EMPIR 19ENV01 traceRadon

Scientific Workshop

Transfer Standards for measurement of ^{222}Rn activity concentration

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TraceRadon objective:

“develop traceable methods for the measurement of outdoor low-level radon activity concentrations in the range of 1 – 100 Bq/m^3 with uncertainties of 10 % (k=1) to be used in climate monitoring and radiation protection networks”

- New traceable low level ^{222}Rn **emanating sources** below 100 Bq/m^3
- A **transfer standard** for the traceable calibration of atmospheric radon monitors according to IEC 61577, at atmospheric radon levels below 100 Bq/m^3

- **Transfer standard**: a portable radon monitor that could be used as a calibration transfer reference device to harmonise the measurement of atmospheric radon in GHG monitoring stations
- Matrix of properties:

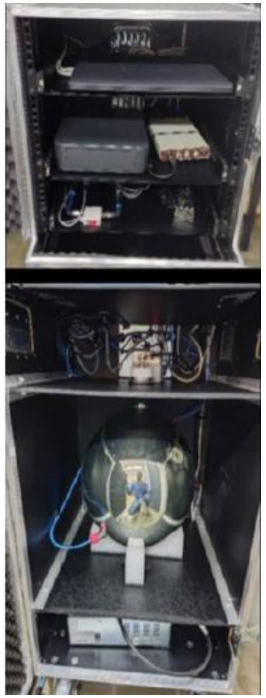
Property	**Recommended range for in field applicability**
Environmental Temperature	-25 °C - +50° C
Environmental Humidity	10%- 100%
Atmospheric Pressure	620 hPa - 1030 hPa
Measurable atmospheric ^{222}Rn activity concentration	1 Bq/m^3 - 500 Bq/m^3
Sensitivity	>0.3 cpm per Bq/m^3
Statistical uncertainty at 4 Bq/m^3 in 1 h (k =2)	<10%
Dimensions	<1m^3
Weight	<30 kg

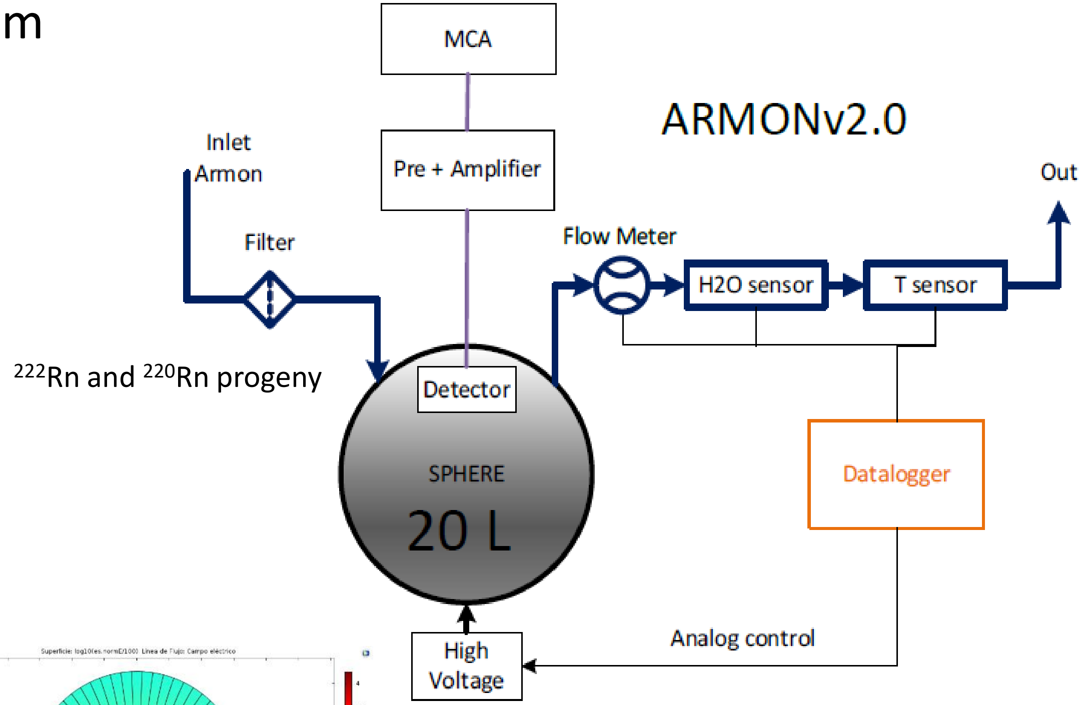
Two transfer standard developed and characterized:

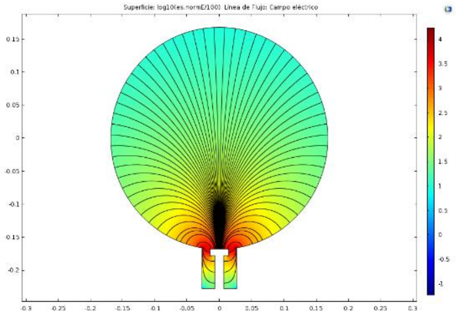
- The Atmospheric Radon MONitor (**ARMON**) designed and built at the Institut de Tecniques Energetiques of the Universitat Politecnica de Catalunya (INTE-UPC), based on electrostatic deposition of ^{218}Po using alpha spectrometric analysis to determine radon activity concentration
- The **200L ANSTO** dual flow-loop radon monitor produced by the Australian Nuclear Science and Technology Organisation (ANSTO), smaller version of existing ANSTO-built radon detectors based on the same measurement principle

ARMON v2.0

- Dimension: 128 cm x 50 cm x 50 cm
- Dried air <1000 ppm
- Flow rate 2 L/min
- Spherical detection volume



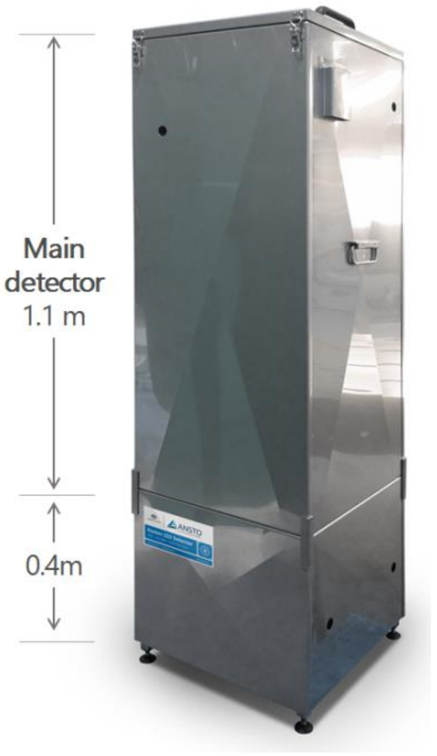


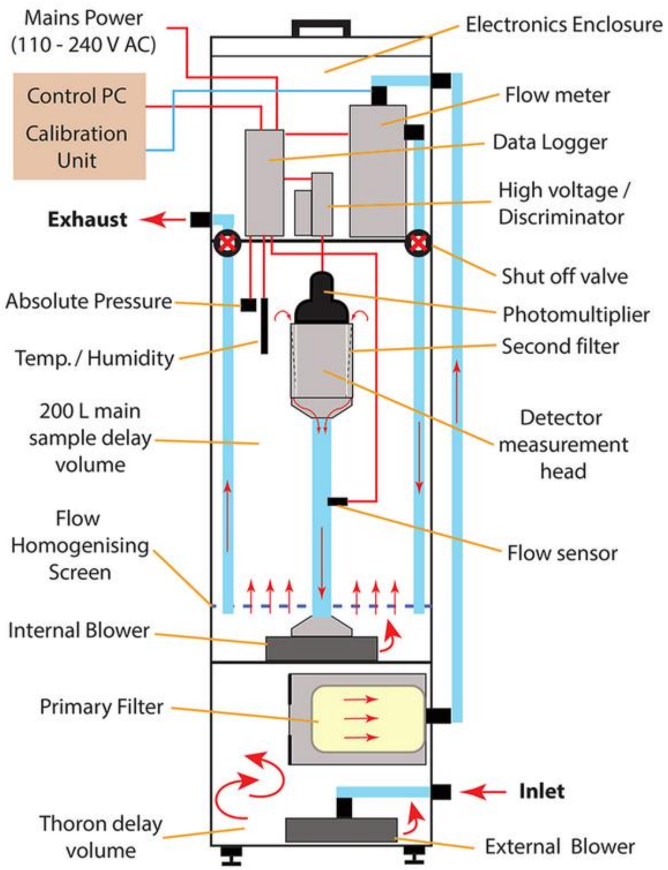


Electrostatic collection of ^{218}Po and ^{216}Po on a PIPs detector surface.

200L ANSTO

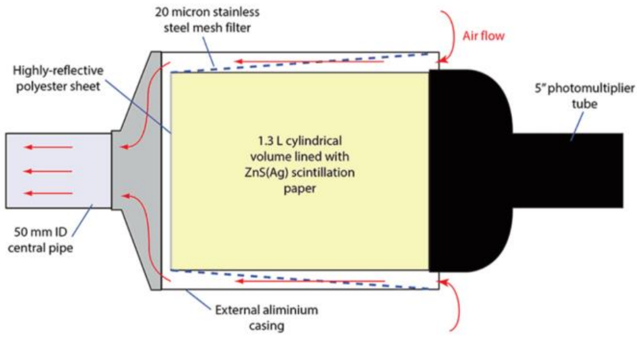
- Dimension: 160 cm x 46 cm x 46 cm
- Flow rate 10-14 L/min
- ^{220}Rn delay ~70 L





Dual flow-loop two-filter detector

Detector measurement head:
ZnS(Ag) –photomultiplier tube assembly

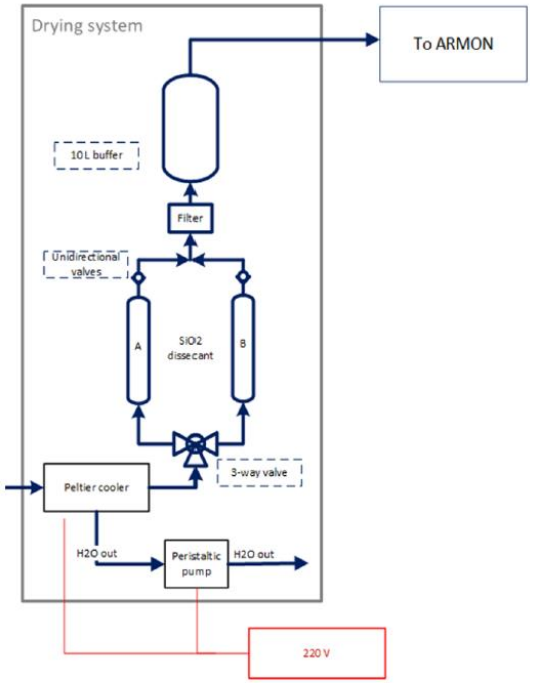


Blank indication test

ARMON

- Zero Gas Air tank at INTE-UPC Radon Laboratory
- Results of the blank indication test of the ARMON

	Zero air	Zero air + silica gel	Zero air + silica gel + buffer
Mean in cpm $(Bq.m^{-3})^{-1}$	0	0.14 (0.40)	0.04 (0.14)
SD in cpm $(Bq.m^{-3})^{-1}$	0	0.05 (0.13)	0.02 (0.06)



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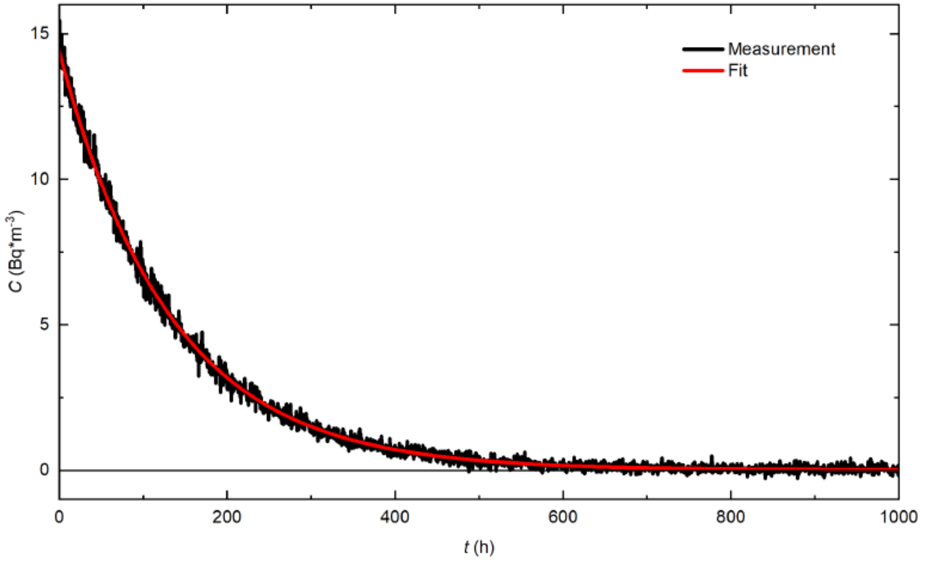
200L ANSTO

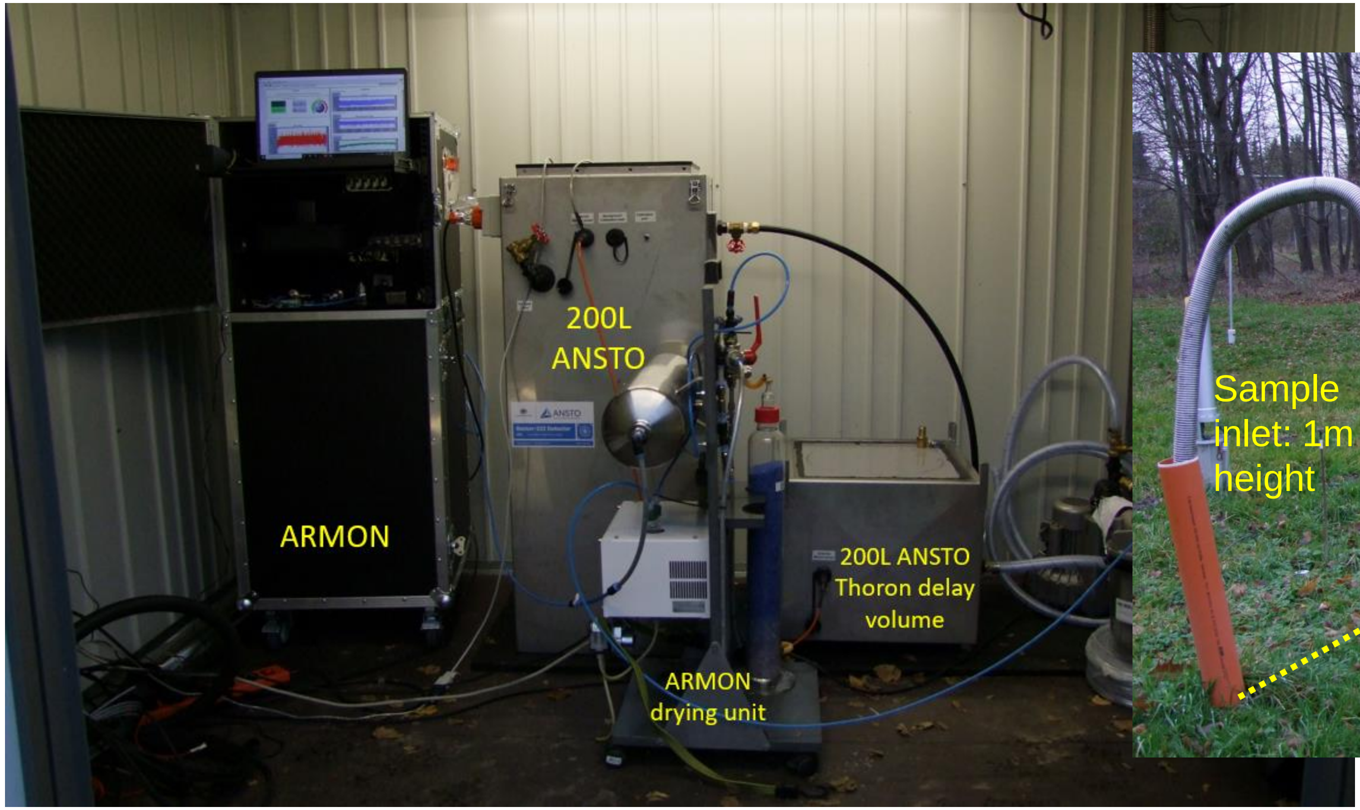
- PTB climate chamber
- ^{226}Ra emanation source close off at $t = 0$
- $C = \Delta M_0 + C_0 e^{-\lambda t}$
- Intrinsic background:

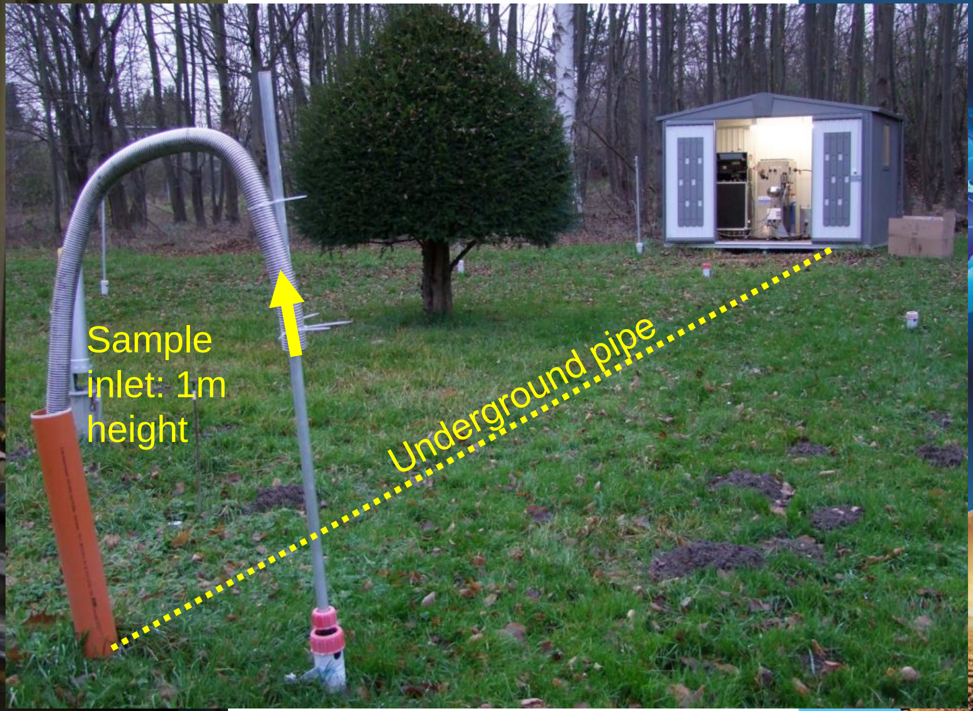
$$\Delta M_0 = (0.01709 \pm 0.0023)\ \mathrm{s}^{-1}$$



Stability comparison of Transfer Standards

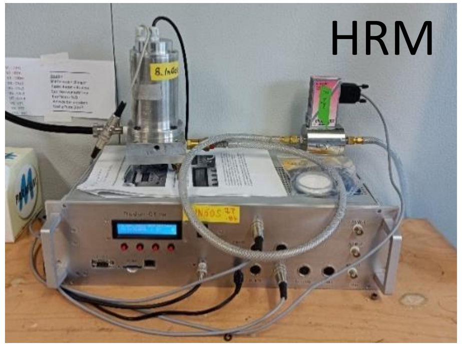
- PTB Braunschweig site, November – December 2021
- Set up: sampling air at 1 m a.g.l.





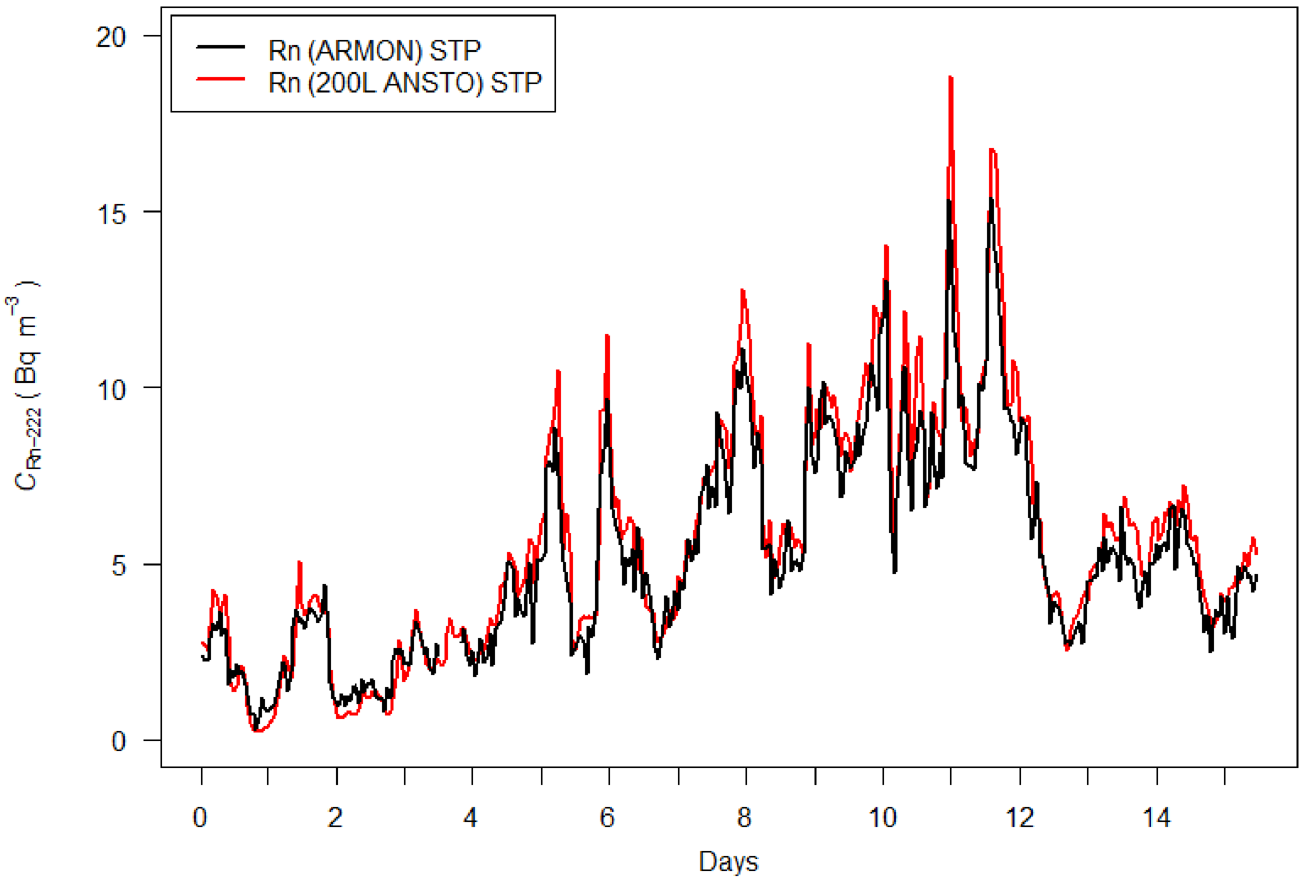
Stability and long-term comparison of Transfer Standards

- Saclay ICOS station, February – September 2022
- Local radon monitor 1500L ANSTO and Heidelberg Radon Monitor
- Different set-ups



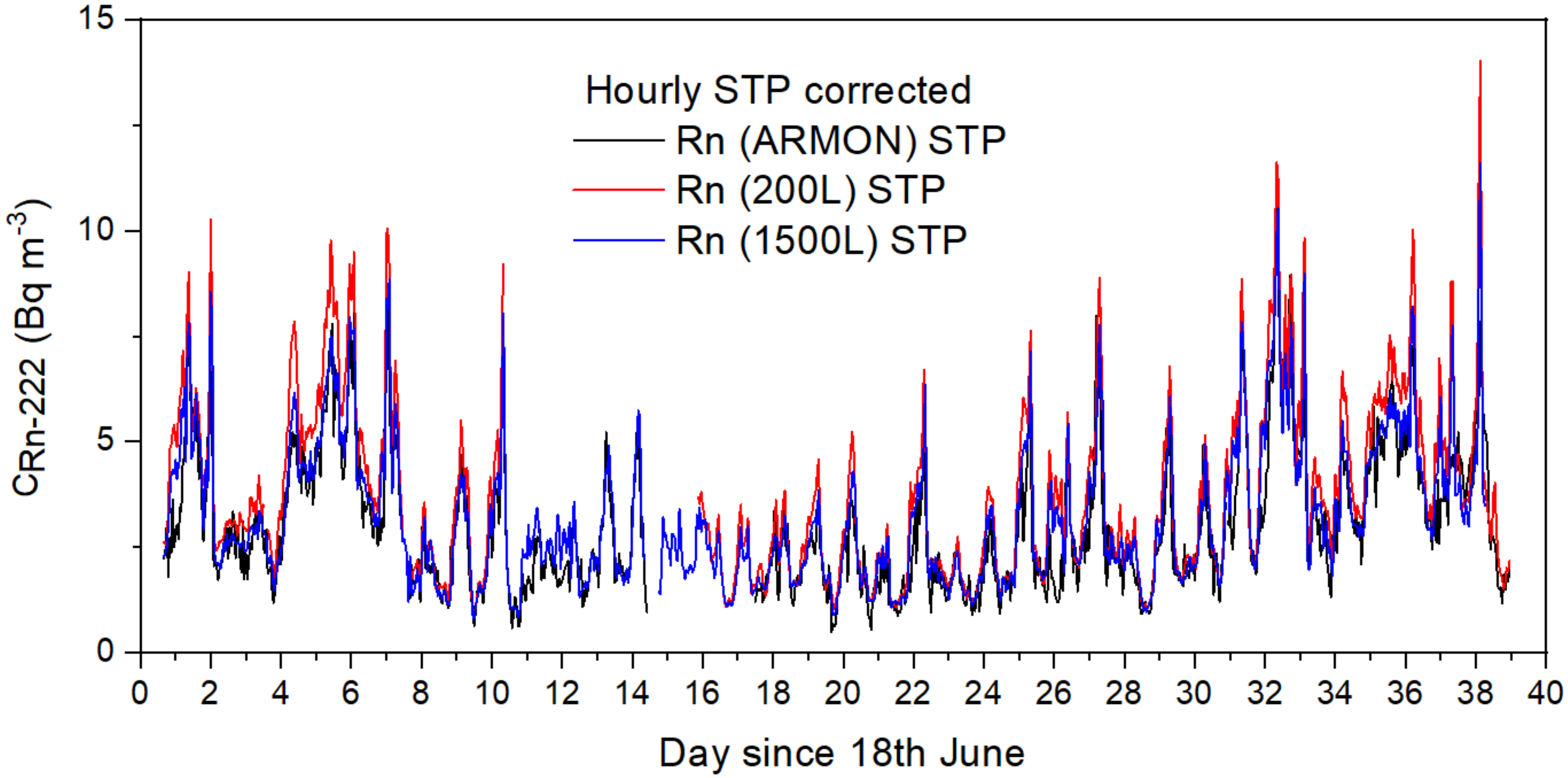
Results from the Transfer Standards comparison

- Time series PTB comparison



Results from the Transfer Standards comparison

- Time series long-term comparison at SAC



Uncertainty budget

ARMON

- $C_{\mathrm{Rn}} = \left[\frac{nc_{Po218}}{t} - \frac{36nc_{Po212}}{64t}\right] - \frac{C_P C_T}{F_{cal}}$
- $F_{cal} = F_{cal0} - b\,[H_2O]$
- $C_P = \frac{P_{ref}}{P}$
- $C_T = \frac{T_{ref}}{T}$

Quantity	Estimate	Uncertainty	Sensitivity Coefficient	Product
x_i		$u(x_i)$	c_i	$c_i^2 \cdot u^2(x_i)$
nc_{Po218}	67.5	8.33	$\frac{C_P\,C_T}{t\,F_{cal}}$	$c_i^2 \cdot u^2(nc_{Po218})$
nc_{Po212}	0.25	0.5	$-\frac{C_P\,C_T}{t\,F_{cal}} \cdot \frac{36}{64}$	$c_i^2 \cdot u^2(nc_{Po212})$
F_{cal0}	0.35 cpm Bq m^{-3}	0.01	$-\left[\frac{nc_{Po218}}{t} - \frac{36}{64}\frac{nc_{Po212}}{t}\right] \cdot \frac{C_P\,C_T}{(F_{cal0} - b\,[H_2O])^2}$	$c_i^2 \cdot u^2(F_{cal0})$
b	3.2·10^{-5} ppm^{-1}	0.4·10^{-5}	$\left[\frac{nc_{Po218}}{t} - \frac{36}{64}\frac{nc_{Po212}}{t}\right] \cdot \frac{C_P\,C_T\,[H_2O]}{(F_{cal0} - b\,[H_2O])^2}$	$c_i^2 \cdot u^2(b)$
$[H_2O]$	~254 ppm	51.8	$\left[\frac{nc_{Po218}}{t} - \frac{36}{64}\frac{nc_{Po212}}{t}\right] \cdot \frac{C_P\,C_T\,b}{(F_{cal0} - b\,[H_2O])^2}$	$c_i^2 \cdot u^2([H_2O])$
P	~1000 hPa	0.3	$-\left[\frac{nc_{Po218}}{t} - \frac{36}{64}\frac{nc_{Po212}}{t}\right] \cdot \frac{C_T\,P_{ref}}{F_{cal}\,P^2}$	$c_i^2 \cdot u^2(P)$
T	~298 K	0.746	$-\left[\frac{nc_{Po218}}{t} - \frac{36}{64}\frac{nc_{Po212}}{t}\right] \cdot \frac{C_T}{F_{cal}\,T_{ref}}$	$c_i^2 \cdot u^2(T)$

Uncertainty budget

200L ANSTO

- $C_{\mathrm{Rn}} = \frac{G_\alpha - B}{t \cdot F_{\mathrm{cal}}} \cdot C_P C_T$

Quantity	Estimate	Uncertainty	Sensitivity Coefficient	Product
x_i		$u(x_i)$	c_i	$c_i^2 \cdot u^2(x_i)$
G_α	520.27 h^{-1}	22.8	$\frac{C_P C_T}{t\ F_{cal}}$	$c_i^2 \cdot u^2(G_\alpha)$
B	61.52 h^{-1}	8.28	$-\frac{C_P C_T}{t\ F_{cal}}$	$c_i^2 \cdot u^2(B)$
F_{cal}	0.03846 cps Bq m^{-3}	0.0013	$\frac{C_P C_T}{t\ F_{cal}^2} \cdot (G_\alpha - B)$	$c_i^2 \cdot u^2(F_{cal})$
P	1004.7 hPa	0.3	$\frac{C_T P_0}{t\ F_{cal}\ P^2} \cdot (G_\alpha - B)$	$c_i^2 \cdot u^2(P)$
T	301.64 K	0.22	$\frac{C_T}{t\ F_{cal}\ T_0} \cdot (G_\alpha - B)$	$c_i^2 \cdot u^2(T)$

Thank you for your attention!

Acknowledgements

TraceRadon project partners:

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