Università degli Studi di Padova

INFN Padova
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

Probing New Physics with the Electron Yukawa coupling

Barbara Anna Erdelyi

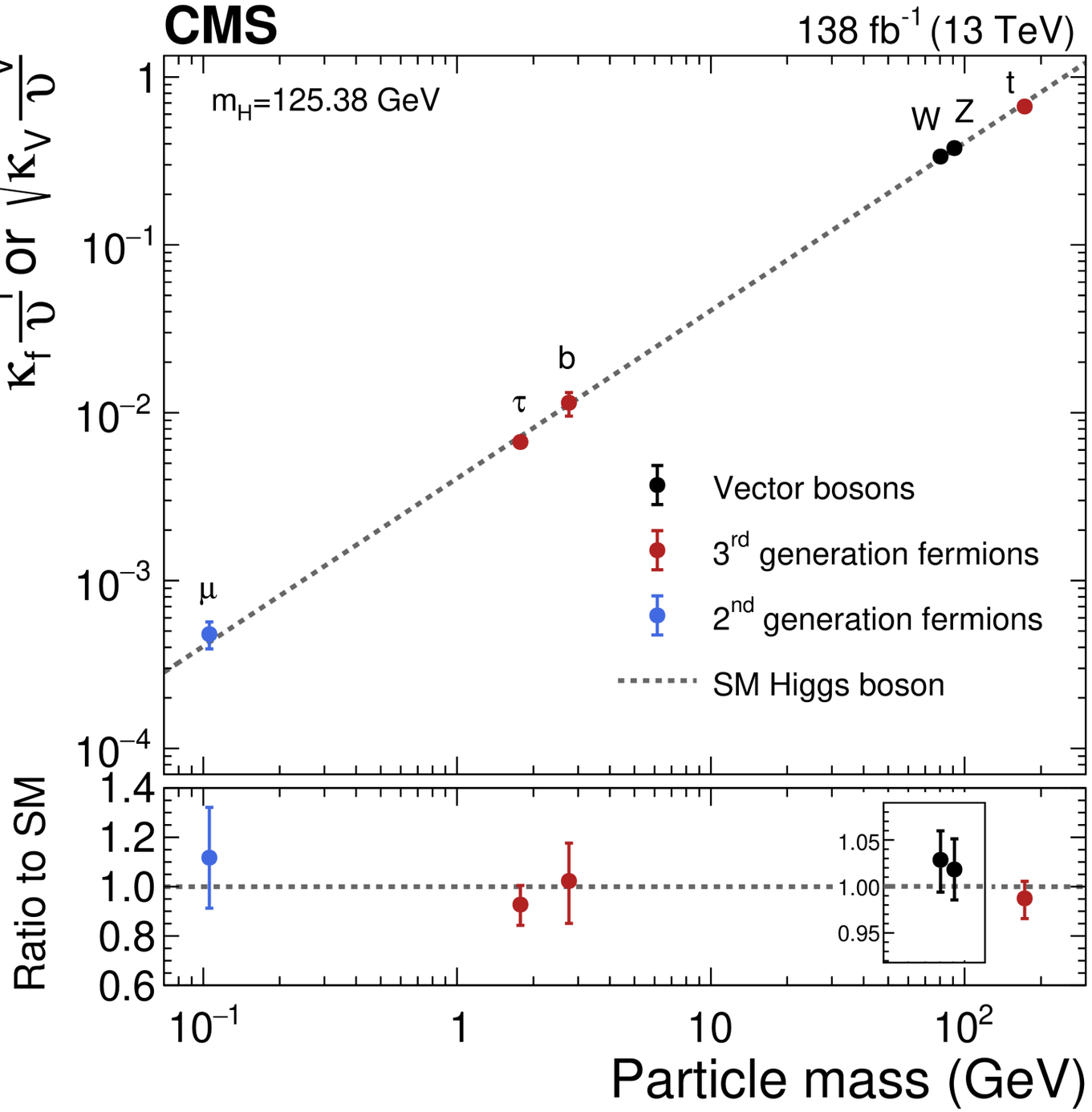
based on JHEP 05 (2025) 135

with Ramona Gröber and Nudžeim Selimović

July 25, 2025

Introduction

Higgs boson couplings



[CMS Collaboration, 2022]

- ✓ couplings to EW gauge bosons;
- ✓ couplings to the third generation massive fermions;
- ✓ coupling to the muon;

- ✗ Higgs self couplings;
- ✗ couplings to the light quarks;
- ✗ coupling to the electron.

$$\kappa_e = \frac{g_{\bar{e}eh}}{g^{SM}_{\bar{e}eh}}$$

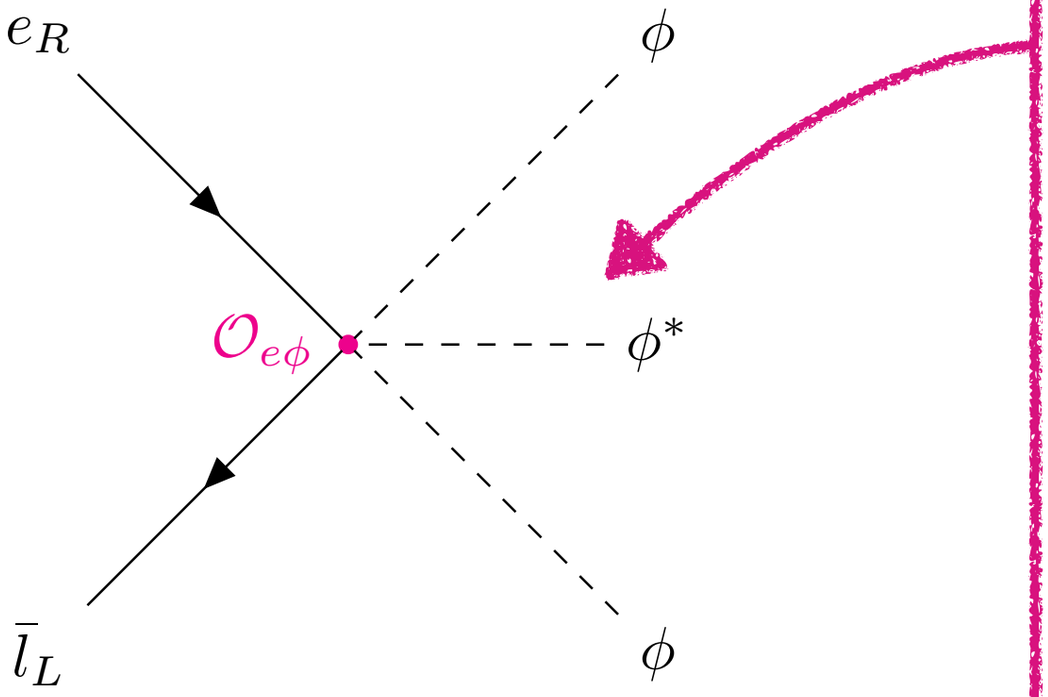
$$|\kappa_e| < 260 \text{ @ } 95\,\% \text{ C.L.}$$

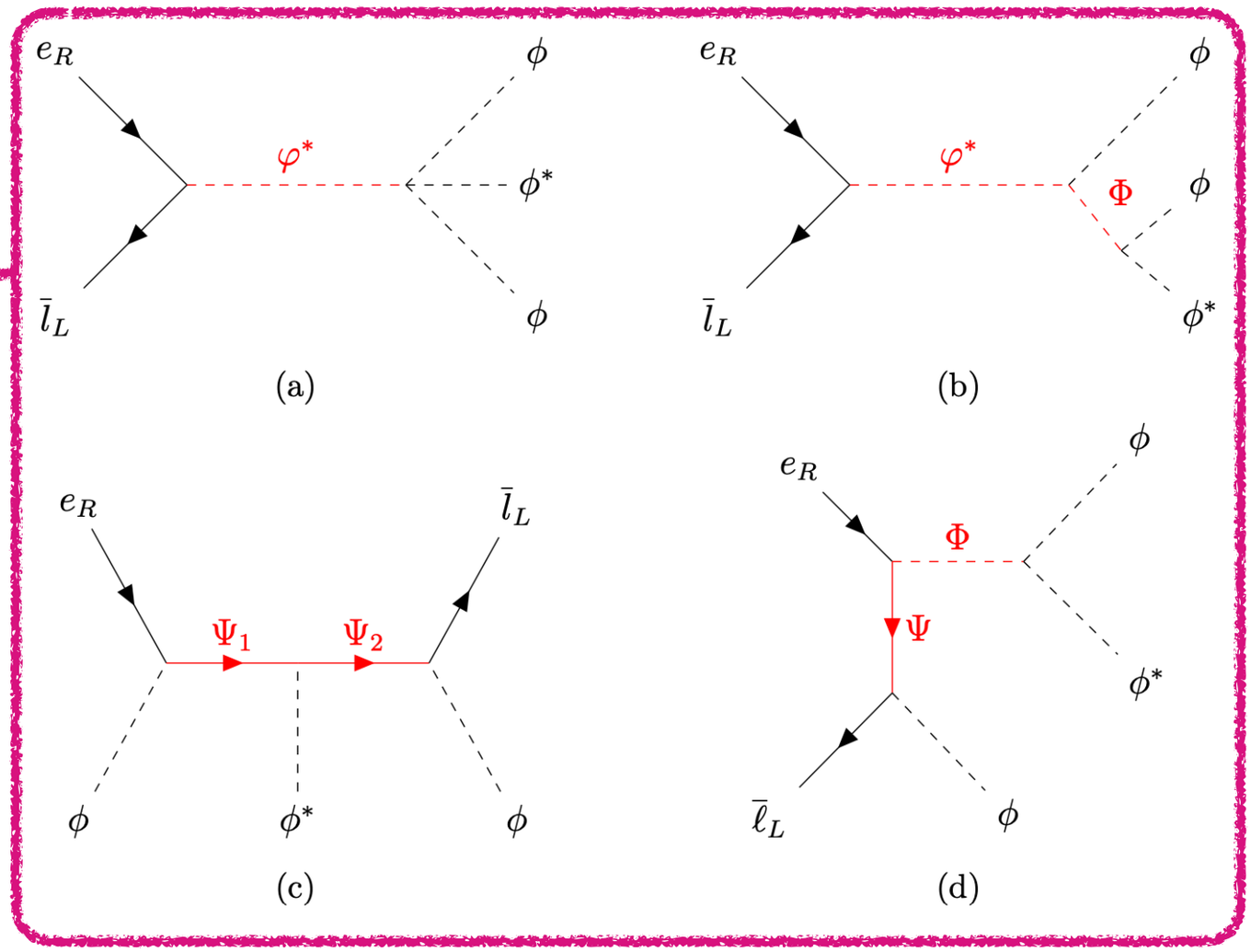
[ATLAS Collaboration, 2019]

Standard Model Effective Field Theory at Dimension Six

$$\mathscr{L}_{SMEFT}^{d=6} = \mathscr{L}_{SM} + \sum_{i=1}^{n_6} \mathscr{C}_i^{(6)}(\mu)\ \mathcal{O}_i^{(6)}, \qquad \left[\mathscr{C}_i^{(6)}\right] = -2$$

$$\mathcal{O}_{e\phi} = \left(\phi^\dagger\phi\right)\left(\bar{l}_L\phi e_R\right)$$





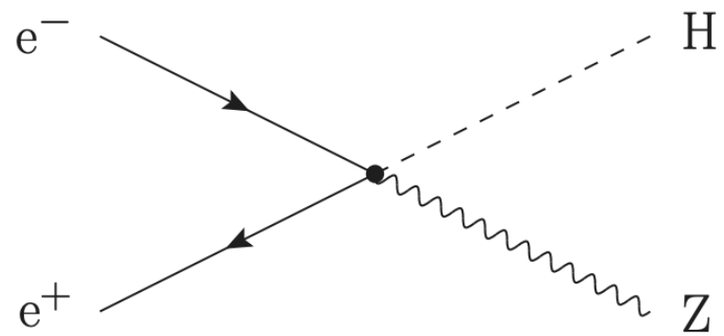
[Grzadkowski, Iskrzyński, Misiak, Rosiek, 2010]

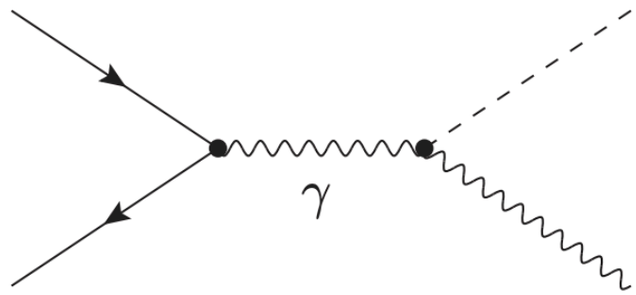
Generated SMEFT Operators

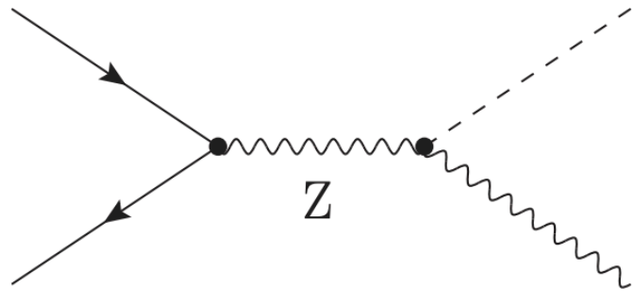
Operators generated at tree- and one-loop level by models with VLL pairs

$\mathcal{O}_{e\phi}$	$(\phi^\dagger\phi)\,(\bar{l}_L\phi e_R)$	$\mathcal{O}_{\phi e}$	$(i\phi^\dagger \overleftrightarrow{D}_\mu \phi)(\bar{e}_R\gamma^\mu e_R)$
$\mathcal{O}_{\phi l}^{(1)}$	$(i\phi^\dagger \overleftrightarrow{D}_\mu \phi)(\bar{l}_L\gamma^\mu l_L)$	$\mathcal{O}_{\phi l}^{(3)}$	$(i\phi^\dagger \overleftrightarrow{D}^I_\mu \phi)(\bar{l}_L\gamma^\mu \sigma^I l_L)$
$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$\lvert\phi^\dagger D_\mu\phi\rvert^2$
$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)\,(B_{\mu\nu}B^{\mu\nu})$	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)\,(W^I_{\mu\nu}W^{\mu\nu I})$
$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^I\phi)\,(W^I_{\mu\nu}B^{\mu\nu})$		

Example diagrams:



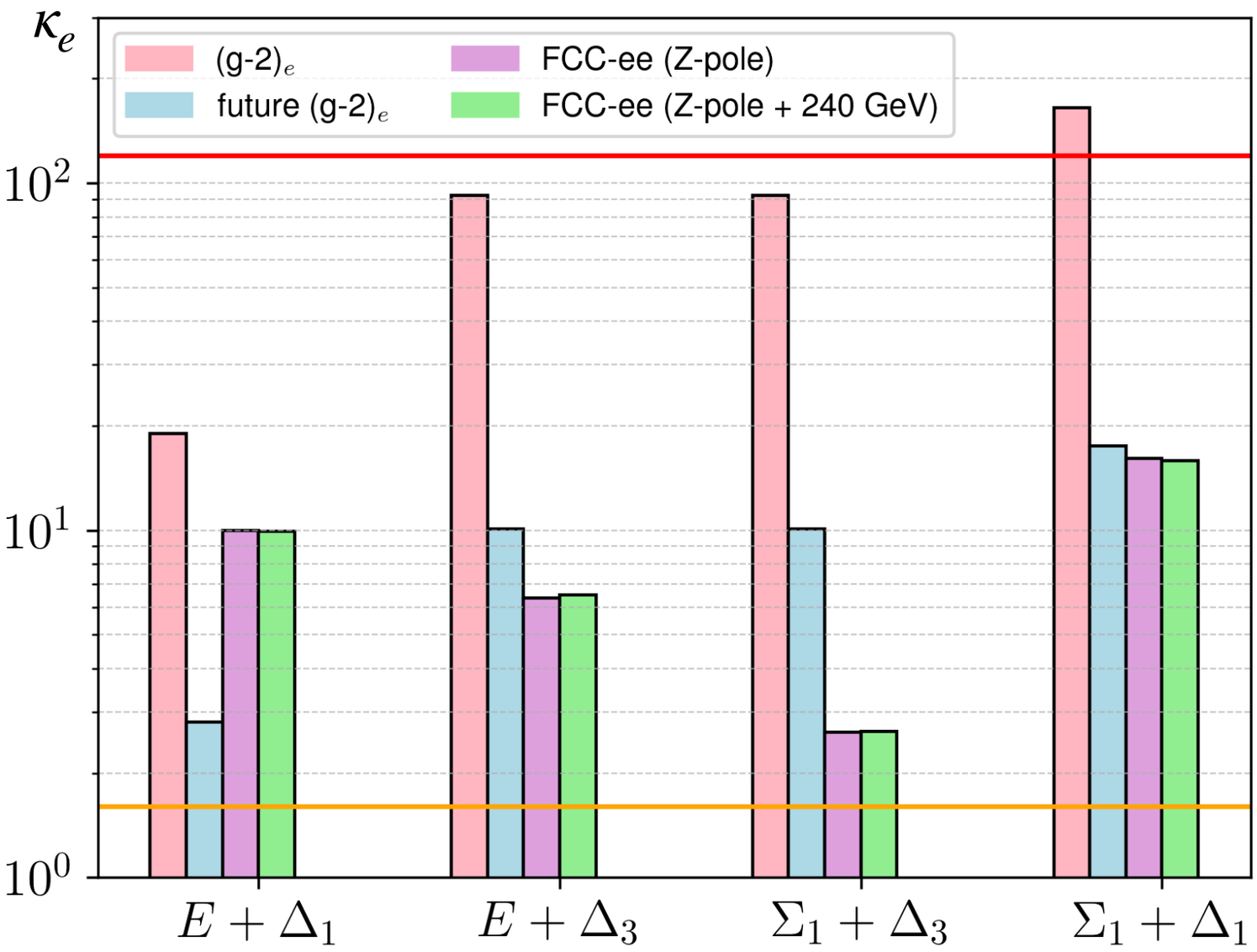




Example formula:

$$\delta m_W = -\,v^2\frac{g_L^2}{4(g_L^2-g_Y^2)}\mathscr{C}_{\phi D} - v^2\frac{g_L g_Y}{g_L^2-g_Y^2}\mathscr{C}_{\phi WB}\,.$$

Results for models with pairs of VLLs



$$\kappa_e = 1 - \frac{v^3}{\sqrt{2} m_e} \mathscr{C}_{e\phi}$$

$\kappa_e = 120$ Projections for HL-LHC [Cepeda et al, 2019]

$\kappa_e = 1.6$ Projection for Higgs pole run at FCC-ee [d'Enterria, Poldaru, Wojcik, 2021]

Thank you!