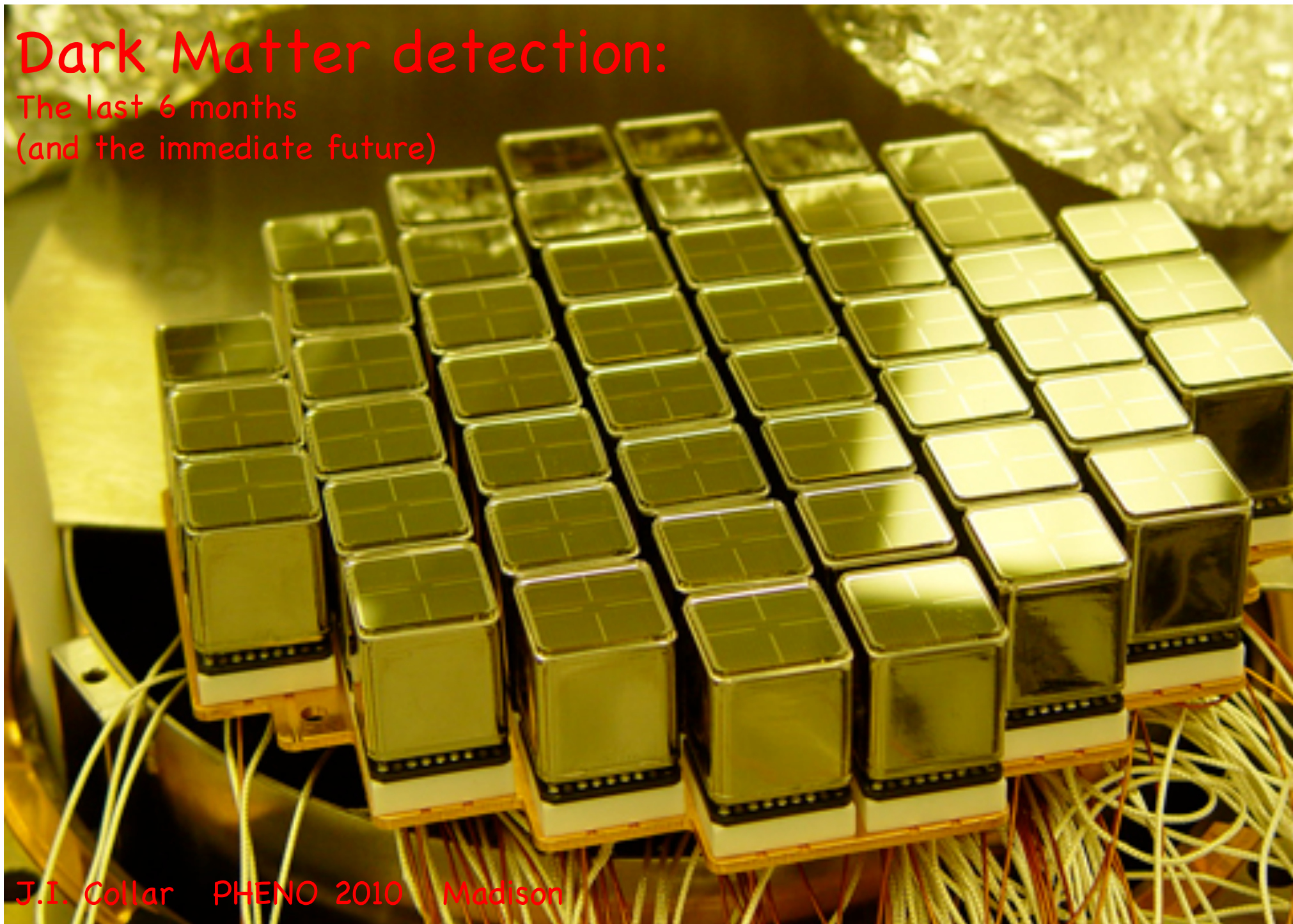


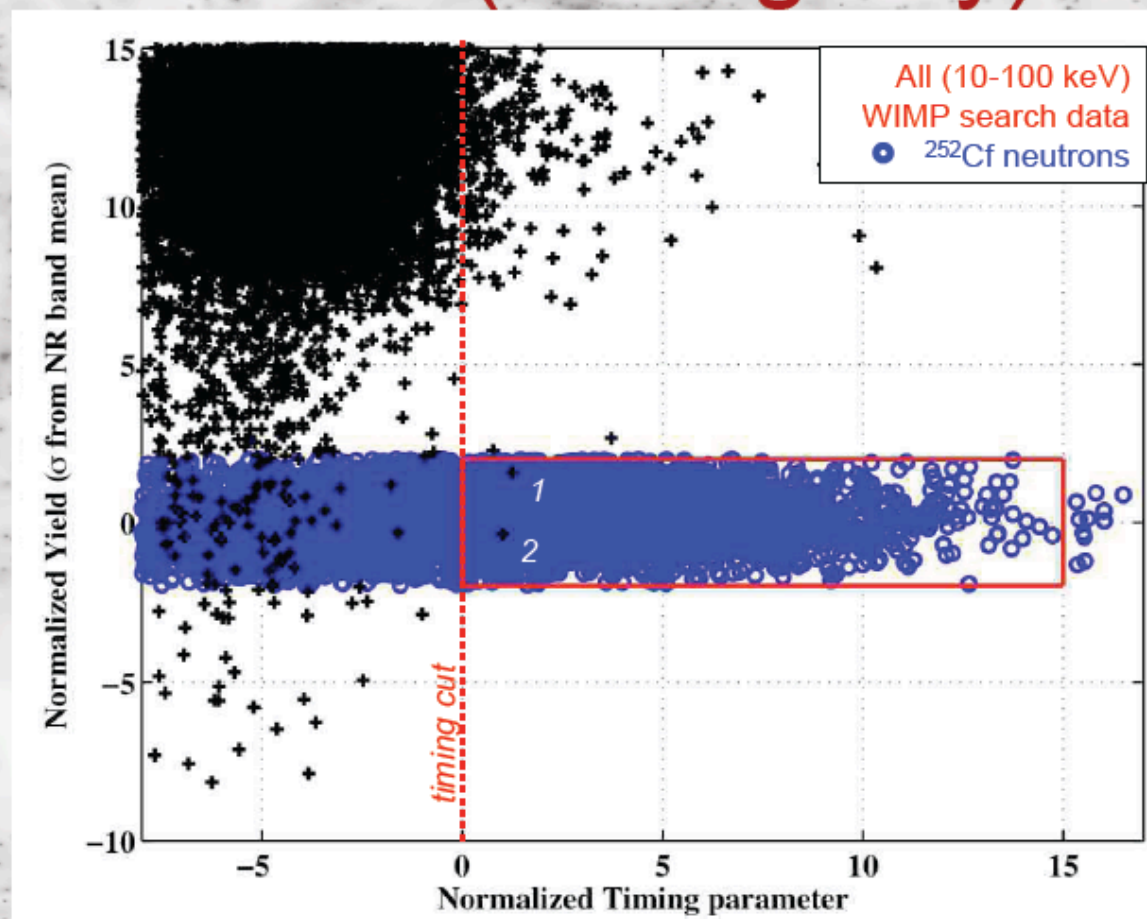
# Dark Matter detection:

The last 6 months  
(and the immediate future)



The field started running a low fever last December...

## CDMS Results (191 kg day)



- 2 events passing all cuts
- Blinded background estimate of  $0.6 \pm 0.1$  events
- What else can we say?

In February things were coming back to normal...

J. Hall UCLA DM10

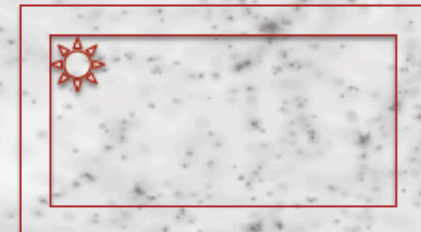
## Likelihood Results (in the acceptance region)

- What is the probability that a true nuclear recoil in the acceptance region is as close to the cut boundaries as the observed events in these detectors?

Event	Unbinned 3D	2D with fit	Unbinned 2D no fit
1	1 %	3 %	4 %
2	12 %	2 %	19 %

- What is the probability of an electron recoil in the acceptance region appearing to look more like nuclear recoils in the acceptance region in these detectors?

Event	Unbinned 3D	2D with fit
1	83 %	28 %
2	54 %	34 %



... when suddenly...

# CoGeNT:

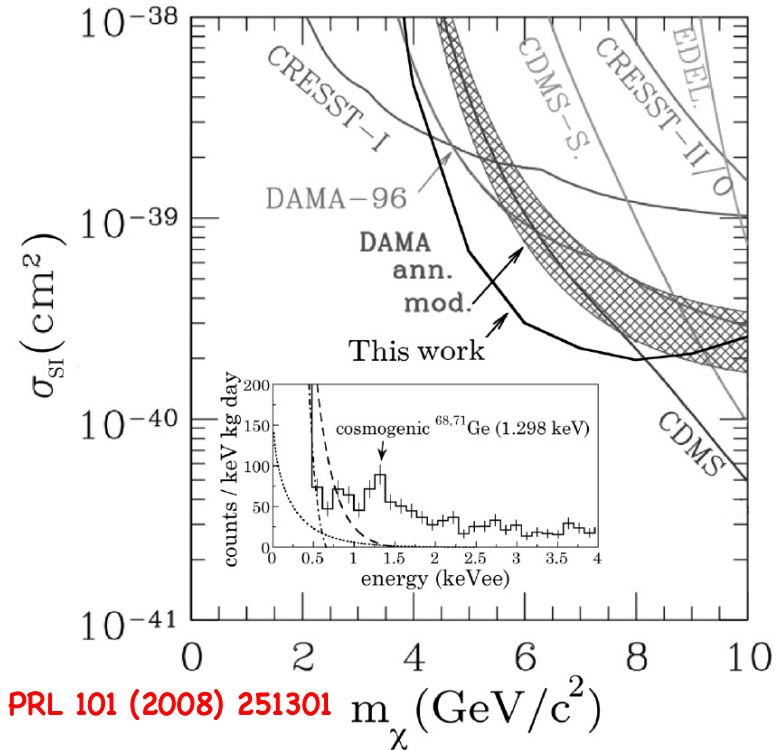
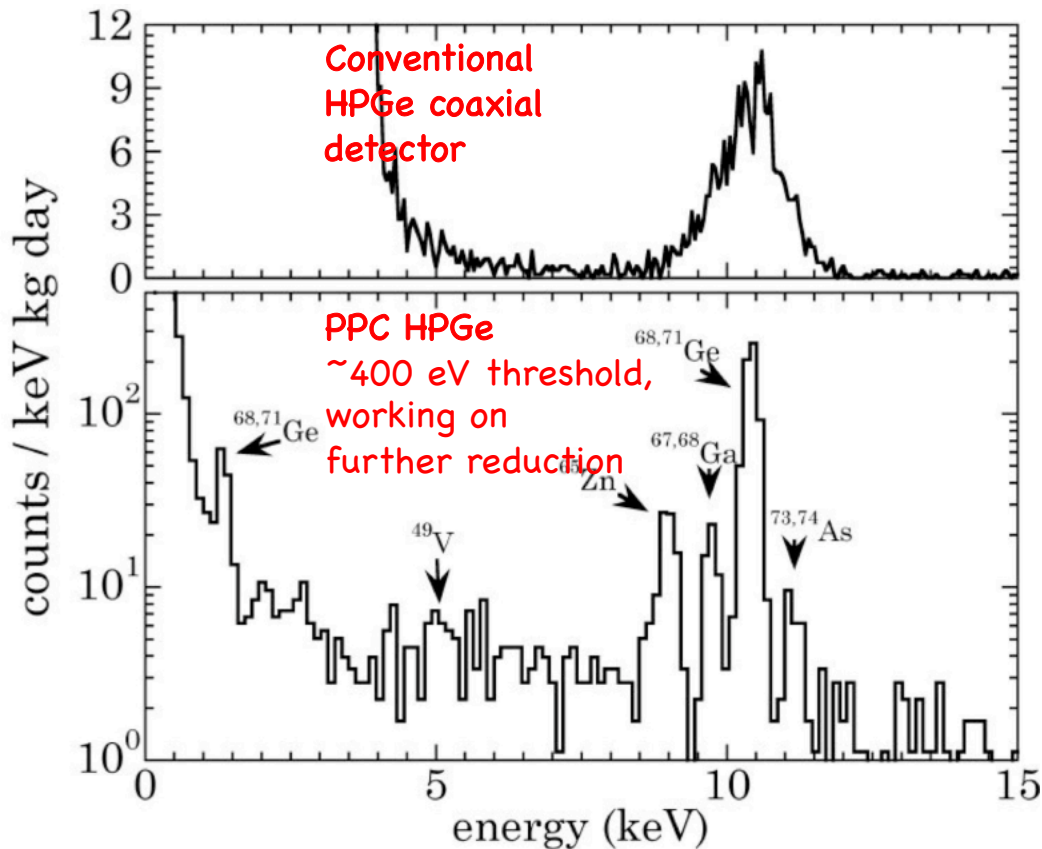
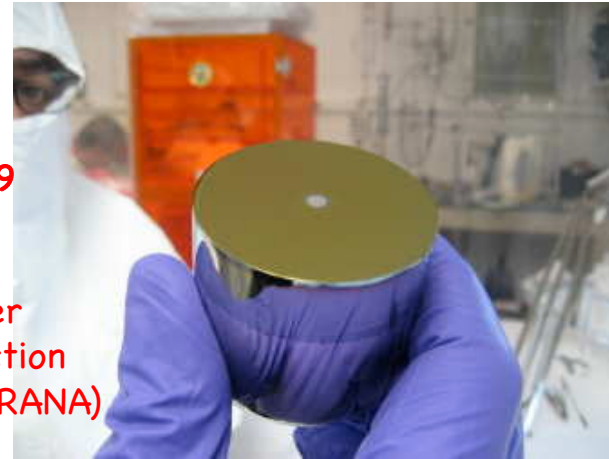
neutrino &  
astroparticle physics  
using large-mass,  
ultra-low noise  
germanium detectors  
(ANL, CANBERRA, LLNL,  
PNL, ORNL, SNL, UC, UNC, UW)  
(mostly a tentacle of MAJORANA)

PPC HPGe

JCAP 09(2007)009

Applications:

- Light Dark Matter
- Coherent  $\nu$  detection
- $\beta\beta$  decay (MAJORANA)

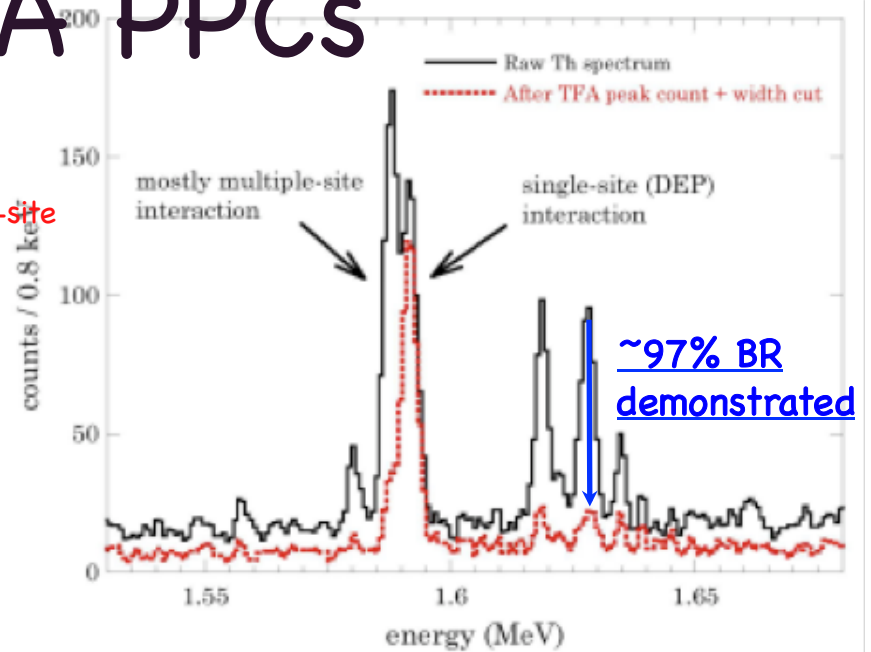
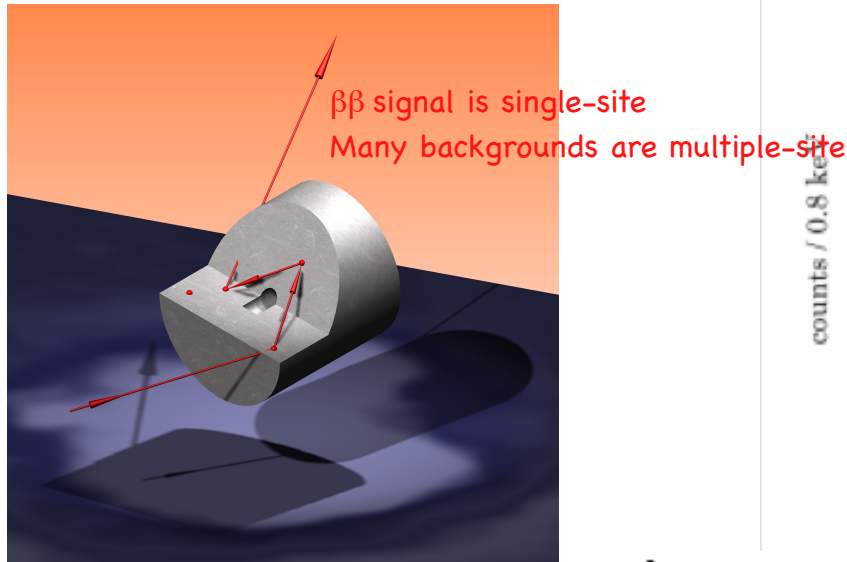


PRL 101 (2008) 251301  $m_\chi$  (GeV/c<sup>2</sup>)

Extensive constraints on DAMA's claim:

- Light WIMPs
- Dark scalars
- Dark pseudoscalars

# MAJORANA PPCs



## Detectors studied / in hand:

(table actually missing a few)

Owner	Dimensions	Mass	Resolution (1.33 MeV)	Manufacturer
U. Chicago (PPCI)	50 mm $\varnothing$ x 44 mm	460 g	1.82 keV	Canberra
PNNL (PPCII)	50 mm $\varnothing$ x 50 mm	527 g	2.15 keV	Canberra
LBNL (SPPC)	62 mm $\varnothing$ x 44 mm	800 g	2.11 keV	LBNL
LANL (MJ70)	72 mm $\varnothing$ x 37 mm	800 g	2.15 keV	PHD's
ORNL (MJ60)	62 mm $\varnothing$ x 46 mm	740 g	4-4.5 keV	PHD's
U. Chicago (BEGe)	"standard"	450 g	<2 keV	Canberra
LBNL (Mini-PPCs)	20 mm $\varnothing$ x 10 mm	17 g		LBNL
ORNL (Big BEGe)	90 mm $\varnothing$ x 25 mm	850 g	1.95 keV	Canberra

Move to modified commercial "BEGe" detectors (quasiplanar PPCs)

18 PPCs already characterized and stored for 60kg MAJORANA demonstrator  
(Second batch of 15 ordered, LANL)

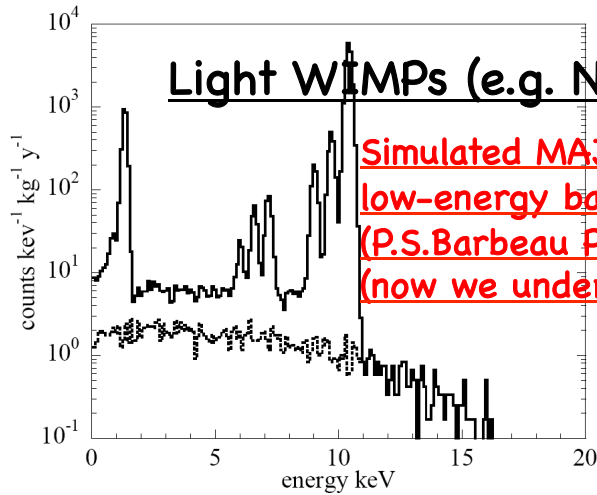
Crystal storage underground

GERDA considering PPCs for 2<sup>nd</sup> phase

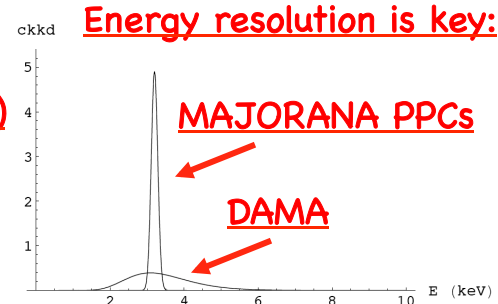
# MAJORANA as a DM detector

Light WIMPs (e.g. NMSSM)

Pseudoscalars etc. (a.k.a. "superWIMPs")



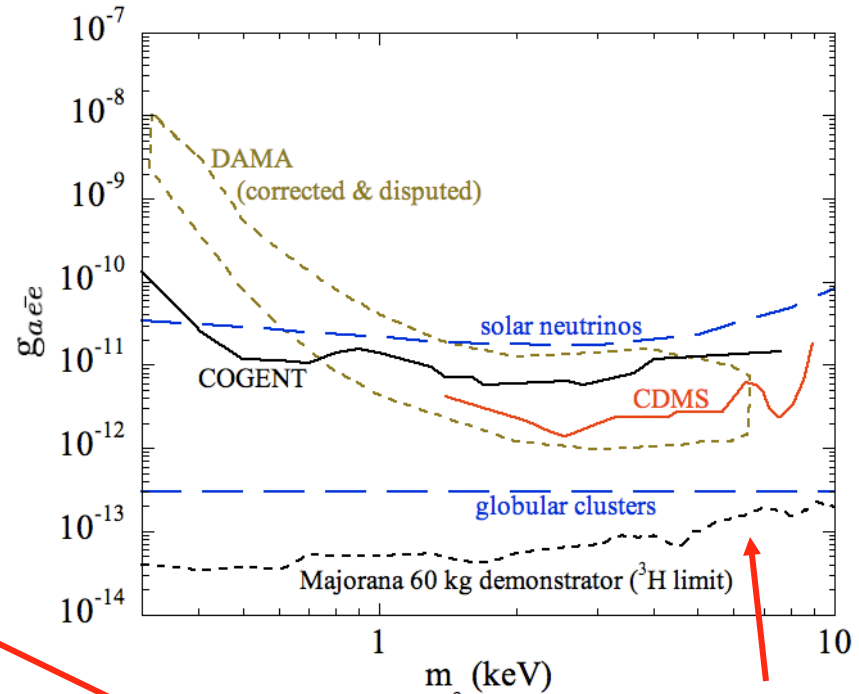
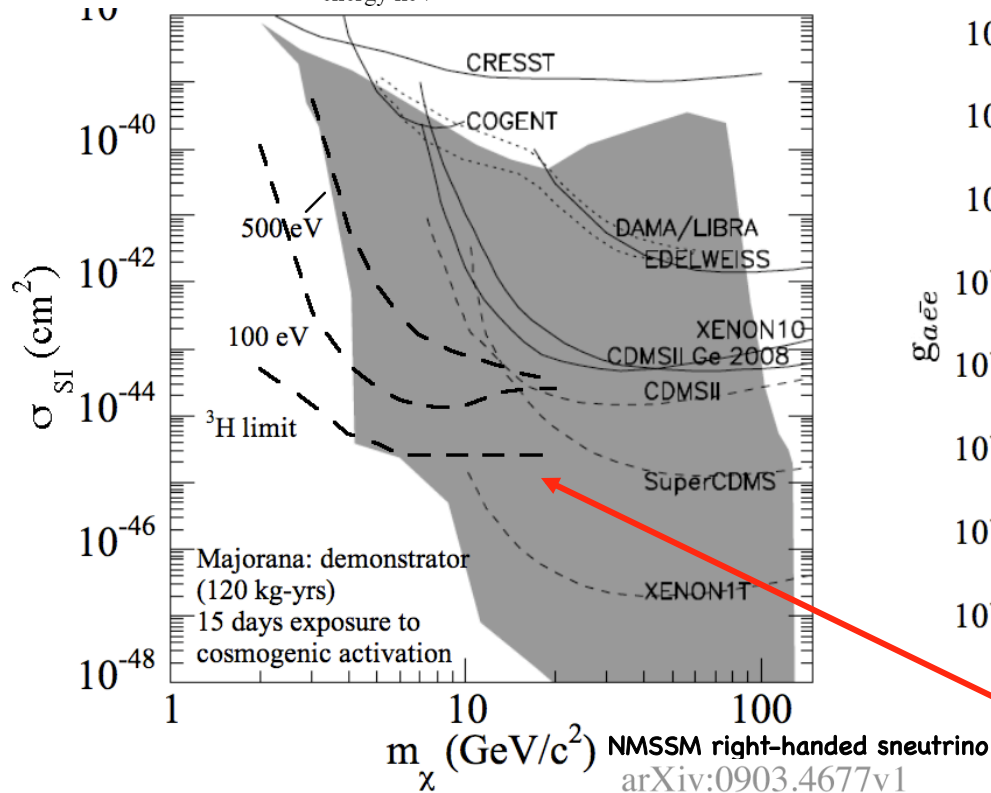
**Simulated MAJORANA-demonstrator  
low-energy backgrounds  
(P.S.Barbeau Ph.D. Diss.)  
(now we understand these much better)**



**Energy resolution is key:**

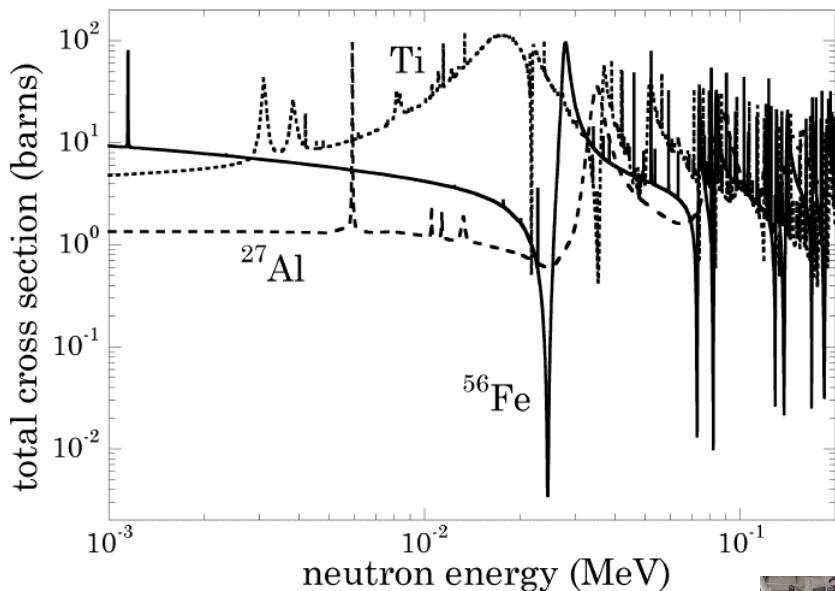
**MAJORANA PPCs**

**DAMA**



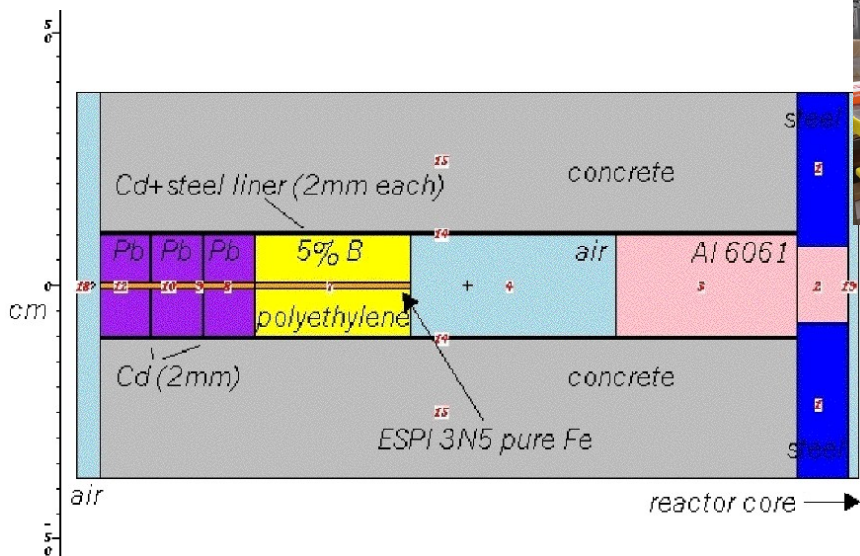
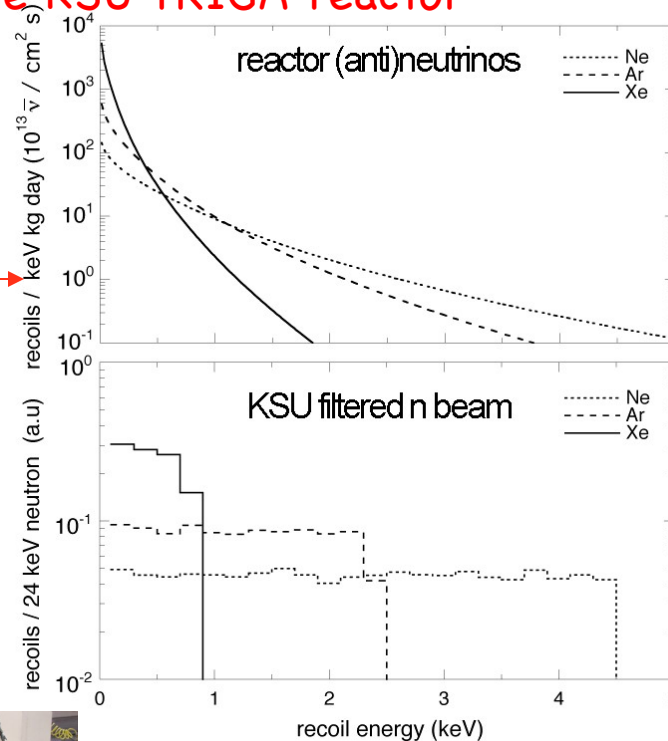
**Possibility of reaching  $^3\text{H}$  limit much nearer now with surface event rejection**

One should always start with the foundations:  
sub-keV recoil calibrations at the KSU TRIGA reactor

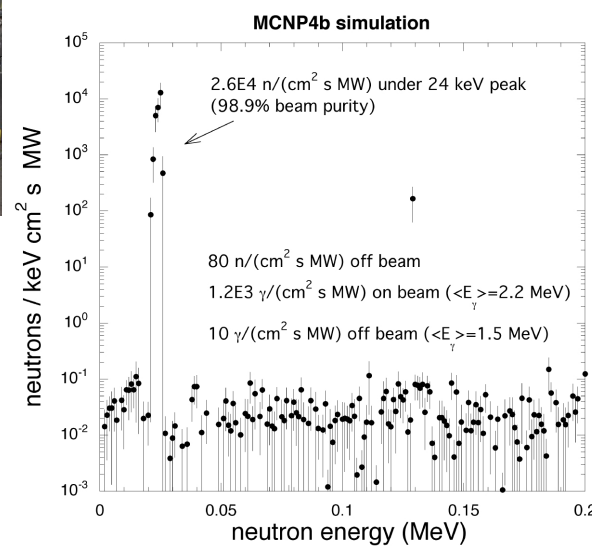


24 keV  
n's  
mimic  
reactor  
 $\nu$ 's

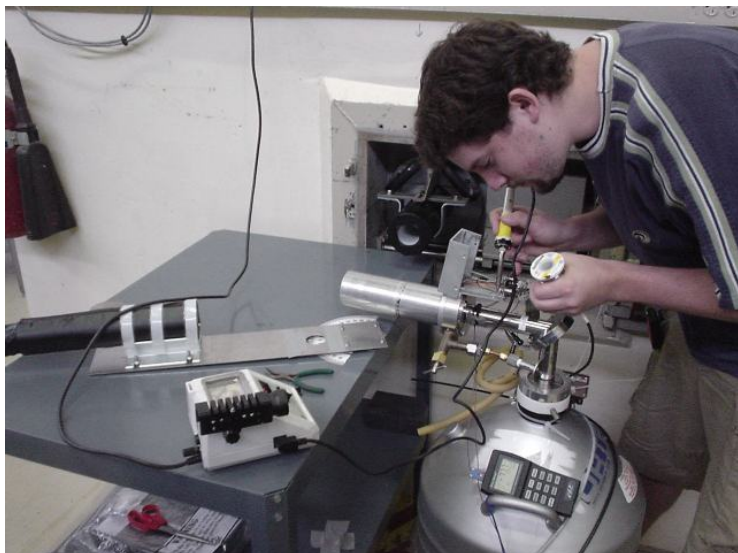
Fe-Al  
filter  
+  
Ti  
post-filter



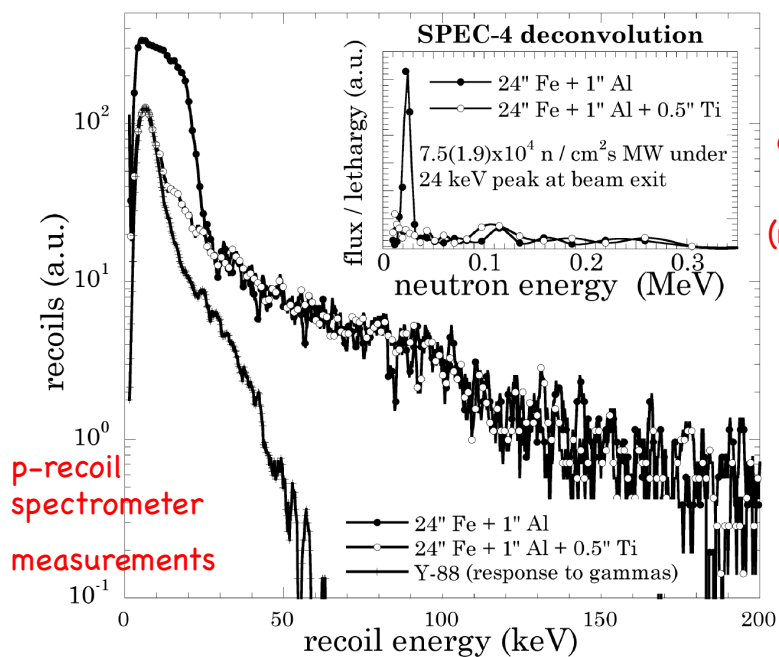
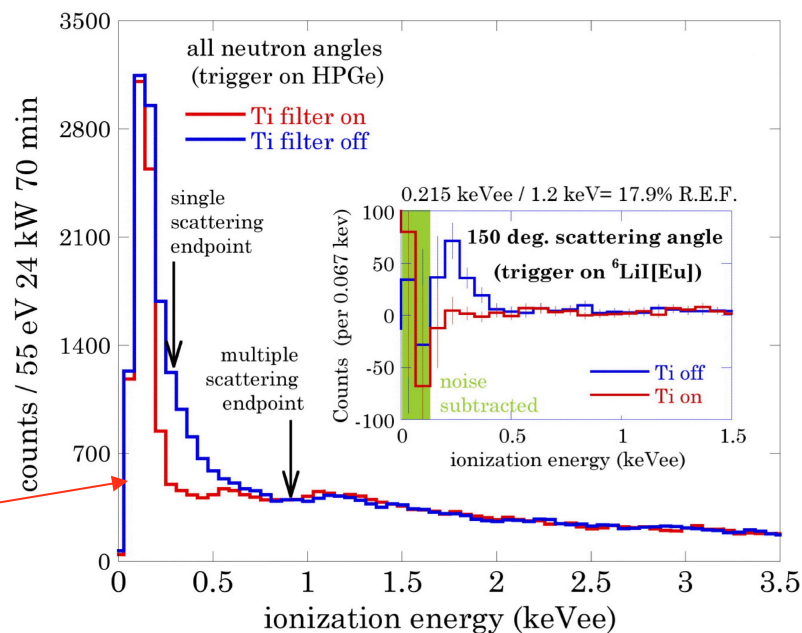
MCNP  
filter  
design



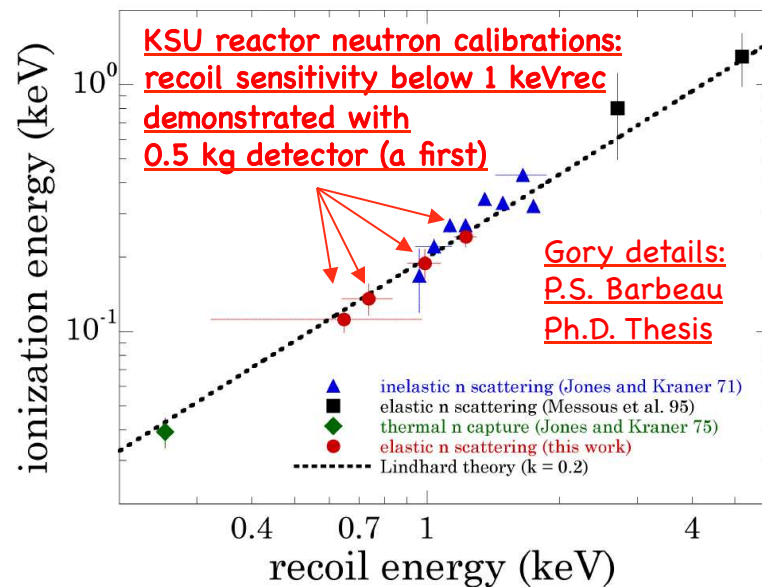
One should always start with the foundations:  
sub-keV recoil calibrations at the KSU TRIGA reactor



Ti post-filter  
"switches off"  
the recoils,  
leaving all  
backgrounds  
unaffected



Beam  
characterization  
studies  
(nucl-ex/0701011)





## Low-energy quenching factors much better understood for germanium than xenon

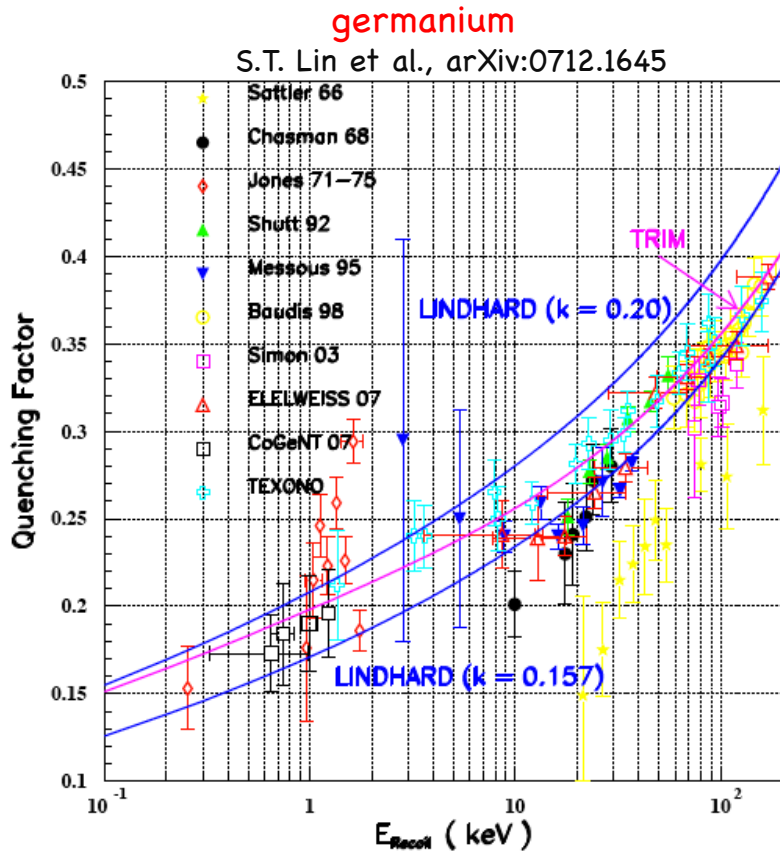


FIG. 3: A compilation of all quenching factor (QF) measurements on germanium, with calculations from the TRIM software [6] as well as by the Lindhard model [7] under two parametrizations ( $k=0.20$  and  $0.15$ ) overlaid.

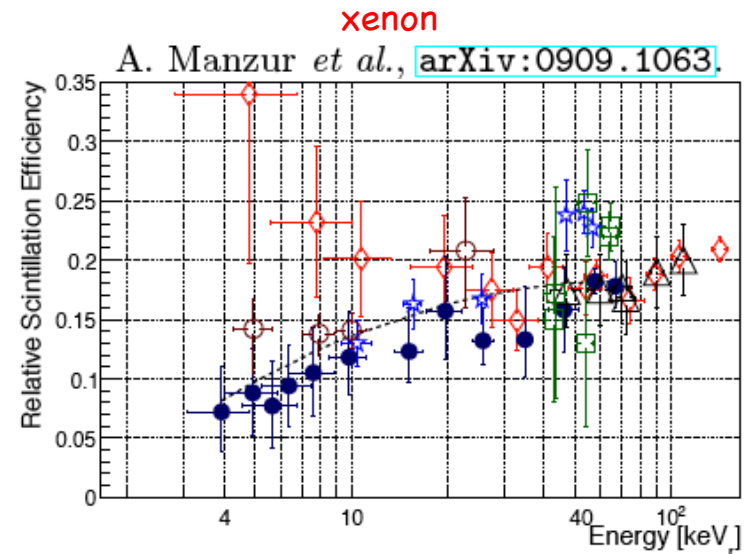
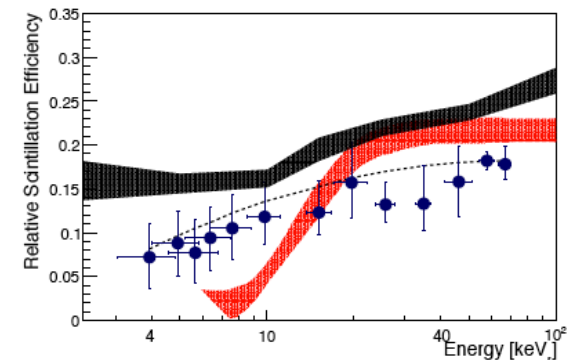


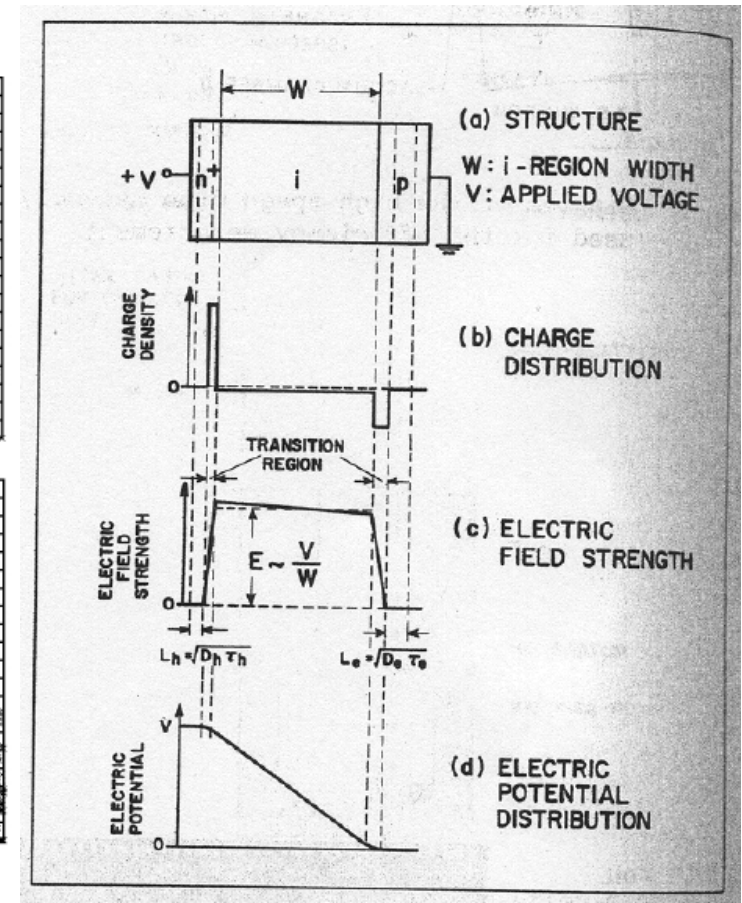
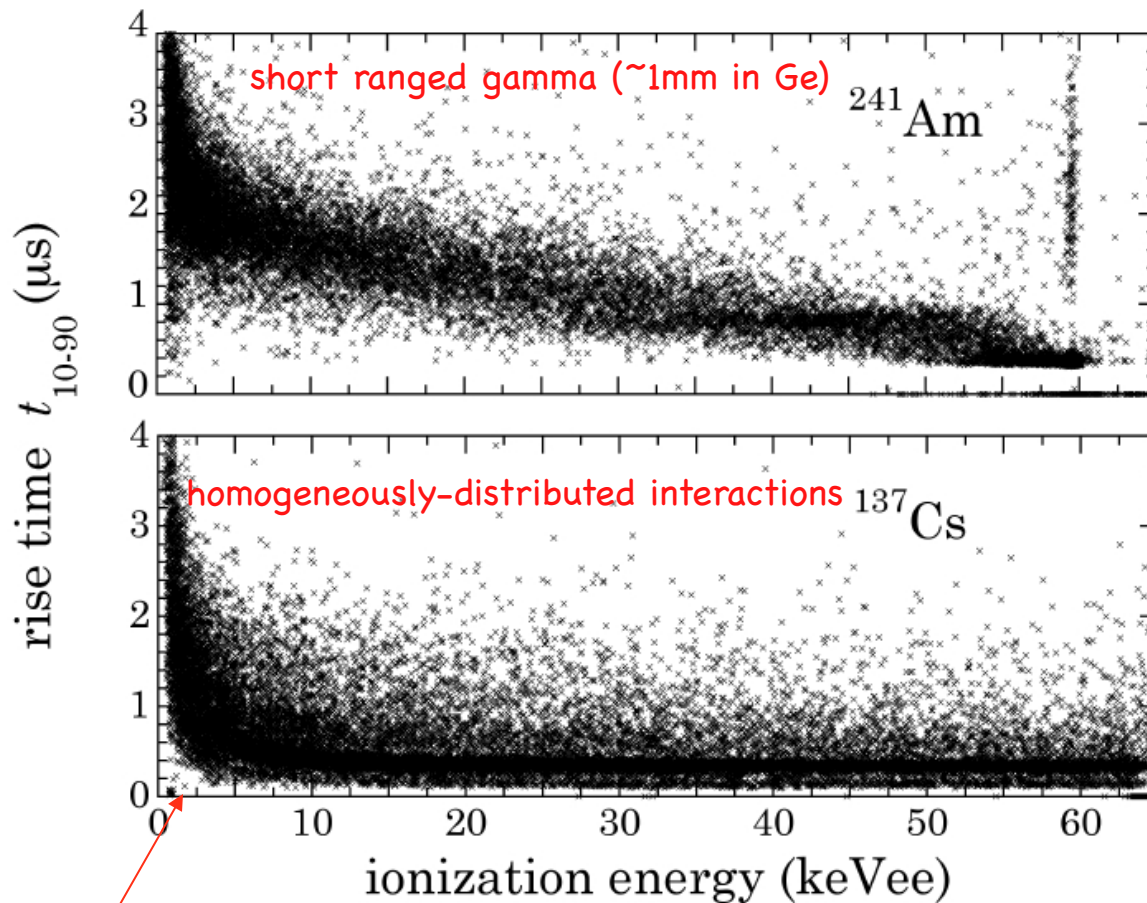
FIG. 11: Scintillation efficiency for nuclear recoils relative to that of 122 keV gamma rays in LXe at zero field, comparing this work (●) to previous measurements from Arneodo ( $\Delta$ ) [5], Akimov ( $\square$ ) [6], Aprile ( $\star$ ) [7], Chenel ( $\diamond$ ) [8] and Aprile ( $\circ$ ) [9]. Also shown is the Section V, which includes quenching due to bi-capping electrons.



# Making an excellent detector even better: PPCs can reject surface events using rise time cuts

Based on a phenomenon ~40 years old (embarrassing!)

n+ contact is only "half-dead"  
Pulses forming in inner side are slow



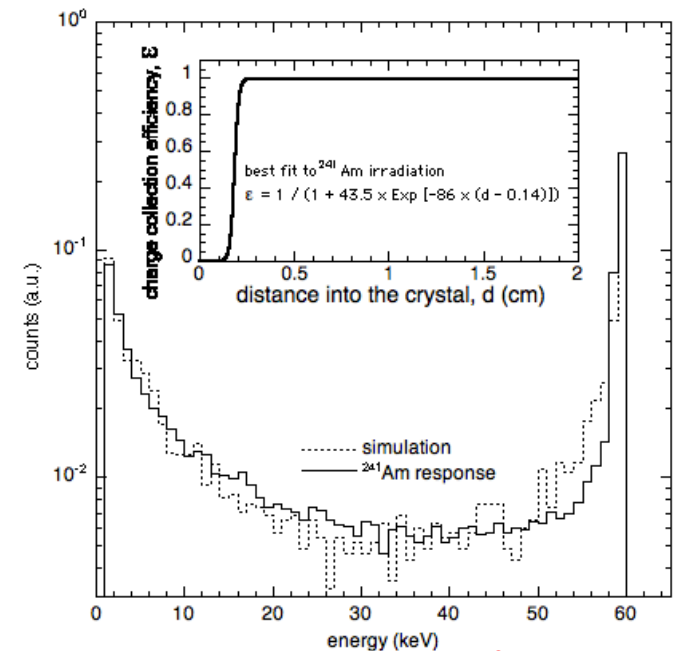
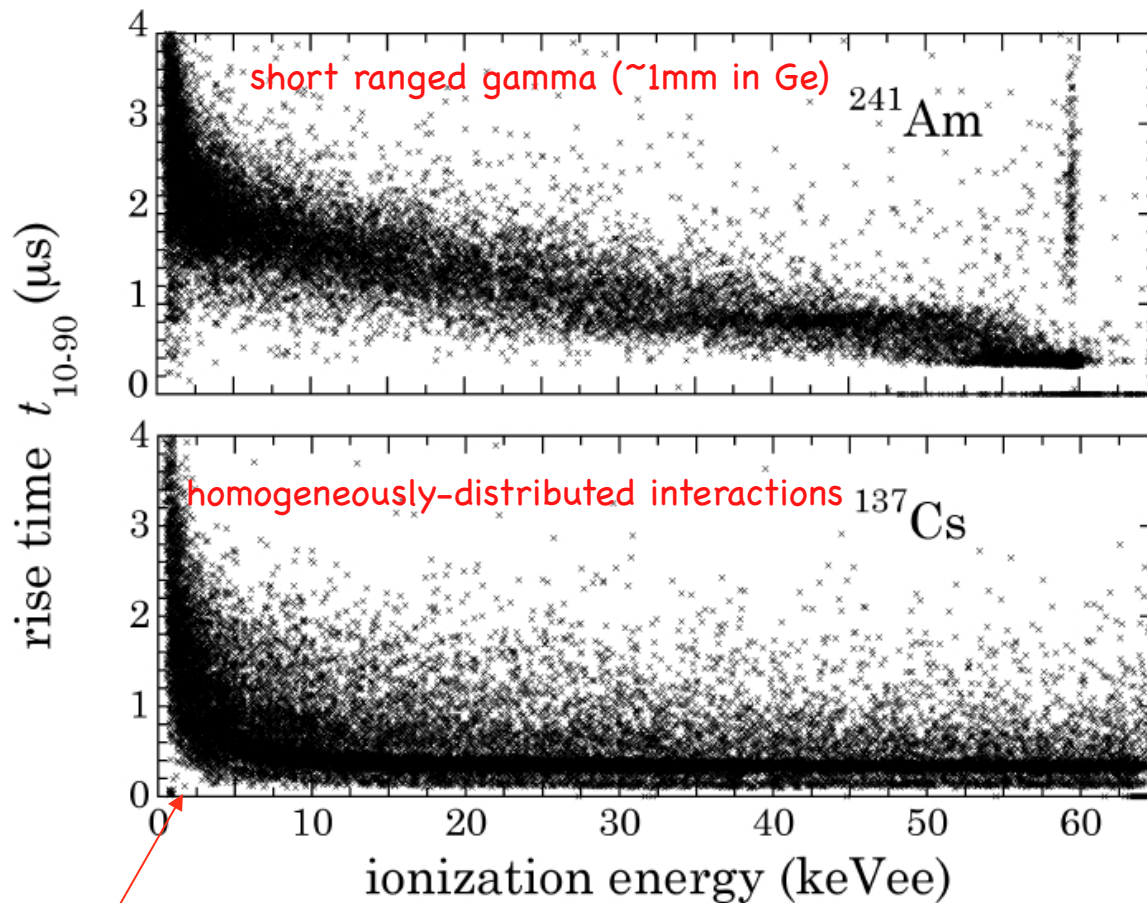
M.G. Strauss and R.N. Larsen, Nucl. Instr. Meth. 56 (1967) 80; E. Sakai, IEEE TNS 18 (1971) 208.

Unfortunately Cs-137 produces plenty surface events as well:  
next best thing, pulser + charge collection simulations

# Making an excellent detector even better: PPCs can reject surface events using rise time cuts

Based on a phenomenon ~40 years old (embarrassing!)

n+ contact is only "half-dead"  
Pulses forming in inner side are slow



Our understanding of n+ contact behavior agrees nicely with the literature

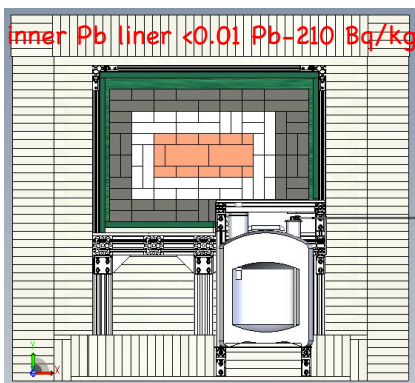
Unfortunately Cs-137 produces plenty surface events as well:  
next best thing, pulser + charge collection simulations

# Making an excellent detector even better: PPCs can reject surface events using rise time cuts

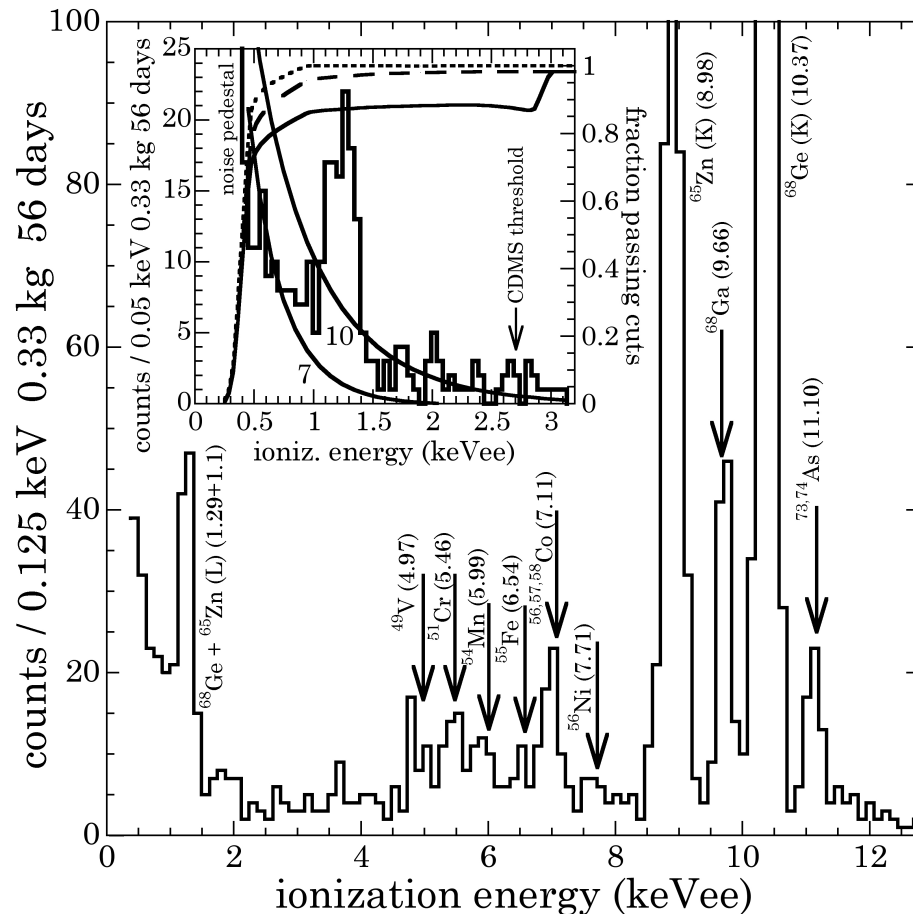
Based on a phenomenon ~40 years old (embarrassing!)



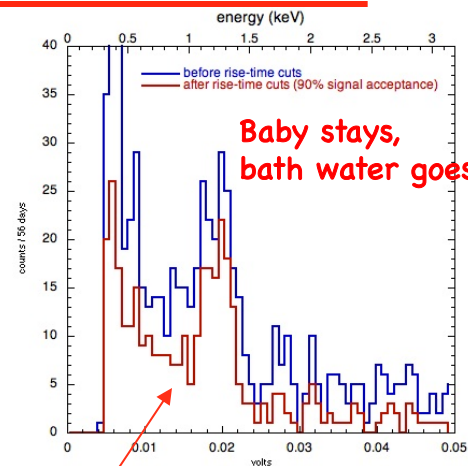
COGENT running  
~20 m away from CDMS  
(just to keep them honest... ;-)



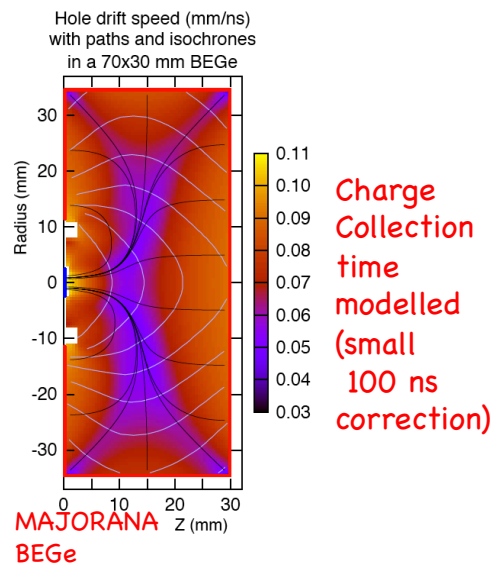
inner Pb liner <0.01 Pb-210 Bq/kg  
NOT nearly "best effort" yet.  
MAJORANA Demonstrator  
background goal is ~x1000 lower



Cuts remove 2-3 times the background above threshold at low-E. Not a massive cut, but enough to start to reveal all expected cosmogenics already at this level of exposure (update: peaks are blatant at 112 d)

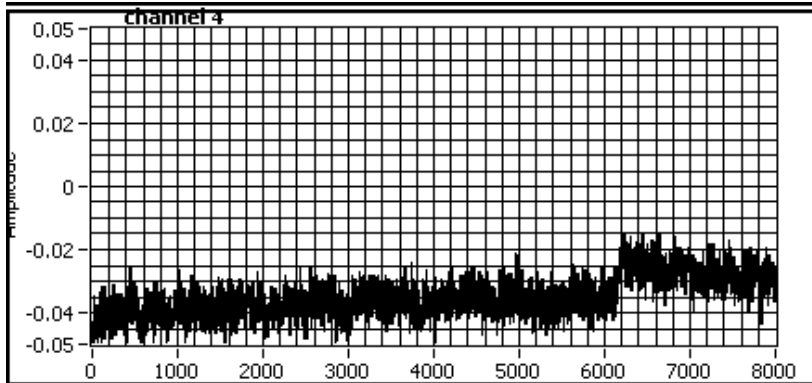
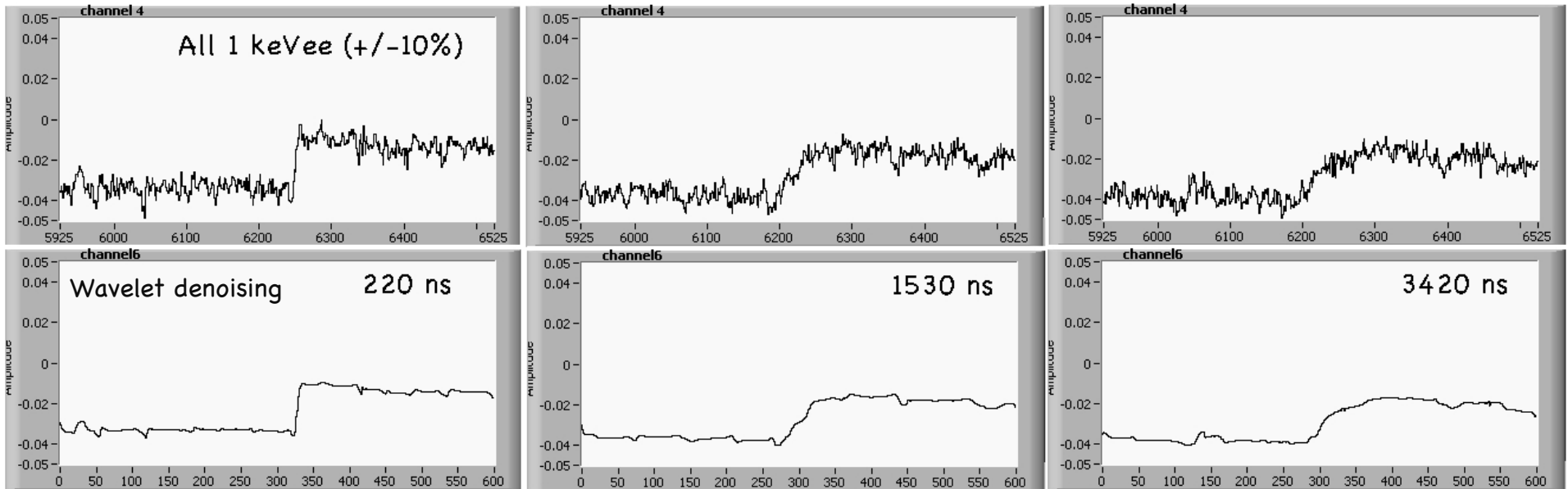


Baby stays, bath water goes  
Bulk signal acceptance monitored down to 1 keVee via L/K EC peak ratios. We need more info on surface background rejection, but it does not look bad at all.

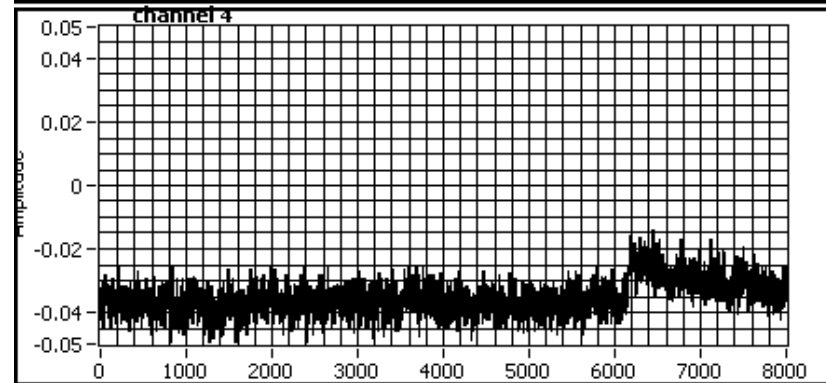


MAJORANA BEGe

Healthy pulses, all the way down to  $\sim 0.4$  keVee threshold  
(electronic noise = one thing the "excess" is not)



0.53 keVee before wavelet denoising



0.55 keVee before wavelet denoising

(full traces are 400  $\mu$ s long, allowing baseline monitoring)

# The "take-home message" transparency

- For  $m_\chi \sim 7-11$  GeV, a WIMP fits the data nicely (90% confidence interval on best-fit WIMP coupling incompatible with zero, good  $\chi^2/\text{dof}$ ).

- Red "island" tells you  $\sim$ where to look (if you believe in WIMPs). Additional knowledge (e.g., more calibrations for fiducial volume and SA/BR) could wiggle it around some (so do the other regions shown, depending on who plots them).

- Not a big deal on its own, it simply means that our irreducible bulk-like bckg is  $\sim$ exponential (the background model without a WIMP component fares just as well).

- We presently cannot find an obvious known source. But we can fancy some unexplored possibilities. It is not neutrons, and there is no evidence yet of detector contamination.

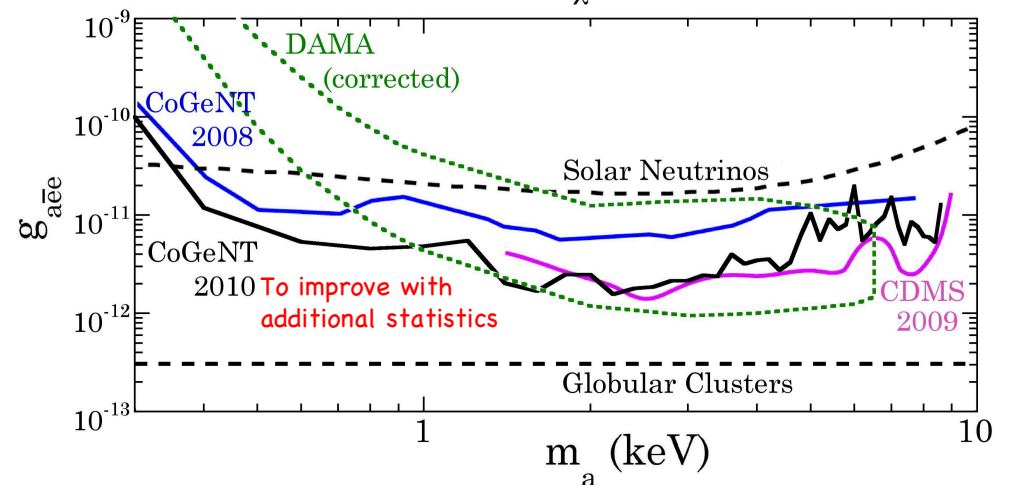
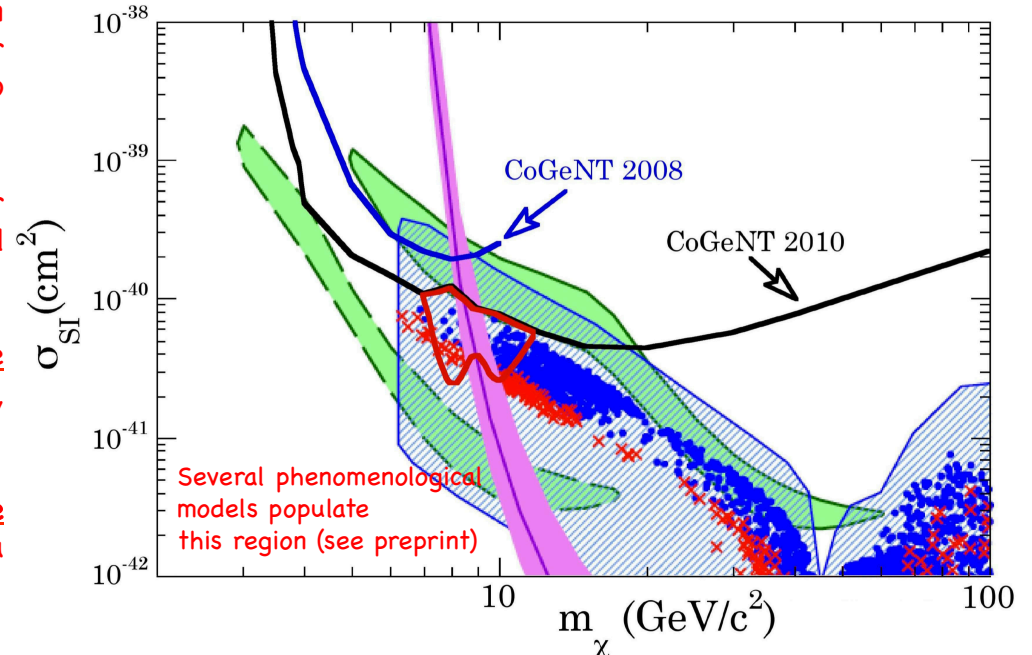
- The low-E excess is composed of asymptomatic bulk-like events (very different from electronic noise), coming in at a constant rate (76 days into data taking).

- The possible subject of interest is where we "got stuck" in phase space (a number of curious coincidences there), for a spectrum where most (if not all) surface events are removed ( $\leftarrow$  major contributors to low-energy spectrum). Caveat Emptor: without DAMA, would we have models there?

- We will attempt to strip the low-E data from known sources of background after a longer exposure, but all of them seem modest (see preprint). Planned additional calibrations will provide improved information on signal acceptance, background rejection and fiducial volume.

- Others will tell if this is cosmologically reasonable or not. BONUS: it seems readily falsifiable by other experiments.

arXiv:1002.4703v1



# CoGeNT: must keep looking for non-exotic explanations

It is possible to come up with **\*MANY\*** natural explanations, however none yet satisfactory.  
 A PPC-based 60kg MAJORANA demonstrator would see annual mod. not just in rate, also in  $\langle E \rangle$ .

N-type surface channel

R.J. Dinger, IEEE TNS 22 (1975) 135; H.L. Malm and R.J. Dinger, IEEE TNS 23 (1976) 76.

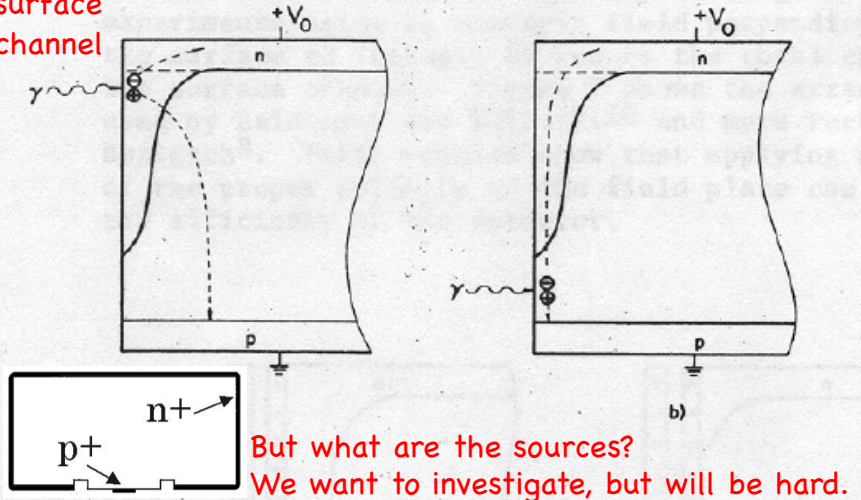
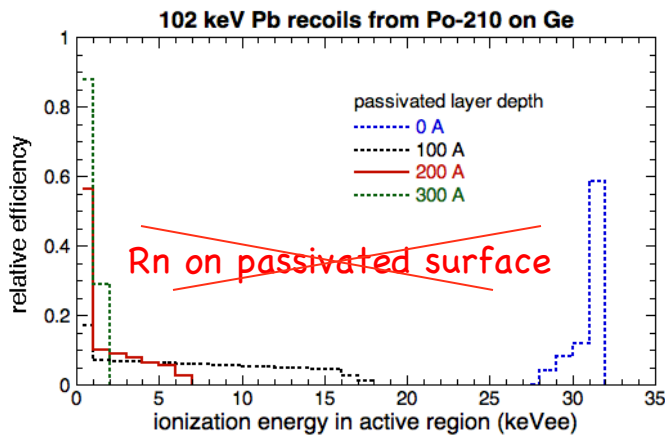
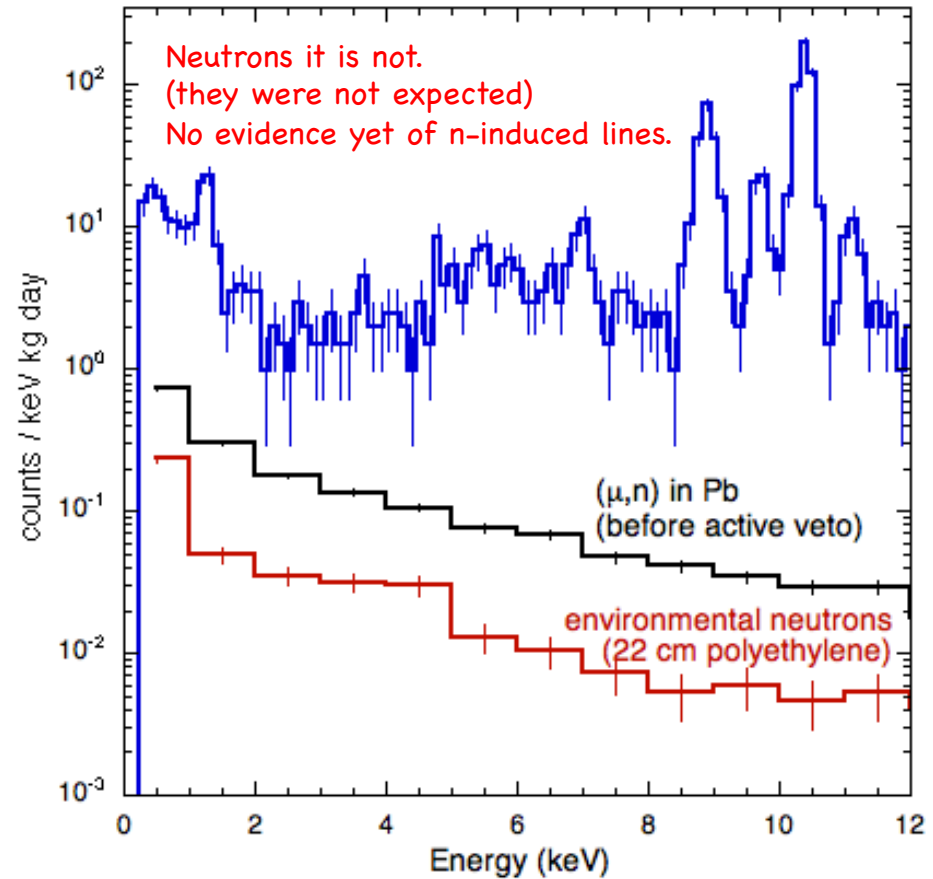


Fig. 4: The paths of the electrons and holes in a detector with an n-type surface channel [for further explanation see text].

But what are the sources?  
 We want to investigate, but will be hard.



~~Neutrons~~  
~~Microphonics~~  
~~Excess electronic noise~~

# CoGeNT: must keep looking for non-exotic explanations

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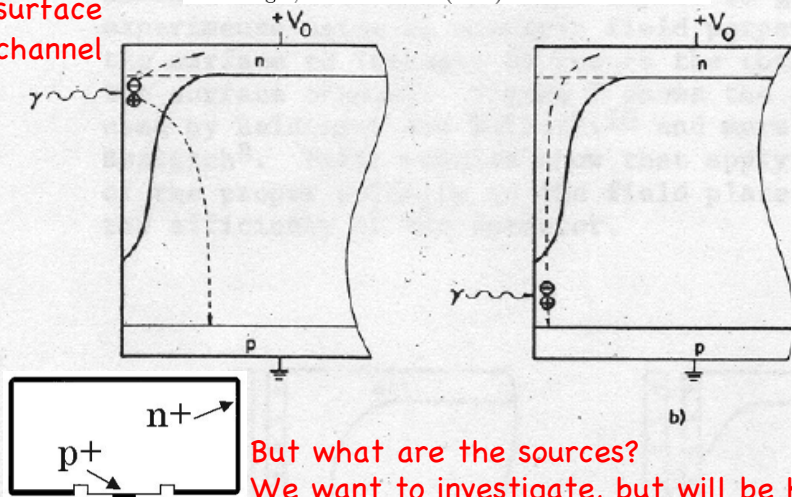
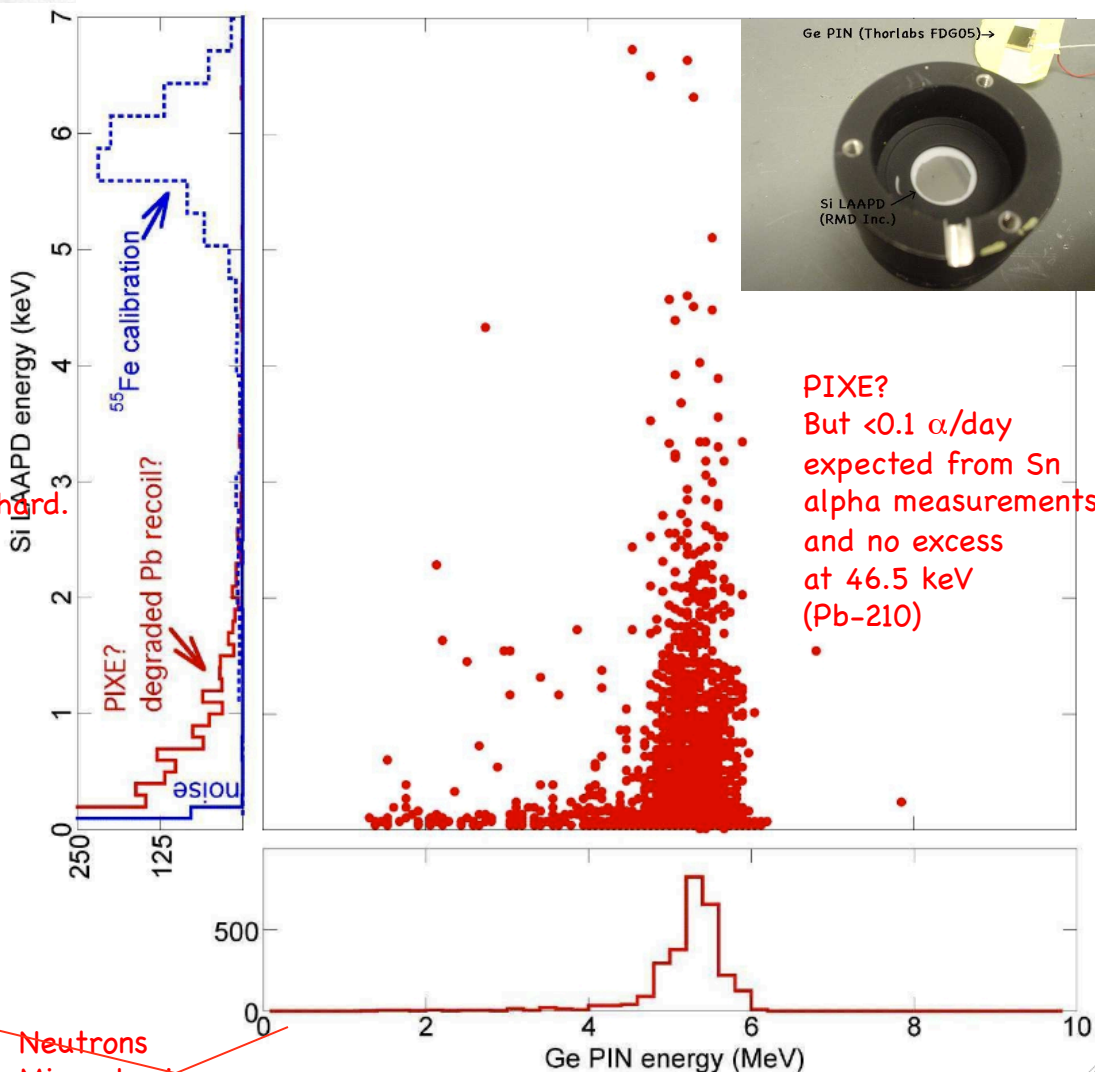
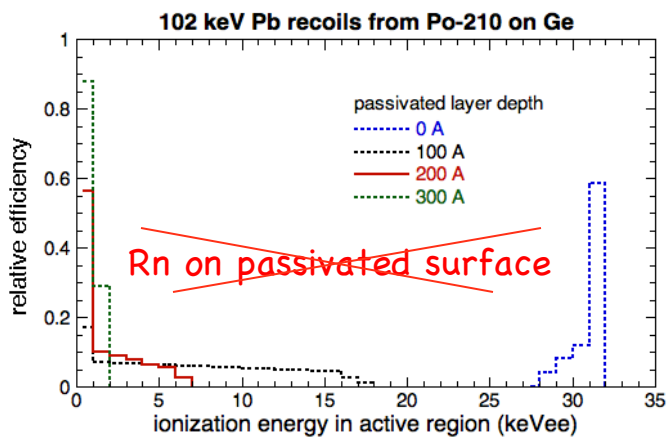


Fig. 4: The paths of the electrons and holes, in detector with an n-type surface channel [for further explanation see text].

But what are the sources?  
 We want to investigate, but will be hard.



PIXE?  
 But  $< 0.1 \alpha/\text{day}$  expected from Sn alpha measurements, and no excess at 46.5 keV (Pb-210)



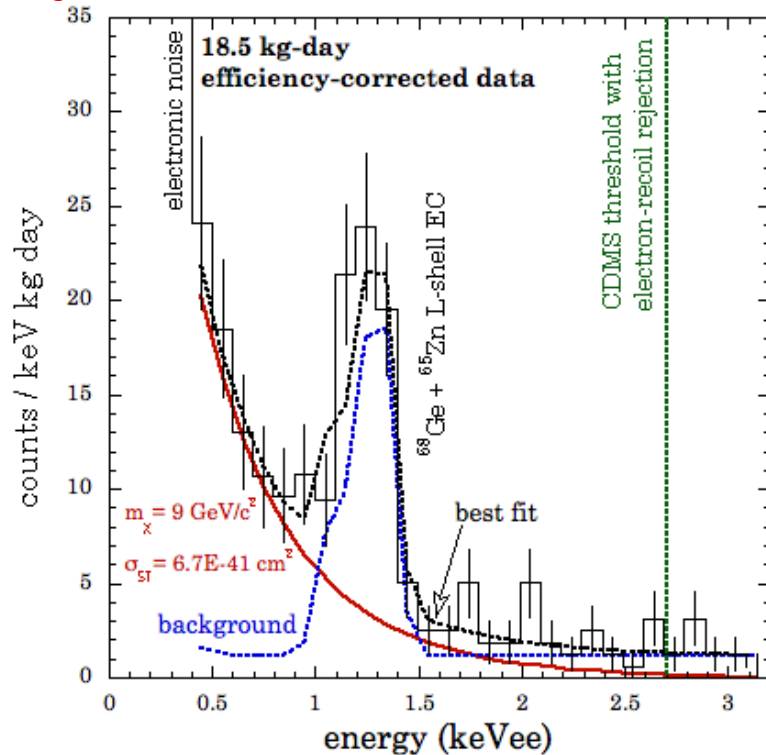
~~Rn on passivated surface~~

~~Neutrons  
 Microphonics  
 Excess electronic noise~~

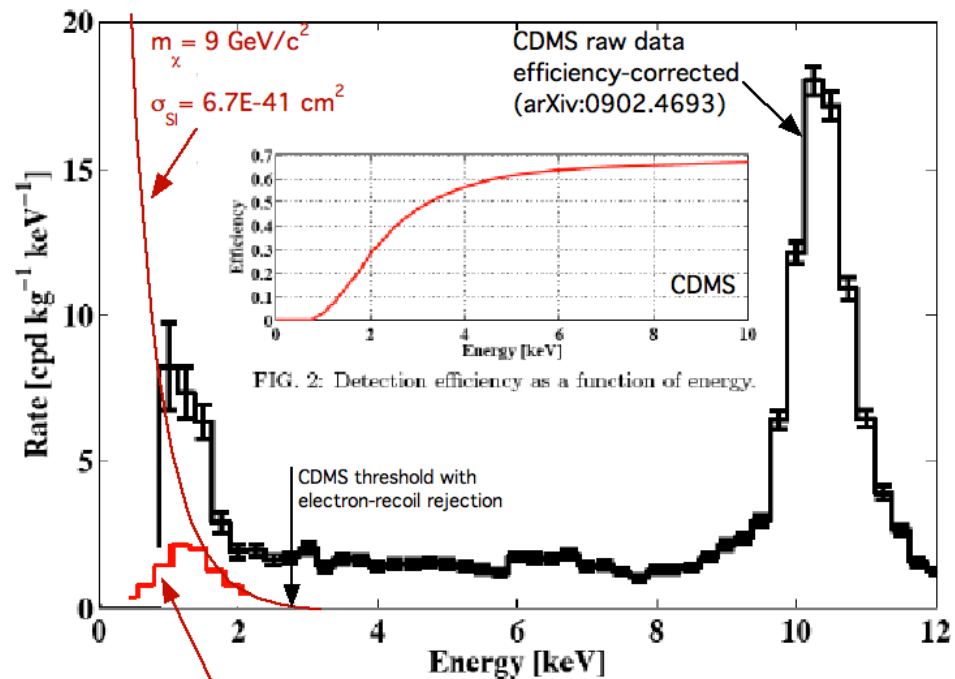


# How do CDMS (the Joneses next door) and CoGeNT compare?

An example WIMP mass in the region:



Where is CDMS in all this?  
(spectrum below for electron recoils, but large band overlap already at ~1.5 keVee)



Quotable: The excess of irreducible bulk-like events in CoGeNT is compatible with the WIMP hypothesis in a region where CDMS, DAMA and (several) phenomenological models (good thermal relics) can coexist. It is also equally compatible with any exponential background.

(Leo Stodolsky, overheard during DM10:

We have >> 100 events we do not understand, WE WIN!!!! ;-)

The predicament: WIMP signals are boring ~exponentials  
(i.e., low-E rise should not be noise)

# How do CDMS (the Joneses next door) and CoGeNT compare?

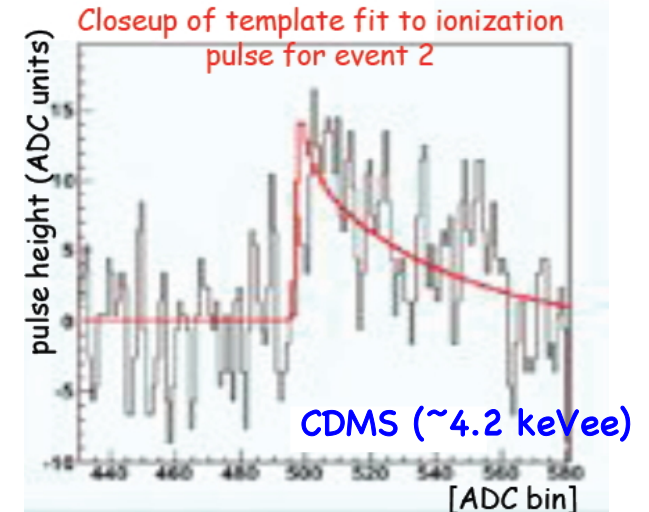
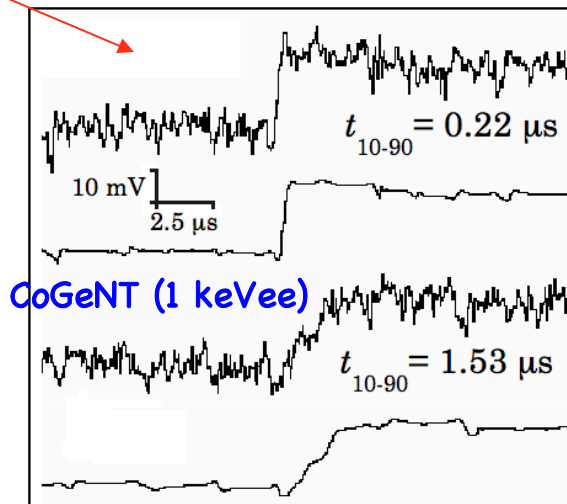
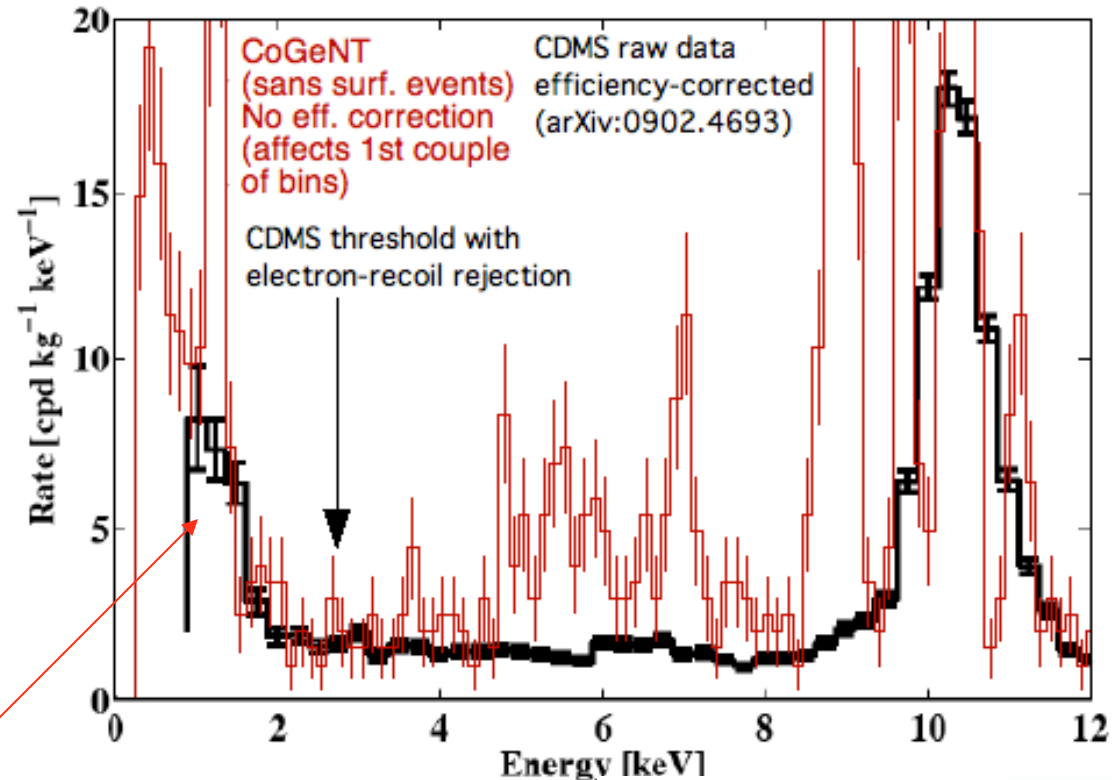
CoGeNT continuum will continue to drop (just 3 mo. underground at beginning of this run, vs. years for CDMS). This applies to cosmogenic peaks as well.

CoGeNT spectrum has cosmogenic partial energy depositions removed (slow pulses). Rise at low-E is stable (over 112 days so far)

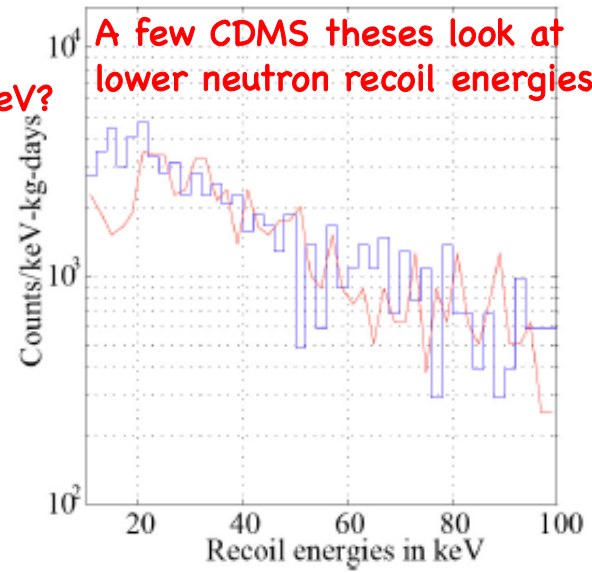
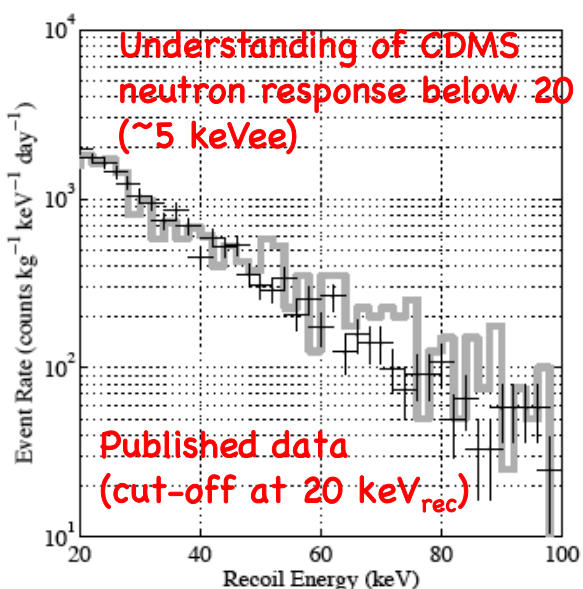
Notice difference in E resolution and order-of-magnitude signal-to-noise in ionization pulses. Also, definition of "threshold".

(Make whatever you want out of this. Keep in mind different resolutions, etc. Me, I am just adding it to the pile of coincidences... I was just trying to compare backgrounds!)

Should CDMS "dig deeper" in energy? This speaker believes so. Can they? Have they?

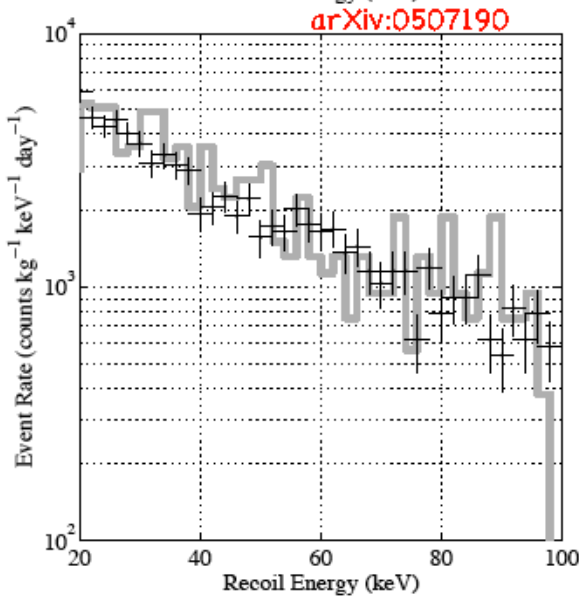


# A look under the CDMS hood: lower energy analysis exists



Present CDMS hardware (mainly due to noise in ionization channel) has a very limited ability to separate electron recoils and nuclear recoils below  $\sim 10 \text{ keV}_{\text{rec}}$

Hence the analysis thresholds used.



C.N. Bailey PhD Diss. CWRU 2010

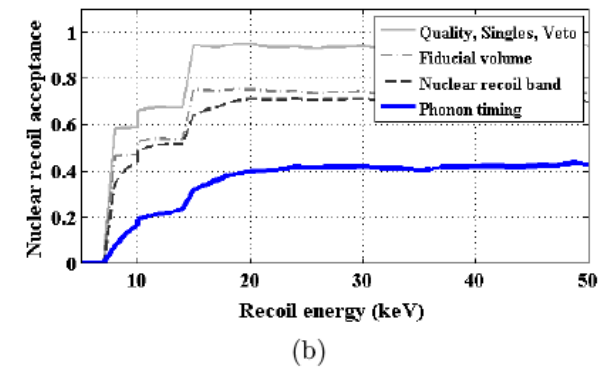
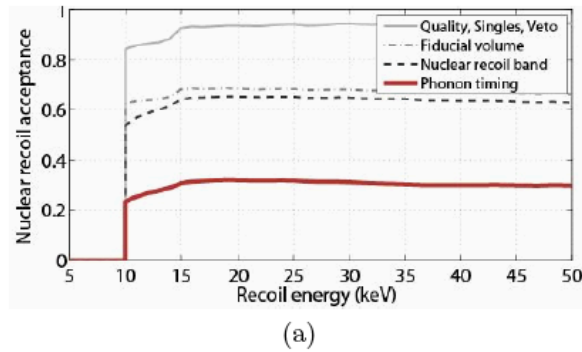


Figure 5.13: The efficiency of the R123 and 124 (a) germanium and (b) silicon WIMP search analysis as a function of phonon recoil energy. Curves represent the total efficiency after the subset of cuts described in the caption were applied to the data. From [17] and [27].

FIG. 10: Comparison of measured  $^{252}\text{Cf}$  neutron recoil spectrum (dots with error bars) and Monte Carlo simulation (gray line) for coadded Ge detectors (top) and Si detectors (bot-

What happens when these low-E cuts are relaxed?  
R. Ogburn CDMS PhD Dissertation 2008

# A look under the CDMS hood: lower energy analysis exists (R. Ogburn CDMS PhD Dissertation 2008)

At low energy the gamma and neutron bands flare in yield until they meet. Photons from the 1.3-keV line in Ge trail down well into the nuclear recoil band. To the extent that the low-energy gammas are caused by neutron activation, the gamma rate can be minimized by exposing the detectors to the  $^{252}\text{Cf}$  neutron source as little as possible.

No spectra nor limits offered, but we get this (and a measurement of neutron recoil signal acceptance under the new set of cuts):

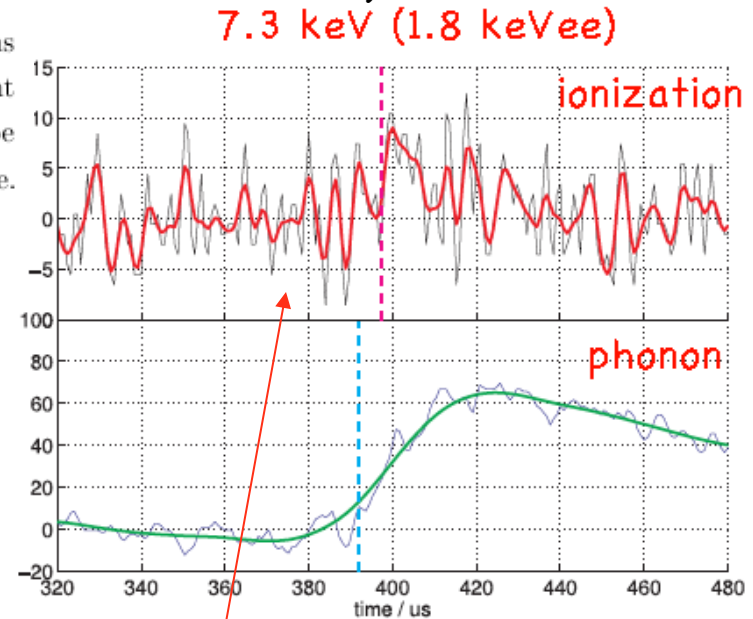
Table B.1: Events in 2-5 keV energy range, Ge detectors

Detector	Live time / d	Counts
T1 Z2	104	49
T1 Z3	108	45
T1 Z5	110	59

Table B.2: Events in 1-5 keV energy range, Si detectors.

Detector	Live time / d	Counts
T2 Z1	72	18
T2 Z2	56	26
T2 Z4	72	25
T2 Z6	68	41

After ~50% eff. correction, all "good" CDMS Ge detectors observe ~4 c/ kg-day in ~0.5-1.1 keVee region. CoGeNT observes ~5 c/ kg-day. The excesses seem to have compatible endpoints. In Si, after ~35% eff. correction, they observe ~12 c/kg-day in 0.2-1.5 keVee bin. Caution: Si is considerably "hotter" than Ge (~3c/keV kg day expected from the usual cosmogenic  $^{32}\text{Si}$  concentration, if nothing done about it)



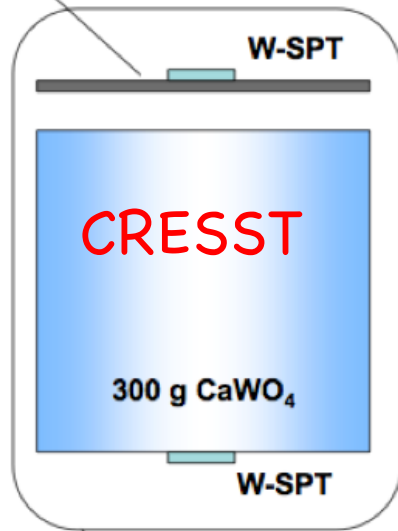
The problem is this (and rise time of phonon channel at lower-E)

Neganov-Luke effect can help reach lower-E and improve resolution, but probably not with bckg rejection.

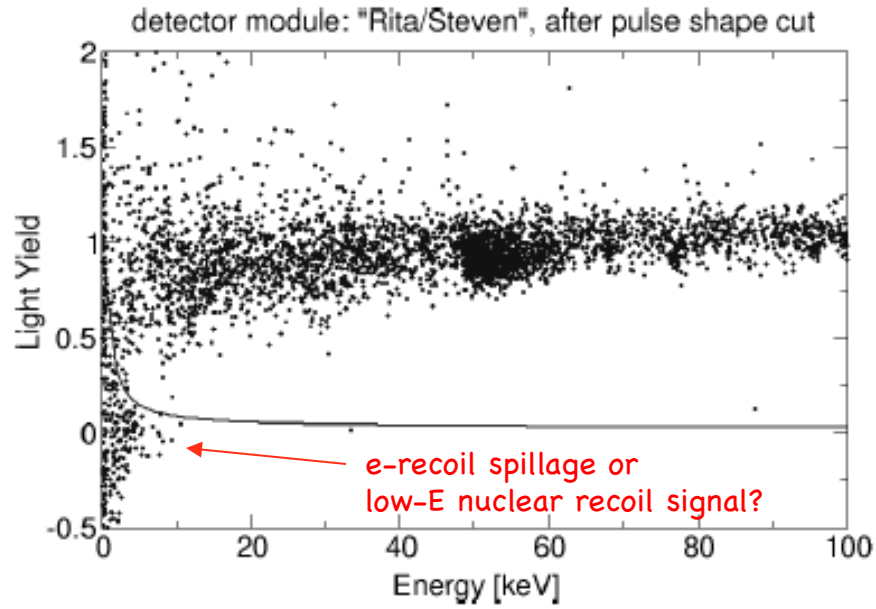
With present electronics, what CDMS has to say (one way or another) about this spectral region has to be taken with a large grain of salt (CoGeNT can at least very efficiently reject most surface events in the same energy region, + we aim at improving bckgs and threshold already this year)

Since we are at it...

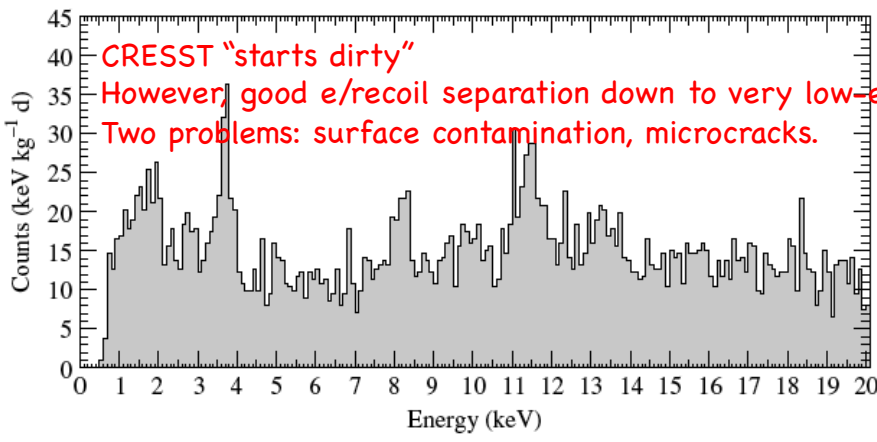
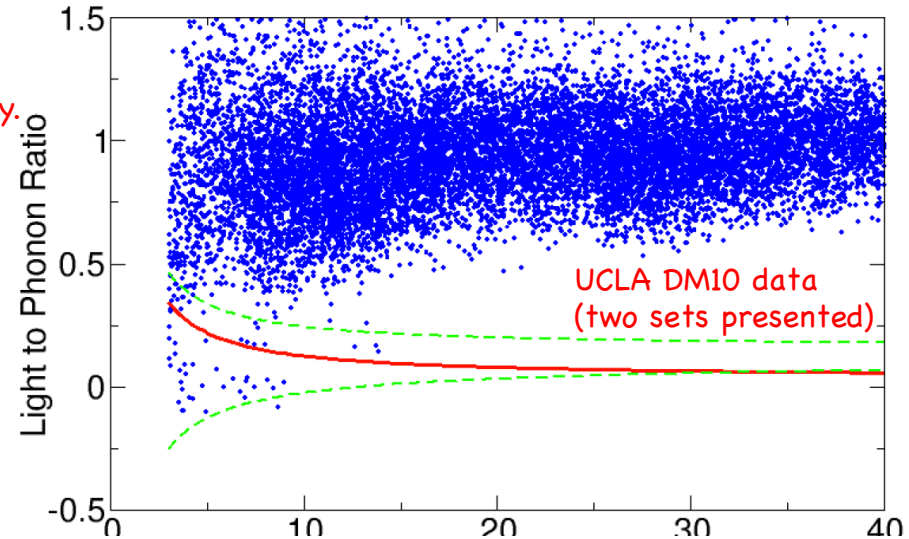
separate calorimeter as  
light detector



light reflector



maja/matis 25.5 kg days

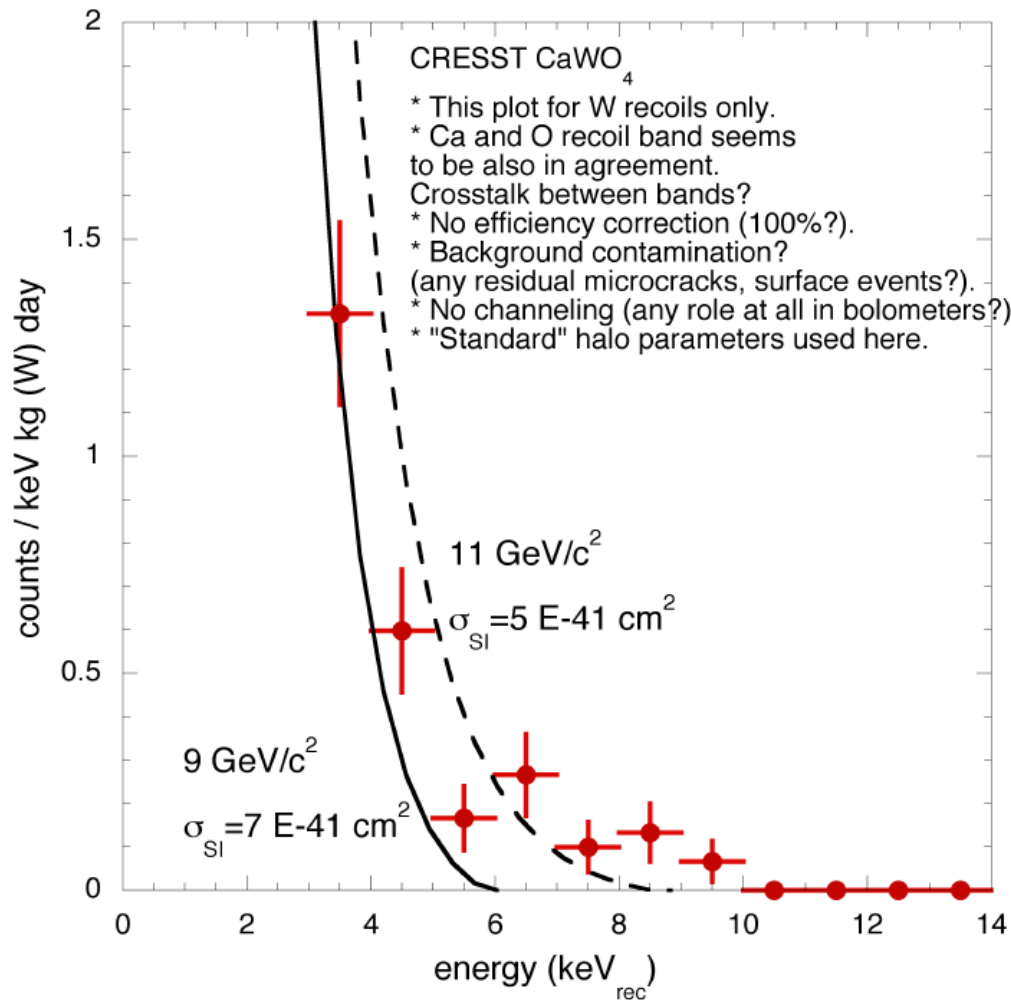


[arXiv:physics/0504151](https://arxiv.org/abs/physics/0504151)

[arXiv:0912.3689v1](https://arxiv.org/abs/0912.3689v1)

Ongoing run: after microcrack and surface event countermeasures, low-E population persists...

Since we are at it...



A very naïve look at CRESST DM10 data.

Another coincidence?

CRESST will have a lot to say soon (one way or another)

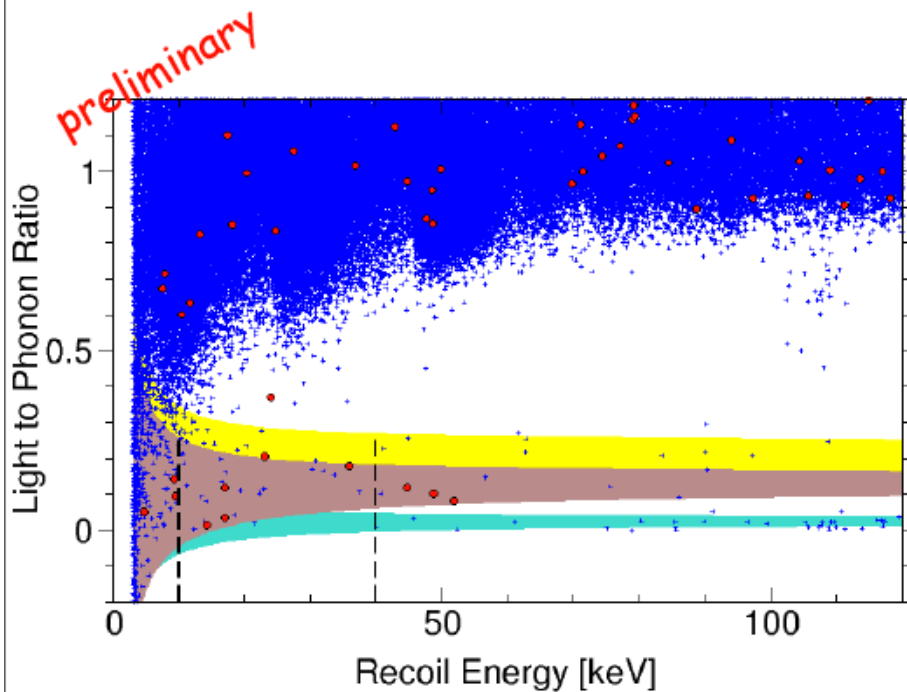
Better band separation than CDMS.

CRESST CaWO<sub>4</sub> target contains three recoiling species. This may be presently an encumbrance, but will soon become a virtue (with planned improved separation of recoil bands)

(we are not the only people wondering)

## What is going on in the Oxygen Band

Several detectors added



- Rate in all detectors equal within statistics
- decrease summer winter there but statistically not yet significant

Neutrons ?

- Rate too high for external neutrons
- „internal“ neutron source only if low energetic

Low mass WIMPs ??

A combined analysis of all recoil-bands is in preparation

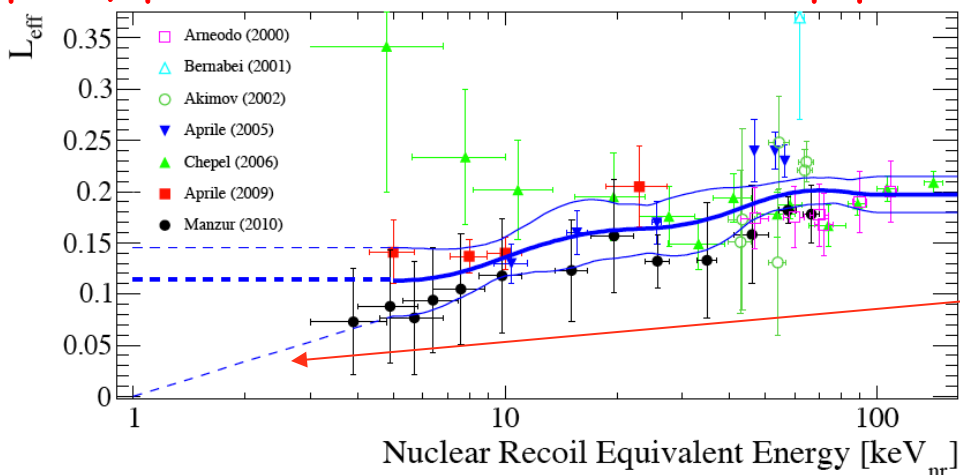
More statistics is needed

# XENON100: Great detector, shame about the analysis

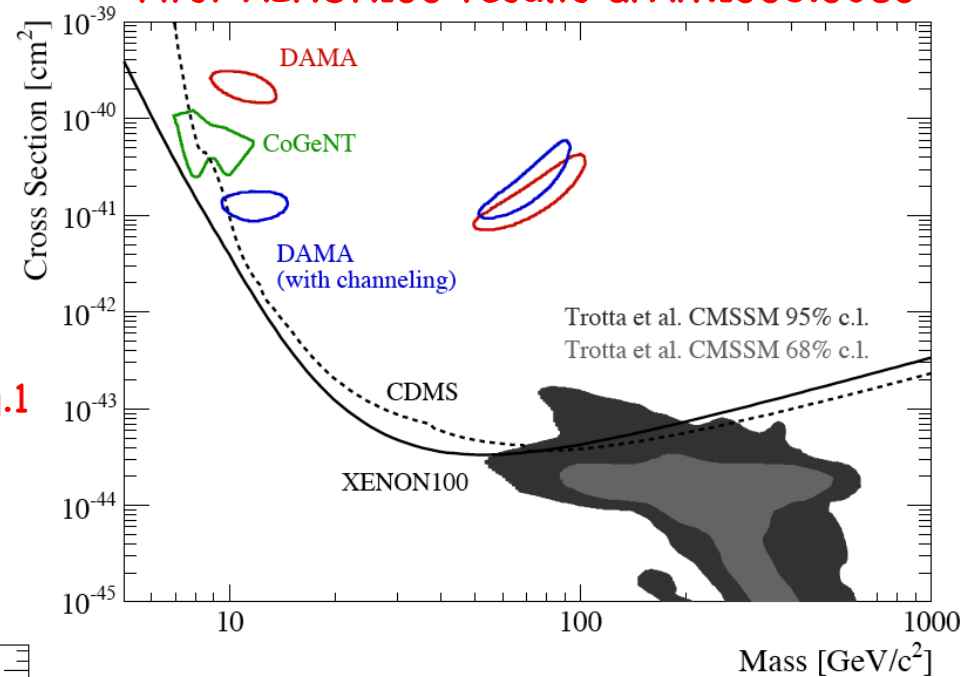
## Criticism (see arXiv:1005.0838v3):

- Blatant bias (historical evolution of  $L_{\text{eff}}$  measurements ignored, including latest XENON10 re-analysis).
- Treatment of LARGE uncertainties absent.
- $L_{\text{eff}}$  model adopted biased and unphysical.
- Lots of smoke and mirrors around critical Fig.1

XENON100 wants you to look at the pretty pictures, not so much to read the paper:



## First XENON100 results arXiv:1005.0380



What is this line?

Notice subtle changes in language from arXiv:1005.0380v1 to arXiv:1005.0380v2...

(no, it is not the lower 90% CL, and no, it does not leave the limits unchanged -not nearly-)

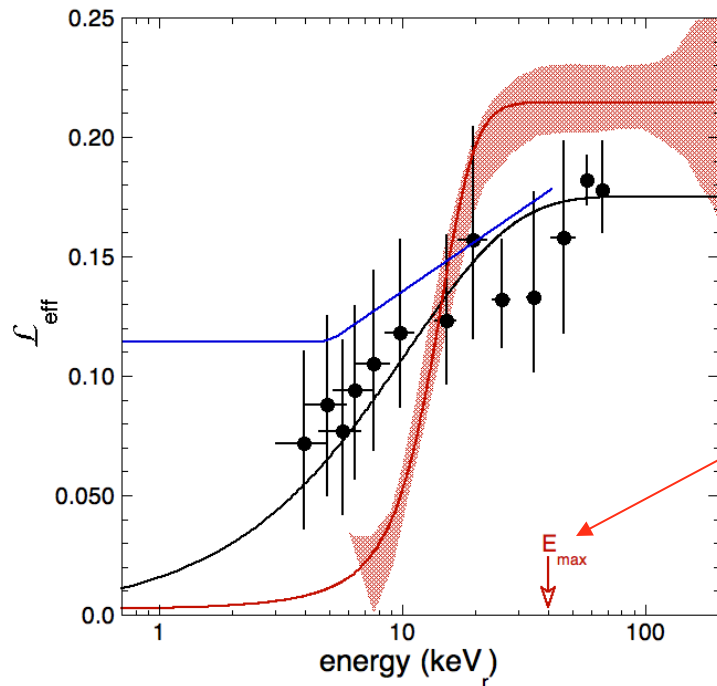
Develop your own opinion (I have one).



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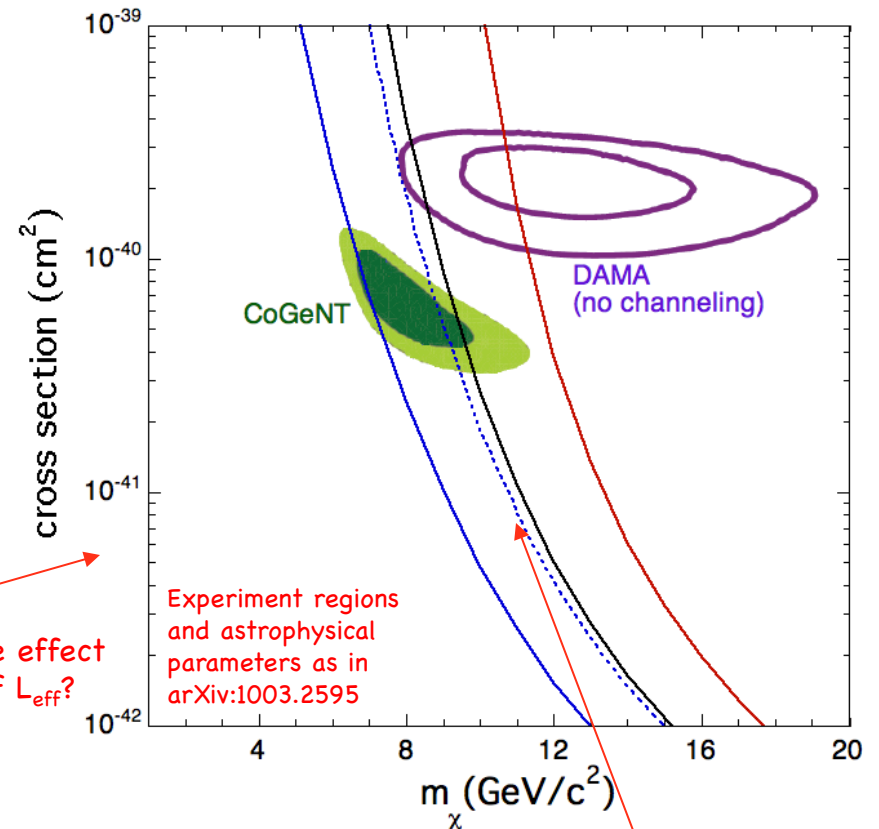


What is the effect of choice of  $L_{\text{eff}}$ ?

Not a matter of belief, it is the law.

**XENON100 light WIMP limits in a nutshell:**  
Limits extracted from an energy region for which calibration data do not exist, using the least conservative (and unphysical)  $L_{\text{eff}}$  model, and against trend in measurements.

Much more like it:



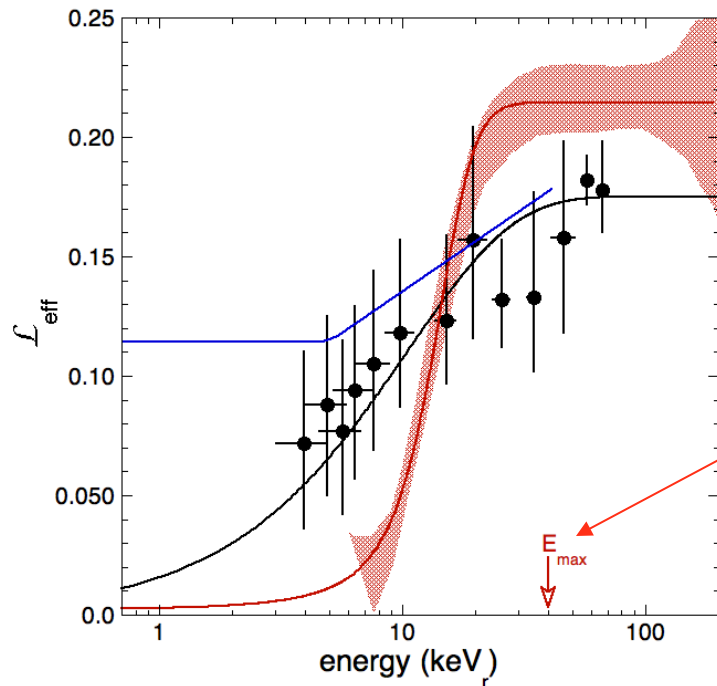
Experiment regions and astrophysical parameters as in arXiv:1003.2595

This is what happens when the "faux" lower 90% C.L. is used...

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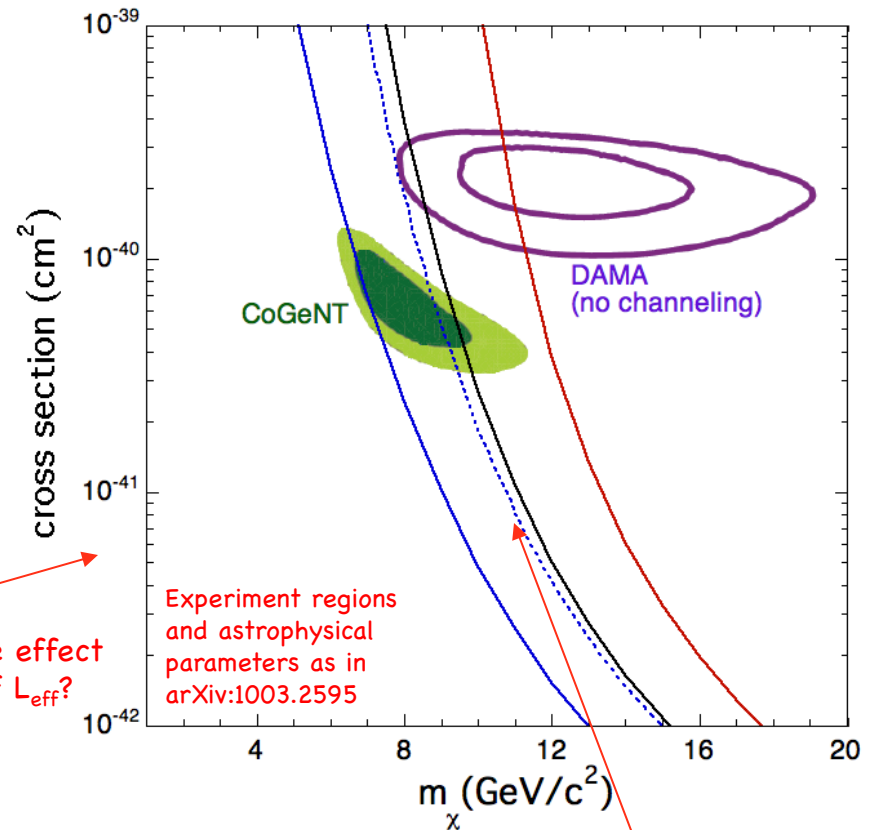


What is the effect of choice of  $L_{\text{eff}}$ ?

Not a matter of belief, it is the law.

Using a "reasonable" adiabatic  $L_{\text{eff}}$  fit to account for kinematic cutoff (as in other scintillators) yields 0.045 (0.25) events above 4 (3) PE threshold for 7  $\text{GeV}/c^2$  WIMP with  $5\text{E}-41 \text{ cm}^2$  SI coupling...

Much more like it:



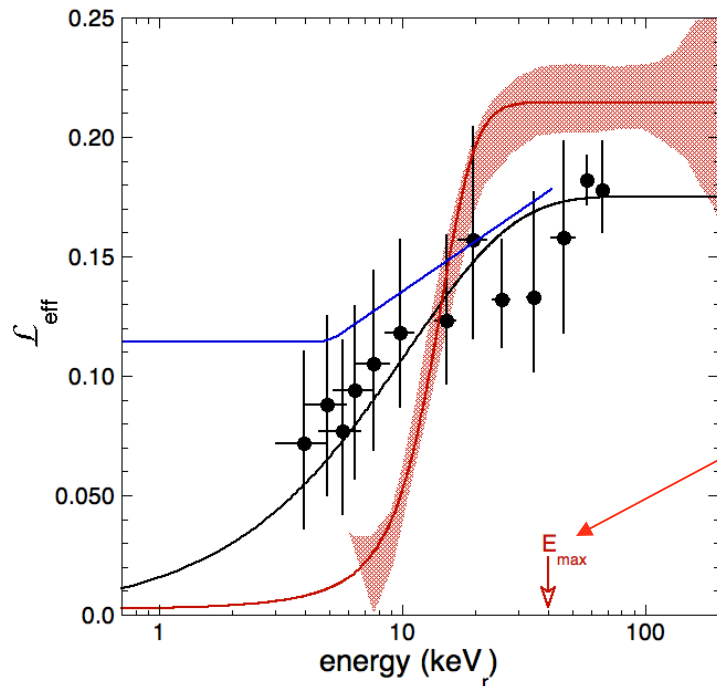
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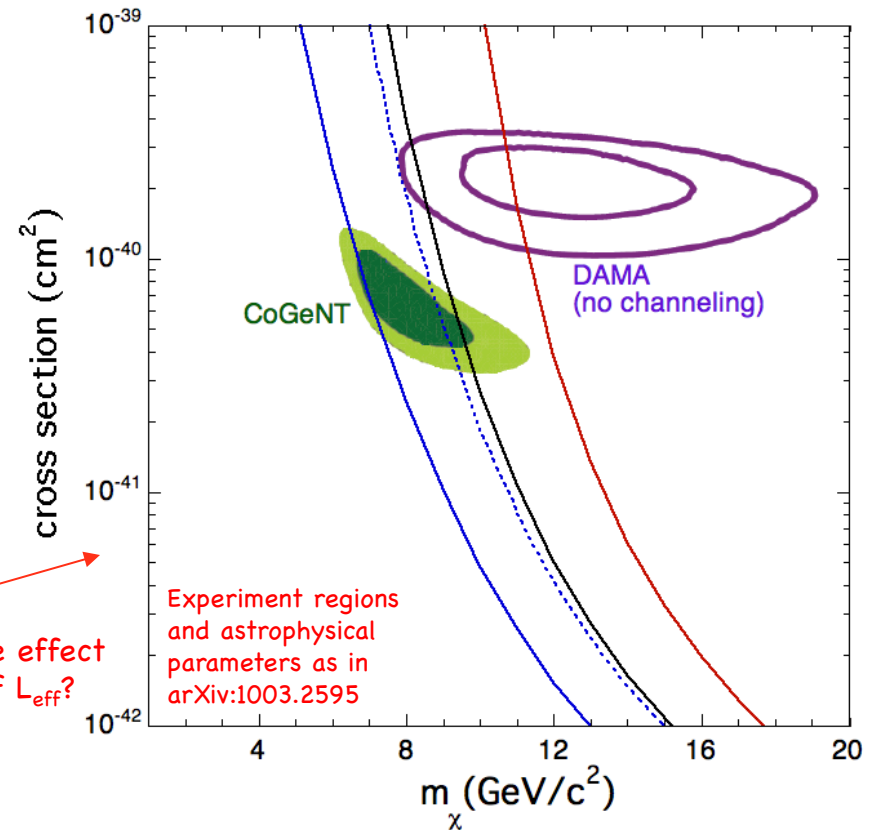
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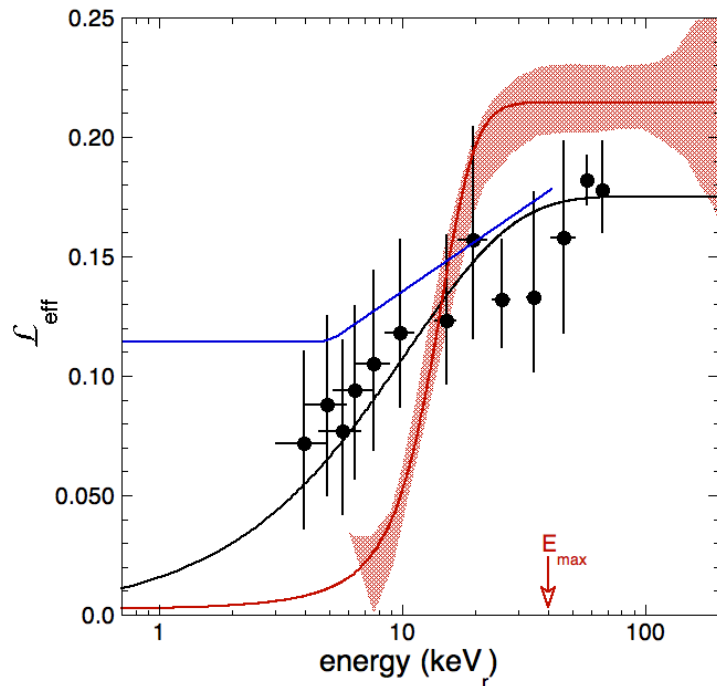
## THE GOOD NEWS:

An analysis this awful does not occur more often than  $\sim$ once/25 years (based on personal statistics)

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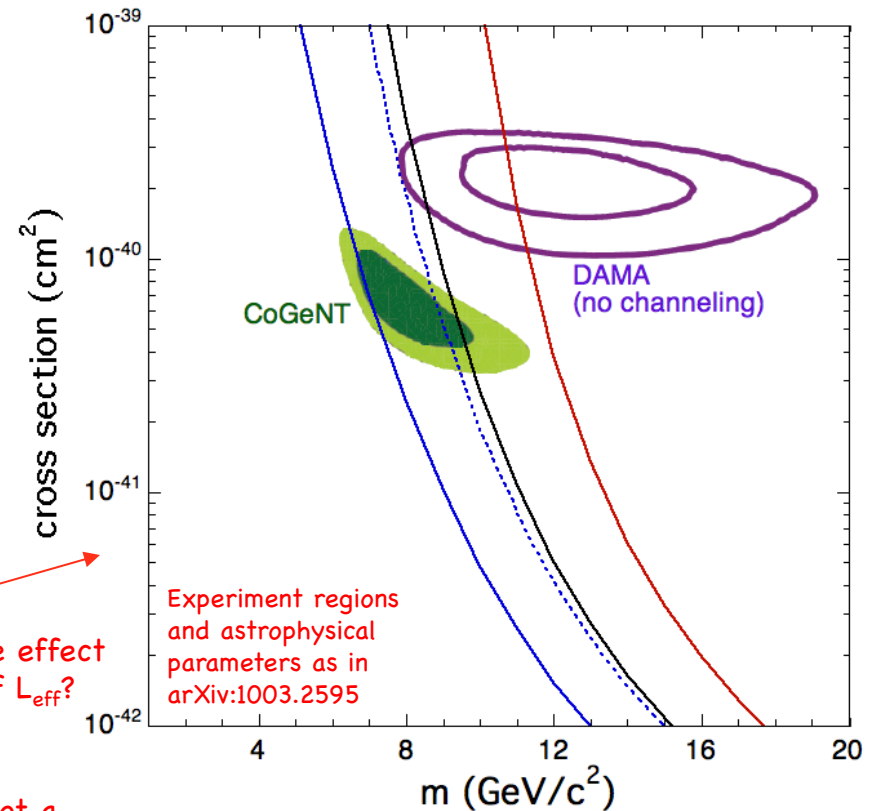
What is the effect of choice of  $L_{\text{eff}}$ ?

As it turns out, not a complete waste of time:

What is the *expected* low-E behavior for the NaI(Tl) quenching factors?

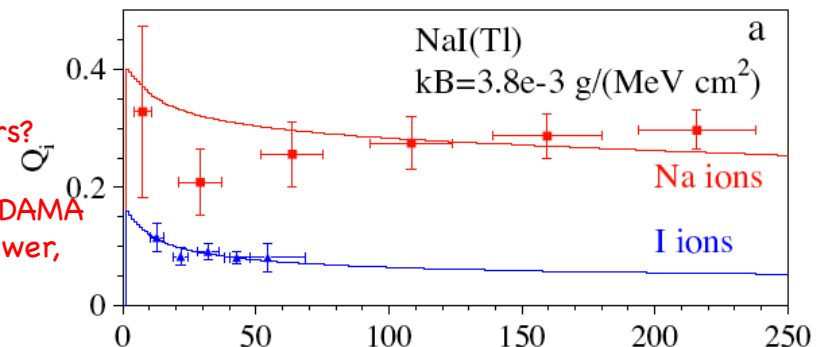
How does it affect the DAMA region? (I know the answer, but you are the phenomenologists...)

Much more like it:



Experiment regions and astrophysical parameters as in arXiv:1003.2595

V.I. Tretyak / *Astroparticle Physics* 33 (2010) 40



## Channeling and Blocking Effects in Crystals

refer to the orientation dependence of ion penetration in crystals.

### Channeling:

Ions incident upon the crystal along symmetry axis and planes suffer a series of small-angle scattering that maintain them in the open “channels” and **penetrate much further** (*ions do not get close to lattice sites*)

### Blocking:

Reduction of the flux of ions **originating in lattice sites** along symmetry axis and planes (*“blocking dip”*)

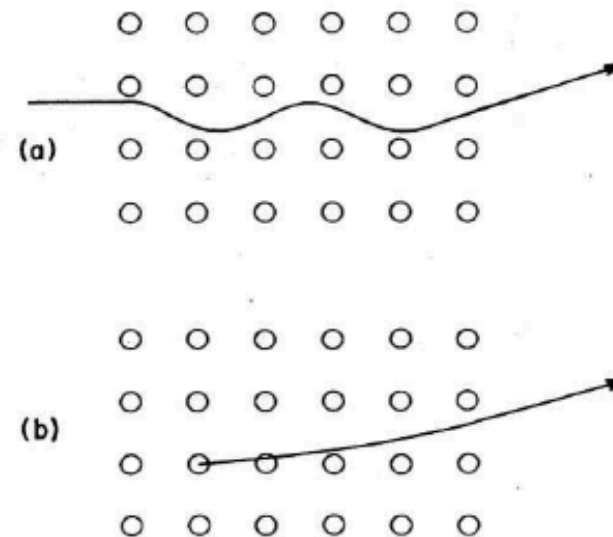


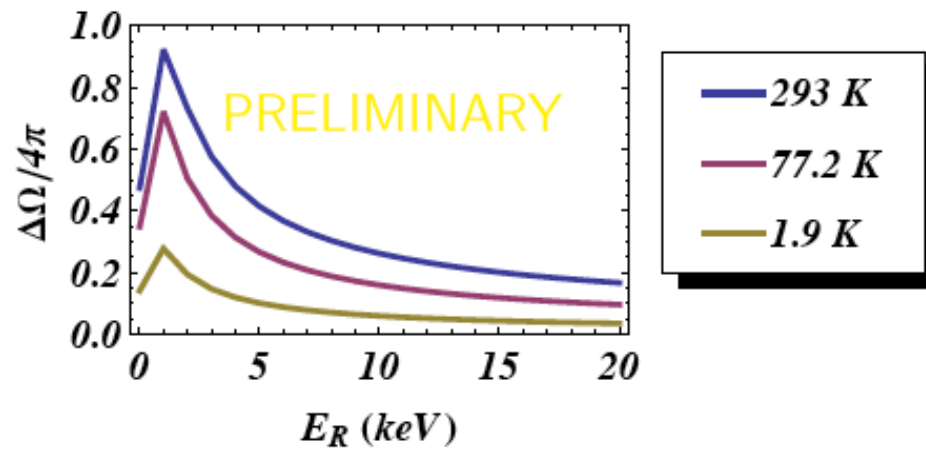
FIG. 1. Schematic illustration of (a) channeling and (b) blocking effects. The drawings are highly exaggerated. In reality, the oscillations of channeled trajectories occur with wavelengths typically several hundreds or thousands of lattice spacings.

(From D. Gemmell 1974, Rev. Mod. Phys. 46, 129)

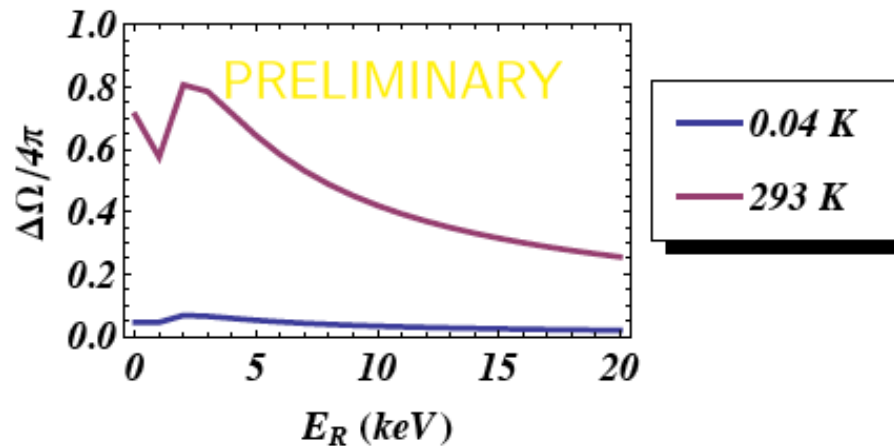
## Channeling within blocking: depends on T

Very small at mK but can be important at room temperature!

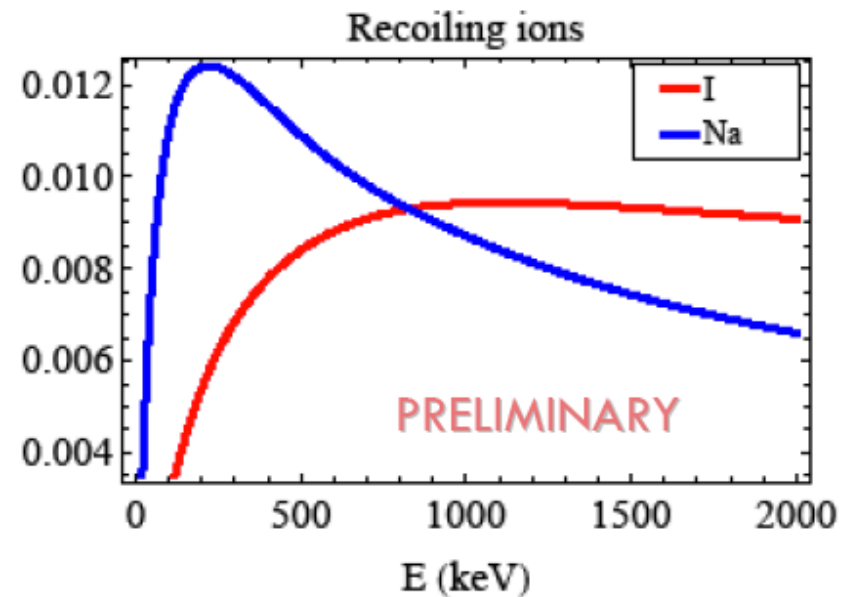
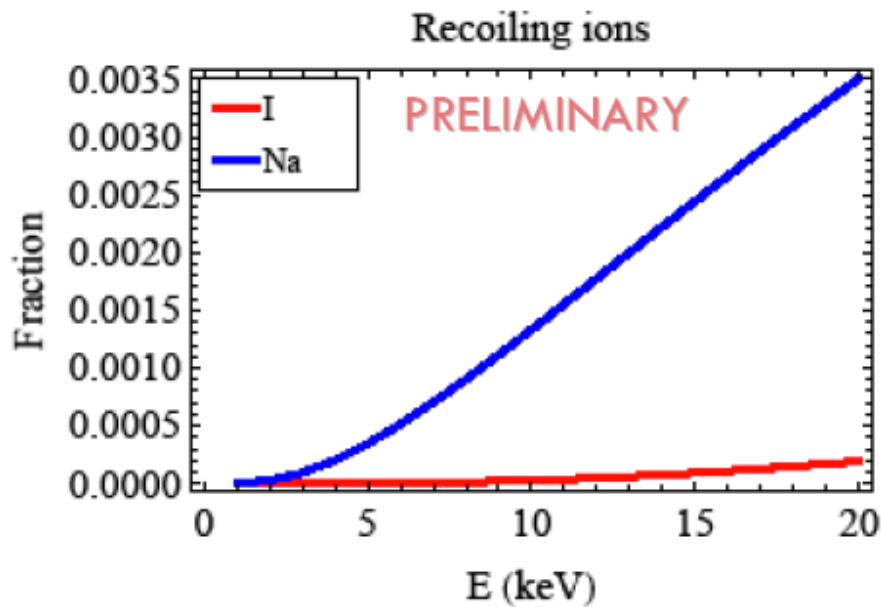
Na in NaI crystal:



Ge crystal:



# Fraction of Recoils that are Channeled



- This result now differs from DAMA results.
- These are upper bounds to what we can expect to be the true fraction.

What next?



# Light WIMPs: what next?

Wee update on CoGeNT:

\* At x3 the exposure everything looks same. Seems like we will be able to strip all low-E cosmogenic peaks very nicely (using higher-energy peaks and known L/K EC ratios -Bahcall et al.-)

\* Additional studies of bckg rejection and fiducial vol. planned for this summer.

\* Upgrade (bckg, threshold) in the making. If we do not already kill the low-E excess next step is 4 x 900g array (see two modulations?)

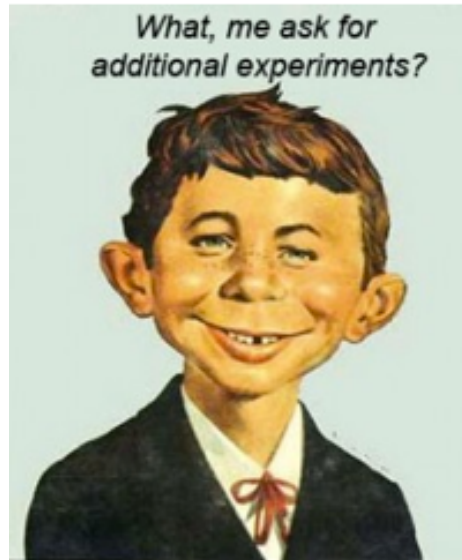
\* We are not going to sit on this one forever... (pragmatic approach: best effort at bckg abatement. Kill it or see it modulate, both interesting results -little room for DAMA interpretations if CoGeNT continues to significantly improve its low-mass sensitivity-)

JOHN N. BAHCALL PHYSICAL REVIEW  
VOLUME 132, 1963

TABLE IV. Comparison of theoretical and experimental  $L/K$  capture ratio.

Isotope	$\left(\frac{q(2s')}{q(1s')}\right)^2$	Usual theoretical ratio [Eq. (13)]	Exchange-corrected ratio [Eq. (4)]	Observed ratio	Number of precision experiments
Ar <sup>37</sup>	1.006	0.0820	0.099	0.100 ±0.003	4
Cr <sup>51</sup>	1.014 <sup>a</sup>	0.0882	0.101	0.1026 ±0.0004	1
Mn <sup>54</sup>	1.020	0.0898	0.102	0.098 ±0.006	1
Fe <sup>55</sup>	1.051	0.0936	0.106	0.106 ±0.003	2
Co <sup>57</sup>	1.017	0.0915	0.103	0.099 ±0.011	1
Co <sup>58</sup>	1.008	0.0907	0.102	0.107 ±0.004	1
Zn <sup>65</sup>	1.041 <sup>a</sup>	0.0970	0.108	0.119 ±0.007	1
Ge <sup>71</sup>	1.083	0.103	0.114	0.1175 ±0.002	2
Kr <sup>79</sup>	1.021 <sup>a</sup>	0.102	0.111	0.108 ±0.005	1

# Light WIMPs: what next?

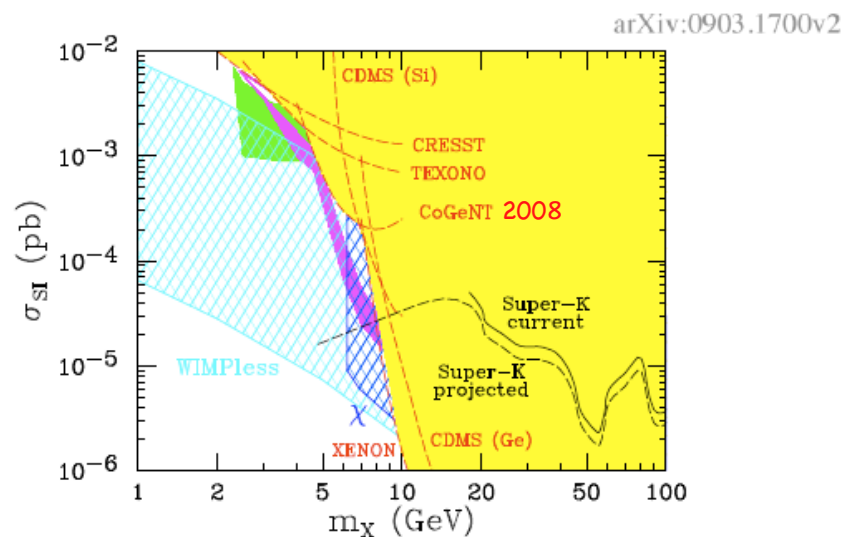
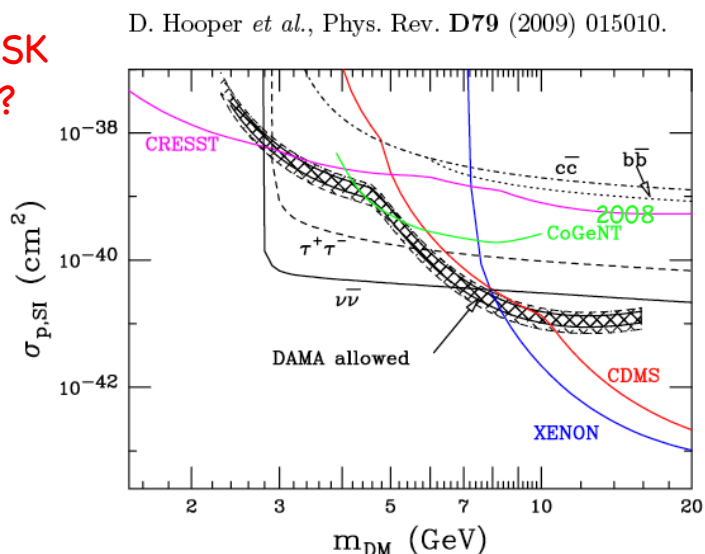


- \* CoGeNT: more exposure, lower  $E_{thr}$ , more calib.&analysis, upgrades...
- \* MALBEK @ Kimballton: different surface channel? Lots to learn from it.
- \* MAJORANA 60 kg Demonstrator: How about two modulations for the price of one?
- \* GERDA: PPCs considered (favored?) for phase two.
- \* CDEX @ CDUL: 10 kg of PPCs in ~2012 in world's deepest UL.
- \* CDMS/Edelweiss with lower threshold?
- \* Si CCDs? (FNAL)
- \* Bolometers? (in particular CRESST)
- \* Indirect Searches? (SK, FERMI, etc.)

At least this "signal"  
seems to have the virtue of being  
easily falsifiable...

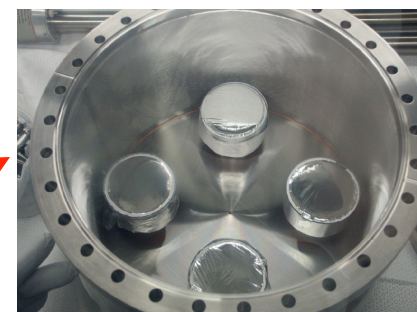
# Light WIMPs: what next?

Within SK reach?



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- \* MAJORANA 60 kg Demonstrator: **How about two modulations for the price of one?**
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- \* Si CCDs? (FNAL)
- \* Bolometers? (in particular CRESST)
- \* Indirect Searches? (SK, FERMI, etc.)

**My \$ is on this pony: MAJORANA 60kg PPC-based (if we do not get rid of CoGeNT's exponential earlier)**



# Heavier WIMPs: what next?

- WARP: delayed by HV failure, but otherwise ready to go (watch it!)
- XMASS: delayed by ~10 cm of steel missing...
- LUX: delayed by DUSEL, but otherwise about to zip up (on surface)
- COUPP: 4 and 60 kg in SNOlab during 2010. Now with alpha rejection!
- XENON100: expect first electron-recoil leakage to be claimed "discovery"  
( $^{85}\text{Kr}$  around the corner...)
- Light WIMPs are not going away:
  - \* CRESST: light WIMP analysis ongoing...
  - \* CDMS light WIMP analysis in preparation...

# Light WIMPs: The plot thickens?

\* All direct-detection WIMP “signals” should be first treated as an unknown background (no, you cannot ignore Occam because this is *your* experiment). An experimentalist’s job is to shoo these away, no matter how enticing.

\* No single WIMP detector can make a teflon-coated case for DM discovery. We are looking for a desperately non-descript signal and we cannot possibly predict all future backgrounds. Directional detectors may be the single exception to this rule.

\* Bias is a sure way to miss an interesting signal. We need to listen to our friends in phenomenology (and viceversa), but only to a certain extent.

\* DM discovery will happen by accretion. I will personally not trust evidence by direct detection experiments only (the “Ouija board” effect). We will need external contribution (indirect, cosmological, accelerator, solid theoretical motivation – including other predictions–)



One background hides the next. If you don't know that “this too shall pass”, you have not been in this field for long enough (or worse).

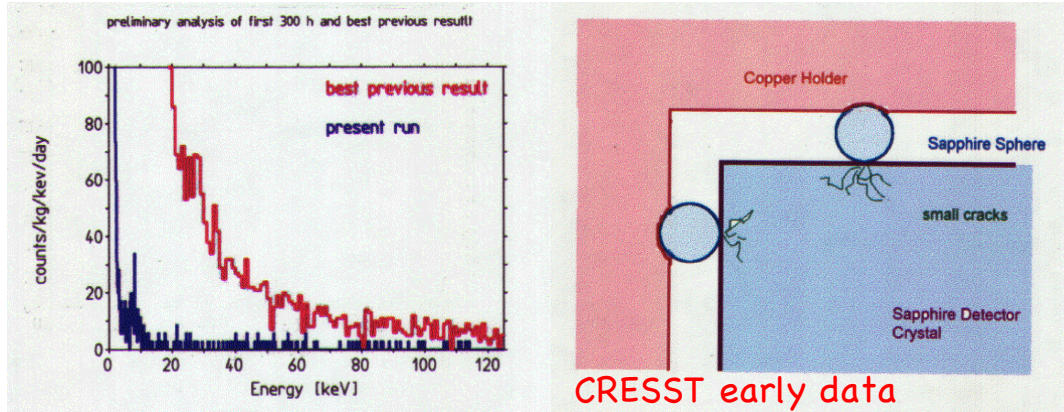
Point enough fingers at the same parameter space and next thing you know you are believing in spirits (or pentaquarks). It always starts with a single finger.



## What will it take to call it "dark matter"?

- **FACT #1:** DAMA may or may not be observing a WIMP effect. CDMS may or may not have observed  $O(1)$  WIMP. COGENT may or may not be pointing at the mass and coupling of culprit. The LHC, indirect searches, other experiments, should help soon.
- **FACT #2:** In a few years (decades?) we will regard Dark Matter as just another expression of environmental radiation (and a background in its own right, affecting future searches for exotica).
- **FACT #3:** Along the way we will bump into many manifestations of natural radioactivity that we have not yet realized are there...

... and many mundane artifacts:



- **FACT #4:** No degree of enthusiasm (impatience?) on our side will hasten this process.



WIMP searches: a quixotic fight against backgrounds