Introduction to Higgs physics

Search for Higgs pair production with the CMS collaboration

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Institut de Physique des 2 Infinis
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Under the supervision of Maxime Gouzevitch

April 24, 2026

Introduction

Understanding the mechanics of the Higgs boson:
Lets derive together the SM equation:

$$L = \frac{1}{4}F \quad F \quad + i \bar{} \; \Theta \quad + \quad {}_i y_{ij} \quad {}_j \quad + h{:}c + jD \quad {}^2 j \quad V(\quad) \qquad (1)$$

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Understanding the mechanics of the Higgs boson:
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Higgs physics: if the Higgs boson was a minecraft block, which one would it be?

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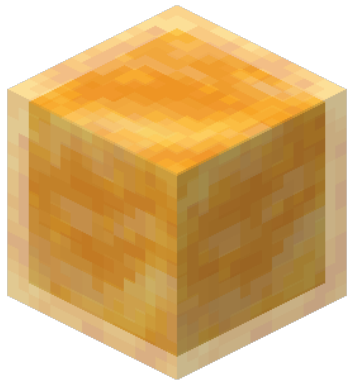
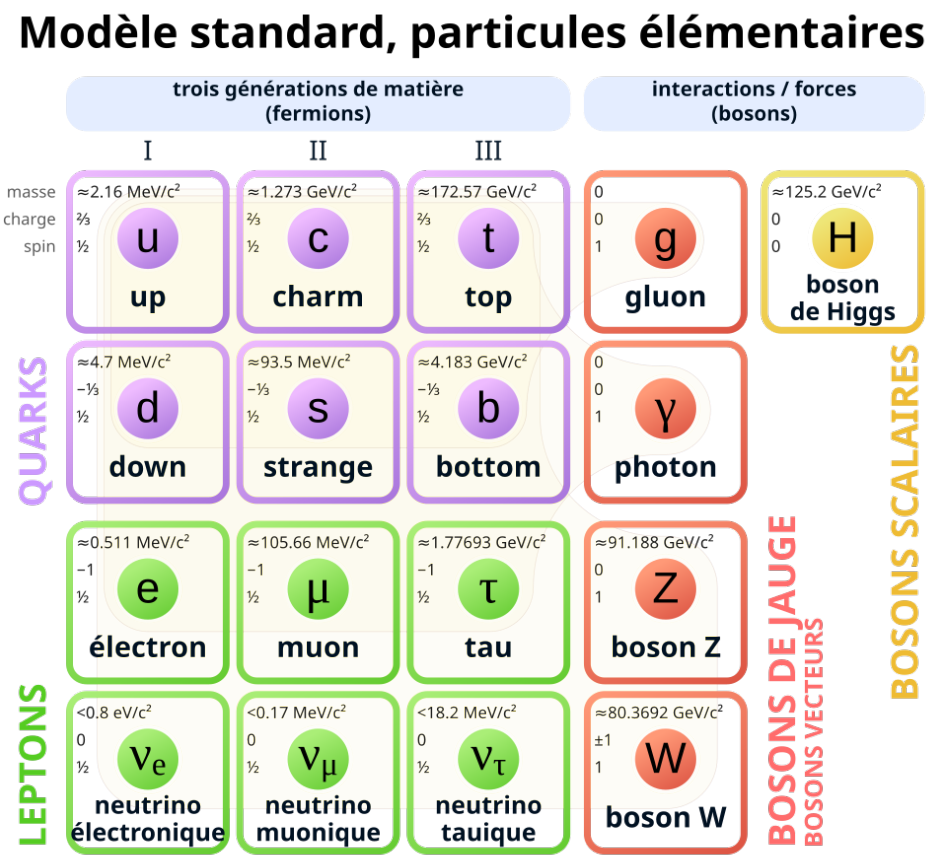


Introduction: the zoology of particles



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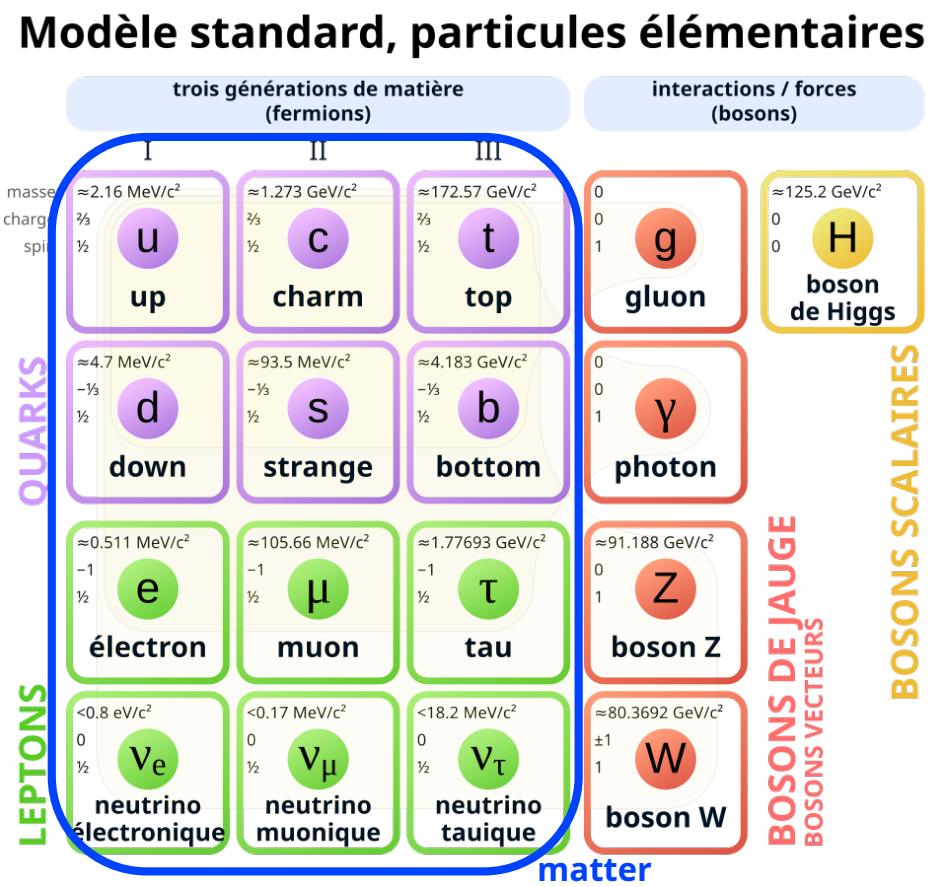

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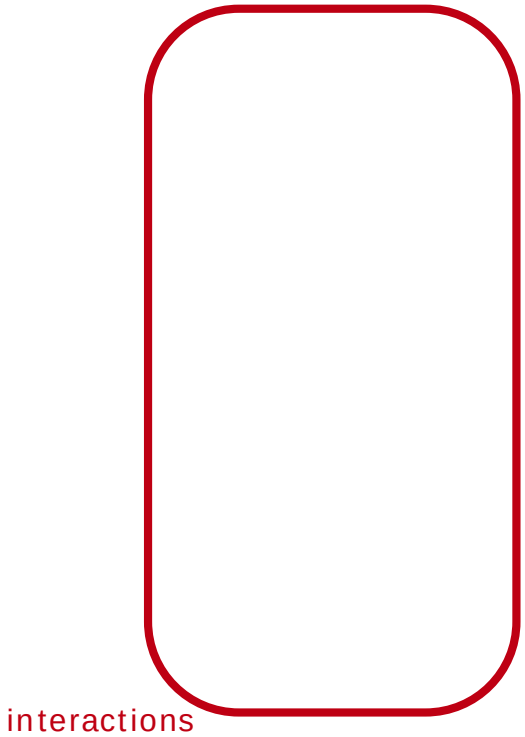

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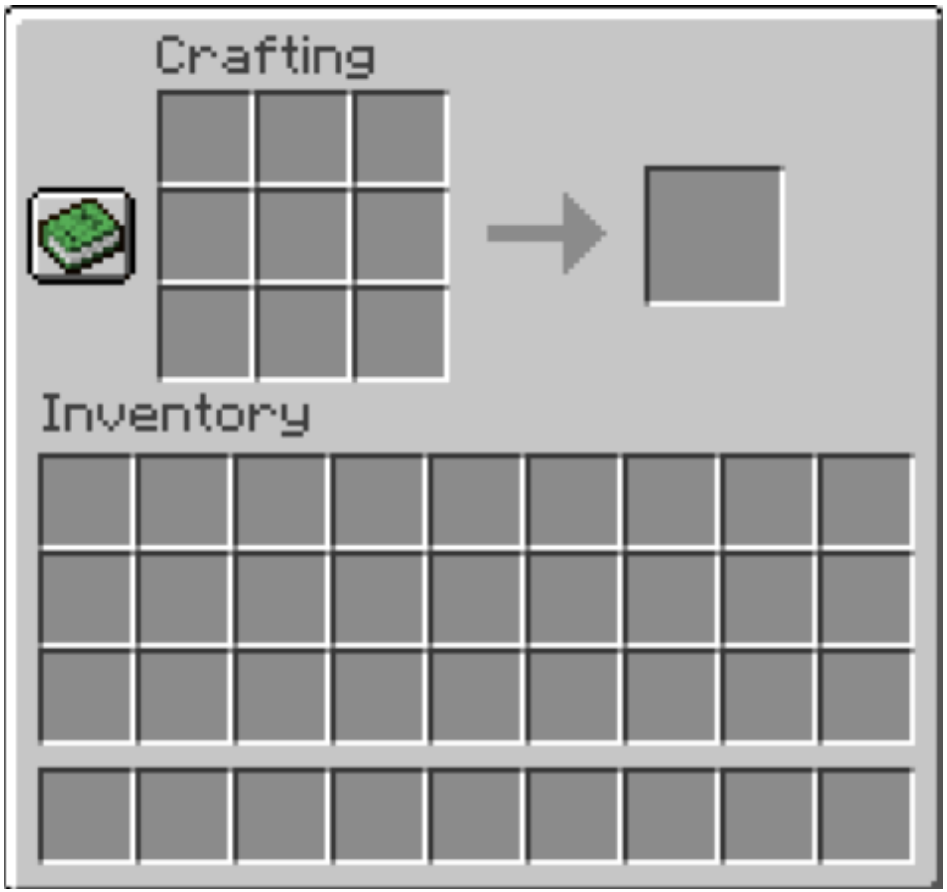

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The Higgs mechanism

What gives particles their mass?

The Brout-Englert-Higgs mechanism (BEH), during the Early Universe

(Technically the Englert{Brout{Higgs{ Guralnik{Hagen{Kibble mechanism, but i am NOT saying that); 1964

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Mass = interaction with the Higgs boson!
The more it interacts = the heavier it is.

simulation of a Higgs boson being produced in CMS. Credit: Lucas Taylor/CMS

A missing piece:

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X Measuring its interaction with other particles
...
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Theoretical value: $_{th} = 0{:}13$.
If $_{th} \neq$: **missing piece in our understanding of the Universe.**

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End goal:

Learn to measure Higgs self-interaction .

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) Data analysis: train Deep Neural Network (DNN) on LHC data to separate background from signal.
) Data simulation: generate LHC-like events, with a Higgs boson pair. Use it to see if we can extract signal.

- Interaction with the Higgs boson: how particles get masses (Higgs mechanism).
- The more they interact = the heavier !
- Particles get masses during the Early Universe.
- Higgs mechanism dependant on a factor:
- only accessible with Higgs doublet: very rare. Need to prepare for measures at the HL-LHC (+other future collisioners)!

Questions

Some suggestions:

- How can they be sure in 2012 that it was the Higgs that they observed?
- Why HH ! b $\bar{b}$ speci cally? And not just b$\bar{b}$, , or another particle in the standard model?
- Why do we need an energy of 13TeV (CERN collision energy) to discover particle whose mass is only 125GeV?
- Why is the Higgs / a Higgs pair so rare of an event?
- What is your favourite minecraft block / owl?
- Have you ever been diagnosed with any sort of mental illness?
- Others questions more than welcome!

Annex

Higgs branching ratios

Annex

Interfering diagrams for di-Higgs production at the LHC:

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