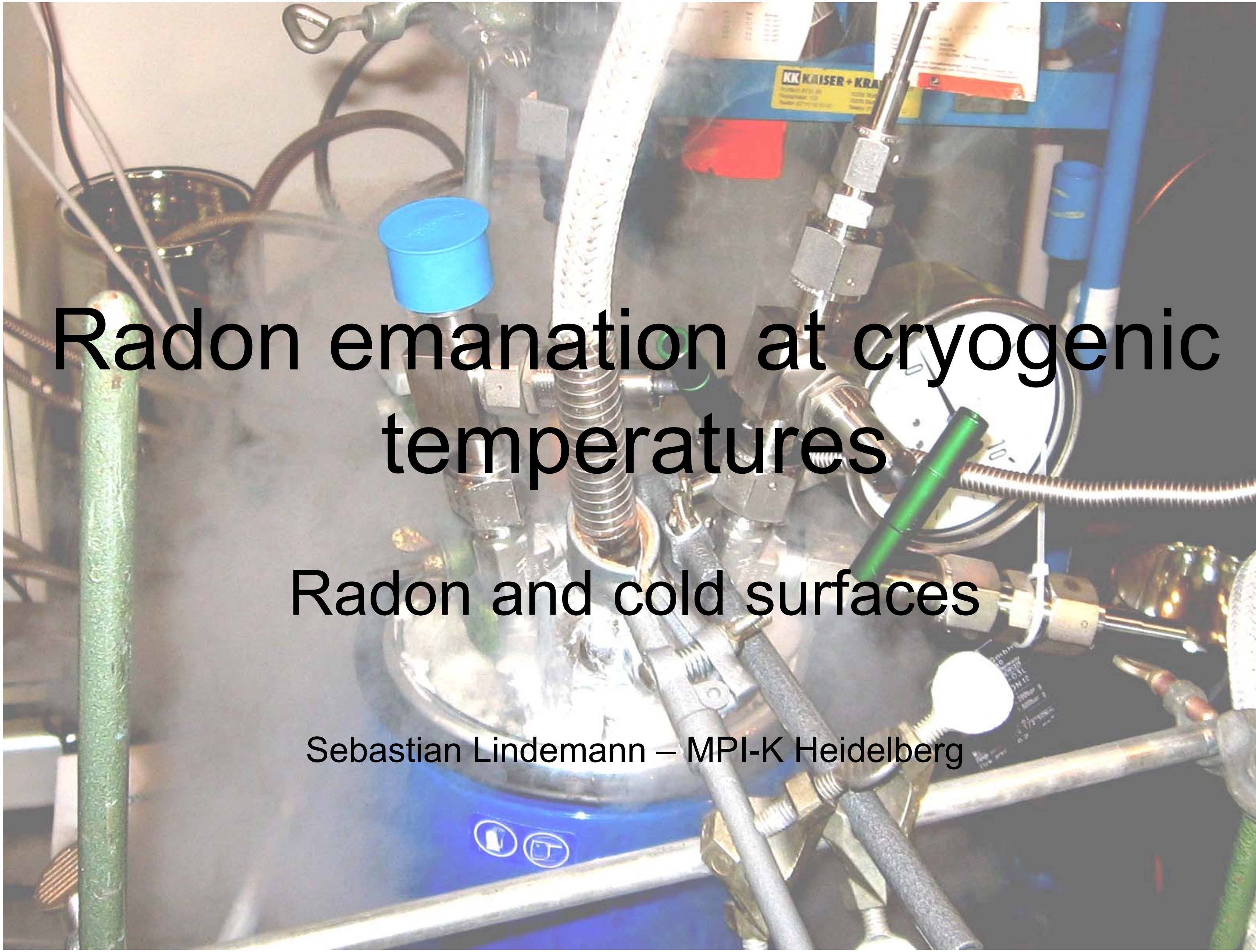


Radon emanation at cryogenic temperatures

Radon and cold surfaces

Sebastian Lindemann – MPI-K Heidelberg

Outline

- Introduction
- Measurements
  - "Warm" (normal) emanation
  - "Cold" emanation into gas (cryostat neck)
  - "Cold" emanation into liquid (cryostat)
- Interpretation of data
- Conclusions for cryostat

Introduction

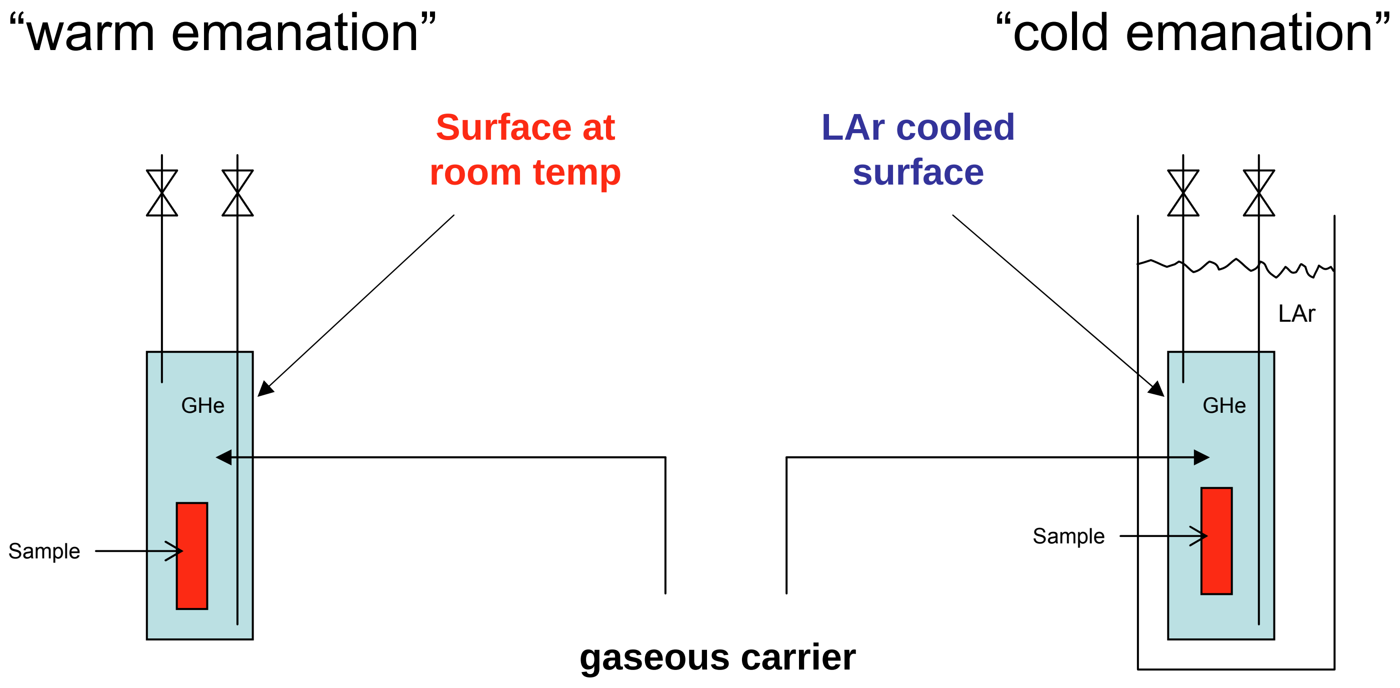
8 mBq $\rightarrow 10^{-4}$ cts/(keV·kg·y)

55 mBq $\rightarrow \sim 10^{-3}$ cts/(keV·kg·y)

55 mBq + shroud $\rightarrow < 4 \times 10^{-4}$ cts/(keV·kg·y)

Does the Rn emanation at cryogenic temperatures differ from the emanation at room temperature?

Measurements – "warm" vs. "cold" emanation

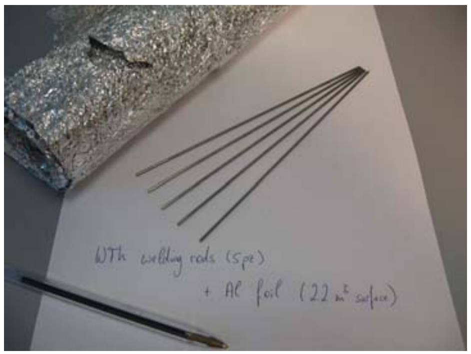


All vessels and valves metal sealed

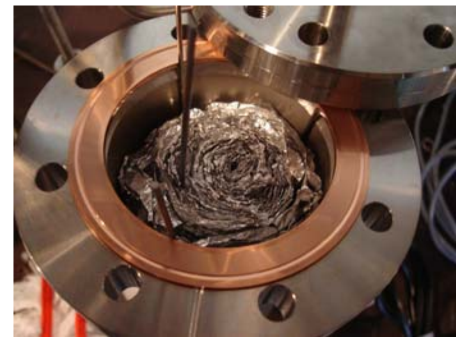
(Leak tested: < 10^{-6} mbar·l/sec)

Measurement – The samples

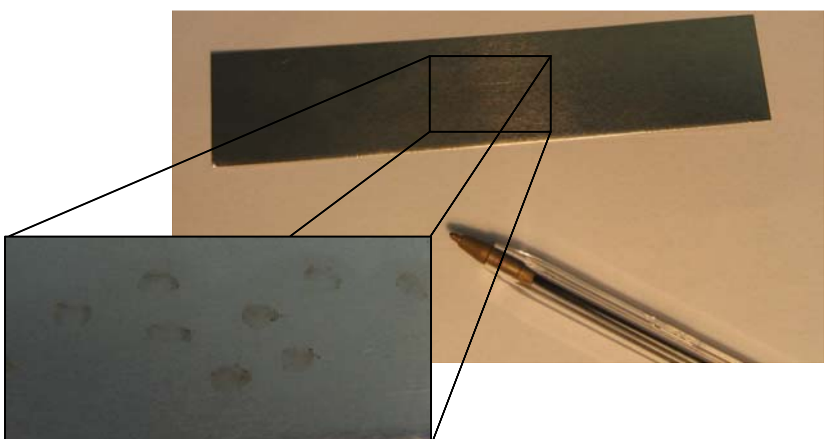
WTh welding rods (5pz) +
Al foil (2.2 m^2 surface)



Al foil + 5 WTh rods in trap



^{226}Ra solution (16mBq) on
small stainless steel plate



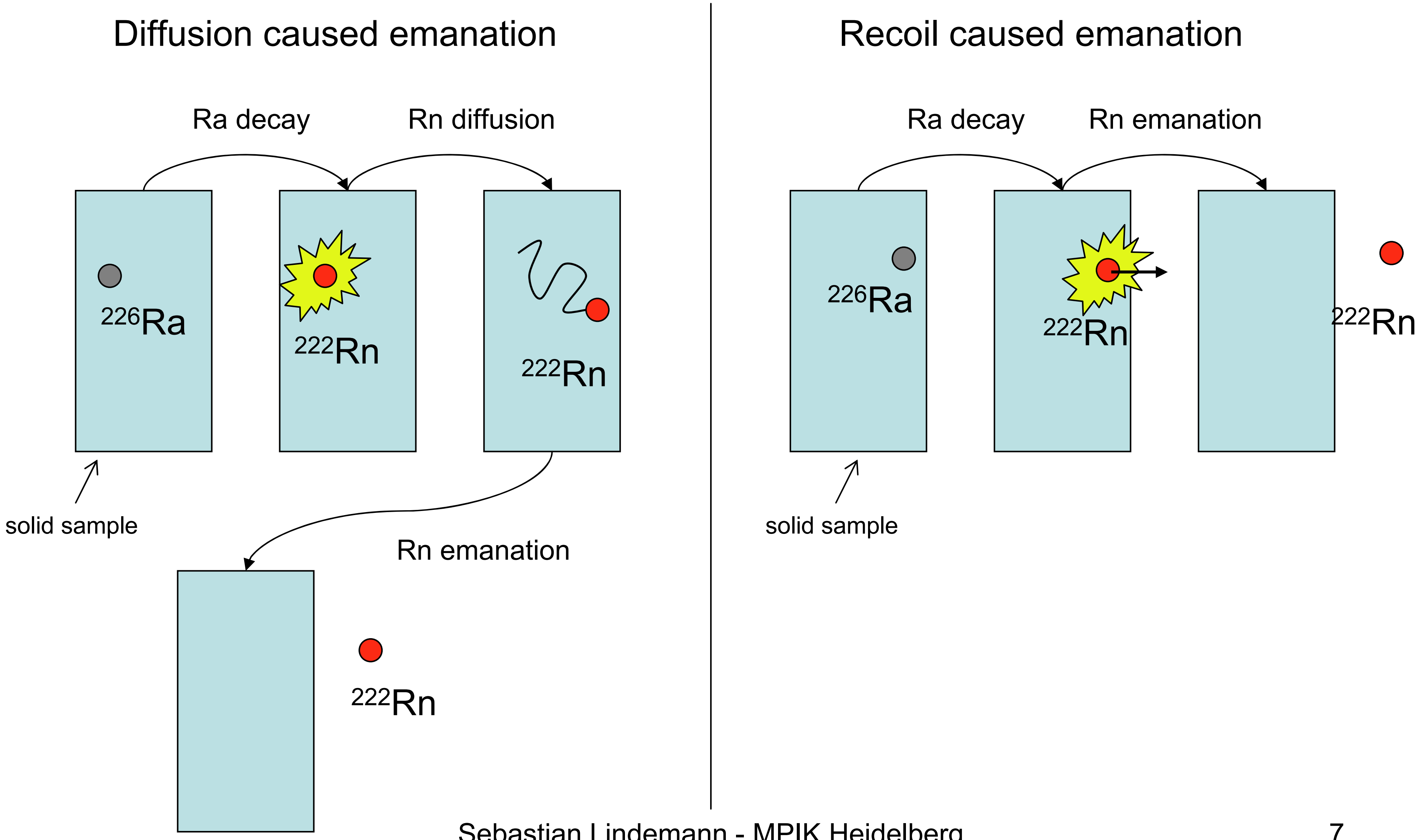
LArTrap + WTh welding rods
(100pz; 4% thorium)

Measurement – The results

^{222}Rn emanation	gaseous carrier (He)	
	room temperature	LAr temperature
Al foil (2.2 m^2)	< 0.12 mBq	-
Welding rods (3pz)	(0.13 ± 0.01) mBq	-
Al foil + welding rods (5pz)	(0.14 ± 0.01) mBq	-
^{226}Ra (16mBq) sol. on stainless steel	(1.4 ± 0.2) mBq	< 0.014 mBq
Tungsten welding rods (4%Th)	(1.5 ± 0.2) mBq	< 0.040 mBq

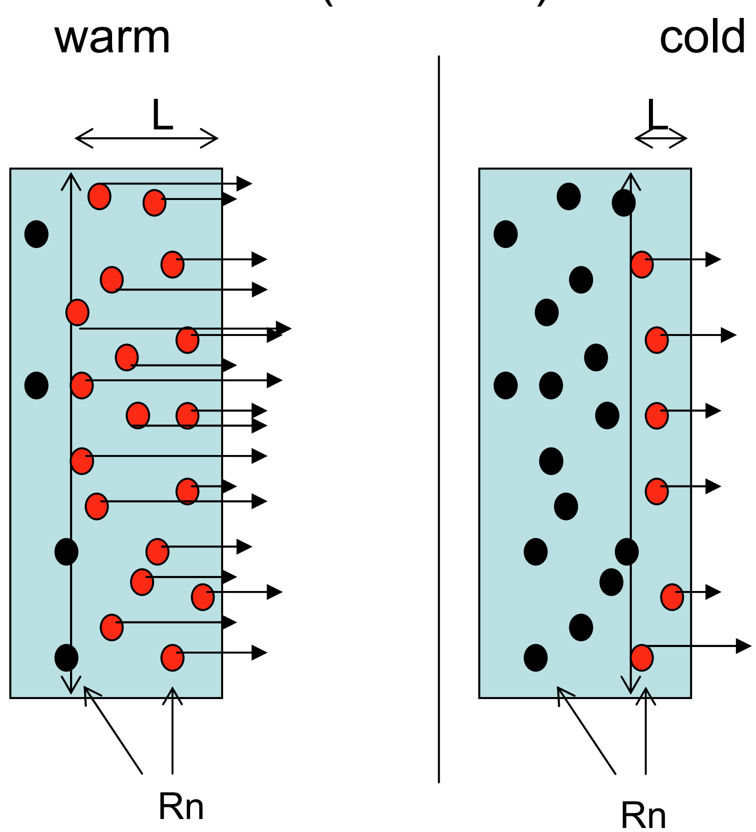
> 40 times lower emanation rate!

Interpretation - Emanation scenarios

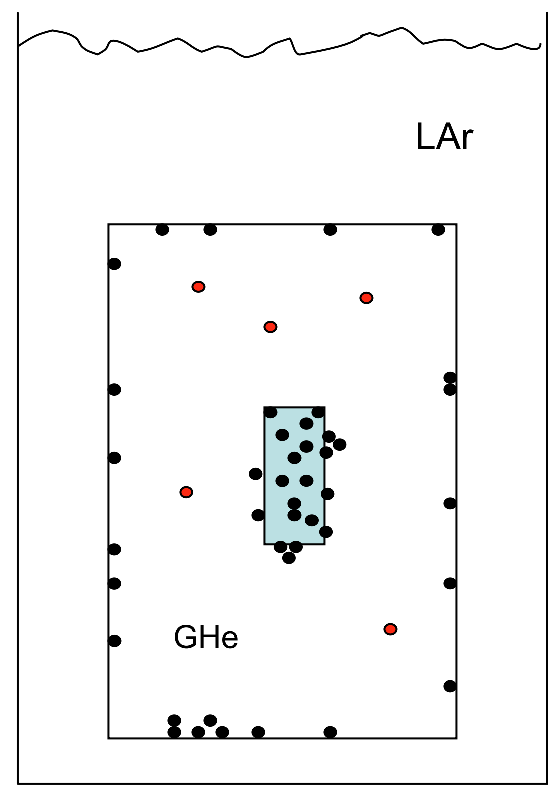


Interpretation – Reduced activity

Reduced diffusion length L
(L = D / λ)

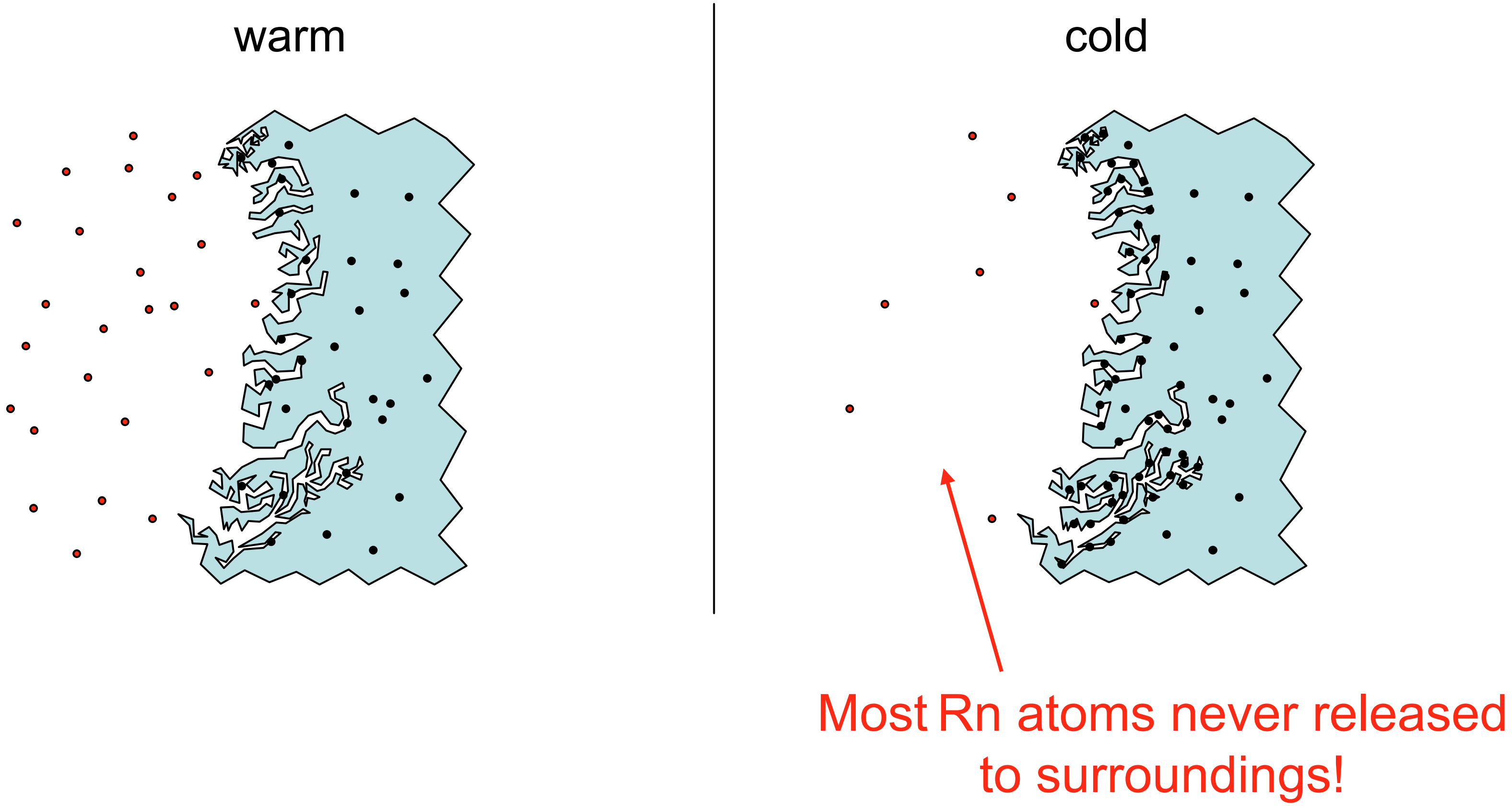


"Freezing out" of Radon



Interpretation – Reduced activity

freezing out + porous (rough) surface effect



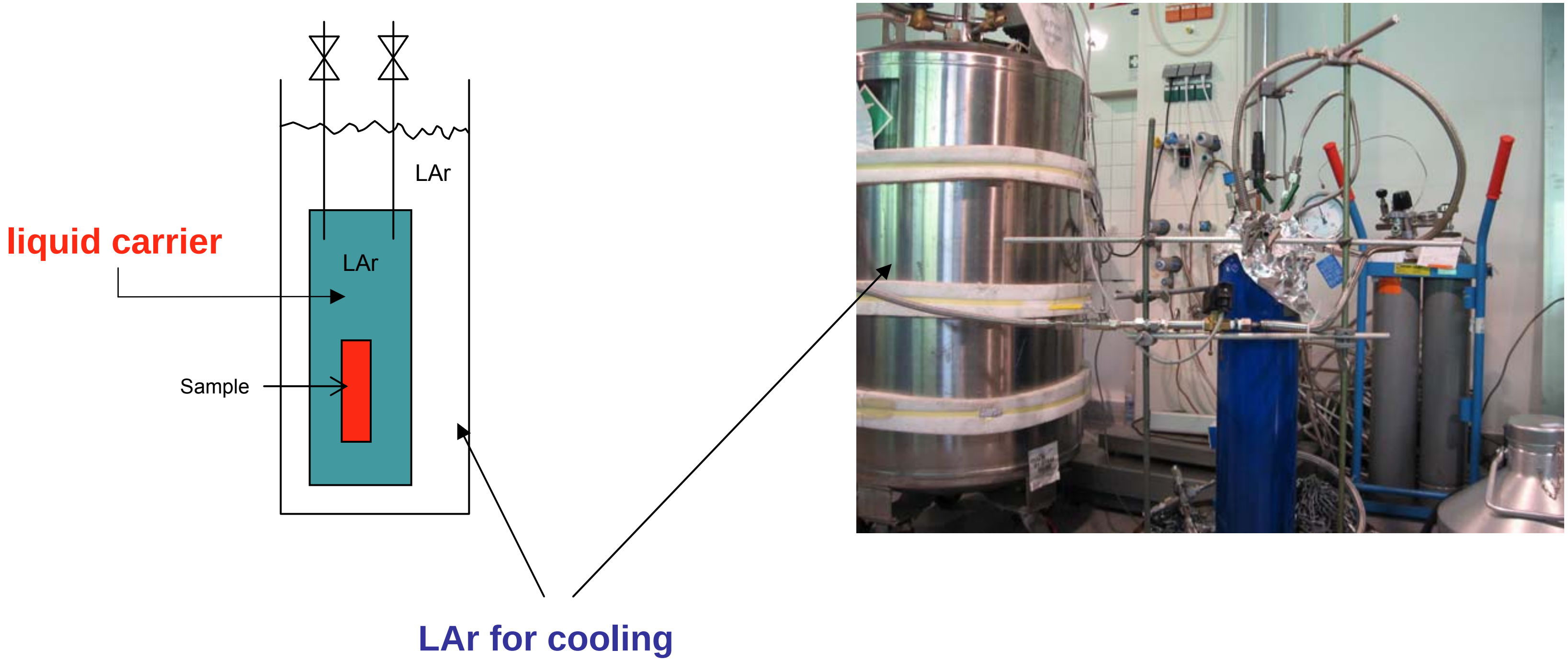
Interpretation – Reduced activity

- Option 1:
  Diffusion length decreases
  - **^{226}Ra sol.**: "new" surface properties ?
  - **WTh rods**: Rn diffusion const. for metals should be too small to explain effects!
- Option 2:
  Freezing out of Rn atoms
  - on **all surfaces** ?
  - predominately **on rough surface of sample** ?

-> NEXT: Immerge sample directly in LAr!

Outlook – LAr as carrier

Emanation



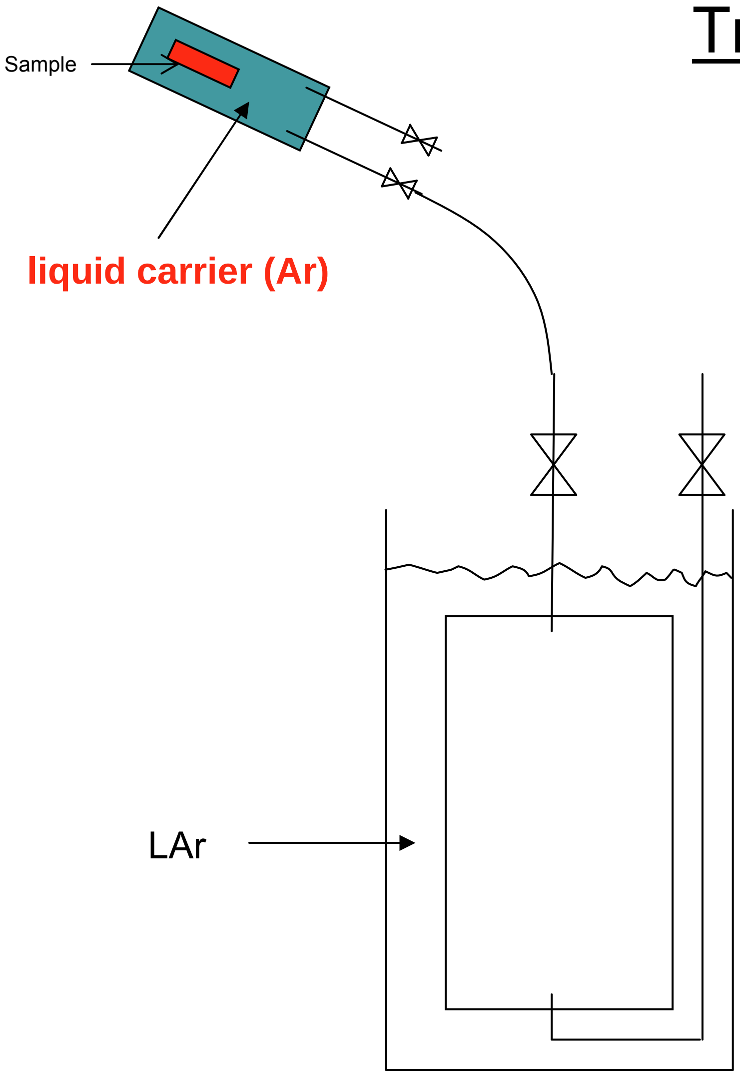
Outlook – LAr as carrier

Filling LArTrap with LAr

LAr storage tank @ MPIK

LArTrap immersed in LAr

Outlook – LAr as carrier



<u>Transferring LAr carrier</u>:

Separating mobile from immobile Radon atoms

-> “GERDA scenario” measurable!

Outlook – LAr as carrier

^{222}Rn emanation	gaseous carrier (He)		liquid carrier (Ar)
	room temperature	LAr temperature	LAr temperature
Al foil (2.2 m^2)	< 0.12 mBq	-	-
Welding rods (3pz)	(0.13 ± 0.01) mBq	-	-
Al foil + welding rods (5pz)	(0.14 ± 0.01) mBq	-	-
^{226}Ra (16mBq) sol. on stainless steel	(1.4 ± 0.2) mBq	< 0.014 mBq	-
Tungsten welding rods (4%Th)	(1.5 ± 0.2) mBq	< 0.040 mBq	**(1.2 ± 0.2) mBq**

still **VERY** preliminary!

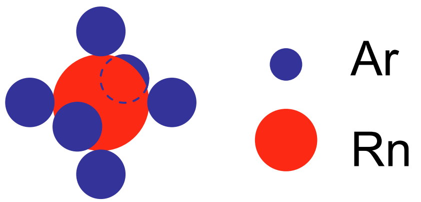
Outlook – LAr as carrier

<u>Interpretation</u>

- **Recoil driven emanation**
- **Rn atoms do not freeze out but stay in liquid because:**
  - **<u>Opt 1</u>**: Radon atoms collide too often with Ar

    -> Rn atoms do not come close enough to surfaces to freeze out (as it is the case for a gaseous carrier)
  - **<u>Opt 2</u>**: Ar atoms freeze on Rn -> Ar-Rn complex

    -> Ar-Rn complex is dissolved in LAr and does not freeze out on surfaces



Conclusions for cryostat

- Rn emanation above LAr → Rn freezes out on cold surface → no problem!(?)
- Rn emanation within LAr → Rn dissolves in LAr → LAr activity as predicted by “warm” measurements