Low *Seesaw* Scale Solution for M_W and $(g-2)_\mu$

by **Arturo de Giorgi** (**Madrid, IFT**)

based on **2211.03797** - *Fortschritte der Physik* (2023)

in collaboration with **L. Merlo** (**Madrid, IFT**), **S. Pokorski** (**Warsaw U.**)

Contribution to: *57th Rencontres de Moriond 2023 - Electroweak Interactions & Unified Theories*

March 23, 2023

UAM

ift Instituto de Física Teórica UAM-CSIC

HIDDeN
Hunting Invisibles: Dark sectors, Dark matter and Neutrinos

This project has received funding /support from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 860881-HIDDeN

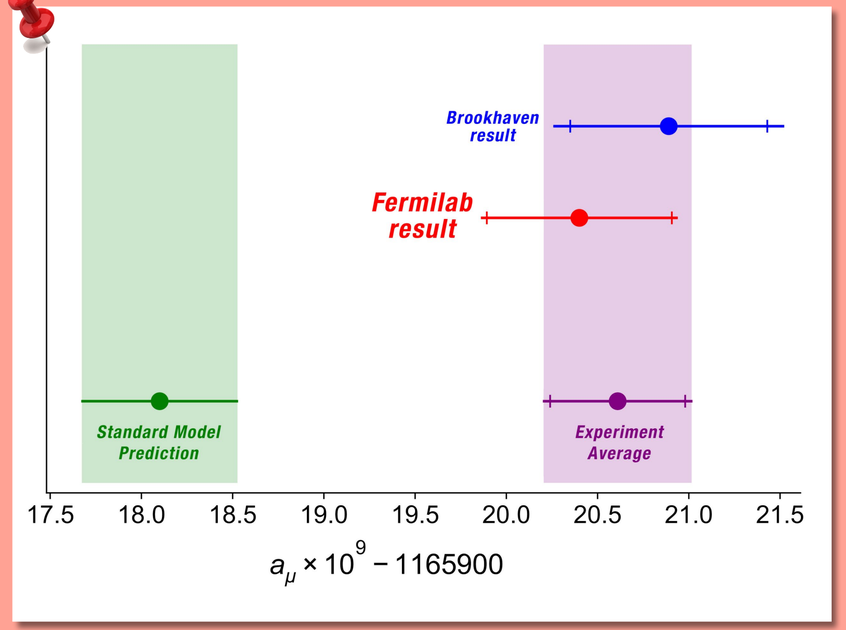
Some Experimental Inputs

ν-Masses

	NO	IO
$\frac{\Delta m^2_{21}}{10^{-5}\ \mathrm{eV}^2}$	$7.41^{+0.21}_{-0.20}$	$7.41^{+0.21}_{-0.20}$
$\frac{\Delta m^2_{3\ell}}{10^{-3}\ \mathrm{eV}^2}$	$+2.507^{+0.026}_{-0.027}$	$-2.486^{+0.025}_{-0.028}$

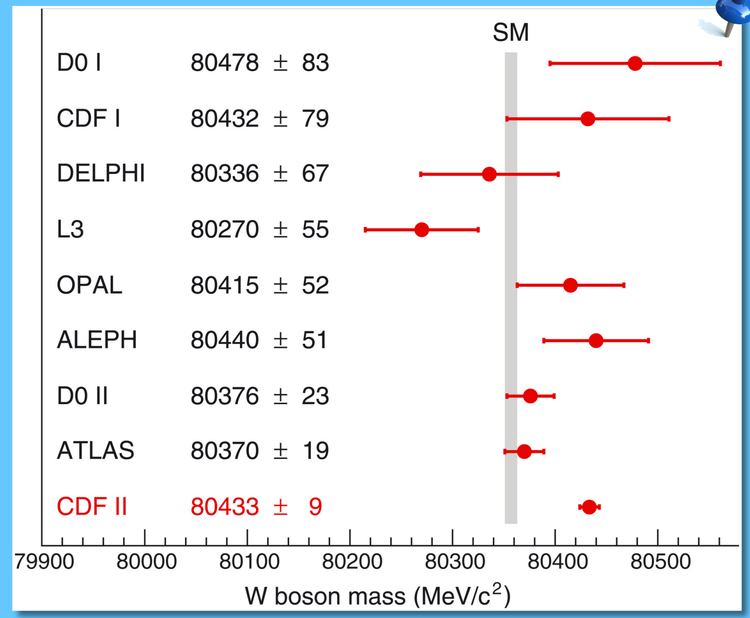
νFit Collaboration [2007.14792]

$(g-2)_\mu$



Muon g – 2 Collaboration, Phys. Rev. Lett. 126 (2021)

M_W



CDF Collaboration, Science 376 (2022), no. 6589 170–176.

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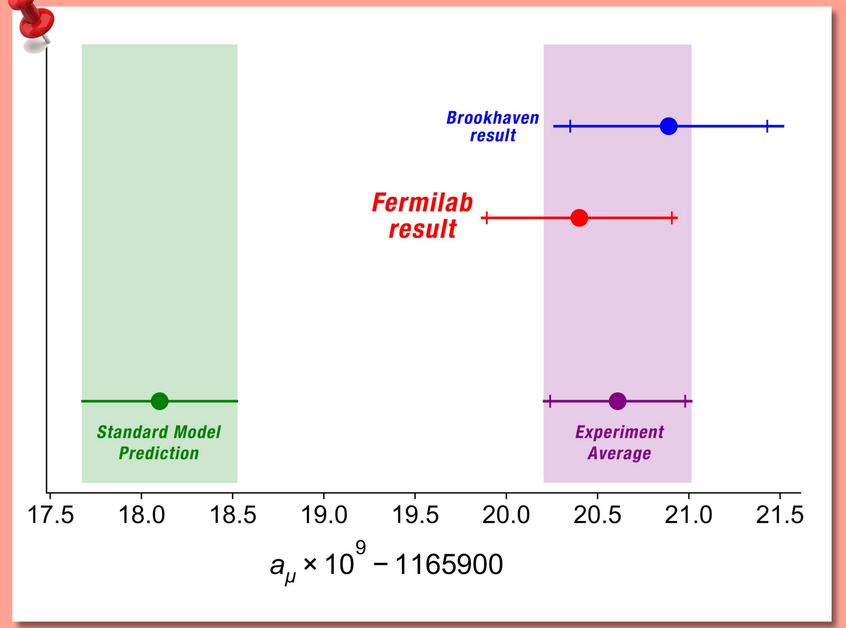
NP in the Leptonic Sector?

$(g-2)_\mu$



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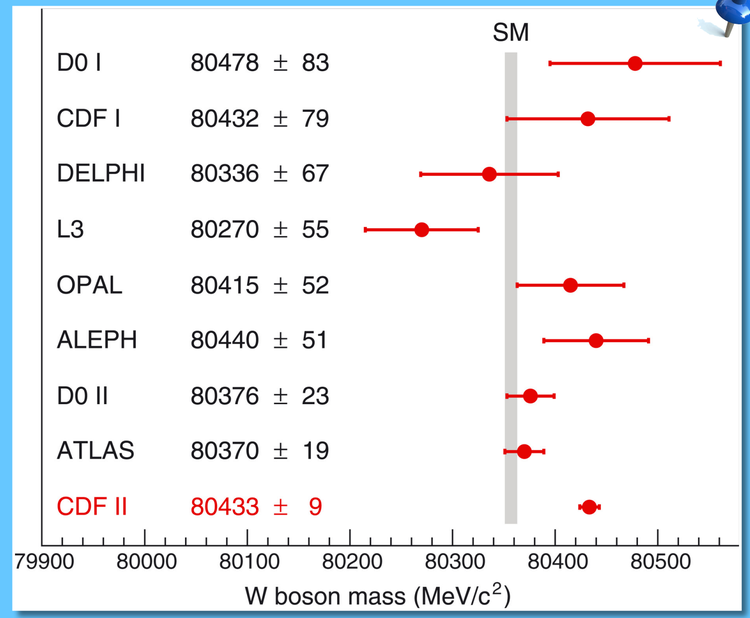


CDF Collaboration, Science 376 (2022), no. 6589 170–176.

A Minimal Extension

K. Kannike et al., JHEP 02 (2012) 106. [Erratum: JHEP 10, 136 (2012)].
R. Dermisek and A. Raval, Phys. Rev. D 88 (2013) 013017.
G. Arcadi et al., Phys. Rev. Lett. 127 (2021), no. 6 061802.
C.-T. Lu et al., JHEP 08 (2021) 073.
G. Guedes and P. Olgoso, JHEP 09 (2022) 181.

- **Only** sterile neutrinos?
  - m_ν ? ✅
  - M_W ? ✅
  - $(g-2)_\mu$? ❌

$$\left(\frac{\delta a_\mu}{10^{-9}}\right) \sim \frac{1}{16\pi^2}|\Theta_{\mu N}|^2 G_F m_\mu^2 \sim \mathcal{O}(1)\ |\Theta_{\mu N}|^2$$

Minimal extension in the leptonic sector? → **2 Vector-Like Leptons** coupling to μ

	$SU(2)_L$	$U(1)_Y$	$U(1)_L$
ℓ_L	**2**	$-1/2$	1
μ_R	1	1	1
H	**2**	$+1/2$	0
N_R	1	1	1
S_R	1	1	-1
ψ_L	**2**	$-1/2$	1
ψ_R	**2**	$-1/2$	1

Low Scale *Seesaws*

D. Wyler and L. Wolfenstein, Nucl. Phys. B 218 (1983) 205–214.
R. N. Mohapatra and J. W. F. Valle, Phys. Rev. D 34 (1986) 1642.
J. Bernabeu et al., Phys. Lett. B 187 (1987) 303–308.
M. Malinsky et al., Phys. Rev. Lett. 95 (2005) 161801.

Small Symmetry Breaking Parameters

$$-\mathscr{L}_Y = \overline{\ell_L} H Y_\mu \mu_R + \overline{\ell_L}\widetilde{H} Y_N N_R + \epsilon\,\overline{\ell_L}\widetilde{H} Y_S S_R + \frac{1}{2}\mu'\,\overline{N_R^c} N_R + \frac{1}{2}\mu\,\overline{S_R^c} S_R + \Lambda \overline{N_R^c} S_R +$$
$$+ Y_R \overline{\psi_L} H \mu_R + Y_V \overline{S_R^c}\widetilde{H}^\dagger \psi_R + Y_V' \overline{\psi_L}\widetilde{H} N_R + M_\psi \overline{\psi_L}\psi_R + M_L \overline{\ell_L}\psi_R + \text{h.c.}\,,$$

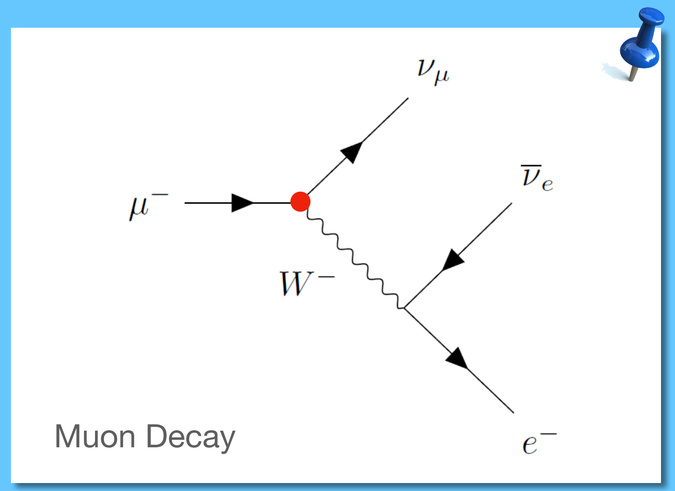
$$\chi \equiv (\nu_L,\, N_R^c,\, S_R^c,\, \psi_L^0,\, \psi_R^{0c})^T$$

$$-\mathscr{L}_Y \supset \frac{1}{2}\overline{\chi}\mathcal{M}_\chi \chi^c$$

$$\mathcal{M}_\chi = \left(\begin{array}{c|ccc|c} 0 & m_N & \epsilon\, m_S & 0 & M_L \\ \hline m_N & 0 & \Lambda & m_{V'} & 0 \\ \epsilon\, m_S & \Lambda & \mu & 0 & m_V \\ \hline 0 & m_{V'} & 0 & 0 & M_\psi \\ M_L & 0 & m_V & M_\psi & 0 \end{array}\right)$$

$$m_\nu \simeq \frac{v^2}{2}\left[\left(Y_N \frac{1}{\Lambda^T}\mu \frac{1}{\Lambda} Y_N^T\right) - \epsilon\left(Y_S \frac{1}{\Lambda} Y_N^T + Y_N \frac{1}{\Lambda^T} Y_S^T\right)\right]$$

M_W



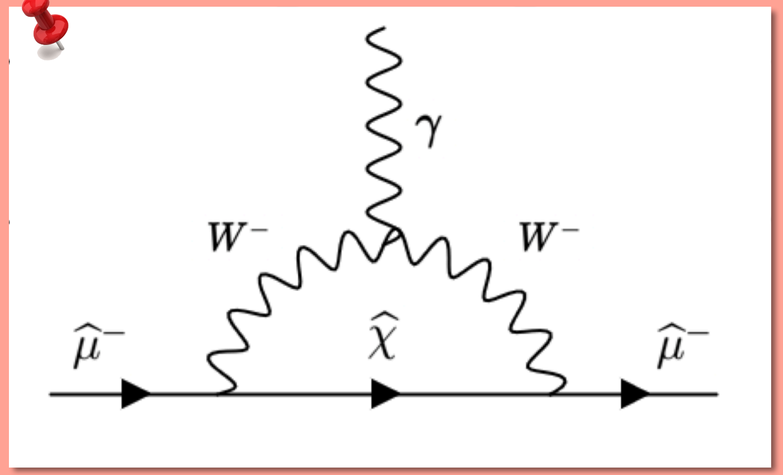
$$G_F = G_\mu(1 + \Delta_G)$$

$$M_W = M_Z \sqrt{\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\pi\,\alpha\,(1 - \Delta_G)}{\sqrt{2}\,G_\mu\,M_Z^2(1 - \Delta r)}}}$$

$$\Delta_G \sim 5 \times 10^{-3}$$

M. Blennow et al., Phys. Rev. D 106 (2022), no. 7 073005.
F. Arias-Aragon et al., JHEP 09 (2022) 210.

$(g-2)_\mu$



What to expect?

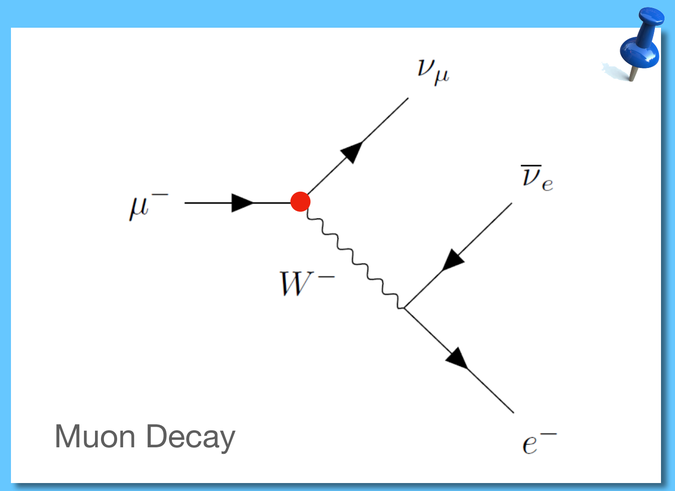
$$\delta a_\mu \sim \frac{Y_i^3}{16\pi^2}\frac{m_\mu}{v}\left[\mathcal{O}\left(\frac{v^2}{M_\psi \Lambda}\right) + \mathcal{O}\left(\frac{v^2}{M_\psi \Lambda}\right)^2\right]$$

$M_\psi, \Lambda \sim \mathcal{O}(10)$ TeV

$M_\psi, \Lambda \sim \mathcal{O}(1)$ TeV

N. Arkani-Hamed and K. Harigaya, JHEP 09 (2021) 025.
N. Craig et al., JHEP 05 (2022) 079.
L. Delle Rose et al., JHEP 05 (2022) 120.

M_W



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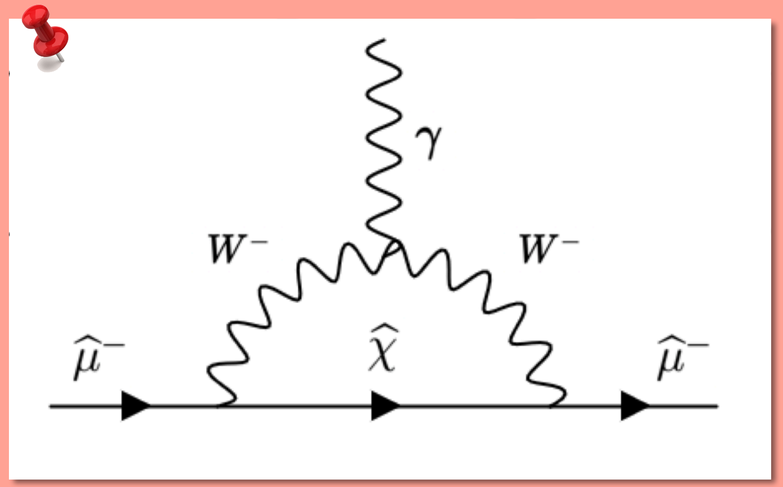

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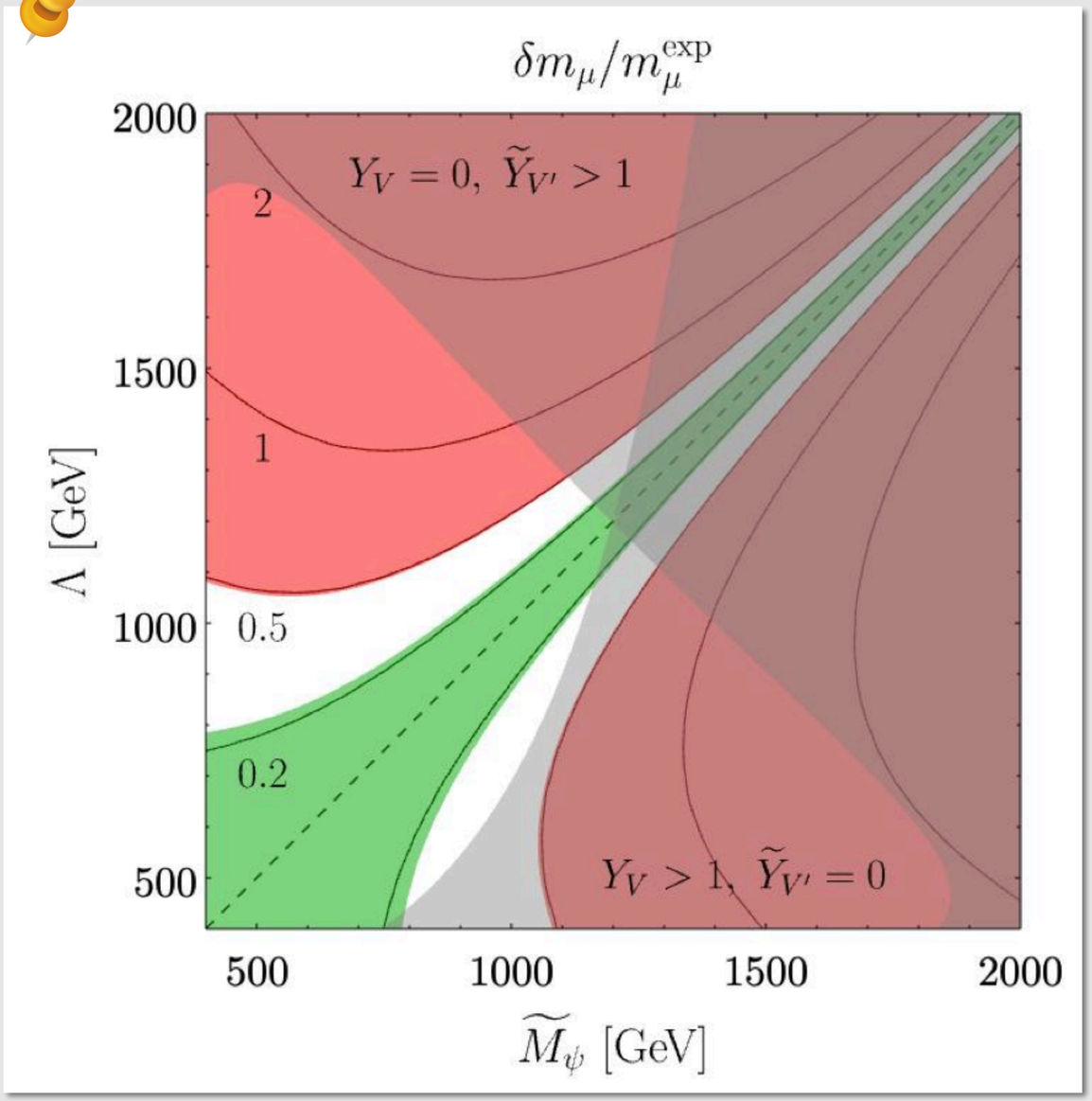

Conclusions

- New particles:

2 Vector-Like Leptons

	$SU(2)_L$	$U(1)_Y$	$U(1)_L$
N_R	1	1	1
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- Possible **simultaneous** explanation of m_ν, $(g-2)_\mu$ and M_W
- NP at ~ $\mathcal{O}(1)$ TeV, or even lower!
- Very rich phenomenology

Thank you!