



Properties of the Higgs Boson

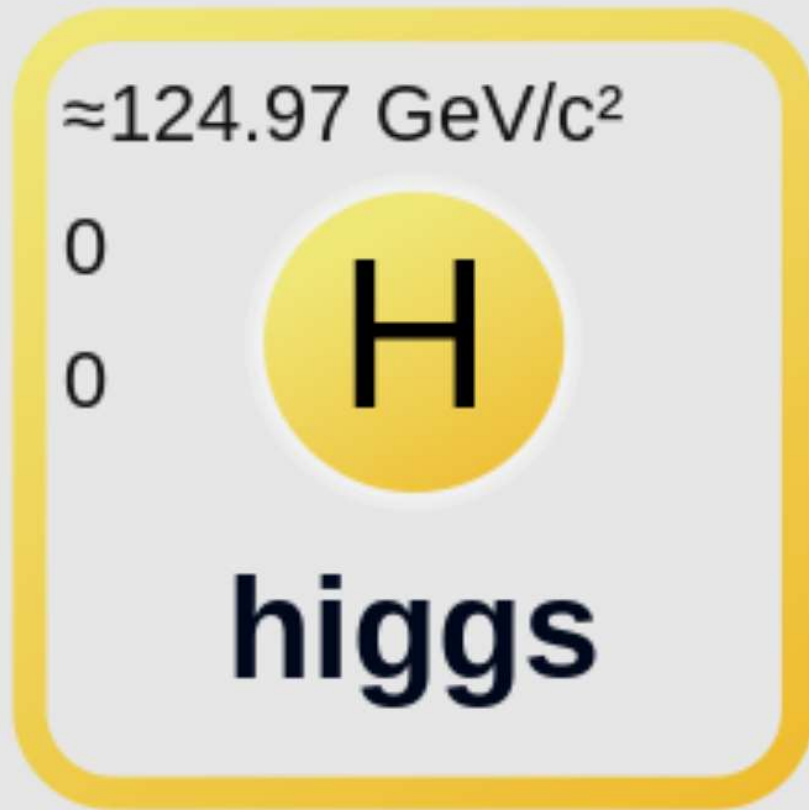
Overview Over the Properties

Standard Model of Elementary Particles

	three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III		
mass	$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	0	$\approx 124.97 \text{ GeV}/c^2$
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
QUARKS	u up	c charm	t top	g gluon	H higgs
	$\approx 4.7 \text{ MeV}/c^2$	$\approx 96 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	d down	s strange	b bottom	γ photon	
LEPTONS	$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.66 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	$\approx 91.19 \text{ GeV}/c^2$	
	-1	-1	-1	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	e electron	μ muon	τ tau	Z Z boson	
	$< 1.0 \text{ eV}/c^2$	$< 0.17 \text{ MeV}/c^2$	$< 18.2 \text{ MeV}/c^2$	$\approx 80.360 \text{ GeV}/c^2$	
	0	0	0	± 1	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

SCALAR BOSONS

GAUGE BOSONS
VECTOR BOSONS



Mass: $\sim 125.1 \text{ GeV}/c^2$ (c.f. **little Higgs**)

Charge: 0

Spin: 0

Parity: Positive

Decays: mostly into particle pairs.

Lifetime: $\sim 10^{-22}$ seconds.

Self-Interaction: Yes.

Coupling: Proportional to particle masses.

VEV: Non-zero



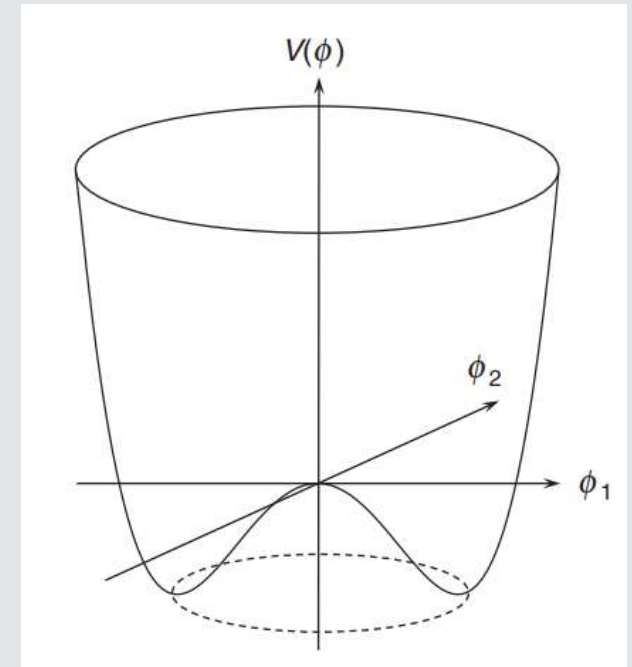
The Higgs Mechanism

Starting point: gauge symmetry of the electro-weak force **$U(1) \times SU(2)$**

Predicts the W-Bosons, the Z-Boson and the Photon, but all massless

Solution: Interaction with the *Higgs field*

The Higgs field is a complex scalar field and has a Sombrero shaped potential



The degenerated non-zero vacuum state of the sombrero potential leads to spontaneous symmetry breaking of the Higgs field

Two different oscillations around that vacuum state, that correspond to two different Bosons: The Higgs Boson and a so-called *Goldstone Boson*

The Goldstone can be absorbed into the gauge field when coupling to other particles, but it leads to a new mass term, which used to be the VEV of the Higgs field

This gives mass to the W and Z Bosons, thus breaking the electroweak force into the electromagnetic and the weak force

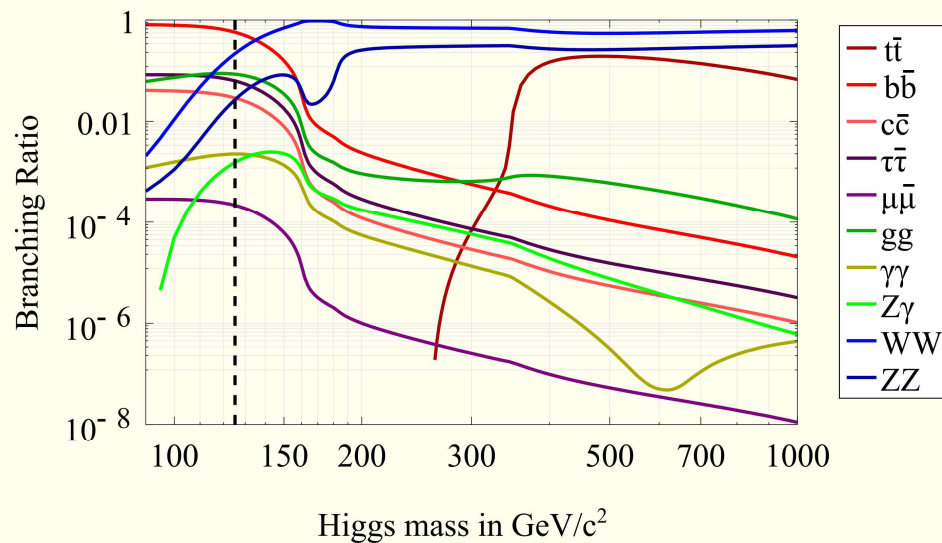
Fermions acquire their mass in very similar way via the Yukawa coupling

A black and white visualization of a particle decay event. A central point of origin emits a dense, chaotic spray of thin, white, curved lines that fan out across the frame. The background is dark with a faint grid pattern and some scattered white pixels. On the right side, there is a large, light-colored, rounded rectangular area with a thin white border and a subtle drop shadow. Inside this area, the title text is displayed in a bold, sans-serif font.

Decay of the Higgs Particle

Table 17.1 The predicted branching ratios of the Higgs boson for $m_H = 125 \text{ GeV}$.

Decay mode	Branching ratio
$H \rightarrow b\bar{b}$	57.8%
$H \rightarrow WW^*$	21.6%
$H \rightarrow \tau^+\tau^-$	6.4%
$H \rightarrow gg$	8.6%
$H \rightarrow c\bar{c}$	2.9%
$H \rightarrow ZZ^*$	2.7%
$H \rightarrow \gamma\gamma$	0.2%



Thank you for your attention!

Pictures are taken from Mark Thomson - Modern Particle Physics and [Higgs boson - Wikipedia](#).

