Optimization of the Selection of Exotic Particles in the SHiP Experiment

Search for Hidden Particles

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Boosting the Future

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Exotic Particles ?

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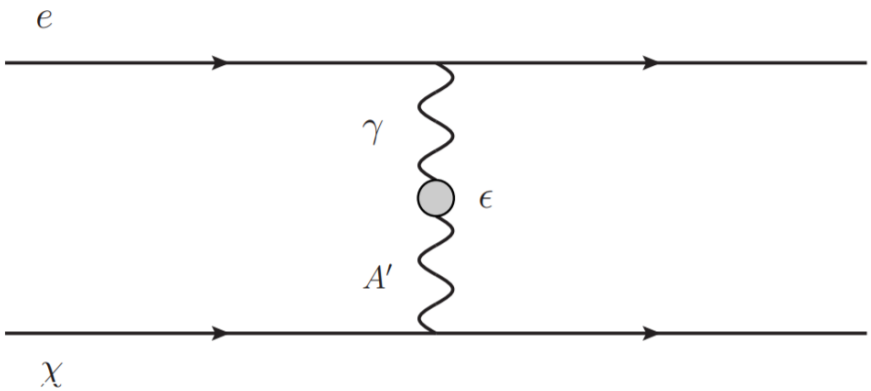
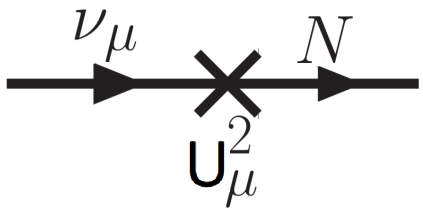
Dark Photons



Utility of the Dark Photon in the current paradigm :

- μ g - 2 discrepancy
- Dark Matter annihilation
- Indirect Dark Matter measurements
- Coexistence with Heavy Neutral Leptons

Heavy Neutral Leptons



Utility of the Heavy Neutral Leptons in the current paradigm :

- Explain the left chirality of neutrinos
- Explain neutrino's low mass
- BAU explanation
- Possible DM candidate

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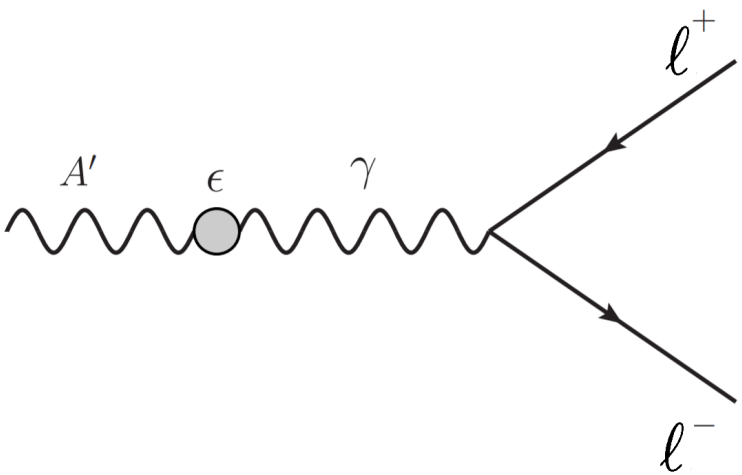
What will I actually have to do ?

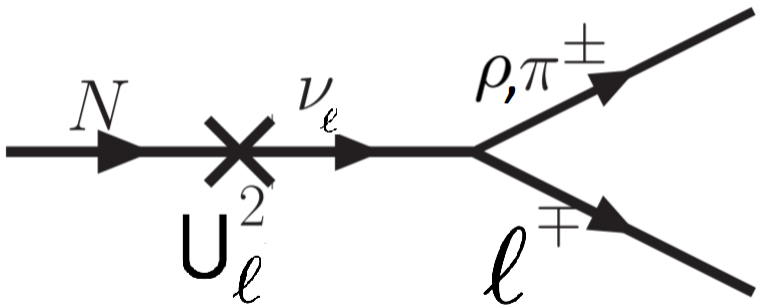
Dark Photons

- $A' \rightarrow e^- e^+$
- $A' \rightarrow \mu^- \mu^+$
- $A' \rightarrow \tau^- \tau^+$



Heavy Neutral Leptons

- $N \rightarrow e^- \pi^+$
- $N \rightarrow e^- \rho^+$
- $N \rightarrow \mu^- \pi^+$
- $N \rightarrow \mu^- \rho^+$



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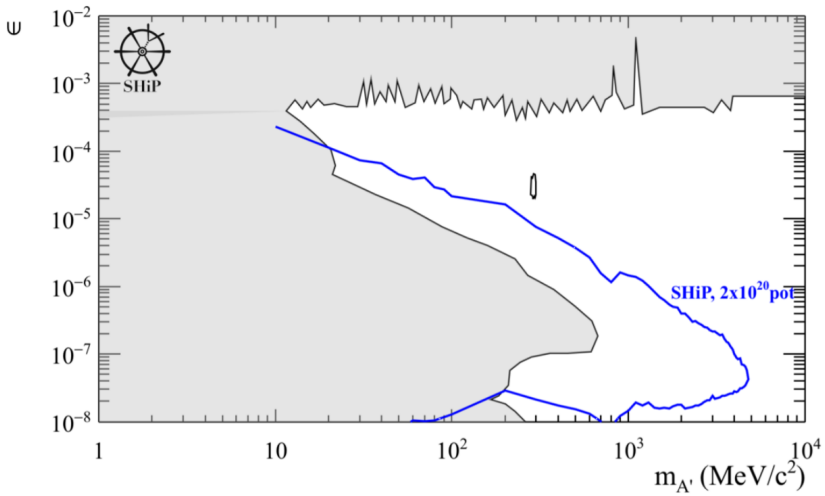
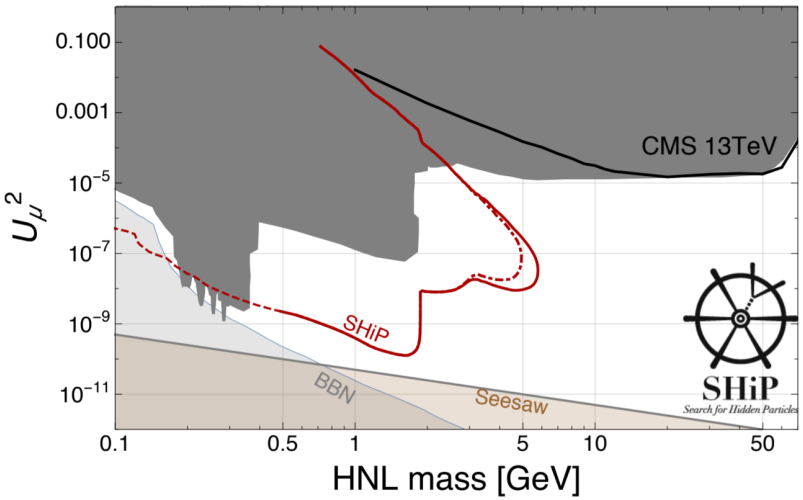
Coupling vs Mass limits that this Monte Carlo guy will guide himself by





Neutrino Oscilations

Progress of Theoretical Physics, Vol. 28, No. 5, November 1962

Remarks on the Unified Model of Elementary Particles

Ziro MAKI, Masami NAKAGAWA and Shoichi SAKATA

Institute for Theoretical Physics
Nagoya University, Nagoya

(Received June 25, 1962)

A particle mixture theory of neutrino is proposed assuming the existence of two kinds of neutrinos. Based on the neutrino-mixture theory, a possible unified model of elementary particles is constructed by generalizing the Sakata-Nagoya model.*) Our scheme gives a natural explanation of smallness of leptonic decay rate of hyperons as well as the subtle difference of G_v's between μ-e and β-decay.

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \mathbf{U}_{\text{PMNS}} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix} \quad (1)$$

$$P\left(\nu_\alpha \rightarrow \nu_\beta\right) = \delta_{\alpha\beta} - 4\sum_{j>i} \mathbf{U}_{\alpha i}\mathbf{U}^*_{\beta i}\mathbf{U}^*_{\alpha j}\mathbf{U}_{\beta j} sin^2\left(\frac{1.27\Delta m^2_{ij} L}{E}\right) \quad (2)$$

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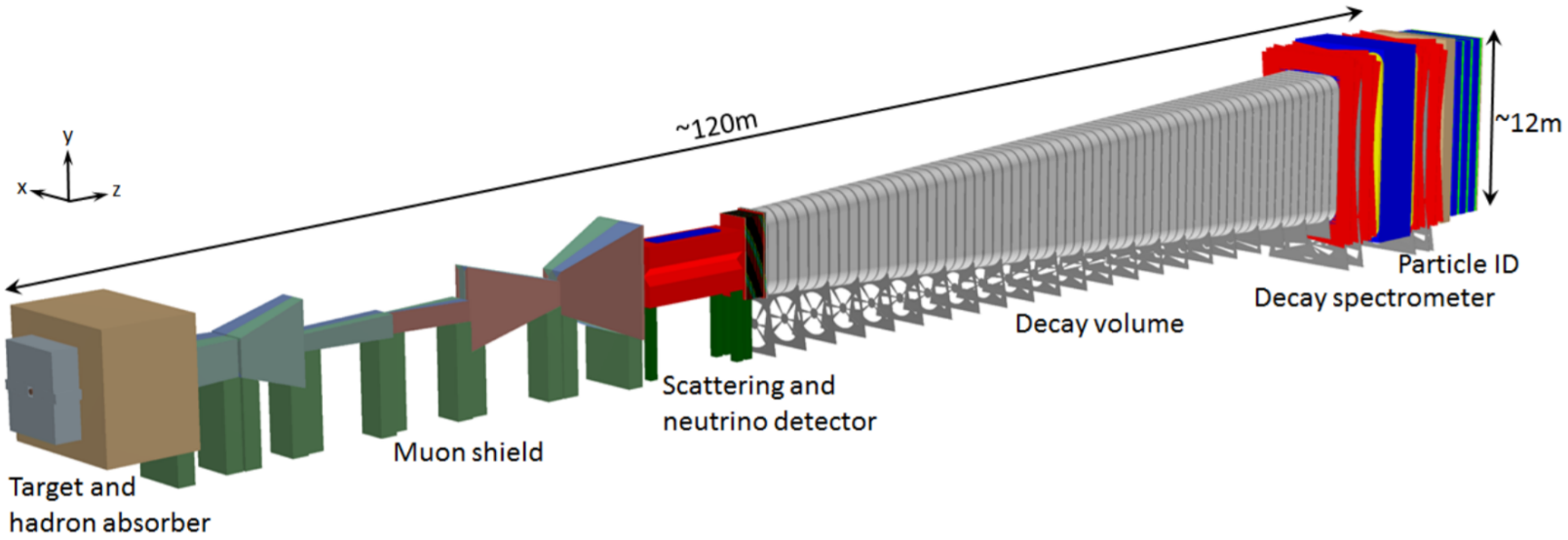
Detector Segments within the SHiP Apparatus



Scattering and Neutrino Detector

- Magnet
- Emulsion Target
- Target Trackers
- Downstream Trackers
- Muon Identification System

Hidden Sector or Decay Spectrometer

- Vacuum Vessel
- Background Tagger
- Straw Tracker
- Timing Detector
- Calorimeter
- Muon Identification System

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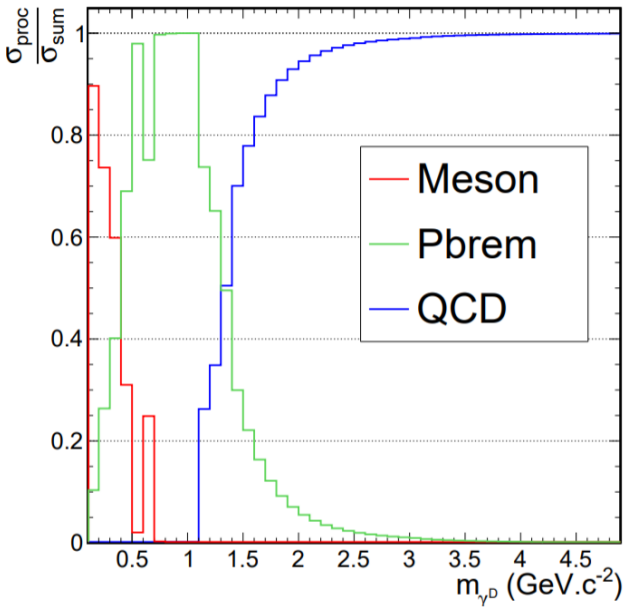
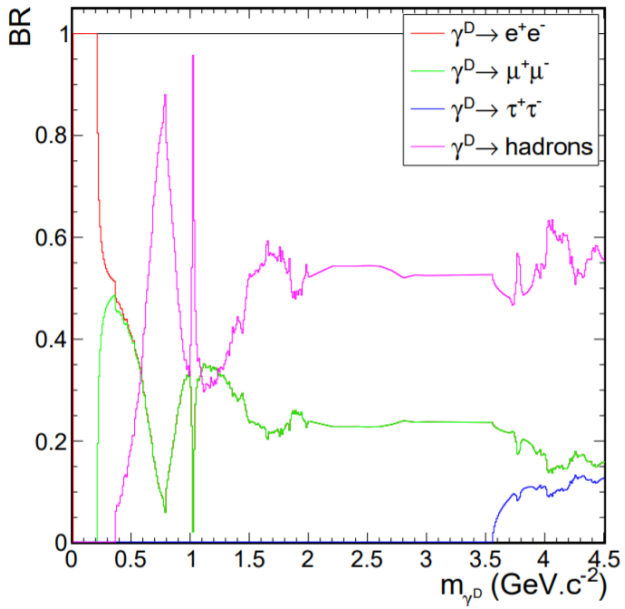
Mass Limits for Dark Photons





Production$^{(1)}$**/Decay**$^{(2)}$ **Mode**	$\mathbf{M_{min}}$ **(GeV/**c^2**)**	$\mathbf{M_{max}}$ **(GeV/**c^2**)**
Meson$^{(1)}$	-	0.7
P bremsstrahlung$^{(1)}$	-	2.0
QCD$^{(1)}$	1.1	-
$e^- + e^+$ $^{(2)}$	-	-
$\mu^- + \mu^+$ $^{(2)}$	0.25	-
$\tau^- + \tau^+$ $^{(2)}$	3.5	-

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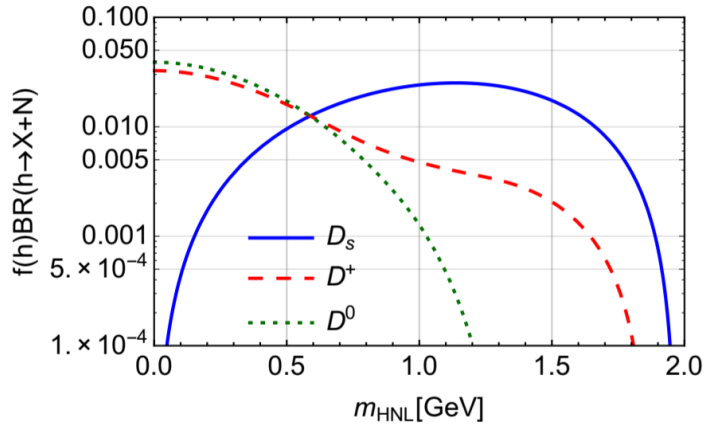
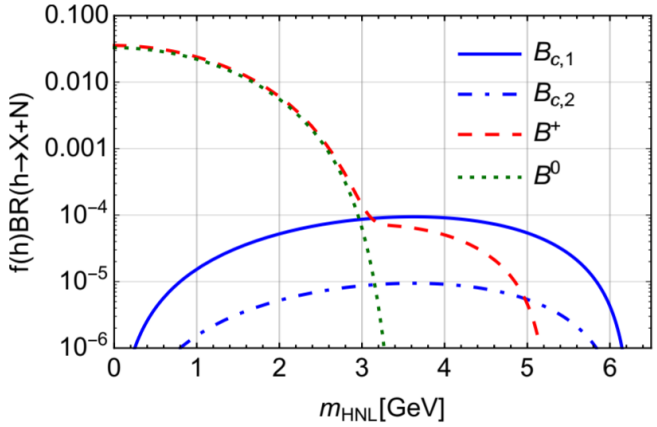
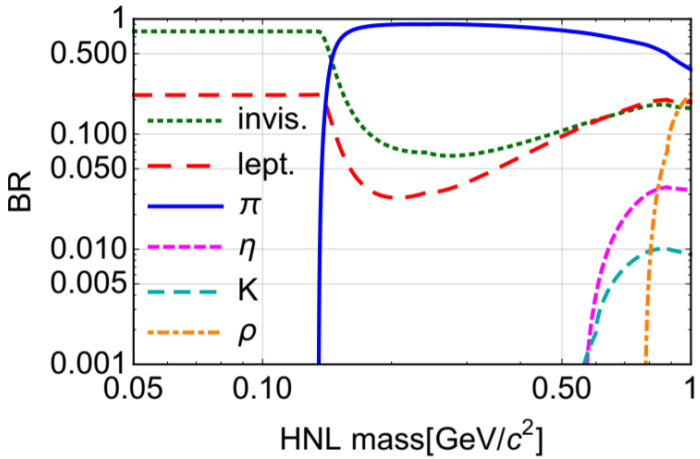
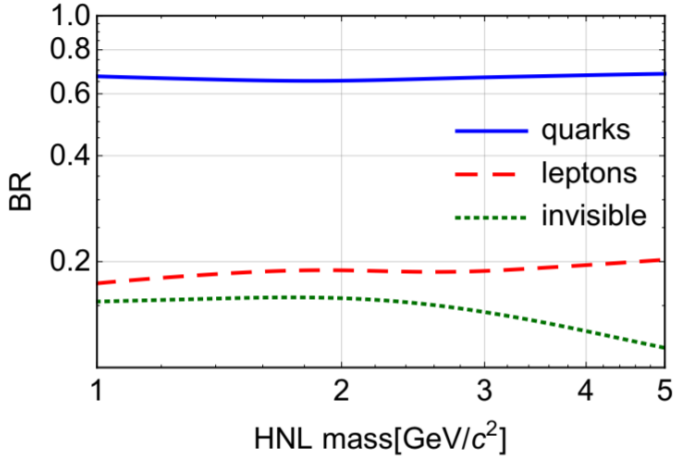
Production and Decay Branchings of Heavy Neutral Leptons

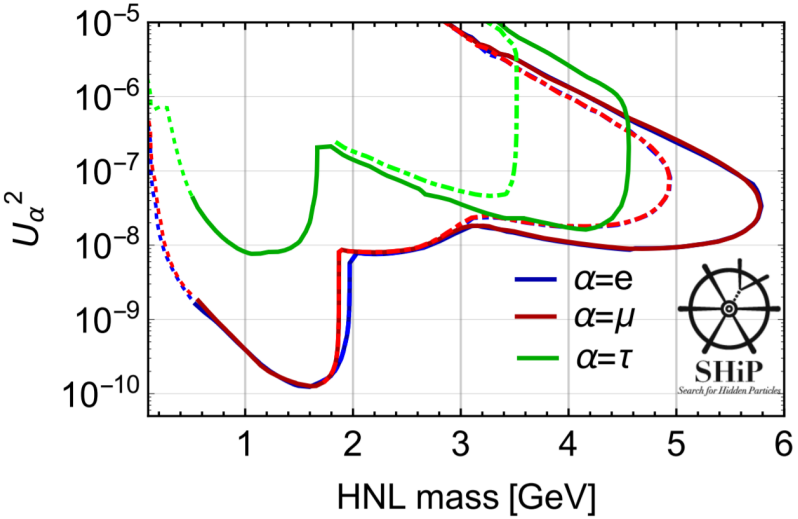








Mass Limits for the Heavy Neutral Leptons



Production(1)**/Decay Mode**(2)	$\mathbf{M_{min}}$ **(GeV/**c^2**)**	$\mathbf{M_{max}}$ **(GeV/**c^2**)**
charmed mesons(1)	0.4	2.00
beauty mesons(1)	0.4	-
π + l (2)	0.14	-
ρ + l (2)	0.80	-

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