

IMPROVED HIGGS NATURALNESS

& SUPERSYMMETRY.

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with Stephen West

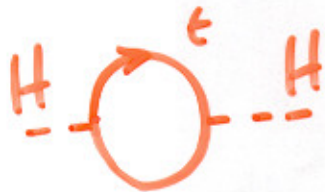
THE SM & NEW PHYSICS.

$$V = m^2 H^2 + \lambda H^4$$

- What is the Higgs mass?

EWPT $\Rightarrow M_H < 285 \text{ GeV (95\%)}$ PDG

- What is the new physics scale?



$$\Delta m^2 = \frac{3y_t^2}{8\pi^2} \Lambda_t^2$$

Fine-tuning $\Rightarrow \Lambda_t < 400 \text{ GeV} \left(\frac{M_H}{115 \text{ GeV}} \right)^{\sqrt{D}}$

$$D \equiv \frac{\partial \log M_H^2}{\partial \log \Lambda_t^2}$$

$\Rightarrow \Lambda_t$ within reach @ LHC.

ELLIS,
ENQVIST,
NANOPOULOS,
ZWIRNER;
BARBIERI,
GIUDICE.

IMPROVED NATURALNESS

- Extend Higgs sector.
- EWPT & fine-tuning constraints changed.
- Overall constraint on Λ_t relaxed.

- Apparent already in 2HDM : BARBIERI,
HALL


heavier Higgs couples dominantly to t .

$$\left. \begin{array}{l} \text{e.g. } M_h \sim 115-150 \text{ GeV} \\ M_H \sim 500-1000 \text{ GeV} \\ \tan\beta \sim 0.8-1 \end{array} \right\} \Lambda_t \sim 2 \text{ TeV.}$$

$\Rightarrow \Lambda_t$ beyond reach of LHC!

- Generic, cf. CHACKO, GOH, HARNIK;
BARBIERI, GREGOIRE, HALL;
BARBIERI, HALL, RYCHKOV.

A SUSY EXAMPLE

- New physics @ $M_{\tilde{t}}$: 

- MSSM? $W = \mu H_u H_d$

X direct searches @ LEP

- NMSSM? $W = \lambda N H_u H_d + K N^3$

X perturbative unification.

- 'fat Higgs'? $W = \lambda N (H_u H_d - V_0^2)$

λ can be large

fine-tuning constraint $\Leftarrow D_i = \frac{\partial \log M_i}{\partial \log M_{\tilde{t}}}$

electroweak constraint $\Leftarrow S, T$ analysis,
 $\Gamma(Z \rightarrow b\bar{b}), b \rightarrow s\gamma$

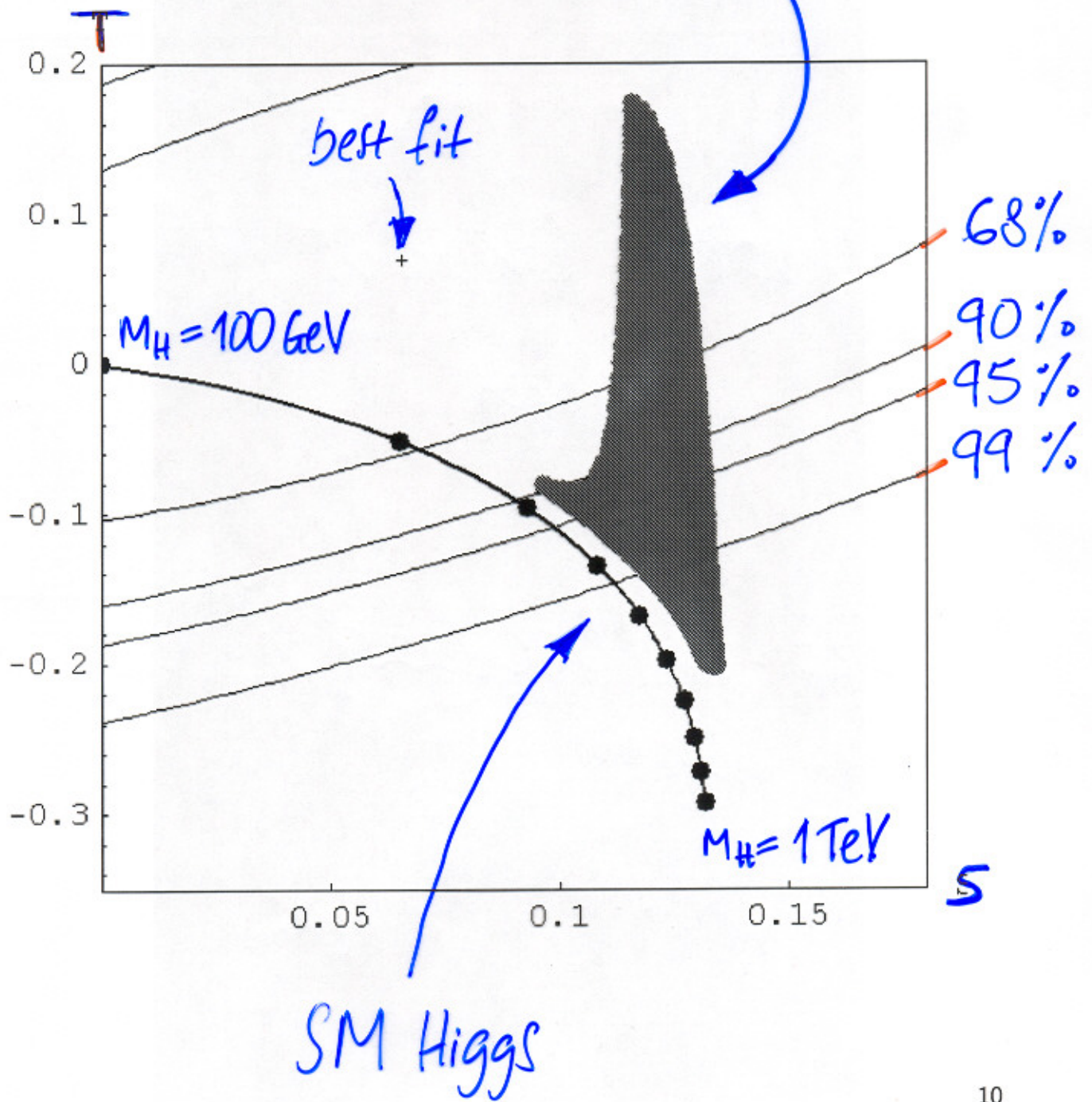
FAYET;
HARNIK,
KRIS,
LARSON,
MURAYAMA;
BIRKEDAL,
CHACKO,
NOMURA.

PEKIN,
TAKSUCHI.

HABER,
LOGAN.

ELECTROWEAK CONSTRAINTS

fat Higgs, $M_H > 2 \text{ TeV}$.

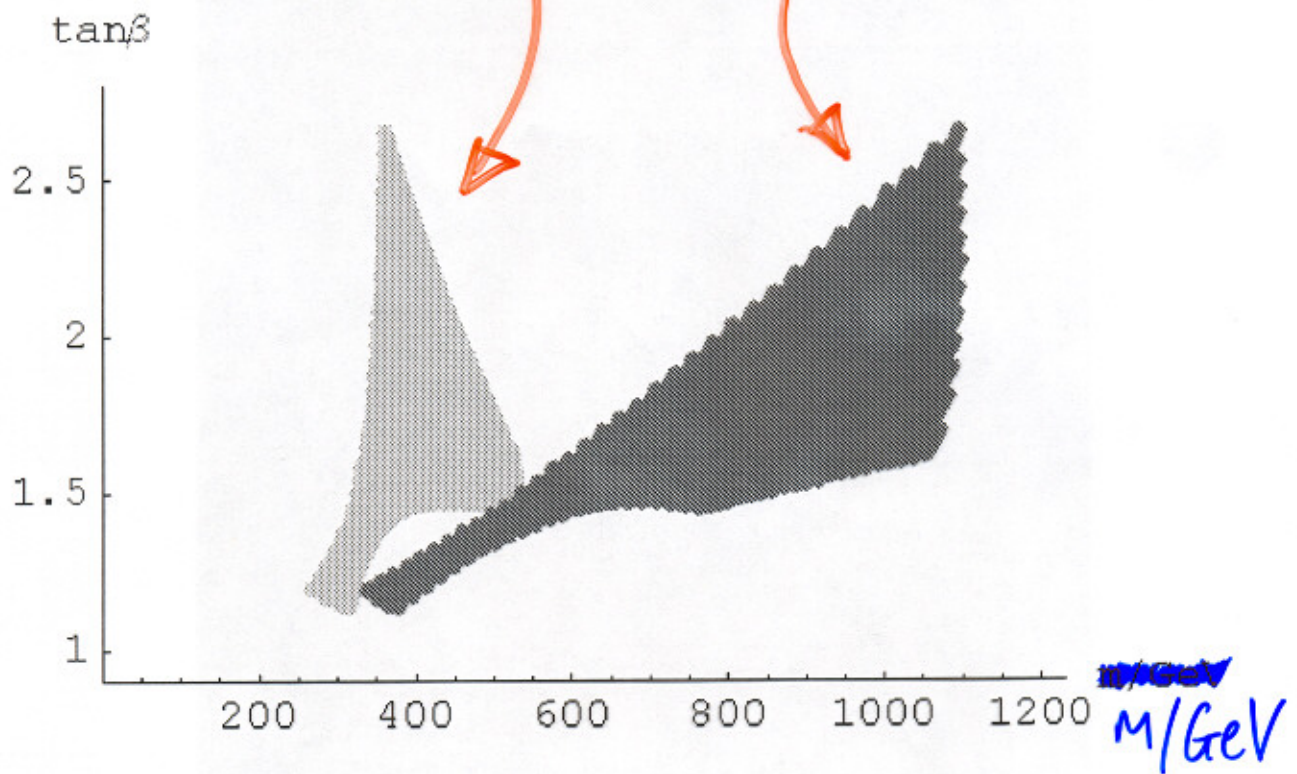


$\Gamma(Z \rightarrow b\bar{b}), b \rightarrow s\gamma$ cuts already applied @ 95%

PARAMETER SPACE

light Higgs mass

heavy Higgs mass



SUMMARY

- Improved naturalness generic with extended Higgs sector
- Includes examples where new physics is SUSY.
- New physics beyond reach of LHC ?
- Let's hope it's not true !