

# **General properties of Composite Higgs models**

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# BSM phenomenology

My research is focused on the **phenomenology of BSM models**.

Main goal of this research (and of the LHC):

Unveil the **nature of the EWSB mechanism**

General strategy:

Build **theoretical framework** to interpret the data

- ▶ look for **motivated** scenarios
- ▶ develop and test hypothetical **models**

# Strongly coupled solution to the Hierarchy Problem

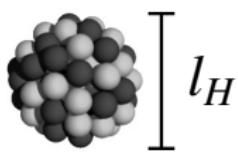
Guideline for BSM:

Instability of the Higgs mass: the **Hierarchy Problem**

Possible solution:

Higgs as a **composite state** from a strong dynamics

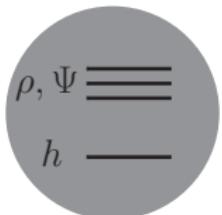
[Georgi, Kaplan]



Higgs mass **IR-saturated, screened** at  $1/l_H$

# Composite Higgs

Postulate a **new strong sector**



## Modified SILH paradigm

[Giudice, Grojean, Pomarol, Rattazzi;  
G. P., Redi, Tesi, Wulzer]

- ▶ **mass scales:**  $m_\rho, m_\psi$
- ▶ **couplings:**  $g_\rho, g_\psi \lesssim 4\pi$

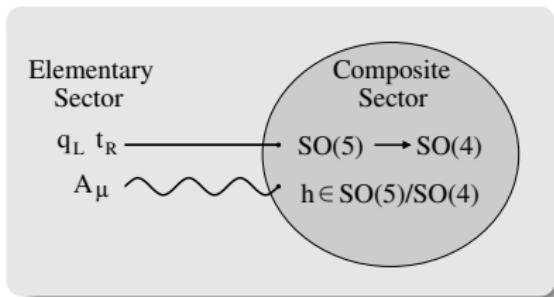
Higgs naturally **light** ( $m_h \ll m_\rho, m_\psi$ ) if it is a **Goldstone**

- ▶ Underlying **symmetry structure**:  $f \simeq m_\rho/g_\rho \simeq m_\psi/g_\psi$
- ▶ Separation of scales for EW precision data:  $v \ll f$

# Composite Higgs

Composite sector with a spontaneously broken **global symmetry**

$$SO(5) \rightarrow SO(4)$$



SM fields obey partial compositeness

$$\mathcal{L}_{mix} = y_L \bar{q}_L \mathcal{O}_L + y_R \bar{t}_R \mathcal{O}_R + \text{h.c.}$$

The mixing gives a small breaking of the global symmetry

- Higgs potential **radiatively induced** (mostly by top-partners)

The quantum numbers of the  $\mathcal{O}_{L,R}$  operators determine the structure of the potential in a  $y_{L,R}/g_\psi$  expansion.

[Mrazek, Pomarol et al.]

All “minimal” models ( $\mathcal{O}_{L,R} \in \mathbf{4}, \mathbf{5}, \mathbf{10}$ ) are in the same class:

$$V \simeq \frac{N_c}{16\pi^2} g_\psi^2 f^4 y^2 \left[ \alpha \sin^2\left(\frac{h}{f}\right) + \beta \frac{y^2}{g_\psi^2} \sin^4\left(\frac{h}{f}\right) \right], \quad \alpha, \beta \sim \mathcal{O}(1)$$

EW precision data require  $\xi \equiv (v/f)^2 \ll 1$

A **cancellation** of  $\alpha$  is needed  $\Rightarrow$  tuning

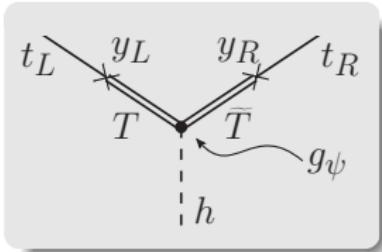
$$\Delta \sim \frac{1}{\xi} \frac{g_\psi^2}{y^2}$$

# Light partners for a light Higgs

[Matsedonskyi, G. P., Wulzer]

The top mass is generated through  
partial compositeness

$$y_t \simeq y_L y_R \frac{f}{m_{light}}$$



- A light Higgs requires light partners

$$m_h \simeq 100 \text{ GeV} \left( \frac{y_t m_{light}}{f} \right)$$

- A large fermion scale  $m_\psi \simeq g_\psi f$  implies **tuning**:

$$\Delta \simeq \frac{1}{\xi} 20 \left( \frac{125 \text{ GeV}}{m_h} \right) \left( \frac{g_\psi}{5} \right)^2$$

# Light partners for a light Higgs

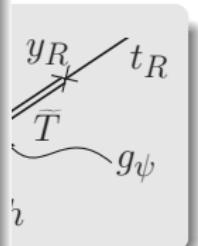
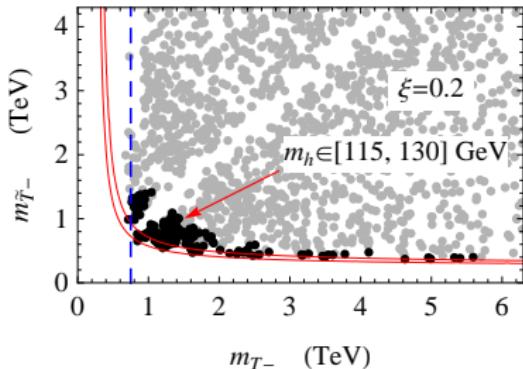
[Matsedonskyi, G. P., Wulzer]

The top mass is  
**partial com**

$$y_t \simeq y_L$$

- A **light Higgs** re

**Light partners:**  $m_{light} \lesssim 1 \text{ TeV}$



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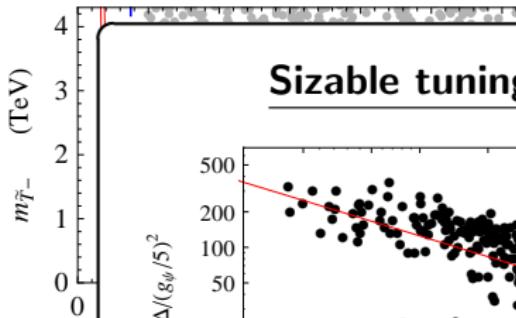
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► A light Higgs

$$m_h \simeq$$

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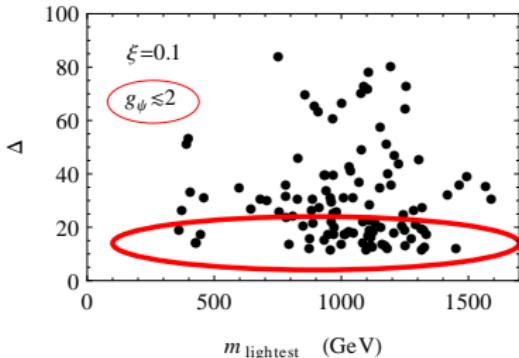


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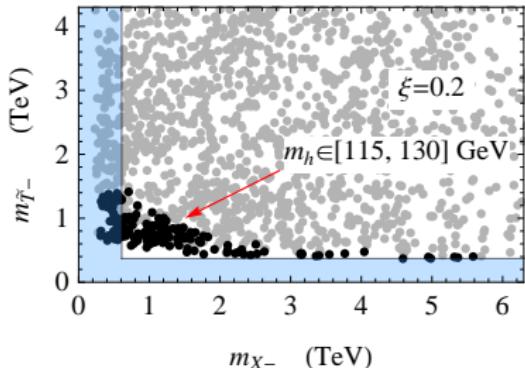
# Conclusions

- A light fermionic scale allows for a **small tuning**



- New **light colored states** easily accessible at the LHC

Current LHC data already give **non-trivial exclusion**



# Conclusions

- Identifying the general properties as a **key to alternative constructions** [Pomarol, Riva; G. P., Redi, Tesi, Wulzer]
  - “Non-minimal” models
  - Totally composite  $t_R$
  - ...

