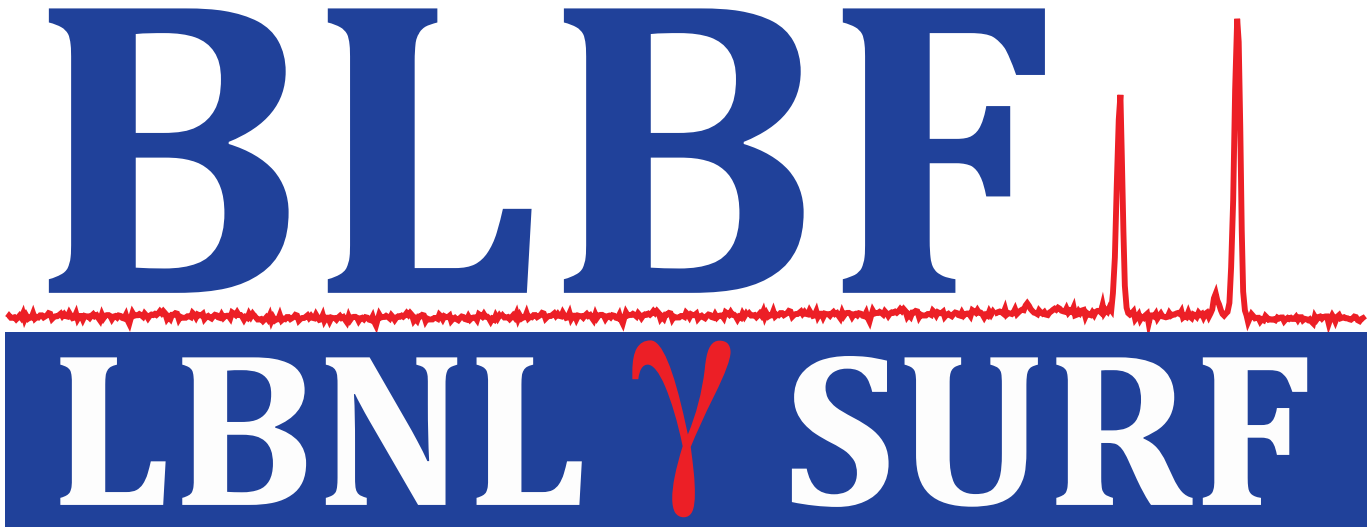


Berkeley Low Background Facility
Services and Updates

Keenan Thomas
UC Berkeley / LBNL

LRT 2015
Seattle, WA

Berkeley Low Background Facility

BLBF
LBNL γ SURF

A.R. Smith[1], A.W.P. Poon[1], Y.D. Chan[1], K.J. Thomas[1,2], E.B. Norman[1,2], K.T. Lesko[3]

[1]Nuclear Science Division, Lawrence Berkeley National Laboratory

[2]Department of Nuclear Engineering, UC Berkeley

[3]Physics Division, Lawrence Berkeley National Laboratory

SURF Science Department:
J. Heise, D. Byram, M. Hanhardt, C. Lichtenwalner

Provides low background, gamma spectroscopy services to a wide variety of projects/experiments

- passive counting for U, Th, K
  (and common man-made/cosmogenics)
- neutron activation analysis of U, Th, K or other trace elements
- neutron flux measurements (beam characterization, etc.)
- environmental measurements, waste assay, etc.

Long History of Low Background Counting

- > 60 years experience
- SNO, KamLAND, CUORE, SNO+, DoubleCHOOZ, Daya Bay, MAJORANA, KATRIN, Sanford Lab, LUX/LZ, + more.

BLBF Open to any project/experiment

Requests for service can be made at website.

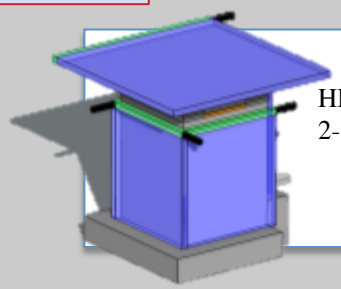
http://lbf.lbl.gov

Facilities and Equipment

Local Site LBNL	Remote Site SURF 4850 L
low activity serpentine 1.5m minimum thickness	4300 m.w.e. overburden
backgrounds dominated by cosmic ray muons, Muon Veto in use	backgrounds dominated by residual activity in detector and shielding
1 x 115% n-type & 1 x 85% p-type ORTEC GMX LLB-HJ; GEM XLB-SL [4" Pb, 0.5" OFHC Cu] N2 radon purge	1 x 85% p-type (soon to be 2x) ORTEC GEM, LLB-HJ [8" Pb, 0.5" OHFC Cu] N2 radon purge

Counting Sensitivities [for ~1kg samples]	Berkeley Site [~1 day]	SURF Site [~2 weeks]
U series	0.5 ppb (6 mBq/kg)	10 ppt (0.1 mBq/kg)
Th series	2.0 ppb (8 mBq/kg)	30 ppt (0.1 mBq/kg)
K	1.0 ppm (30 mBq/kg)	20 ppb (0.6 mBq/kg

BLBF@LBNL
surface



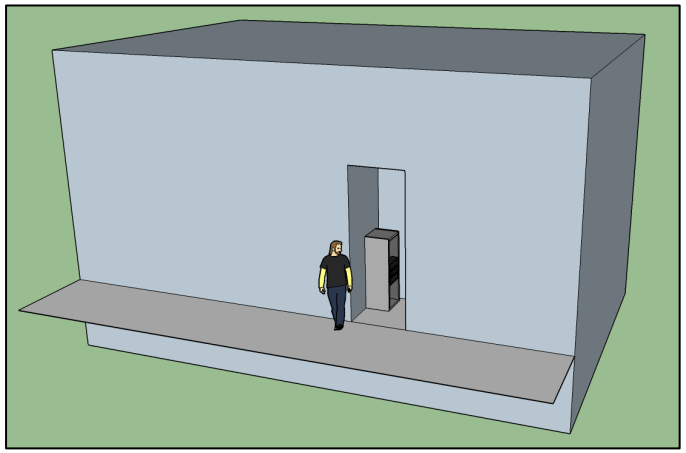
HPGe w/muon veto system
2-3 HPGe detectors in use.

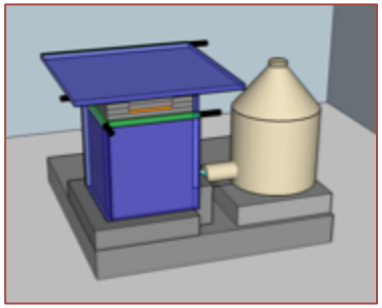
BLBF@SURF
4850L (4300 m.w.e.)

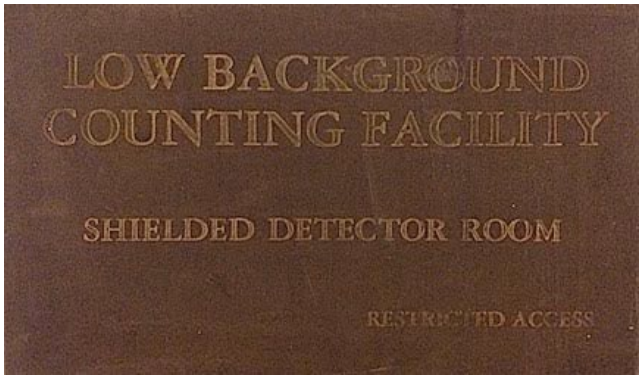
Low Background Counting: All samples are typically counted first at the surface LBNL site, where pending the results (limit or measured value; and requestor's interests) they are then sent to SURF for a more sensitive count. (prioritizes underground spectrometer for samples that actually require the sensitivity.)

Neutron Activation Analysis: Performed at LBNL site only.

Building 72 Low Background Cave



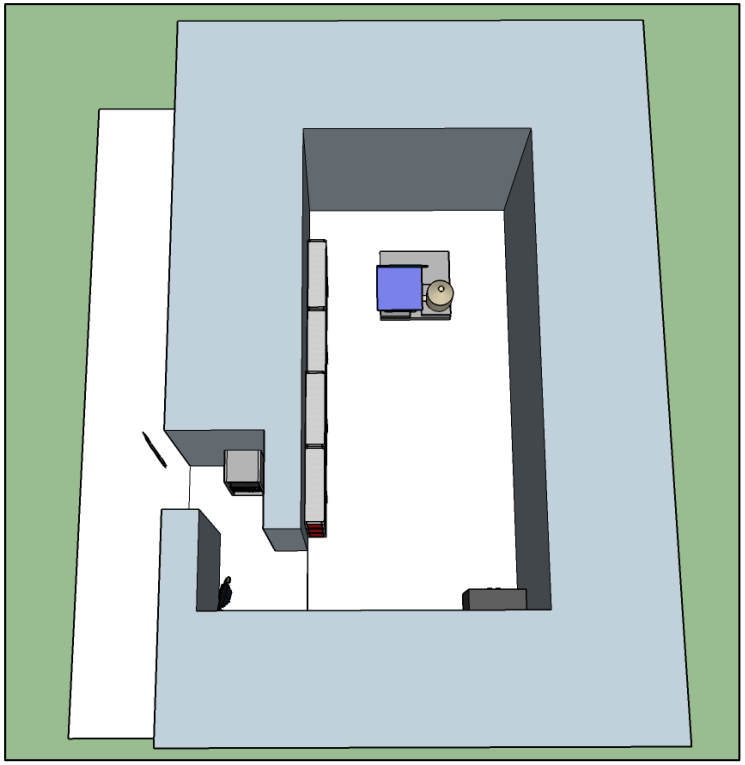




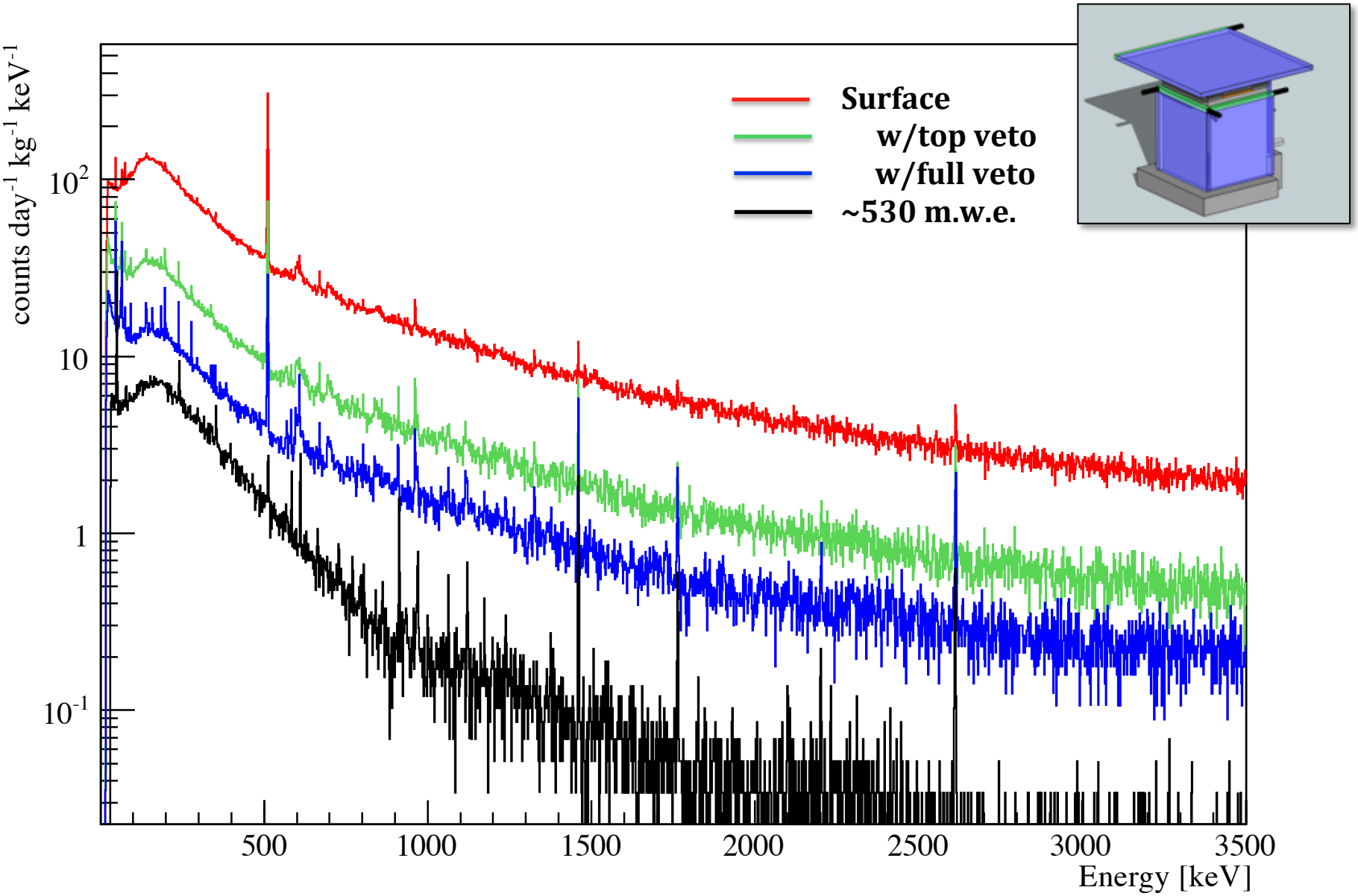
- 500 ton, *single-pour* of Low Activity Concrete
  - Portland Cement, Serpentine
  - ~ 10^3 lower than average for U/Th/K content
- Cave constructed in 1962 by A.R. Smith and H.A. Wollenberg
- Location chosen to be suitably far from Bevatron
- Surveyed hundreds of source materials from around the country

- Inner space: 3.5 m x 7 m x 3.5 m ceiling height
  Outer walls are all 1.5 ~ 2 m thick

- Detectors:
  - 115% n type, w/muon veto (MERLIN)
  - 85% p type, (BIG8)
  - BF3



Muon Veto System



Relocating from Oroville, CA to SURF

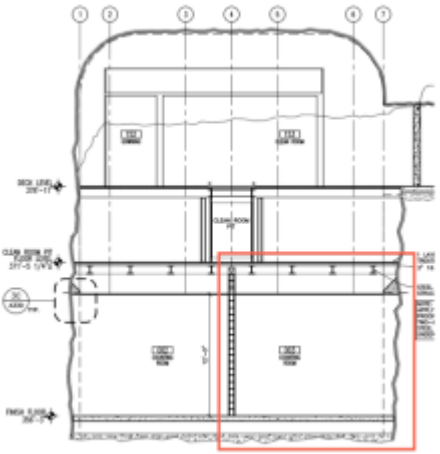
Remote BLBF counting site (at Oroville) relocated to SURF:

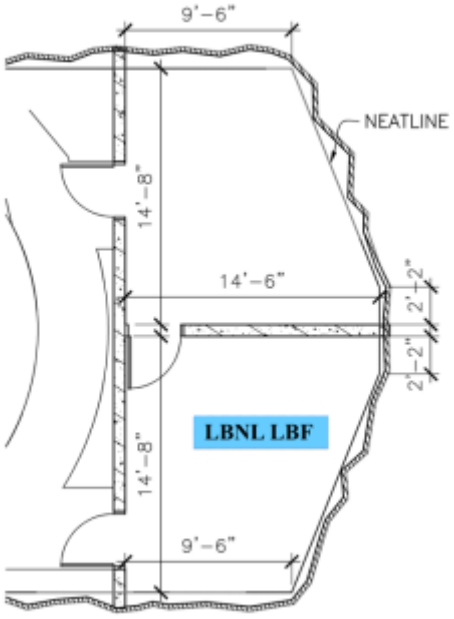
< 6 months total

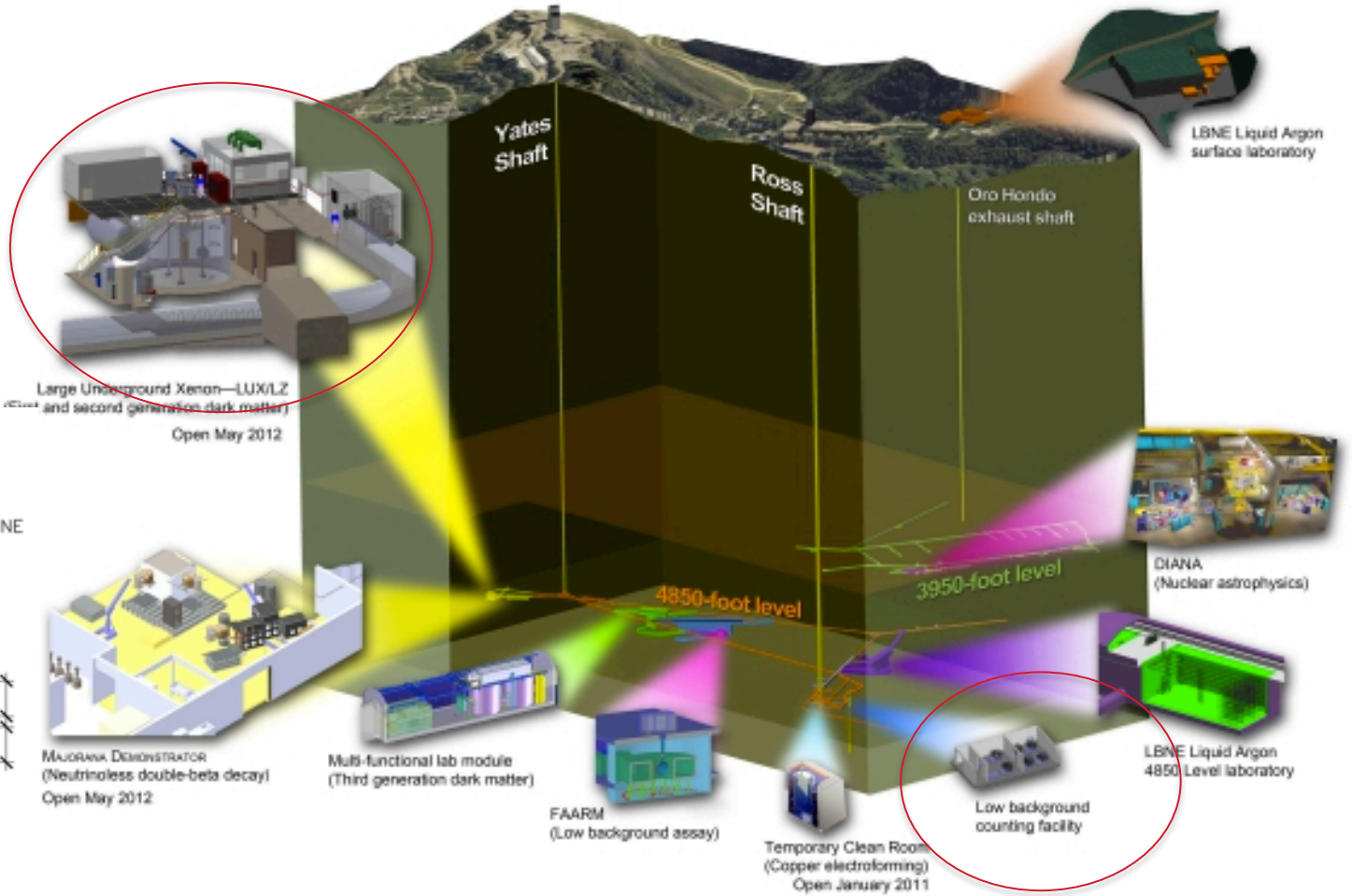
- **Feb 1, 2014:** End of counting operations at Oroville Dam (originally the UCSB/LBL double-beta experiment site from late 1980's).
- **Early March 2014**: Detector relocated to SURF
- **Late March**: Oroville Site decommissioned, shielding and equipment shipped to SD.
- **May 2014**: Detector and shielding installed underground at SURF.
- **June 2014**: Background testing and equipment diagnostics.
- **July 1, 2014**: Counting station back online for receiving of samples.

BLBF counting room on the 4850L of SURF

BLBF Located in the East Counting Room of the Davis Cavern on the 4850L.
(Adjacent to LUX)







4850L ~4300 m.w.e.

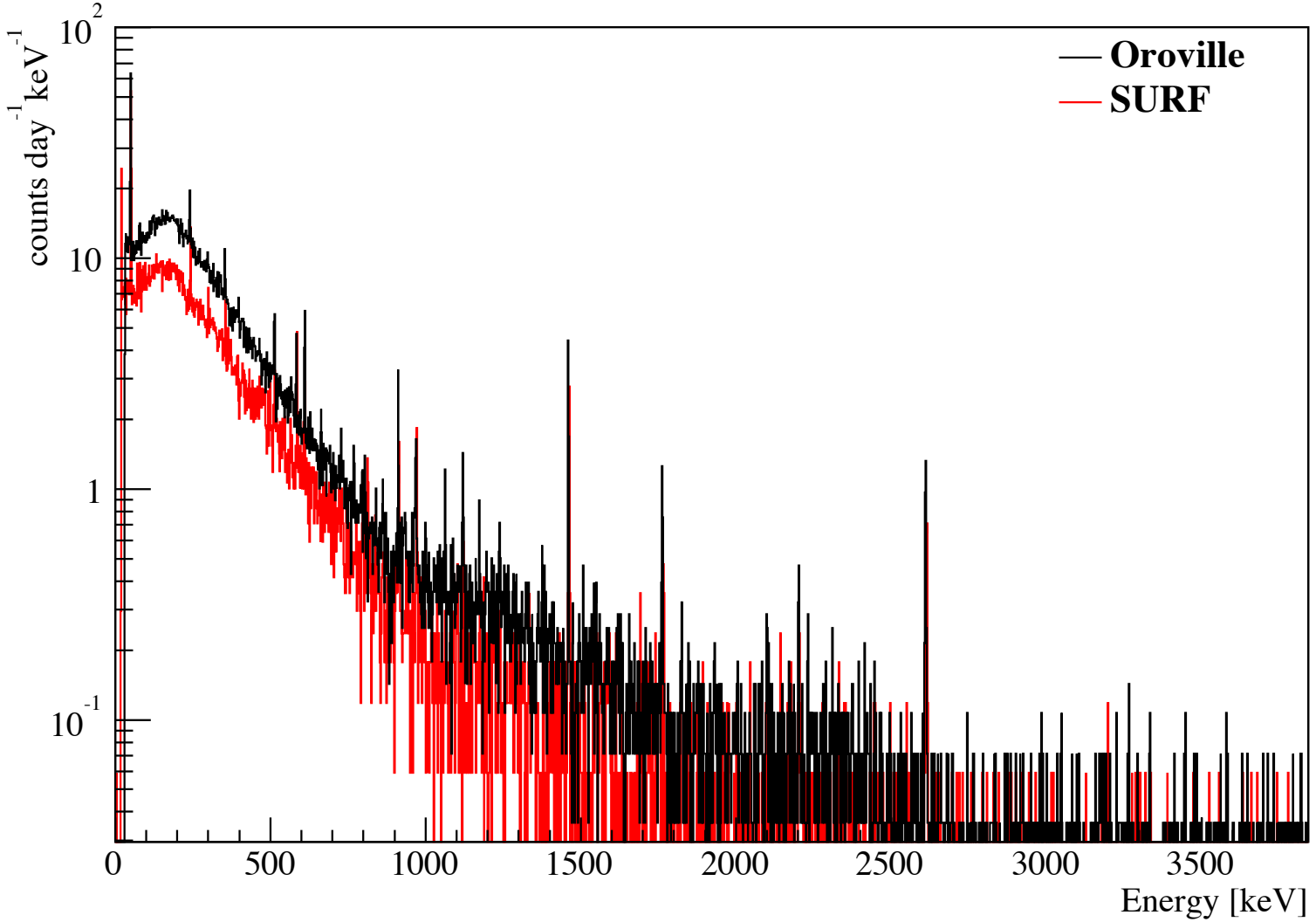
August 2015
Relocate to dedicated Counting lab

BLBF counting room on the 4850L of SURF

BLBF counting room on the 4850L of SURF

Backgrounds at SURF

Backgrounds Reduced in re-installation at SURF.



Comparison of backgrounds at Oroville and SURF. The backgrounds at SURF are ~30% *lower* than Oroville, due to shield configuration improvements.

First Underground Samples (Post Relocation)

First Sample Results – MAJORANA Ag epoxy

		2013 Oroville	2014 SURF
mass	g	62.1	56.5
U	ppb	< 1	< 0.8
Th	ppb	< 3	< 2.2
K	ppm	< 2	< 1.4
^{238}U	mBq/kg	< 12	< 10
^{232}Th	mBq/kg	< 12	< 8.9
^{40}K	mBq/kg	< 62	< 43
^{108m}Ag	mBq/kg	23(4)	20(2)
^{110m}Ag	mBq/kg	15(3)	17(3)

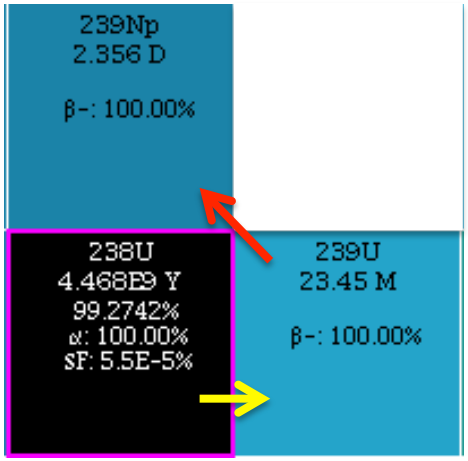
Second Sample Results – LZ Titanium plate

U_e:	0.65(15)	ppb U
U_l:	< 0.01	ppb U
Th:	< 0.03	ppb Th
K:	< 20	ppb K
^{46}Sc:	2.1(1)	mBq/kg
^{44}Ti:	0.09(3)	mBq/kg

Neutron Activation Analysis

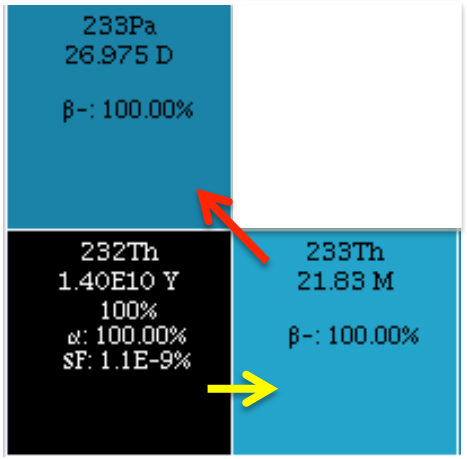
Perform irradiation of samples at either MNRC, MIT, others.

- Ship back to LBNL for counting and analysis.
- Performed several irradiations in 2014
  - Established timely procedures for samples



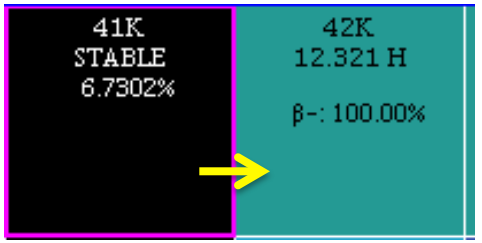
Use of standard monitors to either directly monitor the activation of an isotope of interest, or measure flux.

- Use of ratio method for measuring concentrations
  --cancels out systematic uncertainties (flux, efficiencies, etc.)



<u>Sensitivity-</u> *<u>Your mileage may vary…</u>*

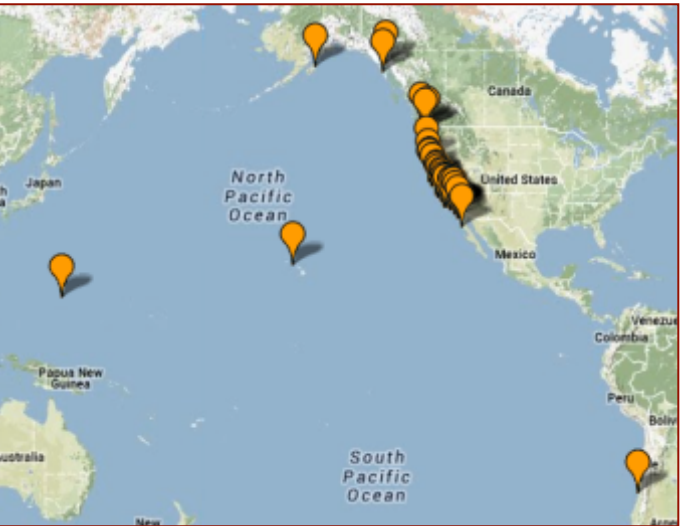
- Often limited by either bulk material composition or contaminants
- Common competing isotopes in samples lately have been ^{82}Br, ^{24}Na, ^{198}Au, ^{187}W, etc.

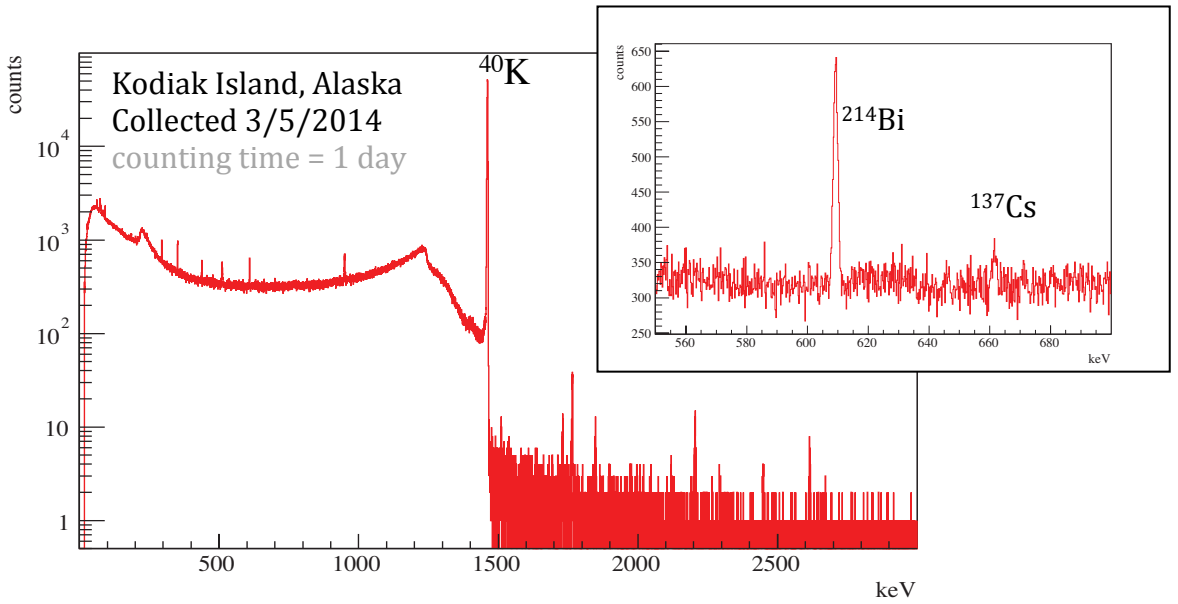


Environmental Monitoring

http://kelpwatch.berkeley.edu

Project PI:
Steven Manley, CSULB
Analysis and Reporting:
Kai Vetter, UCB/LBNL
Mark Bandstra, LBNL
Al Smith, LBNL
Keenan Thomas, UCB/LBNL





- Quell rumors and reports of Fukushima radiation being a significant problem for Pacific Coast of North America.
- Educate public on natural radiation
- Always report ^{40}K, ^{7}Be, U and Th series, etc. for context.
- No definitive evidence of Fukushima related isotopes yet over BKG.

isotope	Bq/kg (dry)	
^{40}K	1900 - 4600	3370
U early	16 – 760	135
U late	0.3 – 4.0	1.8
Th early	0.1 – 5.0	1.0
Th late	0.05 – 1.2	0.3
^{7}Be	0.75 - 45	4.0

isotope	Bq/kg (dry)
^{137}Cs (legacy)	0.10 - 0.50
^{134}Cs	< 0.04
^{131}I (medical)	1 – 250

NaI Compton Suppressor

- 10.1 kg, annular NaI detector (square w/inner well for HPGe)

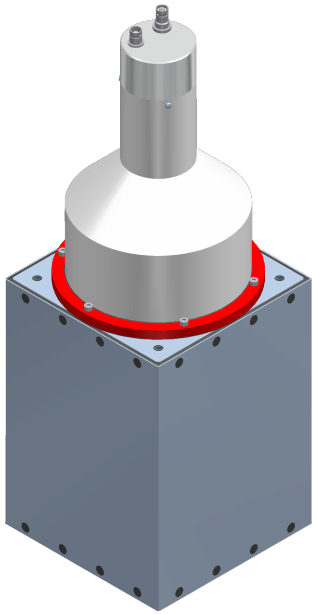
- For general use in:
  - passive counting
  - neutron activation analysis
  - coincidence measurements

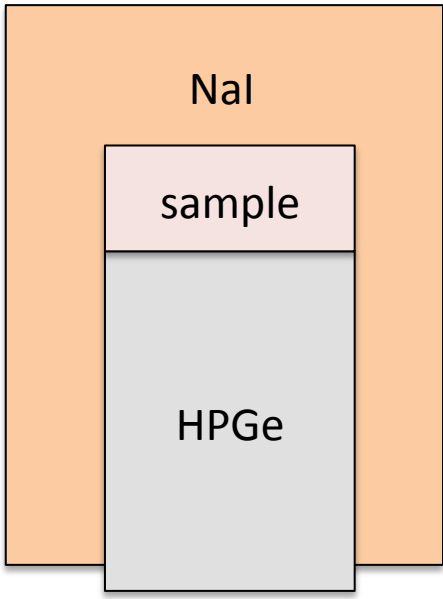
- Designed to fit over MERLIN (and a variety of other HPGe detectors used at LBL)

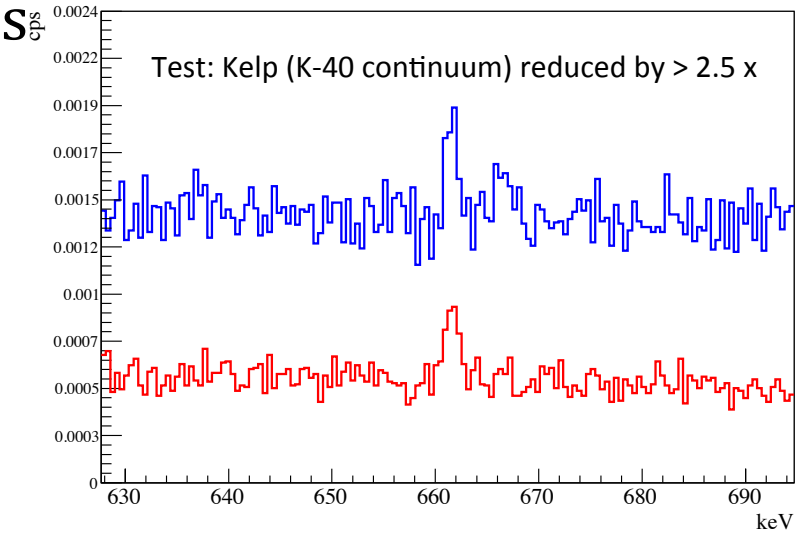
- Designed to fit inside existing shielding

- NaI provides ~3.9pi coverage of sample (by itself)

Master's project for A. Gillick







Neutron-Related Services

The BLBF has often performed various neutron related services to experiments and Projects

- Often in the form of exposure foils for beam characterizations, flux measurements, etc.

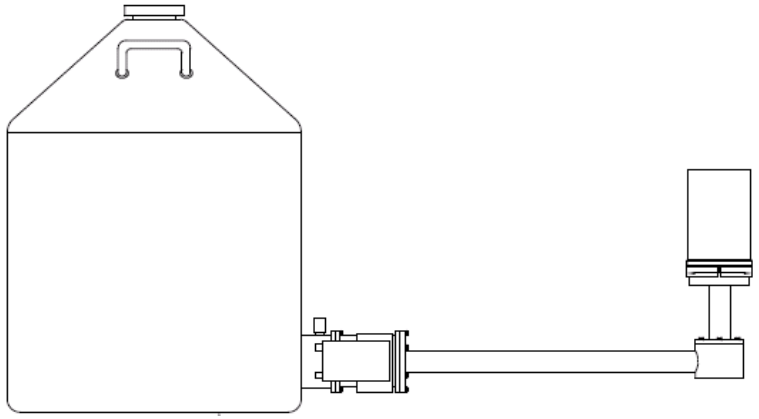
Recent Example of some Neutron Counting:

Cross Calibration of LUX AmBe source (a,n)

- Low emission rate (~100 n/s)
- Tough to predict based on alpha activity
  (really need to measure the n's directly or 4.4 MeV gamma since alpha activity and neutron emission rate are quite sensitive to minor geometric differences)
- Counted at LBNL using several methods (BF3, NaI, foils)
- Cross calibrated with NIST traceable sources

(near) Future

Relocation to the Black Hills Underground Campus at SURF



- To take place in August of 2015
- Dedicated LBC room

Refurbishment of a 2nd detector for underground -- MORGAN

- Twin detector of MAEVE (same size, also a p-type).
- Undergoing a similar conversion process as MAEVE, from a PopTop cryostat to a Low Background HJ
- Will be first installed in BHUC, later followed by MAEVE (staggered) so as not to create any counting outages.
- Several custom upgrades: Au contacts (~~In~~), Syn. Sapphire (~~alumina~~) insulators, HP Al cup (~~OFHC cu~~), 5" length extension to bury deeper in Pb.
- Shield will incorporate existing Old Pb stock. (from the ~1700's)
- Detector expected to provide as good (or better) sensitivity as MAEVE, but more importantly will double our u/g counting capacity.

Summary

The Berkeley Low Background Facility is an active screening facility specializing in low background gamma spectroscopy.

Provides measurements of:

- Passive (low background) counting of U, Th, K or other radioisotopes for physics projects.
- Neutron activation analysis for U,Th,K or other trace elements of interest.
- Neutron beam, foil activation measurements.
- Environmental Monitoring, Waste Assay, etc.

Open to any project/experiment.

Thank You

BLBF
LBNL γ SURF

Visit us at
http://lbf.lbl.gov

Special thanks to OHEP for assisting with relocation.

We acknowledge various support from the DOE Offices of Nuclear Physics, High Energy Physics, and NA22.

BERKELEY LAB
Lawrence Berkeley National Laboratory

Berkeley Nuclear Engineering
UNIVERSITY OF CALIFORNIA

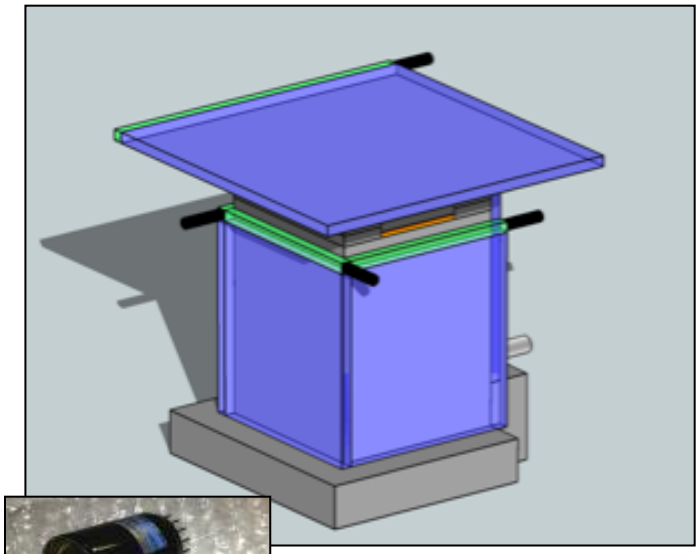
Sanford Underground Research Facility

NSSC 7
NUCLEAR SCIENCE and SECURITY CONSORTIUM

This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number(s) DENA0000979 and by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of Nuclear Physics, of the US Department of Energy under Contract No. DE-AC02-05CH11231.

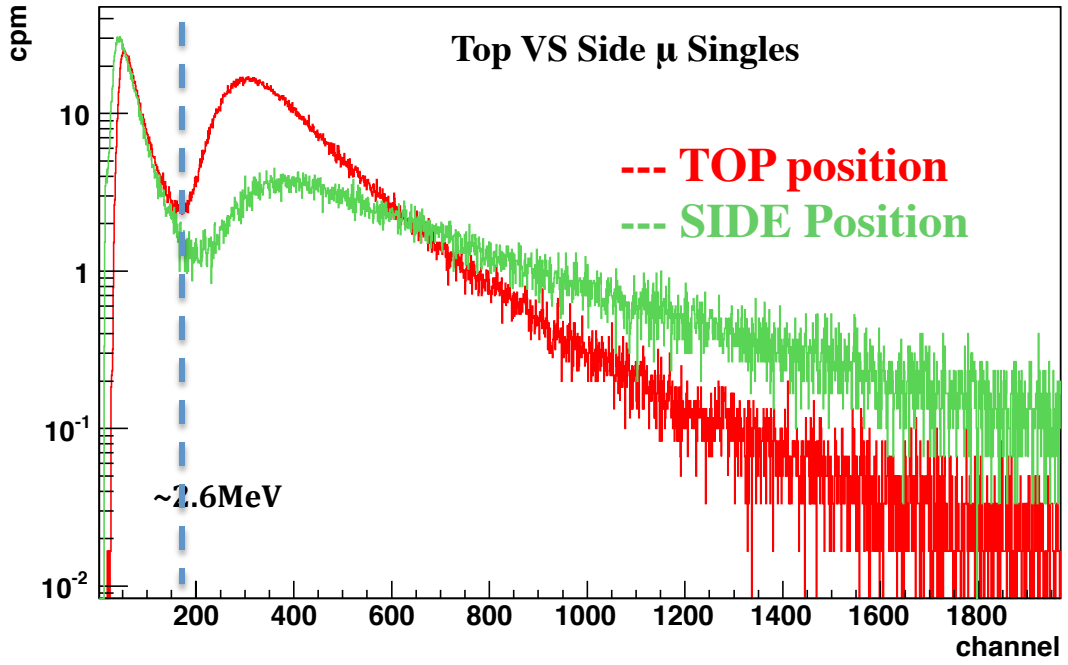
Backup slides

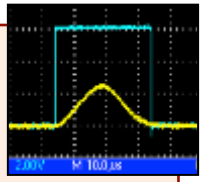
Muon Veto System



Scintillators from Eljen Technologies

1" Hamamatsu PMT (R1924A)

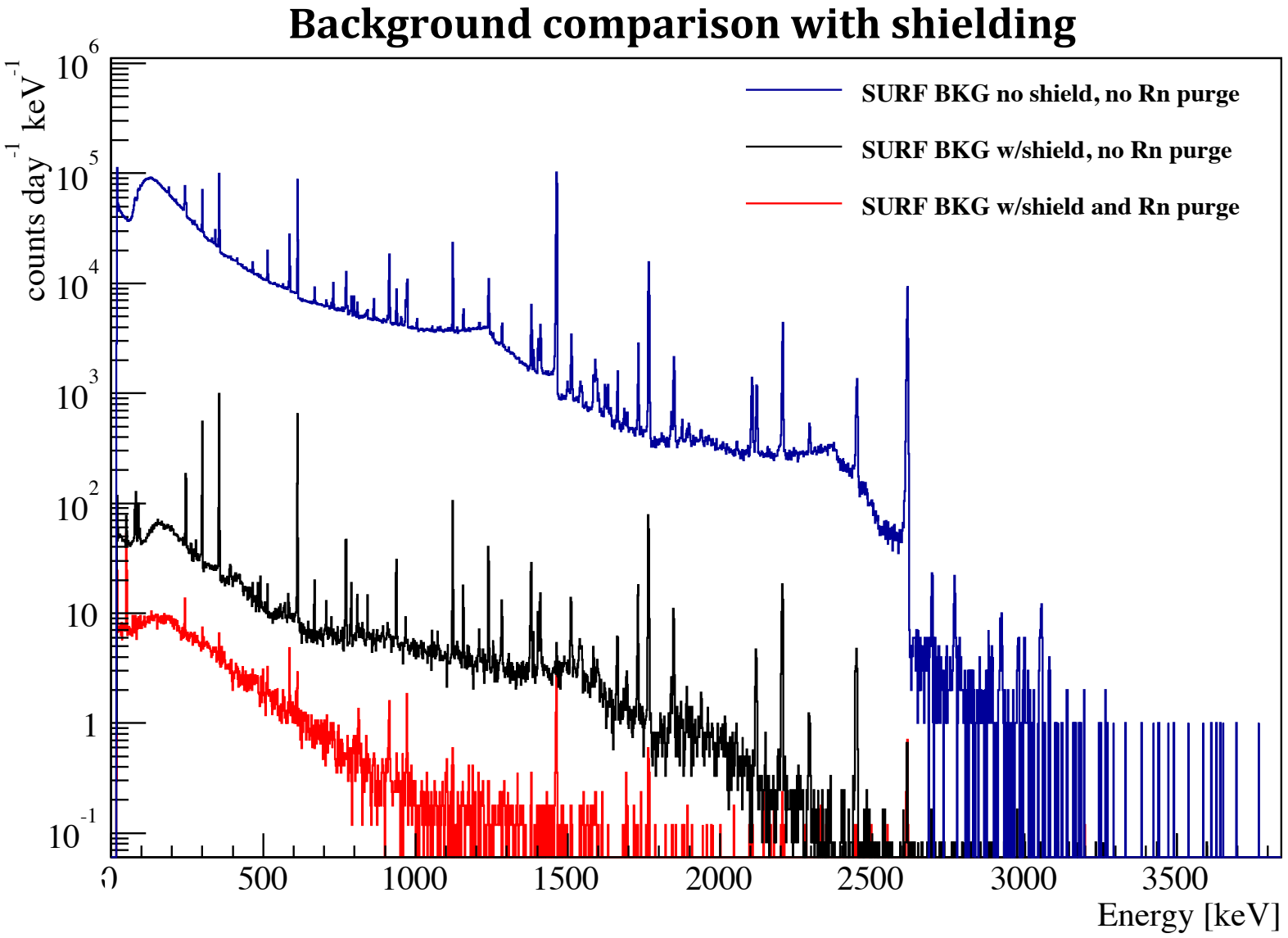




Design Criteria:

- convenient & non-cumbersome for daily use
- simple, stable operation
- Threshold set by separation of gamma and muon separation in scintillator energy spectrum
- Signals over threshold generate logic gate
- Veto rate is stable regardless of threshold and gate length settings, and has a very simple and reliable operation.
- Low external gamma background in LBF counting lab makes this very easy-- false coincidences of 2614 keV gammas aren't an issue even if the threshold is set a little low.

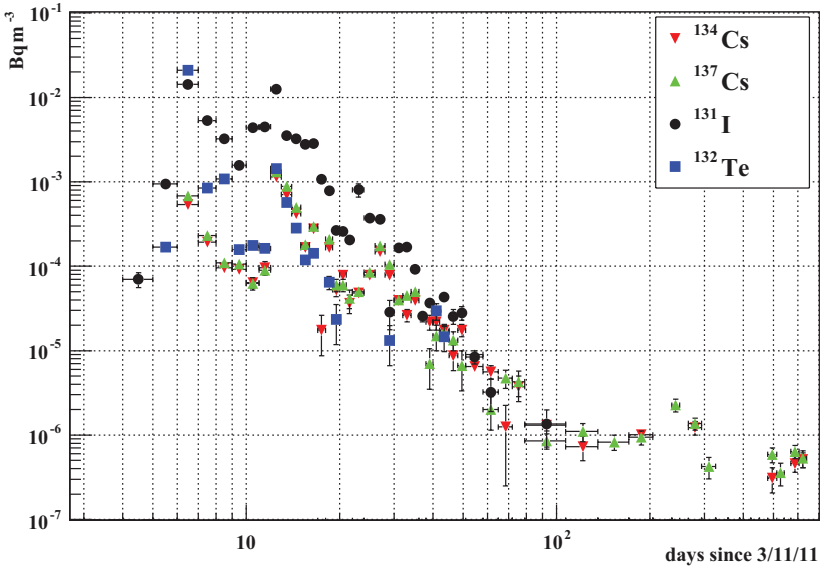
Backgrounds at SURF



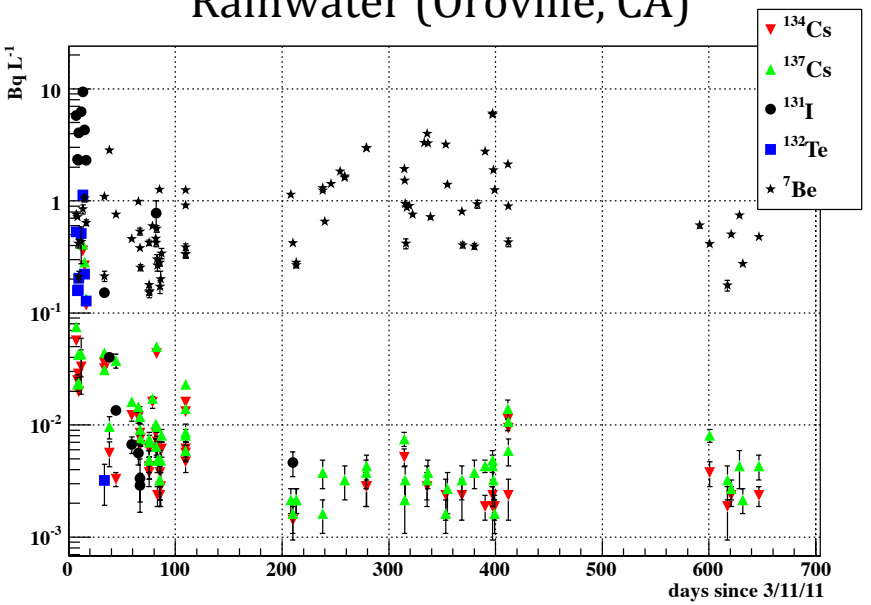
Detector backgrounds in the detector at SURF
--without shielding (top), with shielding (middle), and last with a nitrogen radon purge running (bottom).

Environmental Monitoring

Air Sampler HEPA Filters (LBNL)

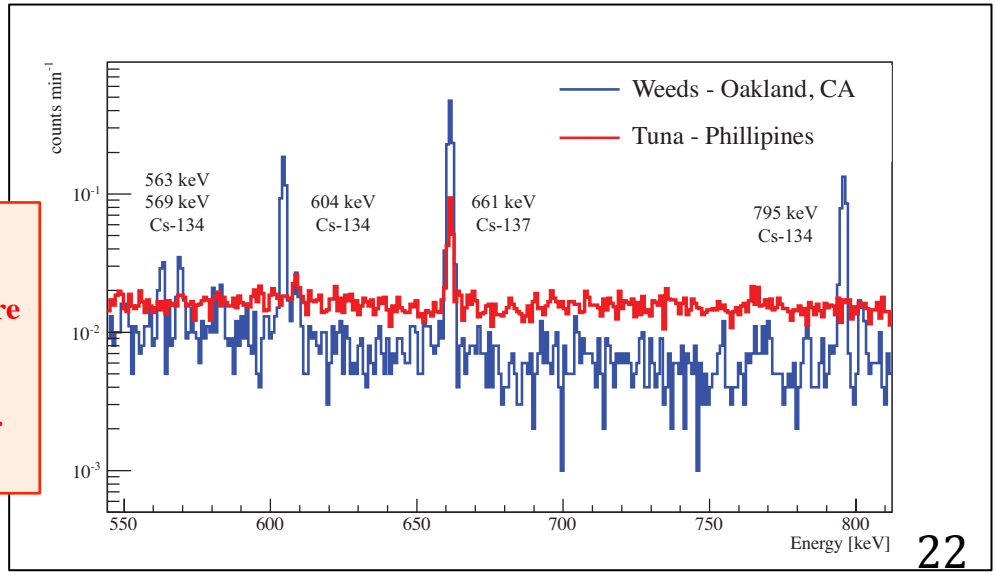


Rainwater (Oroville, CA)



Summary of Fukushima related measurements through the end of 2012 posted.
Including air filters, automobile filters, soil, rainwater, and a set of 2013 samples of seafood.
(open access journal)

Over 1200 automobile filters counted since 2002 with no trace of man-made radioactivity before Fukushima.
The Fukushima Incident provided a proof-of-principle for monitoring method.



A. R. Smith, et al., Journ. Environ. Prot. 5, 207 (2014)

KelpWatch 2014

http://kelpwatch.berkeley.edu

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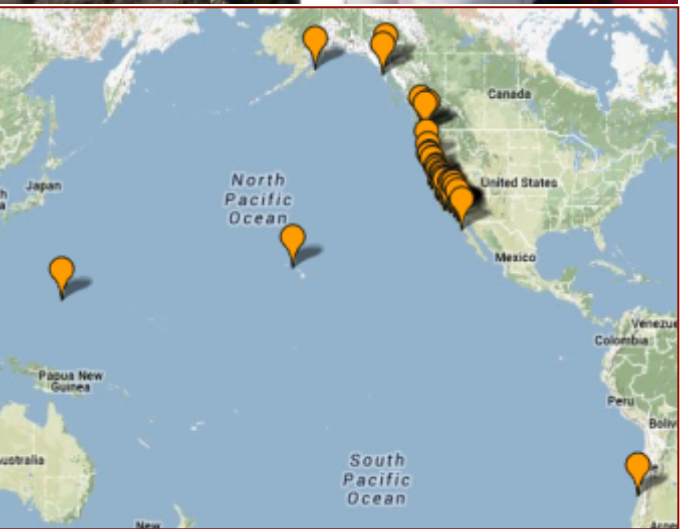

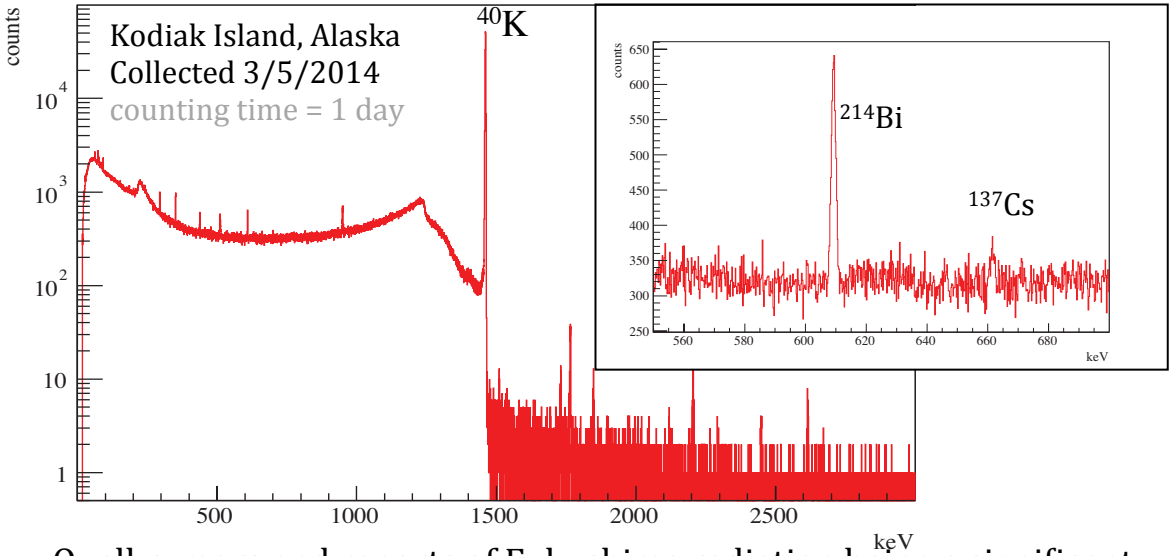

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