Preliminary Results from a Study of the Double Beta Decay of ^{150}Nd

M. C. Perillo Isaac, Y.D. Chan, D. Hurley, R. J. McDonald, E. B. Norman and A. R. Smith

The main contribution to double beta decay (with or without neutrinos) is the ground state to ground state (GS) transition. Transitions to the excited states of the daughter isotope are also possible, if kinematically allowed. The double beta transition to 0^+ excited states is analogous to the ground state to ground state transitions, while a double beta decay from a 0^+ state to a 2^+ excited state is only possible through right handed currents. In the first approximation, the transition rate of the double beta decay with the emission of two neutrinos is proportional to a function of the available energy for the decay [1]. In this scenario the transition rates to excited states are substantially lower than the transition rate to the GS of the daughter isotope.

Here we report the first phase of an experiment where we look for the de-excitation γ -rays of ^{150}Sm populated by the double beta decay of ^{150}Nd using direct counting techniques.

The half life of the 2ν double beta transition of ^{150}Nd to the ground state of ^{150}Sm was recently measured to be $(1.7\,^{+1.0}_{-0.5} \pm 0.35) \times 10^{19}$ y[2] Taking into account the expected dependence on the phase space factor, one can predict a half life for the double beta transition of ^{150}Nd to the first 0^+ excited state of ^{150}Sm to be of the order of 10^{20} y. The de-excitation from this level gives rise to two coincident gamma-ray lines, 334 and 406 keV.

We used a 500 cm^3 n-type HPGe detector to look for the γ -rays following the double beta decay of ^{150}Nd to the excited states of ^{150}Sm. A sample of 5 kg of natural Nd_2O_3 was placed in a Marinelli beaker geometry around the detector. The passive shielding consists of 15 cm of lead and 2 cm of copper and the whole set-up is located at the LBNL - Oroville low background facility (700 mwe). We accumulated data for 1268.67 h in this configuration.

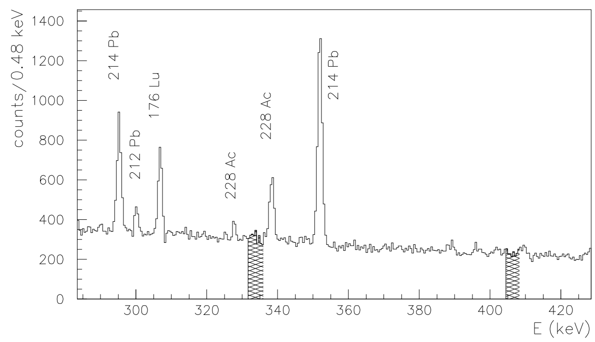

Figure 1: The energy regions of the two gamma-ray lines from the de-excitation of the first 0^+ state are hatched. The peaks from natural radioactive contamination are marked

We did not observe peaks in the energy region where the gamma-ray lines from the de-excitation of ^{150}Sm levels are expected. The lower limit for the half life can be obtained through the upper limit peak area of the gamma lines 334 and 406 keV.

Since the two gamma lines we are looking for have the same intensity (100% branching ratio each), one can add the two energy regions of the spectrum in order to obtain a combined upper limit peak area and hence a better limit for the half life. Our limit for the half life of the double beta decay of ^{150}Nd to the first 0^+ excited state of ^{150}Sm is 4.9×10^{19} years (2.9×10^{19} years), with 68% (90%) confidence level.

Footnotes and References

[1] See “Physics of Massive Neutrinos”, F. Boehm and P. Vogel, Cambrige Unversity

[2] V. A. Artem et al, JETP Lett. 58, 262,(1993)