Double Beta Decay

Standard Model process, second order

\[ (\nu_e, \nu_e) \rightarrow (\nu_x, \nu_x) \]

The half-life is given by:

\[ T_{1/2} = \frac{1}{\lambda} = \frac{1}{\alpha} \left( \frac{A}{12} \right)^{1/2} \]

where \( \alpha \) is the phase-space dependence that is accurately calculable.

\( \alpha = \frac{A^2}{12} \) is the Nuclear Matrix Element, a sizeless number of order 1 that is derived from nuclear theory.

EXO-200 will be the first experiment to measure 2νββ in 100K.

Neutrinoless Double Beta Decay

Similar to "normal" double beta decay, except no neutrinos are emitted:

\[ (\nu_x, \nu_x) \rightarrow (\nu_x, \nu_x) \]

Only occurs if:

\[ 0 \rightarrow 2 \text{ Neutrinos are their own antiparticle} \]

\[ m_\nu \approx 0 \text{ Neutrino are massless} \]

\[ A\nu = \frac{1}{2} \text{ Lepton number is not conserved} \]

The half-life is given by:

\[ T_{1/2} = \frac{1}{\lambda} = \frac{1}{\alpha} \left( \frac{A}{12} \right)^{1/2} \]

where \( \alpha = \frac{1}{2} \left( \frac{A}{12} \right)^{1/2} \) is the effective neutrino mass.

\( \alpha^{1/2} \) includes more than the Gamow-Teller term that is in the 2ν equation.

The difference between 2νββ and 0νββ is seen in the energy spectra of the 2 electrons. Since the rate of 0νββ is anticipated to be much smaller than 2νββ and our energy resolution is finite, we seek a small bump at the end of the 2νββ spectrum.

The sensitivity to neutrinoless double beta decay is given by:

\[ \frac{1}{\lambda} = \frac{1}{\alpha} \left( \frac{A}{12} \right)^{1/2} \]

\[ \gamma_{2ν} \text{ efficiency, } \gamma_{0ν} \text{ isotropic abundance, } A = \text{ mass, } T = \text{ rate, } B = \text{ background} \]

The goal of the experiment is to maximize the time, enrichment, and mass while minimizing the background and improving resolution.