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Nuclear Physics B 904 (2016) 400–447

NUCLEAR PHYSICS B

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# Conformal barrier and hidden local symmetry constraints: Walking technirhos in LHC diboson channels

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Received 29 October 2015; received in revised form 9 January 2016; accepted 21 January 2016

Available online 25 January 2016

Editor: Hong-Jian He

**Abstract**

We expand the previous analyses of the conformal barrier on the walking technirho for the 2 TeV diboson excesses reported by the ATLAS Collaboration, with a special emphasis on the hidden local symmetry (HLS) constraints. We first show that the Standard Model (SM) Higgs Lagrangian is equivalent to the scale-invariant nonlinear chiral Lagrangian, which is further gauge equivalent to the scale-invariant HLS model, with the scale symmetry realized nonlinearly via SM Higgs as a (pseudo-)dilaton. The scale symmetry forbids the new vector boson decay to the 125 GeV Higgs plus $W/Z$ boson, in sharp contrast to the conventional "equivalence theorem" which is invalidated by the conformality. The HLS forbids mixing between the iso-triplet technirho's, $\rho_\Pi$ and $\rho_P$, of the one-family walking technicolor (with four doublets $N_D = N_F/2 = 4$), which, without the HLS, would be generated when switching on the standard model gauging. We also present updated analyses of the walking technirho's for the diboson excesses by fully incorporating the constraints from the conformal barrier and the HLS as well as possible higher order effects: still characteristic of the one-family walking technirho is its smallness of the decay width, roughly of order

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http://dx.doi.org/10.1016/j.nuclphysb.2016.01.020

$\Gamma/M_\rho \sim [3/N_C \times 1/N_D] \times [\Gamma/M_\rho]_{\rm QCD} \simeq 70\,{\rm GeV}/2\,{\rm TeV}$ ($N_D = N_C = 4$), in perfect agreement with the expected diboson resonance with $\Gamma < 100$ GeV. The model is so sharply distinguishable from other massive spin 1 models without the conformality and HLS that it is clearly testable at the LHC Run II. If the 2 TeV boson decay to $WH/ZH$ is not observed in the ongoing Run II, then the conformality is operative on the 125 GeV Higgs, strongly suggesting that the 2 TeV excess events are responsible for the walking technirhos and the 125 GeV Higgs is the technidilaton.


## 1. Introduction

The Higgs boson was discovered at LHC, which is so far consistent with the standard model (SM) [1], having no obvious hints for the new physics beyond the SM, as far as the Higgs decays are concerned. However, the origin of the mass, particularly of the Higgs itself, is a mere input parameter of the SM to be revealed by new physics at deeper level beyond SM.

One of the candidates for such new physics towards the origin of mass is the walking technicolor, which has an approximate scale symmetry and as such produces a large anomalous dimension $\gamma_m \simeq 1$ and a *light composite Higgs as the technidilaton*, a pseudo Nambu–Goldstone (NG) boson of the approximate scale symmetry [2], in sharp contrast to the original technicolor as a QCD scale up [3] which was already excluded long ago by the large flavor-changing neutral currents and large $S$ parameter, as well as most recently and dramatically by the absence of the light 125 GeV Higgs.

It was in fact shown [4–6] that the technidilaton in the walking technicolor of the one-family model [7], with four weak-doublets $N_D = N_F/2 = 4$ in the $SU(N_C)$ gauge group, can be nicely fit to the current 125 GeV Higgs data for $N_C = 4$. It was further shown [6] that the anti-Veneziano limit, $N_C \to \infty$ with $N_C\alpha = {\rm const.}$ and $N_F/N_C = {\rm fixed} \gg 1$, yields the theory becoming walking with infrared conformality, in such a way that the technidilaton mass and couplings vanish in the limit. Numerically, the one-family model with $N_F = 8$ and $N_C = 4$ is already close to the anti-Veneziano limit picture so to have a good approximate scale symmetry for the technidilaton becoming naturally light, as light as 125 GeV, and moreover its coupling *even weaker than the SM Higgs* [6], thus justifying the numerical agreement with the current LHC Higgs data. Recent lattice results in fact suggest that the theory with $N_F = 8$ and $N_C = 3$ has walking signals with anomalous dimension $\gamma_m \simeq 1$ [8] and moreover has a light flavor-singlet scalar bound state as a candidate for the technidilaton [9] (there exists a light flavor-singlet scalar also in the case of $N_F = 12$ [10]). This is in sharp contrast to a folklore that the strongly coupled theory would not produce light weakly coupled composites, which is merely a prejudice based on the analogy with the QCD having no scale symmetry.

Crucial issue is that the walking technicolor will give us not just the Higgs but a plenty of other bound states as new phenomena beyond the SM. Typical of such is the walking technirho, which is described by the effective theory based on the hidden local symmetry (HLS) model successful for the QCD rho meson [11–13] so as to be made scale-invariant via nonlinear realization ("s-HLS" model) [14] in accord with the (spontaneously broken) scale symmetry of the underlying walking technicolor. Also used was a straightforward application of the loop expansion, the HLS chiral perturbation theory [13,15] (usual chiral perturbation theory extended to incorporating the HLS gauge bosons), to the present scale-invariant version, s-HLS model. We