Measurement of the top-quark pair production in pp collision $\sqrt{s}$=7TeV in dilepton final states with ATLAS

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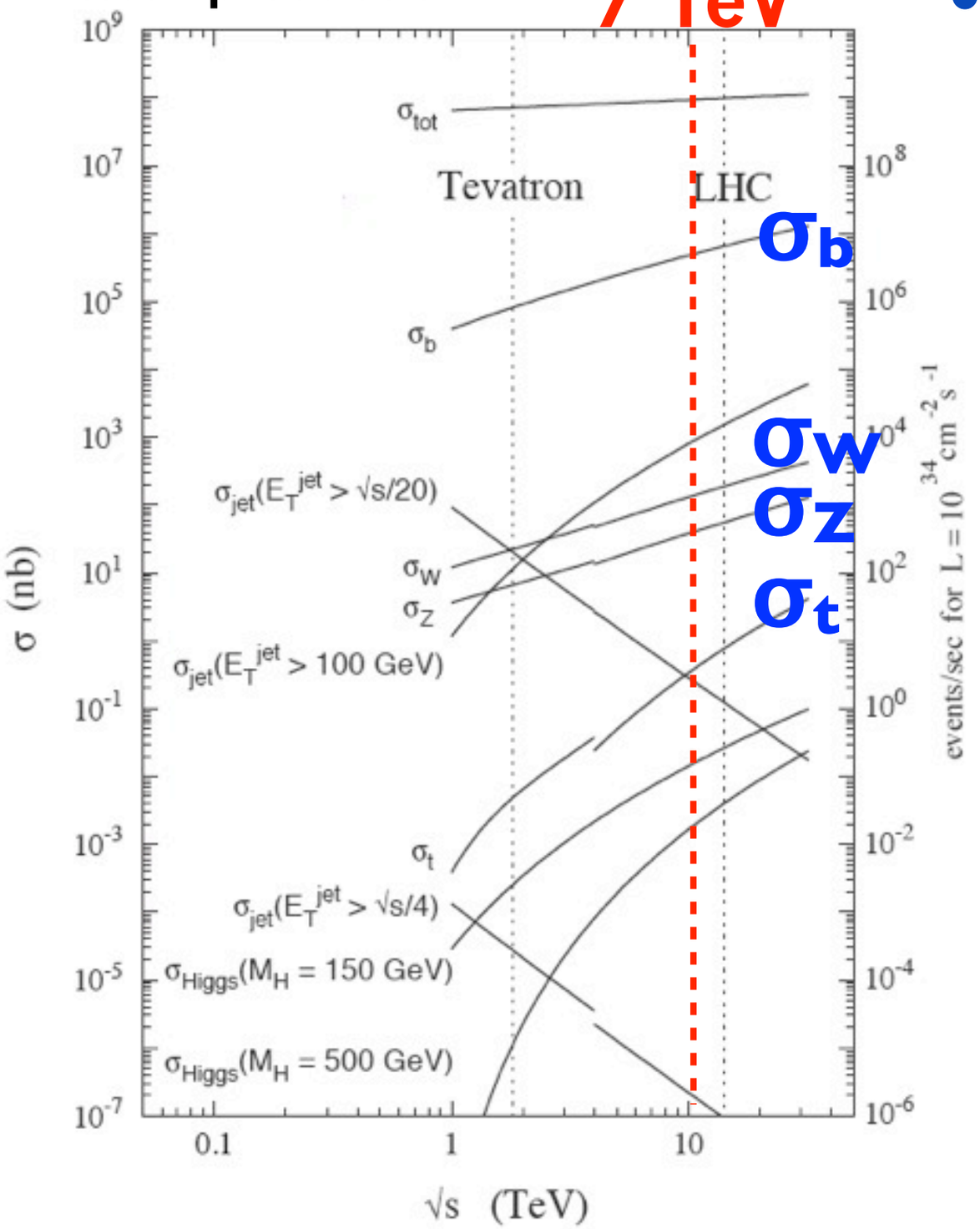
07.12.2011

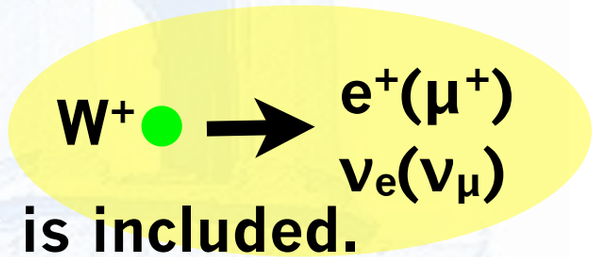
Helmholtz Alliance PHYSICS AT THE TERASCALE
5th Annual Workshop in Bonn

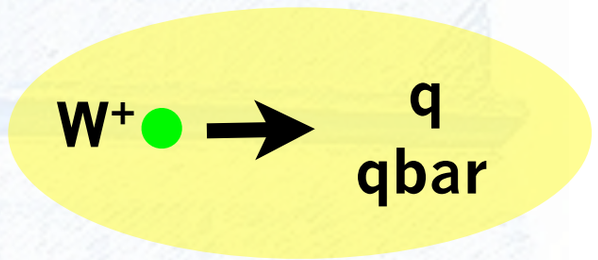
ttbar production and decay

- ttbar production



- ttbar decay categorized by W decay
  - top decay
    - W & b ~100 %
  - W decay
    - leptonic decay
      τ leptonic decay is included.
    - hadronic decay





- dilepton lepton channel
  2 W leptonic decay 6.5 %
- single lepton channel
  1 W leptonic decay 37.9%

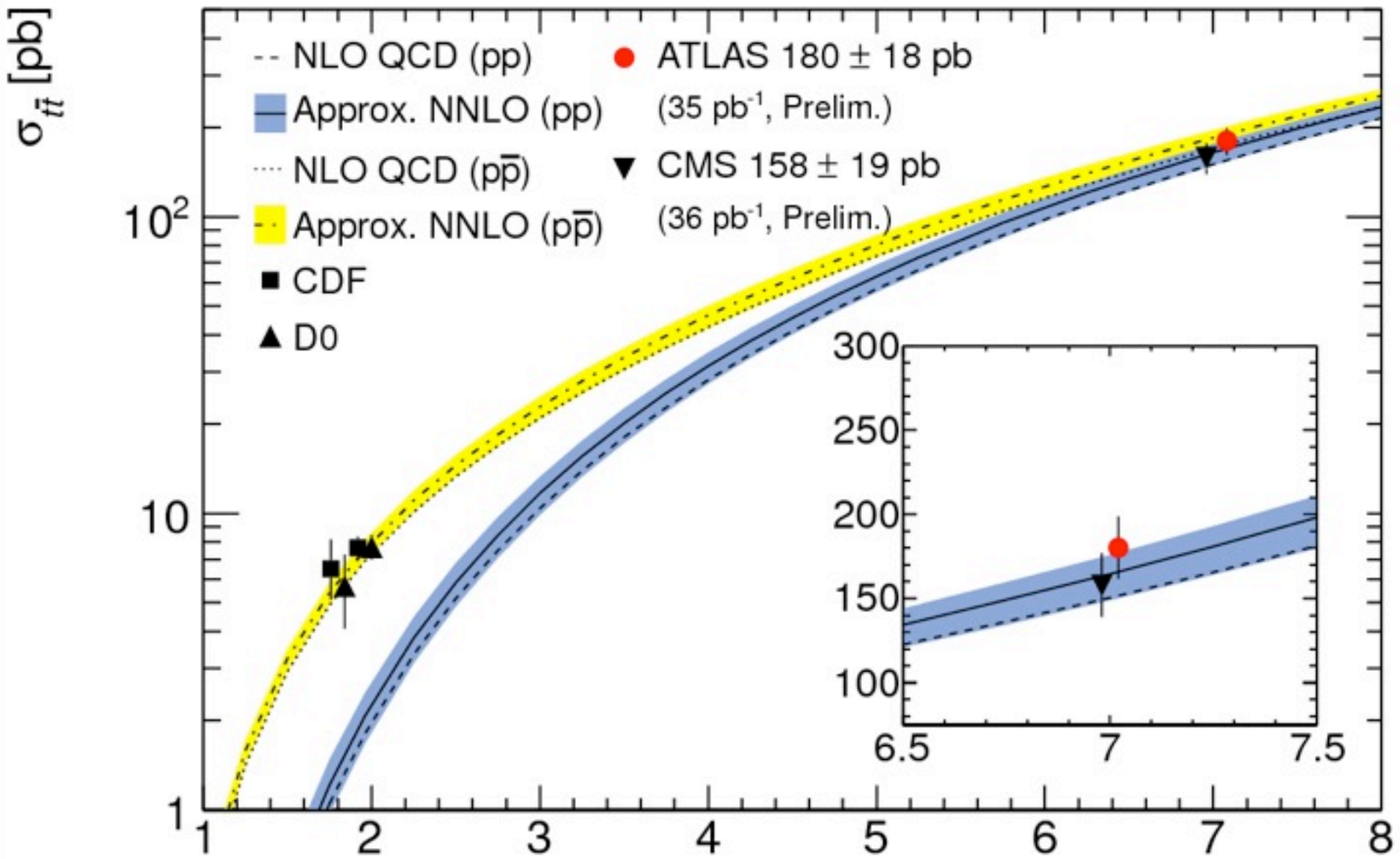
ttbar cross-section measurement with 35pb^{-1}

March in 2011

combination

ATLAS-CONF-2011-040

Uncertainty 10% with 35pb^{-1} in combination



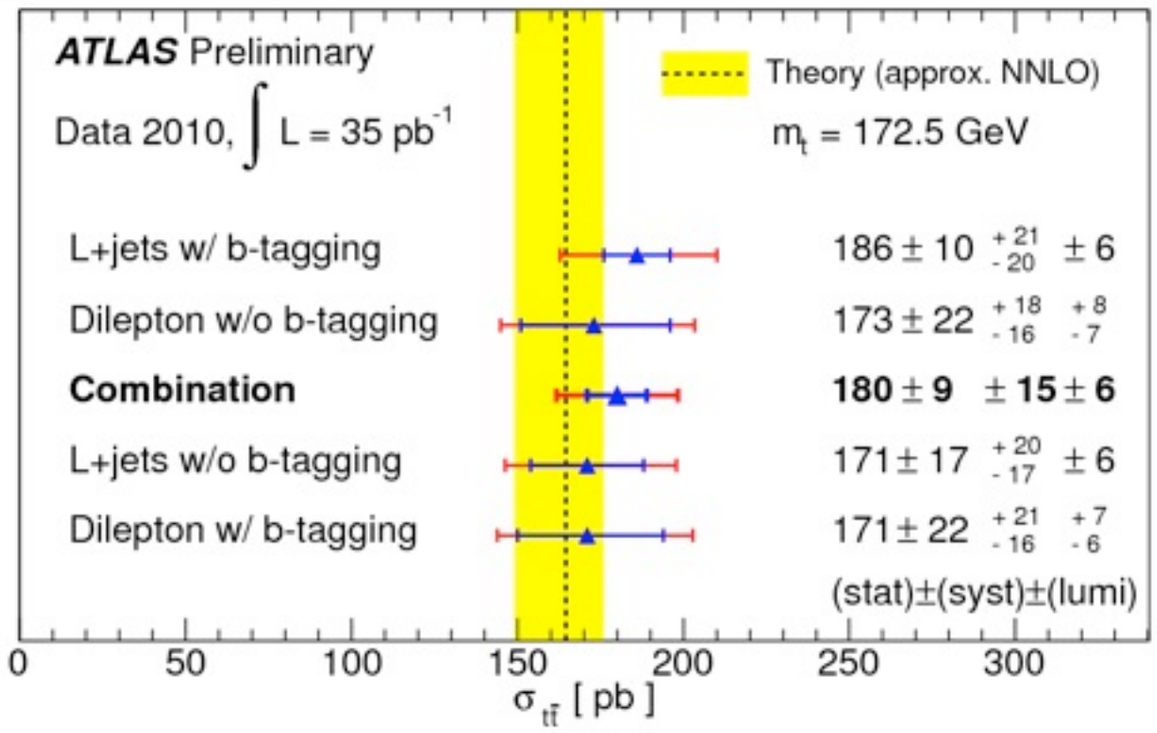
ttbar cross-section measurement with 35pb^{-1}

March in 2011

δσ~10% in combination

δσ~17% with the best dilepton measurement

combination



dilepton

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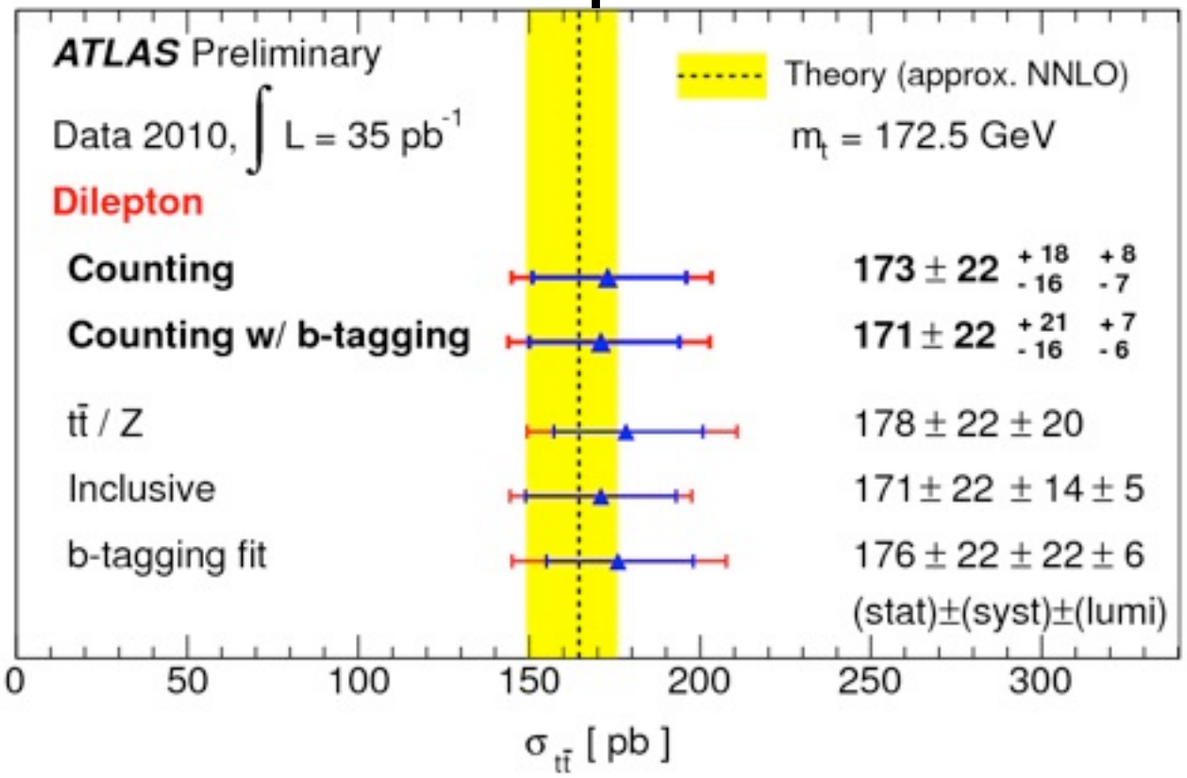
dilepton



- **ttbar/Z** σ_{tt} with luminosity measurement using Z,
- **Inclusive** σ_{tt} with σ_{WW}, $\sigma_{\tau\tau}$, fitting Missing E_T & # of jets,
- **b-tagging fit** σ_{tt} with b-tagging efficiency measurement.

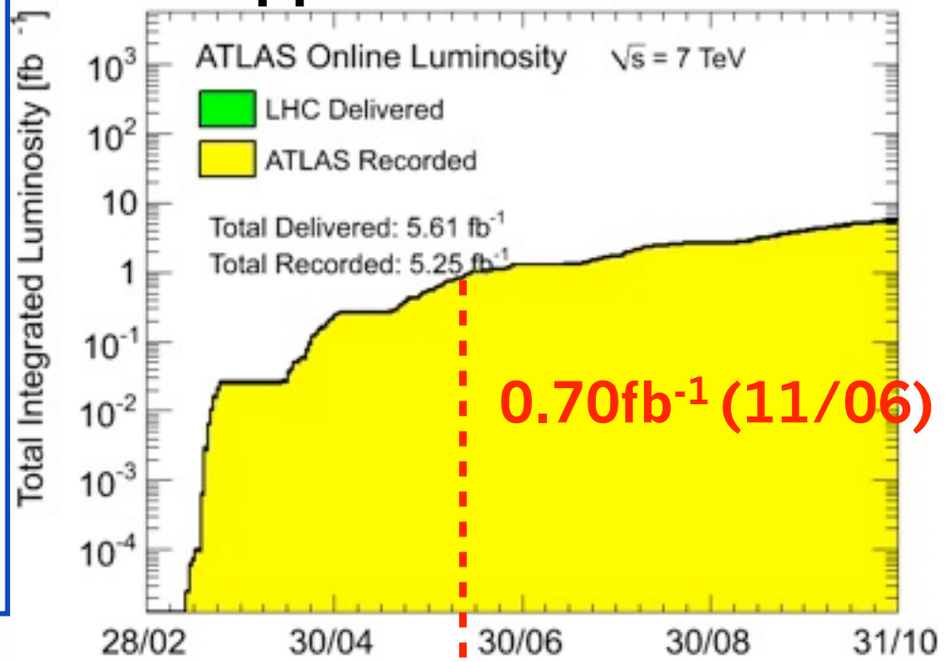
dilepton

arXiv:1108.3699 submitted to Phys. Lett. B

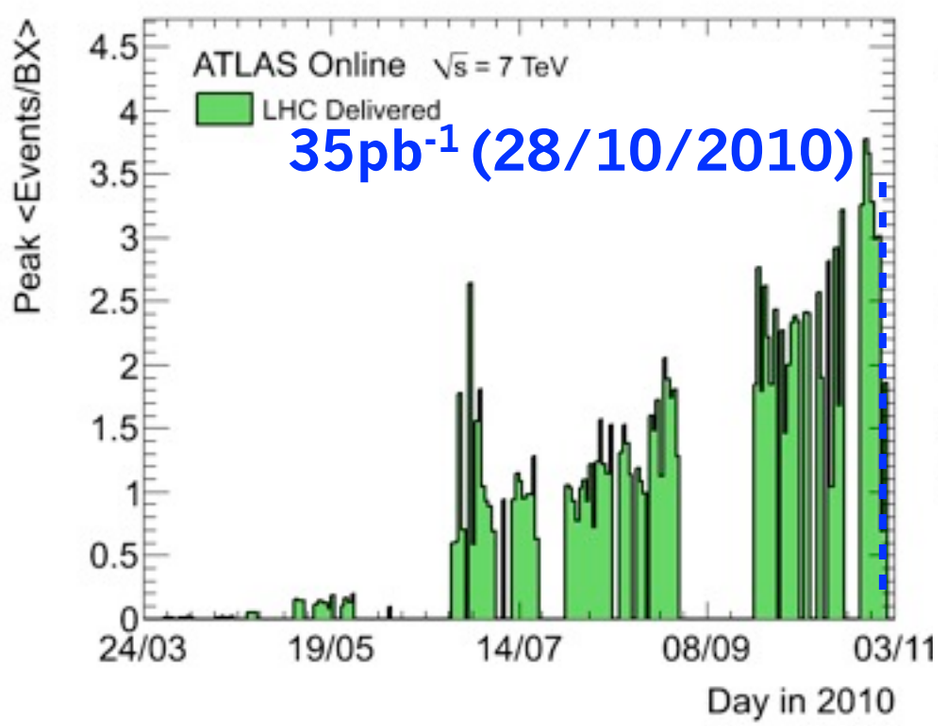
ttbar production cross-section measurement in dilepton channel with 0.70 fb^{-1}

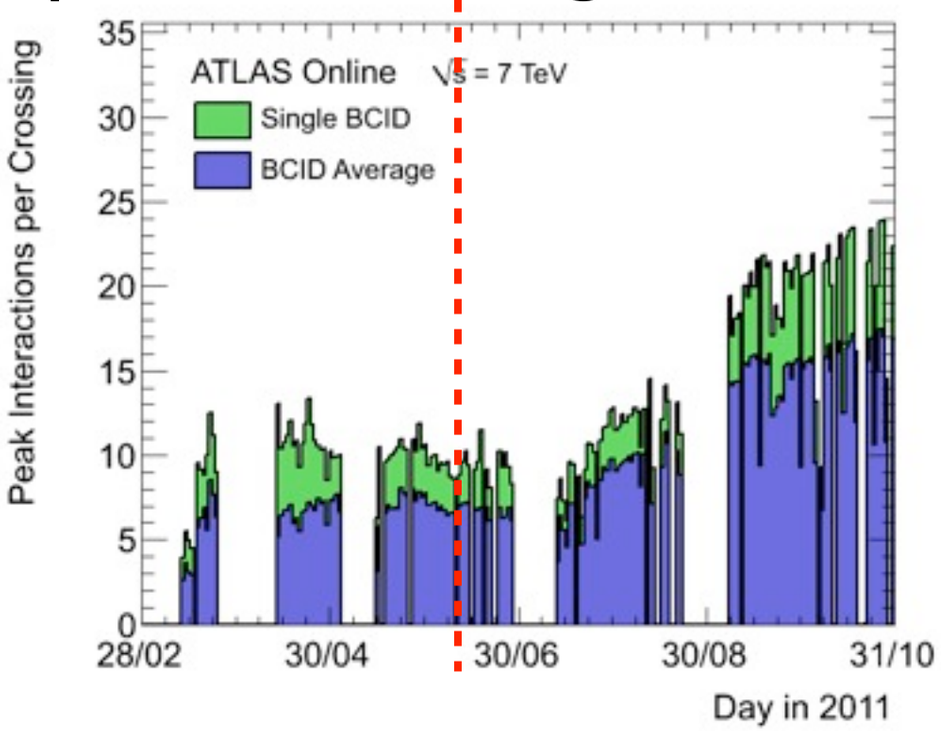
- **Differences from 35 pb^{-1} Analysis**
  - data collected in 2011 are analyzed. (data in 2010 for 35 pb^{-1} analysis)
  - 20 times statistics
  - Optimization for the larger # of pileup events

Integrated luminosity for pp collisions at 7 TeV



peak # of interactions per bunch crossing





Outline

- **Cut and count analysis**
  - 2 identified leptons w/o b-tagging
  - 2 identified leptons with b-tagging

$$\sigma_{t\bar{t}} = \frac{N_{obs} - N_{BG}}{\mathcal{L} \times Acceptance}$$

- **Background - data driven estimate**
  - Z/γ^* + jets (Drell-Yan) for ee/μμ
  - Fake (non-prompt) lepton evnet (W+jets)
- **Background - MC estimate**
  - $Z(\tau\tau)$ + jets
  - single top
  - diboson

Event selection

Good data taking condition, at least 1 single lepton trigger, primary vertex with at least 4 tracks, cosmic muon veto.

- **W/O btagging**

  Exactly two isolated high-p_T opposite charge leptons (e/μ)

  e : p_T > 25 GeV, $|\eta|$ < 2.47, excluding 1.37 < $|\eta|$<1.52
  μ : p_T > 20 GeV, $|\eta|$ < 2.5

  Two or more high p_T (> 20 GeV) anti-k_T(R=0.4) jets with TopoCluster & EM+JES calibration

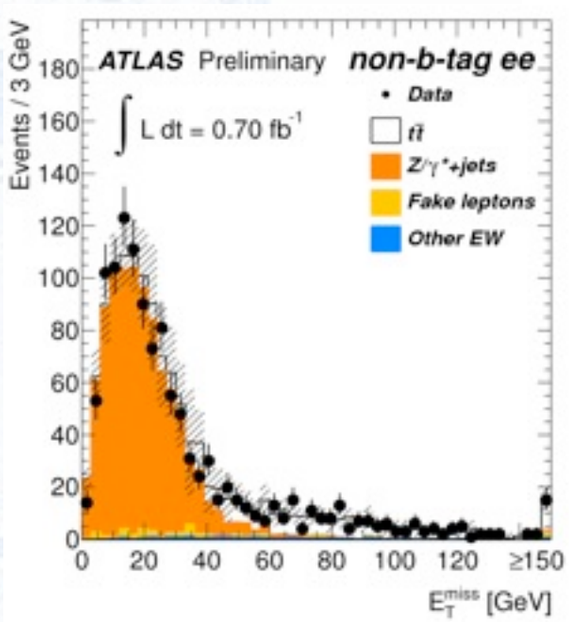
  M_{ll} > 15 GeV && $|M_{ll} - M_Z|$ > 10 GeV

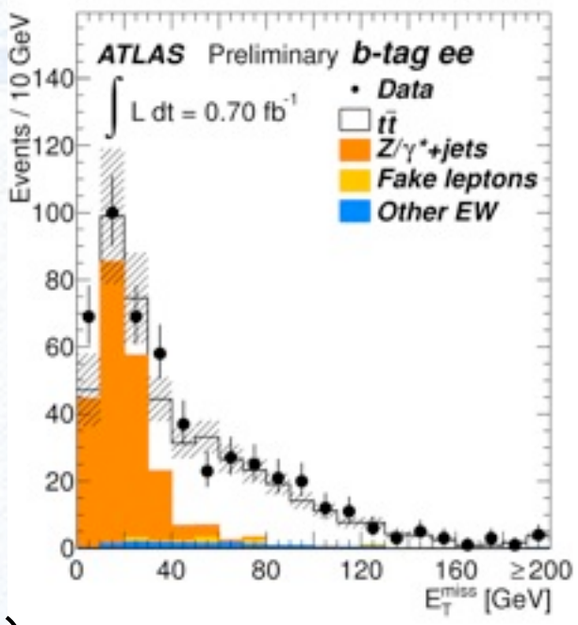
  Missing E_T > 60 GeV for ee, μμ

  HT (sum of all selected lepton p_T and jet E_T) > 130 GeV for eμ

- **With btagging**

  The same as w/o btagging analysis except for
  Missing E_T > 40 GeV for ee, μμ,
  at least 1 btagged jet (b-jet eff. for inclusive ttbar jets = 80 %)



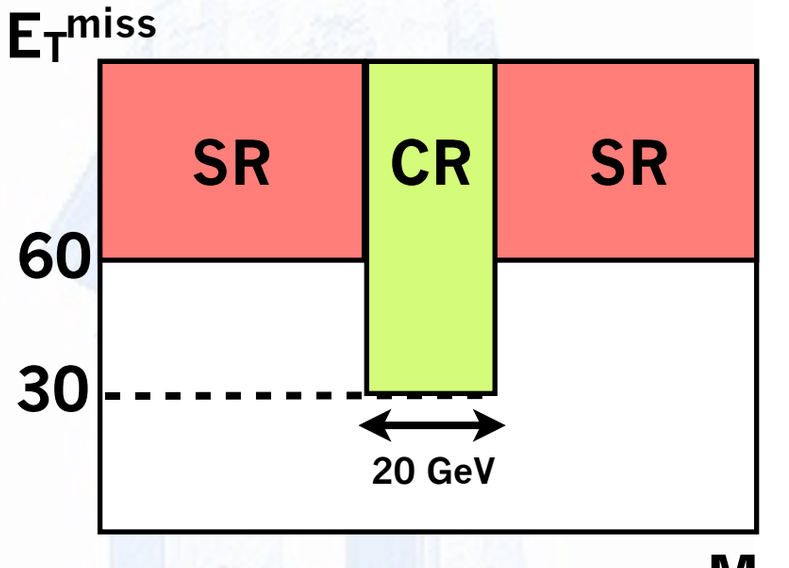


Data driven background estimate

- **Z/γ* + jets (Drell-Yan)**

$$\mathrm{N}_{Z/\gamma^*+\mathrm{jets}} = \frac{\mathrm{MC}_{Z/\gamma^*+jets}(\mathrm{SR})}{\mathrm{MC}_{Z/\gamma^*+jets}(\mathrm{CR})} \times [\mathrm{data}(\mathrm{CR}) - \mathrm{MC}_{\mathrm{other}}(\mathrm{CR})]$$

SR: $|m_{ll}-m_Z| > 10$ GeV, high E_T^{miss}
CR: $|m_{ll}-m_Z| < 10$ GeV, $E_T^{miss} > 30$ GeV

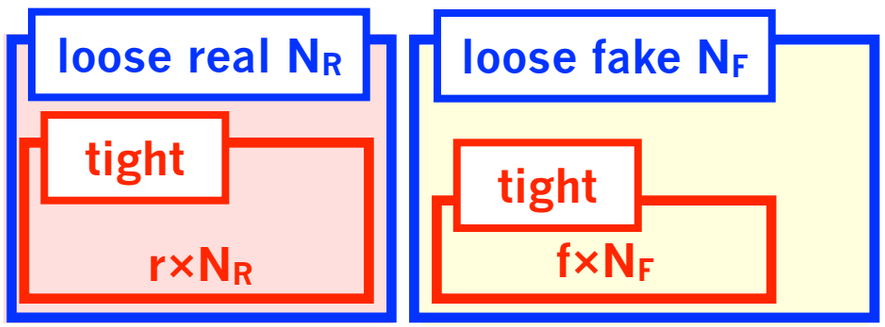


- **Fake lepton event - Matrix method**

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

Single lepton case

$$\begin{bmatrix} N_T \\ N_L \end{bmatrix} = \begin{bmatrix} r & f \\ (1-r) & (1-f) \end{bmatrix} \begin{bmatrix} N_R \\ N_F \end{bmatrix}$$



T : lepton passed tight selection
L : lepton passed loose but not tight selection
R : real lepton
F : fake lepton

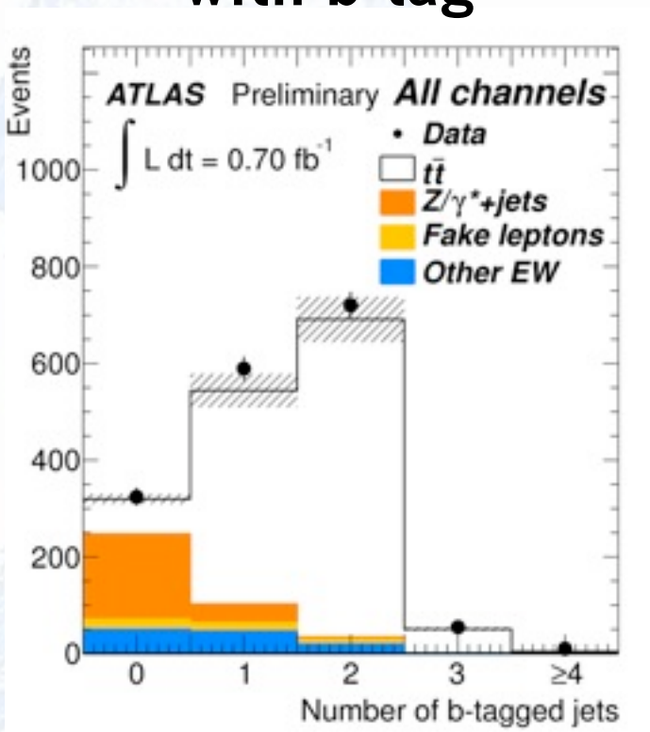
r : eff. tight / loose for real lepton measured in Z sample.
f : eff. tight / loose for fake lepton measured in ttbar single lepton channel control region.

$$N_{fake} = rf \times N_{RF} + fr \times N_{FR} + ff \times N_{FF}$$

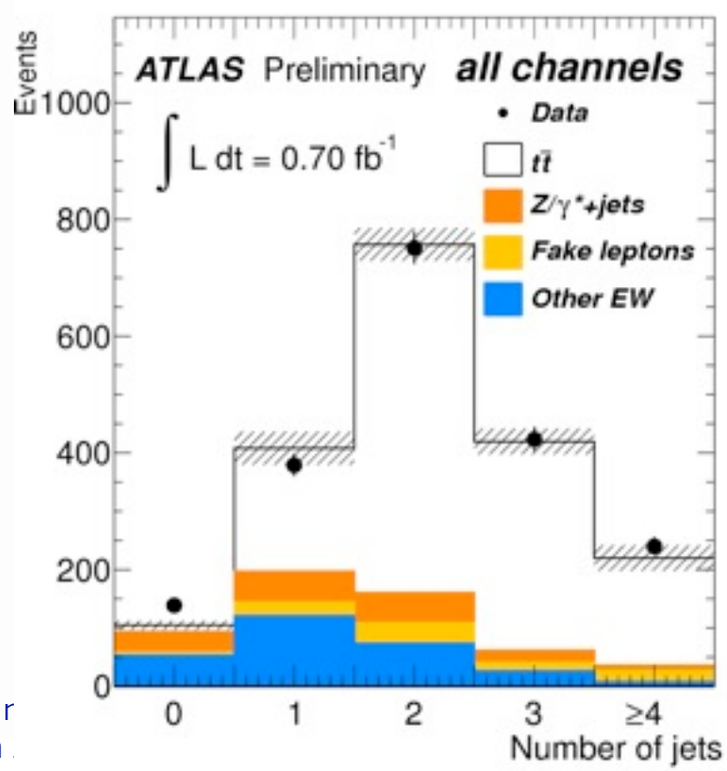
Event Yield

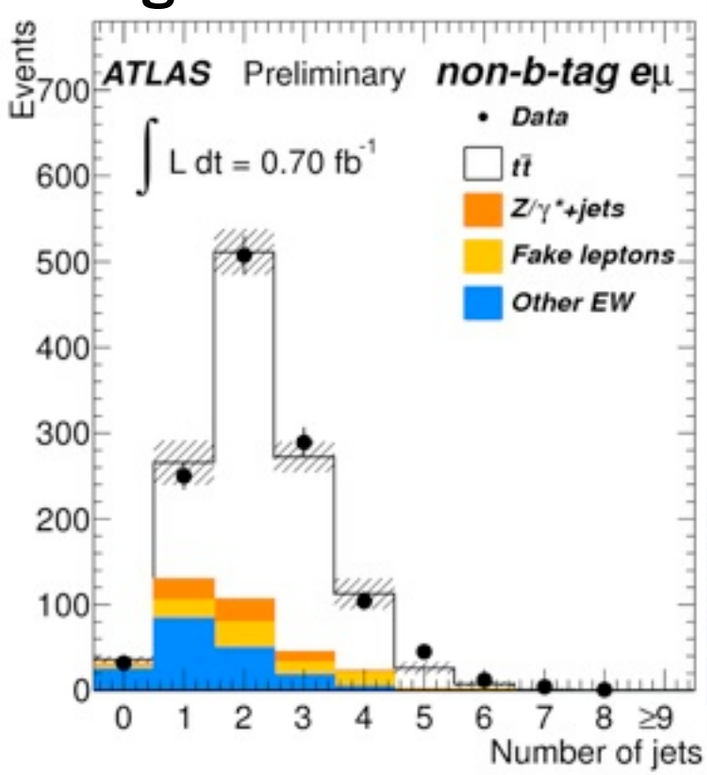
	ee	$\mu\mu$	$e\mu$	b-tag ee	b-tag $\mu\mu$	b-tag $e\mu$
$Z/\gamma^*(\rightarrow ee/\mu\mu)$+jets	$3.8^{+2.5}_{-1.2}$	14.8 ± 4.7	-	$9.3^{+3.7}_{-1.9}$	$19.1^{+2.4}_{-1.6}$	-
$Z/\gamma^*(\rightarrow \tau\tau)$+jets	5.2 ± 2.6	11.2 ± 4.8	43 ± 16	$1.6^{+1.1}_{-0.9}$	$7.0^{+2.8}_{-3.2}$	$9.1^{+3.6}_{-3.7}$
Fake leptons	3.1 ± 2.2	$0.3^{+0.6}_{-0.3}$	44 ± 24	4.9 ± 3.1	1.0 ± 0.8	19 ± 12
Single top quarks	6.6 ± 1.2	16.2 ± 2.0	40.9 ± 5.6	$6.8^{+1.3}_{-1.2}$	$15.4^{+2.5}_{-2.4}$	$30.8^{+4.9}_{-4.5}$
Diboson	5.6 ± 1.0	8.2 ± 1.2	30.9 ± 4.6	2.1 ± 0.8	$2.7^{+0.9}_{-0.6}$	$8.7^{+1.5}_{-1.3}$
Total bkg.	$24.3^{+5.4}_{-4.7}$	50.8 ± 8.4	158 ± 34	$24.7^{+5.2}_{-4.0}$	$45.2^{+4.6}_{-4.4}$	68 ± 14
Predicted $t\bar{t}$	130 ± 16	243^{+22}_{-27}	728 ± 59	161 ± 21	304^{+29}_{-37}	644^{+60}_{-74}
Total	154 ± 17	294^{+23}_{-28}	886 ± 68	186 ± 21	349^{+30}_{-37}	712^{+61}_{-75}
Observed	165	287	962	202	349	823

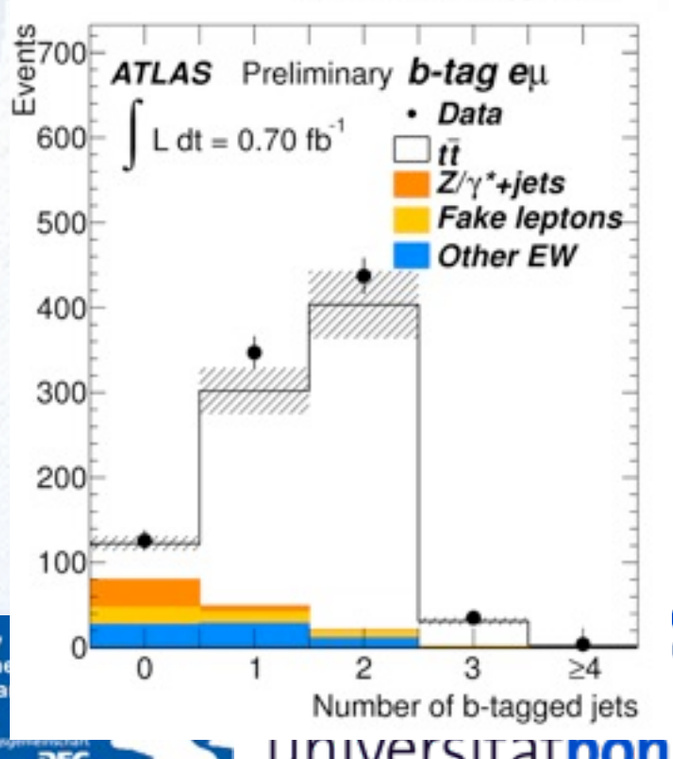
with b-tag



w/o b-tag







Systematics

w/o btagging

Uncertainty Source	ee $\Delta\sigma/\sigma$[%]	$\mu\mu$ $\Delta\sigma/\sigma$[%]	$e\mu$ $\Delta\sigma/\sigma$[%]	Combined $\Delta\sigma/\sigma$[%]
Data statistics	-9.3 / 9.8	-6.6 / 6.8	-4.1 / 4.2	-3.3 / 3.3
Luminosity	-4.0 / 4.7	-3.7 / 4.3	-4.3 / 4.7	-4.2 / 4.6
MC statistics	-4.2 / 4.9	-2.8 / 3.2	-1.9 / 2.1	-1.5 / 1.6
Lepton energy scale	0.0 / 0.9	0.0 / 0.5	-0.3 / 0.3	-0.4 / 0.0
Lepton energy resolution	0.0 / 0.6	-0.5 / 0.8	0.0 / 0.5	-0.4 / 0.3
Lepton indent. scale factor	-5.5 / 6.6	-1.2 / 2.7	-3.1 / 3.4	-2.6 / 2.7
Jet energy scale	-10.0 / 10.6	-3.8 / 7.6	-3.7 / 4.5	-5.9 / 5.3
Jet energy resolution	-0.6 / 0.8	-3.1 / 3.6	-0.6 / 0.7	-0.4 / 0.3
Jet reconstr. efficiency	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0
Drell-Yan prediction	0.0 / 0.0	-0.4 / 0.4	0.0 / 0.0	0.0 / 0.0
Fake leptons	-1.6 / 1.6	-0.4 / 0.4	-3.2 / 3.2	-2.0 / 1.9
MC generator	-4.3 / 5.3	0.0 / 0.0	-2.9 / 3.2	-2.1 / 2.3
Parton shower	-4.7 / 5.8	-0.4 / 0.5	-2.9 / 3.2	-2.3 / 2.4
ISR	-7.1 / 0.6	-0.8 / 3.6	-0.5 / 2.4	-2.4 / 2.5
FSR	-13.6 / 0.6	-0.7 / 4.3	-2.4 / 0.5	-1.3 / 1.4
PDF	-2.4 / 2.8	-1.7 / 2.2	-2.4 / 2.7	-2.3 / 2.5
$E_{\mathrm{T}}^{\mathrm{miss}}$ reconstruction	-1.0 / 1.1	-0.8 / 1.7	0.0 / 0.0	-0.5 / 0.6
Pile-up	-0.6 / 1.3	-0.5 / 1.5	0.0 / 0.0	-0.5 / 0.5
Detector modeling	-0.6 / 1.1	-0.7 / 1.5	-0.7 / 1.2	-1.0 / 1.3
Theoretical cross-sections	-1.4 / 1.3	-1.7 / 1.8	-2.1 / 2.1	-1.9 / 1.9
All systematics	-20 /18	-7.3 /13	-9.2 /11	-9.3 / 10
Stat + Syst	-22 / 20	-9.9 / 15	-10 / 12	-9.8 / 11

with btagging

Uncertainty Source	ee $\Delta\sigma/\sigma$[%]	$\mu\mu$ $\Delta\sigma/\sigma$[%]	$e\mu$ $\Delta\sigma/\sigma$[%]	Combined $\Delta\sigma/\sigma$[%]
Data statistics	-8.3 / 8.7	-5.8 / 6.1	-4.2 / 4.4	-3.2 / 3.3
Luminosity	-3.8 / 4.5	-3.7 / 4.1	-4.3 / 4.7	-4.1 / 4.5
MC statistics	-3.8 / 4.5	-2.6 / 2.9	-2.1 / 2.2	-1.5 / 1.6
Lepton energy scale	-0.7 / 0.0	-0.5 / 0.0	-0.3 / 0.3	-0.3 / 0.3
Lepton energy resolution	0.0 / 0.4	-0.6 / 0.0	0.0 / 0.0	0.0 / 0.3
Lepton ident. scale factor	-5.5 / 6.3	-2.3 / 2.4	-3.1 / 3.4	-2.4 / 2.6
Jet energy scale	-9.7 / 4.8	-4.9 / 5.5	-4.9 / 5.1	-4.7 / 5.3
Jet energy resolution	-1.9 / 2.0	-1.4 / 1.3	-1.4 / 1.4	-1.4 / 1.5
Jet reconstr. efficiency	0.0 / 0.0	-0.6 / 0.0	-0.3 / 0.3	-0.3 / 0.3
Drell-Yan prediction	-0.6 / 0.6	-0.6 / 0.0	0.0 / 0.0	0.0 / 0.0
Fake leptons	-1.9 / 1.8	-0.6 / 0.0	-1.9 / 1.8	-1.1 / 1.2
MC generator	-5.7 / 7.0	-1.3 / 1.3	-2.7 / 2.9	-0.7 / 0.7
Parton shower	-0.6 / 0.0	0.0 / 0.0	0.0 / 4.0	0.0 / 0.3
b-tag efficiency	-3.2 / 4.5	-3.0 / 4.1	-3.5 / 4.7	-3.4 / 4.5
Light quark tag eff.	0.0 / 0.0	-0.6 / 0.0	-0.5 / 0.0	-0.3 / 0.3
ISR	-4.8 / 5.8	-1.5 / 1.5	-0.3 / 0.4	-0.4 / 0.4
FSR	-8.7 / 11.2	-2.8 / 3.1	-0.9 / 0.8	-2.0 / 2.1
PDF	-2.7 / 3.2	-2.3 / 2.5	-2.4 / 2.6	-2.5 / 2.7
$E_{\mathrm{T}}^{\mathrm{miss}}$ reconstruction	-0.9 / 0.0	-1.0 / 0.0	0.0 / 0.0	-0.0 / 0.0
Pile-up	-0.8 / 0.0	-0.3 / 0.0	0.0 / 0.0	-0.0 / 0.0
Detector modeling	-0.7 / 1.4	-0.8 / 2.2	-1.1 / 1.6	-1.9 / 1.8
Theoretical cross-sections	-0.4 / 0.4	-1.1 / 0.6	-0.7 / 0.7	-0.7 / 0.7
All systematics	-16 / 20	-7.9 / 9.9	-8.2 / 11	-8.1 / 9.7
Stat. + Syst.	-19/ 22	-10 / 12	-10 / 13	-9.0 / 11

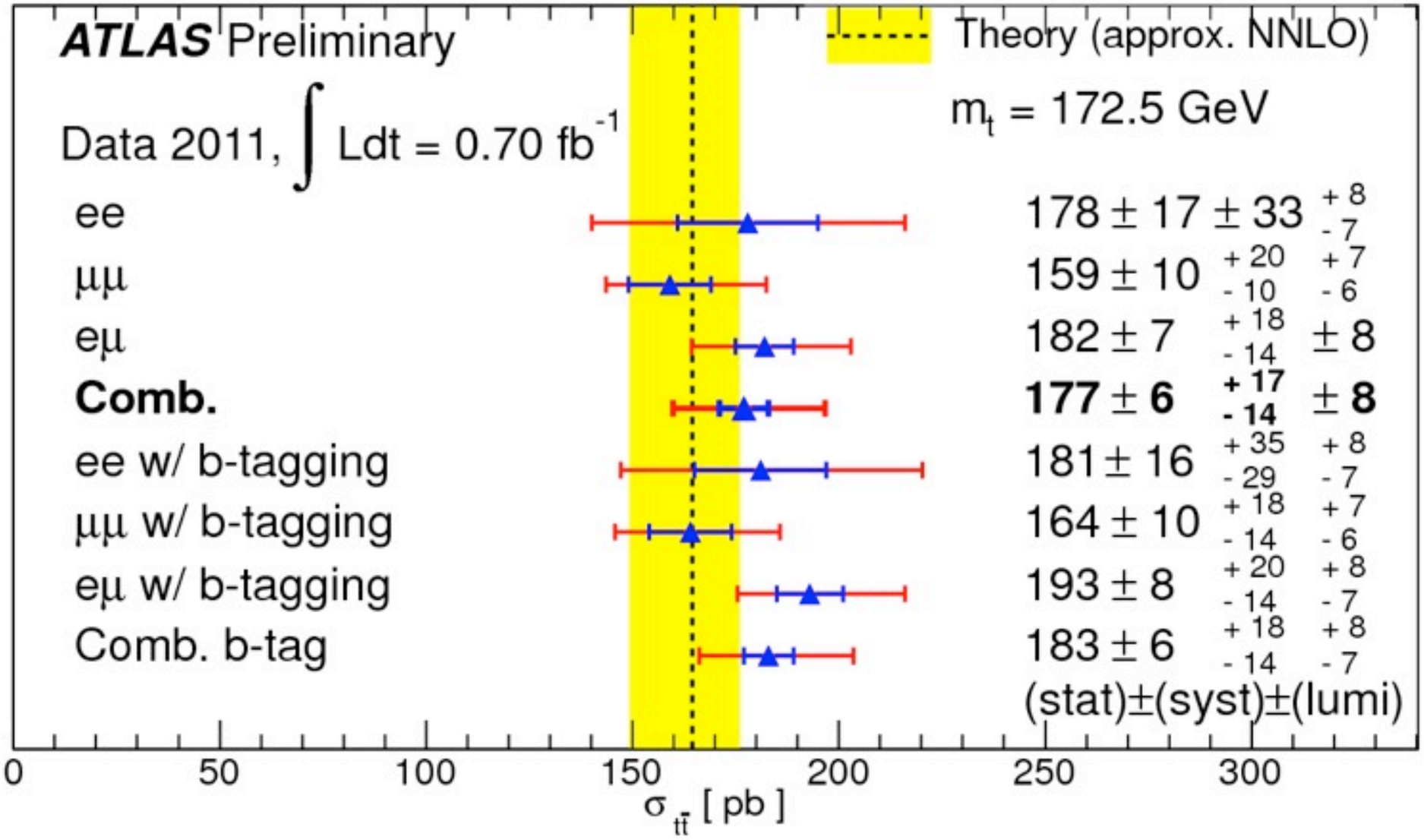
: > 4%

: > 2%, but smaller in the other analysis

Result

ATLAS-CONF-2011-100

Uncertainty 11% in dilepton channel analysis only



$\sigma^{NNLO}tt = 164.57 + 11.45 - 15.78$

Conclusion

- ttbar cross section measurement in dilepton channel is reduced down to 10% (NNLO prediction uncertainty = 10%)
- dilepton channel has enough statistics and the statistical error is ~3%.
- Further effort to reduce the systematic uncertainty in dilepton channel is on going.
  - Multivariate analysis