Chapter 1

Conclusions

Neutrinoless double beta decay ($0\nu2\beta$) is a hypothesised decay where two β decays occur simultaneously, emitting two electrons but no anti-neutrinos. It is clear that this process violates the lepton number and is thus forbidden in the standard model. If this process were observed, it would imply the Majorana nature of the neutrino, and in addition, it allows the extraction of the absolute mass scale of the neutrino (model-dependently). Searching for $0\nu2\beta$ is one of the highest priority items on the modern particle physics agenda. There is a range of experimental techniques currently employed and proposed to search for $0\nu2\beta$.

The SuperNEMO is a ~~next generation~~ $0\nu2\beta$ experiment capable of reaching a half-life sensitivity of $T_{1/2} > 10^{26}$ years, equivalent to an effective Majorana neutrino mass of $\langle m_\beta \rangle < 40$ - 100 meV. The baseline design of SuperNEMO envisages 20 identical planar modules, housing 100 kg of source isotope (^{82}Se) in total. The Demonstrator module, which is about to be commissioned at the Laboratoire Souterrain de Modane (LSM), will search for $0\nu2\beta$ in 7 kg of ^{82}Se source with the aim of reaching zero background in the region of interest. Its unique tracker-calorimeter technology allows for the reconstruction of the 3D topology of the detected event, providing both a powerful background rejection method and evidence for the underlying decay process.

^{214}Bi and ^{208}Tl, as the decay daughters of ^{222}Rn and ^{220}Rn respectively, contribute a large part to the background due to their high β decay Q_β values of 3.27 MeV and 4.99 MeV respectively. All materials are naturally contaminated with traces of the ^{232}Th and ^{238}U. Radon, as a highly diffusive radioactive gas with a relatively long half-life, can enter the SuperNEMO detector generally via emanation from the detector construction material and diffusion from the environment.

To achieve the target sensitivity of SuperNEMO, the activity of radon in the tracker activity needs to be $<150\mu$Bq/m^3, which has imposed a very challenging requirement on the radio-purity of the detector components, construction materials, and the tracker gas. Commercial detectors are not sensitive enough; therefore, a custom-made electrostatic detector was commissioned for SuperNEMO, which is capable of measuring radon down to a level of 1 -2 mBq/m^3. The radon concentration line (RnCL) was developed to be used in conjunction with the electrostatic radon detector, which allowed for the measurement of ultra-low level activity of large gas volumes. The RnCL has demonstrated that it can achieve a sensitivity of 20 μBq/m^3 using 8.4 m^3 of gas which is the volume used for a typical quarter-tracker module radon measurement. A gas purification system called J-trap was used to provide carrier gas of ultra-low and stable radon contamination, for radon measurements.

Using the RnCL, three quarter-tracker modules have been measured of their radon emanation level before and after tracker wire cell installation. Measurements of radon emanation of detector components and construction materials were carried out to screen and select the cleanest possible materials for SuperNEMO, and to build up the background model based on measurements obtained from individual components. Two radon emanation chambers were used for radon emanation measurements of small samples. The sensitivity of chamber 1 and chamber 2 are <0.09 mBq and <0.19 mBq respectively. A number of samples have been measured for SuperNEMO as well as for the LZ experiment.

The demonstrator sensitivity to its radon backgrounds has been studied via Monte Carlo simulations performed with the SuperNEMO software. Using the

`1e1` event topology it is shown that the ^{214}Bi target contamination originated from radon (4 mBq in the tracker volume of 15 m^3) can be measured with a 5% precision within 12 days of data taking.

Bibliography