

Universality in the $SO(5) \times U(1)$ gauge-Higgs unification and LHC/ILC

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with Funatsu, Hatanaka, Orikasa, Shimotani
1301.1744 [PLB 722 (2013) 94]

Summer Institute 2013, Jirisan, Korea, 22 August 2013

Gauge-Higgs unification

gauge theory A_M *in 5 dim.*

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4-dim. components A_μ

extra-dim. component A_y

4D gauge fields
 γ, W, Z

4D Higgs fields
 H

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4D gauge fields
 γ, W, Z

4D Higgs fields
 H
Aharonov-Bohm phase
 θ_H

EW symmetry breaking
Hosotani mechanism

$SO(5) \times U(1)$ gauge-Higgs unification in RS

Agashe, Contino, Pomarol, 2005

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Planck brane

$$SO(5) \times U(1)_X$$

TeV brane

SO(5) x U(1) gauge-Higgs unification in RS

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Planck brane

$$SO(5) \times U(1)_X$$

TeV brane

$$\begin{pmatrix} T \\ B \\ t_L \\ b_L \\ t'_R \\ b'_R \end{pmatrix}_{\frac{2}{3}}$$

$$\begin{pmatrix} U \\ D \\ X \\ Y \\ b'_R \end{pmatrix}_{-\frac{1}{3}}$$

quarks/leptons

vector rep

$$\left(\frac{1}{2}, \frac{1}{2}\right) \oplus (0, 0)$$

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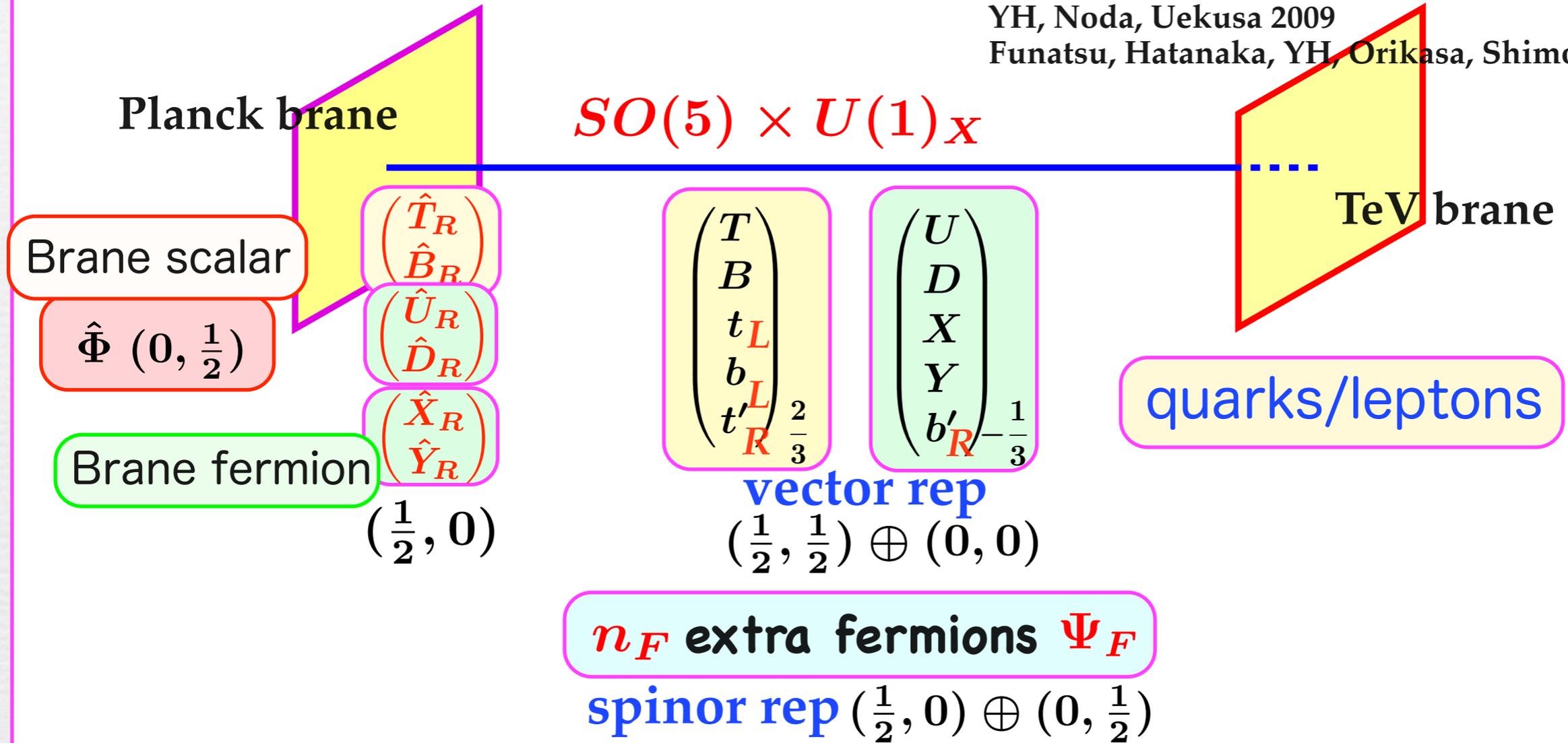
$$\left(\frac{1}{2}, \frac{1}{2}\right) \oplus (0, 0)$$

n_F extra fermions Ψ_F

spinor rep $\left(\frac{1}{2}, 0\right) \oplus \left(0, \frac{1}{2}\right)$

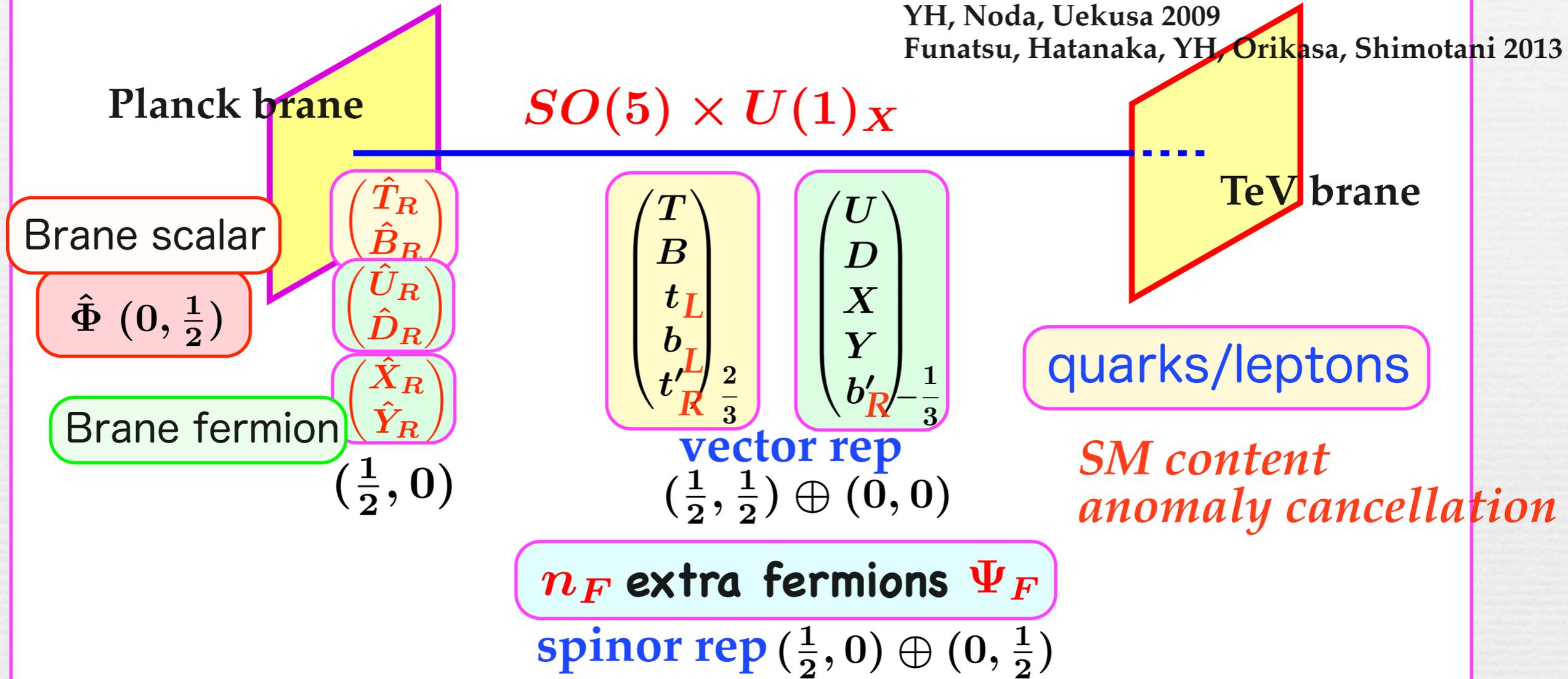
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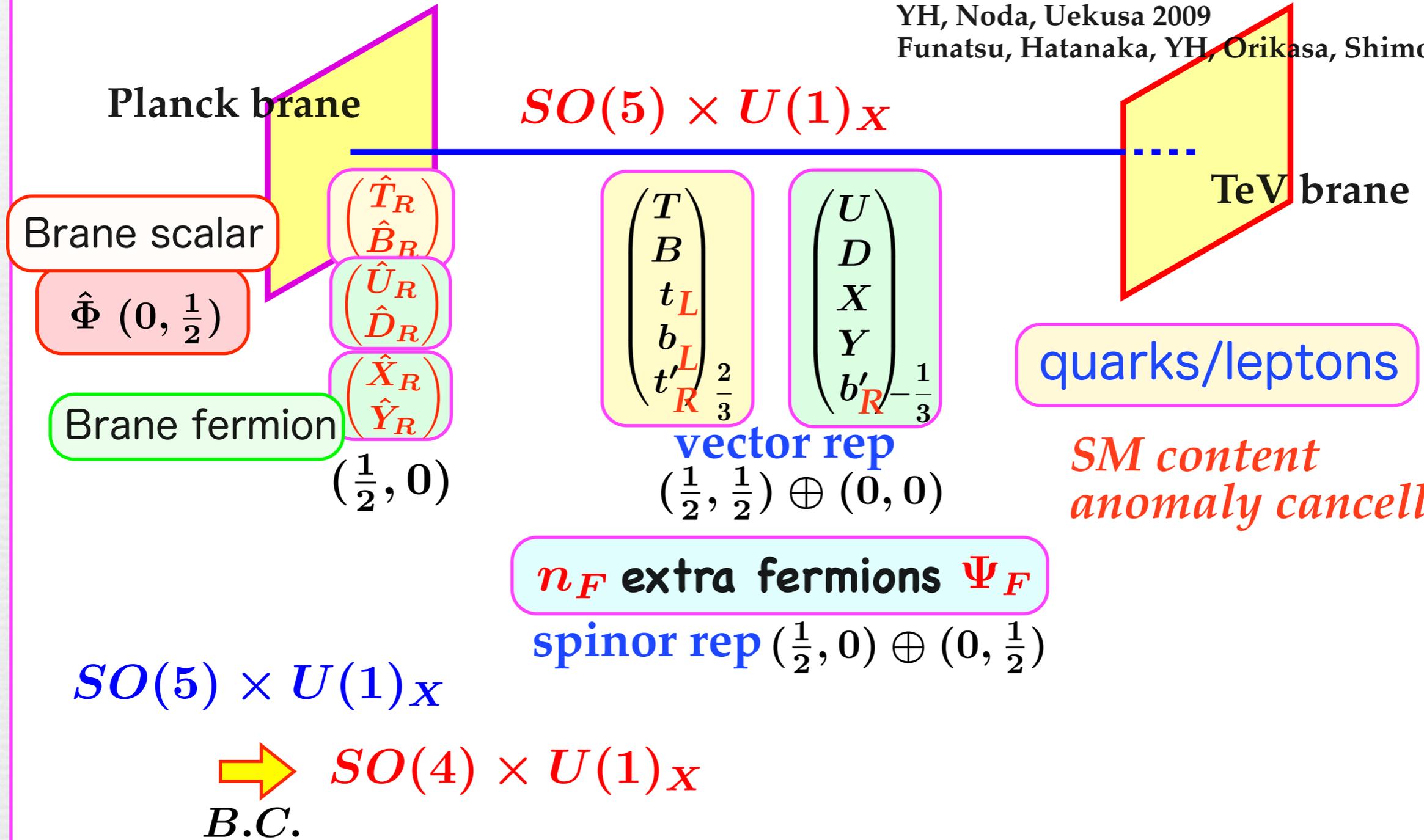
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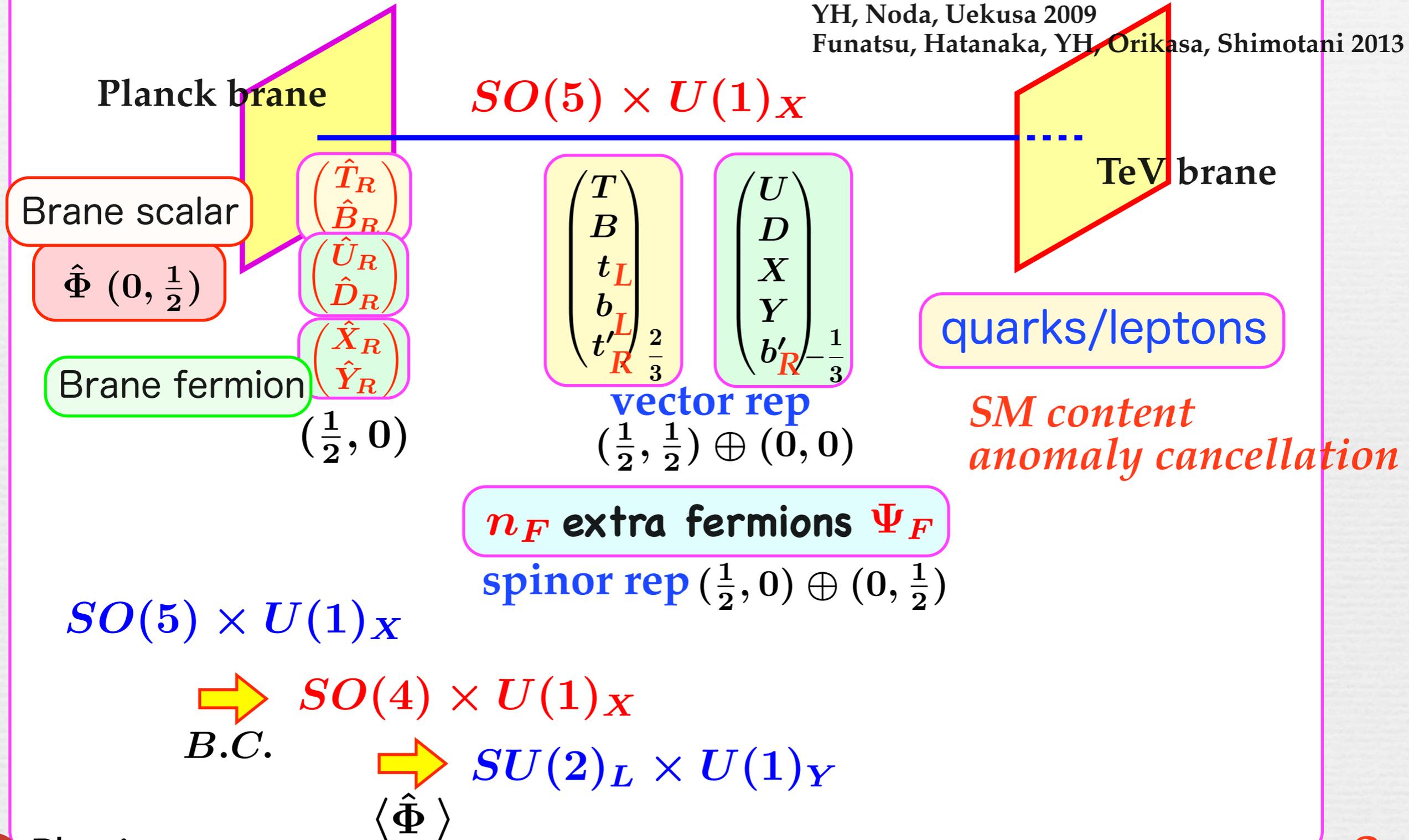
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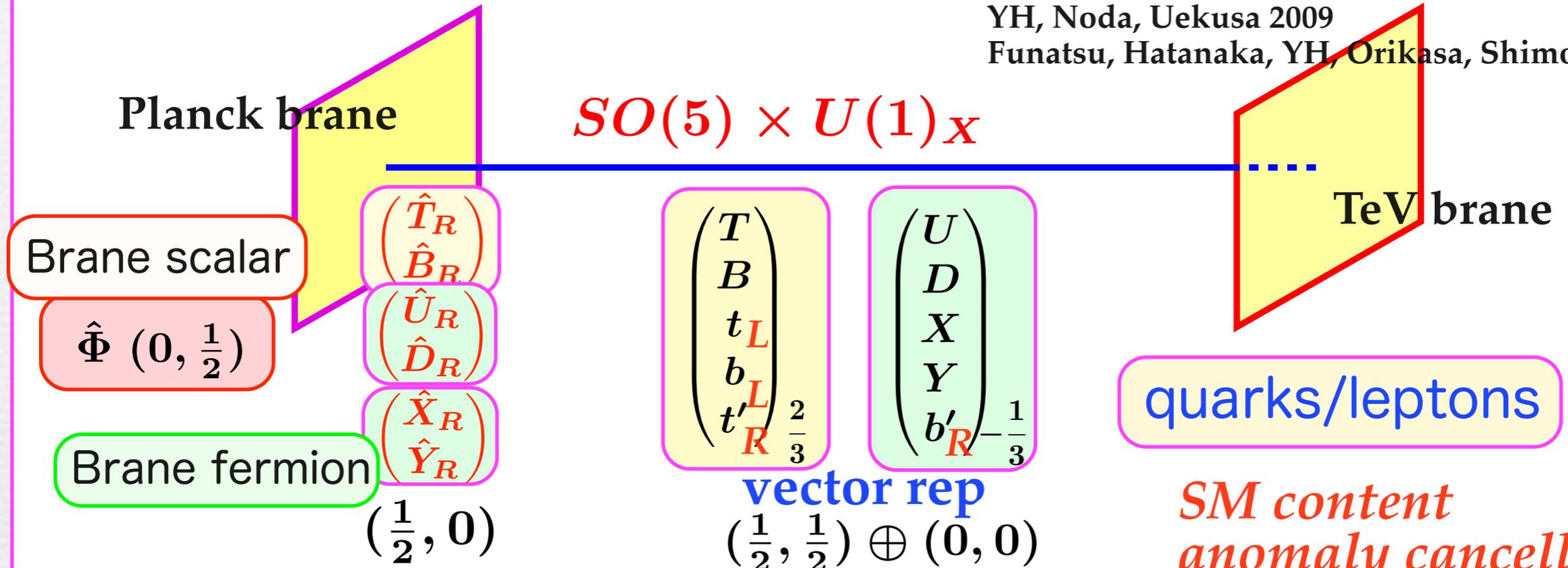
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$SO(5) \times U(1)_X$

$\Rightarrow SO(4) \times U(1)_X$

B.C.

$\Rightarrow SU(2)_L \times U(1)_Y \Rightarrow U(1)_{EM}$

$\langle \hat{\Phi} \rangle$

$\theta_H \neq 0$

$W, Z, Higgs$

Hosotani mechanism

$$V_{\text{eff}}(\theta_H) \ \& \ m_H$$

$V_{\text{eff}}(\theta_H)$ & m_H

parameters

$$k, z_L = e^{kL}, g_A, g_B$$

$$c_t, \tilde{\mu}/\mu_2$$

$$c_F, n_F$$

input

$$m_Z, g_w, \sin^2 \theta_W$$

$$m_t, m_b$$

$$m_H$$

$V_{\text{eff}}(\theta_H)$ & m_H

parameters

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input

$$m_Z, g_w, \sin^2 \theta_W$$

$$m_t, m_b$$

$$m_H$$

$$V_{\text{eff}}$$

$$\theta_H : \frac{dV_{\text{eff}}}{d\theta_H} = 0$$

$$m_H^2 = \frac{1}{f_H^2} \left. \frac{d^2 V_{\text{eff}}}{d\theta_H^2} \right|_{\text{min}}$$

$V_{\text{eff}}(\theta_H) \ \& \ m_H$

parameters

$k, z_L = e^{kL}, g_A, g_B$
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 m_t, m_b
 m_H



V_{eff}

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$m_H^2 = \frac{1}{f_H^2} \left. \frac{d^2 V_{\text{eff}}}{d\theta_H^2} \right|_{\text{min}}$

$m_H = 126 \text{ GeV}$

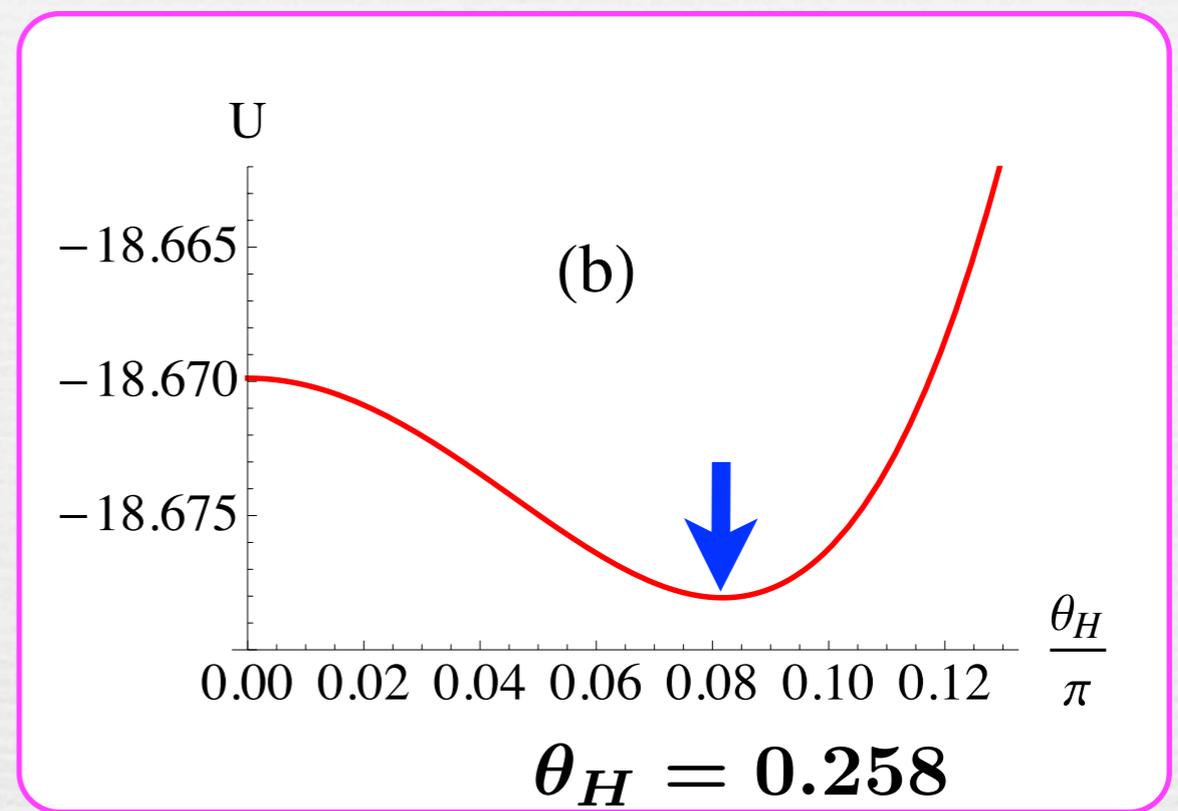
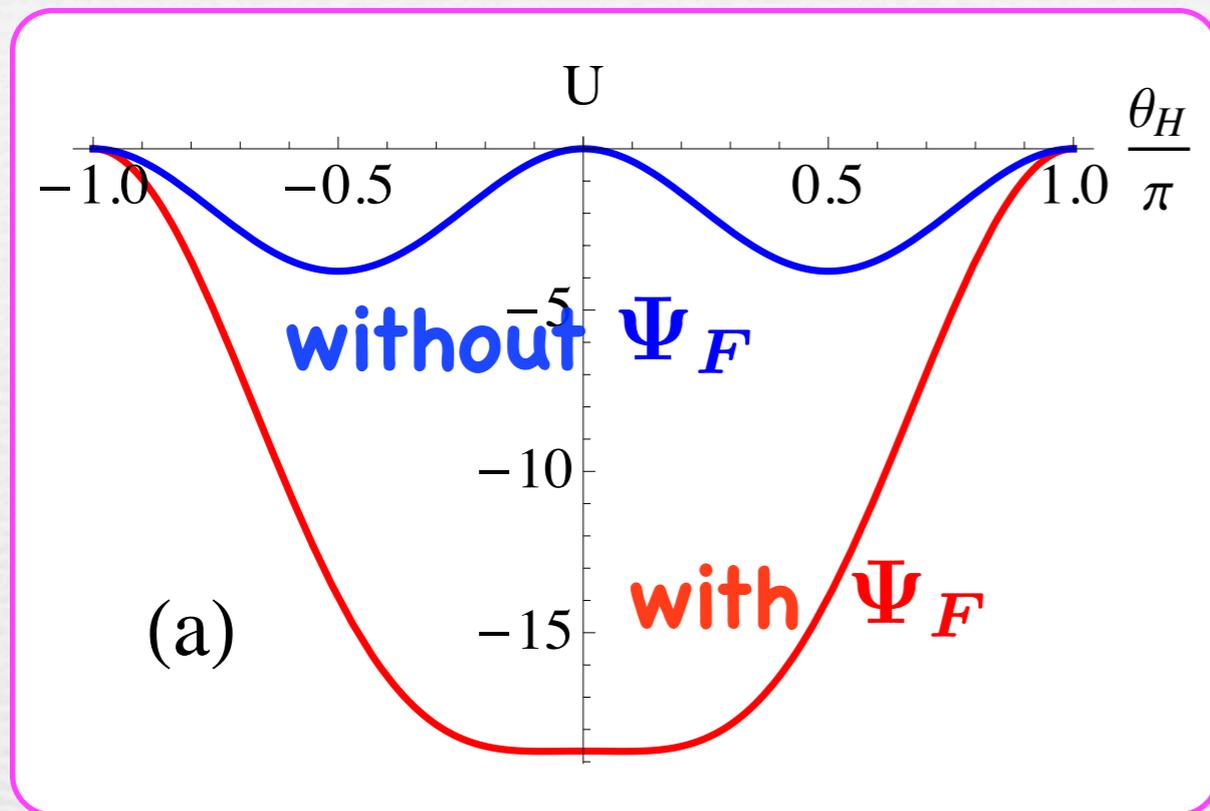
$\theta_H(z_L, n_F)$

gauge couplings
Higgs couplings
KK spectrum

$$V_{\text{eff}} = \left(\frac{m_{\text{KK}}}{2\pi} \right)^4 U$$

$$z_L = 10^7, \quad n_F = 3$$

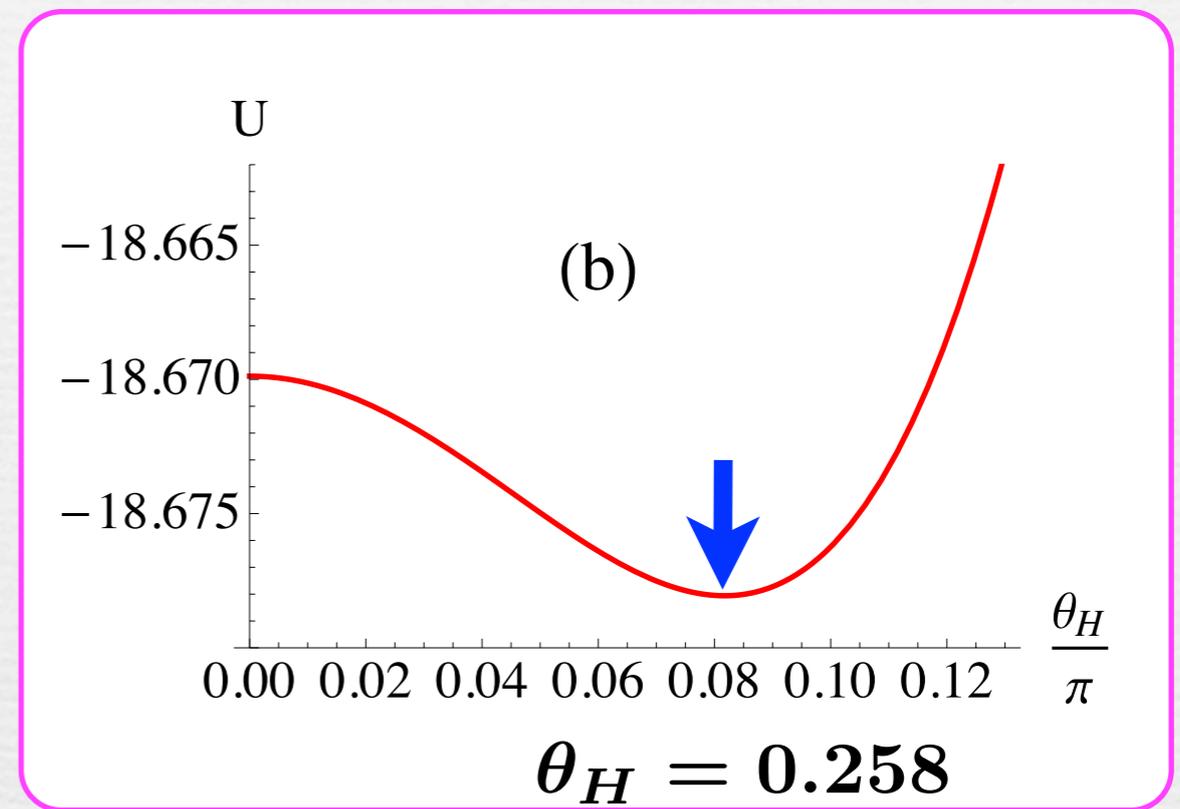
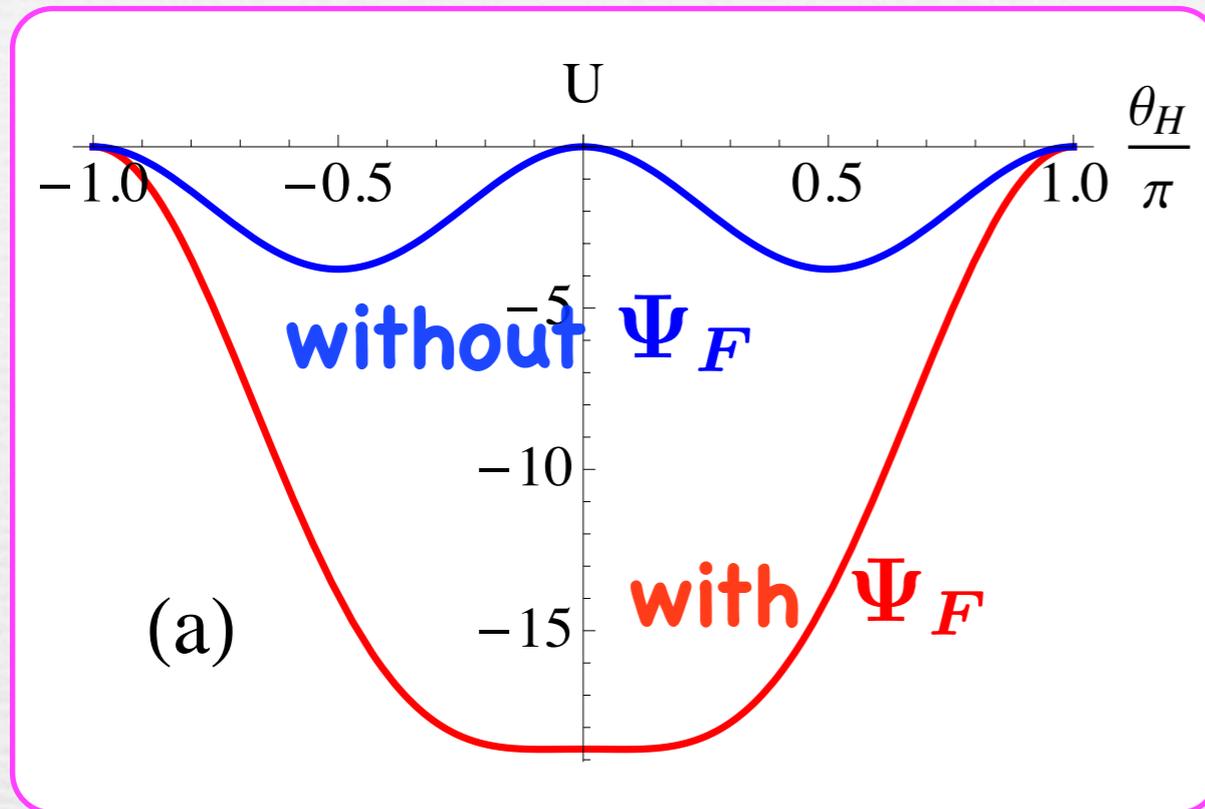
$$c_t = 0.330, \quad c_F = 0.353$$



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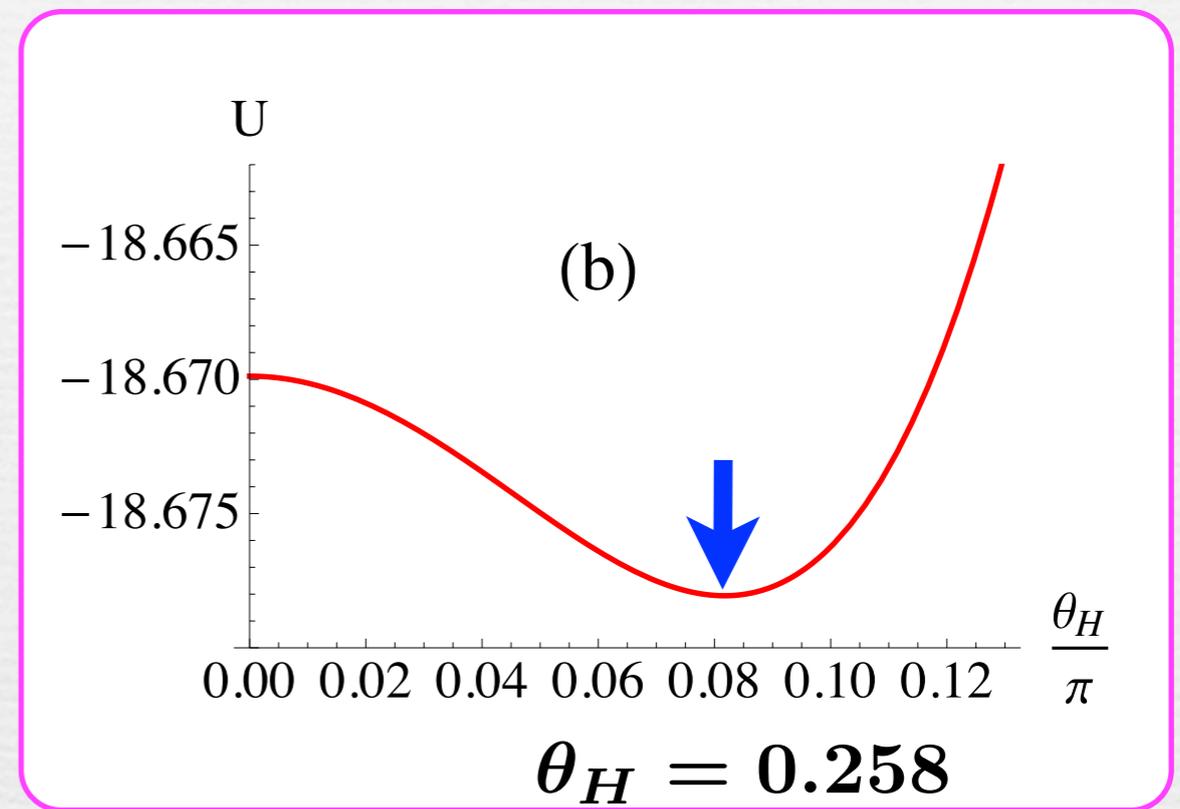
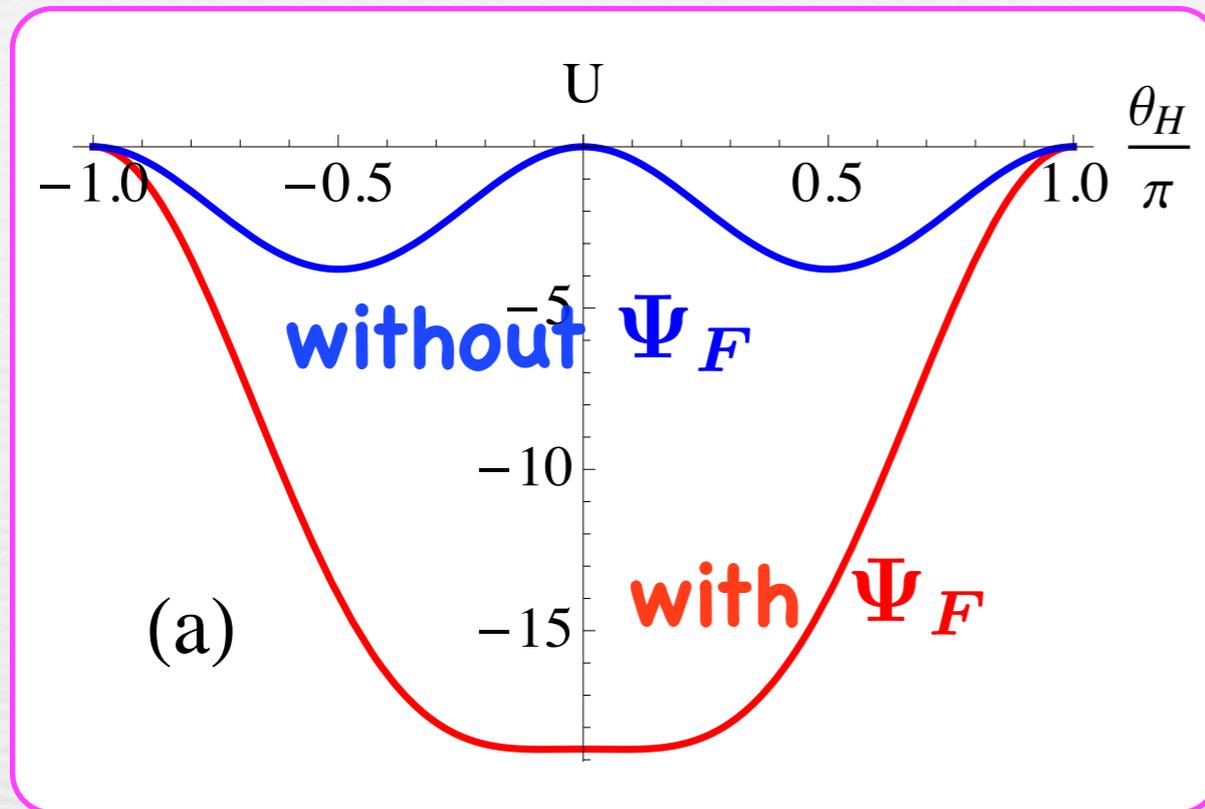


EW symmetry breaking takes place.
Higgs boson at 126 GeV.

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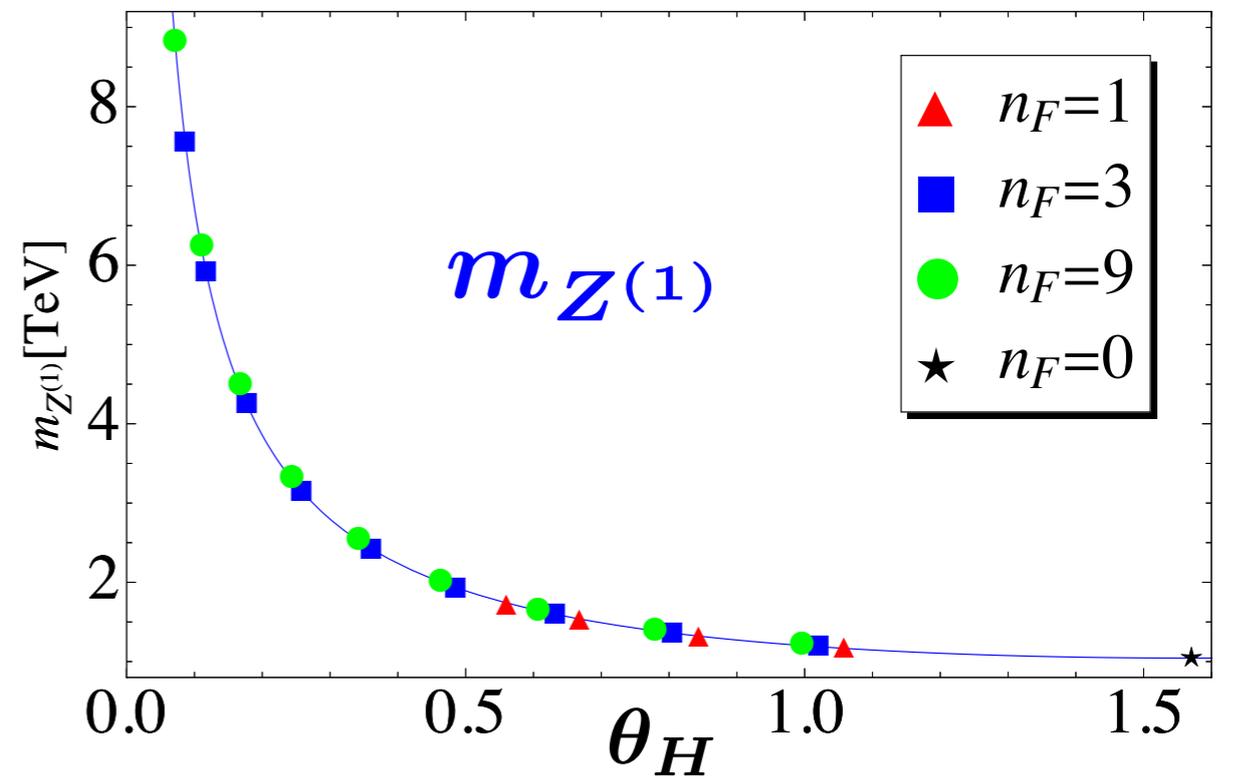
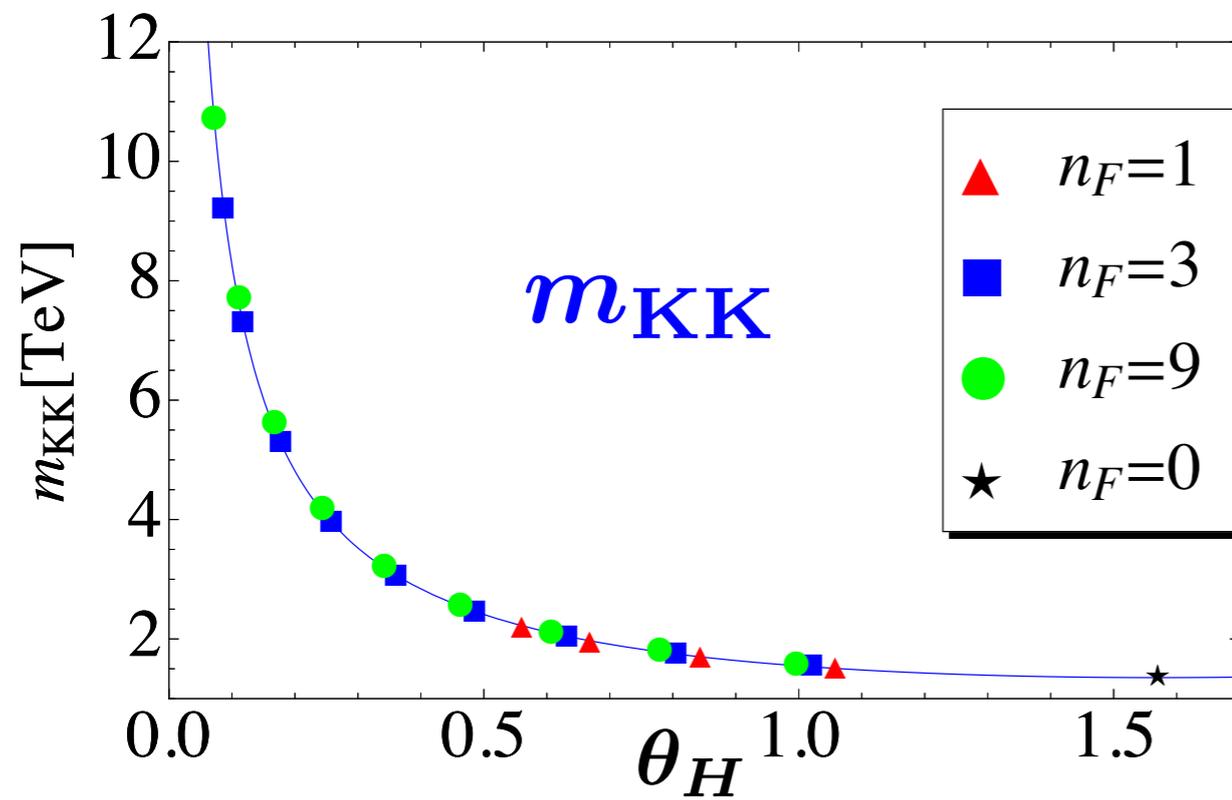
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(No instability problem in GH. \leftrightarrow SM, UED)

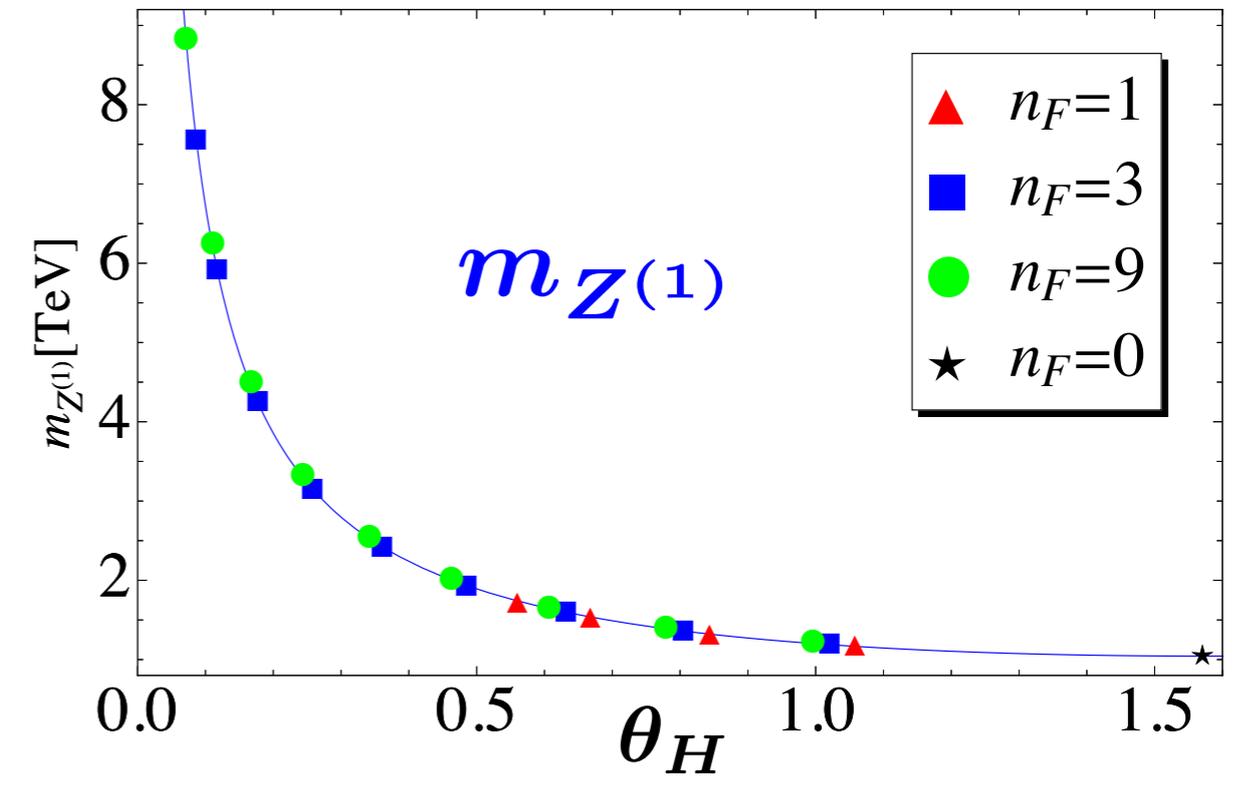
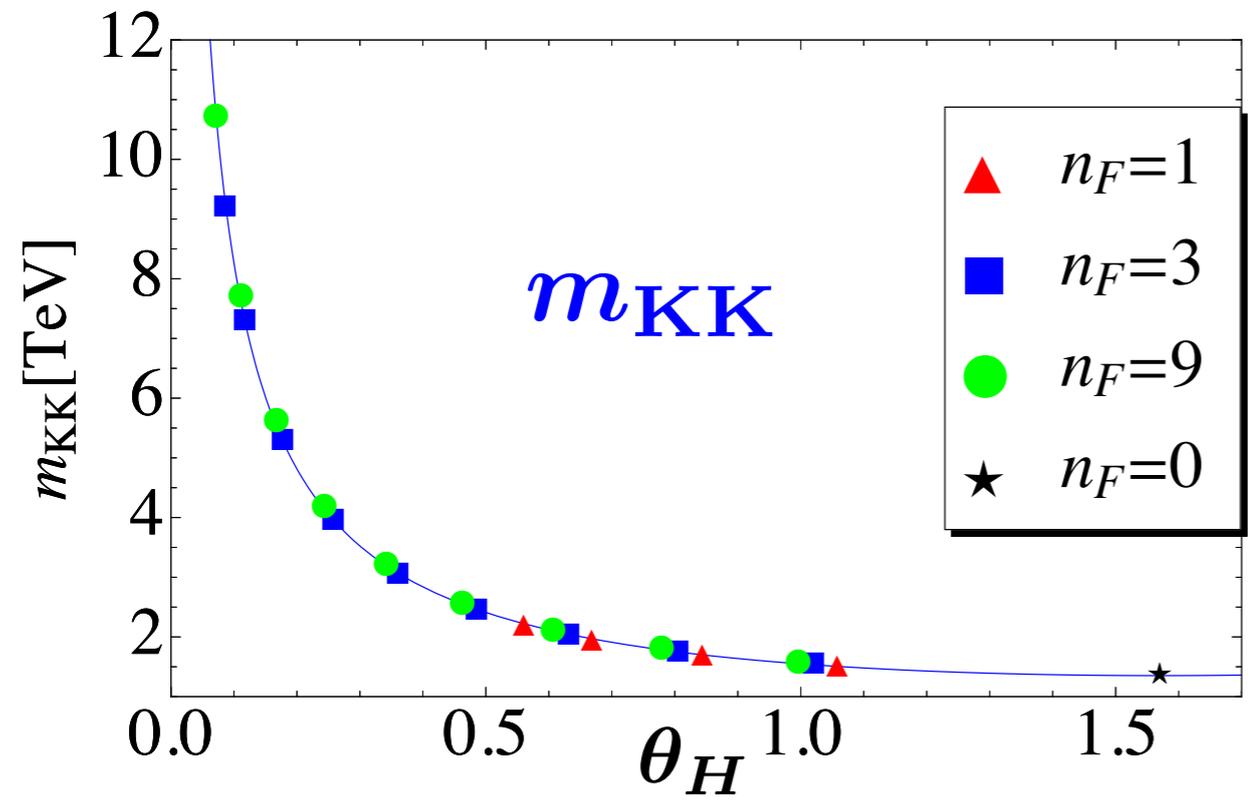
$\theta_H(z_L, n_F)$ & $m_{KK}(z_L, n_F)$ $m_{Z^{(1)}}(z_L, n_F)$

$m_H = 126 \text{ GeV}$



$\theta_H(z_L, n_F)$ & $m_{KK}(z_L, n_F)$ $m_{Z^{(1)}}(z_L, n_F)$

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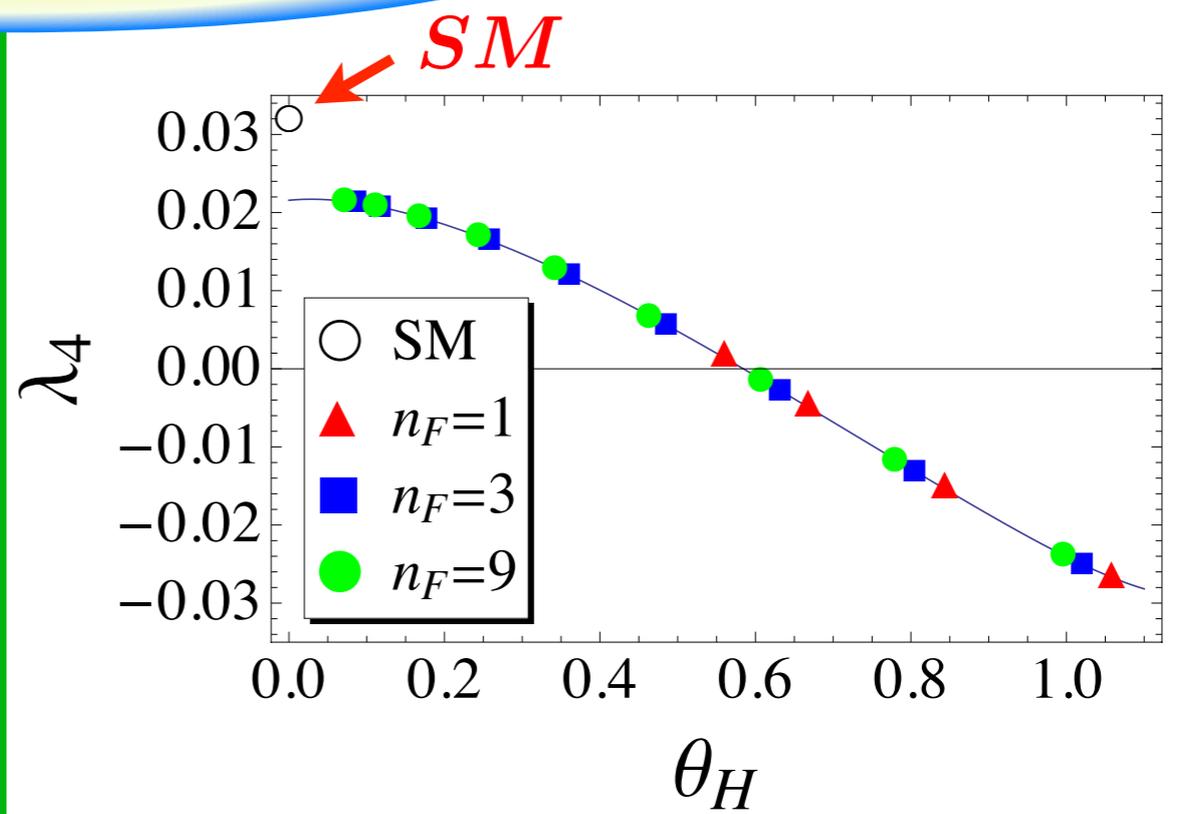
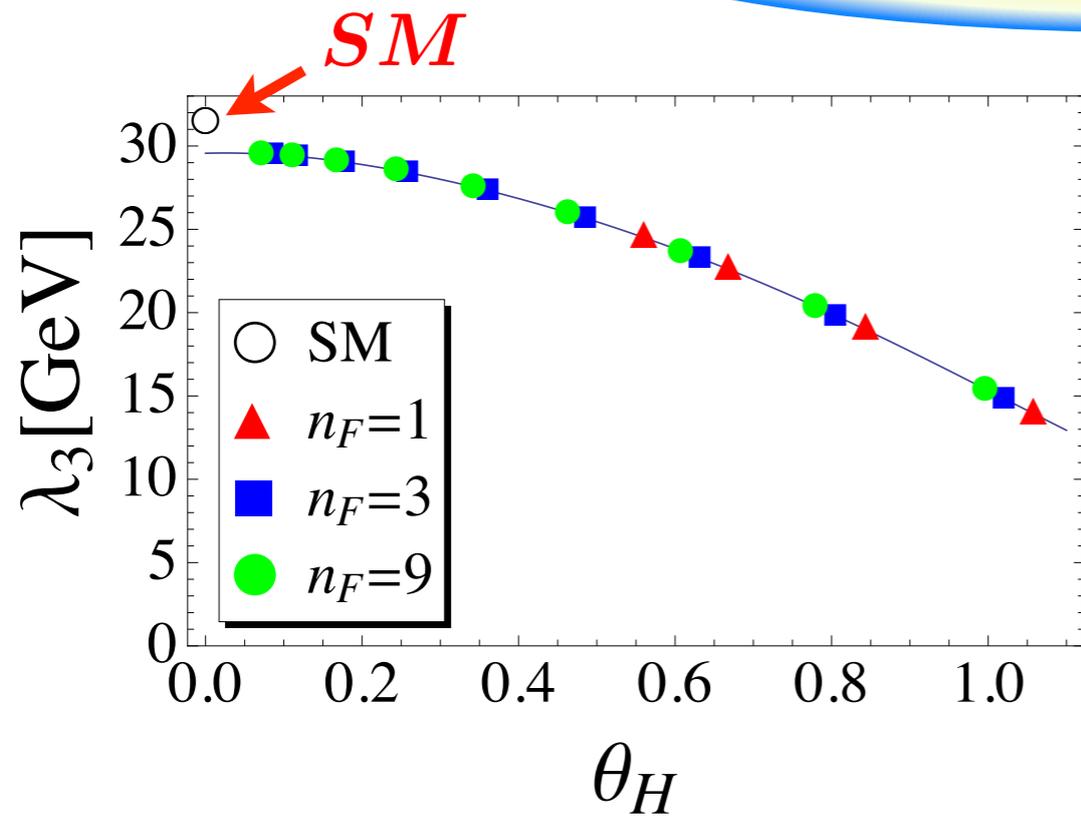


$$m_{KK} \sim \frac{1352 \text{ GeV}}{(\sin \theta_H)^{0.786}}$$

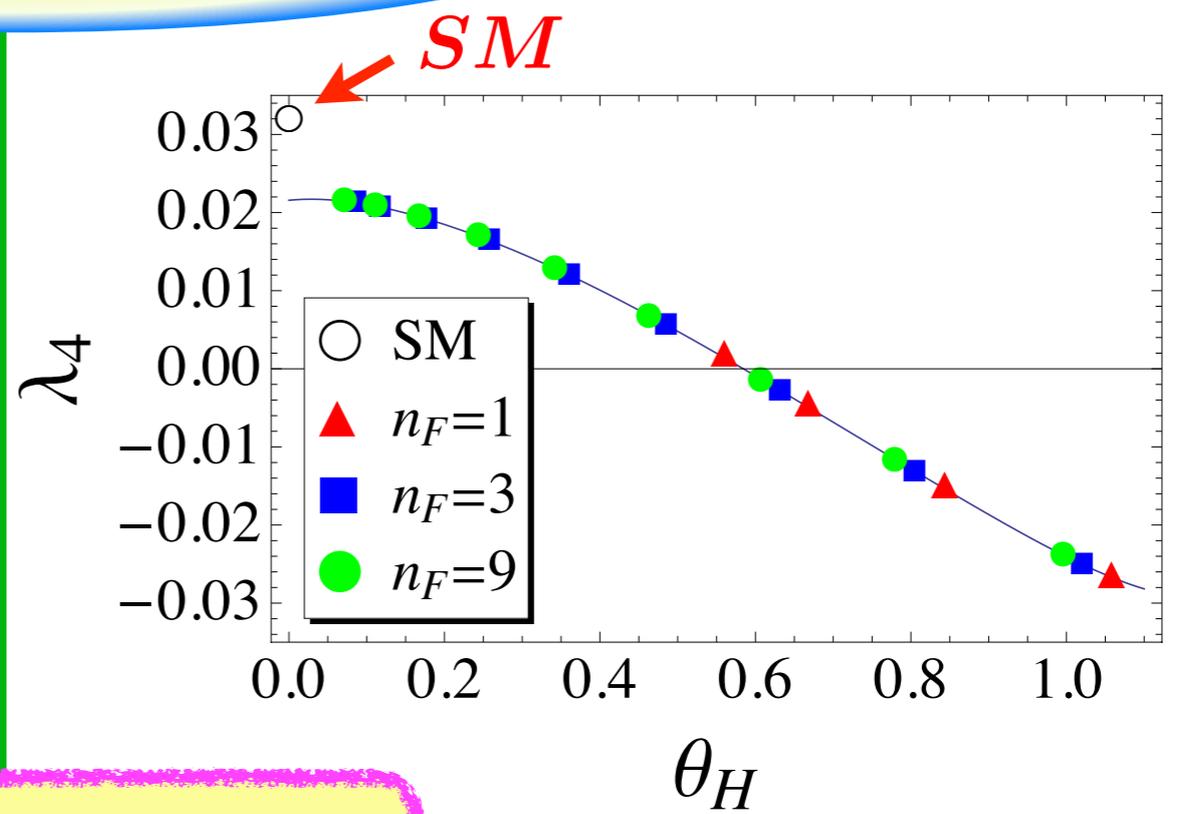
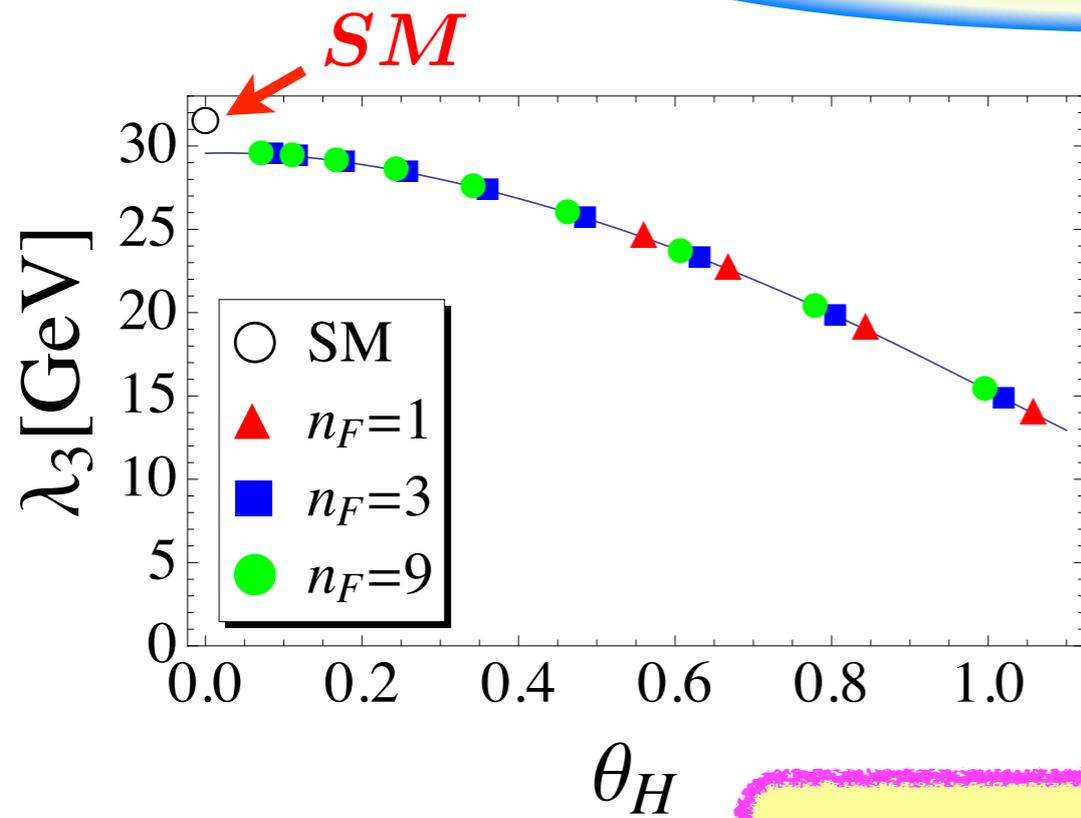
$$m_{Z^{(1)}} \sim \frac{1044 \text{ GeV}}{(\sin \theta_H)^{0.808}}$$

Universality

Higgs self couplings

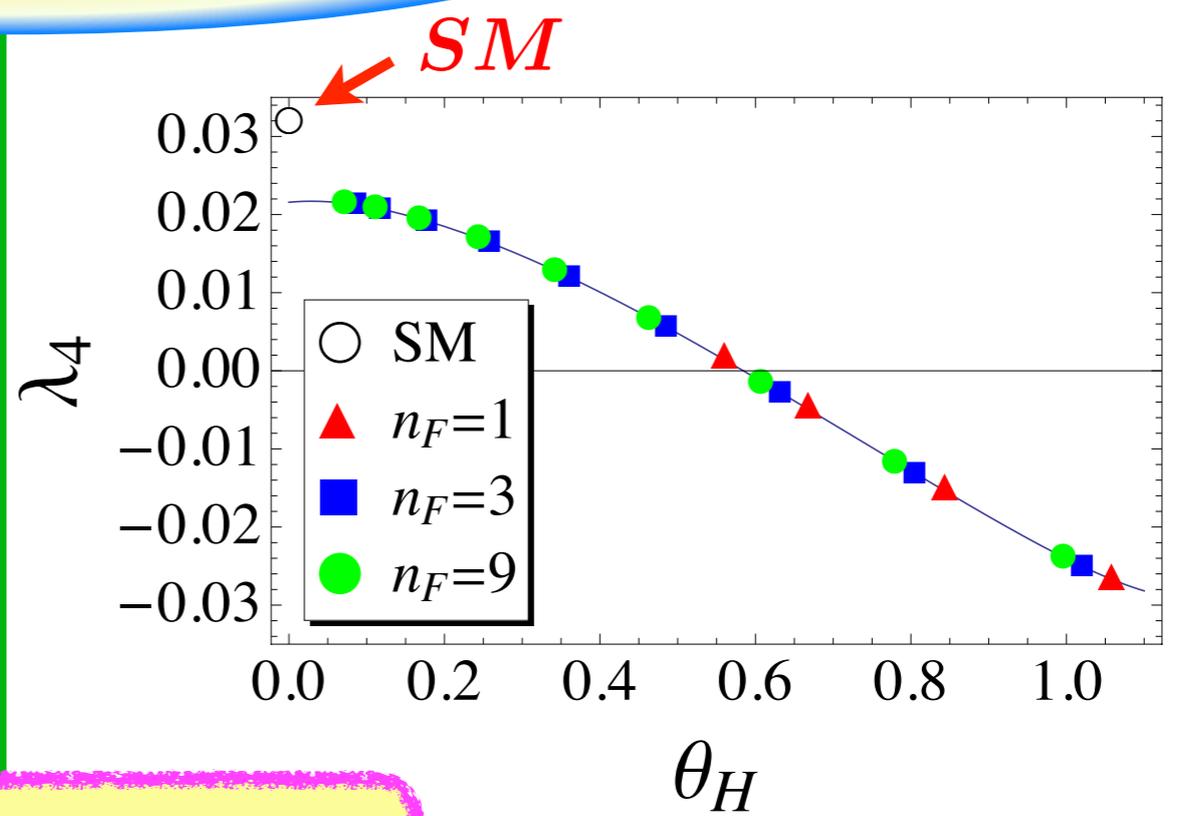
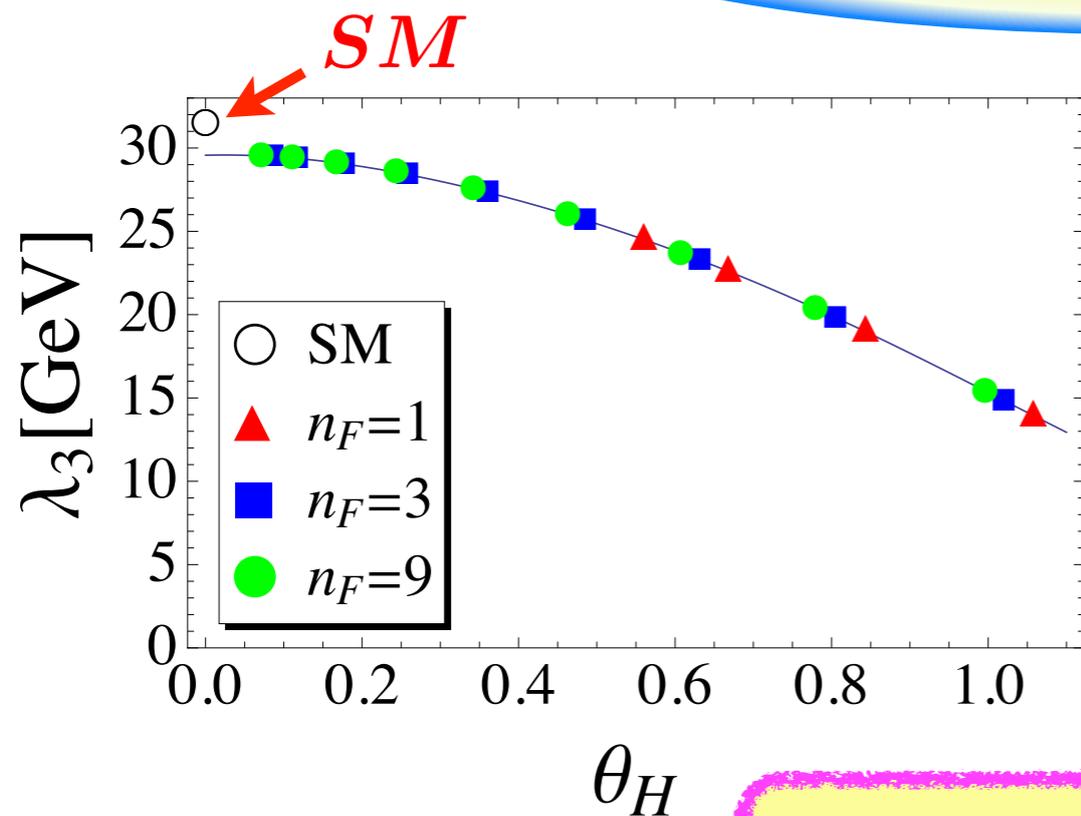


Higgs self couplings



Universality

Higgs self couplings



Universality

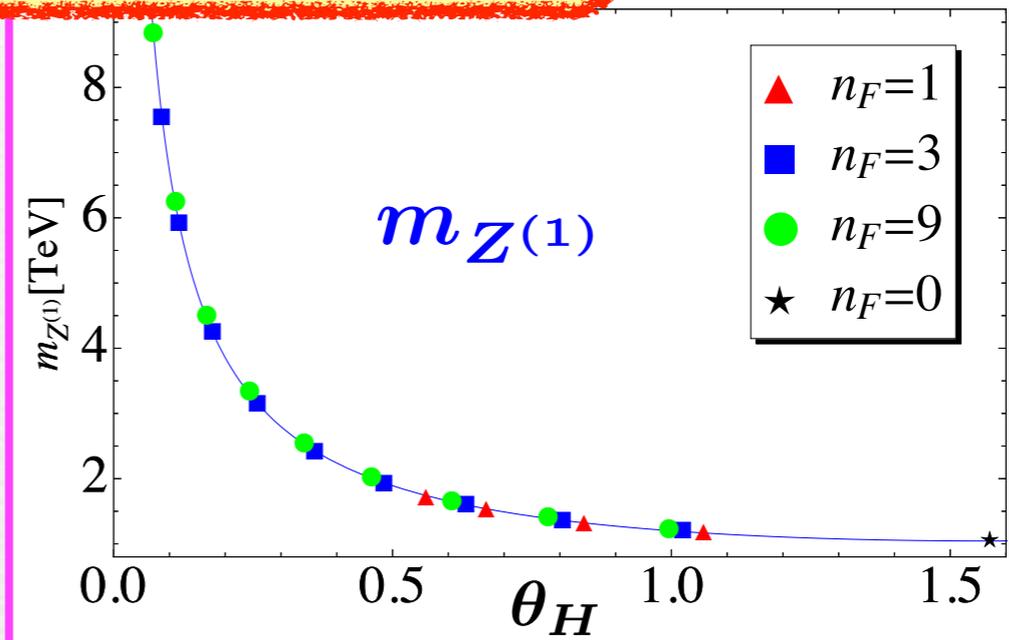
Note:

The model at low energies: close to SM.

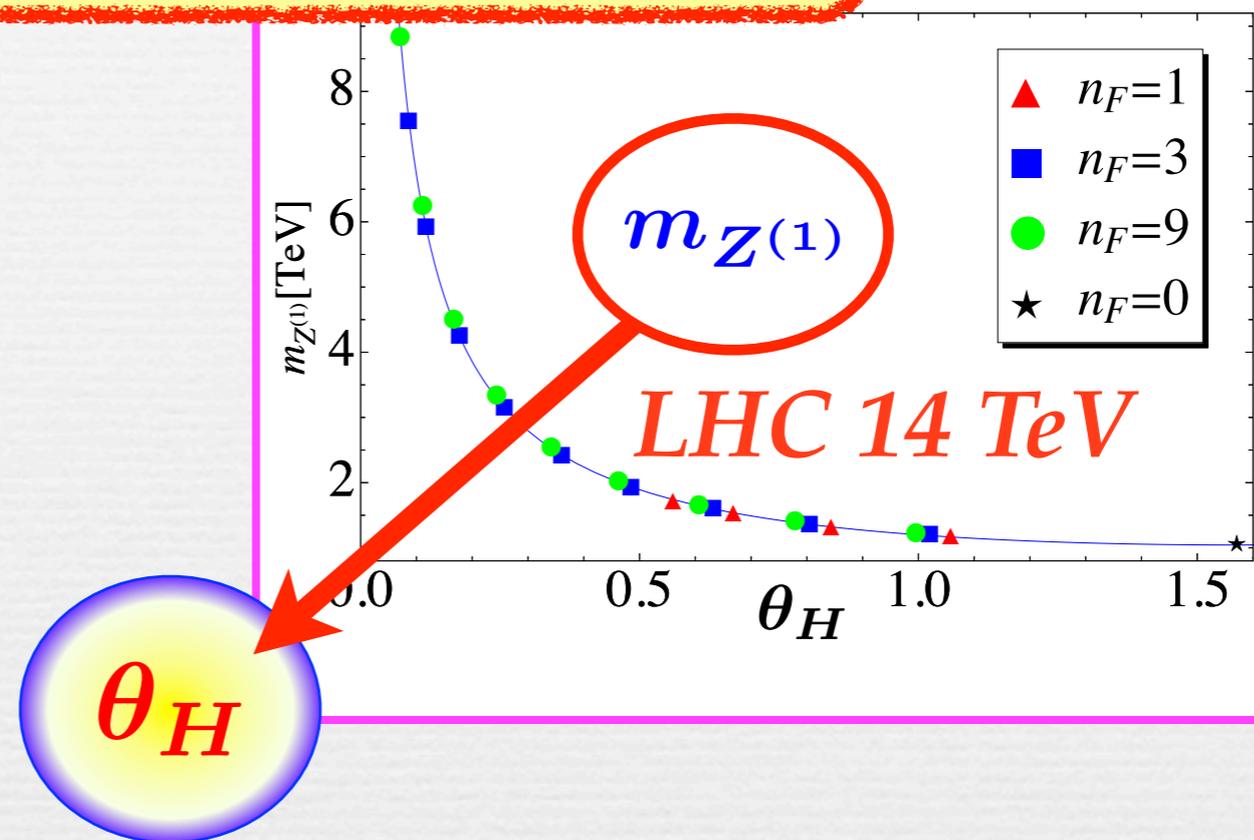
$$Br[H \rightarrow \gamma\gamma, b\bar{b}, ZZ, \dots] \sim Br|_{SM}$$

$$\sigma[gg \rightarrow H] \sim \sigma_{SM} \times \cos^2 \theta_H$$

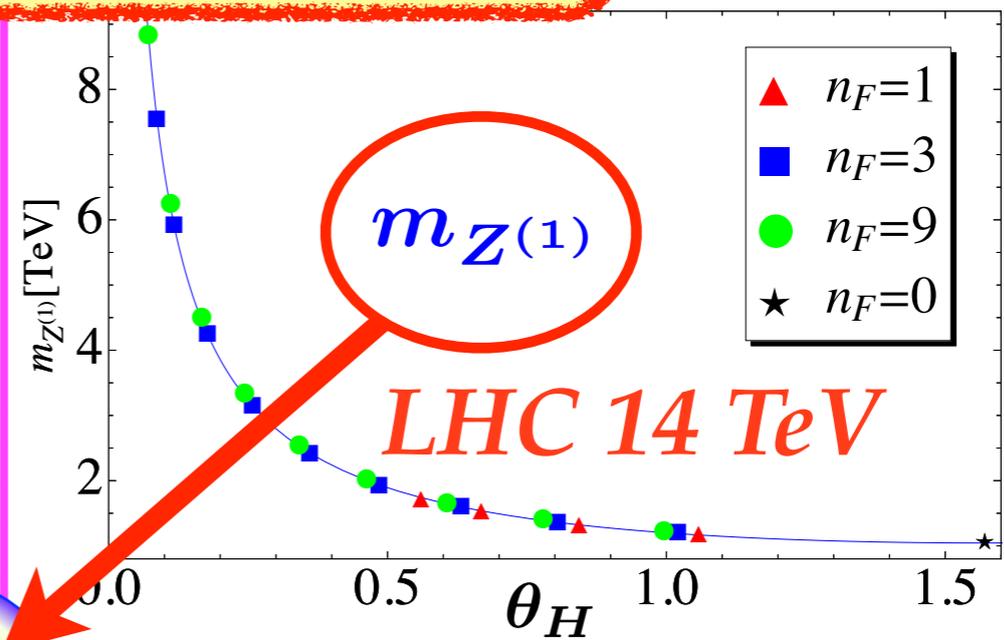
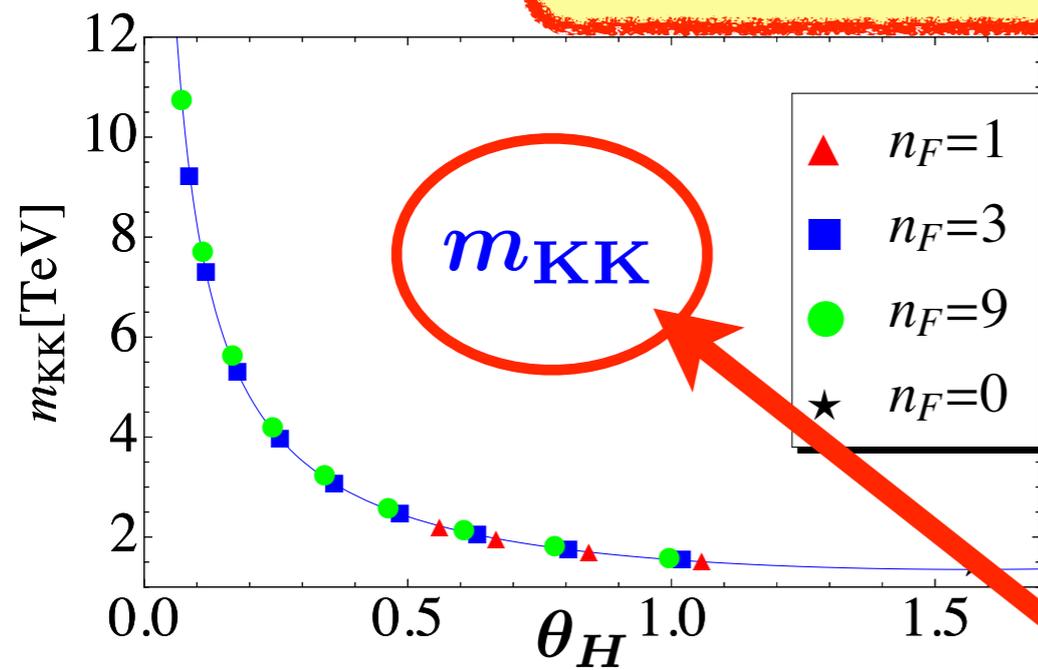
Universality predicts



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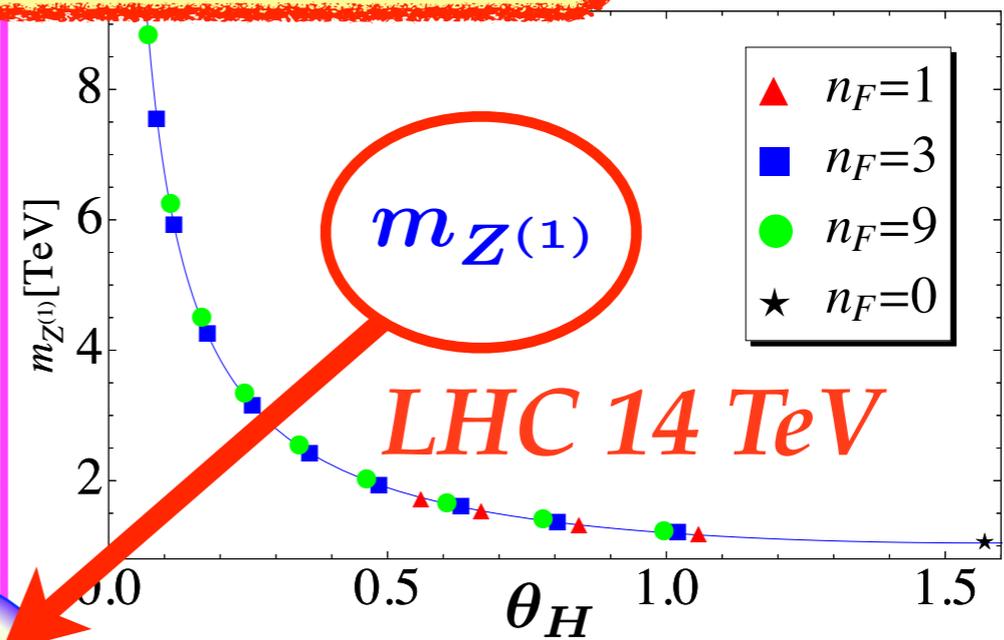
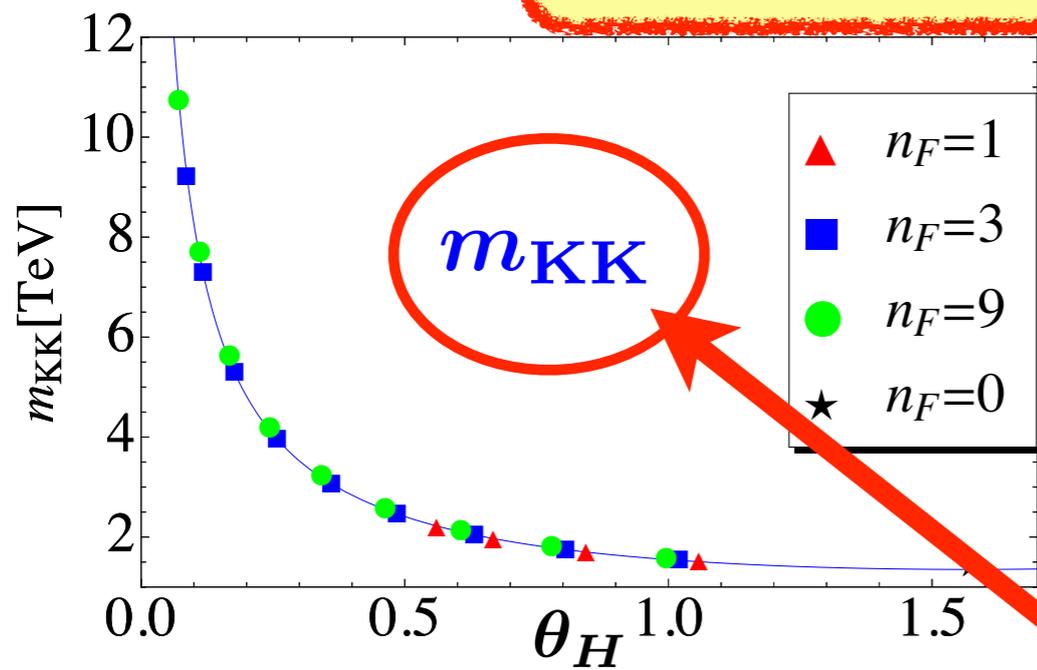


Universality predicts

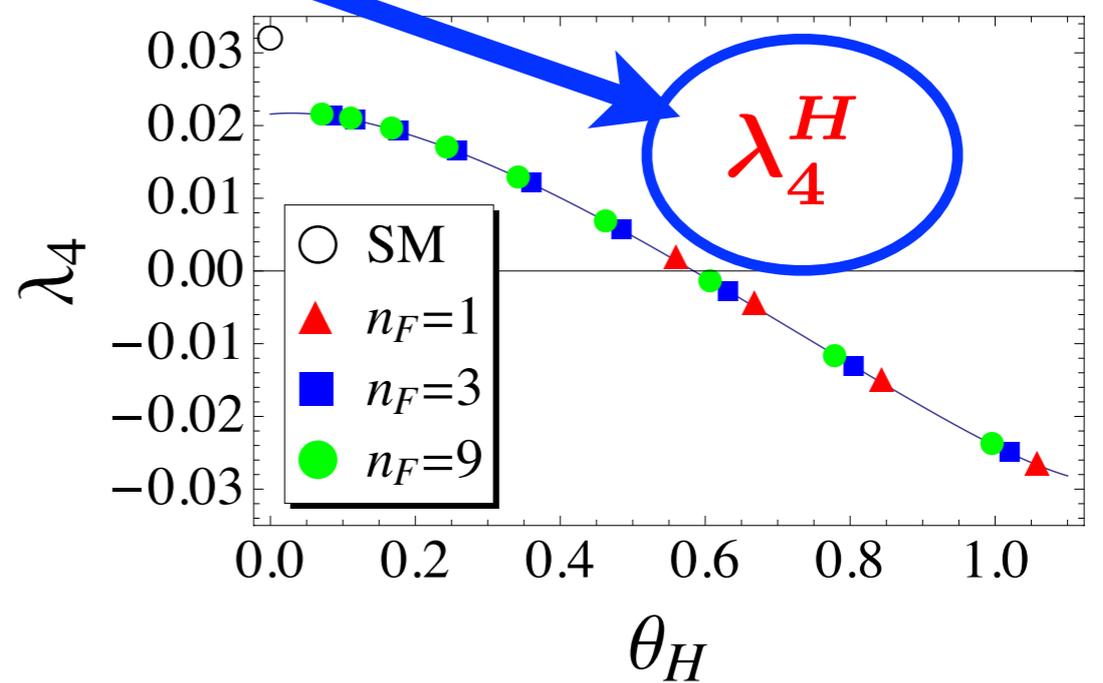
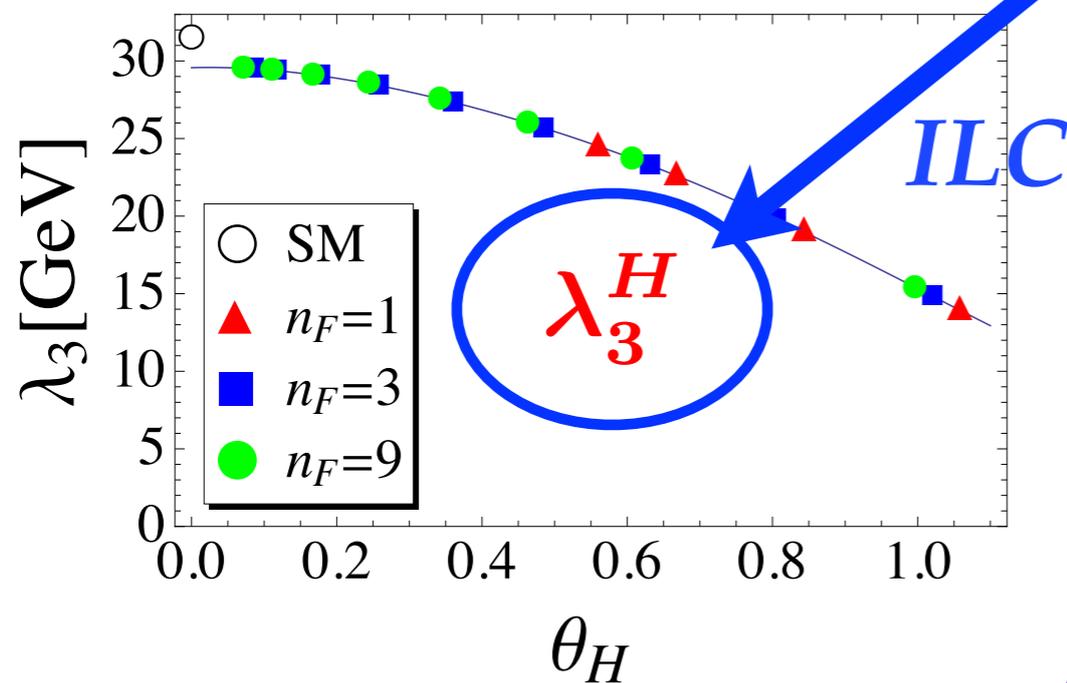


θ_H

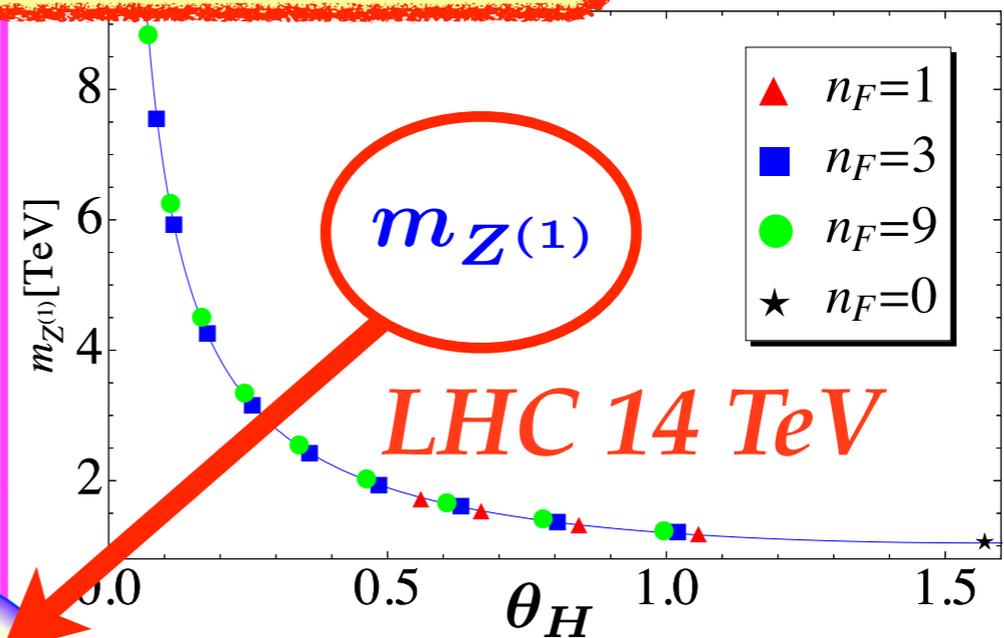
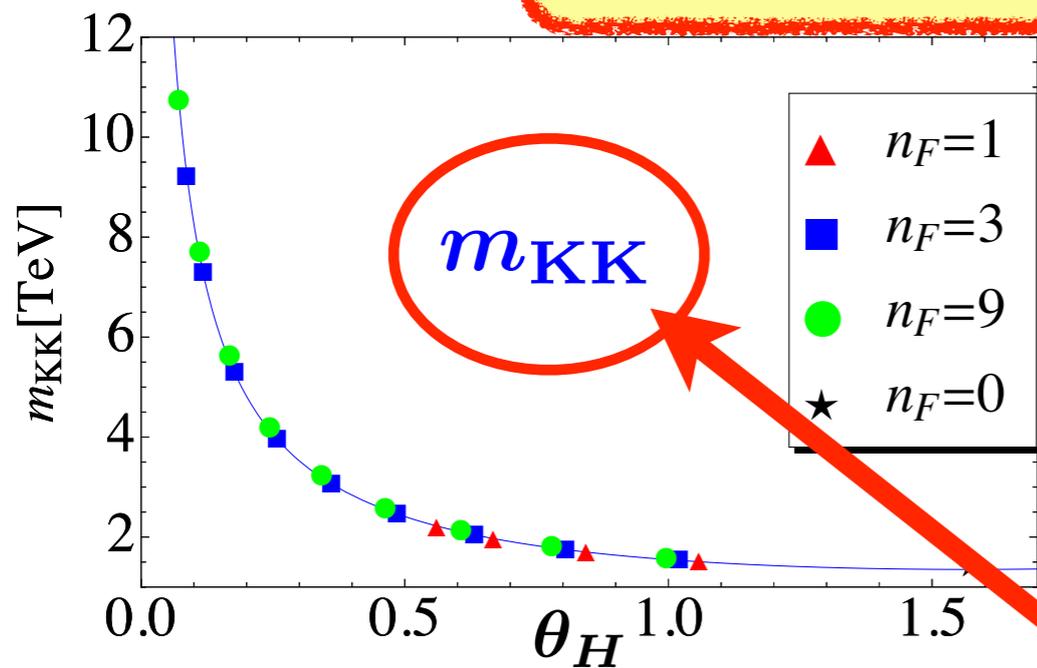
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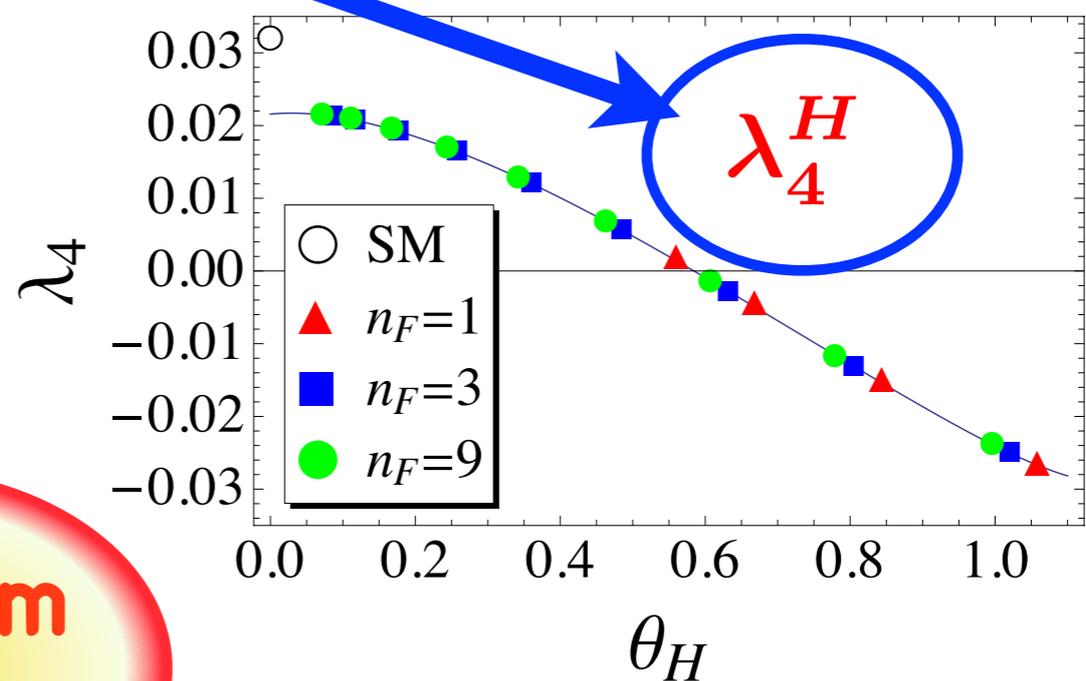
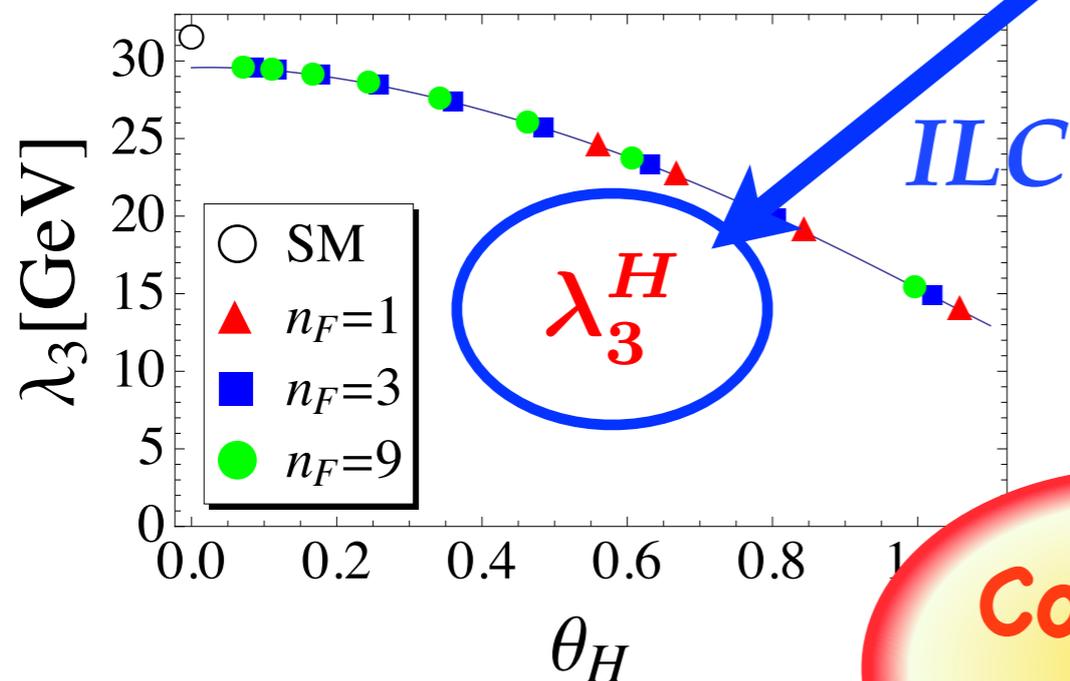
θ_H



Universality predicts



θ_H



Confirm
LHC/ILC