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Development of installation prototype for 37Ar scintillations in liquid argon counting

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One of the most significant evidences of the Comprehensive Test Ban Treaty violation is the appearance of increased concentrations of 37Ar in subsoil air, which is formed in large quantities during the interaction of neutrons with calcium of the rocks. Therefore, the 37Ar measurement together with the measurement of subsoil xenon radionuclides, is a mandatory procedure for on-site inspection.
The half-life of 37Ar is 35.04 days, transforming into 37Cl, it emits very low-energy Auger electrons and X-rays with energy no higher 2.8 keV, which makes it difficult to measure it at the background level varying from 1 to 100 mBq/m3 of air, or from 0.1 to 10 mBq/l of argon preparation.
Traditionally, to measure the activity of 37Ar, proportional gas counter of internal filling are used, which are filled with a counting gas prepared from samples of argon with the addition of methane. Further reduction of the detection limit of 37Ar is limited by the complexities of a significant increase in the volume of argon placed in a proportional counter. One of the ways to increase the volume of the measured sample is to transfer the argon preparation to a liquid state. Using the fact that liquid argon is a effective scintillator, the measurements of 37Ar activity can be performed by registering the emitted photons.
The Khlopin Radium Institute is developing a new highly sensitive installation capable of extending the 37Ar measurement range. The operation of this installation is based on the liquid scintillation principle of registration of low-energy 37Ar radiation, and the condensed argon preparation, isolated from the soil air, performs the function of liquid scintillator. The use of liquefied argon samples will make it possible to multiply the volume of the measured samples without increasing the size of the measuring cell and shielding elements and opens way to significant decrease of the detection limit of 37Ar.
The developed facility will provide the following specifications:
- The capacity of the measuring chamber is about 100 cm3;
- The efficiency of light collecting will be at least 70%
- PMT with a quantum efficiency of at least 20% will be used
- At least 5 photoelectrons will be detected per 37Ar decay;
- Tetra-phenyl butadiene (TPB will be used as a wavelength shifter;
- A combination of active and passive shields will be used;
- The measuring chamber will be made of electrolytically purified copper and aluminum;
- Background counting speed will exceed 0.1 counts per second. - A minimum detectable concentration of 37Ar (MDC) of no more than 8 mBq/m3 of air will be reached