Combined SMEFT interpretation of Higgs, diboson, and top quark data from the LHC

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The Standard Model EFT

Extend SM Lagrangian with **complete, non-redundant basis** of higher dimensional operators

$$\mathscr{L}_{\rm SMEFT} = \mathscr{L}_{\rm SM} + \sum_i^{N_{d5}} \frac{a_i}{\Lambda}\mathscr{O}_i^{(5)} + \sum_i^{N_{d6}} \frac{c_i}{\Lambda^2}\mathscr{O}_i^{(6)} + \sum_i^{N_{d7}} \frac{d_i}{\Lambda^3}\mathscr{O}_i^{(7)} + \sum_j^{N_{d8}} \frac{b_j}{\Lambda^2}\mathscr{O}_i^{(8)} + \dots$$

N_{d6} = 59 (2499) for one (three) flavour generations

pure bosonic operators

X^3		$X^2\varphi^2$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi G}$	$\varphi^\dagger \varphi\, G^A_{\mu\nu} G^{A\mu\nu}$
$Q_{\widetilde G}$	$f^{ABC} \widetilde G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi B}$	$\varphi^\dagger \varphi\, B_{\mu\nu} B^{\mu\nu}$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi W}$	$\varphi^\dagger \varphi\, W^I_{\mu\nu} W^{I\mu\nu}$
$Q_{\widetilde W}$	$\varepsilon^{IJK} \widetilde W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi\, W^I_{\mu\nu} B^{\mu\nu}$
φ^6		$Q_{\varphi \widetilde G}$	$\varphi^\dagger \varphi\, \widetilde G^A_{\mu\nu} G^{A\mu\nu}$
Q_φ	$(\varphi^\dagger\varphi)^3$	$Q_{\varphi \widetilde B}$	$\varphi^\dagger \varphi\, \widetilde B_{\mu\nu} B^{\mu\nu}$
$\varphi^4 D^2$		$Q_{\varphi \widetilde W}$	$\varphi^\dagger \varphi\, \widetilde W^I_{\mu\nu} W^{I\mu\nu}$
$Q_{\varphi\Box}$	$(\varphi^\dagger\varphi)\Box(\varphi^\dagger\varphi)$	$Q_{\varphi \widetilde W B}$	$\varphi^\dagger \tau^I \varphi\, \widetilde W^I_{\mu\nu} B^{\mu\nu}$
$Q_{\varphi D}$	$\left(\varphi^\dagger D^\mu\varphi\right)^* \left(\varphi^\dagger D_\mu\varphi\right)$		

four-fermion operators

$(\bar LL)(\bar LL)$		$(\bar LL)(\bar RR)$	
$Q_{\ell\ell}$	$(\bar\ell\gamma_\mu\ell)(\bar\ell\gamma^\mu\ell)$	$Q_{\ell e}$	$(\bar\ell\gamma_\mu\ell)(\bar e\gamma^\mu e)$
$Q_{qq}^{(1)}$	$(\bar q\gamma_\mu q)(\bar q\gamma^\mu q)$	$Q_{\ell u}$	$(\bar\ell\gamma_\mu\ell)(\bar u\gamma^\mu u)$
$Q_{qq}^{(3)}$	$(\bar q\gamma_\mu\tau^I q)(\bar q\gamma^\mu\tau^I q)$	$Q_{\ell d}$	$(\bar\ell\gamma_\mu\ell)(\bar d\gamma^\mu d)$
$Q_{\ell q}^{(1)}$	$(\bar\ell\gamma_\mu\ell)(\bar q\gamma^\mu q)$	Q_{qe}	$(\bar q\gamma_\mu q)(\bar e\gamma^\mu e)$
$Q_{\ell q}^{(3)}$	$(\bar\ell\gamma_\mu\tau^I\ell)(\bar q\gamma^\mu\tau^I q)$	$Q_{qu}^{(1)}$	$(\bar q\gamma_\mu q)(\bar u\gamma^\mu u)$

bosonic-fermionic operators

$\psi^2\varphi^3$		$\psi^2\varphi^2 D$	
$Q_{u\varphi}$	$(\varphi^\dagger\varphi)(\bar q u\widetilde\varphi)$	$Q_{\varphi\ell}^{(1)}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar\ell\gamma^\mu\ell)$
$Q_{d\varphi}$	$(\varphi^\dagger\varphi)(\bar q d\varphi)$	$Q_{\varphi\ell}^{(3)}$	$(\varphi^\dagger i\overleftrightarrow{D}^I_\mu\varphi)(\bar\ell\tau^I\gamma^\mu\ell)$
$Q_{e\varphi}$	$(\varphi^\dagger\varphi)(\bar\ell e\varphi)$	$Q_{\varphi e}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar e\gamma^\mu e)$
$\psi^2 X\varphi$		$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar q\gamma^\mu q)$
Q_{eW}	$(\bar\ell\sigma^{\mu\nu}e)\tau^I\varphi W^I_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i\overleftrightarrow{D}^I_\mu\varphi)(\bar q\tau^I\gamma^\mu q)$
Q_{eB}	$(\bar\ell\sigma^{\mu\nu}e)\varphi B_{\mu\nu}$	$Q_{\varphi u}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar u\gamma^\mu u)$
Q_{uG}	$(\bar q\sigma^{\mu\nu}T^A u)\widetilde\varphi G^A_{\mu\nu}$	$Q_{\varphi d}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar d\gamma^\mu d)$
Q_{uW}	$(\bar q\sigma^{\mu\nu}u)\tau^I\widetilde\varphi W^I_{\mu\nu}$	$Q_{\varphi ud}$	$(\widetilde\varphi^\dagger iD_\mu\varphi)(\bar u\gamma^\mu d)$

The Standard Model EFT

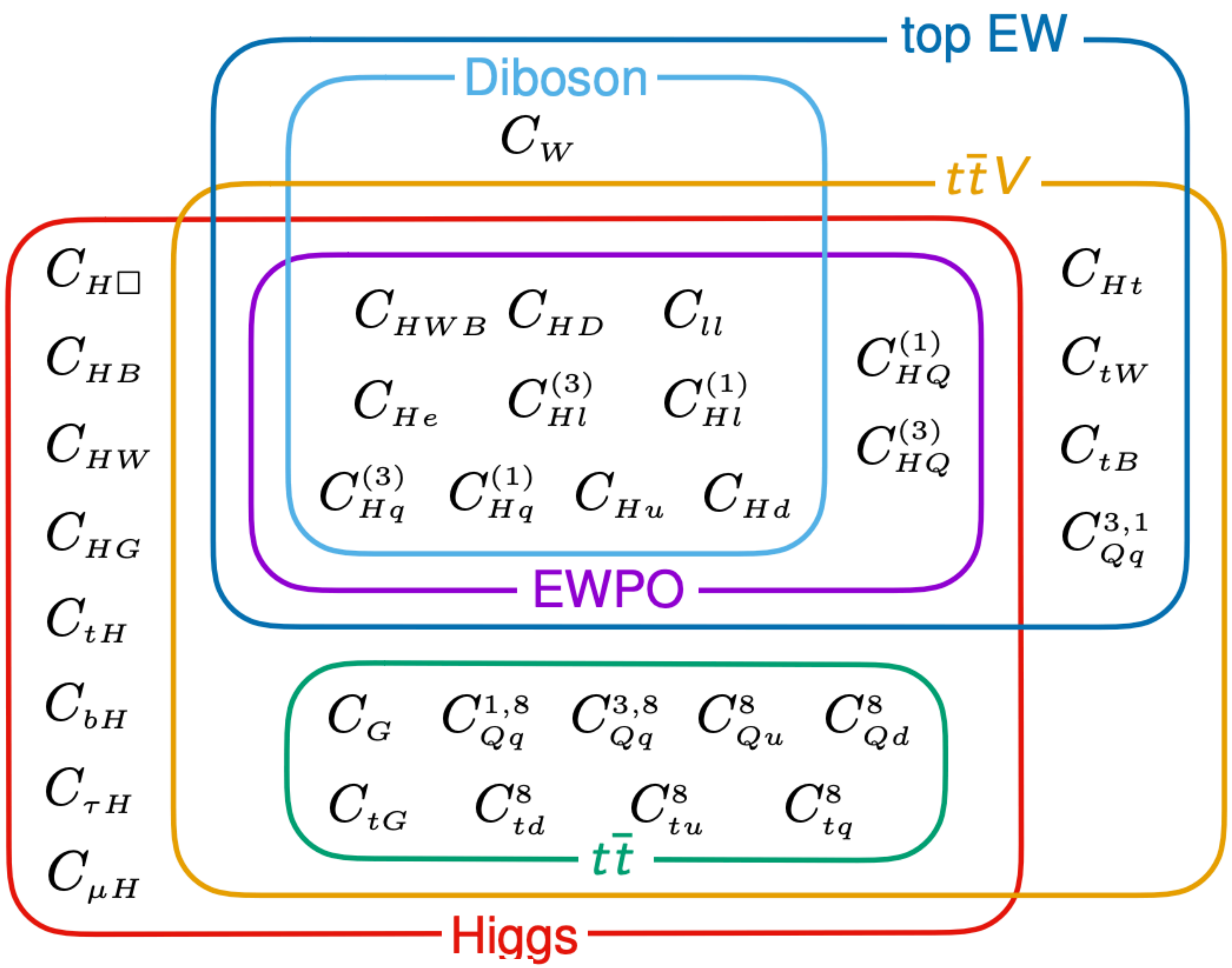
Extend SM Lagrangian with **complete, non-redundant basis** of higher dimensional operators

$$\mathscr{L}_{\rm SMEFT} = \mathscr{L}_{\rm SM} + \sum_i^{N_{d5}} \frac{a_i}{\Lambda}\mathscr{O}_i^{(5)} + \sum_i^{N_{d6}} \frac{c_i}{\Lambda^2}\mathscr{O}_i^{(6)} + \sum_i^{N_{d7}} \frac{d_i}{\Lambda^3}\mathscr{O}_i^{(7)} + \sum_j^{N_{d8}} \frac{b_j}{\Lambda^2}\mathscr{O}_i^{(8)} + \ldots$$

- **Low-energy limit** of generic UV-complete theories (with linearly realized EWSB)
- **Complete basis** at any given mass-dimension: systematic parametrisation of BSM effects
- **Fully renormalizable**, full-fledged QFT: compute higher orders in QCD and EW
- Matched to a large number of **BSM models** that reduce to the SM at low energies
- Some operators induce **growth with the partonic centre-of-mass energy**: increased sensitivity in LHC cross-sections in the TeV region

$$\sigma(E) = \sigma_{\rm SM} \times (E)\left(1 + \sum_i^{N_{d6}} \omega_i \frac{c_i\, v^2}{\Lambda^2} + \sum_i^{N_{d6}} \widetilde{\omega}_i \frac{c_i\, E^2}{\Lambda^2} + \mathscr{O}\left(\Lambda^{-4}\right)\right)$$

The Standard Model EFT



FitMaker, 2012.02779

Fulfilling the potential of the SMEFT framework demands global analyses based on **a wide range of process and data** to cover all relevant **directions in the EFT parameter space**

Notation	Sensitivity at $\mathcal{O}(\Lambda^{-2})$ ($\mathcal{O}(\Lambda^{-4})$)								
	$t\bar{t}$	single-top	tW	tZ	$t\bar{t}W$	$t\bar{t}Z$	$t\bar{t}H$	$t\bar{t}t\bar{t}$	$t\bar{t}b\bar{b}$
OQQ1								✓	✓
OQQ8								✓	✓
OQt1								✓	✓
OQt8								✓	✓
OQb1								(✓)	✓
OQb8								(✓)	✓
Ott1								✓	✓
Otb1								(✓)	✓
Otb8								✓	✓
OQtQb1									
OQtQb8									
O81qq	✓				✓	✓	✓	✓	✓
O11qq	✓				(✓)	(✓)	(✓)	✓	✓
O83qq	✓	✓		(✓)	✓	✓	✓	✓	✓
O13qq	✓	✓		✓	(✓)	(✓)	(✓)	✓	✓
O8qt	✓				✓	✓	✓	✓	✓
O1qt	✓				(✓)	(✓)	(✓)	✓	✓
O8ut	✓					✓	✓	✓	✓
O1ut	✓					(✓)	(✓)	✓	✓
O8qu	✓					✓	✓	✓	✓
O1qu	✓					(✓)	(✓)	✓	✓
O8dt	✓					✓	✓	✓	✓
O1dt	✓					(✓)	(✓)	✓	✓
O8qd	✓					✓	✓	✓	✓
O1qd	✓					(✓)	(✓)	✓	✓
OtG	✓				✓	✓	✓	✓	✓
OtW		✓	✓	✓					
ObW		(✓)	(✓)						
OtZ				✓		✓			
Off		(✓)	(✓)	(✓)					
Ofq3		✓	✓	✓		✓			
OpQM				✓		✓			
Opt				✓		✓	✓		
Otp							✓		

SMEFiT, 1901.05965

The Standard Model EFT

from Lagrangian …

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_{m=1}^{N_6} \frac{c_m}{\Lambda^2}\mathcal{O}_i^{(6)} + \sum_{n=1}^{N_8} \frac{b_j}{\Lambda^4}\mathcal{O}_i^{(8)} + \ldots$$

SM **EFT$_{\rm d6}$** **EFT$_{\rm d8}$**

Linear EFT cross-sections: interference SM-EFT$_{\rm d6}$

Quadratic EFT cross-sections: squares EFT$_{\rm d6}$

to cross-sections ….

$$\sigma_{\rm SMEFT}\left(\boldsymbol{c}, \boldsymbol{\Lambda}\right) \simeq \sigma_{\rm SM} \times \left(1 + \sum_{m=1}^{N_6} \frac{c_m}{\Lambda^2}\sigma_m^{(\rm eft)} + \sum_{m,n=1}^{N_6} \frac{c_m c_n}{\Lambda^4}\sigma_{m,n}^{(\rm eft)} \right)$$

evaluate at (N)NLO QCD + NLO EW

evaluate at NLO QCD
with **SMEFT@NLO**

The Standard Model EFT

… to constraints on the EFT parameters

$$\chi^2(\boldsymbol{c},\Lambda) = \frac{1}{n_{\rm dat}} \sum_{i,j=1}^{n_{\rm dat}} \left(\sigma_{\rm i,SMEFT}(\boldsymbol{c},\Lambda) - \sigma_{\rm i,exp}\right) \left({\rm cov}^{-1}\right)_{ij} \left(\sigma_{\rm j,SMEFT}(\boldsymbol{c},\Lambda) - \sigma_{\rm j,exp}\right)$$

log-likelihood minimisation

Linear EFT cross-sections:

interference SM-EFT$_{\rm d6}$

Quadratic EFT cross-sections:

squares EFT$_{\rm d6}$

to cross-sections ….

$$\sigma_{\rm SMEFT}\left(\boldsymbol{c},\boldsymbol{\Lambda}\right) \simeq \sigma_{\rm SM} \times \left(1 + \sum_{m=1}^{N_6} \frac{c_m}{\Lambda^2}\sigma_m^{(\rm eft)} + \sum_{m,n=1}^{N_6} \frac{c_m c_n}{\Lambda^4}\sigma_{m,n}^{(\rm eft)}\right)$$

evaluate at (N)NLO QCD + NLO EW

evaluate at NLO QCD

with **SMEFT@NLO**

The SMEFiT framework

Theory

(N)NLO QCD + NLO EW for SM xsecs

NLO QCD, both linear and quadratic terms, **with SMEFT@NLO**

State-of-the-art **parton distributions**

Data

Higgs data (signal strengths, diff, STXS), **diboson LEP and LHC**, all available **top quark data** from Runs I+II, VBS, more in progress

Full experimental **correlations** included

SMEFiT

SMEFiT, 2105.00006

Validation

Extensive **statistical toolbox** to validate results: information geometry, PCA, closure testing, …

Full **posterior probabilities** in the EFT coefficients available, likelihoods WIP

Methodology

Two independent fitting methods, **MCfit** and **NestedSampling** (no reliance on linear approx) cross-check each other

Modular structure facilitates adding new datasets of better theory calculations

Operator basis and flavour assumptions

Class	$N_{\rm dof}$	Independent DOFs	DoF in EWPOs
four-quark (two-light-two-heavy)	14	$c_{Qq}^{1,8}$, $c_{Qq}^{1,1}$, $c_{Qq}^{3,8}$, $c_{Qq}^{3,1}$, c_{tq}^{8}, c_{tq}^{1}, c_{tu}^{8}, c_{tu}^{1}, c_{Qu}^{8}, c_{Qu}^{1}, c_{td}^{8}, c_{td}^{1}, c_{Qd}^{8}, c_{Qd}^{1}	
four-quark (four-heavy)	5	c_{QQ}^{1}, c_{QQ}^{8}, c_{Qt}^{1}, c_{Qt}^{8}, c_{tt}^{1}	
four-lepton	1		$c_{\ell\ell}$
two-fermion (+ bosonic fields)	23	$c_{t\varphi}$, c_{tG}, $c_{b\varphi}$, $c_{c\varphi}$, $c_{\tau\varphi}$, c_{tW}, c_{tZ}, $c_{\varphi Q}^{(3)}$, $c_{\varphi Q}^{(-)}$, $c_{\varphi t}$	$c_{\varphi\ell_1}^{(1)}$, $c_{\varphi\ell_1}^{(3)}$, $c_{\varphi\ell_2}^{(1)}$, $c_{\varphi\ell_2}^{(3)}$, $c_{\varphi\ell_3}^{(1)}$, $c_{\varphi\ell_3}^{(3)}$, $c_{\varphi e}$, $c_{\varphi\mu}$, $c_{\varphi\tau}$, $c_{\varphi q}^{(3)}$, $c_{\varphi q}^{(-)}$, $c_{\varphi u}$, $c_{\varphi d}$
Purely bosonic	7	$c_{\varphi G}$, $c_{\varphi B}$, $c_{\varphi W}$, $c_{\varphi d}$, c_{WWW}	$c_{\varphi WB}$, $c_{\varphi D}$
Total	50 (36 independent)	34	16 (2 independent)

- **Dim-6 SMEFT operators** modifying Higgs, dibosons, and top quark properties: **36** (14) **independent** (dependent) **DoFs**

- Flavour assumption is **MFV**, with $\mathrm{U}(2)_q \times \mathrm{U}(2)_u \times \mathrm{U}(3)_d$ in quark sector (special role for top quark) and $\left(\mathrm{U}(1)_\ell \times \mathrm{U}(1)_e\right)^3$ in lepton sector

- Constraints from **LEP EWPOs** imposed via restrictions in parameter space

$$\begin{pmatrix} c_{\varphi\ell_i}^{(3)} \\ c_{\varphi\ell_i}^{(1)} \\ c_{\varphi e/\mu/\tau} \\ c_{\varphi q}^{(-)} \\ c_{\varphi q}^{(3)} \\ c_{\varphi u} \\ c_{\varphi d} \\ c_{\ell\ell} \end{pmatrix} = \begin{pmatrix} -\frac{1}{t_W} & -\frac{1}{4t_W^2} \\ 0 & -\frac{1}{4} \\ 0 & -\frac{1}{2} \\ \frac{1}{t_W} & \frac{1}{4s_W^2} - \frac{1}{6} \\ -\frac{1}{t_W} & -\frac{1}{4t_W^2} \\ 0 & \frac{1}{3} \\ 0 & -\frac{1}{6} \\ 0 & 0 \end{pmatrix} \begin{pmatrix} c_{\varphi WB} \\ c_{\varphi D} \end{pmatrix}$$

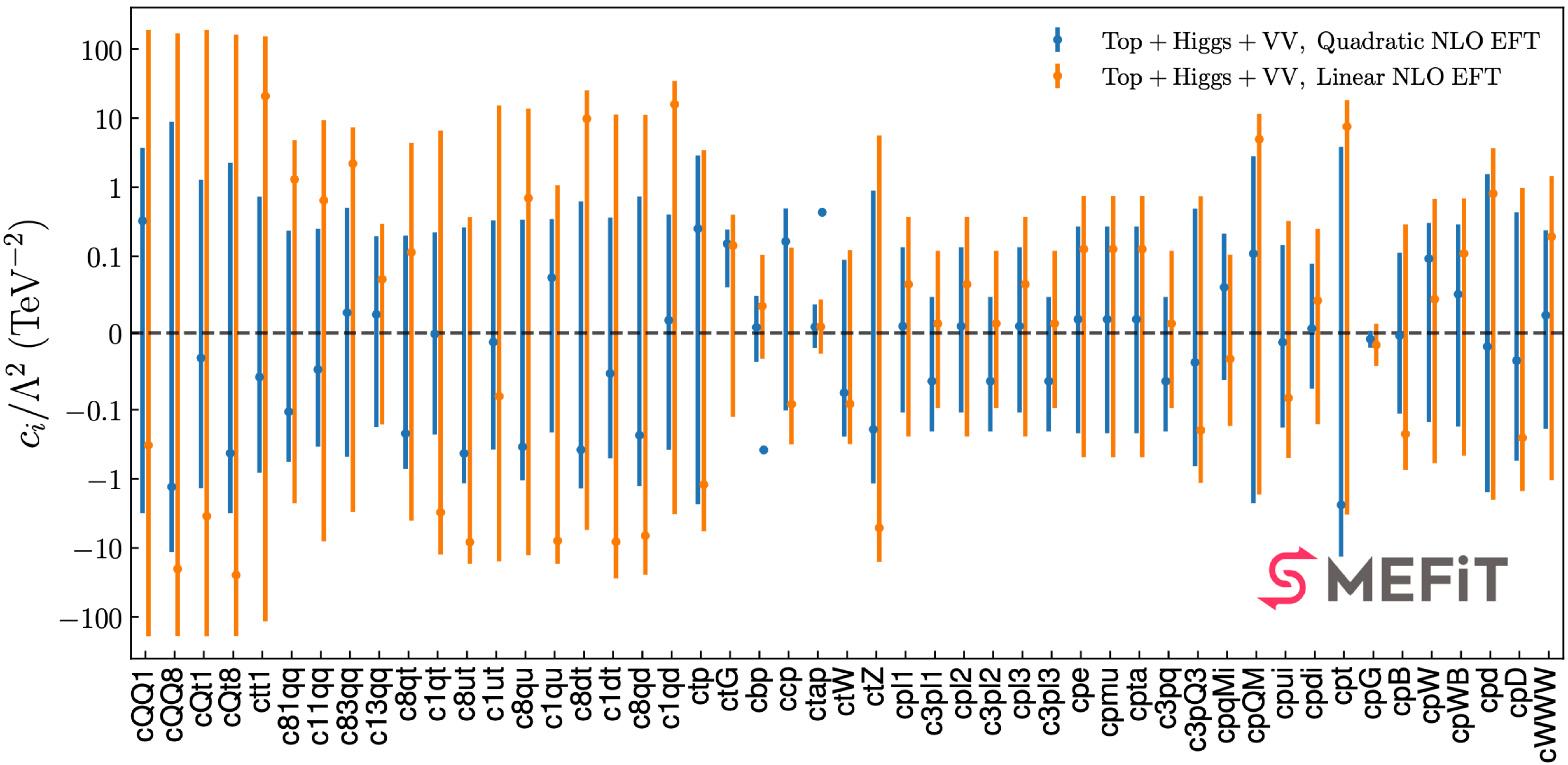
Experimental data

Category	Processes	$n_{\rm dat}$
Top quark production	$t\bar{t}$ (inclusive) **(incl LHC charge asy)**	94
	$t\bar{t}Z$, $t\bar{t}W$ **(incl ptZ in ttZ)**	14
	single top (inclusive)	27
	tZ, tW	9
	$t\bar{t}t\bar{t}$, $t\bar{t}b\bar{b}$	6
	Total	**150**
Higgs production and decay	Run I signal strengths	22
	Run II signal strengths	40
	Run II, differential distributions & STXS	35
	Total	**97**
Diboson production	LEP-2 **(WW)**	40
	LHC **(WW & WZ)**	30
	Total	**70**
Baseline dataset	**Total**	**317**

systematic assessment of fit results **wrt dataset variations**:

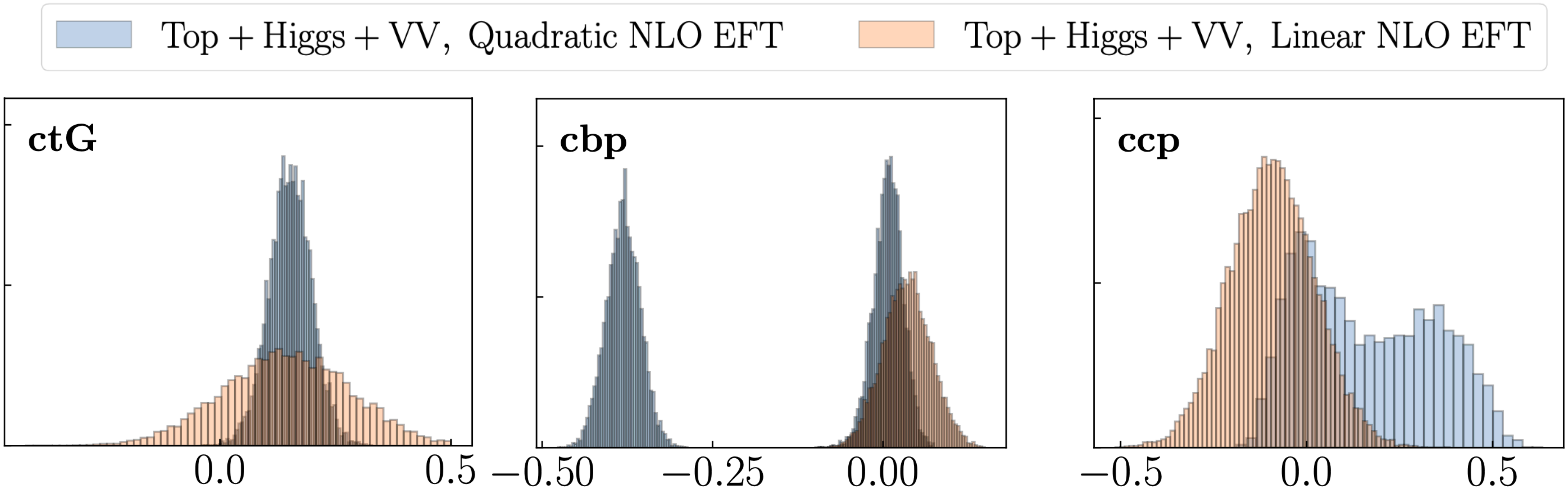
Higgs-only fit, top-only fit, no high-E data, no diboson data …

Results: global fit



- Agreement **with SM at 95% CL** for all EFT coefficients except for $\boldsymbol{c_{tG}}$ in quadratic fit
- Quadratic corrections bring in **sensitivity** (more stringent bounds) *e.g.* for four-fermion operators
- Some DoFs exhibit a second ``**BSM-like" solution** in the quadratic fit

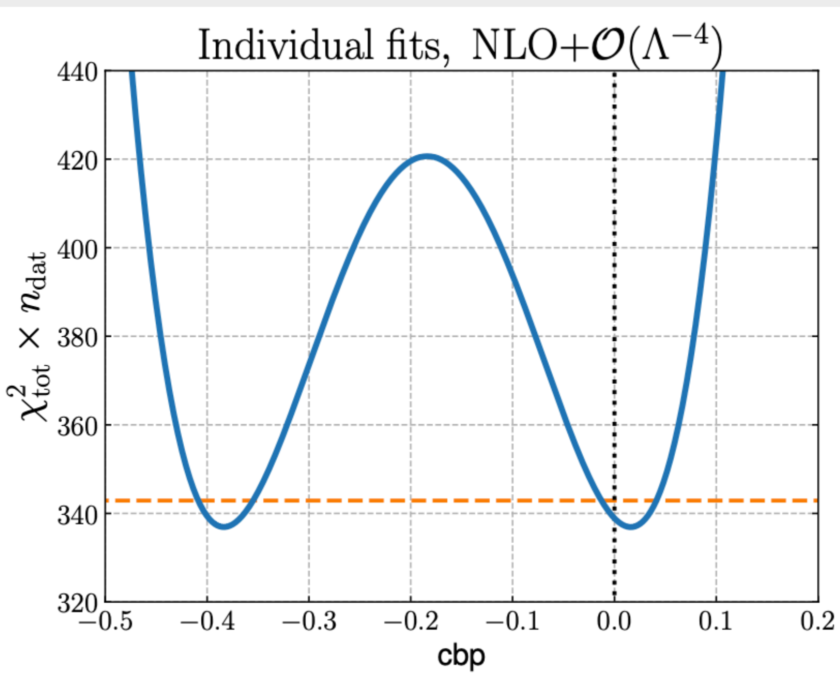
Results: global fit

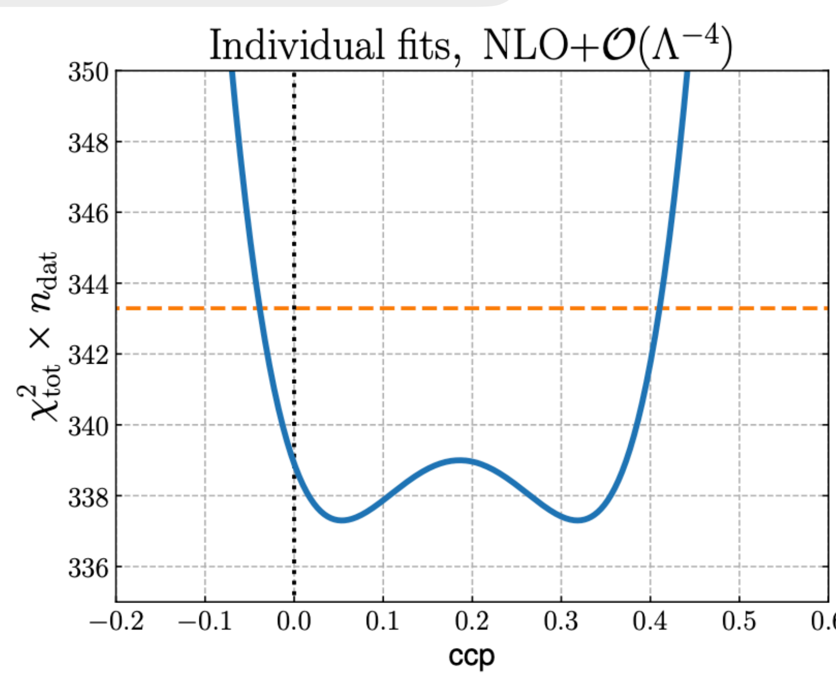


chromo-magnetic operator | *bottom Yukawa* | *charm Yukawa*

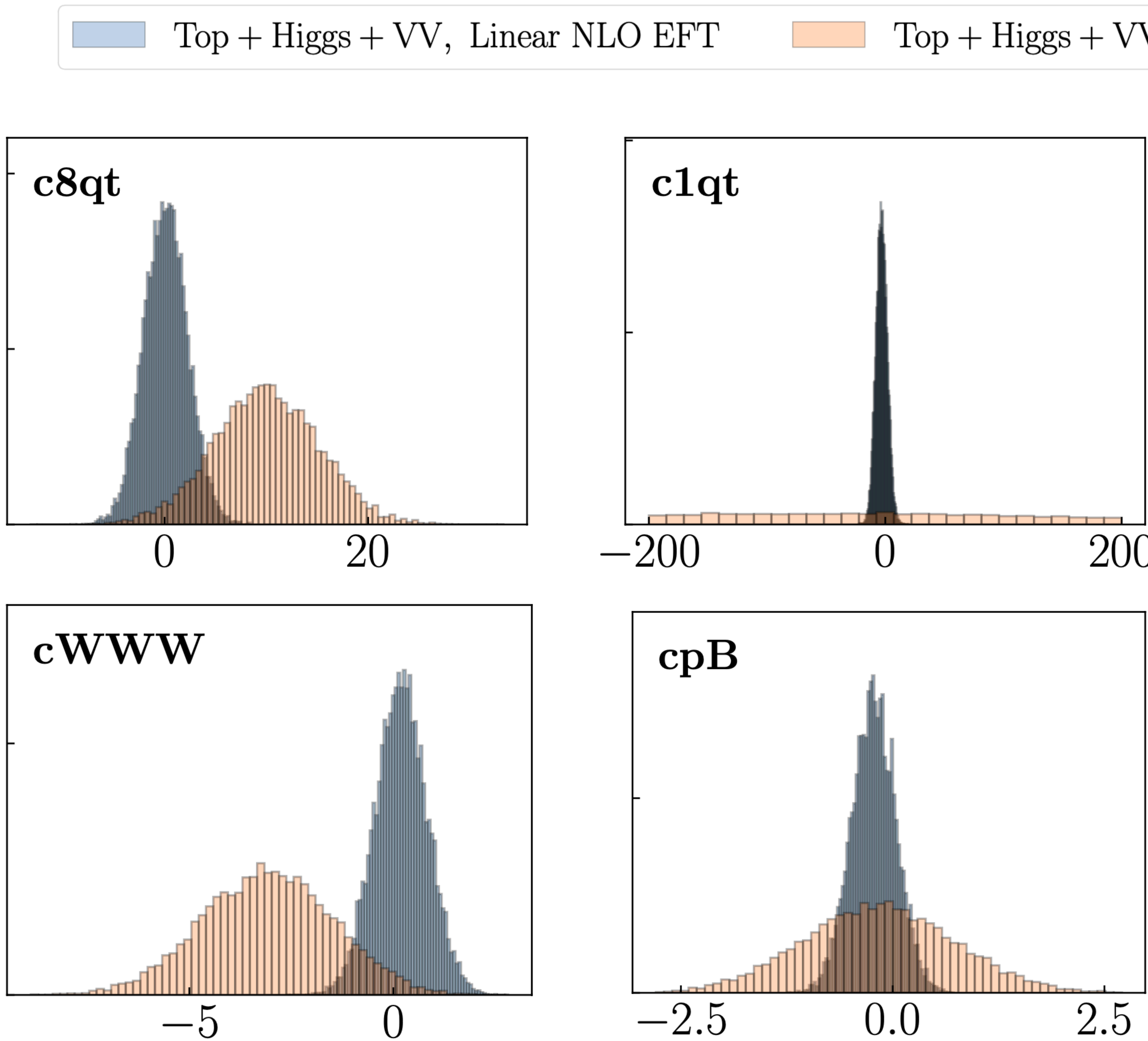
sensitivity of fit results to inclusion of **quadratic EFT corrections**

1-parameter fits



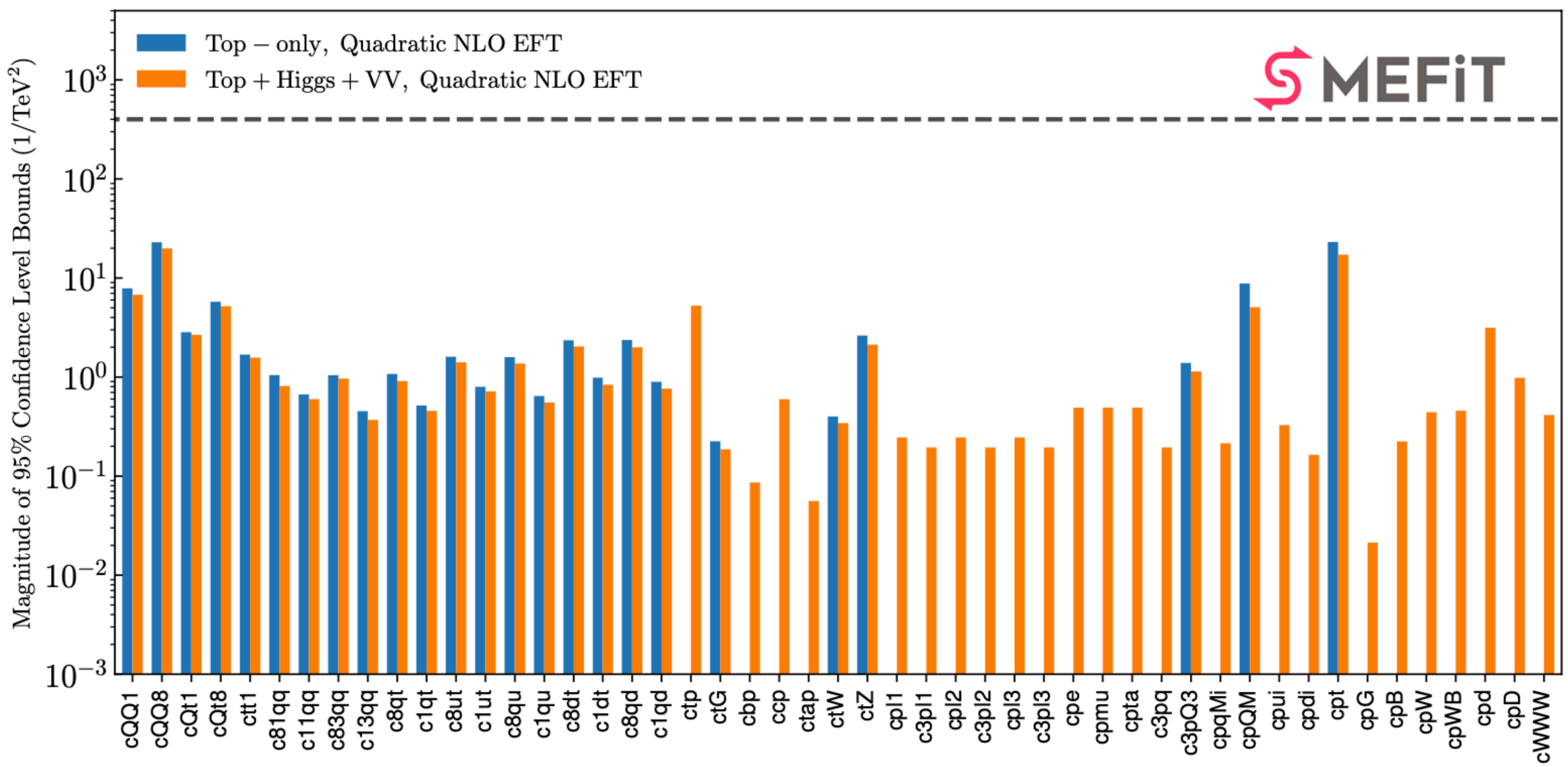


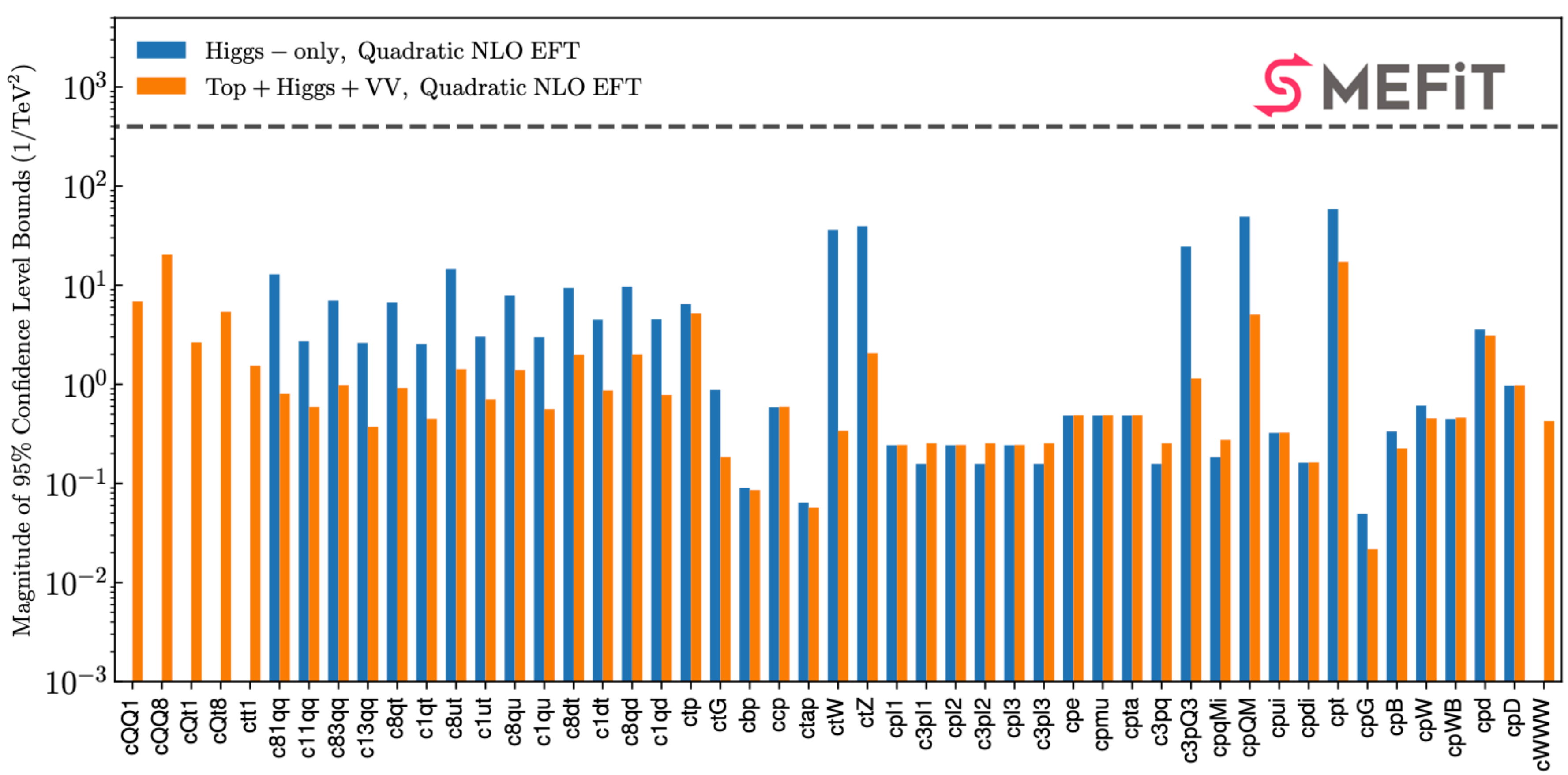
Impact of NLO corrections



- NLO QCD corrections essential for **precision EFT fits**, specially in linear case
- For several operators, new sensitivity enters at NLO
- Impact both in terms of **shift in best-fit value** and in **reduction of fit uncertainties**

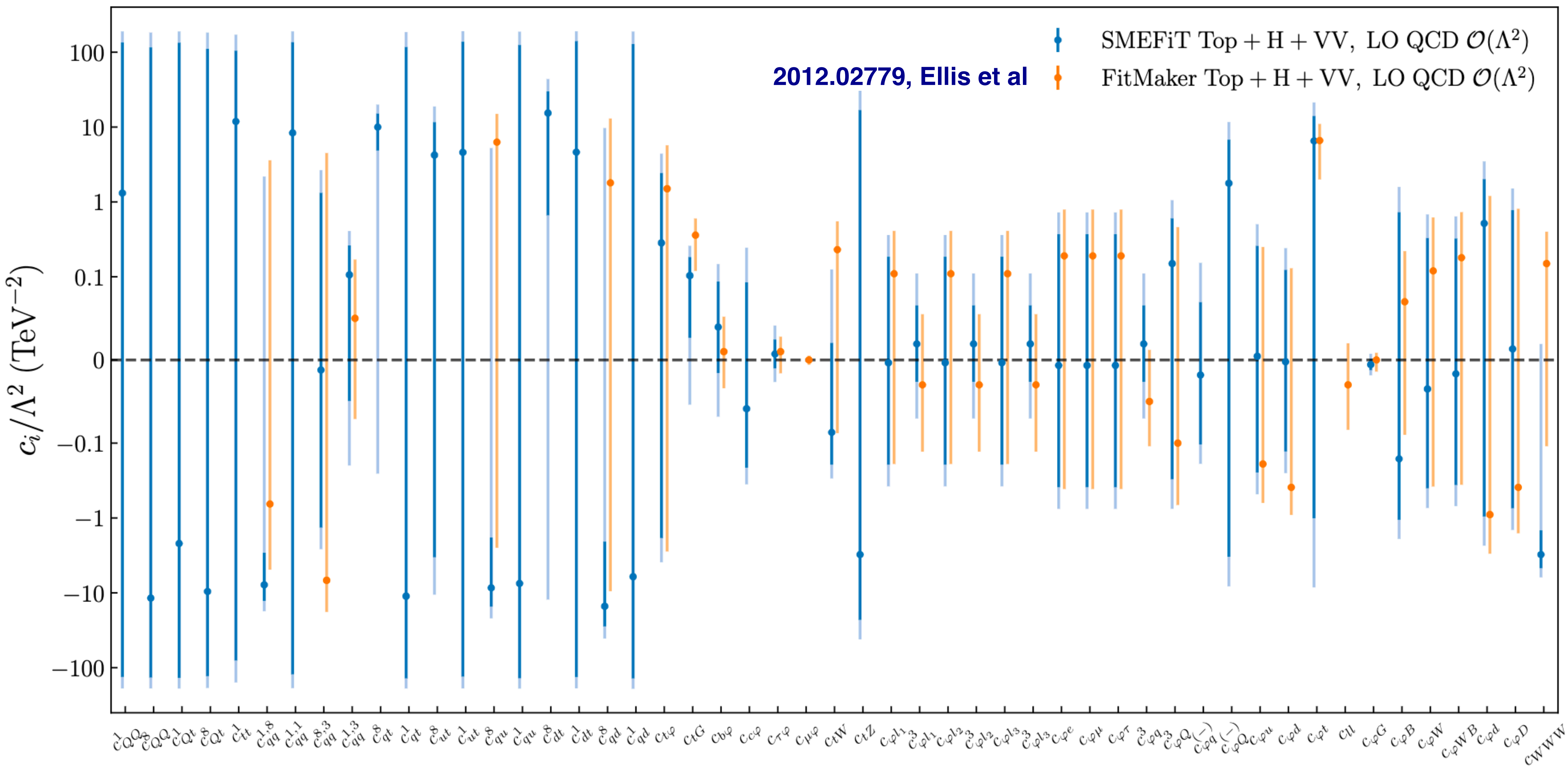
Dataset dependence





- Global fits consistent, but **more accurate**, with top-only or Higgs-only fit
- Top data **boosts the Higgs EFT fit** all across the board
- Diboson data only constraints **cWWW**
- Fit results stable upon **removal of high energy bins** ($E > 1$ TeV)

Comparison with FitMaker



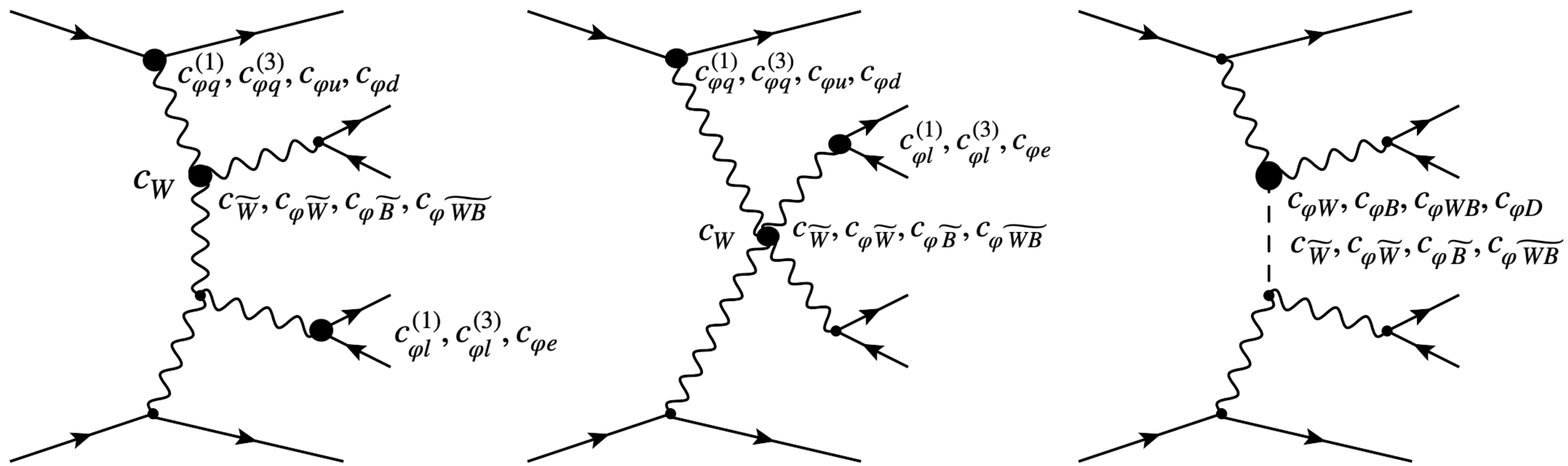
Global (marginalised) fits, 68% and 95% CL ranges (*not a tuned comparison*)

Reasonable consistency but also noticeable differences: need **benchmark comparisons!**

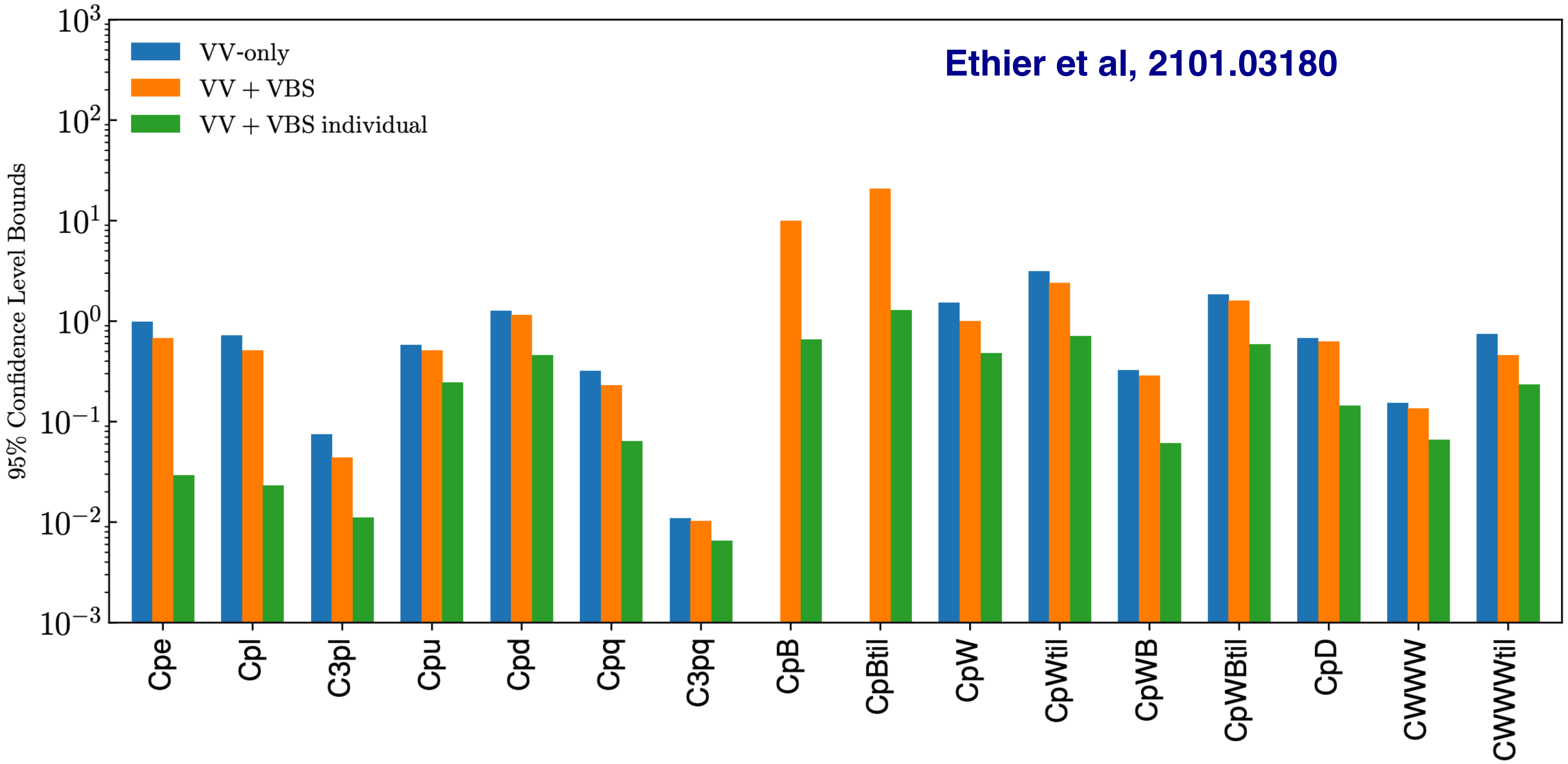
ongoing efforts in LHC EFT WG

SMEFT constraints from vector-boson scattering

Differential VBS measurements (**full Run II dataset**) provide complementary information on SMEFT



Independent cross-check of experimental constraints on **electroweak SMEFT operators**



SMEFT PDFs

``How can you be sure you are not reabsorbing BSM physics into your PDF fits?''

Assuming the **SM**, the theory calculations that enter a global PDF fit are:

$$\sigma_{\rm LHC}(\boldsymbol{\theta}) \propto \sum_{ij=u,d,g,\ldots} \int_{M^2}^{s} d\hat{s}\ \underbrace{\mathscr{L}_{ij}(\hat{s}, s, \boldsymbol{\theta})}_{\textit{SM PDFs}}\ \widetilde{\sigma}_{{\rm SM},ij}(\hat{s}, \alpha_s(M))$$

However in the case of BSM physics, here parametrised by the **SMEFT,** the correct expression is:

$$\sigma_{\rm LHC}\left(\boldsymbol{c}, \Lambda, \boldsymbol{\theta}\right) \simeq \left(\int_{M^2}^{s} d\hat{s}\ \overbrace{\mathscr{L}_{ij}(\hat{s}, s, \boldsymbol{\theta})}^{\textit{SMEFT PDFs}}\ \widetilde{\sigma}_{{\rm SM},ij}(\hat{s}, \alpha_s(M)) \right) \times \left(1 + \sum_{m=1}^{N_6} c_m \frac{\kappa_m}{\Lambda^2} + \sum_{m,n=1}^{N_6} c_m c_n \frac{\kappa_{mn}}{\Lambda^4} \right),$$

PDF parameters

SMEFT coefficients

How different are ``SM PDFs'' & ``SMEFT PDFs''? Can we quantify the risk of **fitting away BSM** in PDFs?

SMEFT PDFs

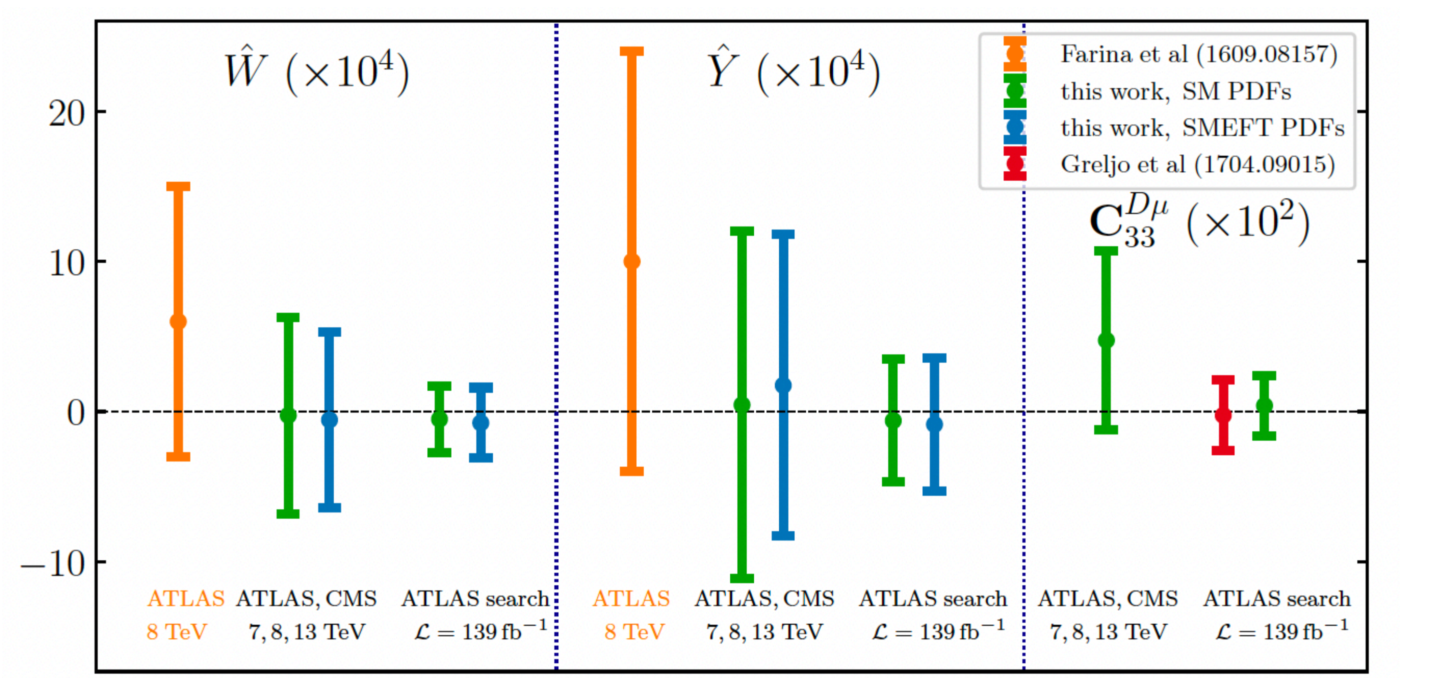
Exp.	$\sqrt{s}$ (TeV)	Ref.	$\mathcal{L}$ (fb^{-1})	Channel	1D/2D	$n_{\rm dat}$	$m_{\ell\ell}^{\rm max}$ (TeV)
ATLAS	7	[120]	4.9	e^-e^+	1D	13	[1.0, 1.5]
ATLAS (*)	8	[86]	20.3	$\ell^-\ell^+$	2D	46	[0.5, 1.5]
CMS	7	[121]	9.3	$\mu^-\mu^+$	2D	127	[0.2, 1.5]
CMS (*)	8	[87]	19.7	$\ell^-\ell^+$	1D	41	[1.5, 2.0]
CMS (*)	13	[122]	5.1	e^-e^+, $\mu^-\mu^+$ $\ell^-\ell^+$	1D	43, 43 43	[1.5, 3.0]
Total						**270 (313)**	

Extract PDFs from global fit where **high-mass DY cross-sections** account for EFT effects in two benchmark scenarios

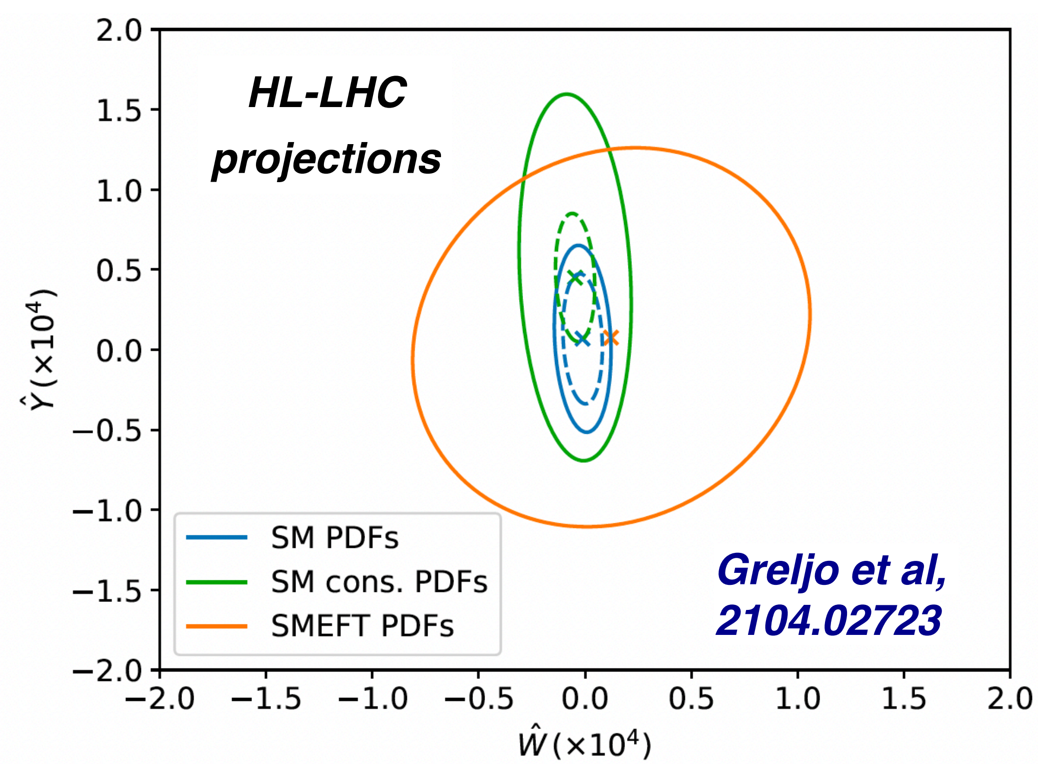
$$d\sigma_{\rm SMEFT} = d\sigma_{\rm SM} \times K_{\rm EFT}$$

$$K_{\rm EFT} = 1 + \sum_{n=1}^{n_{\rm op}} c_n R_{\rm SMEFT}^{(n)} + \sum_{n,m=1}^{n_{\rm op}} c_n c_m R_{\rm SMEFT}^{(n,m)}$$

Available data: limited interplay between PDF and EFT fits, best constraints from **searches**



@**HL-LHC**: EFT effects, if present, would be **reabsorbed into PDFs**



WIP: SMEFT PDFs from top quark data

Matching to UV-complete models

The global SMEFiT analysis framework can be deployed to provide bounds on the **parameters of UV-complete BSM theories**, provided the matching relations are known

For illustration: extend the SM with a **complex scalar** $\varphi \sim (1,2)_{1/2}$

$$\mathcal{L}_{int} = \left(y_\varphi^e\right)_{ij} \bar{e}_{R,i}\varphi^\dagger \ell_{L,j} + \left(y_\varphi^d\right)_{ij} \bar{d}_{R,i}\varphi^\dagger q_{L,j} + \left(y_\varphi^u\right)_{ij} i\bar{u}_{R,i}\varphi^\dagger \sigma_2 q_{L,j}$$
$$+\lambda_\varphi \varphi^\dagger H H^\dagger H + \mathrm{h.c.},$$

Upon integrating out the heavy field, the following **SMEFT operators** are generated

$$\mathcal{O}_{\ell e},\ \mathcal{O}_{qu}^{(1)},\ \mathcal{O}_{qu}^{(8)},\ \mathcal{O}_{qd}^{(1)},\ \mathcal{O}_{qd}^{(8)},\ \mathcal{O}_{ledq},\ \mathcal{O}_{quqd}^{(1)},\ \mathcal{O}_{lequ}^{(1)},\ \mathcal{O}_{H},\ \mathcal{O}_{eH},\ \mathcal{O}_{dH},\ \mathcal{O}_{uH}$$

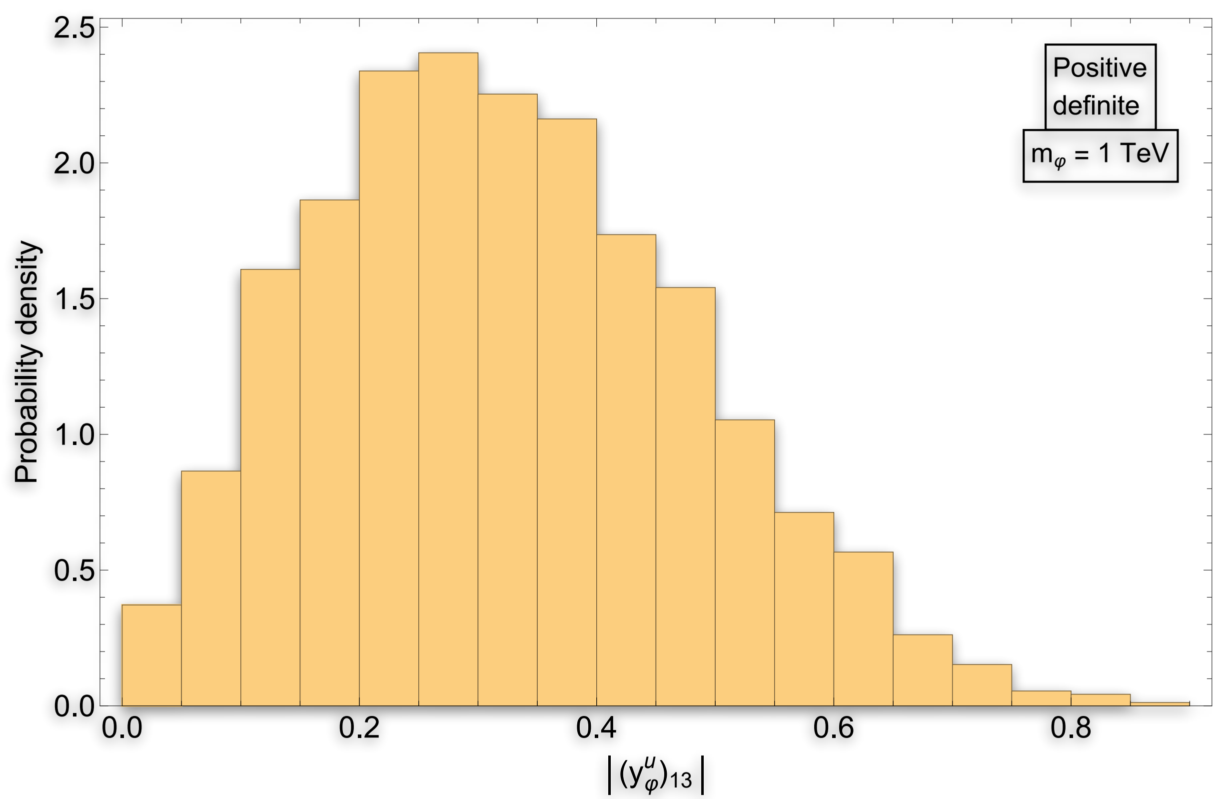
whose **Wilson coefficients** are related to mass and couplings of heavy scalar by

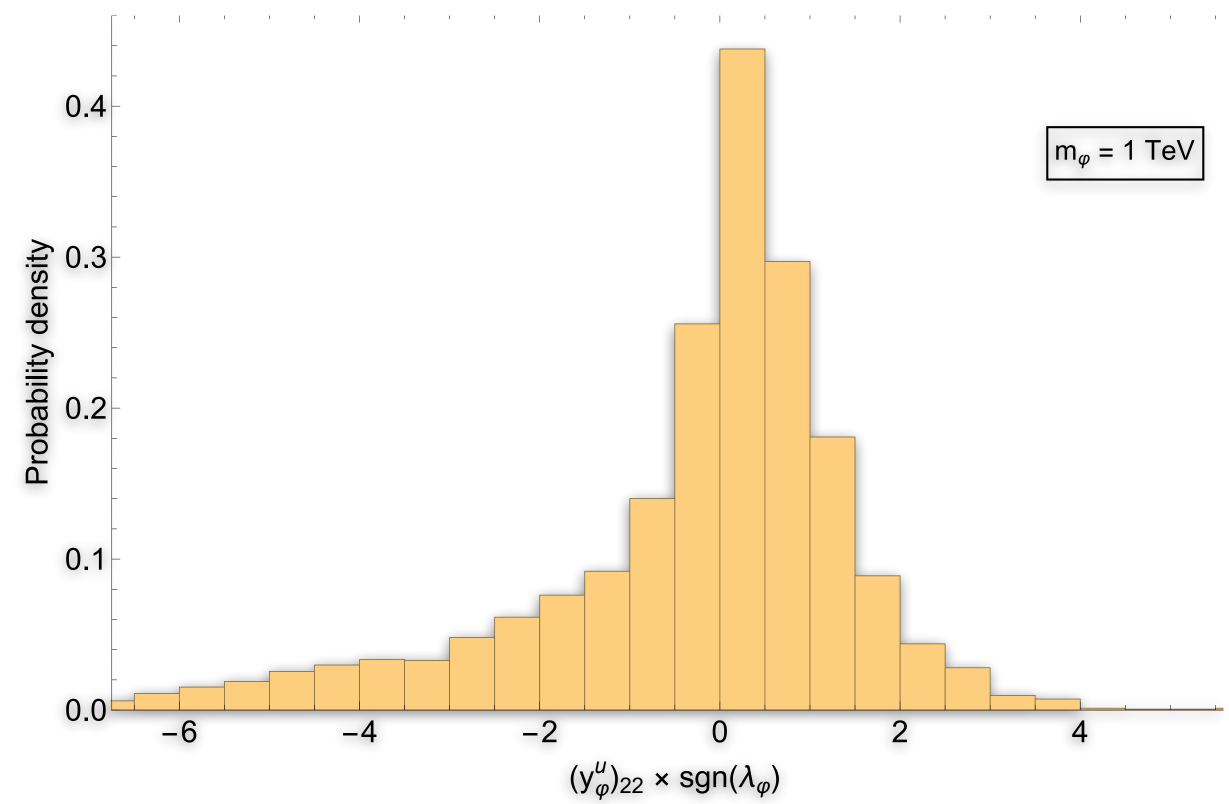
$$\frac{c_{bH}}{\Lambda^2} = \frac{\lambda_\varphi \left(y_\varphi^d\right)_{33}}{m_\varphi^2}, \qquad \frac{c_{cH}}{\Lambda^2} = -\frac{\lambda_\varphi \left(y_\varphi^u\right)_{22}}{m_\varphi^2}, \qquad \frac{c_{Qd}^{(1)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^d\right)_{33}\right)^2}{6\,m_\varphi^2}, \qquad \frac{c_{Qd}^{(8)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^d\right)_{33}\right)^2}{m_\varphi^2},$$
$$\frac{c_{Qt}^{(1)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{33}\right)^2}{6\,m_\varphi^2}, \qquad \frac{c_{Qt}^{(8)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{33}\right)^2}{m_\varphi^2}, \qquad \frac{c_{Qu}^{(1)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{31}\right)^2}{6\,m_\varphi^2}, \qquad \frac{c_{Qu}^{(8)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{31}\right)^2}{m_\varphi^2},$$
$$\frac{c_{tq}^{(1)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{13}\right)^2}{6\,m_\varphi^2}, \qquad \frac{c_{tq}^{(8)}}{\Lambda^2} = -\frac{\left(\left(y_\varphi^u\right)_{13}\right)^2}{m_\varphi^2}, \qquad \frac{c_{tH}}{\Lambda^2} = -\frac{\left(y_\varphi^u\right)_{33}\lambda_\varphi}{m_\varphi^2}, \qquad \frac{c_{\tau H}}{\Lambda^2} = \frac{\left(y_\varphi^e\right)_{33}\lambda_\varphi}{m_\varphi^2},$$

depends on flavour assumptions, must be consistent in EFT and in UV-complete theory

Matching to UV-complete models

Repeat **global SMEFiT analysis** with matching conditions **built in** and derive bounds on UV-complete theory parameters





positive-definite UV couplings require careful statistical interpretation

key advantage: the SMEFT fit already includes constraints from a **very large and diverse** number of experimental measurements

goal: **automating the procedure** as much as possible, so that for a general UV-complete Lagrangian one can efficiently derive **SMEFT-based bounds**

``Bounds on UV-complete models from global SMEFT fits'', G. Magni, J. Rojo, A. Rossia, E. Vryodinou, in preparation

Summary and outlook

- The EFT framework provides a robust strategy to interpret particle physics data in a (mostly) **model-independent manner** of new BSM phenomena

- Only within a **global SMEFT interpretation** it is possible to compare with largest possible class of UV-complete theories and to reduce assumptions i.e. concerning flavour structure

- The SMEFiT framework has been successfully deployed for an **extensive SMEFT analysis of LHC data** (top+Higgs+diboson) based on state-of-the-art EFT calculations

- Progress in the LHCEFT WG on comparing and uniformizing analyses from different groups

- Ongoing work includes considering more processes, constructing optimally-sensitive observables with ML, matching to UV complete models, accounting for flavour and low-energy constraints, further exploring the PDF & EFT interplay …