Introduction for HH benchmarks!

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EF02: Patrick Meade, Isobel Ojalvo

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Plan

- Some background, motivation, discussion questions
- Laying out of the benchmarks submitted
- Which of these should be used or modified?
- What do we still need in terms of benchmarks?

Snowmass has a history of benchmarking

The Snowmass Points and Slopes: Benchmarks for SUSY Searches #1

B.C. Allanach (CERN), M. Battaglia (CERN), G.A. Blair (JAI, UK), M. Carena (Fermilab), A.De Roeck (CERN) et al. (Feb 26, 2002)

Published in: *Eur.Phys.J.C* 25 (2002) 113-123 • Contribution to: Snowmass 2001 • e-Print: hep-ph/0202233 [hep-ph]

pdf links DOI cite 941 citations

In fact as a wee grad student, one of my first intros to Snowmass was what is SPS1a and why do I care?

Snowmass has a history of benchmarking

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Not here to judge prior benchmarks, and now I'm old so...


Bernie
I am once again asking
for Snowmass Benchmarks
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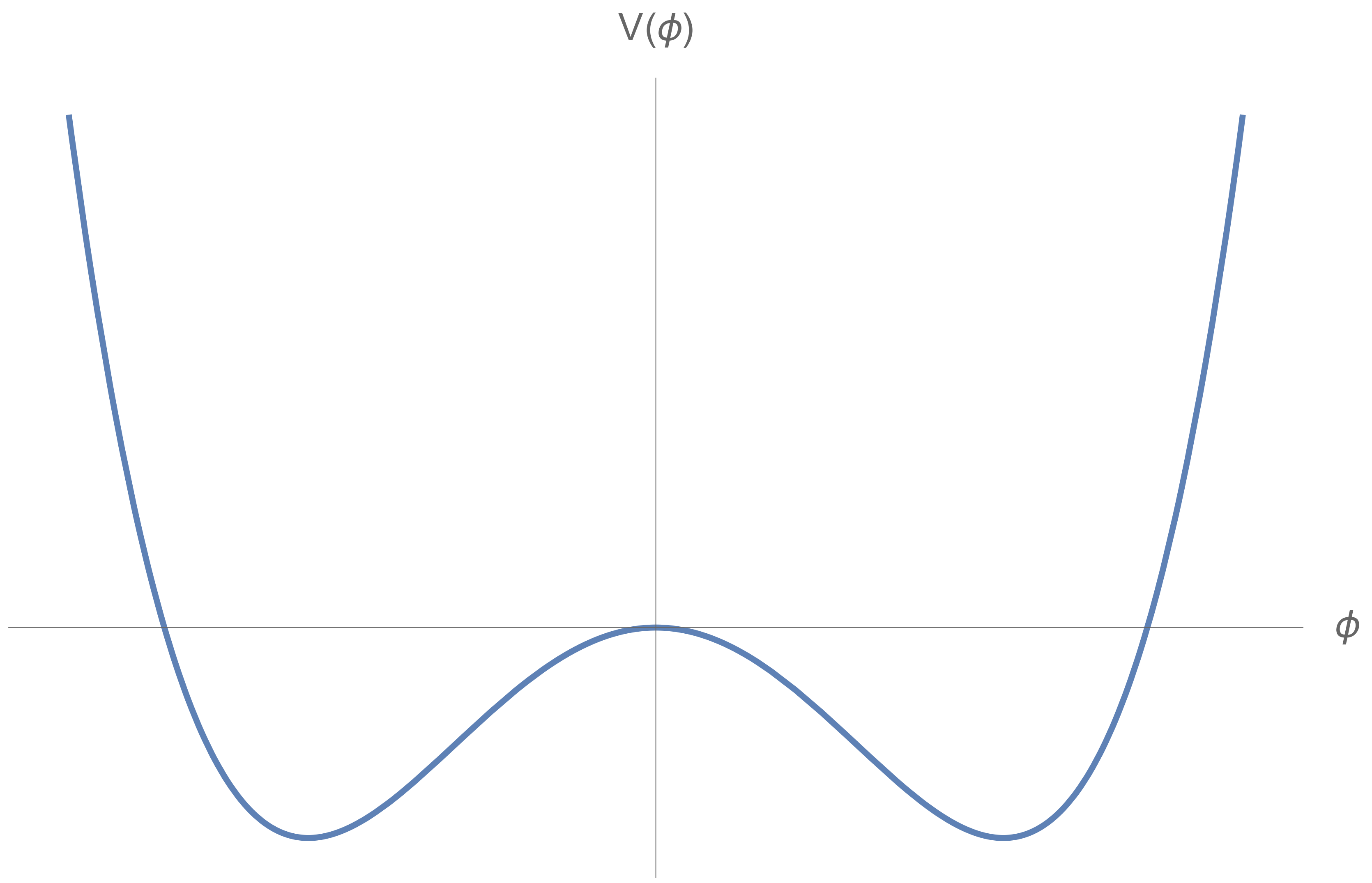
Why do we want di-Higgs benchmarks?

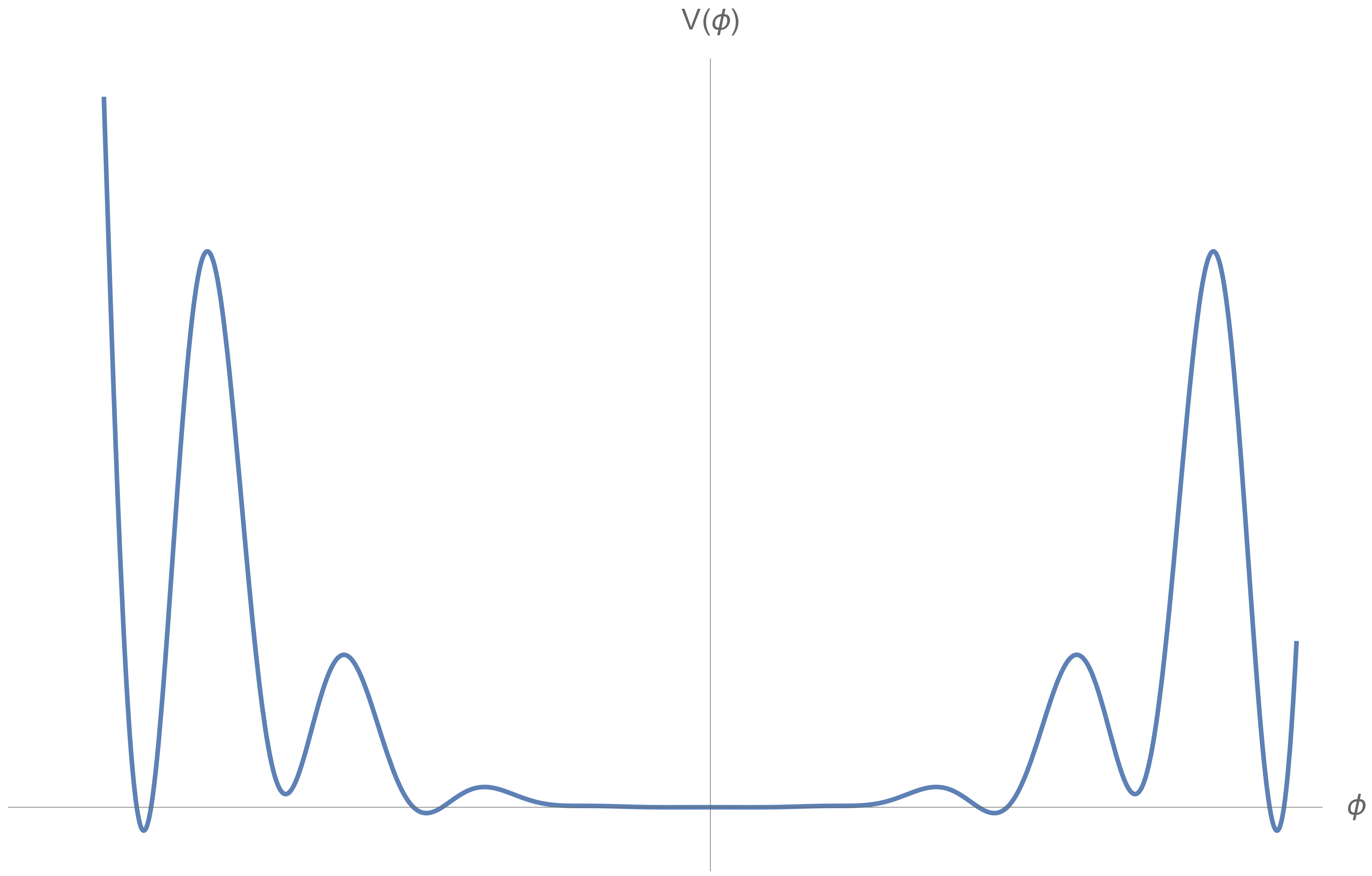
A fundamental experimental question, what is the Higgs potential?



$$\left.\frac{\partial V(\phi)}{\partial \phi}\right|_{\phi=v} = 0$$

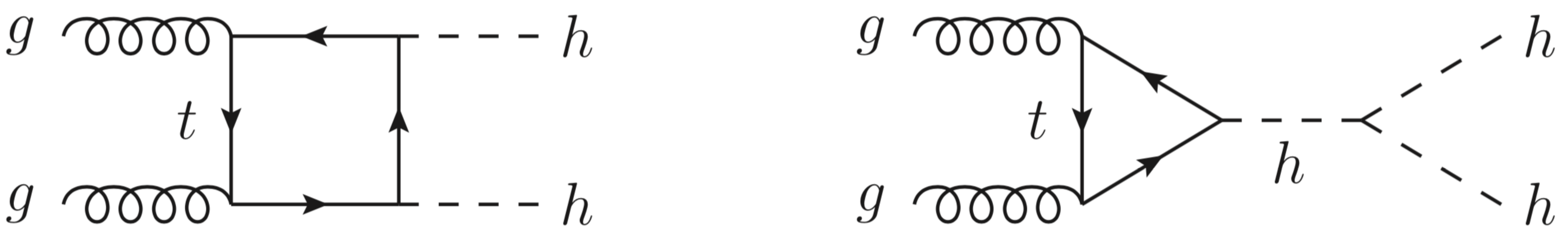
$$\left.\frac{\partial^2 V(\phi)}{\partial \phi^2}\right|_{\phi=v} = m_h^2$$

OR



To learn more we need to look at Higgs self-interactions

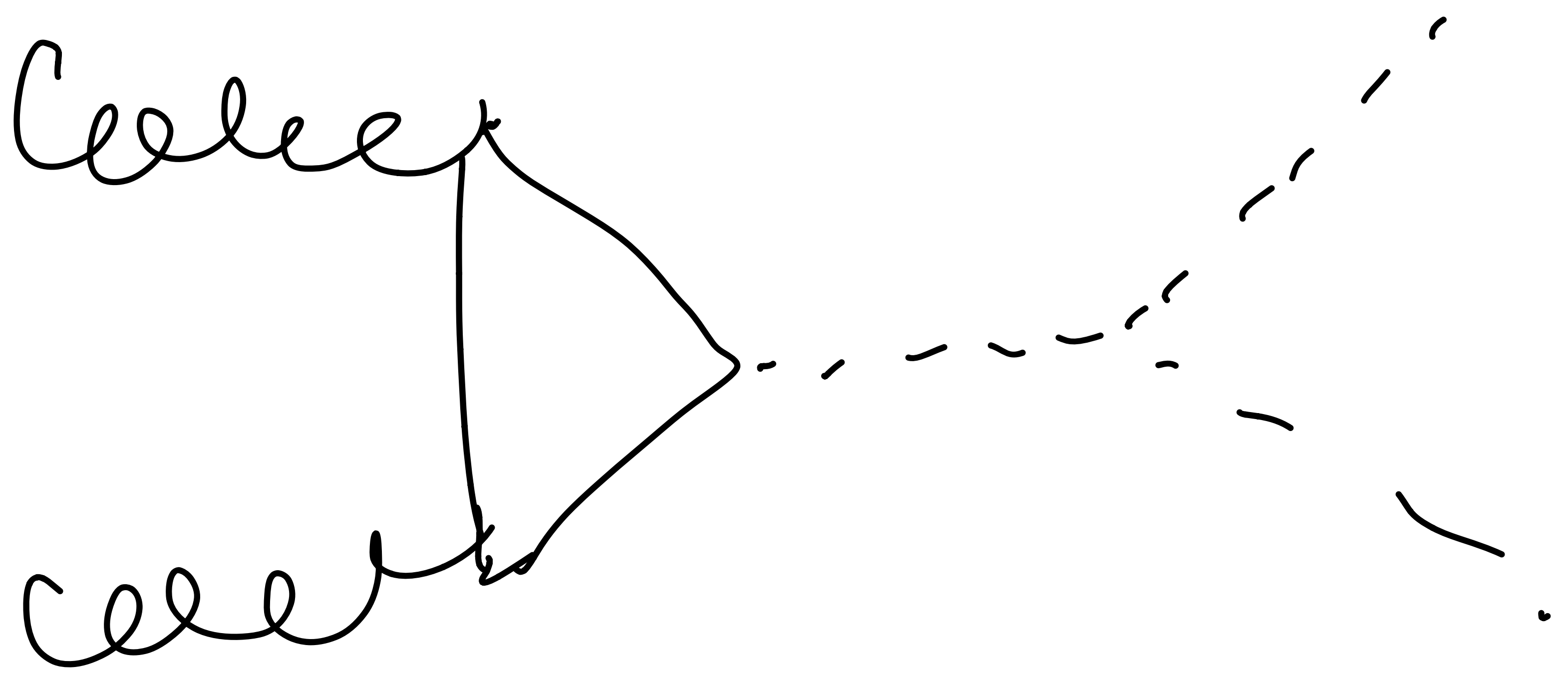
NEVER SEEN BEFORE IN NATURE!
Every other particle changes its type when it interacts with itself

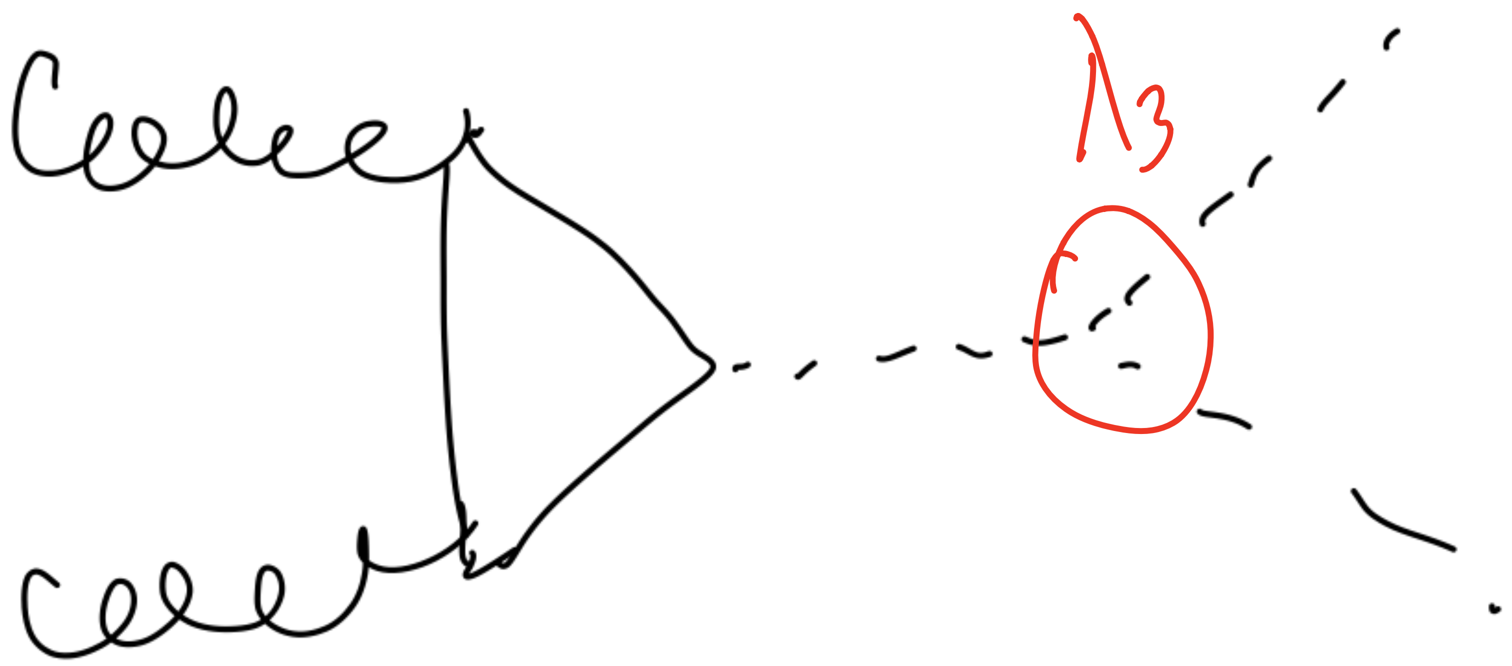


Unfortunately it's very difficult and
it interferes with itself

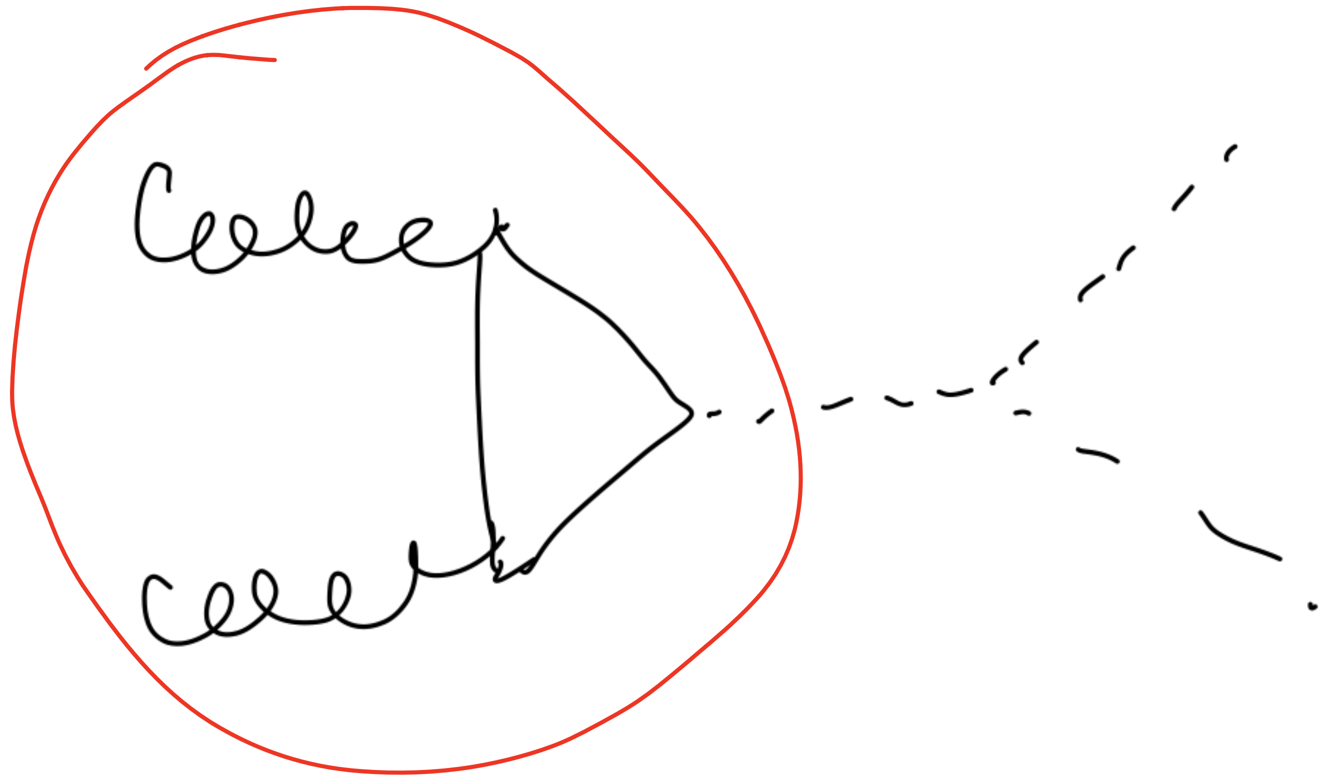
However, just measuring the SM value
would be seeing something qualitatively new!

Of course if it's different than the SM prediction this means BSM

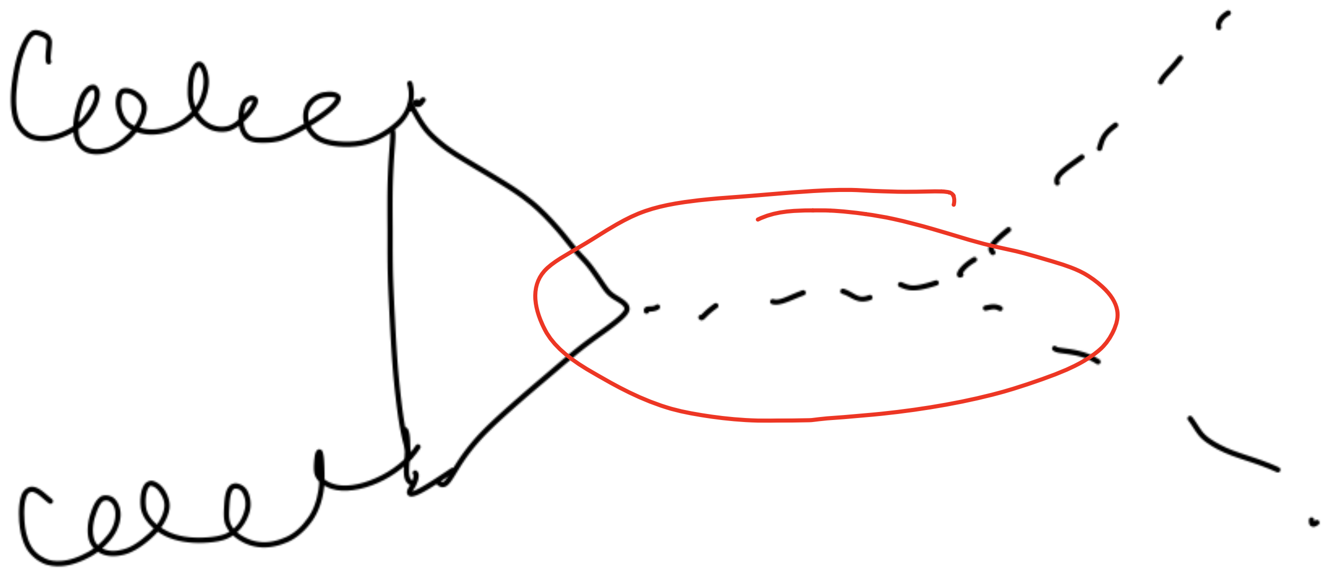




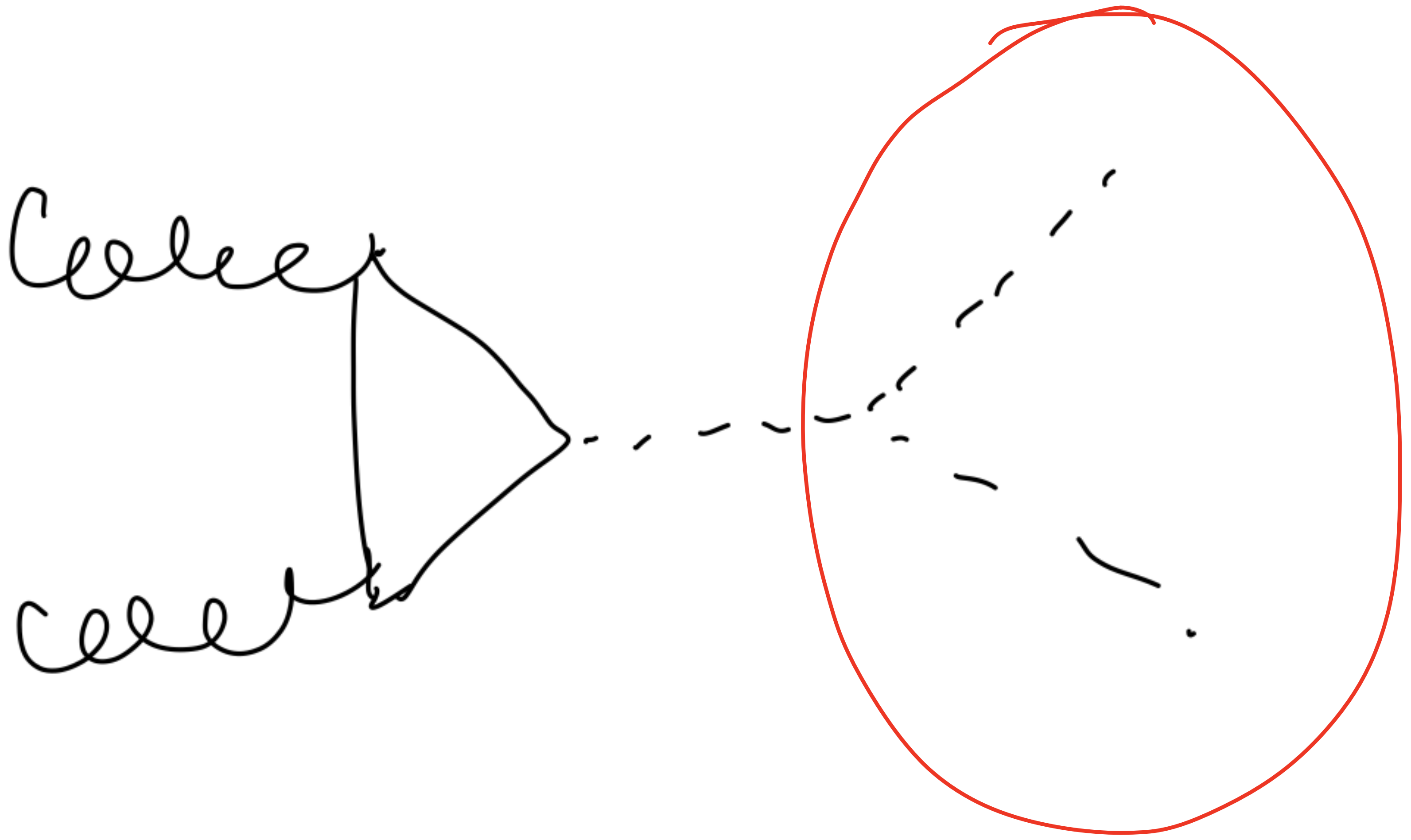
Many ways BSM physics can alter di-Higgs



Initial state



Intermediate state



Final state

How do we choose benchmarks?

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They at least had it "easy" there was an agreed on particle content...

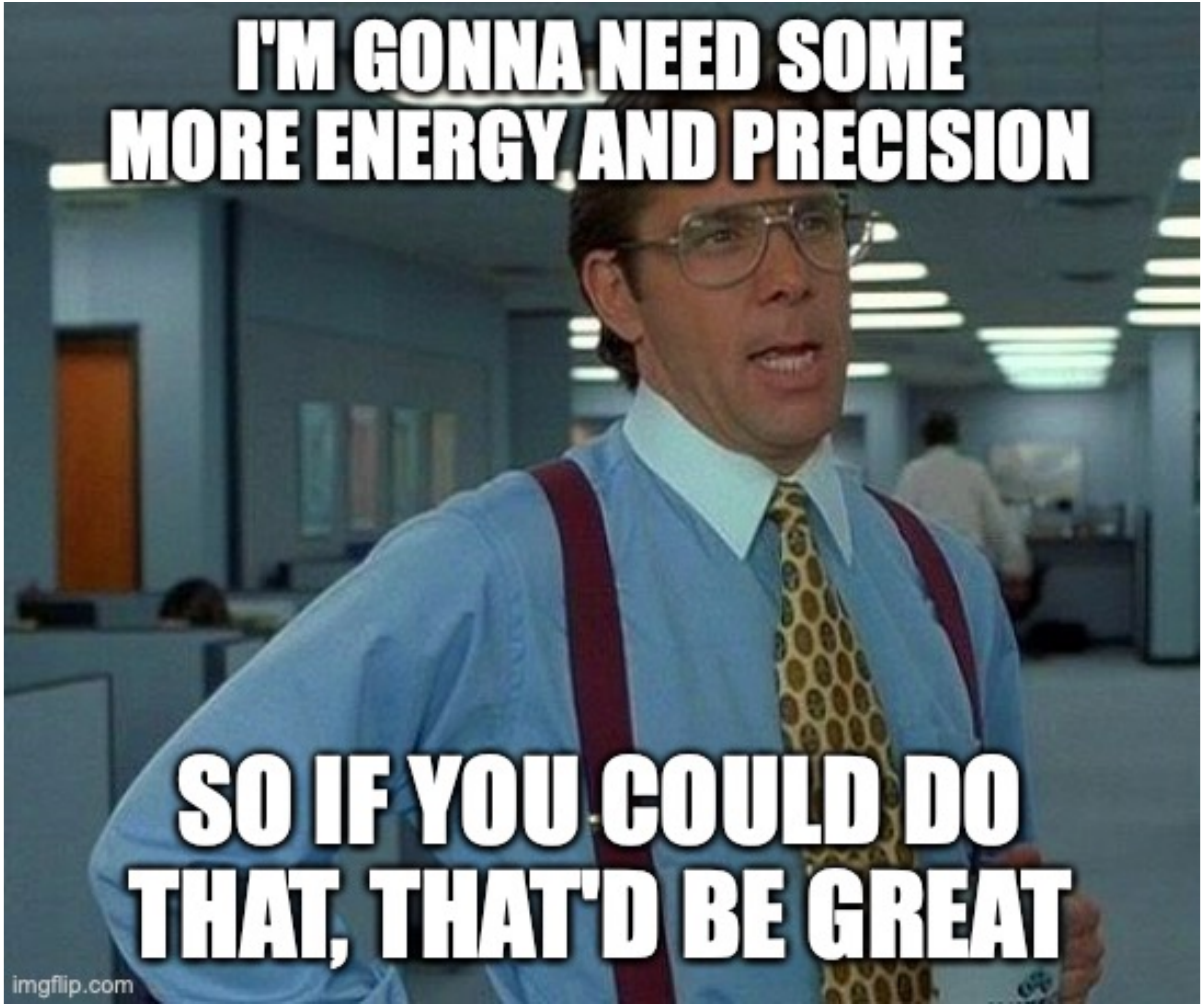
How do we choose benchmarks?

The question of which parameter choices are useful as benchmark scenarios depends on the purpose of the actual investigation. If one is interested, for instance, in setting exclusion limits on the SUSY parameter space from the non-observation of SUSY signals at the experiments performed up to now, it is useful to use a benchmark scenario which gives rise to “conservative” exclusion bounds. An example of a benchmark scenario of this kind is the $m_{\rm h}^{\rm max}$-scenario [5] used for the Higgs search at LEP [6] and the Tevatron [7]. It gives rise to maximal values of the lightest $\mathcal{CP}$-even Higgs-boson mass (for fixed values of the top-quark mass and the SUSY scale) and thus allows one to set conservative bounds on $\tan\beta$ and $M_{\rm A}$ (the mass of the $\mathcal{CP}$-odd Higgs boson) [8]. Another application of benchmark scenarios is to study “typical” experimental signatures of SUSY models and to investigate the experimental sensitivities and the achievable experimental precisions for these cases. For this purpose it seems reasonable to choose “typical” (a notion which is of course difficult to define) and theoretically well motivated parameters of certain SUSY-breaking scenarios. Examples of this kind are the benchmark scenarios used so far for investigating SUSY searches at the LHC [9, 10], the Tevatron [11] and at a future Linear Collider [12]. As a further possible goal of benchmark scenarios, one can choose them so that they account for a wide variety of SUSY phenomenology. For this purpose, one could for instance analyse SUSY with R-parity breaking, investigate effects of non-vanishing $\mathcal{CP}$ phases, or inspect non-minimal SUSY models. In this context it can also be useful to consider “pathological” regions of parameter space or “worst-case” scenarios. Examples for this are the “large-$|\mu|$ scenario” for the Higgs search at LEP [5] and the Tevatron [13], for which the decay $h \to b\bar{b}$ can be significantly suppressed, or a scenario where the Higgs boson has a large branching fraction into invisible decay modes at the LHC (see e.g. Ref. [14]).

A related issue concerning the definition of appropriate benchmarks is whether a benchmark scenario chosen for investigating physics at a certain experiment or for testing a certain sector of the theory should be compatible with additional information from other experiments (or concerning other sectors of the theory). This refers in

What's already being done versus what's new?

If something is already done - is there a theory connection that points to a certain precision?


I'M GONNA NEED SOME MORE ENERGY AND PRECISION
SO IF YOU COULD DO THAT, THAT'D BE GREAT
imgflip.com

What's already being done versus what's new?

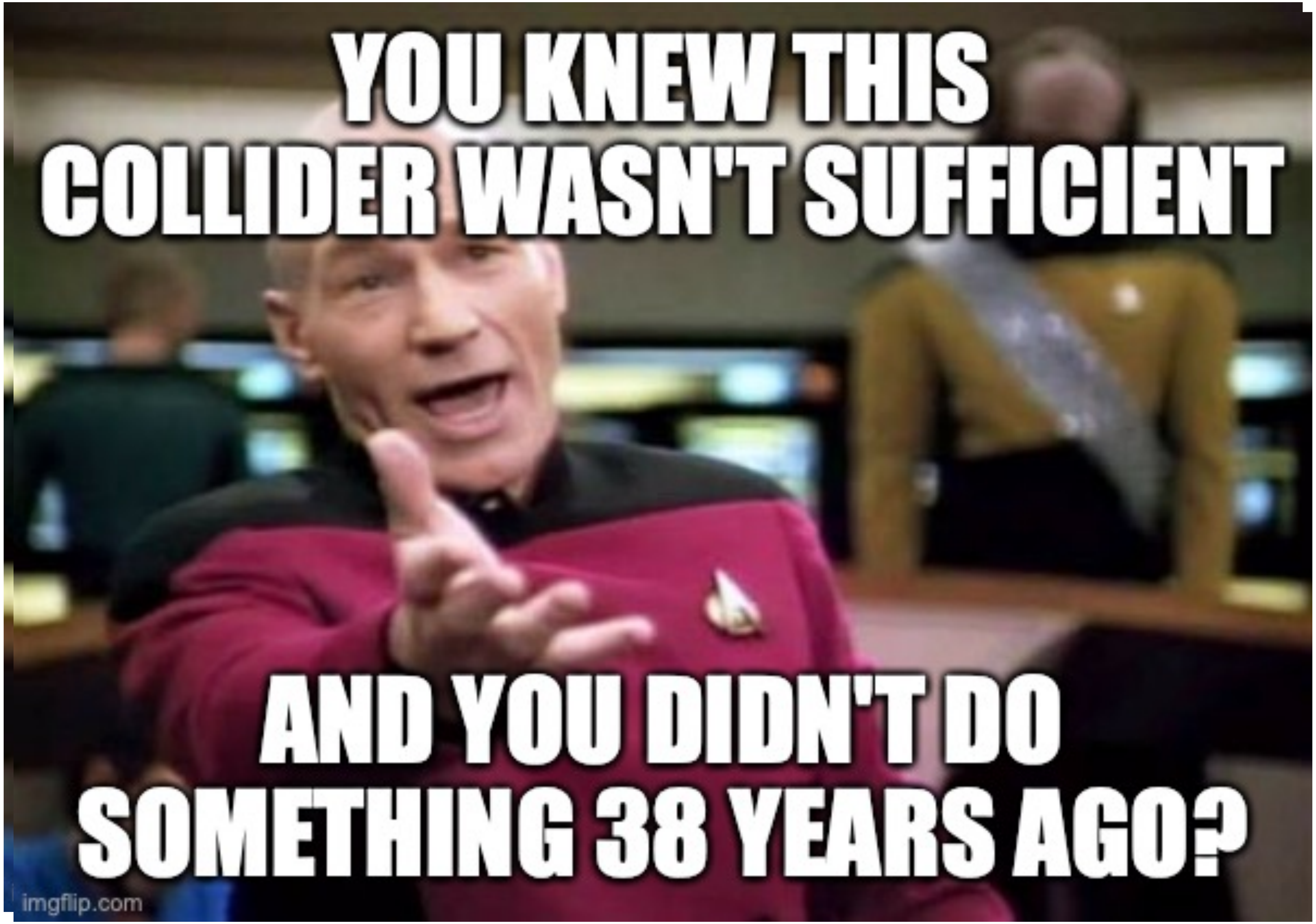
If something is already done - is there a theory connection that points to a certain precision?

(e.g. electroweak phase transition/delayed transition/non-restoration)

Are there qualitatively new phenomena not considered so far that lead to new experimental techniques/needs?

Should we aim benchmarks that exploit different collider options, or is there one collider to rule them all?

Are there any **motivated** reasons we need to push beyond what we have so far?



#Snowmass1982 #Snowmass2058

So…


WHAT DO WE WANT?
BENCHMARKS!
WHEN DO WE WANT THEM?
NOW!
WHAT ARE THEY?
WHO KNOWS!
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