



IMPACT OF RADON ON PERSONAL CONTAMINATION MONITORS AT THE EXIT OF CONTROLLED AREAS IN EDF NPP'S

ISOE Symposium

Maxime KARST (UNIE/GPEX), Cedric CERNA, Thibaud Le Noblet
(CNRS/IN2P3/CENBG)

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SUMMARY

- 1. STUDY CONTEXT**
- 2. FOCUS ON PERSONAL CONTAMINATION MONITORS « C2 » AND « RADON ISSUES »**
- 3. METHODOLOGY OF THIS STUDY – CONTROLLED EXPOSURE TO RADON 222**
- 4. RESULTS AND CONCLUSIONS**

STUDY CONTEXT

- Since 2008, EDF has gradually replaced old personal contamination monitors (C2 Nardeux) with a new generation of beta/gamma PCM



- In order to quantify the impact of Radon and progeny on the triggering of C2 portals, this study has been started with 3 goals :

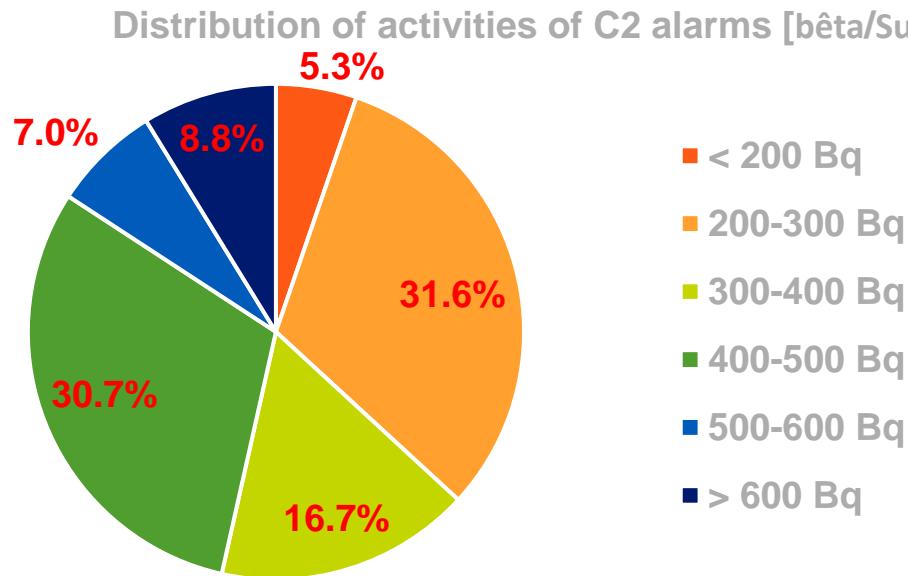
- Provide quantitative explanations to people concerned by the C2 alarms attributed to Radon,
- Improve reliability of “C2 alarm rate” indicator which is monitored monthly by EDF,
- Try to optimize practices to validate presence of radon and avoid C2 alarms.

STUDY CONTEXT

- Radiological cleanliness

- National C2 alarms rate

Example : BLA (01-04/2019) – 66011 C2 controls – 88 real alarms - 114 alarms due to Radon and progeny.



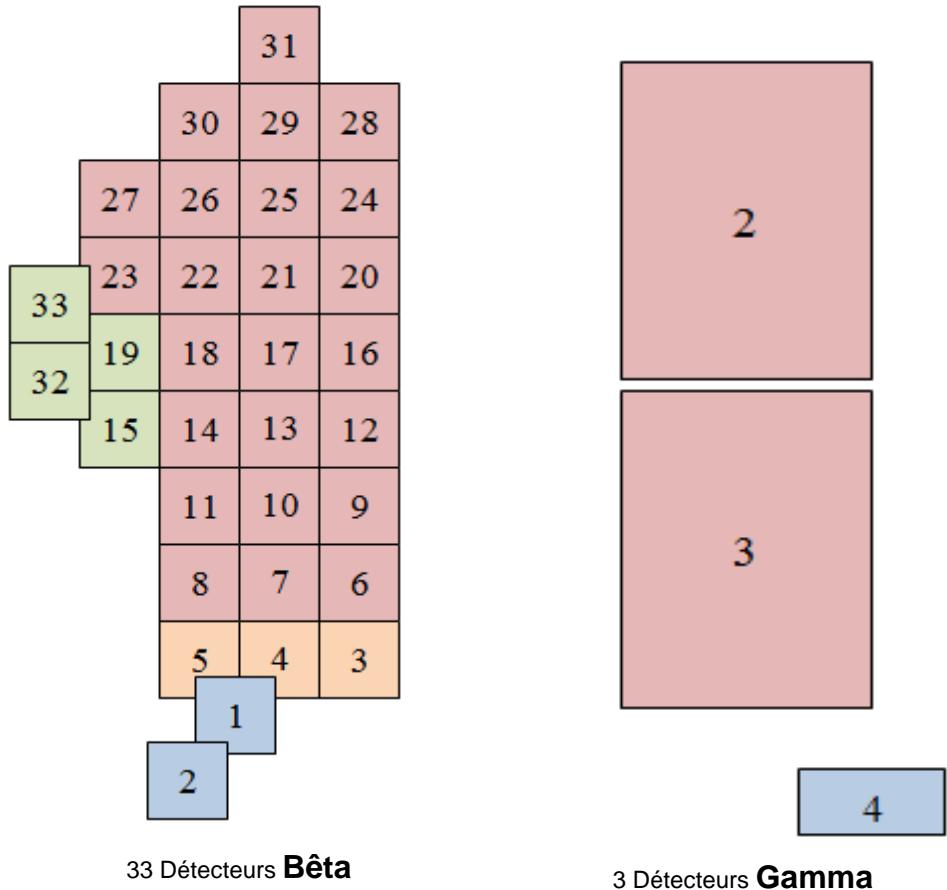
- Need to optimize and understand phenomenon due to radon and progeny

- Support procedure when C2 is in alarm
 - Provide experimental and educational data to workers concerned by C2 detections attributed to Radon

FOCUS ON « C2 » PCM

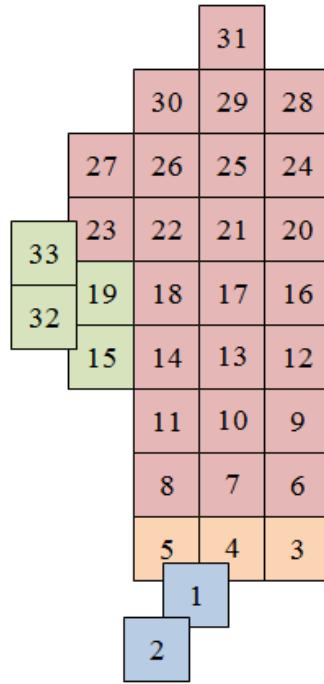
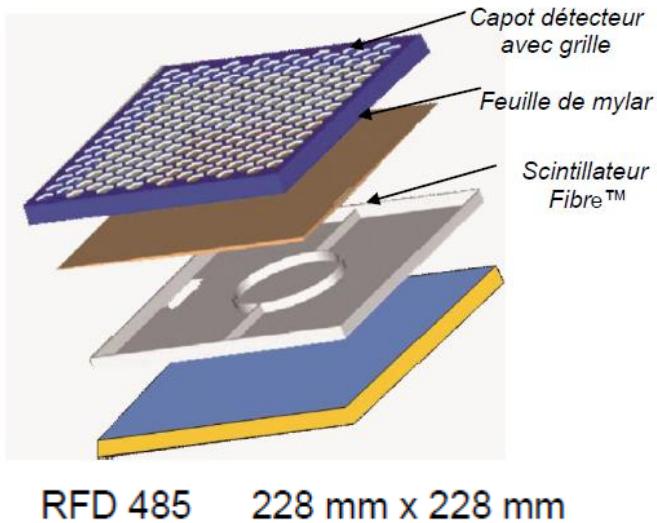


TSEII
(67% of EDF C2
PCM)



- 2 steps control (face and back)
- Around 10 secondes per step

FOCUS ON « C2 » PCM

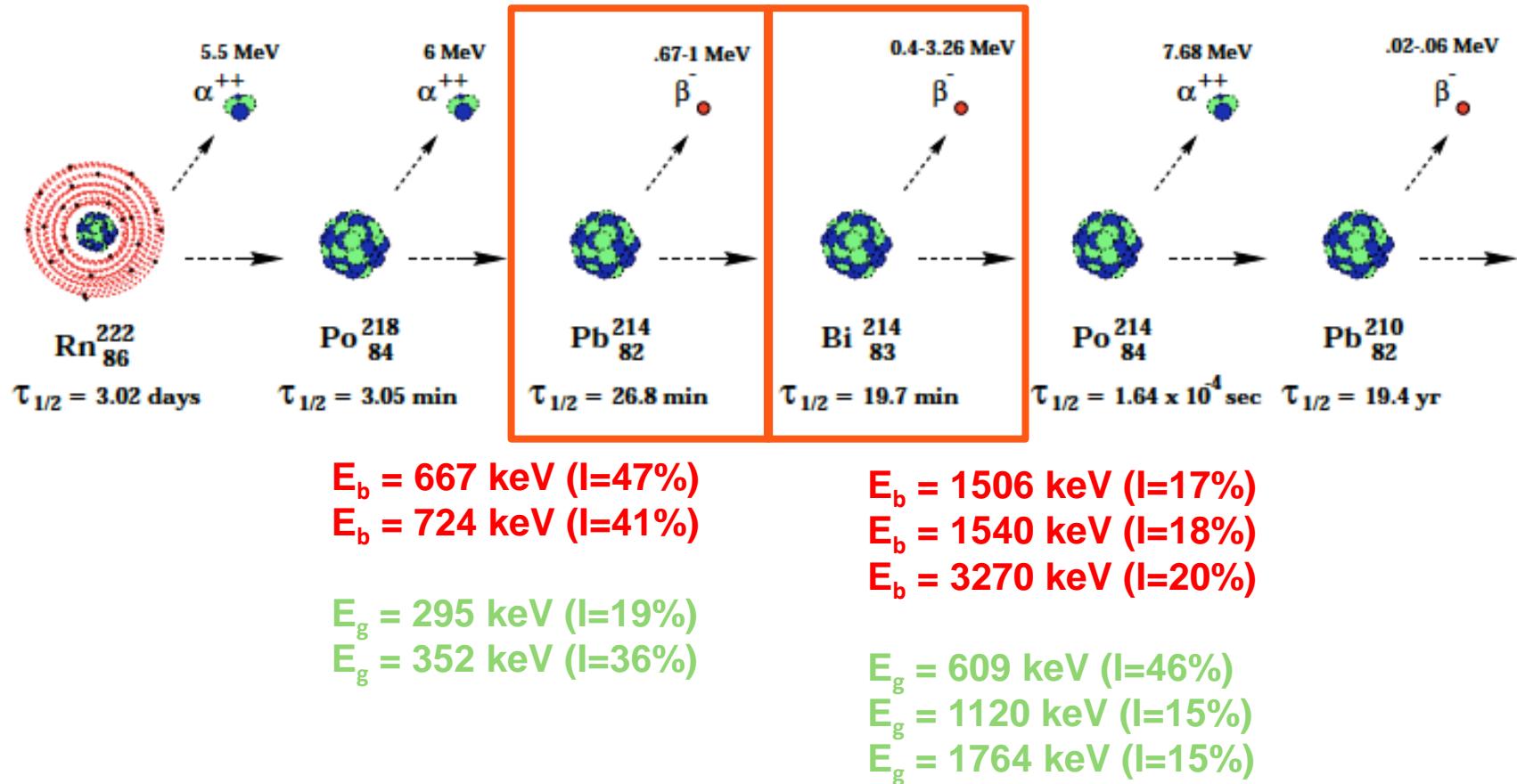


RE - Positions	Rdt (%)
^{60}Co - contact	6,5%
^{60}Co – @ 5 cm	3,2%
^{36}Cl - contact	11,4%
^{90}Sr - contact	22,8 %
^{214}Pb - contact	~10%
^{214}Bi - contact	~12,5%

- Bêta detectors :
 - Calibration with Cobalt 60 **@ 5 cm** and **contact**
 - **Alarm thresholds : 100 Bq hands / 200 Bq body**
 - Detection surface of 1 detector : **485 cm²**
 - Efficiencies knowned : ^{60}Co et ^{36}Cl
 - Efficiencies estimated : ^{214}Pb et ^{214}Bi

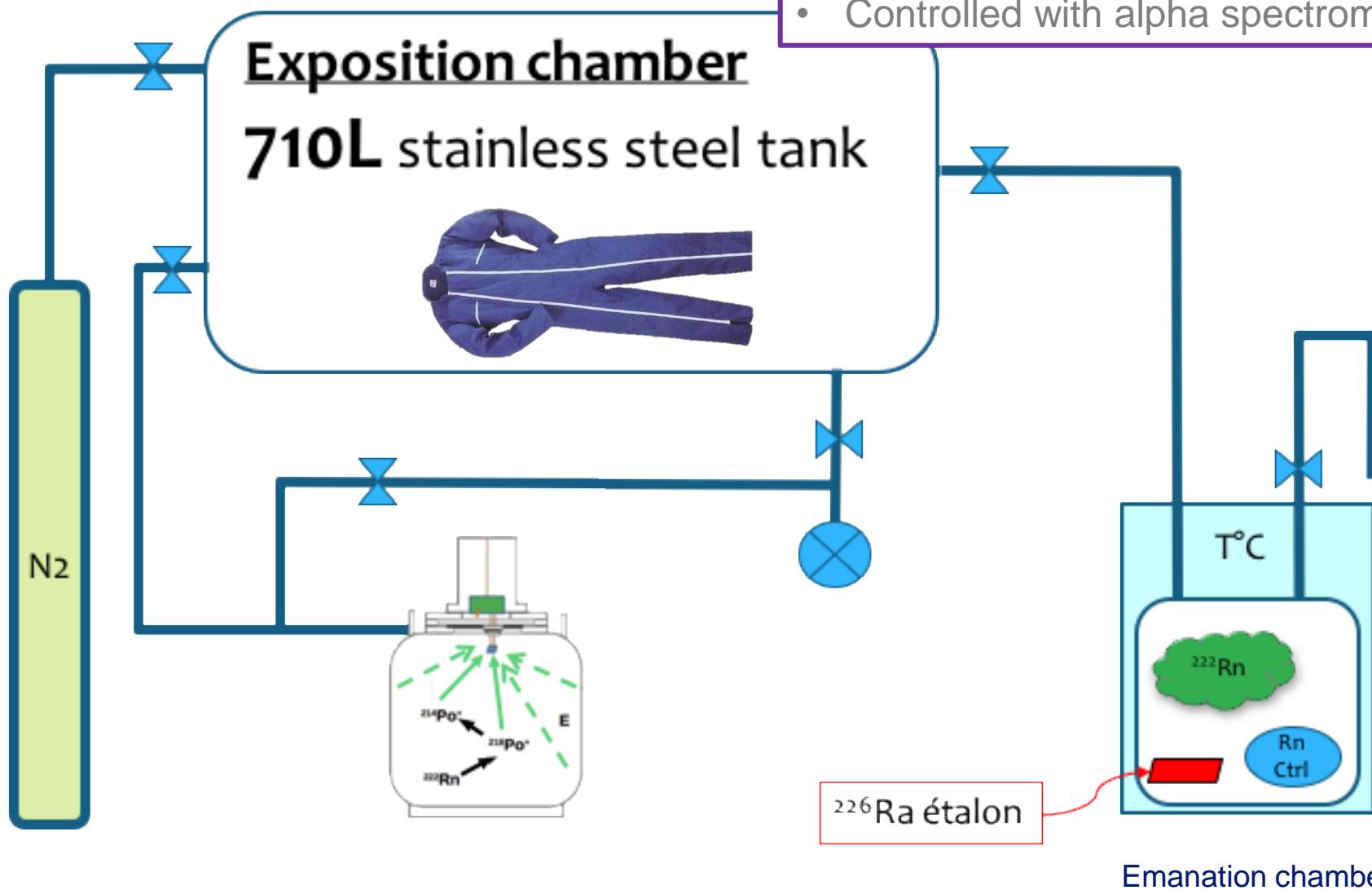
FOCUS ON « RADON ISSUES »

- Radon 222 and progeny : source of alarms at the exit of RCA (clothing contamination) and C3P at the exit of NPP.



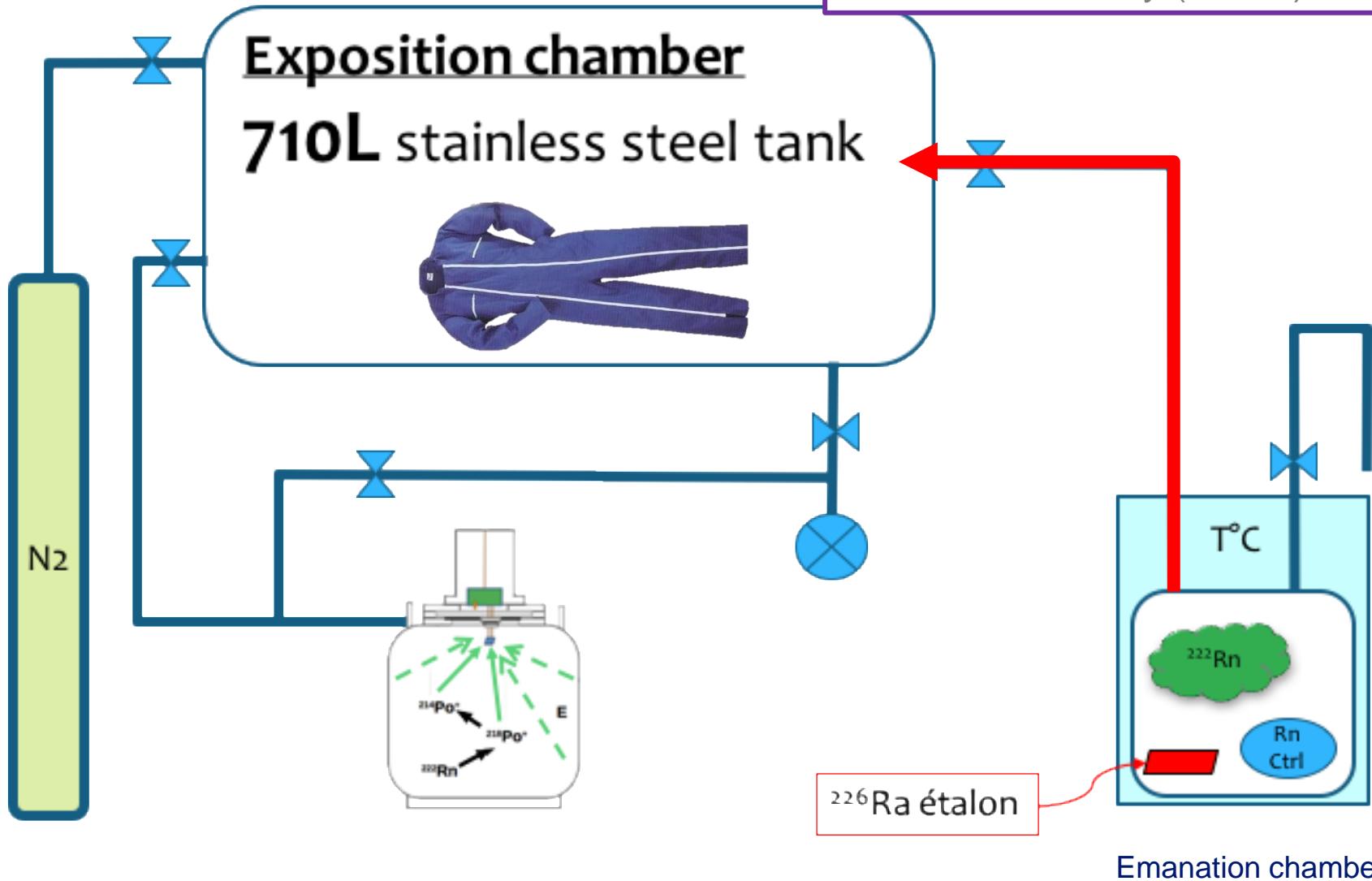
- 3 variables testes : time of exposure / Radon concentration / type of fabric

METHODOLOGY CONTROLLED EXPOSURE

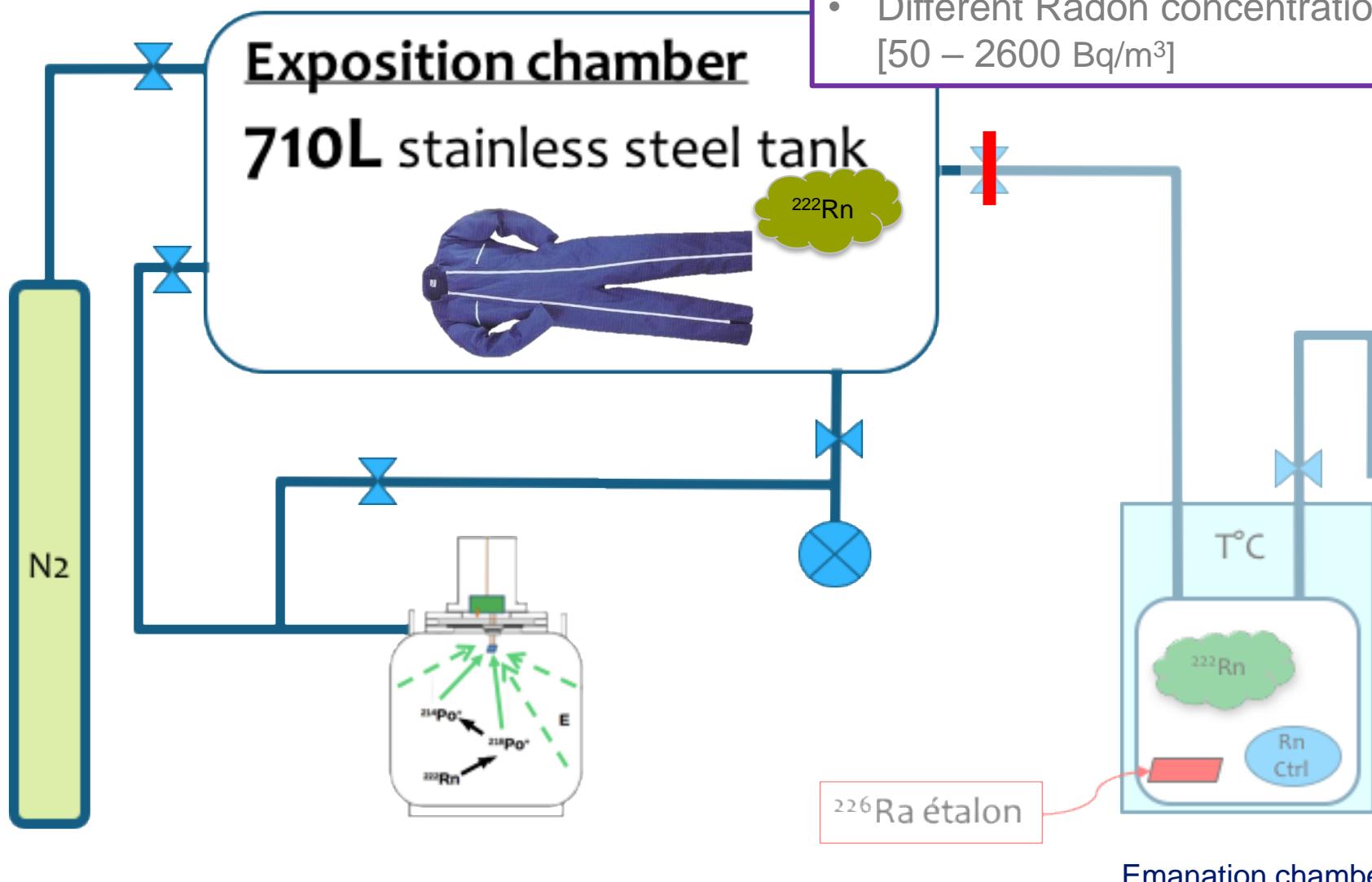


METHODOLOGY CONTROLLED EXPOSURE

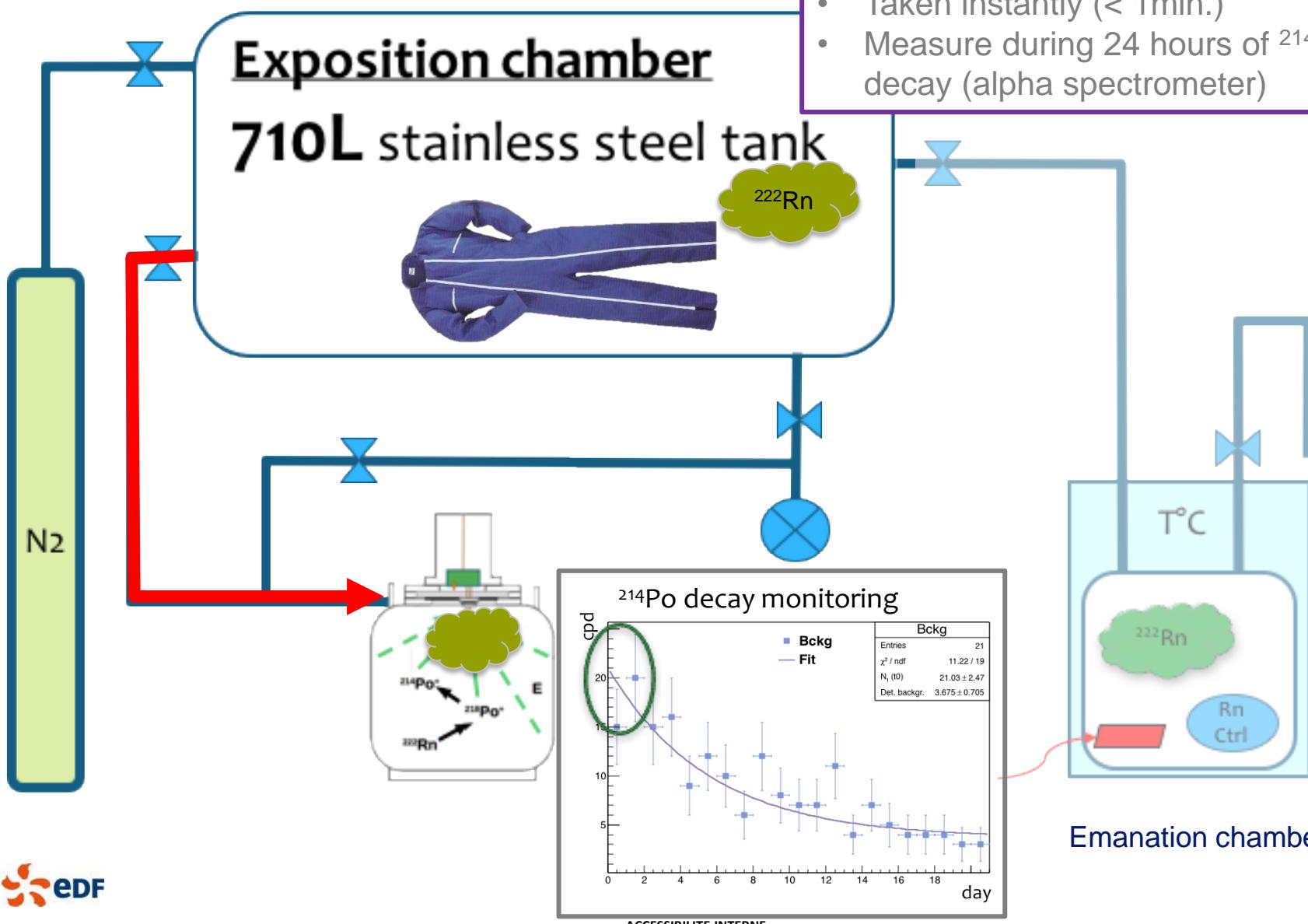
2. Radon transfer to exposition chamber
 - Almost instantly (<5min)



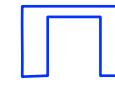
METHODOLOGY CONTROLLED EXPOSURE

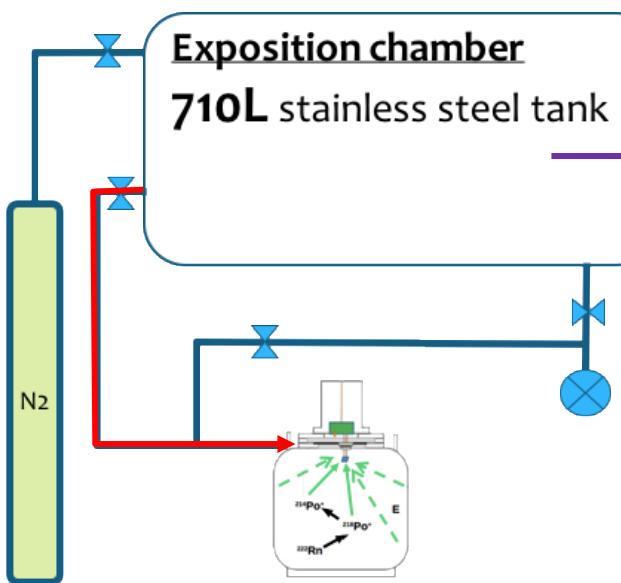


METHODOLOGY CONTROLLED EXPOSURE



METHODOLOGY CONTROLLED EXPOSURE

 Marinelli

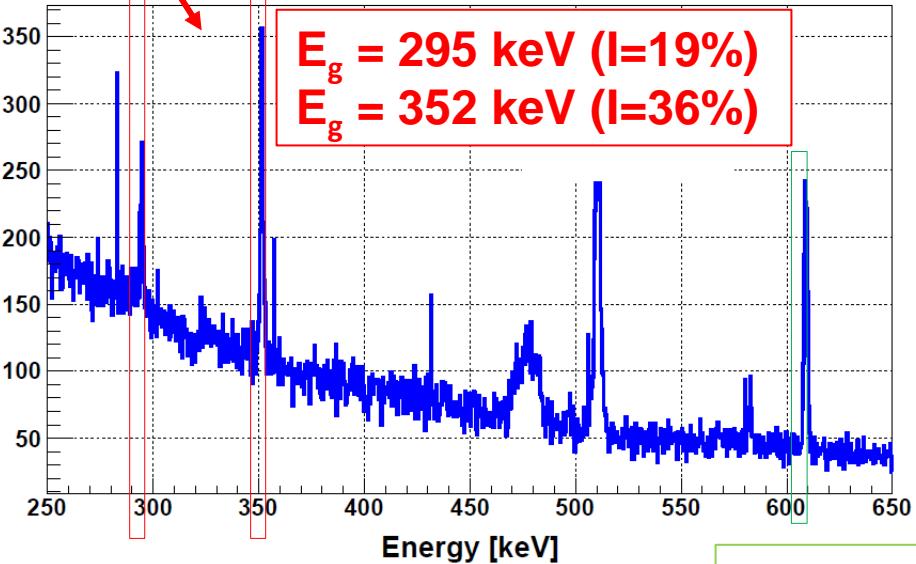
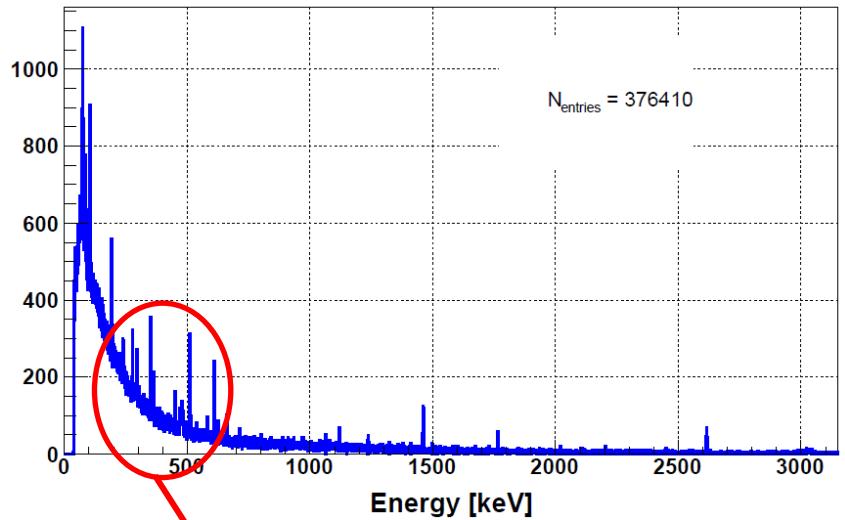


5. Extract of sample
6. Packaging in a Marinelli
7. Measurement with GeHP 300 cm³

- Time to launch HPGe < 5 minutes
- Measurement during 4 hours in ^{214}Pb and ^{214}Bi gamma channels.



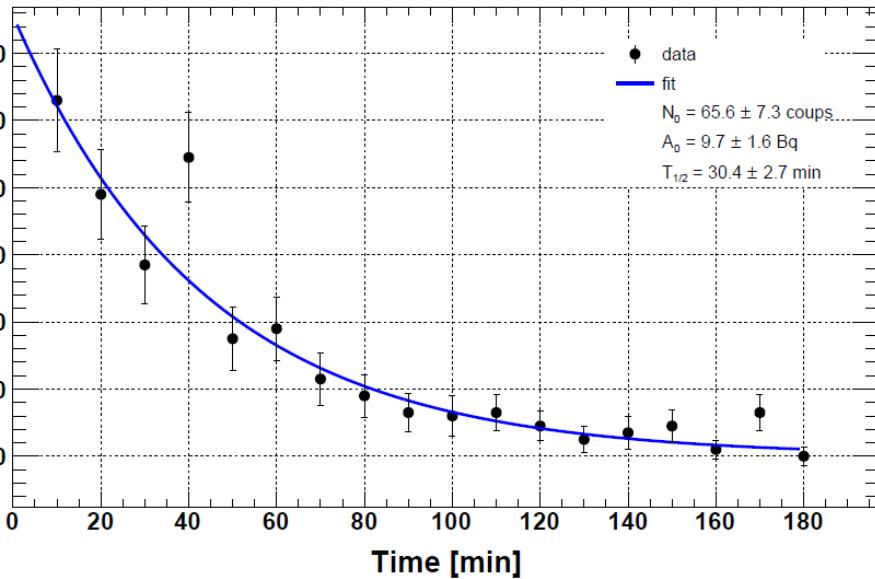
RESULTS – 80 BQ/M3 – 1H05



Sample Description	Sample Composition
T-shirt blue [Omxom]	100% Cotton

$$A_i(^{214}\text{Pb}) = 9,7 \text{ Bq} (\pm 1,6)$$

$$A_i(^{214}\text{Bi}) = 7,8 \text{ Bq} (\pm 1,7)$$



$$E_g = 609 \text{ keV (I=46%)}$$

HOMOGENEITY OF DEPOSITS

- **Sample n°2 :** Blue t-shirt OMEXOM long sleeves. Exposed during 2h46 @ 2627 Bq/m³ of Radon 222. Mesured with COMO170 during 30 secondes on 15 positions :



Variations	Mesures
-68,2%	1
-88,1%	2
3,3%	3
-28,5%	4
-24,5%	5
-82,1%	6
114,6%	7
96,7%	8
29,1%	9
-18,5%	10
49,0%	11
37,1%	12
5,3%	13
-10,6%	14
-14,6%	15

Net average measured value (bêta channel): 5,0 [+/- 0,12] c/s

RÉSULTATS – 80 BQ/M3 – 1H05 – BETA CHANNEL

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Sample Description	Sample Composition
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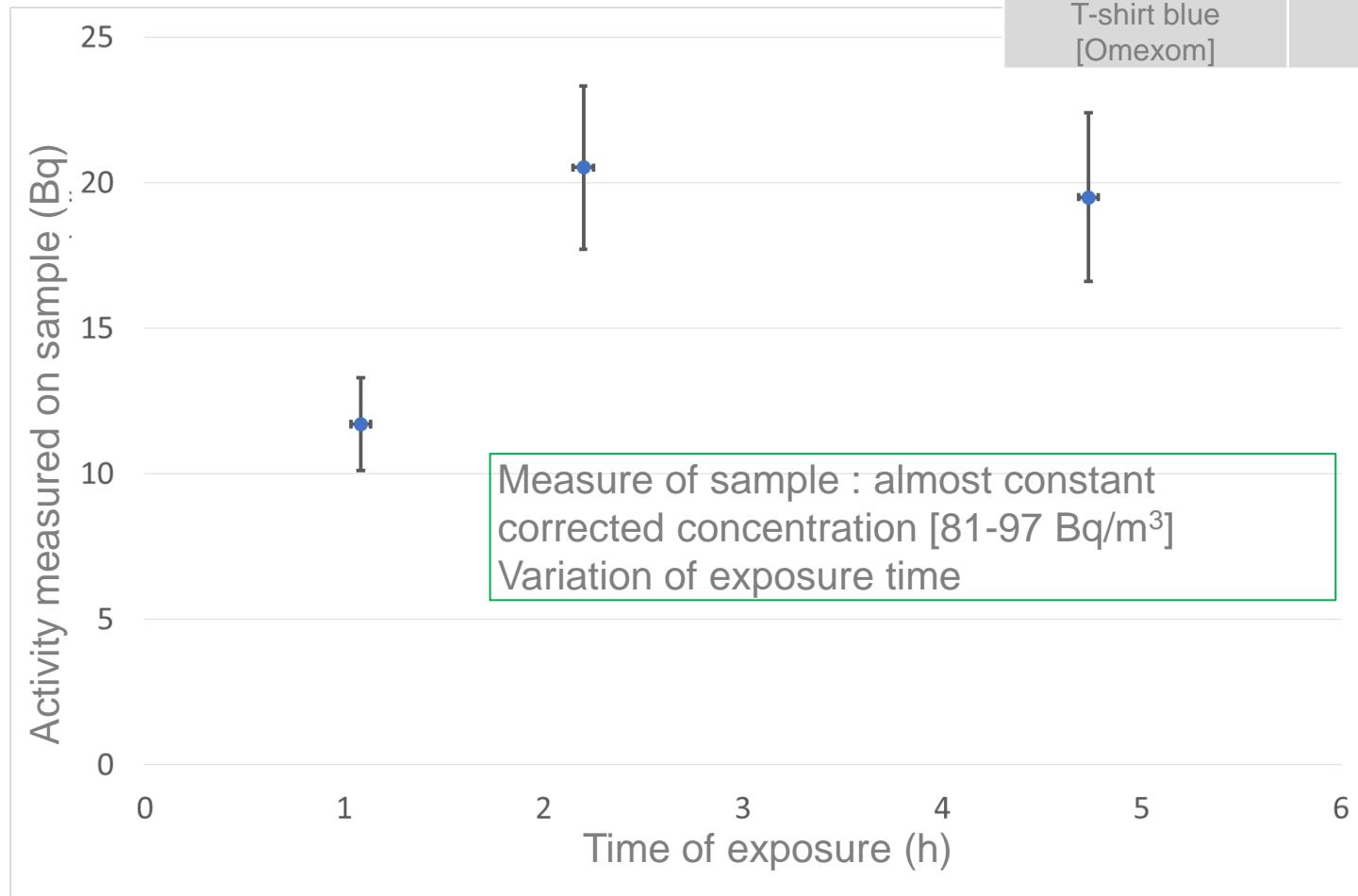
- Hypothesis 1:** activity deposited on surface and not uniformly on 7000cm² [t-shirt]. Factor measured experimentally [-82/+112 %] and set at 2 .
- Detectors surfaces single/quadruple sum : 485 cm² / 1940 cm²

RE - Positions	Rdt (%)
²¹⁴ Pb - contact	~10%
²¹⁴ Bi - contact	~12,5%
⁶⁰ Co – @ 5 cm	3,2%

Activities deposited	Single channel total count rate (c/s)	Bq eq Co60 single channel Hyp 1	Bq eq Co60 quadruple sum channel Hyp 1
9,7 Bq [214Pb]	0,134	4,2	10,5
7,8 Bq [214Bi]	0,135	4,2	10,6
TOTAL		8,4	21,1

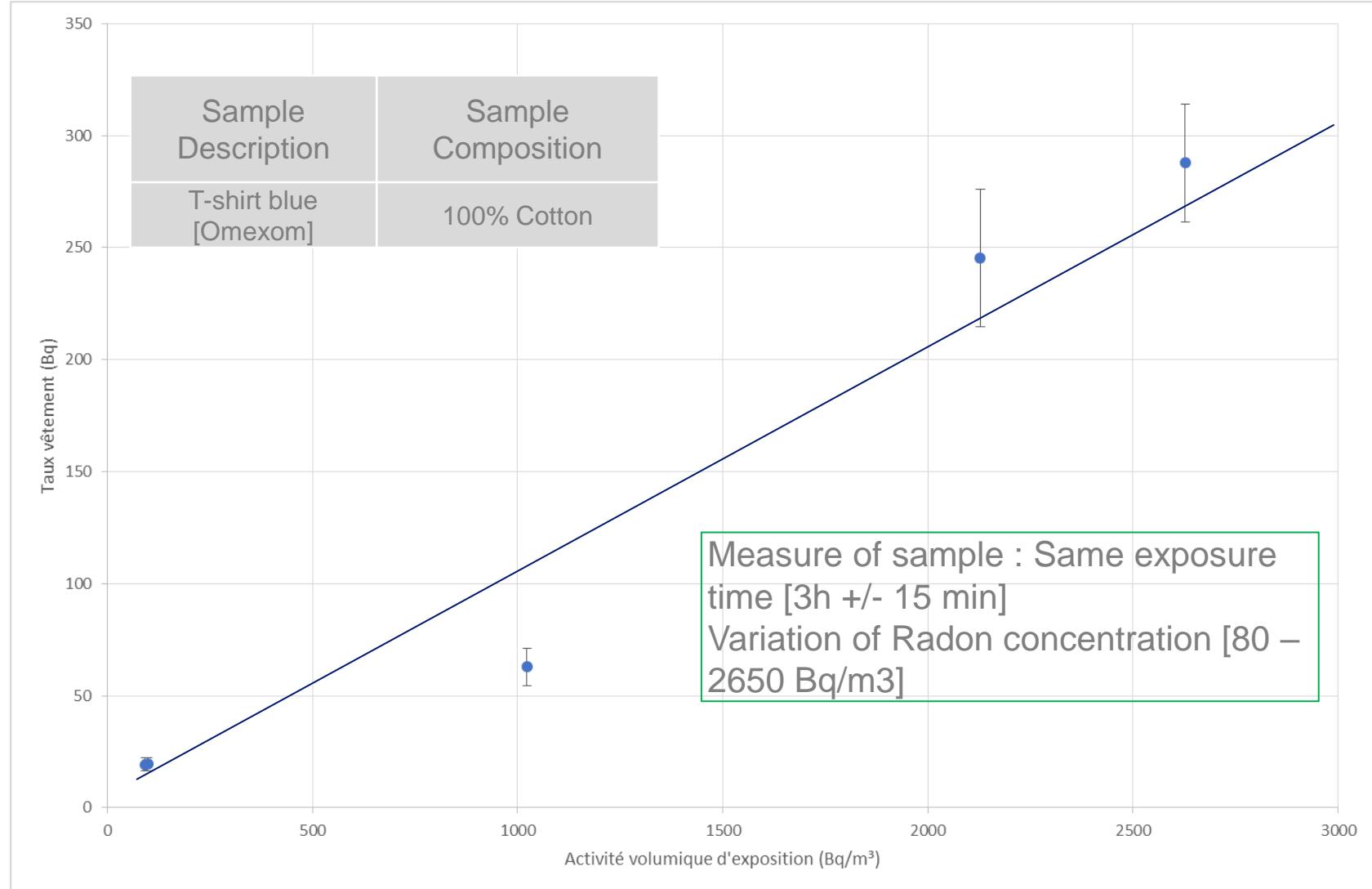
- Very low impact on gamma channels : around 5 Bq eq. Cobalt 60

GENERAL RESULTS



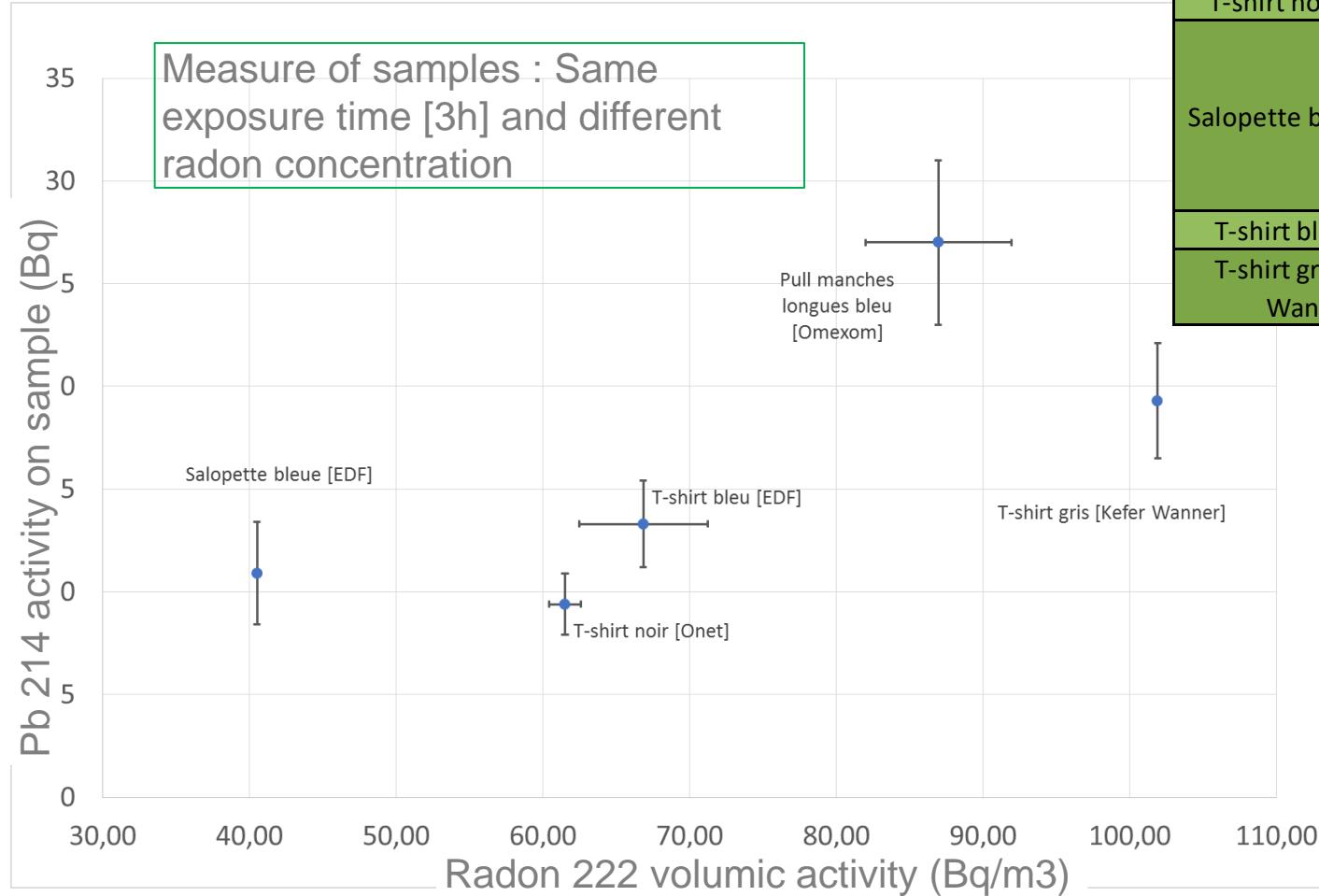
- Activity measured grows up to 1h45 - 2h of exposure and stay stable

GENERAL RESULTS



- Almost linear relation between activity of progeny and radon concentration

GENERAL RESULTS

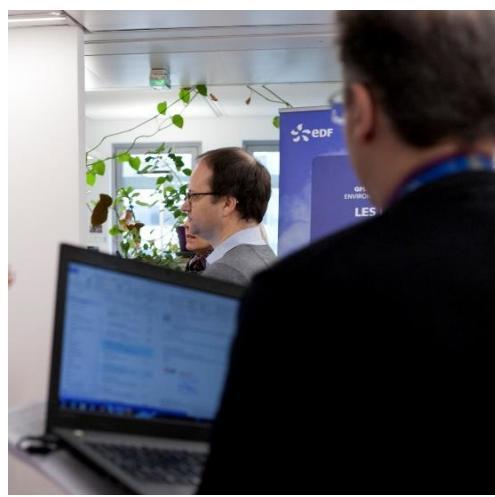


Pull manches longues bleu [Omexom]	80% Coton / 20% Polyester
T-shirt noir [Onet]	100% Coton
Salopette bleue [EDF]	88% Coton / 12% Fibres synthétiques / Fibres antistatiques
T-shirt bleu [EDF]	100% Coton
T-shirt gris [Kefer Wanner]	85% Coton / 15% Viscose

Activites deposited [$^{214}\text{Pb}/^{214}\text{Bi}$]	Bq eq Co60 single channel Hyp 1	Bq eq Co60 quadruple sum channel Hyp 1
9,4 Bq	8,4	27,3
35Bq	30,3	91,0

CONCLUSIONS

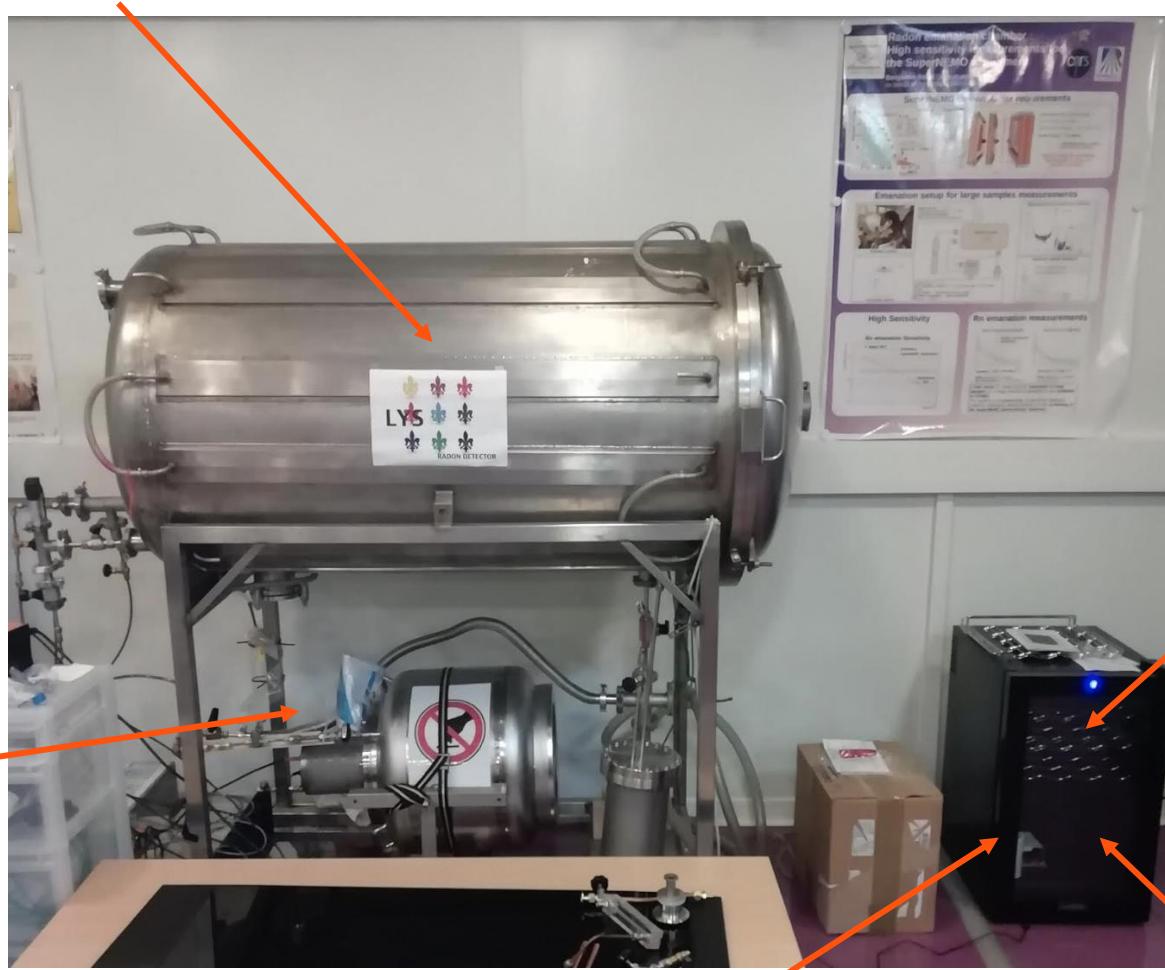
- Deposits of Radon 222 progeny has been observed and measured. **Proportional to Radon concentration**
- **Time of exposure have no effect after 1h45**
- **Most important impact are expected on :**
 - Quadruple sum – Beta channels [from 350 Bq/m³ (Rn222)] - $S_A = 400 \text{ Bq}$
 - Single – Beta channels [from 530 Bq/m³ (Rn222)] - $S_A = 200 \text{ Bq}$
 - Gamma channels [from 3000 Bq/m³ (Rn222)] - $S_A = 600/800 \text{ Bq}$
- **Recommended additional measurement in case of C2 alarm :**
 - Check channels concerned on C2 (only gamma channels => Not Radon issue),
 - Measure with CPO (Precision mode) if clothing contamination,
 - Measure with alpha channel of COMO170,
 - Measure 25 minutes later and check if activity is divided by 2. We can also check pseudo spectrum on CPO Smart
- **C2 alarm caused by radon progeny does not mean that radon concentration is high.**



Thanks

ILLUSTRATIONS

Chambre d'exposition 710 litres



Détecteur
Radon
[2nd contrôle]

Détecteur
Radon
[1^{er} contrôle]

Etalon d'émanation
[Aiguilles de ^{226}Ra]

Etuve
d'émanation

ILLUSTRATIONS

Plateforme Régionale Interdisciplinaire de Spectrométrie Nucléaire en Aquitaine (PRISNA) au CENBG

4 détecteurs HPGe

- Agrément ASN
- Sensibilité < 10mBq/kg
- 300 cm³
- Blindés (Pb et Pb archéo.)
- Salle semi-enterrée



Setup exposition métrologie Radon



EQUILIBRE 214PB – 214BI

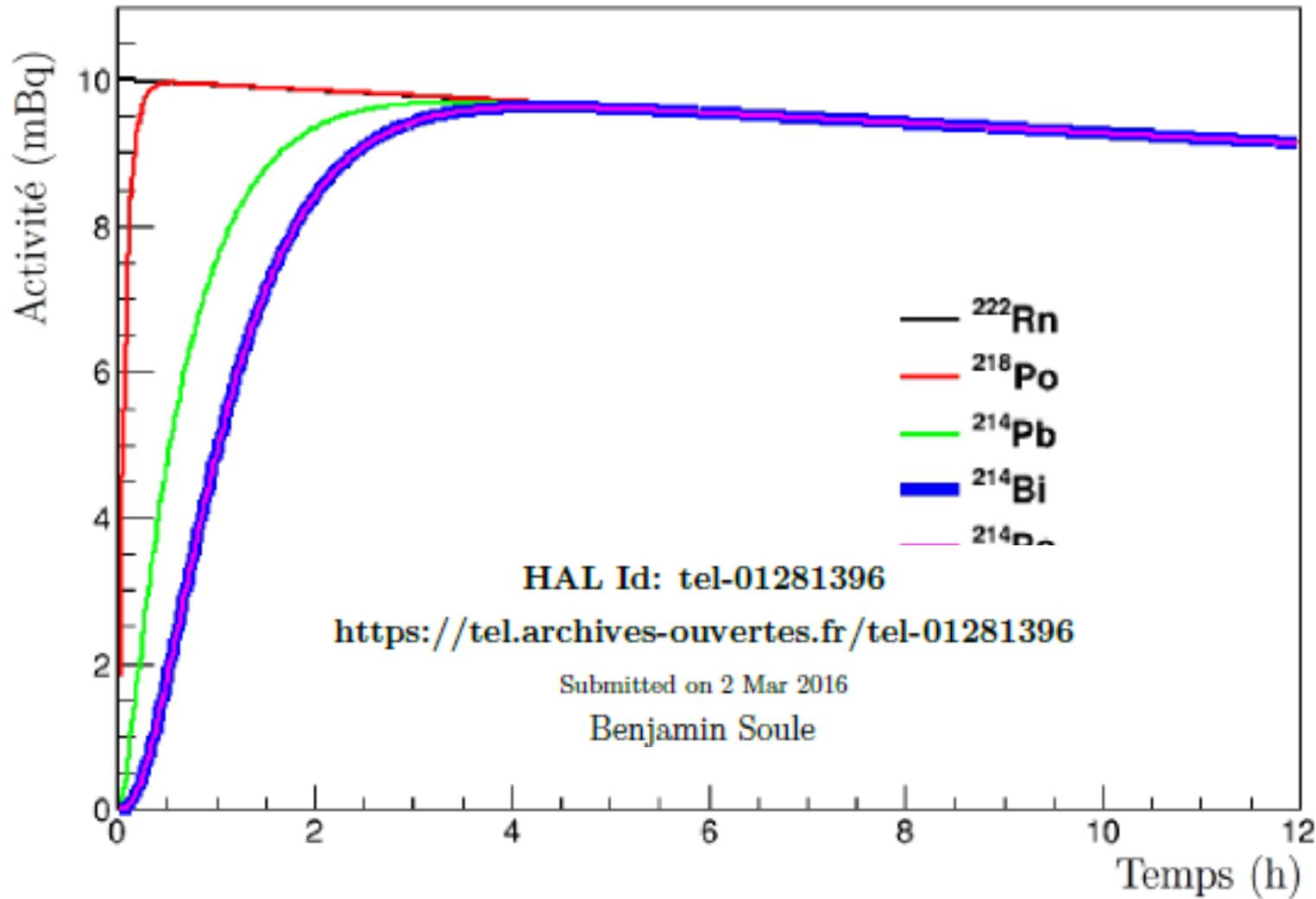


FIGURE 3.4: Activité des différents isotopes de la chaîne radioactive du ^{222}Rn en fonction du temps après introduction de 10 mBq de ^{222}Rn dans un volume isolé.