Top Quark Production at the LHC
ATLAS + CMS

Filipe Veloso
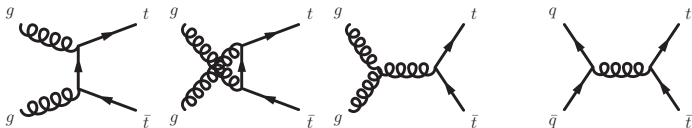
(on behalf of the ATLAS and CMS Collaborations)

Beyond The Standard Model of Particle Physics
Quy Nhon, Vietnam, 15-21.jul.2012

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$t\bar{t}$ production: introduction   ②
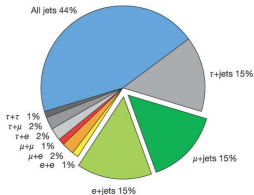
- main top-quark production mechanism at LHC

$$\sigma_{t\bar{t}}^{\text{aprox. NNLO}} = 167^{+17}_{-18} \text{ pb at 7 TeV and } 238^{+22}_{-24} \text{ pb at 8 TeV (arXiv:1007.1327)}$$

- top quark decays about 100% to bW
  W decays define final state topologies

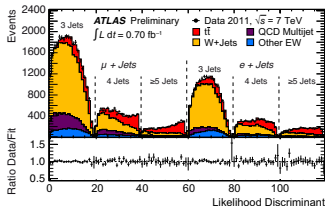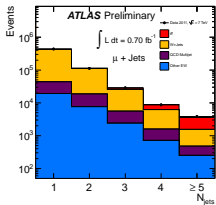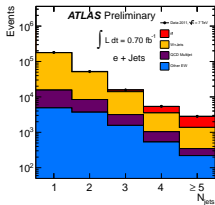Top pair decay channels   Top pair branching fractions

$t\bar{t}$ production: single lepton ③

0.70 fb^{-1}
ATLAS-CONF-2011-121

- event selection: 1 lepton (e, μ); at least 3 jets;
  $E_T^{\text{miss}} > 30$ GeV (e); $m_T^W > 25$ GeV (e); $E_T^{\text{miss}} + m_T^W > 60$ GeV (μ)
- main backgrounds: W+jets and fake leptons from multijet events
- built a likelihood discriminant function using relevant kinematic variables


- cross section obtained with a maximum-likelihood fit to the discriminant distribution using templates for signal and background
- $\sigma_{t\bar{t}}$ measured from combination:
  $\sigma_{t\bar{t}}^{7\ \text{TeV}} = 179.0 \pm 3.9$ (stat.) ± 9.0 (syst.) ± 6.6 (lumi.) pb
- dominant systematics:
  generator ($\pm 3\%$), Jet Energy Scale (JES) $\left(^{+1.8}_{-2.4}\%\right)$, ISR/FSR $\left(^{+1.7}_{-1.3}\%\right)$

$t\bar{t}$ production: single lepton

0.80 (e) 1.09 (μ) fb^{-1}
CMS PAS TOP-11-003

- event selection: 1 lepton (e, μ); at least 1 b-tagged jet;
  $E_T^{miss} > 30$ GeV (e); $E_T^{miss} > 20$ GeV (μ)
- main background: W+jets
- built a likelihood discriminant function using relevant kinematic variables
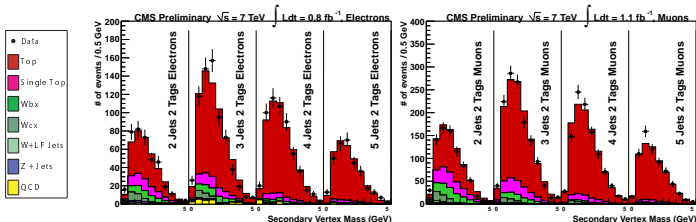
- cross section measured with a profile likelihood method using a fit to n_j, n_b and secondary vertex mass distribution
- $\sigma_{t\bar{t}}$ measured from combination:
  $\sigma_{t\bar{t}}^{7\ \text{TeV}} = 164.4 \pm 2.8$ (stat.) ± 11.9 (syst.) ± 7.4 (lumi.) pb
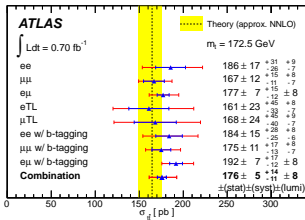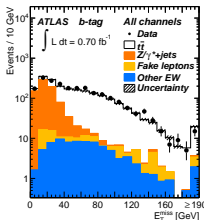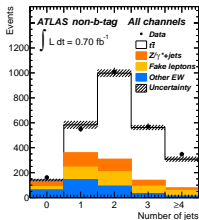- dominant systematics: ℓ ID (3.4%), PDF (3.4%), JES (3.1%)

ATLAS 0.70 fb^{-1}
JHEP 1205 (2012) 059

- event selection: 2 OS leptons (e, μ, TL); at least 2 jets;
  $m_{\ell\ell} > 15$ GeV (SF, TL); $E_T^{miss} > 45$ GeV (TL); $E_T^{miss} > 60$ GeV (SF);
  $|m_{\ell\ell} - m_Z| > 10$ GeV (SF, TL); $H_T > 130$ GeV ($e\mu$); $H_T > 150$ GeV (TL)
- main backgrounds: Z+jets and fake leptons from W+jets and top production

- cross-sections from each channel obtained with a profile likelihood technique
- $\sigma_{t\bar{t}}$ measured from combination: $\sigma_{t\bar{t}}^{7\,TeV} = 176 \pm 5$ (stat.) $^{+14}_{-11}$ (syst.) ± 8 (lumi.) pb
- dominant systematics: generator $\left({}^{+5.1}_{-4.9}\right)$, jet/$E_T^{miss}$ $\left({}^{+4.4}_{-3.4}\right)$, lepton ID $\left({}^{+2.6}_{-2.2}\right)$
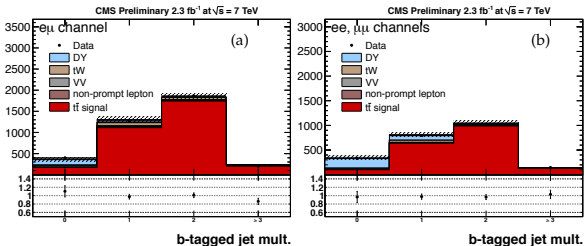
$t\bar{t}$ production: dilepton channel ⑥

2.3 fb^{-1}
CMS PAS TOP-11-005 Up.

- event selection: 2 OS leptons (e, μ); at least 2 jets;
- main backgrounds: Z+jets and fake leptons from top production

- measured cross-section: $\sigma_{t\bar{t}}^{7 \text{ TeV}} = 161.9 \pm 2.5$ (stat.) $^{+5.1}_{-5.0}$ (syst.) ± 3.6 (lumi.) pb
- dominant systematics: JES (2.8%), W BR (2.7%), single top (2.3%)
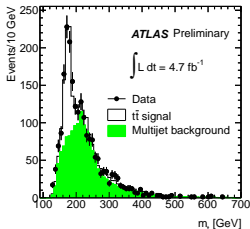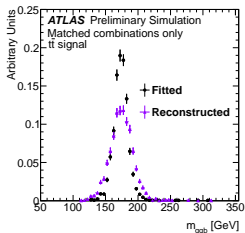
$t\bar{t}$ production: all hadronic

- event selection: 6 jets ($p_T > 55$ GeV, $p_T^{j6} > 30$ GeV), 2 b-tagged), no leptons
- background: multi-jet events (estimated from untagged data samples)
- correct association of jets and m_t determined from kinematic fit based on a likelihood approach

- $\sigma_{t\bar{t}}$ determined from an unbinned likelihood fit to the top quark mass distribution
  $\sigma_{t\bar{t}}^{7\,\text{TeV}} = 168 \pm 12$ (stat.) $^{+60}_{-57}$ (syst.) ± 7 (lumi.) pb
- dominant systematics:
  JES $\left(^{+20}_{-11}\%\right)$, b-tag (17%), ISR/FSR ($\pm 17\%$), parton shower (PS) ($\pm 13\%$)
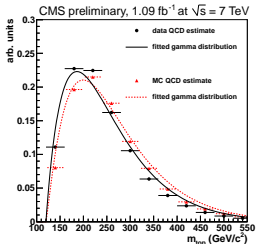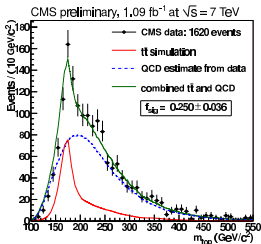
$t\bar{t}$ production: all hadronic

1.09 fb^{-1}
CMS PAS TOP-11-007

- event selection:
  6 jets ($p_T > 60$ GeV, $p_T^{j5} > 50$ GeV, $p_T^{j6} > 40$ GeV, 2 b-tagged), no leptons
- background: multi-jet events (estimated from untagged data samples)
- correct association of jets and m_t determined from kinematic fit

CMS preliminary, 1.09 fb^{-1} at $\sqrt{s}$ = 7 TeV

- CMS data: 1620 events
- $t\bar{t}$ simulation
- QCD estimate from data
- combined $t\bar{t}$ and QCD
- $f_{dg} = 0.250 \pm 0.036$

CMS preliminary, 1.09 fb^{-1} at $\sqrt{s}$ = 7 TeV

- data QCD estimate
- fitted gamma distribution
- MC QCD estimate
- fitted gamma distribution

- $\sigma_{t\bar{t}}$ determined from an unbinned maximum likelihood fit to the reconstructed top quark mass

  $\sigma_{t\bar{t}}^{7\ \text{TeV}} = 136 \pm 20$ (stat.) ± 40 (syst.) ± 8 (lumi.) pb

- dominant systematics: b-tag (15.7%), JES (13.5%), background (± 12.2%)
- cross-check neural network (NN) analysis:

 $\sigma_{t\bar{t}}^{7\ \text{TeV}} = 157 \pm 30$ (stat.) ± 47 (syst.) ± 9 (lumi.) pb

$t\bar{t}$ production: τ+ jets

1.67 fb^{-1}
ATLAS-CONF-2012-032

- event selection: 5 jets ($p_T > 20$ GeV, 2 b-tagged, 1 τ), no leptons
  E_T^{miss} significance $E_T^{miss}/(0.5\sqrt{H_T}) > 8$
- background: multi-jet events and top production
- reconstruct hadronic top from the 3 jets with highest $\sum \vec{p}_T$
- discriminate signal from background using the number of charged tracks associated to the τ candidate
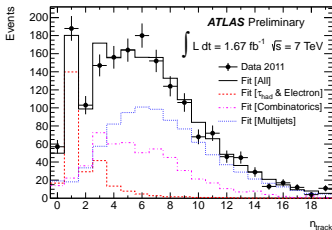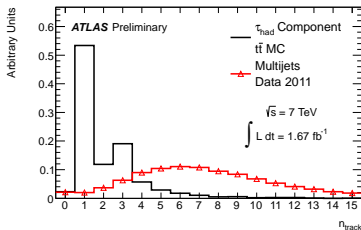
- $\sigma_{t\bar{t}}$ determined from an extended binned-likelihood fit to the n_{track} distribution
  $\sigma_{t\bar{t}}^{7\ \text{TeV}} = 200 \pm 19$ (stat.) ± 43 (syst.) pb
- dominant systematics: ISR/FSR (12%), b-tag (10%), PS (± 7%)
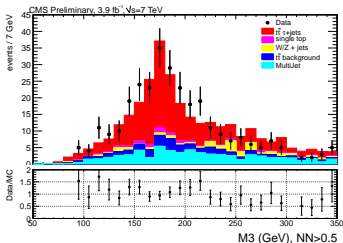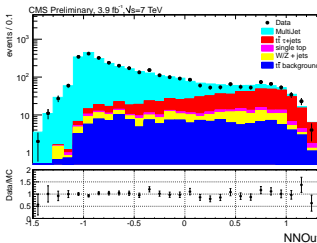
$t\bar{t}$ production: τ+ jets

3.9 fb^{-1}
CMS PAS TOP-11-004

- event selection: 1 τ ($p_T > 45$ GeV), 4 jets ($p_T > 45$ GeV, $p_T^{j4} > 20$ GeV, at least 1 b-tagged) no leptons (e, μ), E_T^{miss} significance $E_T^{miss} > 20$ GeV
- main backgrounds: multi-jet events and top production
- NN with 7 variables used to discriminate between signal and background

- $\sigma_{t\bar{t}}$ determined from a negative log-likelihood fit to the NN output distribution
$$\sigma_{t\bar{t}}^{7\ TeV} = 156 \pm 12\ \text{(stat.)} \pm 33\ \text{(syst.)} \pm 3\ \text{(lumi.)}\ \text{pb}$$
- dominant systematics: jet energy correction (11%), τ ID (9%), E_T^{miss} (7%)

ATLAS 2.05 fb^{-1}
arXiv:1205.2067

- event selection: 1 lepton (e or μ), 1 τ, at least 2 jets (1 b-tagged), $E_{\mathrm{T}}^{\mathrm{miss}} > 30$ GeV, $\sum E_T > 200$ GeV
- main background: jets faking τ from single lepton $t\bar{t}$ production
- discriminate signal from background using boosted decision trees (BDT)
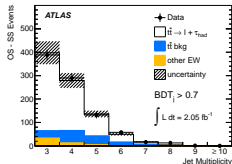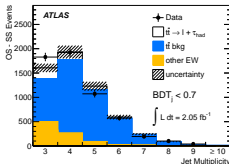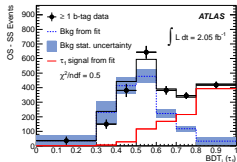
- $\sigma_{t\bar{t}}$ determined by fitting BDT distributions to signal and background templates
- $\sigma_{t\bar{t}}^{7\ \mathrm{TeV}} = 186 \pm 13$ (stat.) ± 20 (syst.) ± 7 (lumi.) pb
- dominant systematics: b-tag ($\sim 9\%$), ISR/FSR ($\sim 4\%$), τ ID ($\sim 3\%$)

$t\bar{t}$ production: τ+ lepton

CMS 2.05 fb^{-1}
arXiv:1203.6810

- event selection: 1 lepton (e or μ), 1 τ, at least 3 jets (at least 1 b-tagged), $E_T^{miss} > 45$ GeV (e), $E_T^{miss} > 40$ GeV (μ)
- main background: jets faking τ from single lepton $t\bar{t}$ production
- top quark mass reconstructed with a kinematical algorithm (KINb)
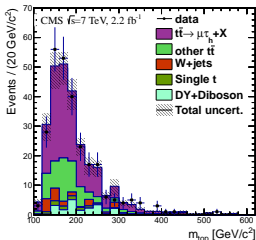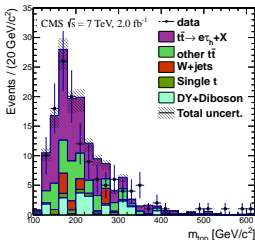
- measured cross section: $\sigma_{t\bar{t}}^{7\ TeV} = 143 \pm 14$ (stat.) ±22 (syst.) ±3 (lumi.) pb
- dominant systematics: background (10.8%), τ ID (6.3%), b-tagging (5.3%)
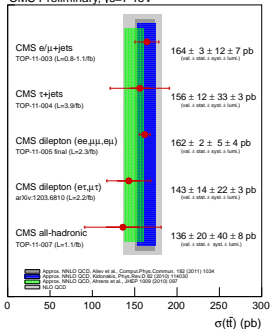
$t\bar{t}$ production: combination ⑬

CMS 0.8 to 1.1 fb⁻¹
CMS PAS TOP-11-024

ATLAS 0.70 to 1.02 fb⁻¹
ATLAS-CONF-2012-024

CMS Preliminary, $\sqrt{s}$=7 TeV

CMS e/μ+jets
TOP-11-003 (L=0.8-1.1/fb)
$164 \pm 3 \pm 12 \pm 7$ pb
(stat.± syst.± lumi.)

CMS τ+jets
TOP-11-004 (L=3.9/fb)
$156 \pm 12 \pm 33 \pm 3$ pb
(stat.± syst.± lumi.)

CMS dilepton (ee,μμ,eμ)
TOP-11-005 final (L=2.3/fb)
$162 \pm 2 \pm 5 \pm 4$ pb
(stat.± syst.± lumi.)

CMS dilepton (eτ,μτ)
arXiv:1203.6810 (L=2.2/fb)
$143 \pm 14 \pm 22 \pm 3$ pb
(stat.± syst.± lumi.)

CMS all-hadronic
TOP-11-007 (L=1.1/fb)
$136 \pm 20 \pm 40 \pm 8$ pb
(stat.± syst.± lumi.)

$\sigma(t\bar{t})$ (pb)

ATLAS Preliminary

15 May 2012

Data 2011

Theory (approx. NNLO)
for m_t = 172.5 GeV

Channel & Lumi.

stat. uncertainty
total uncertainty
$\sigma_{t\bar{t}} \pm$(stat.) $\pm$(syst.) $\pm$(lumi.)

Single lepton 0.70 fb⁻¹ $179 \pm 4 \pm 9 \pm 7$ pb

Dilepton 0.70 fb⁻¹ $173 \pm 6 \,^{+14}_{-11} \,^{+8}_{-7}$ pb

All hadronic 1.02 fb⁻¹ $167 \pm 18 \pm 78 \pm 6$ pb

Combination $177 \pm 3 \,^{+8}_{-7} \pm 7$ pb

New measurements

τ_{had} + jets 1.67 fb⁻¹ $200 \pm 19 \pm 42 \pm 7$ pb
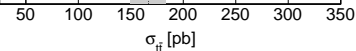
τ_{had} + lepton 2.05 fb⁻¹ $186 \pm 13 \pm 20 \pm 7$ pb

All hadronic 4.7 fb⁻¹ $168 \pm 12 \,^{+60}_{-57} \pm 6$ pb

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

- CMS: combination performed with binned maximum likelihood fit

$\sigma_{t\bar{t}}^{7\ \text{TeV}} = 166 \pm 2\ \text{(stat.)} \pm 11\ \text{(syst.)} \pm 8\ \text{(lumi.)}$ pb ⟶ **8% uncertainty**

$\left(\sigma_{t\bar{t}}^{7\ \text{TeV}} = 162 \pm 2\ \text{(stat.)} \pm 5\ \text{(syst.)} \pm 4\ \text{(lumi.)}\ \text{pb} \quad \boxed{\text{4% with new dilepton}} \right)$

- ATLAS: combination performed with the product of the individual likelihoods

$\sigma_{t\bar{t}}^{7\ \text{TeV}} = 177 \pm 3\ \text{(stat.)} \,^{+8}_{-7}\ \text{(syst.)} \pm 7\ \text{(lumi.)}$ pb ⟶ **6% uncertainty**

$t\bar{t}$ production: new results at $\sqrt{s} = 8$ TeV ⑭

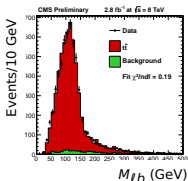- single lepton event selection: 1 lepton; at least 4 jets (at least 1 b-tagged)
- dilepton event selection: 2 leptons (e, μ); at least 1 b-tagged jet;
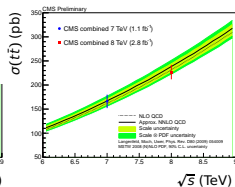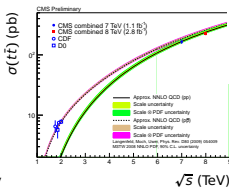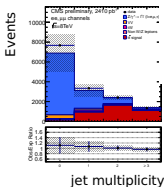

- single lepton channel: $\sigma_{t\bar{t}}^{8\ \text{TeV}} = 228.4 \pm 9.0$ (stat.) $^{+20.0}_{-26.0}$ (syst.) ± 10.0 (lumi.) pb

  dominant systematics: b-tag (8%), factorization scale $\left(^{+6.2}_{-2.1}\%\right)$, JES $\left(^{+4.3}_{-5.0}\%\right)$

- dilepton channel: $\sigma_{t\bar{t}}^{8\ \text{TeV}} = 227 \pm 3$ (stat.) ± 10 (syst.) ± 10 (lumi.) pb

  dominant systematics: luminosity (4.4%), JES (2.5%), lepton efficiencies (1.8%)

- in agreement with QCD predictions up to aprox. NNLO

$t\bar{t}$ differential cross sections

CMS 1.14 fb^{-1}
CMS PAS TOP-11-013

- measurements of the differential top quark pair production cross sections
- both single lepton and dilepton channels
- top quarks reconstructed through kinematic fit (single lepton) or probabilistic method (dilepton)
- $\frac{1}{\sigma}\frac{d\sigma^i}{dX} = \frac{1}{\sigma}\frac{N^i_{Data} - N^i_{BG}}{\Delta^i_X \epsilon^i L}$
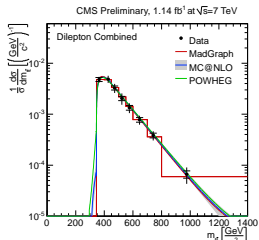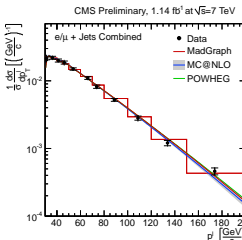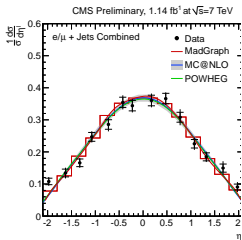
- good agreement found among the different decay channels and with SM predictions
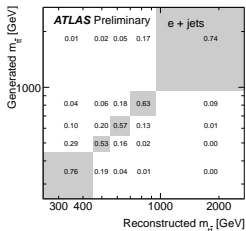
$t\bar{t}$ differential cross sections

2.05 fb^{-1}
ATLAS TOPQ-2011-07

- single lepton channel
- relative differential cross-sections derived as a function of $m_{t\bar{t}}$, $p_T^{t\bar{t}}$ and $y_{t\bar{t}}$
- top quarks reconstructed using a likelihood fit
- unfold detector effects in data using inverted MC migration matrix
- correct for acceptance, luminosity and branching fraction
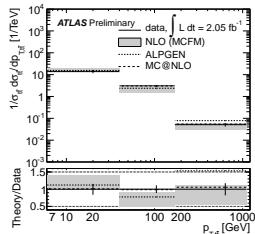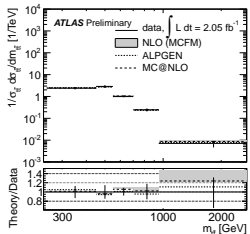
- no significant deviations from the SM expectations are observed

$t\bar{t}\gamma$

1.04 fb^{-1}
ATLAS-CONF-2011-153

- event selection similar to the one used in the top pair-production cross-section measurement plus 1γ with $p_T > 15$ GeV
- discriminate prompt photons from hadron fakes with a template fit method
- main background: $t\bar{t}$ production with a fake lepton
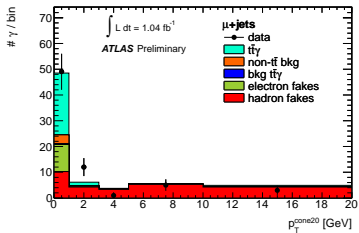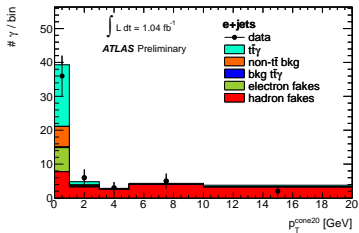
- measured cross section for single lepton and dilepton $t\bar{t}\gamma$ events with $p_T^\gamma > 8$ GeV:

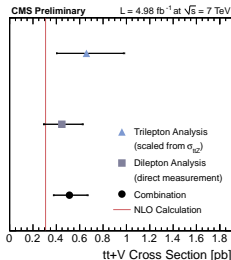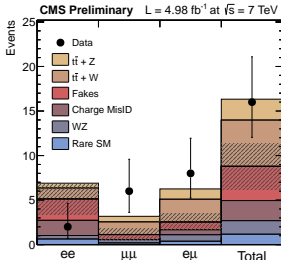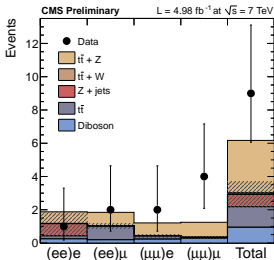$$\sigma_{t\bar{t}\gamma}^{7\text{ TeV}} = 2.0 \pm 0.5 \text{ (stat.)} \pm 0.7 \text{ (syst.)} \pm 0.08 \text{ (lumi.) pb} \qquad \boxed{2.7\sigma \text{ significance}}$$

SM estimation: 2.1 ± 0.4 pb

- dominant systematics: ISR/FSR (16%), pile-up (14%), JES (12%)

$t\bar{t}V$, $V = W, Z$

4.98 fb^{-1}
CMS PAS TOP-12-014

- two event selections
  - trilepton (3 leptons with 2 SF OS, at least 3 jets with 2 b-tagged): search for $t\bar{t}Z$
  - SS dilepton (at least 2 SS leptons, at least 3 jets with 1 b-tagged): search for $t\bar{t}V$, $V = W, Z$


- measured cross sections (and SM estimations):

$$\sigma_{t\bar{t}Z}^{7\ \text{TeV}} = 0.30^{+0.14}_{-0.11}\ \text{(stat.)}\ ^{0.04}_{-0.02}\ \text{(syst.) pb} \quad \boxed{3.66\sigma\ \text{sign.}} \quad \left(\sigma_{t\bar{t}Z}^{7\ \text{TeV, SM}} = 0.1387\ \text{pb}\right)$$

$$\sigma_{t\bar{t}V, V=W,Z}^{7\ \text{TeV, comb.}} = 0.51^{+0.15}_{-0.13}\ \text{(stat.)}\ ^{0.05}_{-0.04}\ \text{(syst.) pb} \quad \boxed{4.67\sigma\ \text{sign.}} \quad \left(\sigma_{t\bar{t}V, V=W,Z}^{7\ \text{TeV, SM}} = 0.308\ \text{pb}\right)$$

- dominant systematic: background estimation (27%)

0.70 fb^{-1}
ATLAS-CONF-2011-142

- measurement of the multiplicity distribution of reconstructed jets in the single lepton channel
- test for ISR effects
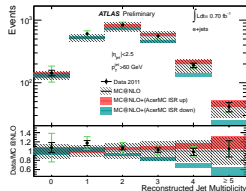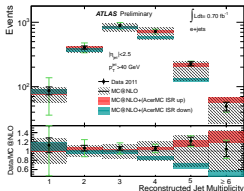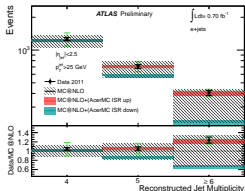
- results agree with expectations
- large systematic uncertainties (dominated by JES)
- no distinction between the different models can be made yet

$t\bar{t}j$

4.7 fb^{-1}
ATLAS-CONF-2012-083

- measurement of $t\bar{t}j$ production cross section in the single lepton channel
- addition jet definitions used:
  - 1: at least one jet without overlapping ($\Delta R < 0.4$) a parton from a top decay
  - 2: events with more than 4 jets
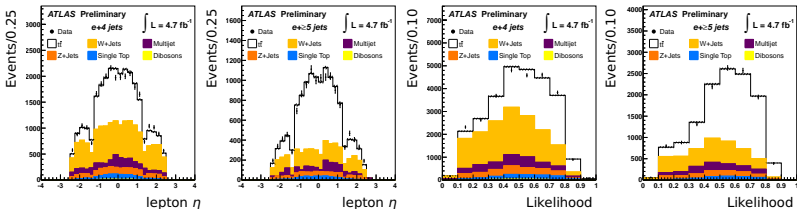
- measured cross-section using definition 1: $\sigma_{t\bar{t}j}^{7\,\text{TeV}} = 102 \pm 2$ (stat.) $^{+23}_{-26}$ (syst.) pb.
- dominant systematics: MC modelling (21%) and JES (14%)
- ratio: $\sigma_{t\bar{t}j}^{7\,\text{TeV}}/\sigma_{t\bar{t}}^{7\,\text{TeV incl.}} = 0.54 \pm 0.01$ (stat.) $^{+0.05}_{-0.08}$ (syst.)
- results can be used to test perturbative QCD calculations of jet activity in $t\bar{t}j$ and to improve MC simulations

# central jet veto

ATLAS 2.05 fb^{-1}
arXiv:1203.5015

- measurement in dilepton channel of the fraction of events without an additional jet with transverse momentum above a threshold Q_0 in a central rapidity (y) interval
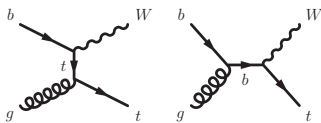- comparison to 4 MC generators (MC@NLO, Powheg, Alpgen and Sherpa)
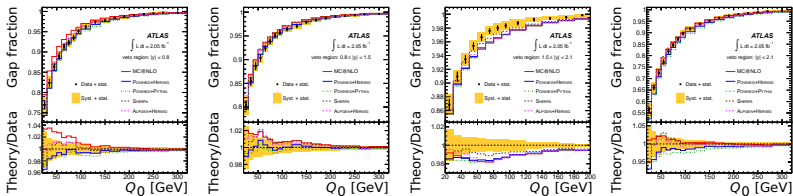
- $|y| < 2.1$: reasonable description of the data
- $1.5 \leq |y| < 2.1$: too much jet activity predicted
- $|y| < 0.8$: MC@NLO produces too little activity
- results constrain ISR uncertainties in other ATLAS measurements
- alternate measurement: veto on events where scalar sum of p_T of additional jets is above threshold in central region (gives similar conclusions)
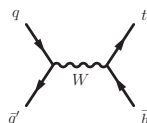
- 3 production mechanisms which involve the *Wtb* vertex
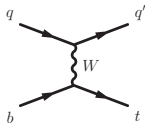
t-channel	Wt-channel	s-channel
$\sigma^{7\ \text{TeV}} = 64.6^{+3.3}_{-2.6}$ pb	$\sigma^{7\ \text{TeV}} = 15.7^{+1.3}_{-1.4}$ pb	$\sigma^{7\ \text{TeV}} = 4.6 \pm 0.3$ pb
PRD83 091503 (2011)	PRD82 054018 (2010)	PRD81 054028 (2010)

- single top allows direct measurement of CKM matrix element $|V_{tb}|$
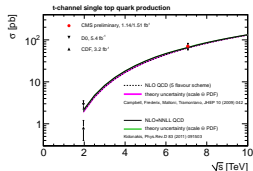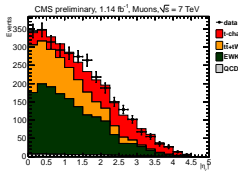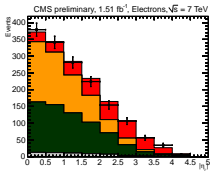- sensitive to BSM (e.g. FCNC, W', H^+)

single-top: *t* channel

1.51(e) 1.14(μ) fb^{-1}
CMS PAS TOP-11-021

- event selection: 1 lepton (e p_T > 30 GeV; μ p_T > 20 GeV); 2 jets (p_T > 30 GeV, 1 b-tagged);
  E_T^{miss} > 35 GeV (e) ; m_T^W > 40 GeV (μ); 130 GeV < m_t < 220 GeV

- main backgrounds: W+jets, top production

- σ_t measured from maximum likelihood fit to the distribution of the pseudorapidity of the light jet $|\eta_j|$

  $\sigma_t^{7\ \text{TeV}} = 70.2 \pm 5.2$ (stat.) ± 10.4 (syst.) ± 3.4 (lumi.) pb.

- dominant systematics: JES $\left(^{+9.2}_{-6.2}\%\right)$, W+jets (7.1%), Q^2 (t-channel) (7.0%)

- determination of $|V_{tb}| = 1.04 \pm 0.09$ (exp.) ± 0.02 (th.)

single-top: *t* channel

ATLAS 1.04 fb^{-1}
arXiv:1205.3130

- event selection: 1 lepton ($e, \mu; p_T > 25$ GeV); 2 or 3 jets ($p_T > 25$ GeV);
  $E_T^{miss} > 25$ GeV ; $m_T^W > (60$ GeV $-E_T^{miss})$
- main backgrounds: W+jets, top production
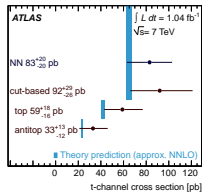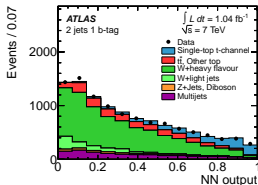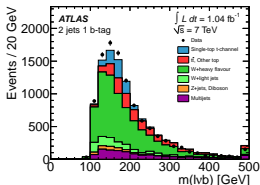
- NN with 12 (18) variables for the 2 (3) jets bin
- σ_t measured with maximum-likelihood fit method:
  $\sigma_t^{7\ TeV} = 83 \pm 4$ (stat.)$^{+20}_{-19}$ (syst.) pb
- dominant systematics: ISR/FSR (14%), *b*-tag effic. (13%), JES (6%)
- determination of $|V_{tb}| = 1.13^{+0.14}_{-0.13}$ (assuming $|V_{tb}| < 1 \rightarrow |V_{tb}| > 0.75$ at 95%CL)
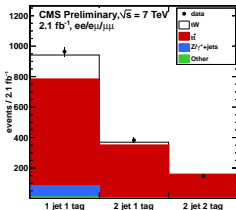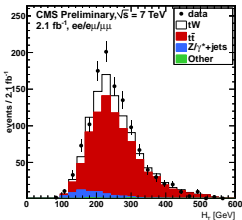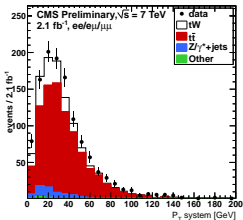- cut-based analysis (used as cross-check):
  $\sigma_t^{total} = 92^{+29}_{-26}$ pb $\qquad \sigma_{(t)} = 59^{+18}_{-16}$ pb $\qquad \sigma_{(\bar{t})} = 33^{+13}_{-12}$ pb

single-top: *Wt* associated production

2.1 fb^{-1}
CMS PAS TOP-11-022

- event selection: = 2 OS leptons (e, μ) with $p_T \geq 20$ GeV, $m_{\ell\ell} > 20$ GeV
  1 jet (b-tagged, $p_T > 30$ GeV), $p_T^{System} < 60$ GeV
  $E_T^{miss} > 30$ GeV (SF), $m_{\ell\ell} < 81$ GeV (SF), $m_{\ell\ell} > 101$ GeV (SF), $H_T > 160$ GeV ($e\mu$)

- main backgrounds: $t\bar{t}$ and Z+jets

- 2.7σ significance ($1.8 \pm 0.9\sigma$ expected) from ratio of maximized likelihood functions

- *Wt* cross-section measured (with 68% CL interval): $\sigma_{Wt}^{7\ TeV} = 22^{+9}_{-7}$ pb

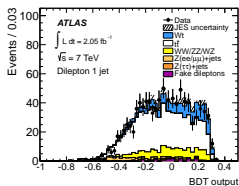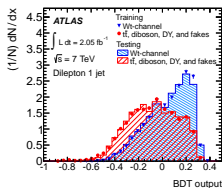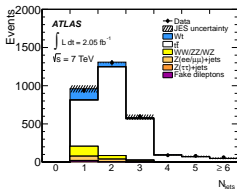- dominant systematics: b-tag (10%), Q^2 ($\sim$ 10%), generator model ($\sim$ 9%)

single-top: *Wt* associated production (26)

- event selection: = 2 OS leptons (e, μ) with $p_T \geq 25$ GeV, =1 jet, $E_T^{miss} > 50$ GeV, $m_{\ell\ell} < 81$ GeV, $m_{\ell\ell} > 101$ GeV, $\Delta\phi(\ell1, E_T^{miss}) + \Delta\phi(\ell2, E_T^{miss}) > 2.5$

- main backgrounds: $t\bar{t}$ and dibosons

- boosted decision trees discrimination

- measure *Wt* cross-section maximizing likelihood function:

$\sigma_{Wt}^{7 \text{ TeV}} = 16.8 \pm 2.9$ (stat) ± 4.9 (syst) pb   first evidence (3.3σ)

- dominant systematics: JES (16%), PS (15%), pileup (10%), generator (10%)

- determination of $|V_{tb}| = 1.03^{+0.16}_{-0.19}$ compatible with measurement from *t*-channel

single-top: *s* channel

0.70 fb^{-1}
ATLAS-CONF-2011-118

- pre-selection:

  $= 1\ell$ (e, μ) with $p_T \geq 25$ GeV; $= 2j$ with $p_T \geq 25$ GeV;
  $E_T^{miss} > 25$ GeV; $m_T^W > 60$ GeV - E_T^{miss}

- optimized ($S/\sqrt{B}$) cut-based analysis:

  # b-tagged jets, m_T^W, m_t, p_T^{j1j2}, $\Delta R_{j1,j2}$, $\Delta R_{j1,\ell}$

- main backgrounds: $t\bar{t}$ ($\sim 39\%$), W+jets ($\sim 34\%$)

- limit on *s*-channel cross-section maximizing likelihood function:

  $\sigma_{s-channel}^{7\ TeV} < 26.5$ pb at 95% CL (expected limit = 20.5 pb)

- dominant systematics:

  generator ($-60 + 20\%$), luminosity (50%), Multijets (40%)
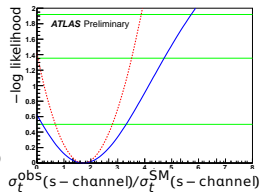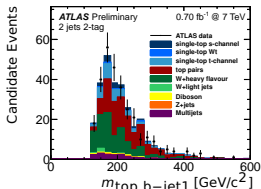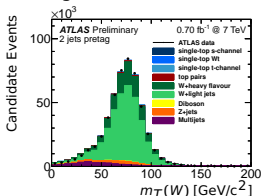
single-top: fcnc at production

ATLAS 2.05 fb^{-1}
PLB 712 (2012) 351–369

- FCNC decay $t \to qg$ is suppressed by GIM mechanism

SM	QS	2HDM	FC 2HDM	MSSM	R SUSY	TC2	RS
$\sim 10^{-12}$	$\sim 10^{-7}$	$\sim 10^{-4}$	$\sim 10^{-8}$	$\sim 10^{-5}$	$\sim 10^{-4}$	$\sim 10^{-4}$	$\sim 10^{-9}$

Acta Phys. Polon. B35 (2004) 2695–2710; Phys. Rev. D68 (2003) 015002; Phys. Rev. D 75 (2007) 015002

- search for FCNC at production by looking to direct top production
- same preselection of standard t-channel analysis
- NN with 11 variables (e.g. transv. momenta, masses, angles, etc. . .)
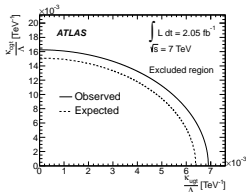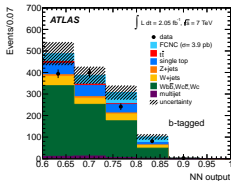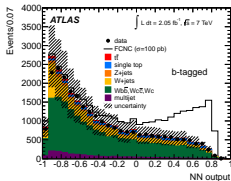
- no evidence for signal found; 95%CL limits derived with Bayesian binned likelihood

$BR(t \to ug) < 5.7 \times 10^{-5}$ $BR(t \to cg) < 2.7 \times 10^{-4}$ world's best limits

summary

- LHC is a top-quark factory

- top-pair production cross-sections measured by ATLAS and CMS at $\sqrt{s} = 7$ TeV and by CMS at $\sqrt{s} = 8$ TeV
- in agreement with SM predictions
- precision is comparable with theoretical predictions

- measured t-channel cross-section
- first evidence for Wt-associated production
- $|V_{tb}|$ measured in t- and Wt-channels in agreement with SM
- search for s-channel and direct top production via FCNC

- stay tuned for more 8 TeV results