

Phenomenologic Studies @ the LHC

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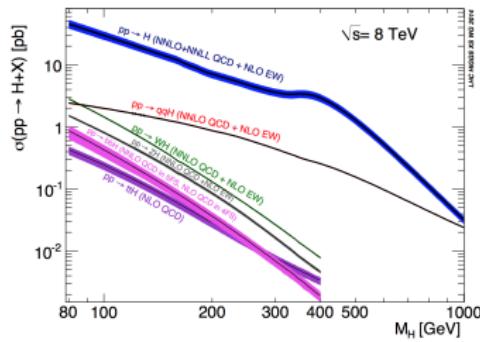
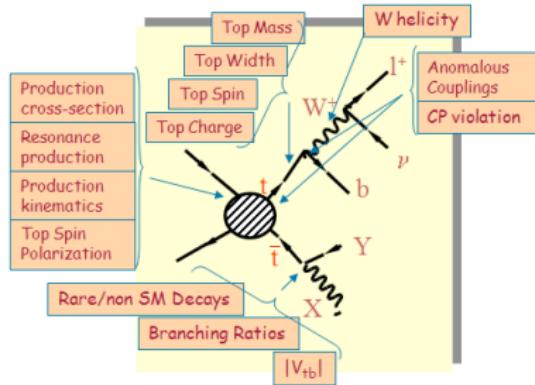


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Top quark and Higgs Phenomenology @ LHC

- $t\bar{t}$ production
 - $\sigma_{t\bar{t}}$
 - Mass
 - Charge
 - W polarization and the $t \rightarrow bW$ decay
 - Anomalous couplings
 - $t\bar{t}$ Spin correlations
 - $t\bar{t}$ resonances
- Single top production
 - Cross section
 - FCNC
- Higgs physics
 - $t\bar{t}H$
 - $pp \rightarrow H + X$



The Wtb vertex is 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 useful (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, i.e. the global fitter developed by the team to find the allowed regions for the anomalous couplings for a given wanted CL

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

General Wtb vertex

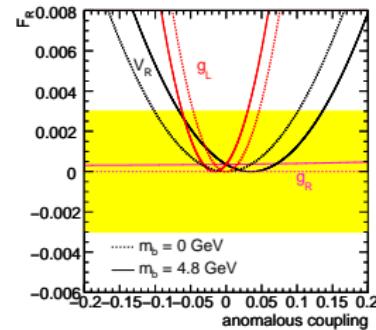
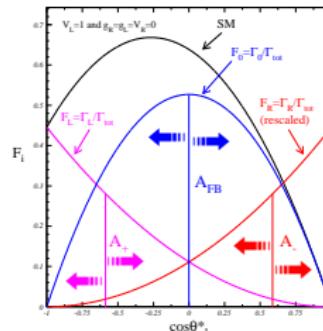
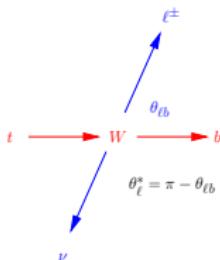
Eur.Phys.J. C50 (2007) 519-533

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

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

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

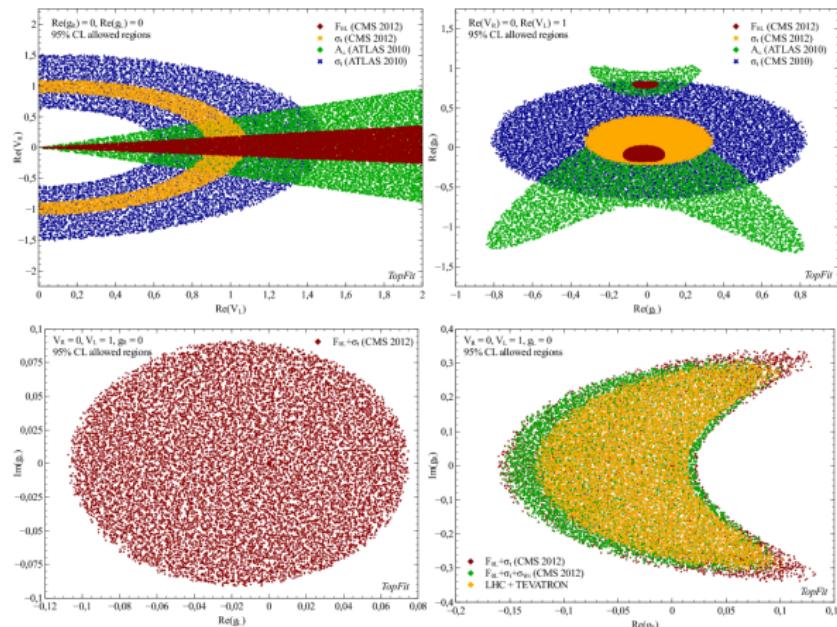
V_R, g_L and g_R
change F_R, F_L and F_0
($\rho_R = F_R/F_0$, $\rho_L = F_L/F_0$)



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

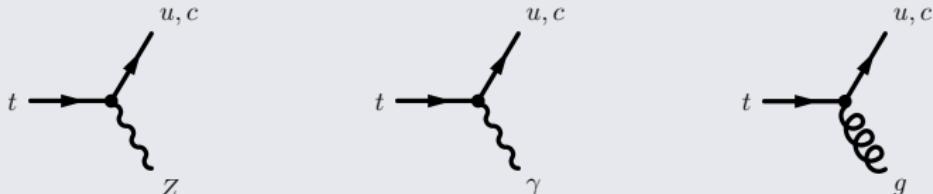
Constraints from LHC and Tevatron data

Phys.Rev. D90 (2014) 11, 113007



(anomalous couplings with both real and imaginary parts)

Several top quark FCNC Vertices Studied:



Enhanced Branching Ratios for several models:

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

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

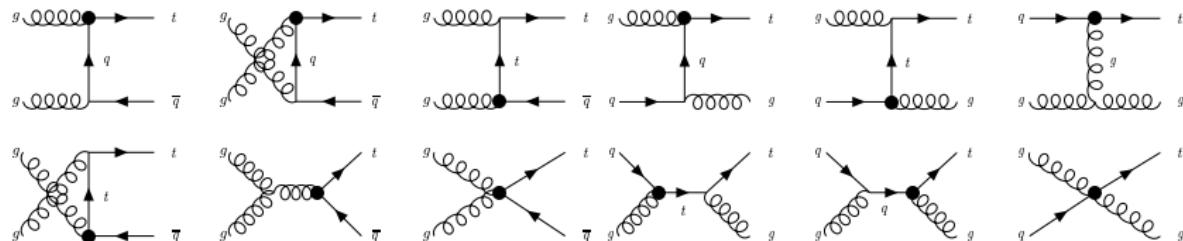
[Acta Phys. Polon. B 35 (2004) 2695]

- 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)



- Eur.Phys.J. C72 (2012) 2222



2-NLO Monte Carlo Generator MEtop

The screenshot shows a website for the DESY ATLAS Group. The header features the ATLAS Experiment logo, a photograph of the ATLAS detector, and the text "DESY ATLAS Group". The navigation menu includes links for Home, Activities, YIG, Job/Thesis Offer, Theses (which is the active page), Links, Members, and Contact. On the left, there's a sidebar with an "ATLAS" button. The main content area displays a list of PhD theses. One thesis from November 2014 is highlighted with a red border.

Date	Name	Title	Link
January 2105	Elena Yatsenko	„Measurement of Neutral Current Drell-Yan production using ATLAS data collected at $\sqrt{s}=8$ TeV”	
November 2014	Conrad Friedrich	Search for single top-quark production via flavour-changing neutral currents in strong interactions using $\sqrt{s} = 8$ TeV ATLAS data	
Juni 2014	Luz Gomez	A search for massive resonances decaying to top quark pairs and jet trigger performance studies with the ATLAS detector at the Large Hadron Collider	File

3-Higgs Physics

29 Mar 2015

Angular distributions in $t\bar{t}H(H \rightarrow b\bar{b})$ reconstructed events at the LHC

S.P. Amor dos Santos¹, J.P. Araque², R. Cantrill³, N.F. Castro^{2,9}, M.C.N. Fiolhais^{1,4}, R. Frederix⁵, R. Gonçalo³, R. Martins², R. Santos^{7,8}, J. Silva⁶, A. Onofre², H. Peixoto⁶, A. Reigoto²

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The associated production of a Higgs boson and a top-quark pair, $t\bar{t}H$, in proton-proton collisions is addressed in this paper for a center of mass energy of 13 TeV at the LHC. Dileptonic final states of $t\bar{t}H$ events with two oppositely charged leptons and four jets from the decays $t \rightarrow bW^+ \rightarrow b\ell^+\nu_\ell$, $\bar{t} \rightarrow \bar{b}W^- \rightarrow \bar{b}\ell^-\bar{\nu}_\ell$ and $h \rightarrow b\bar{b}$, are used. Signal events, generated with MadGraph5_aMC@NLO, are fully reconstructed by applying a kinematic fit. New angular distributions of the decay products as well as angular asymmetries are explored in order to improve discrimination of $t\bar{t}H$ signal events over the dominant irreducible background contribution, $t\bar{t}b\bar{b}$. Even after the full kinematic fit reconstruction of the events, the proposed angular distributions and asymmetries are still quite different in the $t\bar{t}H$ signal and the dominant background ($t\bar{t}b\bar{b}$).

I. INTRODUCTION

taminated by a huge background coming mainly from $nn \rightarrow t\bar{t} + \text{jets}$. For this particular production process

• arXiv:1503.07787, subm. to JHEP

3-Higgs Physics

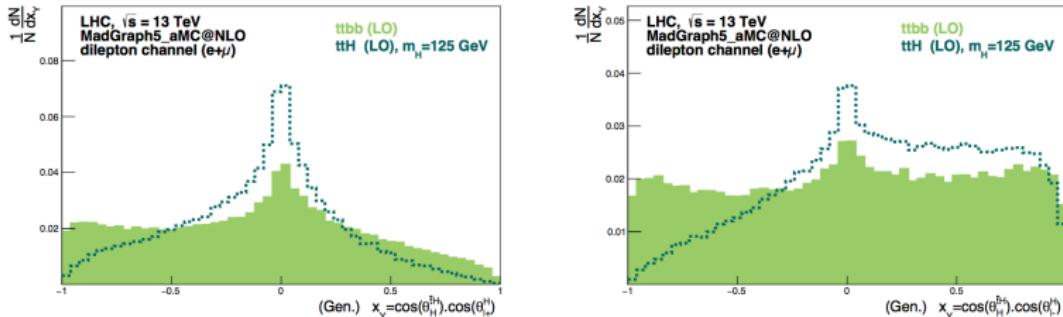
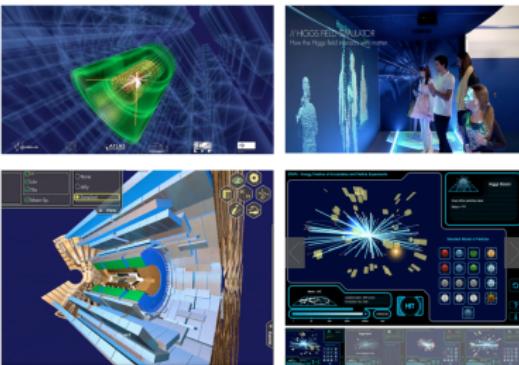
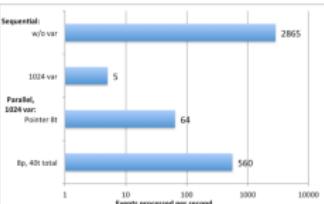
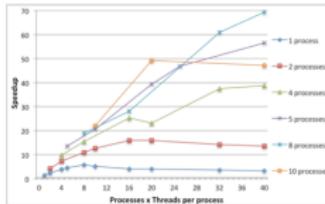
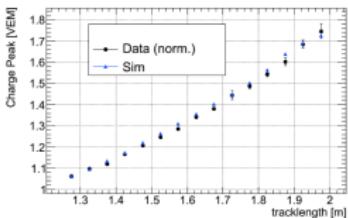
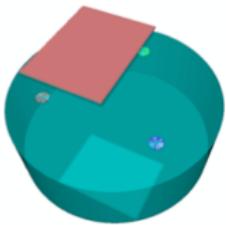


FIG. 6. Generated product of the cosine of the angle between the Higgs momentum direction (in the $t\bar{H}$ centre-of-mass) with respect to the $t\bar{H}$ direction (in the $t\bar{t}H$ system), and the cosine of the angle of the ℓ^+ (left) and ℓ^- (right) momentum (in the Higgs centre-of-mass system) with respect to the Higgs direction (in the $t\bar{H}$ system).

- arXiv:1503.07787, subm. to JHEP

- **Immediate next steps: focus on global fitters for top quark and Higgs physics (angular distributions)**
- **(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)
 - Undergraduate, Master and PhD students have been trained
- at last but not the least....



Universidade do Minho

Relatório de Actividades do LIP-Minho 1 de Janeiro a 31 de Dezembro de 2014

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