Top quark production measurements at ATLAS

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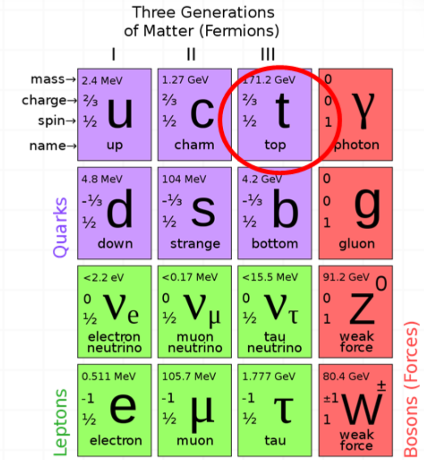
Top quark physics



- Top quark basics:
  - Mass: 173.34 ± 0.27 ± 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 ~1→Important role in the EWSB
  - Life-time shorter than hadronization time
    →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, expecially when used as a background for BSM processes

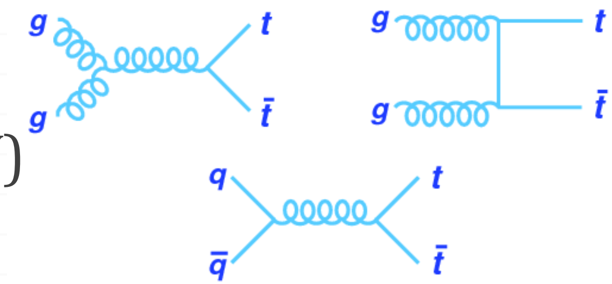
Top quark cross section measurements

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

Top quark pair production and decays

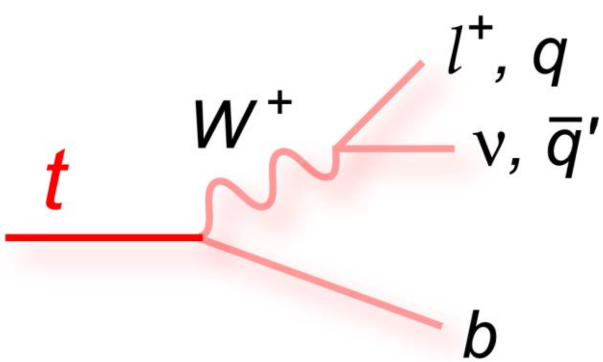
Production mechanisms at LHC

- Gluon-gluon fusion (~85% @ 7 TeV)
- Quark-antiquark annihilation



Decays

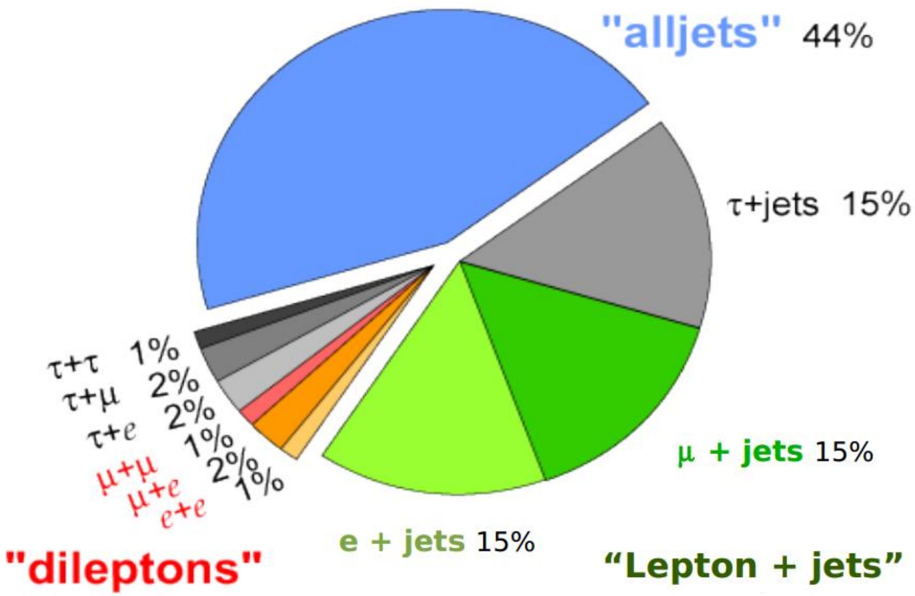
- $t \rightarrow Wb(\sim 100\%)$



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

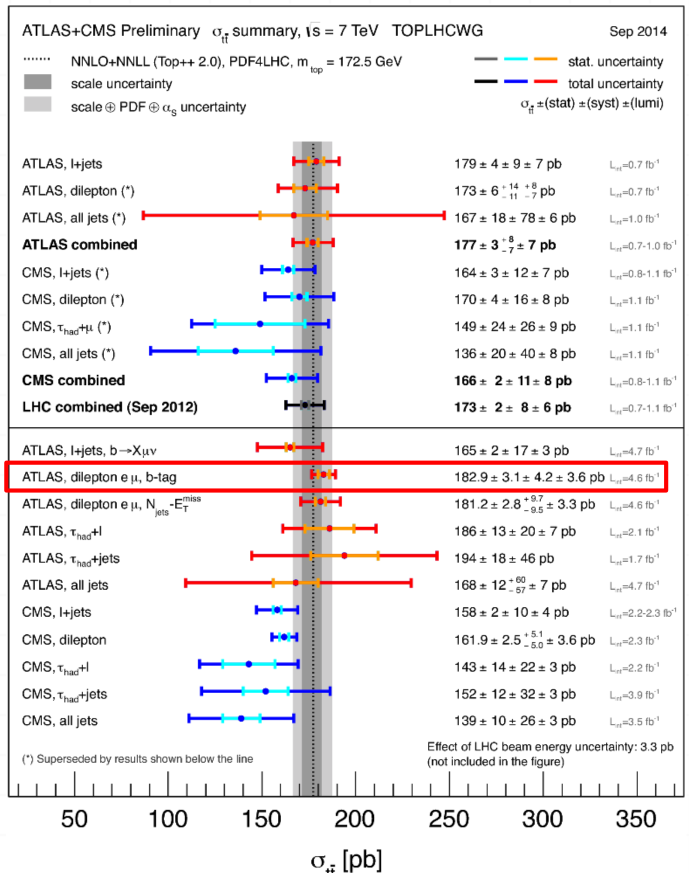
$W \rightarrow q\overline{q'} \sim 66\%$

Top pair final states

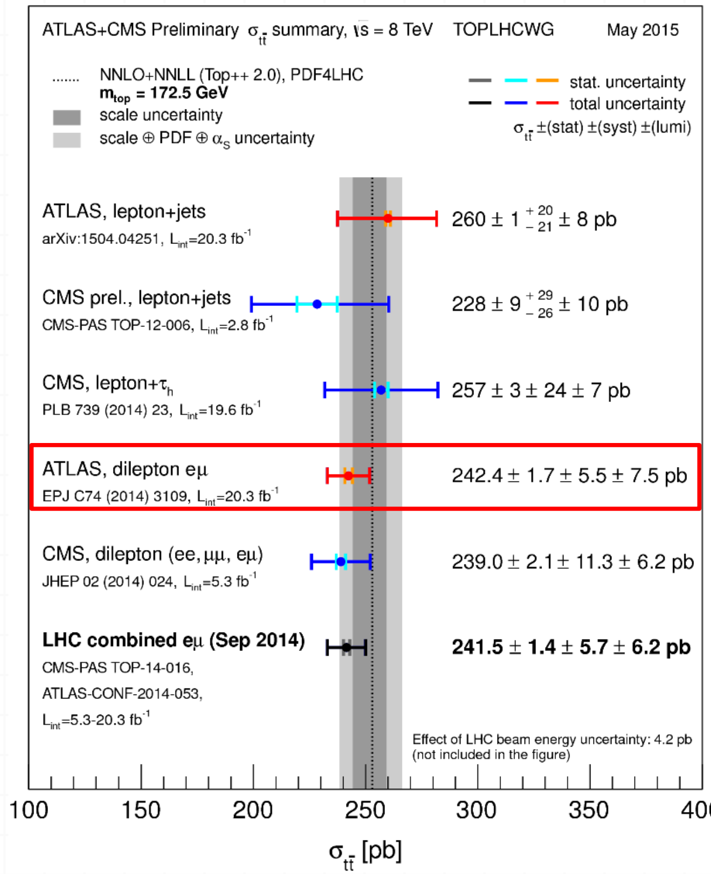


Top quark pair inclusive cross section: summary

$\sigma(t\bar{t})$ @ $\sqrt{s} = 7$ TeV



$\sigma(t\bar{t})$ @ $\sqrt{s} = 8$ TeV



Good agreeement of all measurements with SM predictions

Experimental uncertainties already comparable with theoretical ones

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

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

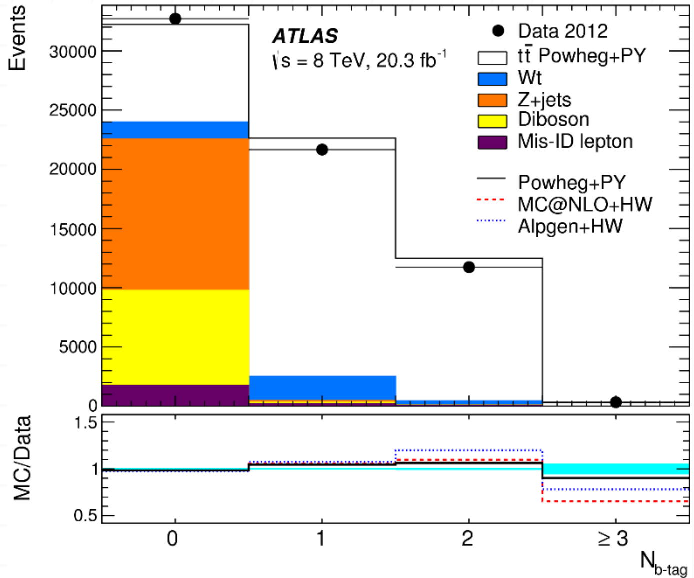
$t\bar{t}$ inclusive cross section $e\mu$ channel

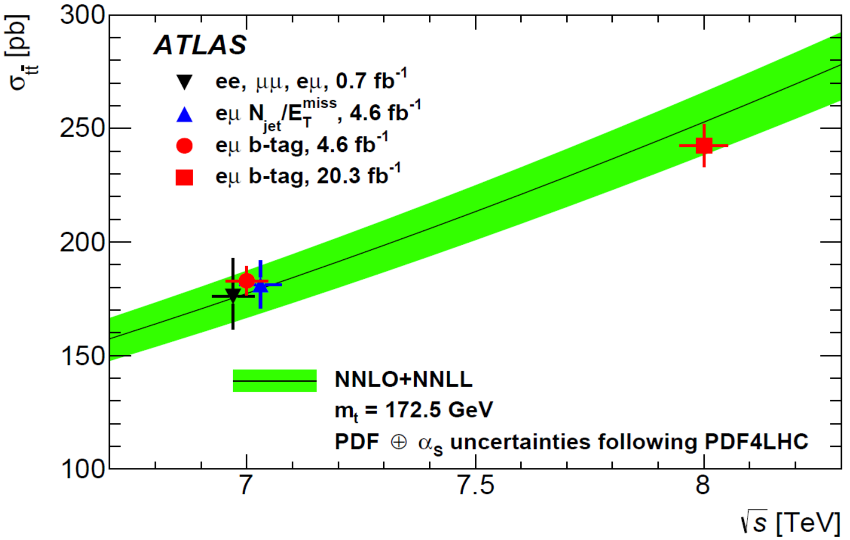
EPJC 74 (2014) 3109

$\sqrt{s} = 7$ TeV, $L = 4.6$ fb^{-1}
$\sqrt{s} = 8$ TeV, $L = 20.3$ 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 ($p_T > 25$GeV, $|\eta| < 2.5$)





Total cross section [pb]

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

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

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

Fiducial cross section [pb]

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

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

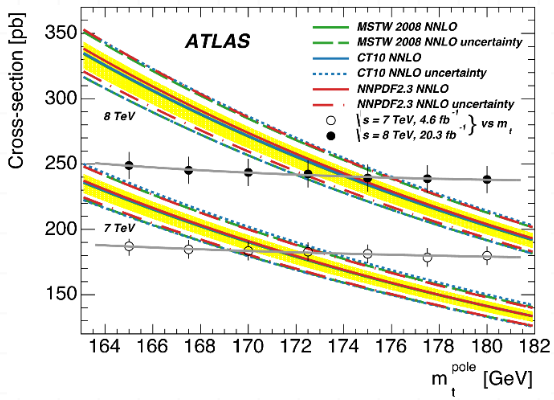
$t\bar{t}$ inclusive cross section $e\mu$ channel

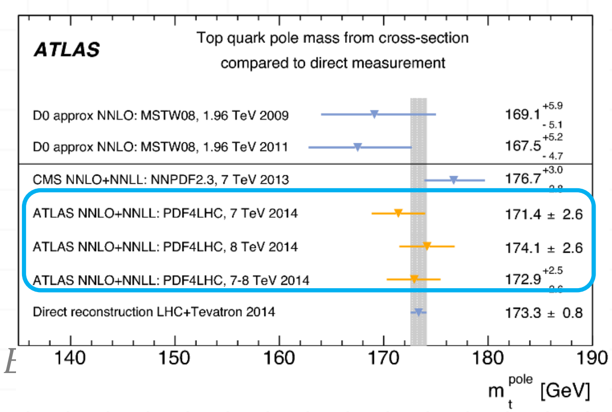
EPJC 74 (2014) 3109

Strong dependence of NNLO σ_{tt} on m_t

- Also σ_{tt}^{meas} shows (weak) dependence on m_t

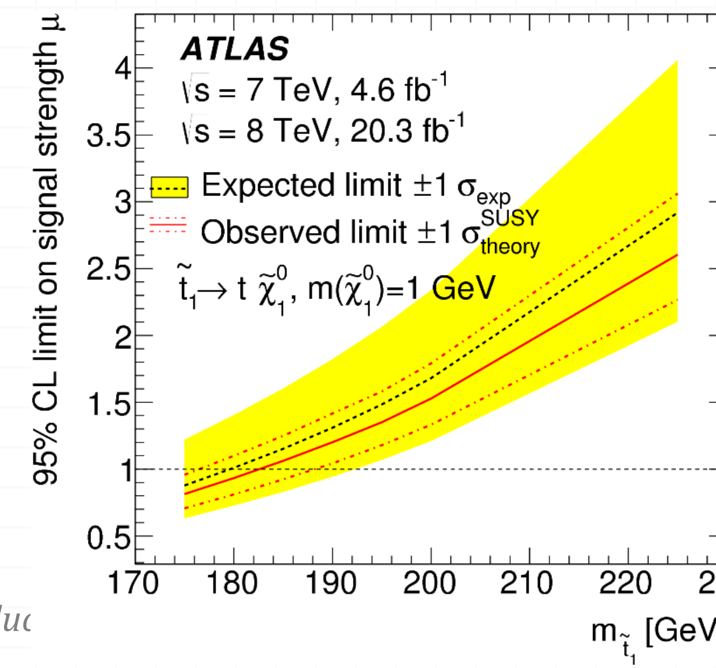
- Extraction of top *pole* mass via the maximization of a Baysian likelihood function





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 $\sigma_{tt}^{meas} - \sigma_{tt}^{th}$ difference
- 95% CL exclusion of stop with $m_t < m_{\tilde{t}_1} < 177$ GeV



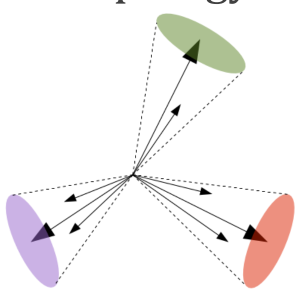
Top quark pairs differential cross section measurements in ATLAS

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

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

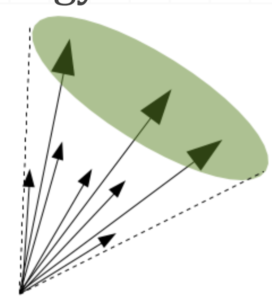
Top reconstruction strategies

‘Resolved’ topology



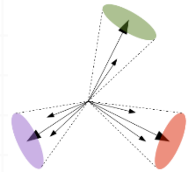
- Optimized for low-p_T (< 300 GeV) top quarks
- Top-quark decay products are well separated and can be recostructed individually
- Top-antitop kinematic evaluated from the reconstructed decay products

‘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

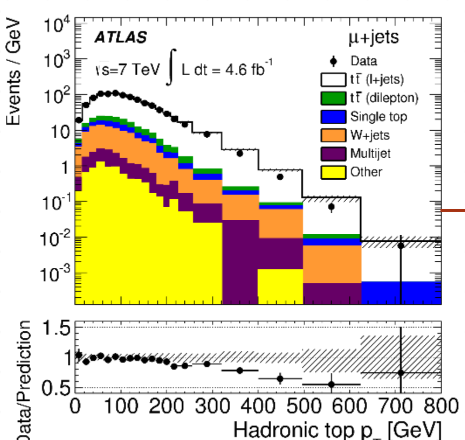


Phys. Rev. D 90, 072004

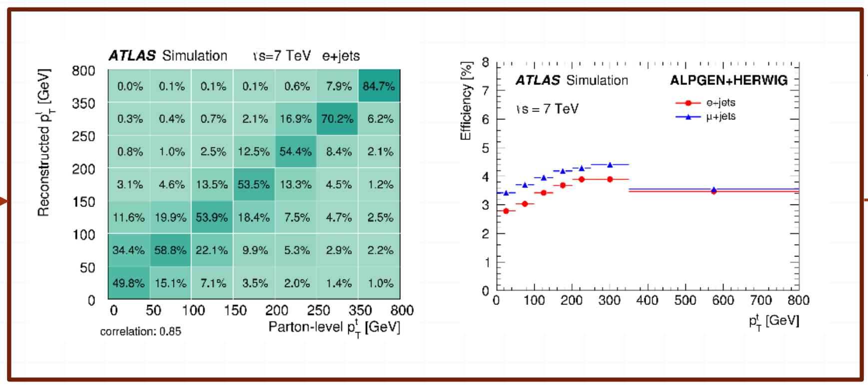
$\sqrt{s} = 7 \text{ TeV}, \ L = 4.6 \text{ fb}^{-1}$

- 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 $\boldsymbol{p_{T,t}}$
  - *Relative* measurement more precise than the *absolute* →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

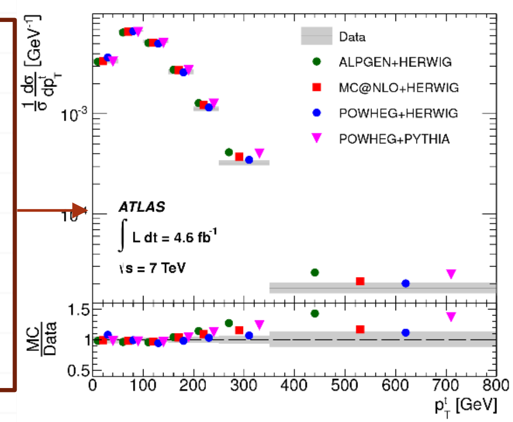
Reco spectrum



Resolution & efficiency corrections



Parton level measurement

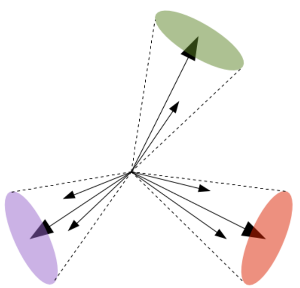


$t\bar{t}$ differential cross section

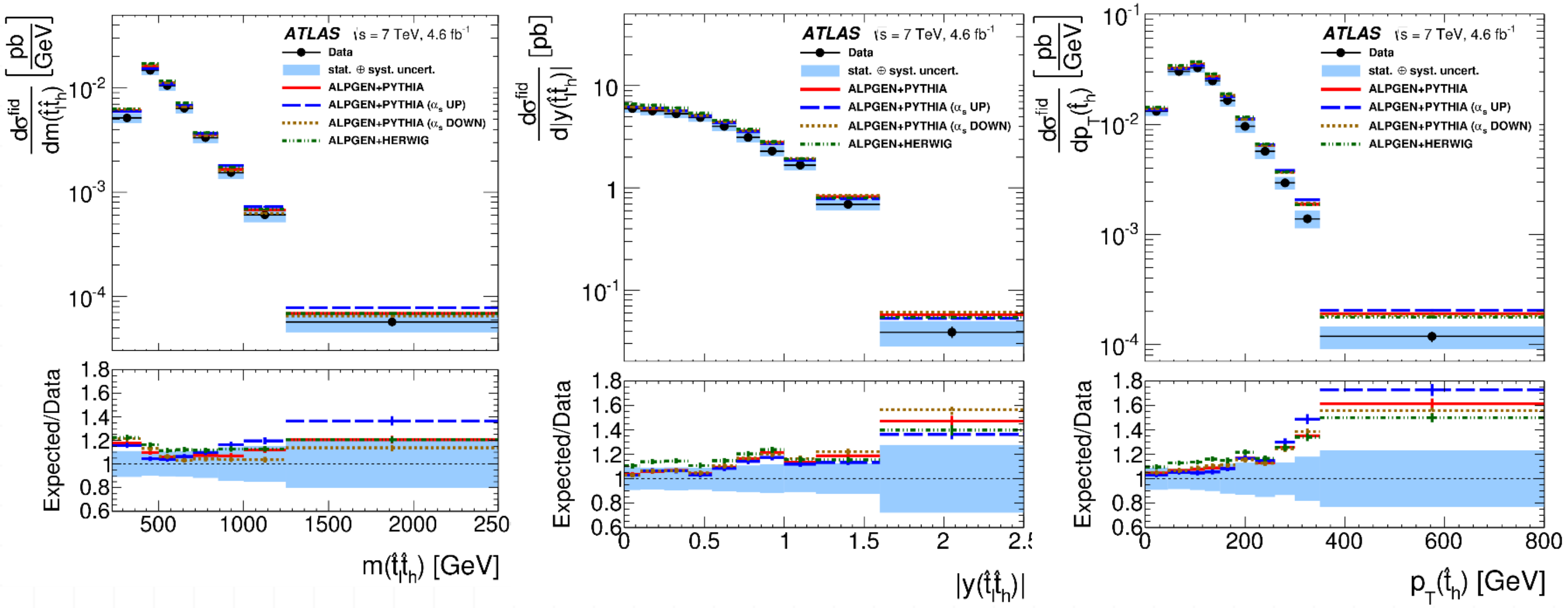
JHEP 06 (2015) 100

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

- Top-antitop differential cross section $\left(\frac{d\sigma}{dX}\right)$ where $X = m_{t\bar{t}}, p_{\mathrm{T},t\bar{t}}, |y_{t\bar{t}}|, p_{T,t}$ 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 $l(e/\mu)$+jets channel
- Main uncertainties: b-tag, JES and IFSR



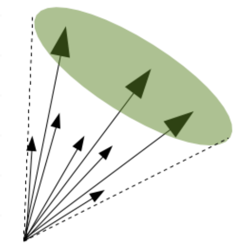
- General trend of data being softer in $p_{T,t}$ above 200 GeV
- Same behavior is observed by the parton level analysis



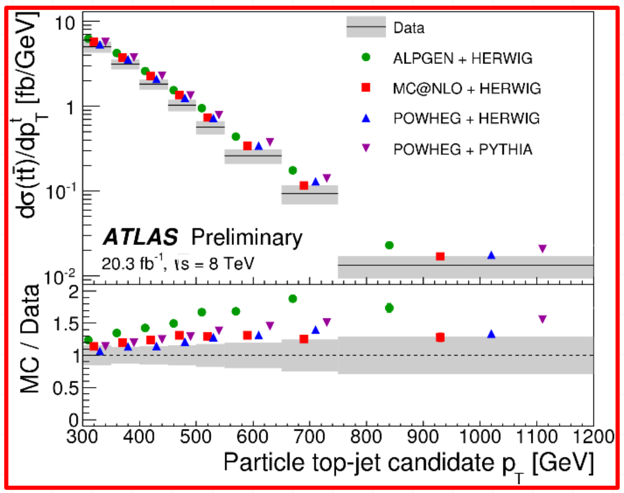
$t\bar{t}$ differential cross section: boosted tops

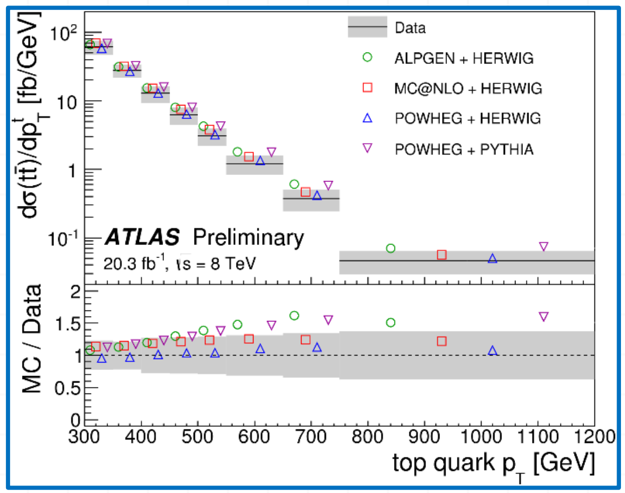
ATLAS-CONF-2014-057

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



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



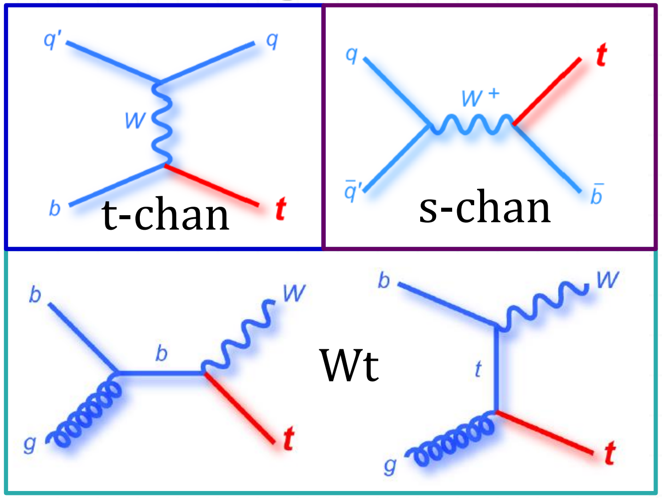


Main uncertainties: large-R jet energy scale

- Extrapolation to parton level affected by an increased signal modelling systematics

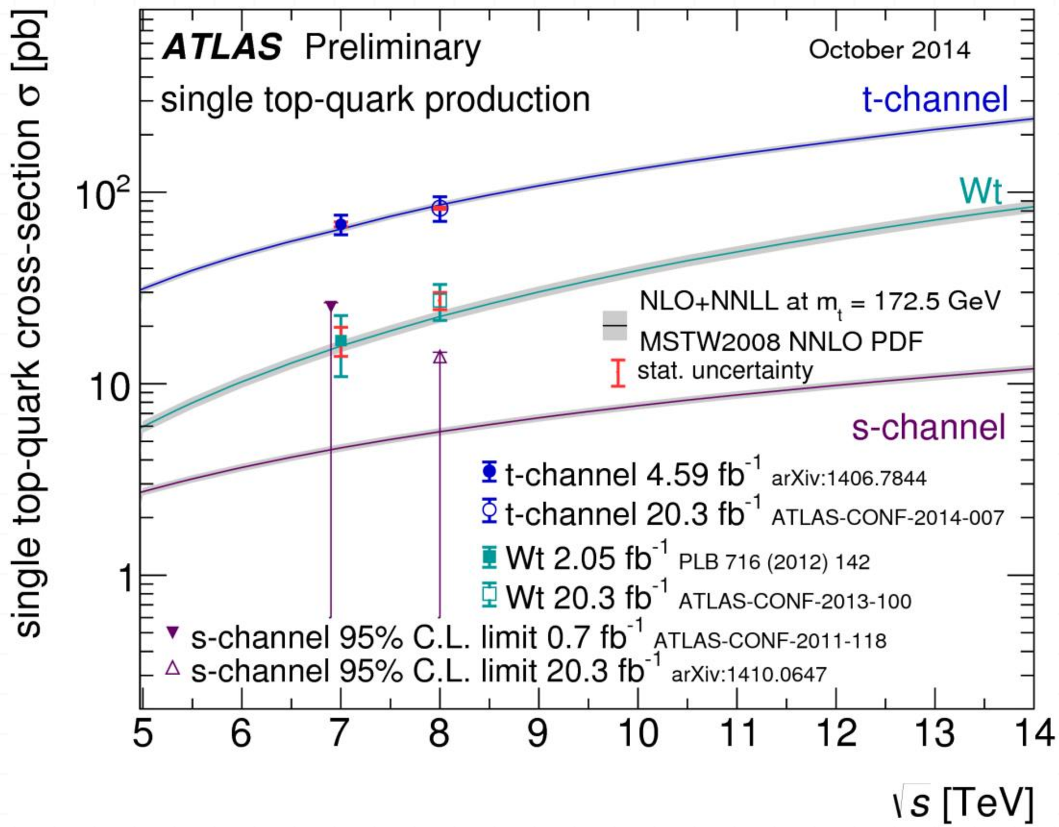
- Measured σ in general lower than predictions
  - Discrepancy tends to increase at high p_T
  - In agreement with the behavior observed in resolved analyses

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)

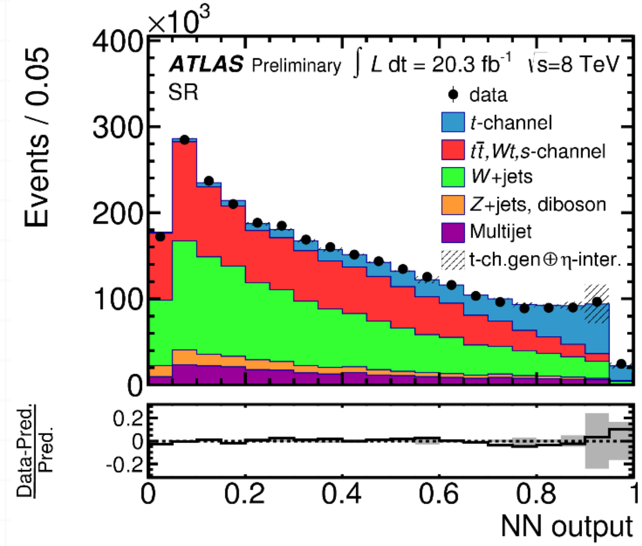
$$R_t = \frac{\sigma_t}{\sigma_{\bar{t}}}$$

Single top t-channel cross section

ATLAS-CONF-2014-007

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

- 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
- $\boldsymbol{\sigma_{t-chan}}$ extracted via a maximum-likelihood fit of the NN output in the data
- Fiducial and total phase space measurements



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

Main uncertainties: JES and signal modelling

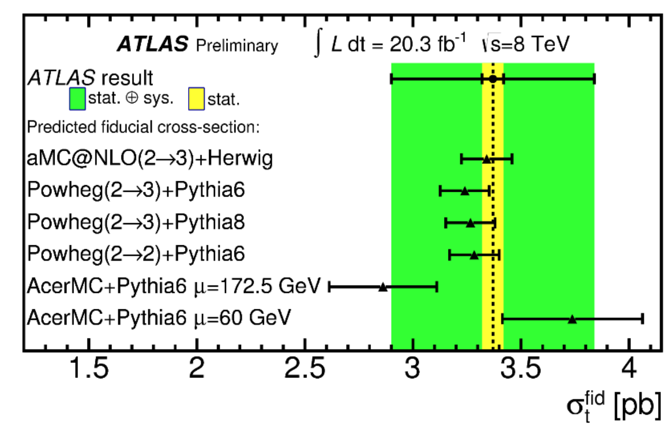
$$\boldsymbol{\sigma^{total}_{t-chan}(\sqrt{s} = 8\ \text{TeV}) = 82.6 \pm 12.1\ \text{pb}\ (\pm 15\%)}$$

(extrapolated via MG5_aMC@NLO)

Additional uncertainty: PDF

$$\sigma^{th}_{t-chan}(\sqrt{s} = 8\ \text{TeV}) = 87.8^{+3.4}_{-1.9}\ \text{pb}\ (^{+3.9\%}_{-2.2\%})$$

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



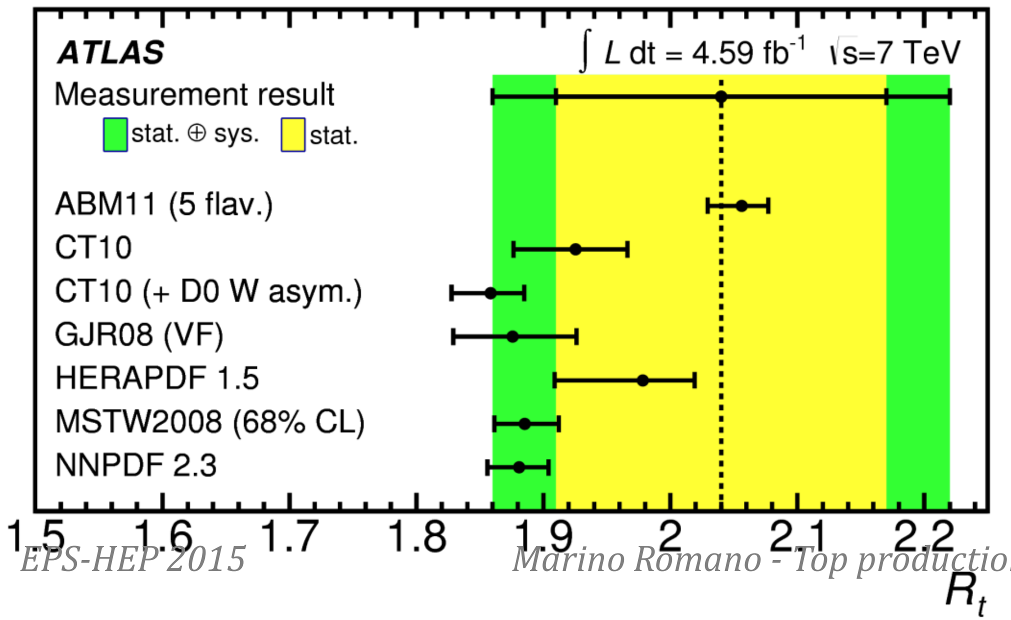
Single top/antitop t-chan ratio

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

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

$\sqrt{s} = 7$ TeV, $L = 4.6$ 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



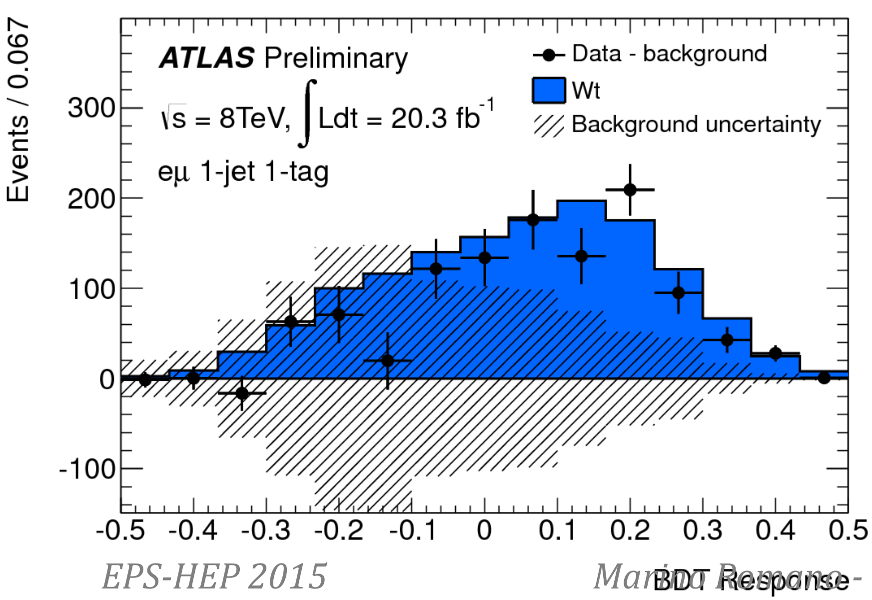
The measurement is in agreement with the predictions from different PDF sets and is dominated by statistical and systematic (MC statistics and PDF) uncertainties

Single top *Wt*-channel cross section

ATLAS-CONF-2013-100

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

- Hard to separate from $t\bar{t}$, interference at NLO
  - Event selected requiring $1e$, 1μ, 1/2jet, 1b-tag, E_T^{miss}
  - Multivariate analysis based on Boosted Decision Tree (BDT) employed to increase the discrimitation 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



$$\boldsymbol{\sigma_{Wt}(\sqrt{s} = 8\ \mathrm{TeV}) = 27.2\ \pm 5.8\ \mathrm{pb}}\ (\pm 21\%)$$
(observed $\mathbf{4.2\sigma}$, expected 4.0σ)

Main systematics: *b*-tagging, JES, generator uncertainties

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

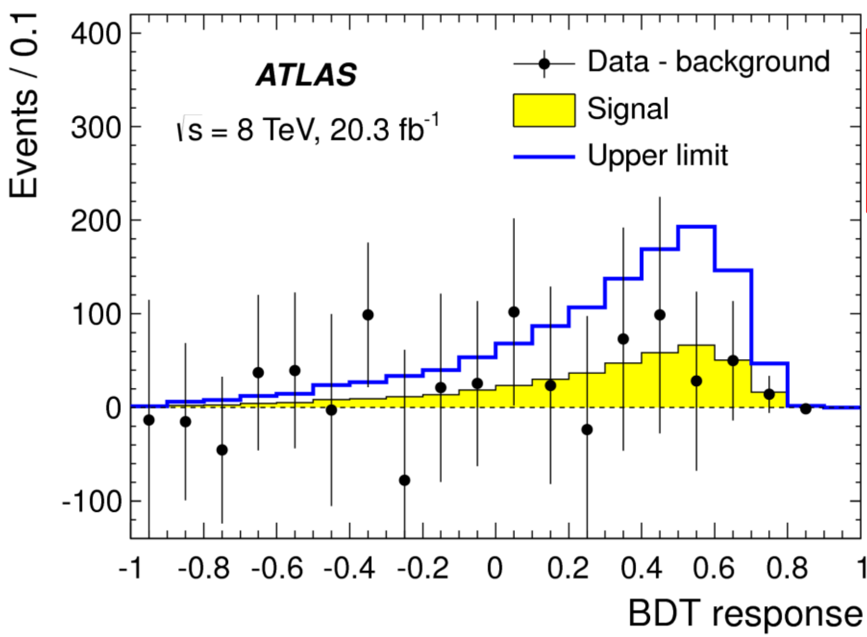
N. Kidonakis, Phys. Rev. D 82 (2010) 054018

Single top *s*-channel search

Phys. Lett. B740 (2015) 118

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

- Low rate in *pp* collissions (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 discrimitation power
  - Most discriminating variable: $|\Delta\phi(t, b)|$
  - Maximum likelihood fit to the BDT output to extract the signal cross section



$\boldsymbol{\sigma_{s-chan}(\sqrt{s} = 8\ \text{TeV}) = 5.0 \pm 4.3}$ **pb** $(\pm 86\%)$
$(\mathbf{1.3\sigma}$, expected $1.4\sigma)$
Upper limit: **14.6 pb** @ 95%CL

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

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

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

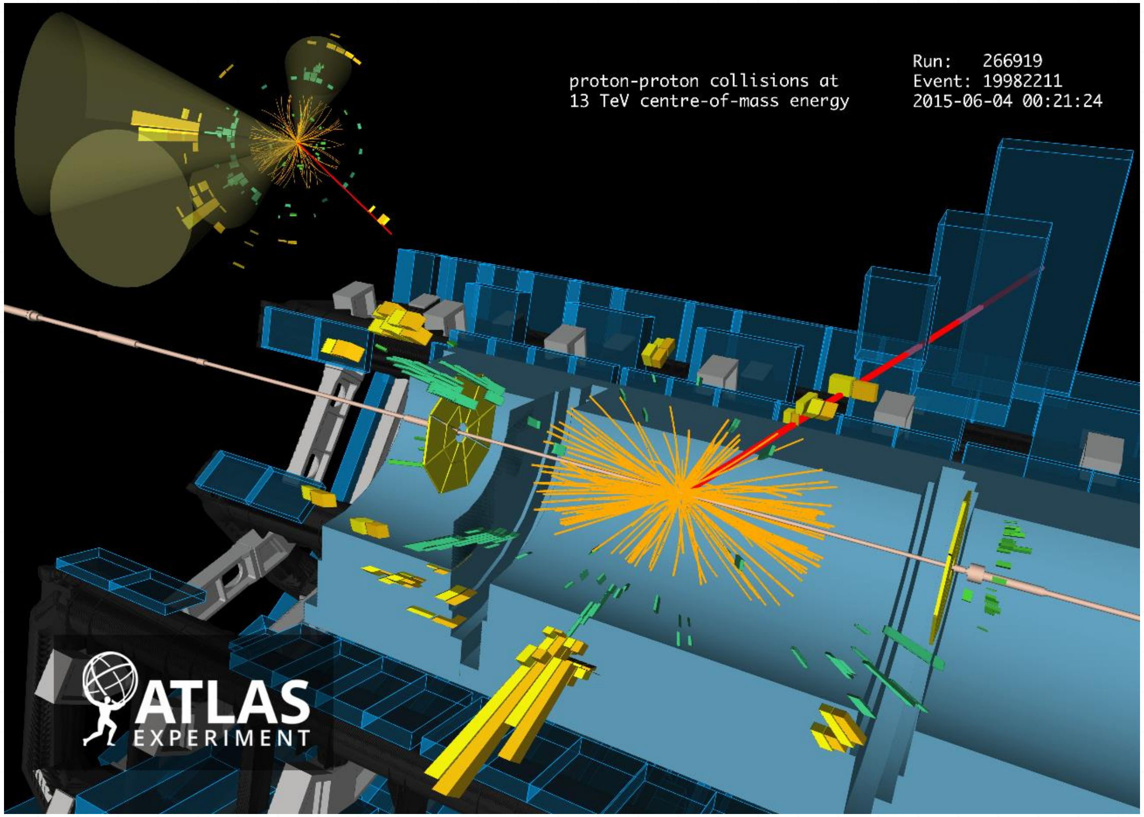
Event Kinematic Distributions in Top-Quark Enriched Samples

BONUS

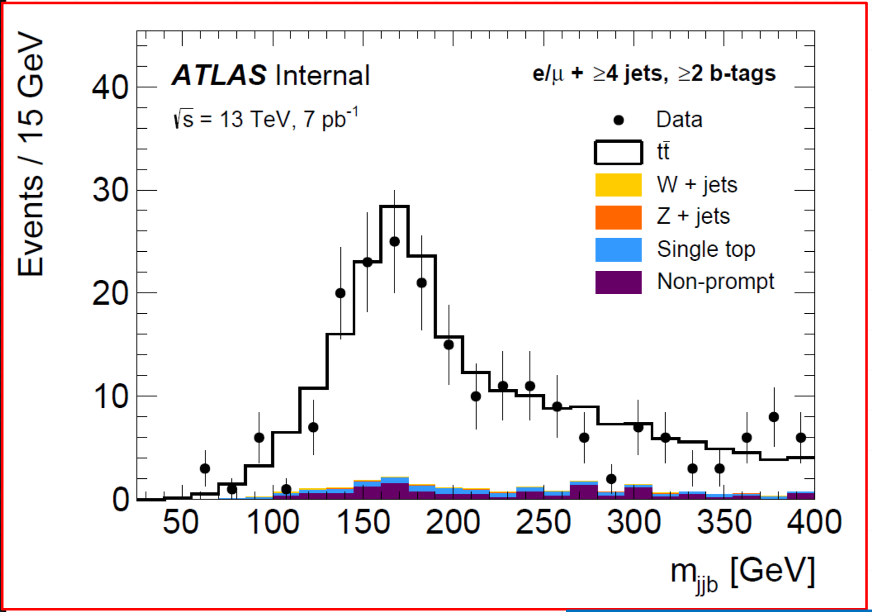
Placeholder for pub note

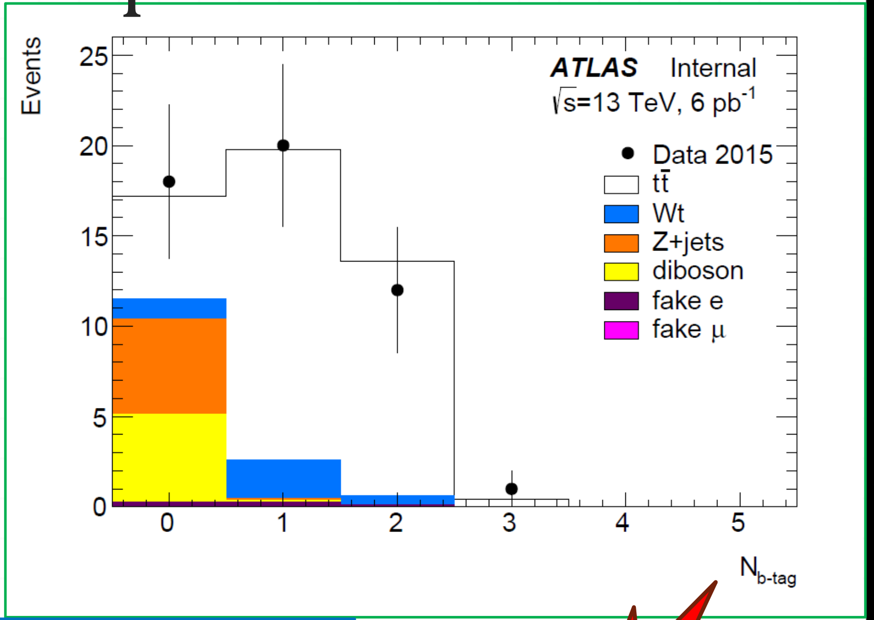
$\sqrt{s} = \mathbf{13\ TeV},\ L = 6/7\ \text{pb}^{-1}$

- Data collected by the ATLAS detector on the 13th and 14th of June 2015 at $\sqrt{s} = \mathbf{13\ TeV}$
- 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

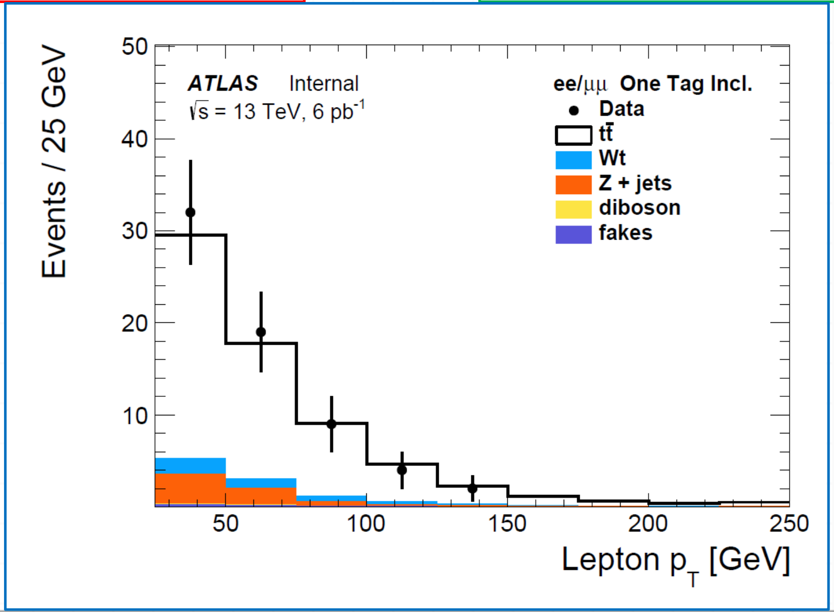


Event Kinematic Distributions in Top-Quark Enriched Samples





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



Placeholder for pub note

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:

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

Common object definitions

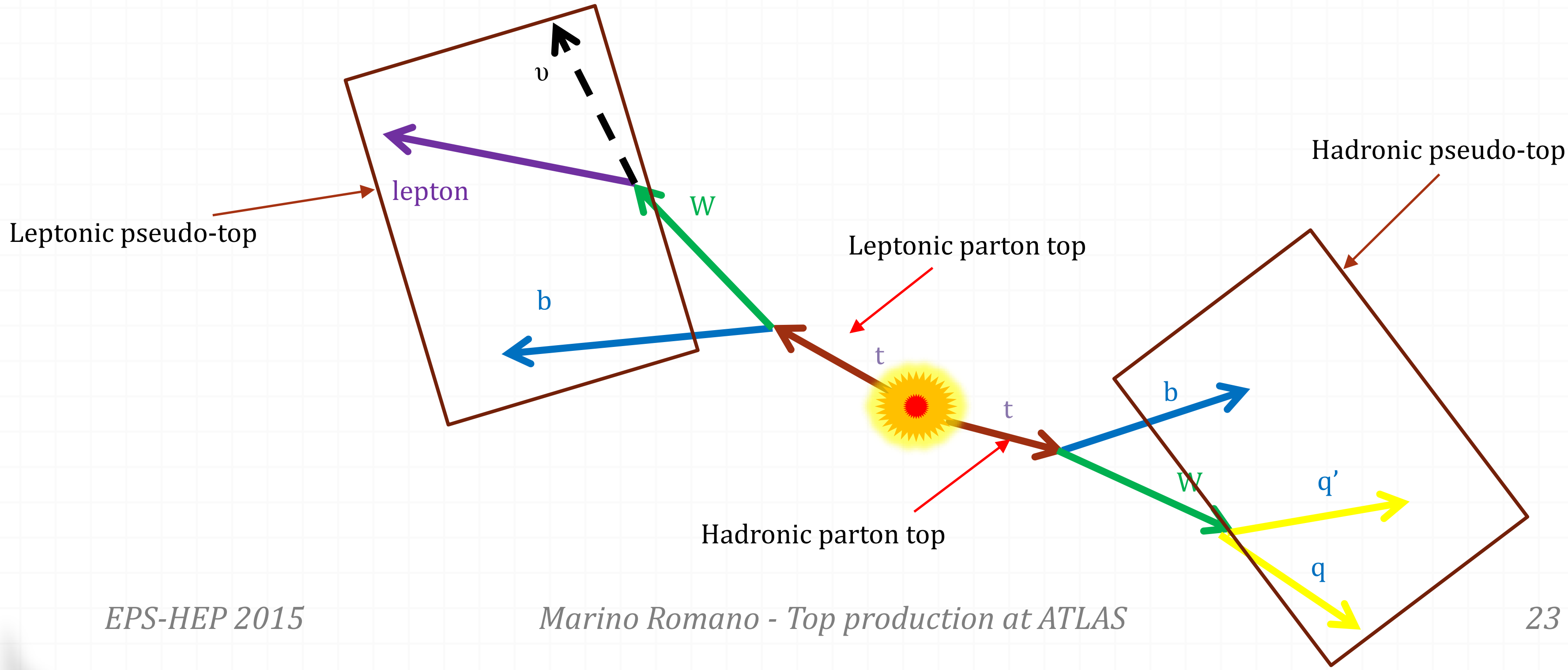
- Details can vary among the different analyses
- Jets:
  - Reconstructed from topological clusters using the anti-kt algorithm ($R = 0.4$)
  - p_T> 25 GeV, $|\eta|$ <2.5
- B-tagging via a Neural network based algorithm (MV1) with average efficiency of 70% and light jet rejection factor ~140
- Electrons:
  - 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.

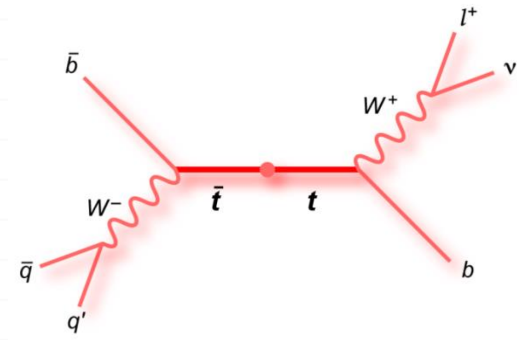
'Particle level' top (or pseudo-top):
- Observable constructed from *stable* particles directly related to the top



Reconstruction of the tt system via kinematic likelihood fit

- The tt system reconstruction is performed trough a kinematic fit using a maximum likelihood approach

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



- The likelihood assesses the compatibility of the event with a typical ttbar 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 j.
- 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

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

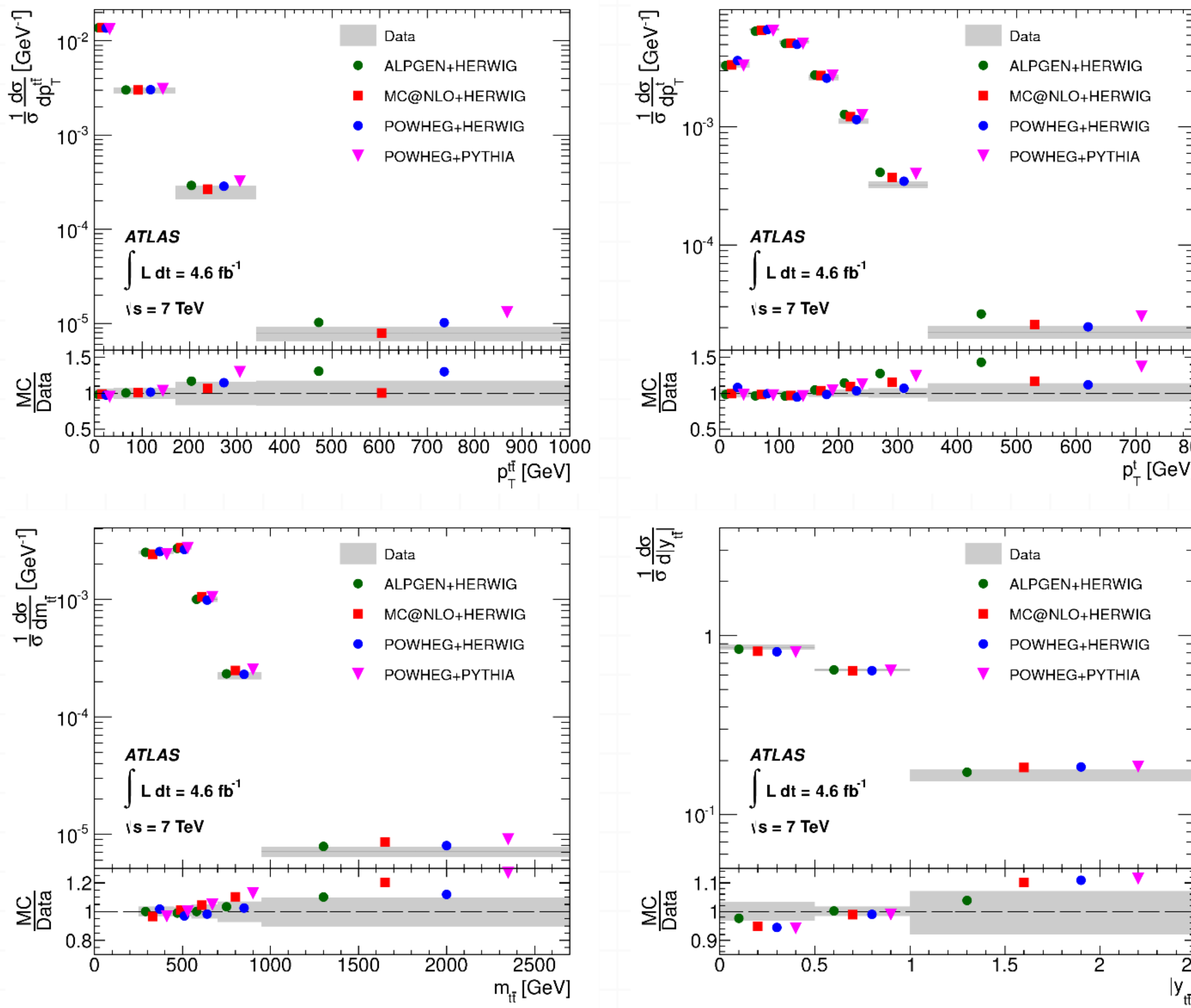
Electron and muon channel combination via the Asymmetric Iterative BLUE (AIB)

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 $|y_{t\bar{t}}|$

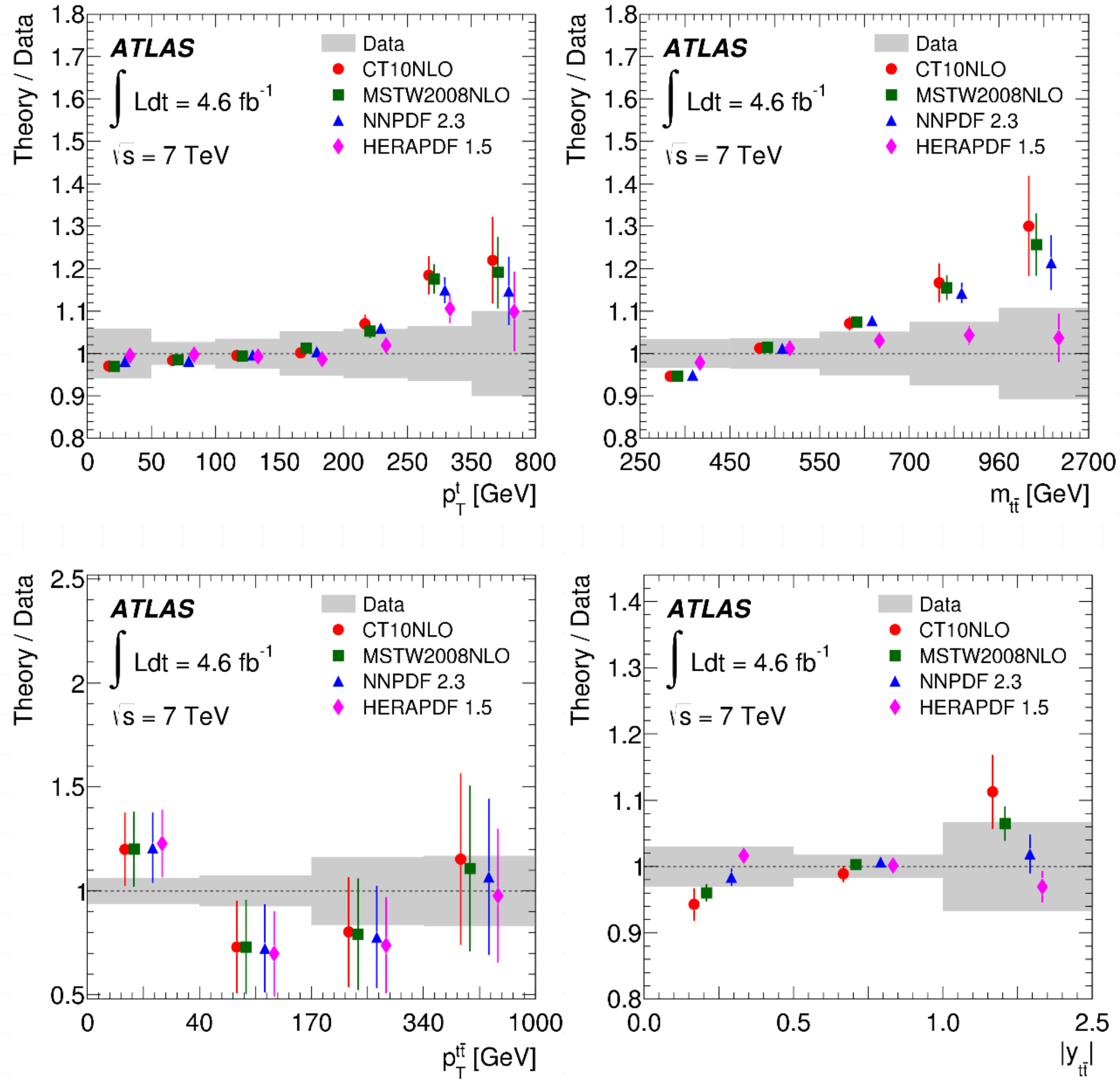


Results: comparison with NLO calculations

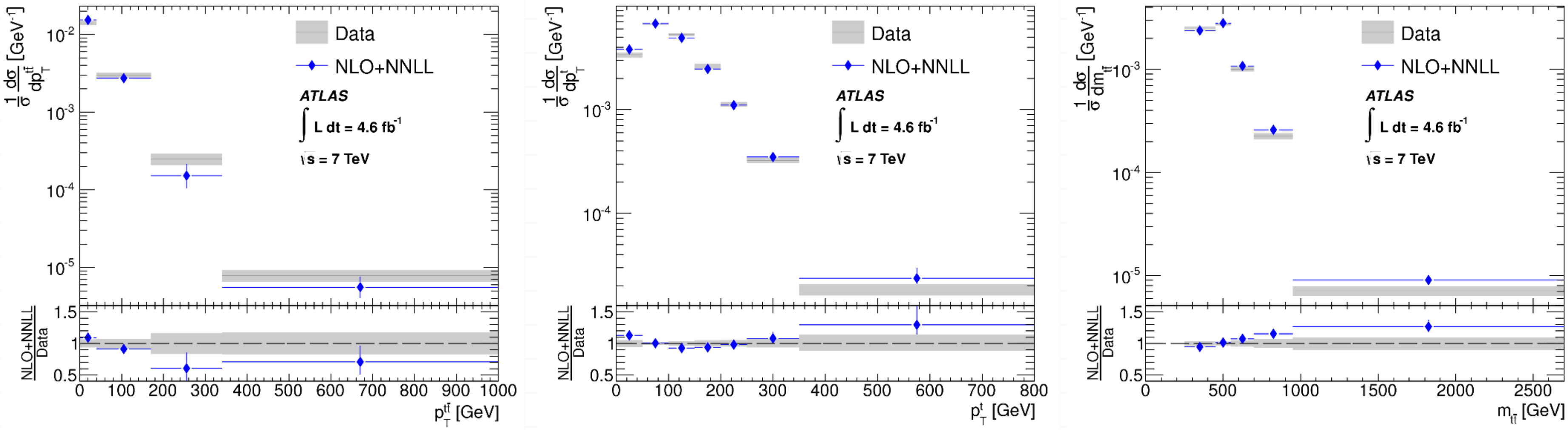
NLO prediction based on MCFM with different PDF sets

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 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 pT > 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

1) Reconstruct neutrino 4-momentum applying W mass constraint

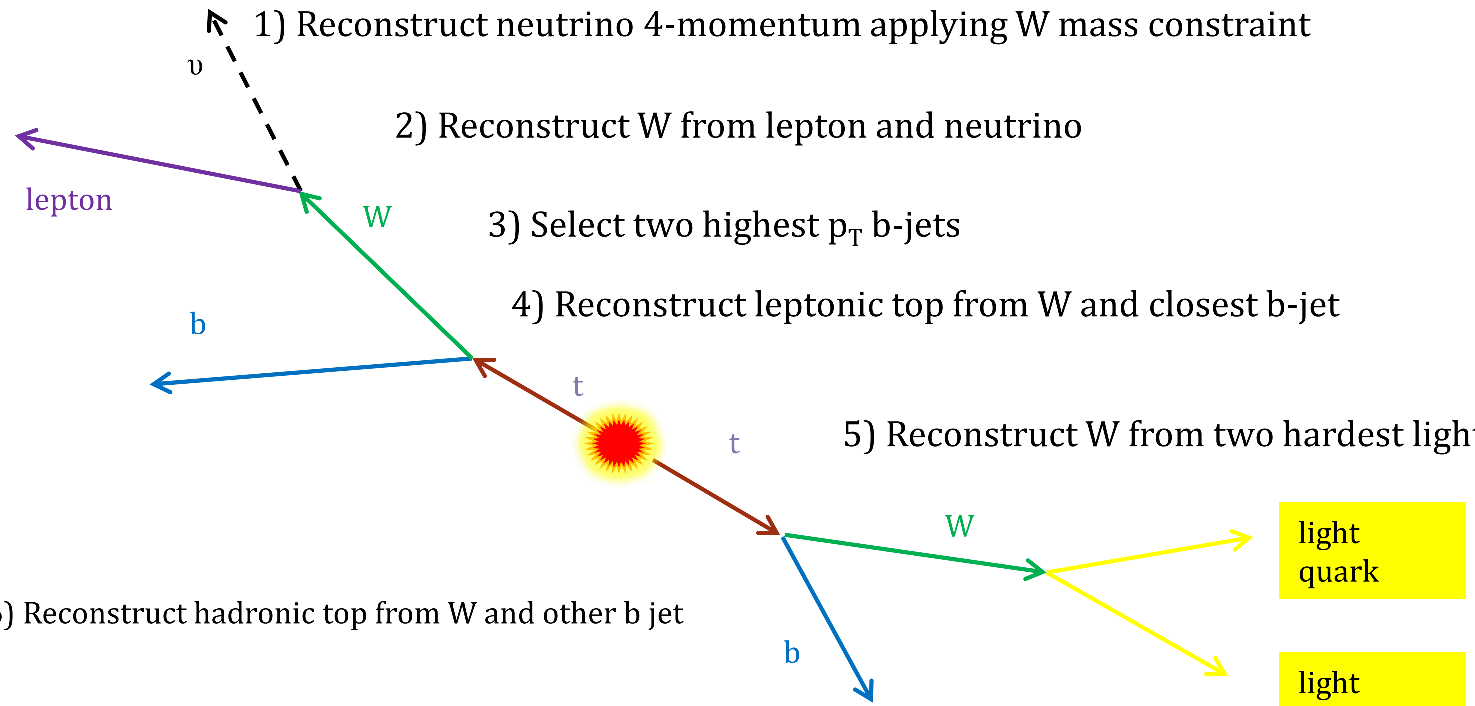
2) Reconstruct W from lepton and neutrino

3) Select two highest p_T b-jets

4) Reconstruct leptonic top from W and closest b-jet

5) Reconstruct W from two hardest light jets

6) Reconstruct hadronic top from W and other b jet



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

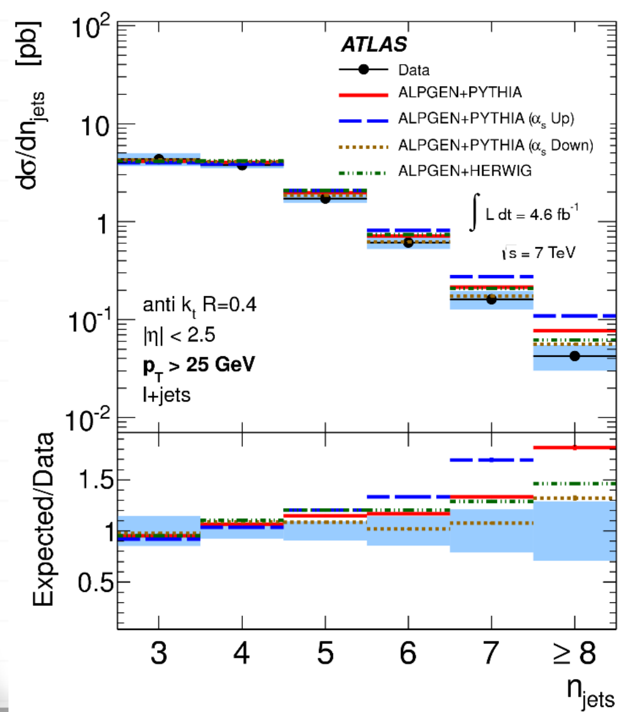
JHEP 01(2015)020

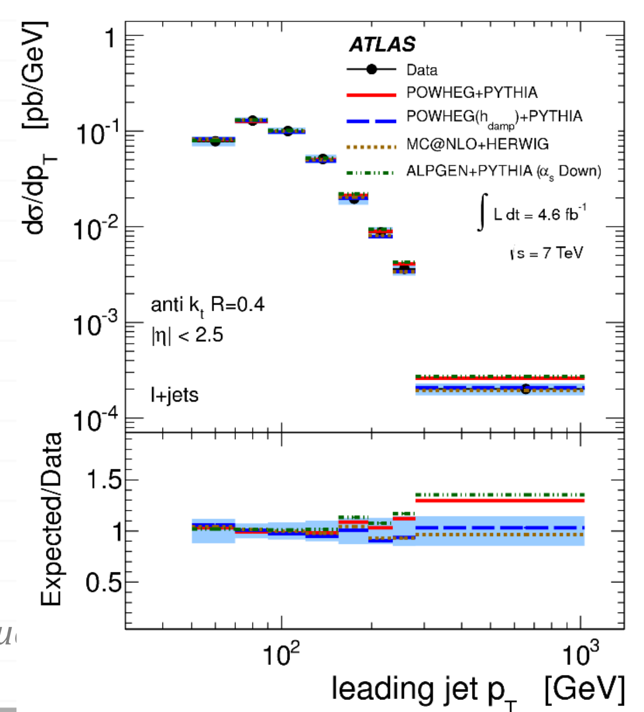
$\sqrt{s} = 7$ TeV, $\int Ldt = 4.6\text{fb}^{-1}$

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

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

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

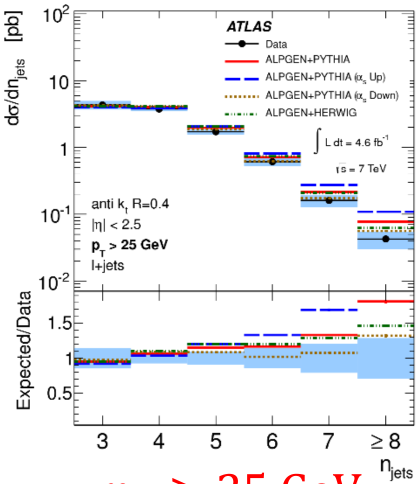




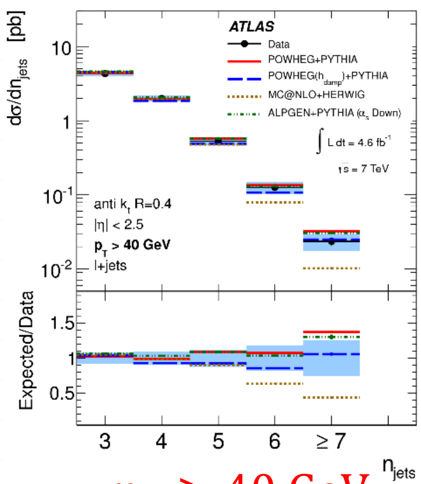
Jet multiplicity in top–anti-top final states

- 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 → particle level
- Measurement is limited by systematic uncertainties,
  - background modelling (at lower jet multiplicities)
  - jet energy scale (at higher jet multiplicities)

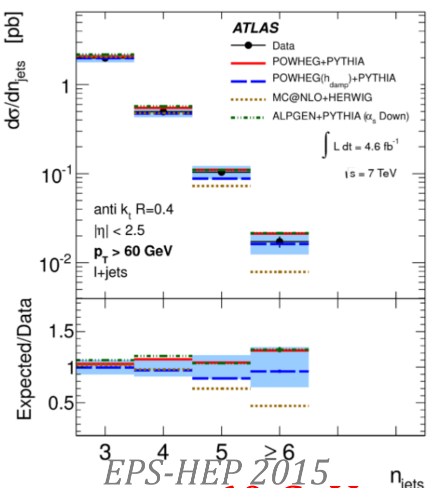
Jet multiplicity in top–anti-top final states



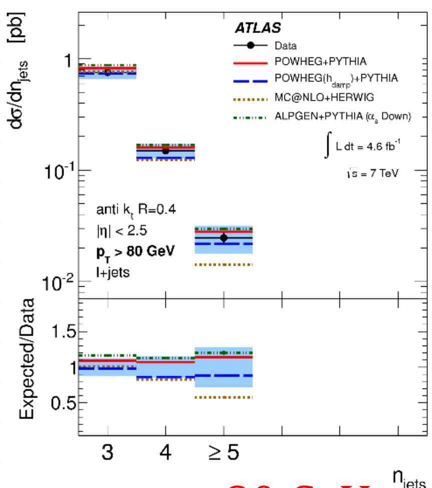
$p_T > 25$ GeV



$p_T > 40$ GeV



$p_T > 60$ GeV



$p_T > 80$ GeV

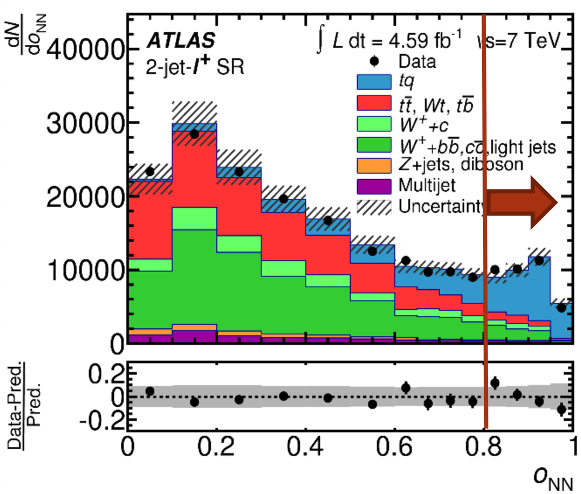
- MC@NLO modelling predicts a lower jet multiplicity spectrum and softer jets
- Predictions from ALPGEN + HERWIG or PYTHIA and POWHEG + PYTHIA are consistent with the data

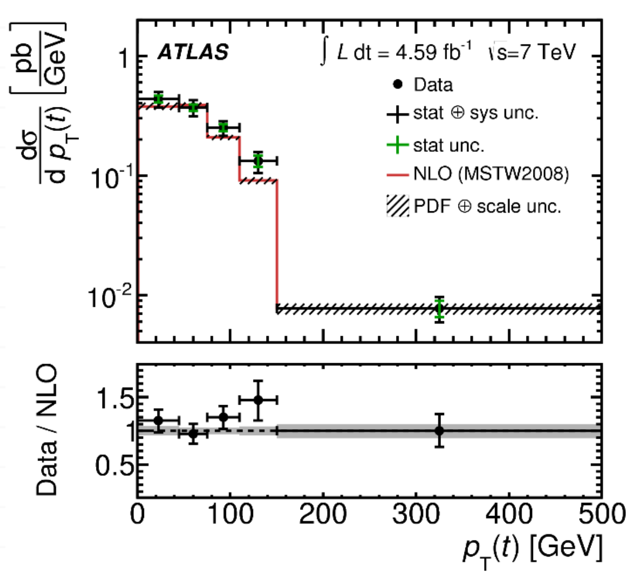
Single top *t*-channel differential cross section

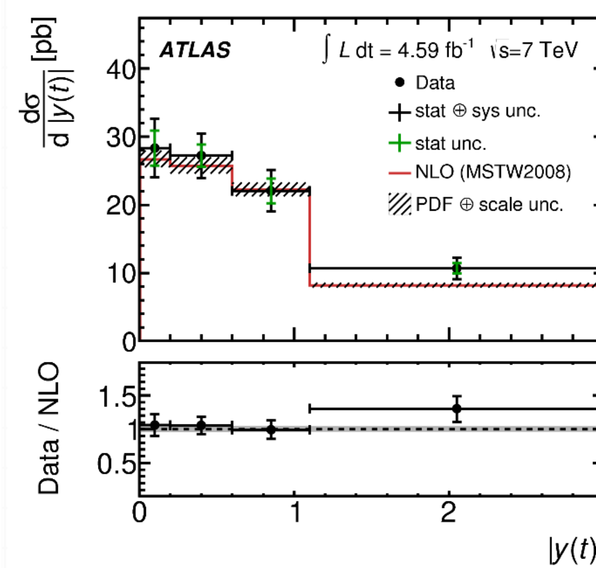
Phys. Rev. D. 90, 112006 (2014)

$\sqrt{s} = 7$ TeV, $\int L dt = 4.6$ 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





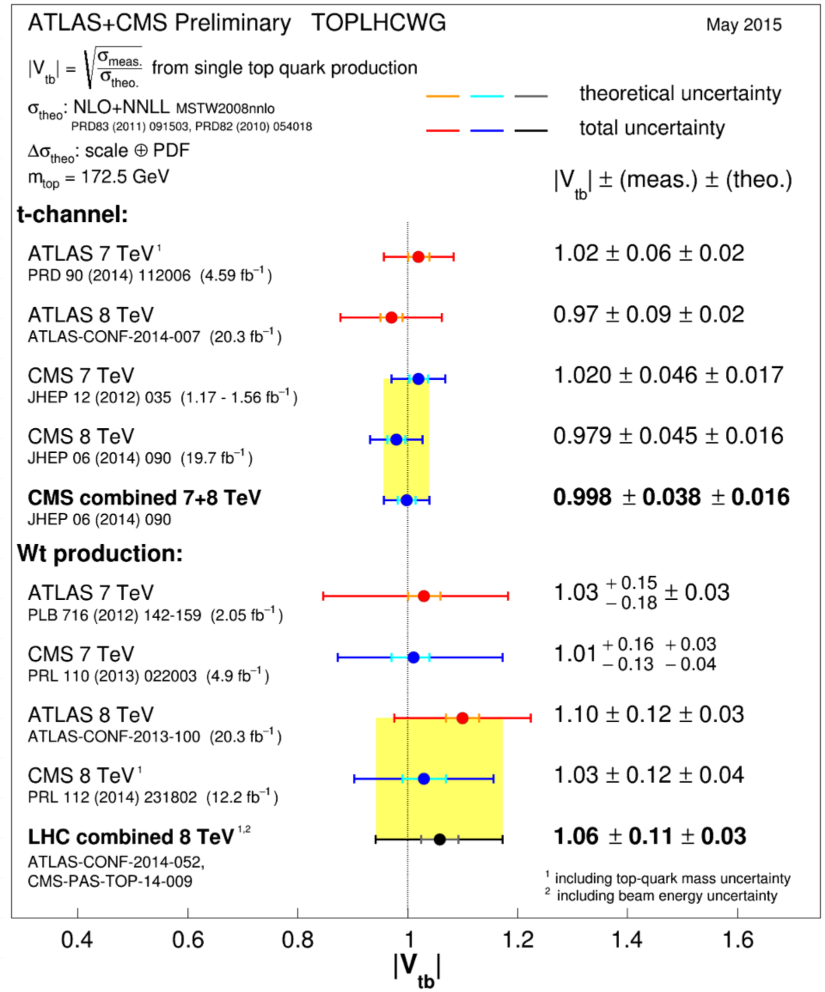


V_{tb} extraction

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

Two general assumptions

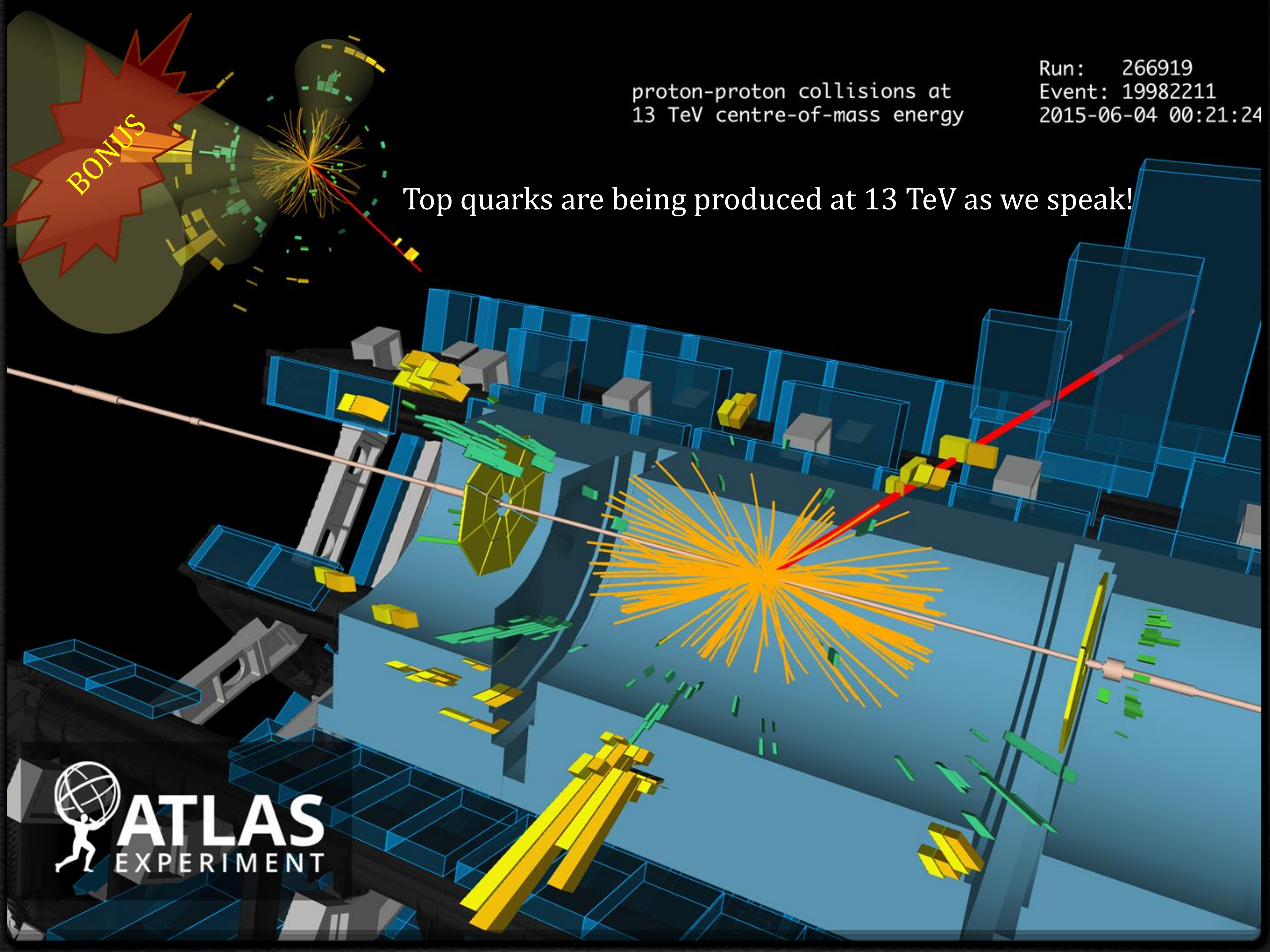
1. W – t – b interaction is left-handed
2. top quark production and decay through |Vts| and |Vtd| are negligible



|Vtb| is extracted by the ratio

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

Where, for the SM, $f = 1$



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

BONUS

Event Kinematic Distributions in Top-Quark Enriched Samples

Placeholder for pub note

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

- Data collected by the ATLAS detector on the 13th and 14th of June 2015 at $\sqrt{s}$ = **13 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