Towards Measurement of the Top Quark Cross Section on ATLAS

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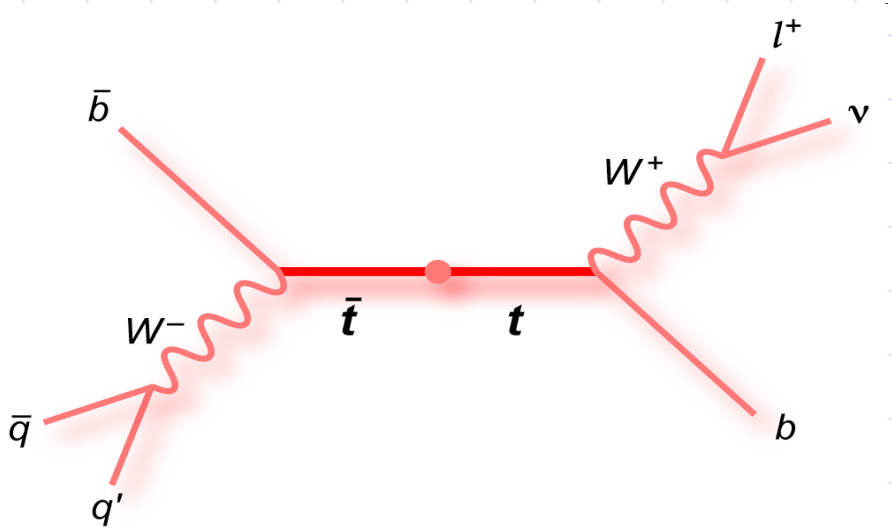
Motivation

- ATLAS is currently re-discovering the Standard Model (*W*, *Z*, …), including *top*, at the LHC
  - Measurement of the production cross-section is compared to theoretical predictions (table below).
  - Eventually the LHC will become a *top* factory and *top* will be used to search for new physics (e.g. *Tt* resonances).
  - Top is a background for many new physics searches as well (Supersymmetry, Higgs, …).

Energy (TeV)	Theory (pb)	Data (pb)
1.96 (Fermilab)	6.6 ± 0.6	8.2 ± 0.9
7 (CERN)	148.50	?
14 (CERN)	827.70	?

Towards *Top* Rediscovery

- We want to measure the *Tt* cross-section in the lepton plus jets decay channel
  - This channel has a branching ratio of 30% (*e* and μ)
  - The experimental signature is one high p_t lepton, four high p_t jets, and large missing transverse energy (MET)
    - Two of the four jets are *b-quark* jets

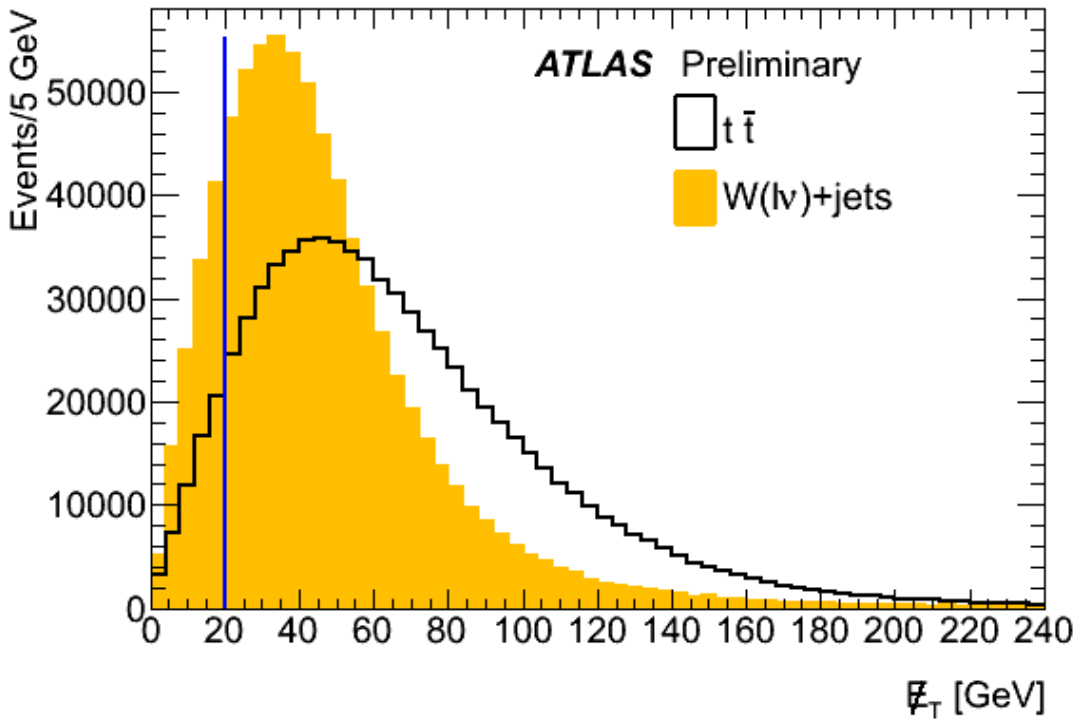


Selection Criteria

- Leptons
  - One *e* or one μ with *pt* > 20 GeV
- Jets
  - At least four jets with pt > 25 GeV and $|\eta| < 2.5$
- *b*-jets
  - At least one jet tagged as a *b*-jet using secondary vertices
- Missing transverse energy
  - MET > 20 GeV and (MET + W transverse mass) > 60 *GeV*
- Other criteria
  - Remove bad jets, ensure good primary vertex, etc.
- Overall efficiency for *top* is approximately 6.3% (9.4%) with (without) *b*-tag requirement

MET Cut

- One of the main backgrounds to *Tt* production is *W*+jets production



Expectations for 2.9 pb^{-1}

Electron + Jets Channel

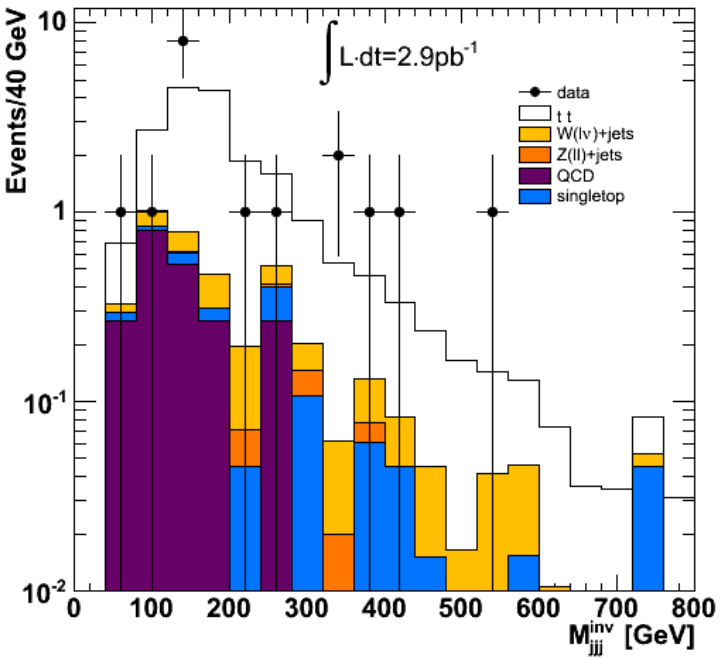
	No b-jet cut	> 0 b-jet tag
Tt	20.5	15
W+jet	15.1	1.1
Z+jet	1.2	0.1
QCD (Data)	23.3	2.1
Single Top	0.6	0.1
Total	60.7	18.4
Data	56	17

Muon + Jets Channel

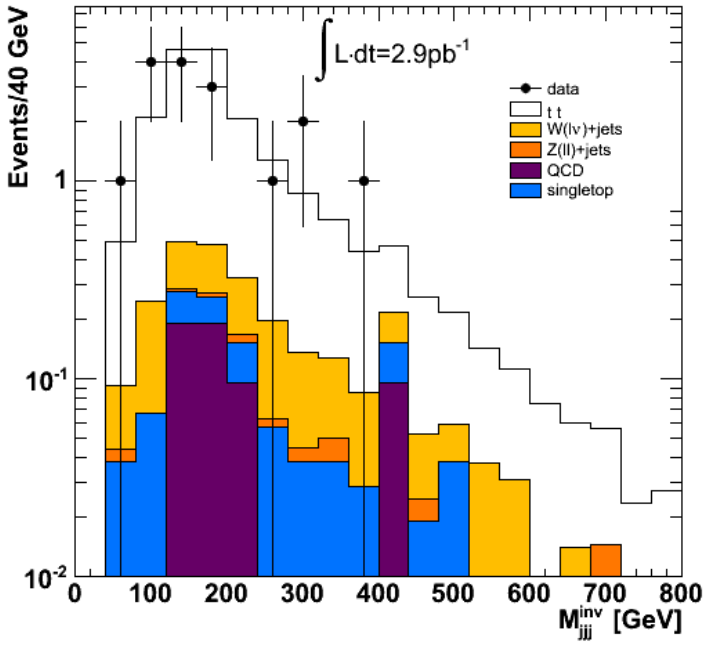
	No b-jet cut	> 0 b-jet tag
Tt	19.7	14.4
W+jet	15.4	1.3
Z+jet	0.7	0.1
QCD (Data)	1.1	0.6
Single Top	0.6	0.2
Total	37.5	22
Data	44	16

Data versus Monte Carlo Comparison with b-tag

Electron + jets channel

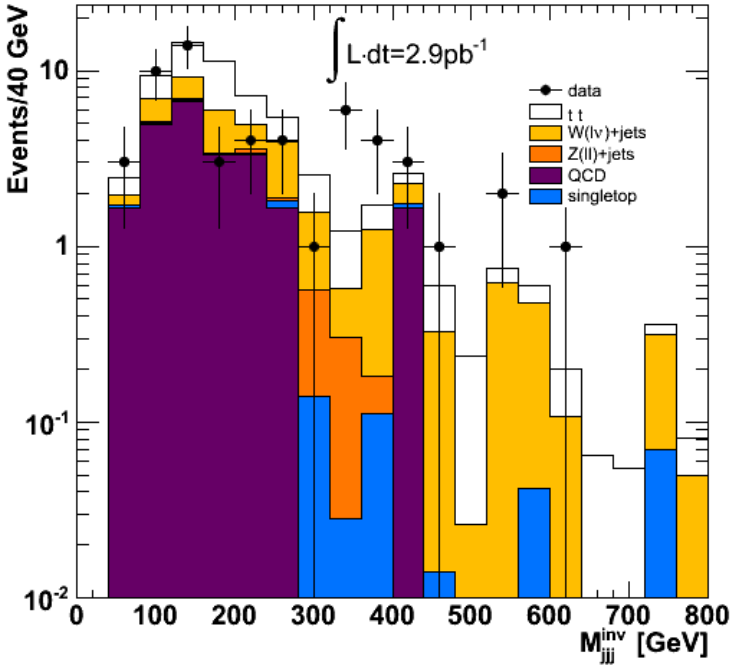


Muon + jets channel

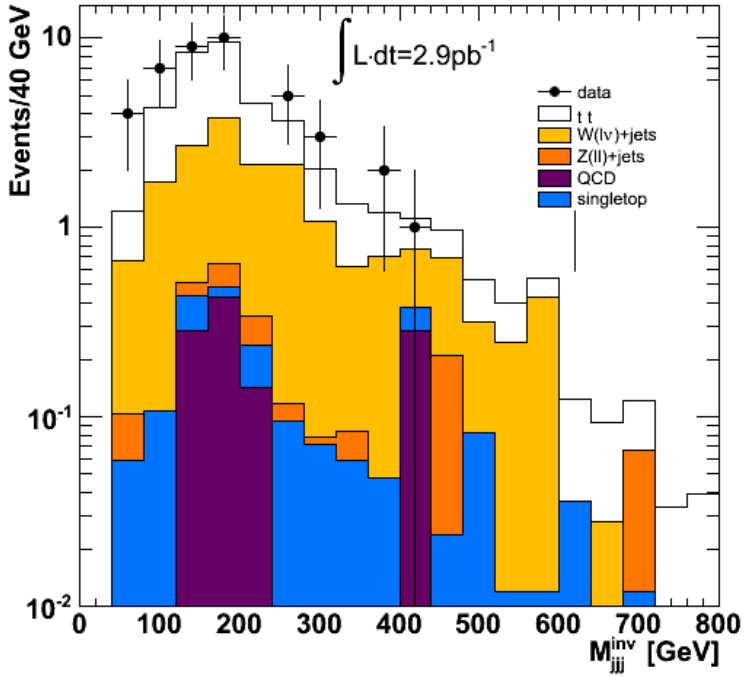


Data versus Monte Carlo Comparison without b-tag

Electron + jets channel



Muon + jets channel



Extracting the Tt Cross Section

$$\sigma_{\bar{t}t} = \frac{N_{\bar{t}t}}{\varepsilon \cdot Br \cdot \int Ldt}$$

- A number of different methods can be used to extract the *Tt* Cross Section
  - Counting
  - Fit to top mass distribution
  - Topological likelihood
- For now, we will estimate some of the largest systematic errors for the counting method

Systematic Errors

-	Electron+jets		Muon+jets	
Source	No b-tag %	> 0 b-tag %	No b-tag %	> 0 b-tag %
Jet Energy Scale	+10.6 -11.1	+7.7 -9.1	+8.7 -11.5	+4.3 -5.2
ISR	+10.6 -5.3	+11.2 -3.8	+6.0 -5.7	+5.7 -4.6
FSR	+6.7 -5.3	+7.6 -6.7	+5.1 -9.3	+6.1 -10.5
MC signal	±3.4	± 4.5	± 2.6	± 3.5

Some of the other significant systematic errors are:

Luminosity, Monte Carlo background, *b*-tagging…

Conclusions

- We presented criteria to select *Tt* production in the lepton plus jets decay channel
- We presented estimates for *Tt* and major background processes for 2.9 pb^{-1}
  - To date, ATLAS has collected 20 pb^{-1}
- We showed agreement between data and Monte Carlo expectations
- We hope to make a first measurement of the *Tt* cross section at 7 TeV in the near future

Backup slides

Status of LHC and ATLAS

- LHC
  - Currently running at 7 TeV
  - Has delivered 20 pb-1 to ATLAS and 1 fb-1 is expected by the end of 2011
  - Peak luminosity now at 7e31 /cm2/s
- ATLAS
  - All detector subsystems are operational with > 98% operational fraction

QCD from data

by-event for the loose and tight samples and summing over the weights:

$$N^{QCD} = \sum_{i=1}^{N_l - N_t} w^i_{l-t} + \sum_{j=1}^{N_t} w^j_t$$

where

$$w_{l-t} = \frac{\epsilon_{fake} * \epsilon_{real}}{\epsilon_{real} - \epsilon_{fake}}$$

$$w_t = \frac{\epsilon_{fake} * (\epsilon_{real} - 1.)}{\epsilon_{real} - \epsilon_{fake}}$$

The ϵ_{real} and ϵ_{fake} in the weight expressions above are the efficiencies of the loose to tight selection cuts, for the signal and the QCD background respectively.

QCD Background

- Tight = all selection criteria
- Loose = all selection criteria with one relaxed which admits more QCD background

$$N_{loose} = N_{tt+Wjets} + N_{QCD}$$

$$N_{tight} = \varepsilon_{tt+Wjets} N_{tt+Wjets} + \varepsilon_{QCD} N_{QCD}$$

Two equations and two unknowns

$$N^{tight}_{tt+Wjets} = \varepsilon_{tt+Wjets} \frac{N_{tight} - \varepsilon_{QCD} N_{loose}}{\varepsilon_{tt+Wjets} - \varepsilon_{QCD}}$$

$$N^{tight}_{QCD} = \varepsilon_{QCD} \frac{\varepsilon_{tt+Wjets} N_{loose} - N_{tight}}{\varepsilon_{tt+Wjets} - \varepsilon_{QCD}}$$

Hadronic top Mass inv.

- from all possible combination of 4 jets (out of N>=4) jets in the event

  --> select a triplet that has the highest combined transverse momentum

  i.e, the combined 4vectors of these 3 jets yields the highest pT among

  all possible N!/[(N-3)!3!] 3 jet combination

  --> Two among the three jets that make the hadronic top are such that they have

  an invariant mass closest to the PDG value of W (80.4 GeV).

Selection Criteria

- **Cut 1:** Exactly one electron ET>20 *GeV* (electron channel) or exactly 1 muon PT>20 *GeV* (muon channel)
- **Cut 2:** Exactly 0 muons PT>20 *GeV* (electron channel) or exactly zero electrons ET>20 *GeV* (muon channel)
- **Cut 3:** Transverse missing energy > 20 *GeV*
- **Cut 4:** Transverse missing energy + W tranverse mass > 60 *GeV* (triangular cut)
- **Cut 5:** At least 4 jets with pt > 25 *GeV*, |eta| < 2.5
- **Cut 6:** >=1 good jet (25 *GeV* and |eta|<2.5) with SV0 weight > 5.72
- **Cut 7:** Jet Cleaning: no bad jets with EMscale Pt > 10 *GeV* (*)
- **Cut 8:** Non-collision background rejection: Require a primary vertex with Ntracks > 4
- **Cut 9:** require ELECTRON (**) trigger for the electron channel and MUON (**) for the muon channel
- **Cut 10:** the lepton matches the trigger - electron channel only (***)
- **Cut 11:** remove events tagged as e-mu overlap

W+njets n=2,3,4,5 (min=4jets)

	#events	cut 5)	cut 11)	σ	K-fact.	fraction
e	120775 (100%)	1189 (0.98%)	149 (0.12%)	2: 377.1 3: 100.9 4: 25.3 5: 6.9	1.22	3.58 (0.12%)
μ	345922 (100%)	2684 (0.77%)	191 (0.05%)	2: 375.3 3: 101.1 4: 25.7 5: 7.0	1.22	5.42 (0.06%)

Z+njets n=2,3,4,5 (min=4jets)

	#events	cut 5)	cut 11)	σ	K-fact.	fraction
e	53982 (100%)	297 (0.55%)	23 (0.04%)	2: 40.3 3: 11.2 4: 2.7 5: 0.8	1.22	0.5 (0.04%)
μ	32983 (100%)	170 (0.51%)	12 (0.04%)	2: 39.6 3: 11.1 4: 2.8 5: 0.8	1.22	0.26 (0.03%)

QCD (min=4jets)

	#events	cut 5)	cut 11)	σ	K-fact.	fraction
e	8618425 (100%)	51 (0.00%)	16 (0.00%)	?	1	16 (0.00%)
μ	774241 (100%)	27 (0.00%)	18 (0.00%)	?	1	18 (0.00%)

ttbar (min=4jets)

	#events	cut 5)	cut 11)	σ	K-fact.	fraction
e	773167 (100%)	67390 (8.72%)	48877 (6.32%)	80.2	1.11	56.42 (6.32%)
μ	773167 (100%)	77968 (10.1%)	48382 (6.26%)	80.2	1.11	55.85 (6.26%)