Cosmogenic Backgrounds and Mitigation of Radioactive Backgrounds

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Second DULIA-bio Workshop
LNGS, Assergi, Italy
November 4-5, 2019
Effect of Overburden
(Why go underground)

Deep underground facilities provide significant rock overburden and commensurate reduction in cosmic ray flux, and cosmic ray-spallation induced products (neutrons)

Muons can be veto’d in anti-coincidence shield; secondary products may be an issue

Cosmogenics may require underground material production or purification
  • May also contribute to backgrounds (e.g. $^{11}$C)

Muon flux depends on
  • Overburden
  • overburden profile
  • seasonal effects

With all of these backgrounds present, there are several methods to measure them and these will be described.
## Techniques to Measure These Backgrounds
(Primarily U/Th decay chains and K)

<table>
<thead>
<tr>
<th>Measurement Method</th>
<th>Background Detected</th>
<th>Sensitivity (for U/Th)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ge spectrometry</td>
<td>$\gamma$ emitting nuclides</td>
<td>10-100 µBq/kg</td>
</tr>
<tr>
<td>• Rn emanation assay</td>
<td>$^{226}$Ra, $^{228}$Th</td>
<td>0.1-10 µBq/kg</td>
</tr>
<tr>
<td>• Neutron activation</td>
<td>primordial parents</td>
<td>0.01 µBq/kg</td>
</tr>
<tr>
<td>• Liquid scintillation counting</td>
<td>$\alpha,\beta$ emitting nuclides</td>
<td>1 mBq/kg</td>
</tr>
<tr>
<td>• Mass spectrometry (ICP-MS; AMS)</td>
<td>primordial parents</td>
<td>1-100 µBq/kg</td>
</tr>
<tr>
<td>• Graphite furnace AAS</td>
<td>primordial parents</td>
<td>1-1000 µBq/kg</td>
</tr>
<tr>
<td>• Röntgen Excitation Analysis</td>
<td>primordial parents</td>
<td>10 mBq/kg</td>
</tr>
<tr>
<td>• $\alpha$ spectrometry</td>
<td>$^{210}$Po, $\alpha$ emitting nuclides</td>
<td>1 mBq/kg</td>
</tr>
</tbody>
</table>

To reach these sensitivities, samples may have to count for several months.
# Uranium Decay Chain

<table>
<thead>
<tr>
<th>Uranium – Radium</th>
<th>Gamma Intensities</th>
<th>A = 4n + 2</th>
<th>63.29</th>
<th>92.38</th>
<th>92.80</th>
<th>112.81</th>
<th>49.55</th>
<th>1001.03</th>
<th>766.38</th>
<th>24.10d</th>
<th>1.17 m</th>
<th>53.20</th>
<th>2.269</th>
<th>4.468x10^7 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb 218</td>
<td>Po 214</td>
<td>Rn 222</td>
<td>Ra 226</td>
<td>Th 230</td>
<td>Th 234</td>
<td>U 238</td>
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<tr>
<td>26.8(9) m</td>
<td>3.10(1) m</td>
<td>3.8235(3) d</td>
<td>1600(1) a</td>
<td>7.538x10^4 a</td>
<td>24.10 d</td>
<td>4.468x10^7 a</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>α none</td>
<td>β none</td>
<td>α none</td>
<td>Bi 214</td>
<td>At 218</td>
<td>Pb 210</td>
<td>214(2) a</td>
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<tr>
<td>9.999% 0.029%</td>
<td>511 0.076</td>
<td>186.211 3.59</td>
<td>67.672 0.378</td>
<td>53.20 0.123</td>
<td>2.269 98.2%</td>
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<tr>
<td>Tl 210</td>
<td>Bi 214</td>
<td>At 218</td>
<td>Pb 210</td>
<td>Po 214</td>
<td>Po 210</td>
<td></td>
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<tr>
<td>1.30(3) m</td>
<td>19.9(4) m</td>
<td>1.5 s</td>
<td>22.3(2) a</td>
<td>164.3(20) us</td>
<td>138.376 d</td>
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<td>4.6%</td>
<td>0.276% 99.724%</td>
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<td>none</td>
<td>none</td>
<td>799.7 0.0104</td>
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<tr>
<td>6.051 32 40.1</td>
<td>1.764 494 15.4</td>
<td>none</td>
<td>Bi 210</td>
<td>5.013 d</td>
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<td>1.120 287 15.8</td>
<td>1.248 110 5.76</td>
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<td>2.044 21 5.05</td>
<td>768.356 4.96</td>
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<tr>
<td>1.377 669 4.00</td>
<td>3.944 591 3.03</td>
<td>none</td>
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<tr>
<td>799 99</td>
<td>298 79</td>
<td>1516 21</td>
<td>1210 17</td>
<td>1070 12</td>
<td>1110 6.9</td>
<td>2010 6.9</td>
<td>45.539 4.2</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

November 5, 2019
Second DULIA-Bio Workshop
# Thorium Decay Chain

<table>
<thead>
<tr>
<th>Thorium</th>
<th>Gamma Intensities</th>
<th>A = 4n</th>
<th>13.52 1.600</th>
<th>63.823 0.264</th>
<th>Ra 228 5.75 a</th>
<th>911.204 25.8</th>
<th>Ac 228 6.15 h</th>
<th>Th 232 1.405x10^19 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma</td>
<td>Intensities</td>
<td>Ra</td>
<td>16.2 0.72</td>
<td>968.971 15.8</td>
<td>204.68 0.021</td>
<td>1620.50 1.49</td>
<td>215.983 0.254</td>
<td>166.410 0.104</td>
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<tr>
<td>Intensities</td>
<td>Po 226</td>
<td>Po</td>
<td>12.75 0.304</td>
<td>338.320 11.27</td>
<td>549.76 0.114</td>
<td>785.37 1.102</td>
<td>131.613 0.131</td>
<td>131.613 0.131</td>
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<tr>
<td>Intensities</td>
<td>219(2) ms</td>
<td>Rn</td>
<td>15.5 0.16</td>
<td>964.766 4.59</td>
<td>240.986 4.10</td>
<td>84.373 1.220</td>
<td>131.613 0.131</td>
<td>131.613 0.131</td>
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<tr>
<td>Intensities</td>
<td>220(2) ms</td>
<td>Ra</td>
<td>15.5 0.16</td>
<td>463.004 4.40</td>
<td>39.858 1.091</td>
<td>727.330 6.58</td>
<td>727.330 6.58</td>
<td>727.330 6.58</td>
</tr>
<tr>
<td>Intensities</td>
<td>222(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>209.253 3.89</td>
<td>35.94% 54.06%</td>
<td>35.94% 54.06%</td>
<td>35.94% 54.06%</td>
<td>35.94% 54.06%</td>
</tr>
<tr>
<td>Intensities</td>
<td>223(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>238.632 43.31</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
</tr>
<tr>
<td>Intensities</td>
<td>224(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>300.087 3.24</td>
<td>592.6 0.592</td>
<td>592.6 0.592</td>
<td>592.6 0.592</td>
<td>592.6 0.592</td>
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<tr>
<td>Intensities</td>
<td>226(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>115.183 3.06</td>
<td>64.2 0.38</td>
<td>64.2 0.38</td>
<td>64.2 0.38</td>
<td>64.2 0.38</td>
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<tr>
<td>Intensities</td>
<td>228(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>131.613 1.28</td>
<td>131.613 1.28</td>
<td>131.613 1.28</td>
<td>131.613 1.28</td>
<td>131.613 1.28</td>
</tr>
<tr>
<td>Intensities</td>
<td>230(2) ns</td>
<td>Th</td>
<td>15.5 0.16</td>
<td>238.632 43.31</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
<td>804.9 0.0019</td>
</tr>
</tbody>
</table>

### Thorium Decay Chain:

- **Thorium (Th)**: The longest-lived isotope in the thorium decay series is Th 232, which is radioactive and decays by alpha emission to a lead isotope.
- **Radon (Rn)**: The daughter of Th 232 is Rn 220, which is stable.

The decay chain progresses through a series of beta and alpha emissions, resulting in the formation of increasingly lighter elements. The chain ends with stable lead isotopes.
### Other Interesting Isotopes

**Usually Present:**

- $^{40}\text{K}$
  - 1460.83 keV
- $^{137}\text{Cs}$
  - 661.66 keV
  - (from fallout)
- $^{60}\text{Co}$
  - $1173.2$ keV
  - $1332.5$ keV
- $^{235}\text{U}$
  - $143.76$ keV
  - $163.33$ keV
  - $185.22$ keV
  - $205.31$ keV

### Occasionally Present:

- $^{54}\text{Mn}$ at 834.85 keV
  - Observed in Stainless Steel
- $^7\text{Be}$ at 477.60 keV
  - Observed in Carbon based materials, due to neutron activation, samples are particularly affected after long flights.
- $^{138}\text{La}$ and $^{176}\text{Lu}$
  - Observed in rare earth samples such as Nd or Gd.
Ge Spectrometry
SNOLAB PGT HPGe Counter

Radon Shielding Box
Crane
Seismic mitigation

Standard 1 L geometry
Max: 4 L, if all of the chamber is used.
Unshielded and Shielded Spectra
(PGT Coax Detector)
## Gamma Counter Sensitivities

<table>
<thead>
<tr>
<th>Isotope</th>
<th>PGT Detector Sensitivity</th>
<th>Well Detector Sensitivity</th>
<th>Gopher Detector Sensitivity</th>
<th>VdA Detector Sensitivity</th>
<th>Coax Detector Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{238}\text{U}$</td>
<td>0.11 mBq</td>
<td>0.04 mBq</td>
<td>0.35 mBq</td>
<td>0.06 mBq</td>
<td></td>
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<tr>
<td>$^{235}\text{U}$</td>
<td>0.15 mBq</td>
<td>0.02 mBq</td>
<td>0.23 mBq</td>
<td>0.04 mBq</td>
<td></td>
</tr>
<tr>
<td>$^{232}\text{Th}$</td>
<td>0.11 mBq</td>
<td>0.23 mBq</td>
<td>0.32 mBq</td>
<td>0.05 mBq</td>
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<tr>
<td>$^{40}\text{K}$</td>
<td>1.40 mBq</td>
<td>N/A</td>
<td>1.29 mBq</td>
<td>0.70 mBq</td>
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<tr>
<td>$^{60}\text{Co}$</td>
<td>0.04 mBq</td>
<td>N/A</td>
<td>0.04 mBq</td>
<td>0.02 mBq</td>
<td></td>
</tr>
<tr>
<td>$^{137}\text{Cs}$</td>
<td>0.14 mBq</td>
<td>0.02 mBq</td>
<td>0.08 mBq</td>
<td>0.03 mBq</td>
<td></td>
</tr>
<tr>
<td>$^{54}\text{Mn}$</td>
<td>0.04 mBq</td>
<td>0.80 mBq</td>
<td>0.05 MBq</td>
<td>0.02 mBq</td>
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<tr>
<td>$^{210}\text{Pb}$</td>
<td>N/A</td>
<td>0.08 mBq</td>
<td>N/A</td>
<td>1.65 mBq</td>
<td></td>
</tr>
</tbody>
</table>
Typical Stainless Steel Spectrum

DEAP 1 sample - steel bolts, nuts, wa Sum sp. total + filter3

Counts

Energy (keV)

Acquired: 3/24/2006 11:12:23 AM
File: C:\HPGe\data\Deap1\total.chn
Detector: #1 XRF-MCA MCB 25

Real Time: 696913.81 s. Live Time: 696912.50 s.
Channels: 8192
DAMIC Ceramic Spectrum

filter

DAMIC, Al-N Ceramic, mass 94.4 g

Counts

Energy (keV)

$^{235}\text{U}$

$^{234m}\text{Pa}$

Acquired: 04/02/2013 8:33:41 AM
File: C:\HPGe\data\130204\filter.chn
Detector: #1 XRF-MCA MCB 25

Real Time: 233987.69 s. Live Time: 233987.05 s.
Channels: 8192
DAMIC Data and Simulation Using Results From PGT HPGe Counter

**SNOLAB data**

1g, 8 Mpixel CCDs
6 cm x 3 cm x 250 μm
~50 days of data
2 CCDs with full AlN and 2 with frame AlN

**Raw spectrum from CCDs at SNOLAB**

- **Cu Kα**
- **231Th γ**
- **Th and Pa X-rays**

**Pixel values in low threshold image**

- **Gaussian fit:** 9 eV RMS noise
- **Pixels with collected charge**

**MI bump (~MeV β)**

- **Few Bq kg⁻¹ of U simulated in AlN**

November 5, 2019
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Gopher Gamma Counter

Gopher HPGE detector, primarily for use by SCDMS, with MOU between U. of Minnesota and SNOLAB.

Currently counting SCDMS and SENSEI samples.

Detector is being re-calibrated to determine a new efficiency equation and to correct the GEANT4 geometry and detector dead layer estimates.
VdA and New Canberra Gamma Counters

VdA HPGE detector, primarily for use by EXO (nEXO), with MOU between Laurentian U and SNOLAB.

Detector is being calibrated to determine a new efficiency equation.

New Canberra Coaxial detector.

Much larger chamber for samples than previous SNOLAB detectors.

General purpose for all experiments. Background runs in progress, efficiency calibration has started.
Canberra Well Detector at SNOLAB

Typical Sample Bottles
Volume is 3 ml

Detector Volume: 300 cm³
Sample Well
$^{210}$Pb Detection: Sensitive to $10^{-19}$ g/g in Plastic

Acrylic vaporized in a furnace and bottoms collected with acid rinse.

Sample can be several kg.

Gamma count for 46 keV line, OR

Plate out Po-210 from aged effluent on metal discs.

---

Figure 5.2: The well detector has an acceptable background. (a) The background decreases as energy increases. (b) In the 44.5–48 keV $^{210}$Pb window, the background is $(10.6 \pm 0.7)$ c.p.d.

Plot from MSc thesis of Corina Nantais, Queen’s University at Kingston, 2014

Typical spectrum from acrylic vapourisation sample
Ge Detectors Calibration Samples

The efficiency of a Ge detector is calculated to minimize systematic uncertainties from the Monte Carlo simulations required for each sample.

Use efficiency derived from measurement of a calibrated source.

Monte Carlo corrections are always done in ratio

$$\epsilon_{sample}(E) = \epsilon_{cal}(E) \times \frac{\epsilon_{MC\ sample}(E)}{\epsilon_{MC\ cal}(E)}$$

SNOLAB counting has always used this technique. New crystals being brought online required new calibration sources. What is shown today is preliminary results for one calibration for illustration.
Pairs of Sources Made to fit all SNOLAB Ge Detectors

<table>
<thead>
<tr>
<th>Sample jar designation</th>
<th>Major isotope</th>
<th>Mass of IAEA component (g)</th>
<th>Activity (Bq major isotope)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRS-18-003-K1</td>
<td>$^{40}$K</td>
<td>49.998 ± 0.005</td>
<td>699.97 ± 1.0</td>
</tr>
<tr>
<td>SRS-18-003-T1</td>
<td>$^{232}$Th</td>
<td>49.966 ± 0.003</td>
<td>162.39 ± 2.25</td>
</tr>
<tr>
<td>SRS-18-004-U1</td>
<td>$^{238}$U</td>
<td>49.950 ± 0.005</td>
<td>246.75 ± 0.75</td>
</tr>
<tr>
<td>SRS-18-003-K2</td>
<td>$^{40}$K</td>
<td>49.928 ± 0.005</td>
<td>698.99 ± 1.00</td>
</tr>
<tr>
<td>SRS-18-003-T2</td>
<td>$^{232}$Th</td>
<td>50.150 ± 0.005</td>
<td>162.99 ± 2.26</td>
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<tr>
<td>SRS-18-004-U2</td>
<td>$^{238}$U</td>
<td>49.933 ± 0.005</td>
<td>246.67 ± 0.75</td>
</tr>
</tbody>
</table>

IAEA certificates available
All detectors are calibrated with IAEA $^{238}$U, $^{232}$Th and $^{40}$K sources and a $^{152}$Eu source from Eckert and Ziegler.

GEANT4 simulations of each detector are completed taking into account the individual detector geometry and sample geometry and location.

Step 1, verify existing methods using the PGT detector which was calibrated in 2005 using a mixed radionuclide source.

Using this method, all of the high purity germanium detectors will be similarly calibrated.
Example (from using original calibration)

Sample from DarkSide

Full Spectrum for PGT Run 171020
Detector: XRF-MCA MCB 25
Sample: Darkside20K, Arlon Circuit Boards, 75.6 g

Detector Efficiency Functions

MC and smooth curve used for sample

MC and smooth curve used for cal
Next Steps to Ge Detectors Comparison Between Different UG Labs

- Program being lead by DarkSide.
- Create several calibration samples containing known quantities of several isotopes, such as U, Th, K, Co, Cs. Samples will be made by the IAEA and will be low activity samples.
- Samples will be prepared using a sample container which will fit all detectors to simplify comparisons.
- The samples will be counted at detectors located at several underground labs with ties to DarkSide, including SNOLAB, LNGS, LSM and LSC (other labs can be added if they are interested)
- The detector groups will be sent the samples to count without knowing the composition of the sample and then they will report their results to a coordinator. The different labs will keep the results confidential until each lab has counted their samples.
- Once all samples have been counted, then a comparison of the results will occur and we see what happens.
- The goal is to determine how each laboratory’s different analyses methods compare and then to determine if there are any fundamental differences once the data is compared, this will also for us to use the same units for the comparison.
- This is in progress, some of the samples have been ordered by SNOLAB via a scientist not directly involved with gamma counting to avoid biases.
ICP-MS Screening

- Good for very small samples or pieces of large samples
- A few drawbacks, sample preparation is destructive and only samples parts of a larger sample.
- Sensitivity down to nBq level can be achieved
- Must ensure all components of the sample preparation process have extremely low backgrounds and work must be performed in a clean room (preferably class 100 or better).

Agilent 8800 ICP-MS
Example of ICP-MS at PNNL
## Comparison of Ge Counting and ICP-MS

<table>
<thead>
<tr>
<th>Element</th>
<th>Rock Sample 8</th>
<th>Rock Sample 11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ge</td>
<td>ICP-MS</td>
</tr>
<tr>
<td>K (%)</td>
<td>1.09 ± 0.01</td>
<td>0.97</td>
</tr>
<tr>
<td>U (ppm)</td>
<td>1.24 ± 0.16</td>
<td>1.21</td>
</tr>
<tr>
<td>Th (ppm)</td>
<td>5.44 ± 0.37</td>
<td>5.54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Shotcrete Sample 15</th>
<th>Concrete Sample 14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ge</td>
<td>ICP-MS</td>
</tr>
<tr>
<td>K (%)</td>
<td>1.78 ± 0.05</td>
<td>1.76</td>
</tr>
<tr>
<td>U (ppm)</td>
<td>2.46 ± 0.09</td>
<td>2.56</td>
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<tr>
<td>Th (ppm)</td>
<td>15.24 ± 0.14</td>
<td>14.90</td>
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</table>
Alpha Counting

Under commissioning at the SNOLAB surface clean lab
Teflon liner tray background runs show 400 nBq/cm\(^2\) emissivity over full energy range (1-10MeV)
Plan to move it underground by 2019 / 2020

Count region: 1800cm\(^2\) square and 707cm\(^2\) circular
Maximum sample weight: 9kg
Maximum sample thickness: 6.3mm

Monitor system of environmental parameters (radon, humidity, temperature, particulates ..)

An ionization chamber with no wires.
Alphas ionize Ar gas.
The top of the XIA has a 1100 V anode. Charge drifts from the grounded sample tray. As the charges drift, they induce a current on the anode.

Risetime is the duration of the leading edge of the pulse, the charge drift time.
Risetime is a discriminating variable to reject mid-air decays. (Short rise time because of short drift distance.) 60us nominal cut.
Electrostatic Counting System (ESCs)  
(Alpha Counter)

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

Sensitivity Levels are:

- $^{222}\text{Rn}$: $10^{-14}$ gU/g
- $^{224}\text{Ra}$: $10^{-15}$ gTh/g
- $^{226}\text{Ra}$: $10^{-16}$ gU/g

Work is ongoing to improve sensitivity even further.

9 counters located at SNOLAB,  
1 on loan to LBL (EXO),  
1 on loan to U of A (DEAP).
Alpha Beta (BiPo) Counting System

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 $^{238}\text{U}$ and $^{232}\text{Th}$ is $\sim 1$ mBq assuming that the chains are in equilibrium.
Radon Emanation

Emanation: Radon atoms formed from the decay of radium escape from the decaying isotopes and into the spaces between the isotopes.

Transport: Diffusion and advective flow cause the movement of the radon atoms through the sample to the surface.

Exhalation: Radon atoms that have been transported to the surface and then exhaled to the surface.

Samples generally placed in a chamber to allow the radium to decay for several half-lives and then radium daughters are accumulated and counted to give the rate in Bq/m²/s of Bq/kg/s

<table>
<thead>
<tr>
<th>Sample</th>
<th>Rate (Bq/m²/s)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shotcrete</td>
<td>1.7-4.2 mBq/m²</td>
<td>J. Bigu and E.D. Hallman SNO-STR-92-064</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>4.6-10.2 µBq/m²</td>
<td>G. Zuzel, H. Simgen, Radon Emanation measurements, GERDA General Meeting, July 11, 2007</td>
</tr>
<tr>
<td>Silicon Rubber</td>
<td>196 mBq/m²</td>
<td>Zuzel, G., AIP Conference Proceedings, Vol. 785, pp. 142-149.</td>
</tr>
</tbody>
</table>
Neutron Activation

Sample is activated with neutrons causing its components to form radioactive isotopes.

Main advantage is that the sample does not need to be destroyed.

Sample can then be counted using usual methods such as Ge spectrometry.

Main drawback is that the sample may remain radioactive for quite some time and there are limited opportunities to irradiate samples as suitable activation reactors are declining.
Röntgen Excitation Analysis

X-ray fluorescence of a sample after being bombarded with high-energy X-rays or gamma rays.

Used for elemental analysis and chemical analysis, used generally for metals, glass, building materials, etc…

For low background experiments, for example, it can be used to measure surface contamination by observing any presence of heavy elements such as iron, calcium and zinc which can be found in mine dust.
The Assay and Acquisition of Radiopure Materials (AARM) Collaboration originally developed the Community Material Assay Database radiopurity.org.

The database is now hosted at SNOLAB.

Several UG labs are now in the early stages of deciding how to improve the database to include future data.
Future Plans at SNOLAB
General Purpose Underground Shielding Tank (GUST)

- General Purpose shielding tank with veto system
- The tank could contain an inner acrylic tank and a PMT array counter
- Walls constructed from bolted, corrugated cylindrical segments of galvanized carbon steel, similar to other SNOLAB water tanks.
- Polyurea lined tank ~ 1 cm thick coats walls, floor, and transition to ss lid, to limit radioactivity from the tank walls.
Summary

- There are many different techniques to measure radioactive backgrounds.

- The technique can depend on several factors:
  - upon its size,
  - whether or not the sample itself is to be used in the experiment
  - can the sample be sacrificed, etc…

- Sometimes a sample can be counted using multiple methods
  - Ge spectrometry to measure the sample bulk
  - α spectrometry to measure the sample surface

- A program is being established to calibrate Ge detectors at several UG labs using common samples which will be sent to each lab for measurement.

- An improved database is being proposed to allow greater involvement with the community in the goal to include data from a much larger set of experiments.