Low Energy WIMP Search Results from CDMS

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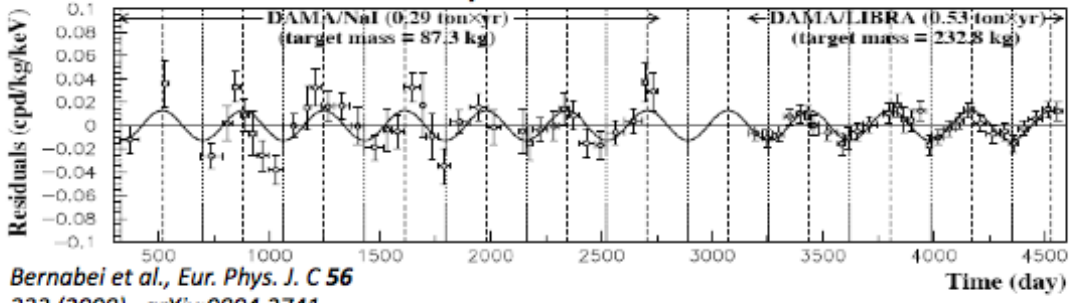
Slide material contributed by David Moore

Low Mass WIMPs

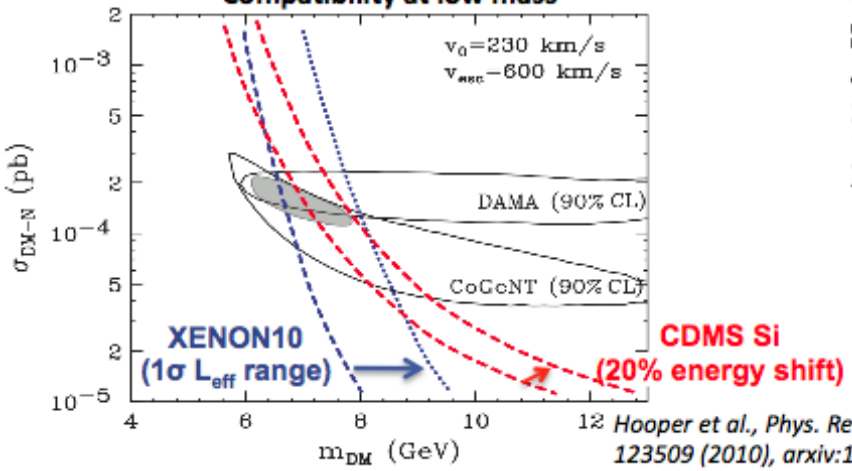
- Results from DAMA/LIBRA, CoGeNT, and others have been interpreted as evidence for elastic scatters from light WIMPs

DAMA/LIBRA annual modulation



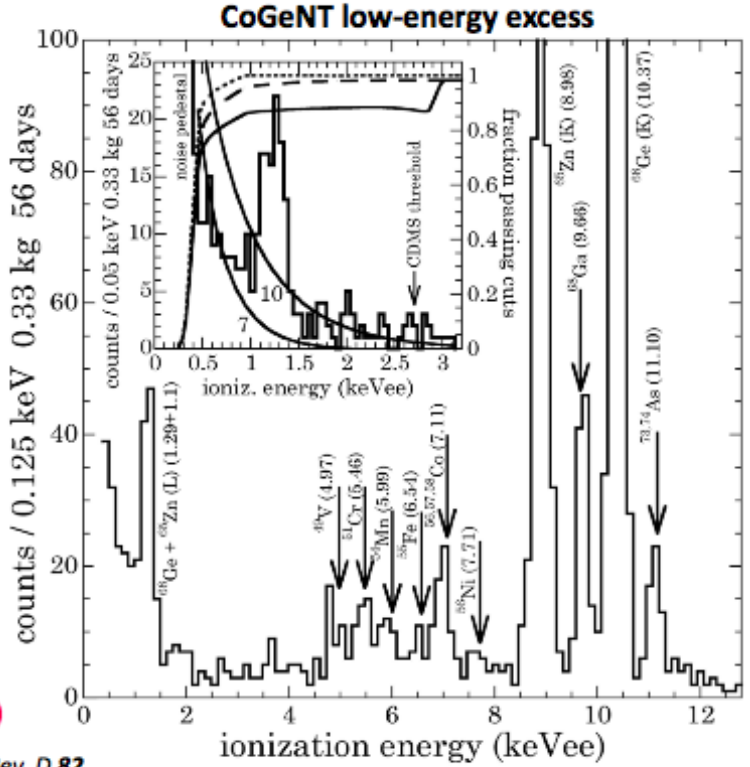
*Bernabei et al., Eur. Phys. J. C **56** 333 (2008), arXiv:0804.2741*

Compatibility at low mass



*Hooper et al., Phys. Rev. D **82**, 123509 (2010), arxiv:1007.1005*

CoGeNT low-energy excess

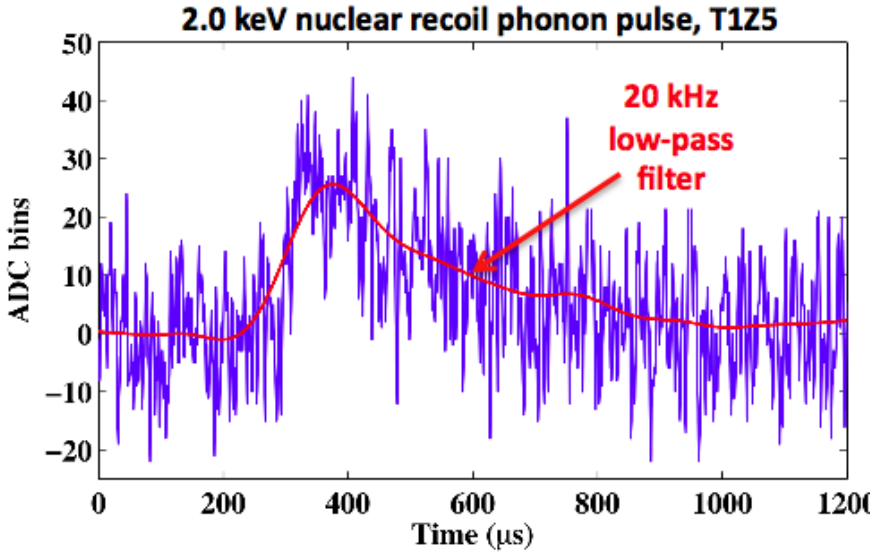


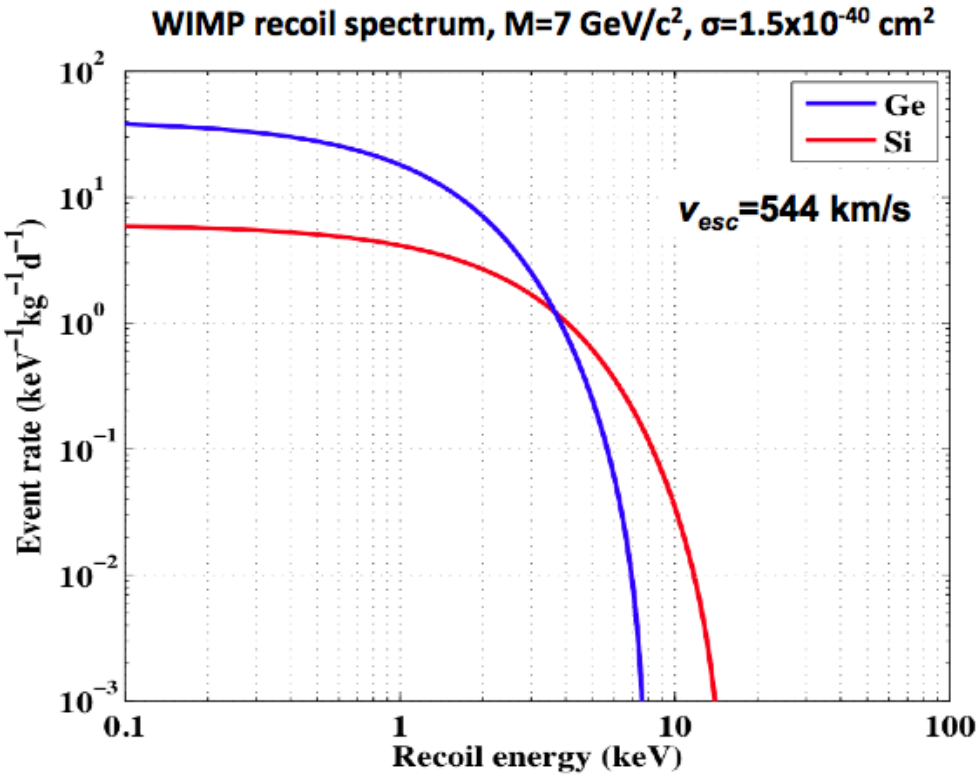
Aalseth et al., arXiv:1002.4703

- Possibly compatible with null results from CDMS Si and XENON due to calibration uncertainties at low energy

Lowering the CDMS Threshold

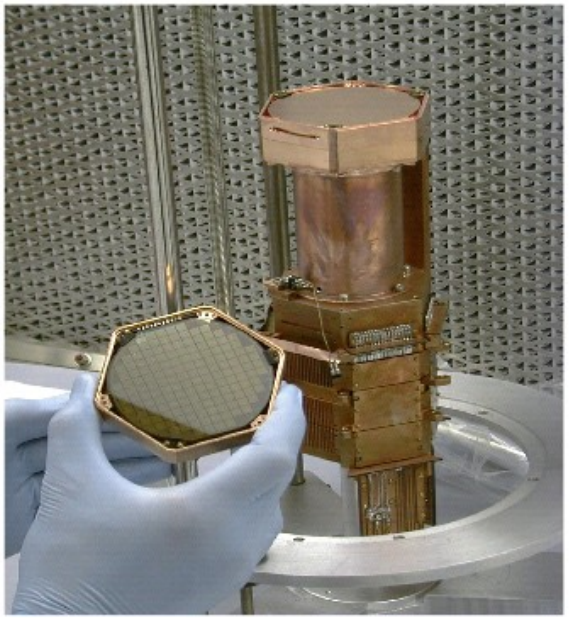
- Lowering analysis threshold below 10 keV yields sensitivity to low mass WIMPs in region of contention.
- The cost = sacrifice some background rejection due to worsening timing resolution. Accept > 1 event background.





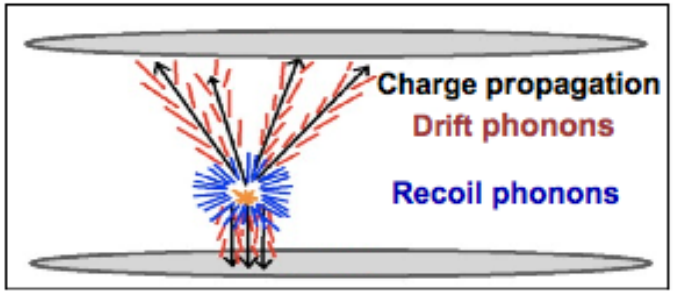
Low Threshold Dataset

- Soudan data from Oct. 2006-Sept. 2008 reanalyzed with 2 keV recoil energy threshold
- Used 8 Ge detectors with lowest trigger thresholds (1.5-2.5 keV)
- Small subset (1/4 of the data) used to study backgrounds at low energy
  - Limits calculated from remaining 241 kg-day raw exposure
  - Results driven by detector with best resolution (T1Z5)
- Measure both ionization and phonons to discriminate against low-energy electron recoil backgrounds

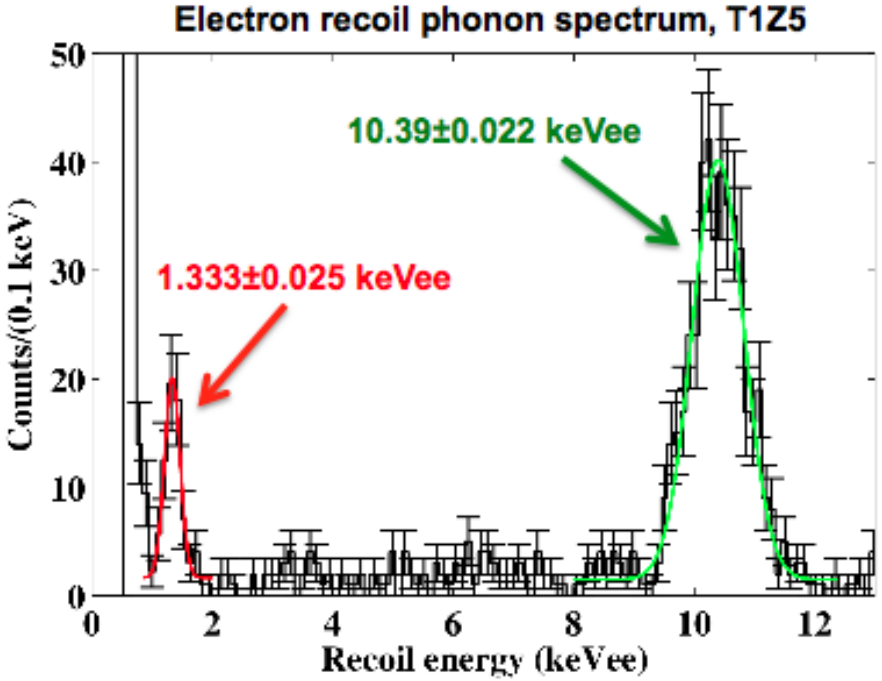


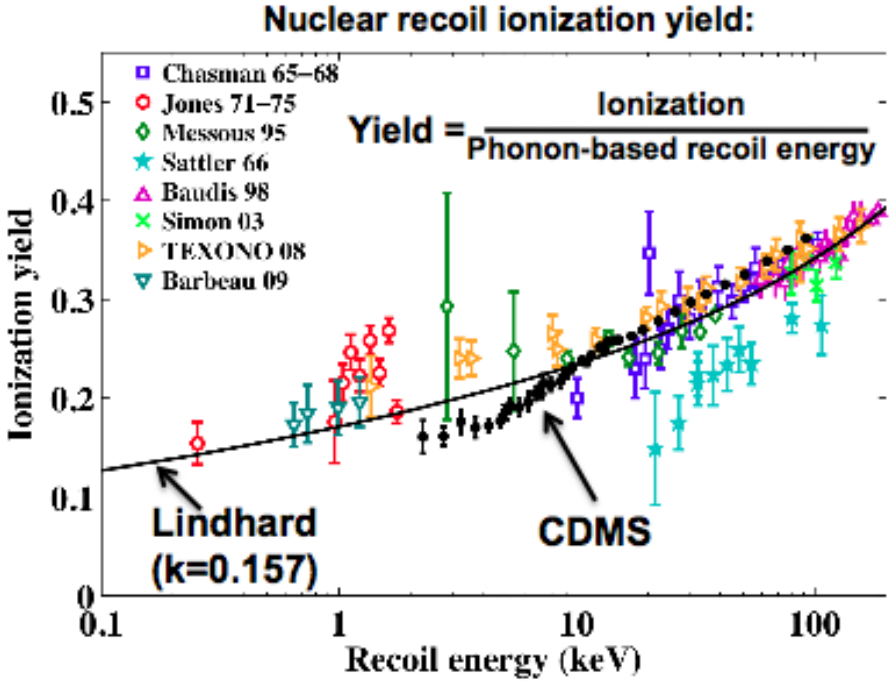
Energy Calibration

- Phonon energy scale calibrated with electron recoil lines at 1.3 keV and 10.37 keV
- Nuclear recoil energy reconstructed from phonon signal alone after subtracting Neganov-Luke phonons (~15% of signal)



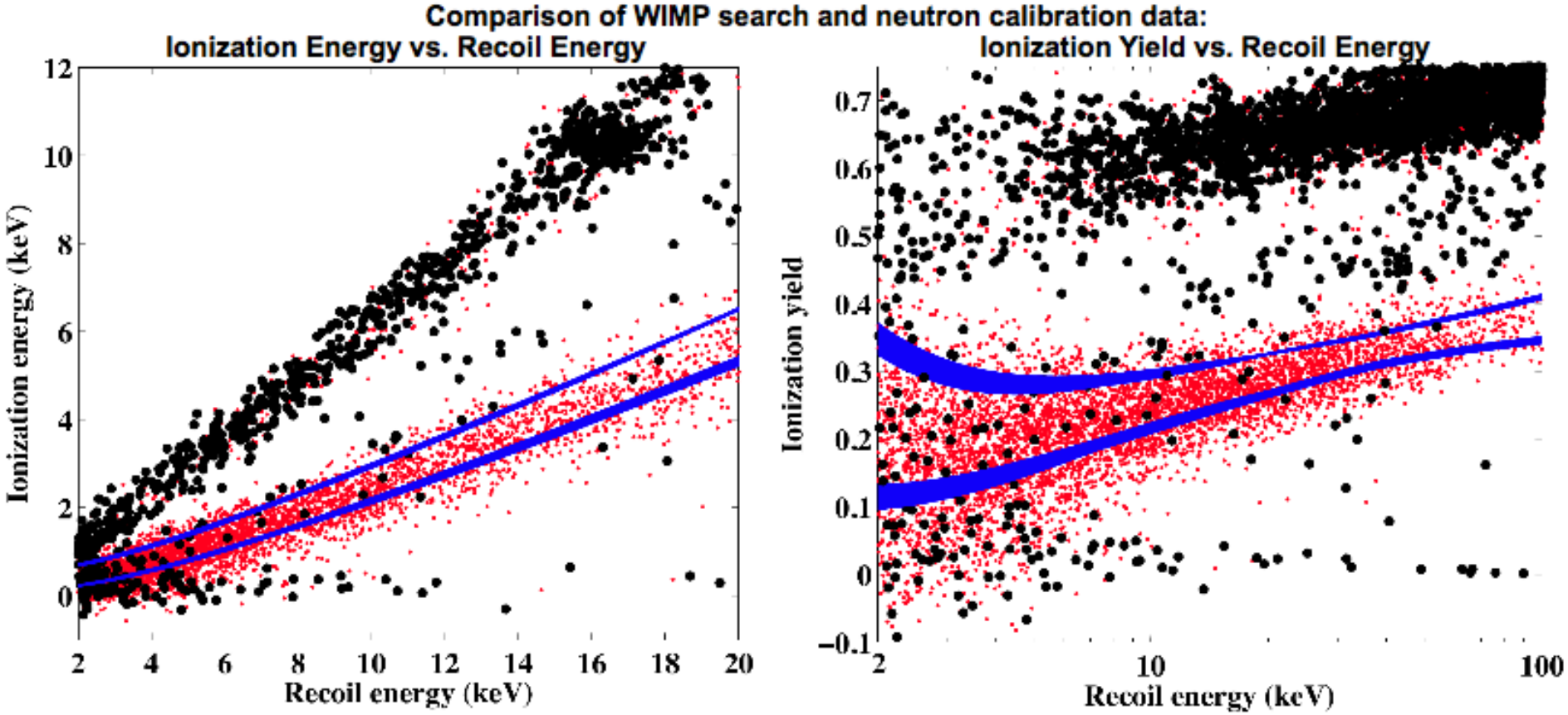
*Neganov and Trofimov, Otkryt. Izobret., **146**, 215 (1985)*
*Luke, J. Appl. Phys., **64**, 6858 (1988)*





Candidate Events

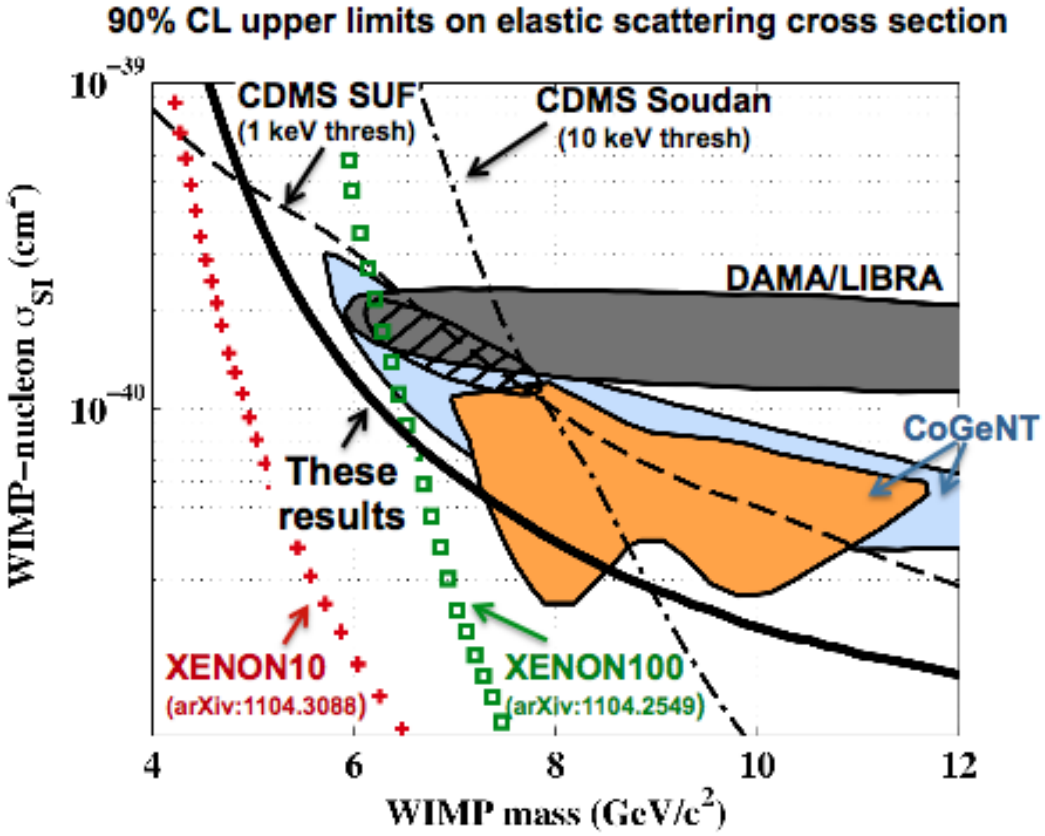
- Nuclear recoil acceptance region defined as (+1.25,-0.5)σ band in ionization energy
  - Maximizes sensitivity to nuclear recoils while minimizing expected backgrounds



90% C.L. Limits

- Conservatively assume all candidates could be from WIMPs
  - No background subtraction!
- Limits set using optimum interval method:

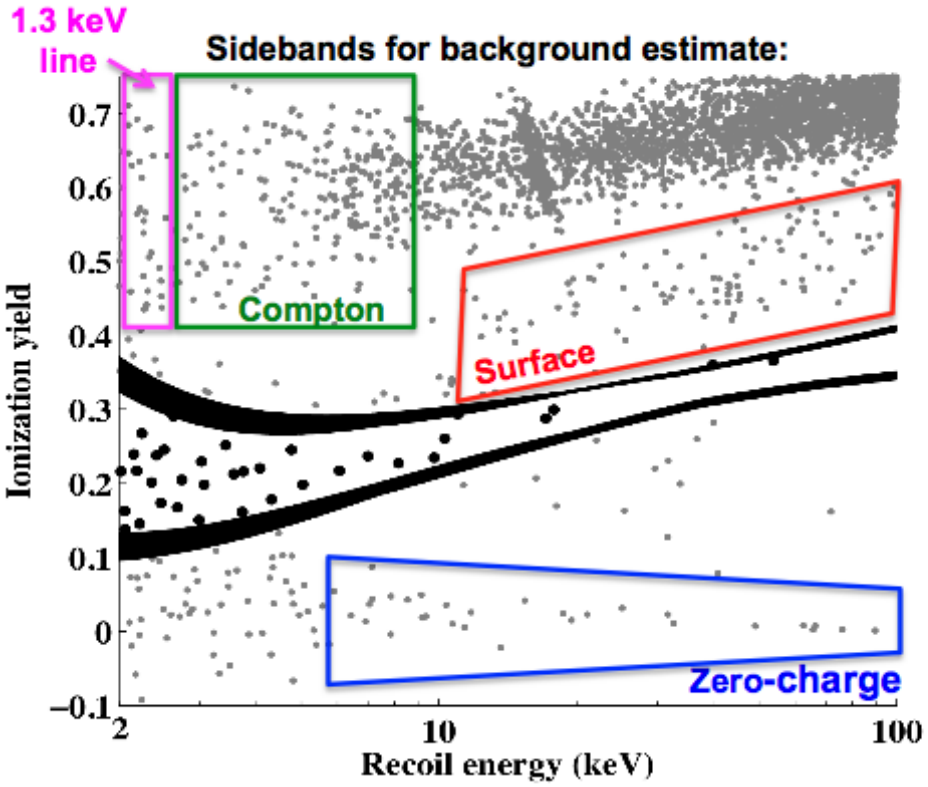
  S. Yellin, PRD, 66, 032005 (2002); arXiv:0709.2701v1 (2007)
- Energy intervals ordered by detector
- For spin-independent, elastic scattering, 90% CL limits incompatible with DAMA/LIBRA and entire CoGeNT excess
- Some parameter space for CoGeNT remains if majority of excess events not due to WIMPs

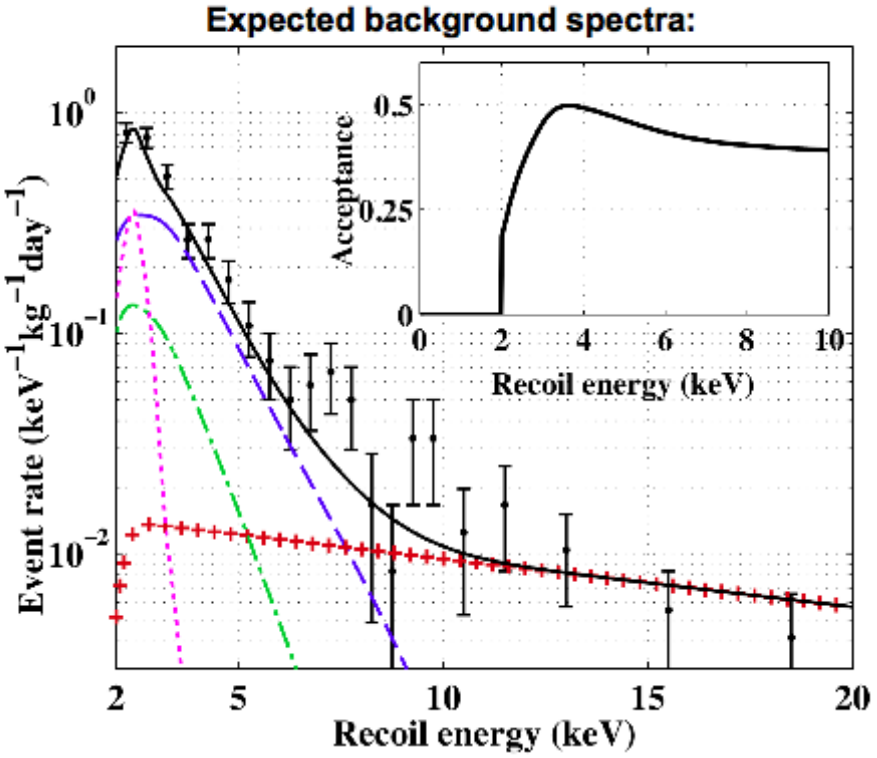


Ahmed et al., PRL **106**, 131302 (2011), *arXiv:1011.2482*
Akerib et al., PRD **82**, 122004 (2010), *arXiv:1010.4290*

Background Composition

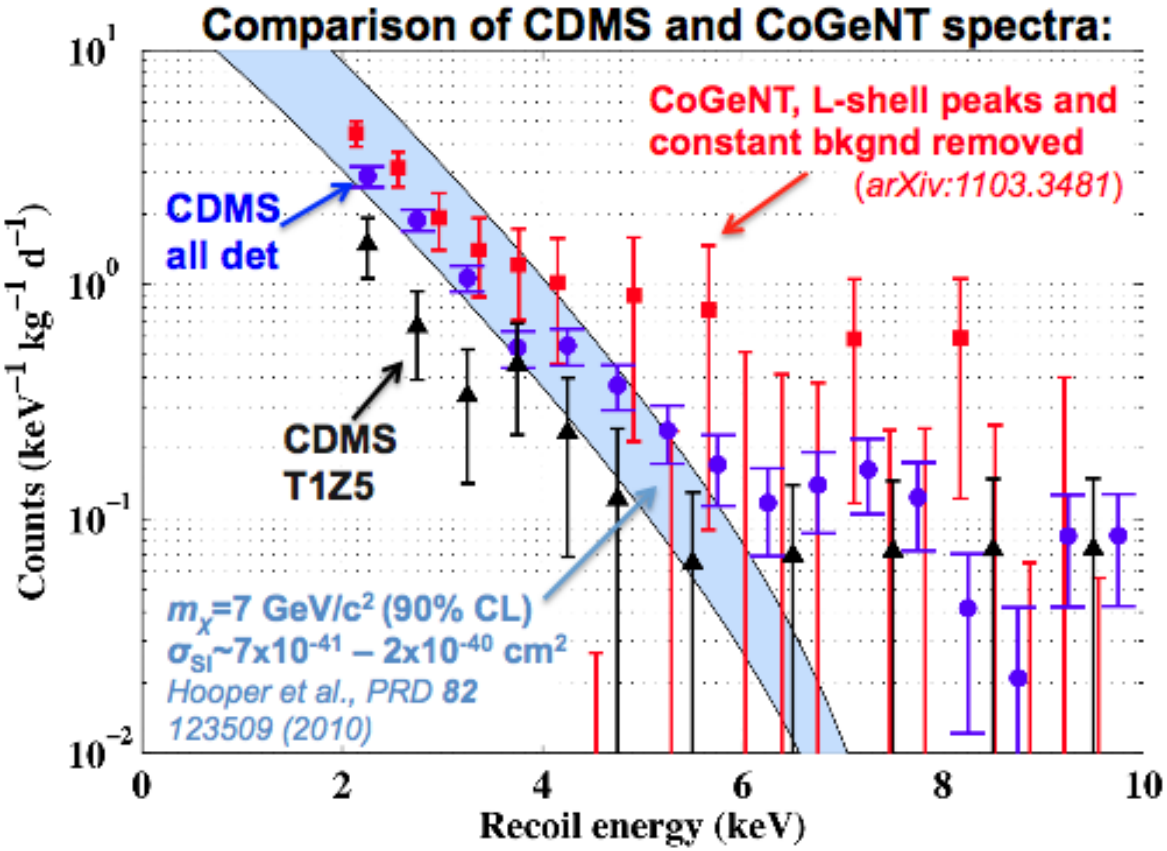
- Observed candidates can plausibly be explained by extrapolations of background estimates from sidebands
  - Possibly significant systematic errors due to extrapolations to low energy
- We do not subtract these backgrounds when setting limits





Comparison to CoGeNT Data

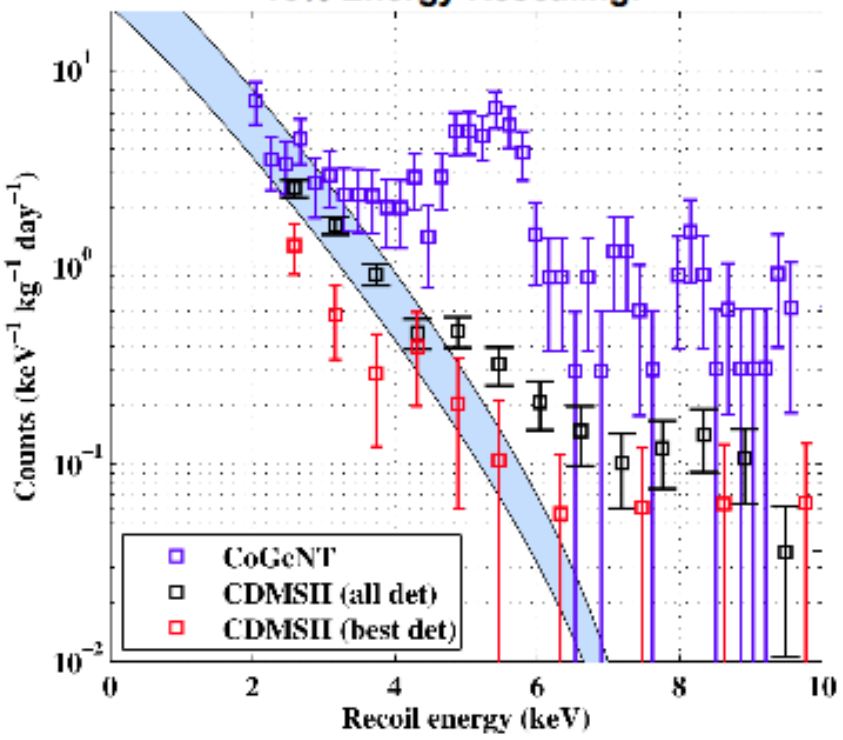
- We can directly compare the rates for CDMSII and CoGeNT since they use the same target material
- Both experiments see an exponential spectrum above threshold
- Rate in T1Z5 inconsistent with CoGeNT excess (unless majority of excess not due to WIMPs)
- No background subtraction for CDMS



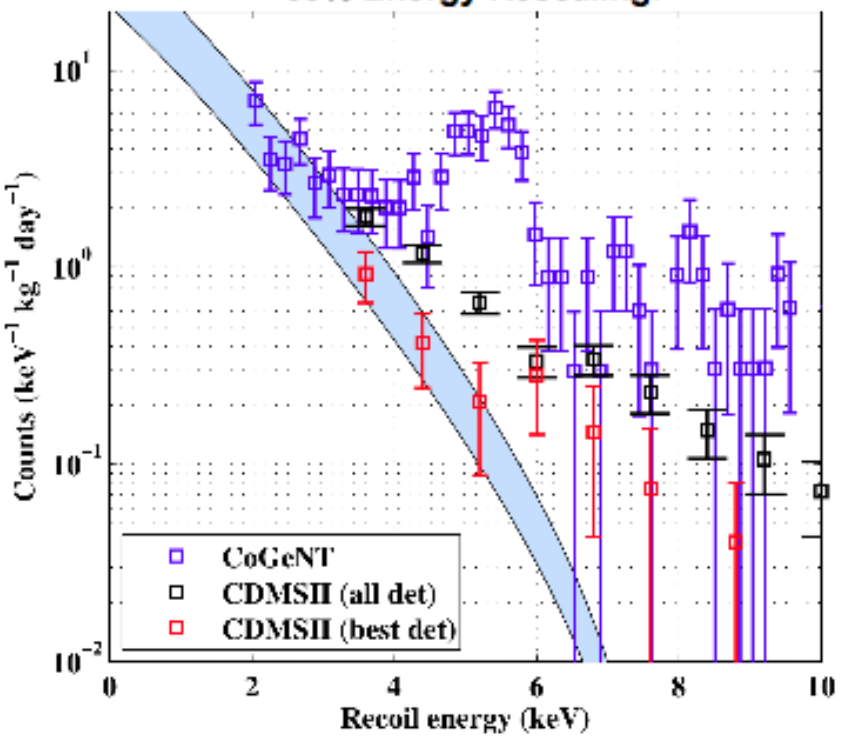
Naive Energy Rescaling

- The CDMS energy scale would need to be off by 15% for the coadded data, or 60% for the best detector for good agreement with CoGeNT (7 GeV/c^2 WIMP)
  - Lower bounds since no background subtraction!
- Energy scale already assumes most conservative values consistent with 1.3 keV electron-recoil activation line at 90% CL

15% Energy Rescaling:



60% Energy Rescaling:



Summary

Ahmed et al., PRL 106 131302 (2011), arXiv: 1011.2482

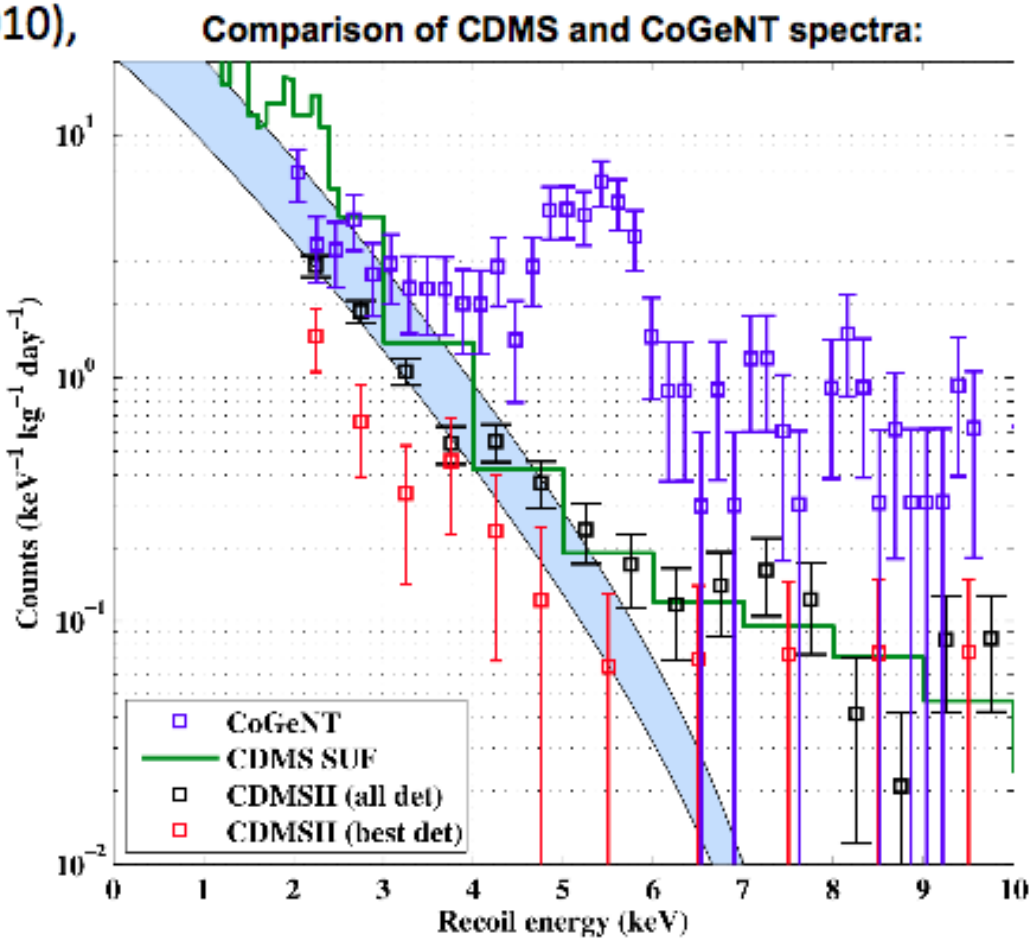
- Presented analysis of CDMSII data with threshold lowered from *10 to 2 keV*
- Backgrounds present in this analysis have been characterized. *No excess events over expected background were observed*
- Despite *no background subtraction*, observed rate of events is incompatible with interpretation of CoGeNT and DAMA data as evidence for spin-independent elastic scattering of WIMPs
- Compatibility between CDMS and CoGeNT data requires majority of CoGeNT excess to be due to background and unexpectedly small CDMS background

Shallow Site Comparison

- A similar analysis of CDMS SUF (shallow-site) data with a 1 keV threshold has recently been published:

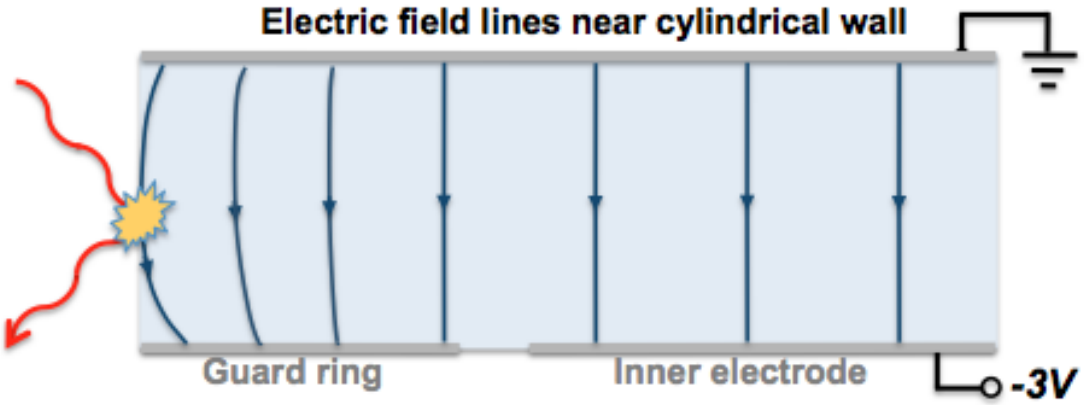
  Akerib et al., PRD **82**, 122004 (2010), *arXiv:1010.4290*

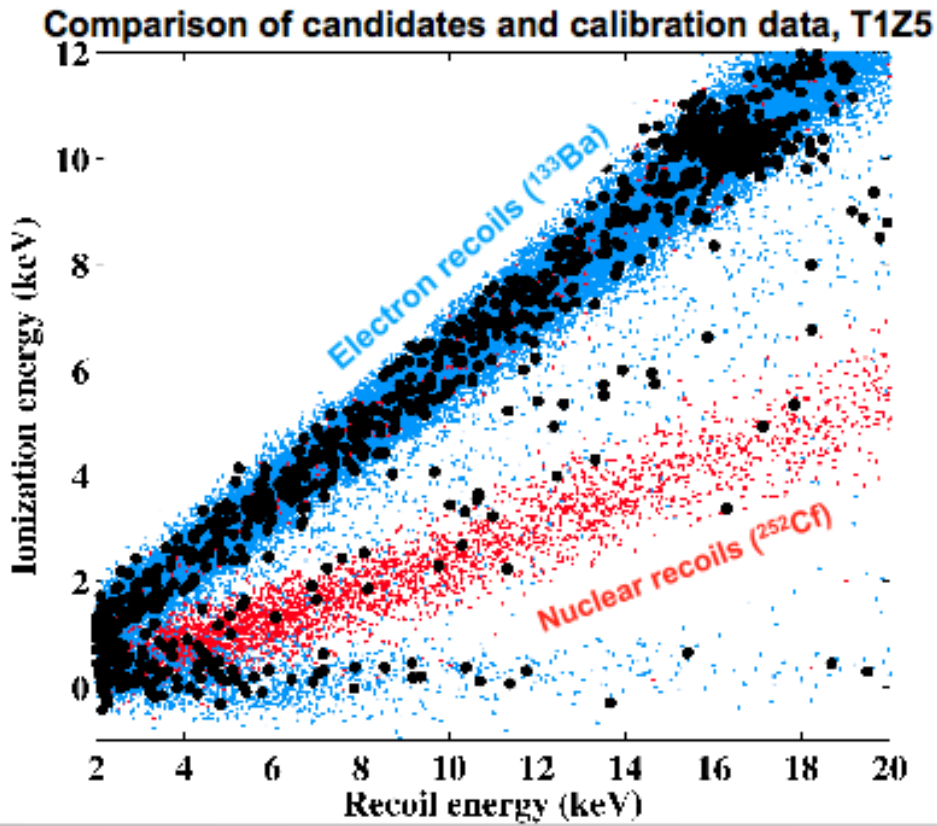
- Spectra agree well at high energies
- At low energies, the CDMS Soudan spectrum is a factor of a few lower than CDMS SUF
- Primary differences are nuclear-recoil band cut and less activation of 1.3 keV line



Zero Charge Events

- Dominant expected background below 10 keV
- Zero-charge events scale with electron-recoil rate, not exposure
- Consistent with electron recoils where charge is collected on cylindrical surfaces
- Pass fiducial volume selection since guard electrode signal consistent with noise
- Exponential spectrum above ~5 keV extrapolated to lower energies





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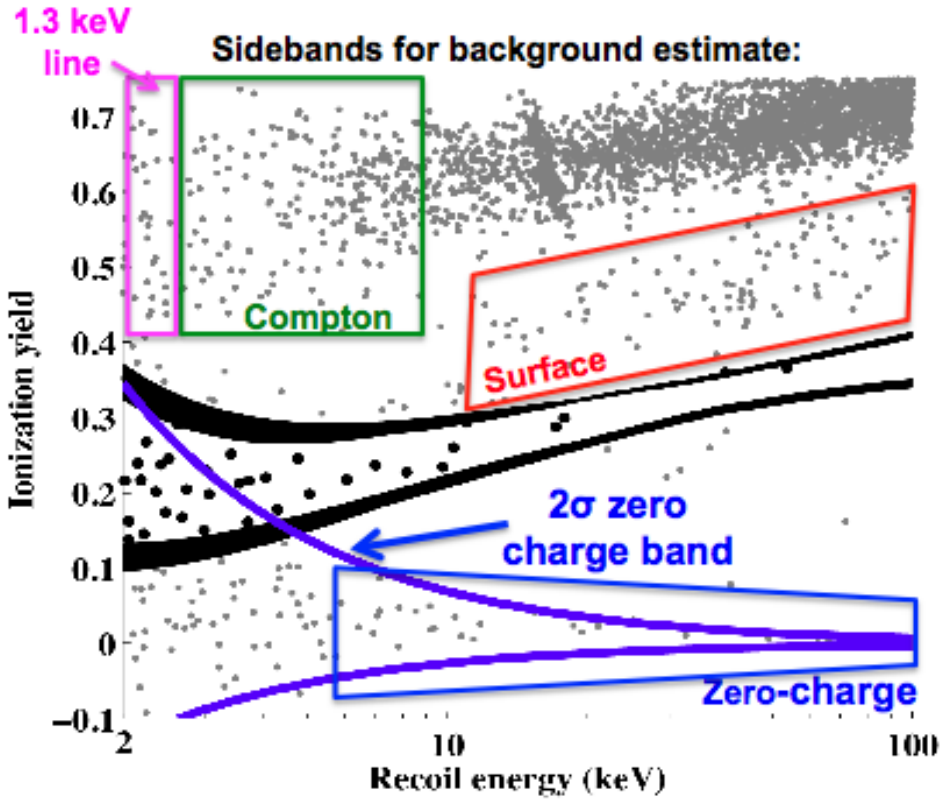

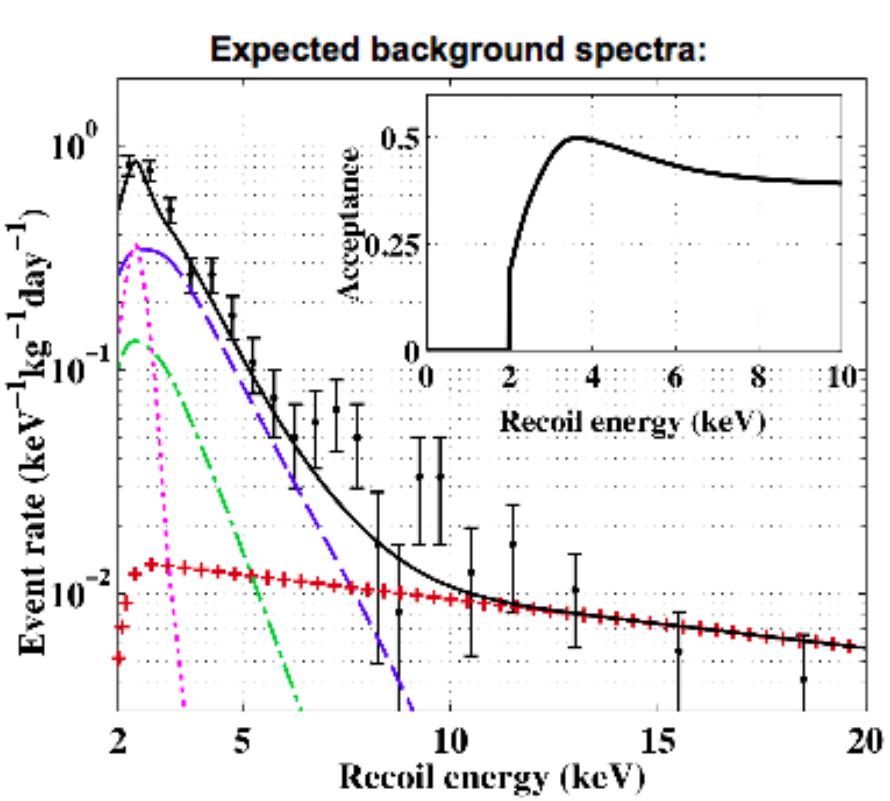

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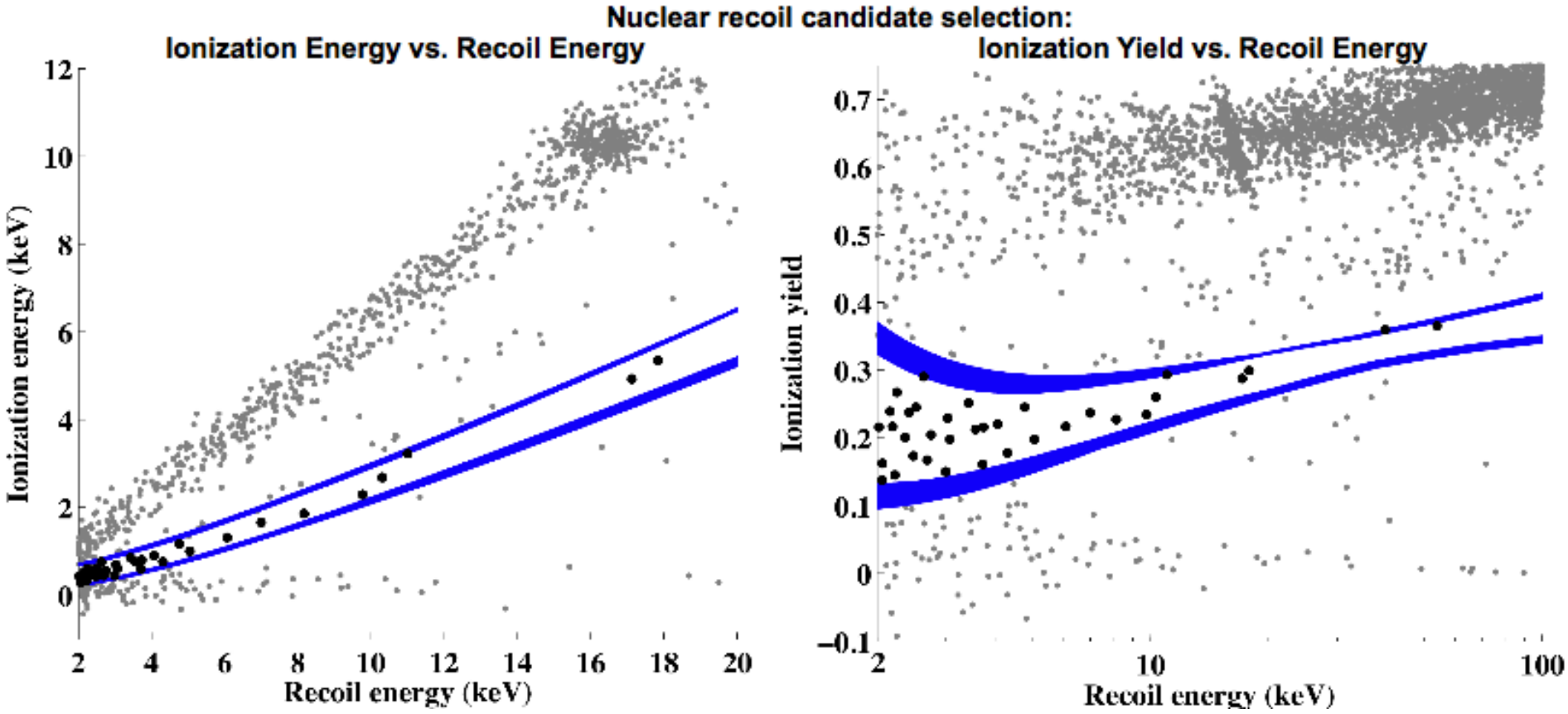
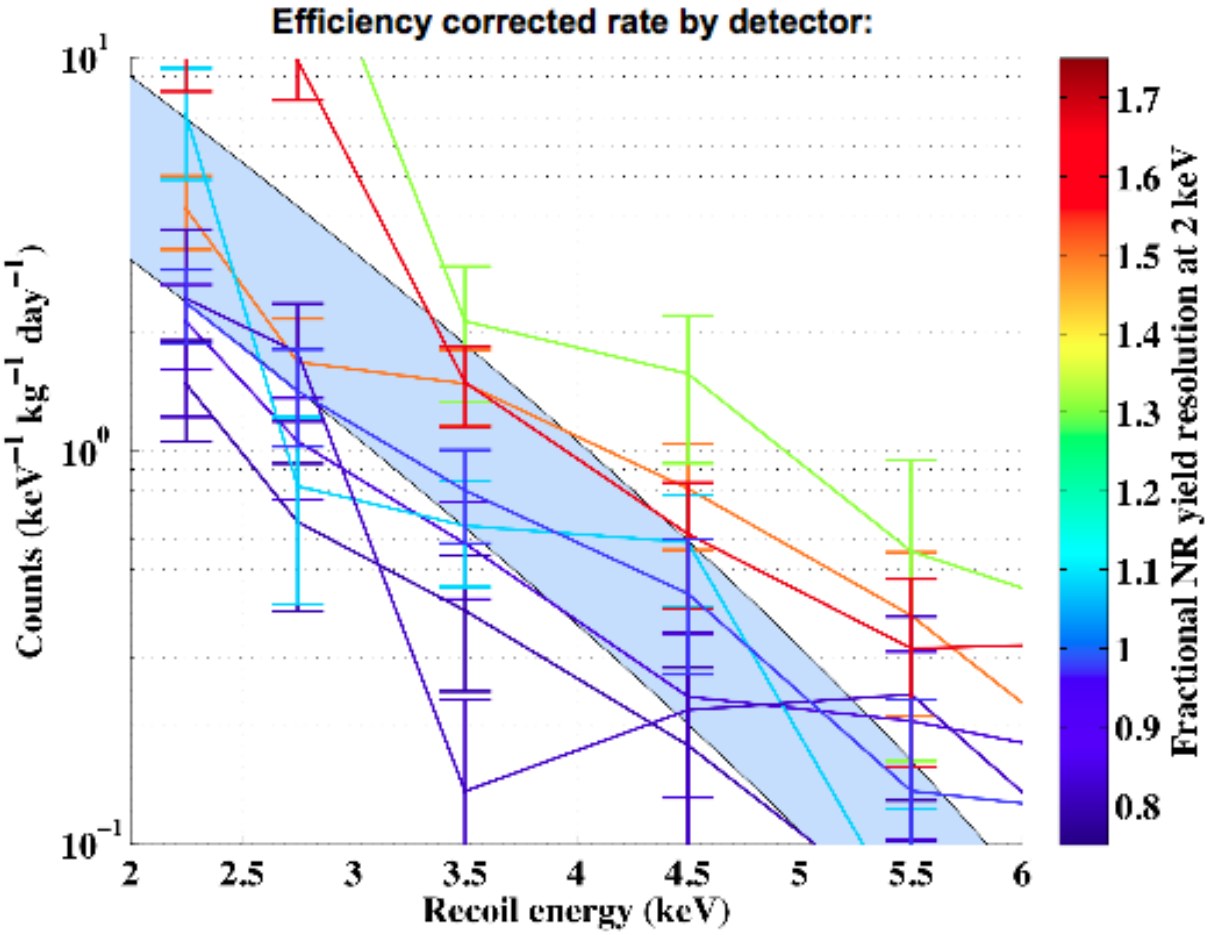


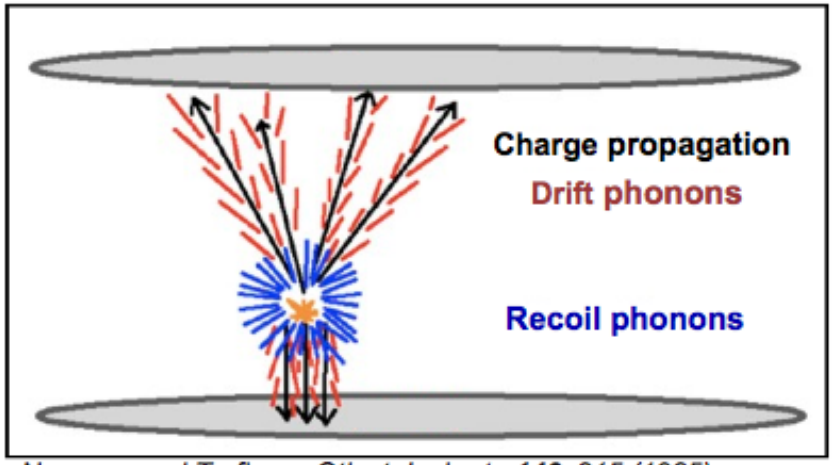
Rate by Detector

- Variations in observed rate by detector correlated with yield resolution



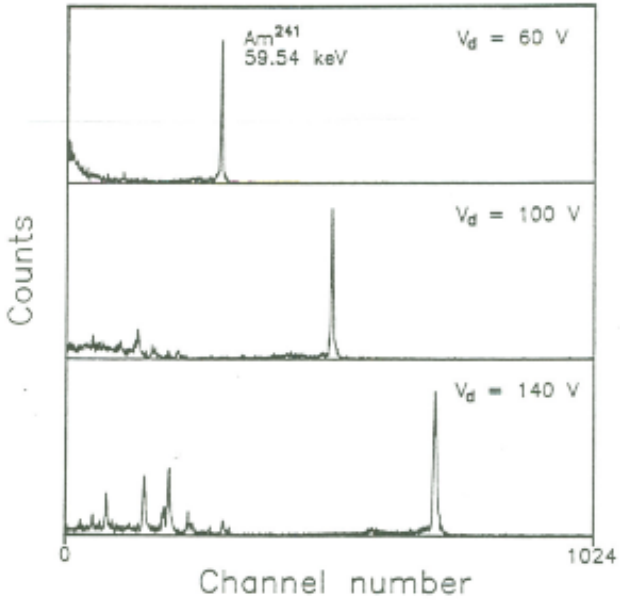
CDMSLITE

- Drifting charges produce phonons proportional to the voltage bias
- Noise is approximately independent of bias
- Ionization measurement only, no background discrimination
- Preliminary tests demonstrated ~50 eV thresholds with existing detectors



*Neganov and Trofimov, Otkryt. Izobret., **146**, 215 (1985)*
Luke, J. Appl. Phys., 64, 6858 (1988)

Calometric ionization measurement (Luke et al.):



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

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