Electroweak Symmetry Breaking in the era of LHC

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Why is EWSB so important?

- It's the only sector of the SM where we don't have direct measurements (Higgs boson)
- Indirect probes: precision tests (LEP I and II):

  $m_h \leqslant 300$ GeV

- LEP bound on the Higgs mass:

  $m_h > 115$ GeV

- Great experimental success: no hints of New Physics in this sector below 5 or 10 TeV! (LEP and Tevatron)

However…

- Only a description of EWSB (Higgs potential). Where does it come from?

  $V(H) = \lambda |H|^4 - m^2 |H|^2$ $m \sim 100$ GeV (EW scale)

- Quantum instability:

  loop corrections $\delta m^2 \sim g/(16 \pi^2) \Lambda_{NPh}^2$

  naturalness requires $\Lambda_{NPh} \lesssim 1$ TeV

- We have direct and indirect evidences of New Physics:

neutrino masses, Dark Matter, Dark Energy, inflation…

The plan:

- Model Building: new mechanisms of EWSB. Spirit guides: naturalness, Dark Matter, unification…
- Implement the new ideas in fully realistic models: reproduce the SM, EW precision tests, flavor physics…
- Signals: predictions at LHC and beyond (ILC, cosmology, astrophysics,…)
- Explore the power of LHC: look for hints and directions in the data, model independent analysis, point out new interesting signatures…

☞ LHC is going to deliver new data very soon!

My recent publications (past year)

- *A Gauge-phobic Higgs*
  G.C., C.Csáki (Cornell), G.Marandella, J.Terning (UC Davis)
  to appear soon.
- *A New Custodian for a Realistic Higgsless Model*
  G.C., C.Csáki (Cornell), G.Marandella, J.Terning (UC Davis)
  hep-ph/0607146, submitted to Phys.Rev.D
- *Field Theory on Multi-throat Backgrounds*
  G.C., C.Csáki (Cornell), C.Grojean (CERN & Saclay), J.Terning (UC Davis)
  Phys.Rev.D74:045019, 2006; hep-ph/0604218
- *The Minimal Set of Electroweak Precision Parameters*
  G.C., C.Csáki (Cornell), G.Marandella (UC Davis), A.Strumia (INFN & Pisa U)
  Phys.Rev.D74:033011, 2006; hep-ph/0604111
- *Fully Radiative Electroweak Symmetry Breaking*
  G.C., C.Csáki, S.C.Park (Cornell)
  JHEP 0603:099, 2006; hep-ph/0510366

Future projects

- *Minimal Natural Supersymmetry*

  w. M.Perelstein and C.Spethman (Cornell)

- *Natural Supersymmetry with a 4th generation*

  w. M.Papucci (UC Berkeley)

- *One-loop T Parameter in Higgsless Models*

  w. C.Csaki (Cornell), G.Marandella and J.Terning (UC Davis)

- *Collider Phenomenology of Higgless Models*
- *Positivity of W and Little Higgs Models with T-parity*

  w. C.Csaki (Cornell), G.Marandella (UC Davis) and A.Strumia (INFN & Pisa U)

EW Precision Tests

G.C., C.Csáki, G.Marandella, A.Strumia
Phys.Rev.D74:033011, 2006; hep-ph/0604111

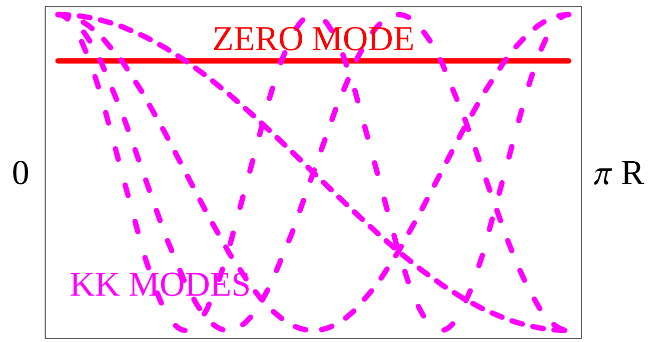
- Large number of well-measured observables: general analysis involves more than 20 operators

  $\delta L = \sum c_i/\Lambda^2 O_i$ Λ = scale of NPh
- We used a new formalism (by Barbieri *et al*) to identify 9 super-constrained parameters: 7 oblique (gauge + leptons) + 2 hadronic.
- Powerful tool to simplify the analysis of models of New Physics:
  - no strong assumptions on new physics: CP cons., and flavor;
  - few parameters to calculate;
  - easier to construct new models that pass those tests!
- We provided a complete fit to the measurements: easy to use with any model.

Gauge-Higgs Unification

G.C., C.Csáki, S.C.Park
JHEP 0603:099, 2006; hep-ph/0510366

- The idea: embed the Higgs doublet in a gauge field (A_5).
- Extra dimension: $A_M = (A_\mu , \mathbf{A_5})$
- Symmetry Breaking by Boundary Conditions



- Gauge symmetry + 5D Lorenz invariance constrain the Higgs potential:
  - loop generated;
  - finite and calculable (no cut-off dependence), stable!
- We proposed the first realistic (and minimal) model based on SU(3)xU(1):
  - m_H ~ 120-150 GeV, KK states (colored fermions – top');
  - EWPTests force M_{KK} > 5 TeV, moderate fine tuning.

Conclusions

- A lot of work is needed to exploit the potentiality of LHC!
- We are waiting for new exciting data:

  - probe new models and ideas;

  - shed light on the EWSB sector (confirm the SM or find New Physics)