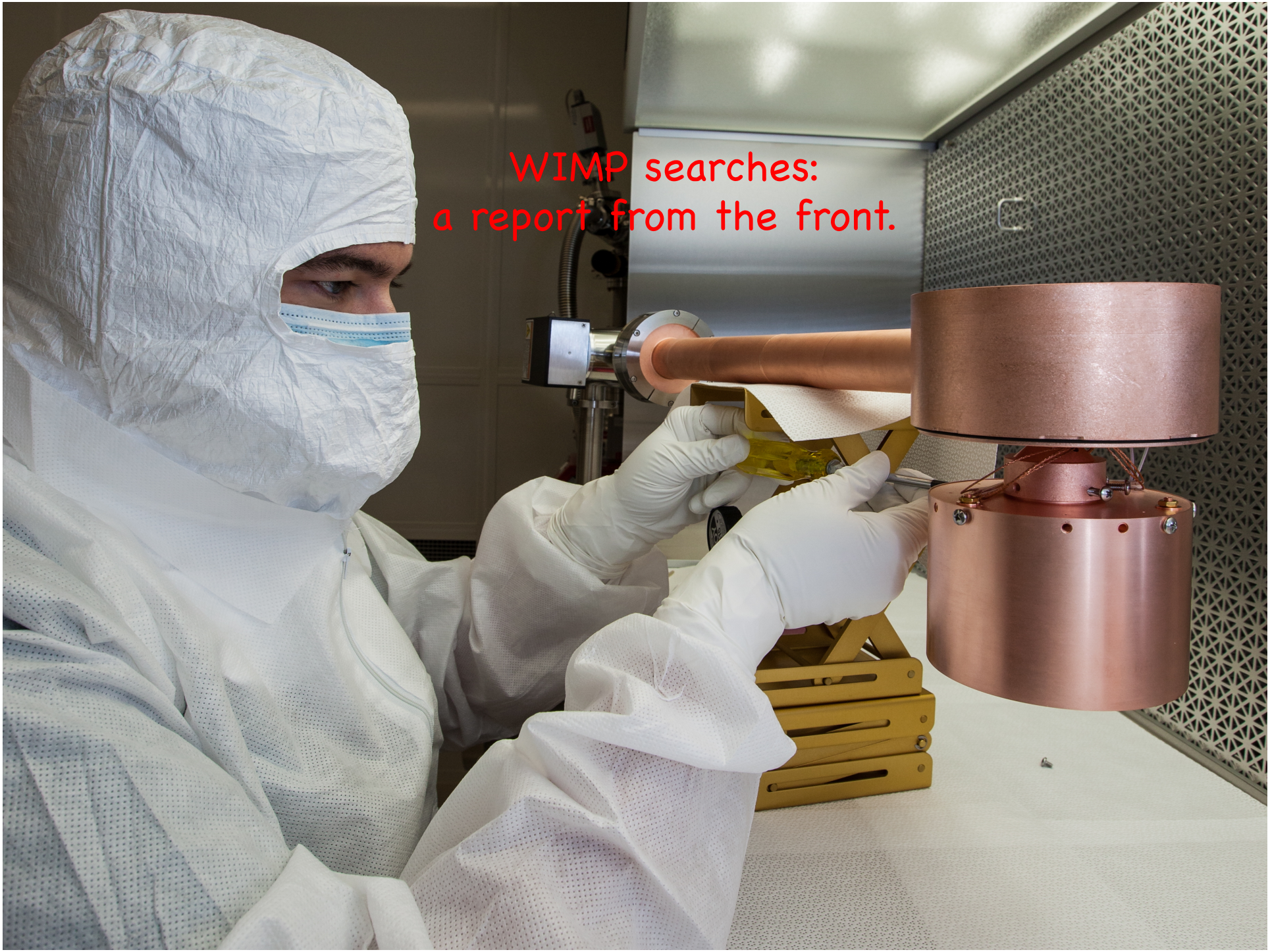
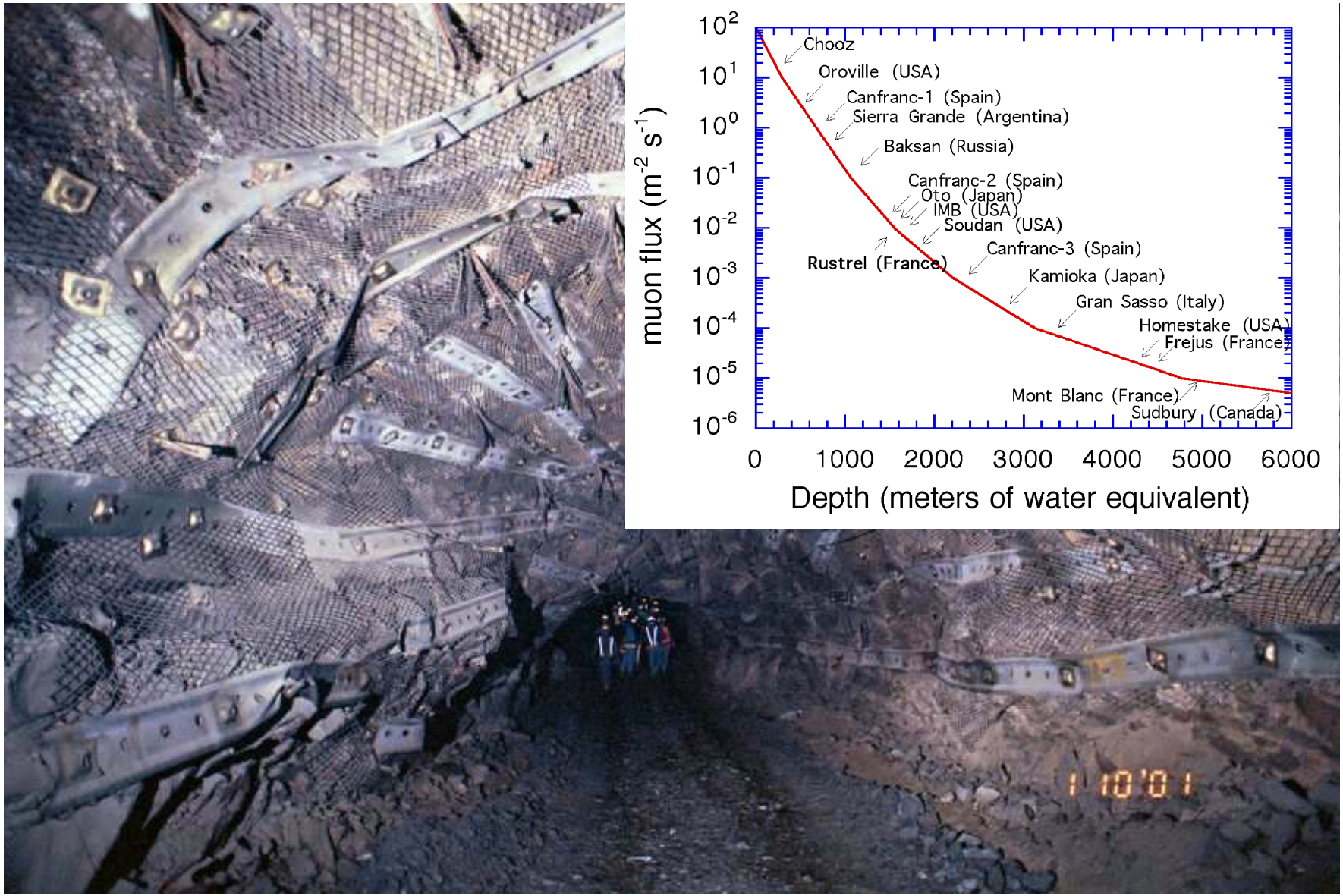

WIMP searches:
a report from the front.

10c intro: How do we look for WIMPs?

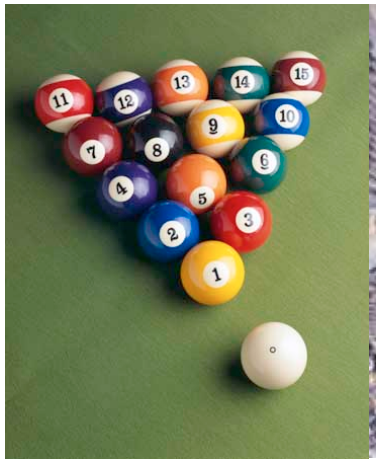
(location, location, location)

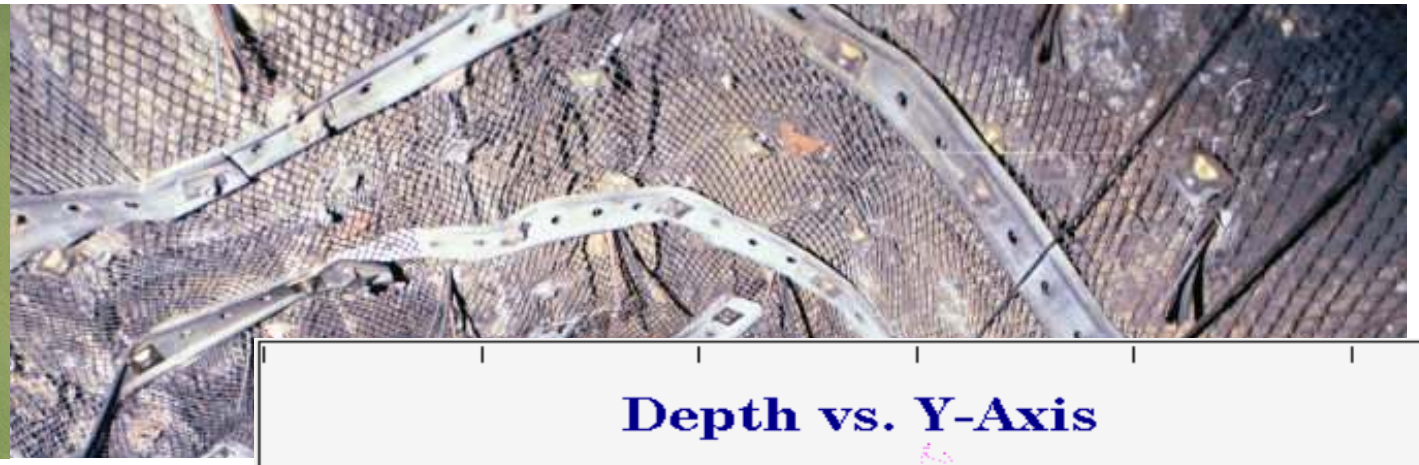
10c intro: How do we look for WIMPs?

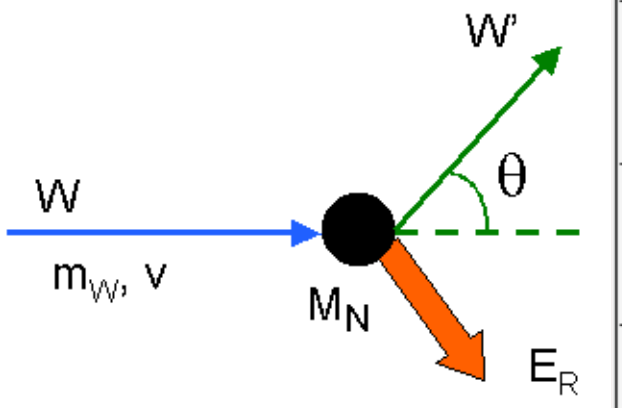


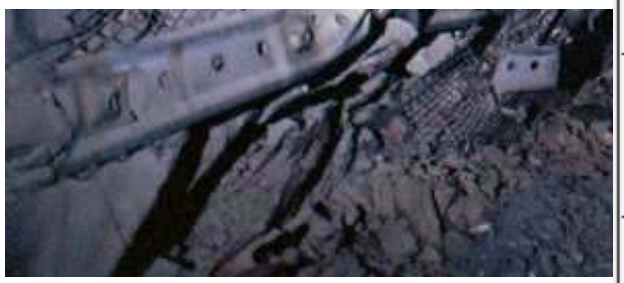
(location, location, location)

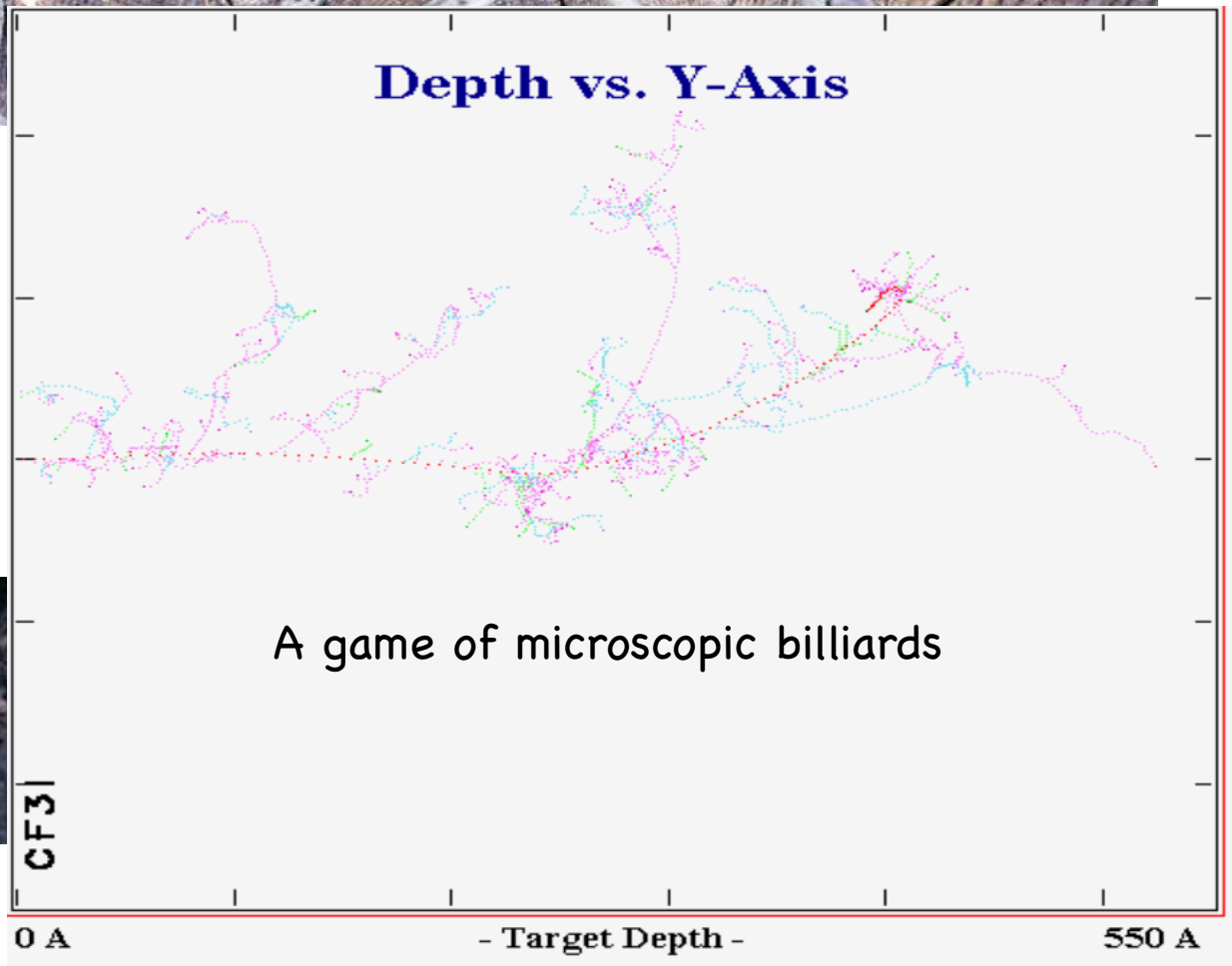
10c intro: How do we look for WIMPs?







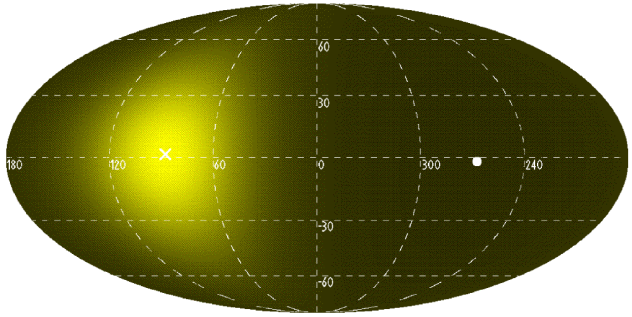


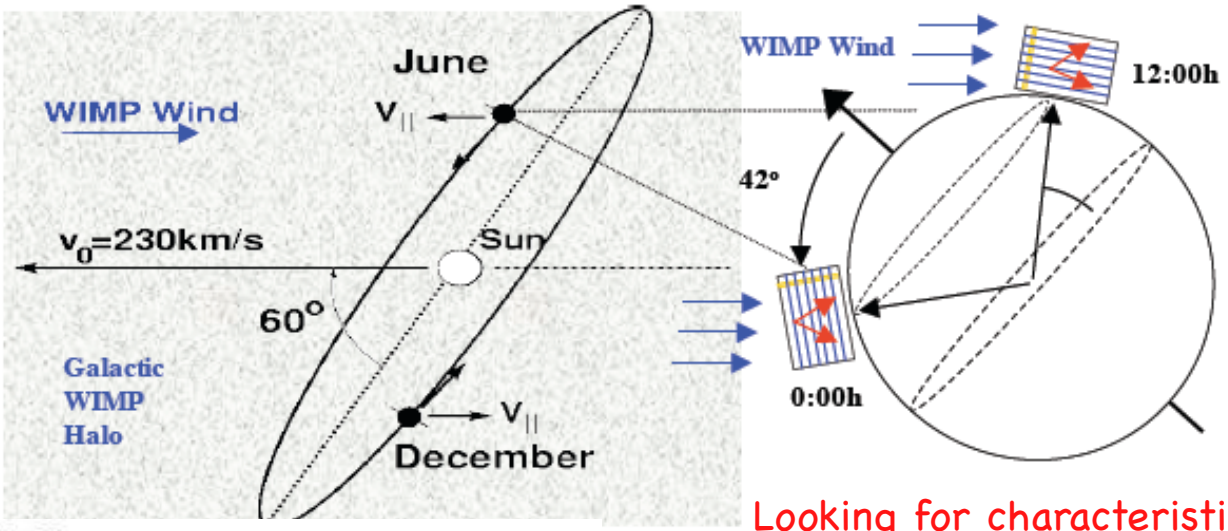


A game of microscopic billiards

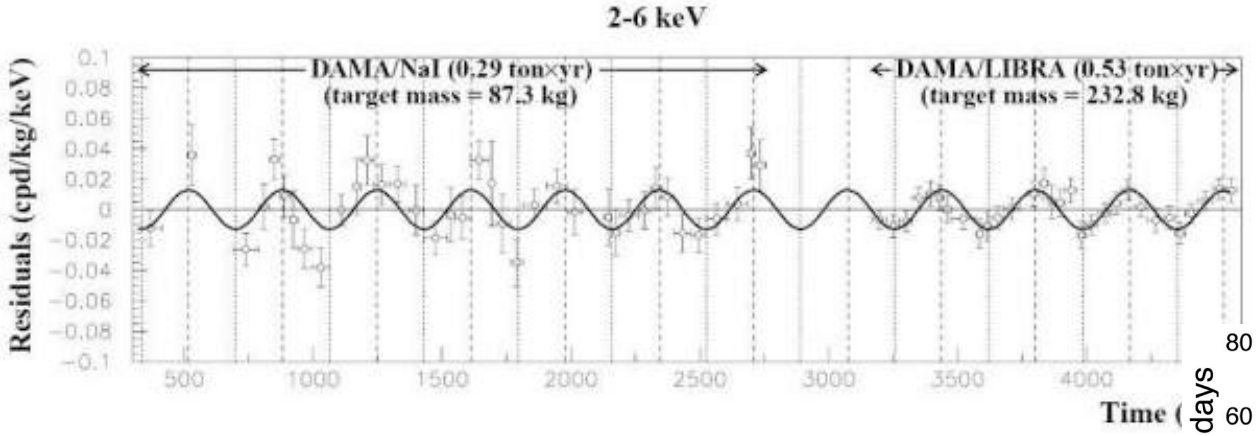
10c intro: How do we look for WIMPs?

A WIMP "wind" from Cygnus

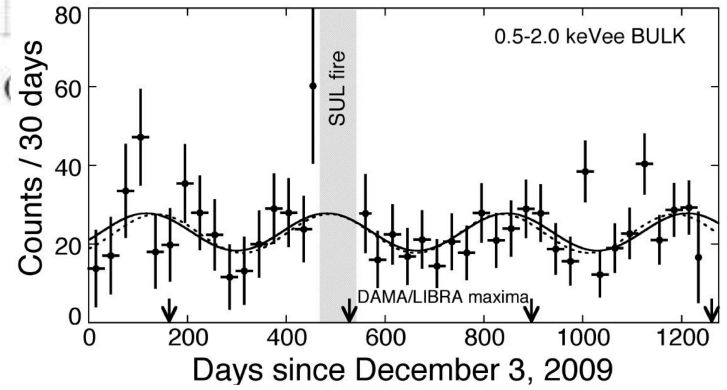




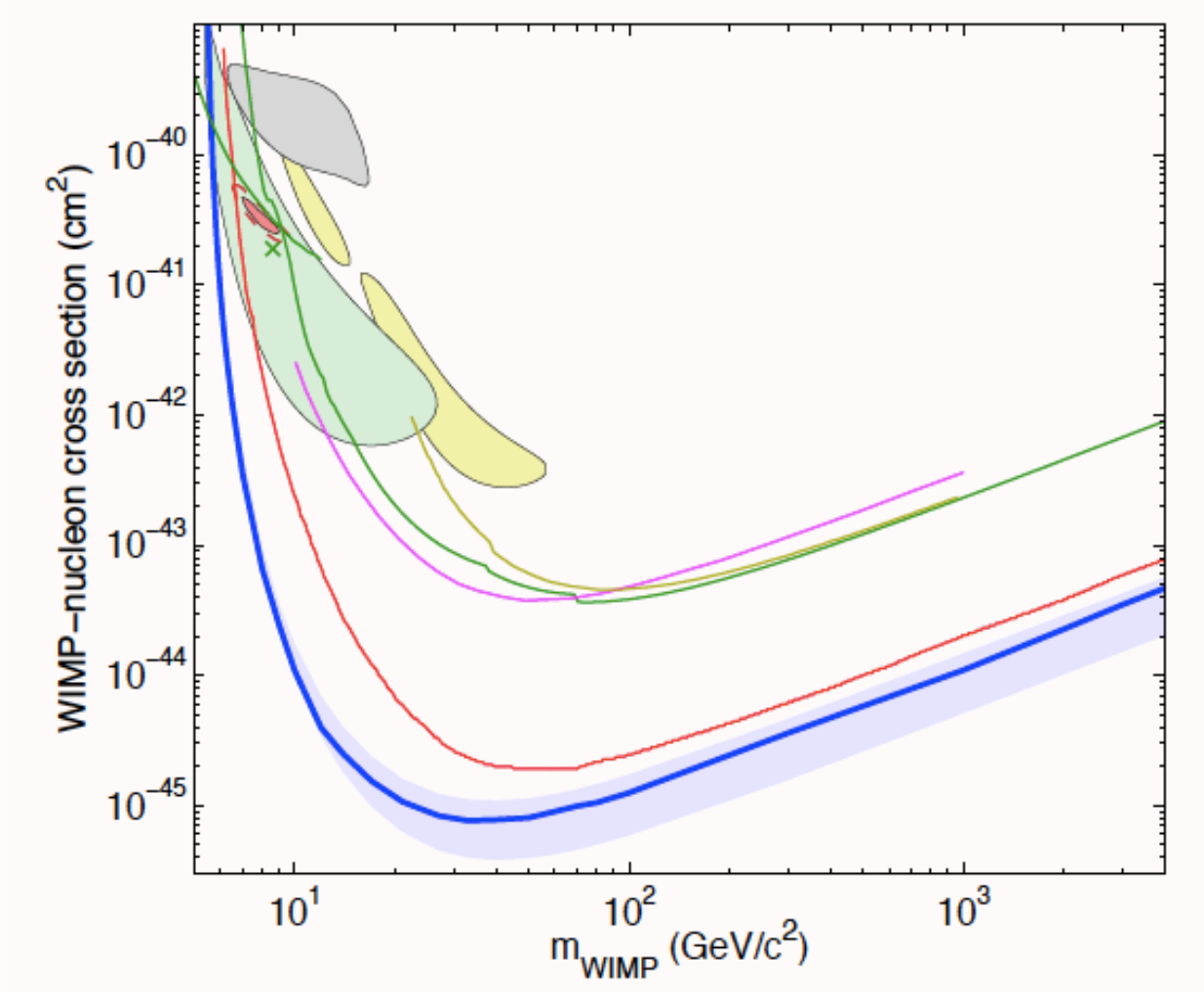
Looking for characteristic signatures from dark matter interactions



Curiosity or DM detection?



LUX: the claim



- Would essentially eradicate any possibility of reconciling low-mass anomalies (DAMA, CoGeNT, CRESST, CDMS-Si) with their null result through tweaks in particle phenomenology (isospin-violating DM, etc.)
- We are informed, via press-conference, that "we screwed up".

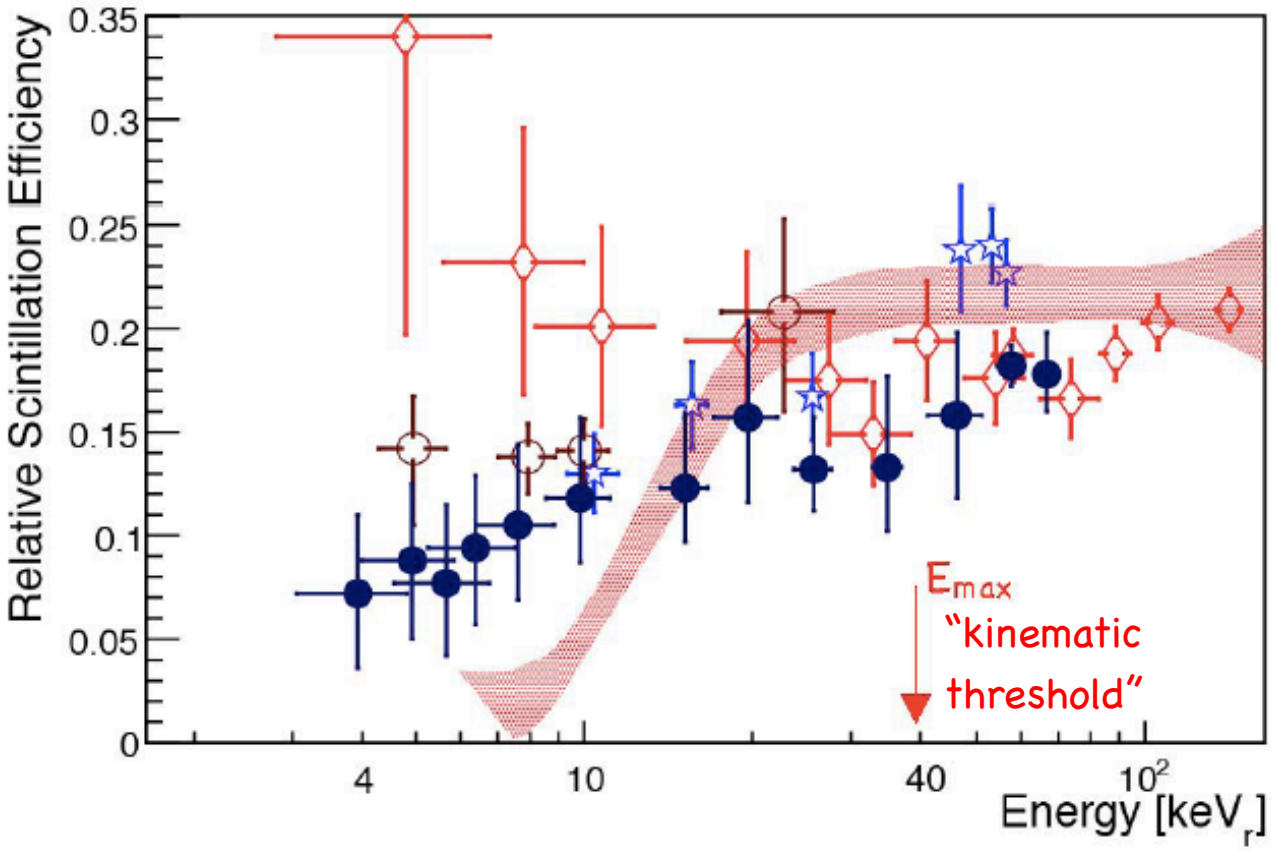
Really?

PRE-LUX ERA	POST-LUX ERA
1) Understand the response of your detector.	1) Talk to the press (esp. if desperate for funding).
2) Produce physics results, share information with your peers.	2) Produce physics results, share information with your peers.
3) Talk to the press (optional, only if you really must).	3) Understand the response of your detector.

- A bit of trickery involved in their treatment of V_{esc}, but today we are just going to concentrate on the whoopers.

The ever-changing $\mathcal{L}_{eff}$

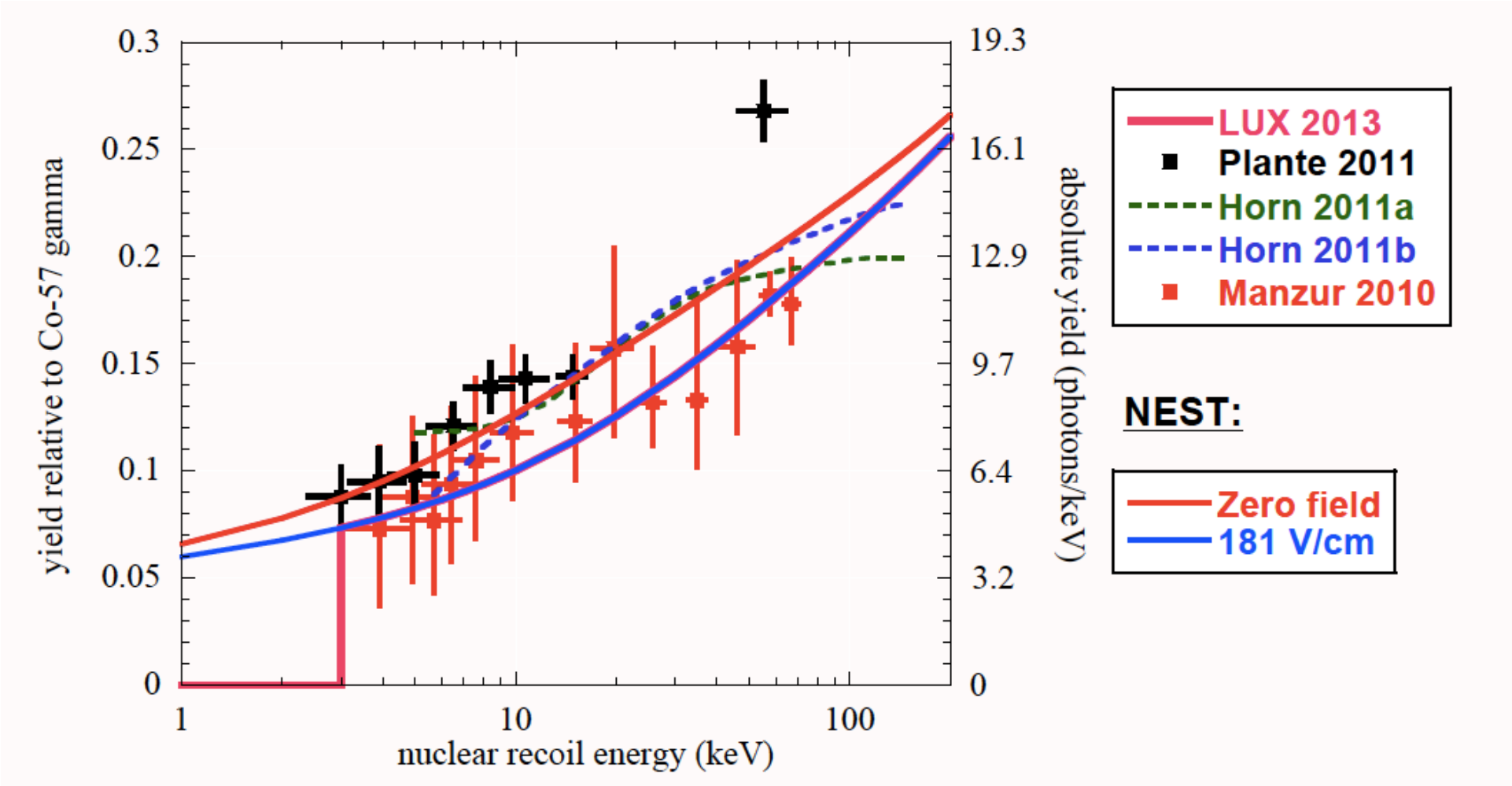
(today I'll claim it is not done mutating)



- This "quenching factor" for primary scintillation (S1) has been in a state of flux over the last decade, monotonically towards smaller values (= less sensitivity)

The ever-changing $\mathcal{L}_{eff}$

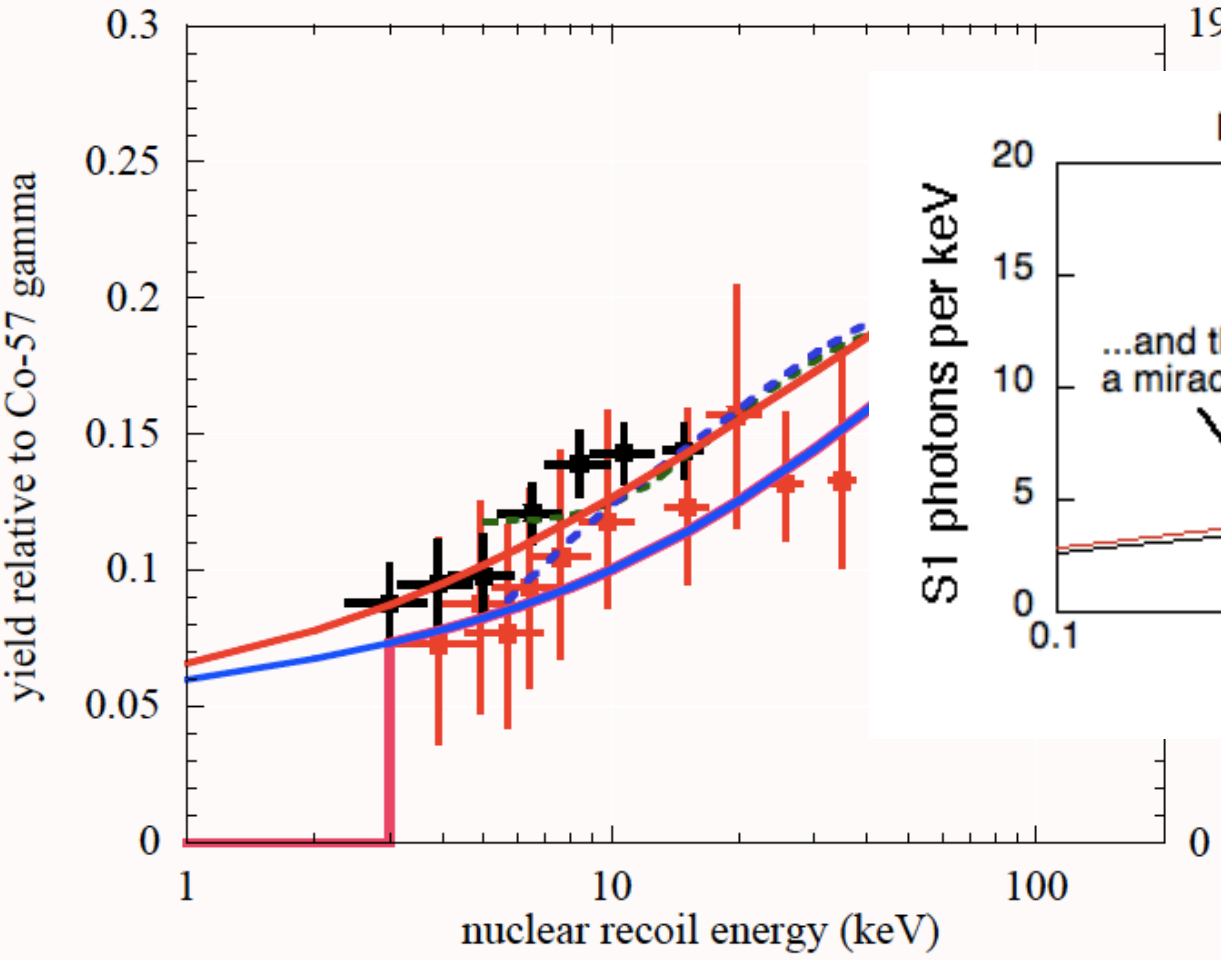
(today I'll claim it is not done mutating)

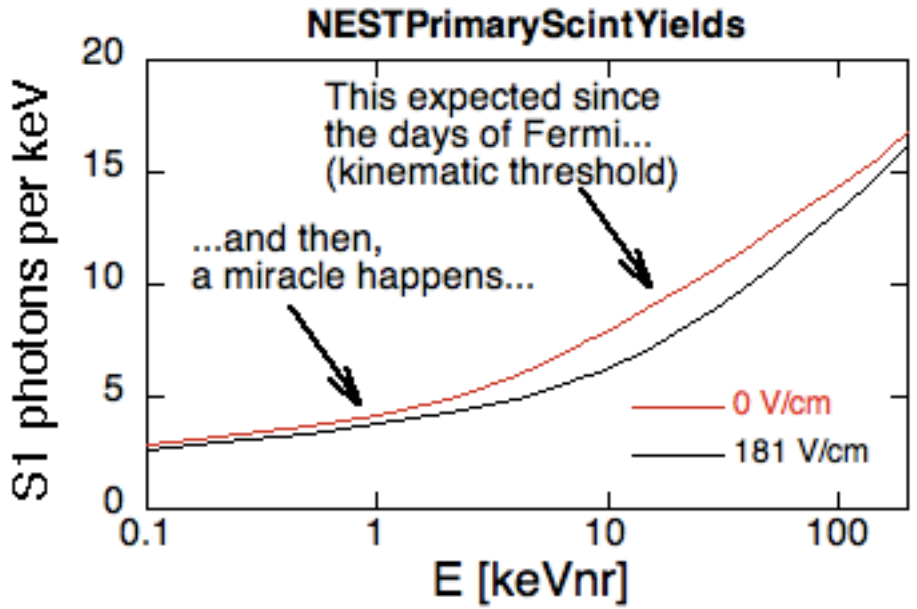


- Semi-empirical models like NEST are only as good as the quality of the data they are fed (guano in -> guano out).

The ever-changing $\mathcal{L}_{eff}$

(today I'll claim it is not done mutating)





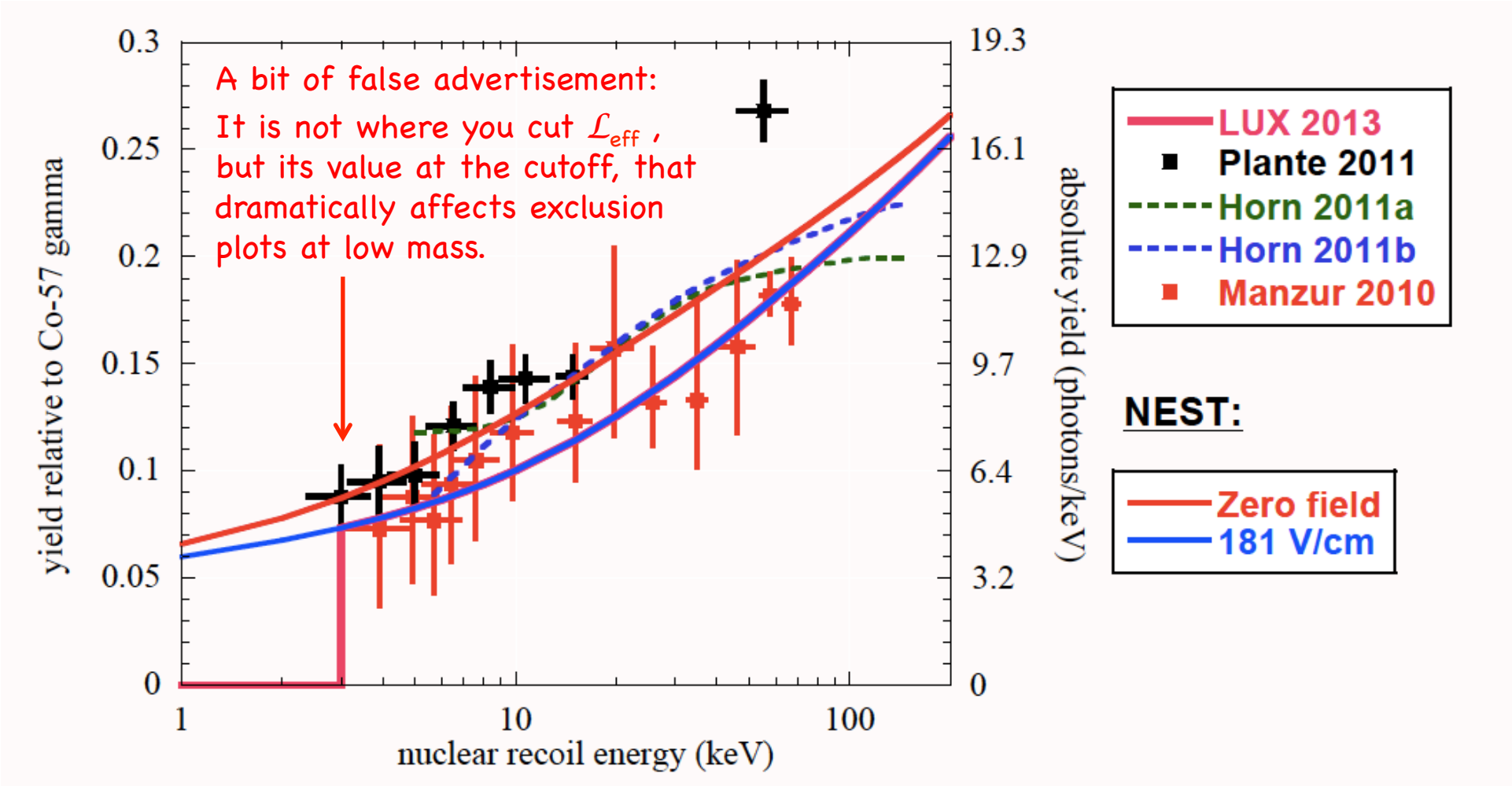
"It is not a question of if $\mathcal{L}_{eff}$ goes to zero, but at what energy it does"

D. McKinsey, LUX co-spokesman, circa 2010 (!?)

- Semi-empirical models like NEST are only as good as the quality of the data they are fed (guano in -> guano out).

The ever-changing $\mathcal{L}_{eff}$

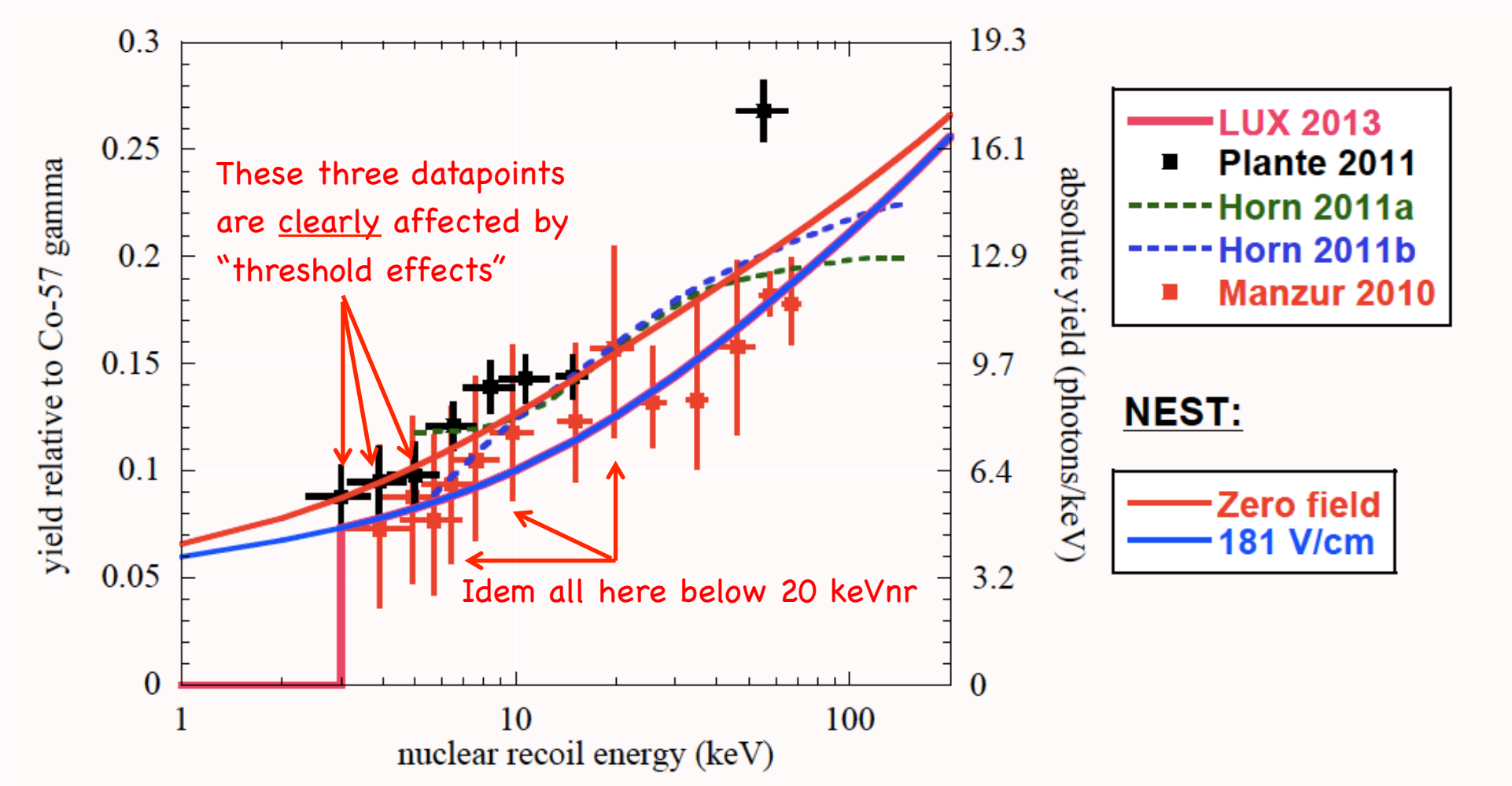
(today I'll claim it is not done mutating)



- Semi-empirical models like NEST are only as good as the quality of the data they are fed (guano in -> guano out).

The ever-changing $\mathcal{L}_{eff}$

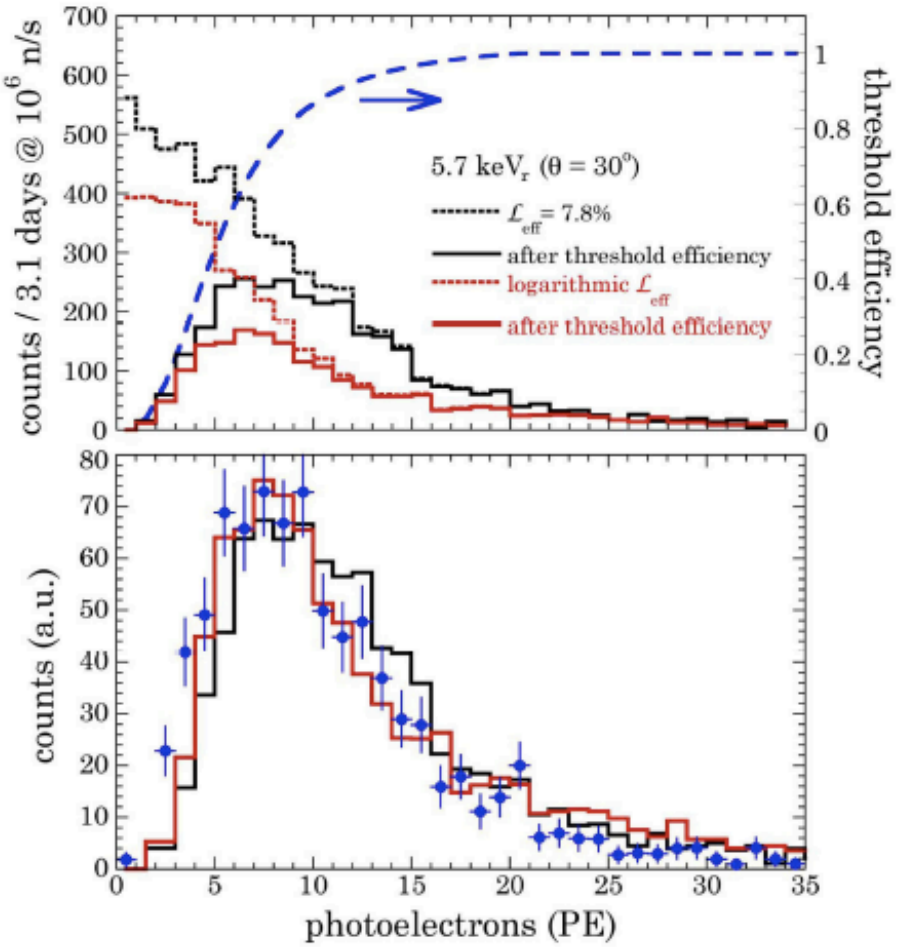
(today I'll claim it is not done mutating)

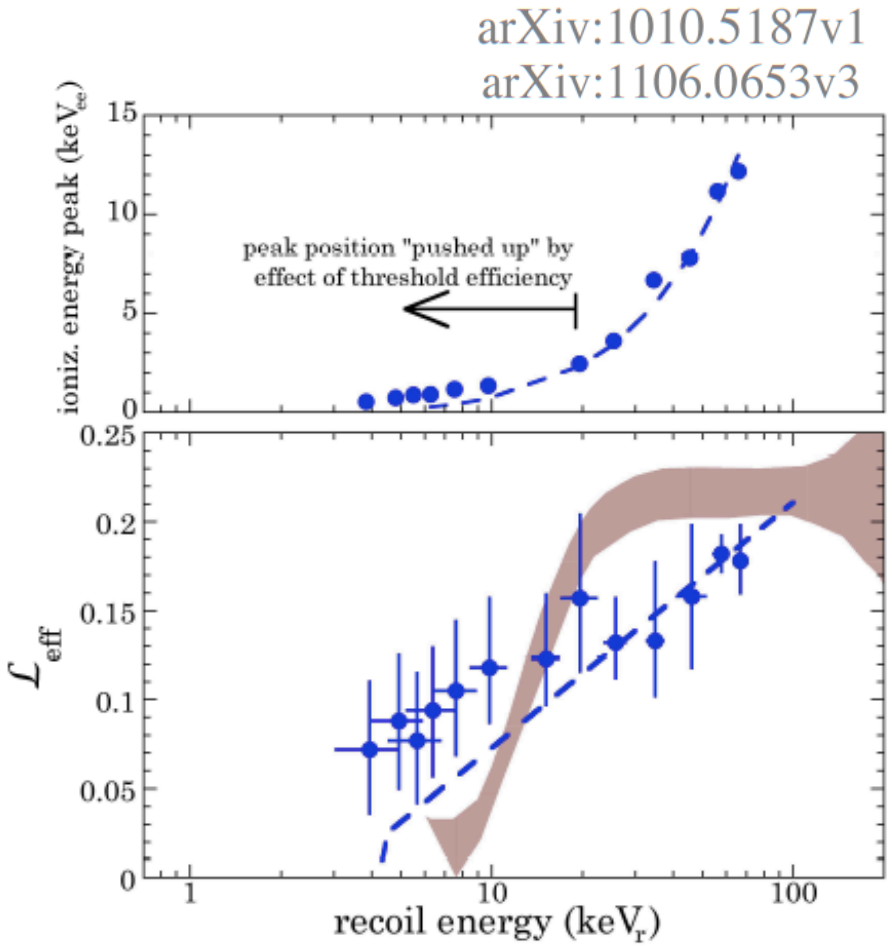


- Latest low-energy $\mathcal{L}_{eff}$ measurements can only be considered an upper limit, and not particularly conservative at that. Because of the specific mistakes made in the methodology employed, it is possible to obtain a finite $\mathcal{L}_{eff}$ at energies where it is identically zero.

The ever-changing $\mathcal{L}_{eff}$

(today I'll claim it is not done mutating)

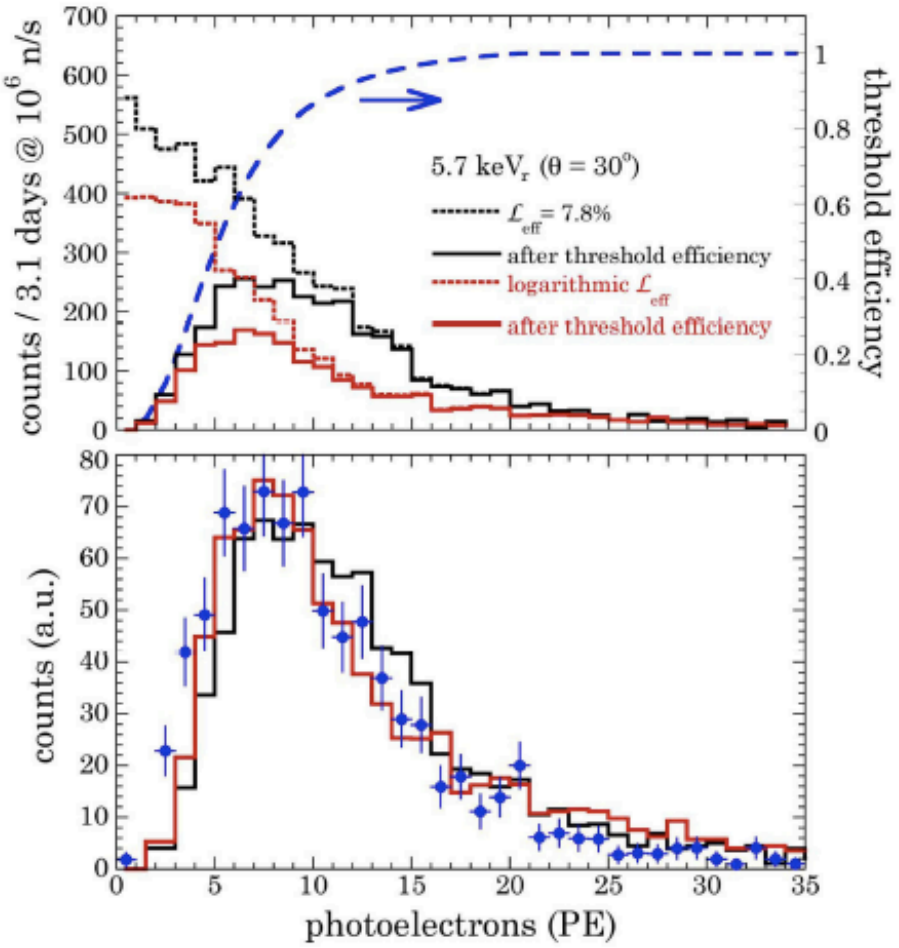


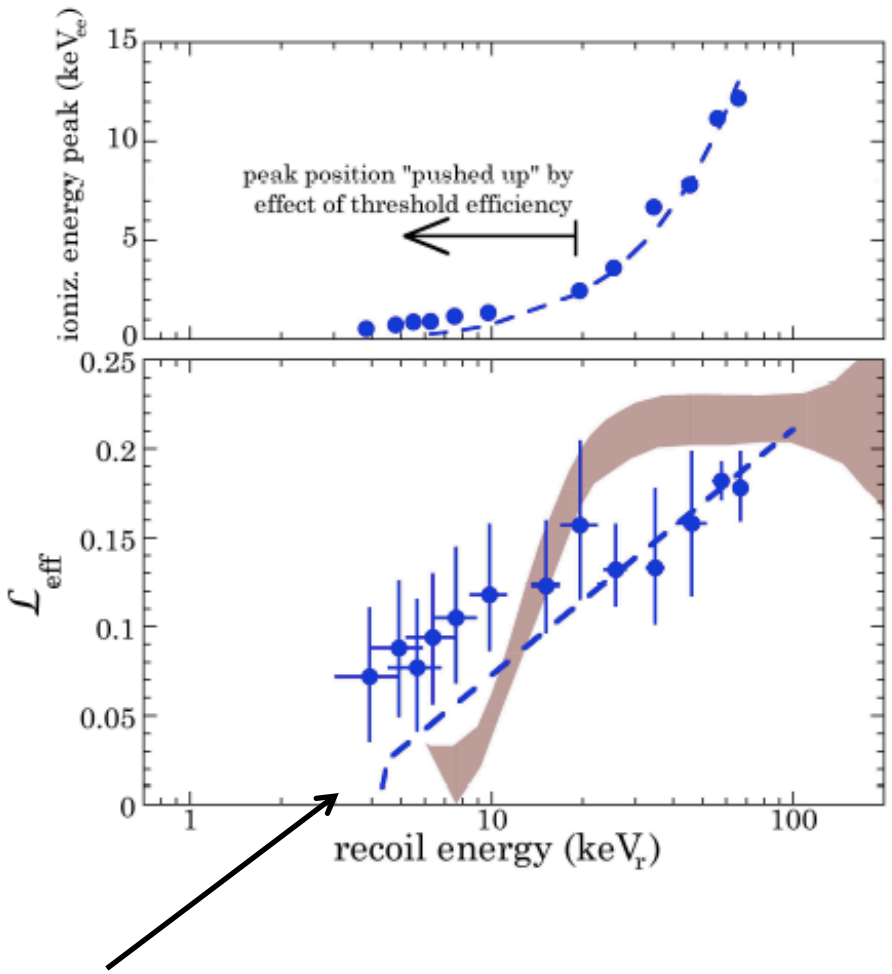


- A "no contest" sort of discussion with the authors of these measurements: the methodology is flawed (no arguing about this). In most recent measurements by Plante, the energy resolution is left a free parameter (and observed to diverge from expected value for datapoints affected by triggering threshold)

The ever-changing $\mathcal{L}_{eff}$

(today I'll claim it is not done mutating)

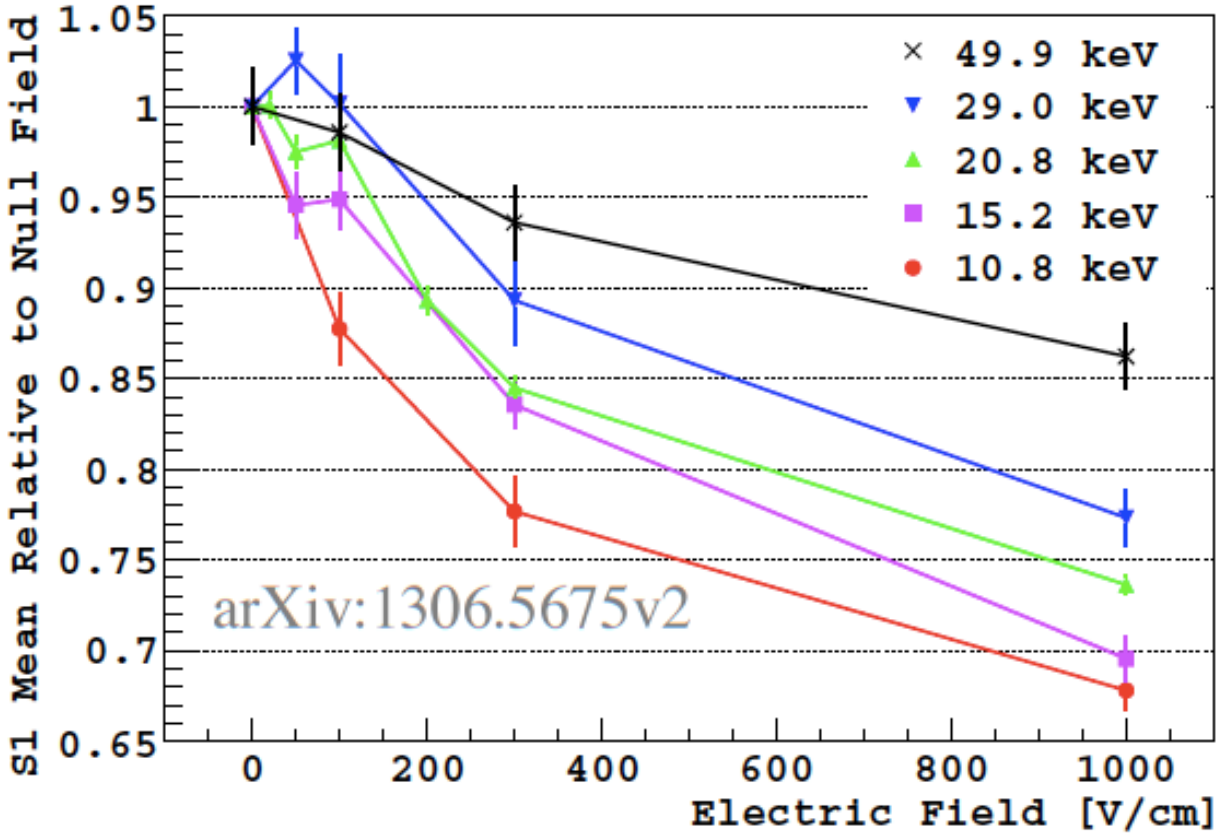




- An Leff rapidly dropping to zero at few keVnr is not only possible, but highly probable. Would render LXe detectors essentially insensitive to WIMPs in the ROI of recent anomalies.

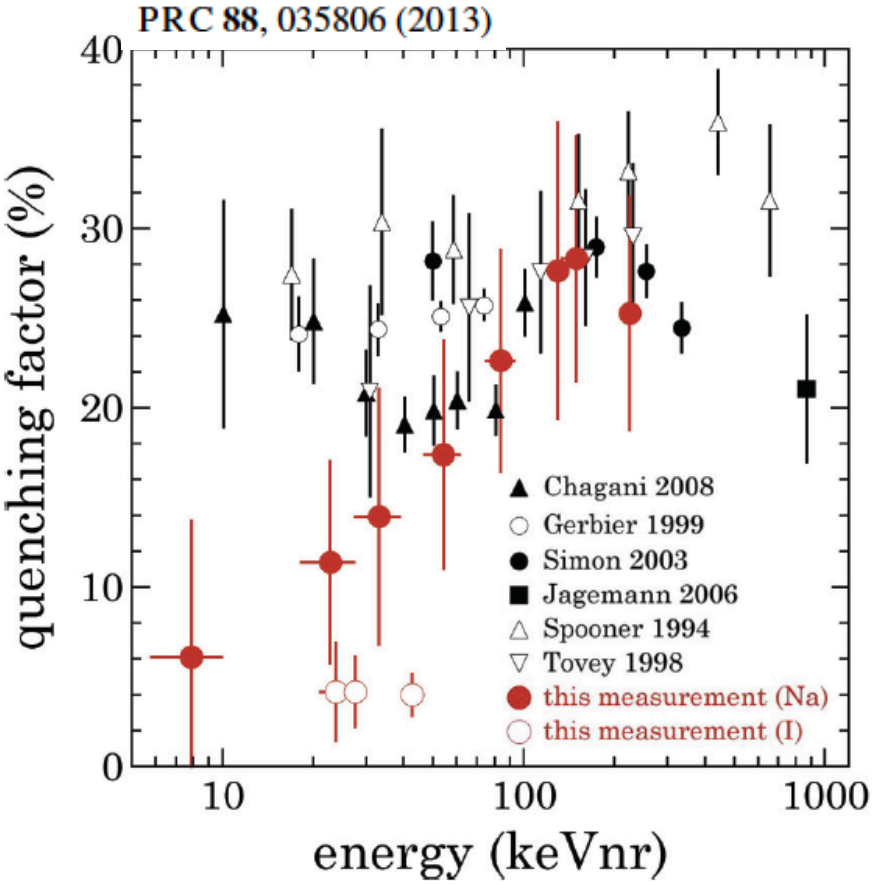
The ever-changing $\mathcal{L}_{eff}$

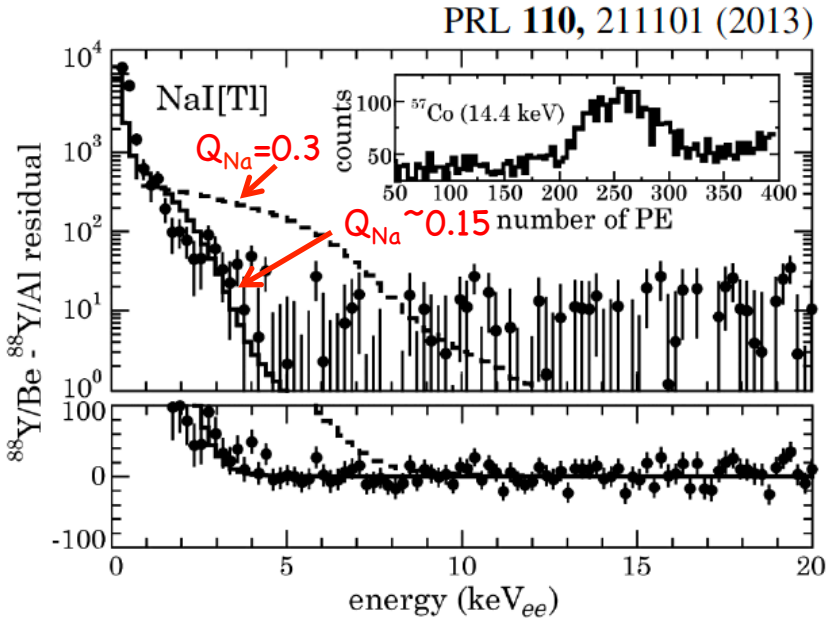
(today I'll claim it is not done mutating)



- BONUS WHEN LIT: LUX assumes that the effect of the drift field on recombination S1 is tiny. This is based exclusively on Manzur *et al.* measurements, which are completely unrealiable. ZEPLIN measures $\mathcal{L}_{eff}$ *in situ* and under drift field, finding it going to zero at few keVnr. SCENE has recently measured a very large effect of this field in LAr, expected to worsen at lower energy. SCENE to repeat measurements with LXe in Feb. 2014.

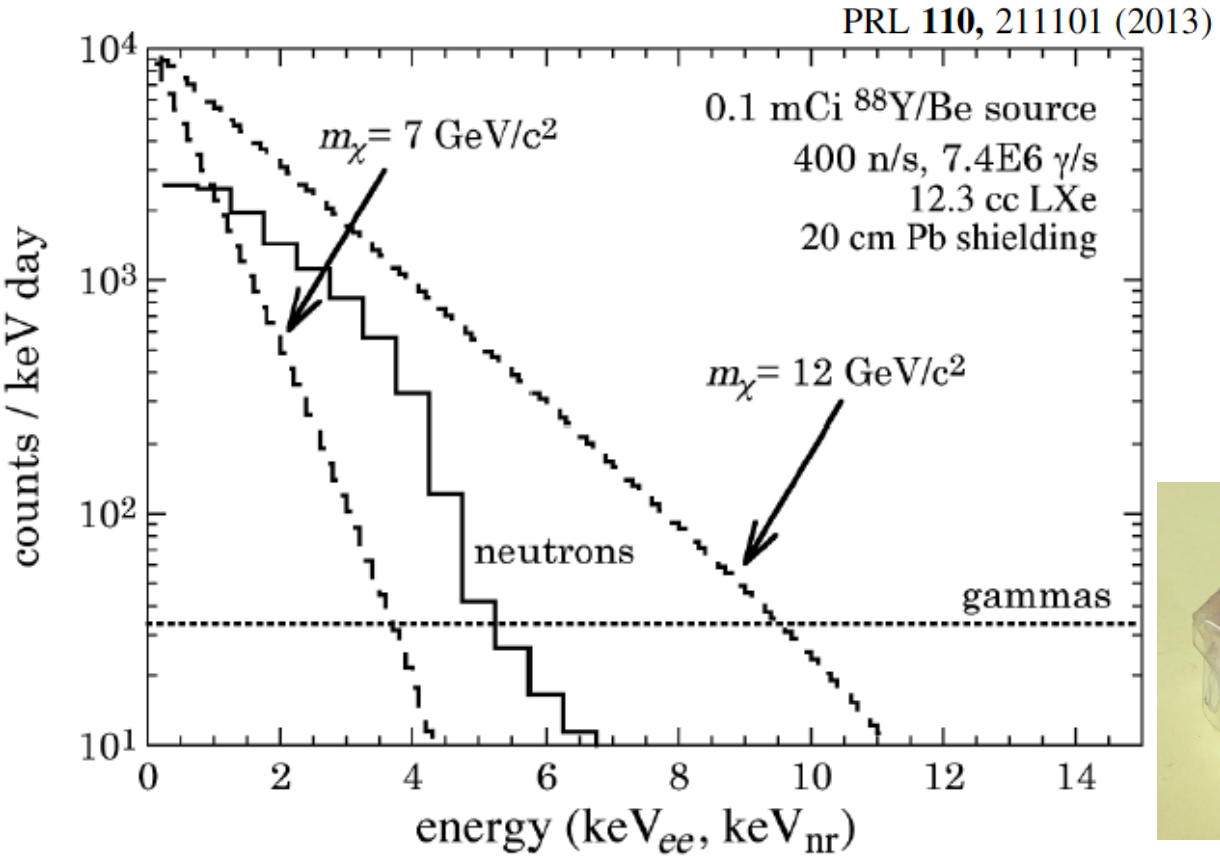
Meanwhile, in NaI[Tl] land…





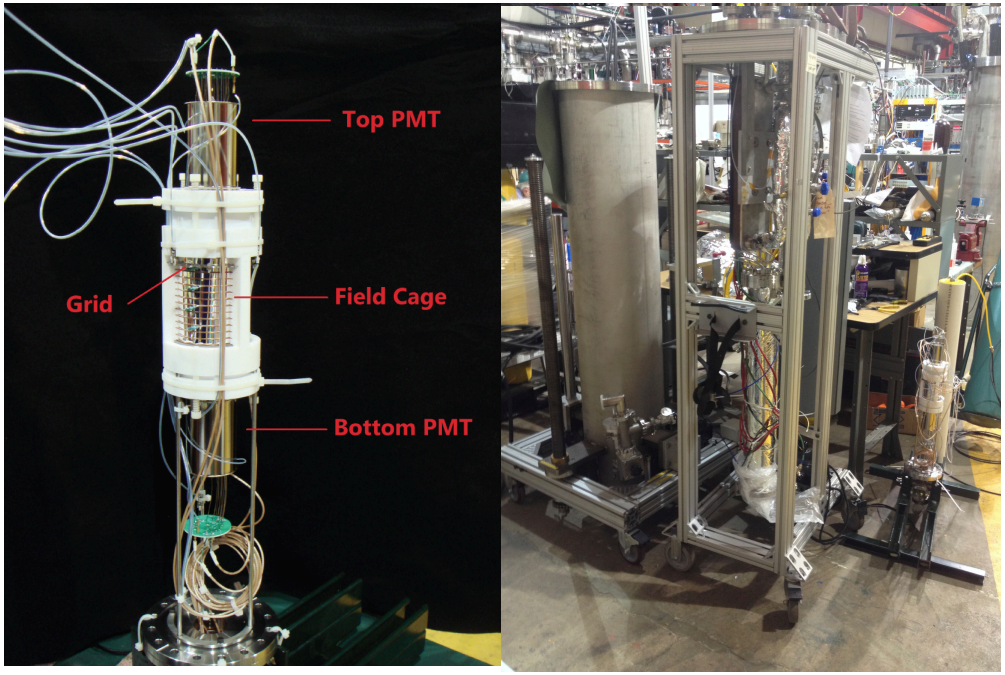
- When measured in absence of threshold effects, the low-energy quenching factor for Na recoils in NaI[Tl] is observed to go to zero at few keVnr.
- These measurements have ~4 more light yield (~4 lower threshold) than previous ones, bypassing this issue of "threshold effects".

Take it while lying down? NEVERRRR…

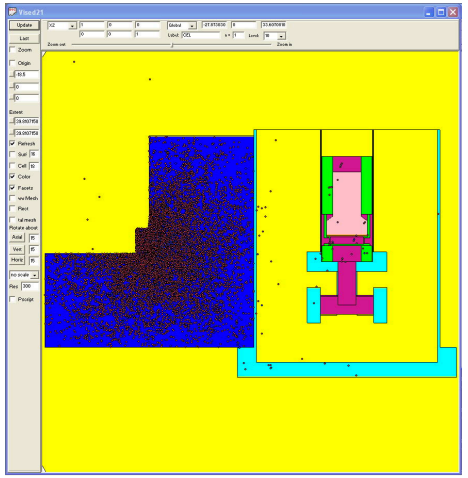


- A photoneutron Y-88/Be source emits monochromatic 152 keV neutrons, creating a recoil distribution essentially identical to that expected from a ~10 GeV WIMP.
- We have successfully used it at UC to characterize the response of NaI[Tl], C3F8, and CF3I. In the case of LXe, it probes exactly the recoil range of interest (<4.5 keVnr) to put these $\mathcal{L}_{eff}$ questions to rest.

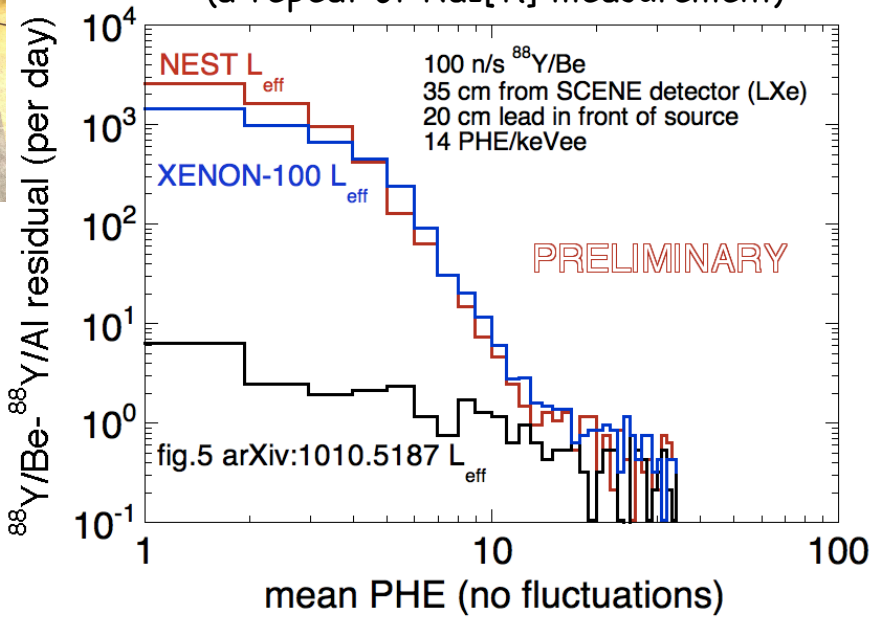
If the mountain won't come to Muhammad…



SCENE chamber at FNAL



(a repeat of NaI[Tl] measurement)

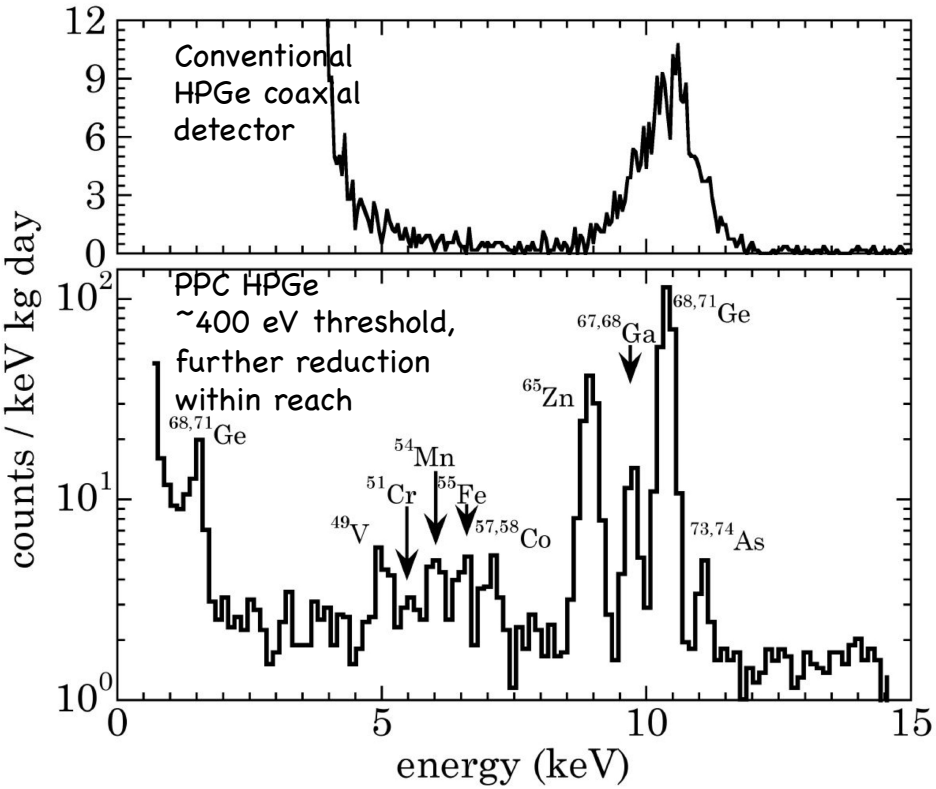


- We will be taking Y-88/Be data on LXe at FNAL by mid-December.
- We shall know who "screwed up" very soon.

(I believe you invited me to discuss something else)

A brief chronology of past CoGeNT results

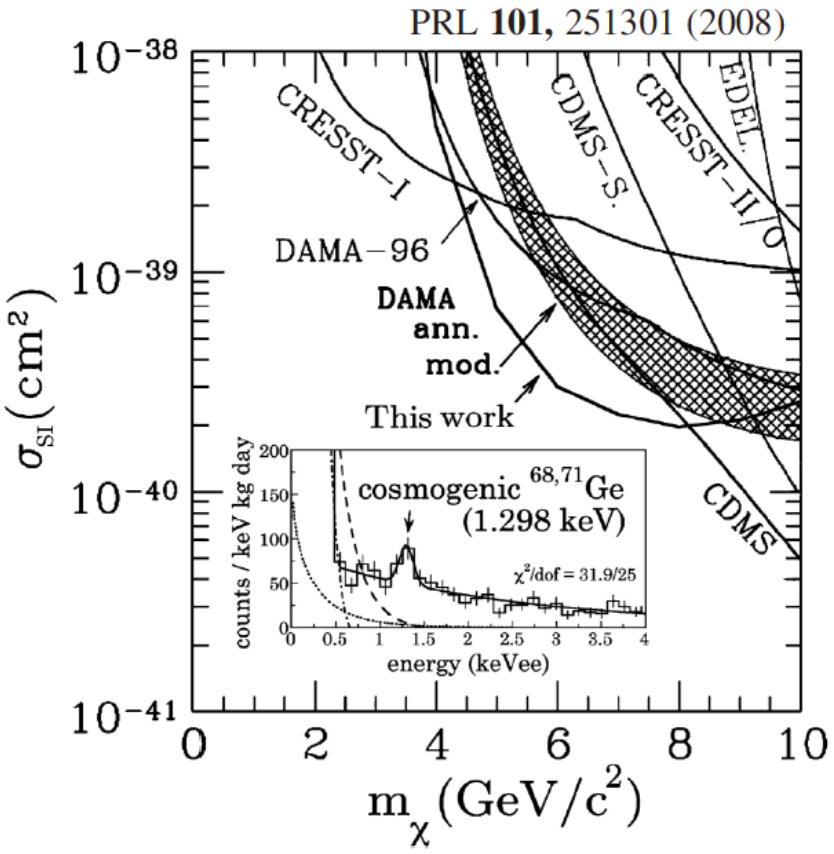
- CoGeNT employs PPCs (JCAP 09 (2007) 009) to search for low-mass WIMPs, specifically aiming to test the DAMA/LIBRA claim. PPCs offer required stability, low threshold, and rejection of surface events. At higher energies, rejection of gamma backgrounds (MAJORANA and GERDA, 0ν ββ-decay searches).



A brief chronology of past CoGeNT results

- CoGeNT employs PPCs (JCAP 09 (2007) 009) to search for low-mass WIMPs, specifically aiming to test the DAMA/LIBRA claim. PPCs offer required stability, low threshold, and rejection of surface events. At higher energies, rejection of gamma backgrounds (MAJORANA and GERDA, $0\nu\ \beta\beta$-decay searches).

- First results (PRL 101 (2008) 251301) in a shallow site eliminated the last region of WIMP parameter space allowed for DAMA/LIBRA within a standard halo model (SHM). This exclusion later confirmed by other searches (e.g., CDMS low-threshold analyses).

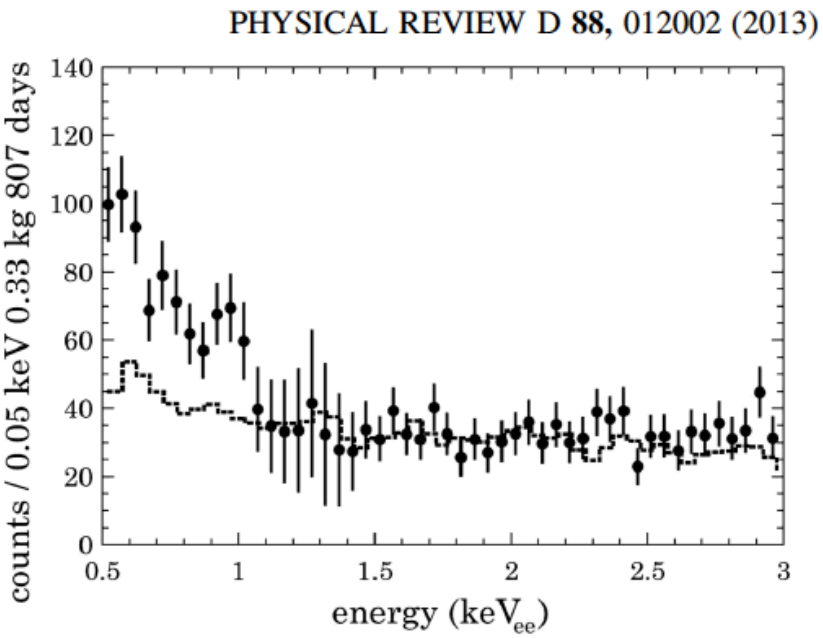


A brief chronology of past CoGeNT results

- CoGeNT employs PPCs (JCAP 09 (2007) 009) to search for low-mass WIMPs, specifically aiming to test the DAMA/LIBRA claim. PPCs offer required stability, low threshold, and rejection of surface events. At higher energies, rejection of gamma backgrounds (MAJORANA and GERDA, $0\nu\ \beta\beta$-decay searches).

- First results (PRL 101 (2008) 251301) in a shallow site eliminated the last region of WIMP parameter space allowed for DAMA/LIBRA within a standard halo model (SHM). This exclusion later confirmed by other searches (e.g., CDMS low-threshold analyses).

- Irreducible low-energy exponential excess found following surface event rejection (PRL 106 (2011) 131301). WIMP interpretation in vicinity of DAMA/LIBRA ROI. The improved rejection allowed for by larger exposure, and a best-effort at background simulation, have thus far failed to account for this excess (PRD 88 (2013) 012002).



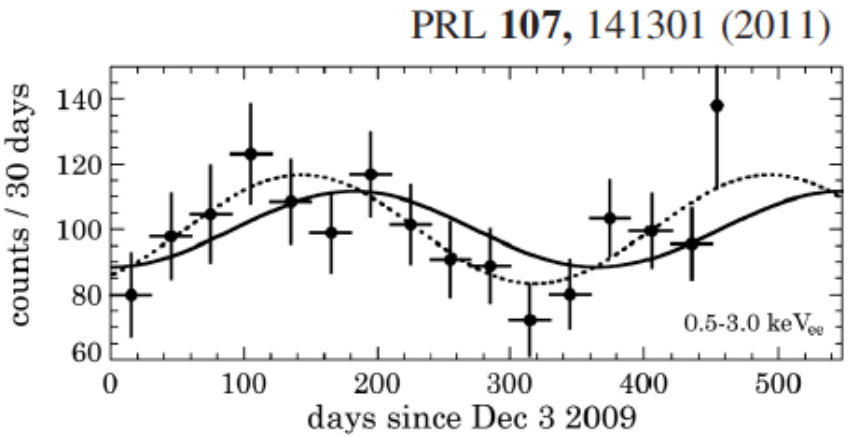
A brief chronology of past CoGeNT results

- CoGeNT employs PPCs (JCAP 09 (2007) 009) to search for low-mass WIMPs, specifically aiming to test the DAMA/LIBRA claim. PPCs offer required stability, low threshold, and rejection of surface events. At higher energies, rejection of gamma backgrounds (MAJORANA and GERDA, $0\nu\ \beta\beta$-decay searches).

- First results (PRL 101 (2008) 251301) in a shallow site eliminated the last region of WIMP parameter space allowed for DAMA/LIBRA within a standard halo model (SHM). This exclusion later confirmed by other searches (e.g., CDMS low-threshold analyses).

- Irreducible low-energy exponential excess found following surface event rejection (PRL 106 (2011) 131301). WIMP interpretation in vicinity of DAMA/LIBRA ROI. The improved rejection allowed for by larger exposure, and a best-effort at background simulation, have thus far failed to account for this excess (PRD 88 (2013) 012002). Possible very similar excess in NR band in CDMS-Ge data (Collar & Fields, arXiv:1204.3559, see also R. Nelson's talk later today).

- Run interrupted by Soudan fire: 15 mo of data exhibit low-energy modulation in bulk events, compatible with DAMA/LIBRA (PRL 107 (2011) 141301). Data-sharing allowed for independent analyses and interpretations.



A brief chronology of past CoGeNT results

- CoGeNT employs PPCs (JCAP 09 (2007) 009) to search for low-mass WIMPs, specifically aiming to test the DAMA/LIBRA claim. PPCs offer required stability, low threshold, and rejection of surface events. At higher energies, rejection of gamma backgrounds (MAJORANA and GERDA, 0ν ββ-decay searches).

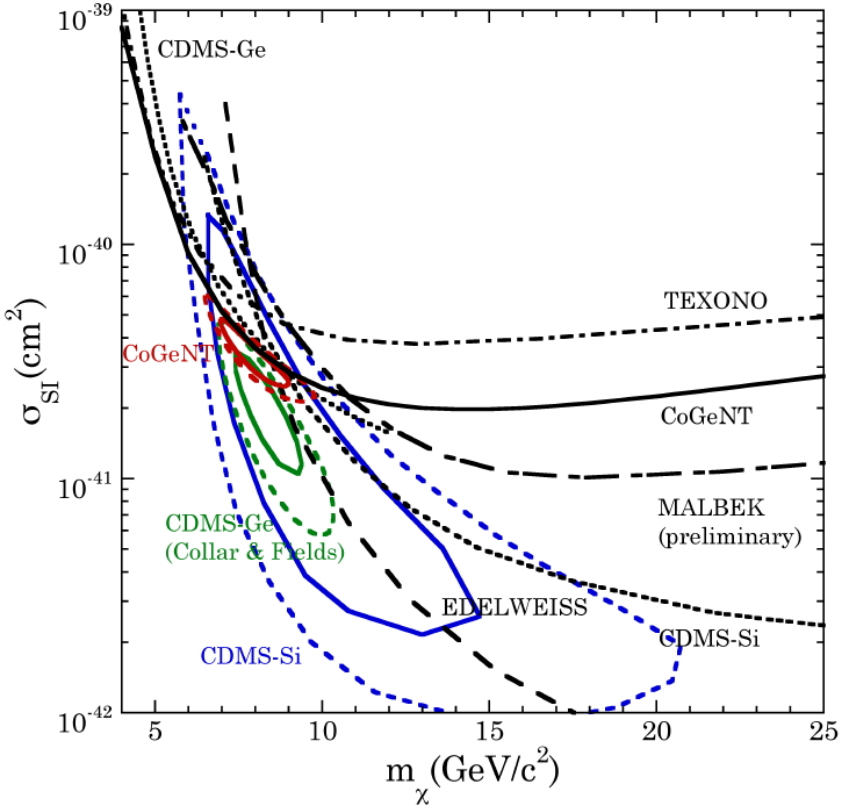
- First results (PRL 101 (2008) 251301) in a shallow site eliminated the last region of WIMP parameter space allowed for DAMA/LIBRA within a standard halo model (SHM). This exclusion later confirmed by other searches (e.g., CDMS low-threshold analyses).

- Irreducible low-energy exponential excess found following surface event rejection (PRL 106 (2011) 131301). WIMP interpretation in vicinity of DAMA/LIBRA ROI. The improved rejection allowed for by larger exposure, and a best-effort at background simulation, have thus far failed to account for this excess (PRD 88 (2013) 012002). Possible very similar excess in NR band in CDMS-Ge data (Collar & Fields, arXiv:1204.3559, see also R. Nelson's talk later today).

- Run interrupted by Soudan fire: 15 mo of data exhibit low-energy modulation in bulk events, compatible with DAMA/LIBRA (PRL 107 (2011) 141301). Data-sharing allowed for independent analyses and interpretations.

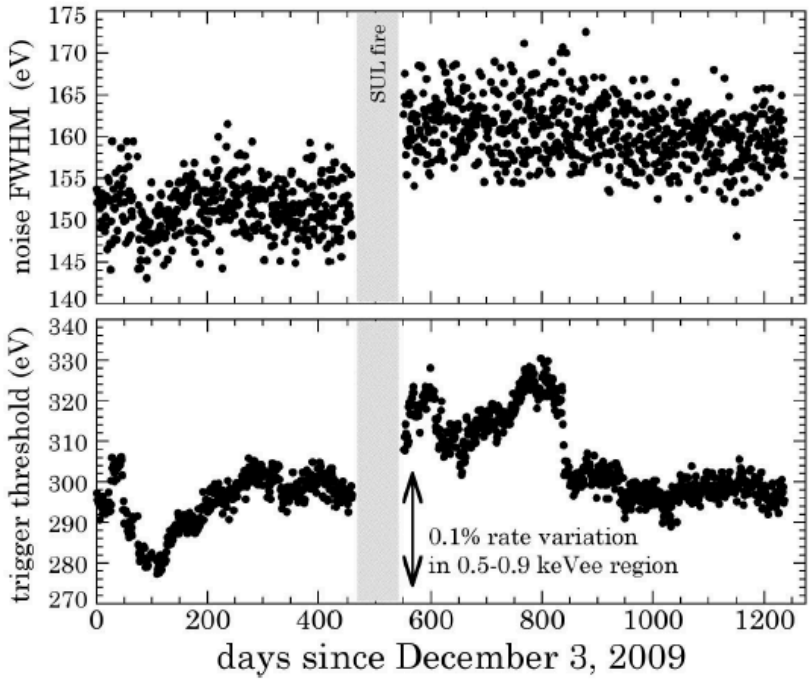
- Much ensuing action: CRESST and CDMS-Si anomalies, XENON exclusions (and criticisms thereof), etc. TBD.

Ge-Si detector landscape (just part of the story)



What is new?

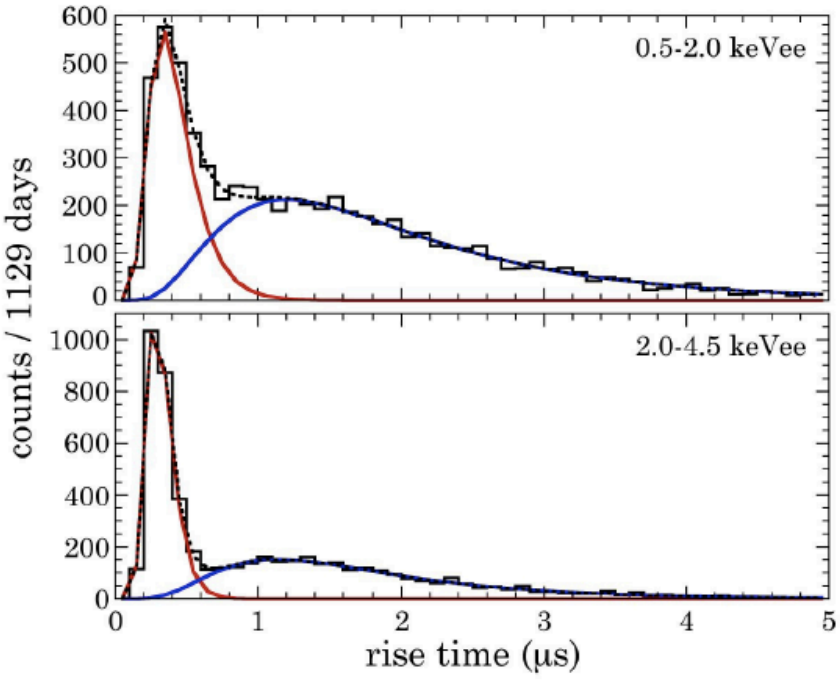
- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been continuously taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).



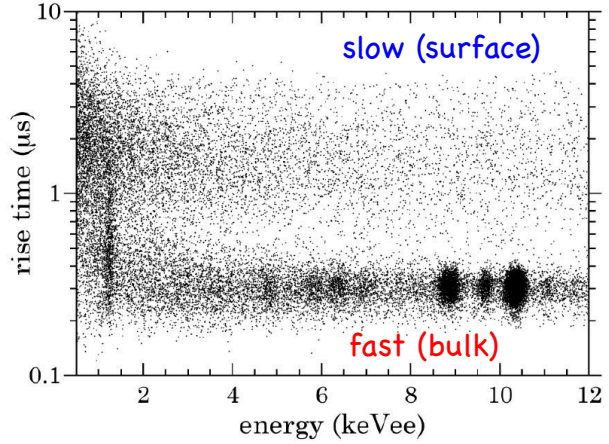
What is new?

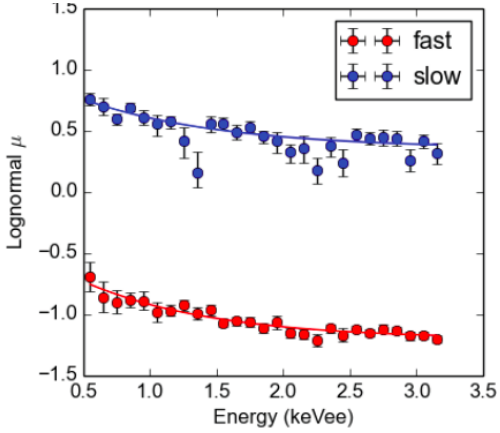
- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been continuously taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).

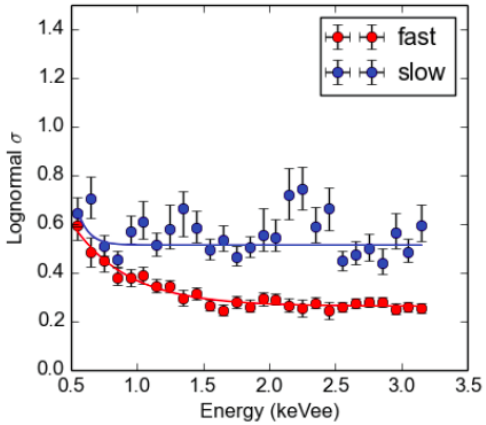
- Large exposure allows optimal separation of bulk and surface events down to 0.5 keVee threshold. Rise-time behavior as predicted by simulations and calibrations (PRD 88 (2013) 012002). Smooth variation of fit parameters with energy.



Regions selected for "toy" analysis







M. Bellis et al., in preparation.

See also poster by M. Kos.

What is new?

- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been continuously taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).

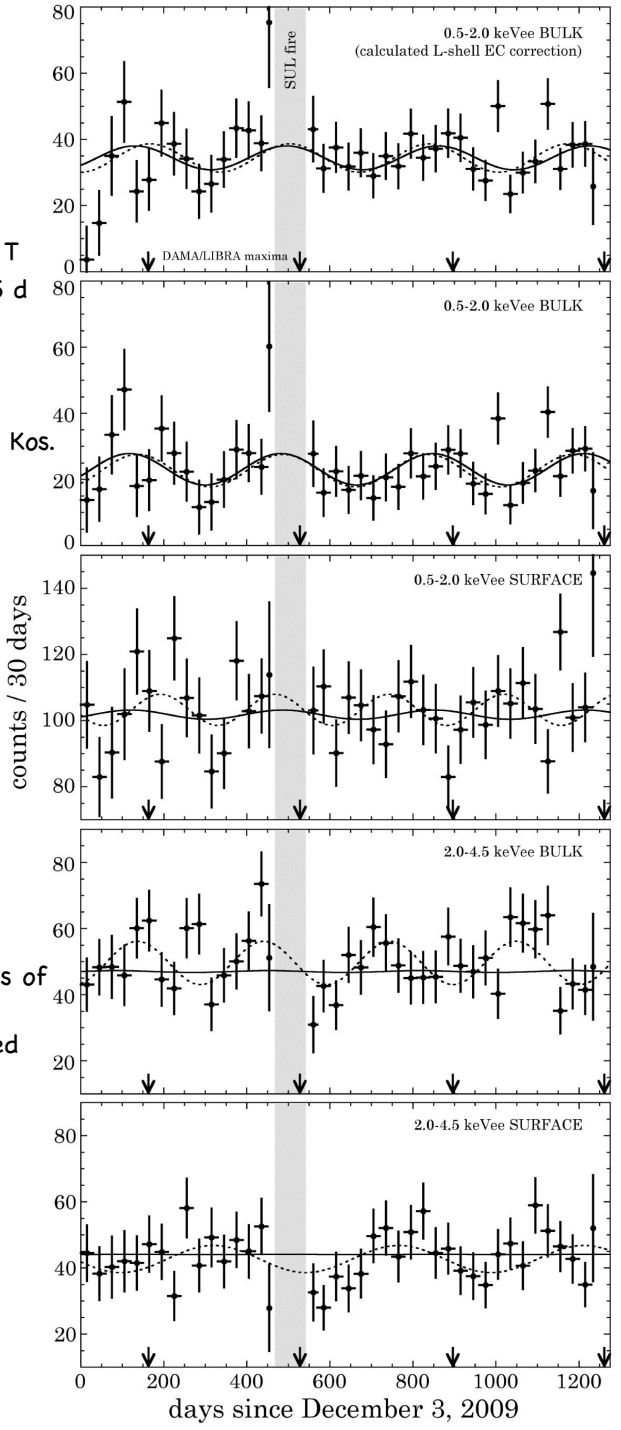
- Large exposure allows optimal separation of bulk and surface events down to 0.5 keVee threshold. Rise-time behavior as predicted by simulations and calibrations (PRD 88 (2013) 012002). Smooth variation of fit parameters with energy.

- Paper under review, preprint to appear soon. Data to be released in energy, time-stamp, and rise-time format. A straightforward analysis indicates a persistent annual modulation exclusively at low energy and for bulk events. Best-fit phase consistent with DAMA/LIBRA (small offset may be meaningful). Similar best-fit parameters to 15 mo dataset, but with much better bulk/surface separation (~90% SA for~90% BR)

Dotted: free T
Solid: T= 365 d

See also poster by M. Kos.

Additional eight months of unanalyzed data acquired (run is still ongoing)



What is new?

- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been <u>continuously</u> taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).

- Large exposure allows optimal separation of bulk and surface events down to 0.5 keVee threshold. Rise-time behavior as predicted by simulations and calibrations (PRD 88 (2013) 012002). Smooth variation of fit parameters with energy.

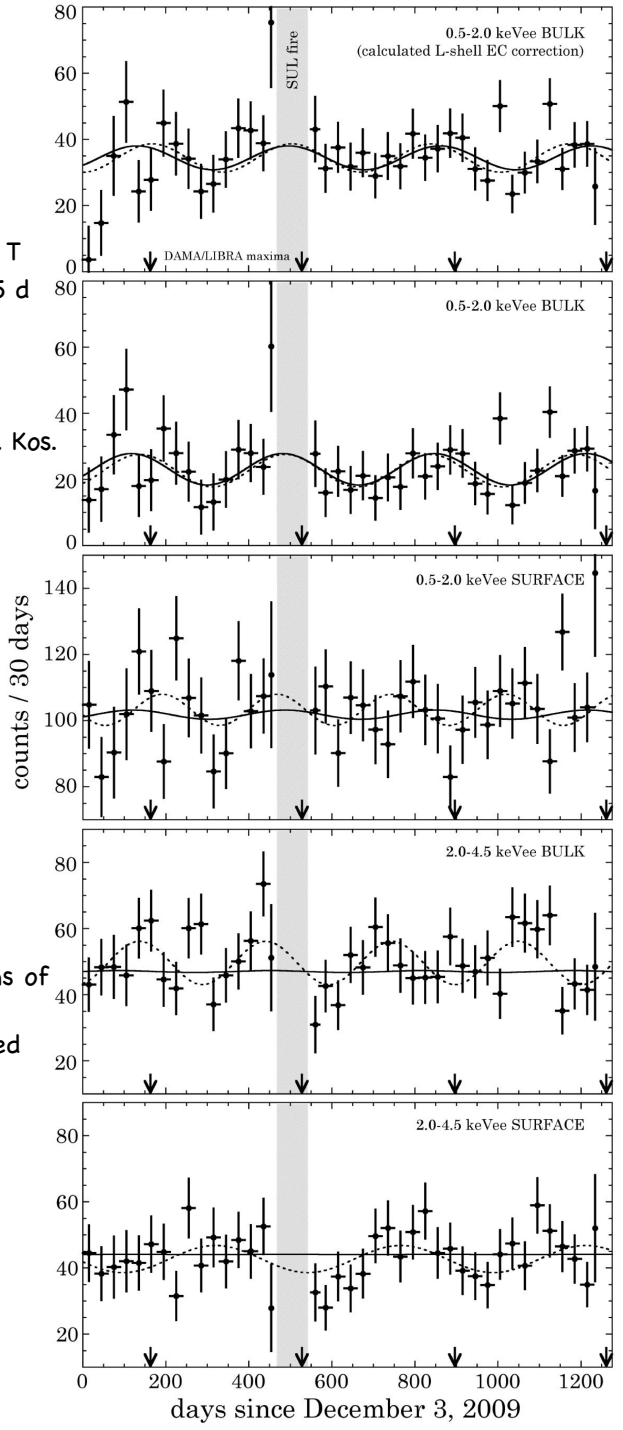
- Paper under review, preprint to appear soon. <u>Data to be released in energy, time-stamp, and rise-time format.</u> A straightforward analysis indicates a persistent annual modulation exclusively at low energy and for bulk events. Best-fit phase consistent with DAMA/LIBRA (small offset may be meaningful). Similar best-fit parameters to 15 mo dataset, but with much better bulk/surface separation (~90% SA for~90% BR)

- Unoptimized frequentist analysis yields ~2.2σ preference over null hypothesis. This however does not take into account the possible relevance of the modulation amplitude found...

Dotted: free T
Solid: T= 365 d

See also poster by M. Kos.

Additional eight months of unanalyzed data acquired (run is still ongoing)



What is new?

- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been <u>continuously</u> taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).

- Large exposure allows optimal separation of bulk and surface events down to 0.5 keVee threshold. Rise-time behavior as predicted by simulations and calibrations (PRD 88 (2013) 012002). Smooth variation of fit parameters with energy.

- Paper under review, preprint to appear soon. <u>Data to be released in energy, time-stamp, and rise-time format.</u> A straightforward analysis indicates a persistent annual modulation exclusively at low energy and for bulk events. Best-fit phase consistent with DAMA/LIBRA (small offset may be meaningful). Similar best-fit parameters to 15 mo dataset, but with much better bulk/surface separation (~90% SA for~90% BR)

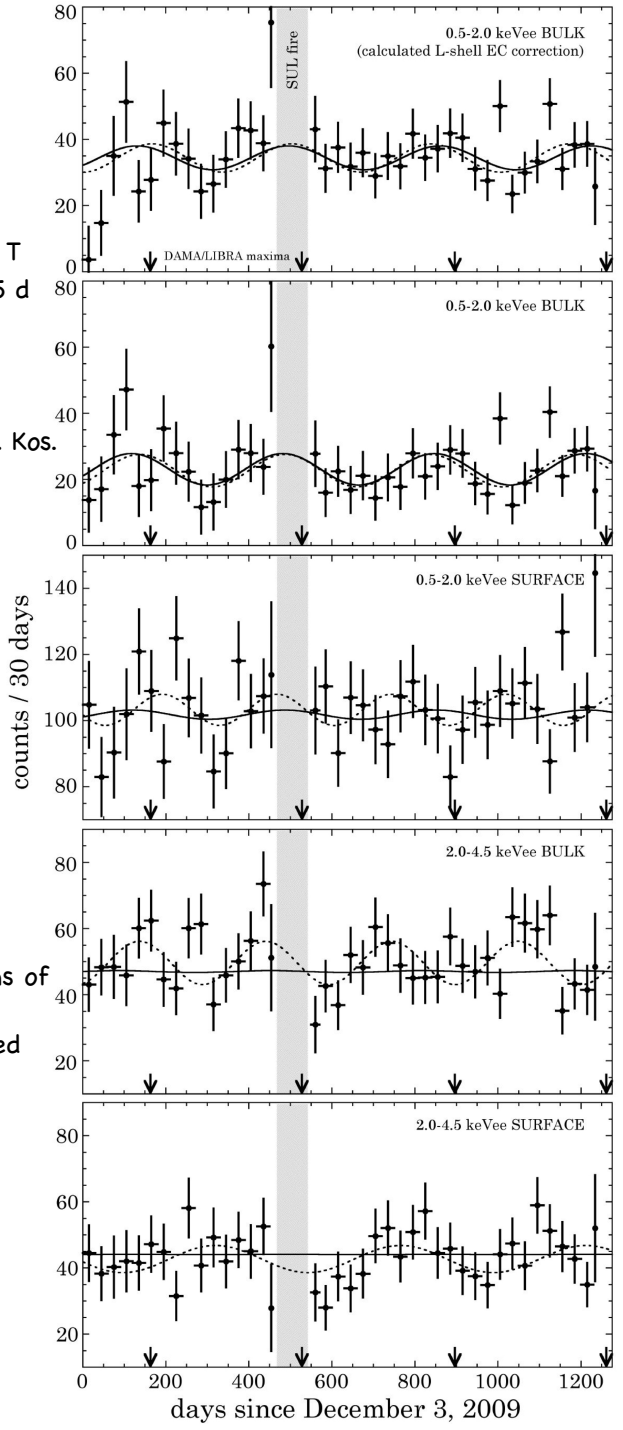
- Unoptimized frequentist analysis yields ~2.2σ preference over null hypothesis. This however does not take into account the possible relevance of the modulation amplitude found...

- Modulation amplitude is 4-7 times larger than that predicted by the SHM. Finding an absence of modulation would have severely constrained non-standard halo models as explanations for DAMA/LIBRA.

Dotted: free T
Solid: T= 365 d

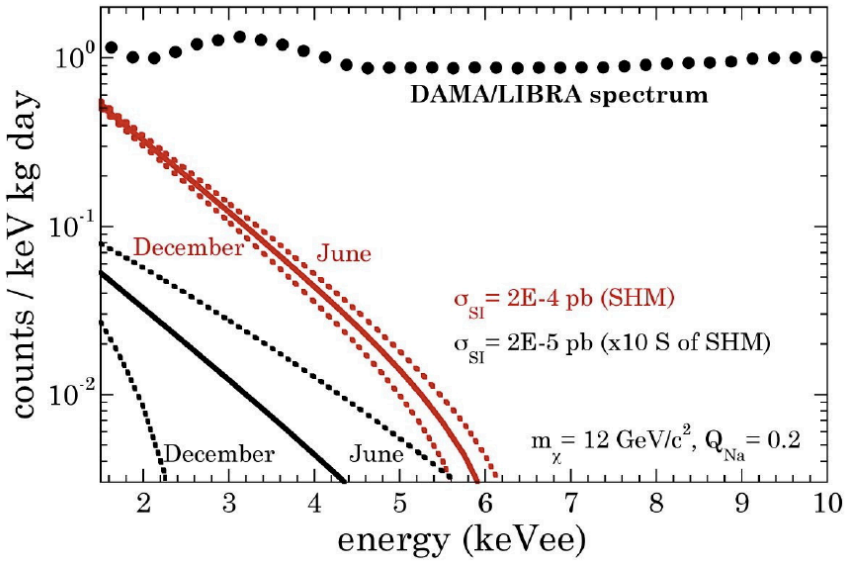
See also poster by M. Kos.

Additional eight months of unanalyzed data acquired (run is still ongoing)



What to make out of this?

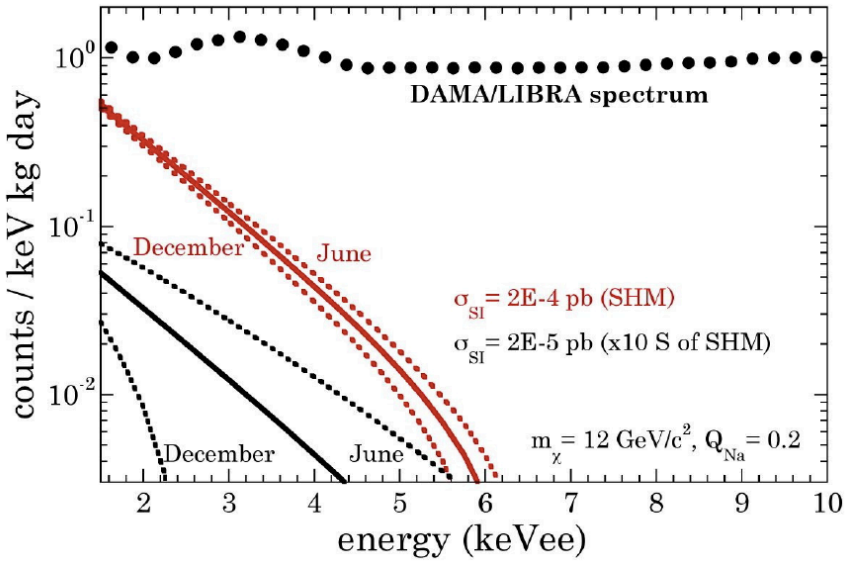
- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.



Rough sketch: two WIMPs inducing the same DAMA/LIBRA observable (absolute modulation), but having a different fractional modulation. A SHM cannot induce the large modulation case.

What to make out of this?

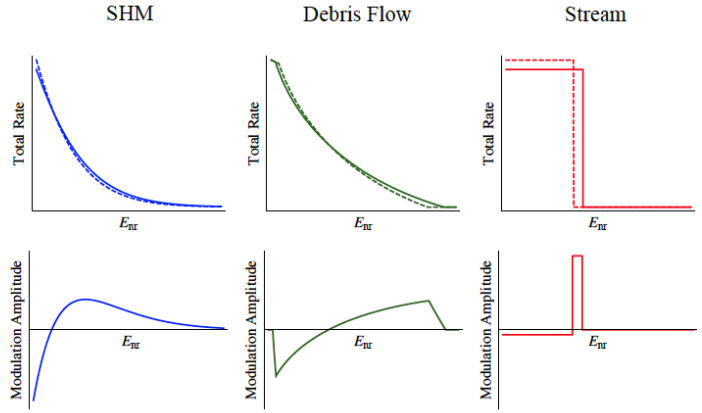
- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.



Rough sketch: two WIMPs inducing the same DAMA/LIBRA observable (absolute modulation), but having a different fractional modulation. A SHM cannot induce the large modulation case.

What to make out of this?

- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.

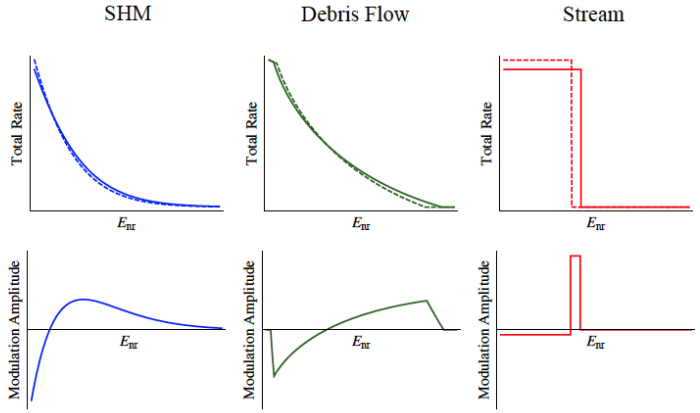


e.g., arXiv:1209.3339

FIG. 3: A comparison of the shapes of the total rate shown at two periods of the year, corresponding to the times of year at which the rate is minimized and maximized, as well as the modulation amplitude, for three different halo components: SHM (left), debris flow (middle), stream (right). The normalization between panels is arbitrary.

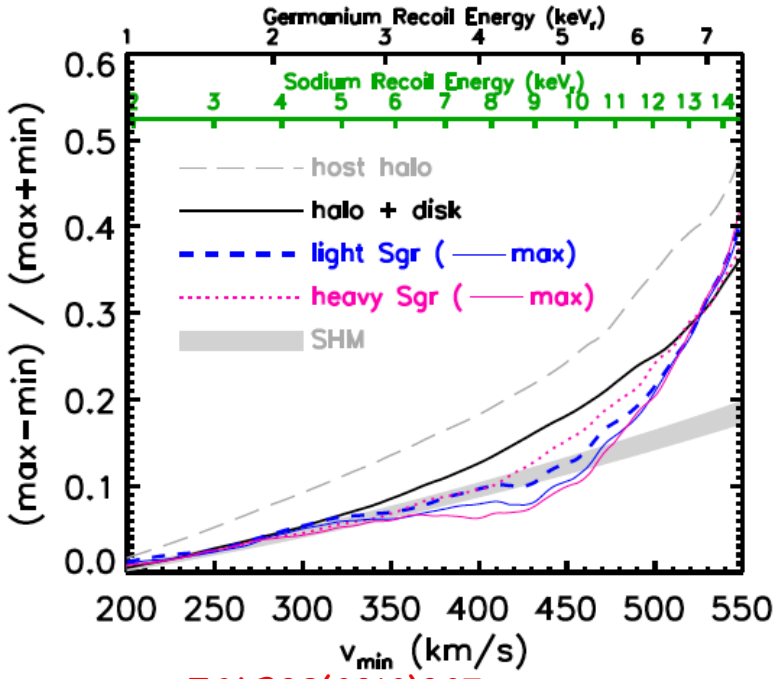
What to make out of this?

- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.
- A large modulation in WIMP rate can arise naturally in many non-SHM, and in particular for large values of v_{min}, like those probed for m_χ~10 GeV (and small Q_{Na}).



e.g., arXiv:1209.3339

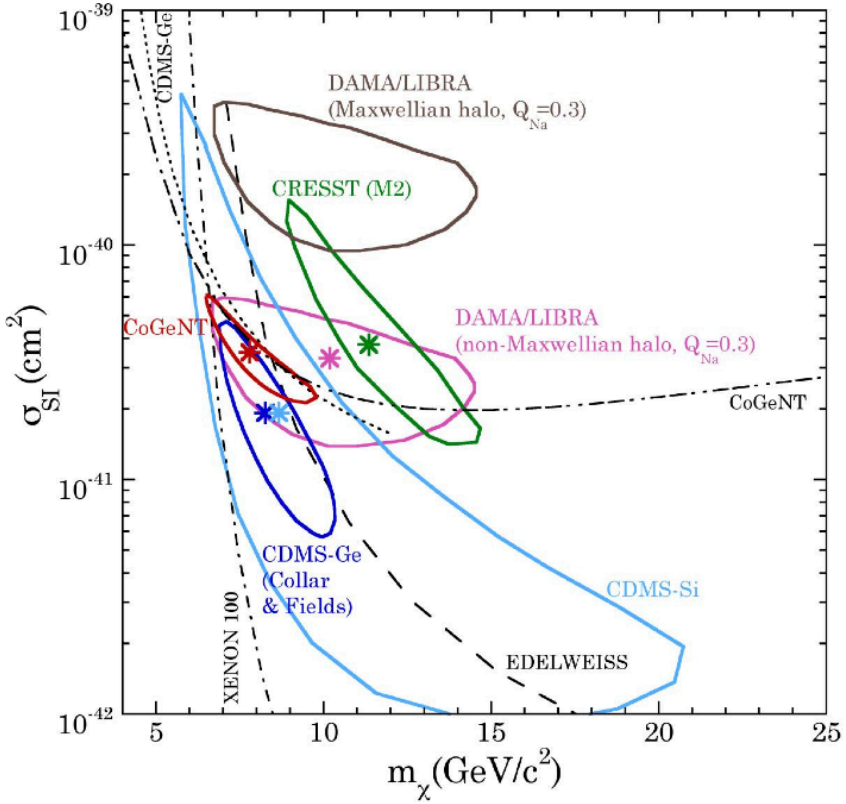
FIG. 3: A comparison of the shapes of the total rate shown at two periods of the year, corresponding to the times of year at which the rate is minimized and maximized, as well as the modulation amplitude, for three different halo components: SHM (left), debris flow (middle), stream (right). The normalization between panels is arbitrary.



e.g., JCAP08(2012)027, arXiv:1111.0292, arXiv:1111.0292...

What to make out of this?

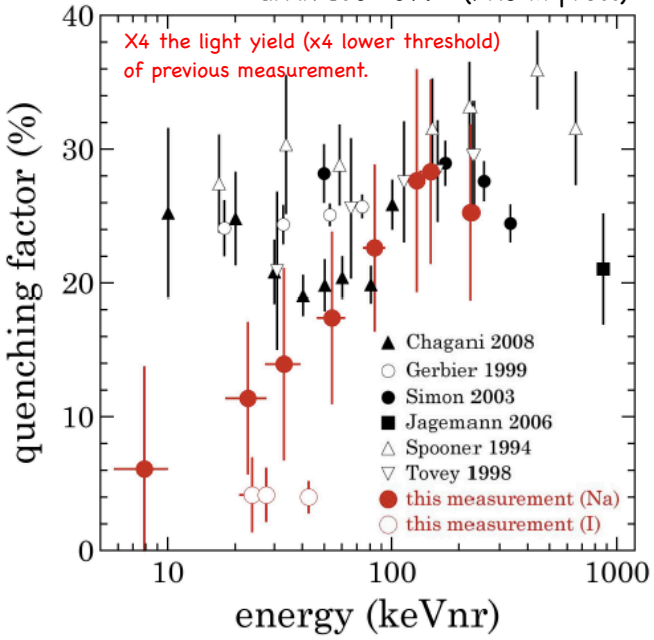
- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.
- A large modulation in WIMP rate can arise naturally in many non-SHM, and in particular for large values of v_{min}, like those probed for m_χ~10 GeV (and small Q_{Na}).
- A large fractional modulation for DAMA/LIBRA, corresponding to that found in CoGeNT data, brings it into agreement with other anomalies (CoGeNT, CDMS-Si, and CRESST if slightly underestimating bckgs)



What to make out of this?

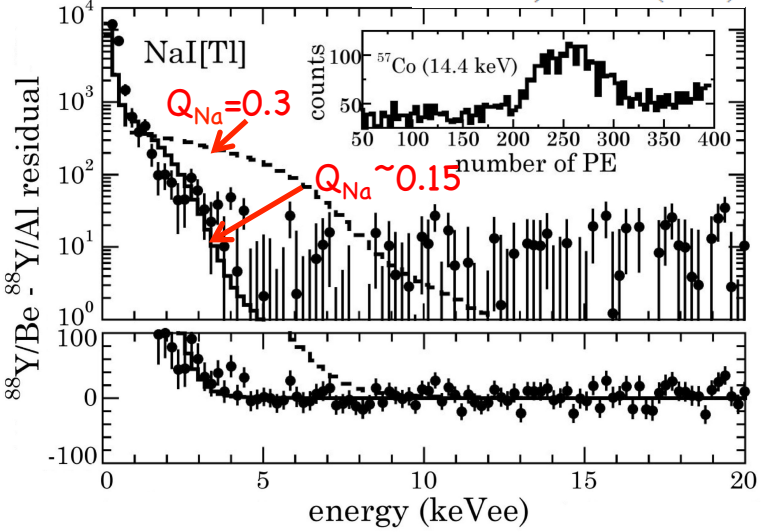
- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.
- A large modulation in WIMP rate can arise naturally in many non-SHM, and in particular for large values of v_{min}, like those probed for m_χ~10 GeV (and small Q_{Na}).
- A large fractional modulation for DAMA/LIBRA, corresponding to that found in CoGeNT data, brings it into agreement with other anomalies (CoGeNT, CDMS-Si, and CRESST if slightly underestimating bckgs)
- However, this statement ignores the 800 lb gorilla in the room: Q_{Na} is not well-established (whereas CoGeNT's Q_{Ge} is solid, see JCAP 09 (2007) 009).

arXiv:1302.0796 (PRC in press)



Full disclosure: I am the author of these two measurements, but was hoping to find Q_{Na}~0.4... (see arguments in PRD 82 (2010) 123509)

PRL **110,** 211101 (2013)

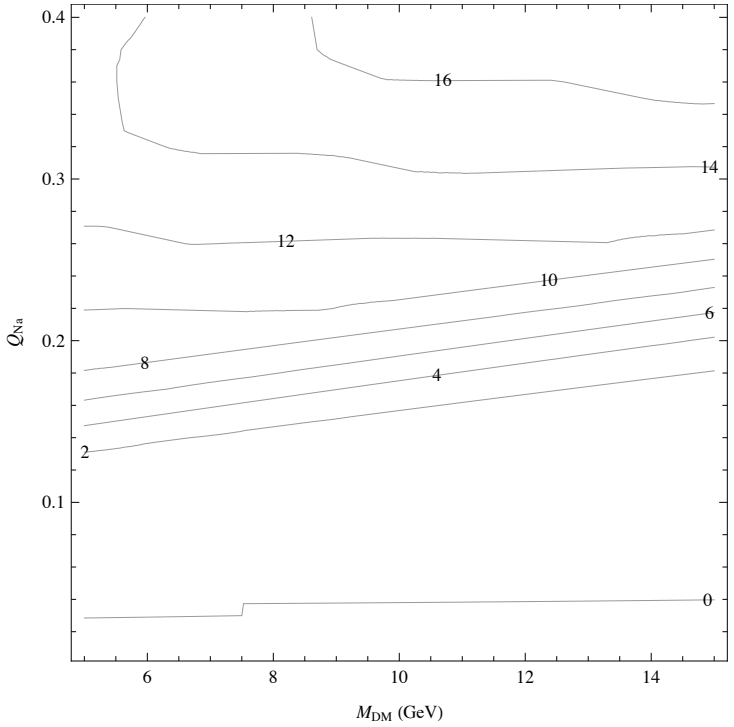


What to make out of this?

- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.
- A large modulation in WIMP rate can arise naturally in many non-SHM, and in particular for large values of v_{min}, like those probed for m_χ~10 GeV (and small Q_{Na}).
- A large fractional modulation for DAMA/LIBRA, corresponding to that found in CoGeNT data, brings it into agreement with other anomalies (CoGeNT, CDMS-Si, and CRESST if slightly underestimating bckgs)
- However, this statement ignores the 800 lb gorilla in the room: Q_{Na} is not well-established (whereas CoGeNT's Q_{Ge} is solid, see JCAP 09 (2007) 009).
- Recent efforts to isolate astrophysical (halo) uncertainties (e.g., PRD 83 (2011) 103514) are the best way to examine this complex situation.

Expected modulation amplitude in CoGeNT (upper limit) as a function of Q_{Na} and WIMP mass, taking DAMA/LIBRA as the input, and removing astrophysical uncertainties. Units are the same as in CoGeNT (counts/30d) plot a few transparencies above.

Plot by Chris Kelso, using the halo-independent formalism by P. Fox *et al.* (PRD 83 (2011) 103514, see also PRD 85 (2012) 043515).

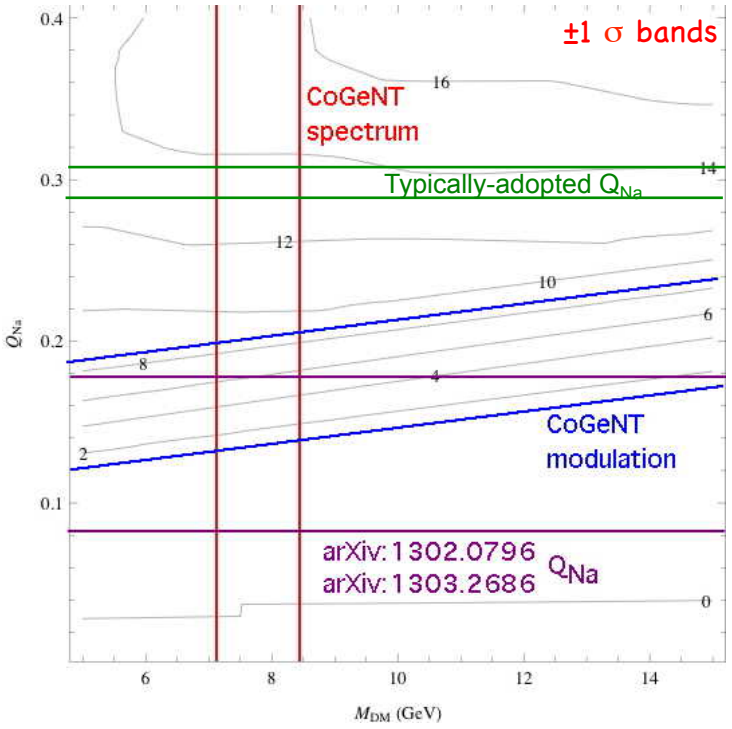


What to make out of this?

- Most (uneducated) statements about the incompatibility of DAMA/LIBRA with other current anomalies forget to notice the underlaying assumption of a SHM.
- The truth is, DAMA/LIBRA shows no obvious spectral excess, and therefore we cannot know the magnitude of a possible **fractional** modulation in WIMP rate. CoGeNT provides both spectral and modulation information, removing this source of uncertainty.
- Most recent work in halo simulations indicates that finding a SHM (specifically a pure Maxwellian distribution at large v) would be the surprise.
- A large modulation in WIMP rate can arise naturally in many non-SHM, and in particular for large values of v_{min}, like those probed for m_χ~10 GeV (and small Q_{Na}).
- A large fractional modulation for DAMA/LIBRA, corresponding to that found in CoGeNT data, brings it into agreement with other anomalies (CoGeNT, CDMS-Si, and CRESST if slightly underestimating bckgs)
- However, this statement ignores the 800 lb gorilla in the room: Q_{Na} is not well-established (whereas CoGeNT's Q_{Ge} is solid, see JCAP 09 (2007) 009).
- Recent efforts to isolate astrophysical (halo) uncertainties (e.g., PRD 83 (2011) 103514) are the best way to examine this complex situation.
- The actual few-keVnr value of Q_{Na} will be keystone in determining if DAMA/LIBRA is in agreement with all other low-energy anomalies, or broadly excluded for any WIMP halo model.

Expected modulation amplitude in CoGeNT (upper limit) as a function of Q_{Na} and WIMP mass, taking DAMA/LIBRA as the input, and removing astrophysical uncertainties. Units are the same as in CoGeNT (counts/30d) plot a few transparencies above.

Plot by Chris Kelso, using the halo-independent formalism by P. Fox *et al.* (PRD 83 (2011) 103514, see also PRD 85 (2012) 043515).



If Q_{Na} is the standard ~0.3, then move on, there is nothing to see here...

A few personal impressions:

- If Q_{Na} for 2-6 keVee in NaI[Tl] is the usual ~0.3, then DAMA/LIBRA and CoGeNT's observations most probably have nothing to do with each other, not within a WIMP context. It would then seem possible to constraint non-SHM scenarios for DAMA, using CoGeNT data.

A few personal impressions:

- If Q_{Na} for 2-6 keVee in NaI[Tl] is the usual ~0.3, then DAMA/LIBRA and CoGeNT's observations most probably have nothing to do with each other, not within a WIMP context. It would then seem possible to constraint non-SHM scenarios for DAMA, using CoGeNT data.

- If on the other hand this Q_{Na} is ~0.15, then four independent pieces of information may be in agreement: CoGeNT's spectral shape, its modulation, DAMA's modulation, and Q_{Na} (recall, no spectral WIMP info from DAMA). Agreement between all present DM anomalies is an enticing possible outcome.

A few personal impressions:

- If Q_{Na} for 2-6 keVee in NaI[Tl] is the usual ~0.3, then DAMA/LIBRA and CoGeNT's observations most probably have nothing to do with each other, not within a WIMP context. It would then seem possible to constraint non-SHM scenarios for DAMA, using CoGeNT data.

- If on the other hand this Q_{Na} is ~0.15, then four independent pieces of information may be in agreement: CoGeNT's spectral shape, its modulation, DAMA's modulation, and Q_{Na} (recall, no spectral WIMP info from DAMA). Agreement between all present DM anomalies is an enticing possible outcome.

- Clearly, additional measurements of Q_{Na} are in order.

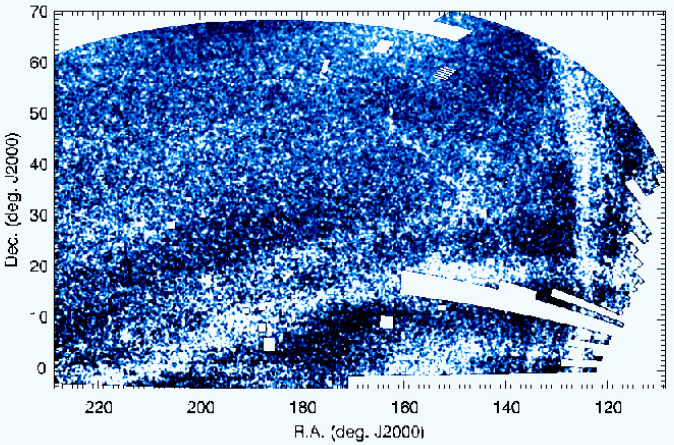
A few personal impressions:

- If Q_{Na} for 2-6 keVee in NaI[Tl] is the usual ~0.3, then DAMA/LIBRA and CoGeNT's observations most probably have nothing to do with each other, not within a WIMP context. It would then seem possible to constraint non-SHM scenarios for DAMA, using CoGeNT data.

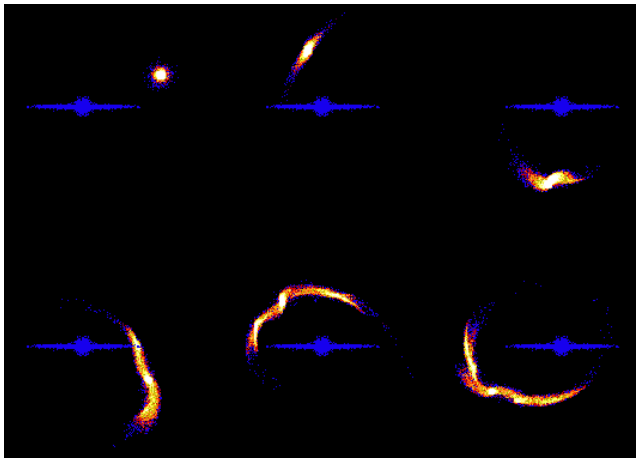
- If on the other hand this Q_{Na} is ~0.15, then four independent pieces of information may be in agreement: CoGeNT's spectral shape, its modulation, DAMA's modulation, and Q_{Na} (recall, no spectral WIMP info from DAMA). Agreement between all present DM anomalies is an enticing possible outcome.

- Clearly, additional measurements of Q_{Na} are in order.

- It seems feasible to attempt an early exercise in "WIMP astronomy" using existing CoGeNT data, i.e., reverse-engineer the halo properties that would give rise to the observed modulation. We are attempting this, in collaboration with M. Bellis and C. Kelso. These predictions could be tested by GAIA satellite observations very soon.



SLOAN star-count map
showing Milky Way tidal streams



A few personal impressions:

- If Q_{Na} for 2-6 keVee in NaI[Tl] is the usual ~0.3, then DAMA/LIBRA and CoGeNT's observations most probably have nothing to do with each other, not within a WIMP context. It would then seem possible to constraint non-SHM scenarios for DAMA, using CoGeNT data.

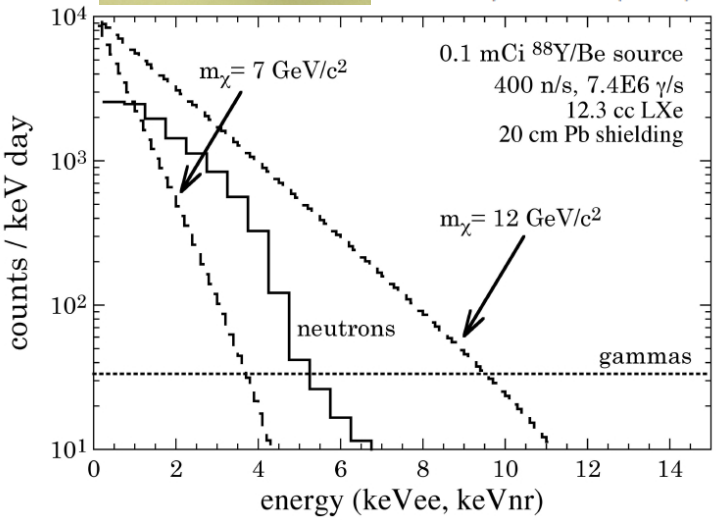
- If on the other hand this Q_{Na} is ~0.15, then four independent pieces of information may be in agreement: CoGeNT's spectral shape, its modulation, DAMA's modulation, and Q_{Na} (recall, no spectral WIMP info from DAMA). Agreement between all present DM anomalies is an enticing possible outcome.

- Clearly, additional measurements of Q_{Na} are in order.

- It seems feasible to attempt an early exercise in "WIMP astronomy" using existing CoGeNT data, i.e., reverse-engineer the halo properties that would give rise to the observed modulation. We are attempting this, in collaboration with M. Bellis and C. Kelso. These predictions could be tested by GAIA satellite observations very soon.

- We should not be left forever wondering about XENON-100 excluding this low-mass ROI or not: *in situ* calibrations with the Y/Be source described in PRL 110 (2013) 211101 should settle this issue, once for all. LUX and XMASS results should also cast light (both feature significantly lower thresholds).

PRL **110,** 211101 (2013)



Standing challenge to XENON-100:
we hear they will gallantly take it up.

(choose your own exiting quote here)

- "In so far as a scientific statement speaks about reality, it must be falsifiable; and in so far as it is not falsifiable, it does not speak about reality". K. Popper

- "Everything should be made as simple as possible, but not simpler". A. Einstein

(choose your own exiting quote here)

- "In so far as a scientific statement speaks about reality, it must be falsifiable; and in so far as it is not falsifiable, it does not speak about reality". K. Popper

- "Everything should be made as simple as possible, but not simpler". A. Einstein

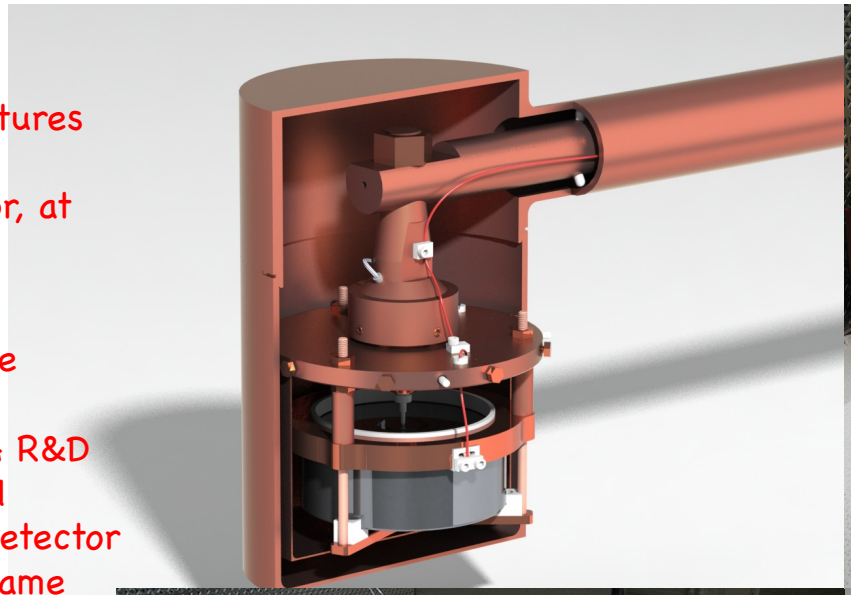
(We have not even opened the particle physics can-of-worms today. However, old grandpa Al is very disappointed at you, if you were really expecting the spherical cow)

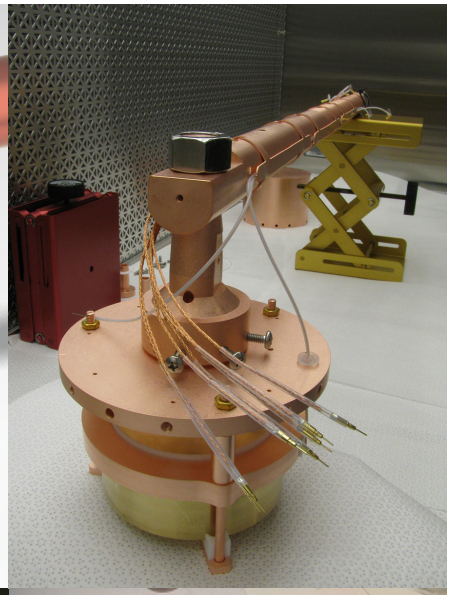
C-4: coming up very soon

* First C-4 detector features ~1/3 of the noise of the existing GoGeNT detector, at ~x3 its mass (1.3 kg)

* Not a one-off: its noise characteristics are now reproducible (CANBERRA R&D supported by NSF award PHY-1003940). Second detector expected to reach the same noise figure at 2.7 kg, the realistic PPC maximum.

* C-4 aims at a x10 total mass increase, ~x20 background decrease, and substantial threshold reduction. Soudan is our laboratory of choice, assuming its continuity.





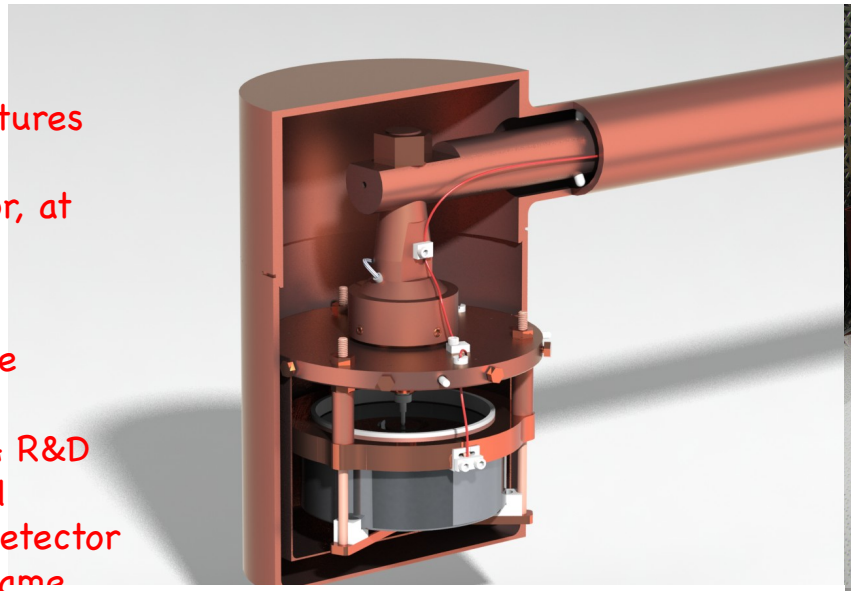
Design and assembly of ULB cryostat at PNNL

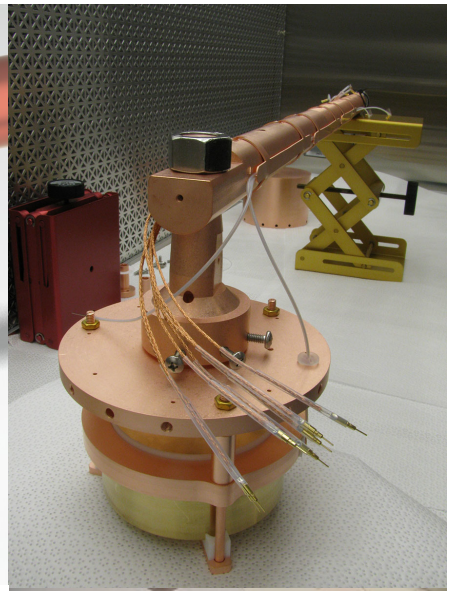
C-4: coming up very soon

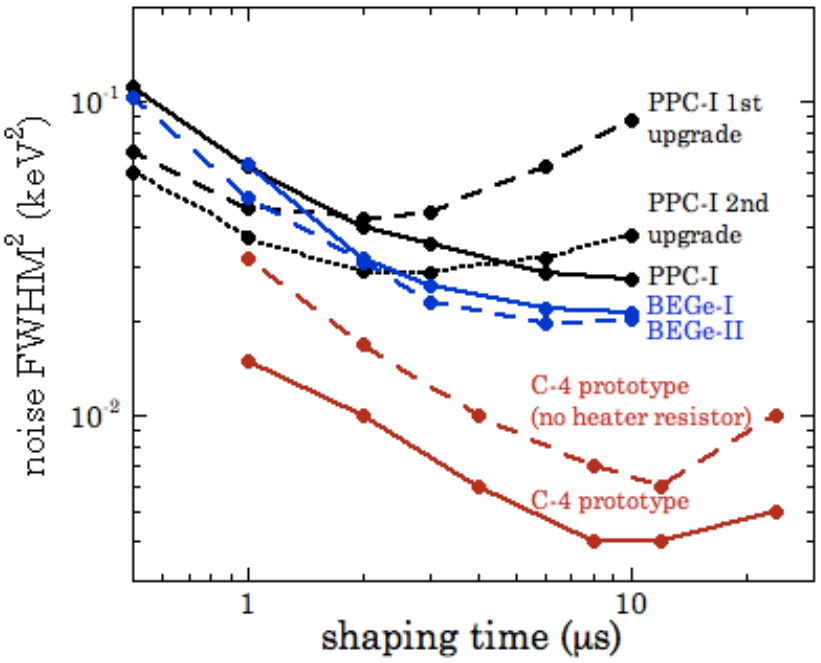
* First C-4 detector features ~1/3 of the noise of the existing GoGeNT detector, at ~x3 its mass (1.3 kg)

* Not a one-off: its noise characteristics are now reproducible (CANBERRA R&D supported by NSF award PHY-1003940). Second detector expected to reach the same noise figure at 2.7 kg, the realistic PPC maximum.

* C-4 aims at a x10 total increase, ~x20 backgrou decrease, and substantial threshold reduction. Sou our laboratory of choice, assuming its continuity.



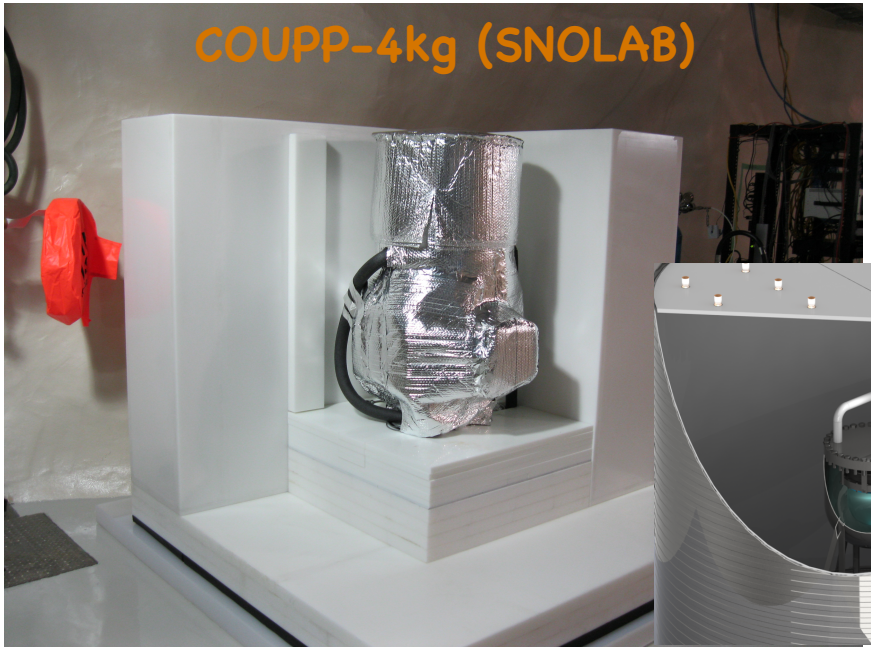




CANBERRA's proprietary modifications to point contact

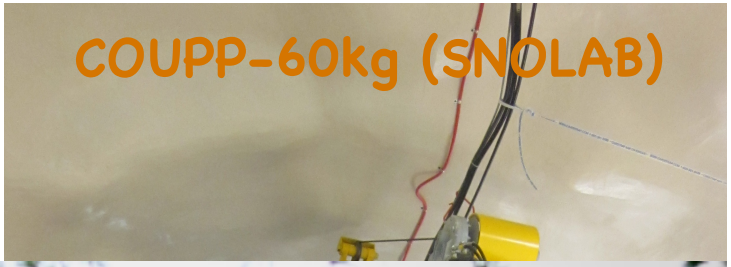
COUPP: A Bubble Chamber search for Dark Matter

- World's best spin-dependent (SD) WIMP-nucleus coupling sensitivity, and very near CDMS' spin-independent (SI) sensitivity.
- 60 kg chamber commissioned at SNOLAB and presently taking physics data. First results this year. Second smaller chamber (PICO-2l) targeting low-mass WIMPs.
- 500 kg design in progress (NSF+DOE funded). Planned start of construction 2014, installation at SNOlab during 2015. PICASSO and COUPP have merged efforts (PICO collaboration).



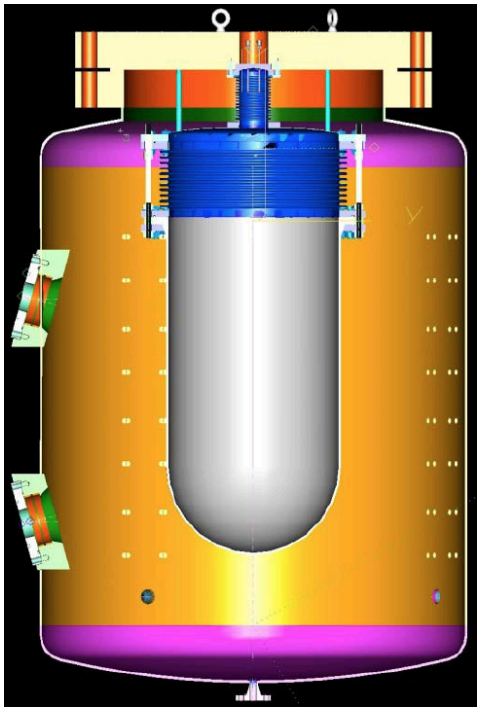
COUPP: A Bubble Chamber search for Dark Matter

- World's best spin-dependent (SD) WIMP-nucleus coupling sensitivity, and very near CDMS' spin-independent (SI) sensitivity.
- 60 kg chamber commissioned at SNOLAB and presently taking physics data. First results this year. Second smaller chamber (PICO-2l) targeting low-mass
- 500 kg design in progress (NS funded). Planned start of cons 2014, installation at SNOlab a PICASSO and COUPP have me (PICO collaboration)

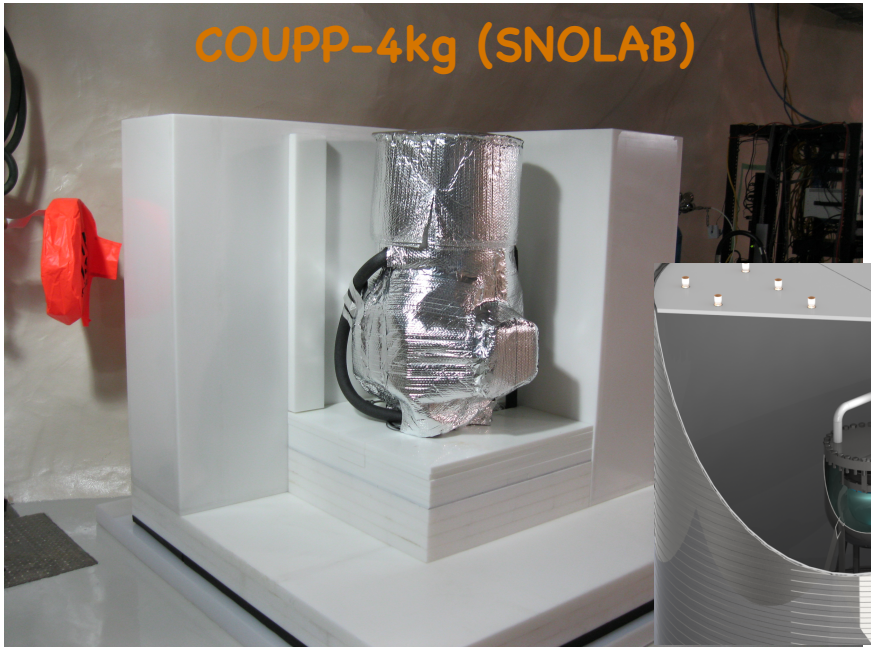


COUPP: A Bubble Chamber search for Dark Matter

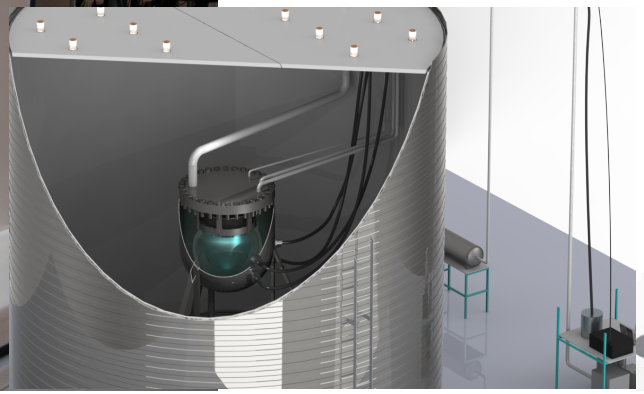
- World's best spin-dependent (SD) WIMP-nucleus coupling sensitivity, and very near CDMS' spin-independent (SI) sensitivity.
- 60 kg chamber commissioned at SNOLAB and presently taking physics data. First results this year. Second smaller chamber (PICO-2l) targeting low-mass WIMPs.
- 500 kg design in progress (NSF+DOE funded). Planned start of construction 2014, installation at SNOlab during 2015. PICASSO and COUPP have merged efforts (PICO collaboration)



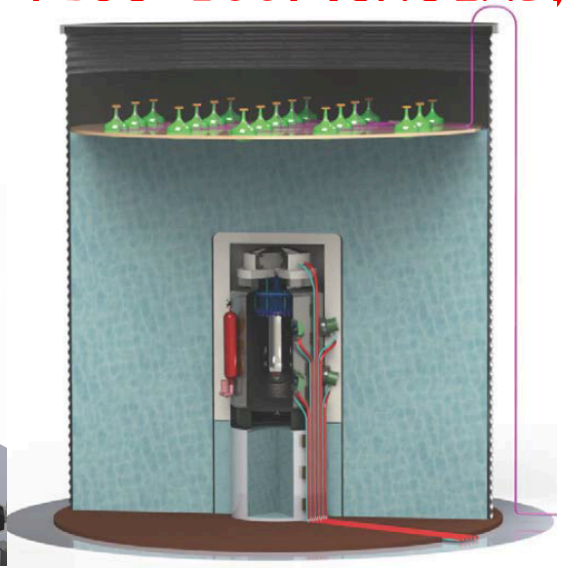
COUPP-4kg (SNOLAB)



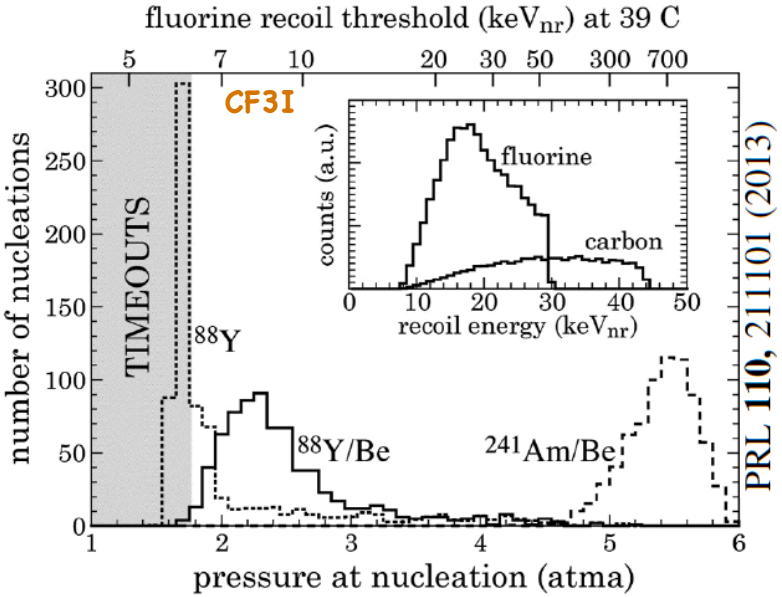
PICO-250l

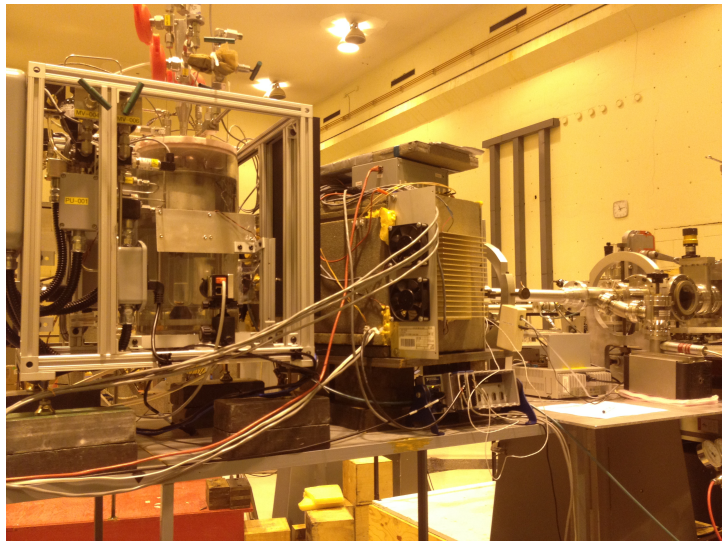


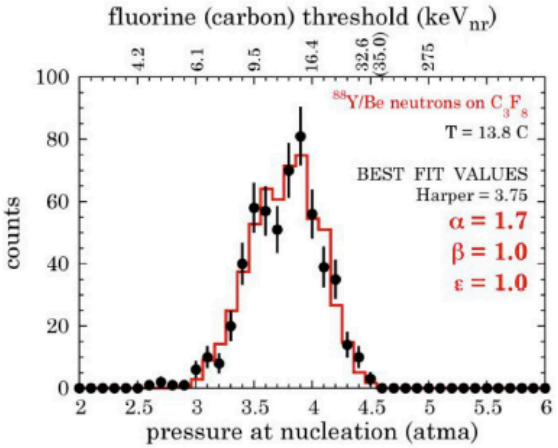
PICO-250l (SNOLAB)

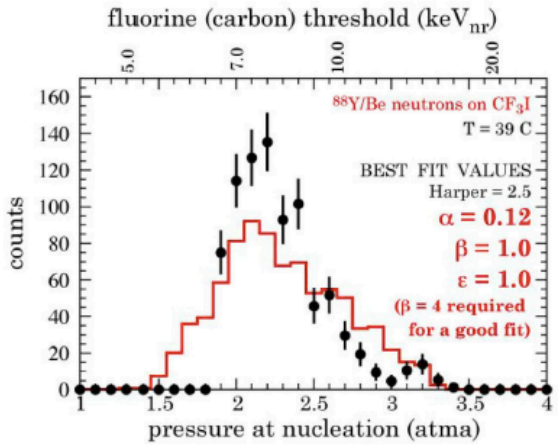


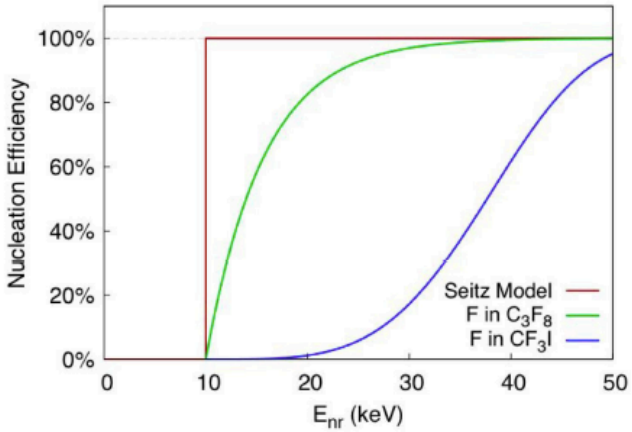
PICO-2l now taking data!
(C3F8, targeted towards low-mass WIMPs)







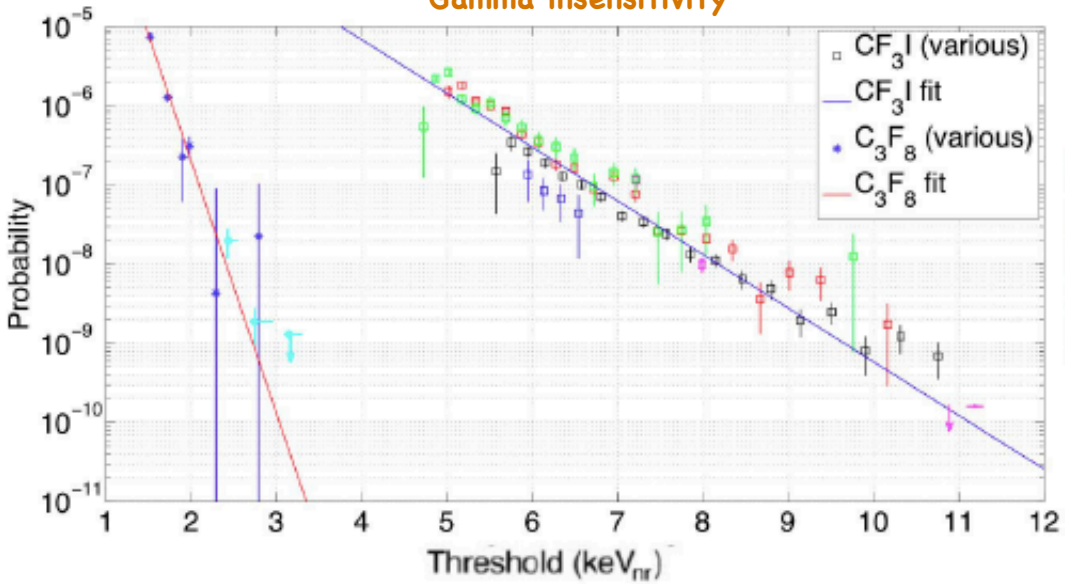




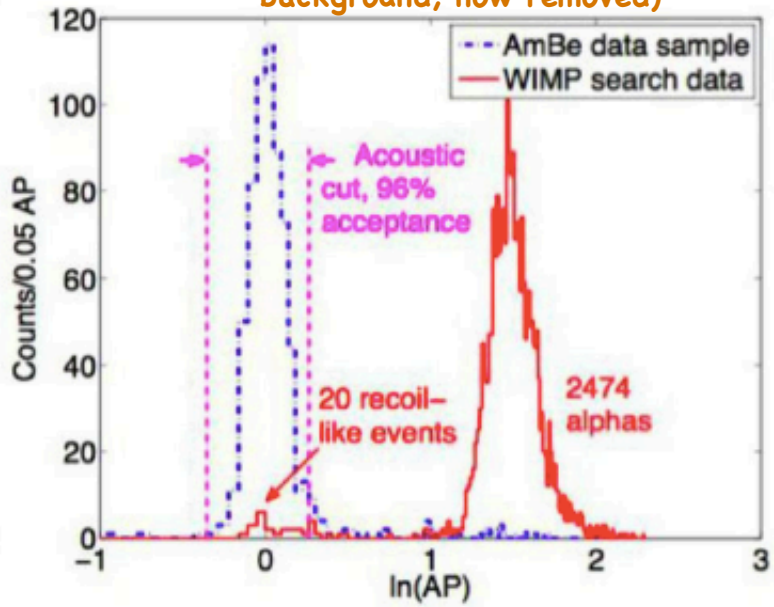
Properly calibrated low-E response
(Y-88/Be + tandem accel. at Montreal)

PICO-2l now taking data!
(C3F8, targeted towards low-mass WIMPs)

Gamma insensitivity



COUPP-4kg
(dominated by (α,n)
background, now removed)



Ability to reach ~3 keVnr threshold
with ~1E-10 electron recoil rejection!

Listening to particle interactions (only a slight exaggeration)

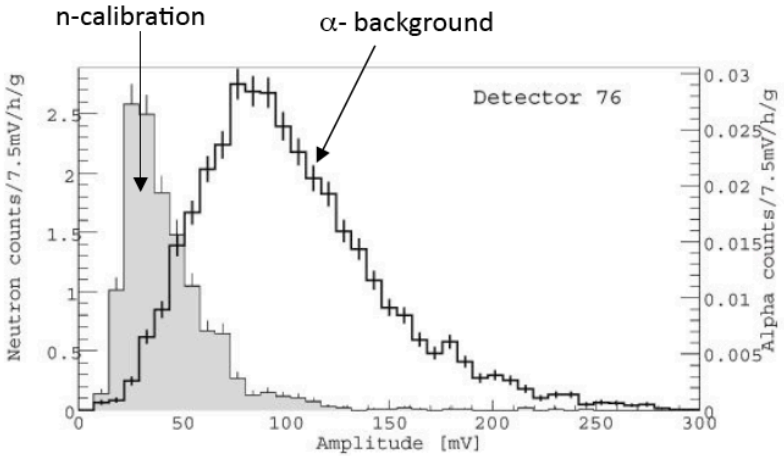
Glaser (1955)

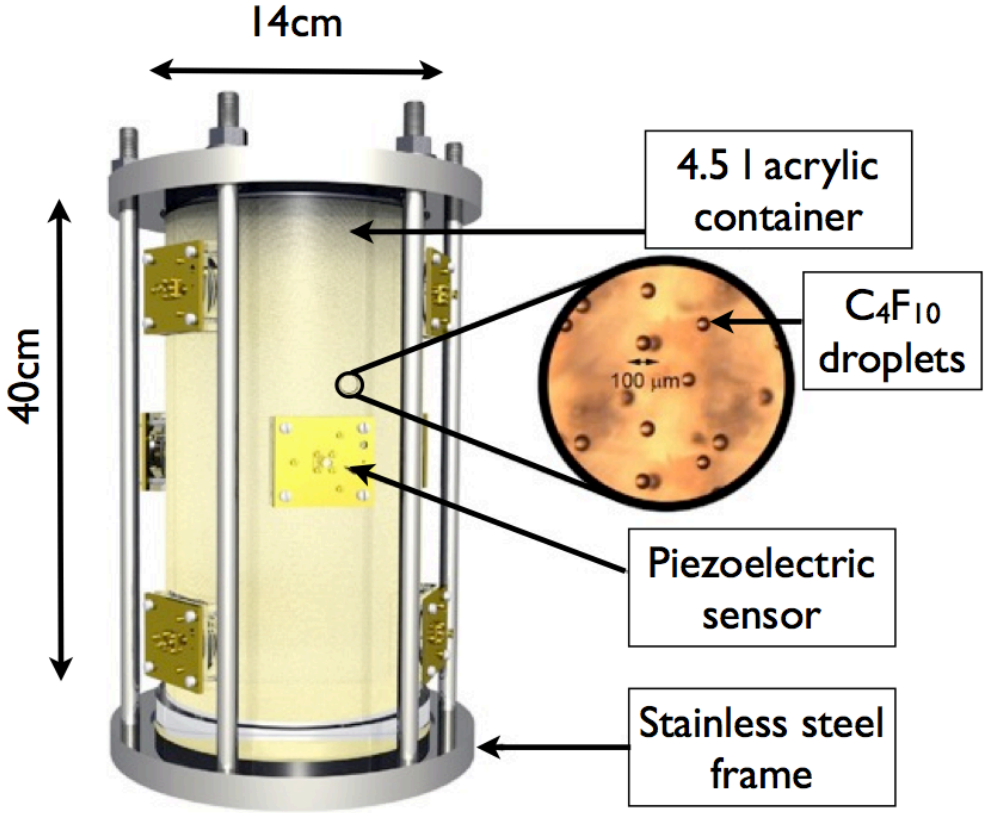
In order to see events more interesting than muons passing straight through the chamber, we took advantage of the violence of the eruption which produces an audible "plink" at each event. A General Electric variable-reluctance phonograph pickup was mounted with its stylus pressing against the wall of the chamber. Vibration signals occurring during the quiescent period after the expansion were allowed to trigger the lights and take pictures. In this way we saw tracks of particles passing through the chamber in various directions,

Martynyuk & Smirnova (1991)

The initial pressure in the volume V depends on the energy transmitted by the particle to that volume. Consequently, the characteristics of the acoustic pulse depend on the parameters of the particle responsible for formation of the bubble....
The parameters of these pulses must depend strongly on the characteristics of the particle.

PICASSO collab. (2009)

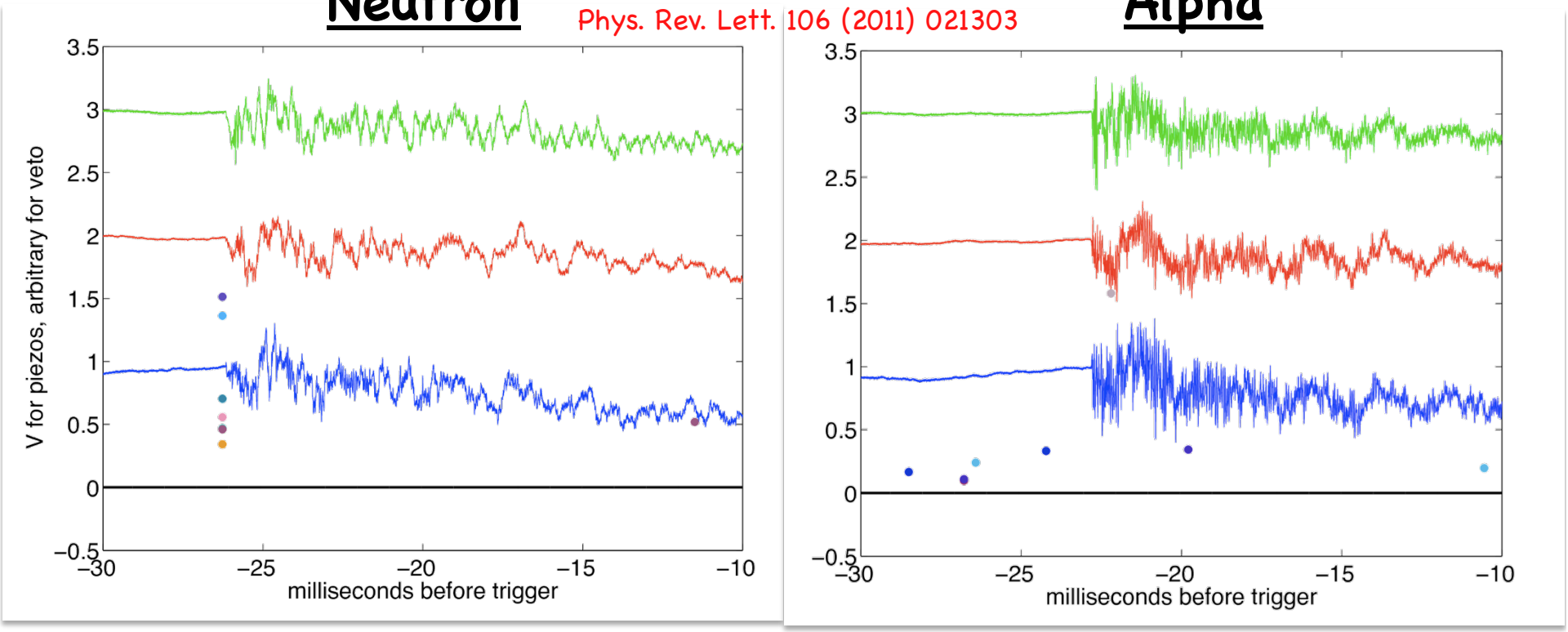




PICASSO demonstrates α – nuc. recoil acoustic discrimination in Superheated Droplet Detectors (SDDs)
F. Aubin *et al.*, New J. Phys 10 (2008) 103017

Listening to particle interactions (only a slight exaggeration)

Neutron Phys. Rev. Lett. 106 (2011) 021303 **Alpha**

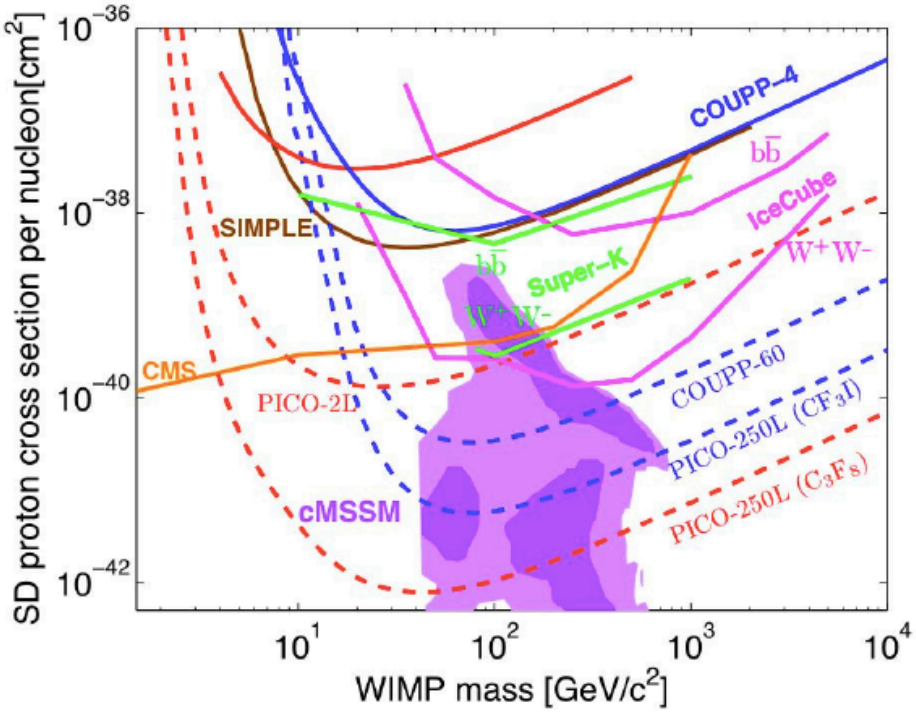


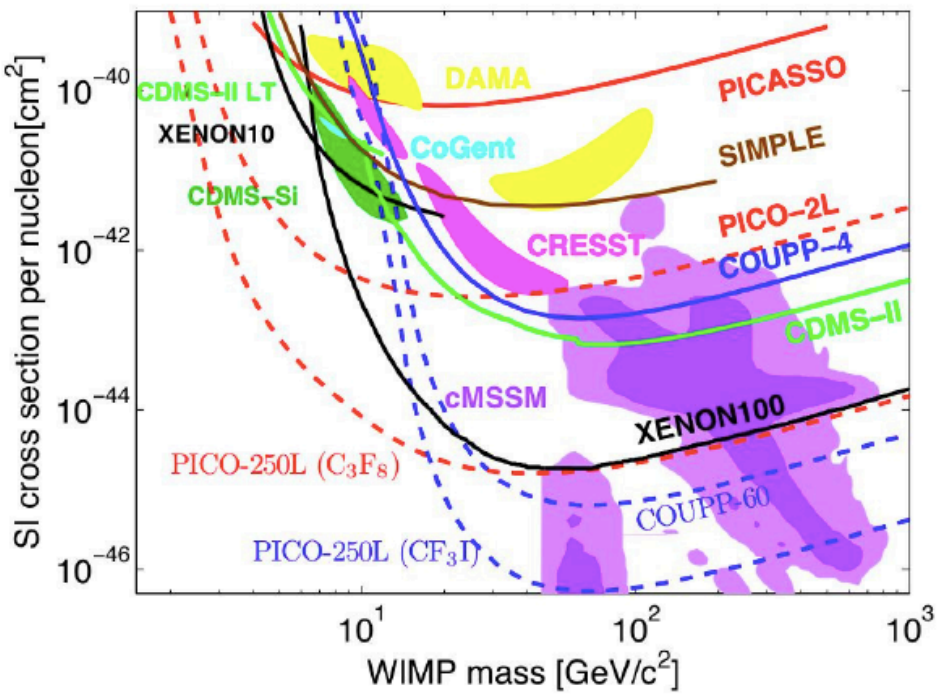
We observe two distinct families of single bubble bulk events in a 4 kg chamber:

- Discrimination increases with frequency, as expected.
- We have a handle on which is which (Rn time-correlated pairs following injection, S-AmBe calibrations, NUMI-beam events).
- Very high discrimination against α's is clear (~1E-5 rejection factor, we don't have enough statistics yet to determine this)
- Discrimination is considerably better than in PICASSO's droplet detectors (multiple reasons for this).
- Challenge in obtaining same discrimination in the larger devices: increasing number of sensors while reducing (α,n).

Relaxes internal radiopurity goals by 4-5 orders of magnitude

PICO-2l now taking data!
(C3F8, targeted towards low-mass WIMPs)





PICO-250l to provide excellent <u>demonstrated</u> sensitivity to low-mass WIMPs and exhaustive exploration of SUSY models via SD couplings