

EPS-HEP 2015
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Top quark production measurements at **ATLAS**

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On behalf of the ATLAS Collaboration

Top quark physics

Three Generations of Matter (Fermions)

	I	II	III	
mass→	2.4 MeV	1.27 GeV	171.2 GeV	0
charge→	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0
spin→	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
name→	u up	c charm	t top	γ photon
	4.8 MeV	104 MeV	4.2 GeV	0
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
Quarks	d down	s strange	b bottom	g gluon
	<2.2 eV	<0.17 MeV	<15.5 MeV	91.2 GeV
	0	0	0	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	Z weak force
	0.511 MeV	105.7 MeV	1.777 GeV	80.4 GeV
	-1	-1	-1	± 1
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
Leptons	e electron	μ muon	τ tau	W weak force

Bosons (Forces)

Top quark basics:

- Mass: $173.34 \pm 0.27 \pm 0.71$ GeV (arXiv:1403.4427, Tevatron-LHC combination)
- Decays: charged current weak decays in $t \rightarrow Wb$

Why study top quark physics?

- Yukawa coupling with the Higgs $\sim 1 \rightarrow$ Important role in the EWSB
- Life-time shorter than hadronization time
 \rightarrow Unique possibility to study a 'bare' quark
- Precise tests of the Standard Model and verification of pQCD
- Privileged window to search for new physics
 - Cross section measurements needed to improve top quark MC modelling, especially when used as a background for BSM processes

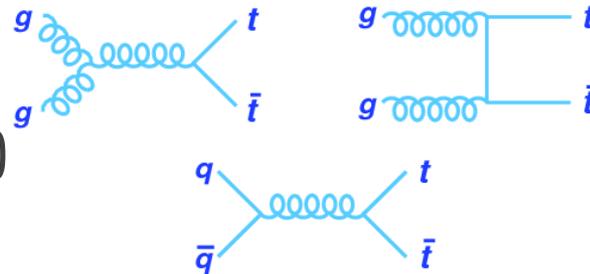
Top quark cross section measurements

- $t\bar{t}$: inclusive and differential
- Single top inclusive

Top quark pair production and decays

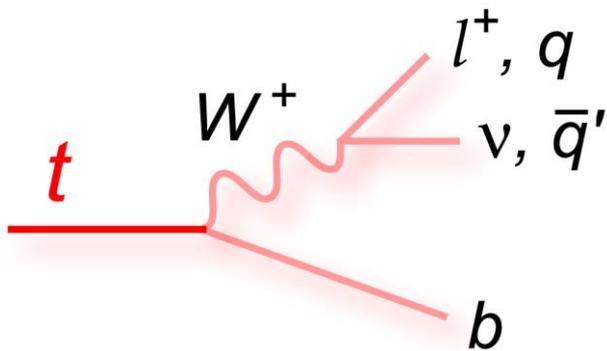
Production mechanisms at LHC

- Gluon-gluon fusion ($\sim 85\%$ @ 7 TeV)
- Quark-antiquark annihilation



Decays

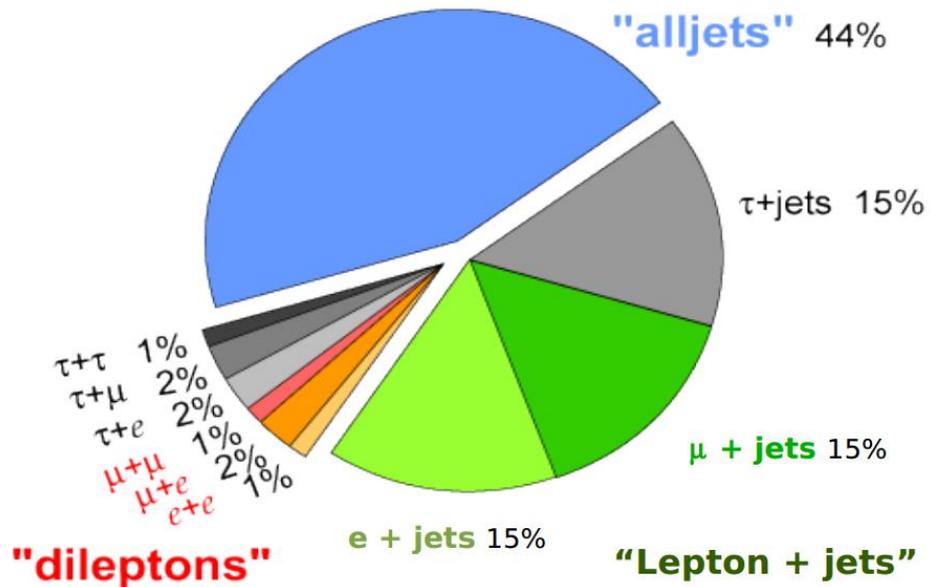
- $t \rightarrow Wb$ ($\sim 100\%$)



$$W \rightarrow l\nu_l \sim 33\%$$

$$W \rightarrow q\bar{q}' \sim 66\%$$

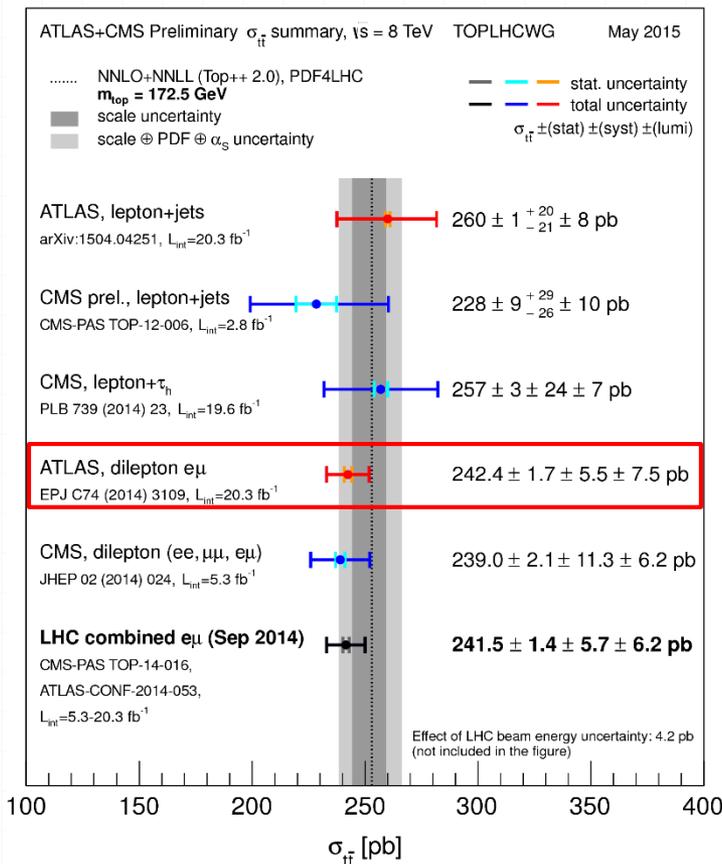
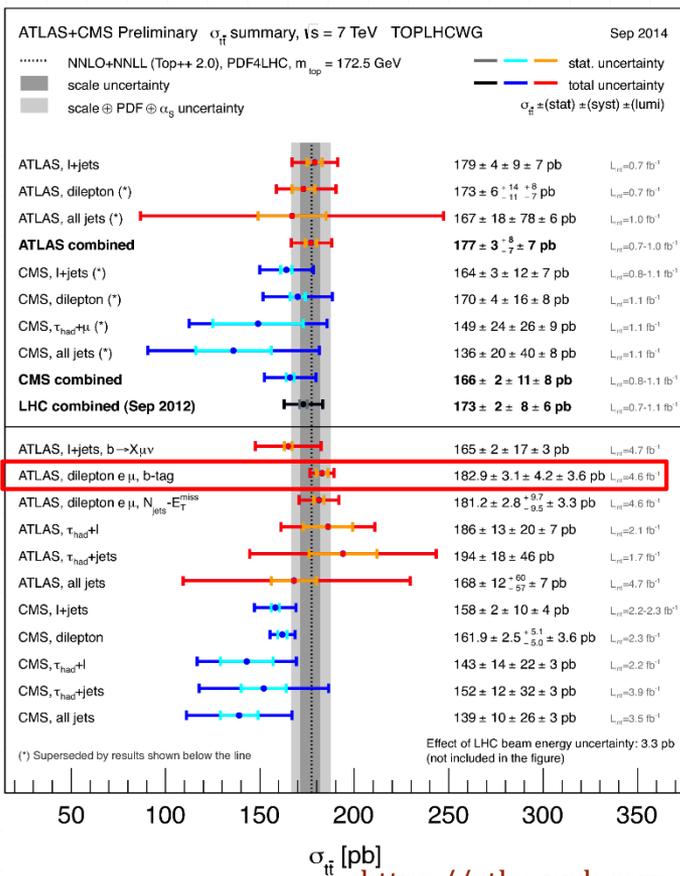
Top pair final states



Top quark pair inclusive cross section: summary

$\sigma(tt) @ \sqrt{s} = 7 \text{ TeV}$

$\sigma(tt) @ \sqrt{s} = 8 \text{ TeV}$



Good agreement of all measurements with SM predictions

Experimental uncertainties already comparable with theoretical ones

Dilepton $e\mu$ measurement is the most precise measurement to date

$t\bar{t}$ inclusive cross section $e\mu$ channel

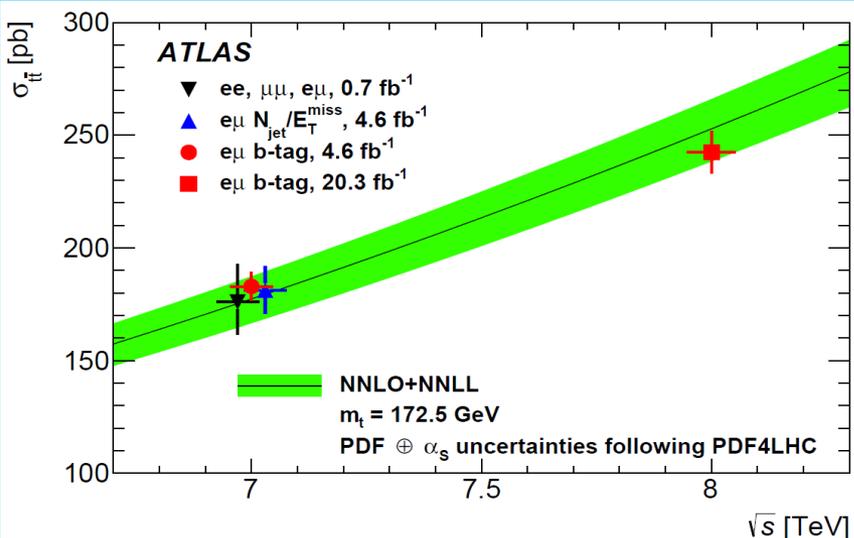
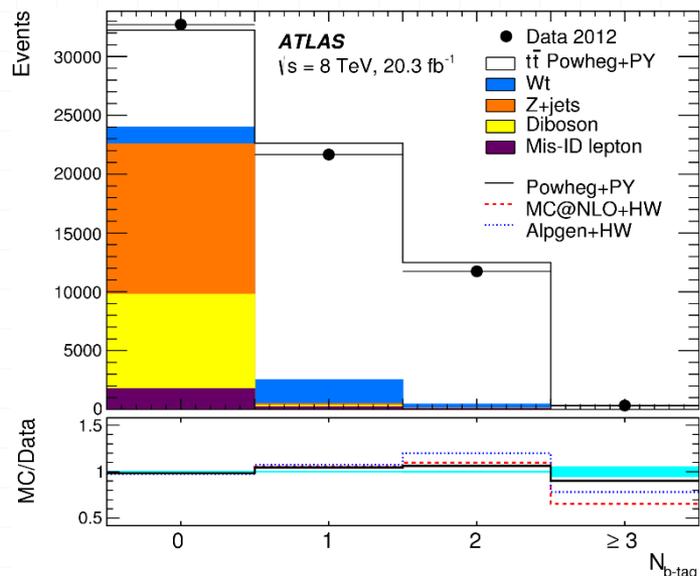
EPJC 74 (2014) 3109

$$\sqrt{s} = 7 \text{ TeV}, L = 4.6 \text{ fb}^{-1}$$

$$\sqrt{s} = 8 \text{ TeV}, L = 20.3 \text{ fb}^{-1}$$

Simultaneous fit of the $t\bar{t}$ production cross section (total and fiducial) and the b -jet reconstruction and tagging efficiency in 1 and 2 b -tag samples

- Correlation between the b -tag probabilities of the 2 jets taken in account
- Significant reduction of major systematics
- Dominating systs: beam energy, integrate lumi, $t\bar{t}$ modelling
- **Fiducial phase space:** $1e$ and 1μ ($p_T > 25\text{GeV}$, $|\eta| < 2.5$)



Total cross section [pb]

$$7 \text{ TeV: } \sigma_{t\bar{t}} = 182.9 \pm 7.1 (\pm 3.9\%)$$

$$8 \text{ TeV: } \sigma_{t\bar{t}} = 242.4 \pm 10 (\pm 4.3\%)$$

NNLO+NNLL predictions

(M. Czakon and A. Mitov, Comp. Phys. Comm. 182 2930 (2014))

$$7 \text{ TeV: } \sigma_{t\bar{t}}^{th} = 177.3 \pm 9.0_{-6.0}^{+4.6} (\pm 5.1\%_{-3.4\%}^{+2.6\%})$$

$$8 \text{ TeV: } \sigma_{t\bar{t}}^{th} = 252.9 \text{ pb} \pm 11.7_{-8.6}^{+6.4} (\pm 4.6\%_{-2.4\%}^{+2.5\%})$$

Fiducial cross section [pb]

$$7 \text{ TeV: } \sigma_{t\bar{t}} = 2.615 \pm 0.082 (\pm 3.8\%)$$

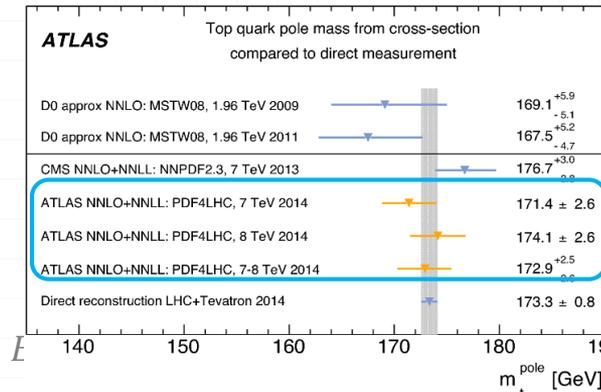
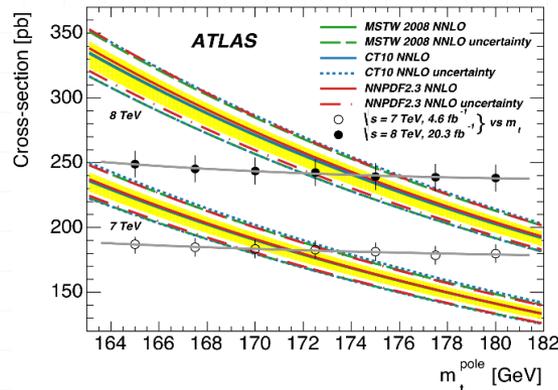
$$8 \text{ TeV: } \sigma_{t\bar{t}} = 3.448 \text{ pb} \pm 0.14 (\pm 4.1\%)$$

$t\bar{t}$ inclusive cross section $e\mu$ channel

EPJC 74 (2014) 3109

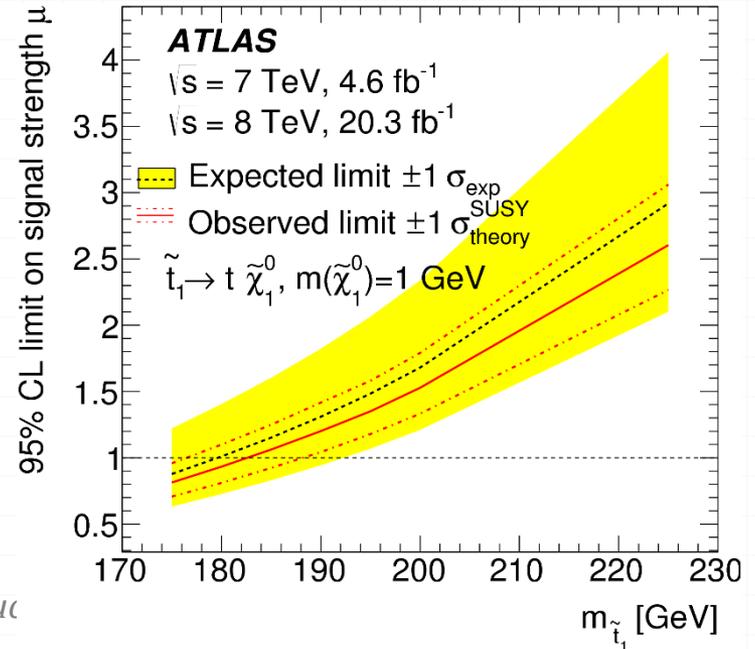
Strong dependence of NNLO $\sigma_{t\bar{t}}$ on m_t

- Also $\sigma_{t\bar{t}}^{meas}$ shows (weak) dependence on m_t
- Extraction of top *pole* mass via the maximization of a Bayesian likelihood function



Constraints on stop pair production

- R-parity conserving SUSY extension of SM with $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ (BR = 100%)
- Fit $\sigma_{\tilde{t}_1\tilde{t}_2}$ to the $\sigma_{t\bar{t}}^{meas} - \sigma_{t\bar{t}}^{th}$ difference
- 95% CL exclusion of stop with $m_t < m_{\tilde{t}_1} < 177 \text{ GeV}$



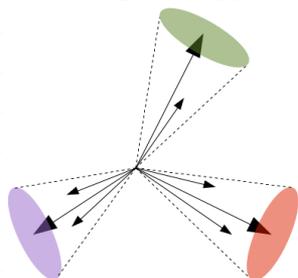
Top quark pairs differential cross section measurements in ATLAS

Total $\sigma_{t\bar{t}}$ measurements show very good agreement with the SM

- New physics phenomena can still affect the *shape* of $\sigma_{t\bar{t}}$

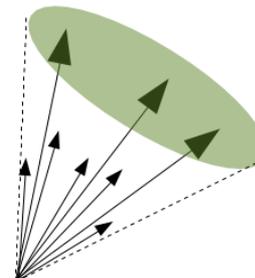
Top reconstruction strategies

'Resolved' topology



- Optimized for low- p_T (< 300 GeV) top quarks
- Top-quark decay products are well separated and can be reconstructed individually
- Top-antitop kinematic evaluated from the reconstructed decay products

'Boosted' topology

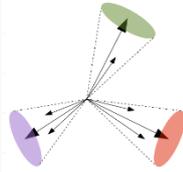


- Optimized for high- p_T (> 300 GeV) top quarks
- Top quark decay products are not isolated
- Hadronically decaying top quark is reconstructed in a single large radius jet

$t\bar{t}$ normalized differential cross section

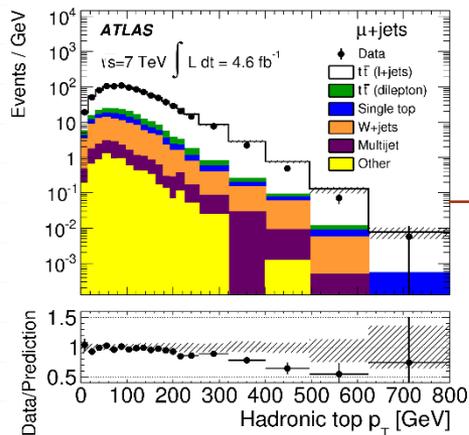
Phys. Rev. D 90, 072004

$\sqrt{s} = 7 \text{ TeV}, L = 4.6 \text{ fb}^{-1}$

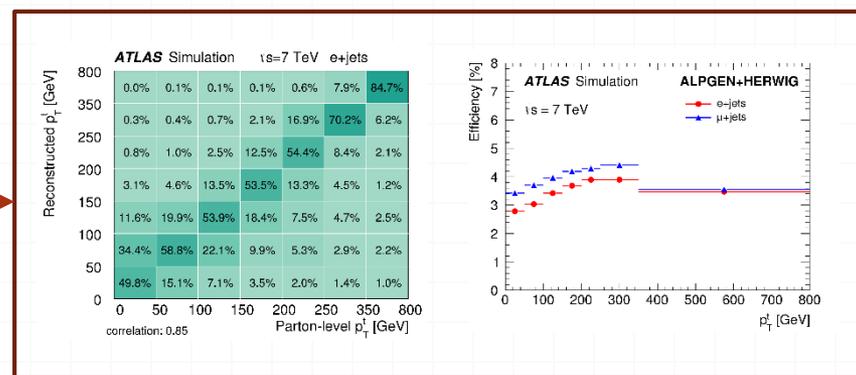


- Top-antitop relative differential cross section $\left(\frac{1}{\sigma} \frac{d\sigma}{dX}\right)$ where $X = m_{t\bar{t}}, p_{T,t\bar{t}}, |y_{t\bar{t}}|$ and $p_{T,t}$
 - Relative measurement more precise than the *absolute* \rightarrow cancellation of correlated systematics
- Events selected in the lepton(e/μ)+jets channel
 - Parton t and \bar{t} reconstructed via a kinematic likelihood fit
- Final parton level measurement extracted via unfolding procedure and extrapolated to the *total* phase space
 - Electron and muon channel combination via the Asymmetric Iterative BLUE (AIB)
 - Main uncertainty (top p_T): $t\bar{t}$ modelling, JES, b -tag

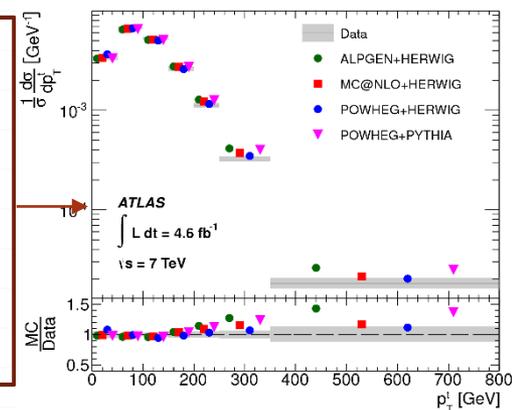
Reco spectrum



Resolution & efficiency corrections



Parton level measurement

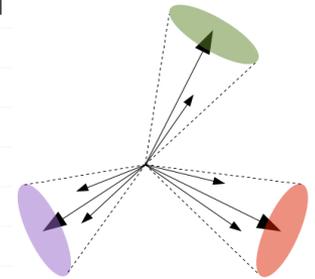


$t\bar{t}$ differential cross section

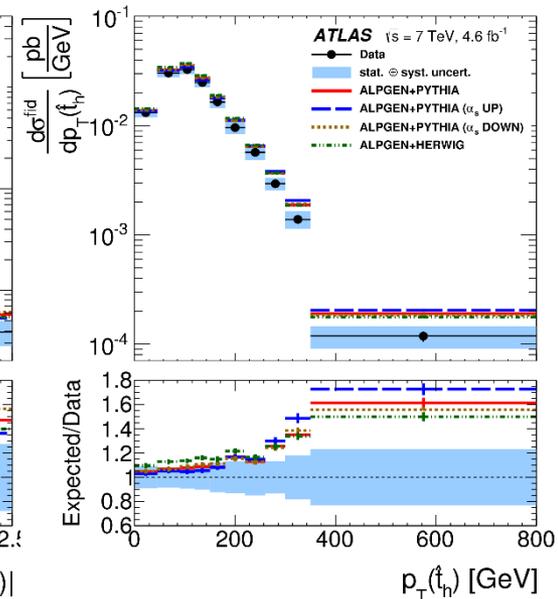
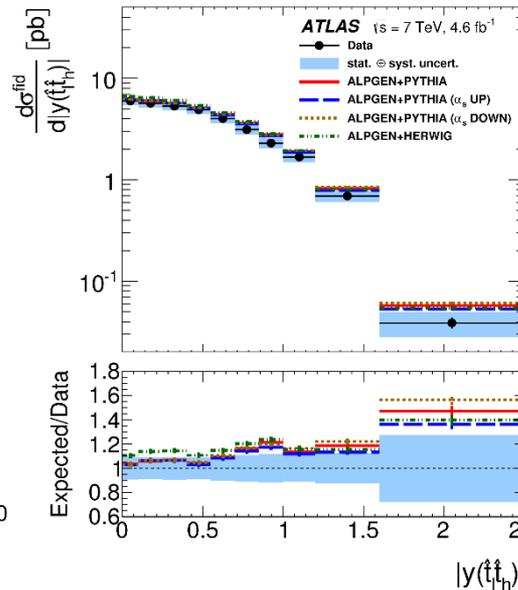
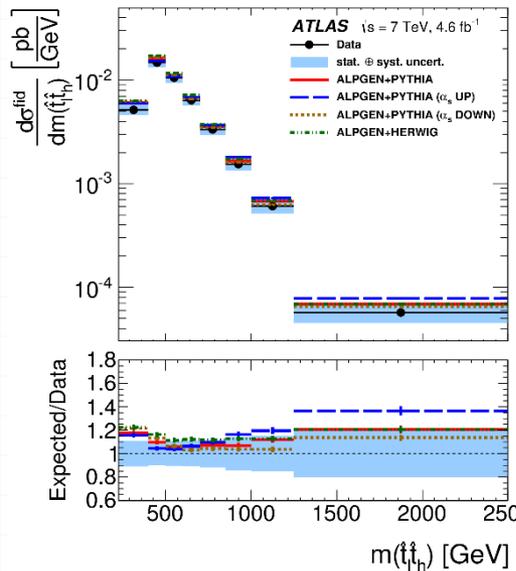
JHEP 06 (2015) 100

$\sqrt{s} = 7 \text{ TeV}, L = 4.6 \text{ fb}^{-1}$

- Top-antitop differential cross section $\left(\frac{d\sigma}{dX}\right)$ where $X = m_{t\bar{t}}, p_{T,t\bar{t}}, |y_{t\bar{t}}|, p_{T,t}$ and $|y_t|$
 - Fiducial measurement: limited to the actual «visible» phase space
 - Pseudo top (\hat{t}) observables built from stable final state objects
- Cut-based analysis in the $l(e/\mu)+\text{jets}$ channel
- Main uncertainties: b -tag, JES and IFSR



- General trend of data being softer in $p_{T,t}$ above 200 GeV
- Same behavior is observed by the parton level analysis

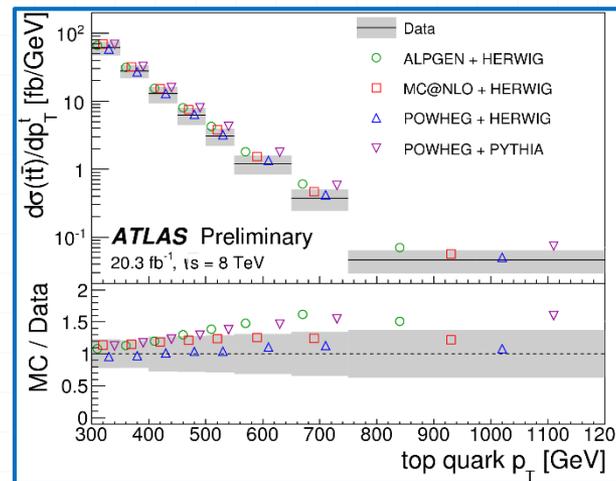
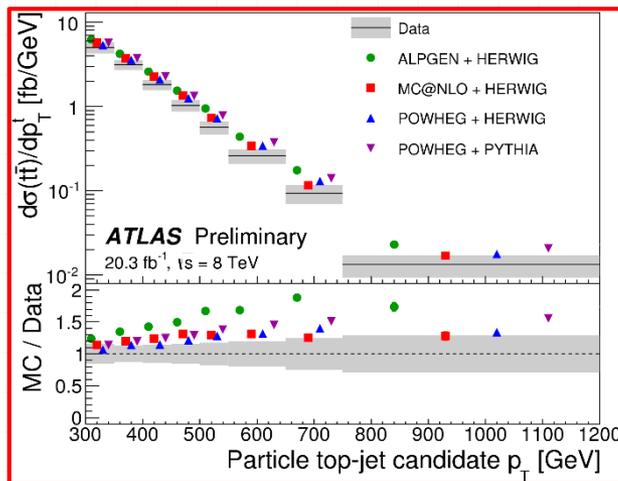
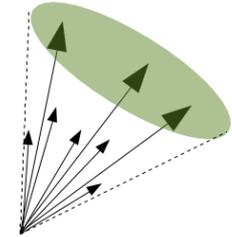


$t\bar{t}$ differential cross section: boosted tops

ATLAS-CONF-2014-057

$\sqrt{s} = 8 \text{ TeV}, L = 20.3 \text{ fb}^{-1}$

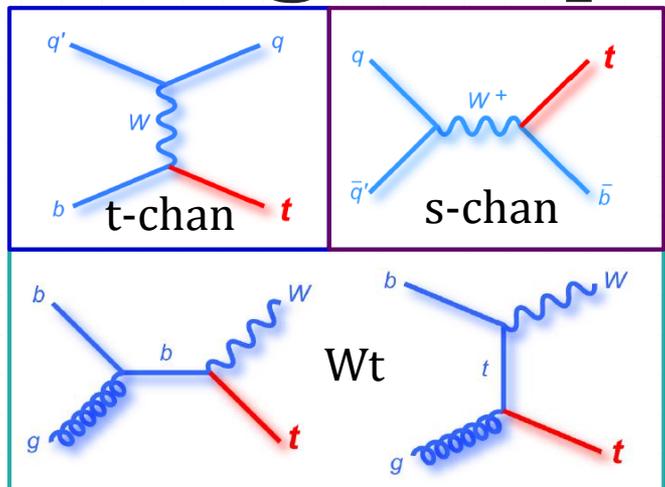
- First measurement $\frac{d\sigma}{dp_{T,t}}$ for high- p_T (boosted) top quarks
- Semi-leptonic (e/μ) channel with $p_T(t_{had}) > 300 \text{ GeV}$
 - Boosted hadronic top defined as a single large- R jet
- **Fiducial** (particle pseudo tops) and **total** (parton tops) phase space measurements



- Main uncertainties:
- large- R jet energy scale
 - Extrapolation to parton level affected by an increased signal modelling systematics

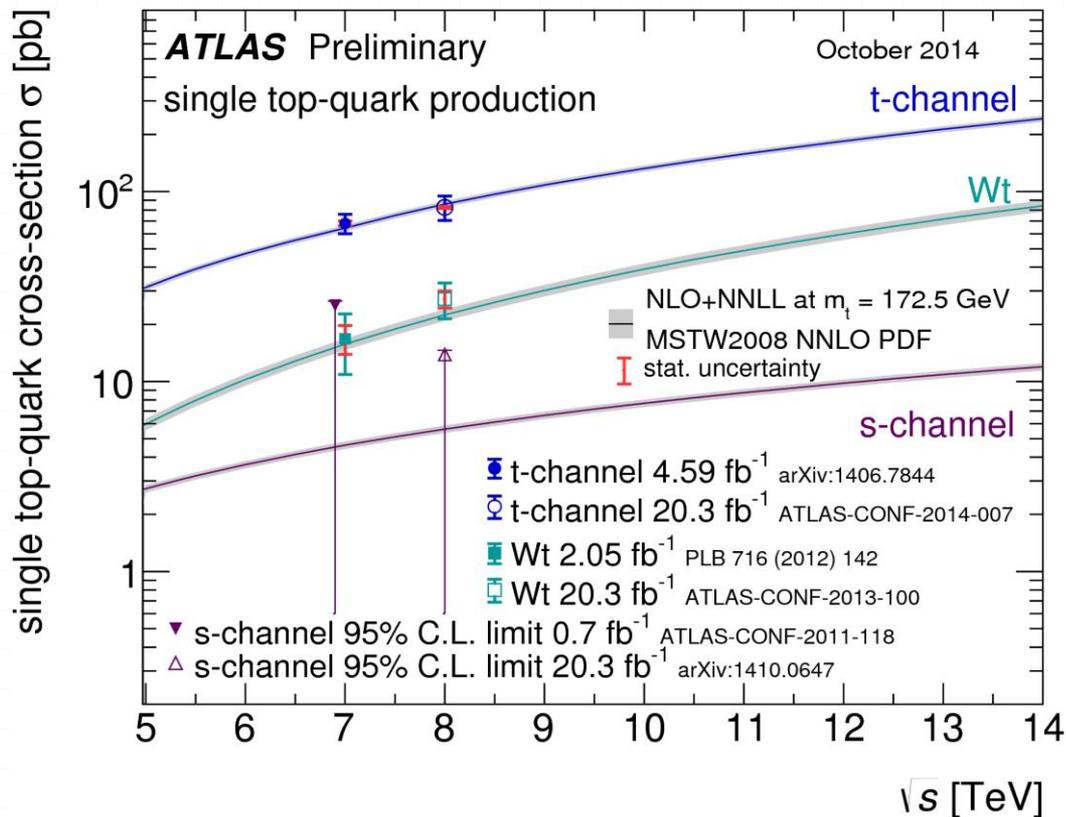
- Measured σ in general lower than predictions
 - Discrepancy tends to increase at high p_T
 - In agreement with the behavior observed in resolved analyses

Single top quark cross section



Cross section summary @ Run I

<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/TOP/>



Measurements at 7 and 8 TeV:

- Cross section for t and Wt channels
 - $|V_{tb}|$ extraction
 - Differential cross sections in the t channel
- Upper limit for the s channel
- Top/antitop t-channel ratio (R_t)

$$R_t = \frac{\sigma_t}{\sigma_{\bar{t}}}$$

Single top t -channel cross section

- A multivariate Neural Network (NN) discriminant trained with the 14 most-sensitive variables
 - Contributions from signal and background evaluated via MC (data driven for Multijet bkg in the μ channel)
- Lepton + 2 jets channel, 1 b -tag
- $\sigma_{t\text{-chan}}$ extracted via a maximum-likelihood fit of the NN output in the data
- **Fiducial** and **total** phase space measurements

$$\sigma_{t\text{-chan}}^{\text{fiducial}}(\sqrt{s} = 8 \text{ TeV}) = 3.4 \pm 0.48 \text{ pb } (\pm 14\%)$$

Main uncertainties: JES and signal modelling

$$\sigma_{t\text{-chan}}^{\text{total}}(\sqrt{s} = 8 \text{ TeV}) = 82.6 \pm 12.1 \text{ pb } (\pm 15\%)$$

(extrapolated via MG5_aMC@NLO)

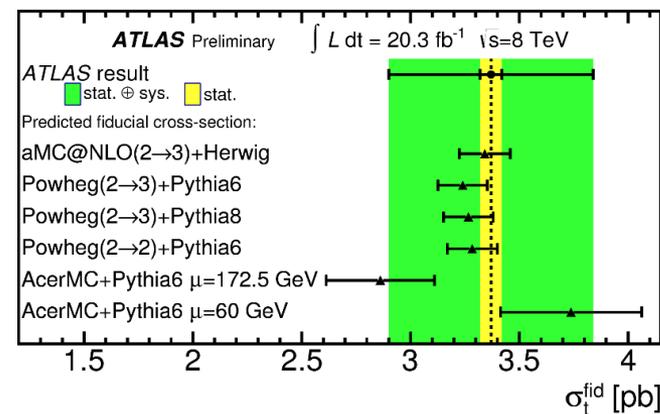
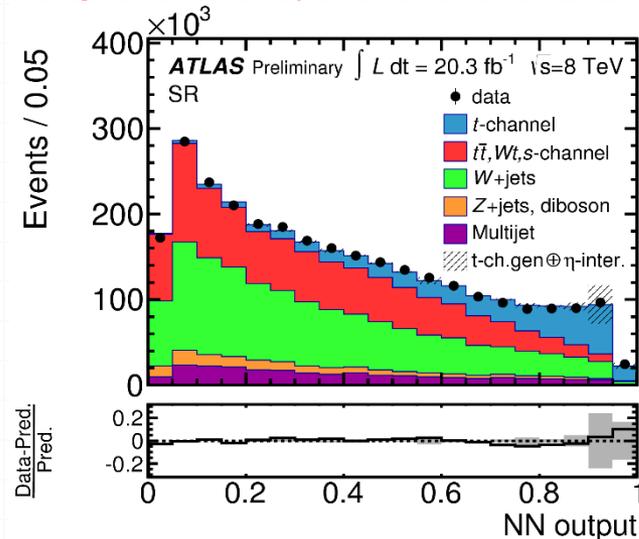
Additional uncertainty: PDF

$$\sigma_{t\text{-chan}}^{\text{th}}(\sqrt{s} = 8 \text{ TeV}) = 87.8_{-1.9}^{+3.4} \text{ pb } \left(\begin{array}{l} +3.9\% \\ -2.2\% \end{array} \right)$$

N. Kidonakis, Phys. Rev. D 83 (2011) 091503

ATLAS-CONF-2014-007

$\sqrt{s} = 8 \text{ TeV}$, $L = 20.3 \text{ fb}^{-1}$



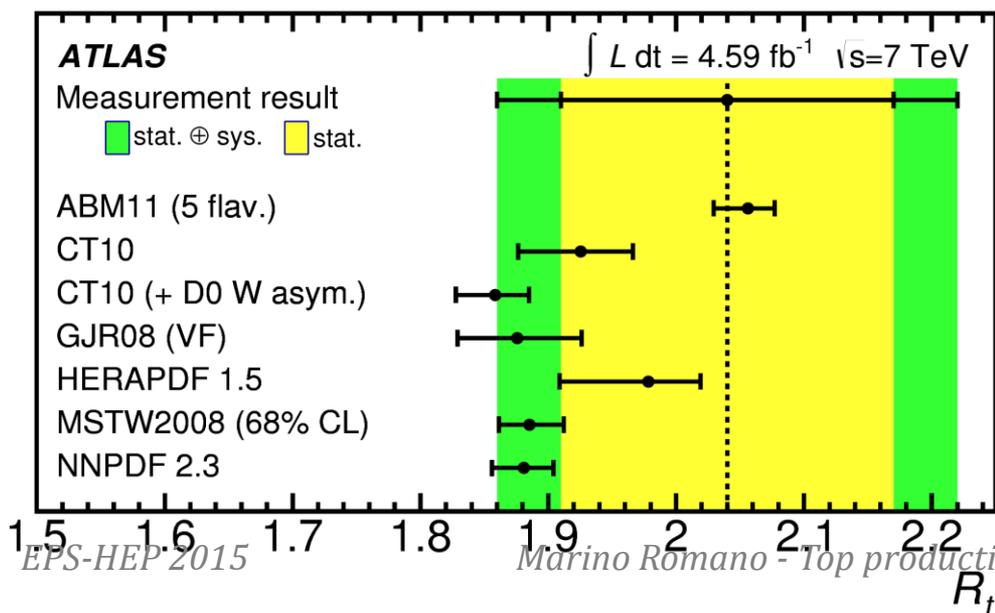
Single top/antitop t-chan ratio

$$R_t = \frac{\sigma_t}{\sigma_{\bar{t}}}$$

Phys. Rev. D. 90, 112006 (2014)

$\sqrt{s} = 7 \text{ TeV}$, $L = 4.6 \text{ fb}^{-1}$

- Very sensitive to the ratio of the PDF of the valence quark in the high x regime
 - Smaller uncertainties because of error cancelations
- Sensitive to new physics effects
- Same analysis technique used in the σ_{tchan} measurement at 8 TeV



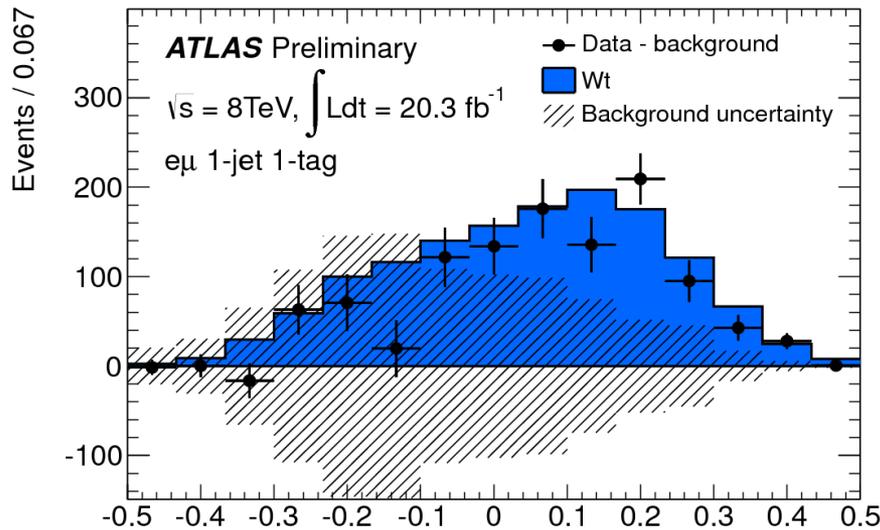
The measurement is in agreement with the predictions from different PDF sets and is dominated by statistical and systematic (MC statistics and PDF) uncertainties

Single top Wt -channel cross section

ATLAS-CONF-2013-100

$\sqrt{s} = 8 \text{ TeV}$, $L = 20.3 \text{ fb}^{-1}$

- Hard to separate from $t\bar{t}$, interference at NLO
- Event selected requiring 1e, 1 μ , 1/2jet, 1b-tag, E_T^{miss}
- Multivariate analysis based on Boosted Decision Tree (BDT) employed to increase the discrimination power
 - BDT trained using Wt as signal and $t\bar{t}$ as background
 - BDT discriminants built separately for 1 and 2 jet samples
- Most discriminating variable: $p_T^{sys}(lep1, lep2, E_T^{miss}, jet1)$
- Maximum likelihood fit to the BDT output to extract the signal cross section



$$\sigma_{Wt}(\sqrt{s} = 8 \text{ TeV}) = 27.2 \pm 5.8 \text{ pb} (\pm 21\%)$$

(observed 4.2σ , expected 4.0σ)

Main systematics: b -tagging, JES, generator uncertainties

$$\sigma_{Wt}^{th}(\sqrt{s} = 8 \text{ TeV}) = 22.4 \pm 1.5 \text{ pb} (\pm 6.7\%)$$

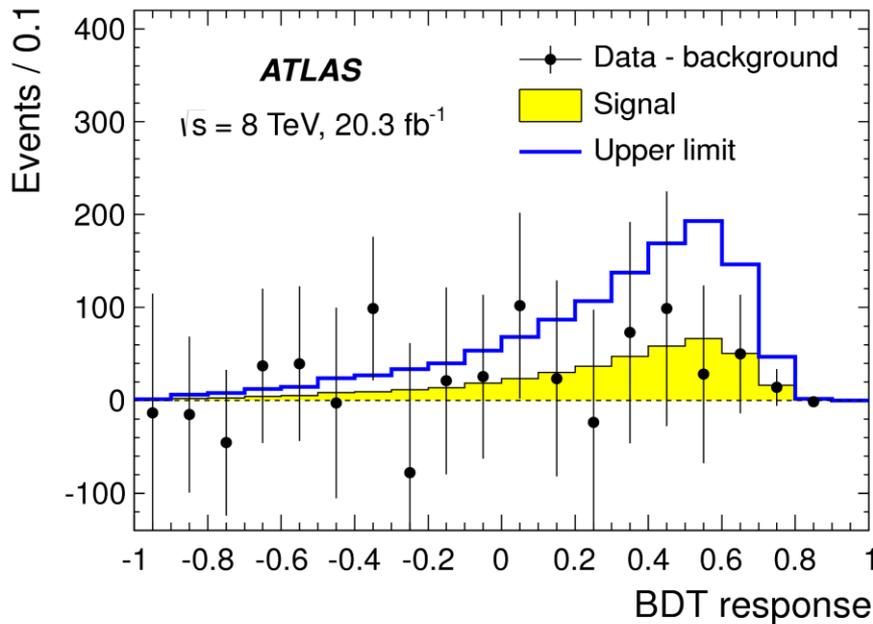
N. Kidonakis, Phys. Rev. D 82 (2010) 054018

Single top s -channel search

Phys. Lett. B740 (2015) 118

$\sqrt{s} = 8 \text{ TeV}$, $L = 20.3 \text{ fb}^{-1}$

- Low rate in pp collisions (was dominant at Tevatron)
 - Event selected requiring 1l, 2b-tag, E_T^{miss}
 - Multivariate analysis based on Boosted Decision Tree (BDT) employed to increase the discrimination power
 - Most discriminating variable: $|\Delta\phi(t, b)|$
 - Maximum likelihood fit to the BDT output to extract the signal cross section



$\sigma_{s\text{-chan}}(\sqrt{s} = 8 \text{ TeV}) = 5.0 \pm 4.3 \text{ pb} (\pm 86\%)$
(1.3σ , expected 1.4σ)

Upper limit: **14.6 pb @ 95%CL**

Main uncertainties: E_T^{miss} and jet energy scale, data & MC statistics

$\sigma_{s\text{-chan}}^{th}(\sqrt{s} = 8 \text{ TeV}) = 5.61 \pm 0.22 \text{ pb} (\pm 3.9\%)$

N. Kidonakis, Phys. Rev. D 81 (2010) 054028

production at ATLAS

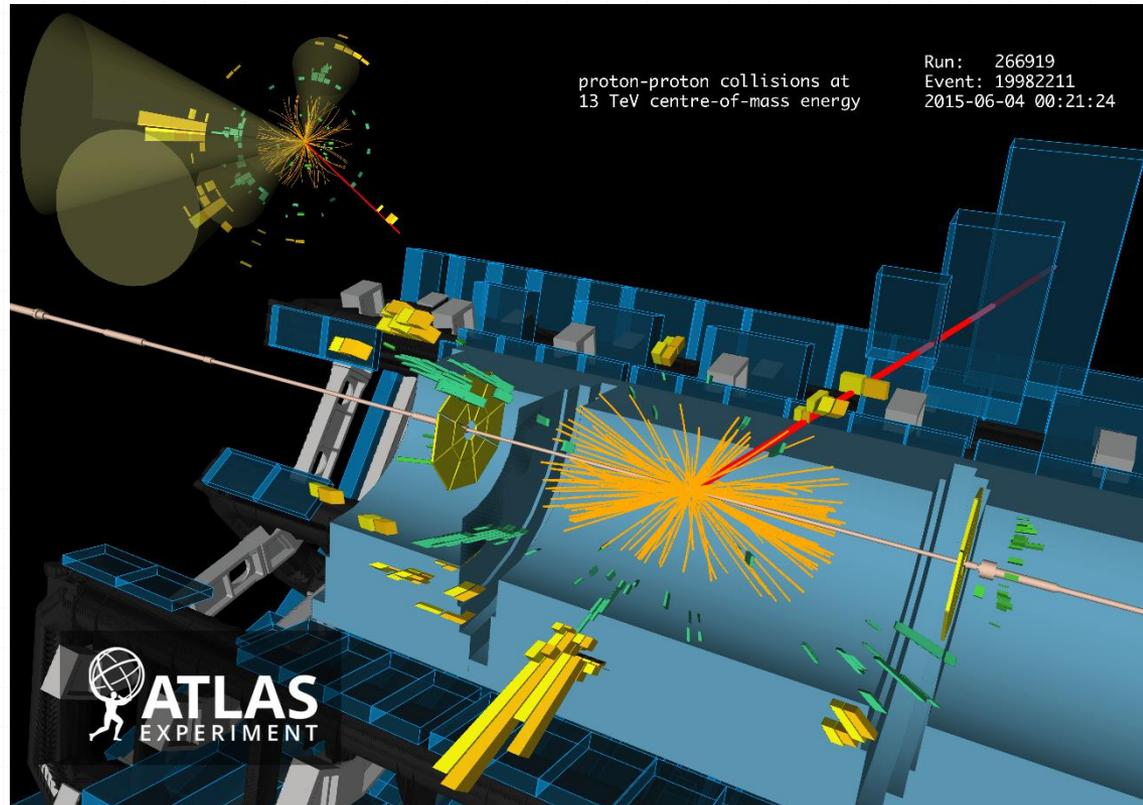
Event Kinematic Distributions in Top-Quark Enriched Samples

BONUS

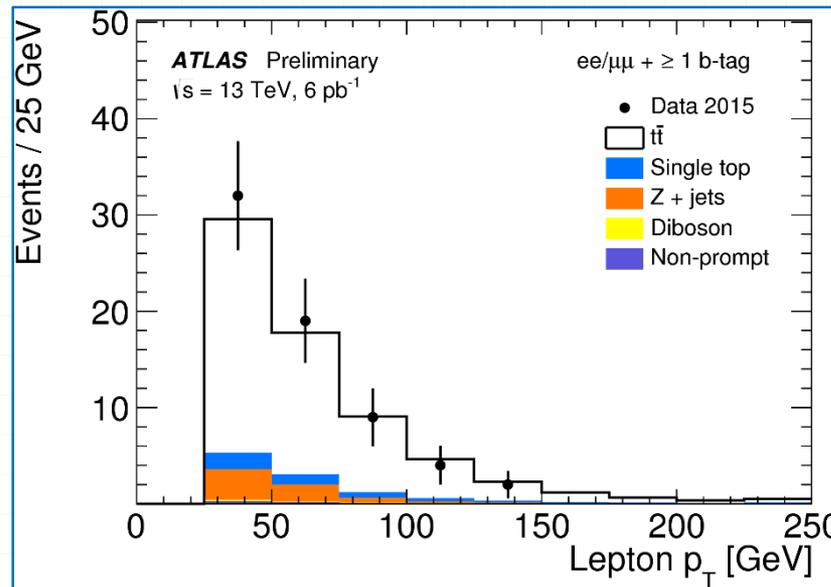
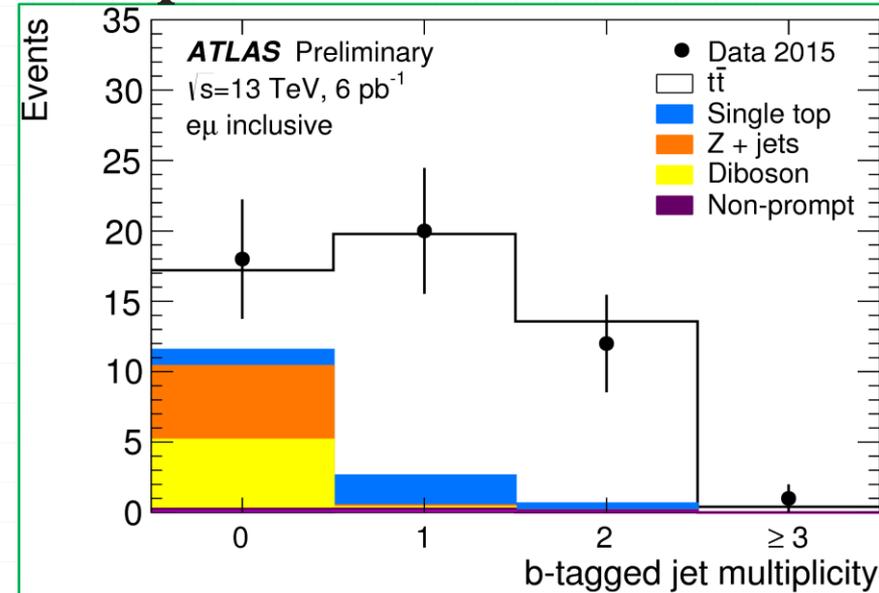
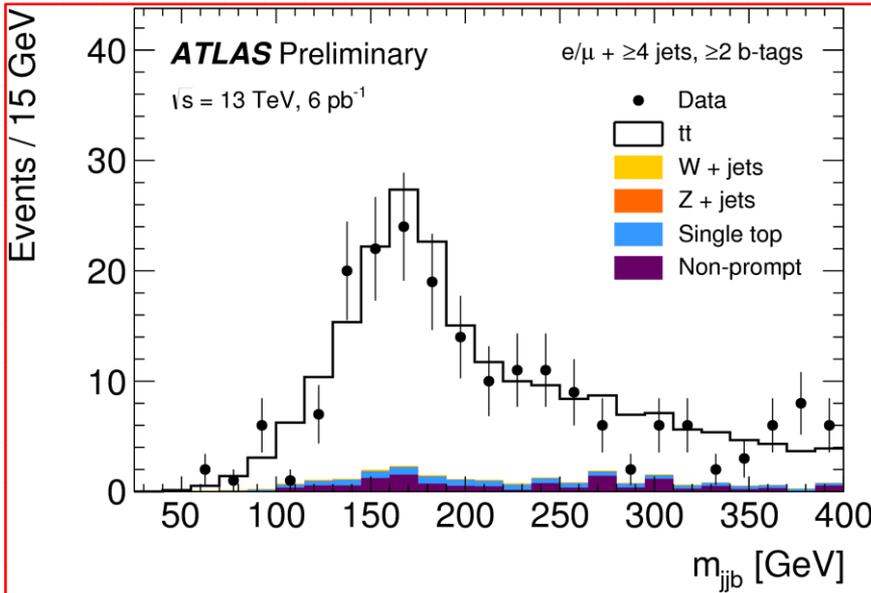
ATL-PHYS-PUB-2015-017

$\sqrt{s} = 13 \text{ TeV}$, $L = 6/7 \text{ pb}^{-1}$

- Data collected by the ATLAS detector on the 13th and 14th of June 2015 at $\sqrt{s} = 13 \text{ TeV}$
- Monte Carlo predictions have been scaled to match the normalisation of the data
- Single lepton (e/μ) and dilepton ($ee/\mu\mu/e\mu$) channel



Event Kinematic Distributions in Top-Quark Enriched Samples



Within the limited statistics, the shape of the kinematic distributions appear well modeled



ATL-PHYS-PUB-2015-017

Summary

- Top quark measurements have provided stringent tests of SM
- Top quark pair production
 - Inclusive cross-section measured with 4% accuracy
 - Top quark pole mass and stop exclusion from inclusive cross section measurements
 - Differential cross sections: resolved and boosted topologies, parton and particle level
 - SM predictions in general good agreement with data
- Single top production
 - Wt -channel rediscovered, s -channel limits set
 - t -channel dataset large enough to investigate single top properties
 - In general, SM has held up remarkably well
- Stay tuned for new results with data in Run II at 13 TeV
 - Higher statistics will improve all analyses
 - Higher energy means greater reach for searches

Backup

Cross section measurements

$\sigma_{t\bar{t}}$:

- can put constraints on SM parameters
- current statistics allow the study of differential spectra

σ_t :

- Sensitive to electroweak physics involving Wtb vertex
- Sensitive to the pdf of the valence quarks

Common object definitions

- Details can vary among the different analyses
- Jets:
 - Reconstructed from topological clusters using the anti-kt algorithm ($R = 0.4$)
 - $p_T > 25$ GeV, $|\eta| < 2.5$
- B-tagging via a Neural network based algorithm (MV1) with average efficiency of 70% and light jet rejection factor ~ 140
- Electrons:
 - EM cluster with track matched
 - Isolation in tracker and calorimeter
 - $E_T > 25$ GeV, $|\eta| < 1.37$ or $1.52 < |\eta| < 2.47$
- Muons:
 - Tracks in inner detector and muon spectrometer
 - Isolation in tracker and calorimeter
 - $p_T > 20$ GeV, $|\eta| < 2.5$
- Missing transverse energy
 - Vector sum of energy deposits in calorimeters, with corrections based on the associated reconstructed object

Top quark pairs differential cross section measurements in ATLAS

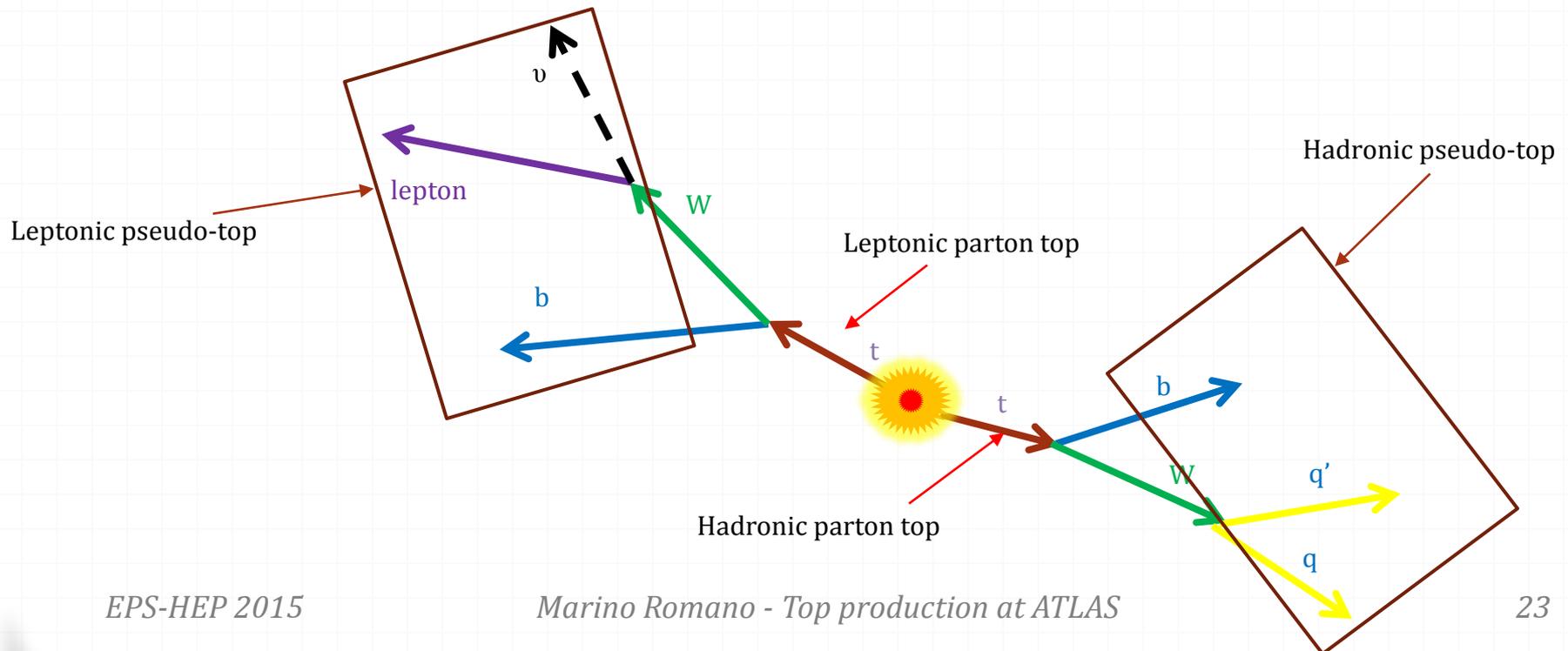
Definition of the object "top-quark"

'Parton-level' top:

- the top quark approximately after final state radiation and before decay.

'Particle level' top (or pseudo-top):

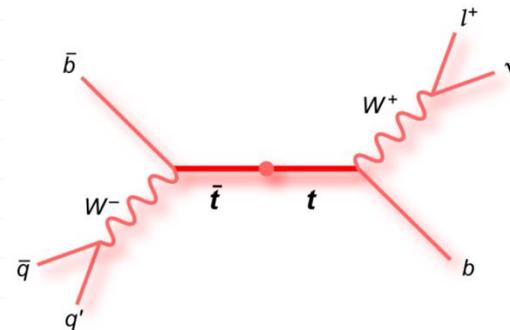
- Observable constructed from *stable* particles directly related to the top



Reconstruction of the $t\bar{t}$ system via kinematic likelihood fit

- The $t\bar{t}$ system reconstruction is performed through a kinematic fit using a maximum likelihood approach

$$\begin{aligned} \mathcal{L} = & \mathcal{B}(\tilde{E}_{p,1}, \tilde{E}_{p,2} | m_W, \Gamma_W) \cdot \mathcal{B}(\tilde{E}_l, \tilde{E}_\nu | m_W, \Gamma_W) \cdot \\ & \cdot \mathcal{B}(\tilde{E}_{p,1}, \tilde{E}_{p,2}, \tilde{E}_{p,3} | m_t, \Gamma_t) \cdot \mathcal{B}(\tilde{E}_l, \tilde{E}_\nu, \tilde{E}_{p,4} | m_t, \Gamma_t) \cdot \\ & \cdot \mathcal{W}(\hat{E}_x^{miss} | \tilde{p}_{x,\nu}) \cdot \mathcal{W}(\hat{E}_y^{miss} | \tilde{p}_{y,\nu}) \cdot \mathcal{W}(\hat{E}_{lep} | \tilde{E}_{lep}) \cdot \\ & \cdot \prod_{i=1}^4 \mathcal{W}(\hat{E}_{jet,i} | \tilde{E}_{p,i}) \cdot P(b \text{ tag} | \text{quark}), \end{aligned}$$



- The likelihood assesses the compatibility of the event with a typical $t\bar{t}$ pair
- The algorithm is fed with the 4 or 5 reconstructed highest-pt jets (and their b-tag info), the lepton and the E_T^{miss}
- The output is the permutation of the four jets, lepton and E_T^{miss} that maximizes the likelihood

From the detector-level spectra to the cross section measurement

The 'detector-level' spectra are linked to the 'parton level' cross section σ_j via

$$N_i = \sum_j M_{ij} \epsilon_j \sigma_j \beta L + B_i$$

Where

- N_i is the number of observed data events in the bin i .
- L is the luminosity
- B_i is the number of background events in the bin i .
- β is the branching ratio
- M_{ij} is the 'migration matrix'
- ϵ_j is the efficiency of the selection

$t\bar{t}$ normalized differential cross section

Phys. Rev. D 90, 072004

$\sqrt{s} = 7 \text{ TeV}, L = 4.6 \text{ fb}^{-1}$

Electron and muon channel
combination via the Asymmetric
Iterative BLUE (AIB)

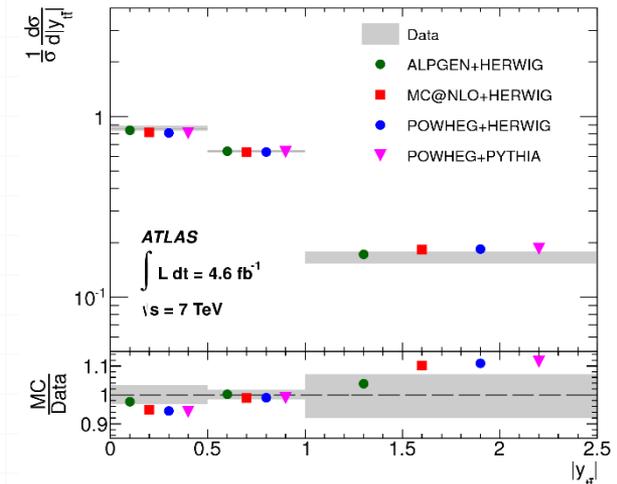
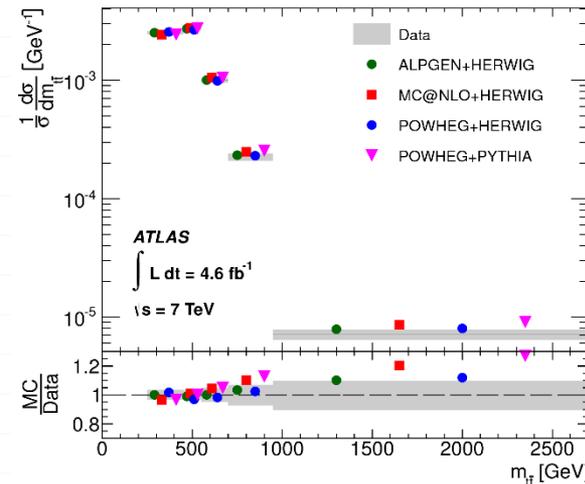
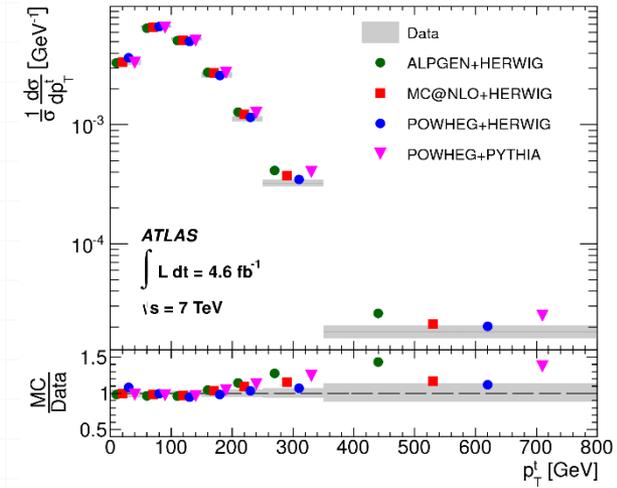
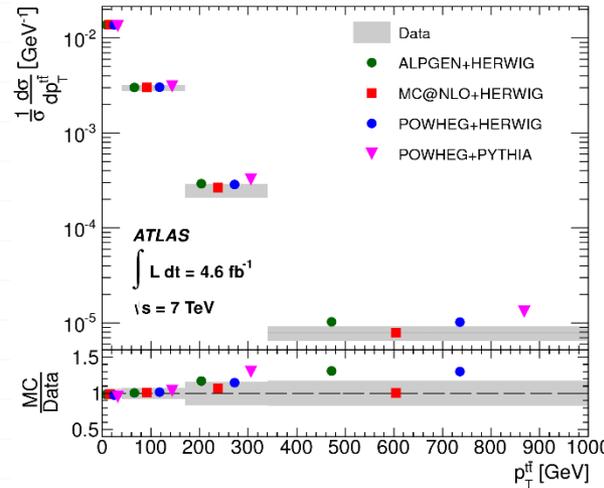
Main uncertainties:

- $p_{T,t}, m_{t\bar{t}}$: JES, generator b -tag;
- $p_{T,t\bar{t}}$: IFSR, generator, PS, JER
- $|y_{t\bar{t}}|$: generator and PS

Comparison to MC generators:

Alpgen, Powheg and MC@NLO
interfaced with Herwig+Jimmy
and Powheg+Pythia

- General trend of data being softer in $p_{T,t}$ above 200 GeV
- All four MC generators describe well the shape of $m_{t\bar{t}}$ and $p_{T,t\bar{t}}$
- Alpgen gives the best prediction of the $|y_{t\bar{t}}|$

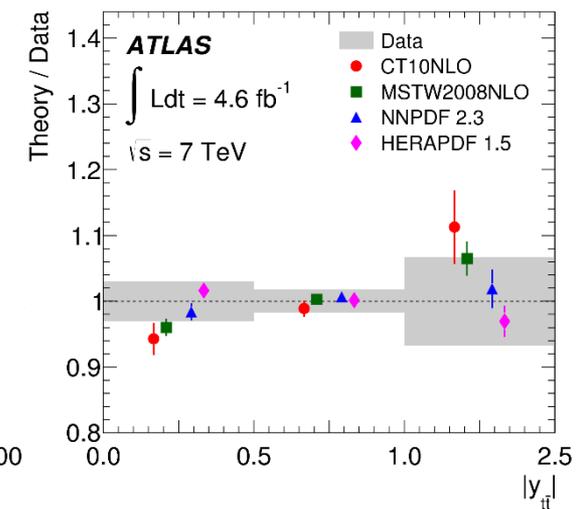
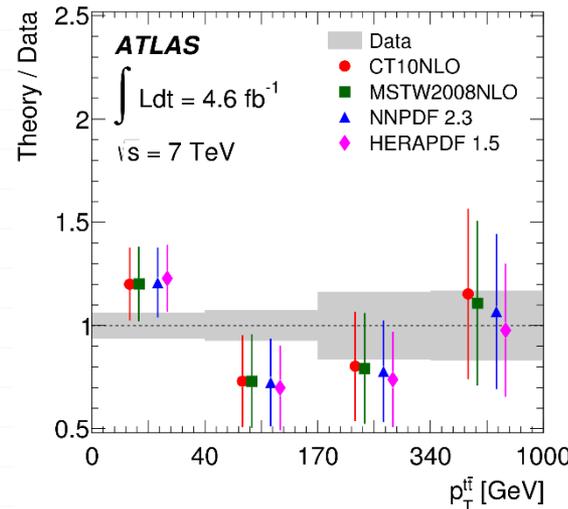
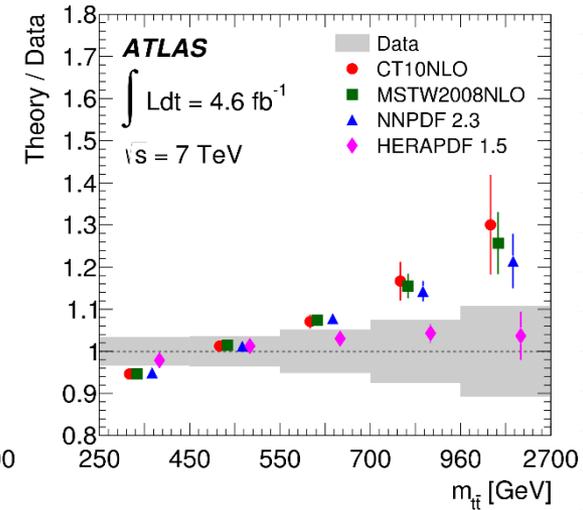
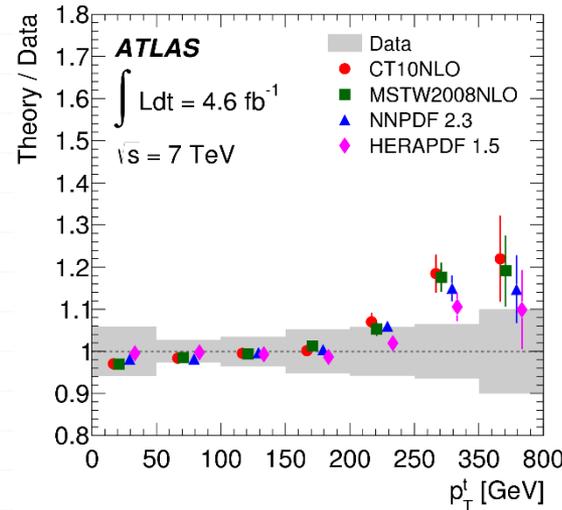


Results: comparison with NLO calculations

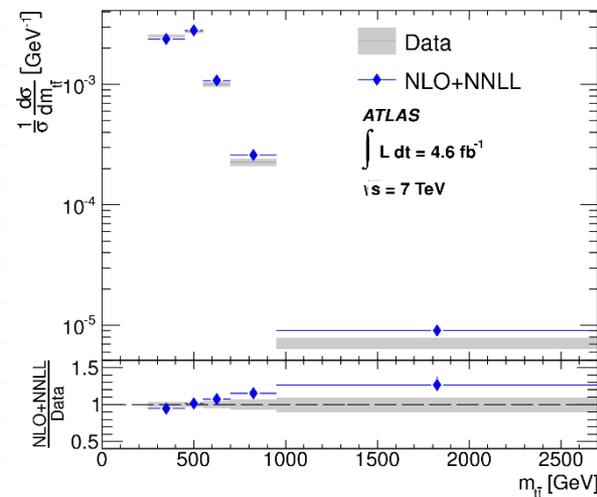
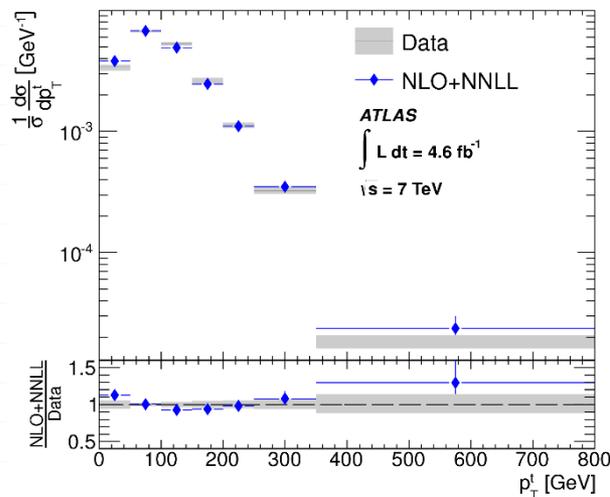
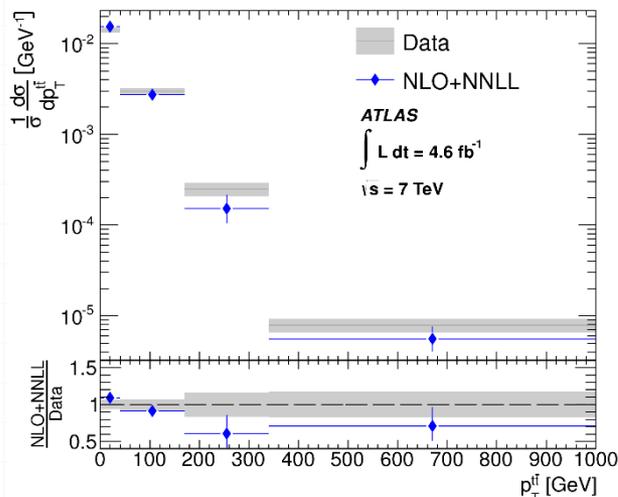
NLO prediction based on MCFM
with different PDF sets

Uncertainty: scale (fixed) and PDF

- A small discrepancy between data and all predictions is observed in $p_{T,t}$ at higher p_T
- Overall better agreement with HERAPDF1.5
- Poor constraining power for $p_{T,t\bar{t}}$ (LO observable)



Results: comparison with approximate NNLO calculations



NLO+NNLL prediction for $p_{T,t}$ (N. Kidonakis, Phys. Rev. D82 (2010) 114030), for $m_{t\bar{t}}$ (V. Ahrens et al., JHEP 1016 (2010) 097) and for $p_{T,t\bar{t}}$ (Hua Xing Zhu et al., Phys. Rev. Lett. 110 (2013) 082001) with the MSTW2008NNLO PDF

Theory uncertainty from the fixed scale variations and, only for $p_{T,t}$, from the alternate dynamic

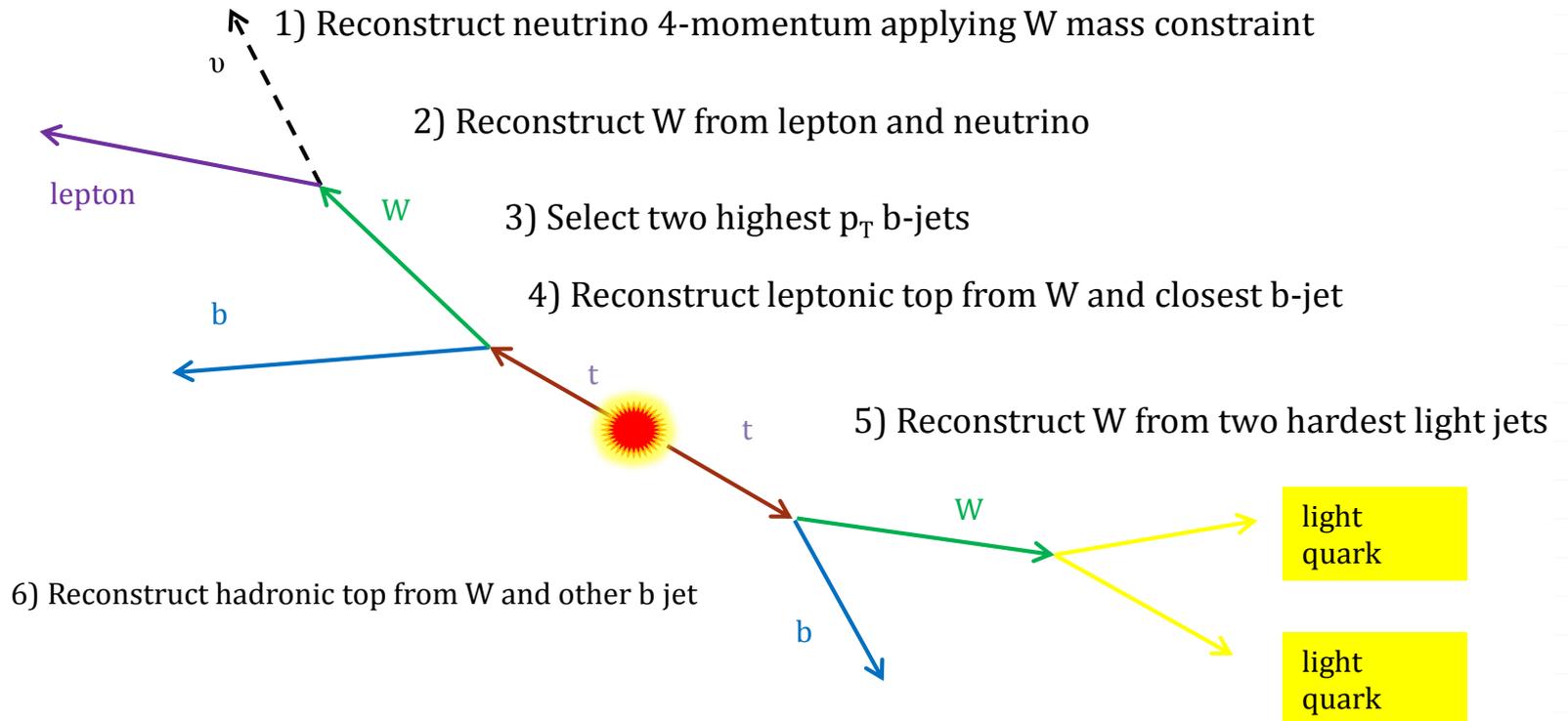
$$\text{scale } \mu = \sqrt{m_t^2 + p_{T,t}^2}$$

- As in the NLO calculation, the $p_{T,t}$ spectrum in data seems softer
- Opposite trend appears for $p_{T,t\bar{t}}$ spectrum
- The $m_{t\bar{t}}$ spectrum is not well described by the NLO+NNLL prediction

“Particle level” object definitions and selection

- Details can vary among the different analyses
- Leptons and jets are defined using particles with a mean lifetime $\tau > 3 \times 10^{-11}$ s
- Prompt leptons (e/mu/nu) *not* generated by the decay of a hadron as well as leptons coming from the decay of a tau
- The electron and muon four-momenta are calculated after the addition of any photon four-momenta, not originating from hadron decay that are found $\Delta R < 0.1$ with respect to the lepton direction (“dressed” leptons)
- Jets:
 - Reconstructed from all stable particles except for the selected electrons, muons and neutrinos, using the anti-kt algorithm ($R = 0.4$)
- ‘b-tagging’:
 - The presence of one or more b-hadrons with $p_T > 5$ GeV associated to a jet defines it as a b-jet.
- Missing transverse energy
 - Vector sum the neutrinos four-momenta
- Events are “selected” at particle level by applying, to the particle level objects, the same requirements applied to the “reco level” objects

Pseudo-Top reconstruction



The pseudo-tops reconstruction is identical at reco and particle level with the exclusion of the neutrino that at particle level is taken from truth

$t\bar{t}$ + jets differential cross section

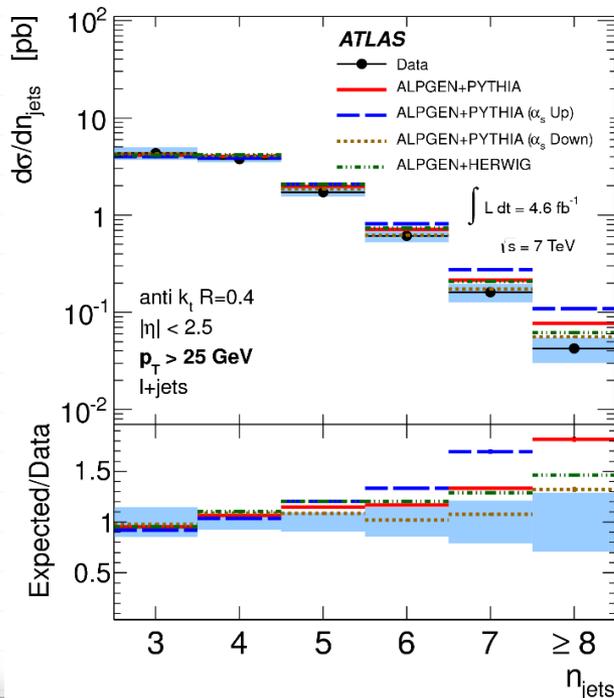
JHEP 01(2015)020

$\sqrt{s} = 7 \text{ TeV}, \int L dt = 4.6 \text{ fb}^{-1}$

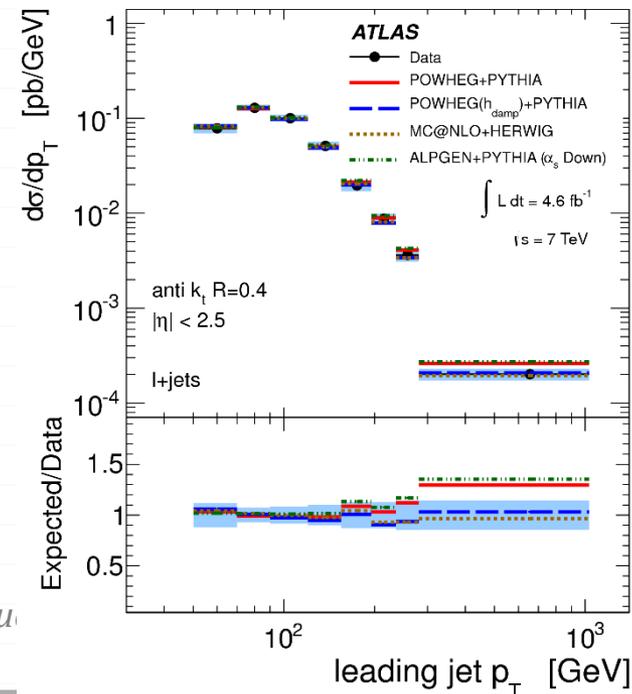
- o Particle level measurement of $\frac{d\sigma_{t\bar{t}}}{dN_{jets}}$ (with different cuts on $p_{T,jet}$) and $\frac{d\sigma_{t\bar{t}}}{dp_{T,jet}}$
- o Limited by systematic uncertainties: background modelling (for $n_{jets} < 4$) and jet energy scale ($n_{jets} \geq 4$)

$\frac{d\sigma_{t\bar{t}}}{dN_{jets}}$: sensitive to hard emissions in QCD
bremsstrahlung processes.

$\frac{d\sigma_{t\bar{t}}}{dp_{T,jet}}$: sensitive to the modelling of higher-order
QCD effects in MC



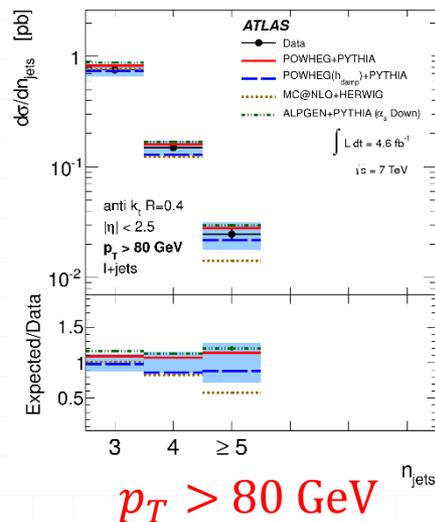
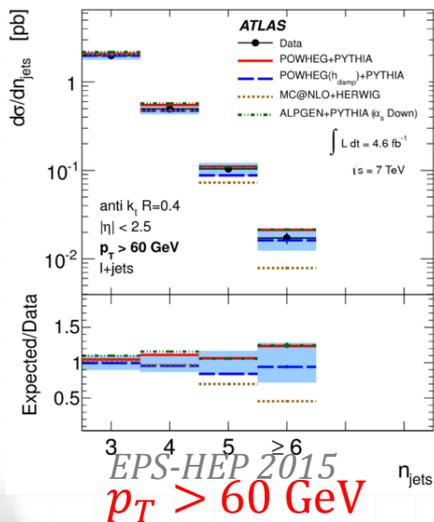
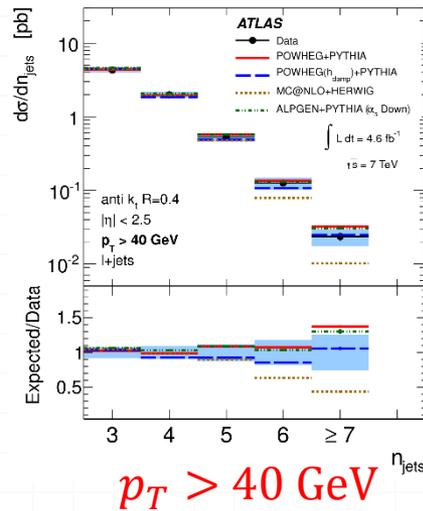
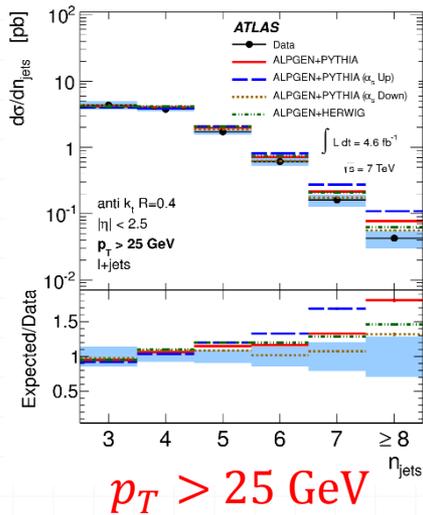
ino Romano - Top produ



Jet multiplicity in top-anti-top final states

- Useful to constrain models of initial and final state radiation (ISR/FSR)
- Provides a test of perturbative QCD
- Single-lepton channel
 - Four jet p_T thresholds: (25, 40, 60, and 80 GeV)
- Results are corrected for all detector effects through unfolding
 - Reconstructed level \rightarrow particle level
- Measurement is limited by systematic uncertainties,
 - background modelling (at lower jet multiplicities)
 - jet energy scale (at higher jet multiplicities)

Jet multiplicity in top-anti-top final states



○ MC@NLO modelling predicts a lower jet multiplicity spectrum and softer jets

○ Predictions from ALPGEN + HERWIG or PYTHIA and POWHEG + PYTHIA are consistent with the data

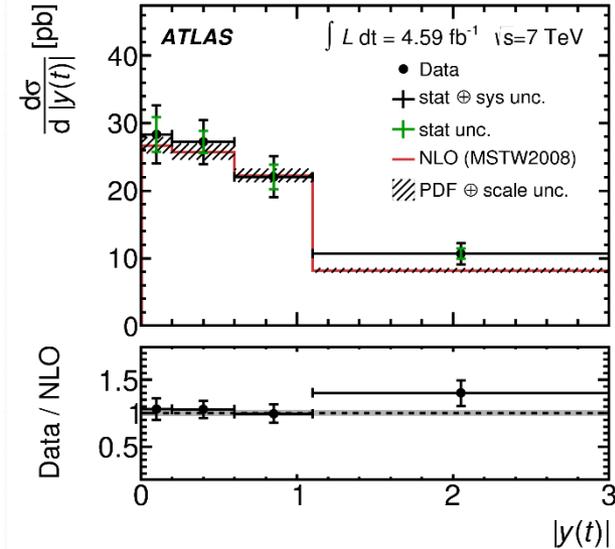
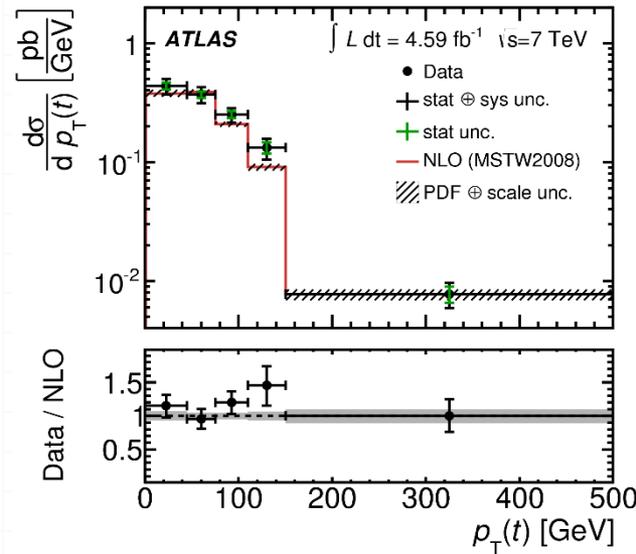
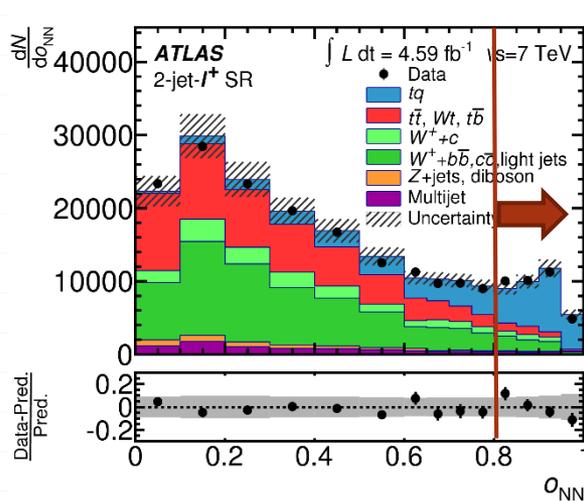
p production at ATLAS

Single top t -channel differential cross section

Phys. Rev. D. 90, 112006 (2014)

$\sqrt{s} = 7 \text{ TeV}, \int L dt = 4.6 \text{ fb}^{-1}$

- Events selected in a high purity ($O_{NN} > 0.8$) region
 - Allows the measurement of differential distributions
- Differential cross section as a function of $p_T(t/\bar{t})$ and $|y(t/\bar{t})|$
 - Reconstructed spectra corrected to parton level via unfolding procedures
- General good agreement with NLO predictions



V_{tb} extraction

A direct determination of V_{tb} can be extracted from the cross-sections measurements (t - and Wt -channel)

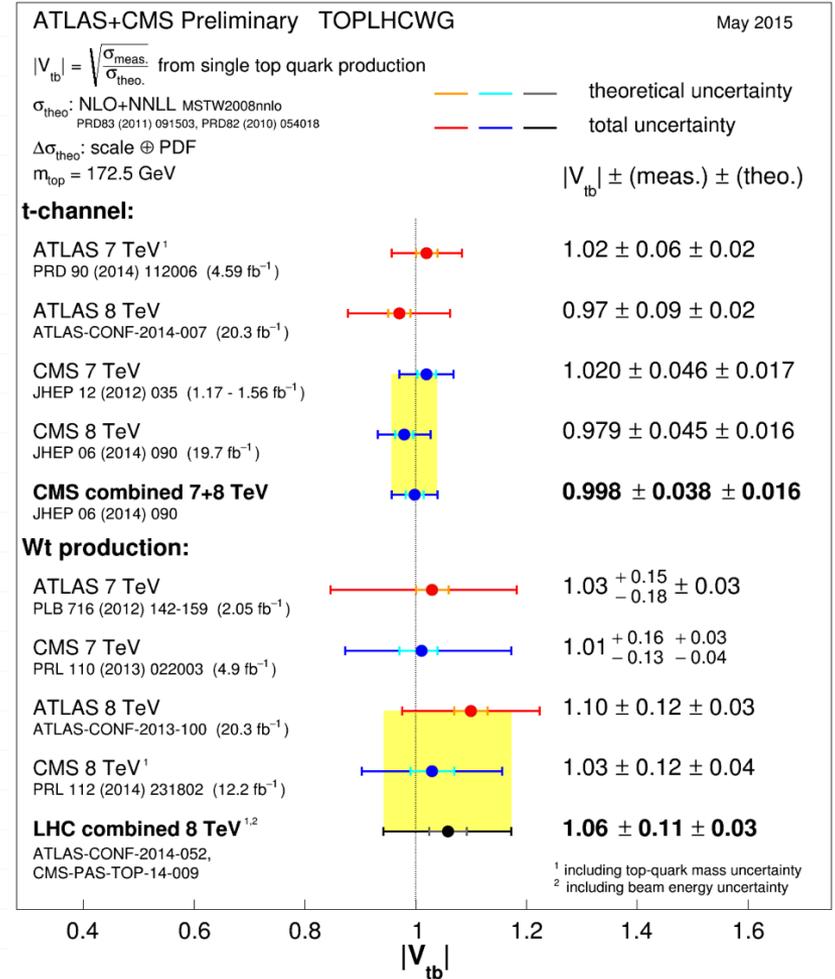
Two general assumptions

1. $W - t - b$ interaction is left-handed
2. top quark production and decay through $|V_{ts}|$ and $|V_{td}|$ are negligible

$|V_{tb}|$ is extracted by the ratio

$$|V_{tb}f|^2 = \frac{\sigma_{st}^{exp}}{\sigma_{st}^{th}}$$

Where, for the SM, $f = 1$

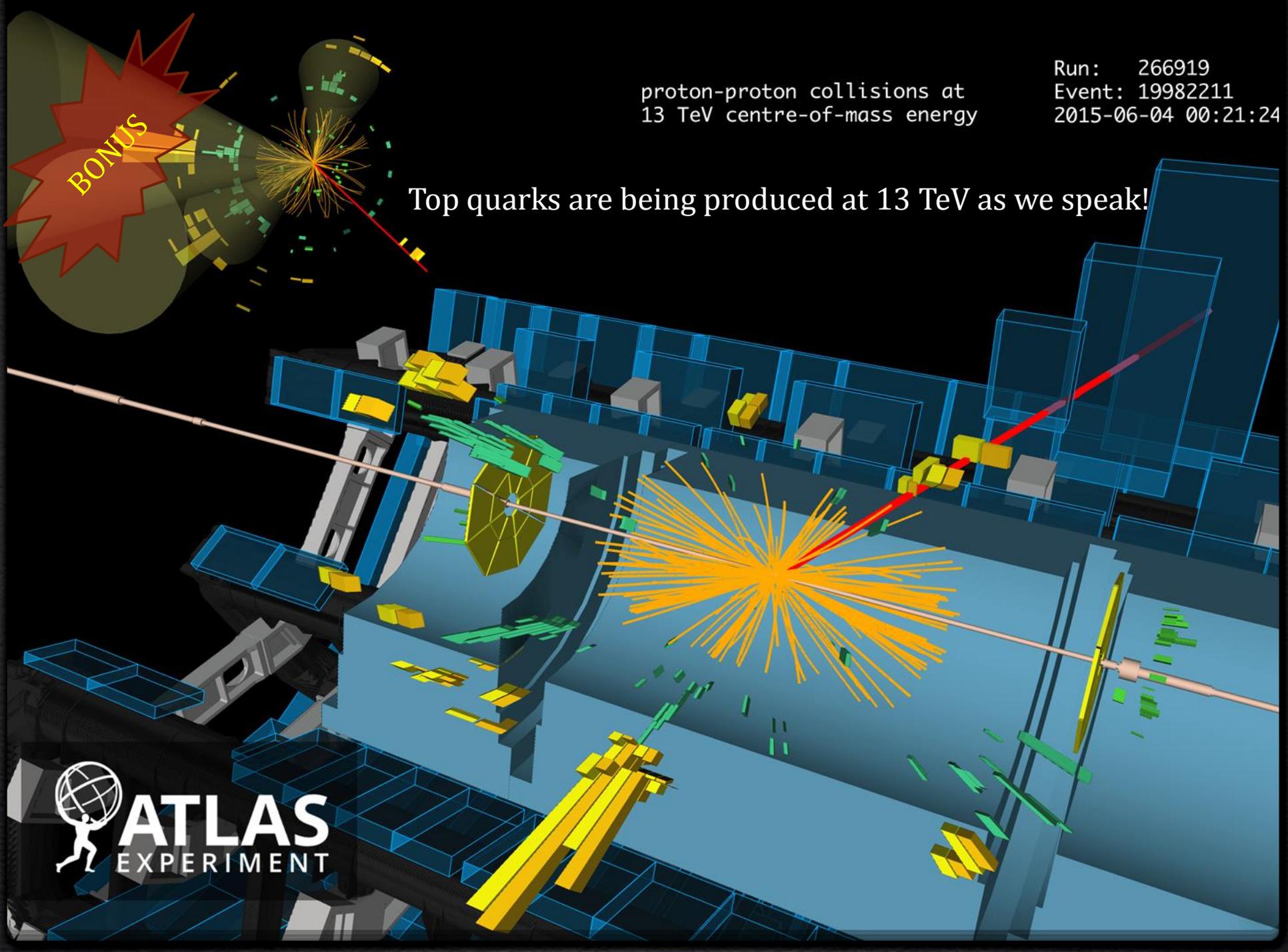


proton-proton collisions at
13 TeV centre-of-mass energy

Run: 266919
Event: 19982211
2015-06-04 00:21:24

Top quarks are being produced at 13 TeV as we speak!

BONUS



Event Kinematic Distributions in Top-Quark Enriched Samples

BONUS

Placeholder for pub note

$\sqrt{s} = 13 \text{ TeV}, \int L dt = 6/7 \text{ pb}^{-1}$

- Data collected by the ATLAS detector on the 13th and 14th of June 2015 at $\sqrt{s} = 13 \text{ TeV}$
- Monte Carlo predictions have been scaled to match the normalisation of the data
- Single lepton (e/μ) and dilepton ($ee/\mu\mu/e\mu$) channel
- Within the limited statistics, the shape of the kinematic distributions appear well modeled

Plots to be approved for EPS

