SIMPs through the axion portal
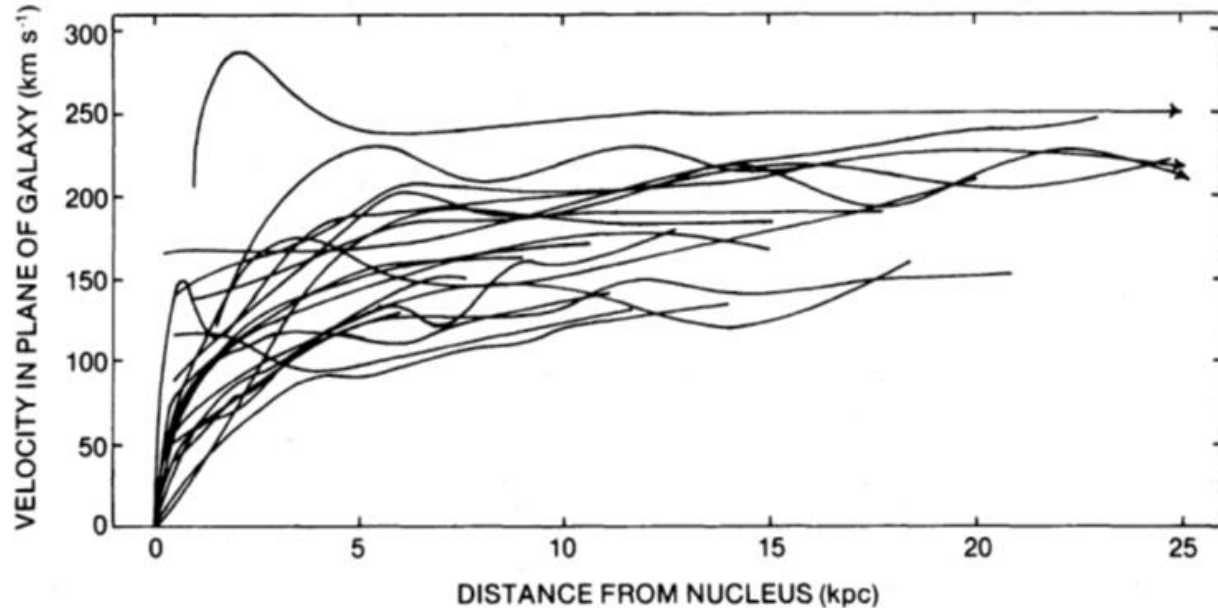
Y. Hochberg, E. Kuflik, **Robert McGehee**, H. Murayama, K. Schutz 1805.XXXXX

Phenomenology 2018, 5/7/2018

The Nature of Dark Matter
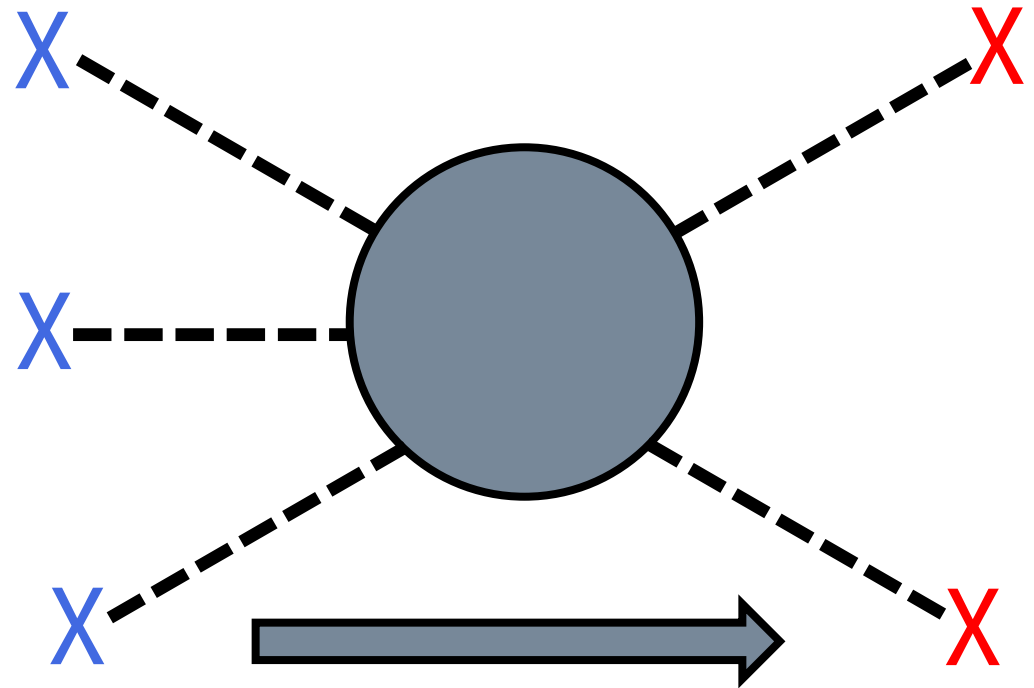

From Rubin et al Astrophys. J. **238** 471

Weakly Interacting Massive Particles (WIMPs)?

Alternative thermal relics?

Robert McGehee 2/12

Strongly Interacting Massive Particles or SIMPs

Y. Hochberg et al., Phys. Rev. Lett. **113**, 171301 (2014)

Relic density set by 3→2

Equilibrium with SM

Strong self interactions

MeV to GeV masses

The SIMPlest Miracle

Sp(N_c) gauge theory

$2N_f$ Weyl fermions

Chiral symmetry breaking

Wess-Zumino-Witten (WZW)

$$\mathcal{L}_{\mathrm{WZW}} = \frac{8N_c}{15\pi^2 f_\pi^5} \epsilon^{\mu\nu\rho\sigma} \epsilon_{abcde} \pi^a \partial_\mu \pi^b \partial_\nu \pi^c \partial_\rho \pi^d \partial_\sigma \pi^e$$
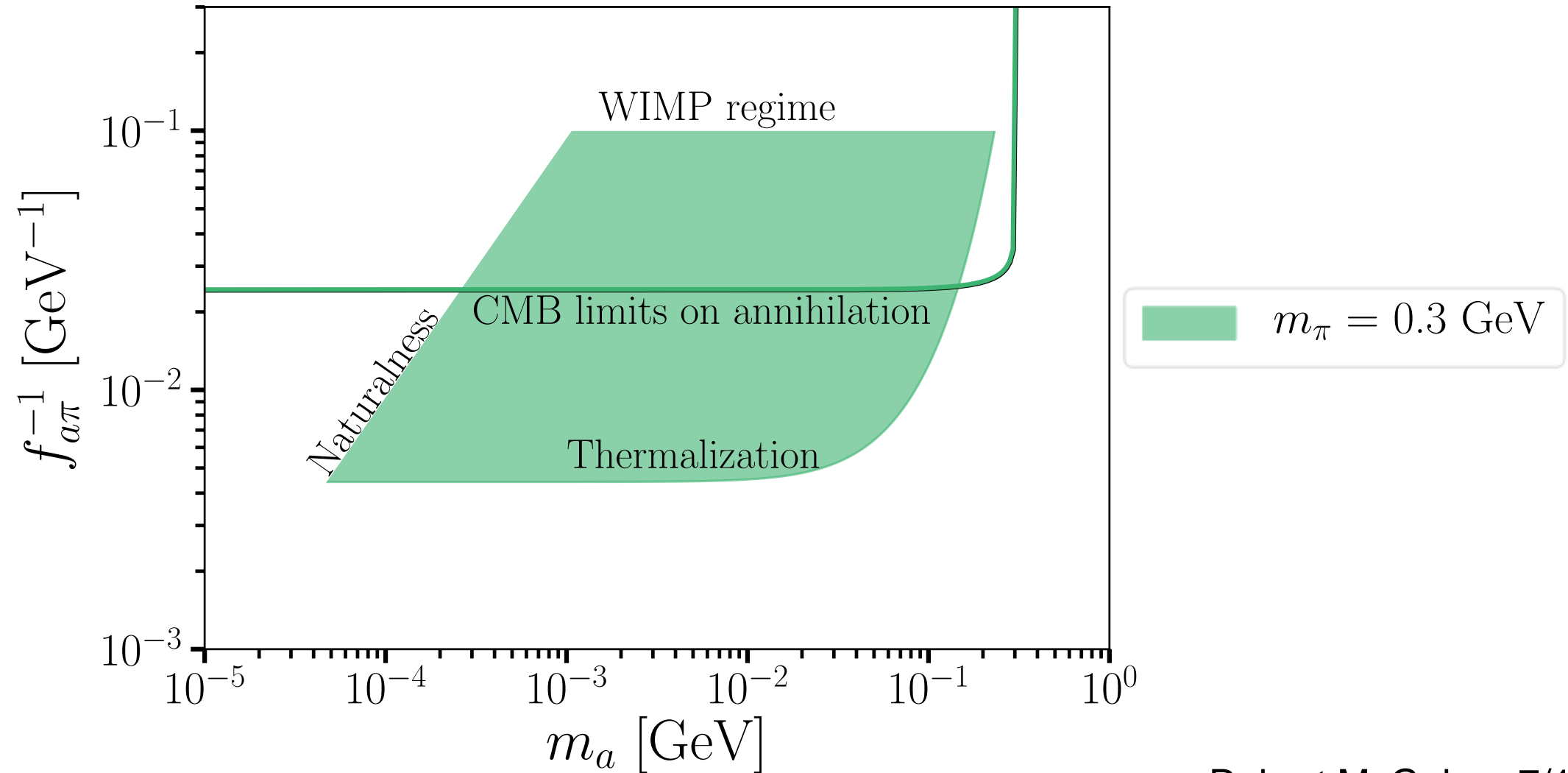
Road Map

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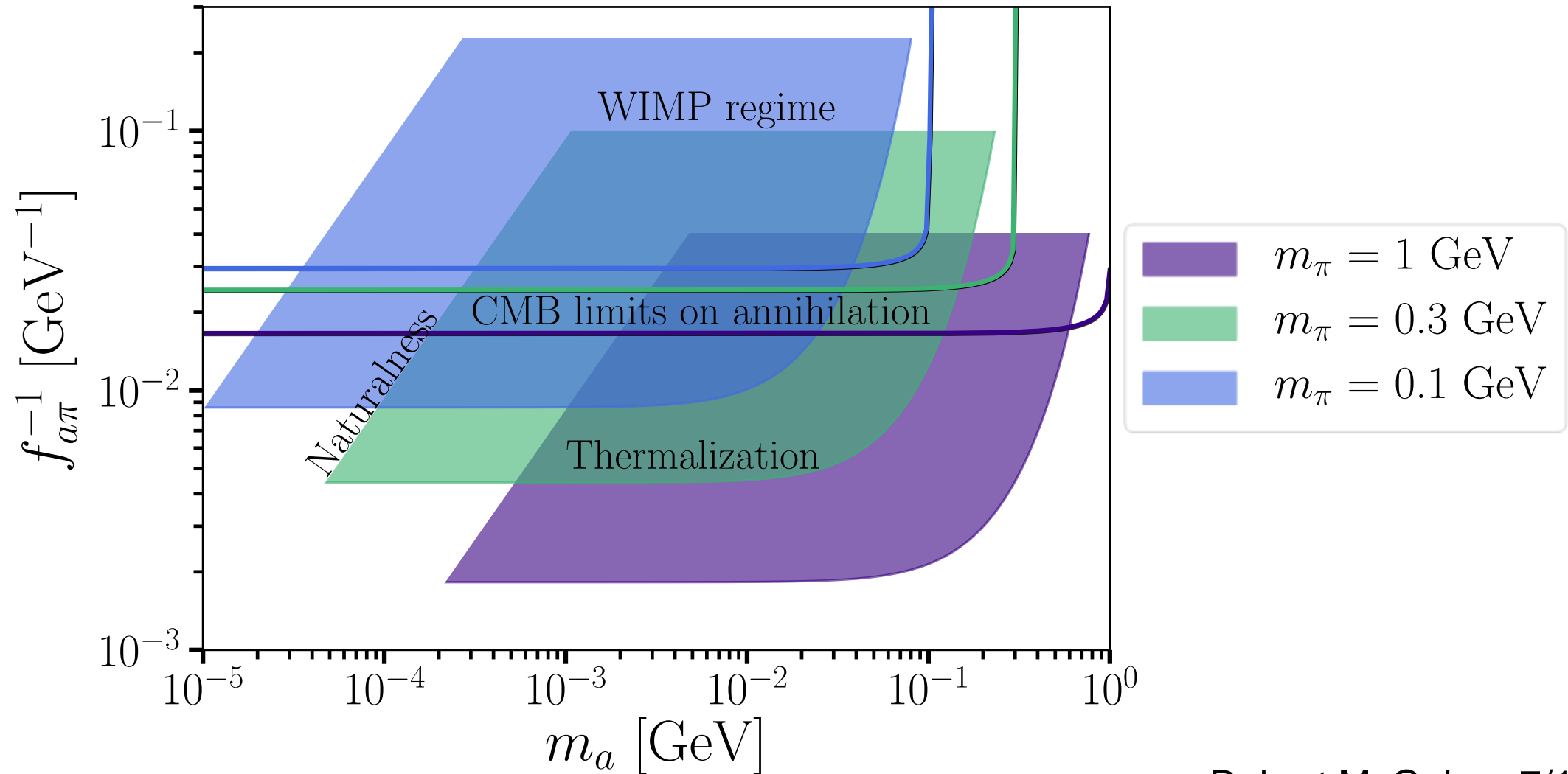
SIMP-Axion Coupling

$$\mathcal{L}_{aq} = -\tfrac{1}{2} m_Q e^{ia/f_{a\pi}} J^{ij} q_i q_j + \text{h.c.} \xrightarrow{\text{Chiral SB}} \mathcal{L}_{aq} = \tfrac{m_\pi^2}{4 f_{a\pi}^2} a^2 \pi^2 + \cdots$$
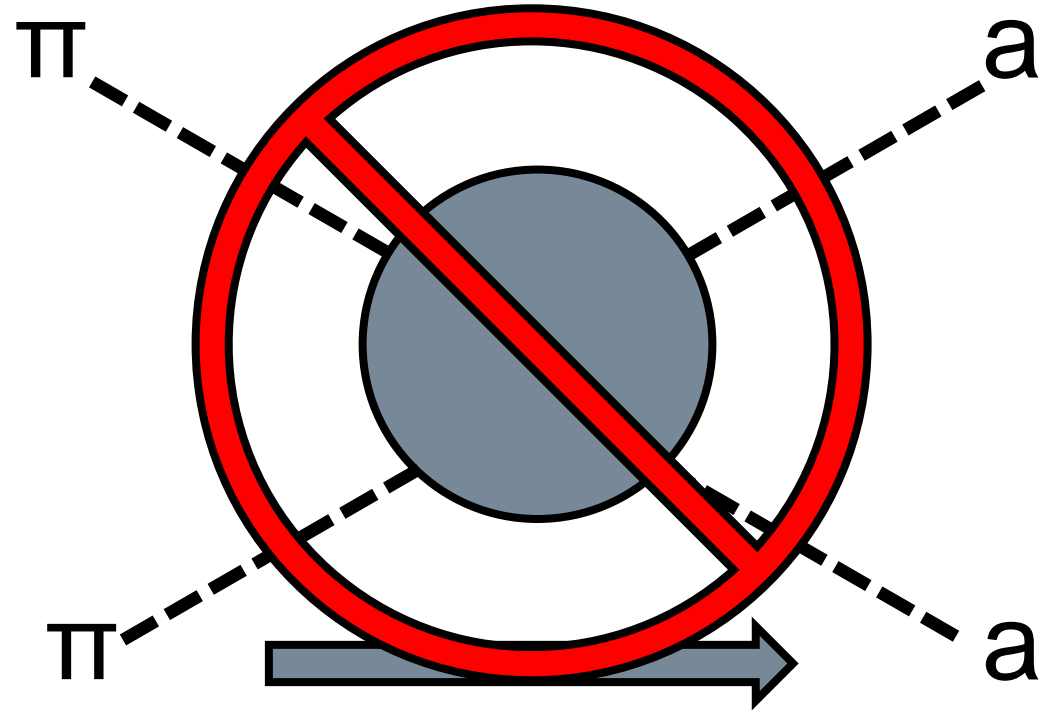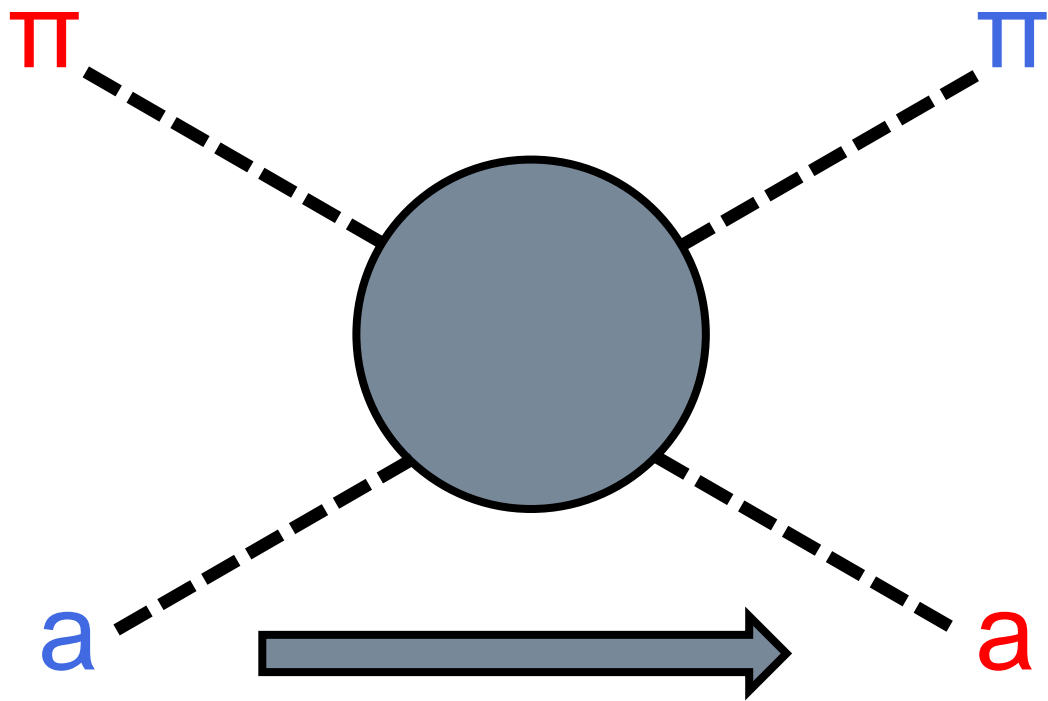
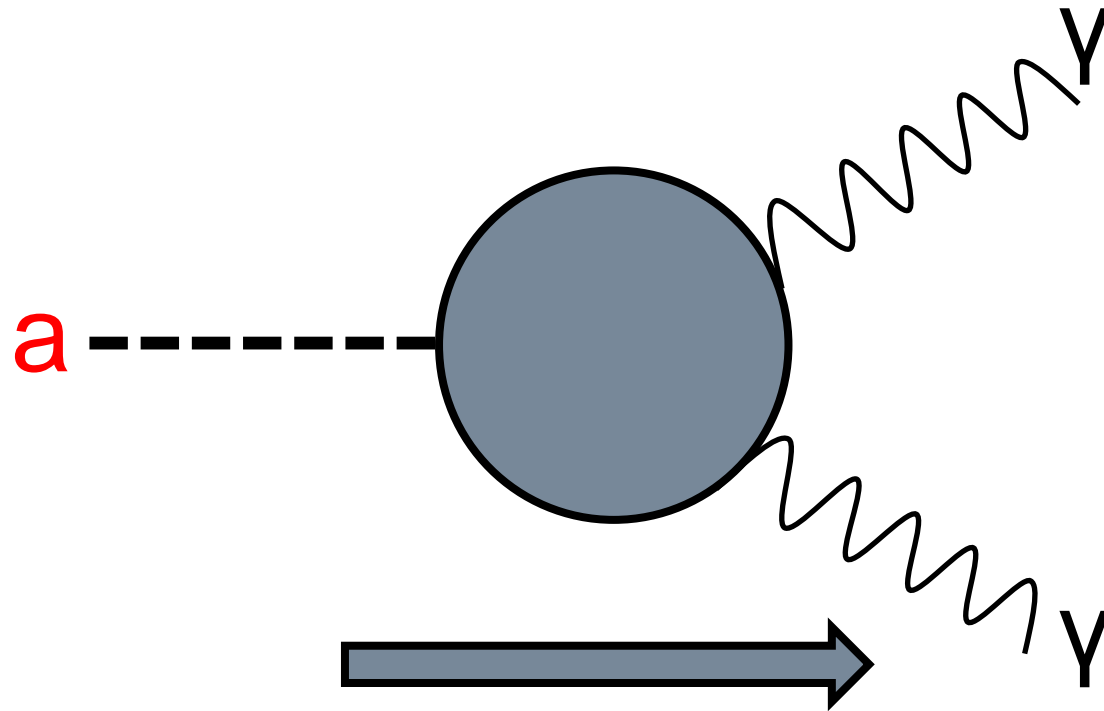# Viable SIMP-Axion Parameter Space
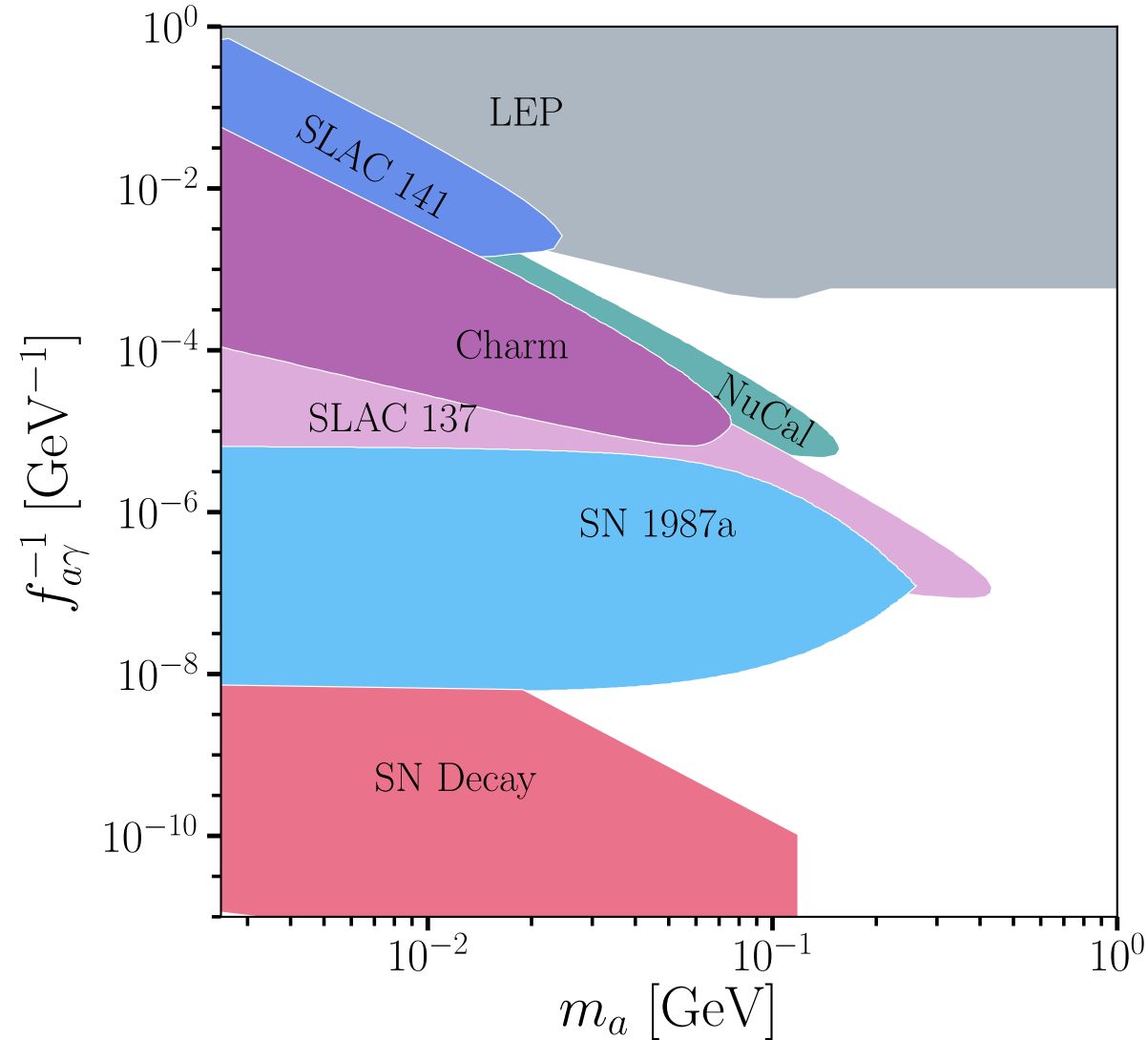
Viable SIMP-Axion Parameter Space
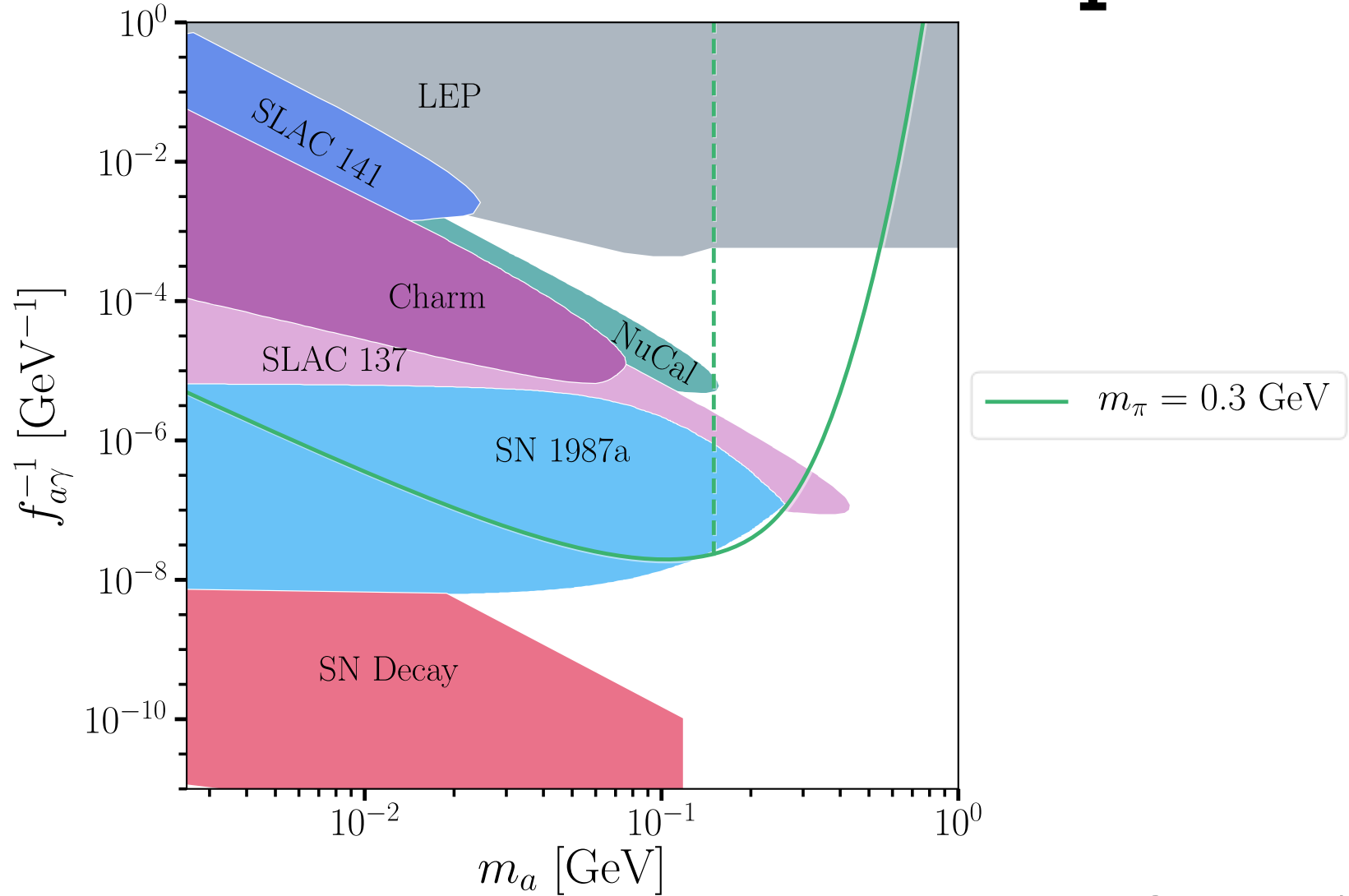
Axion-Photon Coupling

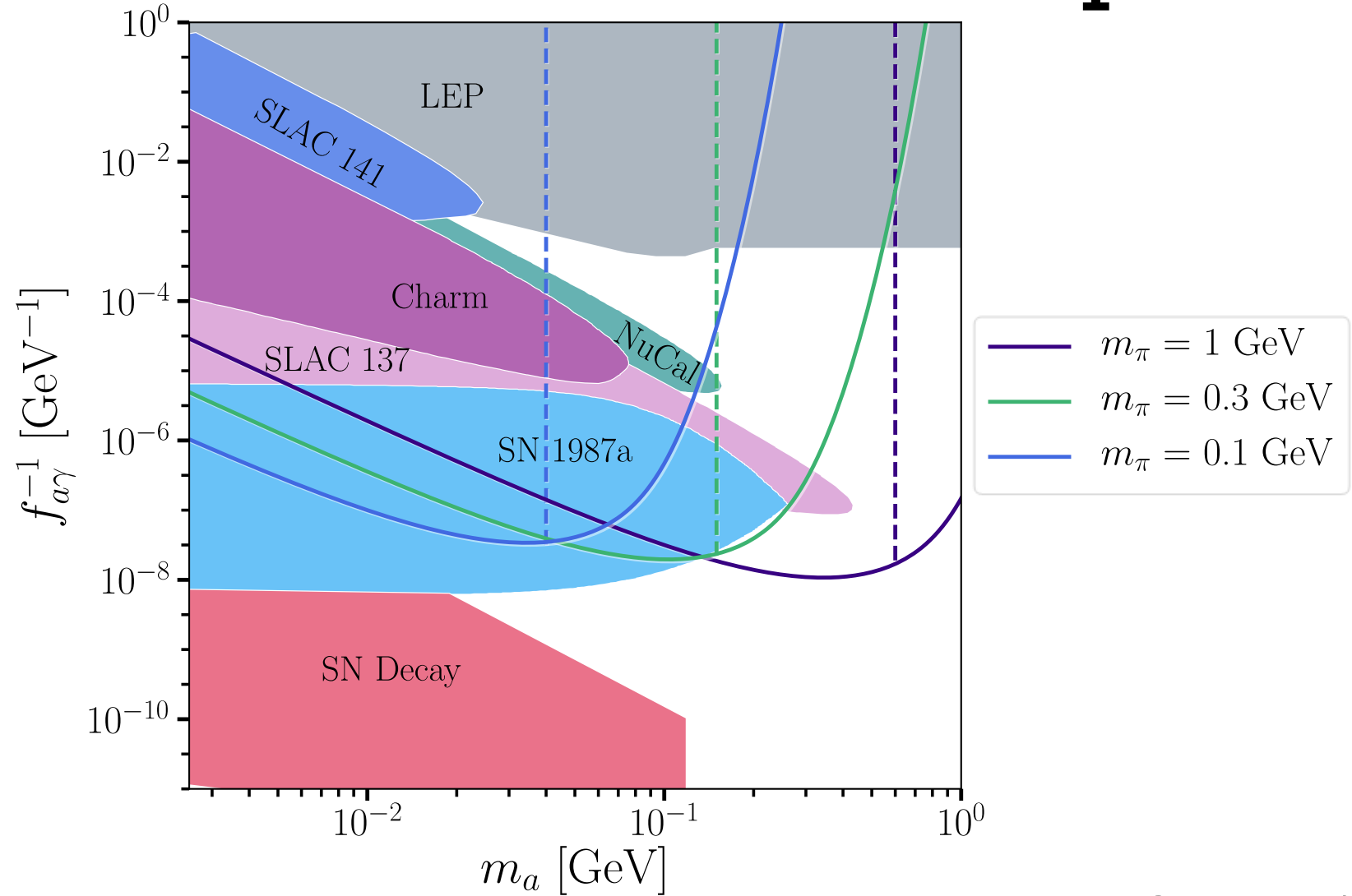$$\mathcal{L}_{a\gamma} = \frac{1}{4f_{a\gamma}} a F^{\mu\nu} \tilde{F}_{\mu\nu}$$

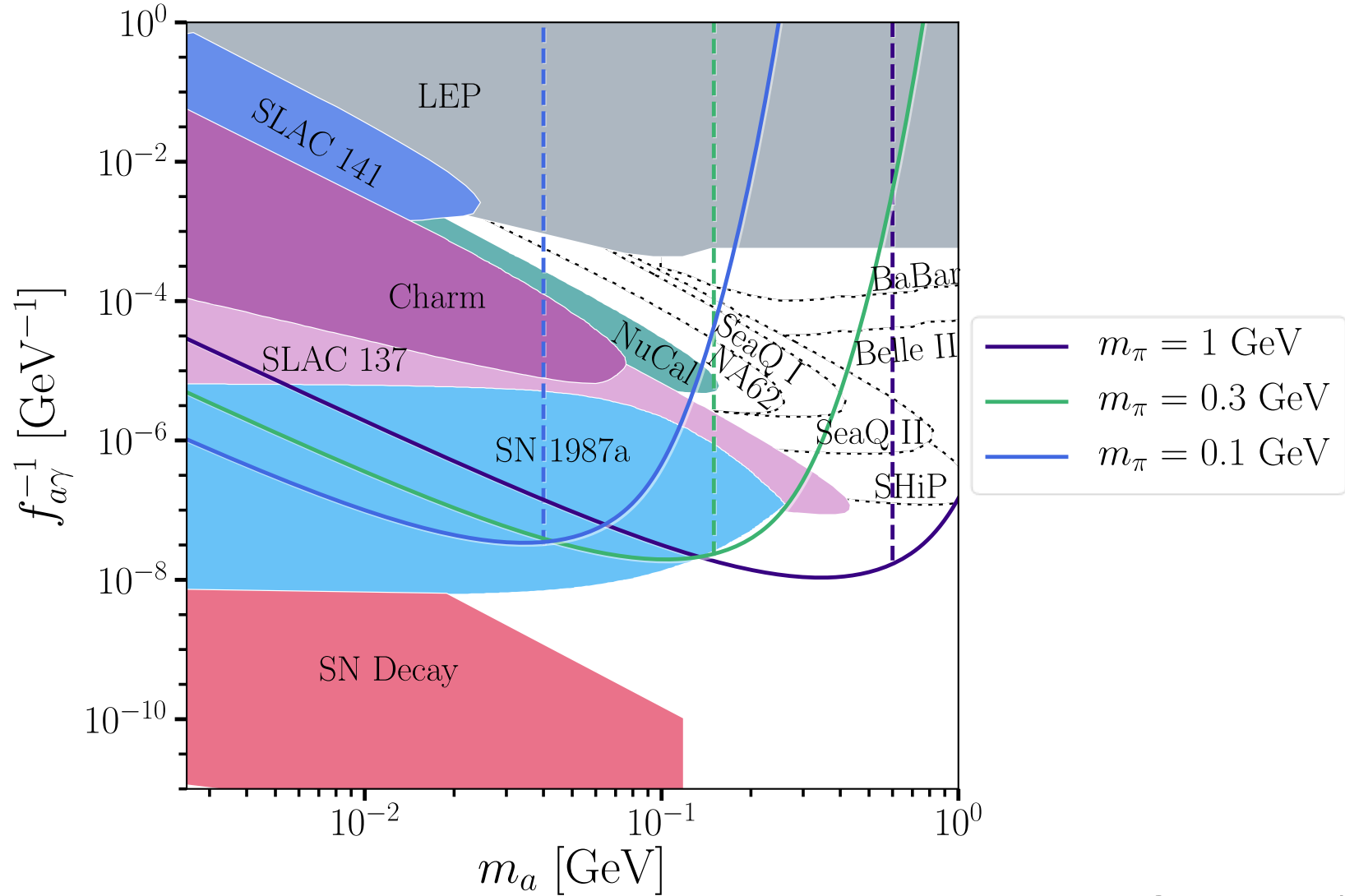# Constraints on Axion-Photon Coupling

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Viable Axion-Photon Parameter Space

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Viable Axion-Photon Parameter Space

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To be probed in the near future…

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Summary

Strongly Interacting Massive Particles (SIMPs) generically predict MeV-GeV thermal relic DM candidates.

The SIMPlest models involve dark pions with the 5-point self interaction realized by the WZW term.
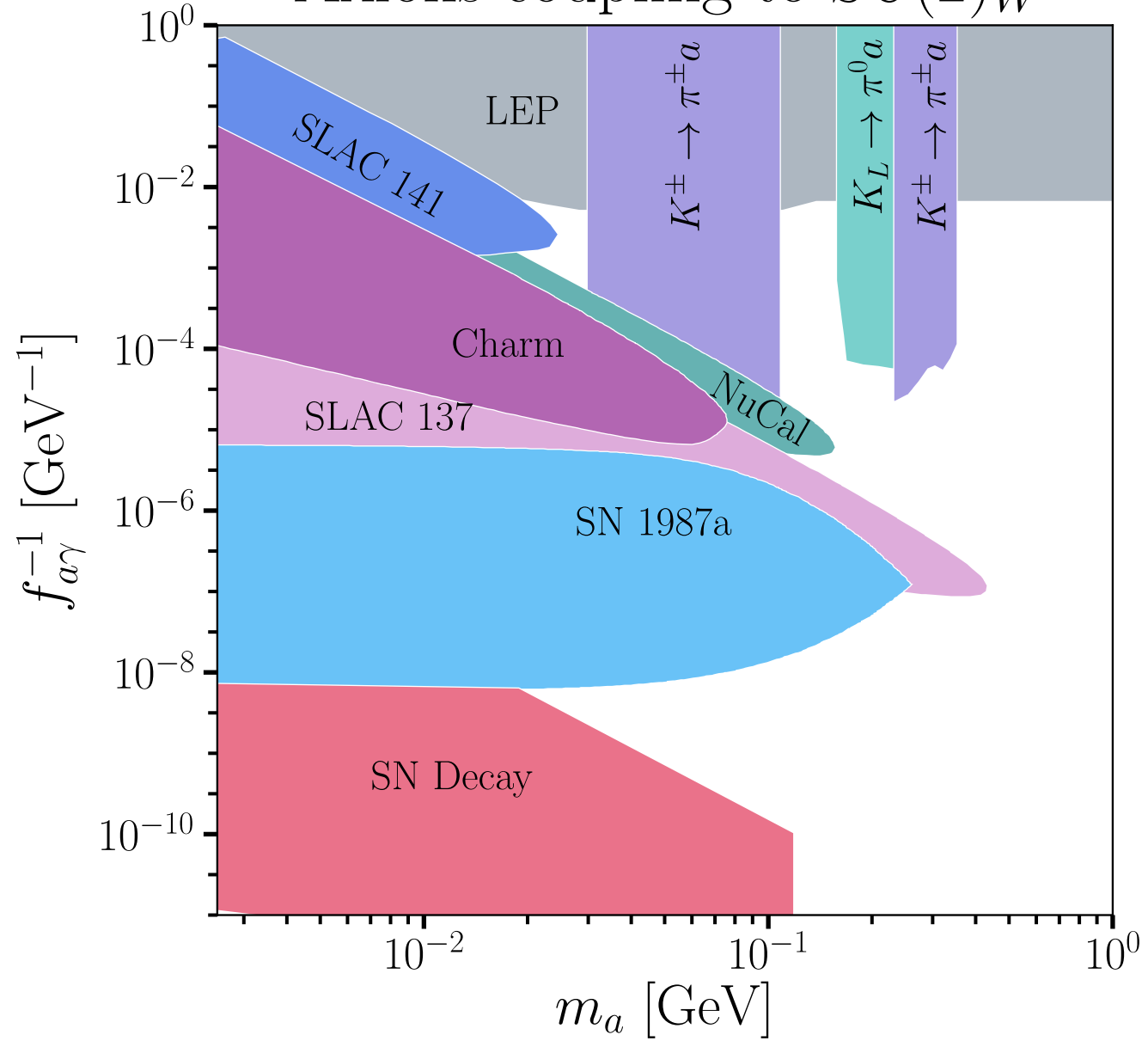
Axions can mediate thermal equilibrium between the SIMPs and SM in such a scenario.

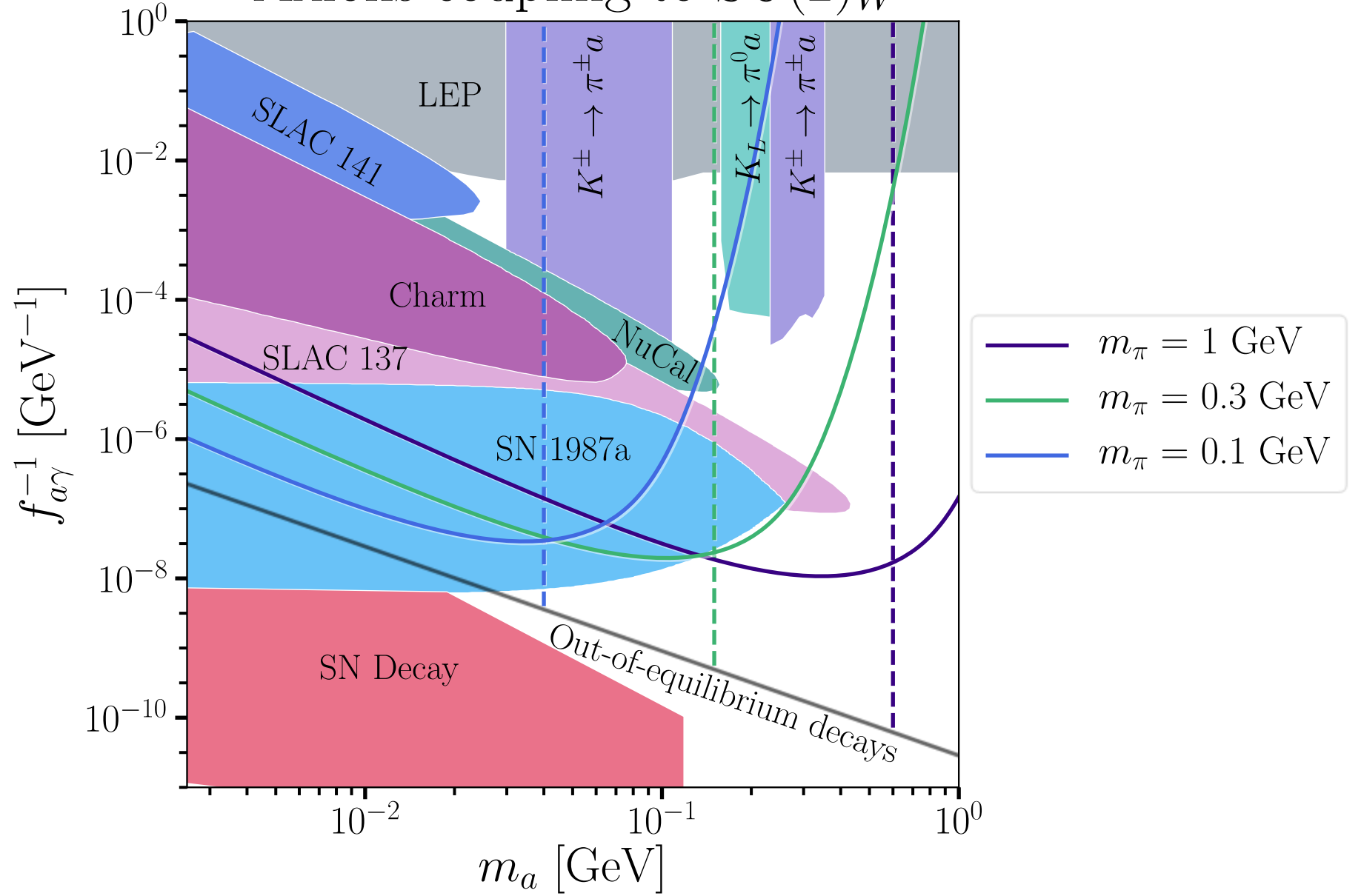The necessary coupling of these axions to SM photons to achieve equilibrium are within reach of future experiments.

Couplings to SM fermions, either leptophilic or universal, also appear possible.

Backup Slides

Axions coupling to SU(2)$_W$

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