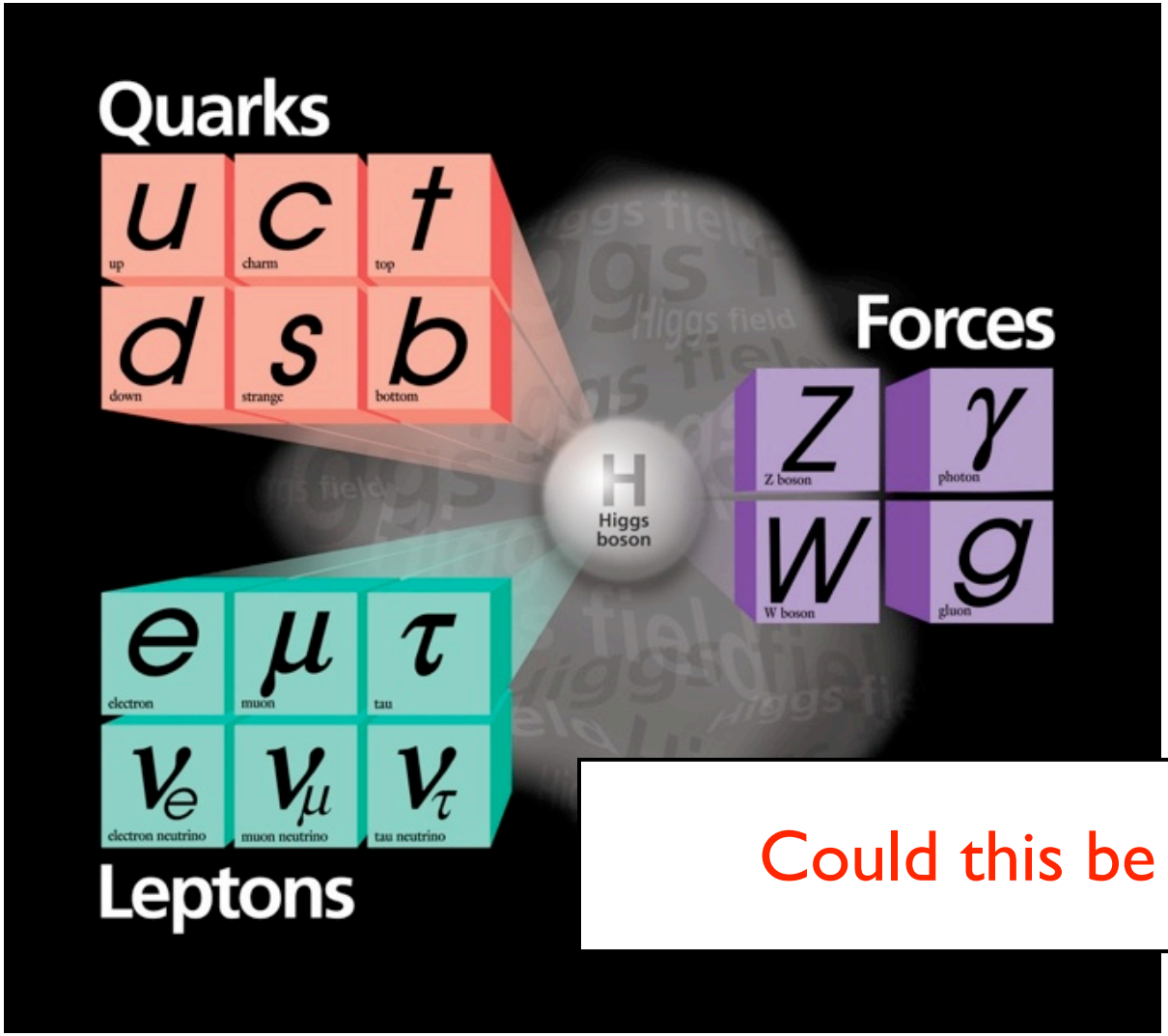
New Physics

New Physics?


Quarks
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up
c
charm
t
top
d
down
s
strange
b
bottom
Forces
Z
Z boson
γ
photon
W
W boson
g
gluon
H
Higgs boson
e
electron
μ
muon
τ
tau
νe
electron neutrino
νμ
muon neutrino
ντ
tau neutrino
Leptons
Higgs field
Could this be it?

New Physics?

The hierarchy problem of the electroweak Standard Model revisited

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Deutsches Elektronen-Synchrotron (DESY),
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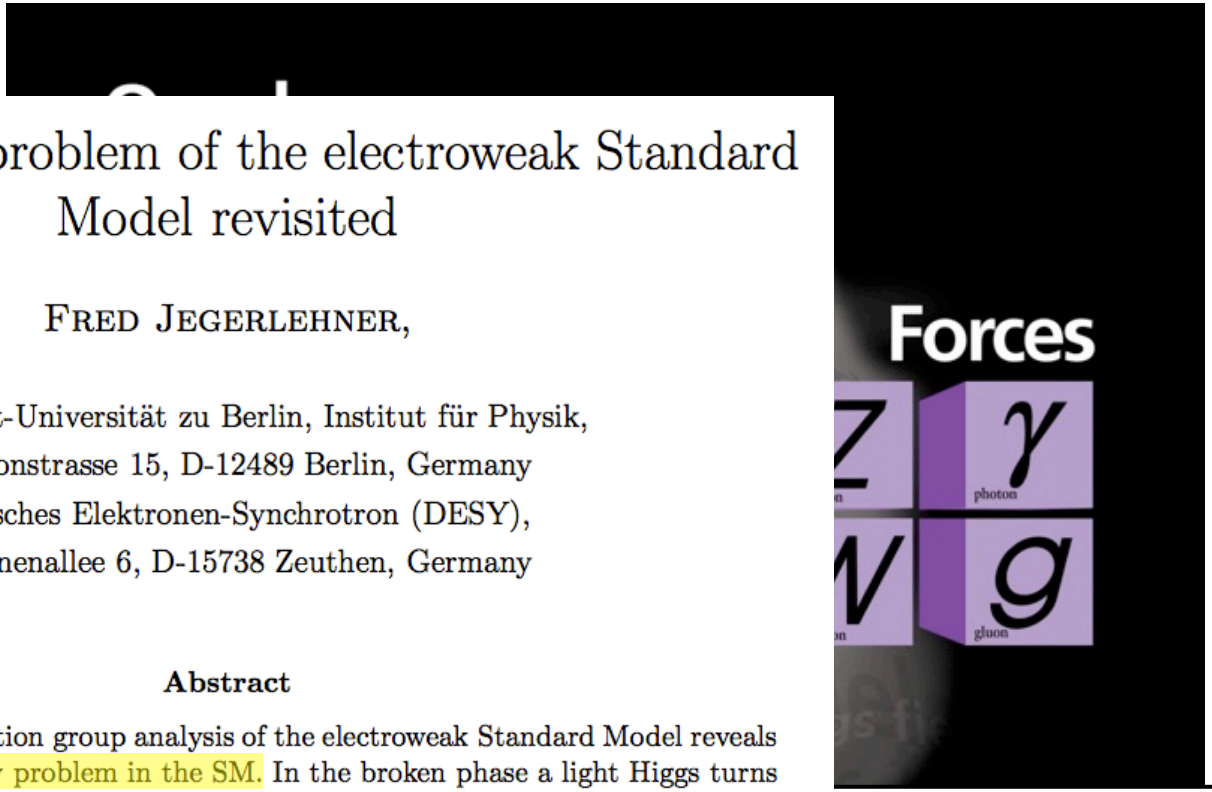
Abstract

A careful renormalization group analysis of the electroweak Standard Model reveals that there is no hierarchy problem in the SM. In the broken phase a light Higgs turns out to be natural as it is self-protected and self-tuned by the Higgs mechanism. It means that the scalar Higgs needs not be protected by any extra symmetry, specifically super symmetry, in order not to be much heavier than the other SM particles which are protected by gauge- or chiral-symmetry. Thus the existence of quadratic cutoff effects in the SM cannot motivate the need for a super symmetric extensions of the SM, but in contrast plays an important role in triggering the electroweak phase transition and in shaping the Higgs potential in the early universe to drive inflation as supported by observation.



Could this be it?

New Physics?

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The hierarchy proble
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A careful renormalization group
that there is no hierarchy problem
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observation.

Natural Tuning: Towards A Proof of Concept

Sergei Dubovsky, Victor Gorbenko, and Mehrdad Mirbabayi

Center for Cosmology and Particle Physics,
Department of Physics, New York University
New York, NY, 10003, USA

Abstract

The cosmological constant problem and the absence of new natural physics at the electroweak scale, if confirmed by the LHC, may either indicate that the nature is fine-tuned or that a refined notion of naturalness is required. We construct a family of toy UV complete quantum theories providing a proof of concept for the second possibility. Low energy physics is described by a tuned effective field theory, which exhibits relevant interactions not protected by any symmetries and separated by an arbitrary large mass gap from the new "gravitational" physics, represented by a set of irrelevant operators. Nevertheless, the only available language to describe dynamics at all energy scales does not require any fine-tuning. The interesting novel feature of this construction is that UV physics is not described by a fixed point, but rather exhibits asymptotic fragility. Observation of additional unprotected scalars at the LHC would be a smoking gun for this scenario. Natural tuning also favors TeV scale unification.

New Physics?

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The hierarchy proble
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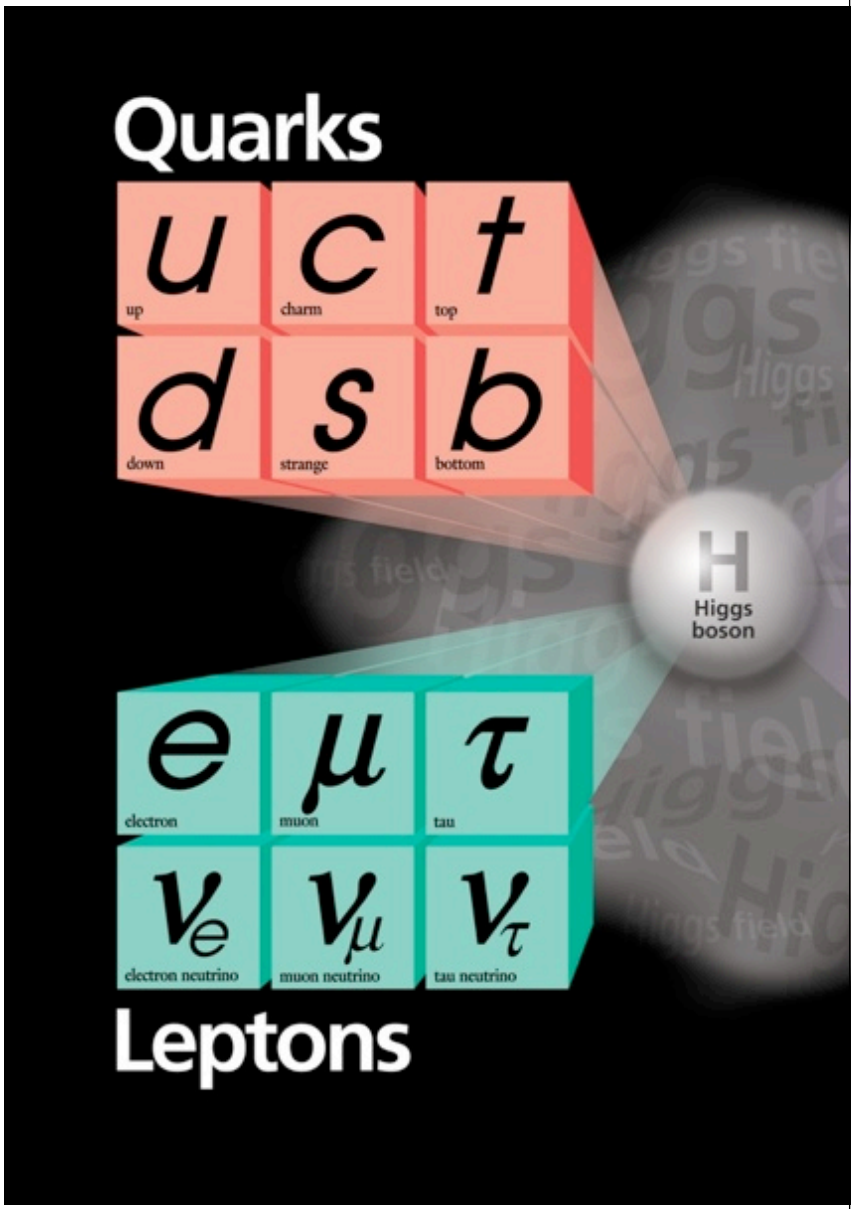
Thanks to Fawzi and Adam
for trying to explain these to us!

Nevertheless

- Clear structure in fermionic sector unexplained
  - Evidence of some selective principle (why are there no neutral colored fermions?)
  - Proton stability, running of couplings suggestive of at least one other scale relevant to SM particles, ~10^{15} GeV
    - Either fine-tuning, or a closer scale



Simplified models for top partners/Vector-like quarks

- Well motivated by naturalness argument (same-spin partners of the top)
- Considerable experimental effort
- Difficult to combine/interpret results (experiments are moving in this direction)
- Many people involved here in Les Houches!

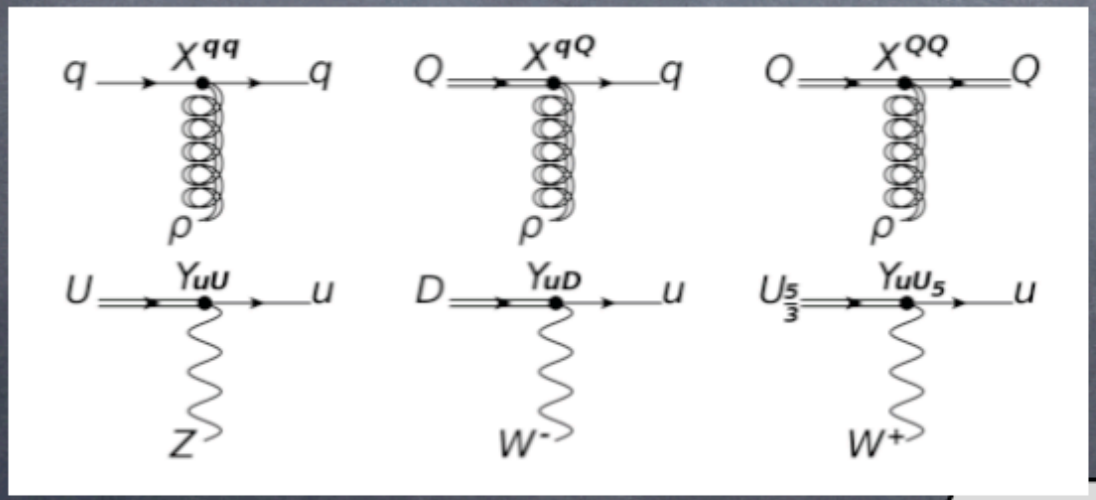
Two classes of simplified models: 'Generic' Q_V - beyond 3rd gen

- Consider a single Q_V in a given representation of SU(2)xU(1).
- Allow for couplings to light (1st) generations - still in the naturalness business!
- Very limited number of parameters: m_Q, g* (coupling strength), R_L (ratio of light/3rd generation decays.
- Implementation of models in FeynRules/MadGraph/CalcHEP available on the WIKI (by G.Cacciapaglia, A.Deandrea, A.Datta)

Two classes of simplified models: MFV right-handed compositeness

M.Redi, V.Sanz, M.de Vries, A.Weiler: 1305:3818

- Model of MFV composite quarks, mainly coupling to a heavy vector and light generation
- 3-body decay into 3 jets, or 2 jets via chromomagnetic operator.

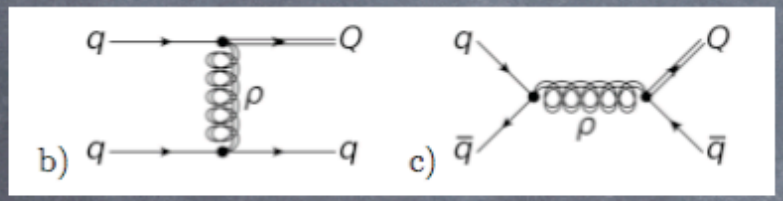


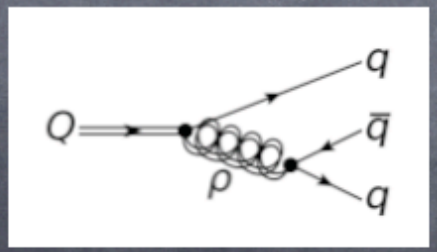
MG model files on the wiki (Veronica & Andreas)

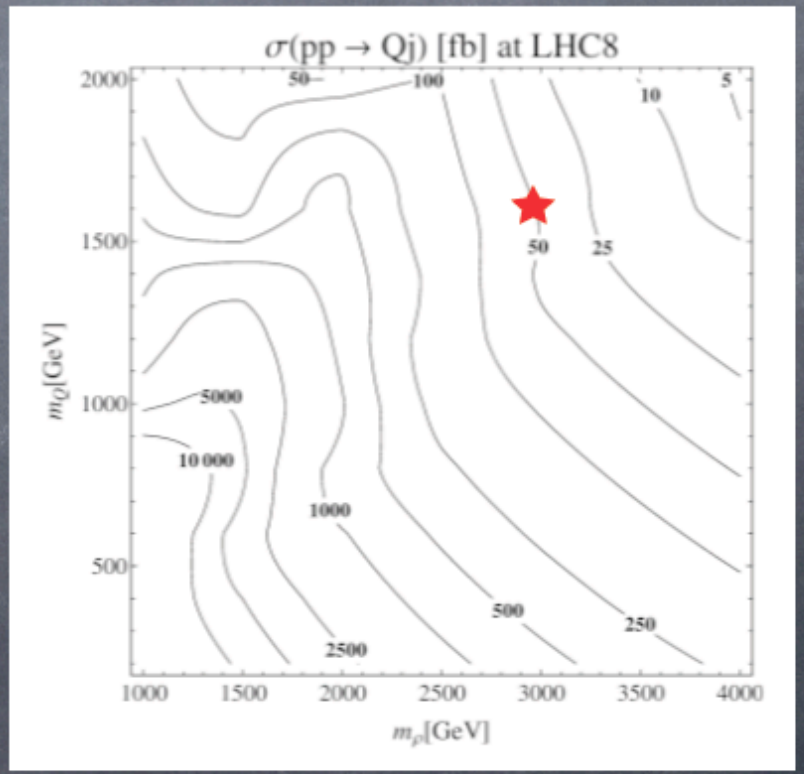
$$m_Q = 1.6\ \text{TeV}, \quad m_\rho = 3\ \text{TeV},$$
$$g_\rho = 3\,, \qquad \theta_{uR} = \theta_{dR} = 0.7\,.$$

MFV right-handed compositeness

- Study of single-production in 3 jets. V.Sanz, J.Ruiz Alvarez







1305:3818

'Generic' Q_V - beyond 3rd gen

- 2 benchmark simplified models:

$$(1, 2/3) = T \Rightarrow T \to W^+ b, W^+ j, Zt, Zj, ht, hj$$

$$(2, 1/6) = \{T, B\} \Rightarrow \begin{cases} T \to Zt, Zj, ht, hj \\ B \to W^- t, W^- j \end{cases}$$

$$(2, 7/6) = \{X, T\} \Rightarrow \begin{cases} X \to W^+ t, W^+ j \\ T \to Zt, Zj, ht, hj \end{cases}$$

- Present in motivated models.
- Milder bounds on couplings from Flavour.

event generation in progress (Jose)

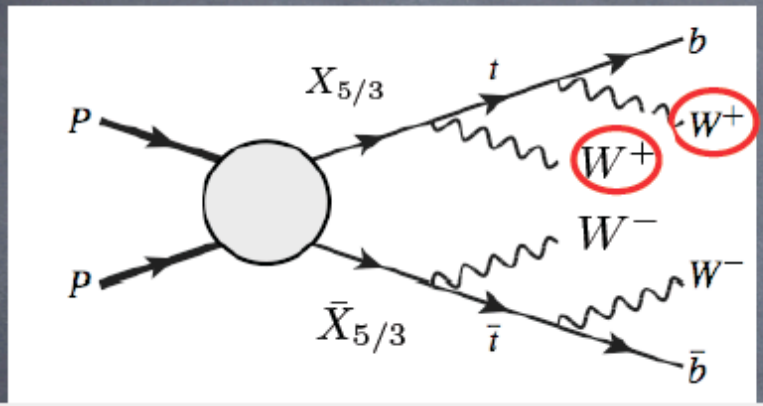
model files on the wiki (Giacomo, Aldo, Asesh)

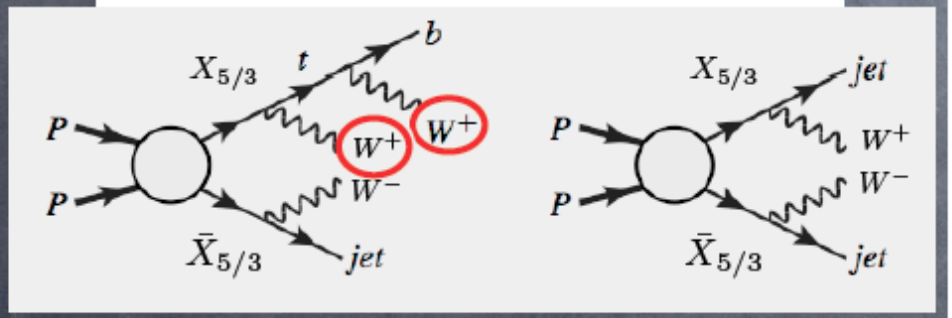
$$m_Q = 1 \text{ TeV}, \quad g^* = 0.1\,, \quad R_L = 0.5$$

'Generic' Q_V - beyond 3rd gen

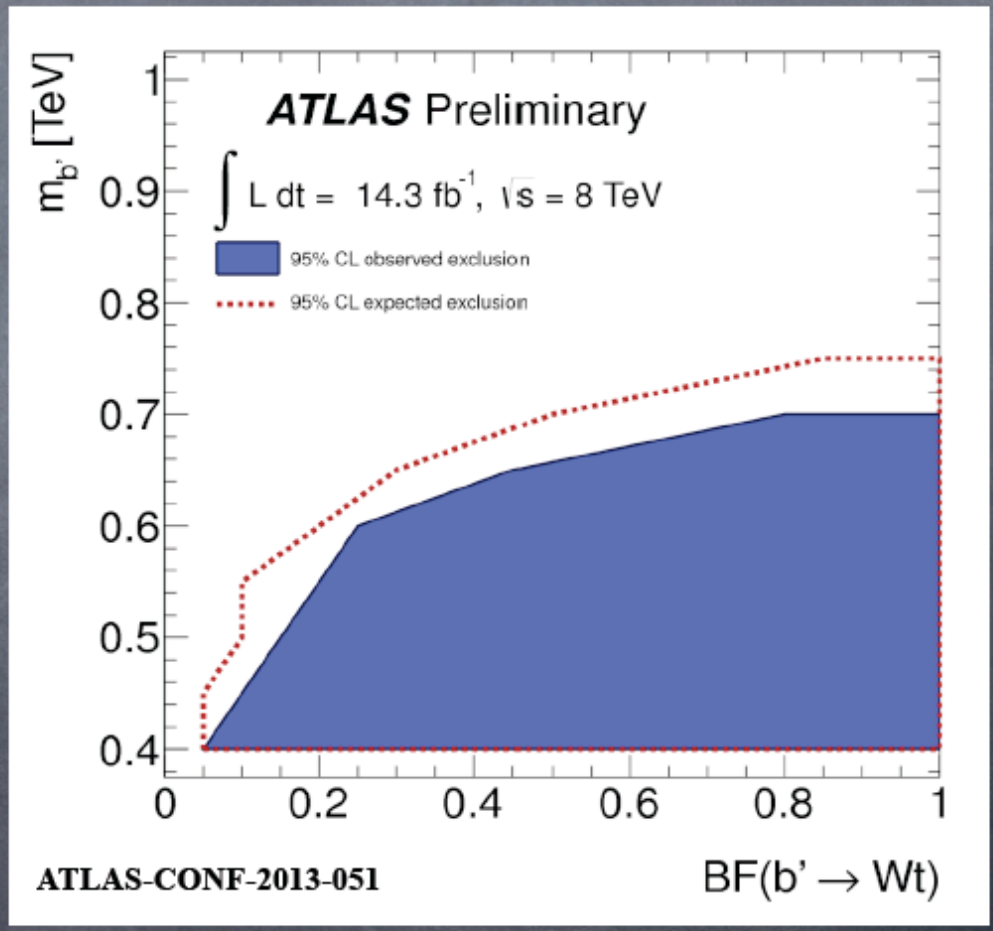
- Combination of searches in Pair Production

A.Belyaev, G.Cacciapaglia, A.Datta, A.Deandrea,T.Golling + L.Panizzi





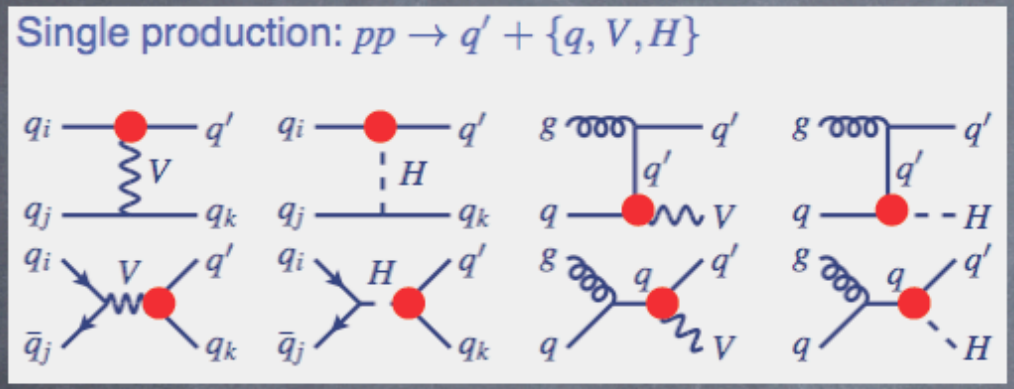
Systematic study for all cases.



'Generic' Q_V - beyond 3rd gen

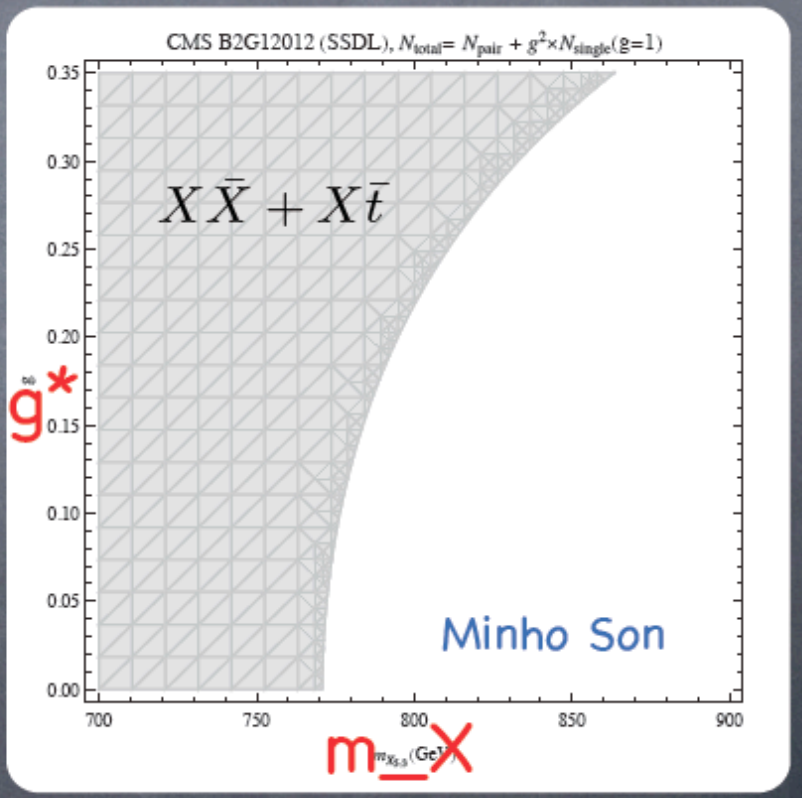
- Combination of searches in Single Production
- New single production channels

L.Basso, A.Belyaev, G.Cacciapaglia, A.Datta
T.Golling, S.Lee, M. Son + M.Buchkremer



Systematic study
for all cases.

Inclusion of couplings
to light generations.



'Generic' Q_V - beyond 3rd gen

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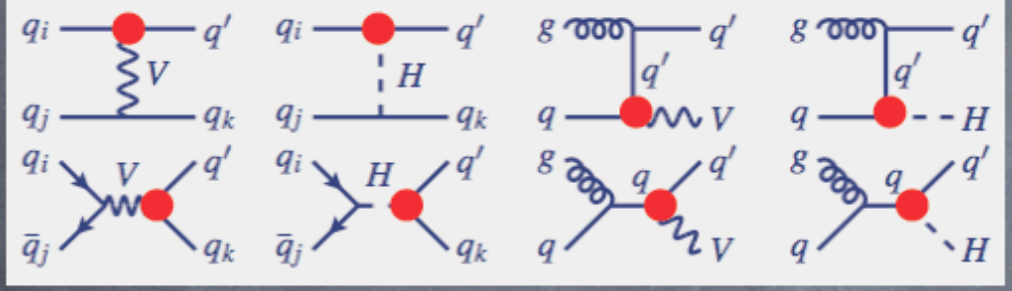
Single production: $pp \to q' + \{q, V, H\}$



Coupling to 1st generation can give large contributions to single-production:

$$\sigma(X\bar{t} + \bar{X}t) = \kappa_X^2 \left(\xi_W \sum_{i=1}^{2} \zeta_i \, (\bar{\sigma}_i^{X\bar{t}} + \bar{\sigma}_i^{\bar{X}t}) \right)$$

1211.5663, 1305:4172

$\bar{\sigma}_{Wi}^{X\bar{t}+\bar{X}t}$	$\bar{\sigma}_{Wi}^{Xj+\bar{X}j}$
3730	98600
127	6490
13.5	-

(in fb)

1305:4172