

pNGb Higgs Naturalness at a Tipping Point

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[hep-ph 2505.06052]



The fine tuning question

$$\Delta \propto \delta_{hXX}, \frac{m_h^2}{M_R^2}$$

Indirect measurements will improve by a factor of $\sqrt{\frac{3000}{140}} \sim 4.6$

Mass searches are expected to improve by a **1.5 -1.9** factor

Roughly: $\frac{\Delta_{\text{indirect}}}{\Delta_{\text{direct}}} \left| \frac{3000}{140} \approx 0.6 \right.$

The impact of precision measurements will grow

The kitchen sink

Gegenbauer Higgs + SUSY Twin Higgs + pNGb Higgs

But... **why**????

- 1) We attempt to characterise the broad landscape of **symmetry-based** naturalness solutions.
- 2) Adding SUSY allows us to interpolate between direct and indirect searches.

The kitchen sink

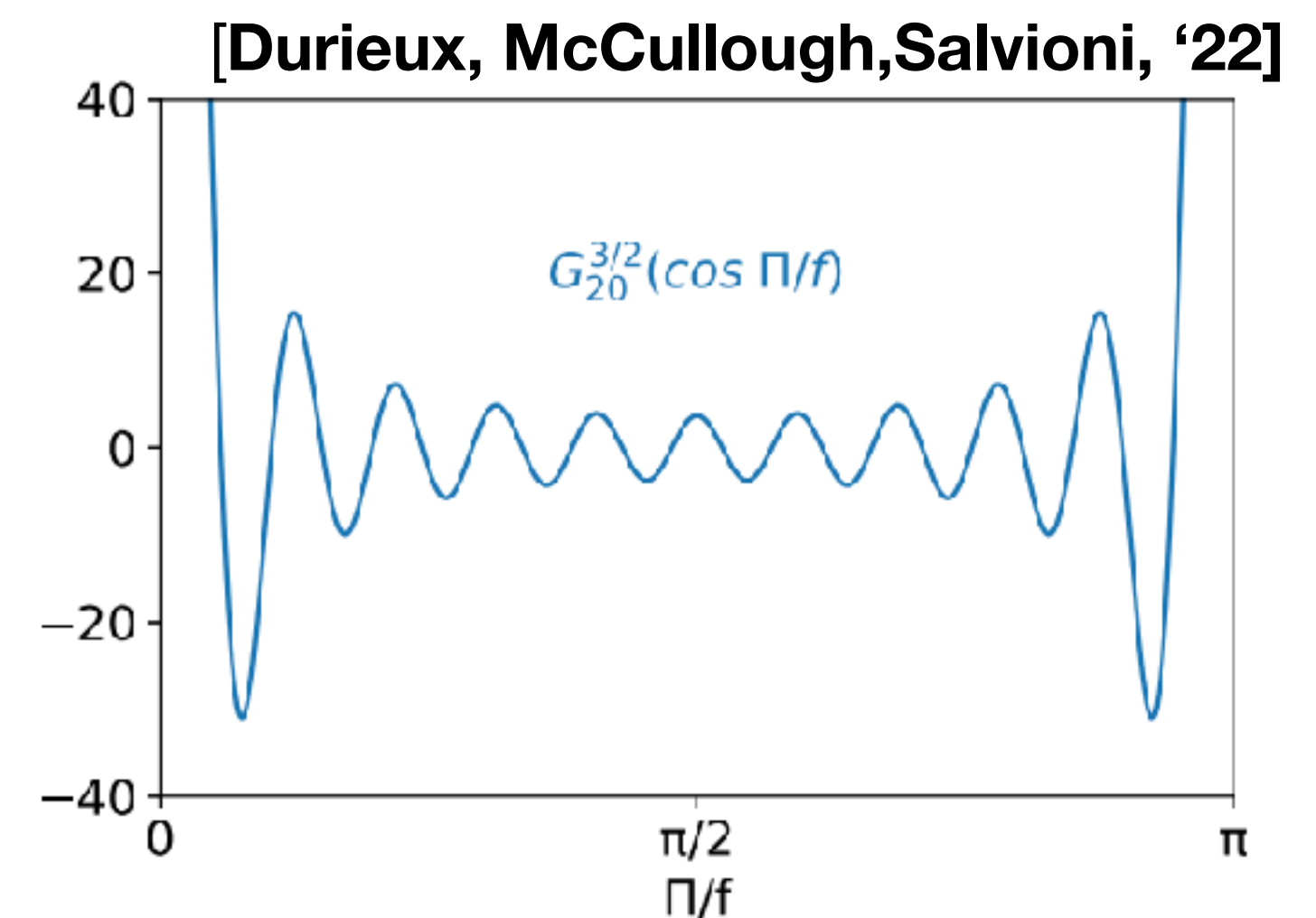
EW interactions: $V_D = \frac{g_Z^2 f^4}{32} \cos^2 2\beta (s_h^4 + c_h^4)$

Yukawa interactions:

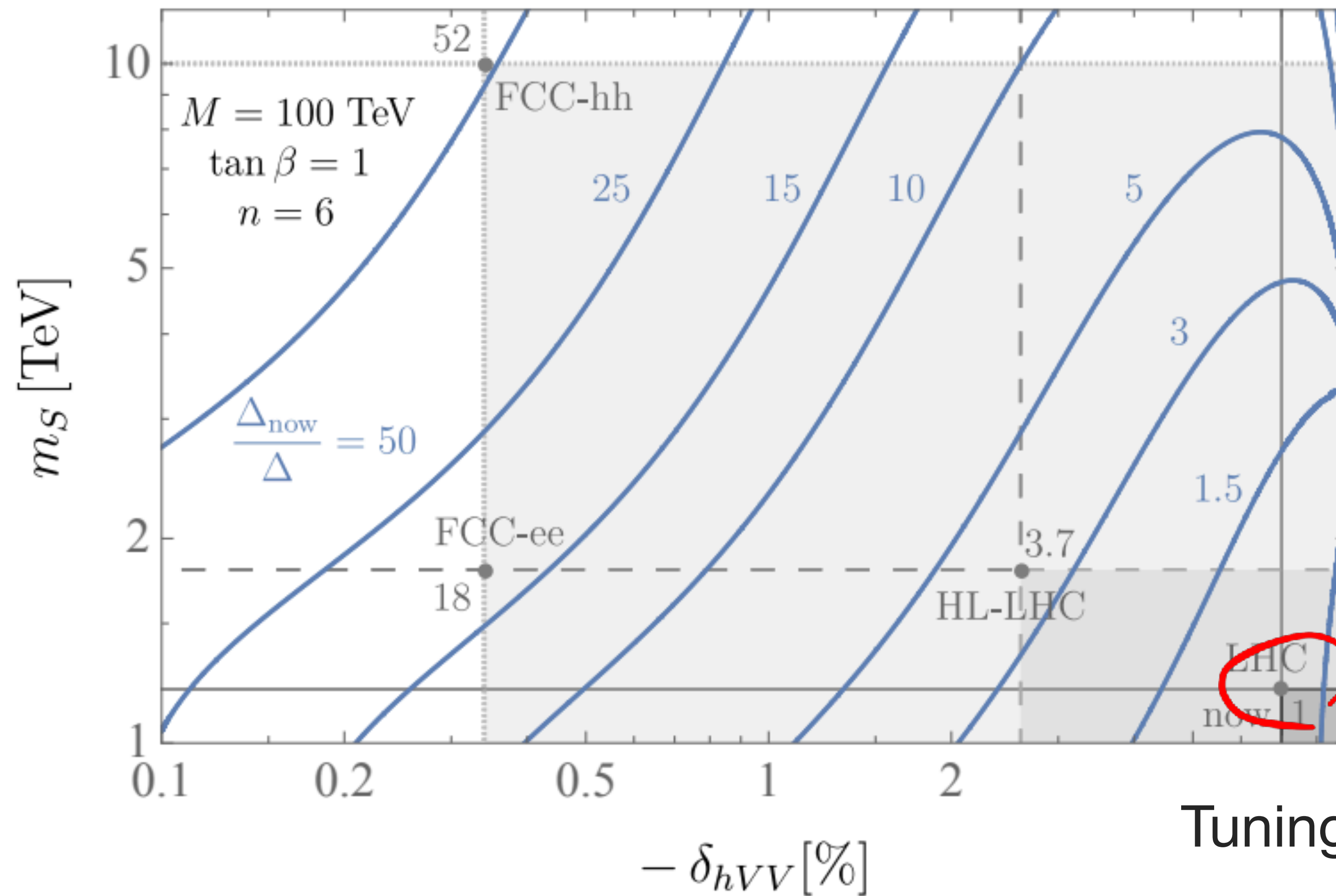
$$V_{t+\tilde{t}}^{A,B} = \frac{N_c}{64\pi^2} \left[(2m_S^2 + y_t^2 s_\beta^2 f^2 s_h^2)^2 \left(\log \frac{2m_S^2 + y_t^2 s_\beta^2 f^2 s_h^2}{2M^2} - \frac{1}{2} \right) - (y_t^2 s_\beta^2 f^2 s_h^2)^2 \left(\log \frac{y_t^2 s_\beta^2 f^2 s_h^2}{2M^2} - \frac{1}{2} \right) \right]$$

Gegenbauer ($SO(8) \rightarrow SO(4)_A \times SO(4)_B$, ~~SUSY~~):

$$V_G^{(n)} = \epsilon H(\beta) \lambda^2 f^4 G_n^{3/2} \left(\cos \frac{2h}{f} \right)$$

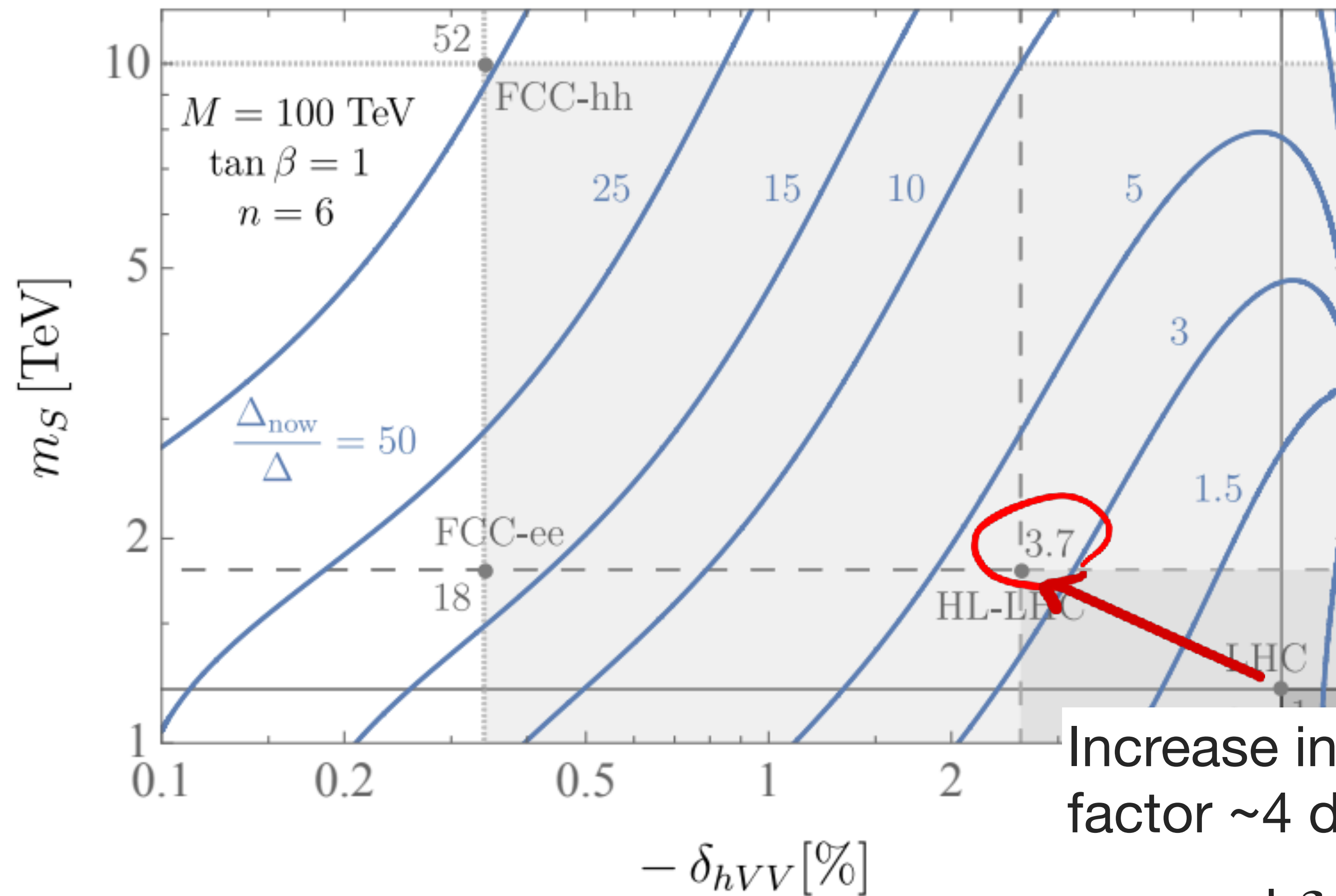


Evolution of the tuning



Tuning driven by $\mathbf{v/f}$

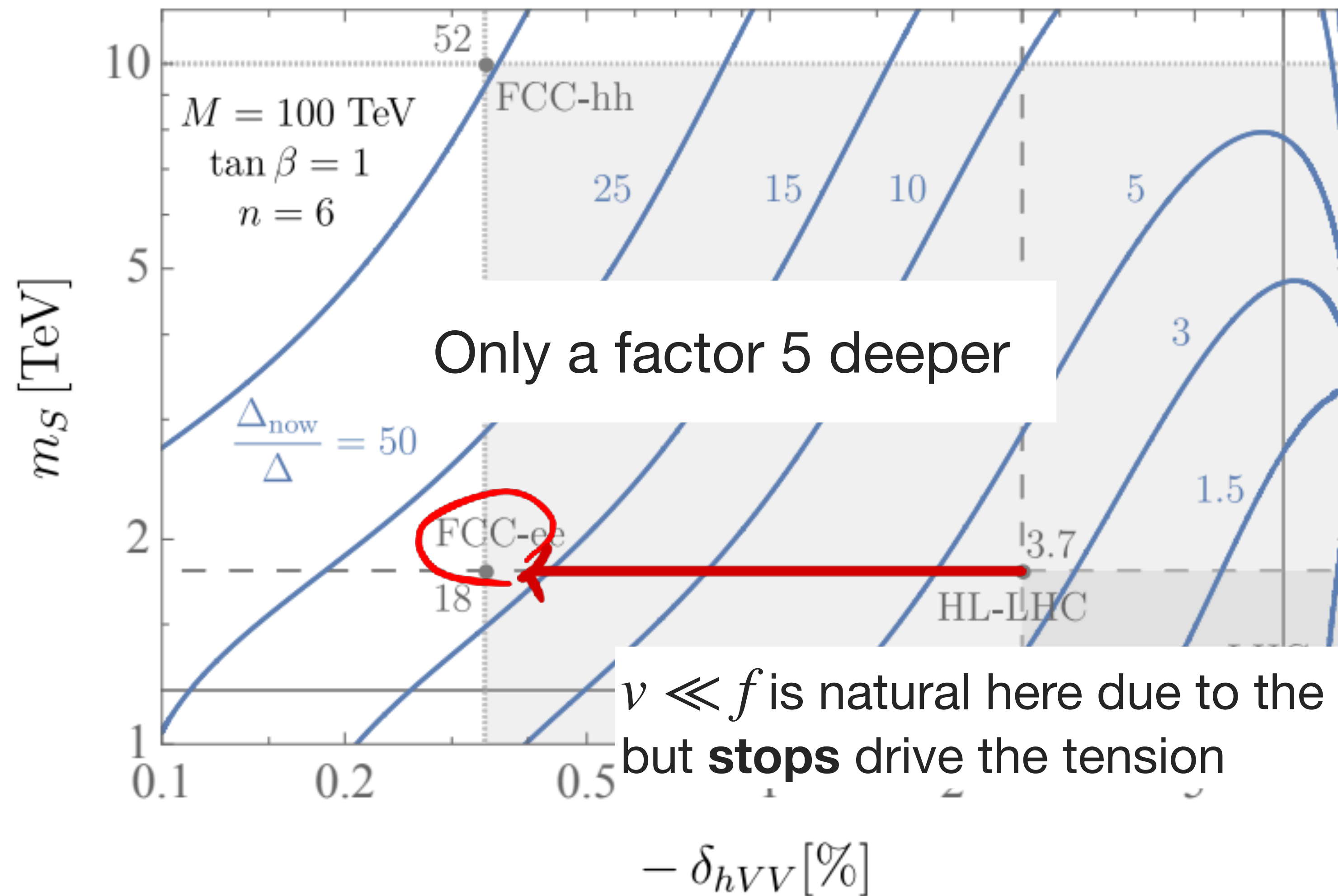
Evolution of the tuning



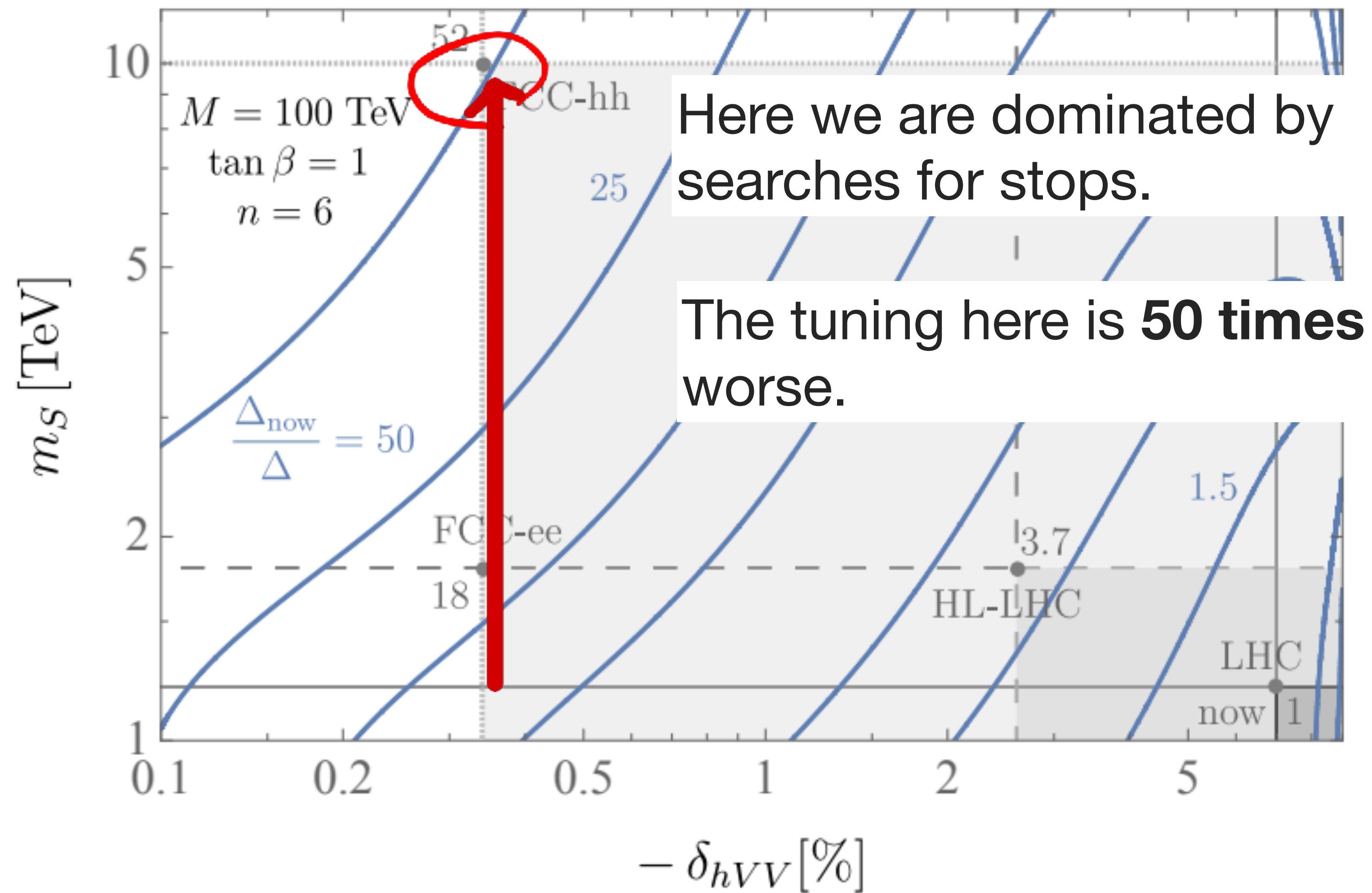
Increase in the tuning by a factor ~ 4 driven by

$$|\delta_{hVV}| < 2.6 \%$$

Evolution of the tuning



Evolution of the tuning



Conclusions

- For pNGB approaches to Higgs naturalness we are presently astride the '**direct search**' and '**indirect precision**' eras.

If all measurements continue to be SM like, even the Kitchen Sink can't scape tuning.

Optimistically: if evidence of naturalness is to arise, it may show first in the form of Higgs coupling deviations.