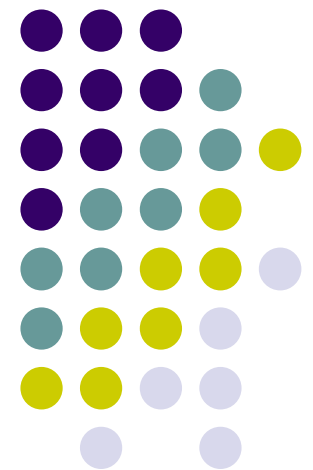


Radon Emanation Measurements

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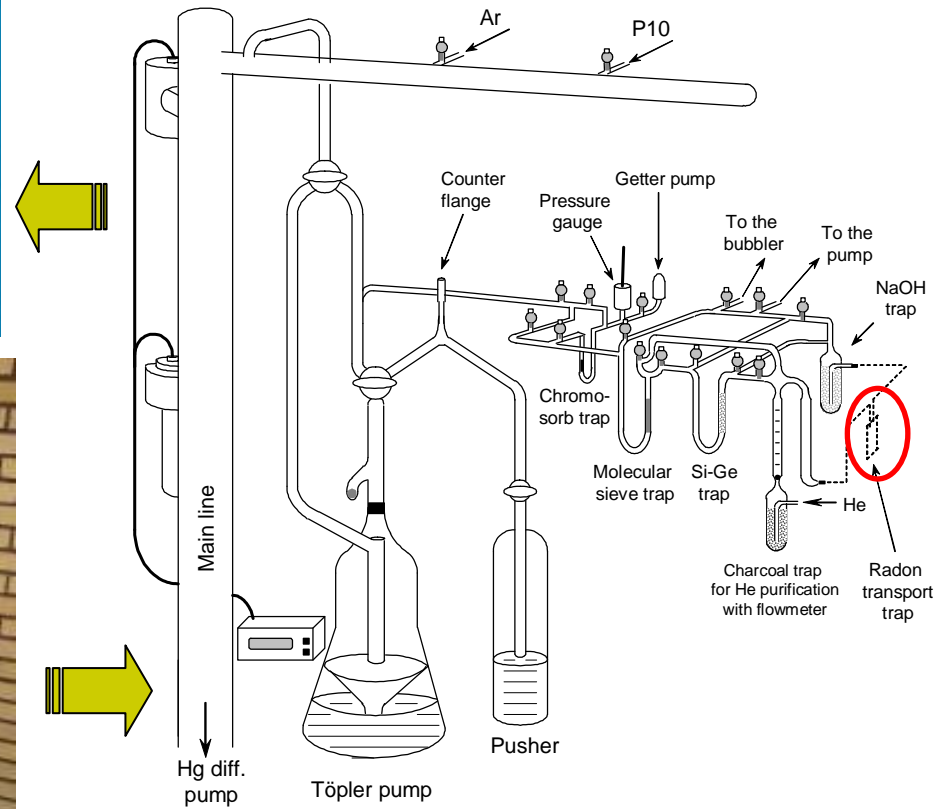
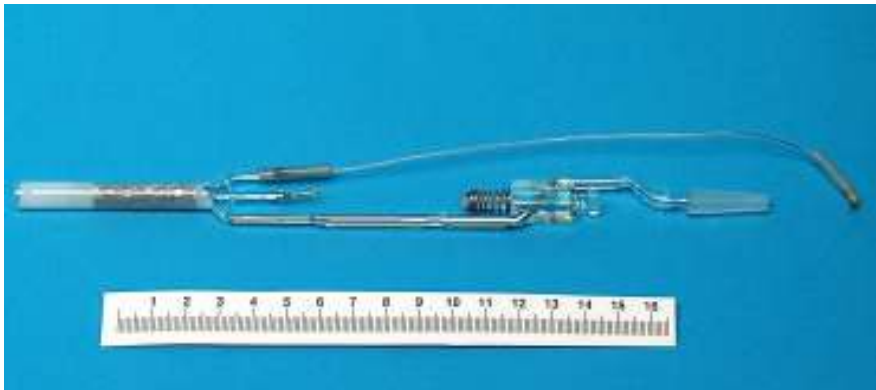
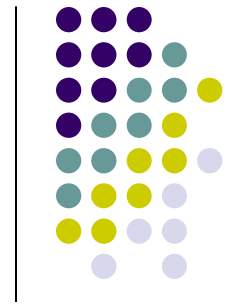


Outlook



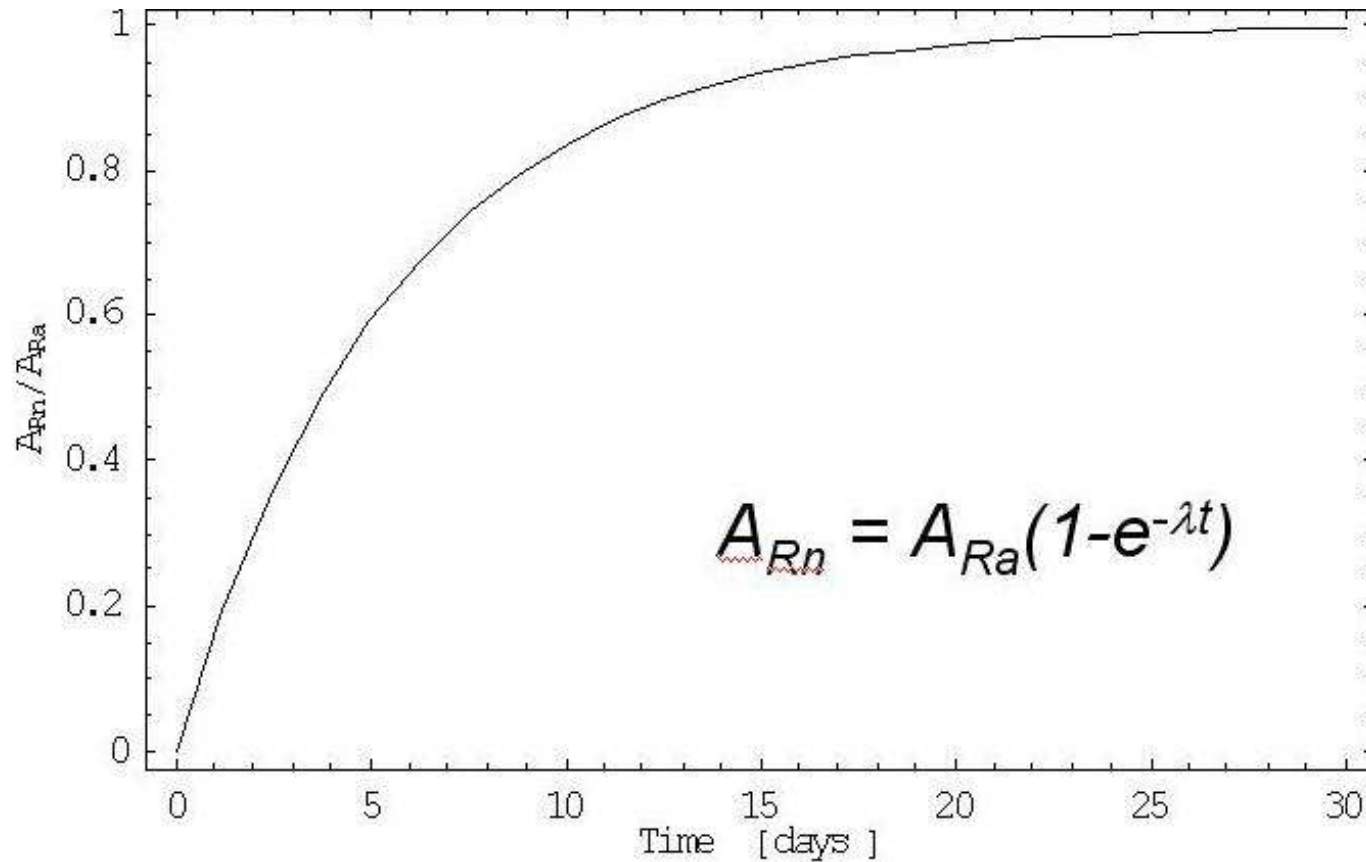
- ^{222}Rn emanation and detection
- Investigated samples
 - Kalrez gaskets
 - Oxygen adsorbers
 - Steel plates with welds
 - Cryogenic valves
 - Magnetic arm
 - Habia cable
 - KF-16 gaskets
 - ^{226}Ra in the water
- Future plans

^{222}Rn detection



**Absolute detection limit
30 – 100 μBq (15 – 50 atoms)**

^{222}Rn emanation



A_{Ra} – emanation rate (^{226}Ra activity seen via ^{222}Rn emanation)

Kalrez gaskets



4 x 262179



1 x 330502





Kalrez gaskets - results

Art. Number	Amount	Total emanation rate [mBq]	Em. rate/gasket [mBq]	Remarks
317483	4	0.64 ± 0.05	0.16	Small chamber; (50 μ Bq)
330502	6	1.29 ± 0.07	0.22	Big chamber, (90 μ Bq)
330500 + 330501	2 + 2	1.54 ± 0.10	0.39	Small chamber
327259	1	0.27 ± 0.06	0.27	Big chamber
254213	4	< 0.05	< 0.01	V #5
262179	4	< 0.04	< 0.01	V #6
327607	4	0.26 ± 0.06	0.07	V #1
327260 + 327262	3 + 1	0.06 ± 0.03	0.02	V #4



Kalrez gaskets – expected signal

Art. Number	Amount	Total emanation rate [mBq]
317483	1	0.16
330502	1	0.22
330500	1	0.40
327259	1	0.27
254213	2	< 0.03
327607	2	< 0.13
262179	2	< 0.02

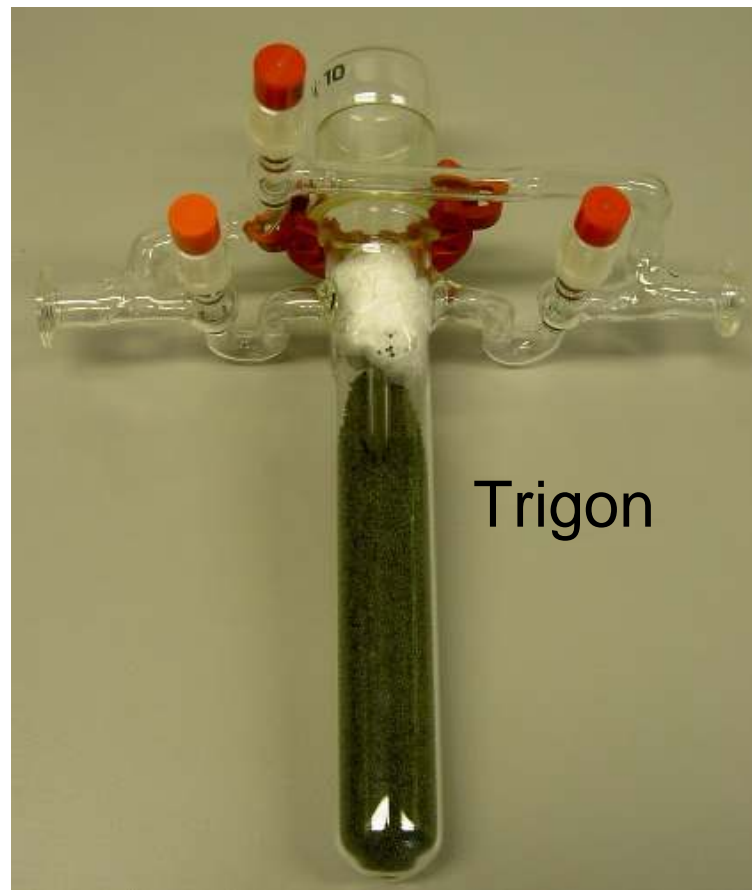
$$\Sigma \leq 0.6 \text{ mBq}$$

Allowed emanation from all sources in the cryostat: ~30 mBq
(0.5 $\mu\text{Bq}/\text{m}^3$ in Ar (STP) $\rightarrow 10^{-4}$ c/kg/keV/y)

Oxygen adsorbers



Oxisorb cartridge



Trigon

Adsorber	Description	Mass	Emanation rate [mBq]	
			Spec. emanation rate [mBq/kg]	Comments
Trigon	Metal oxides on alumina support (Alumina: 80-90 %, Copper oxide: 10-14 %) Ge spec: ~1 Bq/kg U/Th	93 g	46.4 ± 2.3	Room temp.
			498 ± 24	
Oxisorb	MESSER, small cartridge	~100 g	46.2 ± 4.0	At 150 C
			496 ± 42	
			1.9 ± 0.1	Room temp.
			~19	

Steel plates with welds



Stainless steel plates welded as foreseen for the GERDA cryostat

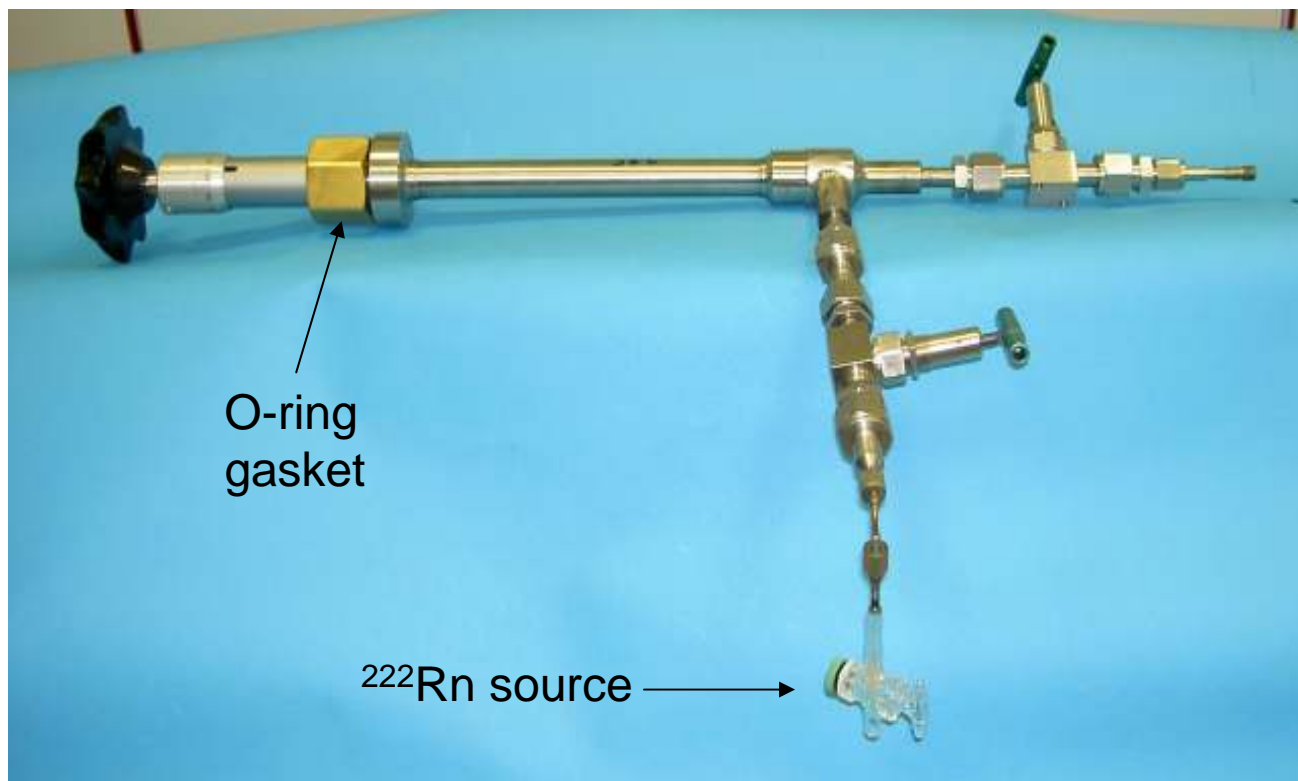
Sample	Description	Emanation rate [mBq/m]	Comments
7 plates	Total surface (both sides): 1.5 m ² Weld length: 2.53 m	0.36 ± 0.04	Standard workshop cleaning procedure (alkaline bath), optically clean. A lot of gas in the Rn samples
2 plates	Total surface (both sides): ~0.4 m ² Weld length: ~0.8 m	< 0.1	After 2-hour etching (20 % ^{*)} HNO ₃ + 1.7 % HF + water) and 30-min passivation (15 % HNO ₃ + water). Not much gas in the Rn samples

^{*)} by weight, procedure suggested by the BAMA company

Stainless steel tape	Total surface (both sides): 71 m ²	10 μBq/m ²	Surface not treated at all
		4.6 μBq/m ²	Surface washed with distilled water

Estimated emanation rate inside the cryostat: $A_{Rn} < \frac{0.1 \times 100}{2} \cong 5 \text{ mBq}$
 Allowed activity in the cryostat: ~30 mBq
 (0.5 μBq/m³ in Ar (STP) → 10⁻⁴ c/kg/keV/y)

Cryogenic valves - WEKA

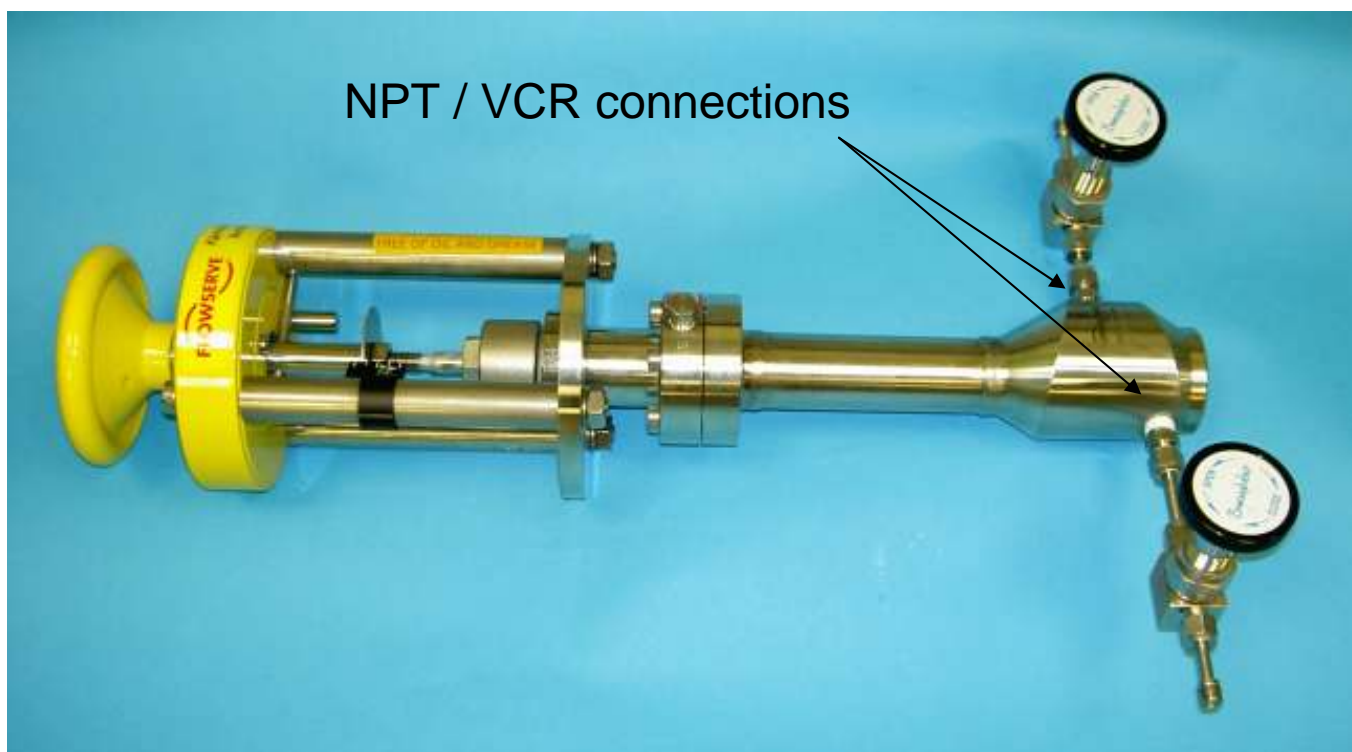


^{222}Rn source:

$A = 150 \text{ mBq}$
 $C \sim 1 \text{ kBq/m}^3$

Stamp gasket	Emanation rate [μBq]	Diffusion rate [μBq]	Comments
Teflon	78 ± 14	< 12	Original gasket
PCTFE	-	< 36	
TRCH 1000	-	< 50	

Cryogenic valves - KAMMER



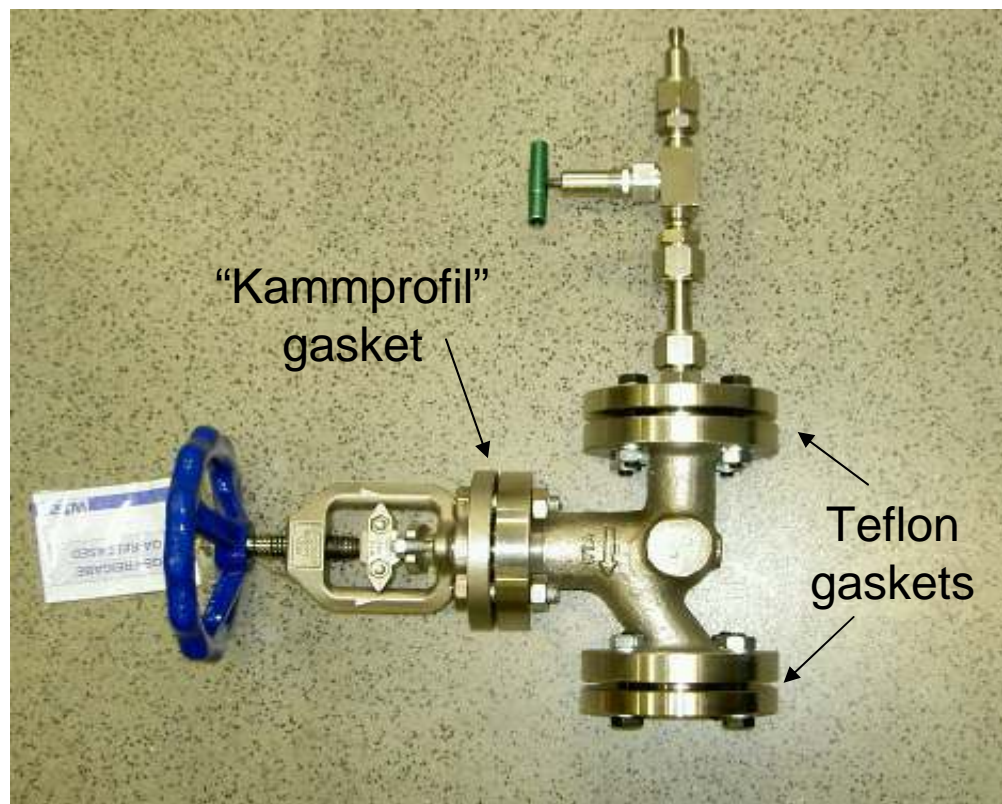
^{222}Rn source:

A = 150 mBq

C ~ 1 kBq/m³

Connection	Emanation rate [μBq]	Diffusion rate [μBq]	Comments
NPT	79 ± 24	-	Teflon sealed
VCR 1/2"	< 54	< 34	Full metal sealed

Cryogenic valves - WTA



Valve status	Emanation rate [mBq]
Open	2.0 ± 0.2
Closed	0.64 ± 0.15

Magnetic arm



Magnetic arms will be installed in the lock.



$$A_{\text{Ra}} = (0.11 \pm 0.05) \text{ mBq}$$

Habia coaxial cable



Sample mass: 514 g

Measured emanation rate:
(0.34 ± 0.09) mBq/kg

KF-16 O-rings



Sample	Amount	Emanation rate [mBq/piece]
Perbunan O-rings (black)	86 g 49 pieces	0.017 ± 0.003
Viton O-rings (green)	144 g 50 pieces	0.680 ± 0.021
Viton O-rings (bright green)	165 g 50 pieces	0.537 ± 0.028

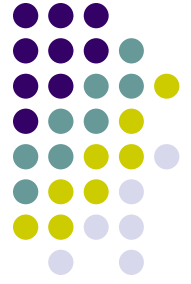
^{226}Ra in water samples



Sample	Description	Ra concentration [mBq/m ³]	Comments
De-ionized water	After the Millipore-ELIX purification system (11 MΩ)	19.1 ± 4.1	13-L sample measured in the small emanation chamber
Purest water	After the Millipore-ELIX and Advantage purification systems (18.2 MΩ)	6.5 ± 2.6	62-L sample measured in the big emanation chamber

Other samples for comparison:

Quartz-distilled water	Double distillation in a quartz apparatus (only a few liters per day)	≤ 5	Samples investigated using the small and big emanation chamber
Borexino water	Reverse osmosis, de-ionization, ^{226}Ra adsorption (18.2 MΩ)	< 0.8	Samples measured using STRAW at GS.



Plans

- Emanation of the cryostat (at SIMIC, without copper, before final cleaning)
- Emanation of the cryostat after cleaning and copper shield assembly (GS)
- Further samples: “Kammprofil” gaskets, WTA valve with indium seals, steel plates with welds after electropolishing, ...