How to reduce background of gamma-spectra?

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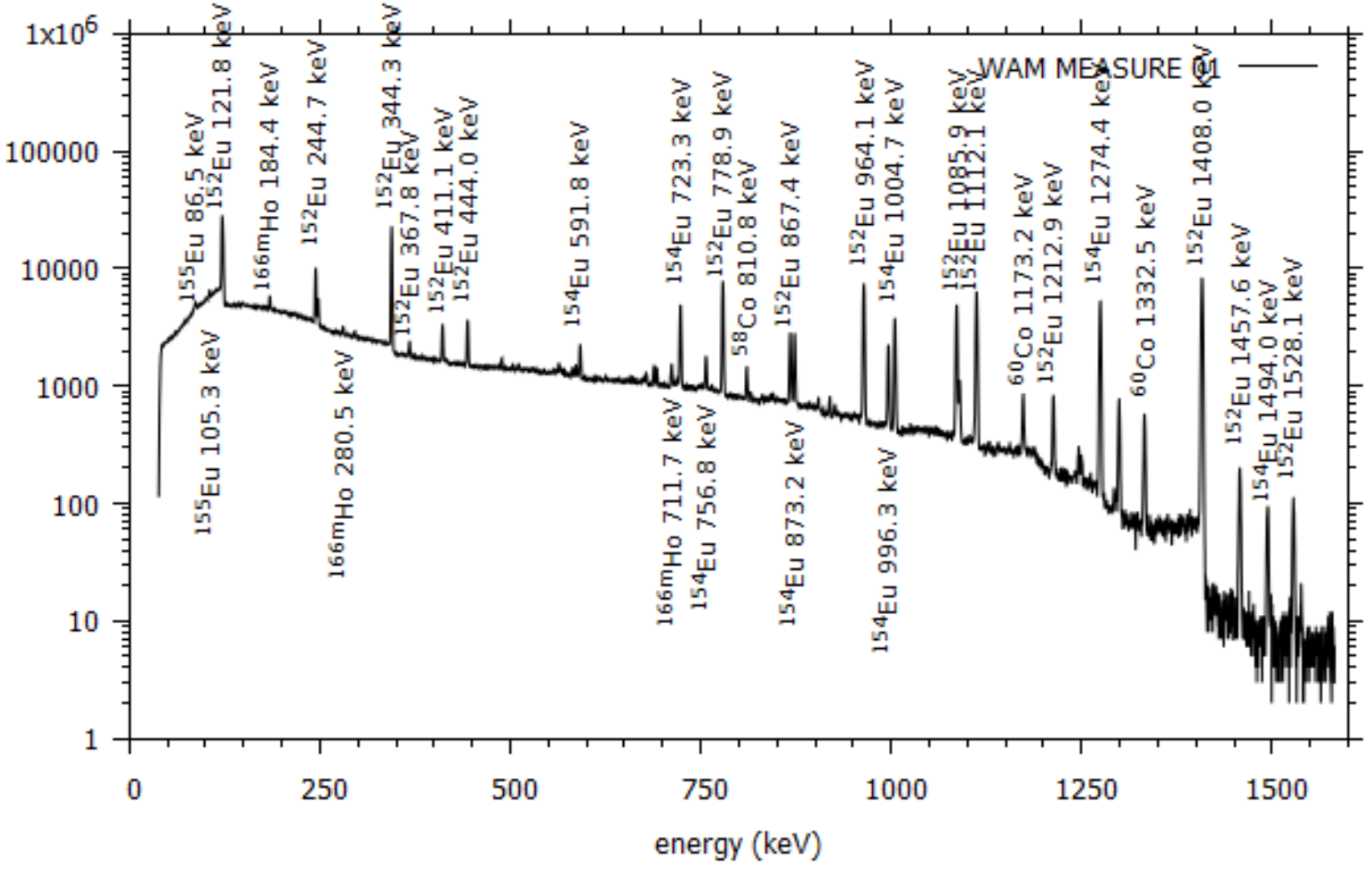
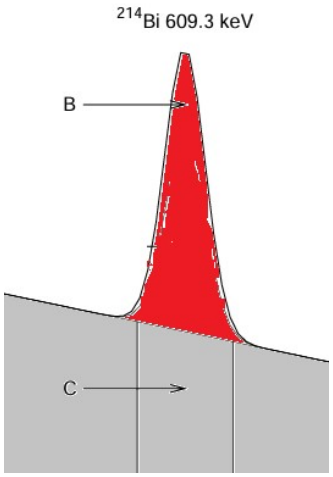
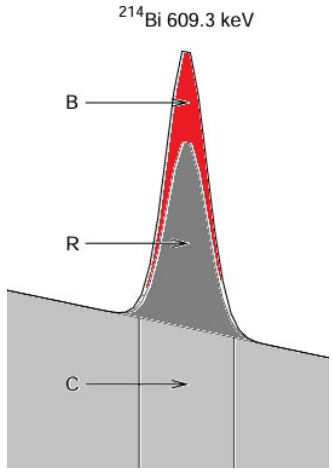
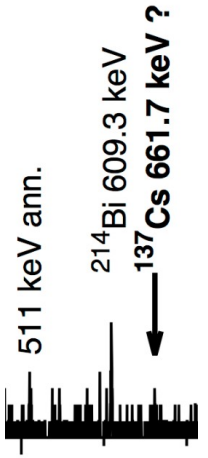
Background in gamma-spectroscopy

Typical gamma-spectrum: peaks on the background continuum
+ gamma-peaks can occur in the background spectrum, too.









Net peak area → activity

Net peak area = gross counts – background counts

Too high background limits the detectability.

Sources of background of gamma-spectra

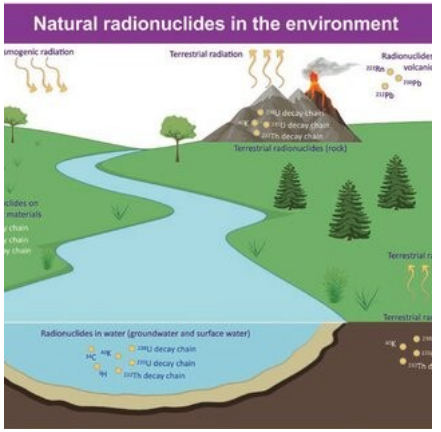
1. Radiations from the activity of the earth's surface
   and construction materials of the laboratory:
   terrestrial radionuclides: ^{238}U and ^{232}Th decay chains, ^{40}K

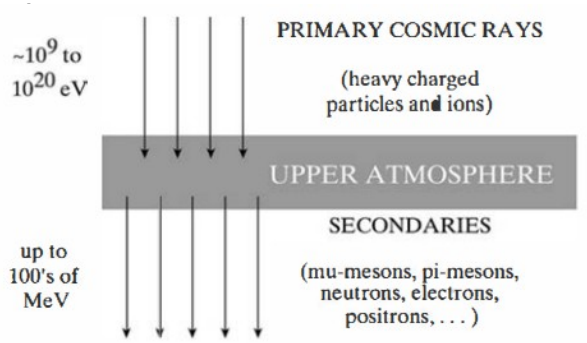
2. Radioactivity in the air surrounding the detector
   – radon (^{222}Rn,^{220}Rn) and its progenies (^{214}Pb, ^{214}Bi, ^{228}Ac, ^{208}

3. The primary and secondary components of cosmic radiation
   ^{70}Ge(n,3n)^{68}Ge, ^{74}Ge(n,γ)^{75m}Ge

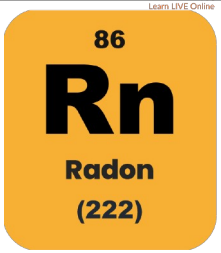
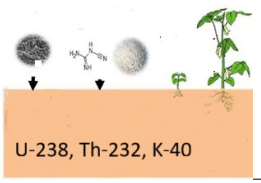
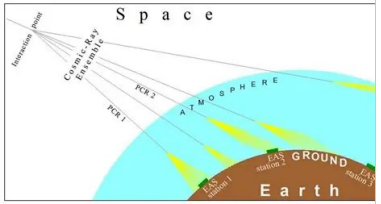
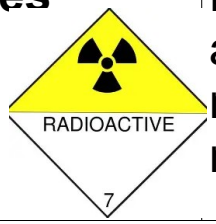
4. Artificial radionuclides in around the detector
   e.g.: fission products from nuclear tests: ^{137}Cs, ^{90}Sr
   industrial and medical radionuclides: ^{60}Co, ^{192}Ir
   radioactive sources in the lab (neighbouring lab...)

(5.) The natural radioactivity of the constituent materials
   of the detector itself,
   ancillary equipment, supports, and shielding placed
   in the vicinity of the detector





How to reduce background?

Origin of background	**Passive methods** of background reduction	**Active methods** of background reduction
radon 	Air-thight closing of the chamber, wait few days until the radon-daughters decay.	ventilation with filtered air Flow of radon-free inert gas (nitrogen)
Terrestrial radionuclides in the environment of the measuring site 	Shielding around the sample and detector: water, iron, lead. Multi-layer shielding against secondary radiation.	Special building materials and construction elements with low radioactivity content.
cosmic rays 	Thick shielding above the detector or put the measurement site underground.	Inhibit of data acquisition in case of cosmic-ray detection (cosmic-veto)
Artificial radionuclides 	Preliminary check of materials around the detector. Use materials from before the nuclear age, or time to decay,	Do not store or use radiation sources in the neighbourhood of measuring site. Separation of levels of activity.

How to reduce background: passive methods

Shielding around the sample and detector

Lead tower

Use of old lead
is preferred
due to ^{210}Pb ($T_{½}$=22.1 y)

Iron chamber

Multi-layer shielding
to reduce secondary radiation

(e.g.: iron – lead - copper)

Use of old shielding materials is preferred

which are produced before the worldwide spread of nuclear techniques
→ free from artificial radionuclides

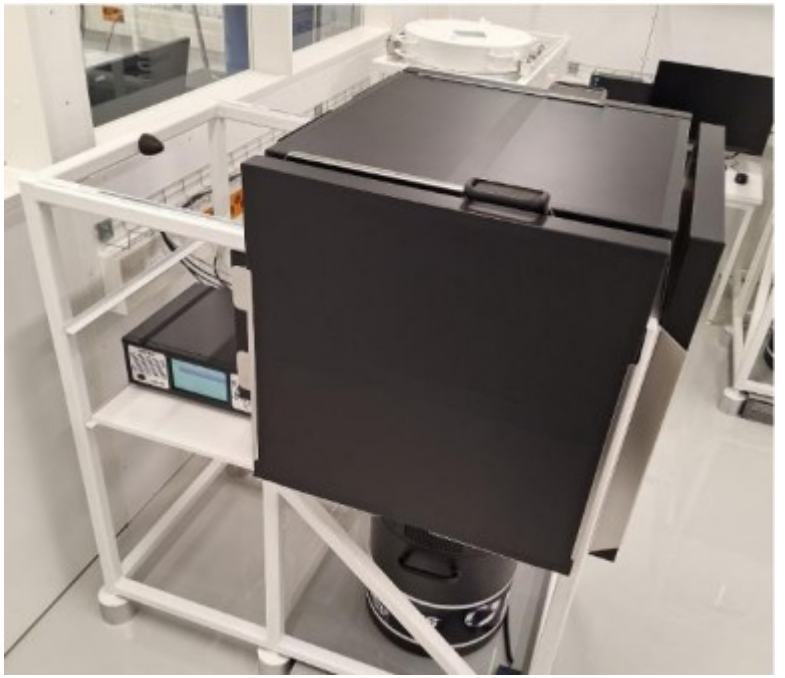
Picture: old Elisabeth-bridge
(Budapest, Hungary)
1903-1945

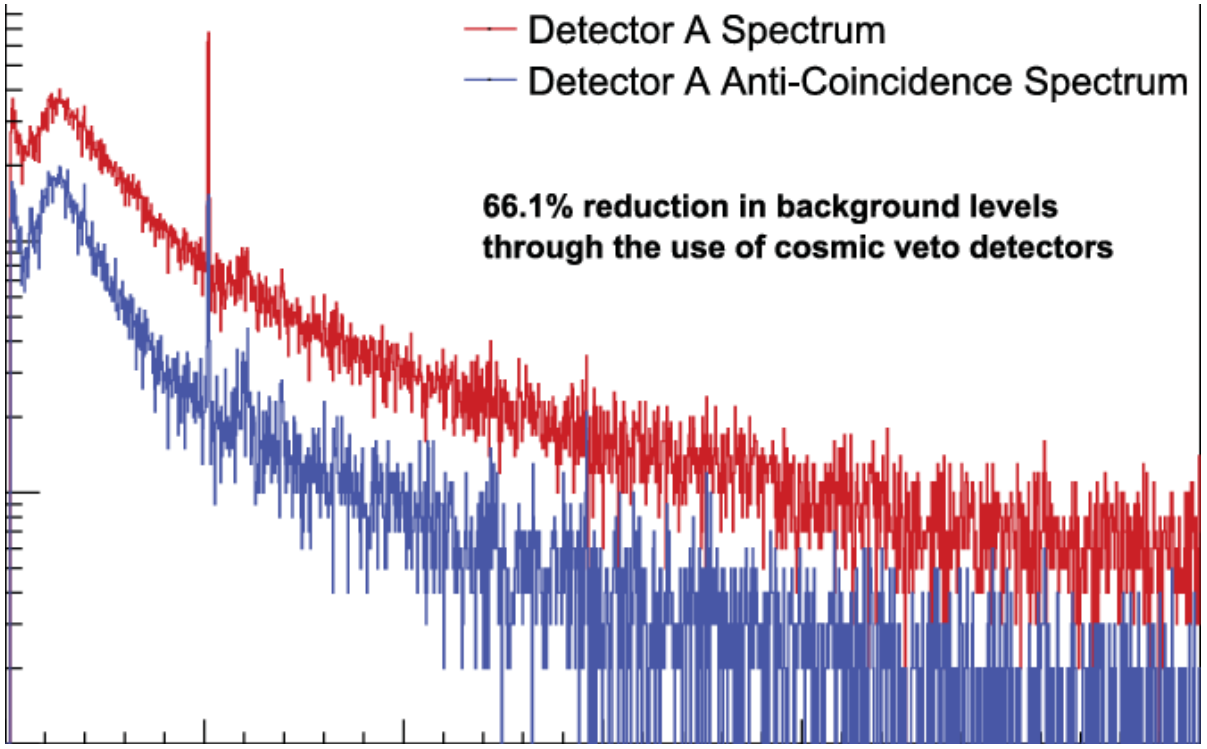
How to reduce background: active methods

COVERT = COsmic VEto
for the Reduction of Total background

plastic scintillators around the detector
with thicker scintillator is above

The data acquisition electronics inhibits the acquisition when cosmic rays are detected.





How to reduce background: active methods

COSSU = Compton Suppression Shield

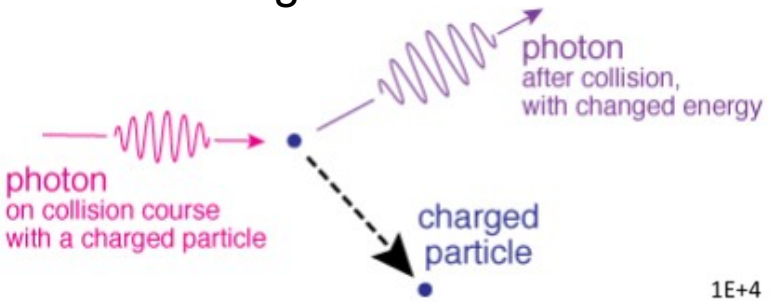
Main HPGe detector inside

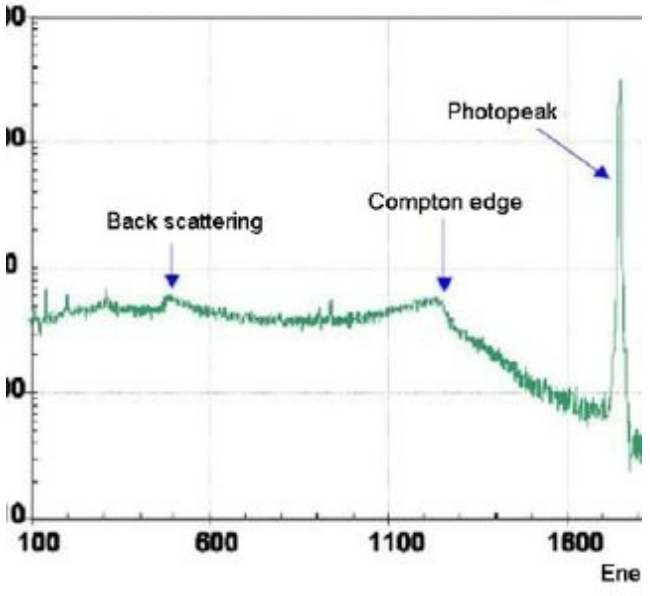
surrounded by scintillation detectors

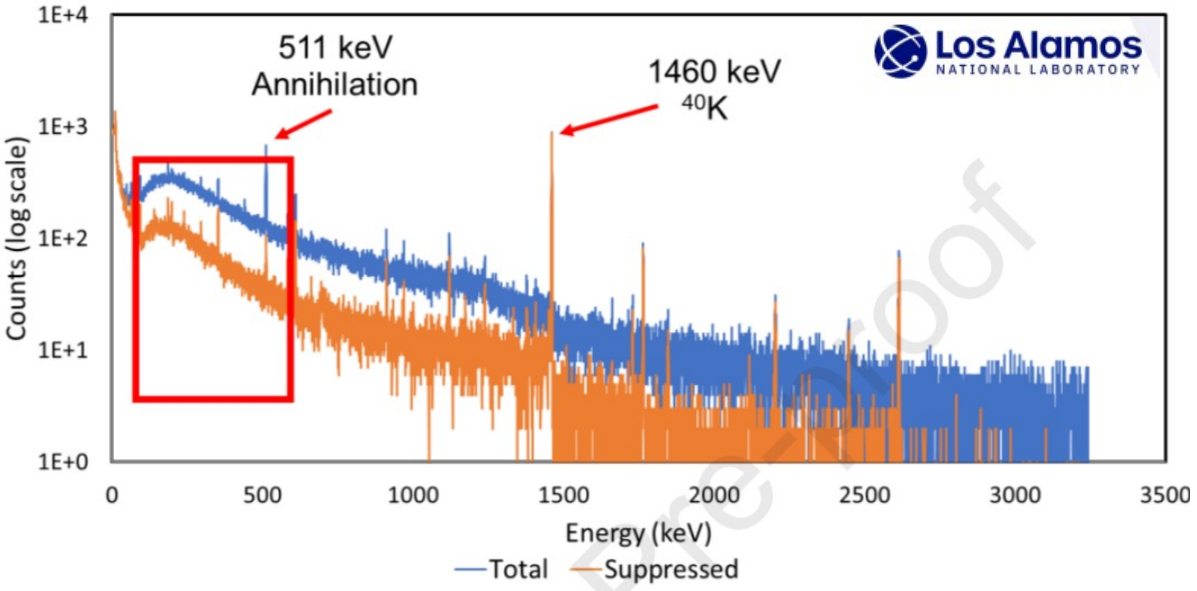
The coincidence of signals from the main detector and one of the surrounding detectors refers to Compton-scattering.

The data acquisition should be inhibited.

The continuous background can be reduced.

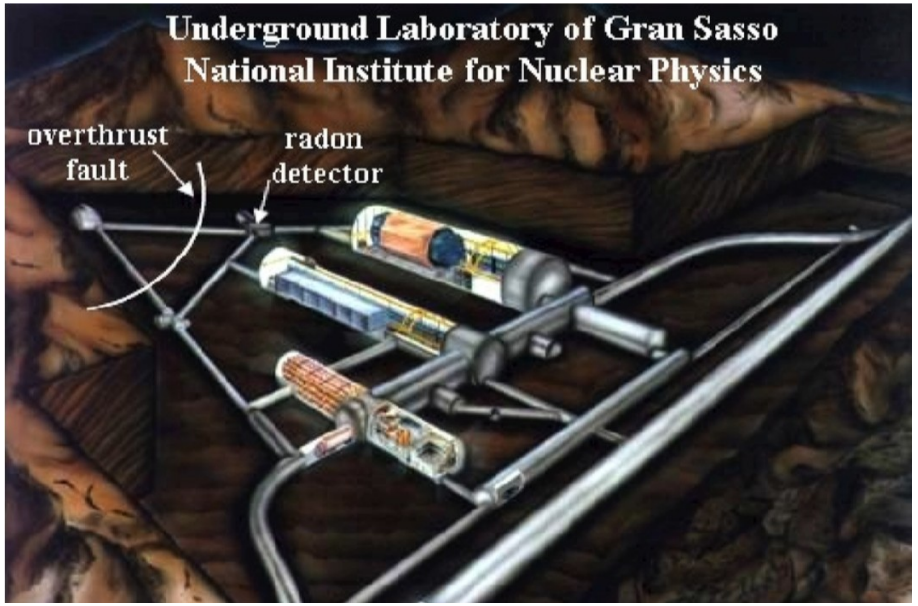




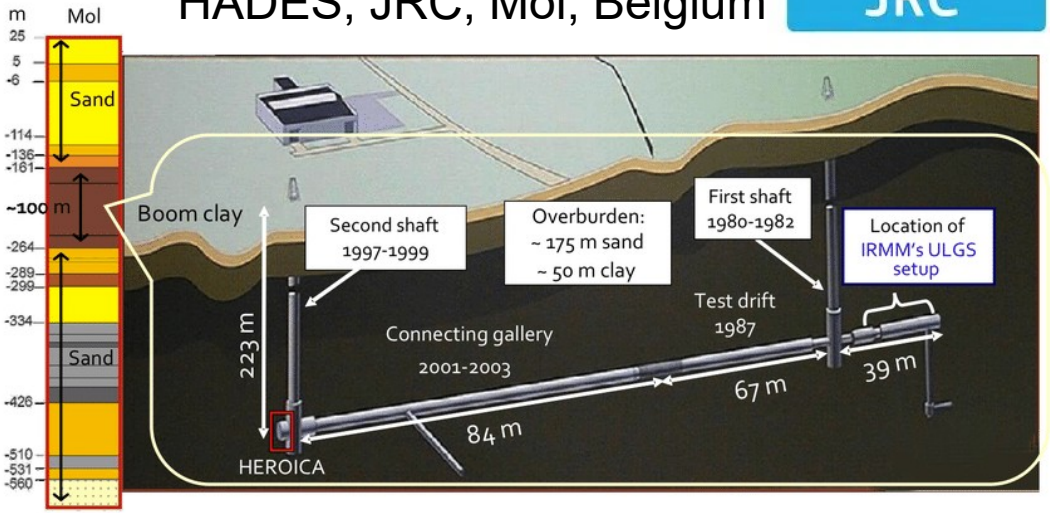


Background at an underground site

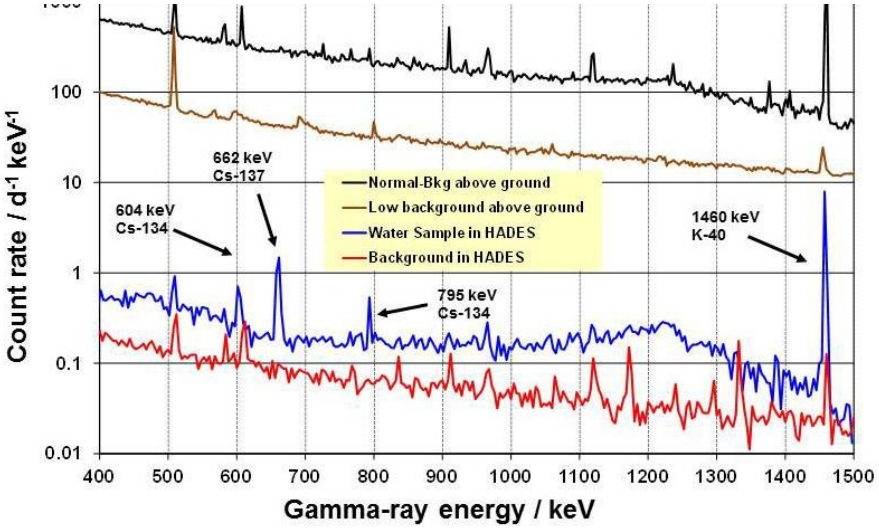
Reduction of cosmic-ray component of the background



HADES, JRC, Mol, Belgium



IAEA Marine Environment Laboratories, Monaco

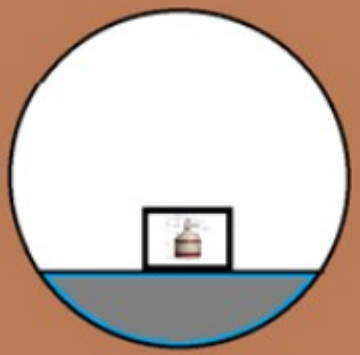


European Underground Laboratories Association - EUL

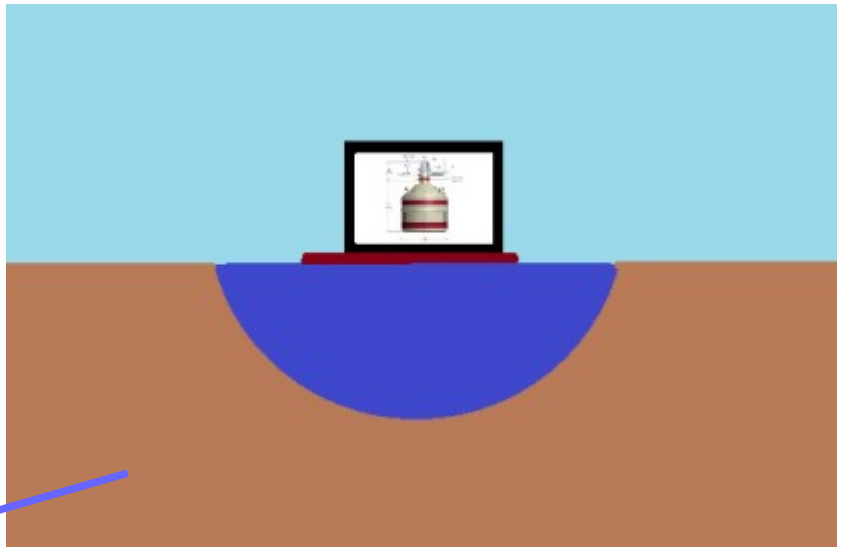
How to reduce background: some fantasies

1. Go underground against cosmic-rays

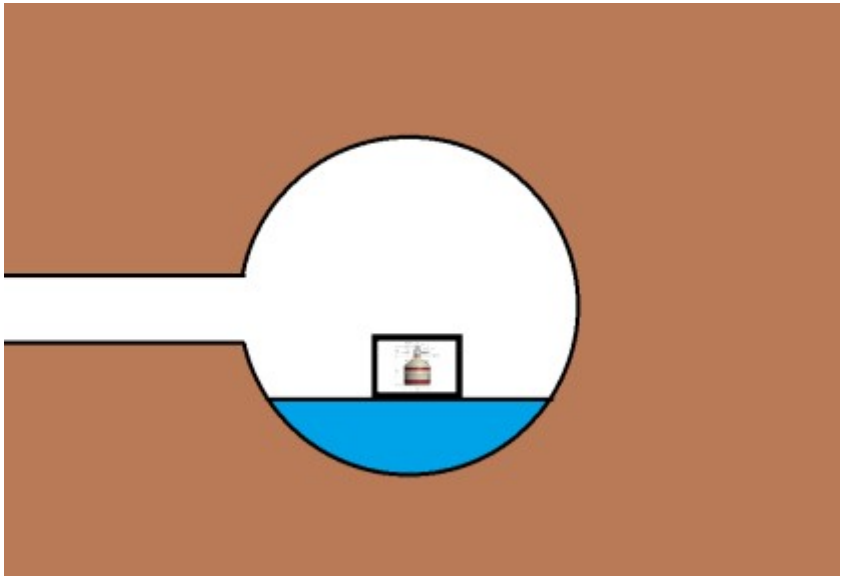
Disadvatage: surrounded by soil and the terrestrial radionnuclides in the soil.



2. Over a lake: radiation from earth is shileded.

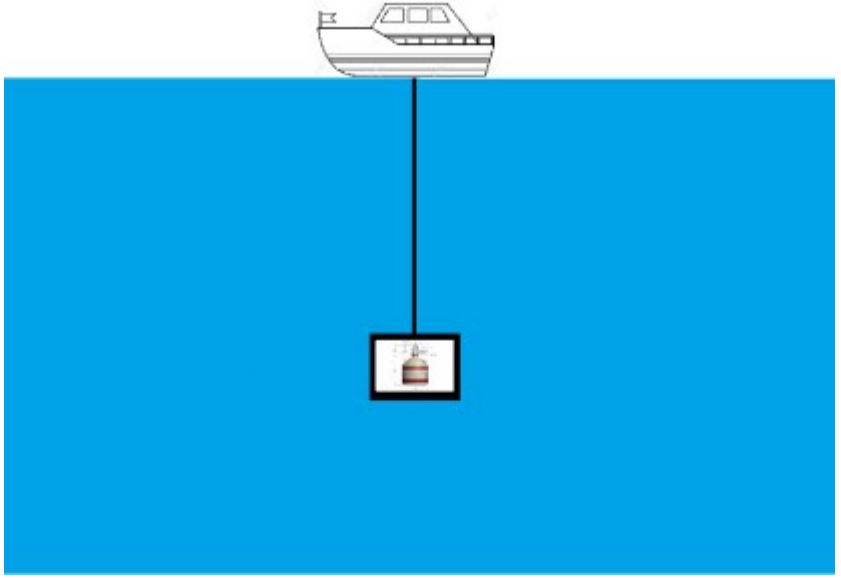


3. Combination of 1 & 2:
Go underground over a lake in a cave.

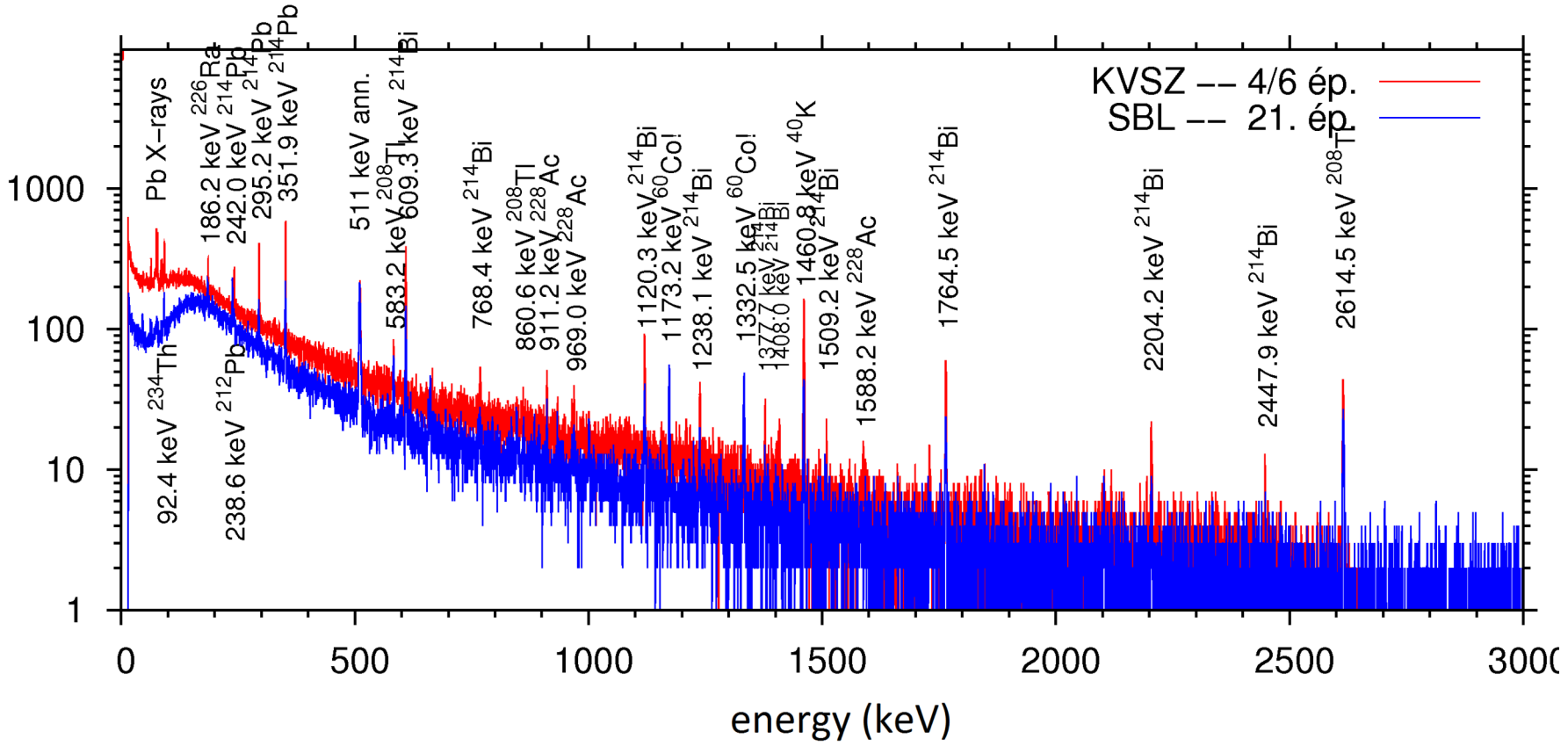


4. Switch-off the radiation of earth: go underwater

Water provides 4π shielding.



Thank you for your attention!



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