CDMS Search for Dark Matter Results

Dark Matter Silver Jubilee

June 19, 2012

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and
SLAC National Accelerator Center

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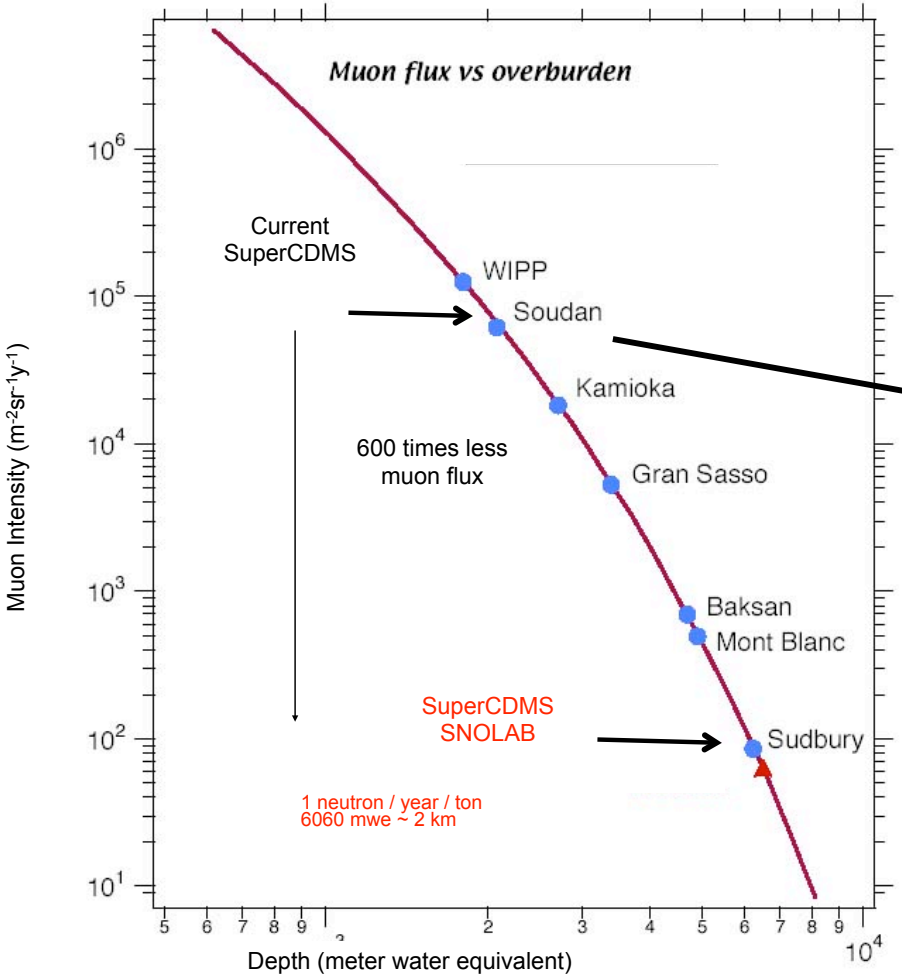
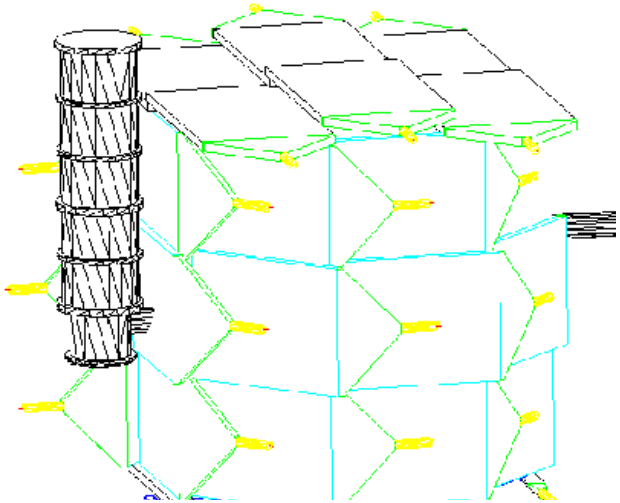
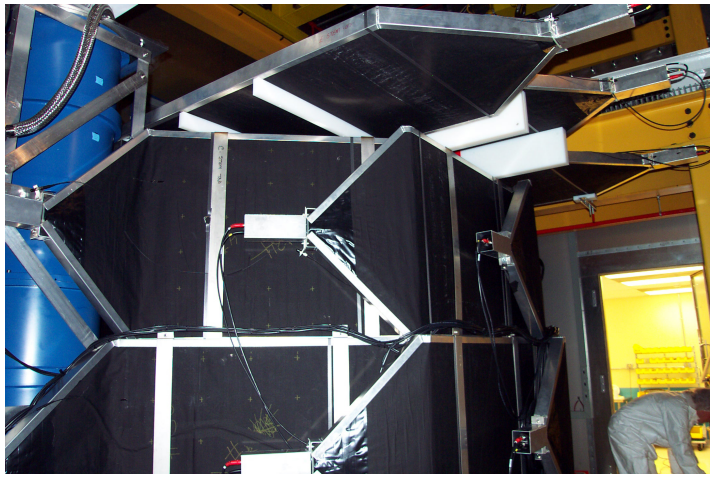
* new collaborators or new institutions in SuperCDMS

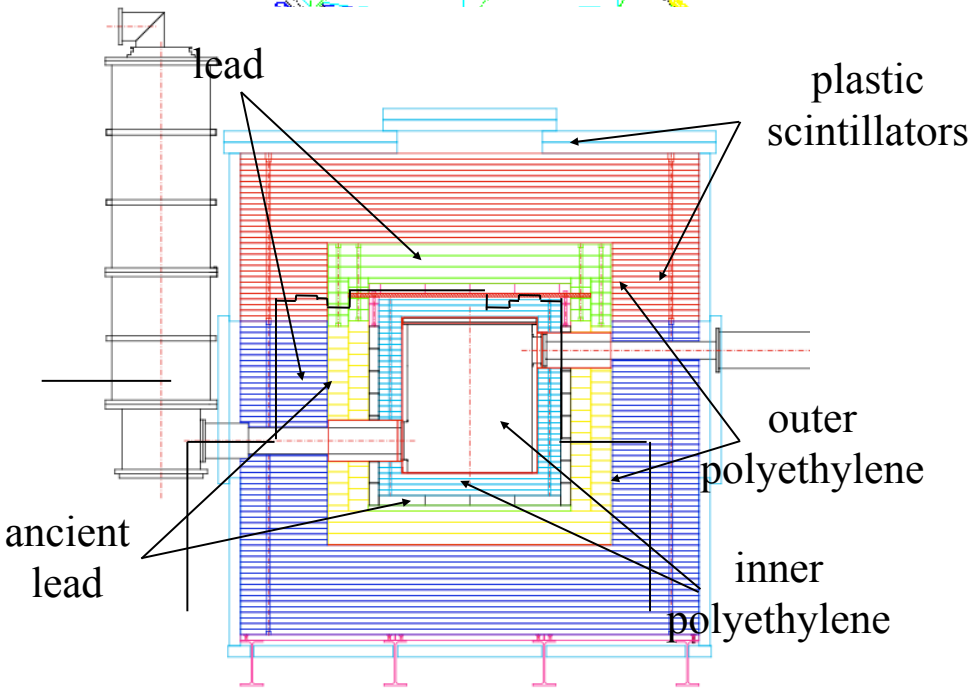
CDMS-II at Soudan (2090 mwe)



CDMS-II Soudan facility

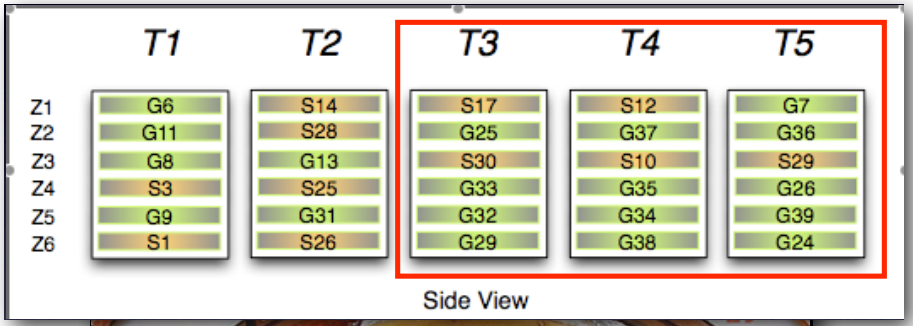


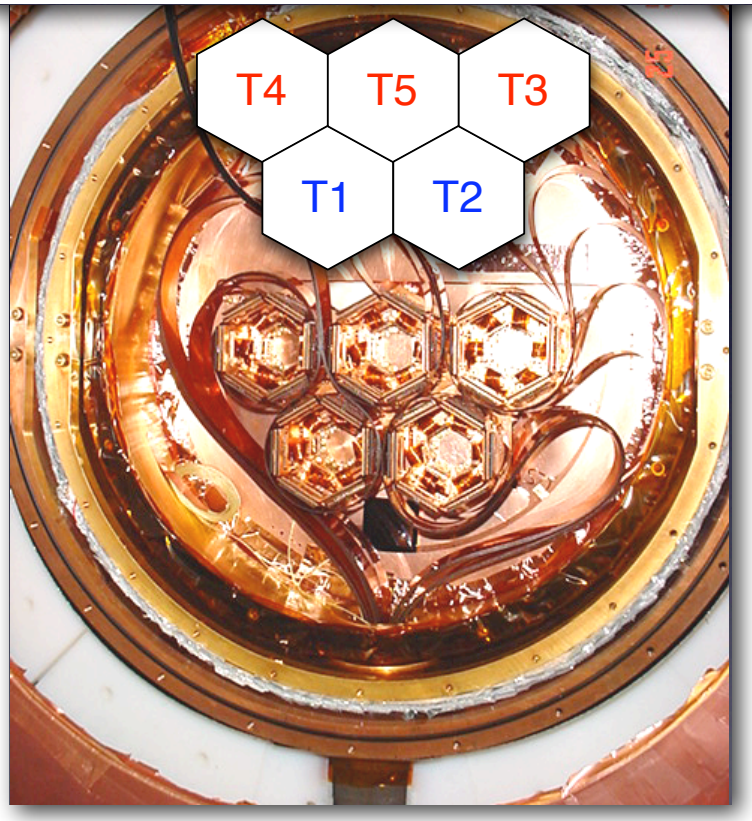




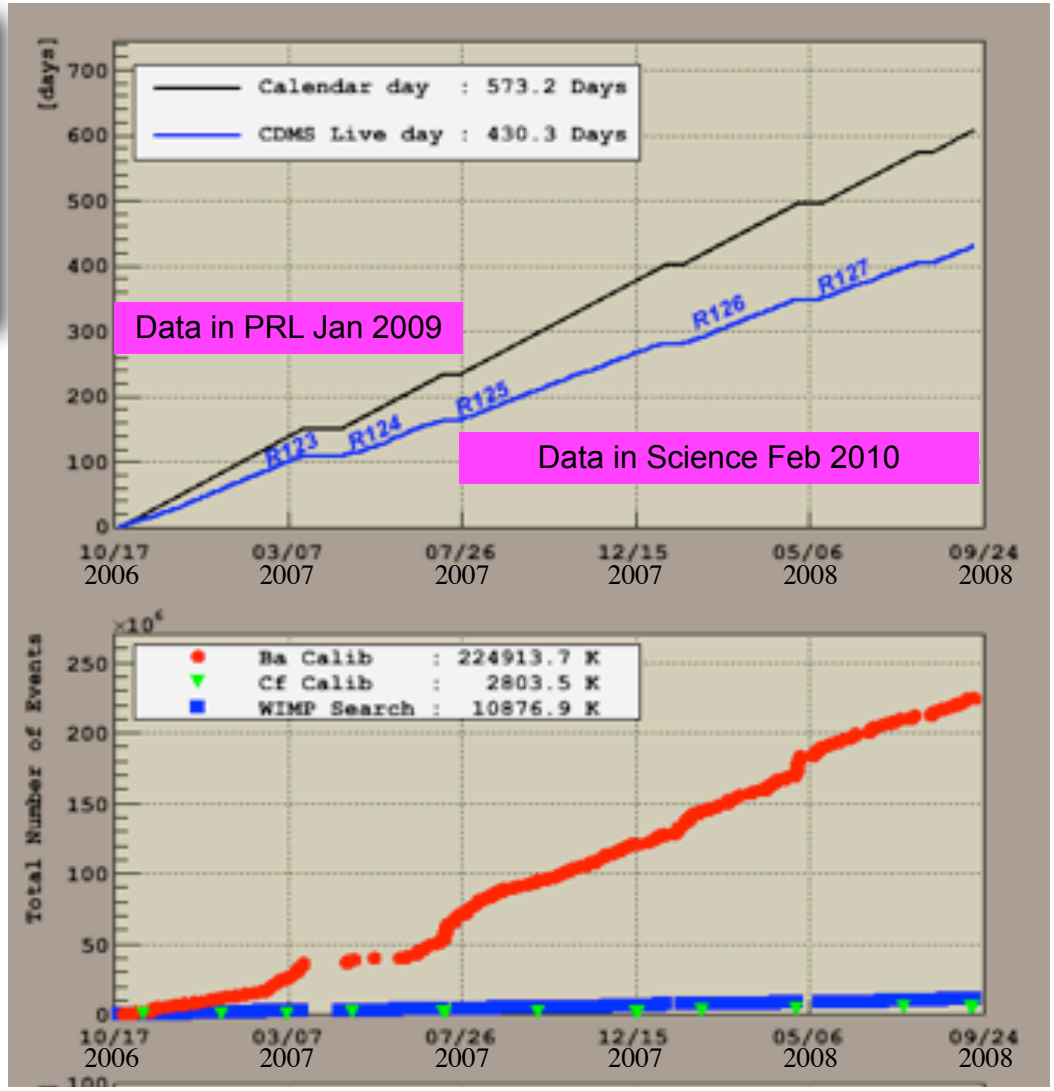
CDMS II Experiment

- 30 detectors - **4.75 kg of Ge**, **1.1 kg of Si**

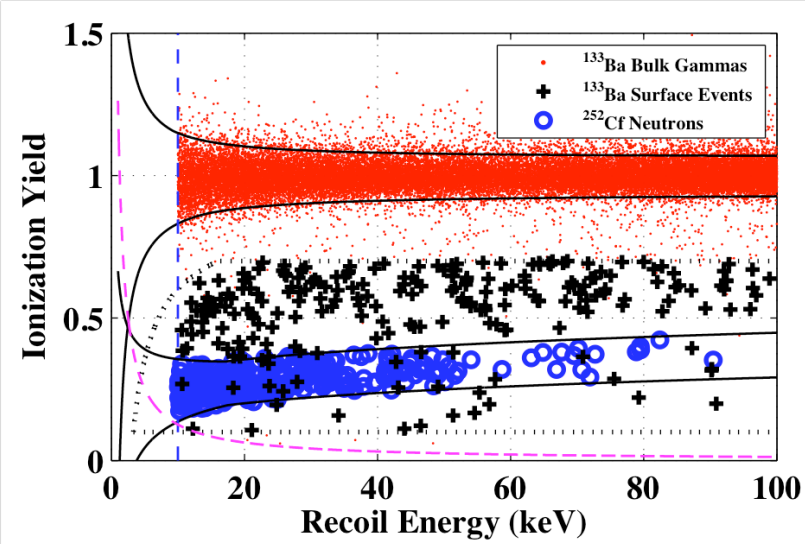


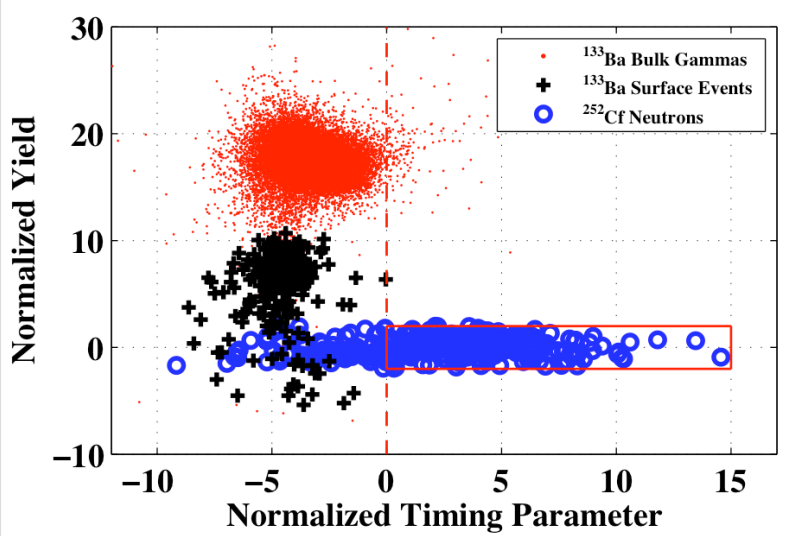


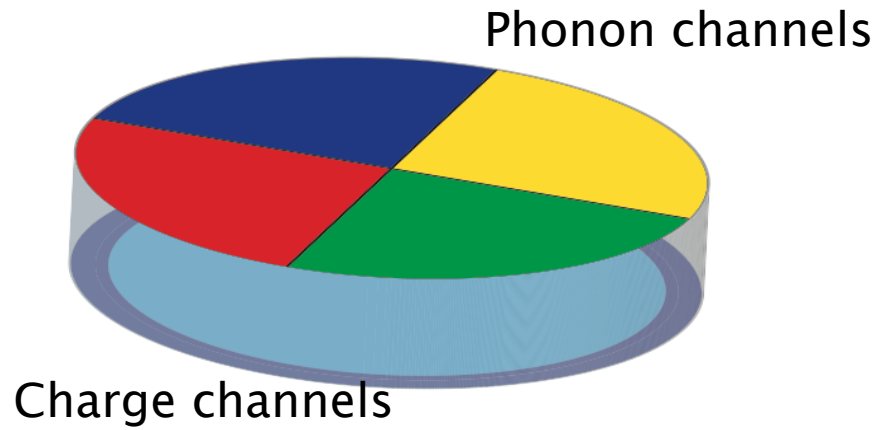
- **Data Run History:**



Detector Specifics







- Phonon and charge channels opposite
- Yield and phonon/charge timing
- Above 10 keV "perfect" ER/NR separation
- Surface events dominate background contribution → need timing cut!

(Z. Ahmed et al. (CDMS) Science **327** 1619 (2010))

search &discovery

Underground detector yields tantalizing hint of dark matter

PHYSICS TODAY
February 2010

The dark matter that dominates the rotation and clustering of galaxies is thought to consist of heavy, weakly interacting particles not yet known but much sought after.

The cosmologists' widely accepted "concordance model" asserts that only about 15% of the mass of matter in the cosmos is baryonic—made of protons and neutrons. Most of the predominating nonbaryonic mass is presumed to consist of still unknown "dark-matter" particles without electromagnetic or strong nuclear interactions, but heavy enough to have been nonrelativistic in the early epochs of galaxy formation.

Just such weakly interacting massive particles (WIMPs) are predicted by most proposed extensions of particle theory's standard model. The leading WIMP candidate is the lightest of the many new species anticipated by the supersymmetry theories. Presumably created in the Big Bang, it could be stable and, with a mass something like 100 times that of the proton, abundant enough to account for the gravitational effects on the clustering and rotation of galaxies whose observation raised the dark-matter issue long ago.

In interactions with nucleons, WIMPs would have very small but nonvanishing elastic-scattering and production cross sections, comparable to those of the ordinary weak interactions. So particle-physics experimenters have been looking for the production of WIMP pairs in high-energy colliders. And on a more modest scale, they

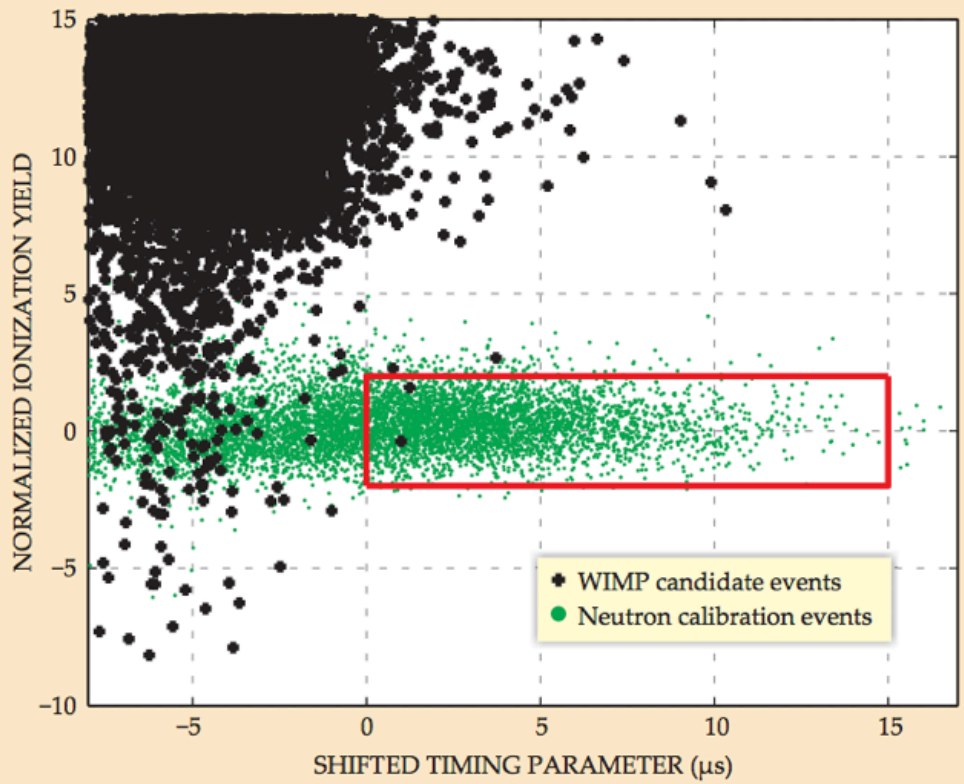
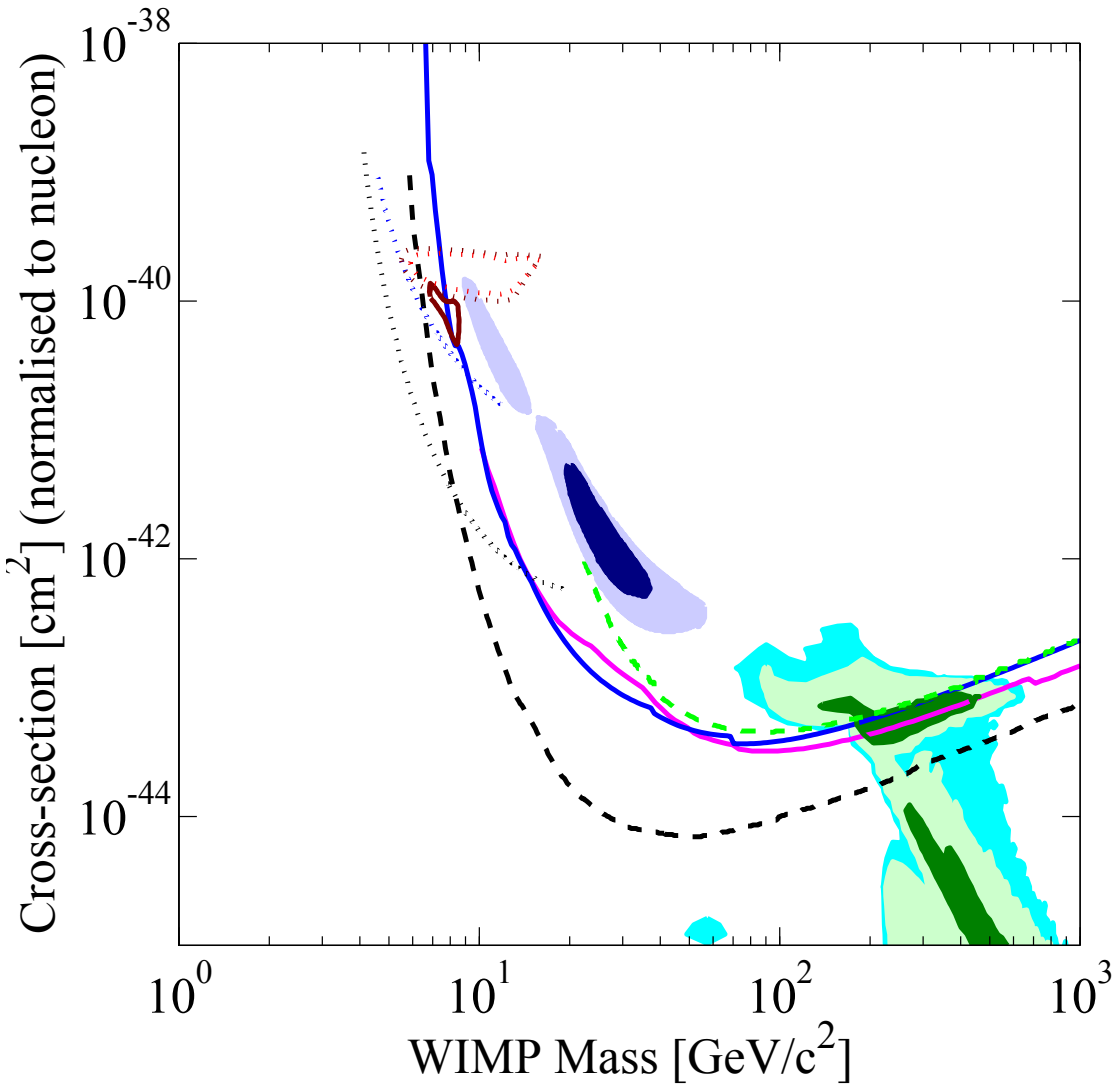


Figure 1. Ionization-yield and timing parameters for candidate WIMP-collision events that survived all prior event-selection cuts in the final year's exposure of the CDMS II dark-matter detector. The two parameters, described in the test, serve to weed out imposter events. Ionization yield is plotted in standard deviations from the mean for nuclear recoils, as measured with neutron collisions (green dots) in calibration exposures. The zero point of the timing parameter is shifted to its final cutoff value. In the signal region defined by the final cuts (red box), only two WIMP candidates survive. (Courtesy of CDMS.)

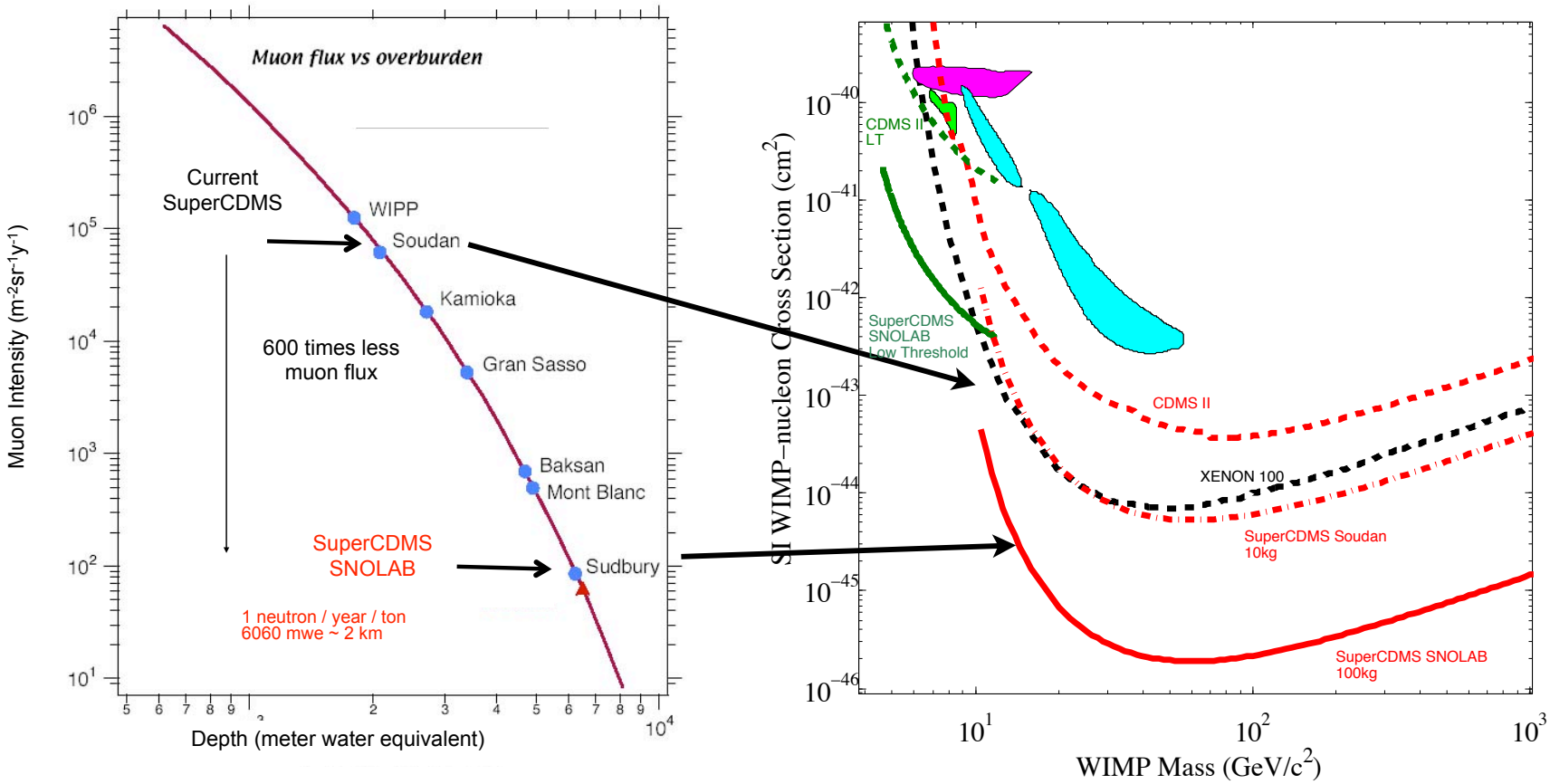
Maximum likelihood analysis points toward leakage surface electrons

Direct Detection Limits & Signals

- Recent upper limits on the WIMP-nucleon spin-independent cross-section (90% C.L.) versus WIMP mass are shown from top to bottom for CDMS II Soudan, Low Threshold [9](blue ...), Xenon 10, S2 only [10] (black ...), Edelweiss II [11] (green), CDMS II Soudan (2009) [12] (blue —), and XENON100 [13] (black). The blue fill region indicates the region where CRESST II reports a signal [14]: 1-sigma allowed region (dark blue), 2 sigma allowed region (light blue). The red dotted portions of the graph demonstrate the regions where DAMA reports a signal: DAMA region (90% CL)) [15] (red), and DAMA region (99% CL)) [15] (dark red). The colored regions show the current cMSSM regions (with recent LHC and Higgs constraints) predicting where WIMPs may be found, assuming flat priors: Strege et. al. [16], at 68% (green), 95% (light green), and 99% (cyan) C.L.



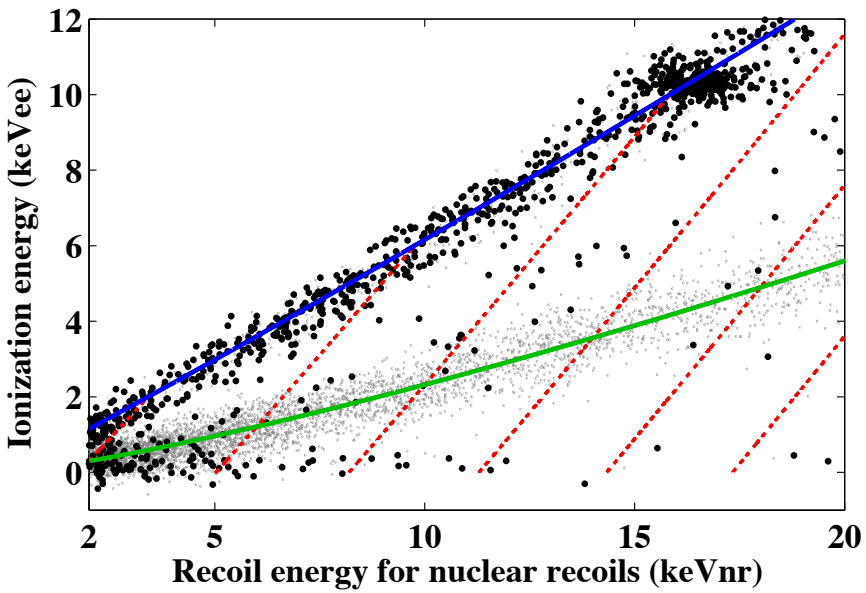
Status of Direction Detection Search

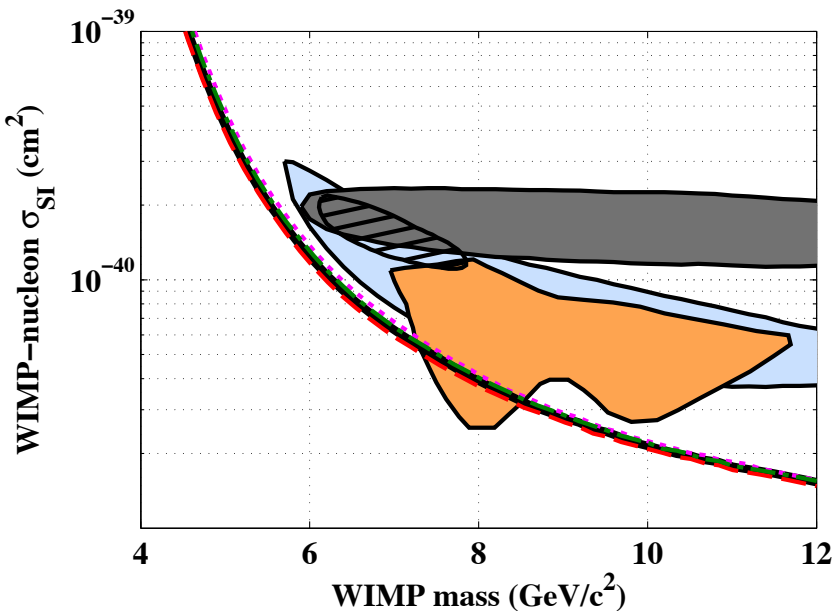


- Variety of techniques search for WIMP dark matter - interesting sensitivity
- Sensitivity has reached below 10^{-44} cm^2 and expect 10^{-46} cm^2 in future

CDMS-II Low WIMP Mass Results (1)

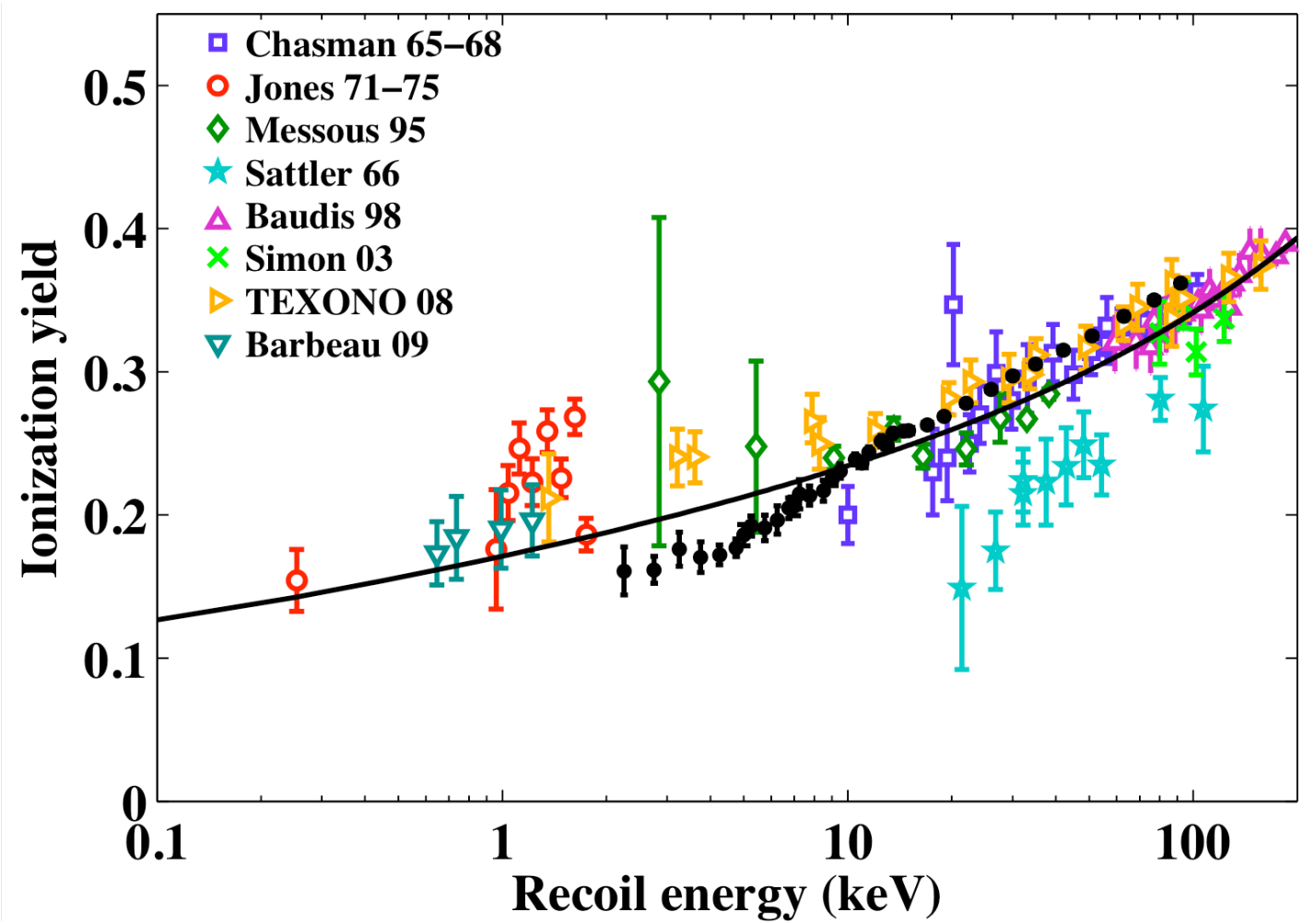
- Results from a Low-Energy Analysis of the CDMS II Germanium Data
  http://arxiv.org/pdf/1011.2482v3.pdf





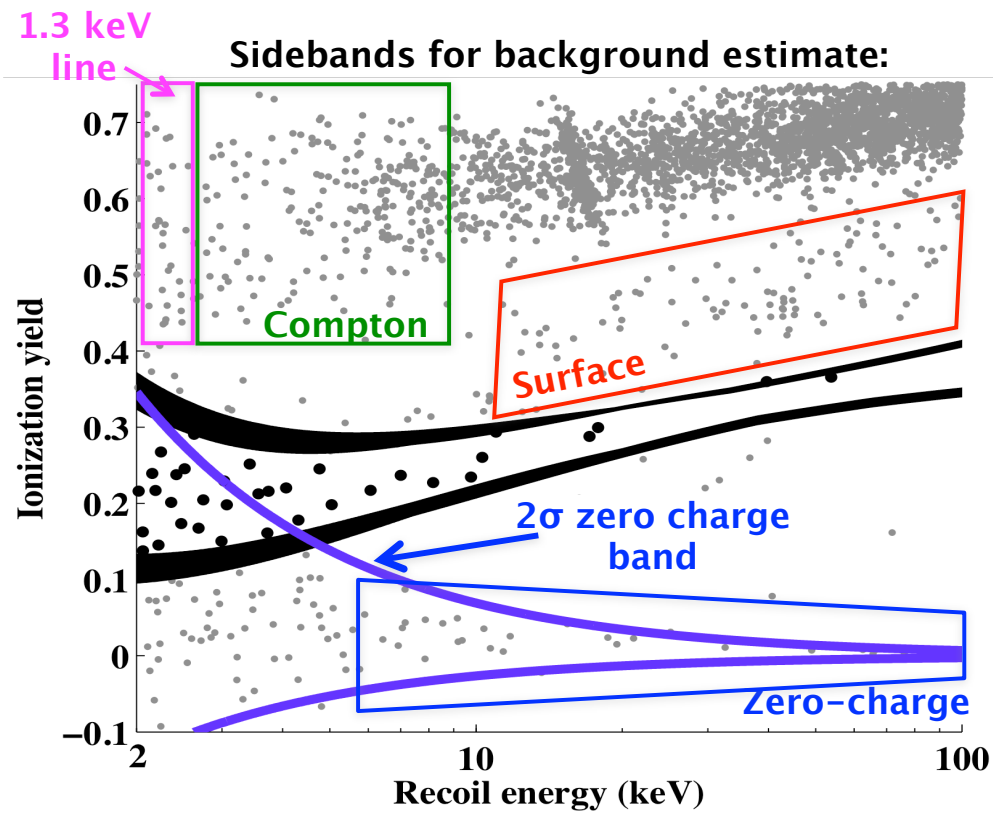
Phonon Energy Scale

(Figure: D. Moore, adapted for publication below)



(arXiv:1011.2482v3; Z. Ahmed et al. (CDMS) Phys. Rev. Lett. **106** 131302 (2011))

Backup Slides (Low Thresh Sidebands)

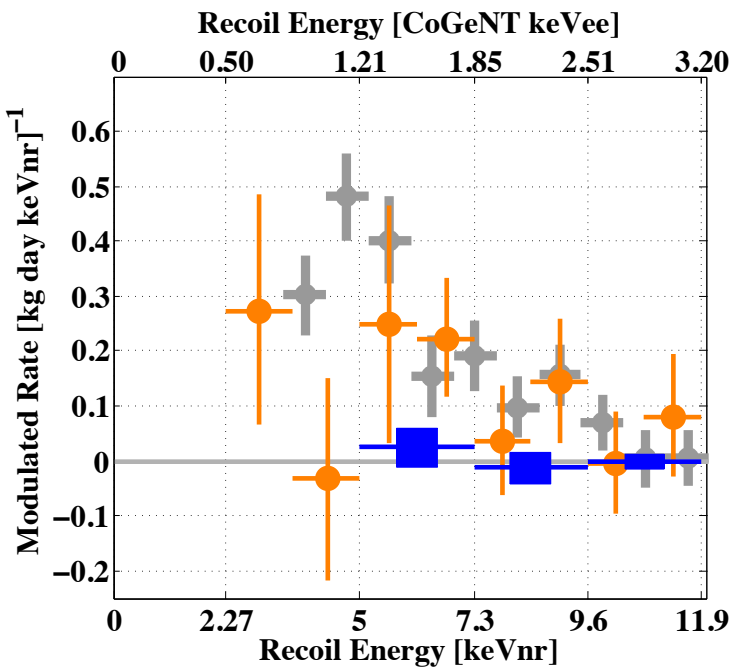


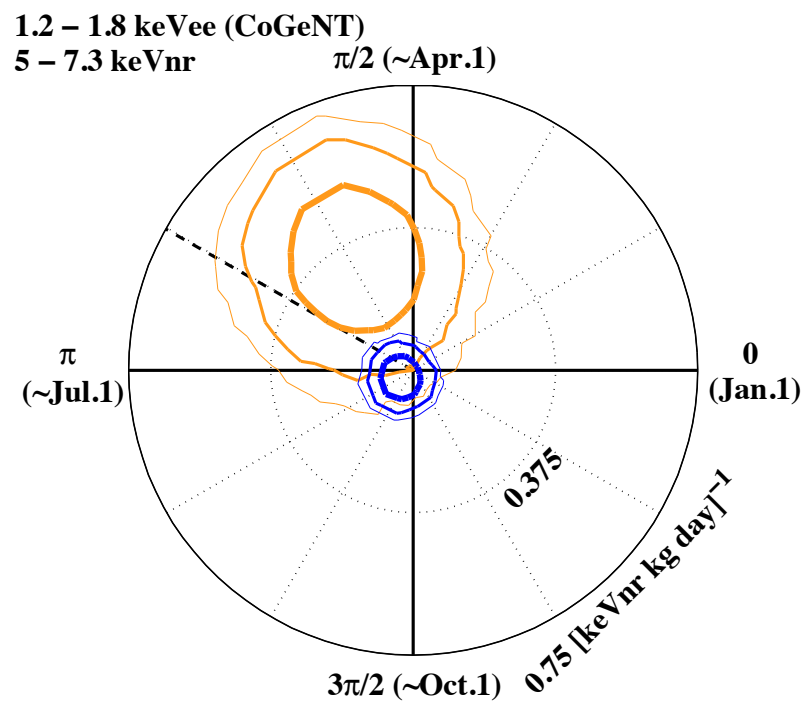
(Figure: D. Moore)

- Likely that zero-charge events account for substantial (~50%) of signal
- Sideband extrapolations prone to errors → assume all true signal
- Lower limit still competitive

CDMS-II Low WIMP Mass Results (2)

- Search for annual modulation in low-energy CDMS-II data http://arxiv.org/pdf/1203.1309v1.pdf





CDMS-II Low WIMP Mass Results (3)

- A Maximum Likelihood Analysis of Low-Energy CDMS Data
  http://arxiv.org/pdf/1204.3559v3.pdf
  - Data captured from Fig. 6 in arXiv:1203.1309v1, summed over 8 Ge detectors
  - Single scatters only (no analysis of multiples included, although available in same figure)
  - Suggests Fig. 2 more objective than figure used in CDMS talks (due to band widths, yield scale), and that immediate impression from Fig. 2 is a large fraction are NR events (not ZC)

Fig. 1: all data with band centers by detector

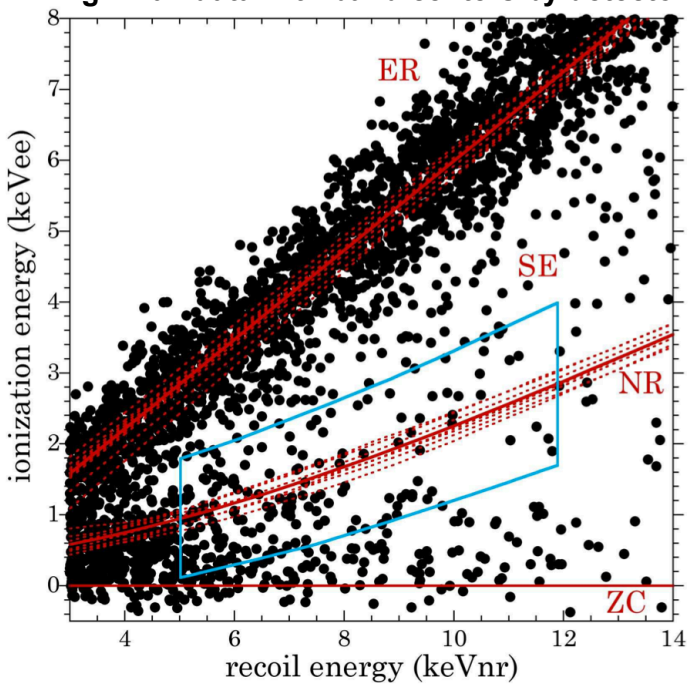
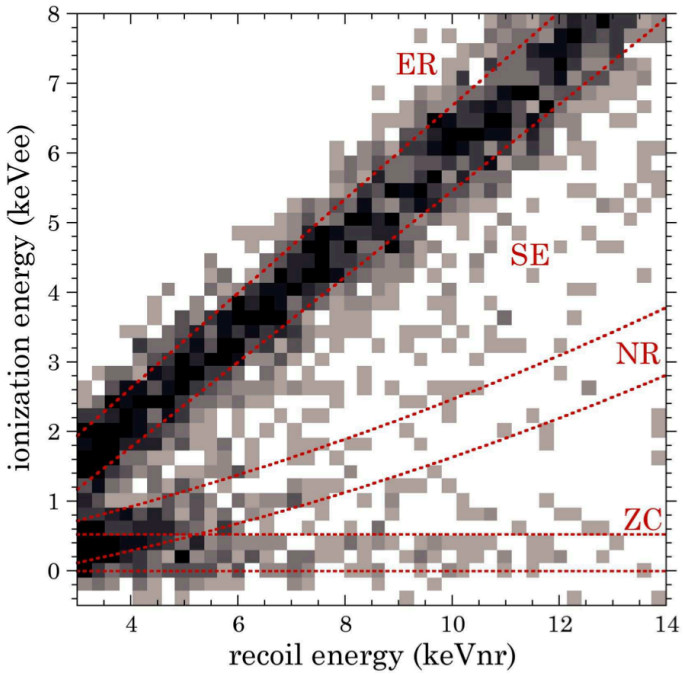
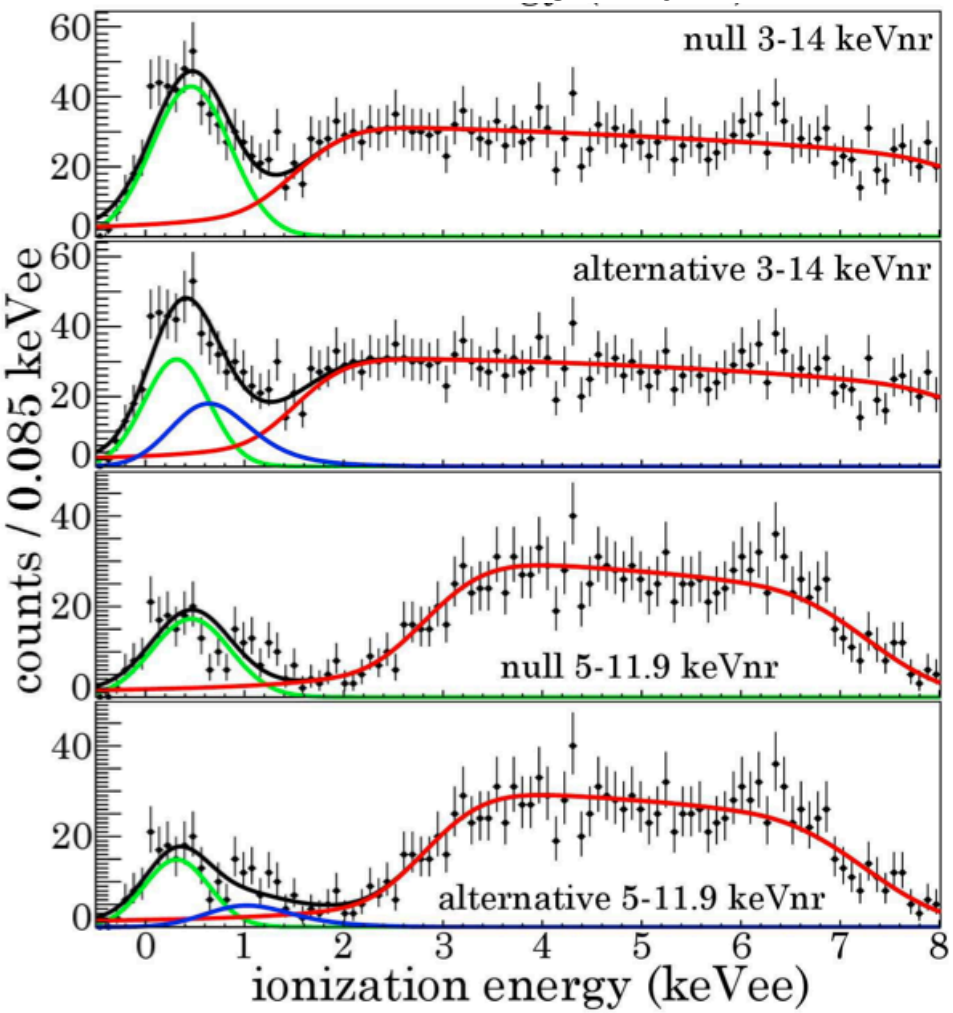


Fig. 2: 2d histogram w/ +/- 1σ bands

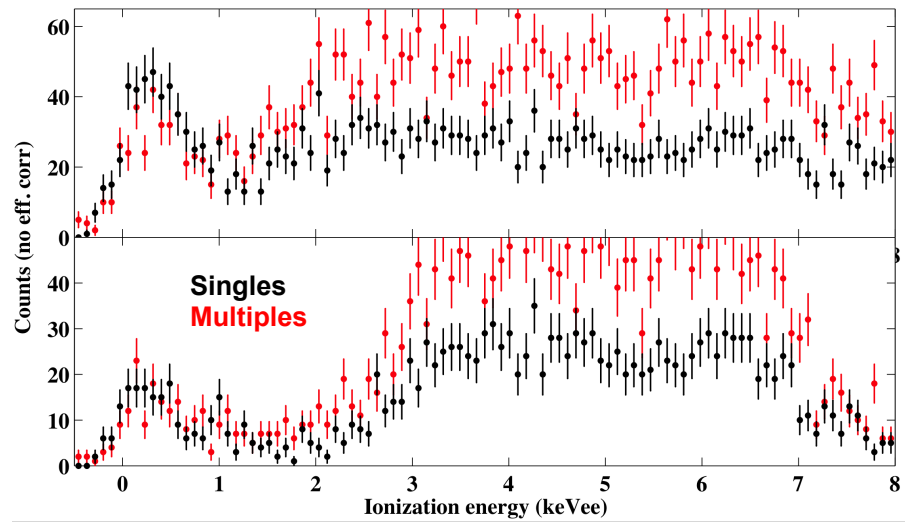


Compare Singles and Multiples

Collar and Fields, singles only:

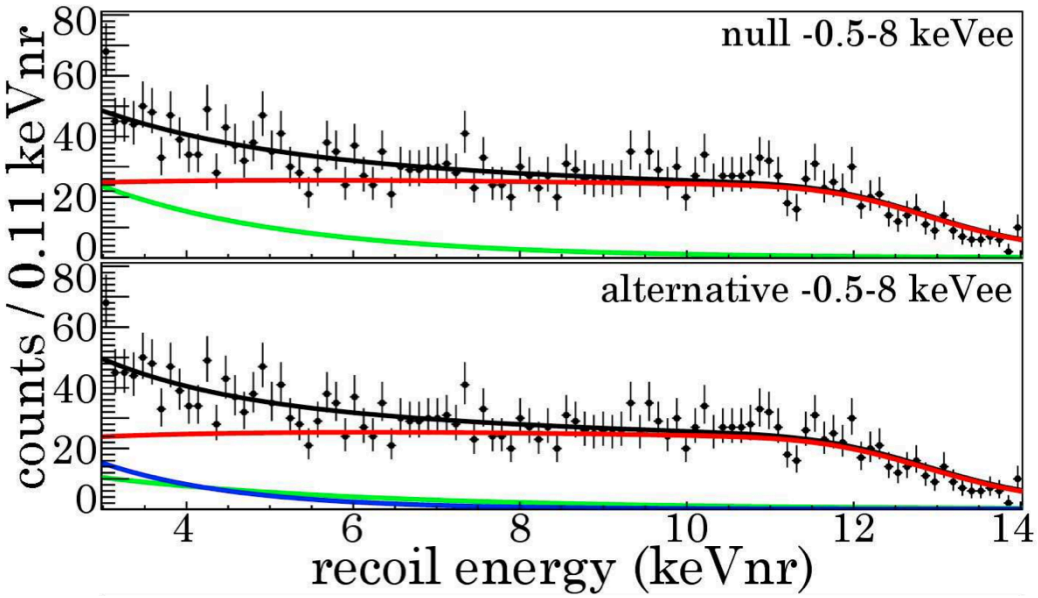


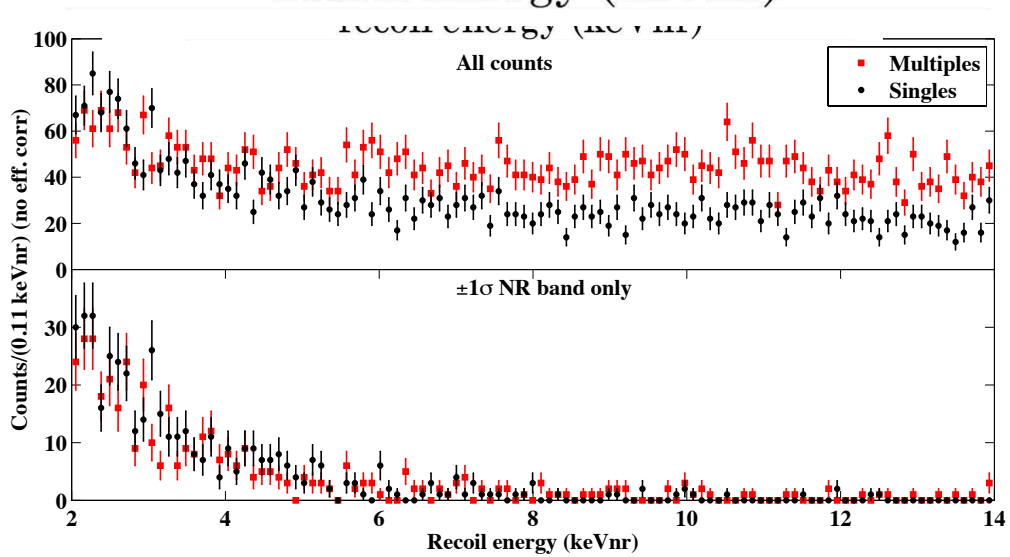
CDMS singles and multiples:



No significant difference between singles and multiples

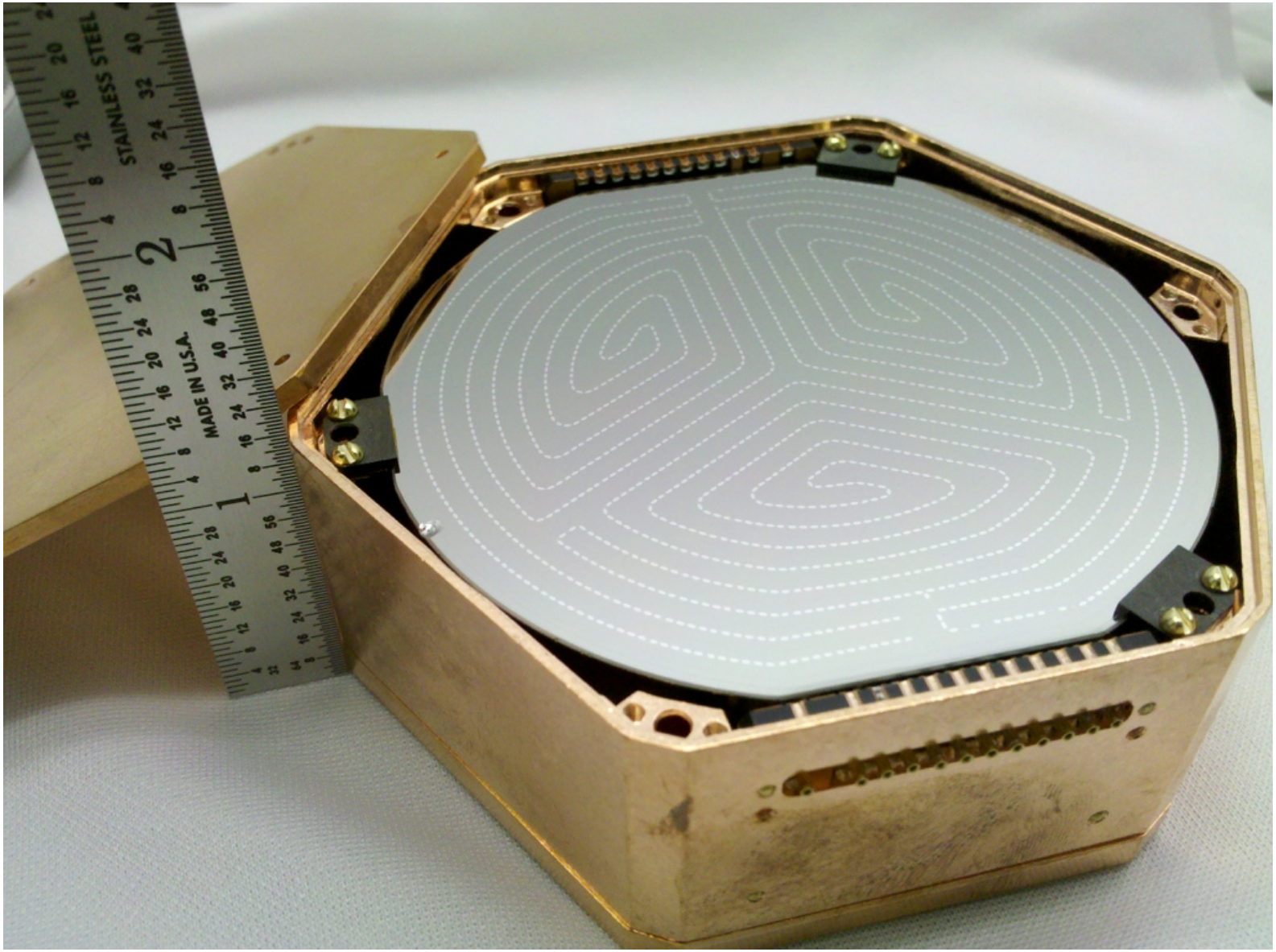
Compare Singles and Multiples



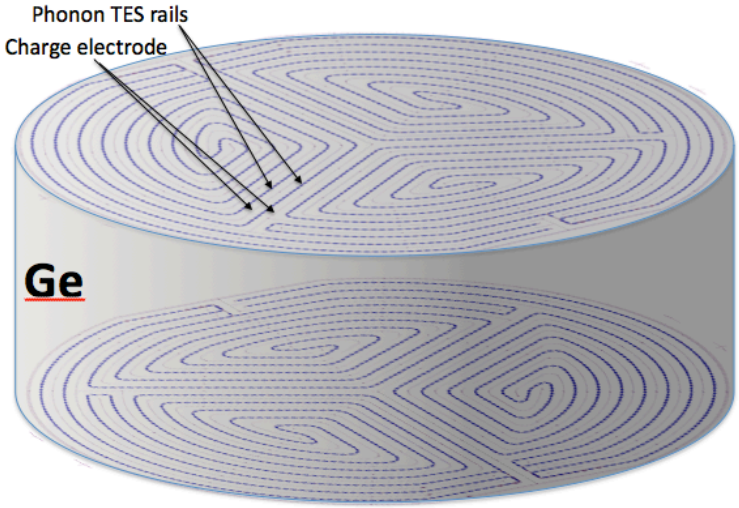


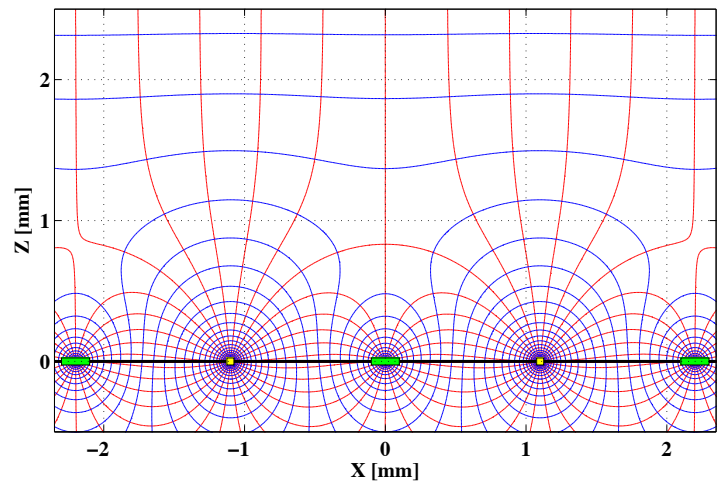
No significant difference between singles and multiples

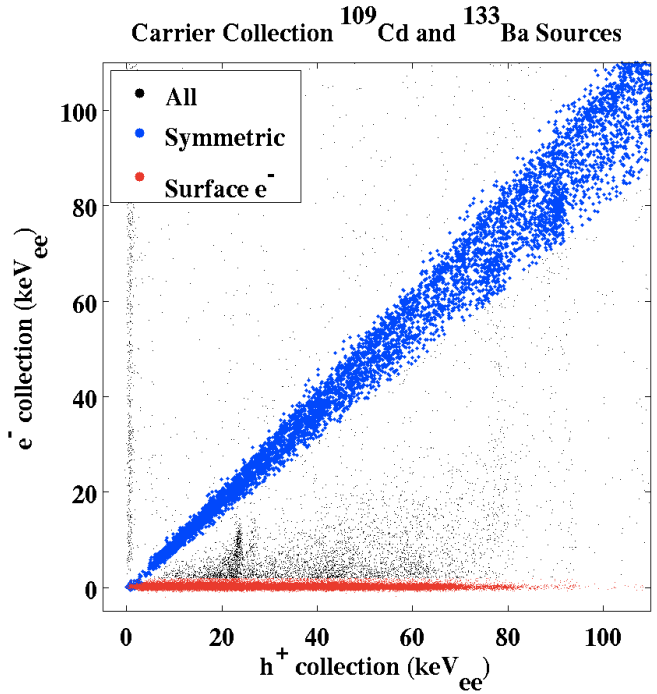
SuperCDMS Soudan detectors (15 = 9 kg)

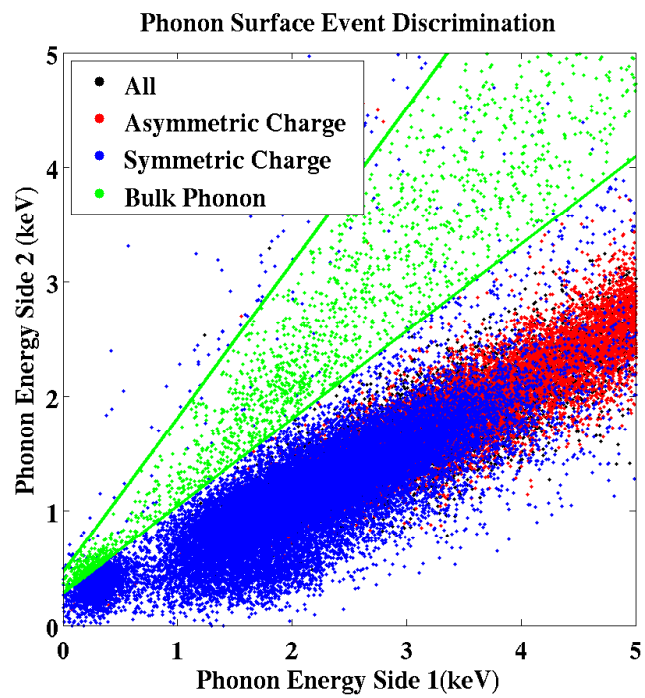


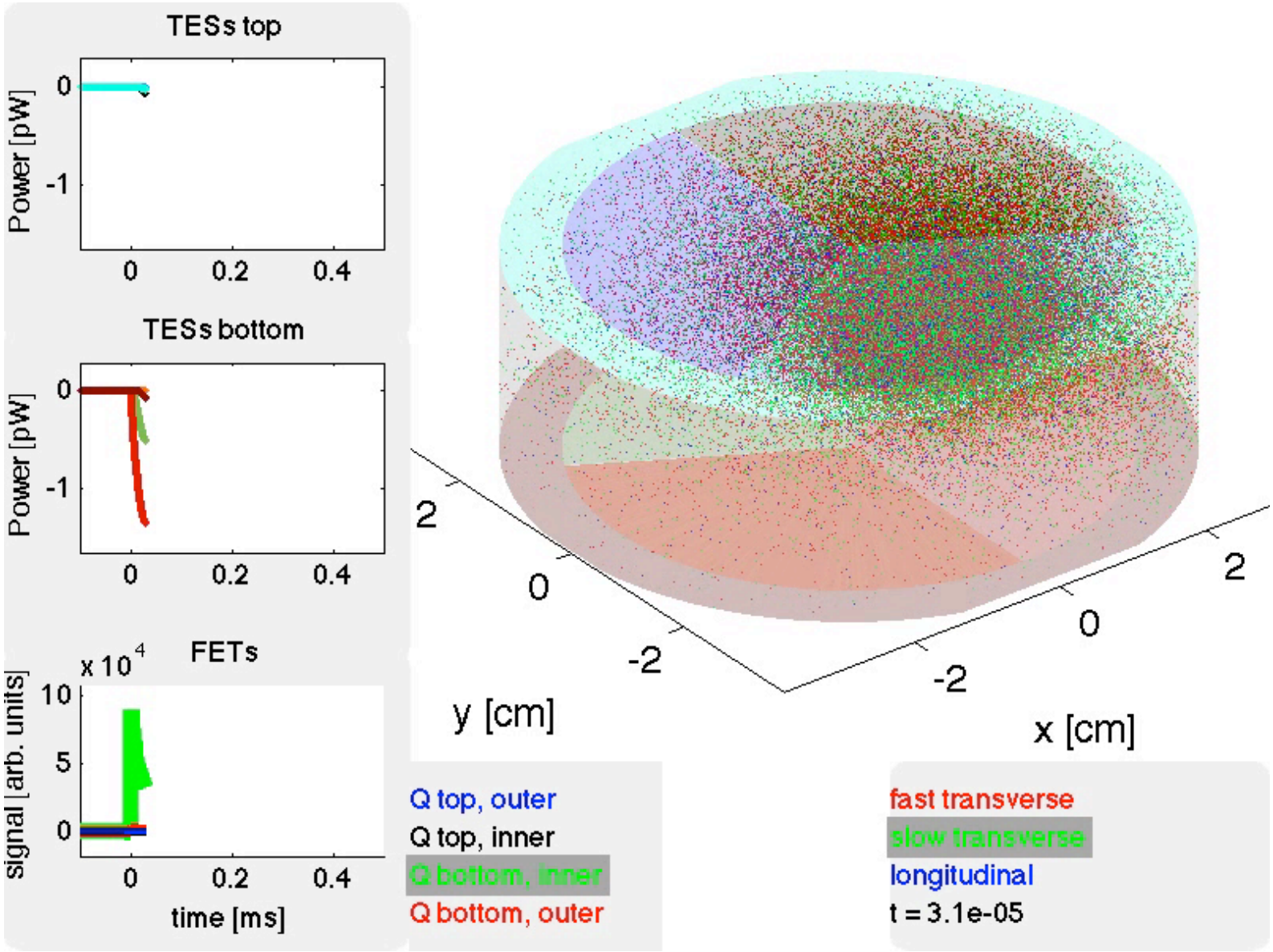
Advanced IZIP Detectors



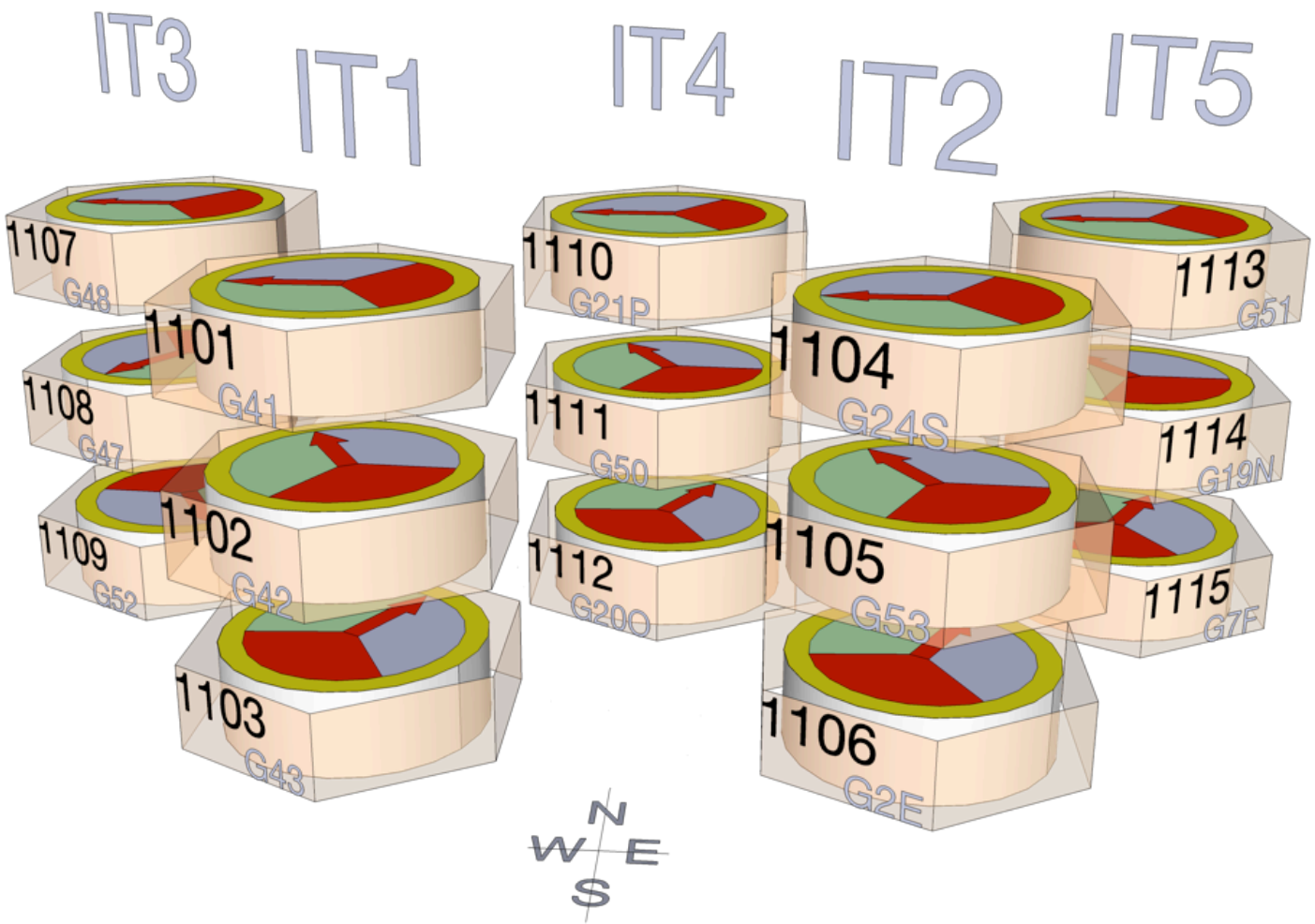






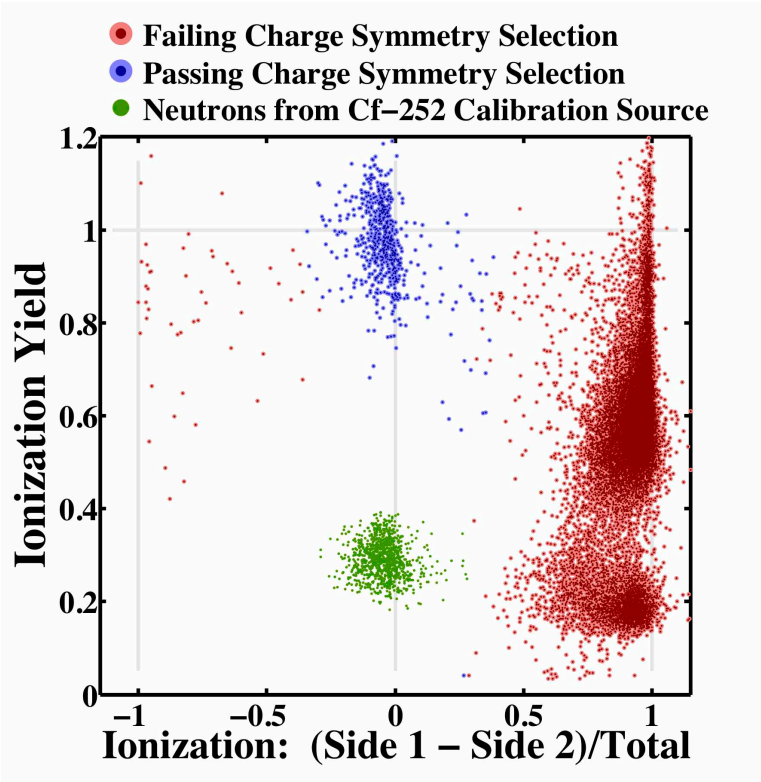

TESs top
Power [pW]
0
-1
0
0.2
0.4
TESs bottom
Power [pW]
0
-1
0
0.2
0.4
FETs
x 10^4
signal [arb. units]
10
5
0
0
0.2
0.4
time [ms]
2
0
-2
y [cm]
2
0
-2
x [cm]
Q top, outer
Q top, inner
Q bottom, inner
Q bottom, outer
fast transverse
slow transverse
longitudinal
t = 3.1e-05

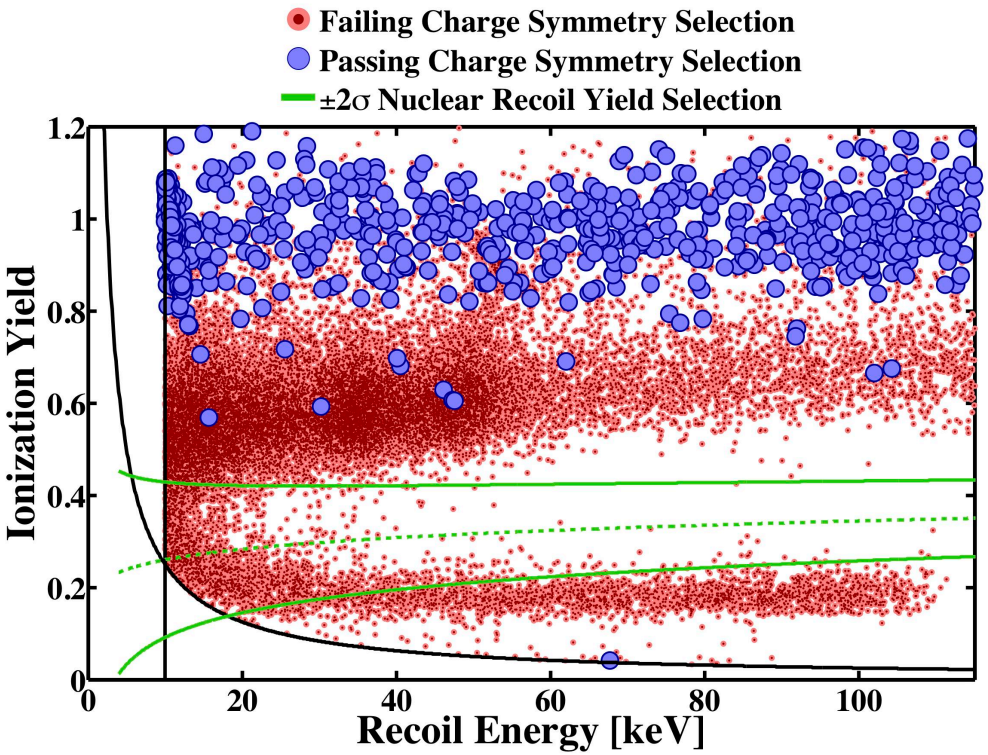
Configuration for 2 year run thru 2013



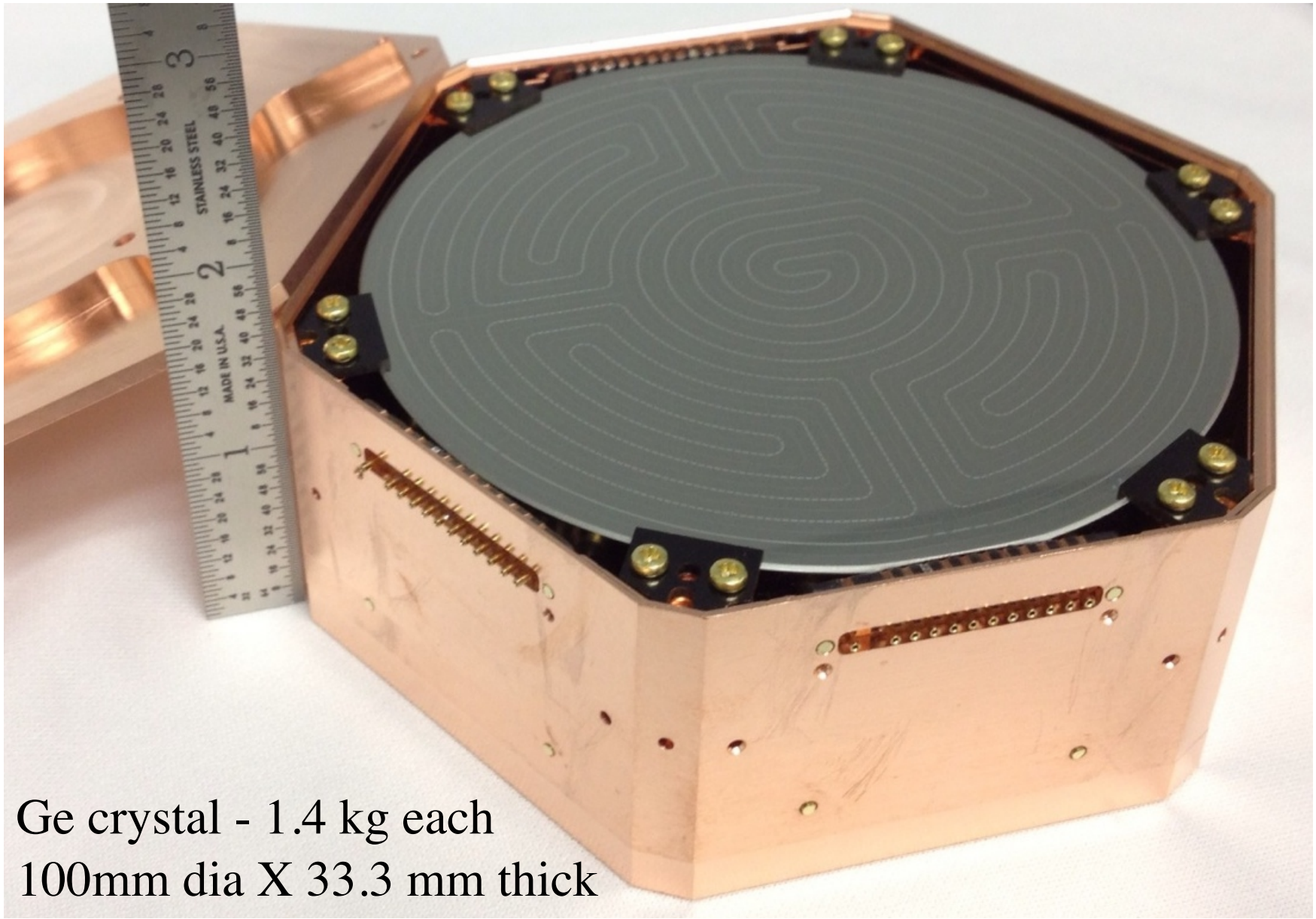
Pb210 Source Data from SuperCDMS Soudan

- Two detectors with one Pb210 decay every min operated for 20 live days corresponds to total Pb210 events for 100 kg SuperCDMS SNOLAB experiment operated for more than two years





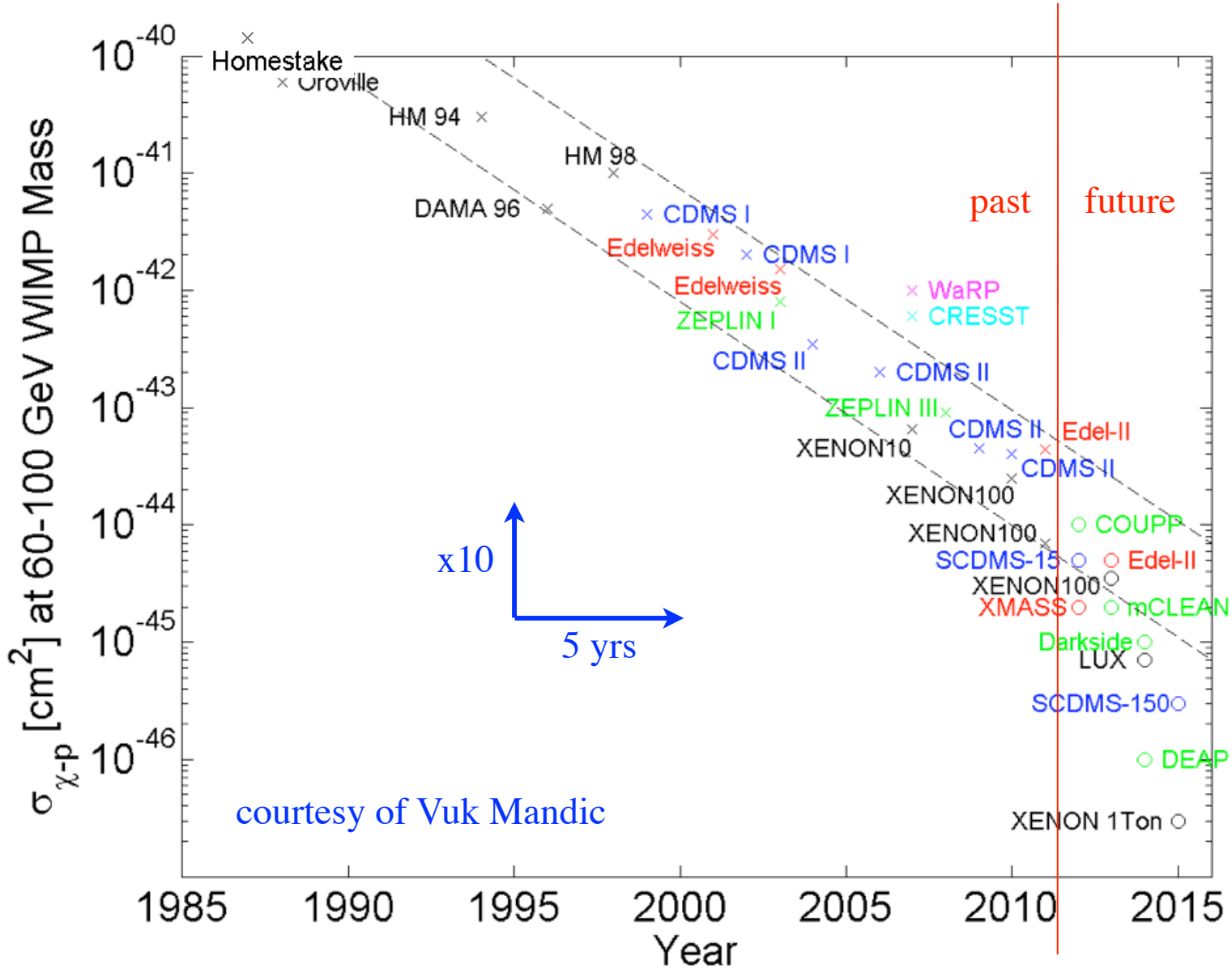
SuperCDMS SNOLAB Detectors



Ge crystal - 1.4 kg each
100mm dia X 33.3 mm thick

Conclusion

- Low mass WIMP analysis of CDMS-II data has been performed with phonon only trigger for total rate and looking for annual modulation within the background
- Limits are inconsistent with CoGeNT, DAMA and CRESST possible signal levels
- Claims by Juan Collar that we have a nuclear recoil signal in our data are not consistent with analysis of the multiple event data sets also presented in our paper
- We have been operating SuperCDMS Soudan for several months with 9 kg of Ge detectors
- Pb210 sources demonstrate that surface electron rejection is sufficient to prevent leakage for 100 kg SuperCDMS SNOLAB experiment operated for three years

WIMP Search Sensitivity

from Mandic