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Measurement of t-channel single-top production at 8 TeV and 13 TeV

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Single Top-Quarks

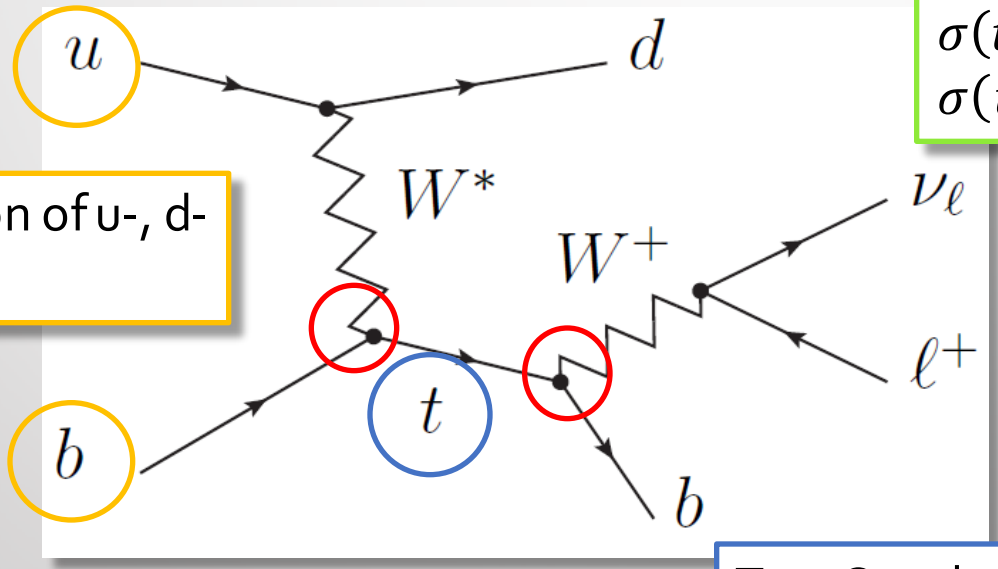
- t-channel (tq) : dominant production channel

NLO Predictions 8 TeV:

$\sigma(tq) = 54.9 \pm 2.3$ pb
$\sigma(\bar{t}q) = 29.7 \pm 1.7$ pb

NLO Predictions 13 TeV:

$\sigma(tq) = 136.0 \pm 5.4$ pb
$\sigma(\bar{t}q) = 81.0 \pm 4.1$ pb



PDF-information of u-, d- and b-quarks

Top-Quark mass

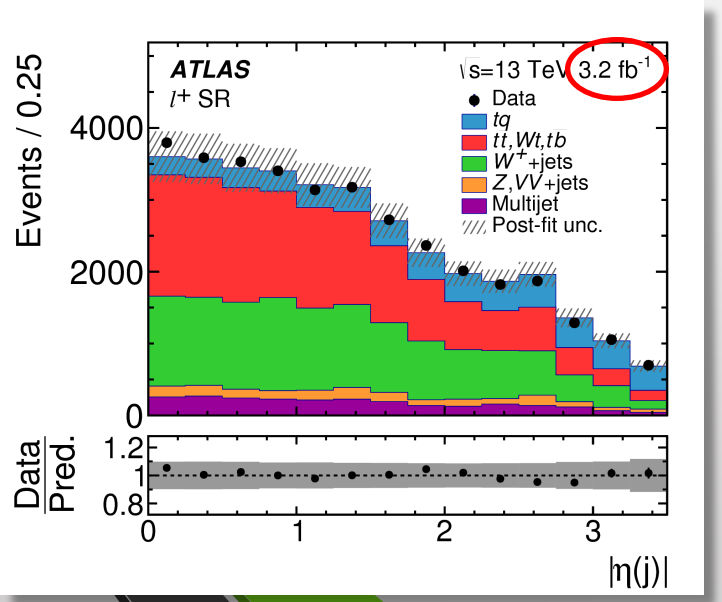
$\sigma(tq) \propto |V_{tb}|^2$ and test of V-A structure of W_{tb} vertex

Event Yield @ 13 TeV

- 1 charged lepton
  - $p_T > 30$ GeV ; $|\eta| < 2.5$
- 2 jets
  - $p_T > 35$ GeV ; $|\eta| < 3.5$
  - 1 b-tagged
- $E_T^{miss} > 30$ GeV
- $m_T(l\, E_T^{miss}) > 50$ GeV

Separate in l^+ and l^- channel to measure tq and $\bar{t}q$ cross sections

Process	ℓ^+ channel	ℓ^- channel
tq	4 200 ± 170	8 ± 3
$\bar{t}q$	5 ± 2	2 710 ± 140
$t\bar{t}$	13 100 ± 790	13 100 ± 790
Wt	1 640 ± 110	1 640 ± 110
$t\bar{b}+\bar{t}b$	298 ± 25	199 ± 18
W^++jets	10 500 ± 2 200	<1
W^-+jets	<1	8 730 ± 1 800
Z, VV+jets	1 530 ± 320	1 410 ± 300
Multijets	2 400 ± 1 200	2 400 ± 1 200
Total expected	33 600 ± 2 600	30 200 ± 2 300
Data observed	34 459	31 056



Dominating backgrounds:
$t\bar{t}$ and $W + jets$

S/B : +channel ~ 14.%
-channel ~ 9.0%

arxiv: 1609.03920

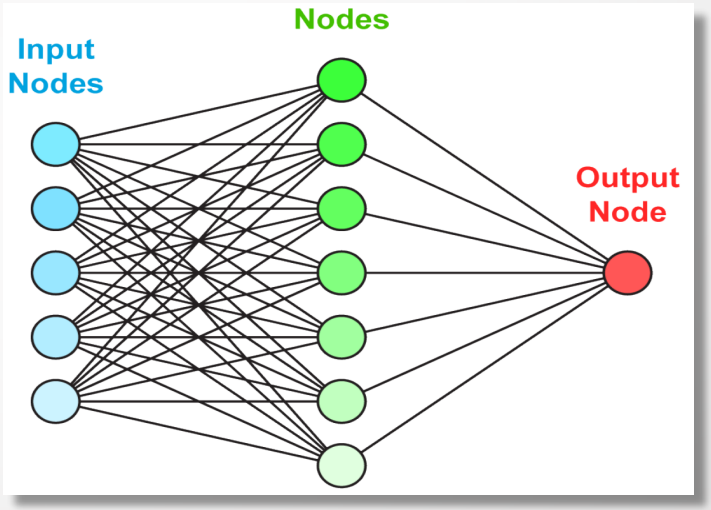
Neural network

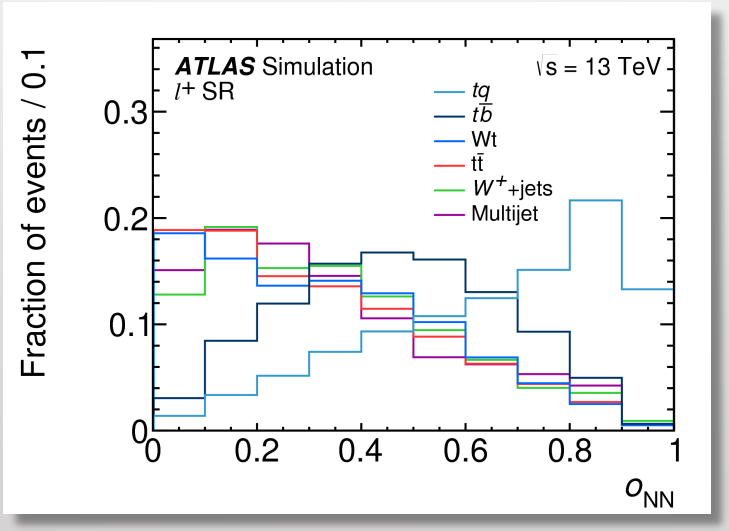
Variable
$m(\ell\nu b)$
$m(jb)$
$m_{\mathrm{T}}(\ell E_{\mathrm{T}}^{\mathrm{miss}})$
$\lvert\eta(j)\rvert$
$m(\ell b)$
$\eta(\ell\nu)$
$\Delta R(\ell\nu b, j)$
$\cos\theta^*(\ell, j)$
$\Delta p_{\mathrm{T}}(\ell\nu b, j)$
$\Delta R(\ell, j)$

Use 10 variables with good separation power and data/MC agreement

$t\bar{t}$ and $W + jets$

Use 50% signal and 50% background





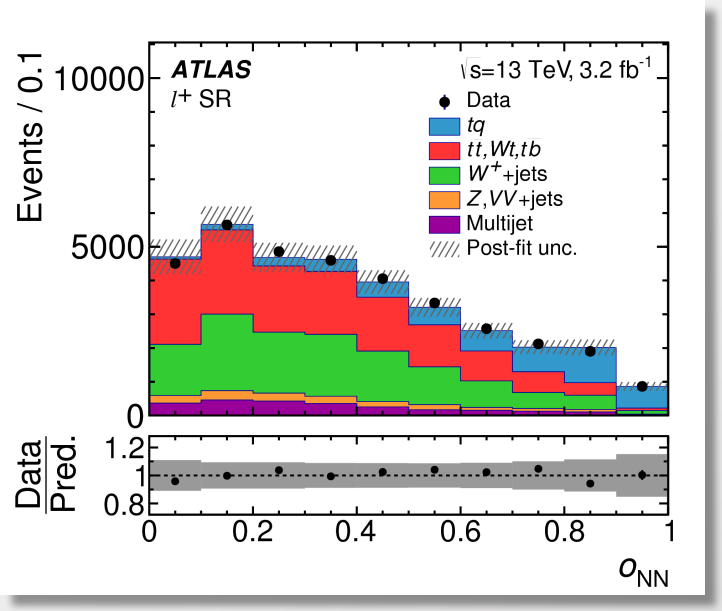
Good separation

arxiv: 1609.03920

Inclusive cross section

Source	$\frac{\Delta\sigma(tq)}{\sigma(tq)}$ [%]	$\frac{\Delta\sigma(\bar{t}q)}{\sigma(\bar{t}q)}$ [%]
Data statistics	± 2.9	± 4.1
Monte Carlo statistics	± 2.8	± 4.2
Reconstruction efficiency and calibration uncertainties		
Muon uncertainties	± 0.8	± 0.9
Electron uncertainties	< 0.5	± 0.5
JES	± 3.4	± 4.1
Jet energy resolution	± 3.9	± 3.1
$E_{\mathrm{T}}^{\mathrm{miss}}$ modelling	± 0.9	± 1.2
b-tagging efficiency	± 7.0	± 6.9
c-tagging efficiency	< 0.5	± 0.5
Light-jet tagging efficiency	< 0.5	< 0.5
Pile-up reweighting	± 1.5	± 2.2
Monte Carlo generators		
tq parton shower generator	± 13.0	± 14.3
tq NLO matching	± 2.1	± 0.7
tq radiation	± 3.7	± 3.4
$t\bar{t}$, Wt, $t\bar{b}+\bar{t}b$ parton shower generator	± 3.2	± 4.4
$t\bar{t}$, Wt, $t\bar{b}+\bar{t}b$ NLO matching	± 4.4	± 8.6
$t\bar{t}$, Wt, $t\bar{b}+\bar{t}b$ radiation	< 0.5	± 1.1
PDF	± 0.6	± 0.9
Background normalisation		
Multijet normalisation	± 0.3	± 2.0
Other background normalisation	± 0.4	± 0.5
Luminosity	± 2.1	± 2.1
Total systematic uncertainty	± 17.5	± 20.0
Total uncertainty	± 17.8	± 20.4

Maximum Likelihood (ML) fit



Measured cross sections:

$\sigma(tq) = 156 \pm 5(stat) \pm 27(syst) \pm 3(lumi)$pb

$\sigma(\bar{t}q) = 91 \pm 4(stat) \pm 18(syst) \pm 2(lumi)$pb

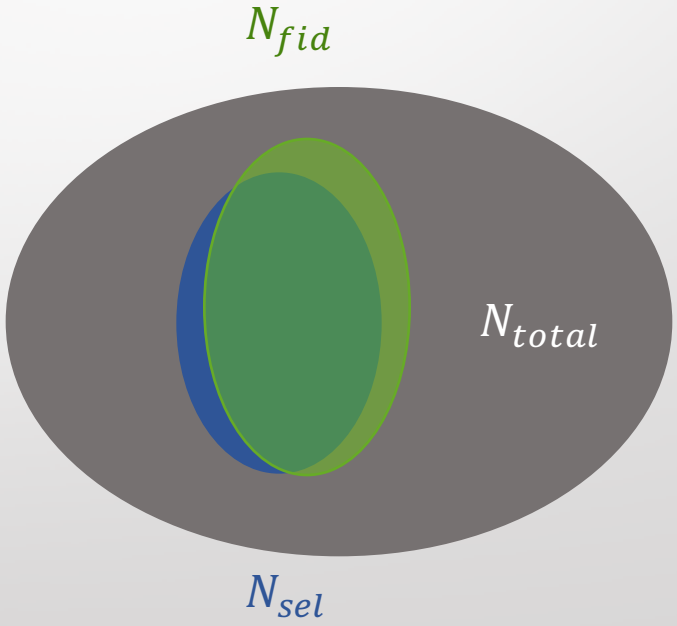
arxiv:1609.03920

Fiducial cross section @ 8 TeV

- Measure the tq cross section widely independent of the choice of signal MC-generator
- Define a fiducial phase-space close to the phase-space of selected data events

Potentially significant reduction of some acceptance uncertainties

- Measure fiducial cross section
- Extrapolate to inclusive cross section



Same strategy

- 1 charged lepton
  - $p_T > 25$ GeV ; $|\eta| < 2.5$
- 2 jets
  - $p_T > 30$ GeV ; $|\eta| < 4.5$
  - 1 b-tagged
- $E_T^{miss} > 30$ GeV
- $m_T\left(l\, E_T^{miss}\right) > 50$ GeV
- $m(l\, b) < 160$ GeV

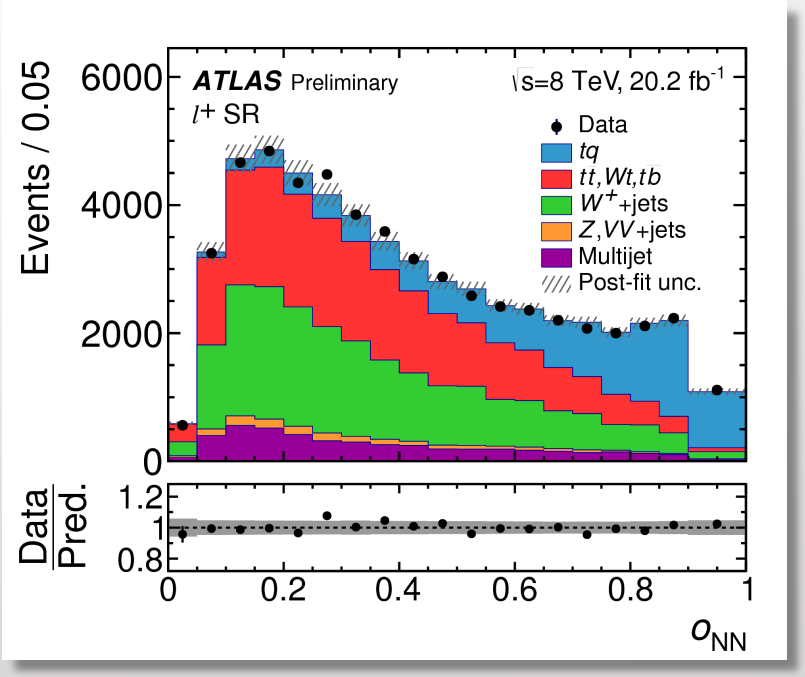
little bit more inclusive

Additional cut to avoid off-shell top-quarks

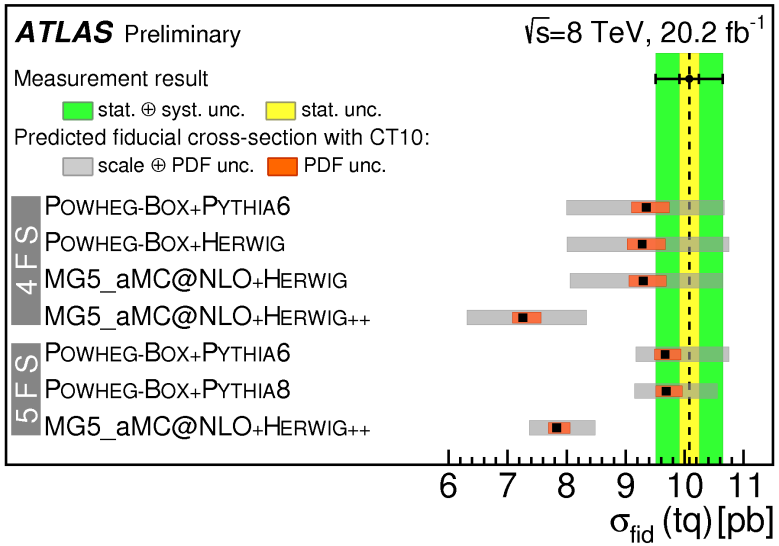
Variable symbol
$m(jb)$
$\lvert\eta(j)\rvert$
$m(\ell\nu b)$
$m_{\mathrm{T}}(\ell E_{\mathrm{T}}^{\mathrm{miss}})$
$\lvert\Delta\eta(\ell\nu, b)\rvert$
$m(\ell b)$
$\cos\theta^*(\ell, j)$

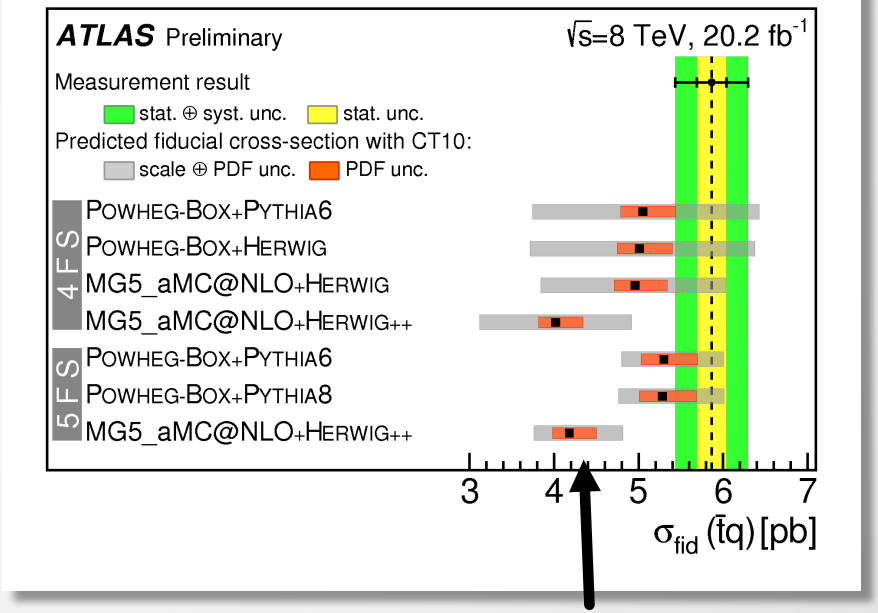
ML fit

Optimised for minimal number of needed variables without loss in uncertainty



8TeV fiducial cross sections





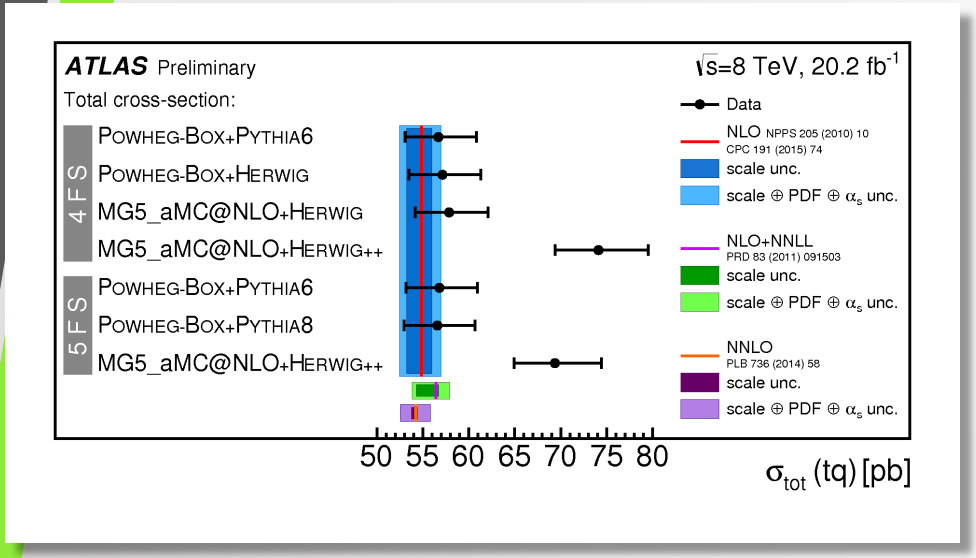
Measured fiducial cross sections :

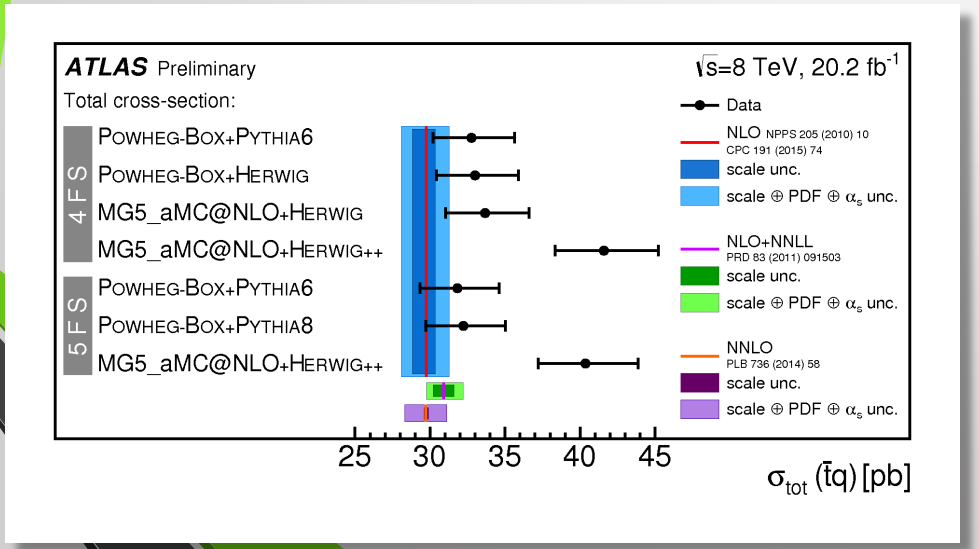
$$\sigma_{fid}(tq) = 10.08 \pm 0.17(stat) \pm 0.53(syst) \pm 0.18(lumi)\text{pb}$$

$$\sigma_{fid}(\bar{t}q) = 5.86 \pm 0.15(stat) \pm 0.42(syst) \pm 0.11(lumi)\text{pb}$$

bug was found regarding neutrinos in jet reconstruction -> leading to smaller acceptance

8TeV inclusive cross sections





Measured extrapolated cross sections using Powheg+Pythia6:

$\sigma_{tot}(tq) = 56.7 \pm 0.9(stat) \pm 2.7(exp) \pm 3.0(theo) \pm 1.1(lumi)$pb

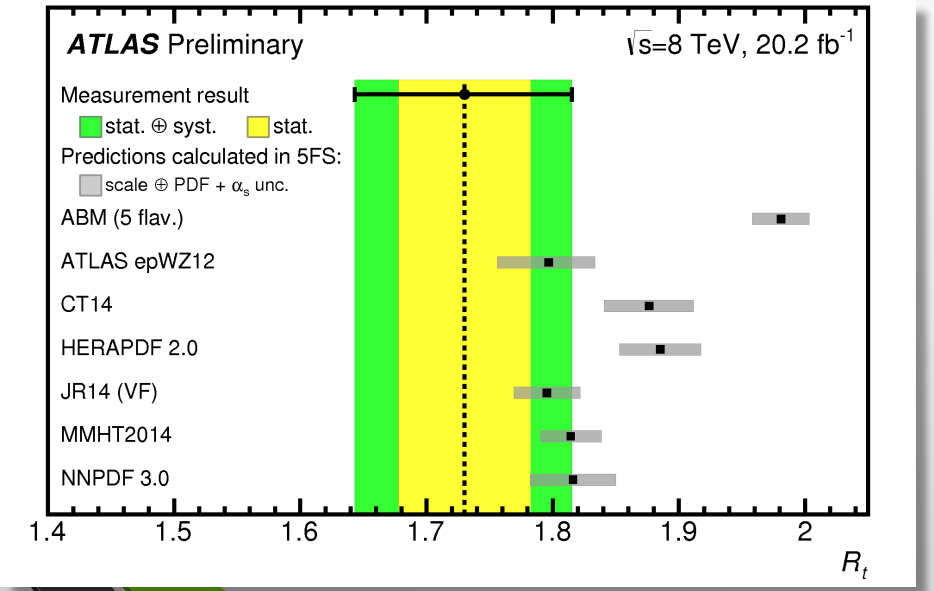
$\sigma_{tot}(\bar{t}q) = 32.8 \pm 0.8(stat) \pm 2.2(exp) \pm 1.7(theo) \pm 0.6(lumi)$pb

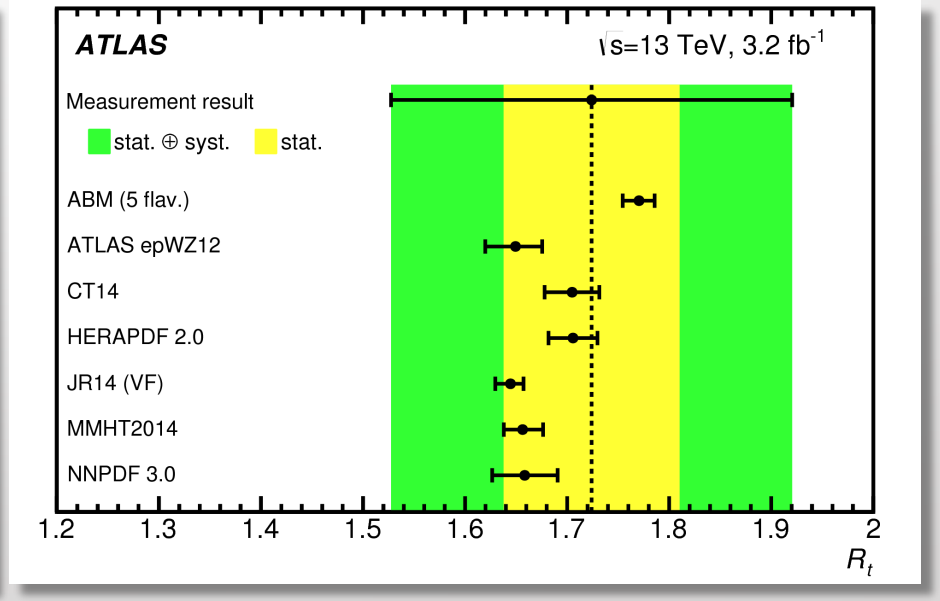
Cross section ratio

- $R_t = \sigma(t)/\sigma(\bar{t})$ ⟵ Sensitive to ratio of the up and down quarks in proton

Measured ratios:

$$R_t^{8\ TeV} = 1.73 \pm 0.05(stat) \pm 0.07(syst)$$
$$R_t^{13\ TeV} = 1.72 \pm 0.09(stat) \pm 0.18(syst)$$

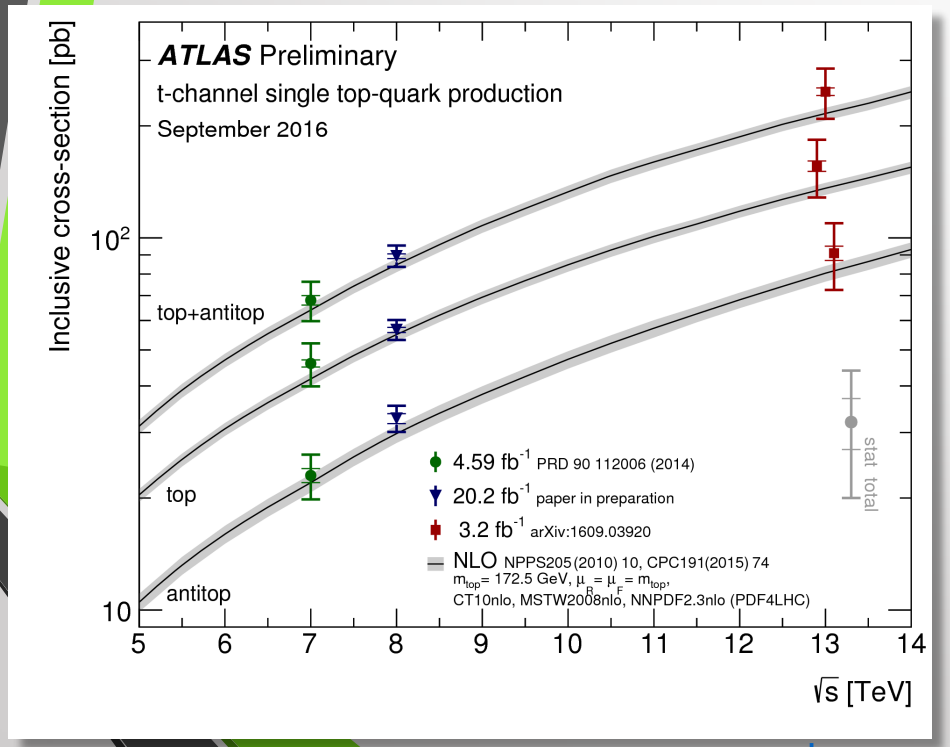


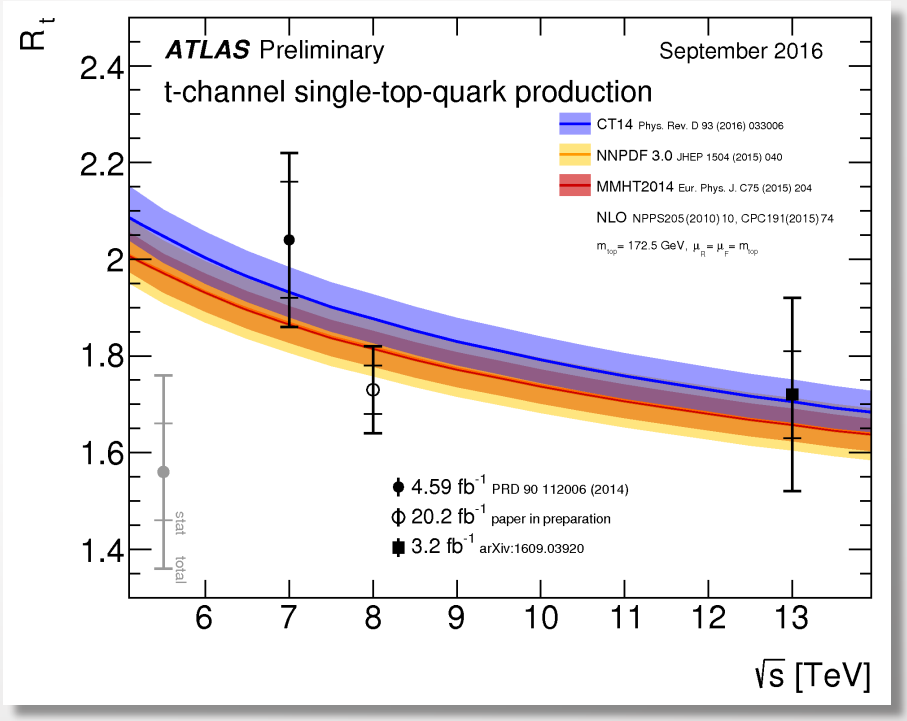


$TOPQ - 2015 - 05$ $arxiv: 1609.03920$

Summary

- Precise measurement of fiducial and total cross sections at 8 TeV
- For differential cross section see next talk from Pienpen





- First measurement of total cross section at 13 TeV
- Using larger dataset and fiducial measurement can improve uncertainties

[summary plots]