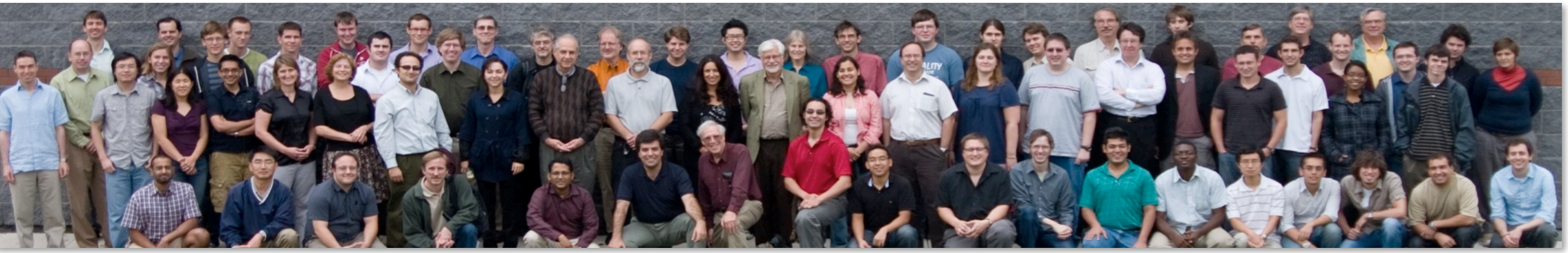
Constraining Light Dark Matter with CDMS II and SuperCDMS

Scott Hertel
MIT, SuperCDMS Collaboration
DPF ’11 (August 10, 2011)

The SuperCDMS Collaboration



Caltech
Z. Ahmed, J. Filippini, S. Golwala, D. Moore, R. Nelson, R.W. Ogburn

Fermilab
D.A. Bauer, J. Hall, F. DeJongh, D. Holmgren, L. Hsu, E. Ramberg, R.L. Schmitt, R. B. Thakur, J. Yoo

MIT
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Santa Clara University
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Southern Methodist University
J. Cooley, B. Karabuga, S. Scorza, H. Qiu

Stanford University
B. Cabrera, M. Cherry , R. Moffatt, L. Novak, M. Pyle, M. Razeti, B. Shank, A. Tomada, S. Yellin, J. Yen

Syracuse University
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University of California, Berkeley
M. Daal, T. Doughty, N. Mirabolfathi, A. Phipps, B. Sadoulet, D. Seitz, B. Serfass, D. Speller, K.M. Sundqvist

University of California, Santa Barbara
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University of Colorado at Denver
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University of Florida
D. Balakishiyeva, T. Saab, B. Welliver

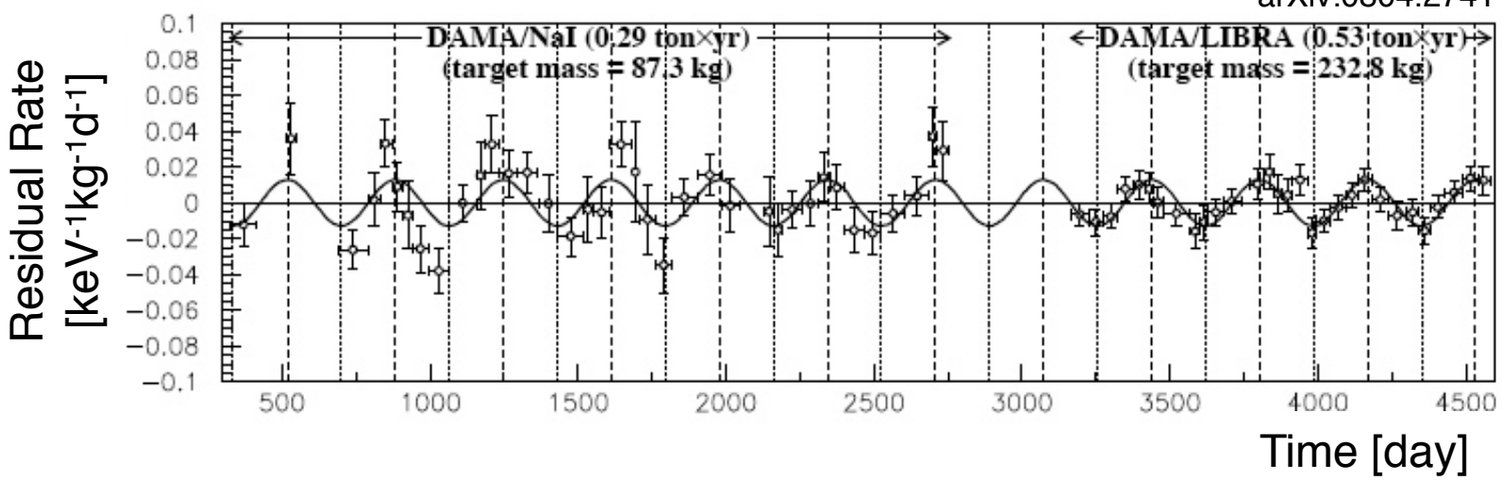
University of Minnesota
P. Cushman, L. Duong, M. Fritts, V. Mandic, X. Qiu, A. Reisetter, O. Kamaev, J. Zhang

University of Texas A&M
A. Jastram, K. Koch, R. Mahapatra, M. Platt , K. Prasad, J. Sander

Motivation: DAMA & CoGeNT

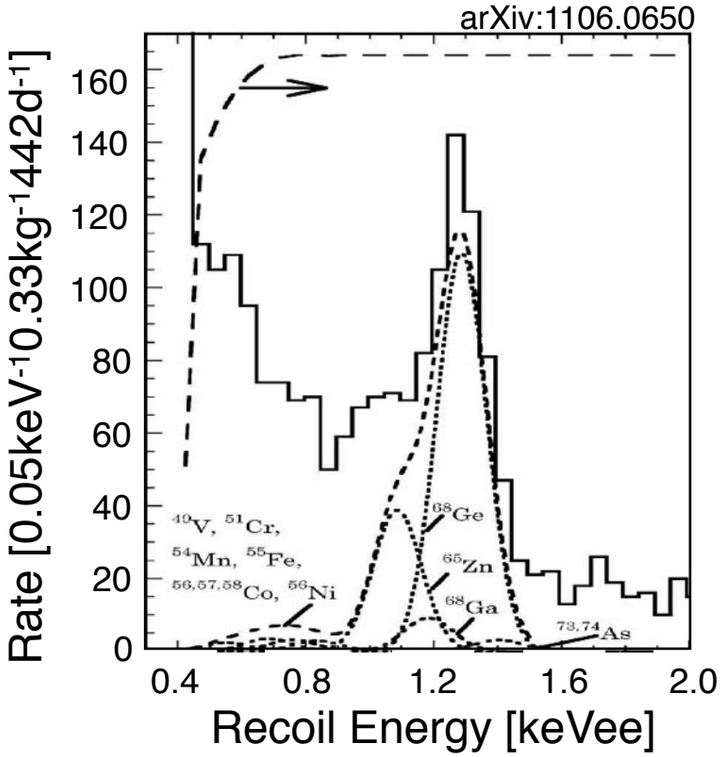
DAMA

arXiv:0804.2741

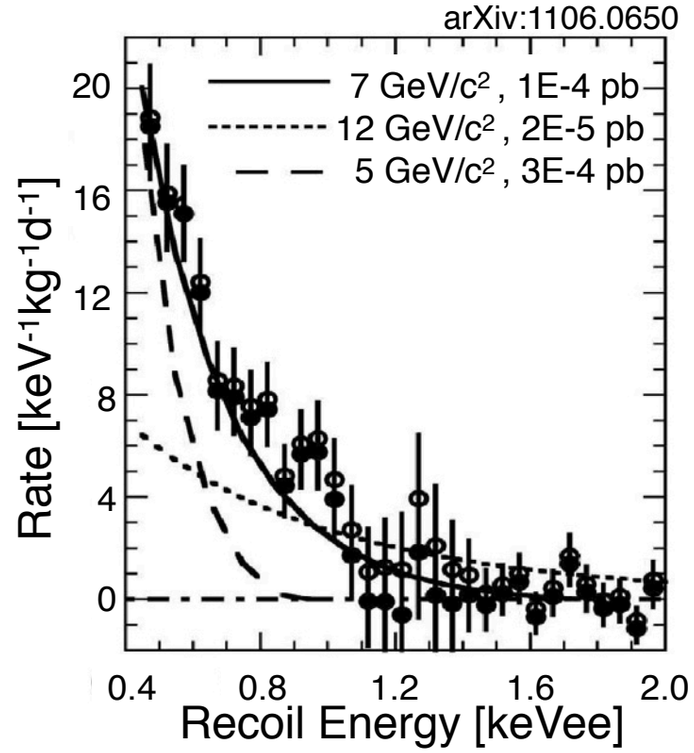


CoGeNT

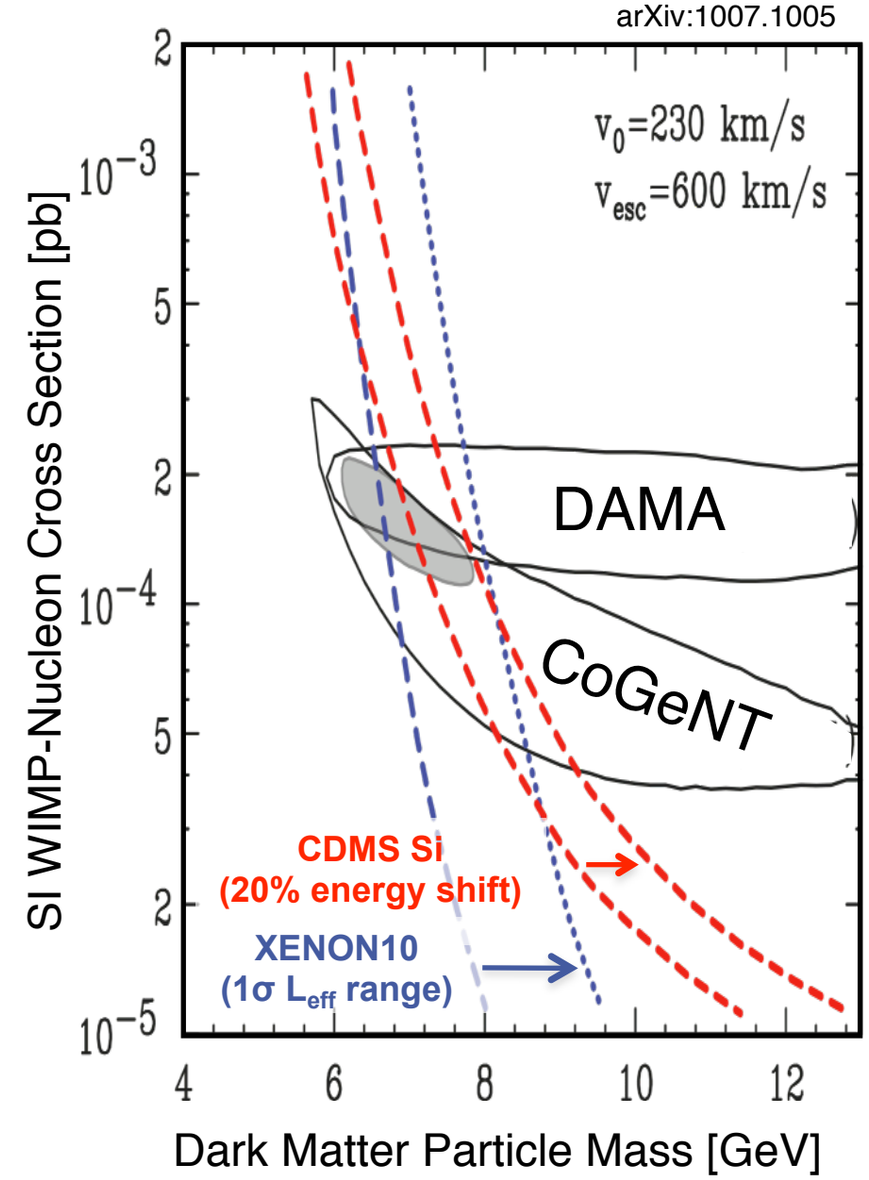
arXiv:1106.0650



arXiv:1106.0650



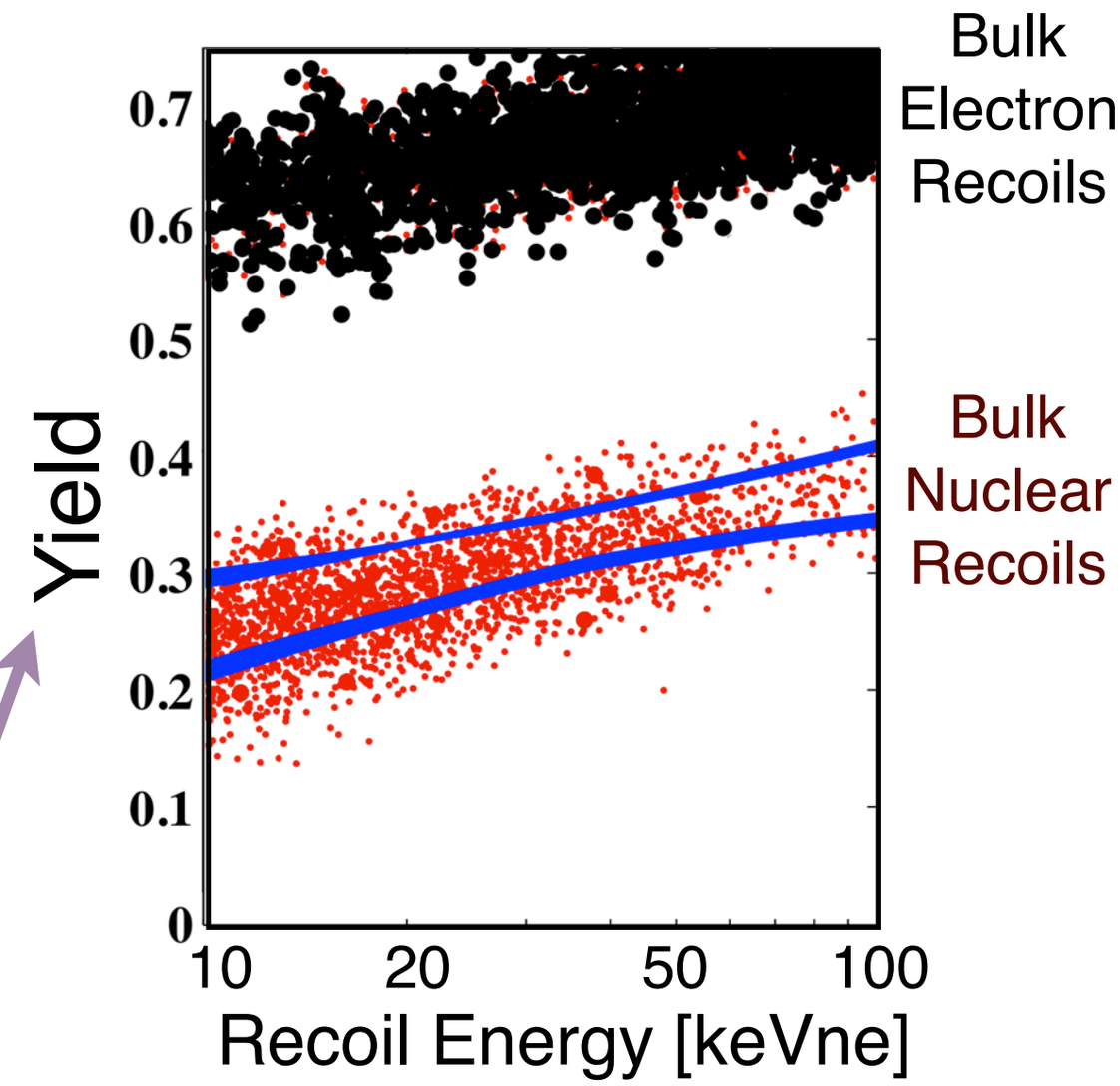
arXiv:1007.1005



CDMS II Detectors

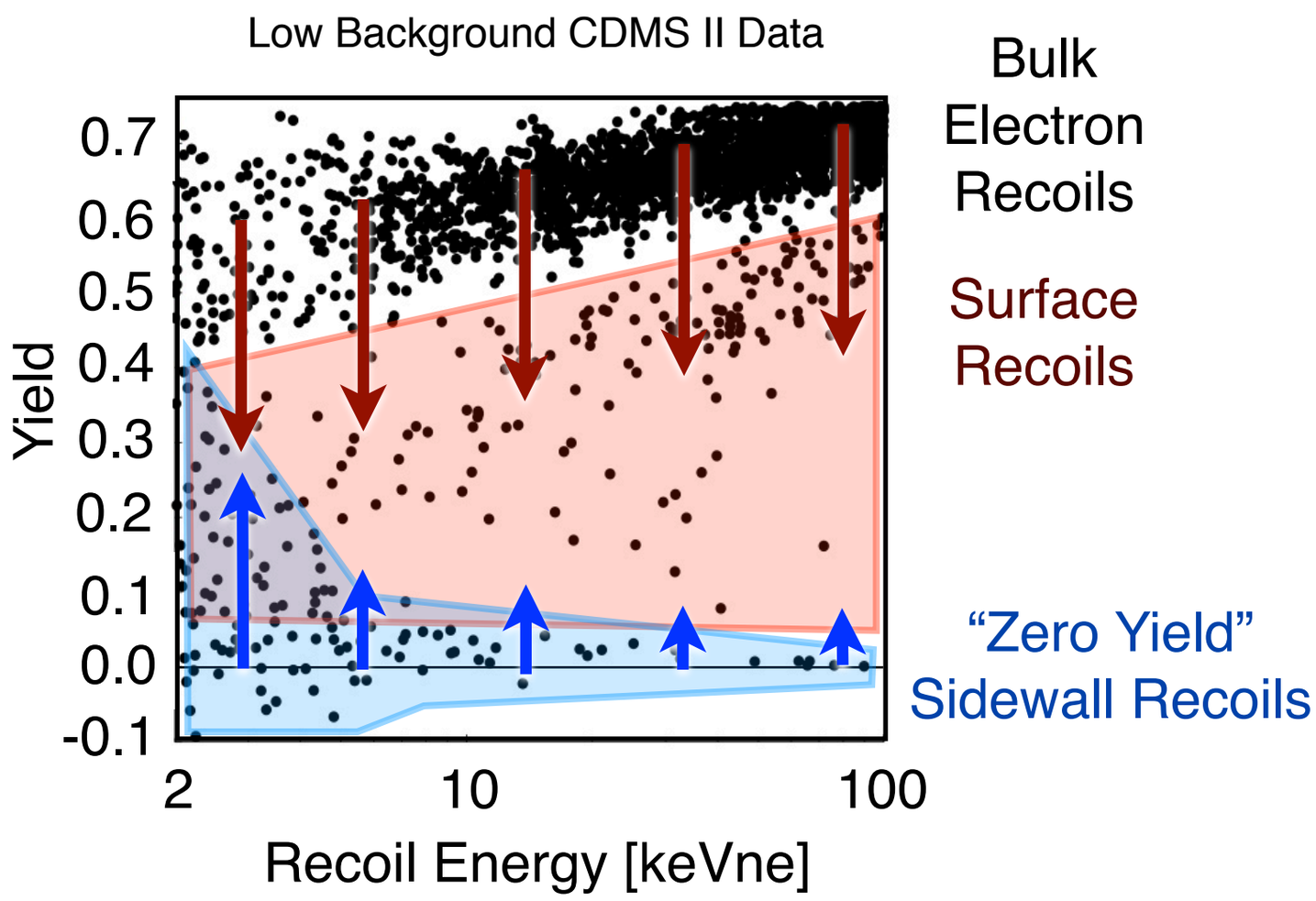
4 Phonon Channels

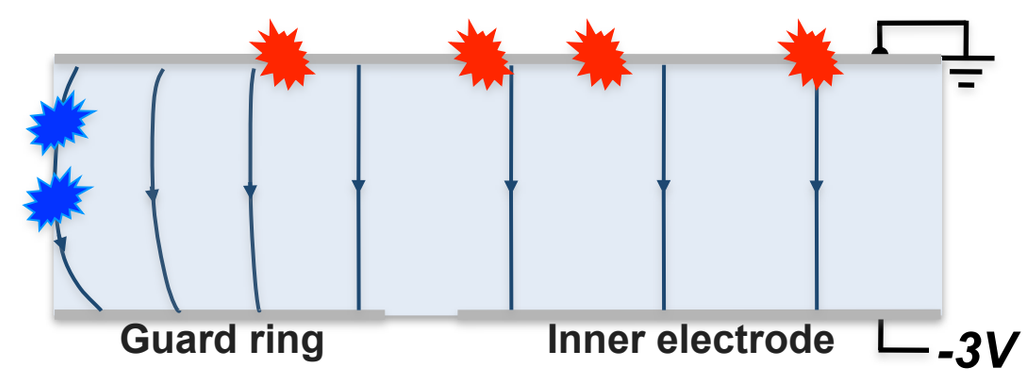
2 Charge Channels



$$\frac{\text{Charge Energy}}{\text{Phonon Energy}} = \text{“Yield”}$$

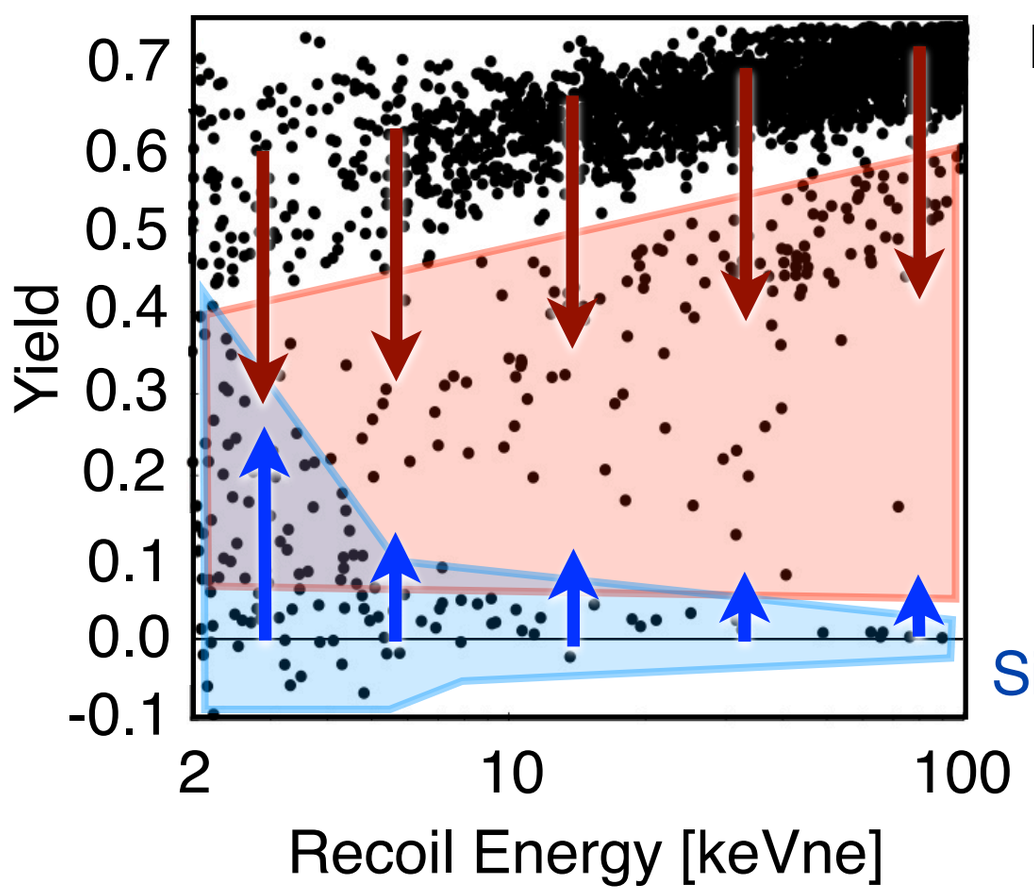
CDMS II at Low Energies





CDMS II at Low Energies

Low Background CDMS II Data

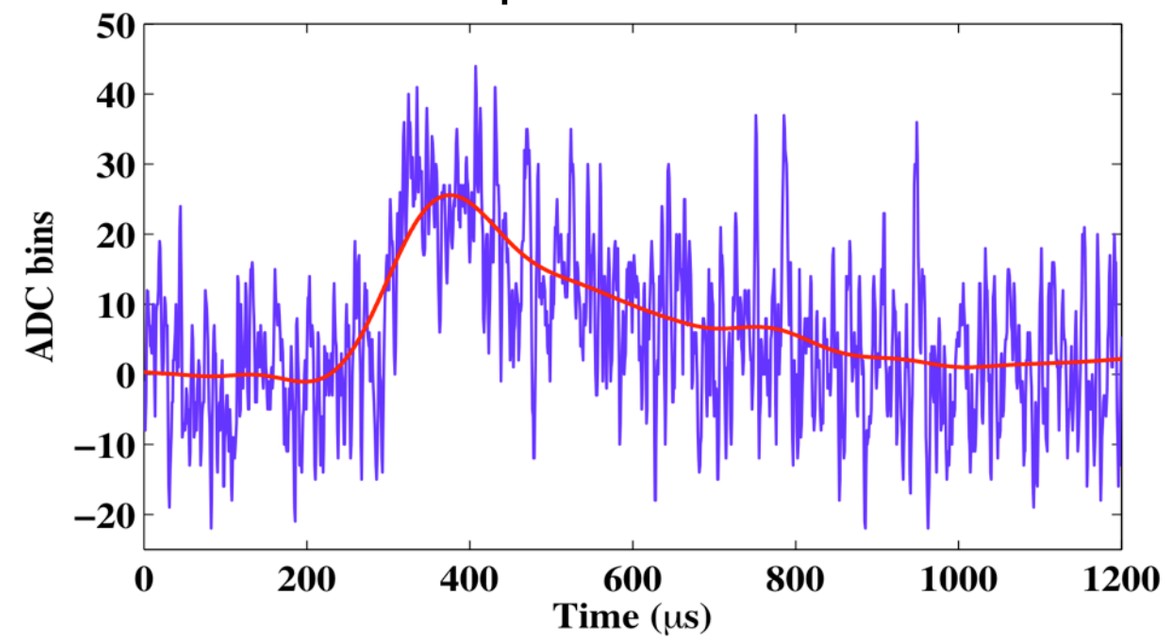


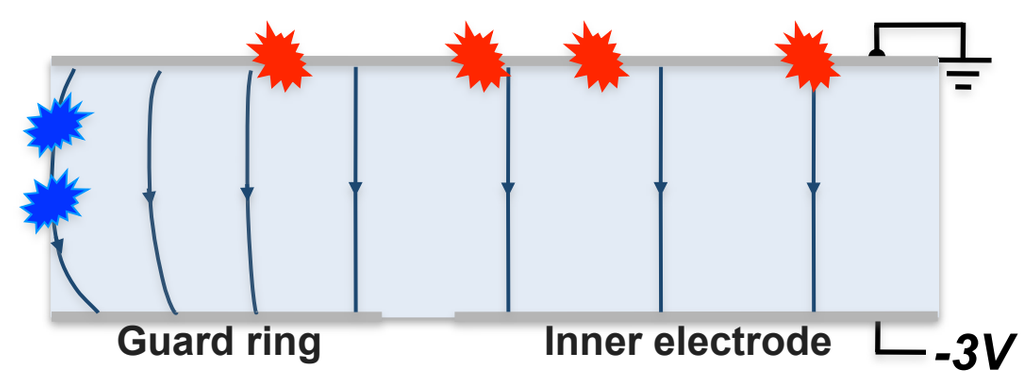
Bulk Electron Recoils

Surface Recoils

"Zero Yield" Sidewall Recoils

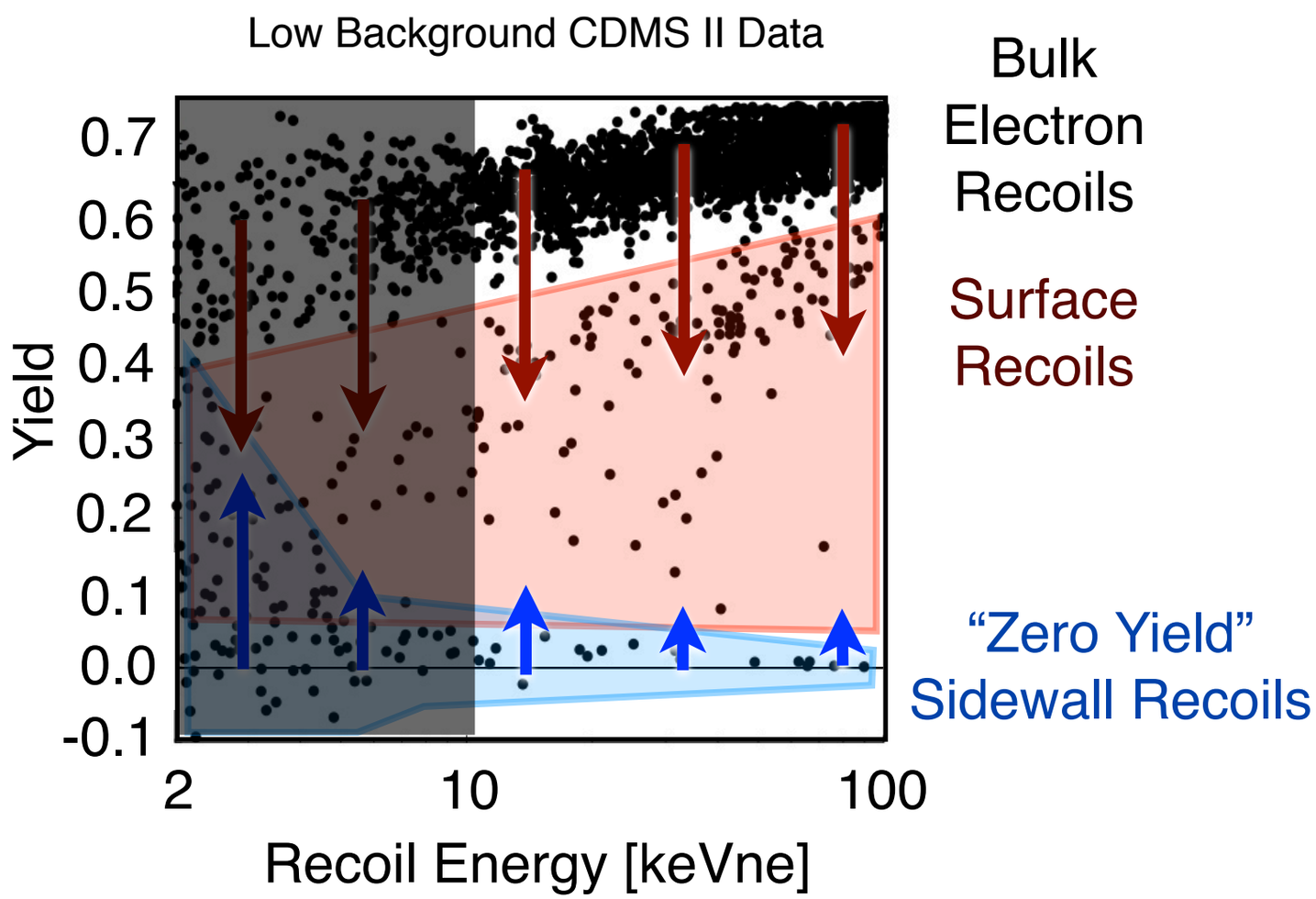
Example 2 keV Pulse

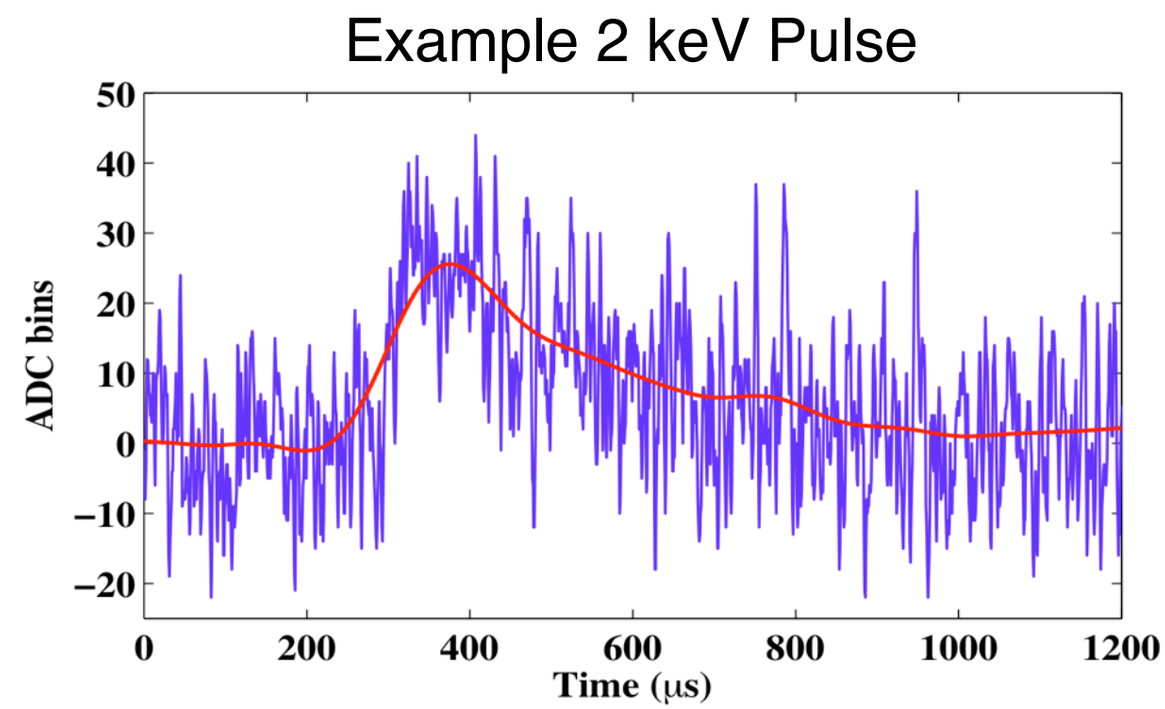


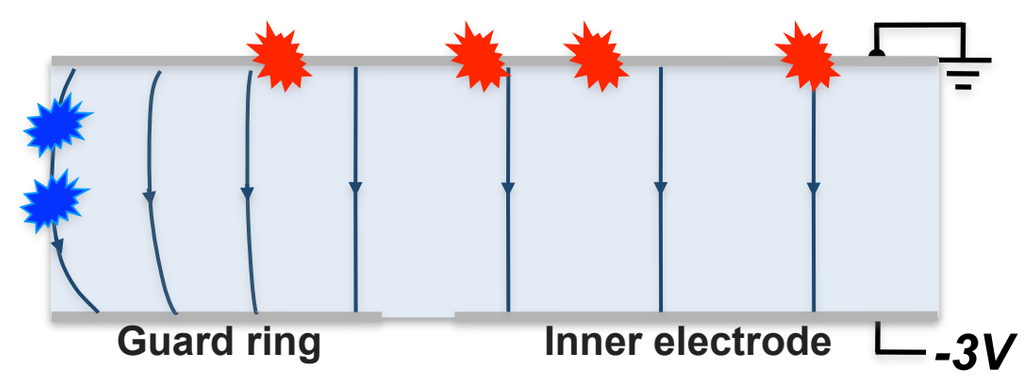


CDMS II at Low Energies

CDMS timing rejection fails below ~10 keV...



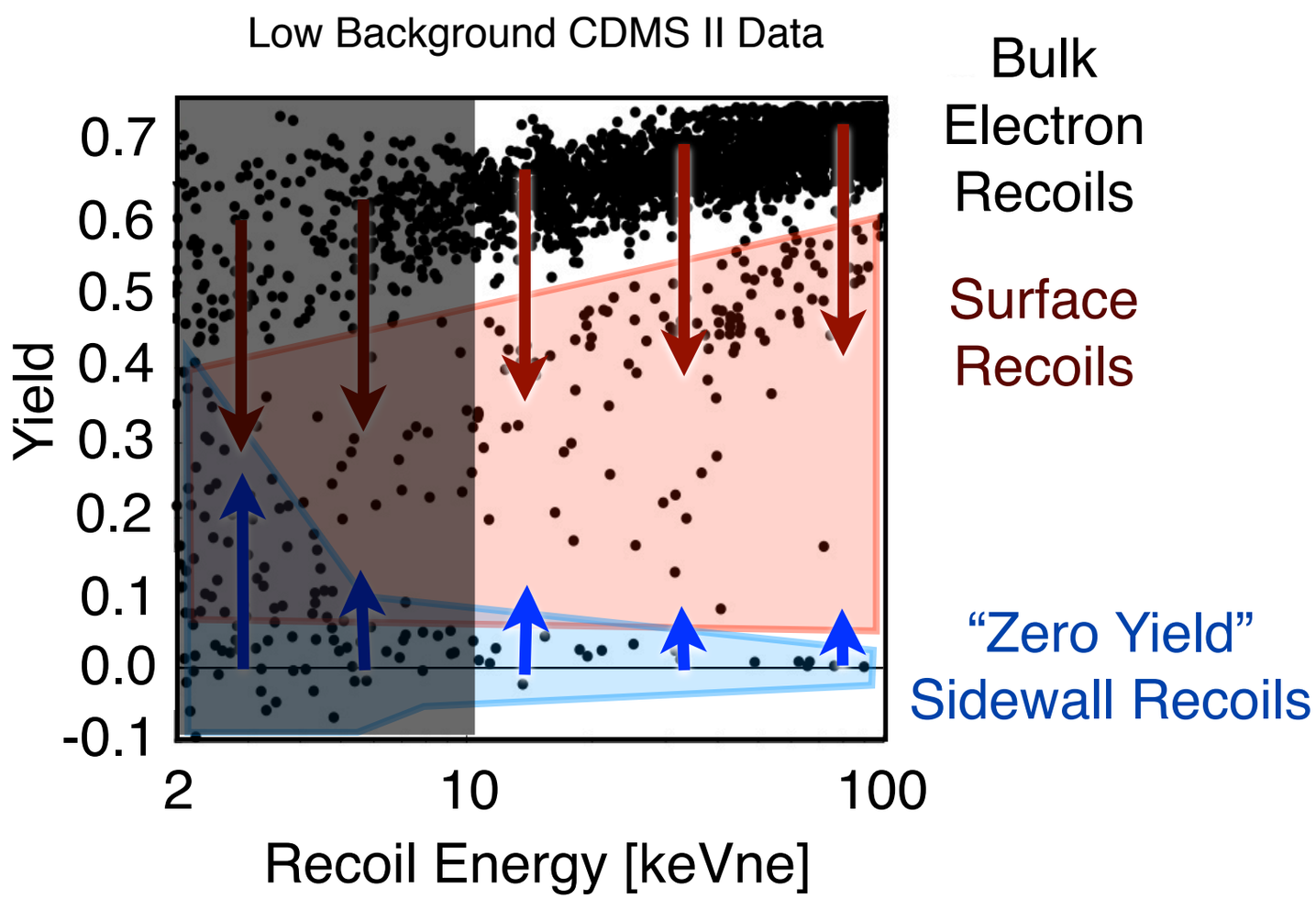


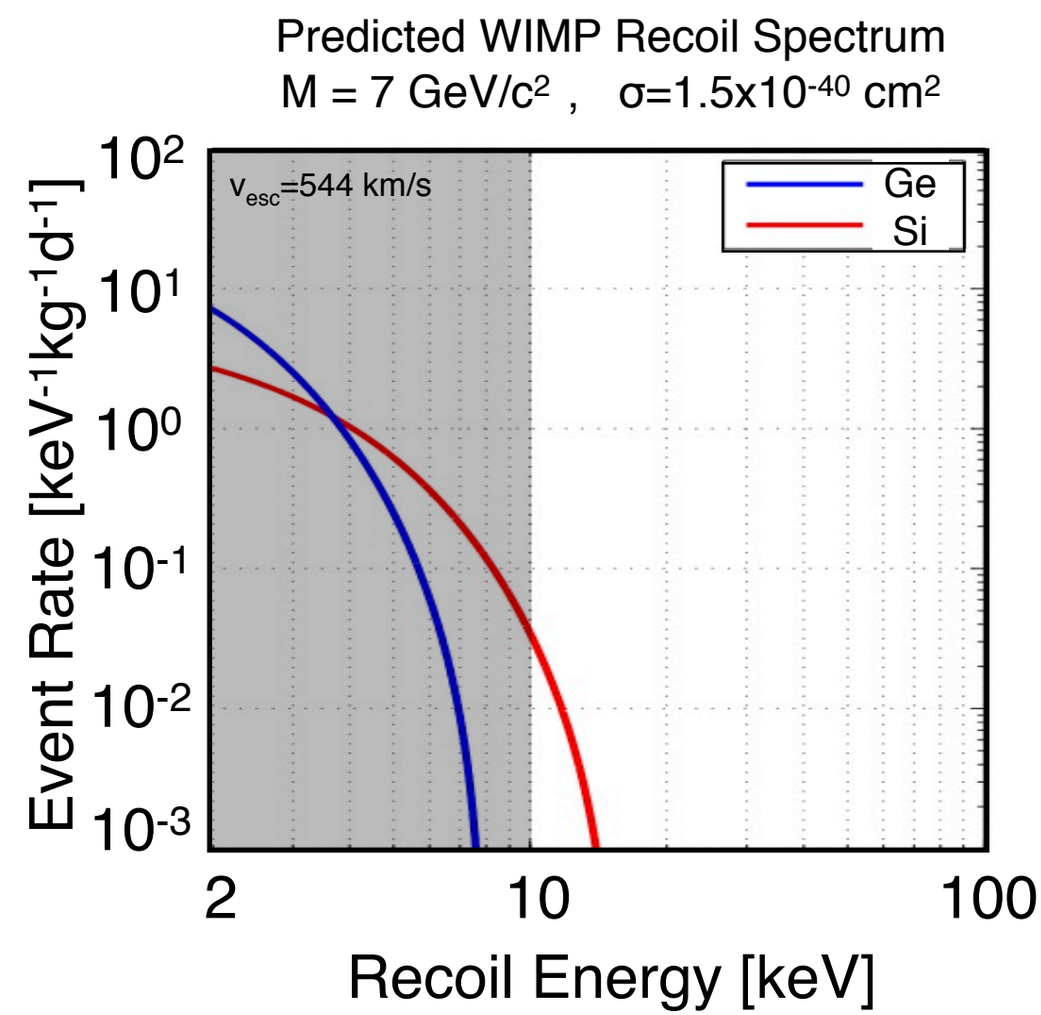


CDMS II at Low Energies

CDMS timing rejection fails below ~10 keV...

... which is precisely the 7 GeV WIMP signal region.





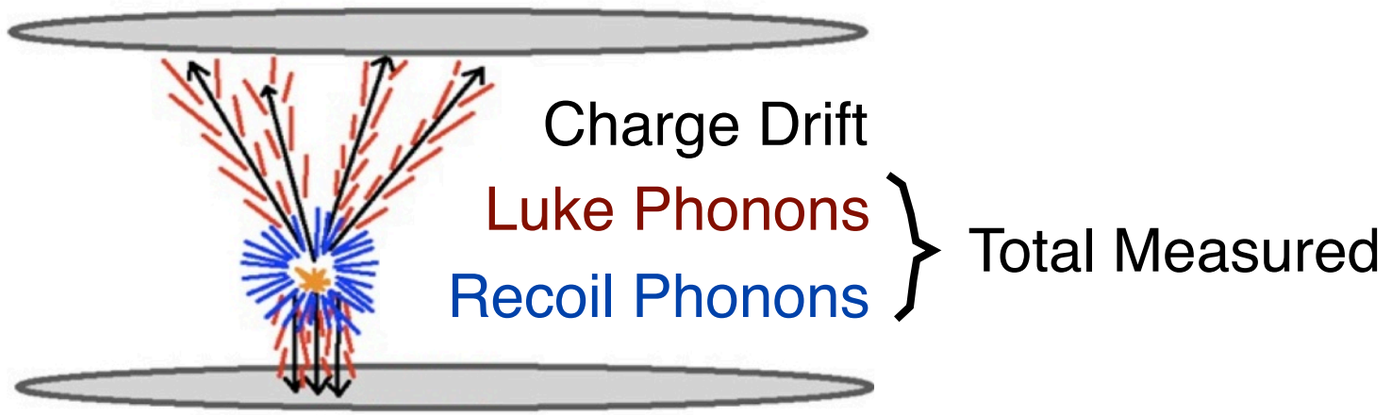
Low Threshold Analysis

2 keVne Threshold
→ Significant Background Rates

Used only 8 Ge detectors with the lowest trigger thresholds (1.5-2.5 keV)
(Yellin method "optimal gaps" happened to all be in a single detector)

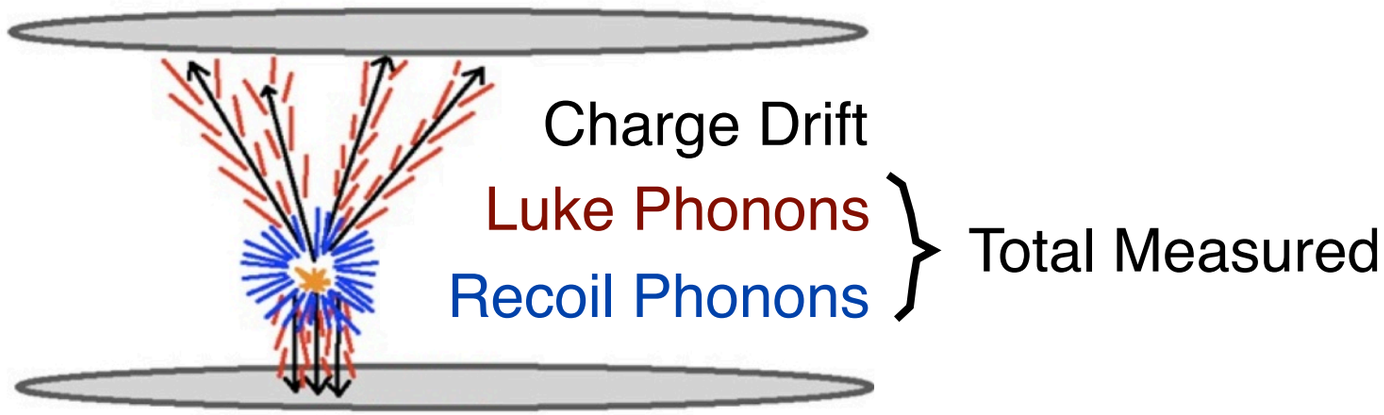
2006-2008 data randomly subdivided:
1/4 used to define cuts in yield
3/4 used to calculate limits (241 kg-days raw exposure)

The Nuclear Recoil Energy Scale



Recoil Energy = Measured - Luke
(Luke from charge measurement)

The Nuclear Recoil Energy Scale



Recoil Energy = Measured - Luke
(Luke from charge measurement)

Alternatively, we can eliminate charge noise
by assuming a particular yield...

Nuclear Recoil Energy = Measured x Scaling Factor

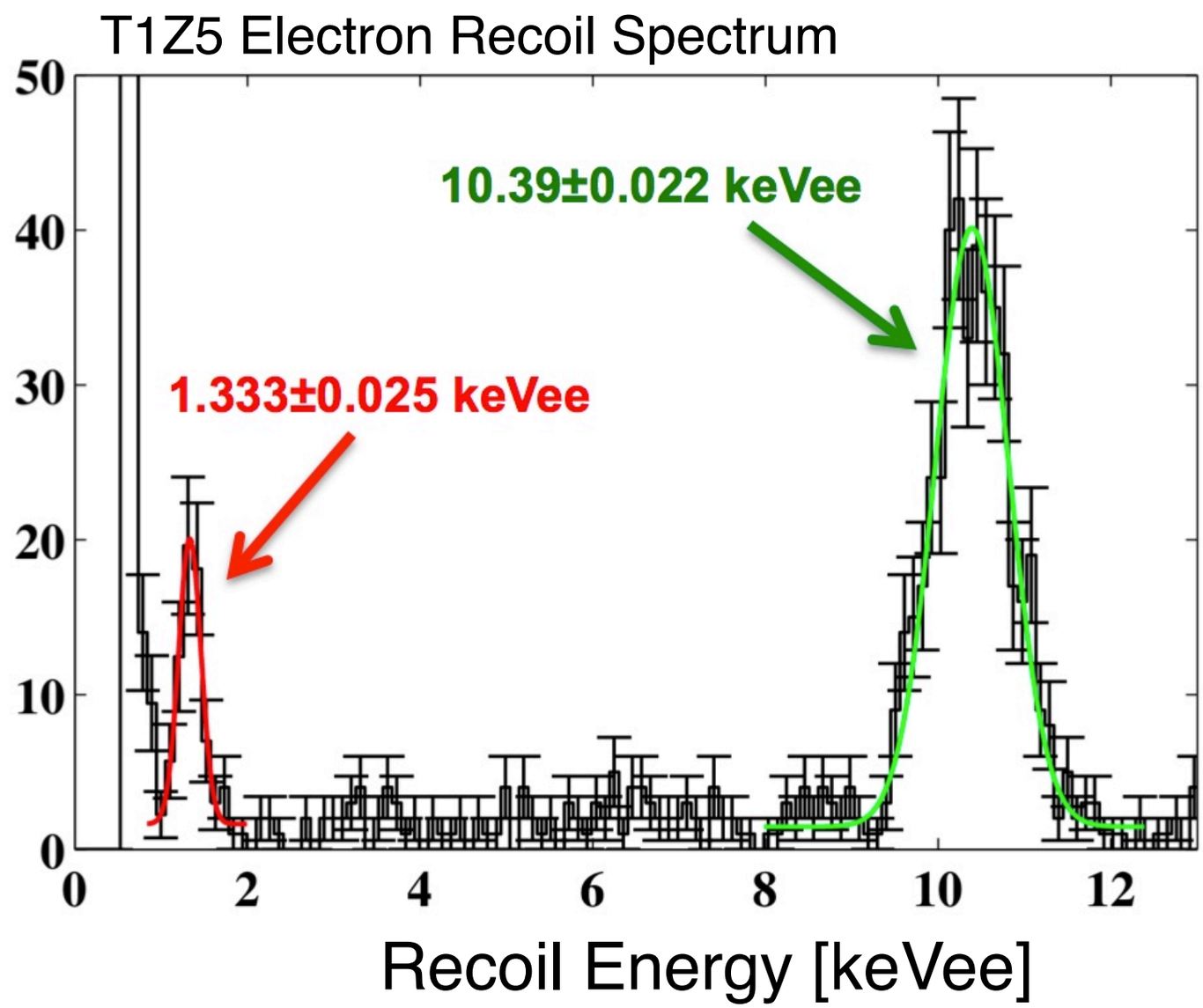
The Nuclear Recoil Energy Scale

Nuclear Recoil Energy = Measured x Scaling Factor

Step 1:

Calibrate the absolute scale using Ge activation lines.

The 1.298 keV line calibration was pushed in the conservative ***over***estimating direction to the 90% confidence level for each detector.

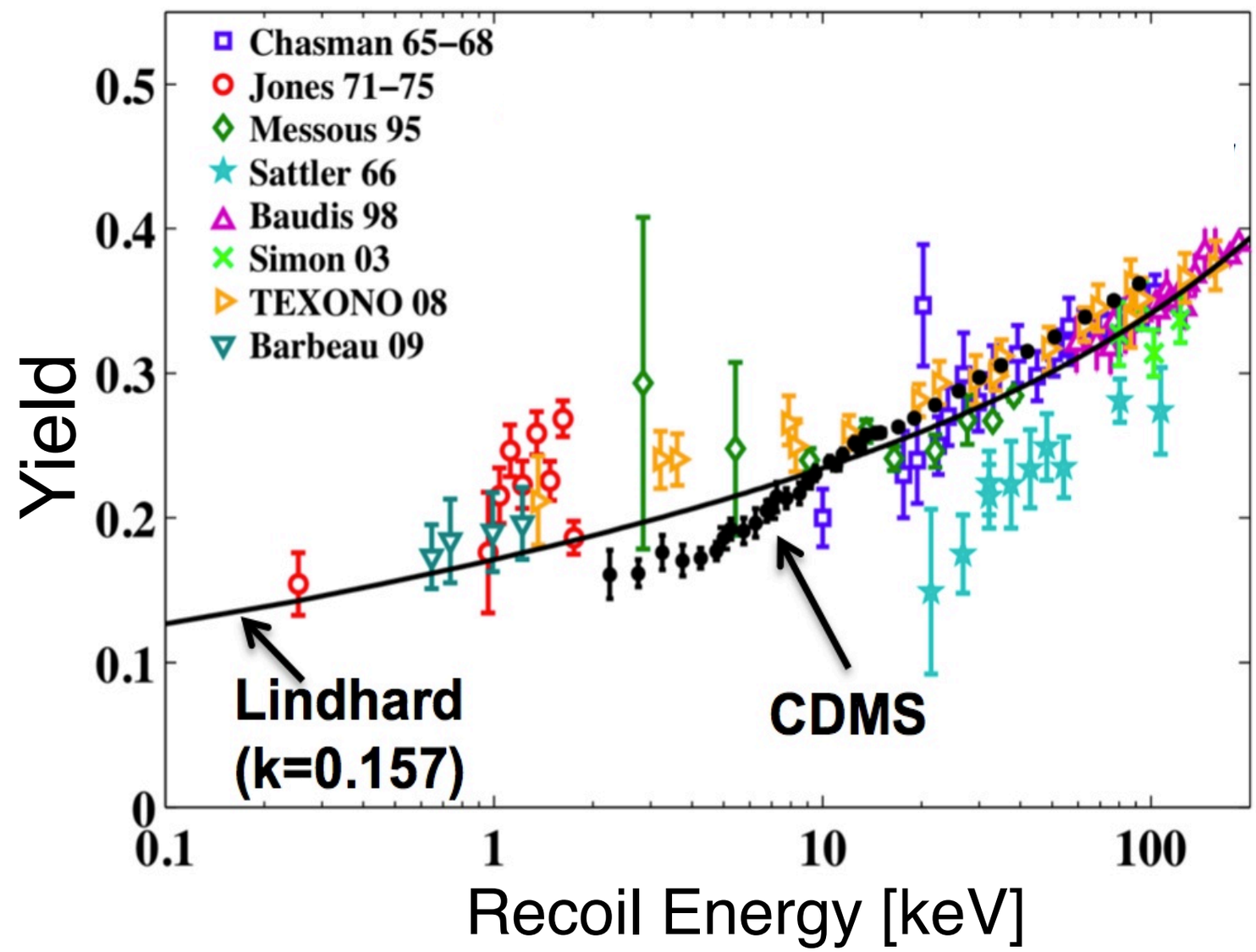


The Nuclear Recoil Energy Scale

Nuclear Recoil Energy = Measured x Scaling Factor

Step 2:
Define a nuclear recoil scaling factor.

Again conservatively, the slightly low yield seen by CDMS was used. If we are off, we are ***over***estimating phonon energy.

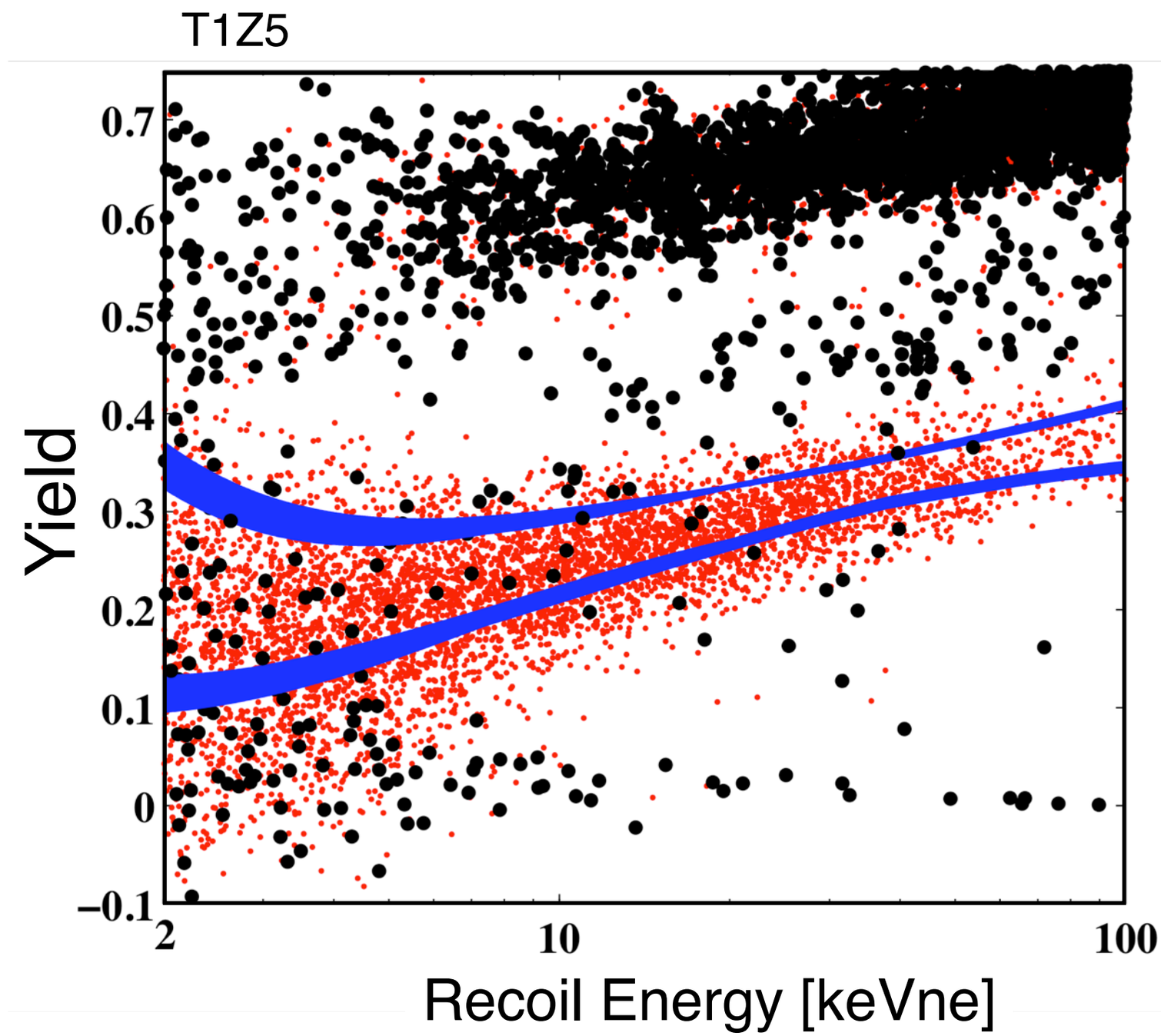


Nuclear Recoil Yield Band Definition

Extrapolating backgrounds into the signal region, it was found that

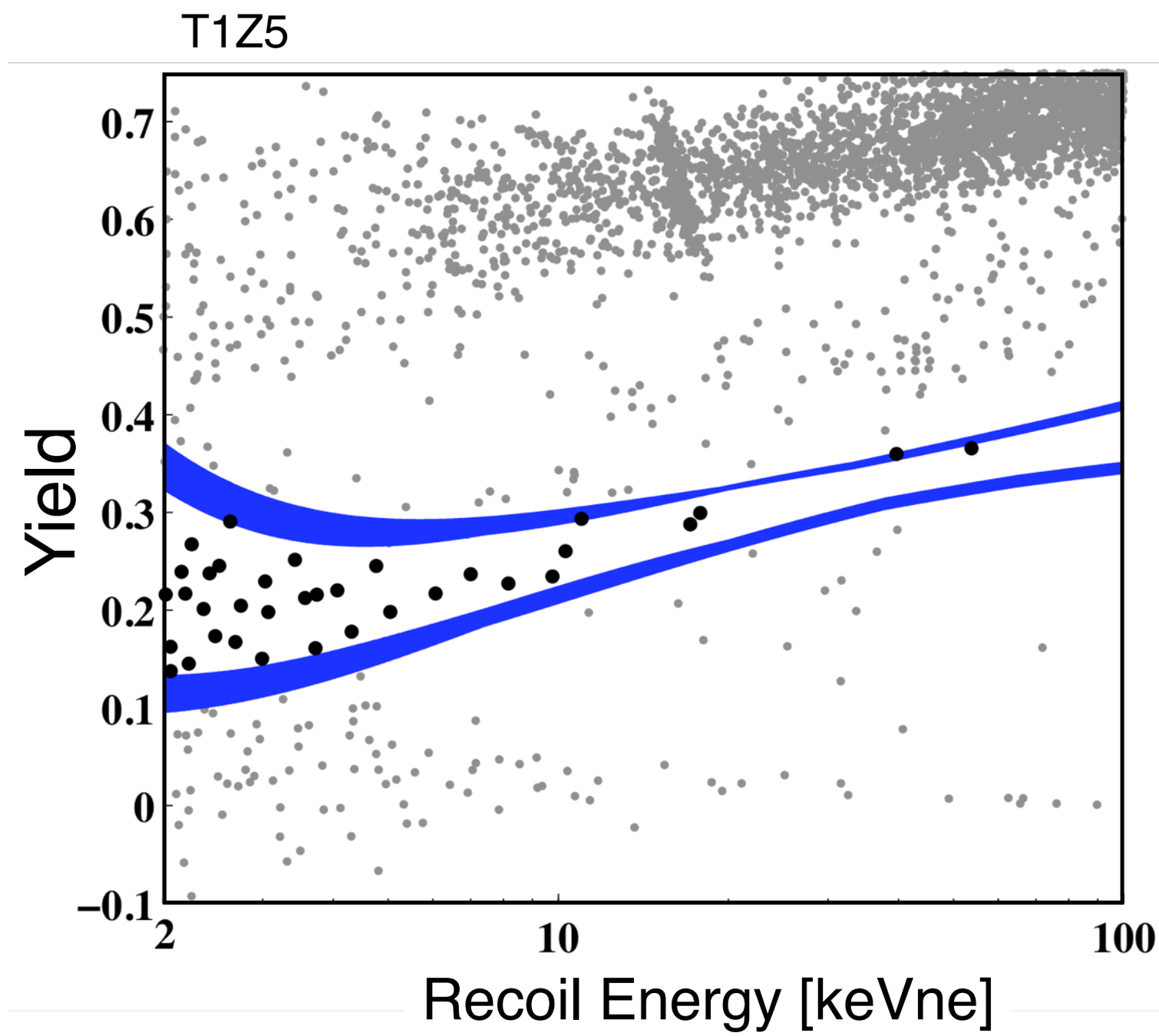
-0.5σ to +1.25σ

maximizes reach.



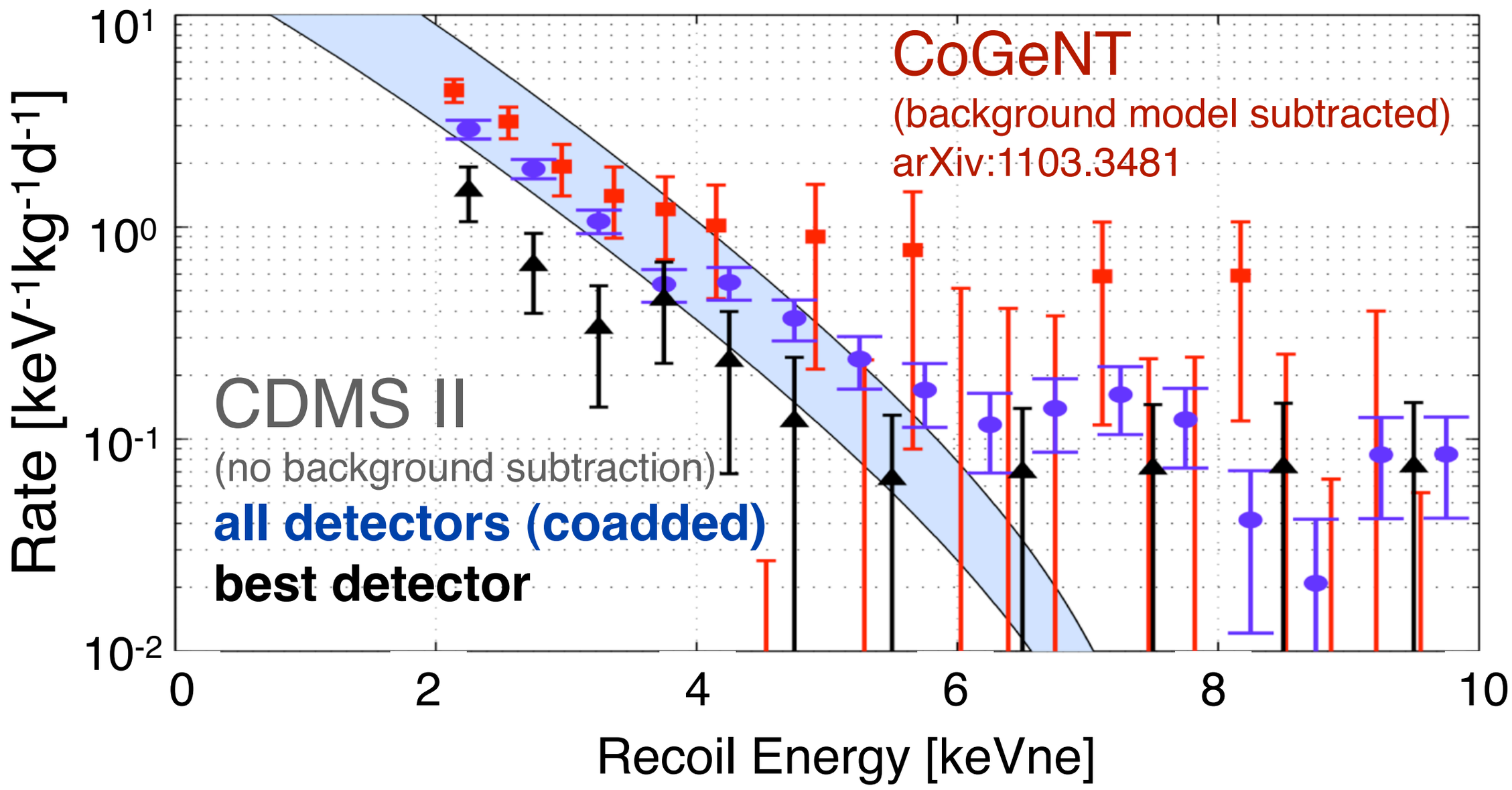
Event Selection

The events within the band are the WIMP candidates.



Spectra

*Blue Region: Hooper et al., PRD **82** 123509 (2010)*
***mχ*=7 GeV/c² (90% CL) σSI~7x10-41 – 2x10-40 cm2**



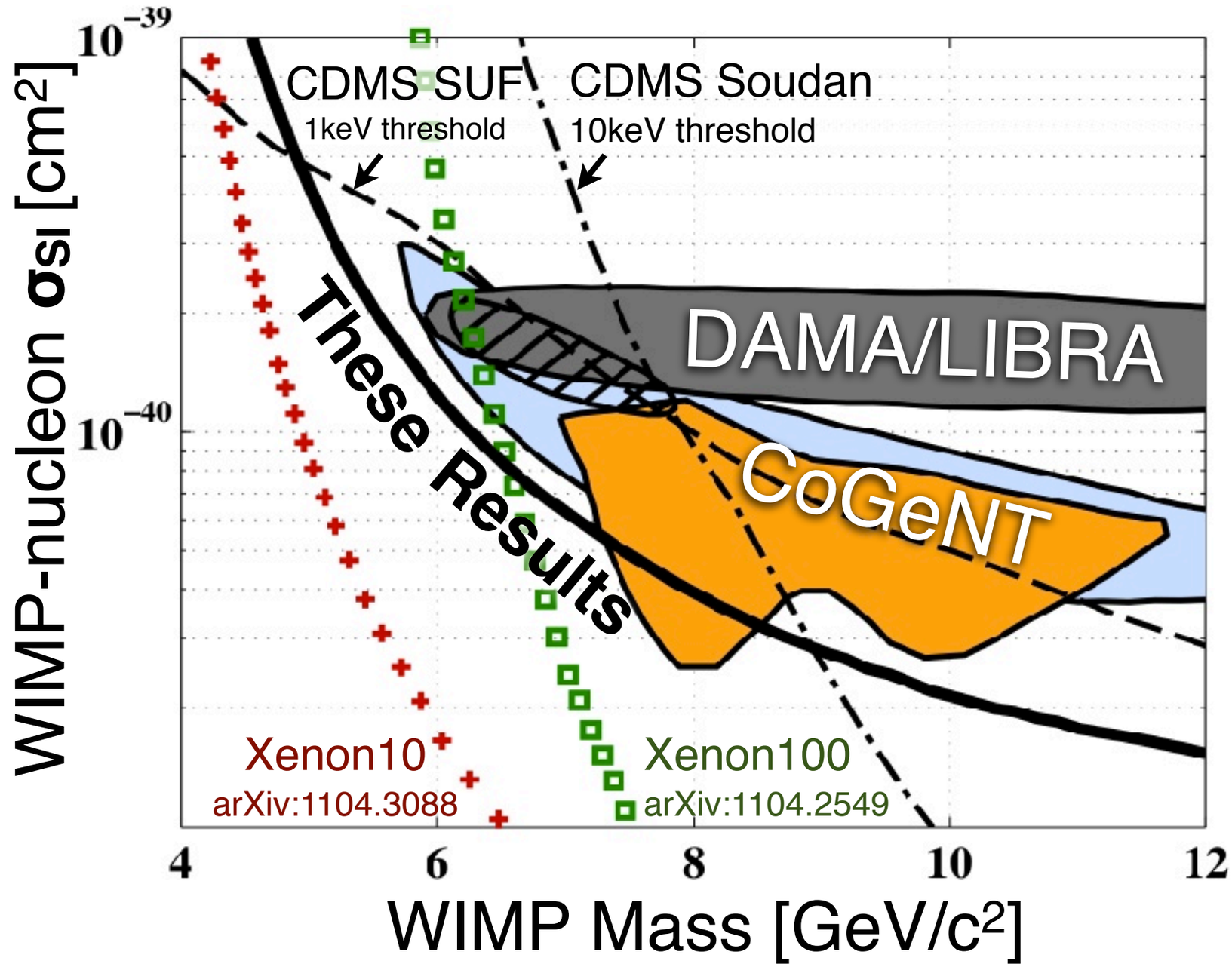
Limits

Conservatively assume all candidates may be WIMPs. (ie, no background subtraction)

Limit defined using optimum interval method
S. Yellin, PRD, 66, 032005 (2002)
arXiv:0709.2701v1 (2007)

Spin-independent elastic scattering WIMP interpretation ruled out for joint DAMA/CoGeNT region.

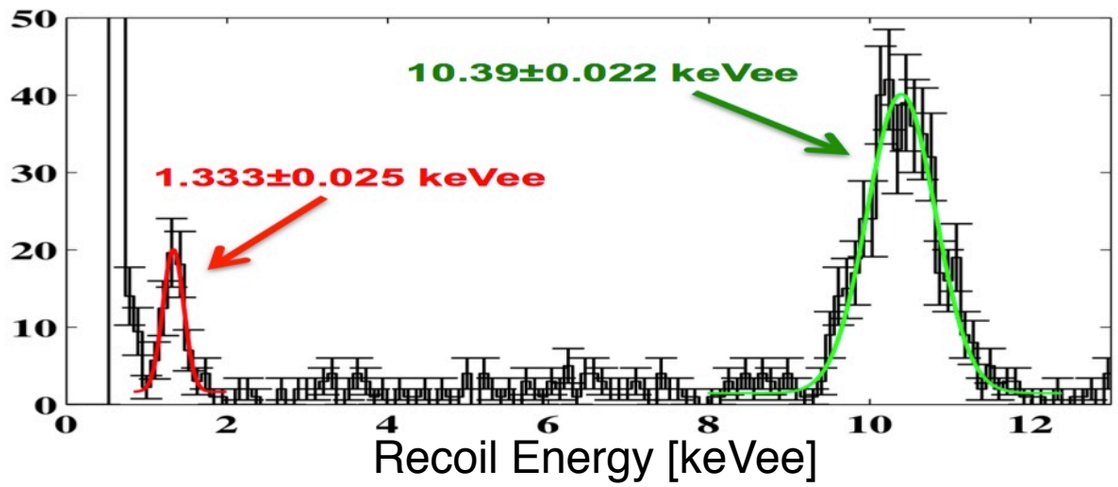
A portion of the CoGeNT region remains, where only a small fraction of the excess is WIMP recoils.

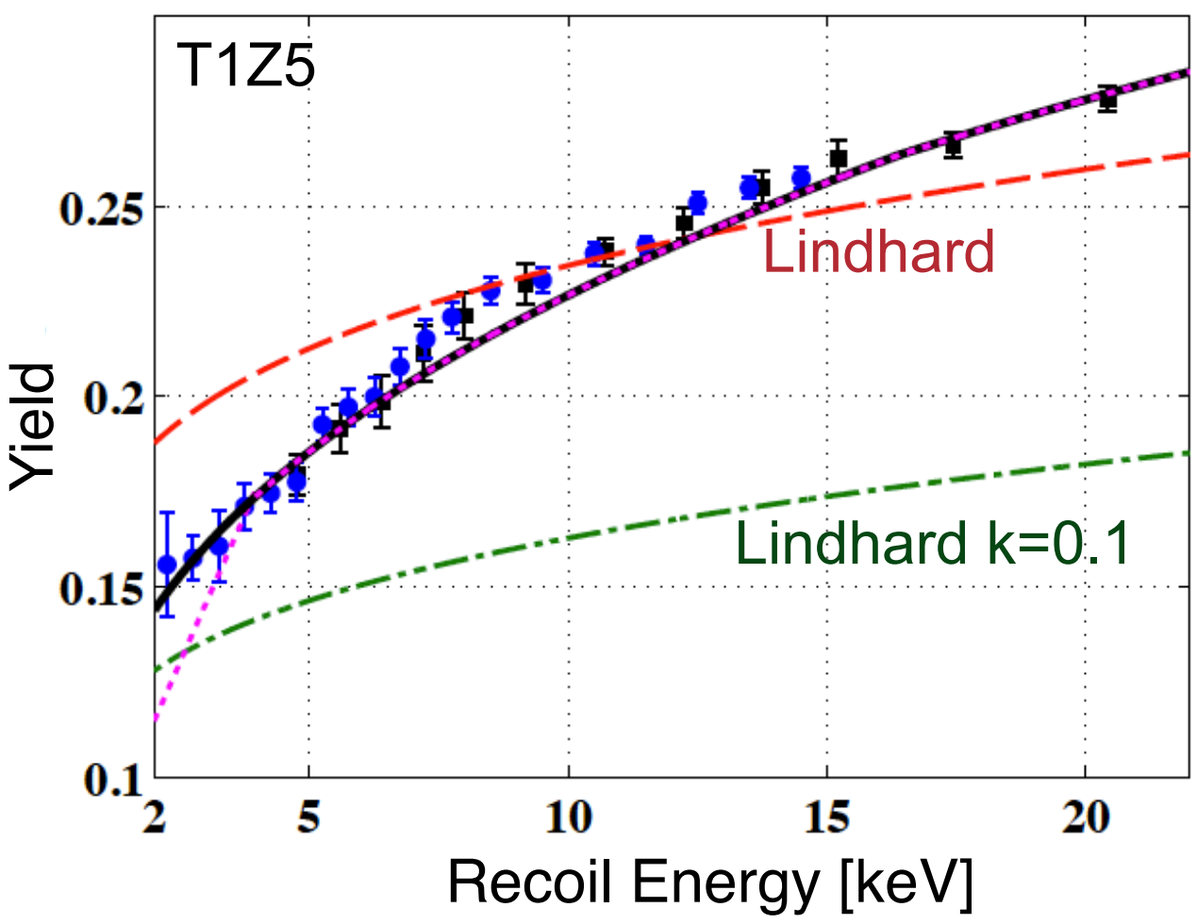


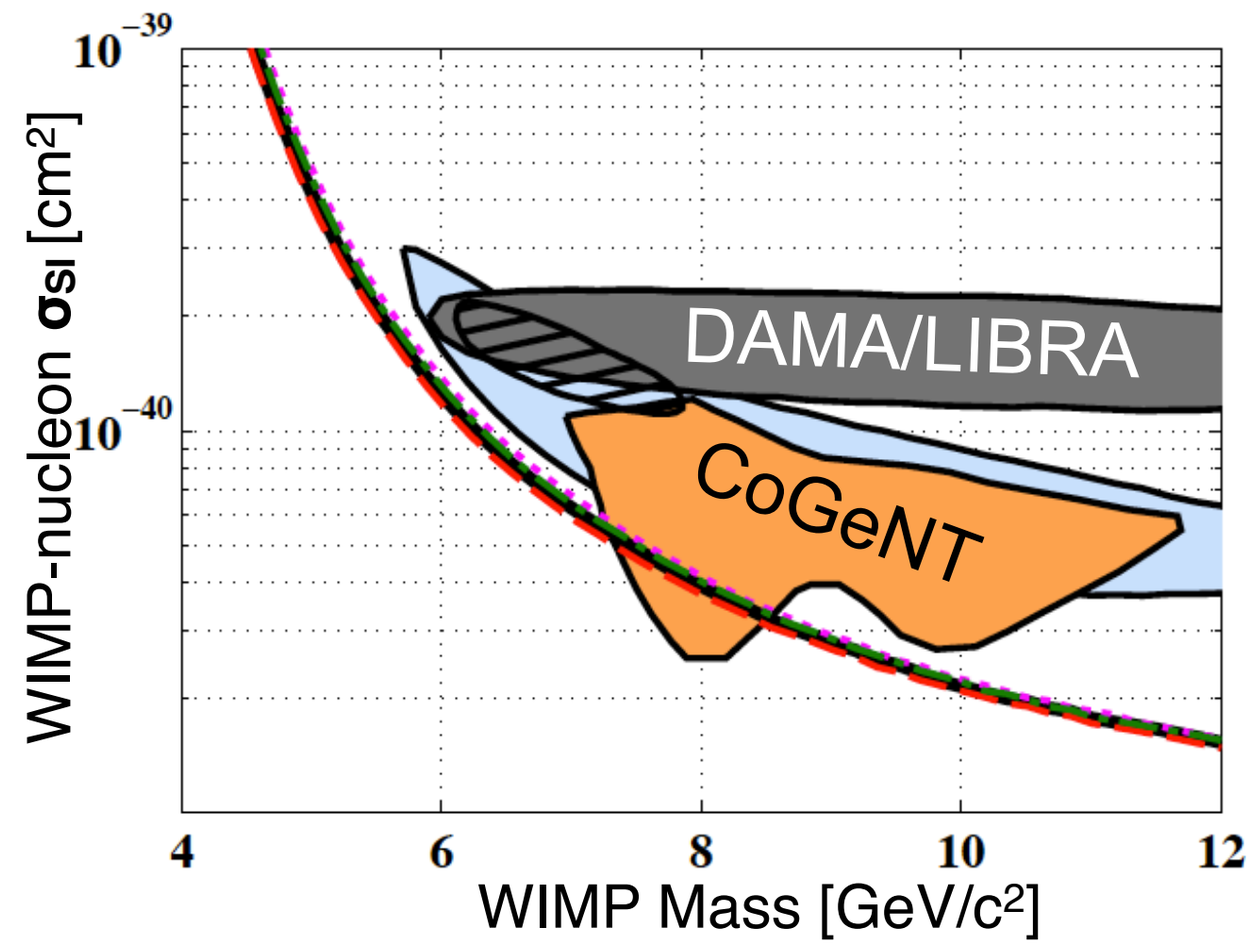
DAMA/LIBRA, light blue CoGeNT region, and combined region: *Hooper et al., PRD* ***82*** *123509 (2010)*

Varying the Nuclear Recoil Energy Scale

T1Z5 Electron Recoil Spectrum

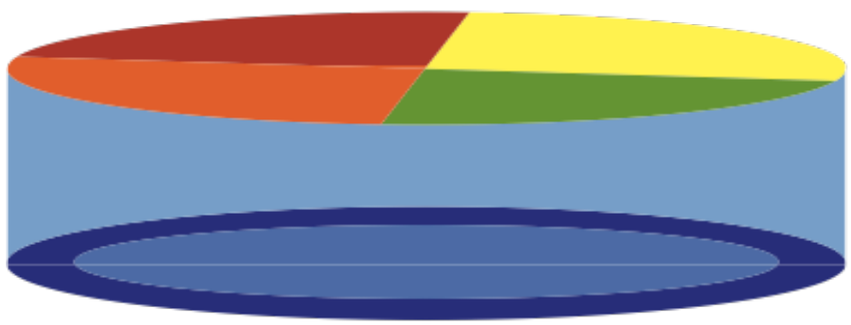




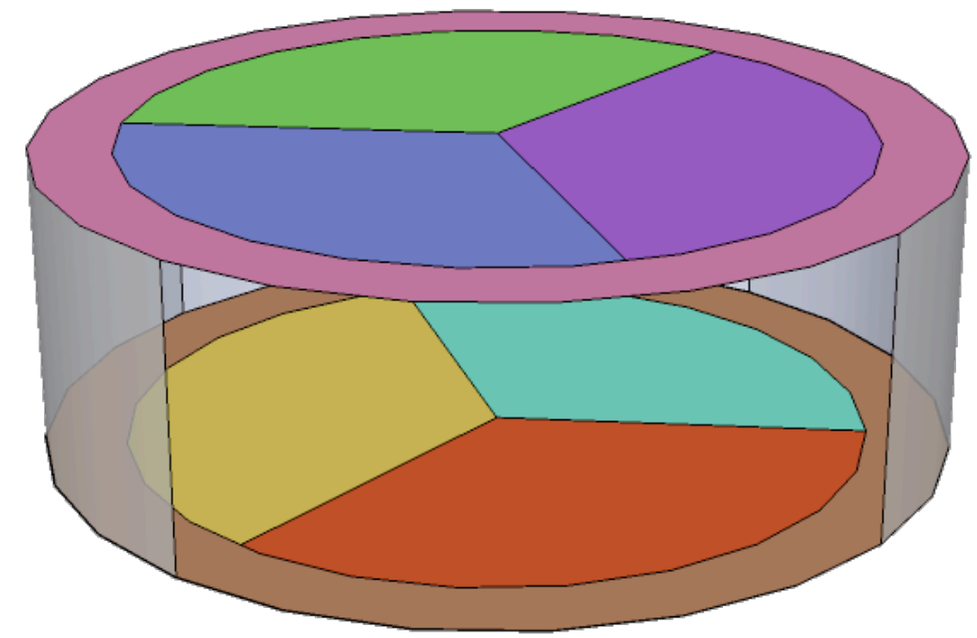


SuperCDMS

Four Phonon Channels

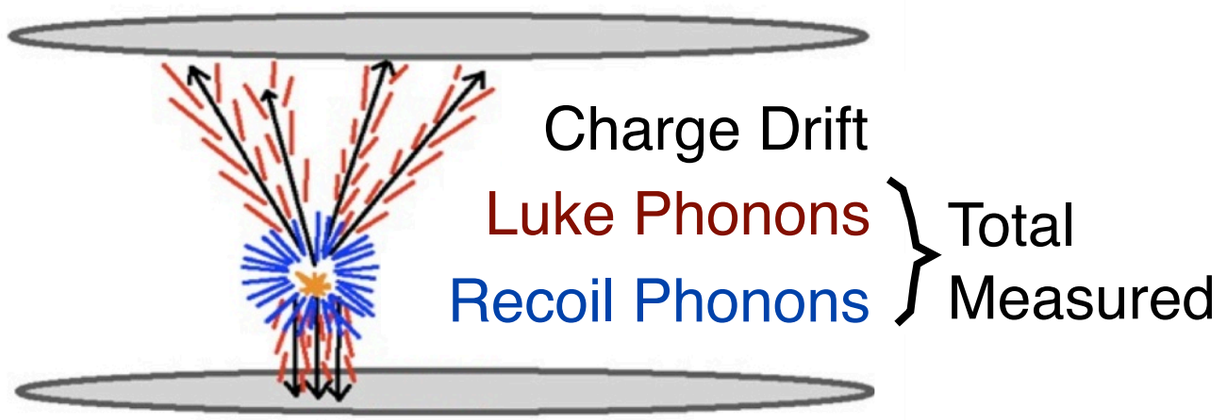


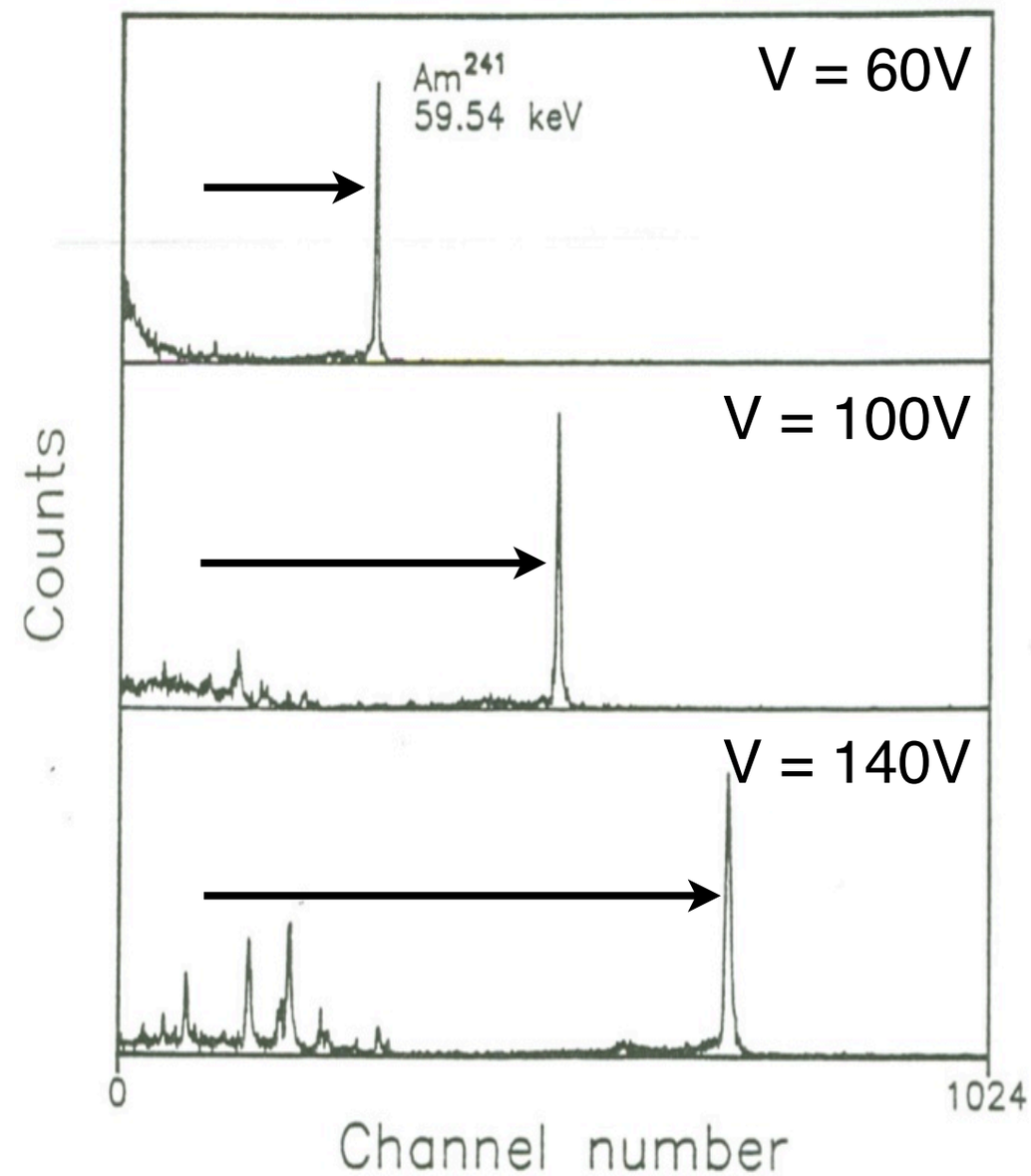
Eight Phonon Channels



Fiducial volume definition is much more stringent, and can be phonon-only.

Luke Phonon Gain





Background rejection destroyed, but threshold greatly lowered (~50eV so far).

Luke et al., Nucl. Inst. Meth. Phys. Res. A, 289, 406 (1990)

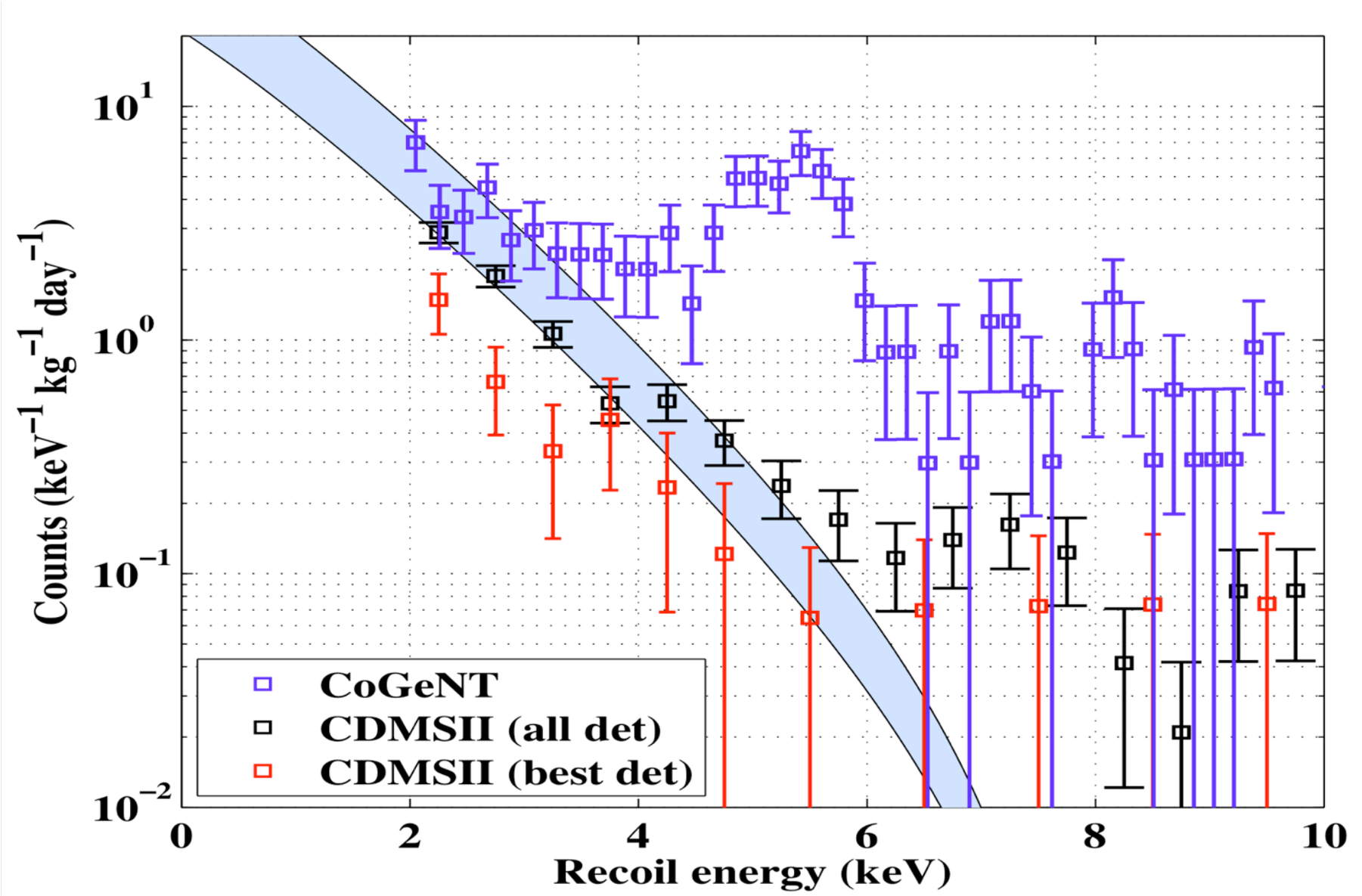
Conclusions

A low-threshold, non-zero-background analysis of the CDMS II exposure is inconsistent with the light wimp interpretation of DAMA/CoGeNT.

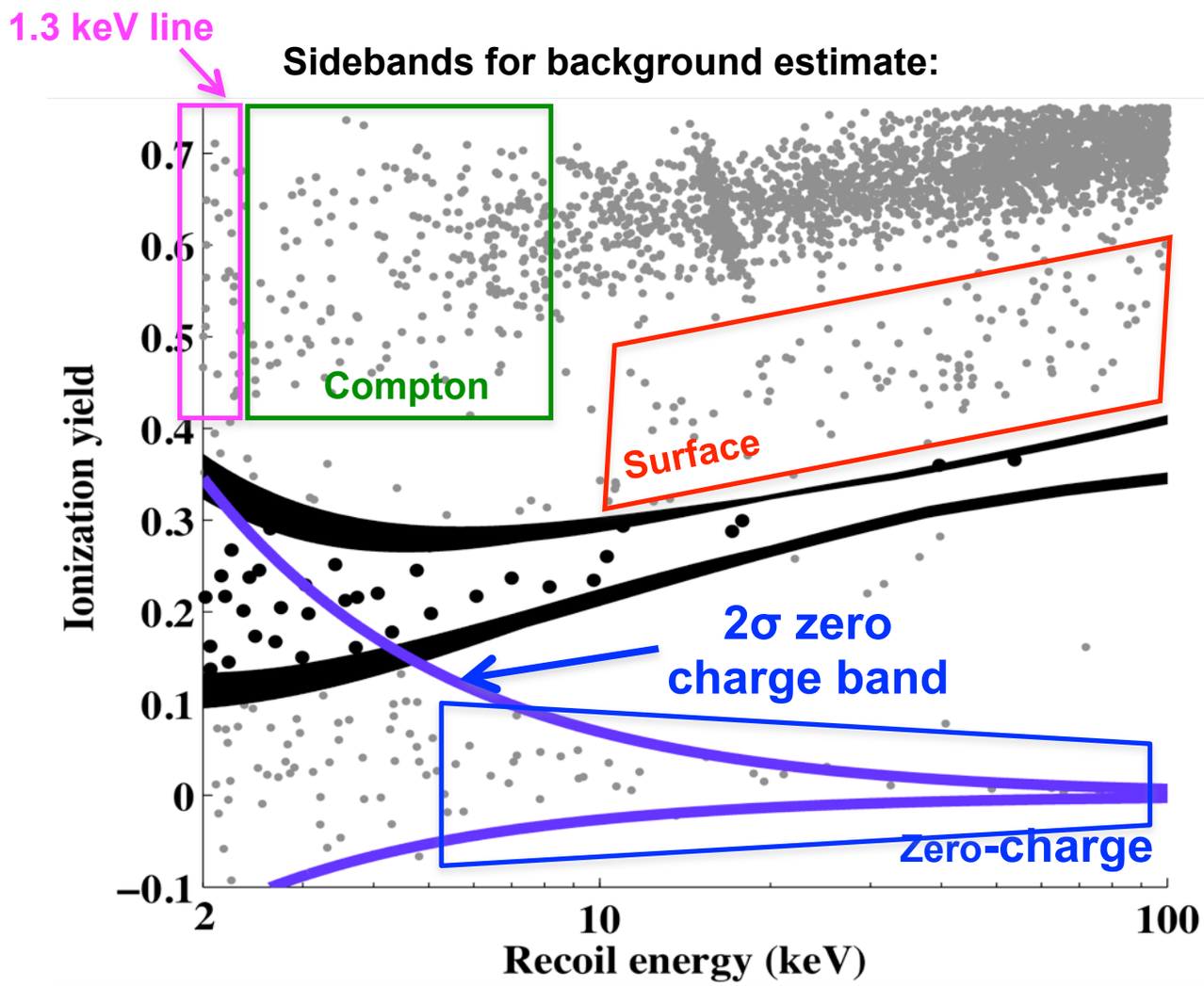
Future detectors will probe the light mass region significantly more effectively.

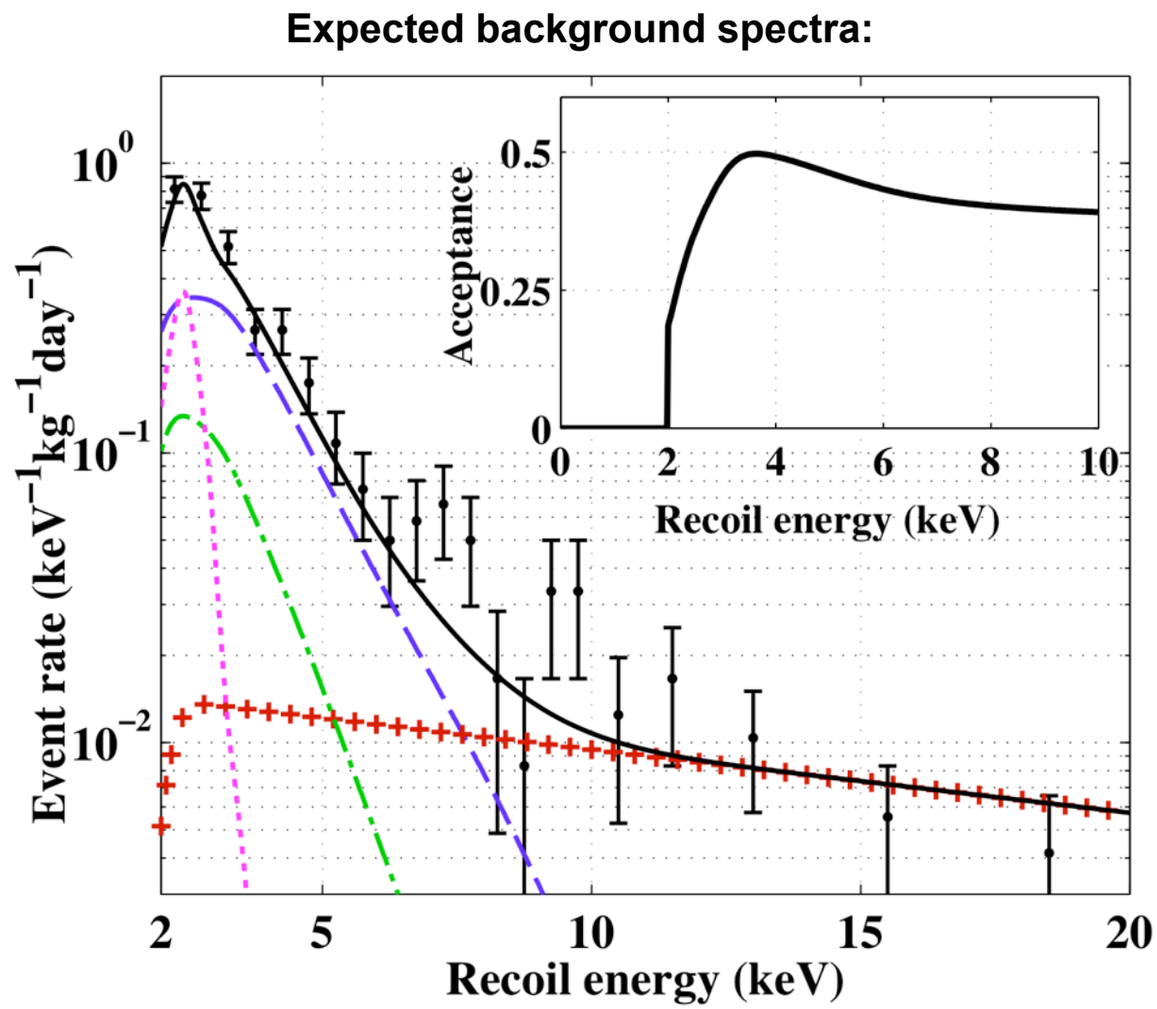
Extra Slides

No CoGeNT Background Subtraction

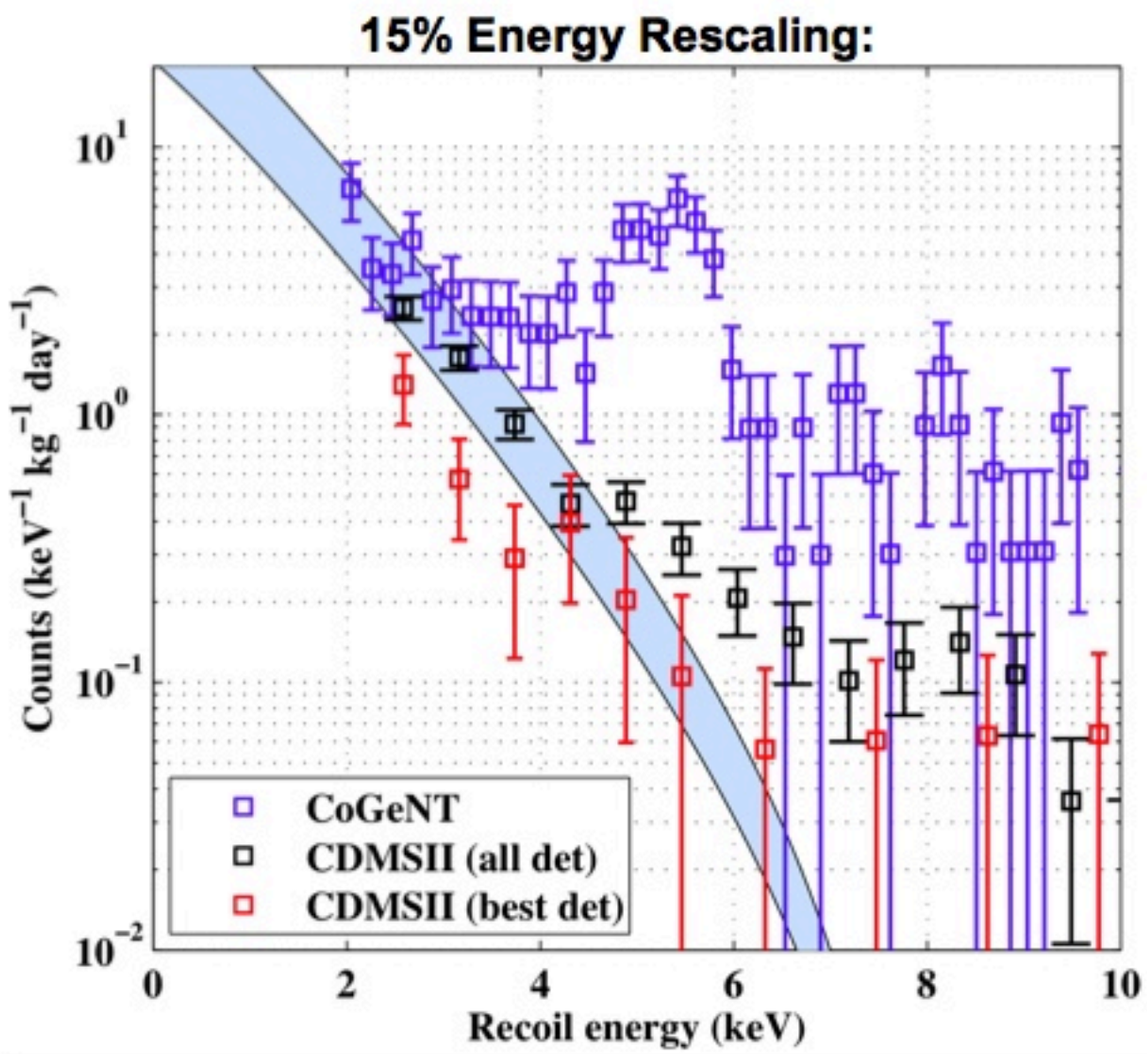


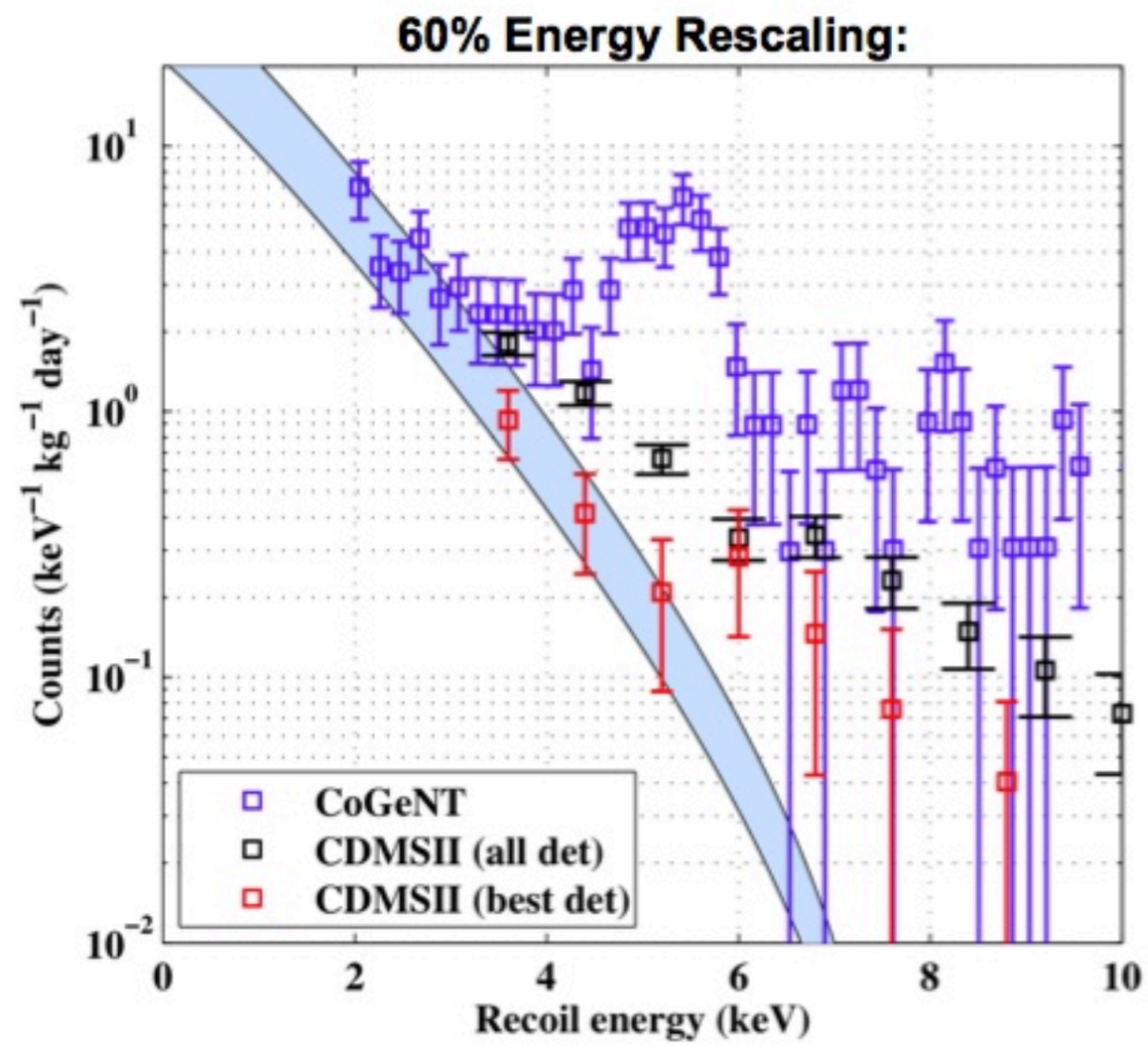
Extrapolating CDMS Backgrounds



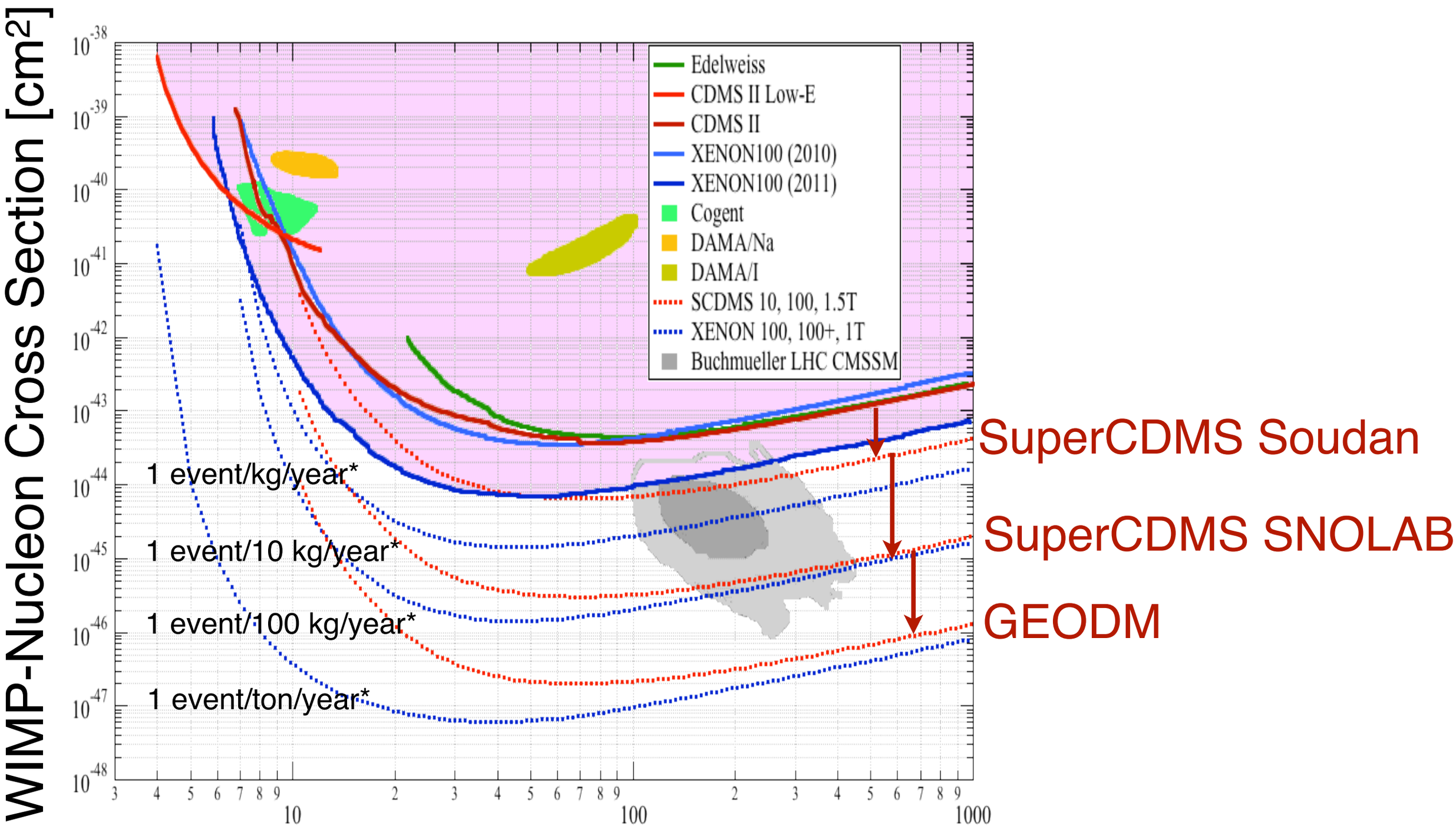


How far do we need to push the energy scale for agreement?





Experimental Outlook



*for a 100 GeV/c² WIMP on Ge target with a 10 keV low energy threshold