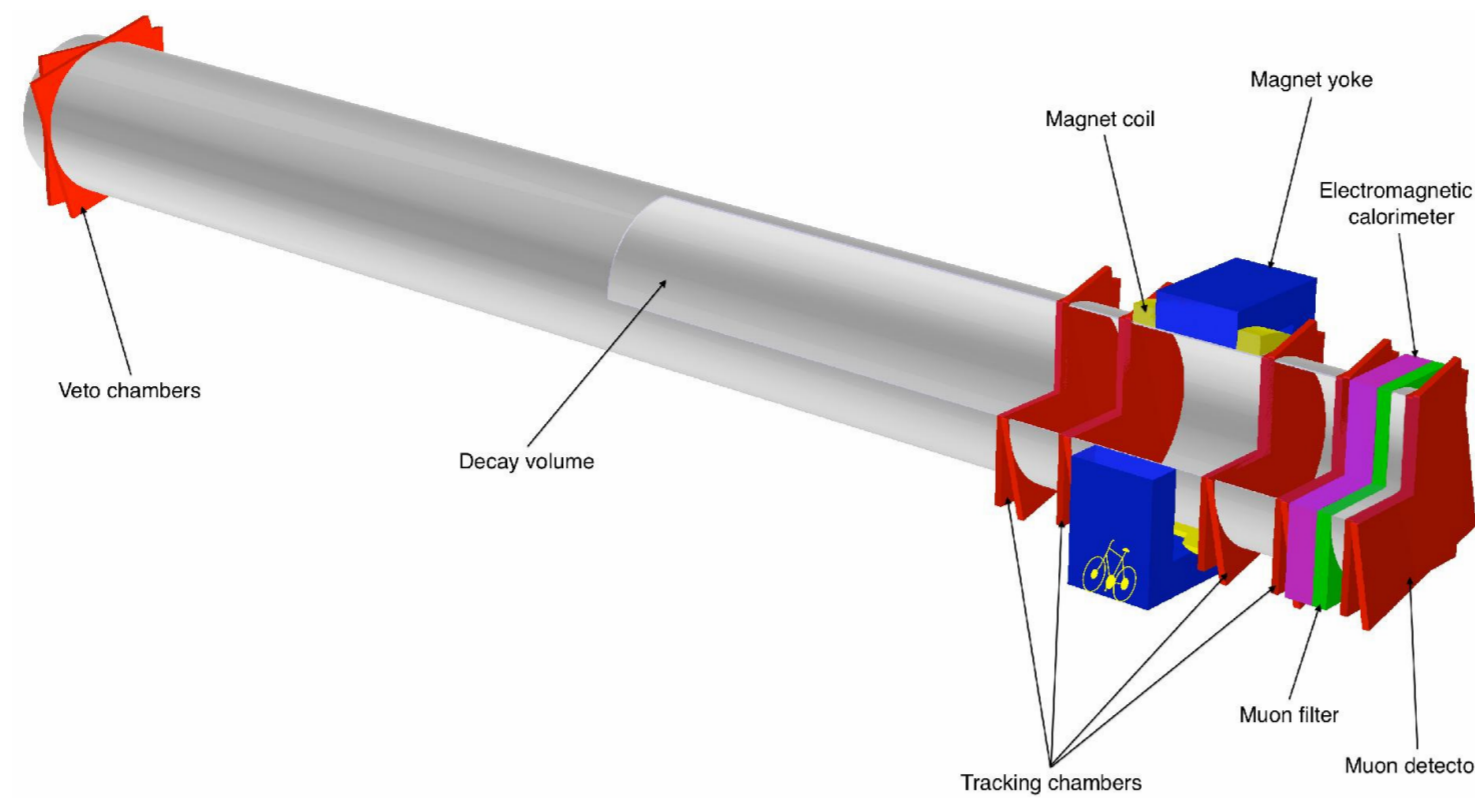


The SHiP experiment [2]

SHiP (*Search for Hidden Particles*) is a proposed new fixed-target experiment at the SPS, designed for the study of very weakly interacting long-lived particles that could solve most problems left open by the Standard Model.



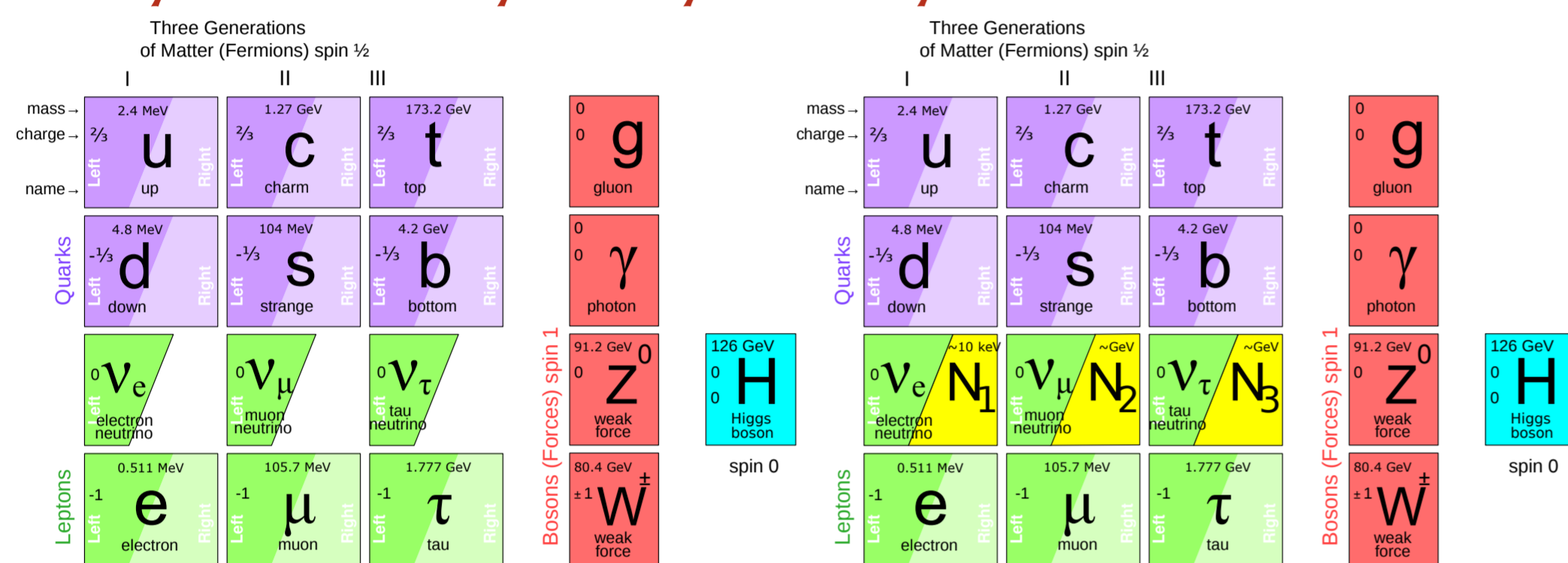
Projects for a future e^+e^- collider [4]

90-400 GeV high-precision e^+e^- collider for strict tests of the Standard Model.



The ν MSM [1]

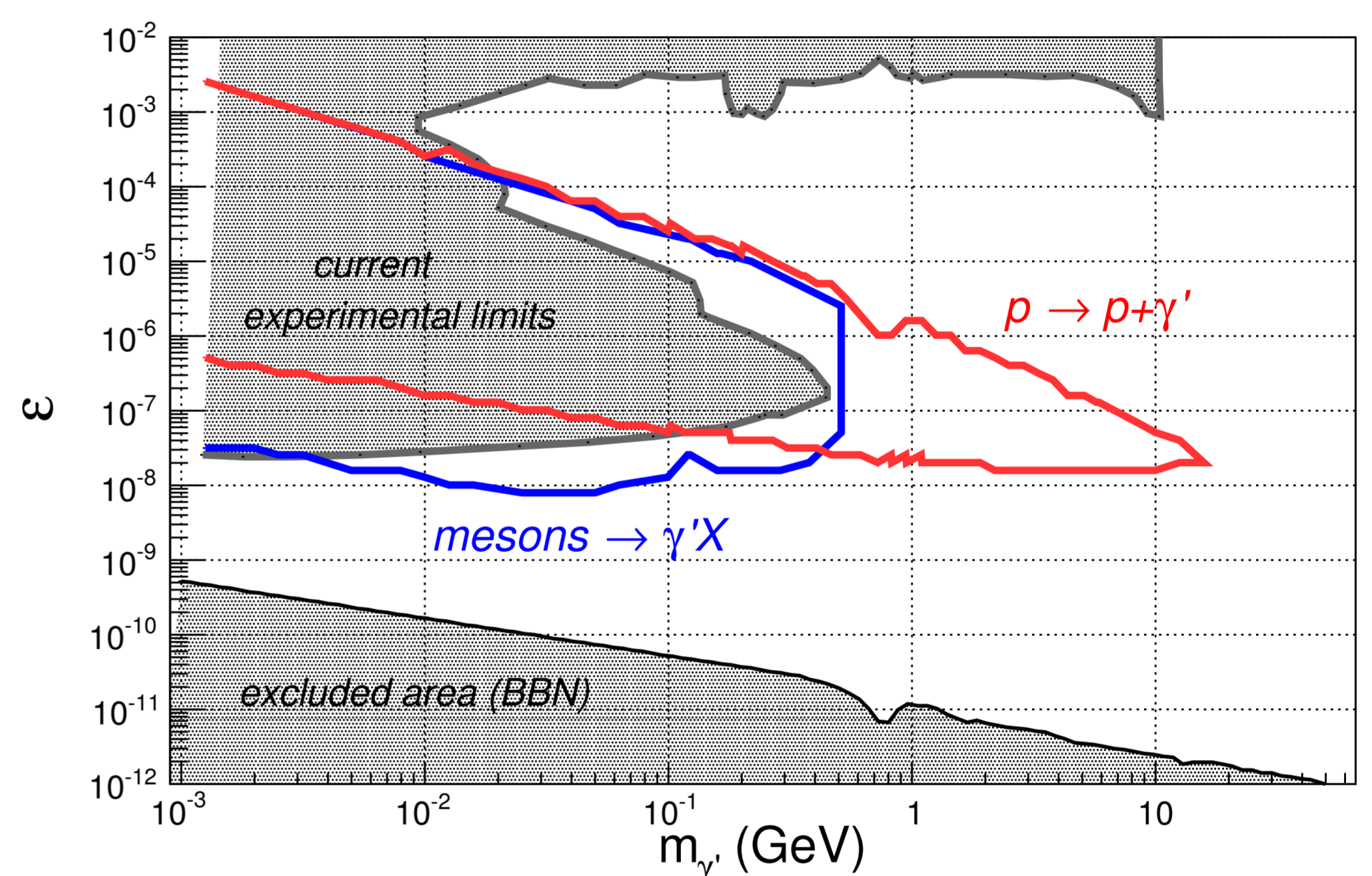
- An extra neutrino (\sim keV) plays the role of **Dark Matter**
- Two heavier ones explain ν **oscillations** and **baryon-antibaryon asymmetry** in the Universe



The vector portal [3]

- Extra $U(1)'$ symmetry with gauge boson γ' (*dark photon*)
- $U(1)'$ broken by Higgs-like mechanism \rightarrow non-zero $m_{\gamma'}$
- Mix to γ through kinetic mixing to particles charged under both $U(1)$ and $U(1)'$: $\mathcal{L}_{eff} = \mathcal{L}_{SM} + \mathcal{L}_{hidden} + \frac{\epsilon}{2} A'_{\mu\nu} F^{\mu\nu}$

SHiP sensitivity to Dark Photons



ϵ is the strength of the kinetic mixing $\gamma' \rightarrow \gamma$.

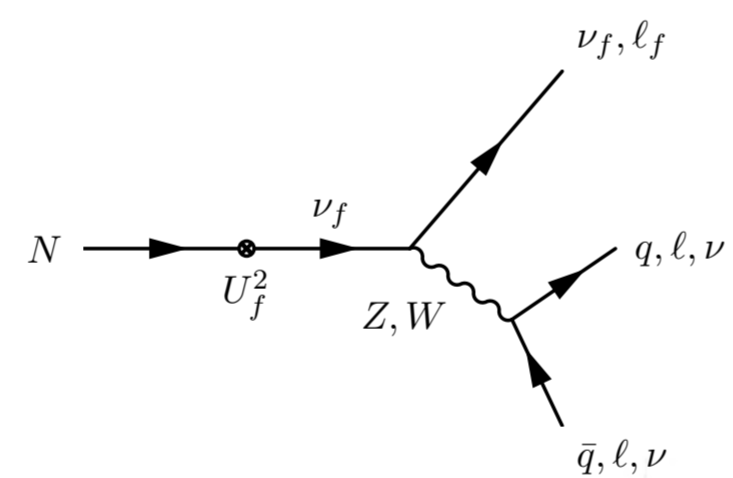
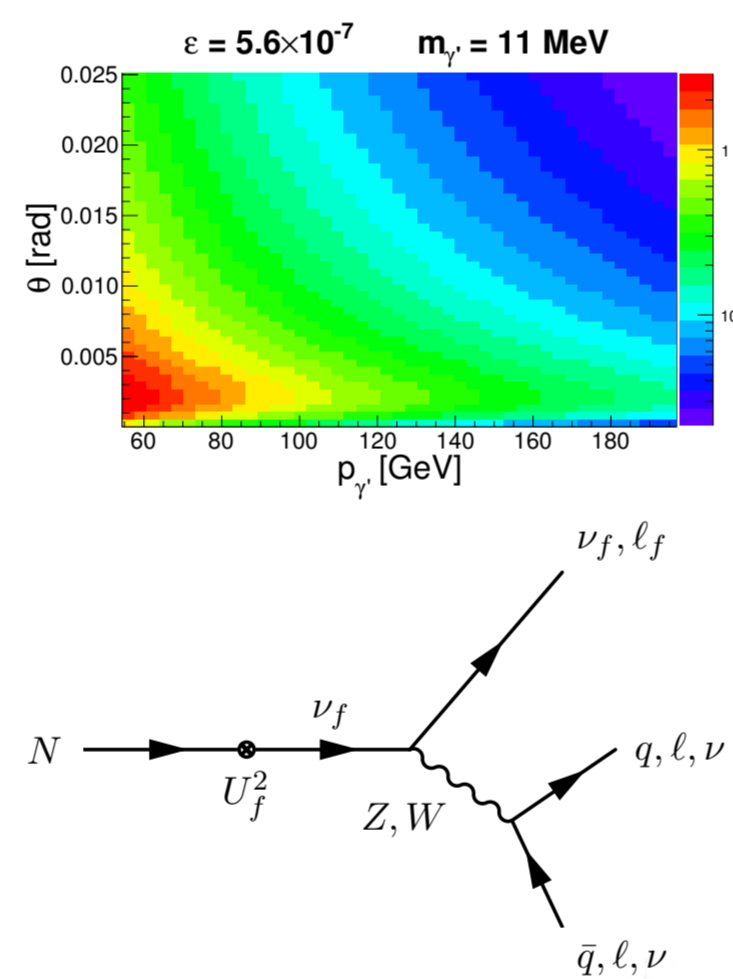
Estimating SHiP's physics reach

- Production: 10^{20} *p.o.t.*
HNL: $D_s \rightarrow \ell N$, $D \rightarrow K \ell N$
 $\gamma': p \rightarrow p\gamma'$, meson decays $\rightarrow \gamma'X$
- (p, θ) -PDF weighted with the probability that the particle decays inside the SHiP volume (\mathcal{P}_{vtx})
- Vertex acceptance: $\int_{SHiP} e^{-l/c\gamma\tau} dl$
- Simulate decays and compute daughters acceptance (\mathcal{A})
- Count the number of events:

$$N = \Phi(p.o.t) \times BR_{prod} \times U_f^2 \times BR_{visible} \times \mathcal{P}_{vtx} \times \mathcal{A}$$

where U_f^2 is the mixing angle to SM particles.

HNL reach at TLEP: $Z^0 \rightarrow \nu N$, similar procedure.



Main backgrounds

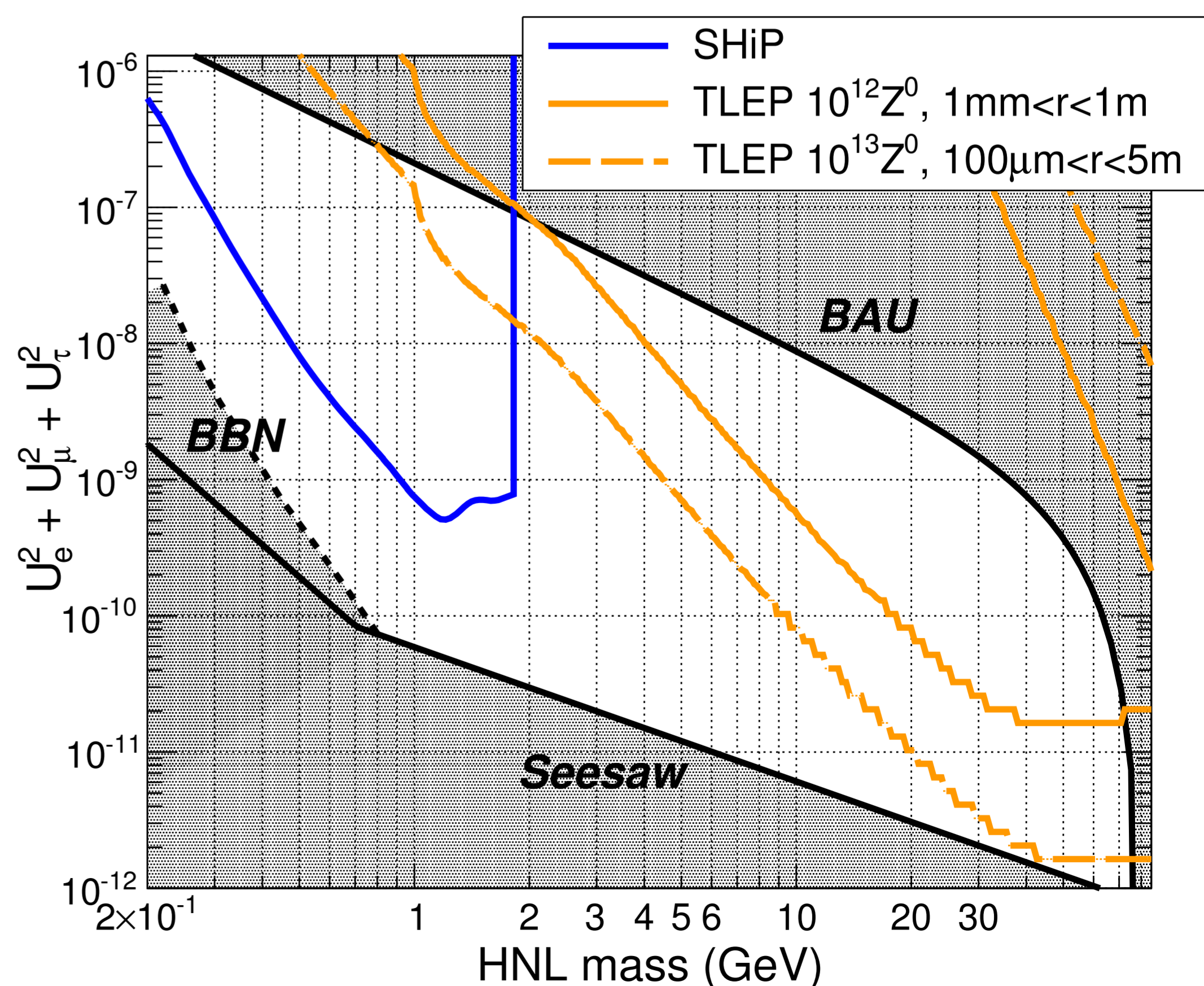
SHiP: it is designed to be a zero-BG experiment: evacuated decay volume, veto chambers, event topology...

TLEP: W^*W^* , Z^*Z^* and $Z^*\gamma^*$ backgrounds suppressed by displacement of the secondary vertex.

References

- [1] T. Asaka, S. Blanchet, and M. Shaposhnikov. "The nuMSM, dark matter and neutrino masses". In: *Phys.Lett.* B631 (2005), pp. 151–156.
- [2] W. Bonivento et al. "Proposal to Search for Heavy Neutral Leptons at the SPS". In: (2013). arXiv: 1310.1762 [hep-ex].
- [3] J. Blümlein and J. Brunner. "New Exclusion Limits on Dark Gauge Forces from Proton Bremsstrahlung in Beam-Dump Data". In: *Phys.Lett.* B731 (2014).
- [4] TLEP Steering Group. *The FCC-ee design study*. 2014. URL: <http://cern.ch/fcc-ee>.

Sensitivity to Heavy Neutral Leptons (*)



Similar results for normal / inverted hierarchy of active ν .