

BSM GROUP — INTRODUCTION

Andrey Katz

Les Houches retreat, November 2015

GROUP MEMBERS

Fellows

- Adrian Carmona
- Andreas Crivellin
- Roberto Franceschini
- Florian Goertz
- Ji-Haeng Huh
- Francesco Riva
- Javi Serra
- Florian Staub
- Daniel Stolarski
- Alfredo Urbano

Staffs

- Roberto Contino (w/ EPFL)
- **Gian Giudice**
- Andrey Katz (w/ UNIGE)
- Matthew McCullough

Associates

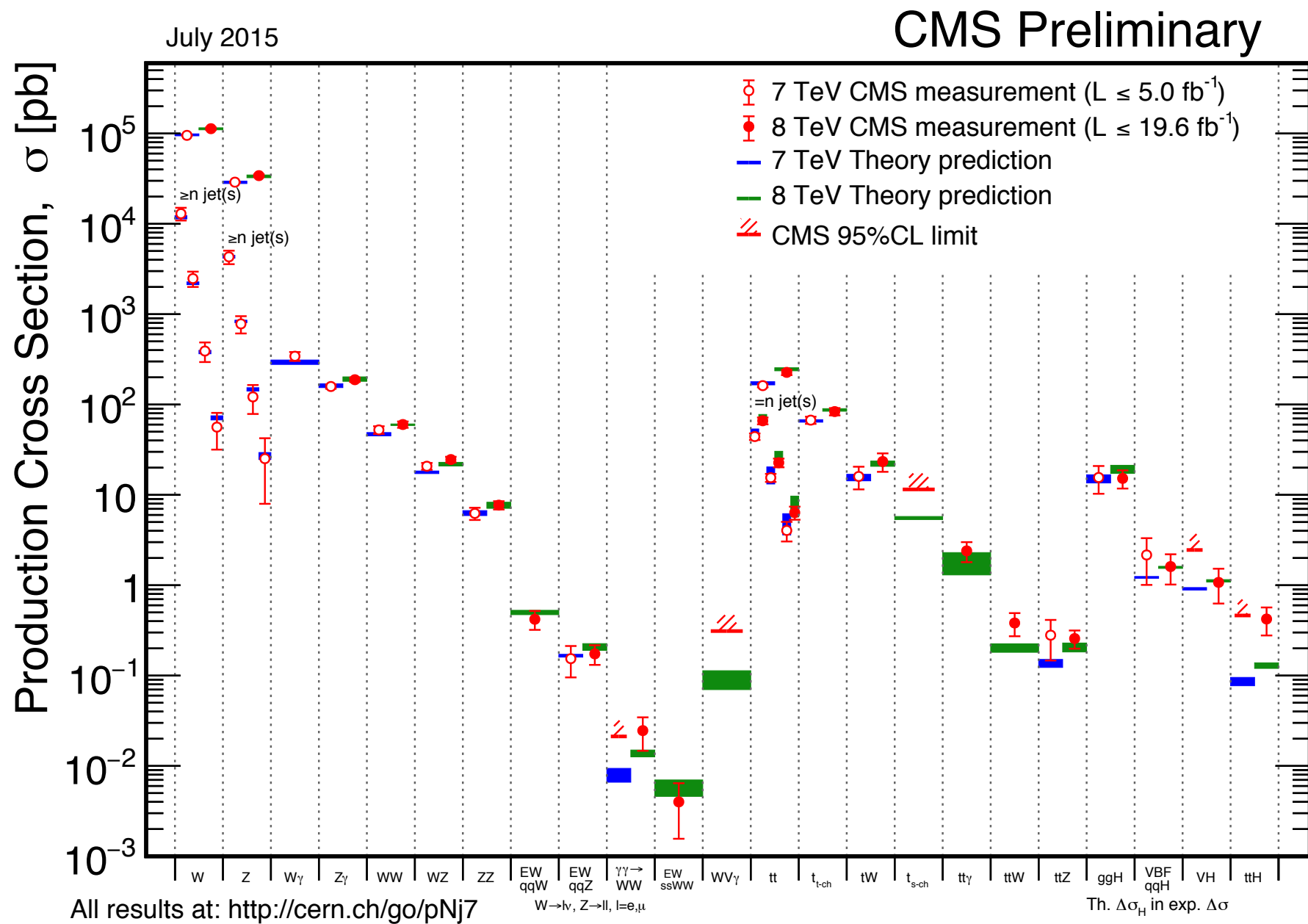
- Jernej Kamenik
- Alex Pomarol

REGULAR GROUP ACTIVITIES

Thursday, 2 pm: BSM forum. Usually, come after a BSM lunch with the speaker at 12:45 pm (*organizers: Franceschini, AK, McCullough, Riva, Stolarski*)

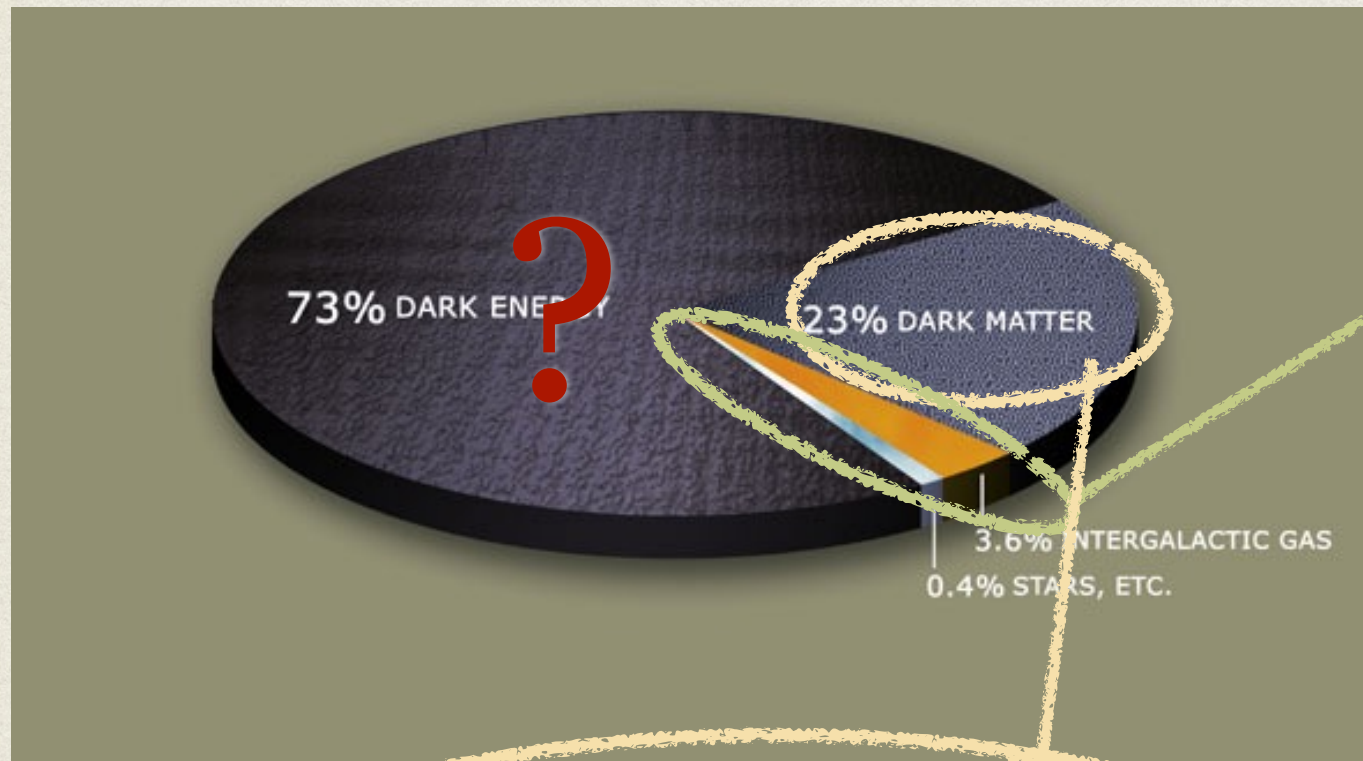
Friday, 2pm: Particle and astroparticle physics seminar (*organizers: Contino, Patella, Zanderighi*)

BEYOND THE SM — WHY?



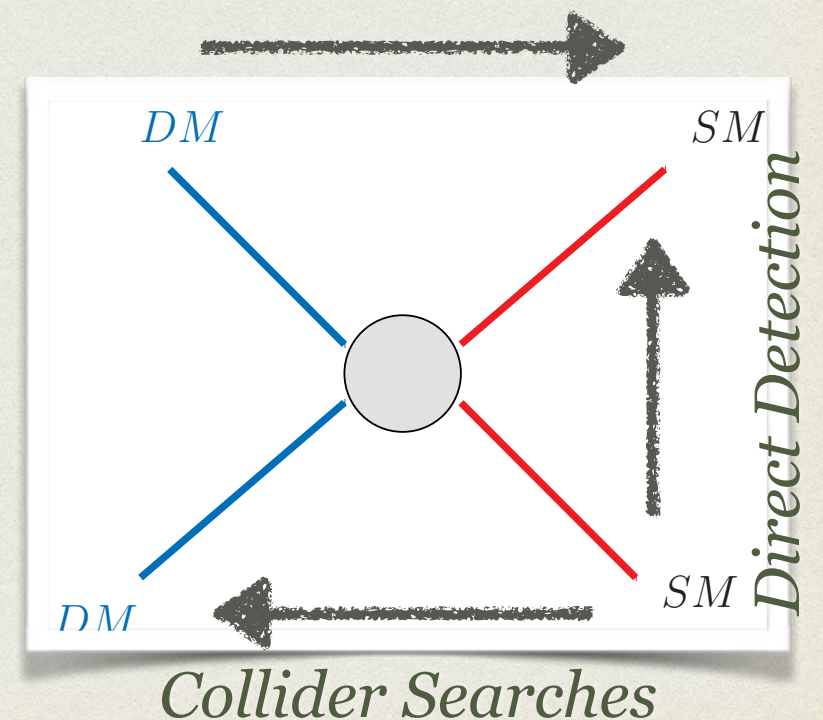
Beautiful agreement between the SM and the LHC measurements. Why thinking about new physics?

ELEPHANTS IN THE ROOM



The SM does not satisfy Sakharov conditions → need NP to explain why matter > antimatter in the Universe

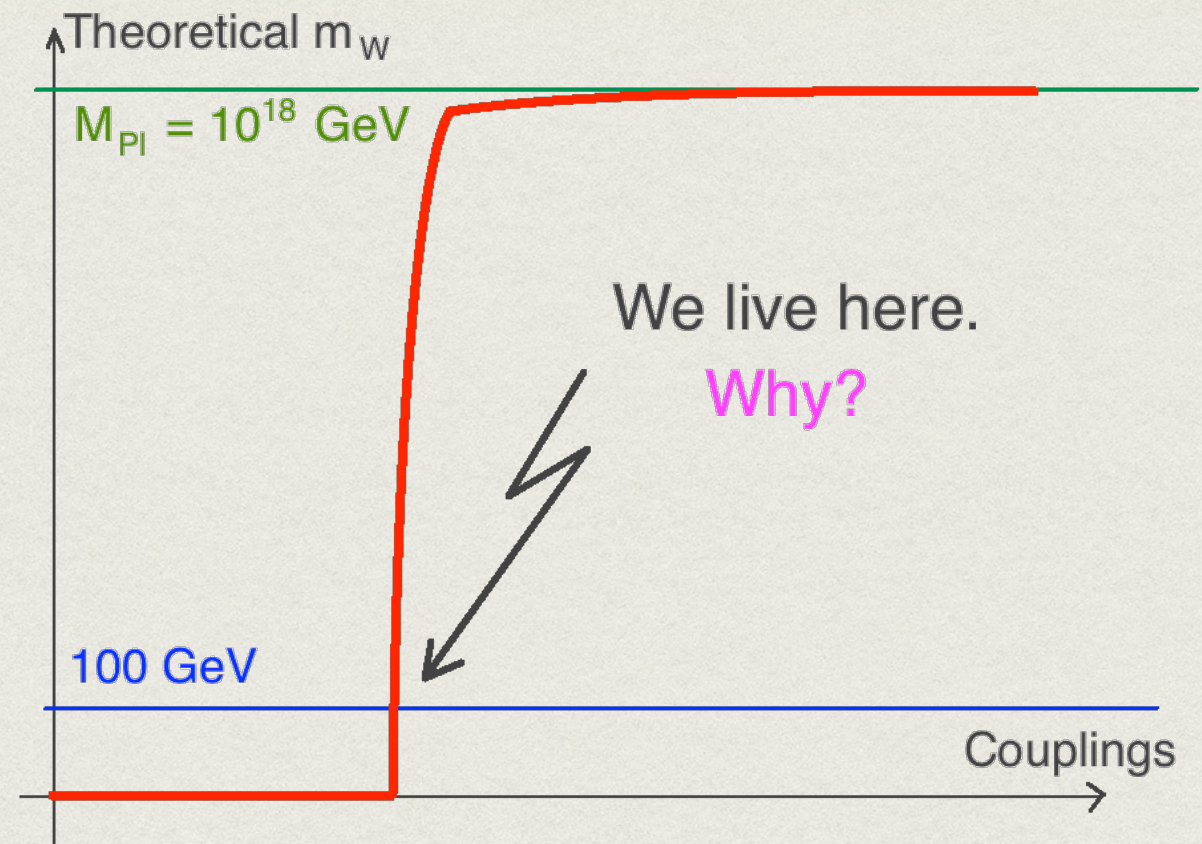
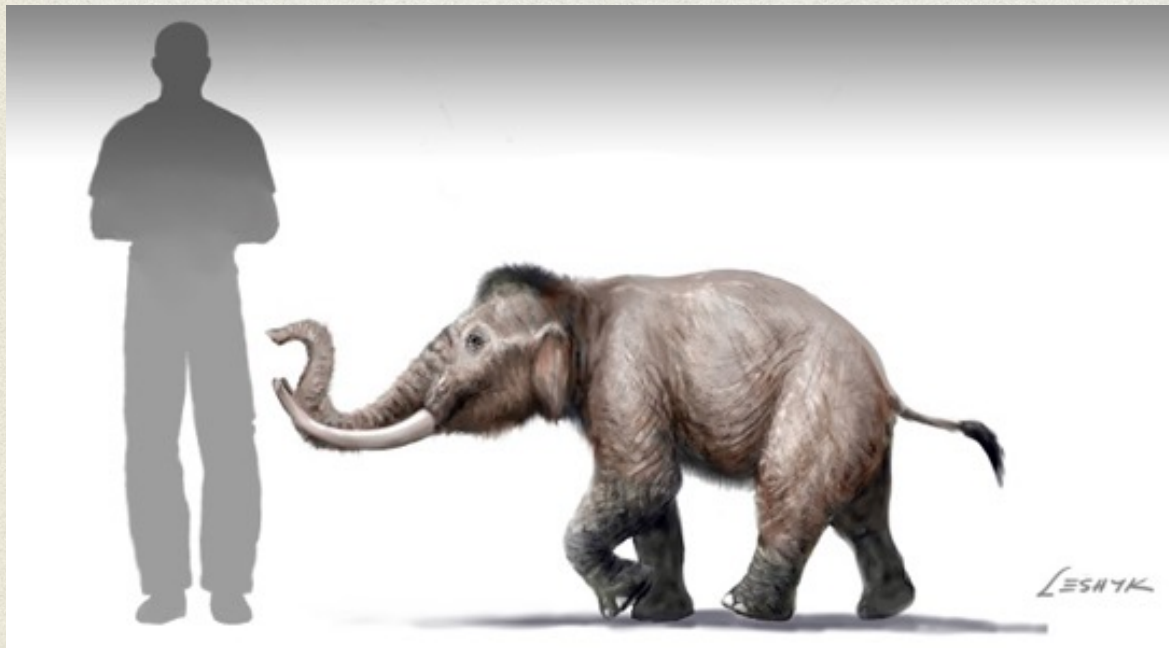
IceCube, Galactic Center



Does the DM have interactions beyond gravitational? How strong are self interactions? What are theoretically motivated candidates?

THEORETICAL MOTIVATION — NATURALNESS

Dwarf elephant in the room



$$G_F^{-1} \propto (m_h)_0^2 + \frac{3y_t^2}{4\pi^2} \Lambda^2 + \dots = 174 \text{ GeV}$$

Physical cutoff of the theory —
sensitivity to high scales

SOLUTIONS TO THE HIERARCHY PROBLEM

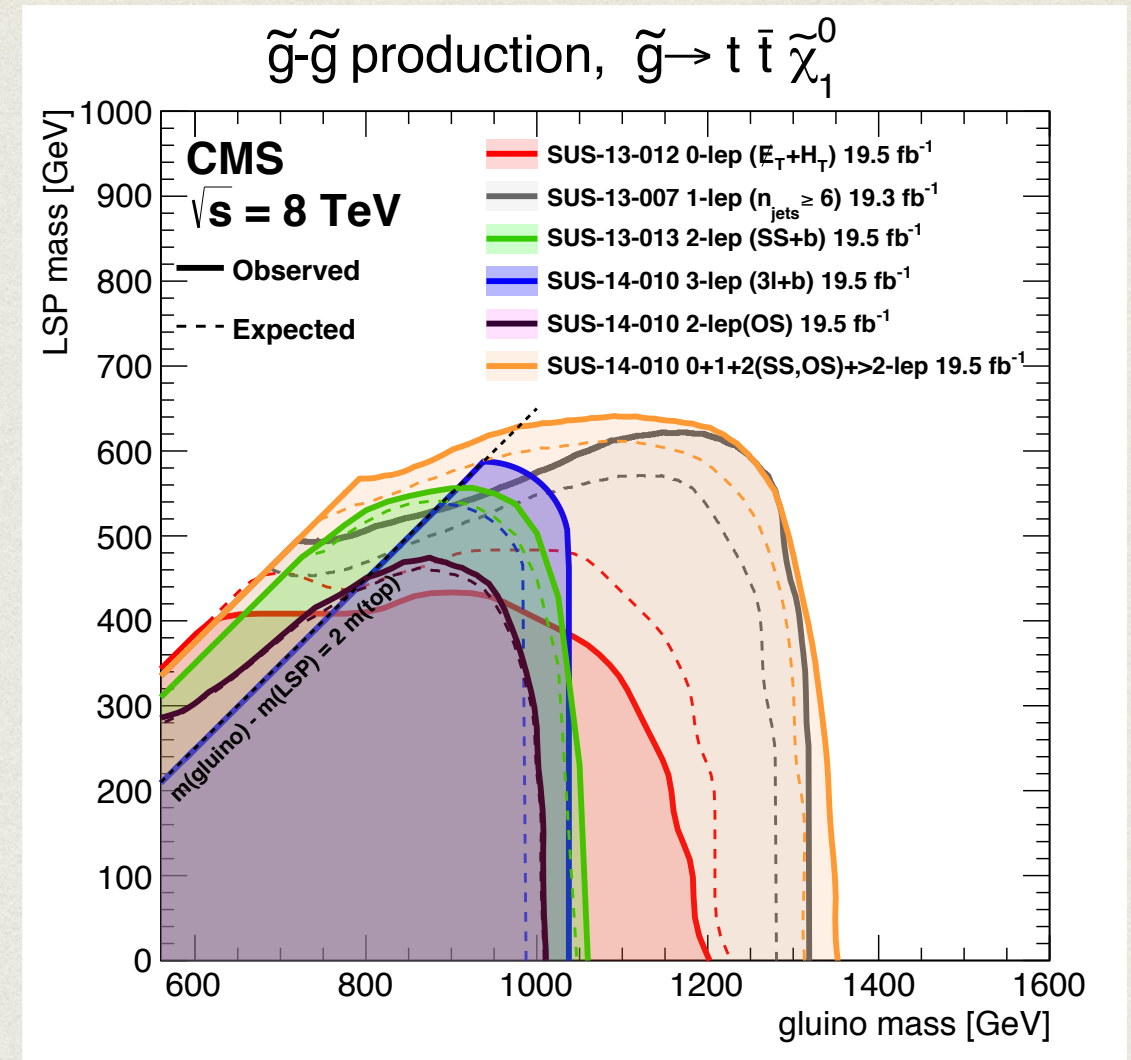
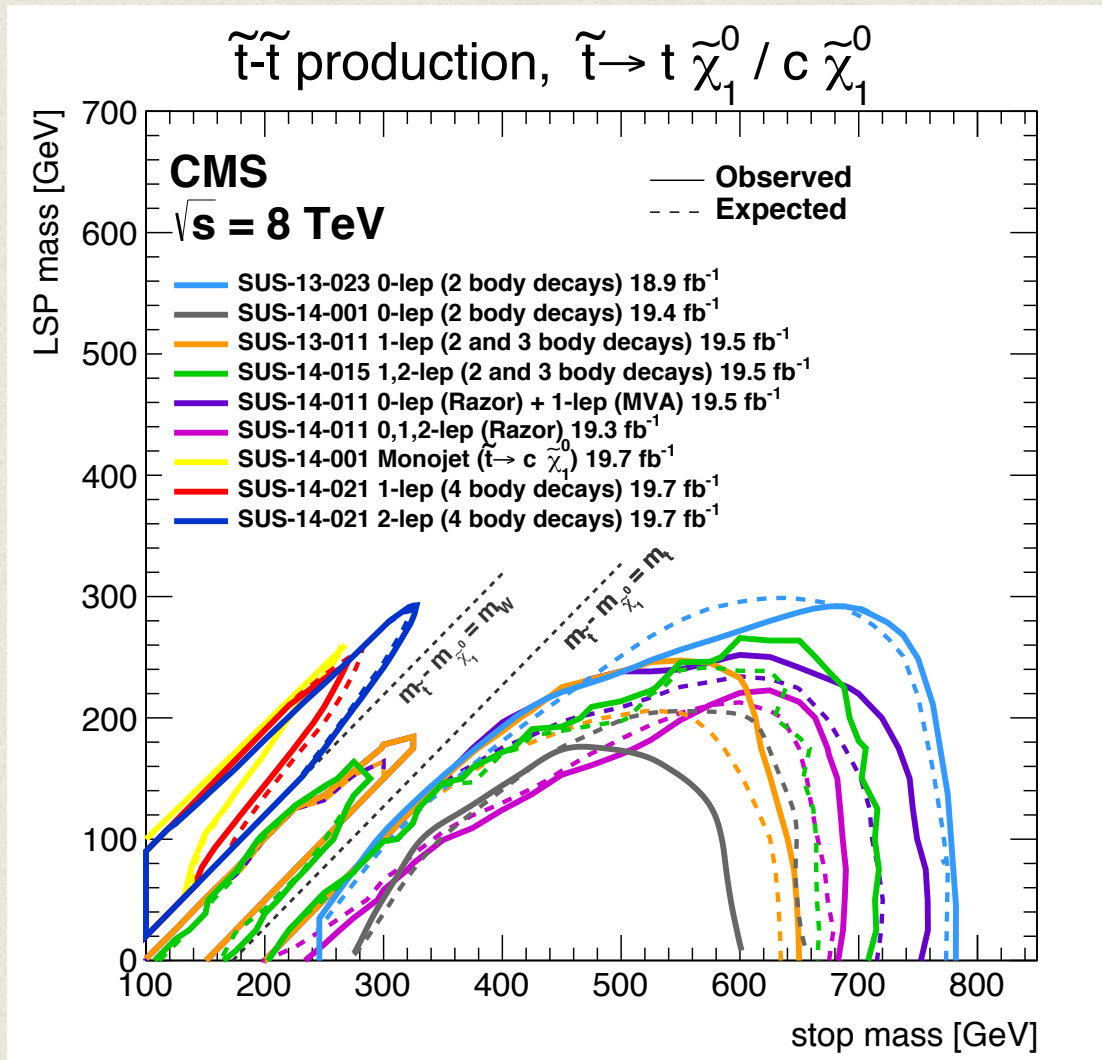
Simple logic: if the inverse fermi constant is proportional to the cutoff of the theory, the NP (cutoff) should be the EW scale

Solution 1: the EW scale is protected by symmetry (supersymmetry)

Solution 2: instead of the SM we have a theory with no relevant operator (compositeness). For this model to be natural the higgs should be composite and higgs mass \approx compositeness scale.

Both predict colored top partners, at the EW scale.

NATURALNESS UNDER PRESSURE

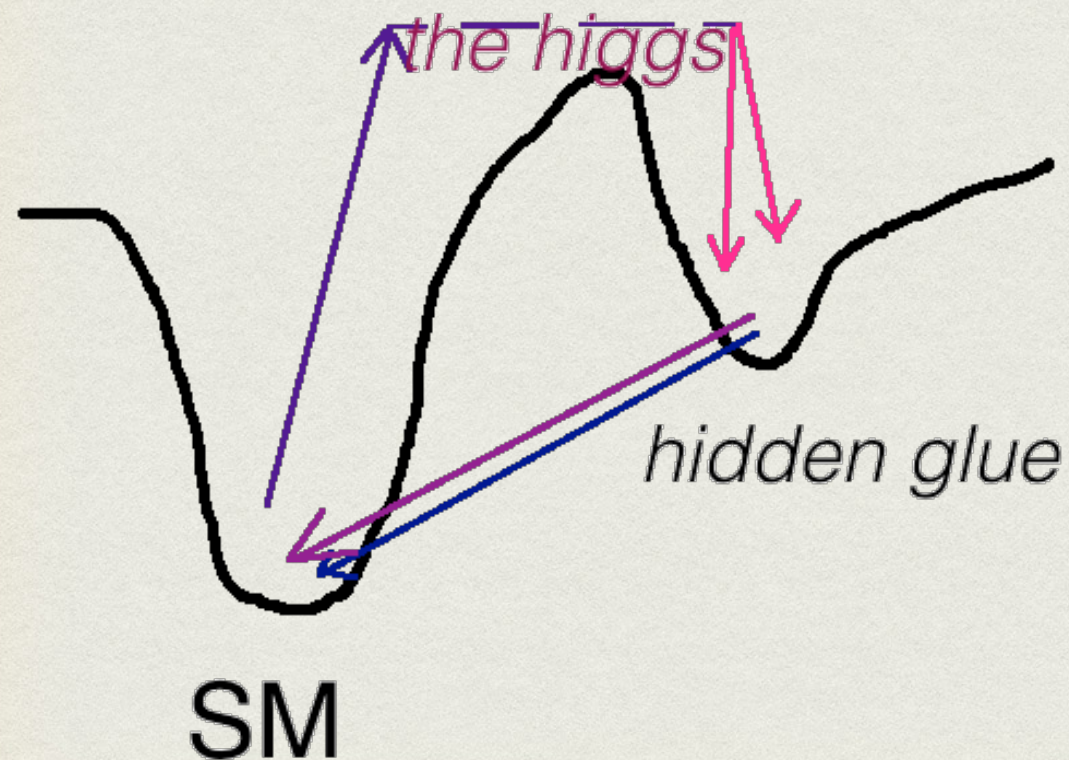


No sign of colored top partner.
Can something more exotic work?

NATURALNESS: MORE EXOTIC SOLUTIONS

Neutral Naturalness.

Basic idea: the top partners are charged under a different color group, not the SM color. The top partners can be either bosonic (folded SUSY) or fermionic (twin Higgs, which realizes at the one-loop level the idea of the higgs as a pNGB). No interesting collider signatures from the top partners, but...



Even more exotic: dynamical solution for the naturalness problem — relaxion. Idea — the higgs mass before the EWSB is a VEV of relaxion field. Relaxion potential: axion + small (technically natural) coupling to the higgs.

NEW PHYSICS AND HIGGS PRECISION MEASUREMENTS

Alongside with direct searches for the new physics, we can get lots of information from precision measurements.
Example: neutral naturalness: hard to spot directly, but its generic prediction — deviation of the higgs couplings

$m_h = 125$ GeV is a special point
all these channels are measurable:

- $h \rightarrow$ diphotons
- $h \rightarrow WW$
- $h \rightarrow ZZ$
- $h \rightarrow$ di-taus
- $h \rightarrow bb$

Why is the Higgs special?

$$\mathcal{L} = |H|^2 \mathcal{O}$$

The only $d < 4$ gauge-invariant portal of the SM.

The field breaks the EW symmetry — might be sensitive to the NP

MYSELF

- Graduated from the Technion in 2008.
- University of Maryland (1st postdoc): 2008-2011
- Harvard (2nd postdoc): 2011-2014
- LD staff at CERN and *professeur titulaire* at the University of Geneva from September, 2014

Research interests:

dark matter direct and indirect detection, baryogenesis, collider signatures of New Physics, “hunt” for (un)naturalness, model building

MYSELF — 2015

- Naturalness in the Dark at the LHC (Craig, AK, Strassler, Sundrum)
- The Fraternal WIMP Miracle (Craig and AK)
- Stop-Catalyzed Baryogenesis Beyond the MSSM (AK, Perelstein, Ramsey-Musolf, Winslow)
- Continuum-Mediated Dark Matter—Baryon Scattering (AK, Reece, Sajjad)
- Complementarity of Direct and Indirect Searches for a Spin-Dependent Dark Matter with a Heavy Mediator (to appear soon; Jacques, AK, Morgante, Racco, Rameez, Riotto)