Impact of air ionization on radon daughters

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[1]LPCA, [2]IJCLAB,[3]LMV

Credit: J. Breton †, J.M. Breton, P. Guitton (Teqoya company)

Introduction: LPCA environment team

17 full time staff
1 post-doc
5 PhD student
11 FTE

Radiological analysis of environmental samples

Irradiation / nuclear characterization

Monte-Carlo simulation from micro to nano-scale of naturally radiative ecosystems

GATE

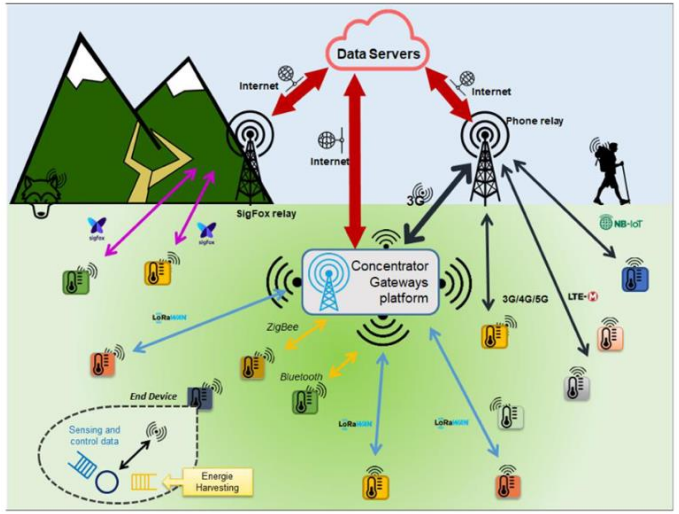
GEANT4-DNA

Big data, from sensor to cloud

IN2P3
2 infinis

Simulation

Deployment of sensor networks



Innovative detector design

radon monitoring in extreme environments

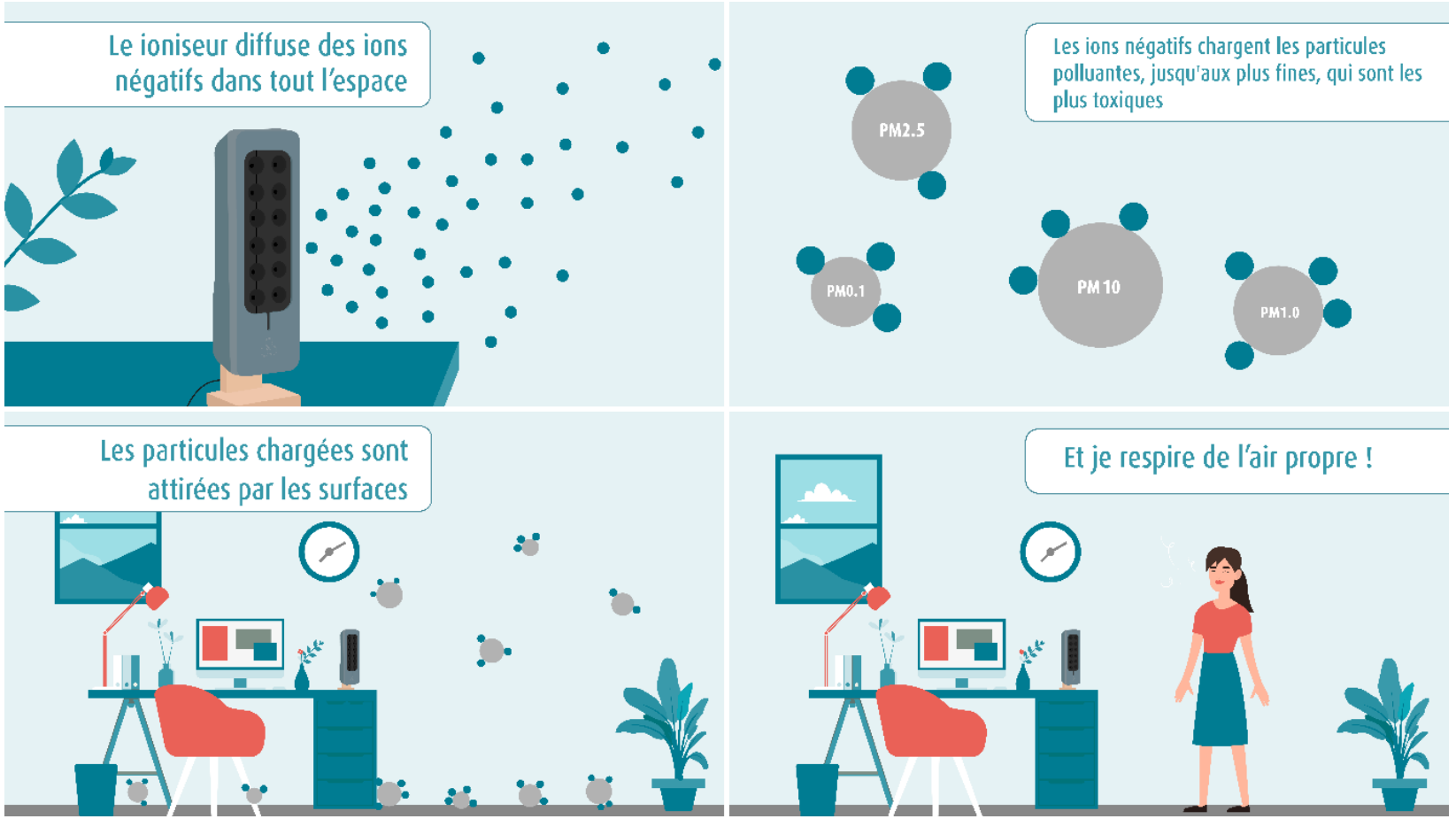
Contexte (1/2)

- Enjeu: mesurer le radon dans les panaches (exposé L. Terray)
- Difficultés: environnement très agressif pour les instruments
  - Pas question de mettre une chambre d'ionisation dans le panache
- Méthodes utilisées à l'Etna
  - Dosimètres passifs
  - Filtration des descendants du radon
- Idées poursuivies au LPCA
  - RAVIOLI: mesure in situ des filtres
  - Calorado/SPAGHETTI : détection des rayonnements γ des descendants du radon

Contexte (2/2)

- L’utilisation des purificateurs d’air s’est développée dans le contexte de l’épidémie de COVID-19
- Plusieurs techniques de purification existent, notamment la production d’ions négatifs
- quel est l’impact d’un ioniseur sur le radon dans la pièce qu’il occupe ?

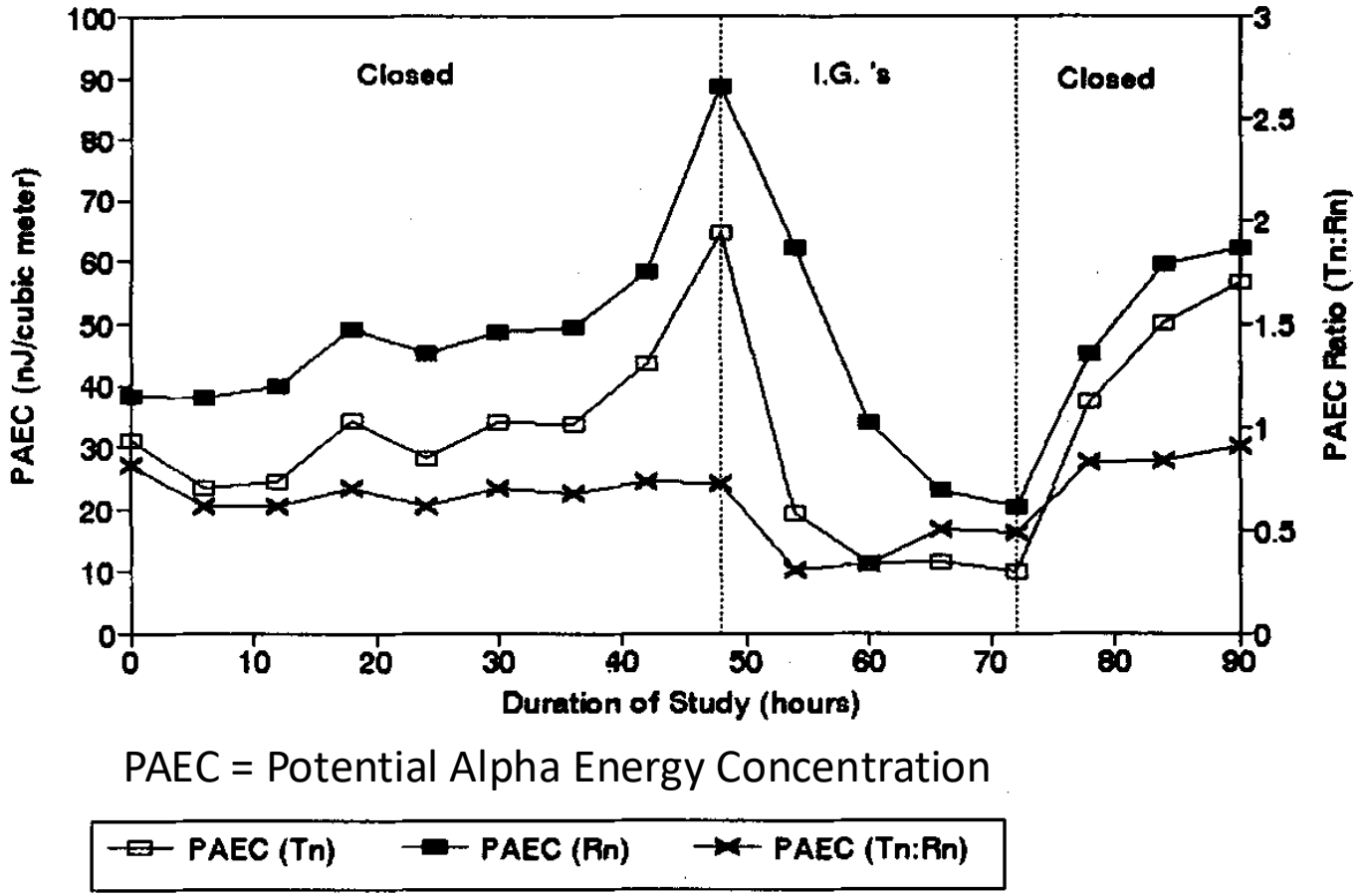
Credit: Teqoya



Hagbom M, Nordgren J, Nybom R, Hedlund KO, Wigzell H, Svensson L. Ionizing air affects influenza virus infectivity and prevents airborne-transmission. Sci Rep. 2015 Jun 23;5:11431. doi: 10.1038/srep11431. PMID: 26101102; PMCID: PMC4477231.

Effect of negative ion generators on radon daughters activity in air

- The impact of ion generators on radon daughters activity in air is known for 40 years
  - But very little recent litterature



PAEC = Potential Alpha Energy Concentration

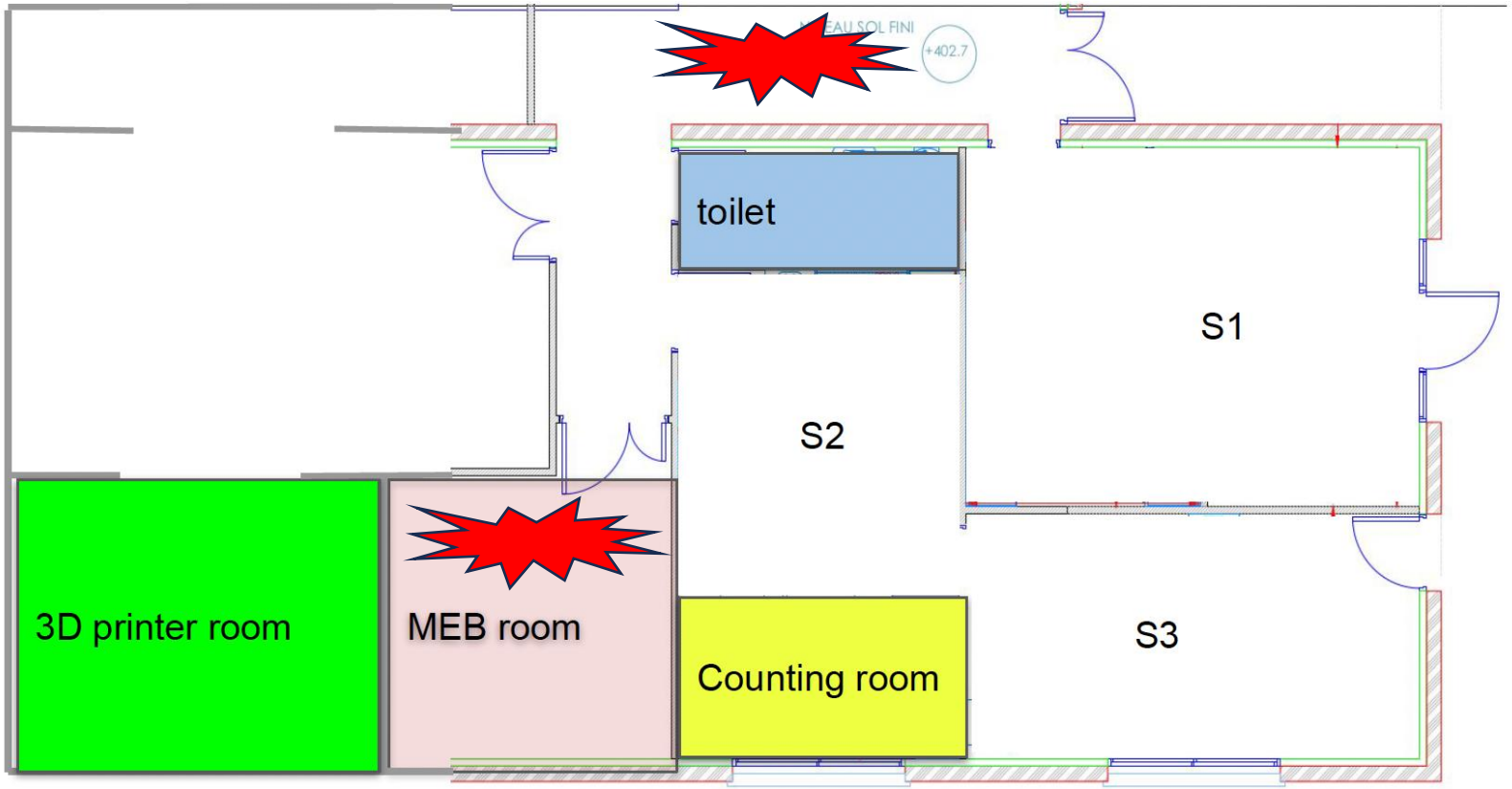
Sheets, Ralph W. and Christopher C. Thompson. “Effects of negative ion generators on radon- and thoron-progeny concentrations in an occupied residence.” Journal of Radioanalytical and Nuclear Chemistry 193 (1995): 301-308.

LPCA experimental rooms and instruments

= rooms where impact of air ionization was measured

ORT-MPC-9604
Alpha/Beta Counting
Multi-Detector System

iSolo – MIRION technologies

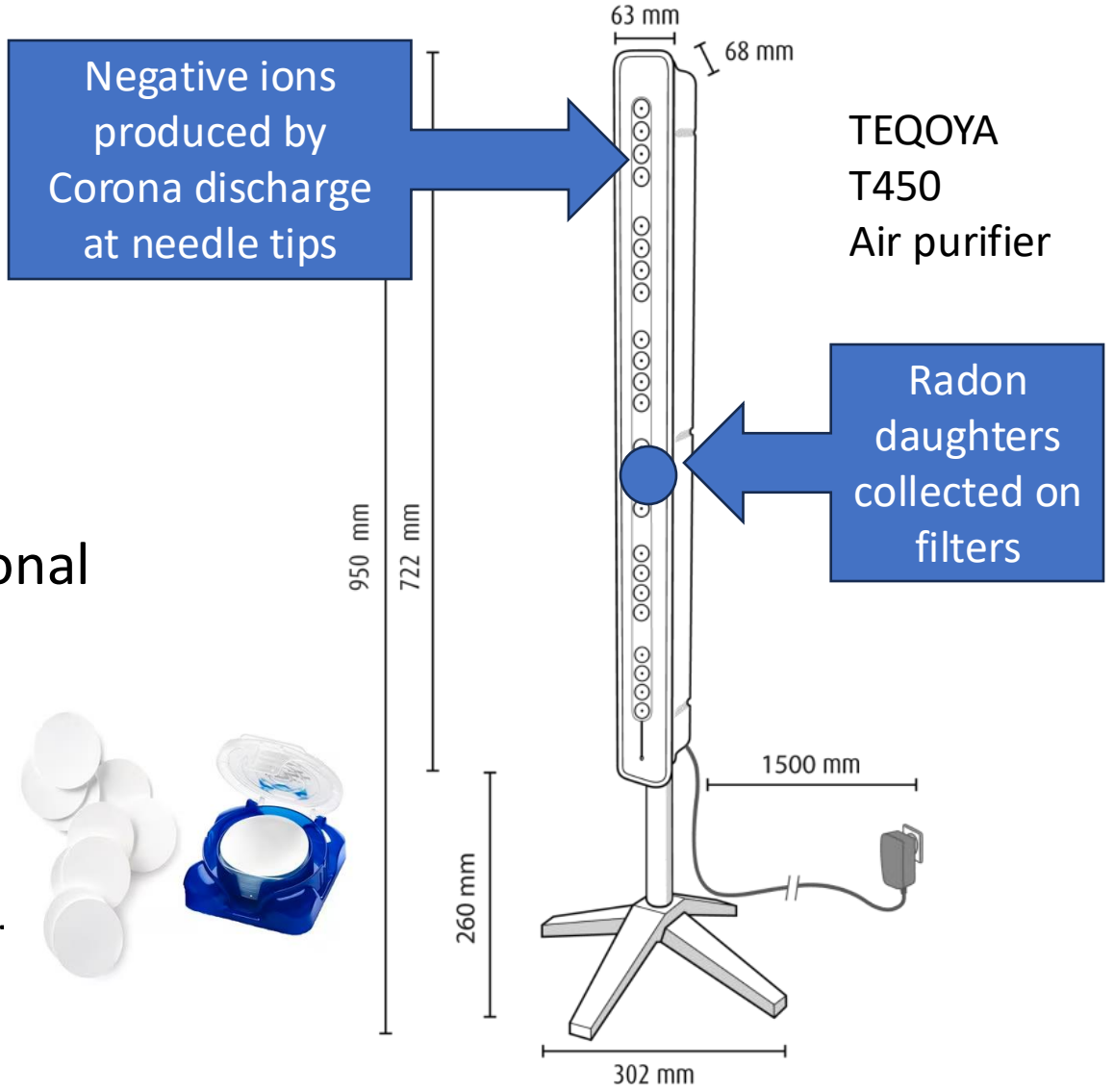


High Resolution Germanium spectrometer

Liquid scintillation detector

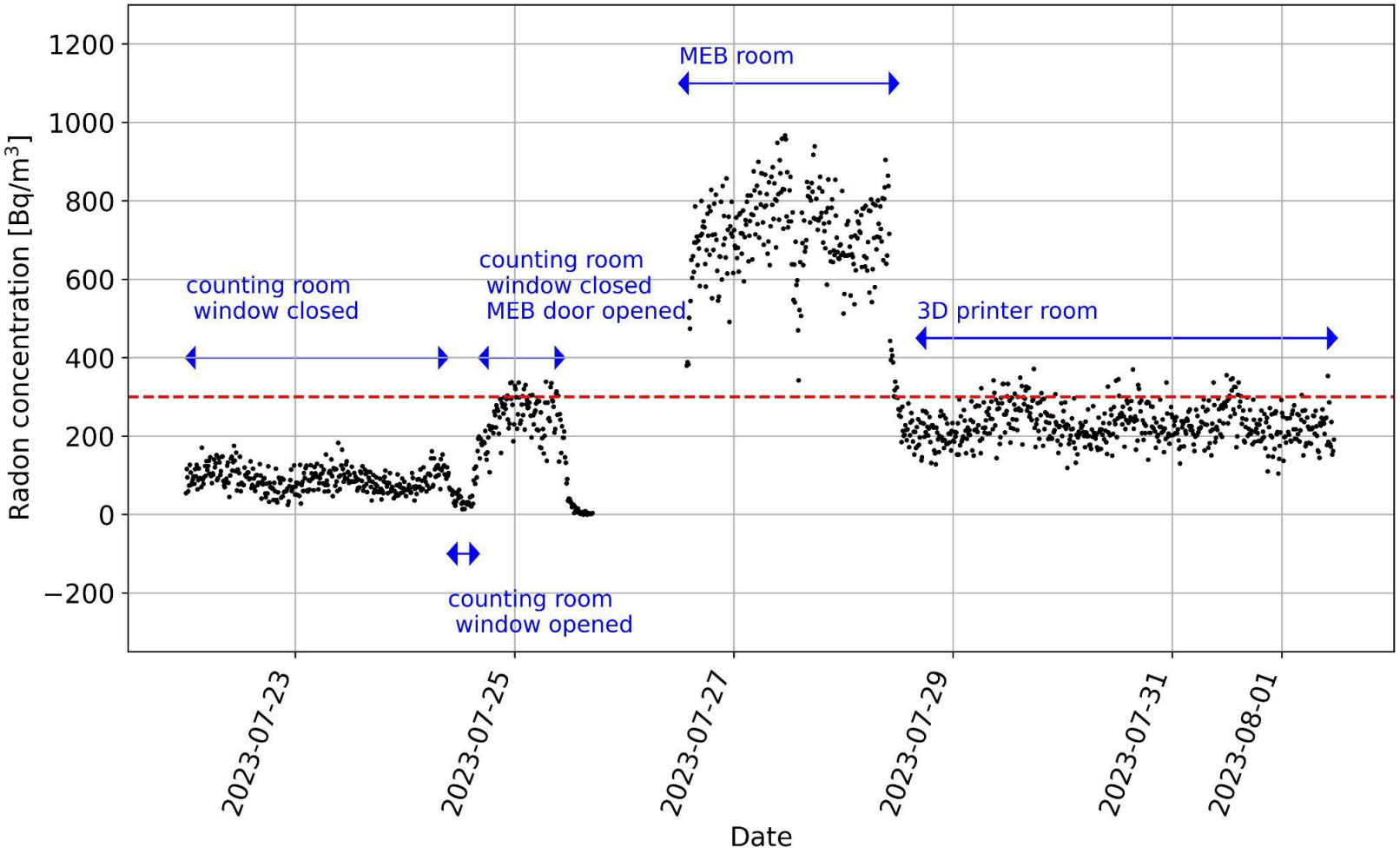
Material and methods

- Nuclear measurements
  - AlphaGuard (Bertin)
  - Radon Eye (FTLab, South Korea)
  - iSolo (PIPS from Mirion, 1 channel)
  - MPC (alpha global and beta global proportional counter - 4 channels, ORTEC)
  - COLIBRI (Mirion)
- Negative ion generators
  - Commercial model (TEQOYA T450)
  - Portable device developed at IJCLAB (D. Bre
- Radioactive aerosol collection on filters
  - Filters used for air sampling
  - Cellulose Acetate fibers filter
  - PolyTetraFluoroEthylene membrane filter



Production of negative ions	density of 450 000 per cm^3 at 1m from the device emission 3000 billion e- per second

Radon background in LPCA extension is significant



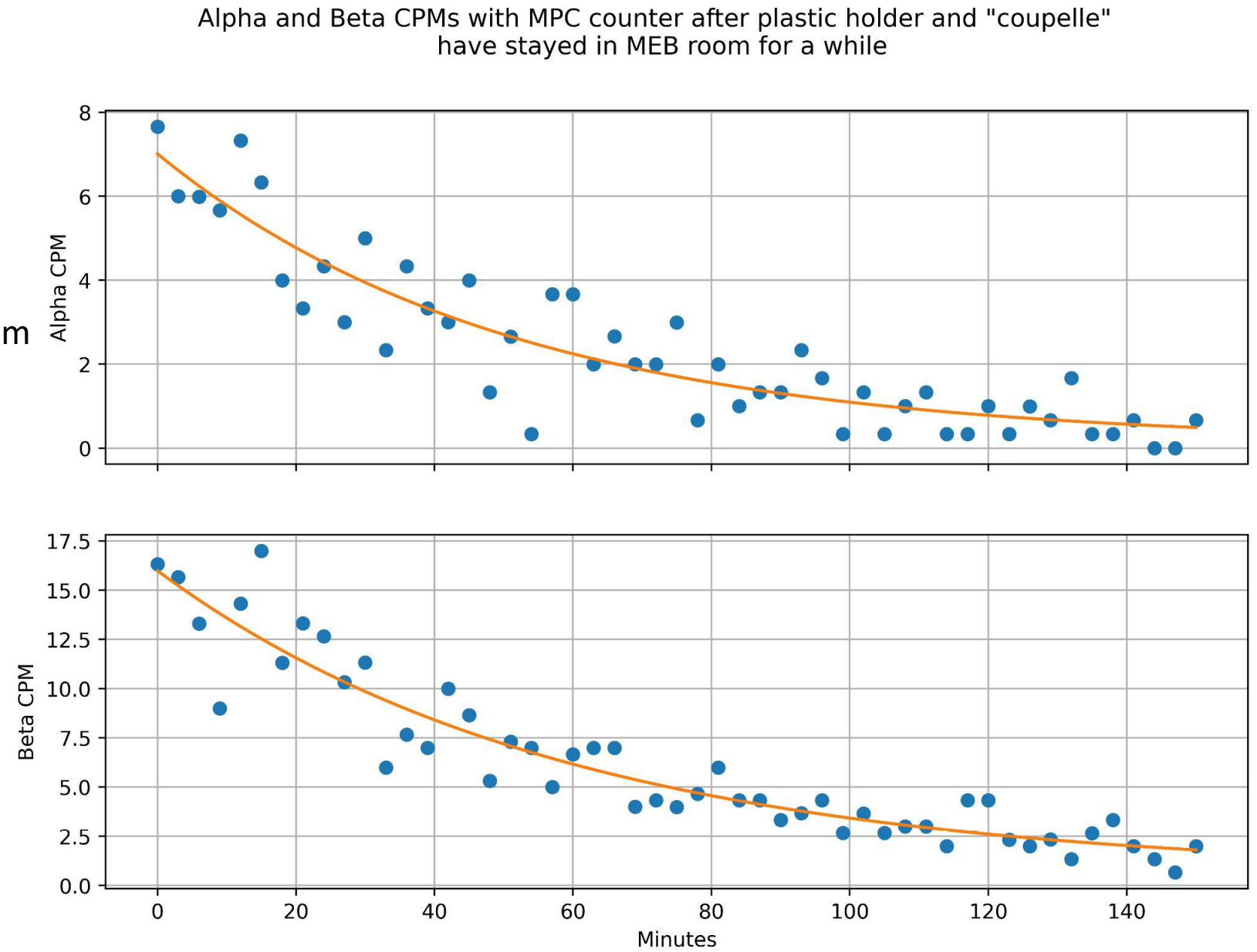
Actions taken to reduce radon contamination:

- radon continuous monitoring in the counting room
- MEB room door kept closed
- air circulation
- nitrogen injection inside HPGe spectrometer shielding

Credit: E. Busato

From background to signal…

α and β activities measured in a steel plate left several minutes in the MEB room



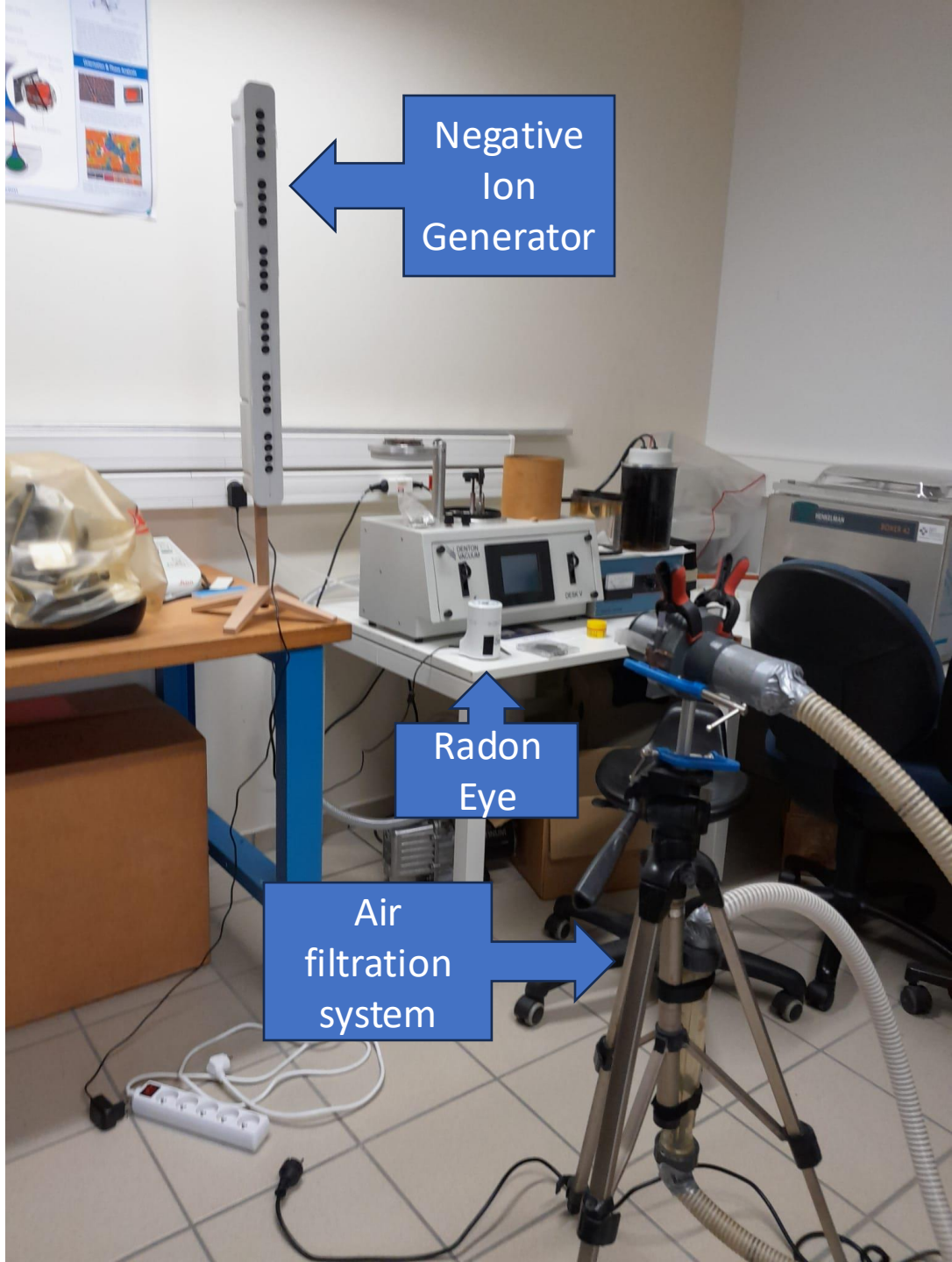
Credit: E. Busato

Experimental method

- Radioactive aerosol sampling by filtration
  - 12 m^3/h vacuum pomp flowrate
  - 2 minute pumping duration

- Radon activity constantly monitored using Radon Eye

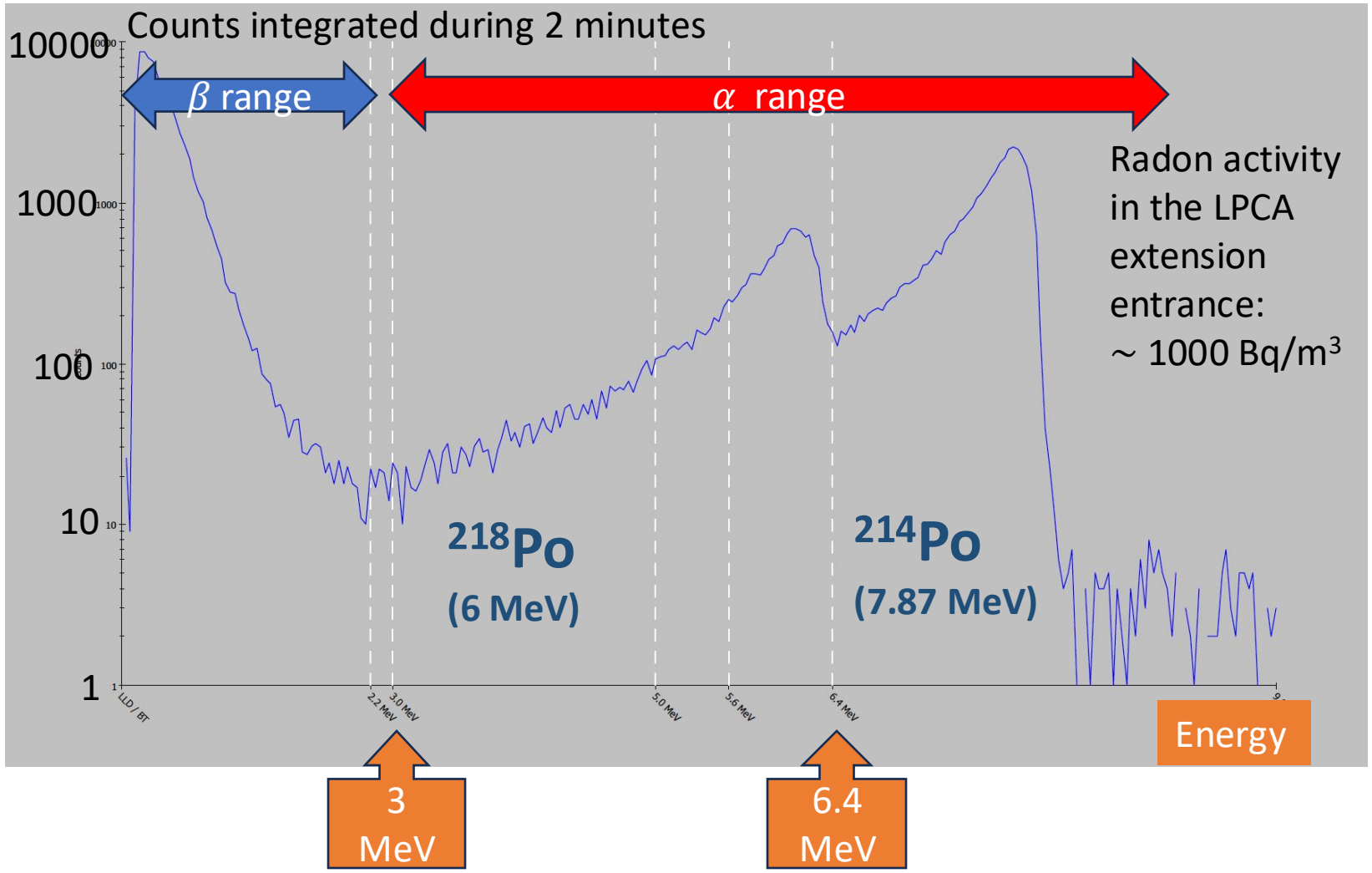
=> radon activity NOT impacted by Negative Ion Generator operation



Significant deposit of radon daughters on Negative Ion Generator

Teflon filter placed 8 hours on top of Negative Ion Generator (NIG) upper needles in LPCA extension entrance

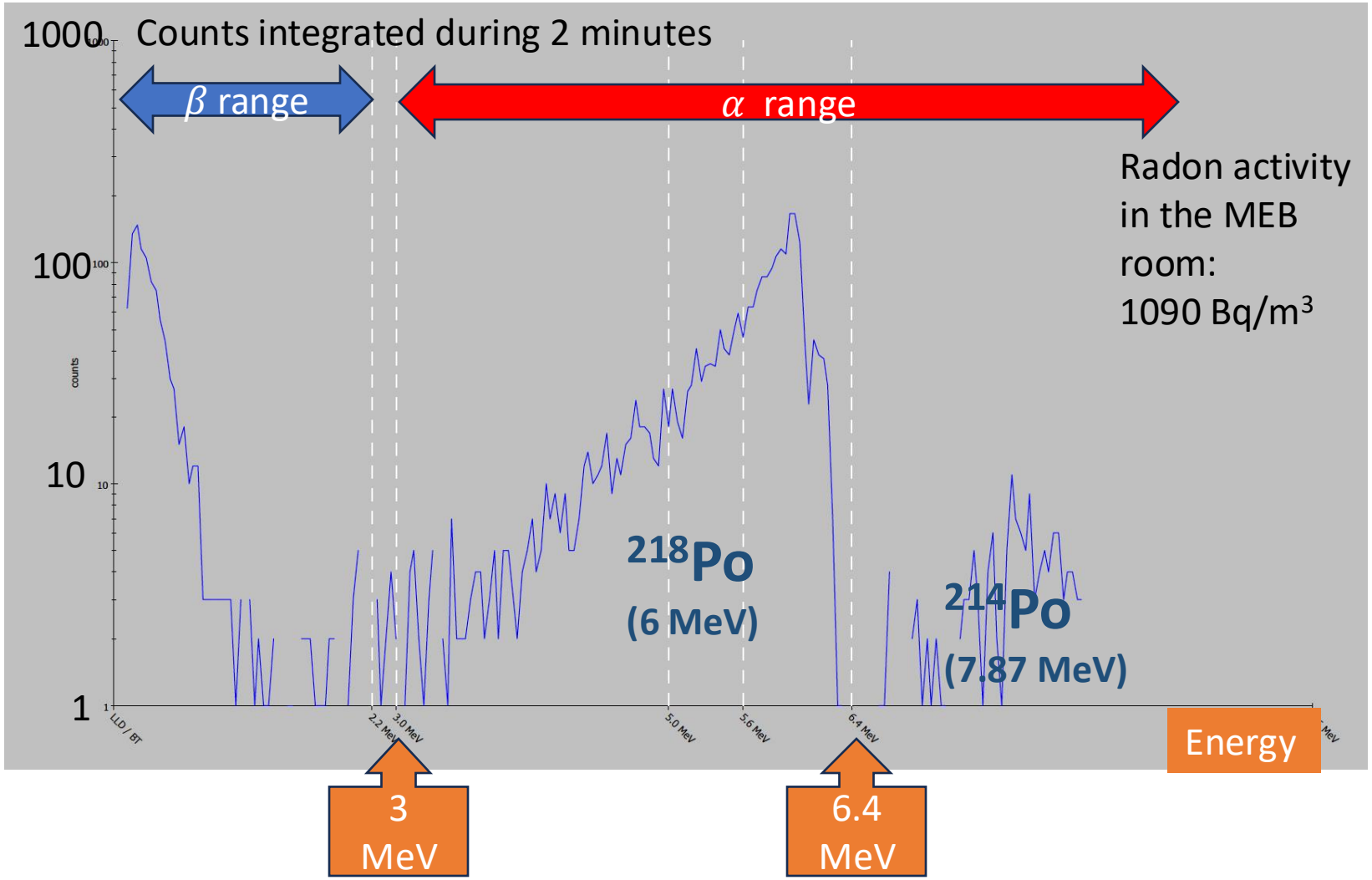
iSolo measurement started one minute after filter removal from NIG:
- α activity: 1600 Bq
- β activity: 1600 Bq



Significant deposit of radon daughters on Negative Ion Generator

Steel plate placed one minute on top of Negative Ion Generator (NIG)
Needles in the MEB room

iSolo measurement started one minute after steel plate removal from NIG:
- α counting rate: 115 counts per second
- β counting rate: 20 counts per second



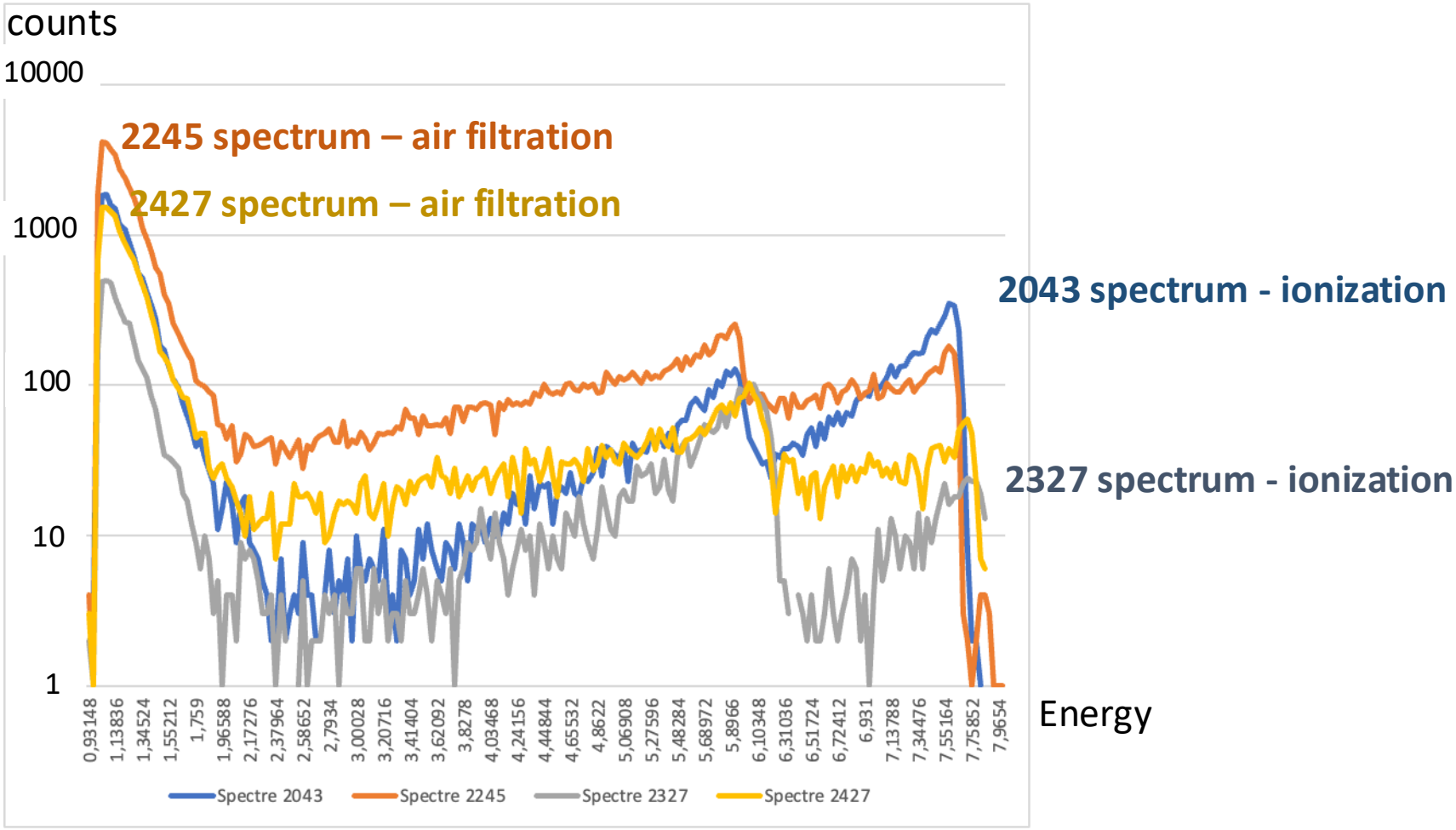
Spectra sampled on cellulose acetate filters on negative ion generator and by air filtration

Spectra 2245 and 2427 using an air filtration system

Spectra 2043 and 2327 by collection on the Negative Ion Generator

Radon daughters deposit by air filtration penetrates in the filter

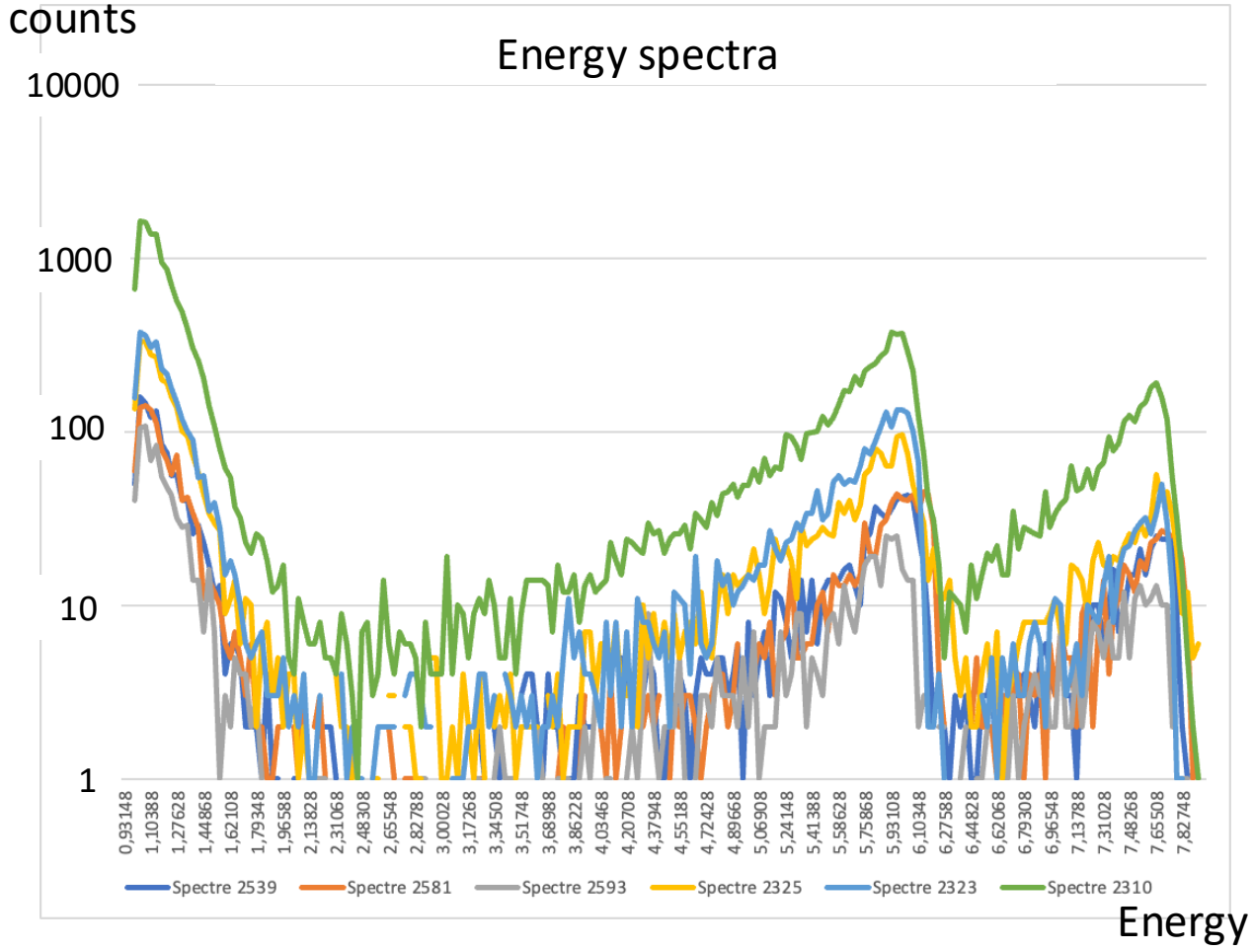
Radon daughters deposit by ionization occurs at the surface of the filter



Luca Terray et al, A simulation-driven spectrometric method to determine α particle attenuation in air filters. *Radiation Measurements*, Elsevier, 2022, 150, pp.106684. ⟨10.1016/j.radmeas.2021.106684⟩. ⟨hal-03531929⟩

Spectra from PTFE (Teflon) filters on negative ion generator and by air filtration

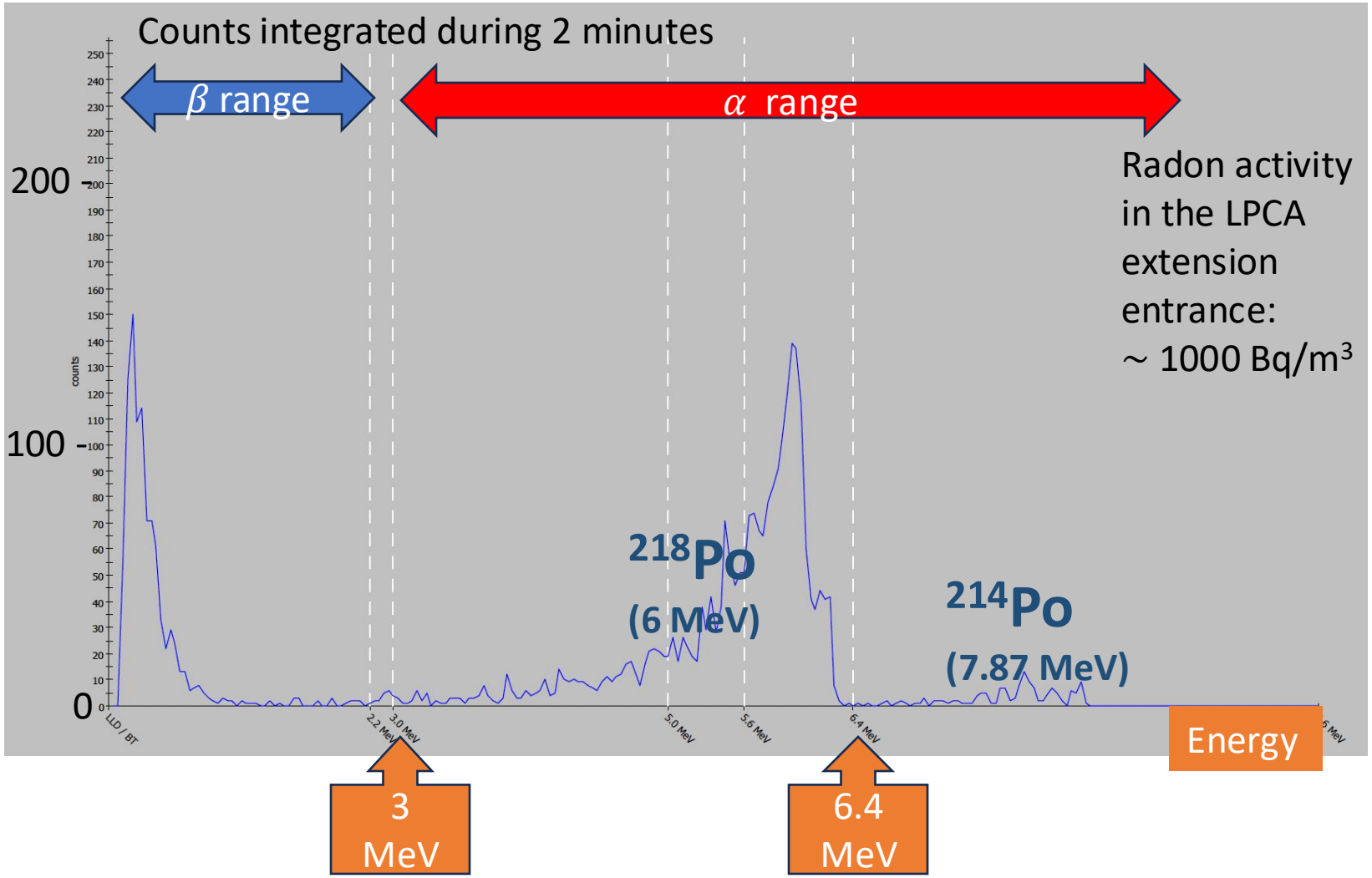
In both cases, radon daughters are deposited at the surface of the filter



Is the ionizer only collecting ^{218}Po ?

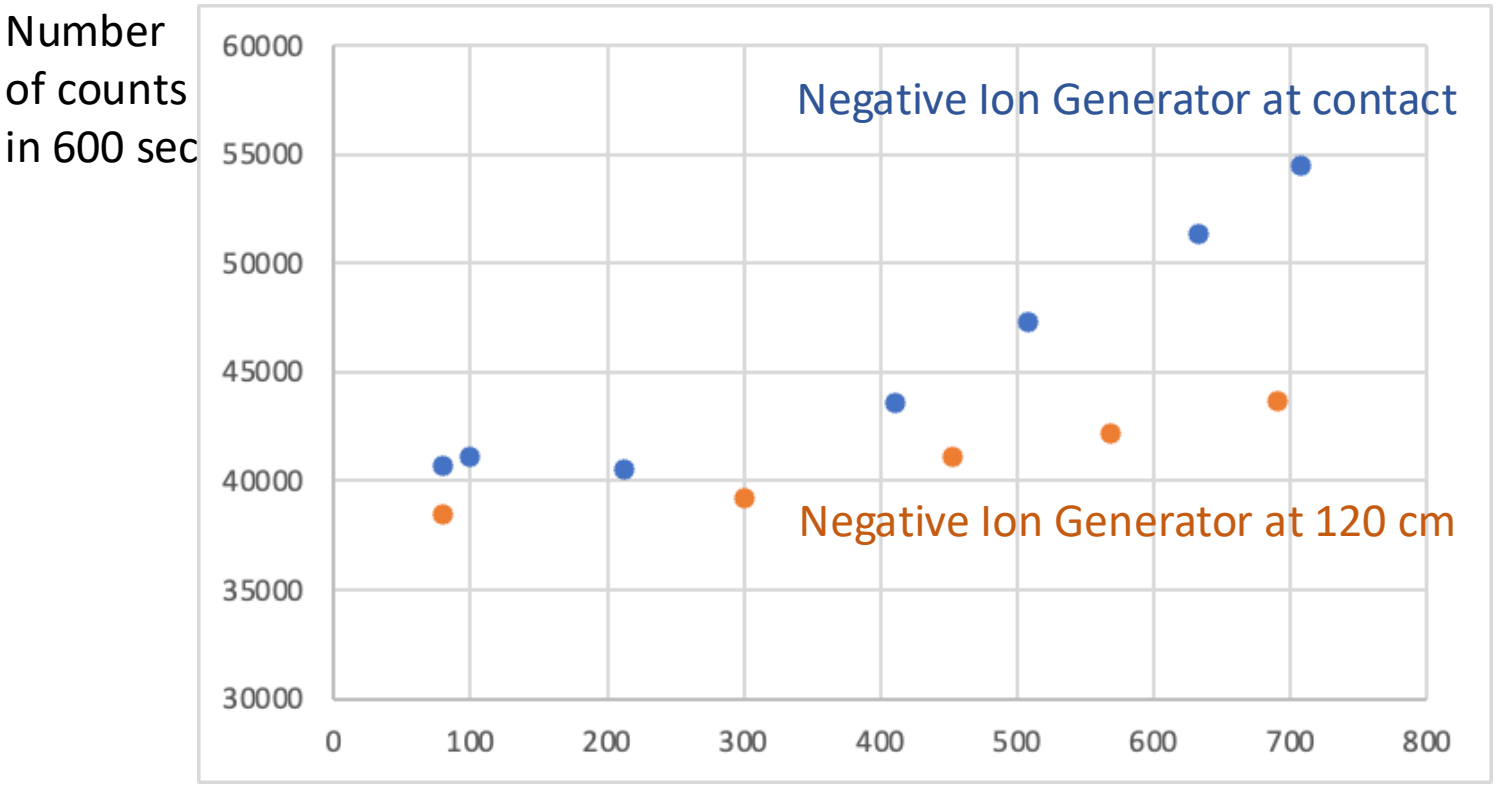
Steel plate placed one minute on top of Negative Ion Generator (NIG) needles in LPCA extension

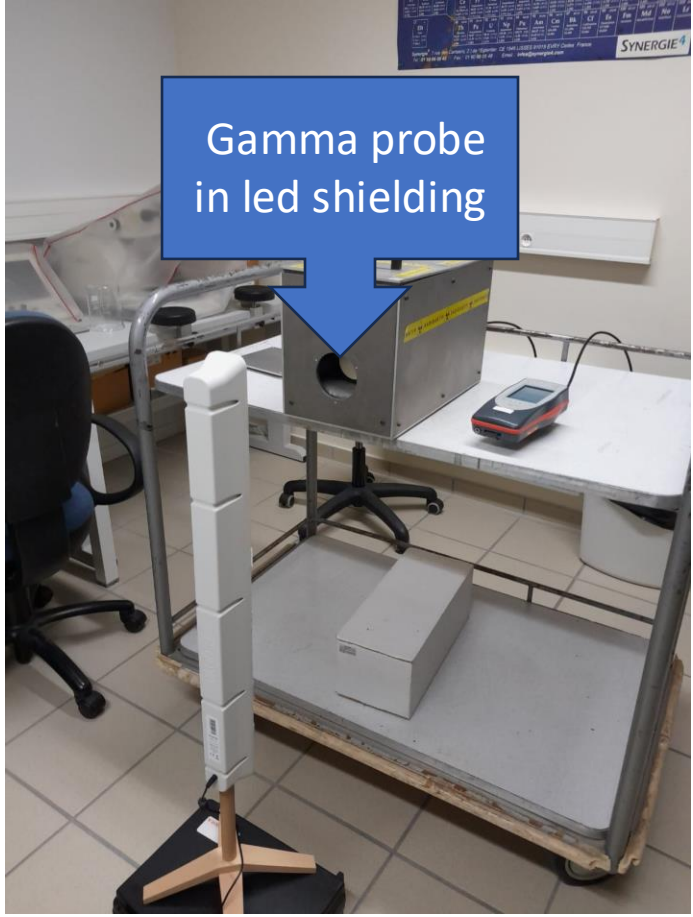
iSolo measurement started one minute after steel plate removal from NIG:
- α activity: 100 Bq
- β activity: 25 Bq



Measurements of γ signal on the Negative Ion Generator

Very preliminary…

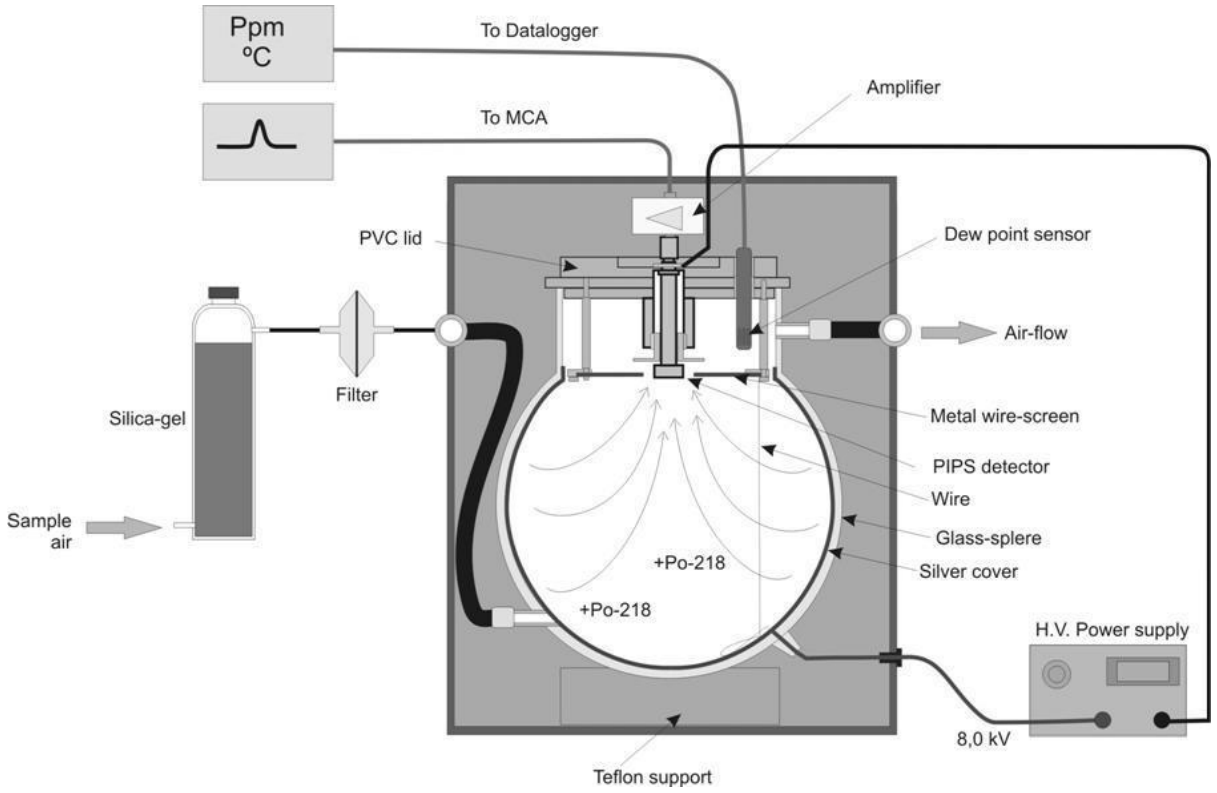


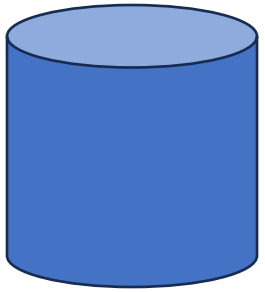


COLIBRI et Gamma Probe SG-2R – MIRION technologies

Conclusion and perspectives

- We observe indoor and outdoor a very significant excess of radon daughter deposit on Negative Ion Generator
- Interesting method to collect radon daughters in situ ?
  - Technically simple/robust
  - Interest for measuring radon in extreme environments ?
- Many questions/issues to be solved:
  - Quantification
  - Impact of humidity





Energy
Energy

Results from iSOLO: time-dependence of Rn daughters

$^{214}Po = {}^{214}Bi$