The Dilaton as Higgs Impostor?

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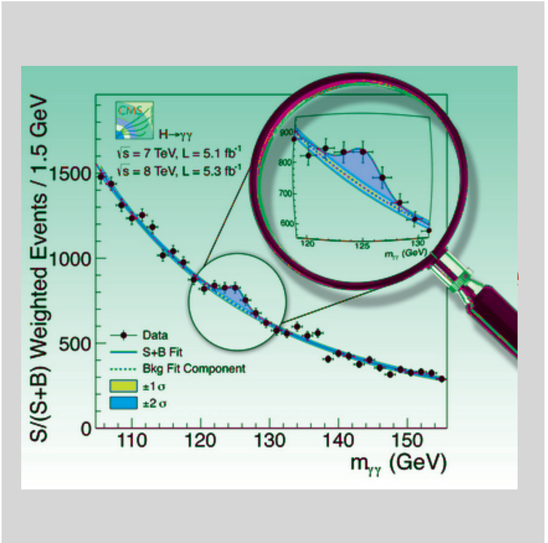
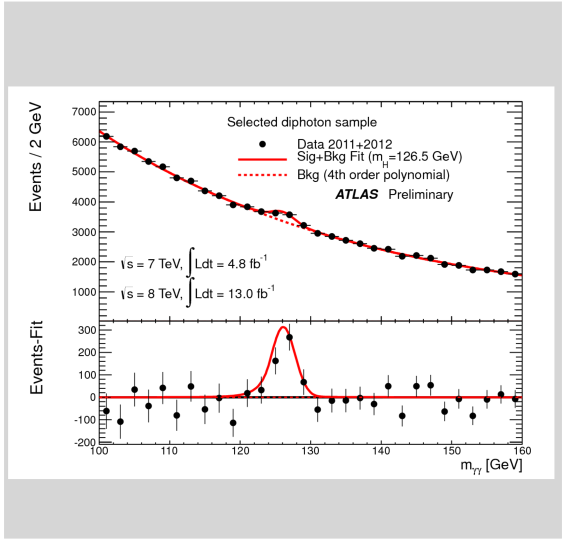
What is the Higgs particle ?

Debate after the discovery and the Nobel Prize





voices: a light Higgs-like scalar was found, consistent with elementary scalar in the Standard Model, and composite states have not been seen below 1 TeV. Strongly coupled Beyond the Standard Model gauge theories are Higgs-less with resonances below 1 TeV.

facts: compositeness and a light Higgs scalar are not incompatible; search for composite states was not based on solid predictions but on naively scaled up QCD and unacceptable old technicolor guessing games.

dilaton: perhaps the most intriguing new scenario, a light pseudo-Goldstone particle of broken scale invariance of the near-conformal gauge theory.

lattice plans: LHC14 will search for new physics from compositeness and SUSY, and the lattice BSM community is preparing quantitative lattice based predictions to be ruled in or ruled out.
We better get it right!

Elementary, or composite?

- After the Higgs is found why bother with BSM? Nothing else was seen and perhaps no new physics below the Planck scale?
- But Standard Model Higgs potential of the elementary scalar is parametrization rather than dynamical explanation:
  $\lambda\phi^4$ not gauge force - severe consequences!
- Built in cutoff from triviality with quadratic divergences leading to fine tuning and the hierarchy problem; vacuum instability.
- Standard Model is low energy effective theory with built in cut-off.
- Can new physics from compositeness hide within LHC14 reach, or just above, with some imprint to see?
- Can we make some predictions on what to expect it in the LHC14 run?

What is the dilaton?

Partially conserved dilatation current

$$m_\sigma^2 \simeq -\frac{4}{f_\sigma^2}\langle 0|\left[\Theta^\mu_\mu(0)\right]_{NP}|0\rangle$$

Partially Conserved Dilatation Current (PCDC) will the gradient flow help to make it precise?

$$\partial_\mu \mathcal{D}^\mu = \Theta^\mu_\mu = \frac{\beta(\alpha)}{4\alpha} G^a_{\mu\nu} G^{a\mu\nu}$$

Dilatation current

$$\langle 0|\Theta^{\mu\nu}(x)|\sigma(p)\rangle = \frac{f_\sigma}{3}(p^\mu p^\nu - g^{\mu\nu} p^2)e^{-ipx}$$

$$\langle 0|\partial_\mu \mathcal{D}^\mu(x)|\sigma(p)\rangle = f_\sigma m_\sigma^2 e^{-ipx}$$

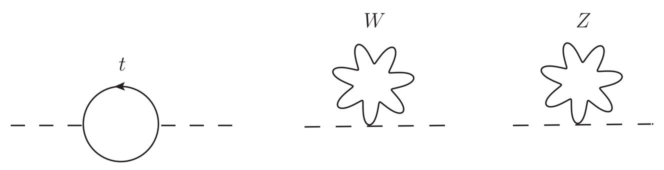
$$\left[\Theta^\mu_\mu\right]_{NP} = \frac{\beta(\alpha)}{4\alpha}\left[G^a_{\mu\nu} G^{a\mu\nu}\right]_{NP} \qquad \frac{m_\sigma}{f_\sigma} \to ?$$

Light dilaton?

but how light is light ?

few hundred GeV Higgs impostor?

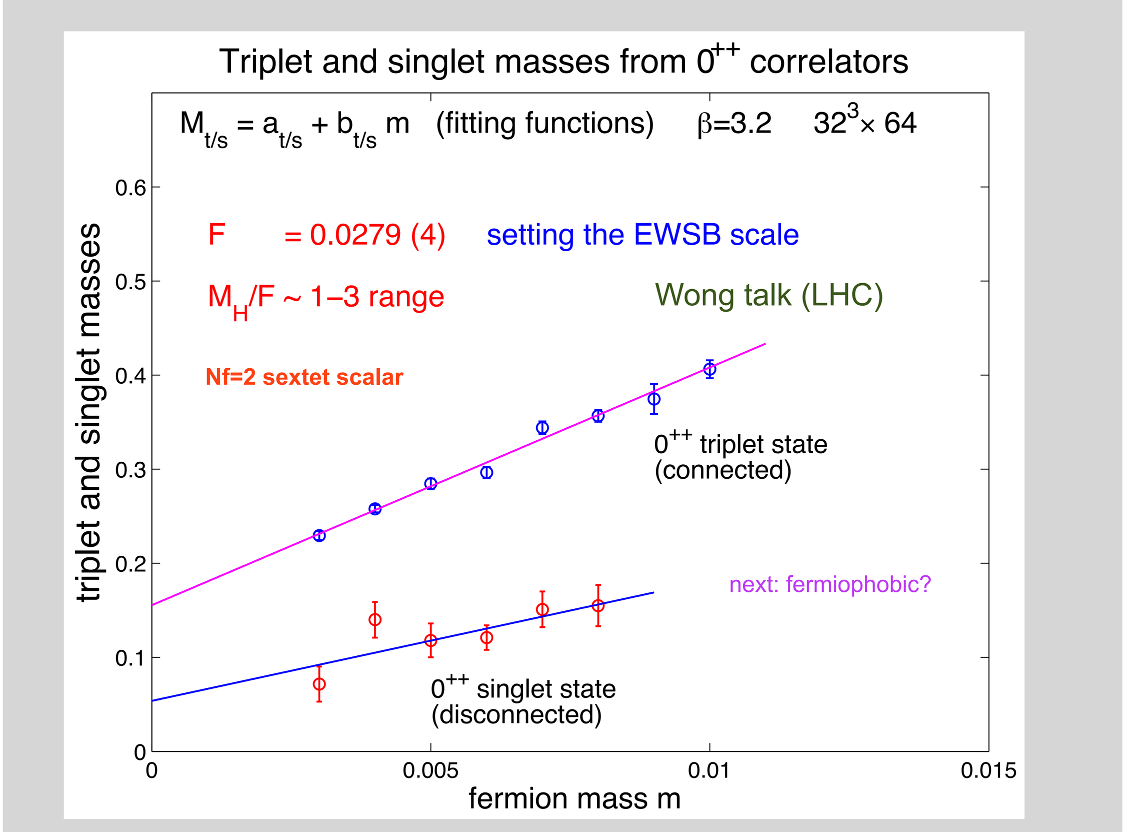
Foadi, Fransden, Sannino
open for spirited theory discussions



$$\delta M_H^2 \sim -12\kappa^2 r_t^2 m_t^2 \sim -\kappa^2 r_t^2 (600\,\mathrm{GeV})^2$$

The big surprise from simulations:

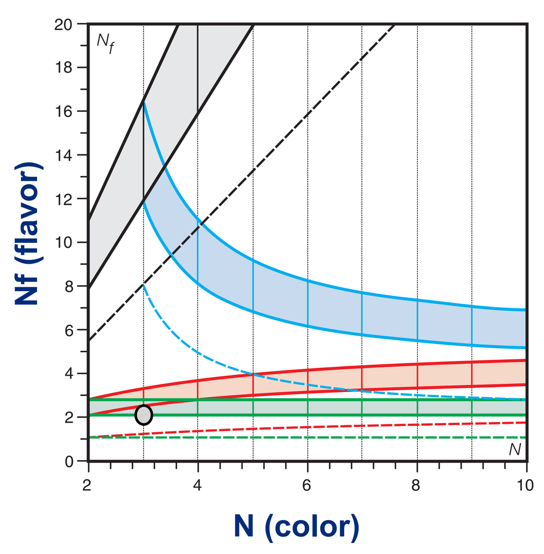
Dilaton-like scalar states in SCGT, or "just a light Higgs" ?



Candidate theory: sextet rep

The model:

SCGT: theory space and conformal window important for composite Higgs realization
space of color, flavor, and fermion representation



to illustrate: sextet SU(3) color rep $\begin{bmatrix} u \\ d \end{bmatrix}$

one massless fermion doublet
χSB on Λ~TeV scale

three Goldstone pions
become longitudinal
components of weak bosons

composite Higgs mechanism
scale of Higgs condensate ~ F=250 GeV

conflicts with EW constraints?

χSB on Λ~TeV scale

walking gauge coupling?

fermion mass generation (effective EW int)

composite Higgs mechanism ?

broken scale invariance (dilaton) ? or light non-SM composite Higgs particle?

Early work using sextet rep:

Marciano (QCD paradigm, 1980)

Kogut,Shigemitsu,Sinclair (quenched, 1984)

recent work:

DeGrand,Shamir,Svetitsky
IRFP or walking gauge coupling

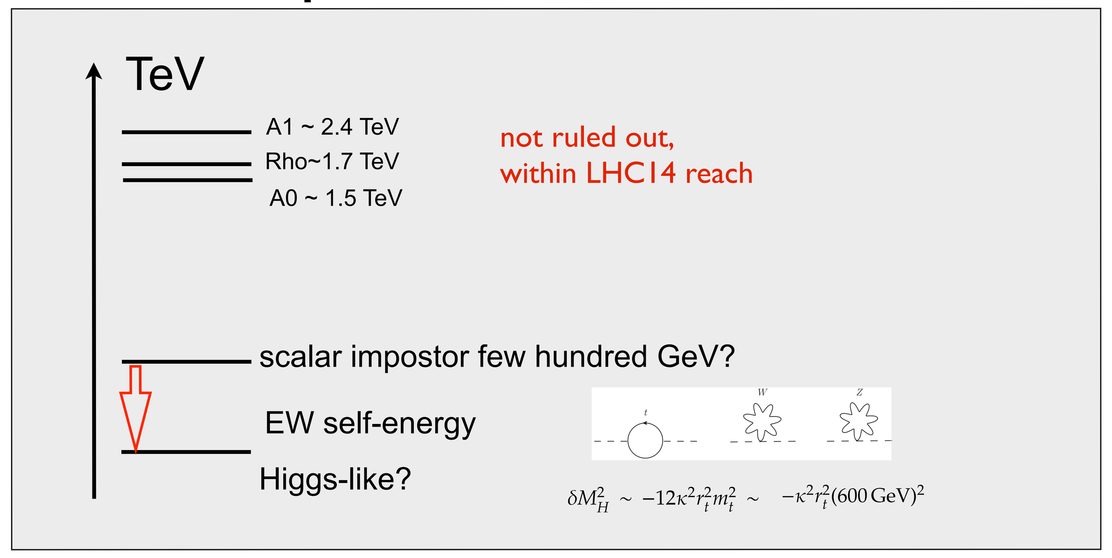
Lattice Higgs Collaboration
χSB

Kogut,Sinclair
finite temperature

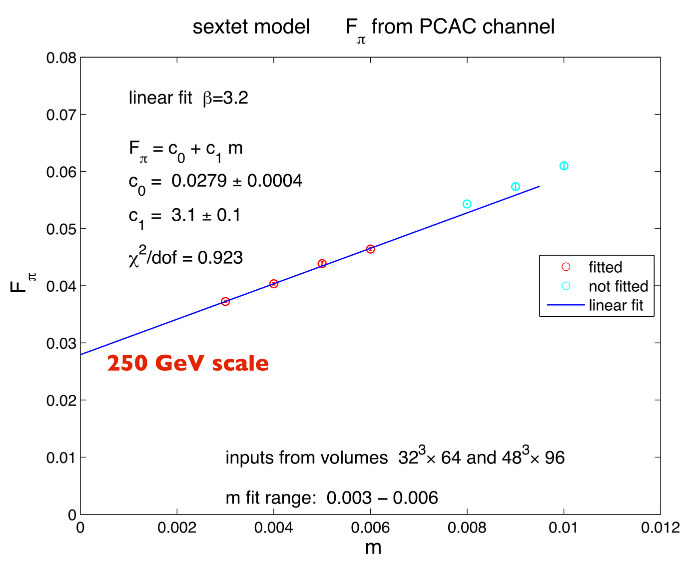
(1) χSB and confinement
(2) light scalar close to CW (with walking) ?

LHC14 predictions

Resonance spectrum



Scale setting in simulation:

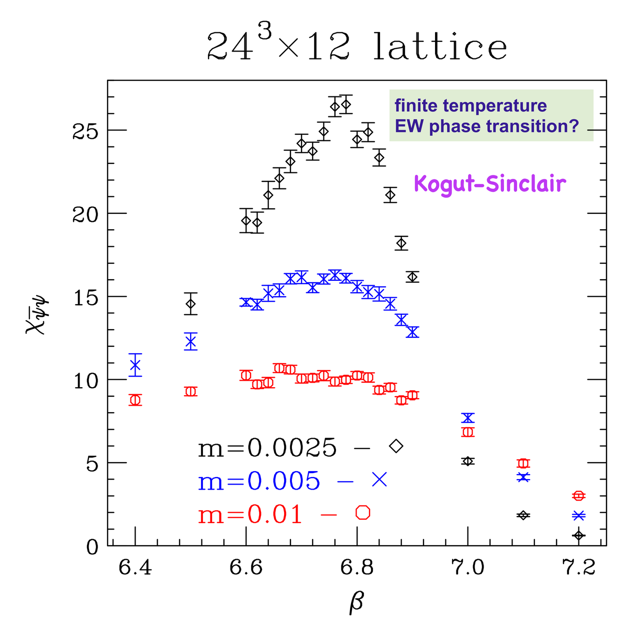


BSM lattice toolset

Early universe: Electroweak transition

Kogut-Sinclair work consistent with χSB phase transition

Relevance in early cosmology (order of the phase transition)?



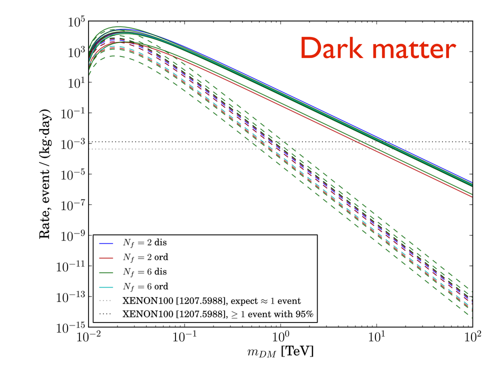
Early universe: Dark matter

self-interacting?
O(barn) cross section would be challenging

The Total Energy of the Universe:

Vacuum Energy (Dark Energy)	~	67 %
Dark Matter	~	29 %
Visible Baryonic Matter	~	4 %

T. Appelquist, R. C. Brower, M. I. Buchoff, M. Cheng, S. D. Cohen, G. T. Fleming, J. Kiskis, M. F. Lin, E. T. Neil, J. C. Osborn, C. Rebbi, D. Schaich, C. Schroeder, S. Syritsyn, G. Voronov, P. Vranas, and J. Wasem (Lattice Strong Dynamics (LSD) Collaboration)



- lattice BSM phenomenology of dark matter
  pioneering LSD work
- Nf=2 Qu=2/3 Qd = -1/3
  udd neutral dark matter candidate
- dark matter candidate sextet Nf=2
  electroweak active in the application
- there is room for third heavy fermion flavor as electroweak singlet
- rather subtle sextet baryon construction (symmetric in color)

References

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