30th Mini-workshop on the frontier of LHC

Long lived particles beyond B meson at Faser

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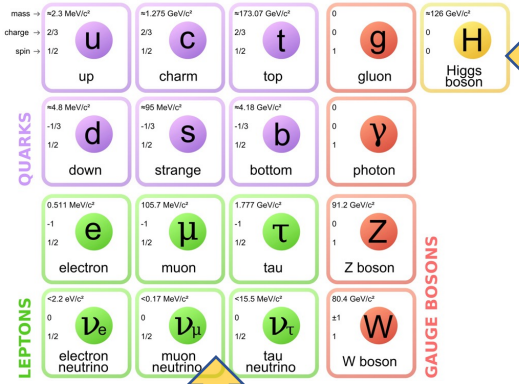
2507.XXXXX (WS, JM. Yang, PX. Zhu, R. Zhu)

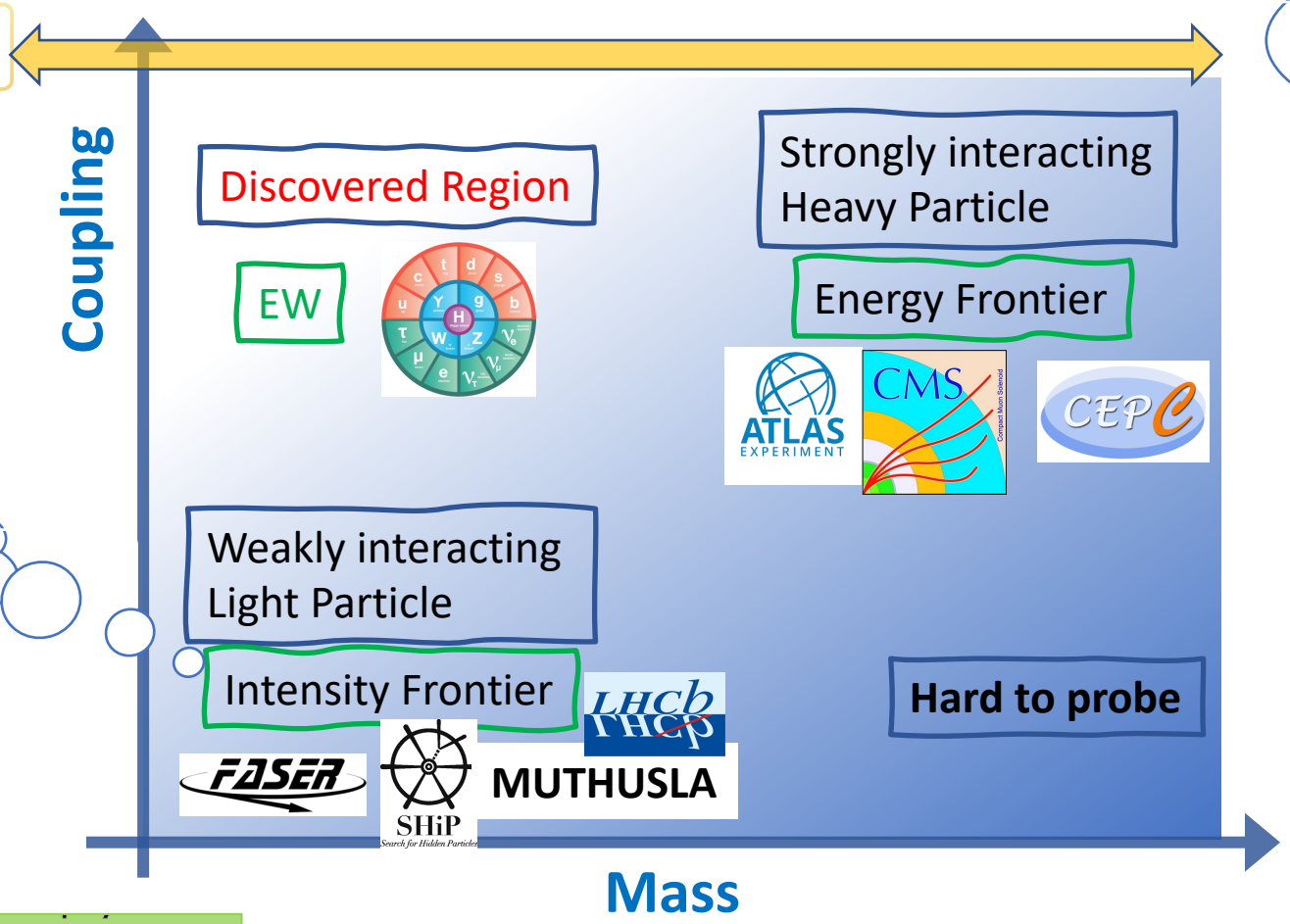
Motivation: LLP



$WIMP, Dark\ Photon$ ..

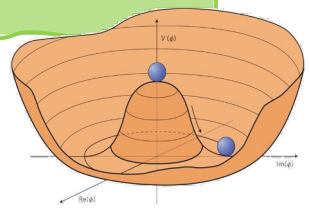
- Naturalness
- Muon g-2
- B anomaly
- …

$$R_{K^{(*)}} = \frac{\mathrm{BR}(B \to K^{(*)}\mu\mu)}{\mathrm{BR}(B \to K^{(*)}ee)}$$



$DM, Dark\ Photon$ …

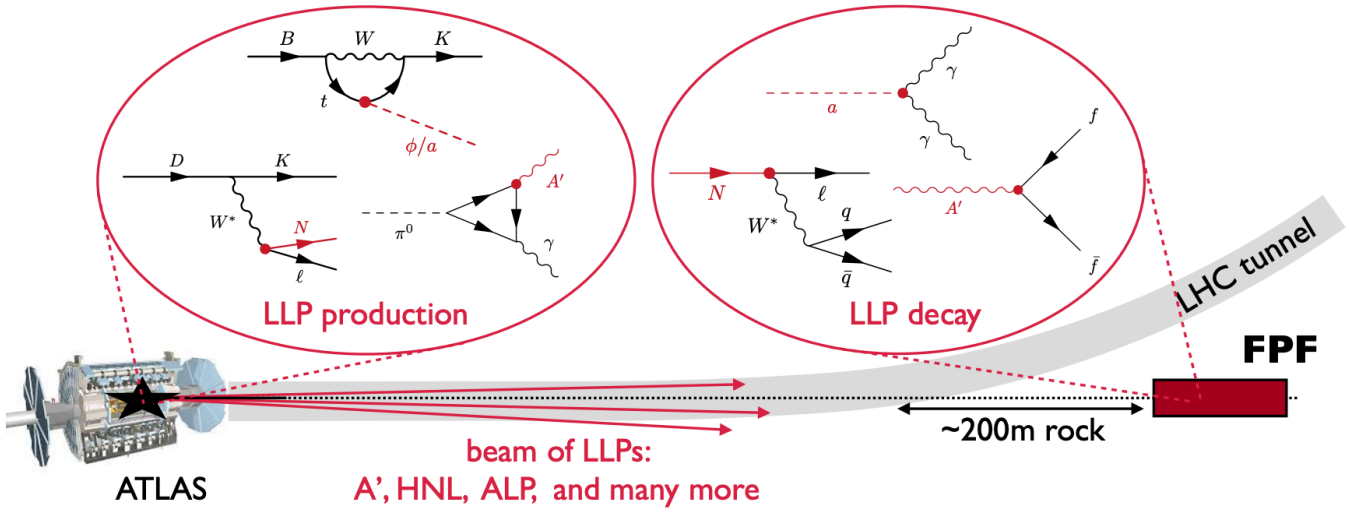
- Naturalness
- Muon g-2
- Phase transition
- …



FASER: ForwArd Search ExpeRiment

***pp* → LLP + X, LLP travels ~480 m, LLP → charged tracks + X**

Weakly interacting
Light Particle



Production

- many hadrons: 10^17 π, 10^16 K, 10^15 D, 10^14 B with E~TeV
- low PT is not covered
- particles are collimated θ ~ ΛQCD/E

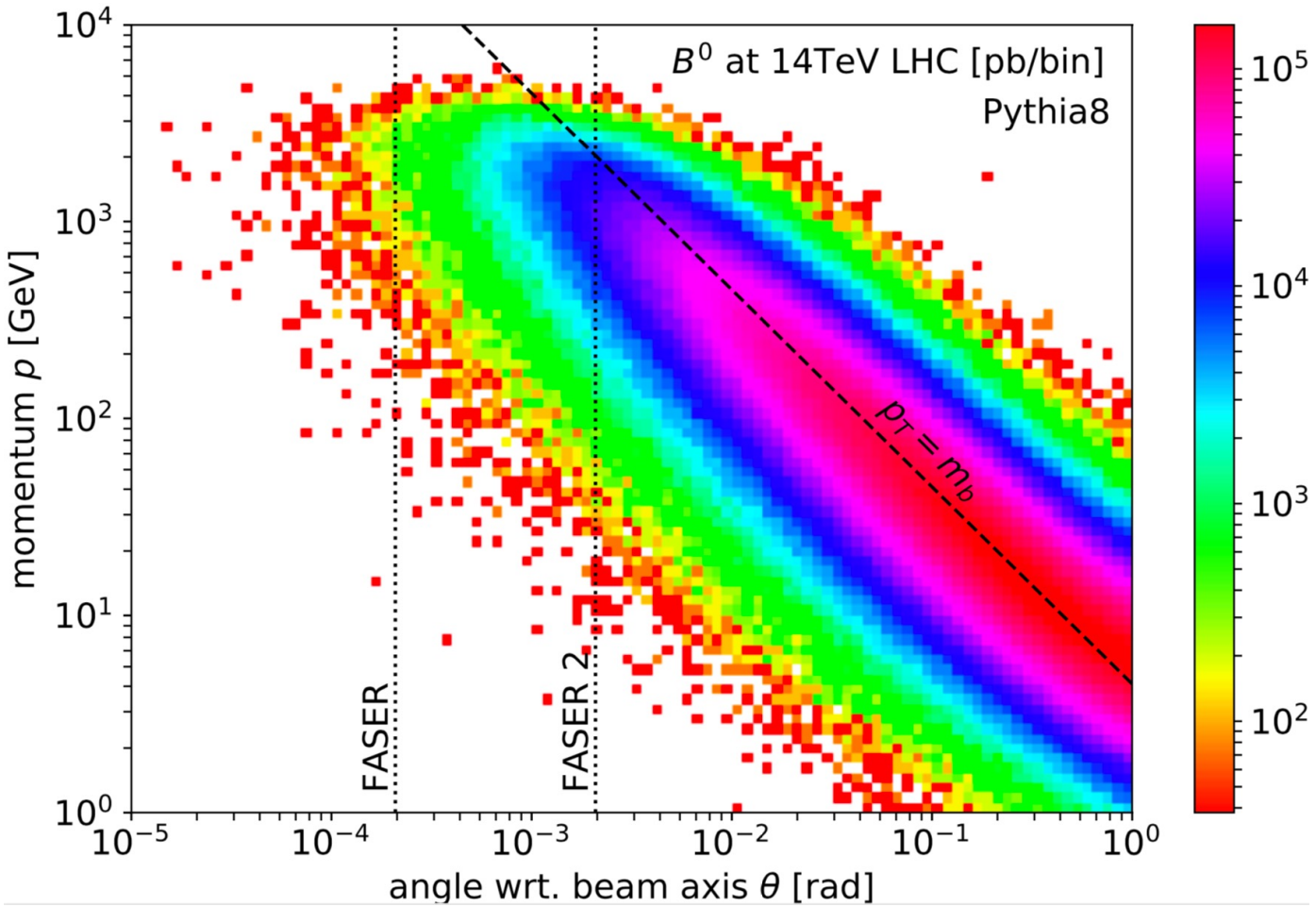
Production

B^0

boosted mesons highly collimated

$p \cdot \theta = p_T \sim$ Mb

FASER: radius R = 10 cm,
lenght D = 1.5 m,
FASER 2: radius R = 1m,
lenght D = 5 m.

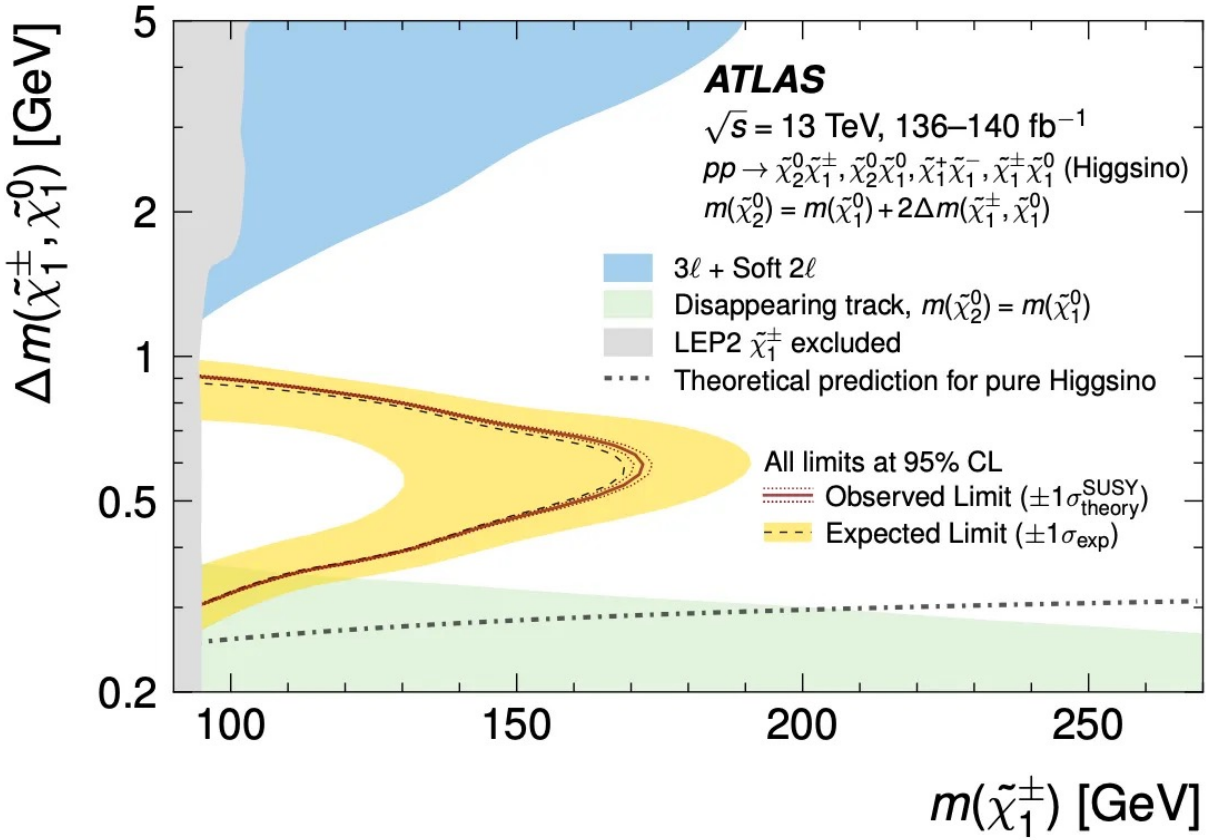


This is the well-known main **LLP source** for FASER, m_b < 5 GeV

Can we push the upper limit? → New LLP source in the forward?

MSSM CASE: $M_{LLP}>M_B$

Near the main ATLAS detector,
It is possible.



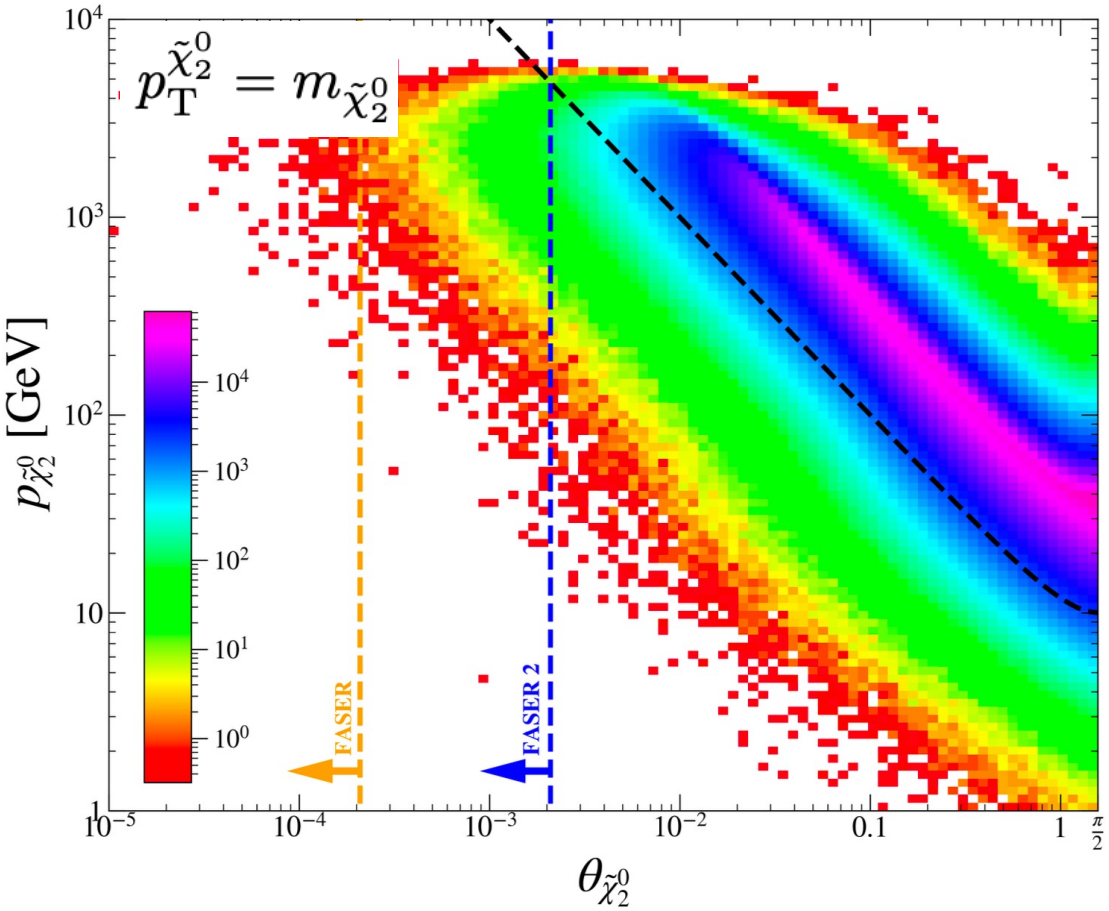
Higgsino-like neutralino

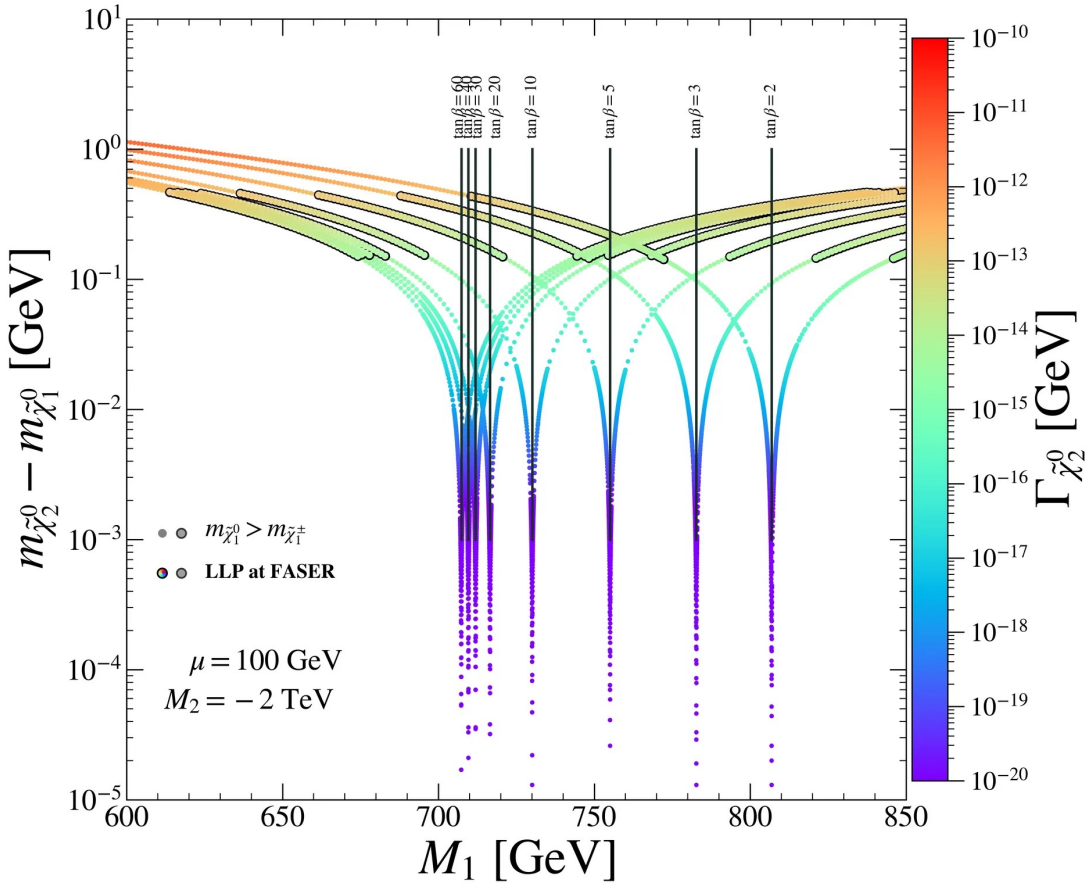
$$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 + \gamma,$$
$$\to \tilde{\chi}_1^0 + Z^* \to \tilde{\chi}_1^0 + f\bar{f}.$$

$$\Gamma(\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\gamma) = \frac{g^2_{\tilde{\chi}_2^0\tilde{\chi}_1^0\gamma}}{8\pi}\frac{\left(m^2_{\tilde{\chi}_2^0} - m^2_{\tilde{\chi}_1^0}\right)^3}{m^5_{\tilde{\chi}_2^0}},$$

$$m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} = \frac{m_Z^2}{2}\left\{[1 + \text{sign}(\mu)\sin 2\beta]\left(\frac{\cos^2\theta_W}{M_2 - |\mu|} + \frac{\sin^2\theta_W}{M_1 - |\mu|}\right)\right.$$
$$\left. + [1 - \text{sign}(\mu)\sin 2\beta]\left(\frac{\cos^2\theta_W}{M_2 + |\mu|} + \frac{\sin^2\theta_W}{M_1 + |\mu|}\right)\right\}.$$
$$\approx m_Z^2\left(\frac{\cos^2\theta_W}{M_2} + \frac{\sin^2\theta_W}{M_1}\right).$$

MSSM CASE: $M_{LLP}>M_B$





Results：

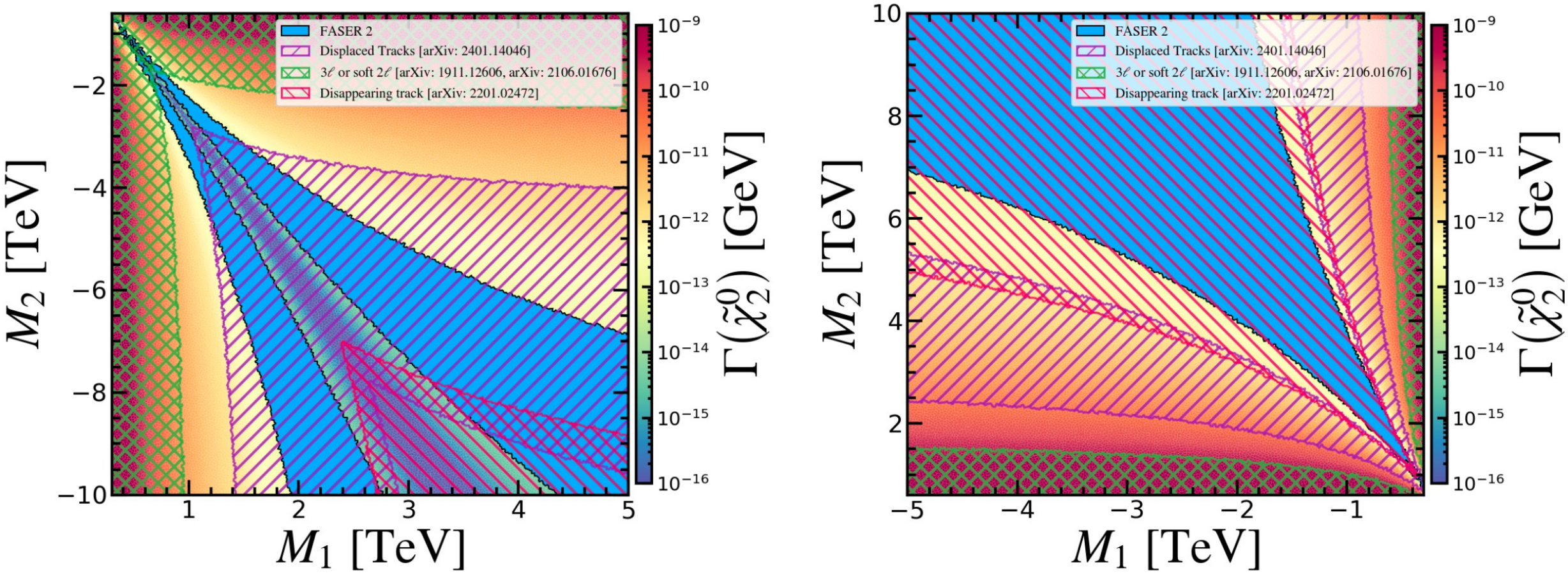
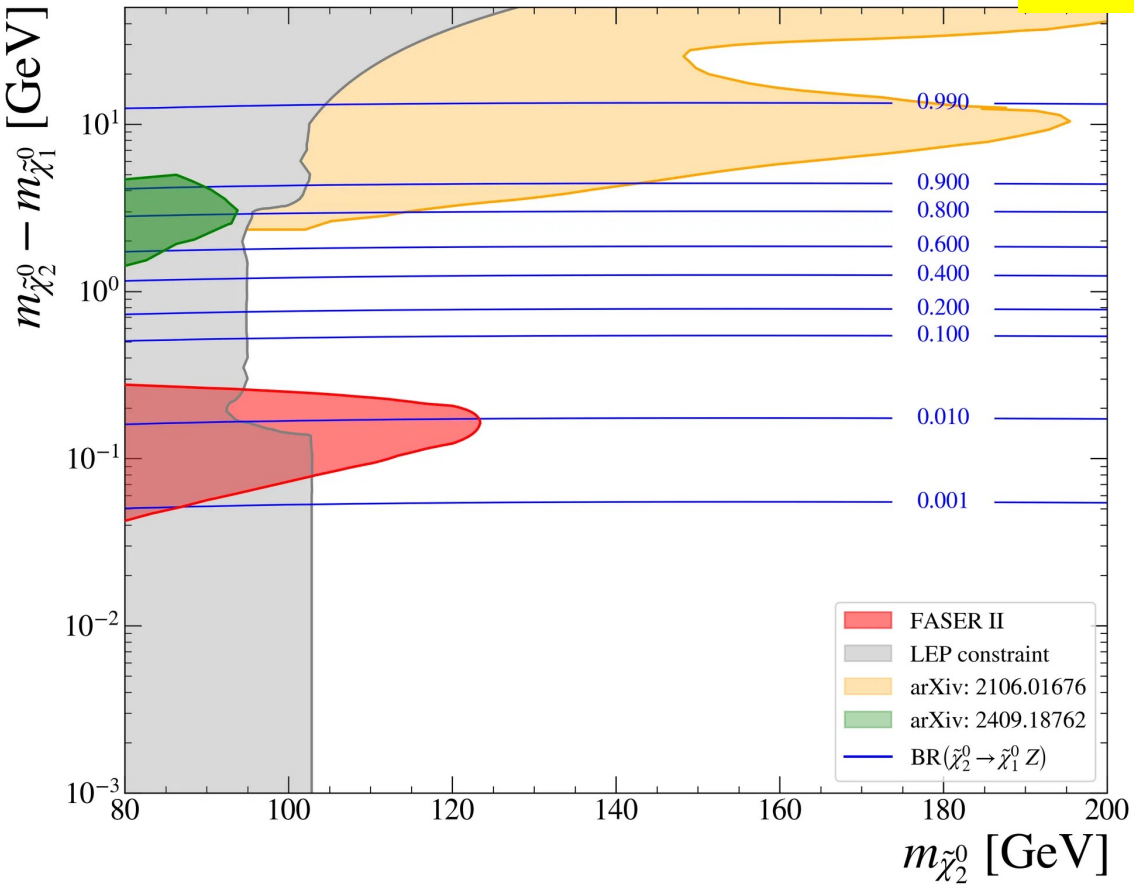
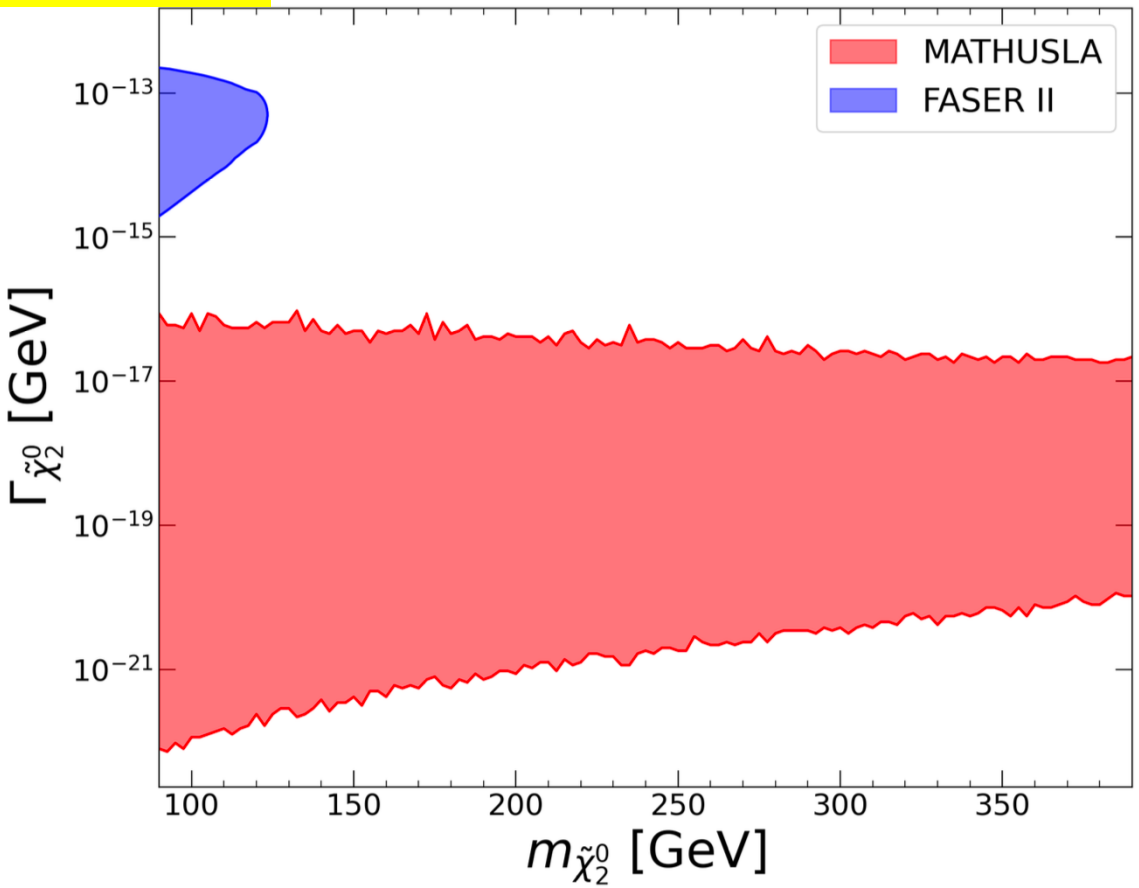


Figure 5. $\mu = 100$ GeV. Left: $\tan\beta = 2$, $\mathrm{sign}(\mu M_2) < 0$; Right: $\tan\beta = 50$, $\mathrm{sign}(\mu M_2) > 0$;

Results

Preliminary





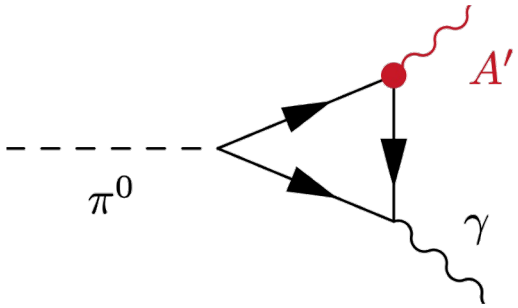
LLP source in the forward region has its own advantages beyond B meson

Thanks !

Production: CP even scalar

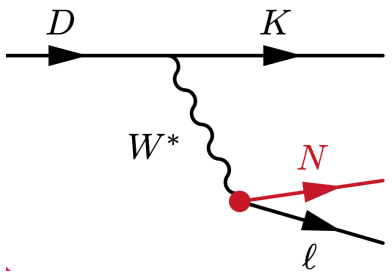
$$\mathcal{L} = -\frac{1}{2}m_\phi^2\phi^2 - \sum_f \xi_\phi^f \frac{m_f}{v}\phi\bar{f}f + \xi_\phi^W \frac{2m_W^2}{v}\phi W^{\mu+}W_\mu^- + \xi_\phi^Z \frac{m_Z^2}{v}\phi Z^\mu Z_\mu$$

$$+\xi_\phi^g \frac{\alpha_s}{12\pi v}\phi G_{\mu\nu}^a G^{a\mu\nu} + \xi_\phi^\gamma \frac{\alpha}{4\pi v}\phi F_{\mu\nu}F^{\mu\nu}.$$

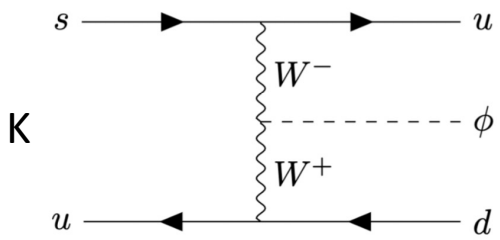


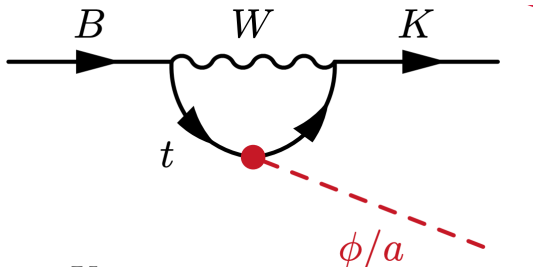
$$K \to \pi\phi,\ \eta^{(\prime)} \to \pi\phi,\ D \to X_u\phi,\ B \to X_s\phi$$

$$\pi^+ \to \ell\nu\phi \qquad K^+ \to \ell\nu\phi \qquad \Upsilon \to \phi\gamma$$



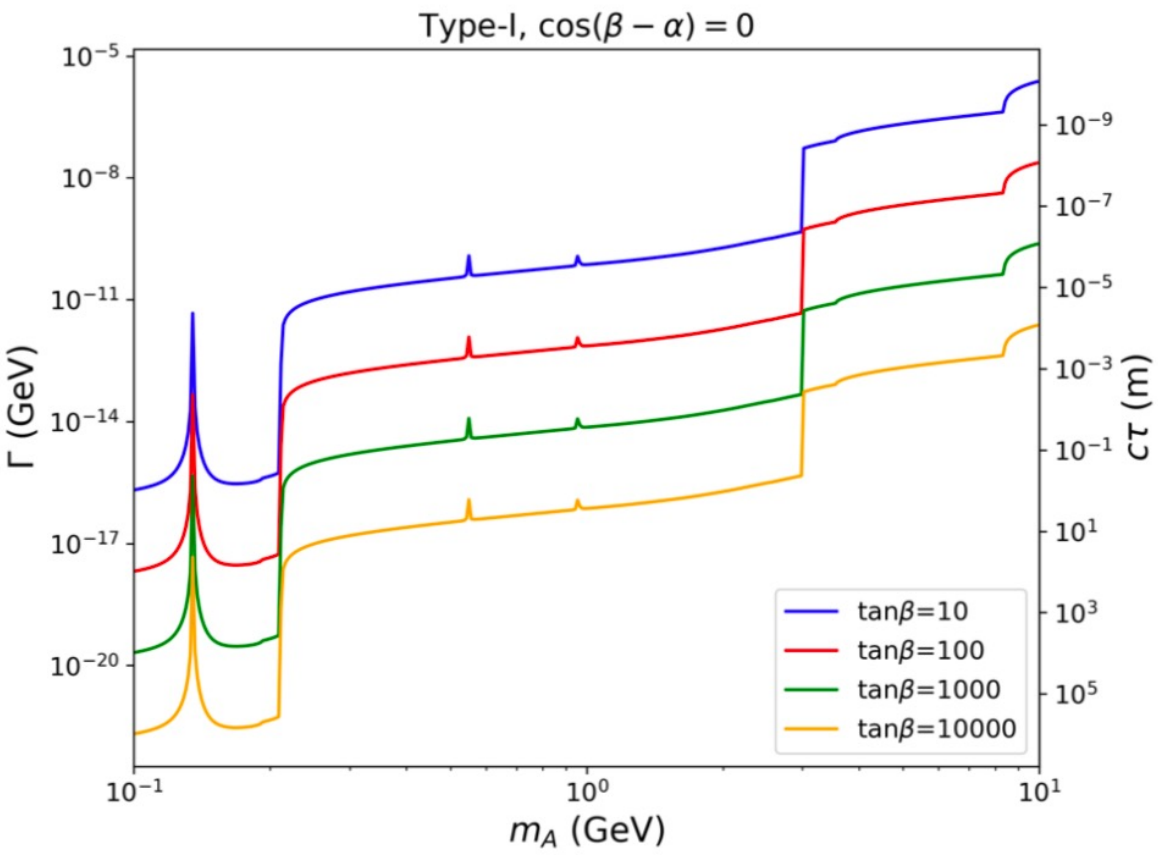
meson	quark content	mass (MeV)
$\pi^\pm$	$u\bar{d}$	139.57018 ± 0.00035
π^0	$\frac{u\bar{u}-d\bar{d}}{\sqrt{2}}$ [a]	134.9766 ± 0.0006
η	$\frac{u\bar{u}+d\bar{d}-2s\bar{s}}{\sqrt{6}}$ [a]	547.853 ± 0.024
η'	$\frac{u\bar{u}+d\bar{d}+s\bar{s}}{\sqrt{3}}$ [a]	957.66 ± 0.24

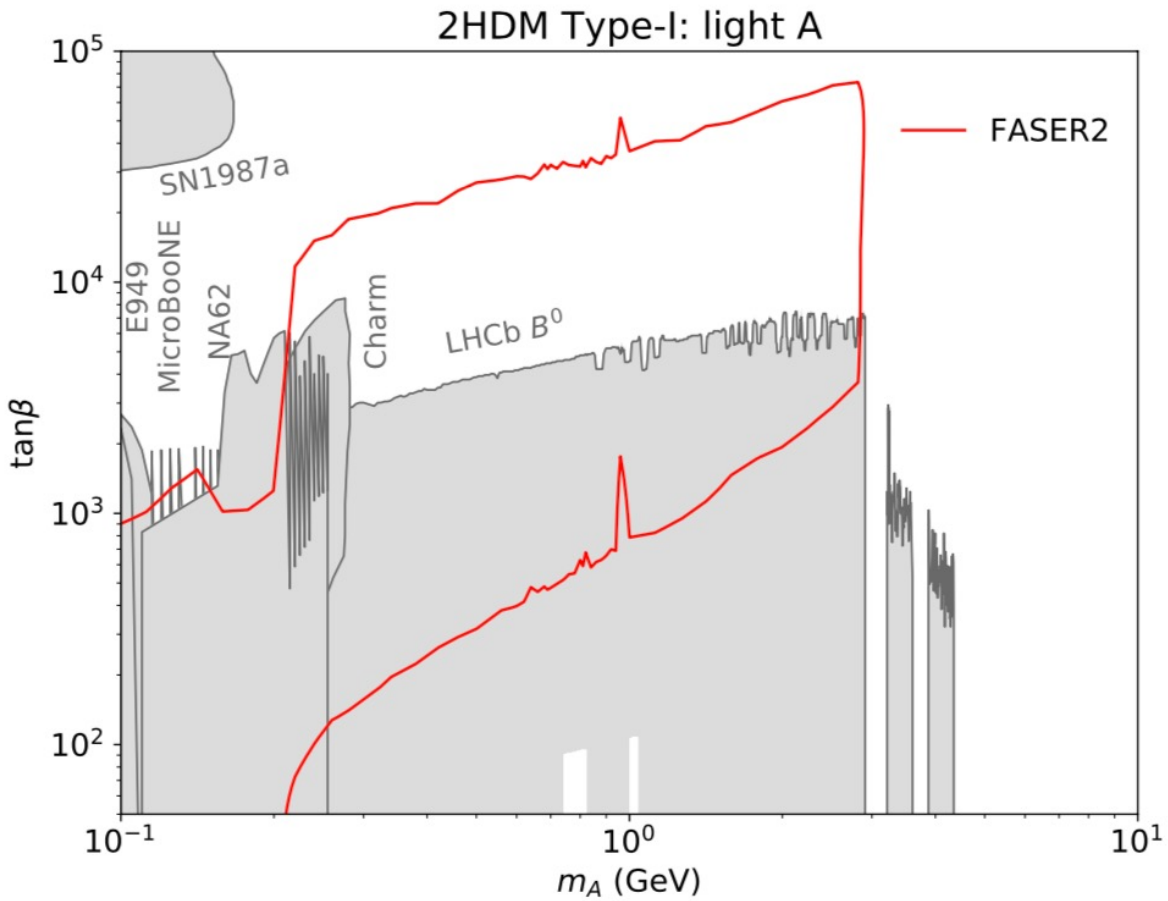




Results: CP odd

$$\xi_A^f|_{\cos(\beta-\alpha)=0} = 1/\tan\beta$$





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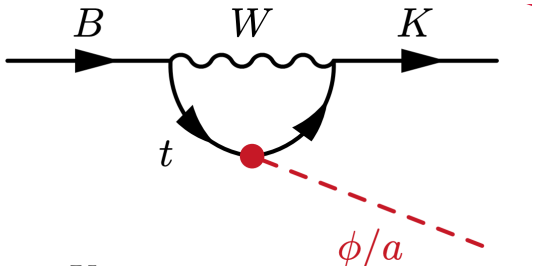

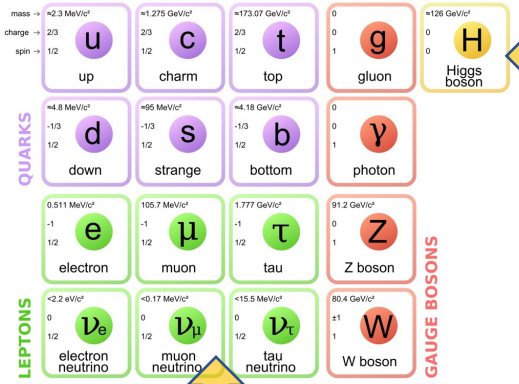

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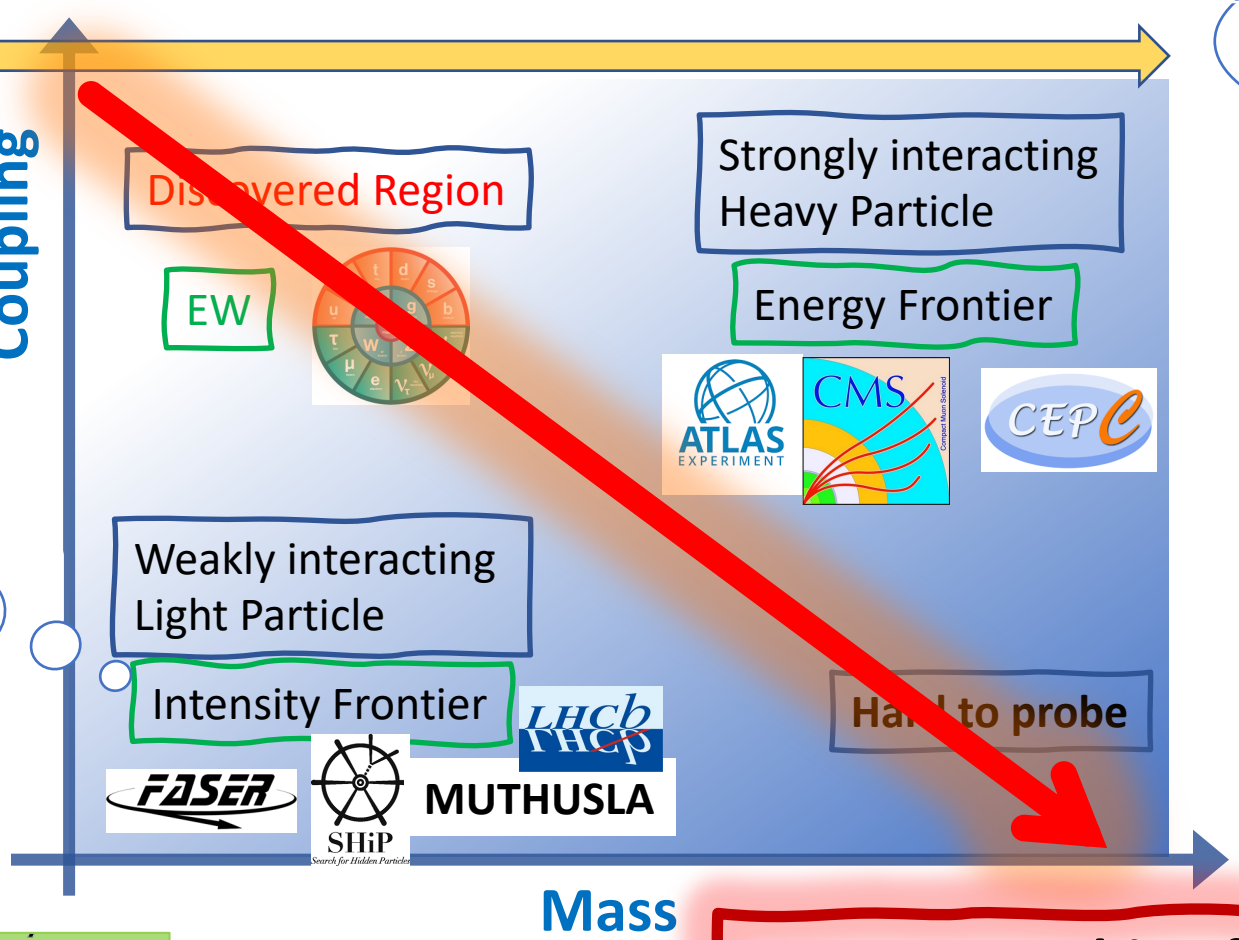

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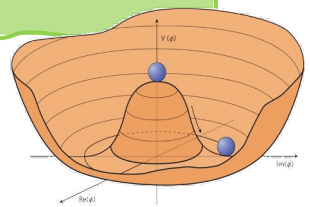

We are searching for BSM discovery