Double β decay of ^{136}Xe

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A liquid-xenon scintillation spectrometer containing 921 g of xenon enriched to 93% in the isotope ^{136}Xe has been used to establish a limit on the $2\beta(0\nu)$ decay of ^{136}Xe: $T_{1/2} \geqslant 2.36 \times 10^{21}$ yr.

Recent results[1] from the search for the $2\beta(0\nu)$ decay of ^{76}Ge have shown that its decay half-life must be $T_{1/2} \geqslant 10^{23}$ yr. Although ^{76}Ge is by no means the best candidate for a study of the $2\beta(0\nu)$ decay from the theoretical standpoint, we could hardly expect a substantially shorter lifetime of the $2\beta(0\nu)$ decay in any other isotope. The most promising isotopes for a further study of the $2\beta(0\nu)$ decay may accordingly be isotopes which are incorporated directly in the composition of the detector, so that detectors with masses of tens or possibly hundreds of kilograms could be developed. Many authors have mentioned that a suitable isotope for this purpose might be ^{136}Xe, and several specific detectors have been proposed for studying the $2\beta(0\nu)$ decay of ^{136}Xe.

In this letter we report the results of a study of the $2\beta(0\nu)$ decay of ^{136}Xe, found with one version of such a detector: a liquid-xenon scintillation spectrometer.

The liquid xenon fills a cylindrical volume with a diameter of 110 mm and a height of 33 mm. This volume is monitored from its end faces by Hamamatsu R-877 photomultipliers with quartz windows. A reflector made from Teflon covers the lateral surface of the cylinder. The entire spectrometer is immersed in a cryostat at − 110 °C, which corresponds to a saturation vapor pressure of 1.4 atm for liquid xenon. Before the detector is filled, the xenon is purified in a system consisting basically of spongy titanium at 800 °C. The energy resolution of the spectrometer at the energy of the $2\beta(0\nu)$ decay of ^{136}Xe, 2481 keV, is 10%. The design of this spectrometer is described in more detail in Refs. 2 and 3.

The spectrometer is enclosed in a passive shield consisting of 4 cm of tungsten, placed directly around the spectrometer inside the cryostat, and 10 cm of lead. The entire apparatus is installed in an underground room at the Baksan Neutrino Observatory of the Institute of Nuclear Studies, at a depth of 860 meters water equivalent, where the flux density of cosmic-ray muons has been reduced to 0.5 $cm^{-2} \cdot day^{-1}$.

The spectrometer background measured over 309 h in this shield is shown in Fig. 1.

There is no structural feature of any sort near the energy of the $2\beta(0\nu)$ decay of ^{136}Xe, i.e., in the region 2481 $\pm$ 187 keV, which would contain 94% of the events of this hypothesized decay. We can thus conclude that there is no peak corresponding to $2\beta(0\nu)$ decay within one standard deviation. Taking into account the 91% detection

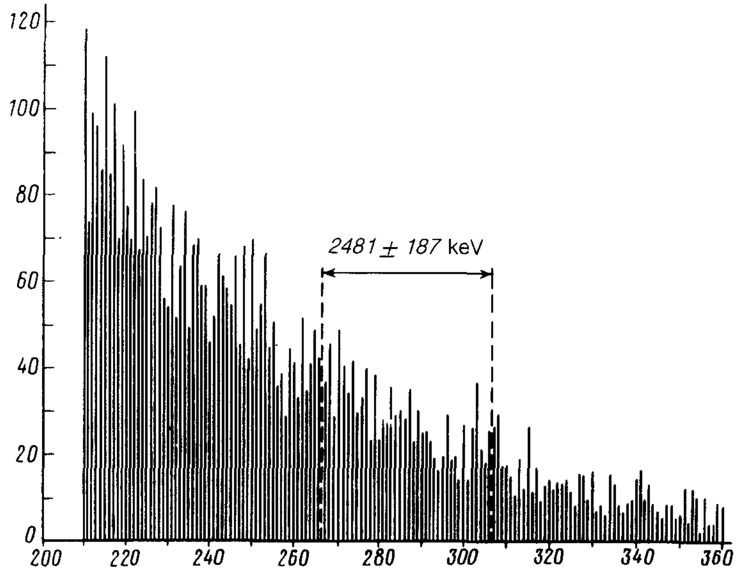

FIG. 1. Background spectrum of the liquid-xenon detector over 309 h. The channel number is plotted along the abscissa, and the number of pulses along the ordinate.

efficiency, we find the following limit on the decay half-life: $T_{1/2}$ (^{136}Xe, $2\beta(0\nu) \geqslant 2.36 \times 10^{21}$ yr (67%).

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