



STUK's new γ -ray laboratory

Design & construction materials

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((video removed because of the large size))

1. General requirements for a radiometric laboratory

From the perspective of low-level gamma-ray spectrometry:

- Rooms should be designed so that the sample flow and work flow is as simple as possible.
- Unusual situations such as high-activity samples, fires, explosions, loss of electricity, accidents etc. must be taken into account.
- Separate air conditioning of the laboratory rooms and air ventilation control.
- Air overpressurization of the measurement rooms and incoming air filtration.
- Low-active construction materials (especially K-40 and Ra-226,228 progeny) are of importance.
- Access control to the labs.
- Shoe boundary.
- ...



Here I focus
this point



Why low-active construction materials are of relevance?

You cannot observe starry sky in daylight!

Activity concentrations in environmental samples are generally low → if there is high background we couldn't detect nothing.

Problem for designing laboratory infra



2. How to ensure low-activity construction materials?

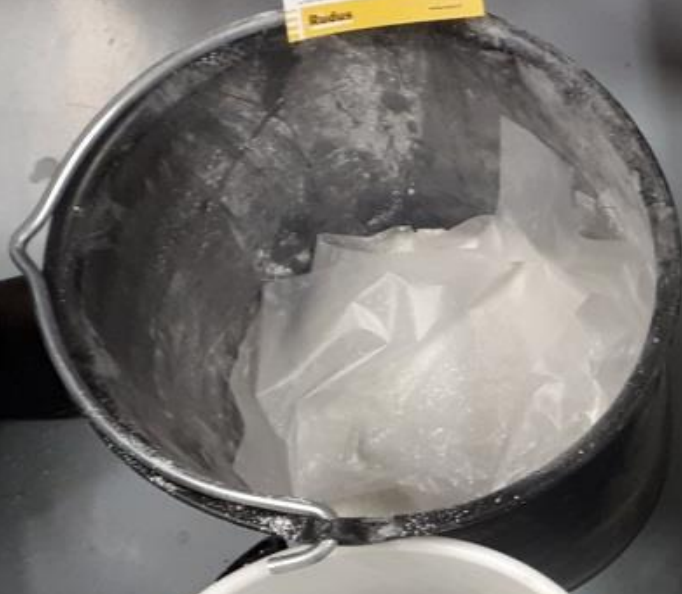
Floors, ceiling, pillars and hollow core slabs are made of concrete:

Cement + gravel + water + ribbed bars (steel)



These raw materials were measured by γ -ray spectrometry

White
cement



Standard
cement



Olivine
sand



Heavy
stones



Diabase
sand



Activity concentrations of materials presented in the previous slide

Radionuclide	White cement (Bq/kg)	Standard cement (Bq/kg)	Heavy stones (Bq/kg)	Olivine sand (Bq/kg)	Diabase sand (Bq/kg)
K-40	27 (8%)	113 (8%)	44 (7%)	4.0 (11%)	95 (8%)
U-238 (Ra-226, Rn-222, Pb-214, Bi-214)	9.7 (21%)	49 (13%)	17 (13%)	< 0.5	9.4 (31%)
U-235 (Th-227, Ra-223, Rn-219, Bi-211)	0.45 (21%)	2.3 (23%)	0.77 (13%)	< 0.04	0.44 (31%)
Th-232 (Ac-228, Pb-212, Bi-212, Tl-208)	3.2 (7%)	11 (8%)	49 (6%)	0.32 (17%)	3.6 (9%)
Cs-137	-	0.56 (9%)	-	-	-



Floors, ceiling, pillars are made of concrete with white cement and low-activity "whitegray" limestone.



However, hollow core slabs are made of concrete with standard cement and low-activity "whitegray" limestone.

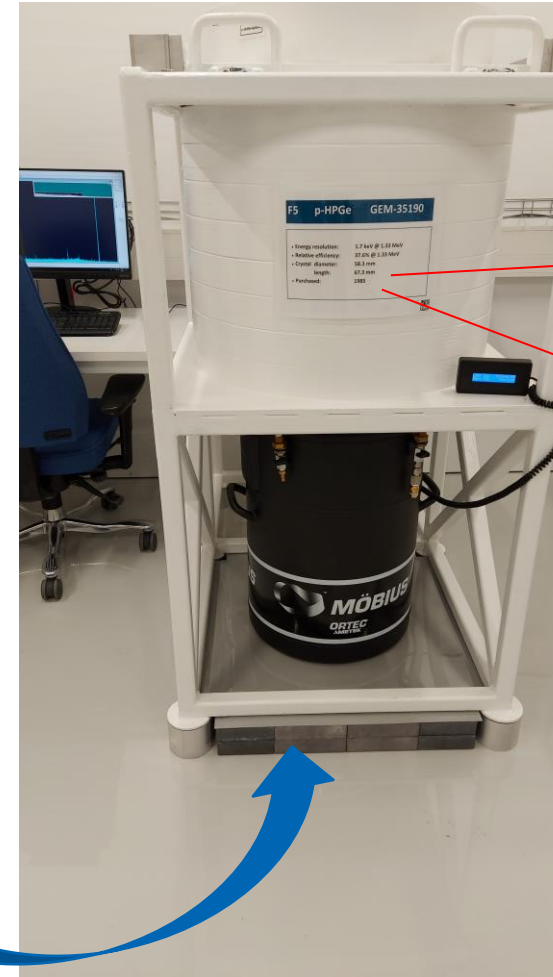


This is because of the EU's mandatory conformity marking



Activity concentrations of test specimen (3 concrete discs drilled from the cast-in-place low-activity concrete)

Radionuclide	Activity concentration
K-40	3.5 – 4.5 Bq/kg
Ra-226	2.0 – 2.3 Bq/kg
Th-232	0.73 – 0.80 Bq/kg



Purchased
1985 !!!

We use lead bricks
below the detectors
despite of the low
concentrations!

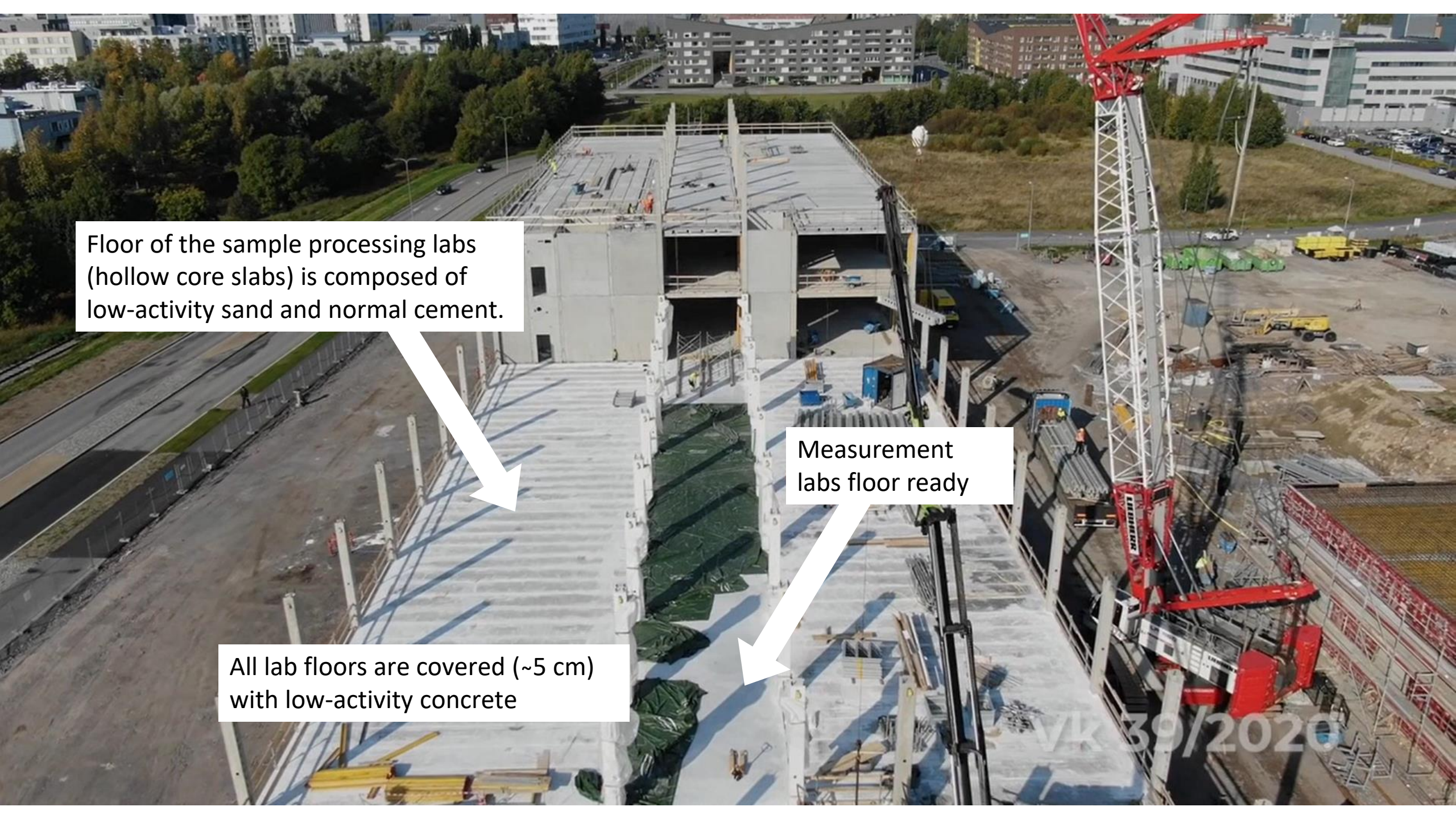


Measurement labs, cast-in-place concrete floor under construction (low-activity cement and sand)

Low-activity pillar

"Normal" pillar (no special concrete)

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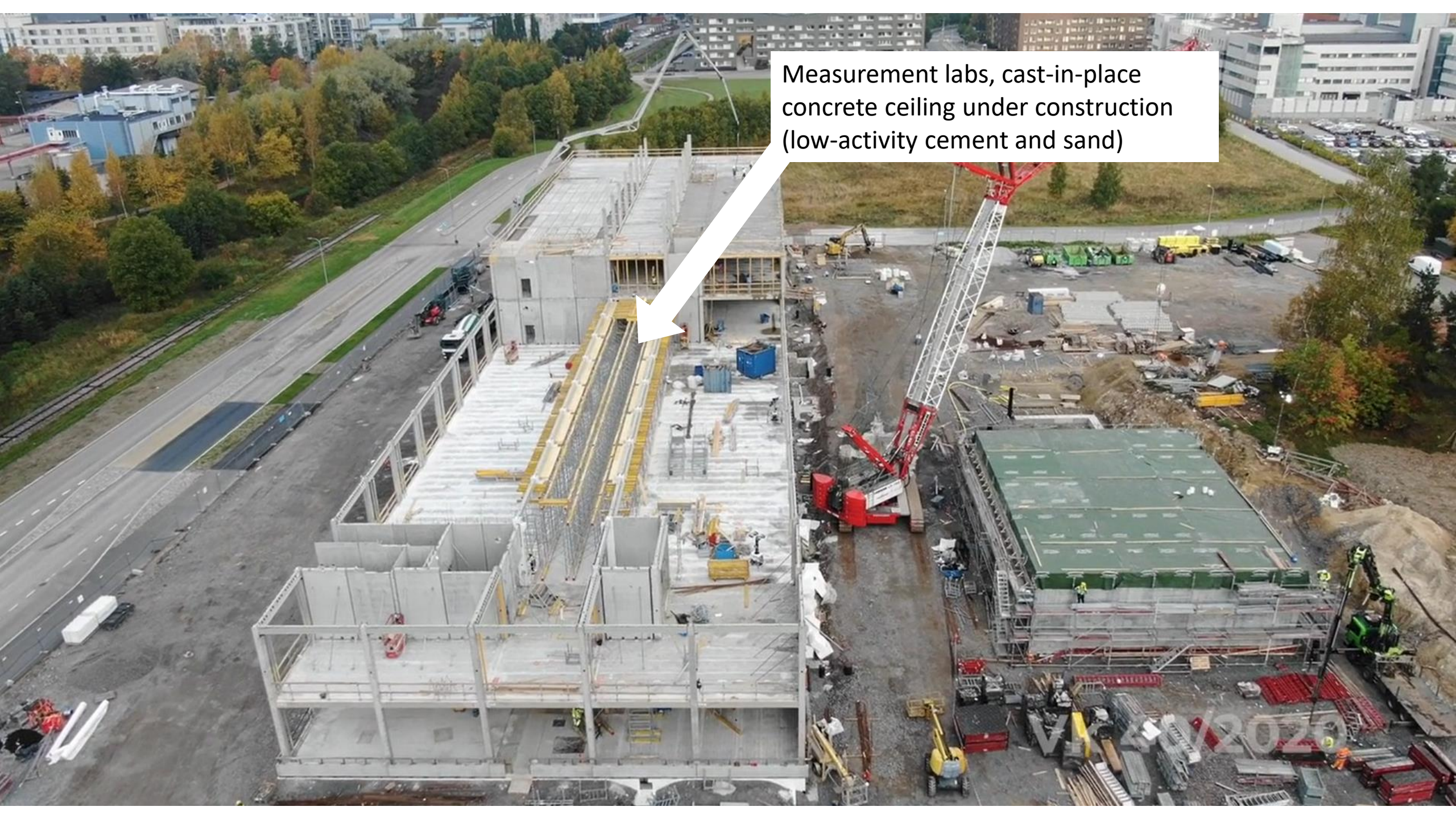
Floor of the sample processing labs
(hollow core slabs) is composed of
low-activity sand and normal cement.

Measurement
labs floor ready

All lab floors are covered (~5 cm)
with low-activity concrete

VK 39/2020

Measurement labs, cast-in-place concrete ceiling under construction (low-activity cement and sand)



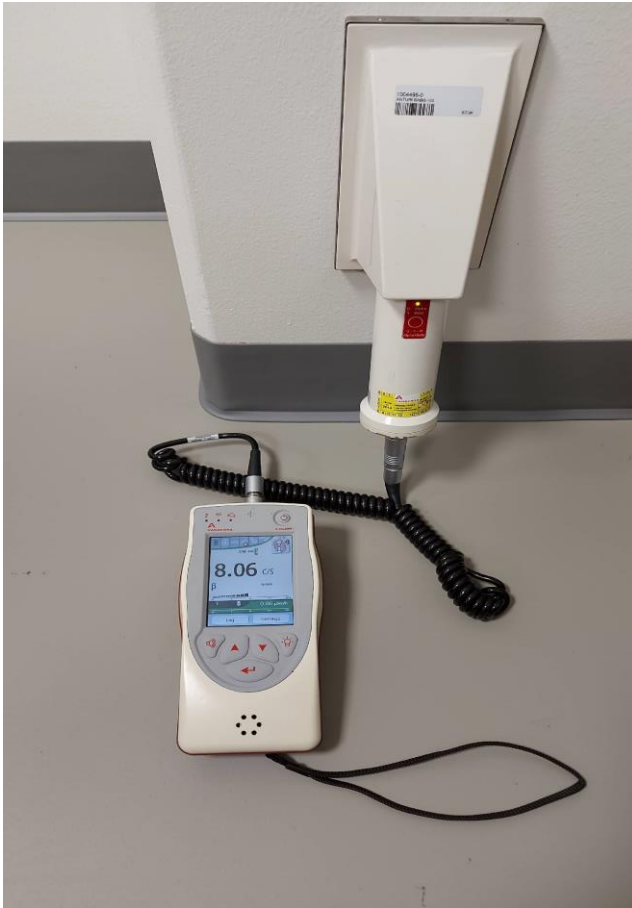
Low-activity ceiling of the labs is now almost ready



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What does this "low-activity" mean in practise?

Let's see some simple tests with a surface contamination (beta count rate) meter



”Normal” pillar
7.2 - 8.7 cnts/s



Low-activity pillar
3.5 - 4.5 cnts/s



”Normal” floor
10.2 - 11.2 cnts/s

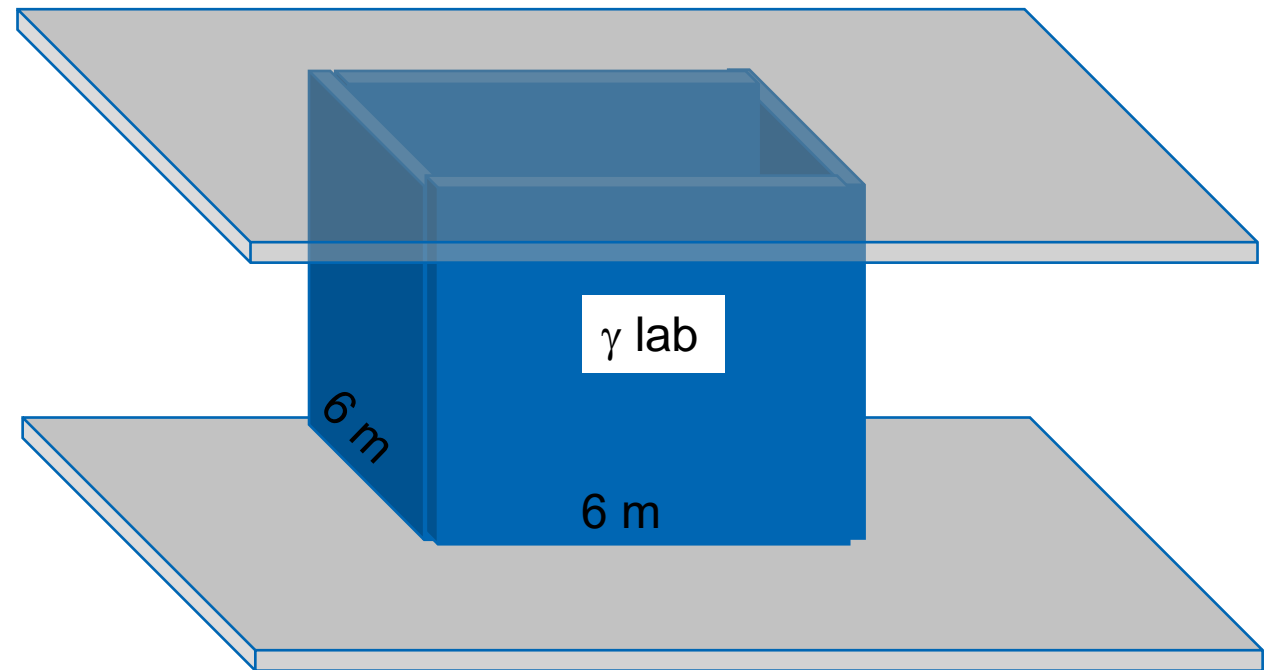


Measurement lab
floor (low-activity)
4.7 - 5.9 cnts/s

3. What about the walls of the measurement rooms – concrete or something else?

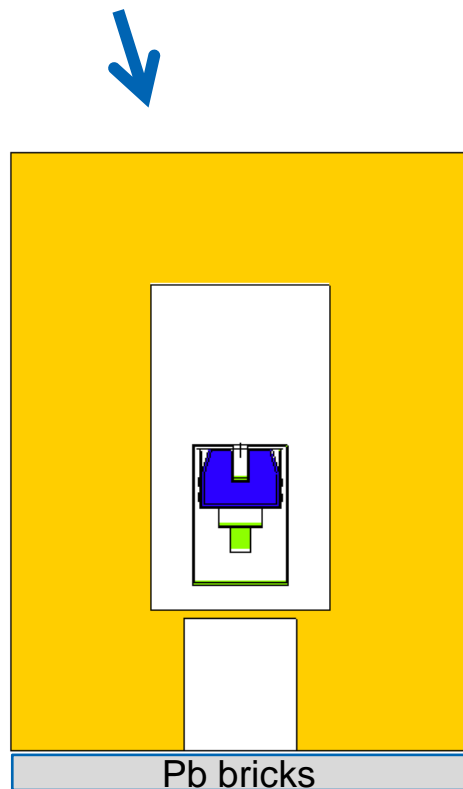
- Because of obvious reasons the floor and ceiling of the measurement labs were made by concrete. However, answer of the abovementioned question is not self-evident!
- MCNP modeling was done before starting to construct the building. Several cases were computed:
 - Floor and ceiling are composed of concrete with different composition. Thickness 25 cm.
 - Walls are made by concrete or by wood panels.
 - Exterior walls of the building (not shown in the picture) were not accounted for.
 - Nuclides considered in the simulations:

Low-active concrete:	^{208}Tl : 3 Bq/kg
	^{40}K : 61 Bq/kg
Standard concrete:	^{208}Tl : 50 Bq/kg
	^{40}K : 800 Bq/kg

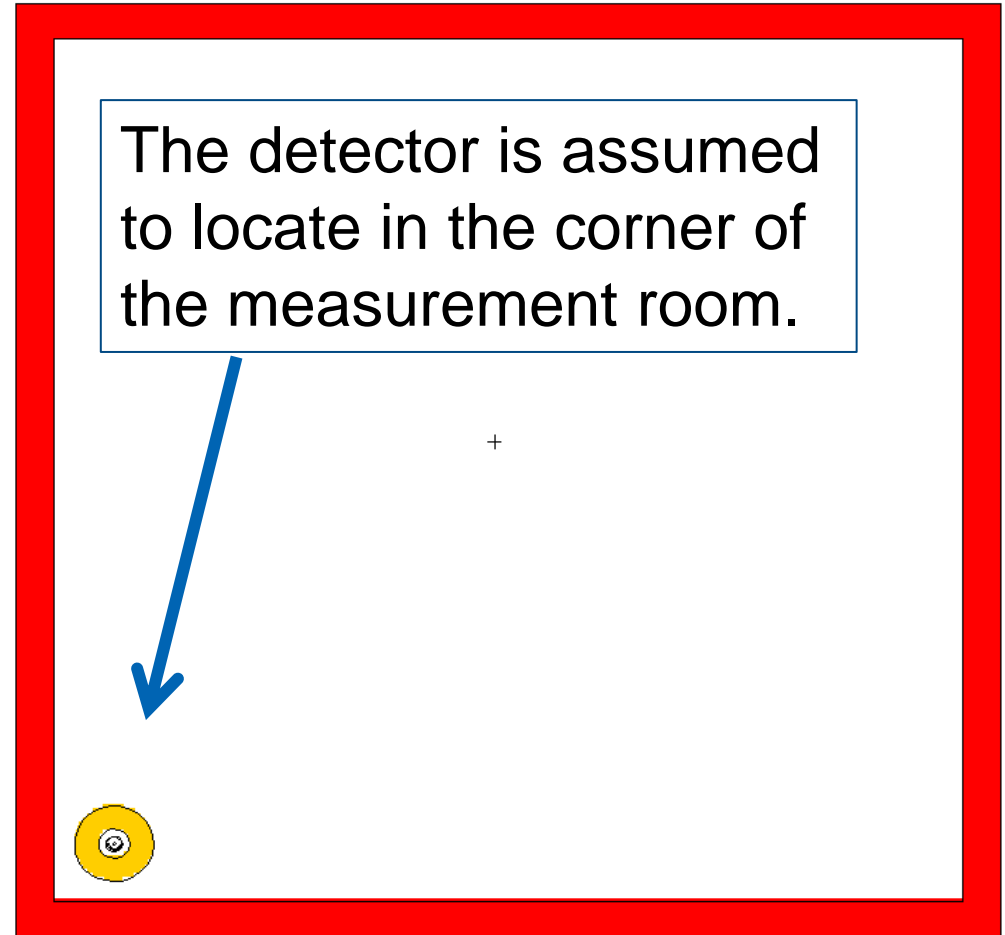


Model of the spectrometer

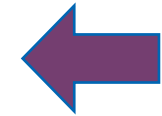
- HPGe detector (blue color)
- 10 cm lead shield (yellow)



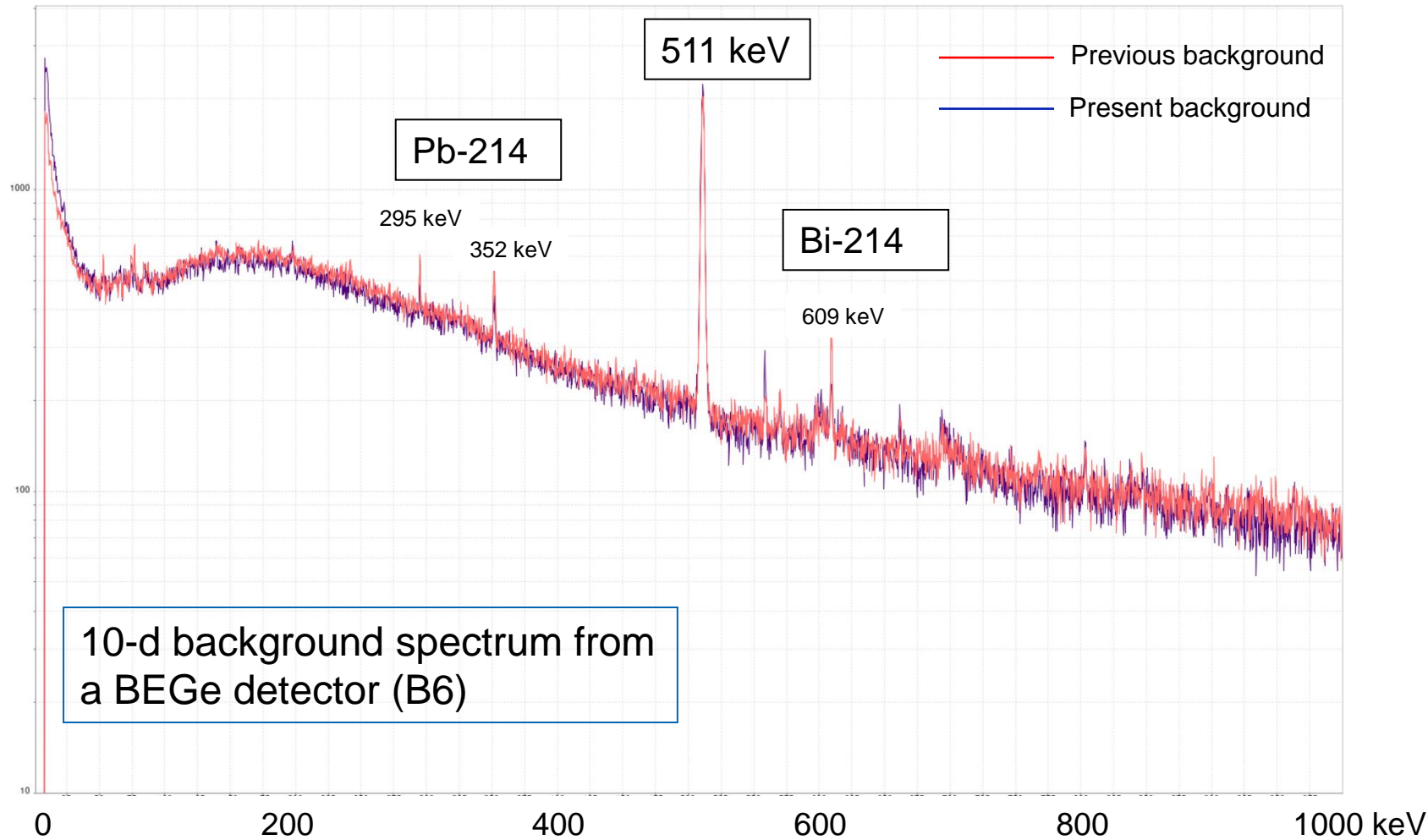
The detector is assumed to locate in the corner of the measurement room.



Calculation case (brief summary)	Relative number of counts
Floor and ceiling are composed of standard concrete, the lightweight partition walls do not contain radionuclides.	100
Floor and ceiling are composed of standard concrete, but walls of the measurement room are composed of low-active concrete.	96
Floor and ceiling are composed of standard concrete, shell panel (5 cm) of the measurement room and walls are low-active concrete.	53
Floor and ceiling are composed of low-active concrete (there is standard concrete outside). The lightweight partition walls do not contain radionuclides.	12
Floor, ceiling and walls of the measurement room are composed of low-active concrete. There is standard concrete outside.	8
Floor, ceiling and walls of the measurement room are composed of low-active concrete. There is low-active concrete outside.	7

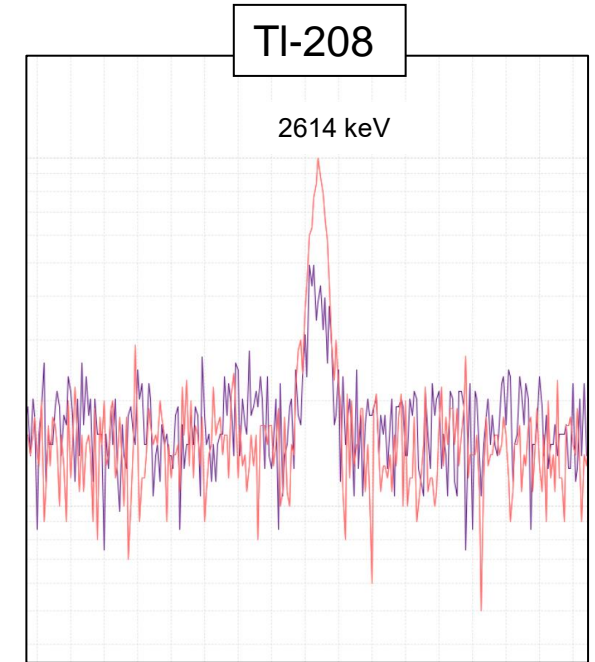
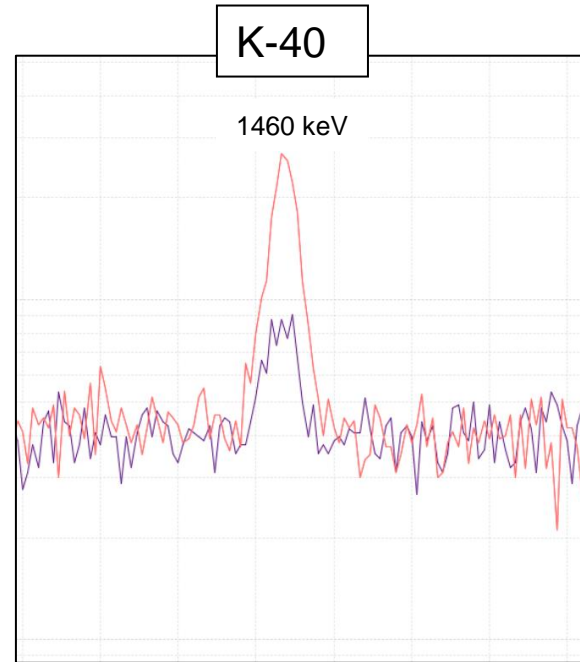
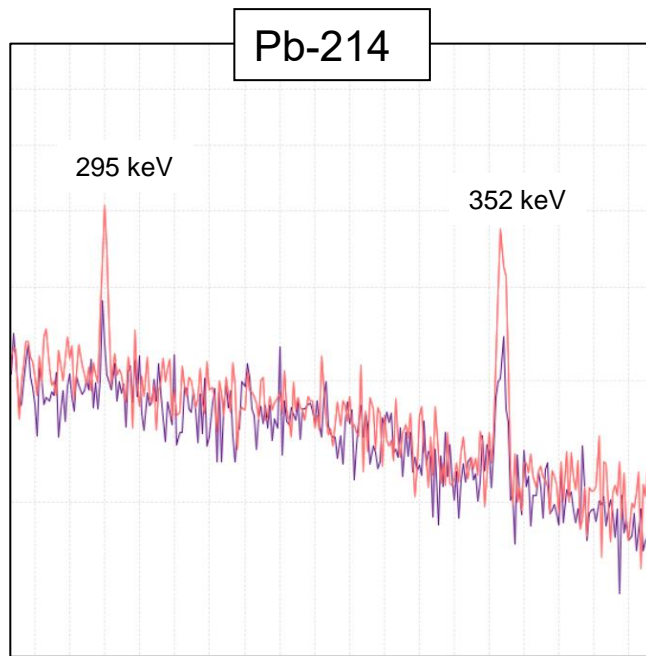


4. Comparison: present background vs. previous one



In general:
previous one \approx present one

- Background peaks of the U- and Th-series nuclides are by a factor of ~ 2 smaller.
- Background peaks caused by cosmic rays are a bit larger.



— Previous background
— Present background