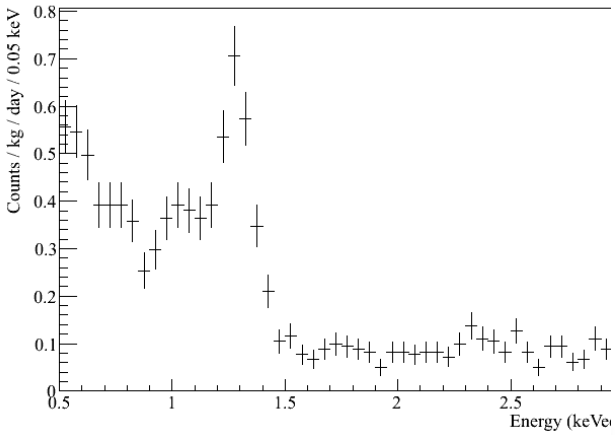
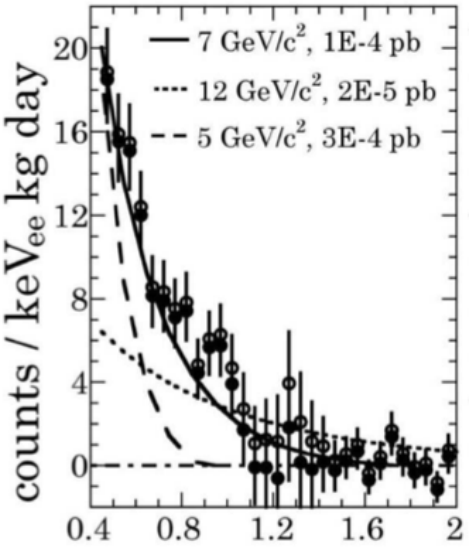
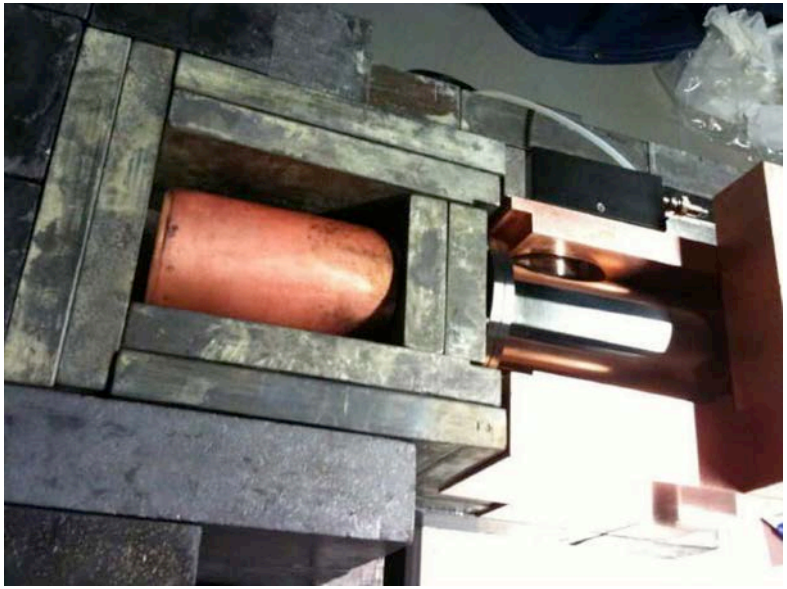
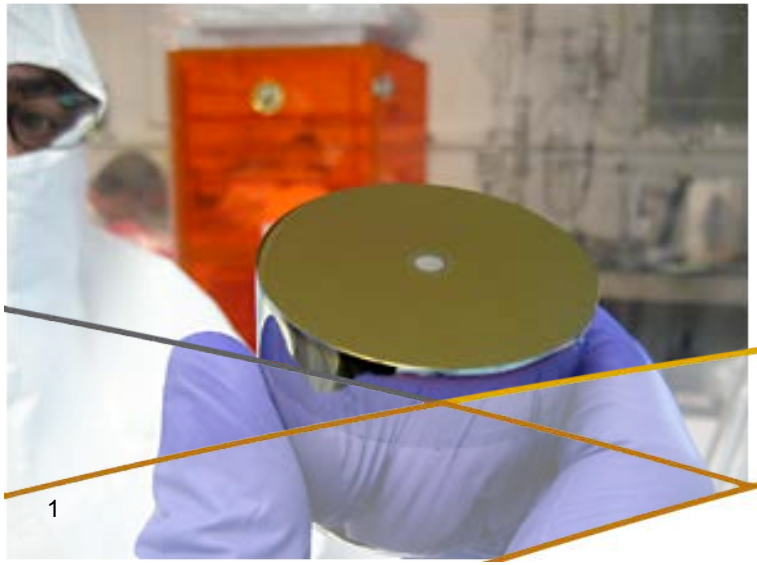


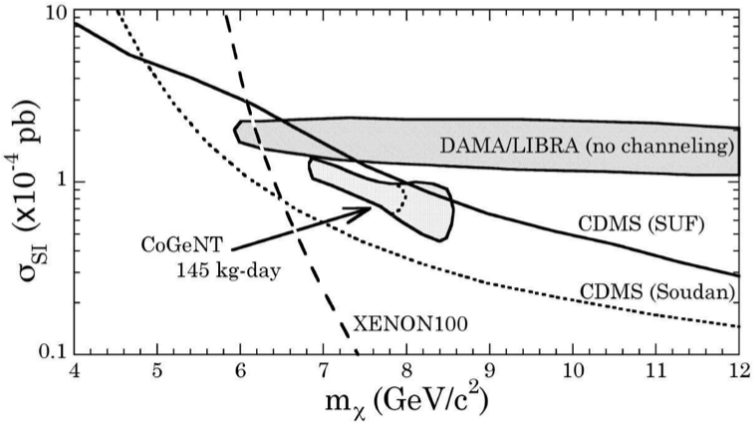




CoGeNT/C-4*: Answers to CF1 WGA's 10 Q's

*** C-4 was not selected in DOE Gen-2 (See end slide)**





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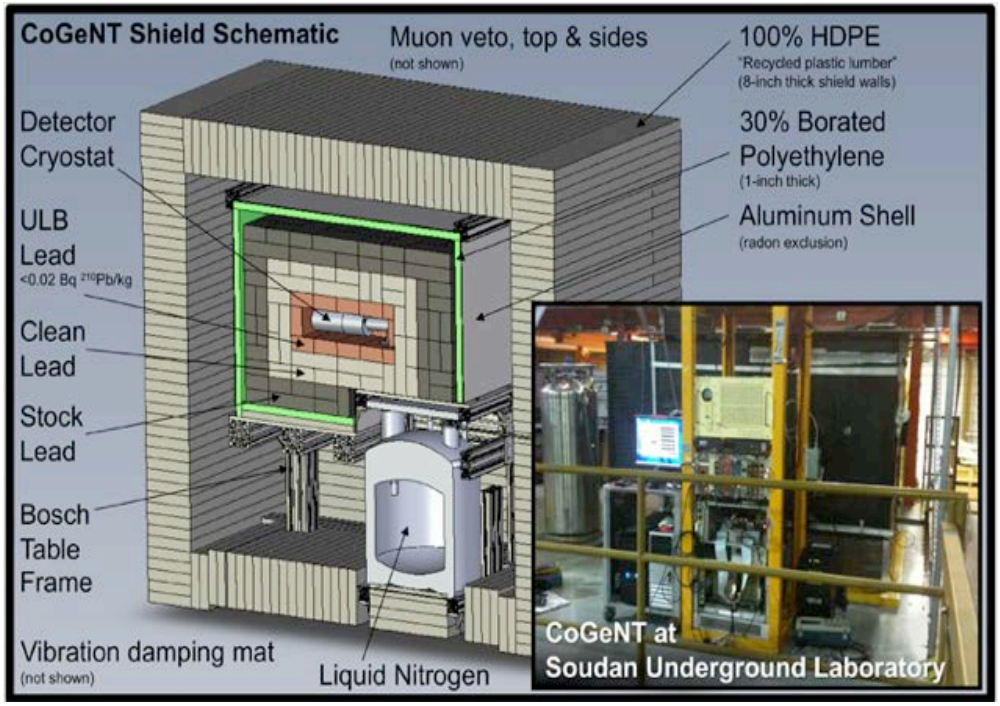
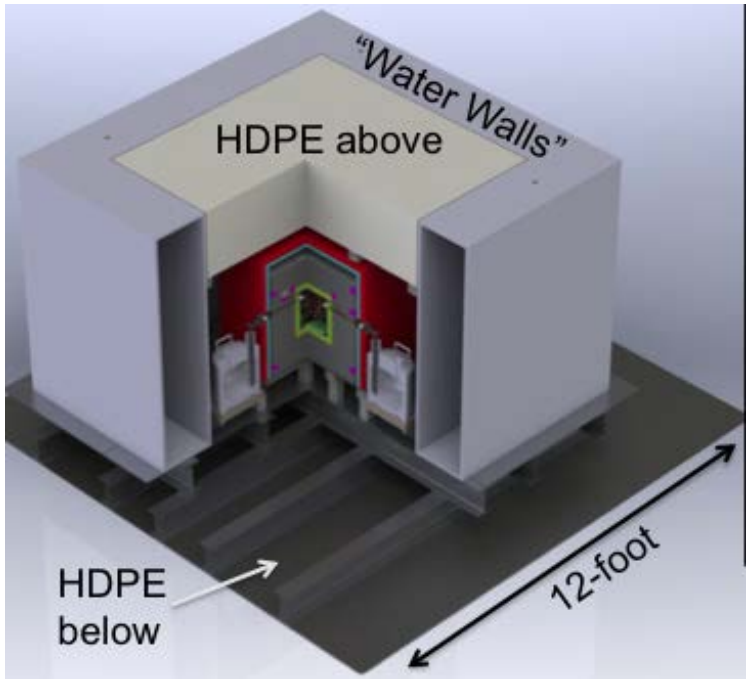
Proudly Operated by Battelle *Since 1965*

1) Target Mass

CoGeNT:
- Soudan mine
- 1 Ge crystal (440 g)
- Data since Dec 2009



C-4:
- Soudan mine
- Four 1 kg Ge crystals
- Data: TBD



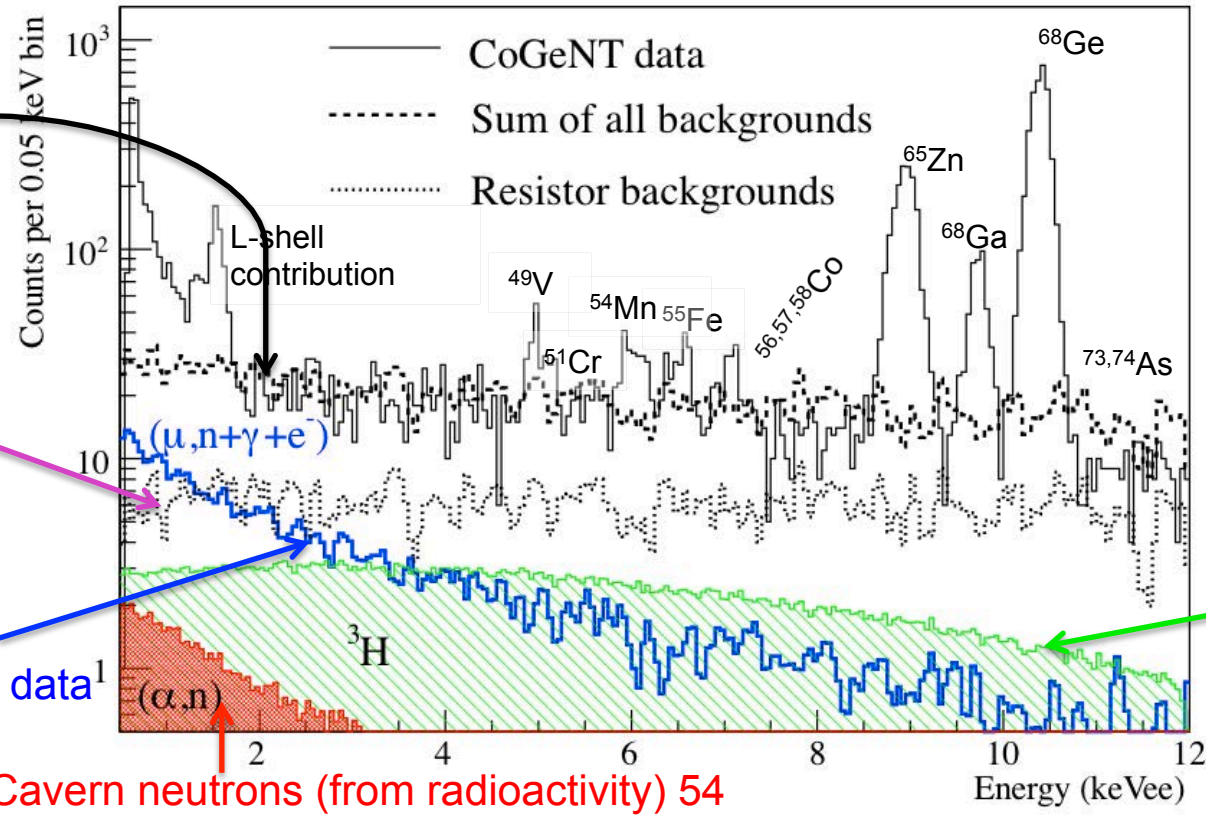
2) Fiducial target mass

- Fiducial target mass is driven by the fixed thickness of the dead-layer composing the high voltage contact on the outside of the Ge crystal. Larger crystals reduces this "surface thickness to volume" ratio
- CoGeNT fiducial mass …. C-4 fiducial mass
- Ratios
  - CoGeNT 0.33/0.44 = 75%
  - C-4 3.8/4.68 = 81%

Table 1. Target mass scenarios for C4. The minimal mass assumes CoGeNT-size crystals.

Scenario	Crystal Dimensions (Ø mm, thick mm)	Crystal Mass (kg)	Active Mass (kg)	C4 Active Mass (kg)
Minimal mass	(60, 30)	0.44	0.33	1.3
Target mass	(90, 35)	1.17	0.94	3.8

3) CoGeNT Backgrounds



Background sum

Resistor gammas ~324 events, ~16% of data

Muon-induced neutrons 339 events, 16% of data

Cavern neutrons (from radioactivity) 54 events, 3% of data

Tritium β-decay 150 events, 7% of data

arXiv:1208.5737

Other sources of background simulated:

- U and Th chain backgrounds in surrounding material (copper)
- Muon-induced neutrons from the cavern
- U and Th chain backgrounds in lead shielding
- Spontaneous fission neutrons from shielding material
- (α,n) neutrons from shielding material

These backgrounds are tiny

3) C-4 Predicted Backgrounds

- Main changes
  - Muon veto
  - Electronics front-end background reduction

Summary of simulated backgrounds in the C-4 experiment compared to CoGeNT. For muon-induced events in the lead shield ("Pb shield: (μ,n)"), (1) the rates include events due to muon-induced electromagnetic cascades and (2) the CoGeNT rate does not have a cosmic ray veto applied while the C-4 rates assume the planned cosmic ray veto is active.

Backgrounds (counts/kg/day)	CoGeNT (0.5–3 keV)	C-4 (0.5–3 keV)	C-4 (0.5–12 keV)
β- and γ-ray backgrounds			
Ge detectors: ^{3}H activation	8.3×10^{-1}	8.2×10^{-1}	2.8×10^{0}
Ceramic resistors: ^{238}U, ^{232}Th	6.2×10^{0}	1.4×10^{0}	6.5×10^{0}
Cu cryostat/shield: ^{238}U, ^{232}Th	5.0×10^{-2}	7.1×10^{-3}	3.4×10^{-2}
Pb shield: ^{238}U, ^{232}Th, ^{210}Po	3.4×10^{-1}	1.4×10^{-1}	5.5×10^{-1}
Neutron backgrounds			
Pb shield: (μ,n)	1.9×10^{0}	2.6×10^{-4}	6.4×10^{-4}
HDPE: ^{238}U fission	1.2×10^{-4}	5.7×10^{-5}	1.3×10^{-4}
HDPE: ^{238}U, ^{232}Th (α,n)	2.2×10^{-4}	1.3×10^{-4}	3.3×10^{-3}
Cavern walls: (α,n)	3.0×10^{-1}	$< 1.4 \times 10^{-3}$	$< 1.4 \times 10^{-3}$
Cavern walls: (μ,n)	7.7×10^{-3}	6.7×10^{-3}	1.6×10^{-2}
Estimated total rate	10	2	10

4) Detector Discrimination

- HPGe ionization spectrometer:
  - No nuclear-recoil vs. electron-recoil discrimination
- There is a “discrimination” of surface events…
  - Pulse rise-time analysis used to cut energy degraded events in the transition layer between the surface dead-layer and the fully active bulk
  - This is an instrumental background discriminator
  - These are our “outlier events” – though we have worked to provide an understanding of how they contribute near threshold
- C-4:
  - Lower the energy threshold further
  - Perform detailed surface event characterizations
  - Develop a physics model from characterization

5) Energy Threshold

- CoGeNT
  - ~300 eV “noise floor/wall”
  - 500 eV analysis threshold
- Pulser used to evaluate trigger efficiency

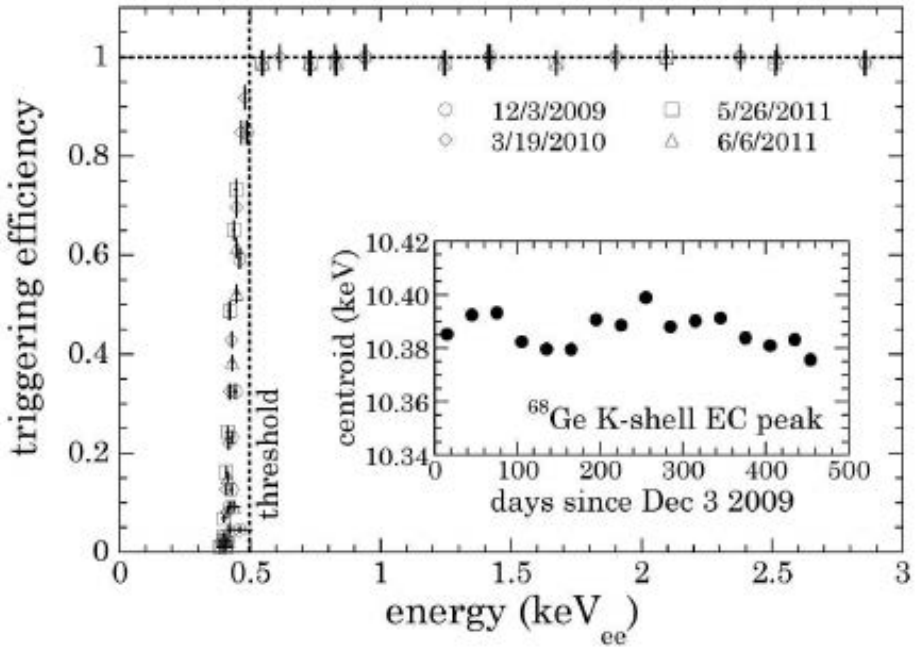


FIG. 7. Trigger efficiency vs. energy equivalent for 10 Hz tailed electronic pulses generated with a 814FP Canberra pulser. Inset: gain shift stability monitored through the centroid of a Gaussian fit to the 10.3 keV cosmogenic peak. The count rate under this peak decayed from roughly 500 to 150 events per month.

- C-4
  - Goal: 50-100 eV “noise floor”

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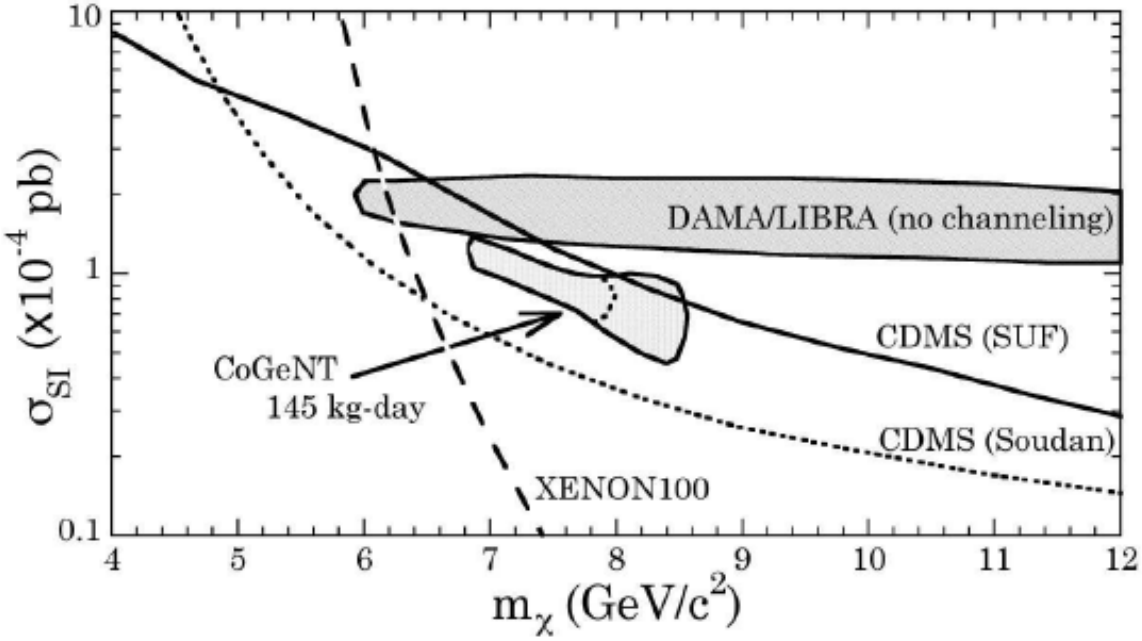
6) CoGeNT Sensitivity

- Phys. Rev. Lett. 107 (2011) 141301
  - 15 months of data



- Now have ~3 years of data yet to analyze

6) C-4 Sensitivity

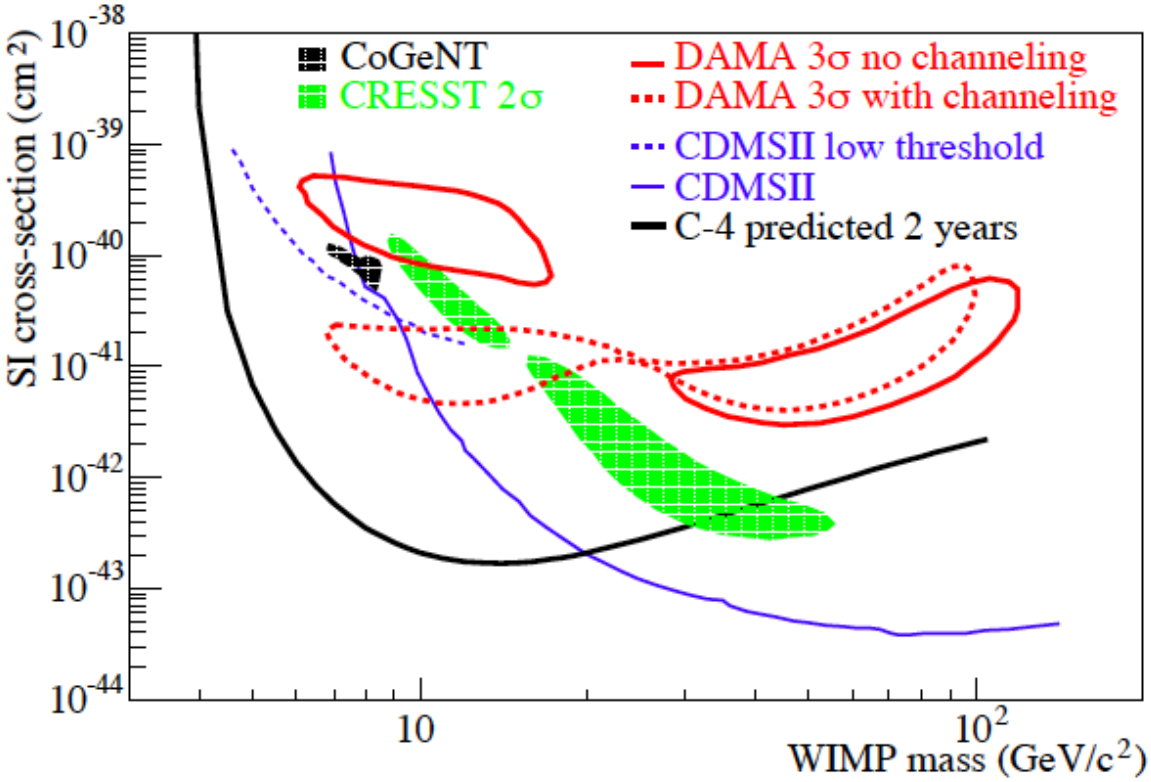


Figure 5: The predicted C-4 WIMP sensitivity after 2 years of running compared to CDMS II sensitivity curves. C-4 is predicted to offer a considerably better sensitivity than the low-threshold CDMS II analysis, up to a WIMP mass of ~15 GeV/c^2. We conservatively do not assume any of the expected improvements to the energy threshold discussed in 4 when calculating these projections.

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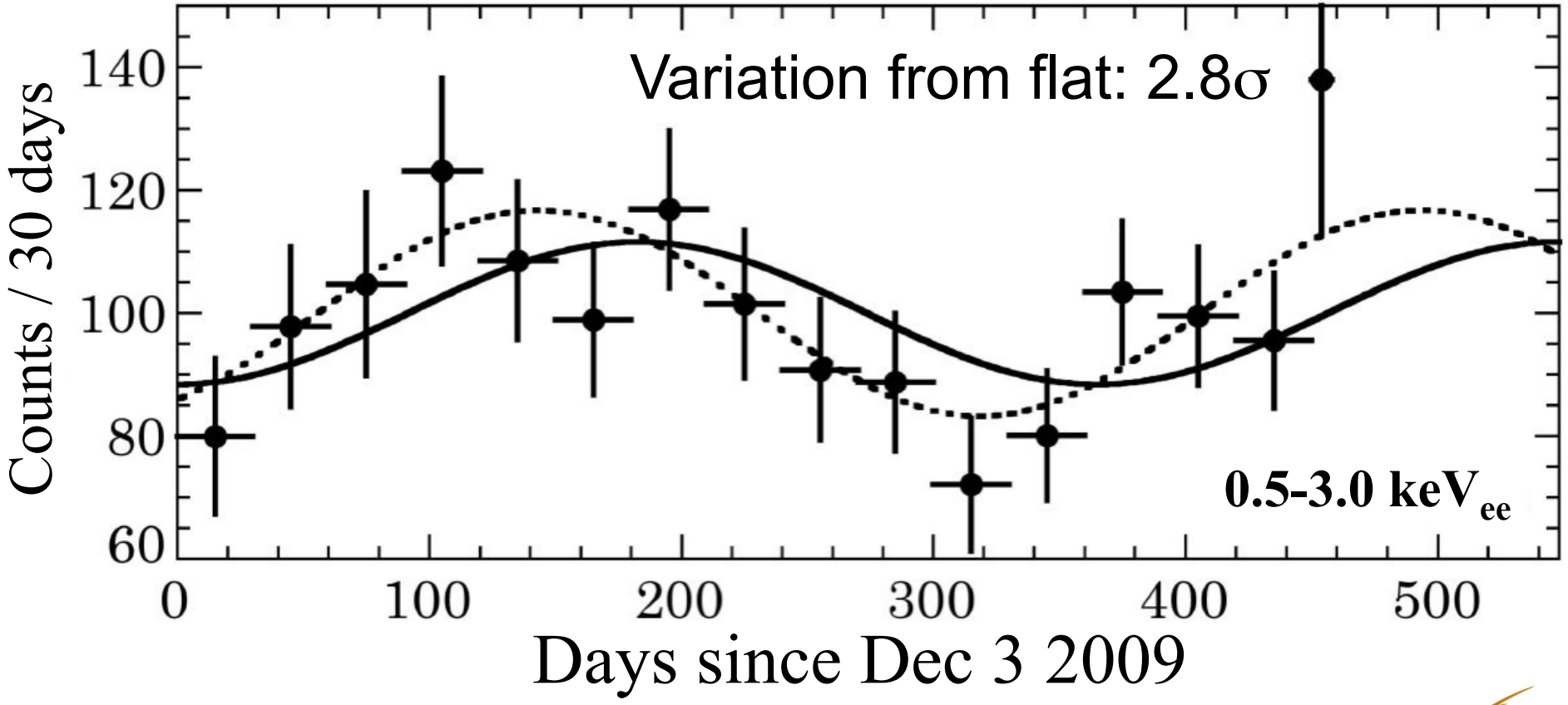
7) Experimental Challenges

- Surface event characterization and analysis
  - The reason for these degraded pulses is understood…
    - But we do not have a predictive model
  - Characterization on individual detectors is needed
    - It is not known if these characterizations will provide "uniform" results across multiple crystals
- R&D would help, but we do not believe it is required
- C-4 was "ready to install"
  - Using a surface characterization program (only 4 detectors)

8) CoGeNT Annual Modulation

- Phys. Rev. Lett. 107 (2011) 141301
  - 15 months of data



- Now have ~3 years of data yet to analyze

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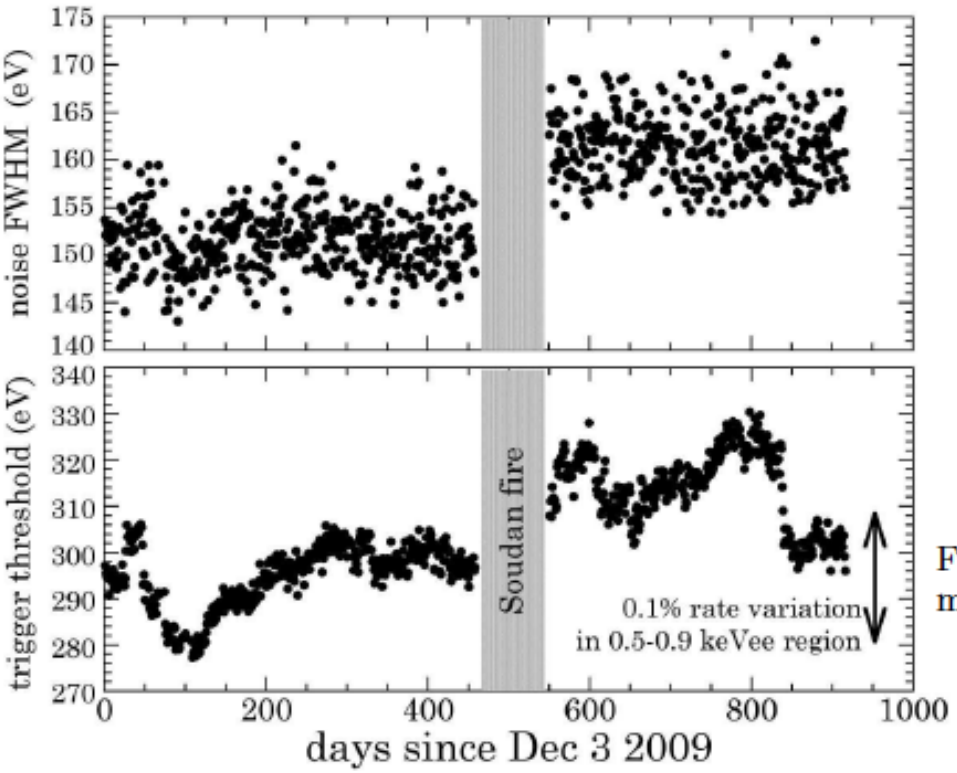
8) CoGeNT Annual Modulation – Stability

- CoGeNT is very stable
  - No obstacle here



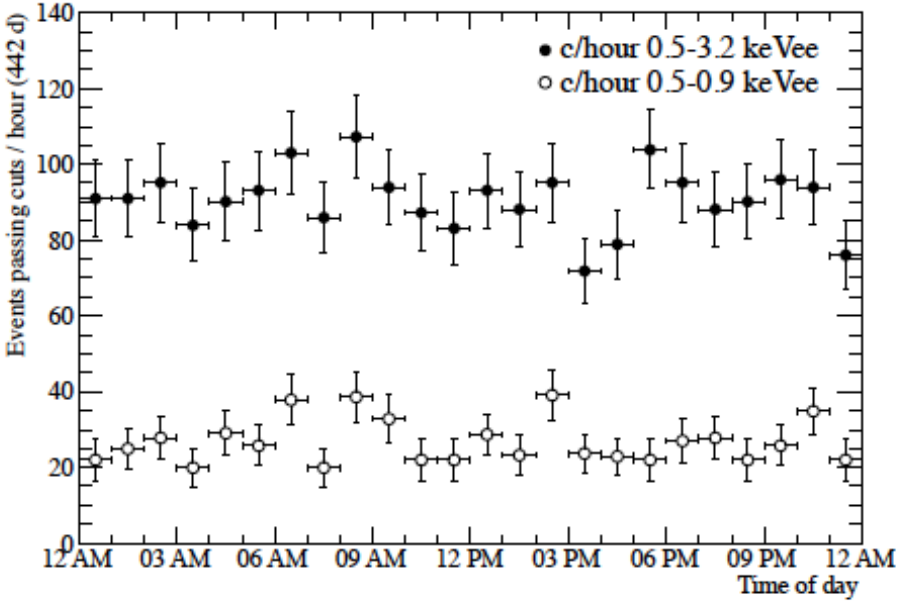


FIG. 9. Diurnal stability of CoGeNT at SUL. Periods of human presence at SUL are ~7 am - 5 pm.

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8) C-4 Annual Modulation

- Assuming CoGeNT represents a real dark matter signal:

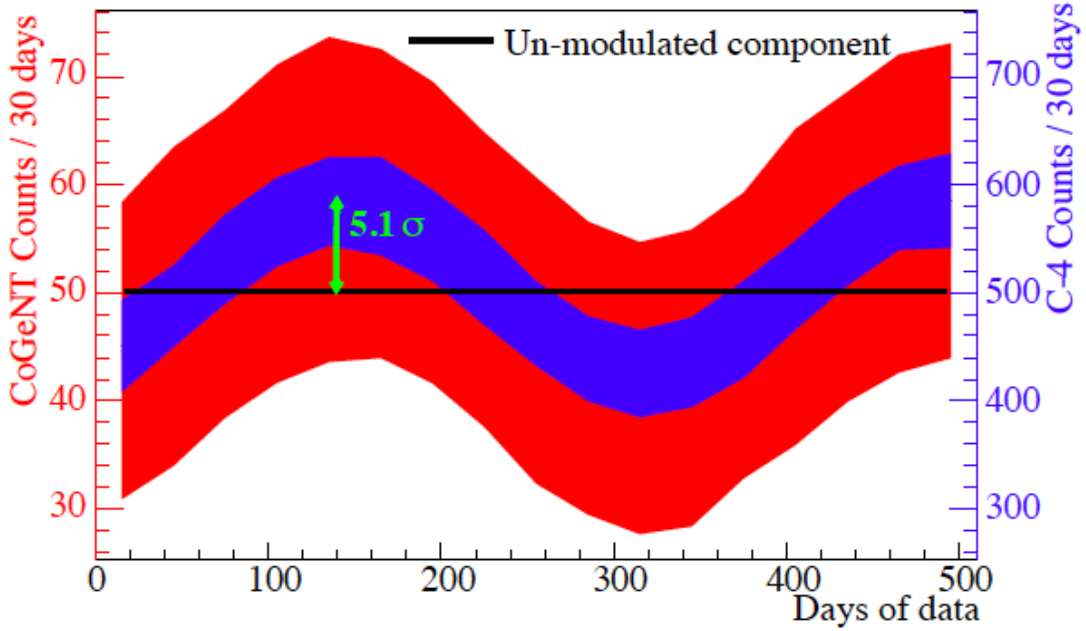


Figure 6: The predicted sensitivity of C-4 (inner narrow blue band - right-hand scale) to an annual modulation assuming the observed CoGeNT modulation amplitude (wider red band - left-hand scale) is due to WIMP dark matter interactions (see text).

C-4 was designed explicitly to test the CoGeNT result

A generic program of modulation sensitivity was not envisioned (though easily tested)

9) Unique Capabilities

- Low energy threshold
- Stability of operation

- Nothing specific to identify scatters as due to dark matter

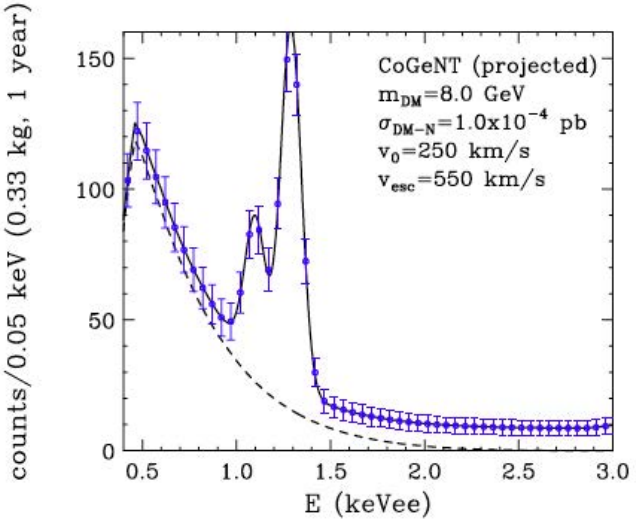
- Technology peculiar to high purity *germanium*
  - But Ge-76 enriched detectors (Majorana*) offer options
  - Ge-73 has spin-sensitivity (Majorana again can address)
    - Enrichment alters the spin-target content

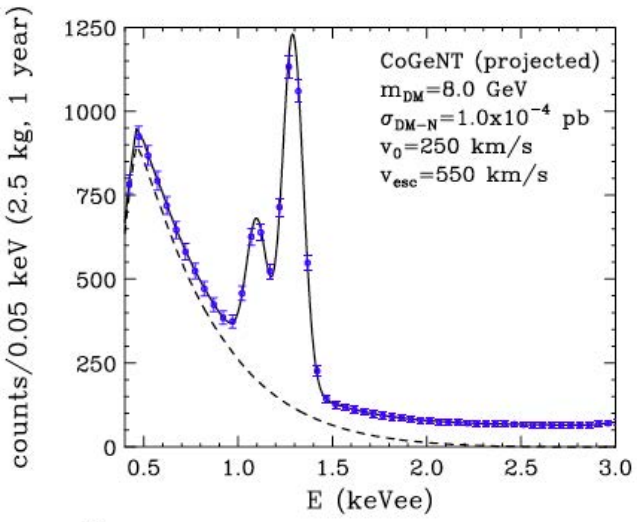
- Enrichment was not planned for C-4

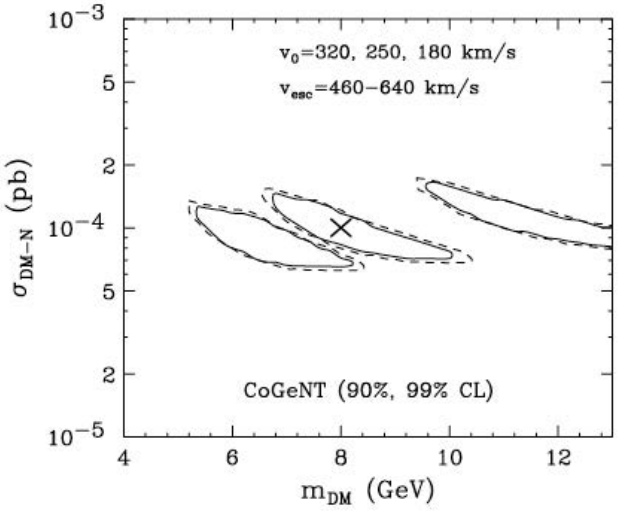
* Majorana Demonstrator with
~0.5 keVee thresholds will do very well!

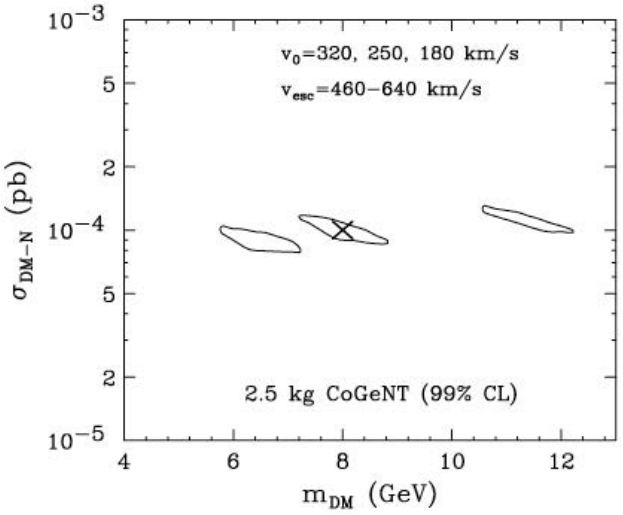
10) WIMP properties

- Kelso and Hooper (JCAP 1102:002 2011)









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Comments on C-4 and DOE Gen-2

- C-4 was not selected for funding in DOE's Gen-2
- Low-energy threshold HPGe proto-type cryostat complete
  - We will put a ~1 kg crystal into the new cryostat
    - Performance will dictate next steps
- 3 years of CoGeNT data collected:
  - An opportunity to recheck the data for a modulation
  - We will perform this analysis
    - We have addressed backgrounds (see slide above)
    - Next analysis should address systematics near threshold with more data