Screening Facilities at SNOLAB

AARM Meeting 12th November 2010
Sanford Lab, Lead, SD

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SNOLAB HPGe Detector

Low Background Gamma Facility at SNOLAB established in 2005

Motivation

- Survey materials for new, existing and proposed experiments at SNOLAB, such as SNO+, DEAP3600, miniCLEAN, PICASSO, EXO, HALO, CDMS ...

Detector

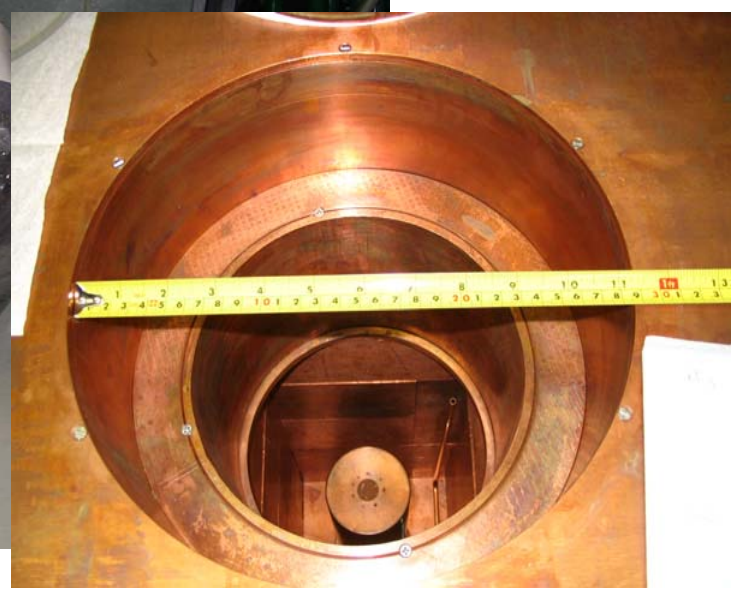
- Constructed at SNOLAB from an older HPGe detector and its associated shielding located underground at 4600 ft level since 1997.
- Counter manufactured by PGT, and refurbished in 2005.
- Endcap diameter 83 mm.
- Relative Efficiency is 55% wrt a 7.62 cm dia x 7.62 cm NaI(Tl) detector.
- Resolution 1.8 keV FWHM.

Shielding

- 2 inches Cu + 8 inches Pb. Plug with hoist to access sample cavity.
- Nitrogen purge at 2L/min to keep radon out.

IL1

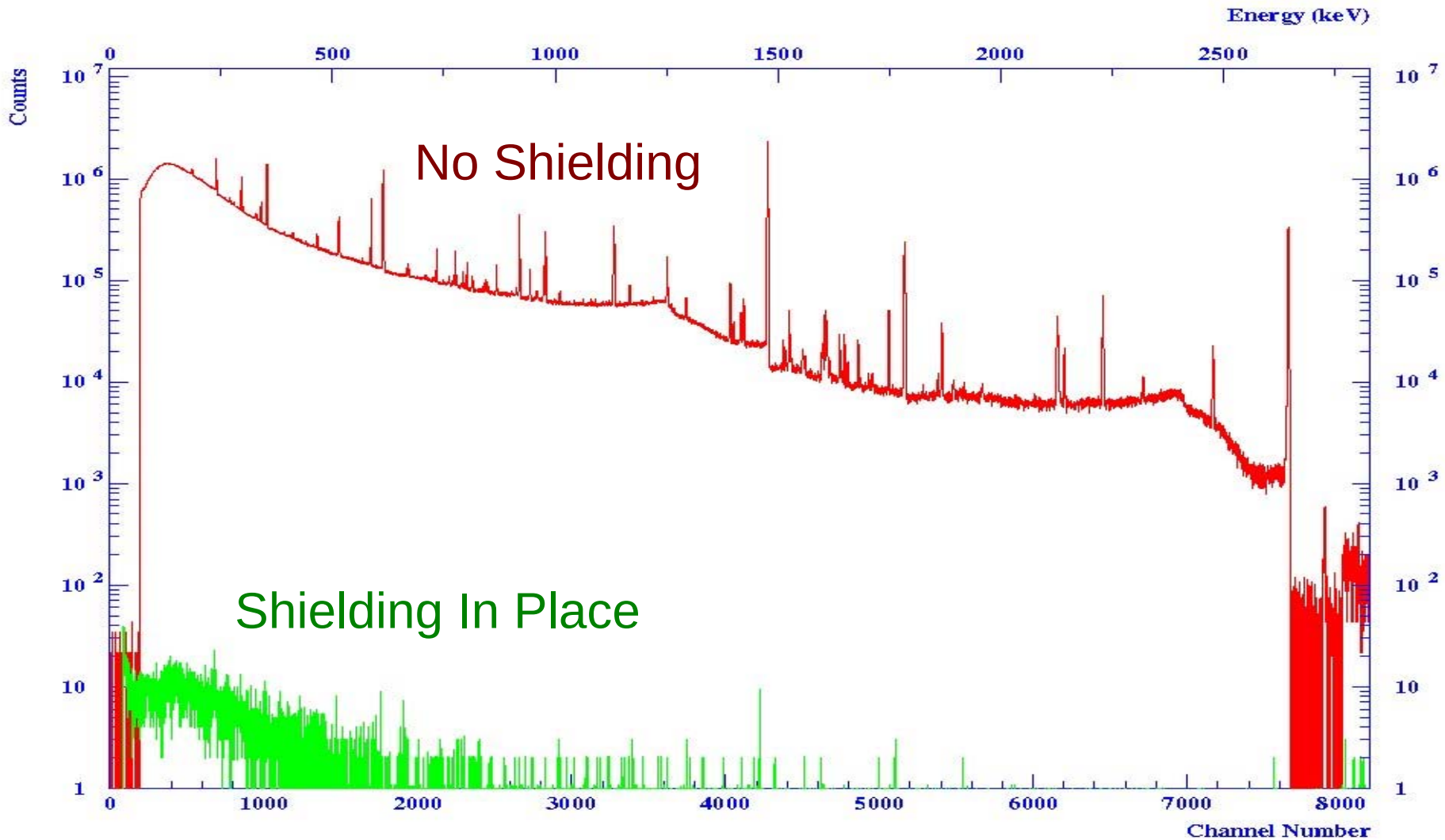
SNOLAB HPGe Counter



Slide 3

IL1 Ian Lawson, 8/22/2010

Unshielded and Shielded Spectra



Background Comparison

Unshielded Versus Shielded Activity

Isotope	Activity Unshielded Crystal(Bq)	Activity Shielded Crystal (Bq)
^{238}U	70.11 ± 1.64	0.00128 ± 0.00016
^{232}Th	36.99 ± 1.21	0.00141 ± 0.00016
^{40}K	1723.33 ± 88.02	0.0189 ± 0.0017
^{137}Cs	1.00 ± 0.15	0.0020 ± 0.0002
^{60}Co	0.023 ± 0.052	0.00036 ± 0.00005

Unshielded Measurements done by Yoram Nir-EL

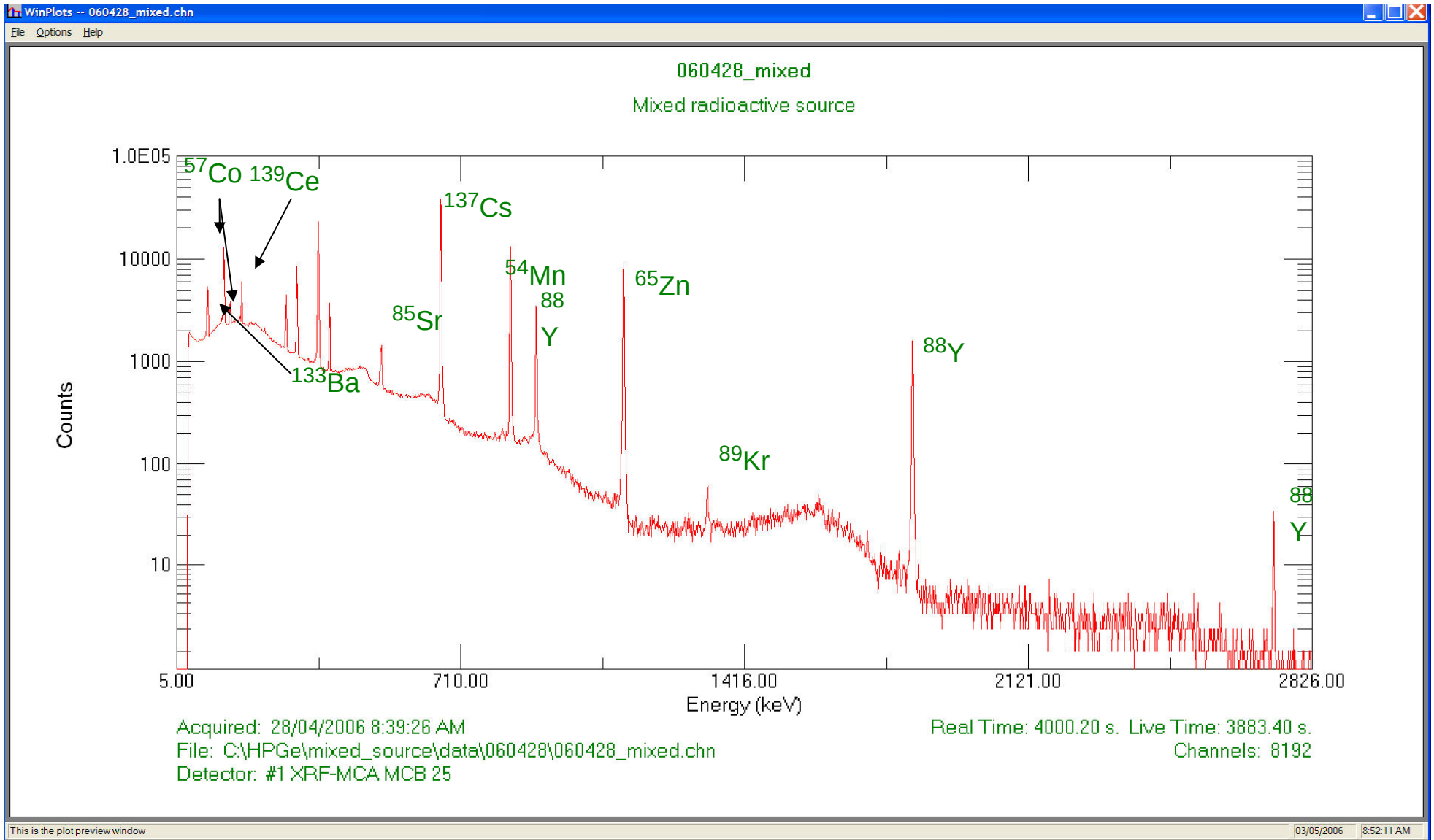
HPGe Detector Sensitivity

Isotope	1 Bq/kg	1 ppb	Sensitivity for Standard Size Samples	Typical for Earth's Crust
^{238}U	81 ppb	12 mBq/kg	~ 1 mBq/kg ~ 0.1 ppb	37 Bq/kg 3 ppm
^{232}Th	246 ppb	4.1 mBq/kg	~ 1.5 mBq/kg ~ 0.3 ppb	45 Bq/kg 11 ppm
^{40}K	32 ppm	0.031 mBq/kg	~ 21 mBq/kg ~ 0.7 ppm	800 Bq/kg 2.5 %

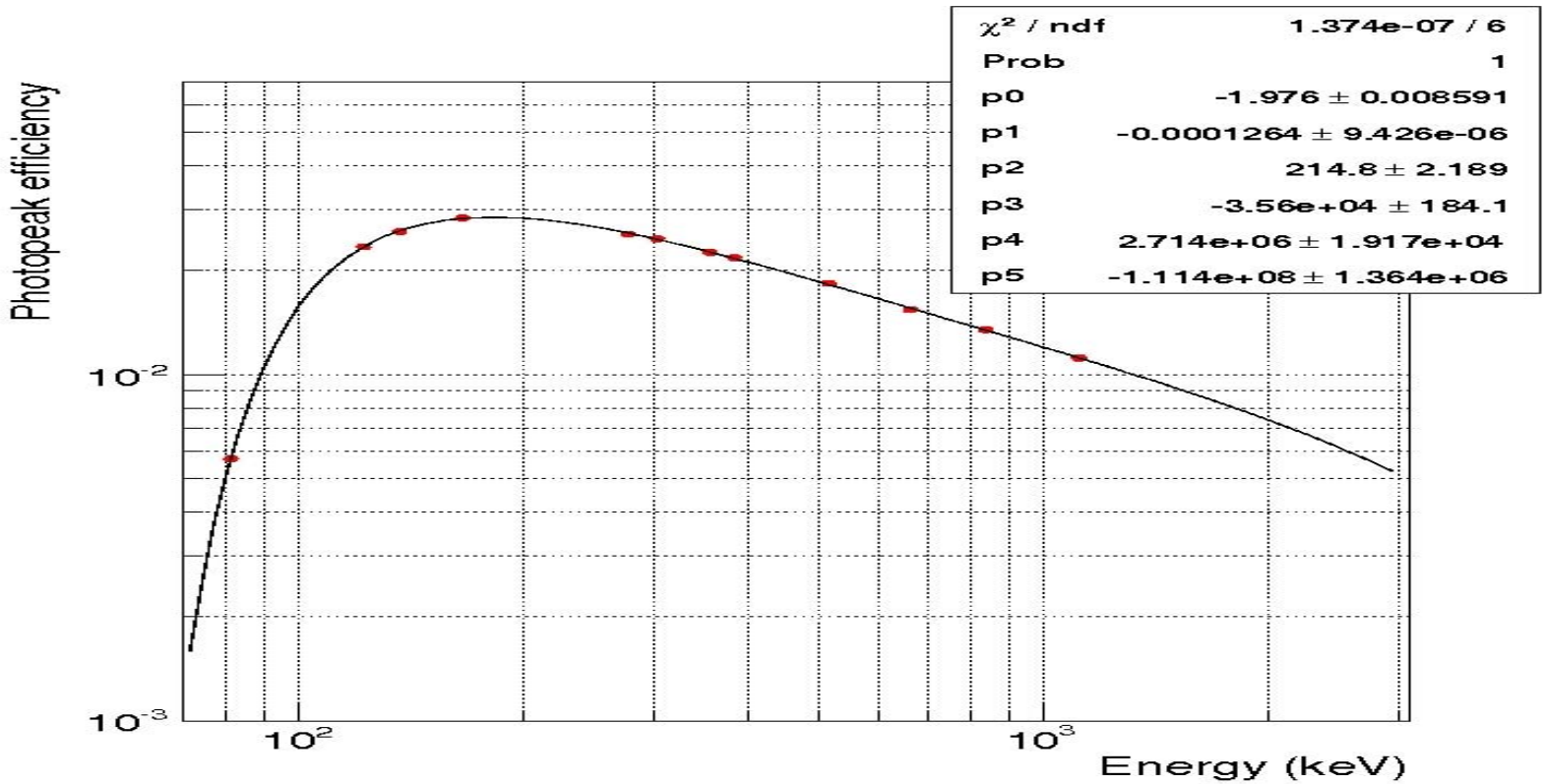
Better sensitivities have been achieved for specialized very large samples combined with an extremely long counting period:

^{238}U: 0.009 ppb,
^{232}Th: 0.02 ppb,
^{40}K: 87 ppb

Calibration Spectrum



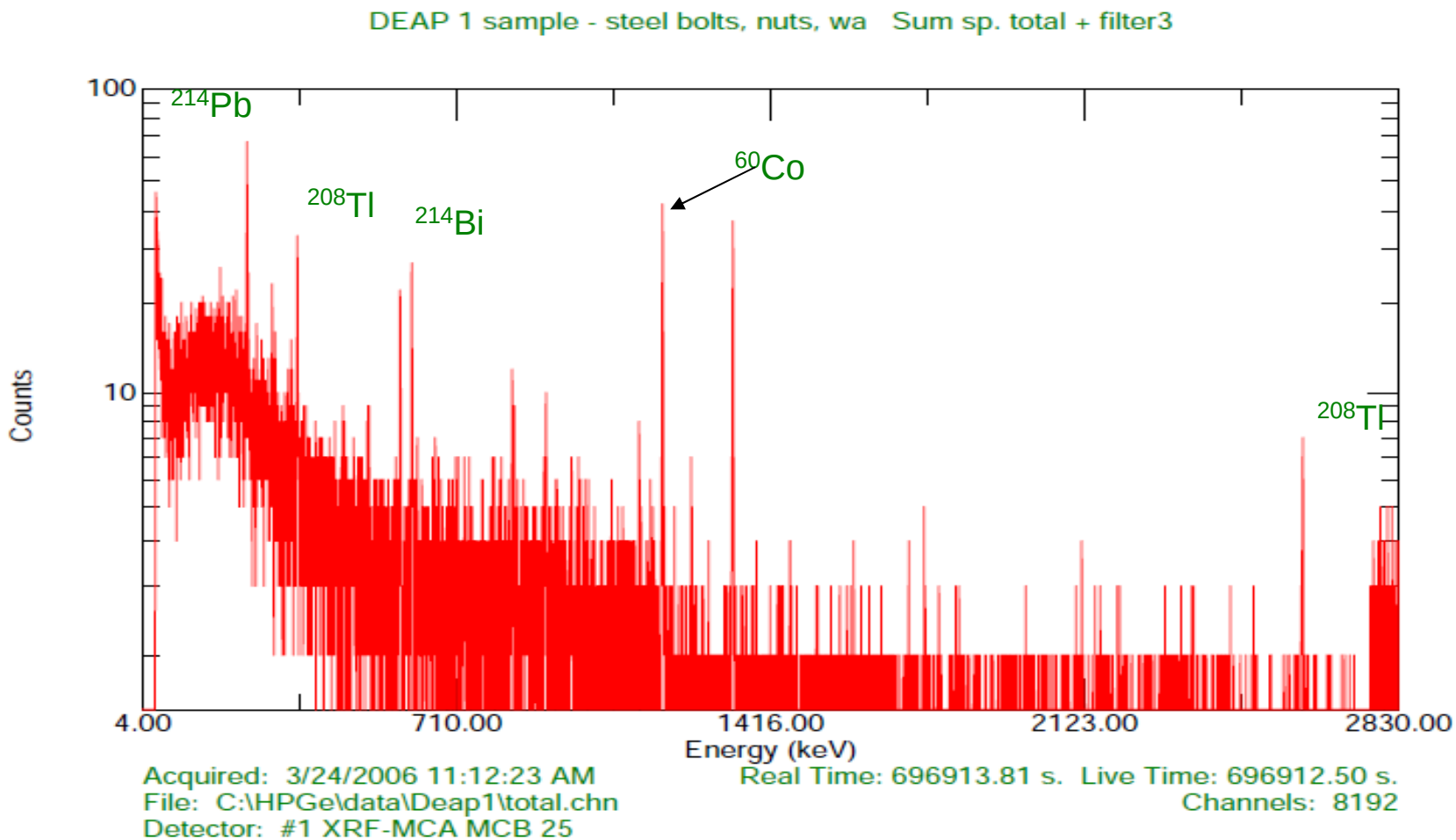
Detector Efficiency From Mixed Calibration Sample



Plot by James Loach

The efficiency is scaled to individual samples using a Geant based Monte Marlo which takes into account the sample components, to account for the density difference between the calibration source and the sample, and the sample geometry.

Typical Stainless Steel Spectrum



Measurements To Date For Each Experiment

Experiment	2006	2007	2008	2009	2010 (Jan-Aug)	Total
SNO	2	7	0	2	0	11
SNO+	0	2	18	14	13	47
SNOLAB	7	3	0	0	3	13
EXO	1	1	0	0	0	2
MiniCLEAN	5	1	9	18	8	41
DEAP	8	8	12	10	5	43
HALO	0	0	0	2	2	4
PICASSO	1	1	4	3	0	9
DM-ICE	--	--	--	--	3	3
Total	24	23	43	49	34	173
Calibrations &Tests	30	34	14	9	1	88

Electrostatic Counting System

(Inherited from SNO MnOx D2O water assaying technology)

Custom large chambers, ultra clean, with PIN diode and low pressure N2 recirculation loops. Either external or internal sample can be assayed for Ra via the Rn emanation rate, where the Rn is transported in the gas loop and decays in the chamber.

- Measures ^{222}Rn, ^{224}Ra and ^{226}Ra levels.

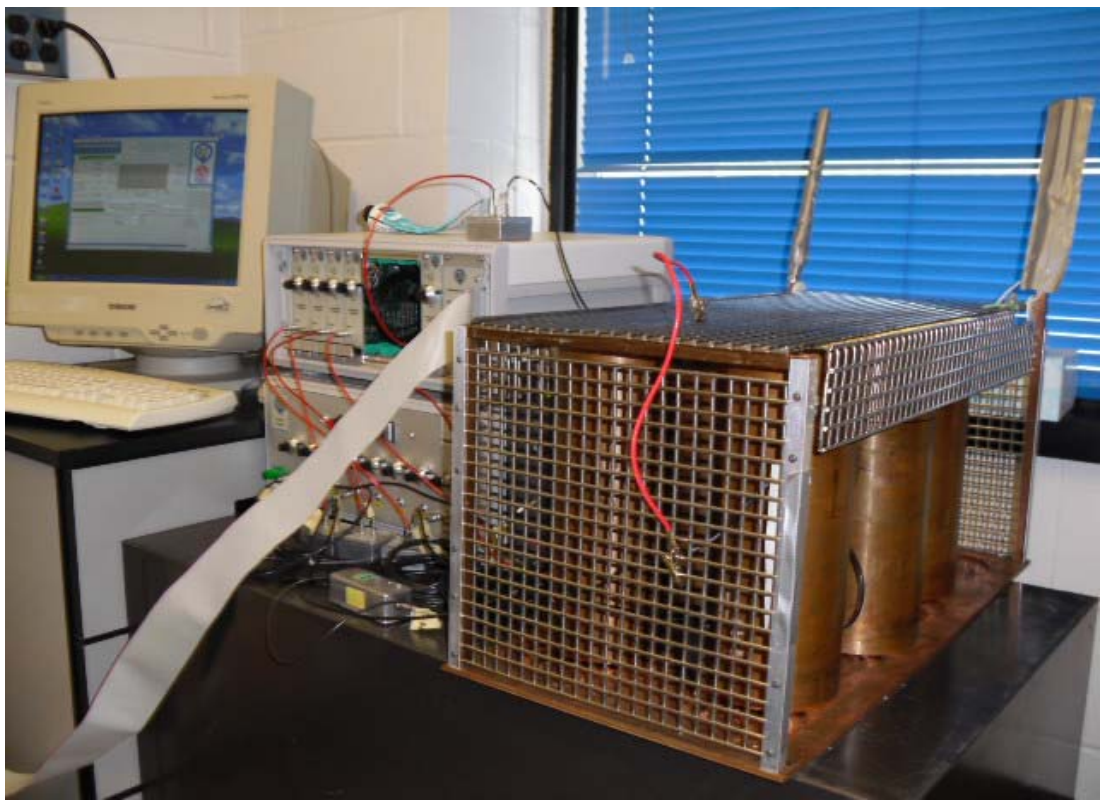
- Sensitivity Levels are:
- ^{222}Rn: 10^{-14} gU/g
- ^{224}Ra: 10^{-15} gTh/g
- ^{226}Ra: 10^{-16} gU/g

Work is ongoing to improve sensitivity even further.

Alpha Beta Counting System

(Also inherited from SNO, from the HTiO D2O water assaying technology)

Scintillator cells coupled to PMTs, with custom electronics channels using PSA to separate beta's and alpha's, and then coincidence gate to detect BiPo's from both the Th and U chains. Offset time spectra analysis can also separate any short half-life dis-equilibria.



Currently located at the SNOLAB hot lab at LU so that spike sources can be measured.

Sensitivity for ^{238}U and ^{232}Th is ~ 1 mBq assuming that the chains are in equilibrium.

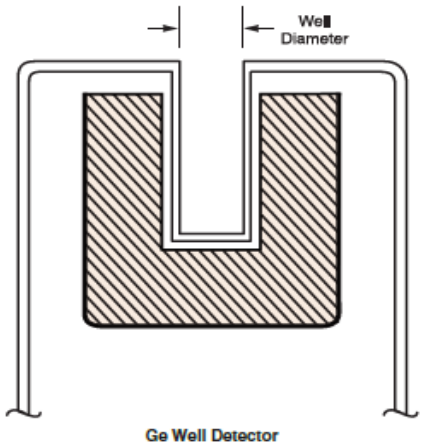
Future Low Background Counting At SNOLAB (I)

- Two new low background high purity Ge Counters have been ordered from Canberra

  One counter is a p-type coaxial detector and the other is a well detector. They are expected to arrive at the end of 2010.

  Canberra will supply the low background shielding for the well detector while SNOLAB will use copper and lead currently in storage together with additional low background material to be acquired.

  Will measure existing lead to determine ^{210}Pb content, this will help us understand the current backgrounds in existing detector and to determine requirements for the new detector.



Ge Well Detector

Future Low Background Counting At SNOLAB (II)

- Neutron background measurements have been started in the SNOLAB expansion (PICASSO).

  System uses 4 2m-long ^{3}He proportional counters from SNO.

  Sensitivity to neutrons is 0.00003 mRem/hr, therefore they will observe neutrons even at very low levels.

  Counters can be deployed inside shielding structures to determine how effective the shielding is at stopping neutrons.

  Previous measurements indicate that the flux varies from 4.8 x 10^{-6} to 1 x 10^{-5} neutrons/cm^2/s.

No shielding

Shielding In Place

Summary

- SNOLAB HPGe low background counting system has run continuously for the past five years and has counted 173 samples so far.

  Counting queue usually remains at between 6 and 10 samples, this sometimes limits when samples can be counted in a timely manner.

  The counter(s) is available for all SNOLAB experiments and can be made available to non-SNOLAB experiments upon request (although capacity is limited).

- Two new Ge counting systems are expected to arrive by the end 2010.

  The new counters should allow much higher sensitivity, effort underway to ensure all materials are low background. The well detector will be used for very specialized small samples such as vapourized acrylic.

- Specialized counting can be done using the ESC or Alpha-Beta Counters.

- Neutron backgrounds can be determined throughout the underground lab and the effectives of neutron shields can be tested.

Comments for AARM

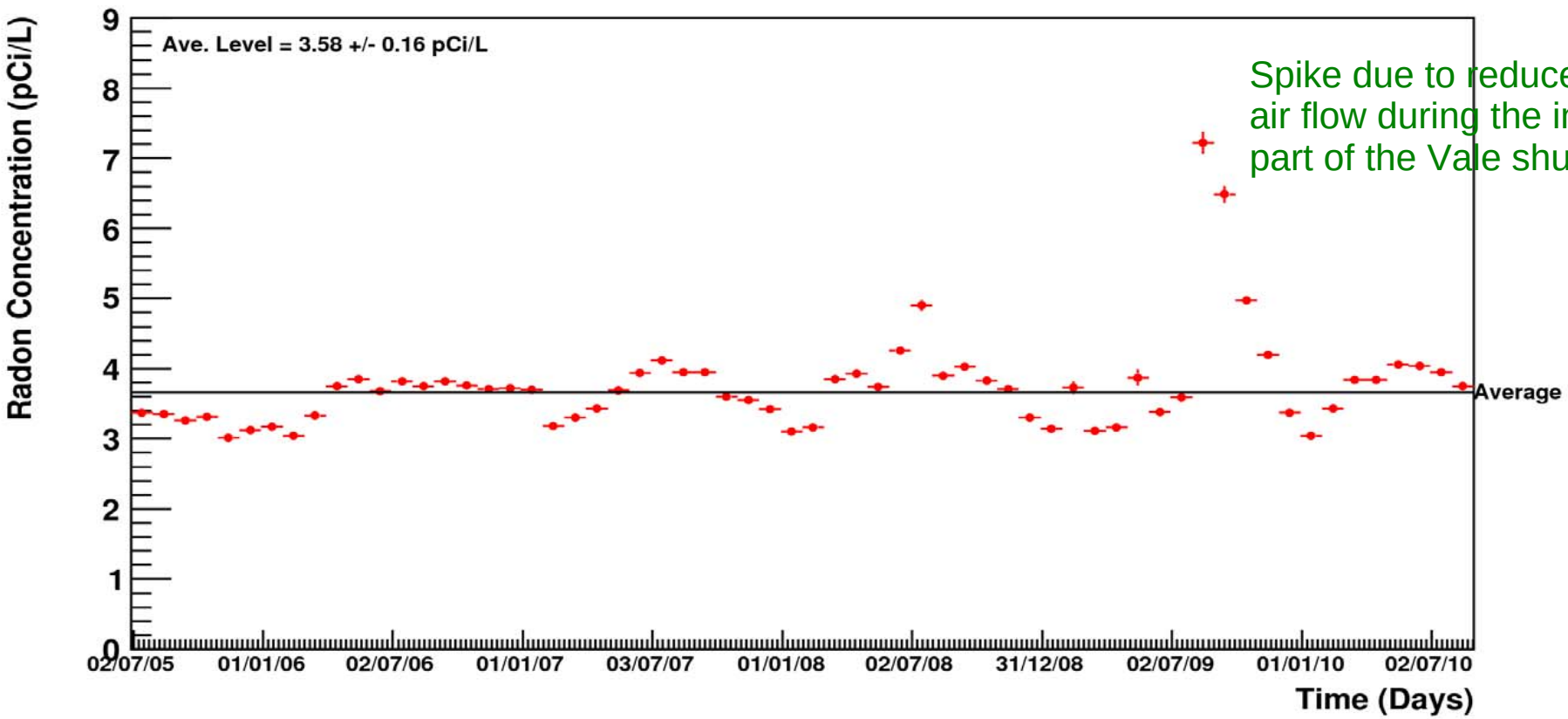
- Screening is not SNOLAB experiments only, prioritized by SNOLAB management committee.
- Occasional samples from other experiments by word of mouth or ex-collaborators.
- Fixed to about ~50/yr maximum samples due to 7-10 days need for good sensitivity on the HPGe.
- This ~50/yr rate means only about 5/yr/experiment which is a significant constraint on experiment support, allowing measurement of only critical samples. Thus there is not much capacity for diagnostic testing or much screening of potential materials. Ideally would need about 3 to 4 detectors (and staff), for good experimental support, and more to provide capacity for wider community support.
- You want to diversify detector type/configurations so the best sensitivity detectors can be used for only that purpose.

Extra information on radon levels at SNOLAB

Radon Levels at SNOLAB With Fresh Air

(Normal Laboratory Operating Conditions)

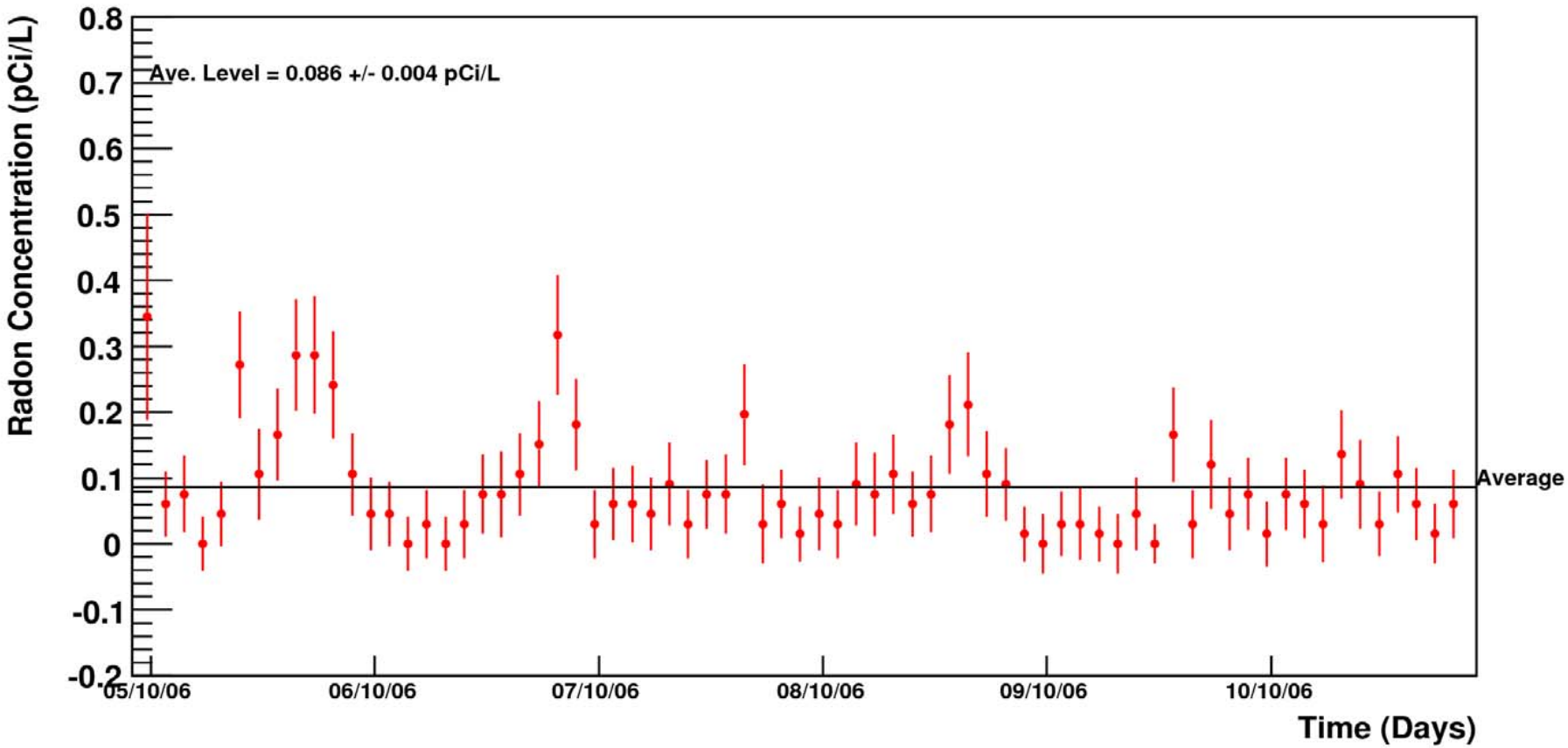
Radon continuously monitored for the several years now.
Radon levels are: 3.50 ± 0.16 pCi/L or 129.5 ± 5.9 Bq/m^3.



Achievable Radon Levels

Using Compressed Air Supplied From Surface

Radon levels: 0.086 ± 0.004 pCi/L or 3.18± 0.15 Bq/m^3.



To use this air, specialized filters have to be used to ensure that all particulate matter is removed from the air before it is used.

To achieve lower levels of radon, radon scrubbing systems would have to deployed.