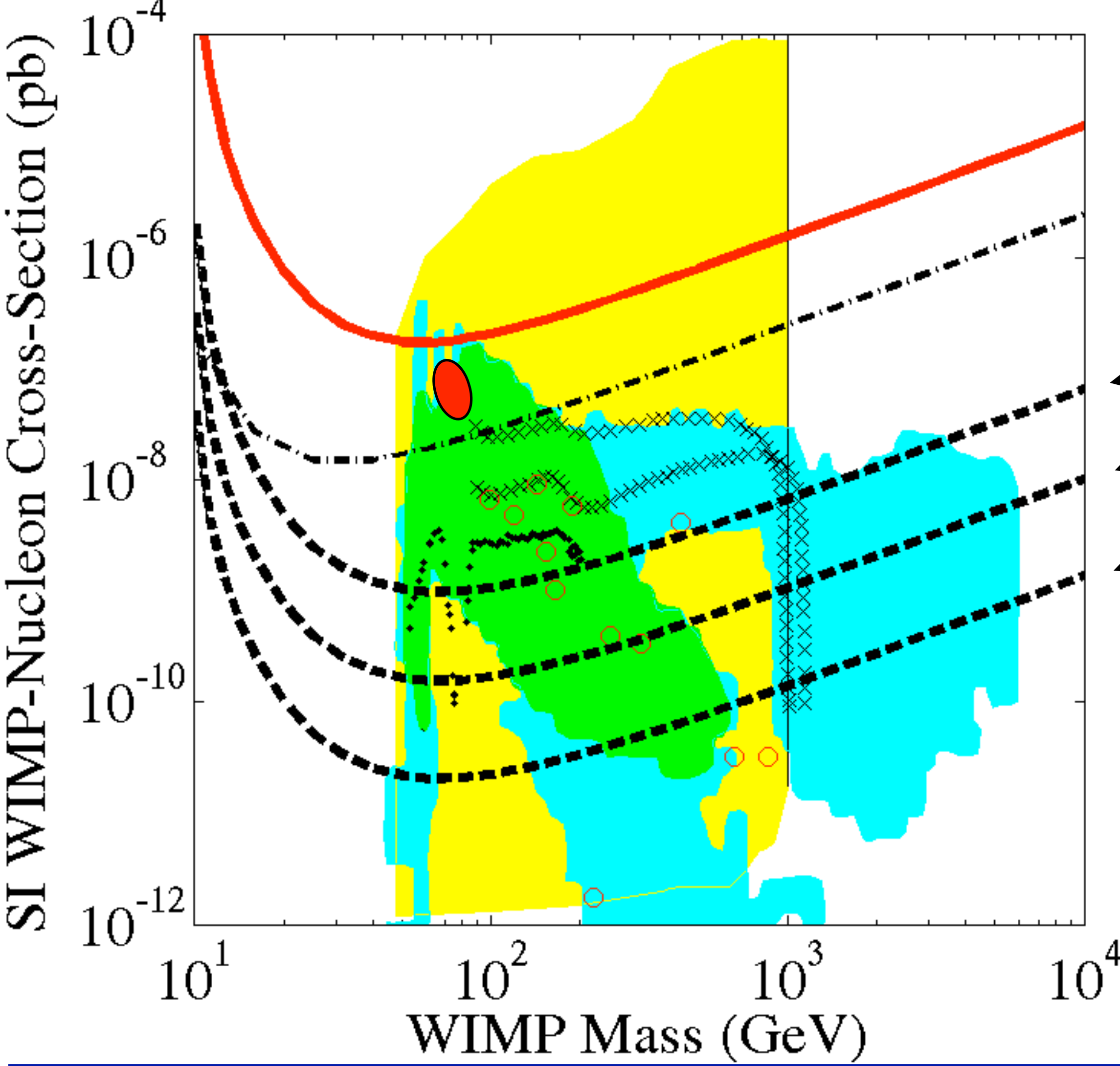
CDMS II goal (end 2007)



- WIMP detection right around the corner, if…

SuperCDMS Reach

Schnee et al, astro-ph/0502435
Brink et al, astro-ph/0503583



Current CDMS II limit
PRL 96, 011302 (2006)

CDMS II goal (end 2007)

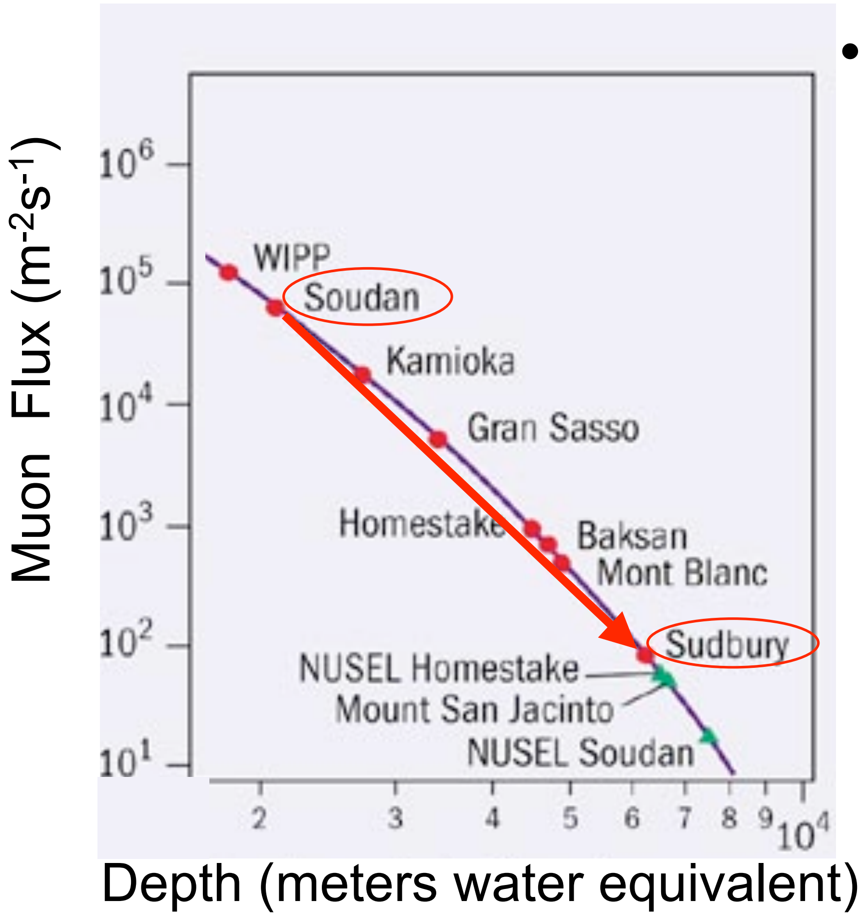
SuperCDMS
25 kg of Ge 2012

150 kg of Ge

1000 kg of Ge

- Maximize discovery potential by being background-free at each phase
- 25-kg phase under review

Remove Muon-induced Neutron Background

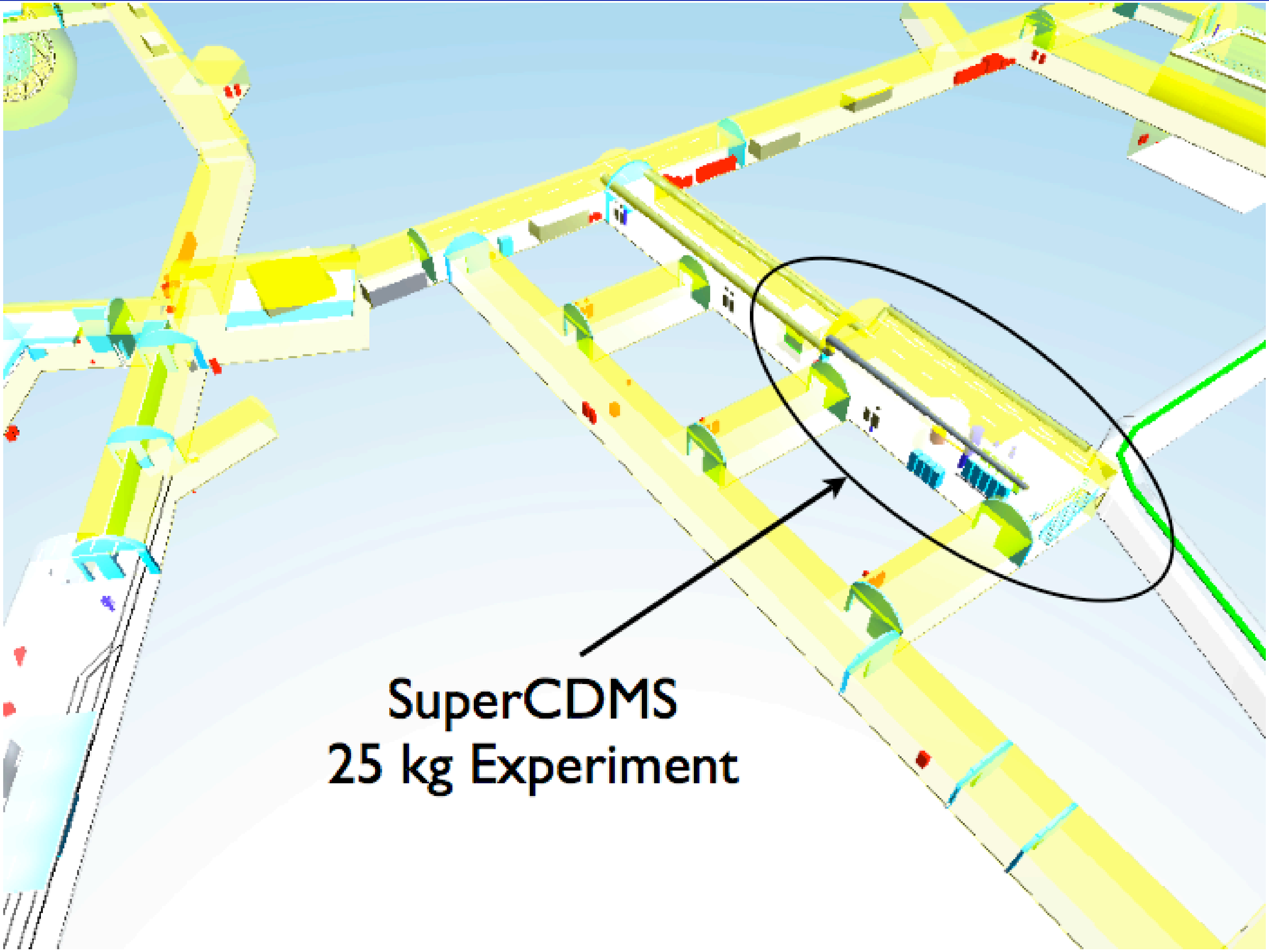


- Move from Soudan, Minn., to SNOLAB, Ontario
  - Reduce muon flux by 500x
  - Reduce high-energy neutron flux by >100x -- problem gone

SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

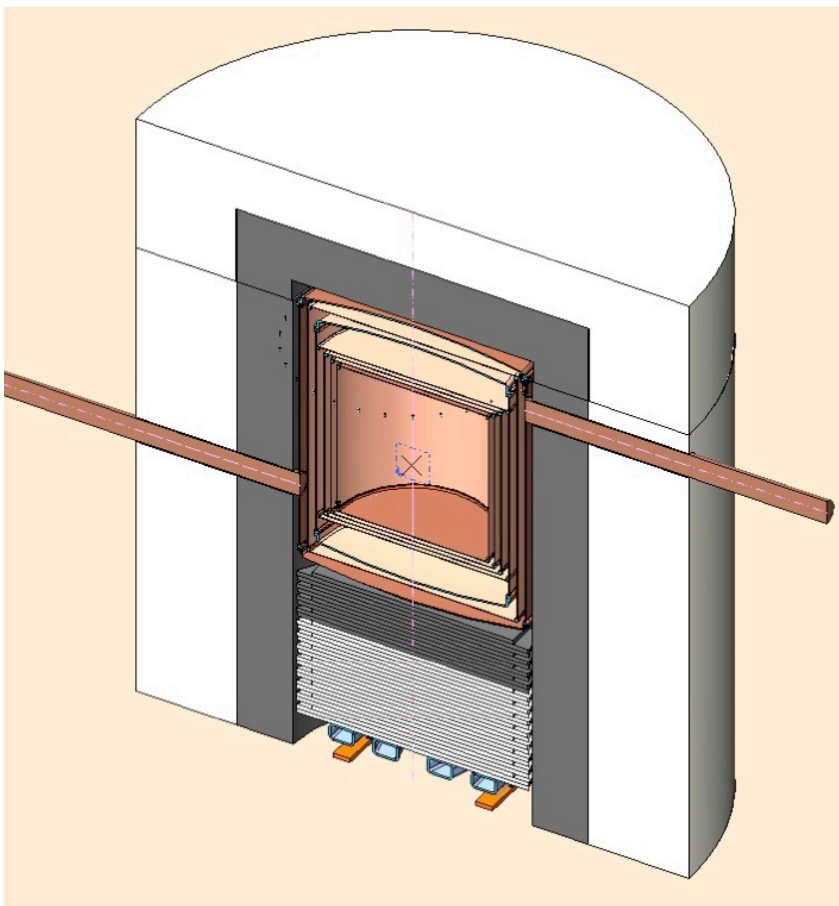
The EAC has reviewed your LOI and endorses it highly as a project appropriate for SNOLAB based upon its exceptional scientific merit, the technical accomplishments achieved to date by the CDMS collaboration, and the well defined program to proceed towards the [SuperCDMS] project.

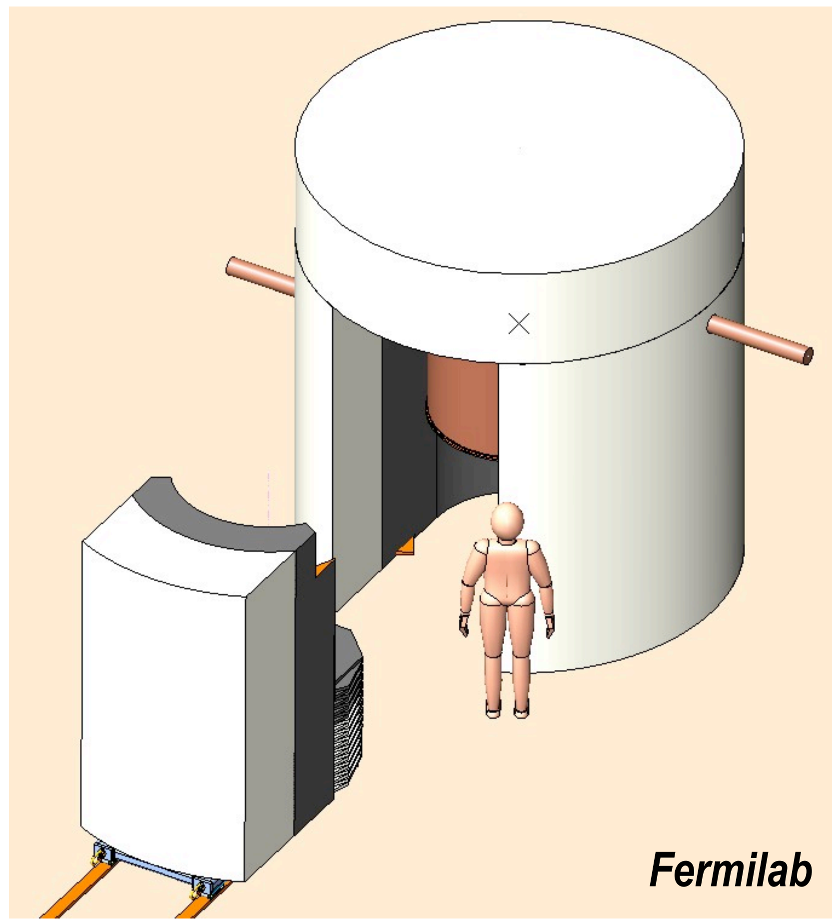
Planned SNOLAB Experimental Space



Cryostat and Shield Design Concepts

- Low head-clearance required by SNOLAB “ladder” space
- Allows for 50% increase in neutron moderator
  - Shield against neutrons from fission and (alpha,n) processes





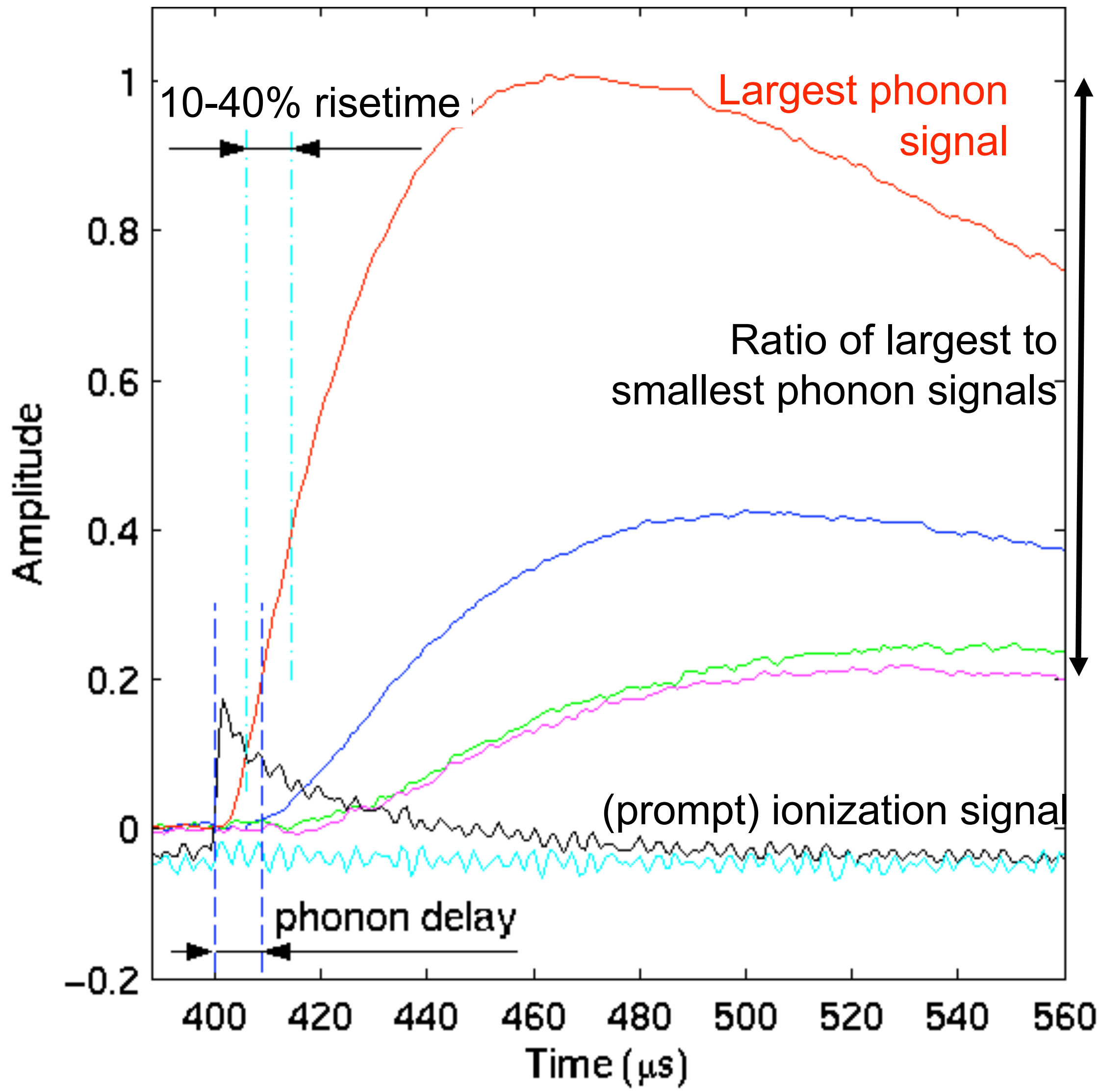
Backgrounds for SuperCDMS 25 kg

	Photons	Electrons
Current raw rate (events/ exposure) [25 kg, 500 days]	10^6	2000
Published rejection	10^6:1	200:1
Rate after rejection	1	10
In hand	0.5	5
Improve detectors 5x	0.1	1
Improve analysis 2x	0.05	0.5
SuperCDMS Goal	0.5	0.5

- Improve rejection
  - in hand: better phonon-timing cuts give ≥350:1 rejection
  - by further analysis improvements
  - via improving detectors
- Improvement by 40x for ton-scale doesn't seem difficult
  - Better analysis
  - Better detectors
  - Lower raw rates via better shielding, cleanliness

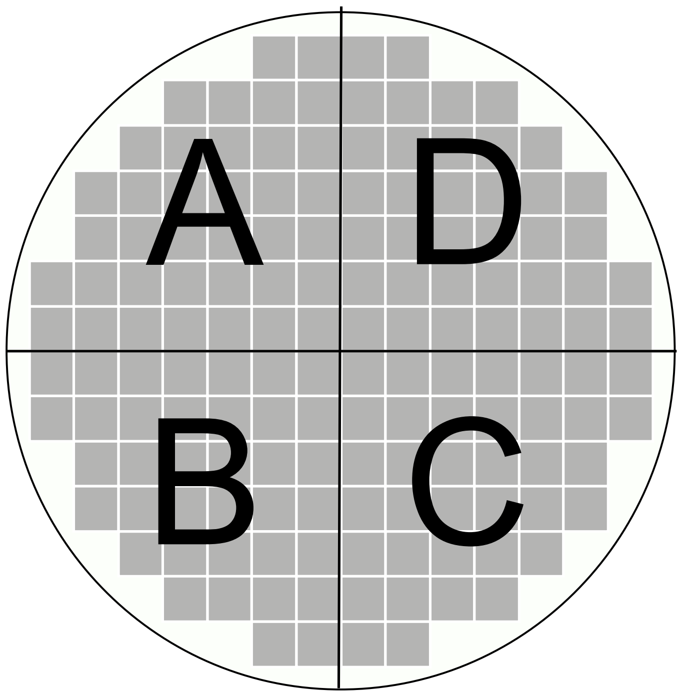
Discrimination of Surface Events

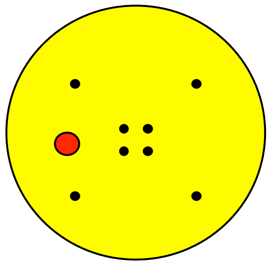
- Combine information on phonon pulse shapes and energy partition between 4 phonon sensors
  - Pulse delay of sensor with largest signal
  - Pulse 10-40% risetime of sensor with largest signal
  - Ratio of energy in sensor with largest signal to energy in sensor with smallest signal
  - Throwing away a large amount of our detectors' information

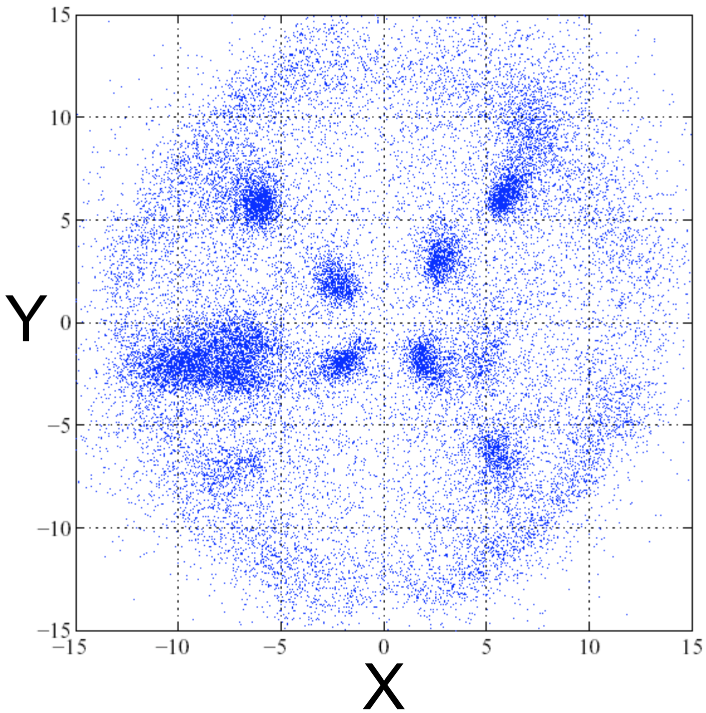


Towards Full Event Reconstruction

- Current XY position imaging is very crude
  - Delay between phonons reaching channel A vs. D
  - Accurate in limit that sensors are points at detector edge
  - Leads to non-linearities and “fold-over” -- events near edge are reconstructed as appearing away from edge







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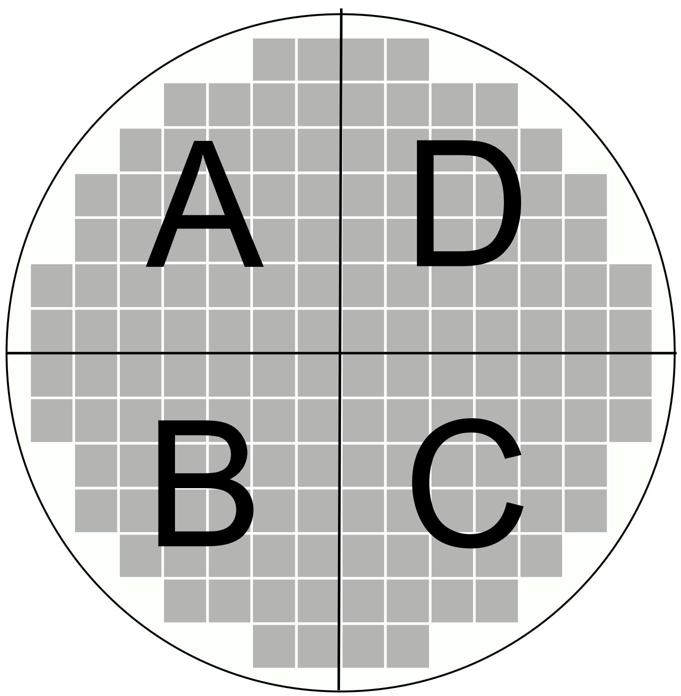
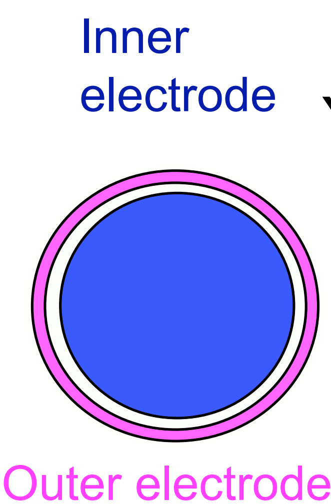
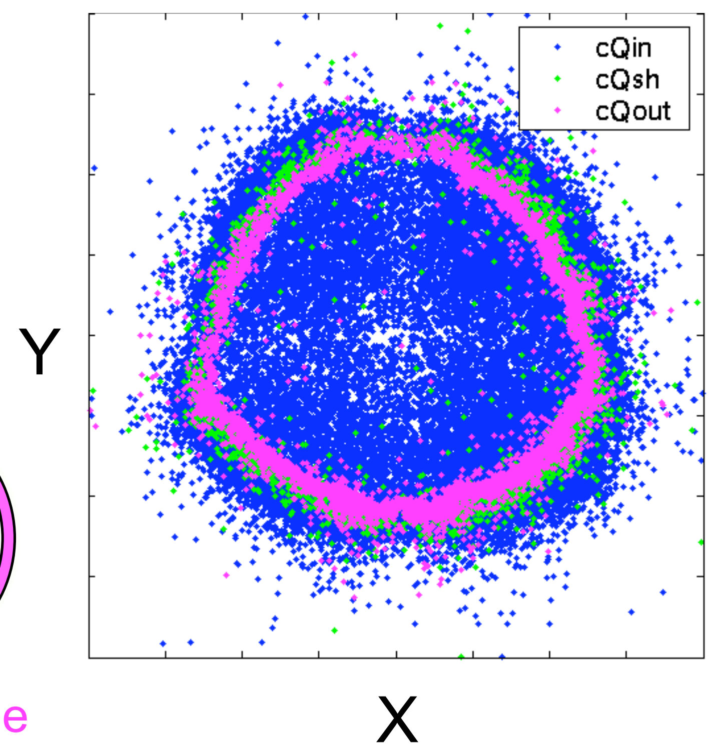
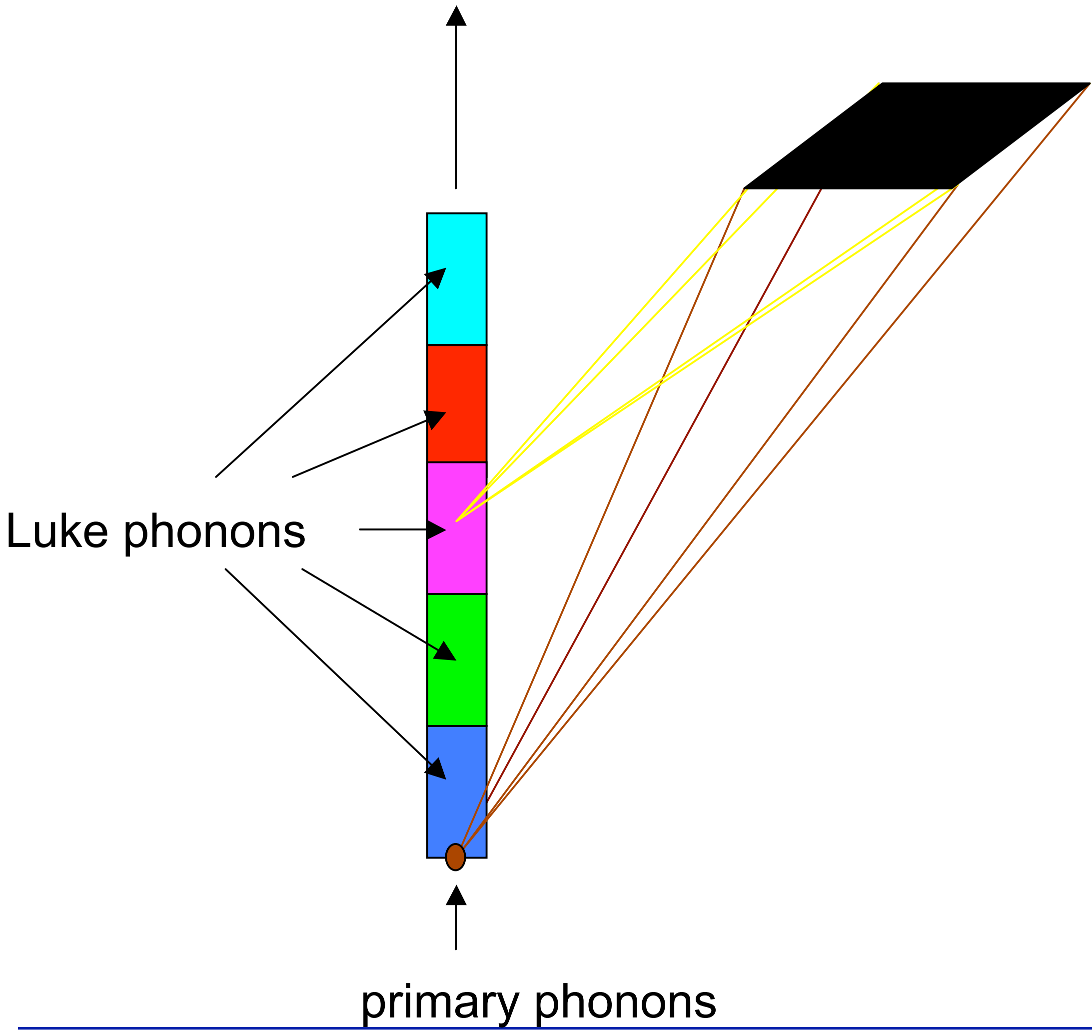






(Very) Simple Model of Phonon Transport

- Treating sensors as extended objects, even with simplified phonon propagation model, helps a lot.



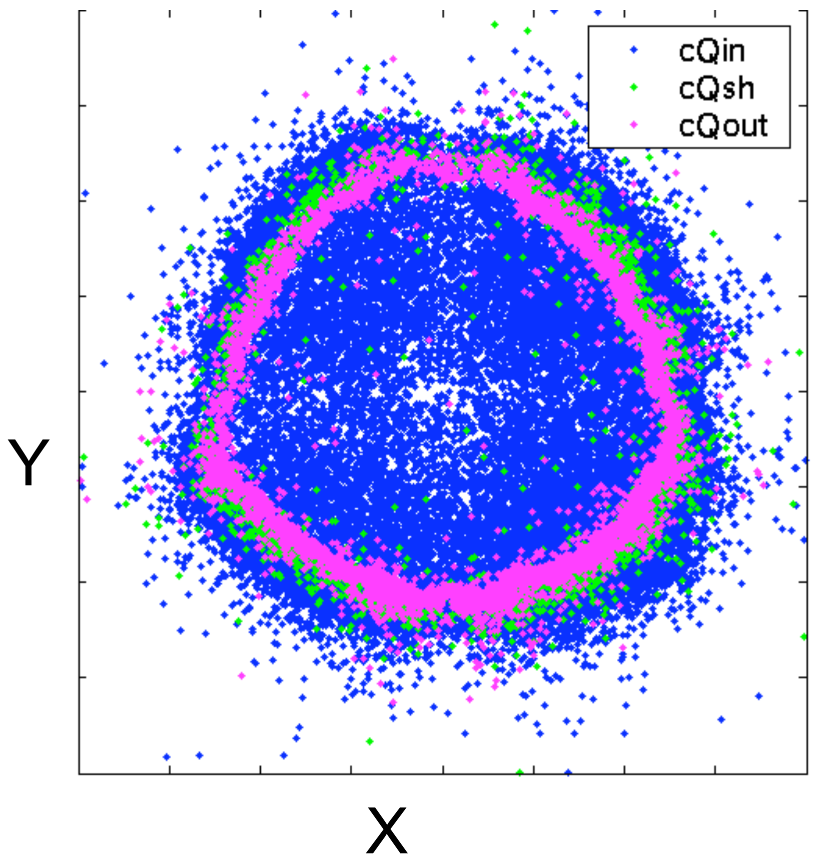
Ignore reflections. Average the times of first phonons to all sensors in quadrant.

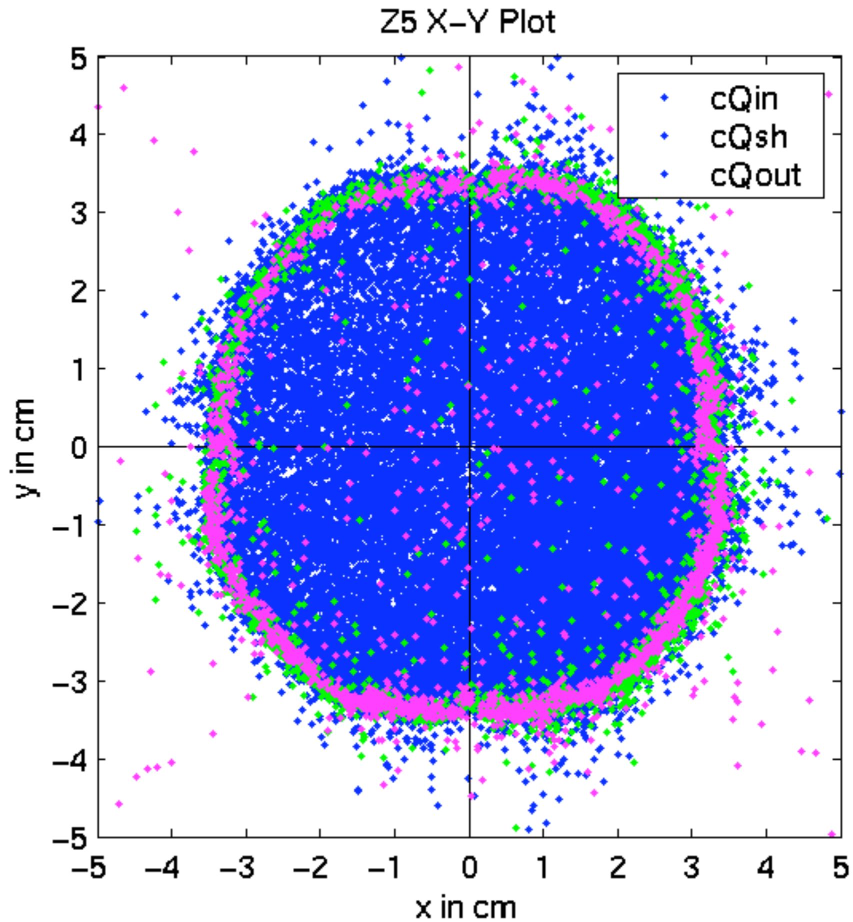
Include primary phonons, Luke phonons and energy released from recombination (after charge drift).

G. Wang, Case

Position Reconstruction Analysis

- Use simplified phonon propagation model to resolve degeneracy in time-delay reconstruction

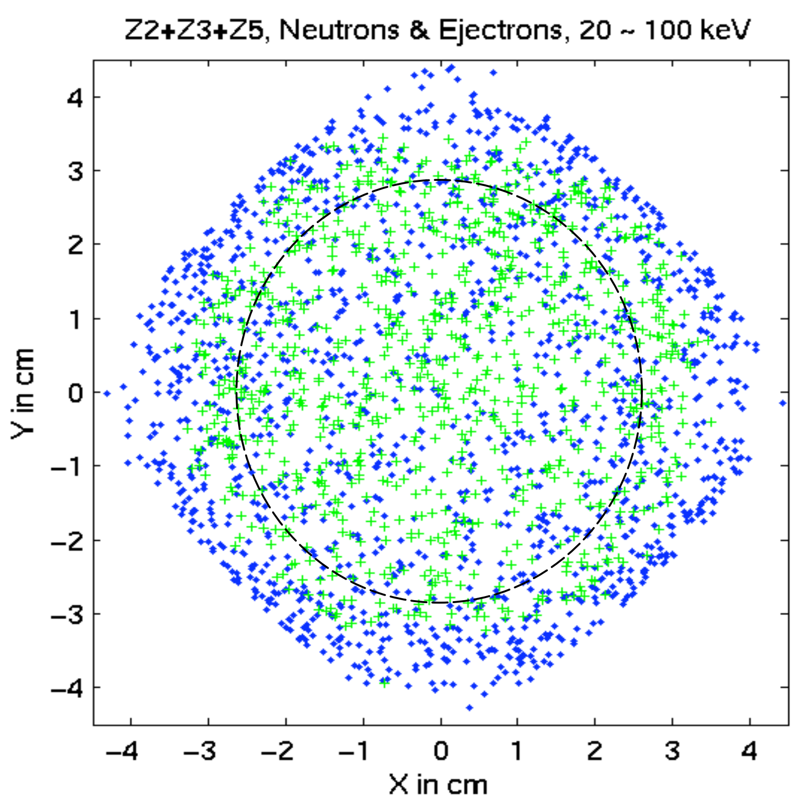


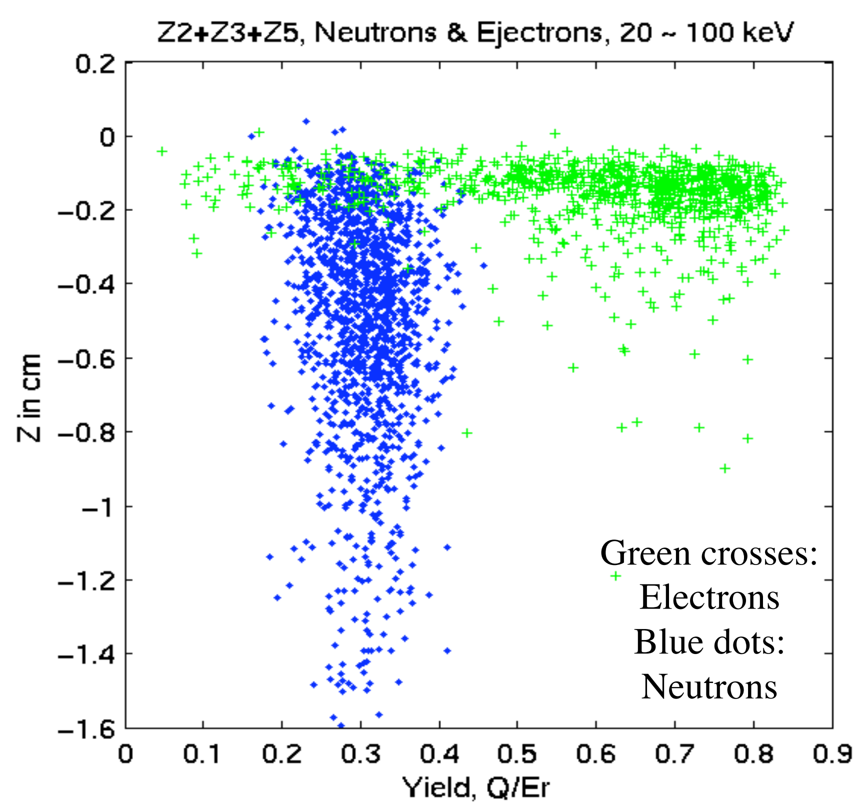


G. Wang, Case

Benefit from Position Reconstruction

- Discriminate nuclear recoils (Blue dots) from surface electron-recoils (green crosses) due to different phonon characteristics

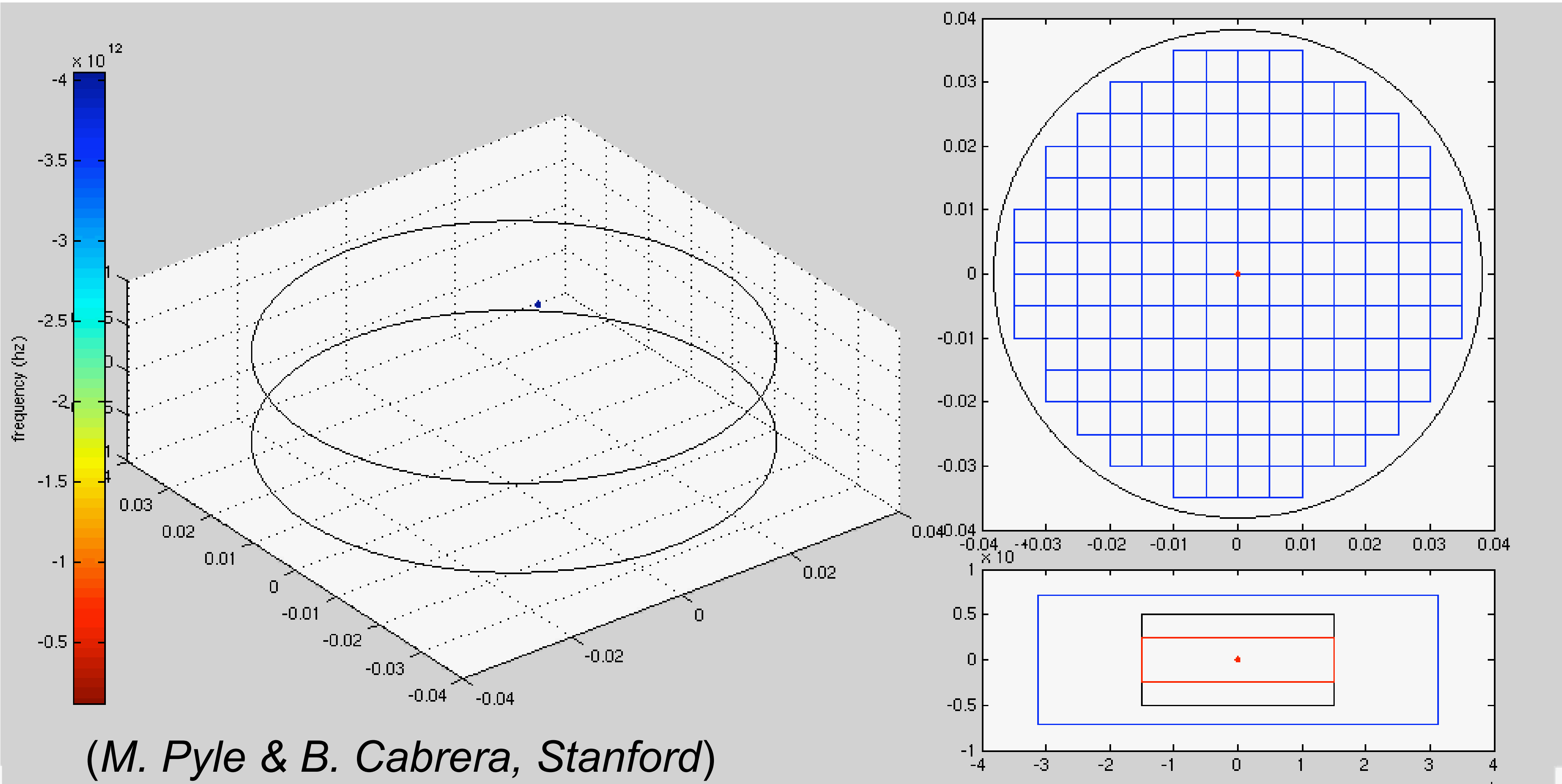




G. Wang, Case

Detector MC progress

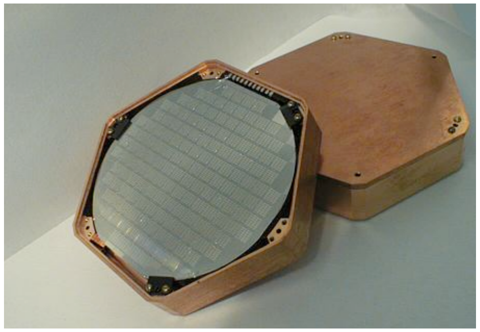
- Use detector MC to improve our understanding of the origin of timing and partition response, allow better reconstruction
- Work is just getting started



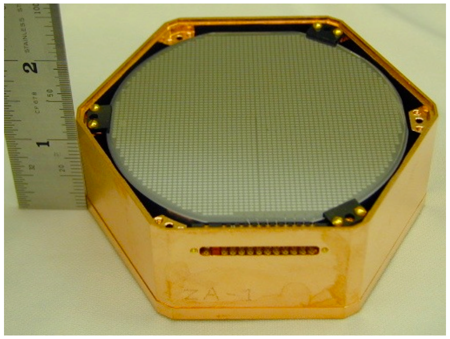
(*M. Pyle & B. Cabrera, Stanford*)

Baseline Detector Improvements for 25 kg

- Increase thickness from 1 cm to 1 inch
  - Less surface area per mass, so 2.54x fewer background surface events per mass
  - Eases production -- make fewer detectors for a given mass

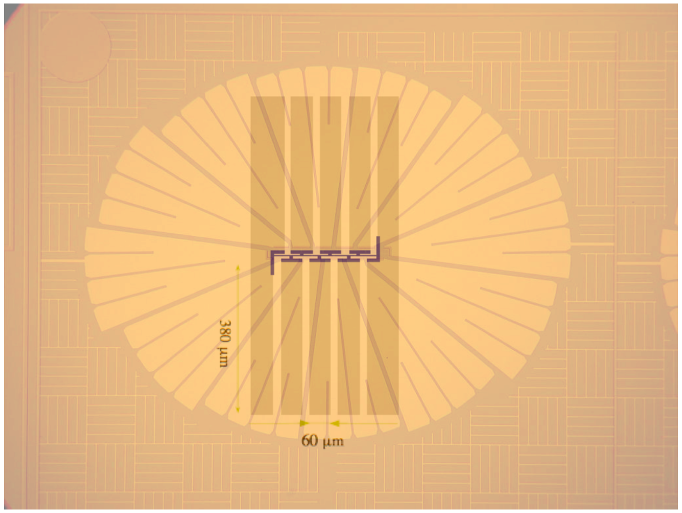


CDMS II ZIPs:
3” diameter x 1 cm
0.25 kg Ge



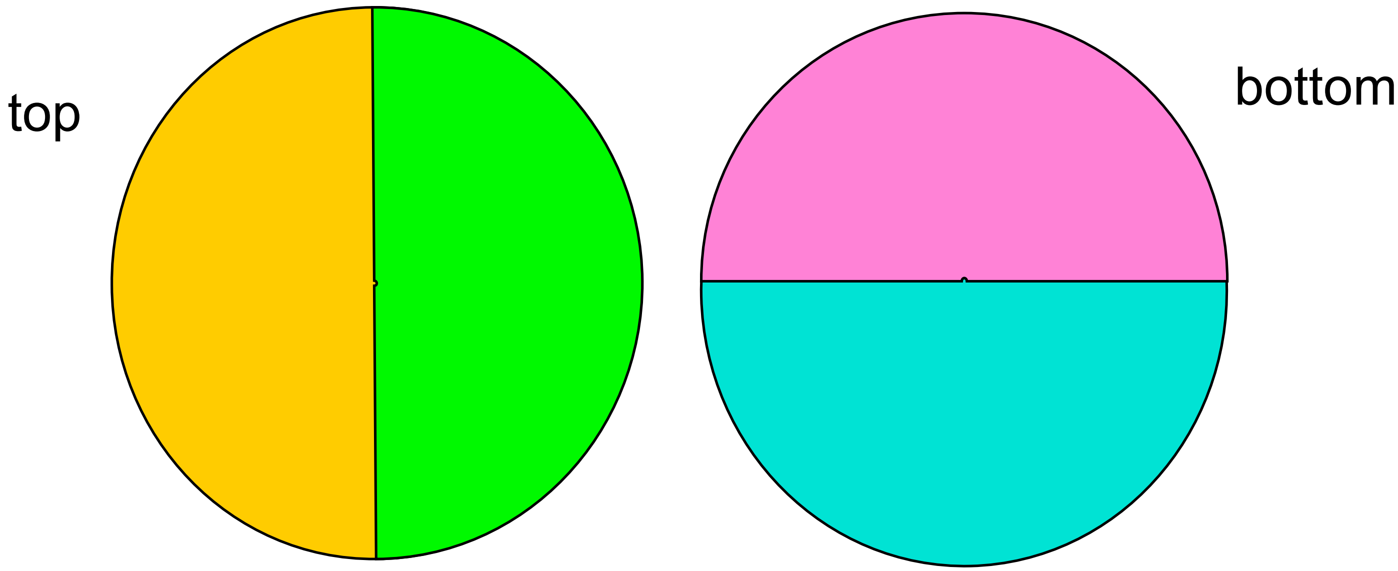
SuperCDMS ZIPs:
3” diameter x 1”
0.64 kg Ge

- Optimize amorphous-Si electrodes
  - Yield-only discrimination of ZIPs is 2x worse than older detectors made with different recipe. Return to old recipe (17:83 H_2:Ar atmosphere) and optimize.
- Increasing Al coverage to increase energy collection > 2x, improve timing discrimination



Detector Development Program

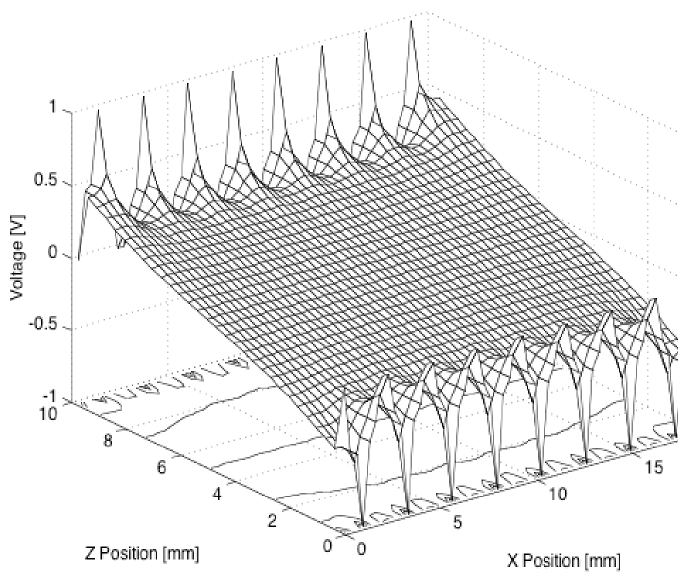
- Developing double-sided phonon sensors

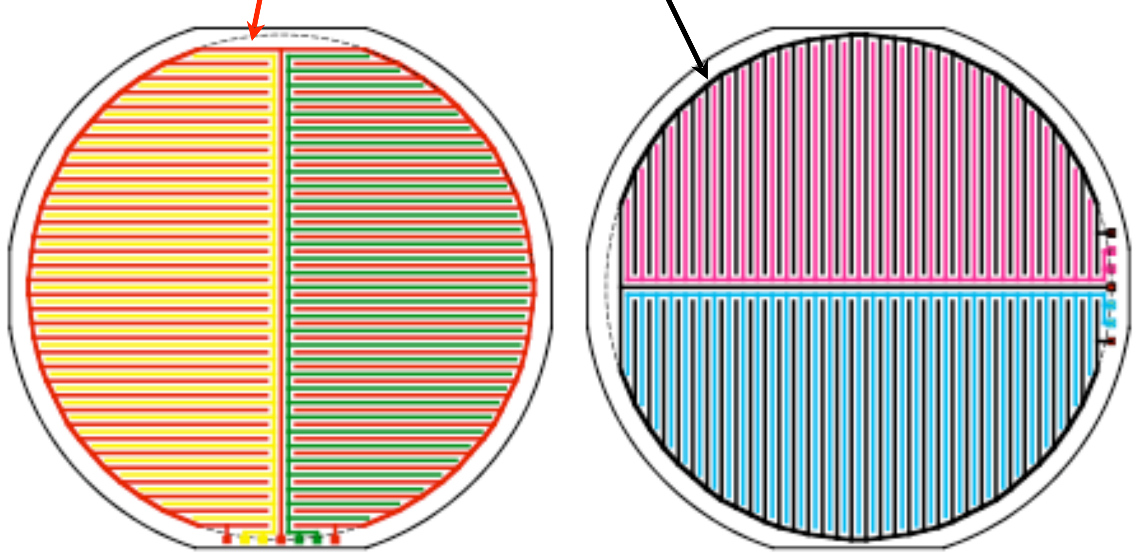


  - Improve event position reconstruction, particularly Z
    - Better timing because fewer reflections before detection
    - Z by timing few μsec top vs. bottom
    - More information for detailed reconstruction
  - Increase phonon signal to noise (twice the sensor area)
- Testing interdigitated ionization electrodes

Interdigitated Ionization Electrodes

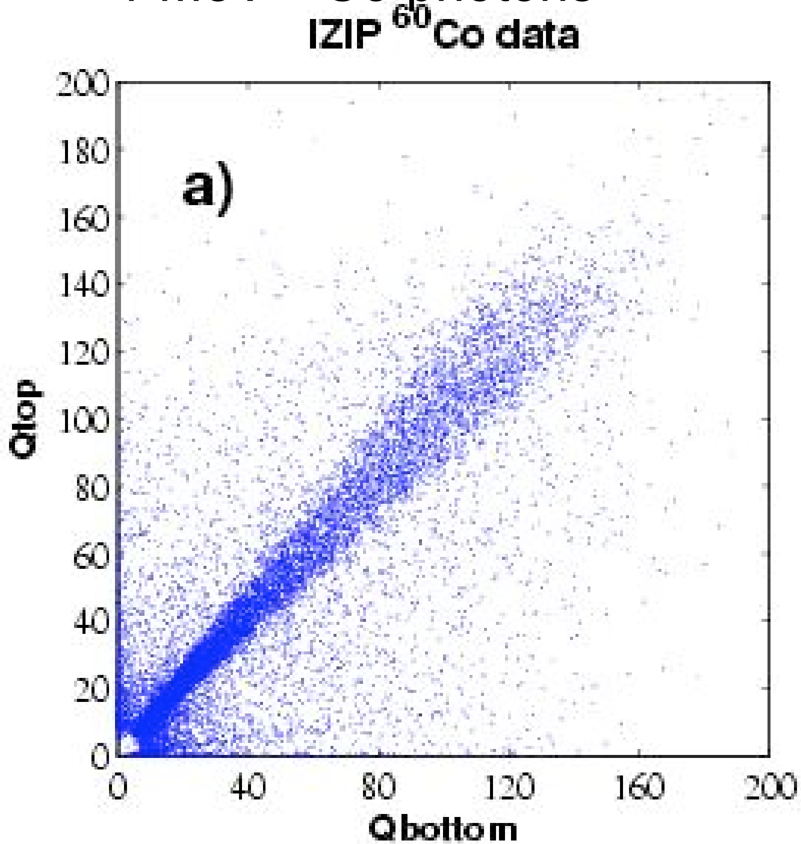
- Alternative method to identify near-surface events (P. Luke)
  - Phonon sensors on both sides are virtual ground reference.
  - Bias rails at +3 V connected to one charge amplifier
  - Bias rails at -3 V connected to other charge amplifier
  - Signals coincident in both charge amplifiers correspond to events drifted out of the bulk.
  - Events in only one charge amplifier are < 1.0 mm of the surface.



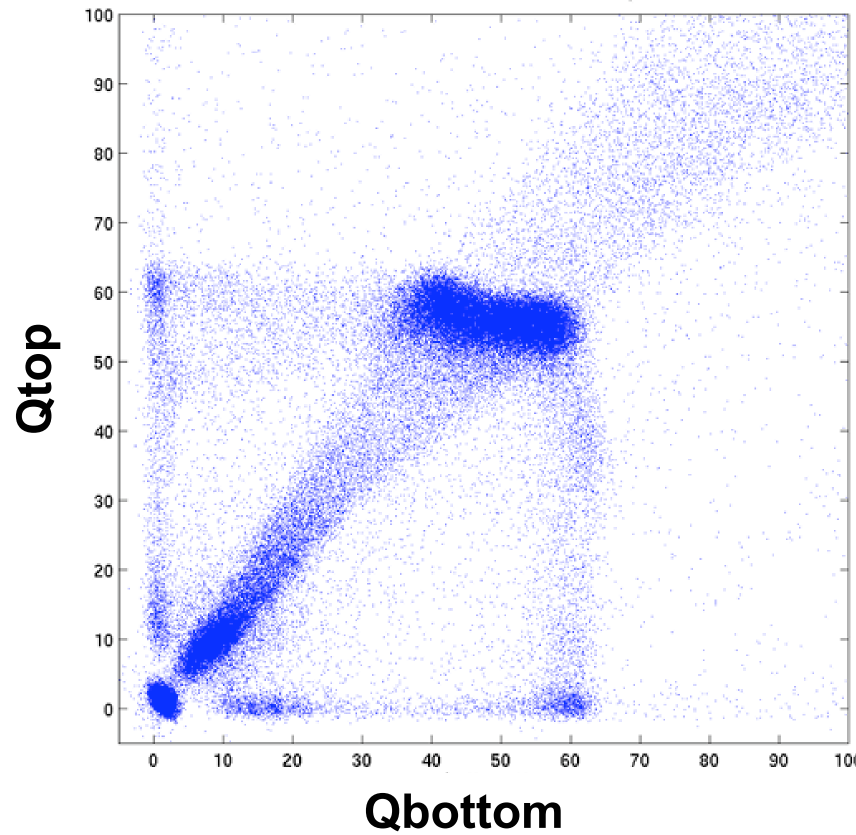


Interdigitated Ionization Electrodes

Bulk Compton scatters from ~1 MeV ^{60}Co photons



Bulk and surface interactions from 14-, 18-, 60-keV ^{241}Am photons

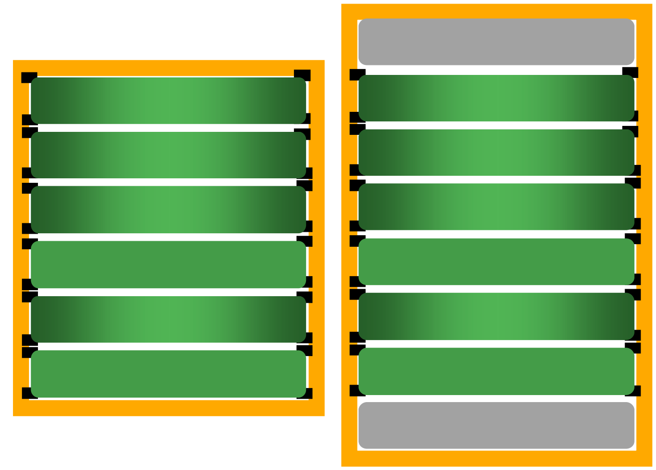


So far, so good. Still need to test fully working detector with neutron and electron sources

C. Bailey

Reduction of Backgrounds

- Reduce photon, beta backgrounds via improved shielding
  - Active (inexpensive) ionization "endcap" detectors to shield betas, identify multiple-scatters
  - Add inner Pb shielding (like we had at shallow Stanford site)



- Reduce beta contamination via active screening/cleaning
  - Observed alpha rate indicates dominated by ^{210}Pb on detectors
    - Improved radon mitigation already in place for towers 3-5 -- preliminary indication is backgrounds successfully reduced
  - Materials surface analysis (PIXE/RBS/SIMS/Auger) (in progress)
    - Limits detector ^{14}C, ^{40}K beta contamination to ~10% of total
  - Developing low-background drift chamber as dedicated alpha/beta screener (I am leading prototype in progress)
    - Necessary for 17 beta emitters that have no screenable gammas/alphas

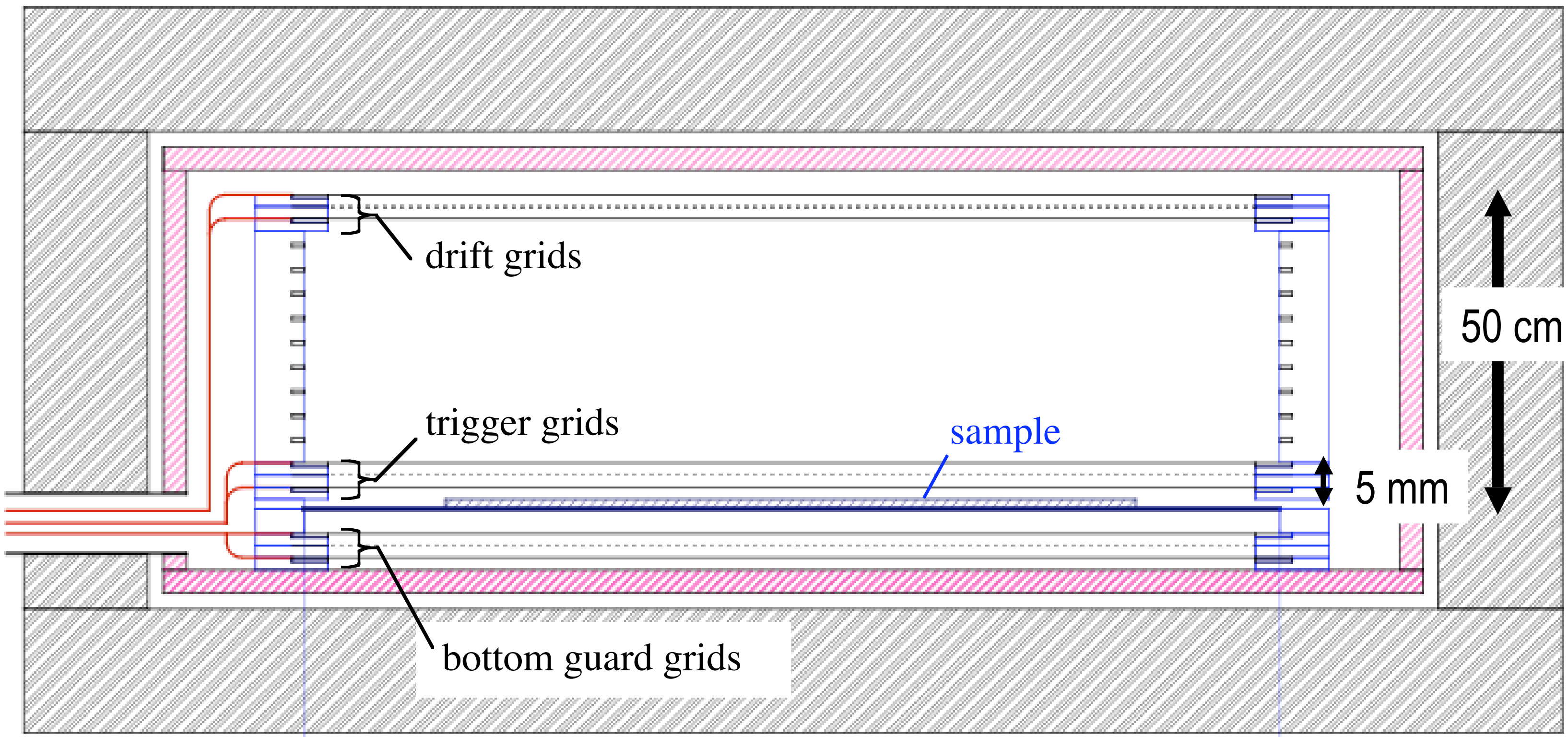
Basic Design Principles

- Backgrounds are proportional to mass of detector
  - Ultraclean materials to minimize internal contamination
  - Underground, shielded apparatus to minimize external backgrounds
- Deploy minimum material needed to stop βs.
  - Gas is best method to achieve this low mass
  - 150 keV e^- ≈ 30 cm Ne (1 atm)
  - Can identify betas with 300 keV endpoint with 50 cm height
  - Could Use Xe (1 atm) for higher-energy betas (range ~7x less)
    - Not for now (requires vacuum chamber); may try with prototype
- Maximize counting statistics
  - Large surface area (horizontal dimension) ~1 m^2
- Guard region to reject events emitted from outside chamber

RWS, D. Akerib, D. Grant, K. Poinar, T. Shutt (Case), S. Golwala, Z. Ahmed (Caltech)

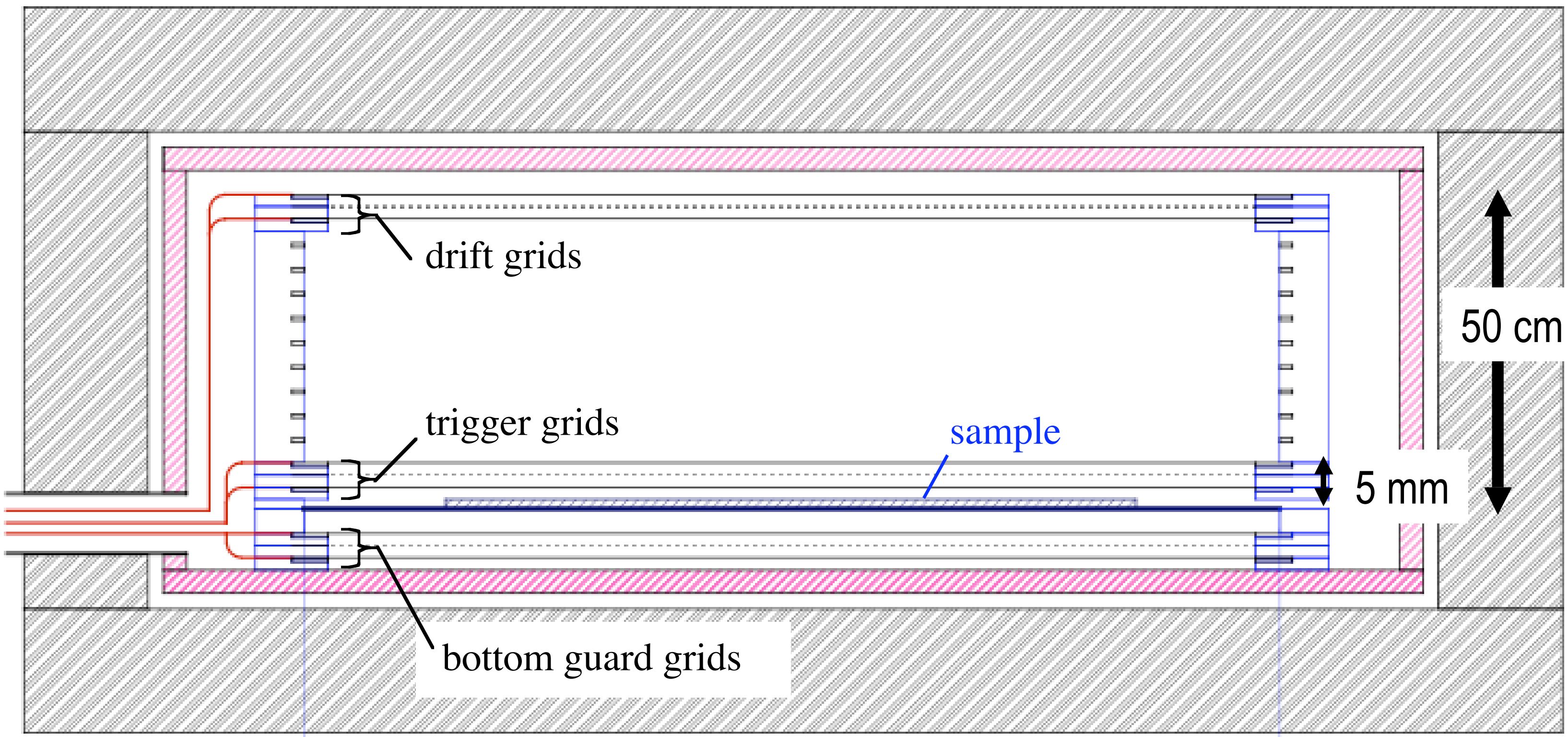
BetaCage

- Multiwire proportional counter
- Wires provide minimum surface area for emissions
  - 25 µm Ø, 1/2 cm spacing - 0.5% coverage
- Crossed grids could yield ~mm xy position information
  - Identify source position of contamination

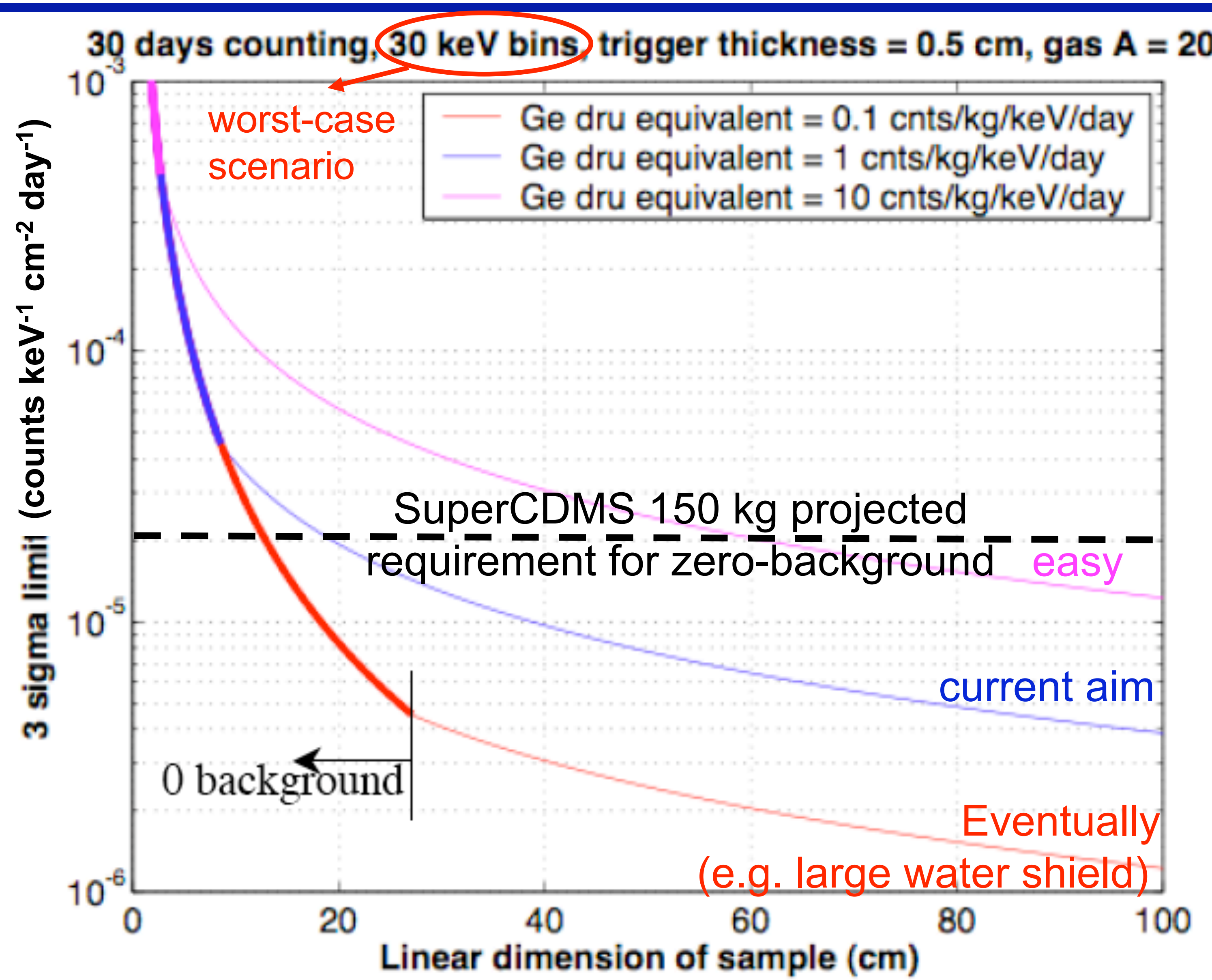


BetaCage

- Reject background interactions in bulk of gas by creating narrow (5 mm) “trigger region” near samples
  - Most gamma interactions in gas don’t cause trigger
  - Reduces backgrounds in gas to 15% of unrejectable total due to gamma interactions in sample that eject electrons into trigger region (these look exactly like beta emission)



Sensitivity (with background subtraction)



Additional Uses

- Would be world's most sensitive screener for all non-penetrating radiation (α's, β's, possibly low-energy photons)
  - More samples and higher efficiency than Ge detectors
  - Improved sensitivity may outweigh diagnostic capability
- Screen for ^{210}Pb via α and β emissions (negligible γ)
  - Important for essentially all rare-event searches
  - Potential applications to Si-chip industry
    - ^{210}Po (Pb daughter) is an α emitter that can cause single-event upset
  - A need exists to screen for ^{210}Pb-^{210}Bi-^{210}Po at a rate of ~0.02 $\alpha/cm^2/day$
- Radioisotope dating with β sources competitive with AMS
  - $^{14}C/^{12}C$ to 10^{-18} , $^{3}H/H$ to 10^{-20} also ^{10}Be, ^{210}Pb, ^{36}Cl
- Detect tracers used in uptake and transport in biology studies

How Do We Build a Ton?

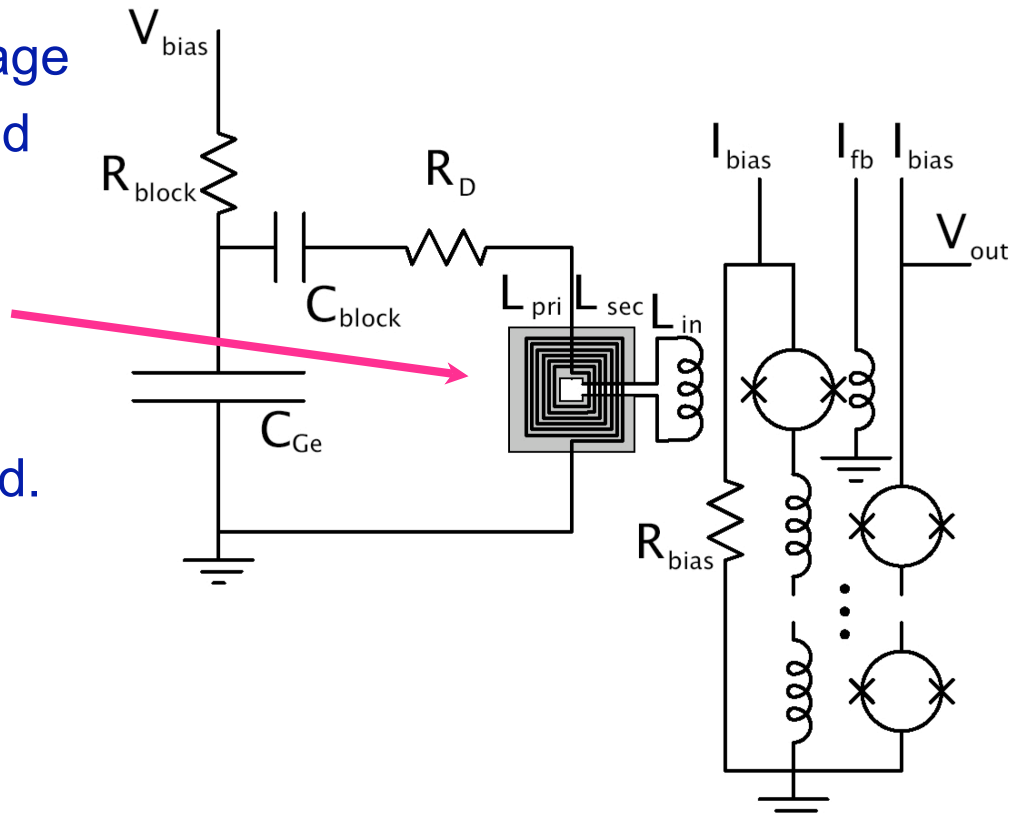
- Streamline detector fabrication
  - Implement improvements to increase fabrication yield, decrease (eventually remove) need for testing and surgery
    - Whole-field mask for first-layer exposures, change wet-etch recipe
    - Increase width of TESs (possible with changed readout)
    - Change from W to Al(Mn) TESs (needs to be demonstrated)
  - Outsource to industry before 125 kg $\Rightarrow$ 1000 kg step
- Switch to “smarter” readout to allow simplified infrastructure
  - Use two-stage SQUIDs (proven technology) for reading out new phonon sensors and ionization sensors
- Reduce mounting material
  - Current towers (to prevent microphonics) probably not necessary (particularly once we switch from FET to SQUIDs for readout of ionization channel)
  - Allows more mass
  - Reduces sources of backgrounds

New Phonon Read-out Schemes

- Two-stage SQUIDs for reading out new phonon sensors allow detector improvements
  - Allows lower R_n, more TESs, better phonon sensor surface area coverage.
    - Will improve effectiveness of present phonon timing cuts even further.
- Two-stage SQUIDs also helps in construction
  - Allows move to Al-Mn TESs to overcome W Tc variability
    - Resitivity of Al-Mn < W, hence risk /design constraint of electro-thermal oscillation if change-over to two-stage SQUIDs not implemented.
  - Commensurate with NIST-style time-domain multiplexing.
    - ZIP detector phonon pulses are probably sufficiently slow to utilize this scheme effectively to reduce the readout wiring to room temperature that would otherwise be required.

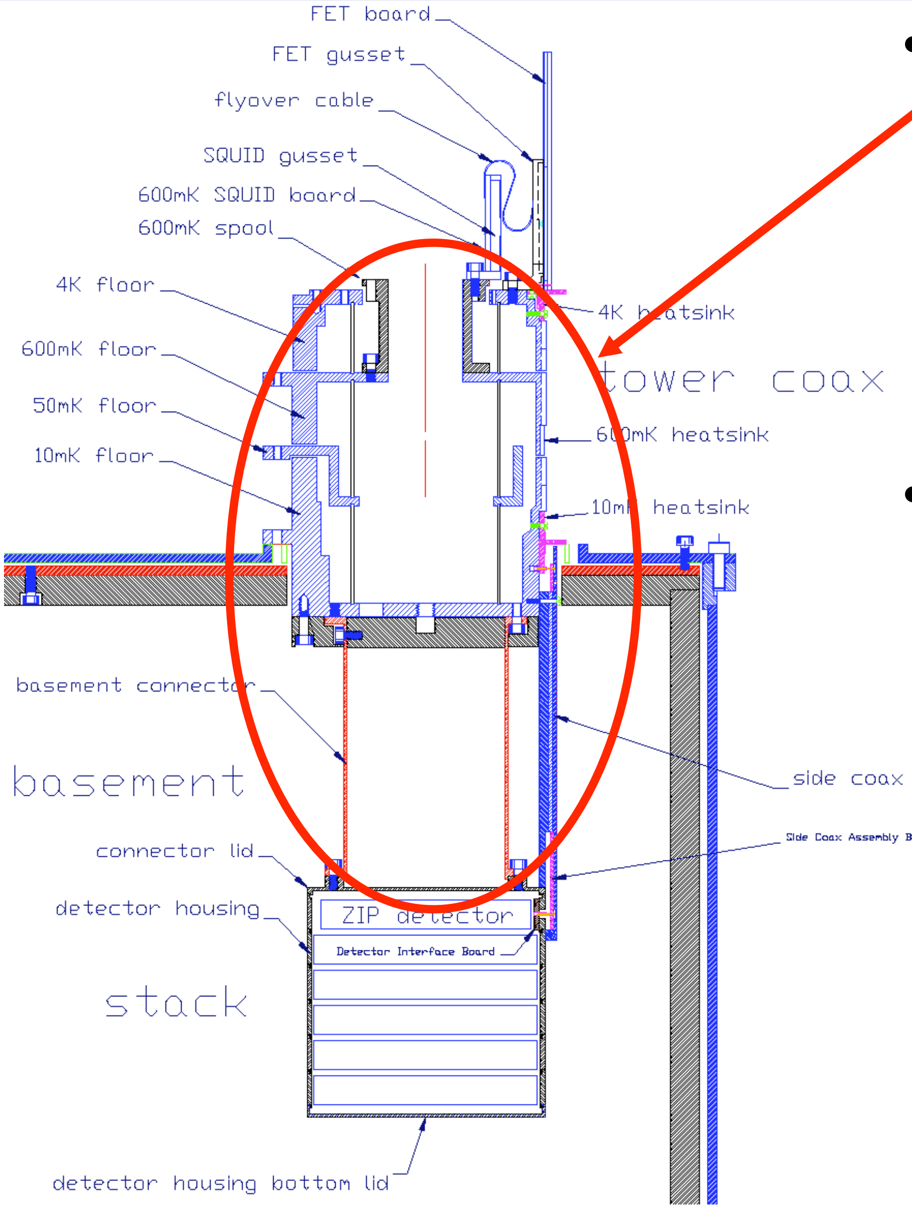
Ionization Read-out with SQUIDs

- Ionization detector transformer-coupled to first stage of two-stage SQUID configuration
  - Eliminate potential microphonics associated with FET readout
  - Eliminate IR photon leakage
  - Eliminate heated FET load on 4 K
  - NIST transformer chip, ~12 mm x 6 mm
  - Critically damped circuit, ~1 MHz sampling required.
  - Simulations predict 0.4 keVee FWHM



K. Irwin, NIST

Simplify Cold Hardware Wiring Package



- Remove rigid (heavy) copper tower and graphite thermal stand-off
  - Microphonics no longer a worry
  - Smaller footprint and heatload
- Don't send SQUID input signals via 4 K connector
  - Left with higher-density, flexible wire bundles
    - Easier to mass produce

Conclusions

- CDMS is the best WIMP-search experiment in the world
- SuperCDMS 25-kg is essentially ready to be built
  - Factor 10 improvement beyond CDMS for relatively small cost
- CDMS technology is the most sure way to achieve sensitivity to study WIMP physics down to SI $\sigma \sim 10^{-46}$ cm^2
  - 10 events/year in 1 ton of Ge for $\sigma \sim 10^{-46}$ cm^2
  - Zero-background goal, characterizable background maximizes discovery potential
- I intend to focus on some of the most critical aspects
  - Reduction of dominant beta backgrounds
  - Improvement of surface-event discrimination via improved analysis/MC
  - Development of improved readout to allow construction of ton-scale experiment
- Both beta screening and cold electronics readout should be useful for experiments other than SuperCDMS too