

Gamma background in the Laboratoire Souterrain de Modane

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Why do we care about radionuclides in the surrounding rock and concrete?

Dark matter:

- U and Th produce **neutrons** via spontaneous fission or via $\alpha + \text{light nuclei} \rightarrow n$
- Even if gammas are relatively well discriminated from nuclear recoils, gamma-induced background is an issue for large mass detector:
From V. Tomasello et al :
 - 19400 single electron recoils/year in 104 kg of Ge, $E_r=10\text{-}50$ keV, beyond 3 m thick water shield (U, Th and K from rock and concrete)

Need \Rightarrow Shield optimization (water + lead)

Selection of concrete ingredients (“30 cm concrete contributes more than 99% of gamma and e^- flux beyond 3 m of water”)

Double beta (tracking plus calorimeter technique):

- Radon in air was the main background source for NEMO III

Composition of the rock in the LSM

Mineralogical composition

Réf: Revue Française de Géotechnique, **12**, pg 57(1979), J.-R Beau *et al* :

« Tunnel Routier du Fréjus: les mesures géotechniques effectués sur le chantier français et leur application pour la détermination et l'adaptation du soutènement provisoire »

Mineral	Content
Phyllite (includes muscovite, chlorite)	20 to 50 %
Calcite	20 to 80 %
Quartz	5 to 30 %
Anthracite, graphite	5%
Pyrite	1%
Feldspath	1%
Epidote	1%



Chemical composition

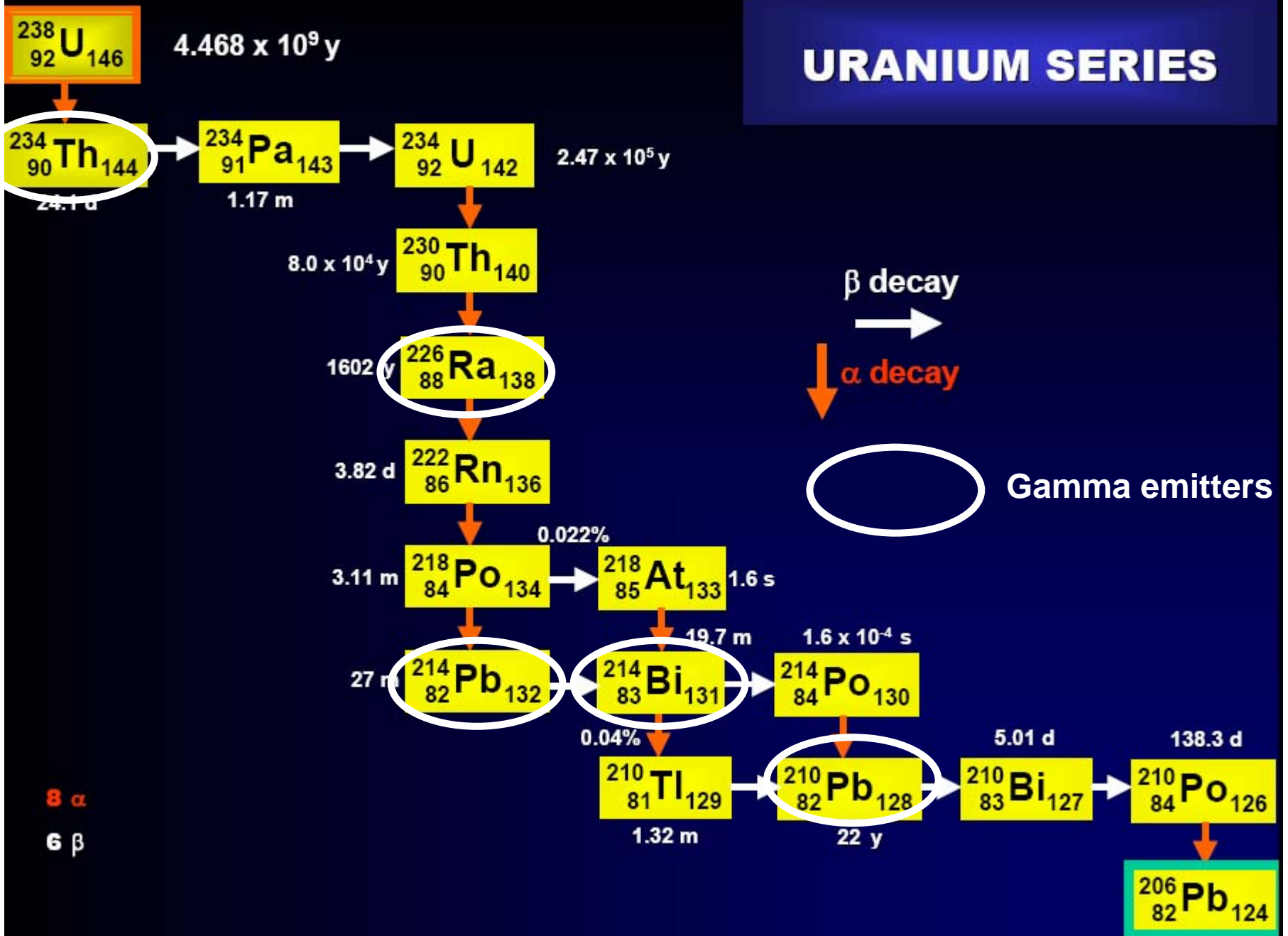
Réf: Astrop. Phys., **9**, pg 163(1998), V. Chazal *et al* :

« Neutron background measurements in the underground laboratory of Modane »

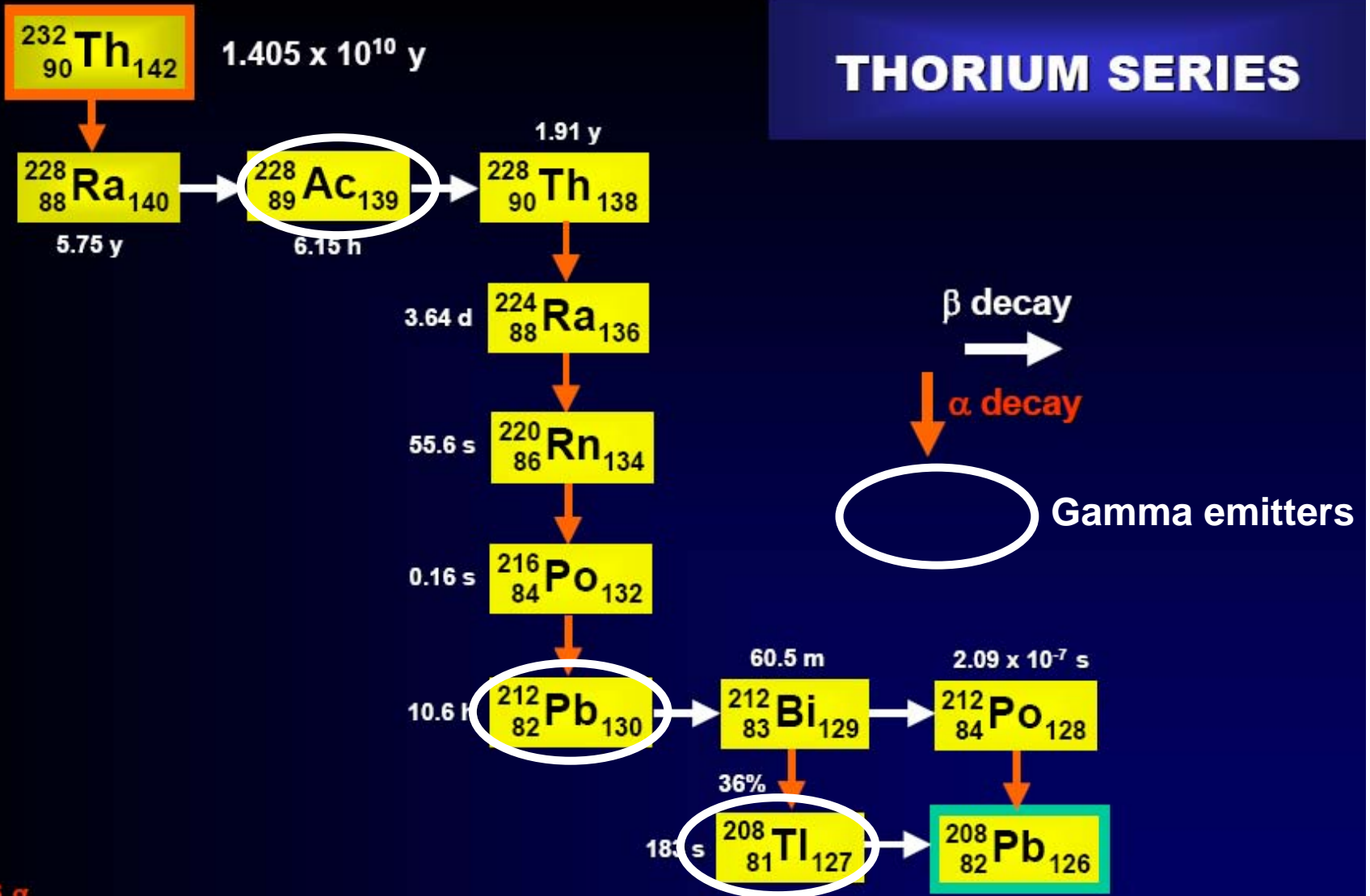
	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	TiO ₂	K ₂ O	Na ₂ O	P ₂ O ₅	Fe ₂ O ₃	w.l.i ^a
Rock	14.9	5.0	0.038	1.4	42.8	0.12	0.25	0.6	0.15	2.8	31.5
Concrete	5.8	1.1	0.008	1.3	51.5	0.17	0.02	0.02	0.15	0.74	38.5

^a w.l.i, weight loss on ignition is the loss of weight after heating 1000°C during few hours

URANIUM SERIES



THORIUM SERIES



6 α

4 β

Gamma background

Measurement of rock samples with a Ge detector:

	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ref.
Concrete	23.5 ± 2.5	5.69 ± 0.82	77.3 ± 13	V. Chazal <i>et al</i>
Rock	10.4 ± 2.5	9.96 ± 0.82	213 ± 30	V. Chazal <i>et al</i>
Rock	11.6 ± 0.4	10.7 ± 0.3	185 ± 5	J. Kisiel <i>et al</i>

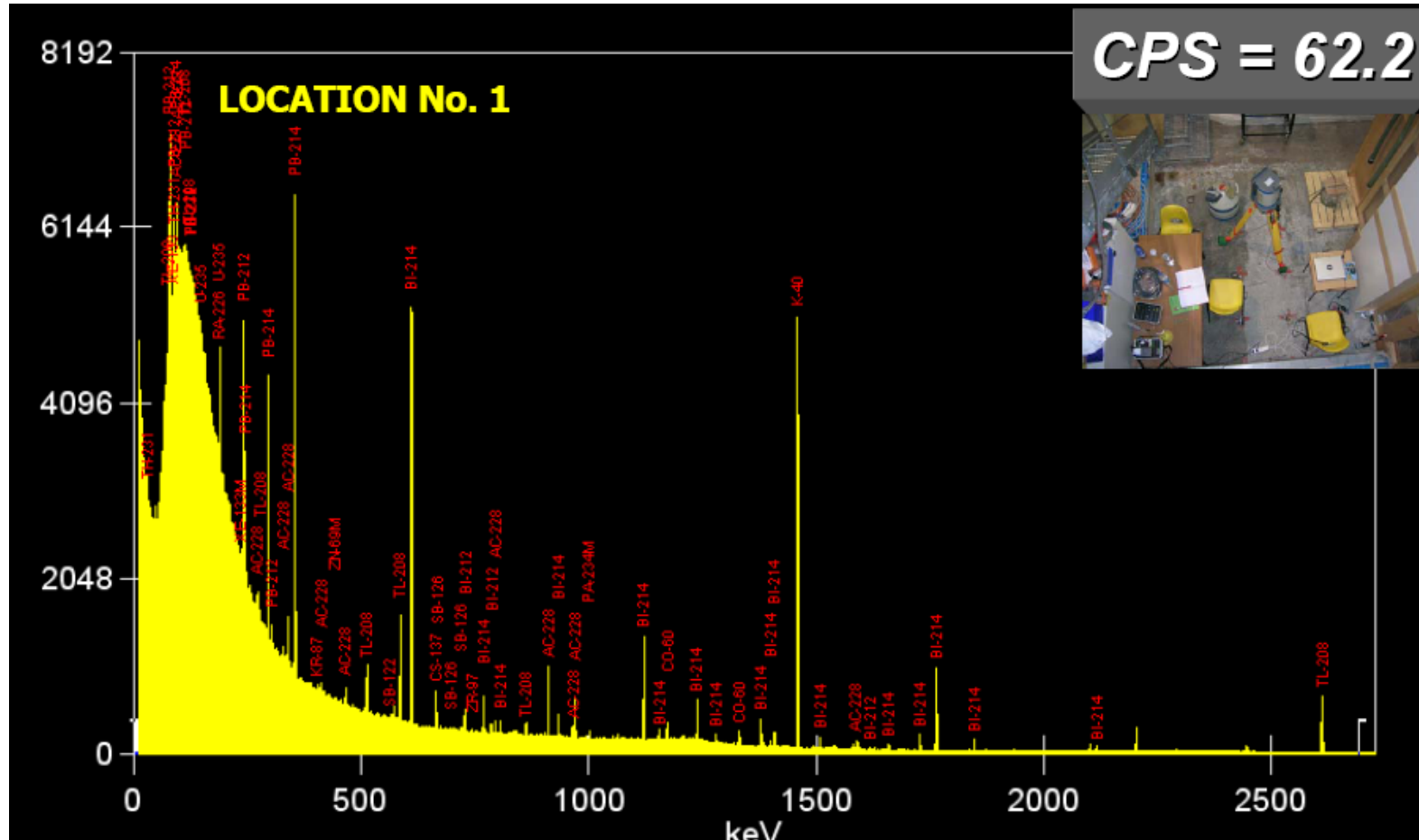
Measurement with a portable Ge detector (averaged over 6 locations in the lab):

	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ref.
	12.3 ± 1.4	4.8 ± 0.9	92 ± 22	J. Kisiel <i>et al</i>

30 cm thick concrete

ILIAS TARI: (2006)

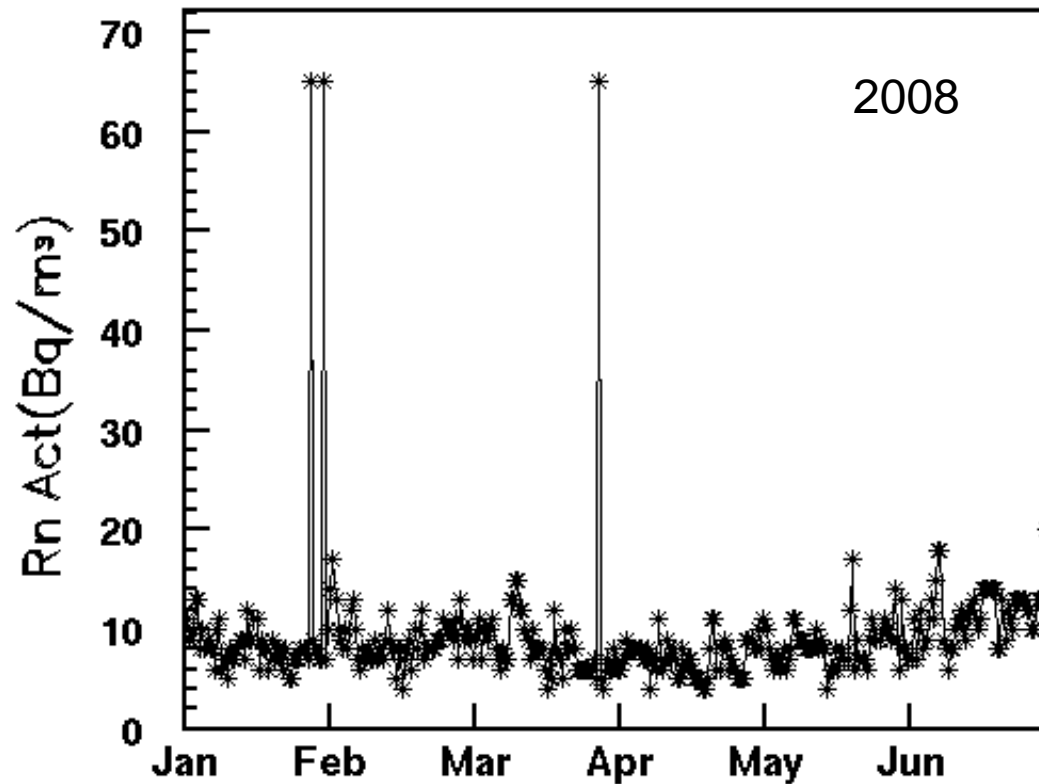
D. Malczewski, J. Kisiel, J. Dorda, University of Silesia, Katowice, Poland
Measurement with a portable Ge in 6 different locations



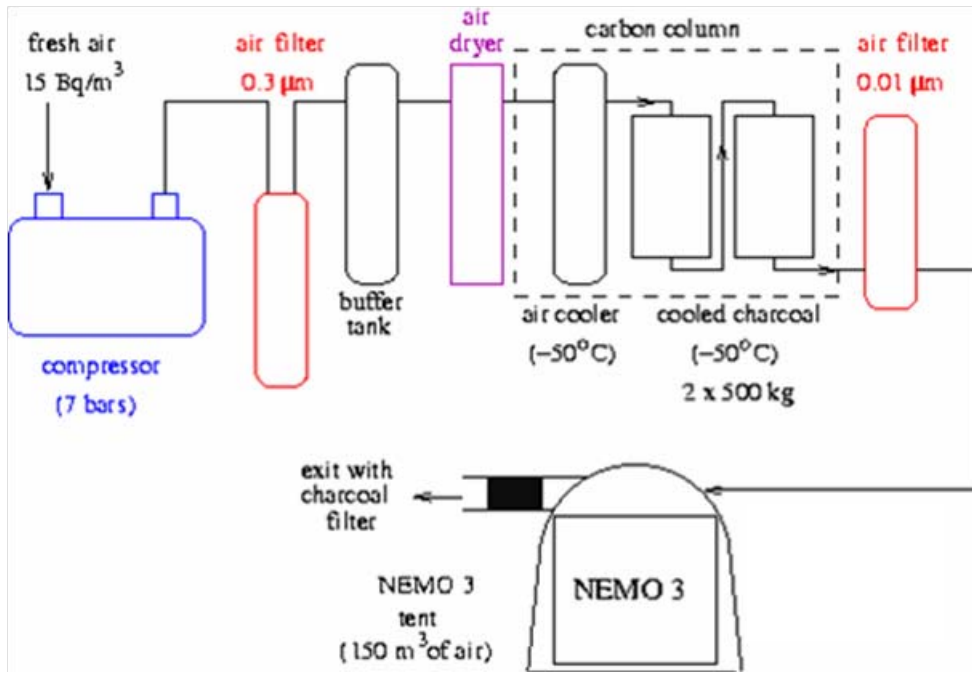
Radon in the laboratory

Ventilation system ensures a full renewal of the air twice per hour

Rn activity: 5 to 15 Bq/m³



Radon reduction facility



Principle:

Time during which radon is trapped in the « filter » : $T_r = K(T) M / Q$

$K(T)$: dynamic adsorption coeff.

M : charcoal mass

Q : Air rate

2 charcoal towers :

$T_1 = -53$ °C, $T_2 = -45$ °C

$M = 2 \times 450$ kg

Same as Kamioka

Output:

Vol. clean air : 125 m³/h

Activity ²²²Rn = 15 mBq/m³

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