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EFT interpretation of LHC data using Fitmaker

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Based on 2012.02779 J. Ellis, M. Madigan, K. Mimasu, V. Sanz, **TY**

Introduction

- SMEFT
- Measurements
- Fitmaker
- Results
- Conclusion

SM to SMEFT framework

- New physics appear to be decoupled at higher energies
- Given particle content, write down *all* terms allowed by symmetries…

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$
Q_L	$\mathbf{3}$	$\mathbf{2}$	$\frac{1}{6}$
q_R^u	$\mathbf{3}$	$\mathbf{1}$	$\frac{2}{3}$
q_R^d	$\mathbf{3}$	$\mathbf{1}$	$-\frac{1}{3}$
L_L	$\mathbf{1}$	$\mathbf{2}$	$-\frac{1}{2}$
l_R	$\mathbf{1}$	$\mathbf{1}$	-1
ϕ	$\mathbf{1}$	$\mathbf{2}$	$\frac{1}{2}$

$$\mathcal{L}_{SM} = \mathcal{L}_m + \mathcal{L}_g + \mathcal{L}_h + \mathcal{L}_y \quad ,$$

$$\mathcal{L}_m = \bar{Q}_L i\gamma^\mu D_\mu^L Q_L + \bar{q}_R i\gamma^\mu D_\mu^R q_R + \bar{L}_L i\gamma^\mu D_\mu^L L_L + \bar{l}_R i\gamma^\mu D_\mu^R l_R$$

$$\mathcal{L}_G = -\frac{1}{4} B_{\mu\nu} B^{\mu\nu} - \frac{1}{4} W_{\mu\nu}^a W^{a\mu\nu}$$

$$\mathcal{L}_H = (D_\mu^L \phi)^\dagger (D^{L\mu} \phi) - V(\phi)$$

$$\mathcal{L}_Y = y_d \bar{Q}_L \phi q_R^d + y_u \bar{Q}_L \phi^c q_R^u + y_L \bar{L}_L \phi l_R + \text{h.c.} \quad ,$$

- …Including **higher-dimensional** operators!

$$+ \quad \mathcal{L}_{\text{SM}}^{\text{dim-6}} = \sum_i \frac{c_i}{\Lambda^2} \mathcal{O}_i$$

- Generated by new physics at scale $\Lambda \gg v$

Operators

- Lagrangian dim-6 operator coefficient normalization: $$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_{i=1}^{2499} \frac{C_i}{\Lambda^2}\mathcal{O}_i$$

- Warsaw basis

[1008.4884 Grzadkowski et al]

X^3		H^6 and H^4D^2		$\psi^2 H^3$	
$\mathcal{O}_G$	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$\mathcal{O}_H$	$(H^\dagger H)^3$	$\mathcal{O}_{eH}$	$(H^\dagger H)(\bar l_p e_r H)$
$\mathcal{O}_{\widetilde G}$	$f^{ABC} \widetilde G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	$\mathcal{O}_{uH}$	$(H^\dagger H)(\bar q_p u_r \widetilde H)$
$\mathcal{O}_W$	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$\mathcal{O}_{HD}$	$\left(H^\dagger D^\mu H\right)^\star \left(H^\dagger D_\mu H\right)$	$\mathcal{O}_{dH}$	$(H^\dagger H)(\bar q_p d_r H)$
$\mathcal{O}_{\widetilde W}$	$\varepsilon^{IJK} \widetilde W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 H^2$		$\psi^2 XH$		$\psi^2 H^2 D$	
$\mathcal{O}_{HG}$	$H^\dagger H\, G_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eW}$	$(\bar l_p \sigma^{\mu\nu} e_r)\tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hl}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar l_p \gamma^\mu l_r)$
$\mathcal{O}_{H\widetilde G}$	$H^\dagger H\, \widetilde G_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eB}$	$(\bar l_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}^I_\mu H)(\bar l_p \tau^I \gamma^\mu l_r)$
$\mathcal{O}_{HW}$	$H^\dagger H\, W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uG}$	$(\bar q_p \sigma^{\mu\nu} T^A u_r)\widetilde H\, G_{\mu\nu}^A$	$\mathcal{O}_{He}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar e_p \gamma^\mu e_r)$
$\mathcal{O}_{H\widetilde W}$	$H^\dagger H\, \widetilde W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uW}$	$(\bar q_p \sigma^{\mu\nu} u_r)\tau^I \widetilde H\, W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar q_p \gamma^\mu q_r)$
$\mathcal{O}_{HB}$	$H^\dagger H\, B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{uB}$	$(\bar q_p \sigma^{\mu\nu} u_r)\widetilde H\, B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}^I_\mu H)(\bar q_p \tau^I \gamma^\mu q_r)$
$\mathcal{O}_{H\widetilde B}$	$H^\dagger H\, \widetilde B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{dG}$	$(\bar q_p \sigma^{\mu\nu} T^A d_r) H\, G_{\mu\nu}^A$	$\mathcal{O}_{Hu}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar u_p \gamma^\mu u_r)$
$\mathcal{O}_{HWB}$	$H^\dagger \tau^I H\, W_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dW}$	$(\bar q_p \sigma^{\mu\nu} d_r)\tau^I H\, W_{\mu\nu}^I$	$\mathcal{O}_{Hd}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar d_p \gamma^\mu d_r)$
$\mathcal{O}_{H\widetilde WB}$	$H^\dagger \tau^I H\, \widetilde W_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dB}$	$(\bar q_p \sigma^{\mu\nu} d_r) H\, B_{\mu\nu}$	$\mathcal{O}_{Hud}$	$i(\widetilde H^\dagger D_\mu H)(\bar u_p \gamma^\mu d_r)$

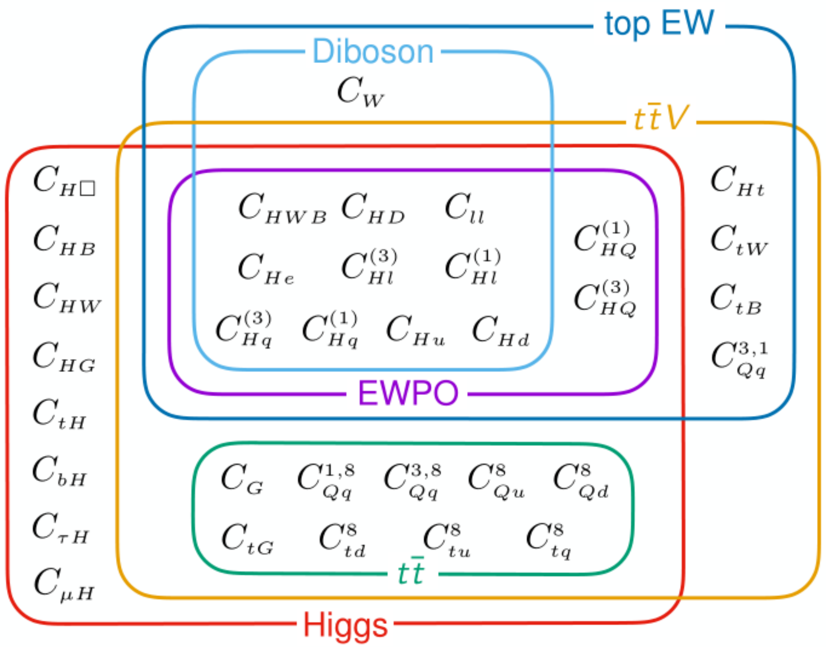
$(\bar LL)(\bar LL)$		$(\bar RR)(\bar RR)$		$(\bar LL)(\bar RR)$	
$\mathcal{O}_{ll}$	$(\bar l_p \gamma_\mu l_r)(\bar l_s \gamma^\mu l_t)$	$\mathcal{O}_{ee}$	$(\bar e_p \gamma_\mu e_r)(\bar e_s \gamma^\mu e_t)$	$\mathcal{O}_{le}$	$(\bar l_p \gamma_\mu l_r)(\bar e_s \gamma^\mu e_t)$
$\mathcal{O}_{qq}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar q_s \gamma^\mu q_t)$	$\mathcal{O}_{uu}$	$(\bar u_p \gamma_\mu u_r)(\bar u_s \gamma^\mu u_t)$	$\mathcal{O}_{lu}$	$(\bar l_p \gamma_\mu l_r)(\bar u_s \gamma^\mu u_t)$
$\mathcal{O}_{qq}^{(3)}$	$(\bar q_p \gamma_\mu \tau^I q_r)(\bar q_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{dd}$	$(\bar d_p \gamma_\mu d_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{ld}$	$(\bar l_p \gamma_\mu l_r)(\bar d_s \gamma^\mu d_t)$
$\mathcal{O}_{lq}^{(1)}$	$(\bar l_p \gamma_\mu l_r)(\bar q_s \gamma^\mu q_t)$	$\mathcal{O}_{eu}$	$(\bar e_p \gamma_\mu e_r)(\bar u_s \gamma^\mu u_t)$	$\mathcal{O}_{qe}$	$(\bar q_p \gamma_\mu q_r)(\bar e_s \gamma^\mu e_t)$
$\mathcal{O}_{lq}^{(3)}$	$(\bar l_p \gamma_\mu \tau^I l_r)(\bar q_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{ed}$	$(\bar e_p \gamma_\mu e_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar u_s \gamma^\mu u_t)$
		$\mathcal{O}_{ud}^{(1)}$	$(\bar u_p \gamma_\mu u_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar u_s \gamma^\mu T^A u_t)$
		$\mathcal{O}_{ud}^{(8)}$	$(\bar u_p \gamma_\mu T^A u_r)(\bar d_s \gamma^\mu T^A d_t)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar d_s \gamma^\mu d_t)$
				$\mathcal{O}_{qd}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar d_s \gamma^\mu T^A d_t)$

$(\bar LR)(\bar RL)$ and $(\bar LR)(\bar LR)$		B-violating	
$\mathcal{O}_{ledq}$	$(\bar l_p^j e_r)(\bar d_s q_t^j)$	$\mathcal{O}_{duq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$
$\mathcal{O}_{quqd}^{(1)}$	$(\bar q_p^j u_r)\varepsilon_{jk}(\bar q_s^k d_t)$	$\mathcal{O}_{qqu}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{quqd}^{(8)}$	$(\bar q_p^j T^A u_r)\varepsilon_{jk}(\bar q_s^k T^A d_t)$	$\mathcal{O}_{qqq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$
$\mathcal{O}_{lequ}^{(1)}$	$(\bar l_p^j e_r)\varepsilon_{jk}(\bar q_s^k u_t)$	$\mathcal{O}_{duu}$	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{lequ}^{(3)}$	$(\bar l_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar q_s^k \sigma^{\mu\nu} u_t)$		

Input scheme:

$$\alpha_{EW}^{-1} = 127.95, \quad G_F = 1.16638\times 10^{-5}\,\mathrm{GeV}^{-2},$$
$$m_Z = 91.1876\,\mathrm{GeV}, \quad m_H = 125.09\,\mathrm{GeV}, \quad m_t = 173.2\,\mathrm{GeV}$$

Operators



X^3		H^6 and H^4D^2		$\psi^2 H^3$	
$\mathcal{O}_G$	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$\mathcal{O}_H$	$(H^\dagger H)^3$	$\mathcal{O}_{eH}$	$(H^\dagger H)(\bar{l}_p e_r H)$
$\mathcal{O}_{\widetilde{G}}$	$f^{ABC} \widetilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	$\mathcal{O}_{uH}$	$(H^\dagger H)(\bar{q}_p u_r \widetilde{H})$
$\mathcal{O}_W$	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$\mathcal{O}_{HD}$	$(H^\dagger D^\mu H)^\star (H^\dagger D_\mu H)$	$\mathcal{O}_{dH}$	$(H^\dagger H)(\bar{q}_p d_r H)$
$\mathcal{O}_{\widetilde{W}}$	$\varepsilon^{IJK} \widetilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 H^2$		$\psi^2 X H$		$\psi^2 H^2 D$	
$\mathcal{O}_{HG}$	$H^\dagger H\, G_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eW}$	$(\bar{l}_p \sigma^{\mu\nu} e_r)\tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hl}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$
$\mathcal{O}_{H\widetilde{G}}$	$H^\dagger H\, \widetilde{G}_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eB}$	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$\mathcal{O}_{HW}$	$H^\dagger H\, W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r)\widetilde{H}\, G_{\mu\nu}^A$	$\mathcal{O}_{He}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$
$\mathcal{O}_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uW}$	$(\bar{q}_p \sigma^{\mu\nu} u_r)\tau^I \widetilde{H}\, W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$
$\mathcal{O}_{HB}$	$H^\dagger H\, B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{uB}$	$(\bar{q}_p \sigma^{\mu\nu} u_r)\widetilde{H}\, B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$\mathcal{O}_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{dG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) H\, G_{\mu\nu}^A$	$\mathcal{O}_{Hu}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{u}_p \gamma^\mu u_r)$
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$\mathcal{O}_{H\widetilde{W}B}$	$H^\dagger \tau^I H\, \widetilde{W}_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dB}$	$(\bar{q}_p \sigma^{\mu\nu} d_r) H\, B_{\mu\nu}$	$\mathcal{O}_{Hud}$	$i(\widetilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
$\mathcal{O}_{ll}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	$\mathcal{O}_{ee}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	$\mathcal{O}_{le}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	$\mathcal{O}_{uu}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	$\mathcal{O}_{lu}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{dd}$	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{ld}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
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$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B-violating	
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$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$	$\mathcal{O}_{duu}$	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

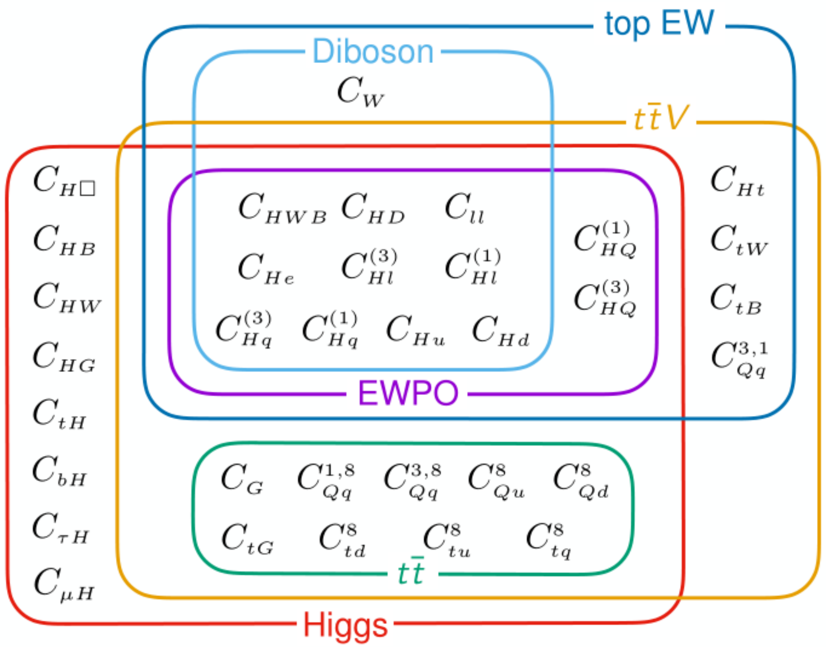
- 20 operators relevant for Higgs, diboson, and EWPO:

EWPO: $\mathcal{O}_{HWB}\,,\ \mathcal{O}_{HD}\,,\ \mathcal{O}_{ll}\,,\ \mathcal{O}_{Hl}^{(3)}\,,\ \mathcal{O}_{Hl}^{(1)}\,,\ \mathcal{O}_{He}\,,\ \mathcal{O}_{Hq}^{(3)}\,,\ \mathcal{O}_{Hq}^{(1)}\,,\ \mathcal{O}_{Hd}\,,\ \mathcal{O}_{Hu}\,,$

Bosonic: $\mathcal{O}_{H\Box}\,,\ \mathcal{O}_{HG}\,,\ \mathcal{O}_{HW}\,,\ \mathcal{O}_{HB}\,,\ \mathcal{O}_{W}\,,\ \mathcal{O}_{G}\,,$

Yukawa: $\mathcal{O}_{\tau H}\,,\ \mathcal{O}_{\mu H}\,,\ \mathcal{O}_{bH}\,,\ \mathcal{O}_{tH}\,.$

Operators



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$\mathcal{O}_{H\widetilde{G}}$	$H^\dagger H\, \widetilde{G}_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eB}$	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$\mathcal{O}_{HW}$	$H^\dagger H\, W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r)\widetilde{H}\, G_{\mu\nu}^A$	$\mathcal{O}_{He}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$
$\mathcal{O}_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uW}$	$(\bar{q}_p \sigma^{\mu\nu} u_r)\tau^I \widetilde{H}\, W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$
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$\mathcal{O}_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{dG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) H\, G_{\mu\nu}^A$	$\mathcal{O}_{Hu}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{u}_p \gamma^\mu u_r)$
$\mathcal{O}_{HWB}$	$H^\dagger \tau^I H\, W_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dW}$	$(\bar{q}_p \sigma^{\mu\nu} d_r)\tau^I H\, W_{\mu\nu}^I$	$\mathcal{O}_{Hd}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$
$\mathcal{O}_{H\widetilde{W}B}$	$H^\dagger \tau^I H\, \widetilde{W}_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dB}$	$(\bar{q}_p \sigma^{\mu\nu} d_r) H\, B_{\mu\nu}$	$\mathcal{O}_{Hud}$	$i(\widetilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
$\mathcal{O}_{ll}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	$\mathcal{O}_{ee}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	$\mathcal{O}_{le}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	$\mathcal{O}_{uu}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	$\mathcal{O}_{lu}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{dd}$	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{ld}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	$\mathcal{O}_{eu}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	$\mathcal{O}_{qe}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{ed}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B-violating	
$\mathcal{O}_{ledq}$	$(\bar{l}_p^j e_r)(\bar{d}_s q_t^j)$	$\mathcal{O}_{duq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$
$\mathcal{O}_{quqd}^{(1)}$	$(\bar{q}_p^j u_r)\varepsilon_{jk}(\bar{q}_s^k d_t)$	$\mathcal{O}_{qqu}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r)\varepsilon_{jk}(\bar{q}_s^k T^A d_t)$	$\mathcal{O}_{qqq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$
$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$	$\mathcal{O}_{duu}$	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

- 20 operators relevant for Higgs, diboson, and EWPO:

EWPO: $\mathcal{O}_{HWB}\,, \mathcal{O}_{HD}\,, \mathcal{O}_{ll}\,, \mathcal{O}_{Hl}^{(3)}\,, \mathcal{O}_{Hl}^{(1)}\,, \mathcal{O}_{He}\,, \mathcal{O}_{Hq}^{(3)}\,, \mathcal{O}_{Hq}^{(1)}\,, \mathcal{O}_{Hd}\,, \mathcal{O}_{Hu}\,,$ Can be constrained setting $|H|^2 \to v^2$

Bosonic: $\mathcal{O}_{H\Box}\,, \mathcal{O}_{HG}\,, \mathcal{O}_{HW}\,, \mathcal{O}_{HB}\,, \mathcal{O}_{W}\,, \mathcal{O}_{G}\,,$

Triple-gauge field strength operators

Yukawa: $\mathcal{O}_{\tau H}\,, \mathcal{O}_{\mu H}\,, \mathcal{O}_{bH}\,, \mathcal{O}_{tH}\,.$

Can only be constrained by Higgs physics

Operators

- Top-specific flavour symmetry:

$$SU(3)^5 \to SU(2)^2 \times SU(3)^3$$
$$= SU(2)_q \times SU(2)_u \times SU(3)_d \times SU(3)_l \times SU(3)_e$$

- + 14 Top operators

See 1802.07237

Top 2F: $\mathcal{O}_{HQ}^{(3)}, \mathcal{O}_{HQ}^{(1)}, \mathcal{O}_{Ht}, \mathcal{O}_{tG}, \mathcal{O}_{tW}, \mathcal{O}_{tB},$

Top 4F: $\mathcal{O}_{Qq}^{3,1}, \mathcal{O}_{Qq}^{3,8}, \mathcal{O}_{Qq}^{1,8}, \mathcal{O}_{Qu}^{8}, \mathcal{O}_{Qd}^{8}, \mathcal{O}_{tQ}^{8}, \mathcal{O}_{tu}^{8}, \mathcal{O}_{td}^{8}$

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Bosonic: $\mathcal{O}_{H\Box}, \mathcal{O}_{HG}, \mathcal{O}_{HW}, \mathcal{O}_{HB}, \mathcal{O}_{W}, \mathcal{O}_{G},$

Triple-gauge field strength operators

Yukawa: $\mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}, \mathcal{O}_{bH}, \mathcal{O}_{tH}.$

Can only be constrained by Higgs physics

X^3	
$\mathcal{O}_G$	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
$\mathcal{O}_{\widetilde{G}}$	$f^{ABC} \widetilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
$\mathcal{O}_W$	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$
$\mathcal{O}_{\widetilde{W}}$	$\varepsilon^{IJK} \widetilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$

H^6 and H^4D^2	
$\mathcal{O}_H$	$(H^\dagger H)^3$
$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$
$\mathcal{O}_{HD}$	$(H^\dagger D^\mu H)^\star (H^\dagger D_\mu H)$

$\psi^2 H^3$	
$\mathcal{O}_{eH}$	$(H^\dagger H)(\bar{l}_p e_r H)$
$\mathcal{O}_{uH}$	$(H^\dagger H)(\bar{q}_p u_r \widetilde{H})$
$\mathcal{O}_{dH}$	$(H^\dagger H)(\bar{q}_p d_r H)$

X^2H^2	
$\mathcal{O}_{HG}$	$H^\dagger H\, G^A_{\mu\nu} G^{A\mu\nu}$
$\mathcal{O}_{H\widetilde{G}}$	$H^\dagger H\, \widetilde{G}^A_{\mu\nu} G^{A\mu\nu}$
$\mathcal{O}_{HW}$	$H^\dagger H\, W^I_{\mu\nu} W^{I\mu\nu}$
$\mathcal{O}_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}^I_{\mu\nu} W^{I\mu\nu}$
$\mathcal{O}_{HB}$	$H^\dagger H\, B_{\mu\nu} B^{\mu\nu}$
$\mathcal{O}_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu} B^{\mu\nu}$
$\mathcal{O}_{HWB}$	$H^\dagger \tau^I H\, W^I_{\mu\nu} B^{\mu\nu}$
$\mathcal{O}_{H\widetilde{W}B}$	$H^\dagger \tau^I H\, \widetilde{W}^I_{\mu\nu} B^{\mu\nu}$

$\psi^2 XH$	
$\mathcal{O}_{eW}$	$(\bar{l}_p \sigma^{\mu\nu} e_r)\tau^I H W^I_{\mu\nu}$
$\mathcal{O}_{eB}$	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$
$\mathcal{O}_{uG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r)\widetilde{H}\, G^A_{\mu\nu}$
$\mathcal{O}_{uW}$	$(\bar{q}_p \sigma^{\mu\nu} u_r)\tau^I \widetilde{H}\, W^I_{\mu\nu}$
$\mathcal{O}_{uB}$	$(\bar{q}_p \sigma^{\mu\nu} u_r)\widetilde{H}\, B_{\mu\nu}$
$\mathcal{O}_{dG}$	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) H\, G^A_{\mu\nu}$
$\mathcal{O}_{dW}$	$(\bar{q}_p \sigma^{\mu\nu} d_r)\tau^I H\, W^I_{\mu\nu}$
$\mathcal{O}_{dB}$	$(\bar{q}_p \sigma^{\mu\nu} d_r) H\, B_{\mu\nu}$

$\psi^2 H^2 D$	
$\mathcal{O}_{Hl}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$
$\mathcal{O}_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}^I_\mu H)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$\mathcal{O}_{He}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$
$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$
$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}^I_\mu H)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$\mathcal{O}_{Hu}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{u}_p \gamma^\mu u_r)$
$\mathcal{O}_{Hd}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$
$\mathcal{O}_{Hud}$	$i(\widetilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$	
$\mathcal{O}_{ll}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$
$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$
$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$
$\mathcal{O}_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$
$\mathcal{O}_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$

$(\bar{R}R)(\bar{R}R)$	
$\mathcal{O}_{ee}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{uu}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{dd}$	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{eu}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{ed}$	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}L)(\bar{R}R)$	
$\mathcal{O}_{le}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{lu}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{ld}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{qe}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$	
$\mathcal{O}_{ledq}$	$(\bar{l}_p^j e_r)(\bar{d}_s q_t^j)$
$\mathcal{O}_{quqd}^{(1)}$	$(\bar{q}_p^j u_r)\varepsilon_{jk}(\bar{q}_s^k d_t)$
$\mathcal{O}_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r)\varepsilon_{jk}(\bar{q}_s^k T^A d_t)$
$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$
$\mathcal{O}_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k \sigma^{\mu\nu} u_t)$

B-violating	
$\mathcal{O}_{duq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$
$\mathcal{O}_{qqu}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{qqq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$
$\mathcal{O}_{duu}$	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$

Operators

- Top-specific flavour symmetry:

$$SU(3)^5 \to SU(2)^2 \times SU(3)^3$$
$$= SU(2)_q \times SU(2)_u \times SU(3)_d \times SU(3)_l \times SU(3)_e$$

Linear fit

- + 14 Top operators

See 1802.07237

Top 2F: $\mathcal{O}_{HQ}^{(3)}, \mathcal{O}_{HQ}^{(1)}, \mathcal{O}_{Ht}, \mathcal{O}_{tG}, \mathcal{O}_{tW}, \mathcal{O}_{tB}$

Top 4F: $\mathcal{O}_{Qq}^{3,1}, \mathcal{O}_{Qq}^{3,8}, \mathcal{O}_{Qq}^{1,8}, \mathcal{O}_{Qu}^{8}, \mathcal{O}_{Qd}^{8}, \mathcal{O}_{tQ}^{8}, \mathcal{O}_{tu}^{8}, \mathcal{O}_{td}^{8}$

- 20 operators relevant for Higgs, diboson, and EWPO:

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Bosonic: $\mathcal{O}_{H\Box}, \mathcal{O}_{HG}, \mathcal{O}_{HW}, \mathcal{O}_{HB}, \mathcal{O}_{W}, \mathcal{O}_{G},$

Triple-gauge field strength operators

Yukawa: $\mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}, \mathcal{O}_{bH}, \mathcal{O}_{tH}.$

Can only be constrained by Higgs physics

X^3		H^6 and H^4D^2		$\psi^2 H^3$	
$\mathcal{O}_G$	$f^{ABC}G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$	$\mathcal{O}_H$	$(H^\dagger H)^3$	$\mathcal{O}_{eH}$	$(H^\dagger H)(\bar l_p e_r H)$
$\mathcal{O}_{\widetilde G}$	$f^{ABC}\widetilde G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	$\mathcal{O}_{uH}$	$(H^\dagger H)(\bar q_p u_r \widetilde H)$
$\mathcal{O}_W$	$\varepsilon^{IJK}W_\mu^{I\nu}W_\nu^{J\rho}W_\rho^{K\mu}$	$\mathcal{O}_{HD}$	$(H^\dagger D^\mu H)^\star (H^\dagger D_\mu H)$	$\mathcal{O}_{dH}$	$(H^\dagger H)(\bar q_p d_r H)$
$\mathcal{O}_{\widetilde W}$	$\varepsilon^{IJK}\widetilde W_\mu^{I\nu}W_\nu^{J\rho}W_\rho^{K\mu}$				

X^2H^2		$\psi^2 XH$		$\psi^2 H^2 D$	
$\mathcal{O}_{HG}$	$H^\dagger H\, G_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eW}$	$(\bar l_p \sigma^{\mu\nu} e_r)\tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hl}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar l_p \gamma^\mu l_r)$
$\mathcal{O}_{H\widetilde G}$	$H^\dagger H\, \widetilde G_{\mu\nu}^A G^{A\mu\nu}$	$\mathcal{O}_{eB}$	$(\bar l_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar l_p \tau^I \gamma^\mu l_r)$
$\mathcal{O}_{HW}$	$H^\dagger H\, W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uG}$	$(\bar q_p \sigma^{\mu\nu} T^A u_r)\widetilde H\, G_{\mu\nu}^A$	$\mathcal{O}_{He}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar e_p \gamma^\mu e_r)$
$\mathcal{O}_{H\widetilde W}$	$H^\dagger H\, \widetilde W_{\mu\nu}^I W^{I\mu\nu}$	$\mathcal{O}_{uW}$	$(\bar q_p \sigma^{\mu\nu} u_r)\tau^I \widetilde H\, W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar q_p \gamma^\mu q_r)$
$\mathcal{O}_{HB}$	$H^\dagger H\, B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{uB}$	$(\bar q_p \sigma^{\mu\nu} u_r)\widetilde H\, B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar q_p \tau^I \gamma^\mu q_r)$
$\mathcal{O}_{H\widetilde B}$	$H^\dagger H\, \widetilde B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{dG}$	$(\bar q_p \sigma^{\mu\nu} T^A d_r) H\, G_{\mu\nu}^A$	$\mathcal{O}_{Hu}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar u_p \gamma^\mu u_r)$
$\mathcal{O}_{HWB}$	$H^\dagger \tau^I H\, W_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dW}$	$(\bar q_p \sigma^{\mu\nu} d_r)\tau^I H\, W_{\mu\nu}^I$	$\mathcal{O}_{Hd}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar d_p \gamma^\mu d_r)$
$\mathcal{O}_{H\widetilde WB}$	$H^\dagger \tau^I H\, \widetilde W_{\mu\nu}^I B^{\mu\nu}$	$\mathcal{O}_{dB}$	$(\bar q_p \sigma^{\mu\nu} d_r) H\, B_{\mu\nu}$	$\mathcal{O}_{Hud}$	$i(\widetilde H^\dagger D_\mu H)(\bar u_p \gamma^\mu d_r)$

$(\bar LL)(\bar LL)$		$(\bar RR)(\bar RR)$		$(\bar LL)(\bar RR)$	
$\mathcal{O}_{ll}$	$(\bar l_p \gamma_\mu l_r)(\bar l_s \gamma^\mu l_t)$	$\mathcal{O}_{ee}$	$(\bar e_p \gamma_\mu e_r)(\bar e_s \gamma^\mu e_t)$	$\mathcal{O}_{le}$	$(\bar l_p \gamma_\mu l_r)(\bar e_s \gamma^\mu e_t)$
$\mathcal{O}_{qq}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar q_s \gamma^\mu q_t)$	$\mathcal{O}_{uu}$	$(\bar u_p \gamma_\mu u_r)(\bar u_s \gamma^\mu u_t)$	$\mathcal{O}_{lu}$	$(\bar l_p \gamma_\mu l_r)(\bar u_s \gamma^\mu u_t)$
$\mathcal{O}_{qq}^{(3)}$	$(\bar q_p \gamma_\mu \tau^I q_r)(\bar q_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{dd}$	$(\bar d_p \gamma_\mu d_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{ld}$	$(\bar l_p \gamma_\mu l_r)(\bar d_s \gamma^\mu d_t)$
$\mathcal{O}_{lq}^{(1)}$	$(\bar l_p \gamma_\mu l_r)(\bar q_s \gamma^\mu q_t)$	$\mathcal{O}_{eu}$	$(\bar e_p \gamma_\mu e_r)(\bar u_s \gamma^\mu u_t)$	$\mathcal{O}_{qe}$	$(\bar q_p \gamma_\mu q_r)(\bar e_s \gamma^\mu e_t)$
$\mathcal{O}_{lq}^{(3)}$	$(\bar l_p \gamma_\mu \tau^I l_r)(\bar q_s \gamma^\mu \tau^I q_t)$	$\mathcal{O}_{ed}$	$(\bar e_p \gamma_\mu e_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar u_s \gamma^\mu u_t)$
		$\mathcal{O}_{ud}^{(1)}$	$(\bar u_p \gamma_\mu u_r)(\bar d_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar u_s \gamma^\mu T^A u_t)$
		$\mathcal{O}_{ud}^{(8)}$	$(\bar u_p \gamma_\mu T^A u_r)(\bar d_s \gamma^\mu T^A d_t)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar d_s \gamma^\mu d_t)$
				$\mathcal{O}_{qd}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar d_s \gamma^\mu T^A d_t)$

$(\bar LR)(\bar RL)$ and $(\bar LR)(\bar LR)$		B-violating	
$\mathcal{O}_{ledq}$	$(\bar l_p^j e_r)(\bar d_s q_t^j)$	$\mathcal{O}_{duq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$
$\mathcal{O}_{quqd}^{(1)}$	$(\bar q_p^j u_r)\varepsilon_{jk}(\bar q_s^k d_t)$	$\mathcal{O}_{qqu}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{quqd}^{(8)}$	$(\bar q_p^j T^A u_r)\varepsilon_{jk}(\bar q_s^k T^A d_t)$	$\mathcal{O}_{qqq}$	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$
$\mathcal{O}_{lequ}^{(1)}$	$(\bar l_p^j e_r)\varepsilon_{jk}(\bar q_s^k u_t)$	$\mathcal{O}_{duu}$	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$
$\mathcal{O}_{lequ}^{(3)}$	$(\bar l_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar q_s^k \sigma^{\mu\nu} u_t)$		

Measurements

- Higgs, diboson, EWPO:

EW precision observables	n_{obs}	Ref.
Precision electroweak measurements on the Z resonance. Γ_Z, $\sigma^0_{\text{had.}}$, R^0_ℓ, A^ℓ_{FB}, A_ℓ(SLD), A_ℓ(Pt), R^0_b, R^0_c A^b_{FB}, A^c_{FB}, A_b & A_c	12	[1]
Combination of CDF and D0 W-Boson Mass Measurements	1	[6]
LHC run 1 W boson mass measurement by ATLAS	1	[57]

Diboson LEP & LHC	n_{obs}	Ref.
W^+W^- angular distribution measurements at LEP II.	8	[5]
W^+W^- total cross section measurements at L3 in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 8 energies	24	[3]
W^+W^- total cross section measurements at OPAL in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 7 energies	21	[4]
W^+W^- total cross section measurements at ALEPH in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 8 energies	21	[2]
ATLAS W^+W^- differential cross section in the $e\nu\mu\nu$ channel, $\frac{d\sigma}{dp^T_{\ell_1}}$, $p_T > 120$ GeV overflow bin	1	[225]
ATLAS W^+W^- fiducial differential cross section in the $e\nu\mu\nu$ channel, $\frac{d\sigma}{dp^T_{\ell_1}}$	14	[58]
ATLAS Zjj fiducial differential cross section in the $\ell^+\ell^-$ channel, $\frac{d\sigma}{d\Delta\varphi_{jj}}$	12	[60]

LHC Run 1 Higgs	n_{obs}	Ref.
ATLAS and CMS LHC Run 1 combination of Higgs signal strengths. Production: ggF, VBF, ZH, WH & ttH Decay: $\gamma\gamma$, ZZ, W^+W^-, $\tau^+\tau^-$ & $b\bar{b}$	21	[8]
ATLAS inclusive $Z\gamma$ signal strength measurement	1	[9]

LHC Run 2 Higgs (new)	n_{obs}	Ref.
ATLAS combination of signal strengths and stage 1.0 STXS in $H \to 4\ell$ including ratios of branching fractions to $\gamma\gamma$, WW^*, $\tau^+\tau^-$ & $b\bar{b}$ Signal strengths|coarse STXS bins| fine STXS bins	16|19|25	[10]
CMS LHC combination of Higgs signal strengths. Production: ggF, VBF, ZH, WH & ttH Decay: $\gamma\gamma$, ZZ, W^+W^-, $\tau^+\tau^-$, $b\bar{b}$ & $\mu^+\mu^-$	23	[11]
CMS stage 1.0 STXS measurements for $H \to \gamma\gamma$. 13 parameter fit | 7 parameter fit	13|7	[12]
CMS stage 1.0 STXS measurements for $H \to \tau^+\tau^-$	9	[13]
CMS stage 1.1 STXS measurements for $H \to 4\ell$	19	[14]
CMS differential cross section measurements of inclusive Higgs production in the $WW^* \to \ell\nu\ell\nu$ final state. $\frac{d\sigma}{dn_{\text{jet}}}$ | $\frac{d\sigma}{dp^T_H}$	5|6	[15]
ATLAS $H \to Z\gamma$ signal strength.	1	[16]
ATLAS $H \to \mu^+\mu^-$ signal strength.	1	[17]

- + Top

Measurements

- Top:

Tevatron & Run 1 top	n_{obs}	Ref.
Tevatron combination of differential $t\bar{t}$ forward-backward asymmetry, $A_{FB}(m_{t\bar{t}})$.	4	[7]
ATLAS $t\bar{t}$ differential distributions in the dilepton channel. $\frac{d\sigma}{dm_{t\bar{t}}}$	6	[18]
ATLAS $t\bar{t}$ differential distributions in the ℓ+jets channel. $\frac{d\sigma}{dm_{t\bar{t}}}$ | $\frac{d\sigma}{d\|y_{t\bar{t}}\|}$ | $\frac{d\sigma}{dp_t^T}$ | $\frac{d\sigma}{d\|y_t\|}$.	7|5|8|5	[19]
CMS $t\bar{t}$ differential distributions in the ℓ+jets channel. $\frac{d\sigma}{dm_{t\bar{t}}}$ | $\frac{d\sigma}{dy_{t\bar{t}}}$ | $\frac{d\sigma}{dp_t^T}$ | $\frac{d\sigma}{dy_t}$.	7|10|8 |10	[20, 226]
CMS measurement of differential $t\bar{t}$ charge asymmetry, $A_C(m_{t\bar{t}})$ in the dilepton channel.	3	[227]
ATLAS inclusive measurement $t\bar{t}$ charge asymmetry, $A_C(m_{t\bar{t}})$ in the dilepton channel.	1	[228]
ATLAS & CMS combination of differential $t\bar{t}$ charge asymmetry, $A_C(m_{t\bar{t}})$, in the ℓ+jets channel.	6	[21]
CMS $t\bar{t}$ double differential distributions in the dilepton channel. $\frac{d\sigma}{dm_{t\bar{t}}dy_t}$ | $\frac{d\sigma}{dm_{t\bar{t}}dy_{t\bar{t}}}$ | $\frac{d\sigma}{dm_{t\bar{t}}dp_{t\bar{t}}^T}$ | $\frac{d\sigma}{dy_t dp_t^T}$.	16|16 |16|16	[22, 229]
ATLAS & CMS Run 1 combination of W-boson helicity fractions in top decay. f_0, f_L & f_R	3	[23]
ATLAS measurement of W-boson helicity fractions in top decay. f_0, f_L & f_R	3	[24]
CMS measurement of W-boson helicity fractions in top decay. f_0, f_L & f_R	3	[25]
ATLAS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W}\|\sigma_{t\bar{t}Z}$	2	[26]
CMS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W}\|\sigma_{t\bar{t}Z}$	2	[27]
ATLAS t-channel single-top differential distributions. $\frac{d\sigma}{dp_t^T}$ | $\frac{d\sigma}{dp_{\bar{t}}^T}$ | $\frac{d\sigma}{d\|y_t\|}$ | $\frac{d\sigma}{d\|y_{\bar{t}}\|}$	4|4|4|5	[28]
CMS s-channel single-top cross section measurement.	1	[29]
CMS t-channel single-top differential distributions. $\frac{d\sigma}{dp_{t+\bar{t}}^T}$ | $\frac{d\sigma}{d\|y_{t+\bar{t}}\|}$	6 |6	[30]
CMS measurement of the t-channel single-top and anti-top cross sections. $\sigma_t\,\|\,\sigma_{\bar{t}}\,\|\,\sigma_{t+\bar{t}}\,\|\,R_t$.	1|1|1|1	[31]
ATLAS s-channel single-top cross section measurement.	1	[32]
CMS tW cross section measurement.	1	[33]
ATLAS tW cross section measurement in the single lepton channel.	1	[34]
ATLAS tW cross section measurement in the dilepton channel.	1	[35]

Run 2 top	n_{obs}	Ref.
CMS $t\bar{t}$ differential distributions in the dilepton channel. $\frac{d\sigma}{dm_{t\bar{t}}}$	6	[36, 230]
CMS $t\bar{t}$ differential distributions in the ℓ+jets channel. $\frac{d\sigma}{dm_{t\bar{t}}}$	10	[37]
ATLAS measurement of differential $t\bar{t}$ charge asymmetry, $A_C(m_{t\bar{t}})$.	5	[38]
ATLAS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W}\|\sigma_{t\bar{t}Z}$	2	[39]
CMS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W}\|\sigma_{t\bar{t}Z}$	1|1	[40]
CMS $t\bar{t}Z$ differential distributions. $\frac{d\sigma}{dp_Z^T}$ | $\frac{d\sigma}{d\cos\theta^*}$	4|4	[41]
CMS measurement of differential cross sections and charge ratios for t-channel single-top quark production. $\frac{d\sigma}{dp_{t+\bar{t}}^T}$ | $R_t\,(p_{t+\bar{t}}^T)$	5|5	[42]
CMS measurement of t-channel single-top and anti-top cross sections. σ_t, $\sigma_{\bar{t}}$, $\sigma_{t+\bar{t}}$ & R_t.	4	[43]
CMS measurement of the t-channel single-top and anti-top cross sections. $\sigma_t\,\|\,\sigma_{\bar{t}}\,\|\,\sigma_{t+\bar{t}}\,\|\,R_t$.	1|1|1|1	[44]
CMS t-channel single-top differential distributions. $\frac{d\sigma}{dp_{t+\bar{t}}^T}$ | $\frac{d\sigma}{d\|y_{t+\bar{t}}\|}$	4|4	[45]
ATLAS tW cross section measurement.	1	[46]
CMS tZ cross section measurement.	1	[47]
CMS tW cross section measurement.	1	[48]
ATLAS tZ cross section measurement.	1	[49]
CMS $tZ\,(Z \to \ell^+\ell^-)$ cross section measurement	1	[50]
ATLAS four-top search in the multi-lepton and same-sign dilepton channels.	1	[51]
ATLAS four-top search in the single-lepton and opposite-sign dilepton channels.	1	[52]
CMS four-top search in the multi-lepton and same-sign dilepton channels.	1	[53]
CMS four-top search in the single-lepton and opposite-sign dilepton channels.	1	[54]
CMS $t\bar{t}b\bar{b}$ cross section measurement in the all-jet channel.	1	[55]
CMS $t\bar{t}b\bar{b}$ cross section measurement in the dilepton channel.	1	[56]

Measurements

- EWPO:

EW precision observables	n_{obs}	Ref.
Precision electroweak measurements on the Z resonance. Γ_Z, $\sigma^0_{\text{had.}}$, R^0_ℓ, A^ℓ_{FB}, $A_\ell(\text{SLD})$, $A_\ell(\text{Pt})$, R^0_b, R^0_c A^b_{FB}, A^c_{FB}, A_b & A_c	12	[1]
Combination of CDF and D0 W-Boson Mass Measurements	1	[6]
LHC run 1 W boson mass measurement by ATLAS	1	[57]

Revised QCD uncertainties on A^b_{FB} not included: [2011.00530 d'Enterria & Yan]

$$\Gamma_Z = \Gamma^Z_{had} + 3\Gamma^Z_\ell + 3\Gamma^Z_\nu \qquad R_\ell = \frac{\Gamma^Z_{had}}{\Gamma^Z_\ell} \qquad \sigma_{had} = 12\pi \frac{\Gamma^Z_e \Gamma^Z_{had}}{\hat{m}_Z^2 \Gamma_Z^2} \qquad A^f_{FB} = \frac{3}{4} A_e A_f \qquad M_W = c_W M_Z$$

$$R_q = \frac{\Gamma^Z_q}{\Gamma^Z_{had}}$$

$$\Gamma^Z_f = \frac{\sqrt{2} G_F M_Z^2 \hat{M}_Z}{6\pi}\left[(g^f_L)^2 + (g^f_R)^2\right] \qquad A_f = \frac{(g^f_L)^2 - (g^f_R)^2}{(g^f_L)^2 + (g^f_R)^2}$$

$$g^f = T^3_f - Q_f s_W^2 \qquad s_W^2 = \frac{1}{2} - \frac{1}{2}\sqrt{1 - \frac{4\pi\alpha}{\sqrt{2} G_F m_Z^2}}$$

$$m_Z^2 = (m_Z^2)^0 (1 + \Pi_{ZZ}) \qquad G_F = G_F^0 (1 - \Pi^0_{WW}) \qquad \alpha(m_Z) = \alpha^0(m_Z)(1 + \Pi'_{\gamma\gamma})$$

Measurements

- Diboson:

Diboson LEP & LHC	n_{obs}	Ref.
W^+W^- angular distribution measurements at LEP II.	8	[5]
W^+W^- total cross section measurements at L3 in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 8 energies	24	[3]
W^+W^- total cross section measurements at OPAL in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 7 energies	21	[4]
W^+W^- total cross section measurements at ALEPH in the $\ell\nu\ell\nu$, $\ell\nu qq$ & $qqqq$ final states for 8 energies	21	[2]
ATLAS W^+W^- differential cross section in the $e\nu\mu\nu$ channel, $\frac{d\sigma}{dp^T_{\ell_1}}$, $p_T > 120$ GeV overflow bin	1	[225]
ATLAS W^+W^- fiducial differential cross section in the $e\nu\mu\nu$ channel, $\frac{d\sigma}{dp^T_{\ell_1}}$	14	[58]
ATLAS Zjj fiducial differential cross section in the $\ell^+\ell^-$ channel, $\frac{d\sigma}{d\Delta\varphi_{jj}}$	12	[60]

(+ WZ)

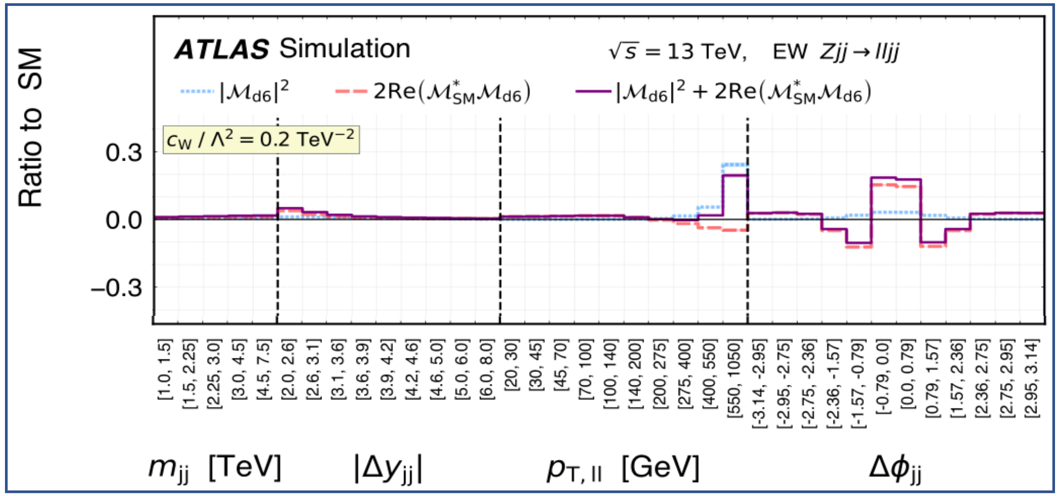
- Conservative approach to unknown bin correlations at LEP: fit to subset of angular distribution bins 1606.06693 Berthier, Bjorn, Trott

$$B_1 = [-1, -0.8],\ B_2 = [-0.4, -0.2],\ B_3 = [0.4, 0.6],\ B_4 = [0.8, 1] \text{ for } \sqrt{s} = \{182.66, 205.92\} \text{ GeV}$$

- LHC WW suppressed linear term

- Zjj recovers interference:

2006.15458 ATLAS



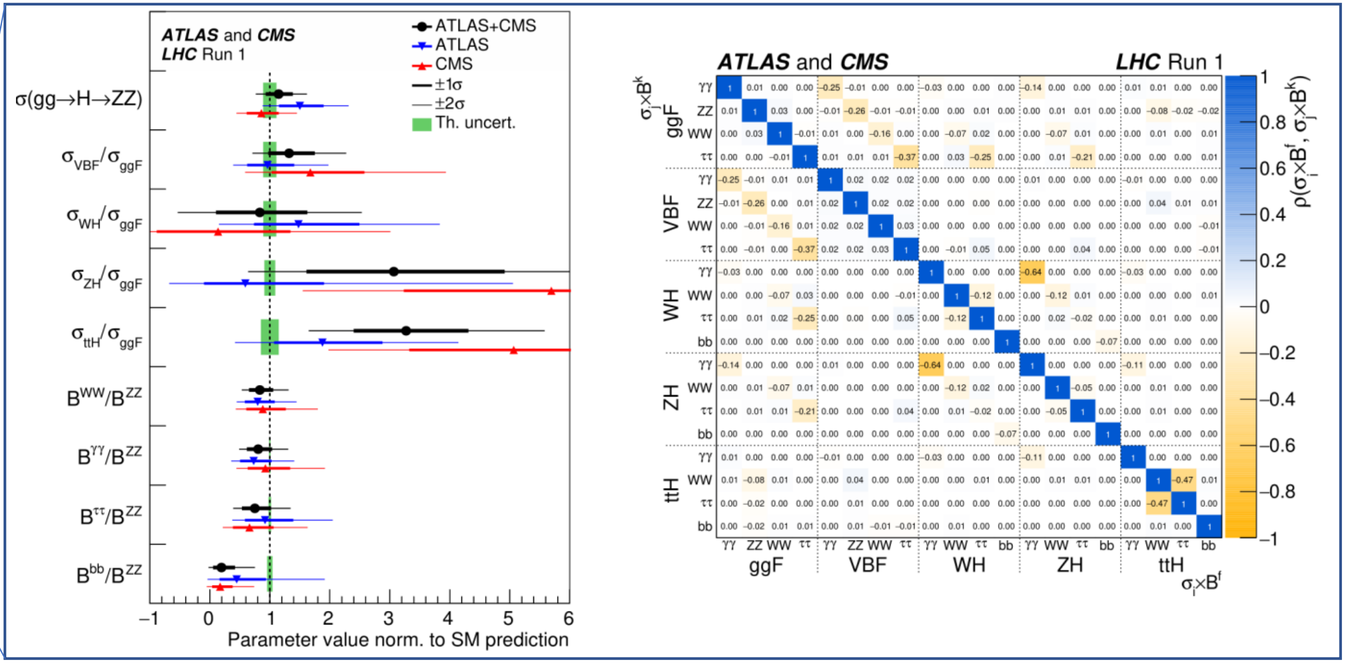
Measurements

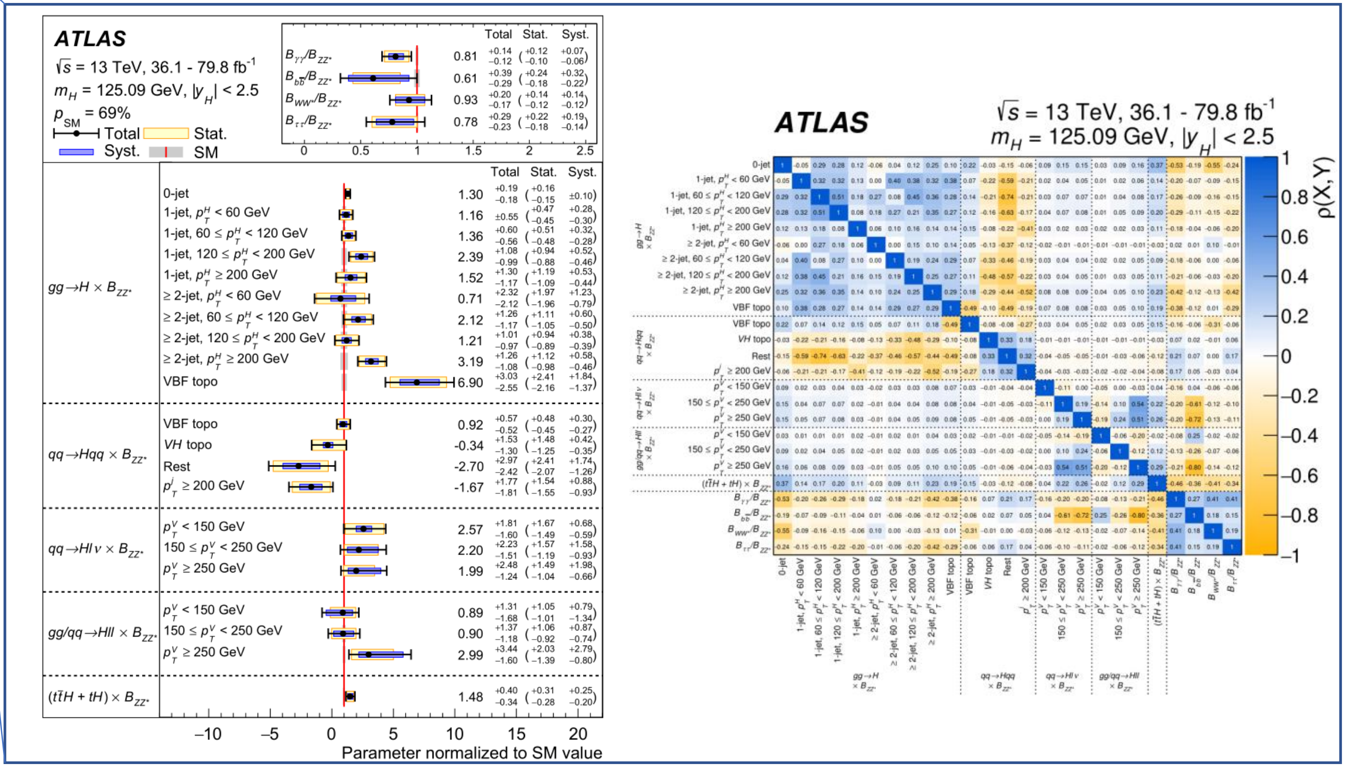
- Higgs:

LHC Run 1 Higgs	n_{obs}	Ref.
ATLAS and CMS LHC Run 1 combination of Higgs signal strengths. Production: ggF, VBF, ZH, WH & ttH Decay: $\gamma\gamma$, ZZ, W^+W^-, $\tau^+\tau^-$ & $b\bar{b}$	21	[8]
ATLAS inclusive $Z\gamma$ signal strength measurement	1	[9]

LHC Run 2 Higgs (new)	n_{obs}	Ref.
ATLAS combination of signal strengths and stage 1.0 STXS in $H \to 4\ell$ including ratios of branching fractions to $\gamma\gamma$, WW^*, $\tau^+\tau^-$ & $b\bar{b}$ Signal strengths|coarse STXS bins| fine STXS bins	16|19|25	[10]
CMS LHC combination of Higgs signal strengths. Production: ggF, VBF, ZH, WH & ttH Decay: $\gamma\gamma$, ZZ, W^+W^-, $\tau^+\tau^-$, $b\bar{b}$ & $\mu^+\mu^-$	23	[11]
CMS stage 1.0 STXS measurements for $H \to \gamma\gamma$. 13 parameter fit | 7 parameter fit	13|7	[12]
CMS stage 1.0 STXS measurements for $H \to \tau^+\tau^-$	9	[13]
CMS stage 1.1 STXS measurements for $H \to 4\ell$	19	[14]
CMS differential cross section measurements of inclusive Higgs production in the $WW^* \to \ell\nu\ell\nu$ final state. $\frac{d\sigma}{dn_{\text{jet}}}$ | $\frac{d\sigma}{dp_H^T}$	5|6	[15]
ATLAS $H \to Z\gamma$ signal strength.	1	[16]
ATLAS $H \to \mu^+\mu^-$ signal strength.	1	[17]

To be added: 2009.04363 CMS 3σ evidence for $H \to \mu\mu^-$

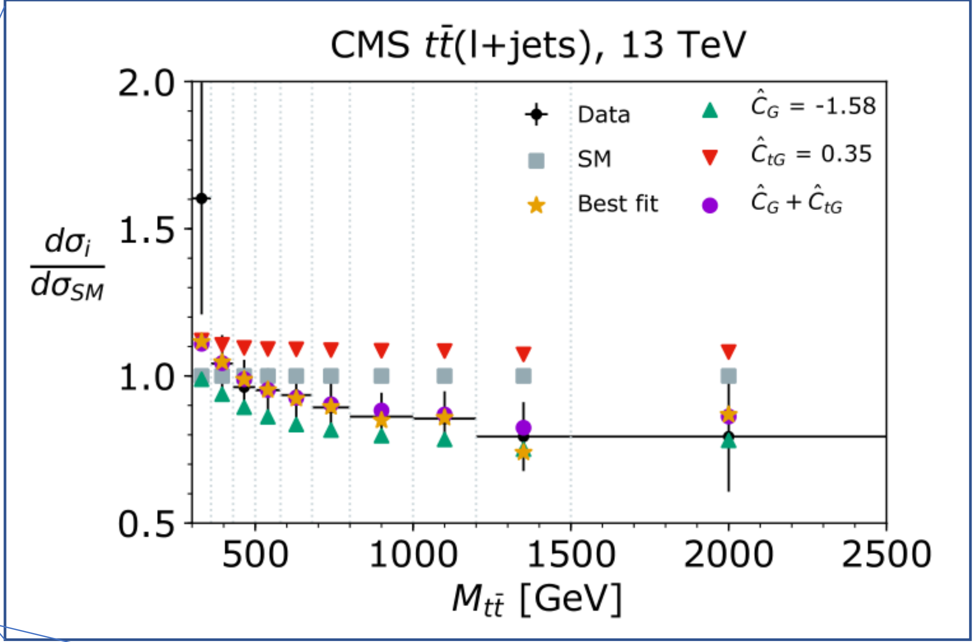


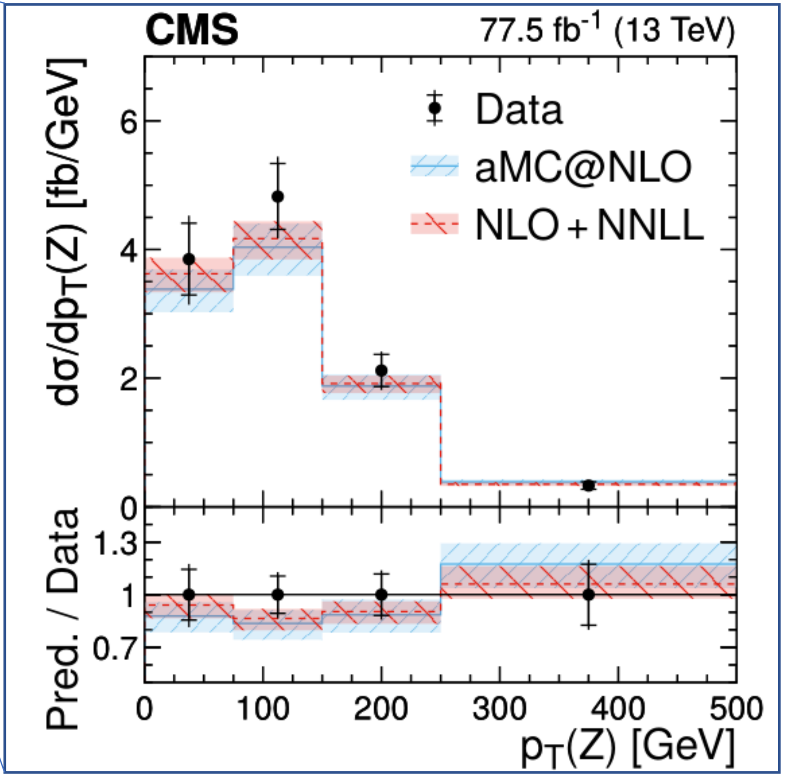


Measurements

- Top:

Run 2 top	$n_{\rm obs}$	Ref.
CMS $t\bar{t}$ differential distributions in the dilepton channel. $\frac{d\sigma}{dm_{t\bar{t}}}$	6	[36, 230]
CMS $t\bar{t}$ differential distributions in the ℓ+jets channel. $\frac{d\sigma}{dm_{t\bar{t}}}$	10	[37]
ATLAS measurement of differential $t\bar{t}$ charge asymmetry, $A_C(m_{t\bar{t}})$.	5	[38]
ATLAS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W} \vert \sigma_{t\bar{t}Z}$	2	[39]
CMS $t\bar{t}W$ & $t\bar{t}Z$ cross section measurements. $\sigma_{t\bar{t}W} \vert \sigma_{t\bar{t}Z}$	$1 \vert 1$	[40]
CMS $t\bar{t}Z$ differential distributions. $\frac{d\sigma}{dp_Z^T}$ $\vert$ $\frac{d\sigma}{d\cos\theta^*}$	$4 \vert 4$	[41]
CMS measurement of differential cross sections and charge ratios for t-channel single-top quark production. $\frac{d\sigma}{dp^T_{t+\bar{t}}}$ $\vert$ $R_t\,(p^T_{t+\bar{t}})$	$5 \vert 5$	[42]
CMS measurement of t-channel single-top and anti-top cross sections. σ_t, $\sigma_{\bar{t}}$, $\sigma_{t+\bar{t}}$ & R_t.	4	[43]
CMS measurement of the t-channel single-top and anti-top cross sections. $\sigma_t \vert \sigma_{\bar{t}} \vert \sigma_{t+\bar{t}} \vert R_t$.	$1 \vert 1 \vert 1 \vert 1$	[44]
CMS t-channel single-top differential distributions. $\frac{d\sigma}{dp^T_{t+\bar{t}}}$ $\vert$ $\frac{d\sigma}{d\vert y_{t+\bar{t}}\vert}$	$4 \vert 4$	[45]
ATLAS tW cross section measurement.	1	[46]
CMS tZ cross section measurement.	1	[47]
CMS tW cross section measurement.	1	[48]
ATLAS tZ cross section measurement.	1	[49]
CMS tZ ($Z \to \ell^+\ell^-$) cross section measurement	1	[50]
ATLAS four-top search in the multi-lepton and same-sign dilepton channels.	1	[51]
ATLAS four-top search in the single-lepton and opposite-sign dilepton channels.	1	[52]
CMS four-top search in the multi-lepton and same-sign dilepton channels.	1	[53]
CMS four-top search in the single-lepton and opposite-sign dilepton channels.	1	[54]
CMS $t\bar{t}b\bar{b}$ cross section measurement in the all-jet channel.	1	[55]
CMS $t\bar{t}b\bar{b}$ cross section measurement in the dilepton channel.	1	[56]





SMEFT fit

Ellis, Madigan, Mimasu, Sanz, TY [2012.02779]

- Combine **Top**, **Higgs**, **diboson**, and **electroweak** data
- *Simultaneous* linear fit at leading order to **34** operators
- Matched to **simplified models** at tree-level and one-loop stop example
- Analytical Hessian method and numerical MCMC algorithm
- Easily extendable database and modular capabilities
- **Fitmaker** public python code to be released

SMEFT fit

Ellis, Madigan, Mimasu, Sanz, TY [2012.02779]

- **Fitmaker**: modular library of observables and theories

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    [ 0.0 , 1.0]
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  ],
  "lambda_gen": 1000.0
}
```

SMEFT fit

Ellis, Madigan, Mimasu, Sanz, TY [2012.02779]

- **Fitmaker**: modular library of observables and theories

```
#import fitmaker
from fitmaker.fitlib.fitter import FitterChiSquare
from fitmaker.theories.SMEFT_fit_full import SMEFT as SMEFT_full

#Load observables
odir = '../fitmaker/observables/'

EWPO_data = ObsGroup({'observable_group_name':"EWPO_data", 'description':"Z pole & W mass data"})
EWPO_data.add_obs(
  ObsGroup.init_from_json(odir+'EWPO/Zpole.json'),
  ObsGroup.init_from_json(odir+'EWPO/Wmass.json')
)

Diboson_data = ObsGroup({'observable_group_name':"Diboson_data", 'description':"LEP & LHC Diboson data"})
Diboson_data.add_obs(
    ObsGroup.init_from_json(odir+'Diboson/LEP2_Diboson.json'),
    Obs.init_from_json(odir+'Diboson/fidmu_WW_enumunu_ptl_ATLAS13.json')
)

Higgs_data = ObsGroup({'observable_group_name':"Higgs_data", 'description':"Updated Higgs signal strength and STXS data"
Higgs_data.add_obs(
    ObsGroup.init_from_json(odir + 'Higgs/Run_1/LHC_Run1_Higgs_SignalStrengths.json'),
    ObsGroup.init_from_json(odir + 'Higgs/new/CMS_Run2_Higgs_SignalStrengths.json'),
    ObsGroup.init_from_json(odir+'Higgs/new_ATLAS/ATLAS_STXS_fine/ATLAS_Run2_STXS1p0_H_ZZ_4l_comb.json')
)

EWPO_Diboson_Higgs_data = ObsGroup({'observable_group_name':"EWPO_Diboson_Higgs_data", 'description':"EWPO, Diboson & Hi
EWPO_Diboson_Higgs_data.add_obs(
  EWPO_data,
  Diboson_data,
  Higgs_data
)

#Load fit
fitter_U3_5 = FitterAnalyticalChiSquare(
    arg_obsgroup = EWPO_Diboson_Higgs_data,
    arg_theory = SMEFT_U3_5,
    arg_theorykwargs = {'Lambda':1000.}
)

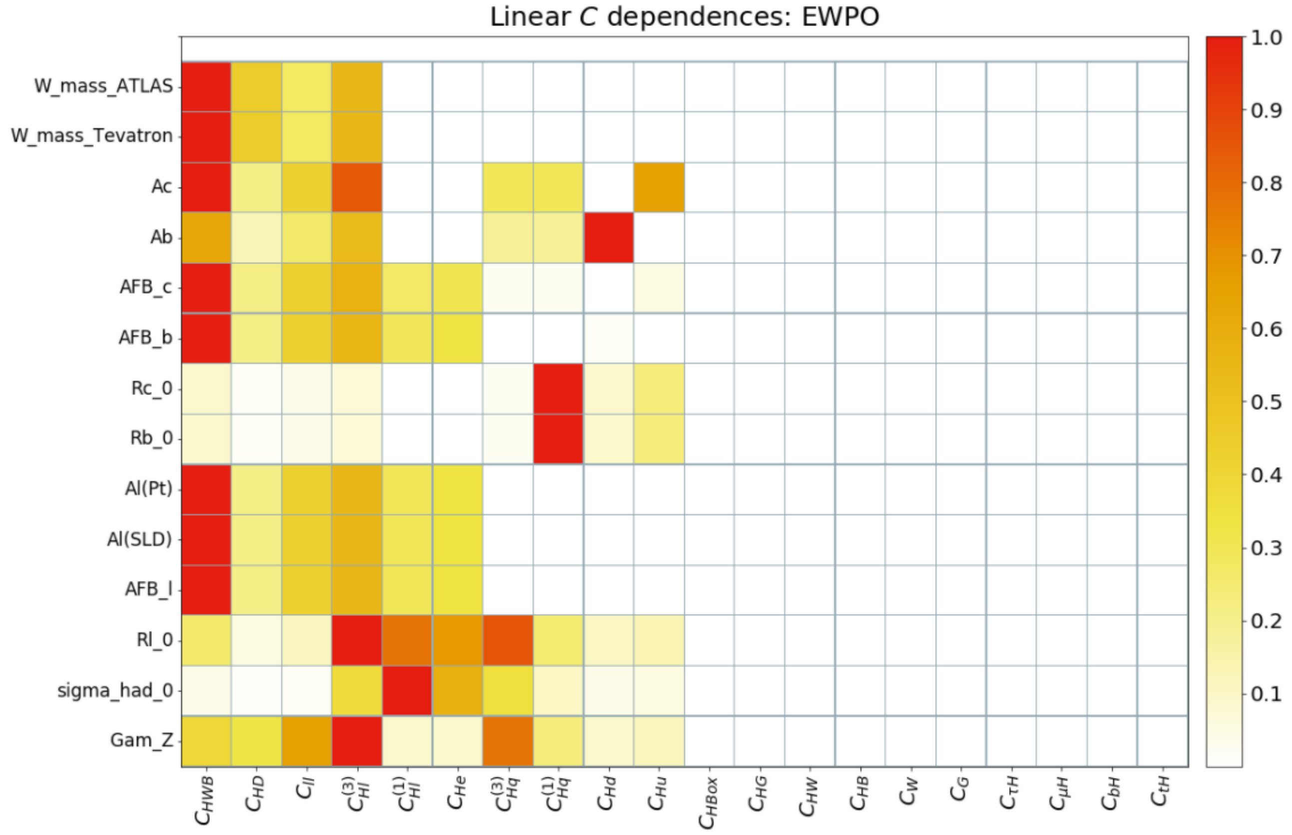
#Get fit results
marg_bestfitc_list_U3_5 = [fitter_U3_5.get_bestfit(c,marginalise=True)[0] for c in coeffs_U3_5]
marg_sd_list_U3_5 = [fitter_U3_5.standard_deviation(c, marginalise=True) for c in coeffs_U3_5]
```

Map operators to observables

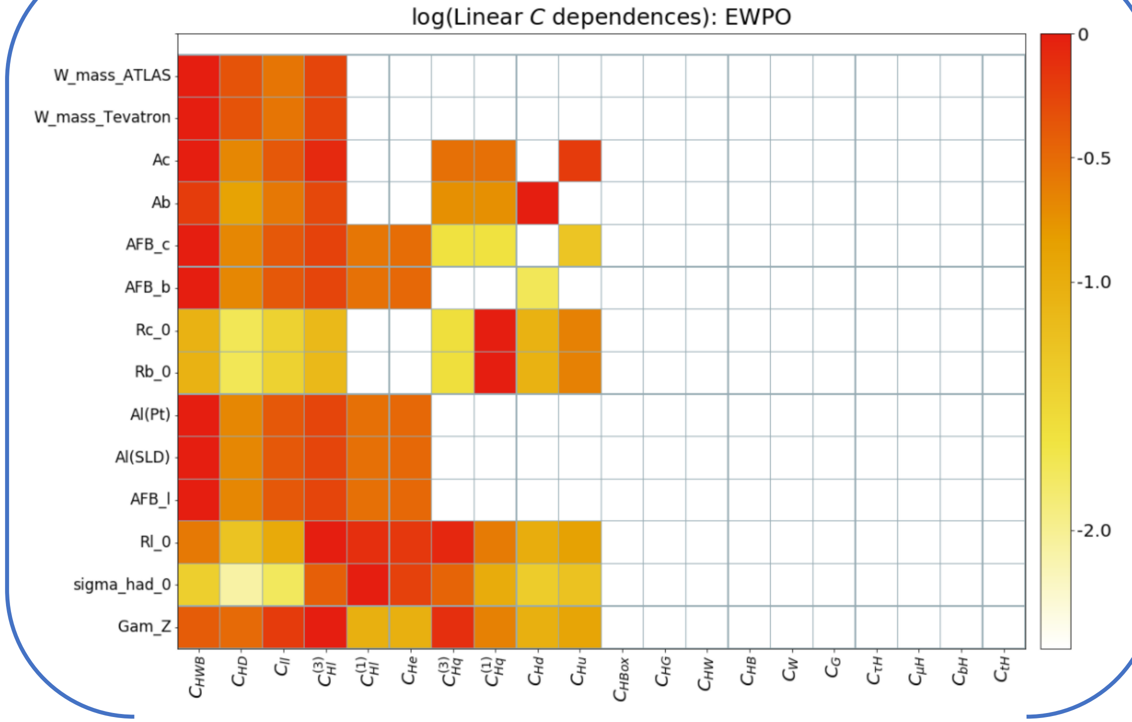
- Keep only linear coefficient dependence

$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$

- (For each observable X, normalised such that largest $a_i^X = 1$)
- EWPO:



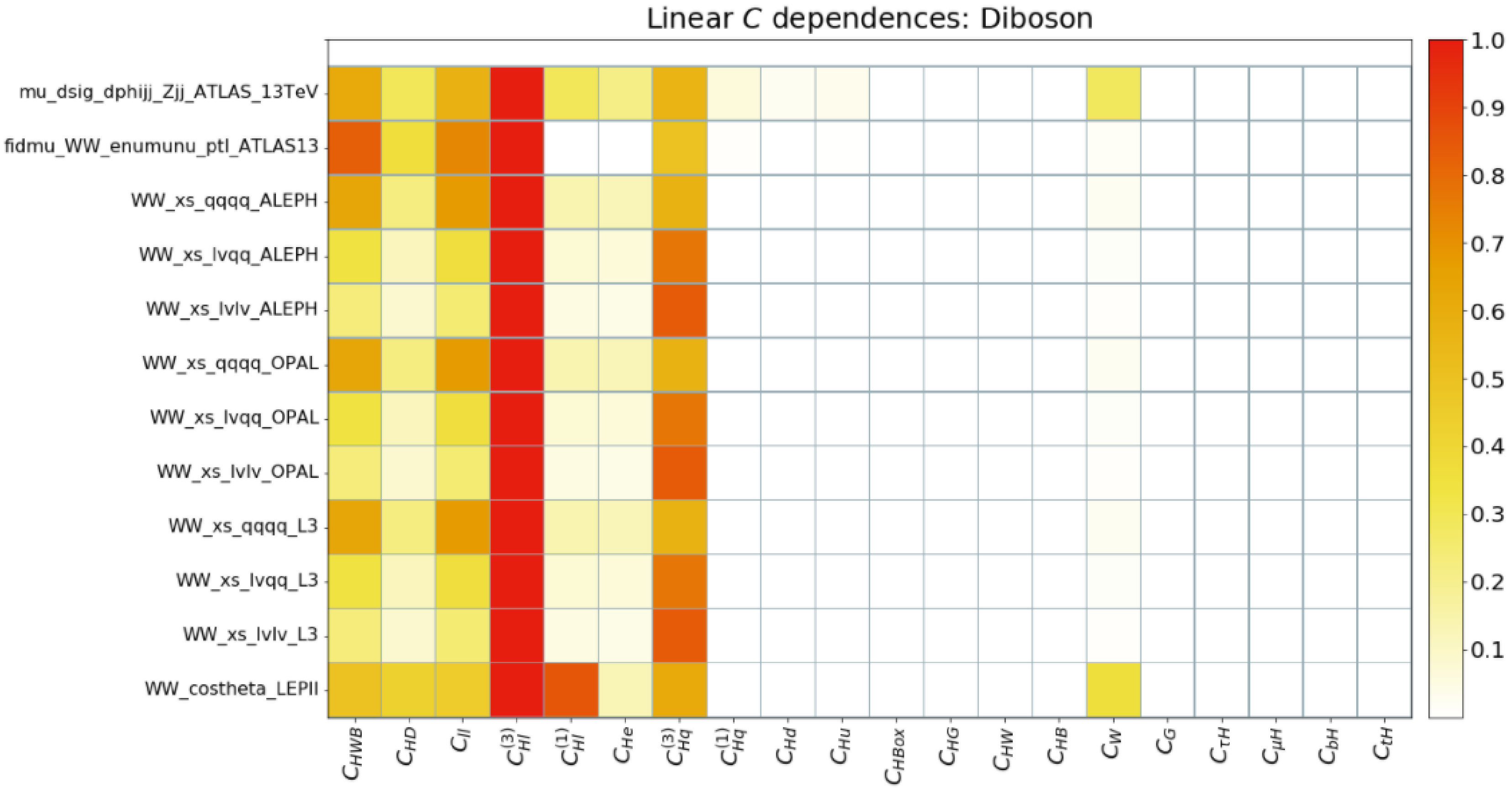
Log scale:



Map operators to observables

- Diboson

$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$



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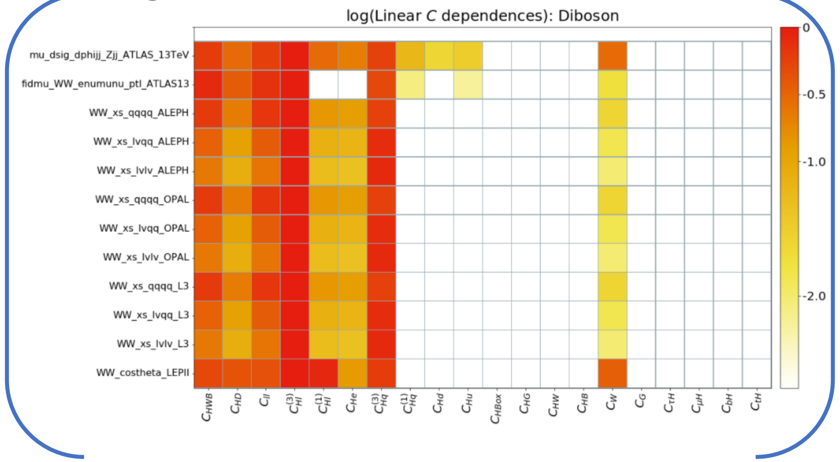
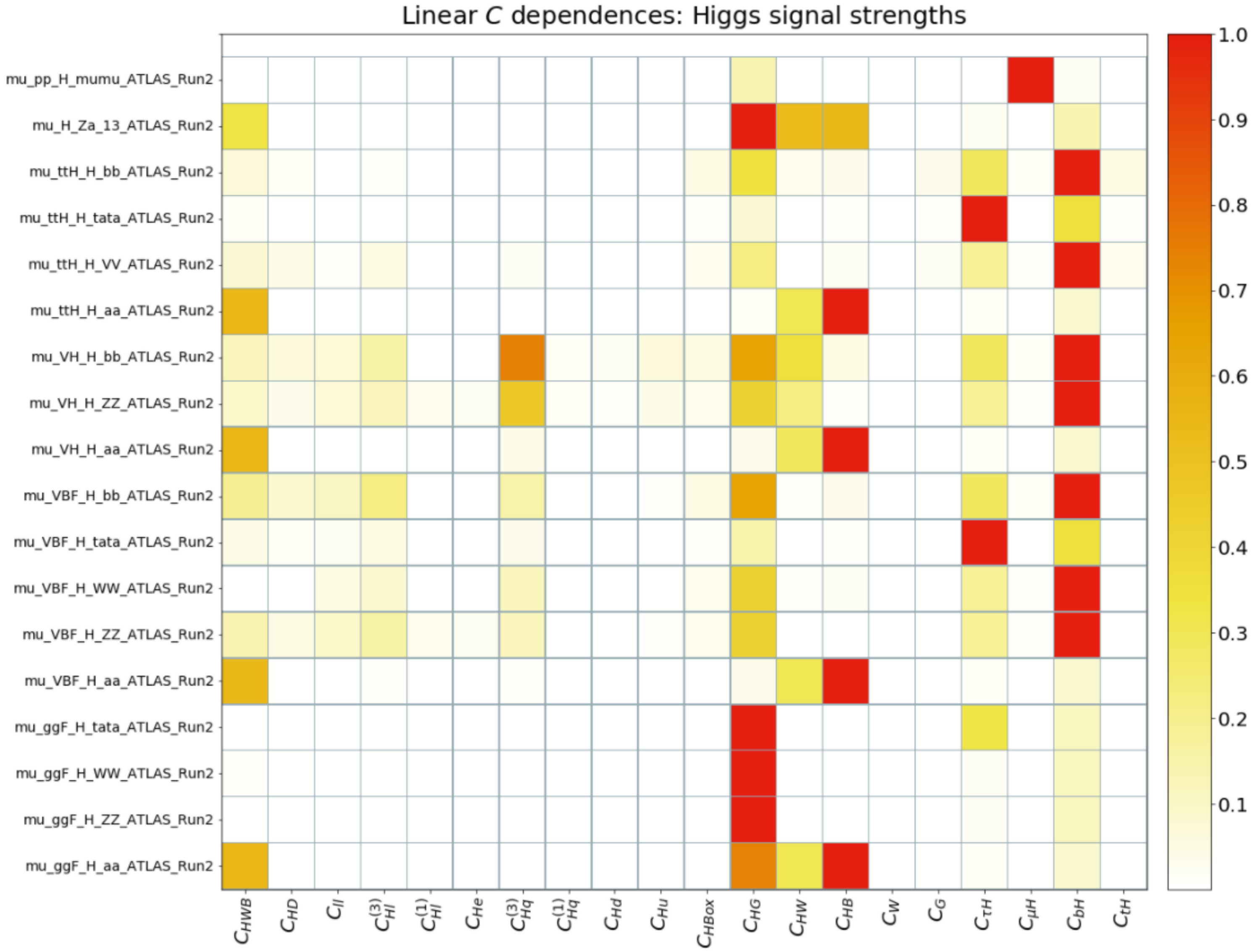


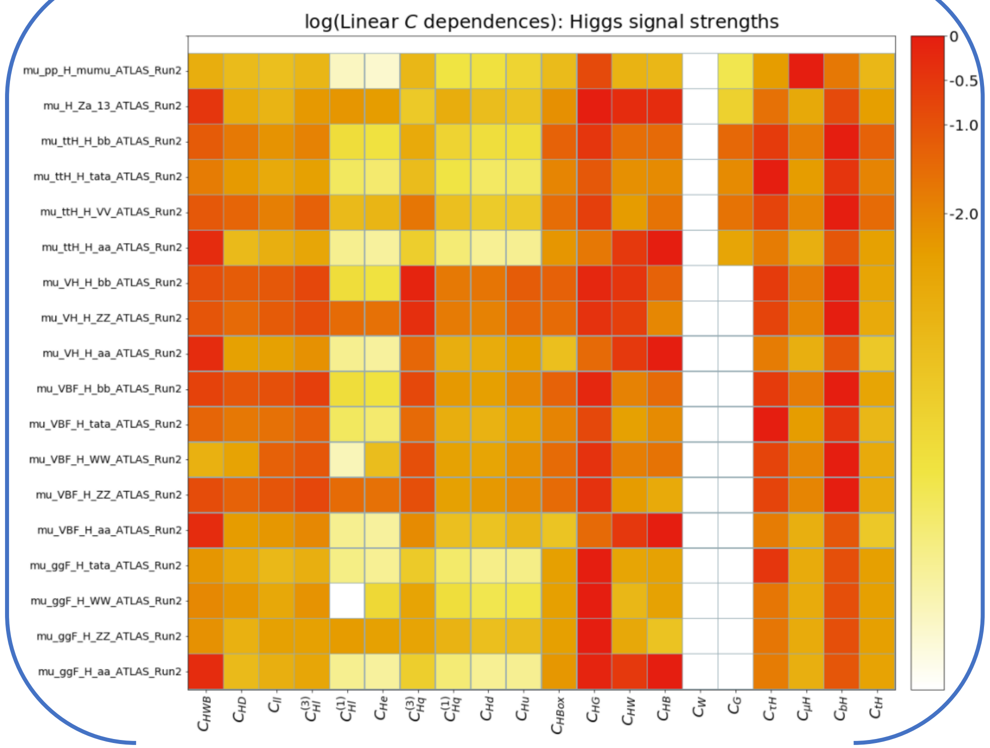
Map operators to observables

- Higgs signal strengths

$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$



Log scale:

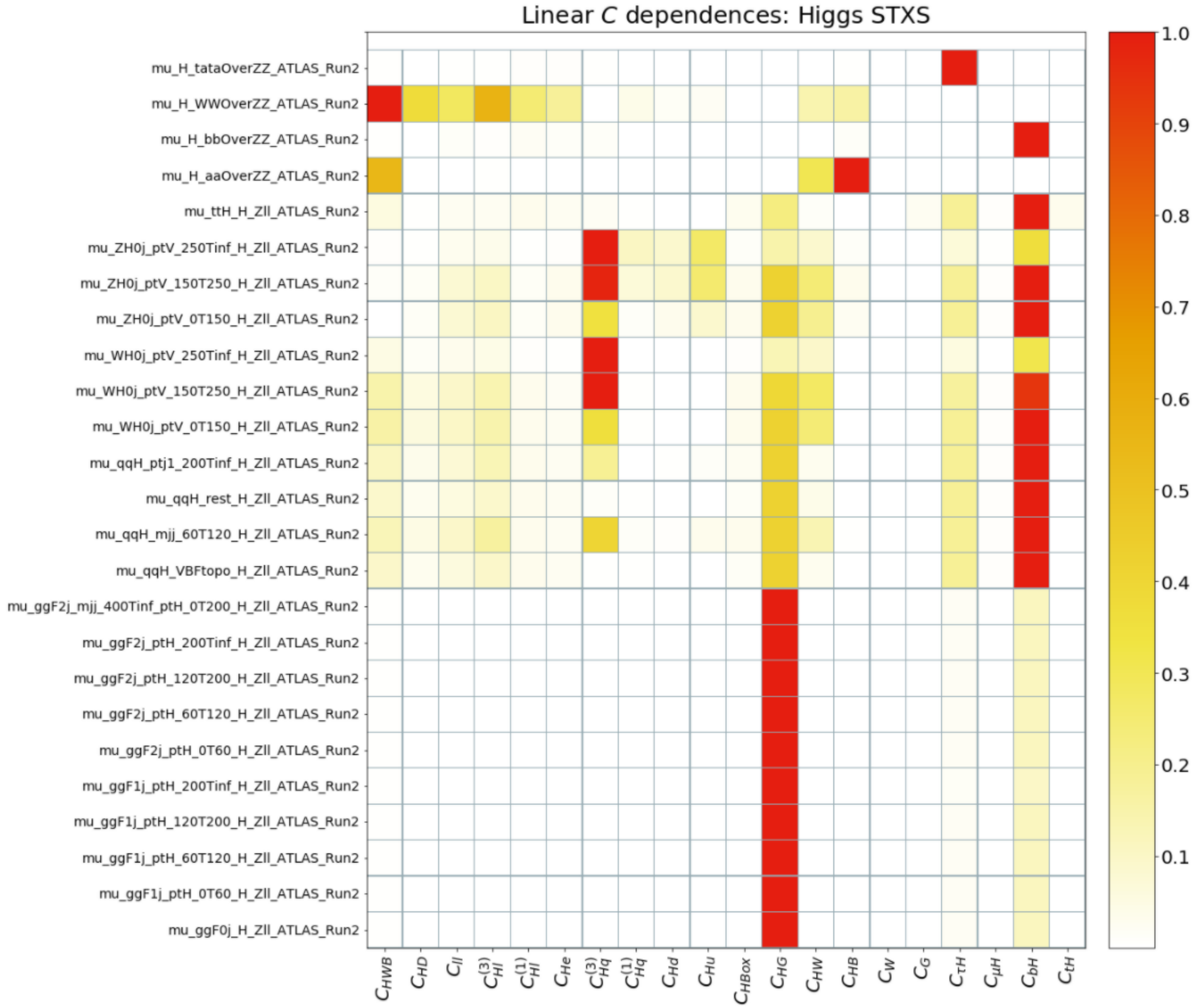


Tevong You

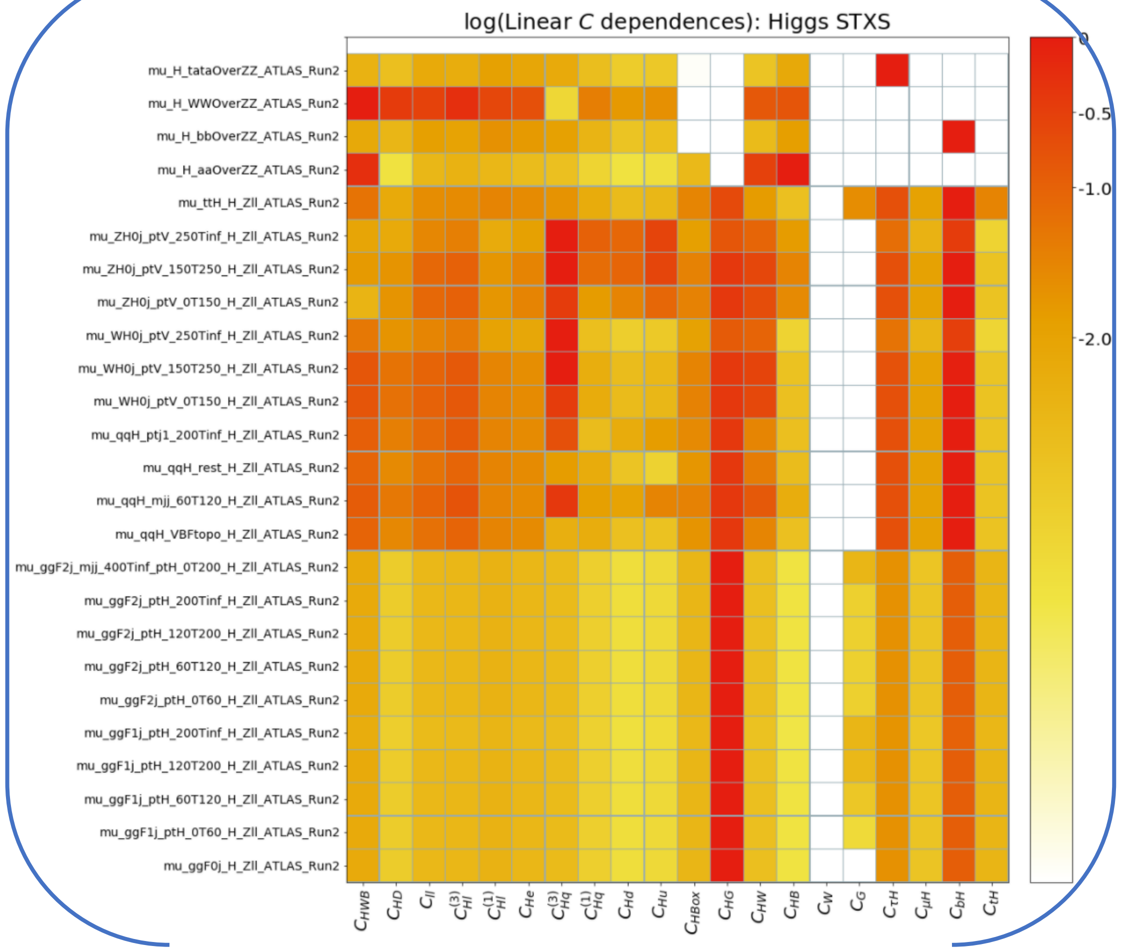
Map operators to observables

- Higgs STXS

$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$



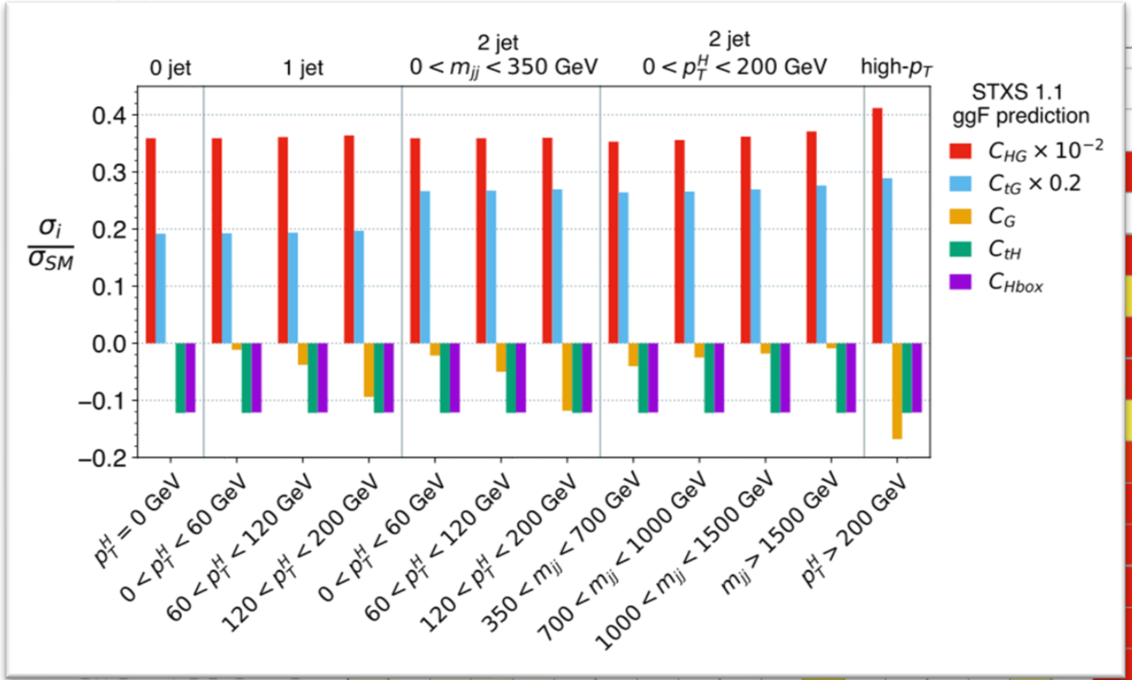
Log scale:

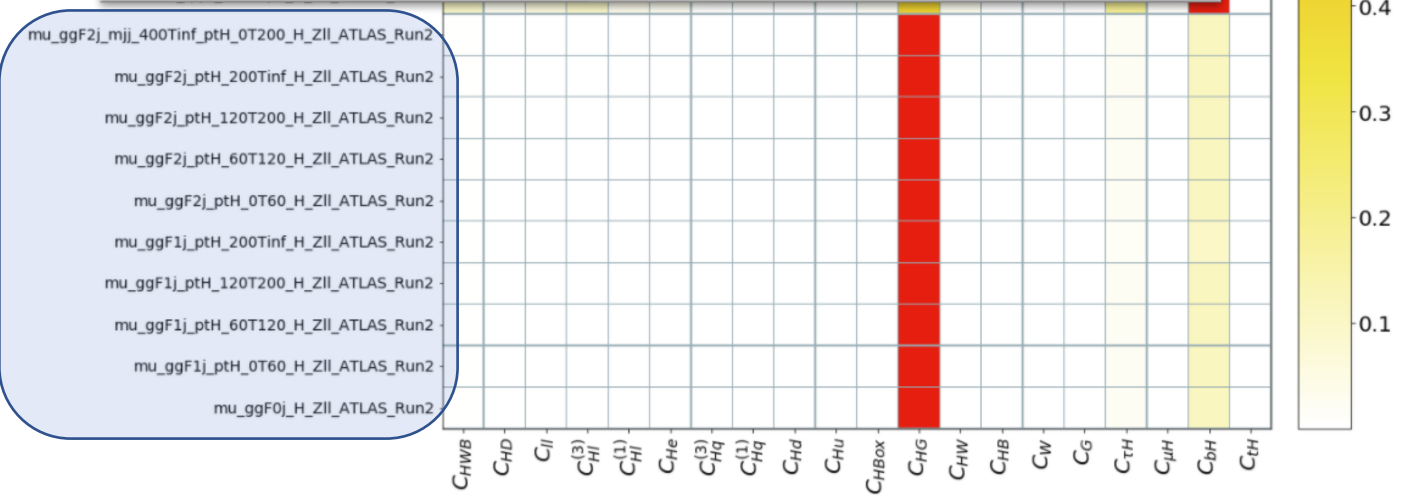


Map operators to observables

$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$

- Higgs STXS

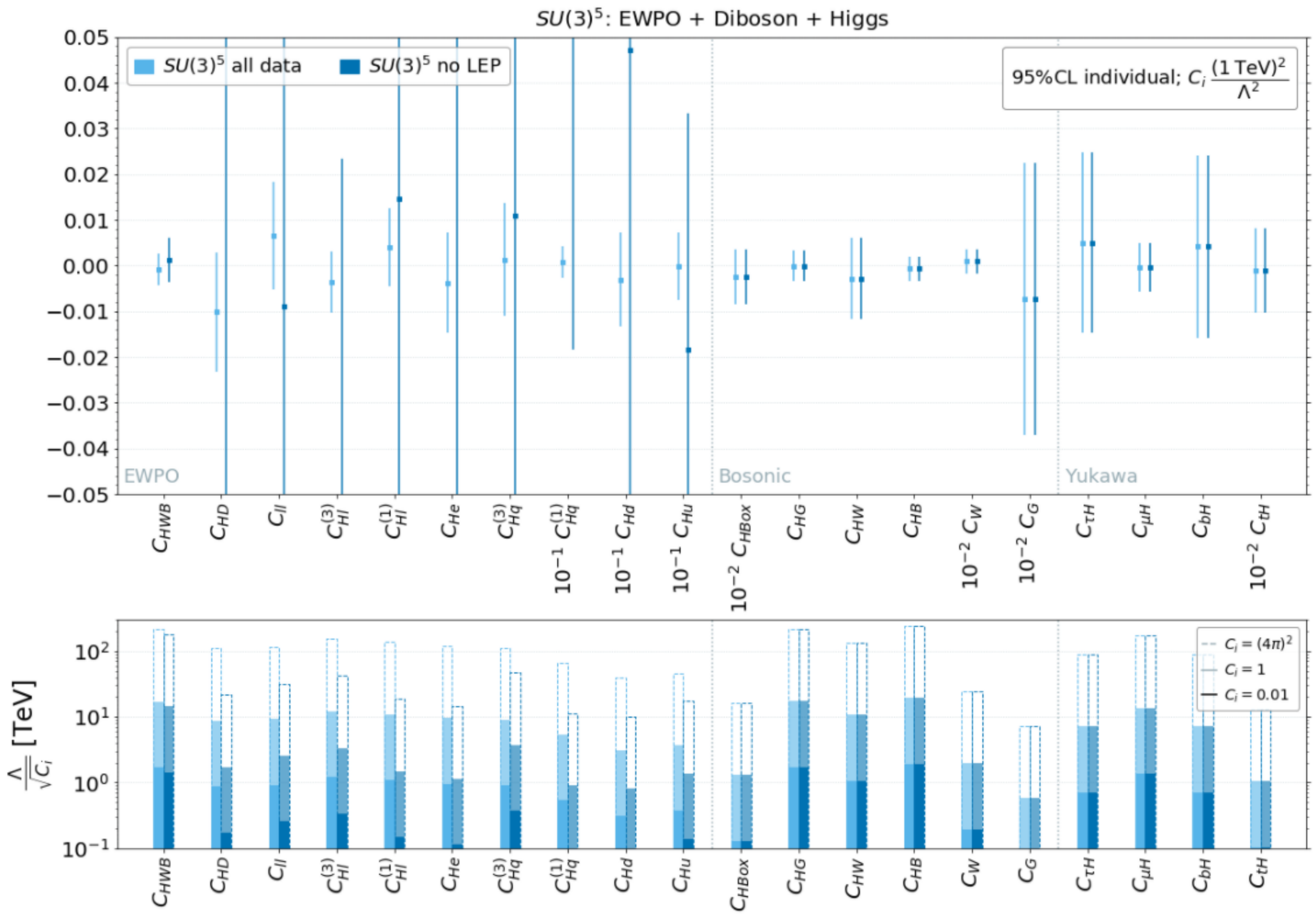




Log scale:

Impact of measurements

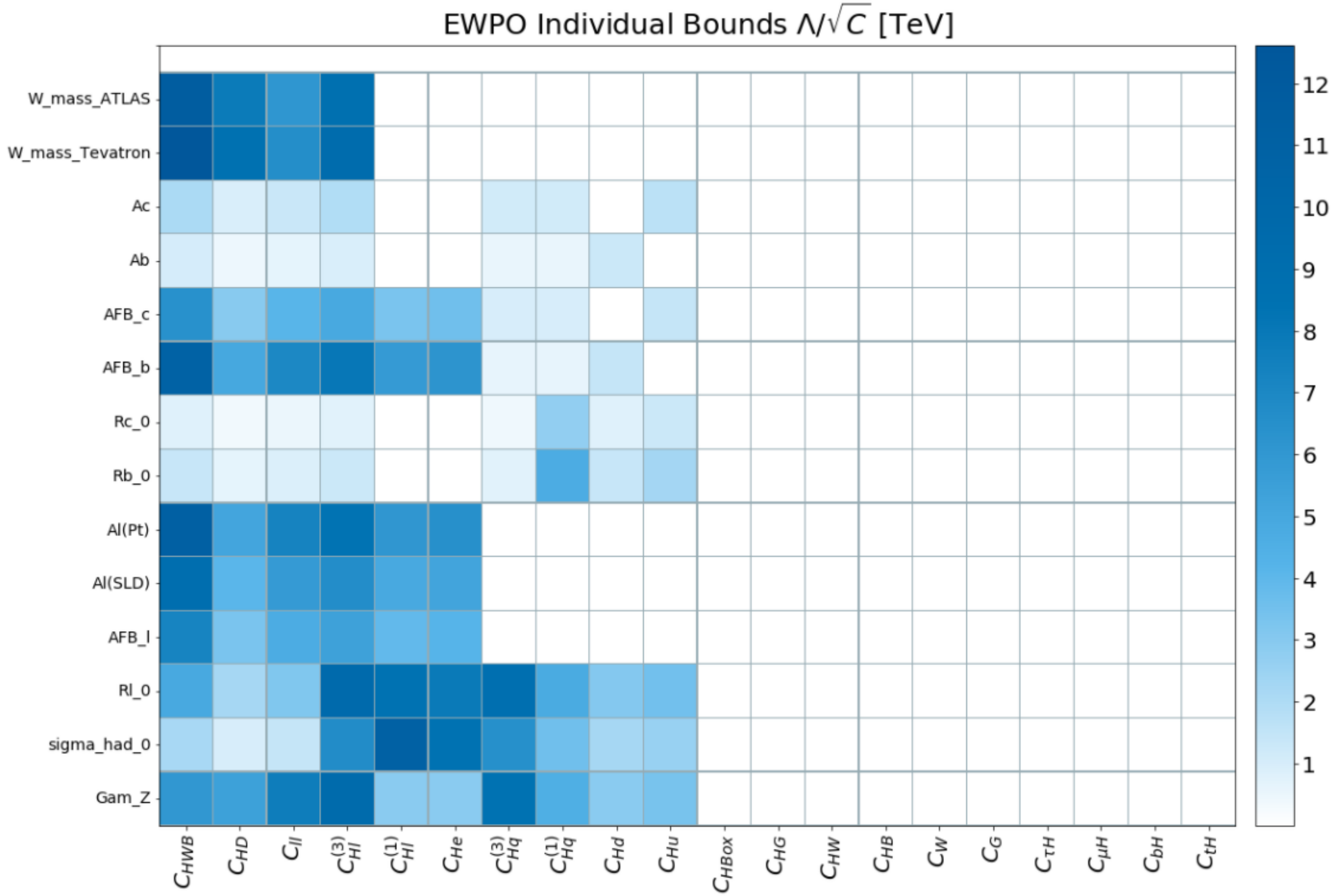
- Individual 95% CL bounds switching on one operator at a time



- Which observables constrain which operators the most?

Impact of measurements

- Individual 95% CL bounds switching on one operator at a time



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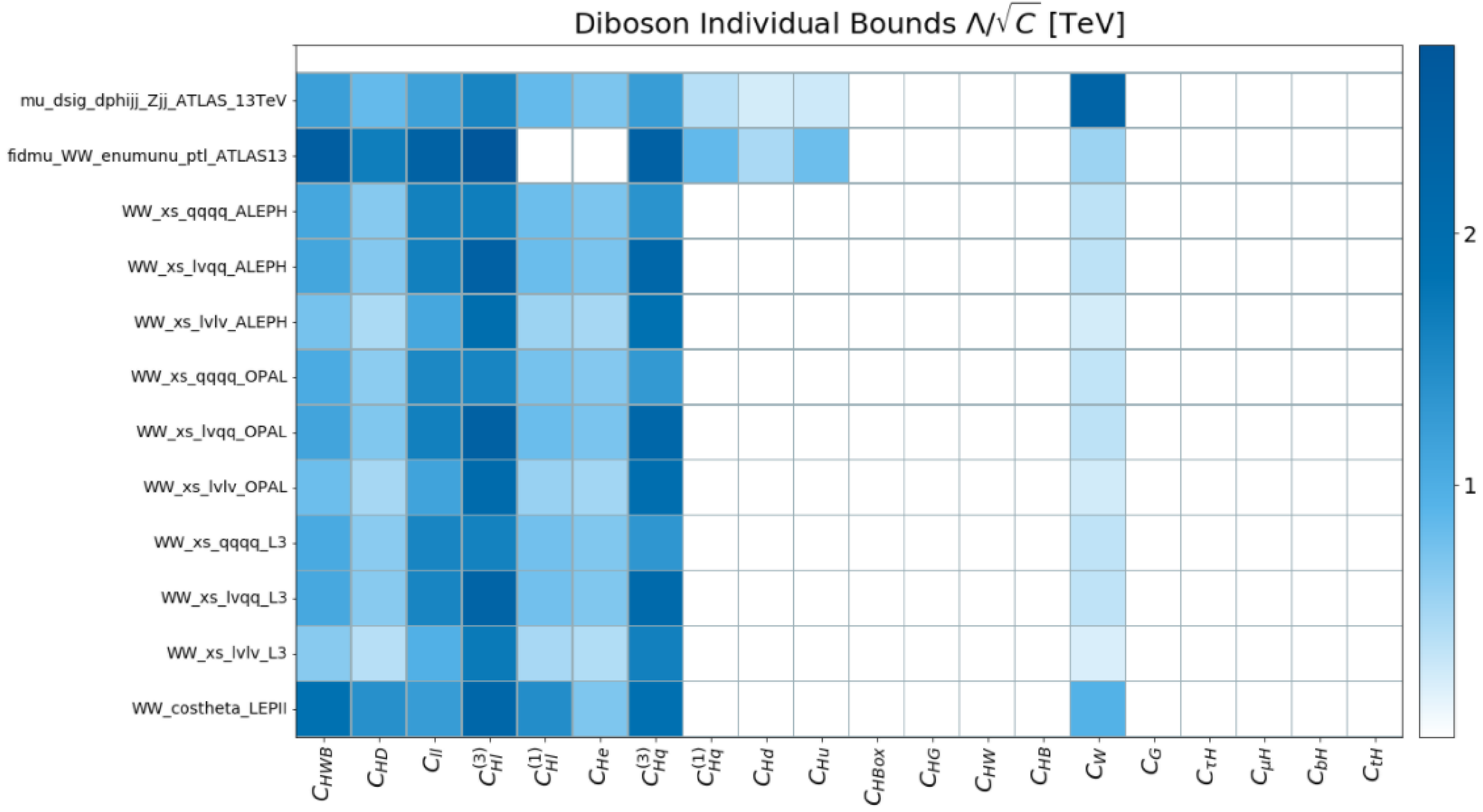

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Tevong You

Impact of measurements

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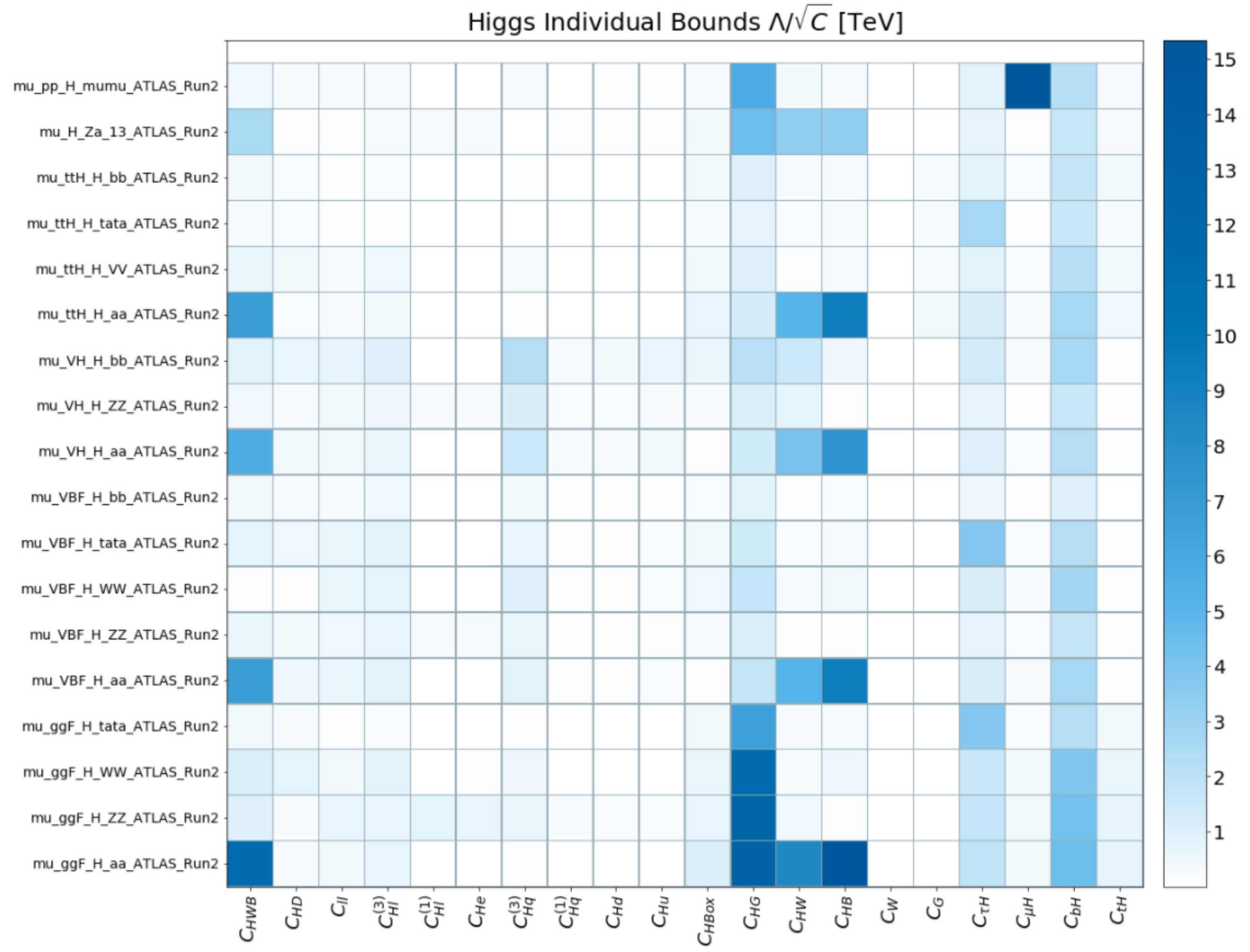
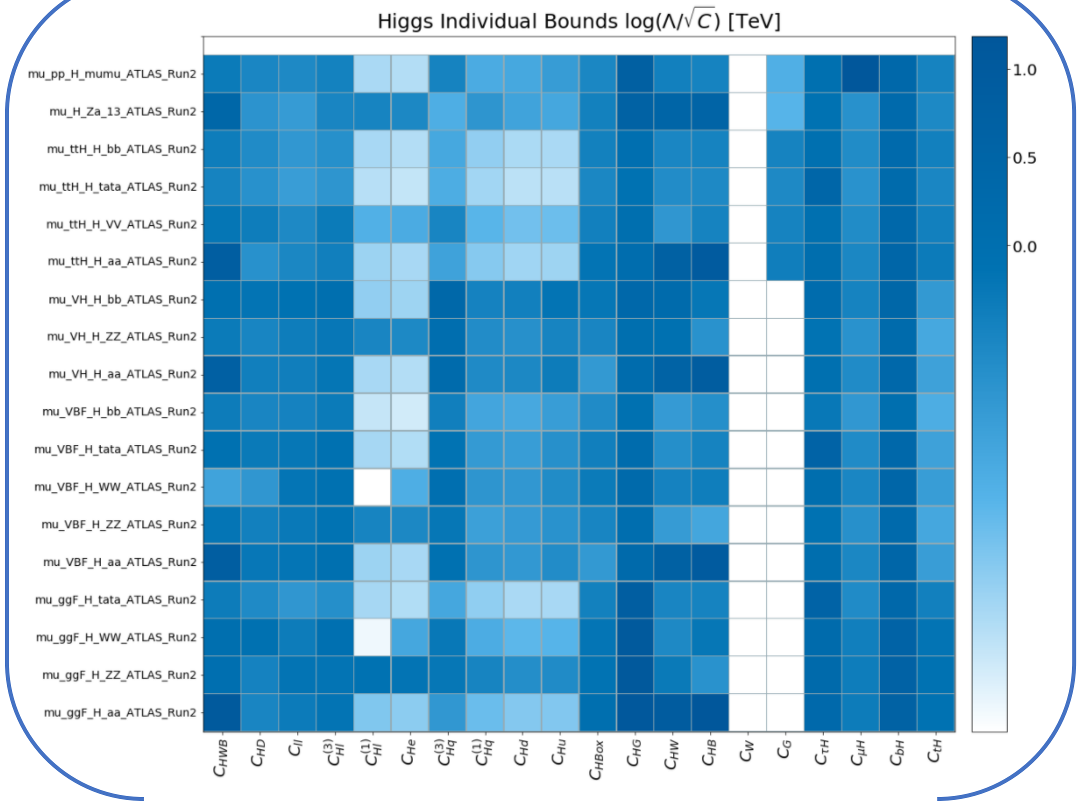


Log scale:



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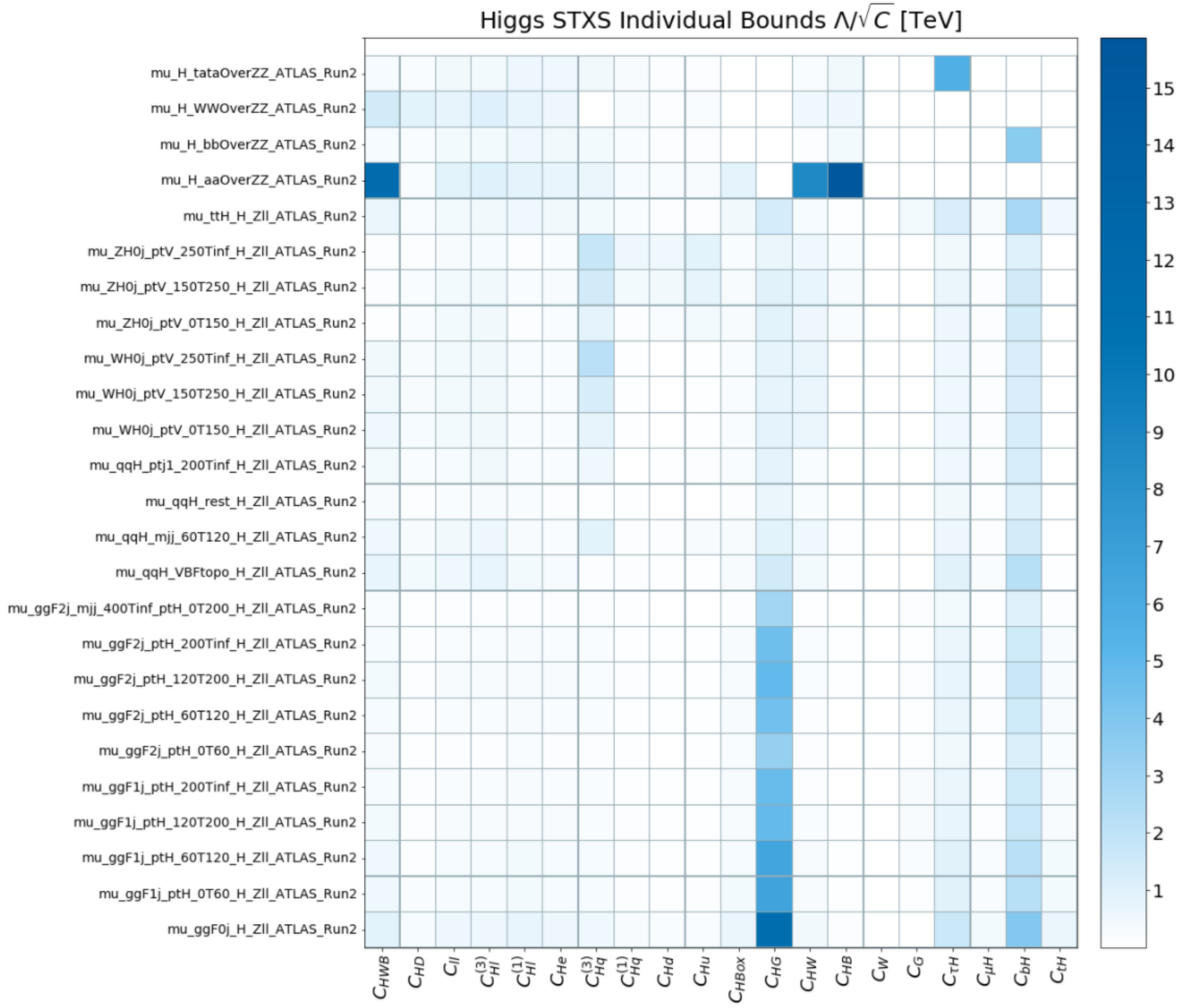

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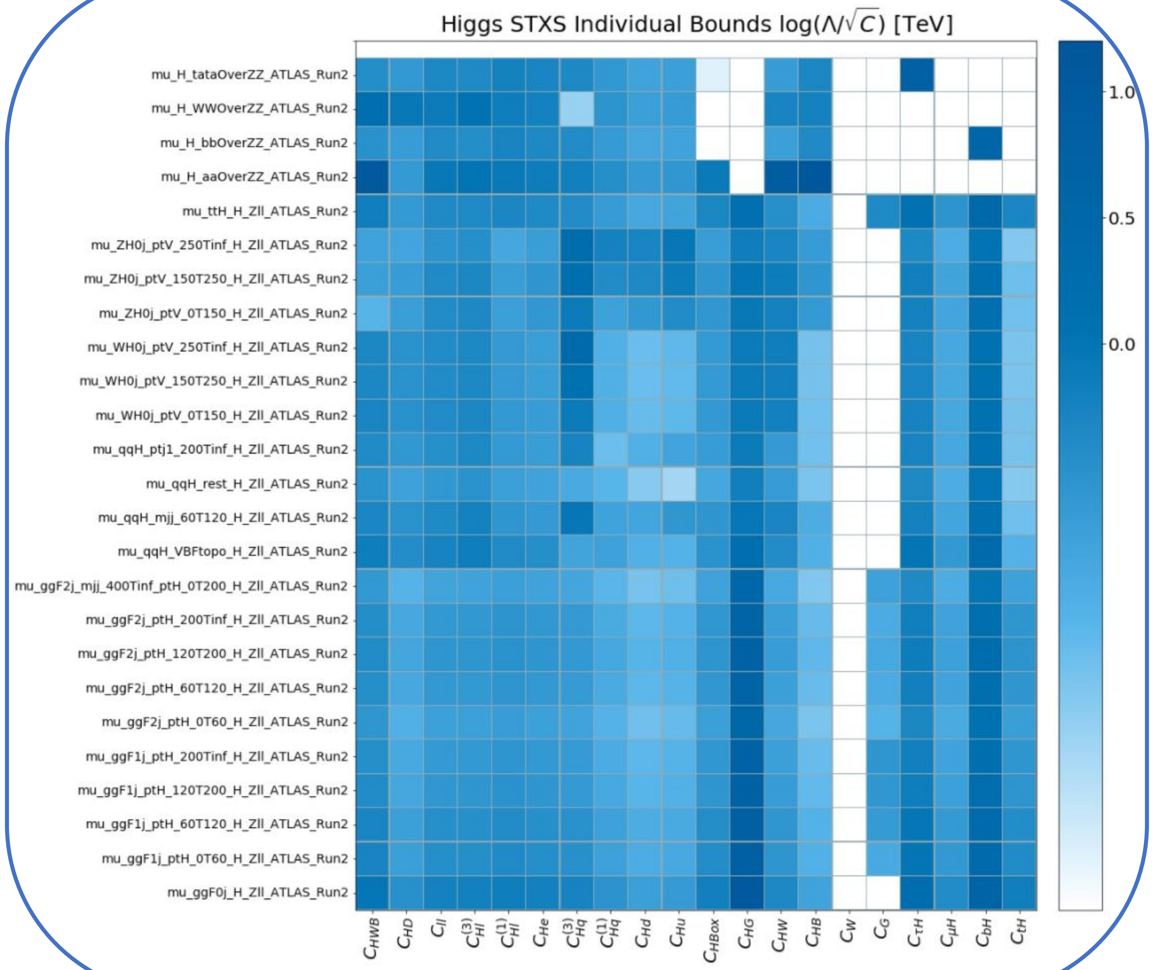

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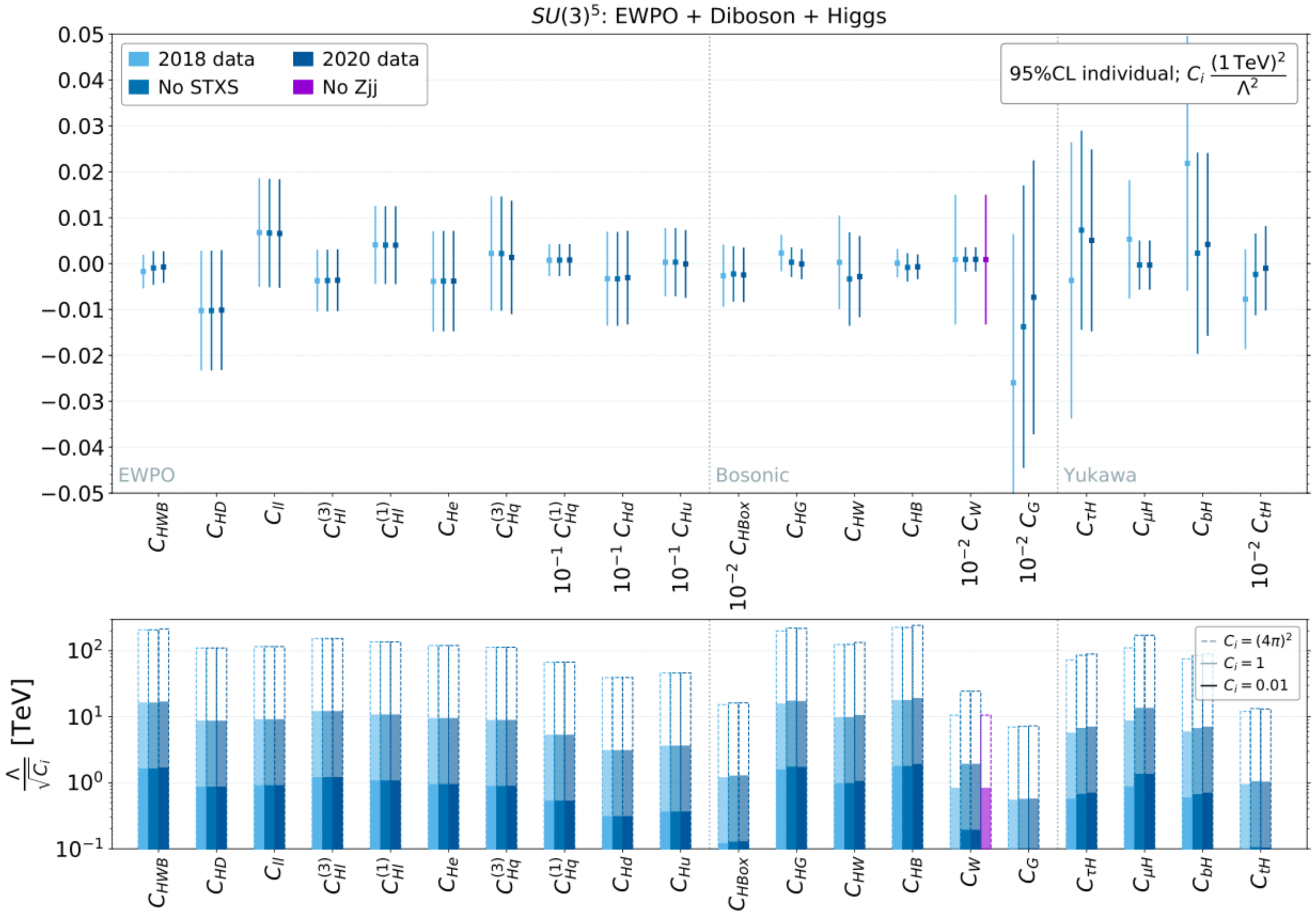
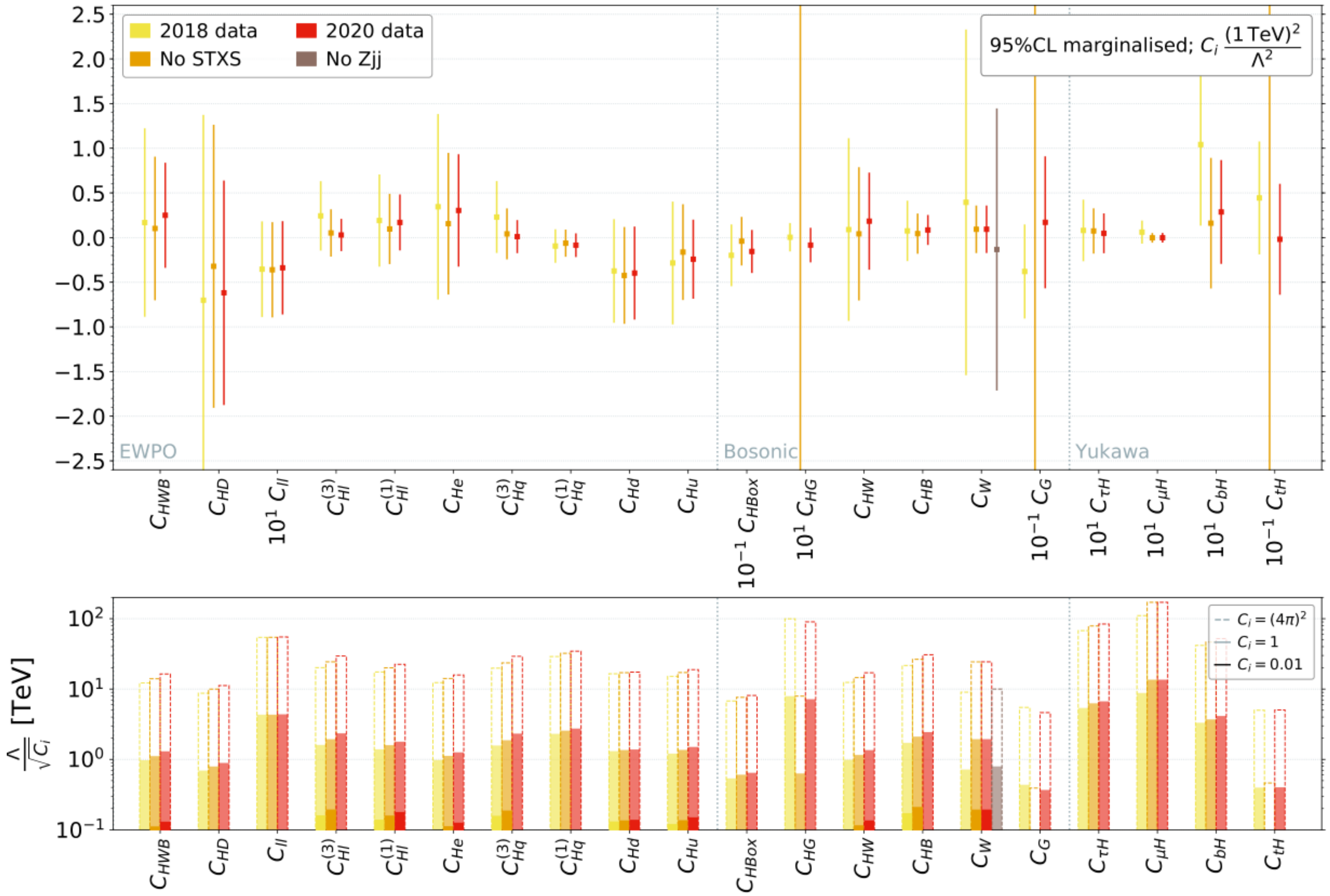


- Individual bounds hardly affected by STXS
- Impact on marginalised constraints

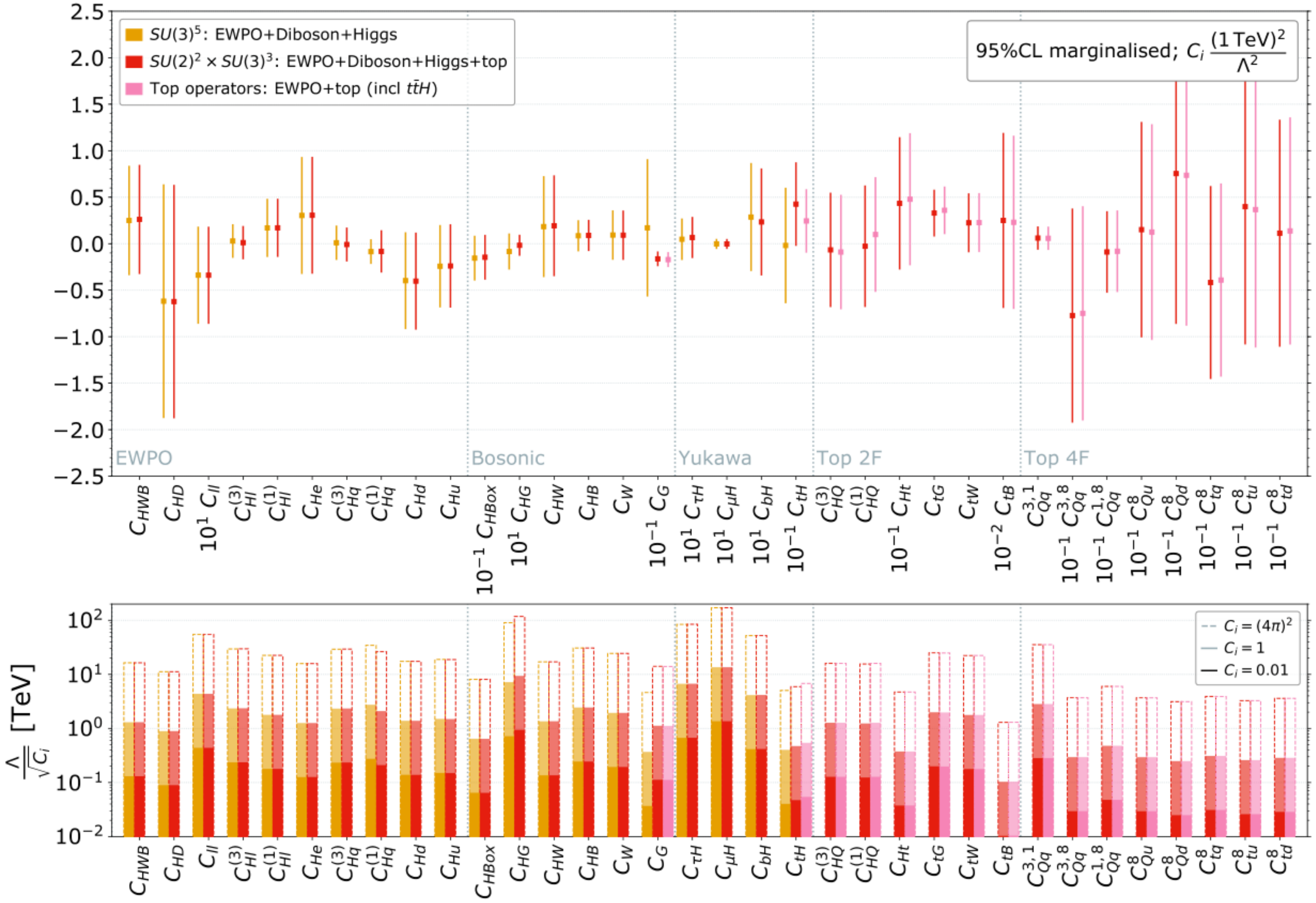
Impact of measurements

- Marginalised 95% CL bounds allowing all **20** operators to vary



Impact of measurements

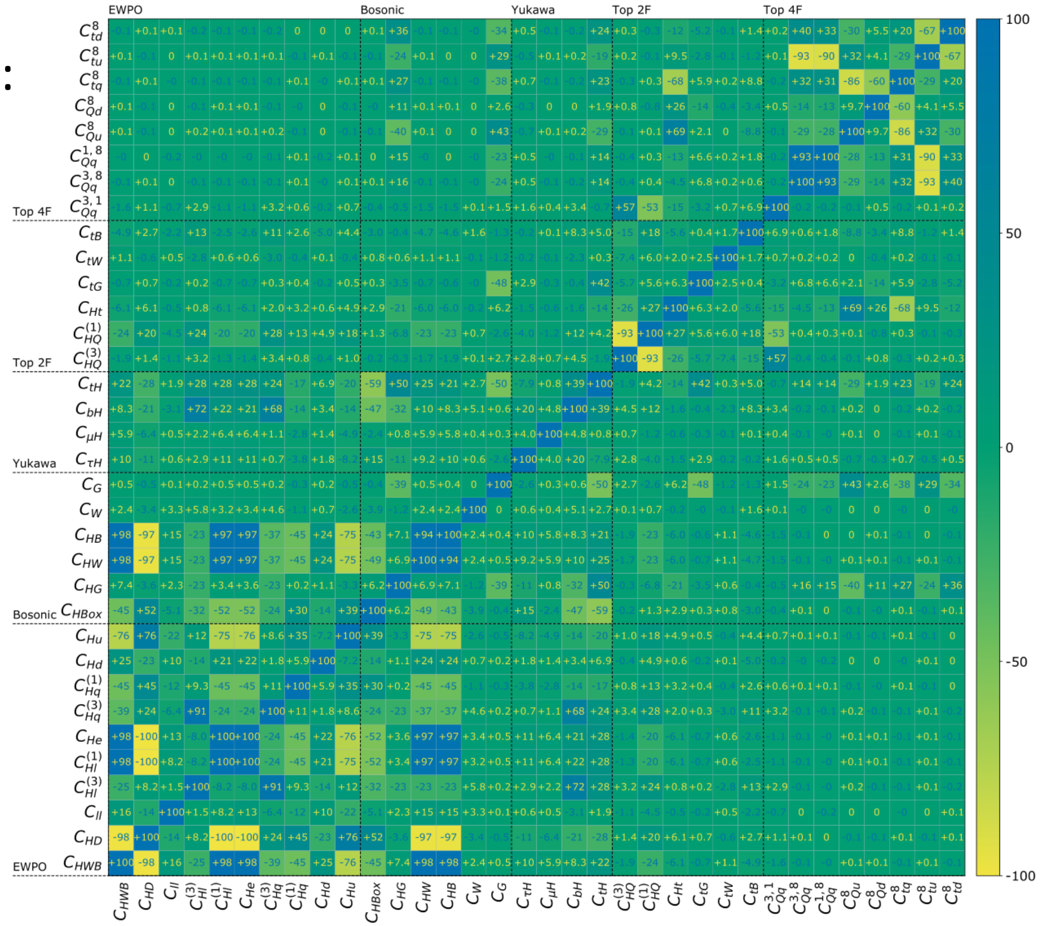
- Marginalised 95% CL bounds allowing all **34** operators to vary

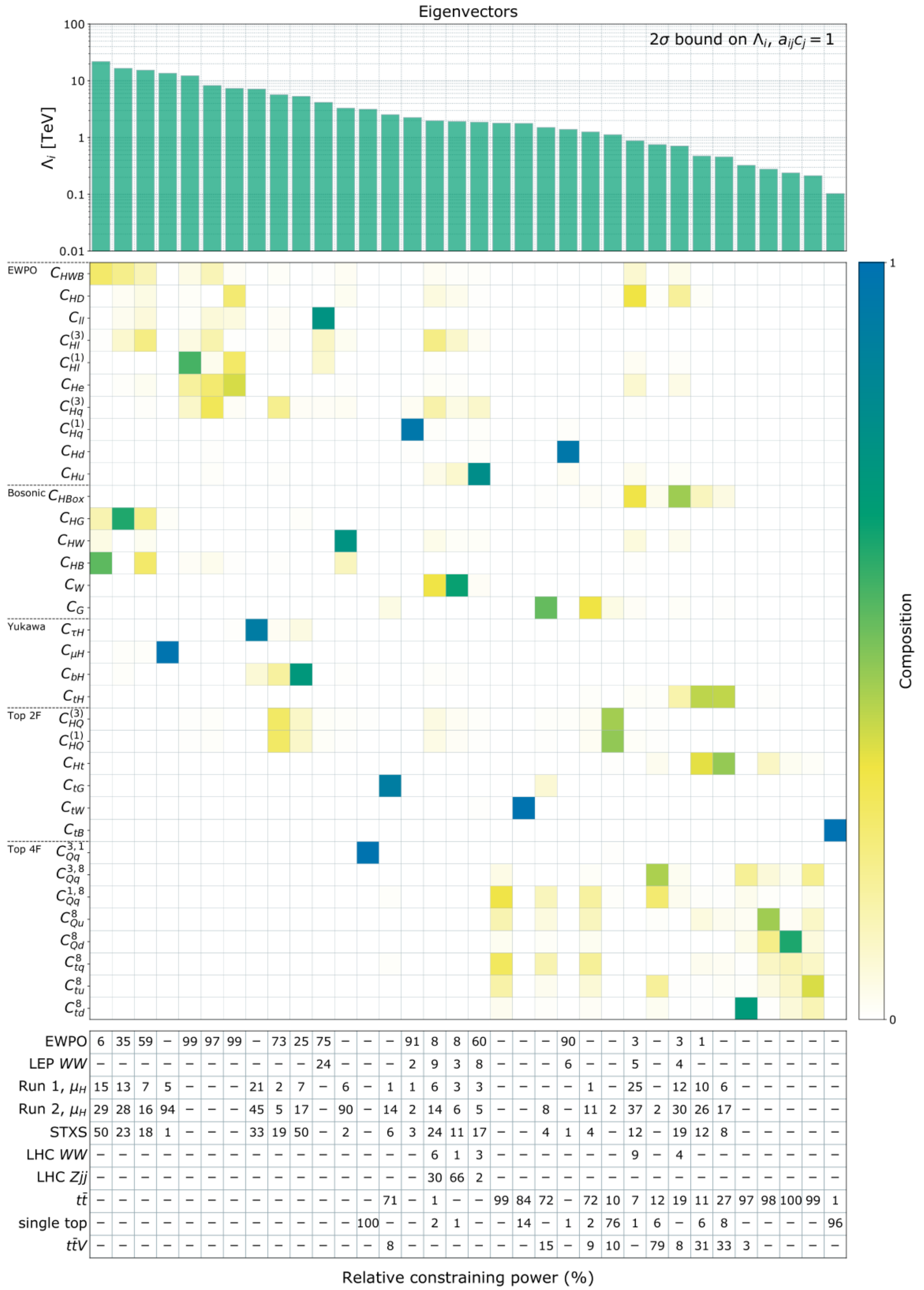


- Which observables constrain which directions in marginalised fit?

Impact of measurements

- Marginalised 95% CL bounds allowing all 20 operators to vary
- Which observables constrain which directions in marginalised fit?
- Principal component analysis: eigenvectors of covariance matrix
- Correlations:
- + Top





Impact of measurements

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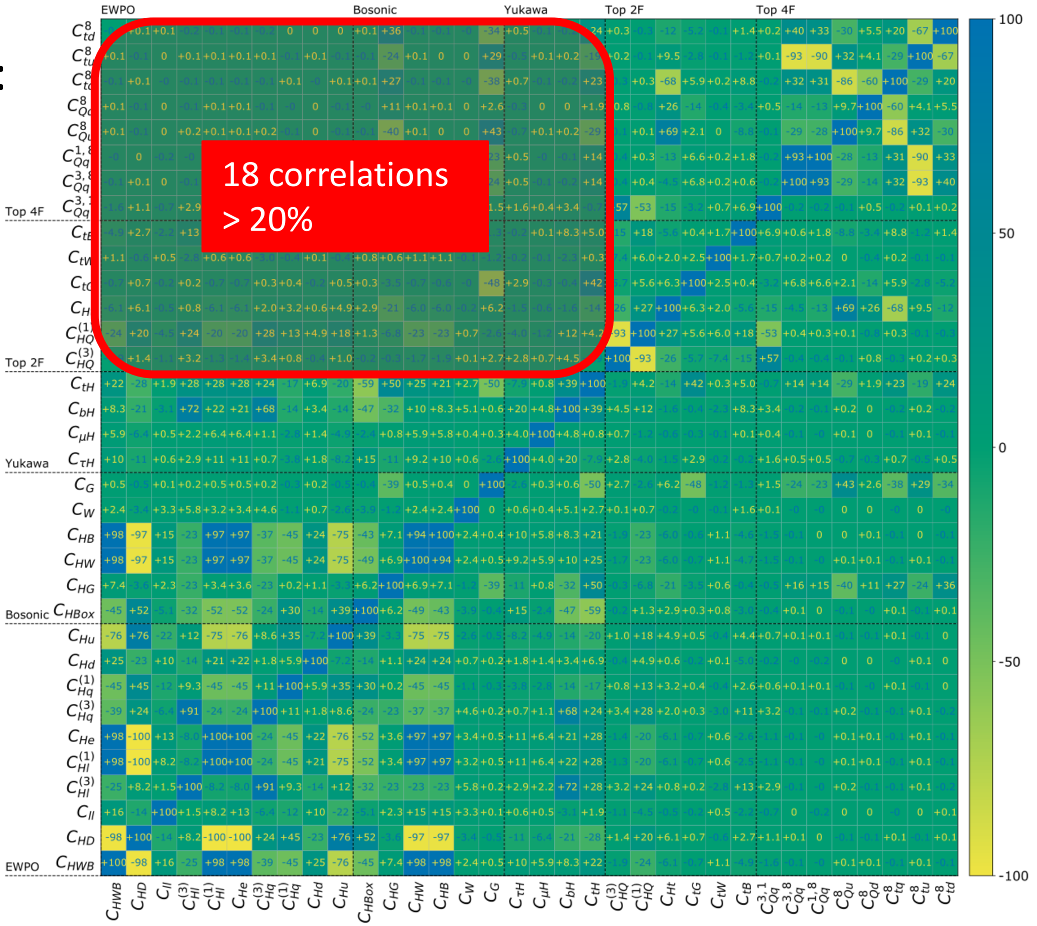
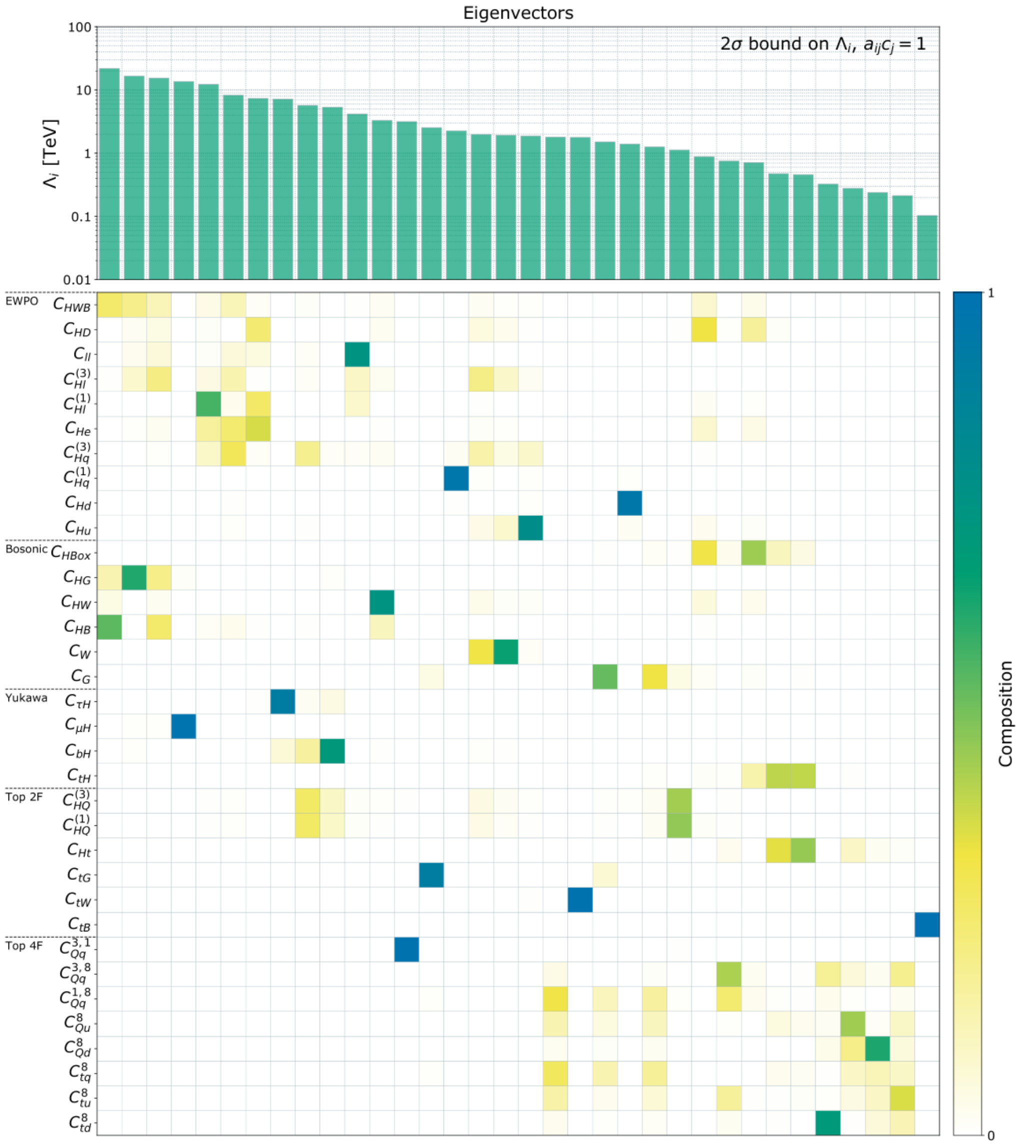


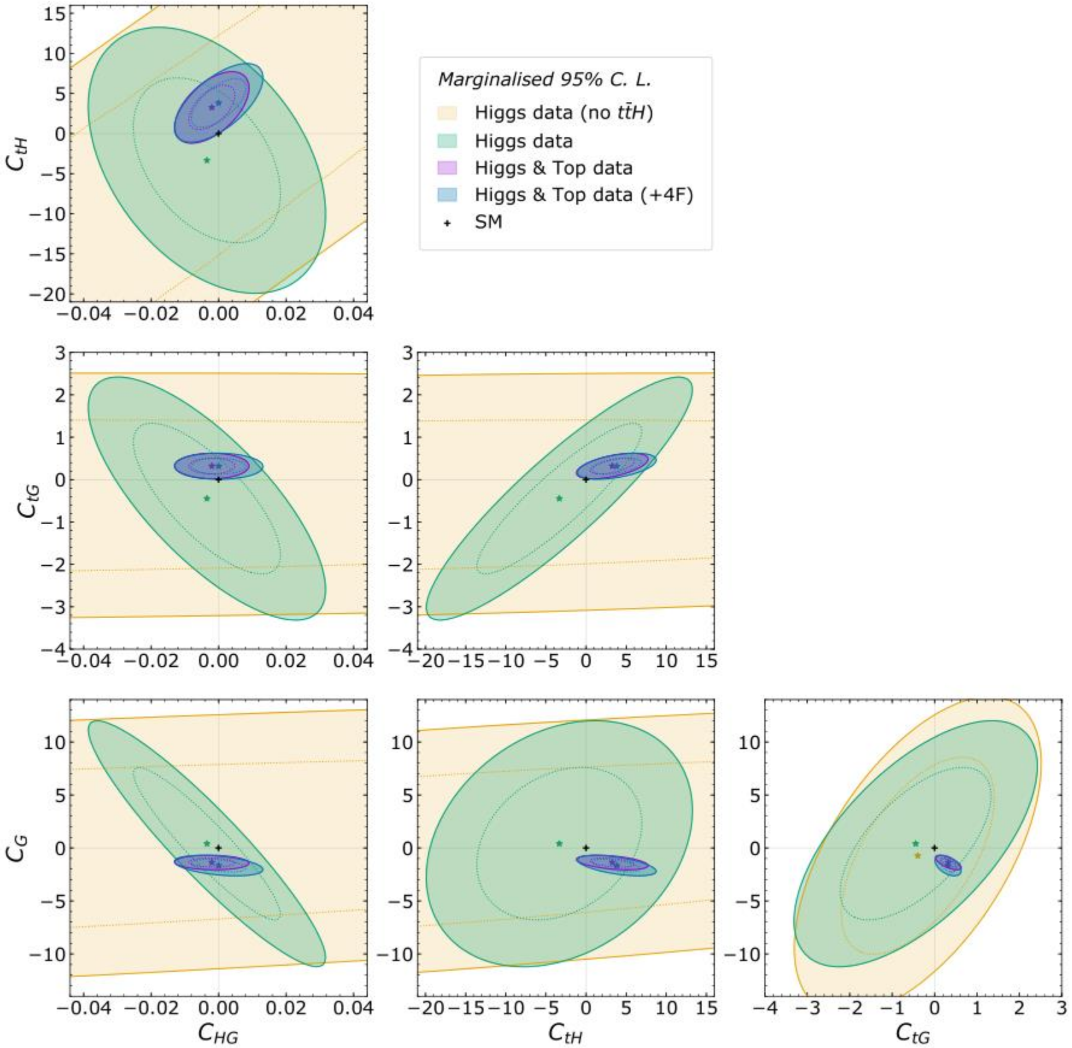


EWPO	6	35	59	–	99	97	99	–	73	25	75	–	–	–	91	8	8	60	–	–	–	90	–	–	3	–	3	1	–	–	–	–	–	–
LEP WW	–	–	–	–	–	–	–	–	–	–	24	–	–	–	2	9	3	8	–	–	–	6	–	–	5	–	4	–	–	–	–	–	–	–
Run 1, μ_H	15	13	7	5	–	–	–	21	2	7	–	6	–	1	1	6	3	3	–	–	–	–	1	–	25	–	12	10	6	–	–	–	–	–
Run 2, μ_H	29	28	16	94	–	–	–	45	5	17	–	90	–	14	2	14	6	5	–	–	8	–	11	2	37	2	30	26	17	–	–	–	–	–
STXS	50	23	18	1	–	–	–	33	19	50	–	2	–	6	3	24	11	17	–	–	4	1	4	–	12	–	19	12	8	–	–	–	–	–
LHC WW	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	1	3	–	–	–	–	–	–	9	–	4	–	–	–	–	–	–	–
LHC Zjj	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	66	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
$t\bar{t}$	–	–	–	–	–	–	–	–	–	–	–	–	–	71	–	1	–	–	99	84	72	–	72	10	7	12	19	11	27	97	98	100	99	1
single top	–	–	–	–	–	–	–	–	–	–	–	–	100	–	–	2	1	–	–	14	–	1	2	76	1	6	–	6	8	–	–	–	–	96
$t\bar{t}V$	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	15	–	9	10	–	79	8	31	33	3	–	–	–	–

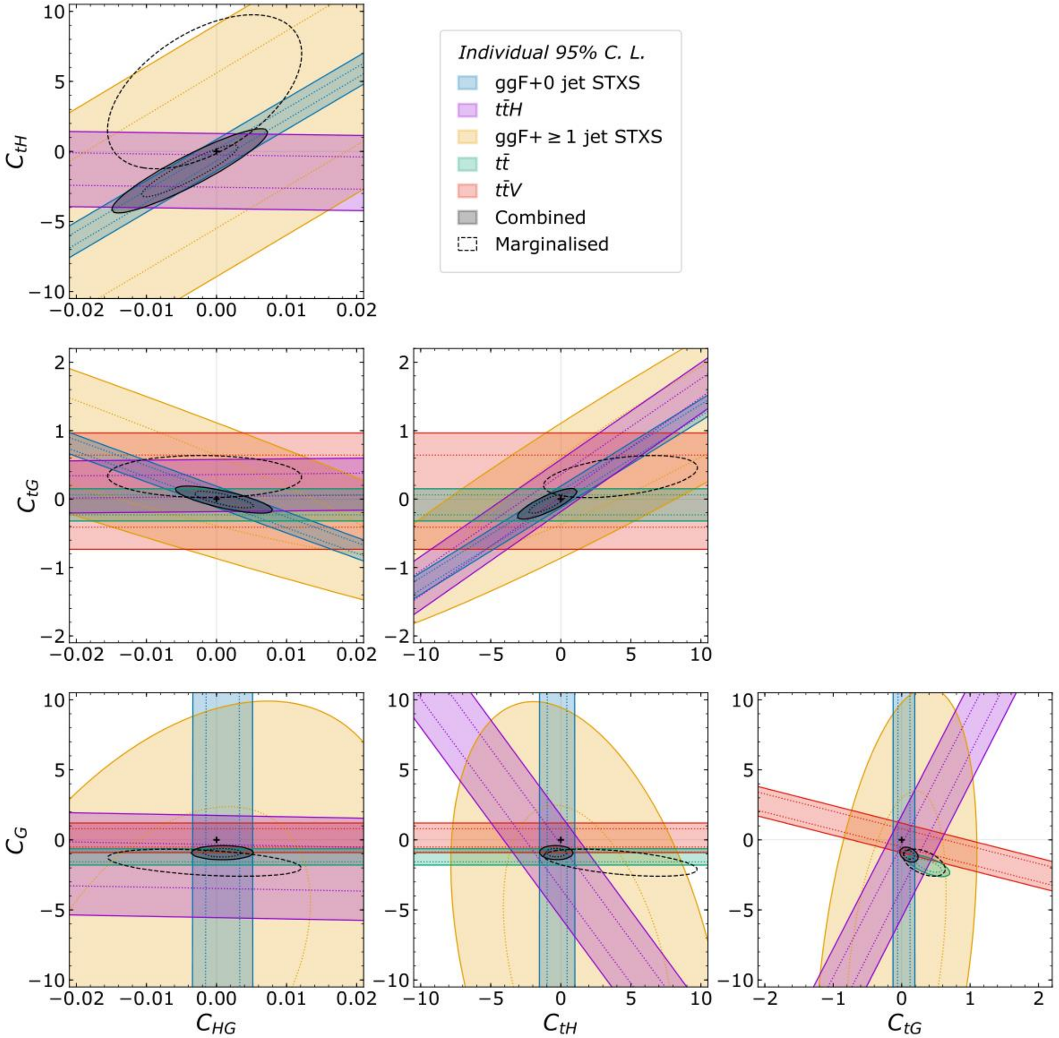
Relative constraining power (%)

Impact of measurements

- Higgs and Top complementarity:
- Fit to $\{C_{H\Box}, C_{HG}, C_{HW}, C_{HB}, C_{tH}, C_{bH}, C_{\tau H}, C_{\mu H}\, C_G \text{ and } C_{tG}\}$



- 2-D fits and marginalised over full fit



Tevong You

SMEFT fit to models

- Simplified models: **renormalisable SM extensions**

Name	Spin	SU(3)	SU(2)	U(1)	Name	Spin	SU(3)	SU(2)	U(1)
S	0	1	1	0	Δ_1	$\frac{1}{2}$	1	2	$-\frac{1}{2}$
S_1	0	1	1	1	Δ_3	$\frac{1}{2}$	1	2	$-\frac{1}{2}$
φ	0	1	2	$\frac{1}{2}$	Σ	$\frac{1}{2}$	1	3	0
Ξ	0	1	3	0	Σ_1	$\frac{1}{2}$	1	3	-1
Ξ_1	0	1	3	1	U	$\frac{1}{2}$	3	1	$\frac{2}{3}$
B	1	1	1	0	D	$\frac{1}{2}$	3	1	$-\frac{1}{3}$
B_1	1	1	1	1	Q_1	$\frac{1}{2}$	3	2	$\frac{1}{6}$
W	1	1	3	0	Q_5	$\frac{1}{2}$	3	2	$-\frac{5}{6}$
W_1	1	1	3	1	Q_7	$\frac{1}{2}$	3	2	$\frac{7}{6}$
N	$\frac{1}{2}$	1	1	0	T_1	$\frac{1}{2}$	3	3	$-\frac{1}{3}$
E	$\frac{1}{2}$	1	1	-1	T_2	$\frac{1}{2}$	3	3	$\frac{2}{3}$
T	$\frac{1}{2}$	3	1	$\frac{2}{3}$	TB	$\frac{1}{2}$	3	2	$\frac{1}{6}$

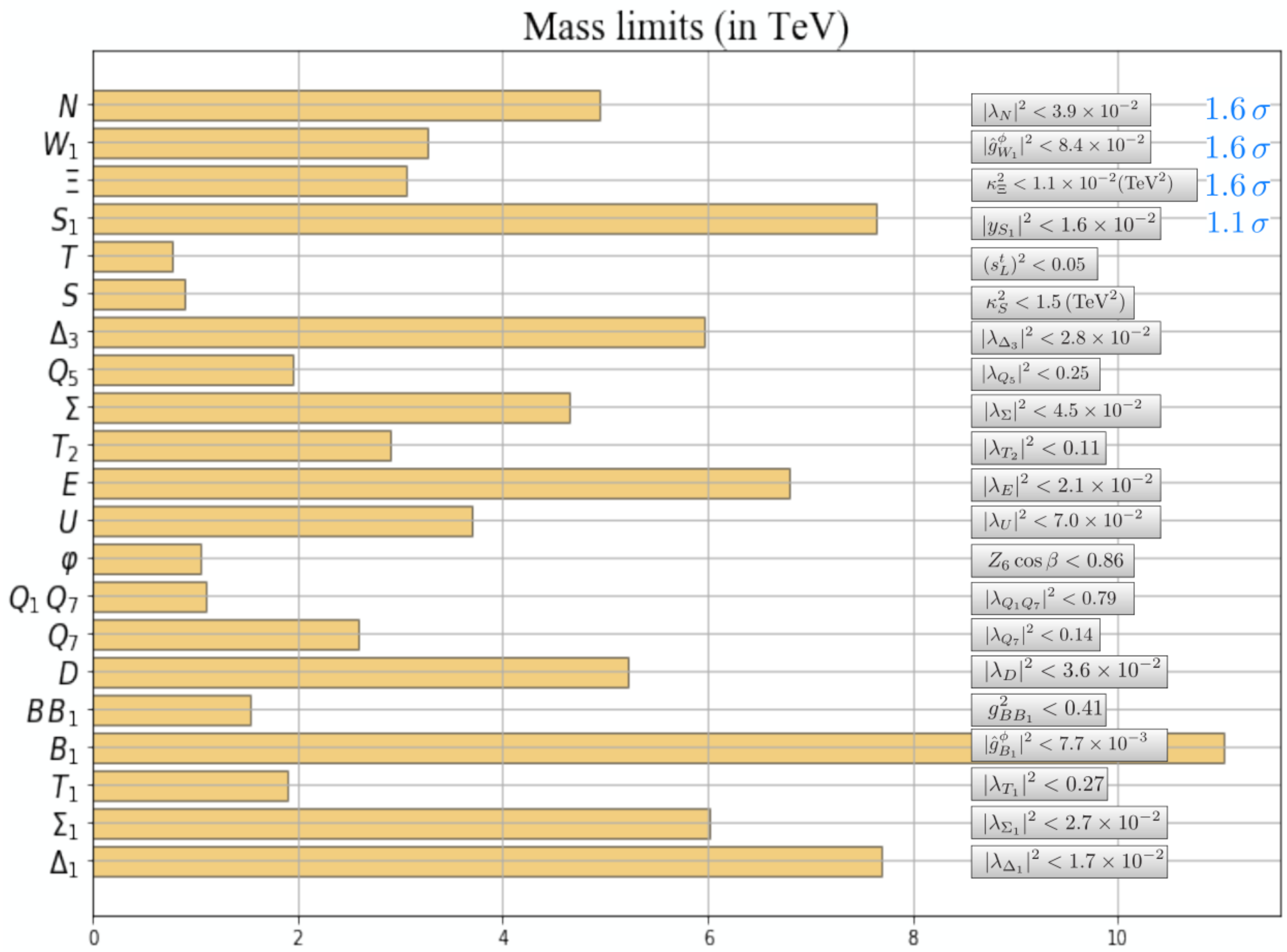
Model	C_{HD}	C_{ll}	C_{Hl}^3	C_{Hl}^1	C_{He}	$C_{H\Box}$	$C_{\tau H}$	C_{tH}	C_{bH}
S						-1			
S_1		1							
Σ			$\frac{5}{8}$	$\frac{3}{16}$			$\frac{y_\tau}{4}$		
Σ_1			$-\frac{5}{8}$	$-\frac{3}{16}$			$\frac{y_\tau}{8}$		
N			$-\frac{1}{4}$	$\frac{1}{4}$					
E			$-\frac{1}{4}$	$-\frac{1}{4}$			$\frac{y_\tau}{2}$		
Δ_1					$\frac{1}{2}$		$\frac{y_\tau}{2}$		
Δ_3					$-\frac{1}{2}$		$\frac{y_\tau}{2}$		
B_1	1					$-\frac{1}{2}$	$-\frac{y_\tau}{2}$	$-\frac{y_t}{2}$	$-\frac{y_b}{2}$
Ξ	-2					$\frac{1}{2}$	y_τ	y_t	y_b
W_1	$-\frac{1}{4}$					$-\frac{1}{8}$	$-\frac{y_\tau}{8}$	$-\frac{y_t}{8}$	$-\frac{y_b}{8}$
φ							$-y_\tau$	$-y_t$	$-y_b$
$\{B, B_1\}$						1	y_τ	y_t	y_b
$\{Q_1, Q_7\}$								y_t	
Model	C_{HG}	C_{Hq}^3	C_{Hq}^1	$(C_{Hq}^3)_{33}$	$(C_{Hq}^1)_{33}$	C_{Hu}	C_{Hd}	C_{tH}	C_{bH}
U		$-\frac{1}{4}$	$\frac{1}{4}$	$-\frac{1}{4}$	$\frac{1}{4}$			$\frac{y_t}{2}$	
D		$-\frac{1}{4}$	$-\frac{1}{4}$	$-\frac{1}{4}$	$-\frac{1}{4}$				$\frac{y_b}{2}$
Q_5							$-\frac{1}{2}$		$\frac{y_b}{2}$
Q_7						$\frac{1}{2}$		$\frac{y_t}{2}$	
T_1		$-\frac{5}{8}$	$-\frac{3}{16}$	$-\frac{5}{8}$	$-\frac{3}{16}$			$\frac{y_t}{4}$	$\frac{y_b}{8}$
T_2		$-\frac{5}{8}$	$\frac{3}{16}$	$-\frac{5}{8}$	$\frac{3}{16}$			$\frac{y_t}{8}$	$\frac{y_b}{4}$
T	$-\frac{M_T^2}{v^2}\frac{\alpha_s(0.02)}{8\pi}$			$-\frac{1}{2}\frac{M_T^2}{v^2}$	$\frac{1}{2}\frac{M_T^2}{v^2}$			$y_t\frac{M_T^2}{v^2}$	

- Classification and tree-level matching dictionary

De Blas, Criado, Perez-Victoria, Santiago [1711.10391]

SMEFT fit to models

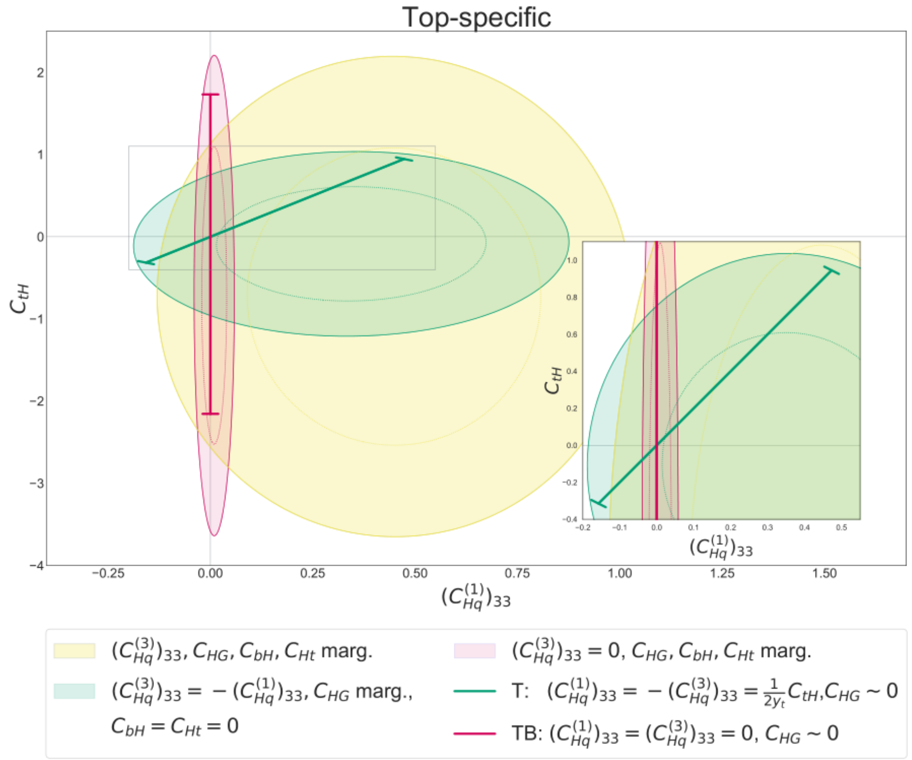
- Streamlines process of interpreting limits on BSM parameter space

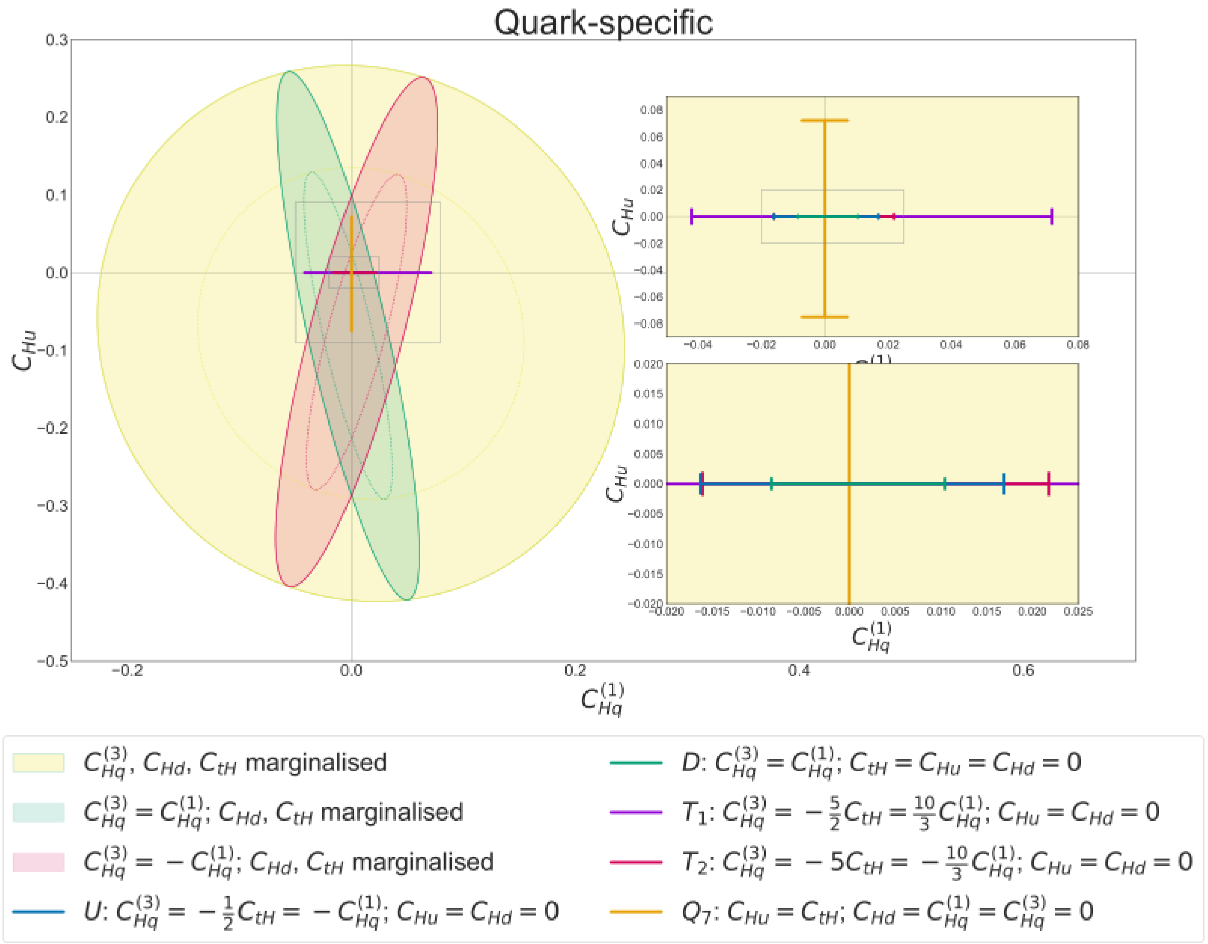


SMEFT fit to models

- Streamlines process of interpreting limits on BSM parameter space

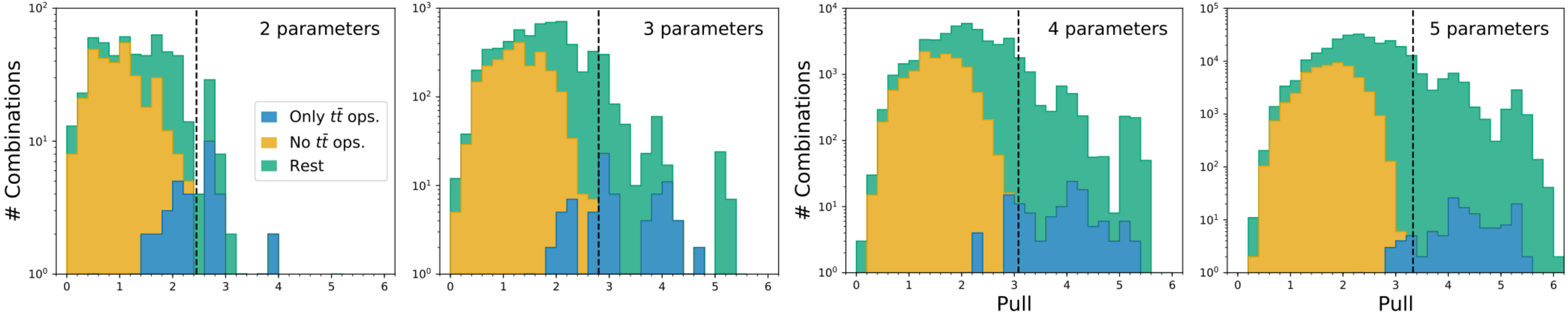
$$
\begin{aligned}
\text{Boson-specific: } & (C_{HD}, C_{H\Box}, C_{tH}) \quad , \\
\text{Lepton-specific: } & (C_{He}, C_{H\ell}^{(1,3)}, C_{\ell\ell}) \quad , \\
\text{Quark-specific: } & (C_{Hu}, C_{Hd}, C_{Hq}^{(1,3)}, C_{tH}) \quad , \\
\text{Top-specific: } & ((C_{Hq}^{(1)})_{33}, (C_{Hq}^{(3)})_{33}, C_{HG}, C_{bH}, C_{tH}, C_{Ht})
\end{aligned}
$$

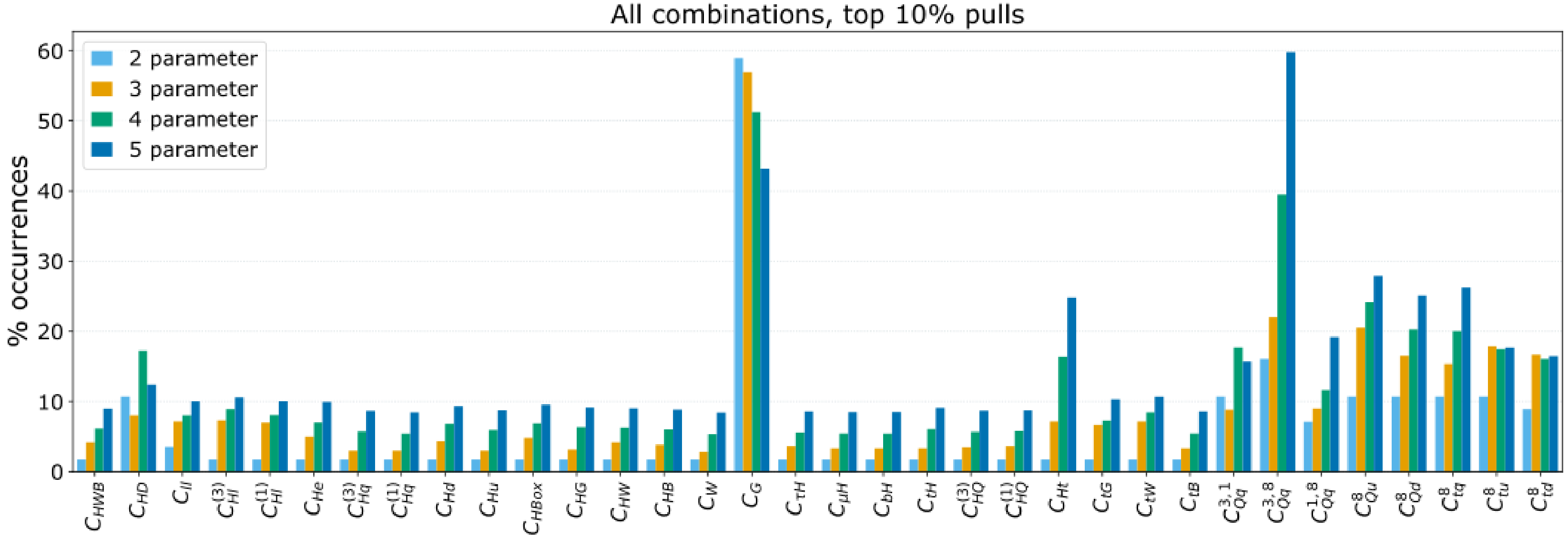




SMEFT fit to models

- Systematic search for pulls in all N parameter combinations of operators





Conclusion

- QED+Fermi theory → chiral electroweak+pion EFT
- Chiral electroweak EFT+Higgs → SM
- SM → SMEFT
- SMEFT → ?
- Fitmaker framework for SMEFT fits