Partially Composite Higgs in Supersymmetry

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based on 1206.4053 [hep-ph] (with Markus Luty and Yuichiro Nakai)

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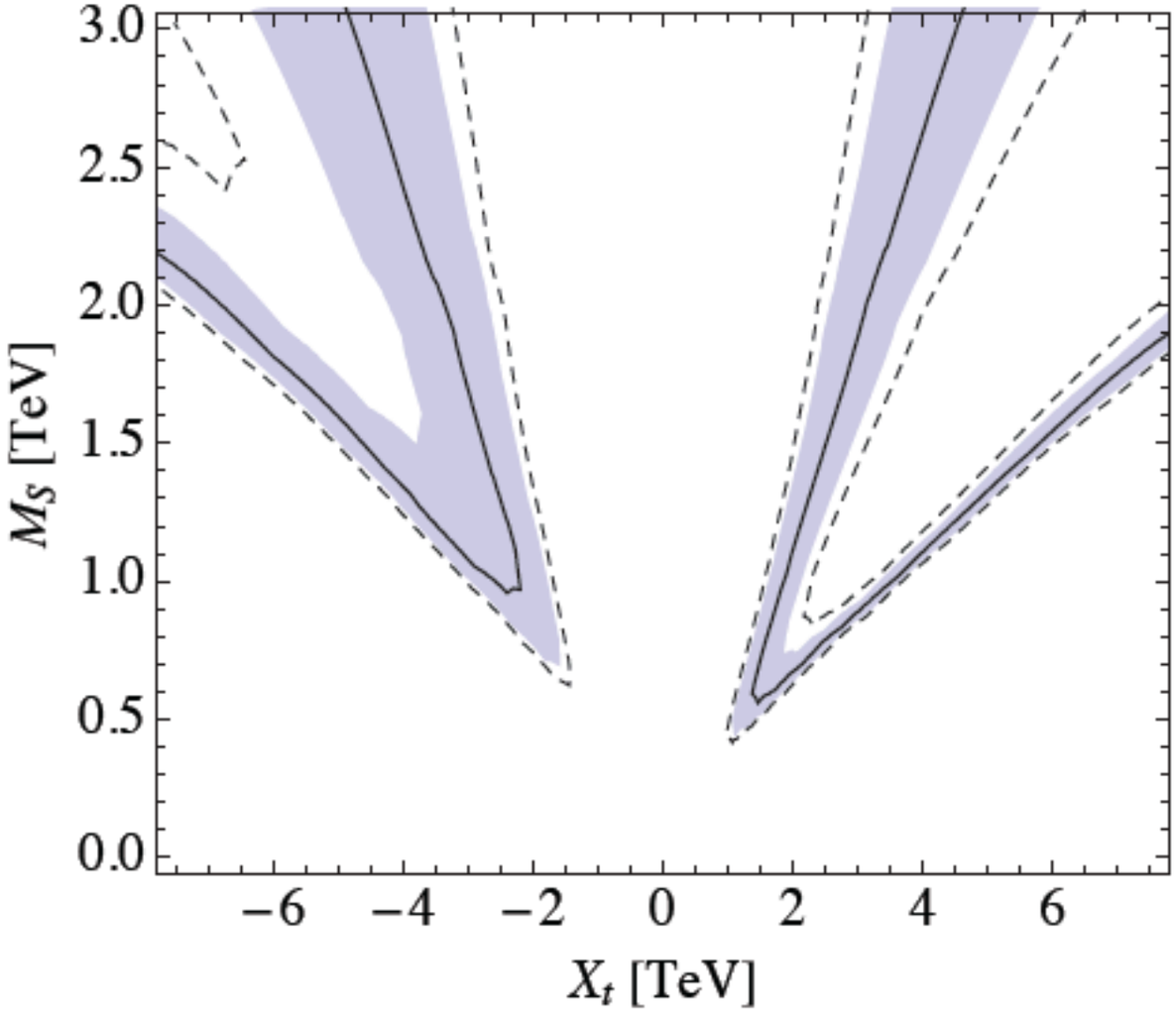
The Higgs boson

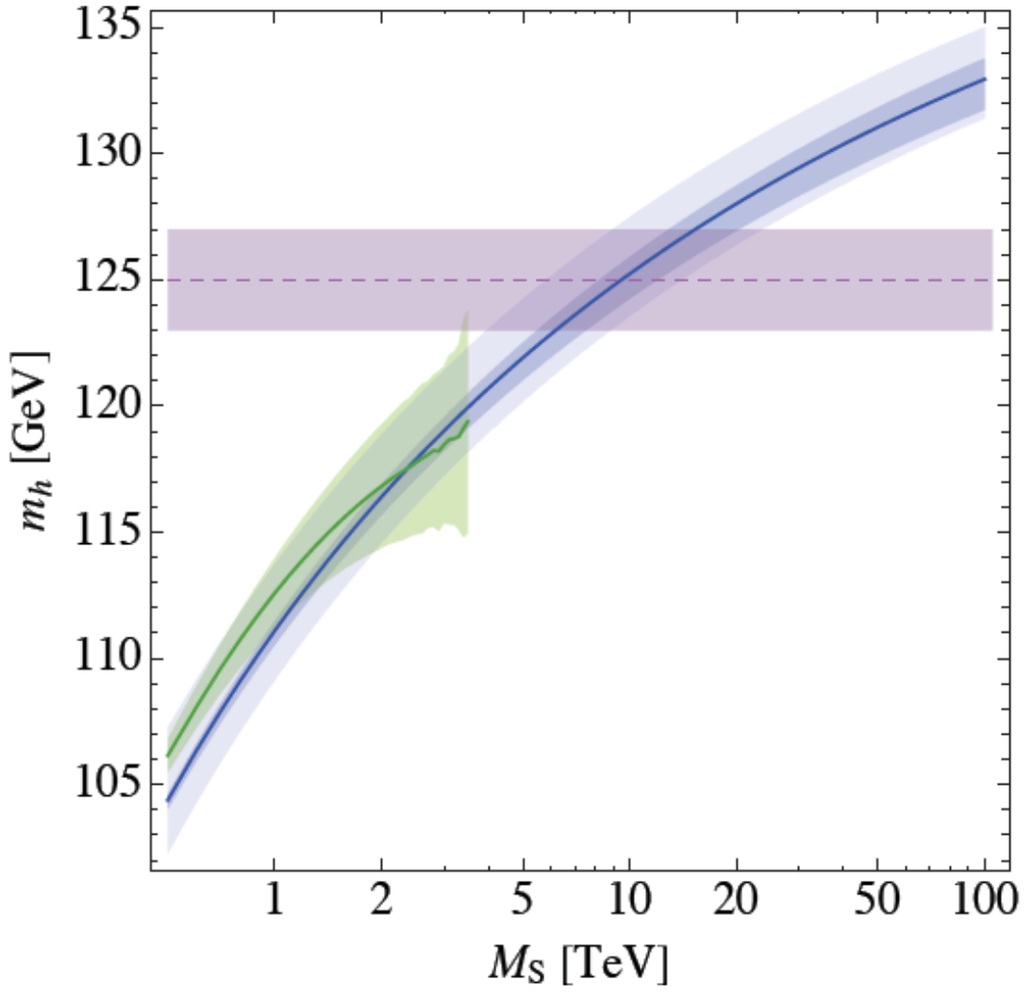
126GeV

light? heavy?

For MSSM believers

It is heavy.





[Draper, Meade, Reece, Shih '11]

For technicolor believers

The scale up sigma meson mass is O(TeV).

126GeV is too light.

This may be suggesting...

The Higgs boson is half elementary and half composite.

In SUSY framework,

The Higgs fields have no quartic potential in the D-flat direction.

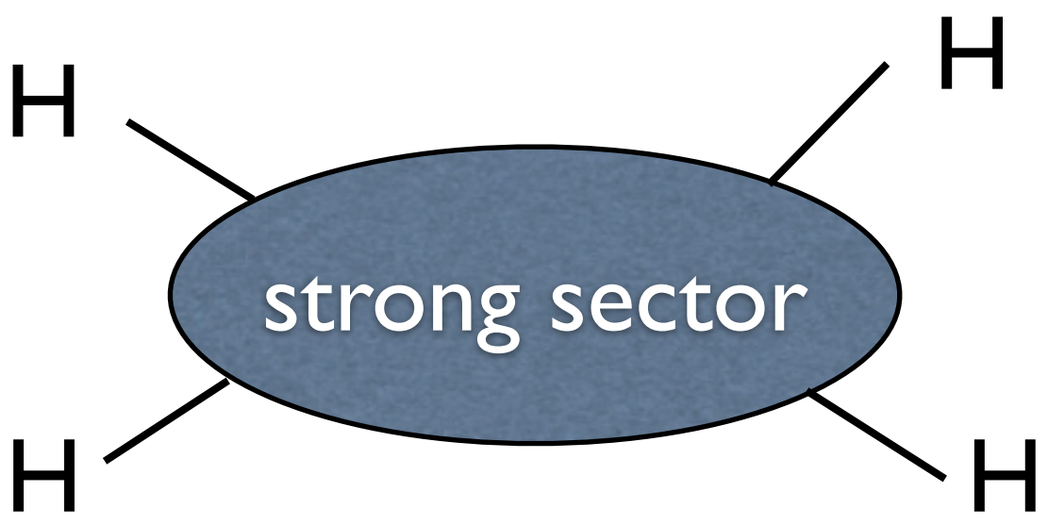
$\longrightarrow$ $m_h=0$ at tree level.

This is an excellent starting point rather than $m_h \sim \Lambda$.

Now we assume that,

the Higgs fields are weakly coupled to a strongly interacting sector so that the Higgs fields are partially composite.

$$W = \lambda_u H_u \mathcal{O}_d + \lambda_d H_d \mathcal{O}_u,$$



The Higgs potential is generated at the quantum level.

The coupling needs to be fairly strong to explain 126GeV.

(As we know, the top Yukawa was not sufficient.)

$\longrightarrow$ UV complete?

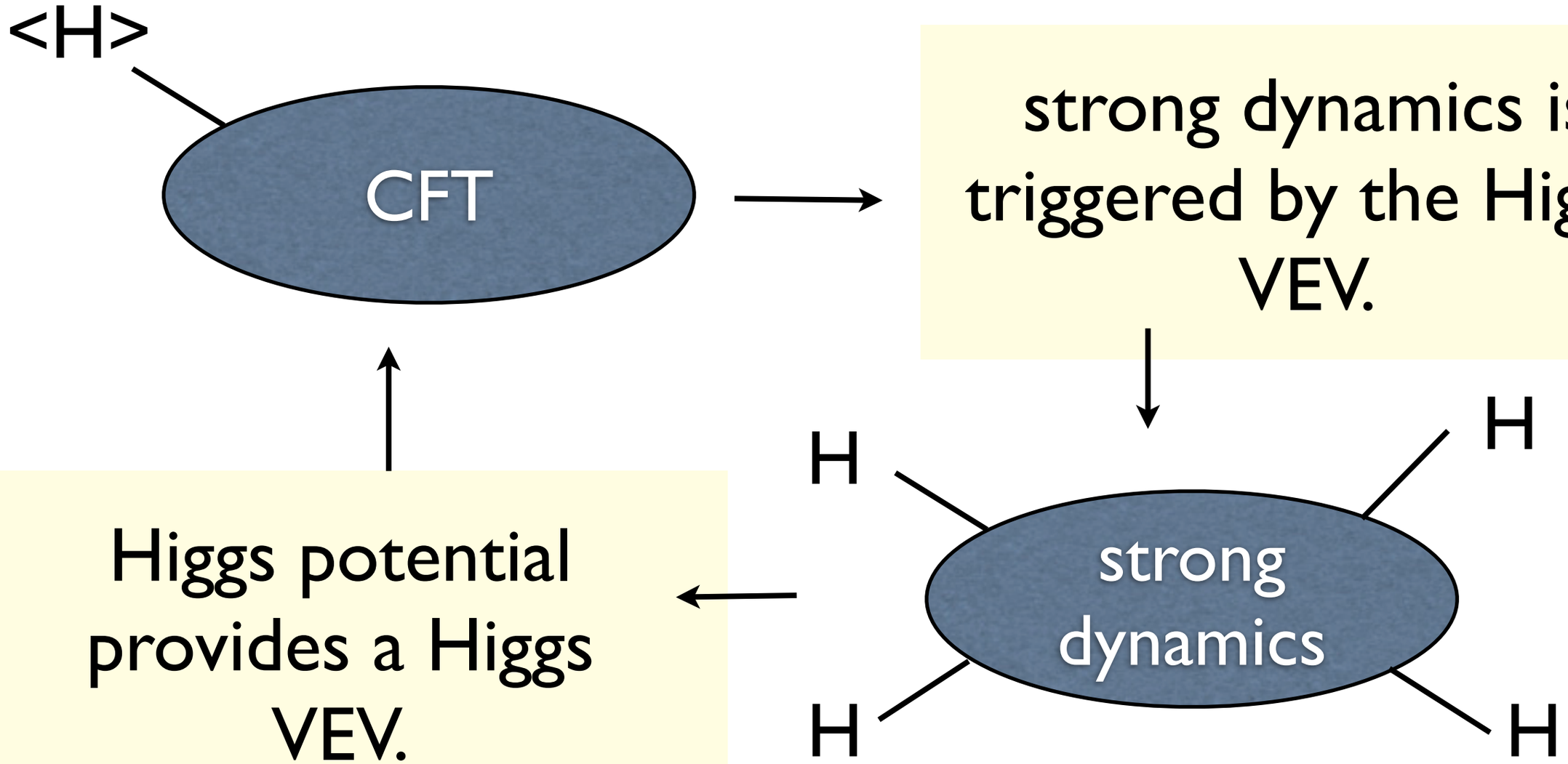
If the strong sector is CFT, there is no UV problem.

$$W = \lambda_u H_u \mathcal{O}_d + \lambda_d H_d \mathcal{O}_u,$$

These are relevant operators if O's have dimension less than 2.

Higgs bootstrap

We can obtain an interesting picture.



General structures

Let's define

dynamical scale

$$\epsilon \sim \frac{\Lambda}{4\pi v}$$

Higgs VEV

This is smaller than one, if the Higgs to CFT coupling is not strong.

Lower dynamical scale than that of technicolor models.

Dynamical superpotential

At the supersymmetric level, one can obtain a dynamical superpotential:

$$\Delta W_{\rm dyn} \sim \frac{\Lambda^3(H)}{16\pi^2}$$

(Naive dimensional analysis)

from this, we have

$$V \sim \frac{\Lambda^6(H)}{(4\pi)^4 H^2} \sim (4\pi)^2 \epsilon^6 v^4$$

For this contribution to explain the 126GeV Higgs,

$$V \sim (4\pi)^2 \epsilon^6 v^4 \sim m_h^2 v^2$$

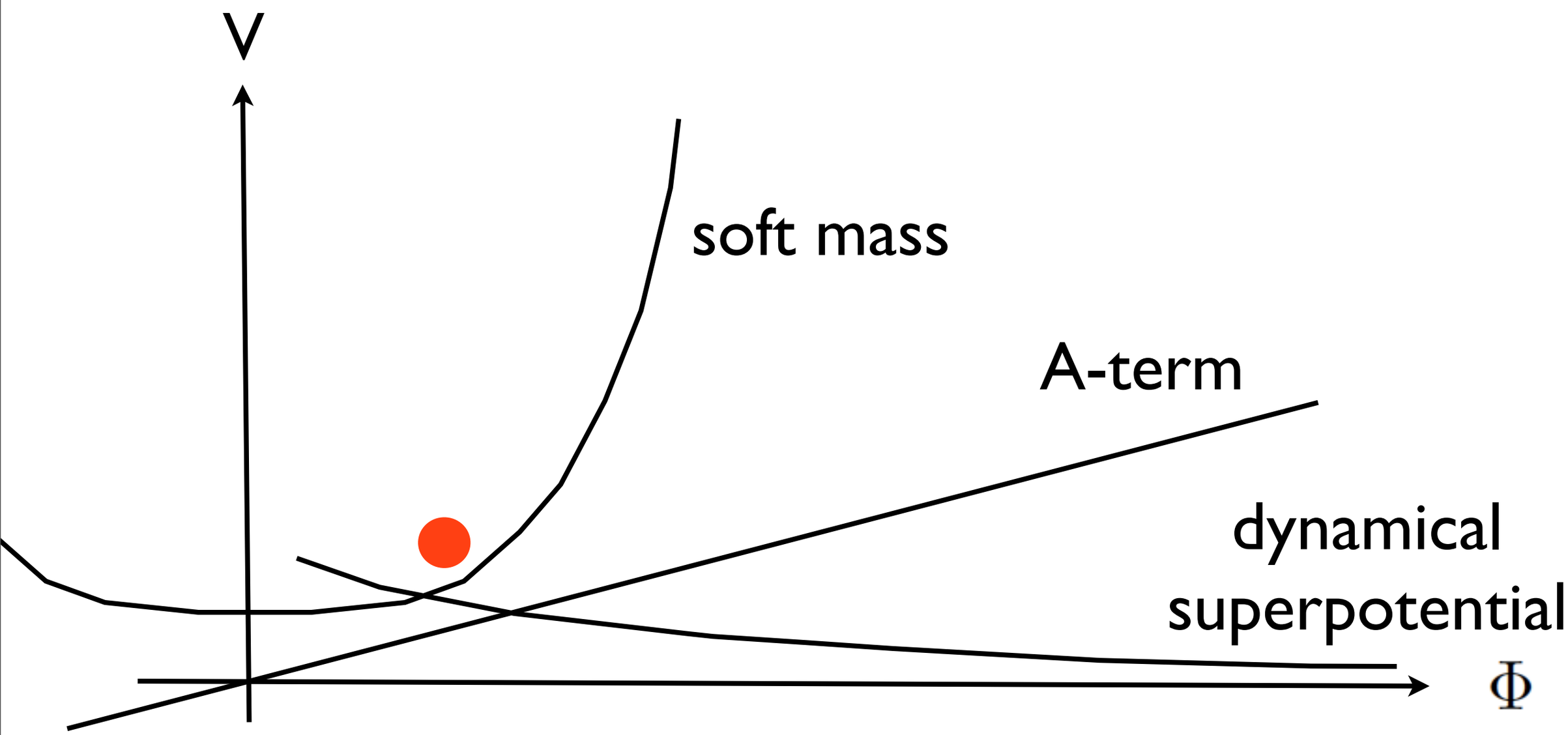
$$\longrightarrow \quad \epsilon \sim 0.4 \qquad (\Lambda \sim 800 \text{ GeV})$$

Just a little bit lower dynamical scale can explain 126GeV Higgs mass.

Since this is a supersymmetric contribution, the Higgsino mass is also generated at O(100) GeV.

Higgs potential

very different from the MSSM!



Electroweak symmetry breaking can happen by a balance between SUSY and SUSY breaking contributions.

A message:

Higgs is light ~126GeV

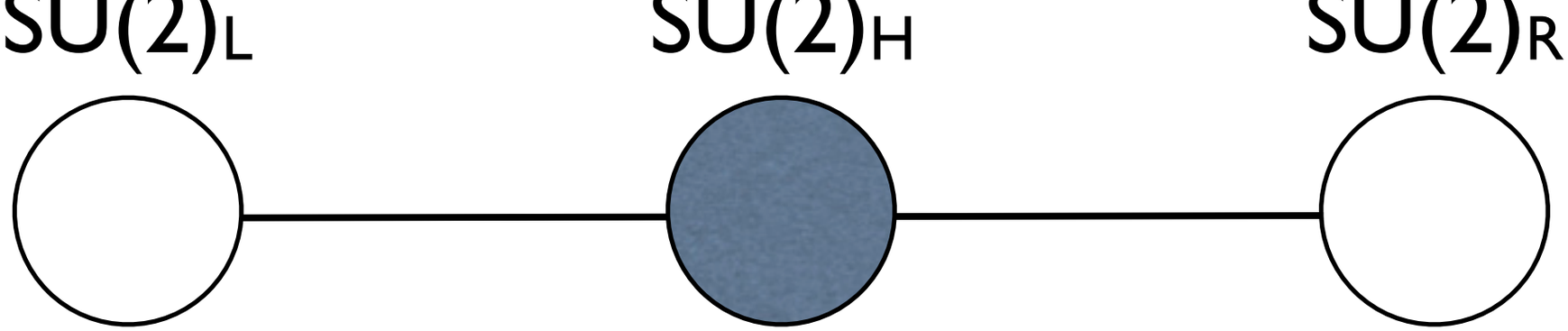
The technirho is also light ~800GeV.

An explicit model

One can obtain a hint from QCD.

Hidden Local Symmetry

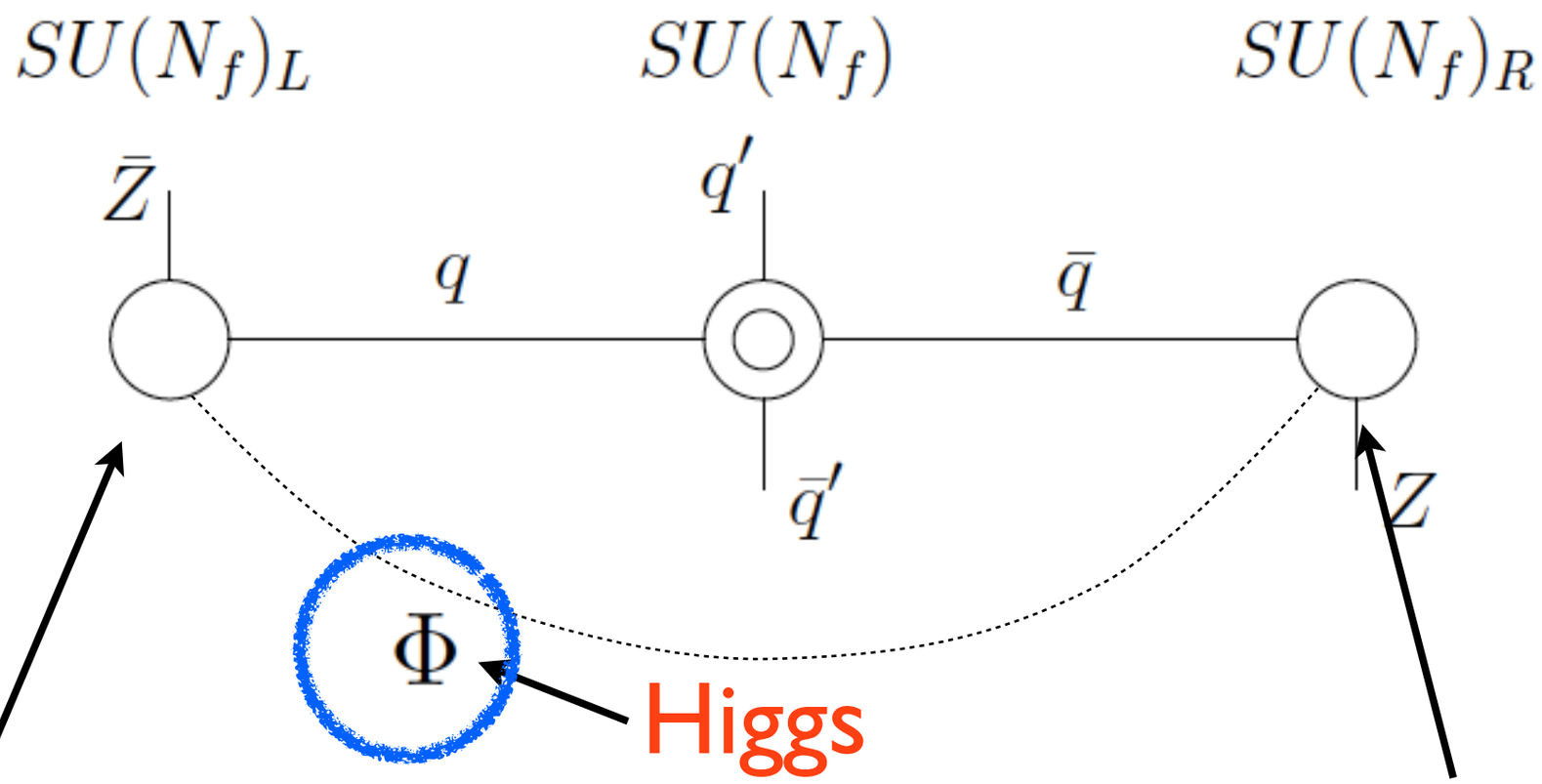
The effective theory of (ρ, π) system.



What's missing for EWSB is the Higgs boson.

One can couple the Higgs fields to it to get a model of Partially Composite Higgs.

HLS + Higgs + SUSY



Weakly gauged ($SU(2)_L$)

W,Z

Weakly gauged ($U(1)_Y$)

B

We can actually obtain the model as the magnetic dual picture of a SUSY QCD in the conformal window.

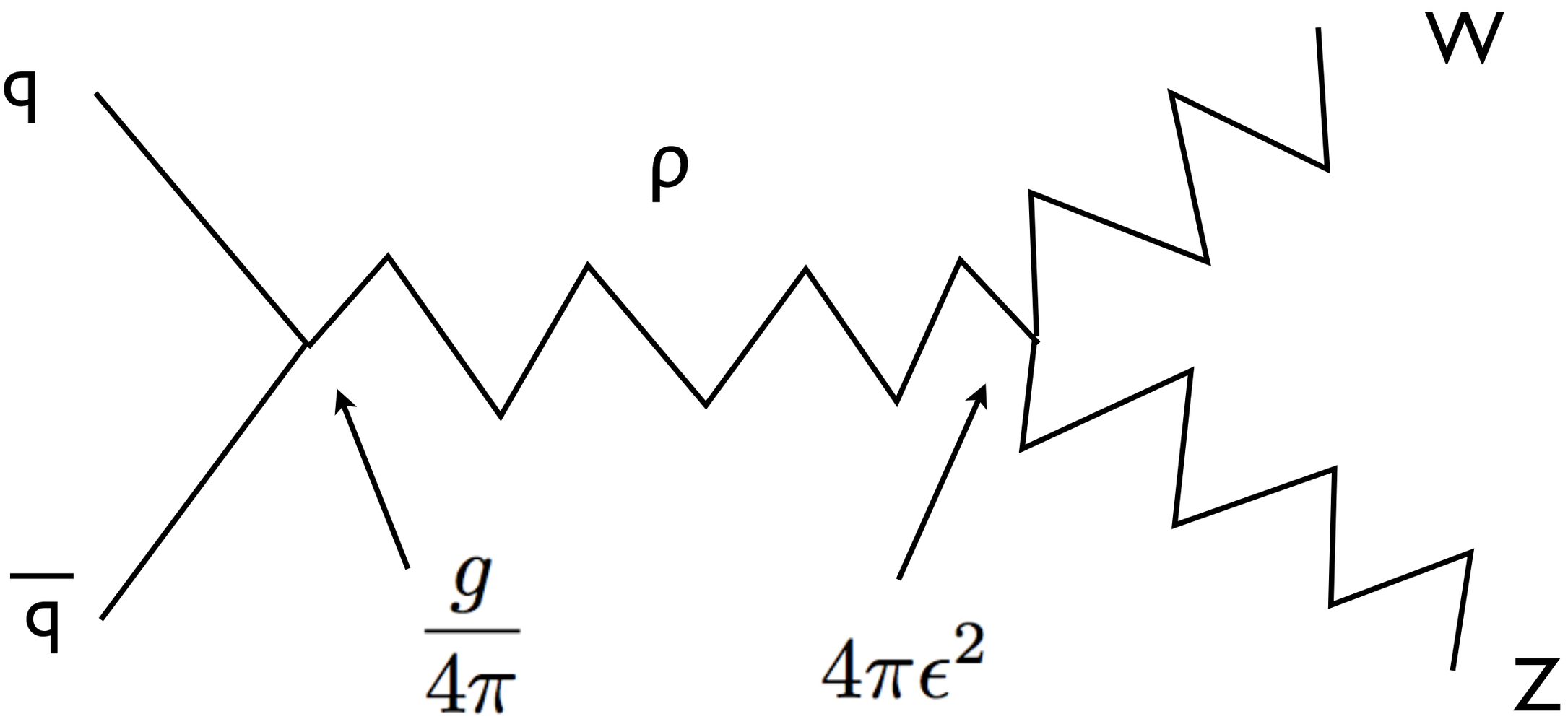
[RK '11]

	$SU(N_c)$	$SU(N_f)_L$	$SU(N_f)_R$	$U(1)_B$	$SU(N_c)_V$	$U(1)_{B'}$	$U(1)_R$
Q	N_c	N_f	1	1	1	0	$(N_f - N_c)/N_f$
$\overline{Q}$	$\overline{N_c}$	1	$\overline{N_f}$	-1	1	0	$(N_f - N_c)/N_f$
Q'	N_c	1	1	0	$\overline{N_c}$	1	1
$\overline{Q}'$	$\overline{N_c}$	1	1	0	N_c	-1	1

Supersymmetric technicolor contains Higgs fields!
(or topcolor)

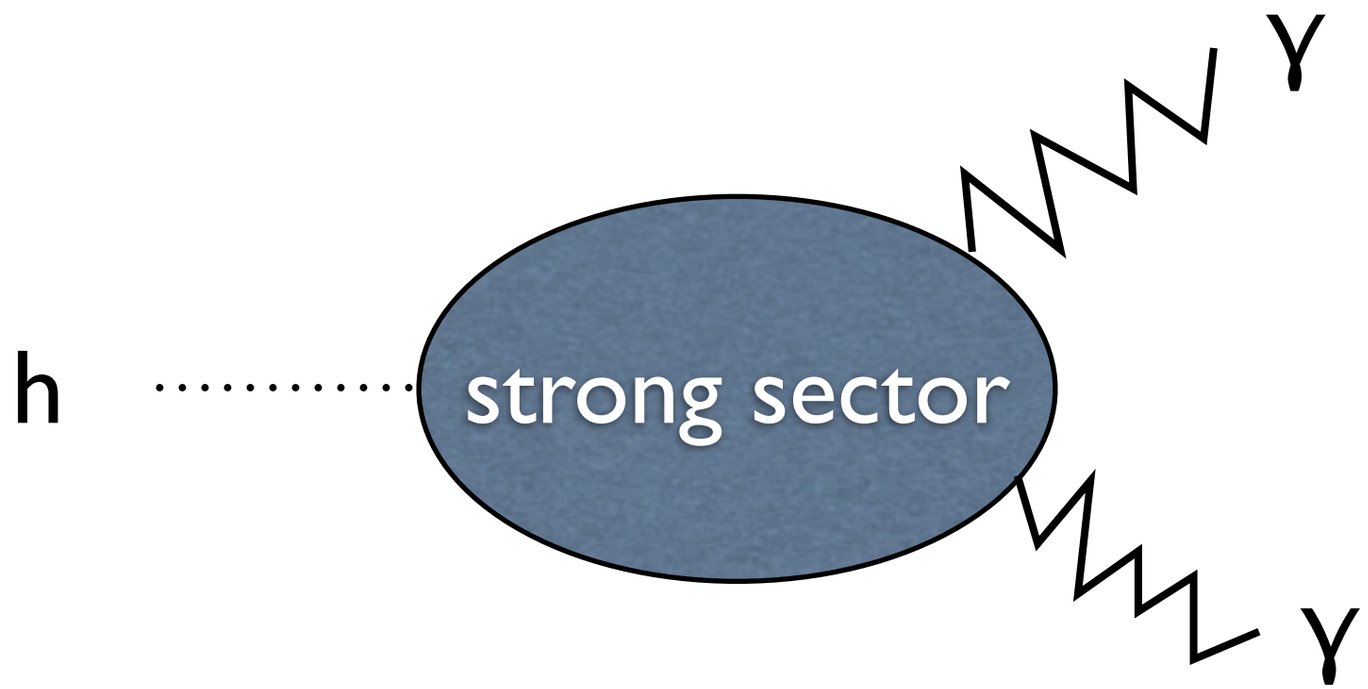
techni-rho at LHC

There should be a light techni-rho meson around 800GeV.



The current bound is around 800GeV!

Higgs decay?



We expect a contribution from the strong sector.

This may be seen. (or we see it already?)

Summary

- light Higgs may be indicating that there is a strong dynamics around 800GeV.
- We should find techni-rho soon at the LHC.