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Thèse de doctorat

Characterization of SuperNEMO demonstrator calorimeter timing performance
Study of 208Tl background rejection influence on the 0nubb decay sensitivity

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Conclusion

The search for the neutrinoless double beta decay is one of the doorways to physics beyond the Standard Model. If the neutrino is a Majorana particle, in addition to providing an explanation for the matter/anti-matter asymmetry observed in the universe, the existence of this mechanism could explain the fact that neutrinos have a very low mass compared to other fermions, through the see-saw mechanism.

NEMO technology, which has already set limits on this mechanism for several isotopes, has given birth to the SuperNEMO detector. With 100 kg of ^{82}Se this detector based on the inique tracko-calo technology would achieve $T^{0\nu}_{1/2} > 5.4 \times 10^{25}$ years, corresponding to $\langle m_{\beta\beta} \rangle = [0.079 - 0.15]$ eV, for 5 years of data acquisition. The SuperNEMO demonstrator, which is nearing the end of installation at the Modane Underground Laboratory with 6.23 kg of ^{82}Se, will complete its commissioning phase by the end of 2020 and will take data for slightly more than two years and a half. With the measurement of SuperNEMO source activities by BiPo-3 detector, we have determined that the demonstrator should achieve a sensitivity at $0\nu\beta\beta$ of $T^{0\nu}_{1/2} > 3.6 \times 10^{24}$ years, corresponding to $\langle m_{\beta\beta} \rangle < [0.31 - 0.59]$ eV. The 25 Gauss magnetic field that will be applied in the detector will have very limited impact on the sensitivity, but it will be necessary to wait for simulations of external background before a more complete study can be carried out and a final conclusion can be drawn on the influence of this magnetic field.

A way to improve this sensitivity is to reject more efficiently the background coming from ^{208}Tl isotope decays in the sources. When this isotope performs a beta decay to an excited level of ^{208}Pb followed by internal conversion of the $2,615$ MeV metastable level, the event can be rejected by measuring the times of flight of the two detected electrons. An X% improvement in sensitivity was achieved, making it possible to reach [range mass eff]. When the demonstrator starts taking data, these activities can be measured more accurately and sensitivity results will be updated. In particular, it is conceivable that the contamination of sources in ^{214}Bi is lower than the upper limit provided by BiPo-3. As this study is based on time-of-flight measurements, the uncertainty in the time measurement of the optical modules impacted the final result on sensitivity [cite result]. A mission was then conducted at Modane to determine this parameter using a ^{60}Co source whose two prompt gamma rays can be detected coincidentally by pairs of calorimeter blocks. Using simulations of the detector, this analysis revealed that the time resolution of optical modules [quote result].

During my PhD, I was also given the opportunity to participate in commissioning data collection and analysis, thus characterising the detector's performances. In particular, by sending electronic pulses through the signal cables of the calorimeter, the condition of each cable and connector could be checked and corrected if necessary. A data base of the length of each cable was made available to the collaboration to improve the accuracy of the coincidence analyses. Data was also taken to calibrate the calorimeter front-end boards in time [donner chiffre du décalage moyen]. These two preliminary analyses will have to be completed by a more complete study aimed at characterising the entire signal transmission chain, from the calorimeter to the DAQ.

The commissioning of the calorimeter is now complete, and the next step in characterising the detector will be to study the performance of the tracker. This step should be completed by the end of 2020.

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