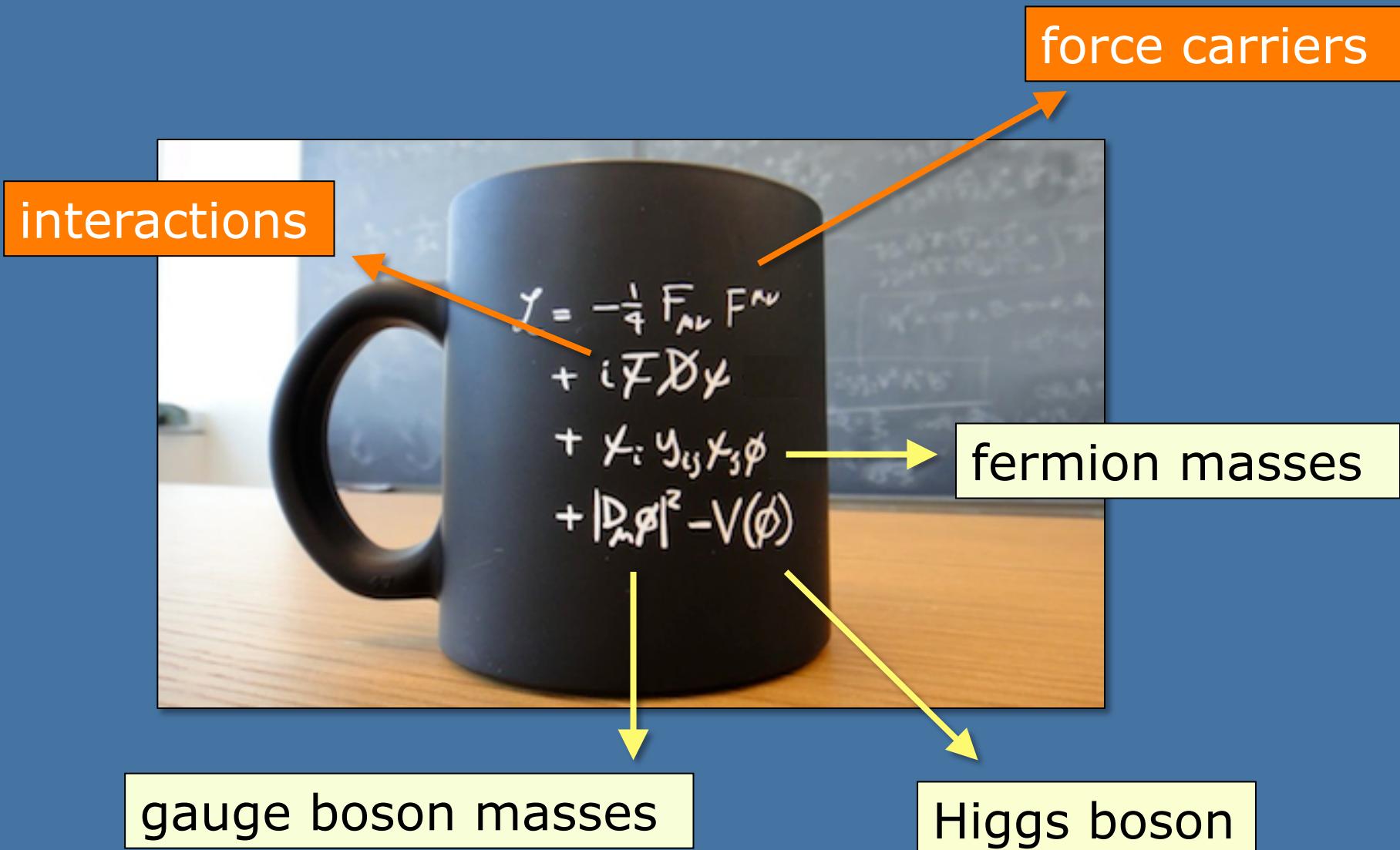
A close-up photograph of a white jigsaw puzzle. Most of the puzzle pieces are white, but one piece in the center is solid blue. This blue piece has a unique, irregular shape that does not fit into the surrounding white puzzle pieces, symbolizing a missing or unique component.

HIGGS PHYSICS

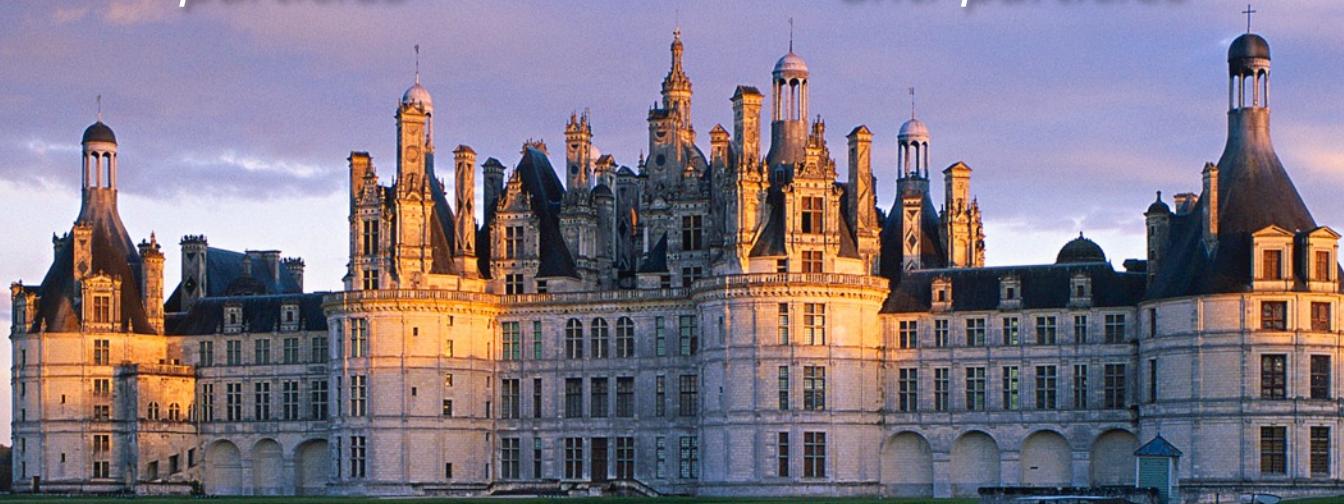
Ivo van Vulpen (Nikhef/UvA)

Structure of the Standard Model



particles

anti-particles



$$-m\bar{\psi}\psi$$

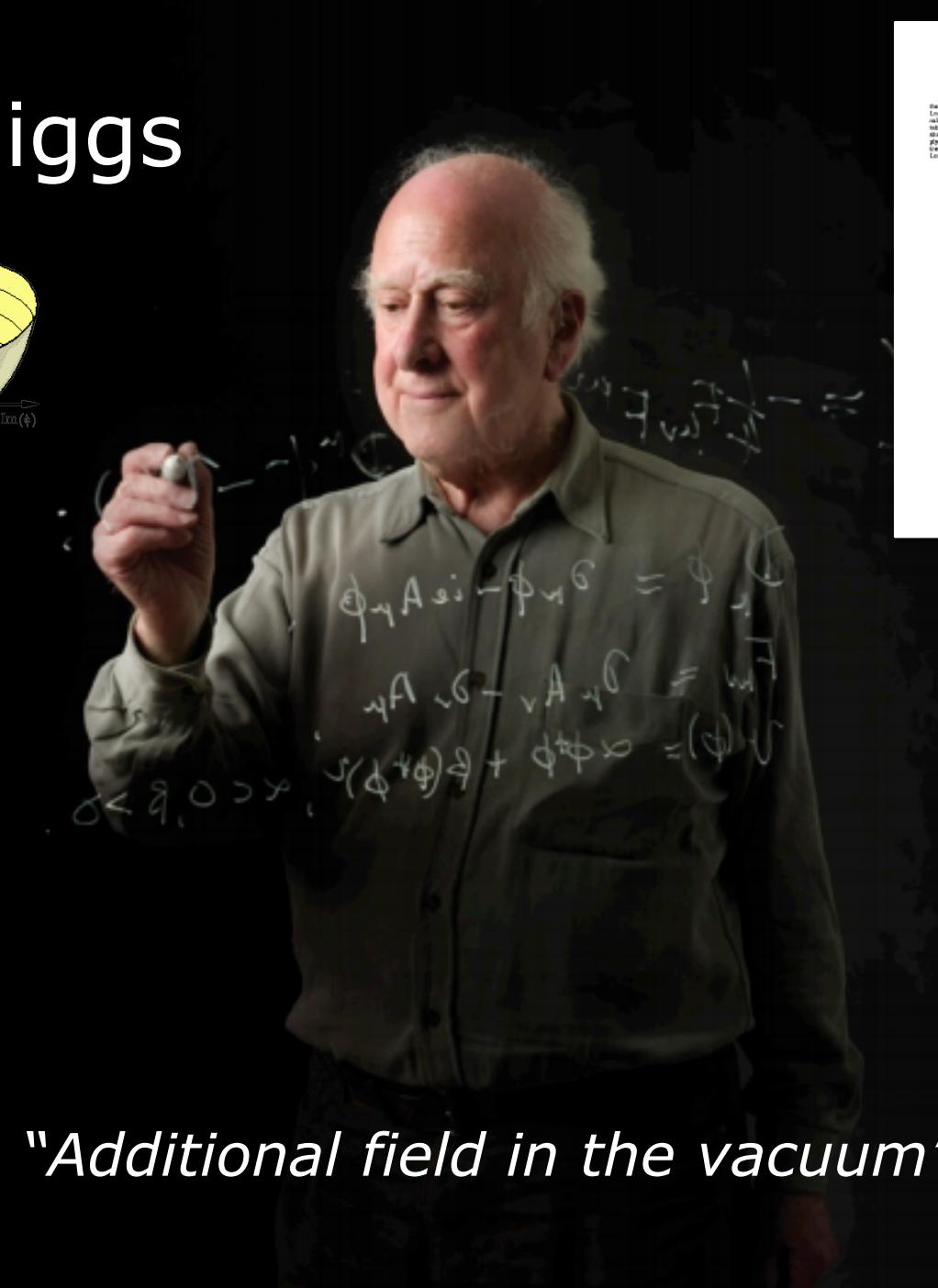
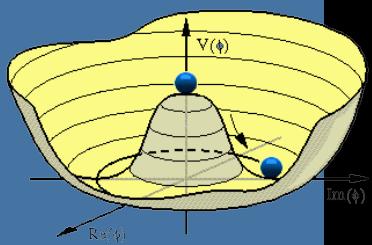
Mass term fermion

$$-\frac{1}{2}m_V^2 V^2$$

Mass term gauge boson

Standard Model does ***not*** allow for massive gauge bosons or fermions

Peter Higgs



"Additional field in the vacuum"

BROKEN SYMMETRIES, MASSLESS PARTICLES AND GAUGE FIELDS

D. W. BOGDAN

Kavli Institute of Mathematics Physics, University of Edinburgh, Edinburgh

Received 21 July 1984

Recently a number of people have discussed the Goldstone theorem in the context of a more general Lie-algebra-invariant theory which violates an internal symmetry condition of the field content, and it is suggested that the theorem does not hold in this case. In this note we show that the theorem does not necessarily apply in such theories, and we also show that if their conditions would apply equally well to Lie-algebra-invariant field theories, certain ψ_i , now

given a priori that the broken Lie algebra is continuous, would be shown to be continuous in the Lie-algebra-invariant case when Lorentz invariance is imposed on a theory. The purpose of this note is to illustrate that the Goldstone theorem is not a simple consequence of the Lie-algebra-invariant condition alone, and that it is much more subtle than one might expect.

Following the procedure and by taking N_0 , we consider a theory of two fermionic scalar fields

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ψ_1, ψ_2 which is invariant under the phase transformation

$$\psi_1 \rightarrow \psi_1 e^{i\theta}, \quad \psi_2 \rightarrow \psi_2 e^{i\theta}, \quad (1)$$

$$\theta \rightarrow \theta + 2\pi.$$

There is a conserved current j_μ with that

$$j_\mu = (\bar{\psi}_1 \gamma^\mu \psi_1, \bar{\psi}_2 \gamma^\mu \psi_2).$$

We assume that the theory is such that symmetry is broken by the non-existence of a non-zero value of θ . Goldstone's theorem is proved in the usual way, i.e. that there exist states $|v_1\rangle, |v_2\rangle$ which satisfy a certain condition.

In this case the theory is no longer symmetric, as a consequence of Lorentz-invariance, the conservation of energy-momentum and the

law of motion, but it still破壞 the invariance under the phase transformation. This is the first of this paper's theorems to us in Edinburg's

work [1]. It is given as follows: "If ψ_1, ψ_2 are scalar fields satisfying $\psi_1 \rightarrow \psi_1 e^{i\theta}, \psi_2 \rightarrow \psi_2 e^{i\theta}$, where θ may be taken as $(1, 0, 0, 0)$, $(0, 1, 0, 0)$, $(0, 0, 1, 0)$, $(0, 0, 0, 1)$, then there exists a special broken frame. The conservation law of motion reduces to $(0, 0, 0, 0)$ in the free-gauge form."

$\psi_1 \rightarrow e^{i\theta} \psi_1, \psi_2 \rightarrow e^{i\theta} \psi_2$ implies $\bar{\psi}_1 \gamma^\mu \psi_1 \rightarrow e^{i\theta} \bar{\psi}_1 \gamma^\mu \psi_1$.

It is normal, however, to assume that the terms in eq. (4) can contribute to θ . The theory is then no longer invariant under $\psi_1 \rightarrow \psi_1 e^{i\theta}, \psi_2 \rightarrow \psi_2 e^{i\theta}$ only if the other terms vanish. Otherwise there is no special broken frame".

There is a second theorem which claims that it is impossible to break a Lie algebra in such a way that a special broken frame θ is obtained. This is the second of this paper's theorems to us in Edinburg's work [1].

Theorem 2: "If ψ_1, ψ_2 are scalar fields which in a theory ψ_1, ψ_2 show indeed a part, this is the case of gauge theories, where as usually we find instead ψ_1, ψ_2 had the

property, given a priori that the broken Lie algebra is continuous, then the theory is not broken at all when Lorentz invariance is imposed on a theory. The purpose of this note is to illustrate that the Goldstone theorem is not a simple consequence of the Lie-algebra-invariant condition alone, and that it is much more subtle than one might expect. Following the procedure and by taking N_0 , we consider a theory of two fermionic scalar fields

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu, \quad (2)$$

treated in order to define a radiation gauge in which the vector fields have any desired properties. We consider a theory of two fermionic scalar fields, the theory being invariant under the Lie-algebra-invariant condition, as has been shown by

Goldstone [2]. The theory is no longer symmetric, as a consequence of the fact that the vector A_μ should not appear in the Fourier transform of the theory.

It is the purpose of this note to show that the conservation law holds in the string theory, as a consequence of the fact that the theory is of the form

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu. \quad (3)$$

Except in the case of Abelian gauge theories, the theory is not invariant under the gauge transformations $A_\mu \rightarrow A_\mu + \partial_\mu \lambda$, because additional terms in the action are present. The reason is that the group is non-Abelian. Now the structure of the theory is such that the theory is not invariant under $A_\mu \rightarrow A_\mu + \partial_\mu \lambda$ if λ is a constant. If λ is a function of x^μ , then the theory is not invariant under $A_\mu \rightarrow A_\mu + \partial_\mu \lambda$ if λ is a function of x^μ and $\partial_\mu \lambda$ is a function of x^μ . We have thus extended the theory to include the possibility of a "spontaneous" $A_\mu \rightarrow A_\mu + \partial_\mu \lambda$ proposed by Kibble [3].

In a subsequent note it will be shown, by consideration of the theory in the limit of small values plus linear in momenta, that the introduction of a gauge field A_μ does not change qualitatively the nature of the particles described by such theories after quantization.

REFERENCES

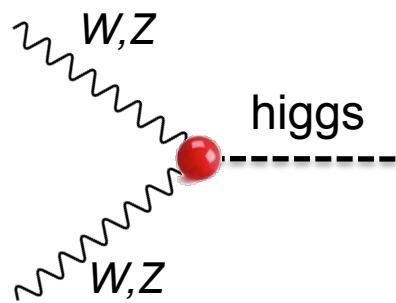
- [1] D. W. Bogdan, *Physica* 12 (1982) 151.
- [2] J. Goldstone, *Advances S. & W. Physics*, Phys. Rev. 188 (1960) 157.
- [3] A. Kibble, *Phys. Rev. Letters* 13 (1964) 51.
- [4] M. Lighthill, *Phys. Rev. Letters* 17 (1964) 711.

Higgs production & decay at the LHC

Production of the Higgs boson

Gauge bosons

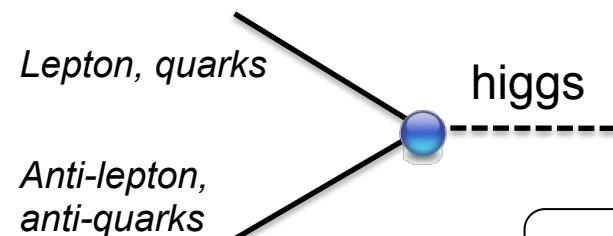
*Massive gauge boson ?
... then the Higgs couples to it*



$$\propto m_V^2$$

Fermions

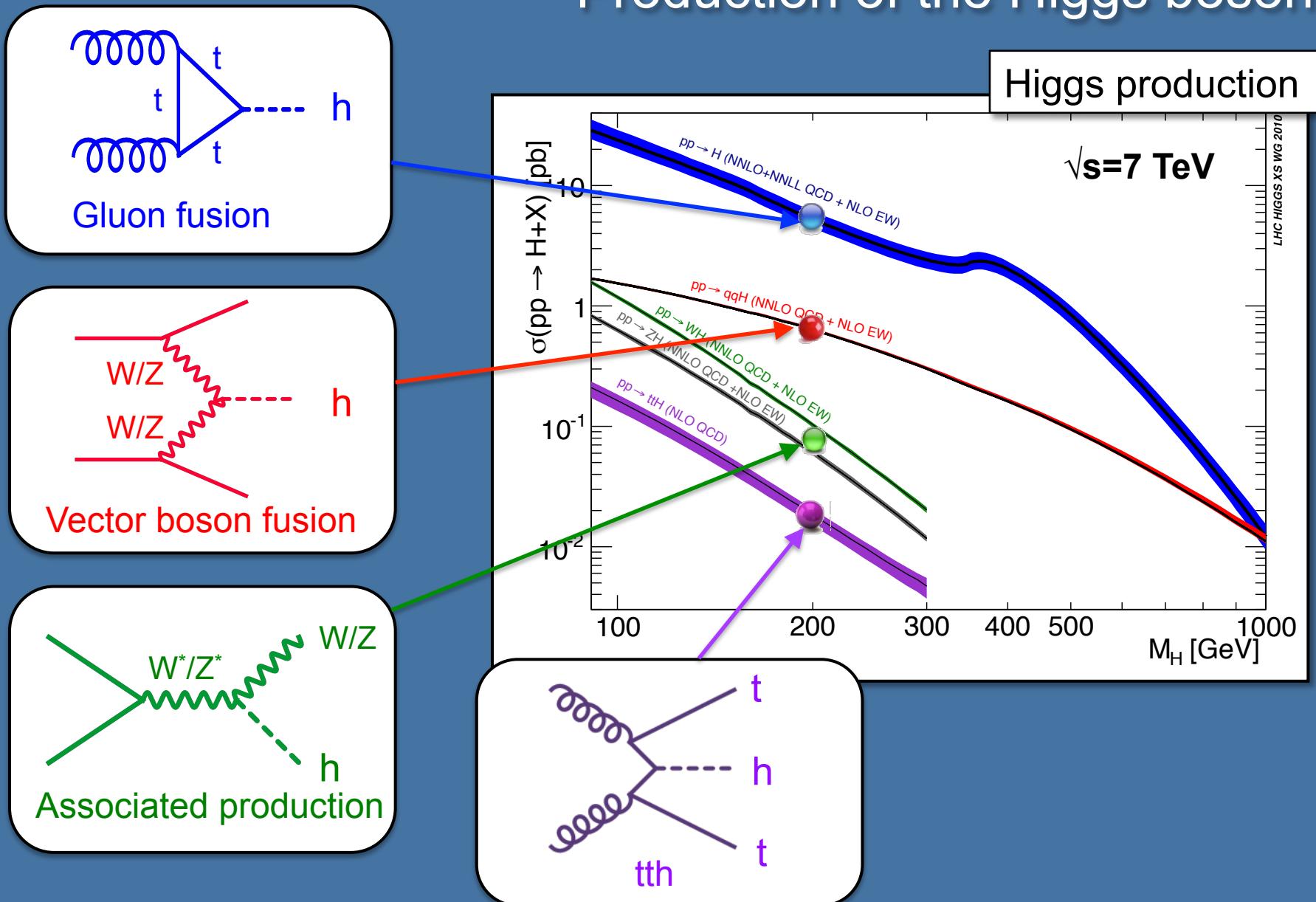
*Massive fermion ?
... then the Higgs couples to it*



Lepton, quarks
Anti-lepton,
anti-quarks

$$\propto m_f^2$$

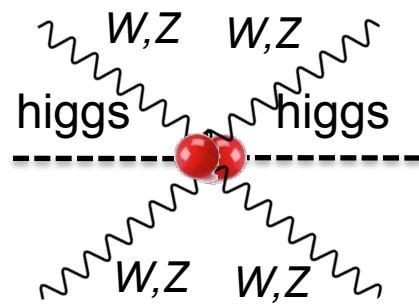
Production of the Higgs boson



Decay of the Higgs boson

Gauge boson

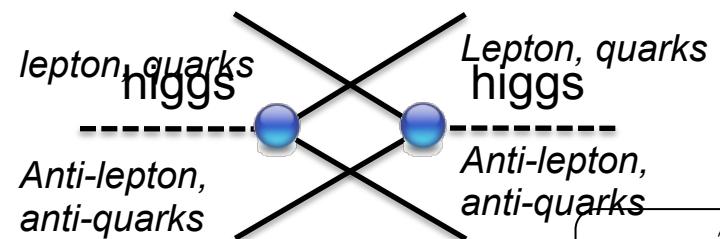
Massive gauge boson ?
... then the Higgs couples to it



$$\propto m_V^2$$

Fermion

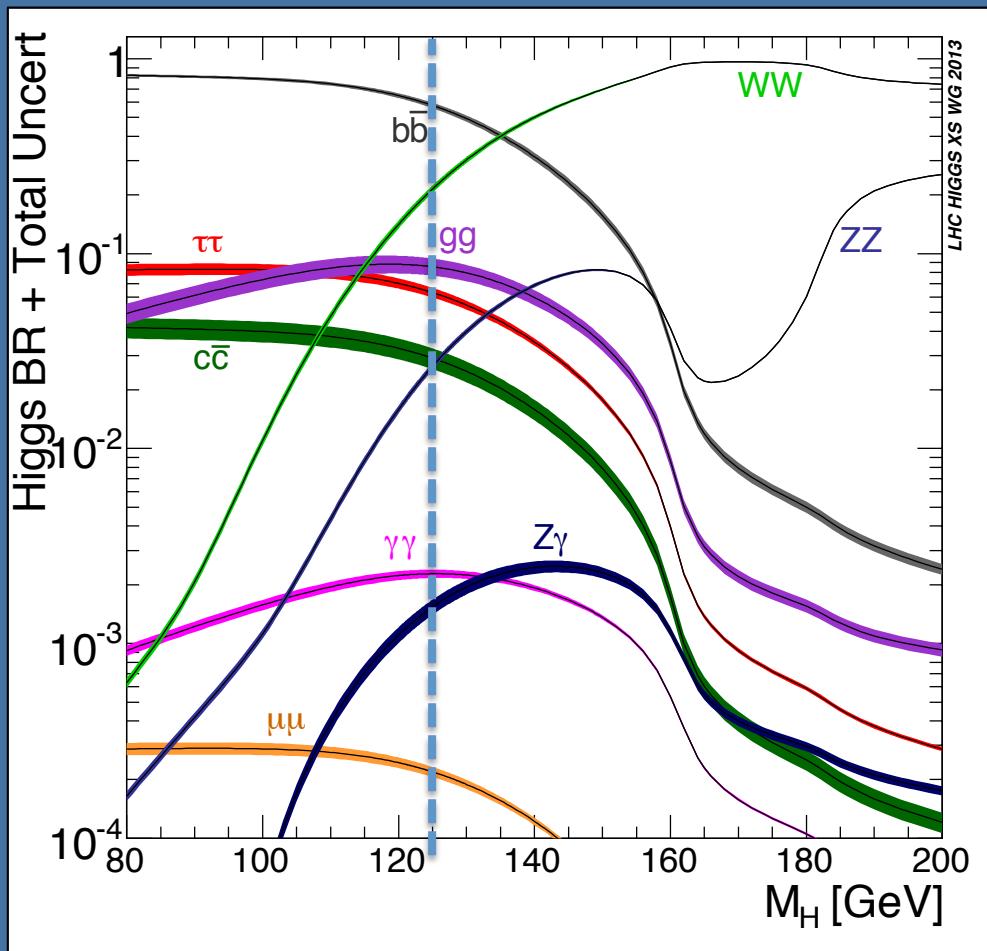
Massive fermion ?
... then the Higgs couples to it



$$\propto m_f^2$$

Higgs boson production

Higgs branching fractions



$$m_h = 125 \text{ GeV}$$

$$\text{Br}(h \rightarrow bb) = 57.7 \text{ \%}$$

$$\text{Br}(h \rightarrow WW) = 21.5 \text{ \%}$$

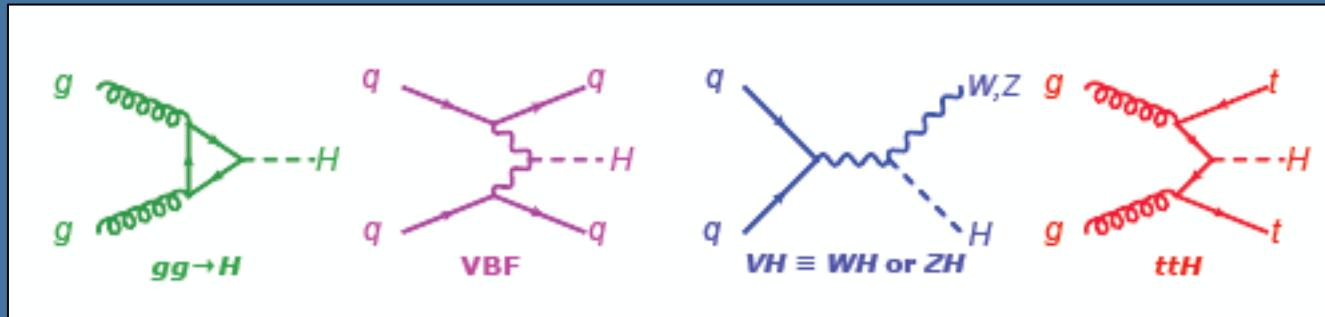
$$\text{Br}(h \rightarrow \tau\tau) = 6.32 \text{ \%}$$

$$\text{Br}(h \rightarrow ZZ) = 2.64 \text{ \%}$$

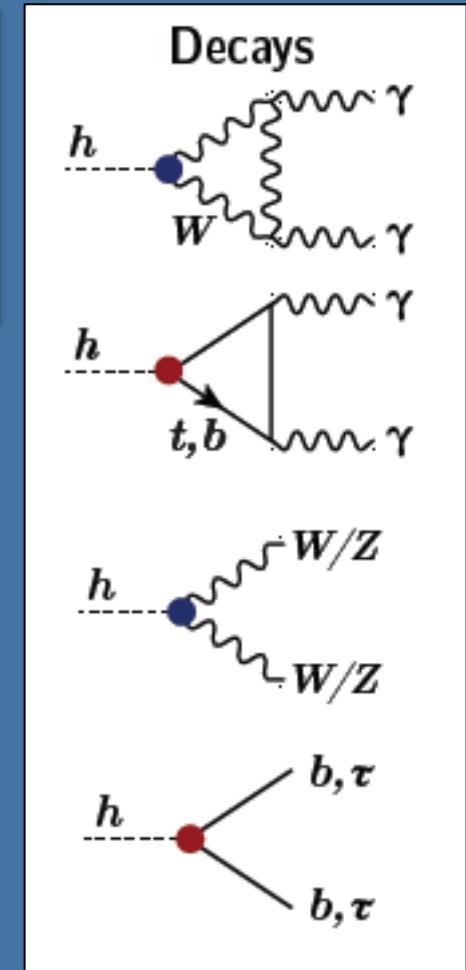
$$\text{Br}(h \rightarrow \gamma\gamma) = 0.23 \text{ \%}$$

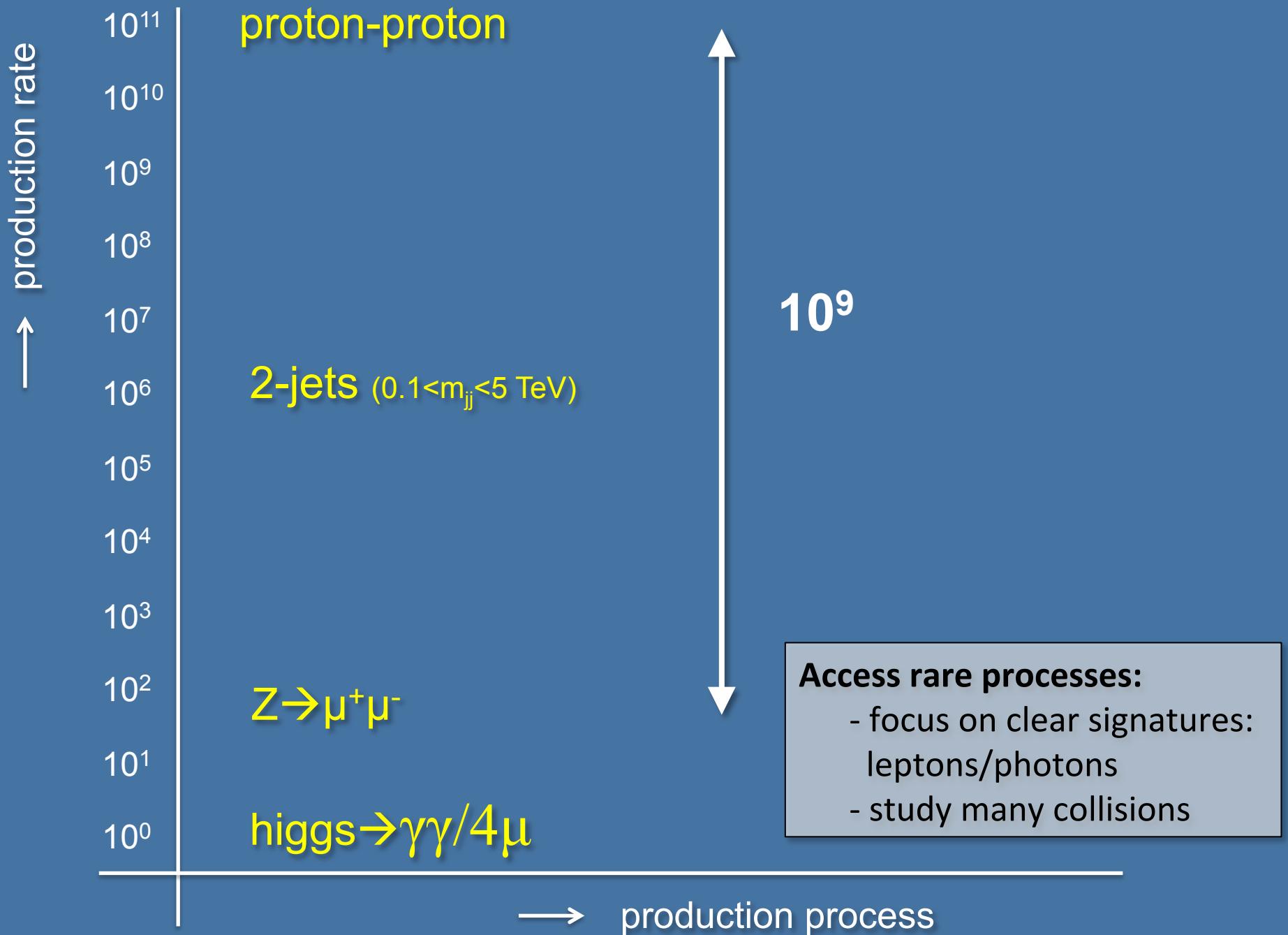
$$\text{Br}(h \rightarrow Z\gamma) = 0.15 \text{ \%}$$

Higgs production and decay

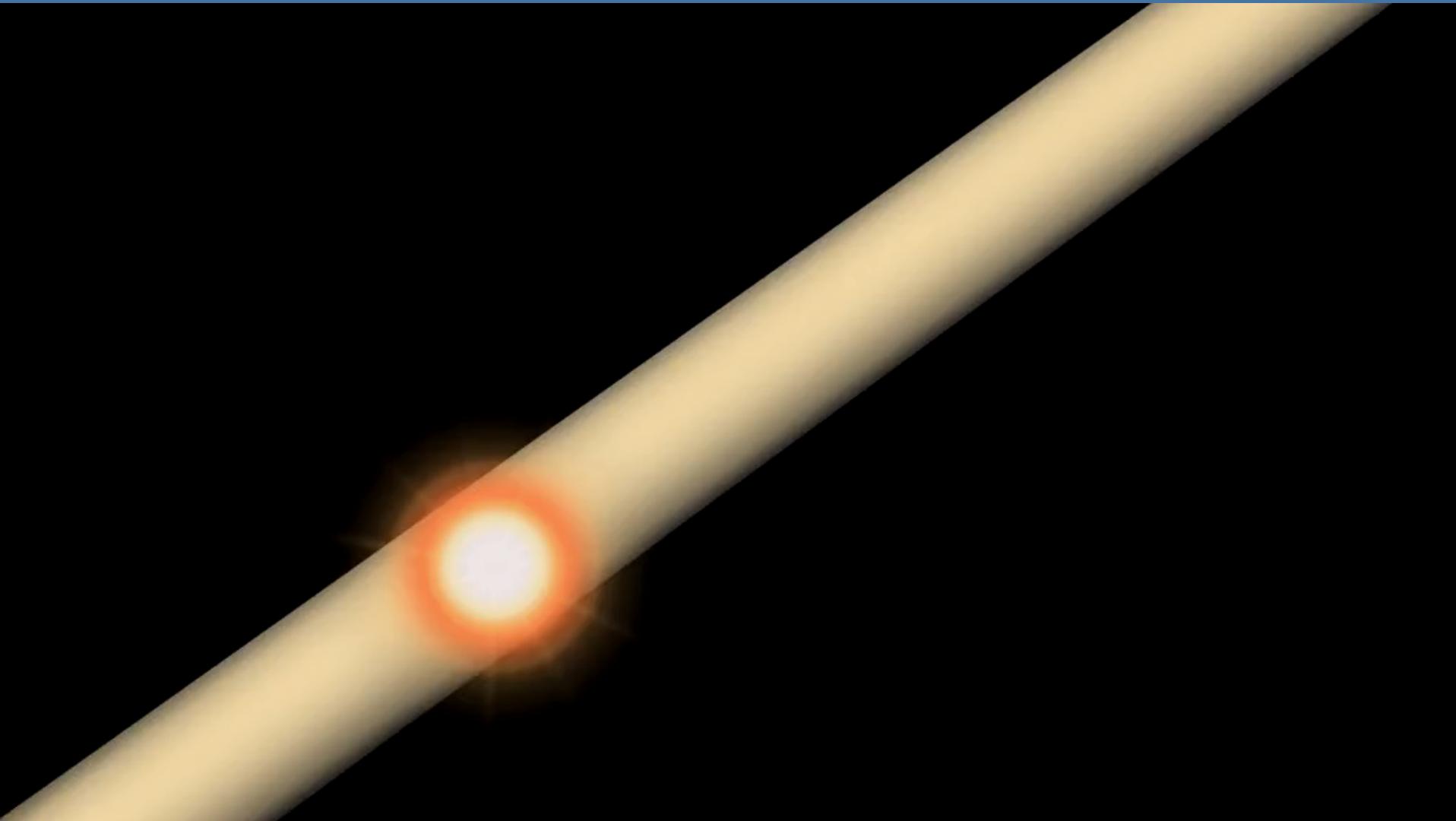


Test all combinations

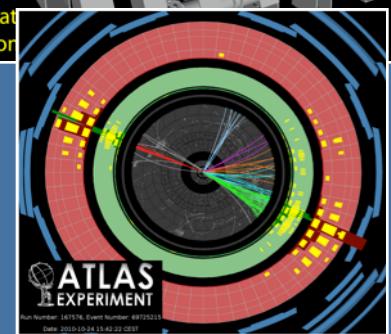
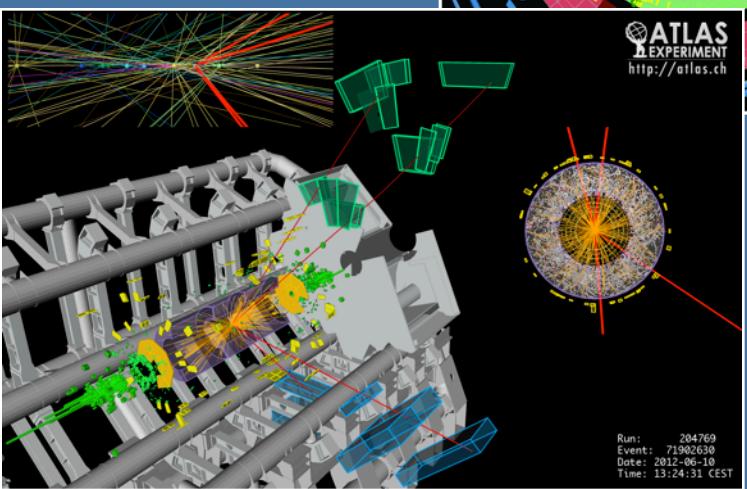
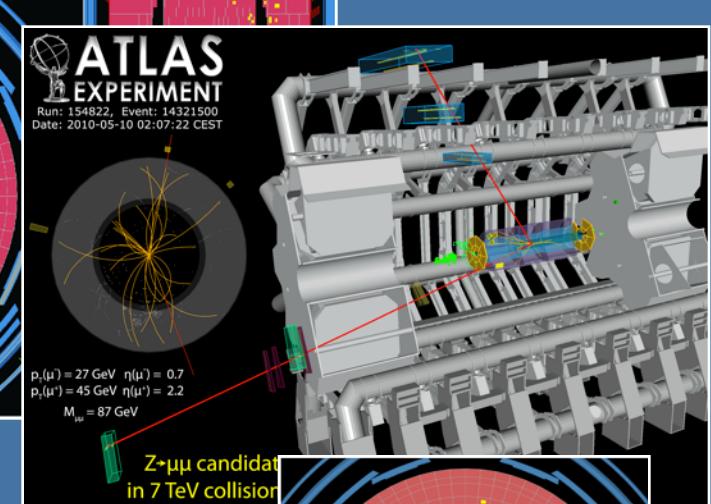
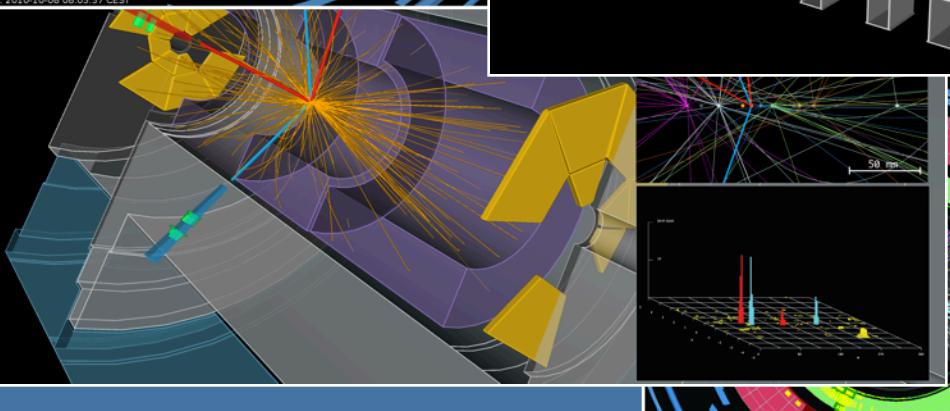
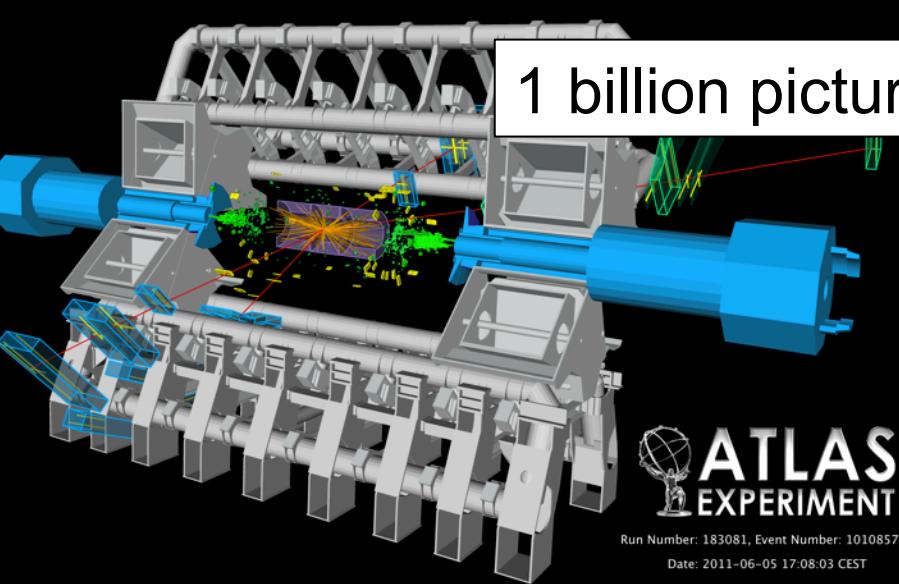
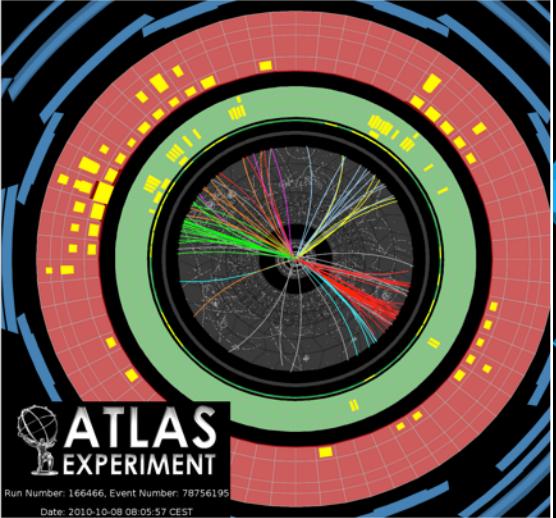


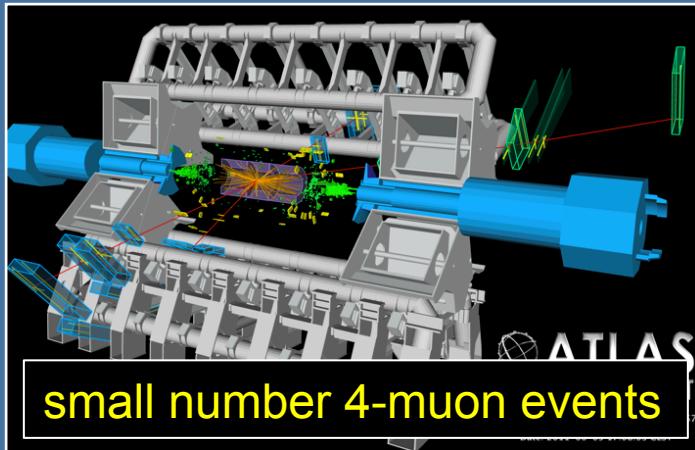


The Large Hadron Collider at CERN



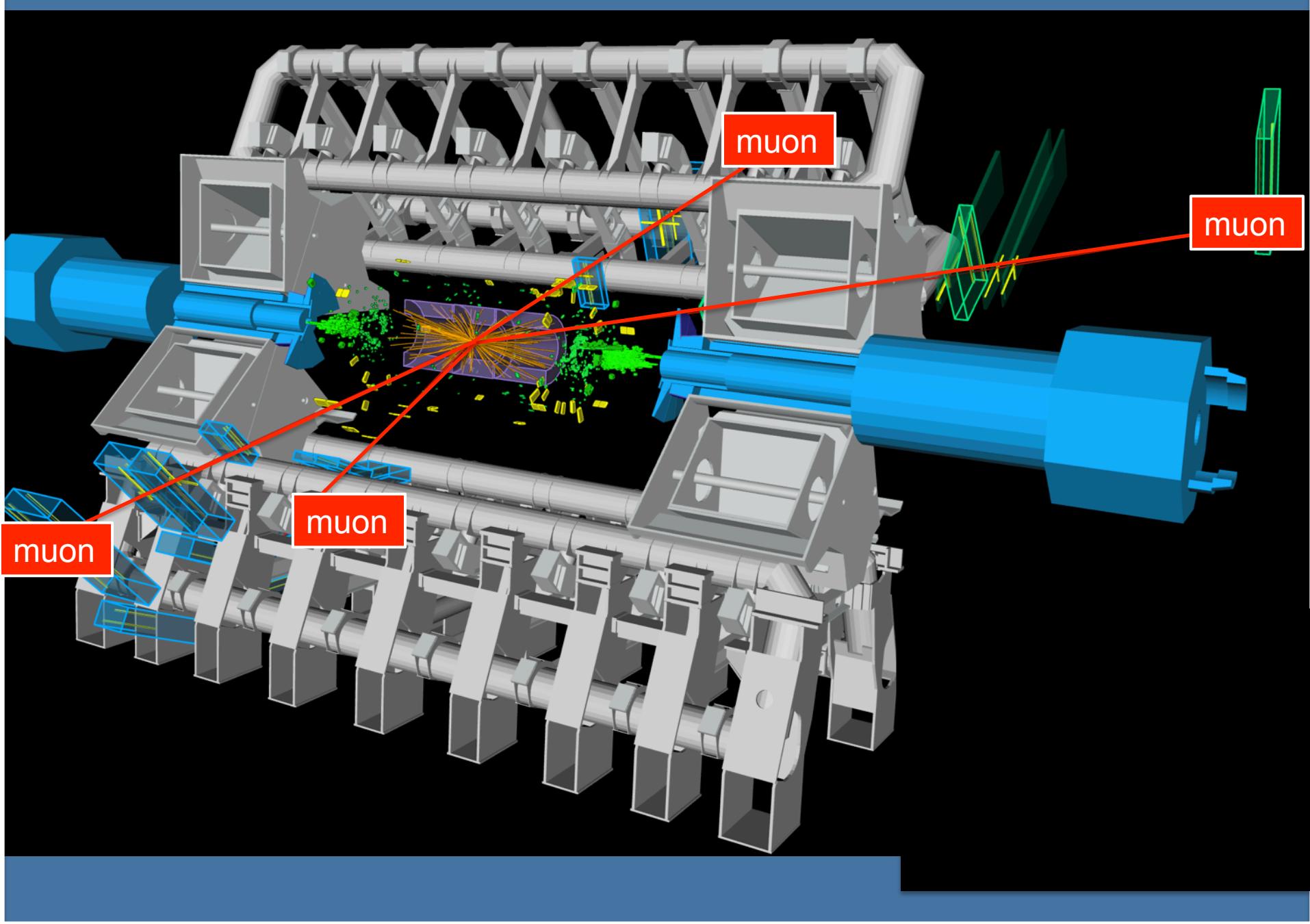
1 billion pictures per second





Tricky:

- 1 billion per second
- can only store 200





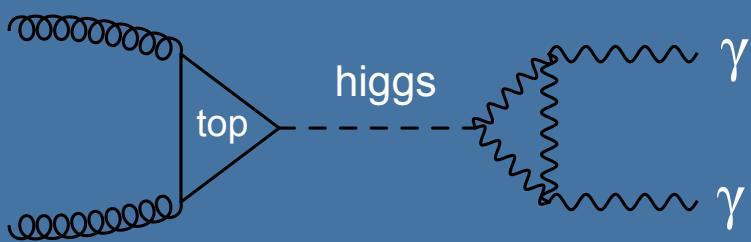
Liu Bolin



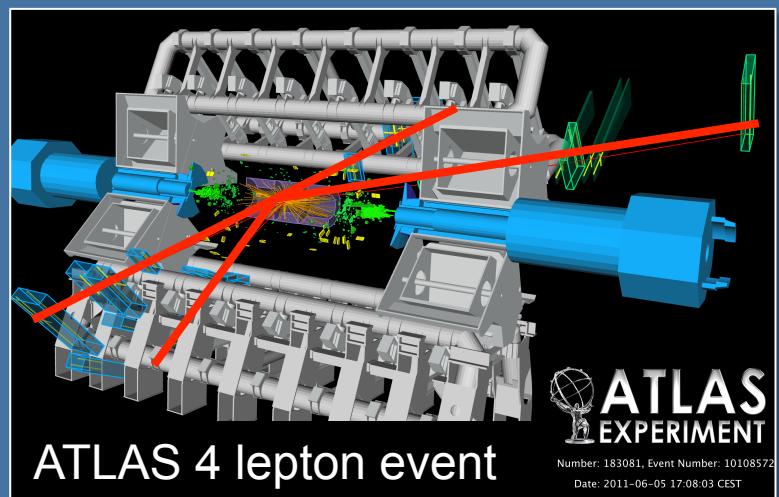
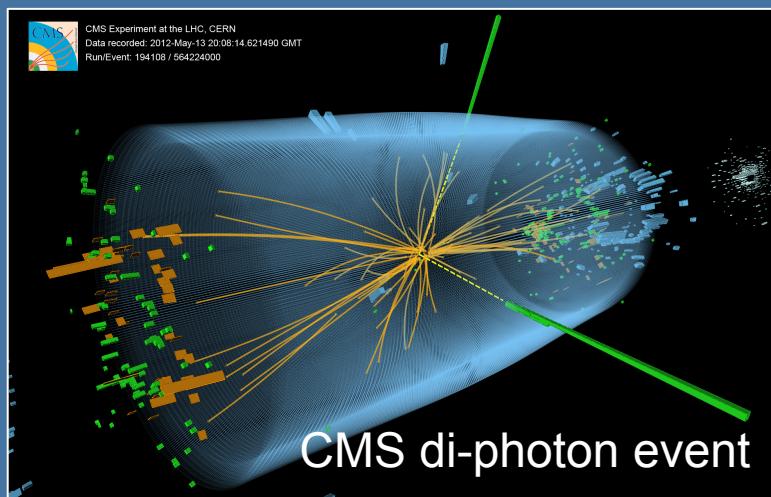
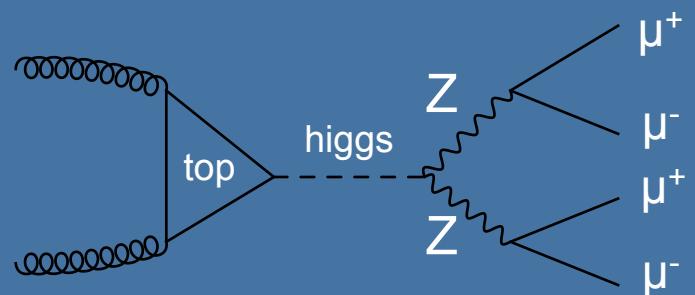
A close-up photograph of a dark blue jigsaw puzzle pieces arranged in a grid pattern. The puzzle pieces have a distinct interlocking shape. A white rounded rectangular box is centered over the middle row of the puzzle, containing the word "discovery".

discovery

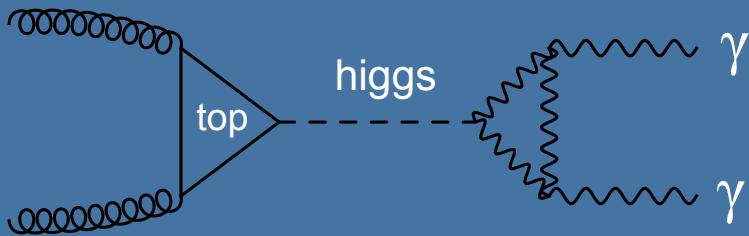
Higgs boson decay to 2 photons



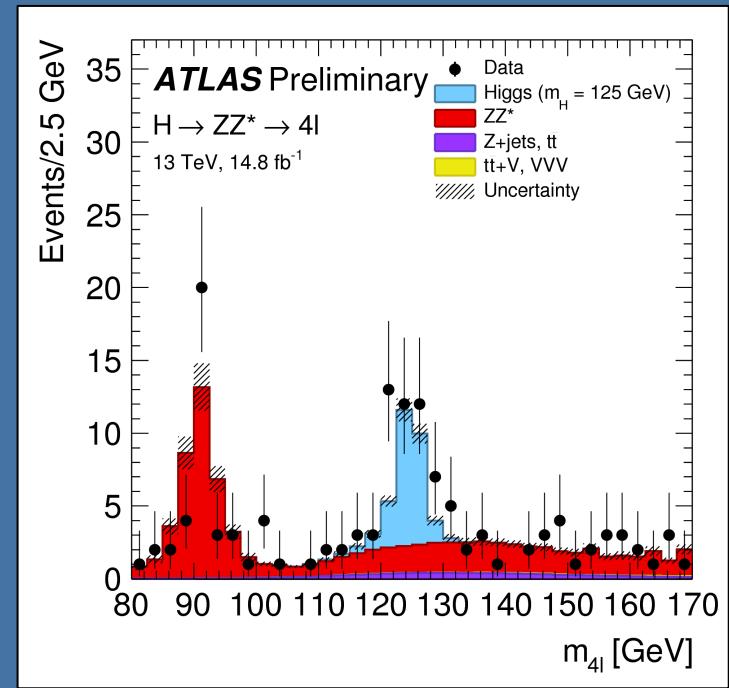
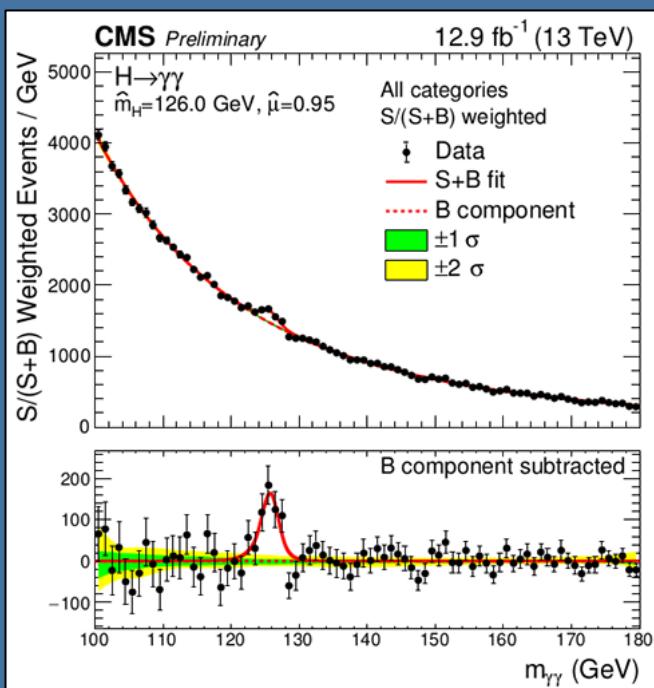
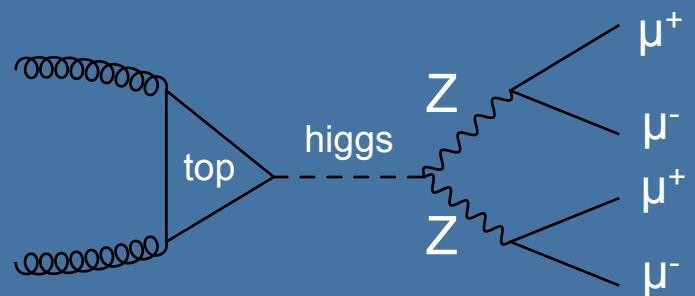
Higgs boson decay to 4 leptons



Higgs boson decay to 2 photons

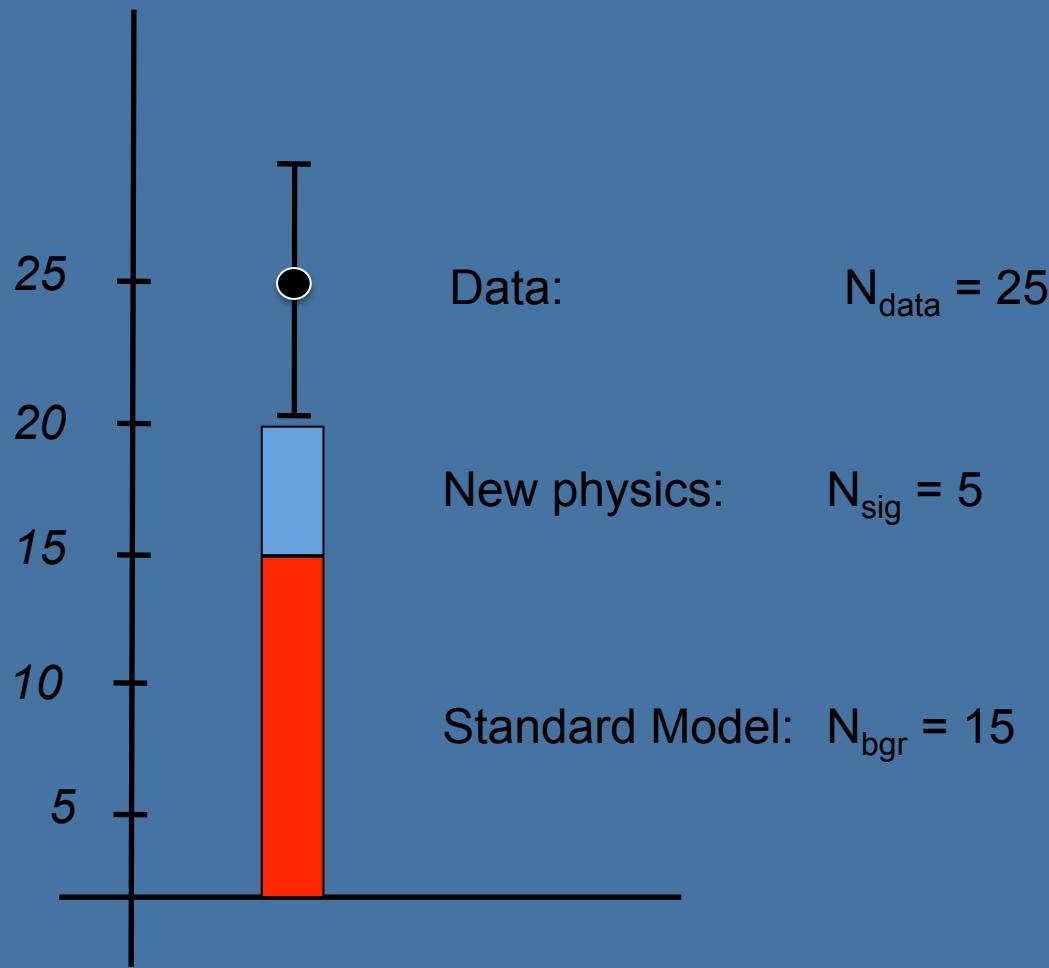


Higgs boson decay to 4 leptons



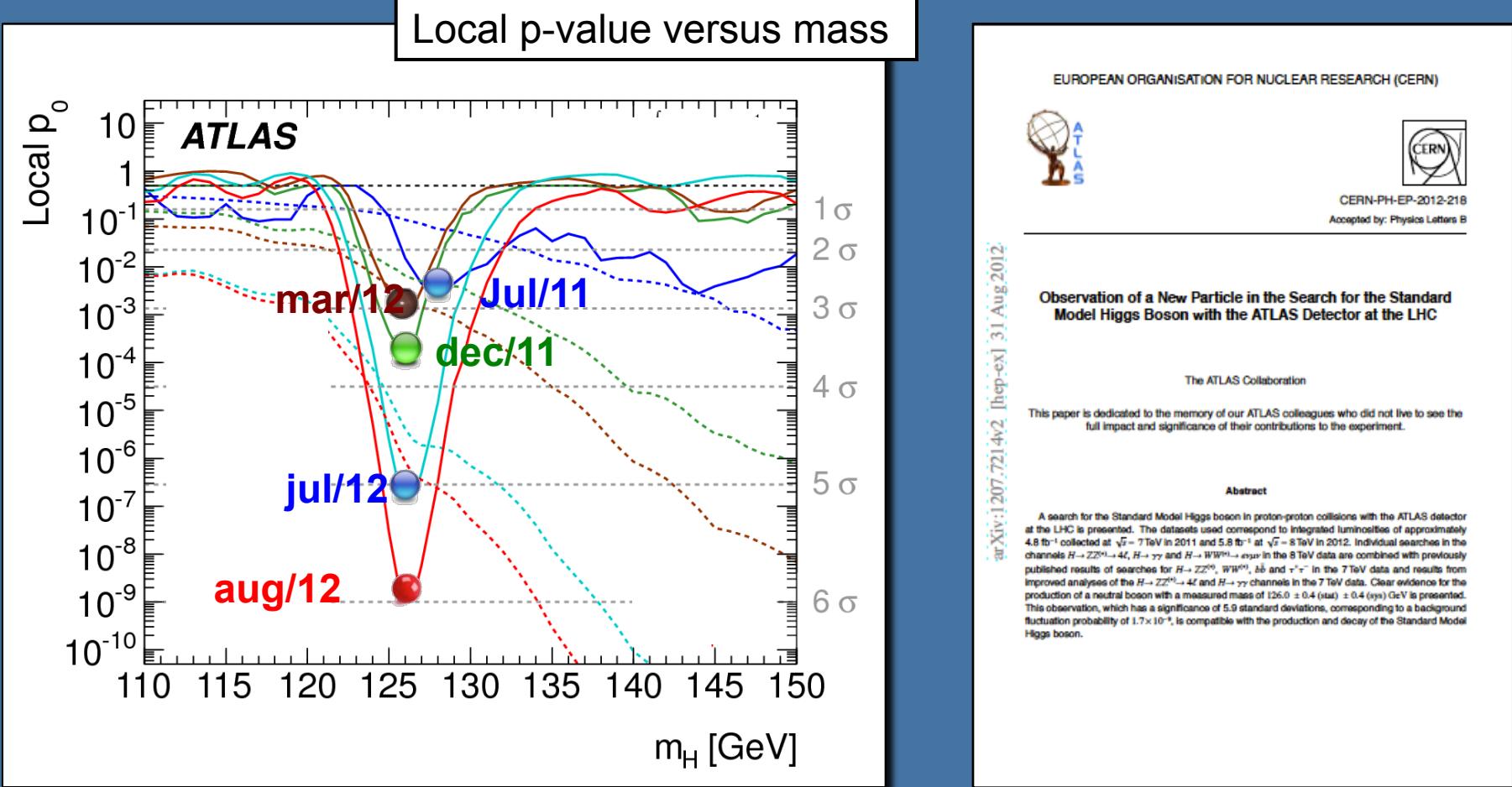
ATLAS+CMS: $m_h = 125.09 \pm 0.21(\text{stat}) \pm 0.11(\text{syst}) \text{ GeV}$

What is significance ?

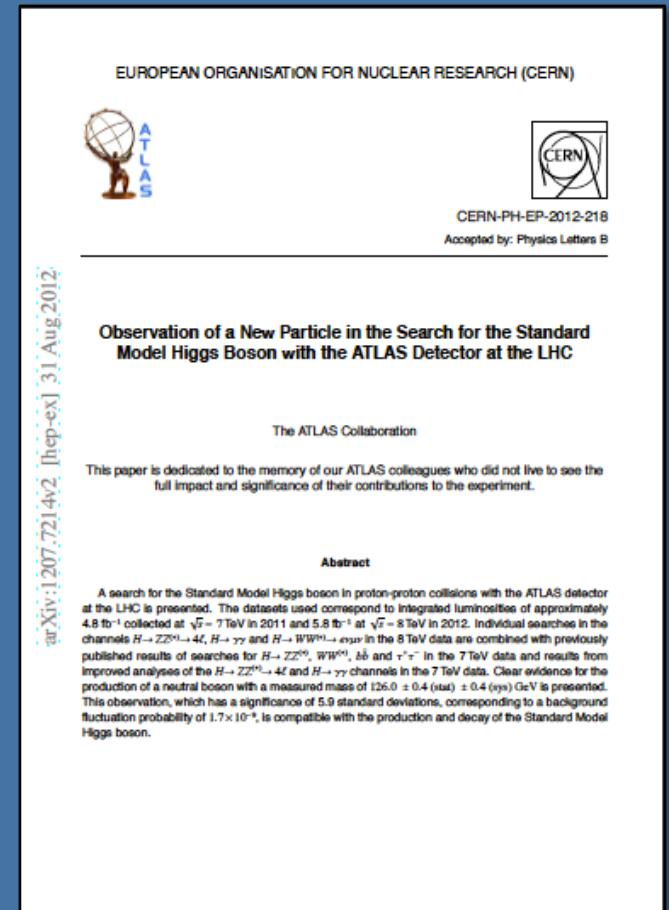
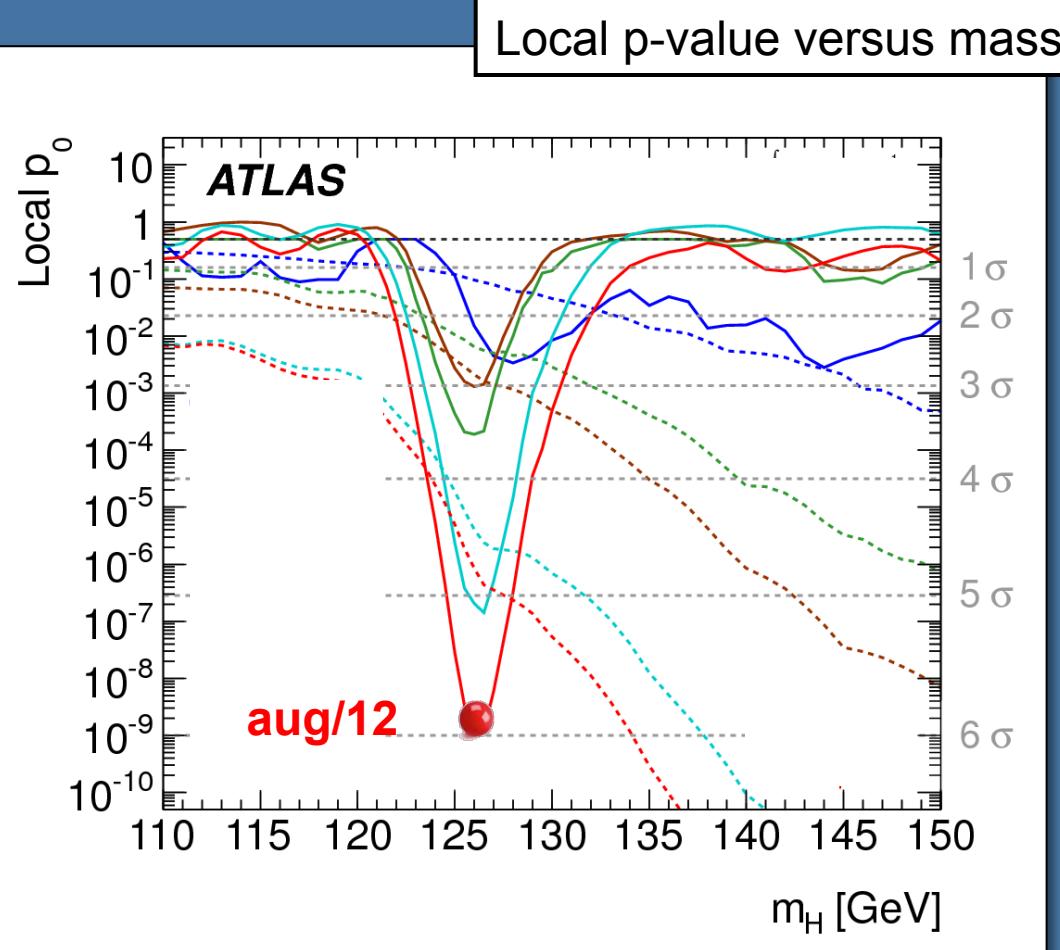


Significance: probability to measure N events (or more) under the background-only hypothesis

A textbook discovery in slow-motion

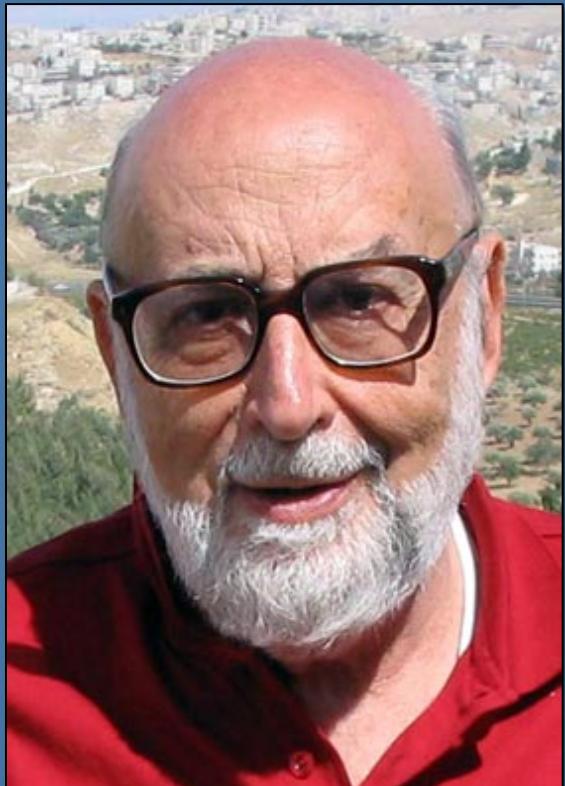


A textbook discovery in slow-motion

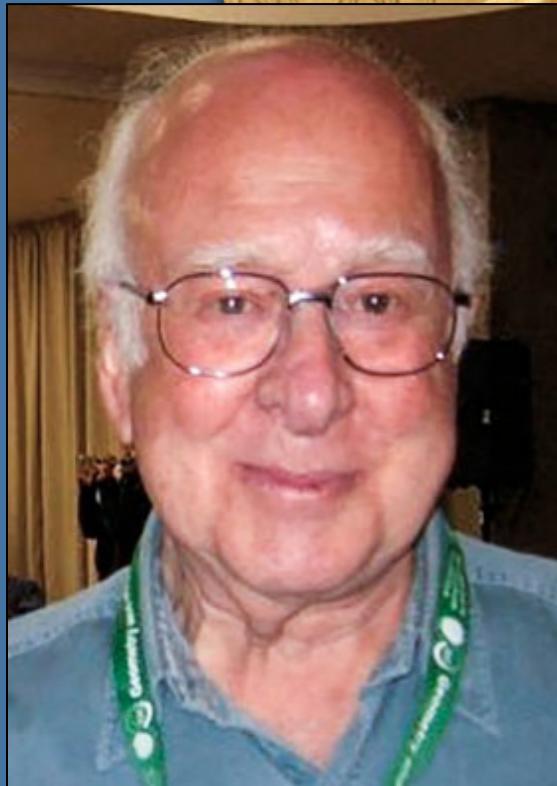


Nobelprize Physics 2013

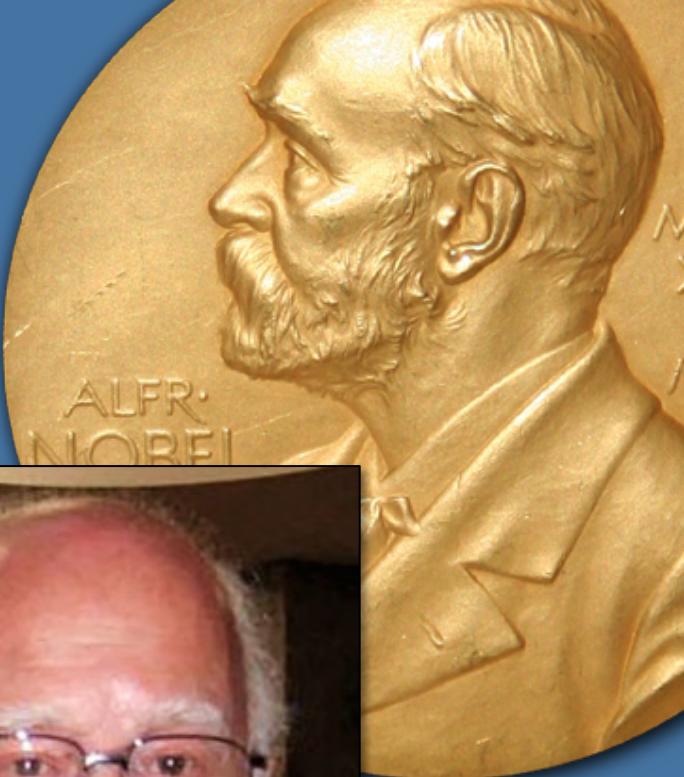
"There is a Higgs field in the vacuum"

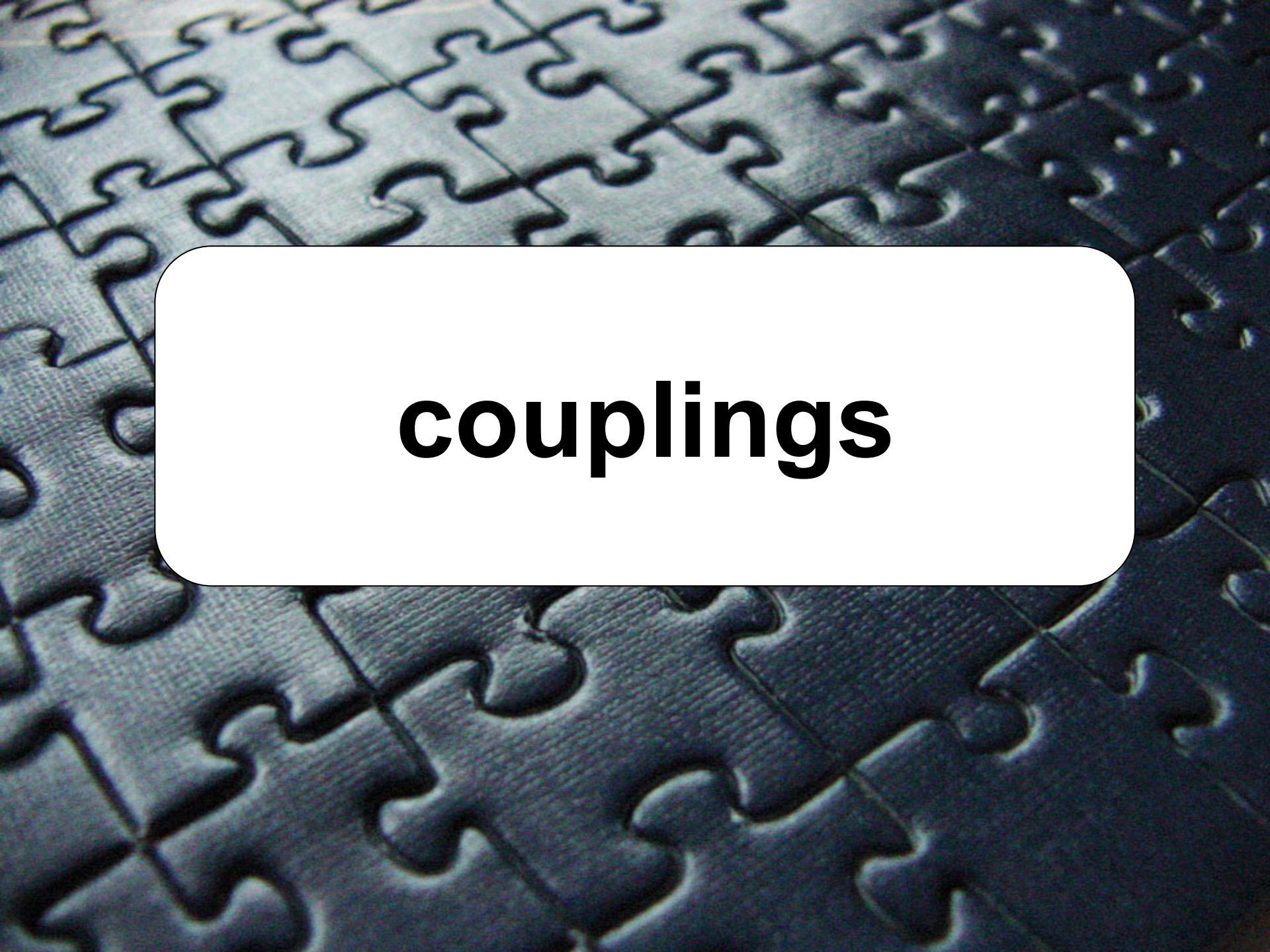


François Englert



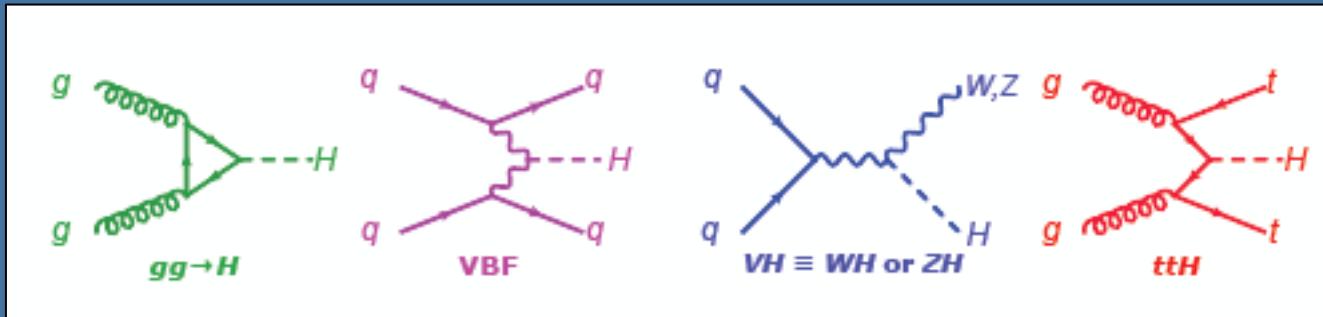
Peter Higgs



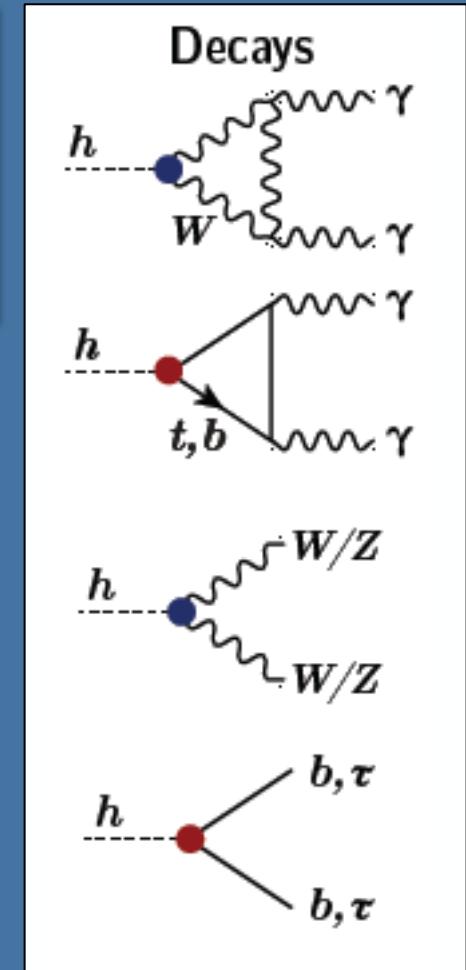


couplings

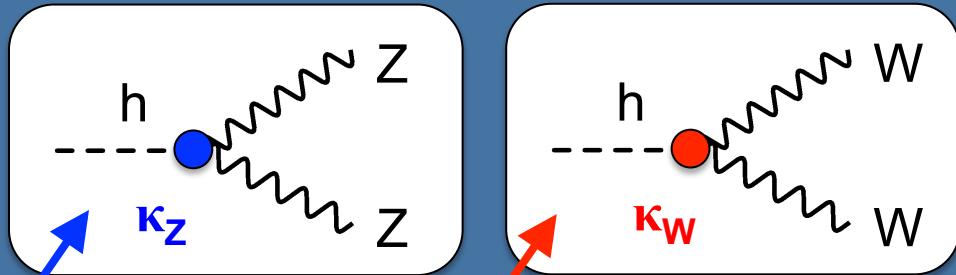
Higgs production and decay



Test all combinations

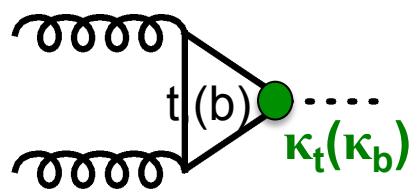


Effective Lagrangian

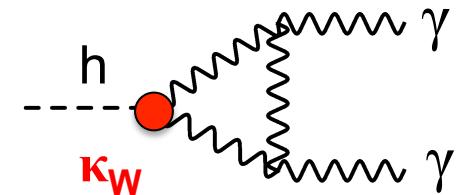
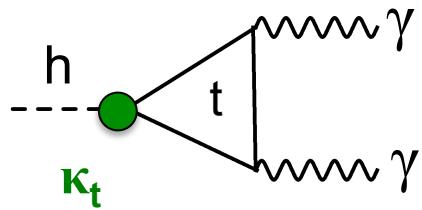


Use scale factors κ to parametrise deviations from SM ($\kappa=1$):

$$\begin{aligned} \mathcal{L} = & \kappa_3 \frac{m_H^2}{2v} H^3 + \kappa_Z \frac{m_Z^2}{v} Z_\mu Z^\mu H + \kappa_W \frac{2m_W^2}{v} W_\mu^+ W^{-\mu} H \\ & + \kappa_g \frac{\alpha_s}{12\pi v} G_{\mu\nu}^a G^{a\mu\nu} H + \kappa_\gamma \frac{\alpha}{2\pi v} A_{\mu\nu} A^{\mu\nu} H + \kappa_{Z\gamma} \frac{\alpha}{\pi v} A_{\mu\nu} Z^{\mu\nu} H \\ & - \left(\kappa_t \sum_{f=u,c,t} \frac{m_f}{v} f \bar{f} + \kappa_b \sum_{f=d,s,b} \frac{m_f}{v} f \bar{f} + \kappa_\tau \sum_{f=e,\mu,\tau} \frac{m_f}{v} f \bar{f} \right) H \end{aligned}$$



$$\kappa_g^2 \propto 1.06\kappa_t^2 - 0.07\kappa_t\kappa_b + 0.01\kappa_b^2$$

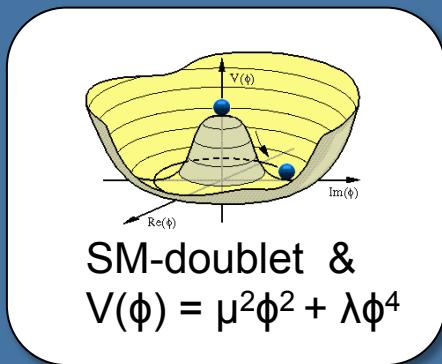


$$\kappa_\gamma^2 \propto 1.59\kappa_W^2 - 0.66\kappa_W\kappa_t + 0.07\kappa_t^2$$

$$\begin{aligned} \mathcal{L} = & \kappa_3 \frac{m_H^2}{2v} H^3 + \kappa_Z \frac{m_Z^2}{v} Z_\mu Z^\mu H + \kappa_W \frac{2m_W^2}{v} W_\mu^+ W^{-\mu} H \\ & + \kappa_g \frac{\alpha_s}{12\pi v} G_{\mu\nu}^a G^{a\mu\nu} H + \kappa_\gamma \frac{\alpha}{2\pi v} A_{\mu\nu} A^{\mu\nu} H + \kappa_{Z\gamma} \frac{\alpha}{\pi v} A_{\mu\nu} Z^{\mu\nu} H \\ & - \left(\kappa_t \sum_{f=u,c,t} \frac{m_f}{v} f \bar{f} + \kappa_b \sum_{f=d,s,b} \frac{m_f}{v} f \bar{f} + \kappa_\tau \sum_{f=e,\mu,\tau} \frac{m_f}{v} f \bar{f} \right) H \end{aligned}$$

Rates and relations are modified if non-SM particles enter in the loops

Extending the Higgs sector



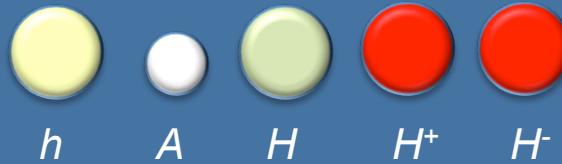
(1) compositeness



(2) extra EW singlet



(3) Two Higgs doublet models



specific couplings h to fermions/bosons

(4) Dark Matter portal

Invisible Higgs decays

Two Higgs doublet models

5 Higgs bosons, lightest one looks very much like the SM one

Coupling lightest Higgs boson w.r.t Standard Model prediction:

Coupling scale factor	Type I	Type II	Type III	Type IV
vector bosons	$\sin(\beta - \alpha)$	$\sin(\beta - \alpha)$	$\sin(\beta - \alpha)$	$\sin(\beta - \alpha)$
up-type quarks	$\cos(\alpha) / \sin(\beta)$	$\cos(\alpha) / \sin(\beta)$	$\cos(\alpha) / \sin(\beta)$	$\cos(\alpha) / \sin(\beta)$
down-type quarks	$\cos(\alpha) / \sin(\beta)$	$-\sin(\alpha) / \cos(\beta)$	$\cos(\alpha) / \sin(\beta)$	$-\sin(\alpha) / \cos(\beta)$
leptons	$\cos(\alpha) / \sin(\beta)$	$-\sin(\alpha) / \cos(\beta)$	$-\sin(\alpha) / \cos(\beta)$	$\cos(\alpha) / \sin(\beta)$



TYPE I:

- 1 doublet for vector bosons
- 1 doublet for fermions

TYPE II: MSSM-like:

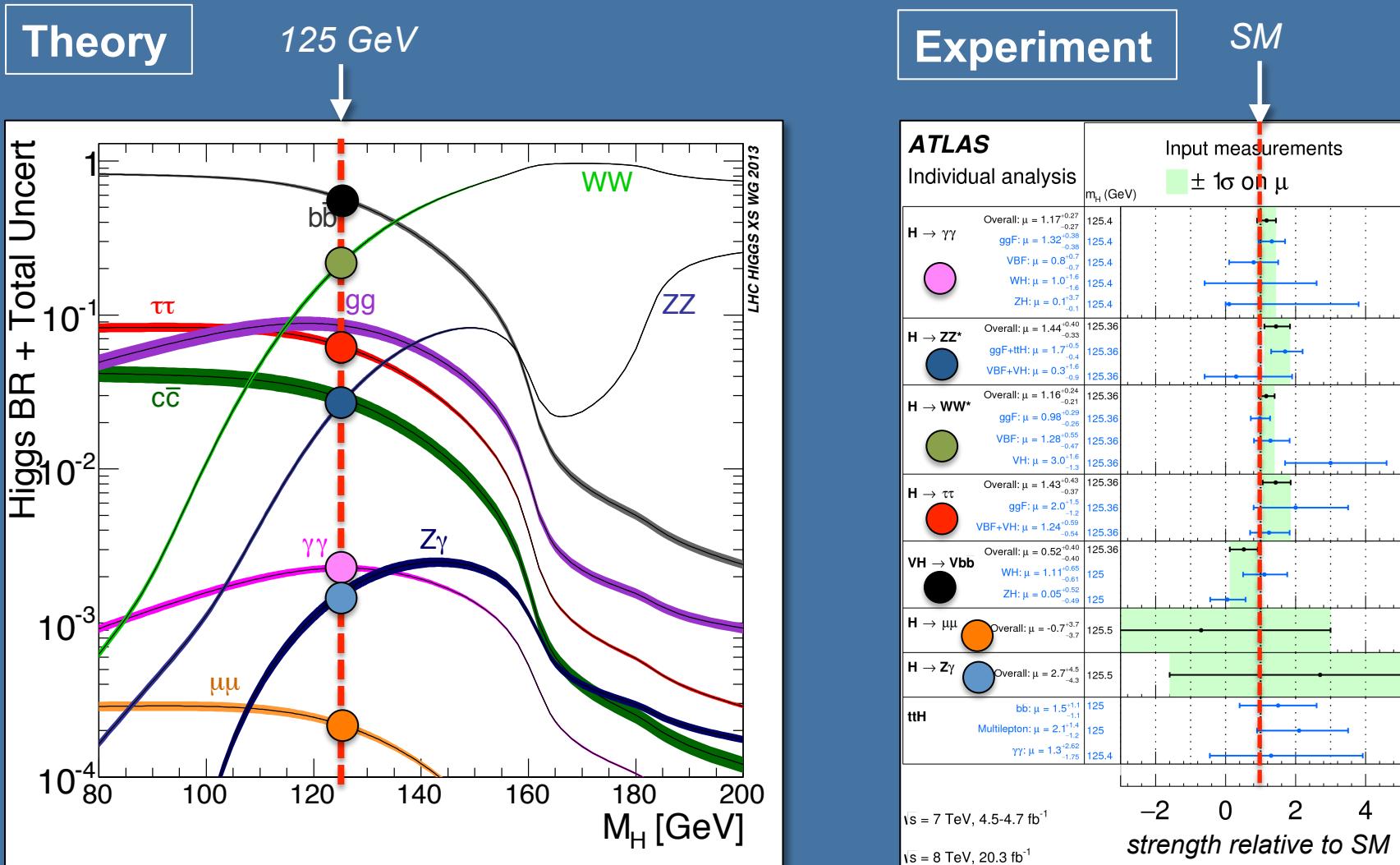
- 1 doublet for up-type
- 1 doublet for down-type

Why measure the mass to high precision ?

Branching ratio's depend on the mass of the Higgs boson

		Δm	$\Delta \Gamma/\Gamma_{125}$
$m_h = 123.7 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.34\%$	-1%	-11%
$m_h = 124.0 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.41\%$		
$m_h = 124.5 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.52\%$	0.4%	-4.5%
$m_h = 125.0 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.64\%$	0.0%	0.0%
$m_h = 125.5 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.76\%$	0.4%	+4.5%
$m_h = 126.0 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.89\%$		
$m_h = 126.3 \text{ GeV}$	$\Gamma(h \rightarrow ZZ) = 2.97\%$	+1%	+12%

Higgs boson couplings



Change in m_h of 500 MeV (0.4%) changes $\Gamma(h \rightarrow ZZ)$ by $\pm 4.5\%$



Observed particle looks very
much like SM Higgs boson



Higgs potential

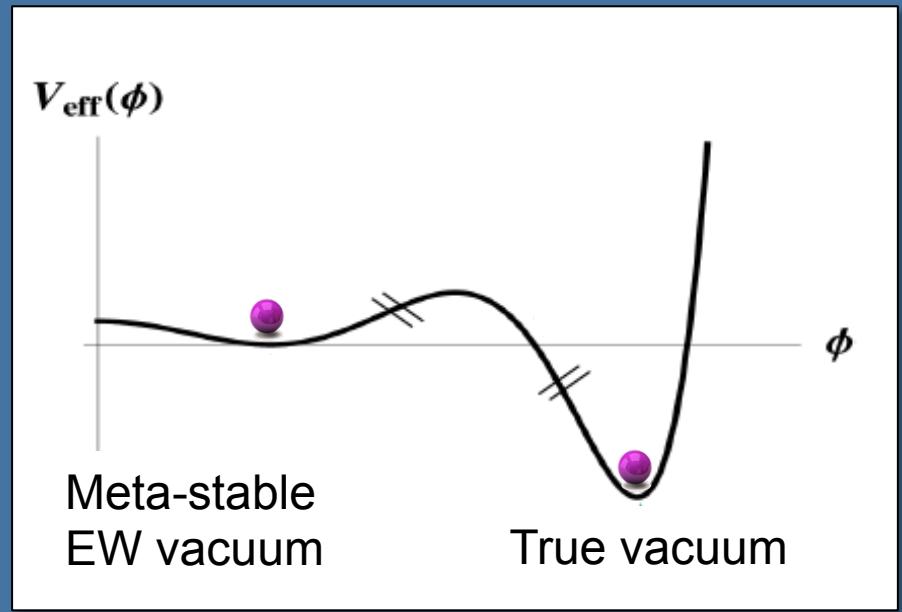
Stability of the vacuum: meta-stability

New physics at the Planck scale:
2 higher dimensional operators

$$V(\phi) = \frac{\lambda}{4}\phi^4 + \frac{\lambda_6}{6}\frac{\phi^6}{M_P^2} + \frac{\lambda_8}{8}\frac{\phi^8}{M_P^4}$$

Tunneling time to true vacuum

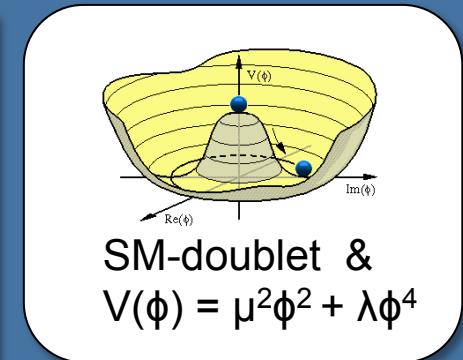
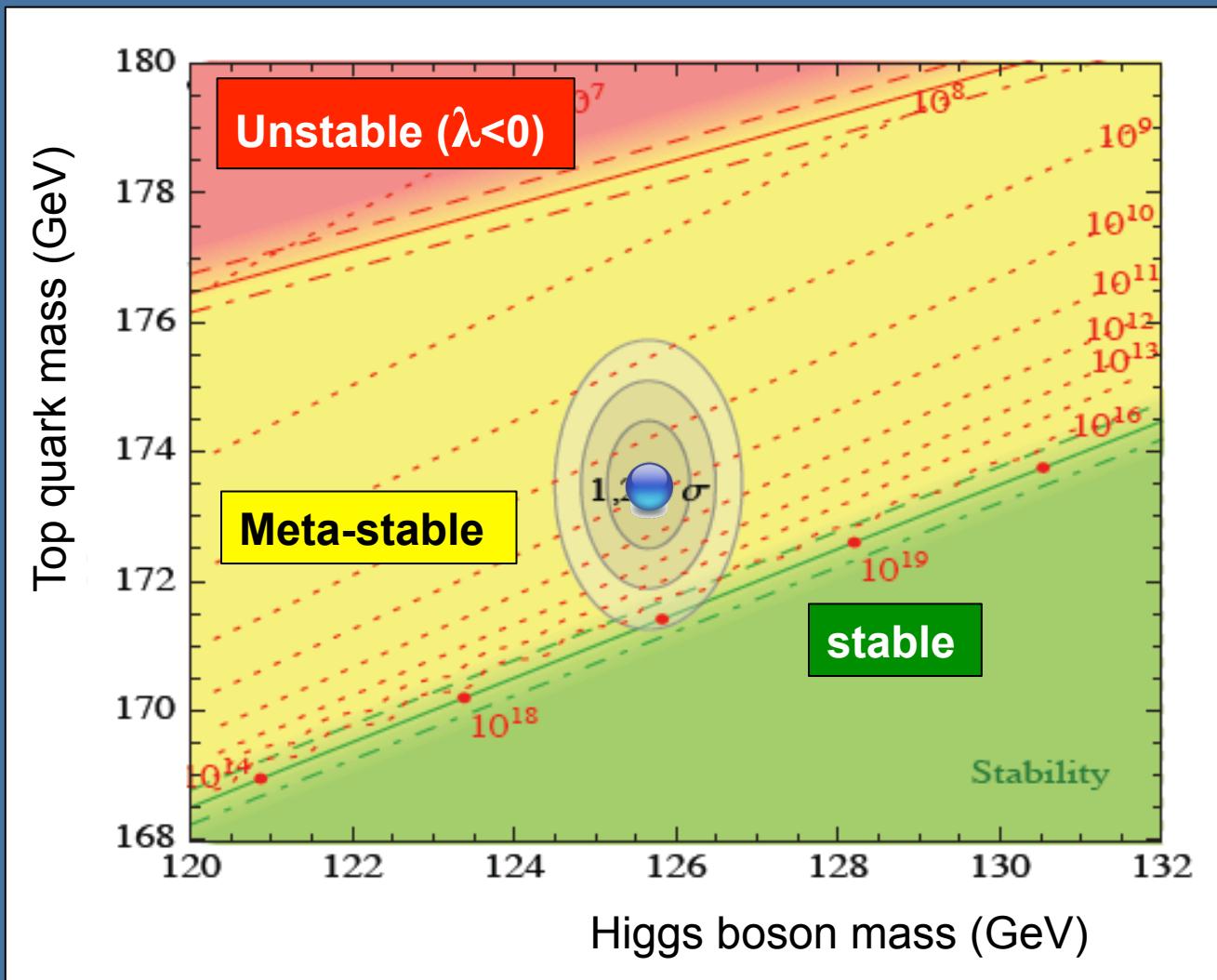
$$\Gamma = \frac{1}{\tau} = T_U^3 \frac{S[\phi_b]^2}{4\pi^2} \left| \frac{\det' [-\partial^2 + V''(\phi_b)]}{\det [-\partial^2 + V''(v)]} \right|^{-1/2} e^{-S[\phi_b]}$$



Not before these guys become World Champion

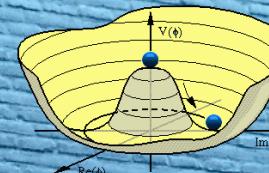


Stability of the vacuum: Higgs potential at high energy



1) Vacuum energy:

Higgs field prediction: 1.00
data (CMB): 0.0000000000



$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

ALBERT EINSTEIN (1879-1955)

2) Range and pattern in fermion masses

3) Higgs quantum corrections

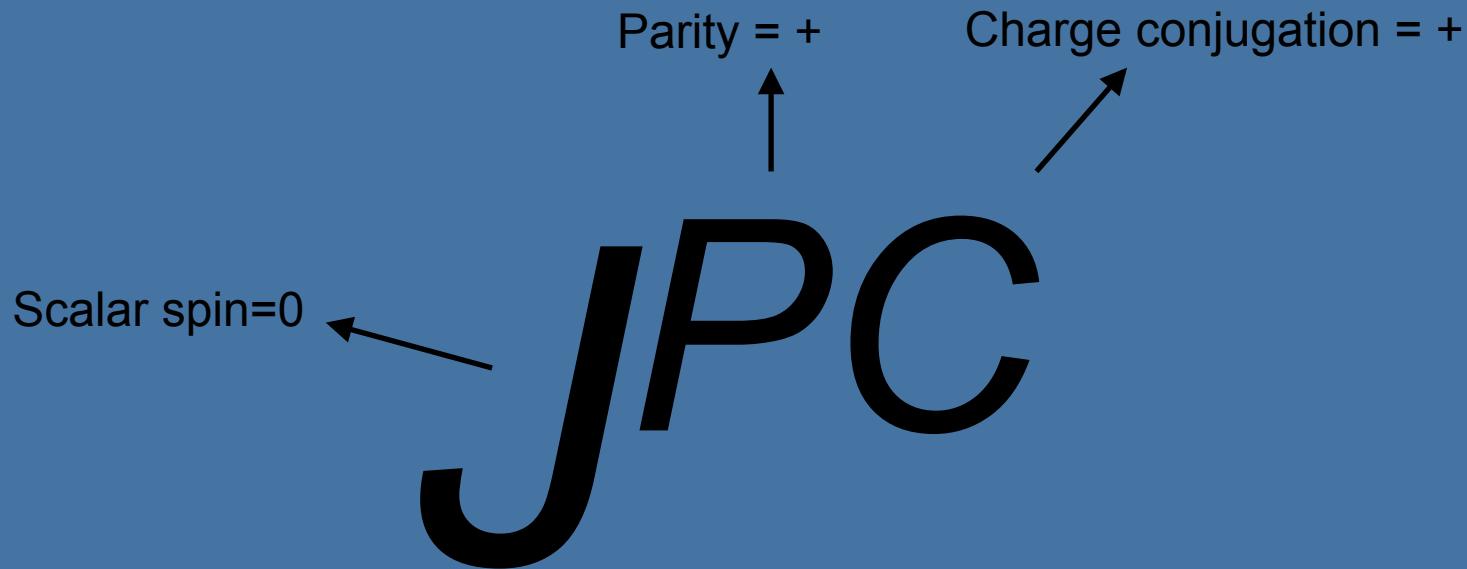
$$h \text{ --- } \text{top} \text{ --- } \left(\Delta m_h^2 \right)_{top} \propto -C \ m_t^2 \Lambda^2 \quad 10^{15} \%$$





spin

Higgs quantum numbers: spin and parity



Differences in each of these parameters lead to different event topologies

- Production angle for different production mechanisms
- Decay angles and event topologies for decay channels

Different scenario's for new particle X

scenario	production	parameters	Model
0_m^+	$gg \rightarrow X$	$g_1^{(0)} \neq 0$	SM Higgs scalar boson
0_h^+	$gg \rightarrow X$	$g_2^{(0)} \neq 0$	scalar higher-dim. op.
0^-	$gg \rightarrow X$	$g_4^{(0)} \neq 0$	pseudo-scalar
1^+	$q\bar{q} \rightarrow X$	$b_2 \neq 0$	exotic pseudo-vector
1^-	$q\bar{q} \rightarrow X$	$b_1 \neq 0$	exotic vector
2_m^+	$g_1^{(2)} \neq 0$	$g_1^{(2)} = g_5^{(2)} \neq 0$	RS graviton min. coupl.
2_h^+	$g_4^{(2)} \neq 0$	$g_4^{(2)} \neq 0$	tensor higher-dim. op.
2_h^-	$g_8^{(2)} \neq 0$	$g_8^{(2)} \neq 0$	“pseudo-tensor”

Structure of the matrix element

Spin 0 (qq production)

$$A(X \rightarrow V_1 V_2) = v^{-1} \epsilon_1^{*\mu} \epsilon_2^{*\nu} \left(a_1 g_{\mu\nu} m_X^2 + a_2 q_\mu q_\nu + a_3 \epsilon_{\mu\nu\alpha\beta} q_1^\alpha q_2^\beta \right) \tilde{f}^{*(2),\mu\nu}$$

Spin 1 (qq production)

$$A(X \rightarrow V_1 V_2) = b_1 [(\epsilon_1^* q)(\epsilon_2^* \epsilon_X) + (\epsilon_2^* q)(\epsilon_1^* \epsilon_X)] + b_2 \epsilon_{\alpha\mu\nu\beta} \epsilon_X^\alpha \epsilon_1^{*,\mu} \epsilon_2^{*,\nu} \tilde{q}^\beta$$

Spin 2 (gg and qq production)

$$\begin{aligned} A(X \rightarrow V_1 V_2) = & \Lambda^{-1} \left[2g_1^{(2)} t_{\mu\nu} f^{*(1)\mu\alpha} f^{*(2)\nu\alpha} + 2g_2^{(2)} t_{\mu\nu} \frac{q_\alpha q_\beta}{\Lambda^2} f^{*(1)\mu\alpha} f^{*(2)\nu\beta} + g_3^{(2)} \frac{\tilde{q}^\beta \tilde{q}^\alpha}{\Lambda^2} t_{\beta\nu} \left(f^{*(1)\mu\nu} f_{\mu\alpha}^{*(2)} + f^{*(2)\mu\nu} f_{\mu\alpha}^{*(1)} \right) \right. \\ & + g_4^{(2)} \frac{\tilde{q}^\nu \tilde{q}^\mu}{\Lambda^2} t_{\mu\nu} f^{*(1)\alpha\beta} f_{\alpha\beta}^{*(2)} + m_V^2 \left(2g_5^{(2)} t_{\mu\nu} \epsilon_1^{*\mu} \epsilon_2^{*\nu} + 2g_6^{(2)} \frac{\tilde{q}^\mu q_\alpha}{\Lambda^2} t_{\mu\nu} (\epsilon_1^{*\nu} \epsilon_2^{*\alpha} - \epsilon_1^{*\alpha} \epsilon_2^{*\nu}) + g_7^{(2)} \frac{\tilde{q}^\mu \tilde{q}^\nu}{\Lambda^2} t_{\mu\nu} \epsilon_1^* \epsilon_2^* \right) \\ & \left. + g_8^{(2)} \frac{\tilde{q}_\mu \tilde{q}_\nu}{\Lambda^2} t_{\mu\nu} f^{*(1)\alpha\beta} f_{\alpha\beta}^{*(2)} + m_V^2 \left(g_9^{(2)} \frac{t_{\mu\alpha} \tilde{q}^\alpha}{\Lambda^2} \epsilon_{\mu\nu\rho\sigma} \epsilon_1^{*\nu} \epsilon_2^{*\rho} q^\sigma + \frac{g_{10}^{(2)} t_{\mu\alpha} \tilde{q}^\alpha}{\Lambda^4} \epsilon_{\mu\nu\rho\sigma} q^\rho \tilde{q}^\sigma (\epsilon_1^{*\nu} (q \epsilon_2^*) + \epsilon_2^{*\nu} (q \epsilon_1^*)) \right) \right] \end{aligned}$$

Conclusions:

Vacuum is indeed filled with the Higgs field

Feels, smells, tastes like SM Higgs

Big questions still open

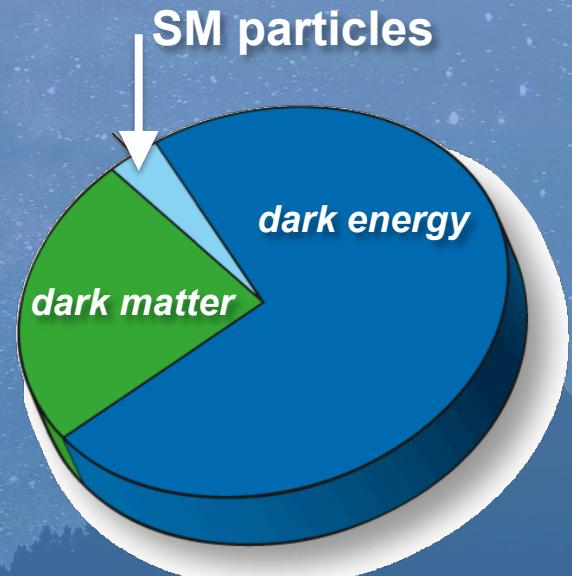
LHC run 2 already started

bigger problems



Standard Model is not the final theory:

- Higgs boson - contribution to vacuum energy 10^{50} wrong
- Higgs boson - quantum corrections diverge
- Fermions: range of fermion masses (10^{12})
- Fermions: neutrino mass & fermion/majorana
- Structure: why 3 particle families, why 3 forces
- Structure: why is gravity not included
- Universe: where is the anti-matter
- Universe: what composes dark matter



Solutions predict deviations from SM & new phenomena ... at 10^{-20} m (10 TeV)

Dreams at the Large Hadron Collider

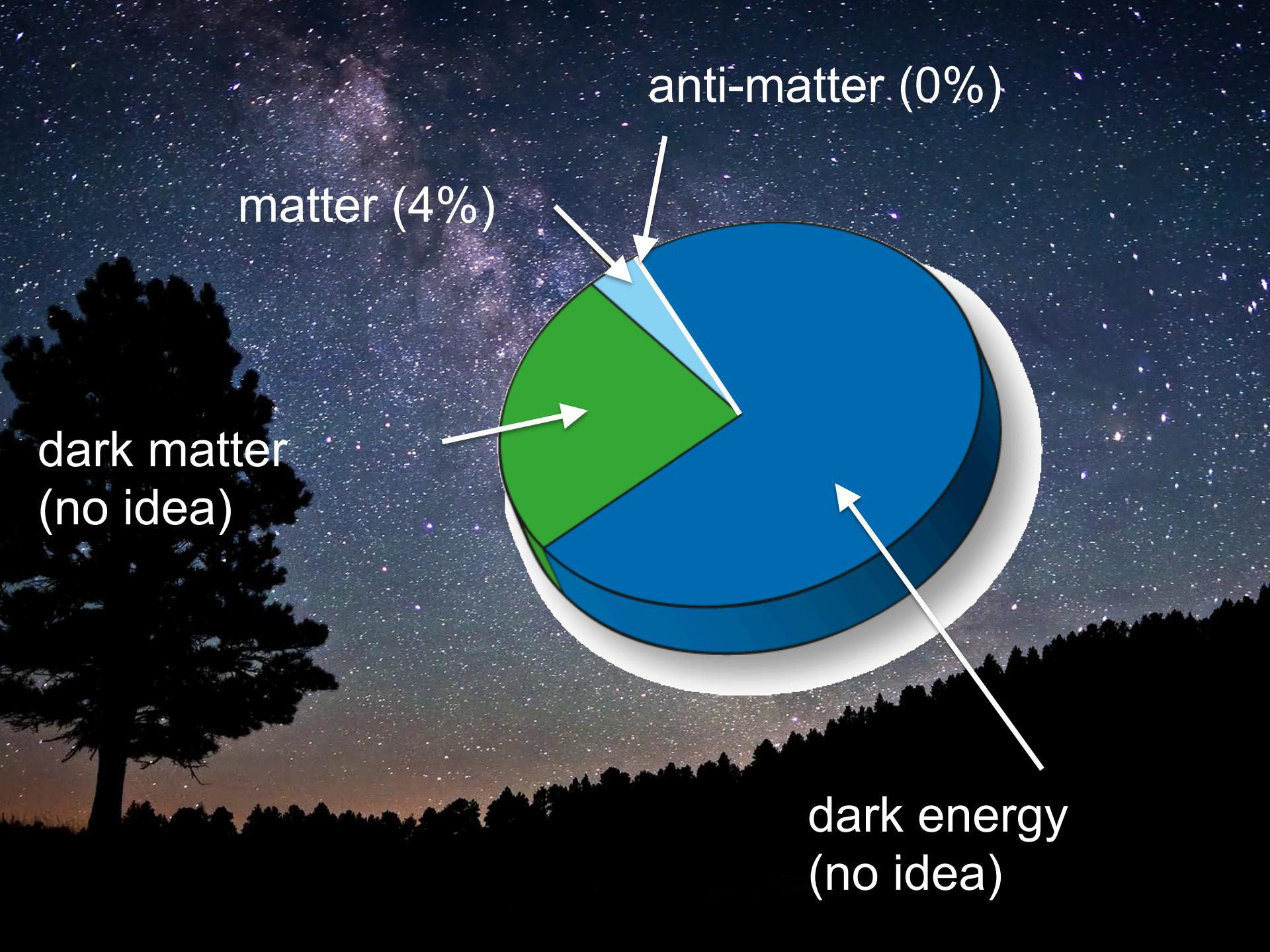
supersymmetry

extra Higgs bosons

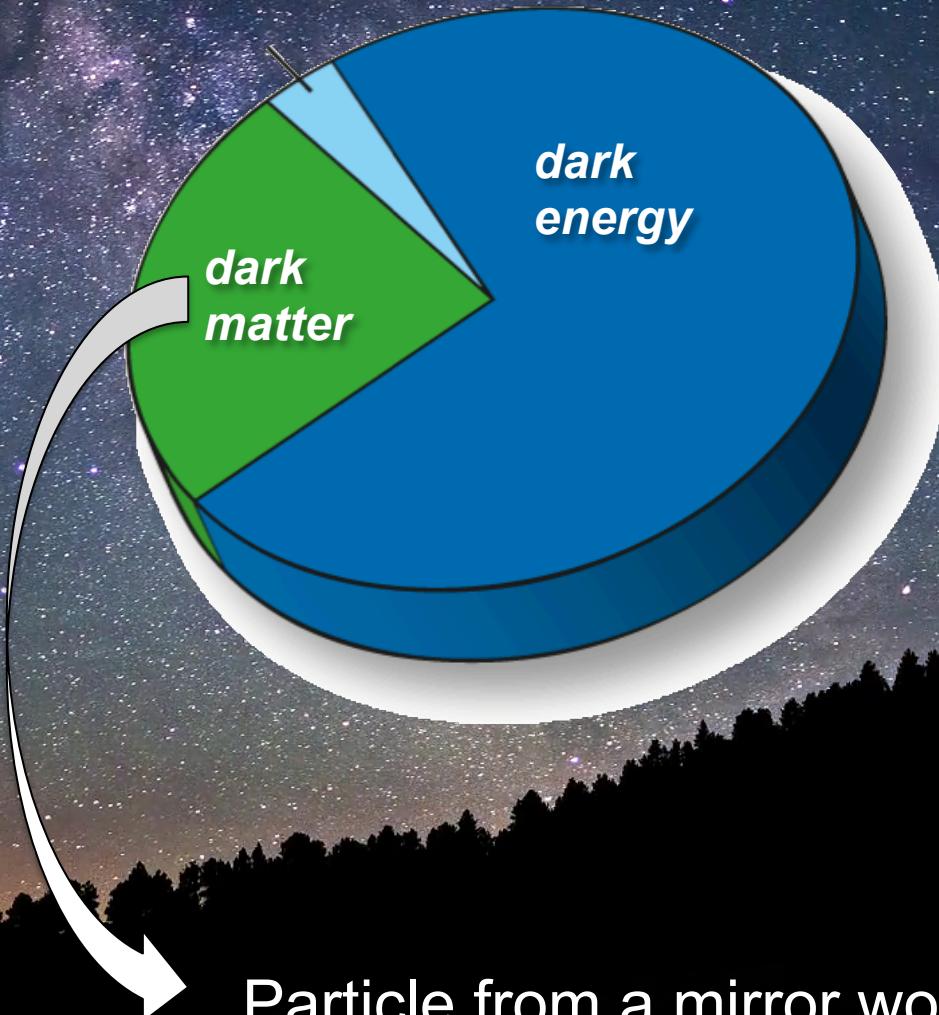
extra gauge groups

extra dimensions





Hypothesis from physicists



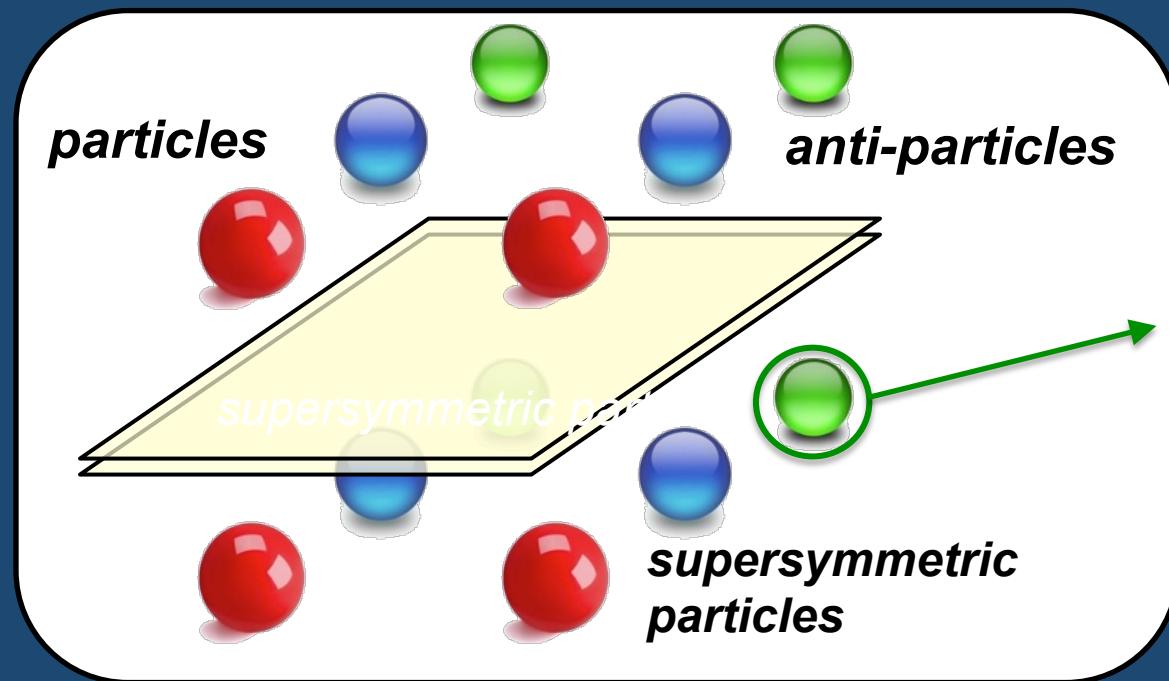
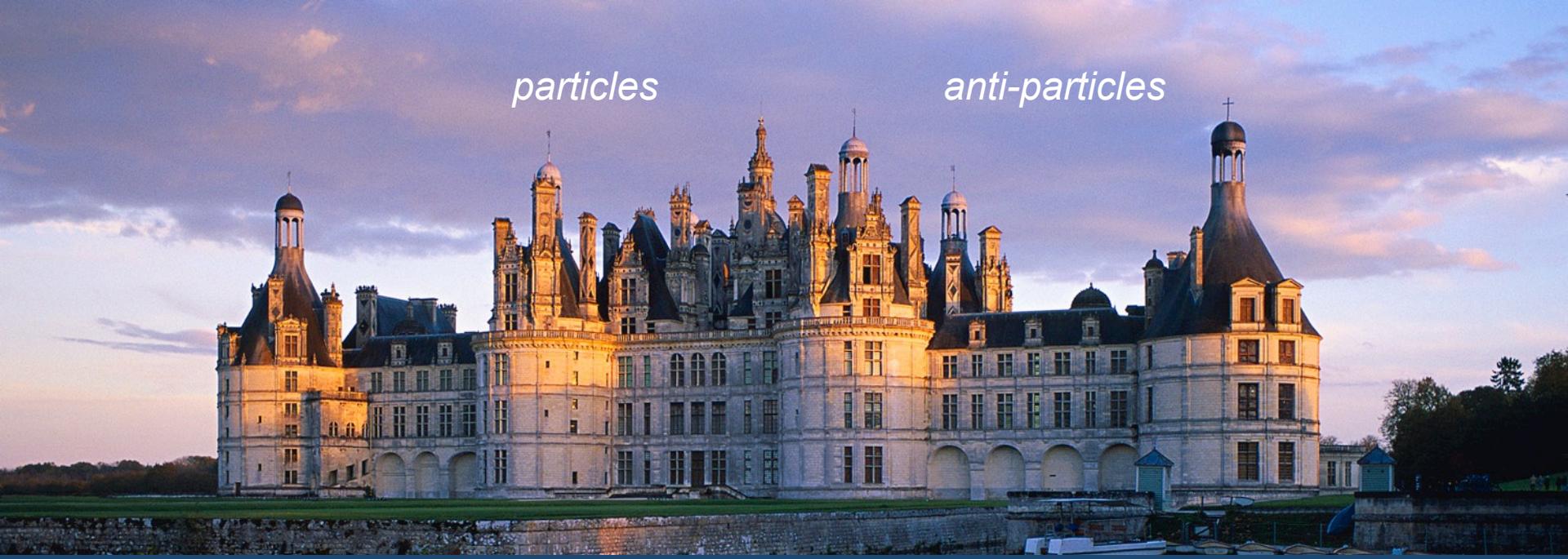


particles

anti-particles

stable matter

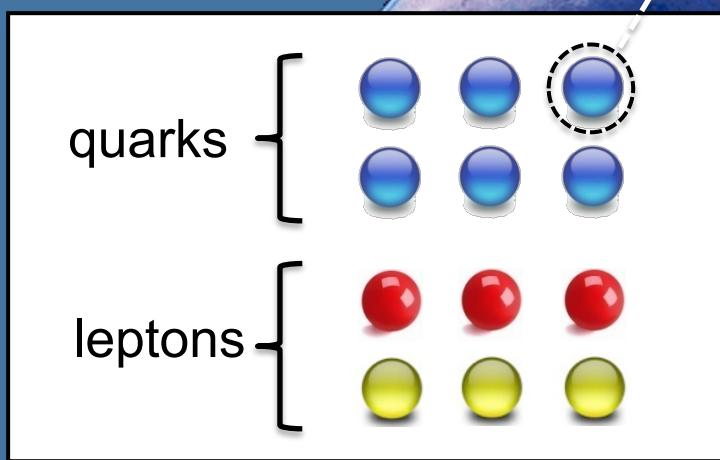




Lightest particle is stable

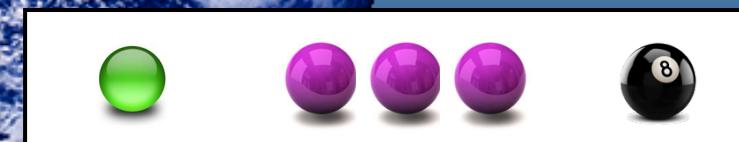
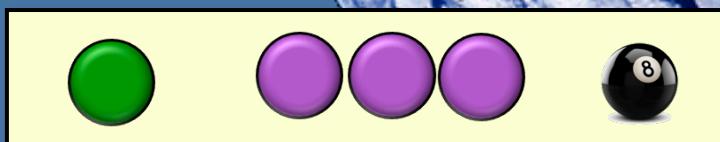
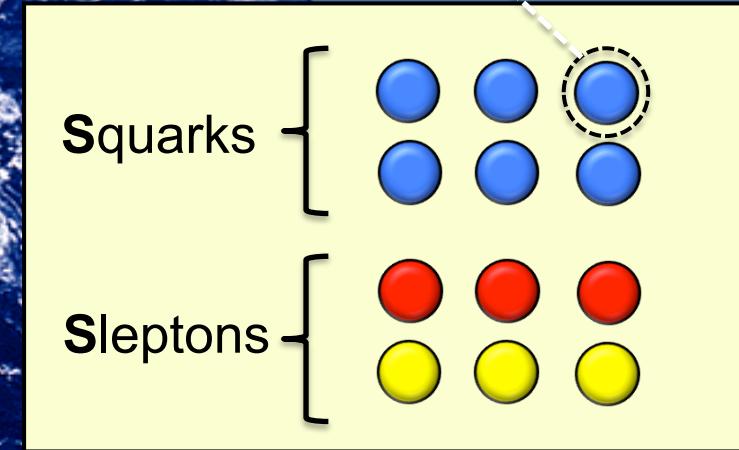
→ *dark matter ?*

FERMIIONS



Top quark

Stop squark



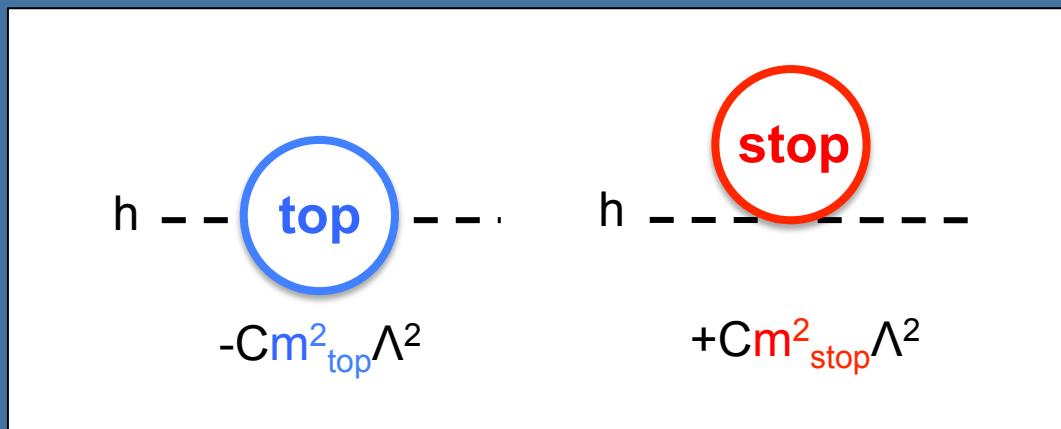
BOSONS

Lightest neutral stable (dark matter candidate)

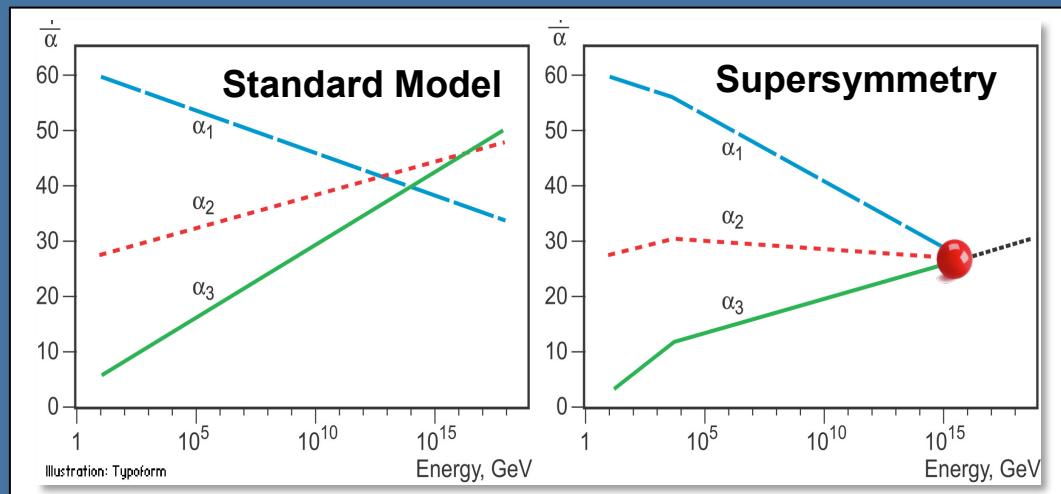


the super in supersymmetry

1) Higgs propagator



2) Unification forces



3) Dark Matter

Lightest supersymmetric particle is stable

Resonances

*Extra gauge bosons and Kaluza-Klein
graviton towers (extra dimensions)*

New gauge bosons:

Elementary particles

up-quark



down-quark



elektron



neutrino



Interactions

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i \bar{\psi} \not{D} \psi + h.c. + y_1 y_2 y_3 \phi + h.c. + |\partial_\mu \phi|^2 - V(\phi)$$

$U(1)_B \times$

$U(1)_Y \times SU(2)_L \times SU(3)_C$

β

z'

g'

g

α_s

$\gamma, W^+, W^-, Z,$

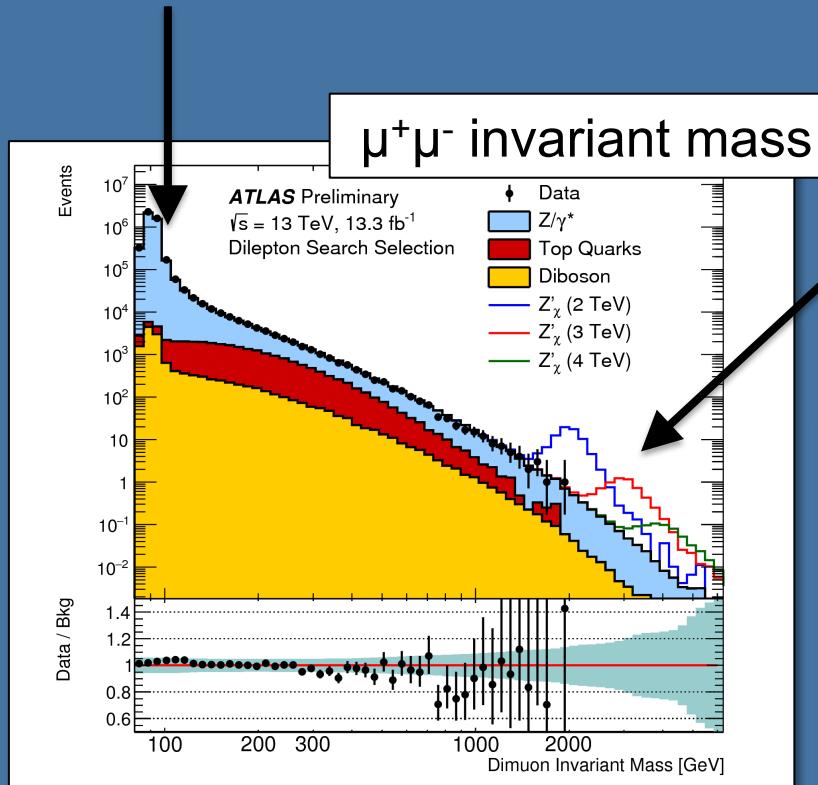
8 gluons

single spinor (1 big family)

gauge unification: $SO(10)$

Looking for di-lepton Z'-resonances

old resonance Z-boson (91 GeV)



new resonances (simulation)

Constraints on Z' masses [TeV]

Model	Width [%]	θ_{E_6} [Rad]	Lower limits on $m_{Z'}$ [TeV]					
			ee		$\mu\mu$		$\ell\ell$	
			Obs	Exp	Obs	Exp	Obs	Exp
Z'_{SSM}	3.0	-	3.85	3.86	3.49	3.53	4.05	4.06
Z'_χ	1.2	0.50	3.48	3.49	3.18	3.19	3.66	3.67
Z'_S	1.2	0.63 π	3.43	3.44	3.14	3.14	3.62	3.61
Z'_I	1.1	0.71 π	3.37	3.37	3.08	3.08	3.55	3.55
Z'_η	0.6	0.21 π	3.25	3.25	2.96	2.94	3.43	3.42
Z'_N	0.6	-0.08 π	3.23	3.23	2.95	2.94	3.41	3.41
Z'_ψ	0.5	0 π	3.18	3.18	2.90	2.88	3.36	3.35

Models with extra (space) also predict di-lepton resonances (Kaluza-Klein)

backup

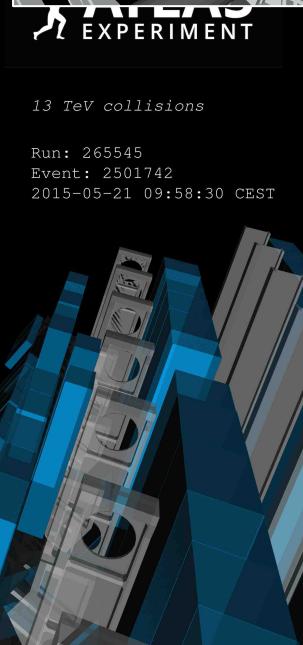
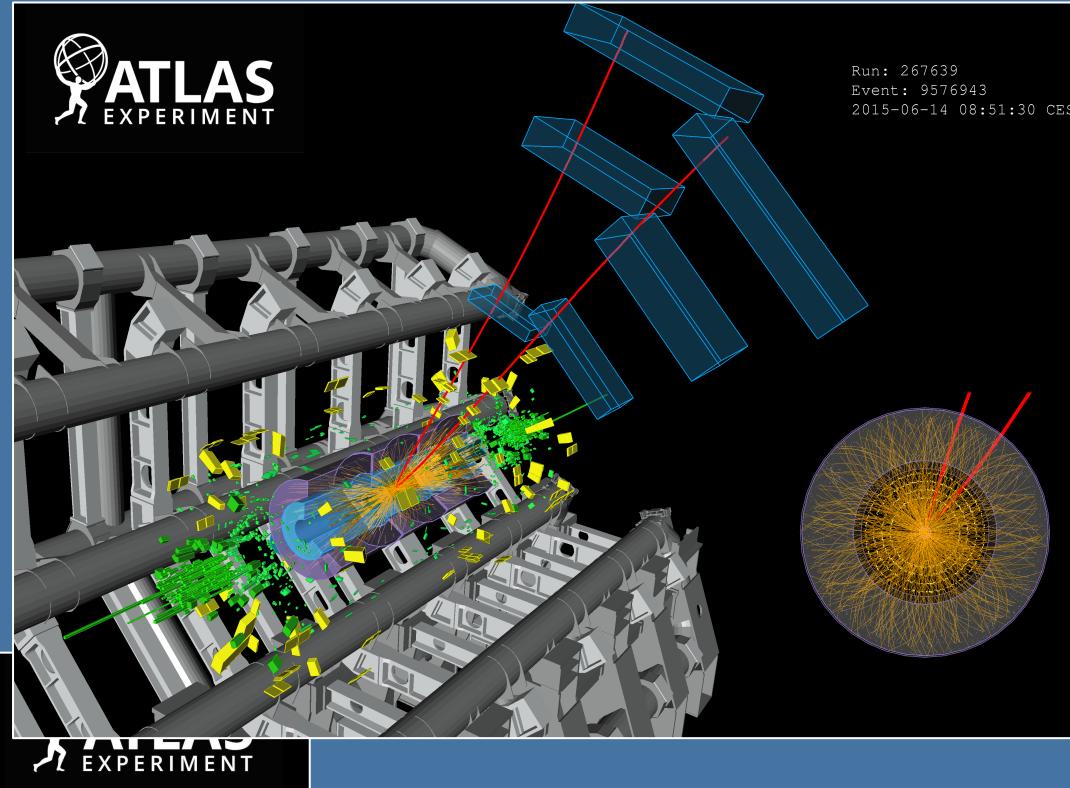
ATLAS control room



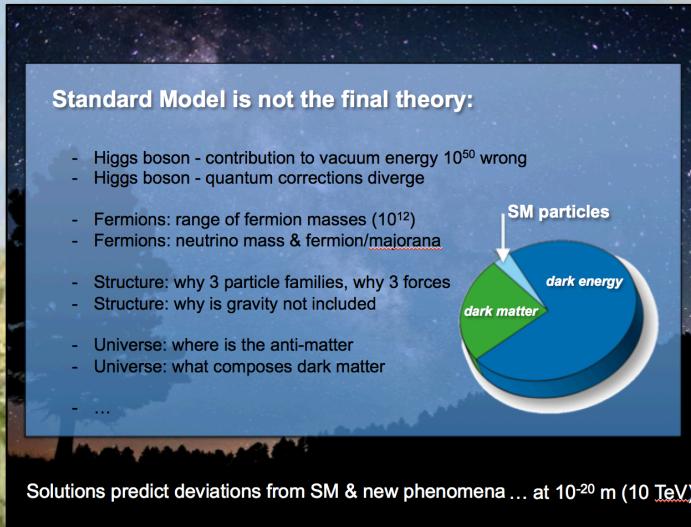
Looking for breakdown of the Standard Model

All results are public:

<https://twiki.cern.ch/twiki/bin/view/AtlasPublic>



problems

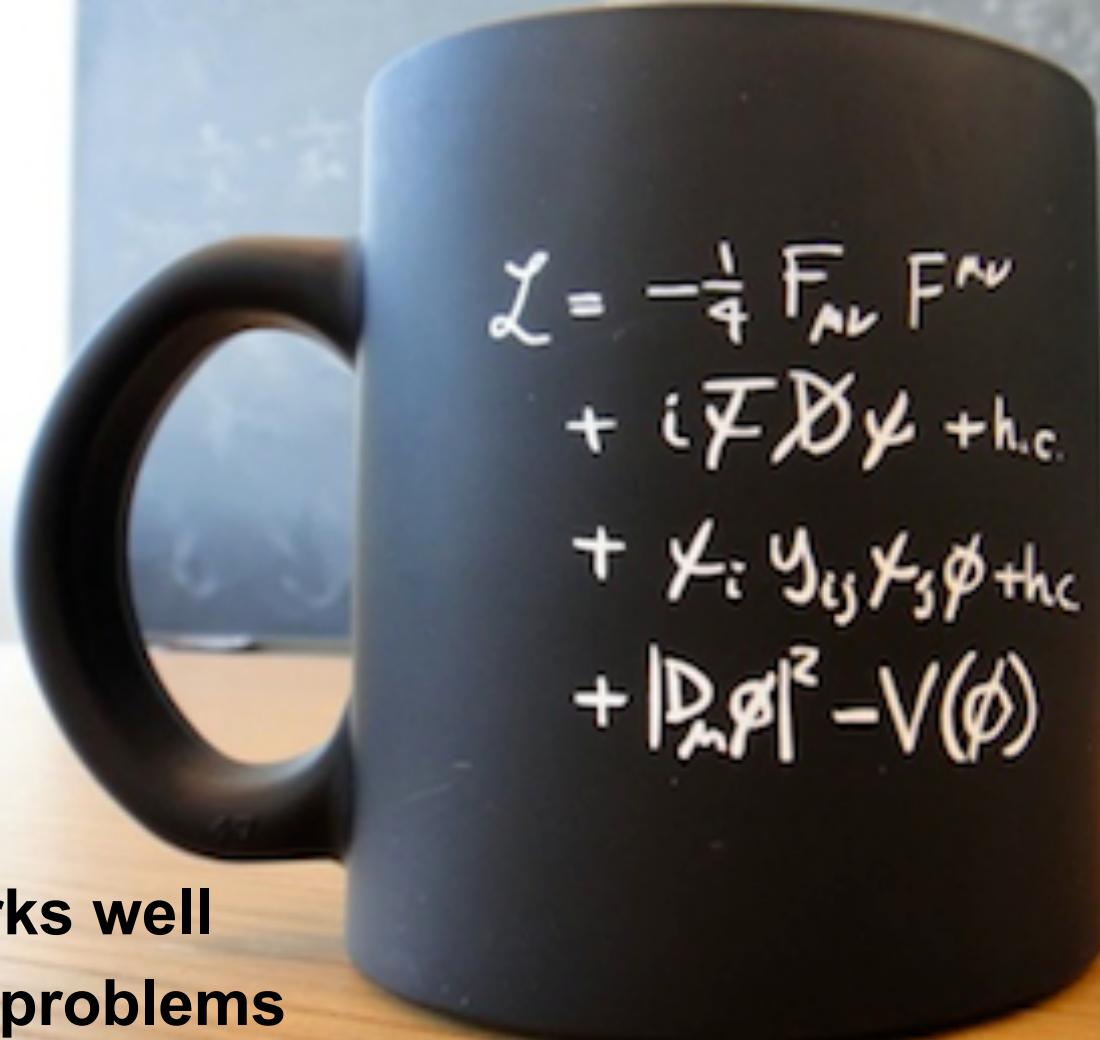


dreams



Much more data coming up ...

The Standard Model



**Works well
Big problems**

Help us !