Search for New Physics in SHiP and at future colliders

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Abstract

SHIP is a newly proposed fixed-target experiment at the CERN SPS aimed at the search for hidden particles that interact very weakly with SM particles. In particular it aims to search Heavy Neutral Leptons (HNLs), which are right-handed partners of the Standard Model (SM) neutrinos. The existence of such particles is strongly motivated by theory, as they can simultaneously explain the baryon asymmetry of the Universe, account for the pattern of neutrino masses and oscillations and provide a Dark Matter candidate.

This work investigates SHiP's physics reach in the parameter space of the Neutrino Minimal Standard Model (νMSM), which is the most minimal model that explains SM cosmological flavours with sterile neutrinos. The sensitivity of future collider experiments was also investigated, to give a comprehensive view of HNL searches in the next decades.

A model introducing an extra $U(1)$ symmetry in the dark sector is also explored. Models with a hidden sector provide a natural candidate for Dark Matter. In most of this models SM particles can interact with the hidden sector via kinetic mixing between the SM photon and a massive Dark Photon, belonging to the hidden sector.

This work shows that the SHiP experiment can improve by several orders of magnitude the sensitivity to Heavy Neutral Leptons below 2 GeV, scanning a large part of the parameter space below the charm meson mass. Similarly SHiP can greatly improve present constraints on Dark Photons. Right-handed neutrinos with mass above 2 GeV can be searched for at a future e^+e^- Z^0 factory. The synergy between SHiP and a future Z^0 factory would allow to cover most of the parameter space for sterile neutrinos of the νMSM.