Search for Flavour Changing Neutral Currents in Top Quark Decays in ATLAS

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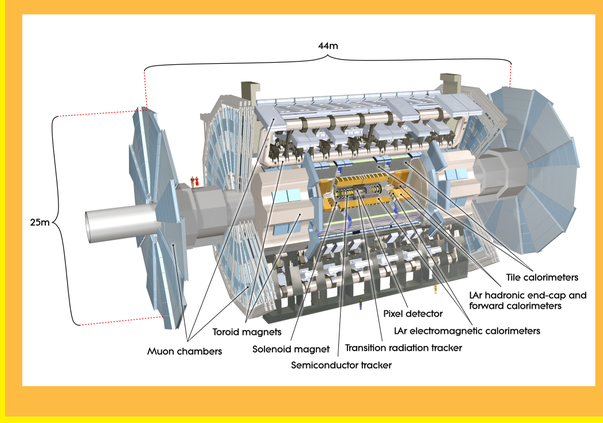
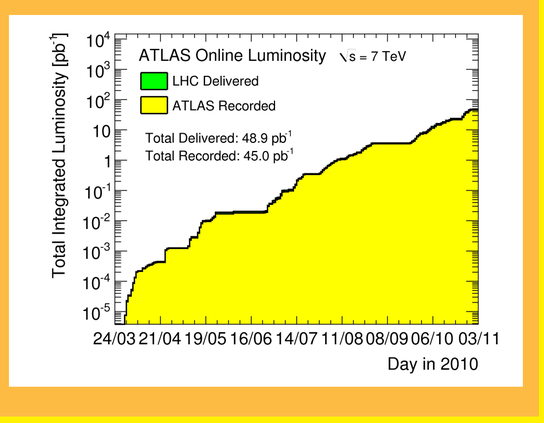
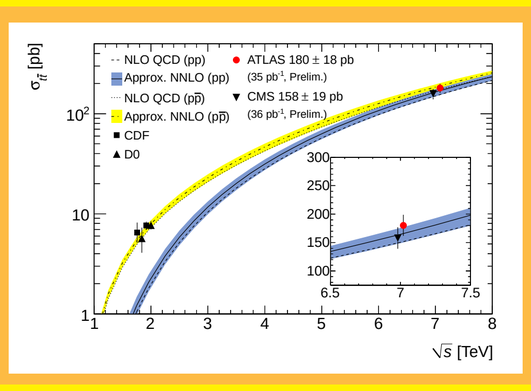
The first ATLAS results on the search for flavour changing neutral current (FCNC) processes involving the top quark are presented. Data collected at a centre-of-mass energy $\sqrt{s} = 7$ TeV during 2010 and corresponding to an integrated luminosity of 35 pb^{-1} are used. The $t \to qZ$ decay channel is searched for by looking for top quark pair production with one top quark decaying through FCNC ($t \to qZ$) and the other through the Standard Model dominant mode ($t \to bW$). Only the leptonic decays of the Z and W bosons were considered ($Z \to e^+e^-, \mu^+\mu^-$ and $W \to e\nu, \mu\nu$) as signal. An upper limit is set on the $t \to qZ$ branching fraction.

The ATLAS detector



Data collected in 2010





The LHC is a top factory, allowing to test rare decays of the top quark with high precision

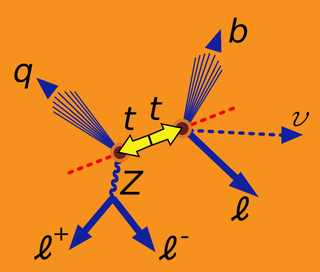
Theoretical predictions for the BR of FCNC top quark decays

Process	SM	QS	2HDM	FC 2HDM	MSSM	$\not R$ SUSY	TC2
$t \to u\gamma$	3.7×10^{-16}	7.5×10^{-9}	—	—	2×10^{-6}	1×10^{-6}	—
$t \to uZ$	8×10^{-17}	1.1×10^{-4}	—	—	2×10^{-6}	3×10^{-5}	—
$t \to ug$	3.7×10^{-14}	1.5×10^{-7}	—	—	8×10^{-5}	2×10^{-4}	—
$t \to c\gamma$	4.6×10^{-14}	7.5×10^{-9}	$\sim 10^{-6}$	$\sim 10^{-9}$	2×10^{-6}	1×10^{-6}	$\sim 10^{-6}$
$t \to cZ$	1×10^{-14}	1.1×10^{-4}	$\sim 10^{-7}$	$\sim 10^{-10}$	2×10^{-6}	3×10^{-5}	$\sim 10^{-4}$
$t \to cg$	4.6×10^{-12}	1.5×10^{-7}	$\sim 10^{-4}$	$\sim 10^{-8}$	8×10^{-5}	2×10^{-4}	$\sim 10^{-4}$

Limits from other experiments

	LEP	HERA	Tevatron
$BR(t \to q\gamma)$	2.4%	0.64%	3.2%
$BR(t \to qZ)$	7.8%	49%	3.2%
$BR(t \to qg)$	17%	13%	2.0×10^{-4} (tug), 3.9×10^{-3} (tcg)

$t\bar{t} \to bWqZ \to b\ell\nu q\ell\ell$ topology



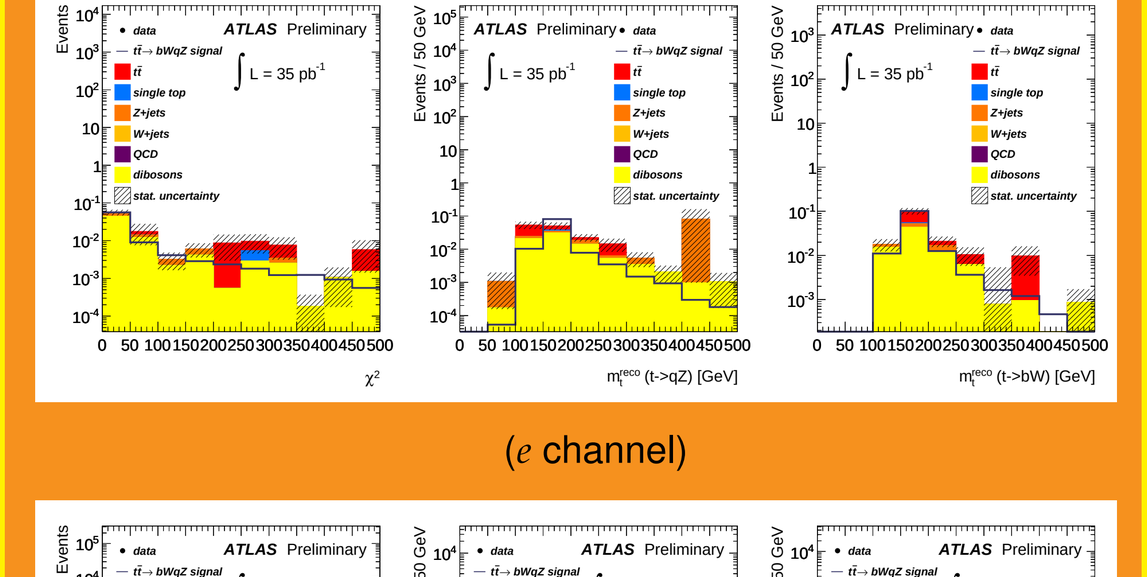
- Preselection: single lepton trigger (e or μ)
  ≥ 2 isolated leptons, same flavour and opp. charges ($p_T > 25, 20$ GeV)
  ≥ 2 central jets
  $\not{E}_T > 20$ GeV
  γ veto ($p_T > 15$ GeV)
- Final selection: 3rd lepton ($p_T > 15$ GeV)

Selection	Preselection		Final selection	
Channel	e	μ	e	μ
W+j, dibosons, single t	3.16 ± 0.11	4.95 ± 0.12	0.08 ± 0.08	0.11 ± 0.08
Z+j	124 ± 3	197 ± 4	0.10 ± 0.08	0.02 ± 0.01
$t\bar{t}$	16.7 ± 0.3	26.2 ± 0.4	0.05 ± 0.02	0.04 ± 0.02
Expected background	144 ± 3	232 ± 5	0.23 ± 0.11	0.17 ± 0.08
Data	125	204	0	1
Signal Efficiency	$(16.30 \pm 0.13)\%$	$(21.66 \pm 0.15)\%$	$(8.53 \pm 0.09)\%$	$(11.96 \pm 0.11)\%$

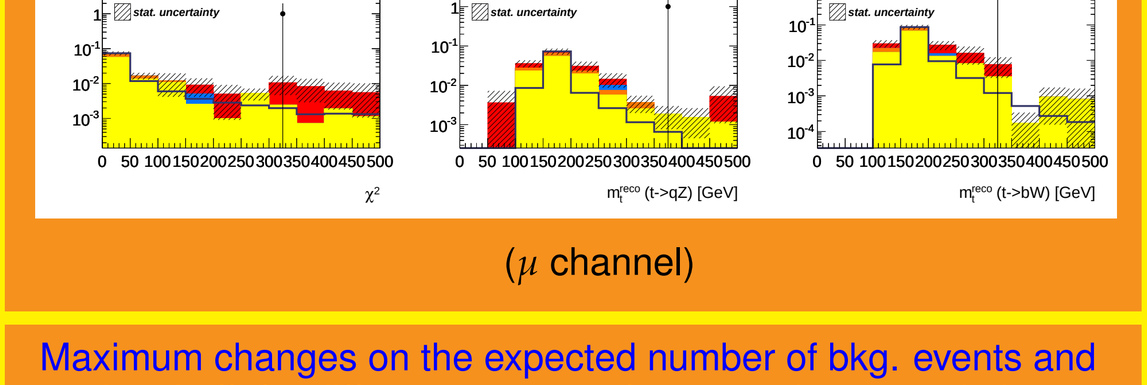
- the choice for the jet and lepton combination together with the determination of the undetected neutrino p_z is done by minimizing

$$\chi^2 = \frac{\left(m^{\text{reco}}_{ja\ell a\ell b} - m_t\right)^2}{\sigma_t^2} + \frac{\left(m^{\text{reco}}_{jb\ell c\nu} - m_t\right)^2}{\sigma_t^2} + \frac{\left(m^{\text{reco}}_{\ell c\nu} - m_W\right)^2}{\sigma_W^2} + \frac{\left(m^{\text{reco}}_{\ell a\ell b} - m_Z\right)^2}{\sigma_Z^2}$$

Distributions after the event selection



(e channel)



(μ channel)

Maximum changes on the expected number of bkg. events and signal eff. for different sources of systematic uncertainties

Source	e		μ	
	Background	Signal	Background	Signal
Jet energy scale	13%	2%	10%	2%
Jet reco. efficiency	2%	2%	2%	2%
Jet energy resolution	2%	<1%	3%	<1%
Electron trigger	2%	1%	<1%	<1%
Electron reco. efficiency	5%	2%	1%	1%
Electron identification	10%	5%	3%	1%
Electron energy scale	2%	<1%	1%	<1%
Electron energy resolution	<1%	<1%	1%	<1%
Muon trigger	2%	<1%	3%	1%
Muon reconstruction and identification	1%	<1%	1%	1%
Muon momentum scale	1%	<1%	1%	<1%
Muon momentum resolution	2%	<1%	1%	<1%
Pile-up	8%	1%	6%	1%
PDF	2%	2%	2%	2%
ISR/FSR	34%	3%	47%	3%
Top quark mass	9%	1%	3%	1%
$t\bar{t}$ cross-section	2%	—	2%	—
SM $t\bar{t}$ generator	10%	—	25%	—
SM $t\bar{t}$ fragmentation	26%	—	26%	—
Z+jets cross-section	25%	—	25%	—
Diboson cross-sections	2%	—	3%	—

95% CL upper limits on $BR(t \to qZ)$

	observed	expected	$[-1\sigma, +1\sigma]$
without systematics	16%	11%	[8%,15%]
with systematics	**17%**	**12%**	[9%,16%]

(CL_S method used; "expected" is the expected limit in the absence of a signal)

significant improvement expected with 2011 data!

References:
- https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TopPublicResults
- https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2011-061

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