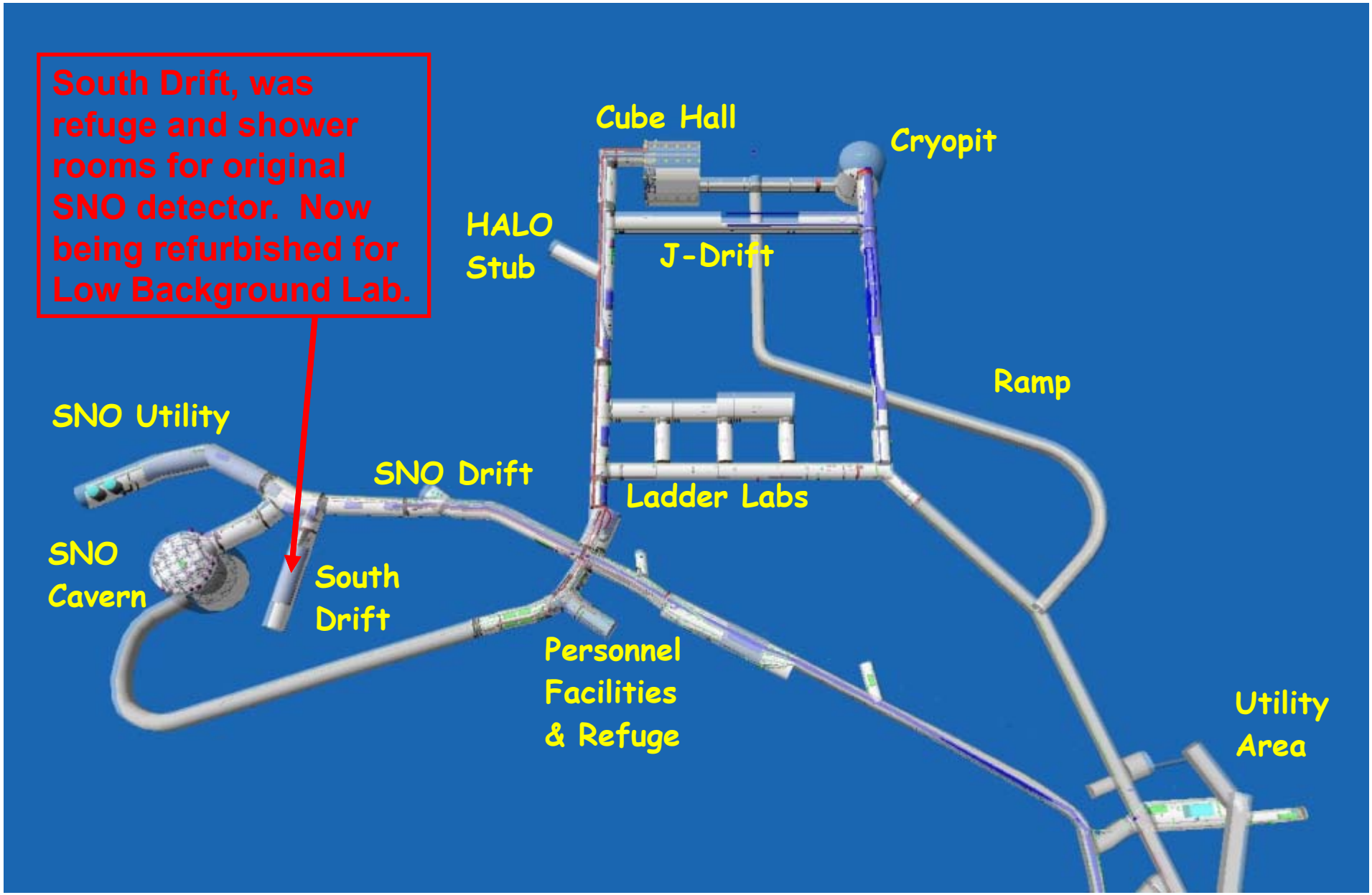
Status and Planning for SNOLAB Low Background Laboratory (LBL)

Richard Ford (SNOLAB)

Future Projects Low Background Meeting (Sudbury)

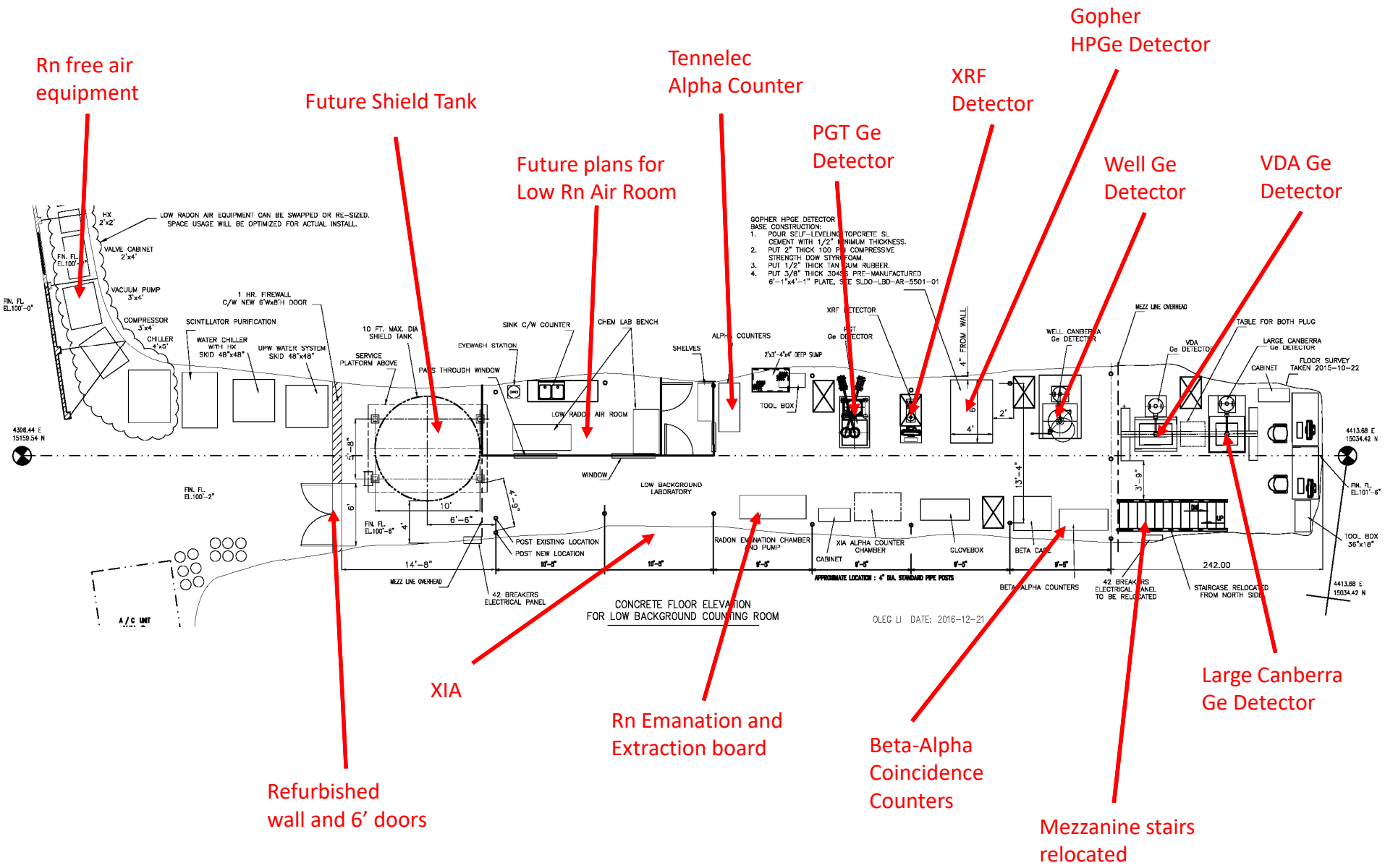
17th July 2019

SNOLAB Underground Facilities



South Drift Today

South Drift Plan for LBL



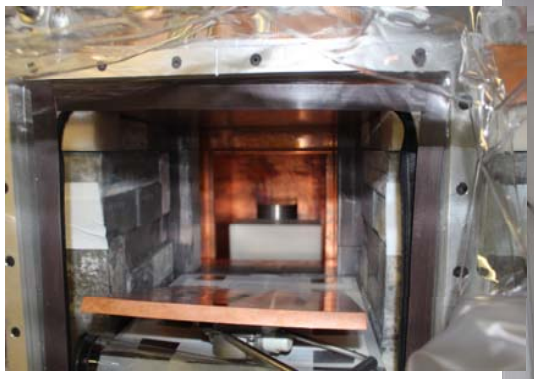
Ge Detectors

PGT

Canberra Well

Canberra Coaxial

VDA HPGe



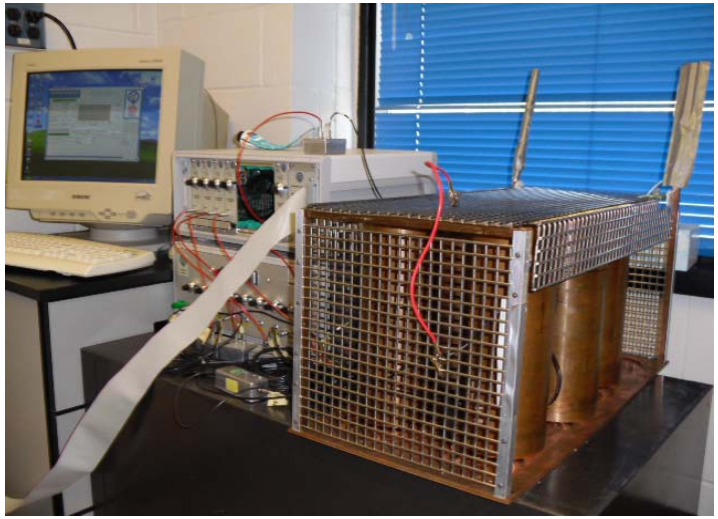
Gopher HPGe

Radium Assay

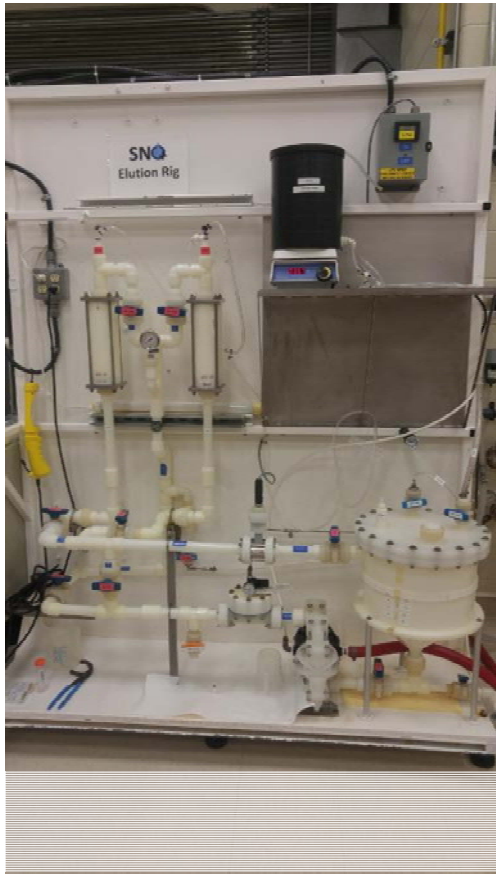
Transparent liquid scintillator vials optically coupled to 2” PMTs.

The technique is combination of pulse shape discrimination and coincidence counting for identifying BiPo events.

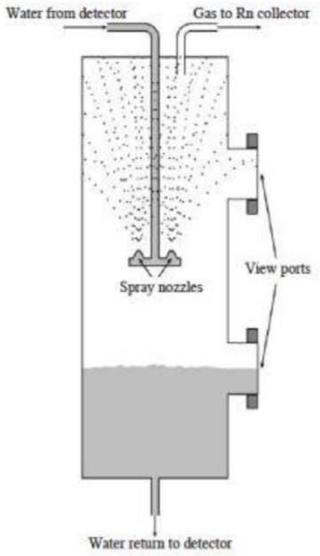
Sensitivity for ^{238}U and ^{232}Th is ~1 mBq assuming that the chains are in equilibrium.

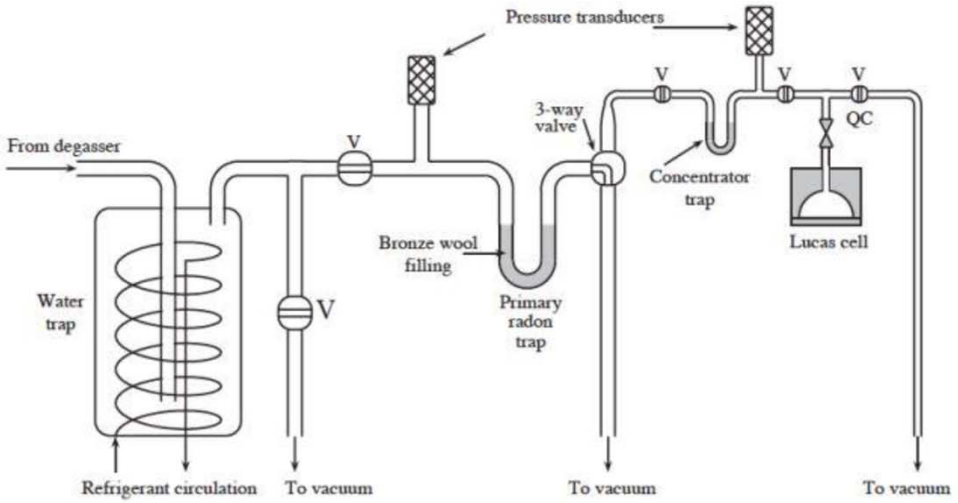


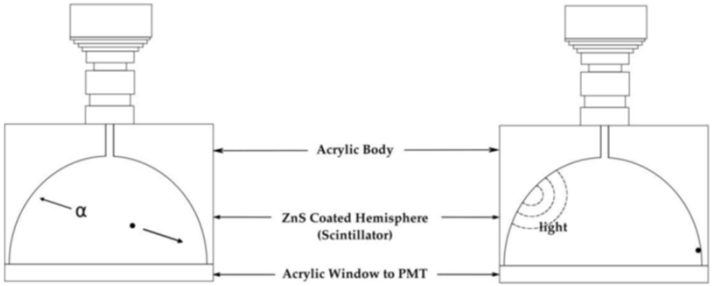
HTiO columns to trap radium for leach measurments or on-line UPW assay

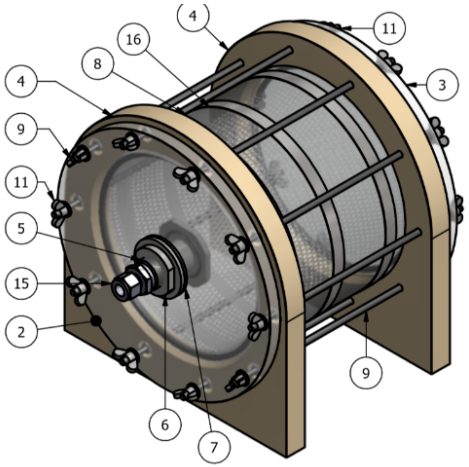


Rn Assay (Lucas cells)









Radium/Radon Assay
Electrostatic Counting System (ESCs)

9 counters located at SNOLAB,
1 on loan to LBL (EXO),
1 on loan to U of A (DEAP).

Originally built for SNO, now used primarily by EXO. However, these counters are owned by SNOLAB so samples can be measured for other experiments.

Measures ^{222}Rn, ^{224}Ra and ^{226}Ra levels. The technique involves recirculation of low pressure gas from sample volume to the ESC.

Sensitivity Levels are:

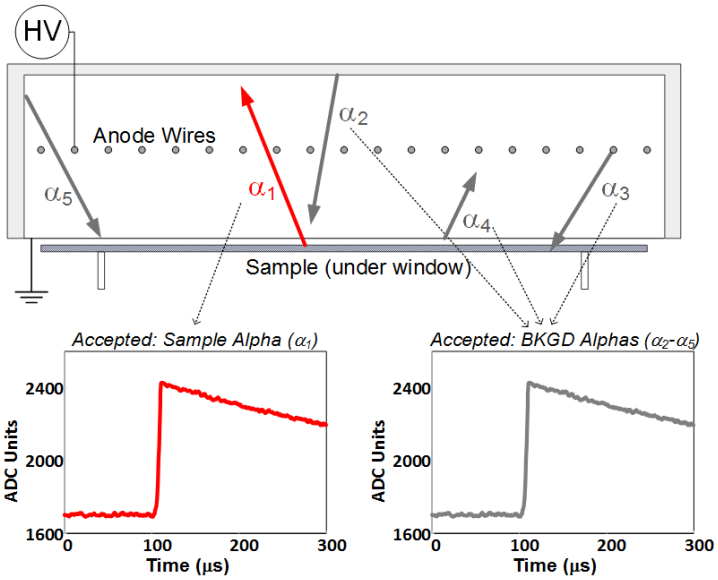
^{222}Rn: 10^{-14} gU/g

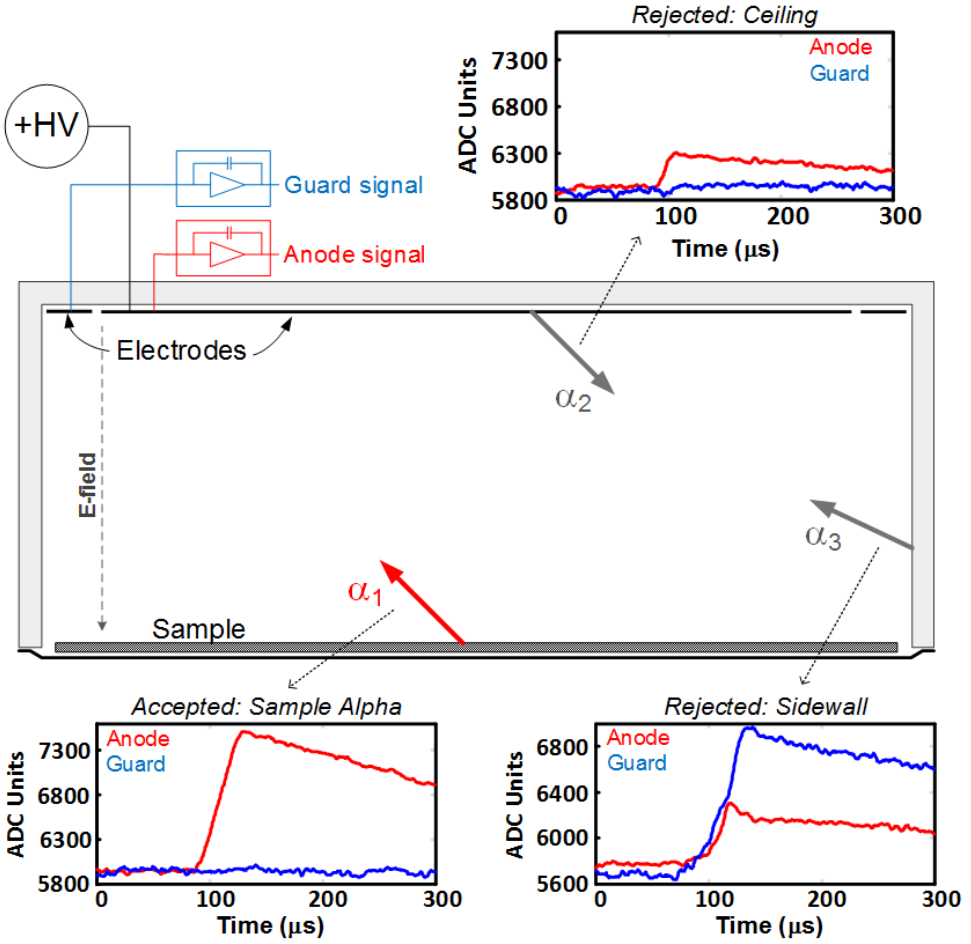
^{224}Ra: 10^{-15} gTh/g

^{226}Ra: 10^{-16} gU/g

Work is ongoing to improve sensitivity even further.

XIA Alpha Counter

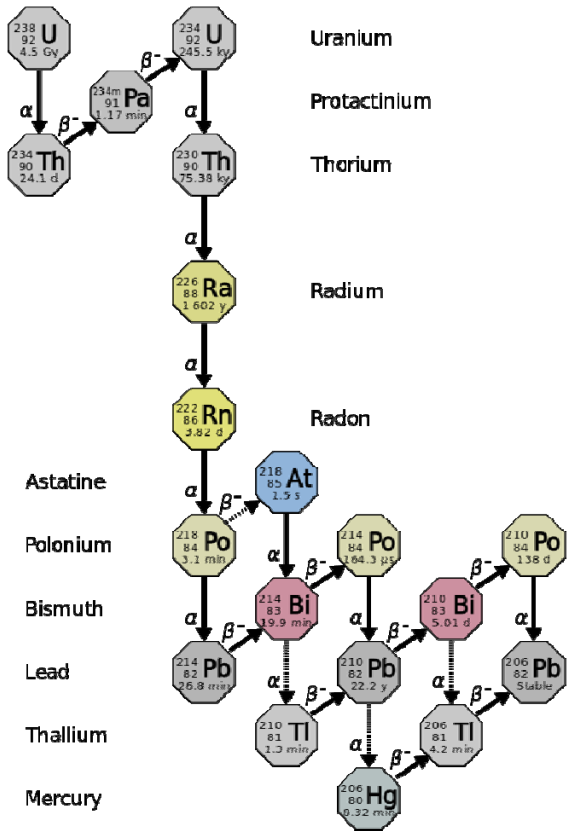




Current Capabilities

- PGT Ge Detector
  - 210 cm^3, 83mm endcap, 1.8 KeV FWHM, shield 2” Cu + 8” Pb
- Canberra Well Ge Detector
  - 300 cm^3 with 3ml well sample volume
- Canberra Large Ge Detector
  - Coaxial 400 cm^3, shield 3” Cu + 4” LB-PB + 6” Pb
- Gopher HPGe Detector (SuperCDMS)
  - 2.0 Kg P-type coaxial, 2” OFHC Cu + 2” LB-Pb + 8” Pb
- XIA Alpha Detector
  - UltraLo-1800, < 0.0001 alpha/cm2/hr
- VDA Ge Detector (EXO)
  - Coaxial from U. Bern, 400 cm3, shield 6” Cu + 6” Pb
- XRF detector
  - From SNO, developed for dust sample counting (Fe, Ca, Zn)
- Tennelec Alpha Counters
  - With front glove box
- Beta-Alpha PSD Coincidence Counters (currently on surface)
  - From SNO developed for Ra counting in liquid scintillator
- Electrostatic Counters (ESCs) - (currently on surface)
  - With low pressure N2 recirculation for Rn and Ra counting.
- Radon Emanation and Extraction Board
  - Small Marinelli shaped chamber – to be rebuild with large chamber
- Liquid particle counting – process systems high-purity cleaning evaluation

Future Low background Counting



Three segments in the chain:

1) ^{238}U – ^{226}Ra
   - Very long half-lives – chemical analysis
2) ^{222}Rn – ^{214}Po
   - Rn diffuses into gas and liquids
   - ^{214}Bi High energy gammas (^{212}Bi in Th)
   - Source of long term ^{210}Pb
   - Rn assay (electrostatic, Lucas cells)
   - Bi-Po counting (beta-alpha coincidence)
3) ^{210}Pb – ^{206}Pb
   - ^{210}Bi 5-day HF (beta Q=1.16MeV)
   - ^{210}Po 138 HF (5.3MeV alpha, 0.8 MeV gamma)
   - Beta-cage screening
   - Lower background HPGe's, or other higher efficiency gamma counting (liquid scintillator?)

Natural breaks in the equilibrium:

- Radium (ionic, leaches easily)
- Radon (gas with 4 day half-life)
- ^{210}Pb

Strategy for Future LBL Capabilities

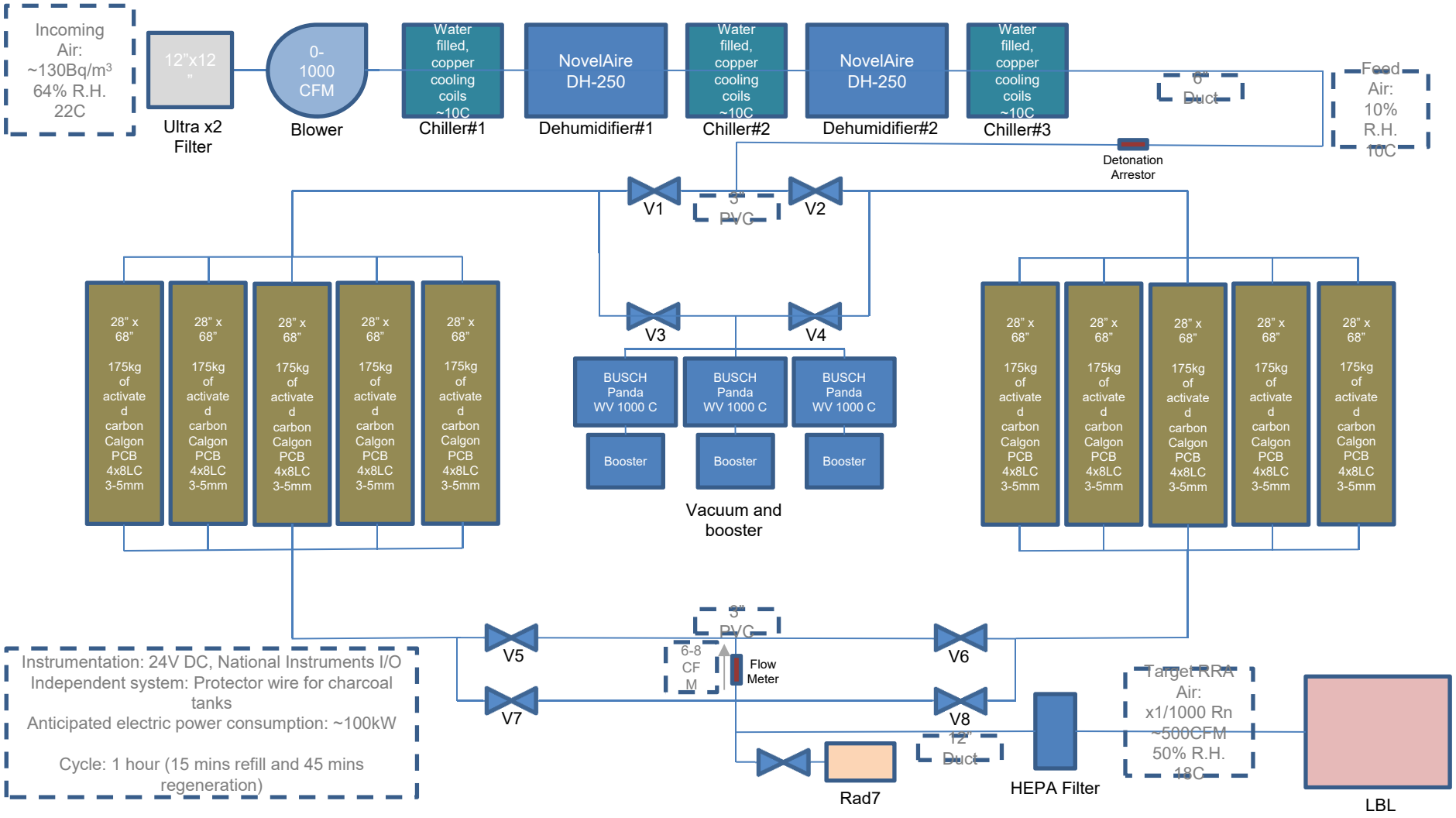
- Facility development in conceptual design:
  - Low Radon Air (LRA) Plant (500 cfm)
  - Cleanroom within the LBL w/LRA
  - Whole LBL ventilated with LRA
  - Test shielding tank
  - Clean machine shop techniques

- Investigating capabilities:
  - Electroforming (mandrel plate, coating deposition, raw stock -> 3D printing)
  - Crystal growth for novel crystals R&D
  - Nano-fabrication (detector fabrication)

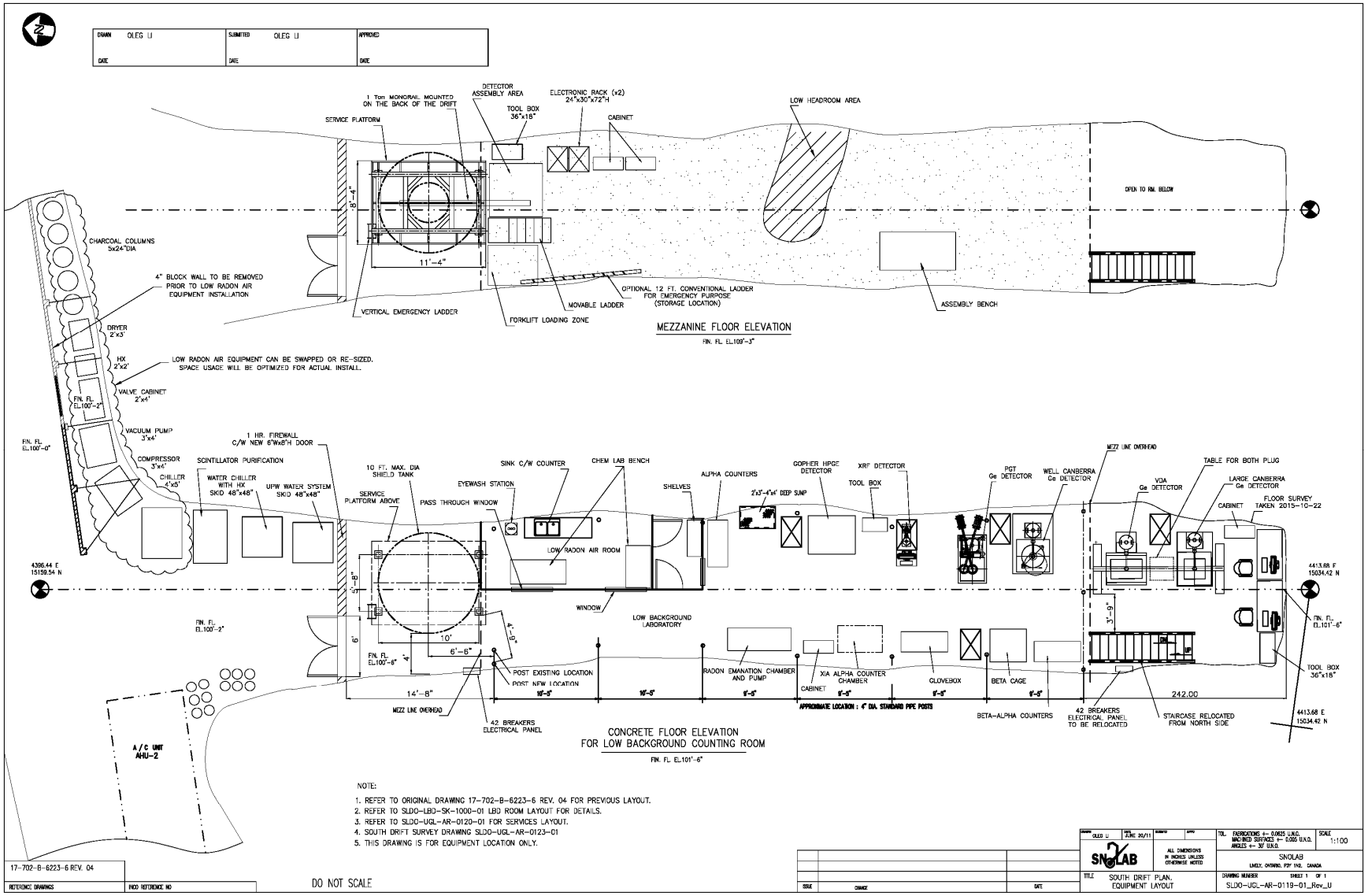
- New detectors:
  - BEGe
  - Beta Cage
  - Full immersion liquid scintillator
  - Other ideas …..

- Low background screening coordination:
  - www.radiopurity.org expanded coordination and service functionality
  - LRT and LRT website as resource portal

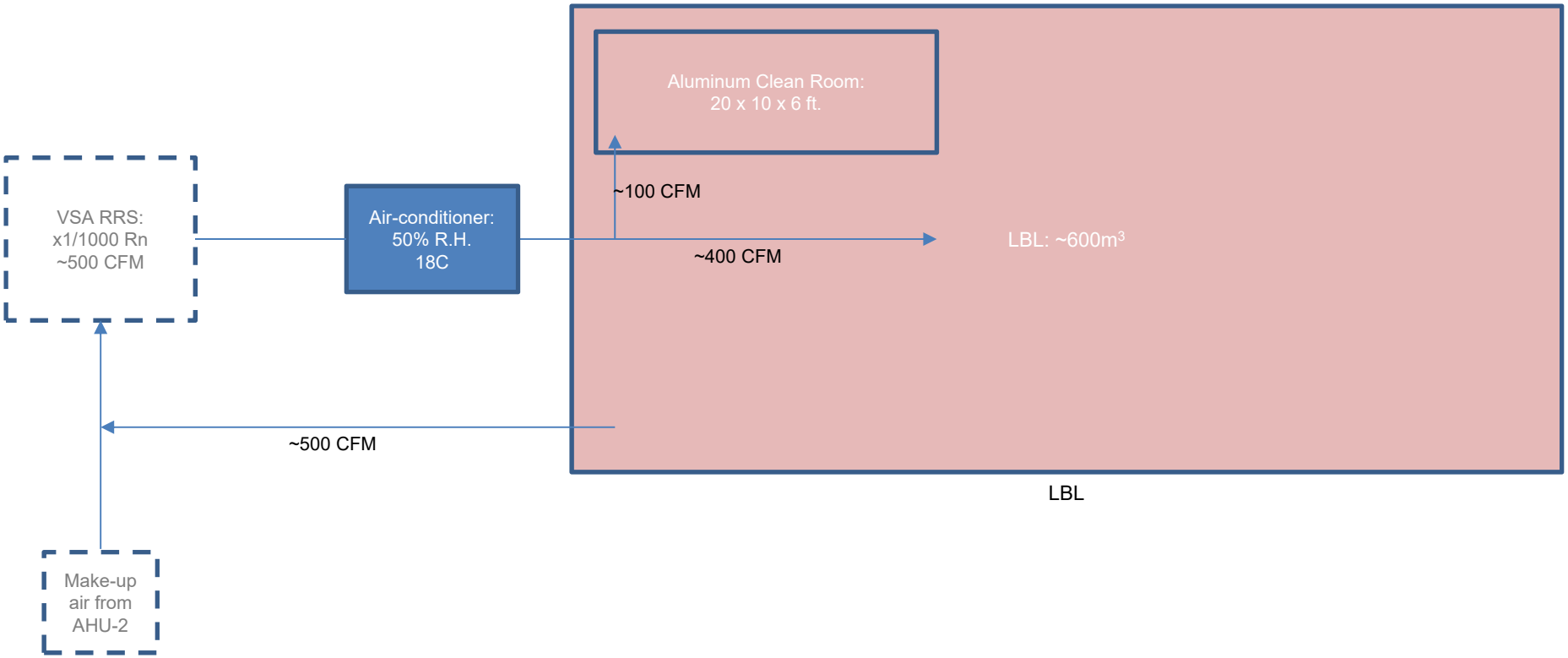
SNOLAB Low Radon Air VSA Concept



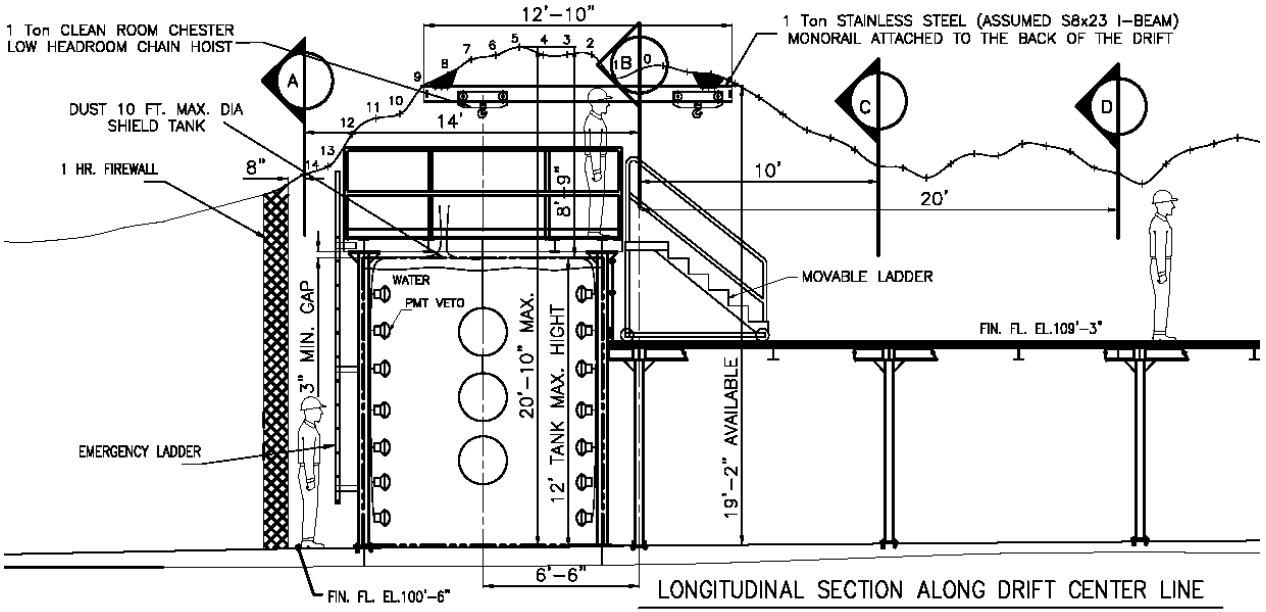
LBL Phase-2

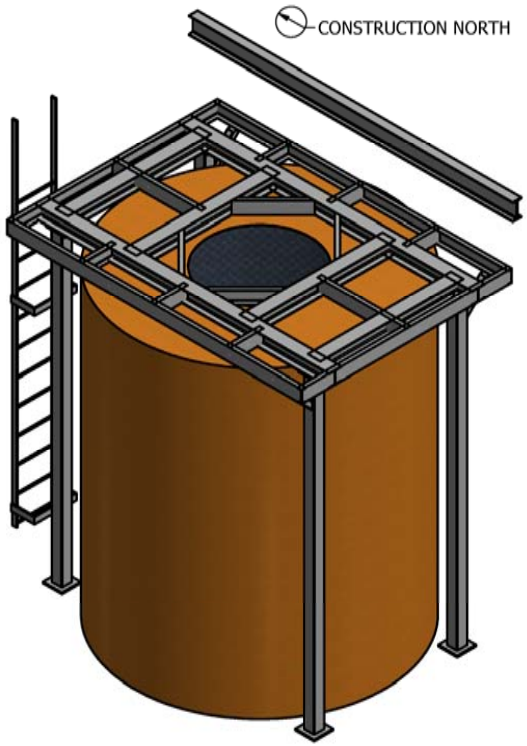

DRAWN OLEG LI
SUBMITTED OLEG LI
APPROVED
1 Ton MONORAIL MOUNTED ON THE BACK OF THE DRIFT
DETECTOR ASSEMBLY AREA
ELECTRONIC RACK (x2) 24"x30"x72"H
TOOL BOX 36"x18"
CABINET
SERVICE PLATFORM
LOW HEADROOM AREA
OPEN TO RM. BELOW
CHARCOAL COLUMNS 5x24"DIA
4" BLOCK WALL TO BE REMOVED PRIOR TO LOW RADON AIR EQUIPMENT INSTALLATION
DRYER 2'x3'
HX 2'x2'
LOW RADON AIR EQUIPMENT CAN BE SWAPPED OR RE-SIZED. SPACE USAGE WILL BE OPTIMIZED FOR ACTUAL INSTALL.
VALVE CABINET 2'x4'
FIN. FL. EL.100'-2"
VACUUM PUMP 3'x4'
FIN. FL. EL.100'-0"
COMPRESSOR 3'x4'
CHILLER 4'x5'
SCINTILLATOR PURIFICATION
WATER CHILLER WITH HX SKID 48"x48"
UPW WATER SYSTEM SKID 48"x48"
1 HR. FIREWALL C/W NEW 6'Wx8'H DOOR
VERTICAL EMERGENCY LADDER
FORKLIFT LOADING ZONE
MOVABLE LADDER
OPTIONAL 12 FT. CONVENTIONAL LADDER FOR EMERGENCY PURPOSE (STORAGE LOCATION)
ASSEMBLY BENCH
MEZZANINE FLOOR ELEVATION
FIN. FL. EL109'-3"
10 FT. MAX. DIA SHIELD TANK
SERVICE PLATFORM ABOVE
PASS THROUGH WINDOW
EYEWASH STATION
SINK C/W COUNTER
CHEM LAB BENCH
SHELVES
ALPHA COUNTERS
2'x3'-4"x4' DEEP SUMP
GOPHER HPGE DETECTOR
XRF DETECTOR
TOOL BOX
PGT Ge DETECTOR
WELL CANBERRA Ge DETECTOR
MEZZ LINE OVERHEAD
VDA Ge DETECTOR
TABLE FOR BOTH PLUG
LARGE CANBERRA Ge DETECTOR
CABINET
FLOOR SURVEY TAKEN 2015-10-22
4396.44 E 15159.54 N
LOW RADON AIR ROOM
WINDOW
LOW BACKGROUND LABORATORY
FIN. FL. EL.101'-6"
4413.68 E 15034.42 N
TOOL BOX 36"x18"
FIN. FL. EL.100'-2"
FIN. FL. EL.100'-6"
POST EXISTING LOCATION
POST NEW LOCATION
RADON EMANATION CHAMBER AND PUMP
XIA ALPHA COUNTER CHAMBER
CABINET
GLOVEBOX
BETA CAGE
BETA-ALPHA COUNTERS
42 BREAKERS ELECTRICAL PANEL TO BE RELOCATED
STAIRCASE RELOCATED FROM NORTH SIDE
242.00
APPROXIMATE LOCATION : 4" DIA. STANDARD PIPE POSTS
14'-8"
MEZZ LINE OVERHEAD
42 BREAKERS ELECTRICAL PANEL
A/C UNIT AHU-2
CONCRETE FLOOR ELEVATION FOR LOW BACKGROUND COUNTING ROOM
FIN. FL EL.101'-6"
NOTE:
1. REFER TO ORIGINAL DRAWING 17-702-B-6223-6 REV. 04 FOR PREVIOUS LAYOUT.
2. REFER TO SLDO-LBO-SK-1000-01 LBO ROOM LAYOUT FOR DETAILS.
3. REFER TO SLDO-UGL-AR-0120-01 FOR SERVICES LAYOUT.
4. SOUTH DRIFT SURVEY DRAWING SLDO-UGL-AR-0123-01
5. THIS DRAWING IS FOR EQUIPMENT LOCATION ONLY.
17-702-B-6223-6 REV. 04
REFERENCE DRAWINGS
ENDO REFERENCE NO
DO NOT SCALE
ISSUE
CHANGE
DATE
SNOLAB
ALL DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED
TOL. FRACTIONS +- 0.0625 U.N.O. MACHINED SURFACES +- 0.005 U.N.O. ANGLES +- 30' U.N.O.
SCALE 1:100
SNOLAB
LIVELY, ONTARIO, P3Y 1N2, CANADA
TITLE SOUTH DRIFT PLAN, EQUIPMENT LAYOUT
DRAWING NUMBER SLDO-UGL-AR-0119-01_Rev_U
SHEET 1 OF 1

SNOLAB Low Radon Air HVAC Concept

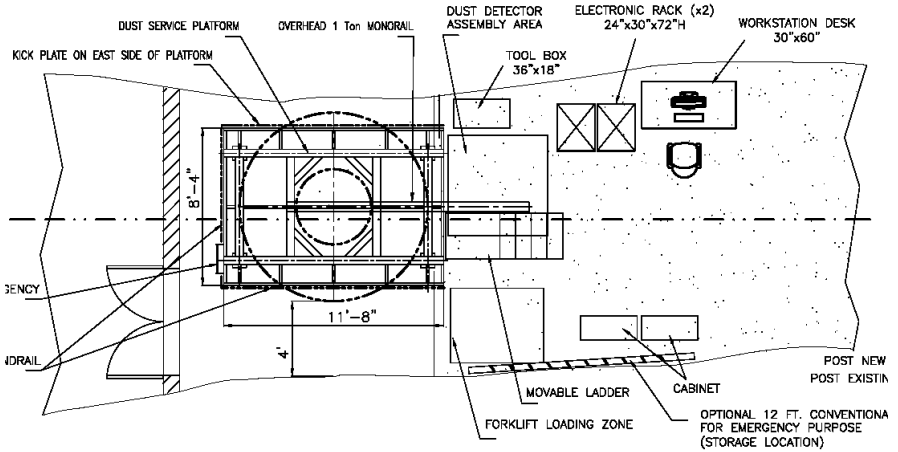


General Purpose Underground Shielding Tank (GUST??)





- Free standing tank with integral deck
- 8 m diameter, 8 m high
- Walls constructed from bolted, corrugated cylindrical segments of galvanized carbon steel
- Polyurea lined tank ~ 1 cm thick coats walls, floor, and transition to ss lid
- O-ring sealed nozzles and penetrations
- Overfilled tank (~ 4 inches above tank lid bottom)



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Community Material Assay Database

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(pf? polyimide kapton -ptfe -raw) AND grouping:EXO

Total result: 10

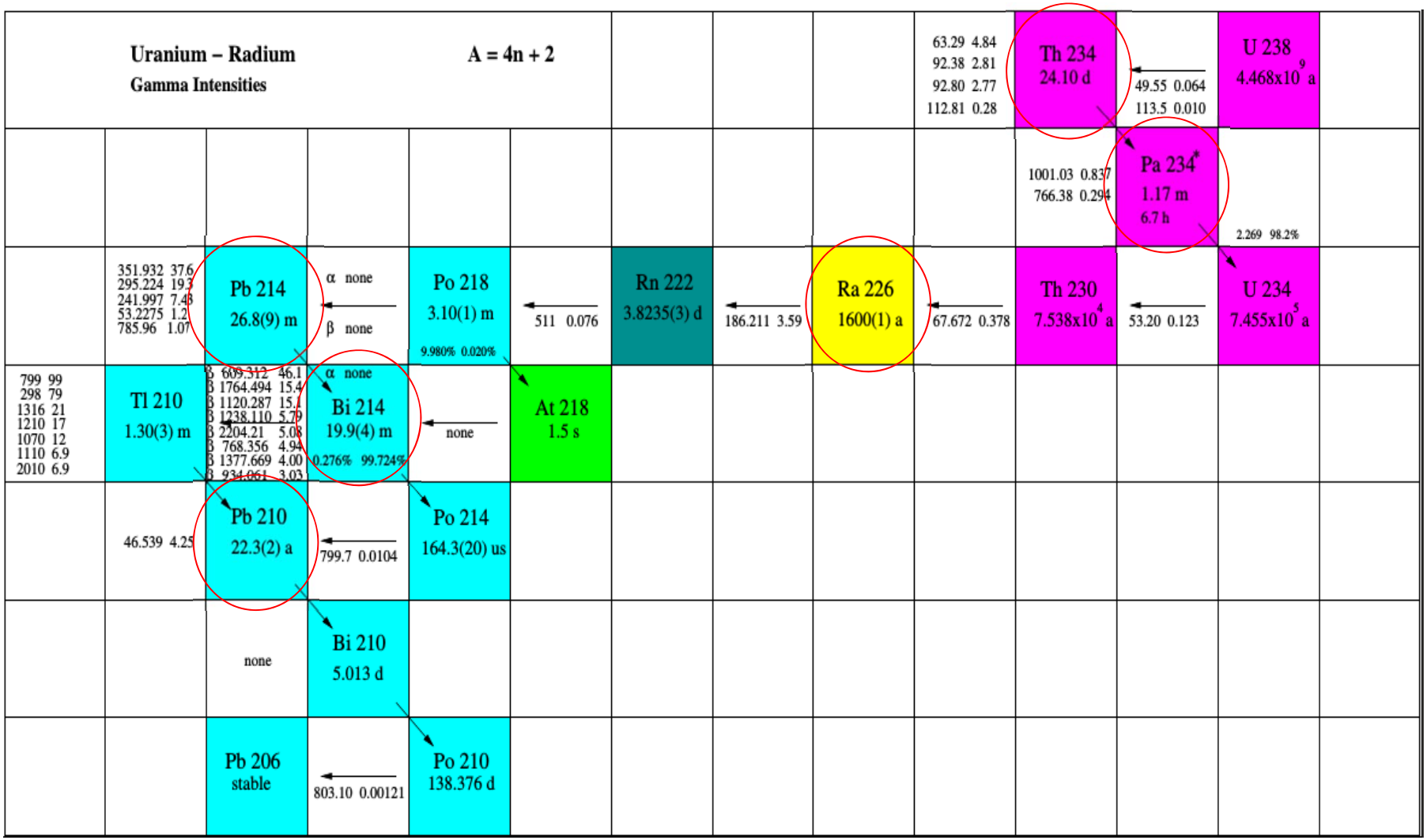
Grouping	Name	Isotope	Amount	Isotope	Amount	
▸ EXO (2008)	Polyimide substrate, Espanex flat cable, Nippon...	Th	450 ppt	U	900 ppt	...
▾ EXO (2008)	PFA, Saint Gobain supplied DuPont 450-HPB	Th	65 ppt	U	75 ppt	

Sample	Description	Saint Gobain supplied DuPont 450-HPB PFA. Material finished using supplier's default procedures.				
	ID	Table 3. #47				
Measurement	Results	K		740	(77)	ppb
		Th		65	(6.5)	ppt
		U	<	75	(95%)	ppt
	Technique	NAA				
	Description	For each of K, Th, and U, natural terrestrial abundance ratios were used to covert from isotopic to total elemental abundances.				
Data	Reference	D.S.Leonard et al., Nucl. Instr. and Meth. A 591 (2008) (http://dx.doi.org/10.1016/j.nima.2008.03.001)				
	Data entry	Matthew Bruemmer / James Loach mbruemmer@smu.edu / james.loach@gmail.com on 2013-01-30 spec v2.01				

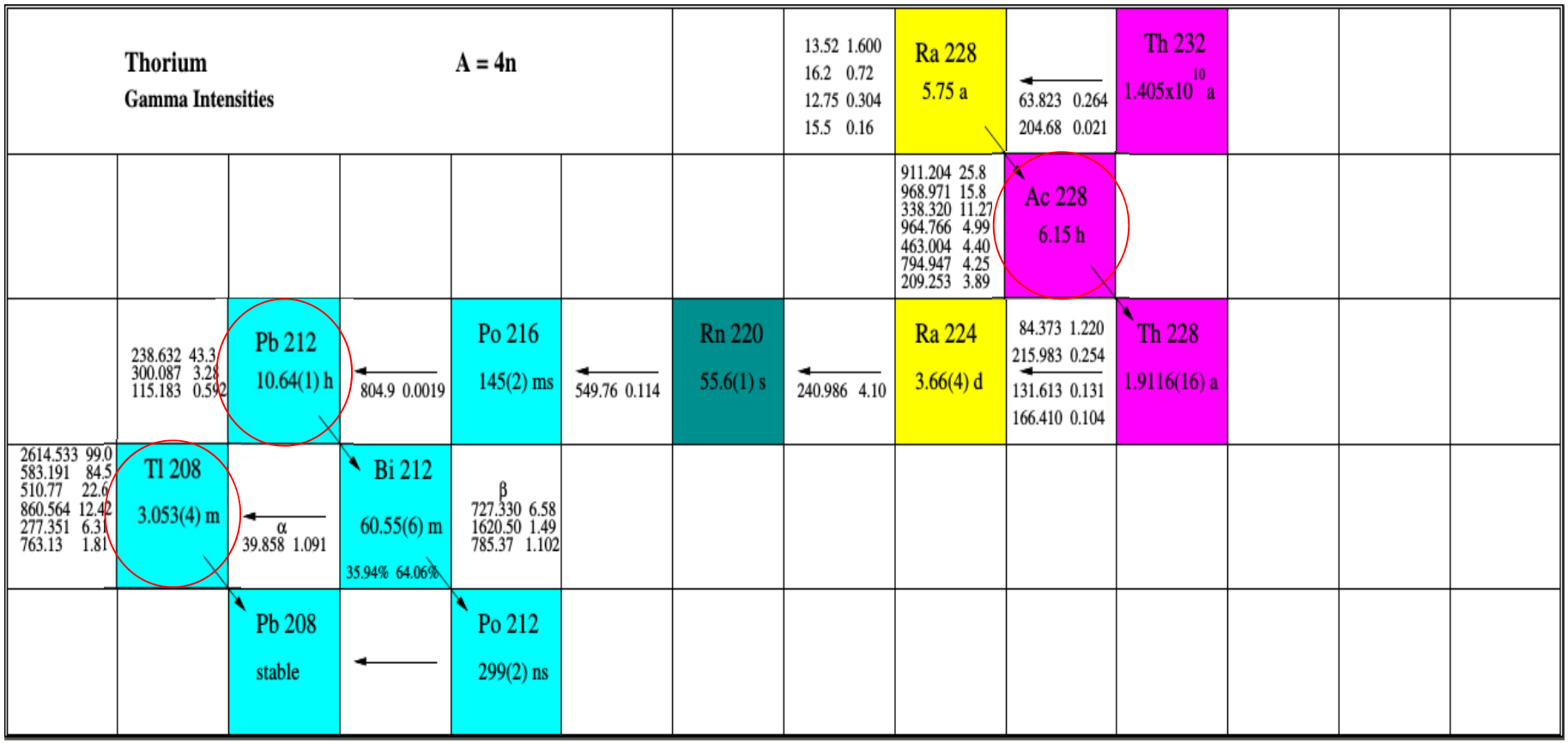
▸ EXO (2008)	PFA, Saint Gobain DuPont 440-HP	Th	13.3 ppt	U	3 ppt	...
▸ EXO (2008)	Polyimide substrate, Espanex flat cable, Nippon...	Th	1600 ppt	U	1500 ppt	...

End

Uranium Decay Chain



Thorium Decay Chain



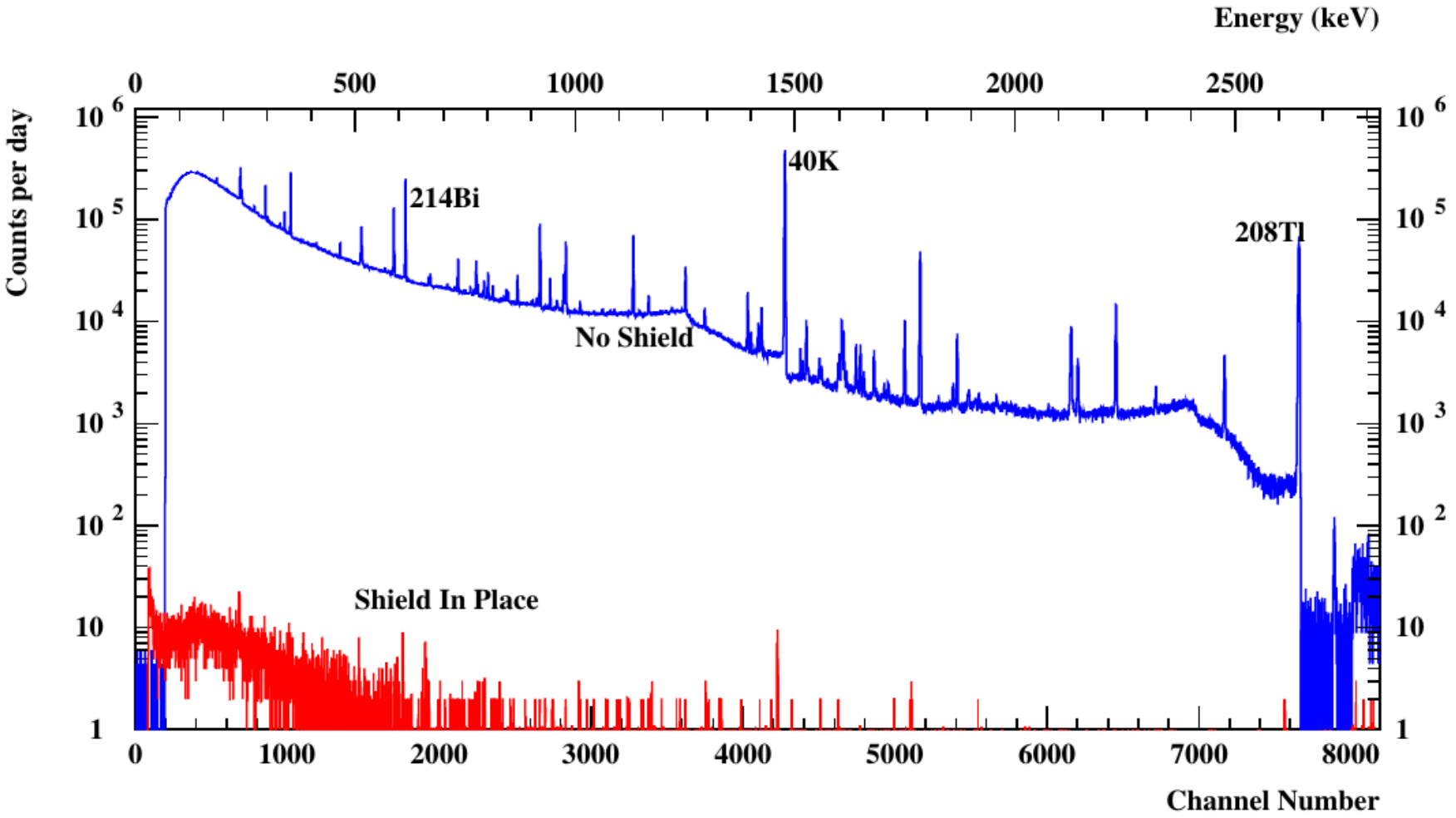
SNOLAB PGT HPGe Counter

(The workhorse detector at SNOLAB)

Additional lead used to dampen microseismic activity from blasting and rockbursts

Unshielded and Shielded Spectra

(PGT Coax Detector)



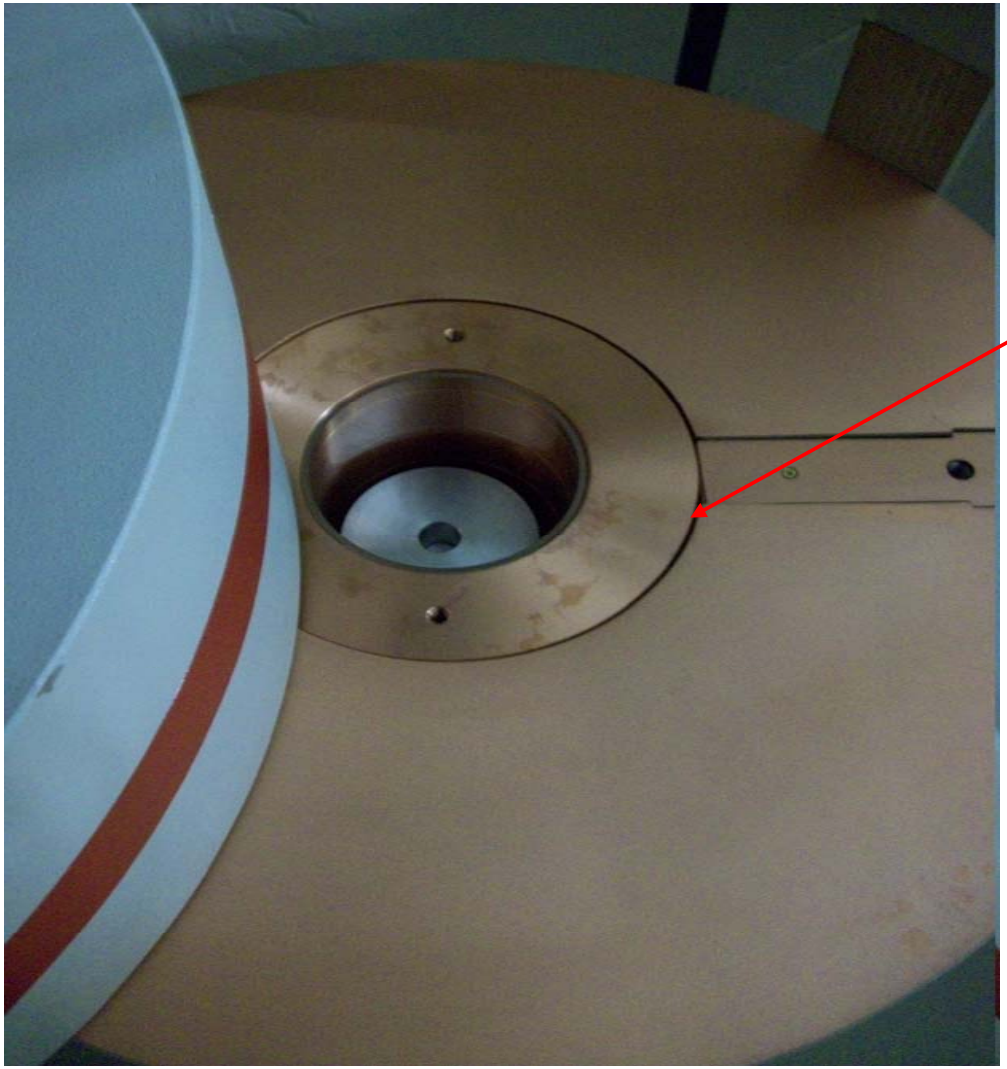
PGT HPGe Typical Detector Sensitivity

(for a standard 1L or 1 kg sample counted for one week)

Isotope	Sensitivity for Standard Size Samples
^{238}U	0.12 mBq
^{235}U	0.17 mBq
^{232}Th	0.11 mBq
^{40}K	1.50 mBq
^{60}Co	0.05 mBq
^{137}Cs	0.14 mBq
^{54}Mn	0.05 mBq

Canberra Well Detector at SNOLAB

Canberra Well Detector at SNOLAB



Detector Volume:
300 cm^3

Sample Well

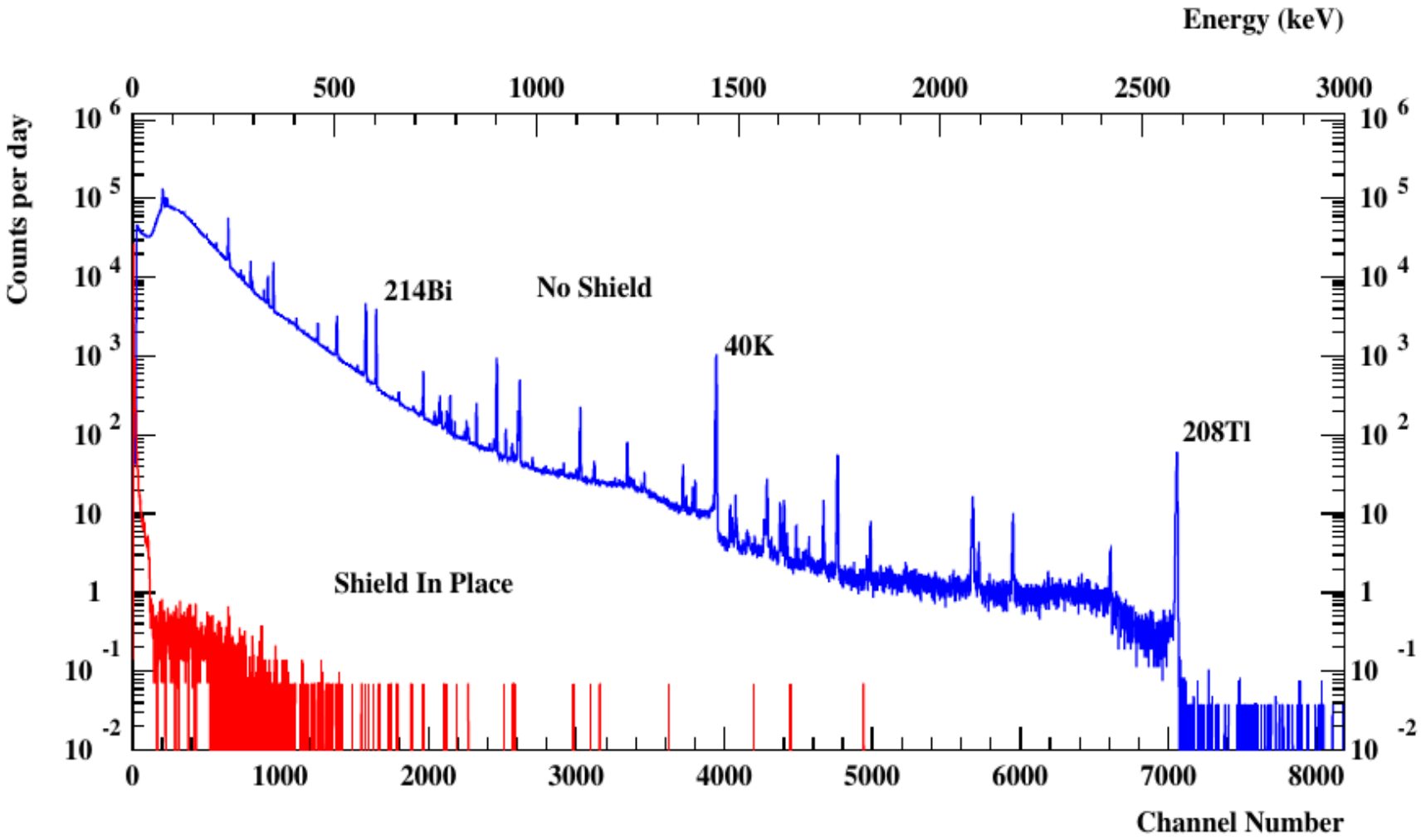
Typical
Sample Containers

Volume is 3 ml

Volume is 8 ml

Unshielded and Shielded Spectra

(Canberra Well Detector)



Canberra Well Detector Sensitivity

Isotope	Sensitivity for Standard Size Samples
^{238}U (↑ ^{226}Ra)	0.04 mBq
^{238}U (↓ ^{226}Ra)	0.03 mBq
^{228}Ac	0.12 mBq
^{232}Th	0.23 mBq
^{235}U	0.01 mBq
^{210}Pb	0.08 mBq

Gopher HPGe

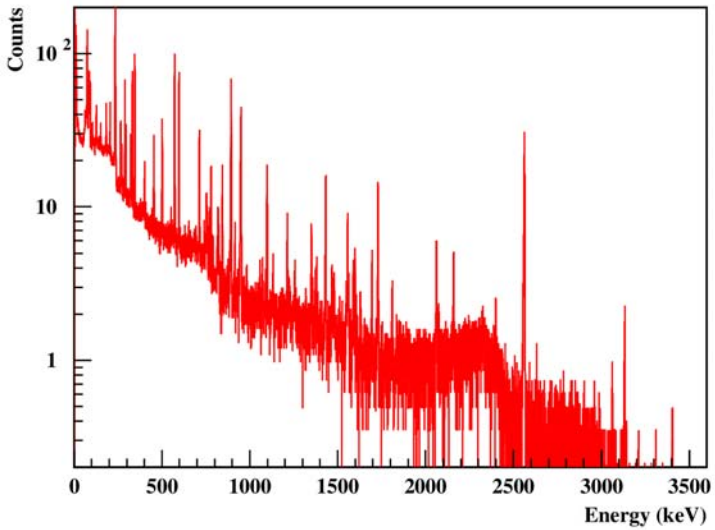
2.0kg of Ge. P-type coaxial

- Canberra Ge detector with thin 1.6 mm Al window, allows sensitivity to 210Pb
- Detector is 400 cm3 and is shielded by
  - 2” inner OFHC copper
  - Surrounded by 2” low-activty Pb
  - Surrounded by > 10” normal Pb
  - Plus some outer polyethelene
- The shielding box is purged with 1.8 lpm of nitrogen boil-off gas.
- Dedicated to SuperCDMS
- Sensitivity of ~ 1 mBq/kg for 3 week run
- Sample changes by SNOLAB scientists and staff
- Queue and Analysis by SuperCDMS
- Current status: Background run in progress

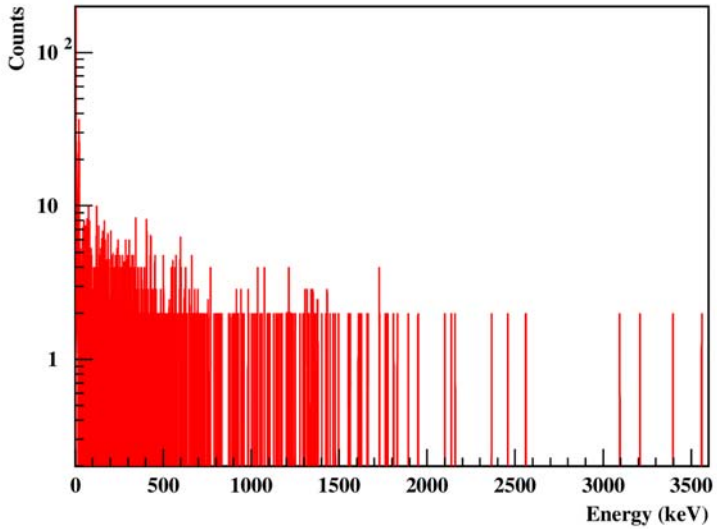
Vue des Alpes HPGe Detector

The VdA HPGE detector has been reconditioned by baking and vacuum pumping for several months.

Calibration runs have been done to verify peak resolution and now a long-term background run is in progress.



Calibratio



Backgroun

Canberra Coaxial HPGe Detector

Canberra 400 cm^3 p-type coaxial HPGE detector acquired in 2011.

Refurbished into an ultra-low detector in 2013 with verified low-background materials.

Shielding is partially assembled.

Machining of the lead bricks is underway for the cold finger and nitrogen purge lines.

Construction of the shielding plug is underway.