Cold Radon Emanation Facility

PPD R&D talk 28 Sep 2022

Outline

- CREF motivation & technologies
- Funding arrangements past-current-future
- Status of facility
- Time schedule

Cold Radon Emanation Facility

Who is involved?

- RAL-PPD
  - Maurits vd Grinten
  - Andrei Khazov
  - Emily Perry
  - Mark Tucker
- UCL
  - Cham Ghag
  - Ruben Saakyan
  - Andrew Stevens
- University of Edinburgh
  - Xin-Ran Liu (now left academia)

What do we do?

- Study radon emanating from sample material
- Do this as a function of temperature
- Do this at high volume capacity

Radon: not a friend of DM searches

Radon

- Radon originating from Uranium and Thorium chains
- Radon-222 has half-life of 3.82 days, once in Xenon it disperses throughout
- Background mimics WIMP signal

Temperature considerations

- Radon diffusion suppressed in some materials at cryogenic temperatures
- Radon recoiling out from surfaces not suppressed
- Limited data available on the overall temperature dependence of radon outgassing from materials
- Very limited data available distinguishing surface from bulk emission

Cryogenic Radon Emanation Facility:

1. Conduct assays under cryogenic conditions
2. Operate with a large chamber volume

This facility:

Sensitivity of < 50 µBq/sample envisaged

Facility consist of:

1. Large cryogenic vacuum vessel & cryostat
2. ISO Class 7 controlled environment
3. Large (~ 200l) test chamber
4. Radon concentration line
5. Radon detector

Following MSSL arrangements

6. UCL & PPD operational running resources

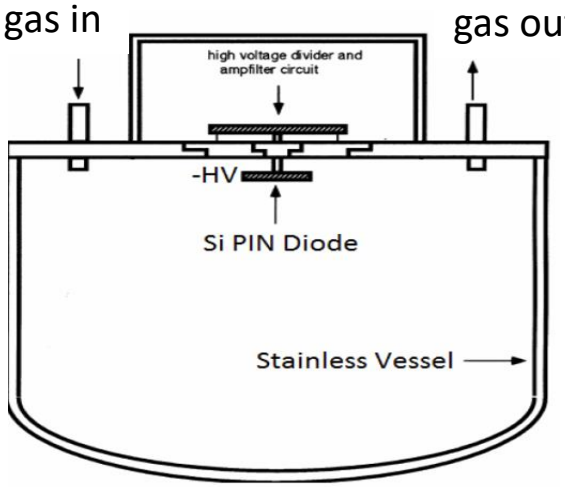
Funding Path:

1. Past - STFC Capital Equipment grant with UCL
2. Current - Xenon Futures
3. Next - Next Generation G3 LXe observatory

Operations scheme

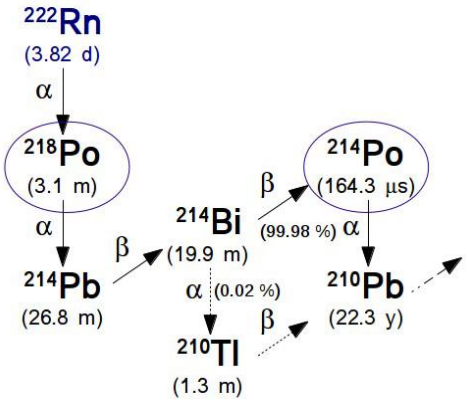
RnCL Operation principle

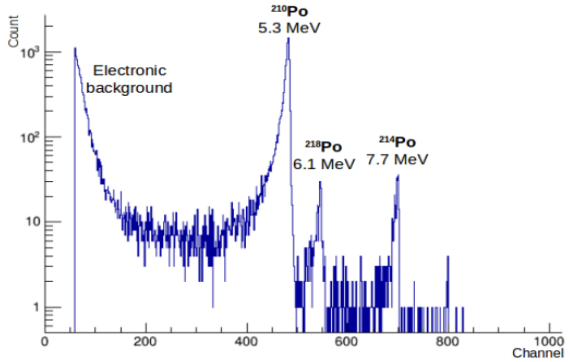
- Drive purified carrier gas through test chamber
- Trap radon in cold carbon traps
- Accumulate radon over a set period
- Warm up and release radon into detector
- Detect Rn decay

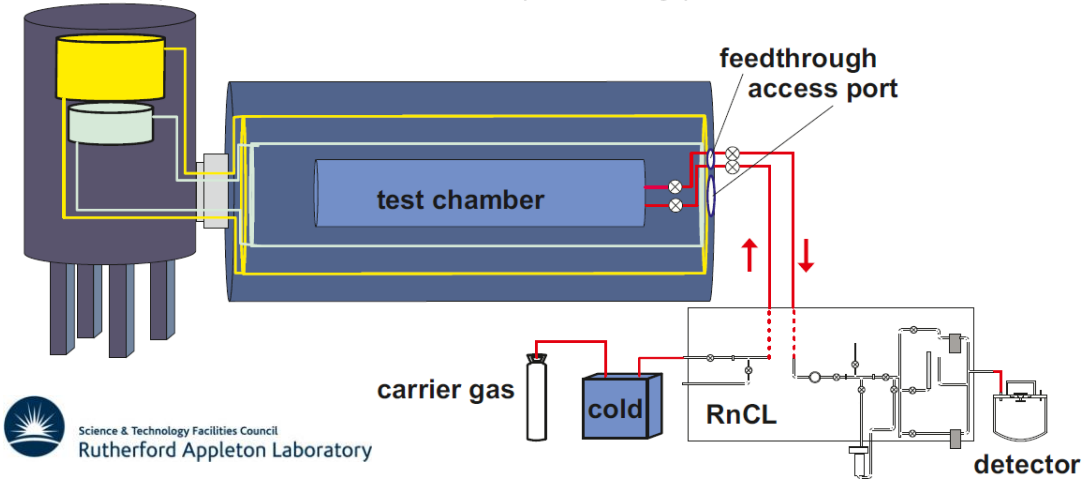


Detector operation

- ^{222}Rn directed into vessel
- Positive decay ions collected on pin diode
- Po alphas identified by energy



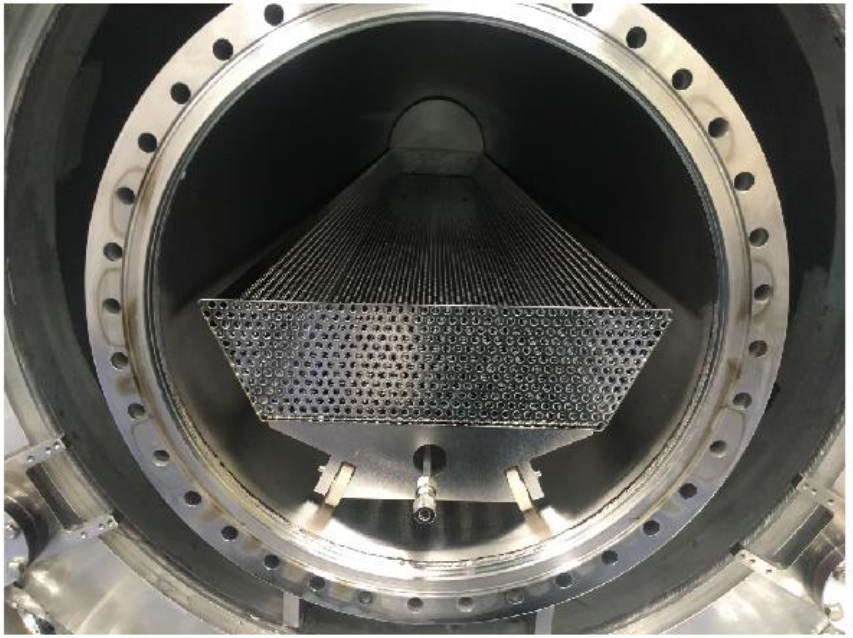




Science & Technology Facilities Council
Rutherford Appleton Laboratory

Experimental Hall R5.2
Cold Radon Emanation Facility

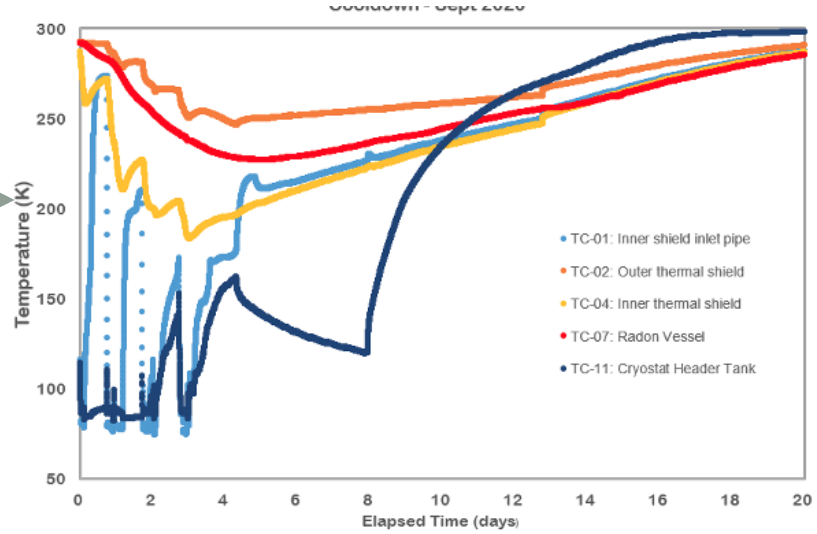
Radon vessel installation



Cryogenic Cooldowns

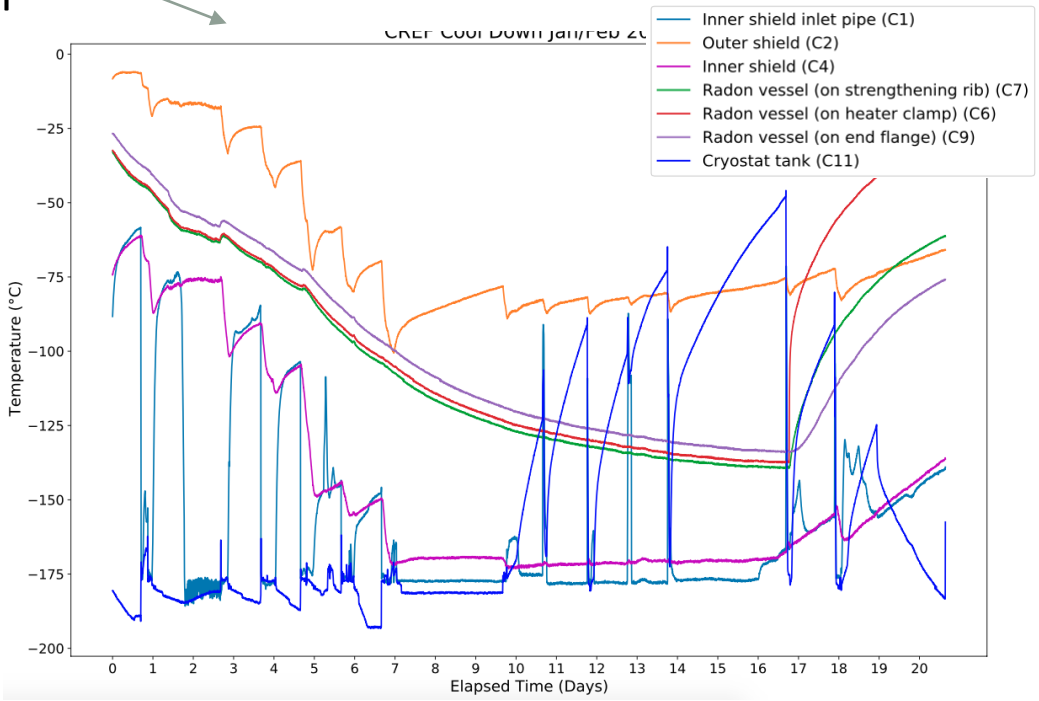
Cool down 1

- LN_2 cooldown of main tank and Rn vessel
- “bare” cooldown: filling with cryogens only

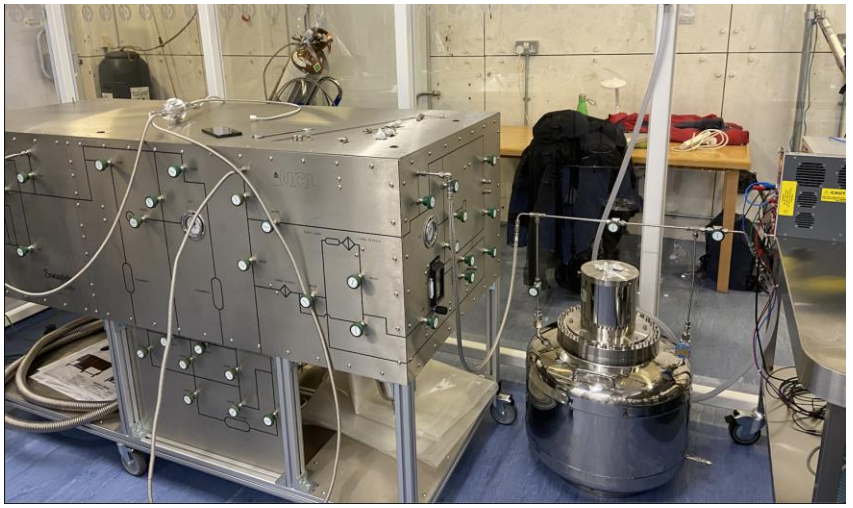


Cool down 2

- LN_2 cooldown of main tank and Rn vessel
- Heaters installed operated on Rn vessel

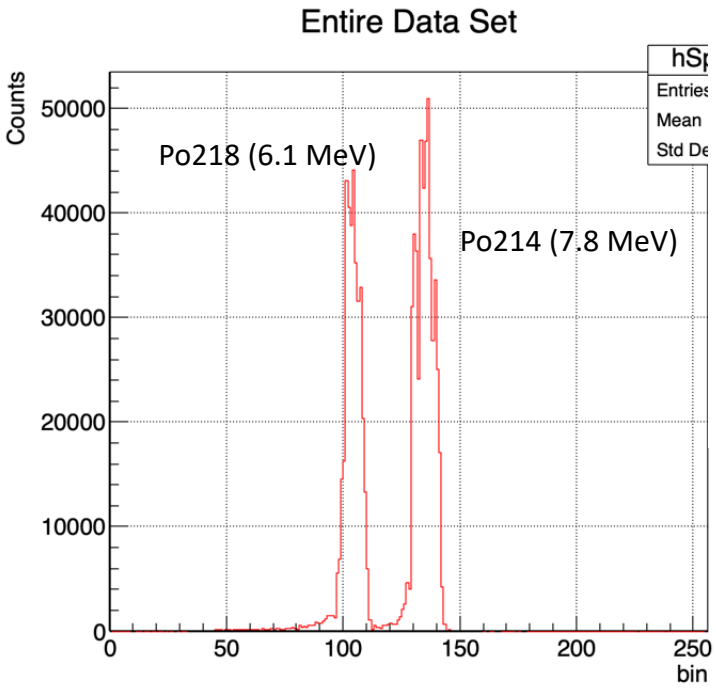


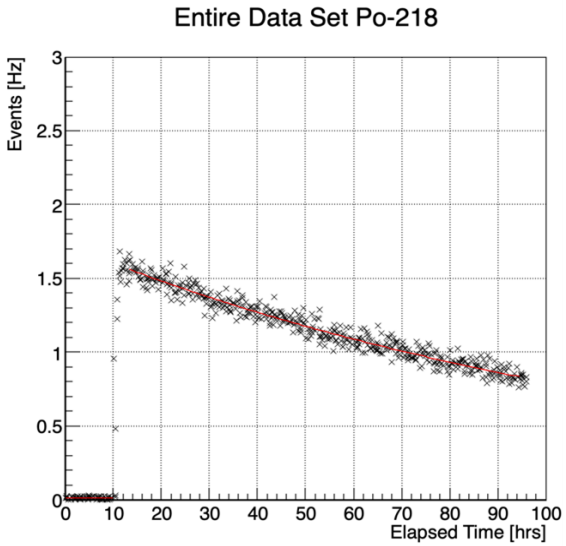
Detector calibration

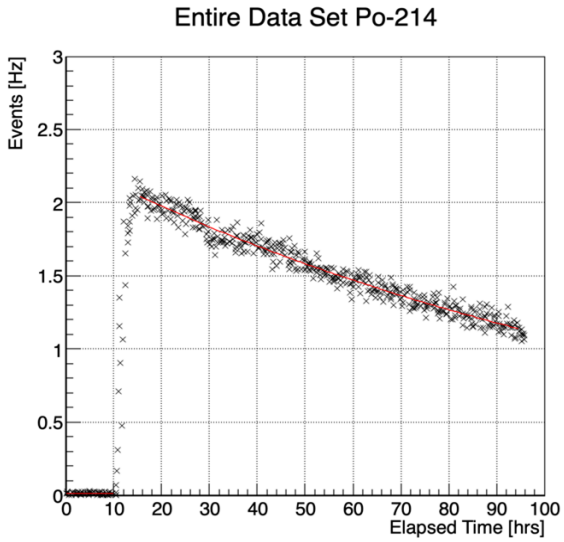


First Detector Calibration at CREF – May 2022

Transfer a known amount of radon into the detector to determine its detection efficiency.





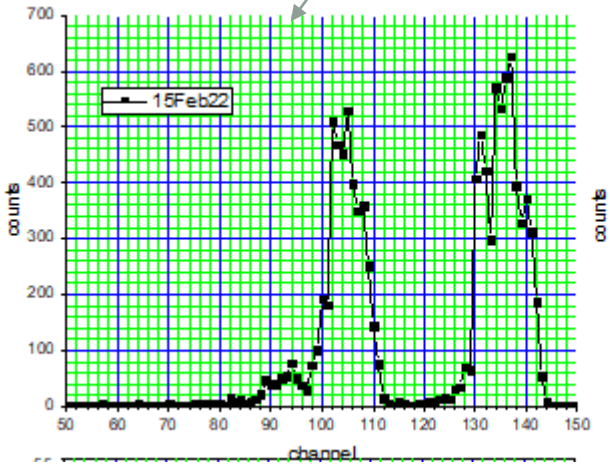


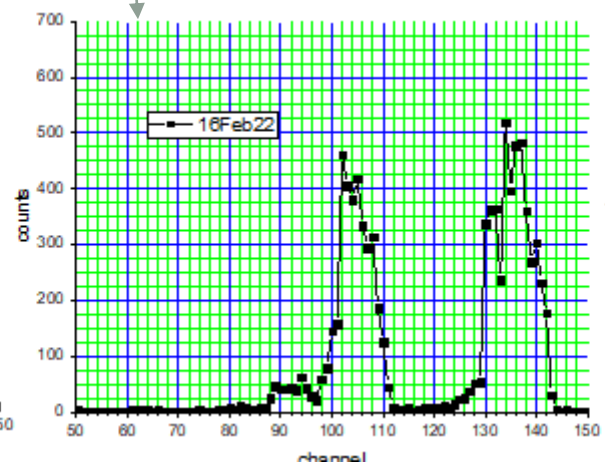
Everything appears as expected:

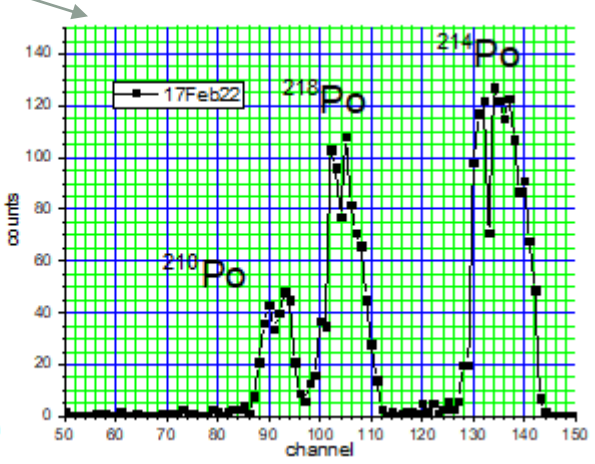
- Peak energy positions agree with values seen in UCL calibration.
- Po218 and Po214 activity curves corresponds to Rn222 half life and distribution as expected.

Some energy spectra post Rn injection

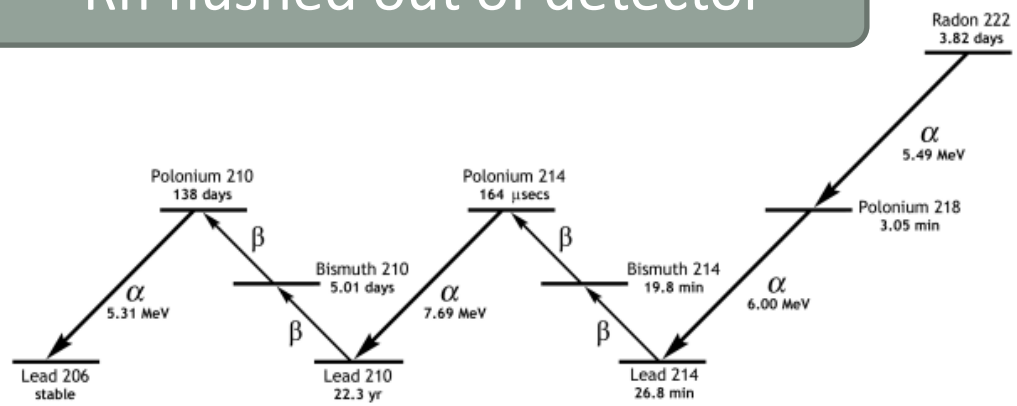
^{222}Rn moved-to/kept-in detector

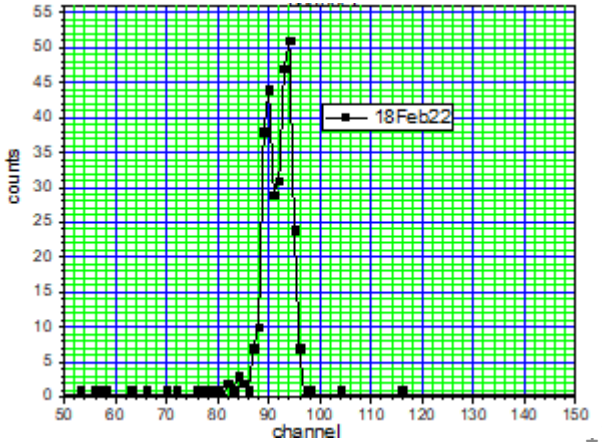






^{222}Rn flushed out of detector



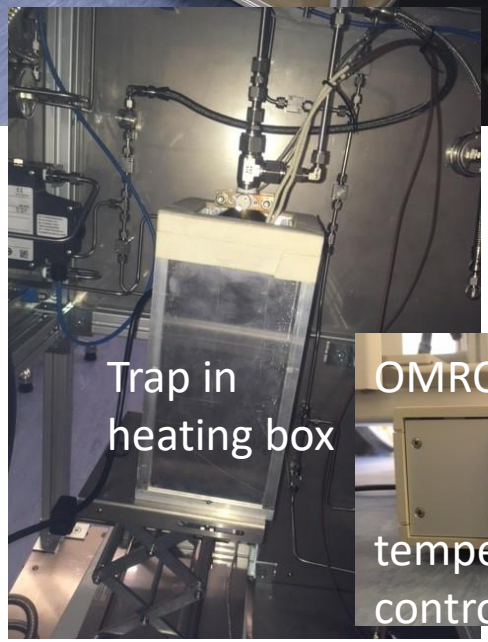



Trap with
cooling coil


Radon
concentration
line with
detector


Trap in cooled
ethanol

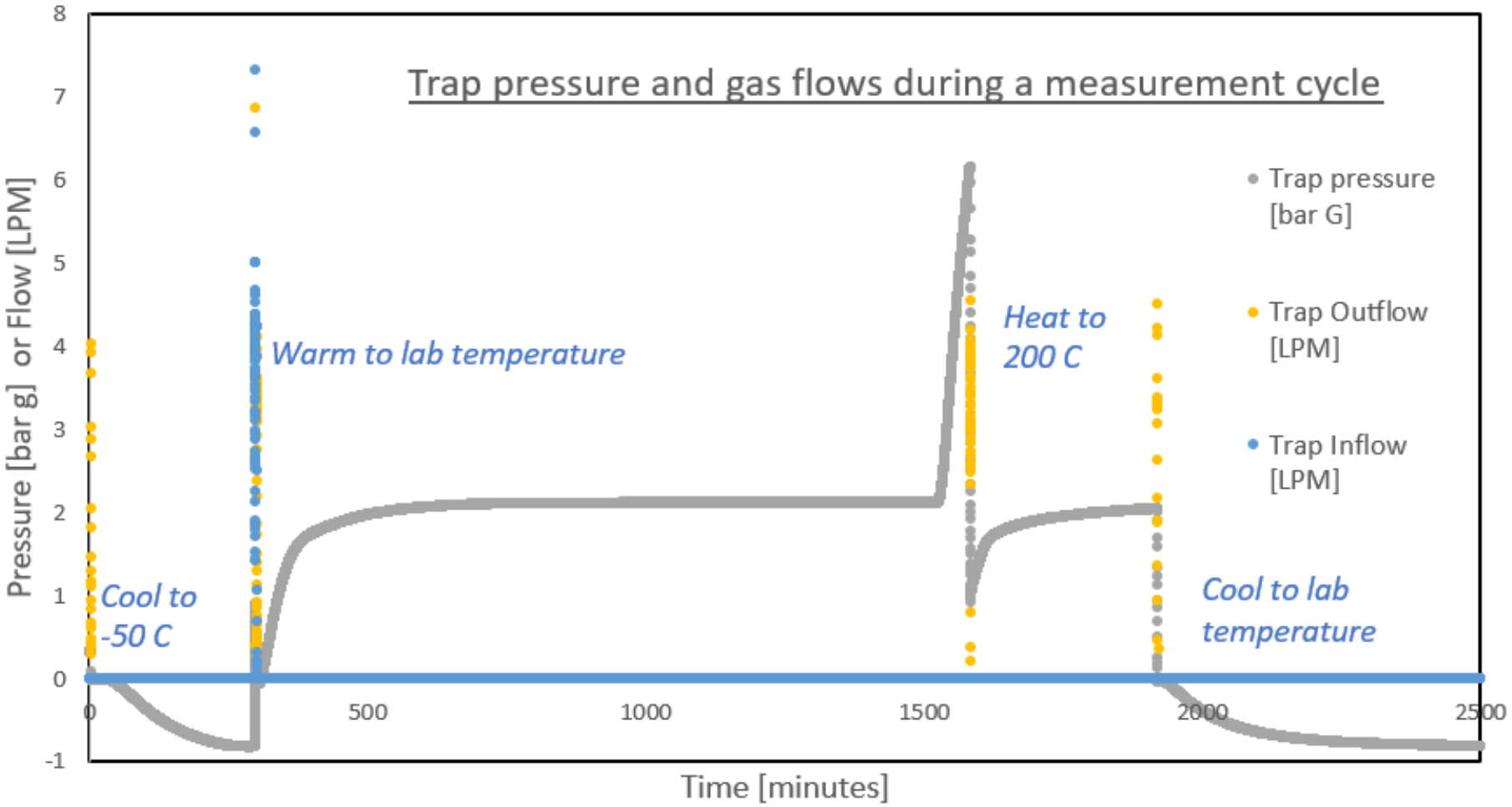

EK90 chiller
(to –90 C)


Trap in
heating box

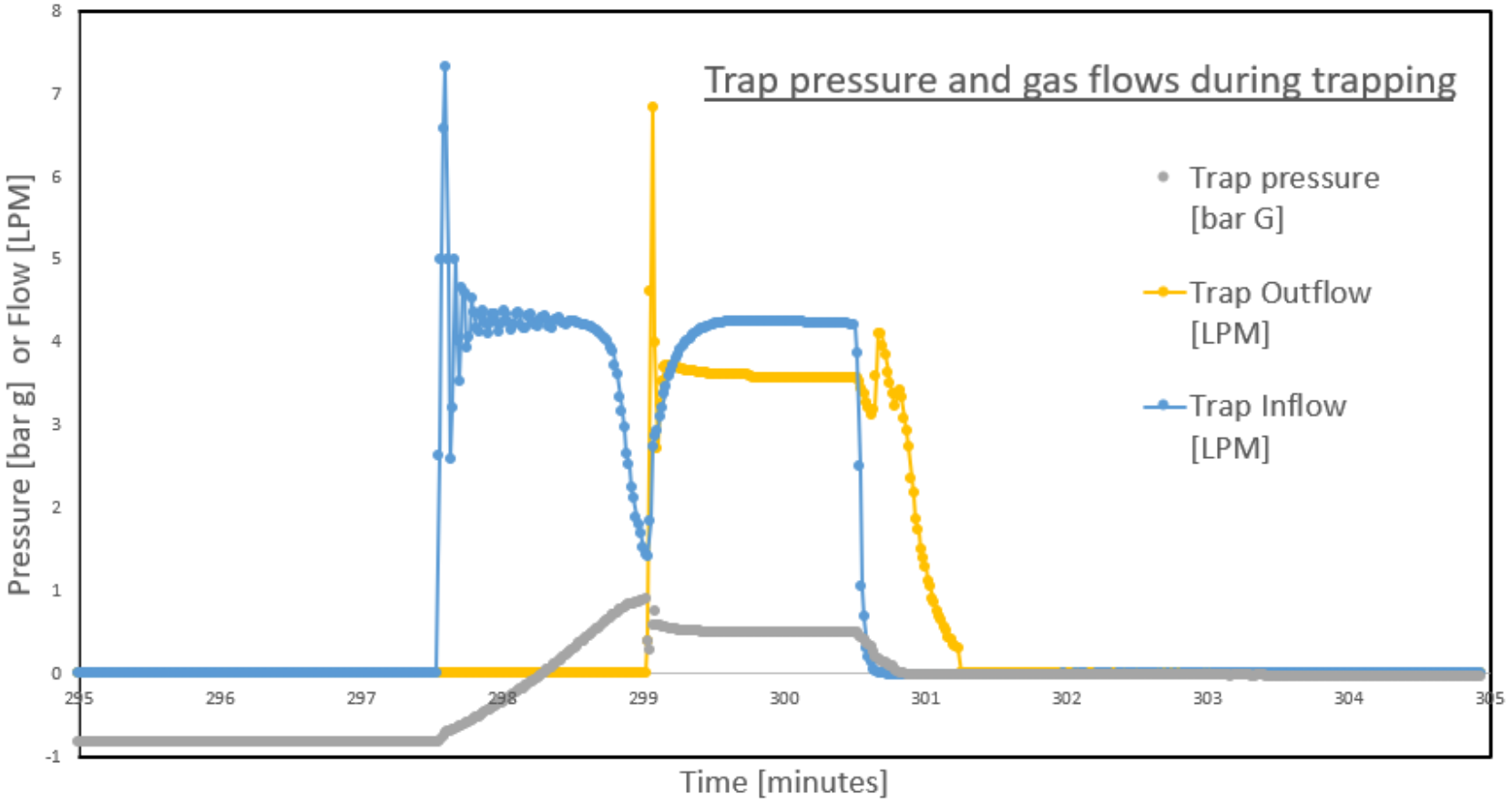

OMRON
229
2000
temperature
controller

A typical measurement cycle

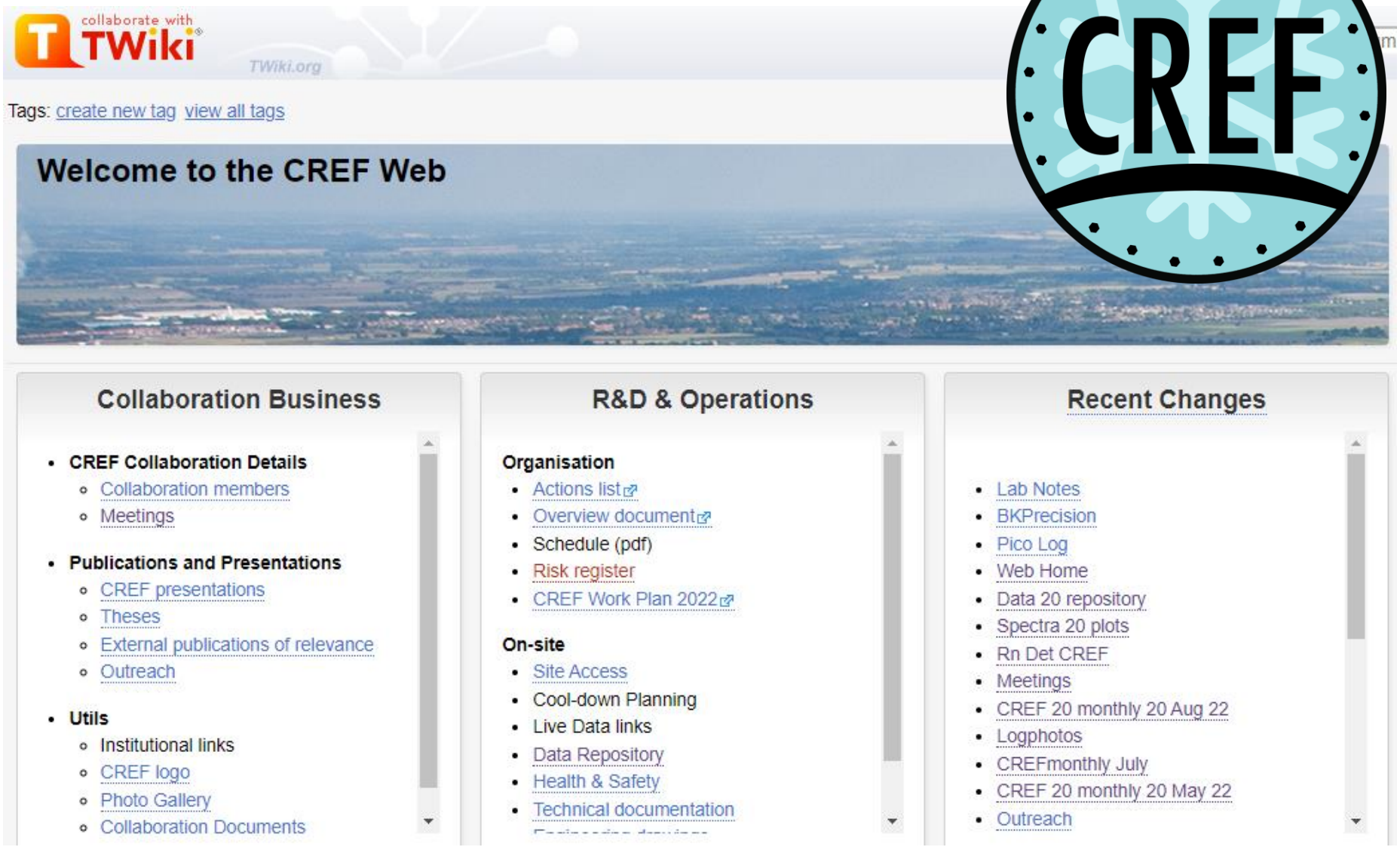
Start with trap at lab temperature, flushed with N_2 gas, and at atmospheric pressure



Gas trapping at T = -50 C



Cold Radon Emanation Facility TWiki



Outlook

- Soon: measure Rn trapping efficiency
- By end of 2022: first cold emanation run
- 2023: further characterising/optimising operational specs
- 2024: fully operational as facility
- Part of G3 programme (post Xenon Futures)

Currently looking into apprenticeship for CREF, joint with TD

Reasons to be cheerful (x3)

- Facility on track to deliver sensitive cold Rn emanation measurement:
  - Cryogenics tested & operational
  - Detector calibrated and performing to spec
  - RnCL, cold trap, calibrations being conducted
- Community building around Facility
- Facility to be centre-stage in the design of next generation rare-event searches: G3, $0\nu2\beta$, …