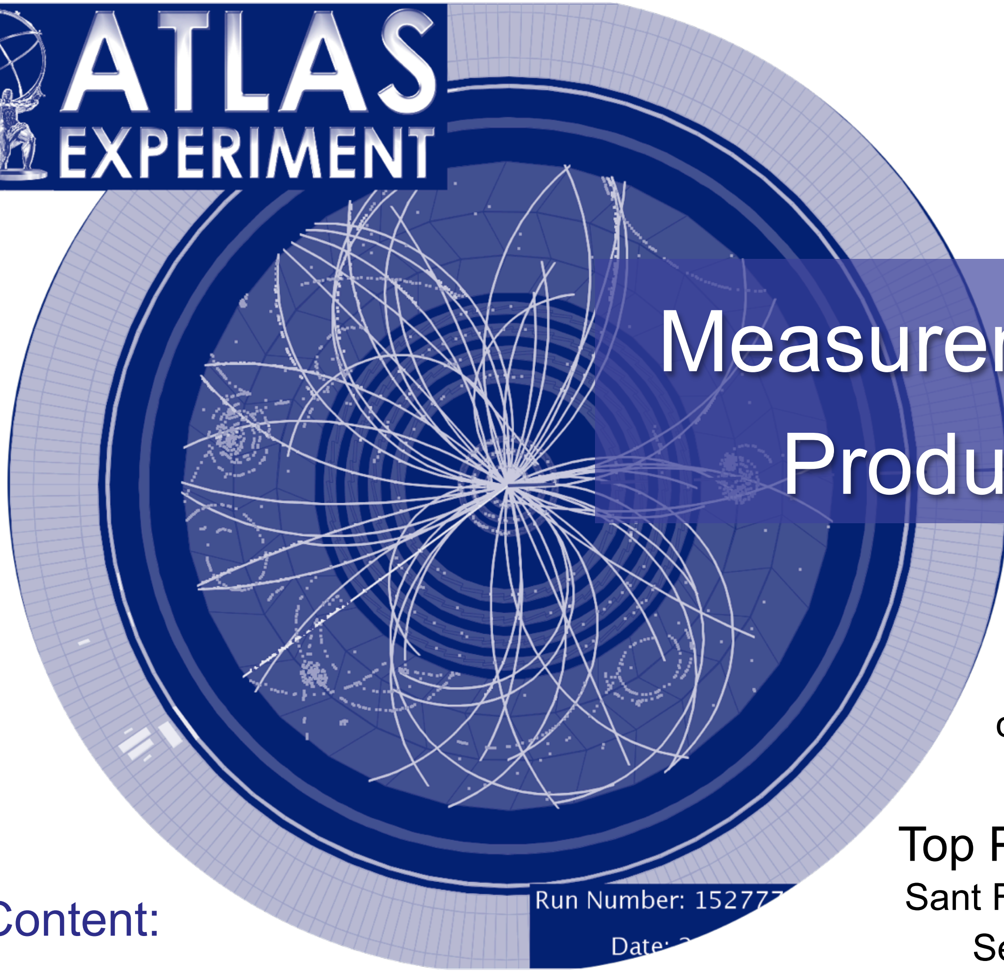
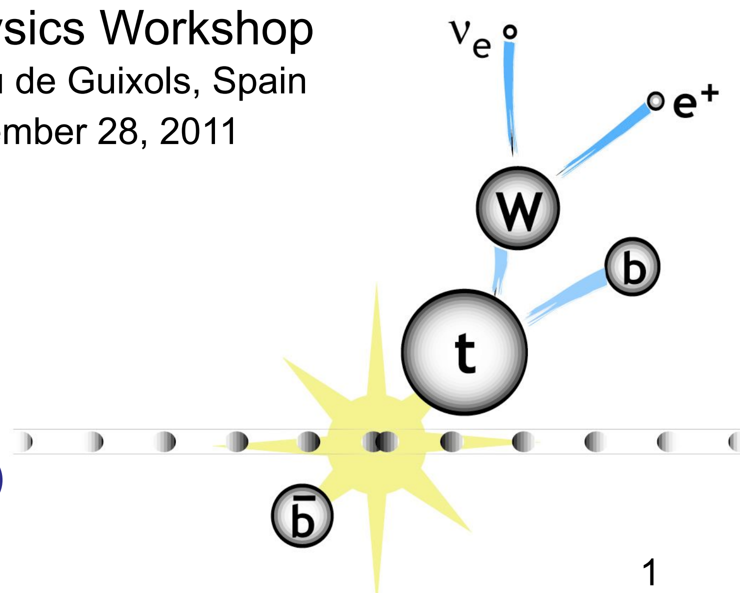


Measurements of Single-Top Production at the LHC

Wolfgang Wagner
Bergische Universität Wuppertal
on behalf of the ATLAS and CMS collaborations

Top Physics Workshop
Sant Feliu de Guixols, Spain
September 28, 2011



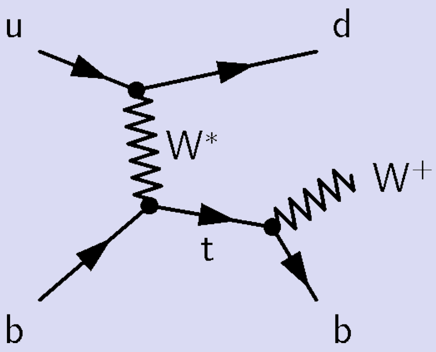
Content:

1) Introduction
2) t-channel measurements (ATLAS and CMS)
3) Wt searches (ATLAS and CMS)
4) Status of s-channel search (ATLAS)
5) Search for FCNC single-top production (ATLAS)
6) Summary

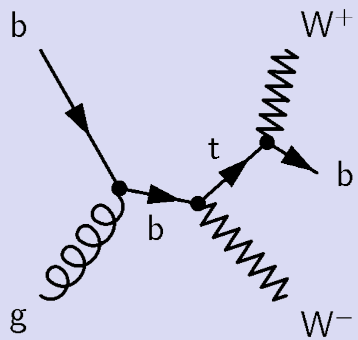
1) Introduction

top-quark production via the weak interaction.

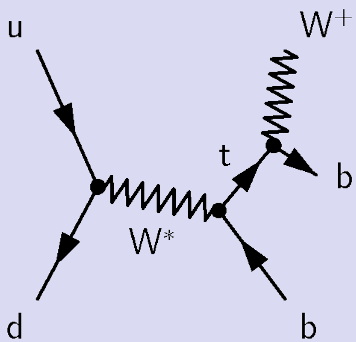
t-channel



associated Wt production



s-channel



cross sections at LHC with $\sqrt{s}$ = 7 TeV (m_t = 173 GeV)

64.2 ± 2.6 pb | 15.6 ± 1.3 pb | 4.6 ± 0.2 pb

cross sections at the Tevatron with $\sqrt{s}$ = 1.96 TeV (m_t = 173 GeV)

2.1 ± 0.1 pb | 0.25 ± 0.03 pb | 1.05 ± 0.05 pb

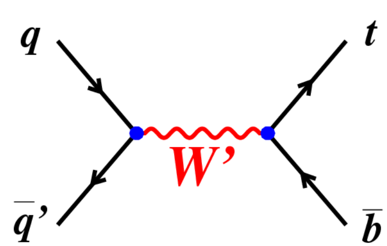
Calculations by N. Kidonakis: arXiv 1103.2792, 1005.4451, 1001.5034
at NLO + NNLL resummation ($NNLO_{approx}$)

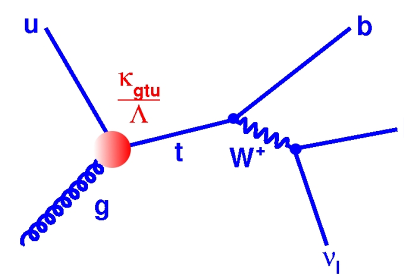
Why look for single top-quarks?

1. Test of the SM prediction.
   - Does it exist? ✔
   - Establish different channels separately.
   - Cross section ∝ $|V_{tb}|^2$
     Test unitarity of the CKM matrix, .e.g.
     Hints for existence of a 4th generation ?
   - Test of *b*-quark PDF: DGLAP evolution

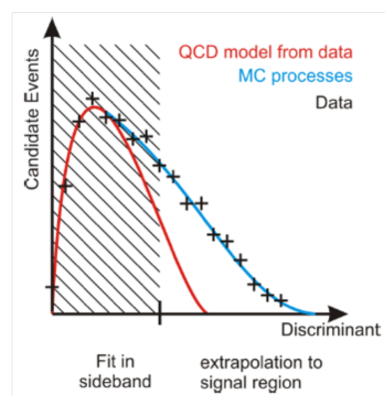
$$V_{ub}^2 + V_{cb}^2 + V_{tb}^2 \stackrel{?}{=} 1$$

2. Search for non-SM phenomena
   - Search W' or H^+ (Wt or s-chan. signature)
   - Search for FCNC, e.g. ug → t
   - …



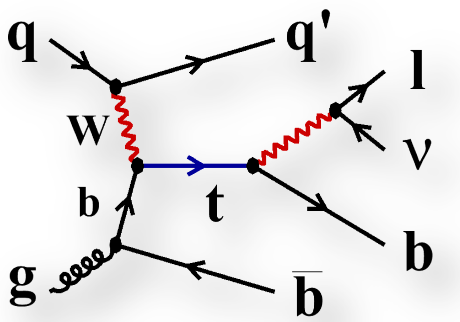


3. Single top as an experimental benchmark
   - Object identification: lepton fake rates, QCD background estimates, b-quark jet identification, …
   - Redo measurements of top properties in different environment, for example, M_{top}, W polarization in top decay, …



Overview of performed analyses

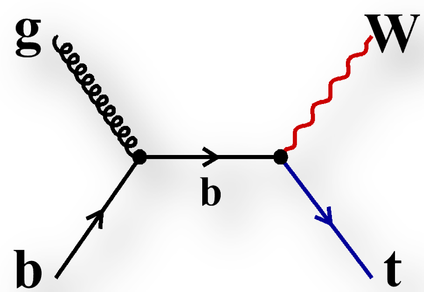
t channel



CMS
- 2D fit
- boosted decision tree

ATLAS
- cut-based
- neural network

Wt channel

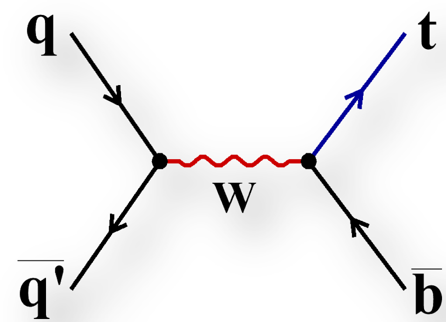


ATLAS: lepton+jets and dilepton channel: cut-based

CMS: dilepton channel

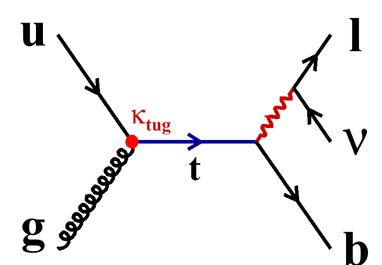
NEW
2.1 fb^{-1}

s channel



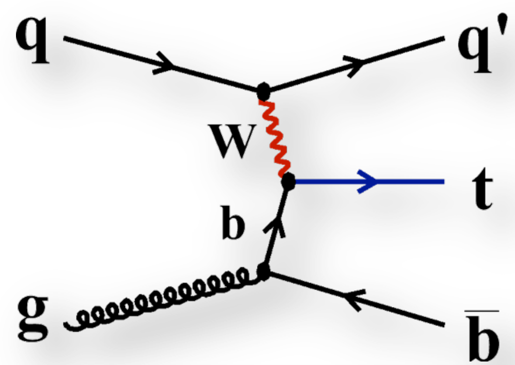
ATLAS: cut-based

FCNC search



ATLAS: neural network

2) t-channel analyses: documentation



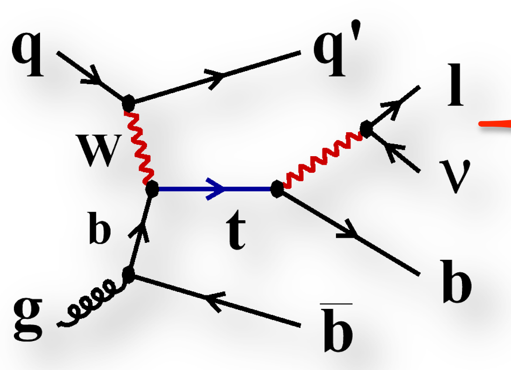
- Largest cross section of single-top processes
- Improved S/B ratio (≈10%) compared to Tevatron (≈7%)

Journal paper with 36 pb^{-1} (3.7 σ)
arXiv:1106.3052 [hep-ex], CMS-PAS-TOP-10-008, CERN-PH-EP-2011-066

Analysis history at ATLAS

- CONF note (Moriond) with 35 pb^{-1} (1.6 σ), ATLAS-CONF-2011-027
- CONF note (PLHC) with 156 pb^{-1} (6.2 σ), ATLAS-CONF-2011-088
- CONF note (EPS) with 0.70 fb^{-1} (7.6 σ), ATLAS-CONF-2011-101

t channel event selection: leptonic W decay

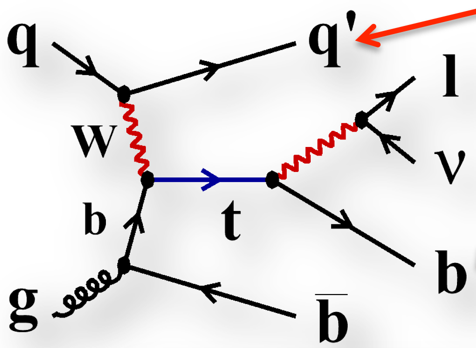


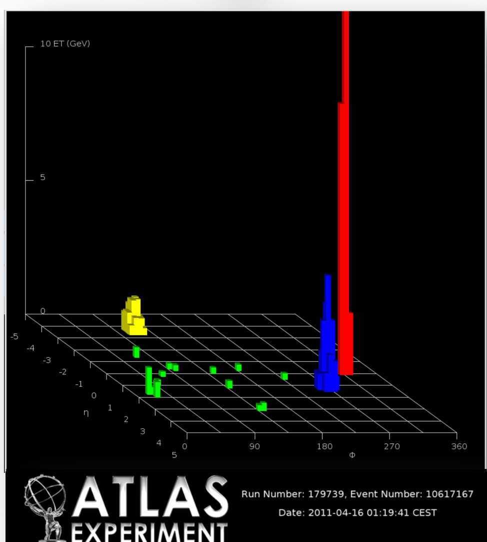
- Select only events with leptonic W decays, to suppress QCD-multijets background.
- Some acceptance due to $W \rightarrow \tau\nu$ decays.

- Data sets defined by single lepton (e / μ) trigger
- Charged lepton selection (electron / muon):
  - ATLAS: $p_T > 25$ GeV, CMS: $p_T(\mu) > 20$ GeV, $E_T(e) > 30$ GeV
  - ATLAS: $|\eta(\mu, e)| < 2.5$, CMS: $|\eta(e)| < 2.5$, $|\eta(\mu)| < 2.1$
  - Relative isolation
- Missing transverse energy (ATLAS only)
  - $E_T^{miss} > 25$ GeV
- QCD multijet veto
  - ATLAS: $M_T(W) > 60\text{ GeV} - E_t^{miss}$
  - CMS: $M_T(W \rightarrow e\nu) > 50$ GeV, $M_T(W \rightarrow \mu\nu) > 40$ GeV

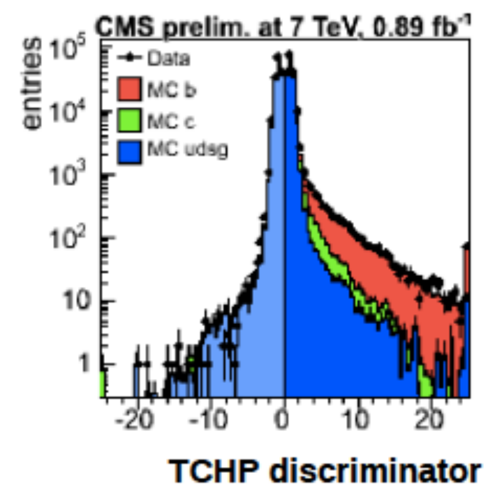
t channel event selection: jets

Measurement of forward jets is crucial to t-channel analyses.





- Jet definition
  - Anti-k_T algorithm (ATLAS) R=0.4, (CMS) R=0.5 (particle flow)
  - (ATLAS) p_T > 25 GeV, (CMS) p_T > 30 GeV
  - $|\eta|$ < 4.5, $|\eta|$ < 5.0
- b quark jet identification
  - (ATLAS) Exactly one secondary vertex tag (in 95% of all 2 jets events the b quark jet from top decay is tagged)
  - (CMS) 2D analysis: veto events with loosely tagged 2nd jet
  - (CMS) BDT analysis: ≥ 1 b tagged jet
- Number of jets
  - (CMS) : 2
  - (ATLAS) NN analysis : 2
  - cut based: 2 & 3

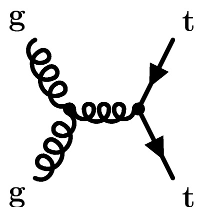


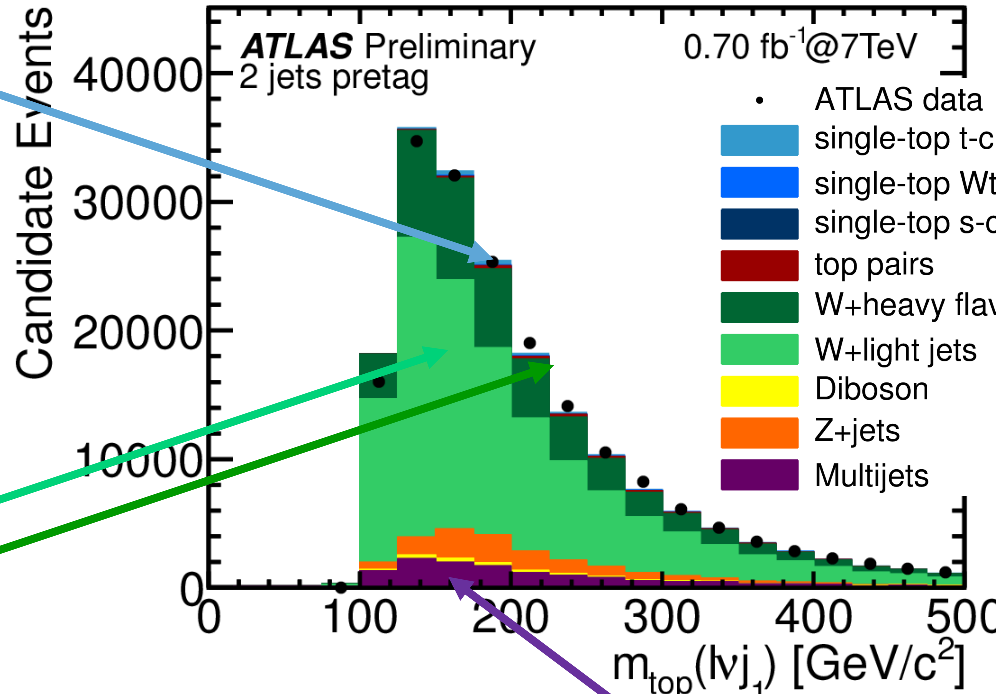
➔ see also talk by Ford Garberson on Monday, session II

Background processes (before b-tagging)

single top t-channel (~1%)

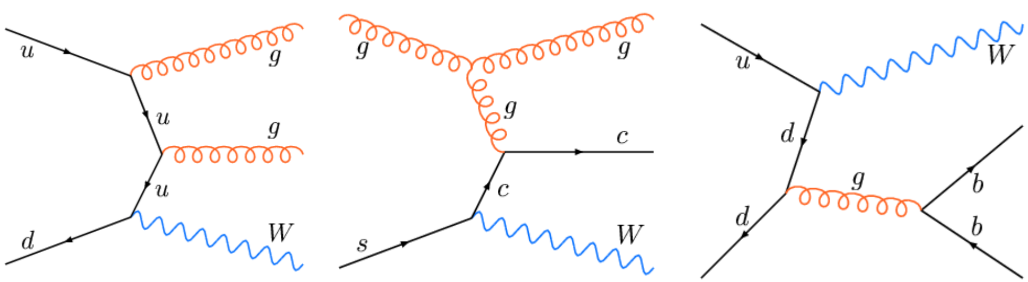
top-antitop pair production (~1%)



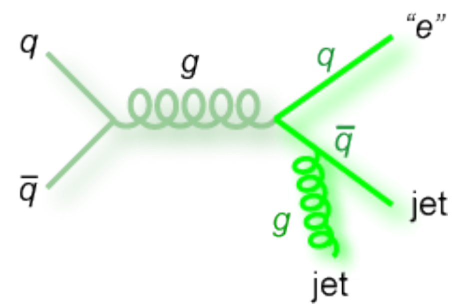


main background: W+jets
with several components:

W + light jets (55 – 65%)
W + charm jets (~20%)
W + bottom jets (2 – 3%)



QCD multijets (fake lepton)
background (5 – 10%)



Background estimation - strategy

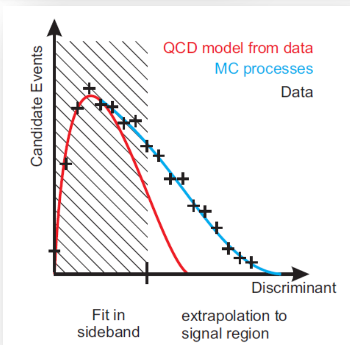
Monte Carlo based backgrounds

Top-antitop pairs, Wt, s-channel, diboson, Z+jets

- MC normalized to theoretical (or measured) cross-section
- Acceptance / efficiency obtained by Monte Carlo

$$N^{\rm pred} = \sigma^{\rm theo} \epsilon_{\rm evt} \int \mathcal{L}\, dt \qquad \epsilon_{\rm evt} = \epsilon_{\rm evt}^{\rm MC} \cdot \epsilon_{\rm BR} \cdot \epsilon_{\rm corr} \cdot \epsilon_{\rm trigger}$$

QCD multijets background



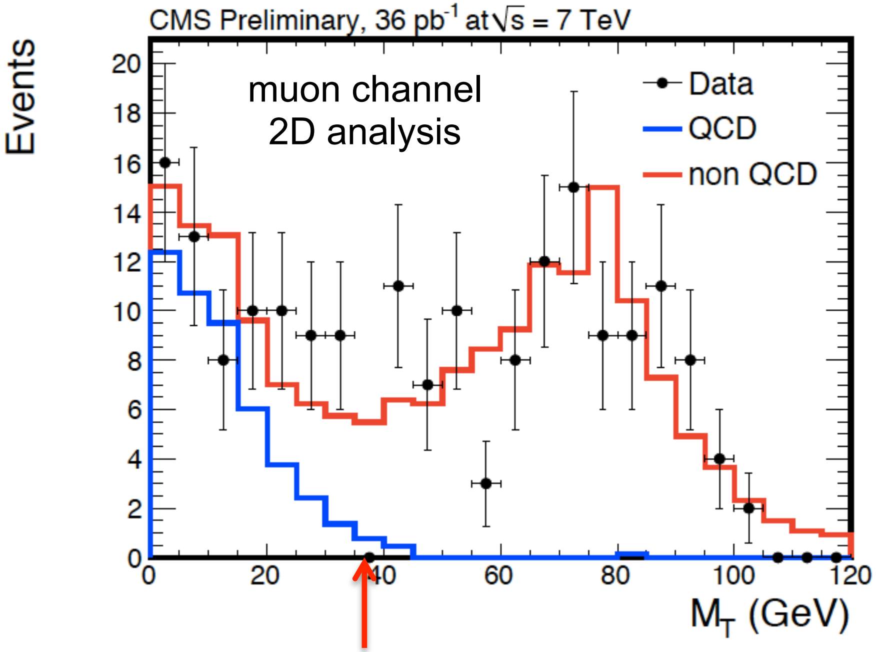
- instrumental background ➔ reliable estimation only from data
- reduce as much as possible ➔ QCD veto
- fit discriminant; ATLAS: E_t^{miss} , CMS: M_T (W)
- data driven event model for multivariate methods: jet-electron model (ATLAS), inverted isolation sample (CMS)

W+jets

- Alpgen (ATLAS) or MadGraph (CMS) LO+LL prediction • data driven scale factors

Multijet background estimate

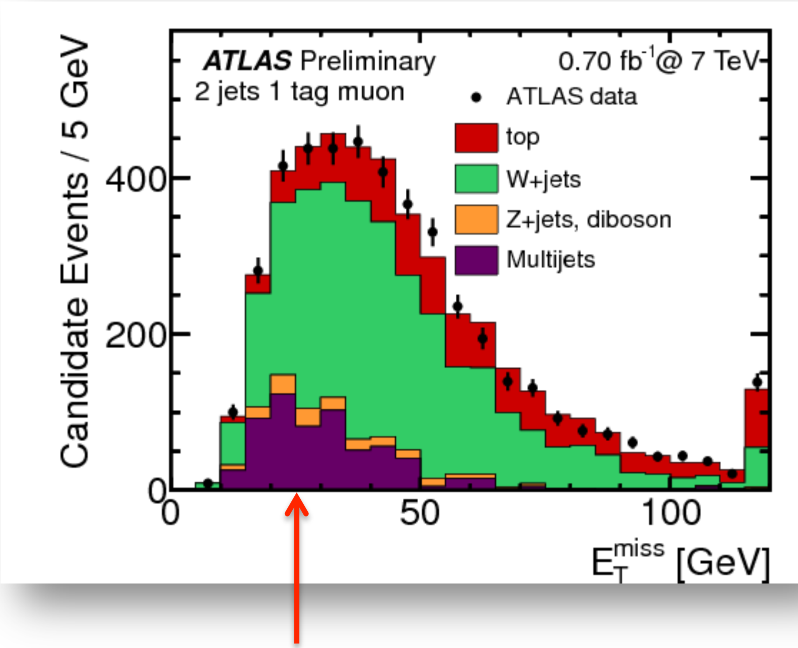
CMS: fit M_T (W)



QCD veto cut

- Reduction of multijets background to 1 – 8%.
- Systematic uncertainties:
  - ±50% muon channel
  - ±100% electron channel

ATLAS: fit E_t^{miss}



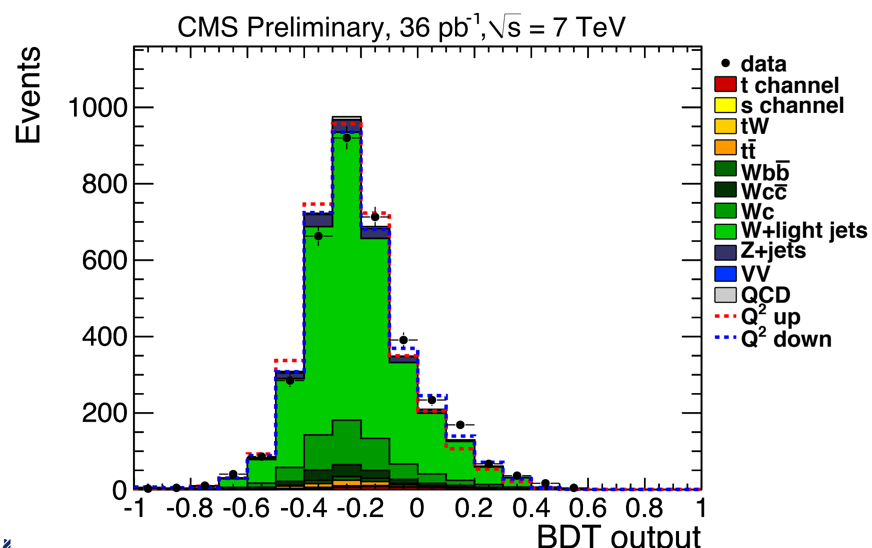
cut value

- jet-electron model works also well for muons
- Fraction of multijets background: 5 – 10%
- Systematic uncertainty: ± 50%

W + jets background estimate

CMS

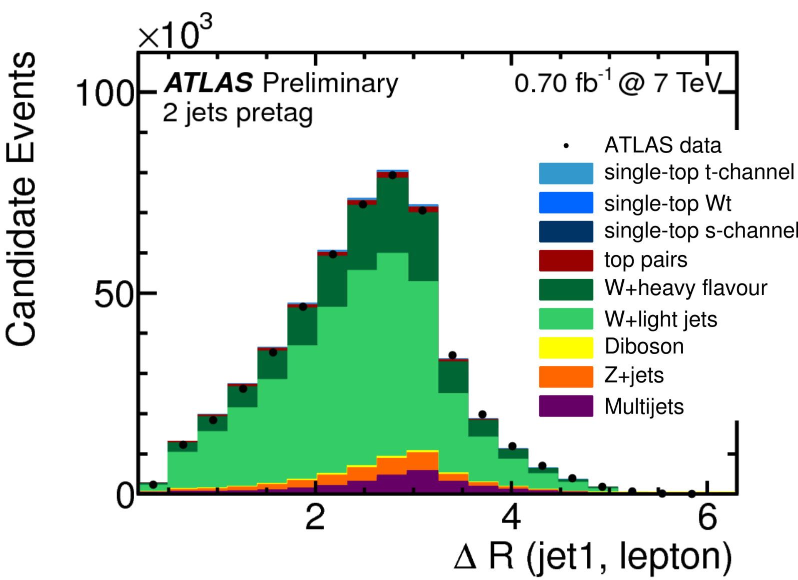
- W + cc, W + bb:
  scale LO prediction by $k_{HF} = 2 \pm 1$,
  (based on top-pair cross section analysis arXiv:1108.3773)
- W + light jets:
  - BDT: scale to NNLO prediction
  - 2D analysis: use control samples without and with loose b-tag



ATLAS

a) Cut based analysis
Calculate scale factors $k_{cc/bb}$, k_{Wc}, k_{light} based on event yield in 1-jet and 2-jet tagged sideband and 2-jet pretagged data set

b) NN analysis
Fit NN output for single-top and backgrounds simultaneously



Overall ALPGEN and Madgraph models work quite well within uncertainties.

Systematic uncertainties: background rates

- Theoretical cross-section uncertainties

Process	ATLAS	CMS
s-channel	± 14%	± 30%
Wt	± 14%	± 30%
top-antitop	+9.5 / -6.9%	± 14% (CMS measurement)
diboson	± 5%	
Z+jets *	± 60%	± 30%

*includes Berends scaling and HF uncertainty

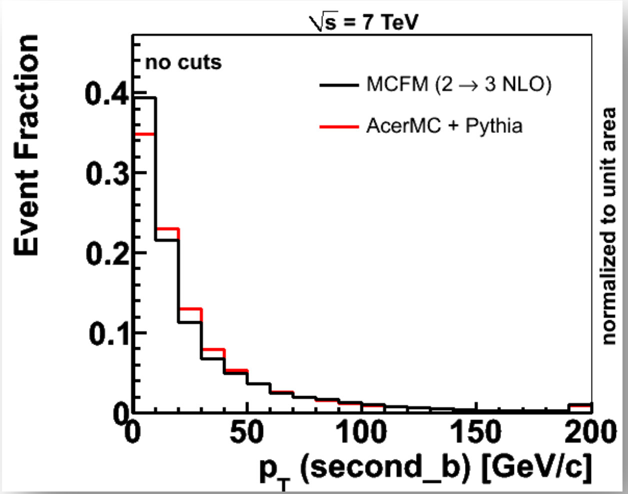
- W + jets and multijets normalization to data

Process	ATLAS	CMS
QCD (electron)	± 50%	± 100% (BDT), +130 / -100% (2D)
QCD(muon)	± 50%	± 50%
W + light jets	± 33%	± 50% (BDT), ± 30% (2D μ), ±20% (2D e)
W + bbbar, W + cbar	± 61%	± 50%
W + c	± 27%	+100 / -50%

Uncertainties on object and kinematic modeling

- Detector simulation and object modeling
  - Jet energy scale, jet energy resolution (ATLAS)
  - MET unclustered energy (CMS)
  - Leptons: trigger, identification efficiencies, energy scale , lepton energy resolution
  - B-tagging / mistag scale factor uncertainty

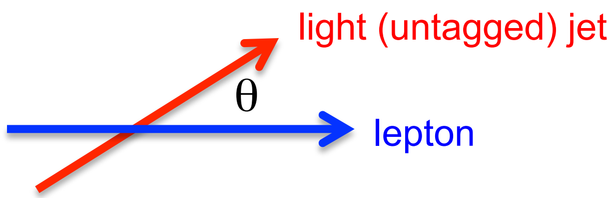
- Monte Carlo generators
  - ISR / FSR
  - t-channel (ATLAS): MCFM vs. AcerMC →
  - t-channel (CMS): MadGraph vs. SingleTop
  - ttbar (ATLAS): MC@NLO vs. Powheg
  - Ttbar (CMS): Q^2 scale
  - PDF: CTEQ6.6 vs MSTW08
  - Q^2 scale for W+jets
  - Pile-up modeling



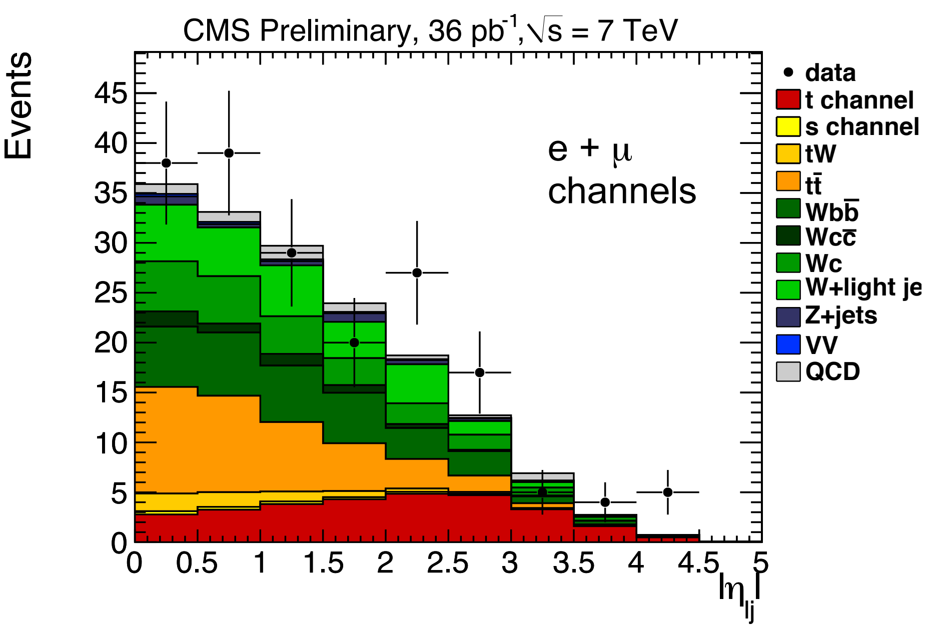
- Luminosity
  - ATLAS: 4.5%
  - CMS: 4%

t-Channel Cross Section at CMS

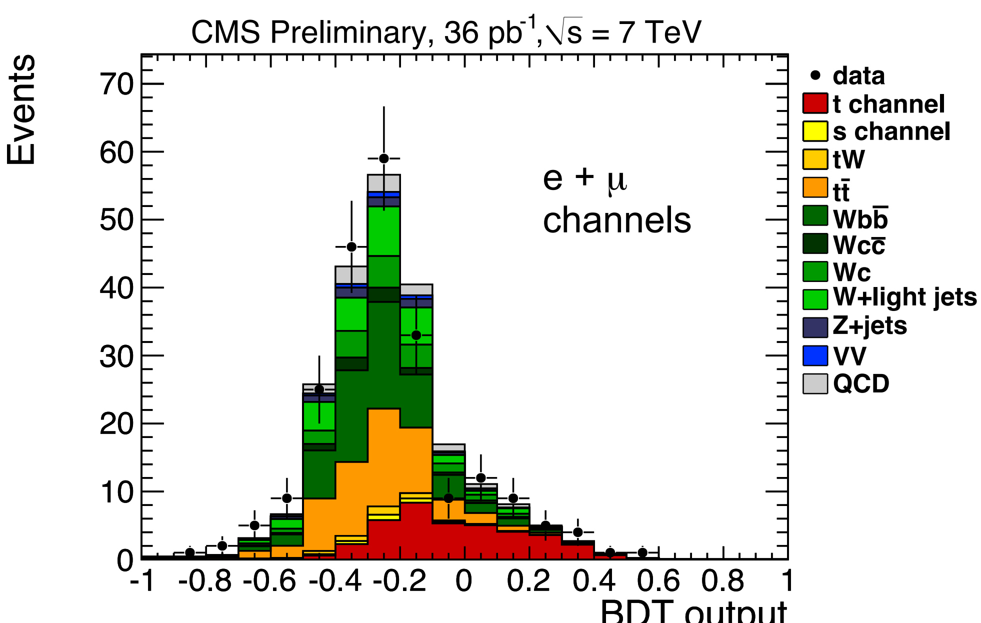
- 2D-analysis:
  |η(light jet)| vs.
  polarisation angle cos θ (light jet, lepton)$_{\text{top r.f.}}$



- Boosted decision tree analysis
- Combine 37 variables in one discriminator
- Bayesian approach for signal extraction
- All uncertainties are parameterized in the likelihood function.
- Nuisance parameters are marginalized.



Significance: 2.1σ expected, 3.7σ observed



Significance: 2.9σ expected, 3.5σ observed

Cross Section Combination at CMS

- χ^2 combination of two analyses results
- Statistical correlation: 51% (pseudo exp.)
- Systematic uncertainties assumed to be 100% correlated.
- arXiv:1106.3052 [hep-ex]

σ (t-ch.) = 84 ± 30 pb

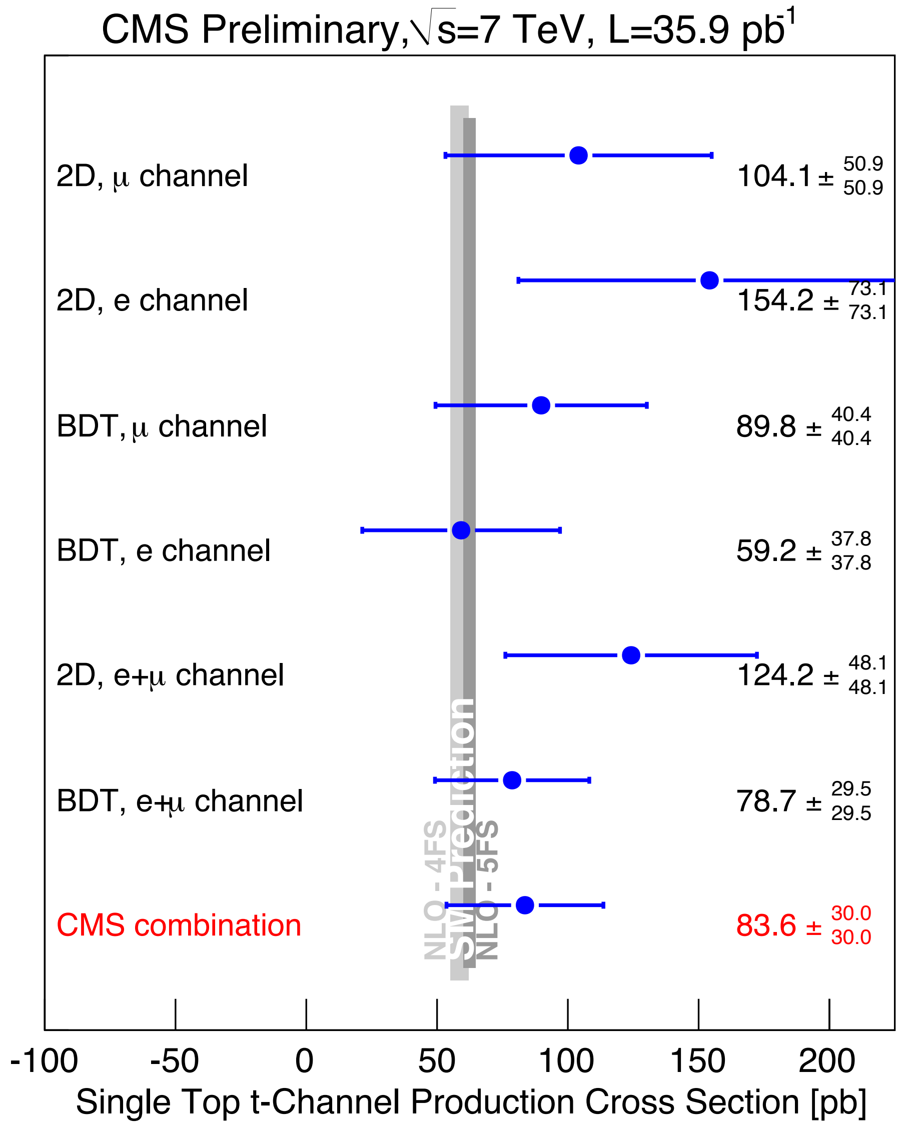
- Extraction of $|V_{tb}|$:

$$|V_{tb}| = \sqrt{\frac{\sigma^{exp}}{\sigma^{th}}} = 1.16 \pm 0.22(exp) \pm 0.02(th)$$

using $\sigma^{th} = 62.3^{+2.3}_{-2.4}$ pb

NLO prediction in the 5-flavour scheme, Campbell, Frederix, Maltoni, JHEP 10 (2009) 042.

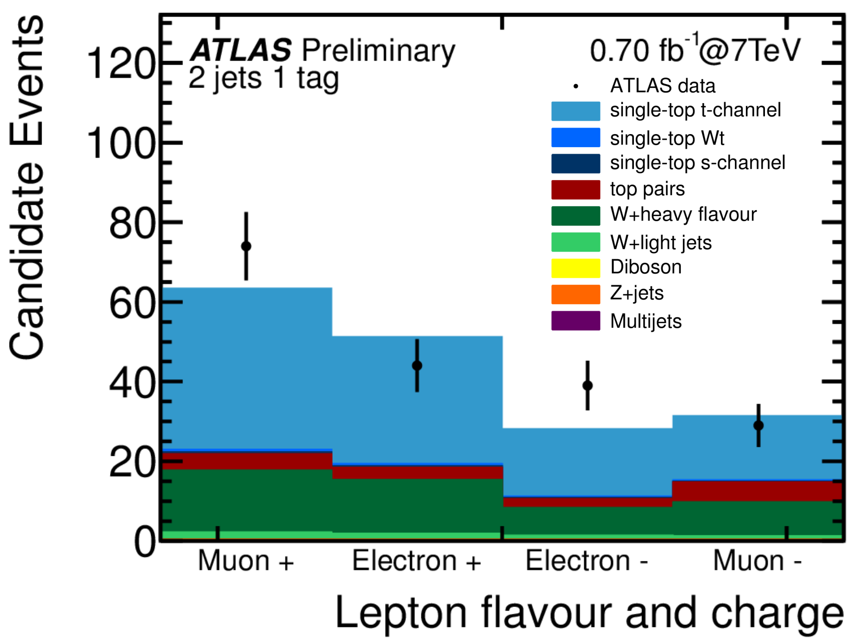
Assumption: $|V_{td}|, |V_{ts}| << |V_{tb}|$



Cut-based analysis at ATLAS

Cut	Value
H_T	> 210 GeV
$M_{l\nu b}$	> 150 GeV & < 190 GeV
$\lvert\eta(\text{light jet})\rvert$	> 2.0
$\lvert\Delta\eta(j_1,j_2)\rvert$	> 1

- Cuts are optimized including systematics
  ➔ strong reduction of jet energy scale uncertainty
- Counting experiment
- Uses 2 and 3-jet channels
- Separation in channels lepton charge and flavor
  ➔ optimize statistical power
- Statistical method: profile likelihood fit



measured cross section:

$\sigma(\text{t-ch}) = 90 \pm 9\ (\text{stat.})\ ^{+31}_{-20}\ (\text{syst.})$ pb

Observed significance 7.6 σ
(expected: 5.4σ)

SM: $\sigma_t = 64.2 \pm 2.6$ pb

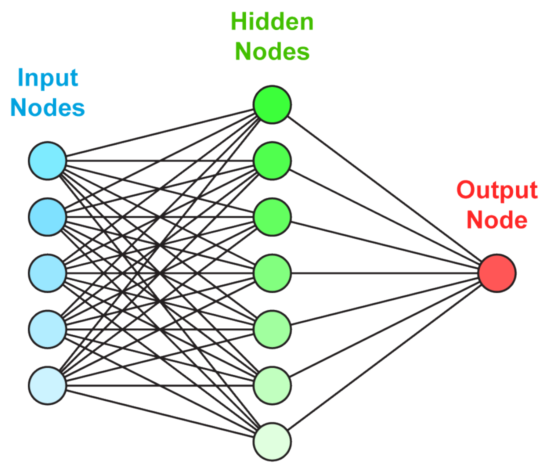
Dominating syst. uncertainties:

- B-tagging: +18 / -13%
- ISR / FSR: ± 14%

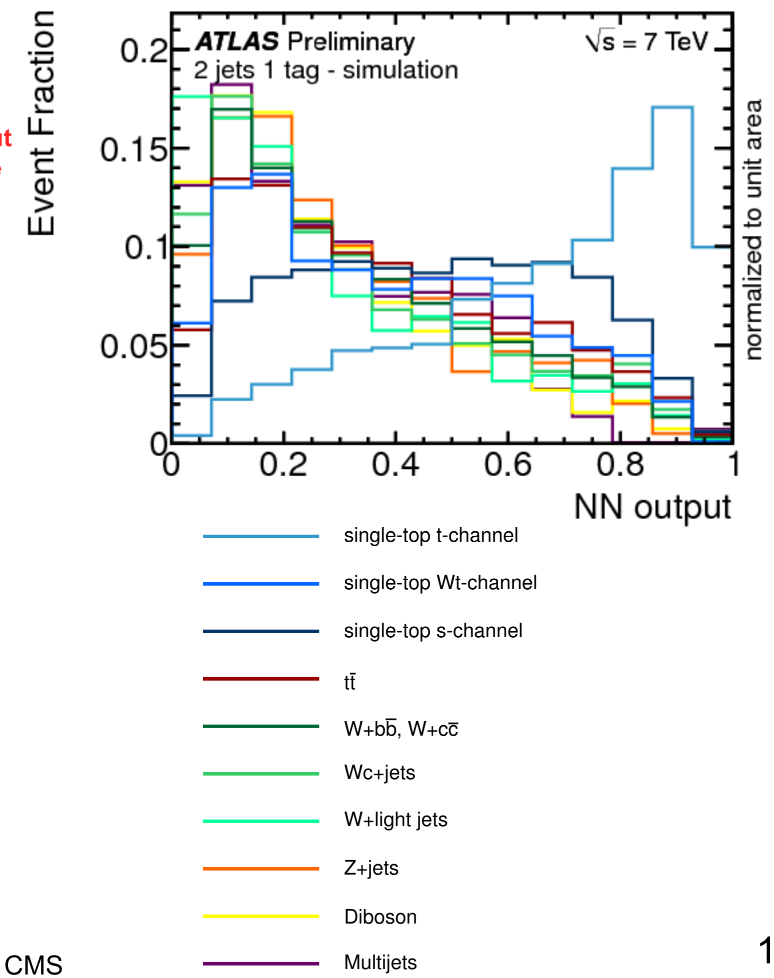
Neural network analysis

Idea: Combine many variables including correlations in one discriminate

Variable	Significance (σ)
$m(\ell\nu b)$	158.36
$\lvert\eta(j_l)\rvert$	119.68
$E_{\mathrm{T}}(j_l)$	82.19
$\Delta\eta(j_1, j_2)$	52.36
$\lvert\Delta\eta(b, \ell\nu)\rvert$	51.93
$p_{\mathrm{T}}(\ell)$	53.39
$m(b)$	40.88
$\eta(\ell)$	38.55
$m_{\mathrm{T}}(W)$	32.62
$E_{\mathrm{T}}^{\mathrm{miss}}$	31.24
$q(\ell)$	25.83
$m(j_1 j_2)$	18.18
H_{T}	14.60

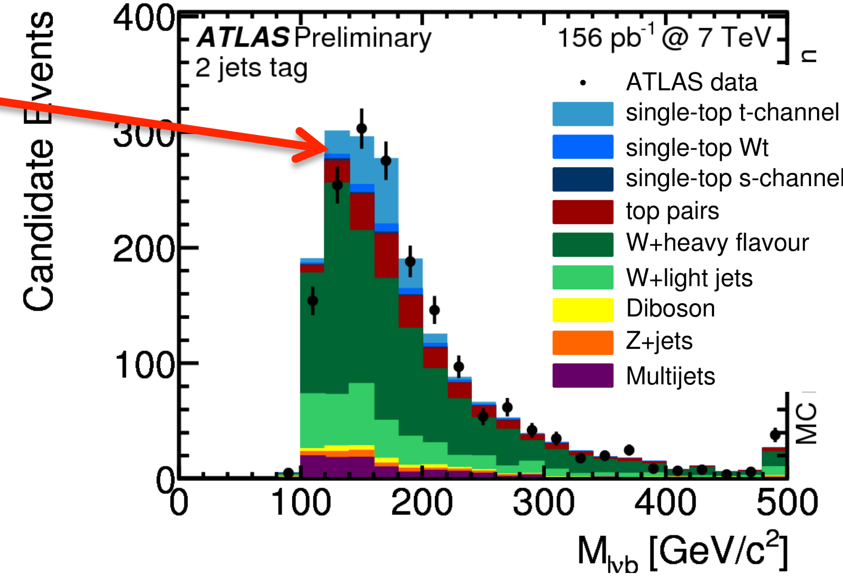


13 input variables
33 nodes in hidden layer



t-channel neural network analysis at ATLAS

- Signal already well visible in $M_{l\nu b}$
- 13 input variables
- Training: 50% signal, 50% background.
- Maximum likelihood fit to NN output distribution.
  ➔ simultaneous determination of background rates
- Frequentist method to estimate systematic uncertainties.



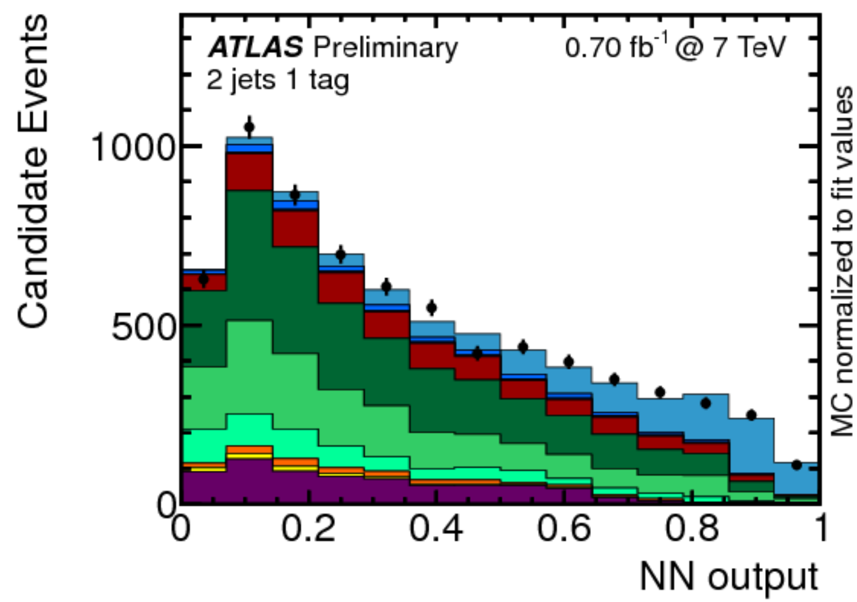
Observed cross section:

σ (t-ch.) = 105 ± 7 (stat.) $^{+36}_{-30}$ (syst.) pb

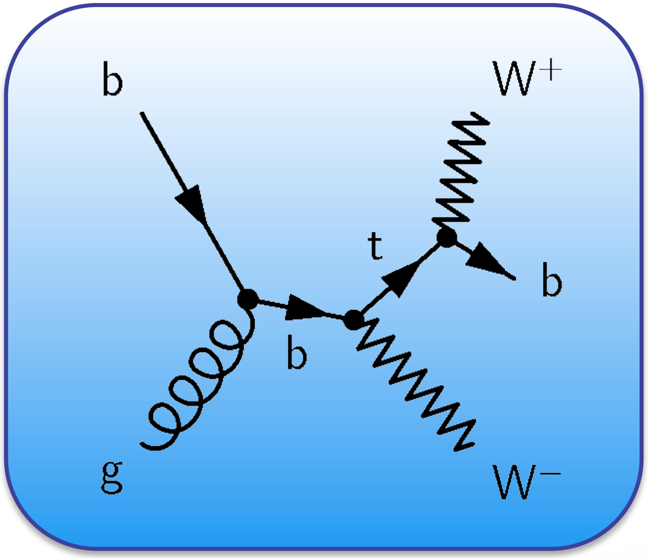
SM: σ_t = 64.2 ± 2.6 pb

Dominating syst. uncertainties:

- Jet energy scale: +32 / -20%
- B-tagging: ±13%
- ISR / FSR: ± 13%



3) Wt analyses



Two channels according to W decay modes:

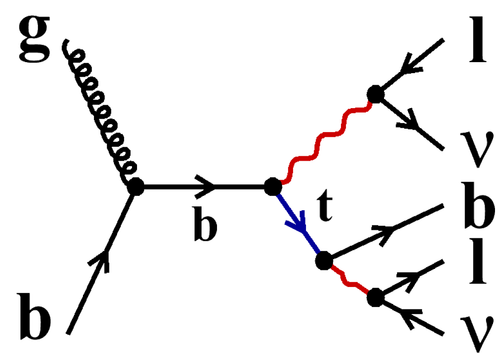
1) Dilepton channel
   both W: $W \to e\nu$ or $W \to \mu\nu$
   ➔ 2 charged leptons, E_T^{miss}, 1 b-jet

2) Lepton + jets channel
   $W \to e\nu$ or $W \to \mu\nu$ + $W \to$ qqbar
   ➔ 1 charged lepton, E_T^{miss}, 3 jets

- CONF note with 35 pb^{-1} (Moriond)
  ATLAS-CONF-2011-027
- CONF note with 0.70 fb^{-1} (EPS)
  ATLAS-CONF-2011-104
- Physics Analysis Summary (TOP2011)
  CMS PAS TOP-11-022

Event selection in the dilepton channel

- Lepton selection (electron / muon):
  - p_T > 25 GeV (ATLAS), p_T > 20 GeV (CMS)
  - $|\eta| < 2.5$
  - Relative Isolation
  - Exactly two leptons (ee / $\mu\mu$ / eμ)
    CMS: loose additional lepton veto



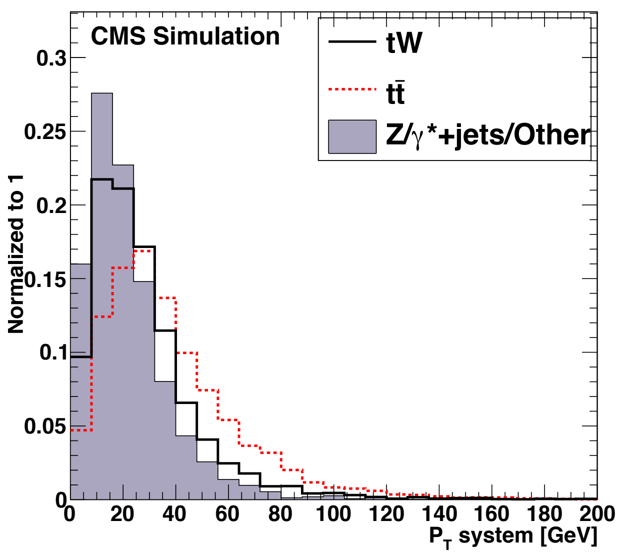
- Jets
  - p_T > 30 GeV
  - ATLAS: $|\eta| < 2.5$, CMS: $|\eta| < 2.4$
  - Exactly one jet. ATLAS: No b- tagging!
    CMS: with b-tag and b-tag veto ("loose" jets)

- Kinematic selection at CMS
  eμ channel: H_T > 160 GeV,
  p_T(lljν=system) < 60 GeV

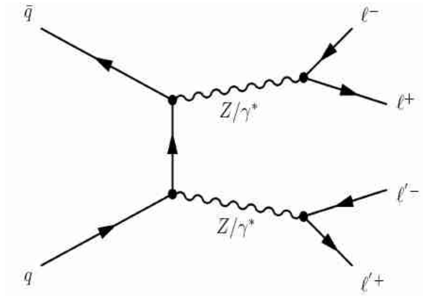
- Missing transverse energy
  - E_T^{miss} > 50 GeV (ATLAS), 30 GeV (CMS, ee/$\mu\mu$)

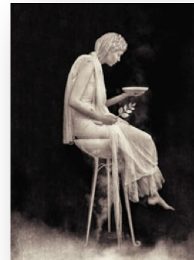
- Z-mass veto (ee/$\mu\mu$ –channel)
  - |M(ll)-M(Z)| > 10 GeV, CMS: M(ll) > 20 GeV

- $Z \rightarrow \tau\tau$ veto (ATLAS)
  - $\Delta\Phi(l_1, E_t^{miss}) + \Delta\Phi(l_1, E_t^{miss}) > 2.5$



diboson
WW / WZ / ZZ

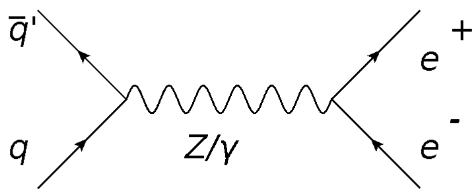


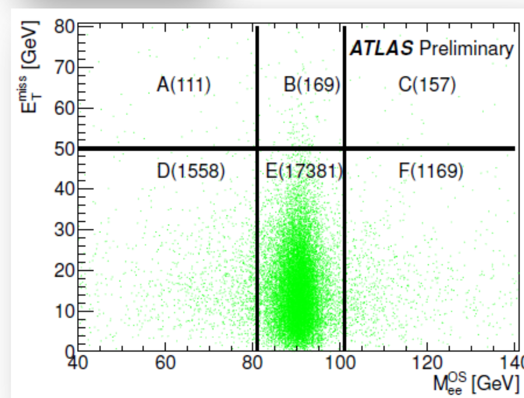


Monte Carlo based

$$N^{\text{pred}} = \sigma^{\text{theo}} \epsilon_{\text{evt}} \int \mathcal{L}\, dt$$

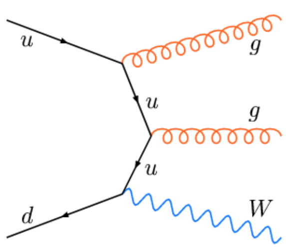
Drell-Yan
$Z/\gamma \rightarrow ll$





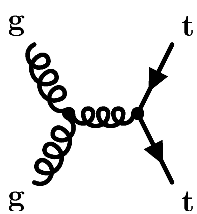
ABCD method
➔ talk by Joanne Cole

W + jets
(lepton fakes)



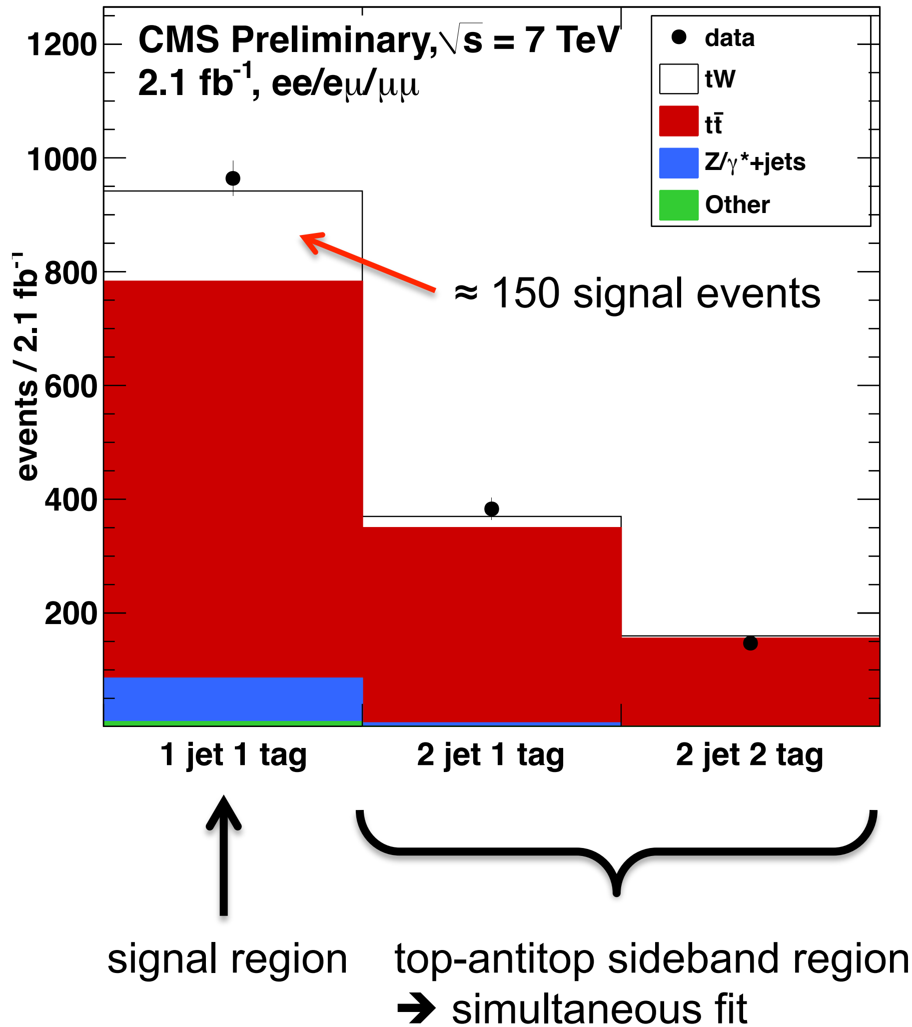
matrix method (ATLAS)
➔ see talk by Jörgen Sjölin on Monday, Session III

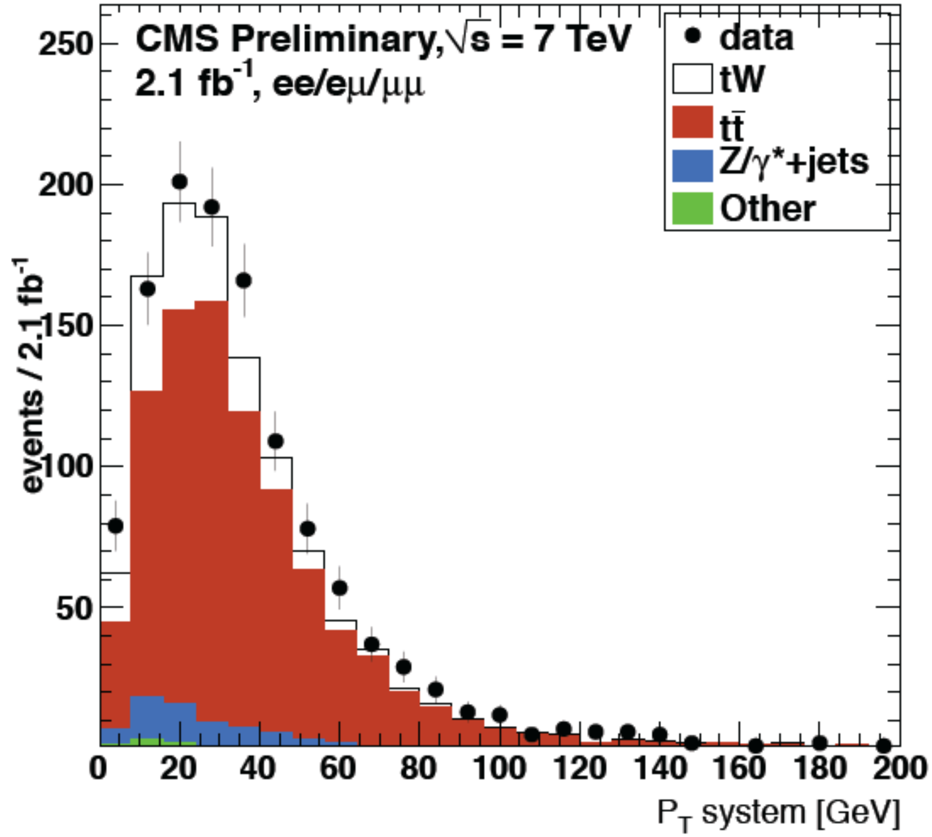
top-antitop
dilepton channel



normalization in W + 2 or more jets side band
CMS: exclusive W + 2 jets sample

Top-antitop background and kinematic modeling





(similar technique in ATLAS)

Good agreement with expected jet multiplicity distribution and kinematic distributions.

Wt dilepton analyses' results

Final event yield for 2.1 fb-1 at CMS:

process	ee channel	$e\mu$ channel	$\mu\mu$ channel
Signal region (1jet, 1tag)			
tW	24.7 ± 0.9	88 ± 2	39 ± 1
$t\bar{t}$	110 ± 4	372 ± 8	174 ± 5
Z/γ^{*}(data-driven)	20.7 ± 3.9	10 ± 2	45.7 ± 6.1
other	1.0 ± 0.2	5 ± 1	2.1 ± 0.2
all background	132 ± 4	387 ± 9	222 ± 8
data	149	539	276

- Observed significance: 2.7σ (1.8σ expected)
- Observed cross section:

$\sigma_{Wt} = 22\ ^{+9}_{-7}$ (stat.+ syst.) pb

SM: $\sigma_{Wt} = 15.6 \pm 1.3$ pb

Event yield after final selection ($N_{jet} = 1$):

Processs	ee	μμ	eμ
Wt	8.6 ± 1.6	11.9 ± 1.7	26.6 ± 2.5
top-antitop	31.8 ± 4.5	48.0 ± 7.0	104.7 ± 15.2
diboson	7.8 ± 1.3	12.1 ± 1.6	17.3 ± 1.8
Drell Yan	6.7 ± 1.4	8.9 ± 2.2	4.0 ± 1.0
Fake lepton	2.3 ± 1.2	0.0 ± 0.6	1.5 ± 0.8
Total expected	57.2 ± 5.1	82.1 ± 7.3	154 ± 15.4
observed	**62**	**73**	**152**

Observed cross section (significance 1.2σ):

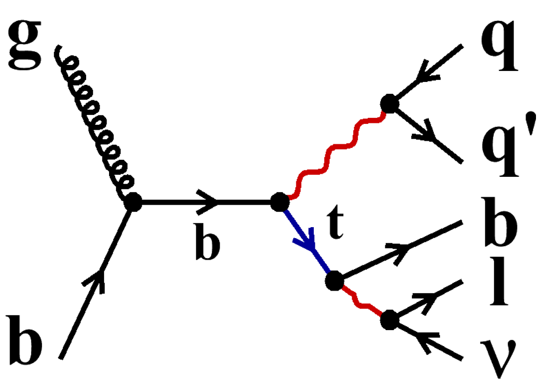
$\sigma_{Wt} = 14.4\ ^{+5.3}_{-5.1}$ (stat.) $^{+9.7}_{-9.4}$ pb

Observed limit @ 95% C.L.
$\sigma_{Wt} < 39.1$ pb

Significances are determined with maximum likelihood ratio:

$$\lambda = \frac{\max_{\beta,\delta_u} L(\beta,\delta_u)}{\max_{\delta_u} L(\beta=0,\delta_u)}$$

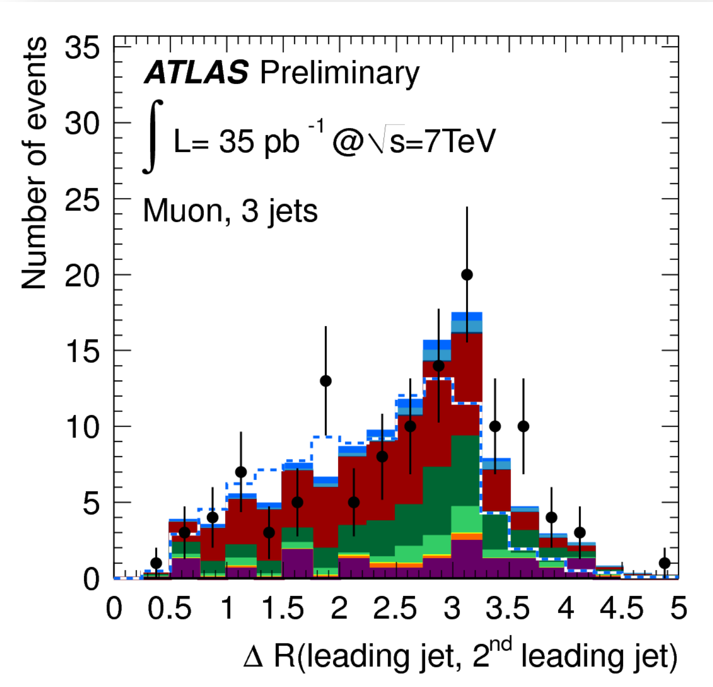
Wt lepton + jets channel



Experimental signature:

- Isolated charged lepton
- Missing transverse energy
- Three high-p_T jets

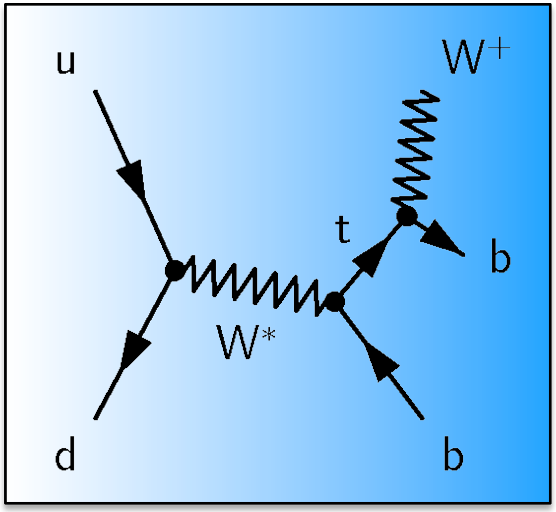
➔ Event selection very similar to t-channel analysis, same background estimation strategy



Analysis of 2010 data with 35 pb^{-1}

- ATLAS-CONF-2011-27 (Moriond 2011)
- Obtain S/B = 4 – 6%
- Dilepton and lepton+jets channel were combined:
  observed limit at the 95% C.L.:
  σ (Wt) < 158 pb
- Multivariate analyses are in preparation.

4) Search for s-channel production



- Smallest cross section of all single-top processes. (antiquarks in the initial state needed)
- Signature similar to t-channel, but:
  - No forward jet.
  - Two central b-quark jets.
  - Jet definition uses: $|\eta| < 2.5$.
  - Use double tagged events.
- First s-channel analysis at ATLAS using 0.70 fb^{-1}.

ATLAS-CONF-2011-118

Cut-based analysis

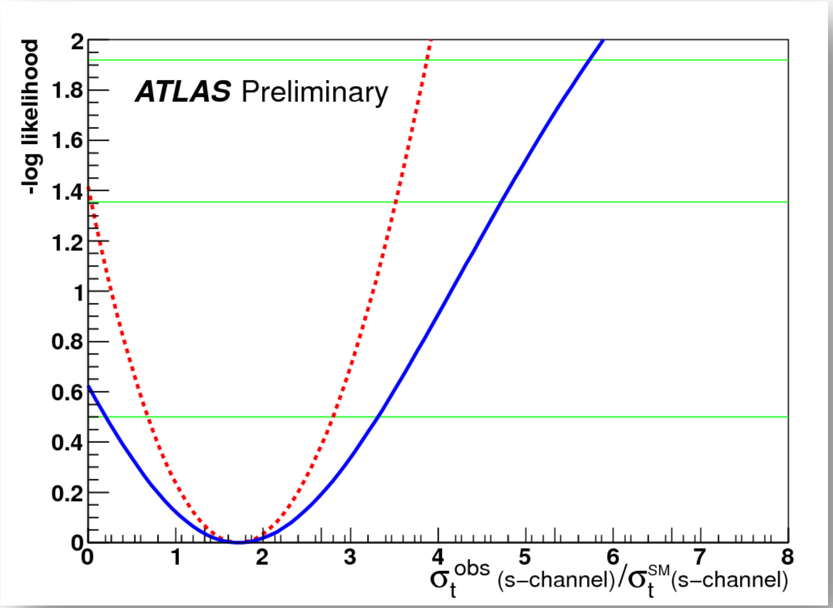
Selection	Signal	Background	$S/\sqrt{B}$
Preselection Only	104	153802	0.26
Number of tagged jets=2	18	415	0.88
$30 < m_{top,jet2} < 247$ GeV/c^2	17	349	0.91
$p_T(jet1, jet2) < 189$ GeV/c	17	346	0.91
$m_T(W) < 111$ GeV/c	17	318	0.95
$0.43 < \Delta R(b-jet1, lepton) < 3.6$	17	308	0.97
$123 < m_{top,jet1} < 788$ GeV/c^2	17	302	0.98
$0.74 < \Delta R(b-jet1, b-jet2) < 4.68$	16	269	0.98

Limit on s-channel production

Event yield after final selection:

	Final Selection
s-channel	16 ± 6
t-channel	33 ± 13
Wt	5 ± 3
$t\bar{t}$	111 ± 47
W+jets	4 ± 5
Wc+jets	10 ± 8
$Wc\bar{c}$+jets	14 ± 12
$Wb\bar{b}$+jets	70 ± 51
Z+jets	1 ± 1
Diboson	4 ± 1
Multijets	17 ± 10
TOTAL Exp	285 ± 17
$S/\sqrt{B}$	0.98
DATA	296

Statistical analysis: Profile likelihood



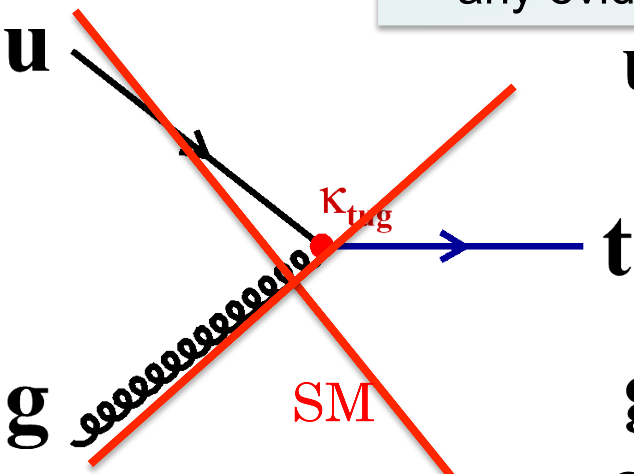
Observed limit @ the 95% C.L.:

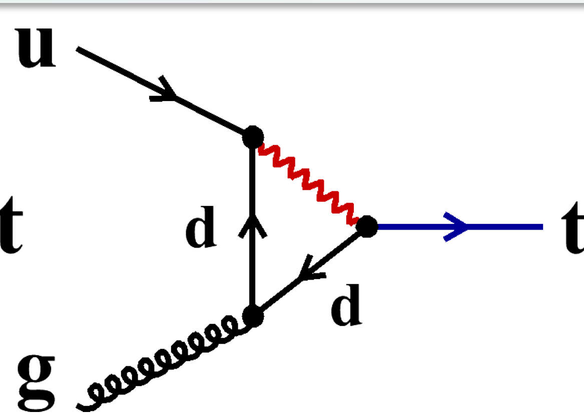
$\sigma_{s\text{-channel}}$ < 26.5 pb

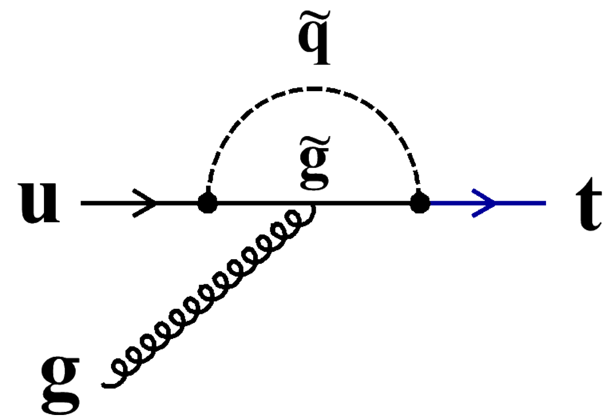
SM: σ_s = 4.6 pb

5) FCNC in top-quark production

FCNC: Flavor-Changing Neutral Currents
- significant in extensions of SM (e.g. SUSY)
- any evidence reveals new physics







GIM mechanism
BR → 10^{-13}
Very effective in the top sector!

Process	SM	SUSY	2HDM
$t \rightarrow u + g$	$3.7 \cdot 10^{-14}$	$8 \cdot 10^{-5}$	10^{-4}
$t \rightarrow c + g$	$4.6 \cdot 10^{-12}$	$8 \cdot 10^{-5}$	10^{-4}

hep-ph/0409342

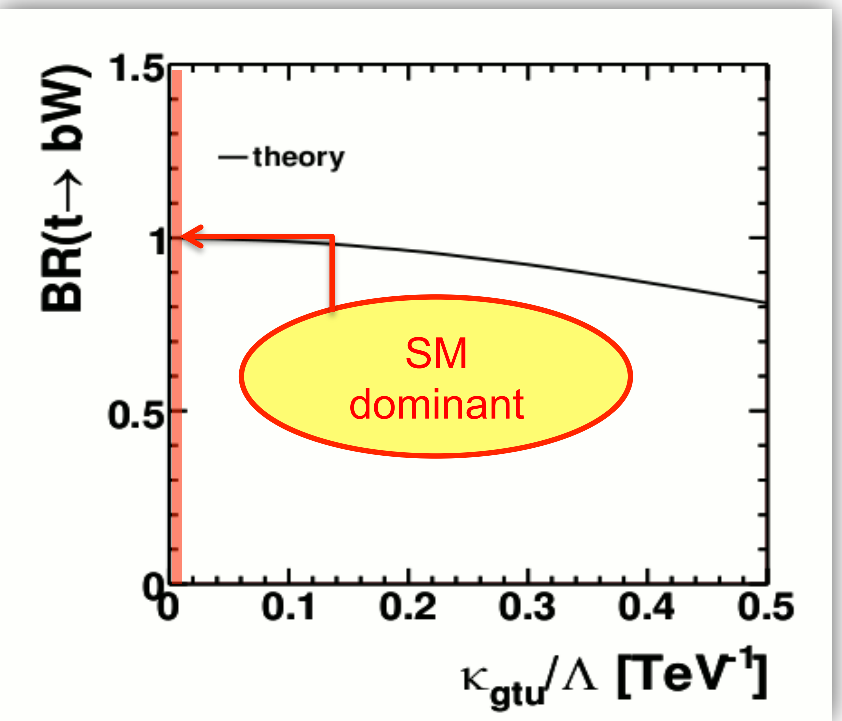
At a hadron collider more effective to look for FCNC production than decay.

FCNC single top quark signature

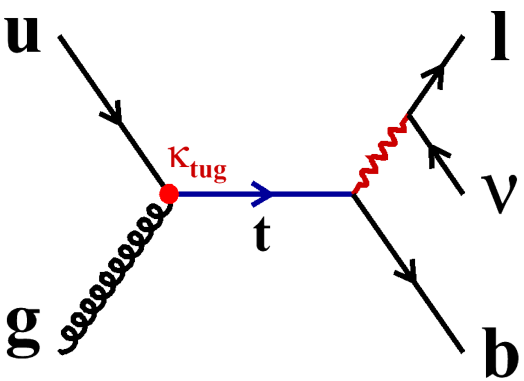
FCNC decays can be neglected since very large couplings are already excluded:

Best current limits by DØ:
Phys. Lett. B 693 (2010) 81

	tgu	tgc
Cross section	0.20 pb	0.27 pb
κ_{tgf}/Λ	0.013 TeV^{-1}	0.057 TeV^{-1}
$\mathcal{B}(t \to fg)$	2.0×10^{-4}	3.9×10^{-3}



FCNC single top-quark production can be studied assuming SM decay of the top quark.



Same event selection as t-channel analyses, but

- Use only central jets: $|\eta| < 2.5$
- Exactly one jet

Protos generator used for signal modeling.

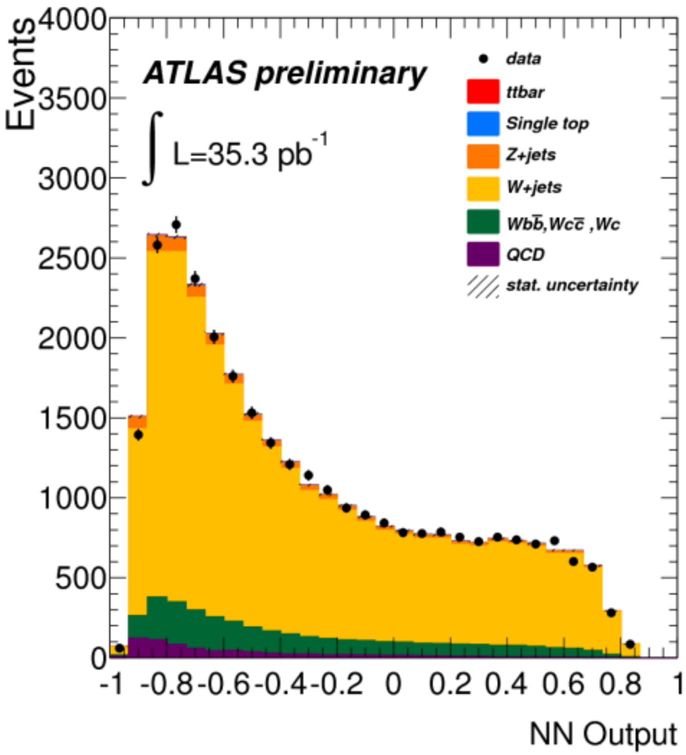
Expected event yield for $L_{int} = 35\ pb^{-1}$

Channel	e			μ			combined		
Signal	0.8	±	0.0	1.2	±	0.0	1.9	±	0.0
Single top	12.9	±	1.3	20.9	±	2.1	33.9	±	2.5
$t\bar{t}$	5.1	±	0.5	6.8	±	0.7	12.0	±	0.9
W+light jets	37.7	±	7.8	71.4	±	14.5	109.1	±	16.5
$Wb\bar{b}/Wc\bar{c}$+jets	7.8	±	1.6	16.8	±	3.5	24.7	±	3.8
$W + c +$ jets	52.6	±	10.6	116.6	±	23.4	169.2	±	25.6
Z+jets + diboson	1.9	±	0.4	11.7	±	2.5	13.5	±	2.5
QCD	14.4	±	7.2	33.1	±	16.6	47.5	±	18.0
total background	132.4	±	15.1	277.5	±	32.5	409.9	±	35.8
data	150			340			490		

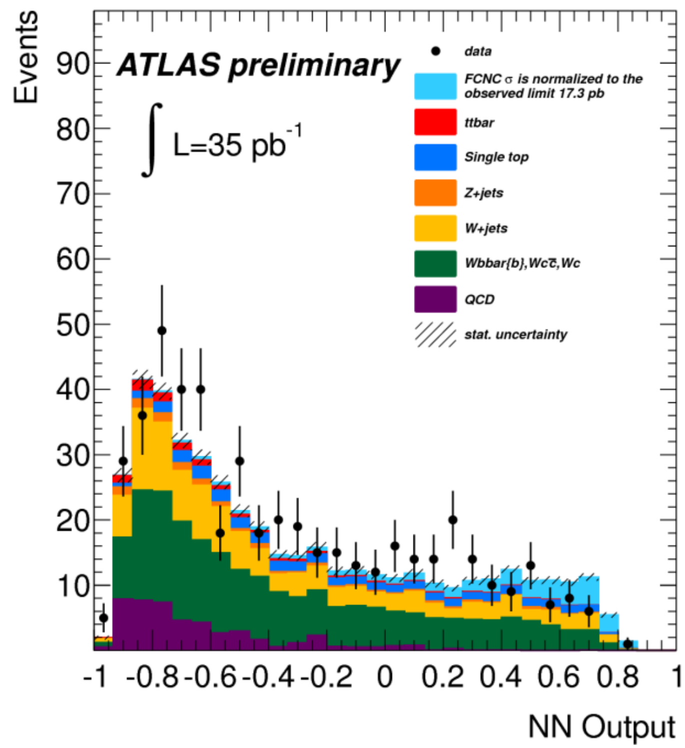
- Uncertainties include statistical and cross-section uncertainties.
- Assumed signal cross section: 1 pb
- Scale factors for W + jets processes are determined in a simultaneous fit to the NN discriminant (not included in the table above).

FCNC neural network search result

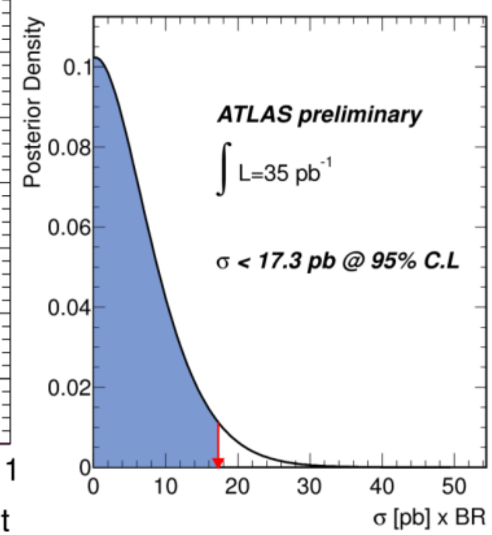
Modeling cross check in pretag data:

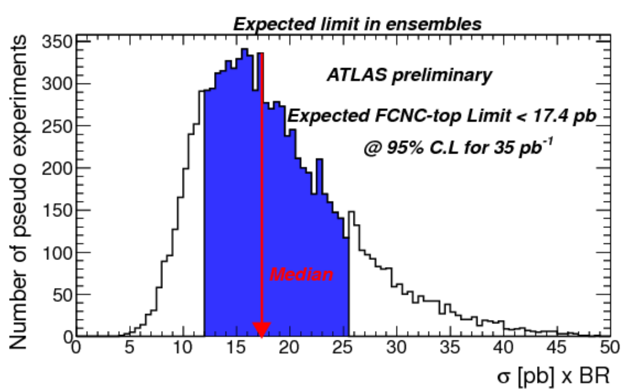


Observed distribution after final selection:



Statistical analysis:
Bayesian method:
posterior density:





- Expected limit @ 95% C.L.: σ_{FCNC} < 17.4 pb
- Observed limit @ 95% C.L.: σ_{FCNC} < 17.3 pb

Will be converted into limits on κ_{tug} and κ_{tcg} using Phys. Rev. Lett. 107 (2011) 092002

ATLAS-CONF-2011-061

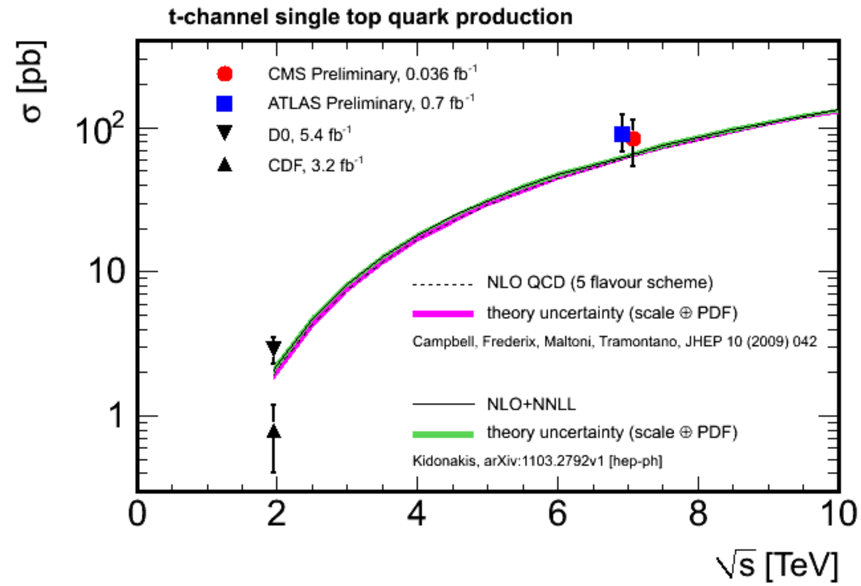
Summary

- Single top t-channel production has been observed at ATLAS (7.6σ @ 0.7 fb^{-1}) and CMS (3.7σ @ 35 pb^{-1}).
- Measured t-channel cross sections are in agreement with the SM (64.2 ± 2.6 pb).

CMS: σ (t-ch.) = 84 ± 30 (stat. + syst.) pb

ATLAS: σ (t-ch.) = 90 ± 9 (stat.) $^{+31}_{-20}$ (syst.) pb

- With 0.70 fb^{-1} (ATLAS) already systematically (~30%) limited (stat. unc. 10%).



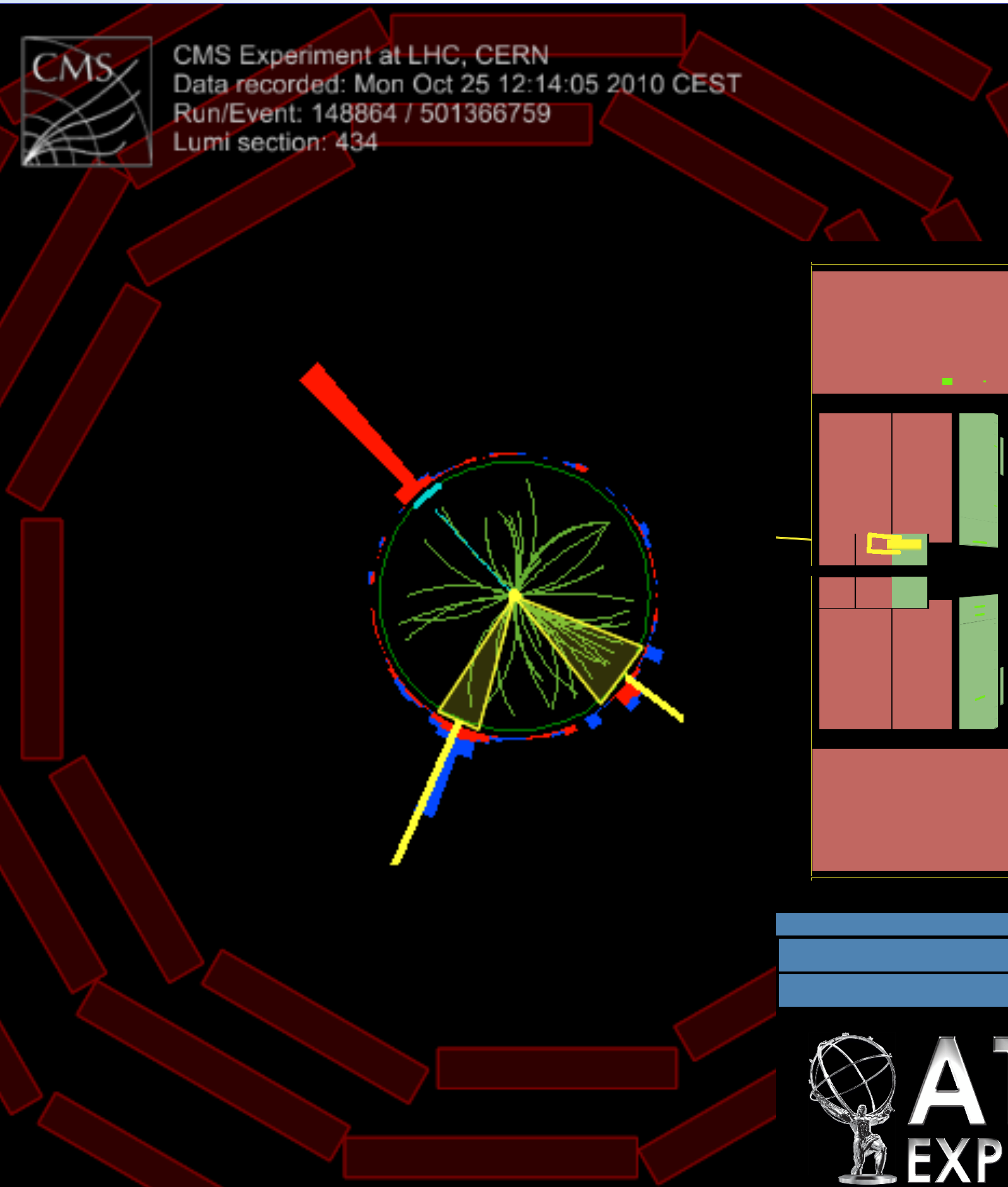
- FCNC search (ATLAS):

  σ_{FCNC} < 17.3 pb @ 95% C.L.

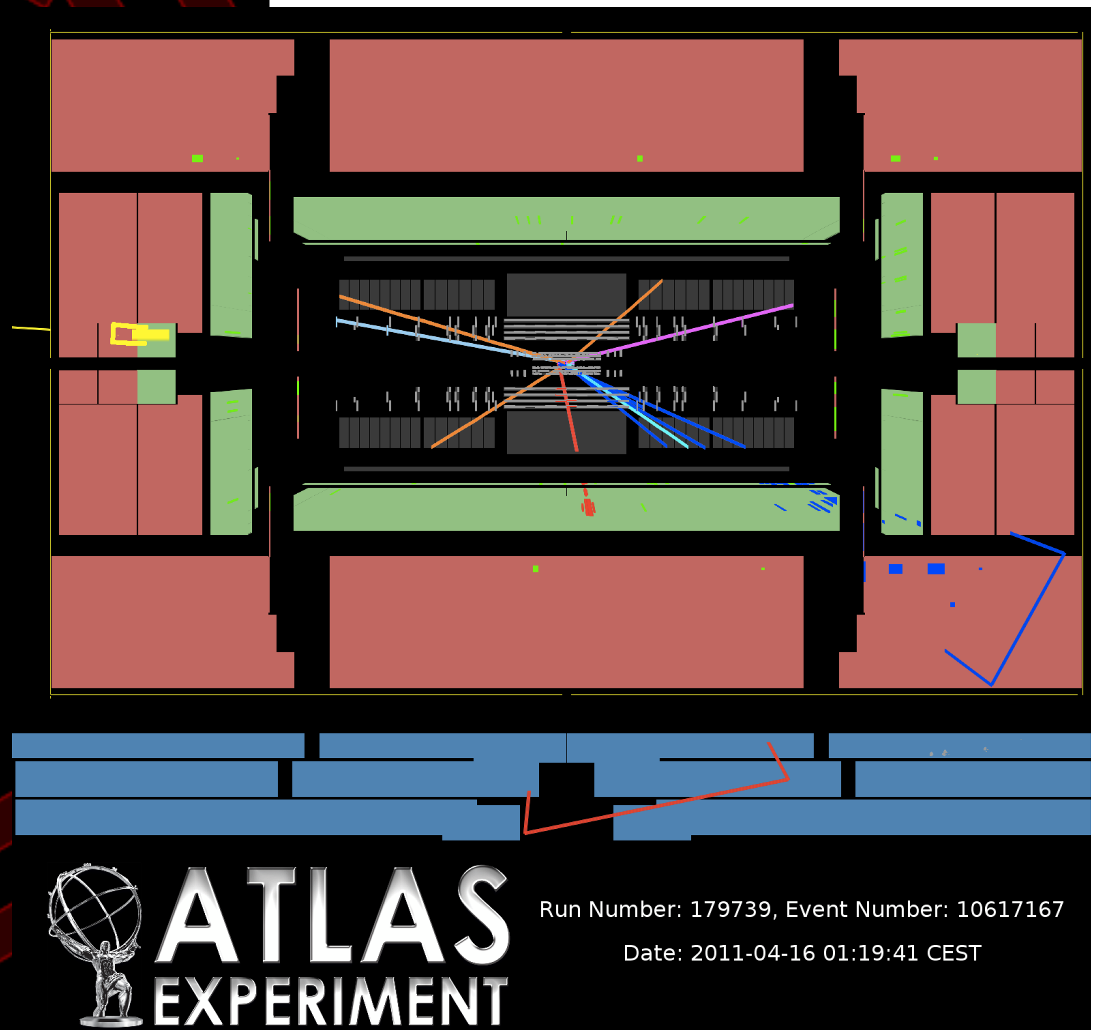
First steps to measure subleading single-top processes:

- Wt @ CMS: 2.7σ
  σ (Wt) = 22 $^{+9}_{-7}$ (stat.+ syst.) pb
- σ (Wt) < 39 pb @ 95% C.L.
- σ (s-chan.) < 26.5 pb @ 95% C.L.

Thank You!



CMS
CMS Experiment at LHC, CERN
Data recorded: Mon Oct 25 12:14:05 2010 CEST
Run/Event: 148864 / 501366759
Lumi section: 434



ATLAS EXPERIMENT
Run Number: 179739, Event Number: 10617167
Date: 2011-04-16 01:19:41 CEST

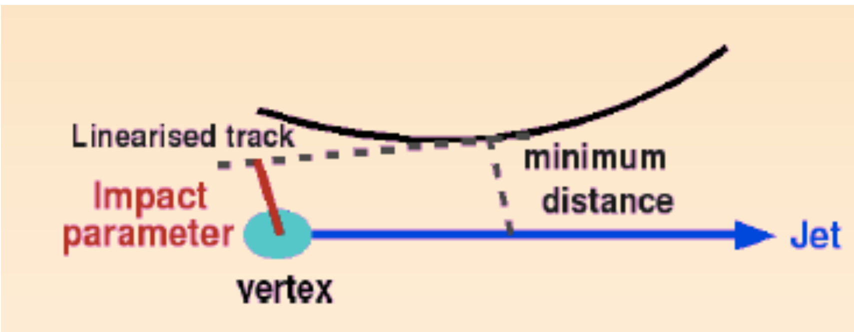
Backup

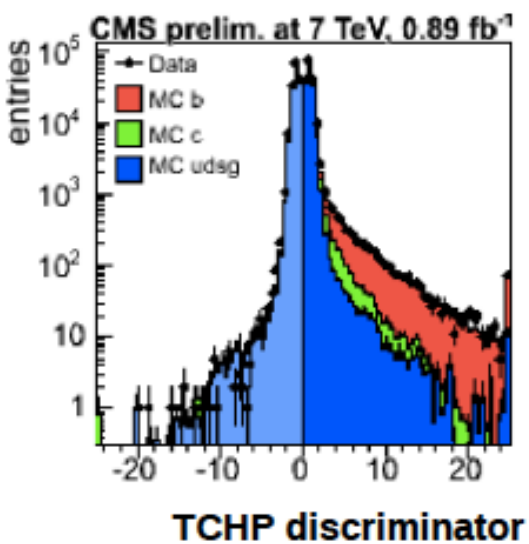
b-jet identification

b hadron lifetime: $\tau \approx 1.5$ ps → $c\tau \approx 450\ \mu$m → typical decay length: *O*(mm)

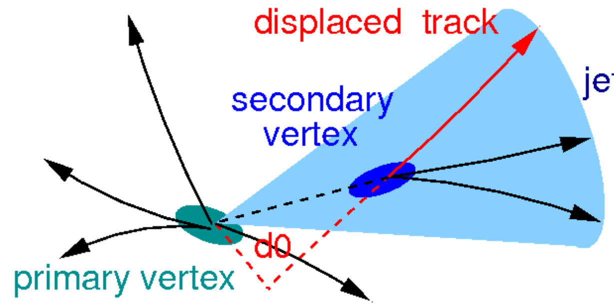
➔ lifetime based b-taggers

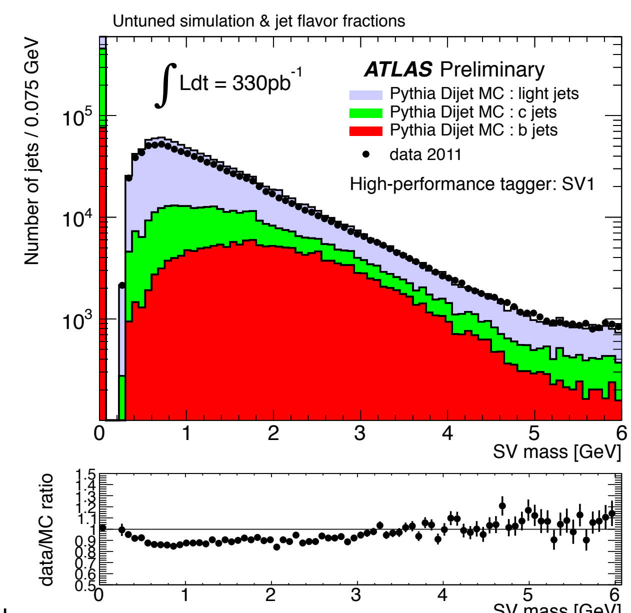
impact parameter based tagger





secondary vertex based tagger





documentation on b-tagging in ATLAS:
ATLAS-CONF-2011-102

Monte Carlo samples

Process	Generator ATLAS 2010 analyses	Generator ATLAS 2011 analyses	Generator CMS 2010 analyses
t-channel single top	MC@NLO +Herwig	AcerMC + Pythia MC@NLO (Wt analyses)	MadGraph + Pythia
Wt	MC@NLO + Herwig	AcerMC + Pythia MC@NLO (Wt analyses)	MadGraph + Pythia
s-channel single top	MC@NLO + Herwig	AcerMC + Pythia MC@NLO (Wt analyses)	MadGraph + Pythia
tt	MC@NLO + Herwig	MC@NLO	MadGraph + Pythia
W+jets (inclusive + heavy flavor samples)	Alpgen+Herwig	Alpgen+Herwig	MadGraph + Pythia
Z+jets (inclusive)	Alpgen+Herwig	Alpgen+Herwig	MadGraph + Pythia
WW,WZ,ZZ	Herwig	Herwig	Pythia

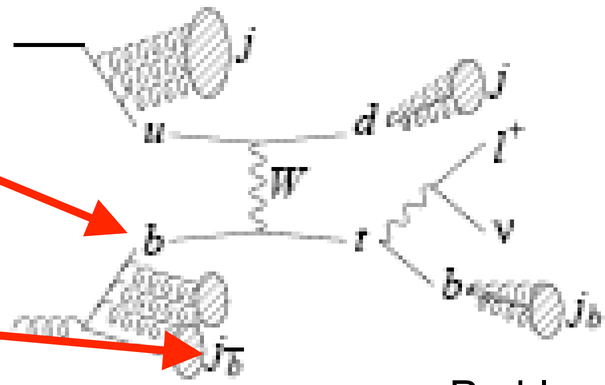
All samples with full detector simulation using GEANT4.

Pileup is simulated with 50 ns bunch trains.

Modeling of Single-Top Events: Example 2nd b Quark

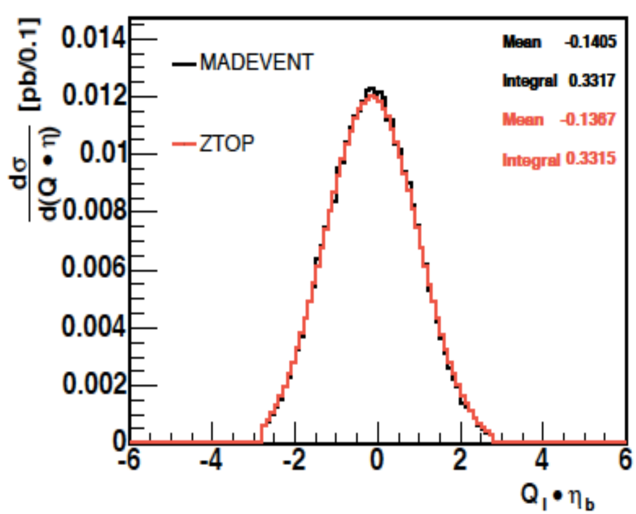
from b-quark PDF

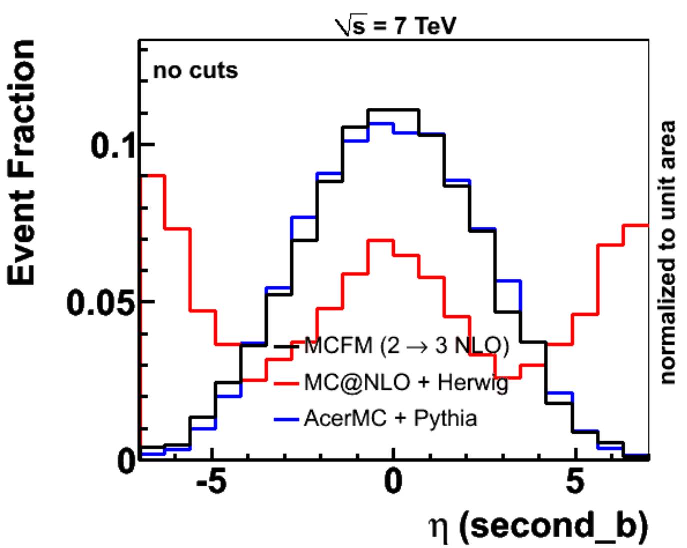
flavour conservation (in strong interaction):
2nd b from shower MC (DGLAP evolution)



Problem in MC@NLO + Fortran Herwig:

Solution:
matching of bu → td and gu → tdb_{bar} processes





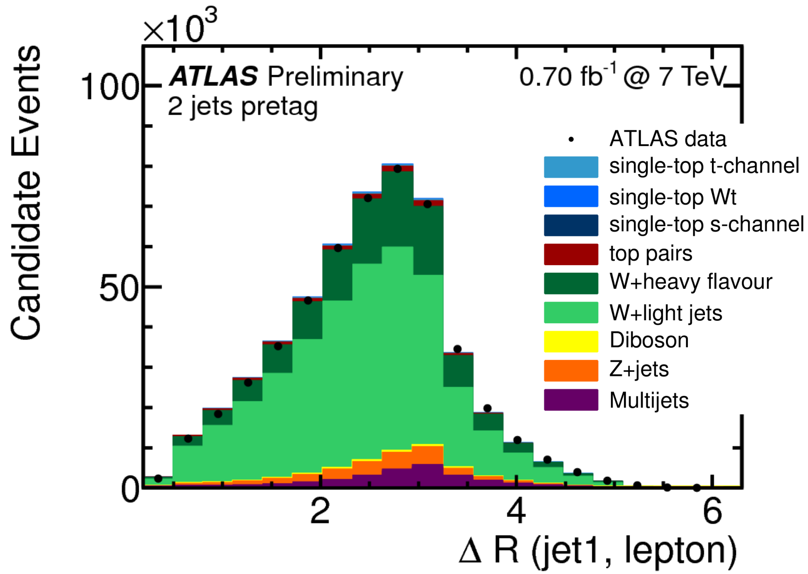
→ Switch of signal generator in ATLAS from 2010 to 2011 analyses
change in acceptance: -20%

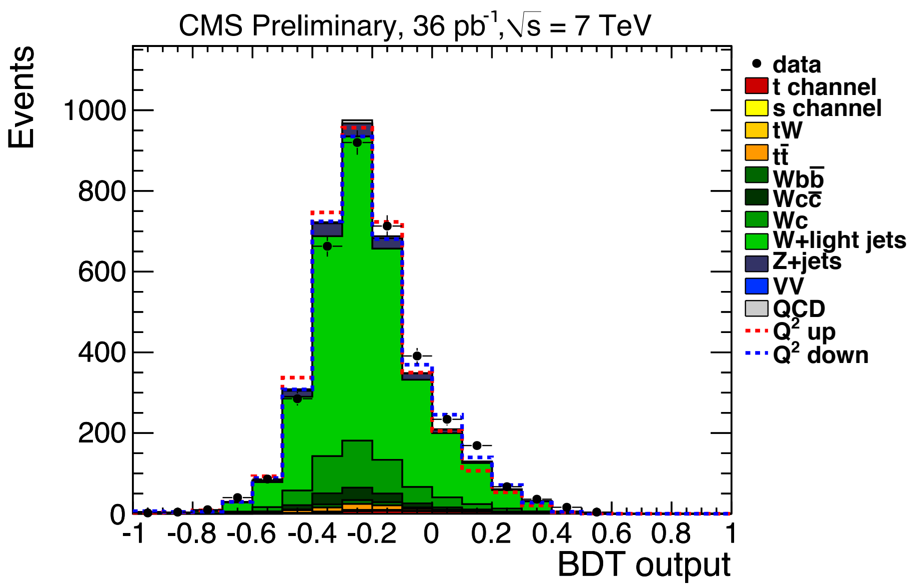
→ issue fixed in Herwig++

W+jets modeling: ALPGEN and Madgraph

ALPGEN (M. Mangano *et al.*) @ ATLAS, Madgraph (Maltoni *et al.*) @ CMS

- models multi-gluon emission by LO matrix elements + parton shower → LO+LL accuracy
- work with Pythia and Herwig
- overlap between ME and PS must be removed → MLM matching
- „hard“ jets are modeled by ME, „softer“ jets by the shower MC
- each process is modeled by many specific „parton“ samples, for example W+b bbar Wbb+0p with W→ eν, Wbb+1p with W→ eν, …
- Overlap between heavy-flavor samples must be removed by hand.

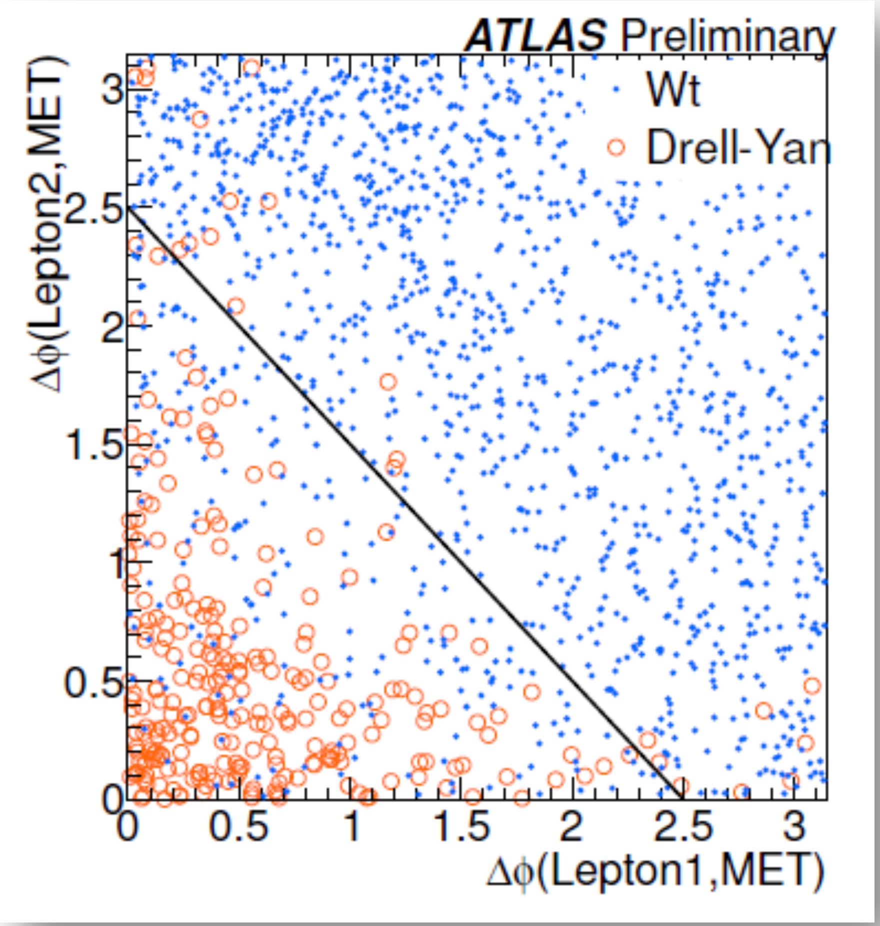




Overall ALPGEN and Madgraph models work quite well within uncertainties.

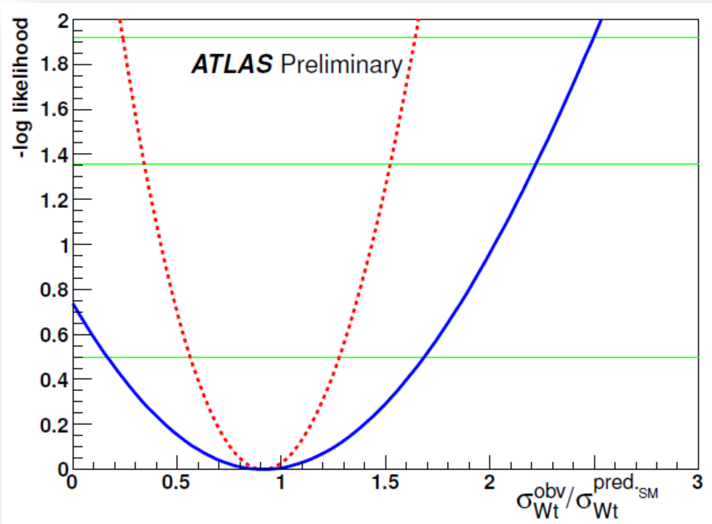
$Z \rightarrow \tau^+\tau^-$ veto

- $Z \rightarrow \tau\tau$ veto (ATLAS)
  - $\Delta\Phi(l_1, E_t^{miss}) + \Delta\Phi(l_2, E_t^{miss}) > 2.5$



Wt systematic uncertainties

Profile maximum likelihood fit:



Statistical uncertainty: +37 / -35%

Dominating syst. uncertainties:

Source	Δ
Jet energy scale	+34 / -35%
Jet energy resolution	+29 / -32%
Jet energy reconstruction	+30 / -33%