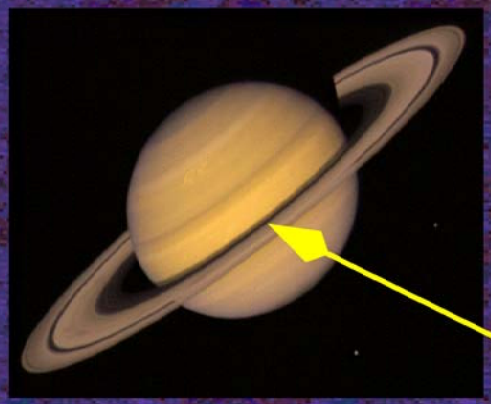
Teilchenphysik mit TESLA

Woher kommt die Masse ?

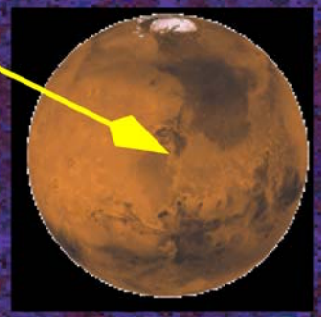
Achim Stahl DESY/Zeuthen

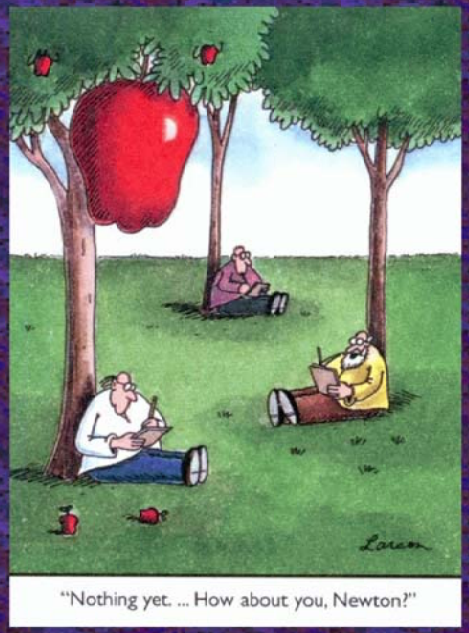
Isaac Newton

(1643 – 1727)

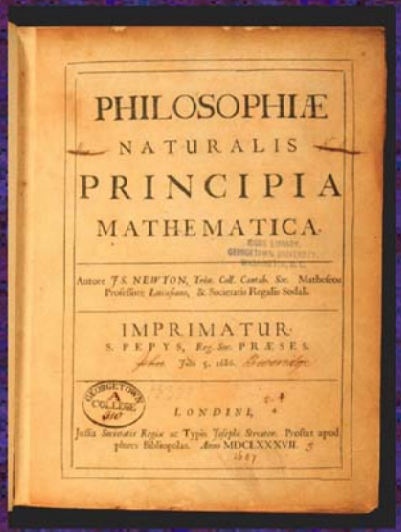


$\vec{F}_{grav}$





$$\vec{F}_{grav} = -G \frac{m_1 m_2}{r^2} \hat{r}$$

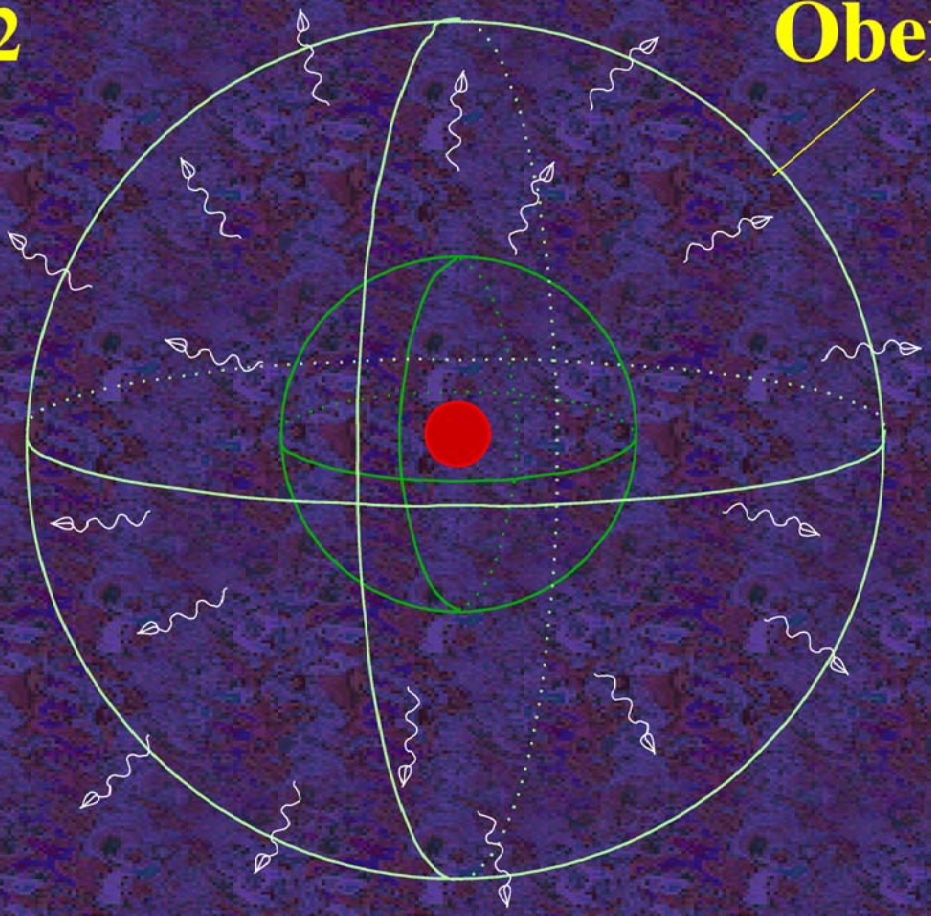

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

Kräfte

werden durch Austauschteilchen vermittlet

Abstandsverhalten

$$F \sim \frac{1}{r^2}$$



Oberflaeche $\sim r^2$

Dichte der Austauschteilchen $\sim \frac{1}{r^2}$

schwere Masse

=

träge Masse

$\leqslant$ 0.1 m
Apfel

1/10,000,000

10^{-9} m
Molecule

1/10

10^{-10} m
Atom

1/10,000

10^{-14} m
Atomic nucleus

1/10

10^{-15} m
Proton

1/1,000

$< 10^{-18}$ m
Electron,
Quark

Der Teilchenzoo:

Neutrino	Elektron	d–Quark	u–Quark
~ meV	511 keV	~ 3 MeV	~ 5 MeV
Neutrino	**Myon**	**s–Quark**	**c–Quark**
~ meV	105 MeV	120 MeV	1.2 GeV
Neutrino	**Tau**	**b–Quark**	**t–Quark**
~ meV	1.8 GeV	4.2 GeV	175 GeV

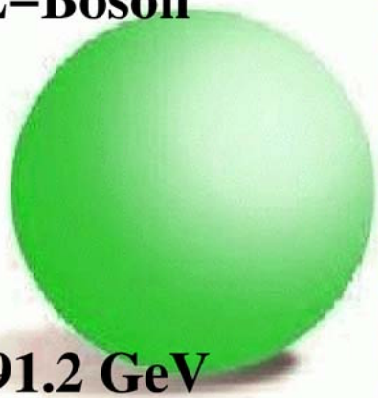
Photon 0

Graviton 0

W–Boson

80.4 GeV

Z–Boson



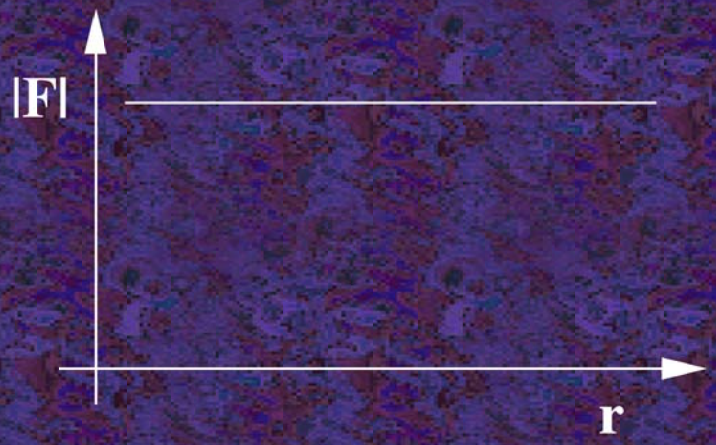
91.2 GeV

Gluon 0

Die Reichweite der Kräfte

z.B. Gravitation

Masseloses Boson



unendliche Reichweite

z.B. schwache Kraft

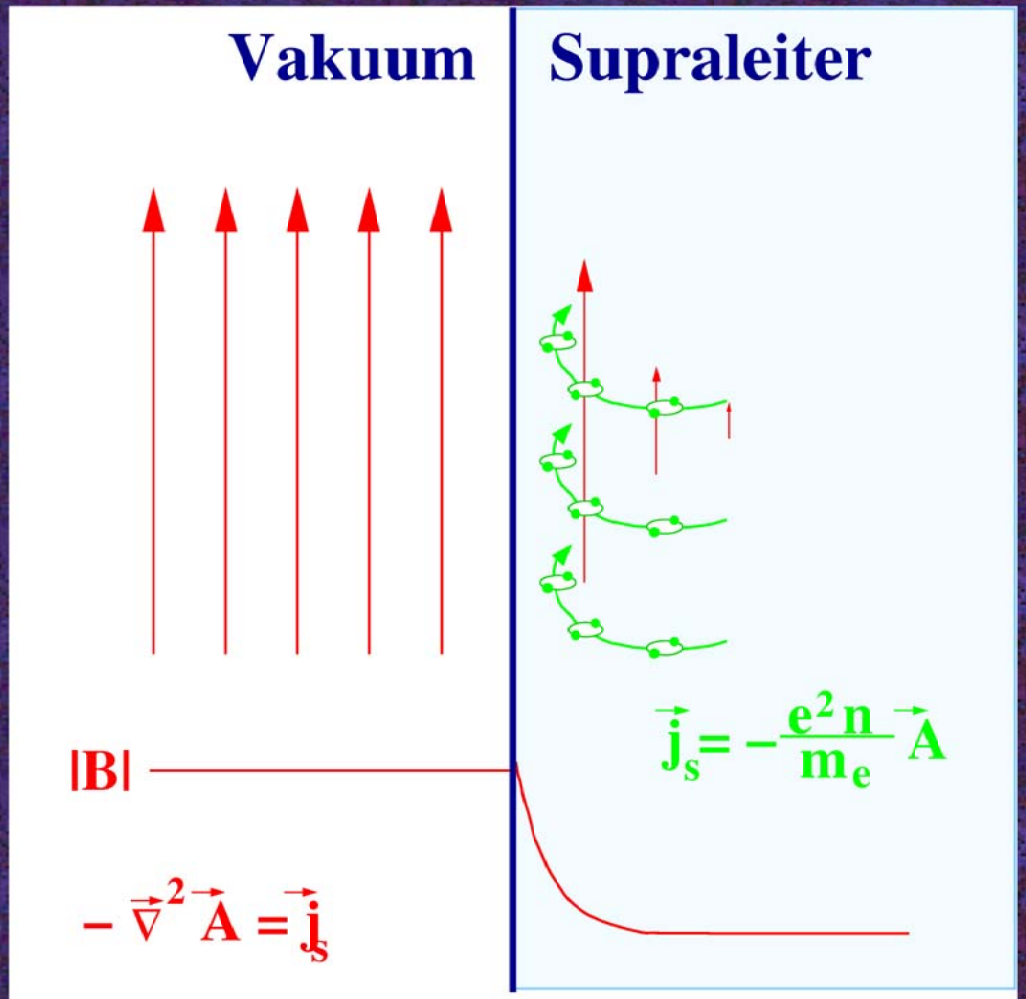
Massive Bosonen

$\Delta t \, \Delta E \sim h$

Heisenberg

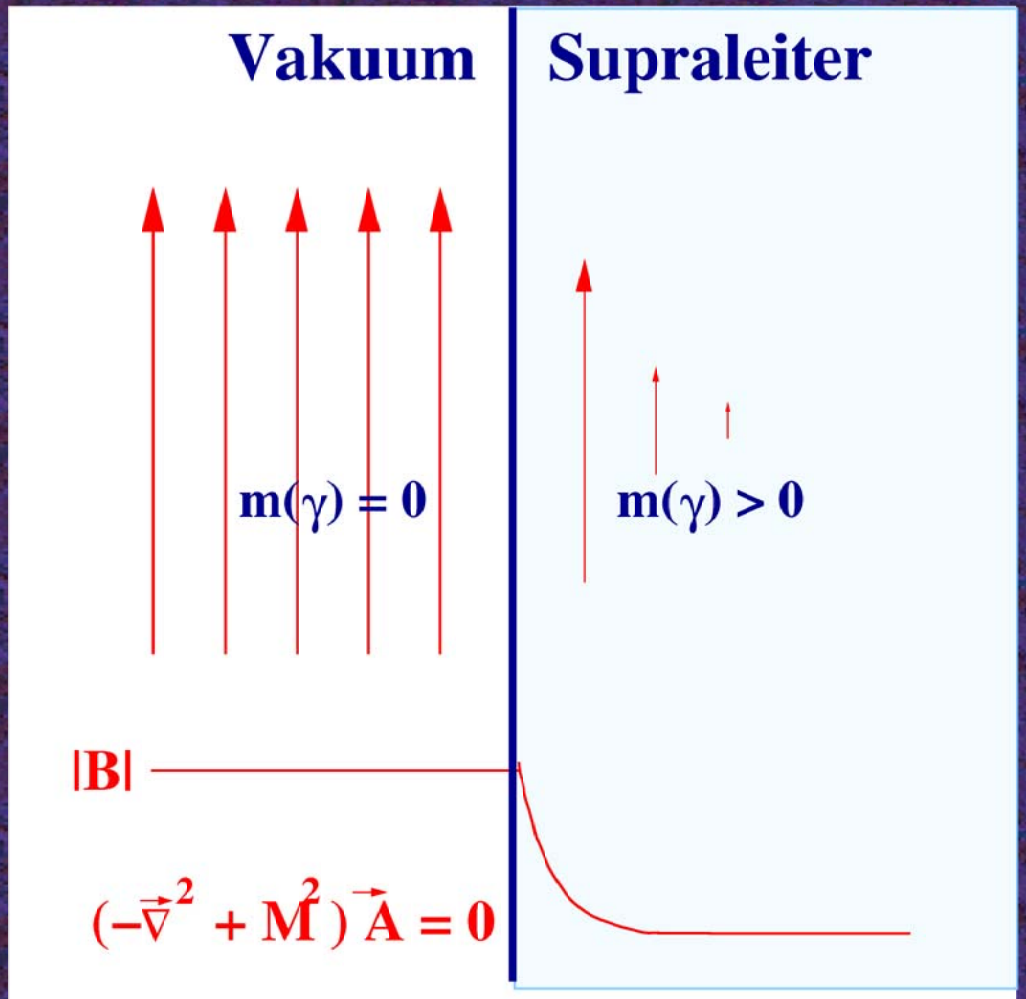
endliche Reichweite

Massive Photonen in der Supraleitung



DGL: masseloses Vektorfeld

Wechselwirkung mit Cooper–Paaren

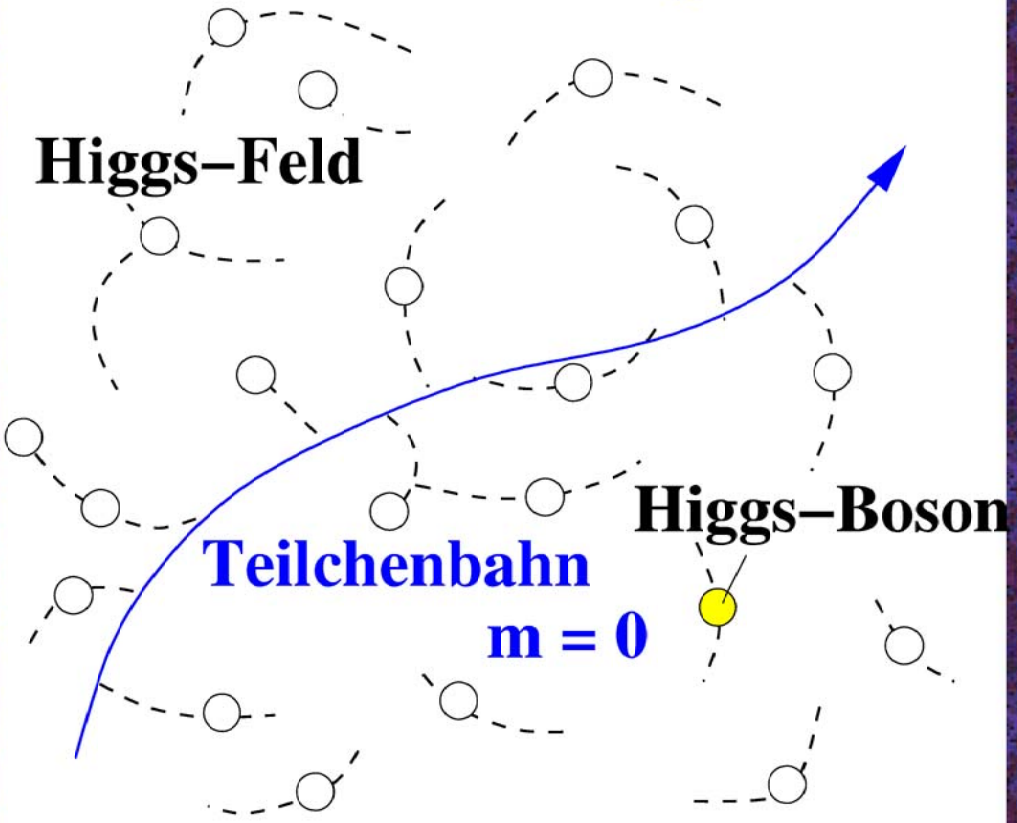


DGL: massives Vektorfeld

$$M^2 = \frac{e^2 n}{m_e}$$

Massive Bosonen in der Teilchenphysik

Modellvorstellung A

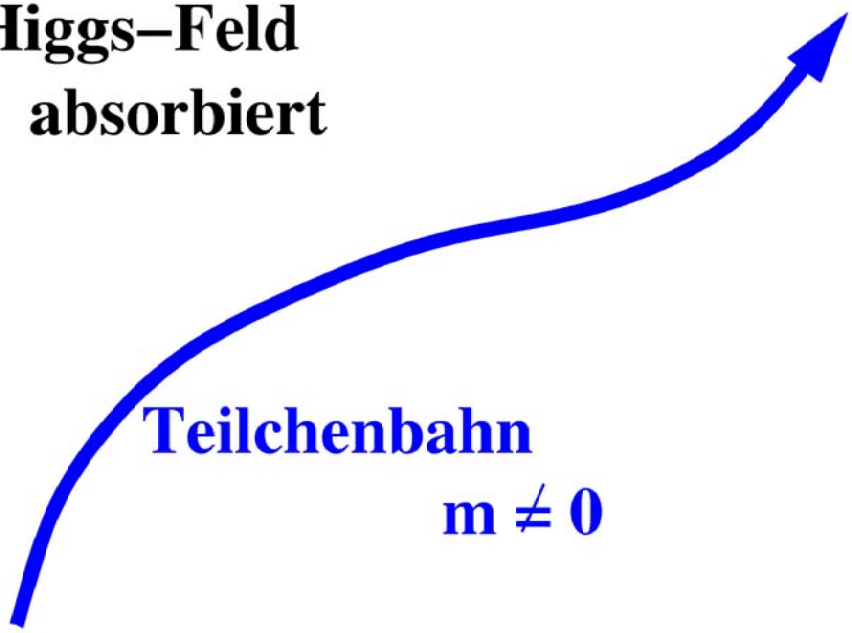


masseloses Teilchen
+
Higgs–Feld

$\Box Z = 0$

Modellvorstellung B

Higgs–Feld
absorbiert



Teilchen mit Masse

$(\Box - g^2 v^2) Z = 0$



Das Higgs–Feld erzeugt Masse durch Wechselwirkung

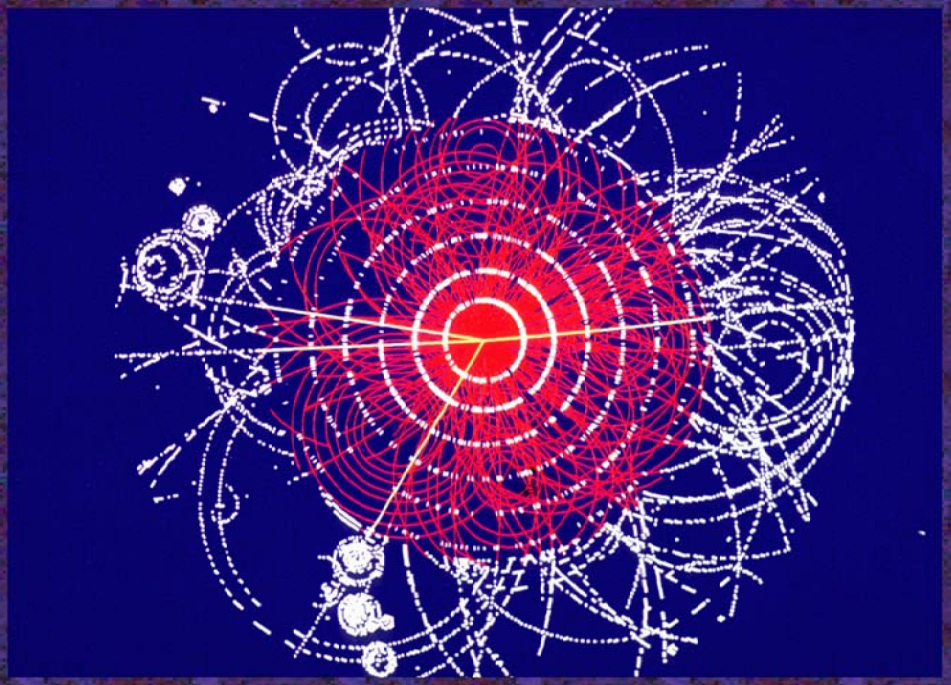

Das Higgs–Boson erscheint selbst

Vier Fragen:

- Existiert ein Higgs–Feld?
- Erfüllt es den ganzen Raum?
- Erzeugt es die Masse der Bosonen ?
- Erzeugt es auch die Fermion–Massen?

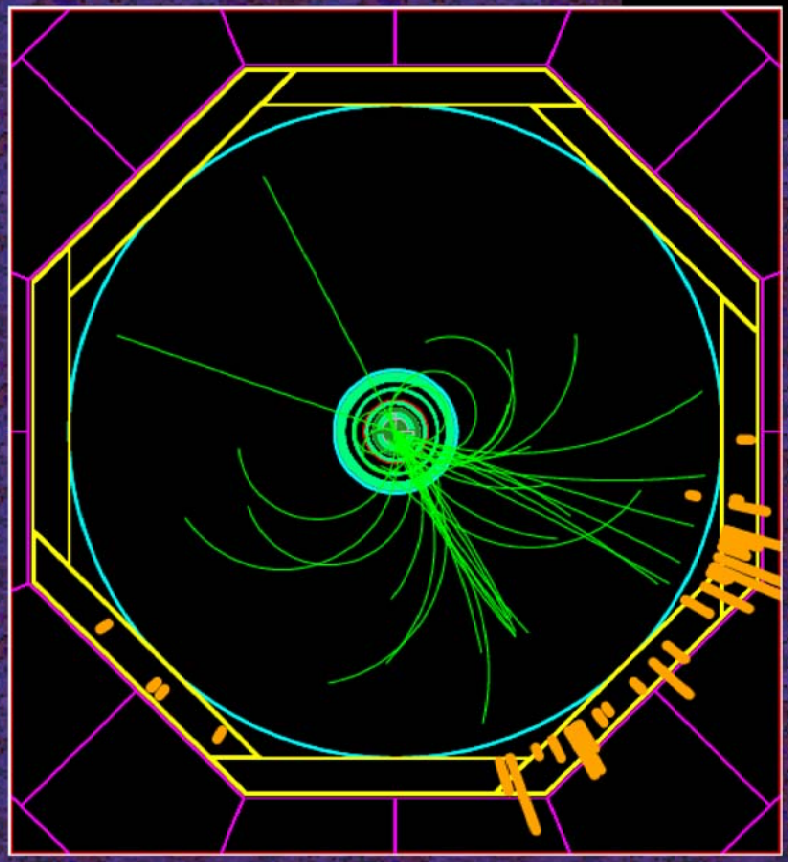
Zwei starke Partner:

Higgs Entdeckung



bei LHC

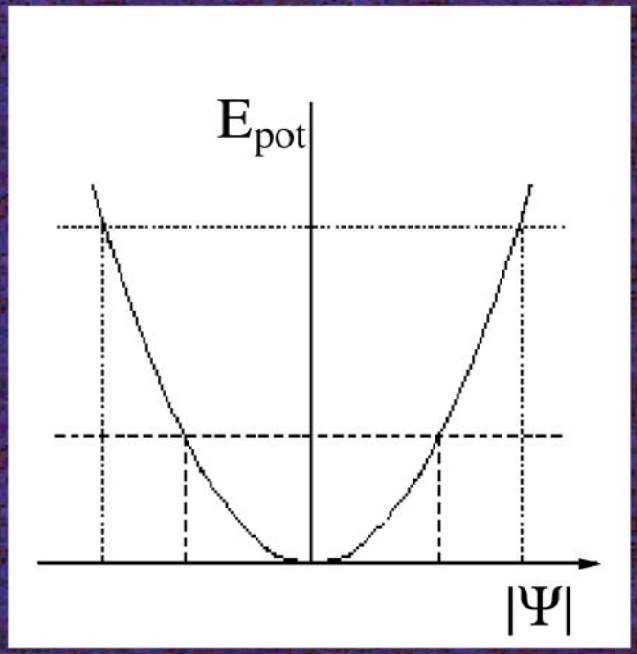
Studium des Higgs–Mechanismus



bei TESLA

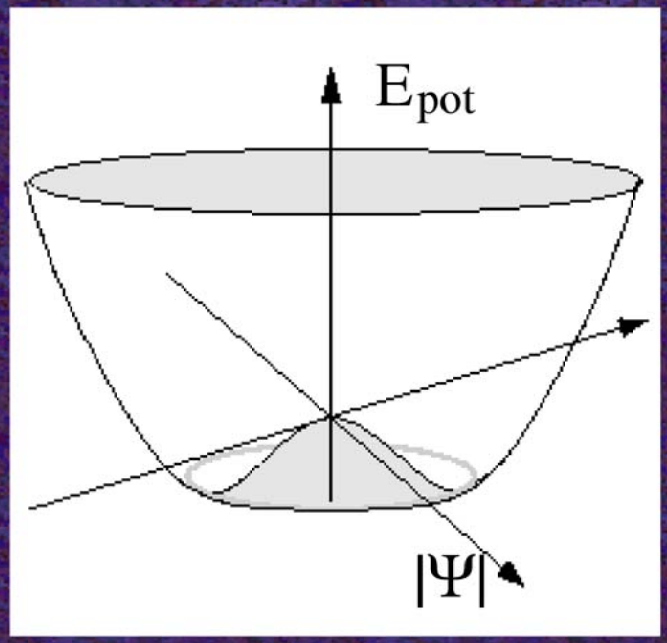
Das Hintergrundfeld:

Oszillator–Potential

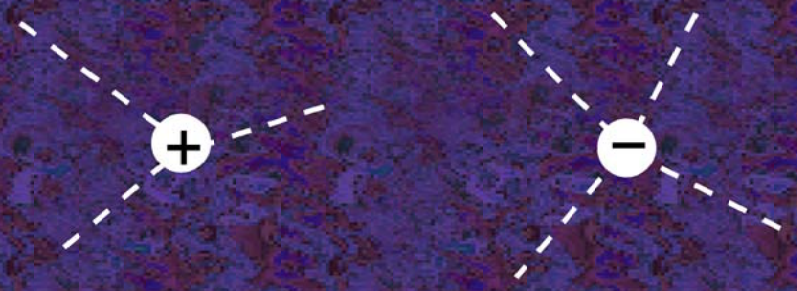


keine Wechselwirkung
der Feldquanten
untereinander

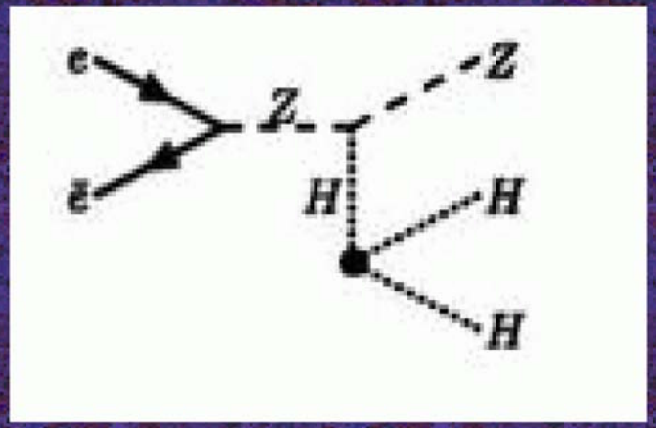
Higgs–Potential



Selbstwechselwirkung



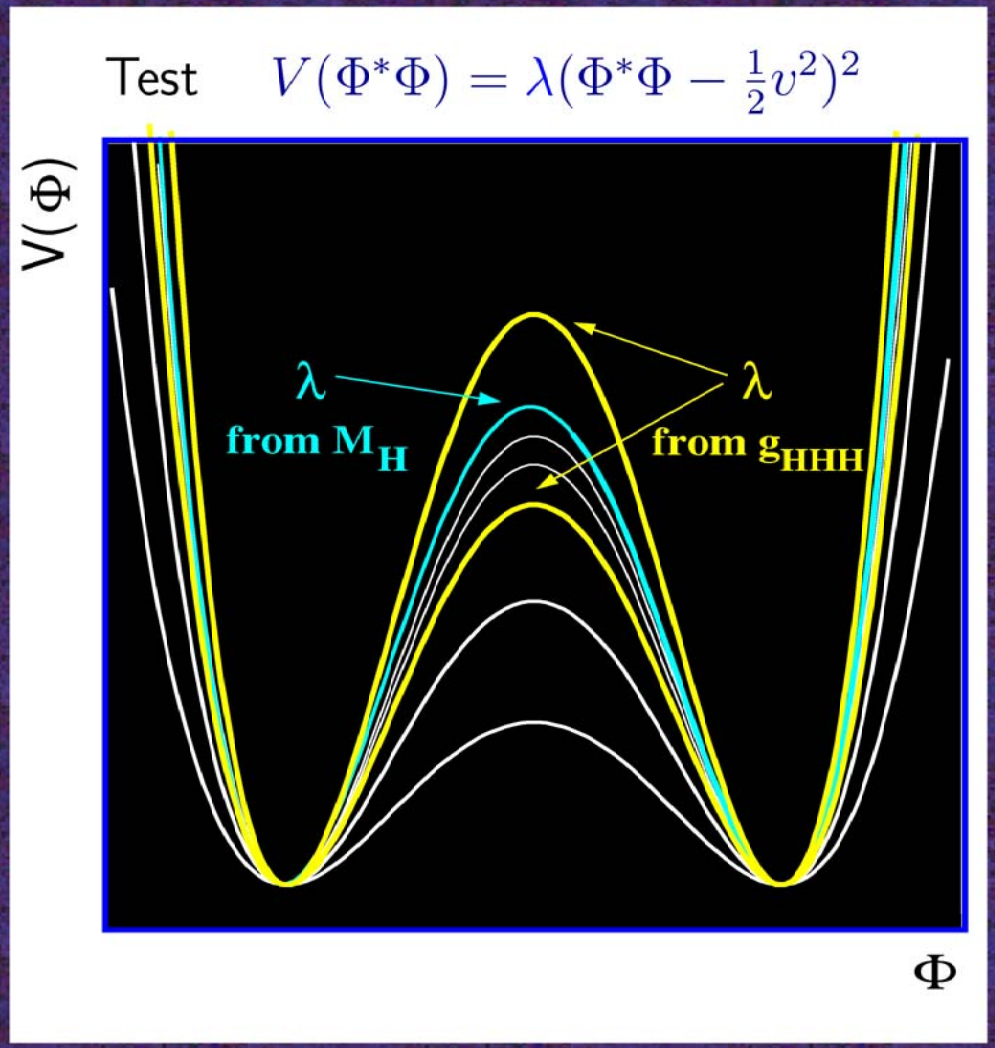
Messung



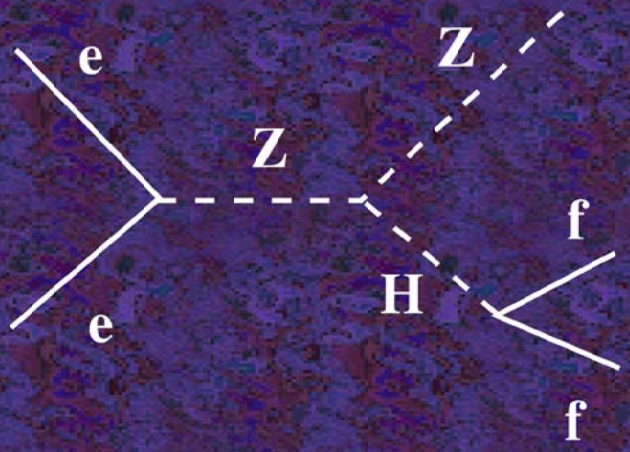
Genauigkeit

v < 0.1 %

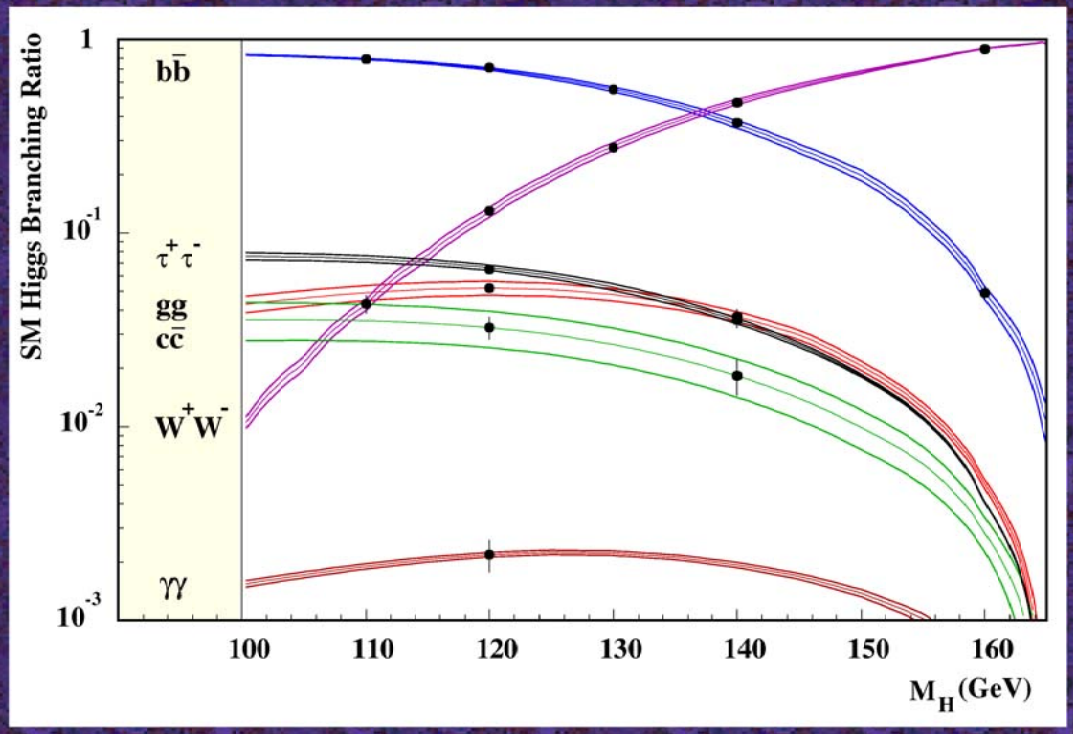
λ ~ 20 %



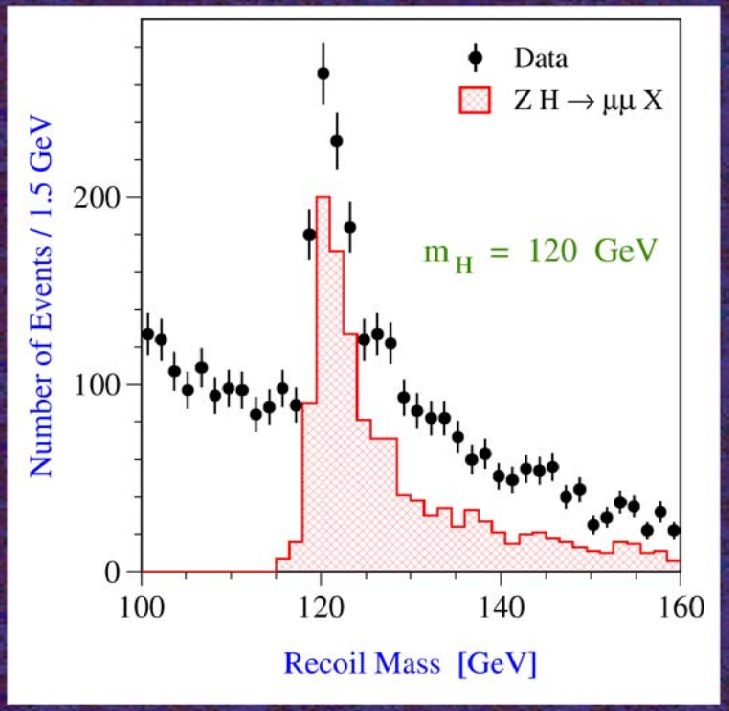
Massenerzeugung



erwartete Genauigkeit



Simulation



bei Übereinstimmung

macht das Higgs die Masse