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A comparison of 238U radioactivity level using HPGe and ICP-MS at CUP

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Two flagship experiments at the Center for Underground Physics (CUP), AMoRE searching for neutrinoless double beta decay and COSINE for WIMP (Weakly Interaction Massive Particle) dark matter, are rare-event search experiments running at the Yangyang underground laboratory (Y2L). It is critical to know radioactivity levels of respective detector materials to control the experiment sensitivities. Inductively coupled plasma mass spectrometry (ICP-MS) and high-purity germanium (HPGe) detector are widely used for radioactivity assay, however, their levels of ^{238}U are quite different in many sample measurements. High intensity gammas in ^{238}U decay chain are from ^{226}Ra, ^{214}Pb and ^{214}Bi in the lower decay chain, and generally only these activities are reported from the ^{238}U chain for HPGe measurement. In contrast, ICP-MS's result is sensitive only to ^{238}U itself. The upper and lower chain activities can be different because of a breakage in chain equilibrium. Using the 63.29 keV and 93.40 keV gammas from ^{234}Th decay and 1001.03 keV gamma from ^{234m}Pa, upper chain radioactivity levels for two samples (A: Na_2CO_3 and B: $CaCO_3$) were recently analyzed and compared with ICP-MS results. Because of the short half-lives of ^{234}Th and ^{234m}Pa, which are directly below ^{238}U in the decay chain, these activities must be in equilibrium and representative of the ^{238}U concentration. Radioactivity levels of ^{234}Th, ^{234m}Pa and ^{226}Ra decay chains in sample A using the HPGe detector are 162.55 ± 19.24 mBq/kg, 115.02 ± 48.74 mBq/kg and 451.29 ± 41.00 mBq/kg respectively. The ^{238}U level using ICP-MS was reported as 14 ppb which is converted to 168 mBq/kg. The levels of ^{234}Th and ^{234m}Pa in sample B with the HPGe detector are 13.85 ± 0.83 Bq/kg and 9.03 ± 0.92 Bq/kg respectively. The ^{238}U level by ICP-MS was reported as 878 ppb (10.5 Bq/kg). These results show HPGe and ICP-MS measurements of ^{238}U concentration are well matched.

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