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The MOON-1 detector construction and the study of backgrounds from radioactive isotopes

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Abstract. MOON is a multilayer system of plastic scintillators and ^{100}Mo films for ^{100}Mo $0\nu\beta\beta$ decays. A prototype detector MOON-1 was built with 6 layers of plastic scintillators and 142g of ^{100}Mo films for background (BG), energy and position resolution studies of the MOON detector. No serious BG from natural radioactive isotopes (RI) for $0\nu\beta\beta$ detection was found.

A prototype detector MOON-1 was built for radioactive isotopes background, energy and position resolution studies of the MOON detector [1]. The MOON-1 consists of 4 inner layers and 2 outer layers (uppermost and lowermost) of plastic scintillators (PLs) and 3 layers of ^{100}Mo films (total 142 g) held in acrylic holders between scintillators. The detector was set in the ELEGANT V [2] shields (Lead - Copper - NaI(Tl)) at Oto Cosmo Laboratory.

Radioactivities in detector components were measured by the Ge detector ELEGANT III [3]. Contamination of the PLs is less than detection sensitivity (<178 mBq/kg for U-chain, <54 mBq/kg for Th-chain). Contamination of ^{100}Mo films were measured at 8.3 ± 1.7 mBq/kg for ^{214}Bi and $(1.9 \pm 0.7) \times 10^{-1}$ mBq/kg for ^{208}Tl at ELEGANT V. The ^{100}Mo films used in ELEGANT V will be replaced by clean ^{100}Mo films with $20 \sim 50$ μBq/kg. The contributions from these RIs are mainly γ rays which don't contribute seriously to the $0\nu\beta\beta$ window.

BG measurements by the MOON-1 PLs and NaI detector array around the PLs have been done. At $\beta\beta$ decay analysis, two signals from adjacent plastic layers (= double layer hit) reduces BG signals and selects true $\beta\beta$ events. MOON-1 detector's main BG for this analysis are double Compton scatterings of γ rays from ^{40}K and ^{208}Tl. The measured and estimated BGs of ^{40}K are consistent. Accidental double layer hit event rate is smaller than the expected decay rate of $0\nu\beta\beta$ decays for ≥ 2.8 MeV energy window. Other measured RI (U and Th chain) impurities in surrounding components are also consistent with expected level. These are not fatal as above.

By measuring $\beta\beta$ vertex points, γ ray BGs will be reduced by orders of magnitude.

References

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