Is the Higgs a Composite Dilaton?

arXiv:1702.04410

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Phenomenology Symposium 2017

Plan Of Talk

1. Introduction:

   a. Fitting lattice simulation data with a Dilaton EFT.

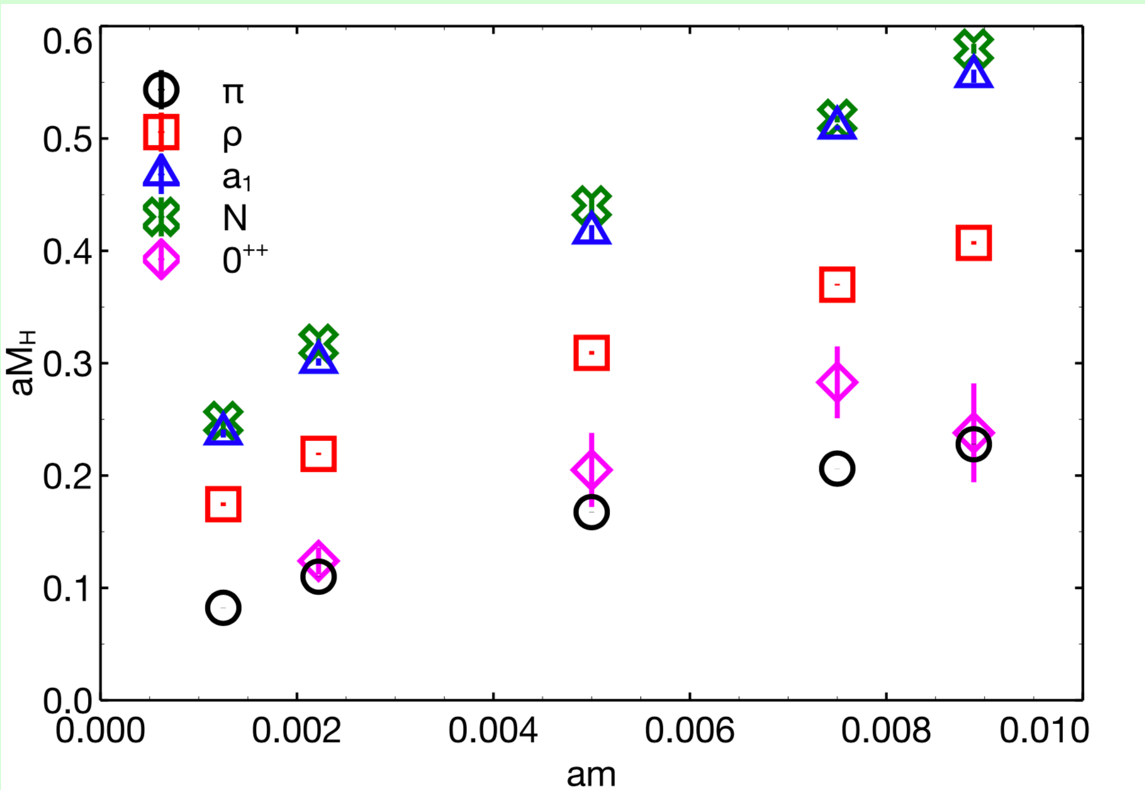
   b. Motivation: Finding UV completion of EW sector.

2. The EFT Framework

3. Comparison with Lattice Data

Outline Of Our Program

Lattice Simulation Data for $N_c = 3$, $N_f = 8$



LSD collaboration – 1601.04027

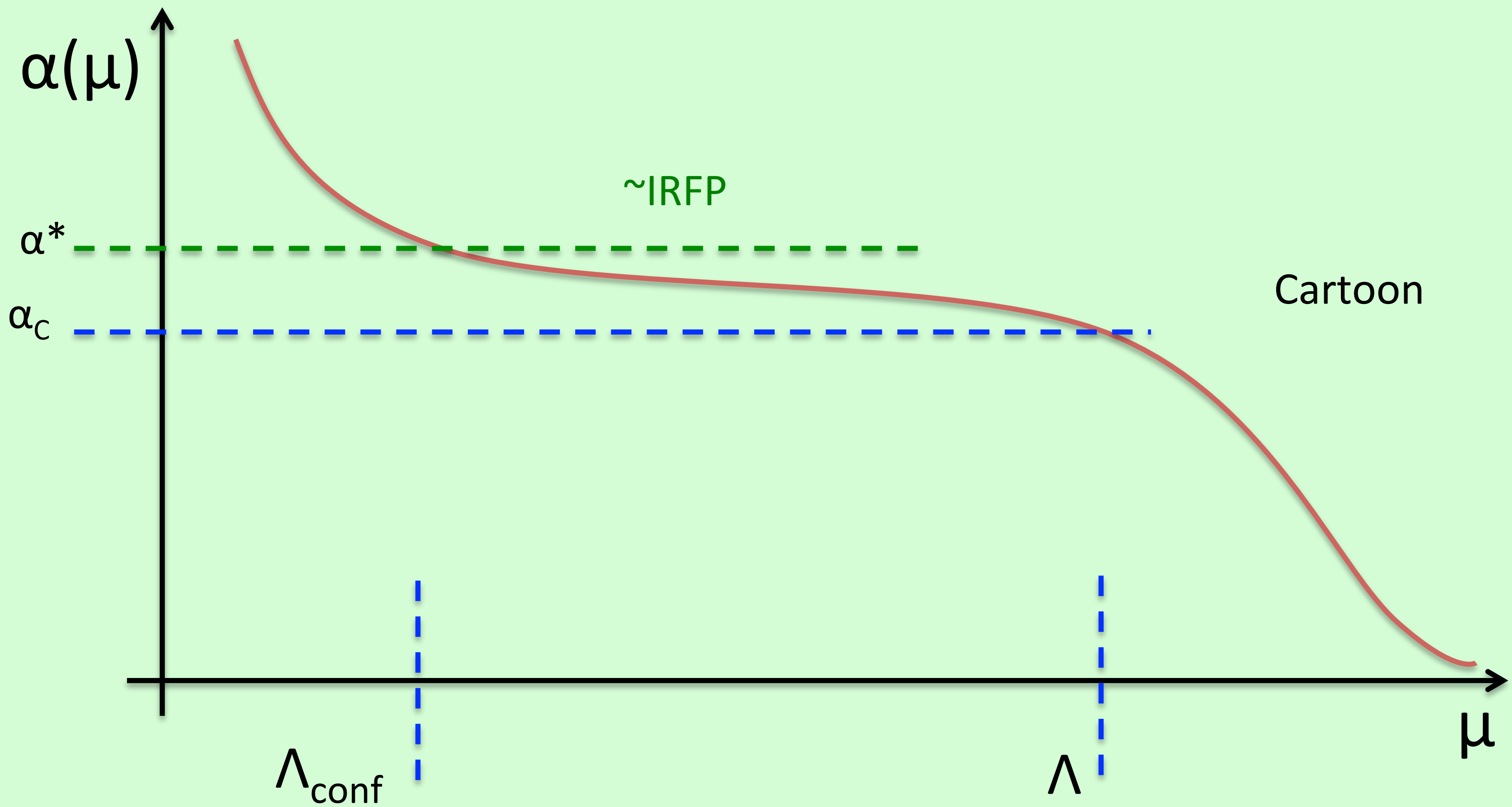
$\mathcal{L} = ?$

$M_{0++} << \Lambda_{conf}$?

- Maybe a Higgs boson
- Maybe light due to a symmetry

Walking Gauge Theories

- Could support a dilaton
- Test by fitting a dilaton EFT to lattice data



EFT Framework

Field content

Symmetries

$N_f^2 - 1$ NGB fields π^a:

$SU(N_f)_L \times SU(N_f)_R \rightarrow SU(N_f)_V$

$$\Sigma = \exp\left\{2i\pi^a T^a / F_\pi\right\} \quad \Sigma \rightarrow L\Sigma R^\dagger$$

Dilaton Field χ:

Scale x Poincare ➔ Poincare

$$\phi(x) \rightarrow e^{\lambda d}\phi(e^\lambda x)$$

Work first at tree level

Terms In The EFT

$$L_\pi = \frac{f_\pi^2}{4}\left(\frac{\chi}{f_d}\right)^2 Tr\left\{\partial_\mu \Sigma \partial^\mu \Sigma^\dagger\right\}$$

$$L_d = \frac{1}{2}\left(\partial_\mu \chi\right)^2$$

$$L_V = -V(\chi)$$

- Potential has a minimum at $\chi=f_d$, and curvature m_d^2
- Let the lattice data determine the form of the potential.

$$L_m = \frac{m_\pi^2 f_\pi^2}{4}\left(\frac{\chi}{f_d}\right)^y Tr\left\{\Sigma + \Sigma^\dagger\right\}$$

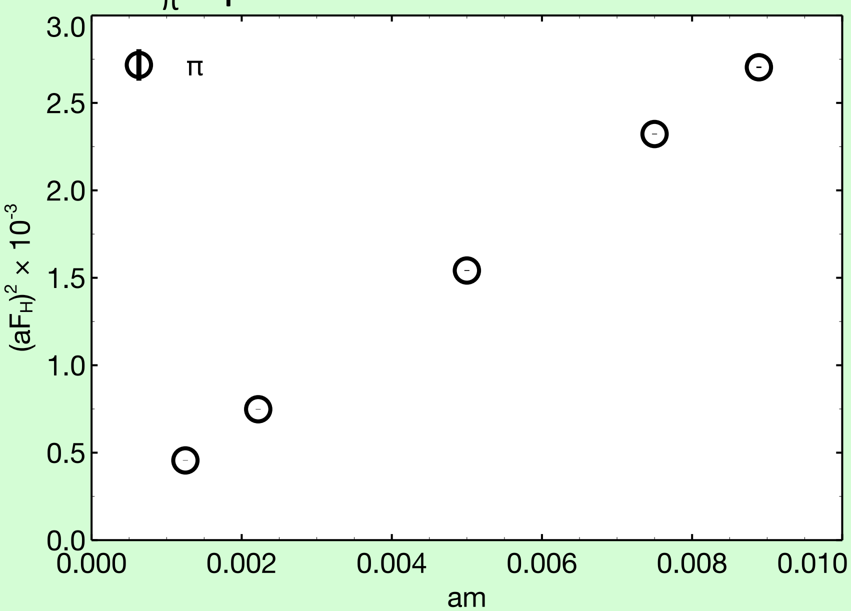
$$m_\pi^2 = 2mB_\pi = \frac{m\langle\bar{\psi}\psi\rangle}{f_\pi^2}$$

- Quark mass term breaks both scale and chiral symmetry.
- y ~ Scaling dimension of $\bar{\psi}\psi$?
- 5 EFT parameters: f_π, f_d, B_π, m_d, y
- Similar terms have appeared before eg 1603.04575

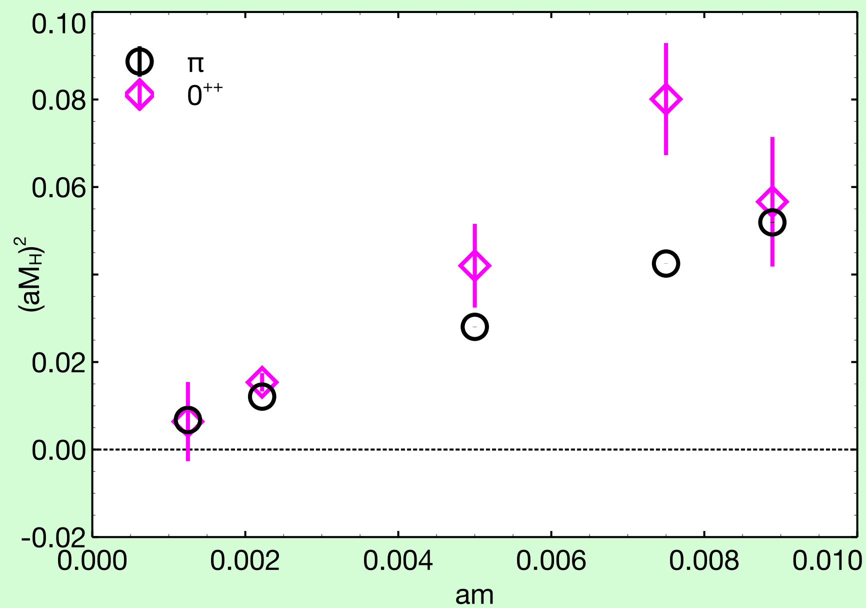
Comparison with LSD Data

$N_c = 3, N_f = 8$

F_π squared vs m



NGB and scalar mass squared vs m.



Lattice data for F_π and M_π can determine y accurately.

$$M_\pi^2 F_\pi^{2-y} = Cm$$

2%

y = 2.1 ± 0.1

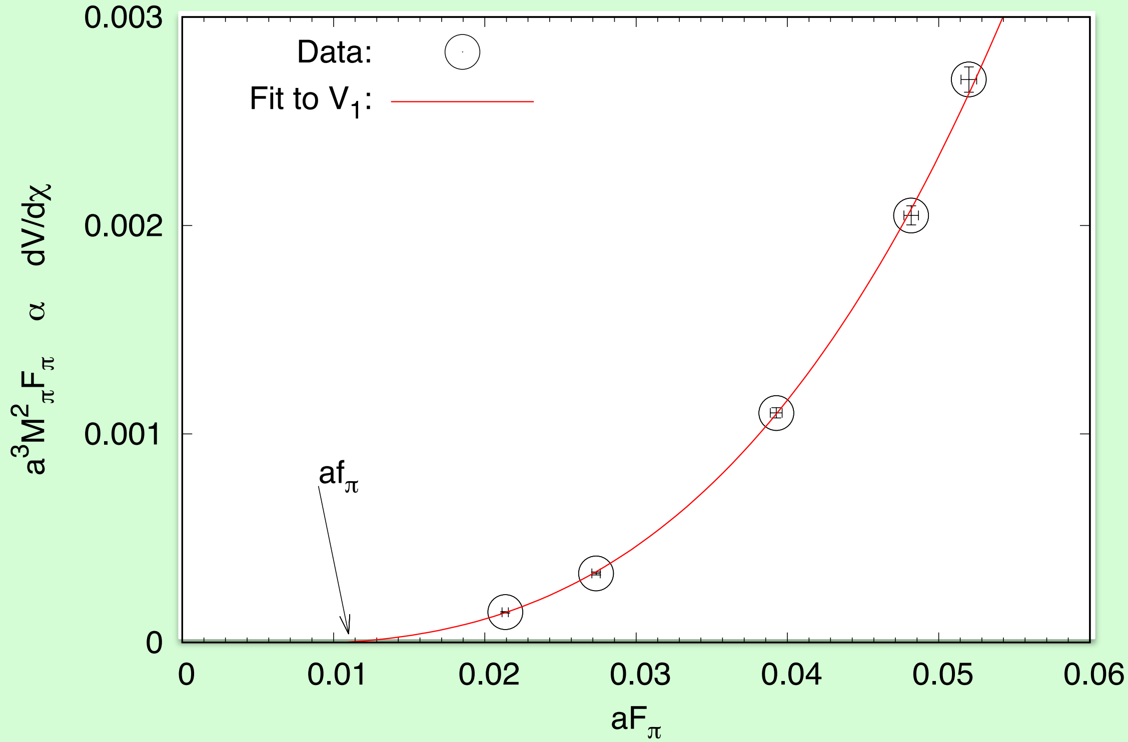
Scaling dimension of $\bar{\psi}\psi$ = 2?

The form of the potential can be determined too:

"Inverse scattering problem"

$$\left.\frac{\partial V}{\partial \chi}\right|_{F_d} = \frac{y N_f f_\pi}{f_d} M_\pi^2 F_\pi$$

$\partial V/\partial \chi$ vs χ



$$F_\pi \propto F_d$$

$$V_1(\chi) = \frac{m_d^2}{8 f_d^2}\left(\chi^2 - f_d^2\right)^2$$

Conclusions

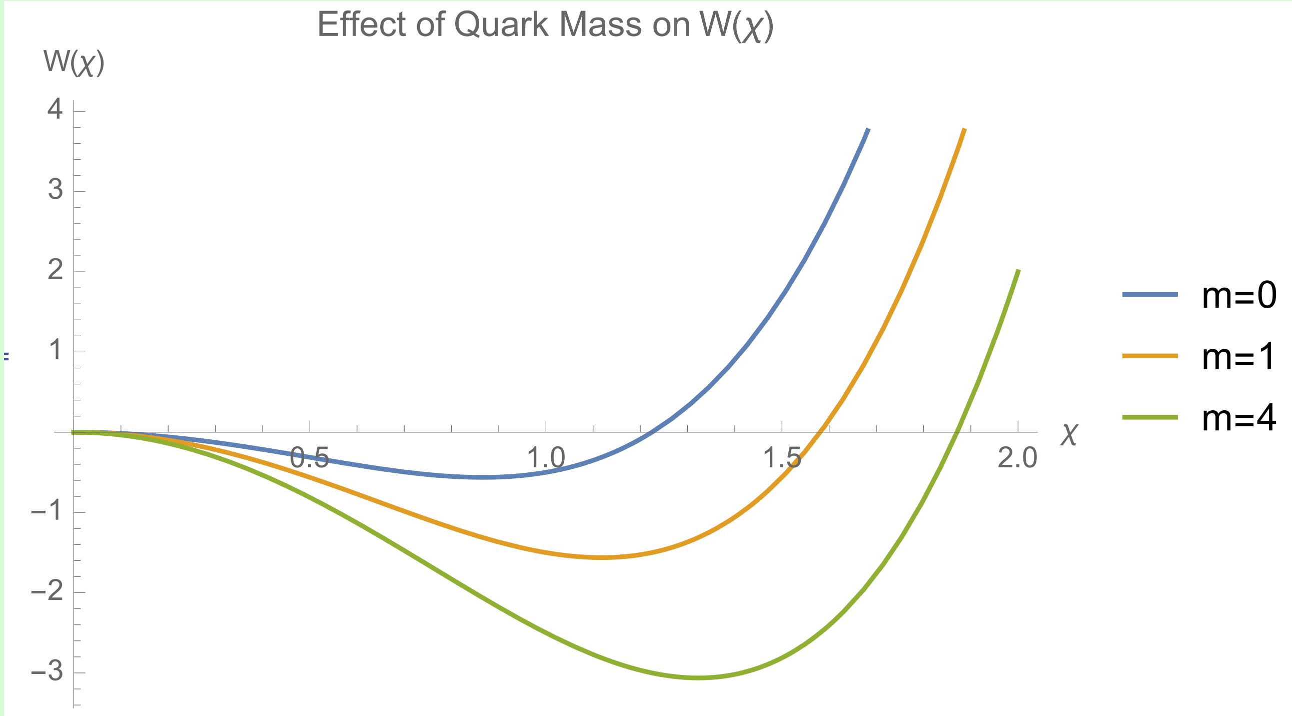
- We've developed a framework to test whether the light scalar in walking theories is a dilaton, without needing negligible quark mass.
- Our EFT framework fits the N_f=8 LSD data well.
- In future, we can extend by calculating loop corrections.
- Our framework makes predictions, which can be tested on the lattice.

[redacted]

Key Features Of Framework

$$W(\chi) = V(\chi) - \frac{N_f m_\pi^2 f_\pi^2}{2}\left(\frac{\chi}{f_d}\right)^y$$

$$F_\pi \propto F_d$$



Minimum of combined potential gives $\langle \chi \rangle = F_d$

Bounds On Model

- Lattice calculations suggest that S parameter is suppressed relative to QCD - see 1602.00796, 1405.4752, 1009.5967.
- Direct detection of heavy spin 1 states challenging due to their large width.
- Coupling of SM fermions to these walking models is model dependent.