Search for Hidden Particles (SHiP)

A. Dätwyler, C. Betancourt, I. Bezshyiko,
A. Buonaura, E. Graverini, N. Serra, B. Storaci

Physik Institut, Universität Zürich
alexander.daetwyler@uzh.ch

General purpose of experiment

SHiP (Search for Hidden Particles)[1] is a beam dump facility at CERN for new Physics. Searches for long lived and very weakly interacting particles are foreseen in different Beyond Standard Model theories:

- Light inflation
- Sgoldstino, light neutralino (SUSY)
- Dark Photon [3]
- Sterile neutrinos: Heavy Neutral Leptons (HNL)
- Light dark matter (mass ∼GeV)

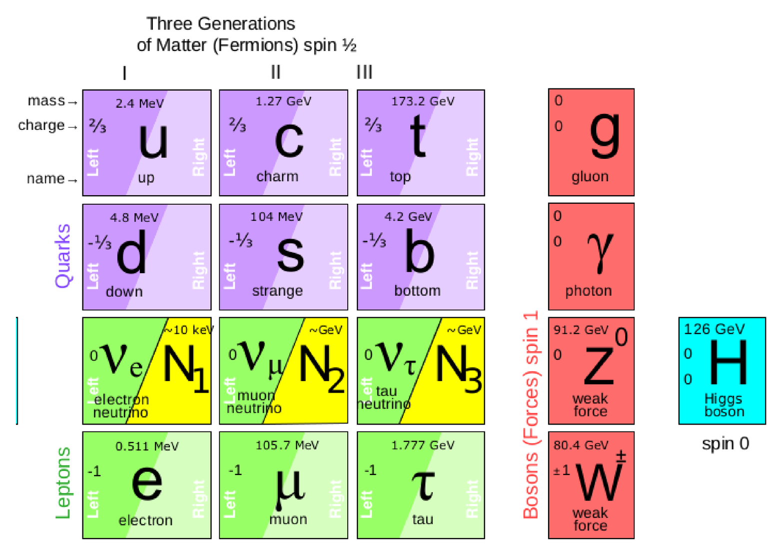
SHiP also performs neutrino physics studies:

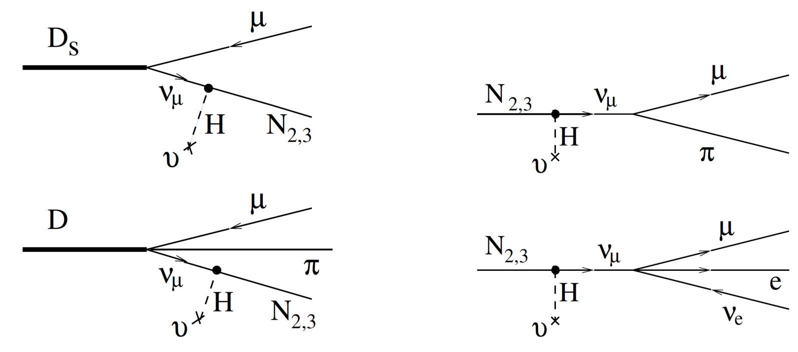
- Aims at the first observation of the tau anti neutrino
- Tau neutrino and anti-neutrino cross section measurement
- Estimation of nucleon structure function
- Estimation of strange quark content of the nucleon

Heavy Neutral Leptons (HNL) [2]

The Neutrino Minimal Standard Model (νMSN) is an extension of the standard model by adding three heavy neutral leptons (shown in the figure below as N_1, N_2 and N_3). Among the three extra neutrinos, there are

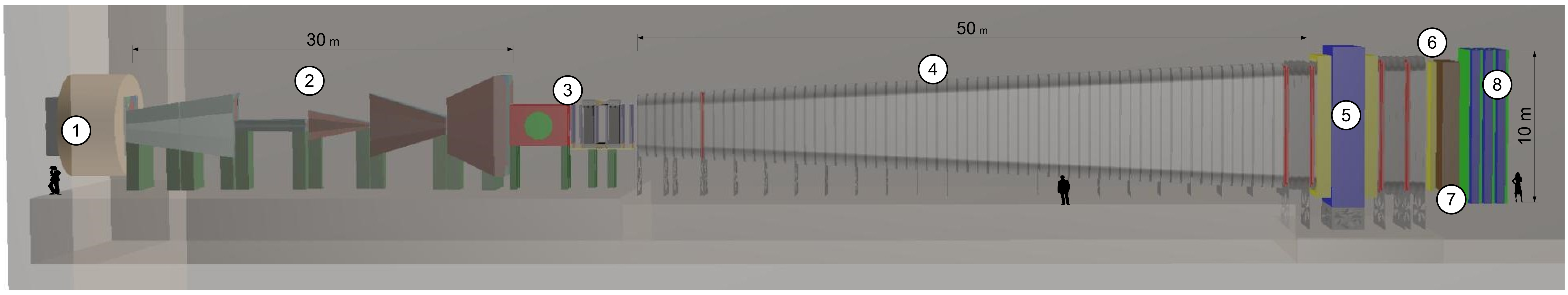
- a light one (mass ∼keV) plays the role of Dark Matter
- Two heavier ones explain ν-oscillations and the matter-antimatter asymmetry in the universe





Production and decay of HNLs

The SHiP experiment



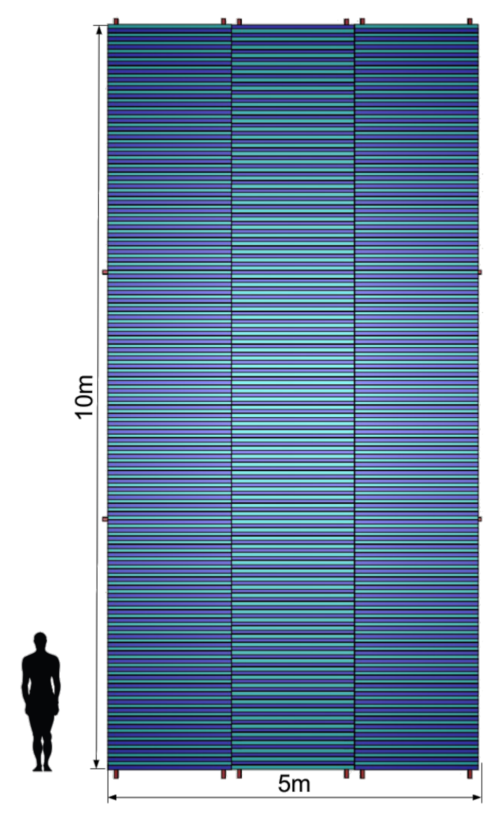
The schematics of the SHiP experiment. $2 \cdot 10^{20}$ protons in 5 years hit the target from the left with an energy of 400 GeV. The numbers in the figure correspond to the numbers in the section "Components of the detector")

Components of the detector

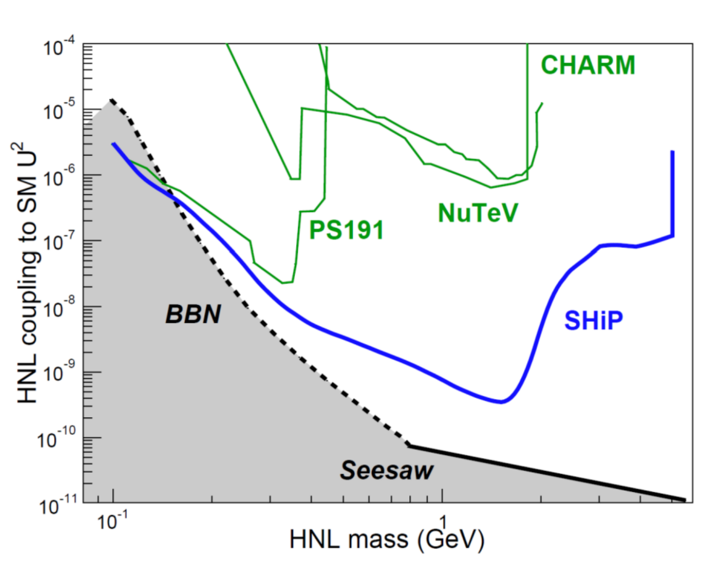
- To maximize flux of Hidden Particles (HP) with respect to standard model particles, the target (1) has to be heavy
- HP show a long lifetime and large transverse momentum → Long decay volume (4)
- HP decay into Standard Model particles → Detectors placed at the end of the decay volume (Spectrometer(5), Timing detector(6), electromagnetic calorimeter(7), hadronic calorimeter(7) and muon detector(8))
- Production and decay rates of HP are strongly suppressed. Necessity to be a 0 background experiment → Hadron stopper behind target and muon shield (2)
- Huge neutrino flux produced at target ($\sim 60000\ \nu_\tau + \bar{\nu_\tau}$)→ Neutrino detector (3)

Contributions of the University of Zürich

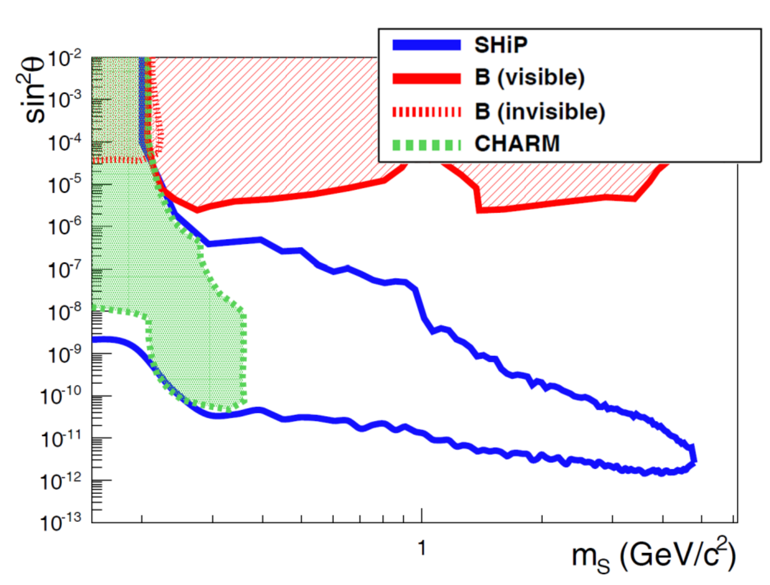
- Development of the veto timing detector based on scintillating bars readout by silicon photomultipliers (shown on the right)
- Performance evaluation and optimization of the tau neutrino detector
- Design and implementation of the magnetic muon shield
- Studies on neutrino background
- Sensitivity estimates for the νMSM (the SHiP flagship theory), and dark photons



Sensitivity



Sensitivity contours for Heavy Neutral Lepton (HNL) coupling to active neutrino as function of HNL mass



Sensitivity contours for light hidden scalar particle (mass m_s) mixing with Higgs

References

[1] M Anelli et al. "A facility to Search for Hidden Particles (SHiP) at the CERN SPS". In: *arXiv preprint arXiv:1504.04956* (2015).

[2] Takehiko Asaka, Steve Blanchet, and Mikhail Shaposhnikov. "The νMSM, dark matter and neutrino masses". In: *Physics Letters B* 631.4 (2005), pp. 151–156.

[3] Johannes Blümlein and Jürgen Brunner. "New exclusion limits on dark gauge forces from proton Bremsstrahlung in beam-dump data". In: *Physics Letters B* 731 (2014), pp. 320–326.