UNIVERSITY OF ALBERTA

June 12th 2019
Collaboration meeting, Grenoble

Gas Purification: Requirements, Status & prospects

NewS-G

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Goals in terms of background

- Crucial to be able to identify the contaminants
  - Traces Uranium, Thorium, Oxygen, H_2O, Radon, Krypton etc.

- Oxygen, H_2O, electronegative impurities
  - Well removed by hot getter included in the loop system
  - But radon rate increased: emanates from the getter!

- Radon …
  - ~ 50mBq in the sphere at Queen's S30
  - Level required for Ne mixture from simulations $< 48\ \mu$Bq

- Status and Next …
  - At LSM for the first commissioning and data taking
  - New horizon

Acceptable level of radon

- Estimated by simulations: (credits Alexis)
  - 10^4 decays of ^{222}Rn homogeneously distributed in volume
  - 10^4 decay of ^{218}Po /^{214}Pb on the inner surface

- Results in dru/Bq…

	He mixture	Ne mixture
^{218}Po	2411	612
^{214}Pb	663	227
^{214}Bi + ^{214}Po	987	210
Total	4061	1050
To obtain 0.05 dru < 1keV	< 12μBq	< 48μBq

Radon mitigation: Strategies

- Radon trap
  - Feasible but CH_4 is also absorbed
  - Tests need to be done to find the optimal conditions of the column (Temperature, Flow) to remove the radon only.
    --> In progress led by José in Marseille with MCP.

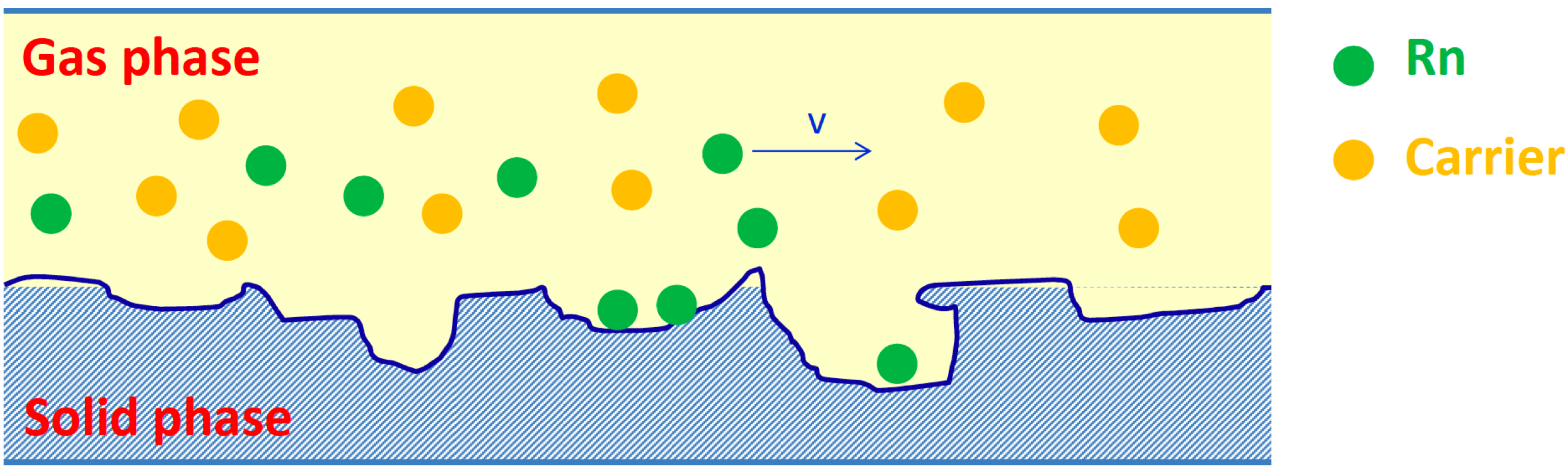
- Queen's tests and plan with S30
  - Run plan already in place in order to control the CH_4 amount.
  - Procedure in place for running with the trap.

- Material for trapping
  - Carboxen 564: Material also with the lowest radioactivity
  - Alternative Carboxen 1000

Radon Capture

- Radon is a noble gas
  - No chemical bond
  - Only adhesion on surface by weak Van Der Waals force

- Radon transport



Credit: José Busto

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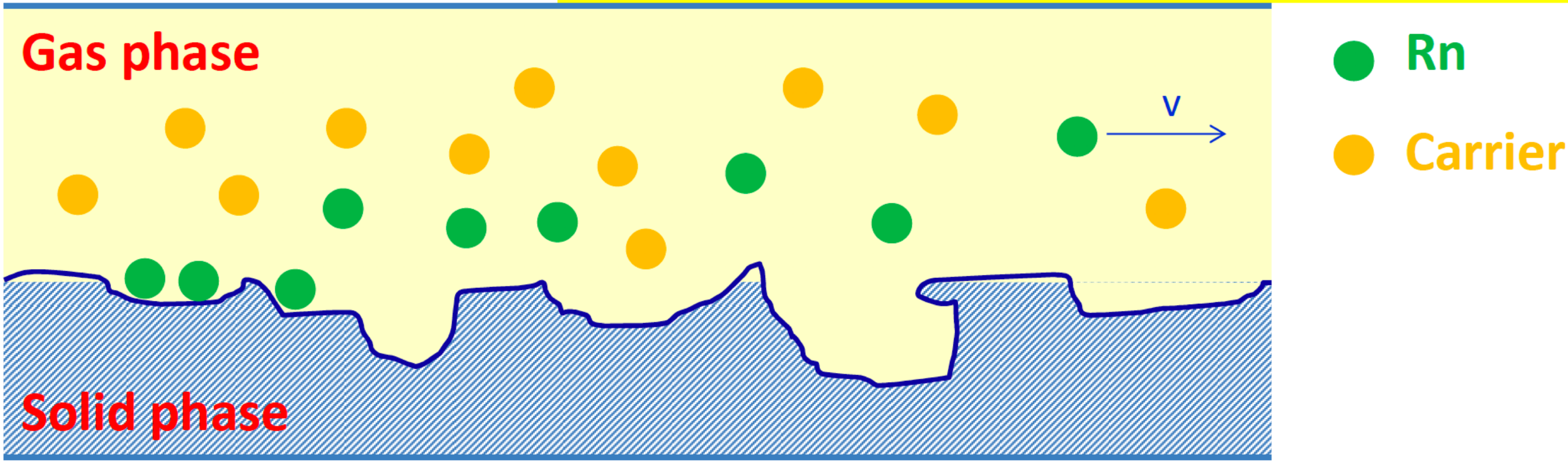
The movement of Radon is delayed



Credit: José Busto

Radon Capture

- Radon is a noble gas
  - No chemical bond
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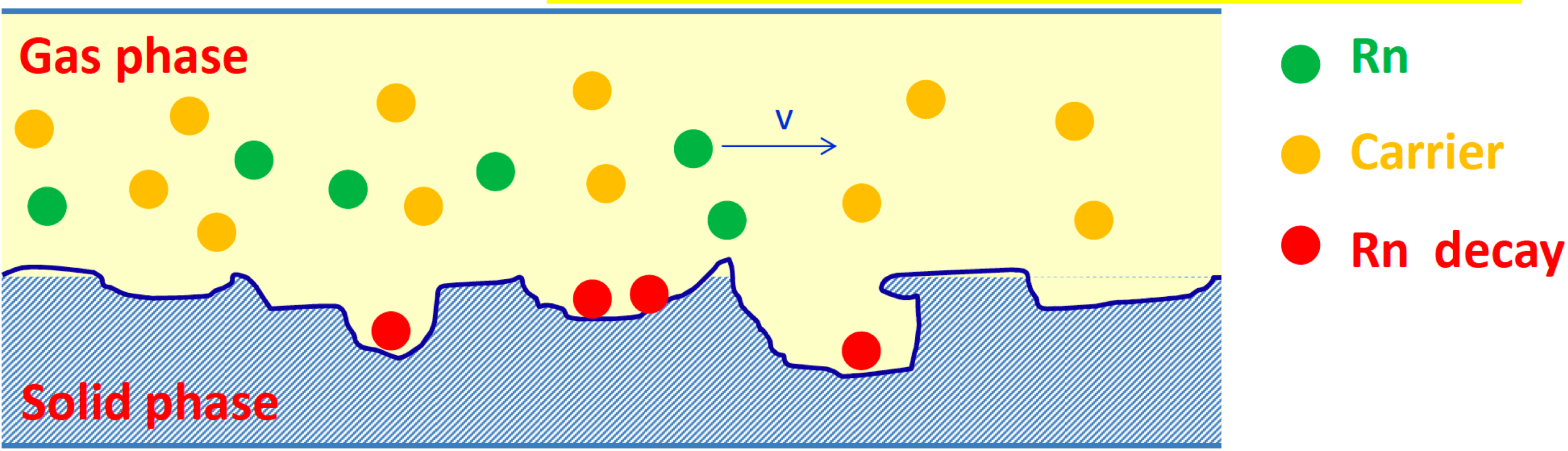
- Radon transport

The movement of Radon is delayed unless Rn decays in the filter



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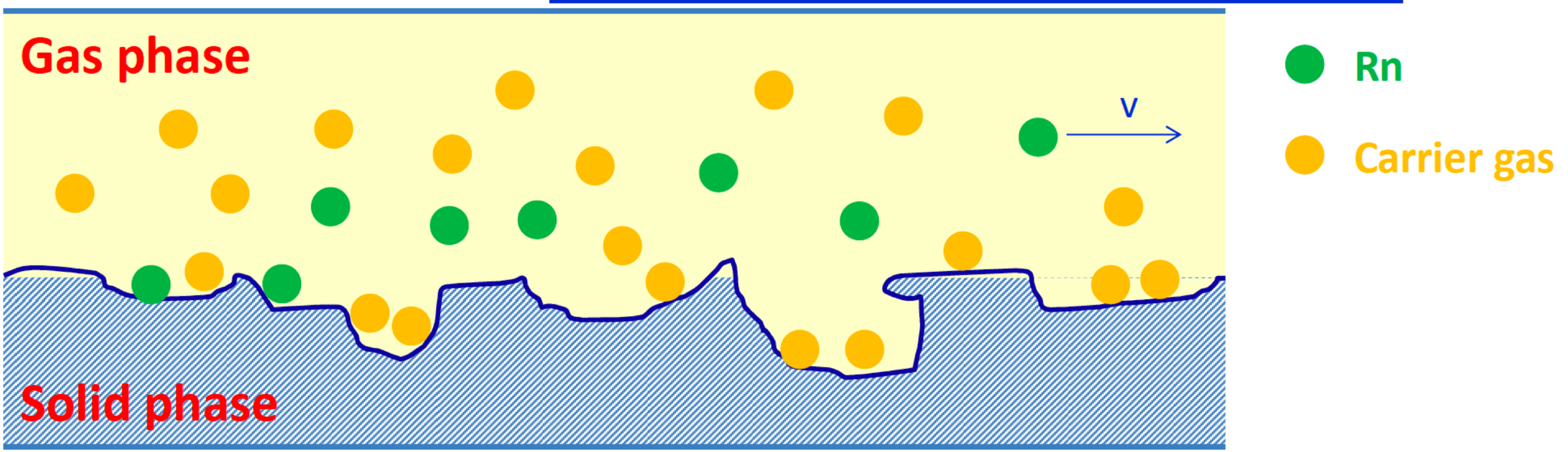
Capture competition between carrier gas and Rn



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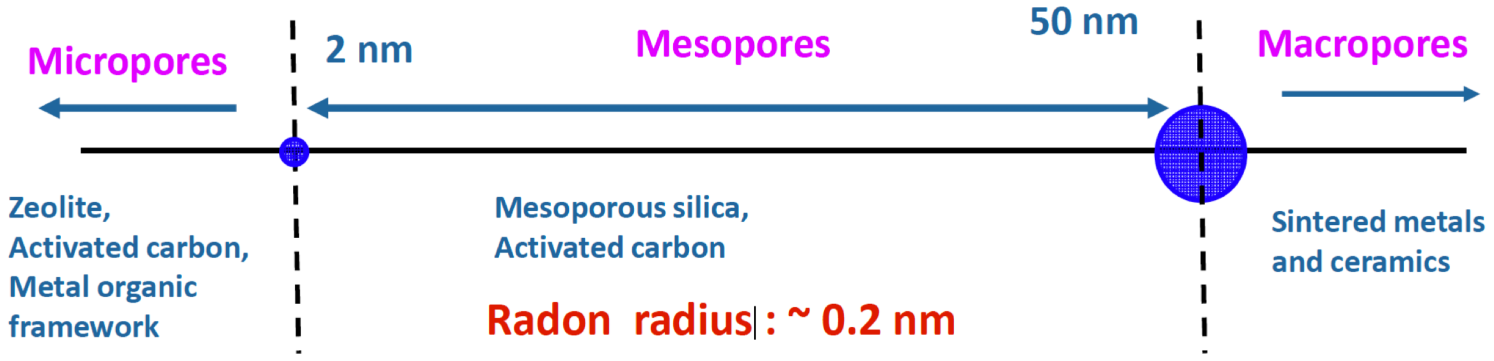
Radon Capture

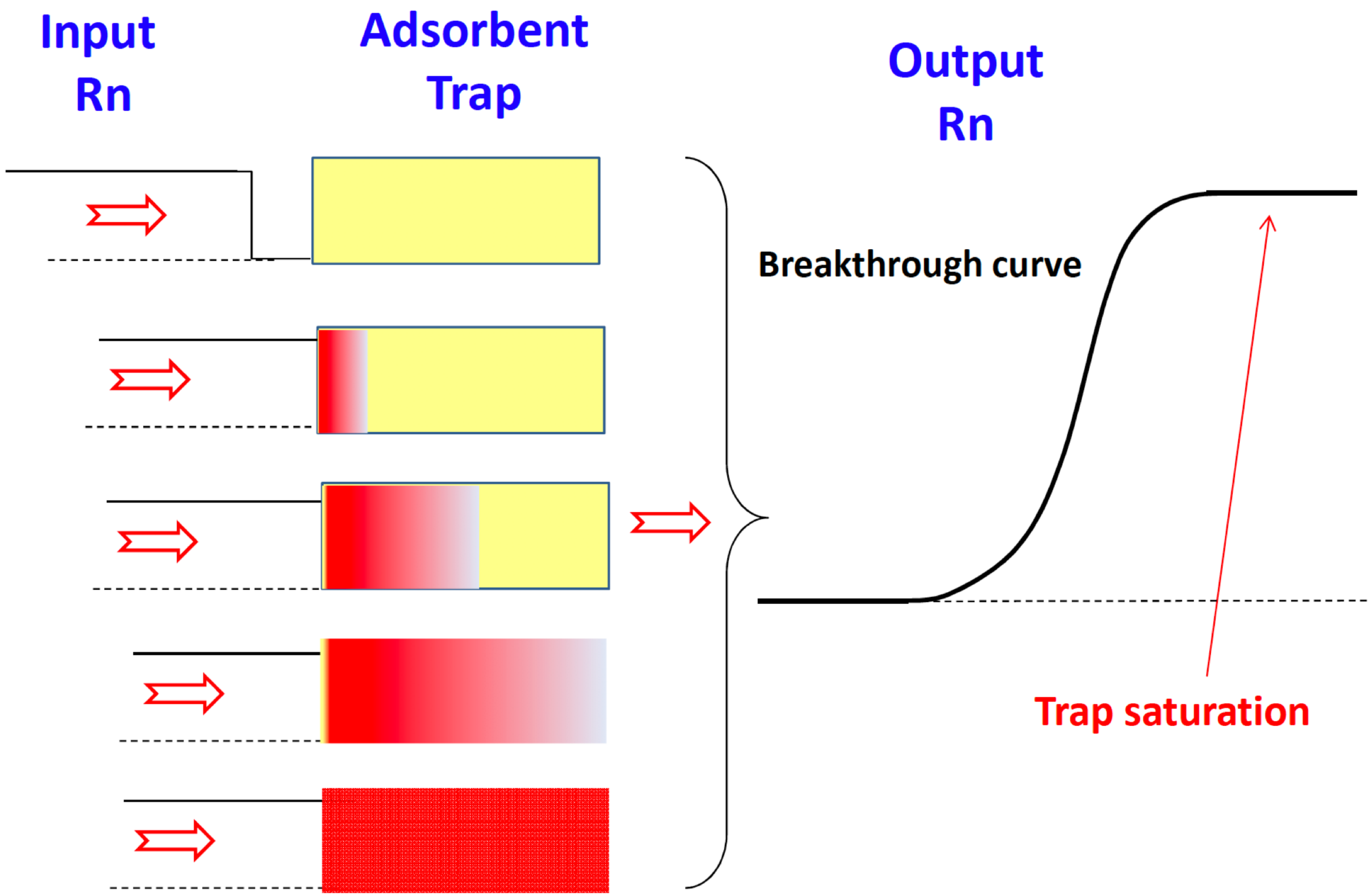
- High surface area
  - Porous materials needed

- Three parameters used to estimate the porosity
  - Specific surface area, ▸ Specific pore volume
  - Pore size, shape and distribution



- **Temperature dependence (thermal agitation)**
- **Carrier gas dependence**

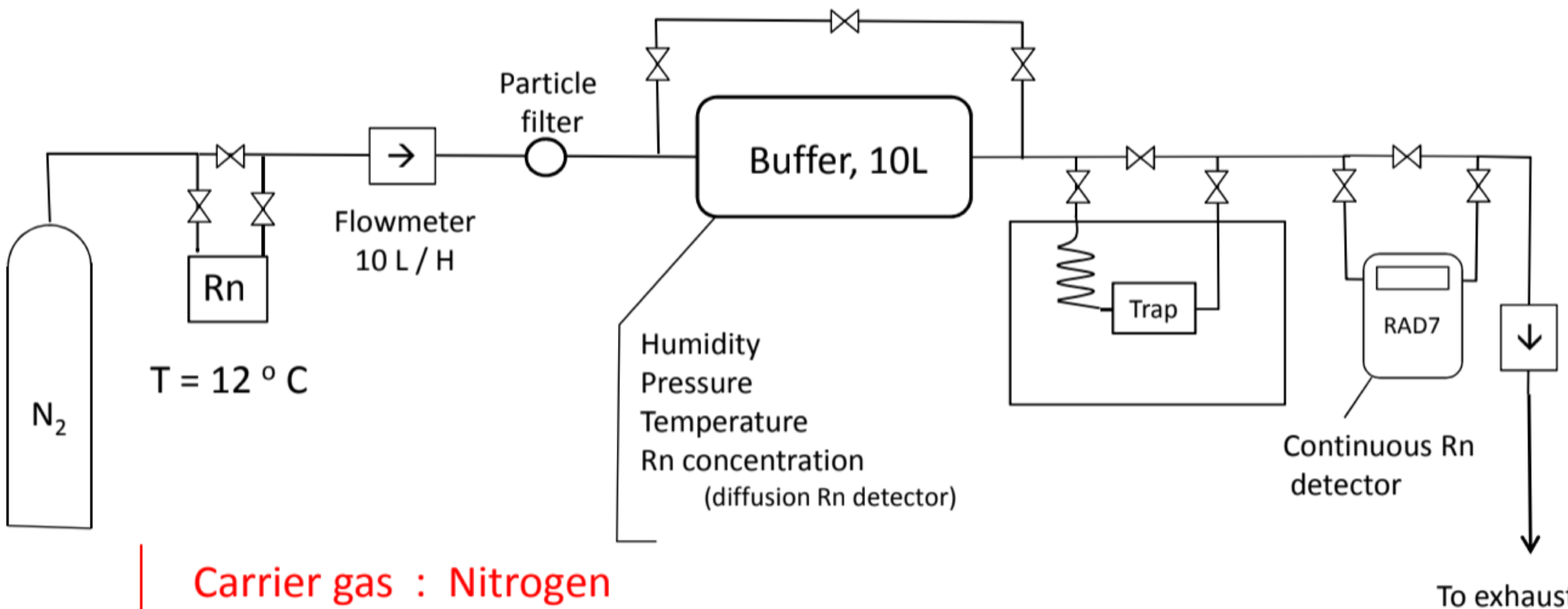
Procedure in place



Future test at Marseille

Radon trap setup in Marseille

Dynamic Rn adsorption

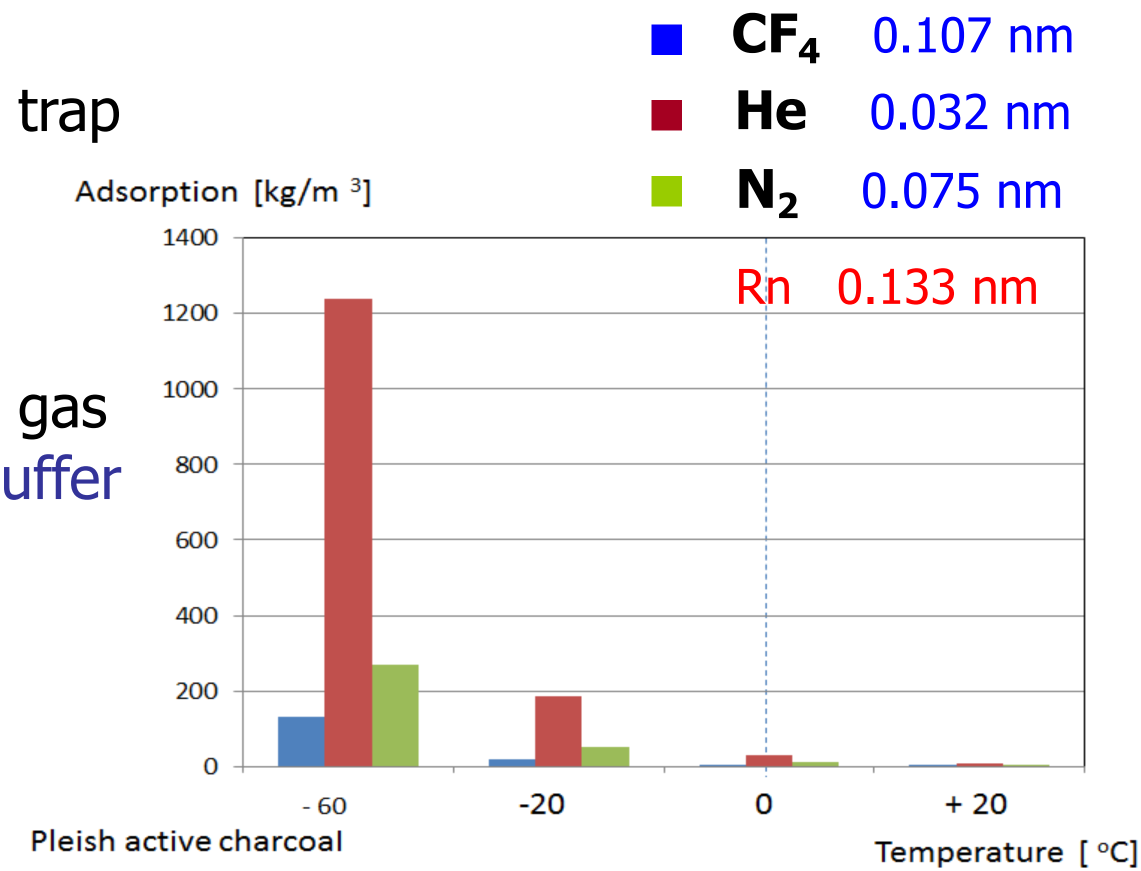


Carrier gas : Nitrogen
Flow : 10 L / H
Rn concentration : ~ 600 Bq / m^3
Trap temperature : + 20 °C to – 50 °C
Pressure : 1 bar
Humidity : ~ 5 %

Absorption factor: K

$$K\ [kg/m^3] = \frac{Rn\ activity\ in\ the\ \mathrm{trap}[Bq/\mathrm{kg}]}{Rn\ activity\ in\ the\ gas[Bq/m^3]}$$

- Radon activity in the trap
  - rad monitor
  - Ge detector
- Radon activity in the gas
  - Diffusion Rn in the buffer



Results for N2 and different carbon

	Temperature °C					
	20		-30		-50	
Samples	K factor(m3/Kg)	error	K factor(m3/Kg)	erreur	K factor(m3/Kg)	erreur
CARBOSEIVE SIII	10,0	6,1	168,4	9,5	728,5	32,9
CARBOXEN 1000	10,8	8,4	80,8	6,7	645,3	27,9
CARBOACT	20,5	2,9	131,9	4,1	425,5	11,4
MOF Basolite C300	8,7	4,8	215,2	10,3	409,2	10,6
K48 SPECIAL	12,5	1,8	92,4	3,5	347,9	10,3
K48	10,0	1,6	61,4	2,8	271,5	12,0
NUCLEARCARB 208C 5KI3	6,9	1,3	43,3	2,5	209,5	7,0
K610	6,2	1,3	22,1	2,6	170,2	6,0
CARBOXEN 569	2,2	6,3	9,7	3,9	99,8	5,7
NUCLEARCARB 208C 5TEDA	3,9	1,2	29,9	2,1	97,5	4,3
ENVIRONCARB 207C	2,2	1,0	12,1	1,7	49,1	3,3

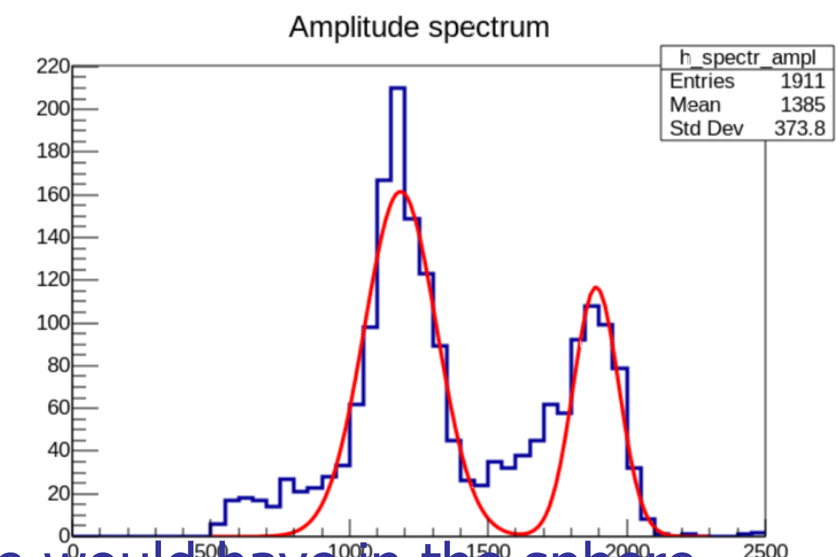
- Thursday with José Busto
  - We will talk more about the new setup and future test in Marseille

Test at Queen’s with S30

Data taking at Queen’s

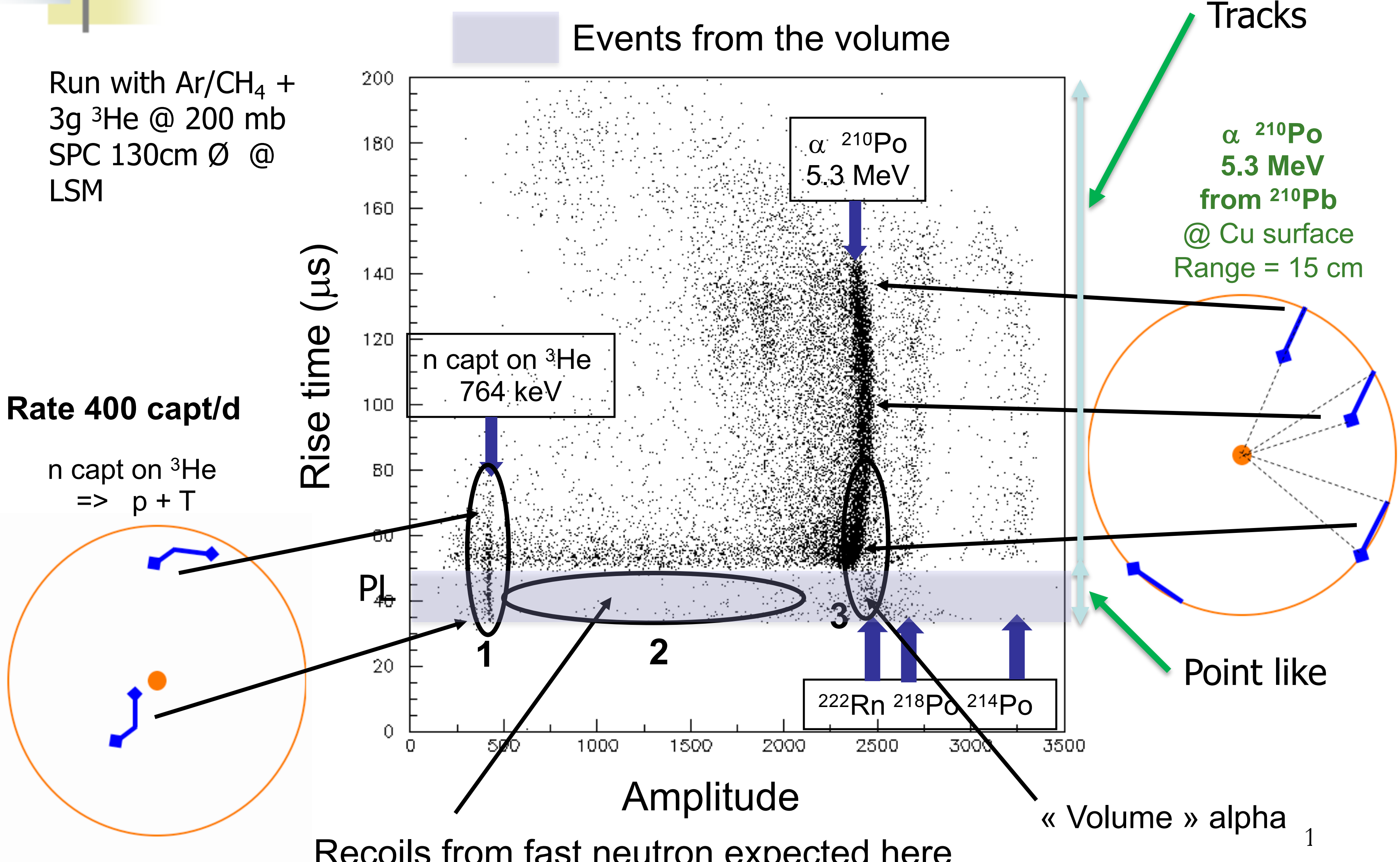
- Run
  - Keep the same conditions of HV1 – HV2 – pressure (3bar)
  - 60h of background run without circulation with getter

- Alpha during this background run
  - We will see the radon222 and Po218 – Po214
  - Po214 will be at the surface
  - According to the simulations (Alexis) the rate of Po214 will be half of the amount of radon we would have in the sphere.



- Analysis ongoing

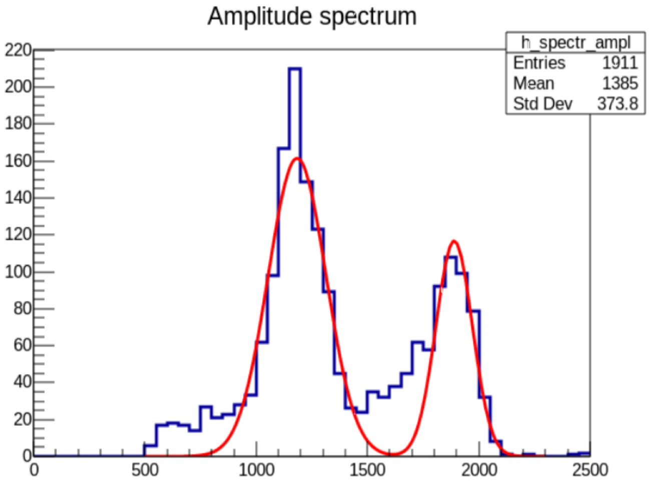
Illustration of particle identification



Run Plan – 2

- Alpha run with the source
  - 30min of Am run without circulation with getter
  - Keep the same conditions of HV1 – HV2 – pressure (3bar)
  - 23h of background run without circulation with getter

- Alpha run
  - We will see the radon222 and Po218 – Po214 with much more statistics!



  - A way to confirm that we see the right amount of the radon in the sphere (according to the amount of Po214).

  - Use the Rad7 monitor in series (will be good)

Run Plan – 3

- Run with the radon trap at Queen's
  - Carboxen 1000 to be shipped at Queen's
  - Run with the trap without circulation with getter
  - Keep the same conditions of HV1 – HV2 – pressure
  - Following the procedure for the trap

- Monitoring of the gas mixture in the sphere
  - Run Am for the calibration of the energy scale
  - RGA in series
  - Spectrometer? (José Busto)

- Time scale
  - Mid-July, we should have the results.

Next

Radon mitigation: Strategies

… Instead of using the getter, why not the GasKleen filter ?

- GasKleen filter
  - Used by PICO to remove O_2, H_2O in C_3F_8
  - Very expensive …
  - Never tested for radon emanation measurements
  - Old filters available at SNOLAB from PICO-2L

- Measurements were done but not very conclusive
  - Setup used in SNOLAB has leaks..
  - Ask to ship it for measurements at Queen's - in France ?
  - These measures need to be done before buying the filter.

Radon mitigation: Strategies

- Electrophoretic radon removal
  - Based on the first ionisation energy, exploiting favorable ion charge-exchange dynamics.

	First ionization Energy (eV)
Rn	10.4875
Xe	12.14
Ne	21.56
CH_4	12.61
F	17.42
Ar	15.75
C_3F_8	13.38

  - By comparing the energy, in collision with xenon ions, radon will be efficiently ionized via charge transfer: $Xe^+ + Rn \rightarrow Xe + Rn^+$

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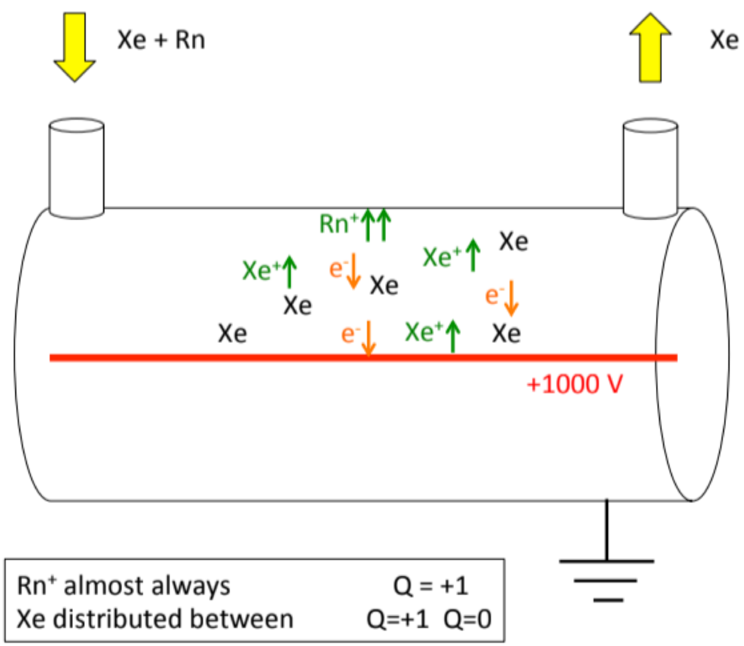

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Summary

- Planning well defined for the next months
  - Results from Queen's during July
  - Analysis to be posted the next weeks
  - José measures will be a complement to define the optimal parameters (Temperature, flow)

- At UofA
  - Exploration of new methods
  - Gaskleen to be sent at Queen's
  - Mounting and assembly of the new trap for testing at Queen's