Gamma background in the Laboratoire Souterrain de Modane

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

Dark matter:

• U and Th produce **neutrons** via spontaneous fission or via
α + 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=10-50 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 »

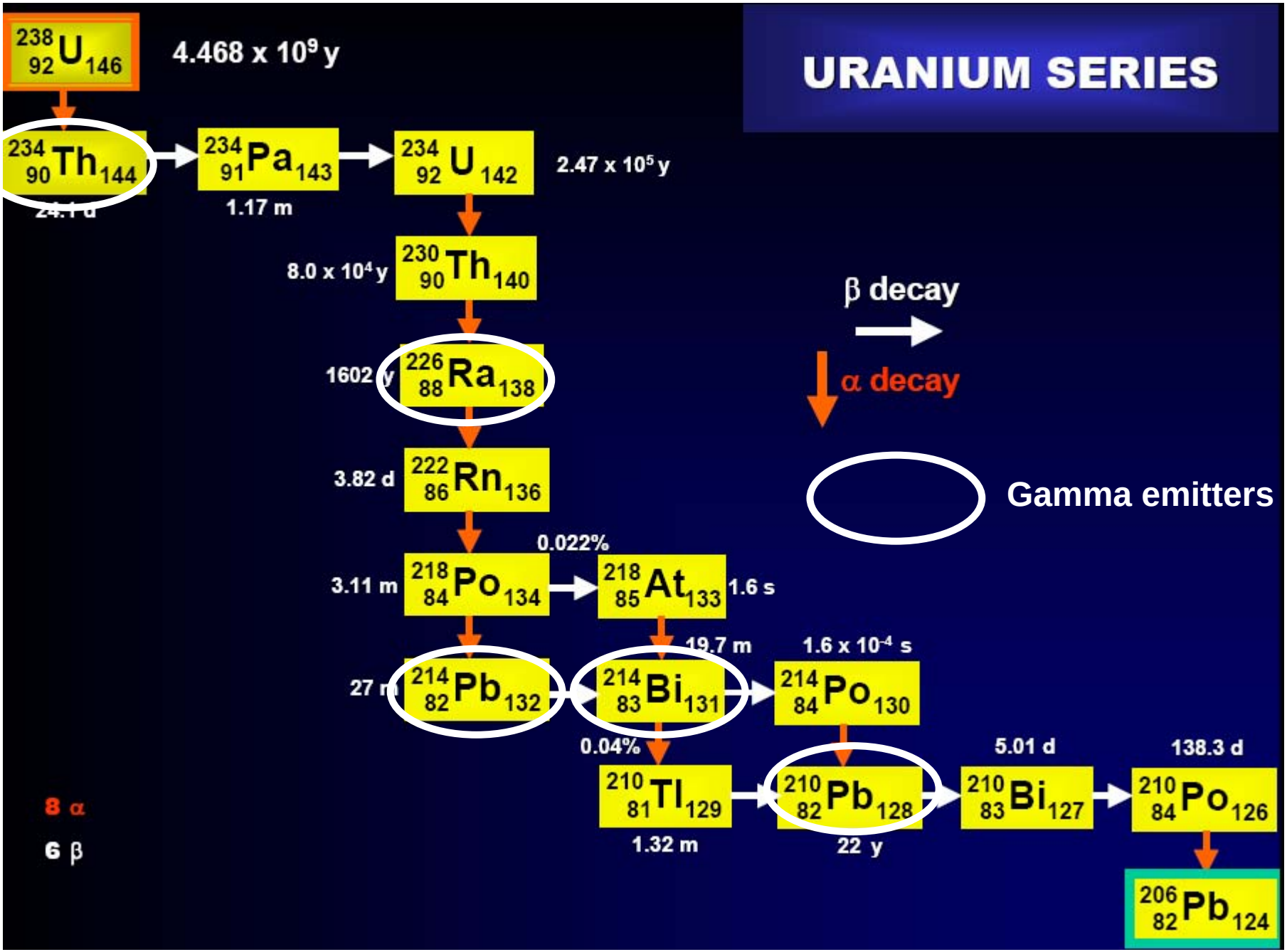
Mineral	Content
Phyllite (includes muscovite, chlorite)	20 to 50 %
Calcite	20 to 80 %
Quartz	5 to 30 %
Anthracite, graphite	5%
Pyrite	1%
Feldspath	1%
Epidote	1%

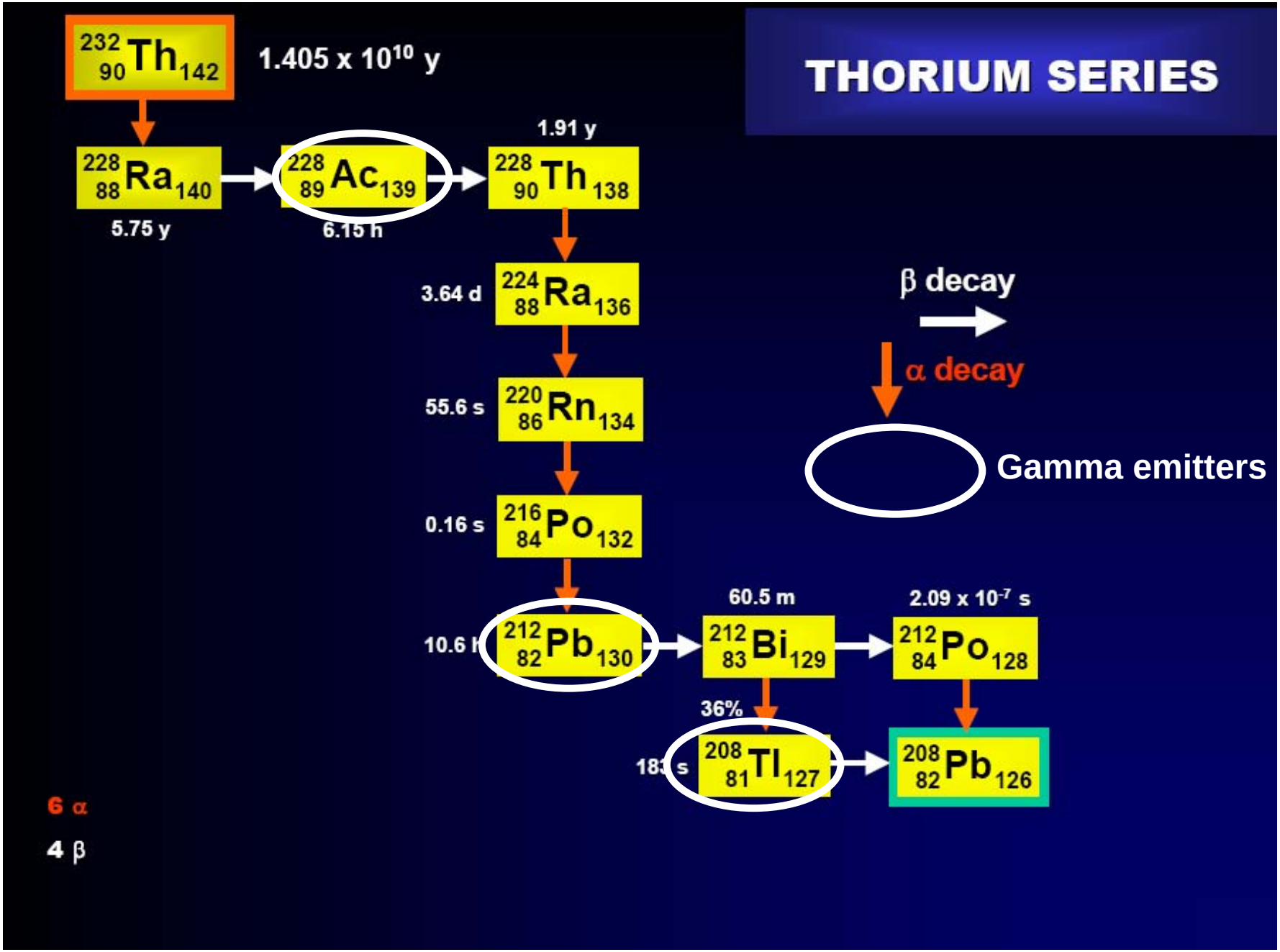
Chemical composition

Réf: Astrop. Phys., **9**, pg 163(1998), V. Chazal *et al* :
« Neutron background measurements in the underground laboratory of Modane »

	SiO_2	Al_2O_3	MnO	MgO	CaO	TiO_2	K_2O	Na_2O	P_2O_5	Fe_2O_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
$^{238}_{92}U_{146}$
4.468 x 10⁹ y
$^{234}_{90}Th_{144}$
24.1 d
$^{234}_{91}Pa_{143}$
1.17 m
$^{234}_{92}U_{142}$
2.47 x 10⁵ y
8.0 x 10⁴ y
$^{230}_{90}Th_{140}$
1602 y
$^{226}_{88}Ra_{138}$
3.82 d
$^{222}_{86}Rn_{136}$
0.022%
3.11 m
$^{218}_{84}Po_{134}$
$^{218}_{85}At_{133}$
1.6 s
19.7 m
1.6 x 10⁻⁴ s
27 m
$^{214}_{82}Pb_{132}$
$^{214}_{83}Bi_{131}$
$^{214}_{84}Po_{130}$
0.04%
5.01 d
138.3 d
$^{210}_{81}Tl_{129}$
1.32 m
$^{210}_{82}Pb_{128}$
22 y
$^{210}_{83}Bi_{127}$
$^{210}_{84}Po_{126}$
$^{206}_{82}Pb_{124}$
β decay
α decay
Gamma emitters
8 α
6 β


THORIUM SERIES
$^{232}_{90}Th_{142}$
1.405 x 10^{10} y
$^{228}_{88}Ra_{140}$
5.75 y
$^{228}_{89}Ac_{139}$
6.15 h
1.91 y
$^{228}_{90}Th_{138}$
3.64 d
$^{224}_{88}Ra_{136}$
55.6 s
$^{220}_{86}Rn_{134}$
0.16 s
$^{216}_{84}Po_{132}$
10.6 h
$^{212}_{82}Pb_{130}$
60.5 m
$^{212}_{83}Bi_{129}$
2.09 x 10^{-7} s
$^{212}_{84}Po_{128}$
36%
$^{208}_{81}Tl_{127}$
$^{208}_{82}Pb_{126}$
β decay
α decay
Gamma emitters
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 *et al*
Rock	10.4 ± 2.5	9.96 ± 0.82	213 ± 30	V. Chazal *et al*
Rock	11.6 ± 0.4	10.7 ± 0.3	185 ± 5	J. Kisiel *et al*

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

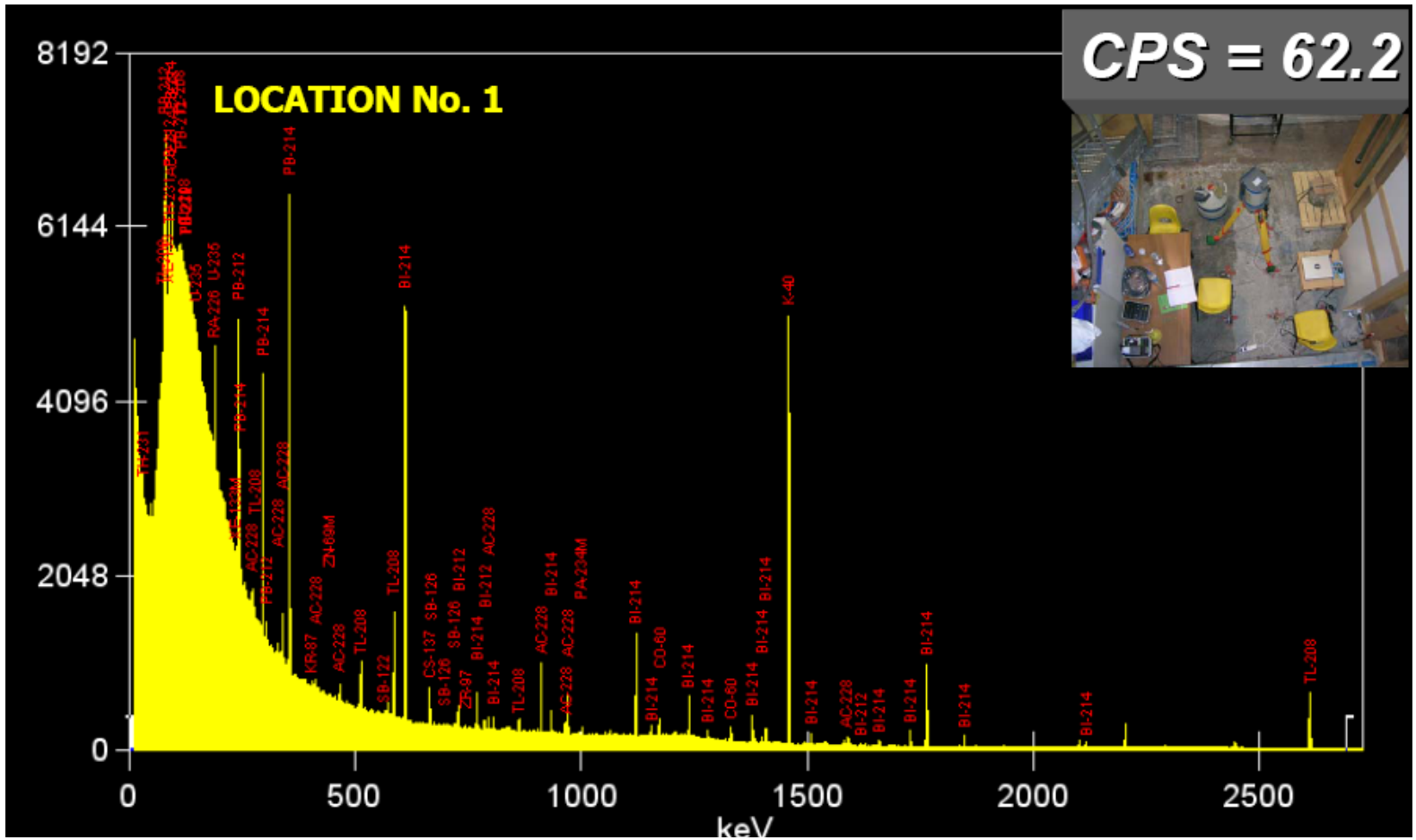
	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ref.
	12.3 ±1.4	4.8 ±0.9	92 ±22	J. Kisiel *et al*

30 cm thick concrete

ILIAS TARI: (2006)

D. Malczewski, J. Kisiel, J. Dorda, University of Silesia, Katowice, Poland

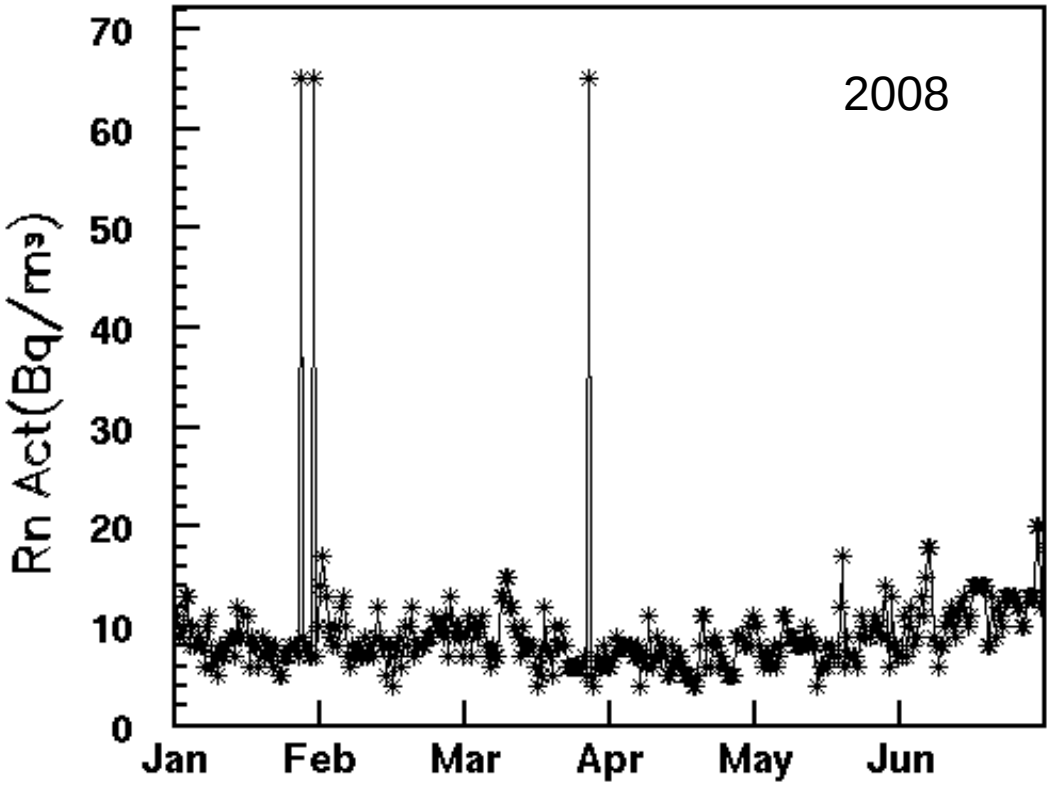
Measurement with a portable Ge in 6 different locations



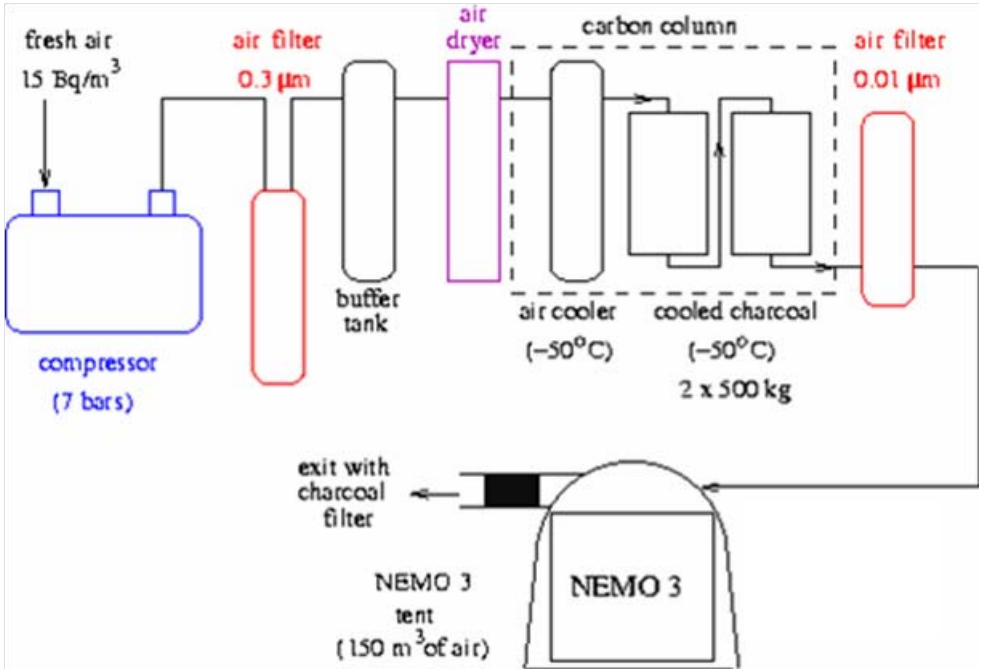
Radon in the laboratory

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

Rn activity: 5 to 15 Bq/m^3



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 x 450 kg

Same as Kamioka

Output:

Vol. clean air : 125 m^3/h
Activity ^{222}Rn = 15 mBq/m^3

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