A global SMEFT analysis of the top quark sector at NLO

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Based on work in progress with:
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Top LHC Working Group meeting, CERN, 20/11/2018

Motivation

The Standard Model EFT

- Heavy bSM physics beyond the direct reach of the LHC can be **parametrised in a model-independent** in terms of complete basis of **higher-dimensional operators**

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_i^{N_{d6}} \frac{c_i}{\Lambda^2} \mathcal{O}_i^{(6)} + \sum_j^{N_{d8}} \frac{b_j}{\Lambda^4} \mathcal{O}_j^{(8)} + \ldots \,,$$

- Some operators induce **growth with the partonic centre-of-mass energy**: increased sensitivity in LHC cross-sections in the TeV region

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

- The number of SMEFT operators is large: **59 non-redundant operators at dimension 6** with Minimal Flavour Violation, **> 2000 operators** without any flavour assumption

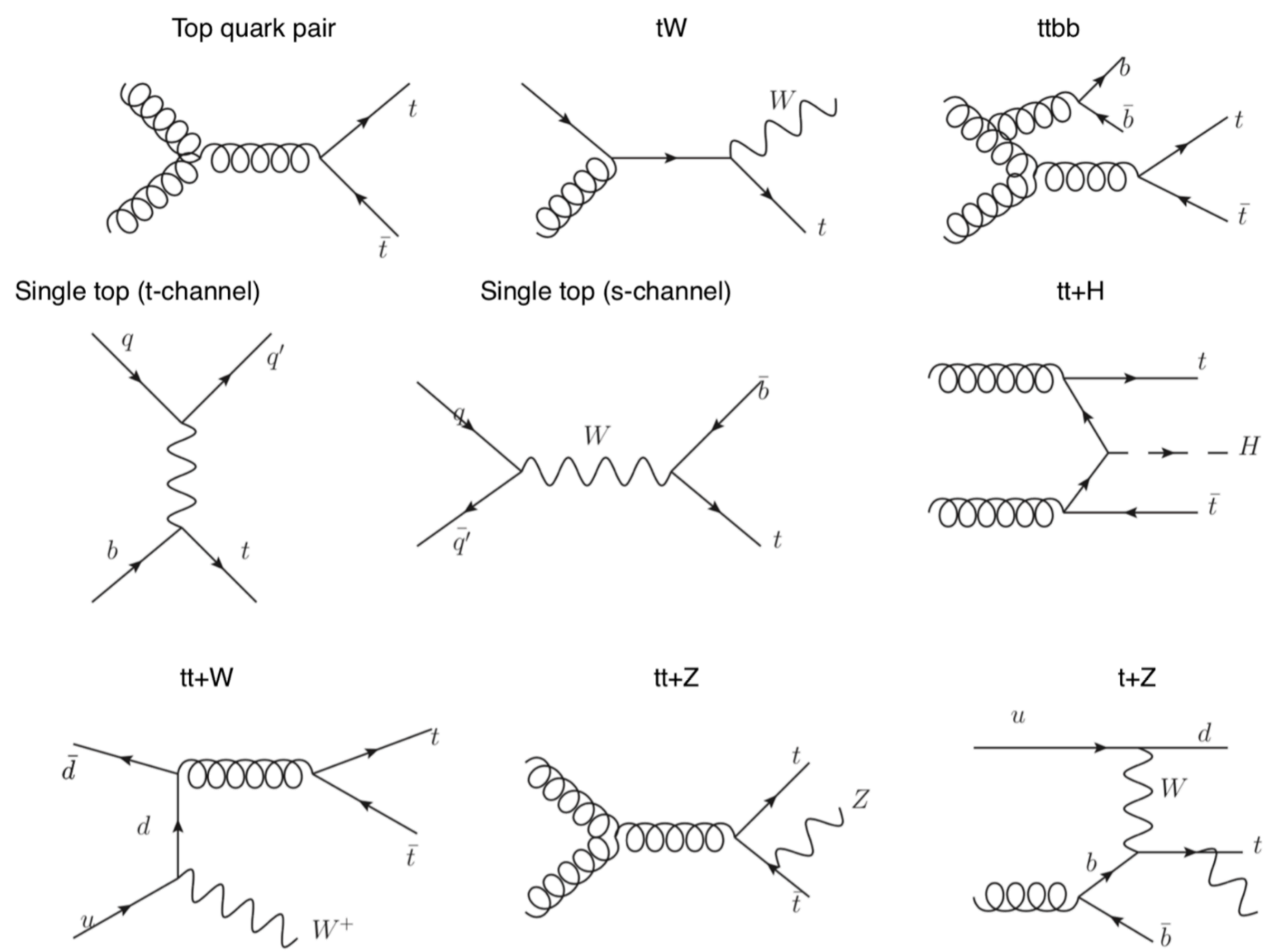
- A global SMEFT analysis needs to explore a **huge complicated parameter space**

The top quark sector of the SMEFT

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							✓		

A large number of different dimension-6 SMEFT operators modify **top production at LHC**

$$\sigma(E) = \sigma_{\rm SM}(E)\left(1 + \sum_i^{N_{d6}} \kappa_i \frac{c_i}{\Lambda^2} + \sum_{i,j}^{N_{d6}} \widetilde{\kappa}_{ij}\frac{c_i c_j}{\Lambda^4}\right)$$



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OQb8								(✓)	✓
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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				✓		✓			
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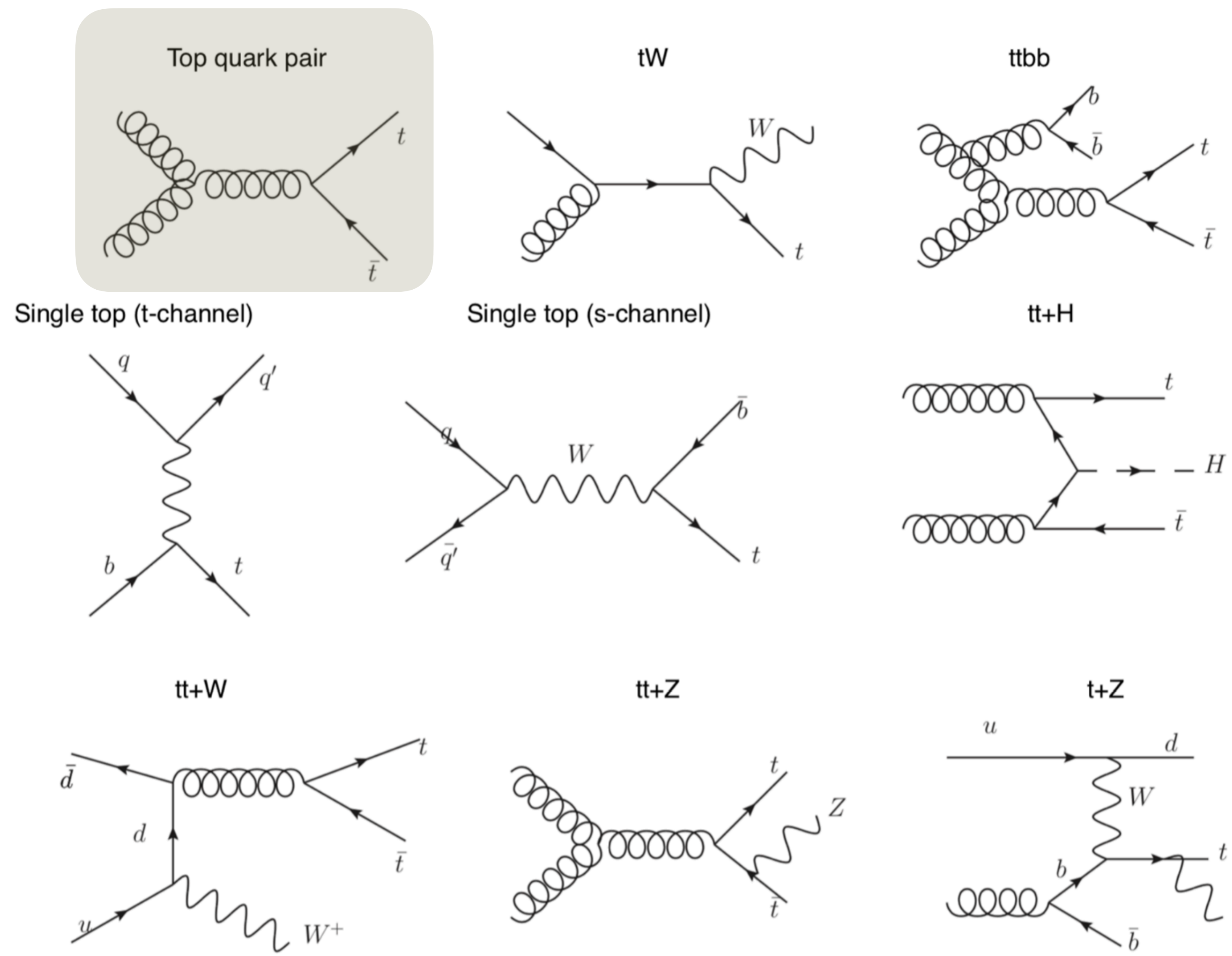

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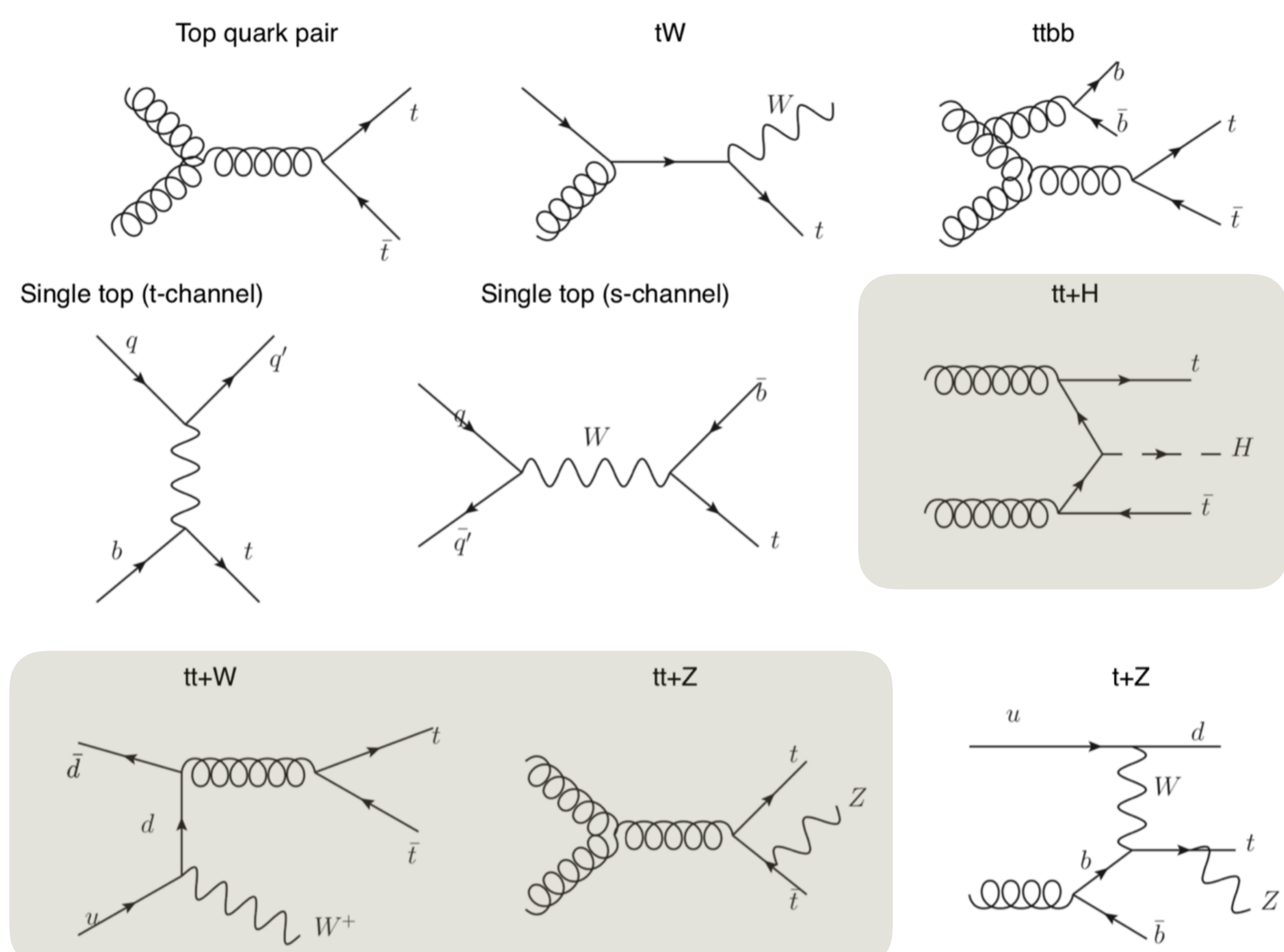

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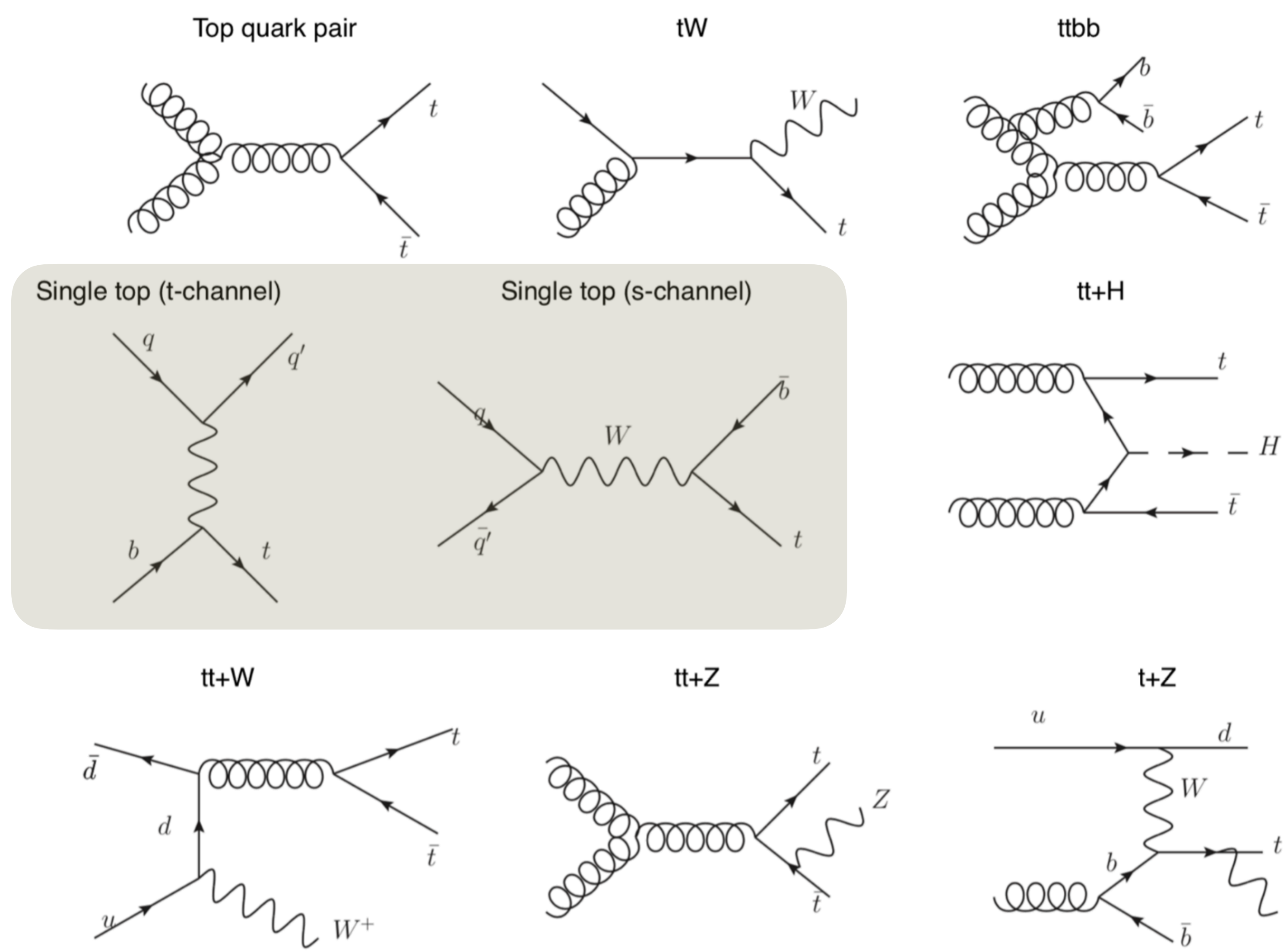
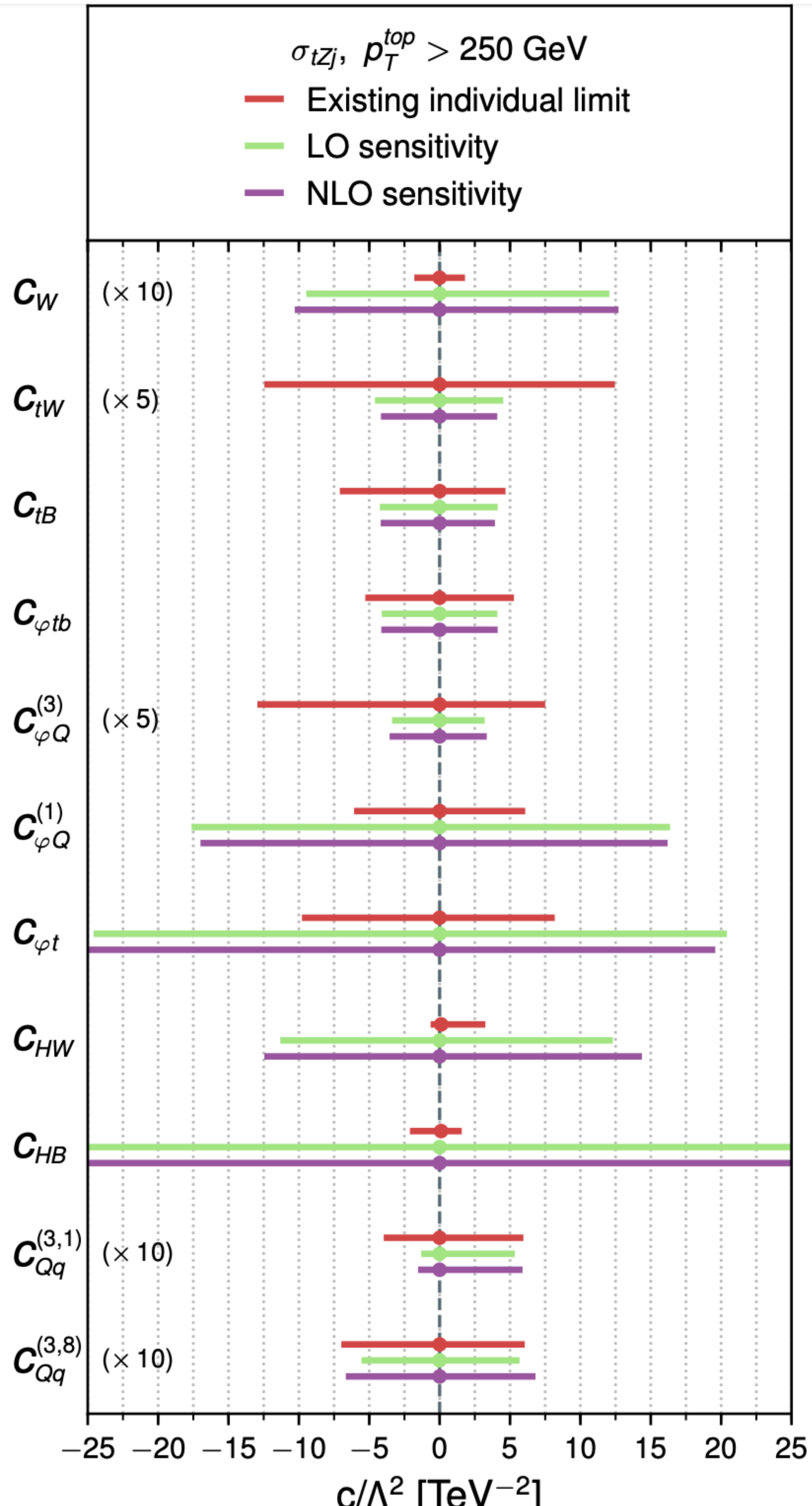


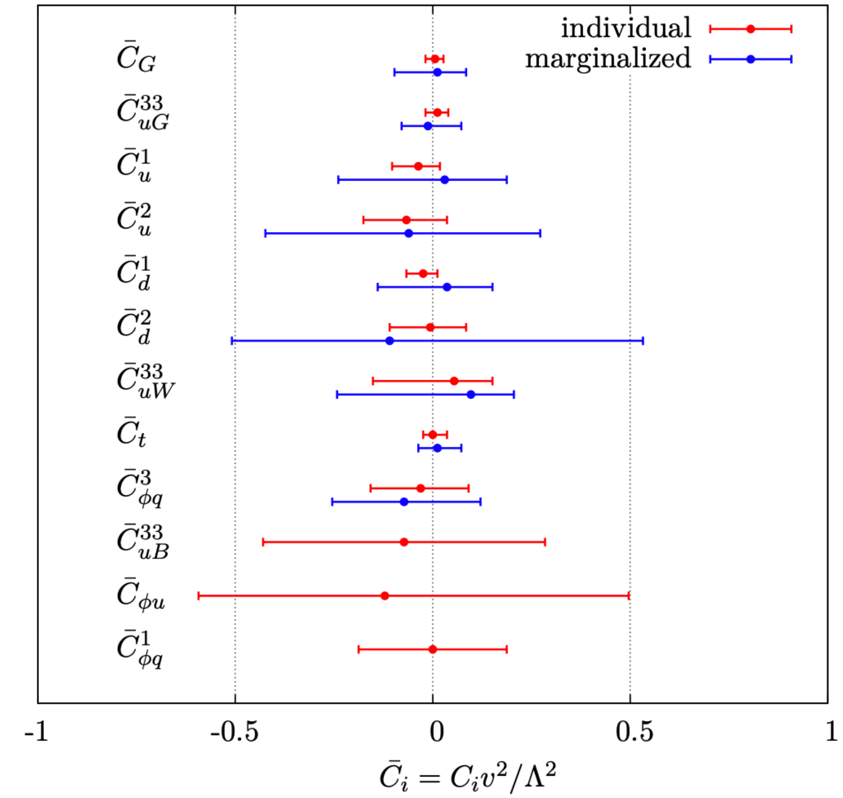
SMEFT constraints from top data

Exploit **rarer processes** at LHC eg ***t+Z+j***



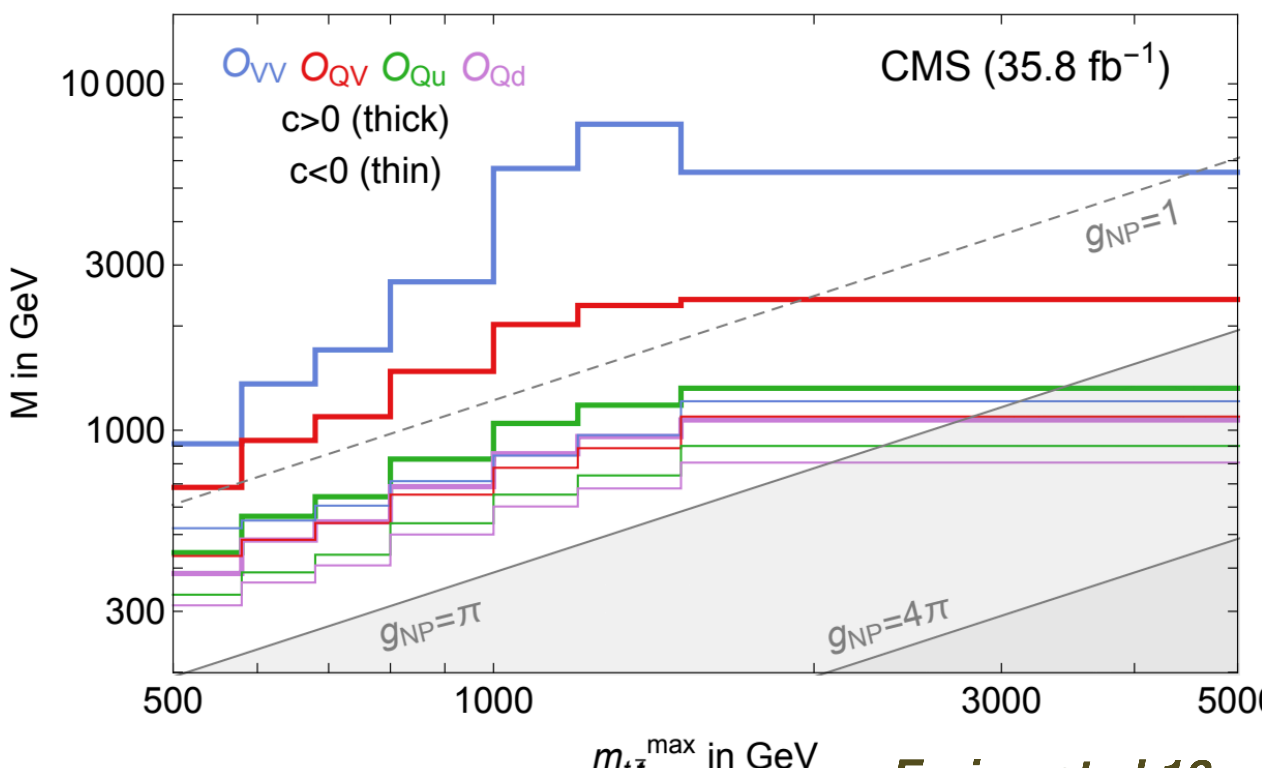
Degrande et al 18

Combine **different processes** in global fit



TopFitter 15

Enhance sensitivity from **high-energy** m_{tt} **tail**



Farina et al 18

Recipe for a SMEFT analysis of top sector

Theory

(N)NLO QCD + NLO EW for SM xsecs

NLO QCD for SMEFT contributions

State-of-the-art PDFs without top data

Data

Inclusive **top quark pair** and **single top**

Associated production with **W, Z, h**

W helicity fractions, asymmetries

Global SMEFT fit

of the two quark sector

Derived bounds can be compared with

specific UV completions

New data incorporated without redoing fit

Delivery

Faithful **uncertainty estimate**

Avoiding under- and over-fitting

Validated on **pseudo-data** (closure test)

Methodology

the SMEFiT approach

From PDF fits to SMEFT analyses

- In global PDF fits, LHC cross-sections (incl. top) are used to **constrain the input PDFs**

$$\sigma^{(\mathrm{th})}\left(Q,\{a_k\}\right) = \sum_{ij} \Gamma_{ij}\left(\alpha_s, Q, Q_0\right) \otimes q_i(x, Q_0, \{a_k\}) \otimes q_j(x, Q_0, \{a_k\})$$

- The PDF parameters ***{a$_k$}*** are determined from the **minimisation** of a figure of merit

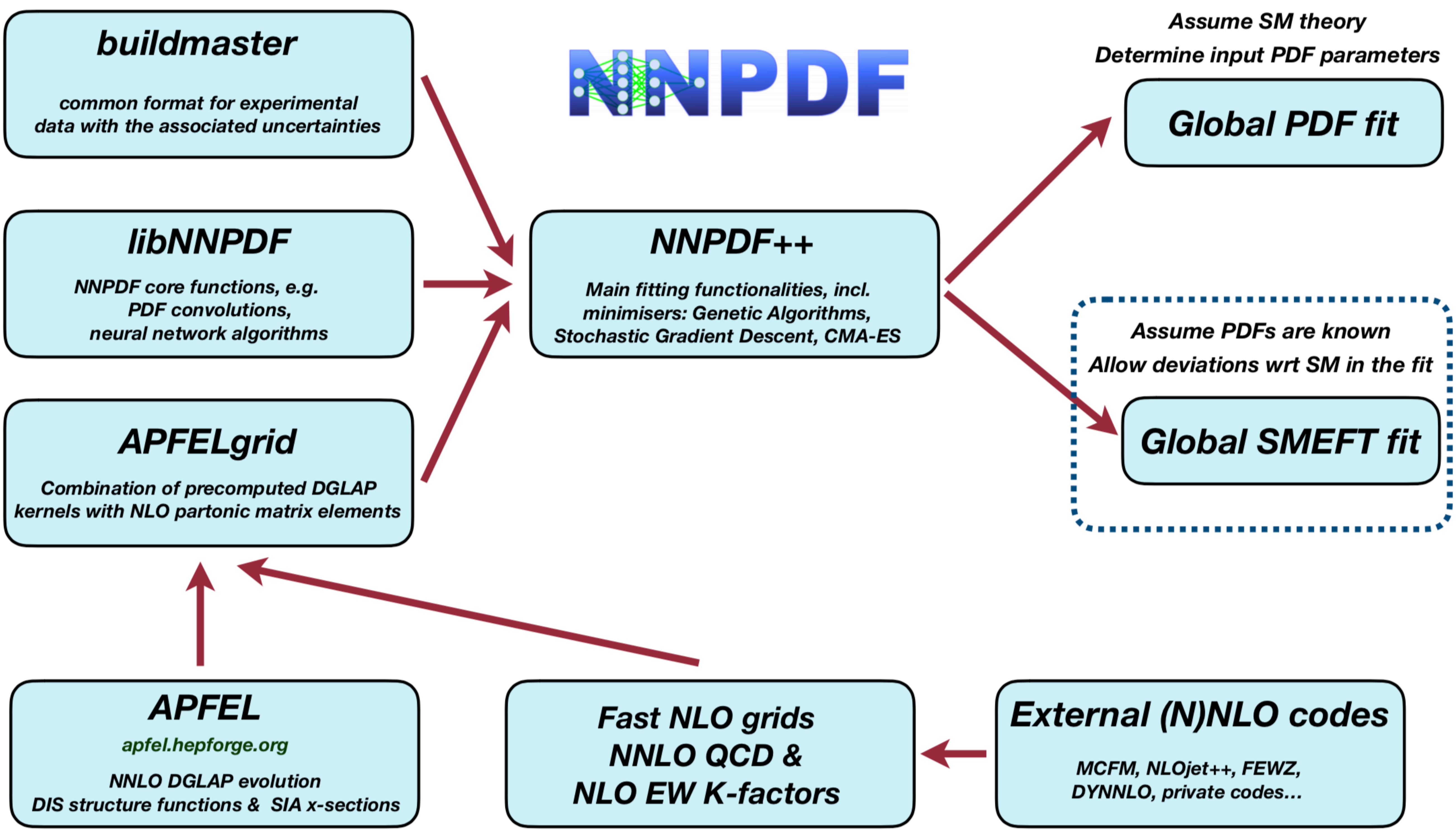
$$\chi^2(\{a_k\}) = \sum_{m,n}^{n_{\mathrm{dat}}} \left(\sigma_n^{(\mathrm{exp})} - \sigma_n^{(\mathrm{th})}\{a_k\}\right) (\mathrm{cov})^{-1}_{mn} \left(\sigma_m^{(\mathrm{exp})} - \sigma_m^{(\mathrm{th})}\{a_k\}\right)$$

- If one now fixes the input PDFs (determined from a different set of data) and includes SMEFT effects, one can **exploit the same PDF fitting approach** to carry out a global SMEFT fit

$$\sigma^{(\mathrm{th})}\left(Q,\{c_k\}\right) = \left(1 + \sum_{k}^{N_{d6}} \frac{c_k \kappa_k}{\Lambda^2}\right) \sum_{ij} \Gamma_{ij}\left(\alpha_s, Q, Q_0\right) \otimes q_i(x, Q_0) \otimes q_j(x, Q_0)$$

$$\chi^2(\{c_k\}) = \sum_{m,n}^{n_{\mathrm{dat}}} \left(\sigma_n^{(\mathrm{exp})} - \sigma_n^{(\mathrm{th})}\{c_k\}\right) (\mathrm{cov})^{-1}_{mn} \left(\sigma_m^{(\mathrm{exp})} - \sigma_m^{(\mathrm{th})}\{c_k\}\right)$$

From PDF fits to SMEFT analyses



SMEFiT structure

Stand-alone **Python code**, which exploits functionalities of the **NNPDF framework**

NNPDF code

- **Experimental data** and covariance matrices
- **NLO** APPLgrids + **NNLO** C-factors (for processes used in PDF fit)

aMC@NLO

- NLO **QCD** (benchmark)
- LO, NLO **SMEFT**
- Both $\mathbf{O(\Lambda^{-2})}$ and $\mathbf{O(\Lambda^{-4})}$ from ***d=6* operators**

MCFM

- NLO **QCD** (consistent choice of PDFs)
- Cross-checks of **aMC@NLO**

Python analysis code

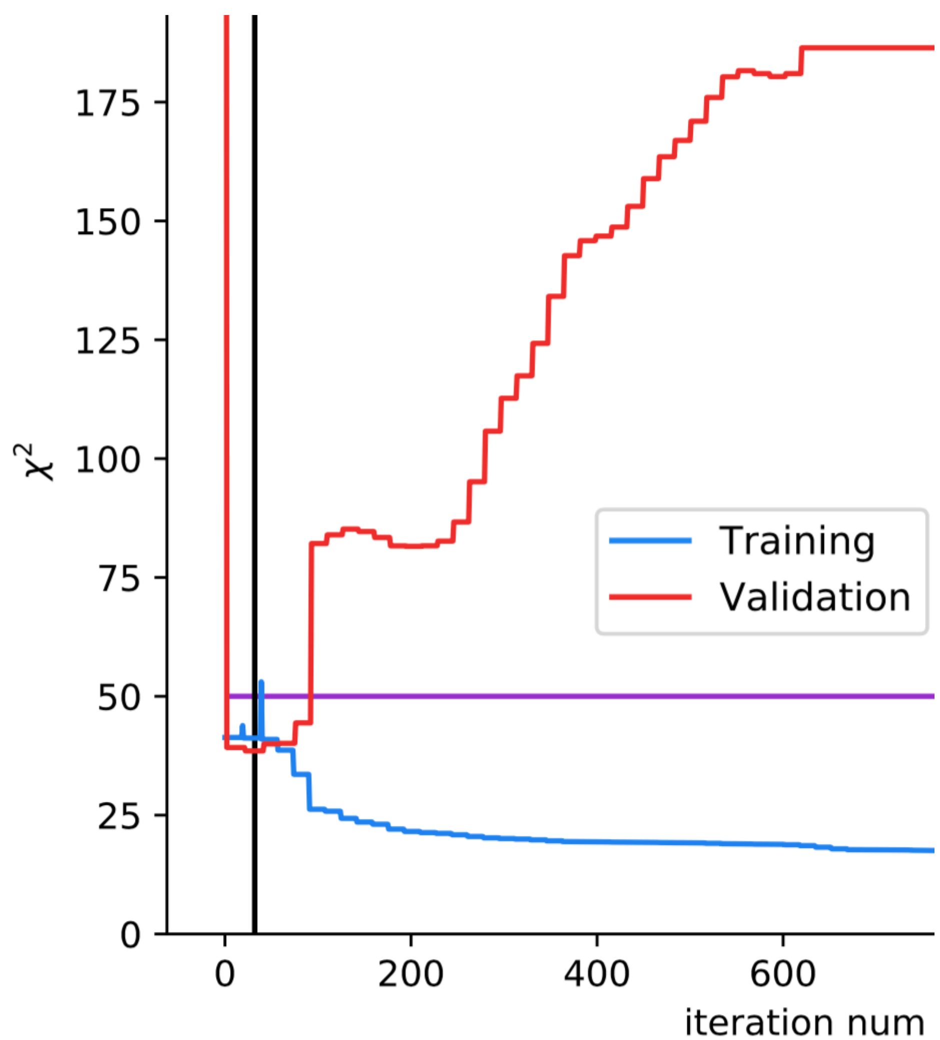
- Assemble **theory predictions** for generic SMEFT Wilson coefficients
- **Optimisation** with Sequential Quadratic Programming (**SciPy**)
- Look-back **cross-validation stopping**
- **Monte Carlo replicas** for uncertainty propagation

Fitting methodology

- Generate large sample of **Monte Carlo replicas** to construct the **probability distribution** in the space of experimental top quark measurements

$$\mathcal{O}_i^{(\mathrm{art})(k)} = S_{i,N}^{(k)}\mathcal{O}_i^{(\mathrm{exp})}\left(1+\sum_{\alpha=1}^{N_{\mathrm{sys}}} r_{i,\alpha}^{(k)}\sigma_{i,c}^{(\mathrm{sys})} + r_i^{(k)}\sigma_i^{(\mathrm{stat})}\right), \quad k=1,\ldots,N_{\mathrm{rep}}$$

- **Cross-validation stopping** to avoid both under- and over-fitting



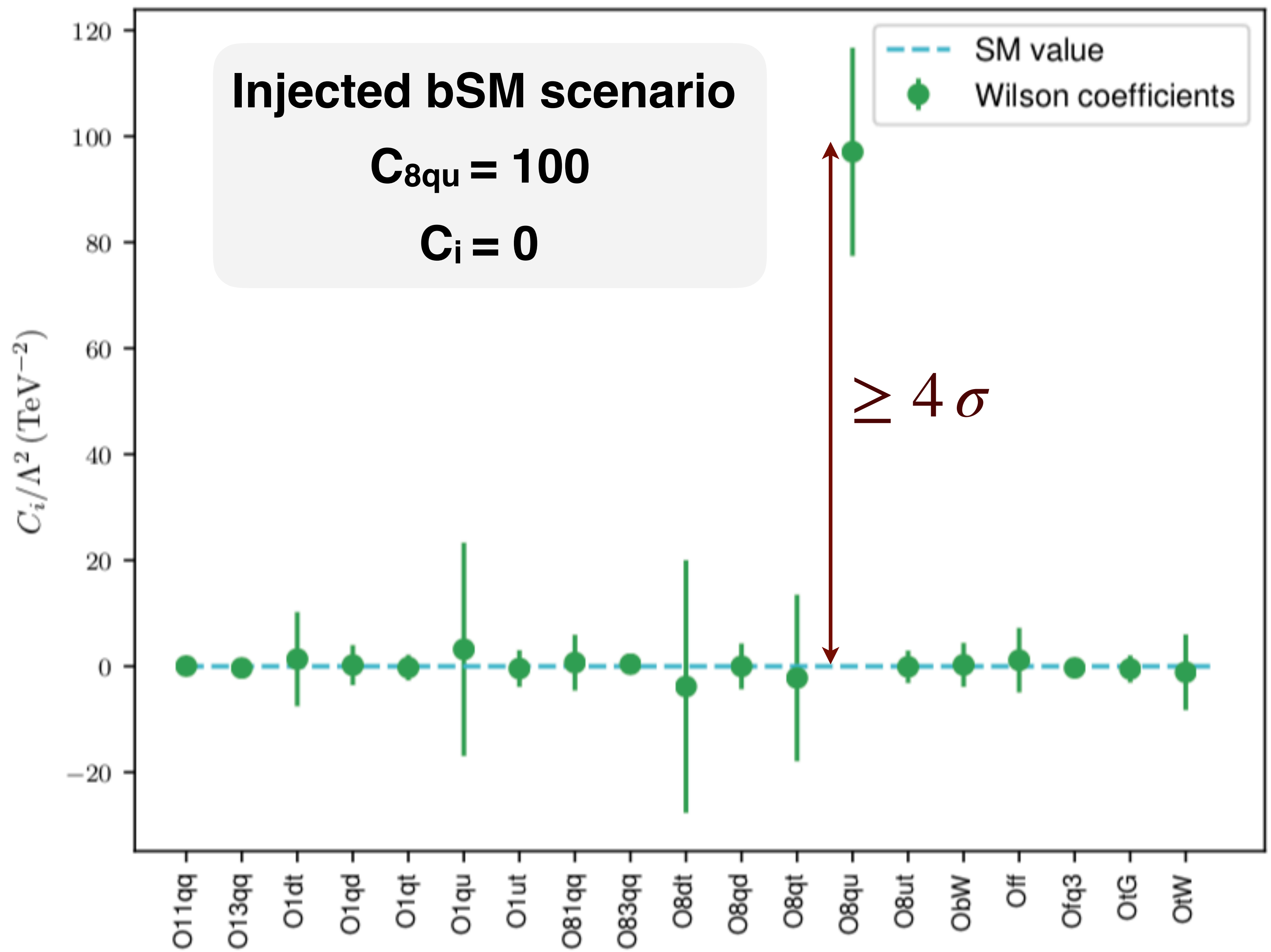
- Methodology validated with pseudo-data based on **closure tests**: decouple from possible data incompatibilities, theory limitations, or **genuine bSM effects**

- **PDF uncertainties** included in the ***χ²*** definition and MC sampling

Closure Tests

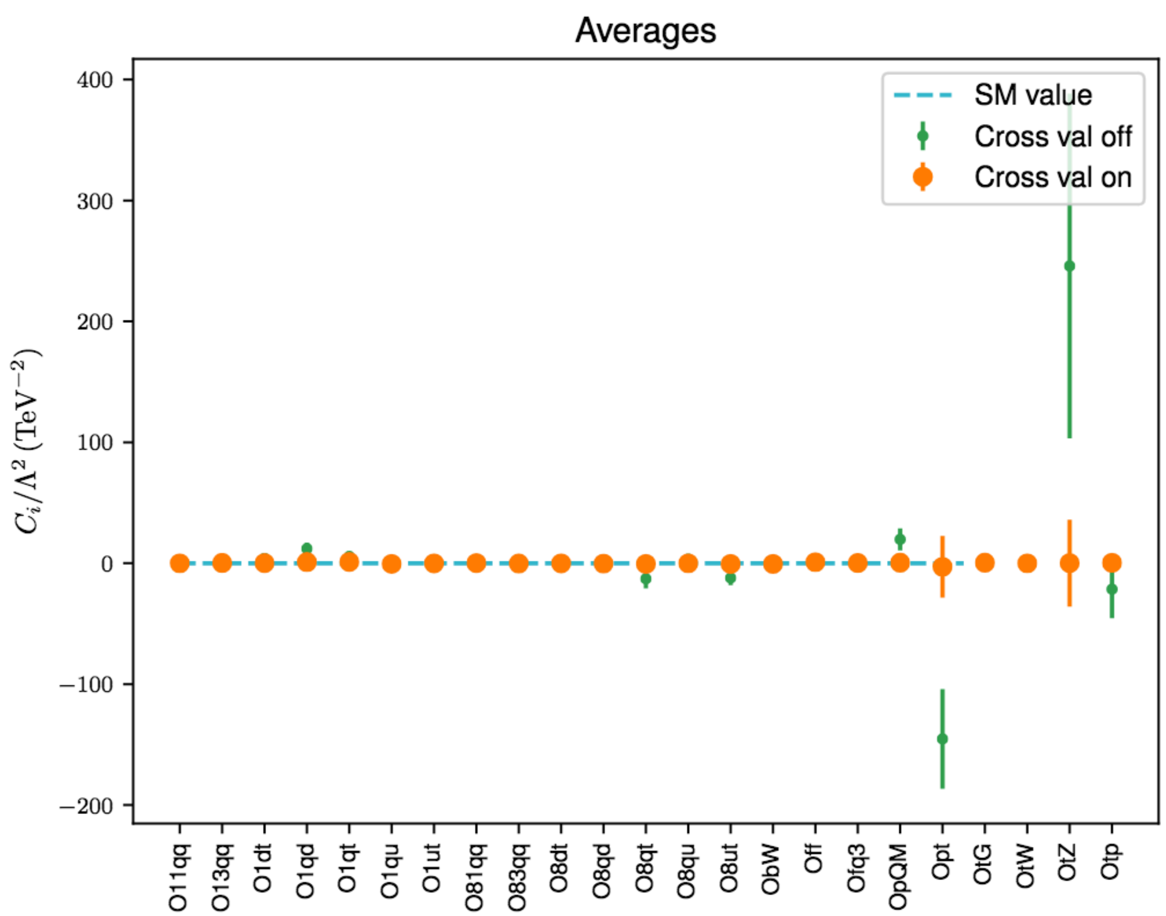
- Generate **pseudo-data based** on a given scenario (SM or BSM) and check that the correct (known) results are reproduced after the fit

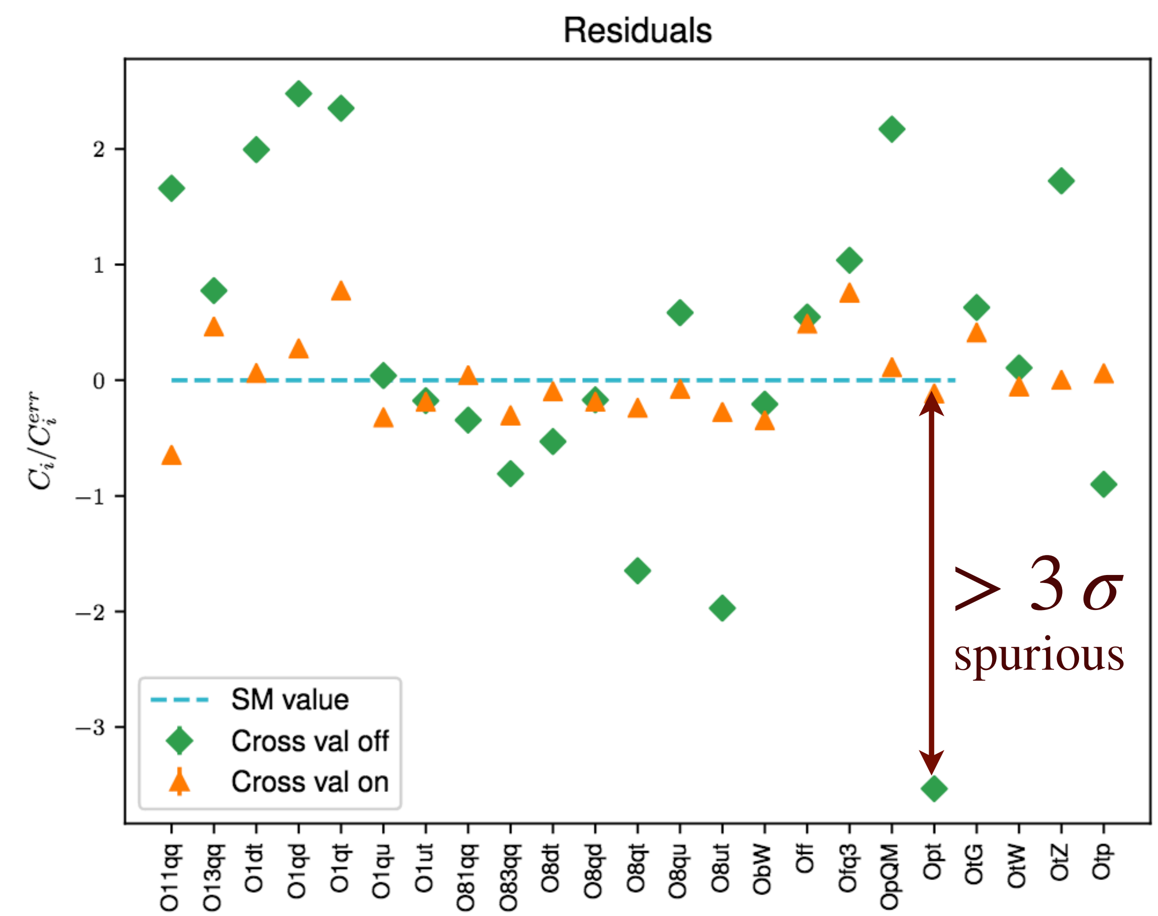
- Allows quantifying the **expected statistical significance** for BSM deviations



Cross-validation

- Since $\boldsymbol{N_{par}}$ is not too different from $\boldsymbol{N_{dat}}$, overfitting will take place for an efficient optimiser
- **Artificial tensions with the SM** are likely to be generated by overfitting!
- Test the role of cross-validation in a closure test with pseudo-data generated with the SM
- Fit residuals **consistent with true result (SM)** only with cross-validation





SMEFiT analysis of the top quark sector

Input dataset (I)

Process	Dataset	$\sqrt{s}$	Info	Observables	$N_{\rm dat}$	Ref
$t\bar{t}$	ATLAS_tt_8TeV_ljets	**8 TeV**	lepton+jets	$d\sigma/d\lvert y_t\rvert$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\lvert y_{t\bar{t}}\rvert$	5, 8, 7, 5	[77]
$t\bar{t}$	CMS_tt_8TeV_ljets	**8 TeV**	lepton+jets	$d\sigma/dy_t$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/dy_{t\bar{t}}$	10, 8, 7, 10	[78]
$t\bar{t}$	CMS_tt2D_8TeV_dilep	**8 TeV**	dileptons	$d^2\sigma/dy_t dp_t^T$, $d^2\sigma/dy_t dm_{t\bar{t}}$, $d^2\sigma/dp_{t\bar{t}}^T dm_{t\bar{t}}$, $d^2\sigma/dy_{t\bar{t}} dm_{t\bar{t}}$	16, 16, 16, 16	[79]
$t\bar{t}$	CMS_tt_13TeV_ljets	**13 TeV**	lepton+jets	$d\sigma/d\lvert y_t\rvert$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\lvert y_{t\bar{t}}\rvert$	7, 9, 8, 6	[83]
$t\bar{t}$	CMS_tt_13TeV_ljets2	**13 TeV**	lepton+jets	$d\sigma/d\lvert y_t\rvert$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\lvert y_{t\bar{t}}\rvert$	11, 12, 10, 10	[85]
$t\bar{t}$	CMS_tt_13TeV_dilep	**13 TeV**	dileptons	$d\sigma/dy_t$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/dy_{t\bar{t}}$	8, 6, 6, 8	[86]
$t\bar{t}$	ATLASCMS_AcMtt_8TeV	**8 TeV**	Asymm comb	$A_C(m_{t\bar{t}})$, Eq. (3.1)	6	[80]
$t\bar{t}$	ATLAS_WhelF_8TeV	**8 TeV**	W helicity fract	F_0, F_L, F_R	3	[81]
$t\bar{t}$	CMS_WhelF_8TeV	**8 TeV**	W helicity fract	F_0, F_L, F_R	3	[82]

Input dataset (II)

Process	Dataset	$\sqrt{s}$	Info	Observables	$N_{\rm dat}$	Ref
Single t	`CMS_t_tch_8TeV_inc`	**8 TeV**	t-channel	$\sigma_{\rm tot}(t), \sigma_{\rm tot}(\bar{t})$ (R_t)	2 (1)	[95]
Single t	`CMS_t_sch_8TeV`	**8 TeV**	s-channel	$\sigma_{\rm tot}(t+\bar{t})$	1	[96]
Single t	`ATLAS_t_sch_8TeV`	**8 TeV**	s-channel	$\sigma_{\rm tot}(t+\bar{t})$	1	[97]
Single t	`ATLAS_t_tch_8TeV`	**8 TeV**	t-channel	$d\sigma(tq)/dp_T^t, d\sigma(\bar{t}q)/dp_T^{\bar{t}}$ $d\sigma(tq)/dy_t, d\sigma(\bar{t}q)/dy_t$	5, 4 4, 4	[98]
Single t	`ATLAS_t_tch_13TeV`	**13 TeV**	t-channel	$\sigma_{\rm tot}(t), \sigma_{\rm tot}(\bar{t})$ (R_t)	2 (1)	[99]
Single t	`CMS_t_tch_13TeV_inc`	**13 TeV**	t-channel	$\sigma_{\rm tot}(t+\bar{t})$ (R_t)	1 (1)	[100]
Single t	`CMS_t_tch_8TeV_dif`	**8 TeV**	t-channel	$d\sigma/dp_T^{(t+\bar{t})}$, $d\sigma/d\lvert y^{(t+\bar{t})}\rvert$	6 6	[101]
Single t	`CMS_t_tch_13TeV_dif`	**13 TeV**	t-channel	$d\sigma/dp_T^{(t+\bar{t})}$, $d\sigma/d\lvert y^{(t+\bar{t})}\rvert$	4 4	[102]
tW	`ATLAS_tW_inc_8TeV`	**8 TeV**	inclusive	$\sigma_{\rm tot}(tW)$	1	[103]
tW	`CMS_tW_inc_8TeV`	**8 TeV**	inclusive	$\sigma_{\rm tot}(tW)$	1	[104]
tW	`ATLAS_tW_inc_13TeV`	**13 TeV**	inclusive	$\sigma_{\rm tot}(tW)$	1	[105]
tW	`CMS_tW_inc_13TeV`	**13 TeV**	inclusive	$\sigma_{\rm tot}(tW)$	1	[106]
tZ	`CMS_tZ_inc_13TeV`	**13 TeV**	inclusive	$\sigma_{\rm fid}(Wbl^+l^-q)$	1	[107]
tZ	`ATLAS_tZ_inc_13TeV`	**13 TeV**	inclusive	$\sigma_{\rm tot}(tZq)$	1	[108]

Input dataset (III)

Process	Dataset	$\sqrt{s}$	Info	Observables	$N_{\rm dat}$	Ref
$t\bar{t}b\bar{b}$	`CMS_ttbb_13TeV`	**13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}b\bar{b})$	1	[87]
$t\bar{t}t\bar{t}$	`CMS_tttt_13TeV`	**13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}t\bar{t})$	1	[88]
$t\bar{t}Z$	`CMS_ttZ_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}Z)$	2	[89, 90]
$t\bar{t}Z$	`ATLAS_ttZ_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}Z)$	2	[91, 92]
$t\bar{t}W$	`CMS_ttW_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}W)$	2	[89, 90]
$t\bar{t}W$	`ATLAS_ttW_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}W)$	2	[91, 92]
$t\bar{t}H$	`CMS_tth_13TeV`	**13 TeV**	signal strength	$\mu_{t\bar{t}H}$	1	[93]
$t\bar{t}H$	`ATLAS_tth_13TeV`	**13 TeV**	total xsec	$\sigma_{\rm tot}(t\bar{t}H)$	1	[94]

The fit includes more than **100 cross-section measurements** at 8 and 13 TeV from **10 different top-quark production processes**

Theory calculations

Process	SM	Code	SMEFT	Code
$t\bar{t}$	NNLO QCD	MCFM/SHERPA NLO + NNLO K-factors	NLO QCD	MG5_aMC
single-t (t-ch)	NNLO QCD	MCFM NLO + NNLO K-factors	NLO QCD	MG5_aMC
single-t (s-ch)	NLO QCD	MCFM	NLO QCD	MG5_aMC
tW	NLO QCD	MG5_aMC	NLO QCD	MG5_aMC
tZ	NLO QCD	MG5_aMC	LO QCD + NLO SM K-factors	MG5_aMC
$t\bar{t}W(Z)$	NLO QCD	MG5_aMC	LO QCD + NLO SM K-factors	MG5_aMC
$t\bar{t}h$	NLO QCD	MG5_aMC	LO QCD + NLO SM K-factors	MG5_aMC
$t\bar{t}t\bar{t}$	NLO QCD	MG5_aMC	LO QCD + NLO SM K-factors	MG5_aMC
$t\bar{t}b\bar{b}$	NLO QCD	MG5_aMC	LO QCD + NLO SM K-factors	MG5_aMC

PDF set: **NNPDF3.1 NNLO no-top**

Operator basis

- We follow the same flavour assumptions as in the **LHC Top WG note**
- Minimal Flavour Violation (MFV), diagonal CKM, zero Yukawas for first two quark gens
- CP conservation assumed
- Include those SMEFT dimension-6 operators of Warsaw basis with **at least one top quark**
- The fit includes a total of **34 independent degrees of freedom**
- Include both **interference** and **quadratic contributions** from these operators

Class	Notation	Degree of Freedom	Operator Definition
	OQQ1	c^1_{QQ}	$2C^{1(3333)}_{qq} - \frac{2}{3}C^{3(3333)}_{qq}$
	OQQ8	c^8_{QQ}	$8C^{3(3333)}_{qq}$
	OQt1	c^1_{Qt}	$C^{1(3333)}_{qu}$
	OQt8	c^8_{Qt}	$C^{8(3333)}_{qu}$
$QQQQ$	OQb1	c^1_{Qb}	$C^{1(3333)}_{qd}$
	OQb8	c^8_{Qb}	$C^{8(3333)}_{qd}$
4-heavy	Ott1	c^1_{tt}	$C^{(3333)}_{uu}$
	Otb1	c^1_{tb}	$C^{1(3333)}_{ud}$
	Otb8	c^8_{tb}	$C^{8(3333)}_{ud}$
	OQtQb1	c^1_{QtQb}	$C^{1(3333)}_{quqd}$
	OQtQb8	c^8_{QtQb}	$C^{8(3333)}_{quqd}$
	O81qq	$c^{1,8}_{Qq}$	$C^{1(i33i)}_{qq} + 3C^{3(i33i)}_{qq}$
	O11qq	$c^{1,1}_{Qq}$	$C^{1(ii33)}_{qq} + \frac{1}{6}C^{1(i33i)}_{qq} + \frac{1}{2}C^{3(i33i)}_{qq}$
	O83qq	$c^{3,8}_{Qq}$	$C^{1(i33i)}_{qq} - C^{3(i33i)}_{qq}$
	O13qq	$c^{3,1}_{Qq}$	$C^{3(ii33)}_{qq} + \frac{1}{6}(C^{1(i33i)}_{qq} - C^{3(i33i)}_{qq})$
	O8qt	c^8_{tq}	$C^{8(ii33)}_{qu}$
	O1qt	c^1_{tq}	$C^{1(ii33)}_{qu}$
	O8ut	c^8_{tu}	$2C^{(i33i)}_{uu}$
$QQqq$	O1ut	c^1_{tu}	$C^{(ii33)}_{uu} + \frac{1}{3}C^{(i33i)}_{uu}$
	O8qu	c^8_{Qu}	$C^{8(33ii)}_{qu}$
2-heavy-2-light	O1qu	c^1_{Qu}	$C^{1(33ii)}_{qu}$
	O8dt	c^8_{td}	$C^{8(33ii)}_{ud}$
	O1dt	c^1_{td}	$C^{1(33ii)}_{ud}$
	O8qd	c^8_{Qd}	$C^{8(33ii)}_{qd}$
	O1qd	c^1_{Qd}	$C^{1(33ii)}_{qd}$
	OtG	c_{tG}	$\mathrm{Re}\{C^{(33)}_{uG}\}$
	OtW	c_{tW}	$\mathrm{Re}\{C^{(33)}_{uW}\}$
	ObW	c_{bW}	$\mathrm{Re}\{C^{(33)}_{dW}\}$
	OtZ	c_{tZ}	$\mathrm{Re}\{-s_W C^{(33)}_{uB} + c_W C^{(33)}_{uW}\}$
$QQ+V,G,\varphi$	Off	$c_{\varphi tb}$	$\mathrm{Re}\{C^{(33)}_{\varphi ud}\}$
	Ofq3	$c^3_{\varphi Q}$	$C^{3(33)}_{\varphi q}$
2-heavy + V/h	OpQM	$c^-_{\varphi Q}$	$C^{1(33)}_{\varphi q} - C^{3(33)}_{\varphi q}$
	Opt	$c_{\varphi t}$	$C^{(33)}_{\varphi u}$
	Otp	$c_{t\varphi}$	$\mathrm{Re}\{C^{(33)}_{u\varphi}\}$

Results

(preliminary)

Fit quality

(preliminary)

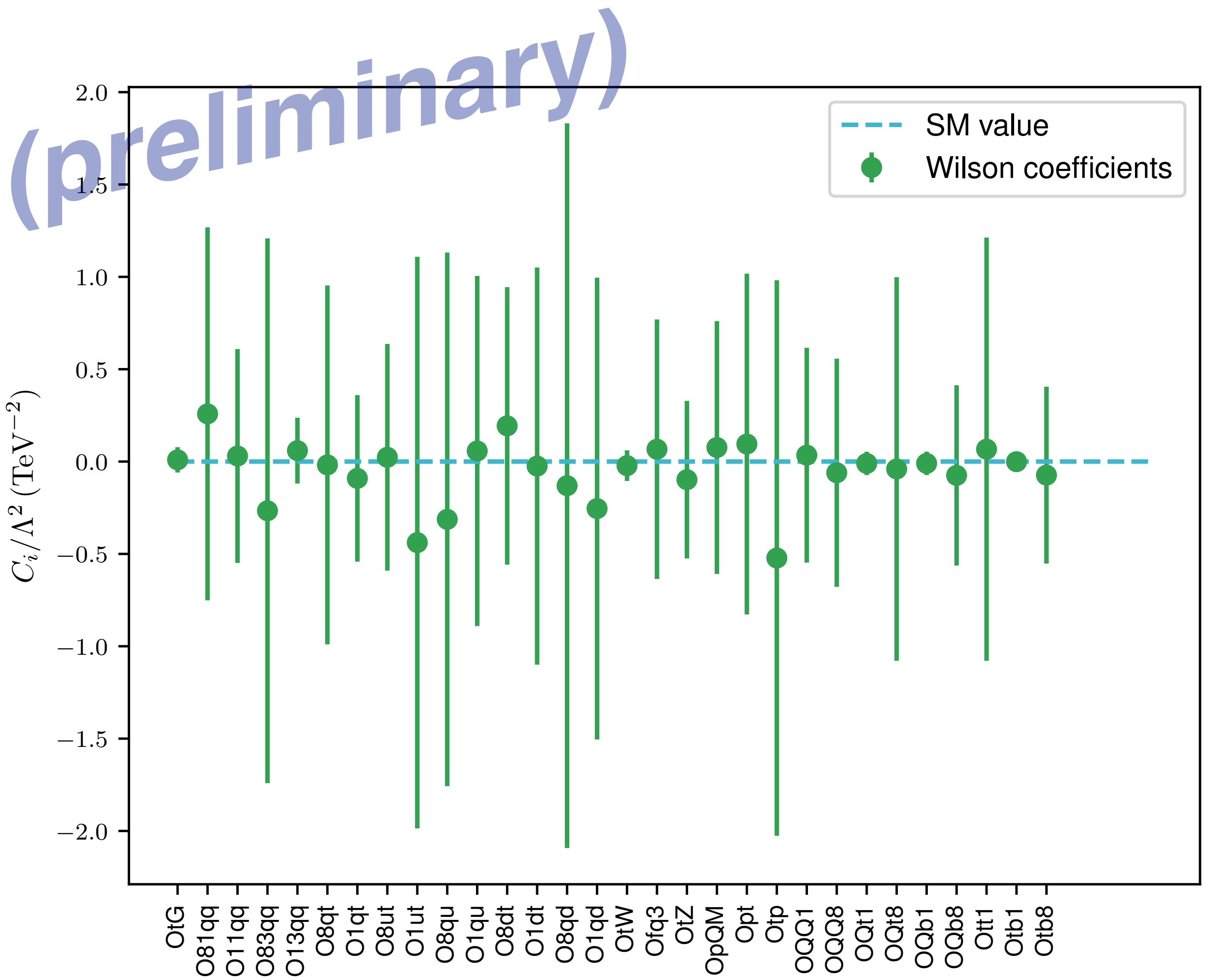
- **Good agreement** between theory (SM and SMEFT) and data for most datasets

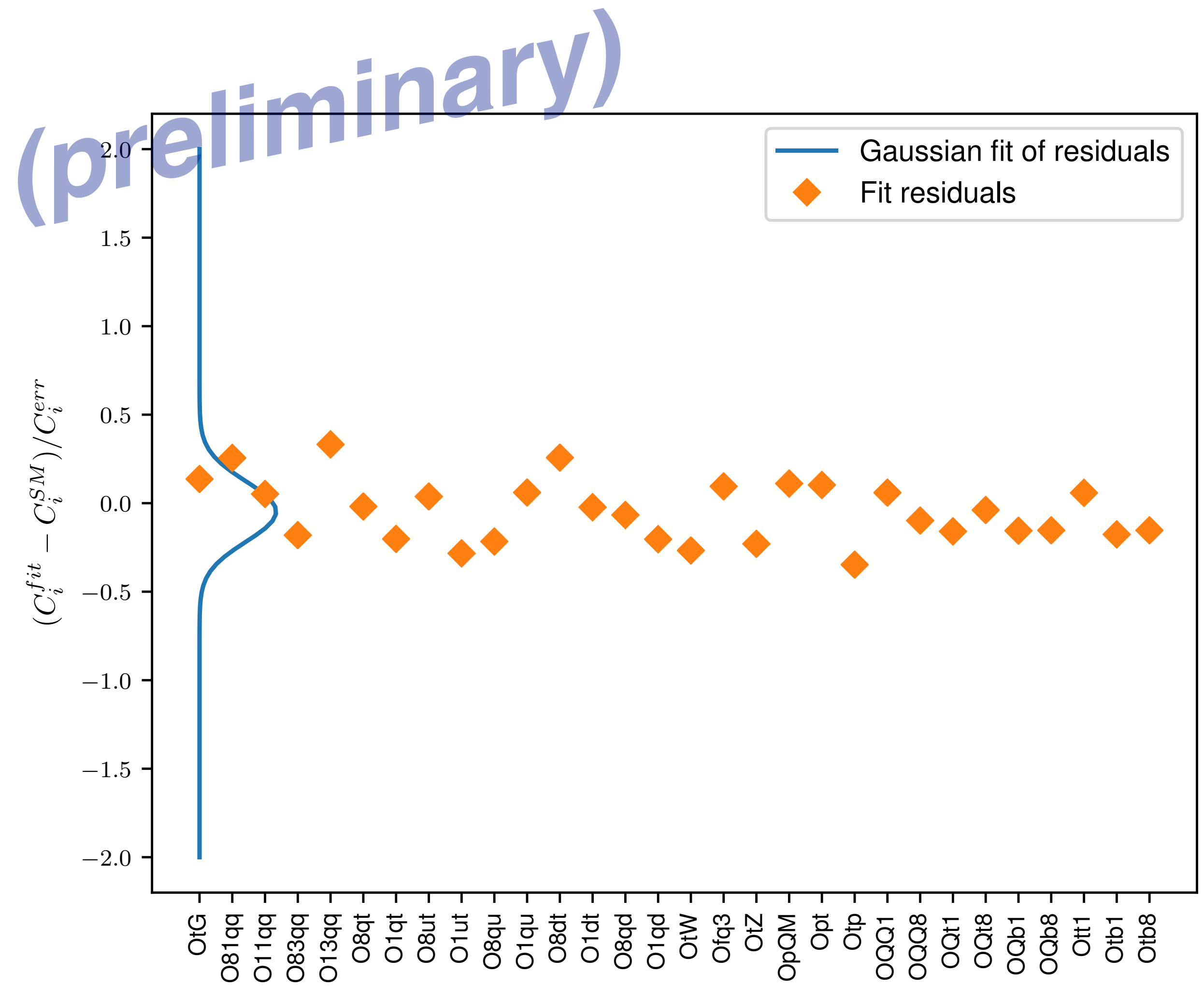
- For the **102 fitted cross-sections**, we find χ^2/n_{dat} *of* **0.81 (0.76) before (after) fit**

- Including SMEFT effects tend to improve agreement with data: need to quantify how **significant** this improvement is

Dataset	$\chi^2/n_{\rm dat}$ (prior)	$\chi^2/n_{\rm dat}$ (fit)	$n_{\rm dat}$
ATLAS_tt_8TeV_ljets [$m_{t\bar{t}}$]	1.51	1.44	7
CMS_tt_8TeV_ljets [y_t]	1.17	1.21	10
CMS_tt2D_8TeV_dilep [$(m_{t\bar{t}}, y_t)$]	1.38	1.38	16
CMS_tt_13TeV_ljets2 [$y_{t\bar{t}}$]	0.25	0.23	8
CMS_tt_13TeV_dilep [$y_{t\bar{t}}$]	0.26	0.26	6
CMS_tt_13TeV_ljets_2016 [y_t]	0.07	0.08	11
ATLAS_WhelF_8TeV	1.98	1.13	3
CMS_WhelF_8TeV	0.31	0.42	3
CMS_ttbb_13TeV	5.00	3.99	1
CMS_tttt_13TeV	0.05	0.08	1
ATLAS_tth_13TeV	1.61	1.11	1
CMS_tth_13TeV	0.34	0.09	1
ATLAS_ttZ_8TeV	1.32	1.18	1
ATLAS_ttZ_13TeV	0.01	0.01	1
CMS_ttZ_8TeV	0.04	0.06	1
CMS_ttZ_13TeV	0.90	0.94	1
ATLAS_ttW_8TeV	1.34	1.24	1
ATLAS_ttW_13TeV	0.82	0.81	1
CMS_ttW_8TeV	1.54	1.46	1
CMS_ttW_13TeV	0.03	0.02	1
CMS_t_tch_8TeV_dif	0.11	0.21	6
ATLAS_t_tch_8TeV [y_t]	0.91	0.61	4
ATLAS_t_tch_8TeV [$y_{\bar{t}}$]	0.40	0.33	4
ATLAS_t_sch_8TeV	0.08	0.23	1
CMS_t_tch_13TeV_dif [y_t]	0.46	0.48	4
CMS_t_sch_8TeV	1.26	1.16	1
ATLAS_tW_inc_8TeV	0.02	0.00	1
CMS_tW_inc_8TeV	0.00	0.01	1
ATLAS_tW_inc_13TeV	0.52	0.62	1
CMS_tW_inc_13TeV	4.29	3.26	1
ATLAS_tZ_inc_13TeV	0.00	0.02	1
CMS_tZ_inc_13TeV	0.66	0.64	1
Total	**0.81**	**0.76**	**102**

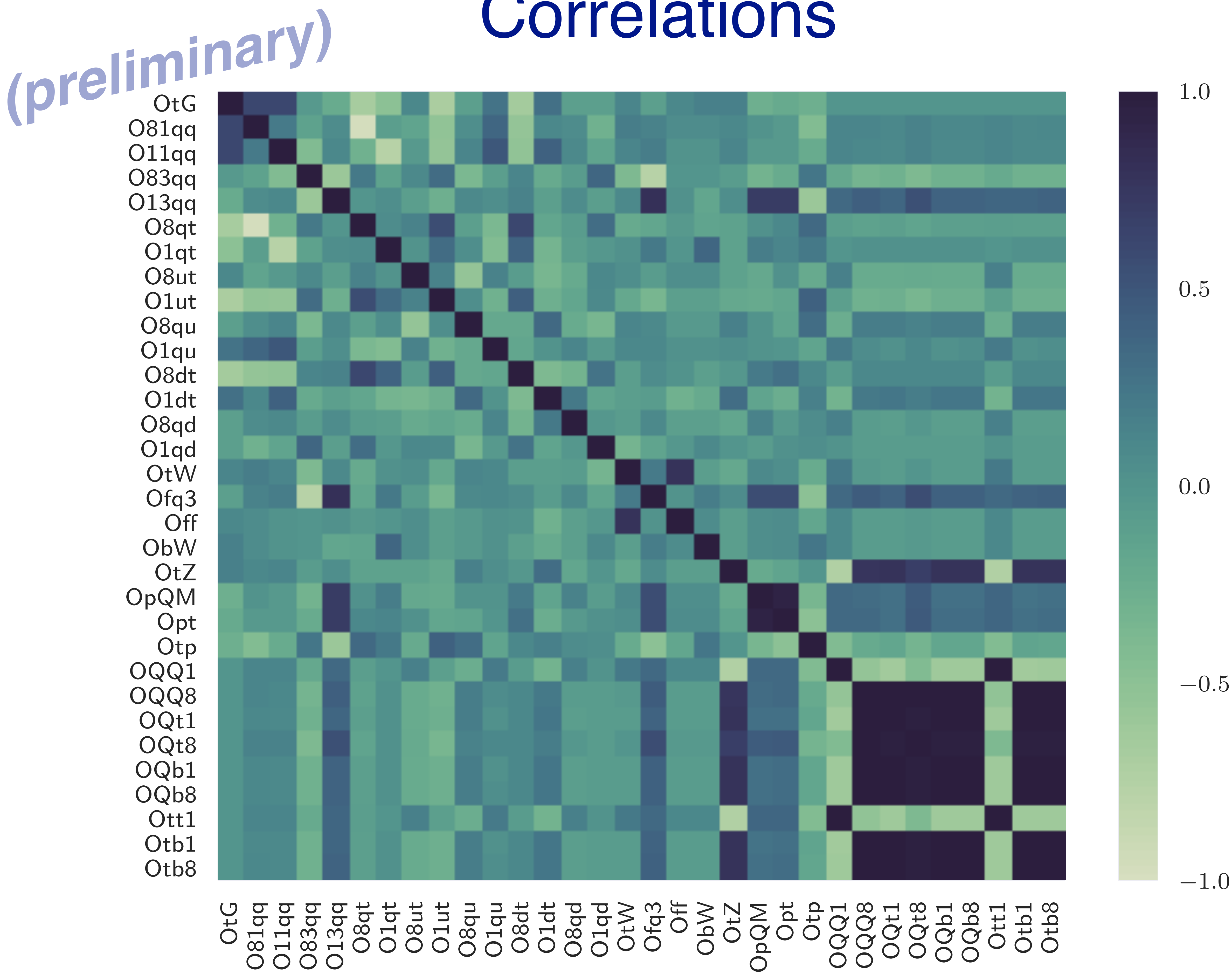
Fit results



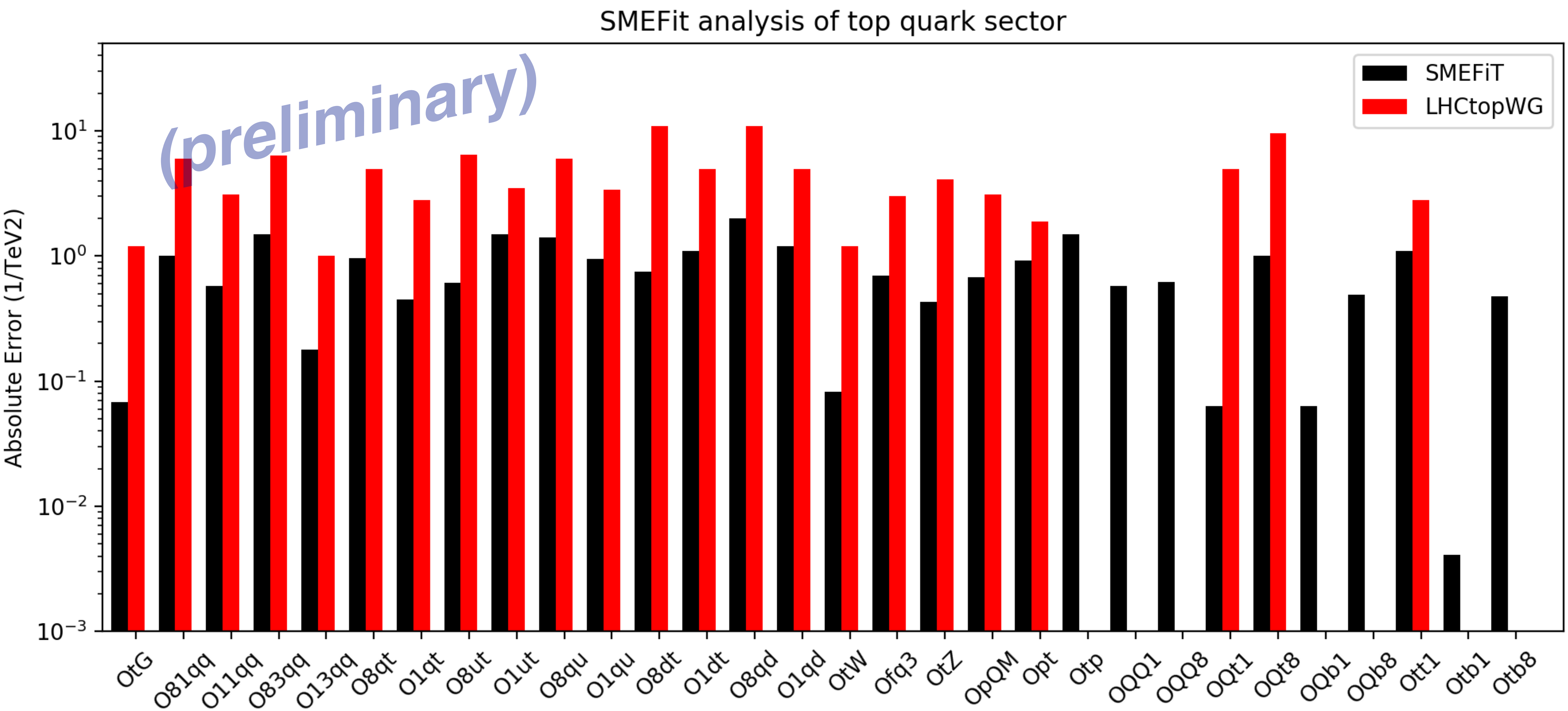


- Agreement with the SM expectation **within uncertainties**
- Bounds on individual operators are in general largely **correlated among them**
- Large differences between the bounds obtained from each operator

Correlations

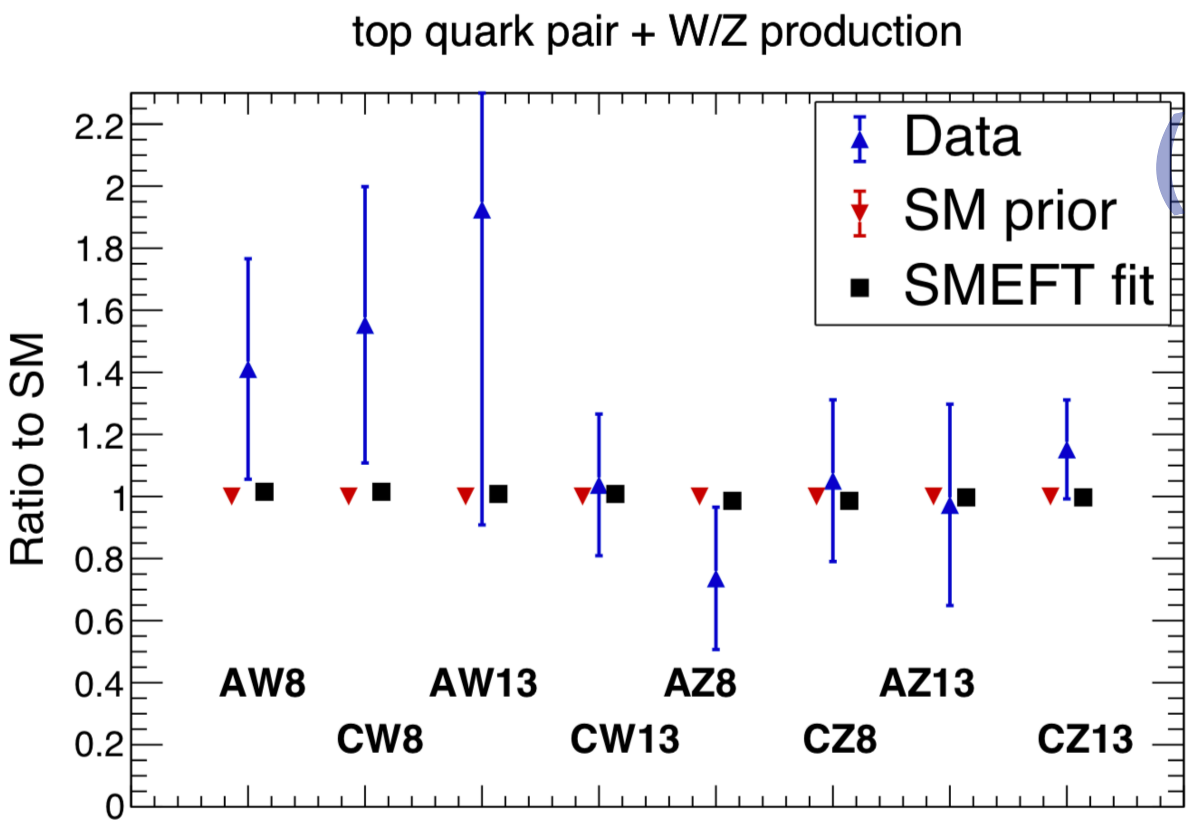


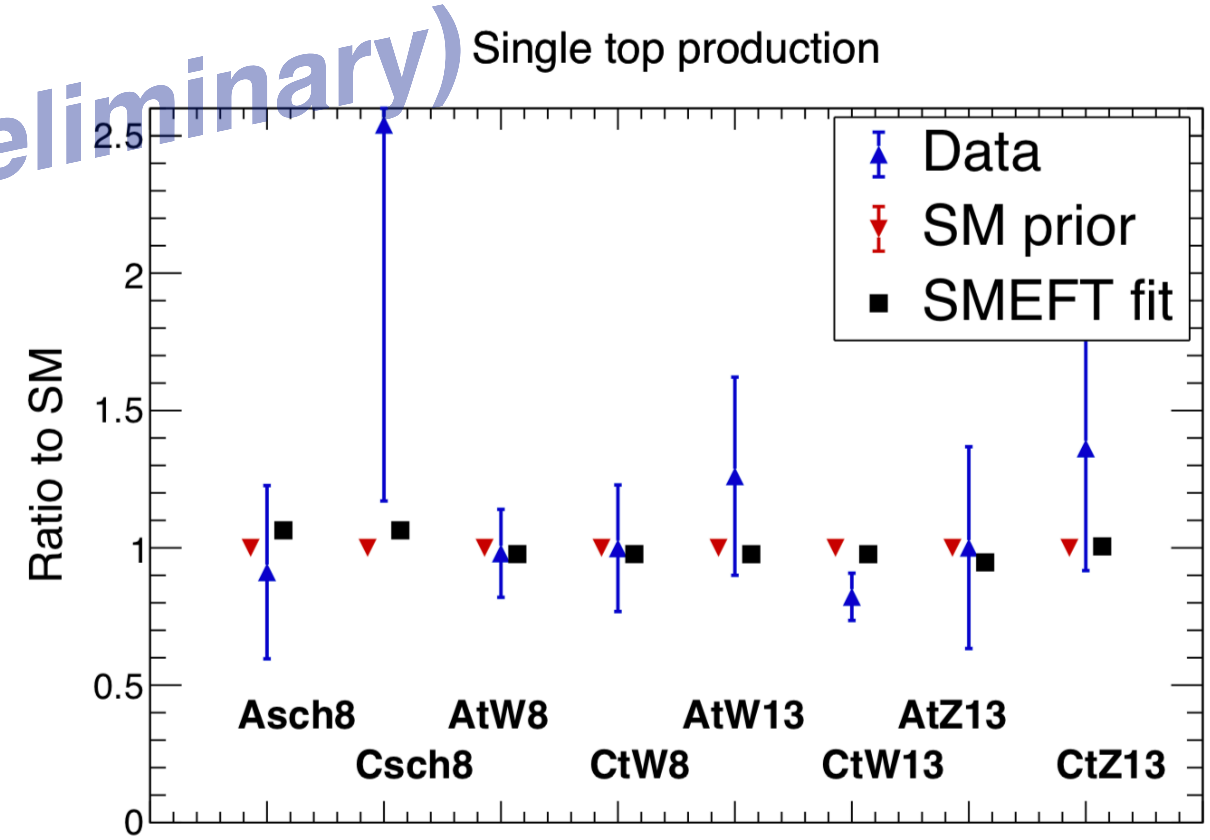
Comparison with previous bounds

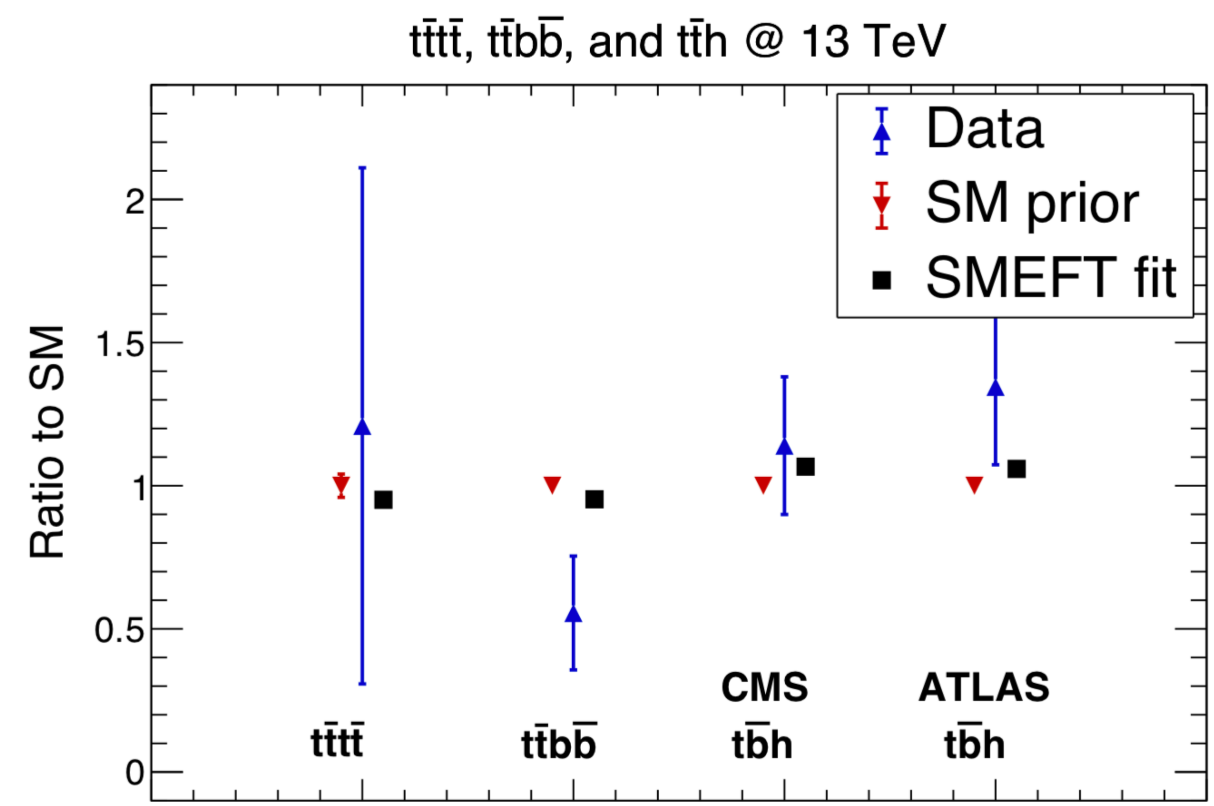


- Compare to bounds reported in the LHC Top WG EFT note (same flavour assumptions)
- **Improvement** found (more stringent bounds) in all fitted degrees of freedom
- For some specific operators **our bounds are the first ones** to be reported

Comparison with data







- The **best-fit SMEFT-induced shift** wrt the SM calculation depends on the process
- For inclusive top quark pair and single top, the SMEFT shifts are < 2%
- For ***tttt, ttbbb***, and ***tth*** the SMEFT shifts can be as large as 5% (reflecting the larger experimental errors)

Summary and outlook

- Presented a novel framework, **SMEFiT,** suitable for global analyses of the SMEFT, which exploit expertise inherited from global PDF fits
- As a proof-of-concept, applied this novel framework to the exploration of the constraints in the SMEFT parameter space provided by **LHC top quark data**
- (preliminary) results indicate **improved constraints** compared to previous studies

- Enlarge the operator fitting basis and include **additional LHC cross-sections** (Higgs, electroweak, jets) as well as flavour and low-energy observables
- Explore implications of our results for specific **UV-complete models**
- Ultimately the **simultaneous determination of PDFs and SMEFT** degrees of freedom might be required to fully exploit the LHC potential