

Abstract

Heavy Neutral Lepton (HNL) is hypothesised to be the right-handed heavy partner to the left-handed Standard Model (SM) neutrino, which is motivated by neutrino mass mechanism proposals. HNLs can be produced from charged kaon decays from the Booster Neutrino Beam (BNB) and subsequently decay in flight at the Short-Baseline Near Detector (SBND), leaving observable signals for detection. The presented thesis focuses on the channel of HNLs in the mass range of 140–260 MeV, decaying into a neutral pion that results in diphoton showers inside the detector. SBND is a 112 tonne liquid argon time projection chamber, which offers an exceptional resolution in calorimetry, spatial and timing. The capability of SBND to search for HNLs is assessed in this thesis, of which the analysis exploits the boosted topology and late arrival features of HNL signals. Two selections of HNLs are presented, with one having a more aggressive background rejection than the other. Both have a background rejection $\mathcal{O}(10^{-4})$ while maintaining a signal efficiency of $\sim 30\%$. An additional truth study under the assumption of an improved timing resolution is also given as a positive outlook approach. Moreover, an assessment of statistical and systematic uncertainties is outlined, followed by a limits setting procedure to set upper limits on the coupling $|U_{\mu 4}|^2$ of Majorana HNLs at the 90% confidence level. Three result scenarios are presented, demonstrating the current and potential physics capabilities of SBND.