Muon EDM in 2HDM + VL

(in preparation)

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SM + VL

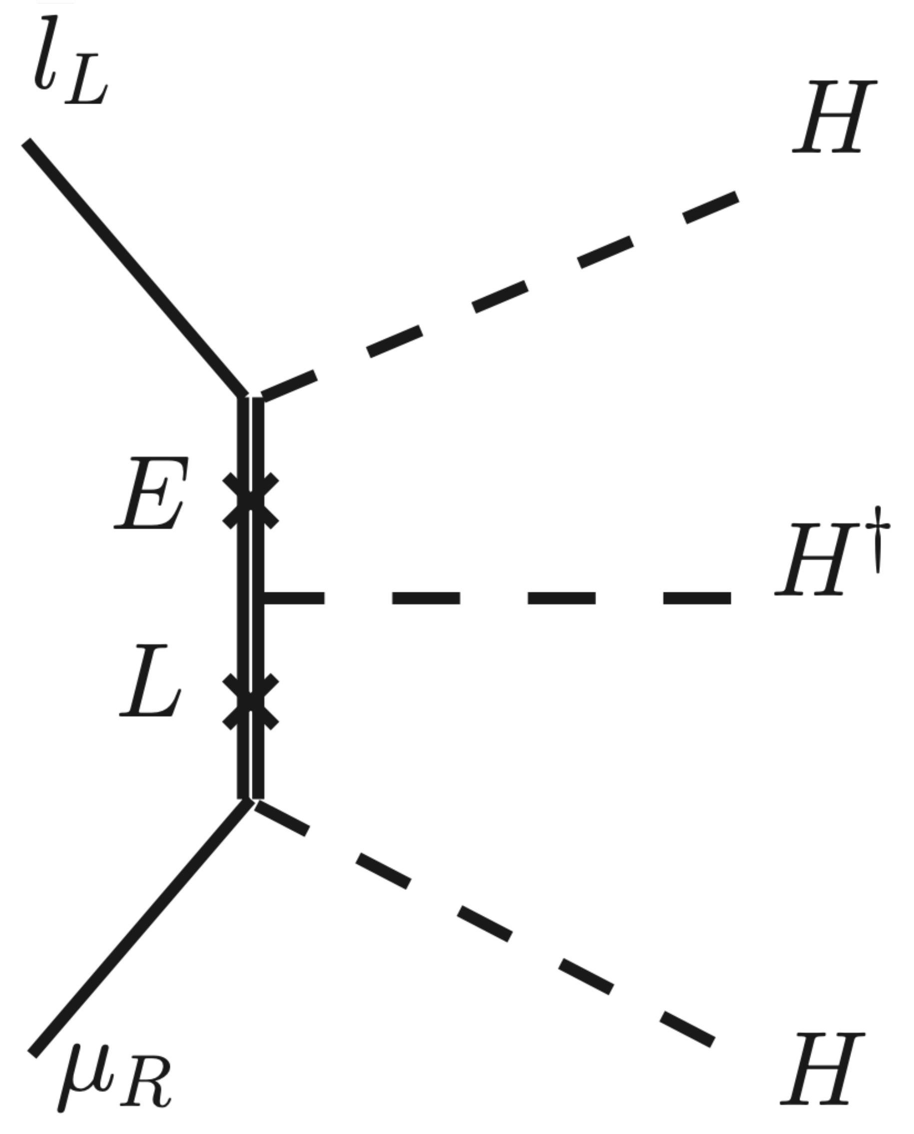
arXiv:1305.3522v2
arXiv:2011.11812v2
arXiv:2103.05645v2
arXiv:2108.10950v2

explains g-2 easily (from Keith Hermanek's talk)

$$\mathcal{L} \supset -y_\mu \bar{\ell}_L \mu_R H - \lambda_E \bar{\ell}_L E_R H - \lambda_L \bar{L}_L \mu_R H - \lambda \bar{L}_L E_R H - \bar{\lambda} H^\dagger \bar{E}_L L_R$$
$$- M_L \bar{L}_L L_R - M_E \bar{E}_L E_R + h.c.$$

	ℓ_L	μ_R	H	$L_{L,R}$	$E_{L,R}$
$SU(2)_L$	2	1	2	2	1
$U(1)_Y$	$-\frac{1}{2}$	-1	$\frac{1}{2}$	$-\frac{1}{2}$	-1

$$\ell_L = \begin{pmatrix} \nu_\mu \\ \mu_L \end{pmatrix}, L_{L,R} = \begin{pmatrix} L^0_{L,R} \\ L^-_{L,R} \end{pmatrix}, H = \begin{pmatrix} 0 \\ v + \frac{h}{\sqrt{2}} \end{pmatrix}$$



$$m_\mu^{LE} \equiv \frac{\lambda_L \bar{\lambda} \lambda_E}{M_L M_E} v^3$$

complex couplings and the muon EDM

$$\mathcal{L} \supset -y_\mu \bar{\ell}_L \mu_R H - \lambda_E \bar{\ell}_L E_R H - \lambda_L \bar{L}_L \mu_R H - \lambda \bar{L}_L E_R H - \bar{\lambda} H^\dagger \bar{E}_L L_R$$
$$- M_L \bar{L}_L L_R - M_E \bar{E}_L E_R + h.c.$$

Two combinations of phases

$$\varphi_\lambda - \varphi_{\lambda_L} - \varphi_{\lambda_E} + \varphi_{y_\mu}$$

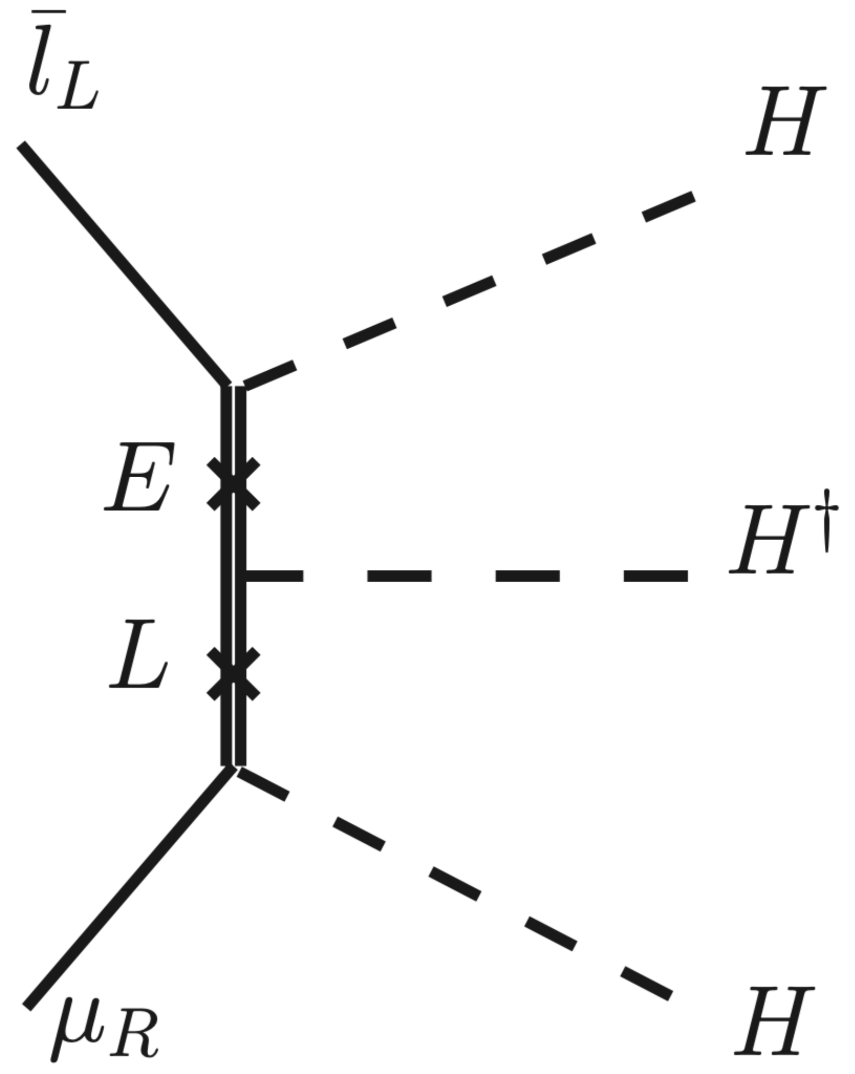
$$\varphi_{\overline{\lambda}} + \varphi_{\lambda_L} + \varphi_{\lambda_E} - \varphi_{M_L} - \varphi_{M_E} - \varphi_{y_\mu}$$

$$m_\mu^{LE} \equiv \frac{\lambda_L \bar{\lambda} \lambda_E}{M_L M_E} v^3$$

Muon mass and field redefinitions

arXiv:2108.10950v2

$$\mathcal{L} \supset -y_\mu \bar{l}_L \mu_R H - \frac{\lambda_L \bar{\lambda} \lambda_E}{M_L M_E} \bar{l}_L \mu_R H H^\dagger H + h.c..$$



$$m_\mu = y_\mu v + m_\mu^{LE} = |m_\mu| e^{i\varphi_\mu}$$

$$m_\mu^{LE} e^{-i\varphi_\mu}$$

$$m_\mu^{LE} \equiv \frac{\lambda_L \bar{\lambda} \lambda_E}{M_L M_E} v^3$$

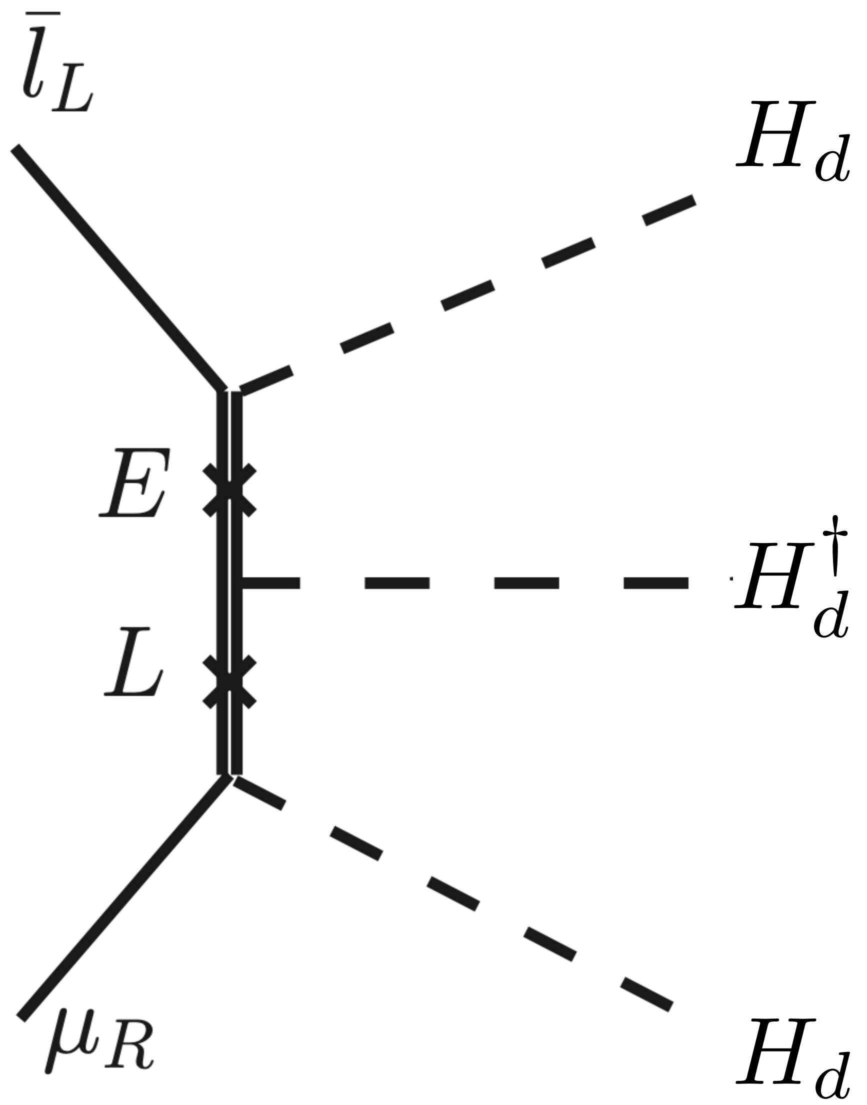
Full calculations in 2HDM+VL

arXiv:2103.05645v2

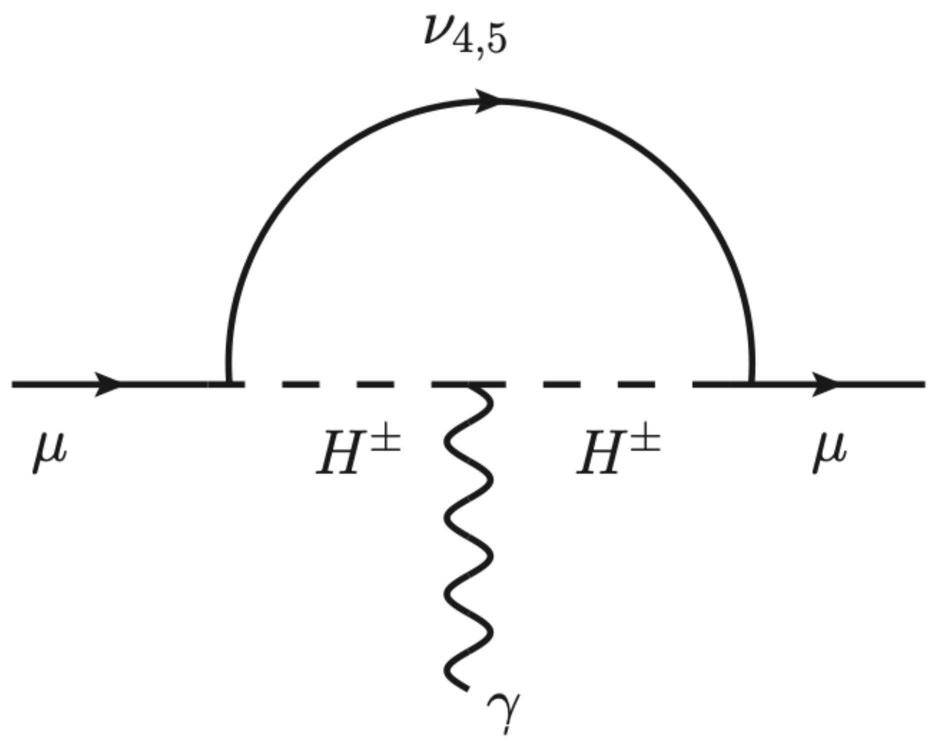
$$\Delta a_\mu \doteq -\frac{|m_\mu|}{16\pi^2}\frac{(1+\tan^2\beta)}{v^2}Re(m_\mu^{LE}e^{-i\varphi_\mu})$$

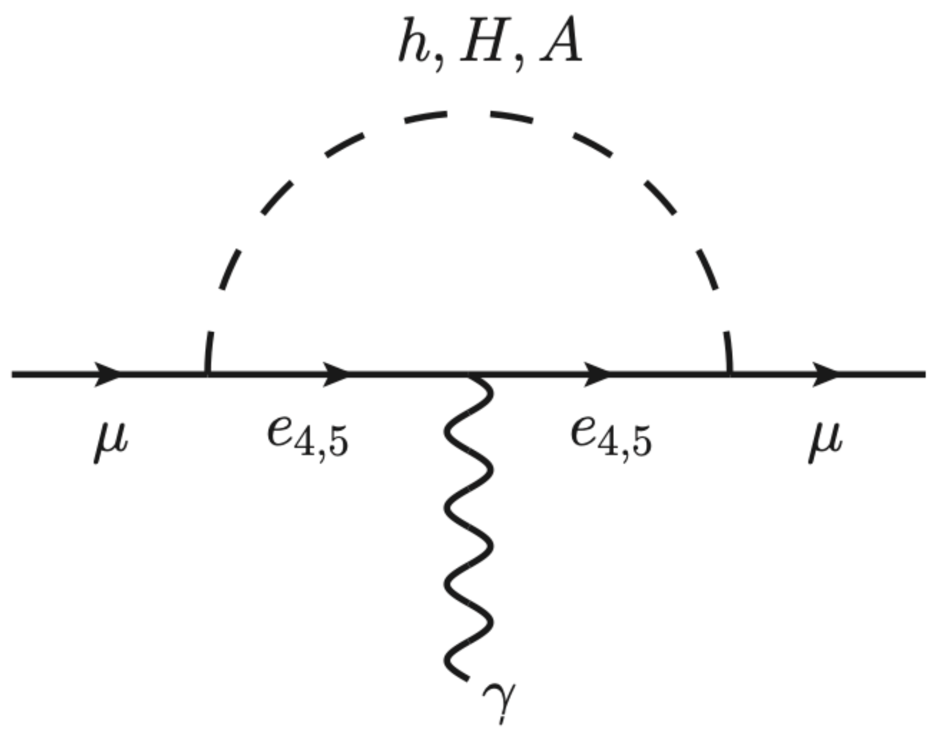
$$d_\mu \doteq \frac{|e|}{32\pi^2}\frac{(1+\tan^2\beta)}{v^2}Im(m_\mu^{LE}e^{-i\varphi_\mu})$$

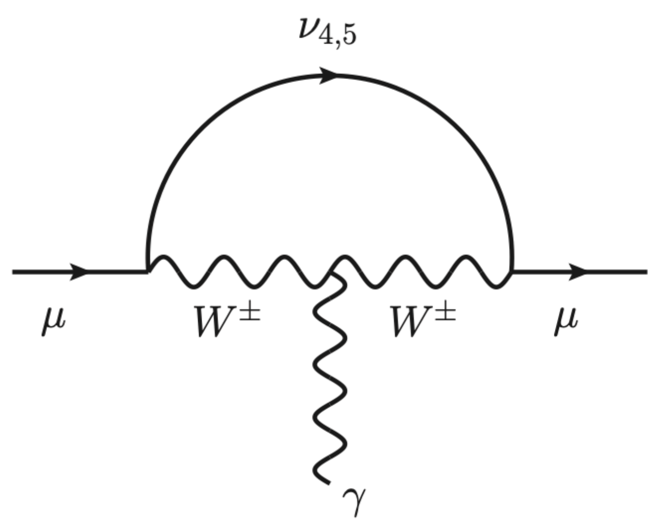
$$m_\mu^{LE} = \frac{\lambda_L\bar{\lambda}\lambda_E}{M_L M_E}v_d^3$$

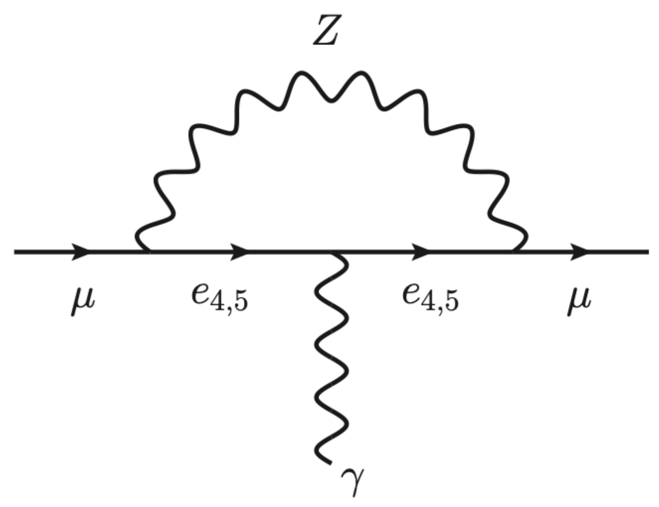


$$\frac{m_\mu^{LE}}{v_d^2} = \frac{\lambda_L\bar{\lambda}\lambda_E}{M_L M_E}v_d$$





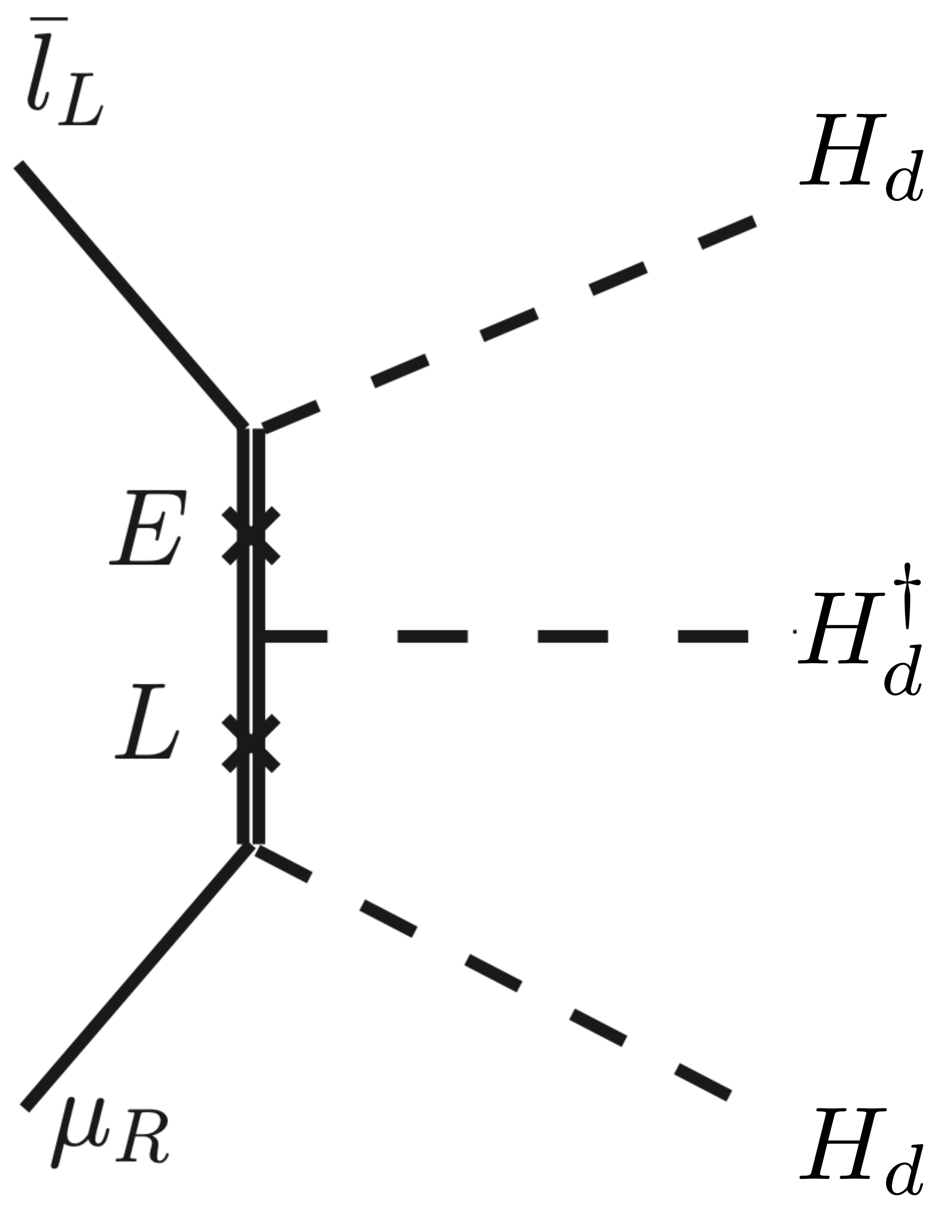




Correlations among g-2, EDM, higgs to mu mu in 2HDM+VL

$$Re(m_\mu^{LE} e^{-i\varphi_\mu}) = -\frac{16\pi^2 v^2}{(1+\tan^2\beta)} \frac{\Delta a_\mu}{|m_\mu|}$$

$$Im(m_\mu^{LE} e^{-i\varphi_\mu}) = \frac{32\pi^2 v^2}{(1+\tan^2\beta)} \frac{d_\mu}{|e|}$$



$$\lambda^h_{\mu\mu} v \doteq |m_\mu| + 2 m_\mu^{LE} e^{-i\varphi_\mu}$$

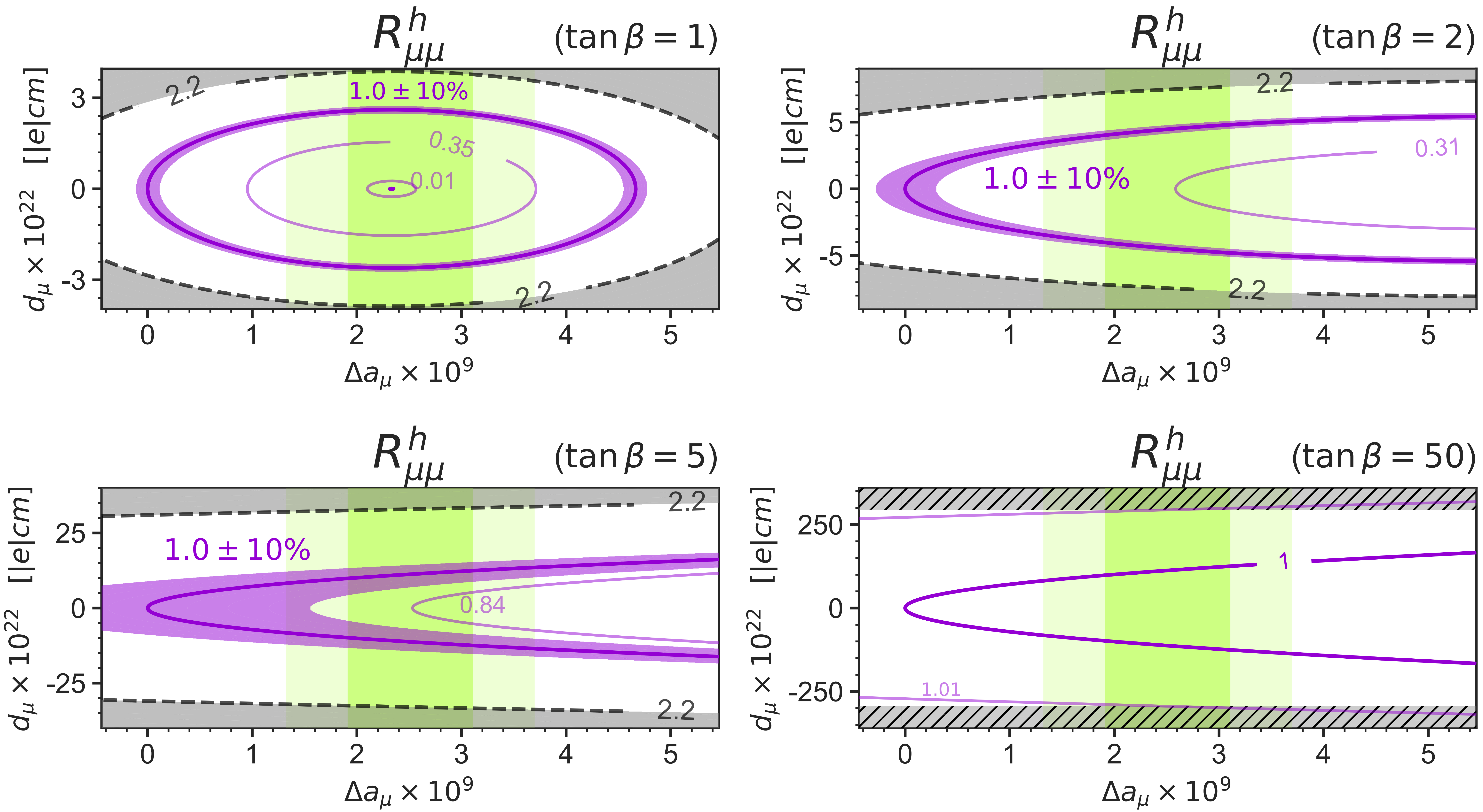
$$R_{h\to\mu\mu} = \frac{|\lambda^h_{\mu\mu}|^2}{|\lambda^h_{\mu\mu}|^2_{SM}}$$

The muon ellipse in 2HDM + VL

$$R_{h\to\mu\mu} = \frac{(\Delta a_\mu - a_0)^2}{a_0^2} + \frac{\left(\frac{|d_\mu|}{|e|}|m_\mu|\right)^2}{(a_0/2)^2}$$

$$a_0 \equiv \frac{|m_\mu|^2}{32\pi^2 v^2}(1 + \tan^2\beta)$$

2HDM + VL



Future sensitivity $\mathcal{O}(10^{-23})\,|\,e\,|\,cm$

at μE1 beamline at the Paul Scherrer Institute (PSI) (arXiv:2102.08838v1)

Summary

- There exist correlations among g-2, EDM, and higgs to mu mu in 2HDM + VL

- Muon EDM can reach up to $\mathcal{O}(10^{-20})\,|e|\,cm$, while explaining g-2 in 2HDM + VL

Thank you for listening!