



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

ISOE Symposium

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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.

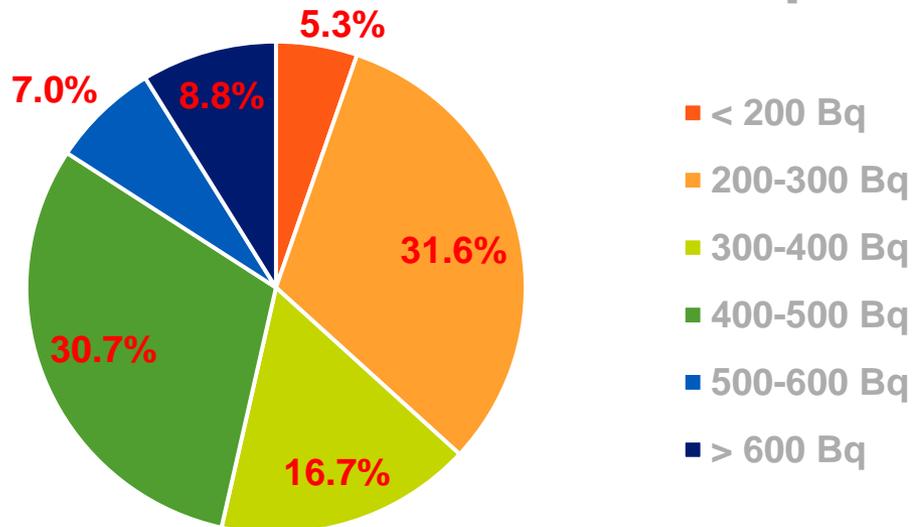
# STUDY CONTEXT

- Radiological cleanliness

- National C2 alarms rate

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

Distribution of activities of C2 alarms [bêta/Sumbêta]



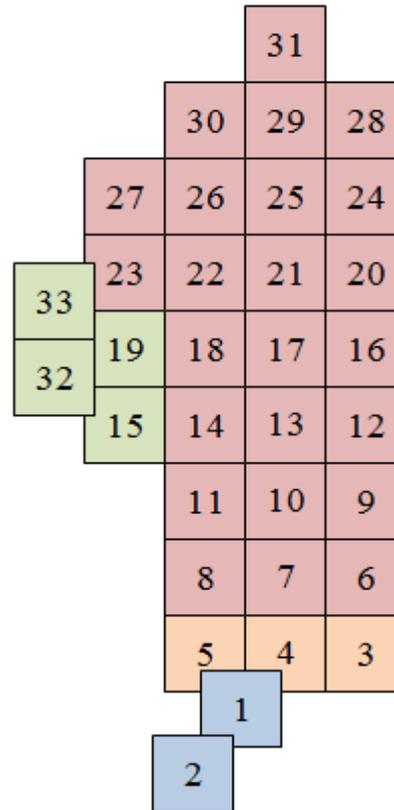
- Need to optimize and understand phenomenon due to radon and progeny

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

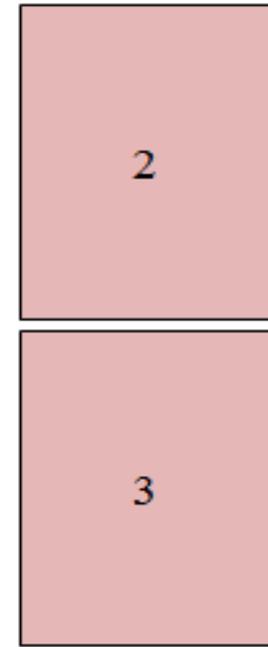
# FOCUS ON « C2 » PCM



TSEII  
(67% of EDF C2  
PCM)



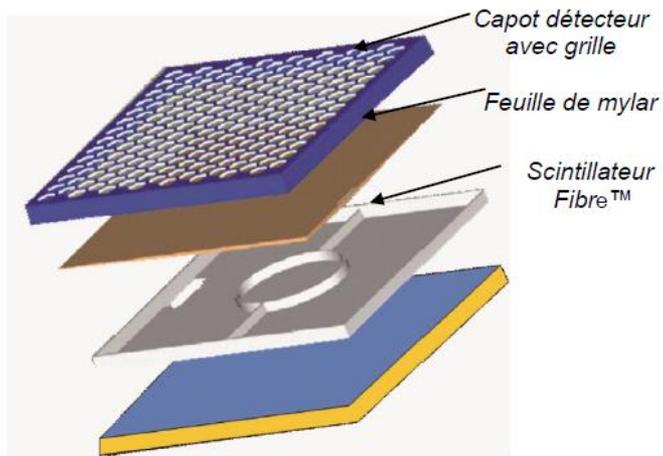
33 Détecteurs **Bêta**



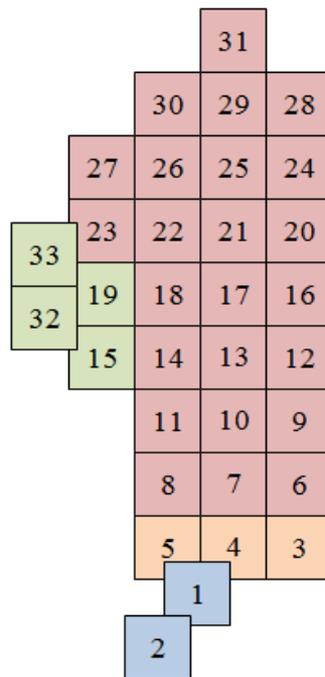
3 Détecteurs **Gamma**

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

# FOCUS ON « C2 » PCM



RFD 485 228 mm x 228 mm



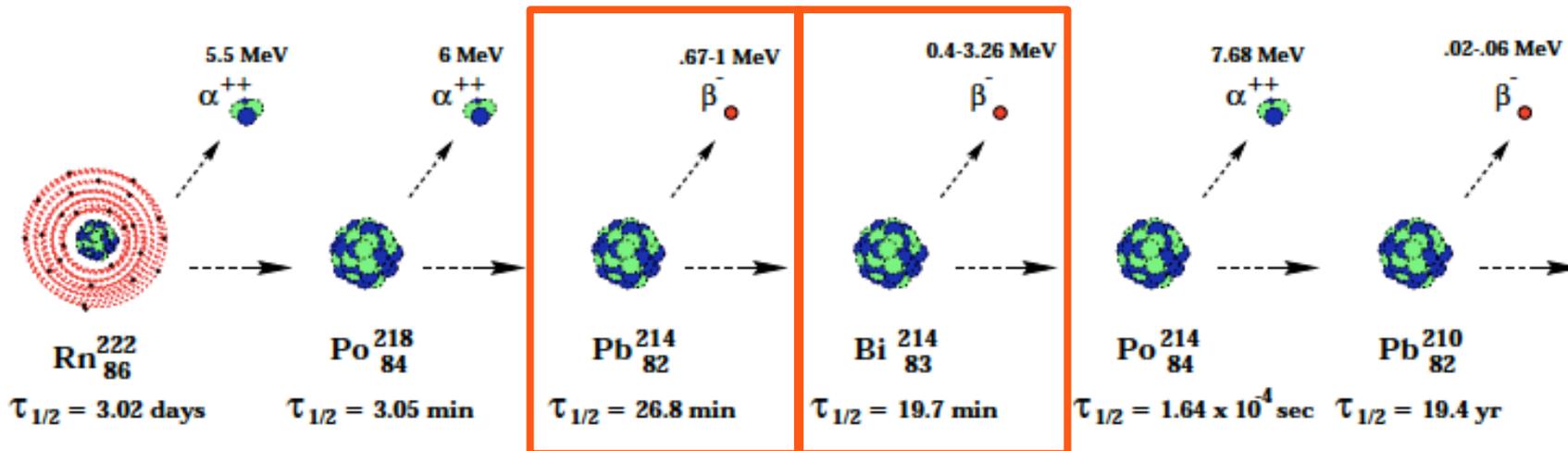
33 Détecteurs **Béta**

RE - Positions	Rdt (%)
$^{60}\text{Co}$ - contact	6,5%
$^{60}\text{Co}$ - @ 5 cm	3,2%
$^{36}\text{Cl}$ - contact	11,4%
$^{90}\text{Sr}$ - contact	22,8 %
$^{214}\text{Pb}$ - contact	~10%
$^{214}\text{Bi}$ - 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 cm<sup>2</sup>
  - Efficiencies knowed :  $^{60}\text{Co}$  et  $^{36}\text{Cl}$
  - Efficiencies estimated :  $^{214}\text{Pb}$  et  $^{214}\text{Bi}$

# 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.



$E_b = 667 \text{ keV (I=47\%)}$   
 $E_b = 724 \text{ keV (I=41\%)}$

$E_g = 295 \text{ keV (I=19\%)}$   
 $E_g = 352 \text{ keV (I=36\%)}$

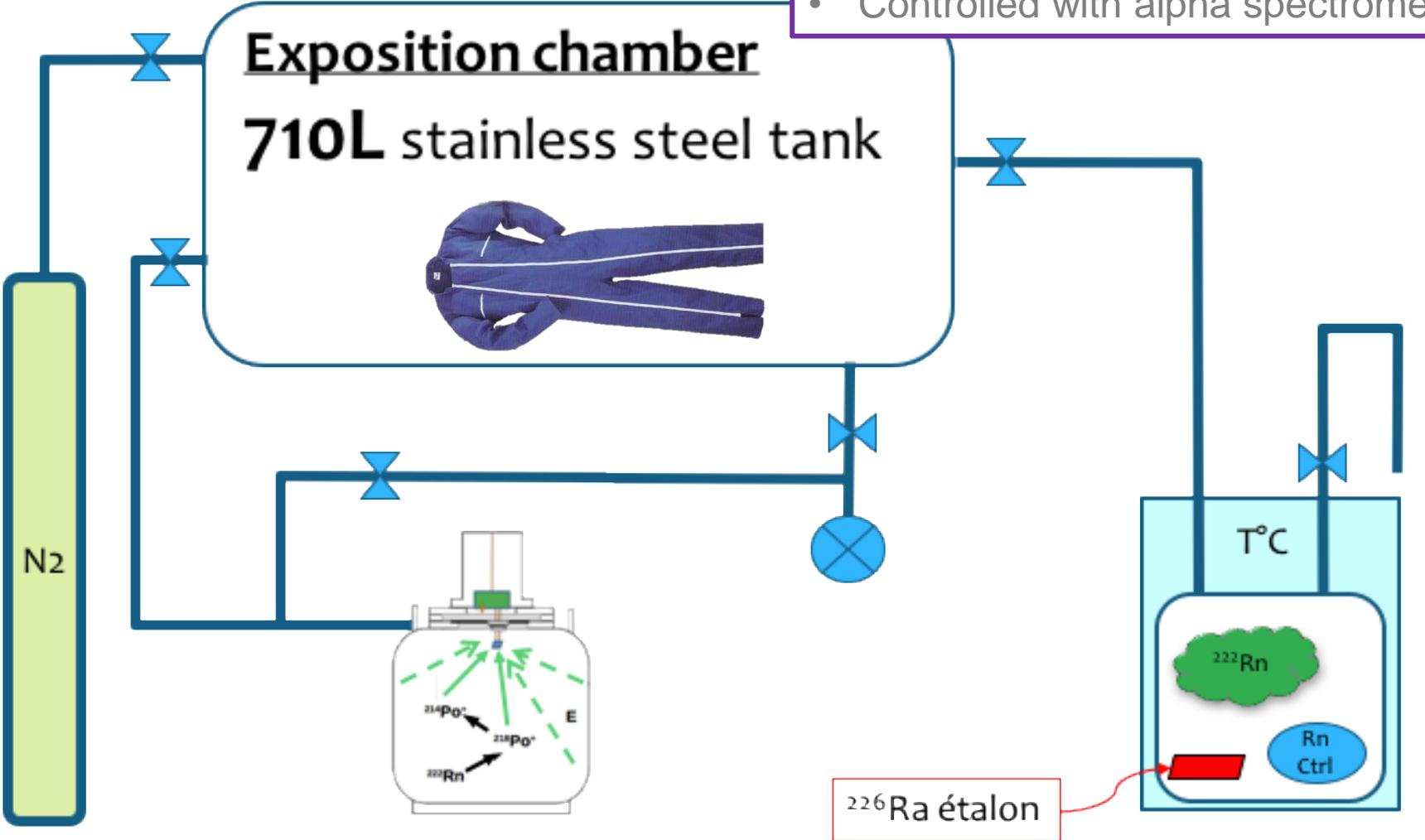
$E_b = 1506 \text{ keV (I=17\%)}$   
 $E_b = 1540 \text{ keV (I=18\%)}$   
 $E_b = 3270 \text{ keV (I=20\%)}$

$E_g = 609 \text{ keV (I=46\%)}$   
 $E_g = 1120 \text{ keV (I=15\%)}$   
 $E_g = 1764 \text{ keV (I=15\%)}$

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

# METHODOLOGY CONTROLLED EXPOSURE

- 1. Radon emanation
  - Duration > 4 j
  - Controlled with alpha spectrometer



Emanation chamber

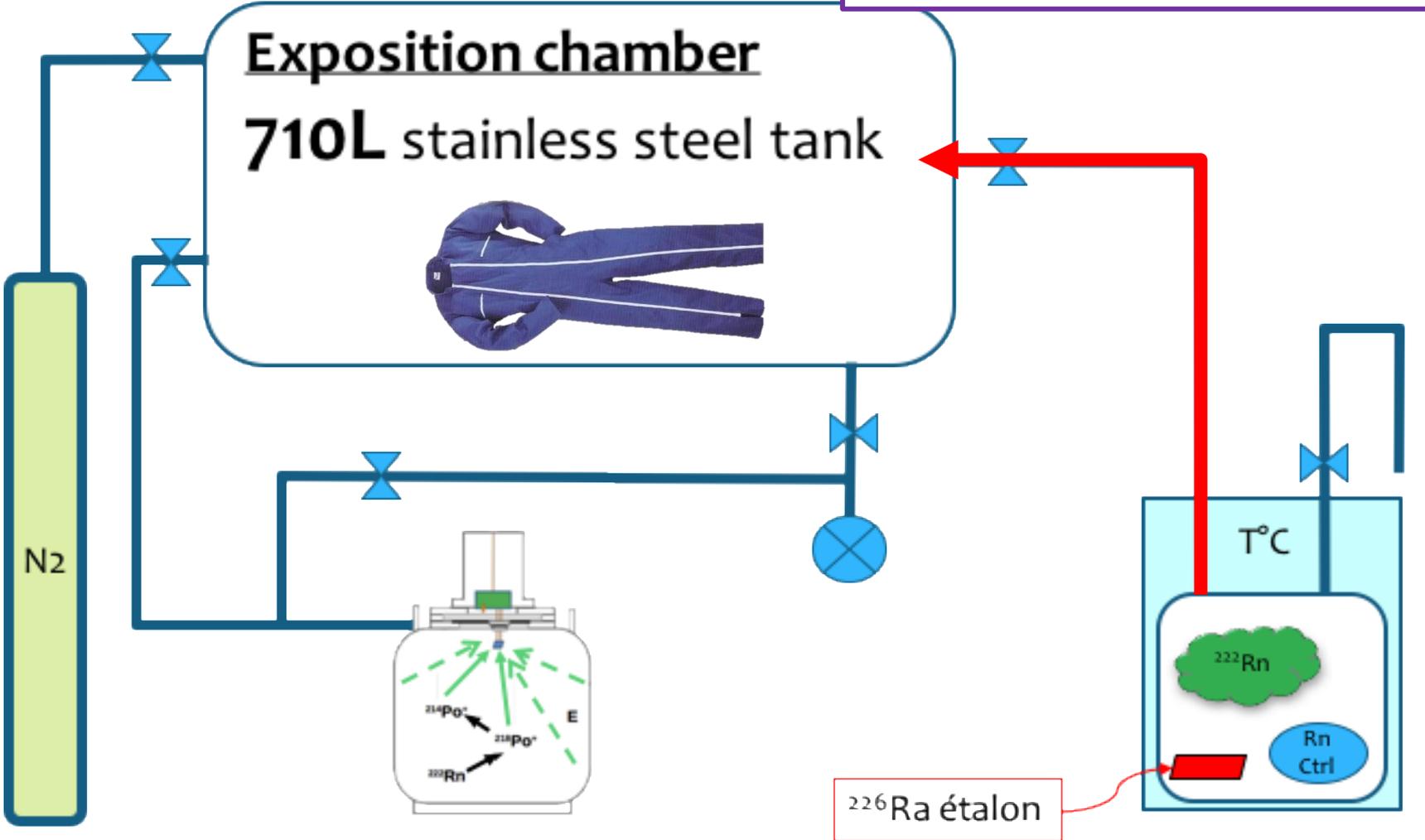


# METHODOLOGY

## CONTROLLED EXPOSURE

2. Radon transfer to exposition chamber

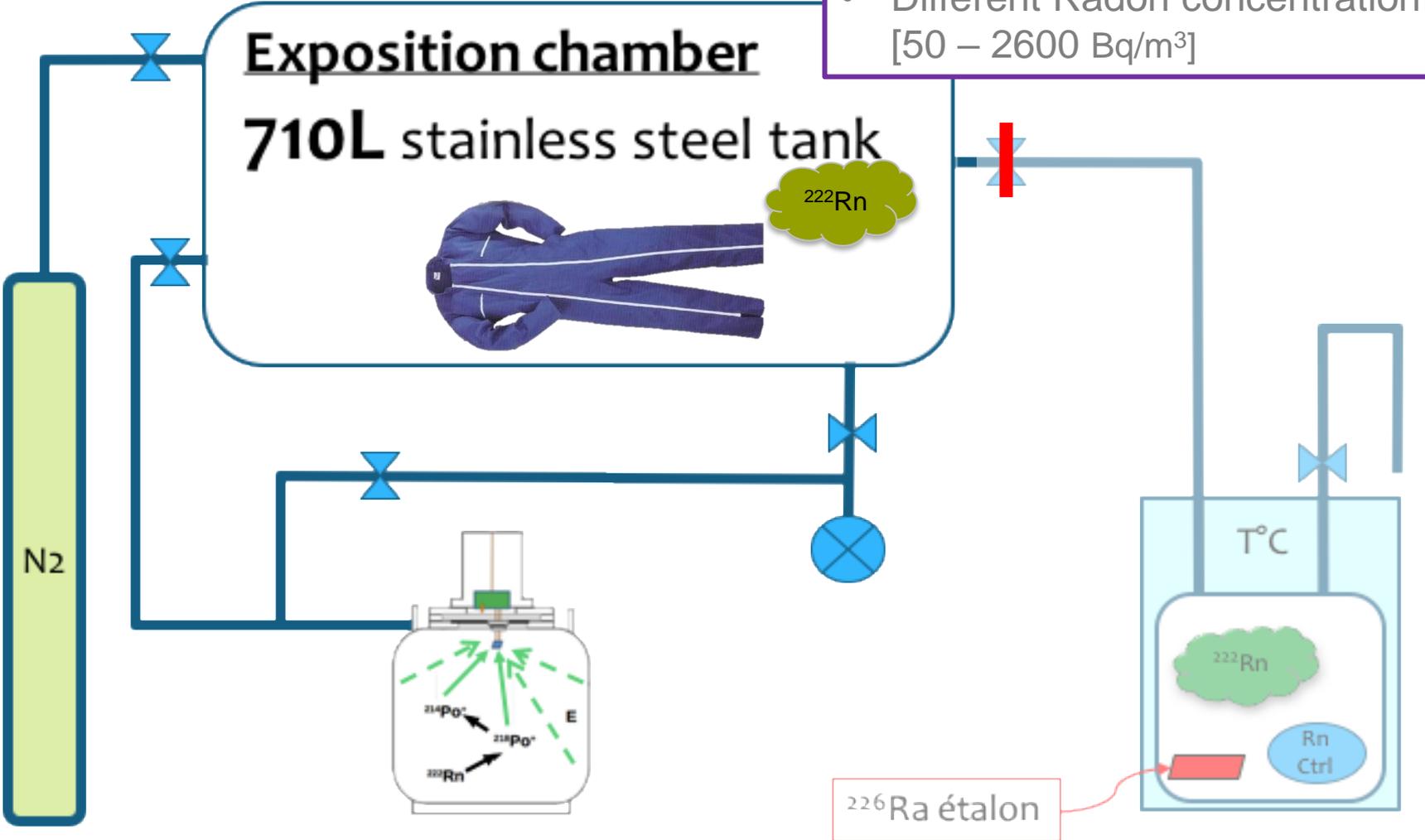
- Almost instantly (<5min)



# METHODOLOGY

## CONTROLLED EXPOSURE

3. Clothes exposed to Radon
- Different time [0,5 – 4h]
  - Different Radon concentration [50 – 2600 Bq/m<sup>3</sup>]

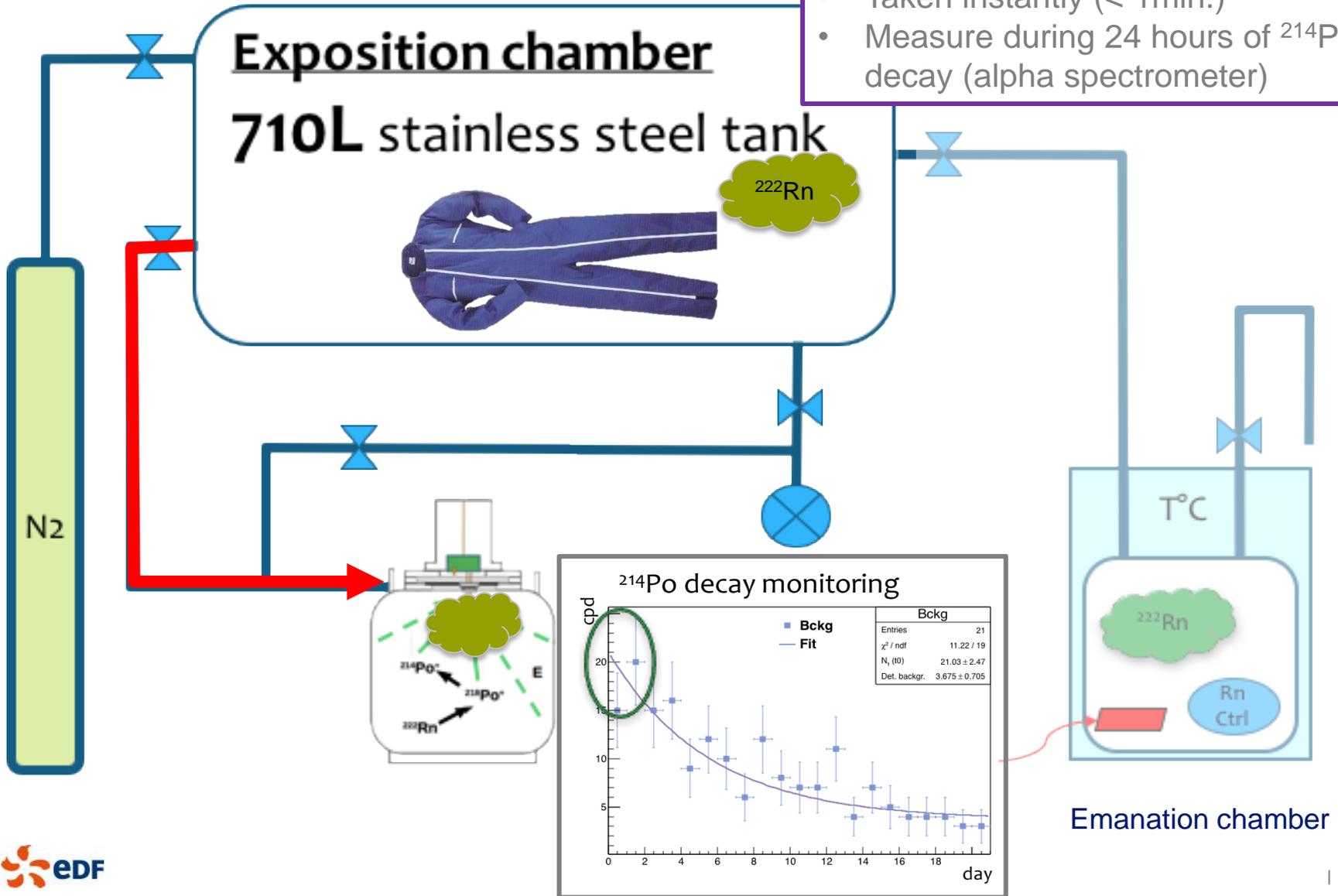


Emanation chamber



# METHODOLOGY

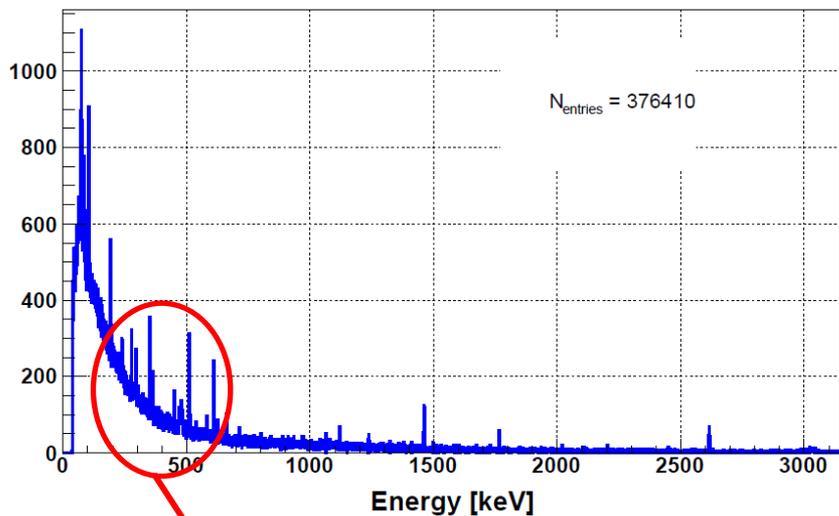
## CONTROLLED EXPOSURE



- At the end of exposure, a sample of gas is measured as final control
  - Taken instantly (< 1 min.)
  - Measure during 24 hours of  $^{214}\text{Po}$  decay (alpha spectrometer)

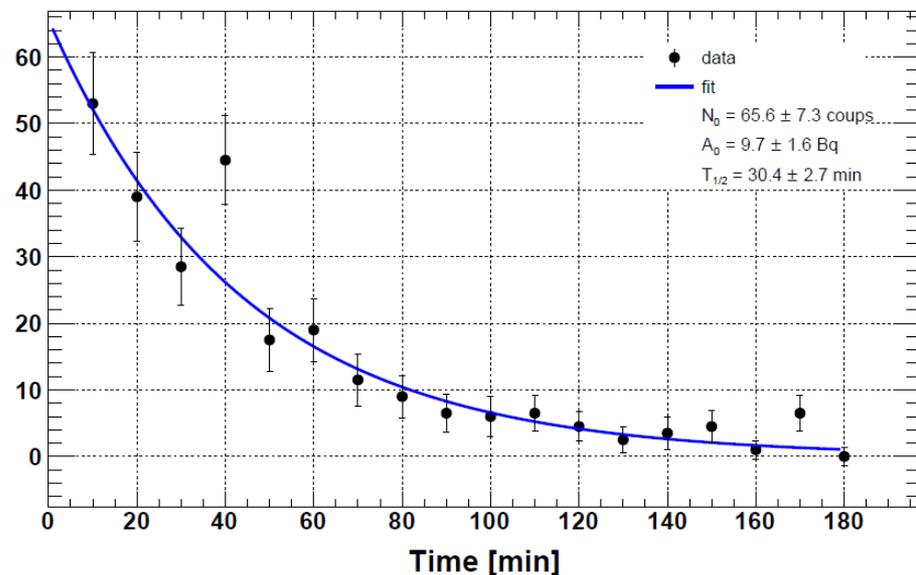
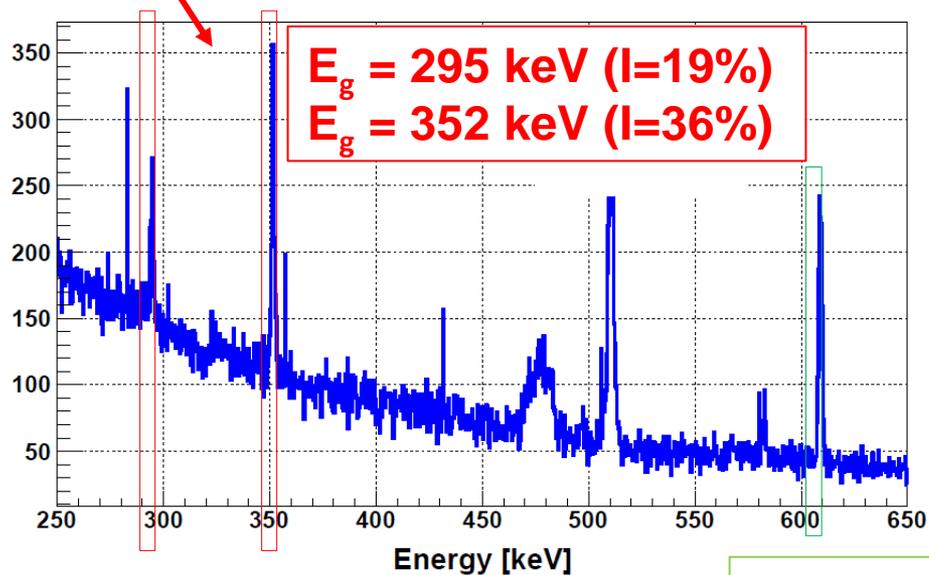


# RESULTS – 80 BQ/M3 – 1H05



Sample Description	Sample Composition
T-shirt blue [Omexom]	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/m<sup>3</sup> of Radon 222. Measured 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

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

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

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

RE - Positions	Rdt (%)
$^{214}\text{Pb}$ - contact	~10%
$^{214}\text{Bi}$ - contact	~12,5%
$^{60}\text{Co}$ – @ 5 cm	3,2%

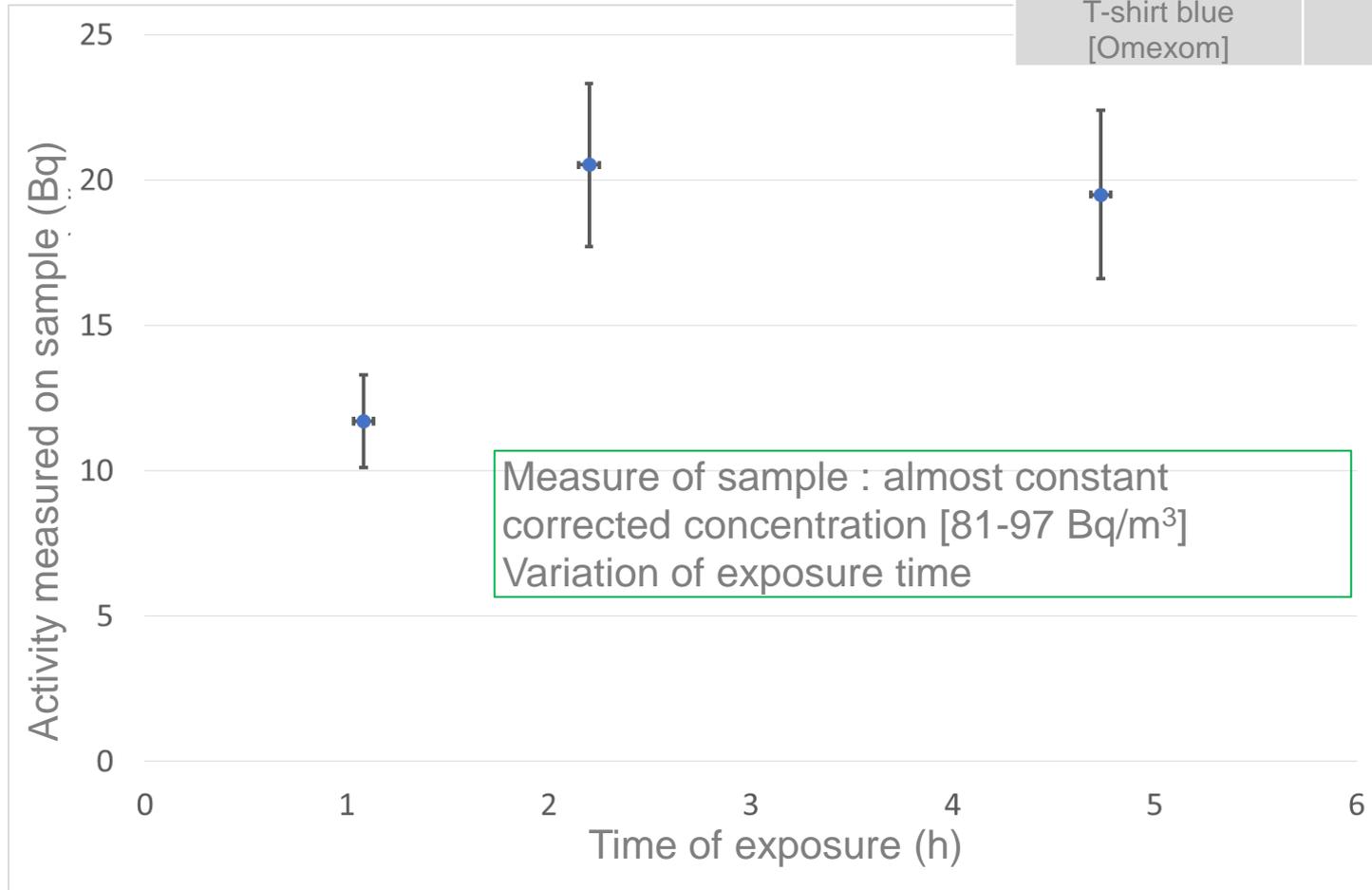
- **Hypothesis 1:** activity deposited on surface and not uniformly on 7000cm<sup>2</sup> [t-shirt]. Factor measured experimentally [-82/+112 %] and set at 2 .
- Detectors surfaces single/quadruple sum : 485 cm<sup>2</sup> / 1940 cm<sup>2</sup>

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 [ $^{214}\text{Pb}$ ]	0,134	4,2	10,5
7,8 Bq [ $^{214}\text{Bi}$ ]	0,135	4,2	10,6
<b>TOTAL</b>		<b>8,4</b>	<b>21,1</b>

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

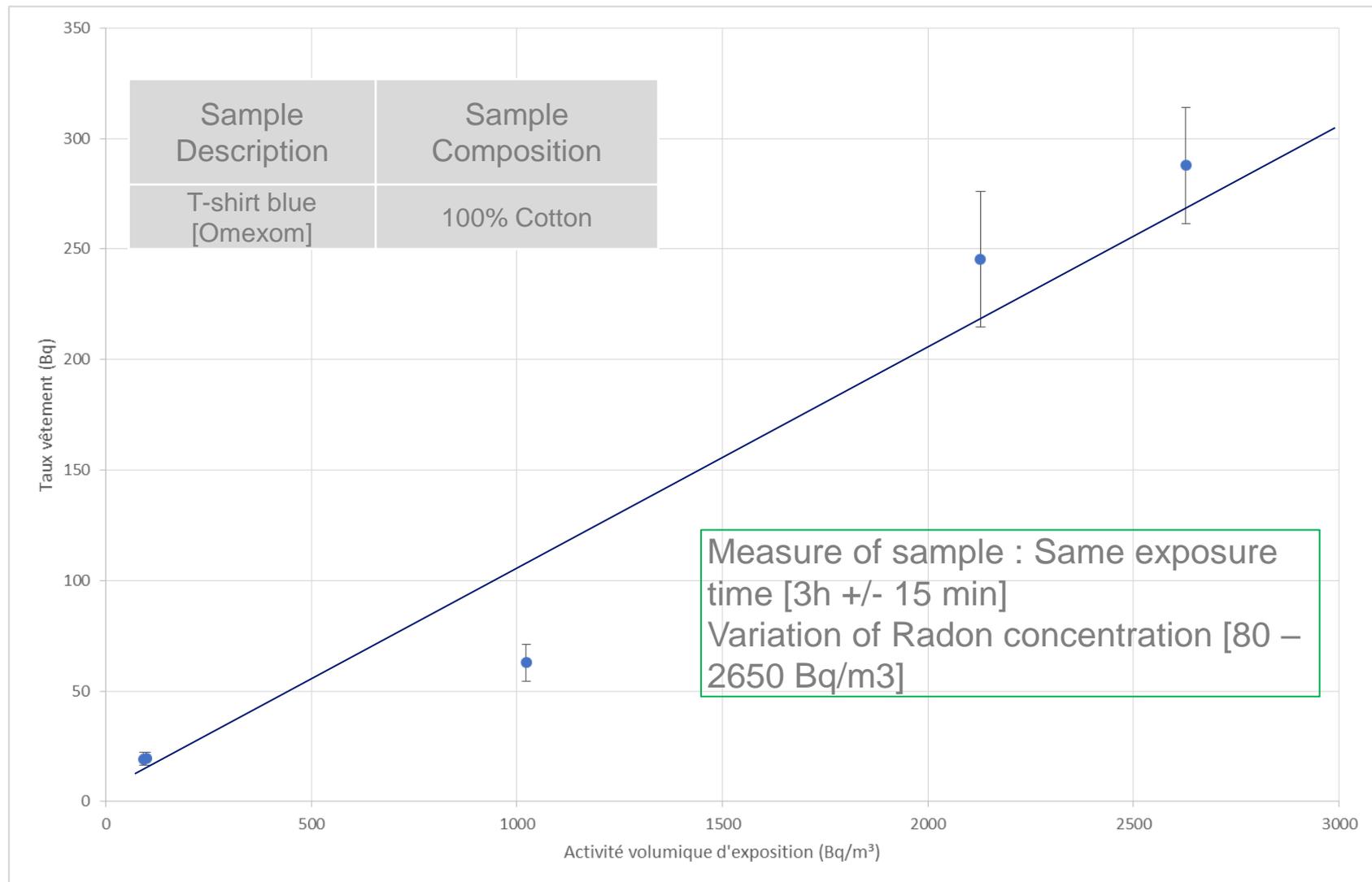
# GENERAL RESULTS

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



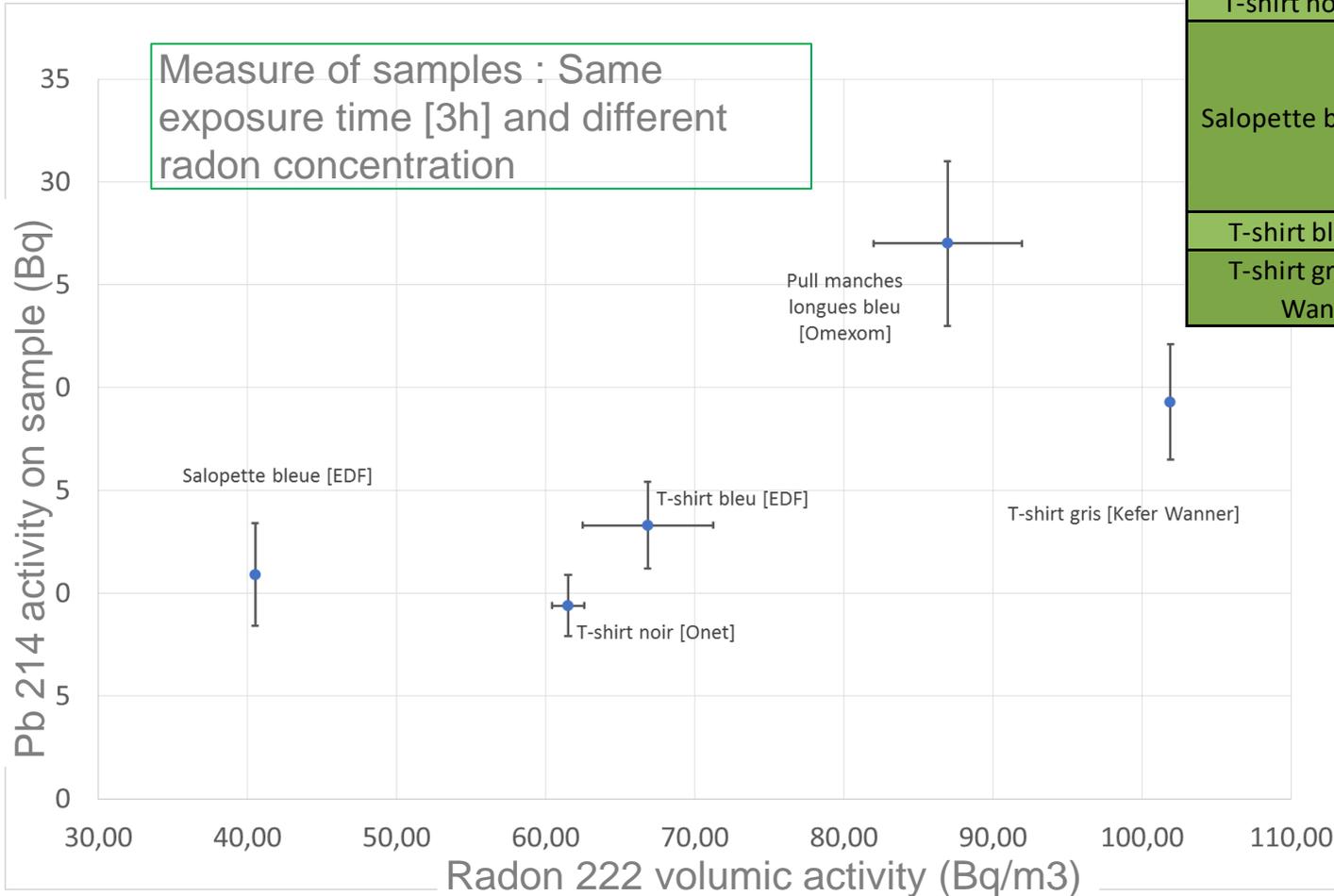
- Activity measured grows up to 1h45 - 2h of exposure and stay stable

# GENERAL RESULTS



- Almost linear relation between activity of progeny and radon concentration

# GENERAL RESULTS

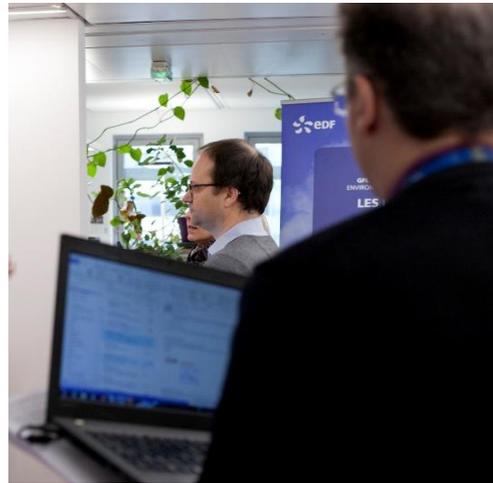
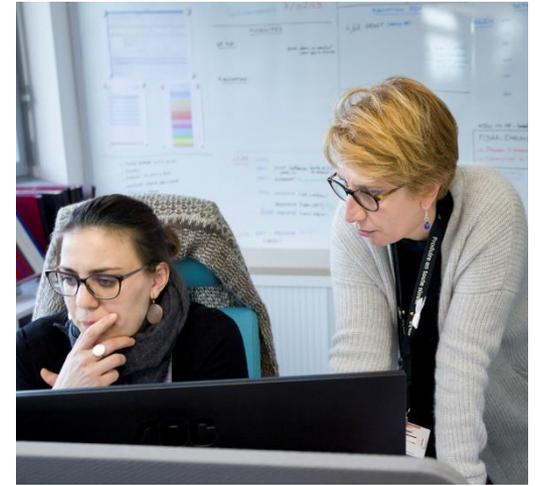


Pull manches longues bleu [Omexom]	80% Coton / 20% Polyester
T-shirt noir [Onet]	100% Coton
Salopette bleue [EDF]	88% Coton / 12% Fibres synthétiques / Fibres antistatiques
T-shirt bleu [EDF]	100% Coton
T-shirt gris [Kefer Wanner]	85% Coton / 15% Viscose

Activites deposited [214Pb/214Bi]	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

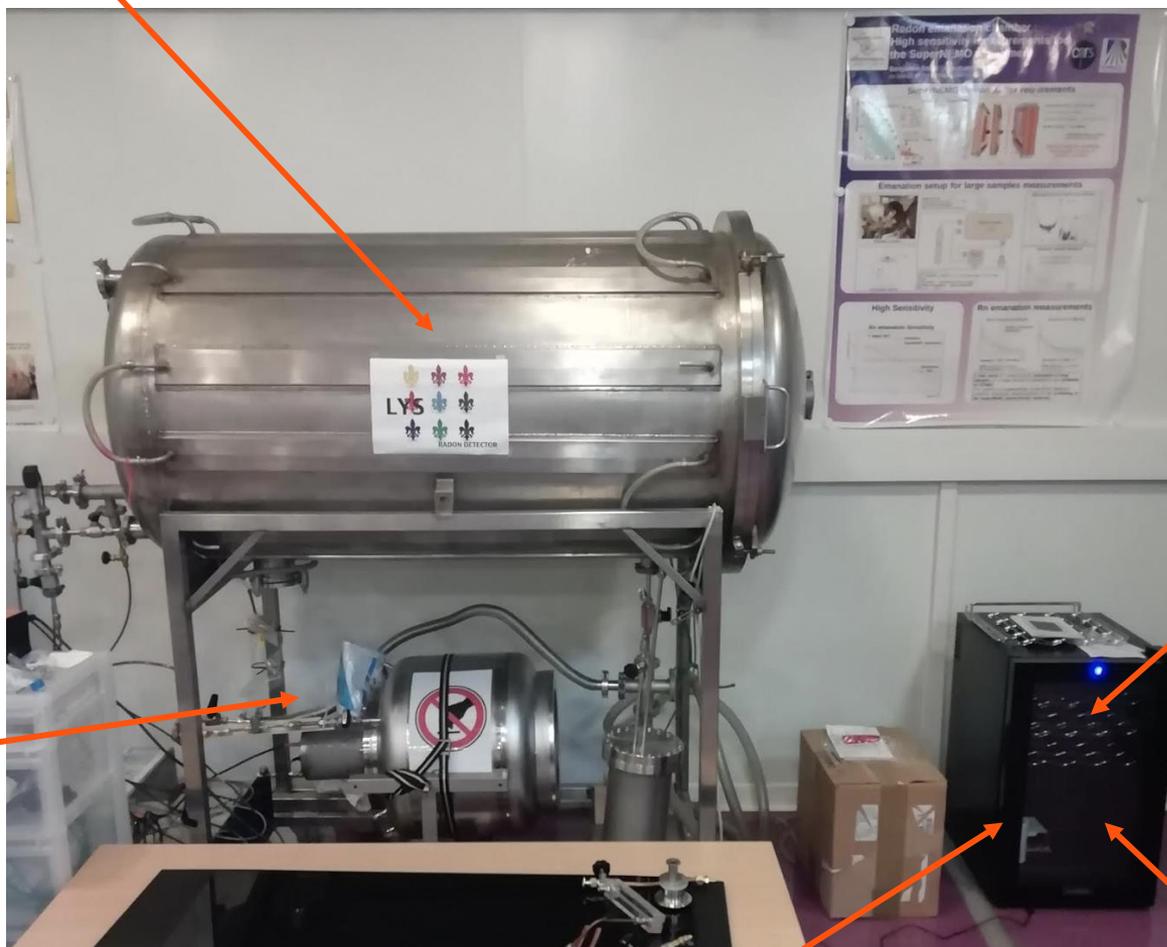
- Deposits of Radon 222 progeny has been observed and measured. **Proportional to Radon concentration**
- **Time of exposure have no effect after 1h45**
- **Most important impact are expected on :**
  - Qadruple sum – Beta channels [from 350 Bq/m<sup>3</sup> (Rn222)] - **S<sub>A</sub> = 400 Bq**
  - Single – Beta channels [from 530 Bq/m<sup>3</sup> (Rn222)] - **S<sub>A</sub> = 200 Bq**
  - Gamma channels [from 3000 Bq/m<sup>3</sup> (Rn222)] - **S<sub>A</sub> = 600/800 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



Déteur Radon  
[2<sup>nd</sup> contrôle]

Déteur Radon  
[1<sup>er</sup> contrôle]

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

Etuve  
d'émanation

# ILLUSTRATIONS

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

## 4 détecteurs HPGe

- Agrément ASN
- Sensibilité < 10mBq/kg
- 300 cm<sup>3</sup>
- Blindés (Pb et Pb archéo.)
- Salle semi-enterrée



## Setup exposition métrologie Radon



# EQUILIBRE 214PB – 214BI

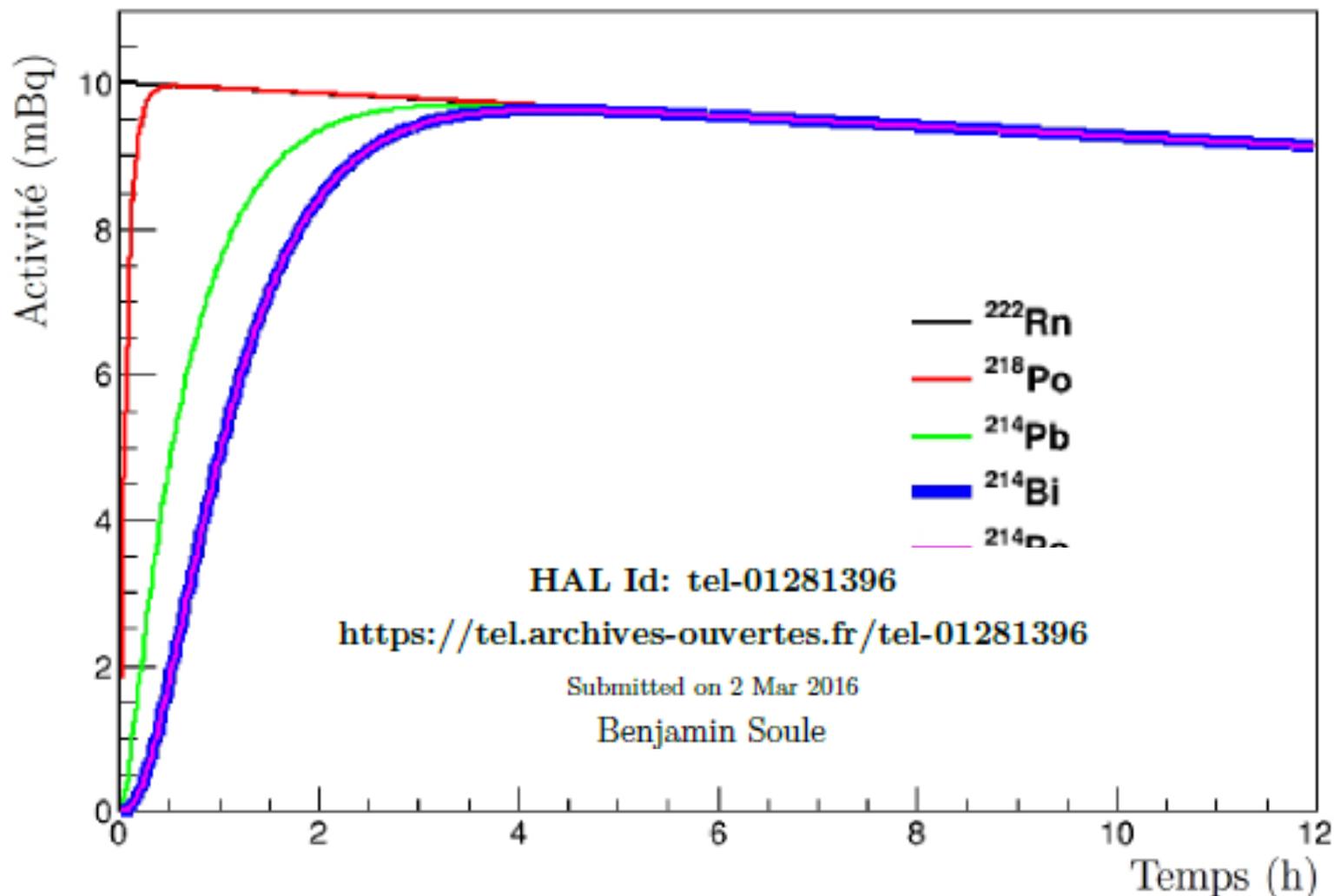


FIGURE 3.4: Activité des différents isotopes de la chaîne radioactive du  $^{222}\text{Rn}$  en fonction du temps après introduction de 10 mBq de  $^{222}\text{Rn}$  dans un volume isolé.