University of Zurich[UZH]

SHiP: an experiment to search for Hidden Particles

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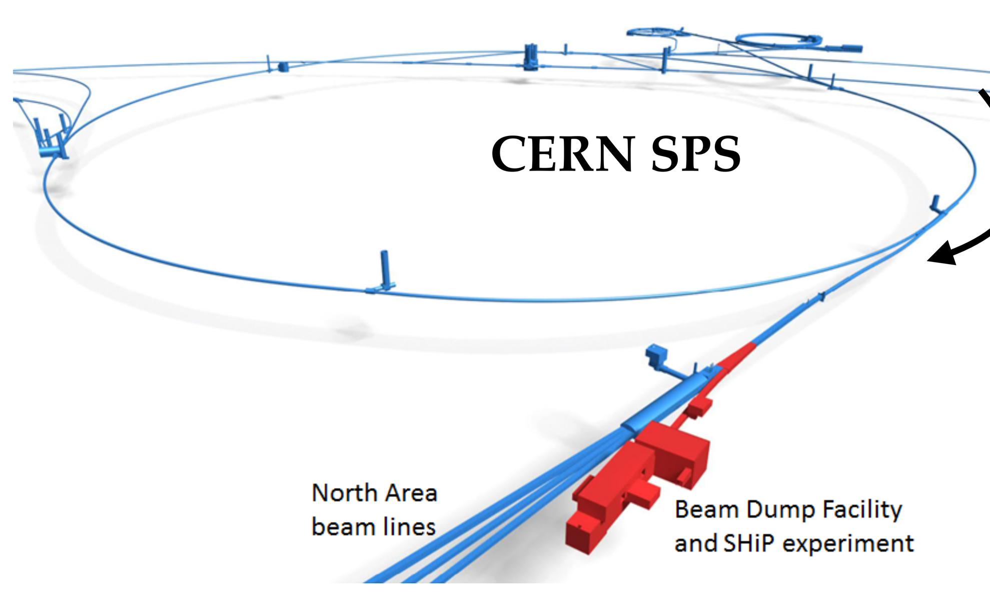
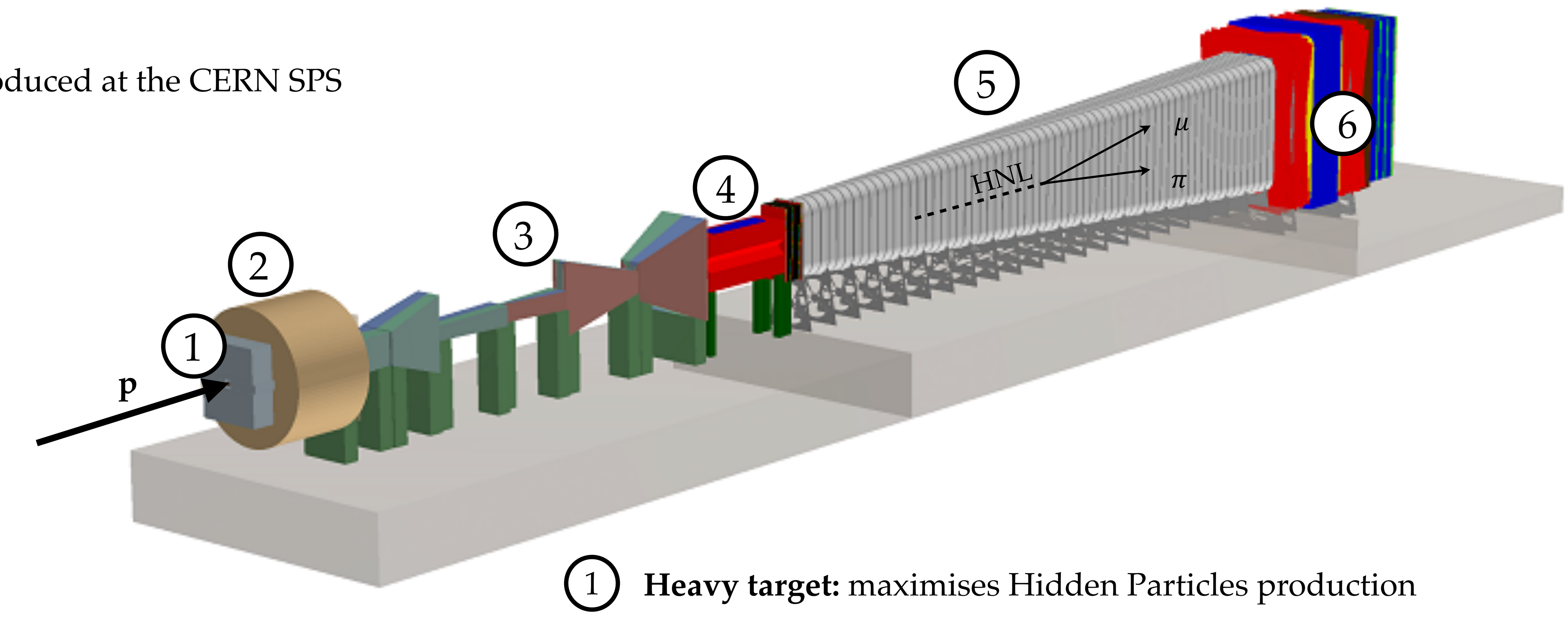
The Facility

- General fixed target facility using 400 GeV protons produced at the CERN SPS
  - 5 years of data taking foreseen
  - $2x10^{20}$ protons on target (pot) collected

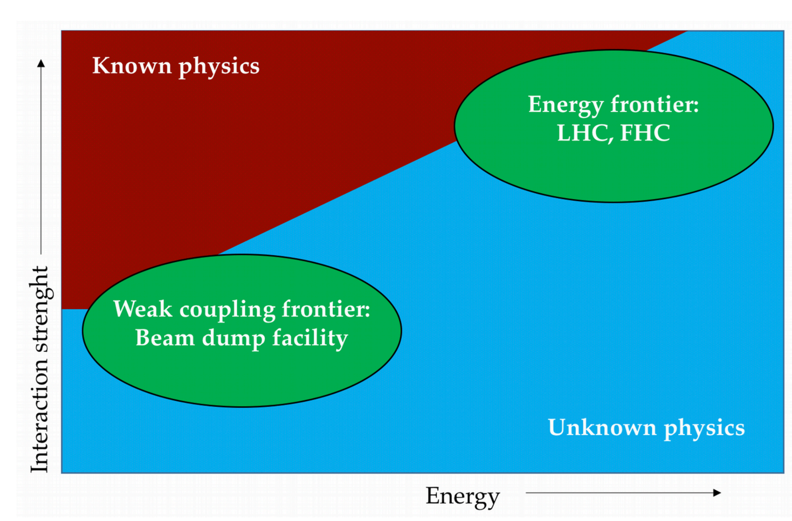




1. **Heavy target:** maximises Hidden Particles production
2. **Hadron stopper:** 5m of Iron to kill all the electromagnetic and hadronic particles
3. **Muon shield:** Sweeping magnets to clear detector region from muon background
4. **Neutrino detector:** Detector made of a modular target of Lead + emulsion films in a magnetic field
5. **Decay volume:** 50 m long vacuum vessel where the Hidden Particles can decay
5. **Particle detectors:** Spectrometer, timing detector, electromagnetic + hadronic calorimeter and muon detector to detect and study properties of the particles produced by the Hidden Particles decay

Motivation and Physics Goal

- SHiP searches for new physics at the intensity frontier, complementing High Energy experiment searches.
- SHiP aims at **exploring Hidden Portals and extension of the SM** incorporating **long-lived** and **very weakly interacting** particles.



Experimental Requirements

- Hidden Particles with m(GeV) produced in heavy meson decays
  - Long life-time
  - Large transverse momentum
  - decay in SM particles

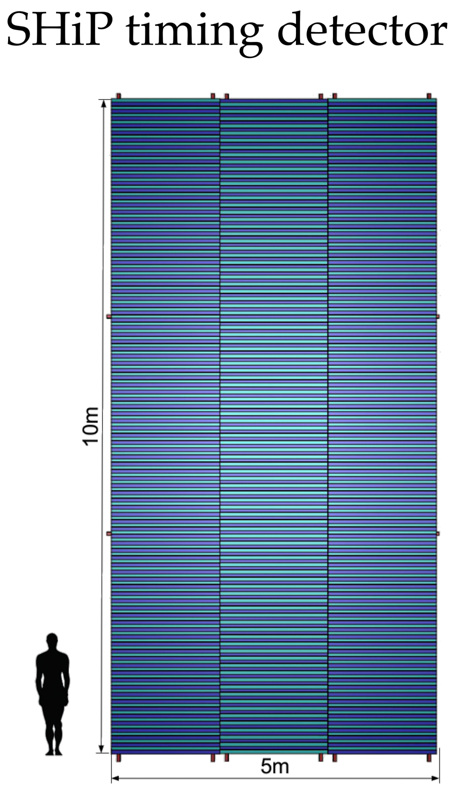
  } Long decay volume ~50 m far from the proton target + equipped with detectors at the far end
- Production and decay rates strongly suppressed

  ➔ Background suppression (0 bkg experiment) { Hadron stopper, Muon shield, Vacuum decay vessel
- Huge neutrino flux from charmed hadron decays ➔ Neutrino detector

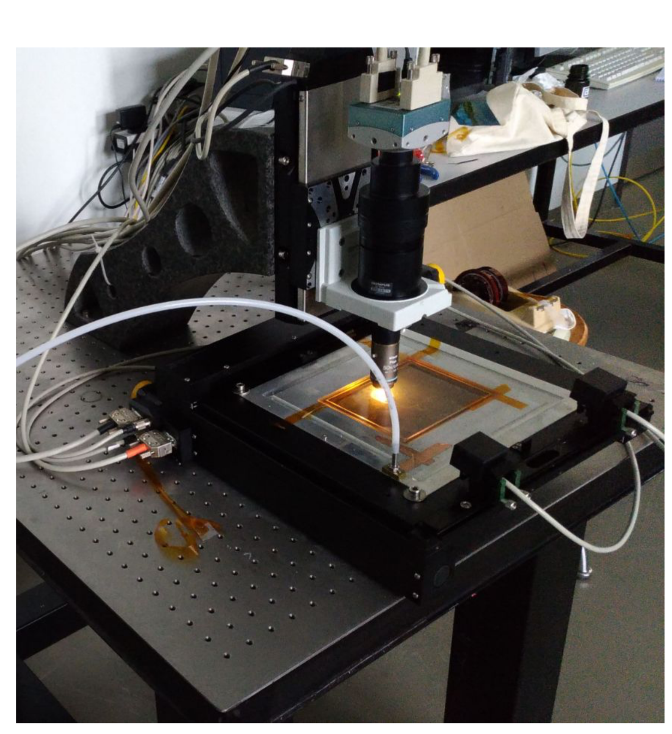
Contributions of the University of Zurich

- Development of the veto timing detector based on scintillating bars readout by silicon photomultipliers
- Design and implementation of the magnetic muon shield
- Studies on neutrino background
- Sensitivity estimates for the νMSM (the SHiP flagship theory) and dark photons
- First measurement of charmed hadrons production cross-section in a thick target with the use of nuclear emulsion technique

SHiP timing detector layout

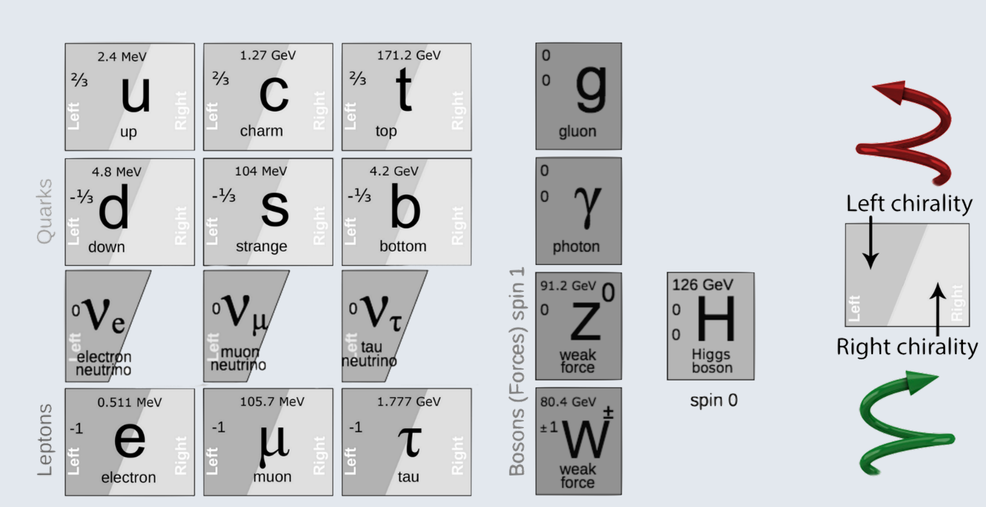


Microscope for emulsion scanning



The Standard Model (SM)

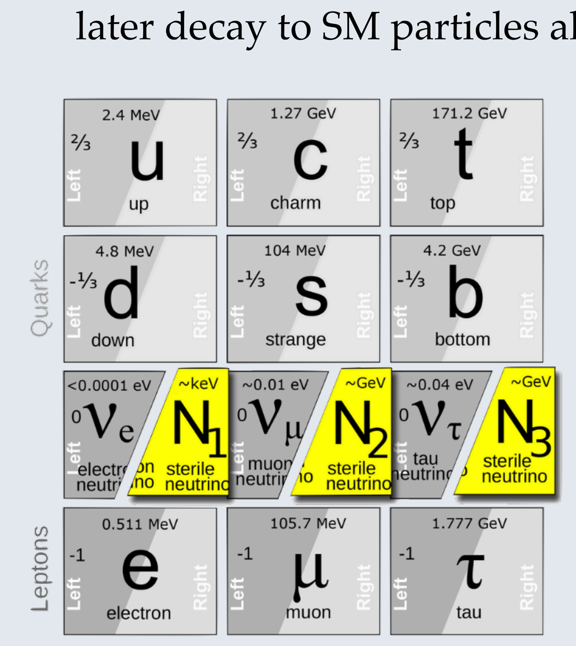
- Most validated theory to describe the fundamental constituents of Nature together with their interactions
- Quarks and leptons are divided in three families:
  - The charged quarks and leptons have both a Right Handed (RH) and Left Handed (LH) chirality component.
  - The neutral leptons (the neutrinos) have only a LH chirality component

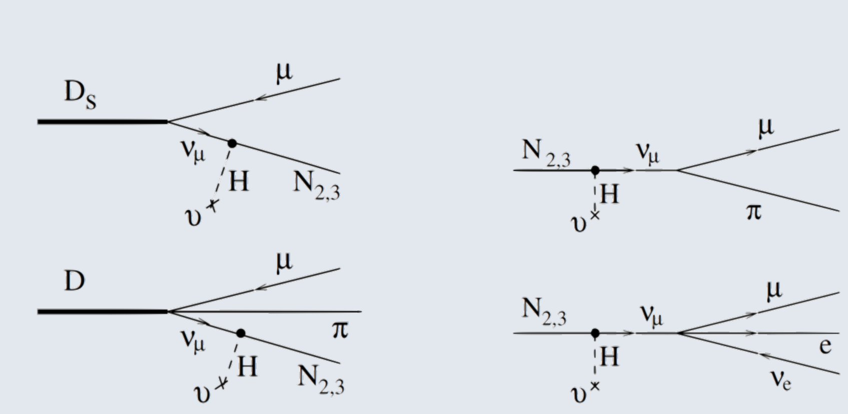


Problems:
1. Neutrino masses (seen from neutrino oscillations)
2. Matter over antimatter (Baryon asymmetry)
3. Presence of non-baryonic Dark Matter

The Neutrino Minimal Standard Model (νMSM)

- One of the many possible extensions of the SM.
- Three Right-Handed neutrinos called Heavy Neutral Leptons (HNL) are paired to the three SM Left-Handed ones
  - The lightest (N_1) good dark matter candidate.
  - N_2 and N_3 "give" masses to neutrinos and can explain baryon asymmetry
- HNLs are produced in the decay of charmed and beauty hadrons and can later decay to SM particles allowing us to detect them





Production and decay of HNLs

Web pages

- https://ship.web.cern.ch/ship/
- https://www.physik.uzh.ch/en/researcharea/ship.html