# Reply to "Comment on 'Feasibility of detecting neutrinoless double-beta decay between pairs of single-beta emitters'"

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A realistic comparison is made of the two suggested decay modes that could be used to search for neutrinoless double-beta decay between pairs of single-beta emitters. Although both experiments are beyond current technical feasibility, the electron capture decay mode is superior. The dominant consideration is the background of bremsstrahlung photons.

The preceding Comment[1] contains theoretical calculations of the transition rate for a specific decay mode, hereafter called the "electron capture" mode, that could be used to search for neutrinoless double-beta decay between pairs of single-beta emitters.[2] The electron capture mode has been suggested by this author[3] as a better experimental method than the originally proposed "beta decay" mode.[2,4]

The prospects for actually performing an experimental test with either mode are not promising. The reasons for this are given in Ref. 3 and can be briefly summarized as follows.

(1) The required mass of radioactive source is extremely large, on the order of grams.

(2) Backgrounds generated by bremsstrahlung, internal and external, will mask the desired signal of double-beta decay.

The purpose of this paper is to compare the experimental feasibilities of the two proposed decay modes.

A careful design of the beta decay mode experiment should start, as is done in Ref. 3 with the electron capture mode, by identifying prospective isotopes. A search has been made for all beta-decay isotopes that are[5]

(1) allowed decays,

(2) $m_e < Q < 2m_e$,

(3) accompanying nuclear gamma rays restricted to a maximum energy of 100 keV (these are the same criteria used in Table I of Ref. 3 for electron capture decays).

There is only one candidate isotope: the neutron, $Q = 782.4$ keV, $T_{1/2} = 10.6$ min, $\log ft = 3.0$.

Neglecting the obvious experimental problem of collecting and storing neutrons, assume that a supply of spheres of condensed neutrons at normal metallic density, each with $r = 6$ $\mu$m, can be maintained. Since the double-beta decay detection scheme[2,4] for the beta decay mode requires two conversions, fast betas to bremsstrahlung and then pair production from the bremsstrahlung, each neutron sphere will need a high $Z$ coating, e.g., a few mm of Pb, to optimize the overall process. The 6 $\mu$m size is chosen by envisioning doing this experiment in the same detector array as described in Ref. 3 for the electron capture mode. Singles rates in individual detectors determine source size.

The two-step conversion process,[2,4] fast betas to bremsstrahlung to positrons, is necessarily a quite inefficient process. Bremsstrahlung fractions are small ($\sim 1\%$) and pair production cross sections at these energies are a few percent, at best, of Compton scattering cross sections. The major experimental problem, as pointed out in Ref. 3, would be the background of single-beta decay-induced bremsstrahlung photons mimicking the signal of the positron, two back-to-back 511 keV annihilation photons.

Estimates for an optimized beta decay mode experiment indicate that it will have 100 times less sensitivity to double-beta decay than the worst of the three electron capture mode experiments ($^{49}V$) summarized in Eq. (4) of the preceding Comment.[1] To make this comparison, the symbol "$\Lambda$," decays per second, has been reinterpreted to mean "decays detected per second separable from background." It is in this sense that the electron capture mode is superior to the beta decay mode of neutrinoless double-beta decay.

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