

Single top, Wt combination + plans for legacy paper

LHC^{TOP}WG



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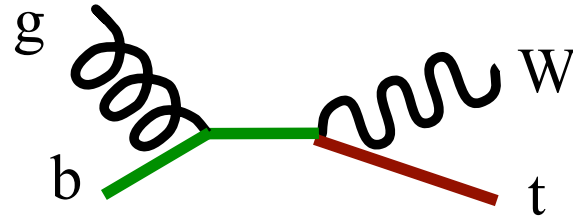


LHC top WG meeting, 17 May 2016

Outline

- Wt cross-section combination at 8 TeV
- Not-yet updated single top summary plots
- Plans for Vtb combination

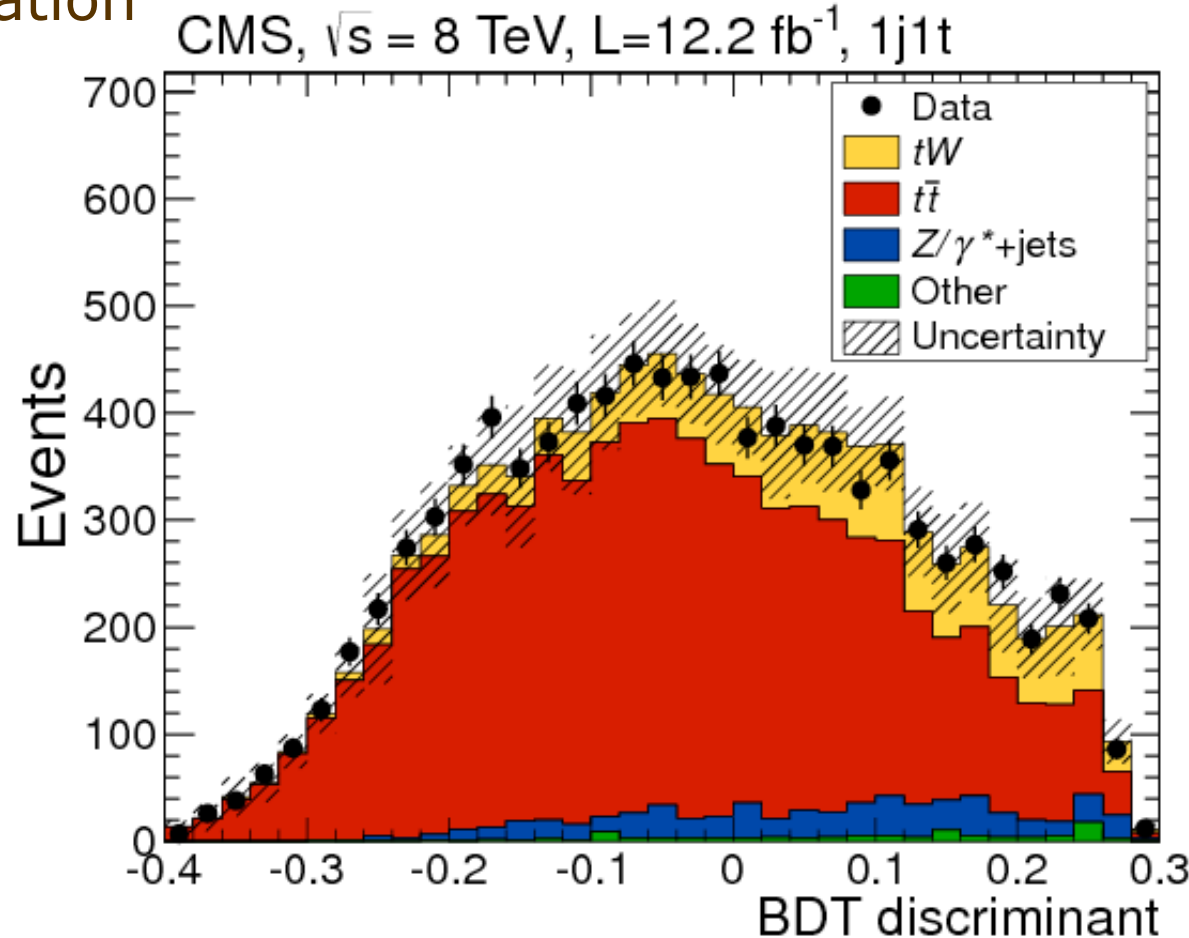
Combination of single top Wt cross-sections at 8 TeV



- Update to previous combination ATLAS-CONF-2014-052; CMS-PAS-TOP-14-009
 - Fall 2014: combination of CMS publication and ATLAS preliminary result at 8 TeV
 - ▶ $25.0 \pm 1.4 \pm 4.4 \pm 0.7$ pb (18.7%)
- Now: Updated ATLAS input
 - JHEP01(2016)064
- Same procedure as before
 - Iterative BLUE
- Small update to systematic uncertainty categories
 - ATLAS result follows LHC top WG recommendations for theory uncertainties
 - ▶ <https://indico.cern.ch/event/340357/sessions/153187>
 - ▶ <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/TheorySystematics>

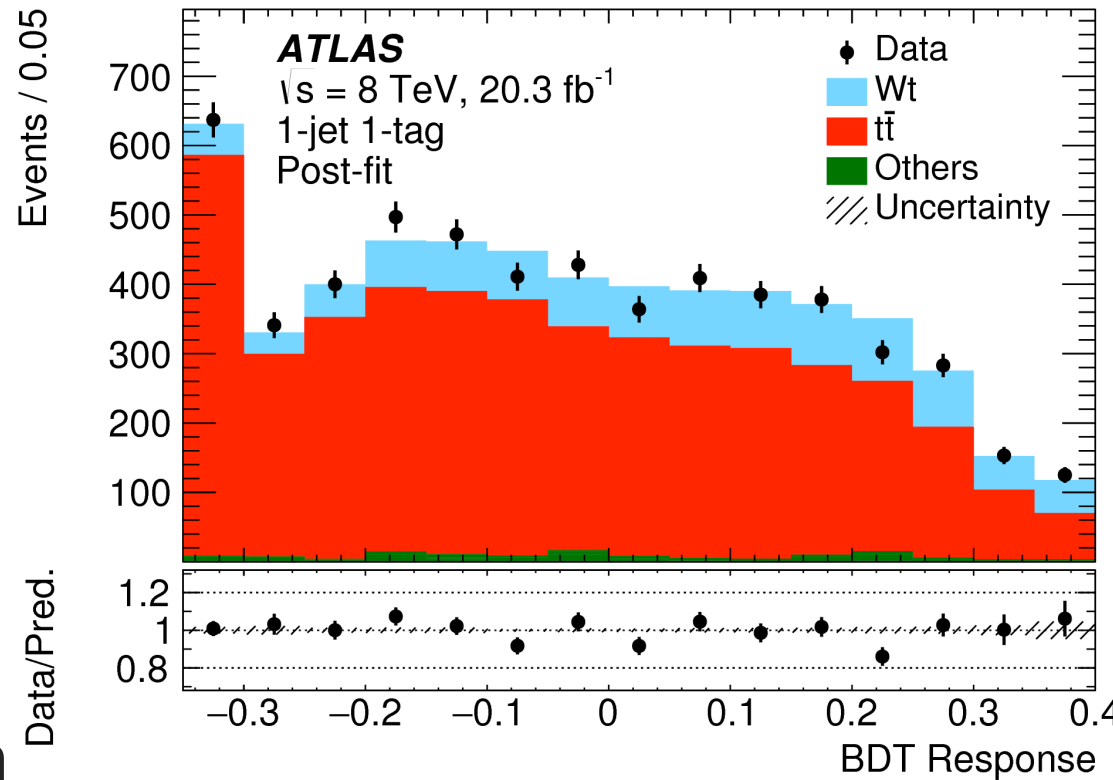
CMS result

- 8 TeV, 12.2 fb^{-1} , ee, e μ , $\mu\mu$, 1-jet and 2-jet with b-tag
- Boosted decision trees to isolate signal
- Profiling experimental systematics, not theory modeling
- Including uncertainty due to top quark mass
 - 9%, corresponding to 2 GeV shift
 - Not considered in combination
- Cross section
 $23.4 \pm 5.4 \text{ pb}$ (23%)
- 6.1 s.d. significance
- PRL 112 (2014) 23180
 - Analysis from 2013
 - Final 8 TeV result for Wt



ATLAS result

- 8 TeV, 20 fb⁻¹
- Dilepton final state
(ee, μμ, eμ)
- One or two b-quark jets
- Boosted decision trees
- Theory systematic uncertainties according to LHC top WG
- RooStats profile likelihood fit to extract cross-section



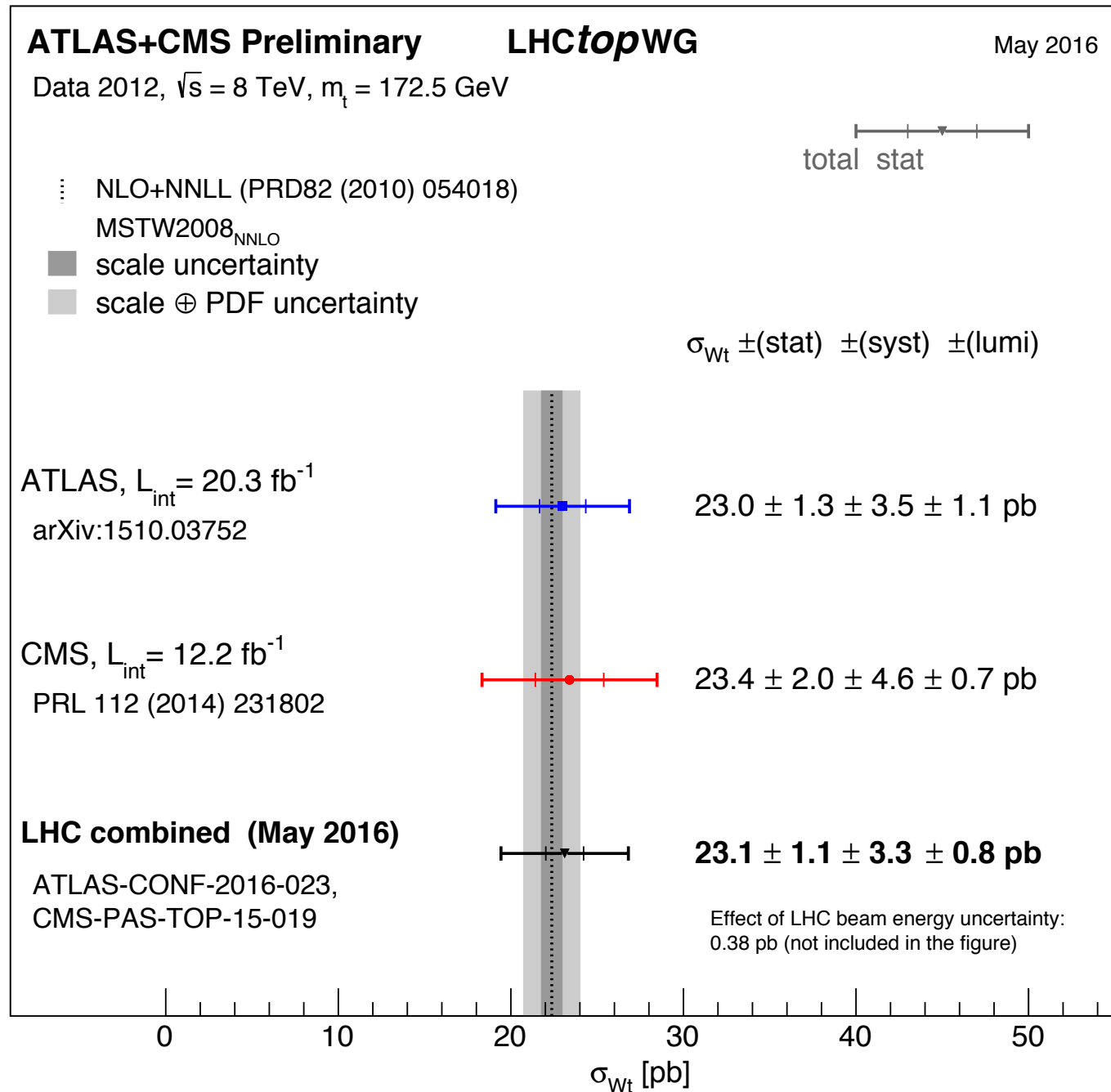
- Profile all systematic uncertainties
- Verified that systematic uncertainty determination gives the same result despite different methods used by ATLAS and CMS
- Cross-section measurement
 - 23.0 ± 1.3 (stat.)_{-3.5}^{+3.2} (syst.) ± 1.1 (lumi.) pb
 - 16% uncertainty
 - 7.7σ significance
- JHEP01 (2016) 064

Systematic uncertainties and correlations

Category	ATLAS		CMS		ρ
Theory modeling	ISR/FSR	8.8%	Ren./fact. scale	12.4%	1.0
	NLO matching method	2.5%			—
	Parton shower	1.7%	ME/PS match. thr.	14.1%	1.0
	PDF	0.6%	PDF	1.7%	1.0
	$Wt/t\bar{t}$ overlap	3.5%	DR/DS scheme	2.1%	1.0
			Top p_T reweight.	0.4%	—
Category subtotal	10.0%		19.0%		0.75
Background normalization	bkg. mod.	2.8%	$t\bar{t}$ cross section	1.7%	0.0
			Z+jets	2.6%	—
Category subtotal	2.8%		3.1%		0.0
Jets	JES common	5.3%	JES	3.8%	0.0
	JES flavour	1.9%			—
	Jet id	0.2%			—
	Jet res.	6.5%	Jet resolution	0.9%	0.0
Category subtotal	8.6%		3.9%		0.0
Detector modeling	Lepton modeling	3.0%	Lepton modeling	1.8%	0.0
	MET scale	5.5%	MET modeling	0.4%	0.0
	MET resolution	0.2%			—
	b -tagging	1.0%	b tagging	0.9%	0.0
	Pileup	2.7%	Pileup	0.4%	0.0
Category subtotal	6.9%		2.0%		0.0
Total	16.8%		21.7%		0.40

Wt cross-section combination

- Iterative BLUE
- Weights:
 - ATLAS 0.70
 - CMS 0.30
- $\chi^2 = 0.01$
 - p-value 0.94



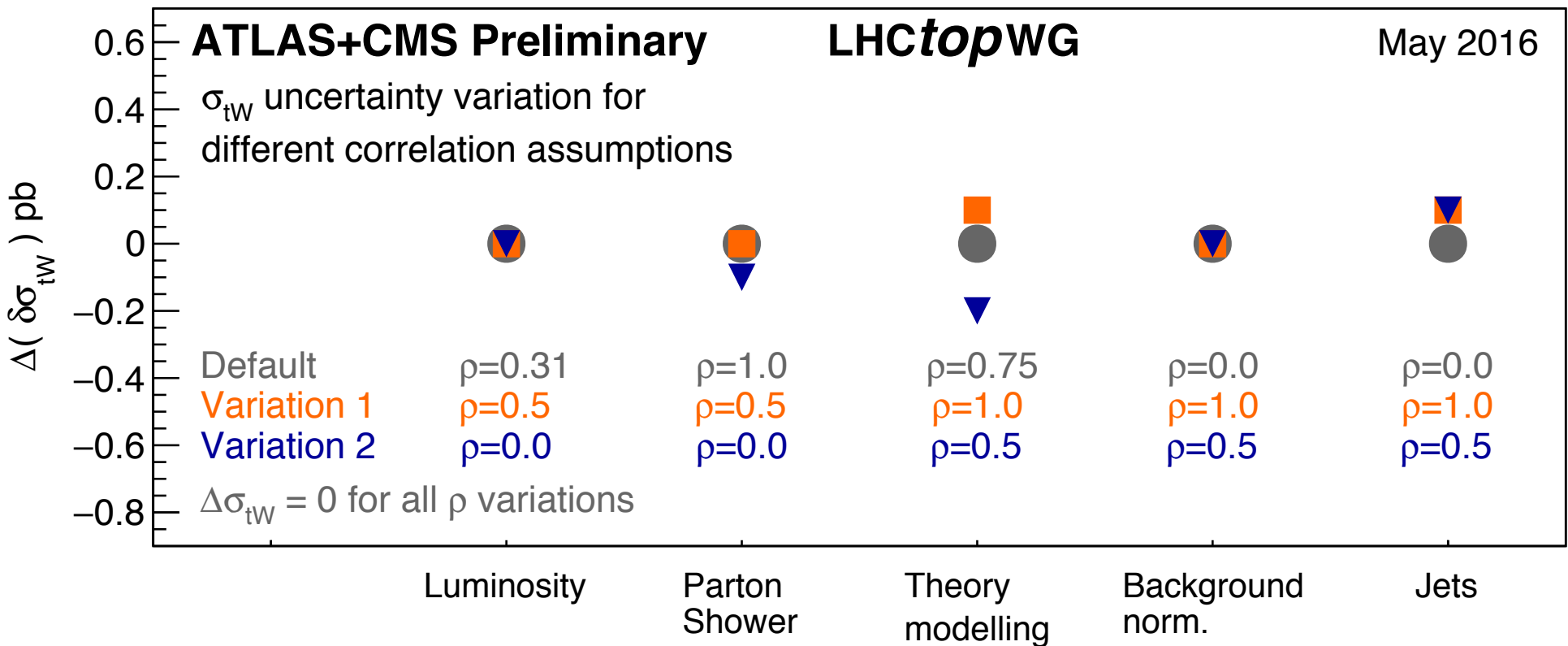
Uncertainty breakdown for combined result

Source	Uncertainty	
	(%)	(pb)
Data statistics	4.7%	1.1
Simulation statistics	0.8%	0.2
Luminosity	3.6%	0.8
Theory modeling	11.8%	2.7
Background normalization	2.2%	0.5
Jets	6.2%	1.4
Detector modeling	4.9%	1.1
Total systematics (excl. lumi)	14.4%	3.3
Total systematics (incl. lumi)	14.8%	3.4
Total uncertainty	15.6%	3.6

Theory modelling source	Uncertainty	
	(%)	(pb)
ISR/FSR, Scale	9.9	2.3
Parton shower, ME/PS match. thr.	5.4	1.2
PDF	0.9	0.2
DR/DS	3.1	0.7
Other theory modelling	1.8	0.4
Total theory modelling	11.8	2.7

Stability checks

- Vary correlation assumption for important systematic uncertainties
 - or uncertainty categories
- Result very stable
 - Central value unchanged



$|V_{tb}|$ determination

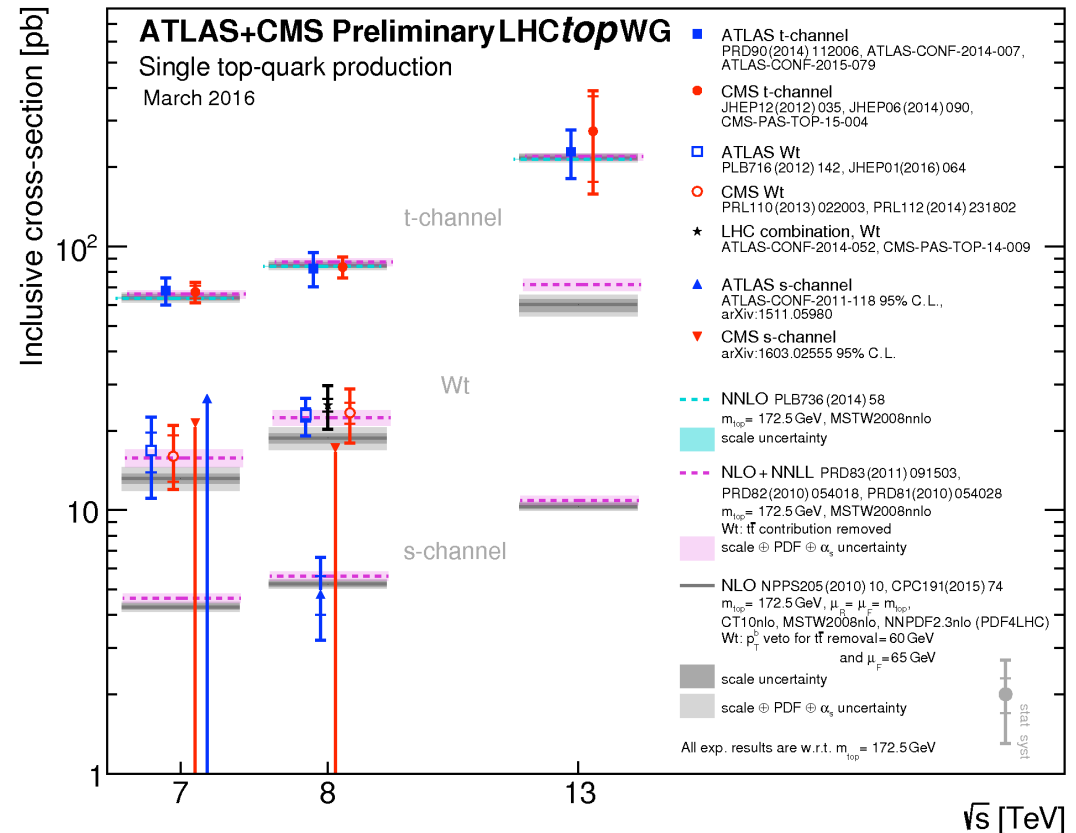
- tW cross section is proportional to $|V_{tb}|^2$
- \Rightarrow Direct determination of $|V_{tb}|$
 - Divide experimental cross-section by theory prediction
 - ▶ NLO+NNLL (PRD82 (2010) 054018)
 - No assumptions about # of generations or CKM unitarity
 - Only assume that top decay is dominated by $|V_{tb}|$
 - tW provides additional information beyond t-channel
- Additional uncertainties
 - Theoretical cross-section (2.3 pb)
 - Top quark mass (1.1 pb, corresponding to shift of 1 GeV)
 - Beam energy (0.38 pb)
- Result for $|V_{tb}|$:
 $|f_{LV} V_{tb}| = 1.02 \pm 0.09$

Coming soon:
Updated single top summary plots

Coming soon: updated summary plot

- Updated Wt combination at 8 TeV
- CMS t-channel updated at 13 TeV (TOP-16-003)
 - 15% uncertainty
- Show limits from individual 7 TeV and 8 TeV fits and combined fit for CMS s-channel

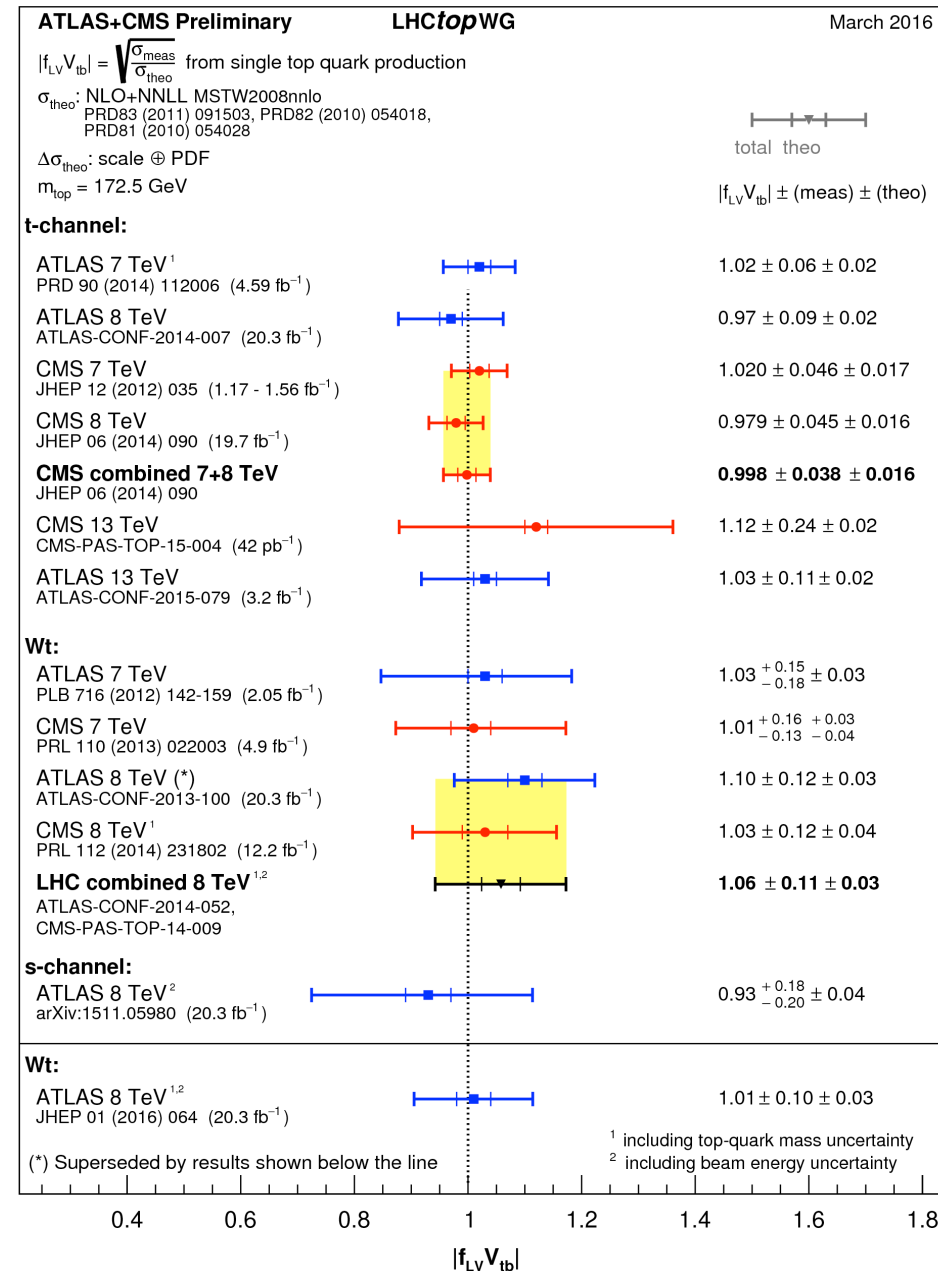
Current single top summary plot



Coming soon: updated Vtb summary

- Updated Wt combination at 8 TeV
- CMS t-channel updated at 13 TeV (TOP-16-003)
 - 7% uncertainty on $|f_{LVtb}|$

Current Vtb summary



Plans for Vtb

|V_{tb}| combination plans

- Single top-quark production cross-sections are proportional to $|V_{tb}|^2$
- Extract value for $|f_L V_{tb}|^2$ by dividing experimental measurement by theory prediction
- Combine values for $|f_L V_{tb}|^2$
 - Then take square root
- Publish as paper
 - Include published single top measurements
 - All 7 TeV and 8 TeV measurements
 - 13 TeV measurements only if published
- Should discuss theory predictions
 - Currently Hathor (NLO) for t-channel and s-channel, Kidonakis (NLO+NNLL) for Wt
 - ▶ Could switch to NNLO for t-channel
 - ▶ Could switch to NLO for Wt
 - Theory uncertainties
 - ▶ And their correlations

Vtb combination assumptions

- Assume V_{ts} and V_{td} are negligible
 - In single top production
 - In top quark decay
- Assume coupling is left-handed vector coupling
 - SM-like kinematics
- No assumptions about CKM unitarity
 - Sensitivity to new physics
 - Top could be mixing with top partner or other NP particles
- For future ideas, see Orso's talk from last year
<https://indico.cern.ch/event/403826>

Conclusions

- Final combination of ATLAS and CMS 8 TeV Wt cross-section measurements
 - Combination of published results
- Combined Wt cross-section measurements:
 $23.1 \pm 1.1 \pm 3.4 \pm 0.8 \text{ pb} = 23.1 \pm 3.6 \text{ pb}$
- Result is stable against correlation variations
- Uncertainty of 15.6% compared to ATLAS: $+15.9_{-16.9}\%$
- $|f_{LV} V_{tb}| = 1.02 \pm 0.09$

- Summary plots with updated Wt combination and latest CMS 13 TeV t-channel result will be approved soon

- V_{tb} combination in preparation
 - All channels and CM energies
 - Of published results