CoGeNT:

neutrino & astroparticle physics using large-mass, ultra-low noise germanium detectors

(ANL, CANBERRA, LLNL, PNNL, ORNL, SNL, UC, UNC, UW)

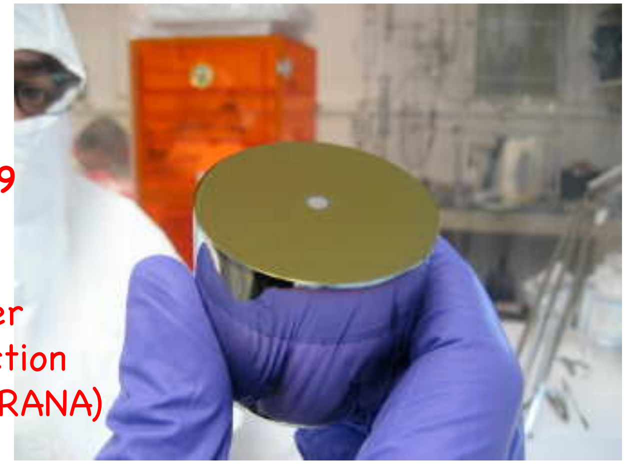
(mostly a tentacle of MAJORANA)

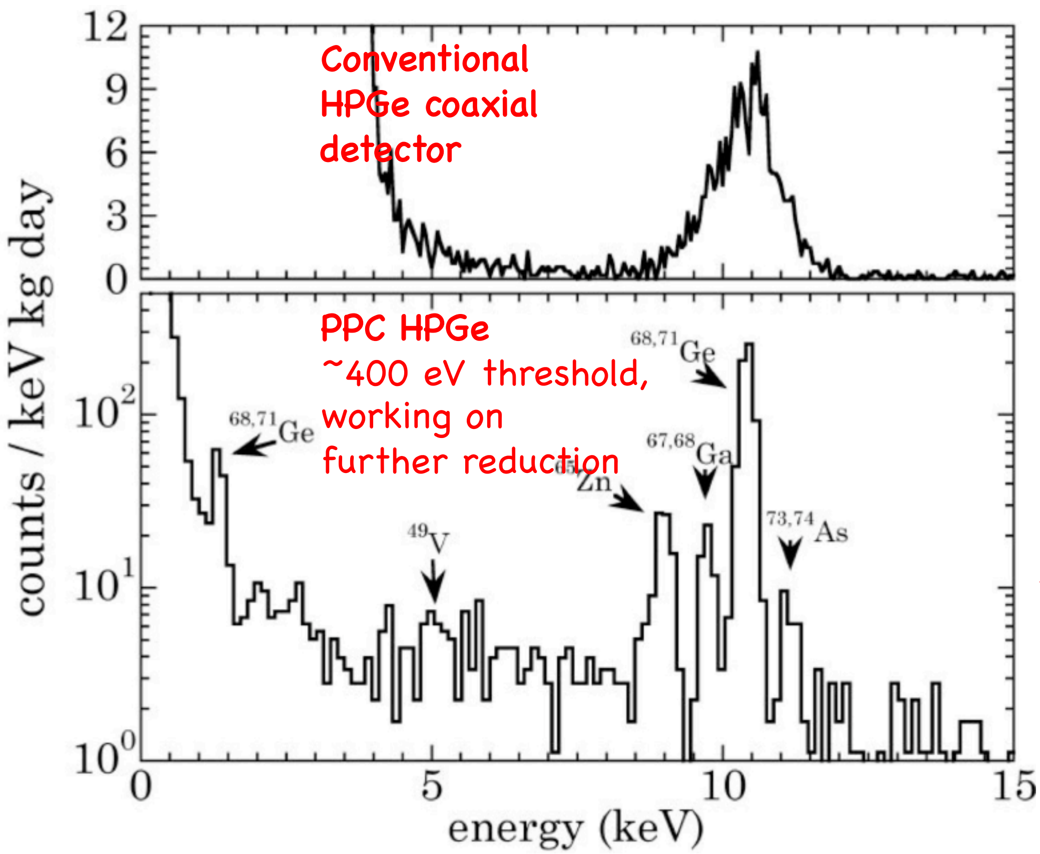
PPC HPGe

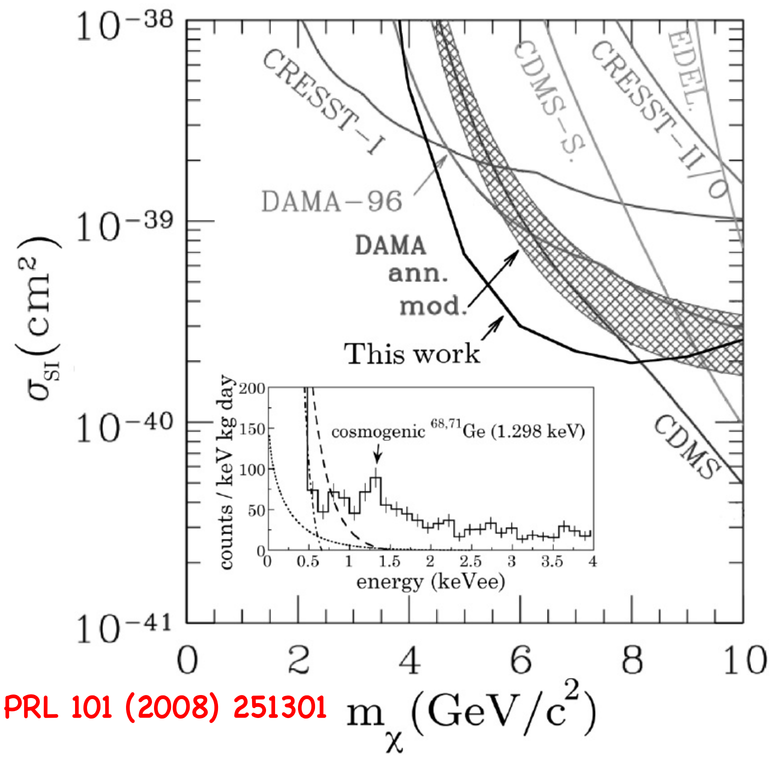
JCAP 09(2007)009

Applications:

- Light Dark Matter
- Coherent ν detection
- ββ decay (MAJORANA)







PRL 101 (2008) 251301

Extensive constraints on DAMA's claim:

- Light WIMPs
- Dark scalars
- Dark pseudoscalars

J.I. Collar, CUNY April 2010

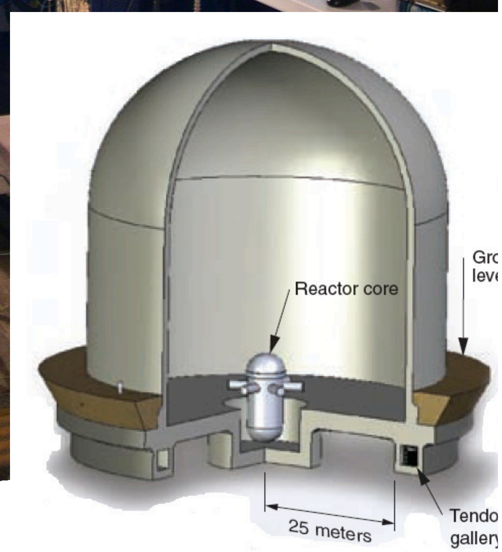
Other applications (ν physics)

"Tendons"

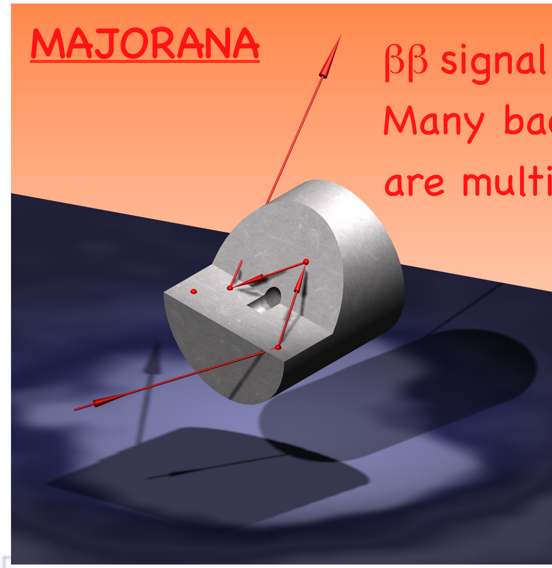
30 mwe

San Onofre
Unit 3 core
20m that way

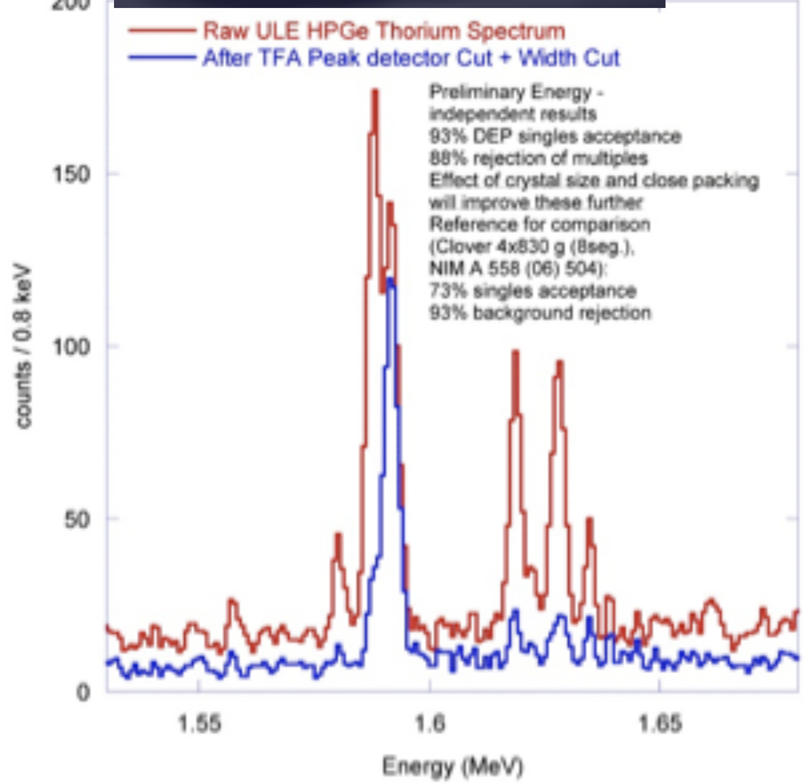
LN2
generation
and auto-transfer



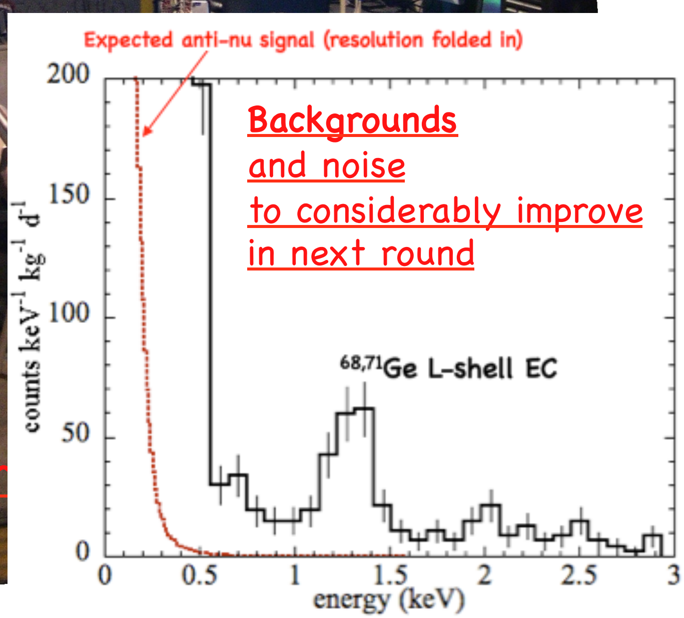
MAJORANA

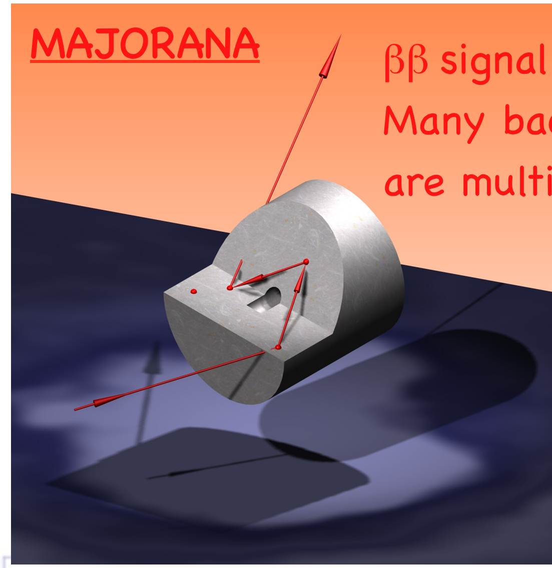


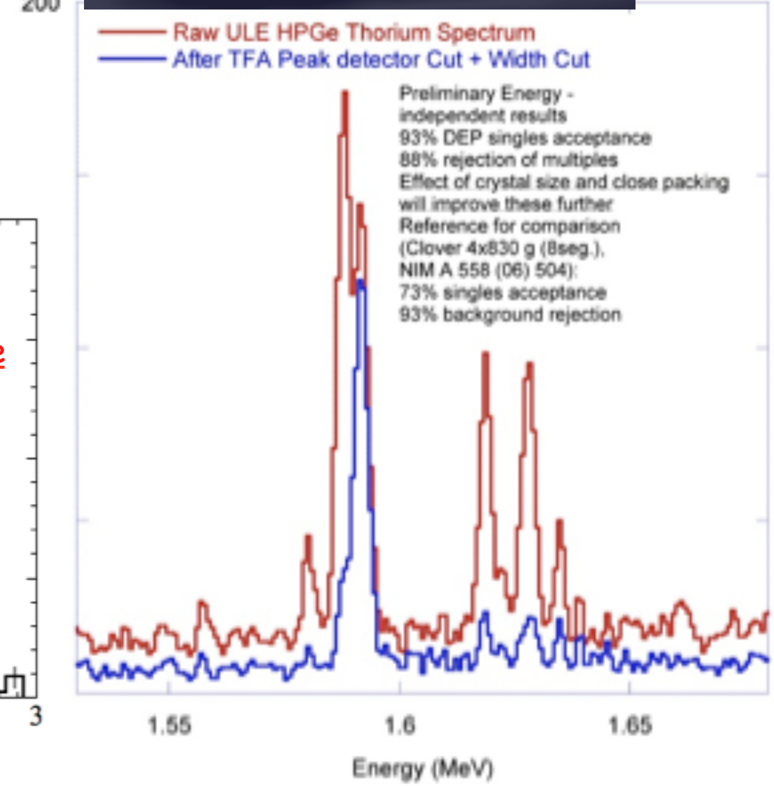
ββ signal is single-site
Many backgrounds
are multiple-site



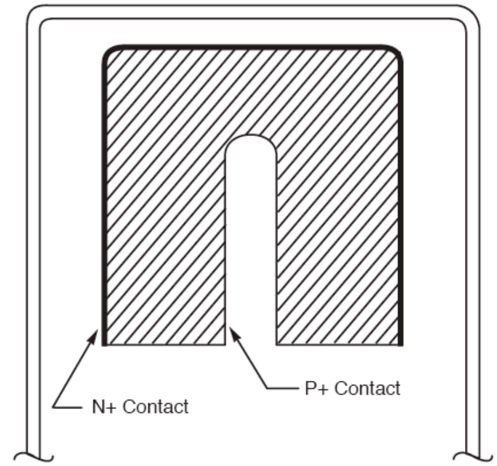
Other applications (ν physics)





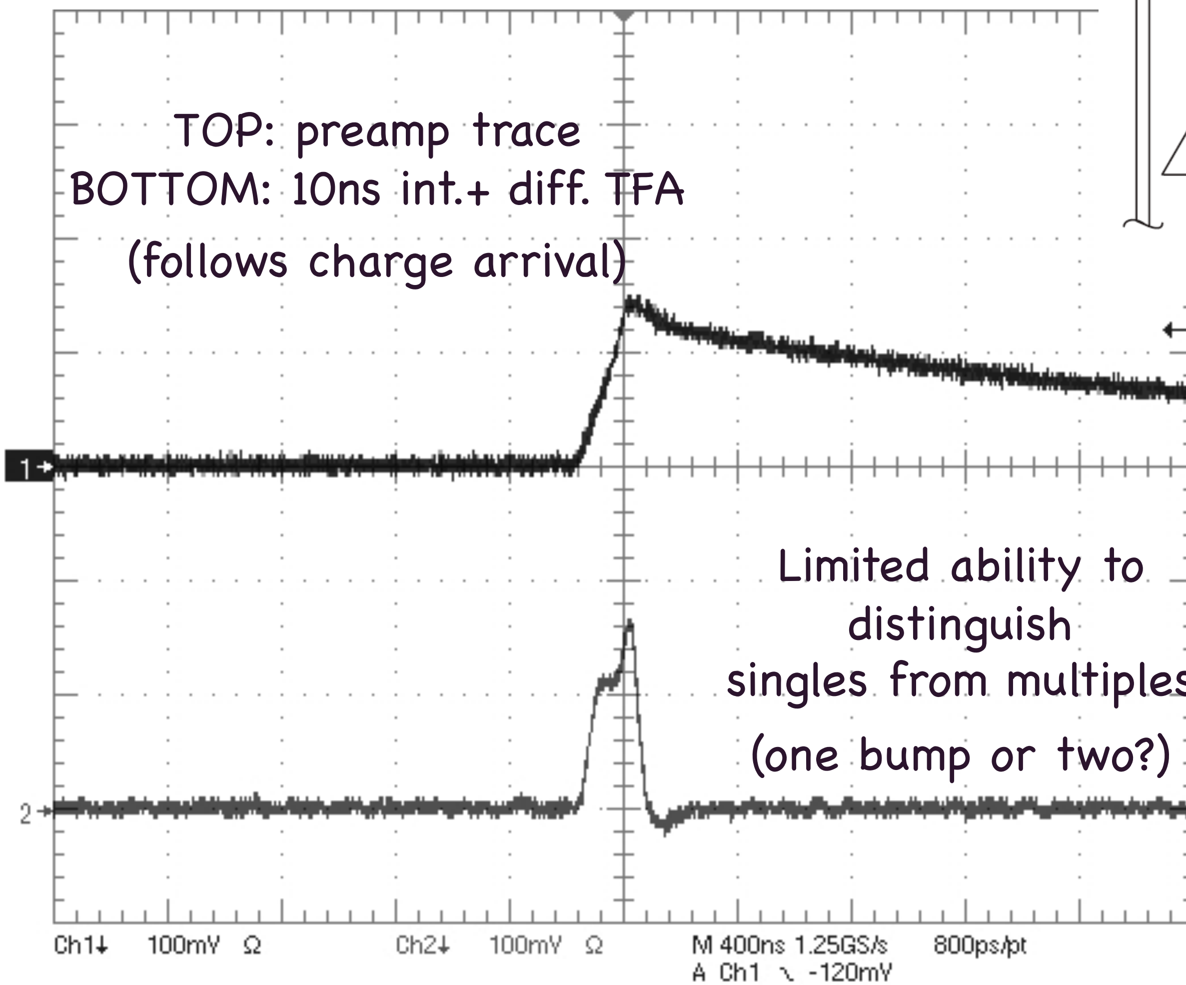


Other nice features brought by the point contact:



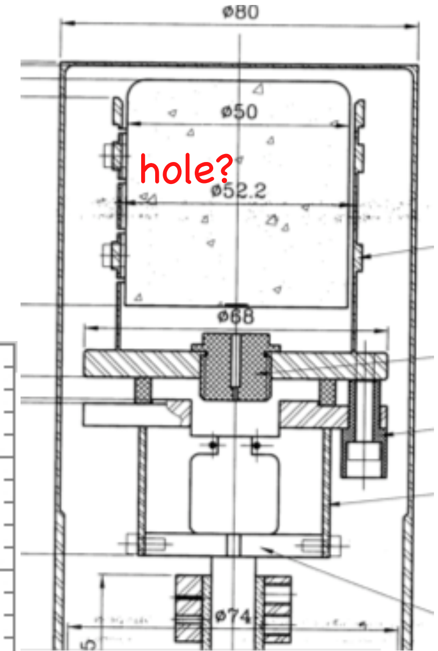
Coaxial Ge Detector Configuration

That was then...

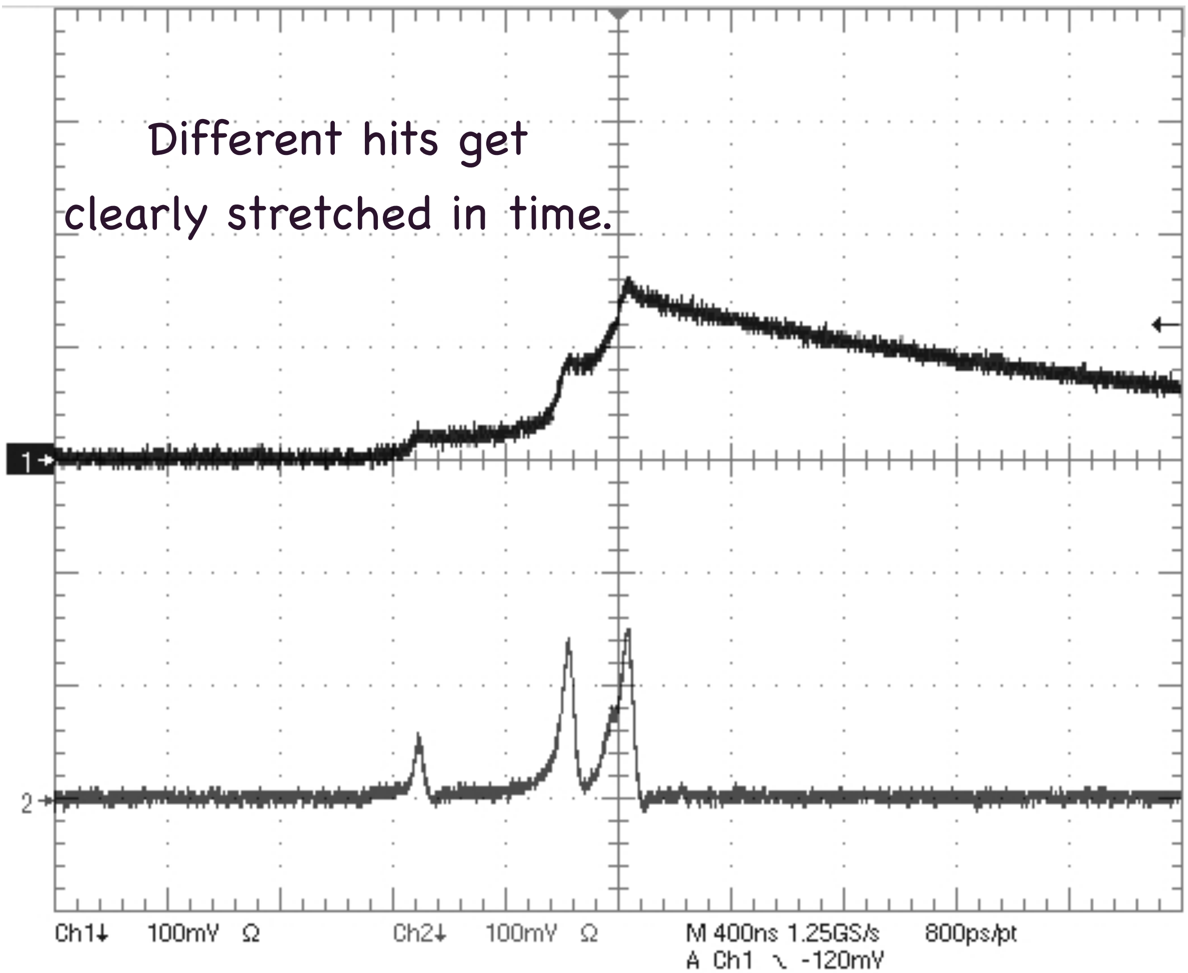


TOP: preamp trace
BOTTOM: 10ns int.+ diff. TFA
(follows charge arrival)

Limited ability to distinguish singles from multiples
(one bump or two?)



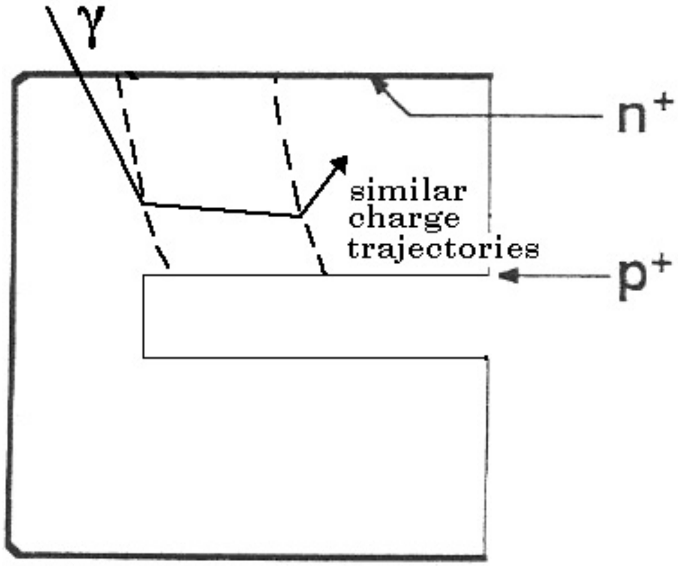
This is now.



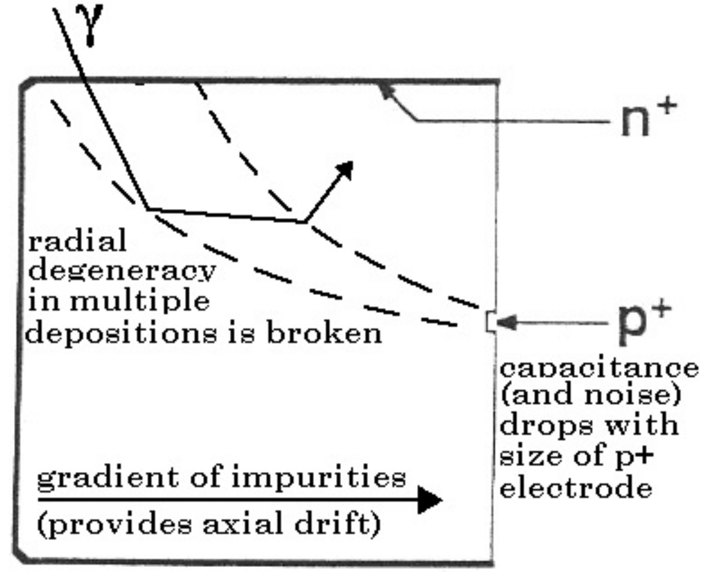
All this with optimal energy resolution and charge collection

(<u>and one channel</u>)

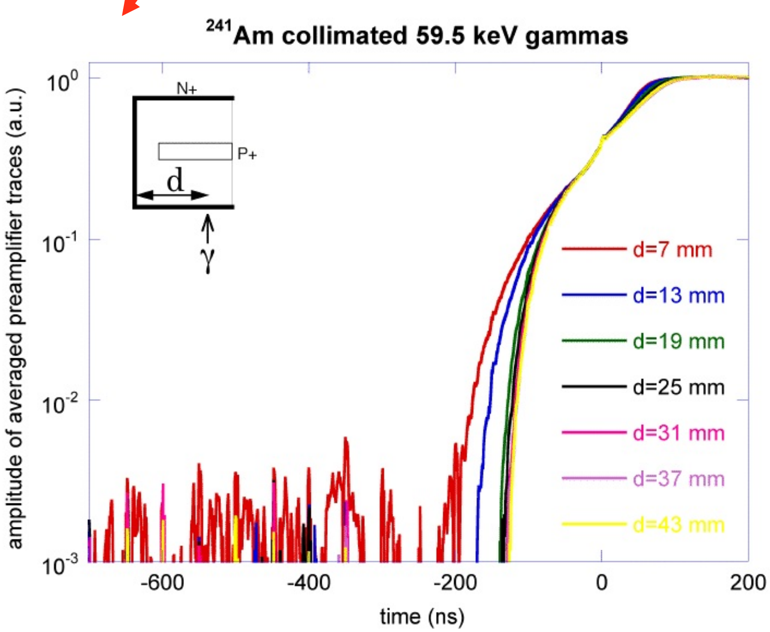
What is happening?

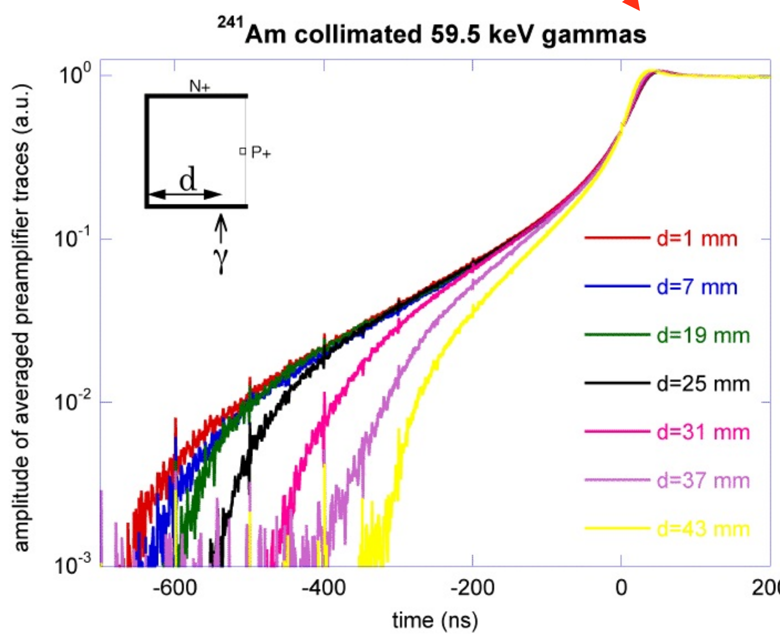


standard coaxial HPGe

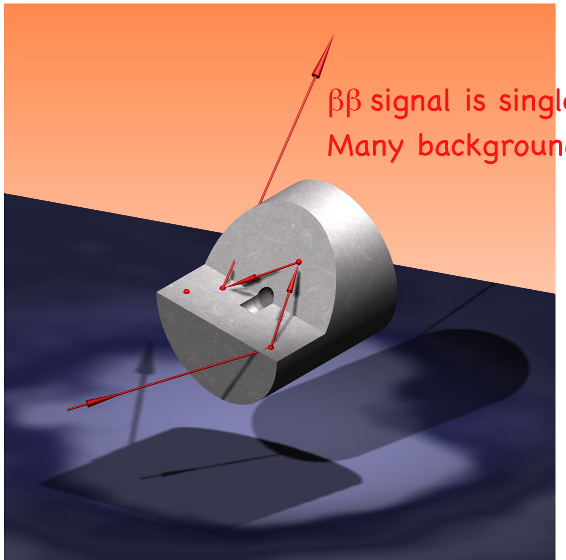


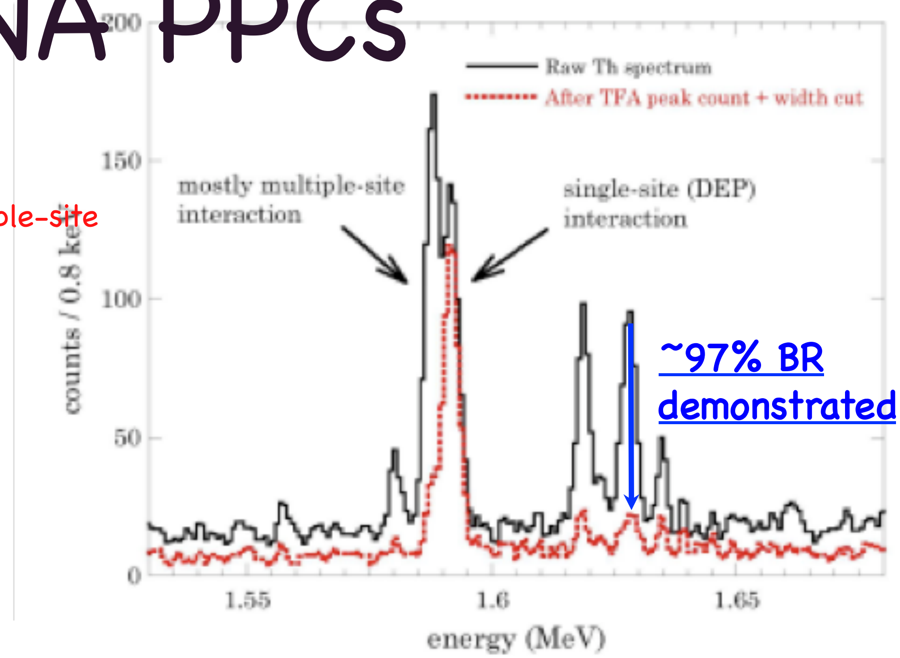
P-type modified electrode





MAJORANA PPCs





Detectors studied / in hand:

(table actually missing a few)

Owner	Dimensions	Mass	Resolution (1.33 MeV)	Manufacturer
U. Chicago (PPCI)	50 mm Ø x 44 mm	460 g	1.82 keV	Canberra
PNNL (PPCII)	50 mm Ø x 50 mm	527 g	2.15 keV	Canberra
LBNL (SPPC)	62 mm Ø x 44 mm	800 g	2.11 keV	LBNL
LANL (MJ70)	72 mm Ø x 37 mm	800 g	2.15 keV	PHD's
ORNL (MJ60)	62 mm Ø 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 Ø x 10 mm	17 g		LBNL
ORNL (Big BEGe)	90 mm Ø x 25 mm	850 g	1.95 keV	Canberra

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

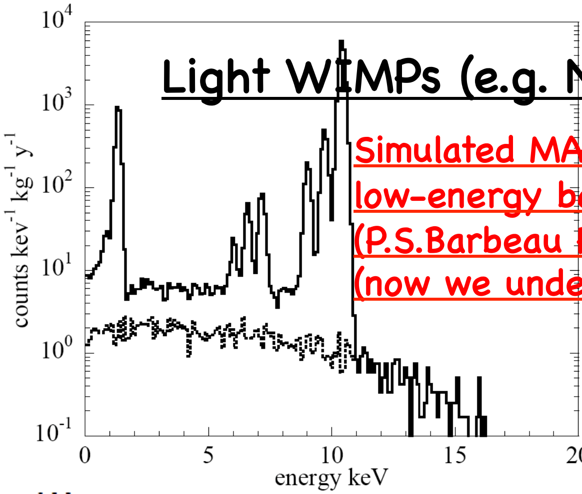
18 PPCs already characterized and stored for 60kg MAJORANA demonstrator
(Second batch of 15 ordered, LANL)

Crystal storage underground

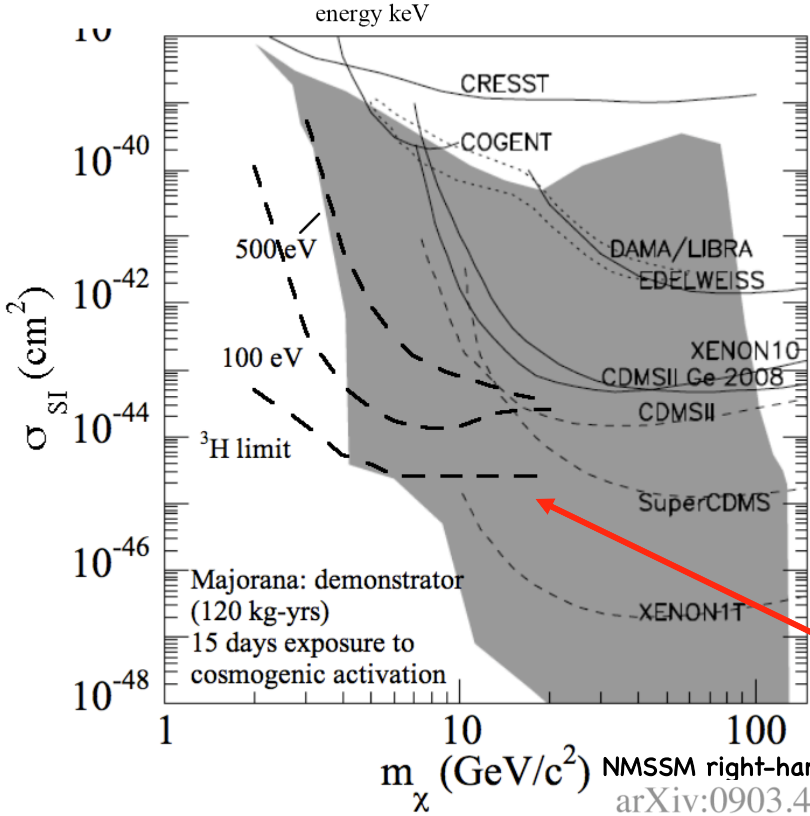
GERDA considering PPCs for 2nd phase

MAJORANA as a DM detector

Light WIMPs (e.g. NMSSM)



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

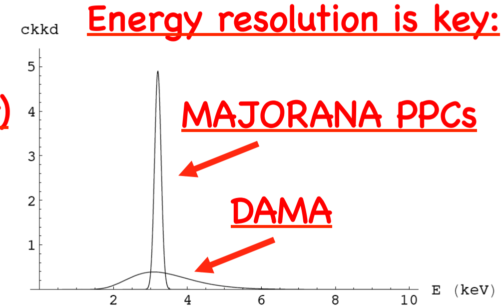


NMSSM right-handed sneutrino

arXiv:0903.4677v1

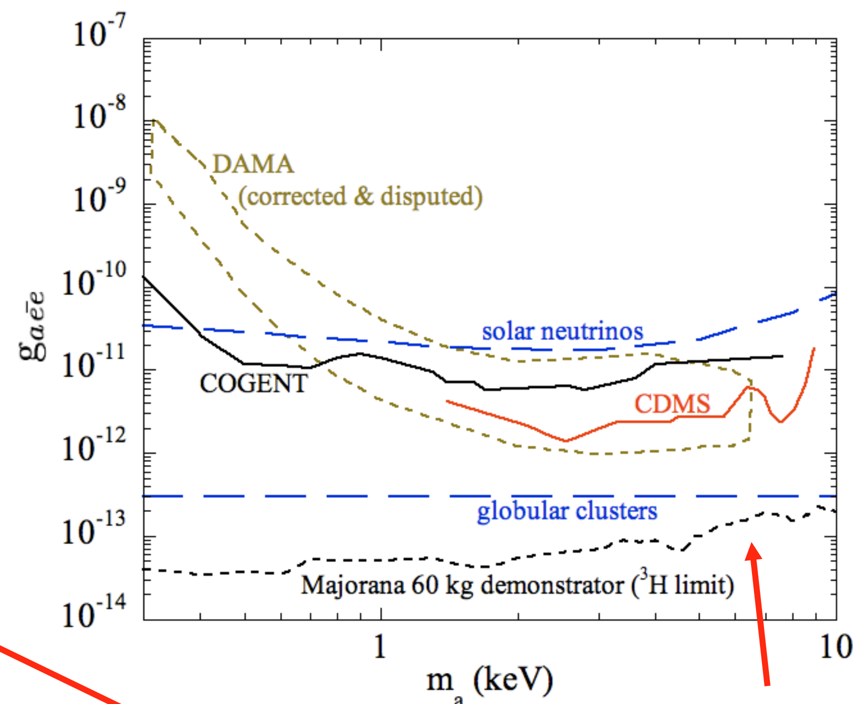
Pseudoscalars etc. (a.k.a."superWIMPs")

Energy resolution is key:



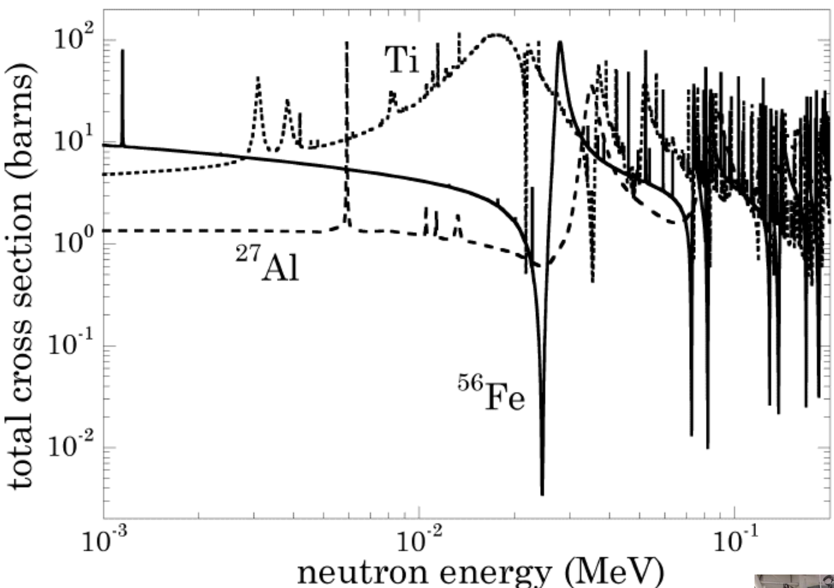
MAJORANA PPCs

DAMA



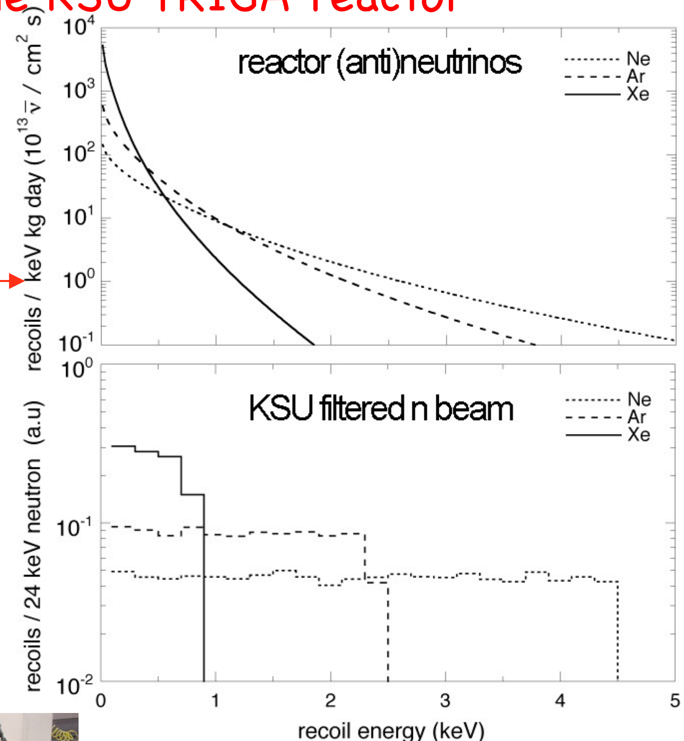
Possibility of reaching ^{3}H limit much nearer now with surface event rejection

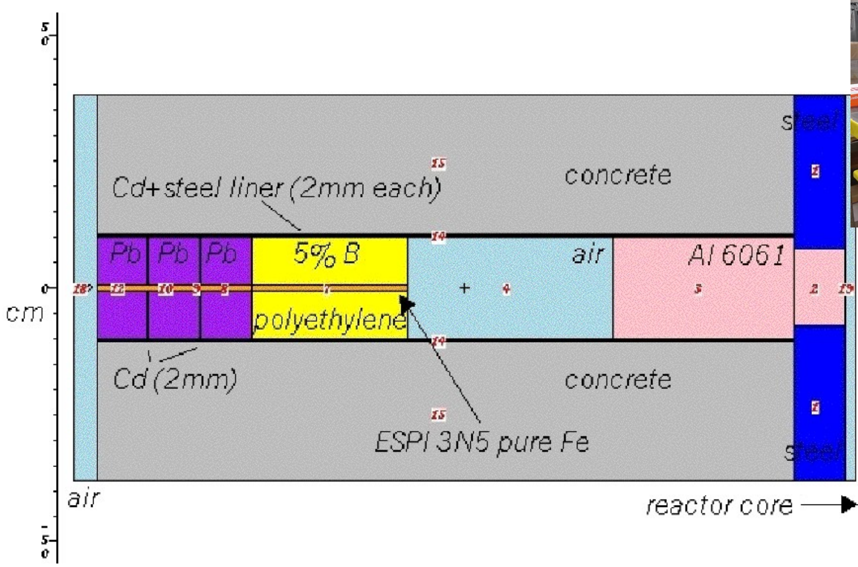
One should always start with the foundations: sub-keV recoil calibrations at the KSU TRIGA reactor



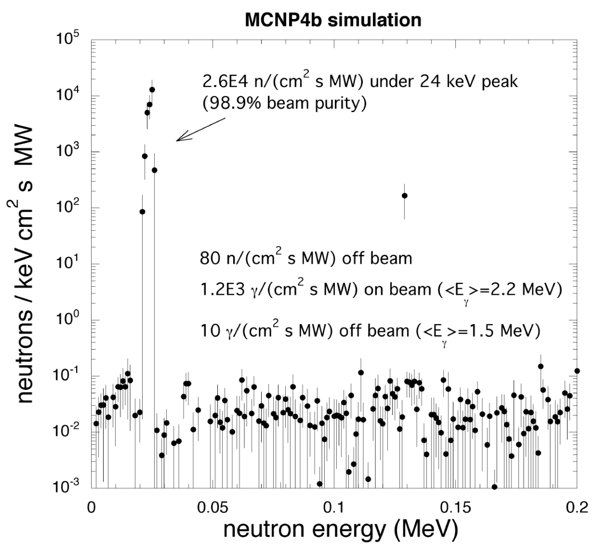
24 keV n's mimic reactor ν's →

← Fe-Al filter + Ti post-filter





← MCNP filter design →



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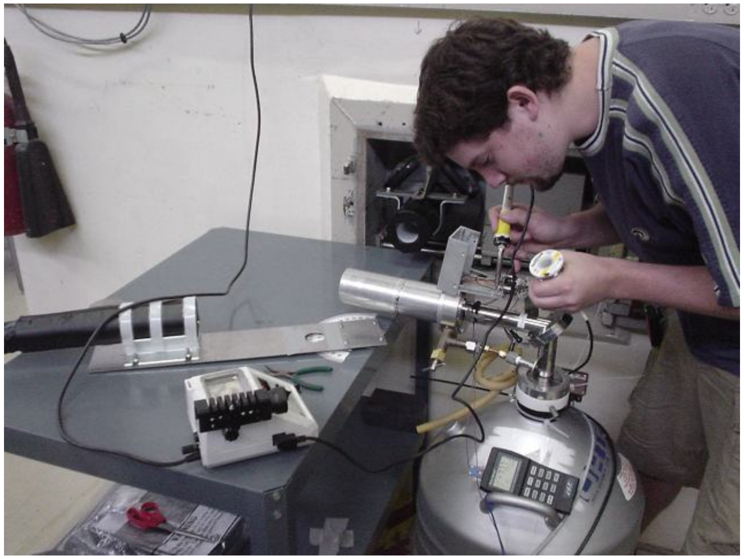
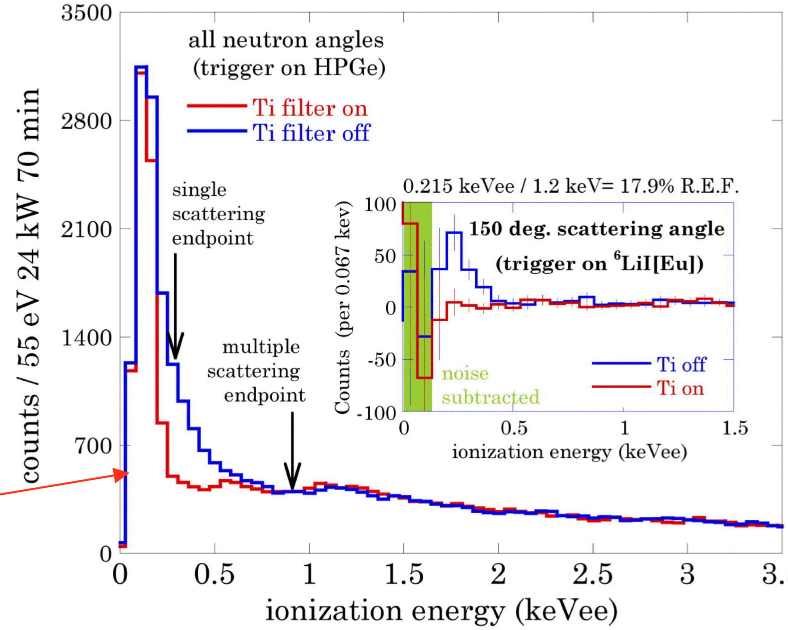
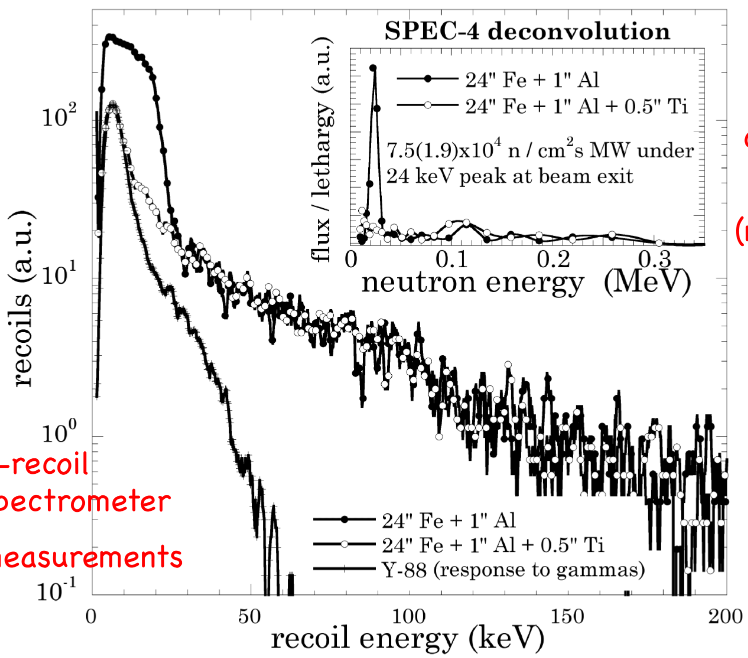




Ti post-filter "switches off" the recoils, leaving all backgrounds unaffected

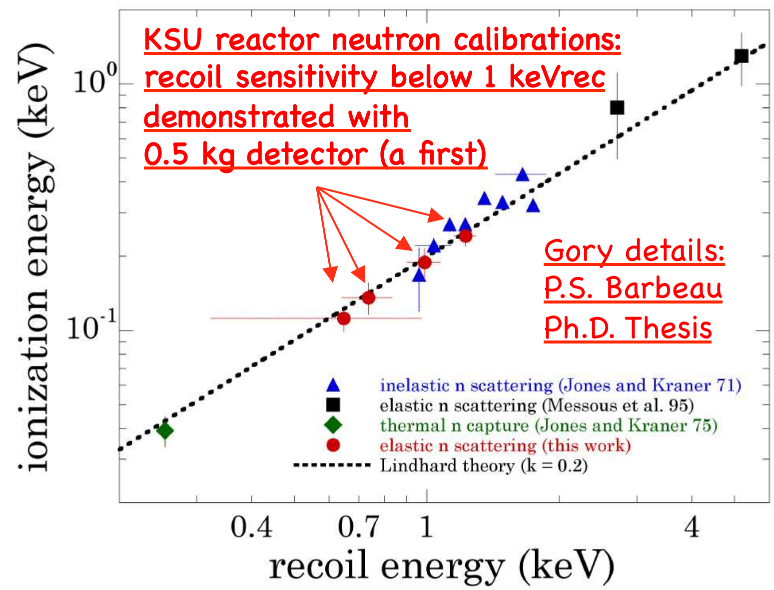


p-recoil spectrometer

measurements

Beam characterization studies

(nucl-ex/0701011)



KSU reactor neutron calibrations: recoil sensitivity below 1 keVrec demonstrated with 0.5 kg detector (a first)

Gory details: P.S. Barbeau Ph.D. Thesis

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

germanium

S.T. Lin et al., arXiv:0712.1645

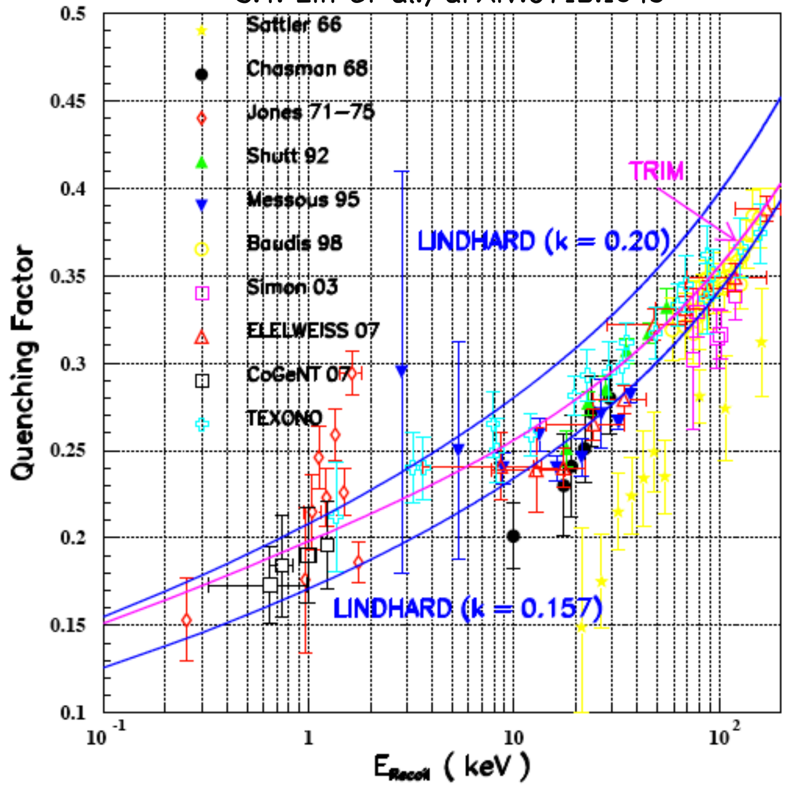


FIG. 3: A compilation of all quenching factor (QF) measurements on germanium, with calculations from the TRIM software [6] as well as by the Lindhard model [7] under two parametrizations (k=0.20 and 0.15) overlaid.

xenon

A. Manzur *et al.*, arXiv:0909.1063.

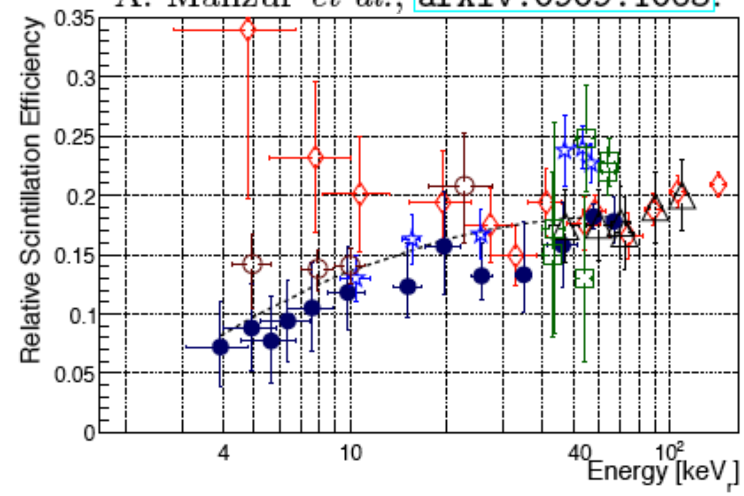
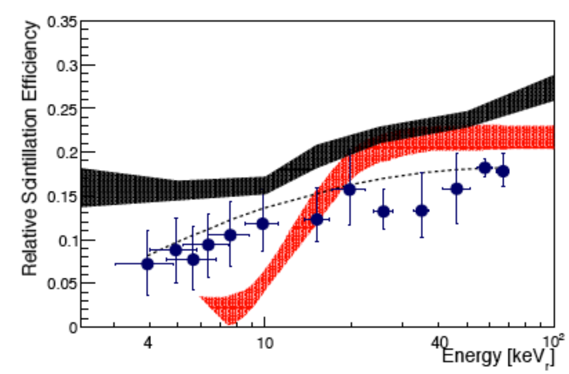


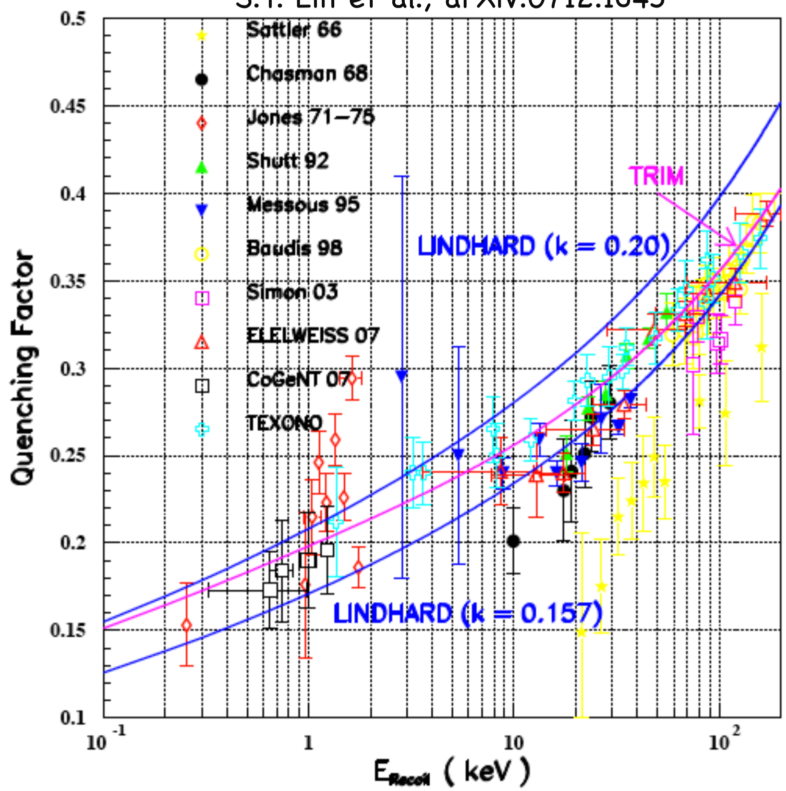
FIG. 11: Scintillation efficiency for nuclear recoils relative to that of 122 keV gamma rays in LXe at zero field, comparing this work (●) to previous measurements from Arneodo (△) [5], Akimov (□) [6], Aprile (☆) [7], Chepel (◇) [8] and Aprile (○) [9]. Also shown is the the
Section [V], which inc
quenching due to bi
caping electrons.



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

germanium

S.T. Lin et al., arXiv:0712.1645



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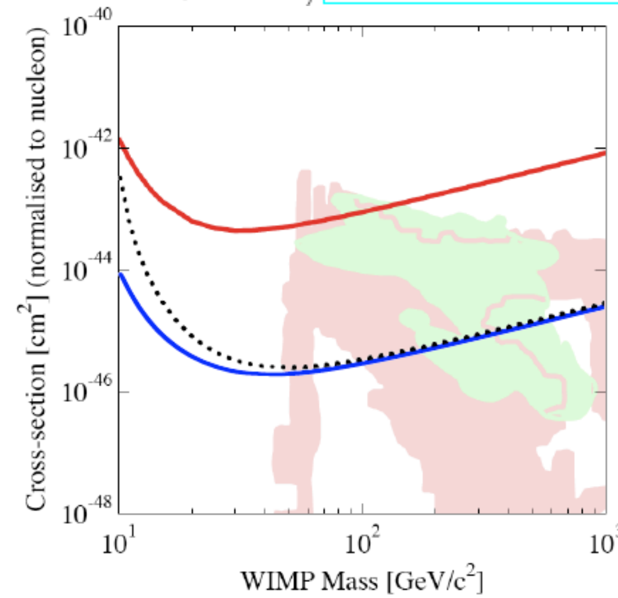
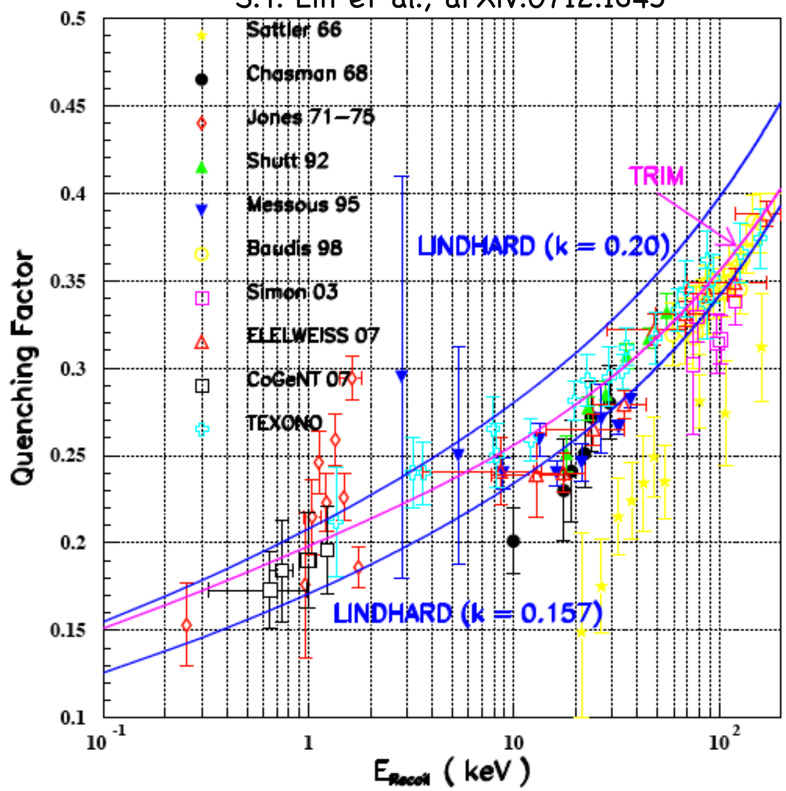


FIG. 15: Projected spin independent dark matter limits for a LXe detector with 30,000 kg day exposure and 0.95 to 5.7 keVee energy window. The bottom solid line shows the limit with $\mathcal{L}_{eff}$=0.19 (5 to 30 keV$_r$ window) while the dotted line shows the limit calculated with the measured $\mathcal{L}_{eff}$ (8.4 to 39.0 keV$_r$ window). Also plotted are the XENON10 result [3] (top solid line) and the regions predicted by [30] (red shaded region) and [31] (green shaded region). Plot generated using [32].

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

germanium

S.T. Lin et al., arXiv:0712.1645



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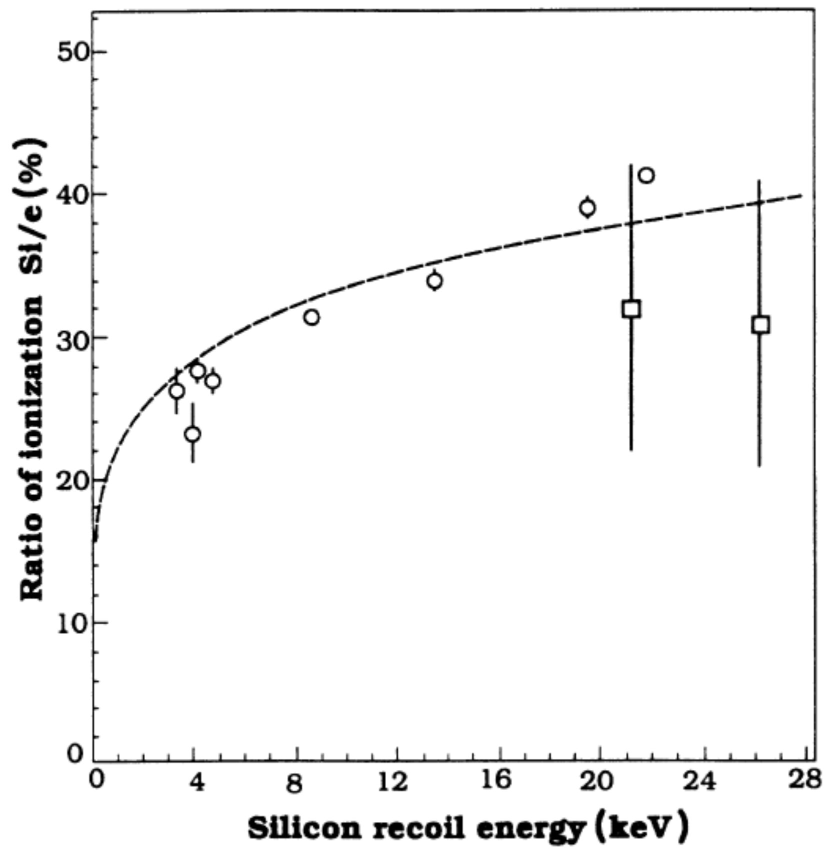
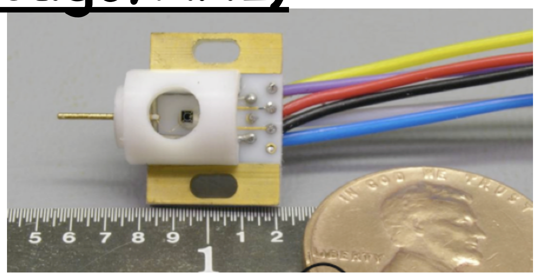
Silicon (PRD 42 (90) 3211)



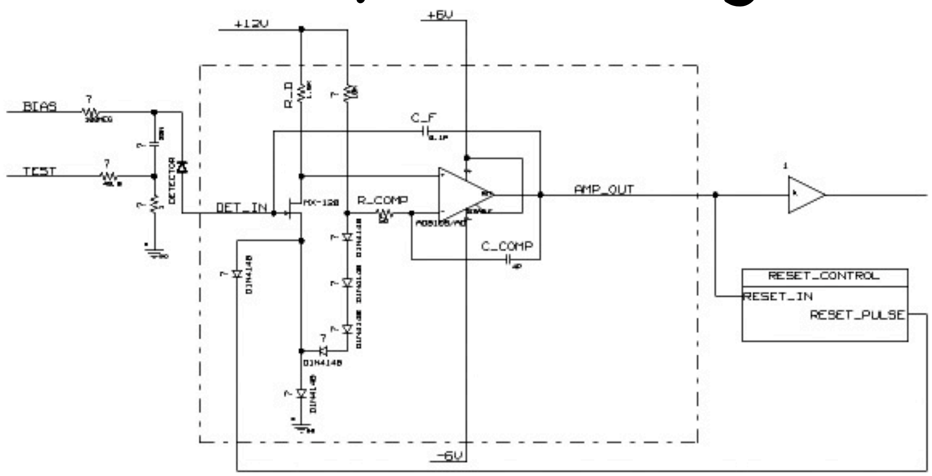
Front End Electronics (Majorana)

Pulse Reset

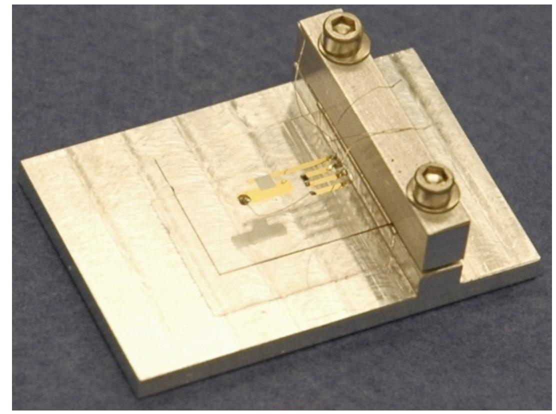
COGENT front ends (U Chicago/ANL)



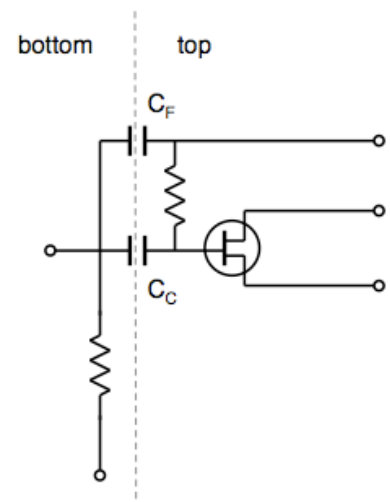
UW "Hybrid" Design



Resistive Feedback



LBNL Design



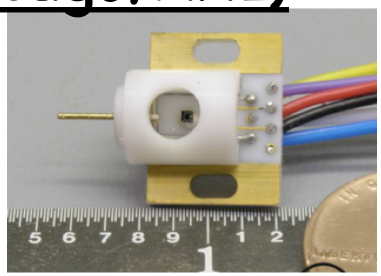
Front End Electronics (Majorana)

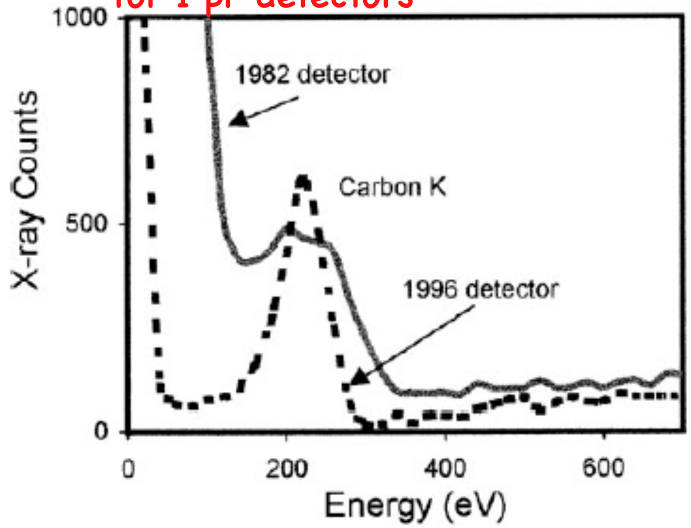
State-of-the-art
for 1 pF detectors

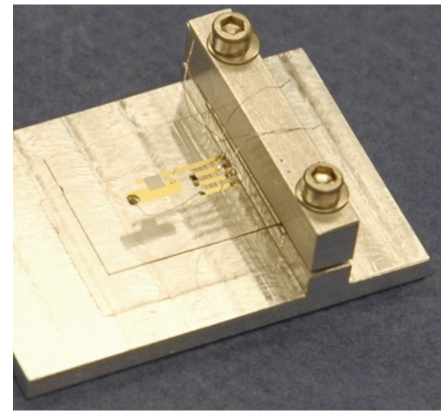
Pulse Rese

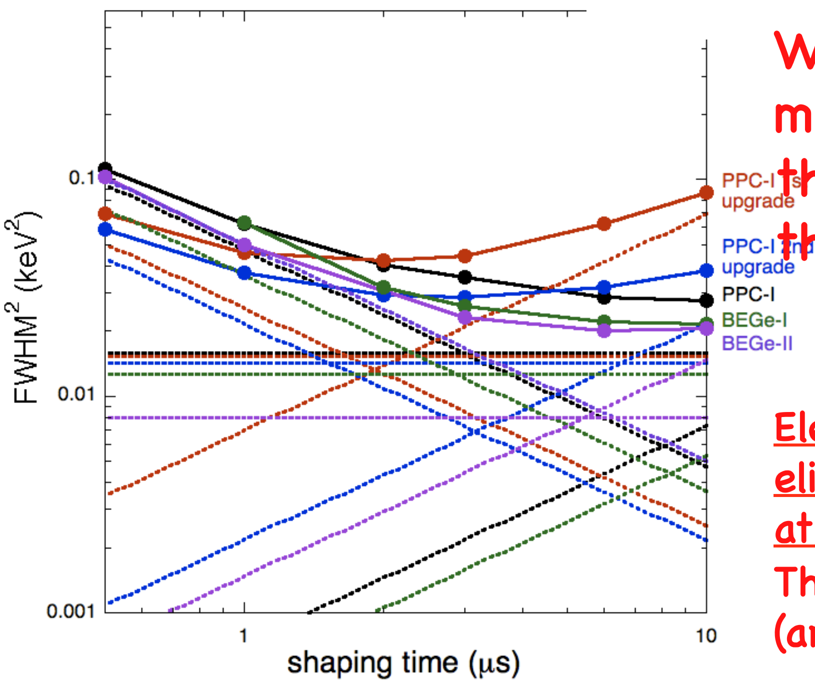
Resistive Feedback

COGENT front ends
(U Chicago/ANL)



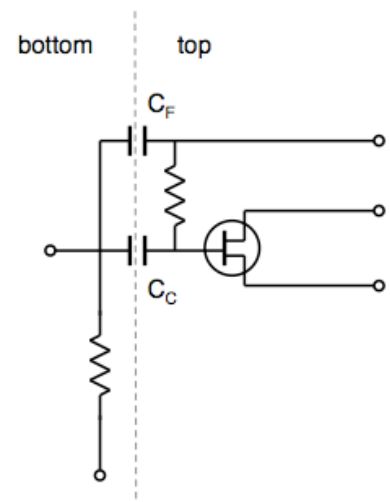






We can do much better than 0.4 keV thresholds

LBNL Design



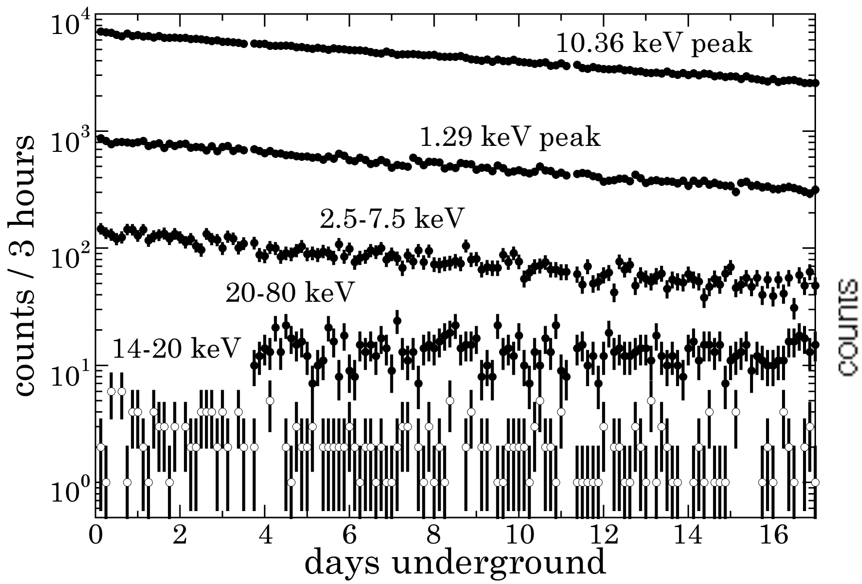
Electronic noise must be eliminated
at the hardware level.
There is no other way around it
(arXiv:0806.1341)

Making an excellent detector even better:

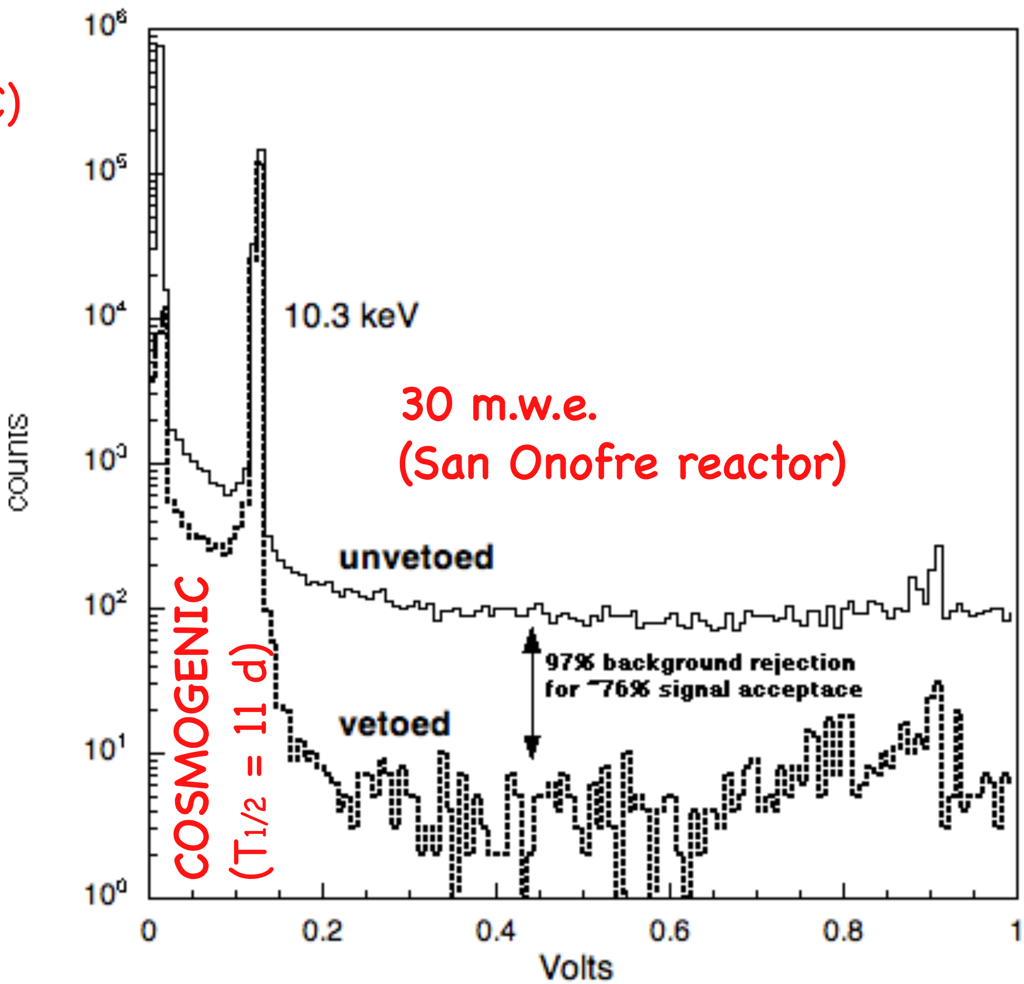
PPCs can reject surface events using rise time cuts

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

A welcome mistake
(accidental n_{th} irradiation of a PPC)



Same decays observed in Soudan detector
(much lower rates)



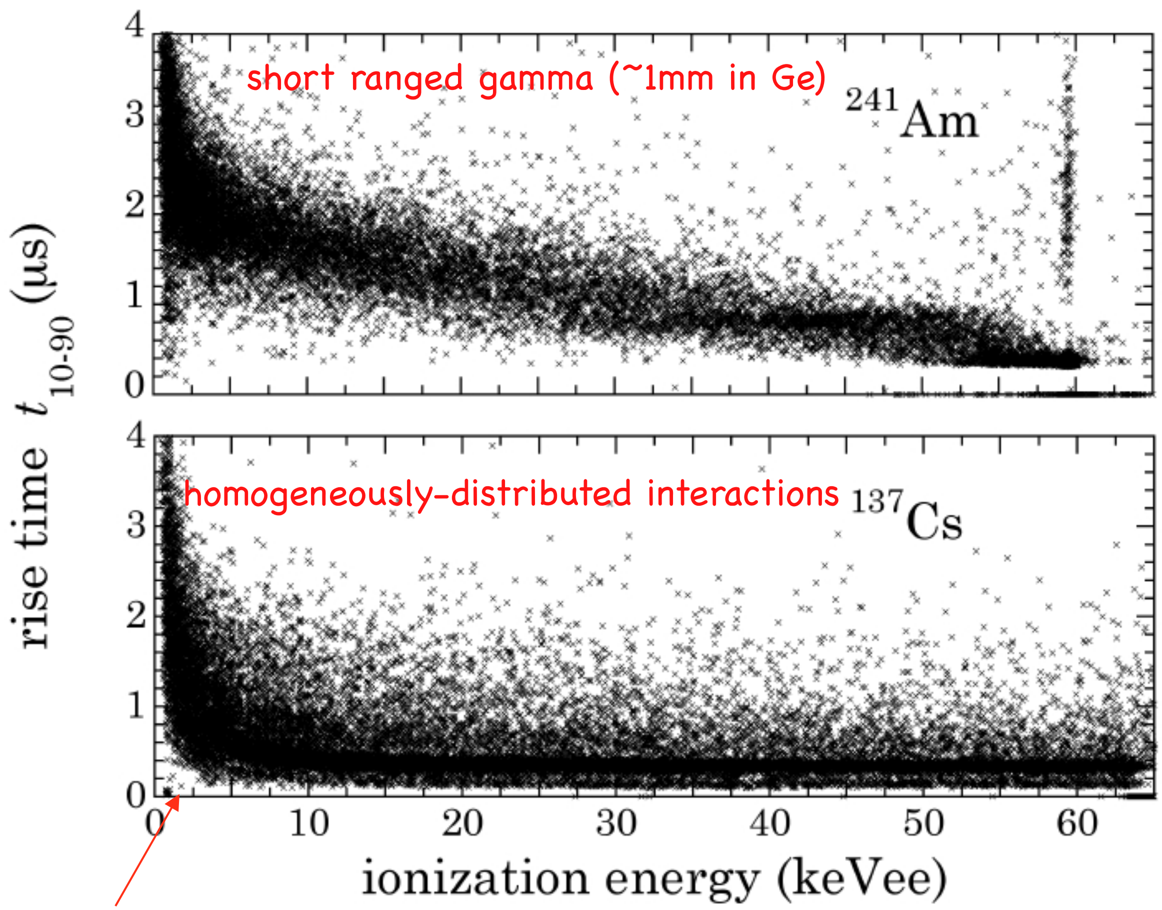
Making an excellent detector even better:

PPCs can reject surface events using rise time cuts

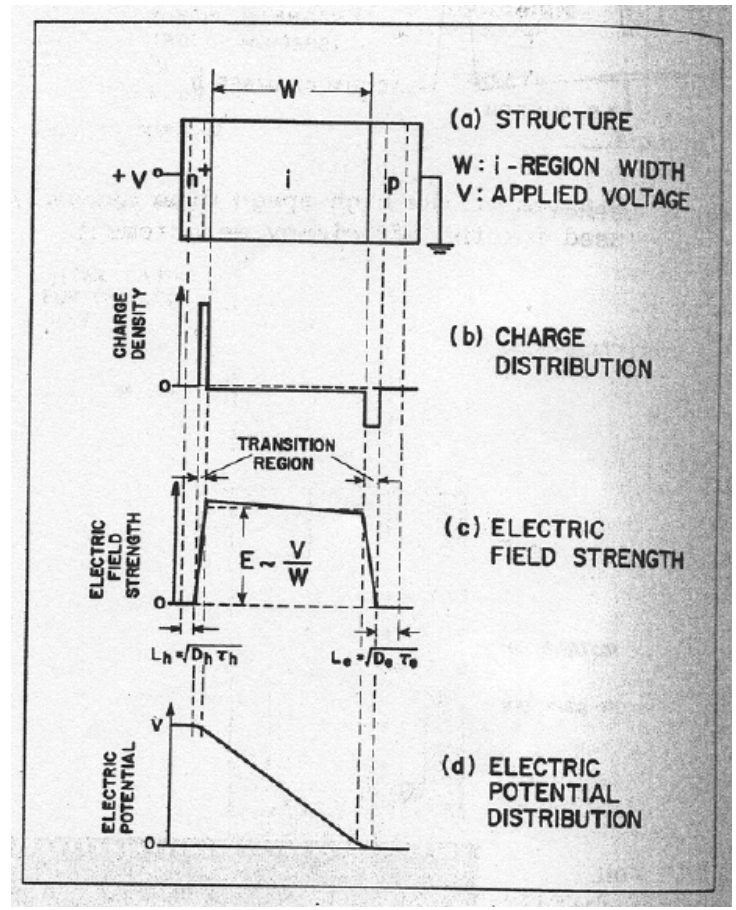
Based on a phenomenon ~40 years old (embarrasing!)

n+ contact is only "half-dead"

Pulses forming in inner side <u>are slow</u>



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



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

Making an excellent detector even better:

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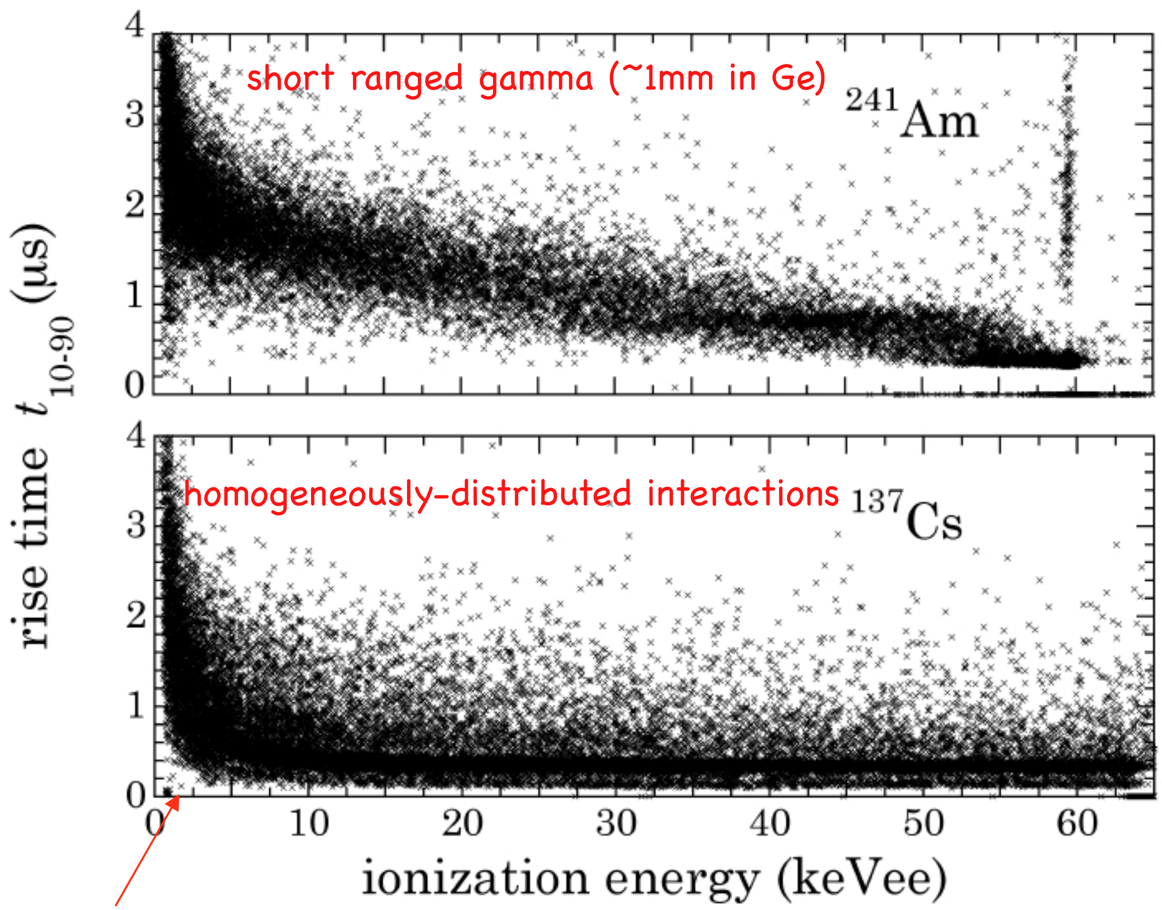
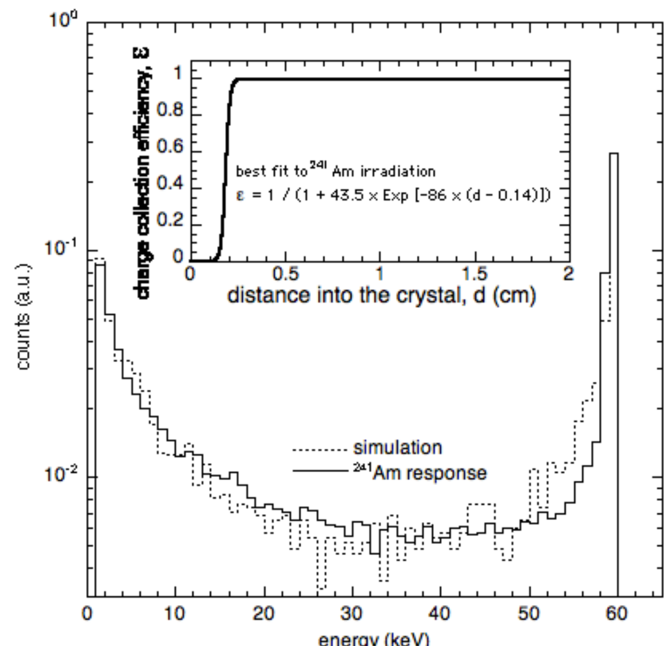




Our understanding of n+ contact behavior agrees nicely with the literature

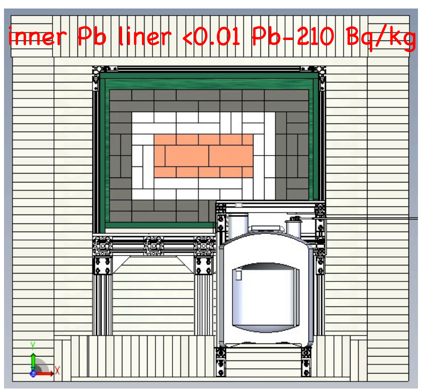
Unfortunately Cs-137 produces plenty surface events as well: next best thing, pulser + charge collection simulations

Making an excellent detector even better:

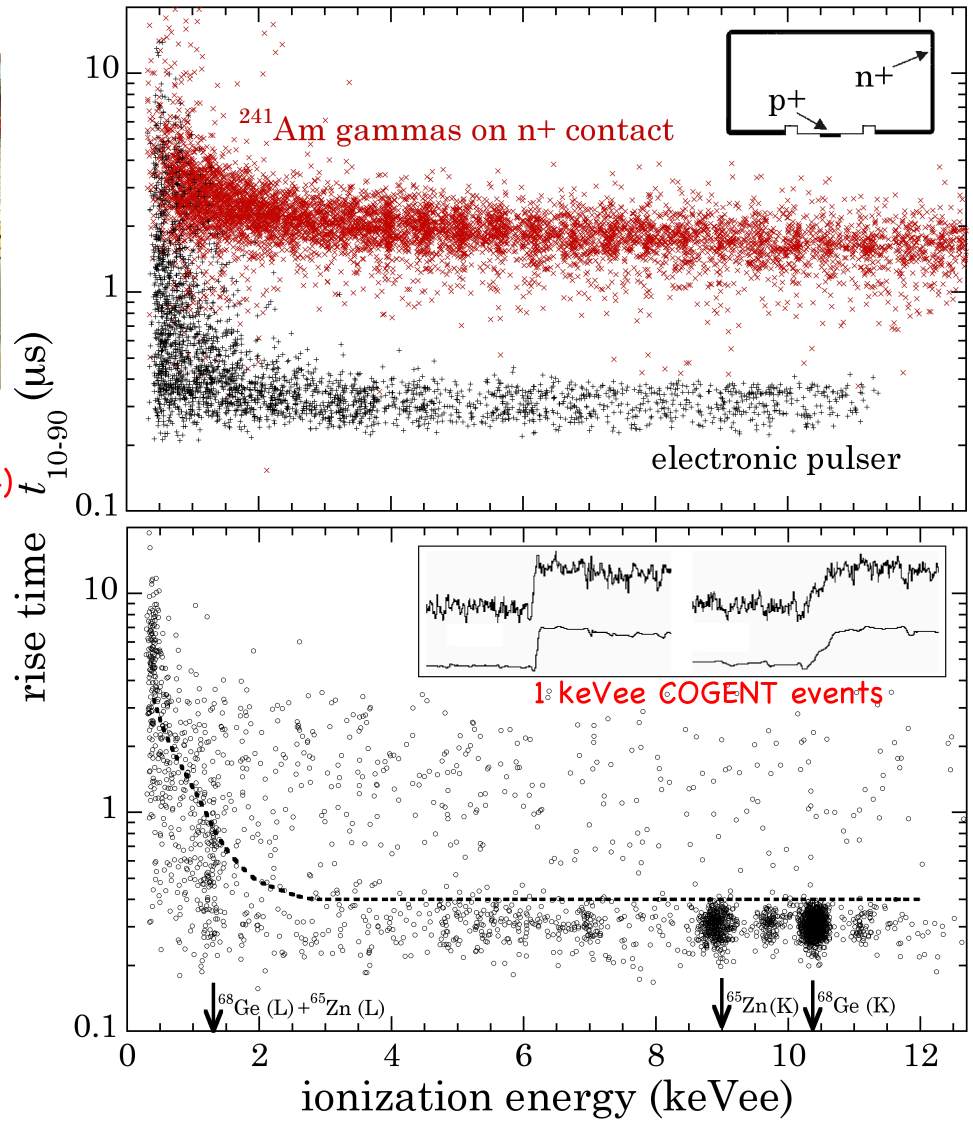
PPCs can reject surface events using rise time cuts

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

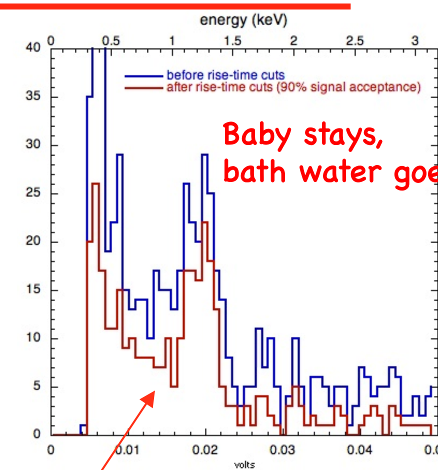
COGENT running
~20 m away from CDMS
(just to keep them honest… ;-)



NOT nearly "best effort" yet.
MAJORANA Demonstrator
background goal is ~x1000 lower

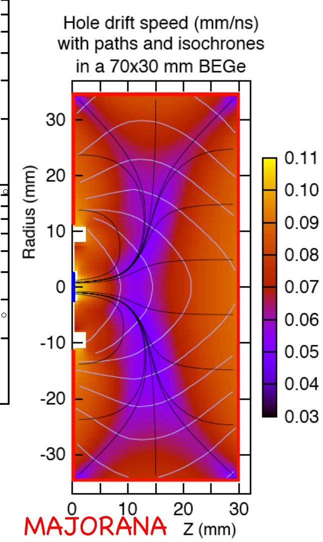


1 keVee COGENT events



Baby stays,
bath water goes

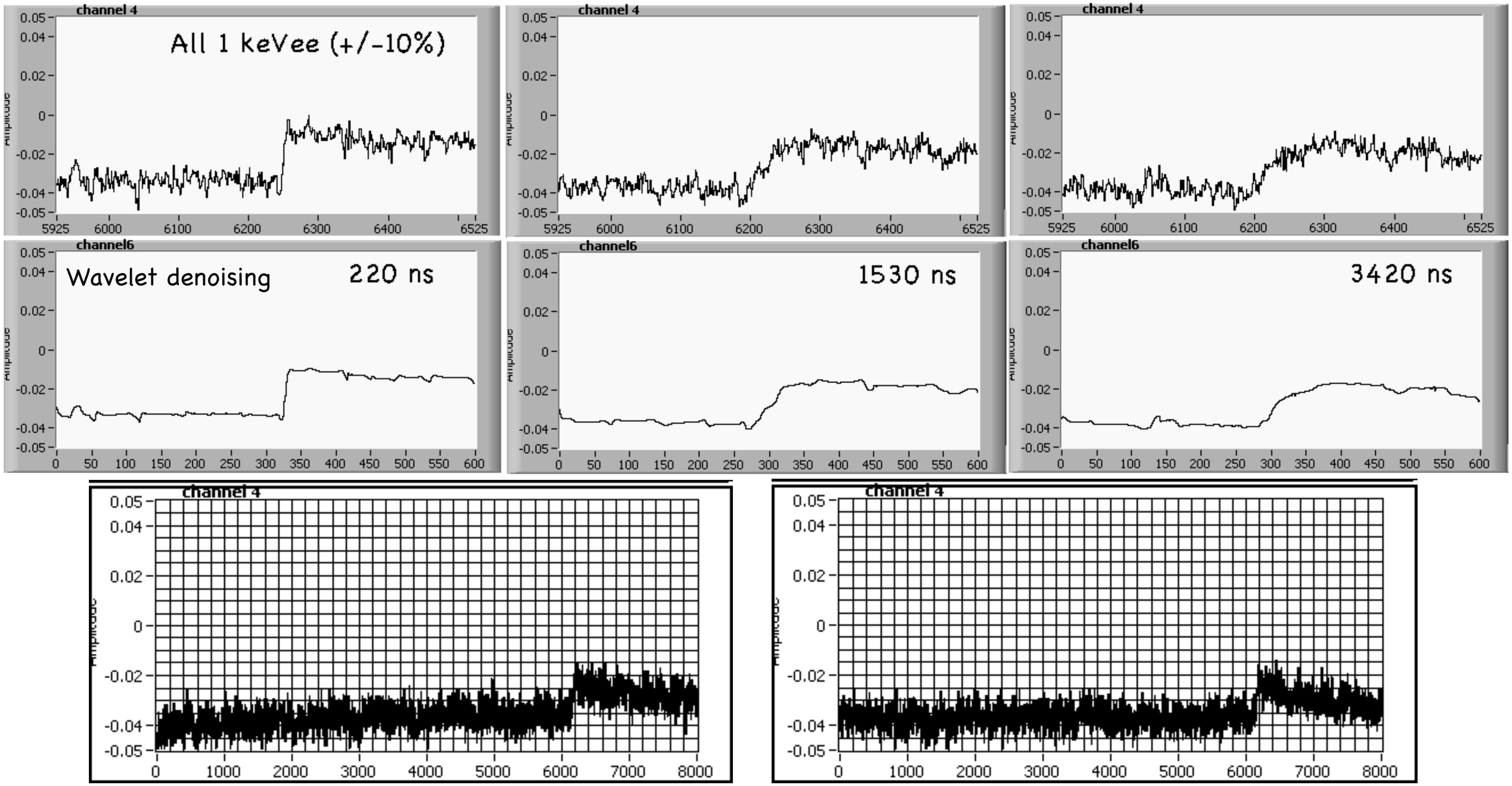
Bulk signal acceptance
monitored down to 1 keVee
via L/K EC peak ratios.
We need more info on surface
background rejection, but it
does not look bad at all.



MAJORANA
BEGe

Charge
Collection
time
modelled
(small
100 ns
correction)

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



0.53 keVee before wavelet denoising

0.55 keVee before wavelet denoising

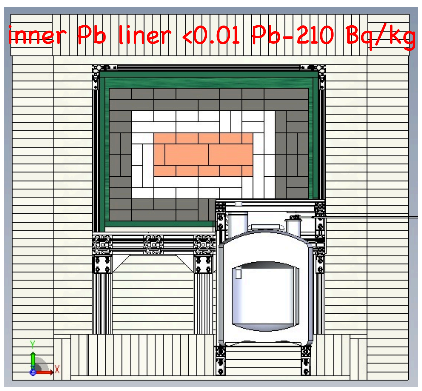
(full traces are 400 μs long, allowing baseline monitoring)

Making an excellent detector even better:

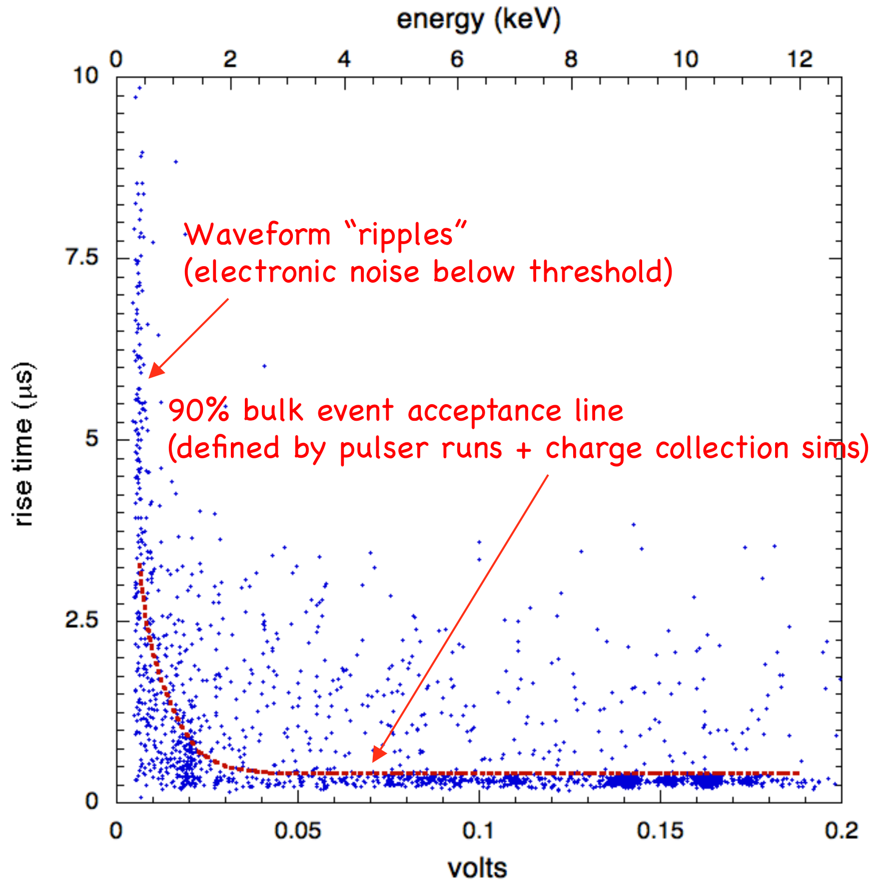
PPCs can reject surface events using rise time cuts

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

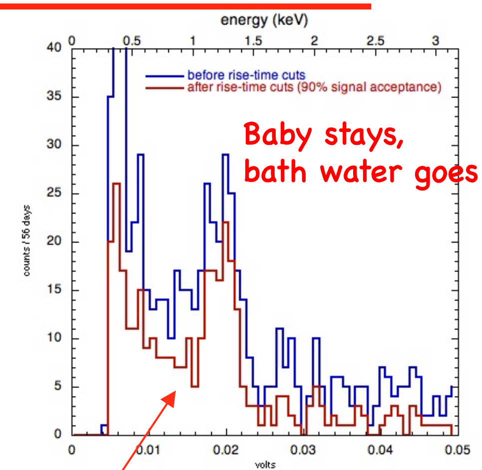
COGENT running
~20 m away from CDMS
(just to keep them honest... ;-)



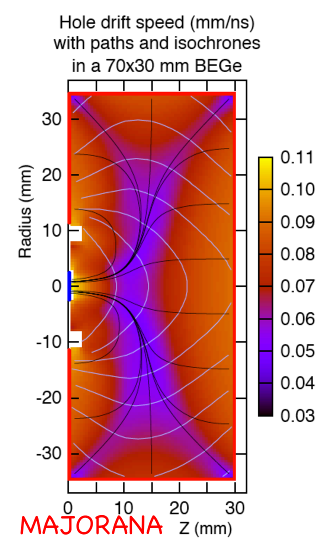
NOT nearly "best effort" yet.
MAJORANA Demonstrator
background goal is ~x1000 lower



At twice the exposure in our preprint, it appears the ability to strip L-shell EC peaks based on their K-shell counterparts is excellent (confirming understanding of bulk signal acceptance). Additional background rejection studies planned.



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.



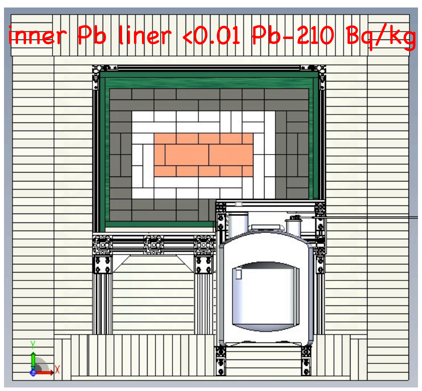
MAJORANA BEGe

Charge Collection time modelled (small 100 ns correction)

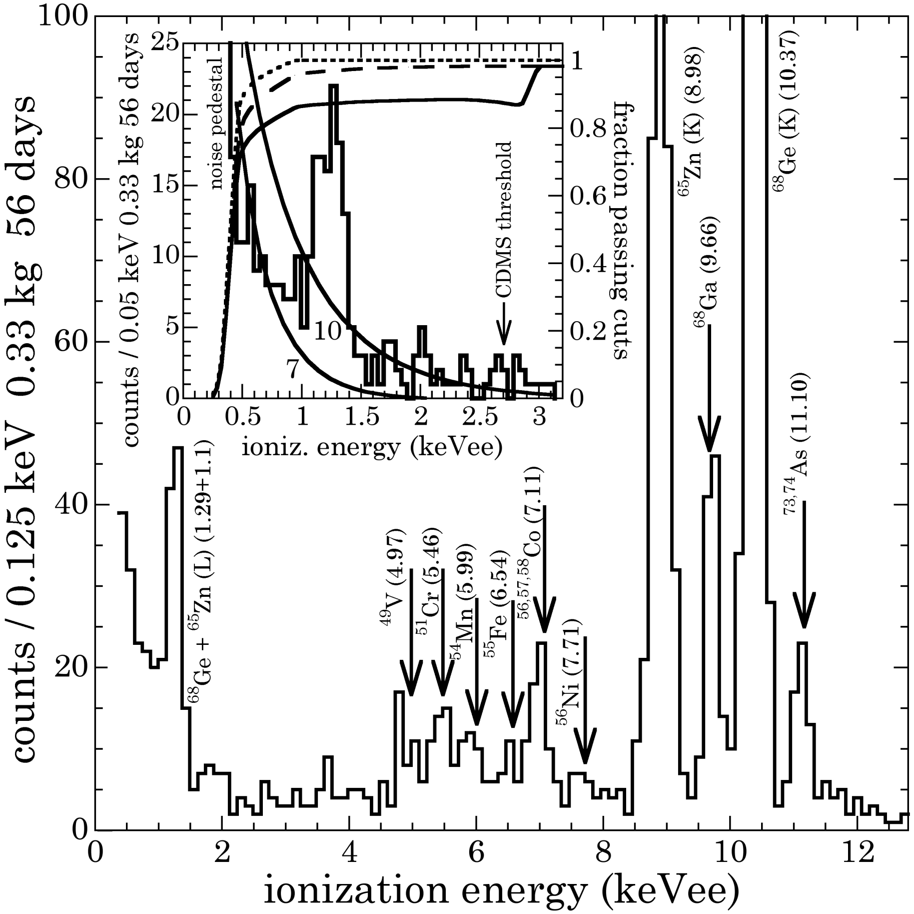
Making an excellent detector even better:
PPCs can reject surface events using rise time cuts

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

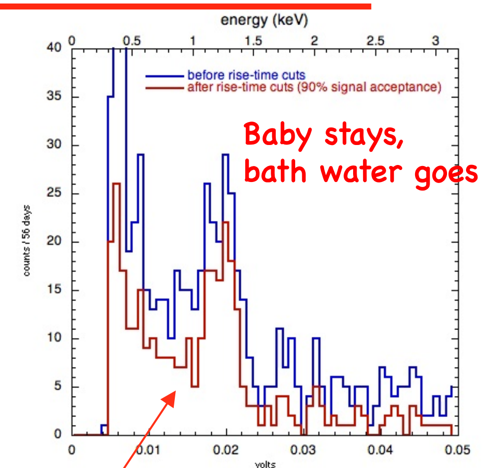
COGENT running
~20 m away from CDMS
(just to keep them honest… ;-)



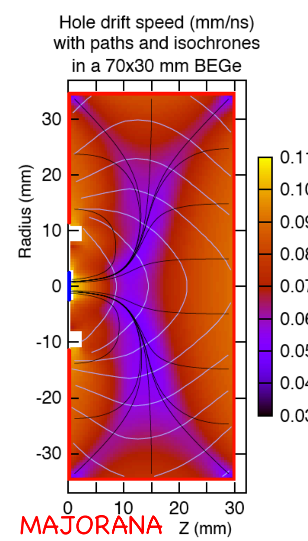
NOT nearly "best effort" yet.
MAJORANA Demonstrator
background goal is ~x1000 lower



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)



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

Charge Collection time modelled (small 100 ns correction)

The "take-home message" transparency

• For m_χ ~7-11 GeV, a WIMP fits the data nicely (90% confidence interval on best-fit WIMP coupling incompatible with zero, good χ^2/dof).

• Red "island" tells you ~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 ~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.

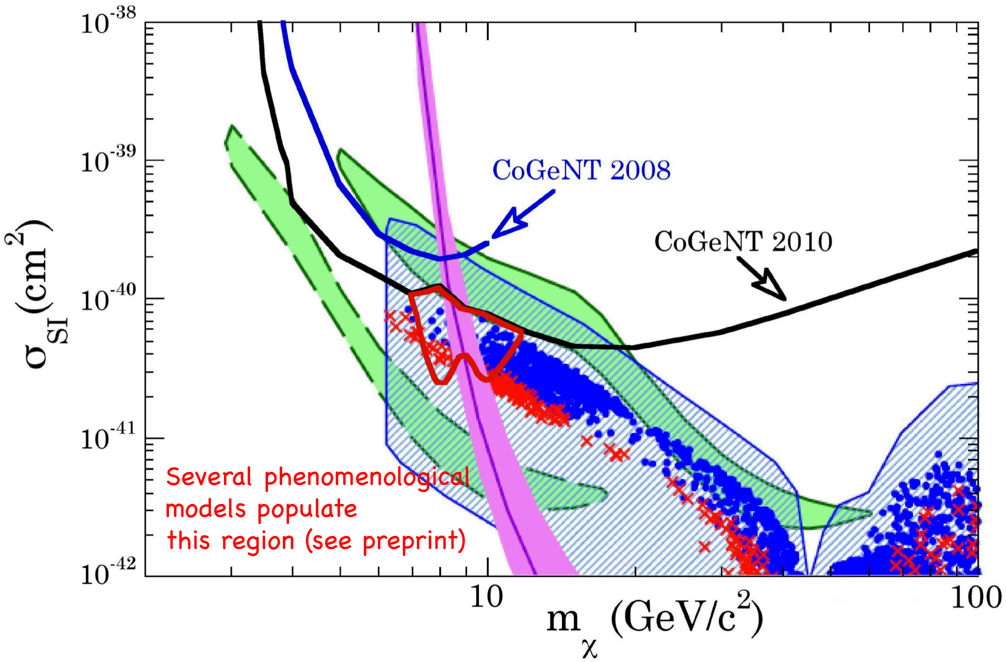
• The low-E excess is composed of asymptomatic **bulk-like** events (very different from electronic noise), coming in at a constant rate (76 days into data taking).

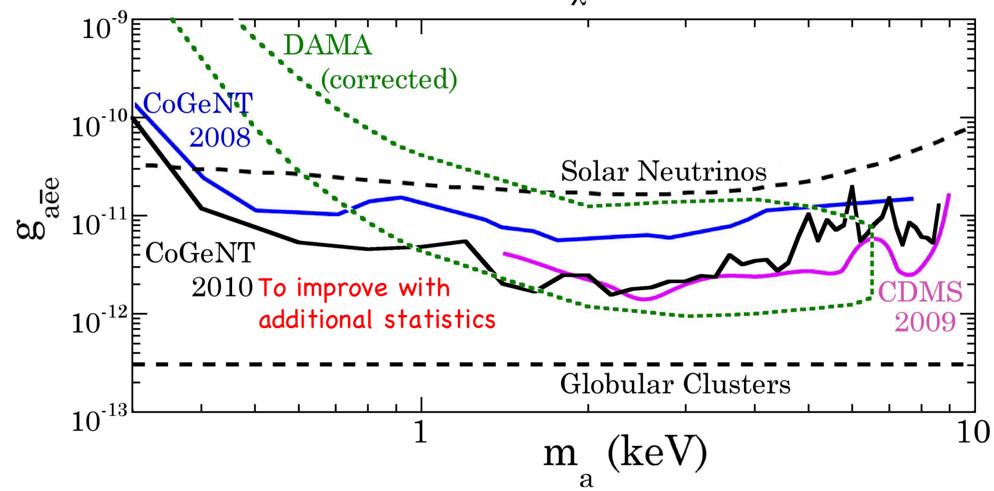
• The possible subject of interest is where we "got stuck" in phase space (a number of curious coincidences there), for a spectrum where most (if not all) surface events are removed (<- major contributors to low-energy spectrum). Caveat Emptor: without DAMA, would we have models there?

• 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





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")*

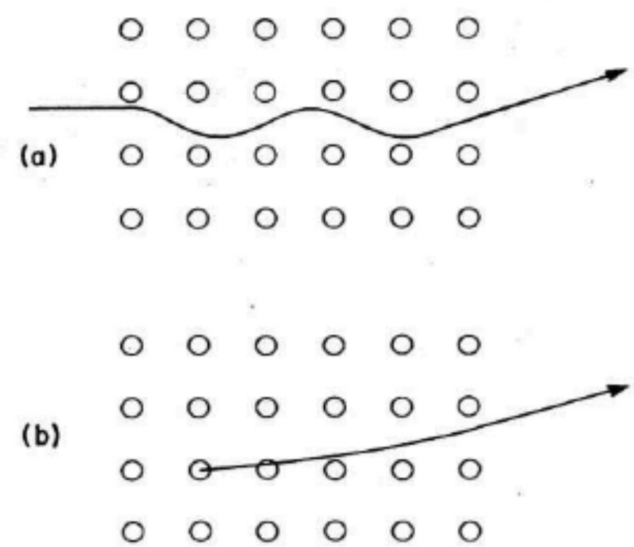


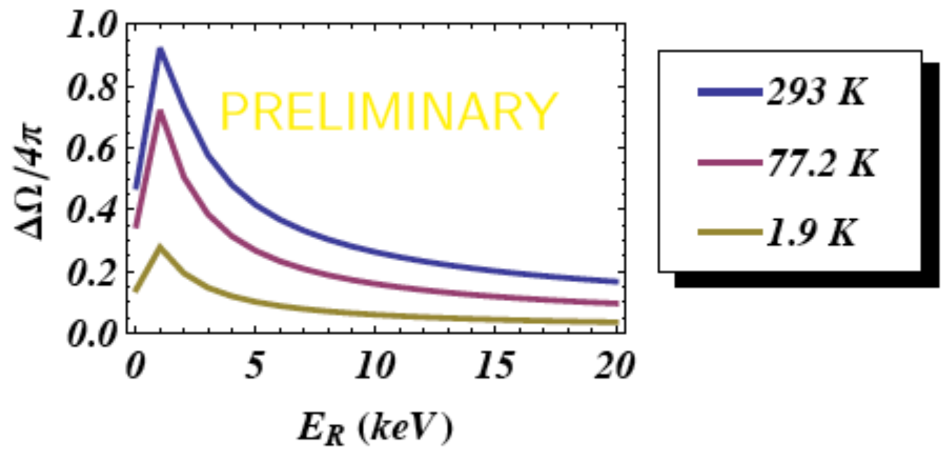
FIG. 1. Schematic illustration of (a) channeling and (b) blocking effects. The drawings are highly exaggerated. In reality, the oscillations of channeled trajectories occur with wavelengths typically several hundreds or thousands of lattice spacings.

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

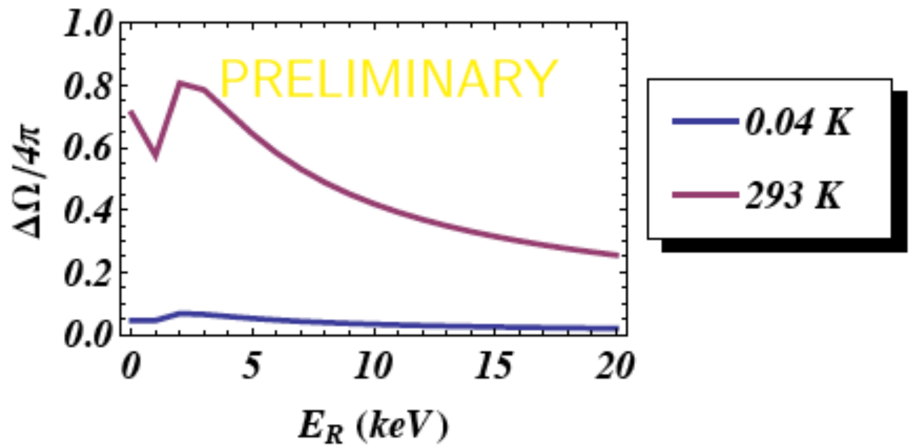
Channeling within blocking: depends on T

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

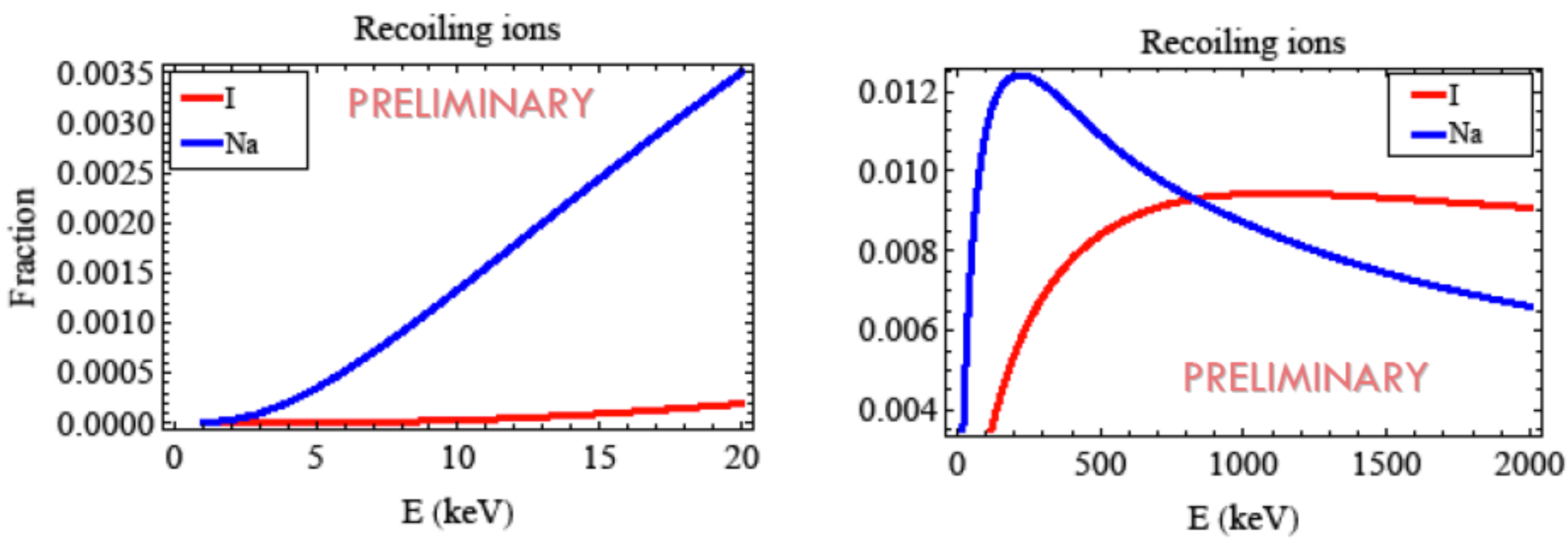
Na in NaI crystal:



Ge crystal:



Fraction of Recoils that are Channeled

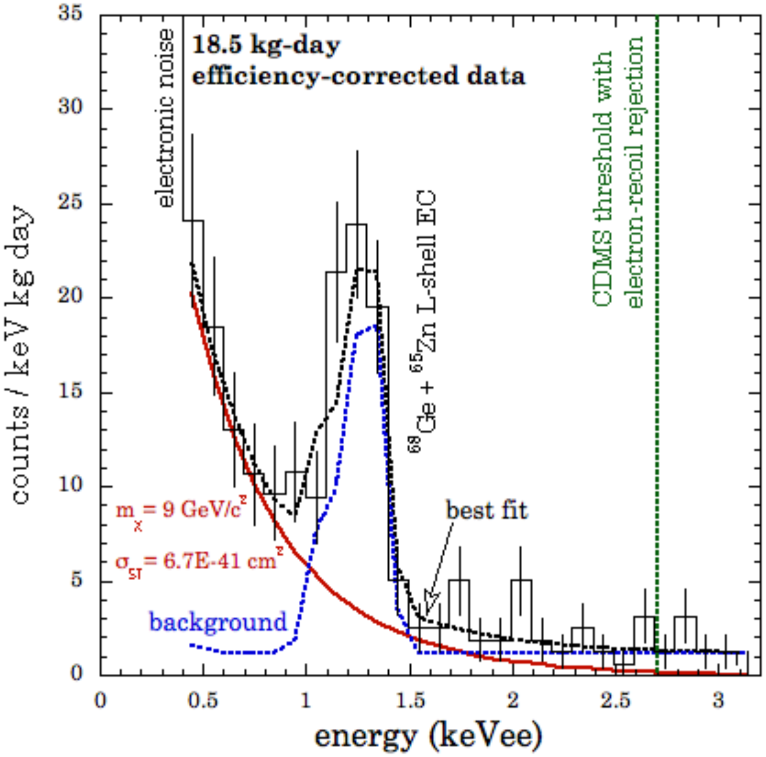


- This result now differs from DAMA results.
- These are upper bounds to what we can expect to be the true fraction.

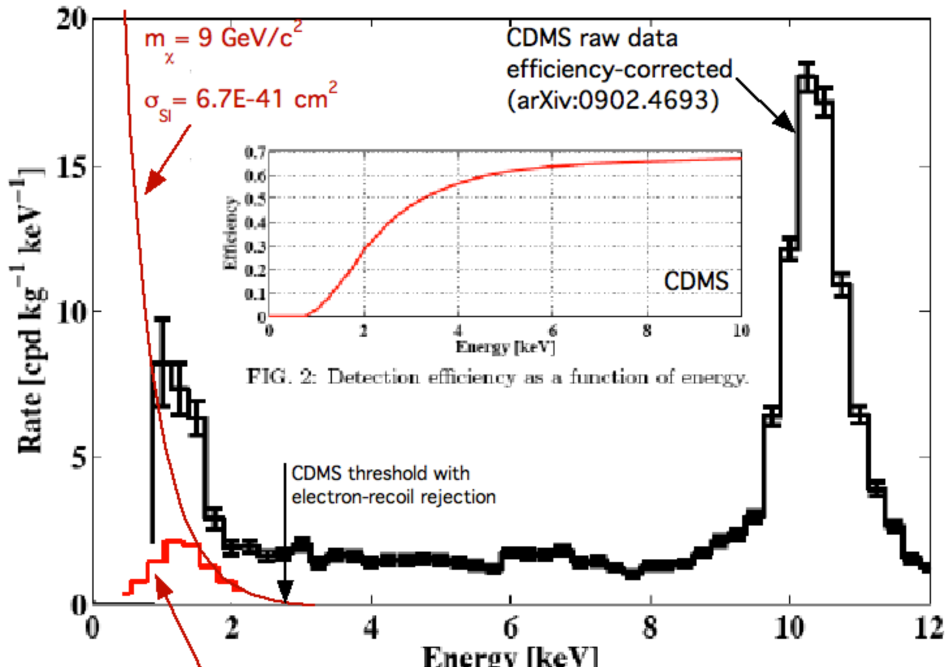
N. Bozorgnia SNOWPAC 2010

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)



L-shell EC ^{68}Ge
(~12% of 10.3 keV peak)

This spectrum for events >3σ_{noise}
(i.e., low-E rise should not be noise)

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!!! ;-)

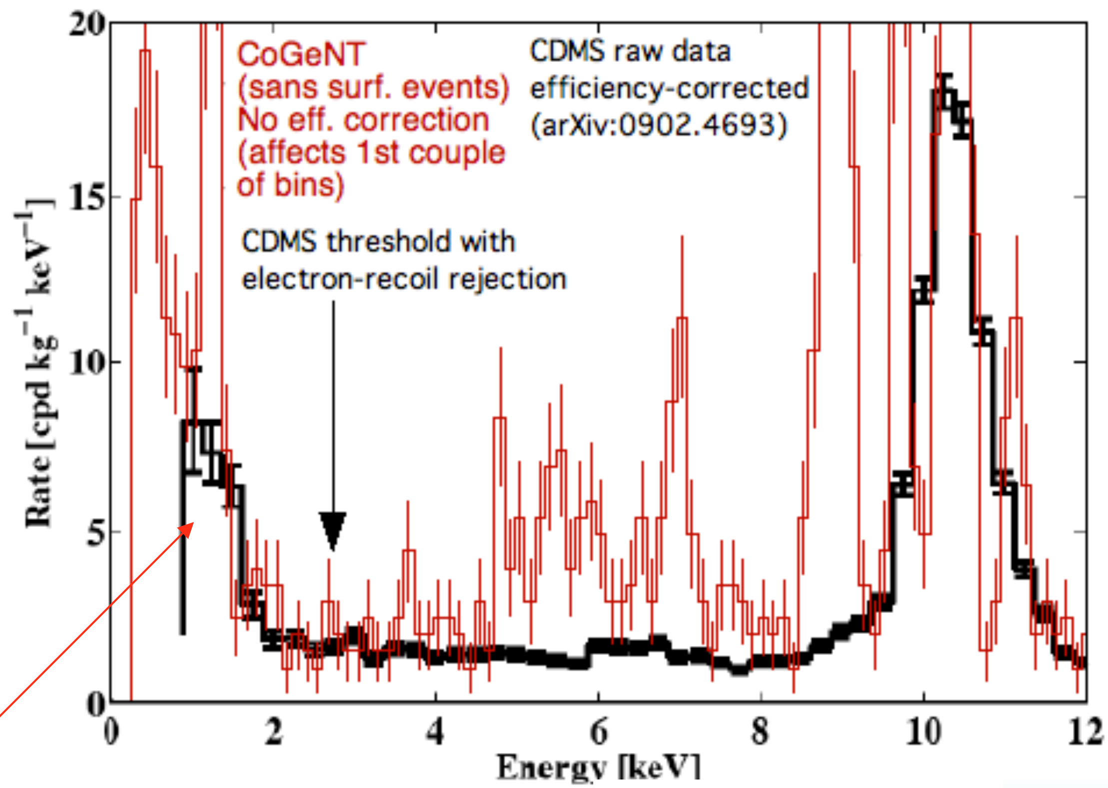
The predicament: WIMP signals are boring ~exponentials

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

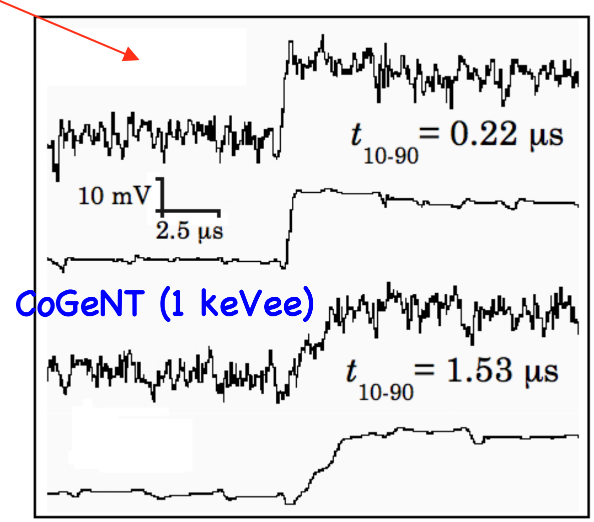
CoGeNT continuum will continue to drop (just 3 mo. underground at beginning of this run, vs. years for CDMS). This applies to cosmogenic peaks as well.

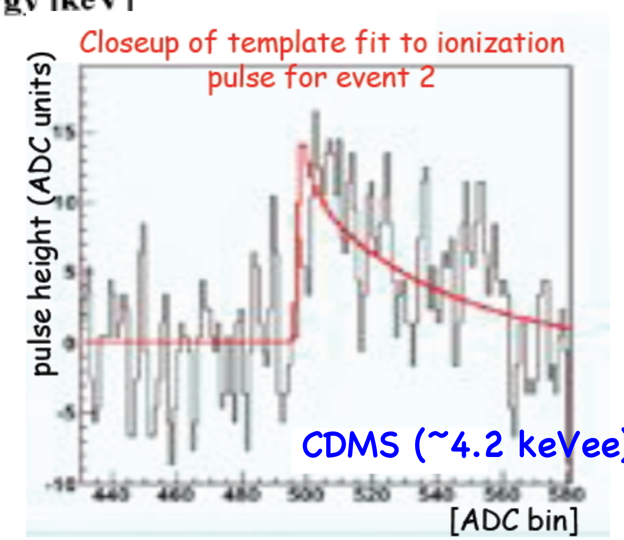
CoGeNT spectrum has cosmogenic partial energy depositions removed (slow pulses). Rise at low-E is stable (over 112 days so far)

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!)



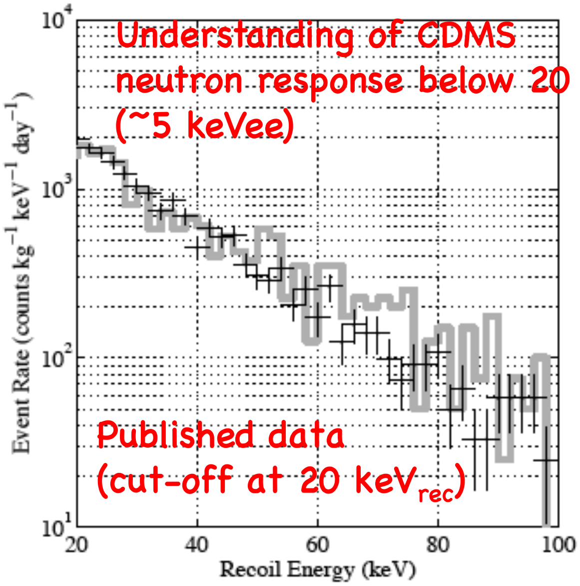


Should CDMS "dig deeper" in energy? This speaker believes so. Can they? Have they?

A look under the CDMS hood: lower energy analysis exists

Understanding of CDMS neutron response below 20 keV? (~5 keVee)

Published data (cut-off at 20 keV_{rec})



arXiv:0507190

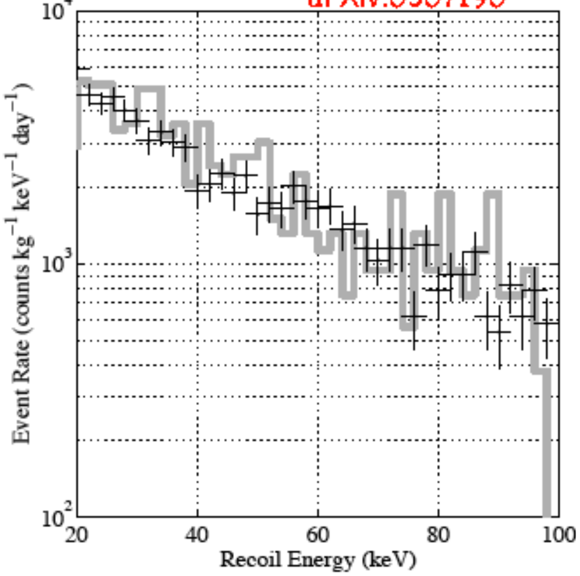
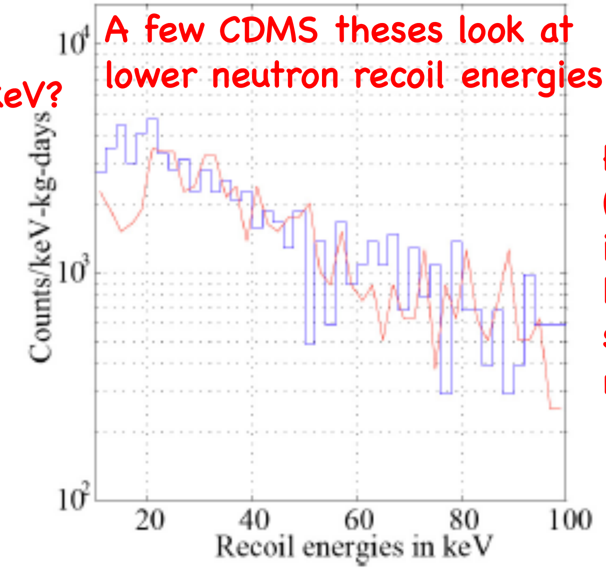


FIG. 10: Comparison of measured ^{252}Cf neutron recoil sp trum (dots with error bars) and Monte Carlo simulation (gray line) for coadded Ge detectors (top) and Si detectors (bot-

A few CDMS theses look at lower neutron recoil energies



Present CDMS hardware (mainly due to noise in ionization channel) has a very limited ability to separate electron recoils and nuclear recoils below ~10 keV_{rec}

Hence the analysis thresholds used.

C.N. Bailey PhD Diss. CWRU 2010

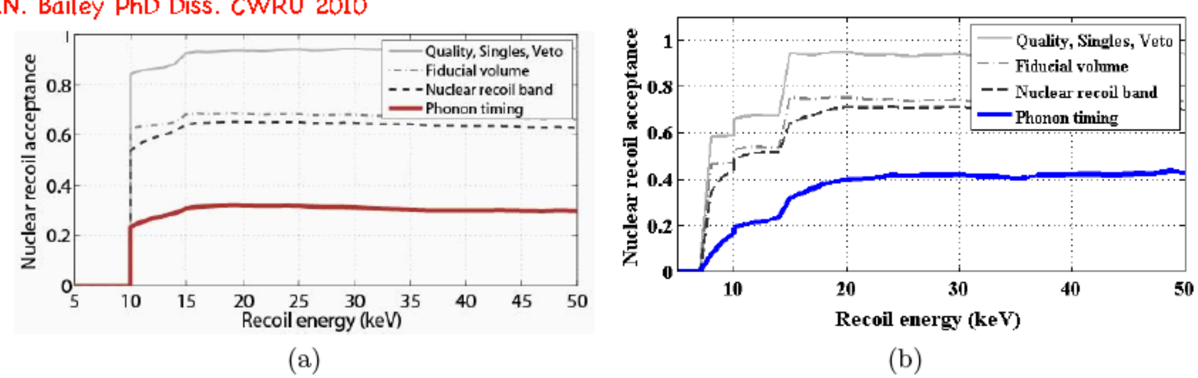


Figure 5.13: The efficiency of the R123 and 124 (a) germanium and (b) silicon WIMP search analysis as a function of phonon recoil energy. Curves represent the total efficiency after the subset of cuts described in the caption were applied to the data. From [17] and [27].

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}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):

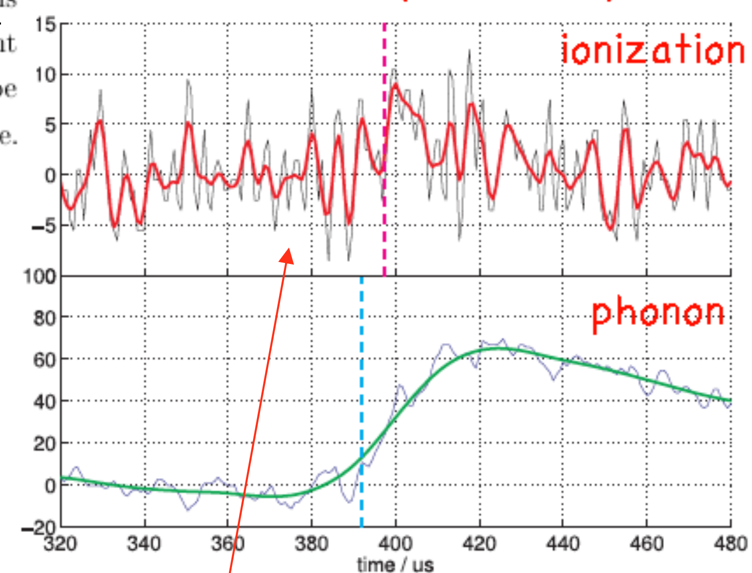
Table B.1: Events in 2-5 keV energy range, Ge detectors

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}Si concentration, if nothing done about it)

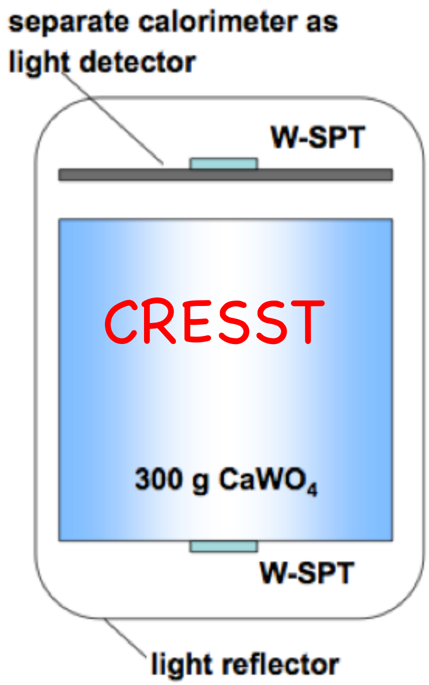


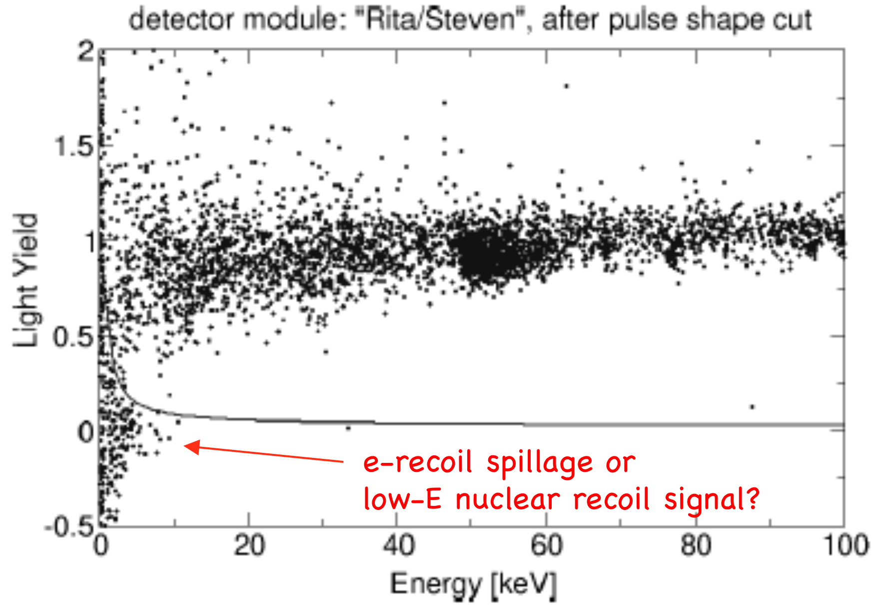
The problem is this (and rise time of phonon channel at lower-E)

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

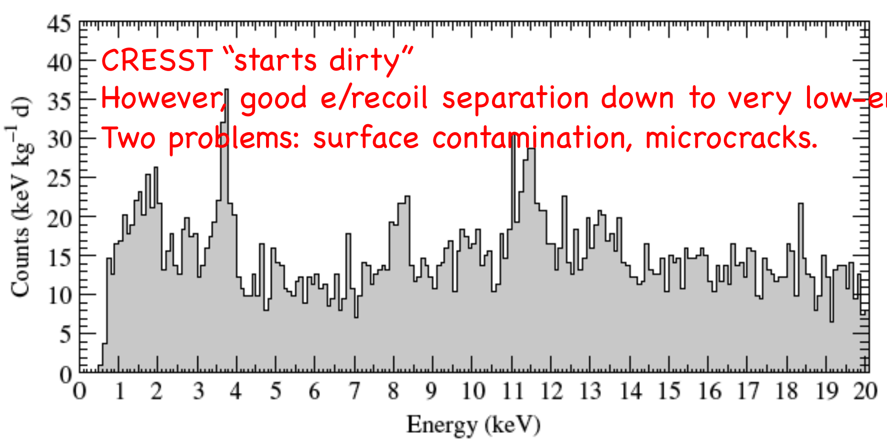
With present electronics, what CDMS has to say (one way or another) about this spectral region has to be taken with a large grain of salt (CoGeNT can at least very efficiently reject most surface events in the same energy region, and we aim at improving bckgs and threshold already this year)

Since we are at it...





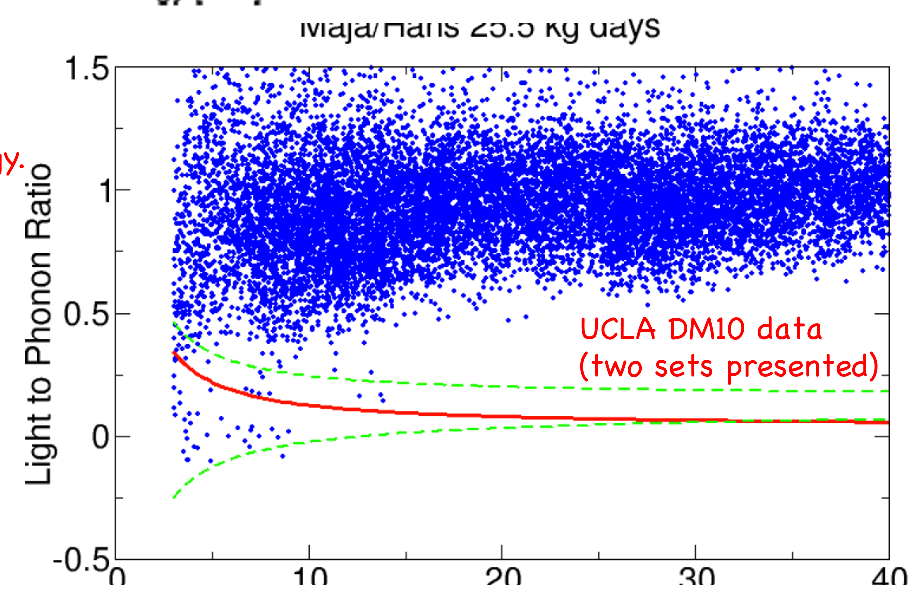
e-recoil spillage or
low-E nuclear recoil signal?



CRESST "starts dirty"

However, good e/recoil separation down to very low-energy.

Two problems: surface contamination, microcracks.



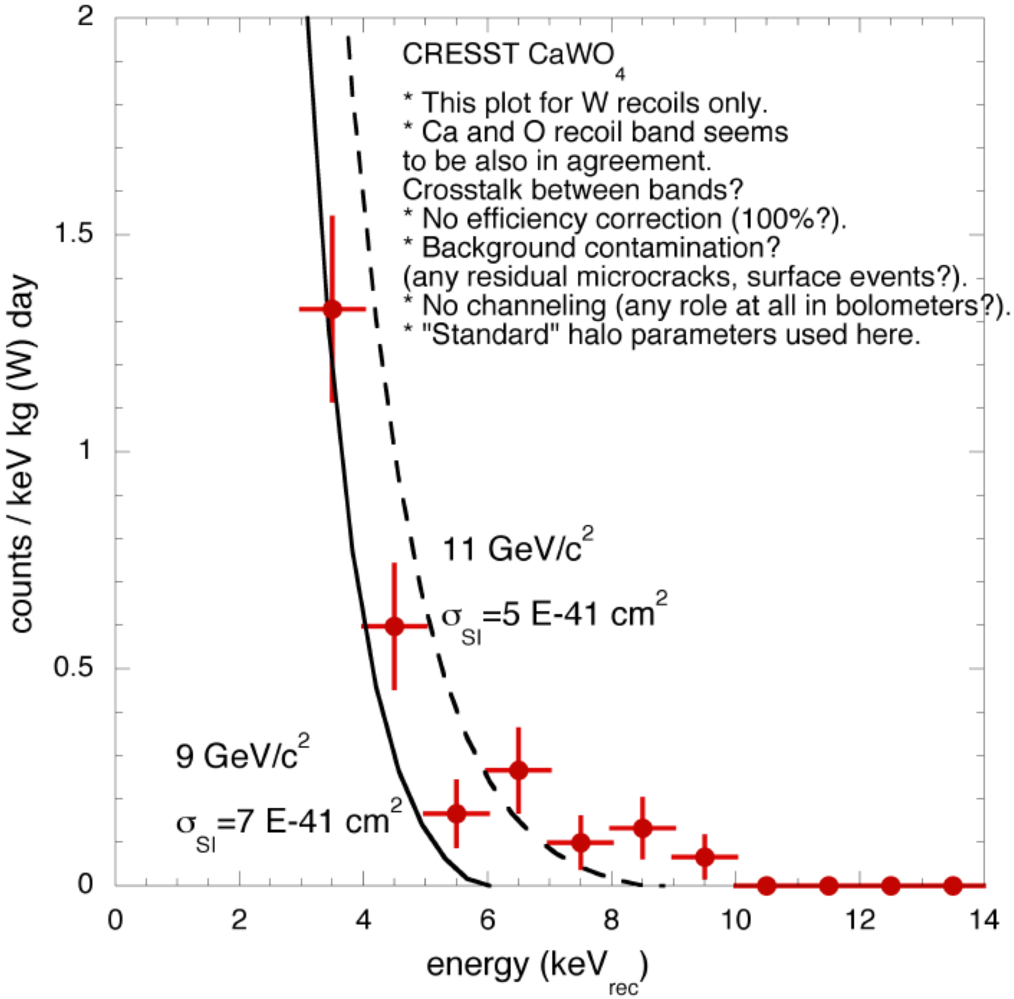
UCLA DM10 data
(two sets presented)

arXiv:physics/0504151

arXiv: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)

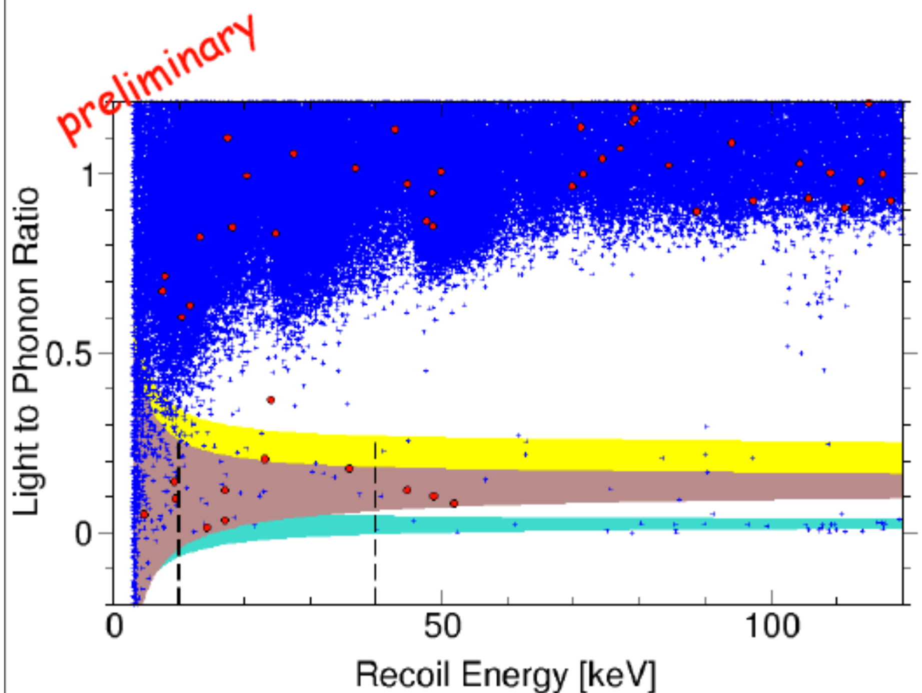
Better band separation
than CDMS.

CRESST $CaWO_4$ 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 statisticallly not yet significant

Neutrons ?

- Rate to high for external neutrons
- „internal" neutron source only if low energetic

Low mass WIMPs ??

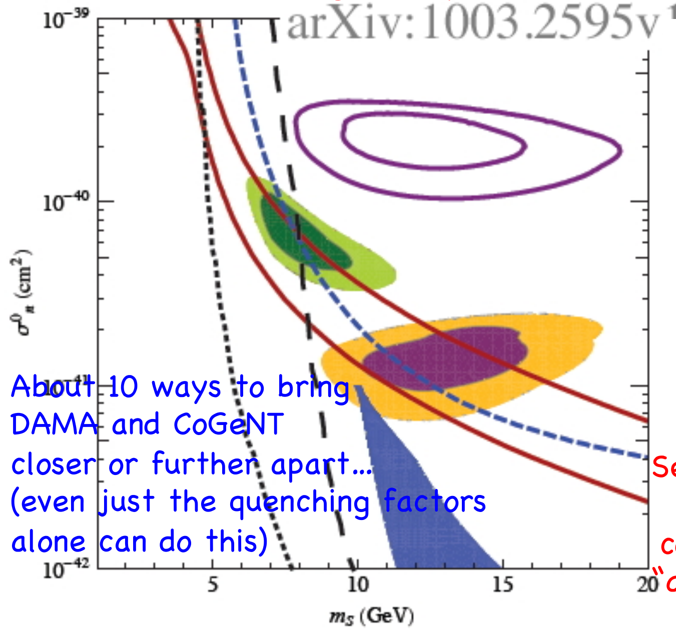
A combined analysis of all recoil-bands is in preparation

More statistics is needed

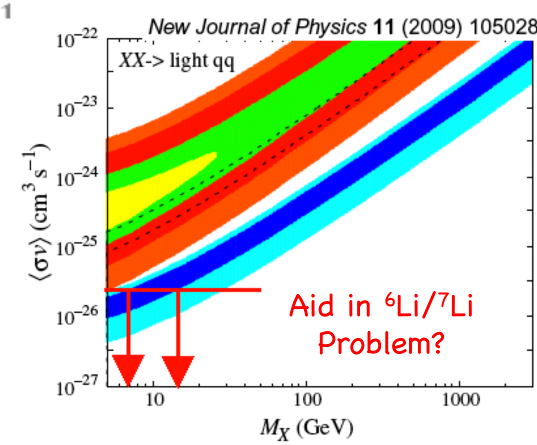
W. Seidel, CRESST talk at WONDER2010

Interpretation & possible relevance:

(I am done trying to update this transparency)

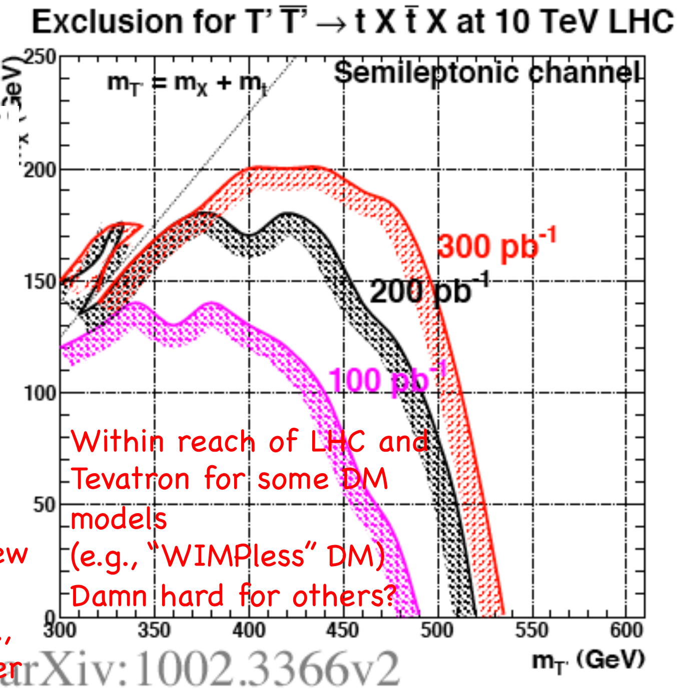


About 10 ways to bring DAMA and CoGeNT closer or further apart… (even just the quenching factors alone can do this)

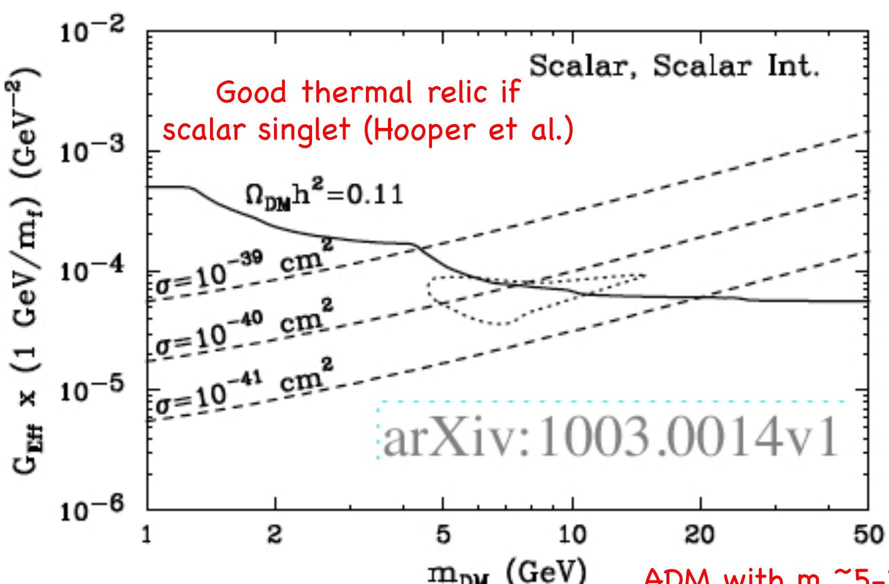


Aid in ^{6}Li/^{7}Li Problem?

Several phenomenologies generate ~few GeV WIMPs, in some instances coadjutant to unrelated problems (e.g., "asymmetric DM" <-> matter/antimatter asymmetry)

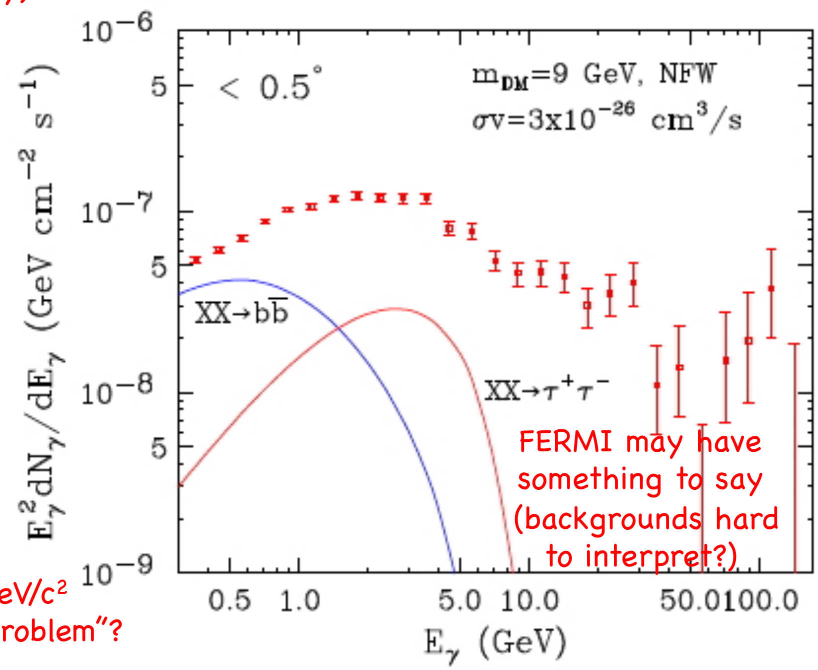


Within reach of LHC and Tevatron for some DM models (e.g., "WIMPless" DM) Damn hard for others?



Good thermal relic if scalar singlet (Hooper et al.)

ADM with m_χ~5-10 GeV/c^2 helps "solar composition problem"? arXiv:1003.4505



FERMI may have something to say (backgrounds hard to interpret?)

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 <E>.

N-type surface channel

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

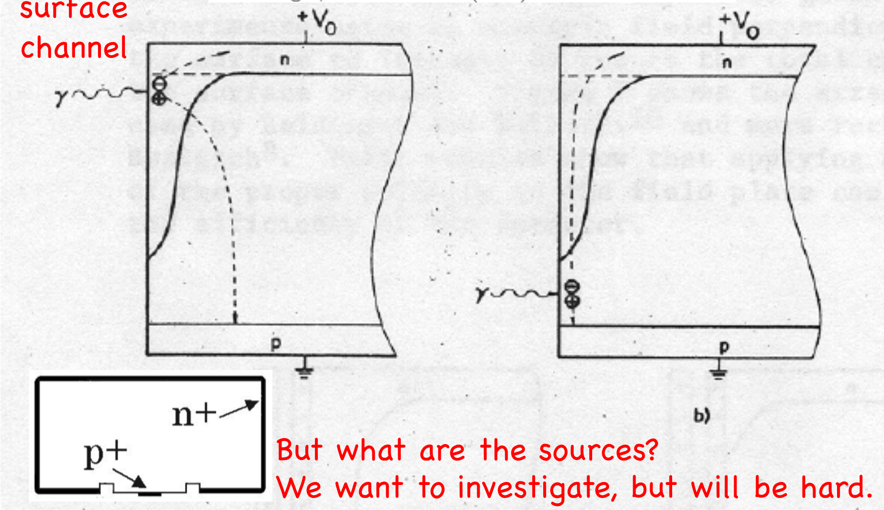
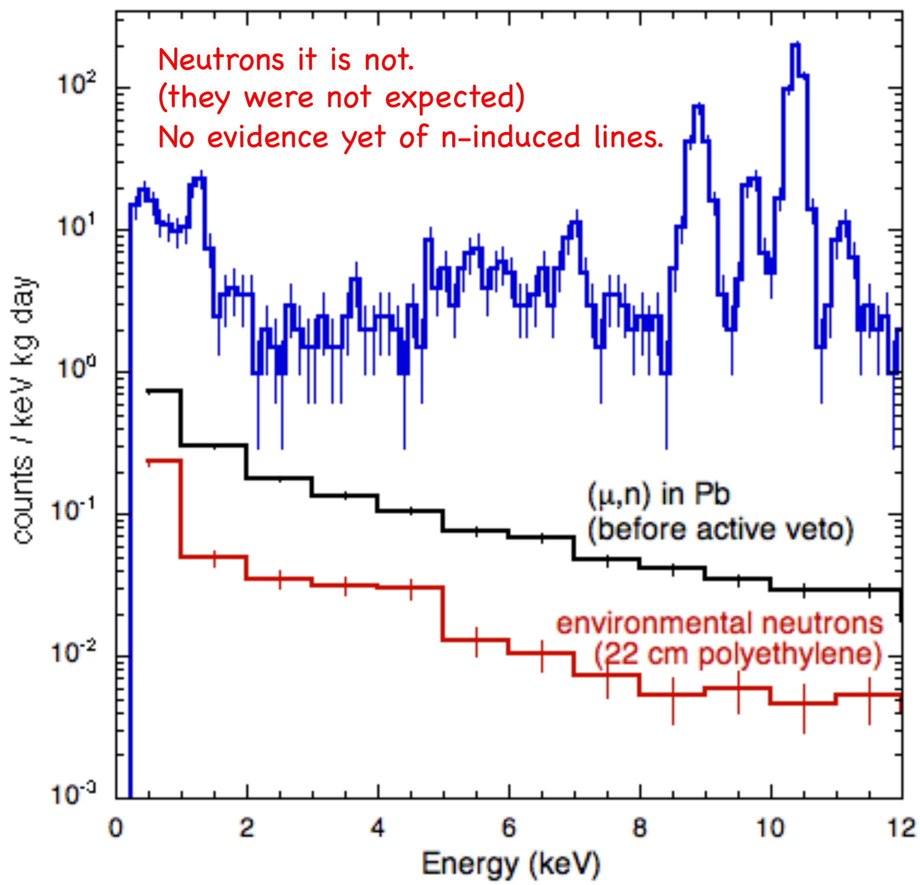
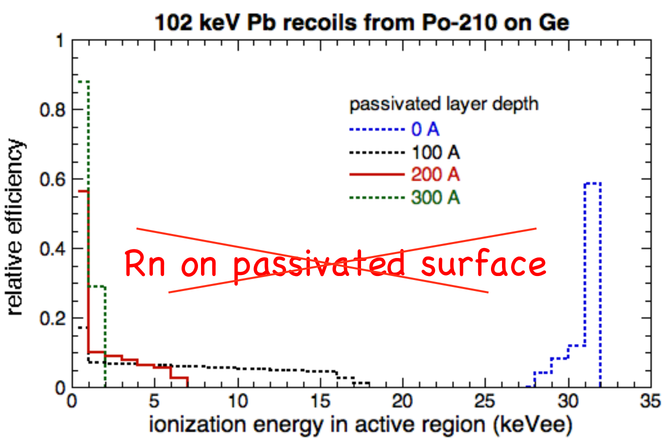


Fig. 4: The paths of the electrons and holes in a detector with an n-type surface channel [for further explanation see text].





~~Neutrons~~

~~Microphonics~~

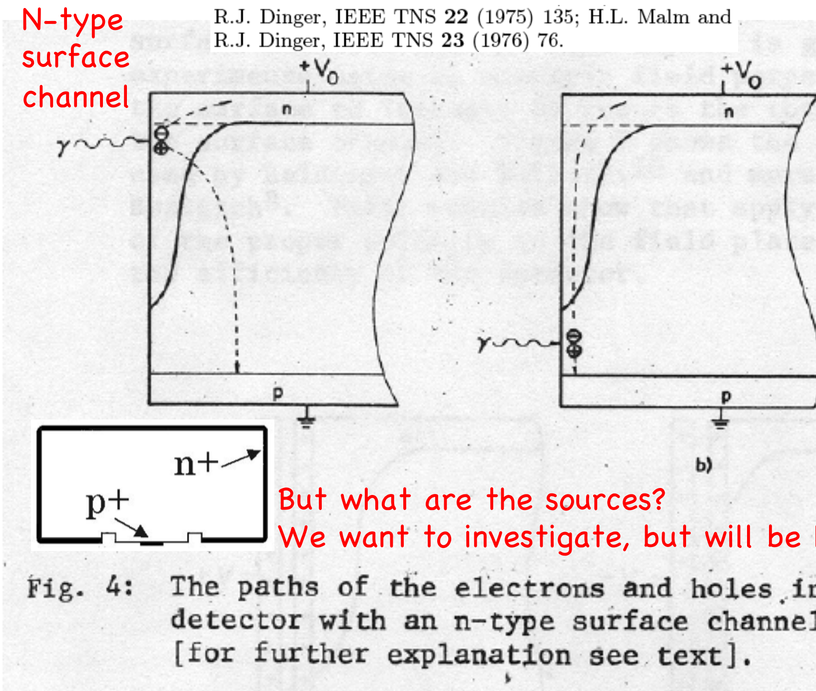
~~Excess electronic noise~~

Must keep looking for non-exotic explanations!

It is possible to come up with *MANY* natural explanations, however none yet satisfactory.

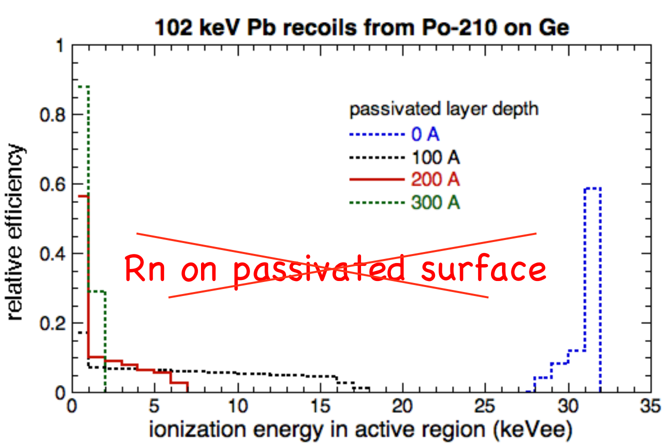
A PPC-based 60kg MAJORANA demonstrator would see annual mod. not just in rate, also in <E>.

N-type surface channel

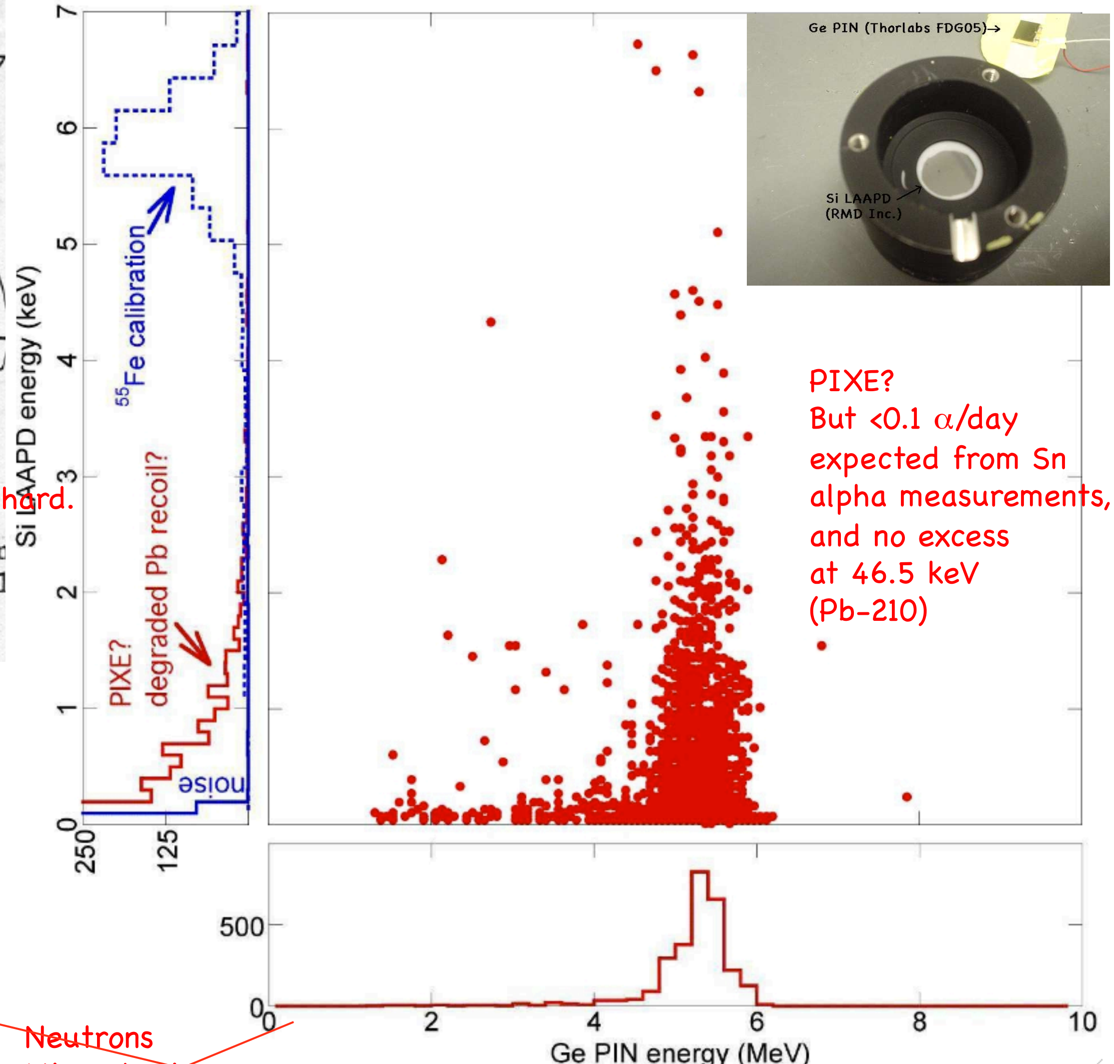


But what are the sources?

We want to investigate, but will be hard.



Rn on passivated surface



PIXE?

But <0.1 α/day expected from Sn alpha measurements, and no excess at 46.5 keV (Pb-210)

Neutrons

Microphonics

Excess electronic noise

What next?

What next?

Wee update on CoGeNT:

* At twice 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?)

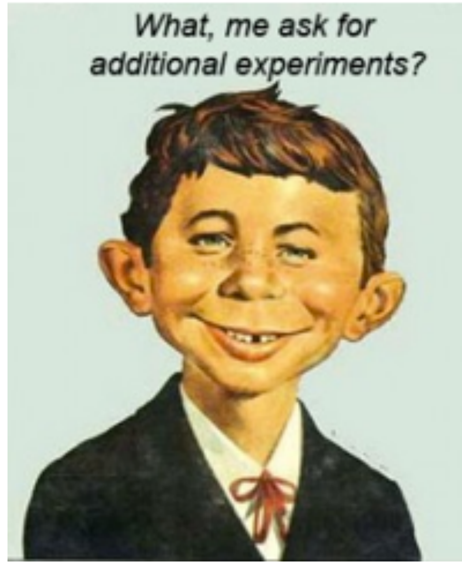
* We are not going to sit on this one forever... (pragmatic approach: best effort at bckg abatement. Kill it or see it modulate, both interesting results -little room for DAMA interpretations if CoGeNT continues to significantly improve its low-mass sensitivity-)

JOHN N. BAHCALL PHYSICAL REVIEW VOLUME 132, 1963

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

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

What next?

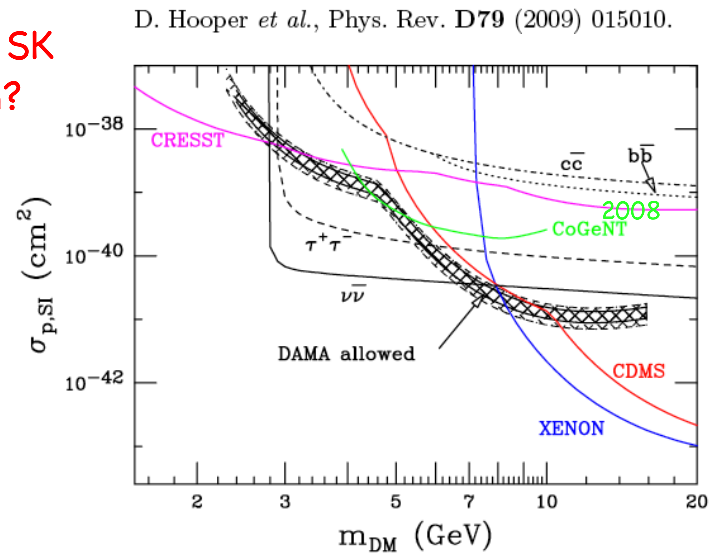


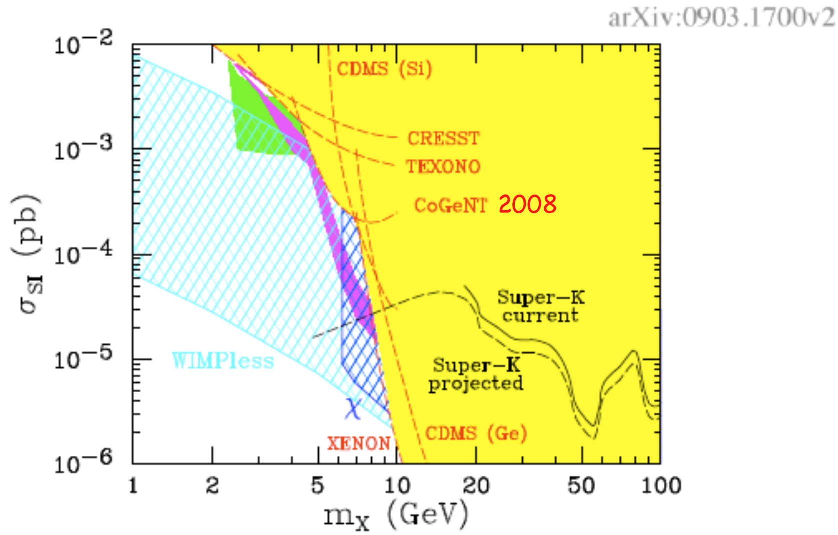
* CoGeNT: more exposure, lower E_{thr}, more calib.&analysis, upgrades…
* MALBEK @ Kimballton: different surface channel? Lots to learn from it.
* MAJORANA 60 kg Demonstrator: How about two modulations for the price of one?
* GERDA: PPCs considered (favored?) for phase two.
* CDEX @ CDUL: 10 kg of PPCs 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…

What next?

Within SK reach?





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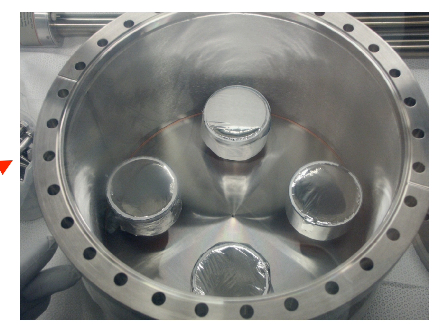
My $ is on this pony: MAJORANA 60kg PPC-based
(if we do not get rid of this exponential earlier)



Light WIMPs: The plot thickens?

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).

* 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.

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.

* 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-)

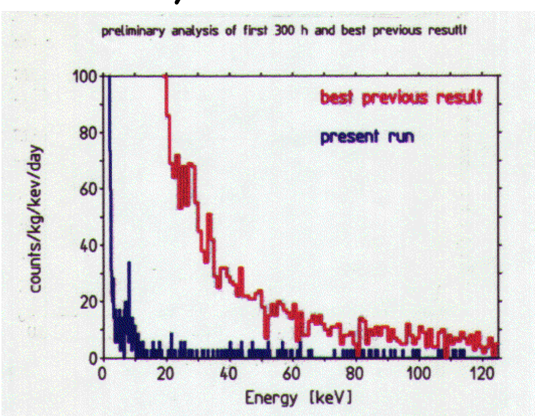
What will it take to call it "dark matter"?

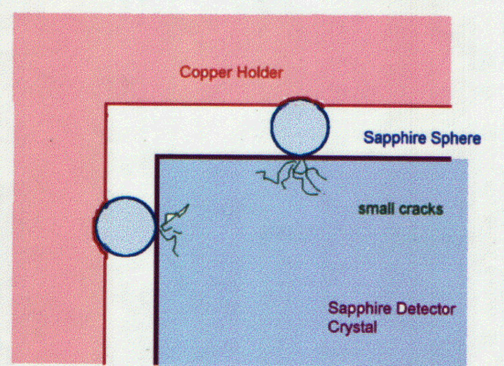
• FACT #1: DAMA may or may not be observing a WIMP effect.
CDMS may or may not have observed O(1) WIMP.
COGENT may or may not be pointing at the mass and coupling of culprit.
The LHC, indirect searches, other experiments, should help soon.

• 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:





CRESST early data

WIMP searches: a quixotic fight against backgrounds

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

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ANL: Pat de Lurgio, Gary Drake, Richard Talaga
CANBERRA Industries: Jim Colaresi, Orren Tench, Mike Yocum
LLNL: Nathaniel Bowden, Steven Dazeley
ORNL: David Radford
PNNL: Craig Aalseth, Jim Fast, Todd Hossbach, Martin Keillor, Jeremy Kephart, Harry Miley, John Orrell
SNL: Belkis Cabrera-Palmer, David Reyna
UC: Phil Barbeau, Juan Collar, Nicole Fields, Charles Greenberg
UNC: John Wilkerson
UW: Mike Marino, Mike Miller, Hamish Robertson, Tim Van Wechel

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