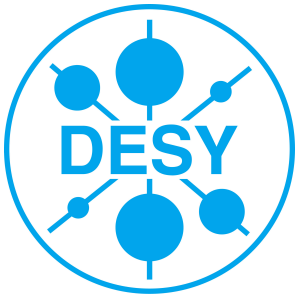


Top2016 Highlights:
Cross Sections and Single Top Results from ATLAS and CMS Collaborations

Callie Bertsche
on behalf of the DESY ATLAS Group

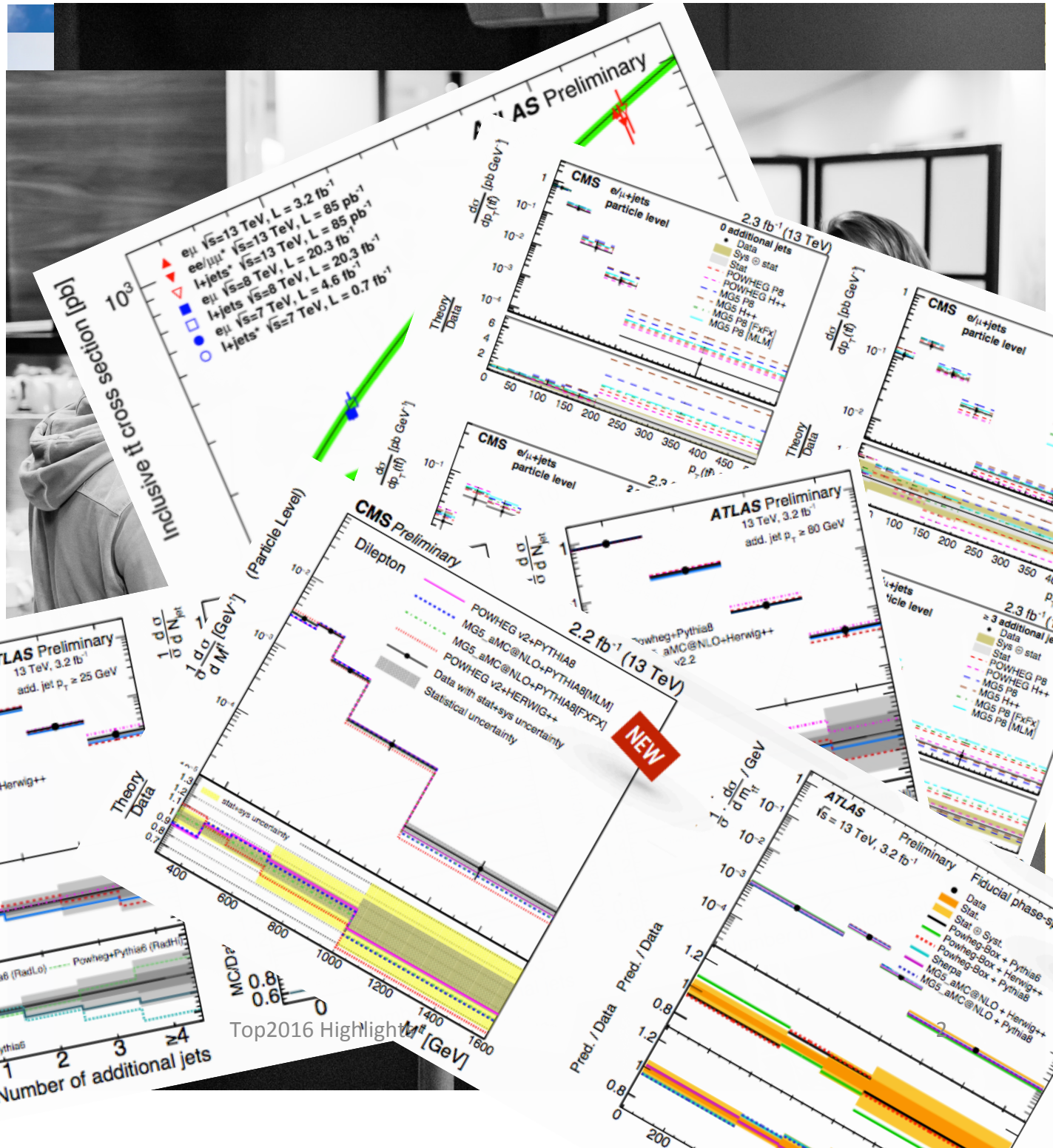
10 October 2016

OLOMOUC, CZECH REPUBLIC
9th International Workshop on Top Quark Physics
19 - 23 September 2016

The Parameters

- 5 days in Czech Rep.
- 131 Participants
- 50 Talks
- 1 Poster Session
- 2 Young Scientist Q&As
- 351* coffee, 253* tea
- ...Lots of great results!

* = +/- 90%



The Overview:
ATLAS & CMS Measurement Highlights

- tT cross-section measurements
- tT differential cross-section measurements
- Single top measurements
- Mass and Properties: Hartmut Stadie's talk

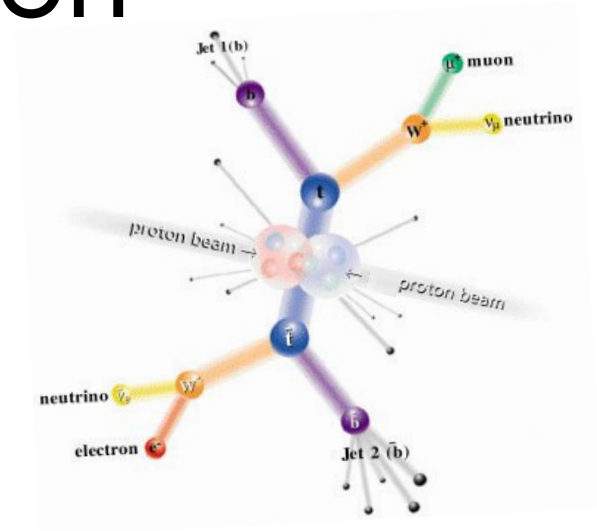
Disclaimer! Too much to cover fully!

ALL REFERENCES AVAILABLE AT: https://indico.cern.ch/event/486433

The Motivation

Top quark measurements are...

- Valuable tests of the Standard Model
  - QCD predictions
  - Bare quark studies as decays before hadronisation
- Excellent method for tuning simulations
  - QCD and PDF modelling
  - Parameter value measurement
- Important probes of new physics
  - Main background of many searches
  - Deviations in production point to or constrain new physics searches, such as stop quark production



tT Cross-Section Measurements

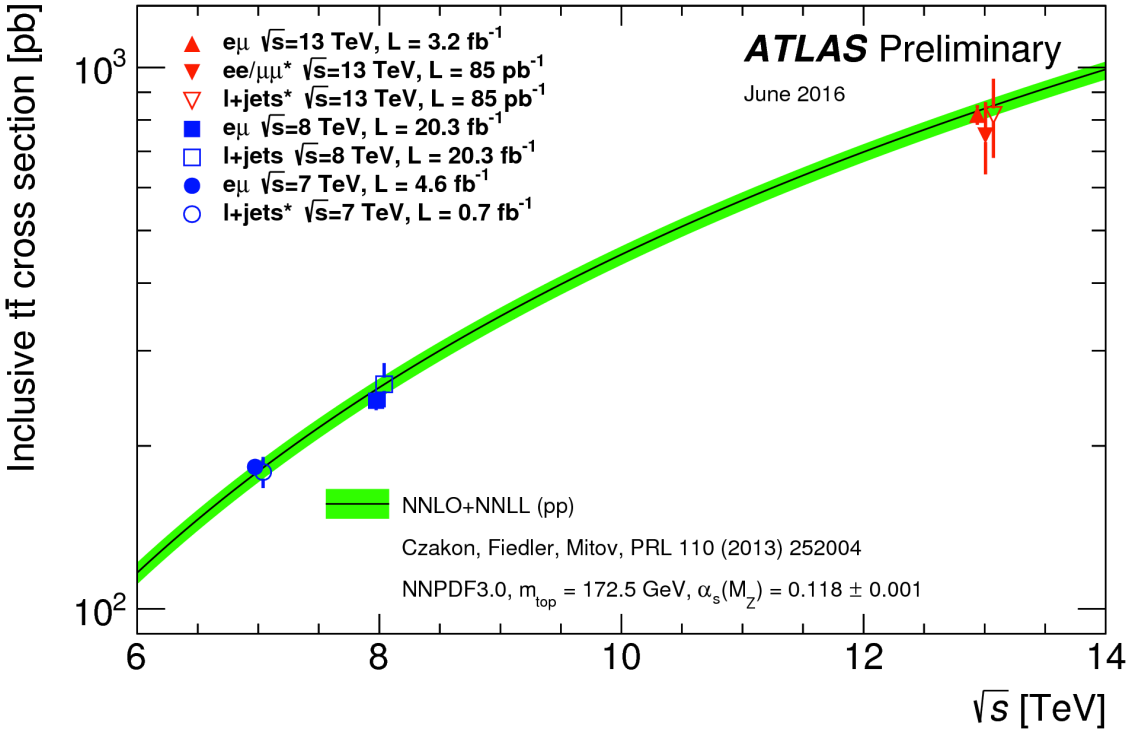
tT Cross-Section Measurements

13 TeV:

- ATLAS+CMS Dilepton *eμ* +2 *b*-tagged jets
- ATLAS Dilepton same flavor (*ee*/*μμ* channels)
- ATLAS+CMS Lepton+jets
- CMS All hadronic

7-8 TeV:

- ATLAS+CMS Dilepton *eμ* +2 *b*-tagged jets
- ATLAS+CMS Lepton+jets



Dilepton $e\mu$+b-tagged Jets

- Clean precise measurement with ~3% background
- Select exactly: $e^{\pm}\mu^{\mp}$,
- Select ≧1 (CMS), 1-2 (ATLAS) b-tagged jets
- Strategic counting measurements

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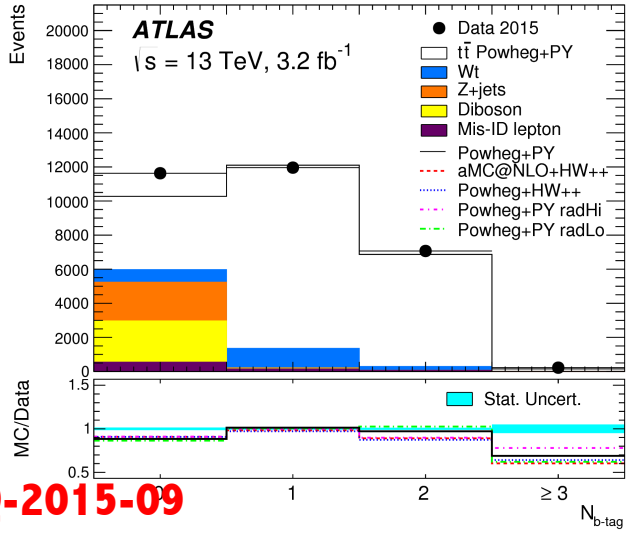

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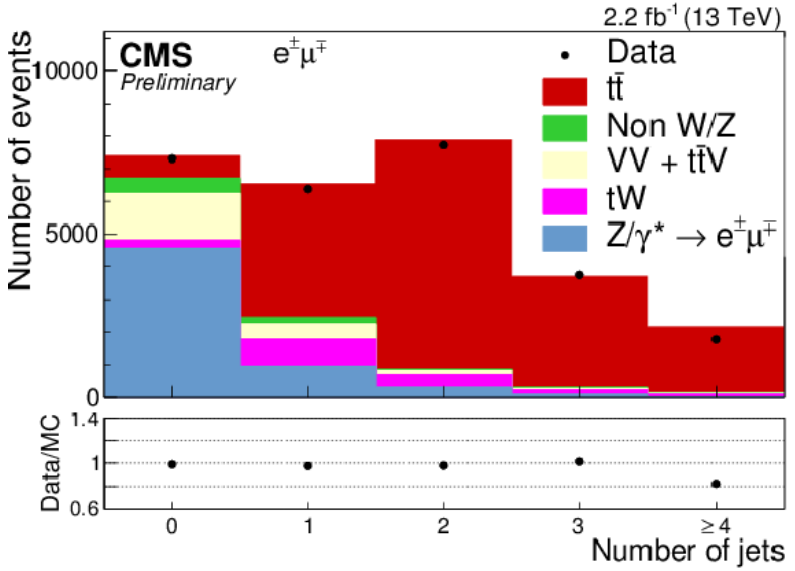


$$N_1 = L\sigma_{t\bar{t}}\,\epsilon_{e\mu} 2\epsilon_b(1 - C_b\epsilon_b) + N_1^{\text{bkg}}$$

$$N_2 = L\sigma_{t\bar{t}}\,\epsilon_{e\mu} C_b \epsilon_b{}^2 + N_2^{\text{bkg}}$$

- $\epsilon_{e\mu}$: $e\mu$ pre-selection selection efficiency
- ϵ_b: combined probability to reco and b-tag a jet within the fiducial volume
- $C_b = \epsilon_{bb}/\epsilon_b{}^2$: tagging correlation factor
  - represents change in tagging efficiency if one jet is already tagged

Source	Number of $e^{\pm}\mu^{\mp}$ events
Drell–Yan	$24 \pm 9 \pm 4$
Non-W/Z leptons	$109 \pm 50 \pm 33$
Single top quark	$463 \pm 6 \pm 145$
VV	$15 \pm 2 \pm 5$
$t\bar{t}V$	$31 \pm 1 \pm 10$
Total background	$642 \pm 52 \pm 149$
$t\bar{t}$ dilepton signal	$10199 \pm 14 \pm 462$
Data	10368

Dilepton eμ+2 *b*-tagged Jets

13 TeV: Consistent Results between Collaborations and SM

	7 TeV [pb] (stat,syst,lum,beam)	8 TeV [pb] (stat,syst,lum,beam)	13 TeV [pb] (stat,syst,lum,beam)
SM	177.3±9.0+4.6-6.0	252.9±11.7+6.4-8.6	832+40-46
CMS	173.6±2.1+4.5-4.0±3.8	244.9±1.4+6.3-5.5±6.4	793±8±38±21
ATLAS	182.9±3.1±4.2±3.6±3.3	242.4±1.7±5.5±7.5±4.2	818±8±27±19±12

ATLAS: 3.9-4.4% uncertainty

CMS: 3.6-5.6% uncertainty (excl. beam uncert.)

Lepton e/μ + Jets

ATLAS 13 TeV:

- 1 energetic e or μ
- ≥4 jets, ≥1 b-tagged jet
- e+jets: $E_T^{miss} > 40$ GeV or $m_T^W > 50$ GeV;
  μ+jets: $E_T^{miss} + m_T^W > 60$ GeV
- Extract cross section: $\sigma_{t\bar{t}}^{\ell j} := \frac{N_{Obs}^{\ell j} - N_{Bgr}^{\ell j}}{\varepsilon_{\ell j} \cdot \mathcal{L}_{Int}}$

CMS 13 TeV: **TOP-16-006**

- 1 energetic e or μ
- ≥1 jet
- Categorize analysis by number of jets and *b*-tagged jets
- Simultaneous binned likelihd
- Shaped fit in 44 categories of jets, *b*-tagged jets
- Extract cross section

Lepton e/μ +Jets

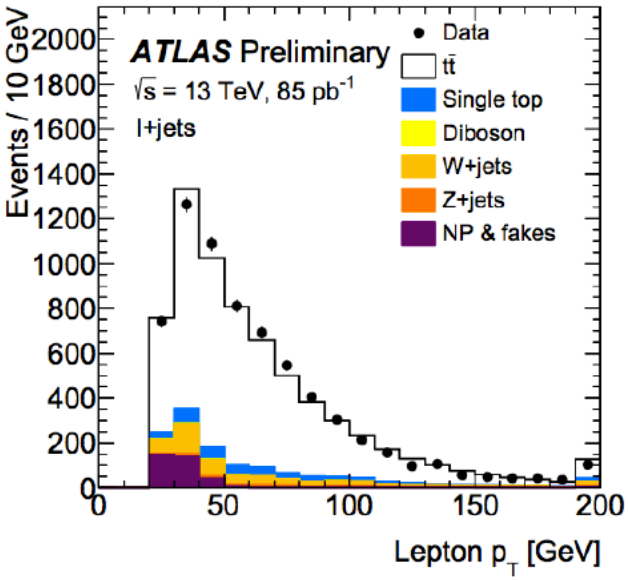
ATLAS 13 TeV:

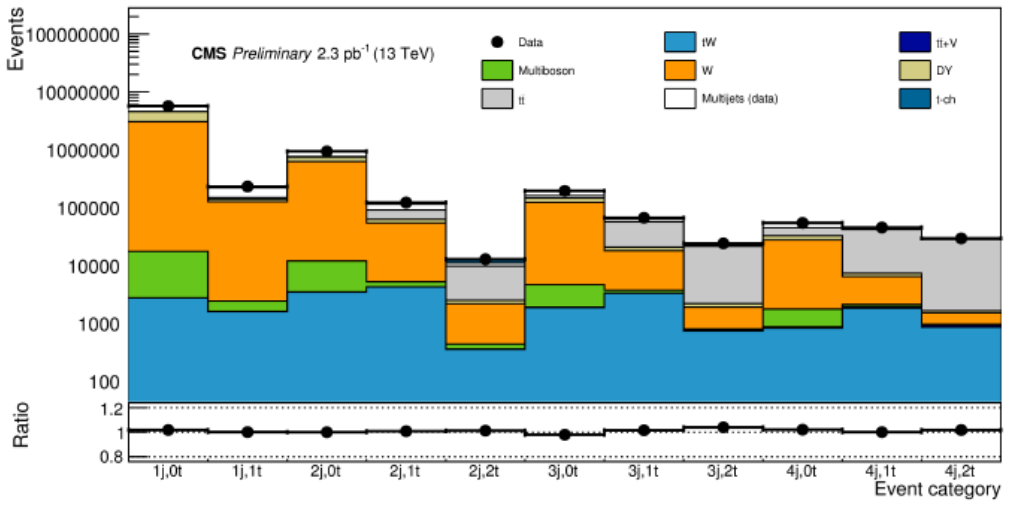
Result: $817 \pm 13\ (stat) \pm 103\ (syst) \pm 88\ (lumi)$ pb

- total: 17%
- stat.: 1.5%
- syst.: 13%
  - ttbar hadronisation: 4.1%
  - JES: 10%
  - *b*-tagging: 4.1%

CMS 13 TeV:

$\sigma = 834.7 \pm 2.5(stat) \pm 20.7(syst)$
$\pm 22.6(lumi) \pm 12.5(extrapol)$





tT Differential Cross-Section Measurements

tT Differential Cross-Section Measurements

13 TeV:

- ATLAS+CMS Dilepton
- ATLAS+CMS Lepton+jets
- ATLAS+CMS All-hadronic

7-8 TeV:

- ATLAS+CMS Dilepton
- ATLAS+CMS Lepton+jets
- CMS All-hadronic

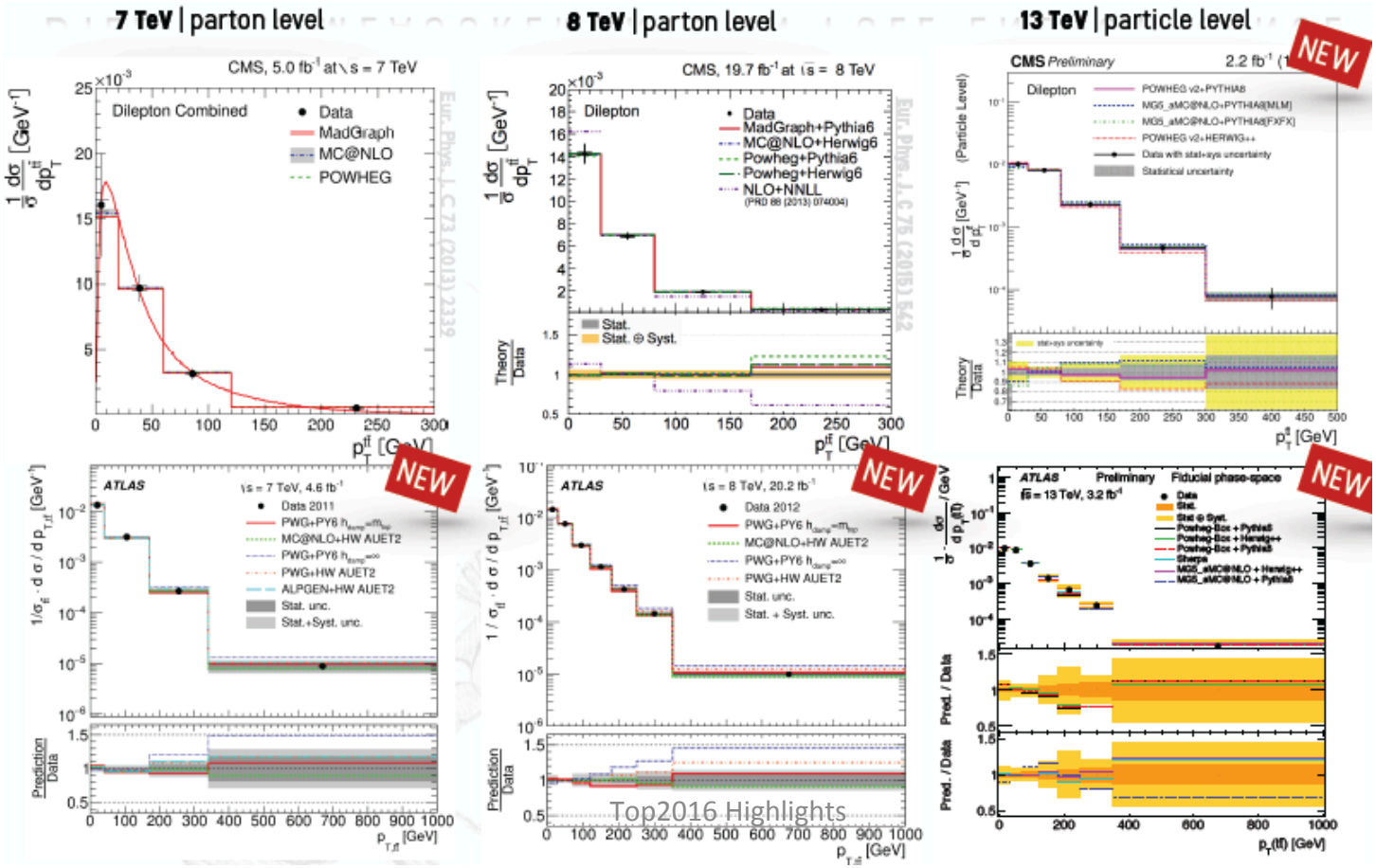
...As functions of a range of variables

- Ordered jet p_T
- Number of extra jets above p_T thresholds
- Scalar sum H_T of extra jet p_T
- Distance between two leading extra jets ΔR
- Top quark pair mass system
- Top quark pair p_T
- ...And more combinations of locations of top quark pairs, mass, etc

13 TeV Differential Cross-Section: Dilepton $e\mu$+b-tagged Jets

ATLAS+CMS:

- Select exactly $e^{\pm}\mu^{\mp}$, ≥1-2 b-tag jets
- Plot as function of range of variables

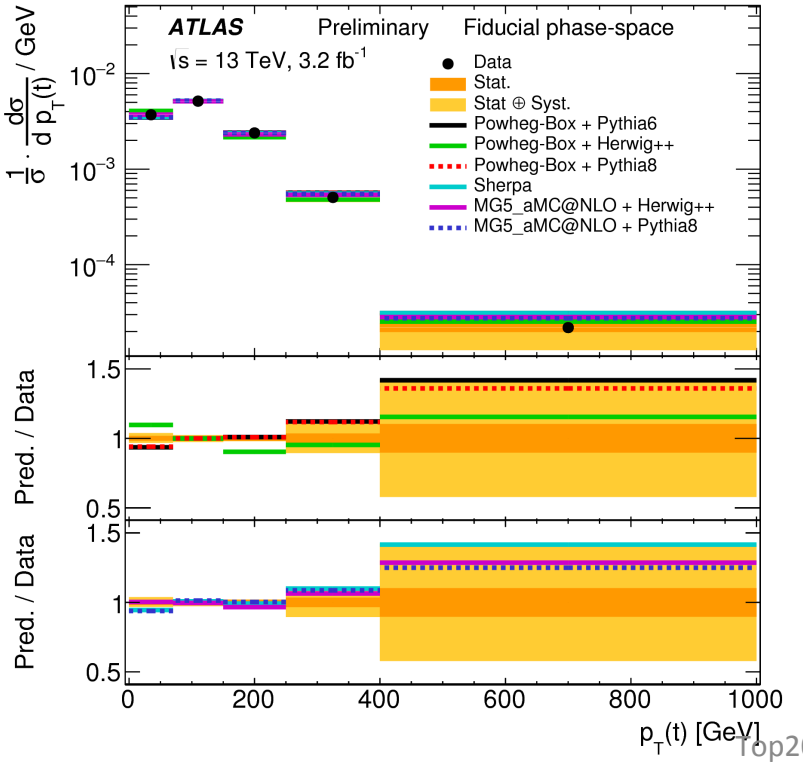


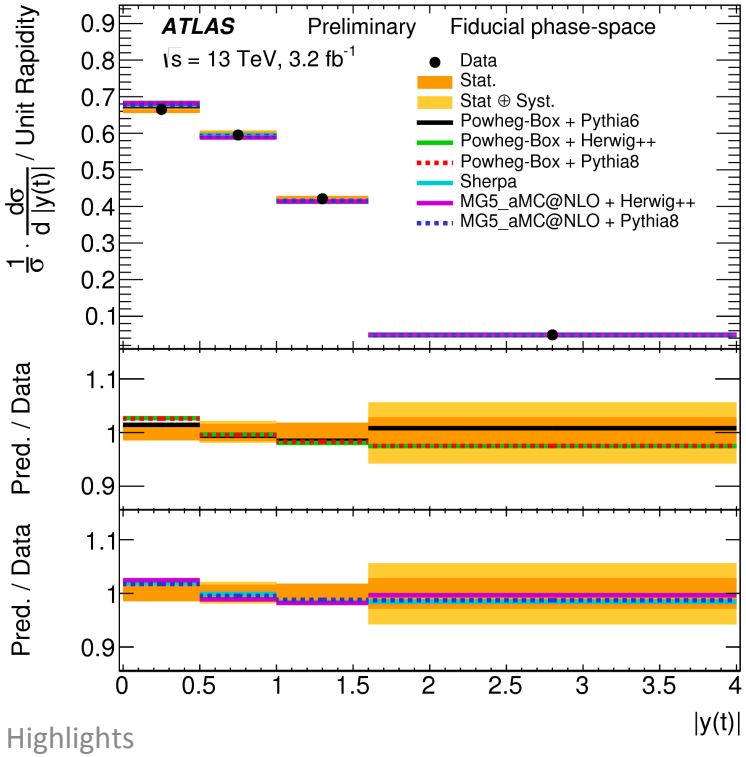
13 TeV Differential Cross-Section: Dilepton $e\mu$+2 b-tagged Jets

ATLAS:

- Select exactly $e^{\pm}\mu^{\mp}$, ≥2 b-tag jets
- Unfold to particle level
- As range of kinematic variables

TOPQ-2016-04



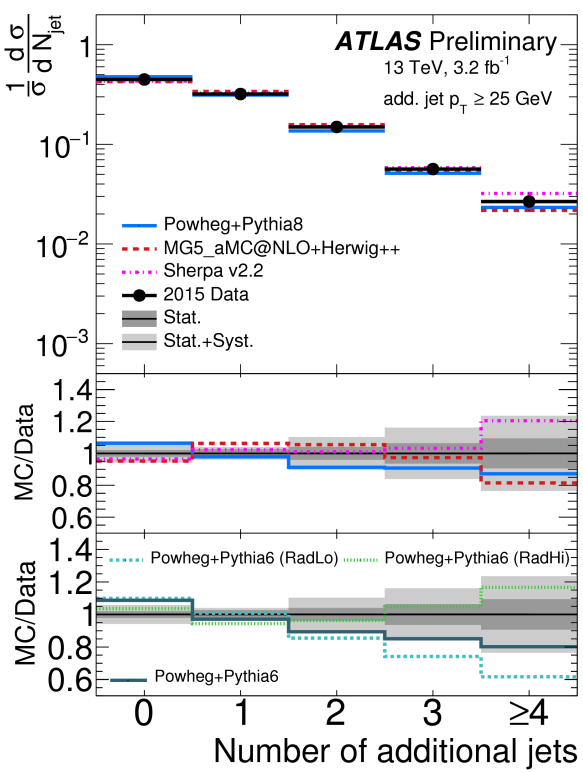


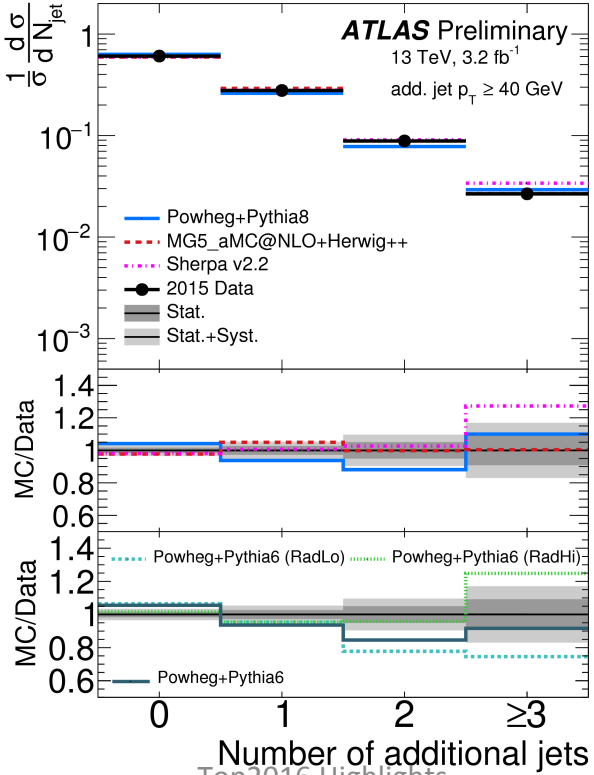
13 TeV Differential Cross-Section: Dilepton $e\mu$+2 b-tagged Jets

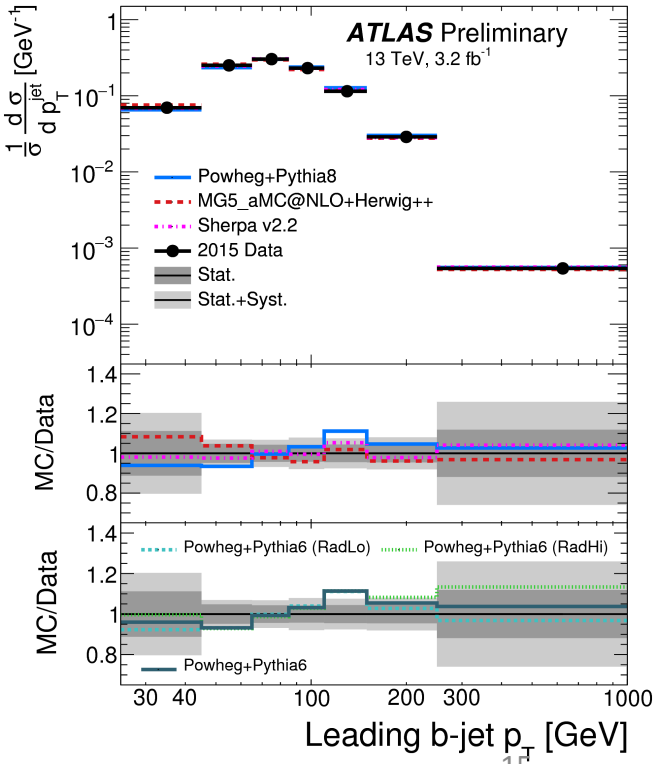
ATLAS:

- Select exactly $e^{\pm}\mu^{\mp}$, ≥2 b-tag jets
- Unfold to particle level
- Plot as range of variables, including extension to gap fraction

TOPQ-2015-17



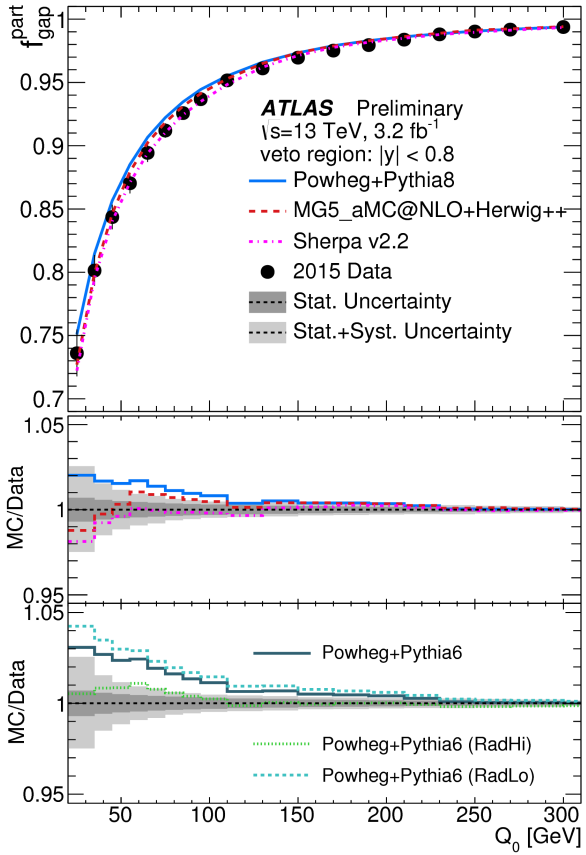


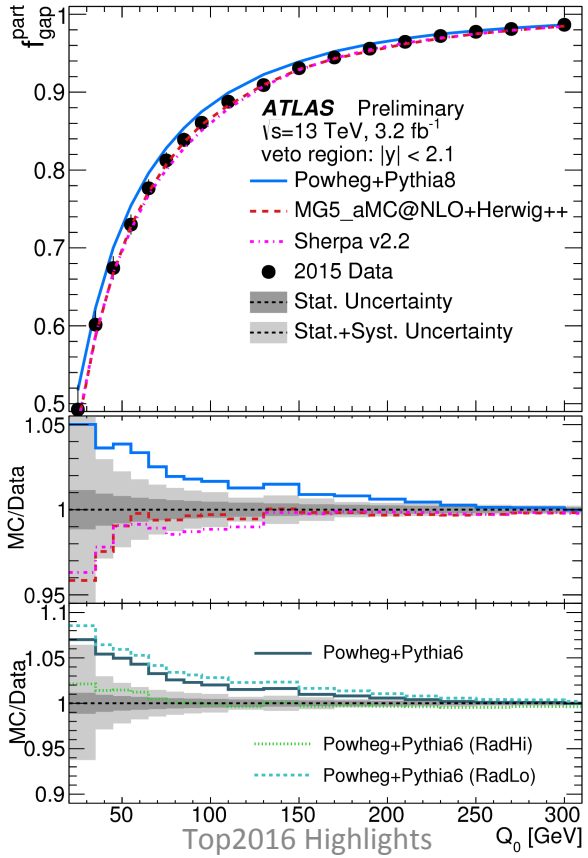


13 TeV Differential Cross-Section: Dilepton $e\mu$+2 b-tagged Jets

ATLAS:

- Extension: Measure as fraction of events without additional jet activity
- For a variety of rapidity regions and invariant mass of the *eubb* system





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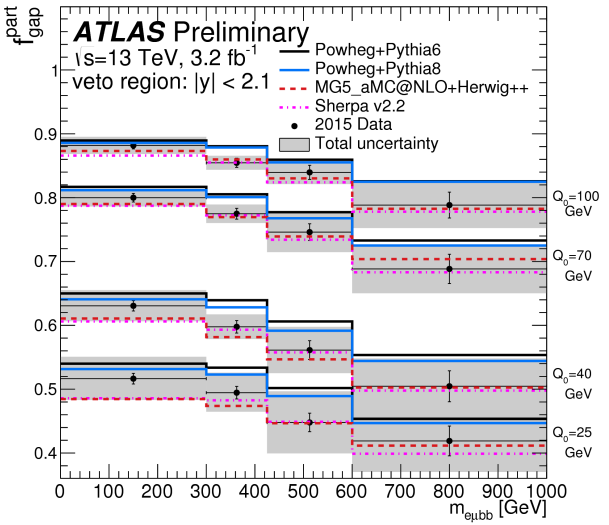
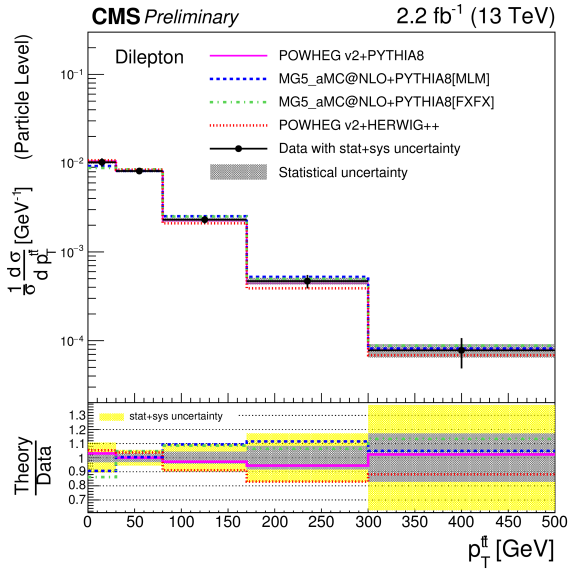


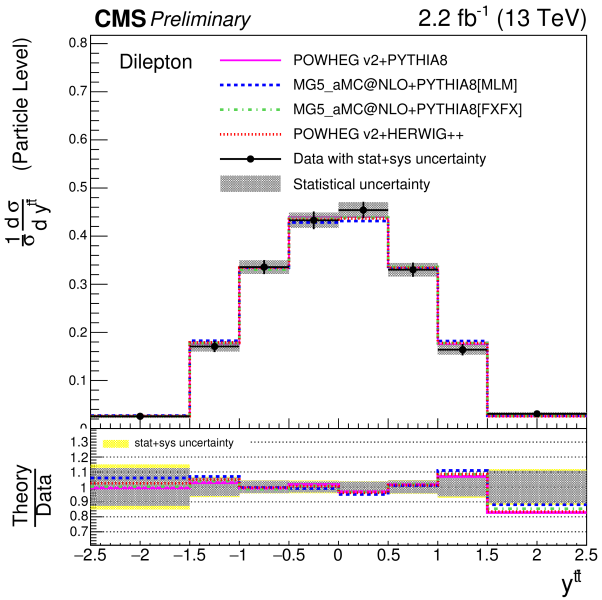
13 TeV Differential Cross-Section: Opposite-sign Dilepton + 2 Jets

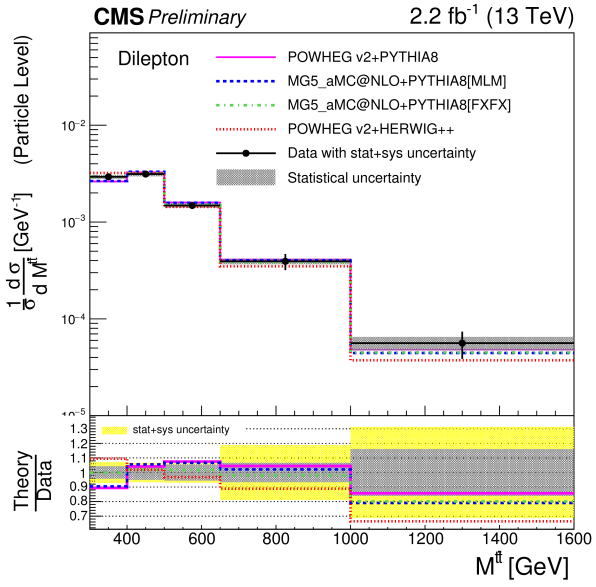
CMS:

- Select two leptons of opposite sign, at least two jets, missing p_T
- Unfold to particle, parton level
- Plot as range of variables

TOP-16-007





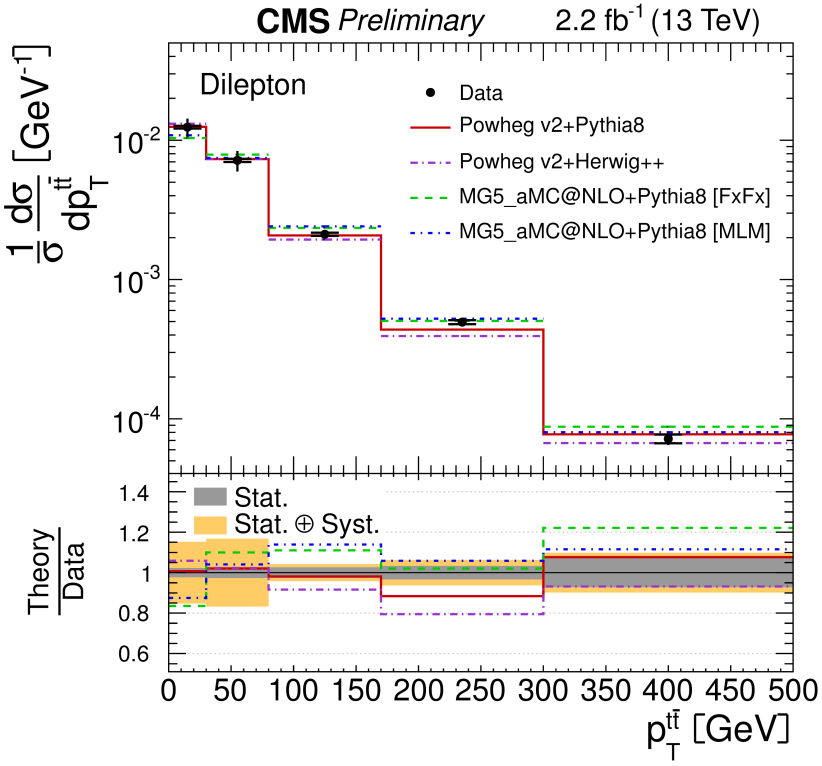


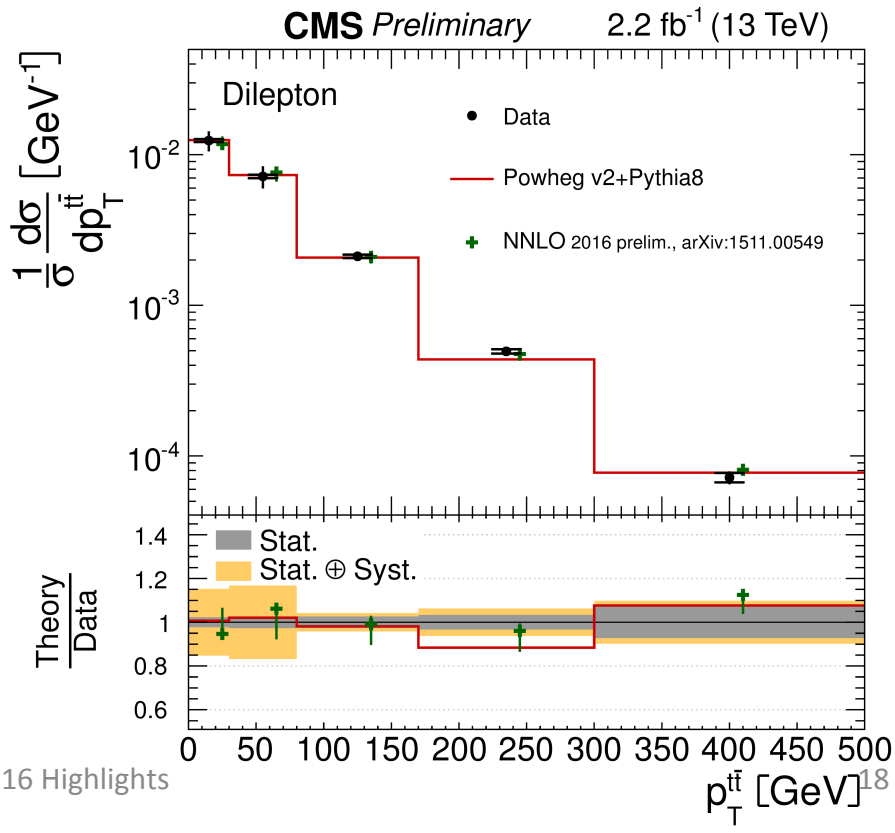
13 TeV Differential Cross-Section: Opposite-sign Dilepton + 2 Jets

CMS:

- Select two leptons of opposite sign, at least two jets, missing p_T
- Unfold to particle, parton level
- Plot as range of variables

TOP-16-011





Single Top Measurements

Single Top Measurements

- Production Mechanisms:

  t-channel: CMS+ATLAS Inclusive 13 TeV cross-section,
  CMS Differential 13 TeV cross-section
  CMS Fiducial 8 TeV cross-section
  ATLAS Differential 8 TeV cross-section

  s-channel: CMS 7-8 TeV Search
  ATLAS 8 TeV cross-section

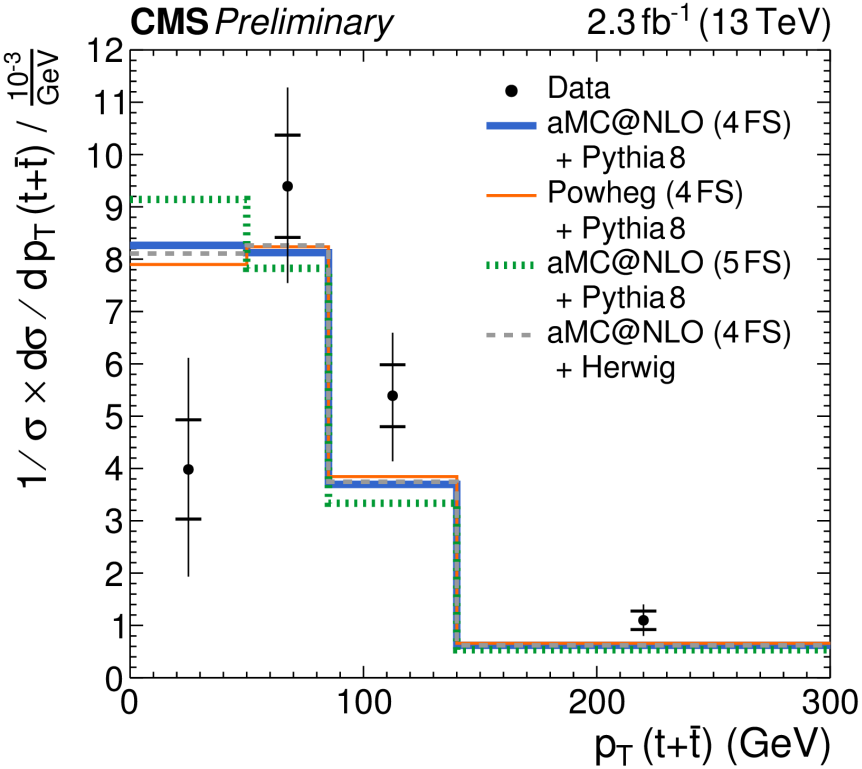
  Wt-channel: ATLAS 13 TeV cross-section
  CMS: Study of Wtb coupling, vtb measurement, polarized sample measuring polarization

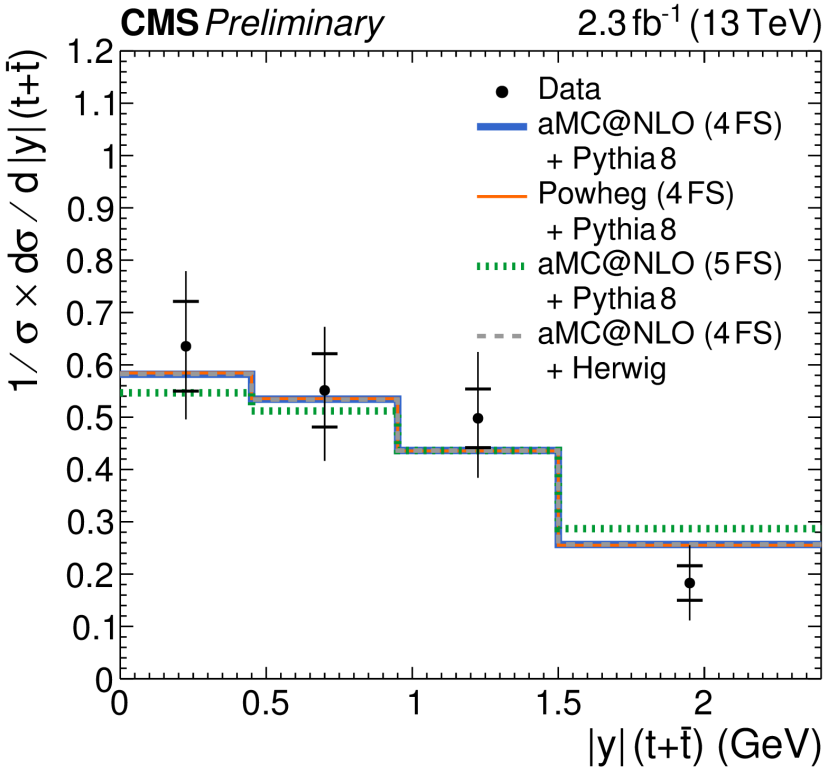
t-channel 13 TeV Differential Cross-Section

CMS:

- Select exactly one μ, one b-jet, one light jet, E_{Tmiss}
- Unfold to parton level
- Plot as function of p_T and |y| of the top quark

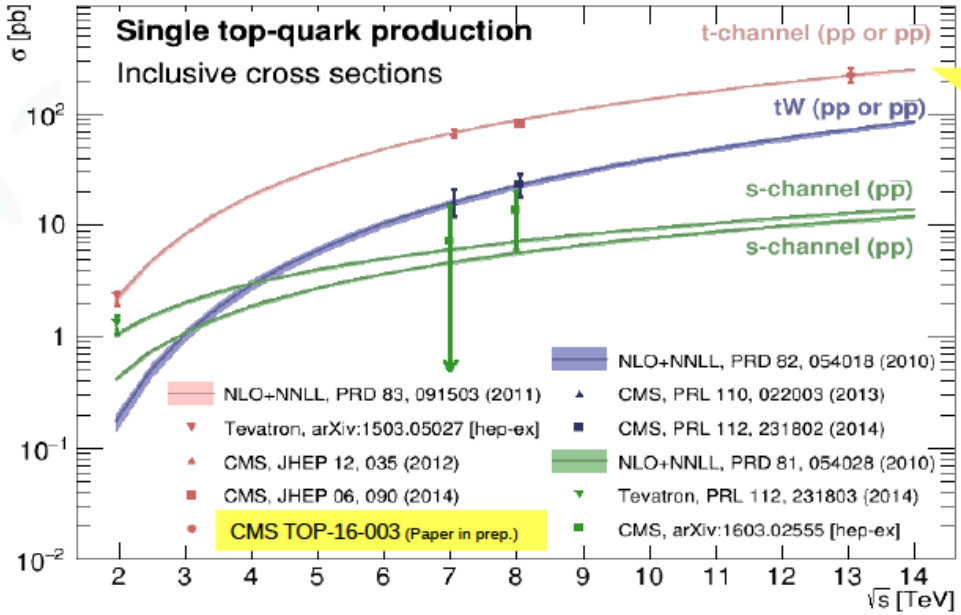
TOP-16-004

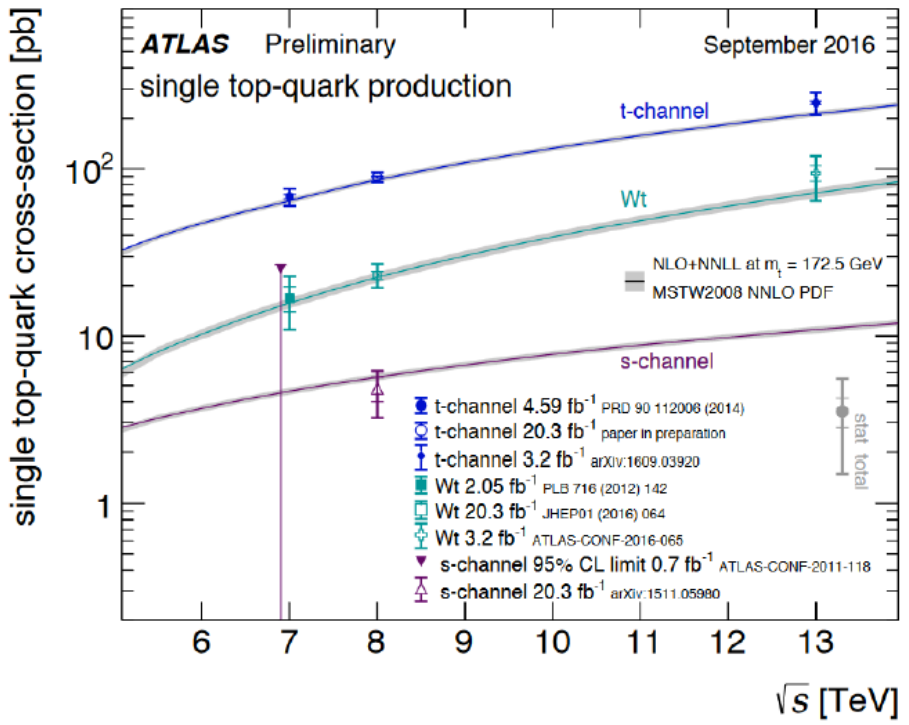




Single Top Measurements

Comprehensive t-channel results at 8 TeV
Results at 13 TeV consistent so far
Main systematic: generator modelling





The Summary

- **Broad** range of strategic measurements at full LHC energy range!!!
- Analyses use variety of unfolding methods and variable distributions for strategic comparisons with theory
- 13 TeV results complement 7 and 8 TeV results
- ATLAS and CMS measurements complementary and consistent
- MC tuning studies ongoing
- Many more results to come using 13 TeV results with 2016 data!

Thank you!