



Universität  
Zürich<sup>UZH</sup>

# Flavour Non-Universal Extensions of the Standard Model

Flavour Non-Universal Composite Higgs\*

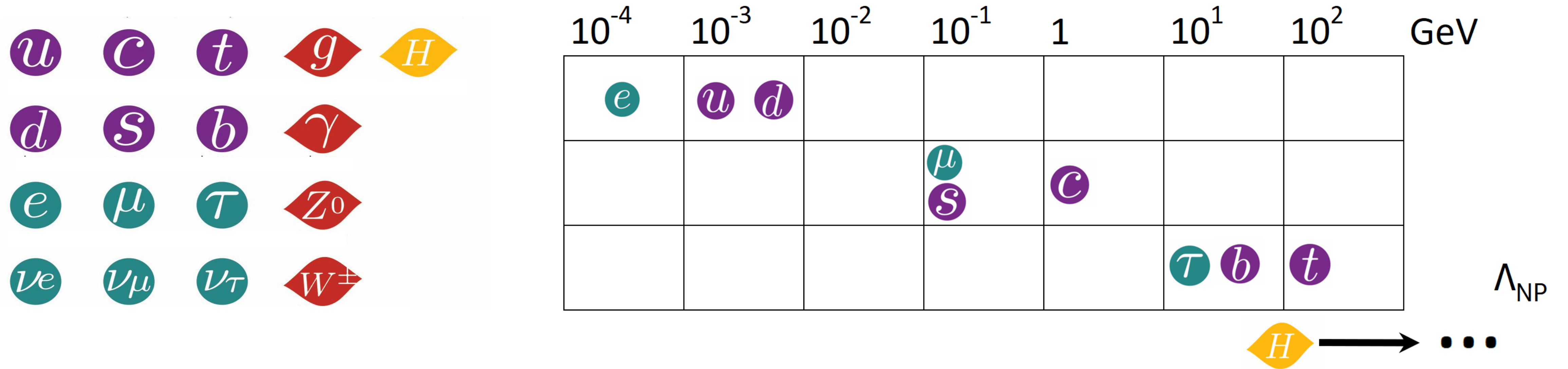
04.07.2024, Invisibles 2024, Bologna

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\*w.i.p, in collaboration with Joe Davighi, Gino Isidori & Sebastiano Covone

# Flavour Puzzle & Higgs Hierarchy Problem



- Hierarchical pattern of fermion masses and mixing angles
- Higgs mass sensitivity to NP

# Flavour Non-Universality

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$$\mathcal{L}_{\text{SM}} = \mathcal{L}_{\text{gauge}} + \mathcal{L}_{\text{Yukawa}} + \mathcal{L}_{\text{Higgs}}$$

Maybe the SM gauge sector *looks flavour-universal* because we only probed it at low energies ?

# Flavour Non-Universality

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Maybe the SM gauge sector *looks flavour-universal* because we only probed it at low energies ?

Hints from the Yukawa sector:

$$V_{\text{CKM}} \approx \begin{pmatrix} 1 & 0.2 & 0.004 \\ 0.2 & 1 & 0.04 \\ 0.009 & 0.04 & 1 \end{pmatrix}$$

$$\Rightarrow V_{11} \gg V_{21} \gg V_{31}$$

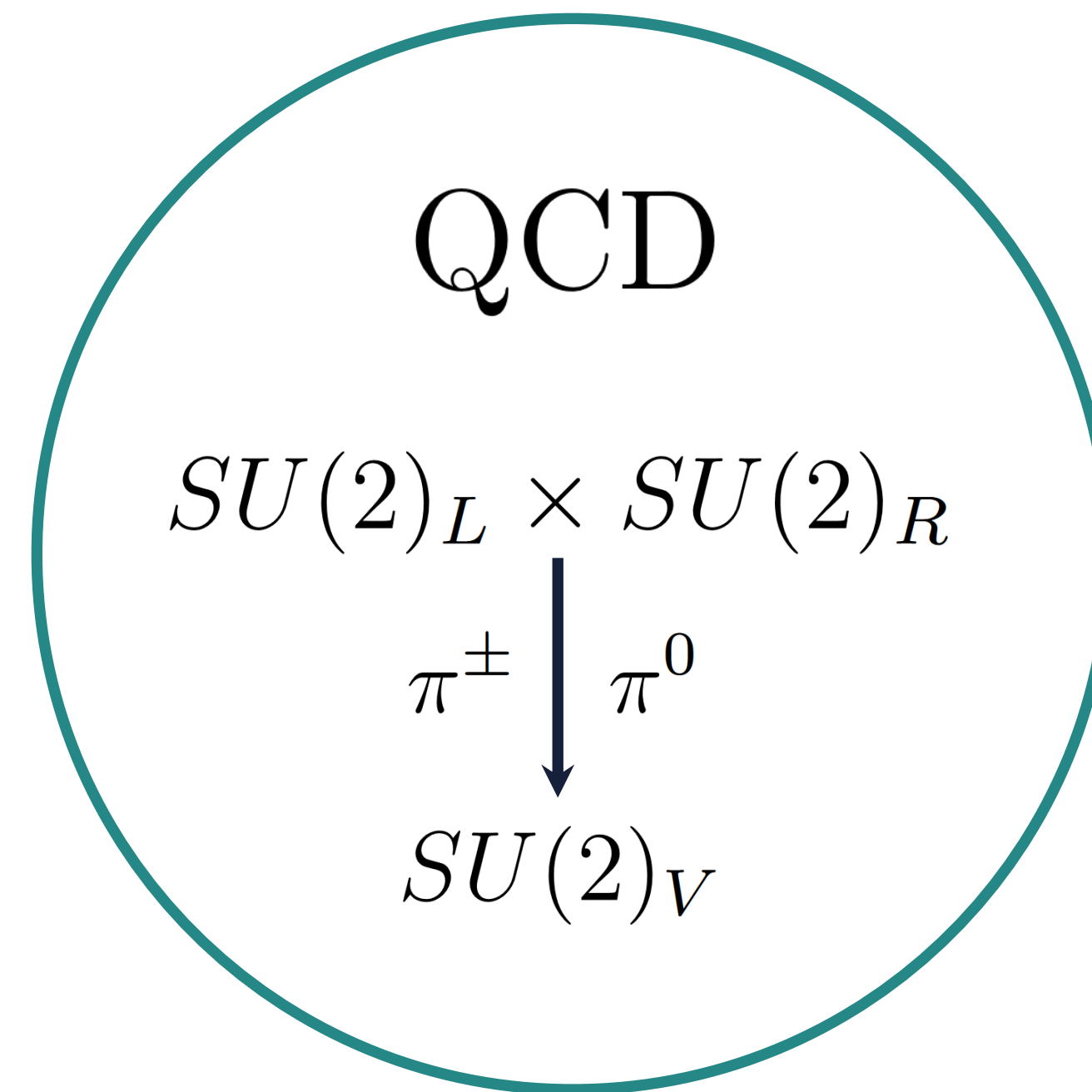
# Flavour Non-Universality

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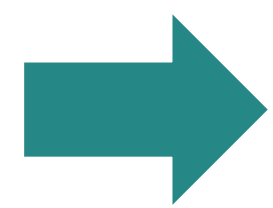
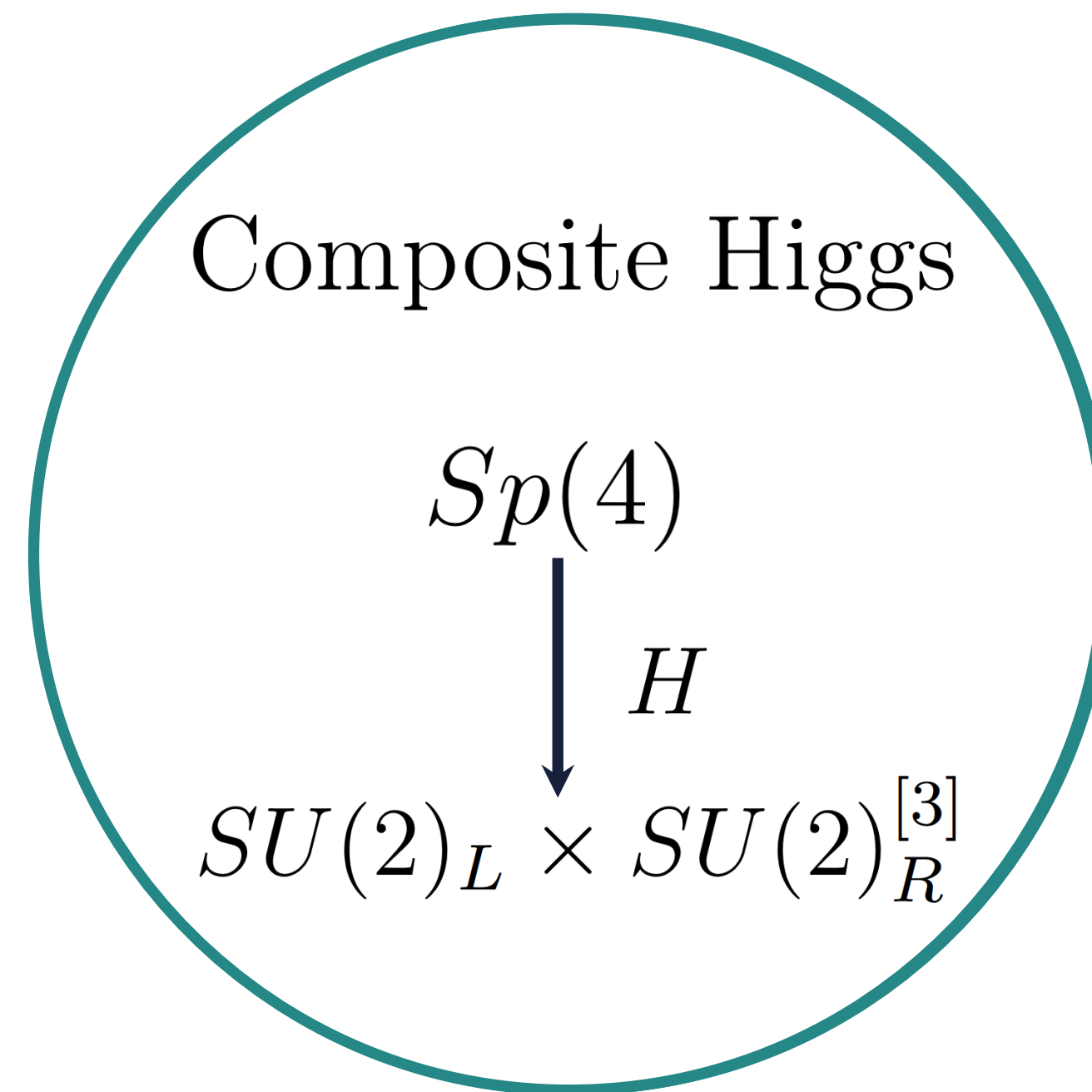
Maybe the SM gauge sector *looks flavour-universal* because we only probed it at low energies ?

Flavour Non-Universal UV completion:  $G_{12} \times G_{3+H} \rightarrow G_{\text{SM}}$

# Higgs Compositeness



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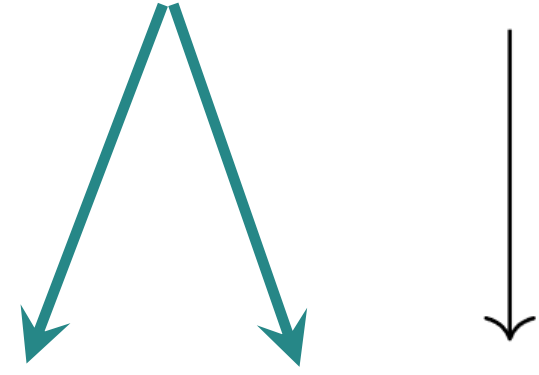


- Higgs emerges as a **pseudo-Goldstone boson** of S.S.B
- Higgs potential generated at 1-loop from explicit sym. breaking terms

# Flavour Non-Universal Composite Higgs

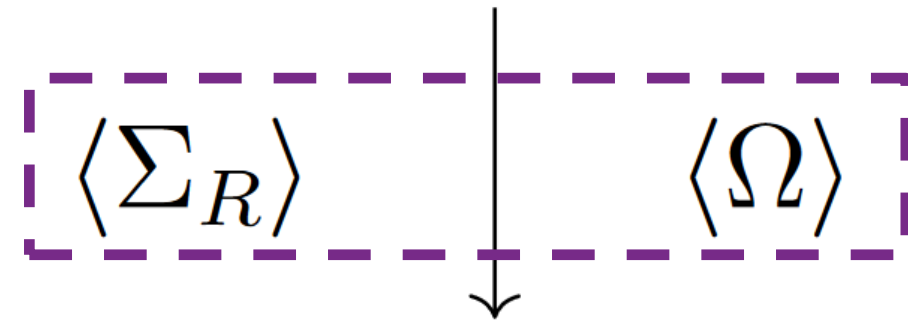
$$SU(3)_c \times Sp(4) \times U(1)_{B-L}^{[3]} \times U(1)_Y^{[12]}$$

Non-perturbative  
dynamics



$$SU(3)_c \times SU(2)_L \times SU(2)_R^{[3]} \times U(1)_{B-L}^{[3]} \times U(1)_Y^{[12]}$$

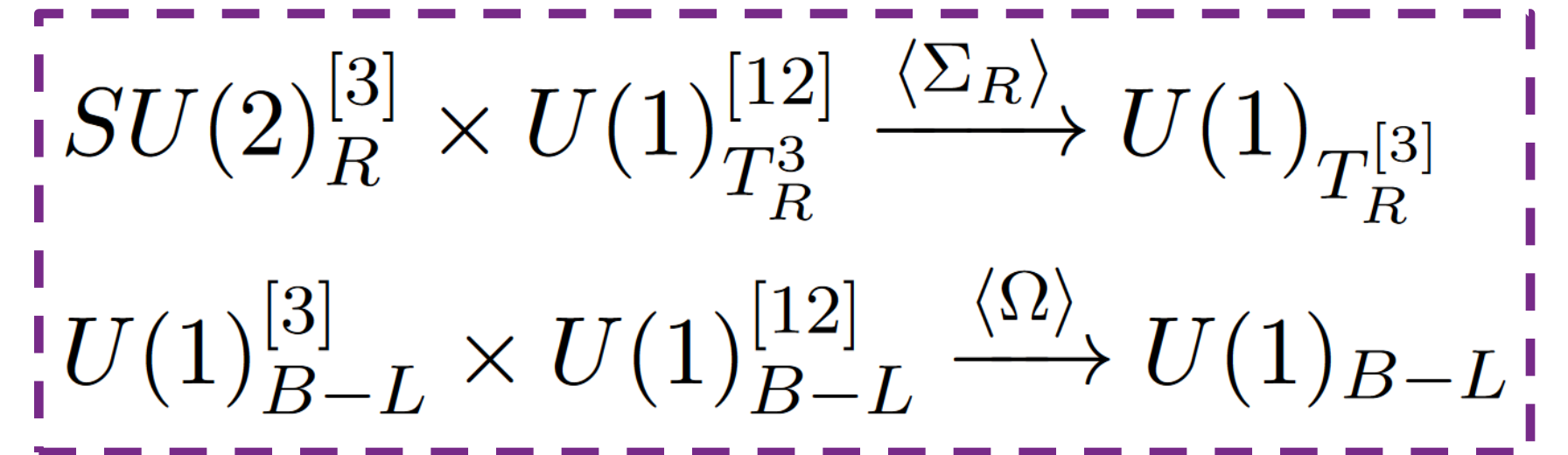
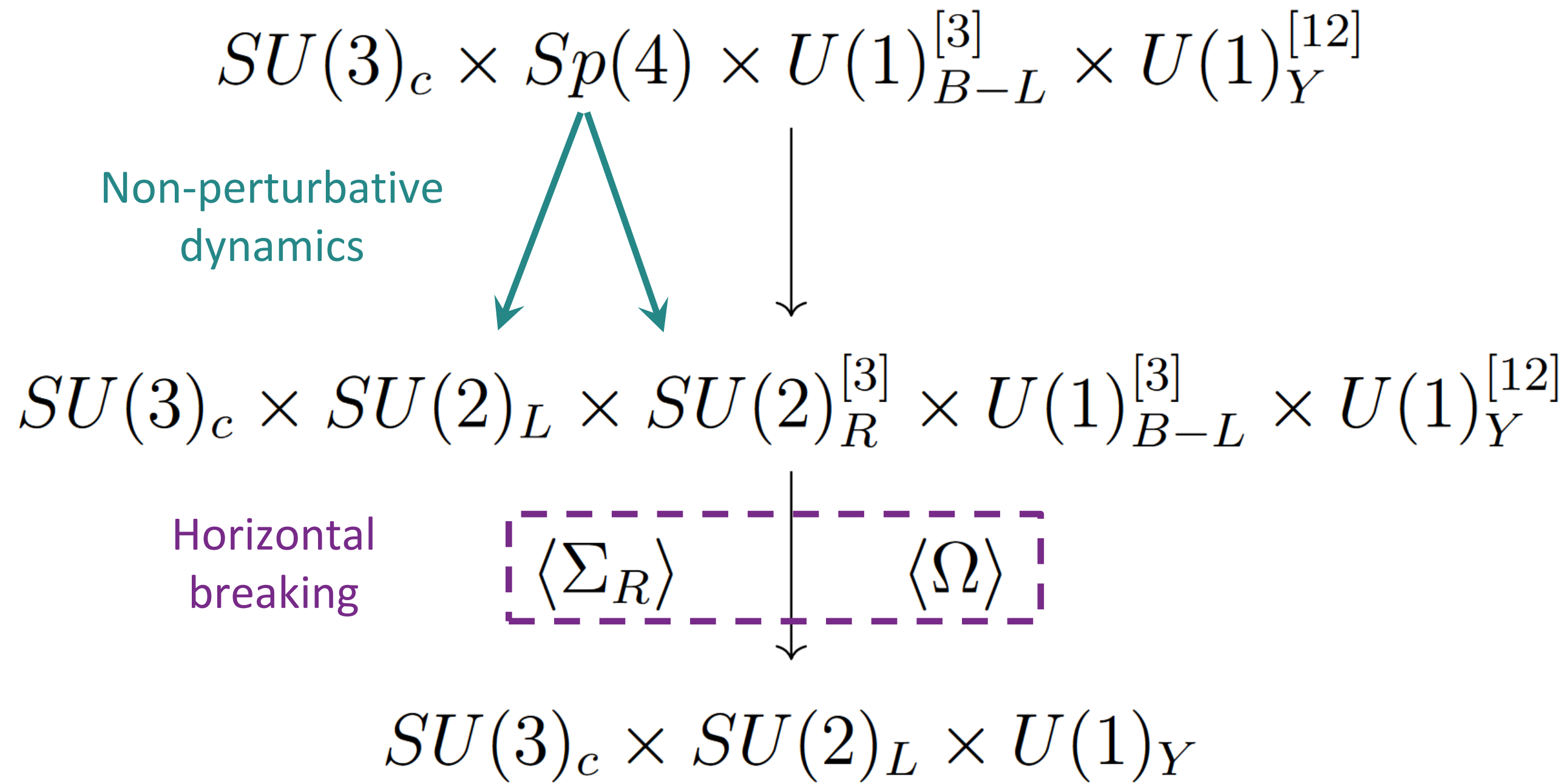
Horizontal  
breaking



$$SU(3)_c \times SU(2)_L \times U(1)_Y$$

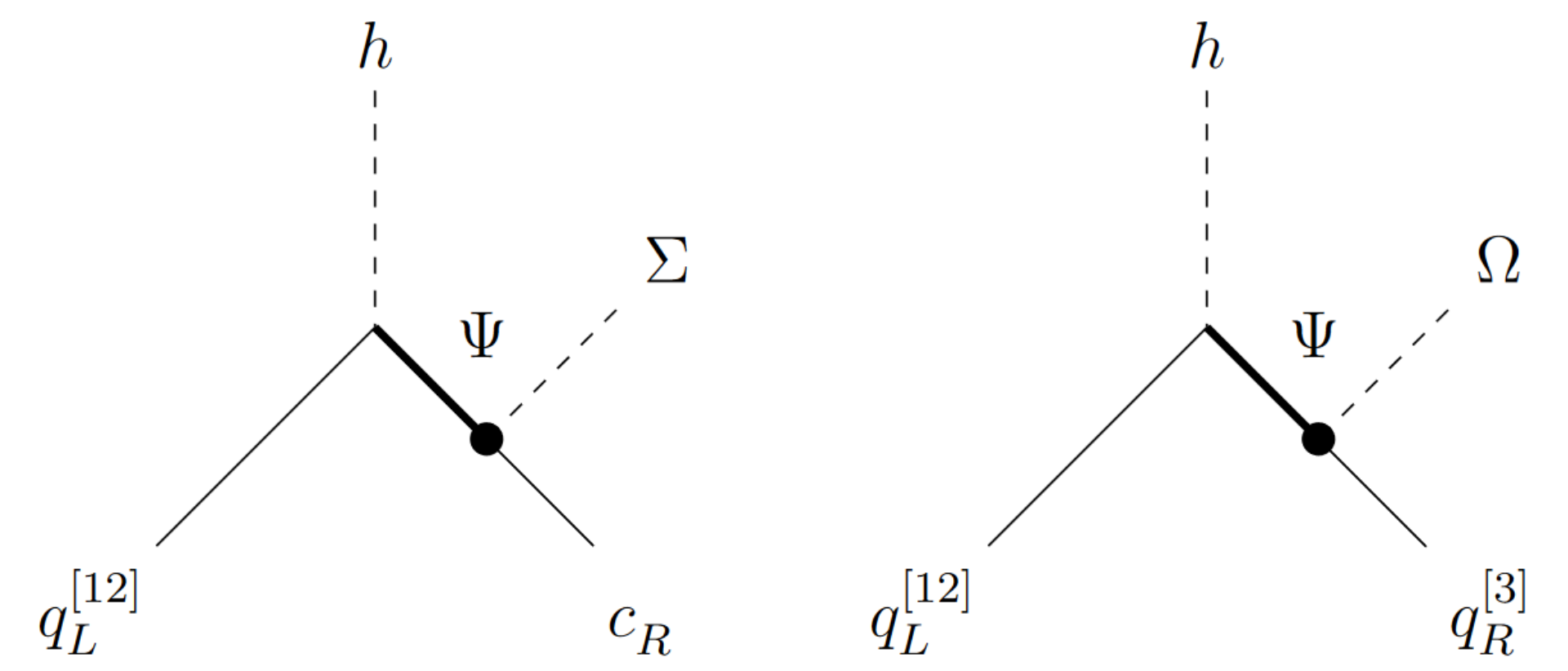


# Flavour Non-Universal Composite Higgs



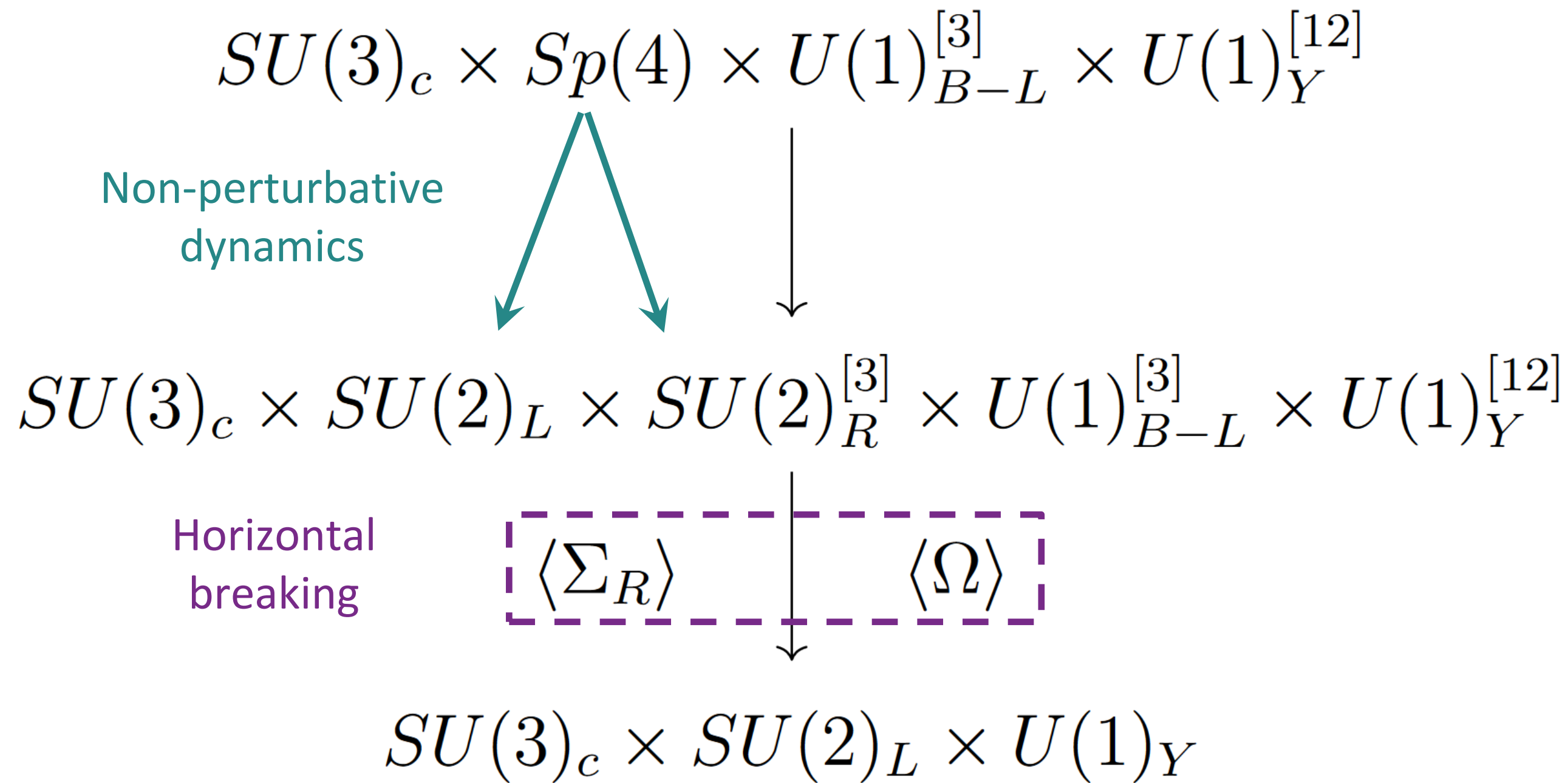
$\epsilon_R = \frac{\langle \Sigma \rangle}{M_F}$      $\epsilon_\Omega = \frac{\langle \Omega \rangle}{M_F}$

$Y_{u,d,e} \sim \begin{pmatrix} U(2)^5 & \\ \epsilon_R & \epsilon_\Omega \\ \epsilon_R \epsilon_\Omega & 1 \end{pmatrix}$



Minimal flavour deconstruction (Barbieri & Isidori) [2312.14004]

# Flavour Non-Universal Composite Higgs

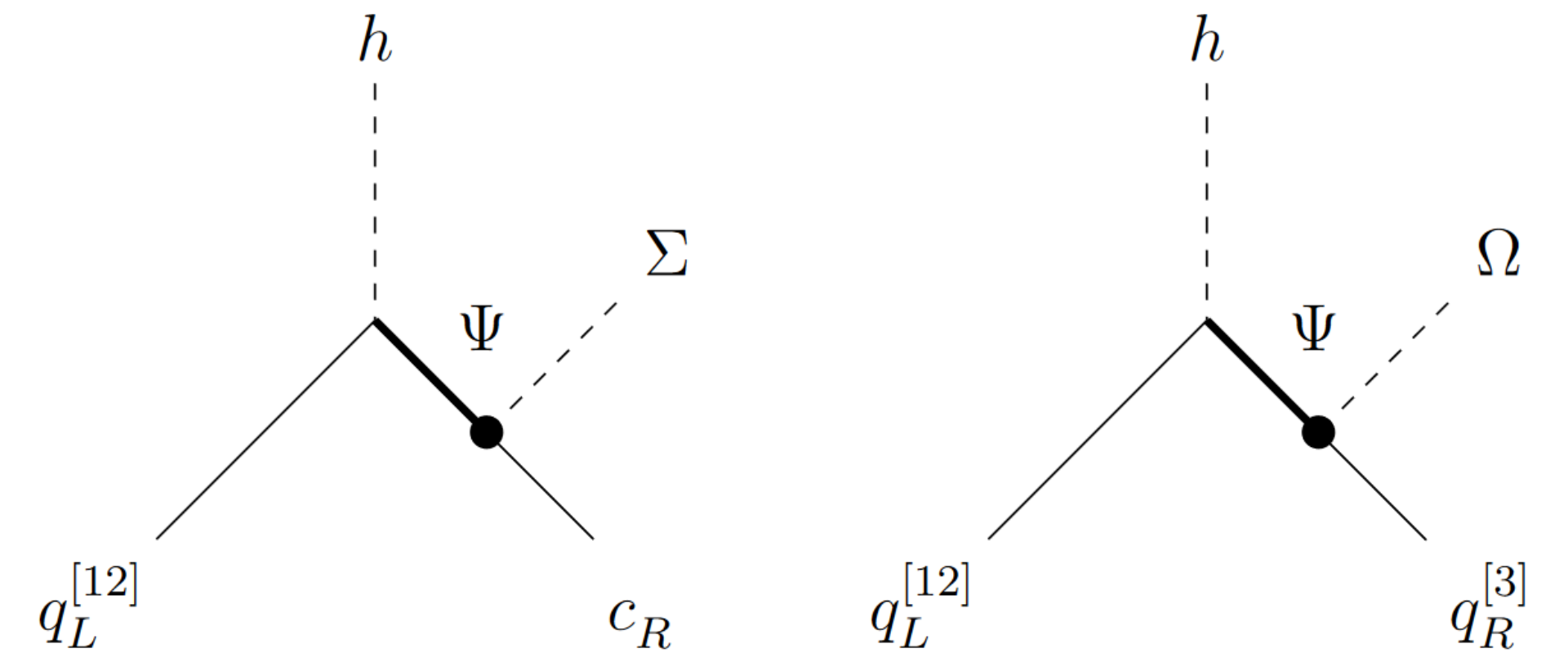
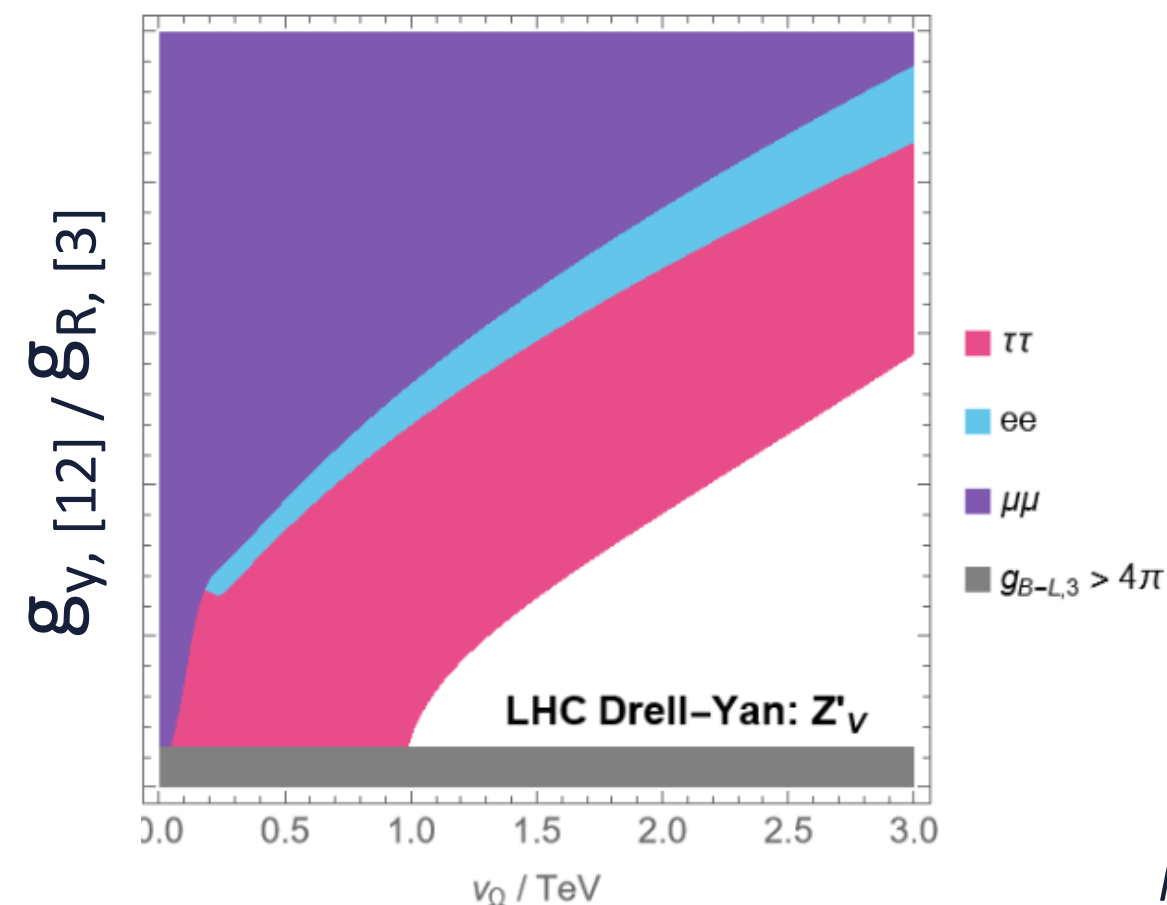
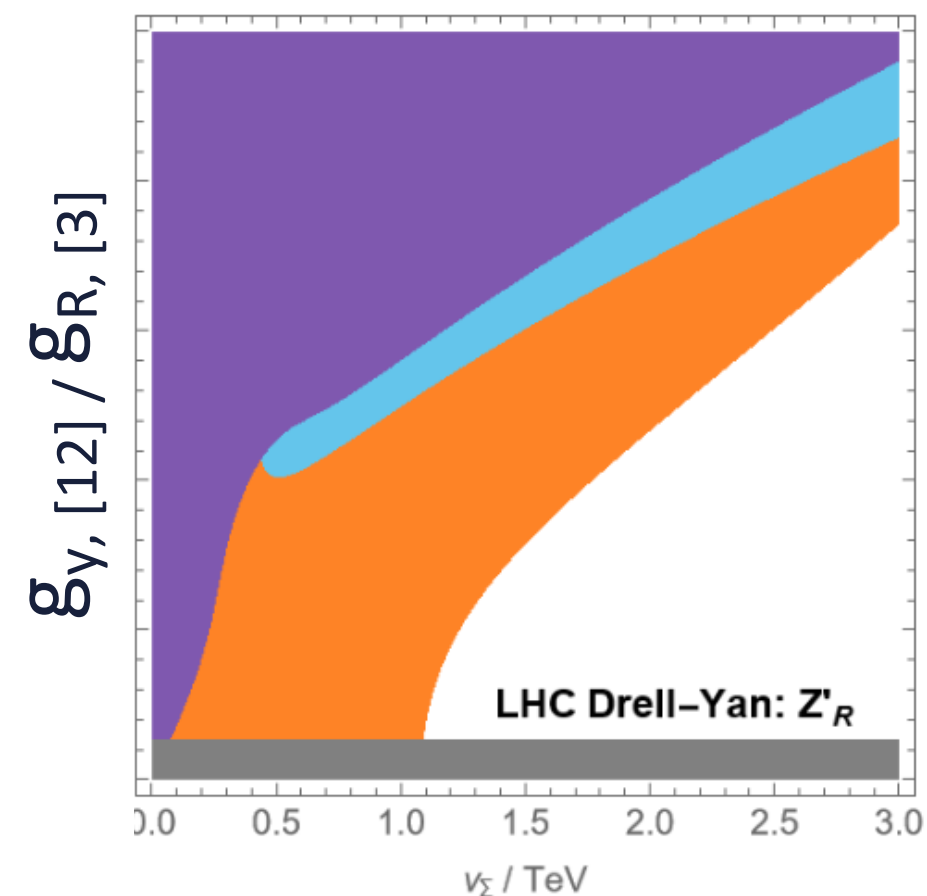


$$\begin{aligned}
 &SU(2)_R^{[3]} \times U(1)_{T_R^3}^{[12]} \xrightarrow{\langle \Sigma_R \rangle} U(1)_{T_R^{[3]}} \\
 &U(1)_{B-L}^{[3]} \times U(1)_{B-L}^{[12]} \xrightarrow{\langle \Omega \rangle} U(1)_{B-L}
 \end{aligned}$$

$$\epsilon_R = \frac{\langle \Sigma \rangle}{M_F} \quad \epsilon_\Omega = \frac{\langle \Omega \rangle}{M_F}$$

$$Y_{u,d,e} \sim \begin{pmatrix} U(2)^5 \\ \epsilon_R & \epsilon_\Omega \\ \epsilon_R \epsilon_\Omega & 1 \end{pmatrix}$$

- Pheno constraints from Drell-Yan, EWPO, ...



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HightPT: A Tool for hight-pt Drell-Yan tails Beyond the Standard Model (L. Allwicher et al.) [2207.10756]

# Conclusion

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- Interesting pheno & possible NP @ few TeV compatible with current exp. bounds
- Exciting model-building avenue to address *simultaneously* the flavour puzzle and the Higgs hierarchy problem

*Electroweak Light Flavour Unification* (J.Davighi, G.Isidori, M.P) [\[2212.06163\]](#)

*Non-universal gauge interactions addressing the inescapable link between Higgs and Flavour* (Davighi & Isidori) [\[2303.01520\]](#)

Thank you for your attention !  
(if you want to know more -> Poster session)