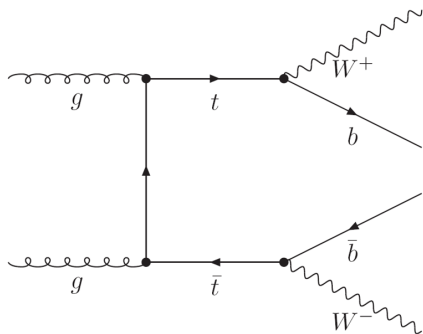# Top Cross Section and Mass Measurements at ATLAS

Chad Suhr on behalf of the ATLAS collaboration
Northern Illinois University

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Top Quark

Theory NNLO(approx) cross section: 165^{+11}_{-16} pb at 7 TeV assuming m_{top} = 172.5 GeV

Production and Decay

- gg scattering/fusion predominant
- decay $\sim$100% to W and b-quark
- top decays:
  - single lepton (BR 37.9%)
  - dileptonic (BR 6.5%)
  - all hadronic and non-leptonic τ decays

Data

- $\sqrt{s}$ = 7 TeV
- Analyses use full 2010 dataset with integrated luminosity of 35 pb^{-1}

Single Lepton Selection and Background

Selection

- lepton trigger
- exactly one lepton (e or μ) with $p_T > 20$ GeV matched to trigger
- $\not{E}_T > 20$ GeV and $\not{E}_T + m_T(W) > 60$ GeV (muon channel)
  $\not{E}_T > 35$ GeV and $m_T(W) > 25$ GeV (electron channel)
- ≥ 3 jets with $p_T > 25$ GeV and $|\eta| < 2.5$

Backgrounds

- Fakes (multi-jet, heavy flavor, photon conversion) - estimated from data
- W+jets/Z+jets - shape from MC, normalization from fit
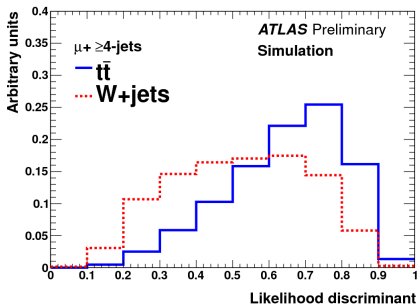- Diboson, single top - shape from MC, normalization from NLO calc

Single Lepton Analysis

Likelihood Discriminant

$$D_i = \frac{\mathcal{L}_{sig}(i)}{\mathcal{L}_{sig}(i) + \mathcal{L}_{bkgd}(i)}$$

$$\mathcal{L}_{sig/bkgd}(i) = \prod_{k=1}^{N_{var}} p_{sig/bkgd,k}(x_k(i))$$
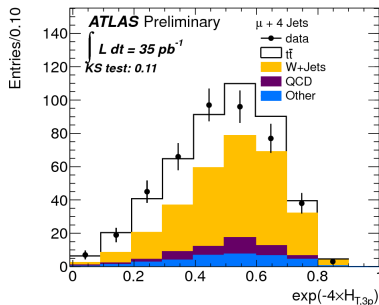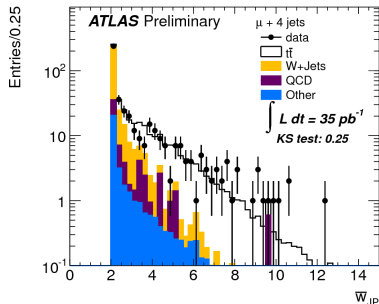
i - event, x_k - kinematic variable

Projective Likelihood

- Used by baseline analysis with and without b-tag
- Discriminant constructed from multiple variables
- MC signal and background models used to select variables for building discriminant
- Used as variable for binned likelihood fit to extract $\sigma_{t\bar{t}}$

Cross Section

$$\sigma_{t\bar{t}} = \frac{N_{sig}}{\int \mathcal{L} \, dt \times \epsilon_{sig}}$$

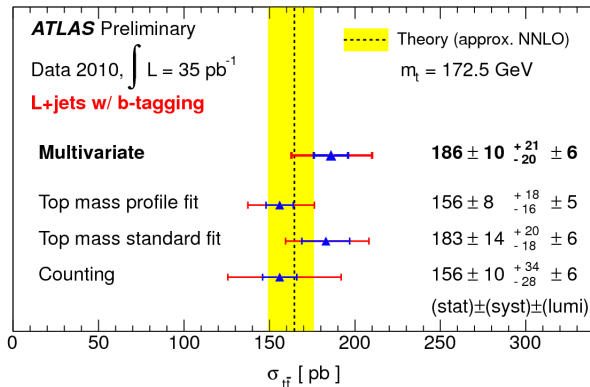# $\sigma_{t\bar{t}}$ Single Lepton with b-tagging

Analysis

Binned likelihood fit of projective likelihood discriminant (D_i) templates

Variables in D_i

- η_{lepton}
- aplanarity
  $exp(-8 \times A)$
- $exp(-4 \times H_{T,3p})$
  $H_{T,3p} = \sum_{i=3}^{N_{njets}} |p_{T,i}^2| / \sum_{j=1}^{N_{objects}} |p_{z,j}|$
- $W_{JP} = -log_{10}P_l$
  P_l is average of two lowest light-jet probabilities in event from JetProb tagger.

$\sigma_{t\bar{t}}$ Single Lepton with b-tagging

For each lepton flavor (e, μ), top normalization is extracted from simultaneous fit of 3,4, and 5+ jet bins.
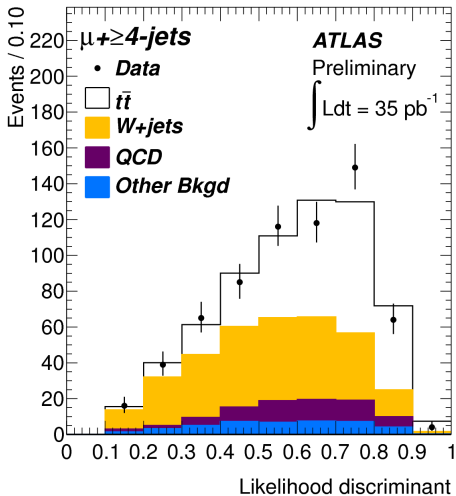

ATLAS Preliminary
Data 2010, $\int L = 35\ pb^{-1}$
L+jets w/ b-tagging

Theory (approx. NNLO)
$m_t = 172.5$ GeV

Multivariate	$186 \pm 10\ ^{+21}_{-20} \pm 6$
Top mass profile fit	$156 \pm 8\ ^{+18}_{-16} \pm 5$
Top mass standard fit	$183 \pm 14\ ^{+20}_{-18} \pm 6$
Counting	$156 \pm 10\ ^{+34}_{-28} \pm 6$
	(stat)±(syst)±(lumi)

$\sigma_{t\bar{t}}$ [pb]

Figure

Results of baseline and complementary cross section measurements with b-tagging

ATLAS-CONF-2011-035 (red text denotes link)

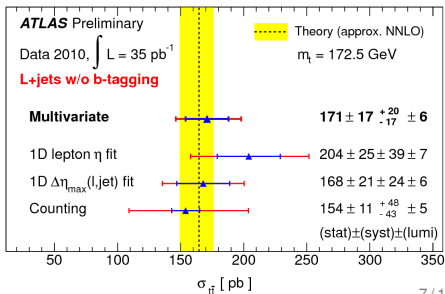# $\sigma_{t\bar{t}}$ Single Lepton without b-tagging

μ+≥**4-jets** — ATLAS Preliminary, $\int Ldt = 35\ pb^{-1}$

- Data
- $t\bar{t}$
- W+jets
- QCD
- Other Bkgd

Likelihood discriminant

ATLAS-CONF-2011-023

Complementary and consistent results are obtained from similar analysis without b-tagging information.
Baseline and complementary cross section measurements without b-tagging (below)

ATLAS Preliminary
Data 2010, $\int L = 35\ pb^{-1}$
L+jets w/o b-tagging

Theory (approx. NNLO)
$m_t = 172.5$ GeV

	$\sigma_{t\bar{t}}$ [pb]
Multivariate	$171 \pm 17\ ^{+20}_{-17} \pm 6$
1D lepton η fit	$204 \pm 25 \pm 39 \pm 7$
1D $\Delta\eta_{max}$(l,jet) fit	$168 \pm 21 \pm 24 \pm 6$
Counting	$154 \pm 11\ ^{+48}_{-43} \pm 5$

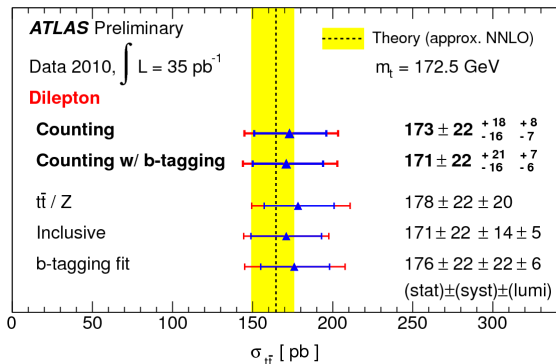(stat)±(syst)±(lumi)

$\sigma_{t\bar{t}}$ Dilepton

Selection

- Two oppositely charged leptons ($ee, \mu\mu, e\mu$) with $p_T > 20$ GeV and at least one matched to trigger
- ≥ 2 jets with $p_T > 20$ GeV and $|\eta| < 2.5$
- ($ee, \mu\mu$) $\not{E}_T > 40$ GeV and $|m_{ll} - m_Z| > 10$ GeV
- ($e\mu$) H_T (all jets, two leptons) > 130 GeV
- Cleaning cuts to eliminate cosmic muons
- Dilepton mass $m_{ll} > 15$ GeV

$\sigma_{t\bar{t}}$ Dilepton
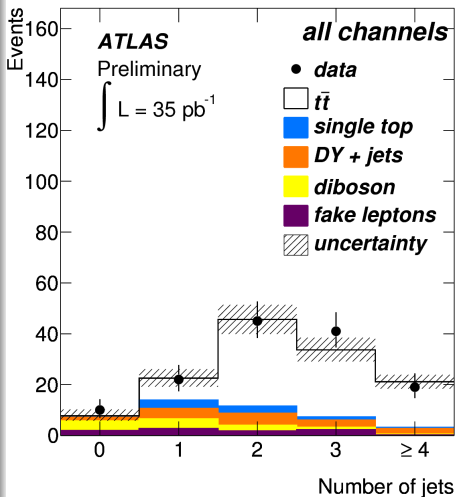
Cut and Count

- Event count for each channel modeled as Poisson distributed about expectation
- Expected variation due to systematic uncertainties parameterized and included in likelihood function with cross section as free parameter


ATLAS Preliminary
Data 2010, $\int L = 35$ pb^{-1}
Dilepton

Theory (approx. NNLO)
$m_t = 172.5$ GeV

Counting	$173 \pm 22 \, ^{+18}_{-16} \, ^{+8}_{-7}$
Counting w/ b-tagging	$171 \pm 22 \, ^{+21}_{-16} \, ^{+7}_{-6}$
$t\bar{t}$ / Z	$178 \pm 22 \pm 20$
Inclusive	$171 \pm 22 \pm 14 \pm 5$
b-tagging fit	$176 \pm 22 \pm 22 \pm 6$
	(stat)±(syst)±(lumi)

$\sigma_{t\bar{t}}$ [pb]

$$\mathcal{L}(\sigma_{sig}, L, \alpha_j) =$$
$$\prod_{i \in channel} Pois(N_i^{obs} | N_{i,tot}^{exp}(\vec{\alpha}))$$
$$\times \; G(L_0 | L, \sigma_L)$$
$$\times \prod_{j \in syst} G(0 | \alpha_j, 1)$$

ATLAS-CONF-2011-034

Combination

Combined likelihood fit

Single likelihood function formed from dilepton likelihood function and approximate single-lepton likelihood function
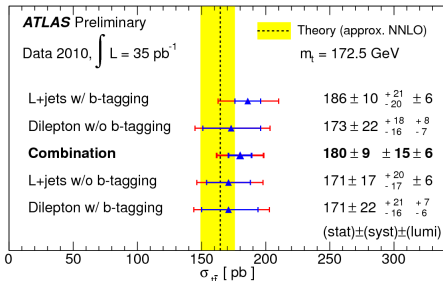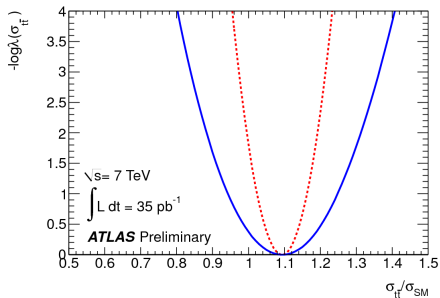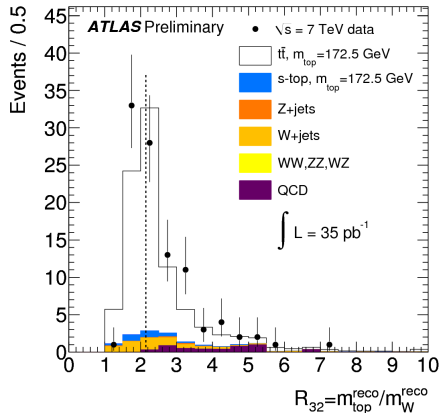

Results

(left) Results of combined likelihood fit with (blue) and without (red) systematics.
(above) Results for baseline analyses and combination.

ATLAS-CONF-2011-040

Top Mass

Mass Ratio

$$R_{32} \equiv \frac{m_{top}^{reco}}{m_W^{reco}}$$

- JES partially cancels
- Strongly sensitive to top mass

Selection

- Event selection as in single lepton cross section analyses
- m_{top}^{reco} - 3 jets with highest combined p_T
- m_W^{reco} - 2 jets w/out b-tag (if b-tag) or 2 jets closest in ΔR (no b-tag)
- 60 GeV $< m_W^{reco} <$ 100 GeV
- Reject events with 2 tagged jets in reconstructed hadronic top

Top Mass

Signal and Background PDF

Continuous PDF defined for signal and background by fits to MC for background and signal with different m_{top} assumptions.
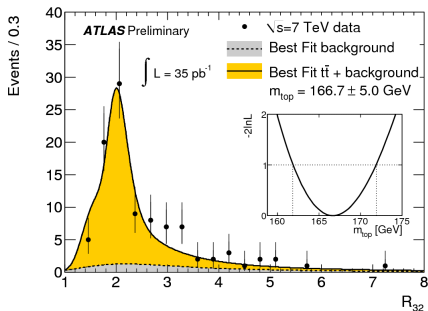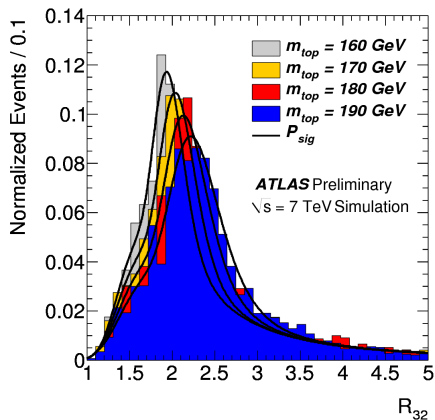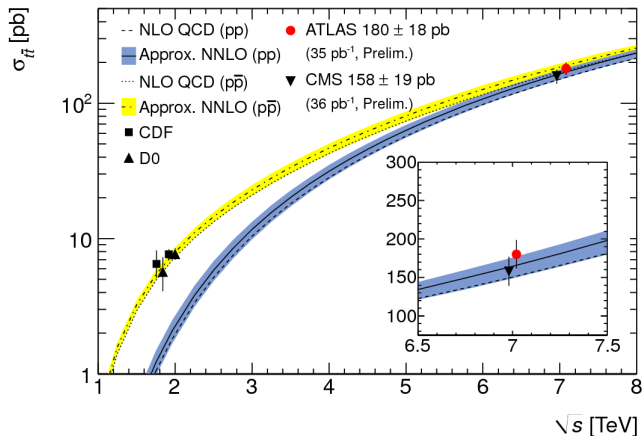

Fit Results

R_{32} data distribution and background and signal templates for best fit.

$m_{top} = 169.3 \pm 4.0(\text{stat}) \pm 4.9(\text{sys})$ GeV (comb. e and μ)

ATLAS-CONF-2011-033

Conclusions

- Consistent results across methods and channels
- Consistent with Standard Model
- More results available at the top public results page.

Top Notes

Links to CONF notes

$\sigma_{t\bar{t}}$

- Single lepton w/o b-tagging
- Single lepton w/ b-tagging
- Dilepton
- Combination

Searches

- $t\bar{t}$ all hadronic search
- Single top search
- Search for FCNC top decays
- Search for anomalous $\not{E}_T$ in $t\bar{t}$ events

Properties

- Top mass
- Top mass from $\sigma_{t\bar{t}}$
- W helicity