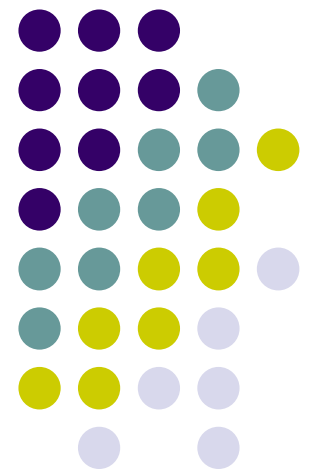


# Purity and purification of Ar with respect to $^{222}\text{Rn}$

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# Introduction



- 3 subprojects:

1: Measurement of  $^{222}\text{Rn}$  in commercial Ar

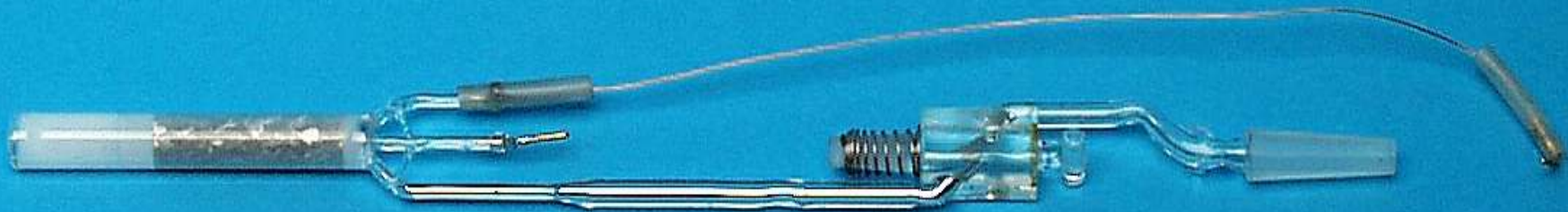
2: Search for clean storage tanks (no news)

3: Design, construction and test of a dedicated  $^{222}\text{Rn}$  purification column for LArGe (and for GERDA)

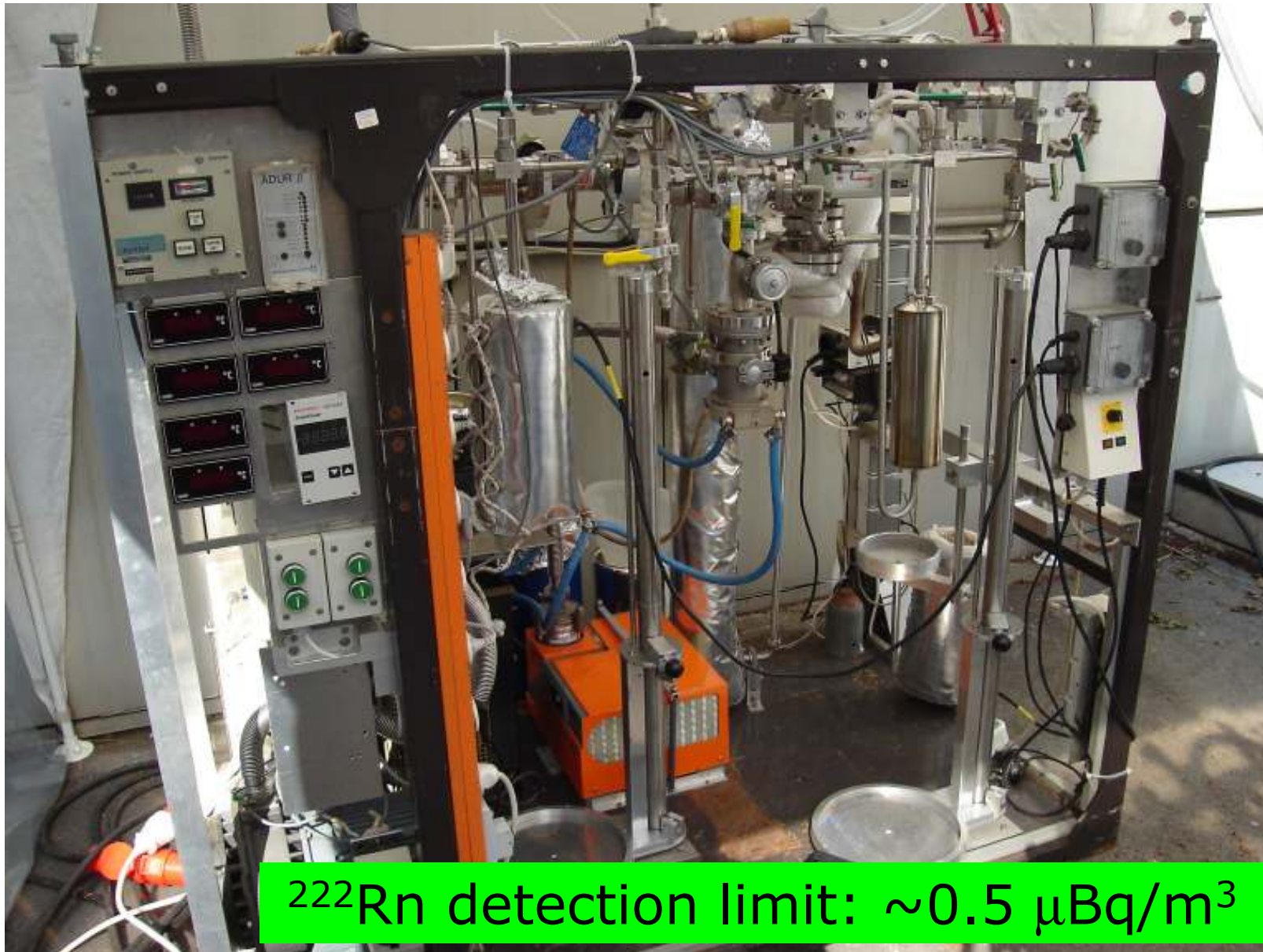
# Low-level proportional counter



Background for  $^{222}\text{Rn}$ :  $\sim 1$  count/day



# Mobile Radon Extraction Unit



$^{222}\text{Rn}$  detection limit:  $\sim 0.5 \mu\text{Bq}/\text{m}^3$

# Air separation plant



Boiling points

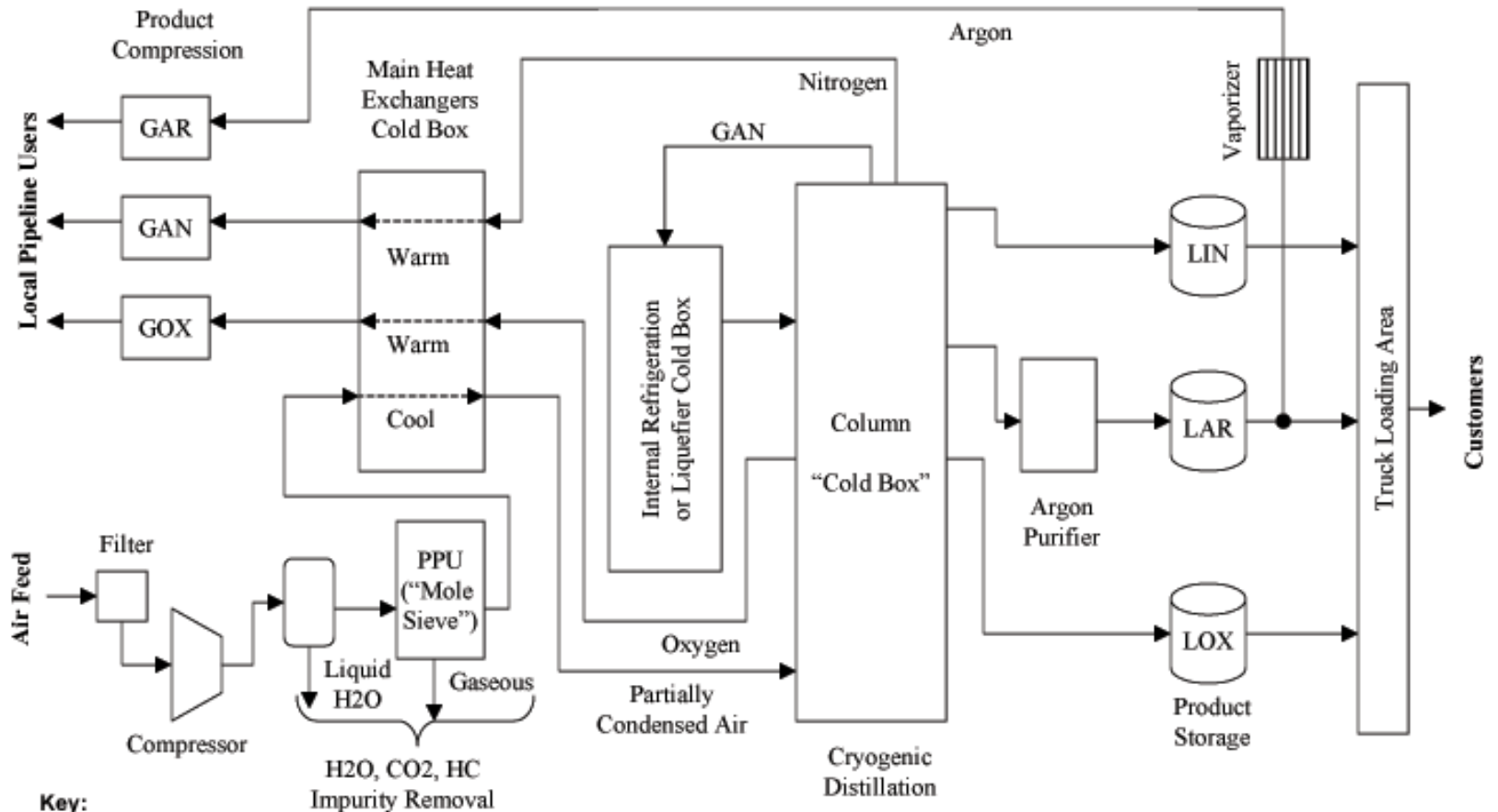


Rn

O<sub>2</sub>

Ar

N<sub>2</sub>



Key:

Gaseous	Product	Liquid
GAN	Nitrogen	LIN
GAR	Argon	LAR
GOX	Oxygen	LOX
CO <sub>2</sub>	Carbon Dioxide	-
H <sub>2</sub> O	Water	H <sub>2</sub> O
HC	Hydrocarbons	-

## Generic Air Separation Unit (ASU)

- Shows inter-relationship of major components
- Specific plants will vary

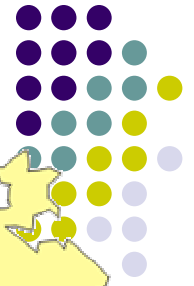
# Initial $^{222}\text{Rn}$ concentration in commercial argon



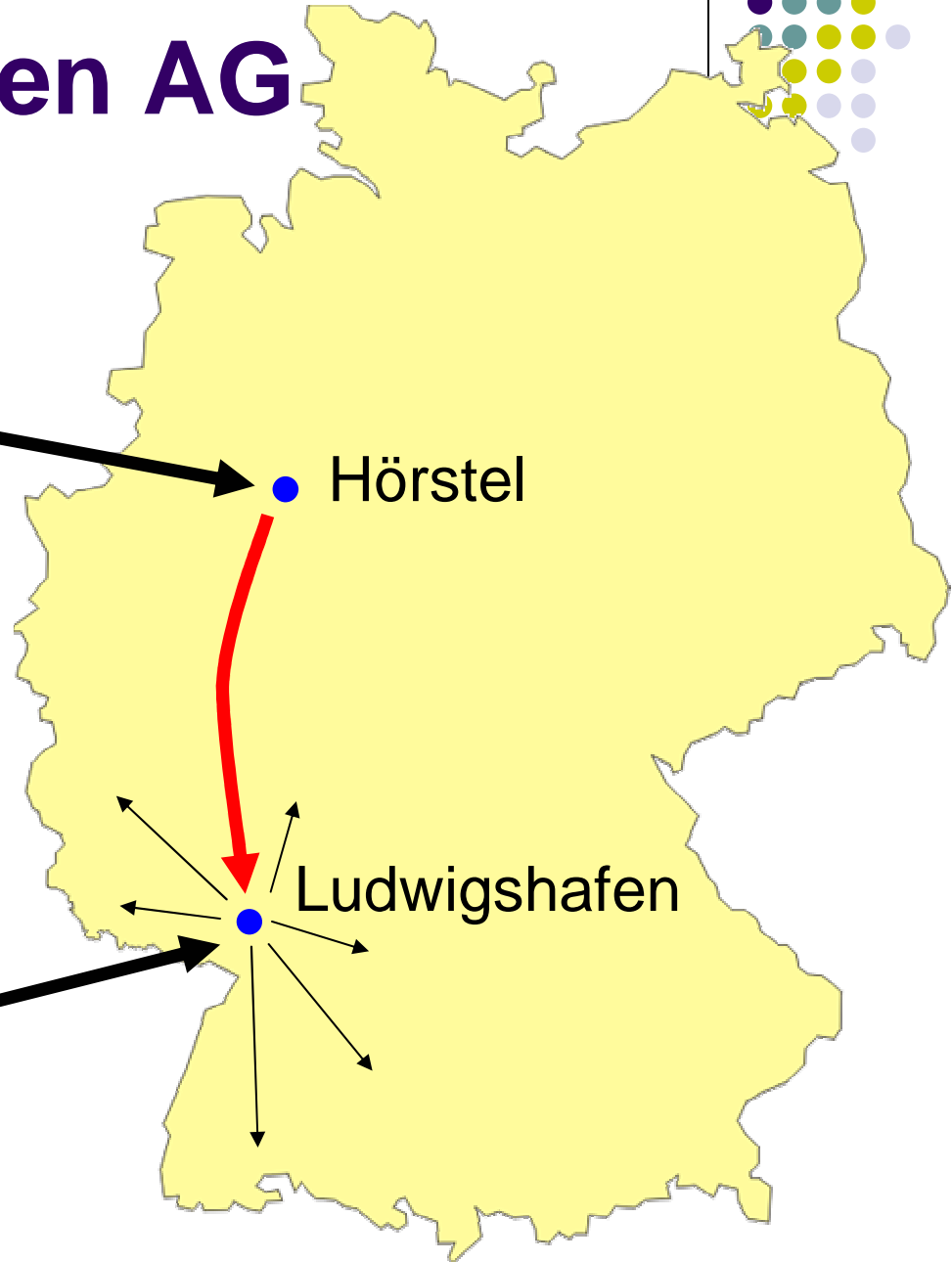
Company	Quality	$^{222}\text{Rn}$ [mBq/m <sup>3</sup> (STP)]
Air Liquide	Ar 4.8	0.3
LINDE AG	Ar 5.0	0.4
Westfalen AG	Ar 6.0	0.4
Westfalen AG	Ar 5.0	8.4
Westfalen AG	Ar 4.6	0.7
Westfalen AG	Ar 4.6	0.8
Westfalen AG	Ar 4.6	1.6
Westfalen AG	Ar 4.6	0.4
Westfalen AG	Ar 4.6	0.009



# Ar production and distribution: Example Westfalen AG



Air  
separation  
plant



Storage in  
Ludwigshafen:  
Distribution center for  
south-west Germany

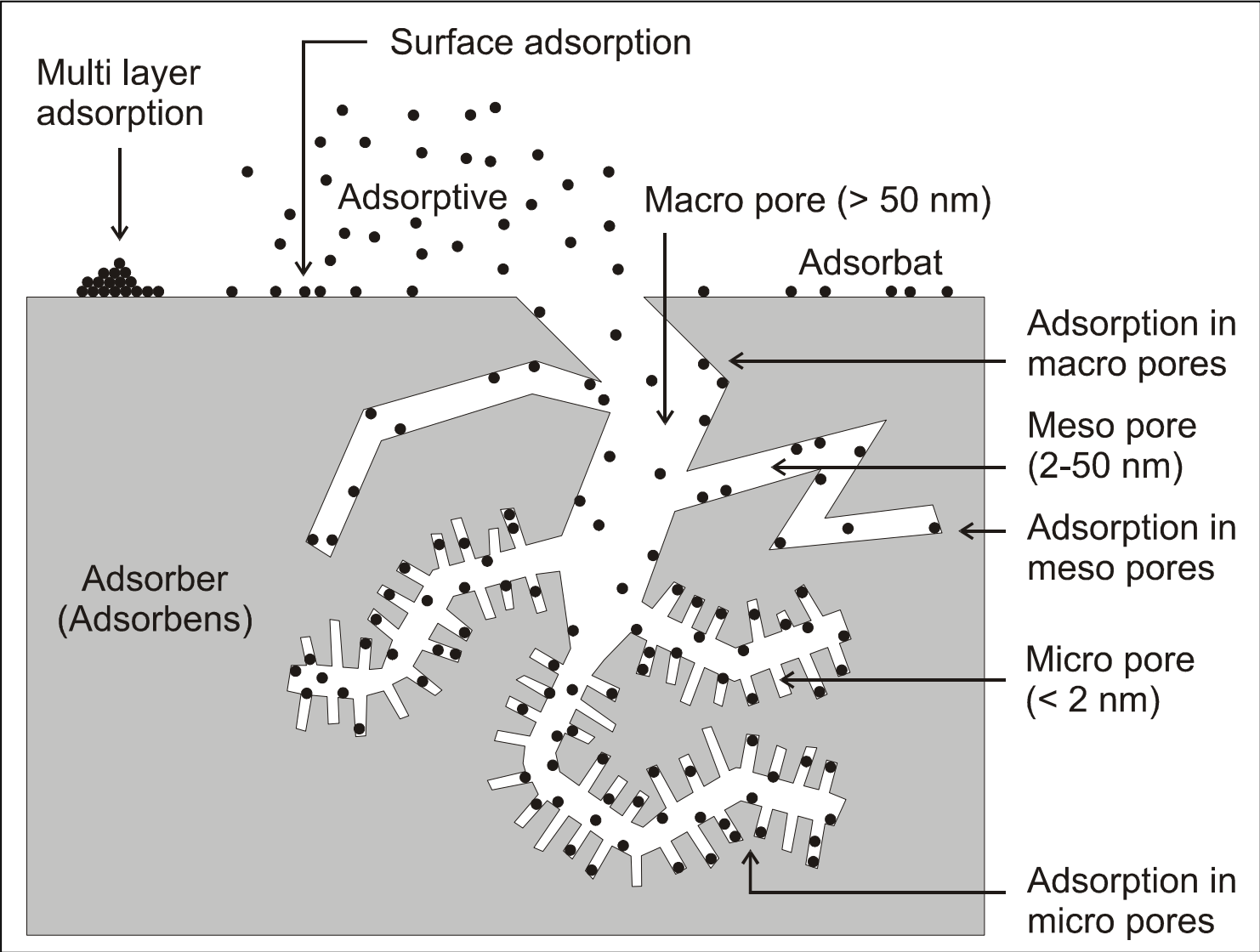
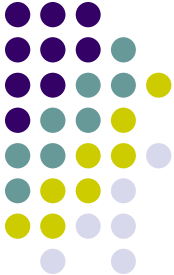
# $^{222}\text{Rn}$ emanation of storage tanks for cryogenic liquids



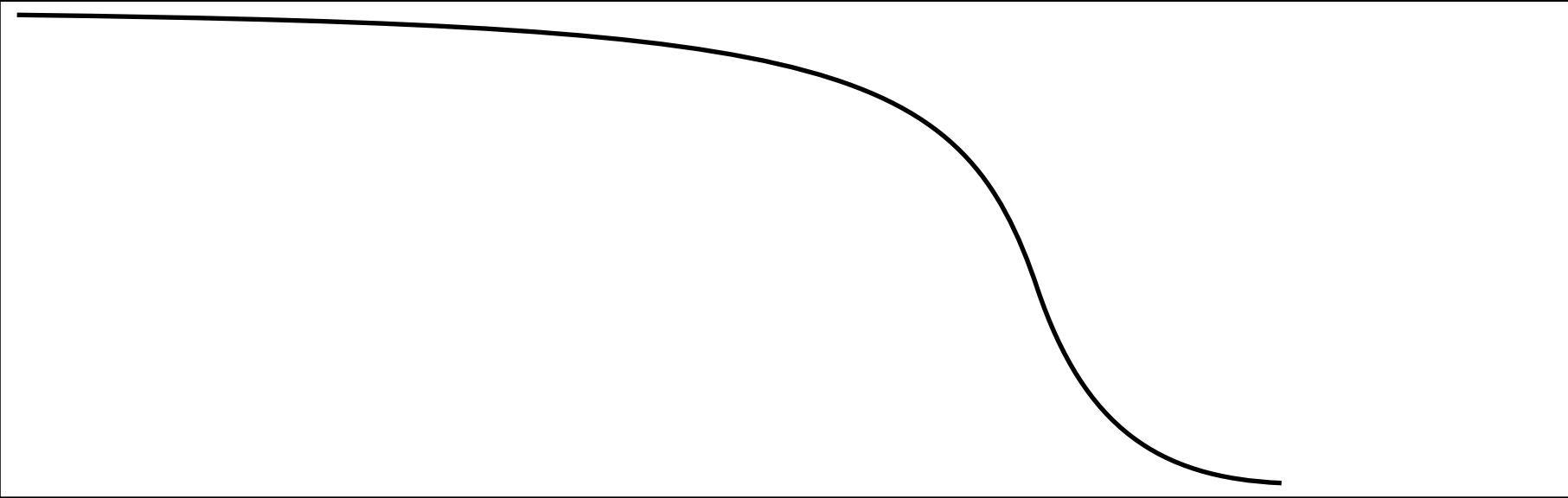
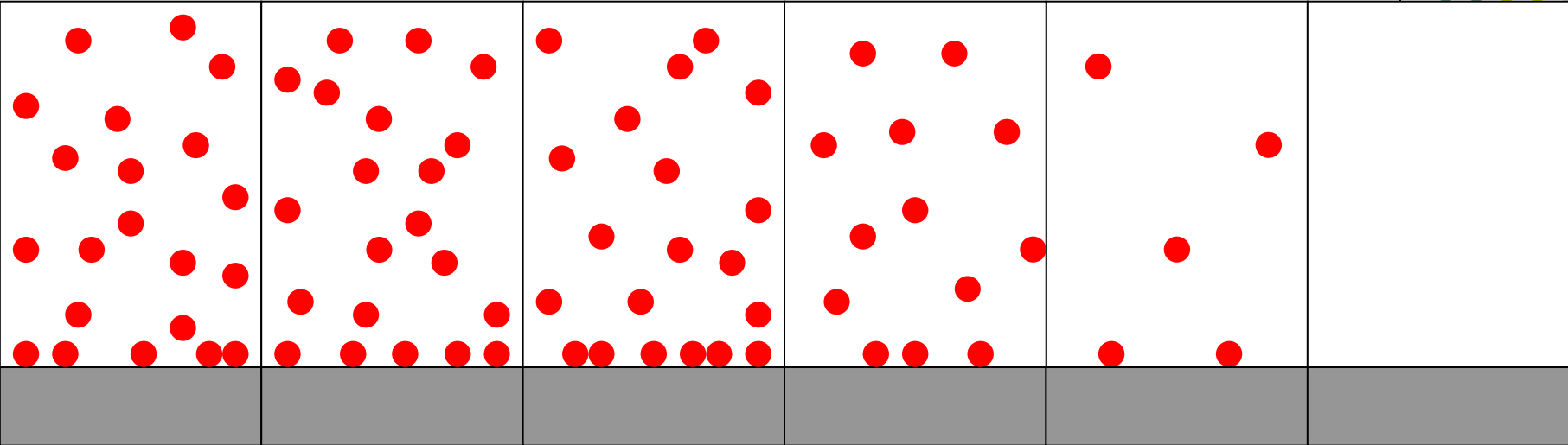
Tank from	Quality of stored gas	Vol. [m <sup>3</sup> ]	$^{222}\text{Rn}$ activity in saturation [mBq]	specific $^{222}\text{Rn}$ act. [mBq/m <sup>3</sup> ]
Westfalen AG	technical	3	177 +- 6	59 +- 2
Westfalen AG	6.0	0.67	42 +- 2	63 +- 3
SOL	6.0	16	65 +- 6	4.1 +- 0.4
LINDE	7.0	3	2.7 +- 0.3	0.9 +- 0.1
Air Liquide	technical	0.67	1.8 +- 0.4	2.7 +- 0.6
<b>LINDE</b>	<b>technical</b>	<b>6.3</b>	<b>3.5 +- 0.2</b>	<b>0.56 +- 0.03</b>



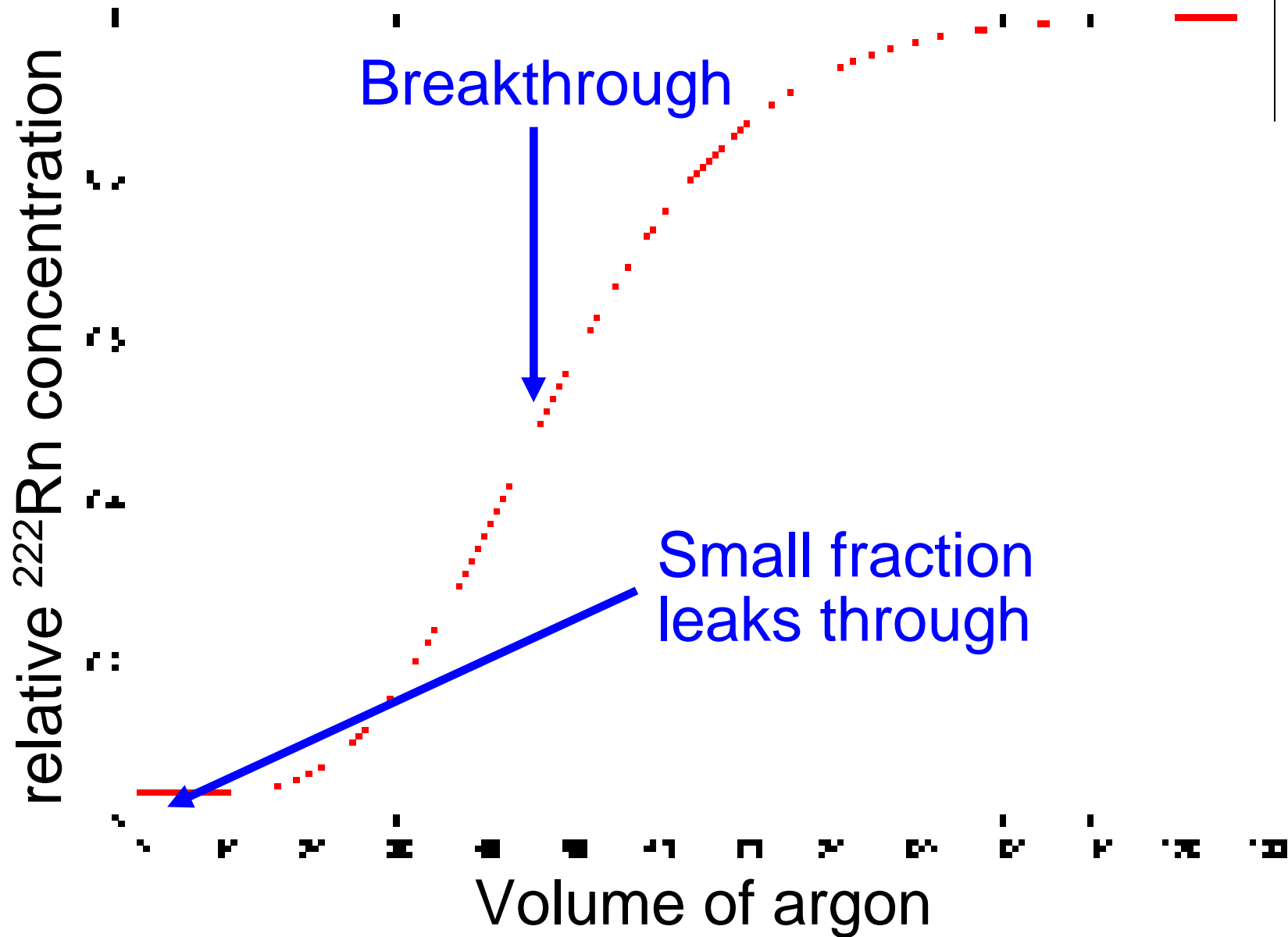
# Adsorption in pores



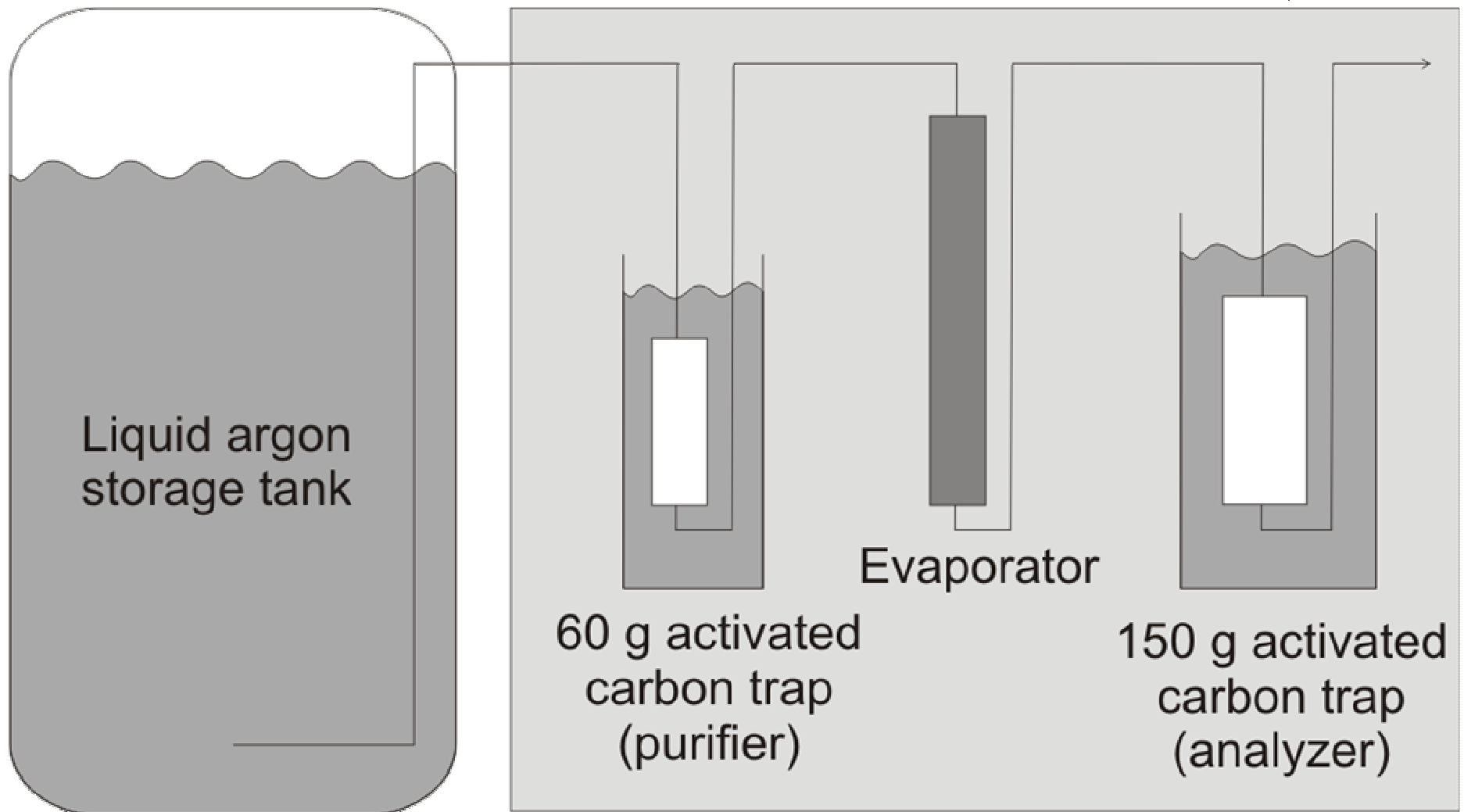
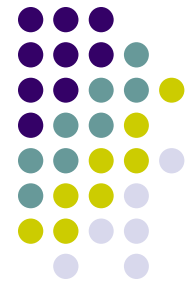
# Column purification



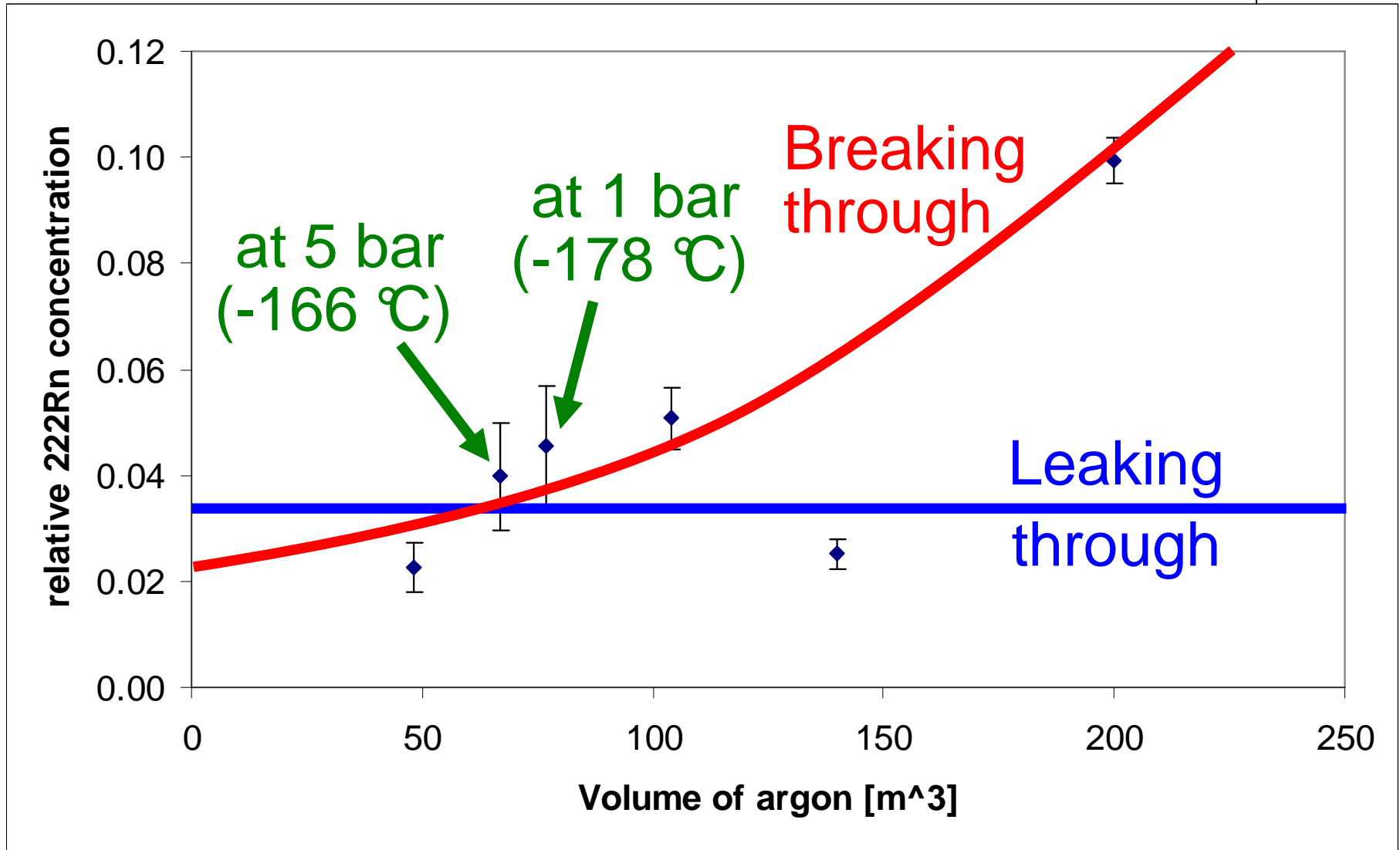
# Expected breakthrough curve



# Experimental setup for liquid phase adsorption tests



# Results for liquid phase adsorption (60 g carbon trap)

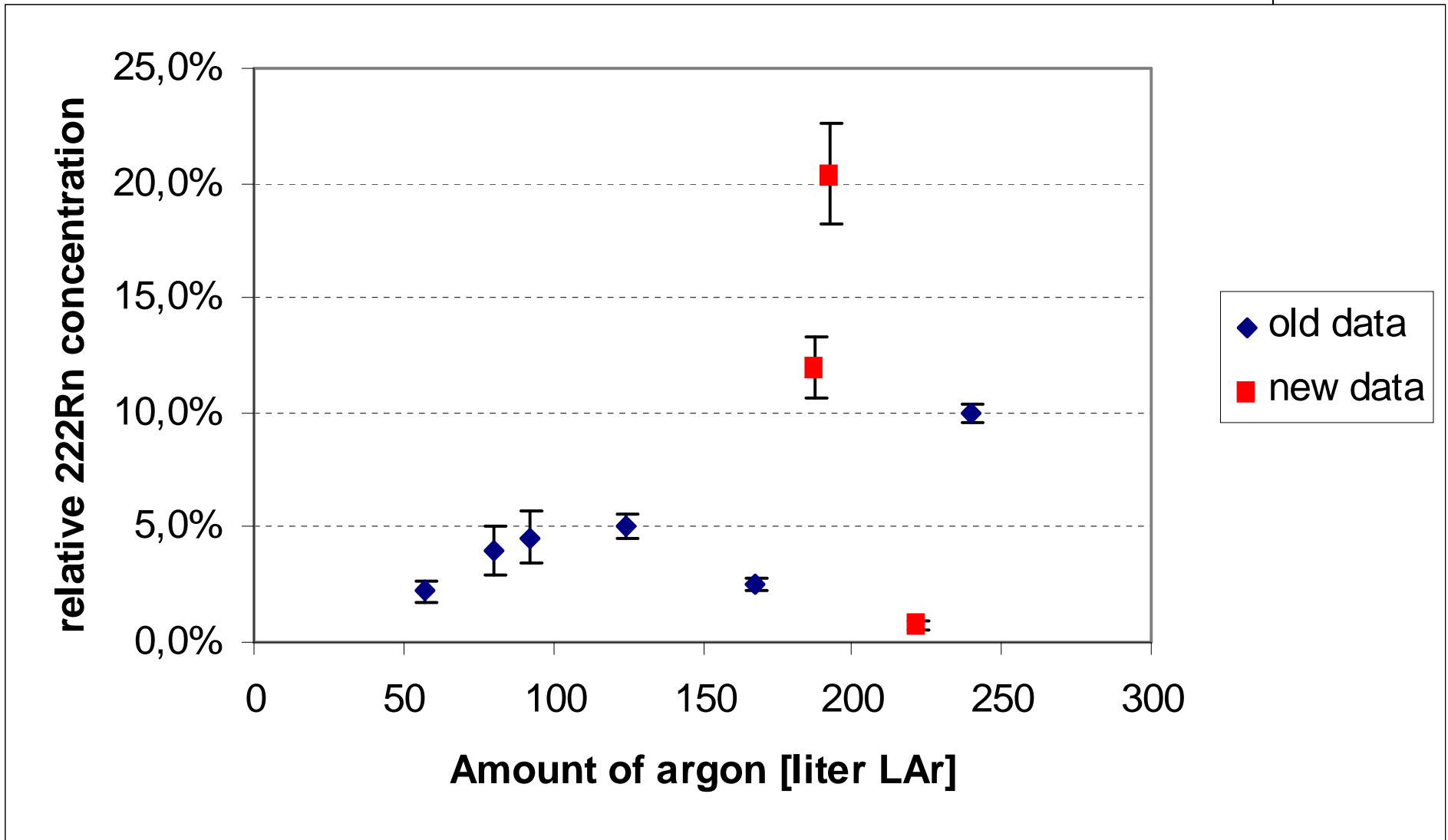


# Results for liquid phase adsorption (60 g carbon trap)



Date	Volume [liter LAr]	$A_{Rn}$ in purifier	$A_{Rn}$ in analyzer	Red. fact.	Leaking fract. 1/R [%]
24.4.07	58	6.9 mBq	0.2 mBq	44	$2.2 \pm 0.5$
4.6.07	80	3.3 mBq	0.1 mBq	25	$4.0 \pm 1.0$
6.6.07	92	4.3 mBq	0.2 mBq	22	$4.6 \pm 1.1$
13.6.05	125	11 mBq	0.6 mBq	20	$5.1 \pm 0.6$
19.4.07	168	28 mBq	0.7 mBq	40	$2.5 \pm 0.3$
26.7.07	188	13 mBq	42 mBq	8	$12 \pm 2$
9.8.07	193	120 mBq	30 mBq	5	$20 \pm 2$
18.7.07	222	60 mBq	0.5 mBq	135	$0.7 \pm 0.2$
8.6.05	240	1100 mBq	120 mBq	10	$9.9 \pm 0.4$

# Results for liquid phase adsorption (60 g carbon trap)





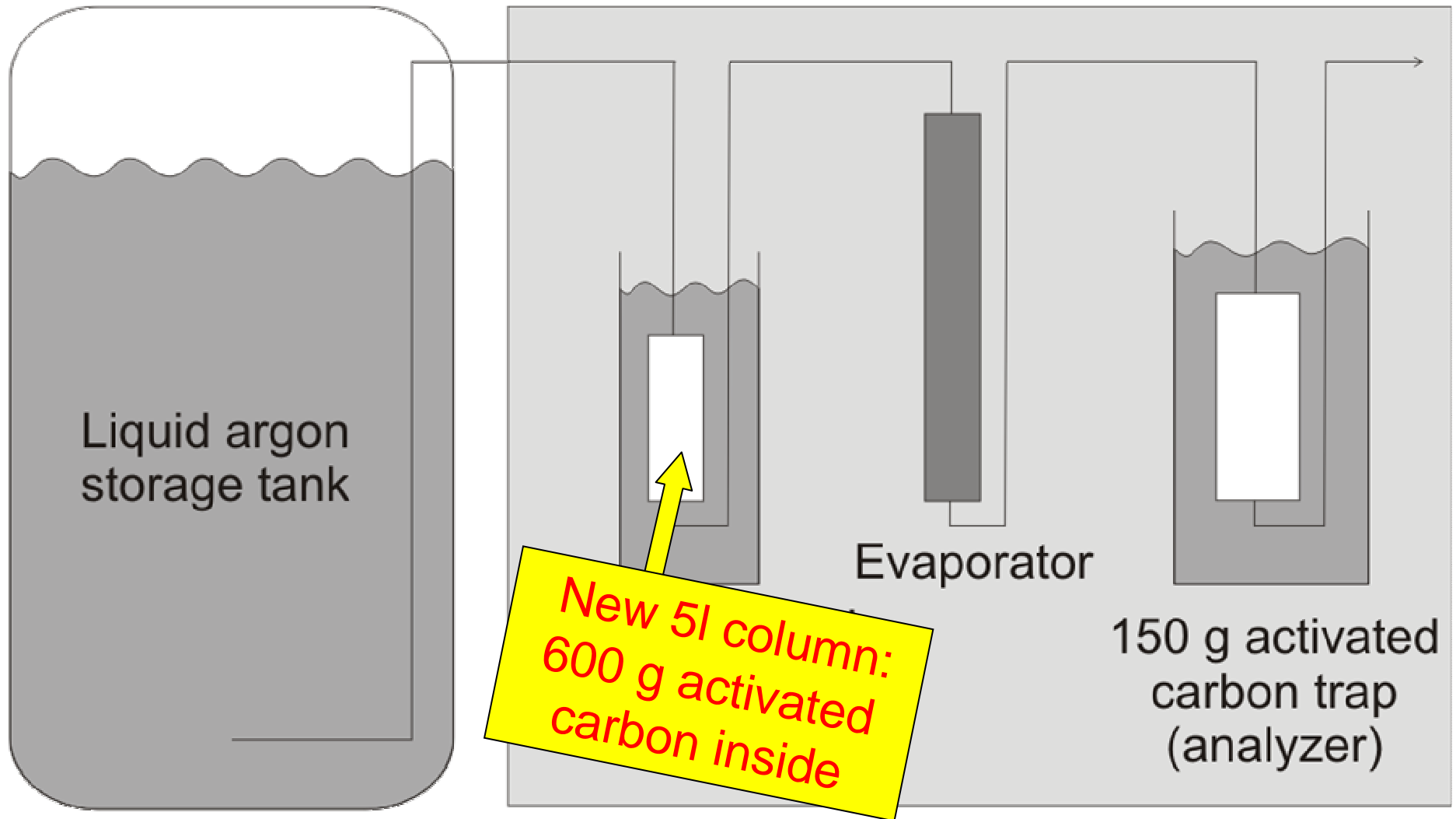
# Results for liquid phase adsorption (60 g carbon trap)



- Overall picture is unclear
- 60g trap is too small for these tests
- No clear indication of breakthrough
- Some hints of “leaking through”
  - Same reduction for different temperature
- If breakthrough, it happens at ~175 liters LAr

⇒ 10x bigger column should be able to purify  $>1 \text{ m}^3$  of LAr

# Experimental setup for liquid phase adsorption tests



# New 5l column

- Filled with 600 g activated carbon
- To be used for Ar purification for filling of LArGe
- Minor modifications required

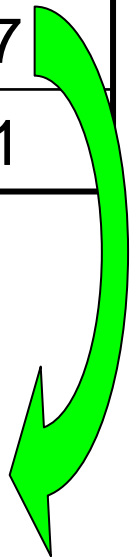


# Results for liquid phase adsorption (600 g carbon trap)

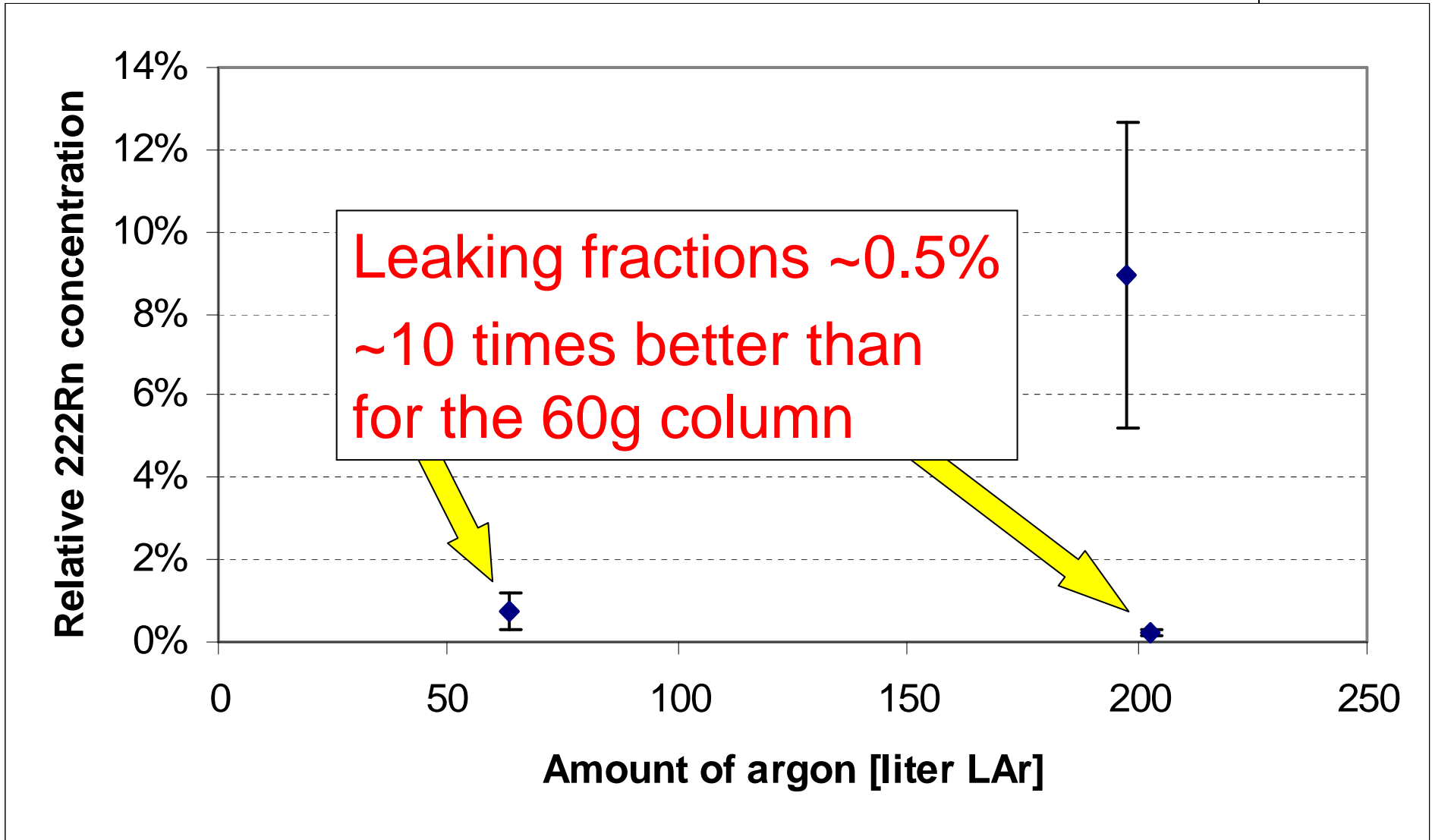


Date	Volume [lit. LAr]	$A_{Rn}$ in purifier	$A_{Rn}$ in analyzer	Red. fact.	Leaking fract. 1/R [%]
11.10.07	64	10.3 mBq	0.1 mBq	130	$0.8 \pm 0.5$
31.10.07	198	1.1 mBq	0.1 mBq	11	$9.0 \pm 3.7$
16.10.07	203	65.7 mBq	0.1 mBq	490	$0.2 \pm 0.1$

Only statistical errors. Large systematic uncertainty, because of very low activity  $\Rightarrow$  Unknown blank contributions have strong impact!



# Results for liquid phase adsorption (600 g carbon trap)





# Conclusions

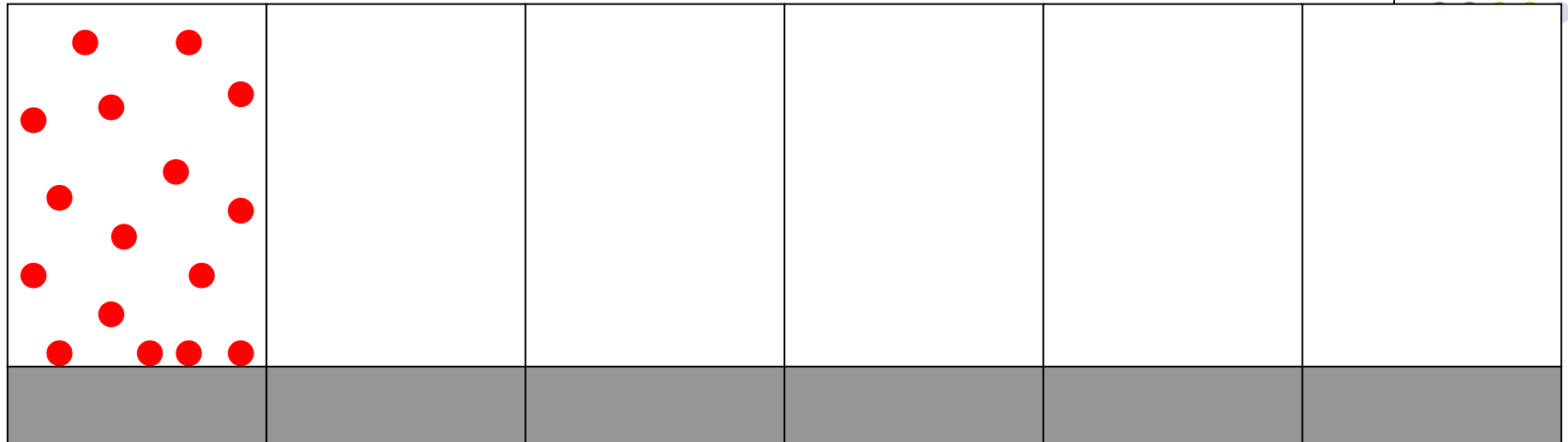
- $^{222}\text{Rn}$  concentration in LAr depends very much on delivery chain
  - Intermediate storage or direct delivery?
- Large differences in tank purities
  - Pure 6 m<sup>3</sup>-tank identified (WARP tank)
- 60g carbon column able to
  - reduce  $^{222}\text{Rn}$  by factor  $\geq 20$
  - purify ~170 liters of LAr
- 600g carbon column (for LArGe) able to
  - reduce  $^{222}\text{Rn}$  by factor ~200

# Extra slides

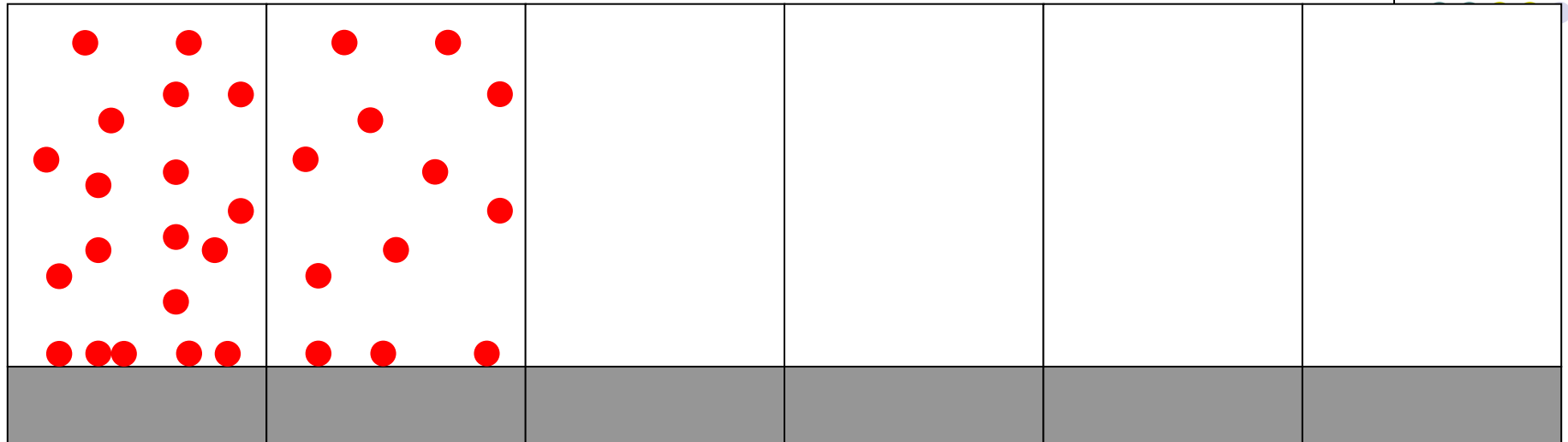




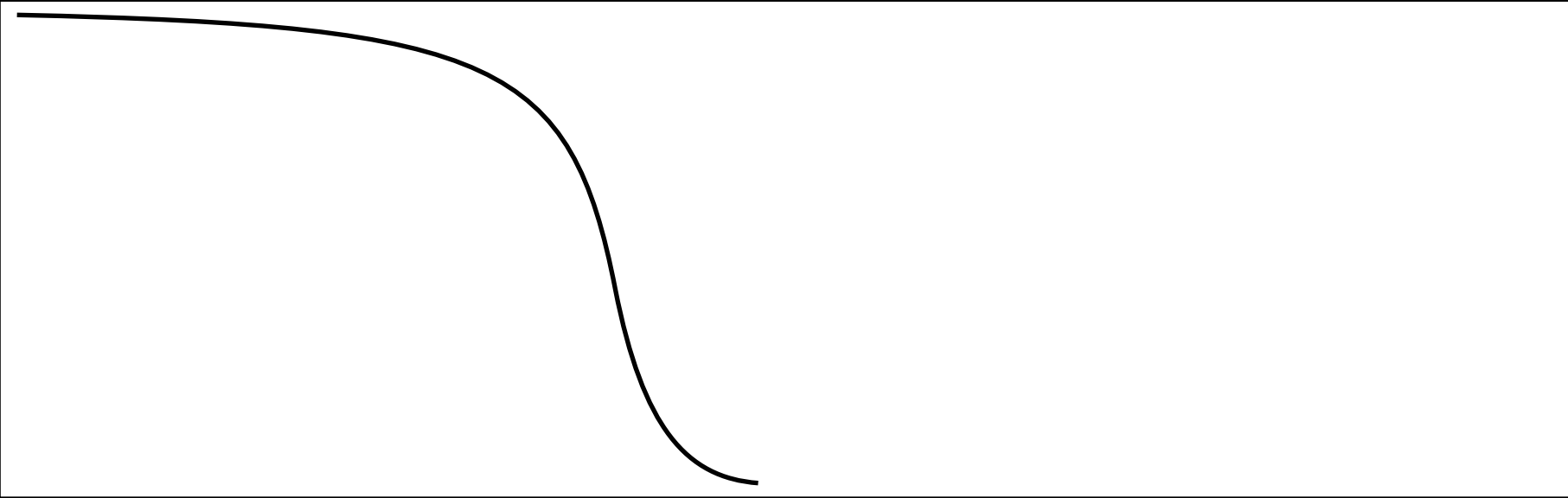
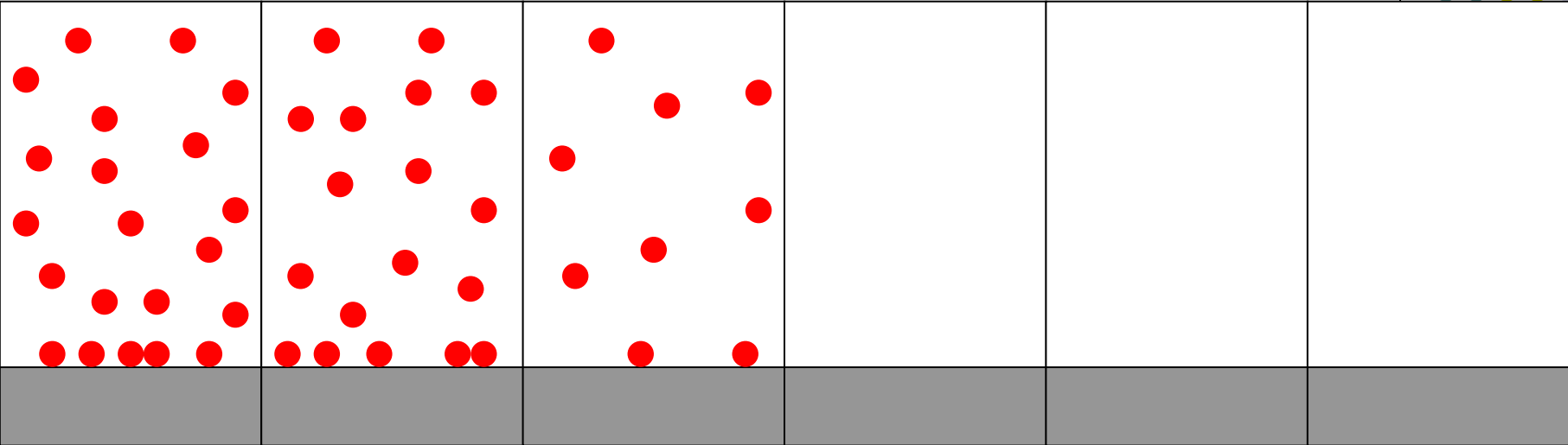
# Column purification



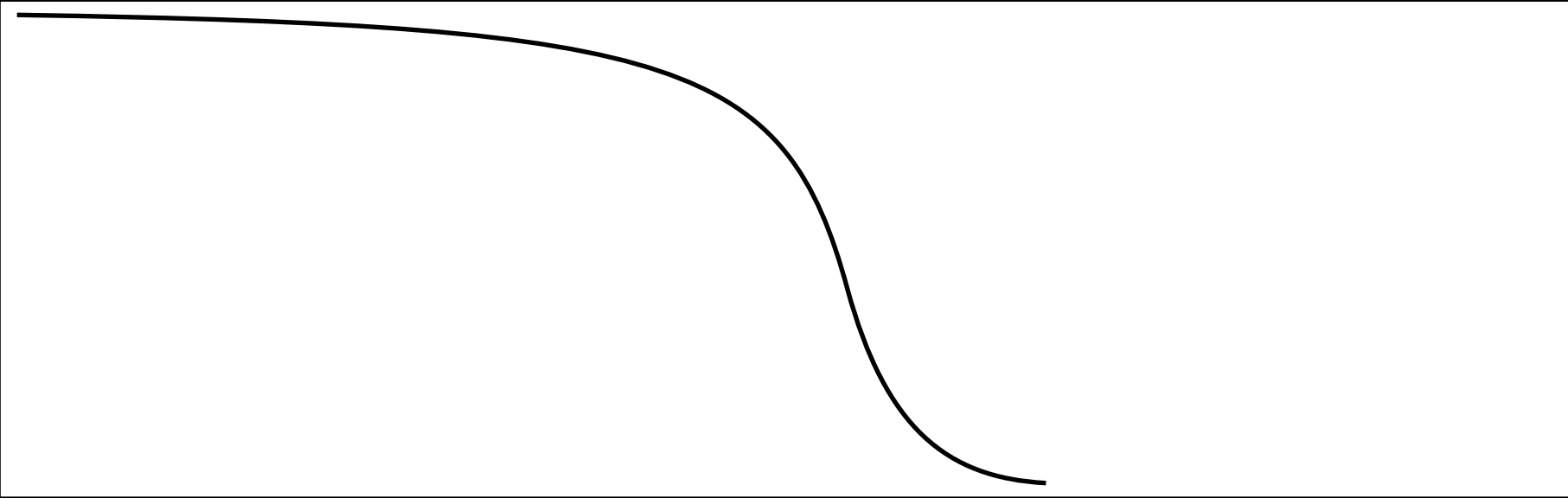
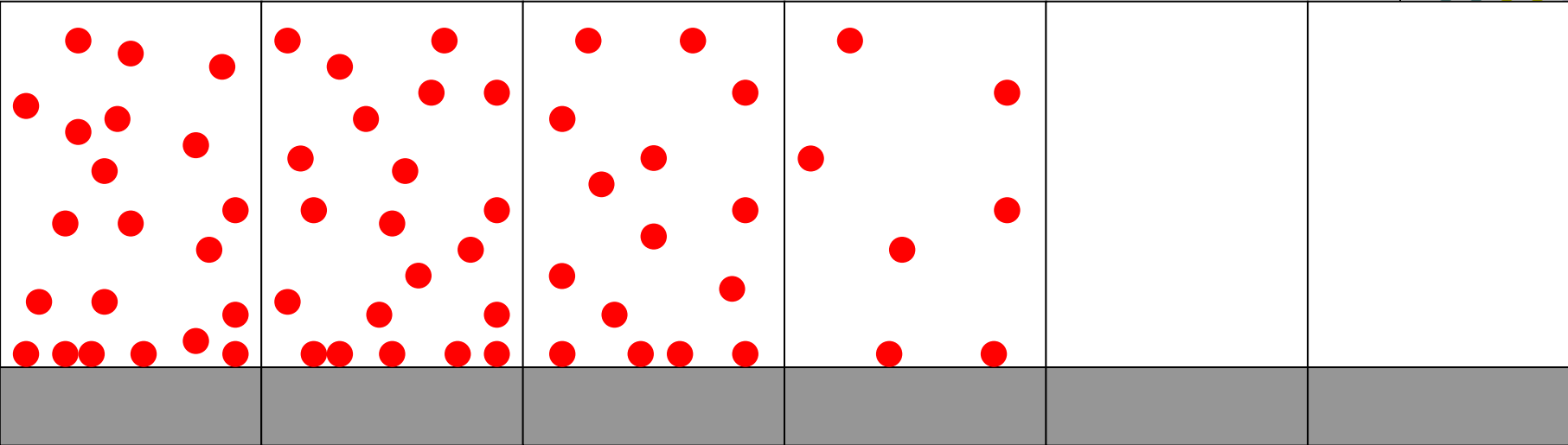
# Column purification



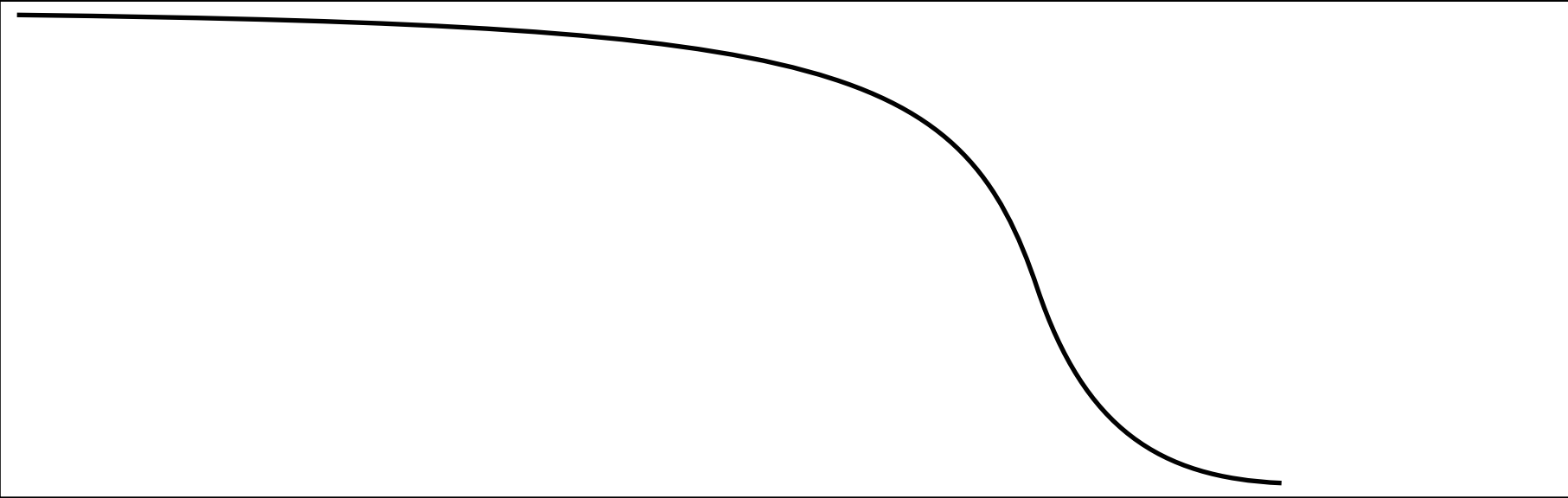
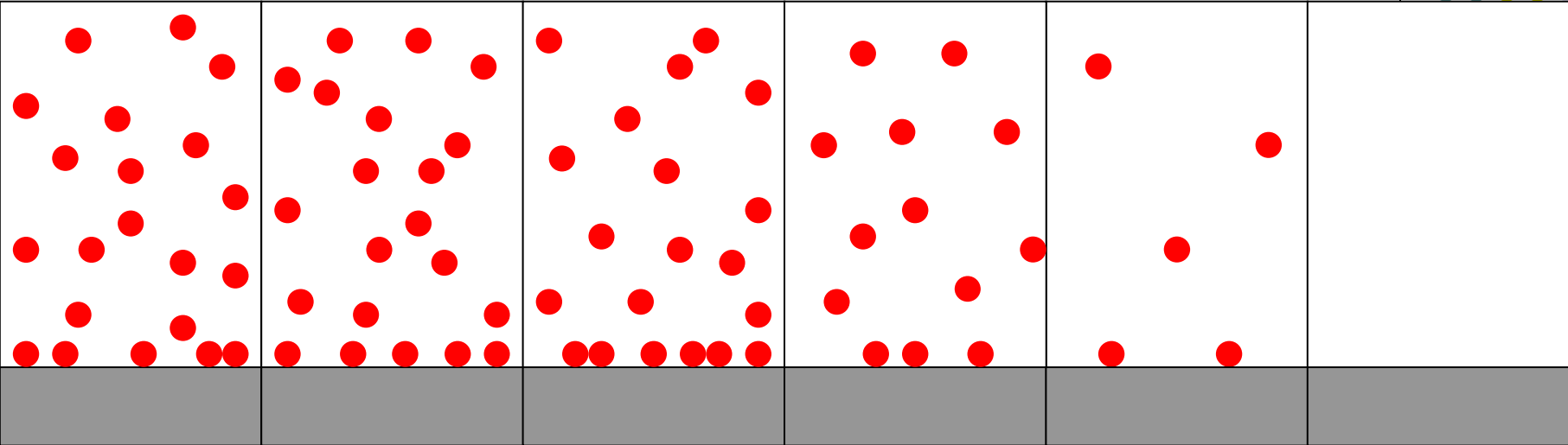
# Column purification



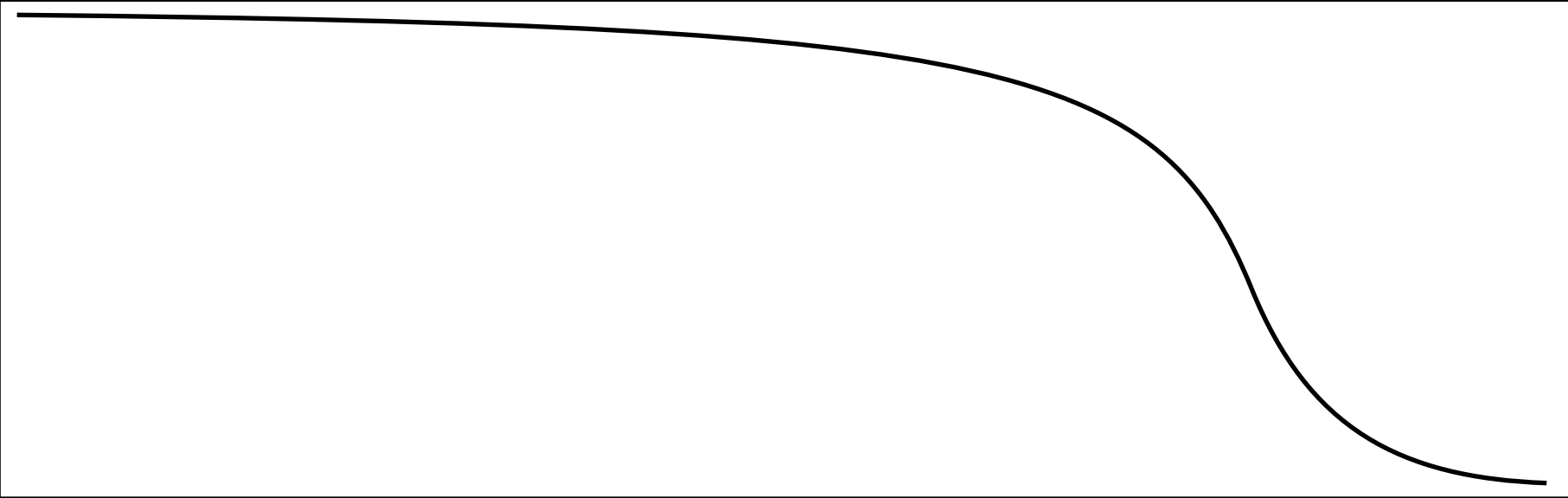
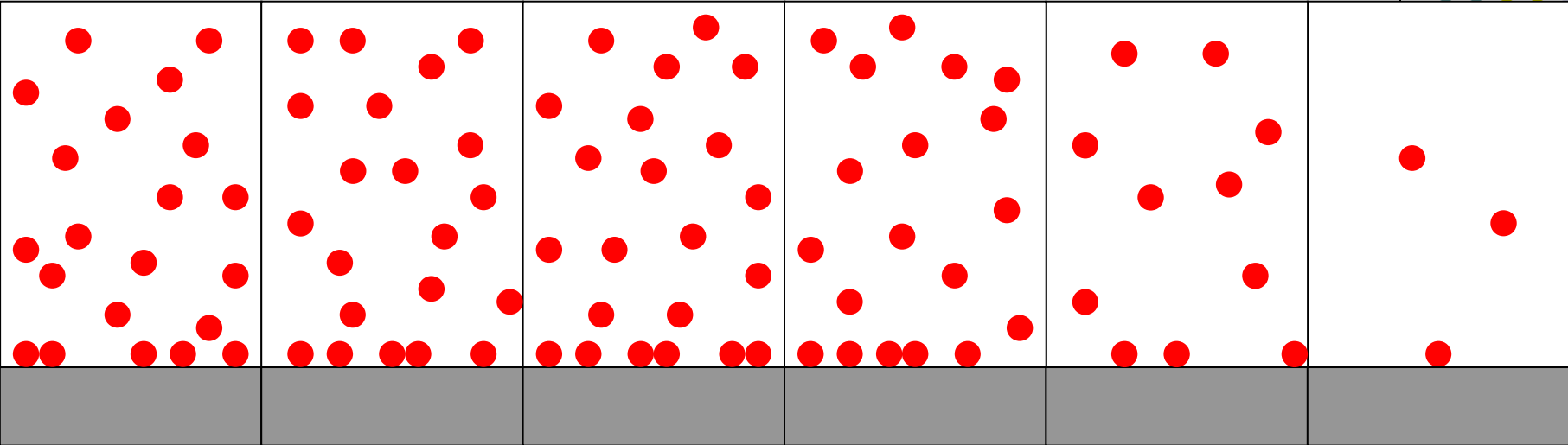
# Column purification



# Column purification



# Column purification



# Results for gas phase adsorption (150 g carbon trap)



Date	Volume [m <sup>3</sup> ]	Initial conc. [mBq/m <sup>3</sup> ]	Final conc. [μBq/m <sup>3</sup> ]	Reduction factor [1/kg]
4.11.04	141	0.20	<0.5	>2700
12.4.07	80	0.27	0.7	2600

**<sup>222</sup>Rn removal in gas phase is very efficient**