

Beyond the Standard Model @ CERN

TH Retreat, Holiday Inn Thoiry, Nov. 4 2010

Christophe Grojean

christophe.grojean@cern.ch

on behalf of the BSM group

BSM?

“Everything which is not SM is BSM”, Gia Dvali

Solving the puzzles and riddles posed by the SM is no an easy task.

We have a very poor understanding of most of its parameters.

They parametrize our ignorance of what lies beyond, as well as what we know of the world at low energies

- Origin of mass? Is there a (SM) Higgs?
- Stabilization of the weak scale? Susy? ExtraDim?
- Flavour? Why so many different types of particles? Masses and mixing? CP phases?
- Cosmic connection: Dark Matter, Baryogenesis
- Unification
- Quantum gravity?

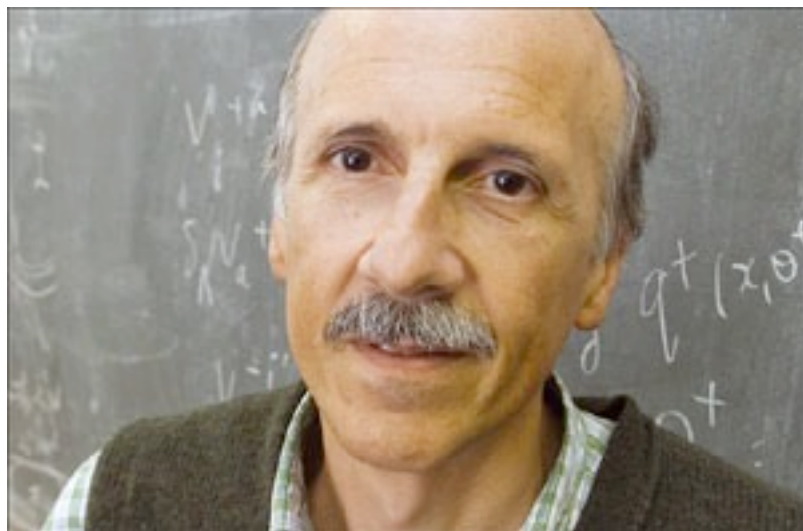
BSM@CERN: the (recent) past

- **Gauge-Higgs unification**: computation of the radiative Higgs potential
Antoniadis, Grojean
- **Composite Higgs**: signatures at the LHC of Little Higgs and Holographic Higgs
Contino, Falkowski, Giudice, Grojean, Rattazzi
- **Higgsless**: construction of a realistic model and how to get a large top mass
Grojean
- **Gauge fields in extra-dimensions**: spectrum and couplings to fermions
Falkowski, Perez-Victoria, Servant
- **Gravity in extra-dimensions**: transplanckian collisions, graviton emission and gravity-loop effects at the LHC
Rattazzi, Sibiryakov, Strumia
- **SUSY phenomenology**: best fits to data
Ellis, Wells
- **Many species phenomenology**: low scale of quantum gravity
Dvali, Redi
- **IR modifications of gravity**: DGP, Horava gravity
Dvali, Redi, Sibiryakov
- **Split susy**: proposal and experimental consequences
Delgado, Giudice, Romanino, Slavich
- **Susy breaking with extra-dimensions**: mediation of susy breaking between hidden and visible sectors
Giudice, Rattazzi
- **New approach to gauge mediation**: variations and models with meta-stability
Antoniadis, Delgado, Giudice, Slavich, Uranga
- **Dark Matter**: susy DM, KK DM and other candidates
Boehm, Boyarsky, Covi, Ellis, Kraml, Servant
- **Electroweak baryogenesis**: baryon asymmetry in non-minimal models
Huber, Konstandin, Servant
- **Leptogenesis**: thermal corrections, implications for neutrino physics, soft leptogenesis
Ibarra, Giudice, Strumia, Lavignac, Raidal, Plumacher, Masina
- **Gravitational waves**: GW produced during the EW phase transition
Grojean, Konstandin, Servant

BSMers: Staff Members



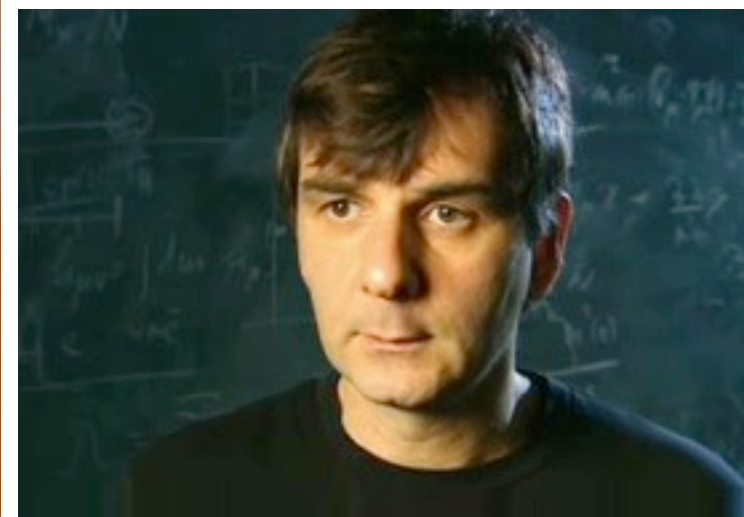
John Ellis



Ignatios Antoniadis



Gian Giudice



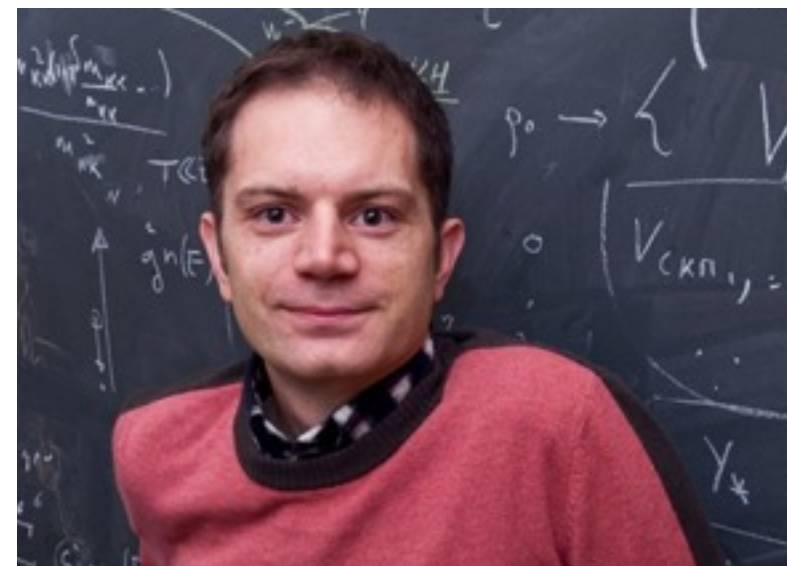
Gia Dvali



James Wells
(on leave)

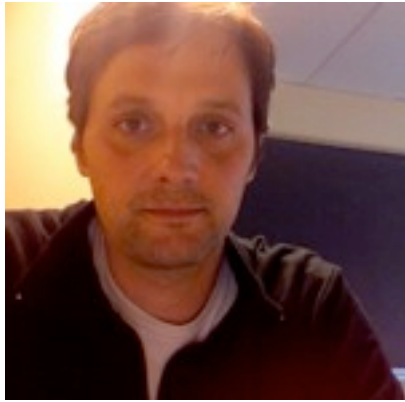


Géraldine Servant



Christophe Grojean

BSMers: Fellows



Andreas Weiler



Filipe Joaquim



Ben Gripaios



Rakhi Mahbubani



Michele Redi



Hyun Min Lee



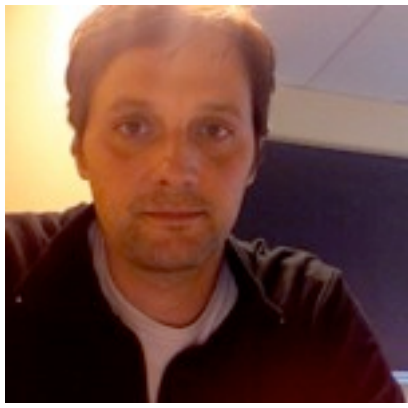
Nazila Mahmoudi



Enrique Fernandez



Oleg Ruchayskyi



Andreas Weiler

CERN: 01/01/09-31/12/11

PhD: '06, TU Munich

Postdoc: Cornell

● Main Interests:

- Theories of the weak scale (susy, strong dynamics, extra dimensions)
- The flavour puzzle
- Direct and indirect searches for new physics at the LHC

● Important Contributions:

- The flavour of the composite pseudo-goldstone Higgs ($\bar{K}-K$ requires $m_p > 10 \text{ TeV}$)
- Natural non-standard Higgs decays ($m_{\text{higgs}} \approx 95 \text{ GeV}$ below LEP bound, $h \rightarrow 4g$ or $4c$)
- A GIM mechanism from extra-dimensions

● Current Projects:

- A solution to the CP problem of partial compositeness/warped flavour w/ M. Redi
- Flavour gauge bosons at the LHC w/ Csaki, Lee, Perez
- Unitarity and the scale of new physics: reexamining the folklore w/ Grojean, Kaminska, Pokorski
- Discrete Susy w/ Bellazzini, Csaki, Grojean
- LHC signatures of TeV scale monopoles w/ Andersen, Grojean, Terning



Ben Gripaios

CERN: 01/09/08-31/08/11

PhD: '04, Oxford

Postdocs: Oxford, EPFL

- **Main Interests:**

- How to discover new physics at LHC? \cancel{E}_T ...
- How to measure its properties? Mass, spin ...
- Models BSM: Strong EWSB, SUSY ...

- **Important Contributions:**

- Transverse observables and mass determination at hadron colliders
- Modified gravity via spontaneous symmetry breaking
- Veneziano-Yankielowicz superpotential terms in $N=1$ SUSY gauge theories
- Anomaly Holography, the Wess-Zumino-Witten Term, and Electroweak Symmetry Breaking.

- **Recent Works:**

- Partially supersymmetric composite Higgs models
- Composite leptoquarks at the LHC
- Beyond the minimal composite Higgs model



Filipe Joaquim

CERN: 01/01/09-31/12/10

PhD: '04, Lisbon

Postdocs: Padova, Madrid

- **Main Interests:**

- SUSY phenomenology
- Neutrino & flavour physics, model building, GUT
- Baryo/Lepto-genesis mechanisms, Dark matter

- **Important Contributions:**

- A New bridge between leptonic CP violation and leptogenesis
- Minimal scenarios for leptogenesis and CP violation
- Leptogenesis, CP violation and neutrino data: What can we learn?

- **Recent Works:**

- A common source for neutrino and sparticle masses
- Beyond the standard seesaw: Neutrino masses from Kahler operators and broken susy
- A_4 -based neutrino masses with Majoron decaying dark matter



Rakhi Mahbubani

CERN: 01/11/09-31/10/11

PhD: '06, Harvard

Postdoc: Fermilab

- **Main Interests:**

- | BSM collider physics
- | Dark Matter
- | Gravity with extra dimensions

- **Important Contributions:**

- | Bounds on the Higgs mass in variations of split supersymmetry
- | The New fat Higgs: Slimmer and more attractive (NMSSM+strong dynamics)
- | Spinless photon dark matter from two universal extra dimensions

- **Recent Works:**

- | Inflation on the Brane with Vanishing Gravity
- | Prospects for top-prime quark discovery at the Tevatron



Michele Redi

CERN: 01/09/09-31/08/11

PhD: '04, Johns Hopkins

Postdocs: NYU, EPFL

● Main Interests:

- Electroweak symmetry breaking & LHC physics
- Applications of AdS/CFT for phenomenology
- Large distance modifications of gravity

● Important Contributions:

- Partially supersymmetric composite Higgs models
- Cascading gravity: Extending the Dvali-Gabadadze-Porrati model to higher dimension
- Black Hole Bound on the Number of Species and Quantum Gravity at LHC
- Supersymmetry breaking by Wilson lines in AdS₅

● Current Projects:

- A solution to the CP problem of partial compositeness/warped flavor w/ A. Weiler
- Non-minimal composite Higgs models w/ Mrázek, Pomarol, Rattazzi, Serra, Wulzer

Other Fellows with BSM interests



Chul Kim

BSM collider physics
soft collinear eff. theory



Marco Cirelli

Dark matter
neutrinos



Thomas Konstandin

GW by cosmological phase transition
CP violation
Baryo/lepto-genesis

?

Matthew Buican

SUSY breaking

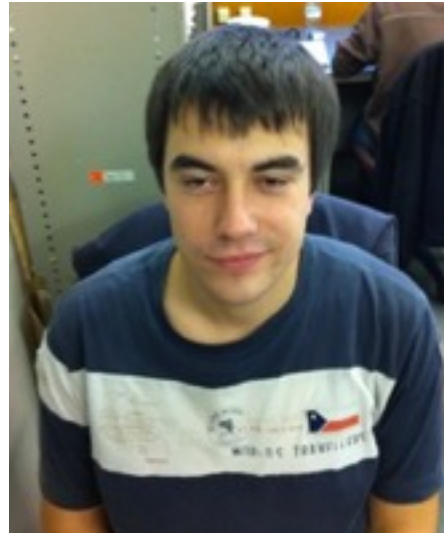
BSMers: Students

Student grants

ERC MassTeV project + UNILHC ITN



Riccardo Torre
CERN+Pisa



Ennio Salvioni
CERN+Padova



Andrea Thamm
CERN+EPFL



Andrei Khmelnitskiy
CERN+INR



Sandeepan Gupta
CERN+Michigan U.

?

Jean-Claude Jacquot
CERN+Bern

BSM Activities

- BSM lunches: Thursdays at 1pm
- BSM forum: Thursdays at 2pm
- TH colloquia: Wednesdays at 2pm
- Particle Physics Phenomenology seminars: Fridays at 2pm
- Workshops, TH Institutes, Conferences...
- ...

You are all invited to join!

My Own Activities

- **In the past**

- | M-theory phenomenology
- | Gravity in extra dimensions
- | Electroweak symmetry breaking in extra dimensions: Higgsless, gauge-Higgs unification
- | Production of gravitational waves during phase transitions

- **Present**

- | Composite Higgs models phenomenology
- | Top physics

- **Future**

- | LHC physics
- | ?

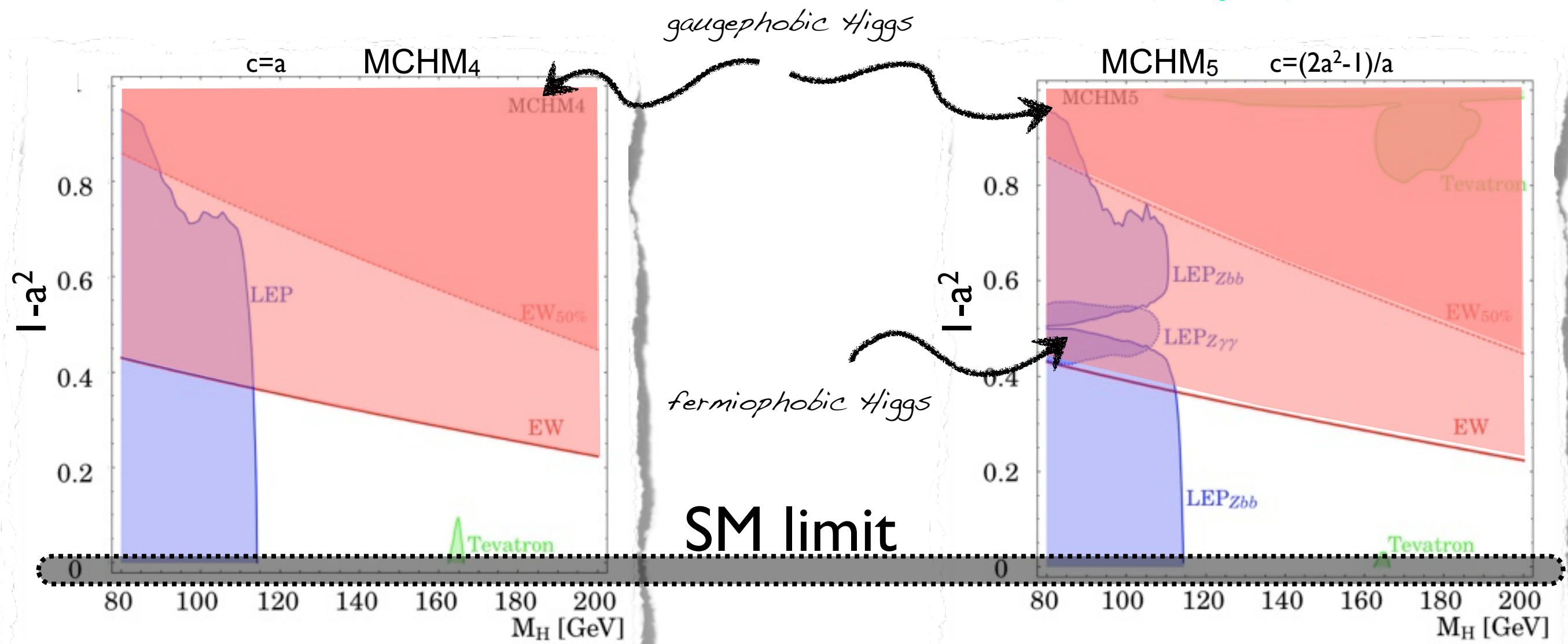
Deformation of the SM Higgs: current constraints

$$\mathcal{L}_{\text{EWSB}} = \frac{v^2}{4} \text{Tr} (D_\mu \Sigma^\dagger D_\mu \Sigma) \left(1 + 2a \frac{h}{v} + b \frac{h^2}{v^2} \right) - \lambda \bar{\psi}_L \Sigma \psi_R \left(1 + c \frac{h}{v} \right)$$

generic 'a', 'b' & 'c'

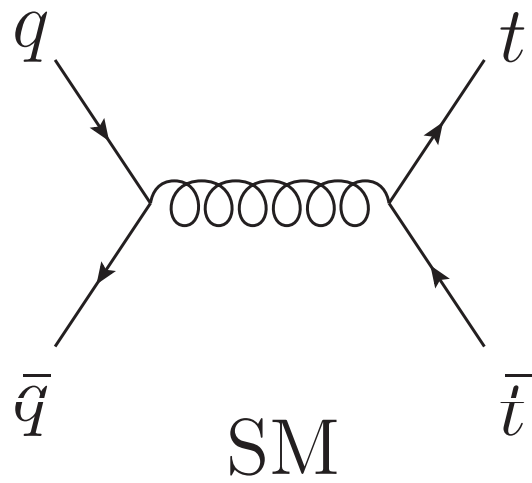
Current EW data constrain only 'a' (and marginally 'c')

Espinosa, Grojean, Muehlleitner '10

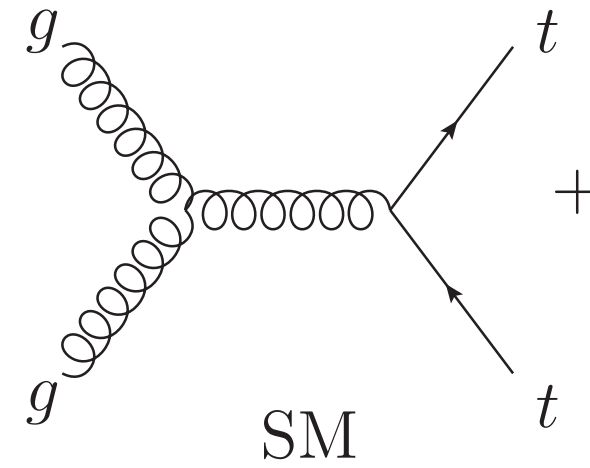


New physics in top pair production

Degrande, Maltoni, Gerard, Grojean, Servant '10



Tevatron: 85%
LHC: 10%



Tevatron: 15%
LHC: 90%

