Behaviour of ^{222}Radon at Cryogenic Temperatures

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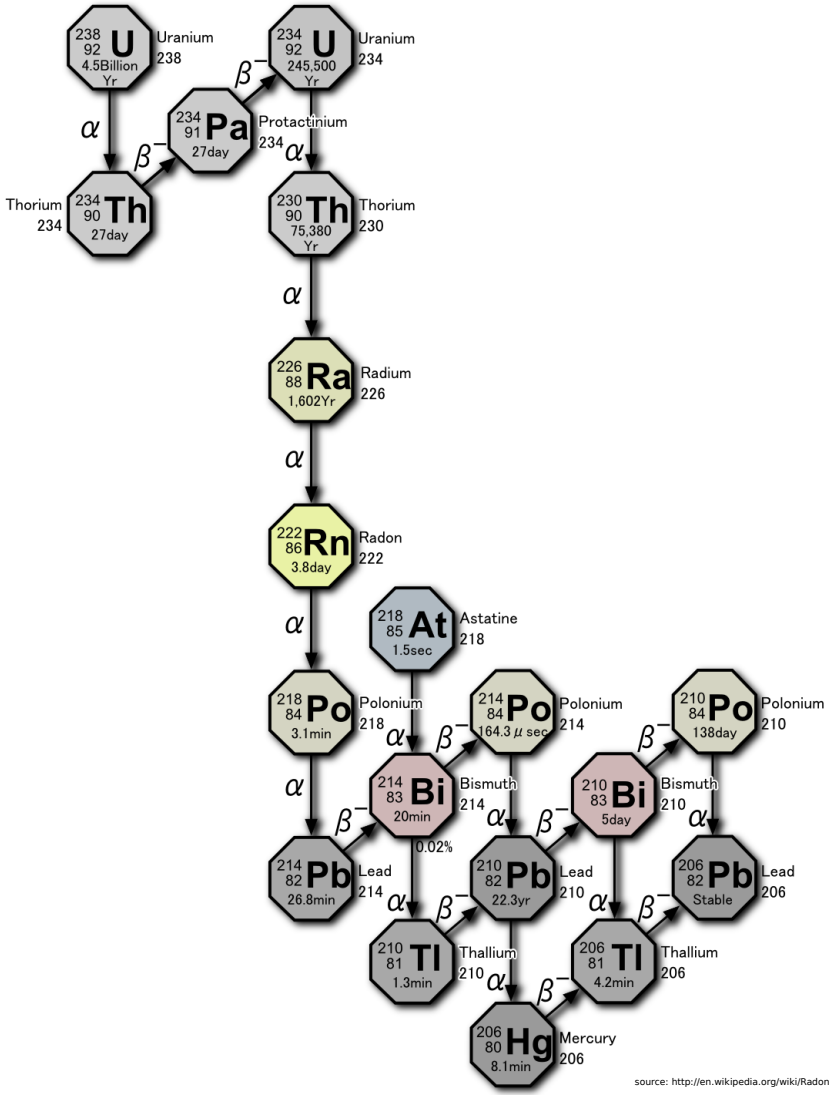
Outline

^{222}Rn from Uranium-238 decay chain



Properties of ^{222}Rn

- inert
- gaseous at room temp.
- produced by α-decay of ^{226}Ra
- $T_{1/2}$=3.8 days
- α-, β- and γ-emitting daughter nuclei with wide energy spectrum

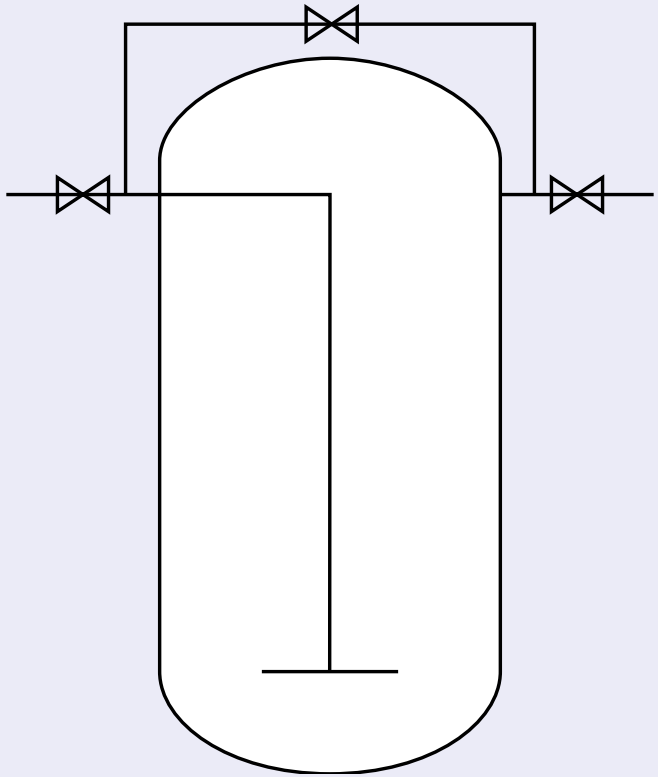
Screening for ^{222}Rn is necessary!

How is this usually done?

- Emanation
- Prop. counter
- Gasline

^{222}Rn emanation

Emanation measurement



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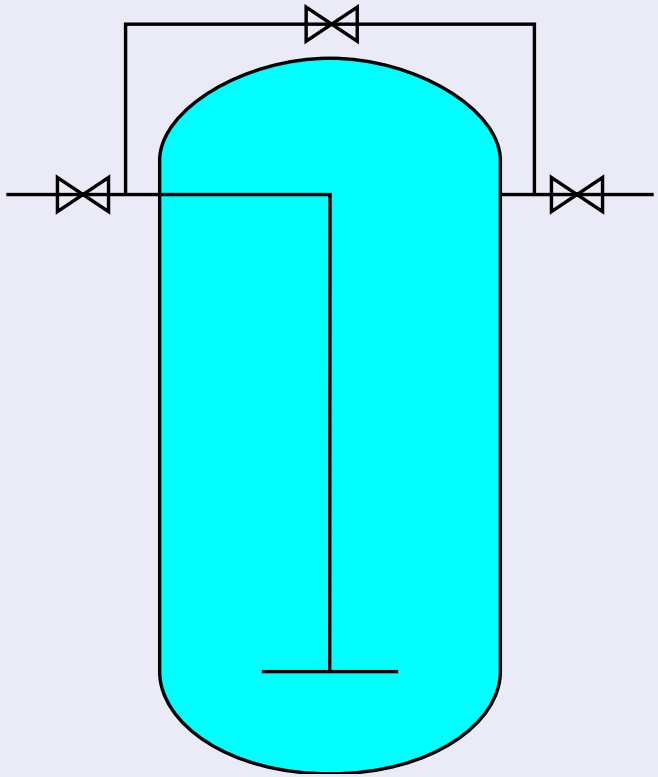

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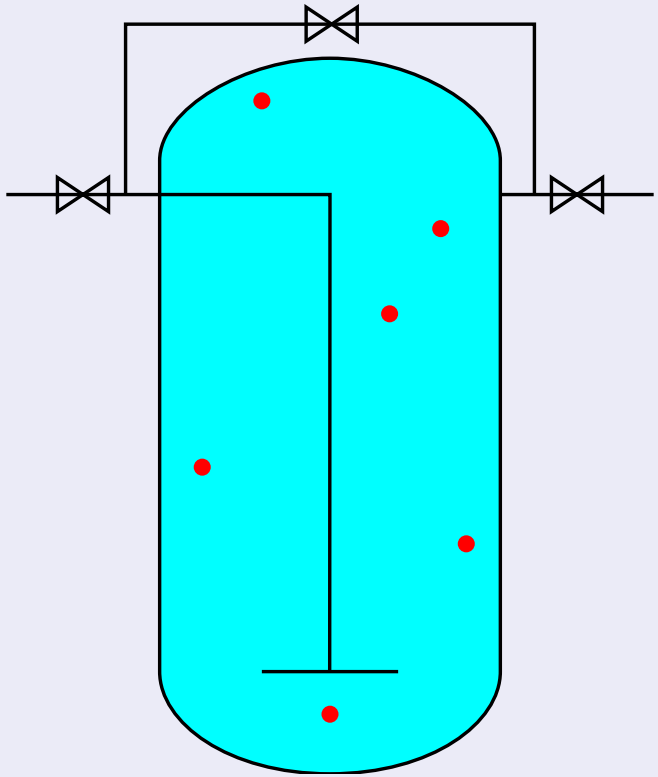

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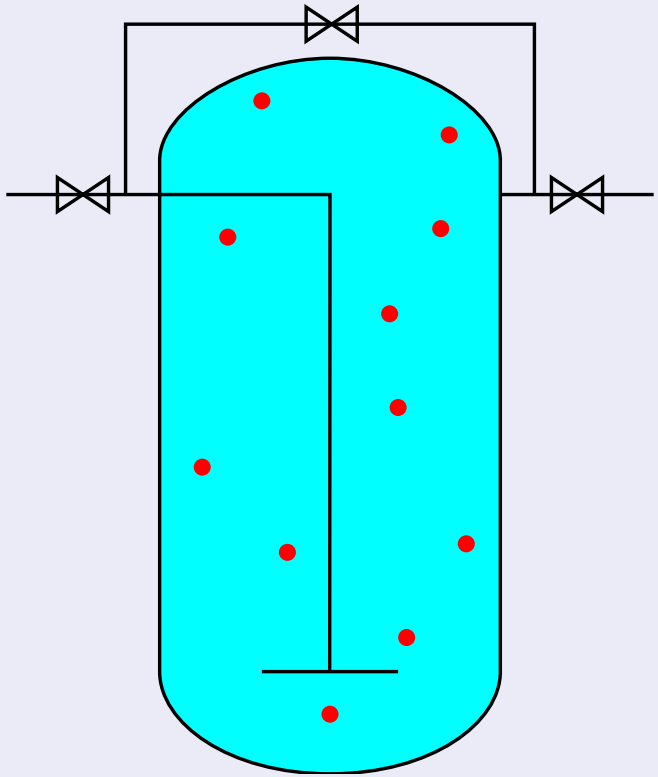

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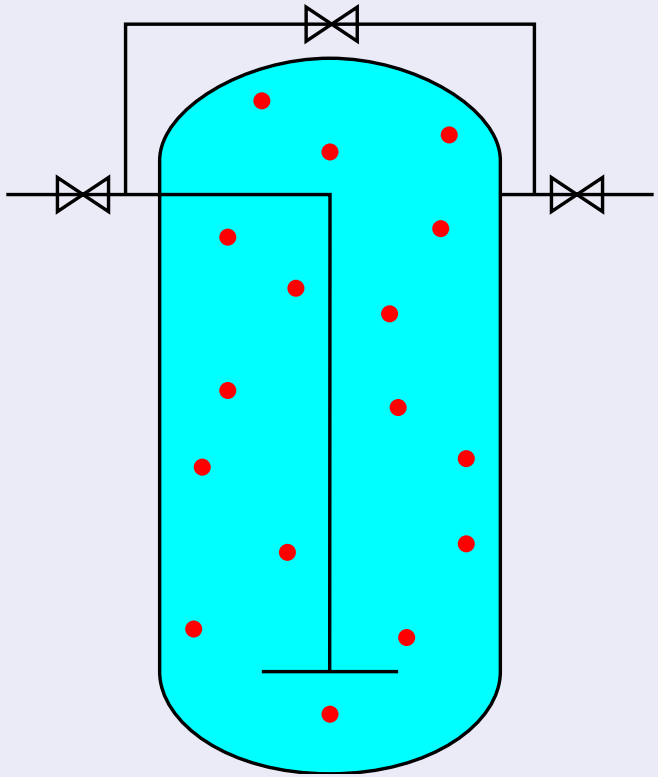

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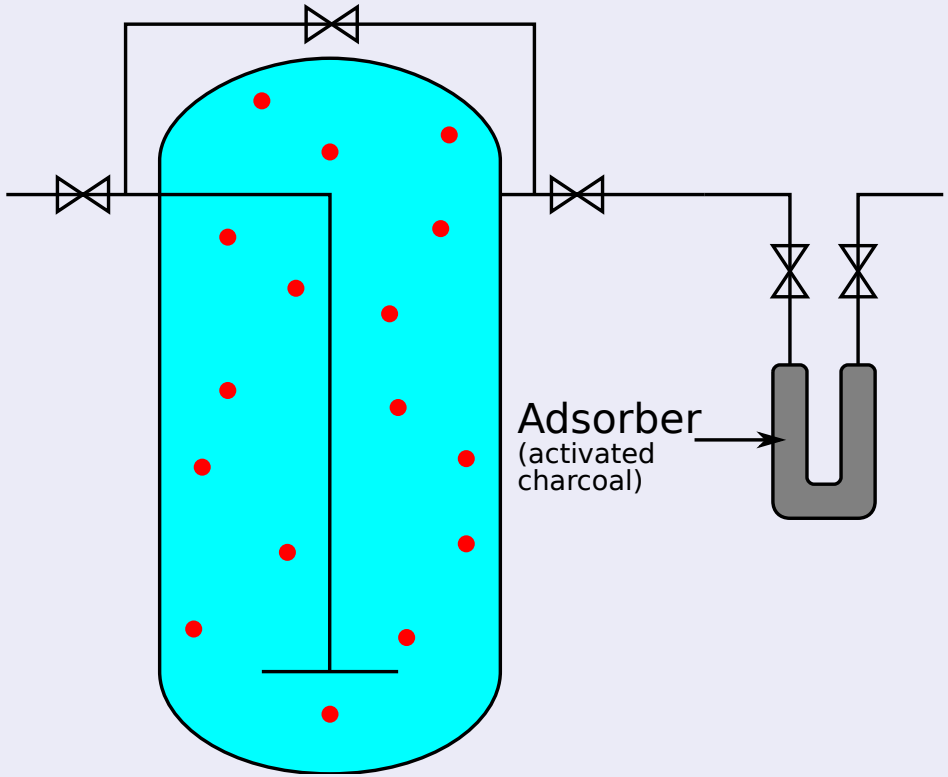

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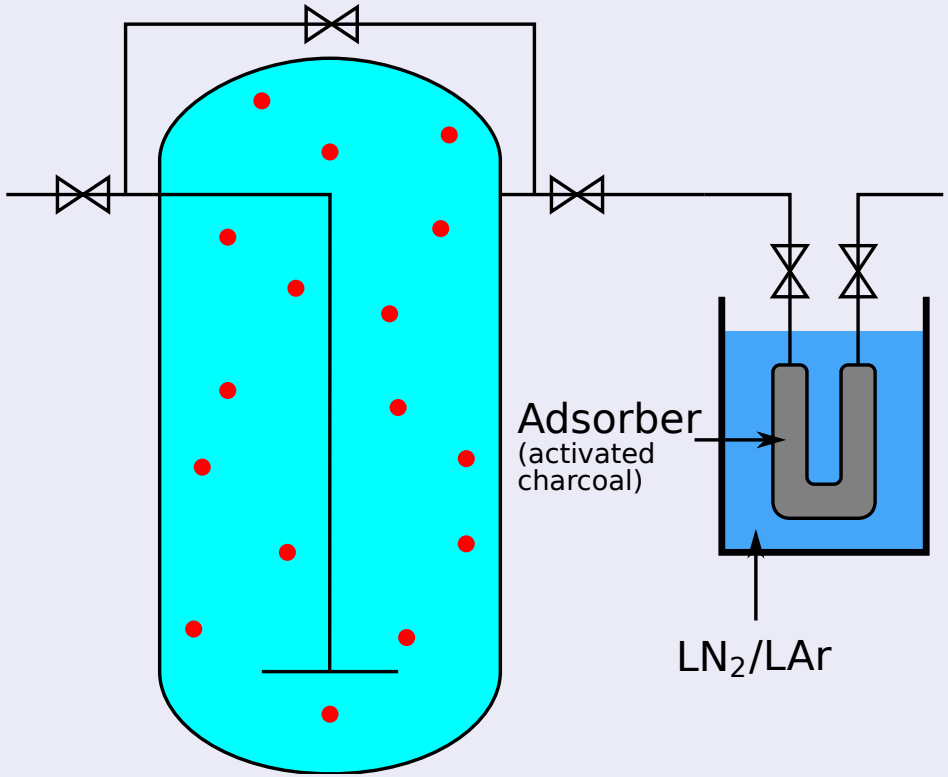

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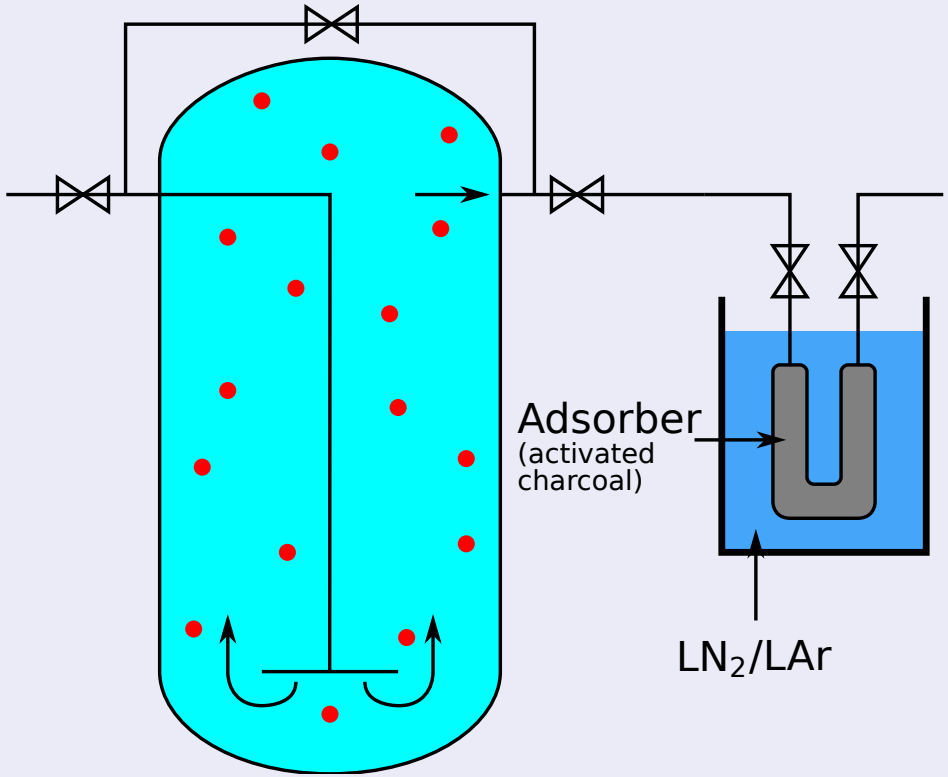

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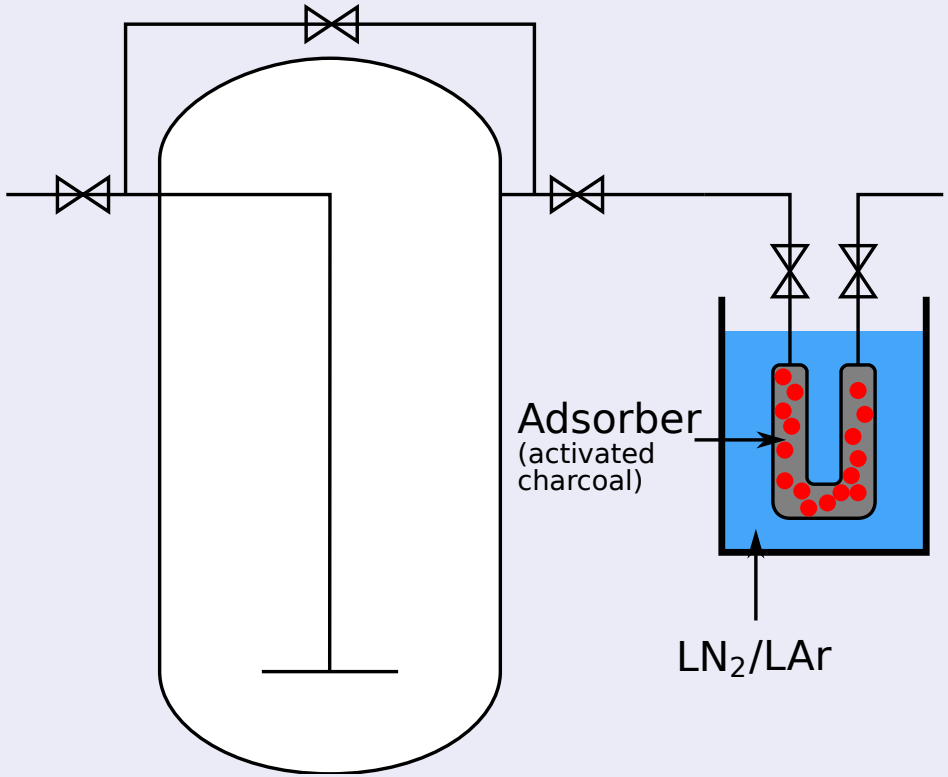

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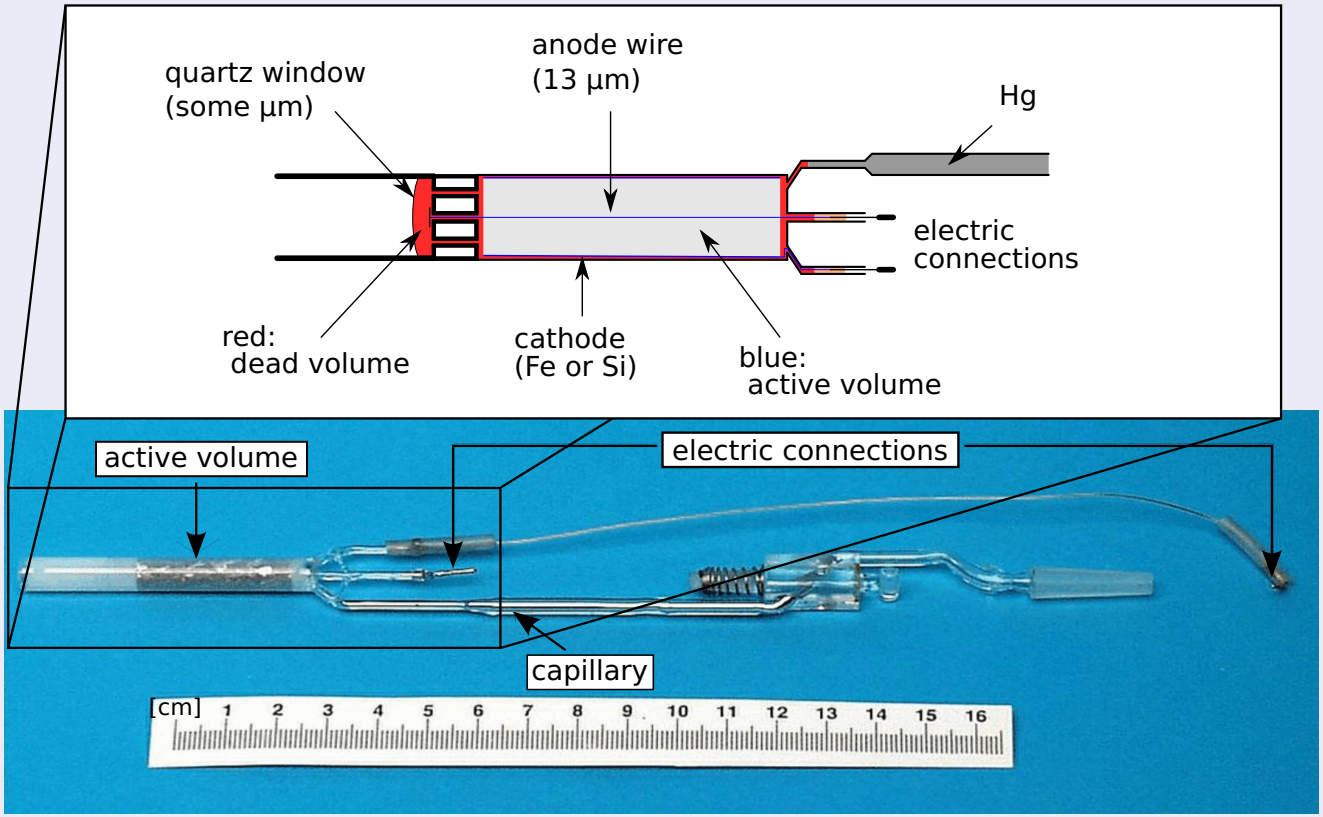
- Gasline

Miniaturized HD2-type proportional counter

(Ray Davis)

^{222}Rn detection at single atom level



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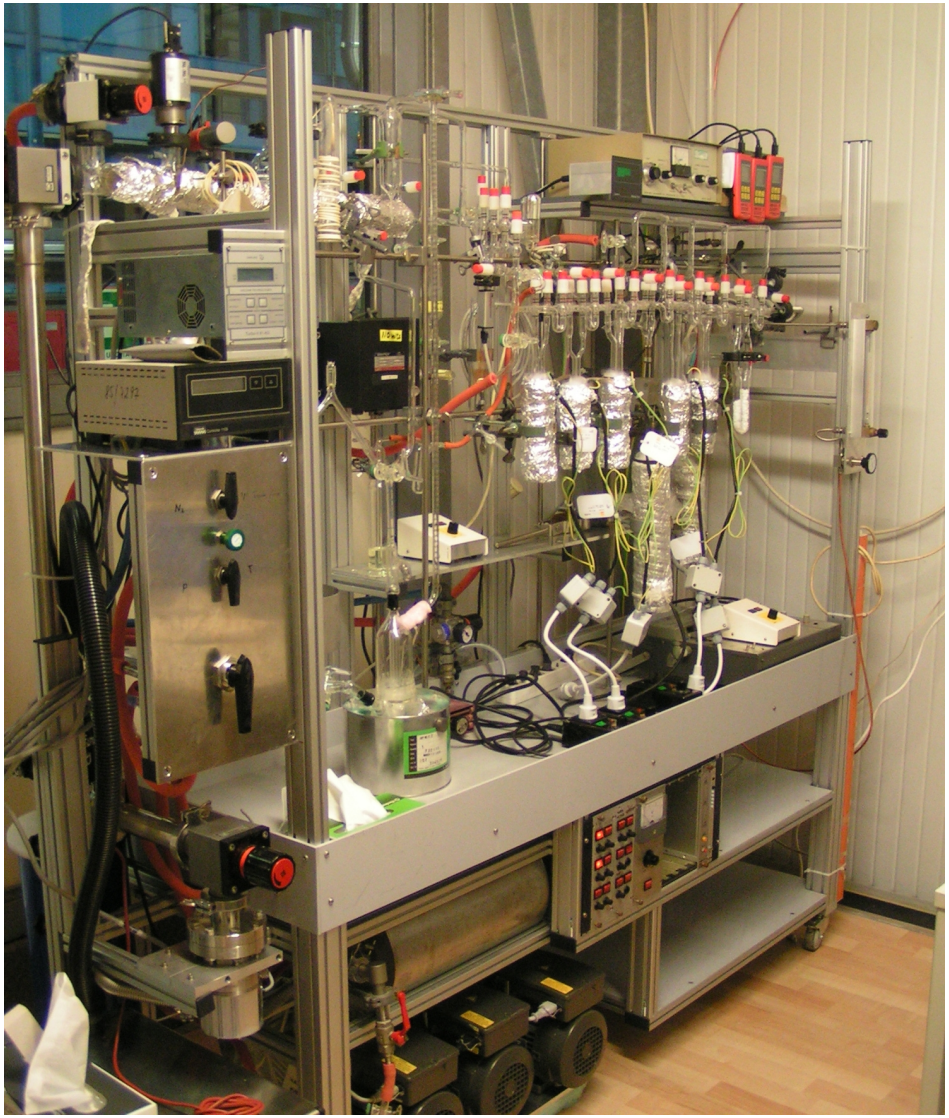
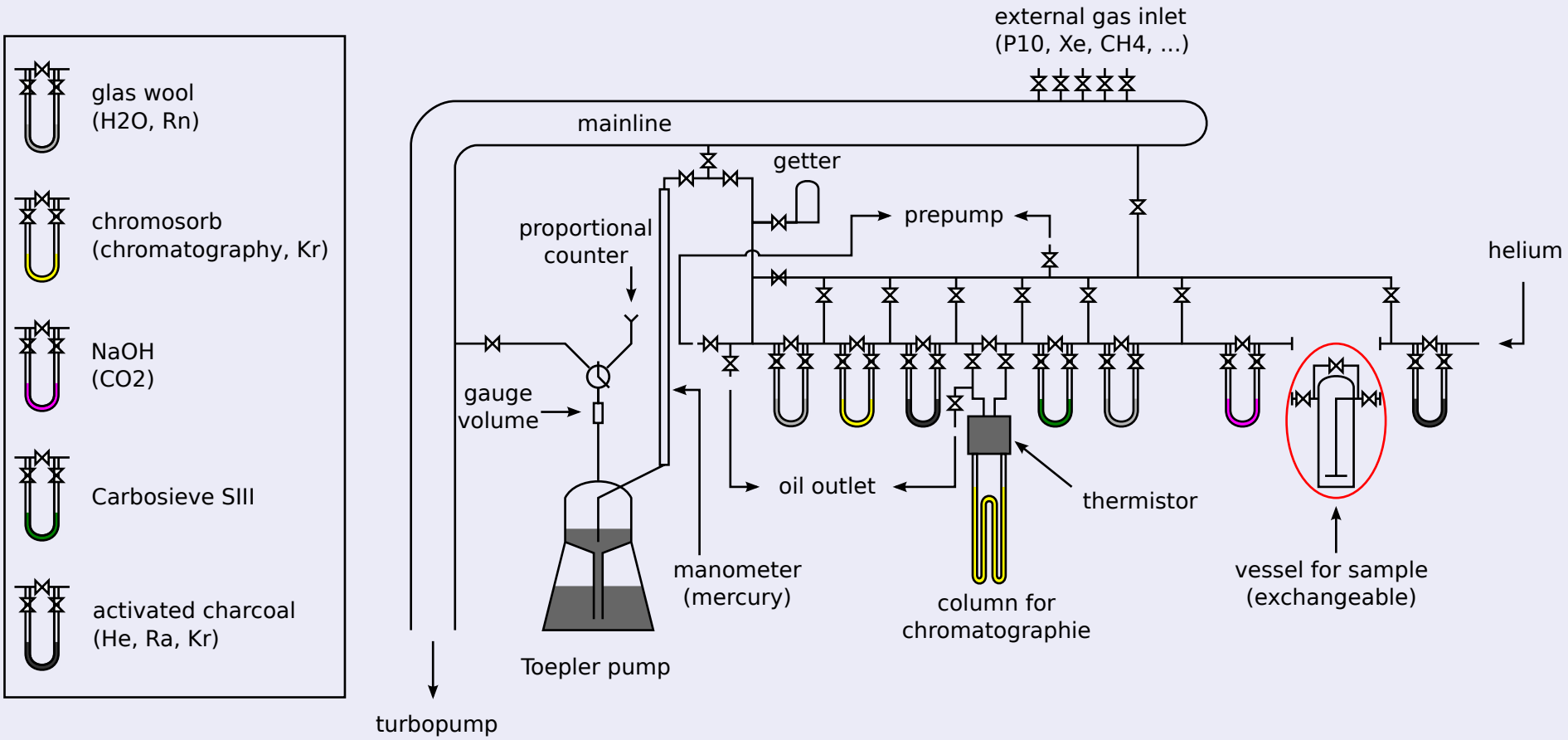
Gasline @ LNGS



Gasline

Purification of sample gases and filling of counter



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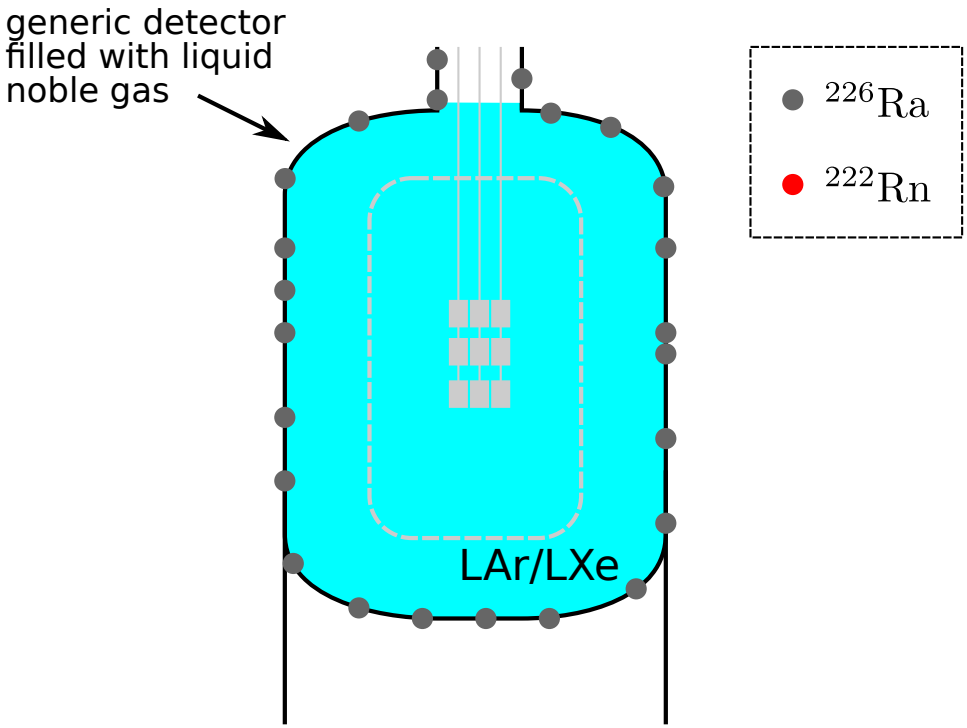
How to translate results to a cryogenic real-life detector?

Radon-induced background



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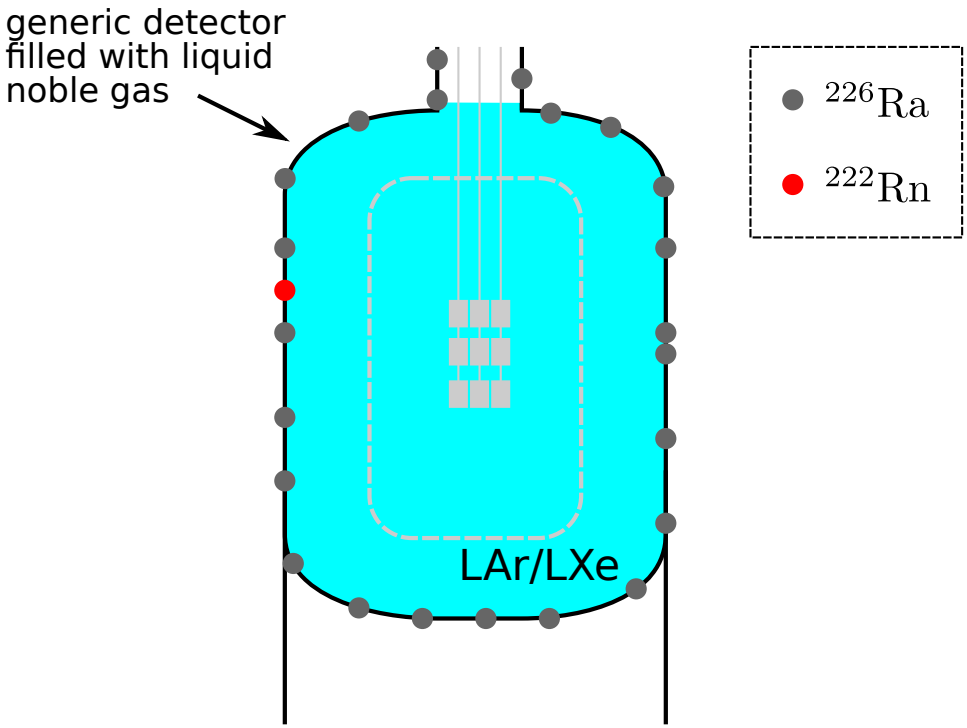

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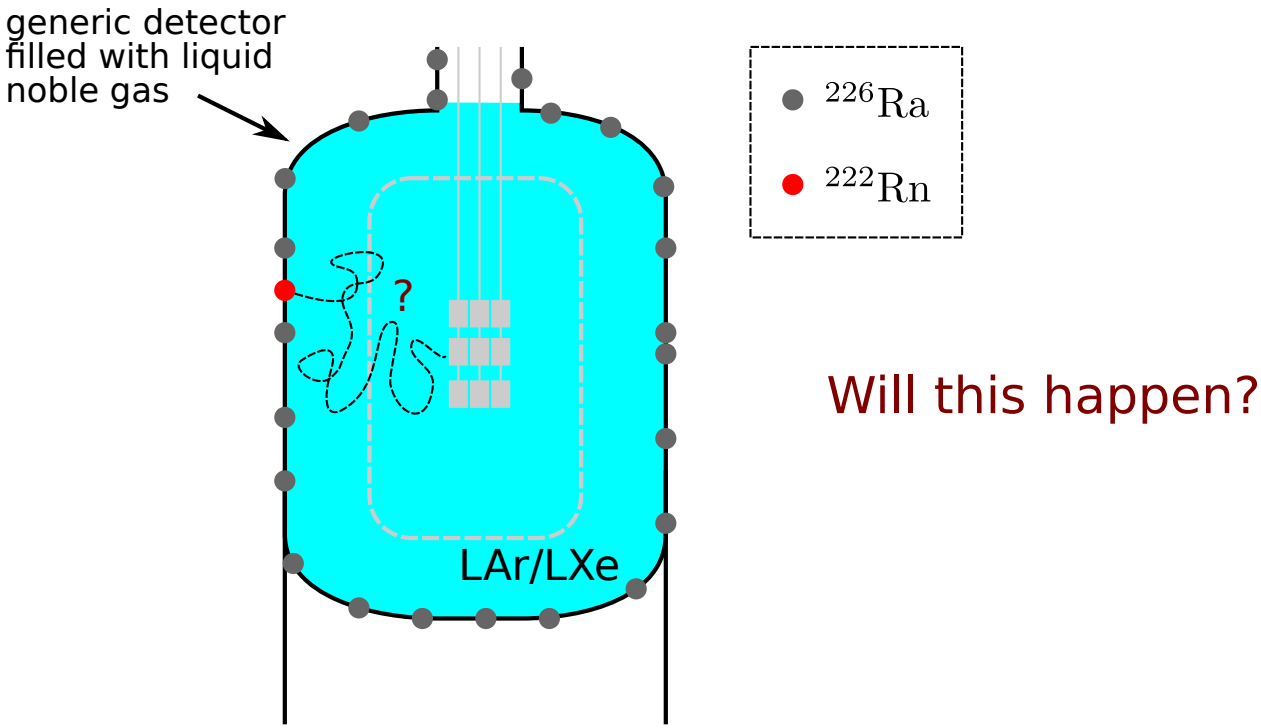
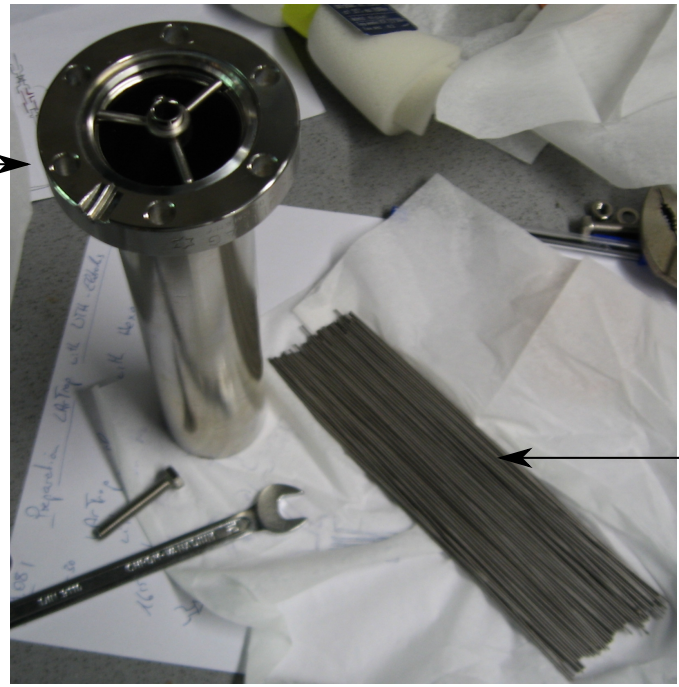


Will this happen?

The cold emanation experiment

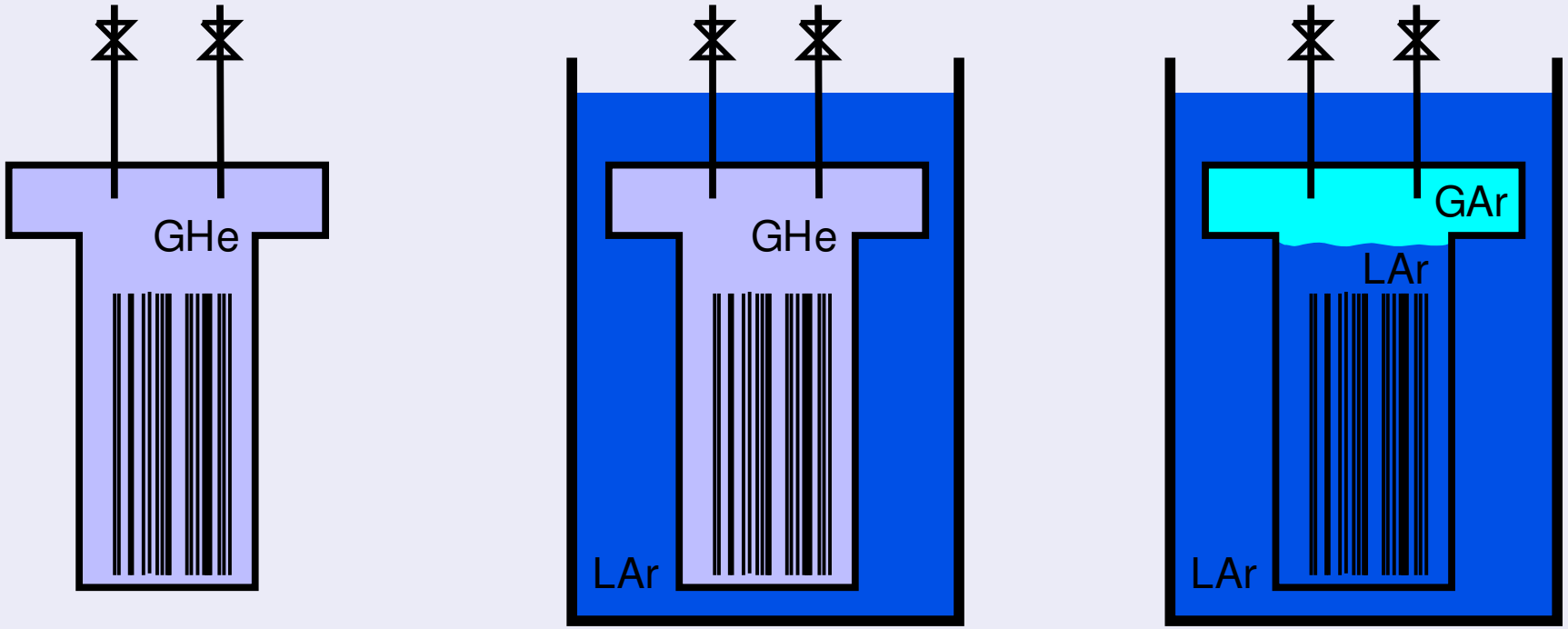
Container:
stainless steel vessel



Source (^{222}Rn emanation):
100 WTh welding rods

The setup

Series of measurements



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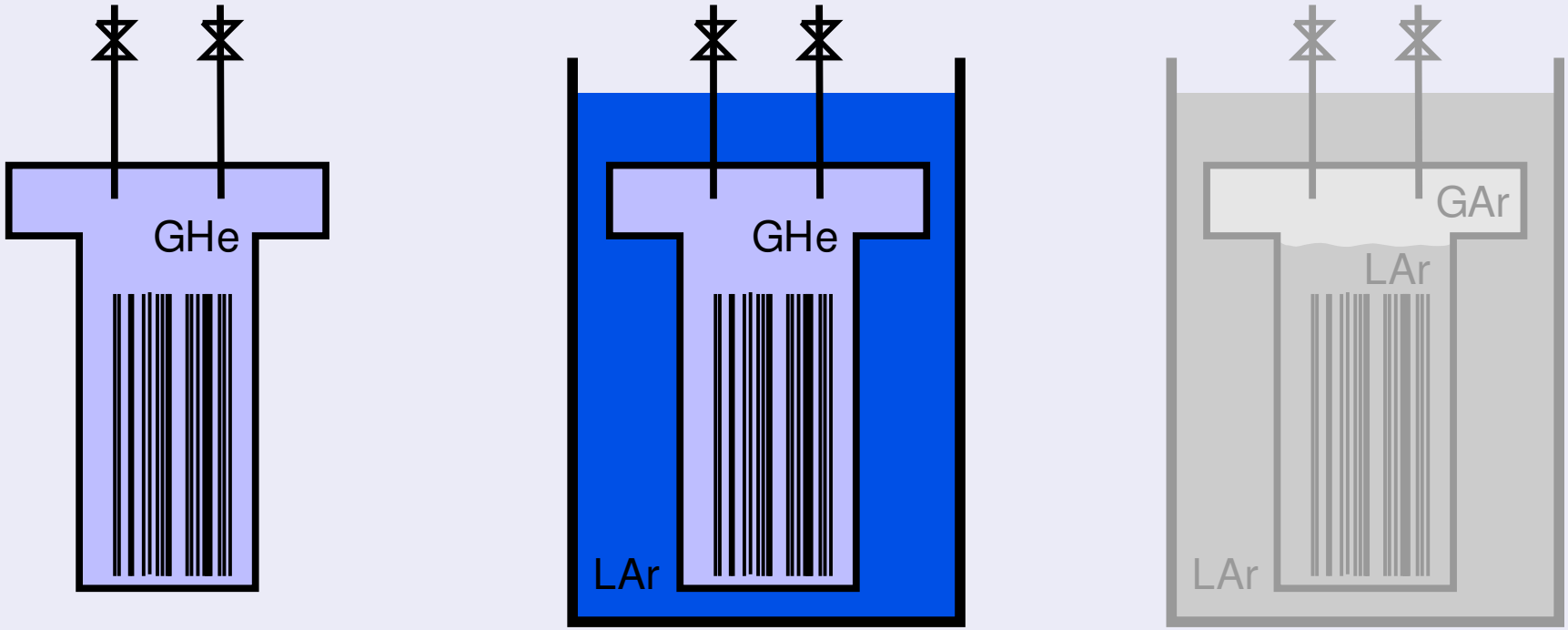


Results

^{222}Rn emanation to GHe:

- Emanation @ room temp. (RT):
  (1.8 ± 0.1) mBq (extraction @ RT)
- Emanation @ LAr temp.:
  < 0.04 mBq (extraction @ LAr)
  (1.24 ± 0.11) mBq (extraction @ RT)

Conclusion

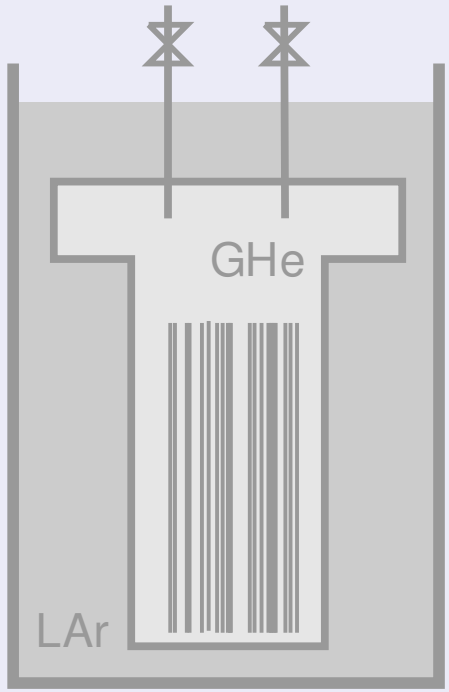
Behaviour of ^{222}Rn in cryo., gaseous, inert environment:

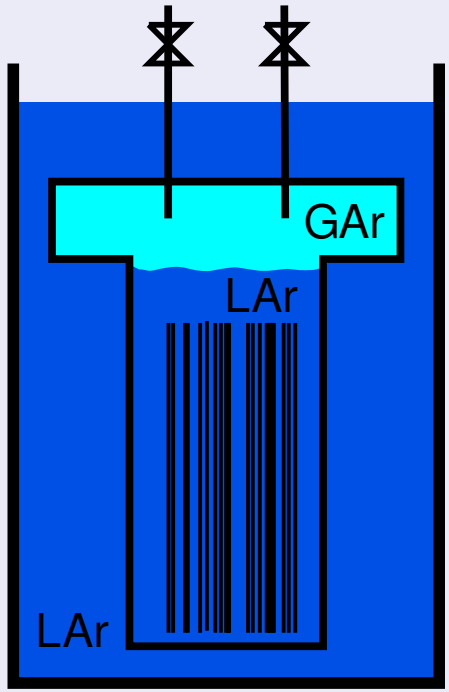
- ^{222}Rn is still produced
- ^{222}Rn sticks to cold surfaces

$\rightarrow$ ^{222}Rn is not mobile

The setup

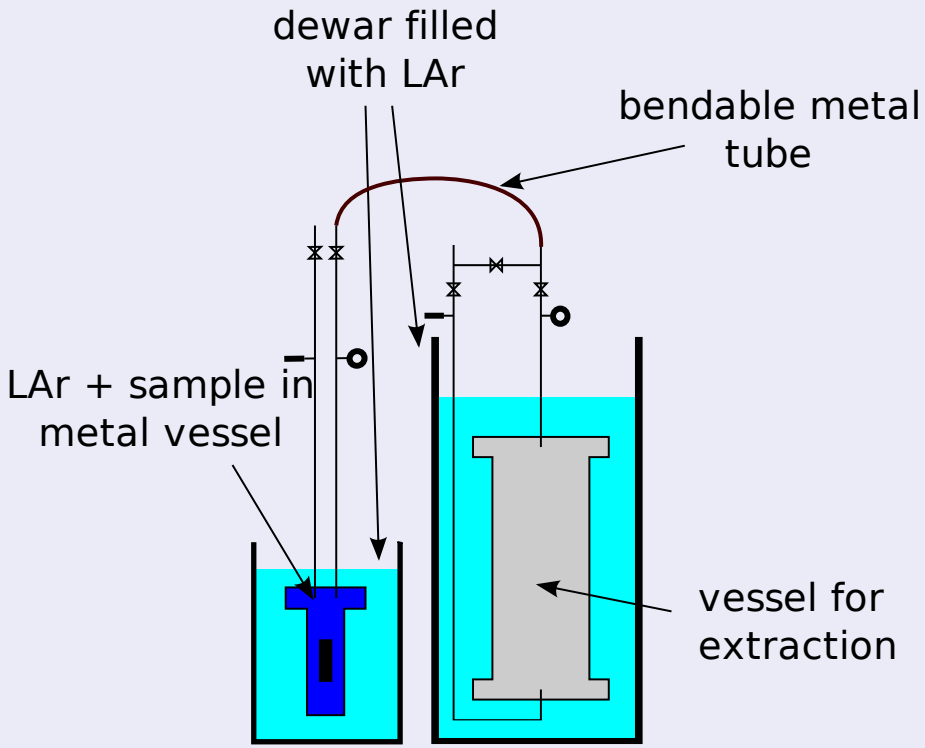
Series of measurements





LAr extraction

Separating liquid argon from vessel and sample



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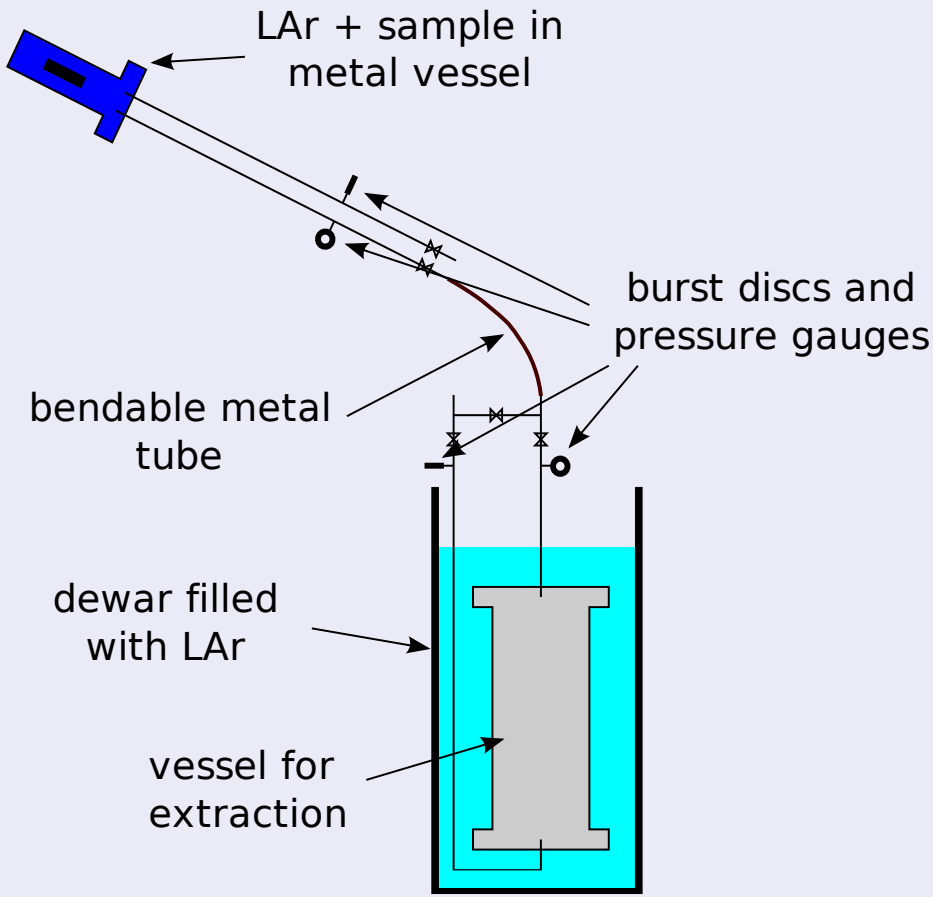

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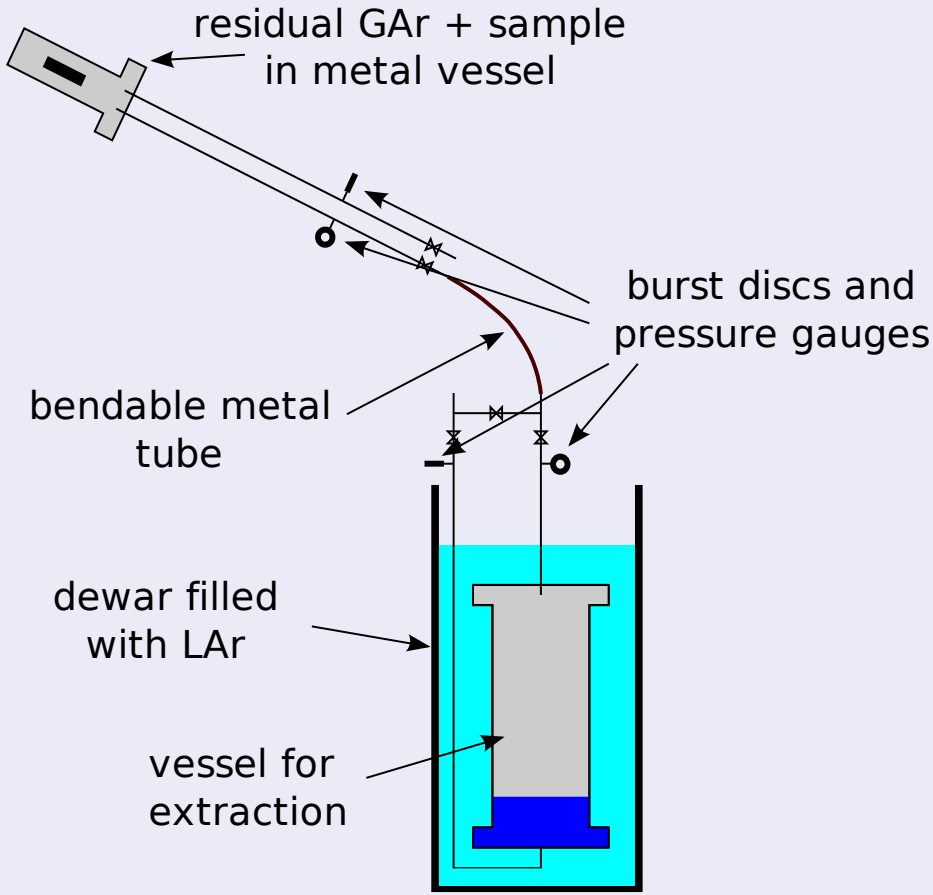

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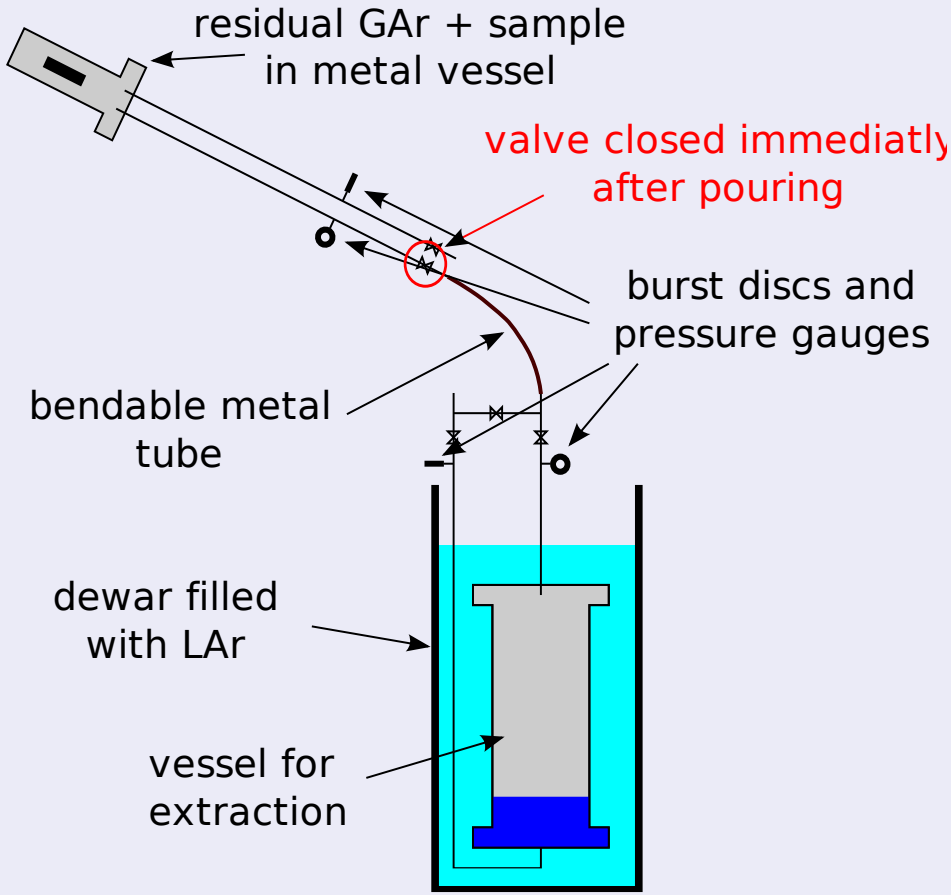
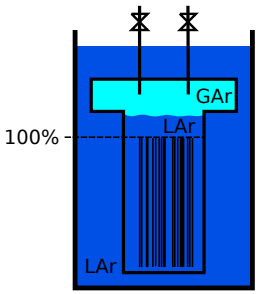
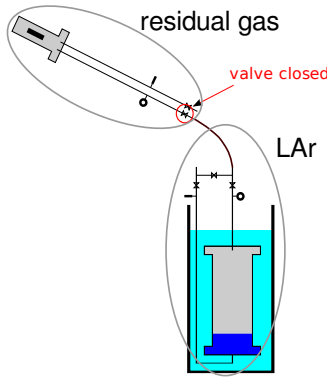


Results

	Amount of LAr		Activity [mBq]		
	total [ml]	WTh covered	residual gas	LAr	sum
1st	216 ± 7	100 %	-	1.0 ± 0.1	-
2nd	144 ± 7	70 %	1.8 ± 0.2	0.6 ± 0.1	2.4 ± 0.2
1st Blank	164 ± 7	-	< 0.025	< 0.032	-
3rd	205 ± 7	100 %	-	1.0 ± 0.1	-
4th	187 ± 7	90 %	1.3 ± 0.1	1.1 ± 0.1	2.4 ± 0.1
5th	189 ± 7	90 %	1.5 ± 0.1	1.1 ± 0.1	2.6 ± 0.1
2nd Blank	144 ± 7	-	< 0.054	< 0.045	-





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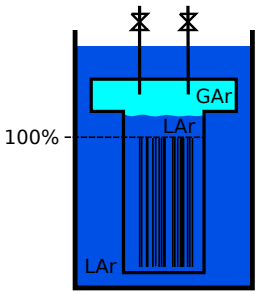

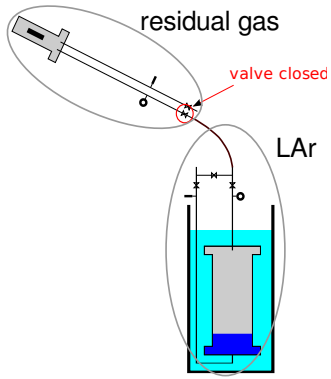

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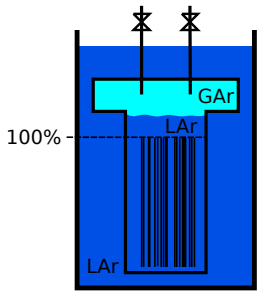

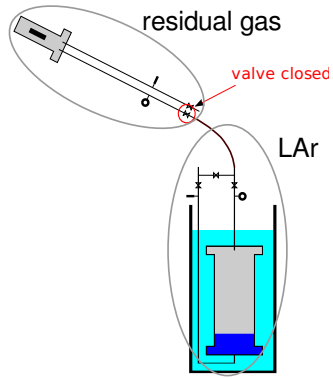

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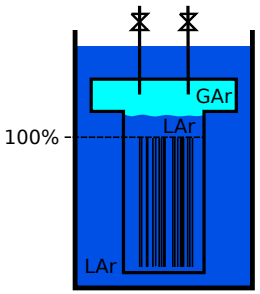
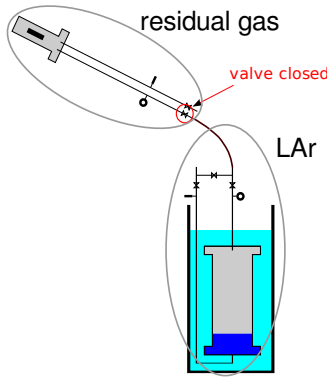




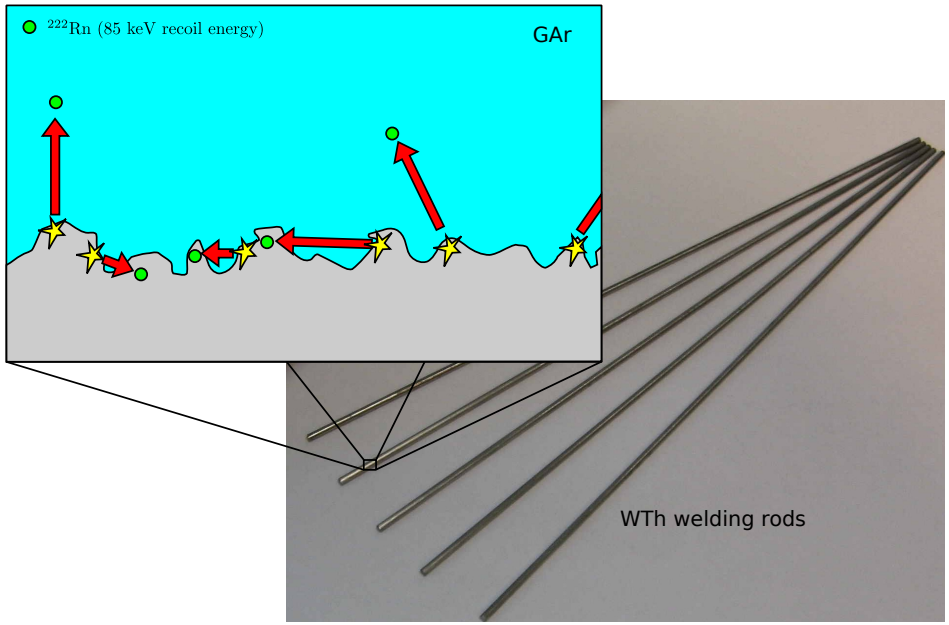
Higher ^{222}Rn emanation rate in LAr

^{222}Rn emanation rate of WTh rods

GHe: (1.8 ± 0.1)mBq
LAr: (2.5 ± 0.1)mBq

Range of 85 keV ^{222}Rn recoil ion[1]

GHe: 395 μm
GAr: 64 μm
LAr: 77 nm



[1] SRIM version SRIM-2008.04, `http://www.srim.org/`

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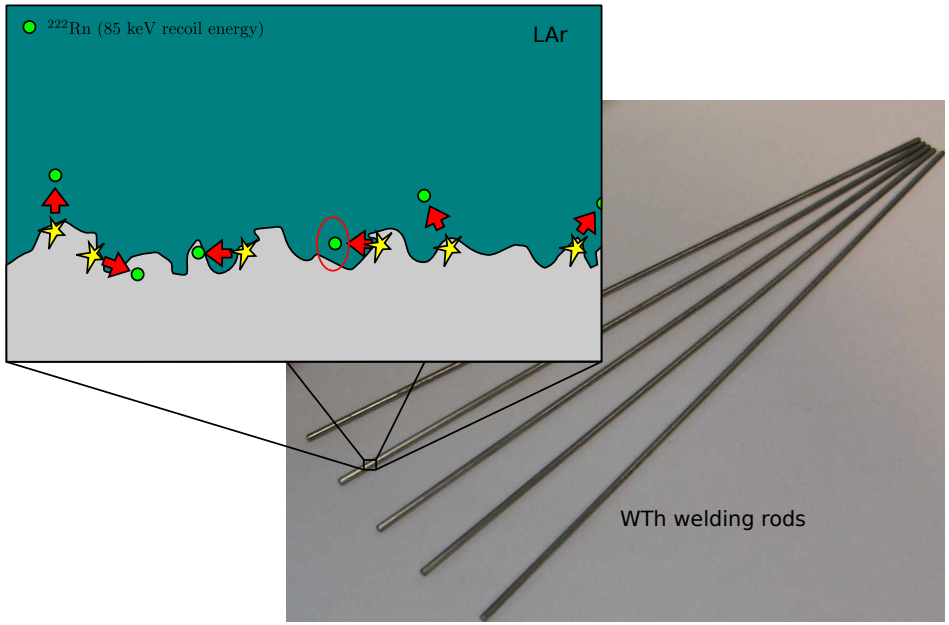

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Summary

- Emanation to cryogenic gaseous environment: ^{222}Rn sticks to cold surfaces

  $\rightarrow$ cryogenic inert gases will be ^{222}Rn-clean

- ^{222}Rn dissolves partially in LAr

- Total ^{222}Rn emanation to LAr is higher than to GHe