ATLAS results on inclusive top quark pair production cross section in dilepton channel

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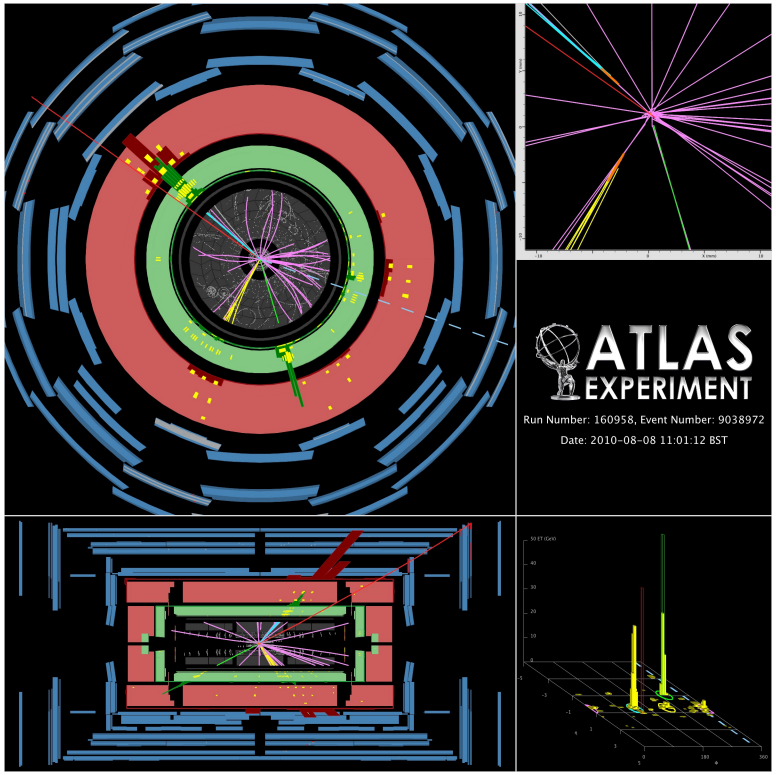
Rencontres françaises sur la physique des hautes énergies au LHC, LHC France 2013, 2-6 avril 2013, Annecy



Object reconstruction
dilepton (e,μ)
- event selection
- background estimation
- result

dilepton (e/μ,τ)

Analysis of 2011 data at √s = 7 TeV

Object reconstruction

To study top quark it implies good understanding of many different objects reconstructed in all different ATLAS subdetectors

Electrons

matched track and EM cluster

tight identification using shower shape variables, ID

central : $|\eta|<2.5$, $p_T>25$ GeV

isolated in ID and ECAL

Triggers

based on single lepton high p_T

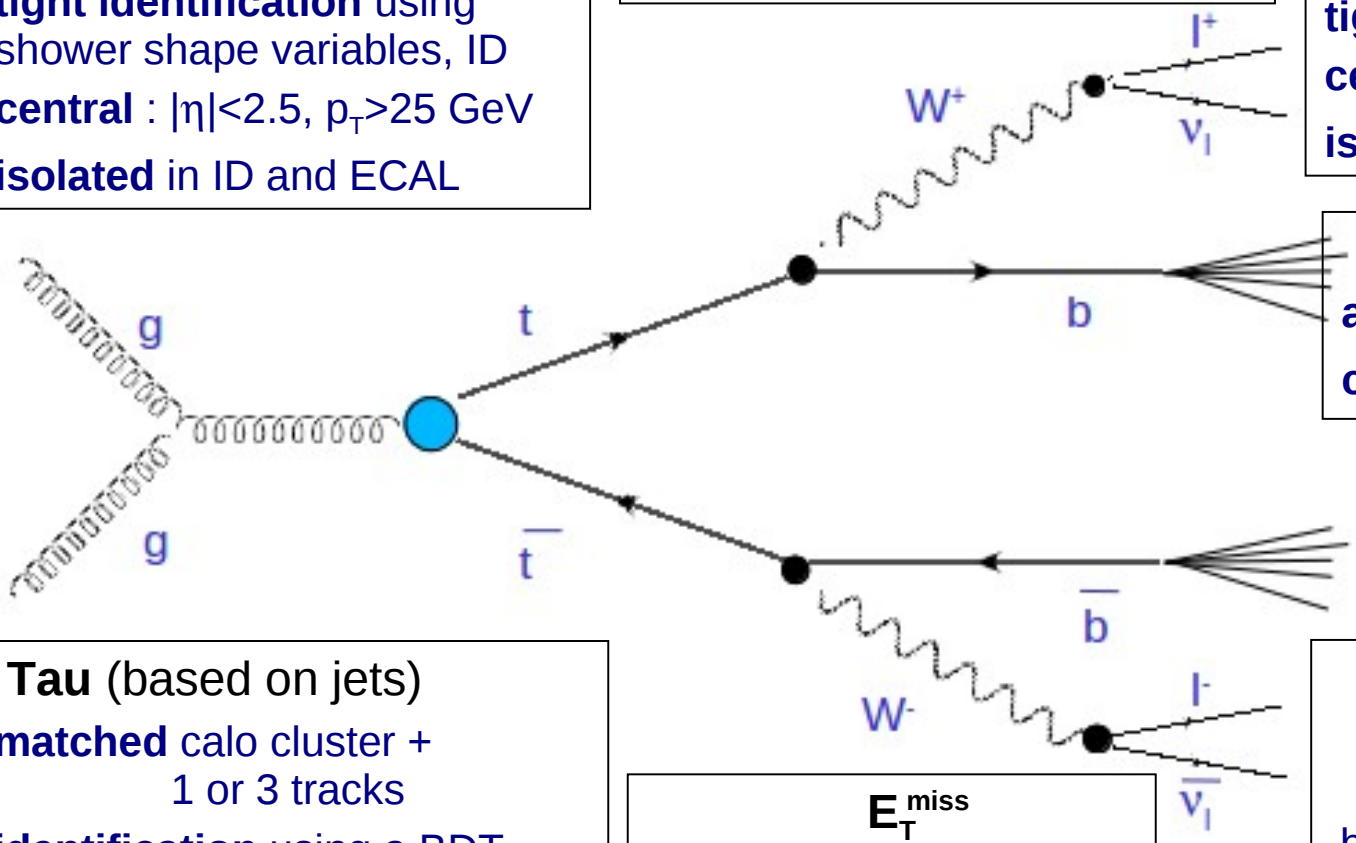
Muons

combined fitted tracks

tight identification

central : $|\eta|<2.5$, $p_T>20$ GeV

isolated in ID and ECAL



Jets

anti-k_T-algorithm (R=0.4)

central $|\eta|<2.5$ $p_T>25$ GeV

Tau (based on jets)

matched calo cluster + 1 or 3 tracks

identification using a BDT

$20<p_T<100$ GeV, $|\eta|<2.3$

E_T^{miss}

vector sum of energy in calorimeter corrected for identified objects

b-tagging

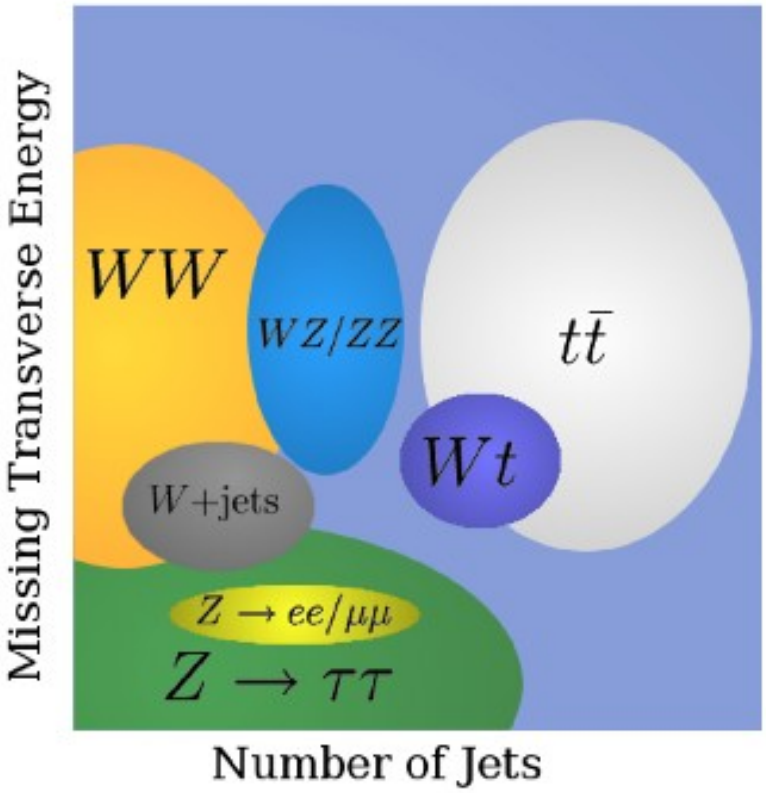
Neural Network based algorithm with average b-tagging efficiency ~70 % and light jet rejection factor ~140

Event selection

Signature :
2 isolated e/μ + E_T^{miss} + jets (1b)

Trigger : 1 single isolated lepton
Offline : $n_{jet} \geq 2$, opposite sign leptons +
E_T^{miss}, ΣE_T(e,μ,jets), m_{ll}(Z veto)
Channels :
8 analyses are performed
ee, μμ, eμ with and without b-tagging
eTL and μTL without b-tagging where
TL = Track lepton = Good quality isolated track

Analysis Strategy : counting experiment
data driven estimation of Z+jets,
W+jets and multijet backgrounds



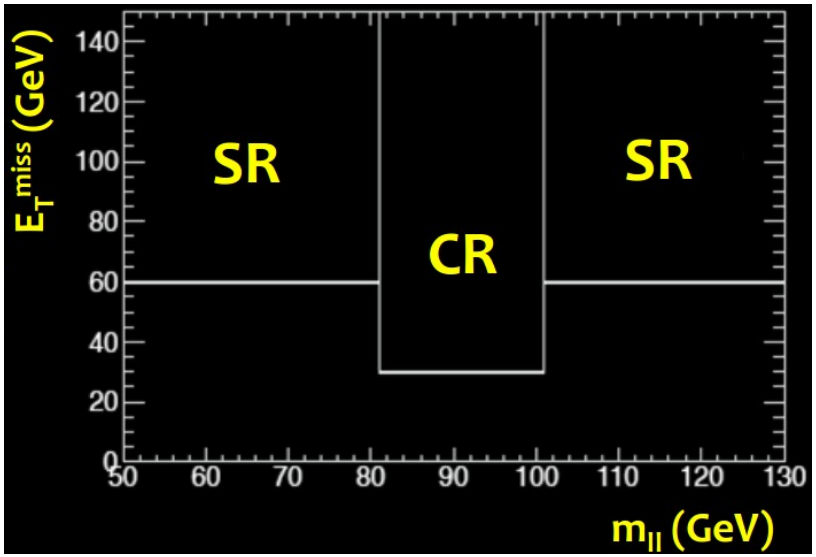
JHEP1205 (2012) 059

	ee	*μμ*	*eμ*	*e*TL	*μ*TL	*b*-tag *ee*	*b*-tag *μμ*	*b*-tag *eμ*
Observed	165	301	963	236	255	201	365	834

Analysis based on 0.70 fb^{-1} @ 7 TeV

Z+jets background

- **Z/γ* + jets events contaminating signal region**
  - large E_T^{miss} possible from mismeasurement
  - difficult to model in Monte Carlo simulation
- **Define control region**
  - $|m_{ll}-m_Z|<10$ GeV and $E_T^{miss}>30$ GeV
  - same jet requirements
- **Determine scale factors**
  - after subtracting other backgrounds



$$N_{Z+jets} = \frac{MC_{Z+jets}(SR)}{MC_{Z+jets}(CR)} \times \left[Data(CR) - MC_{other}(CR) \right]$$

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	ee	$\mu\mu$	$e\mu$	eTL	μTL	b-tag ee	b-tag $\mu\mu$	b-tag $e\mu$
Z/γ^*+ jets	$4.0^{+2.5}_{-1.2}$	$14.4^{+5.4}_{-4.2}$	-	$24.3^{+10.7}_{-9.4}$	$22.0^{+5.3}_{-5.8}$	$9.8^{+1.7}_{-1.3}$	$20.3^{+1.8}_{-2.8}$	–
$Z/\gamma^* \to \tau\tau$+jets	4.9 ± 2.6	11.0 ± 5.0	43 ± 16	$17.0^{+8.4}_{-7.6}$	25 ± 11	$1.8^{+1.1}_{-1.2}$	$7.6^{+3.3}_{-3.6}$	$9.5^{+4.2}_{-3.9}$

Fake lepton background

- **Backgrounds with fake leptons**
  - W+jets (mainly), multijets, tt single lepton, single top ...
- **Determination with 2-dimension matrix method**
  - define Loose and Tight leptons (isolation) which give 4 observable states
    - Loose-Loose, Loose-Tight, Tight-Loose, Tight-Tight
  - also four classes of background
    - Fake-Fake, Fake-Real, Real-Fake, Real-Real

$$\begin{bmatrix} N_{TT} \\ N_{TL} \\ N_{LT} \\ N_{LL} \end{bmatrix} = \begin{bmatrix} rr & rf & fr & ff \\ r(1-r) & r(1-f) & f(1-r) & f(1-f) \\ (1-r)r & (1-r)f & (1-f)r & (1-f)f \\ (1-r)(1-r) & (1-r)(1-f) & (1-f)(1-r) & (1-f)(1-f) \end{bmatrix} \begin{bmatrix} N_{RR} \\ N_{RF} \\ N_{FR} \\ N_{FF} \end{bmatrix}$$

- **Fractions r and f from control samples, then solve equation for N_{RF}/N_{FR}, N_{FF}**
  - fraction r measured from Z(→ ll)+jets events
  - fraction f measured from sample with single loose lepton

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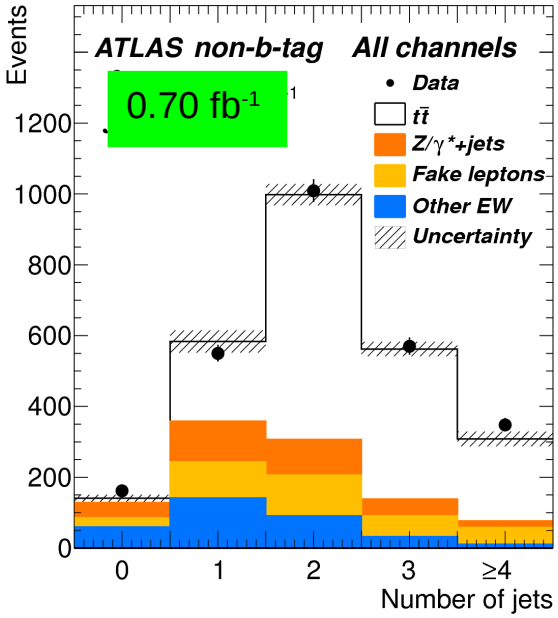
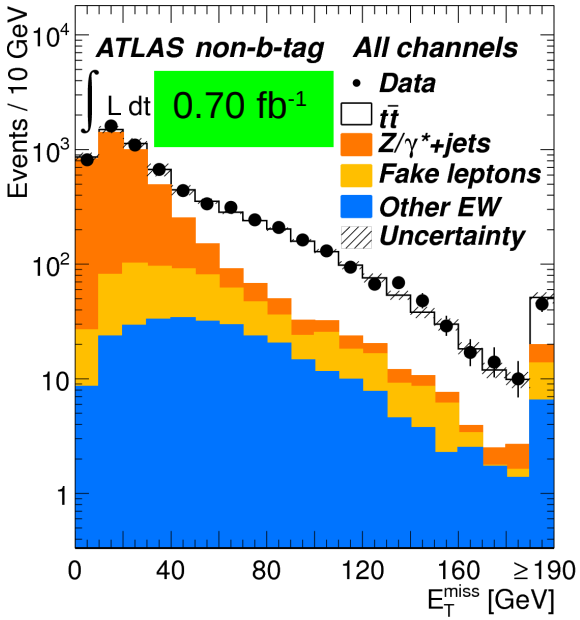
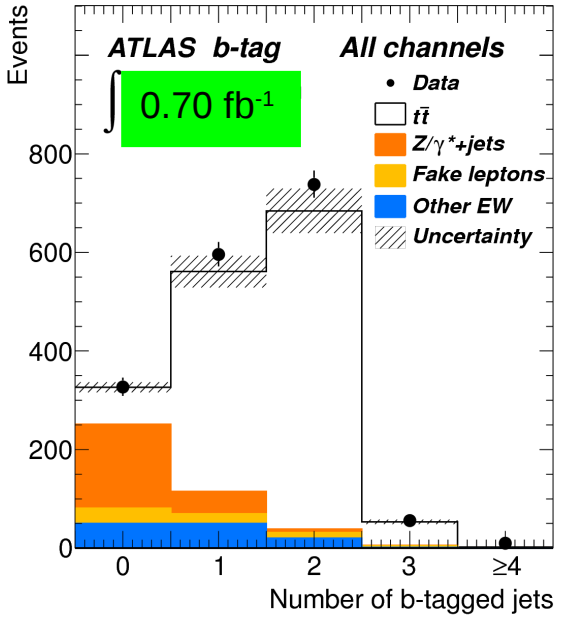
	ee	$\mu\mu$	$e\mu$	eTL	μTL	b-tag ee	b-tag $\mu\mu$	b-tag $e\mu$
Fake leptons	4.0 ± 5.0	6.3 ± 4.1	44 ± 24	74 ± 15	85 ± 17	7.5 ± 6.5	4.9 ± 3.1	20 ± 13

Number of signal and background events







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Fake leptons	4.0 ± 5.0	6.3 ± 4.1	44 ± 24	74 ± 15	85 ± 17	7.5 ± 6.5	4.9 ± 3.1	20 ± 13
Single top quark	$6.4^{+1.2}_{-1.1}$	$16.0^{+1.9}_{-2.2}$	41.1 ± 5.5	$5.7^{+1.0}_{-0.9}$	$6.3^{+0.8}_{-1.1}$	$7.3^{+1.3}_{-1.1}$	$16.2^{+2.2}_{-2.3}$	$33.5^{+4.8}_{-4.7}$
Diboson	5.9 ± 1.1	$8.7^{+1.2}_{-1.5}$	32.9 ± 4.9	$5.9^{+0.9}_{-0.8}$	$4.8^{+0.6}_{-0.7}$	2.2 ± 0.7	$2.6^{+0.9}_{-0.6}$	$8.8^{+1.7}_{-1.6}$
Total background	25.2 ± 6.4	56.5 ± 9.4	161 ± 34	126^{+20}_{-19}	142 ± 21	28.6 ± 6.9	$51.6^{+5.6}_{-5.9}$	71.6 ± 14.1
Predicted $t\bar{t}$	124 ± 17	241^{+15}_{-18}	746 ± 42	112^{+16}_{-18}	110^{+17}_{-16}	159^{+17}_{-21}	304^{+26}_{-35}	675^{+57}_{-75}
Total	149 ± 18	298^{+17}_{-20}	907 ± 54	239 ± 26	253 ± 27	188^{+18}_{-22}	356^{+27}_{-35}	746^{+59}_{-76}
Observed	165	301	963	236	255	201	365	834

Cross section measurement

$\sigma(pp \to t\bar{t})_{NNLOapprox} = 167^{+17}_{-18}$ pb

Computed with: Aliev et. al., HATHOR, arXiv:1007:1327 (2011)

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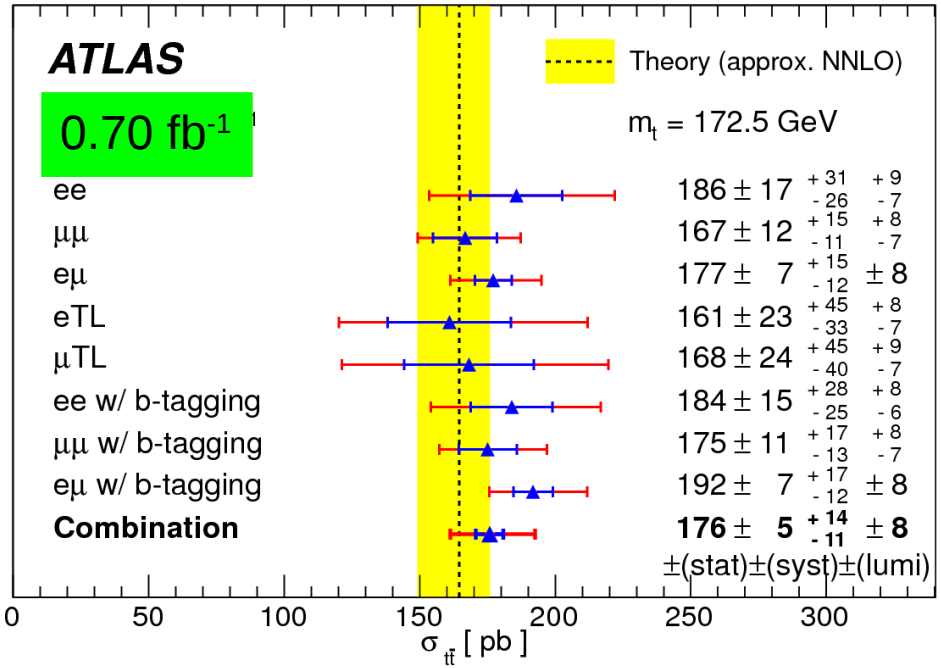


Uncertainties $\Delta\sigma/\sigma$[%]	Combined
Data statistics	±2.9
Luminosity	±4.3
MC statistics	+0.7/-0.6
Lepton uncertainties	+2.6/-2.2
Track leptons	+0.3/-0.2
Jet/E_T^{miss} uncertainties	+4.4/-3.4
b-tagging uncertainties	+0.4/-0.0
Z/γ^* + jets evaluation	+0.3/-0.2
Fake lepton evaluation	±1.7
Generator	+5.1/-4.9
All syst.(except lumi.)	+8.0/-6.5
Stat. + syst.	+9.6/-8.2

$\sigma_{tt} = 176 \pm 5\,(stat)\,^{+14}_{-11}\,(syst) \pm 8\,(lumi)$ pb

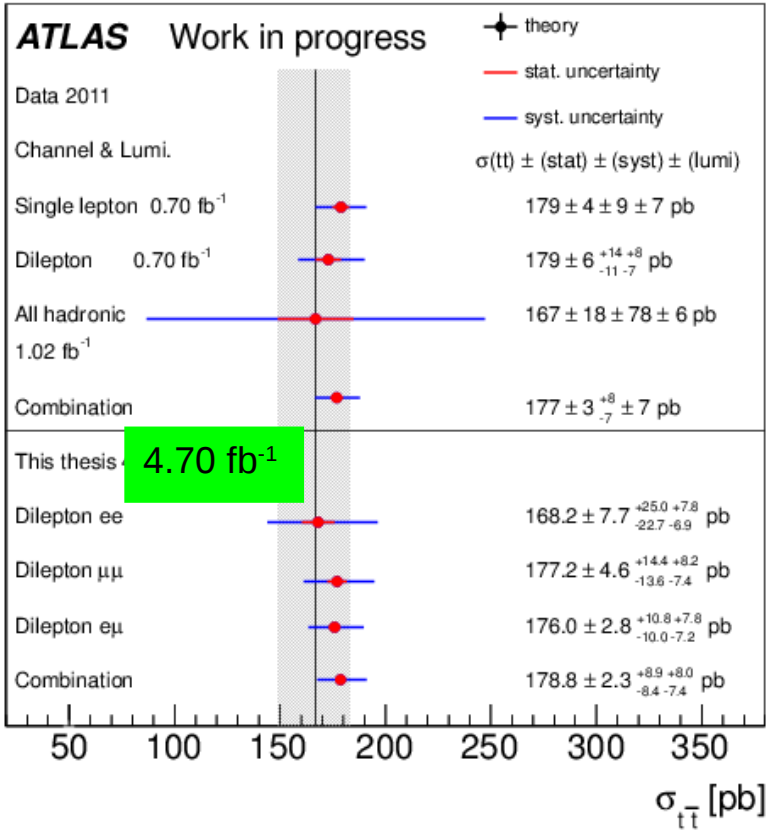
overall precision ~9%,
limited by systematic uncertainties

Systematic uncertainties :
Jet/E_T^{miss} (~4 %), generator (~5%), lepton (~2.5%), fake lepton (~2%)

Other cross section measurement

PhD of Timothée Theveneaux-Pelzer (LPNHE Paris):
Etudes sur la reconstruction des électrons et mesure de la section efficace de production de paires de quarks top dans les canaux en dileptons dans l'expérience Atlas, UPMC, 3 juillet 2012

CERN-THESIS-2012-114



similar Analysis as the published one with 0.7 fb^{-1} but based on 4.7 fb^{-1}
- ee, μμ, eμ channels
- no b-tagging
- dedicated work on fake leptons
- re-estimation of all systematics

overall precision ~7%,
limited by systematic uncertainties

$\sigma_{tt} = 178.8 \pm 2.3\,(\text{stat})\,^{+8.9}_{-8.4}\,(\text{syst}) \pm 8\,(\text{lumi})$ pb

pair production with e/μ + τ + jets

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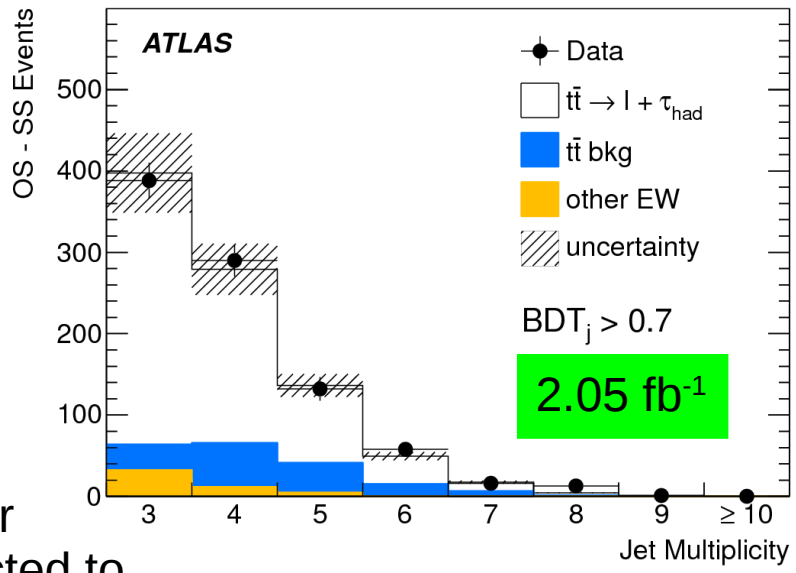
BR could be enhanced by the existence of $H^{\pm}$

Signature :

1 isolated e/μ + τ + E_T^{miss} + jets (1b)



Trigger : 1 single isolated lepton

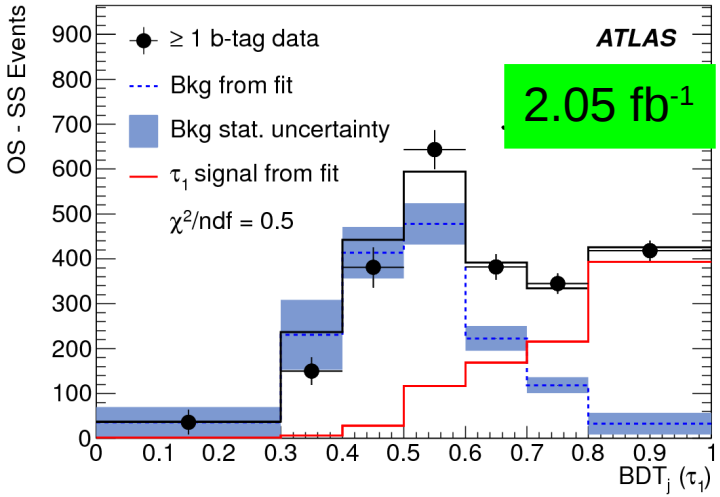
Offline : opposite sign lepton + τ lepton

E_T^{miss}>30 GeV, $\sum E_T$>200 GeV,

2 jets at least one of them is b-tagged

Analysis Strategy : perform template fit of BDT

- background distribution is different with jet flavor
- to reduce # of templates, SS events are subtracted to remove b, gluon originated τ candidates (charge symmetric)



$\sigma_{tt}(\mu+\tau) = 186 \pm 15\ (stat) \pm 20\ (syst) \pm 7\ (lumi)$ pb

$\sigma_{tt}(e+\tau) = 187 \pm 18\ (stat) \pm 20\ (syst) \pm 7\ (lumi)$ pb

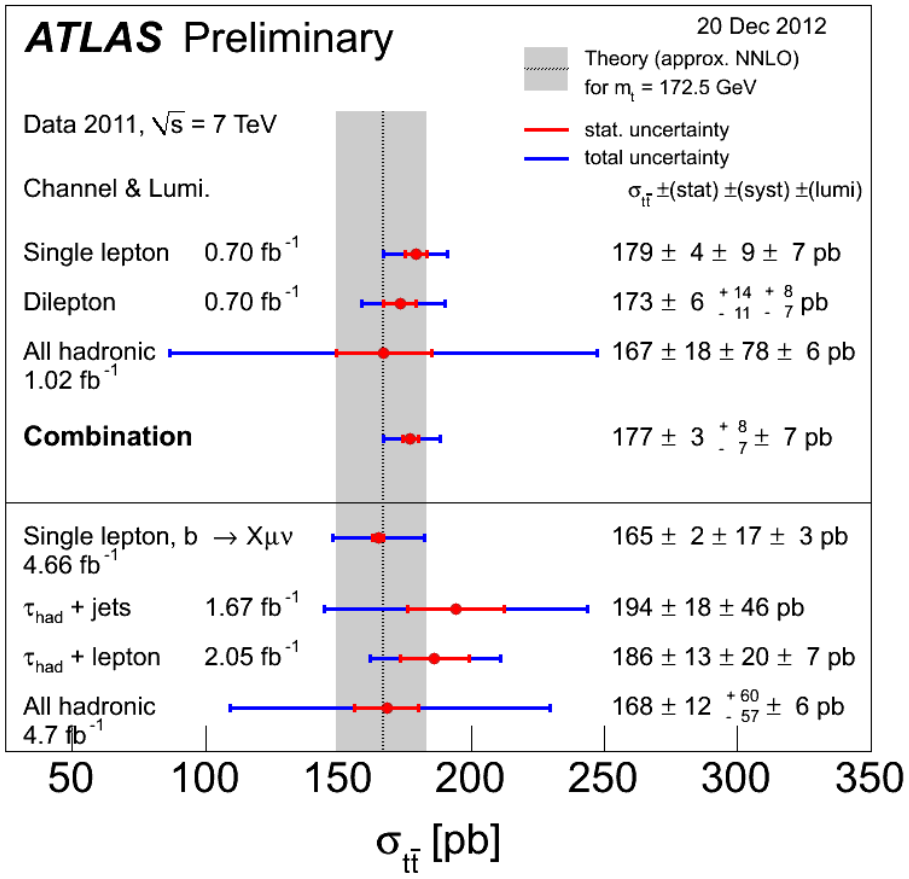
$\sigma_{tt} = 186 \pm 13\ (stat) \pm 20\ (syst) \pm 7\ (lumi)$ pb

overall precision ~14%,
limited by systematic uncertainties

Systematic uncertainties :
b-tag (~9 pb), τ-ID (~4 pb)

Summary

- **ttbar production cross section**
  - measured accuracy for combined measurement < theoretical one
  - σ_{tt} is measured in alternative channels (τ), showing SM is applicable at LHC



NB: combination takes results in dilepton from ee,μμ,eμ without b-tagging

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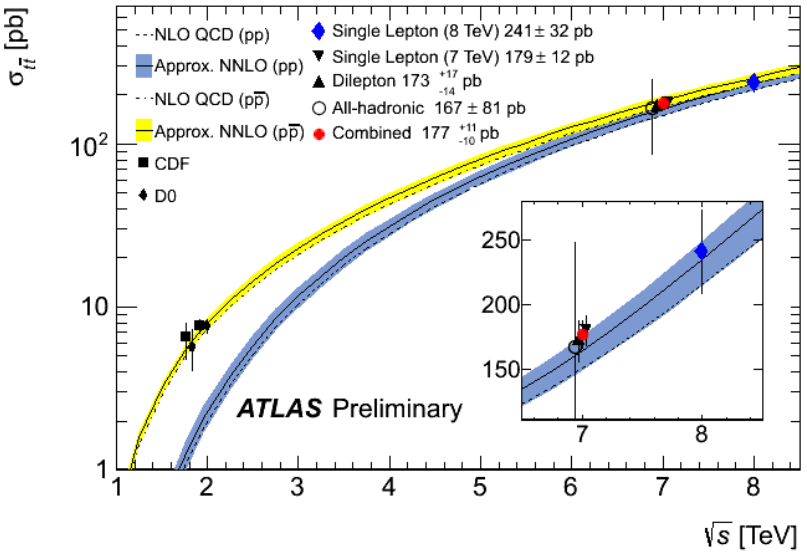

- total precision ~6%, half of theory uncertainty
- agreement of channels within uncertainties