Neutrino Minimal Standard Model — a unified theory of microscopic and cosmic scales

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Snowmass Community Planning Meeting
AF5 organization with contributors

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Letter of Interest:

https://www.snowmass21.org/docs/files/summaries/NF/SNOWMASS21-NF3_NF1-EF9_EF0-RF4_RF6-CF1_CF3-TF11_TF9-AF5_AF0-195.pdf

νMSM: frontier synergies

Indirect probes at accelerators (rare decays, EWPD, lepton universality)

new detectors (FASER, Codex-b, MATHUSLA, Al3X, ANUBIS)

Collider searches for heavy neutrinos

X-ray searches: SRG/eROSITA, SRG/ART-XC, ATHNEA, XRISM, Lynx…

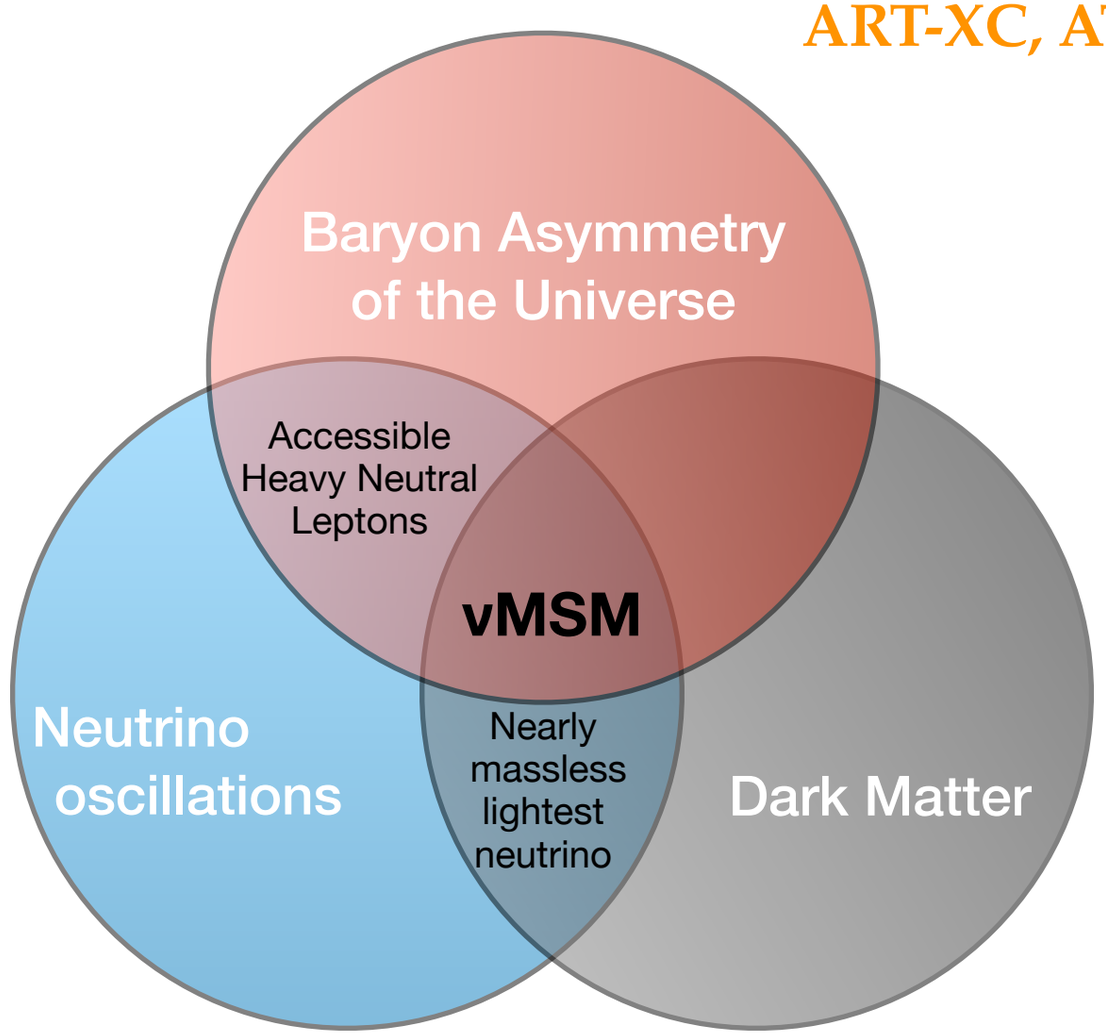
absolute neutrino mass searches (KATRIN ect.)

non-accelerator searches (TRISTAN…)

neutrinoless double β decay

fixed target experiments (SHiP, NA62, DUNE, T2K, DarkQuest)

neutrino oscillation experiments DUNE, Hyper-K



NF, RF, **AF**, EF, CF, TF

CMB and LSS : absolute neutrino mass

astrophysics: supernovae etc.

Structure formation: simulation, observation

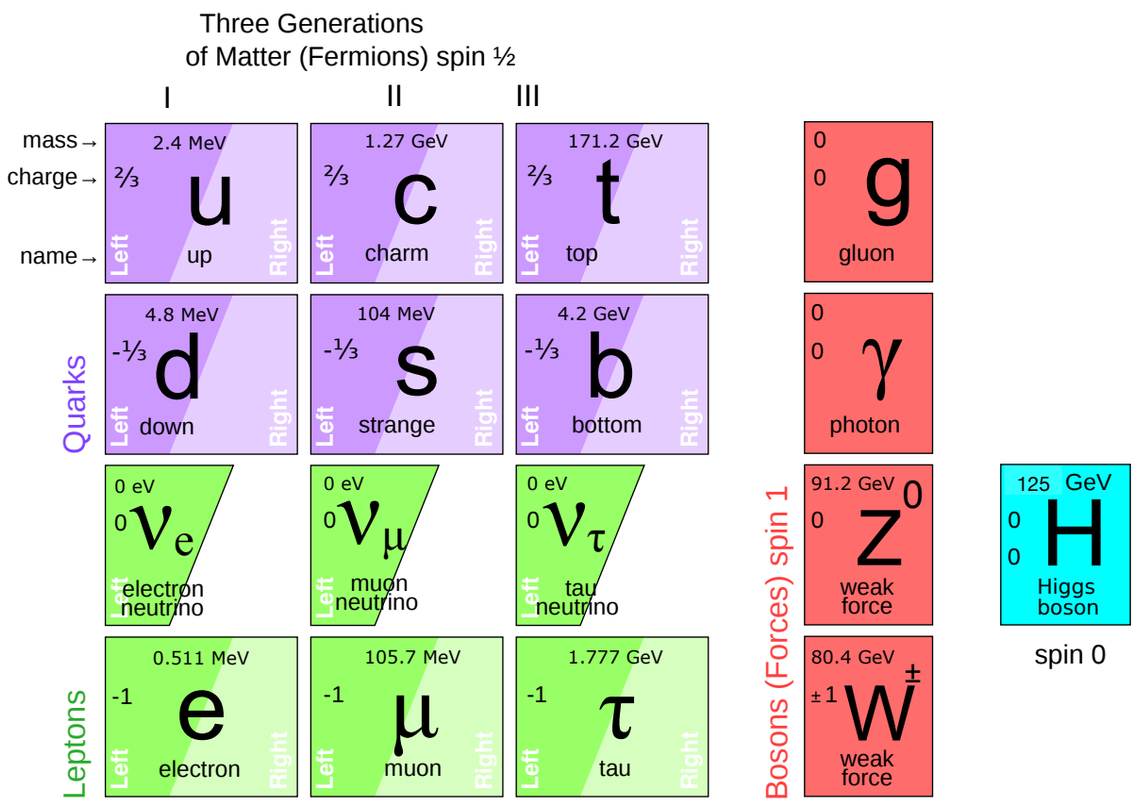
IGM temperature: WDM vs CDM

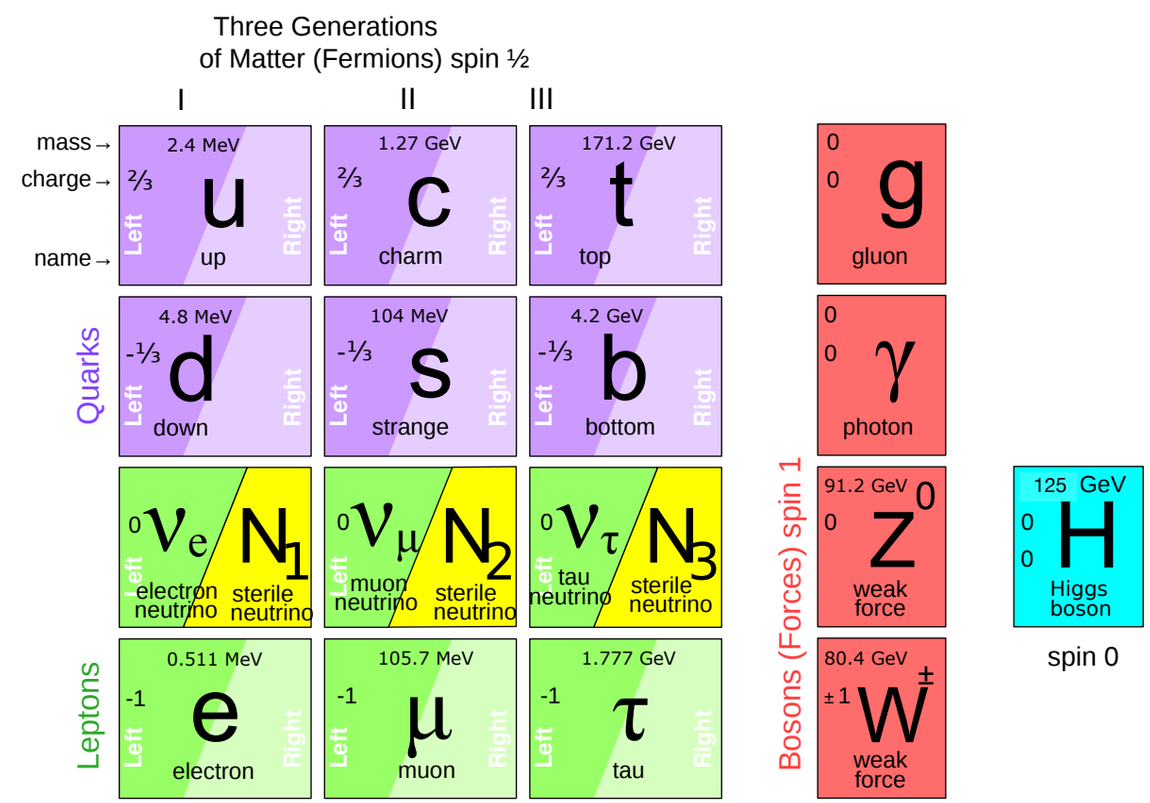
Theory: leptogenesis parameter region

Theory: Sterile neutrino DM production

νMSM
(Neutrino Minimal Standard Model)

Asaka, Blanchet, Shaposhnikov 2005
Asaka, Shaposhnikov 2005

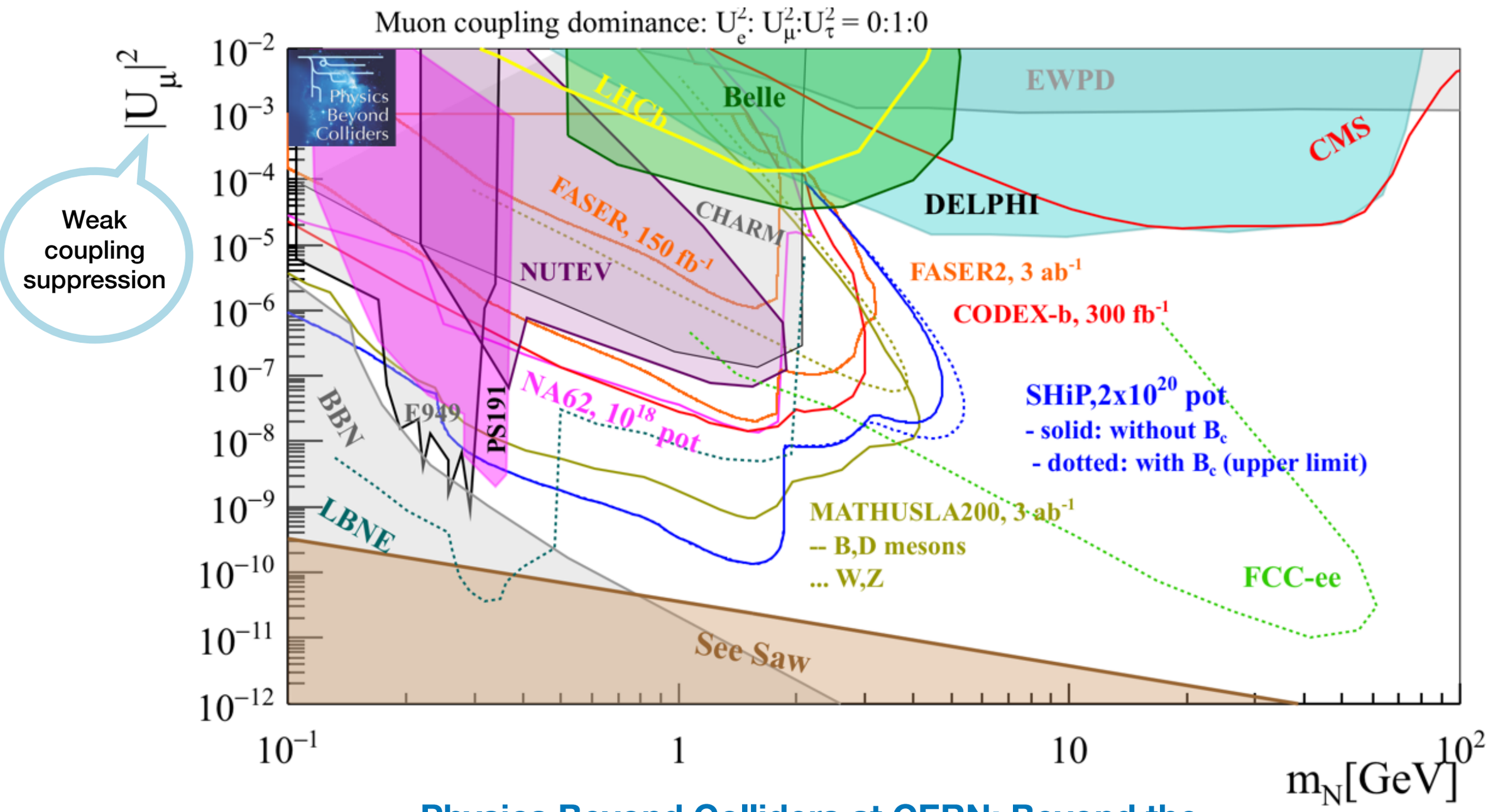




N_1	DM candidate	$m \sim keV$
N_2, N_3	ν masses via see-saw BAU DM production	$M_N \gtrsim 0.1\,GeV$ Nearly degenerate

Akhmedov, Rubakov, Smirnov, 1998
Asaka,Shaposhnikov 2005

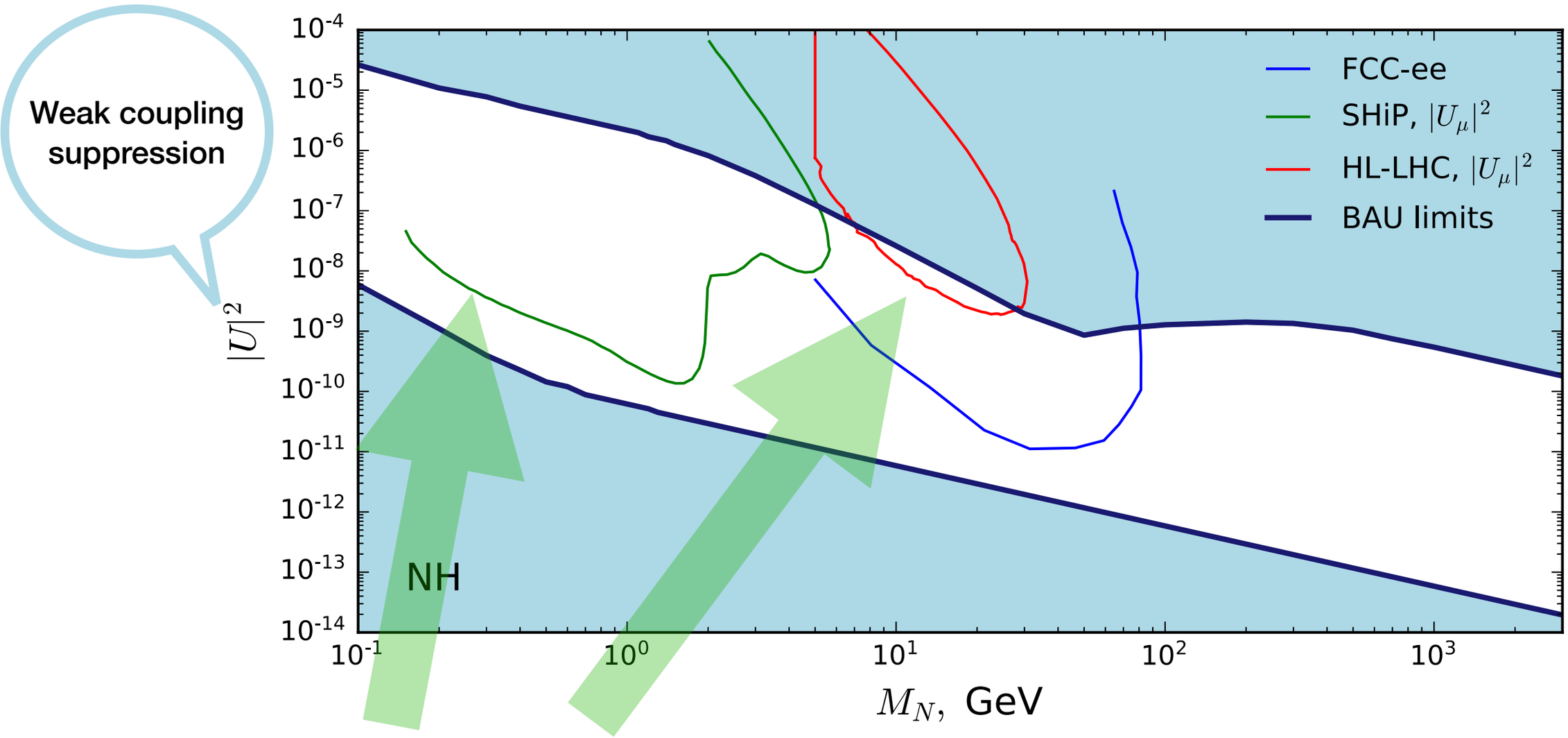
νMSM: testability



Physics Beyond Colliders at CERN: Beyond the Standard Model Working Group Report. 1901.09966

Leptogenesis in the νMSM

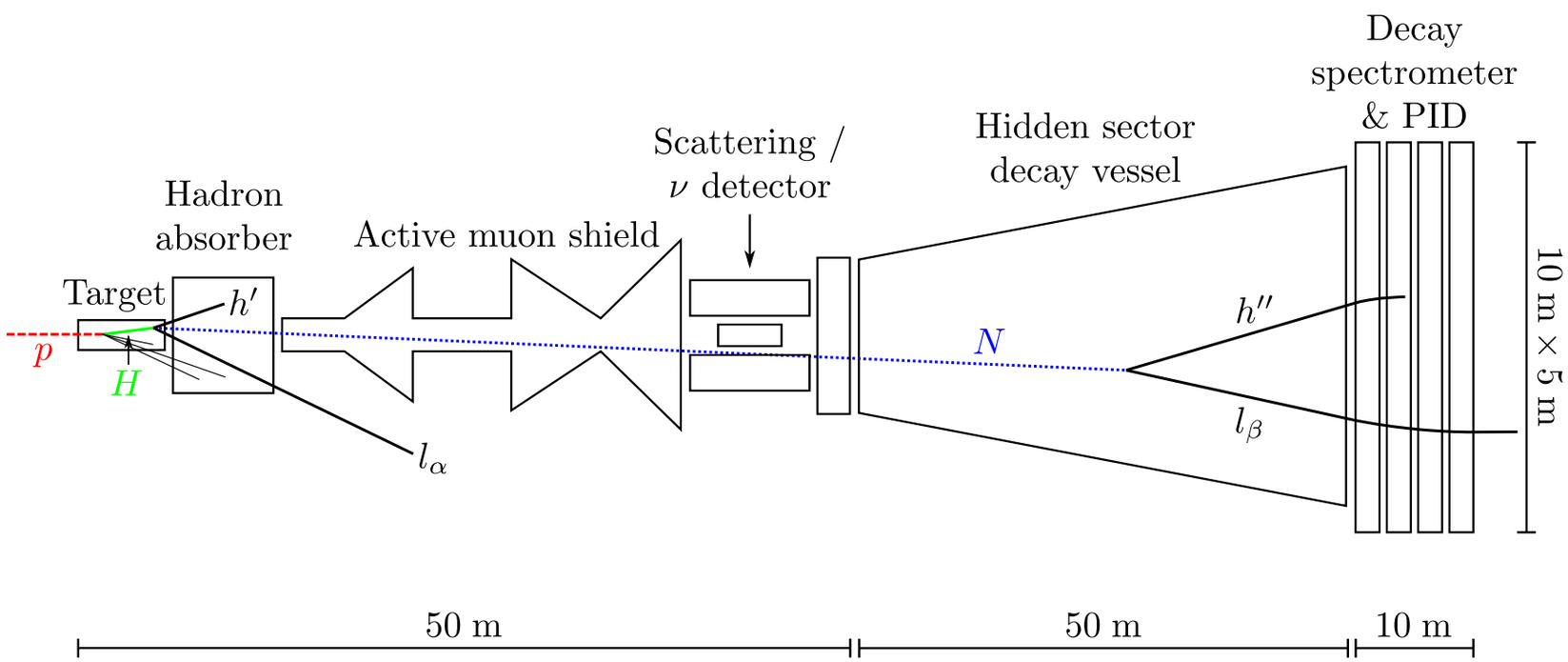
Recent theoretical developments: 1202.1288, 1403.2755, 1605.07720, 1703.06085, 1703.06087, 1401.2459, 1605.07720, 1709.07834, 1711.08469, 1208.4607, 1606.06690,1606.06719, 1609.09069, 1710.03744, 1808.10833, 1811.01971, 1905.08814, 2004.10766, 2008.13771



Complementarity between energy and intensity frontiers

Klaric, Shaposhnikov, Timiryasov 2008.13771

Direct accelerator searches
An example of SHiP (Search for Hidden Particles)



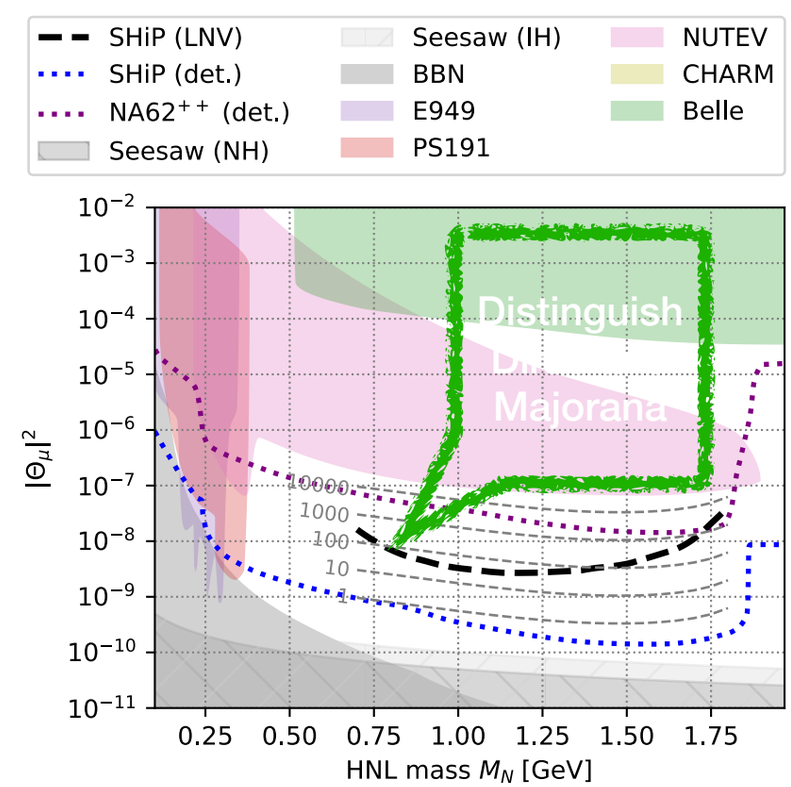
- 400 GeV proton beam from CERN SPS
- 2×10^{20} protons on target in 5 years

- HNLs are produced in decays of heavy mesons (D and B)

  Gorbunov and Shaposhnikov, 0705.1729; also 1805.08567
- They decay to charged particles in the vacuum vessel
- SHiP is extremely sensitive to HNLs.

  SHiP Collaboration, 1811.00930
- For some values of $|U|^2$ SHiP can even differentiate between Dirac and Majorana HNLs

  Taster, Timiryasov 1912.05520



*** HNLs (Heavy Neutral Leptons) or sterile neutrinos or RH neutrinos ⊂ FIPs**

How to accelerate the νMSM?

- Call to action from all frontiers
- Specific to accelerator frontier:
  - Beam dump experiments are perfect to search for the Heavy Neutral Leptons of the NuMSM
  - Coordinate the different AF efforts
  - The NuMSM is a well-defined benchmark model for future searches
  - HNLs at Fermilab?