

Top quark pair to dilepton cross-section using template fits to jet inclusive dilepton data in ATLAS

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Outline

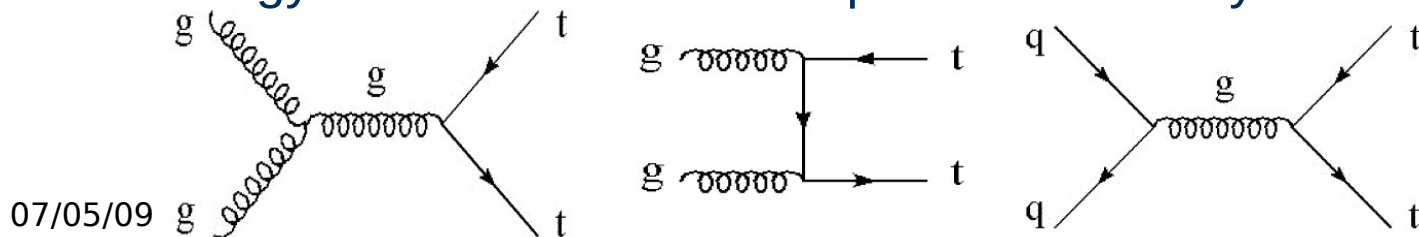
- Introduction
- Top pair production and decay
- Analysis overview
- Event and object selection
- Cutflow and sample composition
- Systematic uncertainties

Introduction

- Goal:
 - Measure the $t\bar{t}$ pair production cross-section in the dilepton channel using early data
 - Lepton channels are ee , $\mu\mu$ and $e\mu$
 - Avoid strong dependence on precise jet energy scale (JES) determination
 - Using a method not sensitive to the absolute normalization of the dominant backgrounds
- This analysis was described in the Atlas CSC note
 - 14TeV was assumed for LHC, now 10TeV is expected for early data, reducing the cross-section about a factor 2
 - An integrated luminosity of 100pb^{-1}
 - CERN-OPEN-2008-020

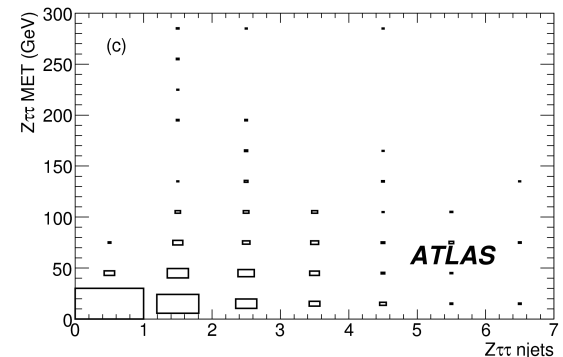
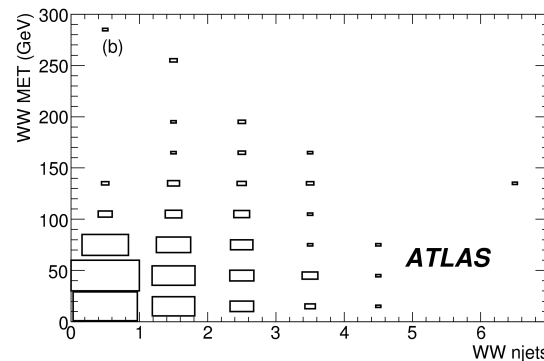
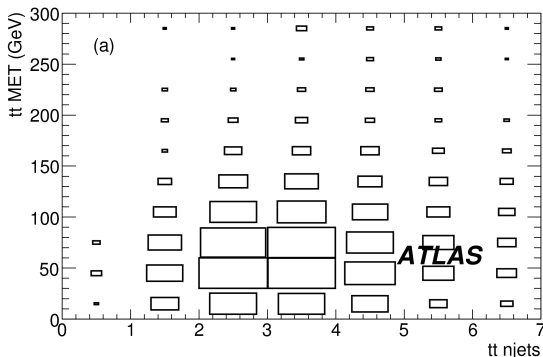
Top pair production and decay

- Top pairs produced both in gluon-gluon and quark-antiquark scatterings (see figure)
 - The NLO cross-section used is $833 \pm 100 \text{ pb}$
 - Amounts to $\sim 83\text{k}$ pairs (for 100 pb^{-1})
- The decays of the Ws determine the event signature
 - Assuming top always decays to Wb
 - Fully hadronic (4/9), semi leptonic (4/9) or fully leptonic (1/9)
- The fully leptonic or di-lepton final state allows for an analysis with small dependence on the JES
 - The analysis will on the other hand be dependent on the lepton energy scale as well as the lepton ID efficiency



Analysis overview

- The method is based on template fits
 - Di-lepton events passing the cuts generate 2D histograms of Et-miss vs #jets in the three channels ee, $\mu\mu$ and $e\mu$
 - The processes $t\bar{t}$, WW and $Z\tau\tau$ to di-leptons have different shapes for their distributions (shown for $e\mu$)
 - WW and $Z\tau\tau$ are the two biggest background contributions
 - Shape templates for the signal are generated from MC



Analysis overview (contd.)

- Shape templates and scale for EWK background taken from MC
 - Contains single top, WZ and ZZ
 - Zee and $Z\mu\mu$ are either considered as EWK or fake background (for $e\mu$)
- Templates for *fake leptons* calculated from data
 - The method uses a per object fake rate
- Signal cross-sections are calculated by fitting templates to data using a binned likelihood fit
 - The acceptance is a constrained parameter in the fit
- Lepton trigger and reconstruction efficiencies measured using tag and probe
 - di-lepton events in a control region where the invariant mass of the leptons is compatible with Z

Event and object selections

- Event selection
 - Events triggered by one or two leptons
 - Combined efficiencies: $e\mu$ 97%, ee 98%, $\mu\mu$ 96%
 - Two oppositely charged leptons
 - ee and $\mu\mu$: $E_{t\text{-miss}} > 35$ (GeV) and not in Z window
- Lepton selection
 - Isolation 6 (GeV) in a 0.2 cone
 - p_T or $ET > 20$ (GeV)
 - A Muon is best match between inner and muon tracks
 - For electrons, apply a “tight” quality criteria to the leading and “medium” to the next leading
 - Expected performance
 - Tight: efficiency 61.7%, jet rejection $8.9e4$
 - Medium: efficiency 77.3%, jet rejection $2.2e3$

Event and object selections (contd.)

- Remove muons overlapping with a jet and a jet overlapping with an electron
 - Jet $ET > 20$ (GeV)
- All objects must be in a fiducial region
 - $\eta < 2.5$
 - Exclude regions with gaps in the calorimeter or without muon chamber coverage

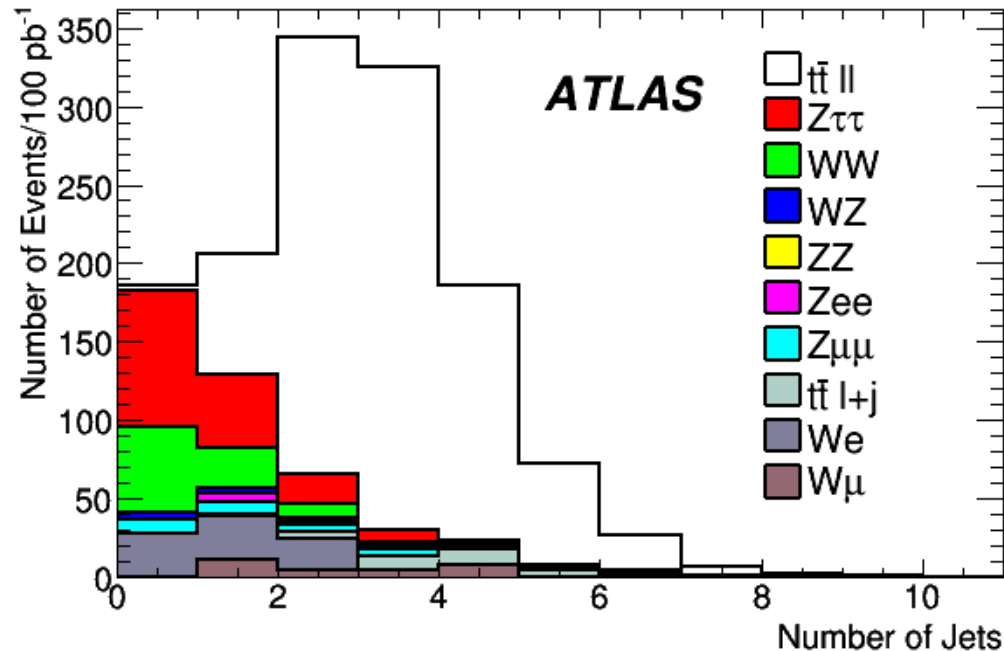
Cutflow

- The table shows the estimated number of events
 - After requiring two opposite sign leptons
 - After all applied quality cuts, Z veto and trigger

	Sample	2l & op.sign			Full sel. & trigg		
		$e\mu$	ee	$\mu\mu$	$e\mu$	ee	$\mu\mu$
Signal	ttbar	700	312	380	516	213	178
	WW	76	32	44	57	17	19
	$Z \rightarrow \tau\tau$	249	101	159	151	10	2
EWK/fake	$Z \rightarrow ee$	5	37418	0	3	9	0
	$Z \rightarrow \mu\mu$	153	0	51139	9	0	18
EWK	WZ	7	34	44	5	3	2
	ZZ	1	24	30	1	1	1
	single top	5	3	2	3	1	1
Fake	$W \rightarrow e\nu$	42	69	0	35	28	0
	$W \rightarrow \mu\nu$	152	0	40	11	0	11
	ttbar (semi)	30	20	7	12	11	2

Sample composition

- The figure shows the signal contribution from the most significant sources, versus number of jets



Systematic uncertainties

- Enter in two ways
 - Two lepton acceptance
 - Shape of 2D templates
- Impact on observables (cross-sections) calculated by introducing shifts in the model and then running the full analysis
 - For JES, the jet energies and $E_{t\text{-miss}}$ are simply scaled
- The fake rate uncertainty is assumed to be 50% in CSC, but the method is designed to handle 100%

Systematic uncertainties (contd.)

- The table below shows the impact of the systematics
 - All three di-lepton channels are combined
 - Last column is the uncertainty due to changes in the template shape

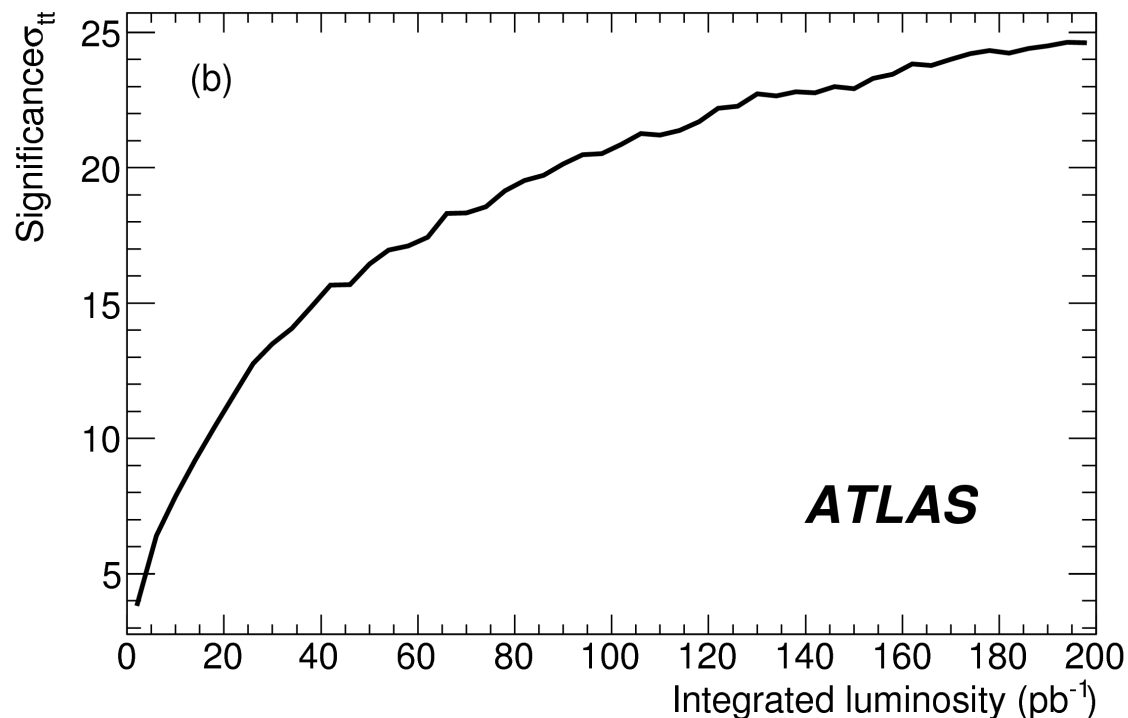
Source	Shift	Acceptance $\Delta\sigma/\sigma$	Shape $\Delta\sigma/\sigma$
JES	$\pm 5\%$	-	$\pm 2\%$
PDF	-	$\pm 2\%$	-
ISR/FSR	-50%+100%	$\pm 2\%$	$\pm 2\%$

- The combined uncertainty becomes

$$\Delta\sigma/\sigma = 4(stat) \pm 4(syst) \pm 2(PDF) \pm 5(lumi)\%$$

Significance

- Significance for all three channels ($e\mu$, ee and $\mu\mu$)
 - Estimated in pseudo experiments
 - Includes all systematic uncertainties



Summary and plans

- The analysis can be looked upon as a hypothesis test of the standard model
 - Can be applied to early data
 - The cross-section for the dominant backgrounds are measured and not taken from MC
 - Lepton fakes are estimated from data
 - Reduced dependency on precise JES
- Plans for the near future includes:
 - Fake lepton estimation procedure
 - The reco. algorithms are constantly evolving, our procedure must make use of the latest tools available
 - Estimation of systematic uncertainties
 - Many of our required analysis tools are already in place but fairly extensive MC generation is needed