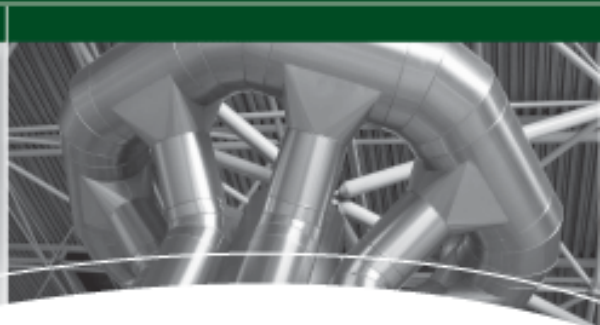


Radon Progeny Dosimetry Using Alpha Track Detector Technology

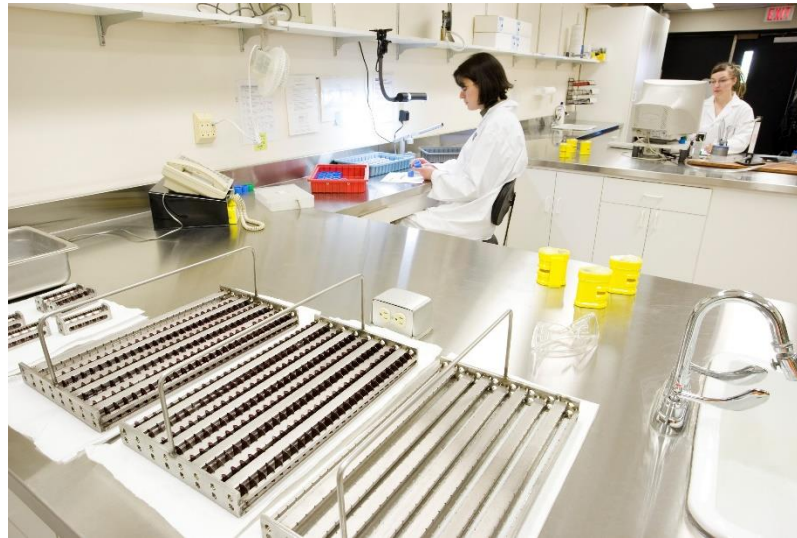
CARST 2019



Radiation Safety
Institute of Canada
Institut de radioprotection du Canada



- Occupational exposures to radon progeny
- Methods to measure worker doses
- Personal alpha dosimetry service

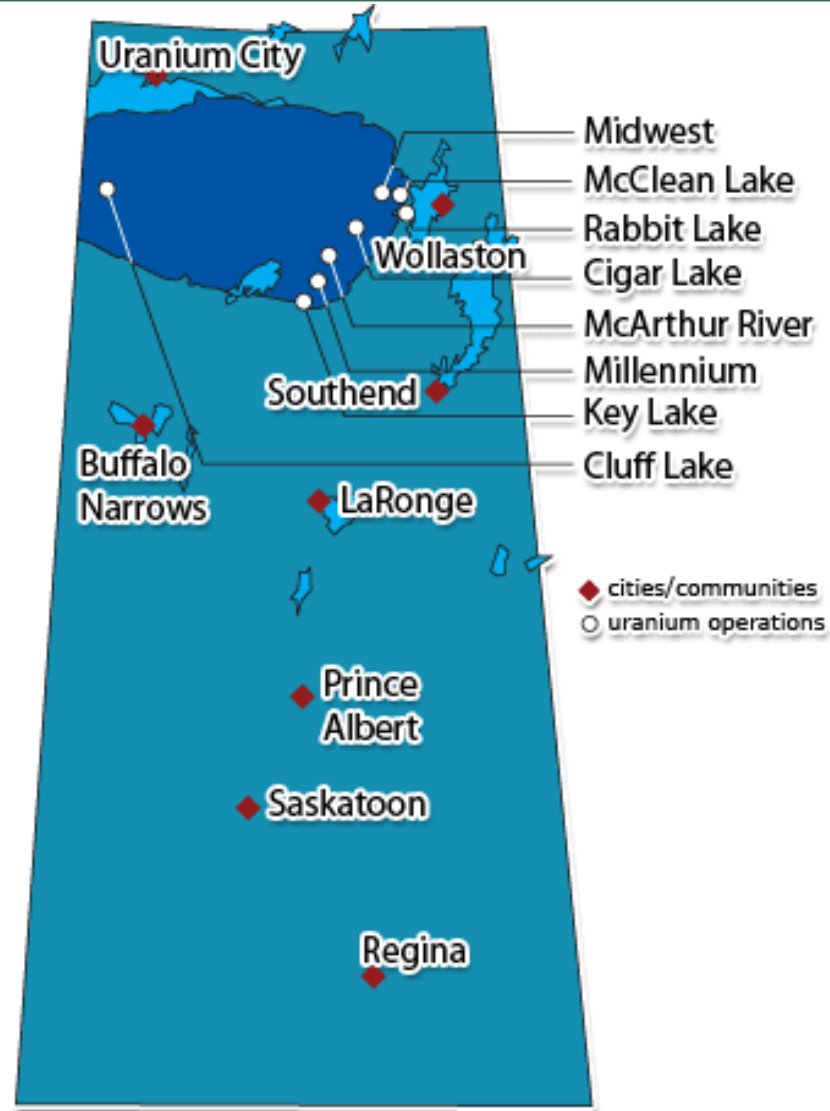


- Founded in 1980, the Radiation Safety Institute of Canada is an independent, national organization dedicated to promoting and advancing radiation safety in the workplace, in the environment and in the community
- Our commitment to the principle of “good science in plain language”® underpins everything we do

- Public information on radiation safety
- Training and education
- Consulting
- Instrument calibration
- Sealed source leak testing
- Radon testing
- Radon calibration chamber services
- ***Personal alpha dosimetry services***

Uranium in Saskatchewan

Good Science in Plain Language®



- Uranium concentrations in soils
 - In soils: ~3 ppm
 - Uranium mine
 - 0.1% ore grade: 1,000 ppm
 - 1% ore grade: 10,000 ppm
 - 20% ore grade: 200,000 ppm



- In Canada uranium mining and milling are licensed activities under the Canadian Nuclear Safety Commission (CNSC)
- A Licence is required



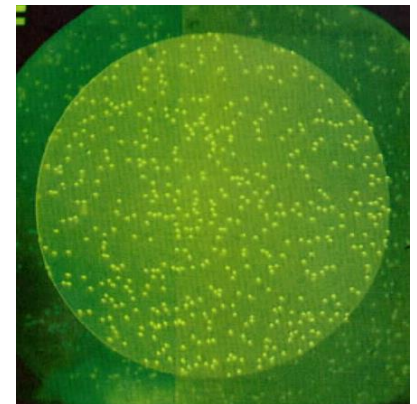
- Radiations of concern in a uranium mining
 - Gamma radiation – external radiation
 - Radon progeny – internal exposure
 - Long-live radioactive dust – internal exposure



- Effective dose = Sum of doses from all sources of exposure
- Members of the public < 1 mSv/year
- Nuclear Energy Workers (NEW)
 - 50 mSv (1 year)
 - 100 mSv (5 year)



- Potential Alpha Energy Concentration (PAEC)
 - One Working Level (WL) is equivalent to a potential alpha energy concentration of 1.3×10^5 MeV/L in air
 - One WLM corresponds to an exposure of one Working Level (WL) during a reference working period of one month (170 h)
- Dose unit – WLM



- Annual Limit of Intake (ALI)
 - The amount of activity taken into the body through inhalation and/or ingestion

- Dose unit – Bq



- Occupational Exposure Limits
 - Radon Progeny: 4 WLM
 - 5 mSv/WLM – ICRP 65
 - Uranium ore long-lived radioactive dust: 4500 Bq
 - Inhalation Annual Limit of Intake

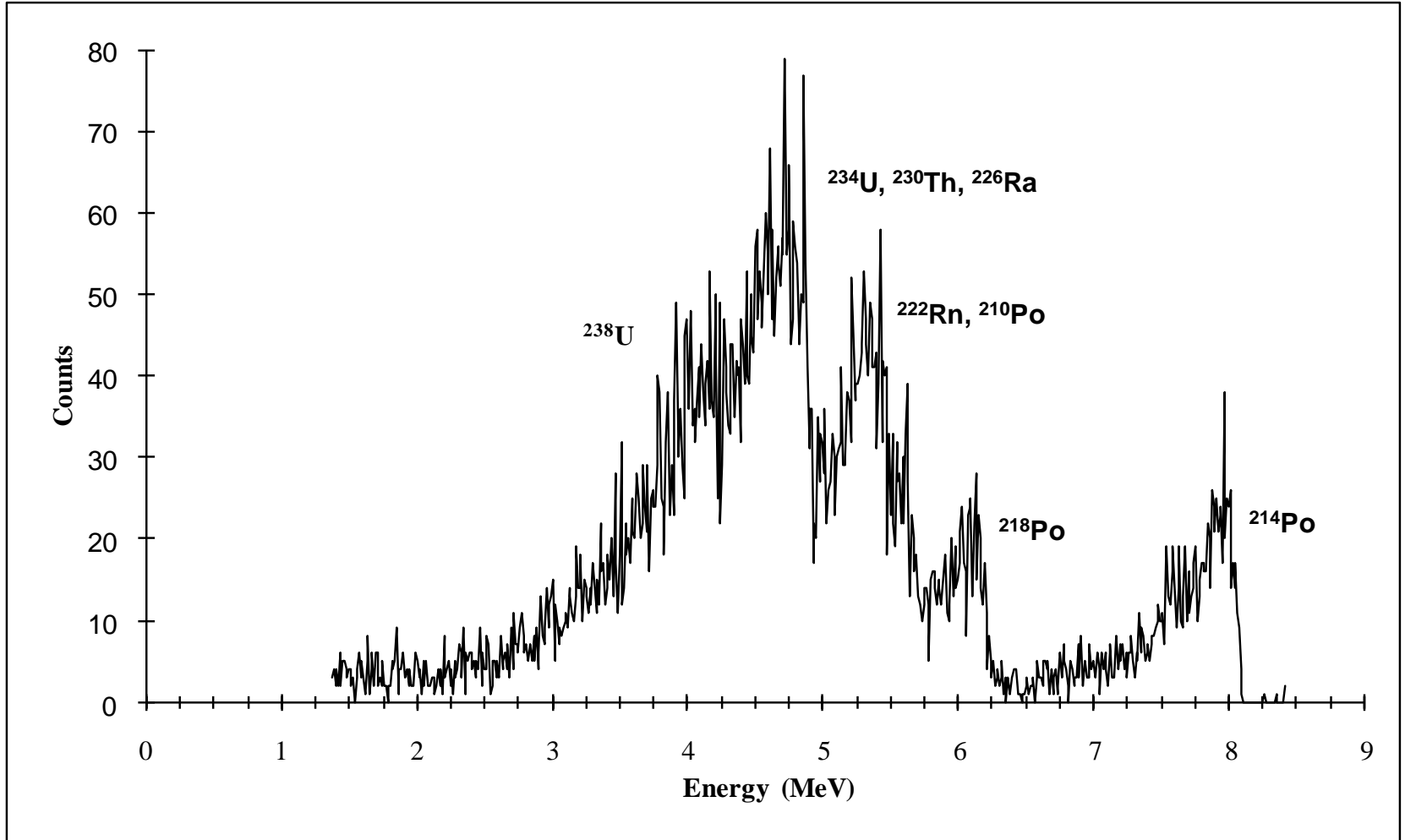
- Measurement/estimate of worker doses from the inhalation of radon progeny and long-lived radioactive dust





LLRD Alpha Spectrum

Good Science in Plain Language®



- Grab sampling program
 - Determine sampling locations and frequencies
 - Establish sampling protocol – Kusnetz/Rolle
 - Track the amount of time workers spend in work areas being monitored
- Limitations
 - Temporal and spatial limitations
 - Time records management/accuracy



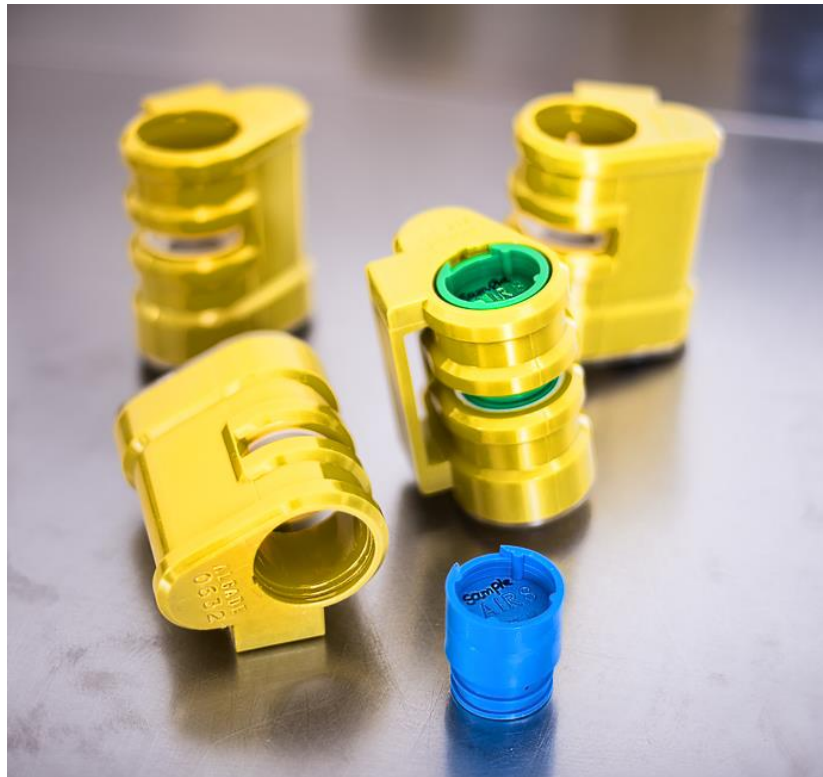
- The only way to ensure a representative exposure measurement is by using personal dosimetry methods



- Dosimetry services must be licensed with the Canadian Nuclear Safety Commission (CNSC)

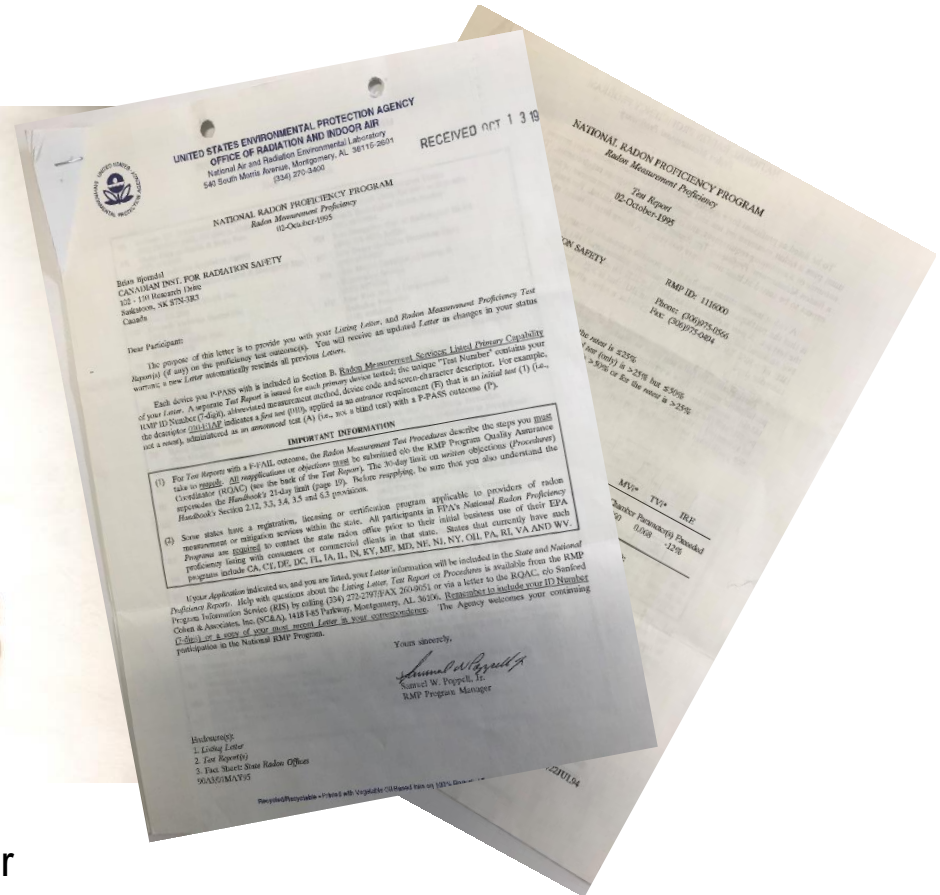


- Developed in the 1970's by the French CEA



- Canadian uranium mines and mills
- Australia uranium mines
- Low level radioactive waste management facilities
- Studies in non-uranium mines
- Traditionally not used for dosimetry in radon in homes applications
 - Was used for radon in homes screening for many years





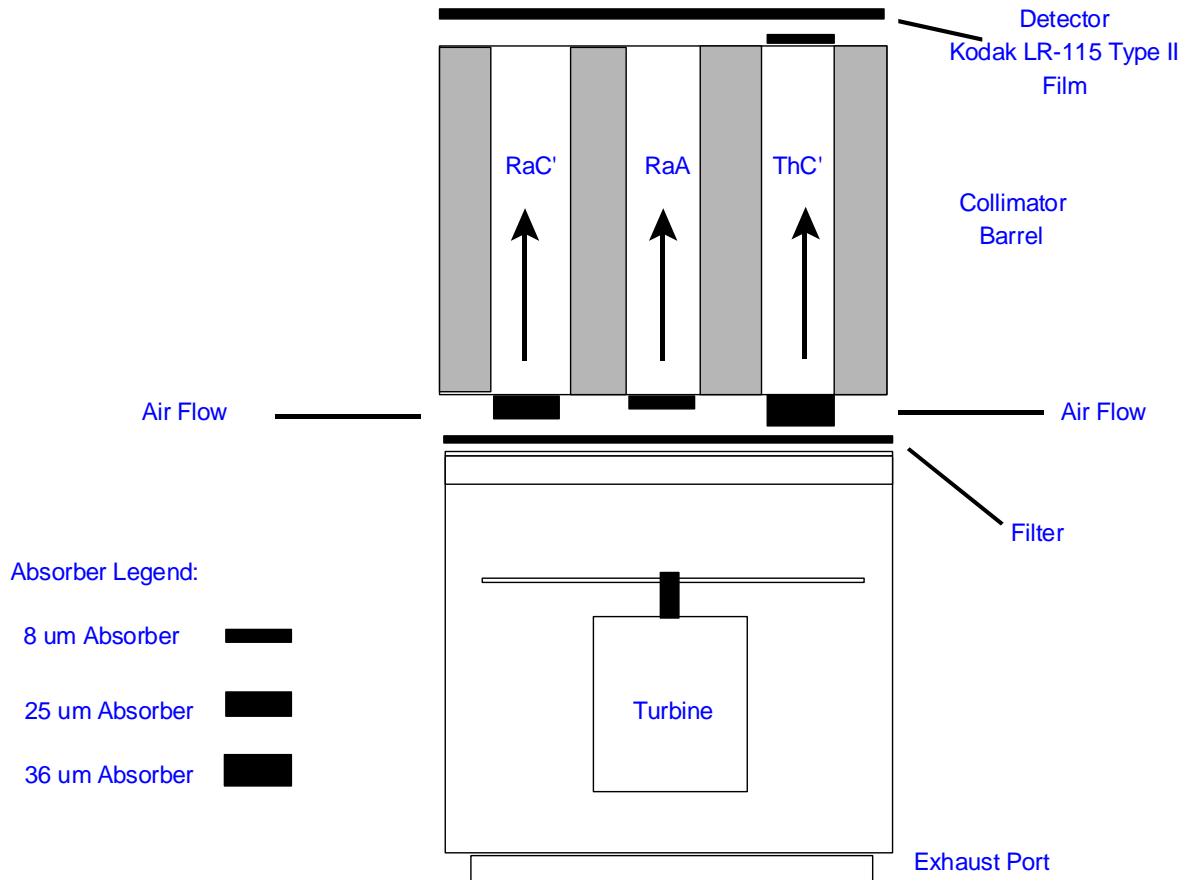
EPA Approved Radon Monitor
National Radon Proficiency Program

- The Personal Alpha Dosimeter is designed to measure:
 - Radon Progeny
 - ^{218}Po (RaA)
 - ^{214}Po (RaC')
 - Thoron Progeny
 - ^{212}Po (ThC')
 - Alpha emitting Long-Lived Radioactive Dust (LLRD)



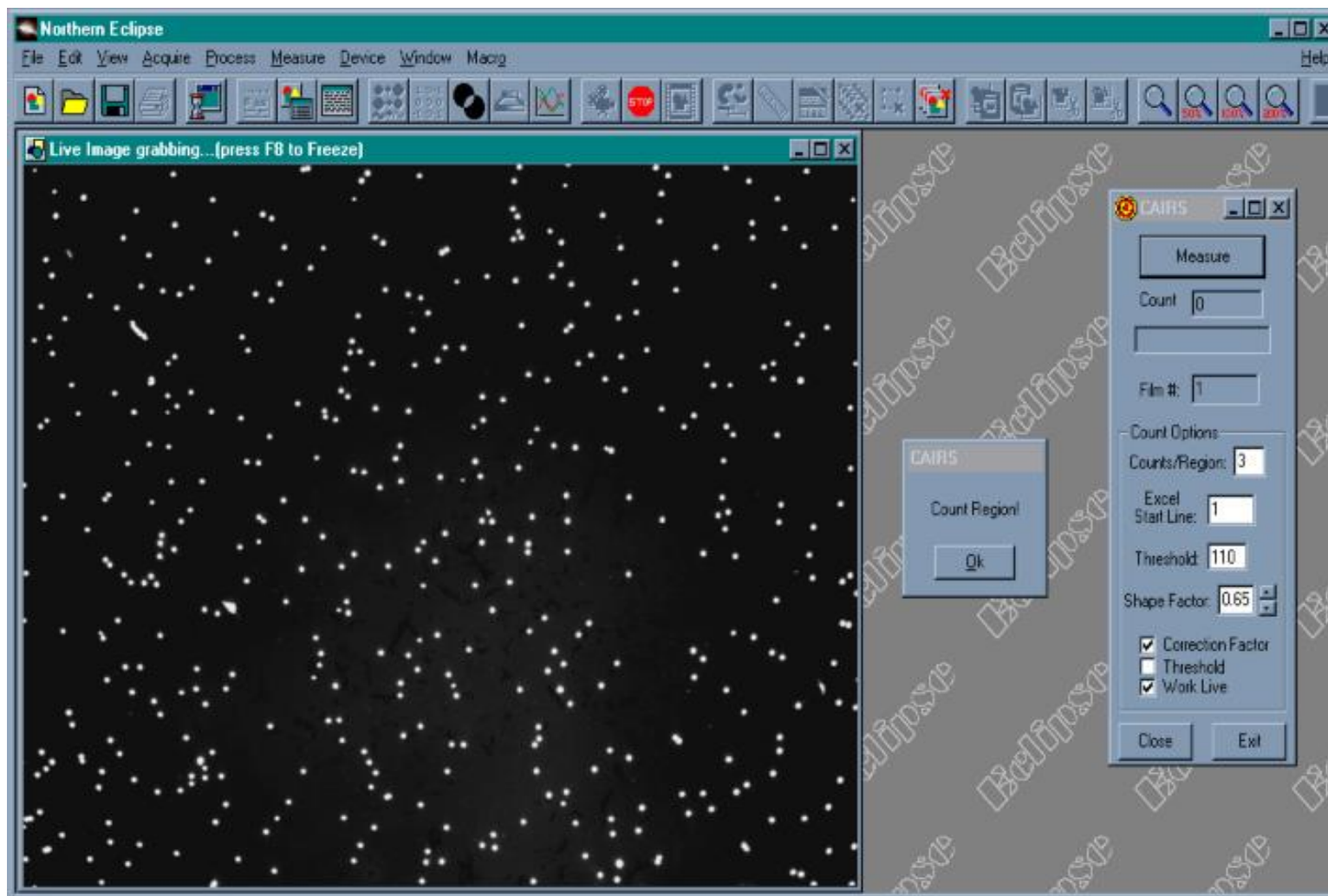
- Individual sampler – pump
- Dosimeter head – solid state nuclear track detector



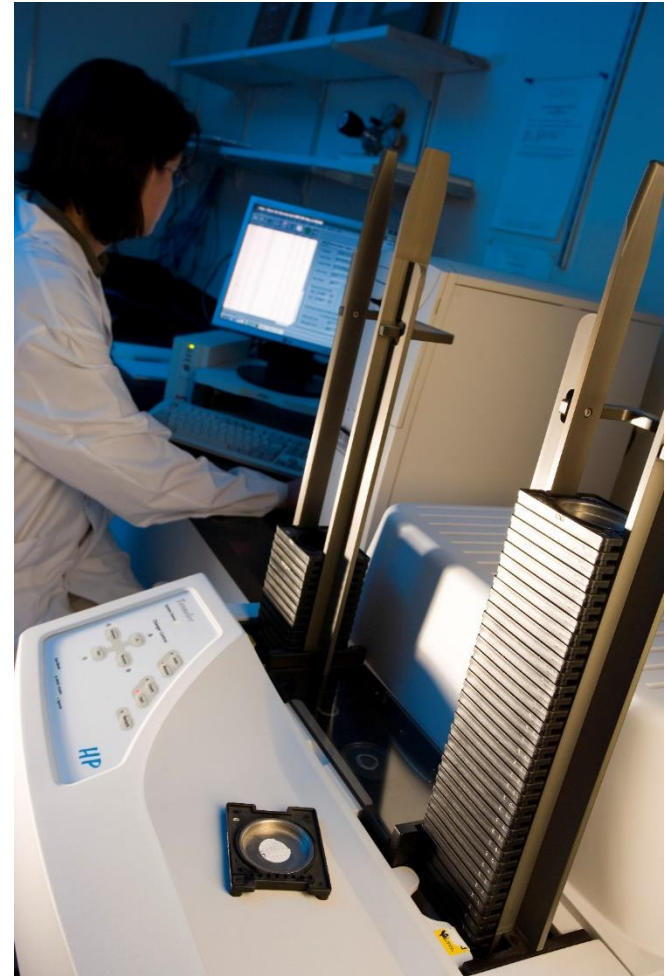


- The tracks are enlarged by etching the films in a sodium hydroxide solution (NaOH) which can then be counted using an image analysis system (IAS)





- The LLRD deposited on the dosimeter head filter is counted using a low background automated alpha/beta counting system



Last Name	First Name	Employee ID	Head No.	PAD No.	Radon Progeny (RnP) (WLM)	RnP LDL ² (WLM)	Thoron Progeny (TnP) (WLM)	TnP LDL ² (WLM)	LLRD Exposure (Bq)	LLRD Exposure MDA ²² (Bq)	Comments
ONE	WORKER	1	NL 001 H	9701	0.007	0.002	0.003	0.002	4	6	
TWO	WORKER	2	NL 002 H	9702	0.235	0.002	0.002	0.002	188	6	
THREE	WORKER	3	NL 003 H	9703	2.349	0.002	0.004	0.002	356	6	
Total					2.591		0.009		548		
Average					0.864		0.003		183		
Maximum					2.349		0.004		356		

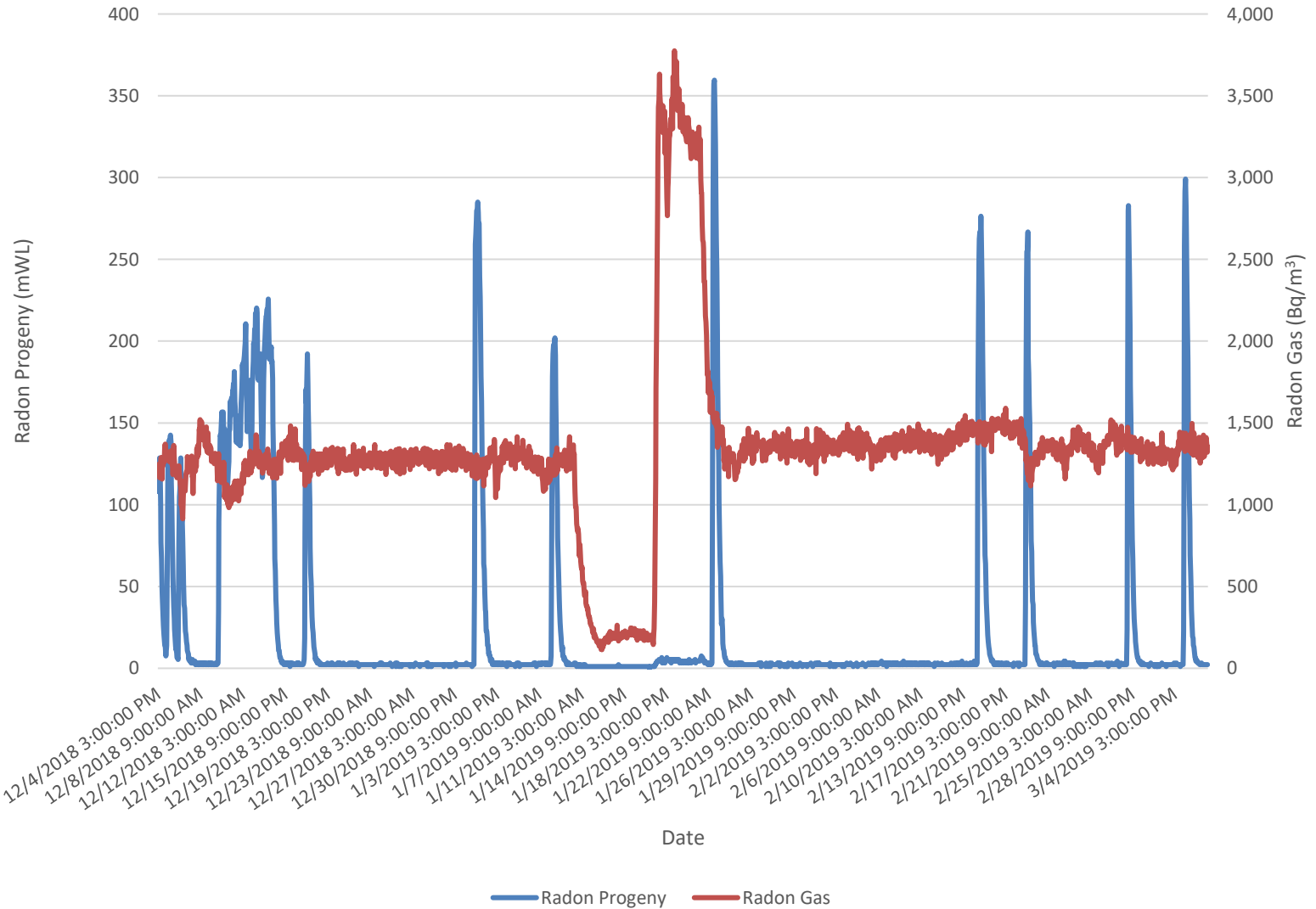
- Occupational Exposure Limits
 - Radon Progeny: 4 WLM (5 mSv/WLM)
 - Thoron Progeny: 14 WLM
 - Inhalation of LLRD (Uranium): 4500 Bq

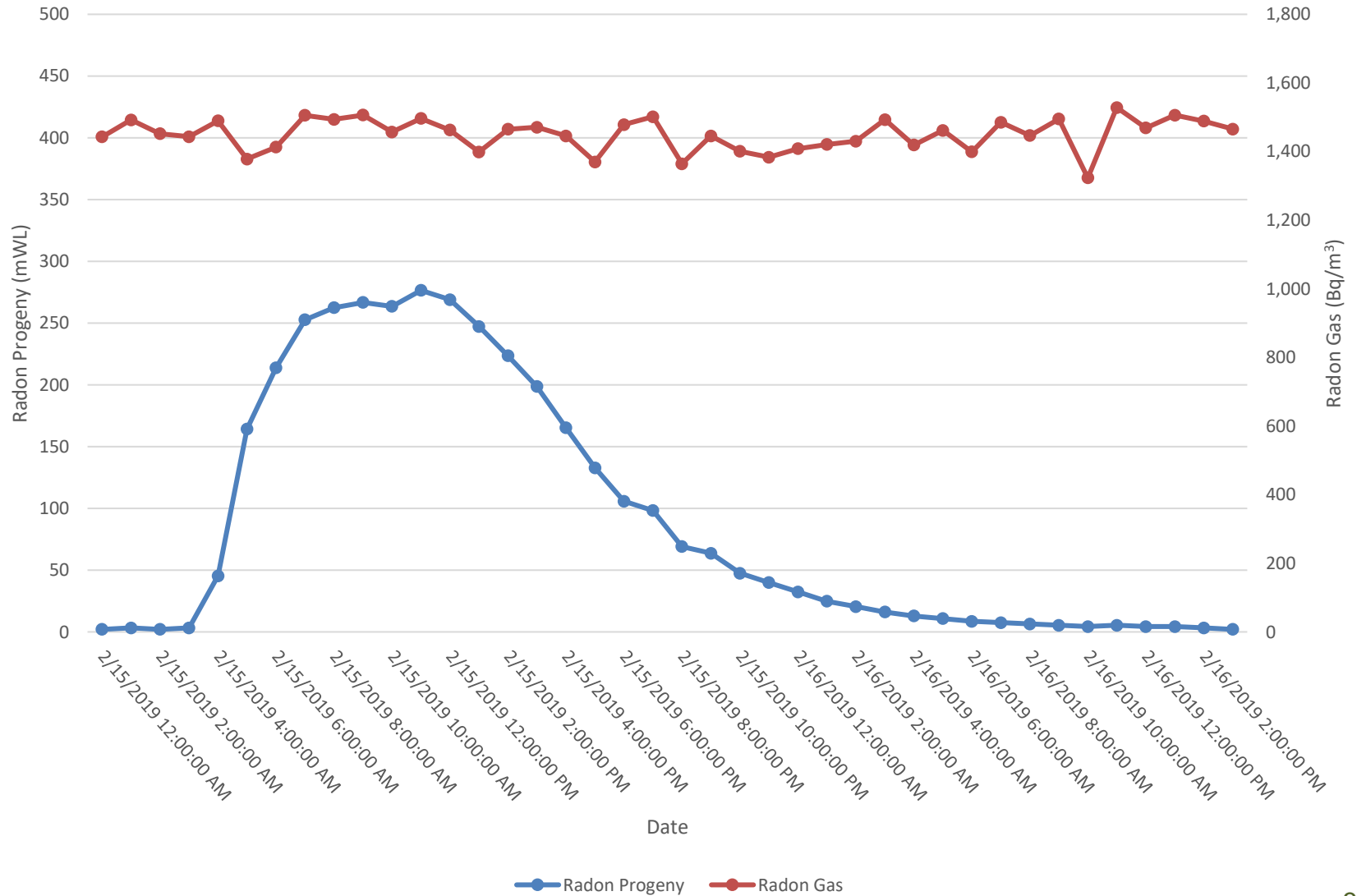
- Radon gas concentrations
- Equilibrium conditions ($F = 0.1-0.2$)
- Unattached fraction ($\sim 1\%$)



- The PAD has undergone extensive independent testing for the measurement of radon and thoron progeny
 - French CEA
 - CANMET chamber
 - Field inter-comparison tests
 - Bowser-Morner chamber
 - RSIC chamber



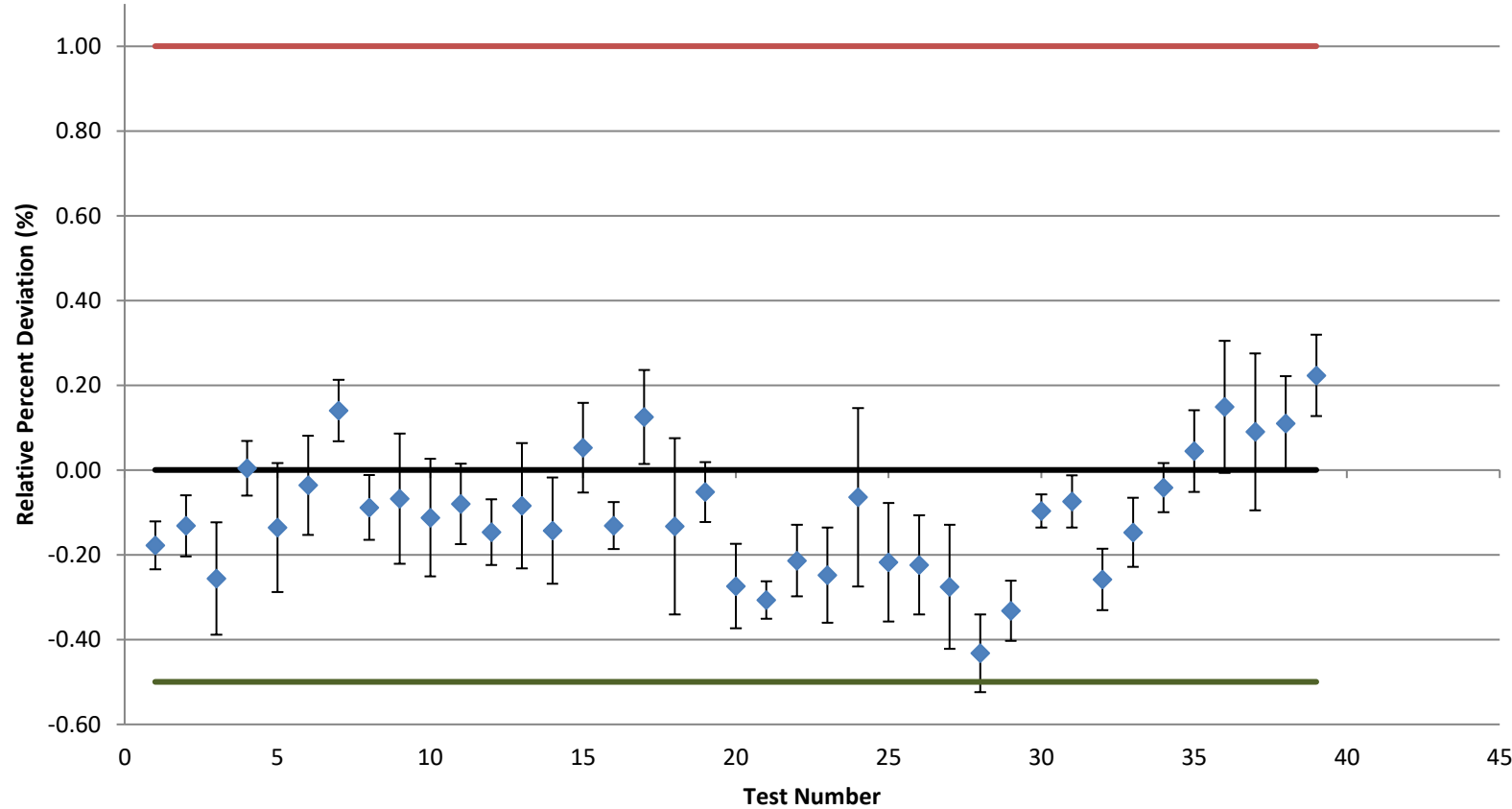




- CNSC S-106 Revision 1 Performance Specifications
- Accuracy Specifications for Measurement of Exposure to Radon Progeny for One Dosimetry Period.

Range Of Measurements	Overall Accuracy (95% Confidence)
≥ 0.05 WLM ($177 \mu\text{J h m}^{-3}$) to < 0.10 WLM ($354 \mu\text{J h m}^{-3}$)	+100% / -50%
≥ 0.10 WLM ($354 \mu\text{J h m}^{-3}$)	+50% / - 33%

PAD Independent Test Results Bowser-Morner



◆ Average Percent Deviation — CNSC LSL — CNSC USL — Centerline

Thank You!

