2024/06/26

Water assays for SNO+

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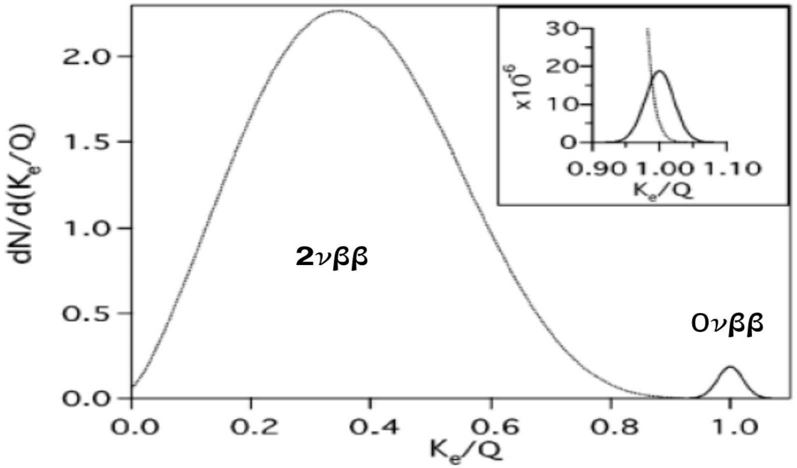
SNOLAB

SNO+

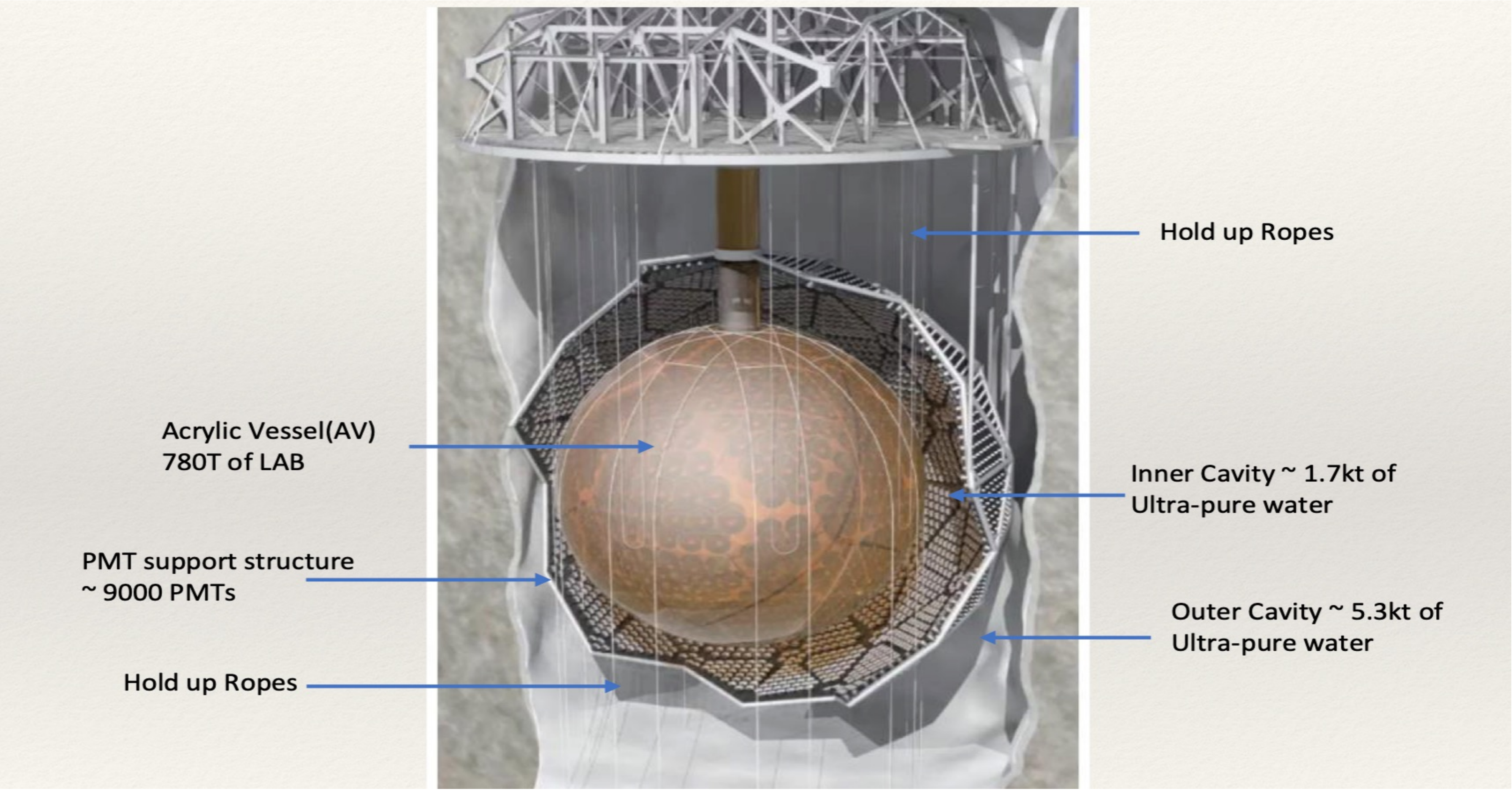
- Multi-purpose neutrino detector
- Rare event search
- A stringent **background** budget



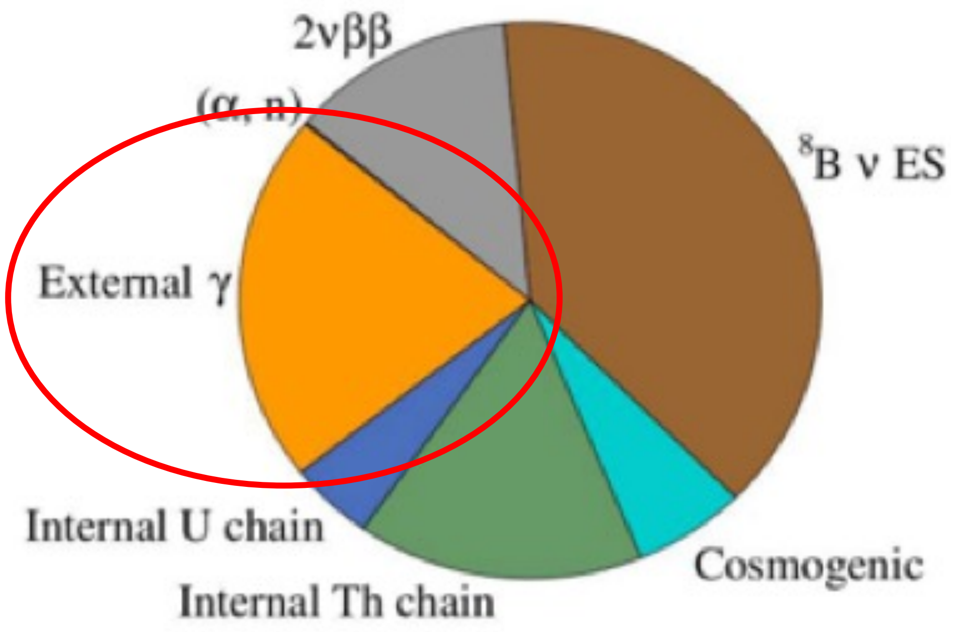
Physics goals:

- **$0\nu\beta\beta$**
- Solar neutrinos
- Geo neutrinos
- Geo antineutrinos
- Reactor antineutrinos
- Supernova neutrinos

SNO+ Detector



SNO+ backgrounds



Expected background in 0νββ phase

Backgrounds	1 year	5 year
$2\nu\beta\beta$	6.3	31.6
B^8	7.3	36.3
Uranium Chain	2.1	10.4
Thorium Chain	1.7	8.7
External	3.6	18.1
(a,n)	0.1	0.8
Cosmogenic	0.7	0.8
Total	21.8	106.8

Expected $0\nu\beta\beta$: 22 events/year

SNO+ external backgrounds

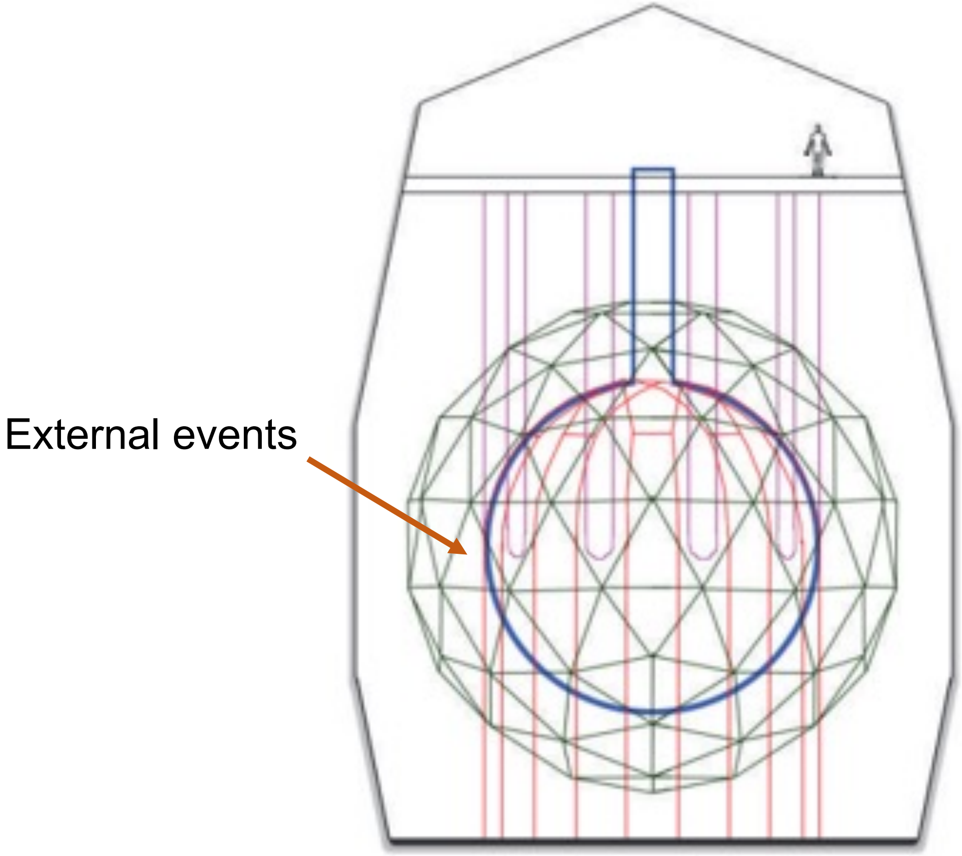
Sources:

- Mine walls
- Ultra-pure water
- Hold-up and hold-down ropes
- PMTs

Radioactivity:

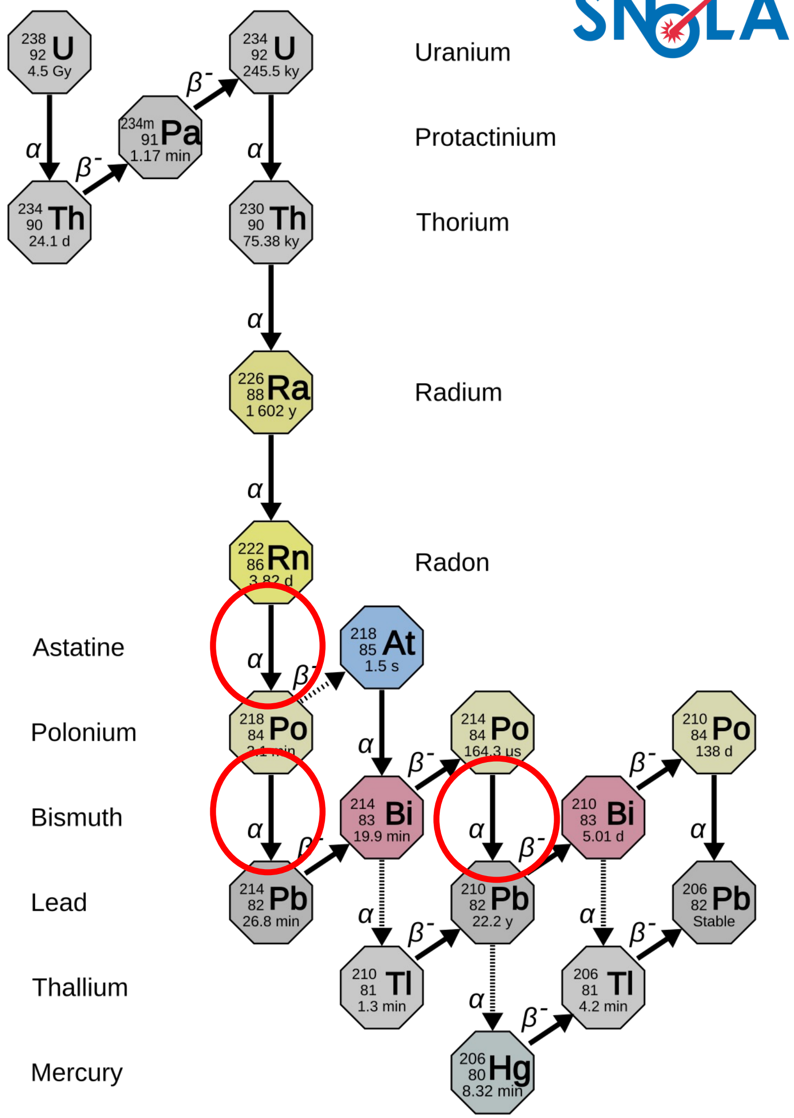
- ^{238}U decay chain, ^{222}Rn and its daughters

Target Concentration: $2.1 \times 10^{-13} gU^{238}/H_20$



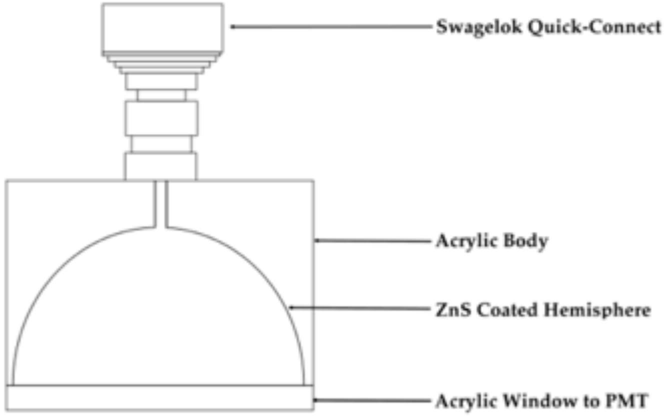
Uranium-238 decay chain

- Radon-222 is a gaseous decay product
- Half-life of 3.82 days
- Has a characteristic alpha decay
- Enables **radon assay** technique
    - 3 alphas emitted for every radon



Lucas cells

- Acrylic body
- Coated with zinc sulphide
- Alphas emit scintillation light when they interact with ZnS
- Lucas cells are used to store the assay sample



SNO+ assays

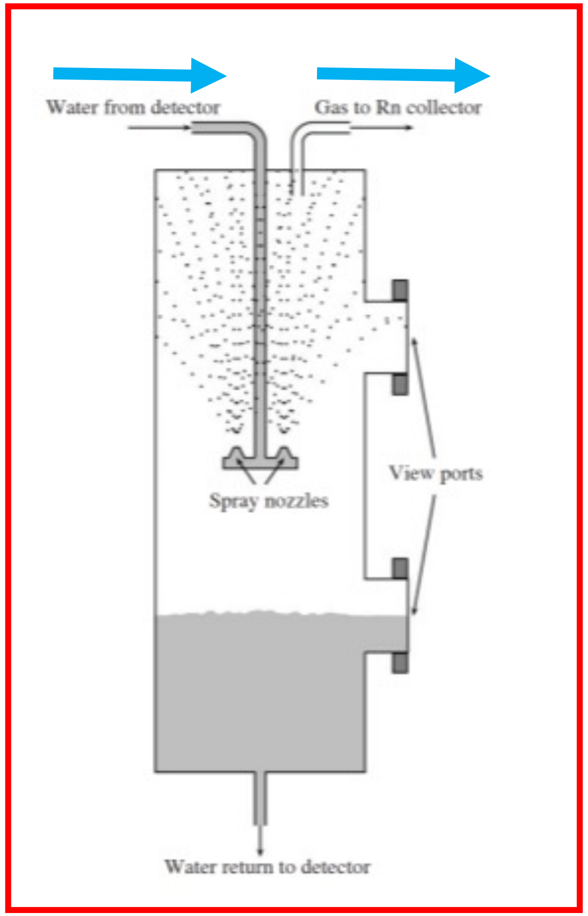
- Ex-situ measurement that can be done to determine the radon concentration
- Can be done for:
  - Gas
  - Water
  - Scintillator (coming soon!)

Water assays as monitoring tool

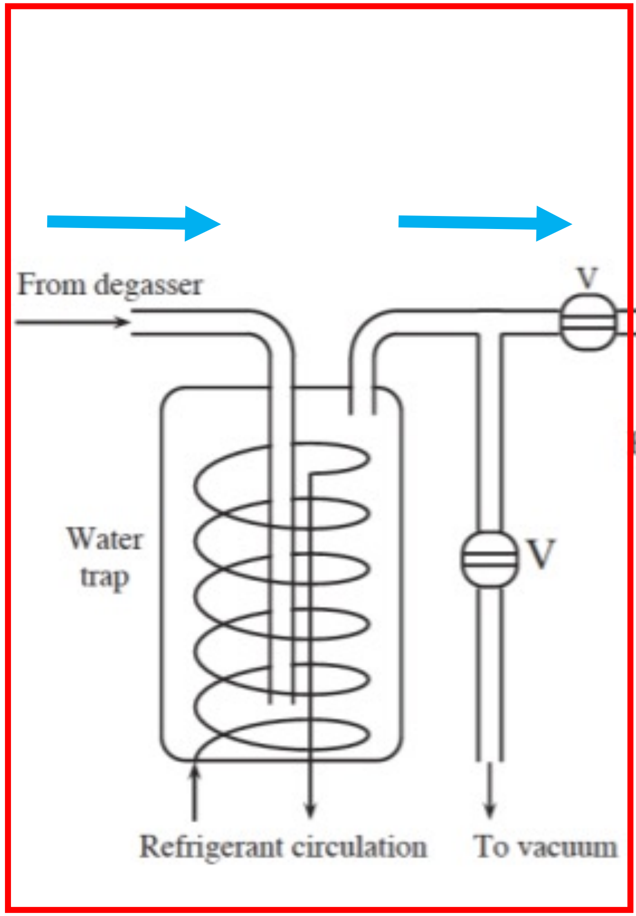
- ✓ Ensure backgrounds are within target level
- ✓ Can be first indication of radon ingress
- ✓ Verify in-situ measurements
- ✓ Ensure proper functioning of the UPW plant

Water assay technique

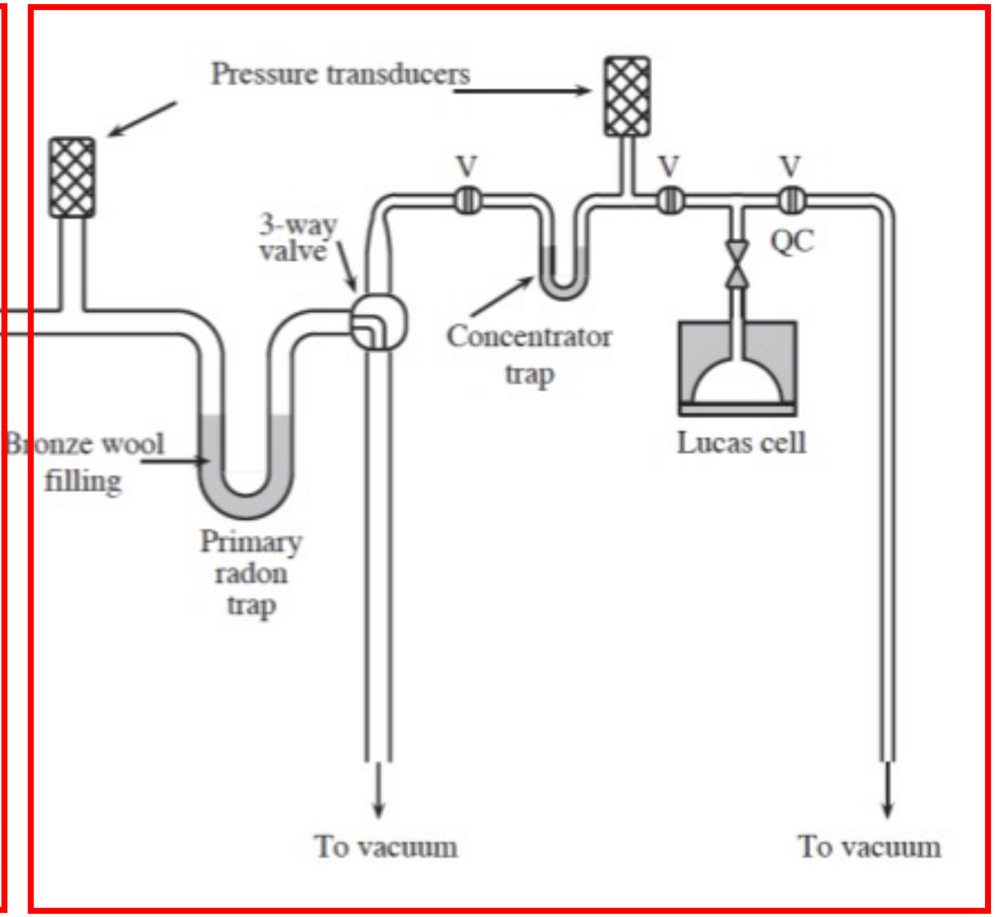
Degasser



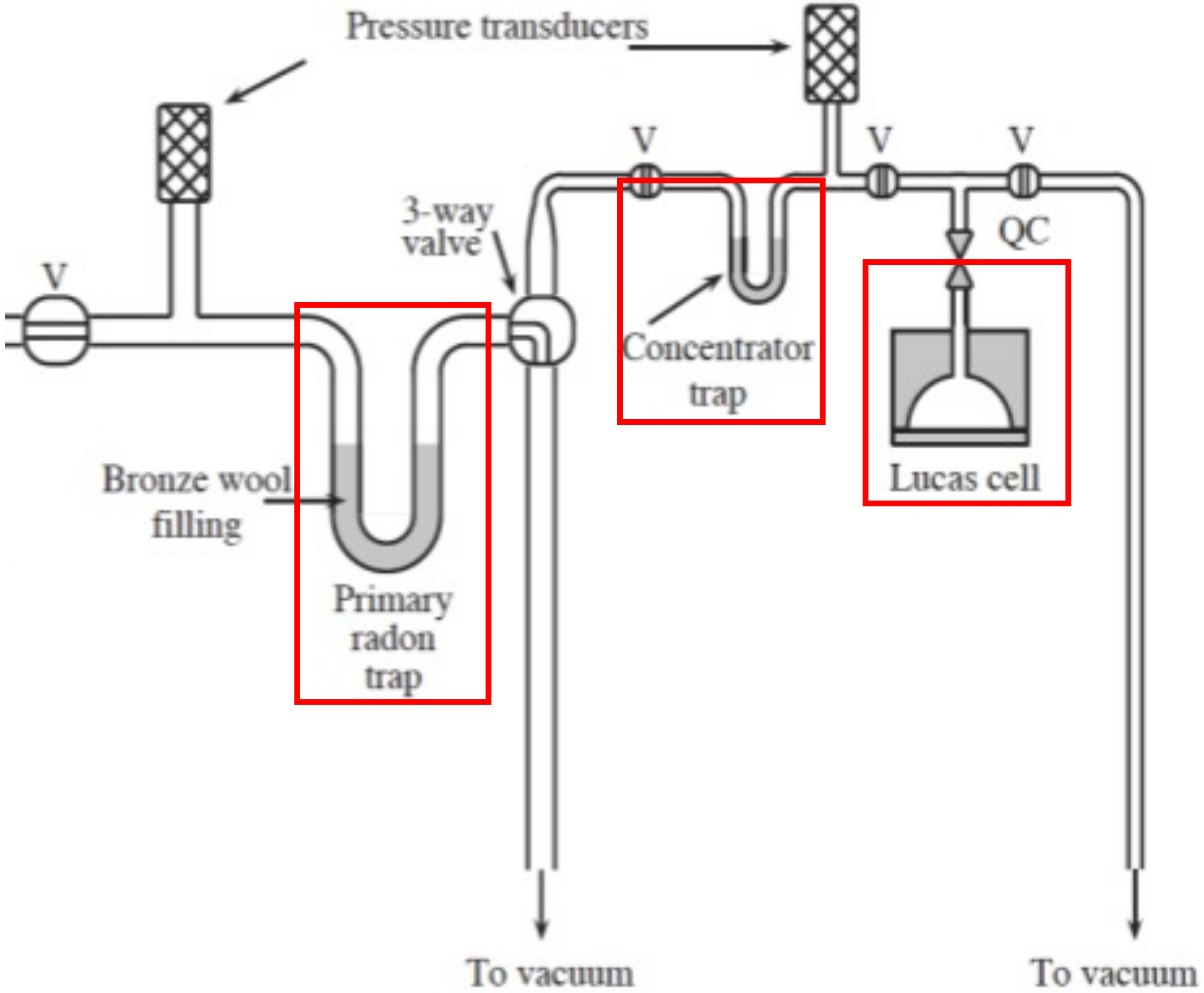
Water vapour trap



Radon extraction



Water assay technique



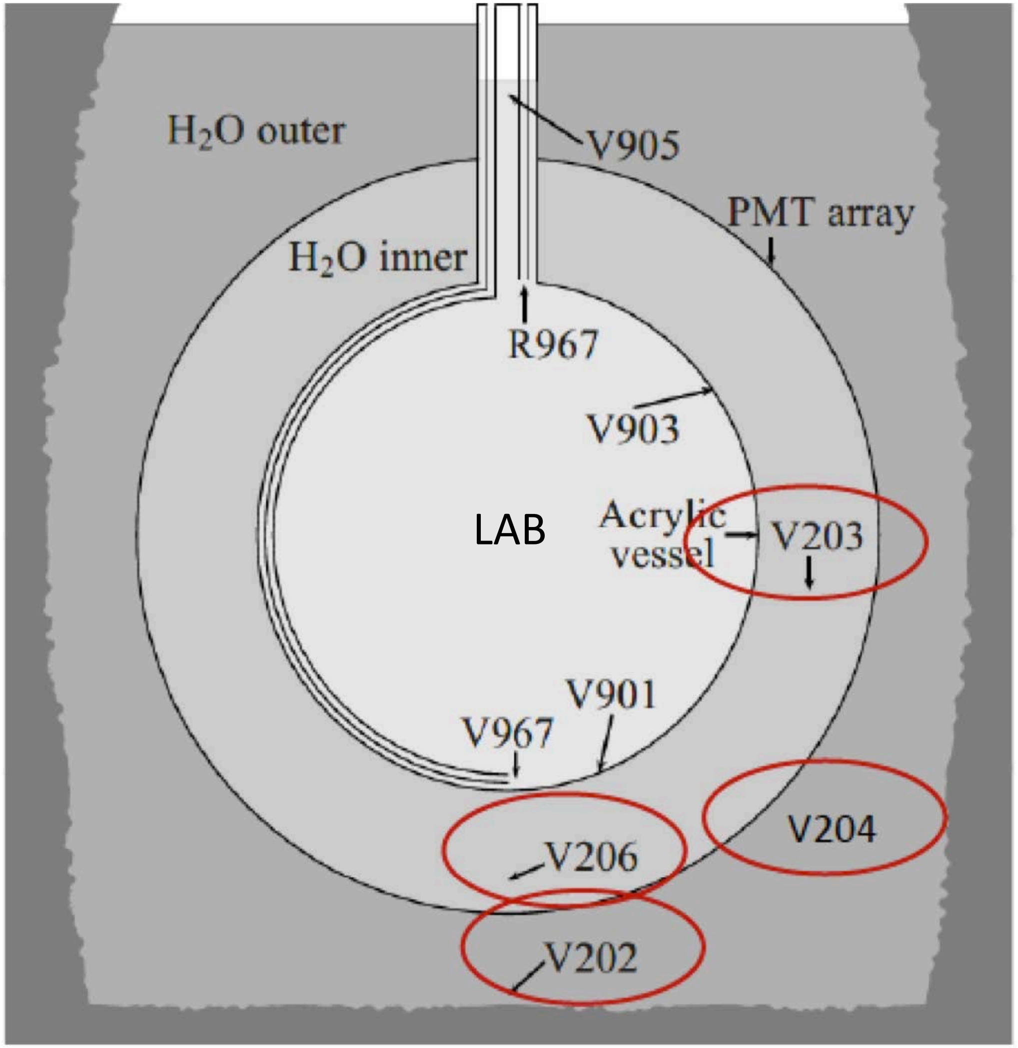
Assay sample

$$R(\text{atoms/sample}) = \frac{N - B_{lc} t_{count}}{\varepsilon_{trap} \varepsilon_{transfer} \varepsilon_{count} \varepsilon_{degassing} (e^{-\lambda t_{delay}})(1 - e^{-\lambda t_{count}})} - R_{bg}$$

N = number of alphas
B_{lc} = Lucas cell background
t_{count} = counting time
ε_{trap} = trapping efficiency
$\varepsilon_{transfer}$ = transfer efficiency
ε_{count} = counting efficiency
$\varepsilon_{degassing}$ = degassing efficiency
t_{delay} = delay between completion of assay and Lucas cell counting time
R_{bg} = background of the radon board

MDG skid

Water assay sample ports



MDG skid background

Background assays

- Run in closed loop configuration

Date	Time (min)	Radon atoms/sample	Conc. g/g
10/11/2022	30	183	6.09 E-14
08/02/2023	60	64	9.85 E-15
18/01/2024	30	49	1.49 E-14

Target Concentration: $2.1 \times 10^{-13} gU^{238}/H_20$

UPW plant closed loop

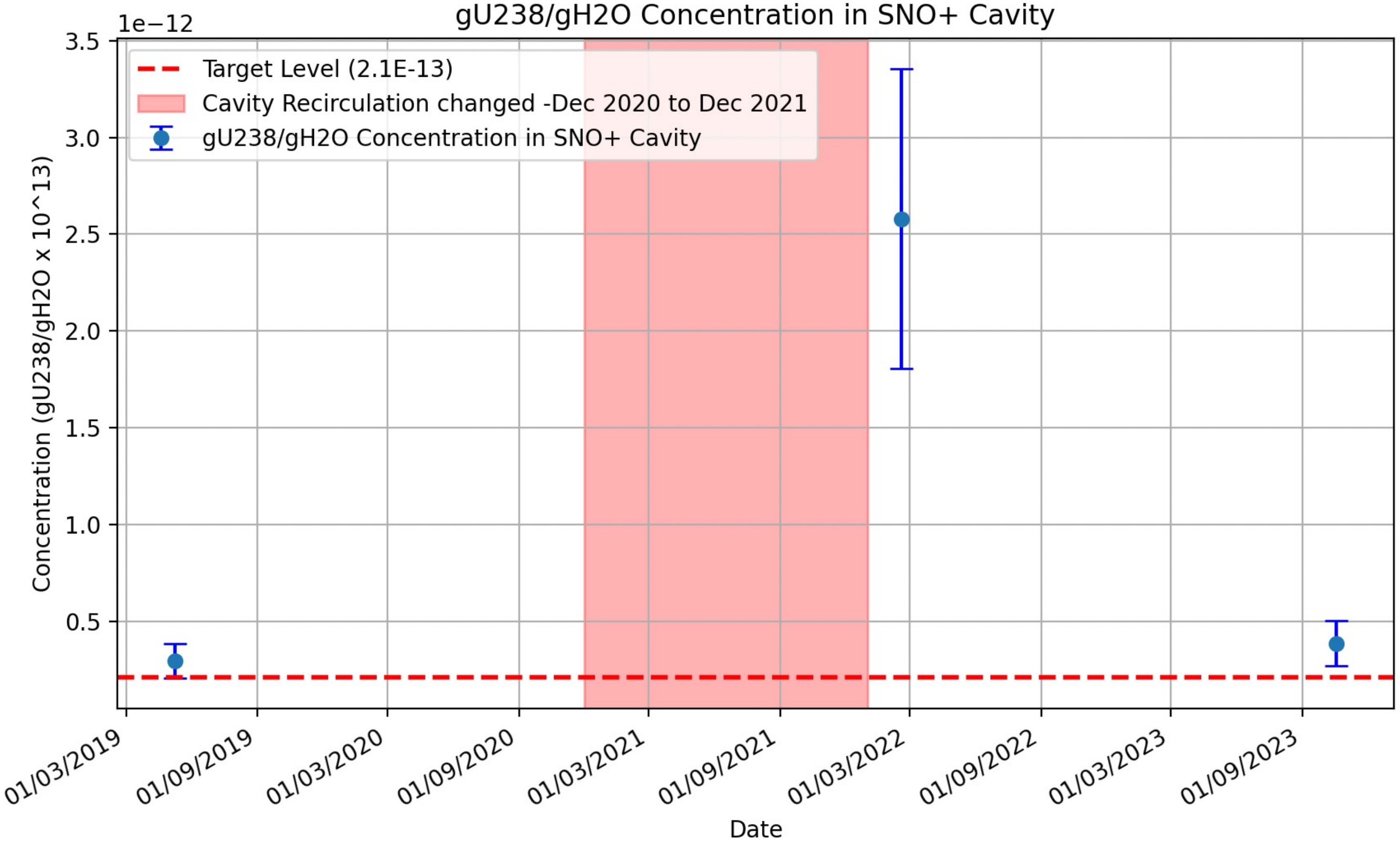
New pump was installed in the UPW plant

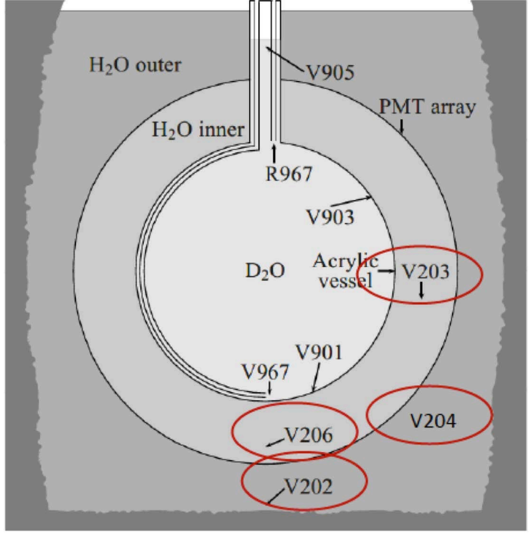
Purification factor of the UPW plant

Date	Time (min)	Radon atoms/sample	Conc. g/g
21/11/2023	20	-30	-9.08 E-15
28/11/2023	20	61	2.46 E-14

Water assay results

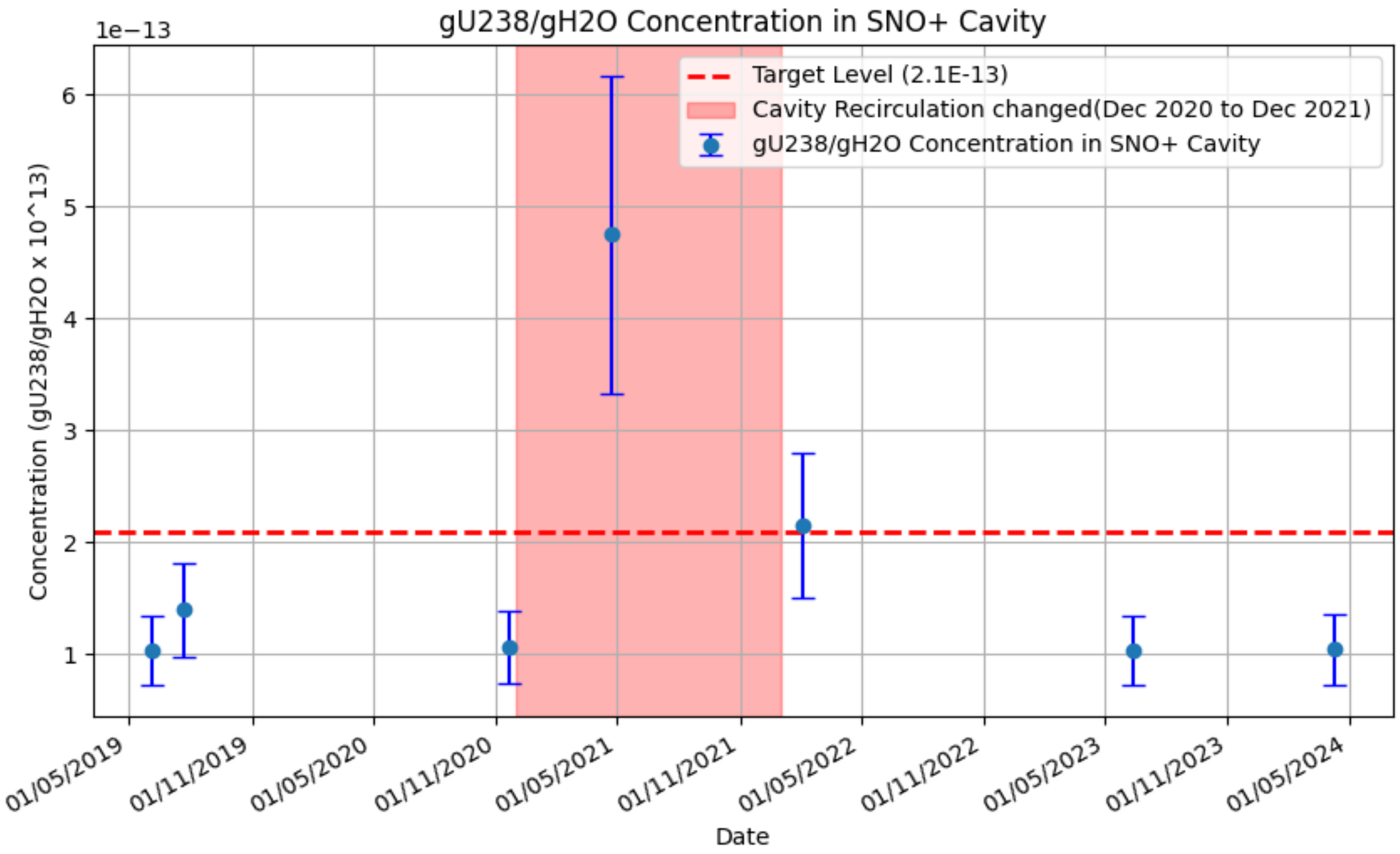
V-202

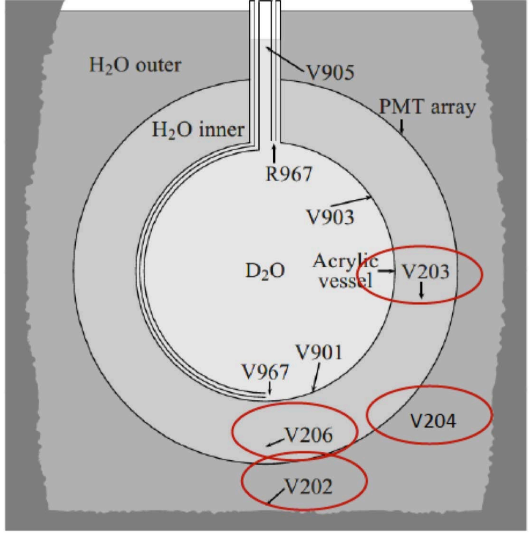




Water assay results

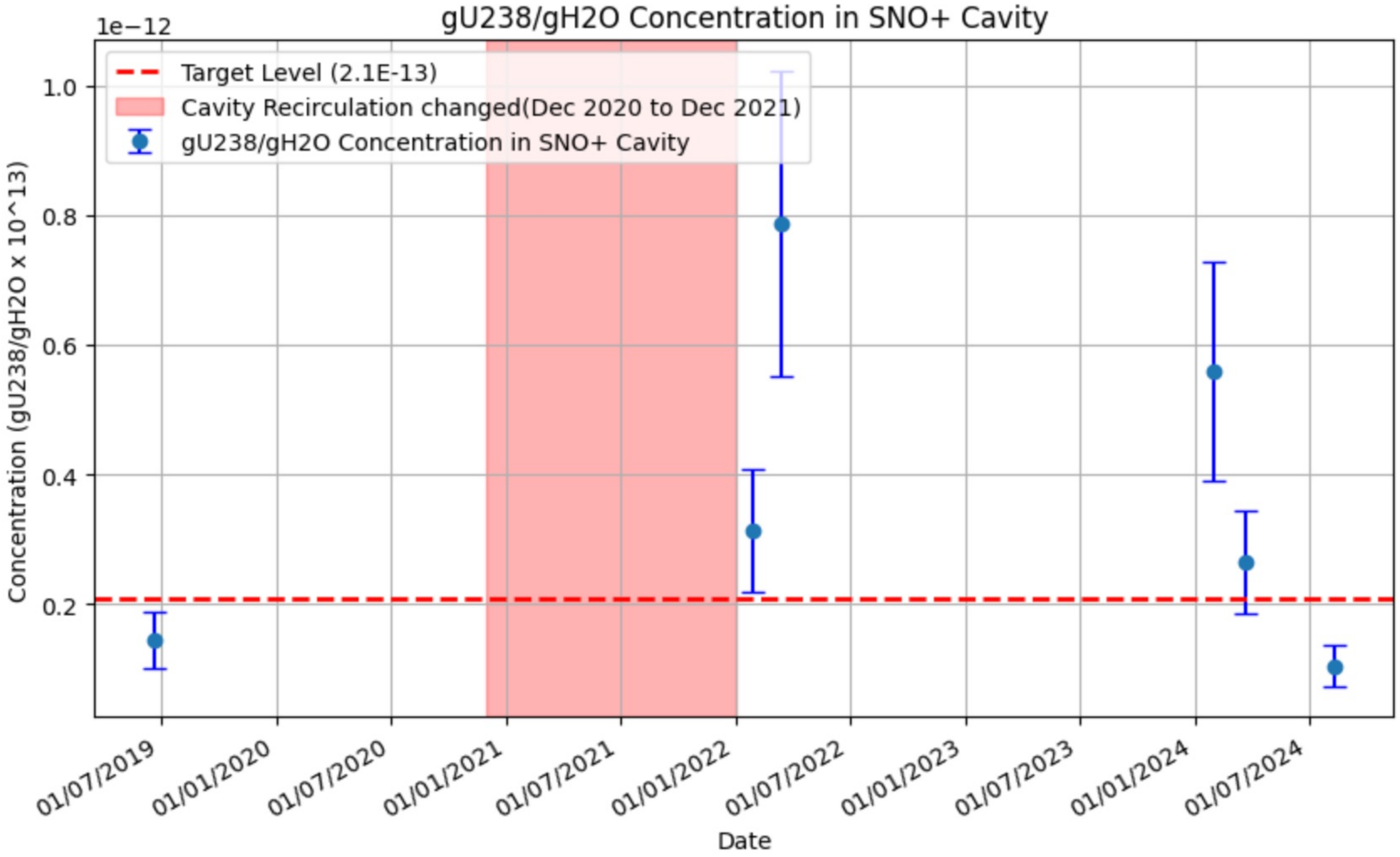
V-203

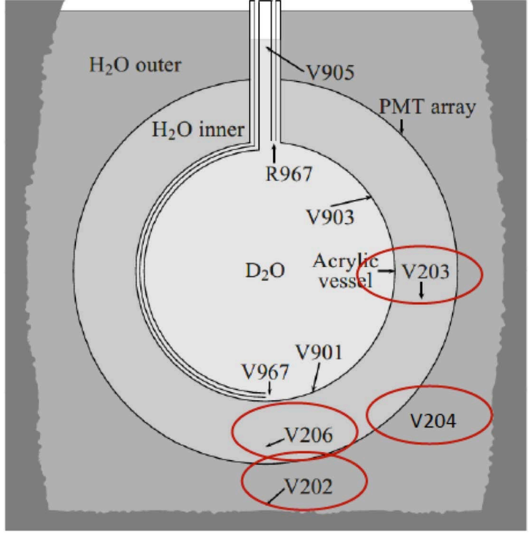




Water assay results

V-206





Conclusion

- SNO+ is maintaining target back ground levels
- Consistent assay results
- Background assays are required to ensure they are in good working order
- Multiple water assays per year for monitoring purposes