NATURALNESS OF EW SYMMETRY BREAKING

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★ THE STANDARD MODEL AND EWSB

- Introducing naturalness

★ GOING BEYOND THE STANDARD MODEL

- Supersymmetry
- Little Higgs

★ CONCLUSIONS

Thanks to my collabs. in these topics : A. BRIGNOLE, A. CASAS
I. HIDALGO, I. NAVARRO

THE STANDARD MODEL AND EWSB

The SM works extremely well (‰) but

"seems to have been designed by a committee" (John Baez)

It does not look fundamental

$SM|_\Lambda$ valid only up to some scale Λ

Clues on Λ from EWSB, parametrized by $V = \frac{1}{2} m^2 h^2 + \frac{1}{4} \lambda h^4$

m^2 only mass scale in SM

$m^2 < 0 \Rightarrow$ EWSB $\Rightarrow$

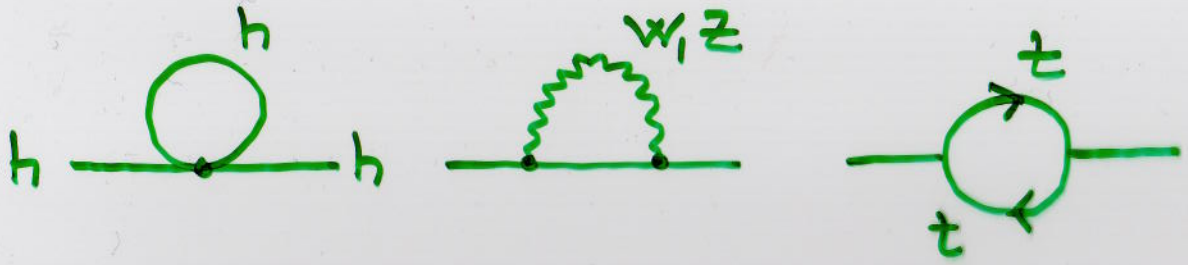
$$\langle h^2 \rangle \equiv v^2 = -\frac{m^2}{\lambda} = (246\,\text{GeV})^2 \quad M_Z, M_W$$

$$m_h^2 = 2\lambda v^2$$

Unknown but expected to be light

BUT, THERE IS A PROBLEM

Quantum corrections to m^2 go like Λ^2



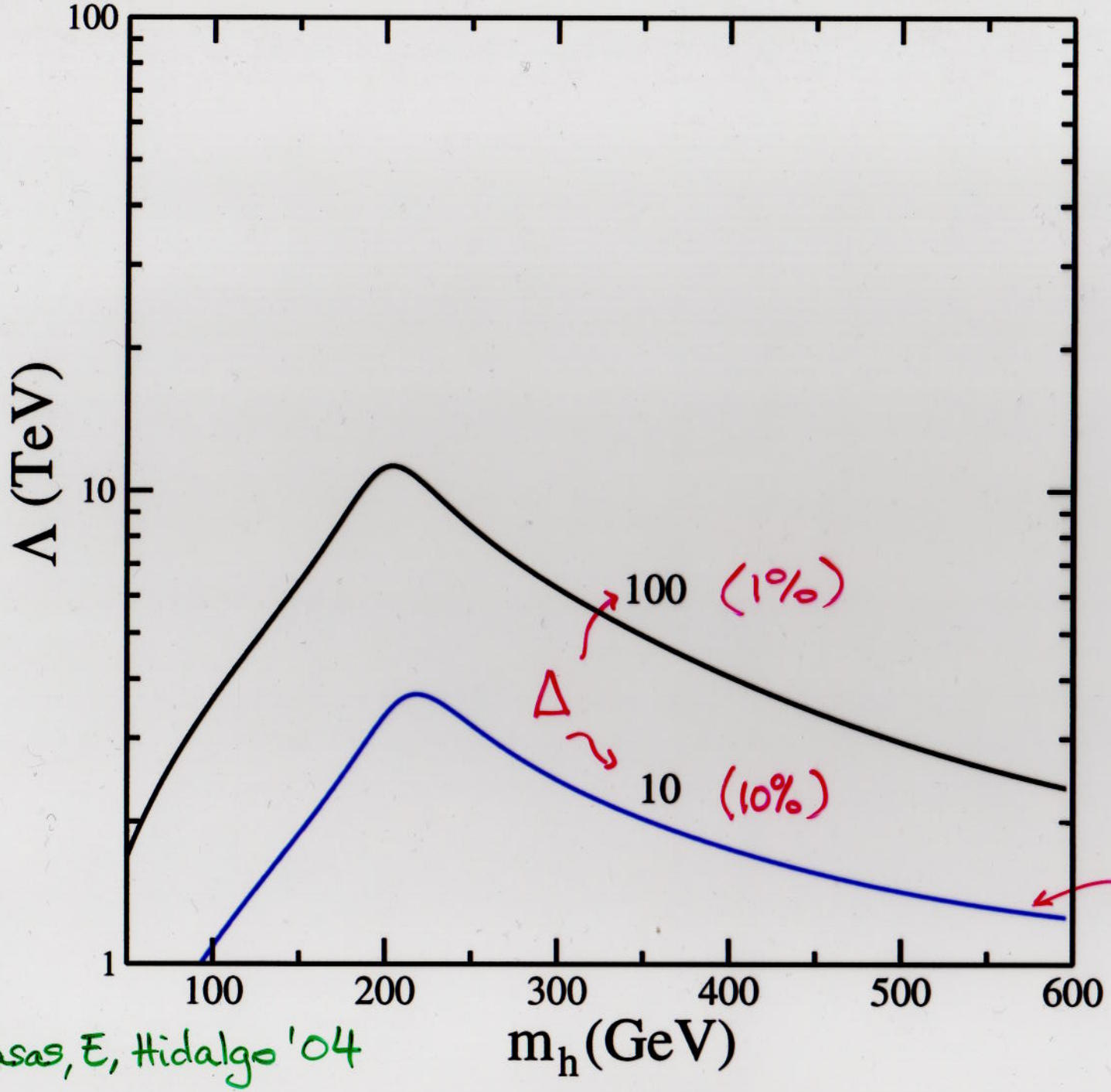
$$\delta m^2 = \frac{3\Lambda^2}{64\pi^2}\left(8\lambda + 3g^2 + g'^2 - 8\lambda_t^2\right)$$

δm^2 very large for $\begin{cases} \Lambda \sim M_{Pl} & \text{Large Hierarchy Problem} \\ \Lambda \sim 10\ \text{TeV} & \text{Little Hierarchy Problem} \end{cases}$

⇨ Cancellation between $m^2|_{tree}$ and δm^2 to get v^2 right

Or, assuming $\left|\frac{\delta m^2}{m^2}\right| < \Delta\ (\sim 10)$ ⇨ $\Lambda \lesssim 2$ TeV (m_h-dep)

NATURALNESS CRITERIUM



Casas, E, Hidalgo '04

MORE SOPHISTICATED ANALYSIS A LA BARBIERI – GIUDICE

$$v^2 = v^2(p_\alpha)$$

↑ INPUT PARAMS.

$$\frac{\delta v^2}{v^2} = \Delta_{p_\alpha} \frac{\delta p_\alpha}{p_\alpha}$$

$$\Delta \equiv \sqrt{\sum_\alpha \Delta_{p_\alpha}^2}$$

GOOD FOR LHC.

TO REMOVE THE Λ^2 SENSITIVITY IN m^2

⇩

NEW PARTICLES + NEW SYMMETRIES

AT ~ TeV SCALE

Examples :

SUPERSYMMETRY

Superpartners ($\tilde{SM}$) + Supersymmetry (broken at $\tilde{m} \sim 1$ TeV)

h ↔ fermion (chiral)

LITTLE HIGGS

"Little" partners ($W', Z', T, \phi \ldots$) + Global Symmetry (with explicit "collective" breaking at $f \sim 1$ TeV)

h → (Pseudo) Goldstone