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# New Physics: Where do we stand?

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Let's state the obvious

We know there is new physics beyond the SM

**Empirical evidence of BSM**

Neutrinos

Dark Universe

Matter-antimatter asymmetry



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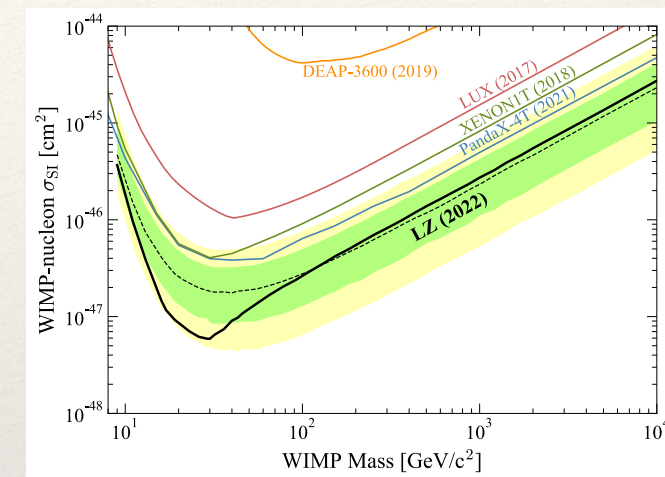
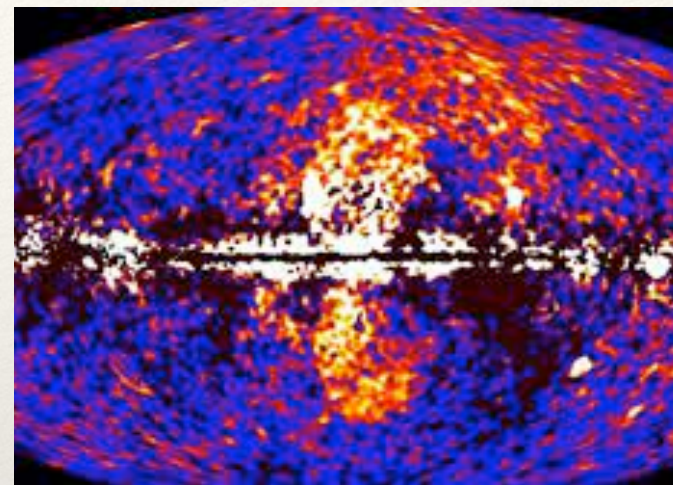
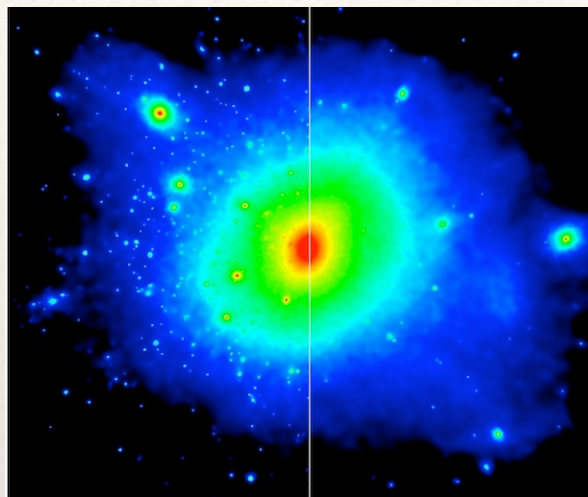
ICHEP 50+ years: grit, ingenuity, and a pinch of luck on Nature's side



# BSM nowadays

**very active** in **Dark Matter** and **Neutrino** model-building,  
and **somewhat less** in Baryogenesis, Dark Energy, Inflation,  
and Gravitational Waves

In DM plenty of  
model building,  
excesses and new  
developments



**In this talk**

I will focus mostly on our efforts in understanding the  
**electroweak sector**, driven by the LHC  
10 years after the discovery of the Higgs  
the field has changed tremendously,  
yet the key ideas remain the same



Before we get into EWSB, types of model building



**Recycled models:** taking elements from here and there, build a model which explains something. Allows to correlate different probes, is a lab for new ideas, keeps the momentum in case of a discovery



**Possibly long-lasting:** less specific, develop mechanisms or ideas e.g. CW, Supersymmetry, dimensional transmutation, dualities / holography, various uses of symmetries... Often result of going on a tangent, seeking some rationale or notion of mathematical beauty

The broad ideas I will talk about today are products of those long-lasting explorations, and they are still standing



post-W,Z discovery and pre-Higgs discovery

three decades to think on BSM & EWSB



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Why BSM? Isn't the SM Higgs mechanism ok?

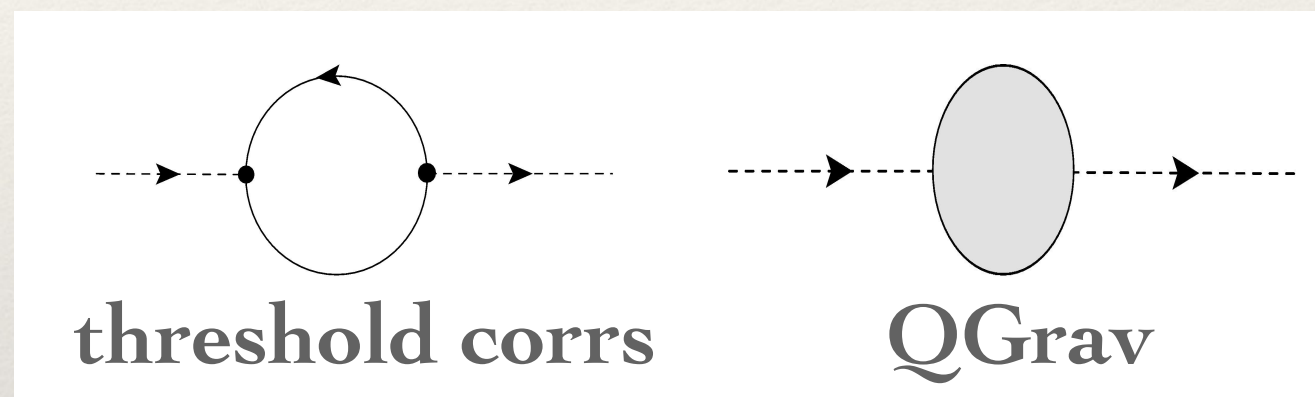


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Why BSM? Isn't the SM Higgs mechanism ok?

A light fundamental scalar is a quantum conundrum

Quantum  
corrections to scalars  
e.g. mass



$$\delta m_\phi^2 \propto c_1 \Lambda_{NP}^2 + c_2 M_{Pl}^2$$

$(\text{Physical mass})^2 = (\text{bare mass})^2 + (\text{unsuppressed Qcorrections})^2$   
**light scalar = enormous fine-tuning**



post-W,Z discovery and pre-Higgs discovery

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back then, two main routes



### **No Higgs particle**

EW phase transition triggered  
by some new strong dynamics,  
confinement

Technicolor & xdim duals  
difficult to hide from clean LEP  
data+precise low-energy  
Models were baroque or naive



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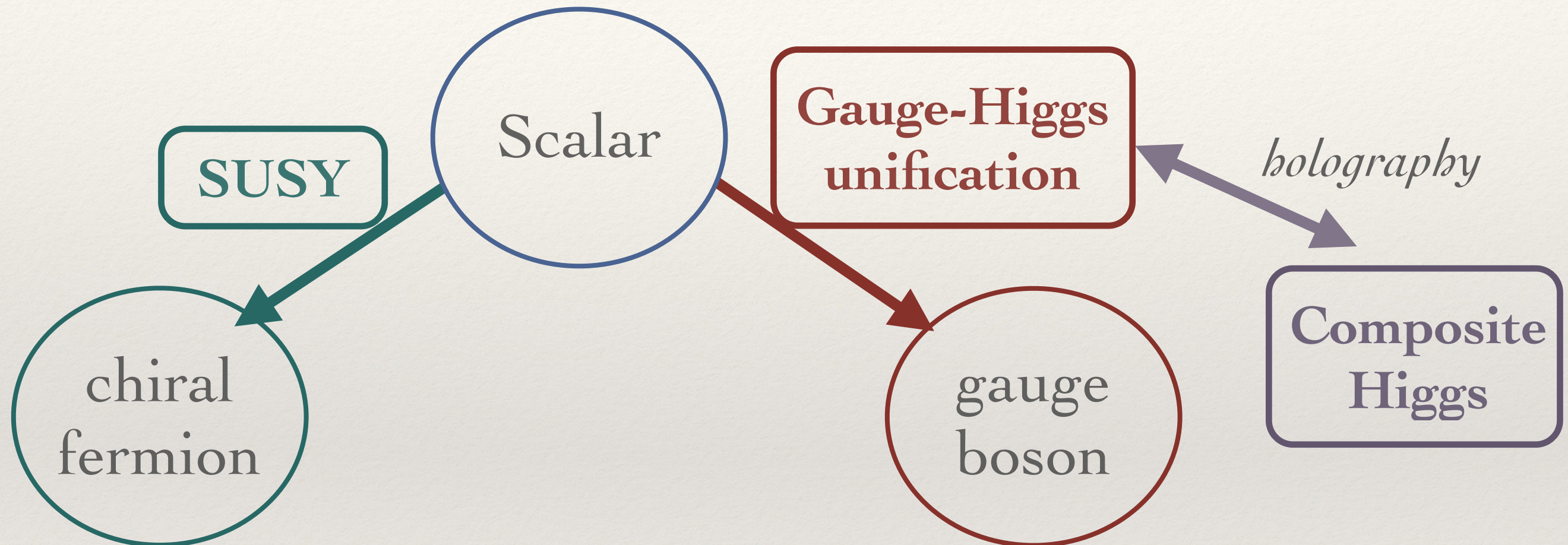
### **Higgs, but with entourage**

new mechanism to keep it  
naturally light  
Supersymmetry,  
compositeness, little Higgs,  
extra-dimensions  
Consistency: new light  $< \text{TeV}$   
resonances



post-W,Z discovery and pre-Higgs discovery  
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Stable Higgs through symmetries



Many, many possible realizations (phenomenology)  
Predict new states, to be discovered  
(SUSY partners, techni-baryons and mesons, spin-two...)  
AND induce deviations in the Higgs behaviour



post-W,Z discovery and pre-Higgs discovery  
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Stable Higgs through symmetries

**SUSY**

Scalar

**Gauge-Higgs  
unification**

*holography*

Exploring the  
boundaries of  
QFT  
unification

Inspired by  
string theory  
and the  
promise of the  
ultimate  
theory

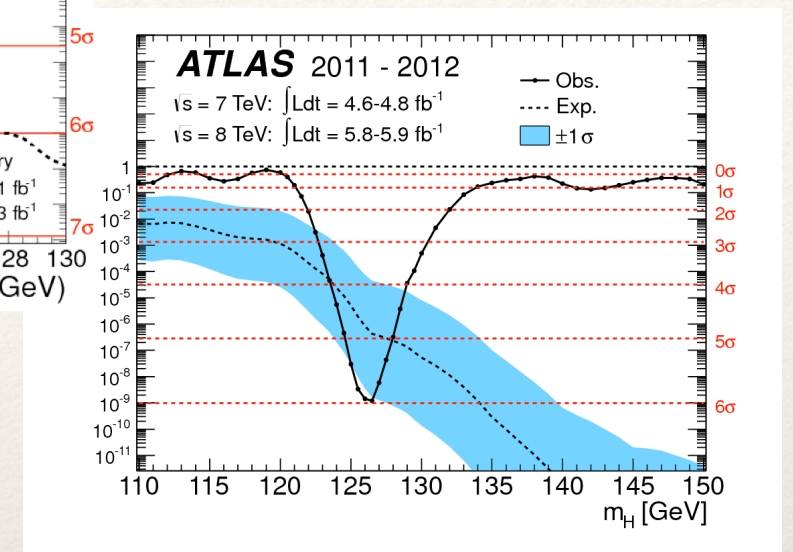
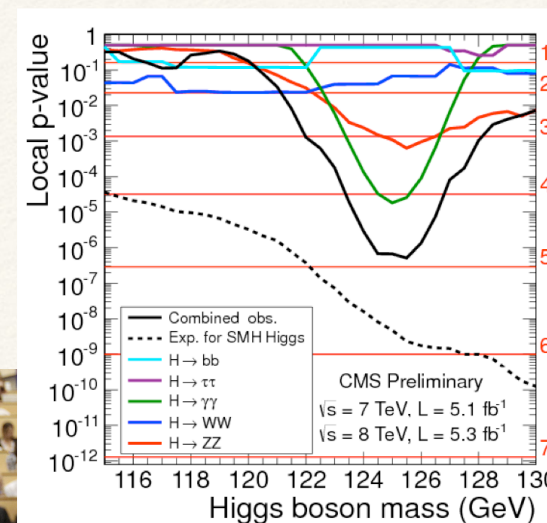
**Composite  
Higgs**

Inspired by  
Nature's way  
of making  
scalar dofs and  
string theory

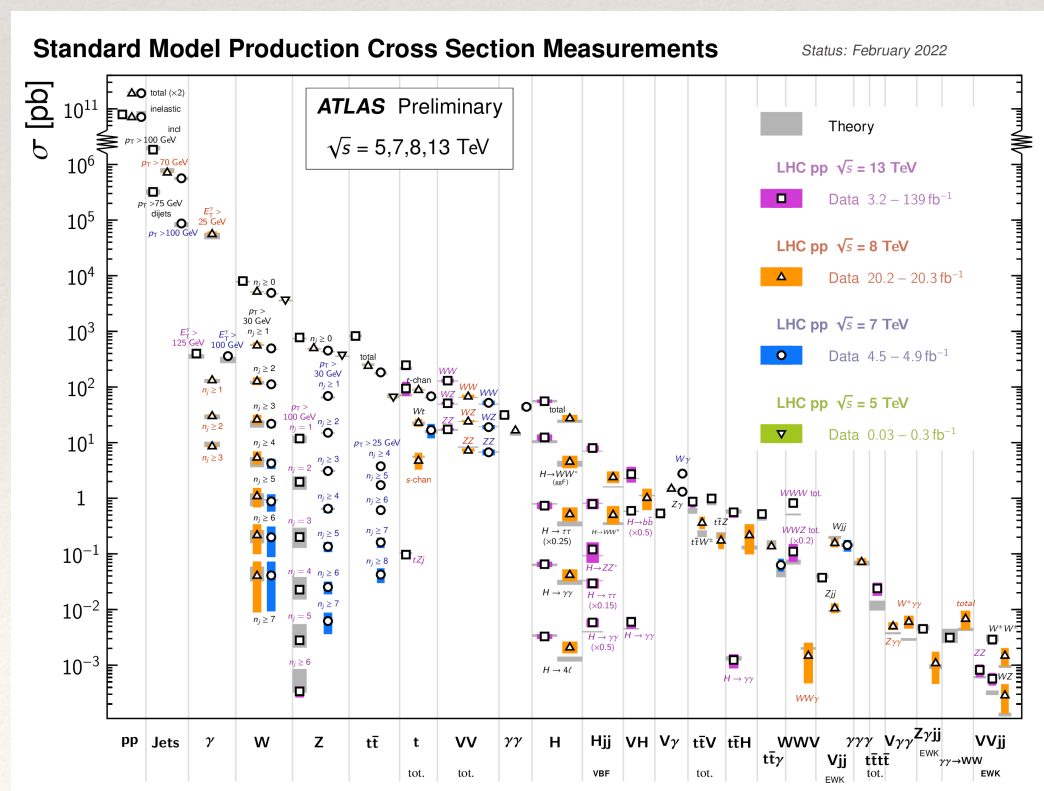
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AND induce deviations in the Higgs behavior



# And then, there was the discovery



With a Higgs particle already walking and quacking like a SM-Higgs



In 10 years, the LHC went from a hadron / discovery / dirty machine to a **precision machine** where we can test the boundaries of the SM



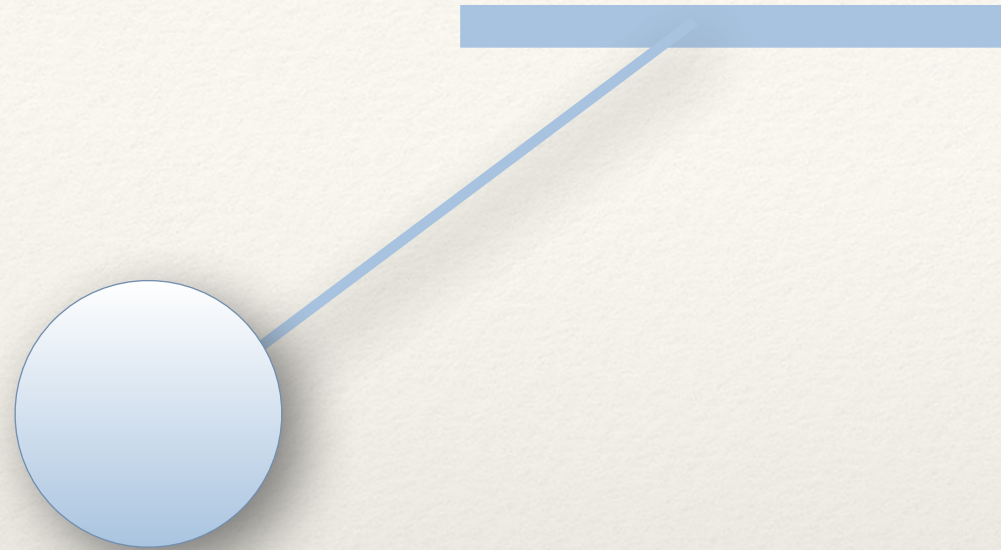
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**SM enthusiast:**

fine-tuning is a technical notion  
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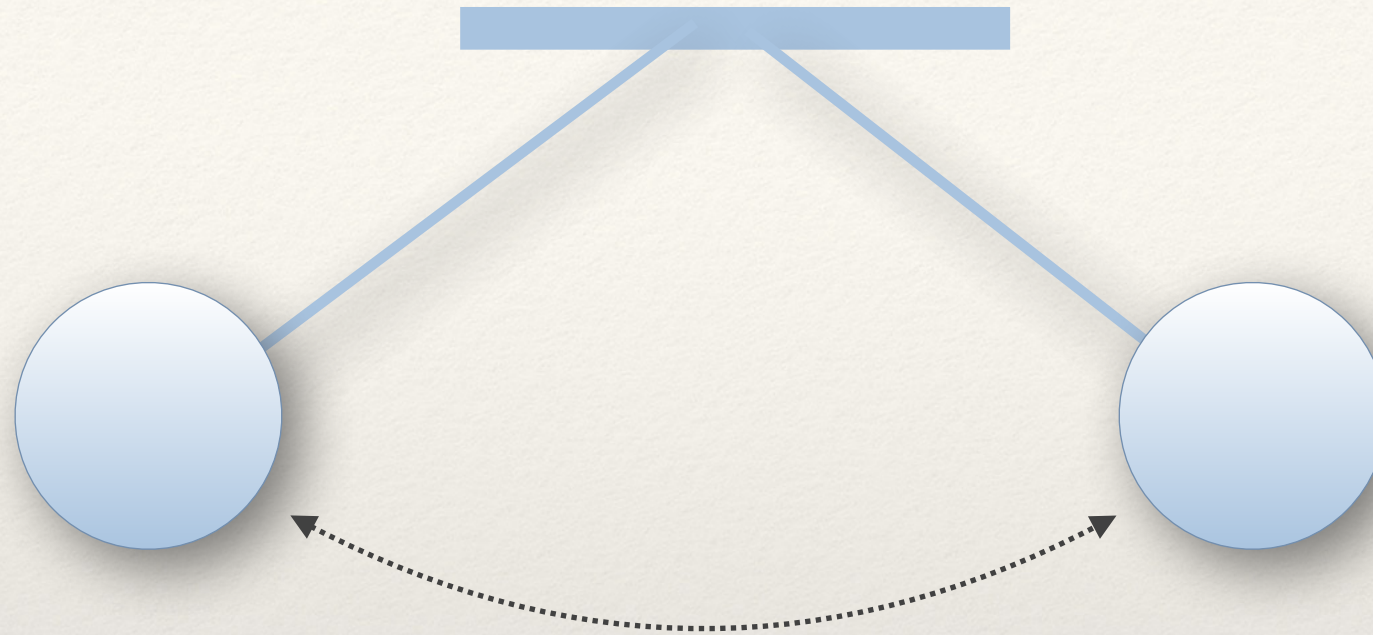
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*crying wolf is bad PR?*



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**BSM hopeful:**

we do not understand EWSB  
precision is an opportunity to  
see the SM breaking down  
*Are we in a Michelson moment?*  
need to keep pushing on with  
direct & indirect searches



# Final comments and personal thoughts

Precise measurements at the LHC are testing the SM  
to, I should hope, its breaking point

But so far all the evidence supports the SM  
and gives no clear hint of BSM  
except hopes in flavour,  $g-2$ ,  $m_W$ , photon HVP...

With the problem of  $WW$  scattering we had a beacon to follow towards the EW scale, but we no longer have one

As a result, many BSM efforts have long moved to more *dynamical* areas like DM, where a good stream of results and ephemeral excesses motivates furious model building  
Despite the fact that DM could hate us or could be too light or too heavy to ever be accessible



## Final comments and personal thoughts

The Physics programme at the LHC will continue ~15 more years, and future colliders may start being built in between

We're talking about a long time for *business as usual*



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We all should **renew** the enthusiasm that built the LHC, be a lot more outspoken about the profound *ideas* we explore

*Stop with the crying wolf mindset:*

a lot of disciplines rely on exploring big questions  
(*how does the mind work? is there life in other planets?*)

and thrive because are seen as worthy

Focusing on sure deliverables (SM) misses the point



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We theorists should engage again with exploring purely  
theoretical avenues, beyond immediate testing

out-of-the-box ideas are too often considered niche / crackpotty  
and hindering job prospects

but remember these crazy ideas are what many of us are here for



**Thank you!**  
**Questions or comments?**