

Development of CANDLES Low Background HPGe Detector and Half-life Measurement of Ta-180m

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Low background HPGe detector is commonly used as high energy resolution gamma-ray spectrometer for radioactivity measurement. At Kamioka Underground Observatory (2700 m.w.e.), a HPGe detector system was developed in CANDLES Experimental Hall for material screening, tantalum-180m (^{180m}Ta) half-life measurement and multipurpose use.

To improve the sensitivity for the detector system, various background reduction techniques were employed, including hermetic shieldings design, suppression of radon gas effect, and off-line analysis. A new type of pulse shape discrimination (PSD) method was specially developed for coaxial Ge detector. Using the new PSD method, microphonics noise and Compton background event at energy region less than 200 keV can be rejected effectively. In addition, Monte Carlo simulation by GEANT4 was constructed to acquire the detection efficiency and study the interaction of gamma-rays with detector.

Among all nuclear isomers that exist in nature, ^{180m}Ta has the longest half-life of more than 10^{16} years, which is yet to be finalized up until now. The low background HPGe detector system of CANDLES Collaboration was utilized to achieve the most sensitive detection of ^{180m}Ta decay. Two phases of tantalum physics run were completed, which Phase II has upgraded shielding system. By combining the Tantalum Phase I and Phase II result, total livetime of 358.2 days was obtained. With various low background techniques and long-term measurement, the world most stringent half-life limit of ^{180m}Ta has been successfully achieved.

Primary author: Dr CHAN, Wei Min (Research Center for Nuclear Physics, Osaka University)

Presenter: Dr CHAN, Wei Min (Research Center for Nuclear Physics, Osaka University)

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