THE TOP QUARK ELECTRO-WEAK COUPLINGS AFTER LHC RUN 2

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- Recent measurements at LHC allow for a robust and precise characterisation of the top quark EW interactions.
- A global analysis at NLO precision including LHC, LEP/SLD and Tevatron data in the SMEFT framework is presented here.
- A careful analysis of the impact of correlations among measurements and uncertainties in the EFT setup is included.

Follow an **EFT description** to parametrise the deviations from the SM

$$X = X_{SM} + \sum_i \frac{\mathcal{C}_i}{\Lambda^2} X_i^{(1)} + \sum_{ij} \frac{\mathcal{C}_i \mathcal{C}_j}{\Lambda^4} X_{ij}^{(2)} + \mathcal{O}(\Lambda^{-4}) = X_{SM} \times \left(1 + \sum_i \frac{\mathcal{C}_i}{\Lambda^2} \frac{X_i^{(1)}}{X_{SM}} + \sum_{ij} \frac{\mathcal{C}_i \mathcal{C}_j}{\Lambda^4} \frac{X_{ij}^{(2)}}{X_{SM}}\right) + \mathcal{O}(\Lambda^{-4})$$

Here, we consider **8 dim-six operators** in the **Warsaw basis:**

- ☆ Left/Right-handed couplings of top/bottom to Z: $O_{\varphi t}, O^{-}_{\varphi Q}, O^{(3)}_{\varphi Q}$
- ☆ EW dipole operators: O_{tZ}, O_{tW}, O_{bW}
- ☆ Top Yukawa: $O_{t\varphi}$
- ☆ Charged current interaction: $O_{\varphi tb}$

Dependence derived with **MadGraph5_aMC@NLO,** plus **SMEFT@NLO** and **TEFT_EW**

Fitting model to data using **Bayesian inference with HEPfit**

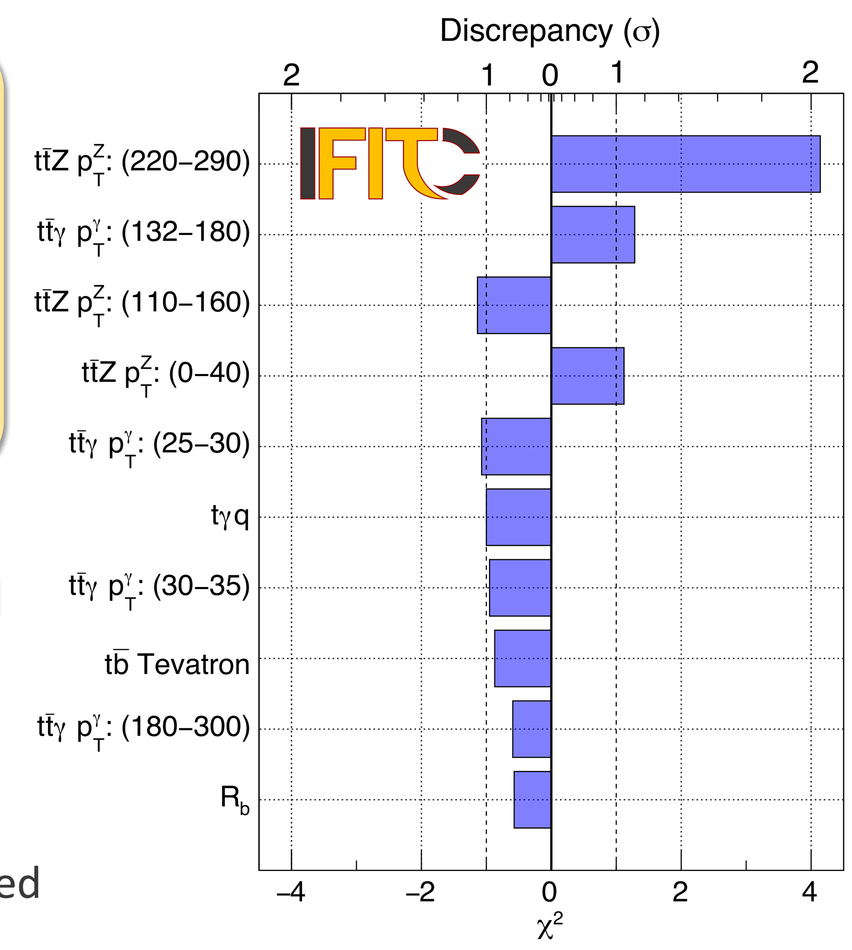
Measurements included

For the first time, we include:
☆ **Differential measurements for $pp \to t\bar{t}Z$ / $t\bar{t}\gamma$**
☆ **QCD predictions at NLO**

Process	Observable	$\sqrt{s}$	$\int \mathscr{L}$	Experiment
$pp \to t\bar{t}H$ NLO	cross section	13 TeV	140 fb^{-1}	ATLAS
$pp \to t\bar{t}W$ NLO	cross section	13 TeV	36 fb^{-1}	CMS
$pp \to t\bar{t}Z$ NLO	(differential) x-sec.	13 TeV	140 fb^{-1}	ATLAS
$pp \to t\bar{t}\gamma$ NLO	(differential) x-sec.	13 TeV	140 fb^{-1}	ATLAS
$pp \to tZq$ NLO	cross section	13 TeV	140 fb^{-1}	CMS
$pp \to t\gamma q$ NLO	cross section	13 TeV	36 fb^{-1}	CMS
$pp \to tb$ (s-ch) NLO	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS
$pp \to tW$ NLO	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS
$pp \to tq$ (t-ch) NLO	cross section	8 TeV	20 fb^{-1}	ATLAS+CMS
$t \to W^+ b$ NLO	F_0, F_L	8 TeV	20 fb^{-1}	ATLAS+CMS
$p\bar{p} \to tb$ (s-ch) LO	cross section	1.96 TeV	9.7 fb^{-1}	Tevatron
$e^-e^+ \to b\bar{b}$ LO	R_b, A^{bb}_{FBLR}	$\sim$ 91 GeV	202.1 pb^{-1}	LEP

How well does the SM describe data?
- **SM fit:** including all the observables (30 bins) gives very good agreement with $\chi^2 \sim 21$ (p-value$\sim$0.85)
- Largest contributions to the χ^2 from a few $t\bar{t}Z$ and $t\bar{t}\gamma$ differential p_T bins

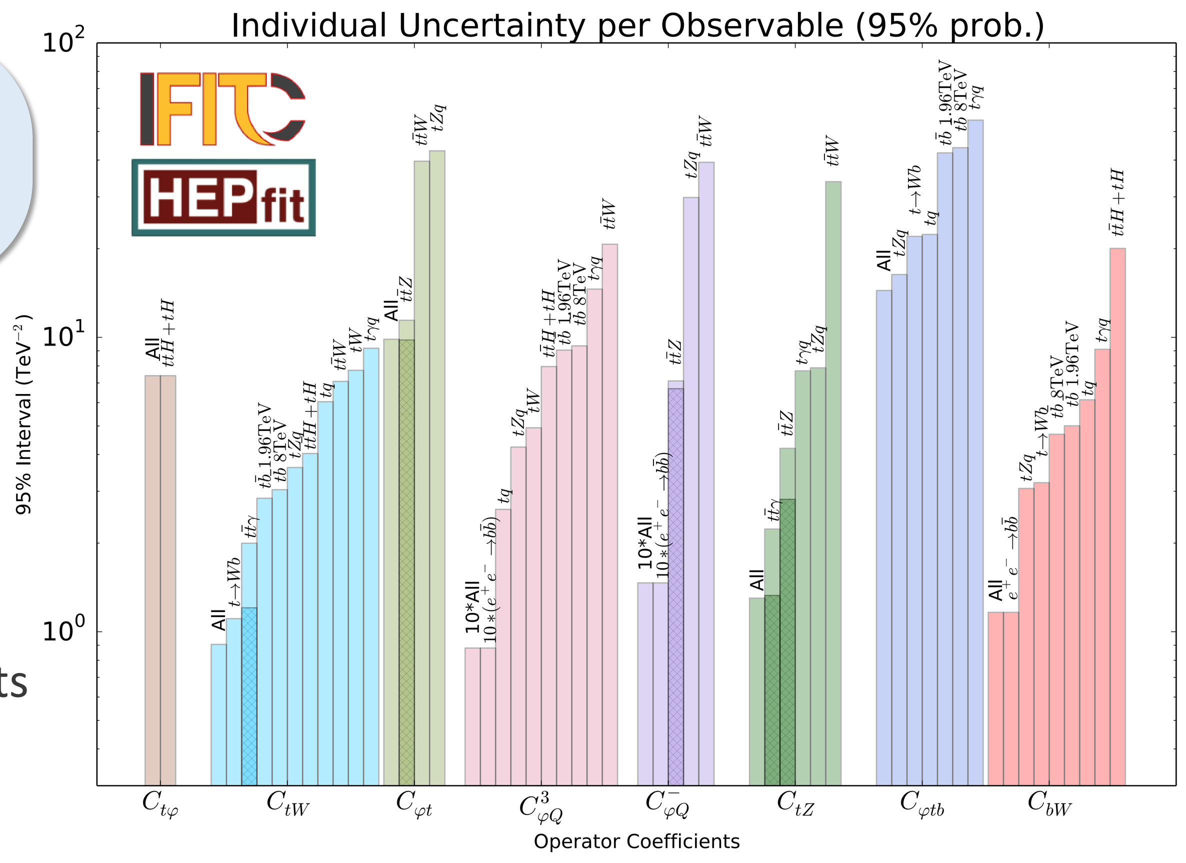
The beloved Standard Model



Correlations between differential p_T bins, LEP observables and W boson helicity fractions published in the experimental results are included

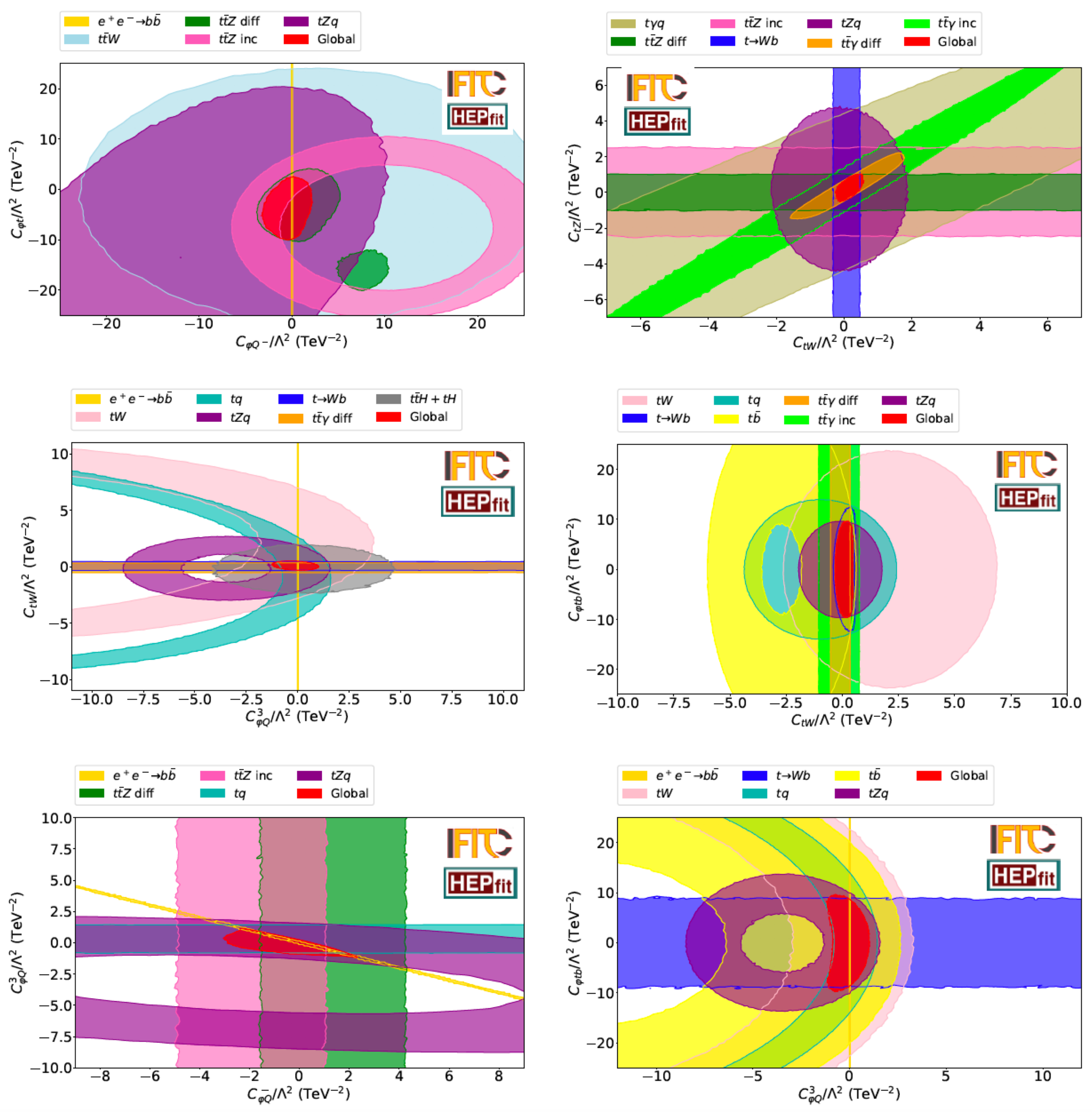
Towards a global fit to the top EW couplings

Sensitivity of each observable



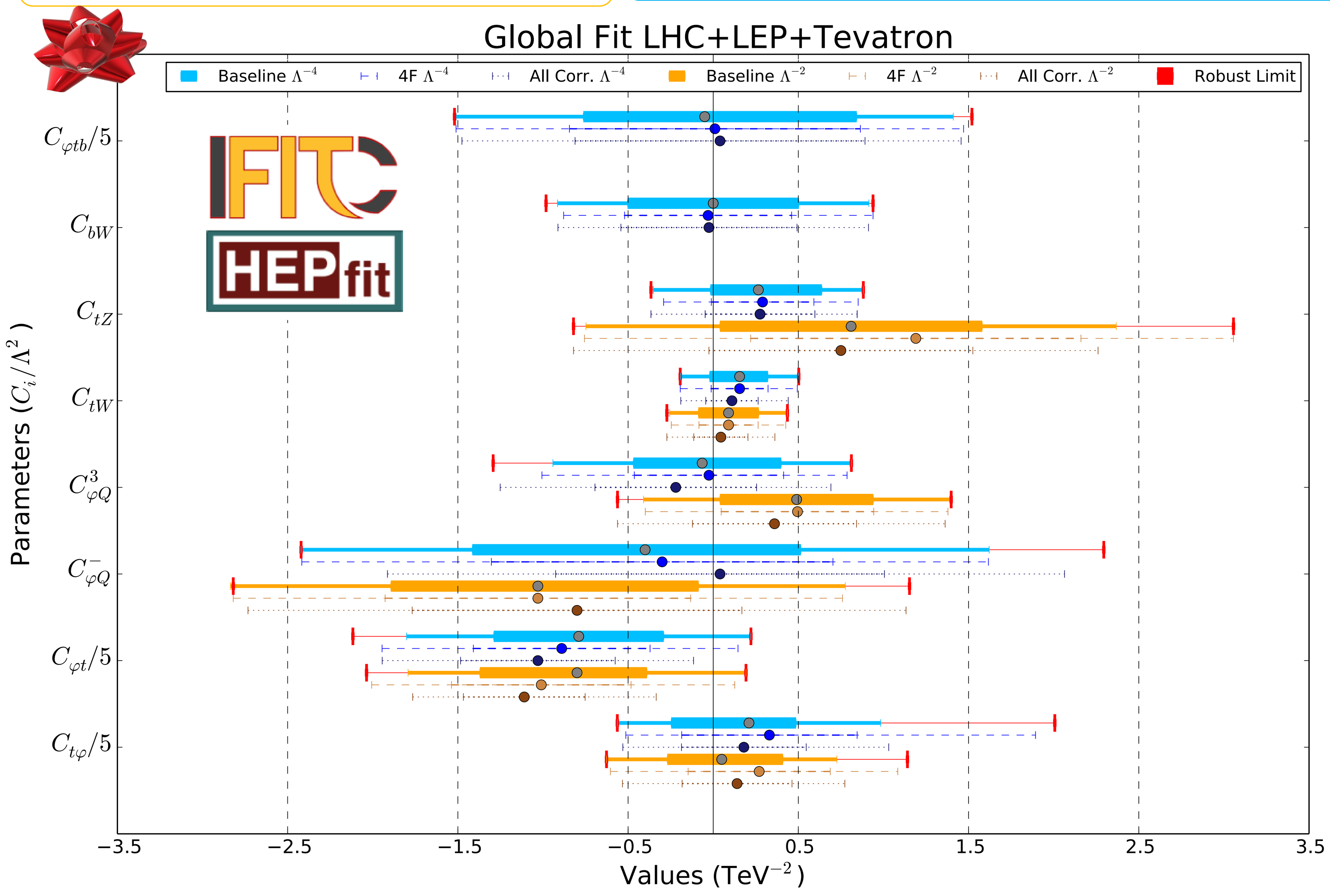
Differential measurements indicated as darker bars

☆ 2D 95% probability contours showing complementarity between measurements
☆ Watch out for: LEP in $C^{-}_{\varphi Q}, C^{(3)}_{\varphi Q}$; $t\bar{t}Z$ in $C_{tZ}, C_{\varphi t}$; $t\bar{t}\gamma$ and W hel. in C_{tW}; tZq in $C_{\varphi tb}$



Global fit

Linear, Λ^{-2} terms (SM – D6 interf.) | Quadratic, $\Lambda^{-2} + \Lambda^{-4}$ terms (D6 – D6 interf.)



Linear fit vs. quadratic fit
☆ Overall comparable results
☆ Main difference between the two sets of results seen for C_{tZ}

A **significant improvement** on all Wilson coefficients
☆ **Differential measurements** improve C_{tZ} limits by a factor 2
☆ **LEP/SLD data** are still very competitive
☆ Central values compatible with SM within 2σ
☆ 95% prob. bounds ± 0.35 to ± 8 TeV^{-2}

Yeah!

OUR UNIQUENESS: check the robustness of the fit:
☆ **Correlations between different observables (ansatzs for non-published correlations have been estimated)**
☆ Effect of 3 additional operators: O_{tG} and two 4-fermion op. O^8_{tu} and O^8_{td}
☆ Missing higher-orders in α_S in EFT parametrisations
→ **Robust limits:** envelope obtained from results of new fits with these effects

COOL!

Recent LHC results allow to significantly improve the bounds from previous fits and the obtained limits are quite robust. Future work could include imaginary parts in the operators and additional data from Higgs, EW and flavour physics.