THE TOP-QUARK EW COUPLINGS AFTER LHC RUN2

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INTRODUCTION

In this work we present the results of a global fit of the top electro-weak couplings of the top quark to currently available data. The analysis considers the relevant dimension-six (D6) two-fermion operators that affect the top-quark electro-weak couplings in the Standard Model Effective Field Theory. Furthermore, we include, for the first time, the QCD corrections at NLO for most of the processes.

EFFECTIVE FIELD THEORY

- We adopt an EFT description to parametrize the deviations from the SM.

$$\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm SM} + \frac{1}{\Lambda^2}\sum_i C_i O_i + \mathcal{O}\left(\Lambda^{-4}\right).$$

- The Wilson coefficients can be later interpreted in terms of NP mediators.
- We include Λ^{-2} terms from the interference between the SM and D6 operators.
- We also include Λ^{-4} operators arising from two insertions of D6 operators.
- The effects of D8 operators, contributing to the same Λ^{-4} order, are omitted.
- We only consider the EW two-fermion operators and ignore the imaginary parts.
- The four-fermion operators are ignored.

The relevant operators, in the Warsaw basis, are:

Left and right-handed couplings of the top and bottom quark to the Z	EW dipole operators
$O^3_{\varphi Q} \equiv \frac{1}{2}(\bar q \tau^I \gamma^\mu q)\left(\varphi^\dagger i \overleftrightarrow{D}^I_\mu \varphi\right)$	$O_{uW} \equiv (\bar q \tau^I \sigma^{\mu\nu} u)\left(\epsilon\varphi^* W^I_{\mu\nu}\right)$
$O^1_{\varphi Q} \equiv \frac{1}{2}(\bar q \gamma^\mu q)\left(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi\right)$	$O_{dW} \equiv (\bar q \tau^I \sigma^{\mu\nu} d)\left(\varphi W^I_{\mu\nu}\right)$
$O_{\varphi u} \equiv \frac{1}{2}(\bar u \gamma^\mu u)\left(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi\right)$	$O_{uB} \equiv (\bar q \sigma^{\mu\nu} u)\left(\epsilon\varphi^* B_{\mu\nu}\right)$
$O_{\varphi d} \equiv \frac{1}{2}(\bar d \gamma^\mu d)\left(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi\right)$	$O_{dB} \equiv (\bar q \sigma^{\mu\nu} d)\left(\varphi B_{\mu\nu}\right)$

Chromo magnetic dipole operators	Top/Bottom yukawa
$O_{uG} \equiv (\bar q \sigma^{\mu\nu} T^A u)\left(\epsilon\varphi^* G^A_{\mu\nu}\right)$	$O_{u\varphi} \equiv (\bar q u)(\epsilon\varphi^*\, \varphi^\dagger\varphi)$
$O_{dG} \equiv (\bar q \sigma^{\mu\nu} T^A d)\left(\varphi G^A_{\mu\nu}\right)$	$O_{d\varphi} \equiv (\bar q d)(\varphi\, \varphi^\dagger\varphi)$

Charged current interaction
$O_{\varphi ud} \equiv \frac{1}{2}(\bar u \gamma^\mu d)\left(\varphi^T \epsilon i D_\mu \varphi\right)$

- The operators that are written in gray are not included in the fit.
- Following the prescriptions of the LHC top physics Working Group [1] we will work with $O^-_{\varphi Q}$ instead of $O^1_{\varphi Q}$ and O_{xZ} instead of O_{xB} ($x = u, d$):

$$O^1_{\varphi Q} \to O^-_{\varphi Q} = O^1_{\varphi Q} - O^3_{\varphi Q}; \qquad O_{xB} \to O_{xZ} = -\sin\theta_W O_{xB} + \cos\theta_W O_{xW}$$

METHOD & DATA

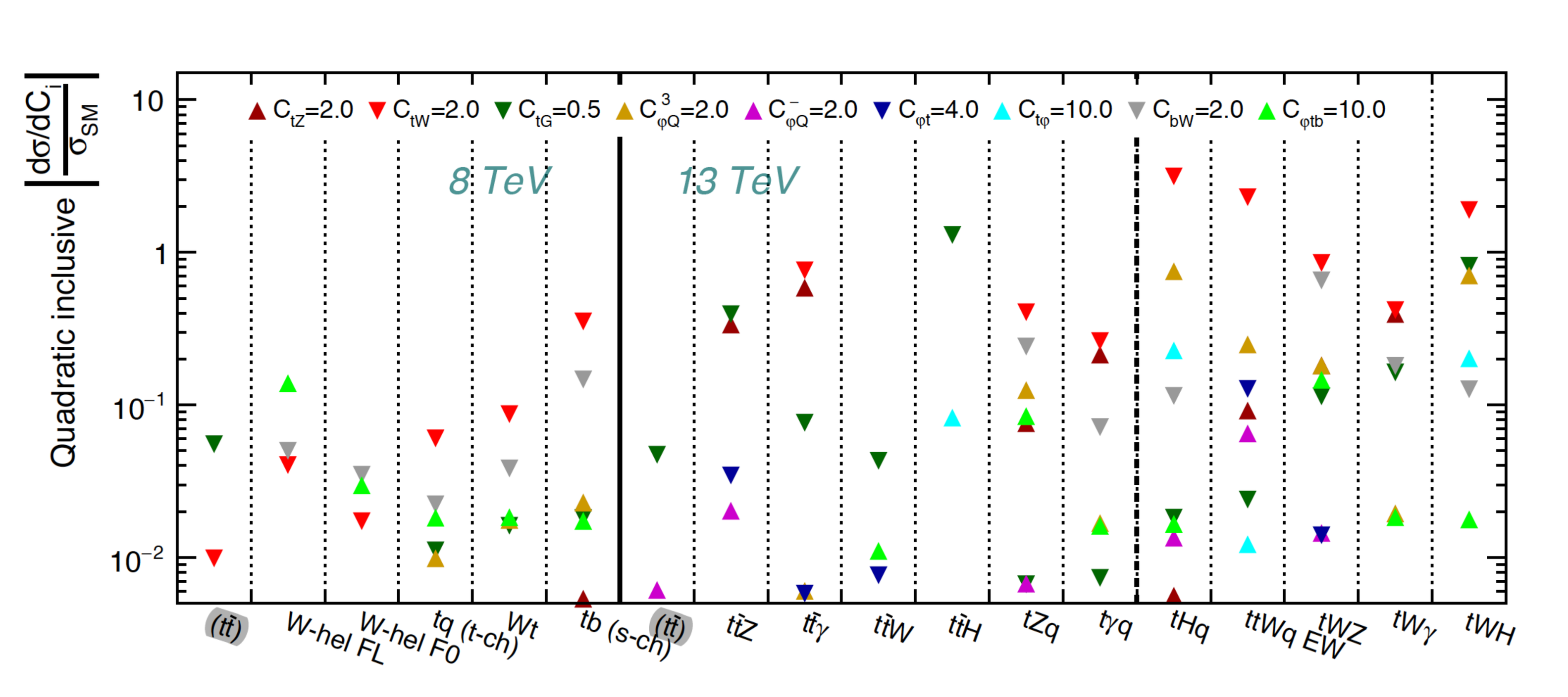
- The dependence of the observables included in the fit on the Wilson coefficients is calculated at NLO in QCD with the Monte Carlo generator `MG5_aMC@NLO` [2].
- We have used the `SMEFT@NLO` UFO [3] model for all the observables except C_{bW}, $C_{\varphi tb}$, C_{bZ} and $C_{\varphi b}$ where the `TEFT_EW` UFO [4] model was used
- The fit is performed as a Bayesian statistical analysis of the model using the open source `HEPfit`.

The observables included in the fit are the following:

Process	Observable	$\sqrt{s}$	$\int \mathcal{L}$	Experiment	Parametrisation @
$pp \to t\bar tH$	cross section	13 TeV	140 fb^{-1}	ATLAS [5]	NLO
$pp \to t\bar tW$	cross section	13 TeV	36 fb^{-1}	CMS [6]	NLO
$pp \to t\bar tZ$	(differential) x-sec.	13 TeV	140 fb^{-1}	ATLAS	NLO
$pp \to t\bar t\gamma$	(differential) x-sec.	13 TeV	140 fb^{-1}	ATLAS	NLO
$pp \to tZq$	cross section	13 TeV	140 fb^{-1}	CMS	NLO
$pp \to t\gamma q$	cross section	13 TeV	36 fb^{-1}	CMS	NLO
$pp \to tb$ (s-ch)	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS	NLO
$pp \to tW$	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS	LO
$pp \to tq$ (t-ch)	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS	NLO
$t \to W^+b$	F_0, F_L	8 TeV	20 fb^{-1}	ATLAS+CMS	LO
$e^-e^+ \to b\bar b$	R_b , A^{bb}_{FBLR}	~ 91 GeV	202.1 pb^{-1}	LEP	LO

SENSITIVITY

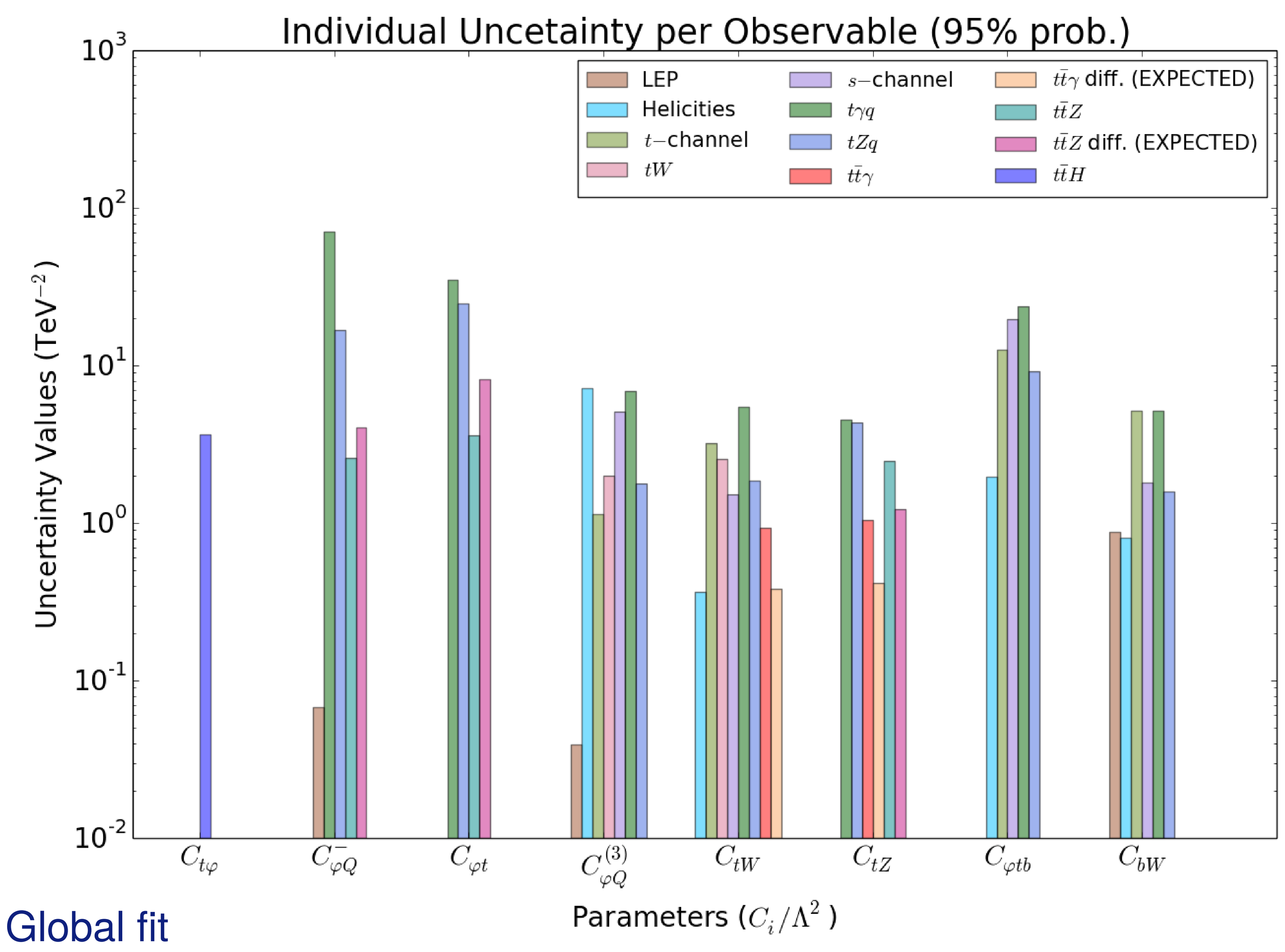
- Here we show the sensitivity of each observable with each Wilson coefficient



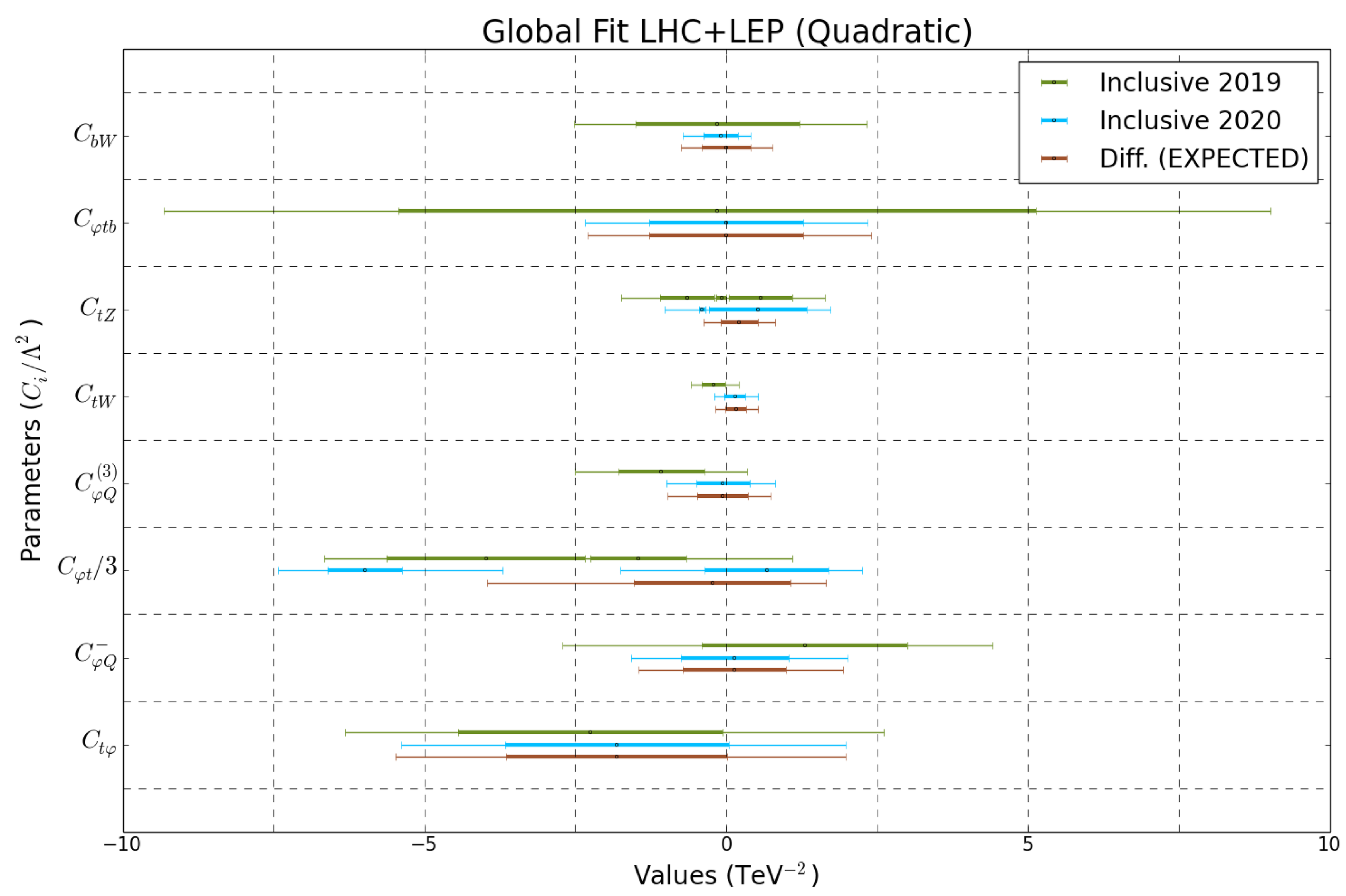
- The observables of the right part (after the dotted-dashed line) are not included because cross-section measurements are not available yet.
- The $pp \to t\bar t$ process is also omitted in the fit in order to be consistent as it is used to reduce the dependence of $pp \to t\bar tX$ on Wilson coefficients that have not been included.

RESULTS OF THE FIT

- Uncertainty from individual constraints per observable.



- Global fit



CONCLUSIONS

- All results compatible with $C_i = 0$ (SM) within 68% probability.
- We expect that the preliminary differential cross section measurements for $t\bar tZ$ and $t\bar t\gamma$ can improve the limit on C_{tZ} by a factor two.
- LEP EW precision measurements provide tight individual bounds on several operators; in the global fit the impact is a factor two improvement of the bound on the left-handed coupling $C^-_{\varphi Q}$.
- These limits are the most stringent bounds on the top EW couplings from an EFT analysis that includes all relevant two-fermion degrees of freedom [8-10].

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