

Phenomenologic Studies @ the LHC

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Governo da República
Portuguesa



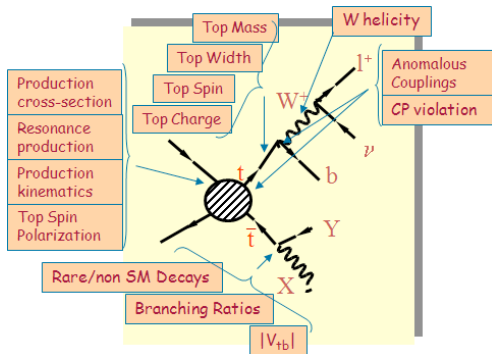
The Team

- Antonio Onofre
- Augusto Barroso
- Francisco del Águila Giménez
- Henrique Carvalho
- João Carvalho (on leave)
- José Santaigo Perez
- Juan Antonio Aguilar-Saavedra
- Marco Sampaio
- Miguel Fiolhais (PhD student)
- Miguel Won (PhD student)
- Mikael Chala (PhD student)
- Nuno Castro
- Pedro Ferreira
- Pittau Roberto
- Renato Júnior
- Rita Monteiro
- Rui Santos



Rich Top quark Phenomenology @ LHC

- $t\bar{t}$ production
 - $\sigma_{t\bar{t}}$
 - Mass
 - Charge
 - W polarization and the $t \rightarrow bW$ decay
 - Anomalous couplings
 - $t\bar{t}$ Spin correlations
 - FCNC
 - $t\bar{t}$ resonances
- Single top production
 - cross section
 - FCNC



1- The Wtb vertex structure and TopFit

Why is it necessary a precise **model-independent** measurement of the Wtb vertex structure?

- It may reveal physics beyond the Standard Model
 - V_{tb} could be different from the Standard Model value
 - Anomalous couplings may appear at the vertex
- It may help understand possible other new physics beyond the Standard Model
 - top quarks decay almost exclusively to $t \rightarrow W^+ b$
 - understanding the structure of the Wtb vertex helps revealing possible non-standard $t\bar{t}$ production at LHC, $Zt\bar{t}/\gamma t\bar{t}$ couplings at ILC, etc.
 - important for B and K physics (indirect limits on anomalous couplings, see later)

The Wtb vertex must be determined by a global fit to several observables:

- Several, theoretically equivalent, observables studied for $t\bar{t}$ production at LHC (not all explored yet @ LHC)
- Single top cross section usefull (sensitive to V_{tb} and anomalous couplings)
- Indirect limits from $b \rightarrow s\gamma$ available (not used)
- All couplings are allowed to vary freely in TopFit to find the allowed regions for a given CL

$t\bar{t}$ Production: Anomalous couplings at the Wtb vertex

General Wtb vertex

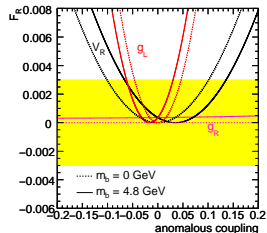
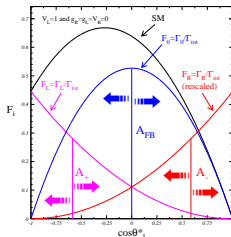
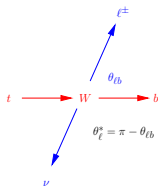
Eur.Phys.J. C50 (2007) 519-533

$$\mathcal{L} = -\frac{g}{\sqrt{2}} \bar{b} \gamma^\mu (V_L P_L + V_R P_R) t W_\mu^- - \frac{g}{\sqrt{2}} \bar{b} \frac{i\sigma^{\mu\nu} q_\nu}{M_W} (g_L P_L + g_R P_R) t W_\mu^-$$

- New **angular asymmetries** and **helicity ratios** were introduced to probe anomalous couplings:

$$A_t = \frac{N(\cos \theta_\ell^* > t) - N(\cos \theta_\ell^* < t)}{N(\cos \theta_\ell^* > t) + N(\cos \theta_\ell^* < t)}$$

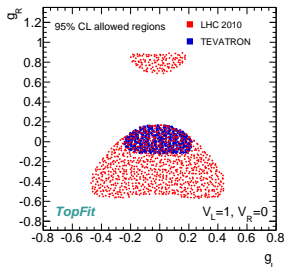
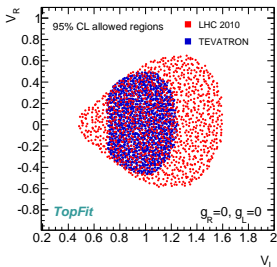
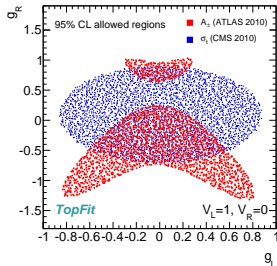
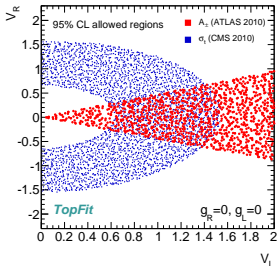
V_R, g_L and g_R
change F_R, F_L and F_0
($\rho_R = F_R/F_0, \rho_L = F_L/F_0$)



(NLO) $A_{FB} = -0.2269$, $A_+ = 0.5429$, $A_- = -0.8402$, $\rho_L = -0.8402$ and $\rho_R = -0.8402$

Constraints on the Wtb vertex from early LHC data

Phys.Rev.D84 019901,2011



2- Monte Carlo Generator: PROTOS (+TRIADA)

The PROTONS generator

PROTONS: PROgram for TOP Simulations

developed and maintained by J.A. Aguilar-Saavedra (jaas@ugr.es)

Available processes in PROTONS in version 2.2

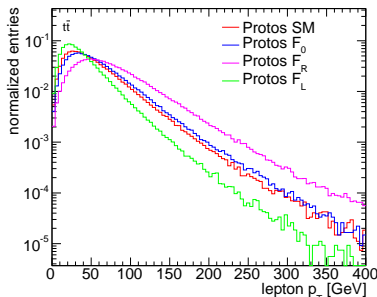
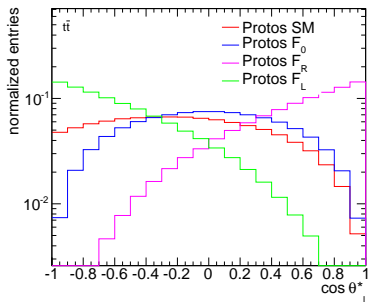
- (Anomalous) Wtb couplings (V_R, g_L, g_R)
 - $t\bar{t}$
 - single top ($tj, t\bar{b}j, t\bar{b}, tW, t\bar{b}W$)
- Top pair production with FCN decays and single FCN top production
 - $t\bar{t} (\rightarrow XqWb, X = Z, \gamma, g, H)$
 - single top ($Zt, \gamma t, Ht, \text{direct}(2 \rightarrow 1)$)
- Top processes with four-fermion effective operators (ex. $uu \rightarrow t\bar{t}$, same sign production)
- Heavy vector-like quark production
- Triada 1.1: a generator for seesaw messengers (heavy neutrinos, Z', W' , etc.)

$t\bar{t}$ templates generation with PROTONS

- PROTONS can be used to build different W polarization templates (changing the values of the anomalous couplings):

	V_L	V_R	g_L	g_R
$F_0 = 1$	1.53205	0	-0.01989	0.714647
$F_L = 1$	0.504619	0.001919	0	1.08275
$F_R = 1$	0.001919	0.504619	1.08275	0

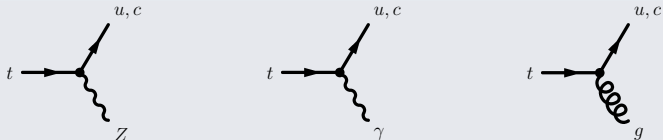
(for $m_t = 172.5$ GeV, $m_W = 80.4$ GeV and $m_b = 4.8$ GeV)



3- Monte Carlo Generator: METop (NLO generator)

Single top production through FCNC

Several top quark FCNC Vertices Studied:



Enhanced Branching Ratios for several models:

BR($t \rightarrow \text{FCNC}$) in several models:

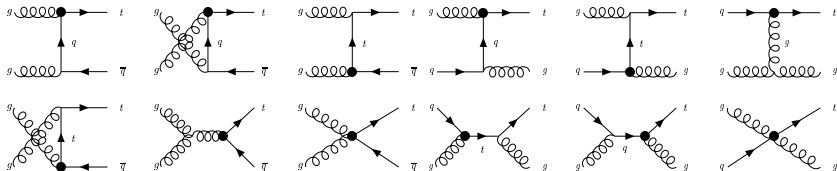
	SM	QS	2HDM	FC 2HDM	MSSM	\mathcal{R} SUSY
$t \rightarrow q\gamma$	$\sim 10^{-14}$	$\sim 10^{-9}$	$\sim 10^{-6}$	$\sim 10^{-9}$	$\sim 10^{-6}$	$\sim 10^{-6}$
$t \rightarrow qZ$	$\sim 10^{-14}$	$\sim 10^{-4}$	$\sim 10^{-7}$	$\sim 10^{-10}$	$\sim 10^{-6}$	$\sim 10^{-5}$
$t \rightarrow qg$	$\sim 10^{-12}$	$\sim 10^{-7}$	$\sim 10^{-4}$	$\sim 10^{-5}$	$\sim 10^{-5}$	$\sim 10^{-4}$

[Acta Phys. Polon. B 35 (2004) 2695]

- Effects of FCNC may manifest at **top quark production** and **decay** and indicates the existence of New Physics beyond the Standard Model

What was the contribution from the project?

- A new NLO generator is now available (METop) to the community and it has been used by the LHC Collaborations
- It includes @ NLO single top + jet production ($g g \rightarrow \bar{q} t + X$, $g q \rightarrow g t + X$)
(many contributions from Strong and EW sectors)



(see Miguel Won's talk on METop)

- **Immediate next steps: "ScannerS" a tool to constrain the Higgs sector parameter phase space (see Marco Sampaio's talk)**
- **(almost) Final thoughts:**
 - The project has been able to establish a good collaboration between Experimentalists and Theorists
 - Several tools have been developed and are available to the LHC community (several others are in the pipeline)
 - Master and PhD students have been trained
- at last but not the least....

Next Top Quark Workshop



TOP 2012
5th International Workshop on Top Quark Physics
September 16-21, 2012
Winchester, U.K.

Home General Programme Participants Posters Proceedings Bulletin Organization TOP2012



Past TOP Conferences

- TOP 2011, Saint Feliu de Guixols, Spain
- TOP 2008, La Biodola, Isola d'Elba, Italy
- TOP 2010, Bruges, Belgium
- TOP 2006, Coimbra, Portugal

NEWS: - First bulletin released
- Call for the organization of TOP2013

<http://pprc.qmul.ac.uk/top2012>
September 16 - 21, 2012
(Winchester, England)
Next Call for 2013:

TOP 2012
5th International Workshop on Top Quark Physics
September 16-21, 2012
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Call for proposal of organization of the next edition of the Workshop TOP2013

The International Advisory Committee has issued a call for the organization of the next edition of the Top Quark Workshop: the 6th International Workshop on Top Quark Physics, TOP2013.

The call is opened until **1st July 2012**. The next edition is expected to take place in September / early October 2013.

For the choice of location, please send proposals suggesting possible venues. A proposal for the Local Organizing Committee would also be appreciated. The review of proposal will be done during summer 2012 and the decision will be taken during TOP2012.

Please take care to send the information to the TOP2012 International Advisory Committee:

Antonio Onofre (Antonio.Onofre@cern.ch)
Roberto Tenchini (Roberto.Tenchini@cern.ch)
Jorgen D Hendri (Jorgen.D.Hendri@cern.ch)
Marlene Boorman (boorman@llnwd.ac.uk)

and/or other members of the IAC