Status of “other” ongoing combinations

Jeremy Andrea, Veronique Boisvert
On behalf of the ATLAS and CMS top working groups

Introduction

- ATLAS-CMS combinations the main purpose of the LHCtopWG :
  - it allows to improve precisions of measurements,
  - but also to better compare results and understand the differences.

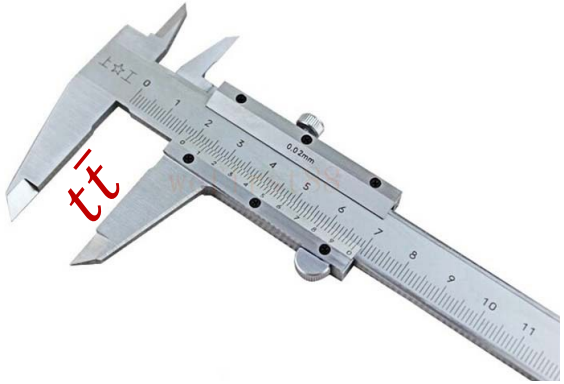
- In the past few years, several combinations performed, using usually the BLUE method with deep understanding of systematics and correlations.

- Ongoing/future combinations are going one step further :
  - Combination of more top-properties measurements, Ac (see link), top mass (see link), V_{tb} from **single top cross section**, **W-helicity**,
  - Associated production, $t\bar{t}b\bar{b}$ (see link);
  - Combination of differential measurements, Ac (see link), $t\bar{t}$ **cross section**,
  - New combination techniques, going beyond BLUE, **inclusive** $t\bar{t}$ **cross section**.

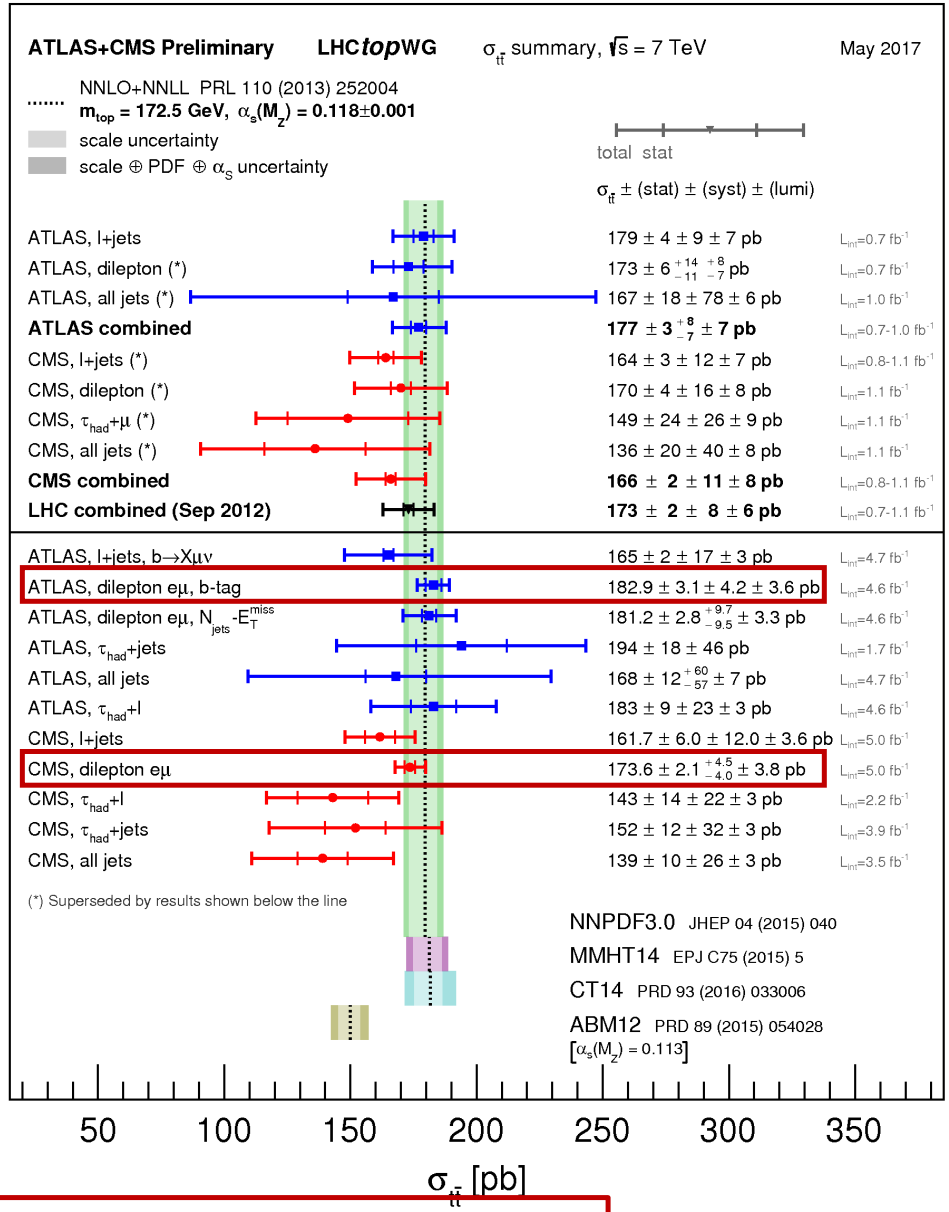
Discussed in this talk

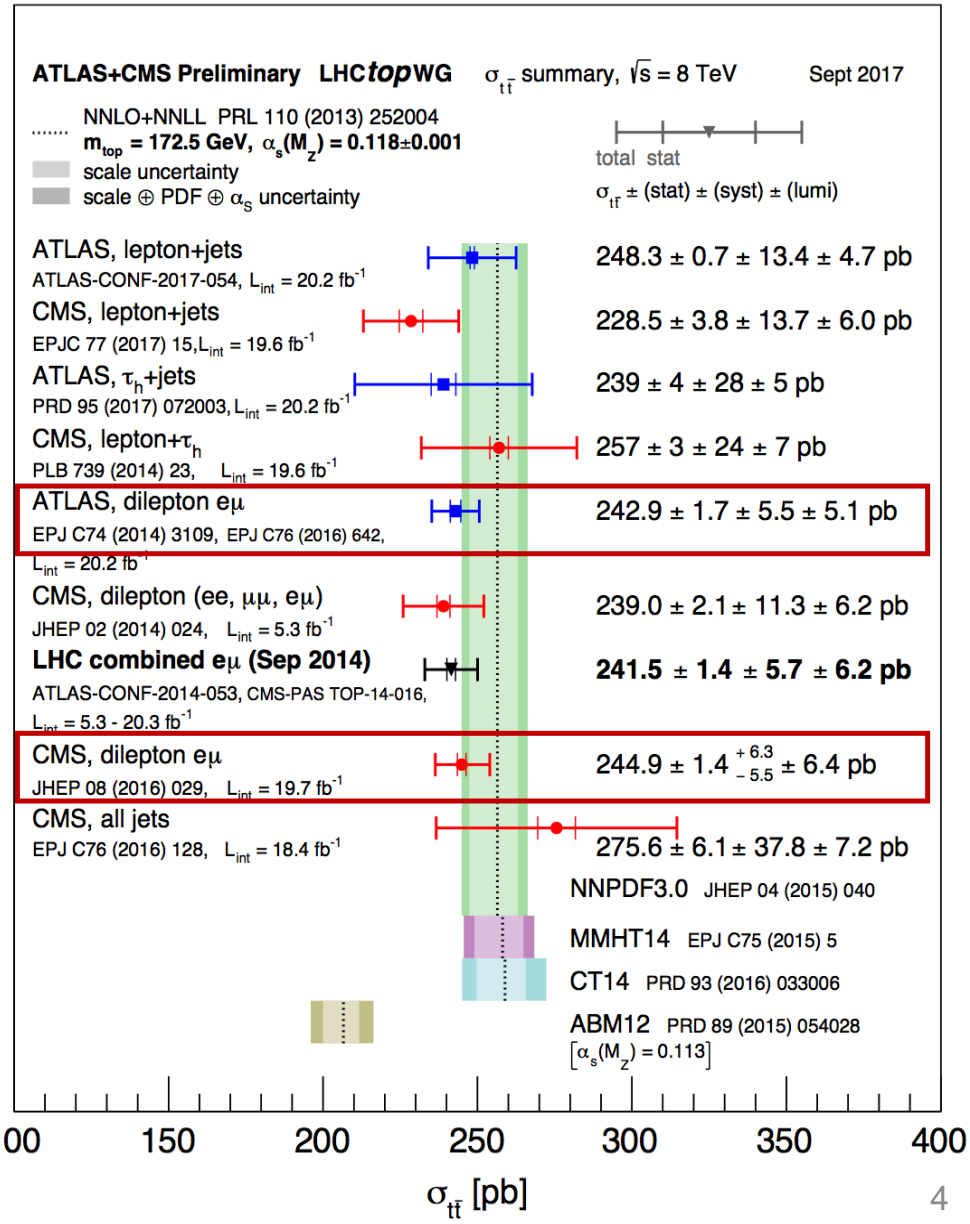
$t\bar{t}$ inclusive cross section (Run I)

Contact persons :
Barbara Alvarez Gonzalez, Veronique Boisvert (ATLAS)
Jan Kiesler (CMS)



Latest results

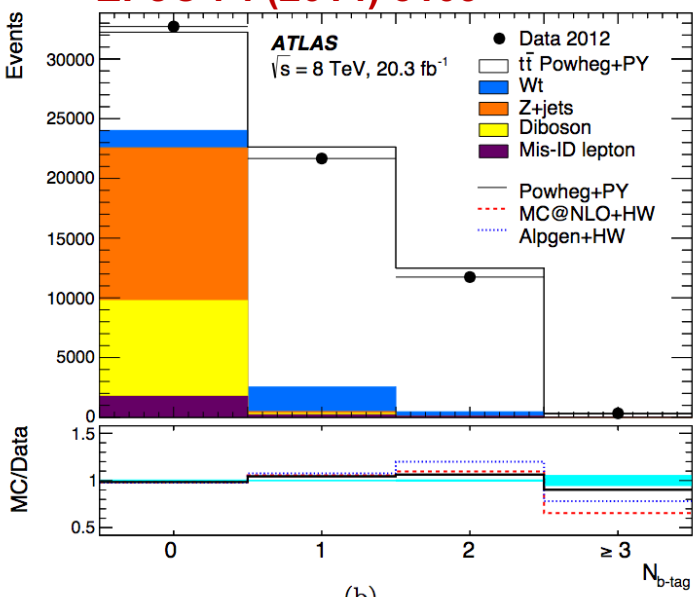




Most precise ATLAS and CMS results

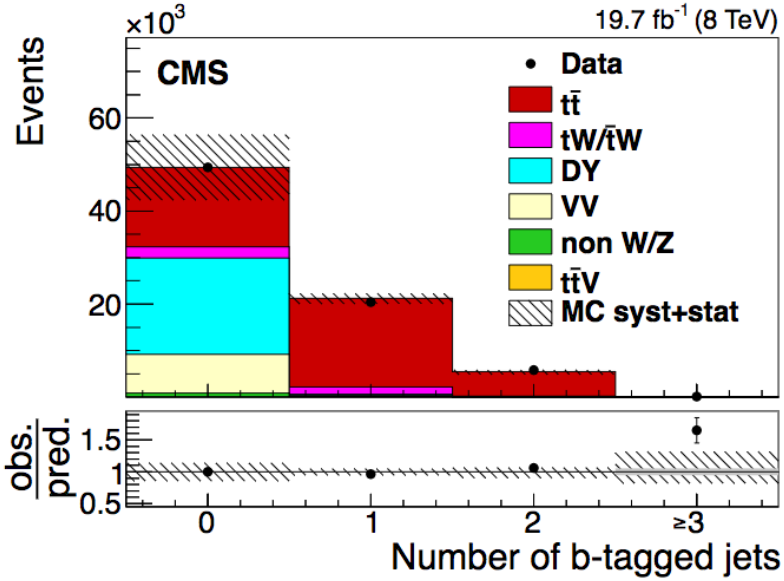
Inputs

EPJC 74 (2014) 3109



- Precision[(b)]
  - 3.2% (8 TeV),
  - 3.5% (7 TeV).
- Dominant uncertainties
  - Luminosity,
  - Statistics (7 TeV),
  - Signal modelling and PDF,
  - tW background.

JHEP 08 (2016) 029



- Precision
  - 3.7% (8 TeV),
  - 3.6% (7 TeV).
- Dominant uncertainties
  - Luminosity,
  - Lepton ID/Iso,
  - Z+jets background,
  - Trigger,
  - Statistics (7 TeV).

Dominant exp. systematics are different between ATLAS and CMS.
A significant gain can be expected.

Combination techniques Out of the BLUE

- Analysis strategies are different :
  - ATLAS : Simultaneous determination of fiducial cross section and b-tagging efficiency,
  - CMS : Multi-differential simultaneous fit of fiducial cross section at 7 and 8 TeV.

- BLUE not well suited for combination of measurements where the sources of systematics are significantly correlated (eg from a likelihood fit with multiple nuisance parameters).

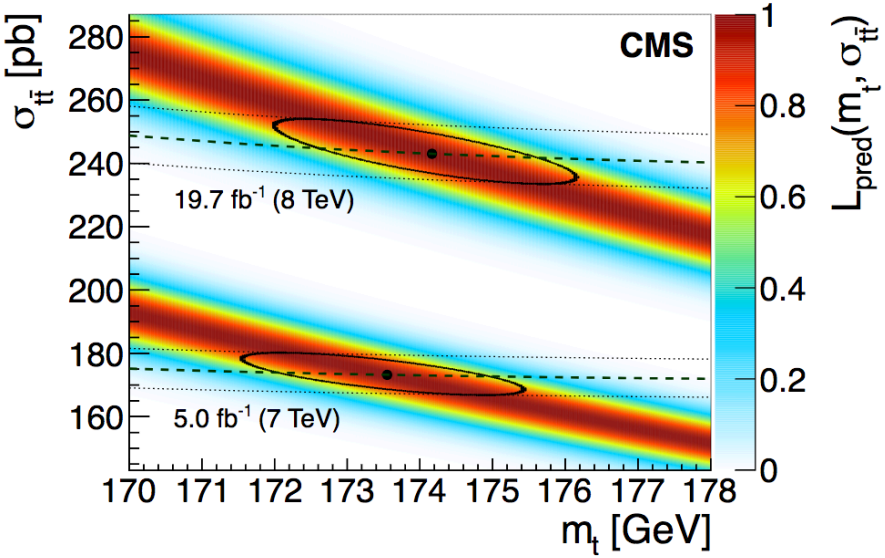
- Move away from the BLUE combination, develop a more elaborated technique.

- New combination technique and tool ("Convino") has been developed (J. Kieseler, arXiv 1706.01681, accepted by JHEP) and is being deployed :
  - Use postfit covariant matrices,
  - Account for correlations of systematics.

- Discussed within statistics committees at both ATLAS and CMS.

Status and Summary

EPJC 74 (2014) 3109



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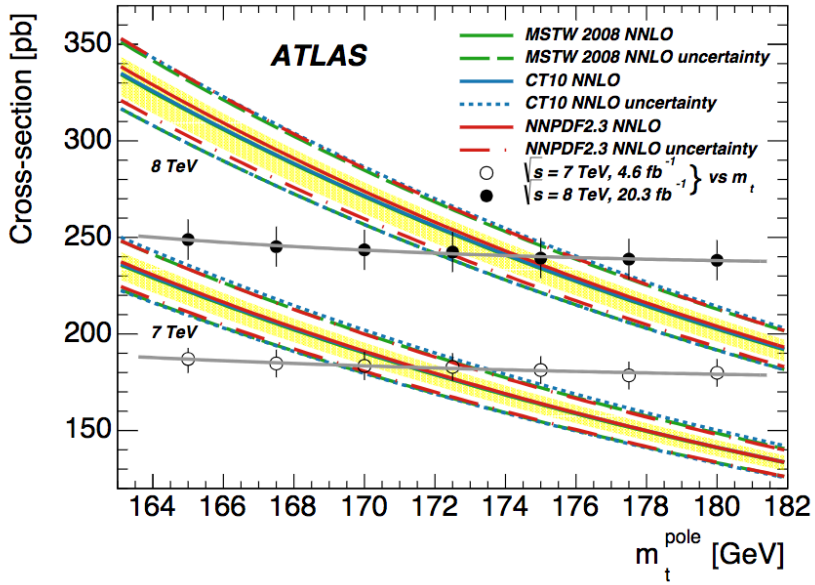


- All ingredients of the combination are there:
  - inputs to the combination prepared (central values, covariance matrices, splitting of uncertainties),
  - combination method ready, accepted by EPJC and citable for the combination paper,
  - Complete results (not approved yet) results look very promising.

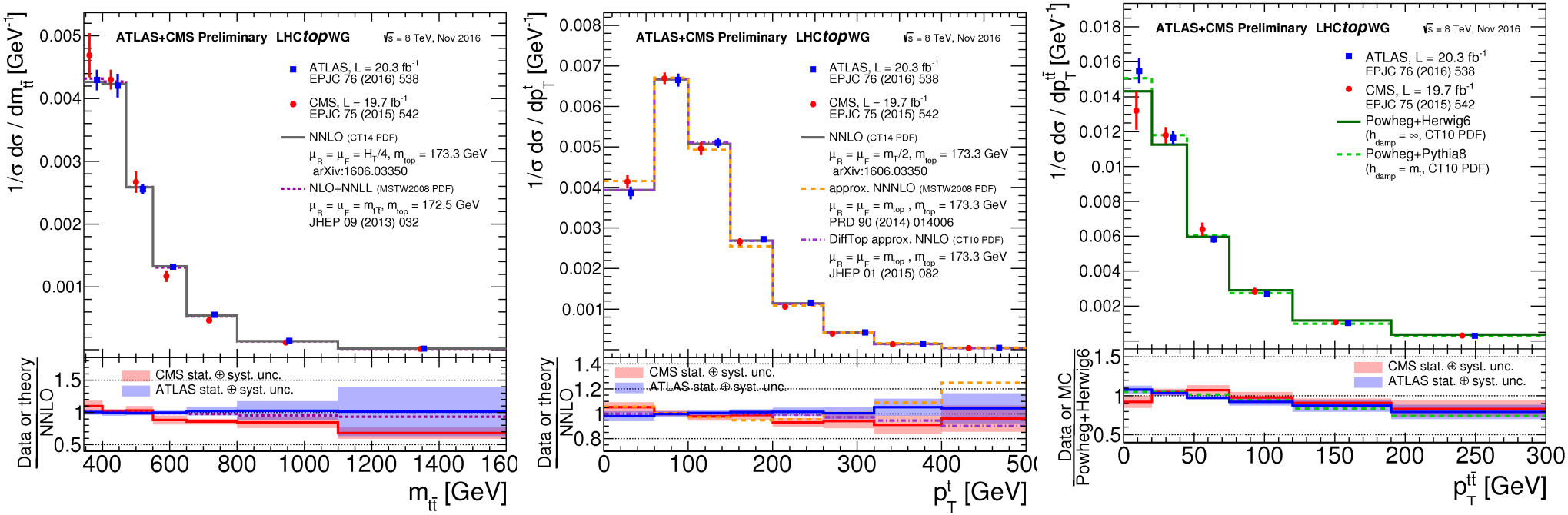
- Also extraction of pole mass and α_s investigated :
  - compare measurements to the theoretical cross sections $\sigma_{t\bar{t}}(m_t)$ or $\sigma_{t\bar{t}}(\alpha_s)$

Differential $t\bar{t}$ cross section (run I and run II)

Contact persons :
Run I : Francesco Spano (ATLAS), Maria Aldaya (CMS)
Run II : James Howarth (ATLAS), Otto Hindrichs (CMS)

Differential cross section run 1

- Differential cross sections in $t\bar{t}$: crucial to better understand the modelling.
- Combination of the most precise measurements in l+jets :
  - Parton level,
  - Uses the same binning,
  - Uses the same phase space definition (fully inclusive phase space).



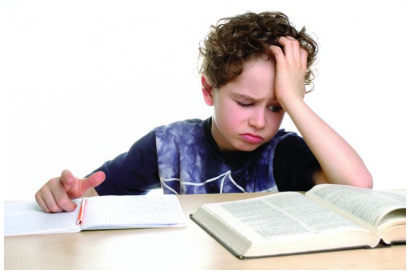
- Combination done with BLUE “a la Ac”. Accounts for bin-by-bin correlations within and across experiments.
- Also testing the use of Convino together with J. Kieseler

Differential cross section run 2

- Challenges for run 2 combinations :
  1. Same definition of parton level (after radiation, before decay), to be checked carefully. Discussed at the last open meeting link,
  2. Also, different binnings are used.

- Possible solutions/investigated approaches :
  1. Compare the two definitions of parton-level using MC, determine a migration matrix,
  2. Agree on a similar binning for next measurements (possible two set of binnings, one following LHCtopWG recommendations). Existing tool for combination with different binning ?

- Other opportunity : particle level combination. Harmonization of particle level definitions required.



Single top cross section and V_{tb} combinations (Run I)

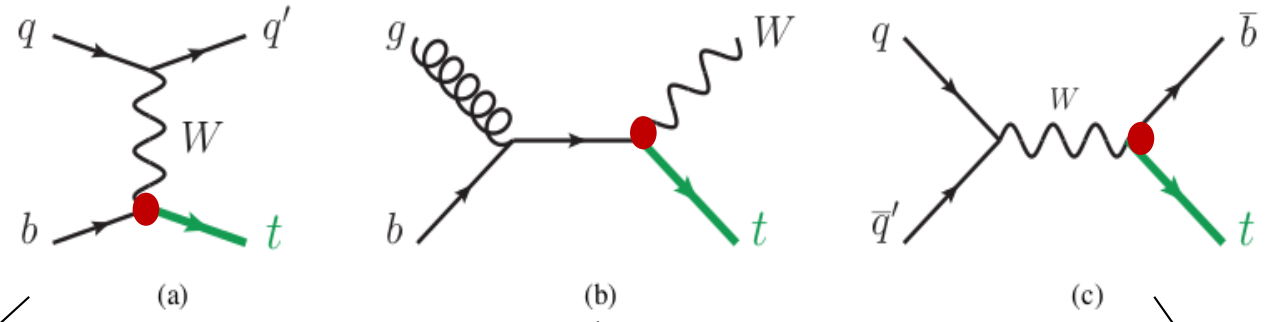
Contact persons :
Carlos Escobar, Reinhard Schwienhorst (ATLAS)
Nadjieh Jafari, Jeremy Andrea(CMS)

Single top cross section and V_{tb} combinations

- An estimator for the size of V_{tb} extracted from single top cross section measurements (assuming $|V_{tb}| >> |V_{ts}|, |V_{td}|$) :

$$|f_{LV}V_{tb}|^2 = \frac{\sigma_{t,exp}}{\sigma_{t,theo}}$$

- The single top cross section, σ_t, determined for different channels:



ATLAS ***t*-channel**

7 TeV: Phys. Rev. D. 90, 112006 (2014),
8 TeV: arXiv:1702.02859, Sub. EPJC.

CMS

7 TeV: JHEP 1212 (2012) 035,
8 TeV: JHEP 1406 (2014) 090.

ATLAS **tW-channel**

7 TeV: Phys.Lett. B716 (2012) 142,
8 TeV: JHEP 1601 (2016) 064.

CMS

7 TeV: Phys. Rev. Lett.110 (2013) 022003,
8 TeV: Phys. Rev. Lett. 112 (2014) 231802.

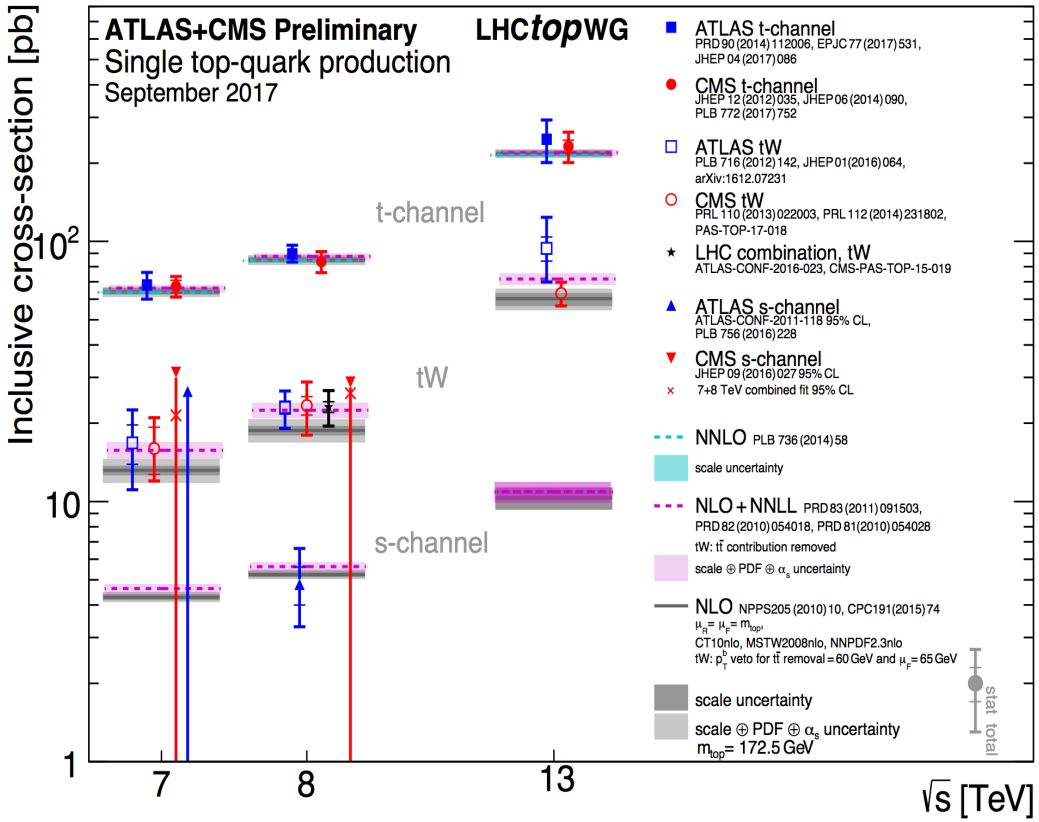
ATLAS ***s*-channel**

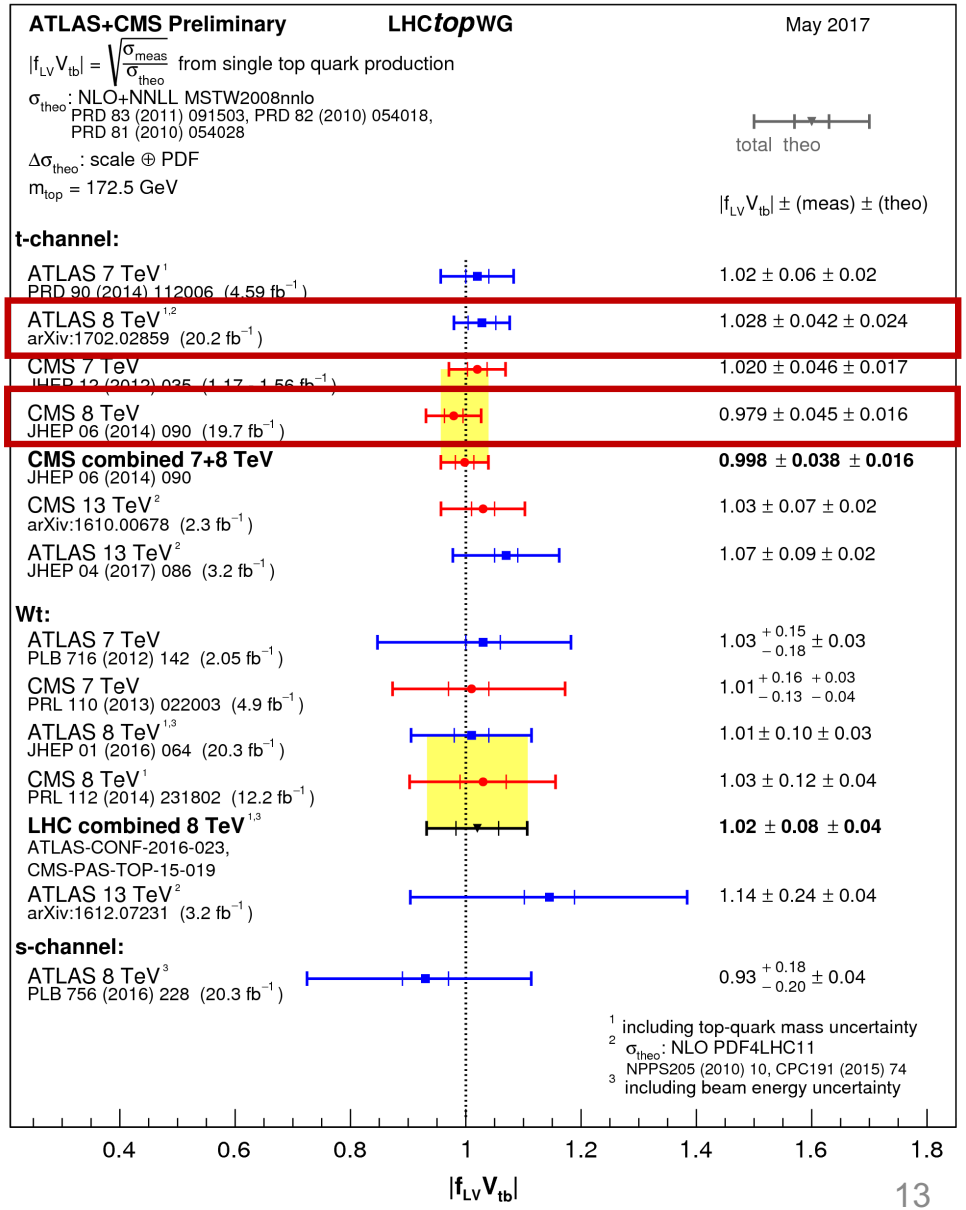
7 TeV: Not published,
8 TeV: JHEP 1601 (2016) 064.

CMS

7 TeV and 8 TeV: JHEP 09 (2016) 027.

Summary plots





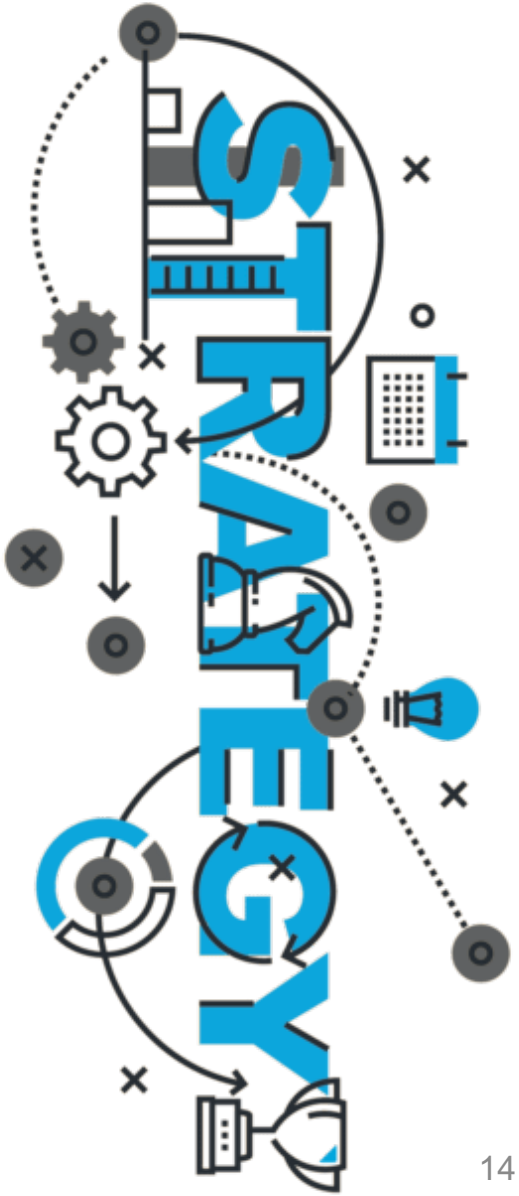
Strategy

- Combination of $|f_{LV}V_{tb}|^2$:
  - rely on the cross sections,
  - does not depends on the production mode nor the beam energy => combine all the channels at all (run I) energies,
  - predicted cross sections for t- and s-channels from HATHOR (NLO) and NLO+NLL (Kidonakis) for tW.

- Combination of cross sections :
  - done per production mode and per beam energies, 3 channels*2 beam energies (7+8TeV) -1 (8 TeV only for s-channel),
  - => 5 different combinations.

- Combination strategy :
  - use a simple and robust method : iterative BLUE method,
  - “usual” studies of correlations.

- Dominant sources of systematics in both experiments :
  - signal modelling, highly correlated among experiments,
  - Jet Energy Scale, not correlated.



Status of the paper

- Analysis pasted through almost all reviews steps of both collaborations.
  - ATL-COM-PHYS-2017-1039,
  - CMS-TOP-17-006.

- Authors are working on implementing the remaining (editorial) corrections to the paper draft, performing the remaining checks.

- Main open question : feasibility of combination of R_t (ratio of top and anti-top cross sections).
  - Gathering the needed inputs.
  - Understand (anti) correlations of systematic in the ratio.

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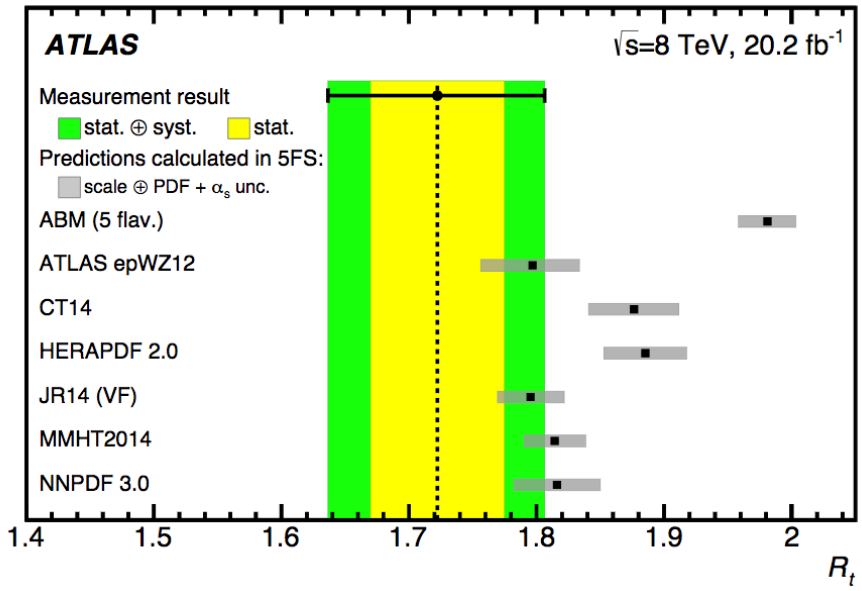


W helicity (Run I)

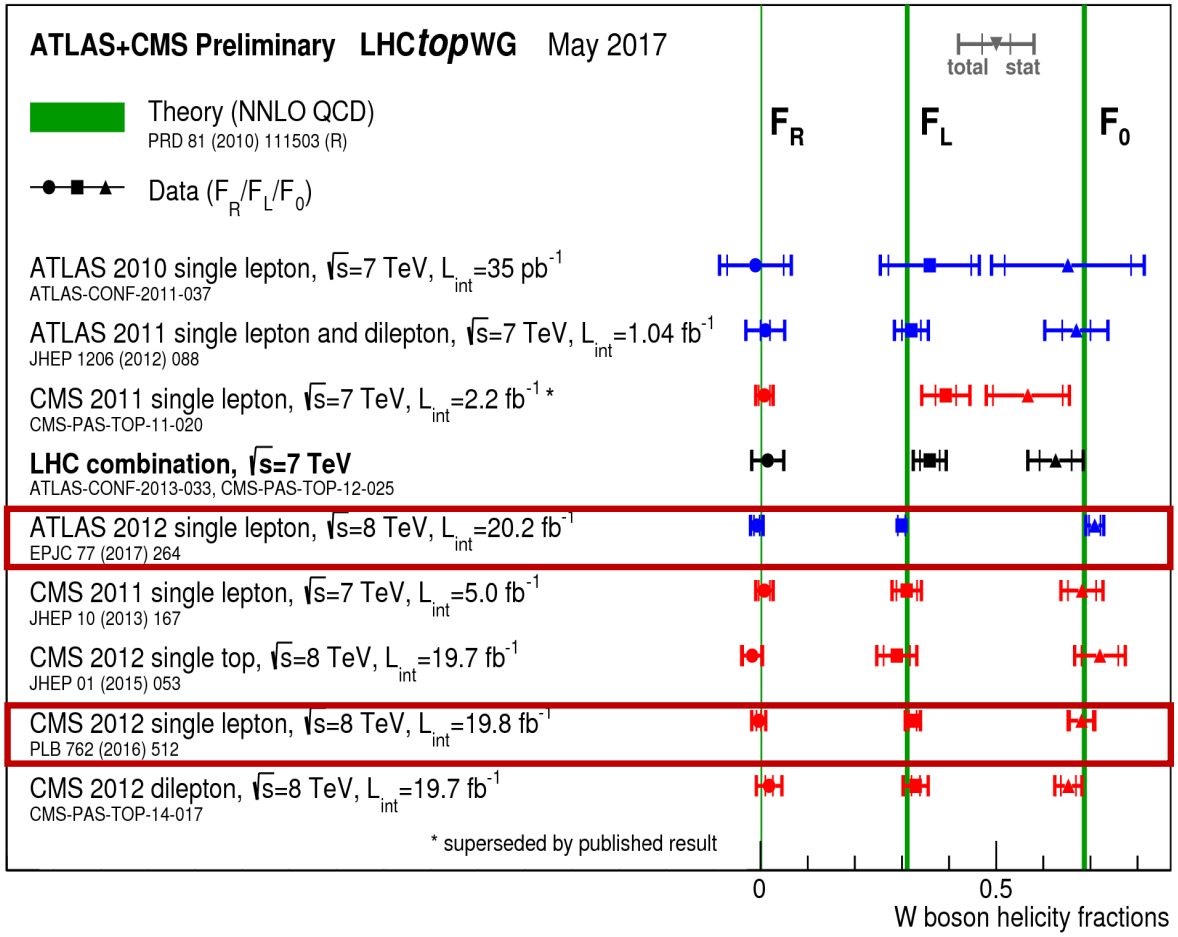
Contact persons :
Mohammad Kareem (ATLAS)
Mara Senghi (CMS)

W-helicity (run I)

- First plan for combing W-helicity fraction measurements.

- Baseline plan (under discussion)
  - combine the most precise measurements at 8 TeV,
  - use a BLUE method.

- Open questions :
  - should we include dilepton channels ? Single top ?
  - Should we include 7 and 8 TeV ?
  - Combination of e+jets and mu+jets (CMS) with l+jets (ATLAS) ?
  - BSM interpretation : still anomalous couplings or move to EFT ?



Conclusion

- Combination is the key for :
  - accessing higher precision,
  - better understand and compare ATLAS and CMS results.

- The LHCtopWG continues to be very active, with a large and ambitious program of combinations.

- What's next at 13 TeV ? Open for discussion.
  - $t\bar{t}$ inclusive and differential cross section, spin correlations ?
  - Single top t-channel, tW-channel ?
  - EFT ?

Thanks to the contacts and conveners for their help in preparing these slides