

Semi-dark **Higgs decays**: sweeping the Higgs **neutrino floor**

Jose Manuel Cano
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Semi-invisible Higgs decays remain **poorly** explored on both grounds (with notable exceptions, e.g. $h \rightarrow \gamma, b\bar{b} + \text{invisible}$, for a complete list see ¹)

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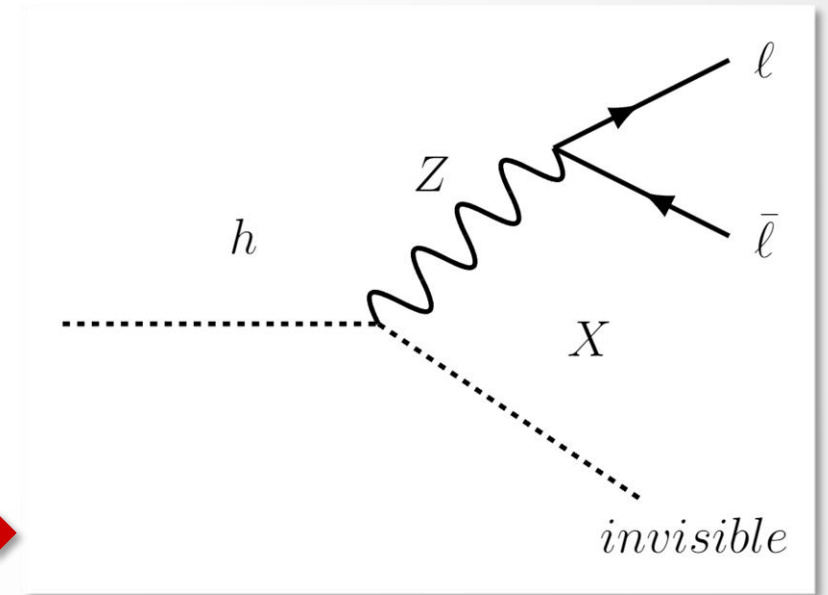
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Note this topology is **already present** in the **SM**

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(and $h \rightarrow WW^* \rightarrow \ell \bar{\ell} \nu \bar{\nu}$)

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Where coherent elastic neutrino-nucleus scattering can pose an

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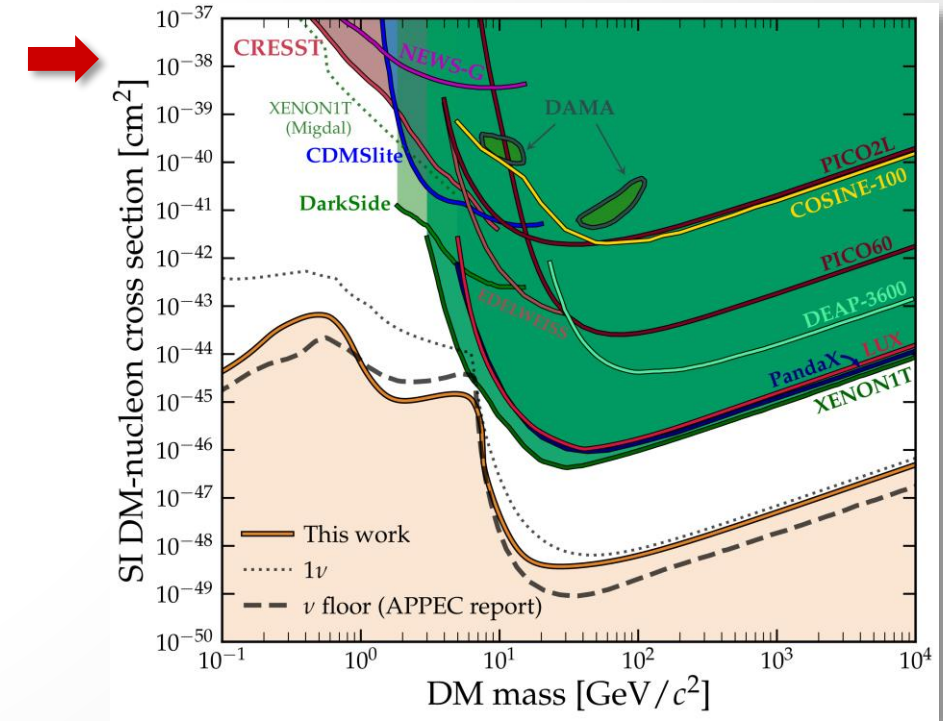
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O'Hare 2109.03116

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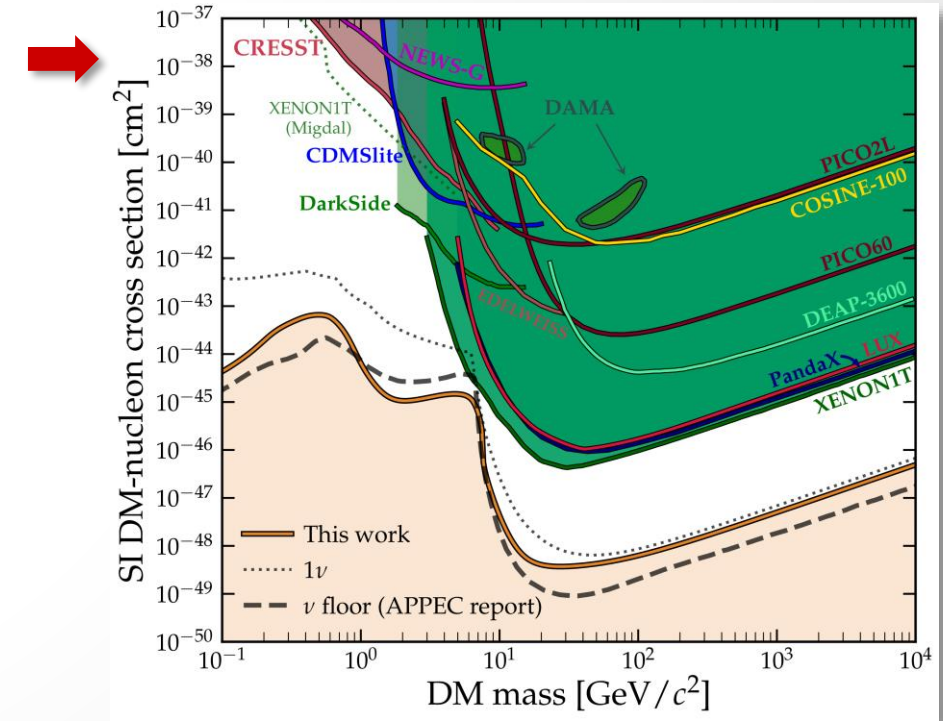
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We refer to the above as the “**Higgs neutrino floor**” and like its
analogue, it provides a **sensitivity target** for experiments:

$$BR(h \rightarrow Z \nu \bar{\nu})_{SM} = 5.4 \cdot 10^{-3}$$



O'Hare 2109.03116

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Best production channel to study this decay at the **LHC**?

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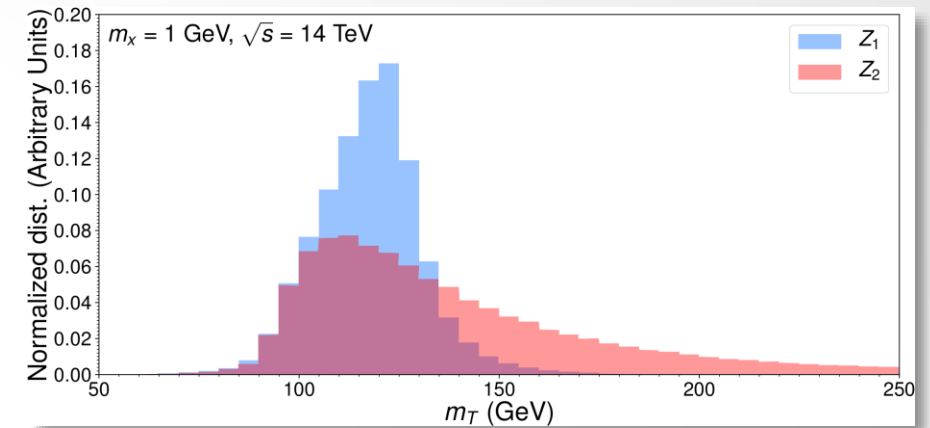
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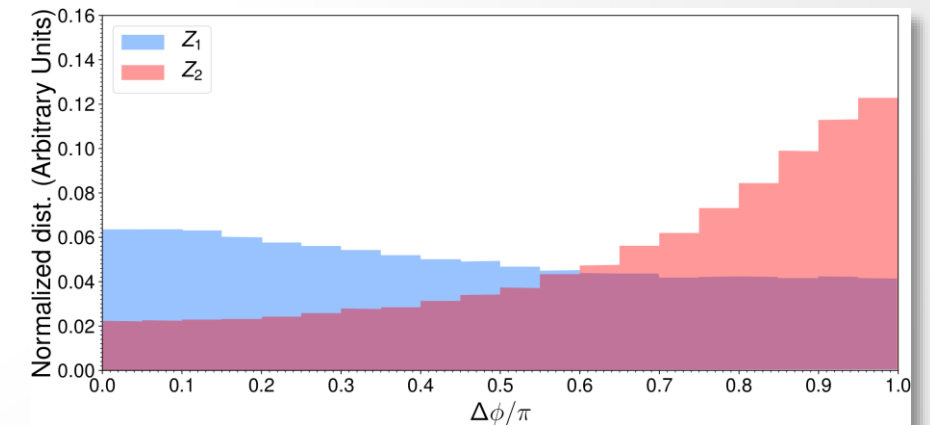
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↳ We build a NN taking as input:



$$M_T^2 = \left(\sqrt{m_{\ell\ell}^2 + |\vec{p}_T^{\ell\ell}|^2} + \cancel{E}_T \right)^2 - |\vec{p}_T^{\ell\ell} + \vec{\cancel{E}}_T|^2$$



$\Delta\phi(Z, \vec{\cancel{E}}_T)$

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$$m_{4\ell}$$

$$m_{\ell\ell_1} \quad m_{\ell\ell_2}$$

$$p_T^{\ell\ell_1} \quad p_T^{\ell\ell_2}$$

$$p_T^{\ell_1}, p_T^{\ell_2}, p_T^{\ell_3}, p_T^{\ell_4}$$

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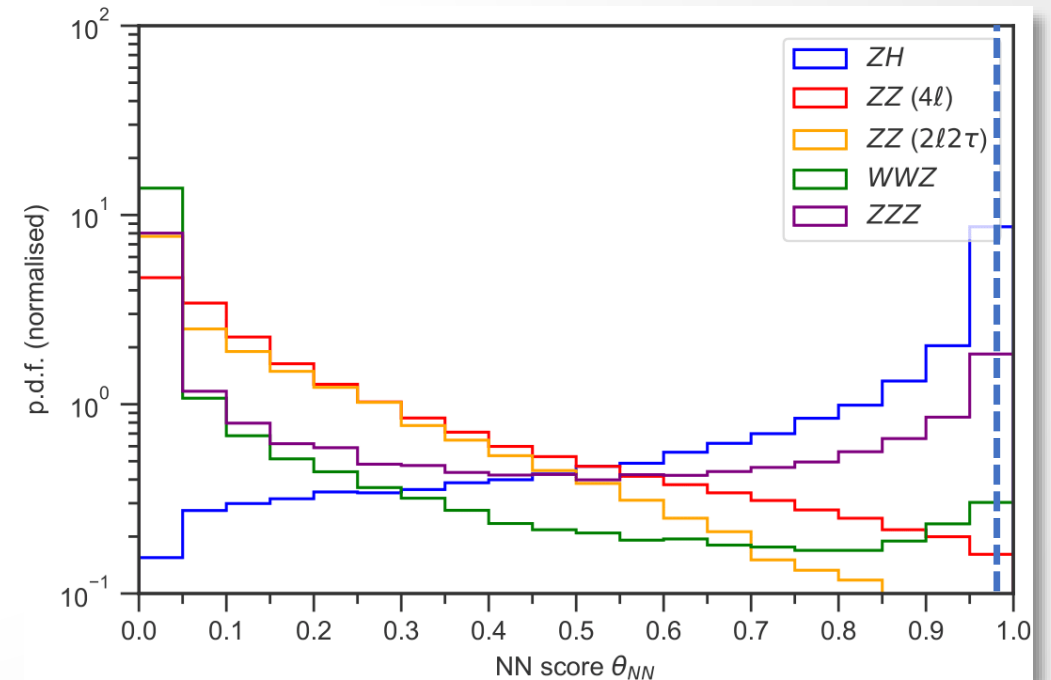
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Optimal cut →

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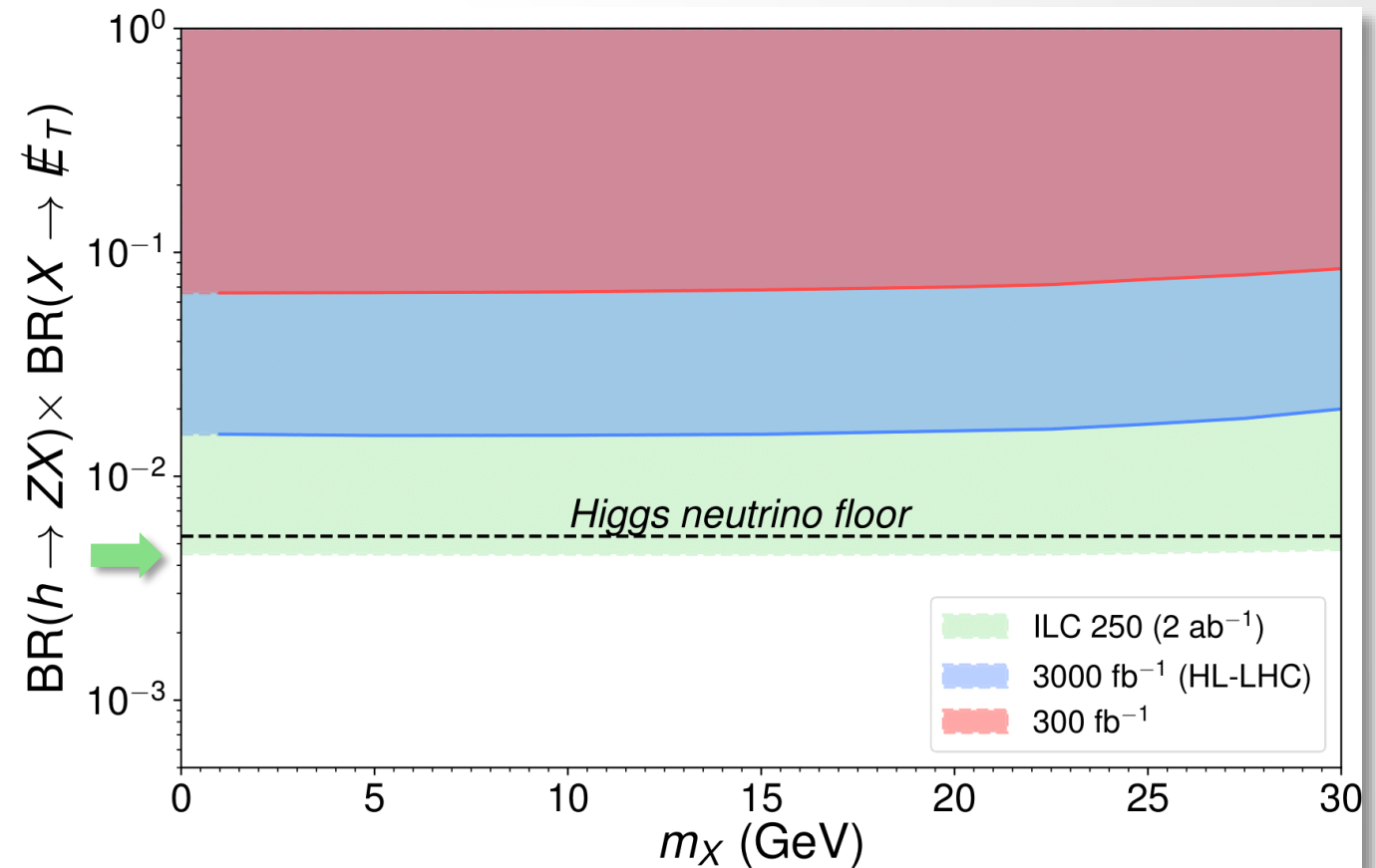
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2HDM + a

Two Higgs doublet models extended by a singlet pseudoscalar mediator and a fermionic singlet **DM** particle constitute the minimal renormalizable realization of a pseudoscalar portal to **DM** ²:

$$V = V_{\text{2HDM}} + \frac{\mu_{a_0}^2}{2} a_0^2 + m_\chi \bar{\chi} \chi + \frac{\lambda_a}{4} a_0^4 + \lambda_{a1} a_0^2 |H_1|^2 \\ + \lambda_{a2} a_0^2 |H_2|^2 + i \kappa a_0 H_1^\dagger H_2 + y_\chi a_0 \bar{\chi} i \gamma^5 \chi + \text{h.c.}$$

2

Ipek, McKeen, Nelson, [PRD 90](#) (2014), 055021
No, [PRD 93](#) (2016), 031701
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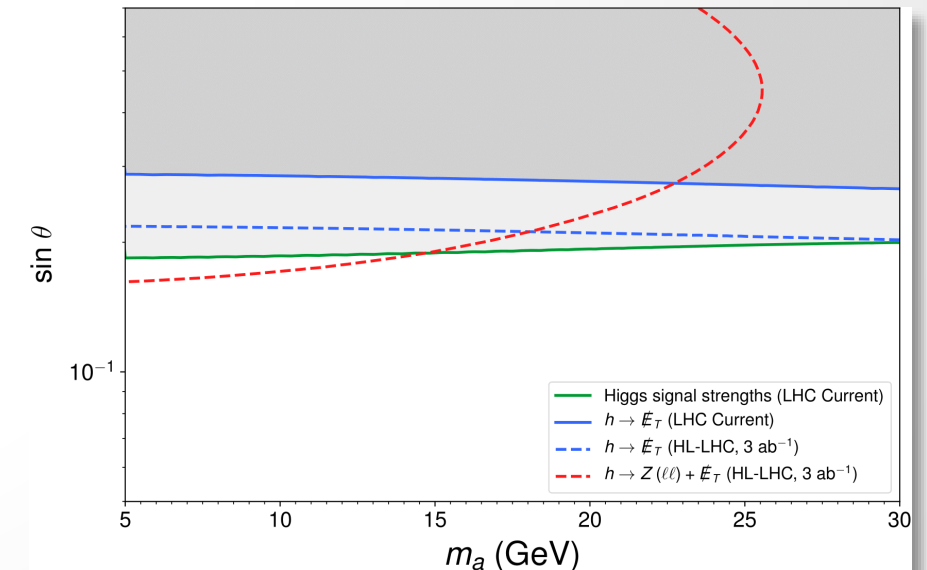
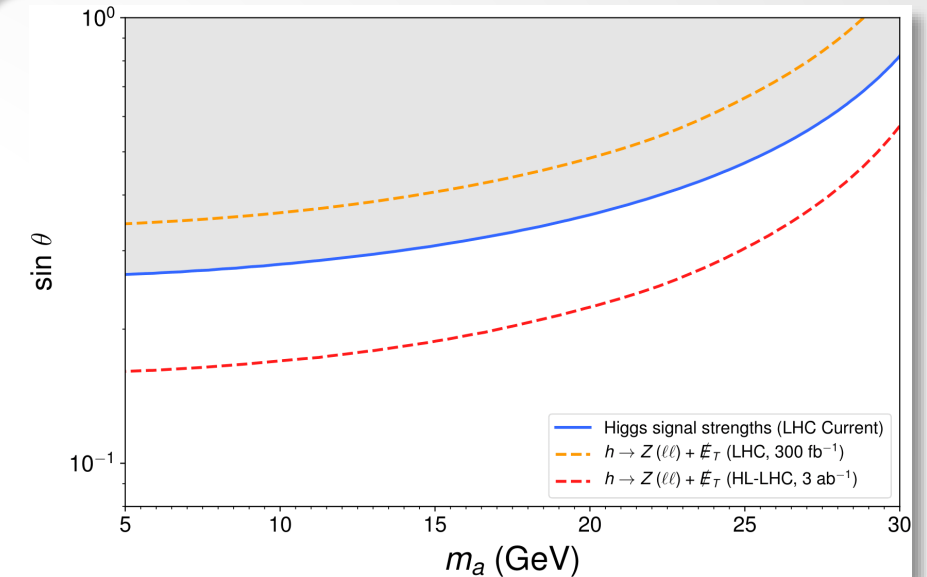
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Axion-like particles

Interactions between the **SM** Higgs and light **axion-like particles (ALPs)** are a well-motivated BSM possibility **3**, with exotic Higgs decays representing a **key experimental signature** for these scenarios...

$$c_{a\gamma\gamma}/f_a \, a \, F^{\mu\nu} \tilde{F}_{\mu\nu} \quad \bigg/ \quad c_{aBB}/f_a \, a \, B^{\mu\nu} \tilde{B}_{\mu\nu}$$

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Brivio, Gavela, Merlo, Mimasu, No, del Rey, Sanz, [EJPC 77 \(2017\) 8, 572](#)
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If ***a*** couples to some hidden sector particle(s) (see e.g. **4**), its dominant decay mode(s) may be into the **dark sector**, thus **invisible** at colliders. This encompasses the intriguing possibility that the **ALP** may be a **mediator** between the **SM** and the **DM** candidate.

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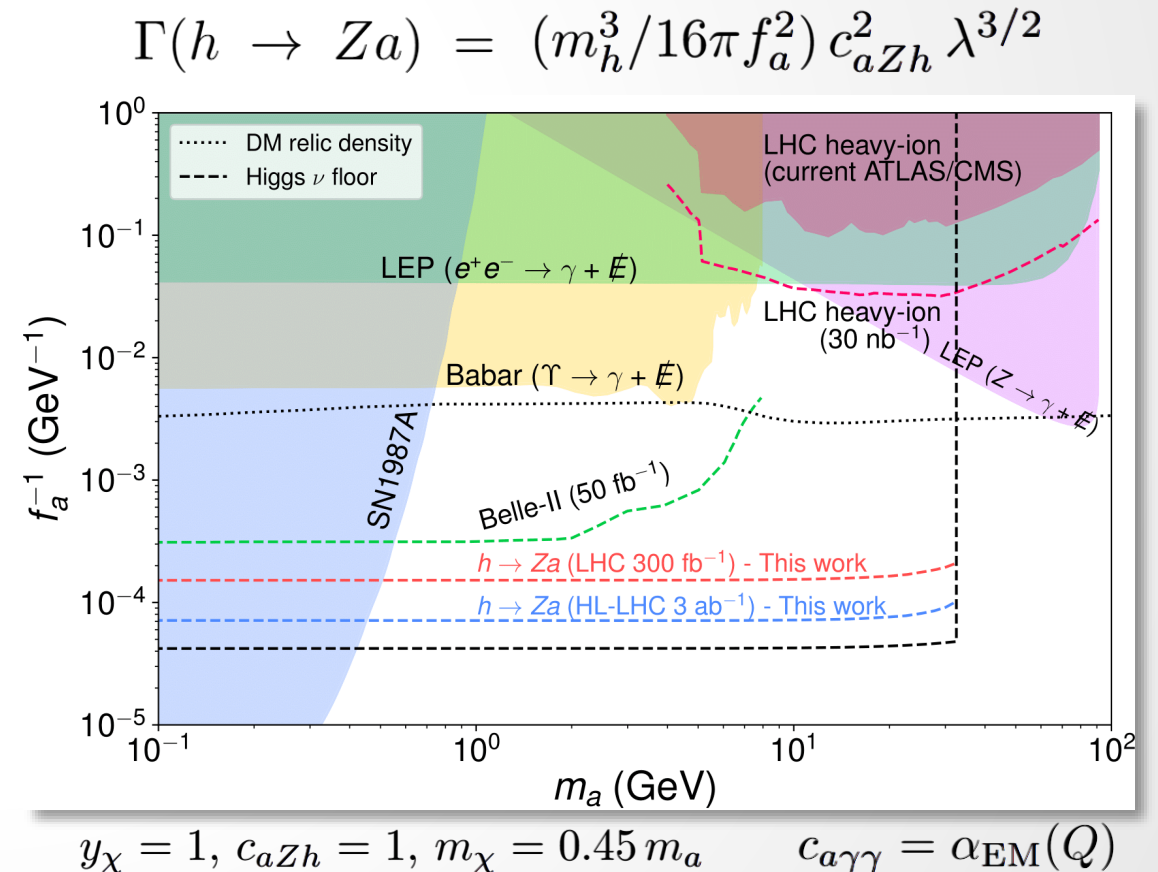
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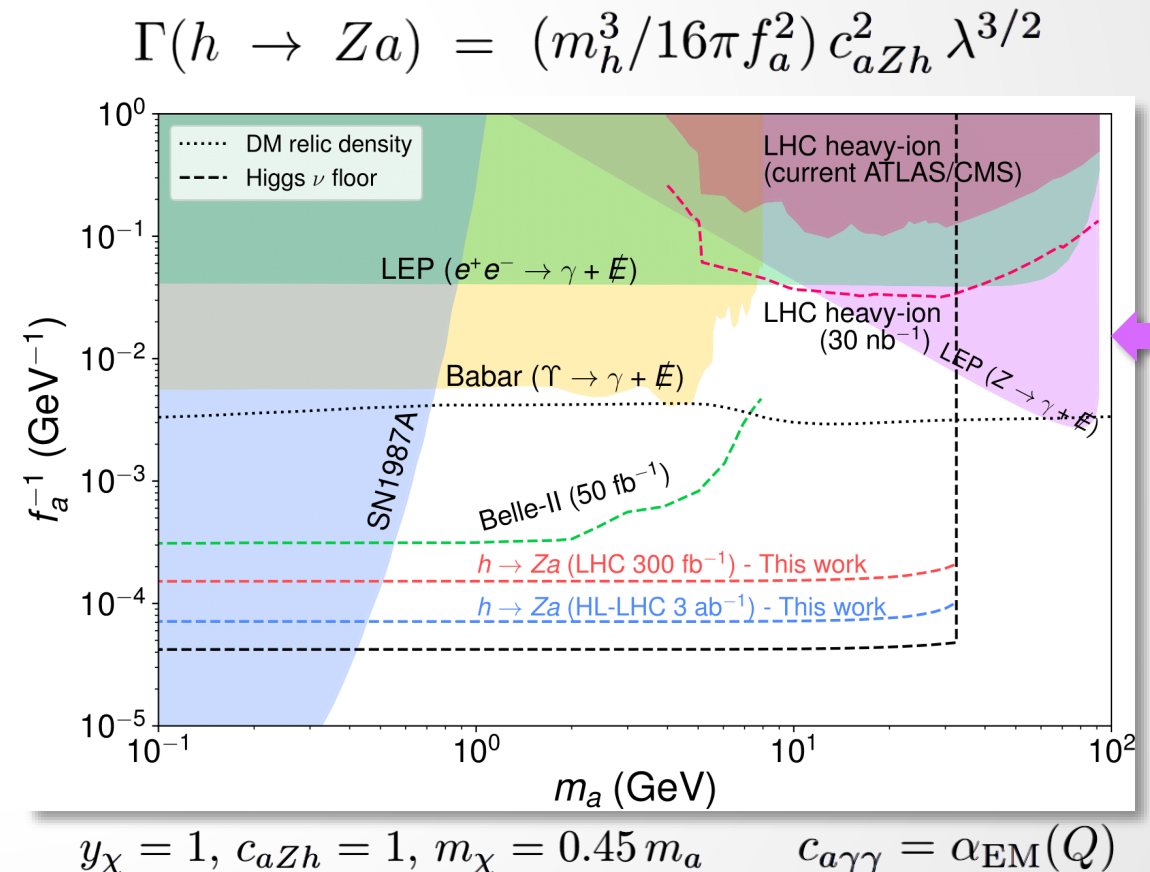
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Workshop on
Multi-Higgs Models
30Ago - 2Sept 2022
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come chat for more details!

