Why is theory important?

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- We are meeting here at Snowmass on the Mississippi to try to gain consensus as to future facilities in HEP
- Many options are available and it can be overwhelming to decide amongst the many attractive possibilities
- Guidance from theory can play a crucial role

- LHC has found a Higgs but no SUSY, and yet theorists tout ``naturalness" as motivation for weak scale SUSY
- Indeed in panel discussion we've heard that to tame large log contributions to m(h) requires sub-TeV top squarks
- In other papers, it is claimed that for certain choices of GUT scale relations, finetuning collapses in the scalar sector, allowing top squarks in the multi-TeV sector: this is called the focus point region
- It is no wonder that ``naturalness" can be confusing

- Let's eschew any discussion of the vagaries of high scale physics for the moment and focus on something closer to home: the weak scale scalar potential

$$V_{\rm scalar} = (m_{H_u}^2 + \mu^2)|h_u^0|^2 + (m_{H_d}^2 + \mu^2)|h_d^0|^2 - B\mu(h_u^0 h_d^0 + {\rm h.c.}) + \frac{1}{8}(g^2 + g'^2)\left(|h_u^0|^2 - |h_d^0|^2\right)^2$$

Setting derivatives equal to zero allows to find the minimum and relate vevs to the vector boson masses

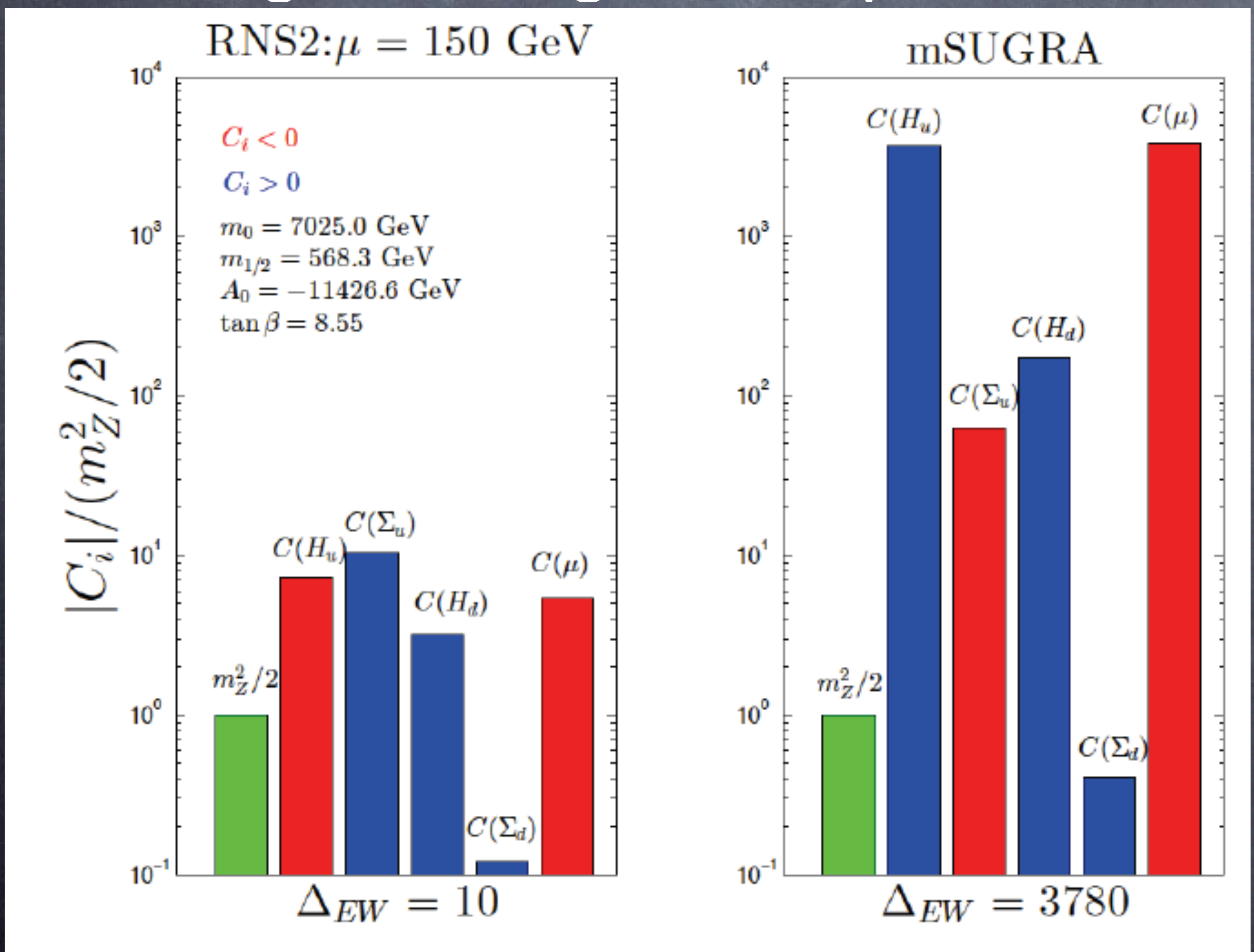
$$\frac{M_Z^2}{2} = \frac{m_{H_d}^2 + \Sigma_d^d - (m_{H_u}^2 + \Sigma_u^u)\tan^2\beta}{\tan^2\beta - 1} - \mu^2 \simeq -(m_{H_u}^2 + \Sigma_u^u) - \mu^2$$

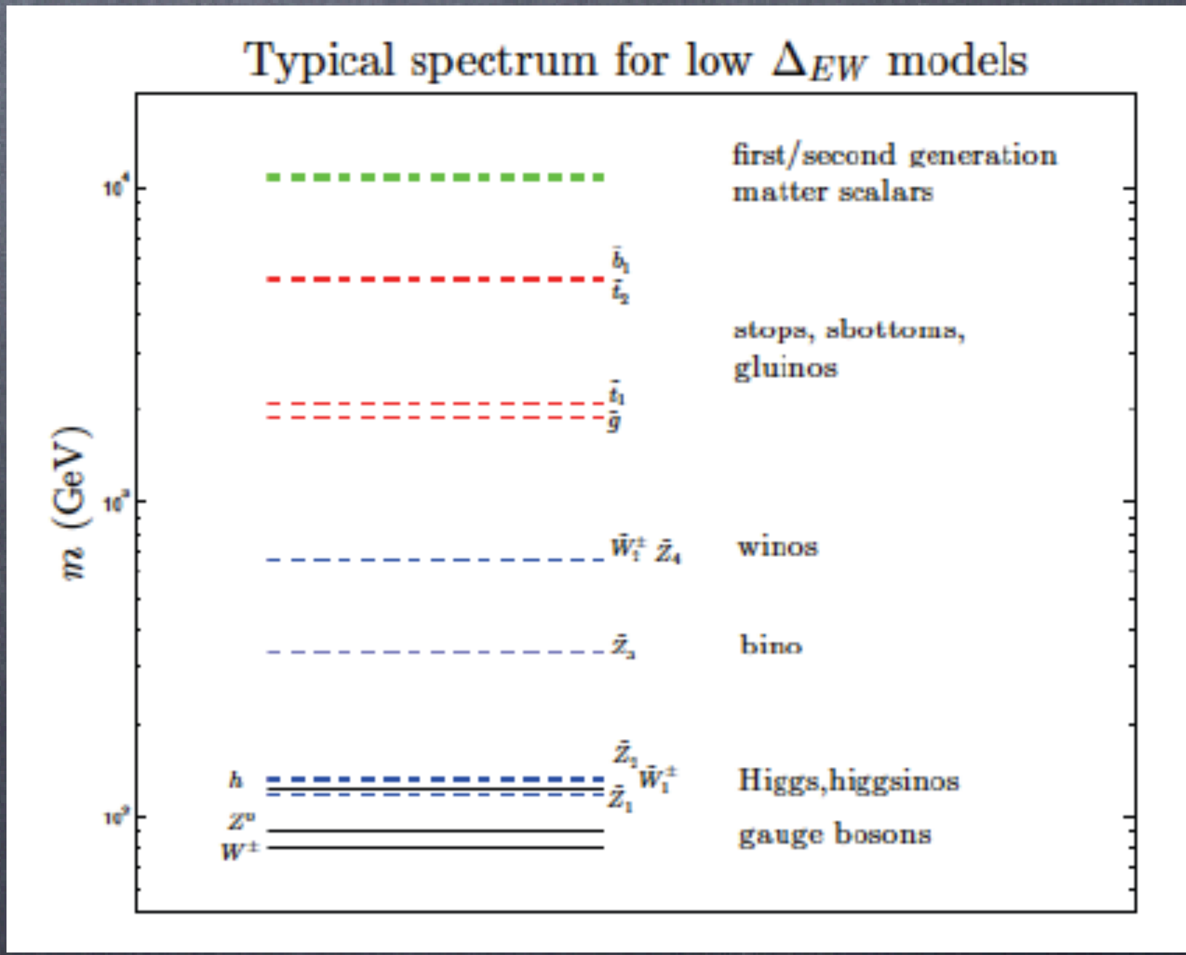
In computer codes which calculate sparticle masses, m(Hu)^2 is driven to large negative values.
mu^2 is set by hand to be large positive so that the two terms nearly cancel to give m(Z)~91.2 GeV

This we call electroweak finetuning; it is independent of high scale physics and unambiguous

To avoid EW finetuning:

- |mu|~m(Z)~100-200 GeV: light higgsinos!
- m(Hu)^2 driven small negative: FP or NUHM
- minimize radiative corrections: stops highly mixed but can live at 1-2 TeV (t1), 2-4 TeV (t2) scale:
  large mixing also uplifts m(h) to 125 GeV





- The 100-200 GeV higgsinos have highly compressed spectra: soft decay products can easily elude LHC searches
- Remaining spectra may be well beyond LHC reach
- The 100-200 GeV higgsinos would be readily apparent at ILC with E(cm)~300-500 GeV
- ILC would be higgsino factory in addition to Higgs factory

Lesson: US community should unite in support of the Japanese ILC initiative to bring this machine to reality!