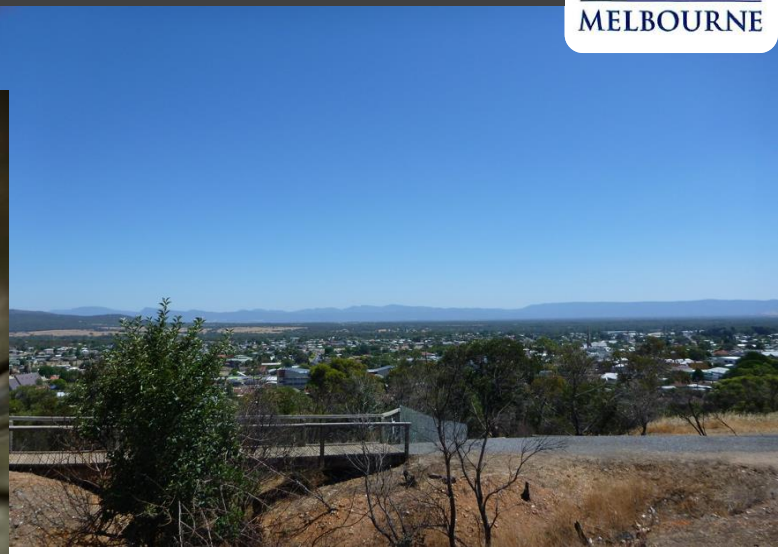
STAWELL GOLD MINE IN VICTORIA



Matteo Volpi on behalf of CoEPP group

STAWELL GOLD MINE MEASUREMENTS

- These measurement have been made with the help of ANSTO, which provided us with the radon, gamma and neutron counters. They also provided us the rock analysis.

- ANSTO: Australian Nuclear Science and Technology Organisation is the home of Australia's nuclear expertise

- We also thank Crocodile gold corp and the Stawell gold mine staff for the help and the availability

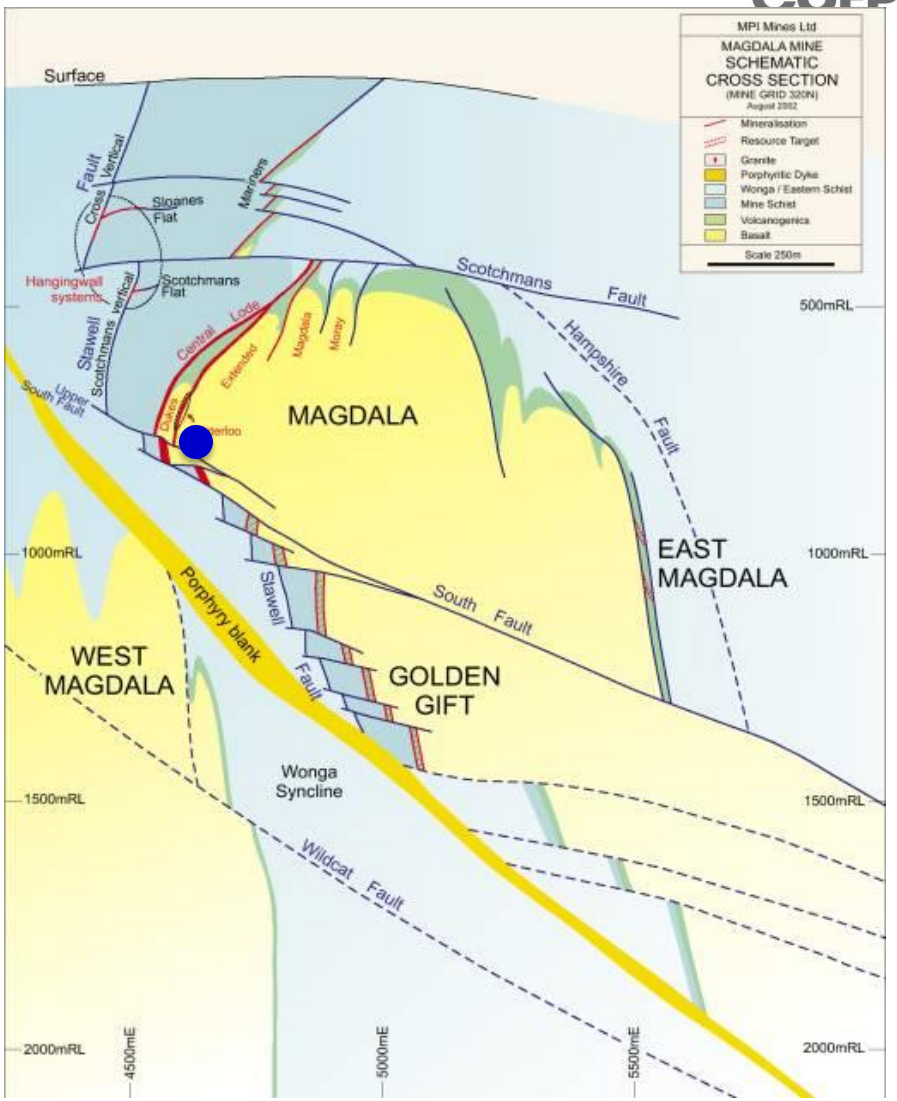
STAWELL GOLD MINE

1600m maximum depth, with caverns at many different depths including at 1000m+ depth

Many caverns have concrete sprayed surfaces

The access road supports mining vehicle traffic.

The mine is “dry”, has power, there are compressed air and fibres available

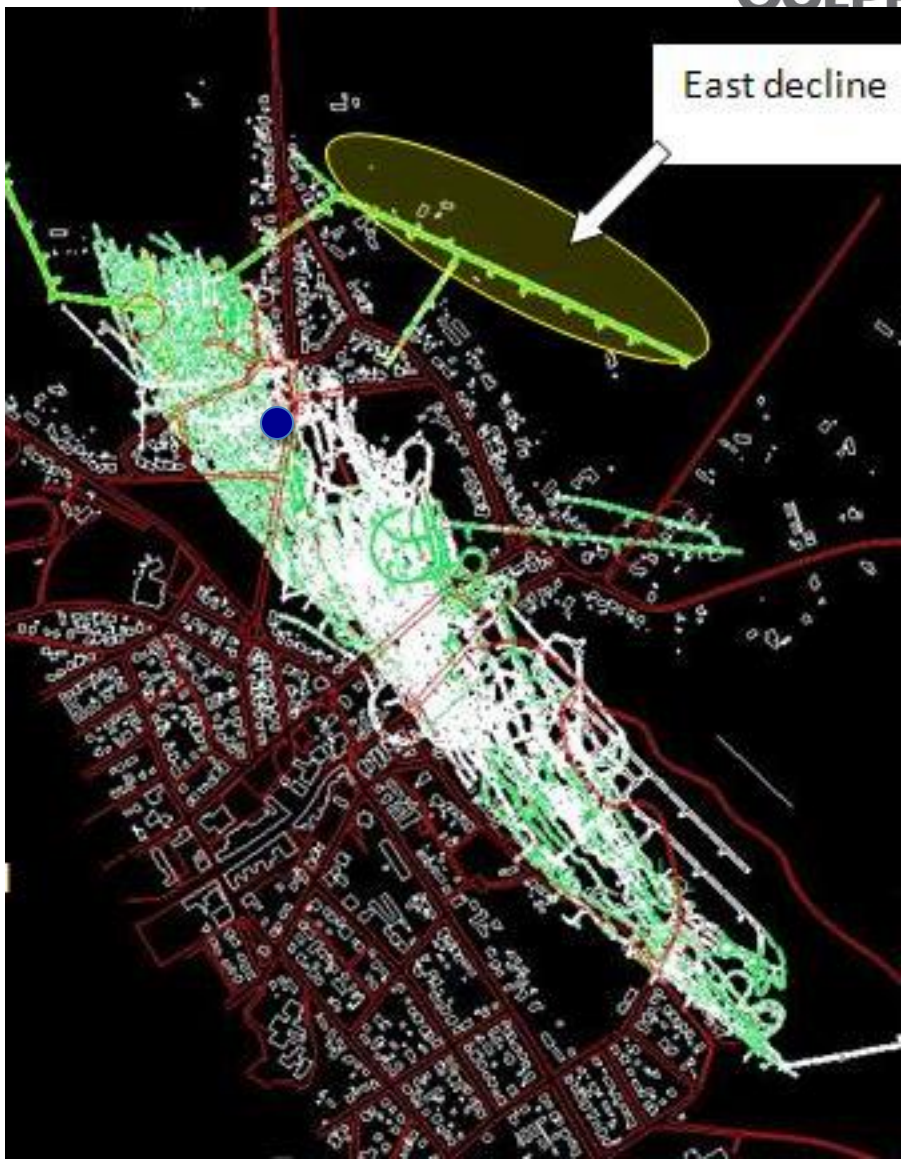


More info on http://www.youtube.com/watch?v=FqVi-nPtlok

FACILITIES IN STAWELL GOLD MINE

There is a cavern at about 1.1 km deep, about 3.1 Km water equivalent (basalt density of the mine ~ 2.86 t/m^3)

All sites are served with electricity, internet and can be reached by car/truck.



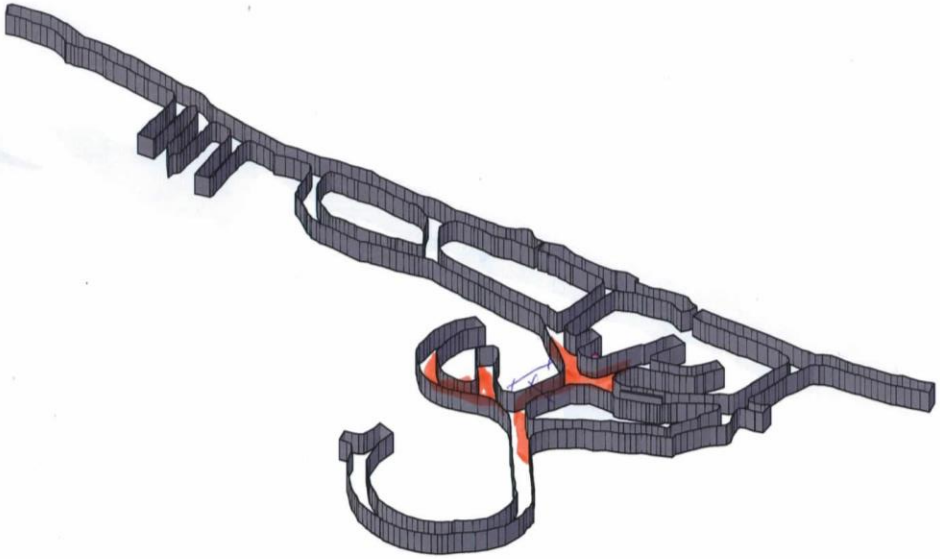
Plan view with surface topo

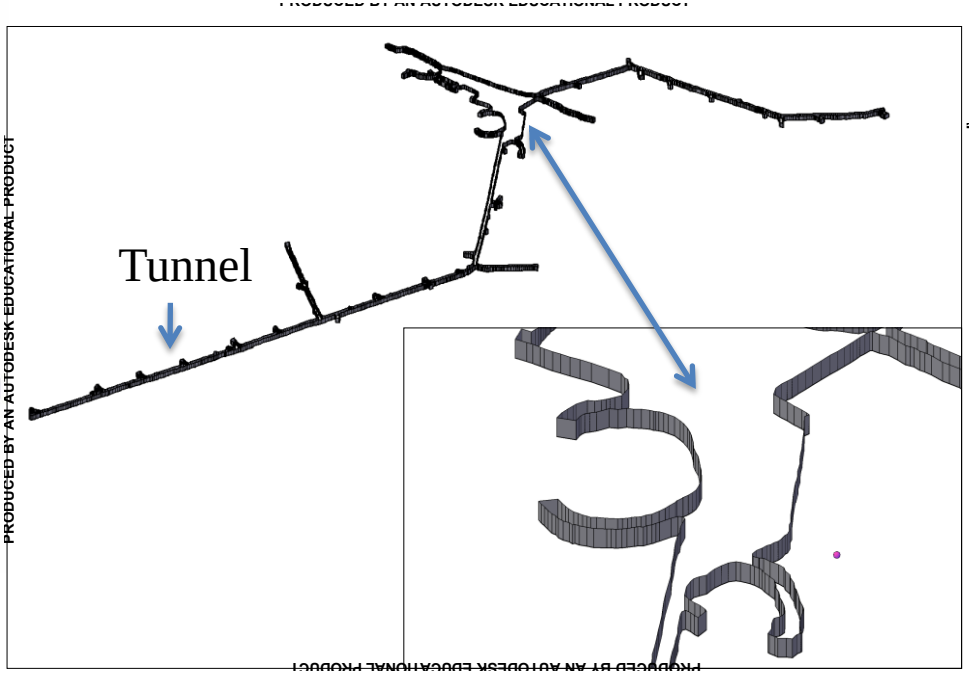
SITES OF THE MEASUREMENTS

The measurements are performed in 2 different locations that can be ventilated, lower levels can be accessed but need more babysitting from the mine.

Workshop: 729 m deep

Cavern : 880 m deep





WORKSHOP @729M

LUNCHROOM @ 880M (ELECTRICITY DISCONNECTED)

ACCEPTANCE CRITERIA FOR THE SITE

Acceptance criteria for environmental and cosmic-induced background for an underground site to host a dark matter experiment:

	Typical values	Limit values
Overburden	(1.6 - 6) km.w.e.	> 3 km.w.e. (~1.1 km for standard rock)
Muon flux	$(5 \times 10^{-7} - 4 \times 10^{-10})$ μ/cm²/s	$< 5 \times 10^{-8}$ μ/cm²/s
Neutron flux	10^{-6} n/s/cm²	$< 10^{-6}$ n/s/cm²
Gamma flux	0.1 γ/s/cm²	< 0.1 γ/s/cm²
Radon concentration	50-100 Bq/m³	< 50 Bq/m³

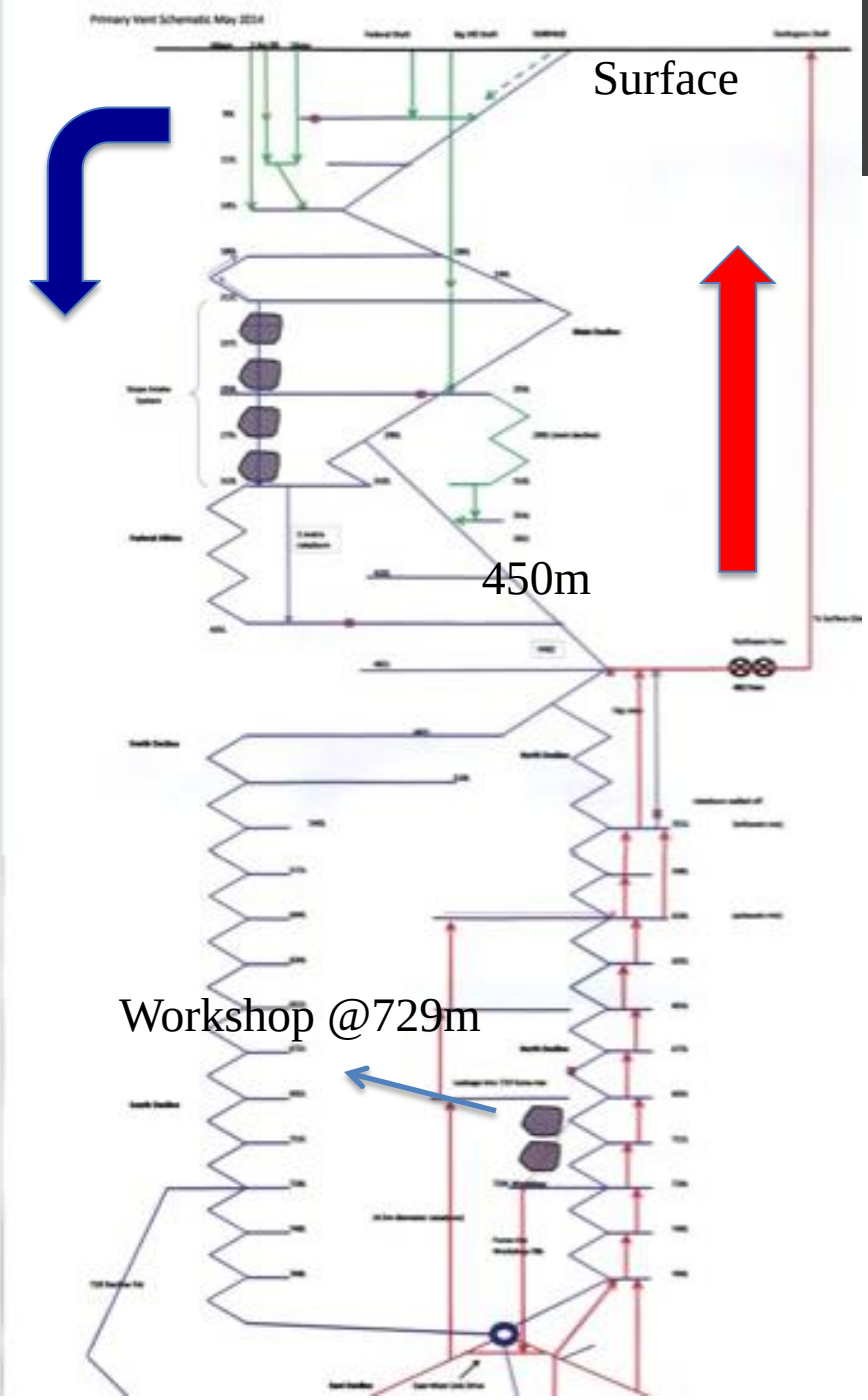
RADON MEASUREMENTS

- We used Alpha Guard monitors provided by ANSTO, to measure the concentration of the radon along the mine
- They are pulse-counting ionization chambers (alpha spectroscopy) for their measurements, and offer a high detection efficiency
- They also measure and record simultaneously:
  - ambient temperature
  - relative humidity
  - atmospheric pressure with integrated sensors.

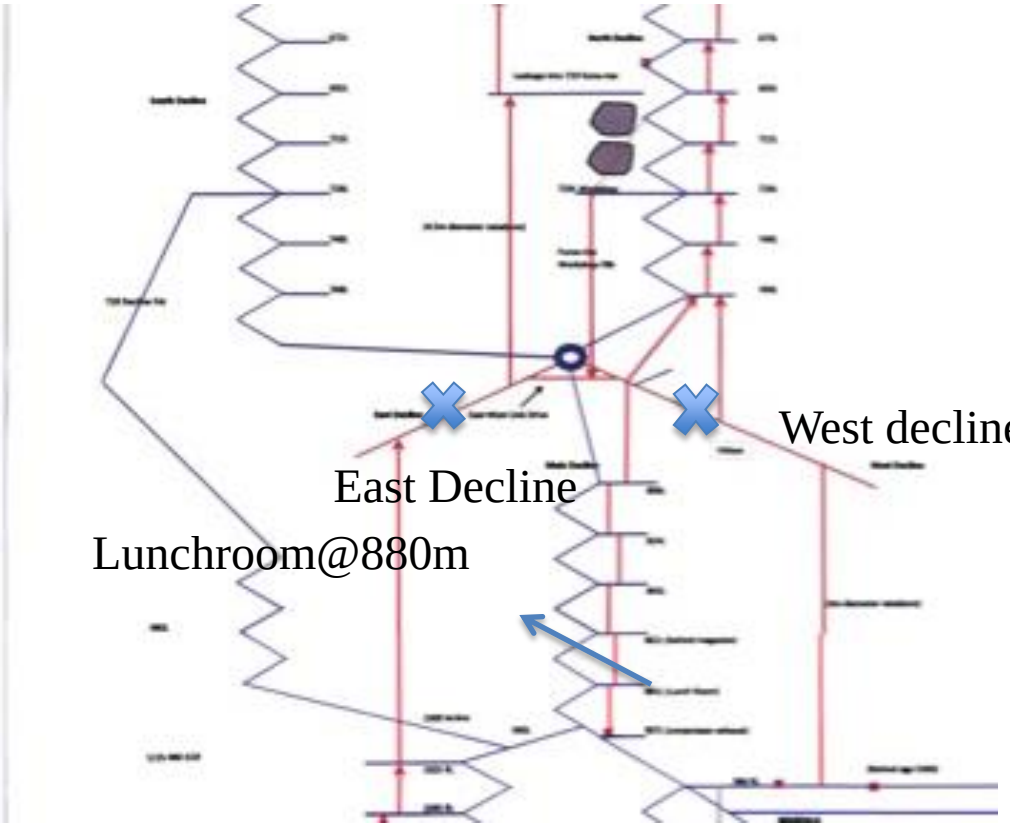
The Alpha Guard Professional Radon Monitor

Radon concentration in the air depends on local geology, but increases in closed halls. This can only be attenuated by proper ventilation;

VENTILATION SYSTEM MAP



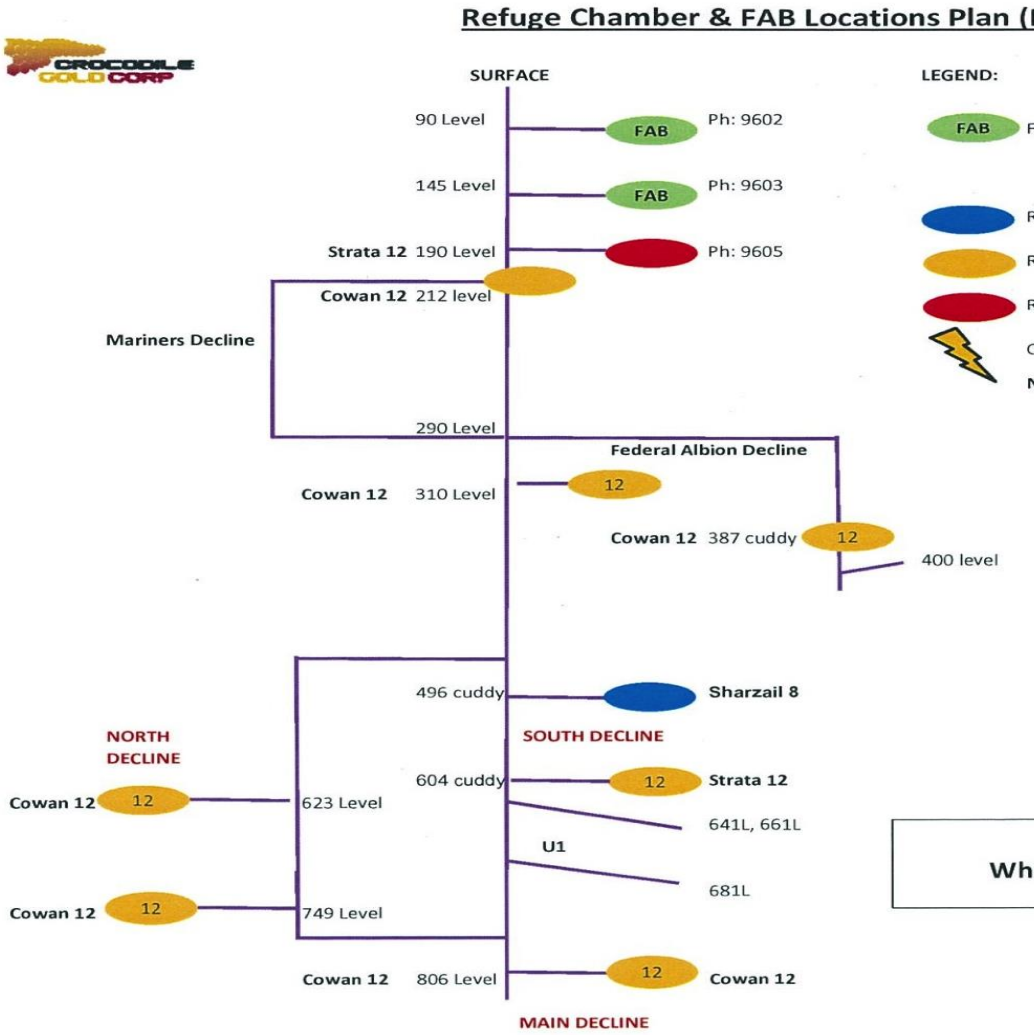
Bottom part of the mine



The East and West doors were open/closed, in order to pull primary ventilation flow down the lower mine declines once more.

RADON MEASUREMENTS

- The mine has hermetic refuges. They received compress air directly from the surface. We monitored the radon level inside and outside the refuge at 806 m



RADON INSIDE THE REFUGE @806M

806m	Radon Bq/m³	error	Temp. C°	Pressure bar	Humidity	Integration time
Averages	36	5	21	1056	21%	12 days

- **This is compatible with the protocol when we use the compressed air**
- The monitor located outside the refuge agrees with the other results at 880m deep (with no ventilation or mix or recycled and new air ventilation)

806m	Radon Bq/m³	error	Temp. C°	Pressure bar	Humidity	Integration time
Averages	408	40	25	1057	88%	14 days

- This represent a sample measurement, we did in many different places and at different times (over 2 months) and the result is stable

ROCK COMPOSITION

Rock composition and concrete on walls contribute to the radioactive background.

ANSTO analyzed the rock and concrete samples collected in various site.

Client ID	^{40}K activity Bq/kg	^{210}Pb activity Bq/kg	^{226}Ra activity Bq/kg	^{228}Ra activity Bq/kg	^{228}Th activity Bq/kg	^{238}U activity Bq/kg
1. Basalt - 596/597	505 ± 27	79 ± 7	55 ± 4	34 ± 2	33 ± 3	53 ± 8
2. Quartz - 596/597	246 ± 14	14 ± 4	3 ± 1	3 ± 1	< 6	< 11
3. Basalt - 729	228 ± 13	8 ± 3	2 ± 1	< 2	7 ± 1	< 9
4. Concrete - 729 [Wall]	317 ± 19	37 ± 8	14 ± 2	23 ± 2	25 ± 7	< 23
5. Basalt - 729	902 ± 49	77 ± 8	44 ± 3	67 ± 4	63 ± 8	57 ± 10
6. Concrete - 729 [Wall]	99 ± 6	< 17	8 ± 1	13 ± 1	8 ± 3	< 13
7. Concrete - 729 [Floor]	339 ± 20	< 31	10 ± 2	17 ± 2	15 ± 6	< 27
8. Quartz - 729	24 ± 3	< 18	< 3	< 2	< 6	< 12
9. Basalt - 729	22 ± 4	< 9	6 ± 1	< 2	< 6	8 ± 3
10. Concrete - 729 [Wall]	96 ± 9	< 15	12 ± 2	10 ± 1	10 ± 4	< 14
11. Basalt - 880	22 ± 5	24 ± 4	30 ± 2	3 ± 1	< 7	19 ± 4
12. Concrete - 880	308 ± 18	< 16	17 ± 2	25 ± 2	24 ± 5	< 16
13. Concrete - 880	104 ± 10	< 21	65 ± 5	30 ± 2	30 ± 6	61 ± 9
14. Mud + Concrete - 880 tunnel	96 ± 8	< 13	13 ± 2	4 ± 1	< 7	< 11

We will collected more rock sample from different parts to analyse.

COMPARISON WITH LNGS

- LNGS

	^{238}U (ppm)	^{232}Th (ppm)
Rock Hall A	6.80	2.167
Rock Hall B	0.42	0.062
Rock Hall C	0.66	0.066
Concrete	1.05	0.656

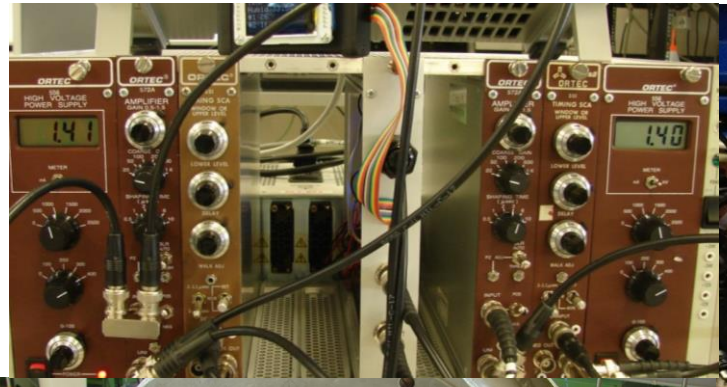
- Workshop@729m

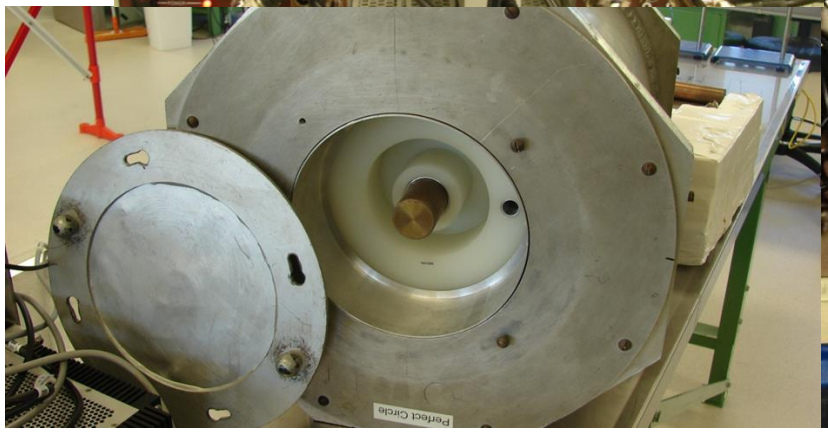
Type@workshop	^{238}U (ppm)	^{232}Th(ppm)
Basalt	0.64 (average)	1.63 (average)
Quartz	< 0.97	1.39
Concrete (Wall)	< 1.86	3.84
Concrete (Floor)	< 2.18	3.49

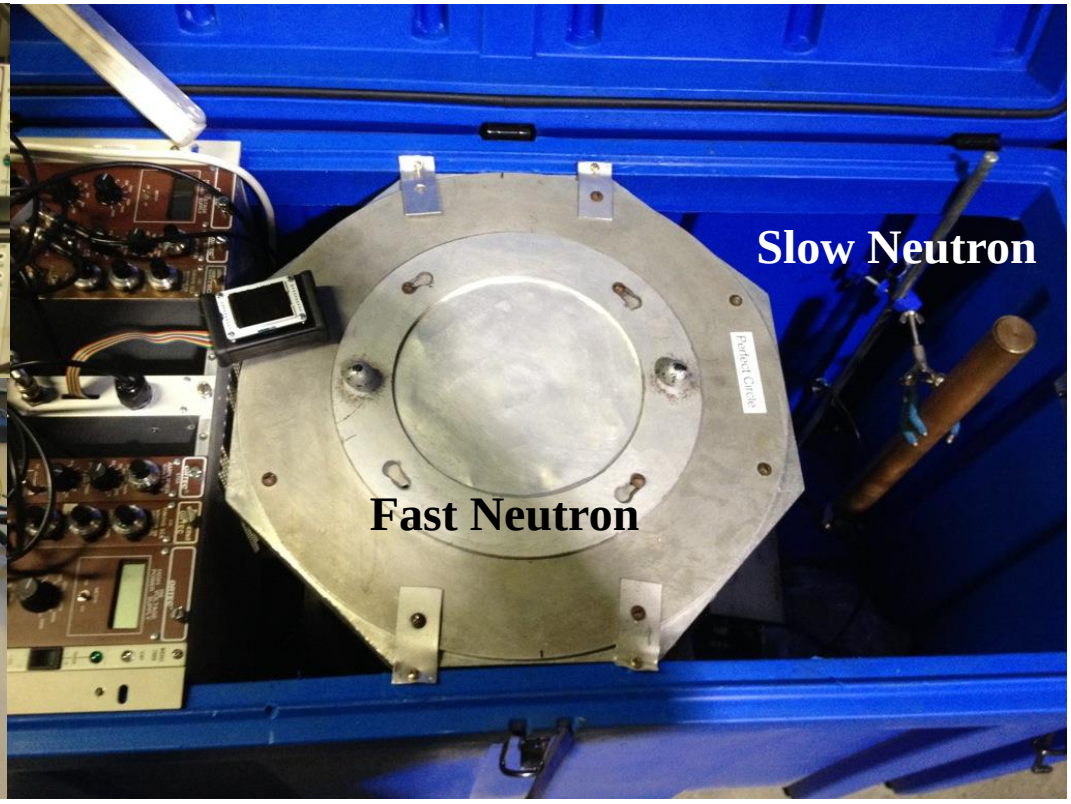
We are compatible with the protocol

NEUTRON FLUX MEASUREMENTS

- Slow neutron (<0.5 eV) and fast neutron (up to 10 MeV and above) are measured with two BF_3 proportional tubes.
  - One BF_3 tube is mounted in a free air geometry for the detection of slow neutrons
  - The other BF_3 tube is mounted in a long counter for the detection of fast neutrons.







NEUTRON FLUX RESULTS AND NEXT

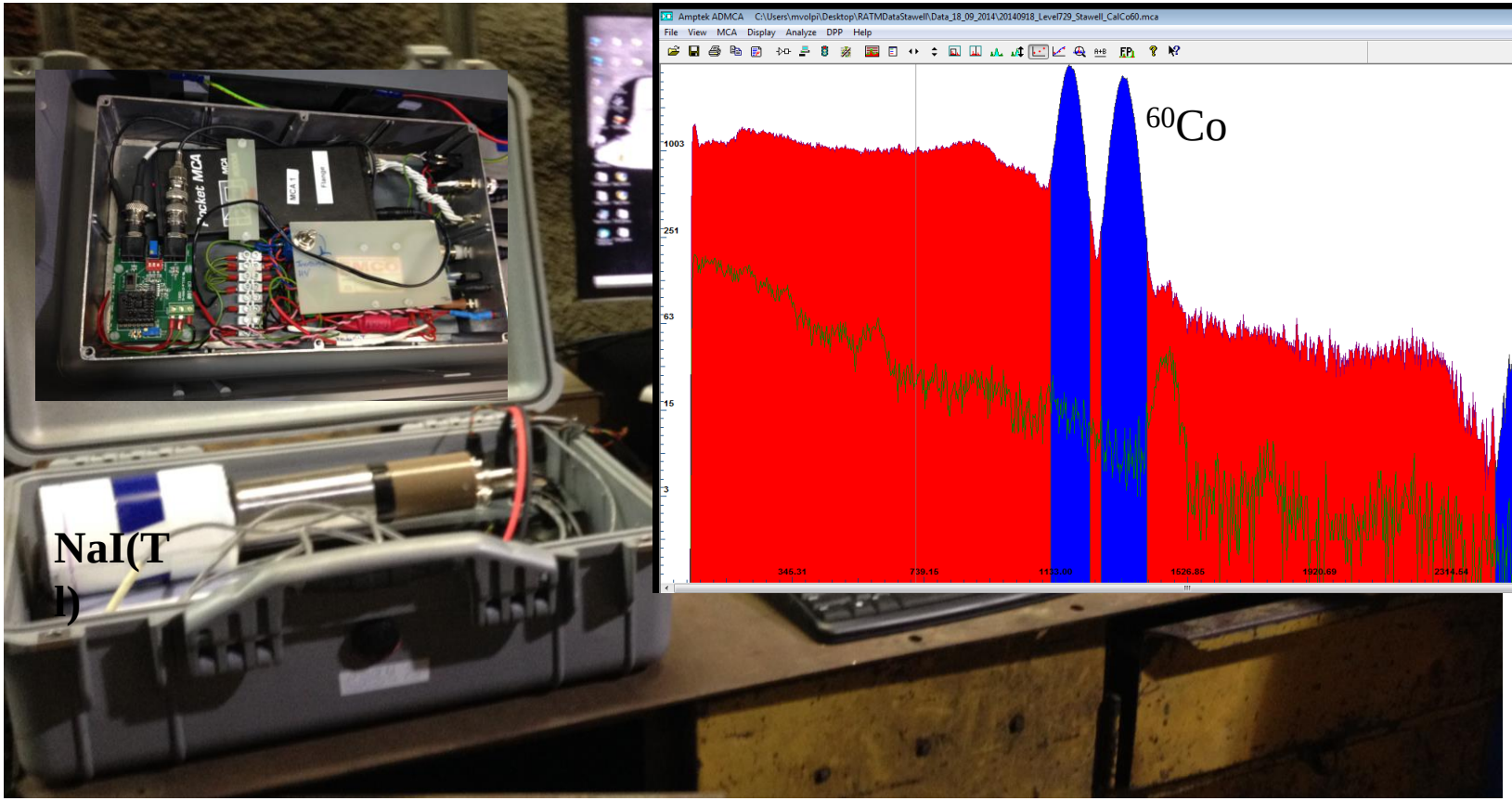
Preliminary estimation

Slow neutron flux = 6.92 x 10^{-6} cm^{-2}/s^{-1} $\pm$ 2.7% (stat) +5% (eff.)
Fast neutron flux = 2.02 x 10^{-6} cm^{-2}/s^{-1} $\pm$ 6% (stat) +5% (eff.)

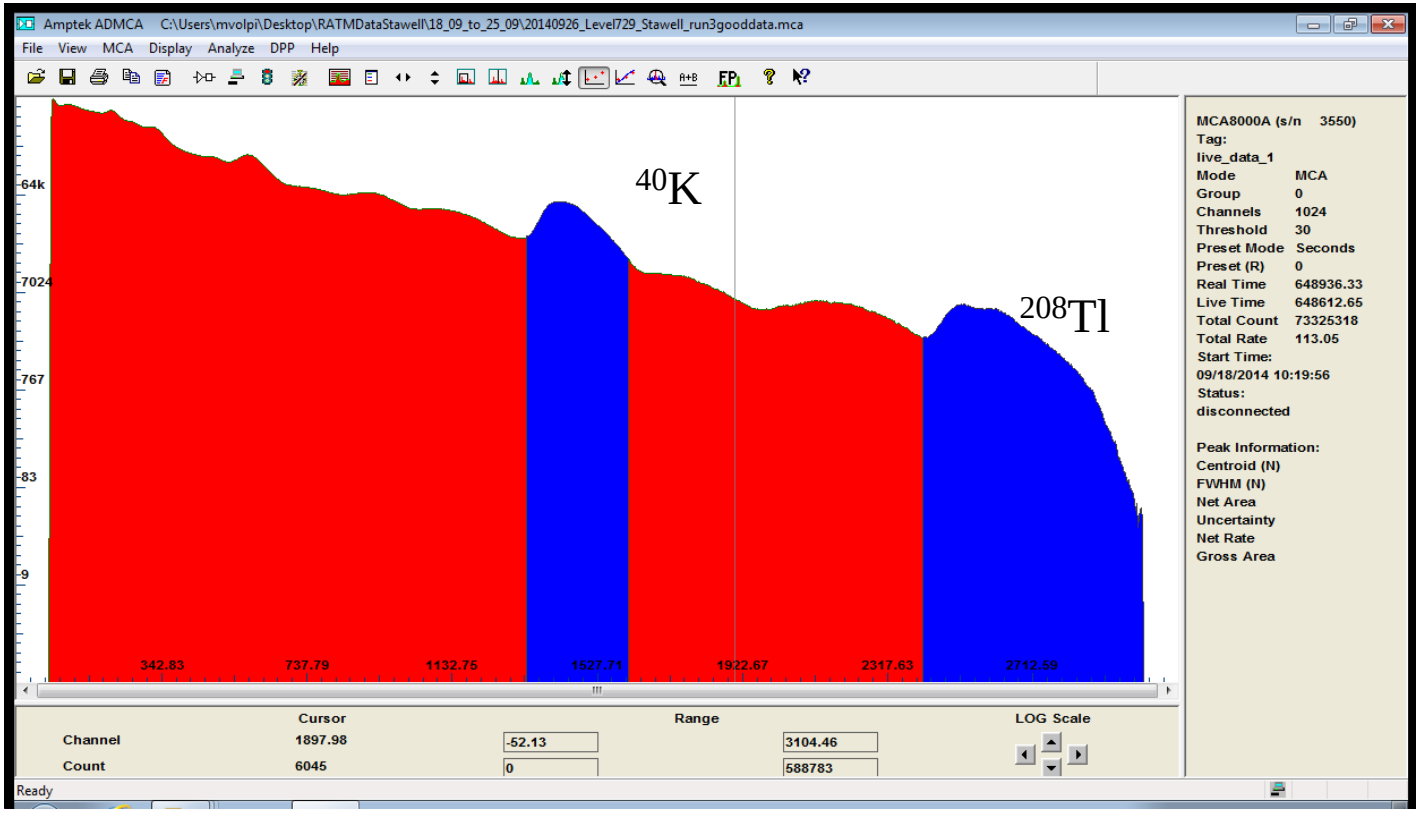
- Juan Collard (Chicago) will lend us ^{3}He proportional counters and set up used for … to measure the spectra.
- Neutron simulations are underway (Joshua Ellis)

PHOTON FLUX

- Spectroscopy measurements is performed with portable, NaI(Tl) 6” detector
  - Energy range up 3 MeV over 1024 channels
  - Calibration done with a ^{60}Co source



PHOTON FLUX



Gamma flux (one week measure) , all range 0 to 3 MeV : 1 $cm^{-2}s^{-1}$

2.2 x 10^{-2} at 1.466 MeV

3.4 x 10^{-3} at 2.615 MeV

- This is compatible with the protocol

SUMMARY

- Investigating different location

We did measurements but we were limited by the electronics. We don't' reach the resolution necessary to distinguish the background with the muon MIP. New system under construction.

	Limit values
Overburden	> 3 km.w.e. (~1.1 km for standard rock)
Muon flux	$< 5 \times 10^{-8}$ μ/cm²/s
Neutron flux	$< 10^{-6}$ n/s/cm²
Gamma flux	< 0.1 γ/s/cm²
Radon concentration	< 50 Bq/m³

The BF_3 are counting. First preliminary results are promising.

We setup the NaI crystal. Preliminary measurement compatible with the protocol

Under control if you use the compressed air system.

MINE COST AND INTEREST

Gold extraction in the mine will be going for sure until the end of 2015, then is uncertain

The Stawell community is really supportive: they are asking money to the State and Federal government to re-convert the mine as a training site and a DM experiment site

Cost of support for maintaining operations to allow initial DM lab is ~ 1-2 M AU$ (600K-1.2M EU) a year (mine engineer for safety, power, ventilation, transport, etc). Infrastructure expected to be covered by other activities/governments.

We need to add the cost of reconnecting electricity and optical fibres of the site at 1025m and costs for providing suitable laboratory accomodation.

EXTRA SLIDES

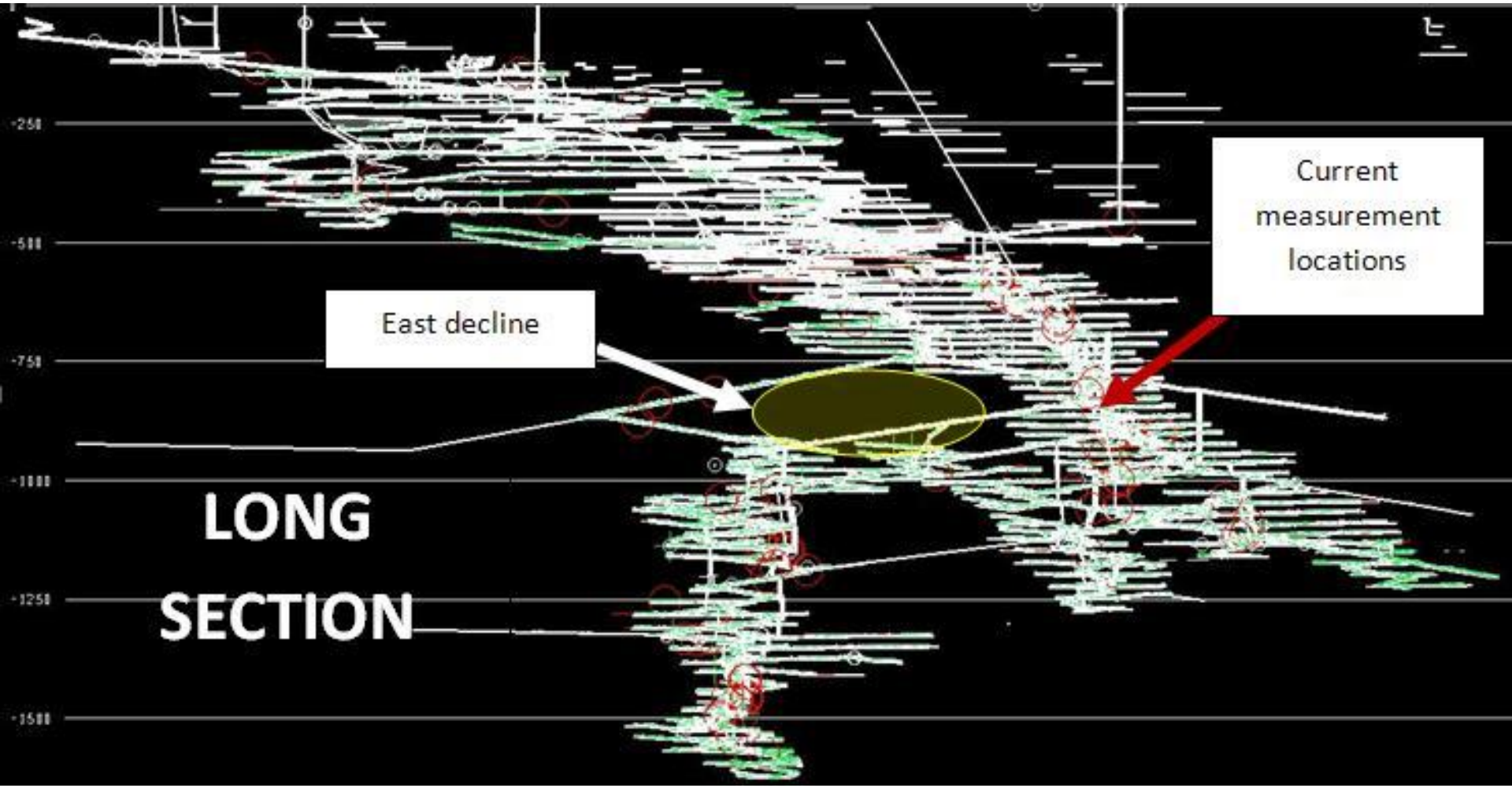
From Bq/Kg to ppm

The conversion factors for the primordial nuclides are given by:

$$1\ \text{Bq}\ {}^{238}\text{U/kg} = 81\ \text{ppb U}\ (81\ 10^{-9}\ \text{gU/g})$$
$$1\ \text{Bq}\ {}^{232}\text{Th/kg} = 246\ \text{ppb Th}\ (246\ 10^{-9}\ \text{gTh/g})$$
$$1\ \text{Bq}\ {}^{40}\text{K/kg} = 32.3\ \text{ppm K}\ (32.3\ 10^{-6}\ \text{gK/g})$$

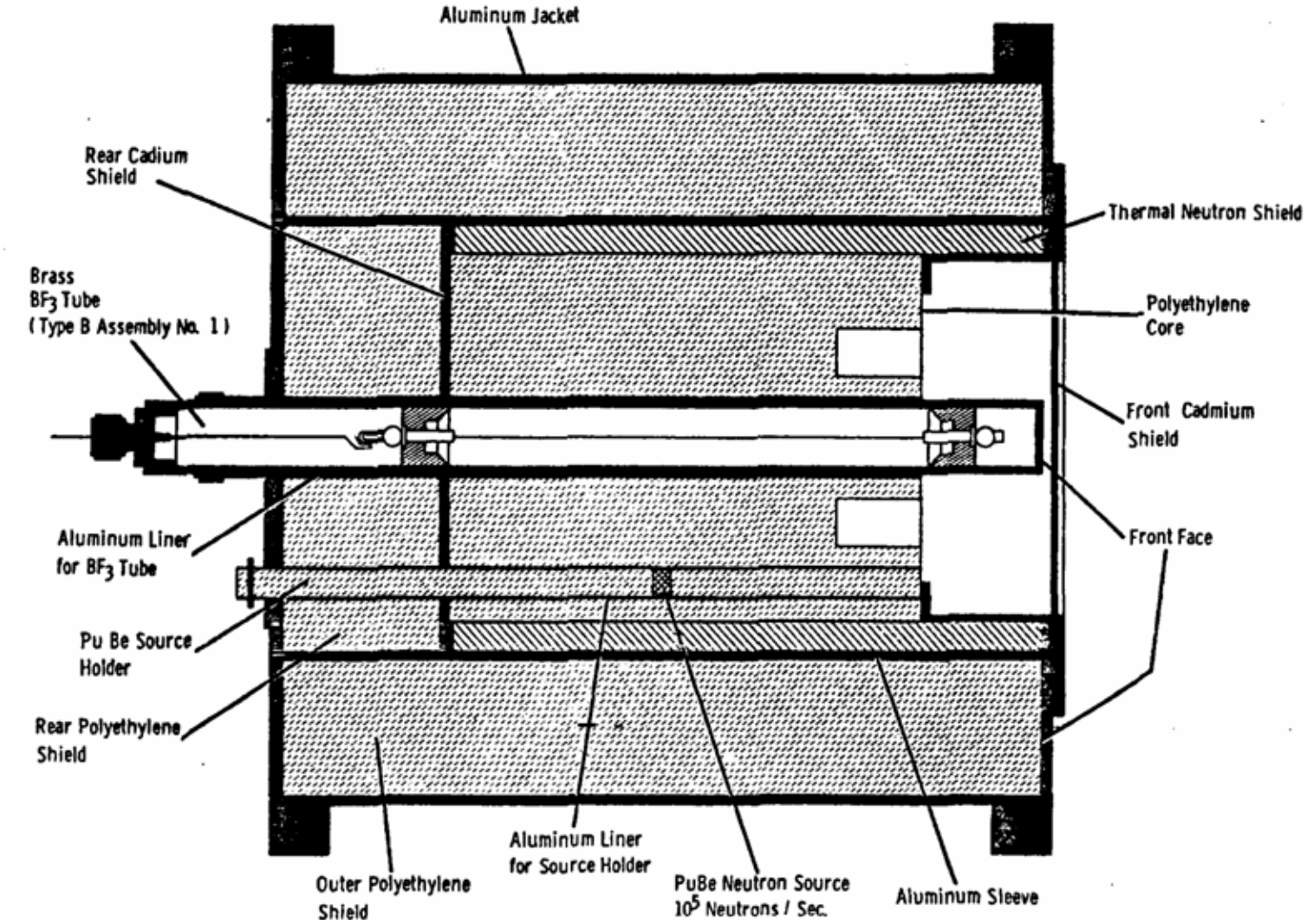
The relationship is valid for any daughter in the ^{238}U or ^{232}Th chain only if the chain is in equilibrium.

STAWELL GOLD MINE MAP



POSSIBLE SITE

FAST NEUTRON DETECTOR



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