The Abdus Salam
International Centre for Theoretical Physics

United Nations
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Beyond the Standard Model: Results with the 7 TeV LHC Collision Data

19 - 23 September 2011

Higgs

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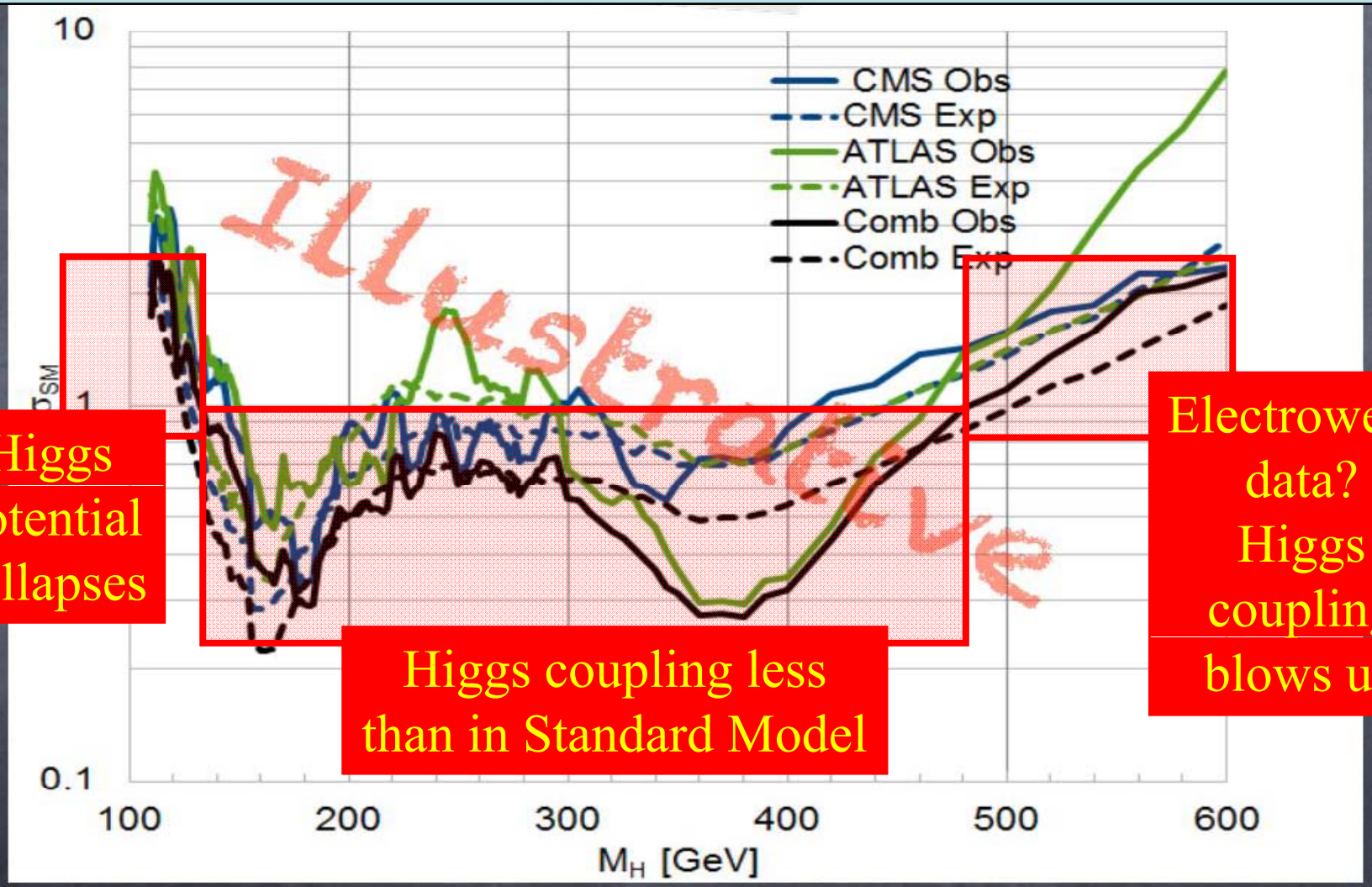
The Stakes in the Higgs Search

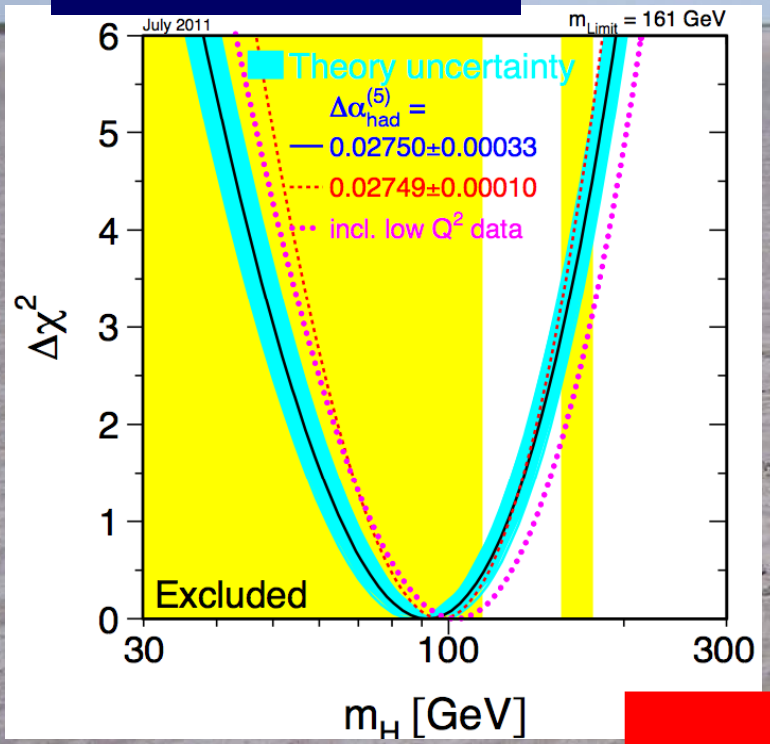
- How is particle symmetry broken?
- Is there an elementary scalar field?
- What is the fate of the Standard Model?
- Did mass appear when the Universe was a picosecond old?
- Did Higgs help create the matter in the Universe?
- Did a related inflaton make the Universe so big and old?
- Why is there so little dark energy?

There must be New Physics beyond the Higgs Boson

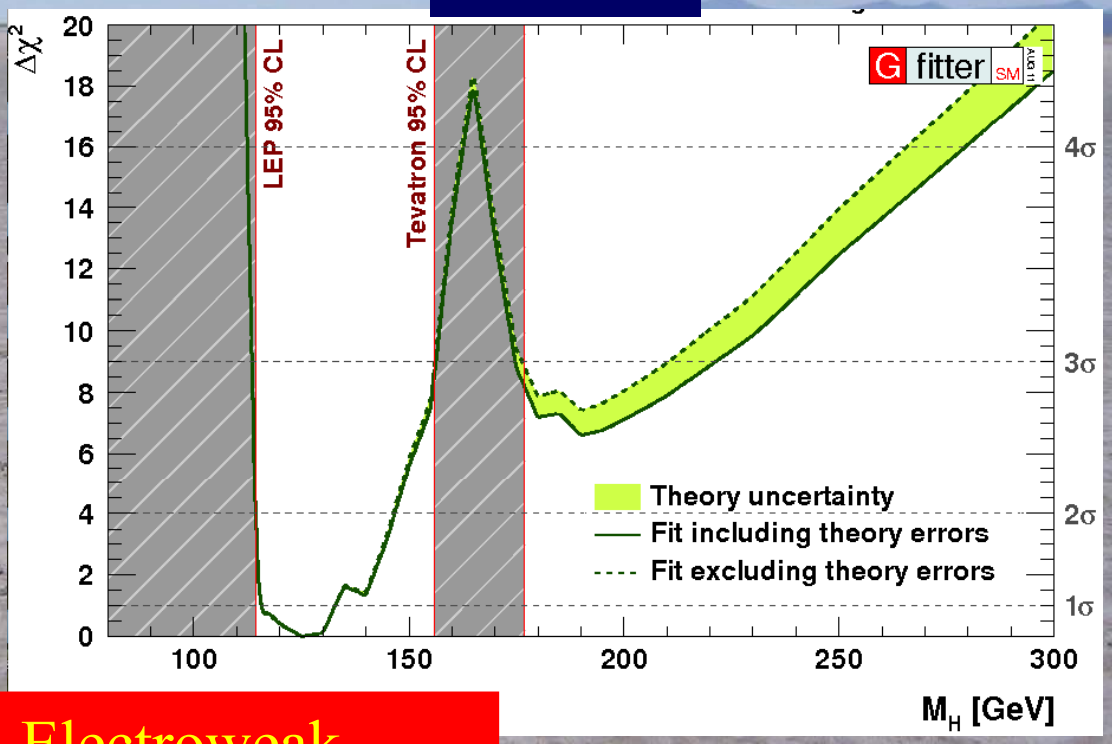


m_H: Blue Band vs Green Band

LEPEWWG



Gfitter



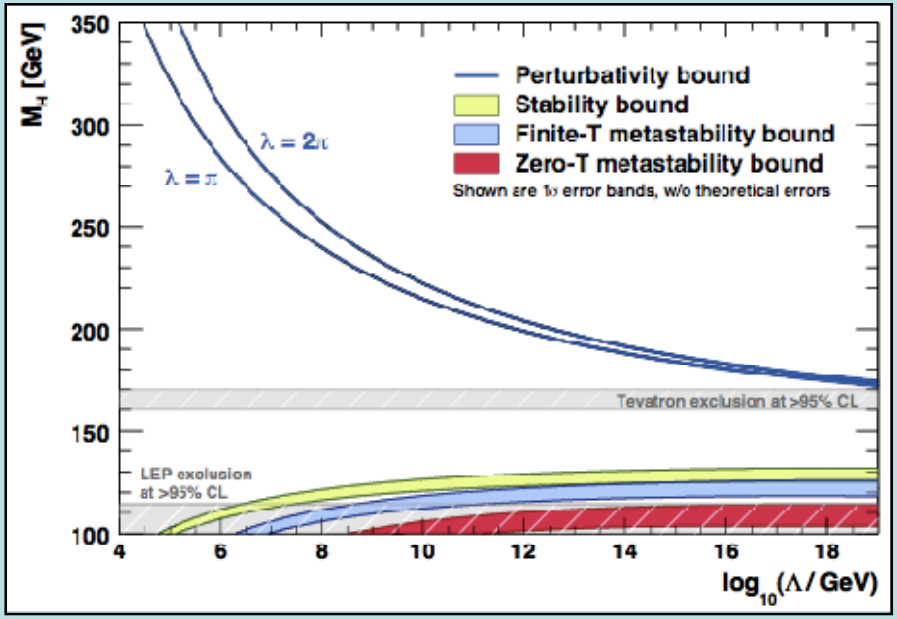
Precision data vs LEP, Tevatron

Electroweak data strongly disfavour Higgs > 500 GeV

Combination with LHC

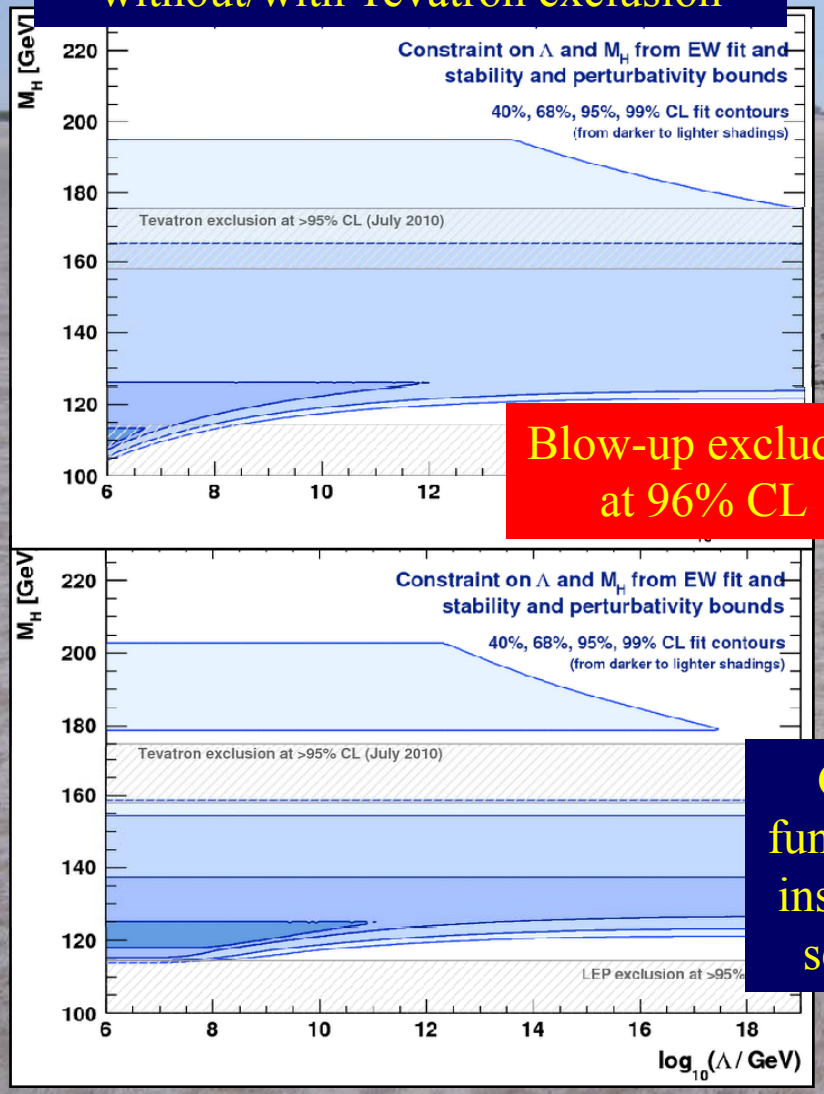
Theoretical Constraints on Higgs Mass

- Large → large self-coupling → blow up at low energy scale Λ due to renormalization
- Small: renormalization due to t quark drives quartic coupling < 0 at some scale Λ
  → vacuum unstable
- Bounds on Higgs mass depend on Λ



What is the probable fate of the SM?

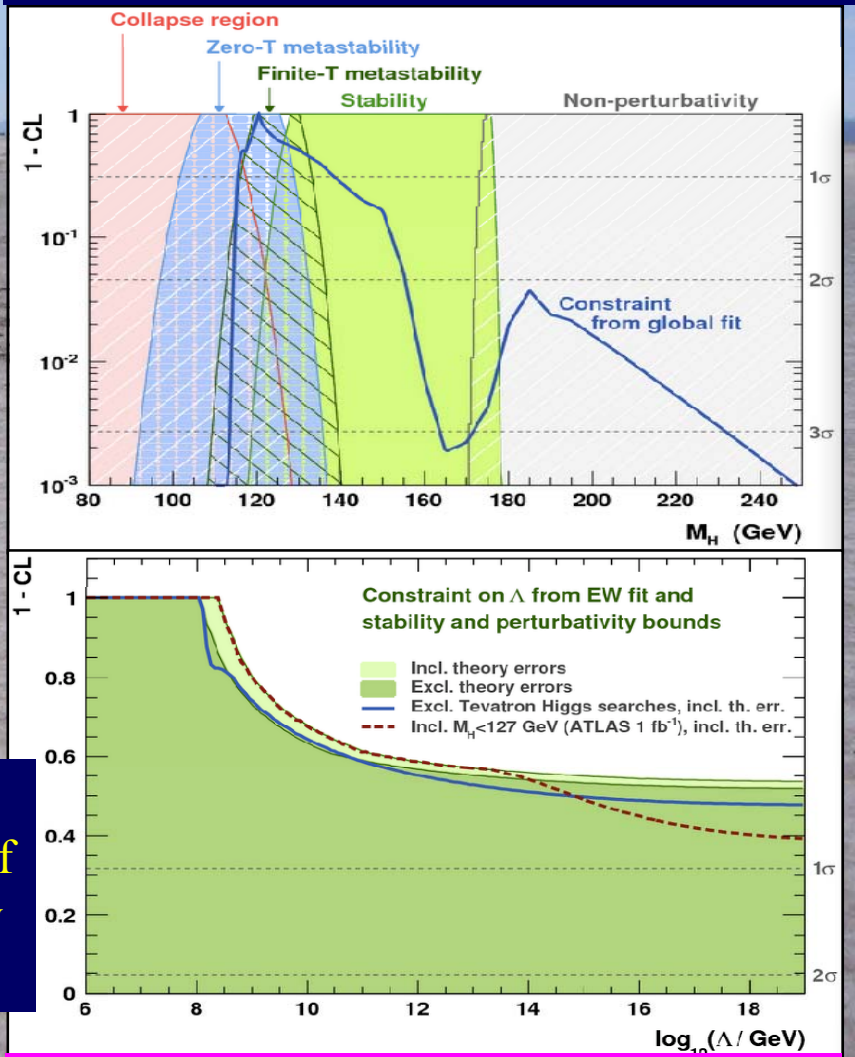
Confidence Levels (CL) without/with Tevatron exclusion



Blow-up excluded at 96% CL

CL as function of instability scale Λ

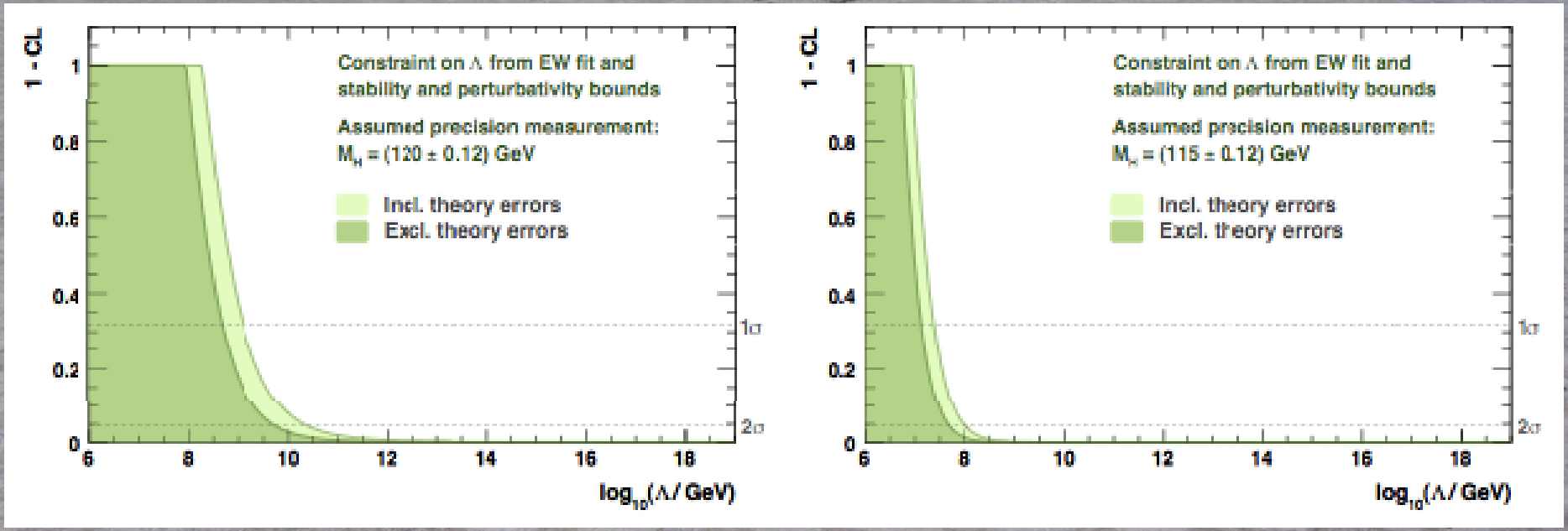
Confidence Levels (CL) for different fates



Espinosa, JE, Giudice, Hoecker, Riotto, arXiv0906.0954

The LHC will Tell the Fate of the SM

Examples with LHC measurement of m_H = 120 or 115 GeV



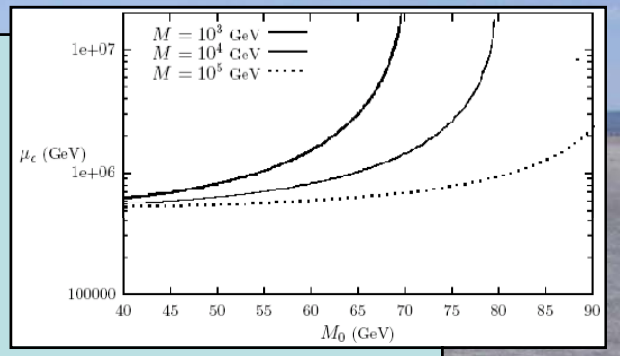
Espinosa, JE, Giudice, Hoecker, Riotto

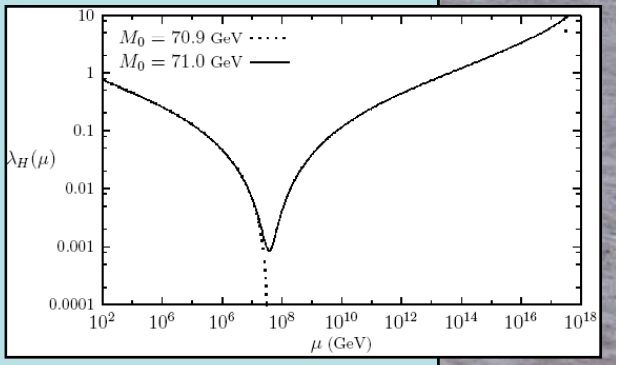
How to Stabilize a Light Higgs Boson?

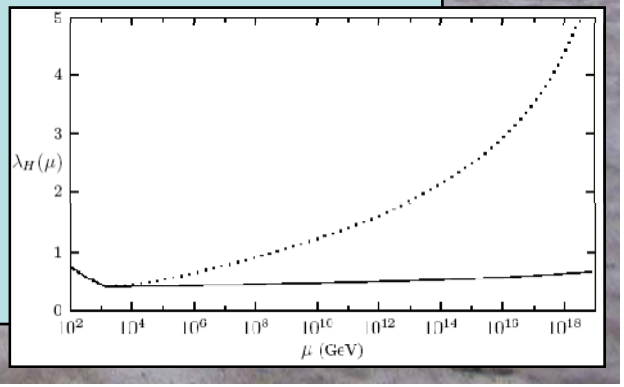
- **Top quark destabilizes potential:**
- **introduce introduce stop-like scalar**:

$$\mathcal{L} \supset M^2|\phi|^2 + \frac{M_0}{v^2}|H|^2\,|\phi|^2$$

- Can delay collapse of potential:
- But new coupling must be fine-tuned to avoid blow-up:
- Stabilize with new fermions:
  - just like Higgsinos
- Very like **Supersymmetry!**







What if the Higgs is not a Higgs?

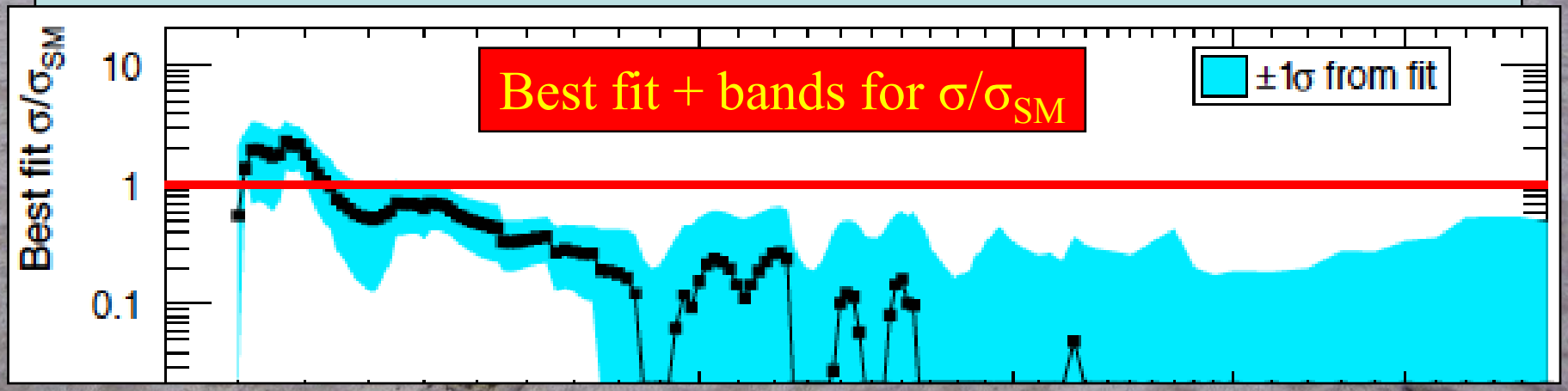
- Tree-level Higgs couplings ~ masses
  - Coefficient ~ 1/v
- Couplings ~ dilaton of scale invariance
- Broken by Higgs mass term $-\mu^2$, anomalies
  - Cannot remove μ^2 (Coleman-Weinberg)
  - Anomalies give couplings to $\gamma\gamma$, gg
- **Generalize to pseudo-dilaton of new (nearly) conformal strongly-interacting sector**
- Couplings ~ m/V (V > v?), additions to anomalies

A Phenomenological Profile of a Pseudo-Dilaton

- New strongly-interacting sector at scale ~ V
- Pseudo-dilaton only particle with mass << V
- Universal suppression of couplings to Standard Model particles ~ v/V
- Possible enhancement of coupling to gg
- Possible suppression of coupling to γγ
- Modified self-couplings: effective potential
- ~ χ^4 [ln(χ/V) – ¼] + anomalous dimensions
- Pseudo-baryons as dark matter?

How to present the results?

- Exclusion of the Higgs is as big a deal as discovering it
  - Need confidence level > 95%: 99%?
- Plan for measurement of Higgs
  - Plot best fit of cross section



Where this Picture was taken …