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## Low-Background Multi-Channel PMT for Next-Generation Xenon Detectors

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In the PandaX-4T experiment, R11410 photomultiplier tubes (PMTs) account for approximately 47% of the detector's material-induced electron recoil background, representing a major limitation in background reduction. As future liquid xenon detectors, such as the proposed PandaX-20T with a 20-tonne target, aim to reach sensitivities  $3.5 \times 10^{-49} \text{ cm}^2$  at  $40 \text{ GeV}/c^2$  near the irreducible neutrino floor, further suppression of internal backgrounds underscores the need for improved photon sensors.

To address this challenge, we present the development of a low-radioactivity, multi-channel 2-inch PMT (R12699), co-developed with Hamamatsu. Radiopurity screening shows significantly reduced  $^{60}\text{Co}$  and U/Th chain activities compared to R11410. Cryogenic characterization at  $-100^\circ\text{C}$  demonstrates stable operation with a gain of  $4.2 \times 10^6$ , a dark count rate of 2.5 Hz/channel, and an afterpulse probability of 0.5%. These results position R12699 as a promising candidate for future xenon-based rare event searches.

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