Combinations of top quark measurements at the LHC

(excluding mass)

Mara Senghi Soares

CIEMAT - Madrid

On behalf of the ATLAS and CMS Collaborations

TOP2015: 8th International Workshop on Top Quark Physics
14-18 Sep 2015, Ischia (Italy)

Introduction

Outline:

Introduction

presenting ATLAS+CMS combinations on

Top production

- **$t\bar{t}$, single top**

Top properties

- **charge asymmetry, W helicity**

Other LHCTOPWG activities

Outlook

Introduction

- **Main motivations for LHCTOPWG combinations:**
  - **gain in precision**
    - **combine statistically uncorrelated data samples**
    - **profit from complementarity on systematic effects in different measurements/experiments**
  - **improved coordination between experiments**
  - **improved coordination with theorists on modeling uncertainties**

Introduction

- **Main motivations for LHCTOPWG combinations:**
  - **gain in precision**
    - **combine statistically uncorrelated data samples**
    - **profit from complementarity on systematic effects in different measurements/experiments**
  - **improved coordination between experiments**
  - **improved coordination with theorists on modeling uncertainties**

- **Technical aspects:**
  - Combining measurements is all about correlations
  - Identify uncertainties of similar source and their correlations
    - for different data taking periods
    - across decay channels
    - across experiments…

- Much of the work used for results in this talk was developed in the context of top quark mass combinations
  - See *talk from Andreas Maier (Session 10)*

Introduction

- **Method: BLUE (Best Linear Unbiased Estimator)** Simple and robust!
  - **weighted sum of input measurements** taking into account uncertainties and their correlations **minimizing combined uncertainties**
- **Try to disentangle as much as possible correlations ϱ**

Introduction

- **Method: BLUE (Best Linear Unbiased Estimator)** Simple and robust!
  - **weighted sum of input measurements** taking into account uncertainties and their correlations **minimizing combined uncertainties**
- **Try to disentangle as much as possible correlations ϱ**
- **Typical uncertainties and ϱ's across experiments (examples):**

ρ=0

- Statistical
- Detector response:
  - *trigger, objects ID, lepton scale, resolutions,*
- Pile-up
- Data-driven backgrounds

ρ=1

- Theory-dependent uncertainties
  - *PDF, cross-sections for normalizations, all unc estimated in the same way using MC...*
- Backgrounds from MC
- LHC: beam energy

ρ=[0,1]

- b-tagging: *method, detector response, flavour dependency in MC*
- Luminosity: *experiment measurement, LHC calibration*
- JES: *detector response, parton-to-jet models, calibrations, flavour....long list of components with various ϱ*

Introduction

- **Method: BLUE (Best Linear Unbiased Estimator)** Simple and robust!
  - **weighted sum of input measurements** taking into account uncertainties and their correlations **minimizing combined uncertainties**
- **Try to disentangle as much as possible correlations ϱ**
- **Typical uncertainties and ϱ's across experiments (examples):**

ρ=0

- Statistical
- Detector response:
  - *trigger, objects ID, lepton scale, resolutions,*
- Pile-up
- Data-driven backgrounds

ρ=1

- Theory-dependent uncertainties
  - *PDF, cross-sections for normalizations, all unc estimated in the same way using MC...*
- Backgrounds from MC
- LHC: beam energy

ρ=[0,1]

- b-tagging: *method, detector response, flavour dependency in MC*
- Luminosity: *experiment measurement, LHC calibration*
- JES: *detector response, parton-to-jet models, calibrations, flavour....long list of components with various ϱ*

- **Input correlations: not always "black-and-white":**
  - **some partial correlations hard to estimate, knowledge already increased with experience**
  - **hypotheses tests: check stability re-running combinations varying ϱ over a large range**

Top quark production: $t\bar{t}$

Top quark pair cross sections [8TeV]

Input measurements:

CMS TOP-14-016
ATLAS-CONF-2014-054

ATLAS (20.3 fb-1) eμ channel

Simultaneous fit for cross-section and ε_b (*probability for a jet from a top decay to be in the acceptance and b-tagged*)

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

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

- **σ(tt) = 237.7 ±1.7(stat) ±7.4 (sys) ±7.4 (lumi)**

CMS (5.3 fb-1) originally: ee, eμ, μμ channels; only eμ used

Simple cut-and-count analysis

different systematics

- **σ(tt) = 239.0 ±2.1(stat) ±11.3 (sys) ±6.2 (lumi)**

Top quark pair cross sections [8TeV]

- **Uncertainty on combination 10% lower than more precise input measurement**
- Obvious **gain** on statistics

	ATLAS	CMS	Correlation	LHC combination
Cross section [pb]	242.4	239.0		241.5
Uncertainty [pb]				
Statistical	1.7	2.6	0	1.4
Detector model				
Trigger	0.4	3.6	0	1.0
Lepton scale and resolution	1.2	0.2	0	0.9
Lepton identification	1.7	4.0	0	1.6
Jet resolution	1.2	3.0	0	1.2
Jet identification	0.1	–	–	0.1
b-tagging	1.0	1.7	0	0.8
Pileup	–	2.0	–	0.5
Non-JES subtotal	2.6	6.7	0	2.6
UncorrJES	0.6	4.3	0	1.2
InsituJES	0.6	0.6	0	0.5
IntercalibJES	0.3	0.1	0.5	0.2
FlavourJES	0.9	2.9	1	1.4
bJES	0.1	–	–	0.1
JES subtotal	1.3	5.2	0.4	1.9
Class subtotal	2.9	8.5		3.2
Signal model				
Scale	0.7	5.6	0.5	1.9
Radiation	–	3.8	–	1.0
Generator and parton shower	3.0	3.3	0.5	2.7
PDF	2.7	0.5	1	2.1
Class subtotal	4.1	7.5	0.3	4.0
Background from data				
Z+jets	<0.1	1.5	0	0.4
Lepton misidentification	0.8	1.9	0	0.8
Class subtotal	0.8	2.4	0	0.9
Background from simulation				
Dibosons	0.3	0.5	1	0.4
Single top quark	2.0	2.3	1	2.1
Class subtotal	2.0	2.4	1	2.1
Luminosity				
Beam modelling	2.9	5.0	1	3.5
Luminosity determination	6.9	3.6	0	5.1
Class subtotal	7.5	6.2	0.3	6.2
Total systematic	9.3	13.4		8.4
Total	9.4	13.6		8.5

Top quark pair cross sections [8TeV]

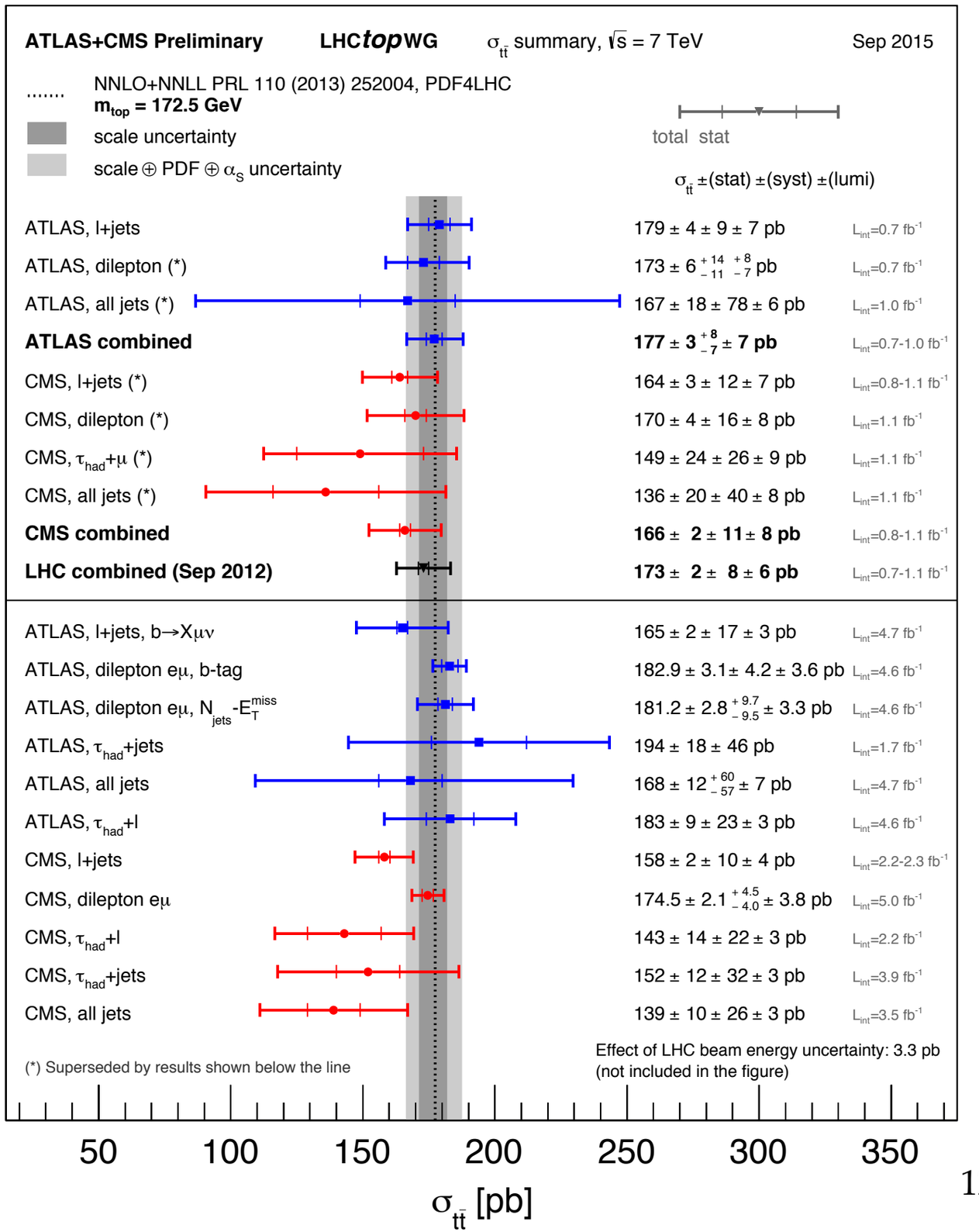
- **Uncertainty on combination 10% lower than more precise input measurement**
- Obvious **gain** on statistics

Combination:
- $\sigma = 241.5 \pm 1.4 \pm 8.4$ pb

χ^2 probability of combination =82%
ATLAS weight: 73% CMS weight:27%

	ATLAS	CMS	Correlation	LHC combination
Cross section [pb]	242.4	239.0		241.5
Uncertainty [pb]				
Statistical	1.7	2.6	0	1.4
Detector model				
Trigger	0.4	3.6	0	1.0
Lepton scale and resolution	1.2	0.2	0	0.9
Lepton identification	1.7	4.0	0	1.6
Jet resolution	1.2	3.0	0	1.2
Jet identification	0.1	–	–	0.1
b-tagging	1.0	1.7	0	0.8
Pileup	–	2.0	–	0.5
Non-JES subtotal	2.6	6.7	0	2.6
UncorrJES	0.6	4.3	0	1.2
InsituJES	0.6	0.6	0	0.5
IntercalibJES	0.3	0.1	0.5	0.2
FlavourJES	0.9	2.9	1	1.4
bJES	0.1	–	–	0.1
JES subtotal	1.3	5.2	0.4	1.9
Class subtotal	2.9	8.5		3.2
Signal model				
Scale	0.7	5.6	0.5	1.9
Radiation	–	3.8	–	1.0
Generator and parton shower	3.0	3.3	0.5	2.7
PDF	2.7	0.5	1	2.1
Class subtotal	4.1	7.5	0.3	4.0
Background from data				
Z+jets	<0.1	1.5	0	0.4
Lepton misidentification	0.8	1.9	0	0.8
Class subtotal	0.8	2.4	0	0.9
Background from simulation				
Dibosons	0.3	0.5	1	0.4
Single top quark	2.0	2.3	1	2.1
Class subtotal	2.0	2.4	1	2.1
Luminosity				
Beam modelling	2.9	5.0	1	3.5
Luminosity determination	6.9	3.6	0	5.1
Class subtotal	7.5	6.2	0.3	6.2
Total systematic	9.3	13.4		8.4
Total	9.4	13.6		8.5

Top quark pair cross sections [7 TeV]

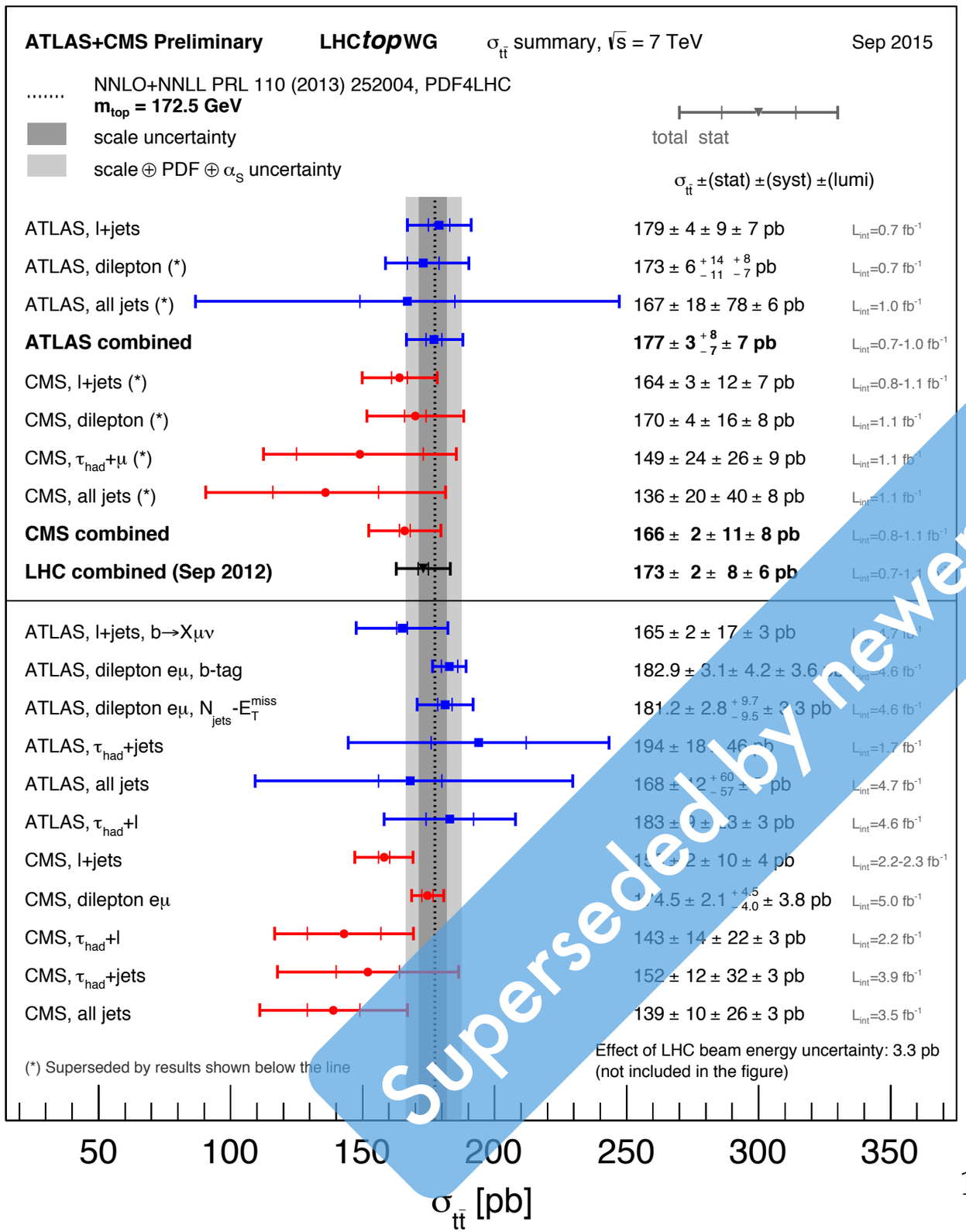


CMS TOP-12-003
ATLAS-CONF-2012-134

7 TeV input measurements:

- ATLAS (0.7-1.02 fb^{-1}):
  - dilepton (ee,eμ,μμ), single lepton+jets and all jets final states
- CMS (1.09-1.14 fb^{-1}):
  - dilepton (ee,eμ,μμ), μ$\tau_{hadronic}$, single lepton+jets and all jets final states
- Measurements pre-combined per experiment
  - σ = 173 ±2 ±8 ±6 pb

Top quark pair cross sections [7 TeV]

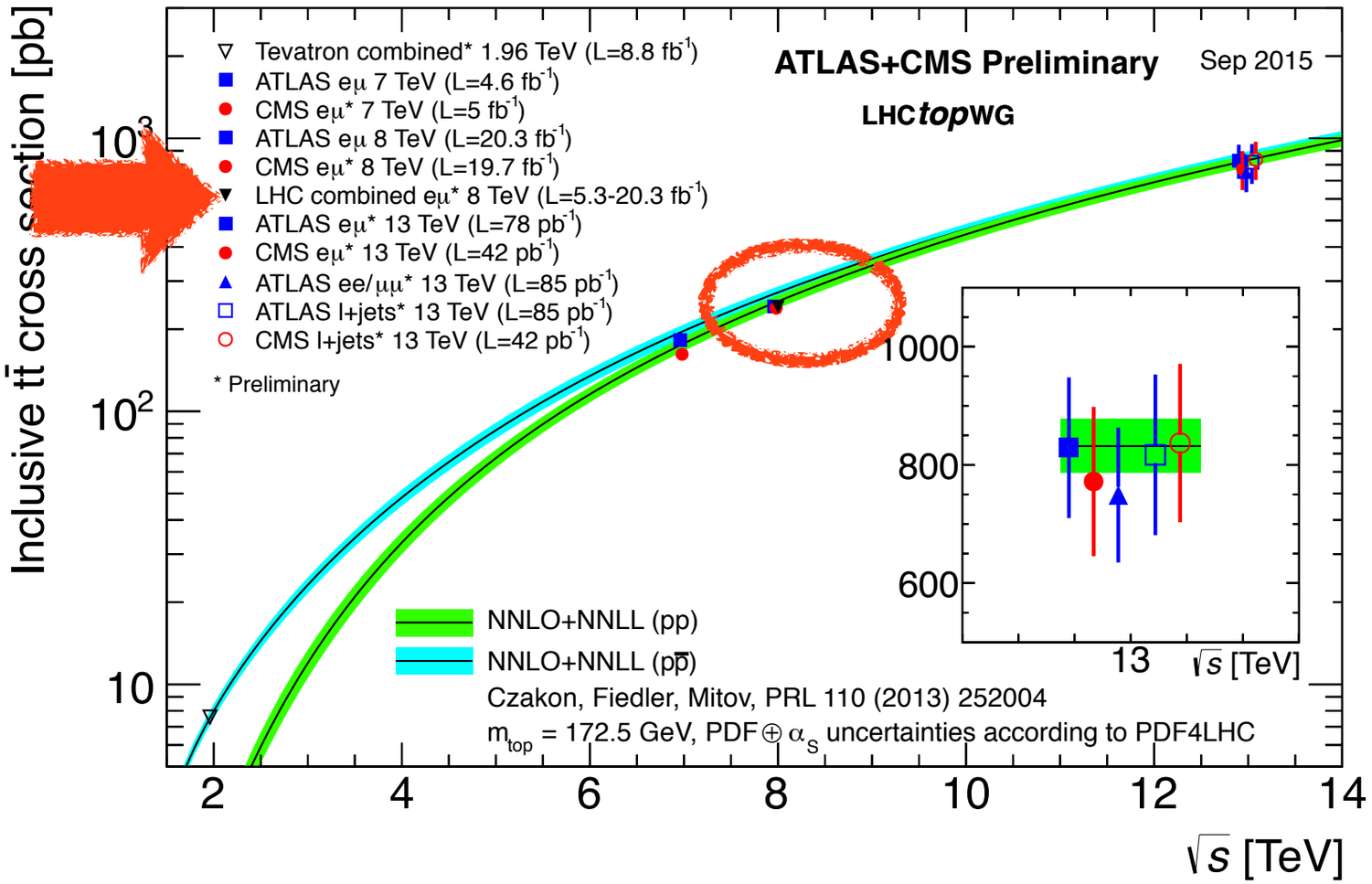


CMS TOP-12-003
ATLAS-CONF-2012-134

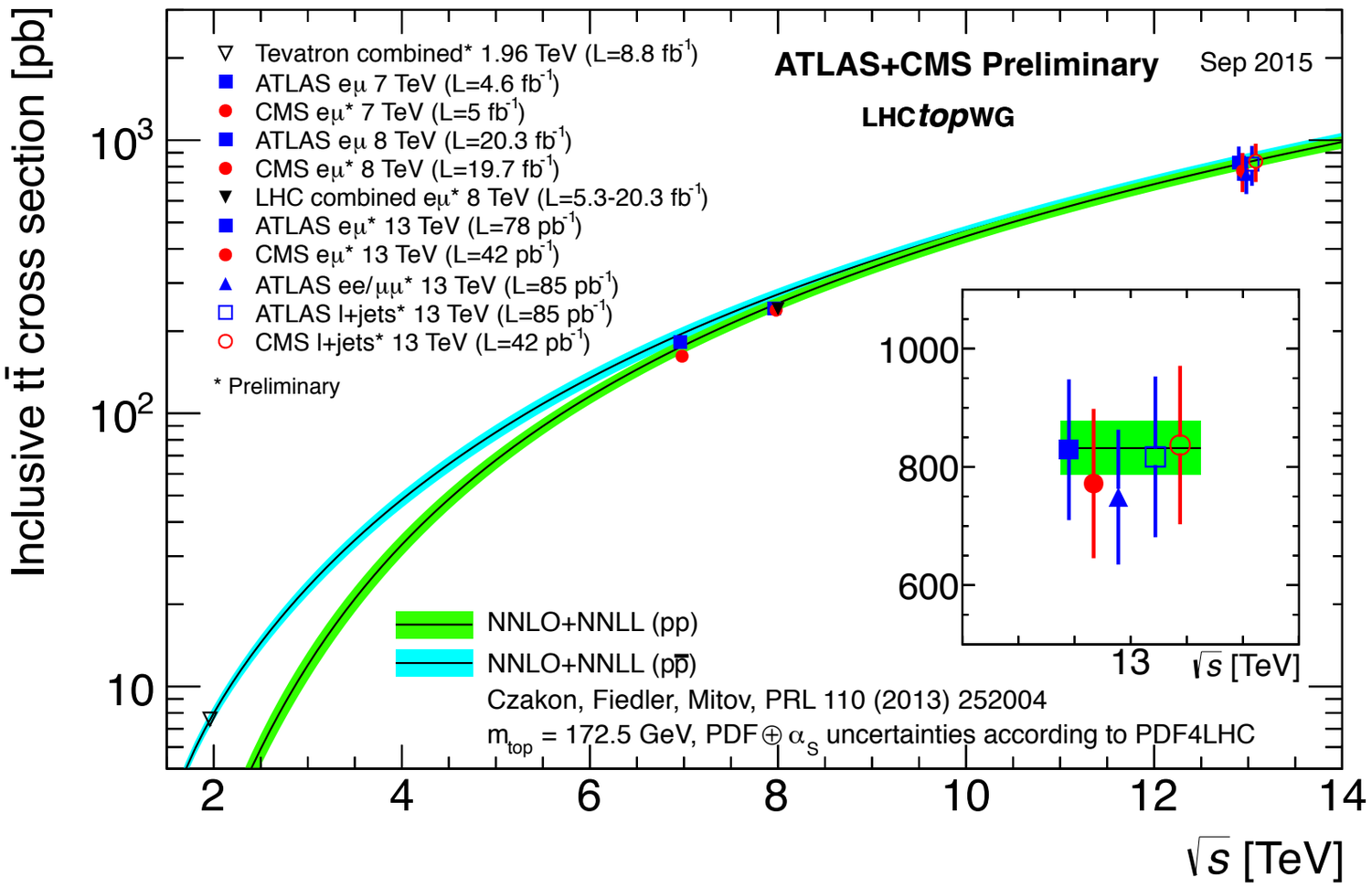
7 TeV input measurements:

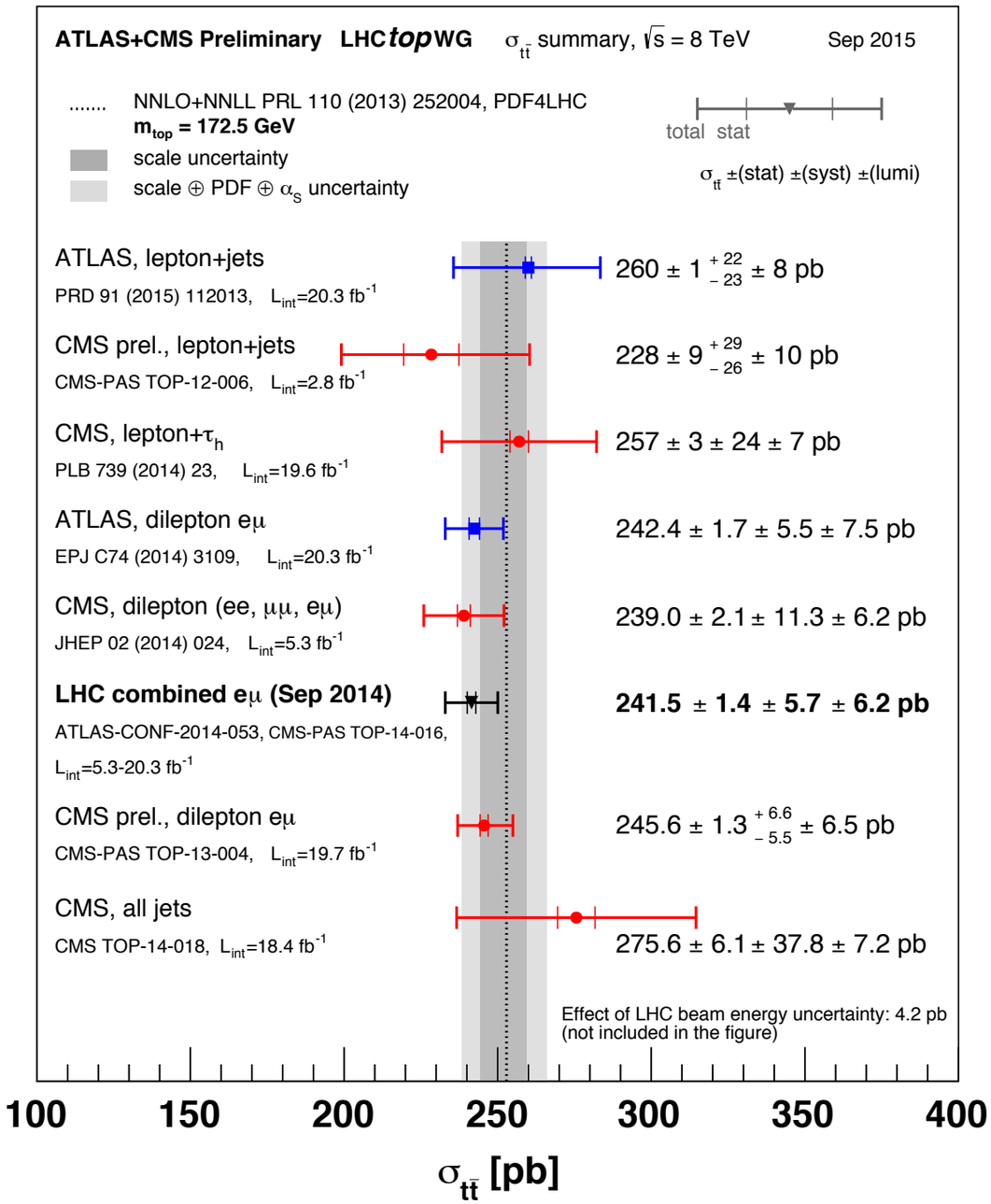
- ATLAS (0.7-1.02 fb^{-1}):
  - dilepton (ee,eμ,μμ), single lepton+jets and all jets final states
- CMS (1.09-1.14 fb^{-1}):
  - dilepton (ee,eμ,μμ), μ$\tau_{hadronic}$, single lepton+jets and all jets final states
- Measurements pre-combined per experiment
  - σ = 173 ±2 ±8 ±6 pb

Top quark pair summary



Top quark pair summary





- Most precise single measurements (8 TeV)
  - 242.4 ±9.5 pb
  - 245.6 ±9.3 pb [CMS update, not used]

3.9%

- Combination:
  - 241.5 ±8.5 pb

3.5%

Top quark production:
single top quark

tW production cross section

CMS TOP-14-009
ATLAS-CONF-2014-052

Input measurements:

- ATLAS (20.3 fb^{-1}):
  - eμ final state
  - 27.2±5.8 pb
- CMS (12.2 fb^{-1}):
  - ee,eμ,μμ final states
  - 23.4±5.4 pb
- Similar analysis strategies: BDT to separate signal and background

tW production cross section

CMS TOP-14-009
ATLAS-CONF-2014-052

Category	ATLAS		CMS		ρ
Data statistics	Data statistics	7.1%	Fit statistics	8.1%	0.0
Category subtotal		**7.1%**		**8.1%**	**0.0**
Simulation statistics	Sim. statistics	2.8%	Sim. statistics	2.4%	0.0
Category subtotal		**2.8%**		**2.4%**	**0.0**
Luminosity		3.7%		3.0%	—
Category subtotal		**3.7%**		**3.0%**	**0.31**
Theory modeling	ISR/FSR	5.9%	Ren./fact. scale	12.4%	1.0
	tW gen. and PS	11.0%			—
	$t\bar{t}$ gen. and PS	7.5%	ME/PS match. thr.	14.1%	1.0
	PDF	2.5%	PDF	1.7%	1.0
	$tW/t\bar{t}$ overlap	1.4%	DR/DS scheme	2.1%	1.0
			Top p_T reweight.	0.4%	—
Category subtotal		**14.8%**		**19.0%**	**0.66**
Background normalization	bkg. mod.	3.6%	$t\bar{t}$ cross section	1.7%	0.0
			Z+jets	2.6%	—
Category subtotal		**3.6%**		**3.1%**	**0.0**
Jets	JES common	10.0%	JES	3.8%	0.0
	JES flavour	5.0%			—
	Jet id	0.2%			—
	Jet res.	0.7%	Jet resolution	0.9%	0.0
Category subtotal		**11.2%**		**3.9%**	**0.0**
Detector modeling	Lepton modeling	2.4%	Lepton modeling	1.8%	0.0
	MET scale	4.1%	MET modeling	0.4%	0.0
	MET resolution	4.5%			—
	b-tagging	8.4%	b tagging	0.9%	0.5
			Pileup	0.4%	—
Category subtotal		**10.6%**		**2.0%**	**0.17**
Total		**23.3%**		**21.7%**	**0.38**

tW production cross section

CMS TOP-14-009
ATLAS-CONF-2014-052

Category	ATLAS		CMS		ρ
Data statistics	Data statistics	7.1%	Fit statistics	8.1%	0.0
Category subtotal		**7.1%**		**8.1%**	**0.0**
Simulation statistics	Sim. statistics	2.8%	Sim. statistics	2.4%	0.0
Category subtotal		**2.8%**		**2.4%**	**0.0**
Luminosity		3.7%		3.0%	—
Category subtotal		**3.7%**		**3.0%**	**0.31**
Theory modeling	ISR/FSR	5.9%	Ren./fact. scale	12.4%	1.0
	tW gen. and PS	11.0%			—
	$t\bar{t}$ gen. and PS	7.5%	ME/PS match. thr.	14.1%	1.0
	PDF	2.5%	PDF	1.7%	1.0
	$tW/t\bar{t}$ overlap	1.4%	DR/DS scheme	2.1%	1.0
			Top p_T reweight.	0.4%	—
Category subtotal		**14.8%**		**19.0%**	**0.66**
Background normalization	bkg. mod.	3.6%	$t\bar{t}$ cross section	1.7%	0.0
			Z+jets	2.6%	—
Category subtotal		**3.6%**		**3.1%**	**0.0**
Jets	JES common	10.0%	JES	3.8%	0.0
	JES flavour	5.0%			—
	Jet id	0.2%			—
	Jet res.	0.7%	Jet resolution	0.9%	0.0
Category subtotal		**11.2%**		**3.9%**	**0.0**
Detector modeling	Lepton modeling	2.4%	Lepton modeling	1.8%	0.0
	MET scale	4.1%	MET modeling	0.4%	0.0
	MET resolution	4.5%			—
	b-tagging	8.4%	b tagging	0.9%	0.5
			Pileup	0.4%	—
Category subtotal		**10.6%**		**2.0%**	**0.17**
Total		**23.3%**		**21.7%**	**0.38**

Source	Uncertainty (%)	Uncertainty (pb)
Data statistics	5.5%	1.4
Simulation statistics	1.8%	0.5
Luminosity	2.7%	0.7
Theory modeling	15.8%	4.0
Background normalization	2.3%	0.6
Jets	5.3%	1.3
Detector modeling	4.9%	1.2
Total systematics (excl. lumi)	17.5%	4.4
Total systematics (incl. lumi)	17.7%	4.4
Total uncertainty	18.6%	4.7

Combination:
$25.0 \pm 1.4 \pm 4.4 \pm 0.7$(lumi) pb

χ^2/n.o.f. = 0.37
ATLAS: 43% CMS: 57%

tW production cross section

CMS TOP-14-009
ATLAS-CONF-2014-052

Category	ATLAS		CMS		
Data statistics	Data statistics	7.1%	Fit statistics	8.1%	0.0
Category subtotal		**7.1%**		**8.1%**	**0.0**
Simulation statistics	Sim. statistics	2.8%	Sim. statistics	2.2%	0.0
Category subtotal		**2.8%**		**2.4%**	**0.0**
Luminosity		3.7%		3.0%	—
Category subtotal		**3.7%**		**3.0%**	**0.31**
Theory modeling	ISR/FSR	5.9%	Ren./fact. scale	1.4%	1.0
	tW gen. and PS	11.0%			—
	$t\bar{t}$ gen. and PS	7.5%	ME/PS match. thr.	14.1%	1.0
	PDF	2.5%	PDF	1.7%	1.0
	$tW/t\bar{t}$ overlap	1.4%	DR/DS scheme	2.1%	1.0
			Top p_T reweight.	0.4%	—
Category subtotal		14.8%		**19.0%**	**0.66**
Background normalization	bkg. mod.	3.6%	$t\bar{t}$ cross section	1.7%	0.0
			Z+jets	2.6%	—
Category subtotal		**3.6%**		**3.1%**	**0.0**
Jets	JES comm.	10.0%	JES	3.8%	0.0
	JES flav.	5.0%			—
	Jet i	0.2%			—
	Leptons	0.7%	Jet resolution	0.9%	0.0
Category subtotal		**11.2%**		**3.9%**	**0.0**
Detector modeling	Lepton modeling	2.4%	Lepton modeling	1.8%	0.0
	MET scale	4.1%	MET modeling	0.4%	0.0
	MET resolution	4.5%			—
	b-tagging	8.4%	b tagging	0.9%	0.5
			Pileup	0.4%	—
Category subtotal		**10.6%**		**2.0%**	**0.17**
Total		**23.3%**		**21.7%**	**0.38**

Source	Uncertainty (%)	Uncertainty (pb)
Data statistics	5.5%	1.4
Simulation statistics	1.8%	0.5
Luminosity	2.7%	0.7
Theory modeling	15.8%	4.0
Background normalization	2.3%	0.6
Jets	5.3%	1.3
Detector modeling	4.9%	1.2
Total systematics (excl. lumi)	17.5%	4.4
Total systematics (incl. lumi)	17.7%	4.4
Total uncertainty	18.6%	4.7

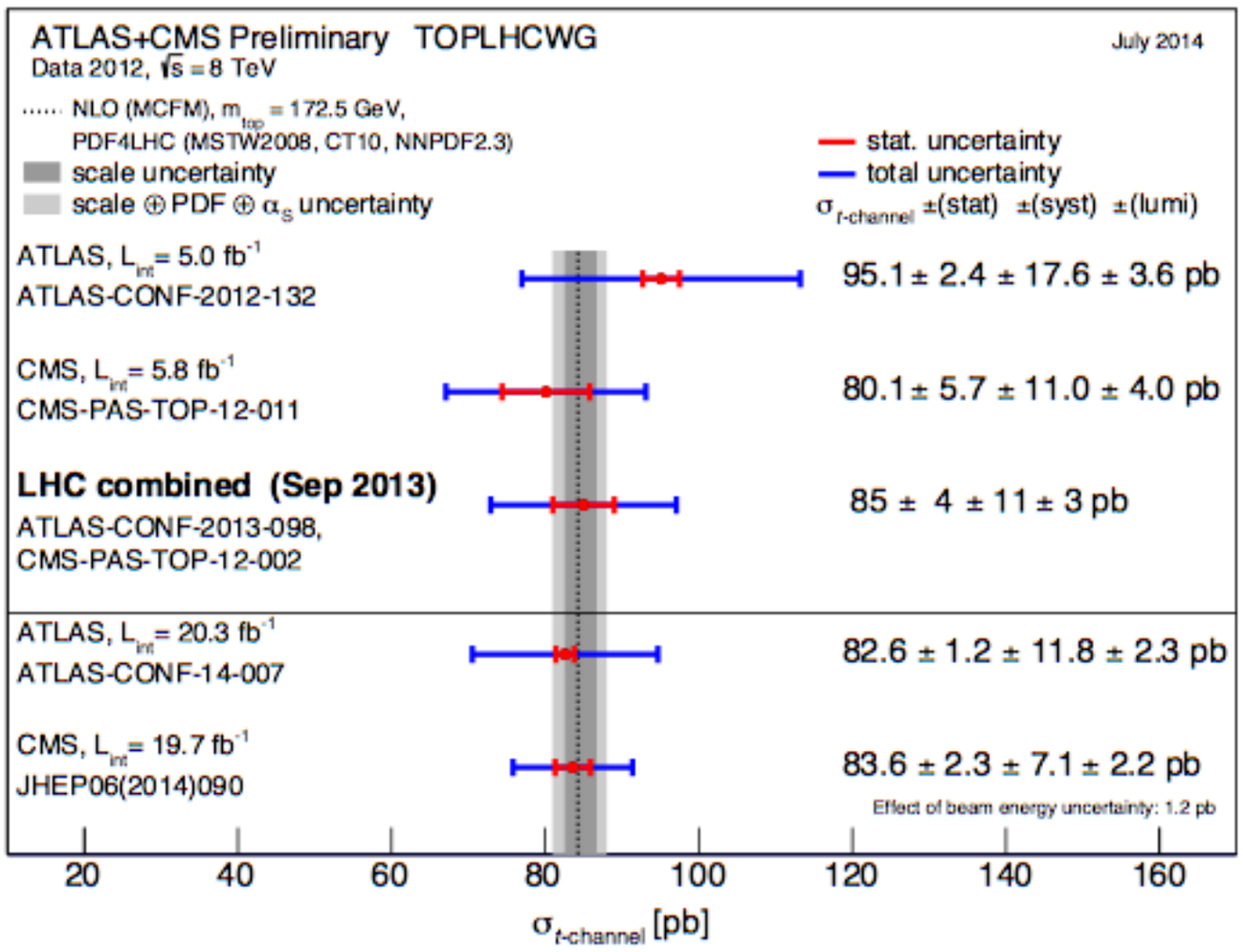
Combination:
$25.0 \pm 1.4 \pm 4.4 \pm 0.7$(lumi) pb

χ^2/n.o.f. = 0.37
ATLAS: 43% CMS: 57%

Superseded by new measurement (presented at this conference)

Single top quark t channel

CMS TOP-12-002
ATLAS-CONF-2013-061

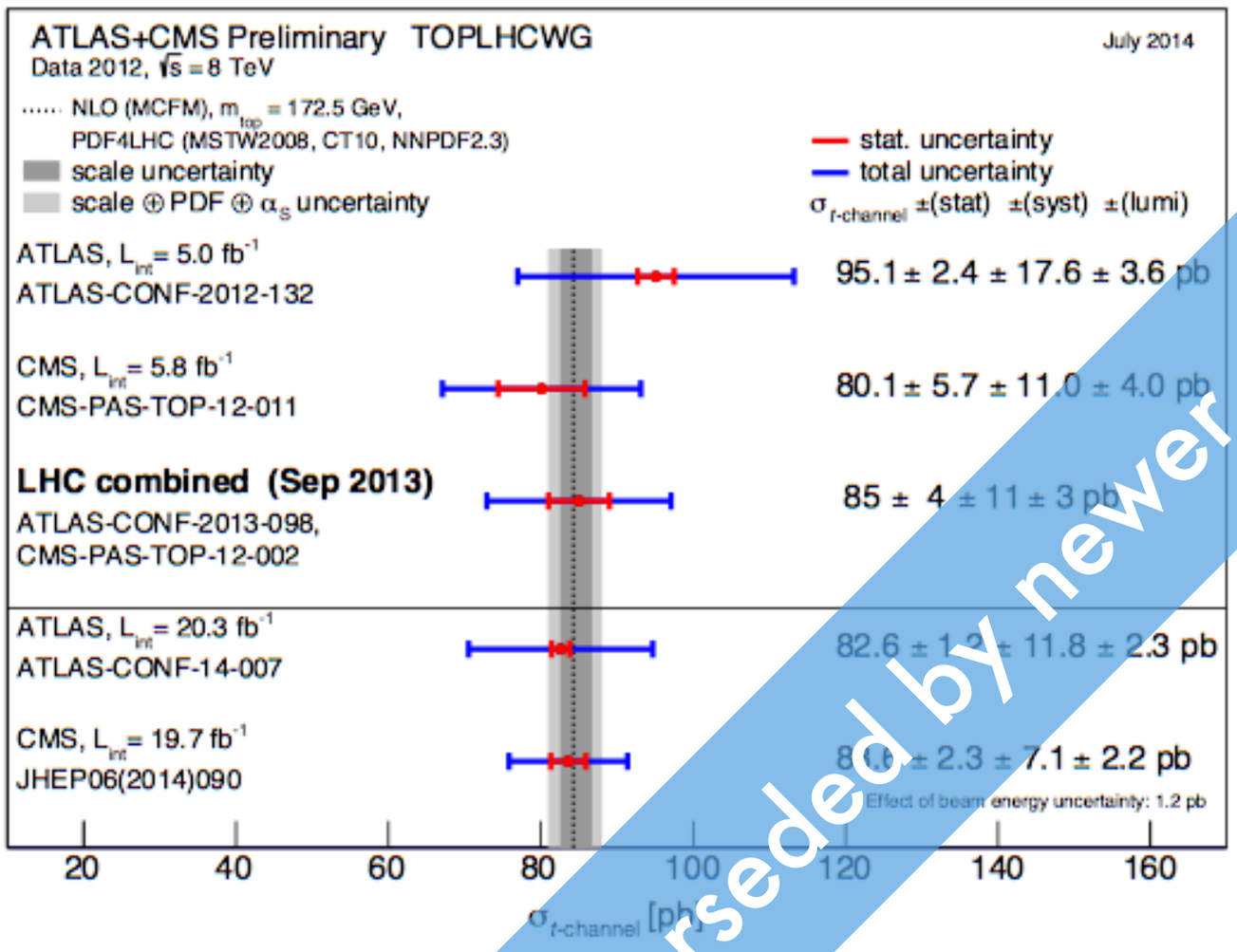


8 TeV input measurements:

- ATLAS (5.8 fb^{-1}):
  - Signal to background separation from multivariate discriminant neural network
  - systematics dominated
- CMS (5.0 fb^{-1}):
  - Signal to background separation from likelihood fits to templates η of light jets
  - relatively larger stat, smaller syst

Single top quark t channel

CMS TOP-12-002
ATLAS-CONF-2013-061

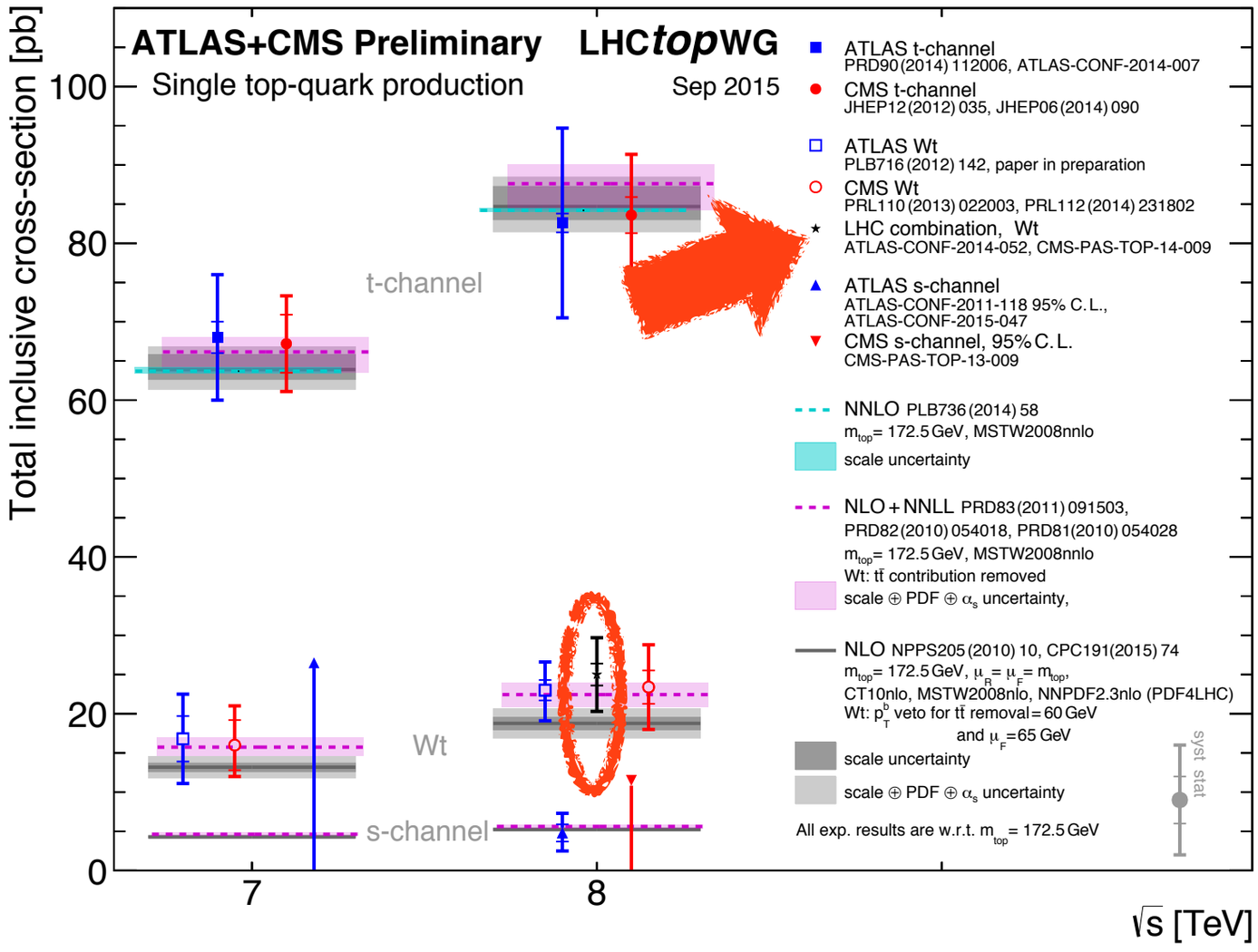


Superseded by newer measurements

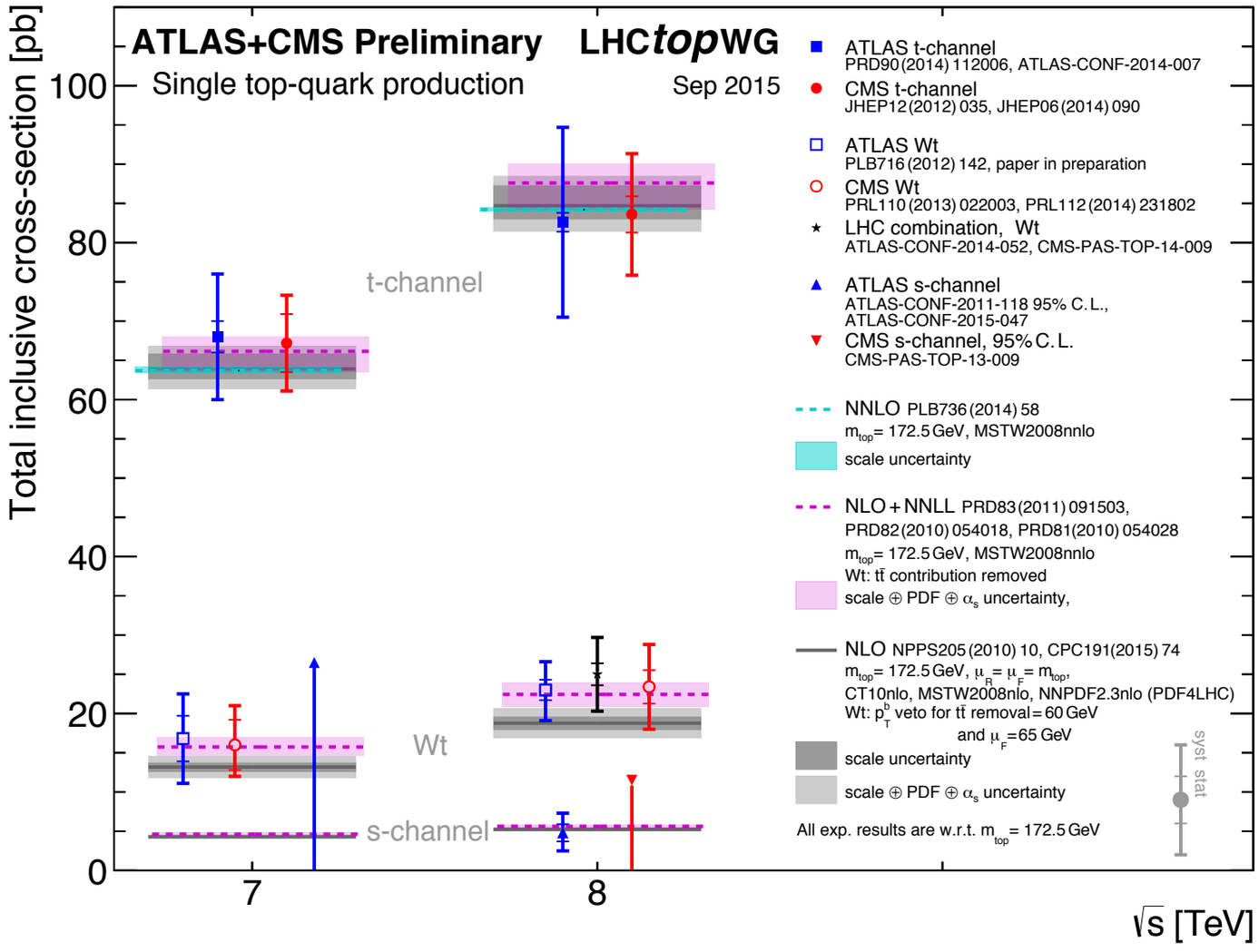
8 TeV input measurements:

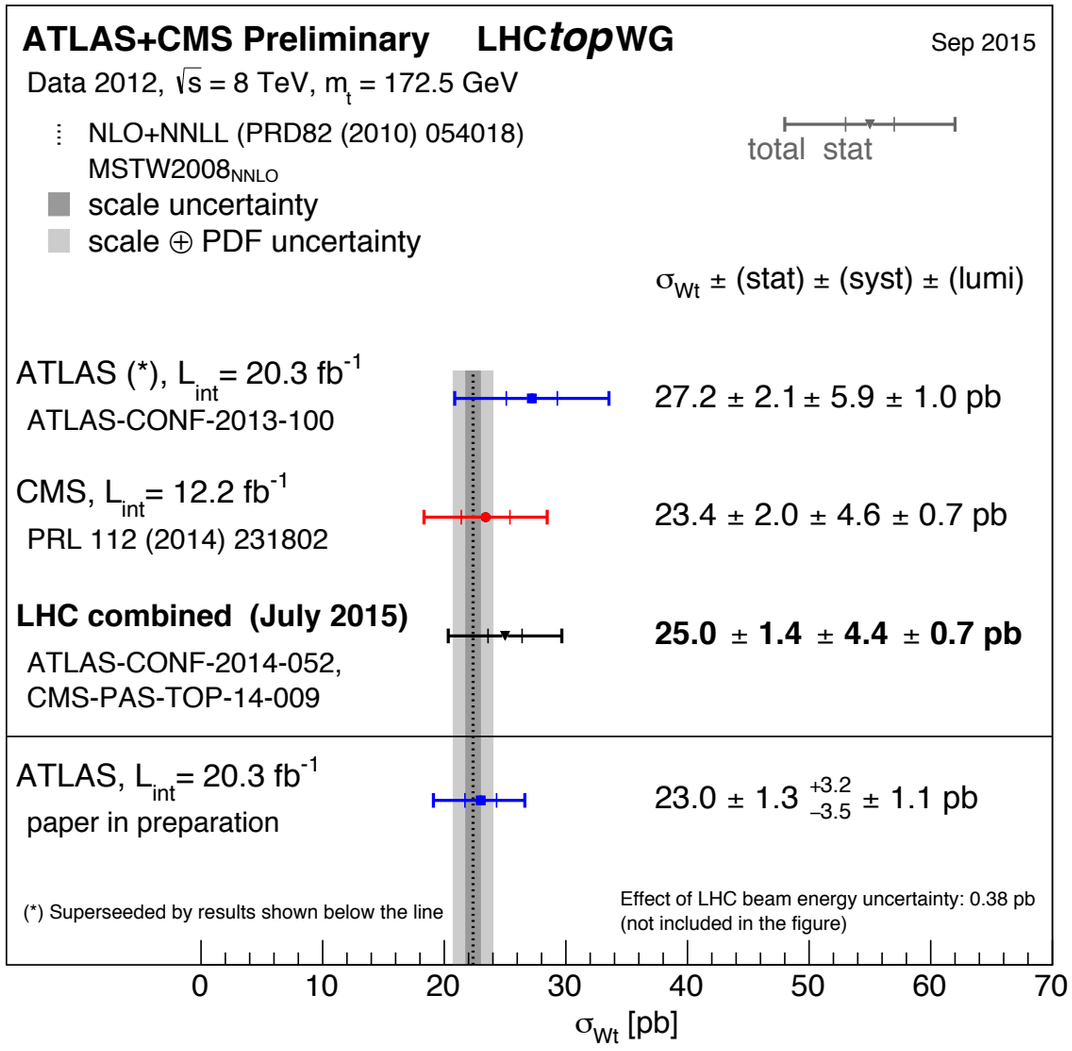
- ATLAS (5.8 fb^{-1}):
  - signal to background separation from multivariate discriminant neural network
  - systematics dominated
- CMS (5.0 fb^{-1}):
  - Signal to background separation from likelihood fits to templates η of light jets
  - relatively larger stat, smaller syst

Single top quark summary



Single top quark summary





- Most precise single measurement (tW)
  - 23.4 ±5.4 pb — 21%
- Combination:
  - 25.0 ±4.6 pb — 19%

…until yesterday! 😀

(New ATLAS measurement17% [not used])

Vtb from single top quark production

CMS TOP-14-009
ATLAS-CONF-2014-052

Assuming Wtb vertex is left-handed and V_{ts} and $V_{td} << V_{tb}$

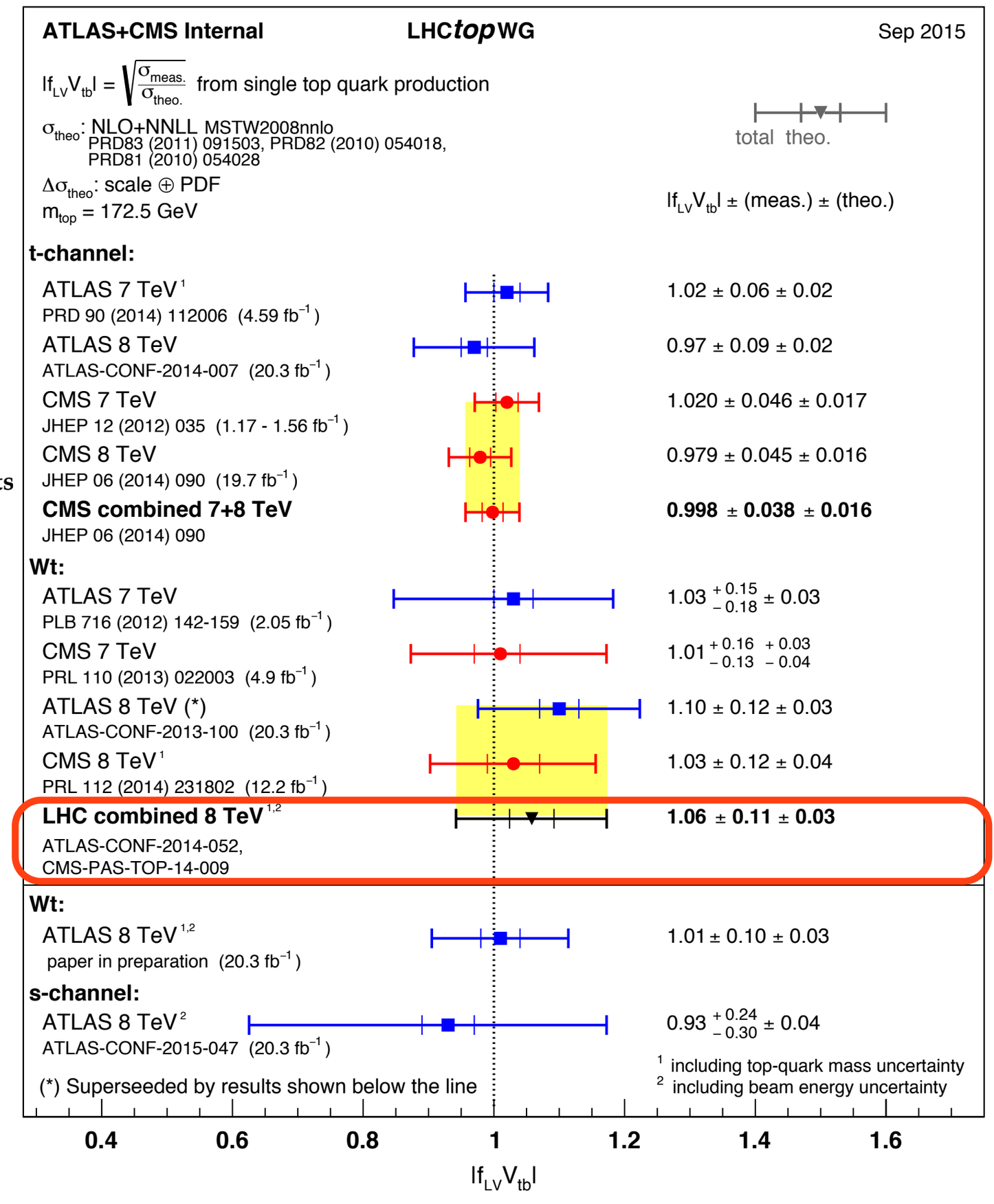
$$V_{tb}^2 = \sigma_{meas}/\sigma_{theor}$$

Beam energy affects theory calculation: uncertainty 0.38 pb added

Top quark mass affects measurements and theory calculation: uncertainties added

Requiring $|V_{tb}| <= 1$:

$|V_{tb}| > 0.79$ at 95%CL



Top quark properties

$t\bar{t}$ charge asymmetry (7 TeV)

CMS TOP-14-006
ATLAS-CONF-2014-012

pp collisions: on average quarks (valence&sea) carry more momentum than antiquarks (sea)

Top quarks rapidity distribution slightly broader than antiquarks

$\Delta|y| = |y_t| - |y_{tbar}|$

$N^+ \Rightarrow \Delta|y| > 0$

$N^- \Rightarrow \Delta|y| < 0$

$$A_C = \frac{N^+ - N^-}{N^+ + N^-}$$

Related to Tevatron asymmetry (excess seen), but much milder effect

Deviations from SM (A_c=0.0115 ±0.0006) in new physics models

Using l+jets final states at 7 TeV

$t\bar{t}$ charge asymmetry (7 TeV)

CMS TOP-14-006
ATLAS-CONF-2014-012

- ATLAS measurement: 4.7 fb-1
  - Ac=0.006 ±0.010 [stat+sys]
- Unfolding:
  - Fully Bayesian Unfolding
  - Marginalization procedure for systematic uncertainties (likelihood used in unfolding is marginalized integrating out its dependency on nuisance parameters)
  - For combination: used uncertainties before marginalization to access systematic uncertainties one by one
  - Ac=0.006 ±0.010 ±0.005 [0.011]
- Model dependence: check dependence on $t\bar{t}$ kinematics using MC with various axigluon models

- CMS measurement: 5 fb-1
  - Ac=0.004 ±0.010 ±0.011
- Unfolding:
  - Generalized matrix inversion method
  - No marginalization, original measurement used
- Model dependence: check dependence on $t\bar{t}$ kinematics using pseudo-experiments with (model independent) asymmetries generated by reweighting

See talk from T.Schwarz Sec. 6

$t\bar{t}$ charge asymmetry (7 TeV)

		ATLAS	CMS	Comb.	Corr.
	A_C	0.006	0.004	0.005	0.058
	Statistical	0.010	0.010	0.007	0
Uncertainties	Detector response model	0.004	0.007	0.004	0
	Signal model	< 0.001	0.002	0.001	1
	W+jets model	0.002	0.004	0.003	0.5
	QCD model	< 0.001	0.001	0.000	0
	Pileup+MET	0.002	< 0.001	0.001	0
	PDF	0.001	0.002	0.001	1
	MC statistics	0.002	0.002	0.001	0
	Model dependence				
	Specific physics models	< 0.001	*	0.000	0
	General simplified models	*	0.007	0.002	0
	Systematic uncertainty	0.005	0.011	0.006	
	Total uncertainty	0.011	0.015	0.009	

CMS TOP-14-006
ATLAS-CONF-2014-012

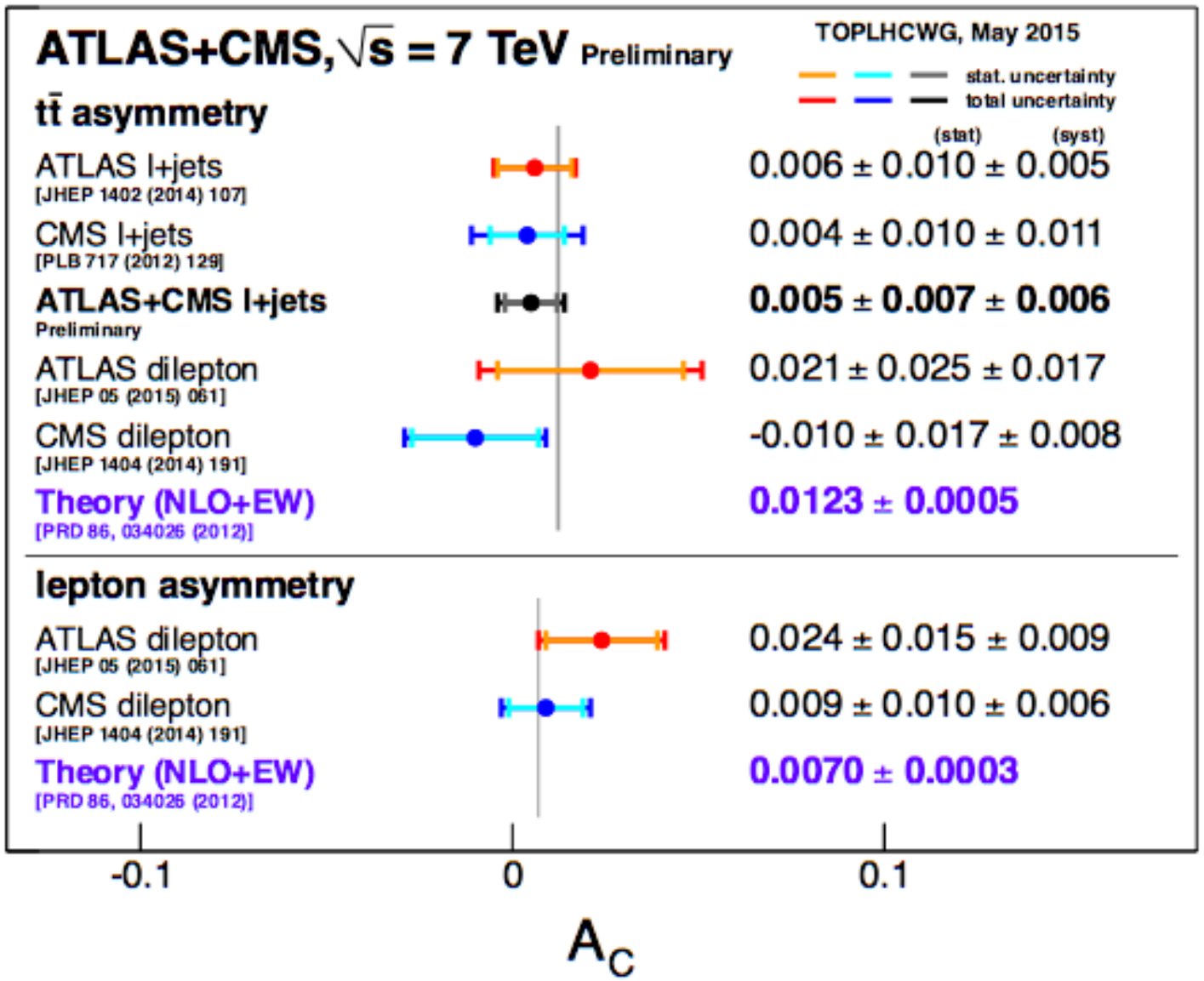
$$A_c = 0.005 \pm 0.007 \pm 0.006$$

χ^2 of combination =0.012 Prob=91%

ATLAS weight: 65%
CMS weight: 35%

$t\bar{t}$ charge asymmetry (7 TeV)

CMS TOP-14-006
ATLAS-CONF-2014-012



- Most precise single measurement
  - 0.006 ±0.011
- Combination:
  - 0.005 ±0.009

10% improvement

W-boson helicity in tt̄ decays

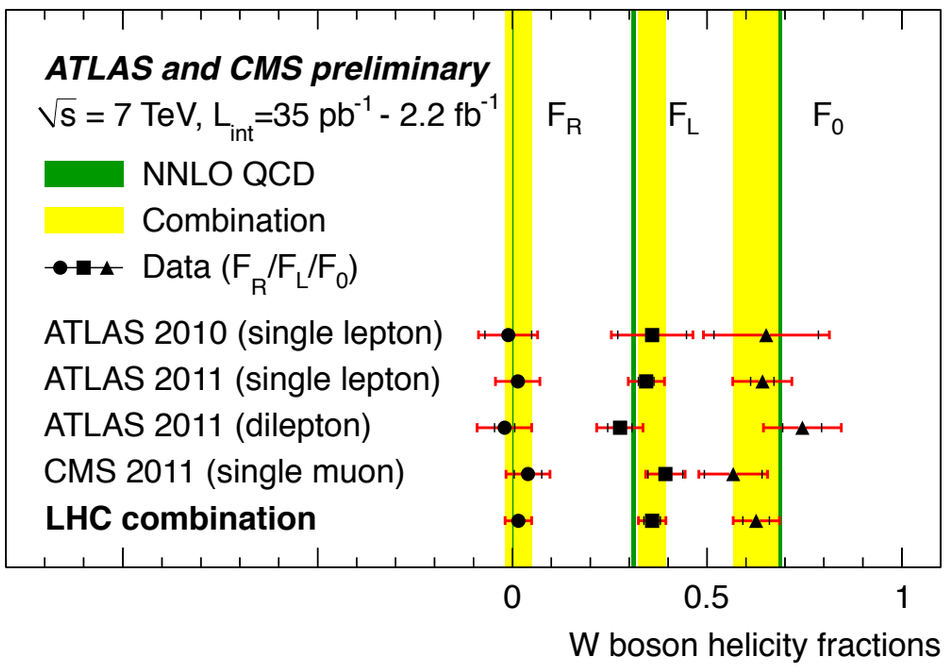
CMS TOP-12-025
ATLAS-CONF-2013-033

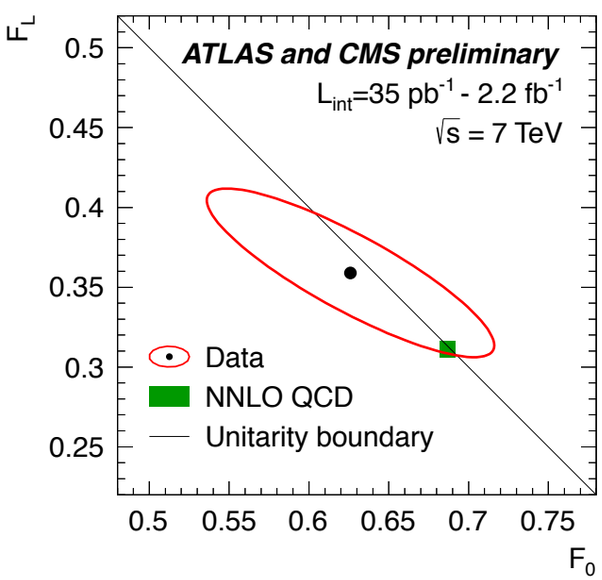
W-boson helicity fractions F_0,F_L,F_R (from angular distributions of decay products) can be translated to limits on anomalous coupling on Wtb vertex

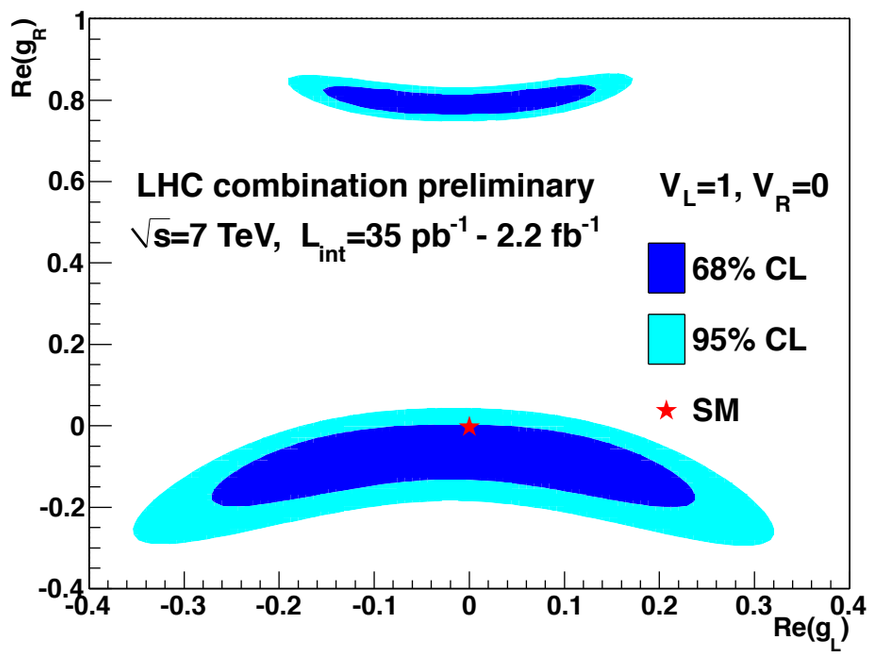
Additional complication: each measurement correspond to a pair of correlated numbers
(technically ➡ nr of inputs = 2x nr of measurements)

Advantage of combination: more than improvement on precision, de-correlation of F_0,F_L due to different systematic uncertainties greatly improve limits on anomalous coupling

- ATLAS (0.35-1.04 fb^{-1}):
  - l+jets (2010, 2011 data)
  - dilepton (2011 data)
- CMS (2.2 fb^{-1}):
  - μ+jets channel, 2011 data







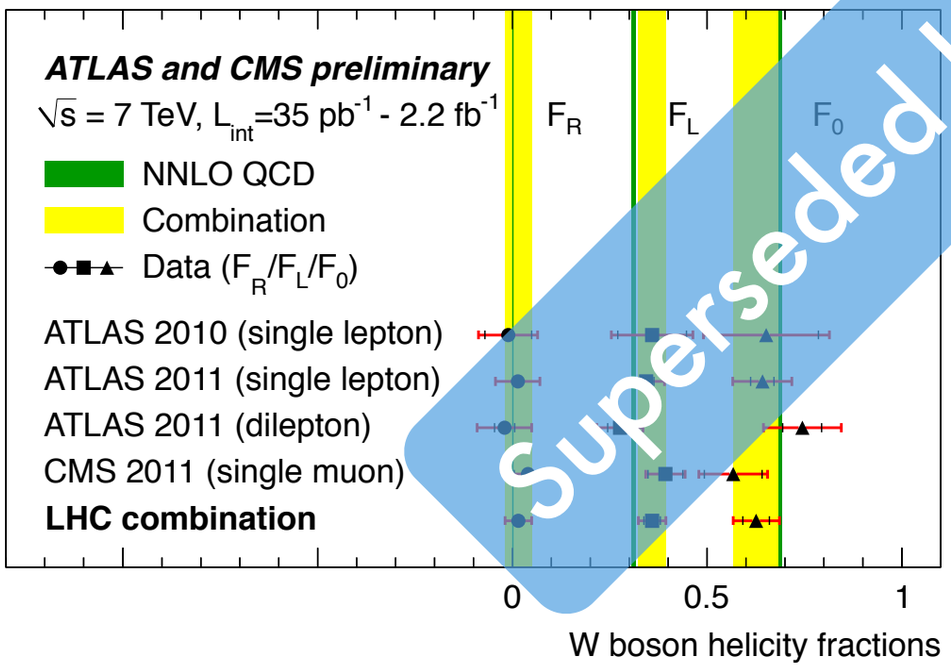
W-boson helicity in tt̄ decays

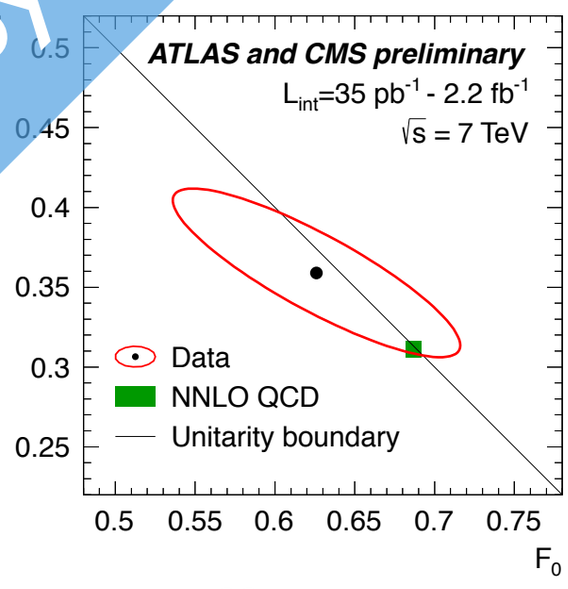
CMS TOP-12-025
ATLAS-CONF-2013-033

- **W-boson helicity fractions F_0,F_L,F_R (from angular distributions of decay products) can be translated to limits on anomalous coupling on Wtb vertex**
- **Additional complication: each measurement corresponds to a pair of correlated numbers**
  (technically ➡ nr of inputs = 2x nr of measurements)
- **Advantage of combination: more than improvement on precision, de-correlation of F_0,F_L due to different systematic uncertainties greatly improve limits on anomalous coupling**

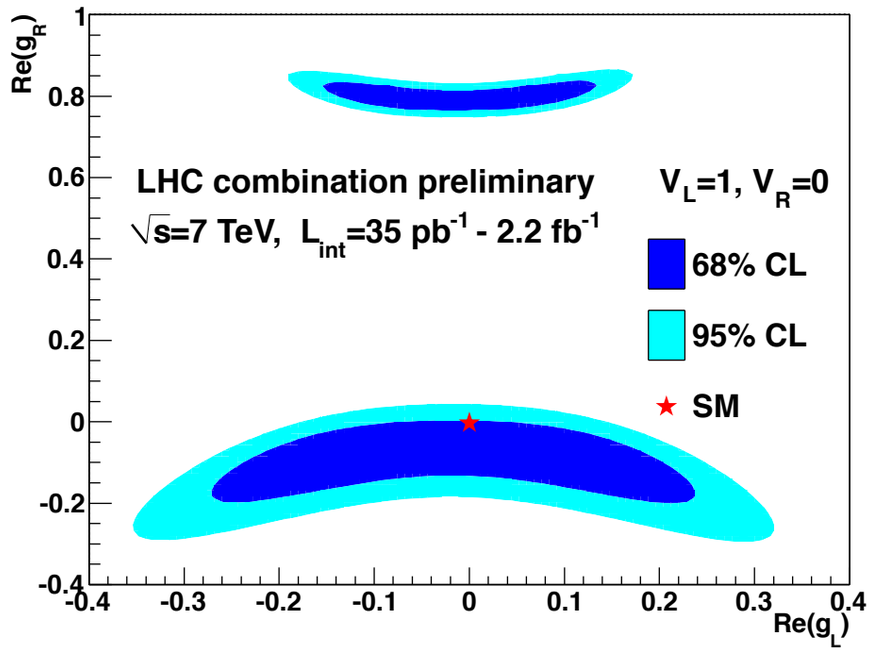
Superseded by newer measurements

- ATLAS (0.35-1.04 fb^{-1}):
  - l+jets (2010, 2011 data)
  - dilepton (2011 data)





- CMS (2.2 fb^{-1}):
  - μ+jets channel, 2011 data



Other LHCTOPWG activities

Unpublished LHCTOPWG: ongoing/ done work and future activities

Much of the work involved in combinations is "unseen"

Since 2011 Collaborations worked hard to understand / homogenize systematic uncertainties as much as possible

Examples:

- **jet energy scale —> both experiments now estimate uncertainties subdivided in categories correlated/uncorrelated**

CMS JME-14-003
ATLAS-PHYS-PUB-2014-020

- **Initial/final state radiation widely debated in first combinations**
  - **for CMS: included in "renorm and factorisation scale uncertainties"**
  - **for ATLAS: alternative samples**

Understand different MC/tunes

For Run II: *a priori* work to compare Monte Carlo tunes/parameters

https://indico.cern.ch/event/375429/timetable/#20150520

Unpublished LHCTOPWG: ongoing/ done work and future activities

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SingleTopRefXsec

TWiki > LHCPhysics Web > TopLHCWG > SingleTopRefXsec (2015-09-15, ReinhardSchwienhorst)

Edit Attach PDF

NLO single-top channel cross sections

ATLAS-CMS recommended predictions for single-top cross sections using the Hathor v2.1 program

Introduction

The goal is to provide a common reference cross section for single top to be used by t… …m the newly available *t* channel NNLO prediction and its uncertainties are fully expressed and available for the parame… …ce cross section is obtained with

Common recommendations for reference cross sections

Unpublished LHCTOPWG: ongoing/ done work and future activities

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SingleTopRefXsec

TWiki > LHCPhysics Web > TopLHCWG > SingleTopRefXsec (2015-09-15, ReinhardSchwienhorst)

Edit Attach PDF

NLO single-top channel cross sections

ATLAS-CMS recommended predictions for single top cross sections using the Hathor v2.1 program

NEW! (2015-09-15)

Common recommendations for reference cross sections

Introduction

The goal is to provide a common reference cross section for single top to be used by t … the newly available *t* channel NNLO prediction and its uncertainties are fully expressed and available for the parame… …ce cross section is obtained with

Unpublished LHCTOPWG: ongoing/ done work and future activities

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SingleTopRefXsec

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/TtbarNNLO

NLO single-top channel cross sections

ATLAS-CMS recommended predictions for single-top cross sections using the Hathor v2.1 program

↓ Introduction

TWiki > LHCPhysics Web > WebPreferences > TtbarNNLO (2015-09-14, MariaJoseCosta)

Edit Attach PDF

NNLO+NNLL top-quark-pair cross sections

ATLAS-CMS recommended predictions for top-quark-pair cross sections using the Top+ program (M. Czakon, A. Mitov, 2013)

- Introduction
- Prescription
- Recommendations for most analyses
- Proposed citation and list of references
- Tables and Figures
  - Top-quark-pair cross sections at 7, 8, 13, and 14 TeV calculated for specific top-quark-mass v
  - Parametrisations
  - Figures

PAGE UNDER CONSTRUCTION

Introduction

Predictions for top-quark-pair cross sections at NNLO+NNLL soft gluon resummatio (M.Czakon, A. Mitov, Comput.Phys.Commun. 185 (2014) 2930) in a common ATLAS-CMS effort. The go on for top-quark-pair (ttbar) production to be used by the ATLAS and CMS collaborations.

Prescription

Common recommendations for reference cross sections

Unpublished LHCTOPWG: ongoing/ done work and future activities

- **Any important precision measurement is worth combining: complementarity on syst +stats**
  - **Differential cross sections**
    - **detailed comparison of simulation: top p_T spectra was investigated**
    - **At 13 TeV, very high p_T : measurements on boosted regimes serious candidates**
  - **"Associated" top quark production (backgrounds to ttH)**
    - **$t\bar{t}W$, $t\bar{t}Z$**
    - **$t\bar{t}bb$**

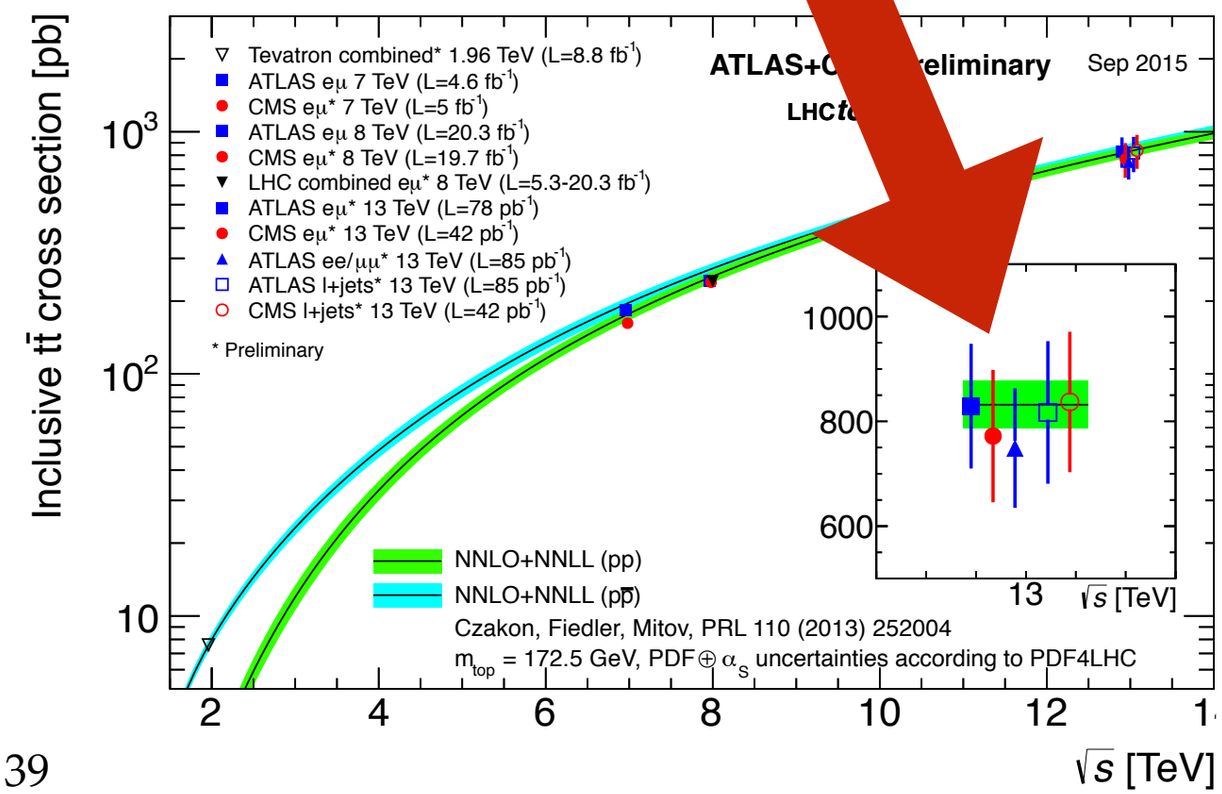
ongoing discussions suggestions/possibilities

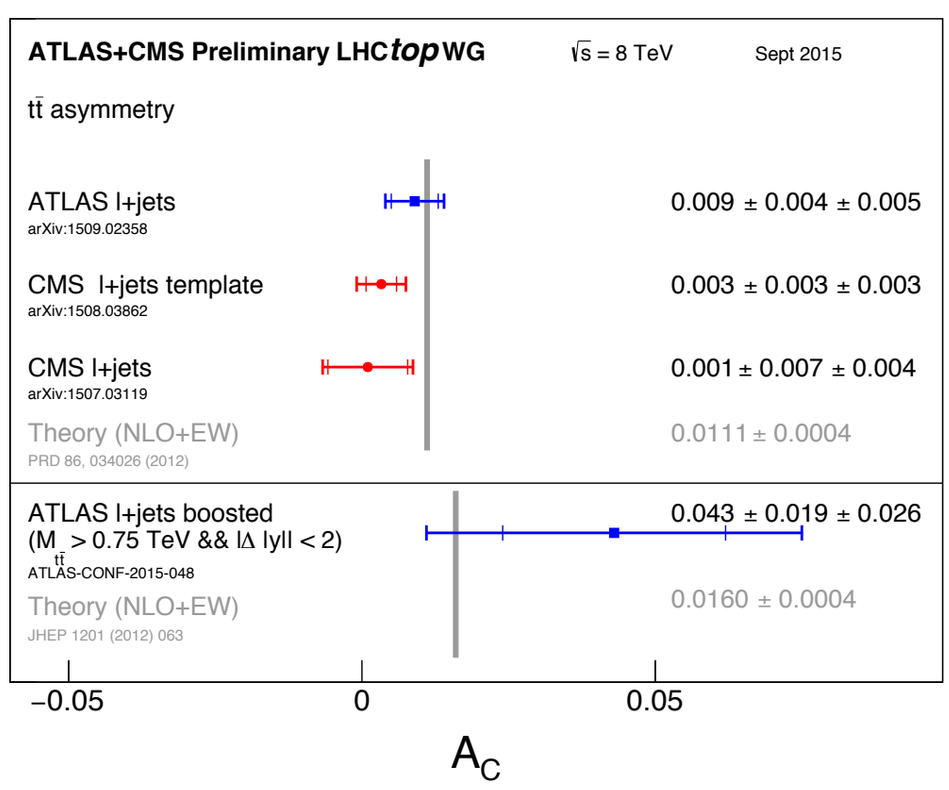
- **Properties and more:**
  - **lepton asymmetry, spin correlations, top polarization, limits on anomalous couplings from single-top, R_b**
  - **Single top cross sections: inclusive; combine top / anti-top separately probes quark content of the proton (PDF)**
  - **Limits on FCNC from top decays and single top production**

Unpublished LHCTOPWG: ongoing/ done work and future activities

More foreseen & ongoing work:

- **Run II measurements**
- **Run I updates: wor recombining "legacy" measurements from experiments**
  - **$t\bar{t}$ inclusive cross tions (working on remaining differences in systematic uncertainties)**
  - **Charge asymmetry a TeV (3 new measurements available)**

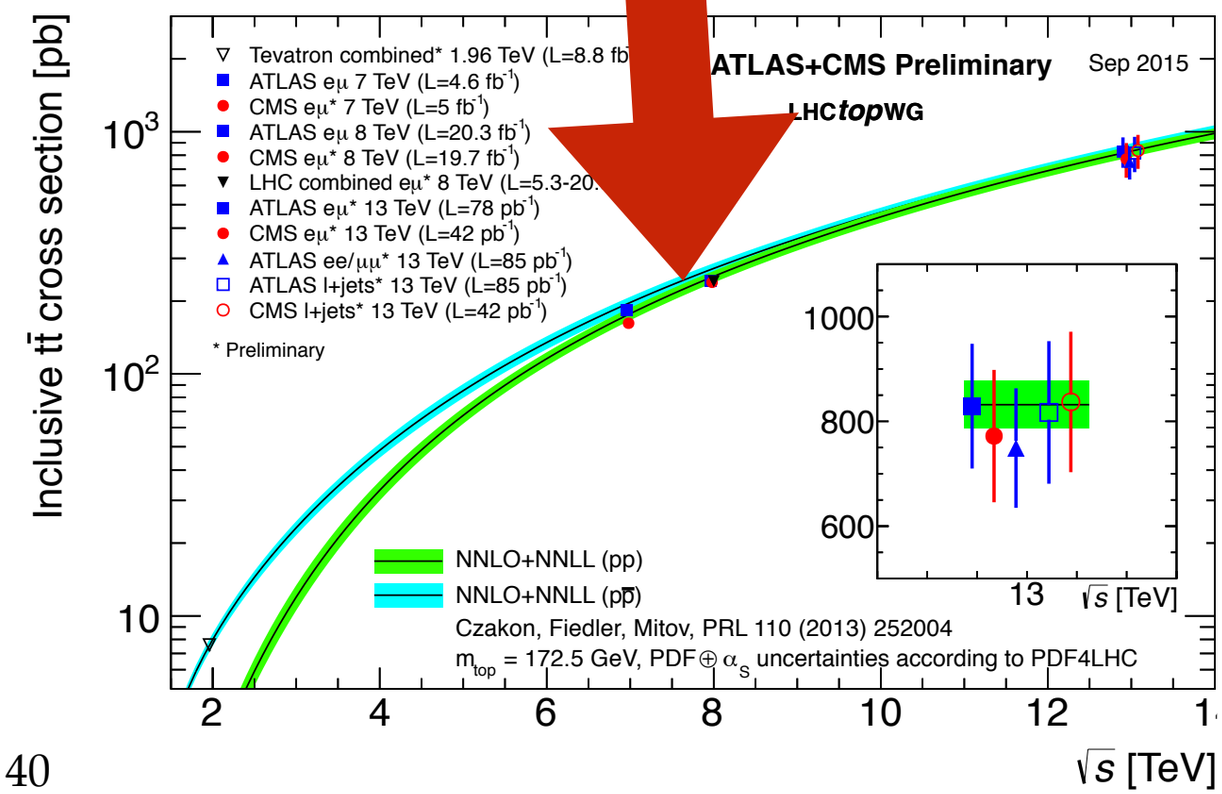


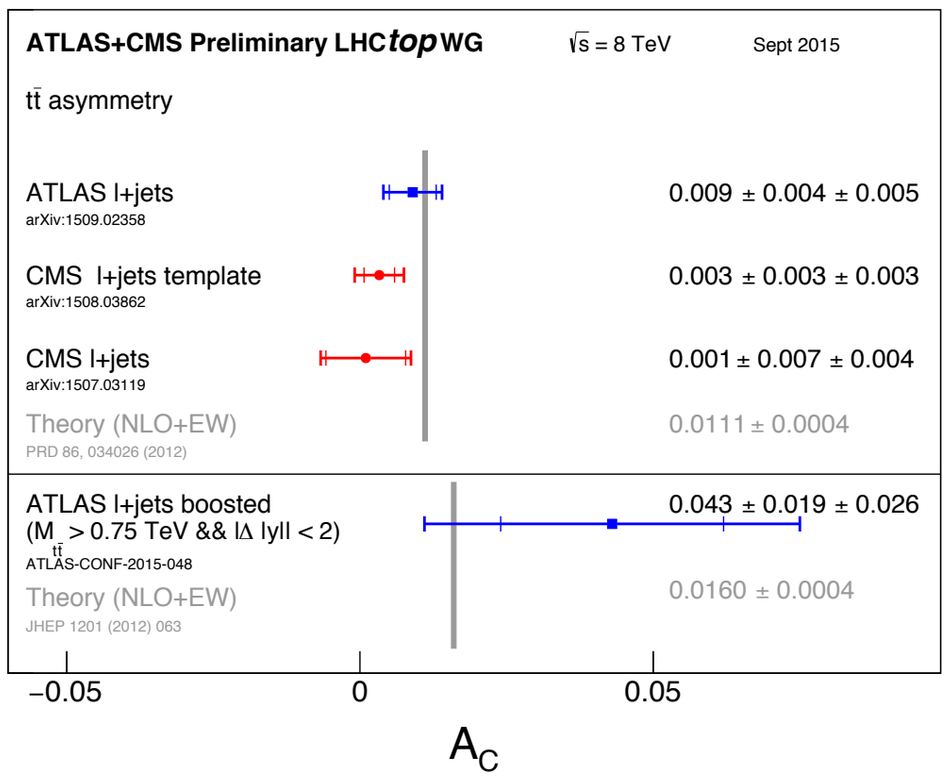


Unpublished LHCTOPWG: ongoing/ done work and future activities

More foreseen & ongoing work:

- **Run II measurements**
- **Run I updates: worth recombining "legacy" measurements from experiments**
  - **$t\bar{t}$ inclusive cross sections (working on remaining differences in systematic uncertainties)**
  - **Charge asymmetry at 8 TeV (3 new measurements available)**

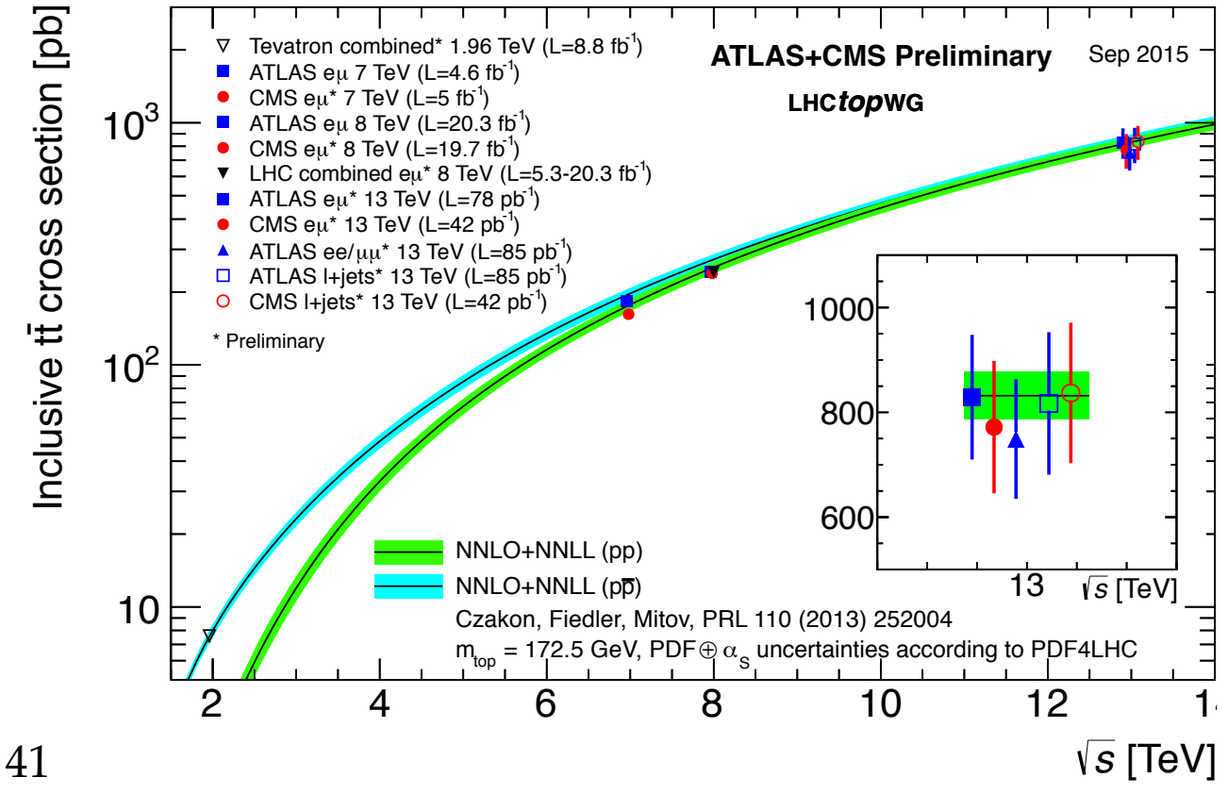


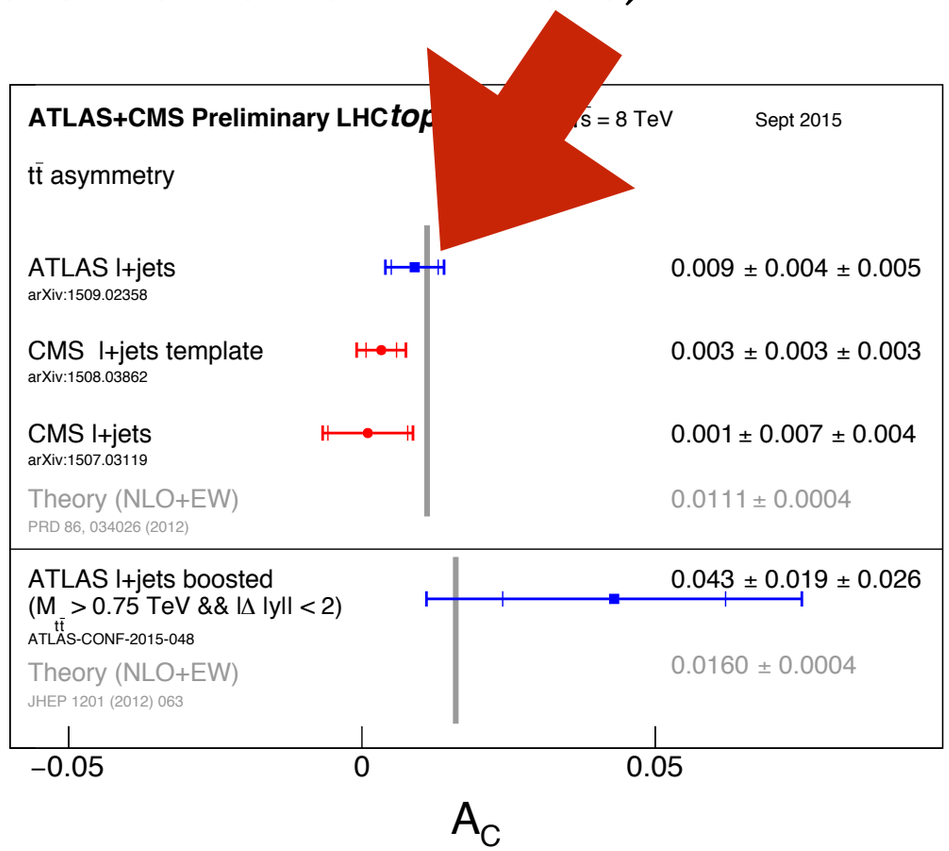


Unpublished LHCTOPWG: ongoing/ done work and future activities

More foreseen & ongoing work:

- **Run II measurements**
- **Run I updates: worth recombining "legacy" measurements from experiments**
  - **$t\bar{t}$ inclusive cross sections (working on remaining differences in systematic uncertainties)**
  - **Charge asymmetry at 8 TeV (3 new measurements available)**





Unpublished LHCTOPWG: ongoing/ done work and future activities

More foreseen & ongoing work:

- **Run II measurements**
- **Run I updates: worth recombining "legacy" measurements from experiments**
  - **$t\bar{t}$ inclusive cross section (working on remaining differences in systematic uncertainties)**
  - **Charge asymmetry at 8 TeV (3 new measurements available)**
  - **W boson helicity, single top cross section**
  - **V_{tb} from t-channel**

ongoing discussions suggestions/possibilities

- Improve combinations using other methods?
  - **Combine likelihoods?**

Summary and conclusions

Summary

LHCTOPWG activities:

- **$t\bar{t}$ cross sections:**
  - **at 7 TeV**
  - **at 8 TeV: (improves precision w.r.t. "legacy" measurements)**
- **single top cross sections:**
  - **t-channel**
  - tW-channel **(until this conference, 3% improvement w.r.t. more precise)**
- **charge asymmetry (10% improvement w.r.t. more precise)**
- **W-boson polarization in top decays**

Conclusions

Advantages of combinations go beyond precision:

- Forum for discussions, beneficial to the collaborations
  - Involving theorists on discussions helps improving consistency in theory modeling uncertainties
  - Checks consistency across experiments
- Early measurements combinations: exercise harmonization of systematics, methodologies, etc
- Exploits full LHC potential (systematics and statistics)...

...one way of maximizing the chances of seeing our so desired signs of new physics

Backup slides

Model uncertainties

σ_{tt} 8 TeV

Generator & Parton Shower
- CMS:POWHEG+PYTHIA vs POWHEG+HERWIG
- ATLAS:POWHEG+PYTHIA vs MC@NLO+HERWIG

Radiation
- ATLAS: different PYTHIA tunes, guided by additional jets measurements
- CMS: matching scale (Matrix Elements vs Parton Shower)

Scale
- ATLAS: factorization and renormalization summed up; POWHEG (NLO)
- CMS: factorization and renormalization simultaneously; MADGRAPH+ PYTHIA (LO)

σ_{tW} 8 TeV

top pair Generator & Parton Shower
- CMS: matching scales
- ATLAS:POWHEG+PYTHIA vs MC@NLO+HERWIG

tW Generator & Parton Shower
- ATLAS:POWHEG+PYTHIA vs MC@NLO+HERWIG
- CMS: Diagram Subtraction vs Diagram Removal schemes

Radiation and Scale (tt and tW)
- ATLAS: different PYTHIA tunes, guided by additional jets measurements
- CMS: factorization and renormalization simultaneously; MADGRAPH+ PYTHIA (LO)