

m_W in the SMEFT

[E. Bagnaschi, J. Ellis, M. Madigan, KM, V. Sanz, T. You; JHEP 08 (2022) 308]

J. Ellis, KM, F. Zampedri; 2304.06663]

Ken Mimasu

King's College London

MWDays23 workshop, CERN

19th of April 2023

Outline

Predicting m_W & interpreting measurements in the SMEFT

Global fits with EWPO, Higgs & Diboson data

Mapping to single field extensions of the SM

Interplay with CKM unitarity

Beyond dimension-6: scalar triplet model

SMEFT is...

$$\mathcal{L}_{\text{eff}} = \sum_i \frac{c_i \mathcal{O}_i^D}{\Lambda^{D-4}}$$

Model independent

- Underlying assumptions

Heavy new physics: $M > E_{\text{exp}}$

SM field content & gauge symmetries

Linear EWSB: Higgs = doublet

Systematically improvable

- Double expansion

higher dim. $\frac{E^2}{\Lambda^2}$ & $\{g_s, g, g'\}$ *more loops*

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Global

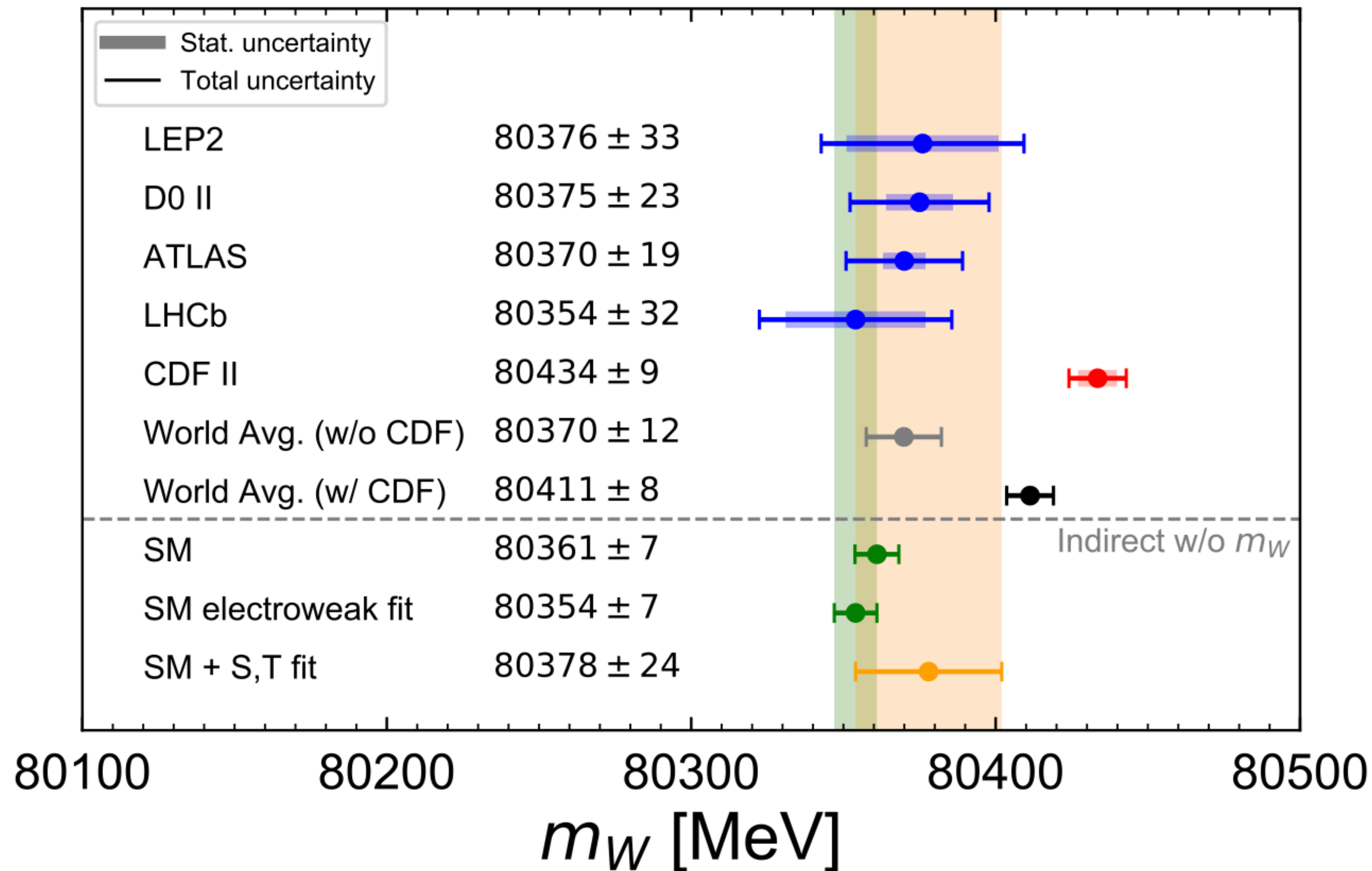
- Model independence: we don't know what operators NP will generate
- *Patterns & correlations* among observables are key
- Ultimate goal: complete SMEFT likelihood confronted with HEP data

EWPO, *Higgs*, *multiboson*, *top*, DY, *flavor*,...

$\mathcal{L}(c_i) \Rightarrow$ **indirectly constrain many UV models**

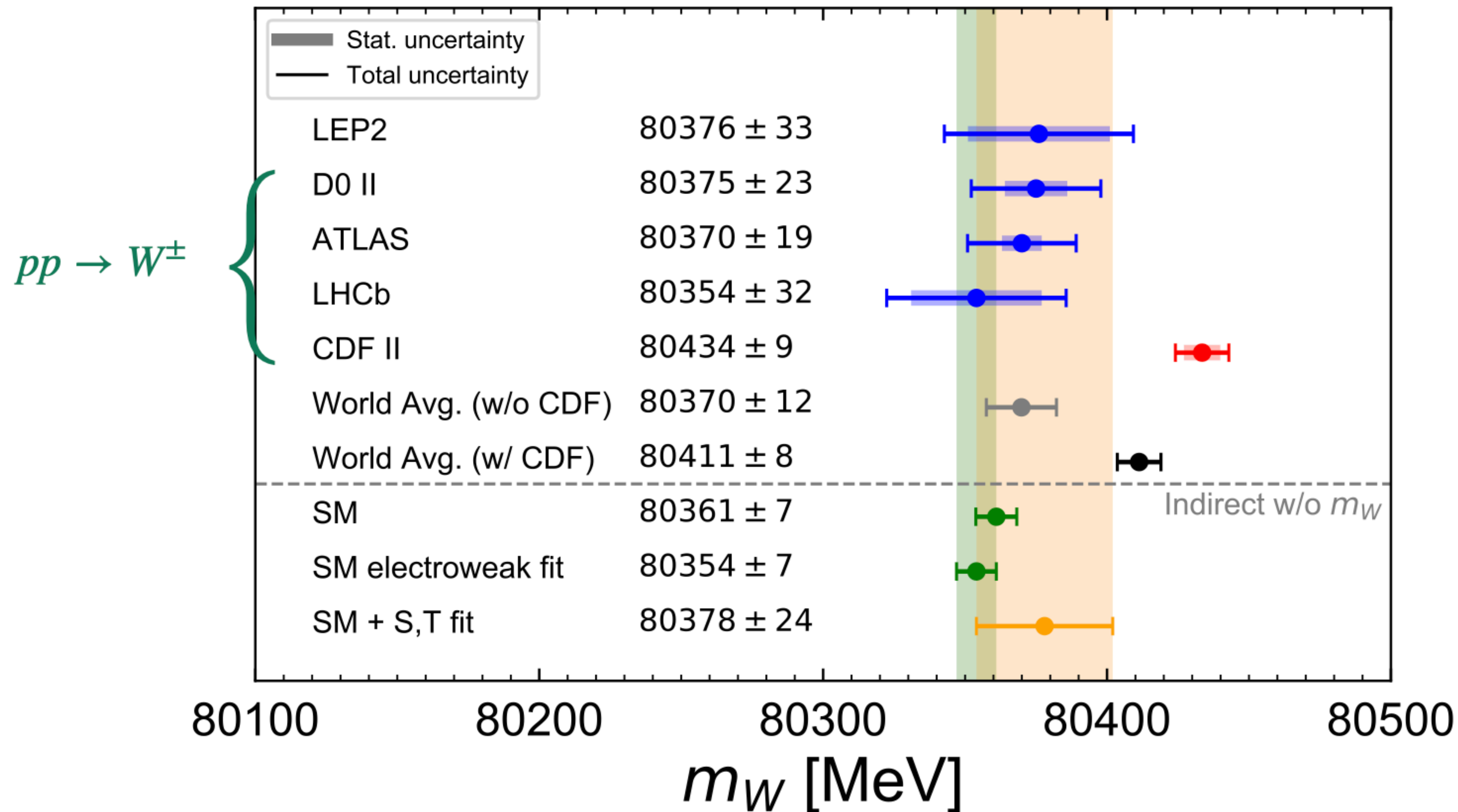
m_W measurements

[Bagnaschi, Ellis, Madigan, KM, Sanz & You; JHEP 08 (2022) 308]



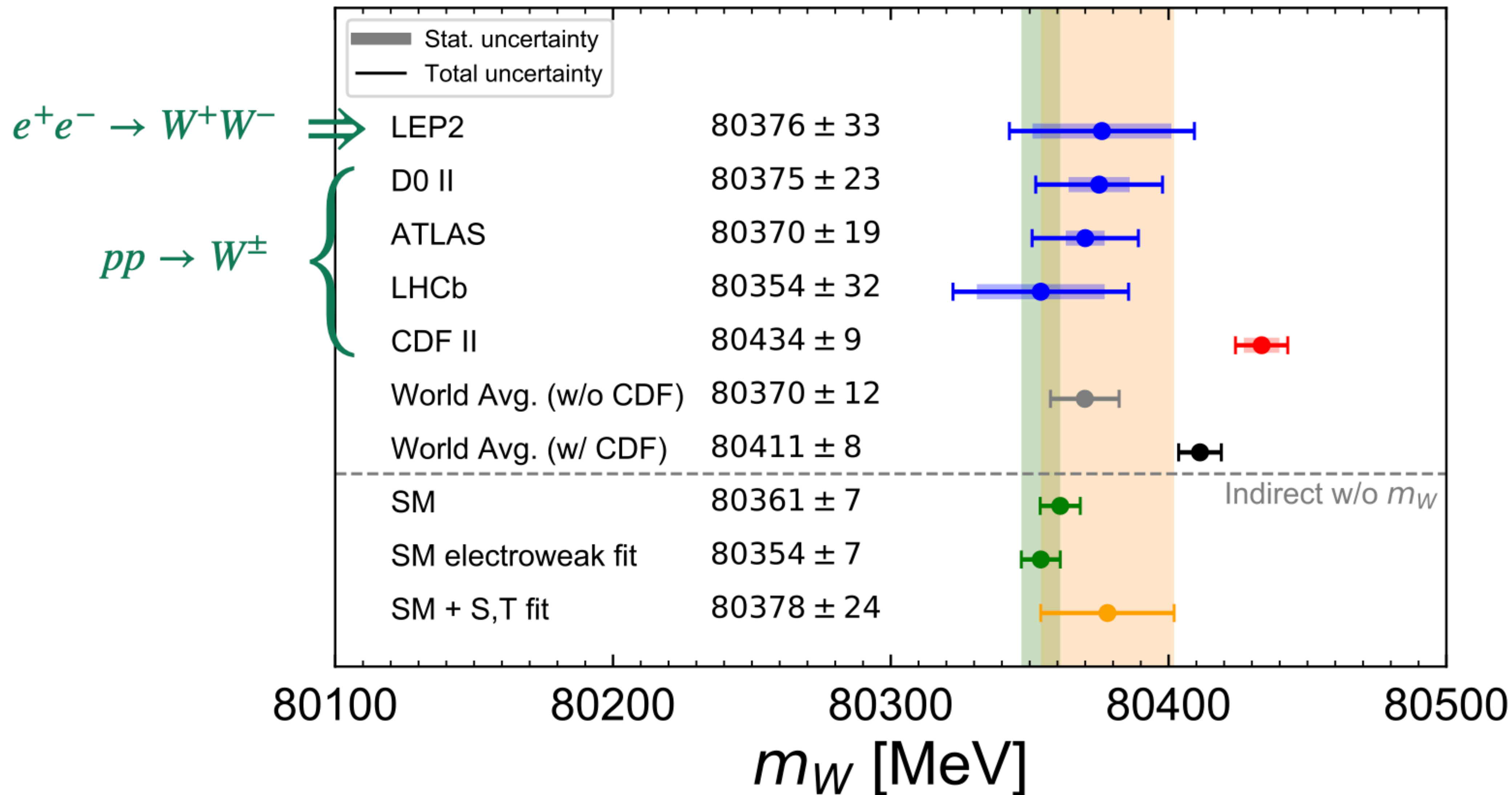
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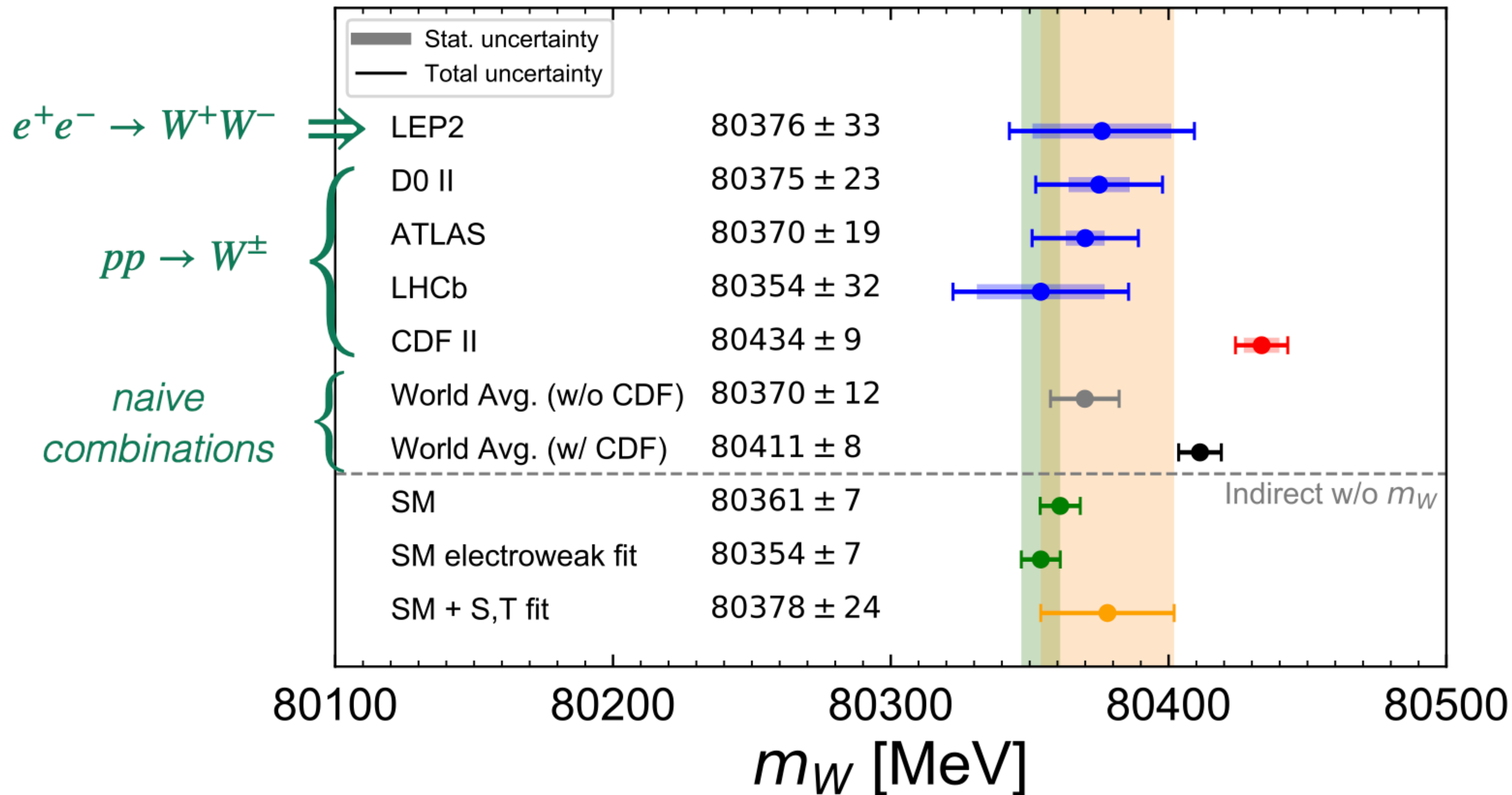
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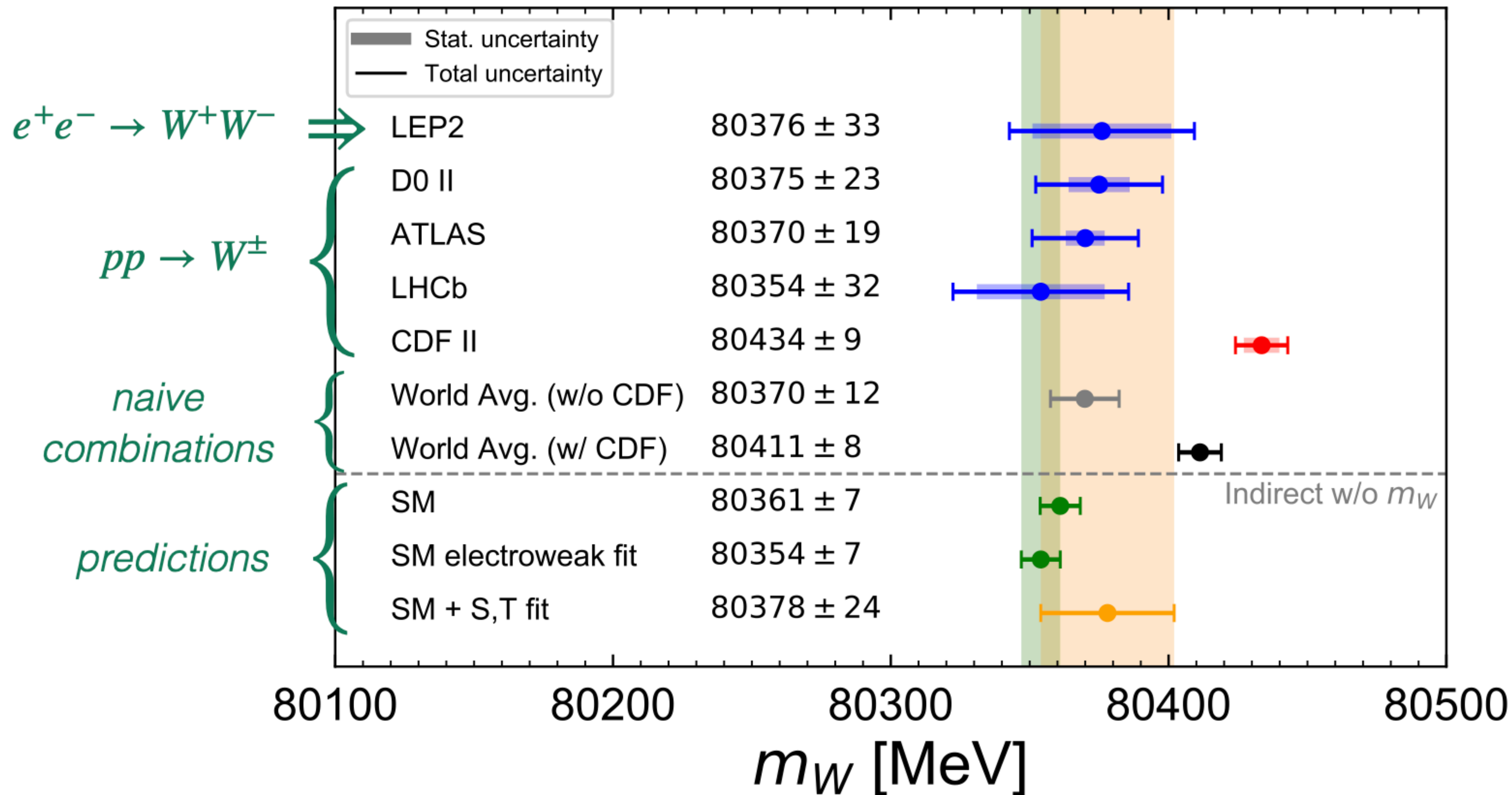
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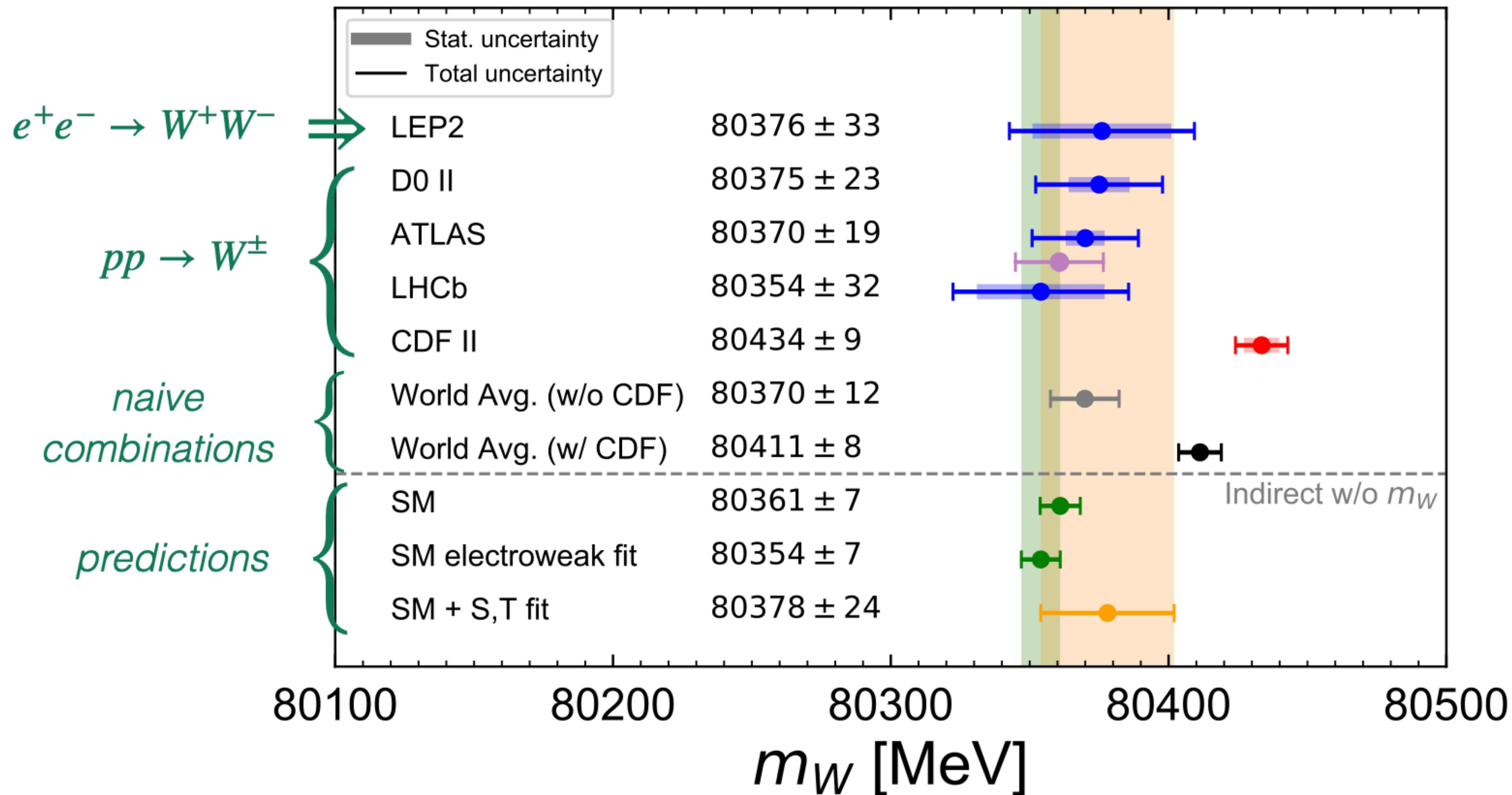
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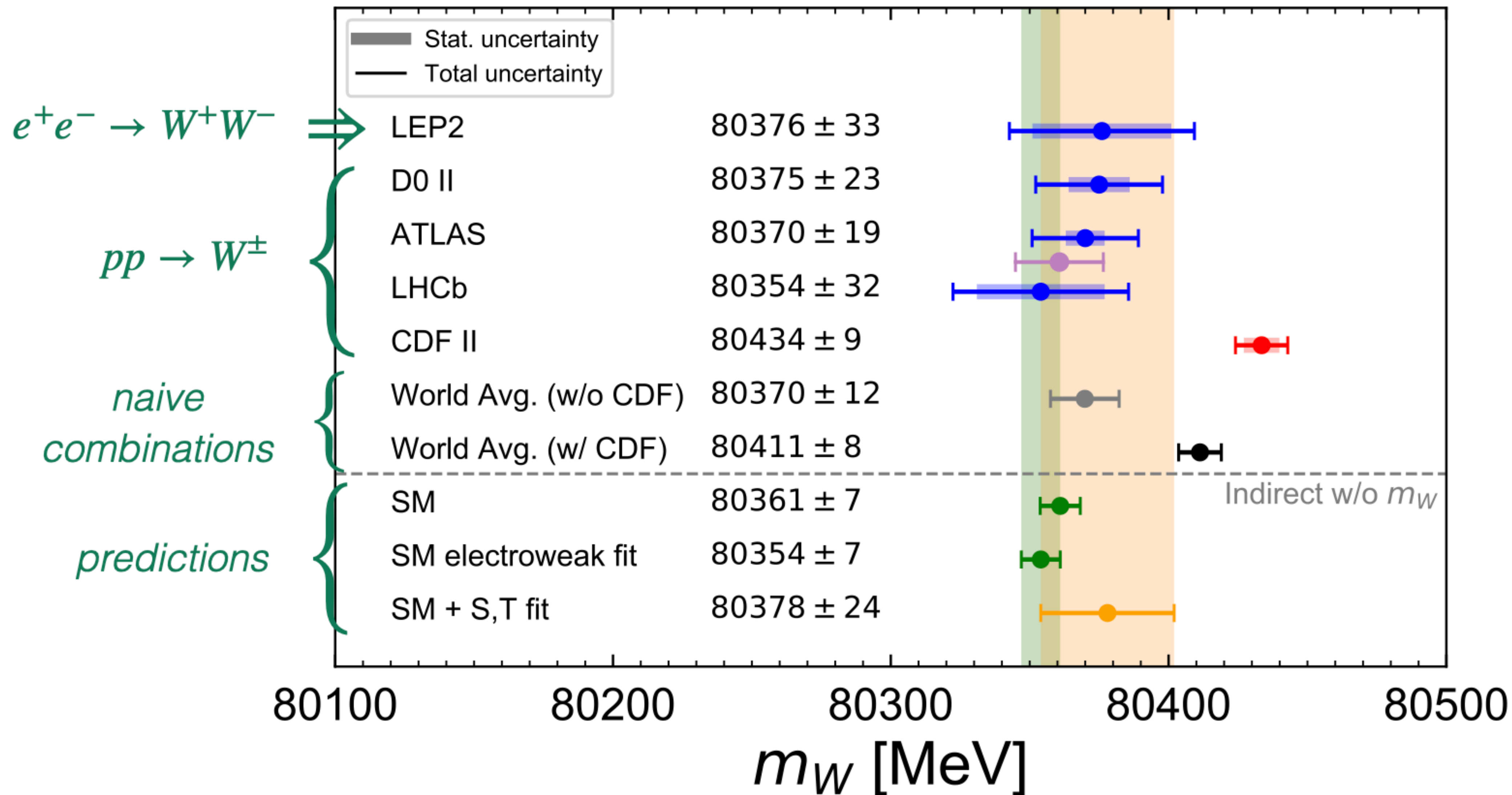
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ATLAS update, Run 1 re-analysis: $m_W = 80360 \pm 16$ MeV

m_W measurements

[Bagnaschi, Ellis, Madigan, KM, Sanz & You; JHEP 08 (2022) 308]



SM + fit to S & T parameters: $m_W = 80378 \pm 24$ MeV

m_W prediction in SMEFT

$$\frac{\delta m_W^2}{m_W^2} = -\frac{\sin 2\hat{\theta}_w}{\cos 2\hat{\theta}_w} \frac{\hat{v}^2}{4\Lambda^2} \left(\frac{\cos \hat{\theta}_w}{\sin \hat{\theta}_w} C_{HD} + \frac{\sin \hat{\theta}_w}{\cos \hat{\theta}_w} \left(4C_{HI}^{(3)} - 2C_{II} \right) + 4C_{HWB} \right)$$

Dimension-6: 4 operators modify $m_W(G_F, \alpha_{EW}, m_Z)$

- Shift input parameter relations w.r.t SM $\Rightarrow m_W(G_F, \alpha_{EW}, m_Z, C_i)$


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Δm_Z^2



$\mathcal{O}_{HWB} \equiv H^\dagger \tau^I H W_{\mu\nu}^I B^{\mu\nu} \propto S$

$\mathcal{O}_{HD} \equiv (H^\dagger D^\mu H)^\star (H^\dagger D_\mu H) \propto T$




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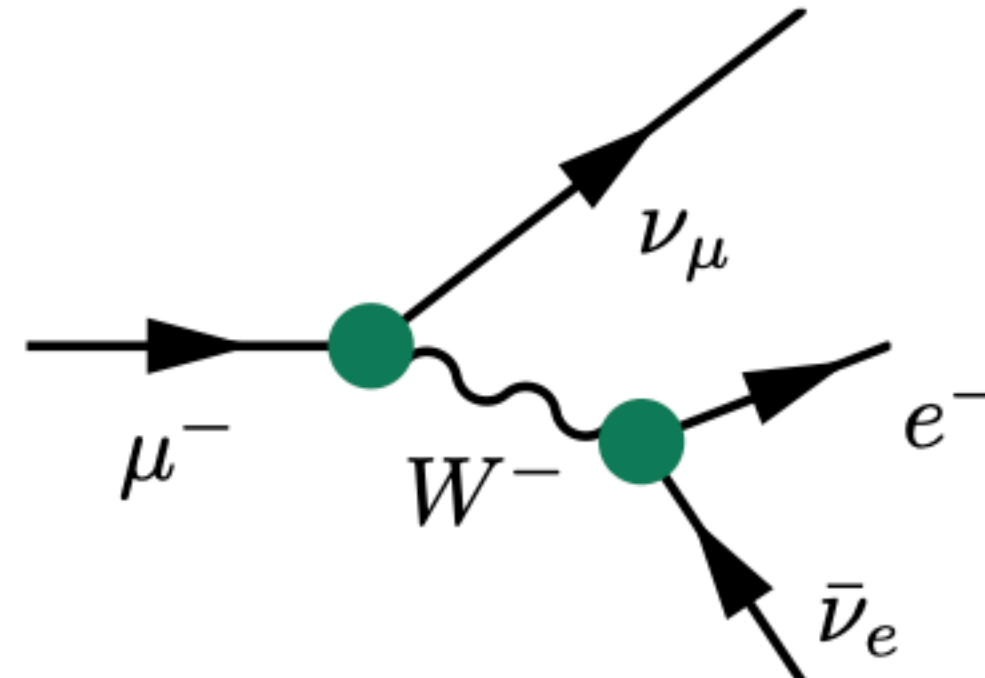
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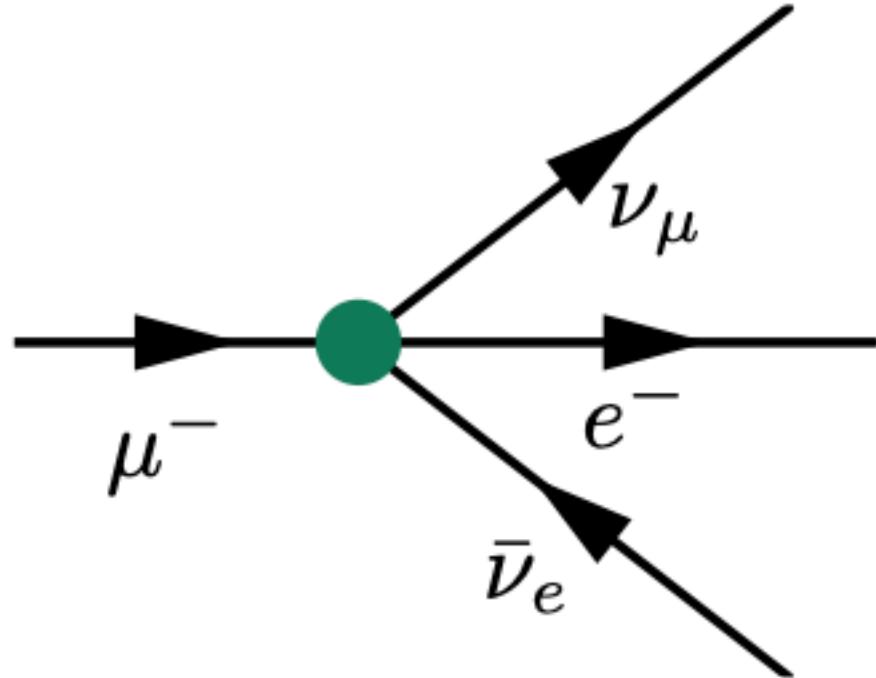
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ΔG_F

$\mathcal{O}_{H\ell}^{(3)} \equiv (H^\dagger i \overleftrightarrow{D}_\mu^I H) (\bar{\ell}_{1,2} \tau^I \gamma^\mu \ell_{1,2})$


$\mathcal{O}_{\ell\ell} \equiv (\bar{\ell}_1 \gamma_\mu \ell_2) (\bar{\ell}_2 \gamma^\mu \ell_1)$


m_W interpretation in SMEFT

New physics can yield correlated effects in many places

- SMEFT motivates global approach $\Rightarrow \delta m_W^2$ does not occur in isolation
- *e.g.* modified widths/branching fractions, production & decay kinematics,...
- Biases in interpreting data that hasn't accounted for such effects?

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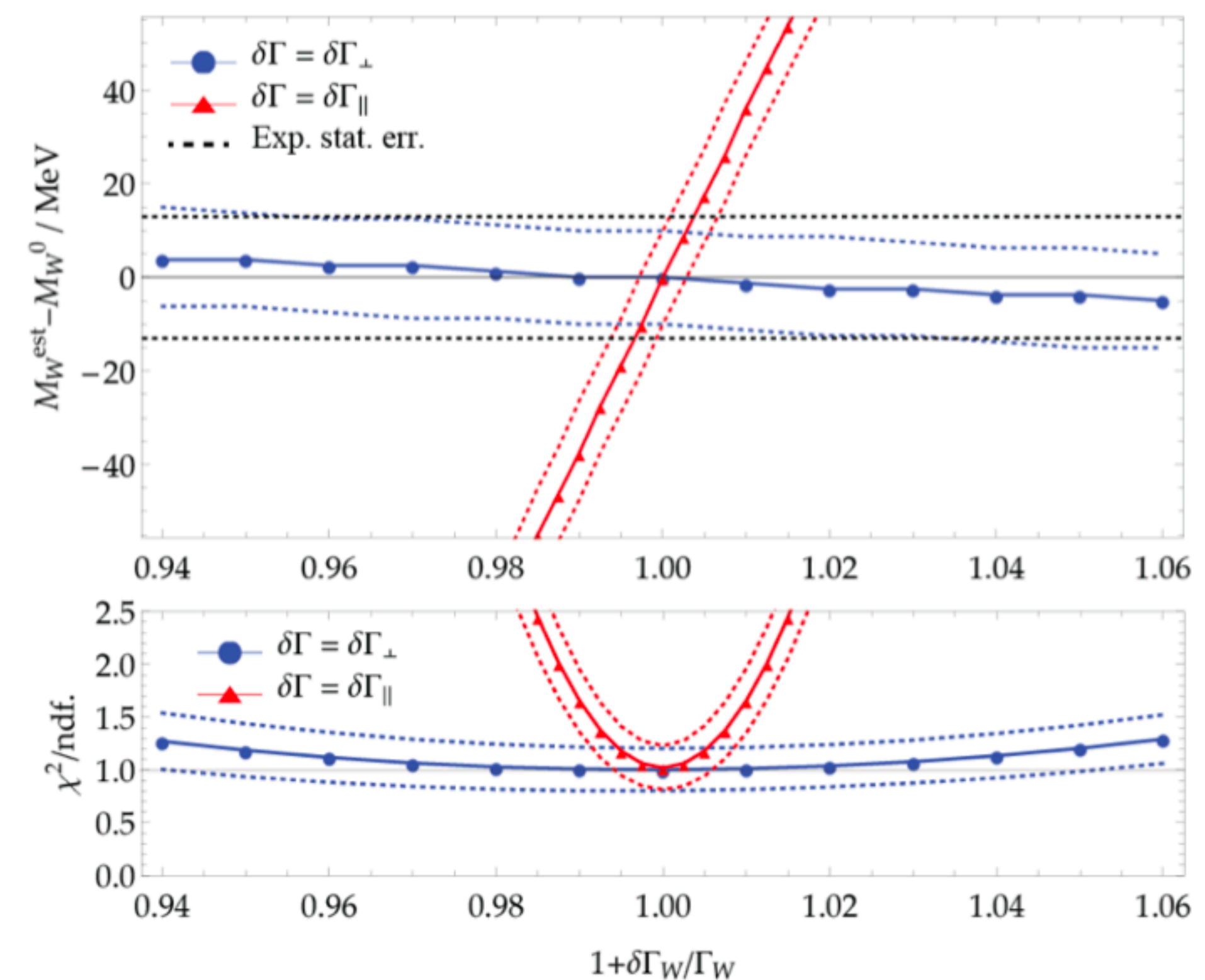
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W boson width shift:
$$\frac{\delta\Gamma_W}{\Gamma_W} = \frac{\hat{v}^2}{\Lambda^2} \left(\frac{8}{3} C_{Hl}^{(3)} + \frac{4}{3} C_{Hq}^{(3)} - C_{ll} \right) - \frac{3}{2} \frac{\delta m_W^2}{m_W^2}$$

[Bjorn & Trott; PLB 762 (2016) 426-431]

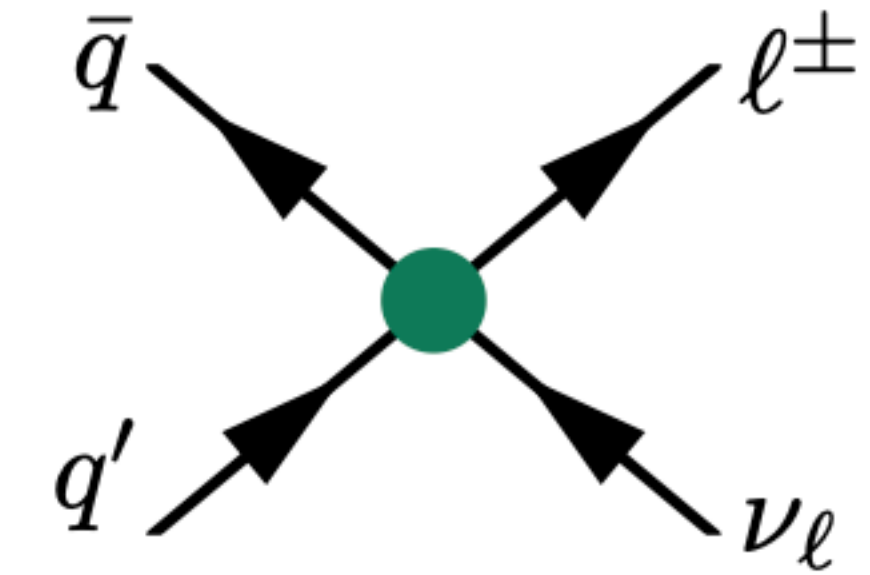
- Affects overall normalisation & shape of template m_T & p_T^l distributions
- Estimated bias dominated by normalisation, which is left to float in experimental analyses
- No significant bias expected from Γ_W



m_W interpretation in SMEFT

Other contact interactions?

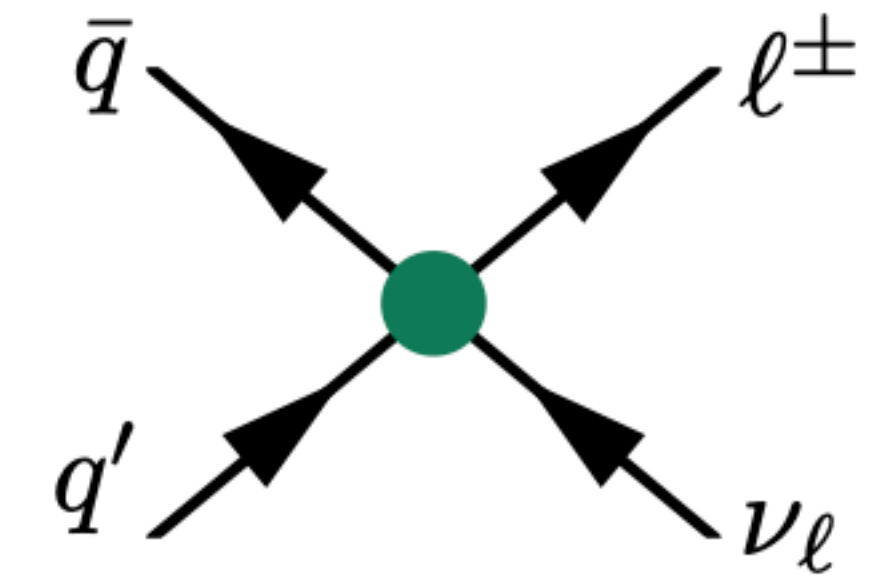
- Interference effects with charged-current 4F operators
- May be overwhelmed by narrow W peak...
- Constrained by charged current Drell Yan. Not studied so far...



m_W interpretation in SMEFT

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LEP II extraction: $\sigma(e^+e^- \rightarrow W^+W^-)$

As discussed in [Bjorn & Trott; PLB 762 (2016) 426-431]

- Various methods to extract m_W , assuming the SM for $\sigma(W^+W^-)$
- Other possible SMEFT effects not accounted for
- Triple gauge coupling modifications (\mathcal{O}_W), W - coupling shifts, dipoles?

Safest to do a simultaneous fit to m_W & C_i

Input scheme

m_W is a prediction when using, e.g., $\{\alpha_{EW}, G_F, m_Z\}$ as inputs

- We use: $\alpha_{EW}^{-1} = 127.95$, $G_F = 1.16638 \times 10^{-5} \text{ GeV}^{-2}$, $m_Z = 91.1876 \text{ GeV}$

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If m_W is part of the input set...

- Other data must be used to compensate
- e.g., $\{m_W, G_F, m_Z\}$ input scheme: use $a_{EW}(m_Z)$ instead

$$\left. \frac{\delta\alpha_{EW}}{\alpha_{EW}} \right|_{\{m_W, G_F, m_Z\}} \propto \left. \frac{\delta m_W^2}{m_W^2} \right|_{\{\alpha_{EW}, G_F, m_Z\}}$$

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α_{EW} prediction deviates from SM if CDF m_W is input

- α_{EW} uncertainty dominated by parametric m_W error
- Similar constraints expected in this case

Global context

Global new physics searches via high precision/energy

- **Z & W-pole data:** handle on the EW gauge sector [Han & Skiba; PRD 71 (2005) 075009]
[Falkowski & Riva; JHEP 02 (2015) 039]
- **LHC:** thriving Higgs & top programmes
- Probing gauge interactions at high energy (**VV, VBS, VVV, ...**)

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Cross-talk between EWPO, Diboson & Higgs data

- Significant correlations among operators \Rightarrow data
- Allows for a **closed fit** to flavor-universal SMEFT

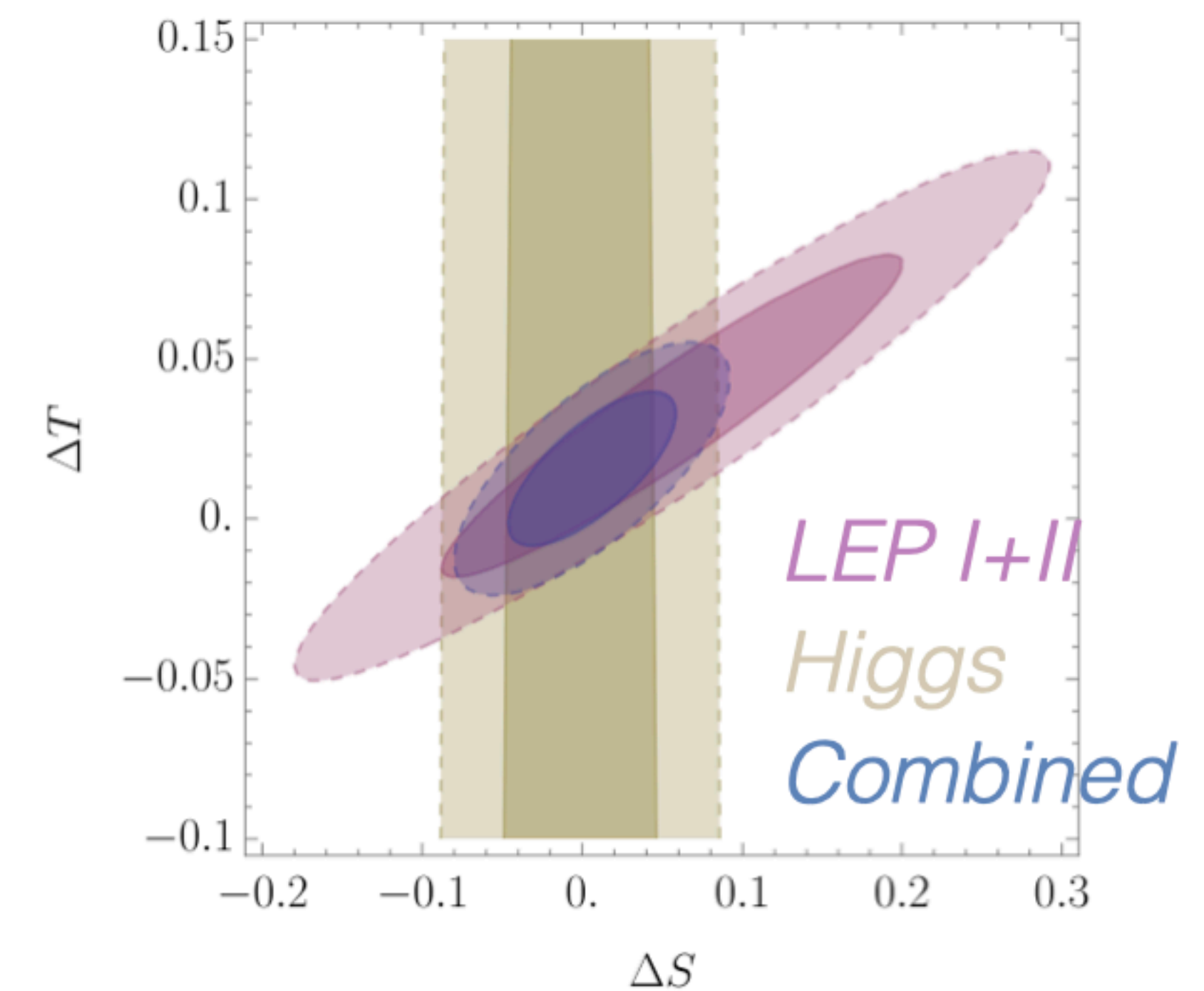
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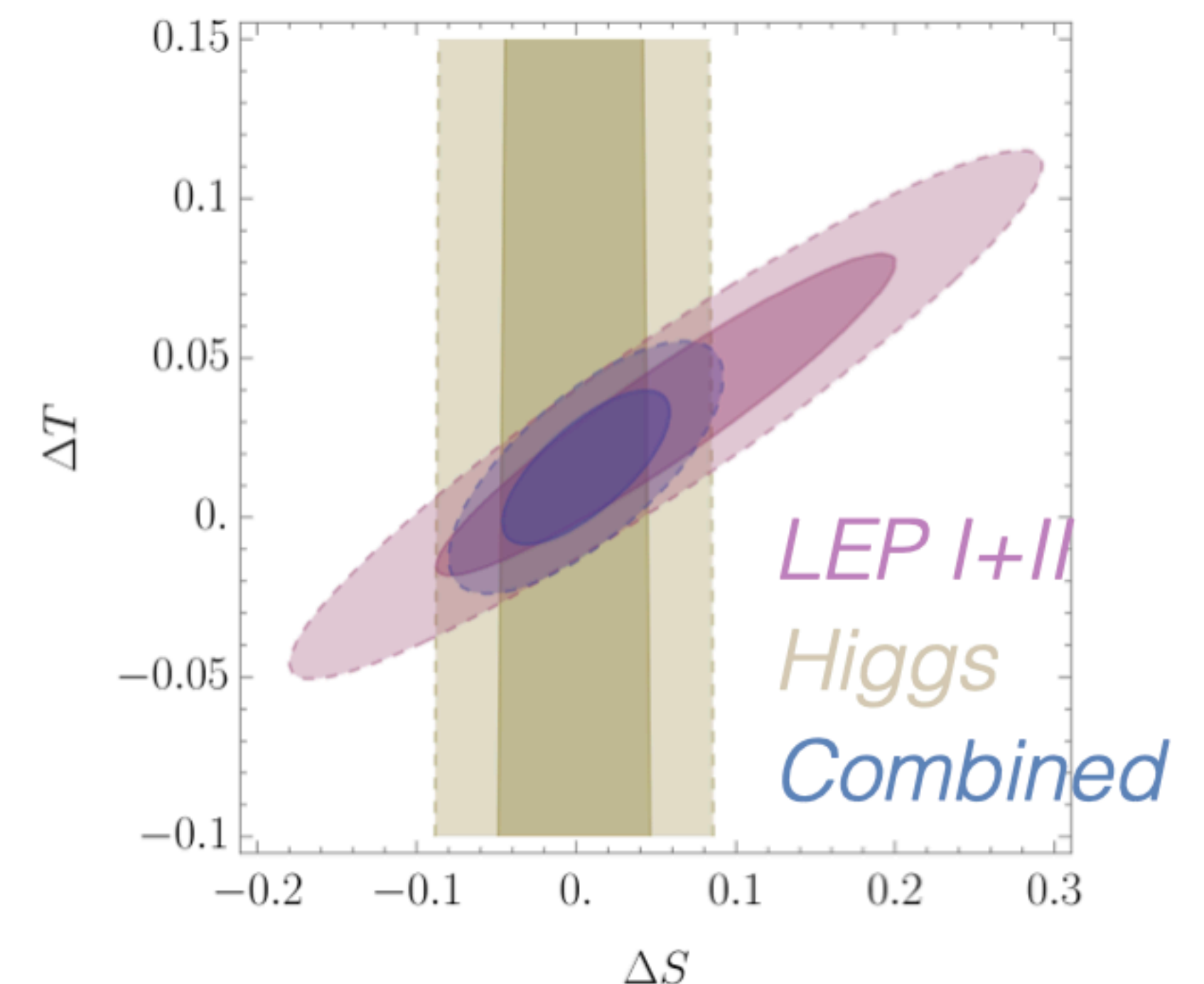
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Can the SMEFT accommodate the m_W measurements alongside other data?



[Ellis et al.; JHEP 06 (2018) 146]

The fit

fitmaker <https://gitlab.com/kenmimasu/fitrepo>
public-friendly version w/ example notebooks in progress

Top, Higgs, Diboson and Electroweak Fit to the Standard Model Effective Field Theory

John Ellis,^{a,b,c} Maeve Madigan,^d Ken Mimasu,^a Veronica Sanz^{e,f} and Tevong You^{b,d,g}

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Global SMEFT interpretation of 4 categories of data

Based on

- 14 • Electroweak Precision Observables (EWPO): Z-pole & W-mass [Ellis et al.; JHEP 06 (2018) 146]
- 118 • LEP2 & LHC diboson production: differential WW, WZ, Zjj
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204 measurements across categories

- Chosen to be statistically independent & maximise reach
- Correlations included when publicly available (mostly are)

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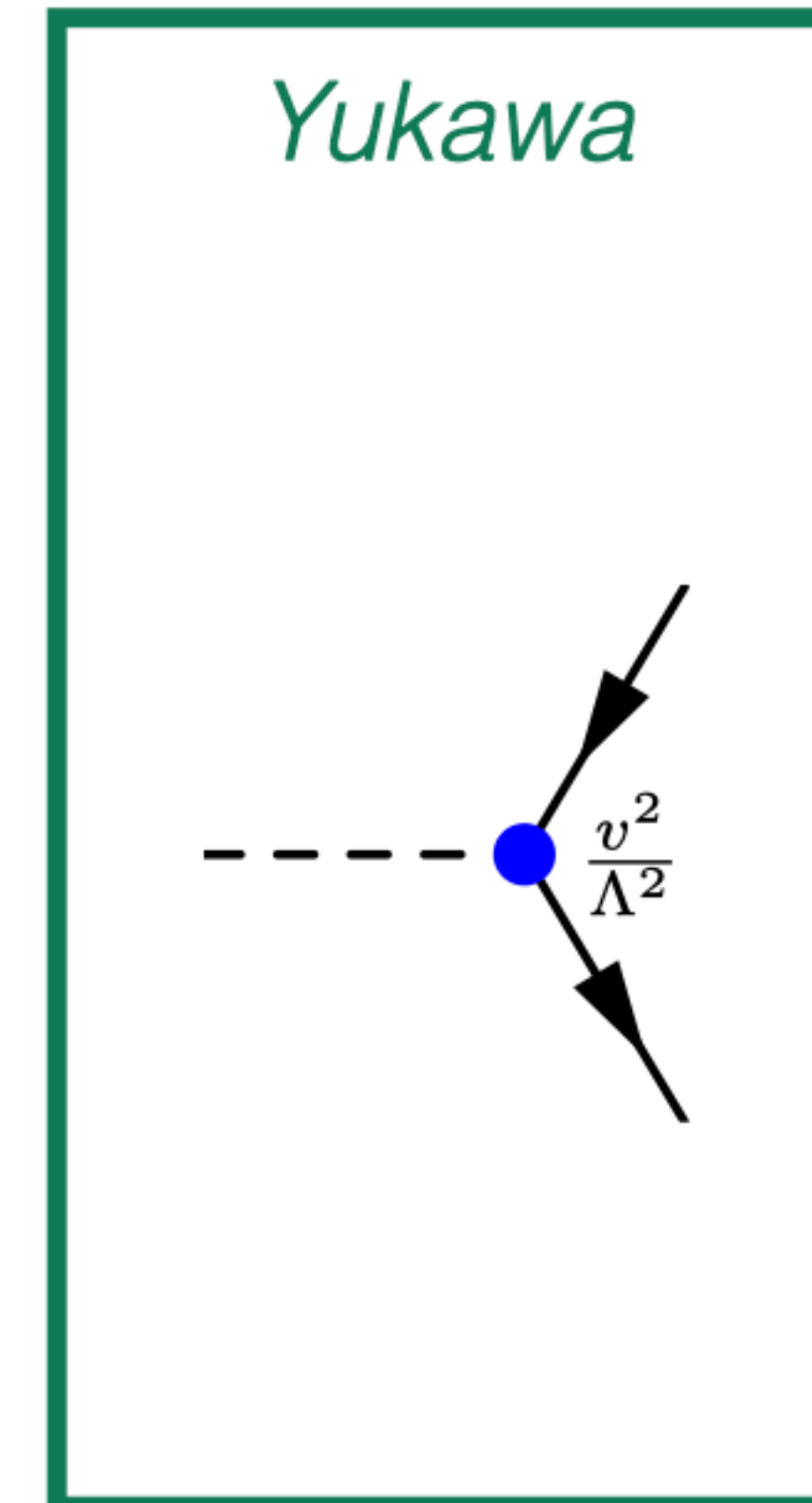
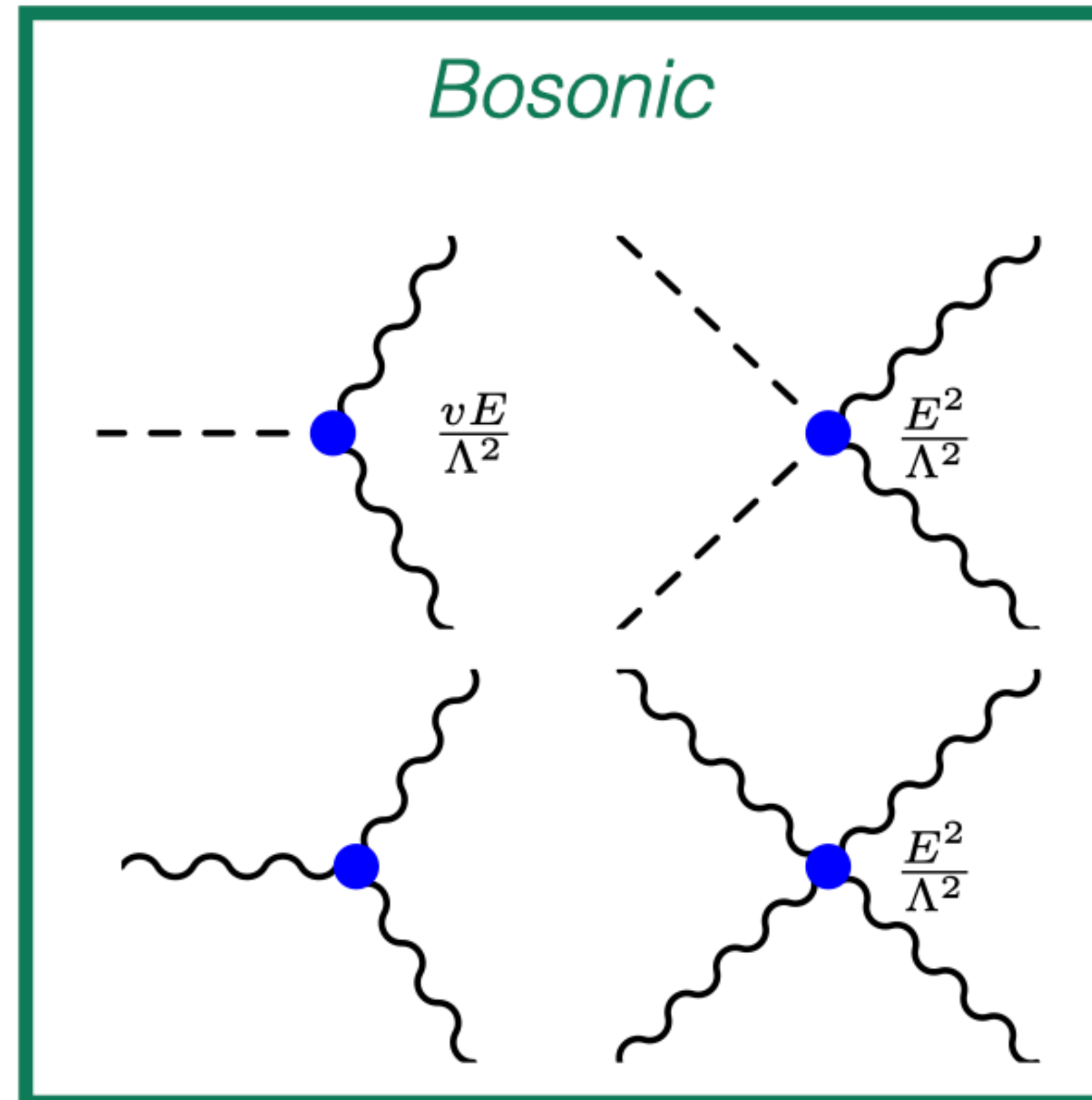
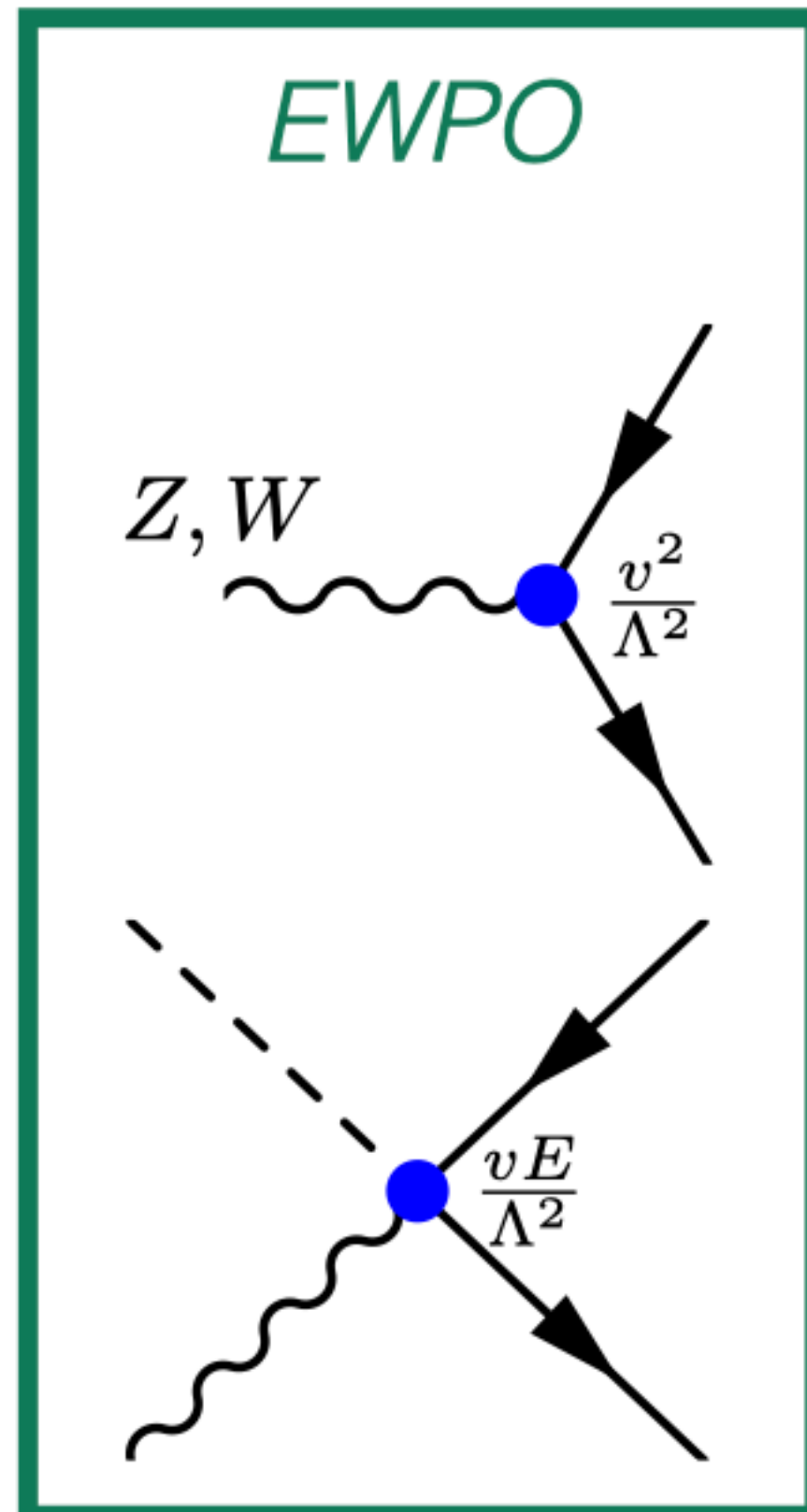
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Linear EFT approximation:
$$\mu_X \equiv \frac{X}{X_{SM}} = 1 + \sum_i a_i^X \frac{C_i}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$

Degrees of freedom

EWPO:	$\mathcal{O}_{HWB}, \mathcal{O}_{HD}, \mathcal{O}_U, \mathcal{O}_{Hl}^{(3)}, \mathcal{O}_{Hl}^{(1)}, \mathcal{O}_{He}, \mathcal{O}_{Hq}^{(3)}, \mathcal{O}_{Hq}^{(1)}, \mathcal{O}_{Hd}, \mathcal{O}_{Hu}$
Bosonic:	$\mathcal{O}_{H\Box}, \mathcal{O}_{HG}, \mathcal{O}_{HW}, \mathcal{O}_{HB}, \mathcal{O}_W, \mathcal{O}_G$
Yukawa:	$\mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}, \mathcal{O}_{bH}, \mathcal{O}_{tH}$
	20

Universal $U(3)^5$ flavor scenario + Yukawa



S & T parameter fit

$$\frac{v^2}{\Lambda^2} C_{HWB} = \frac{gg'}{16\pi} S$$

$$\frac{v^2}{\Lambda^2} C_{HD} = -\frac{g^2 g'^2}{2\pi(g^2 + g'^2)} T$$

No m_W data

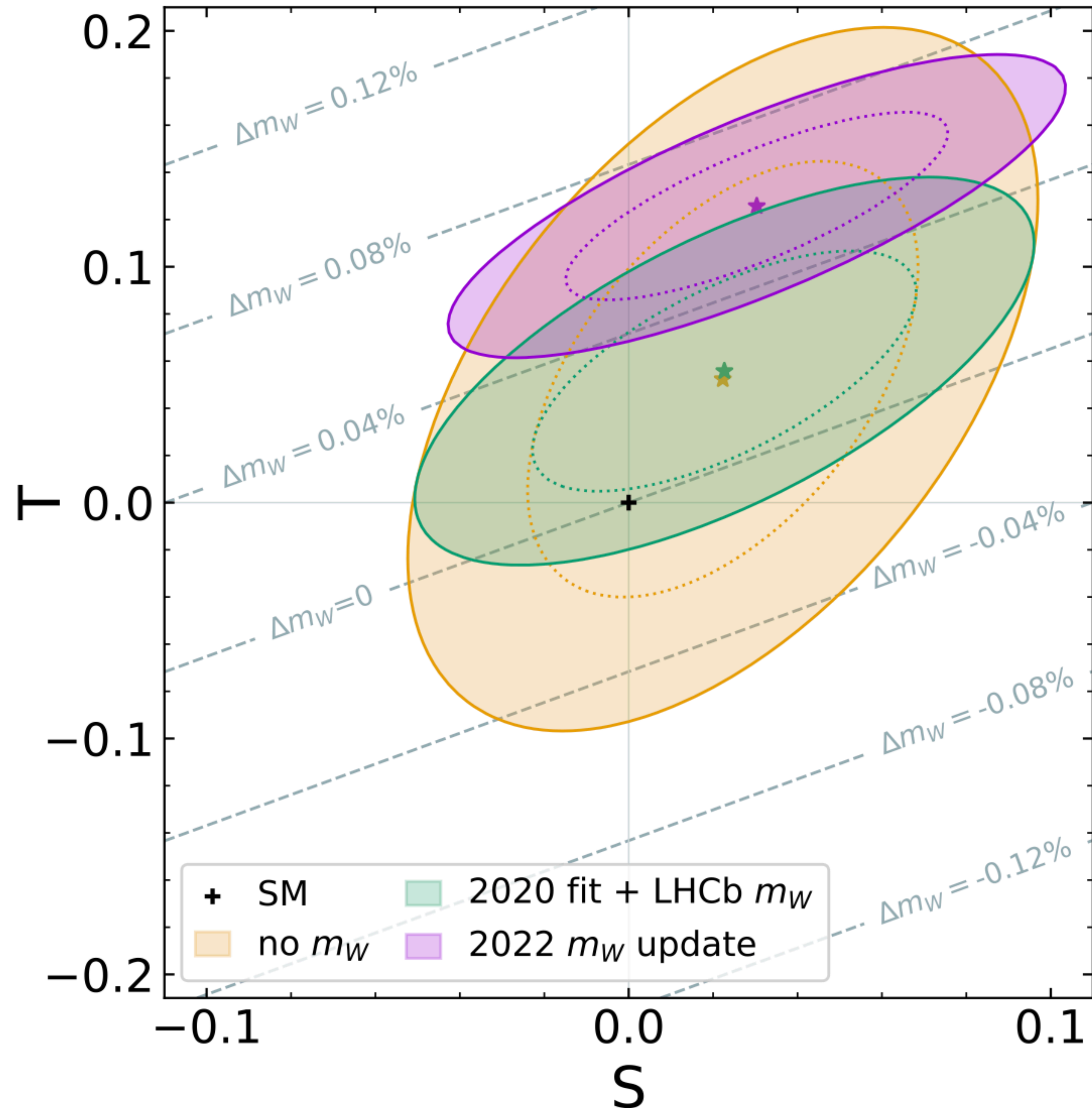
SM compatible $< 1\sigma$

Without CDF m_W

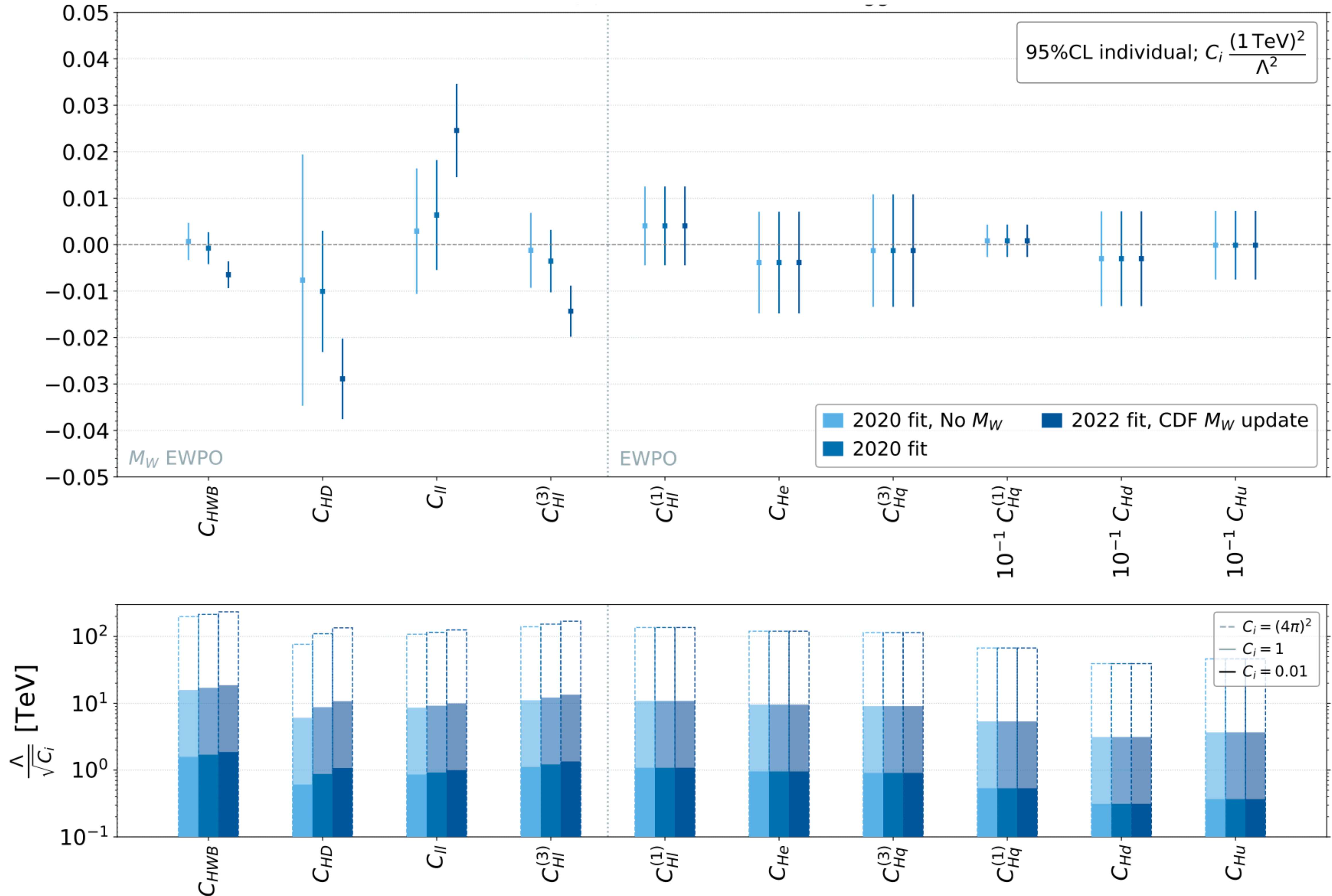
SM compatible $< 2\sigma$

With CDF m_W

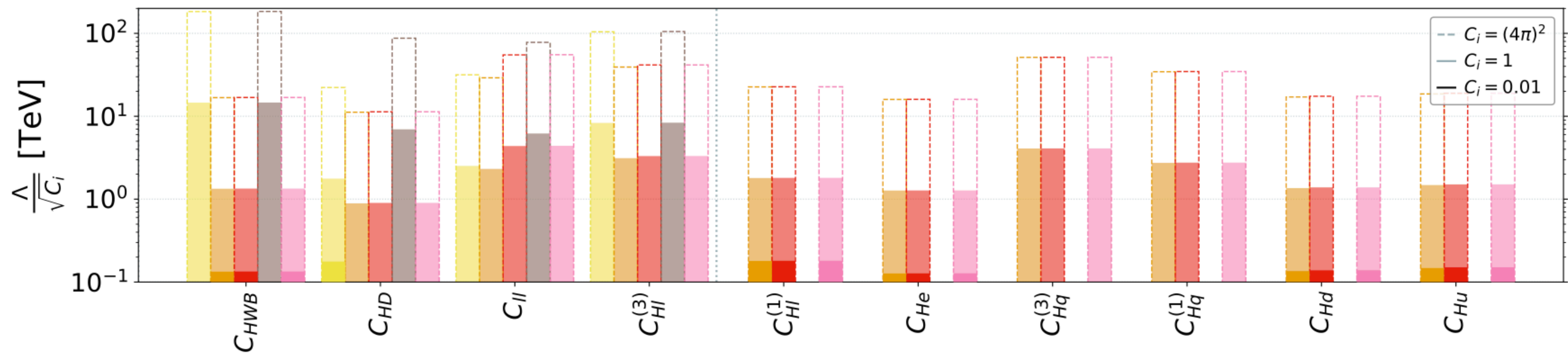
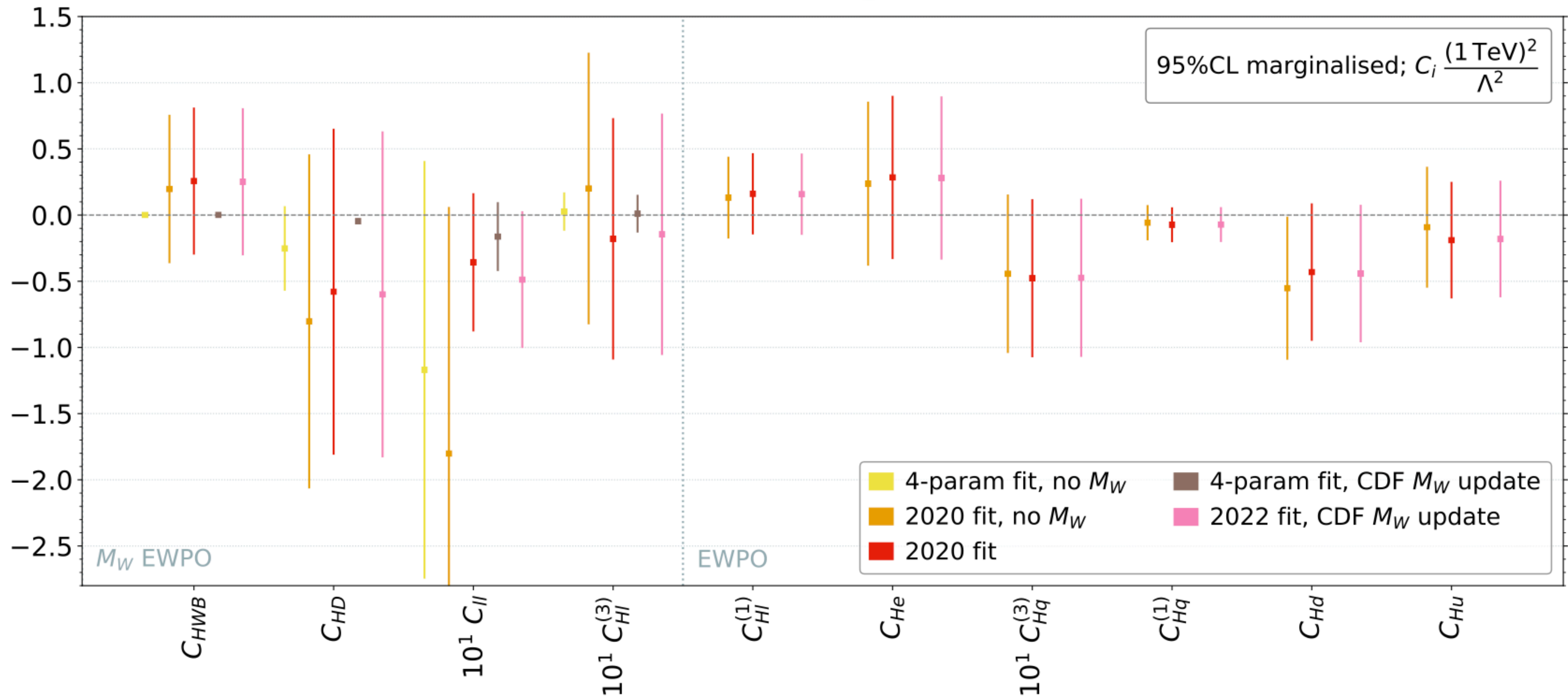
SM incompatible $\gg 3\sigma$



SMEFT fit (individual)

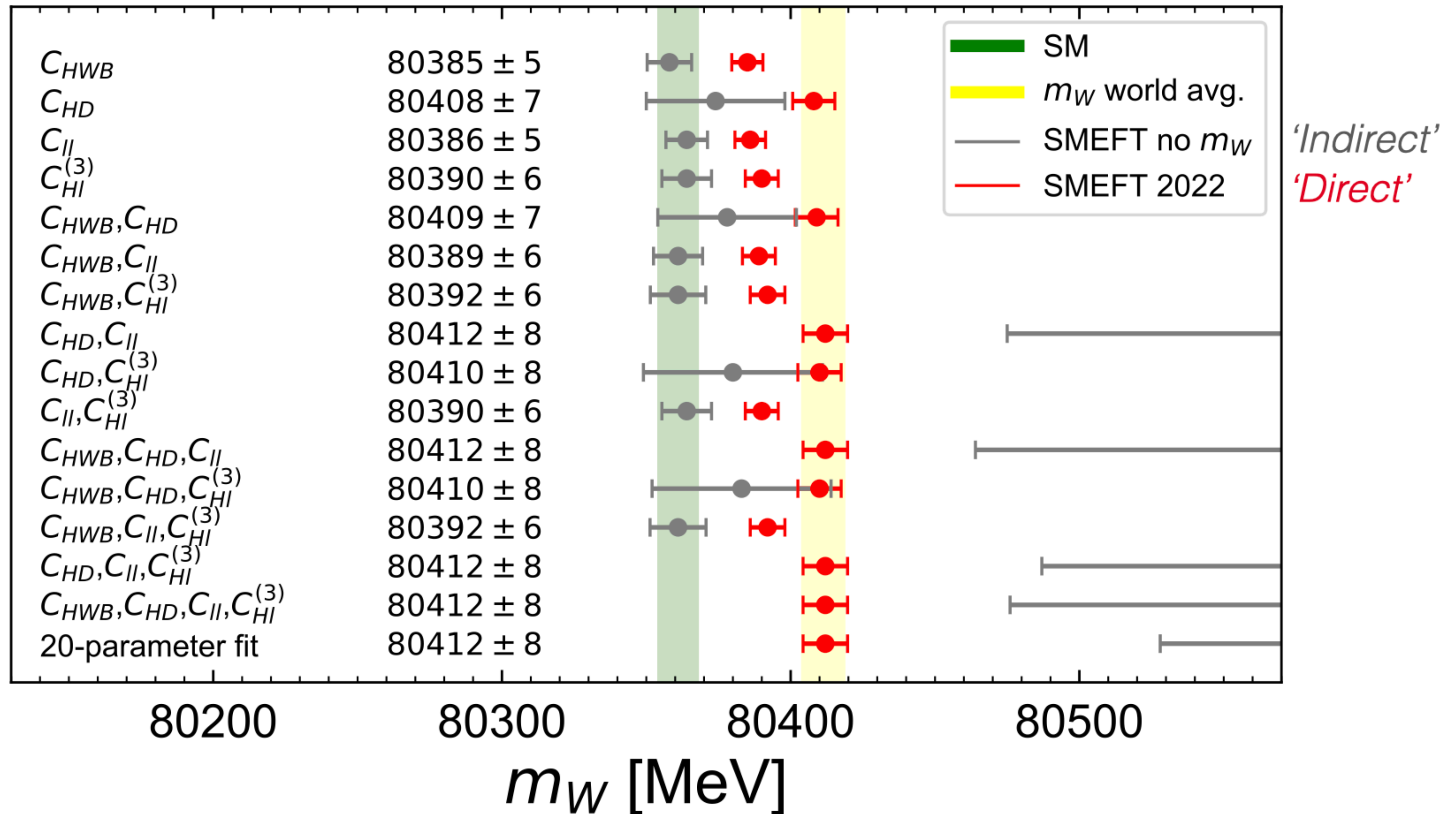


SMEFT fit (marginalised)



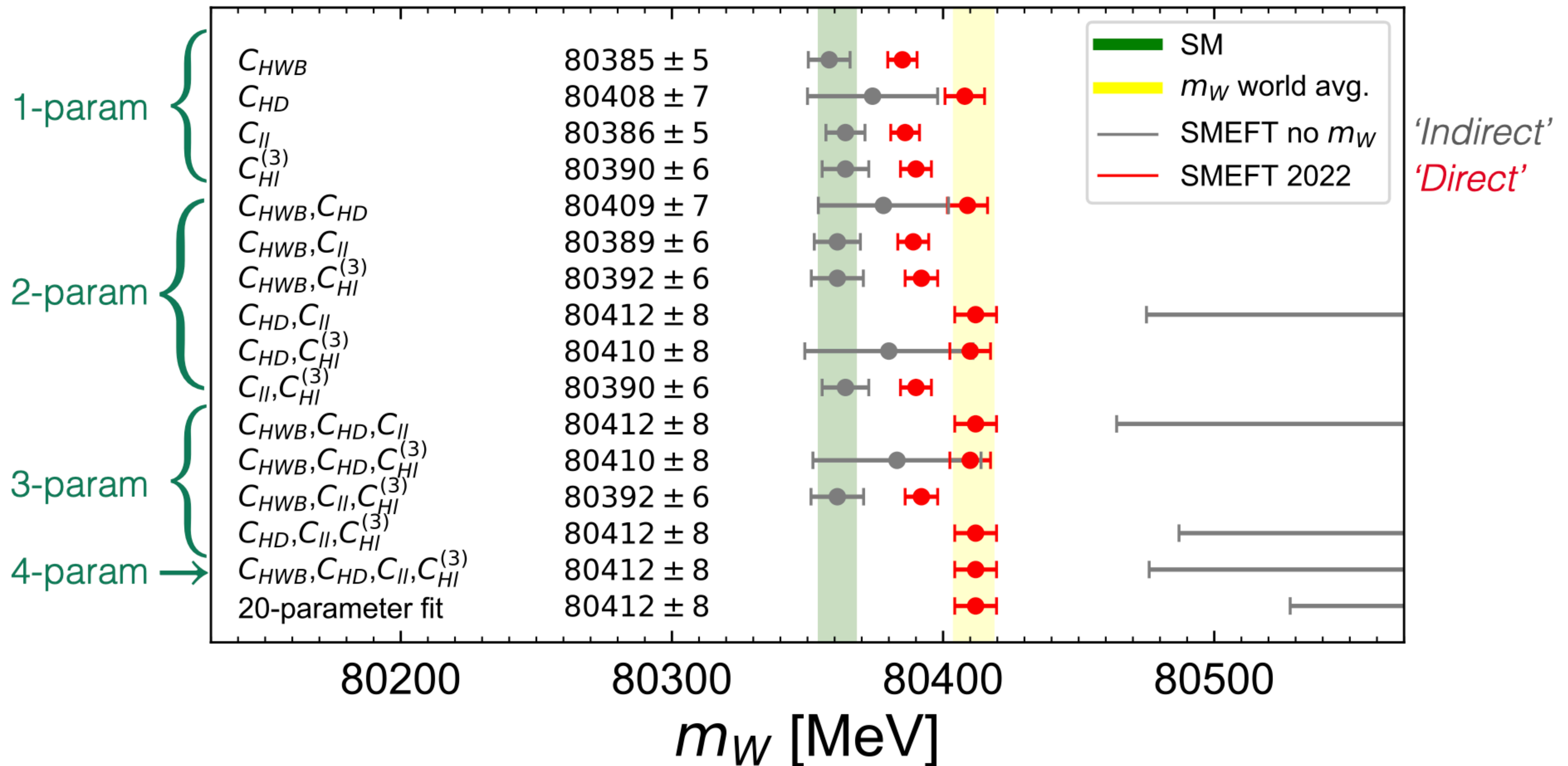
Direct vs indirect m_W

Focus on 4-parameter subspace: all possible combinations



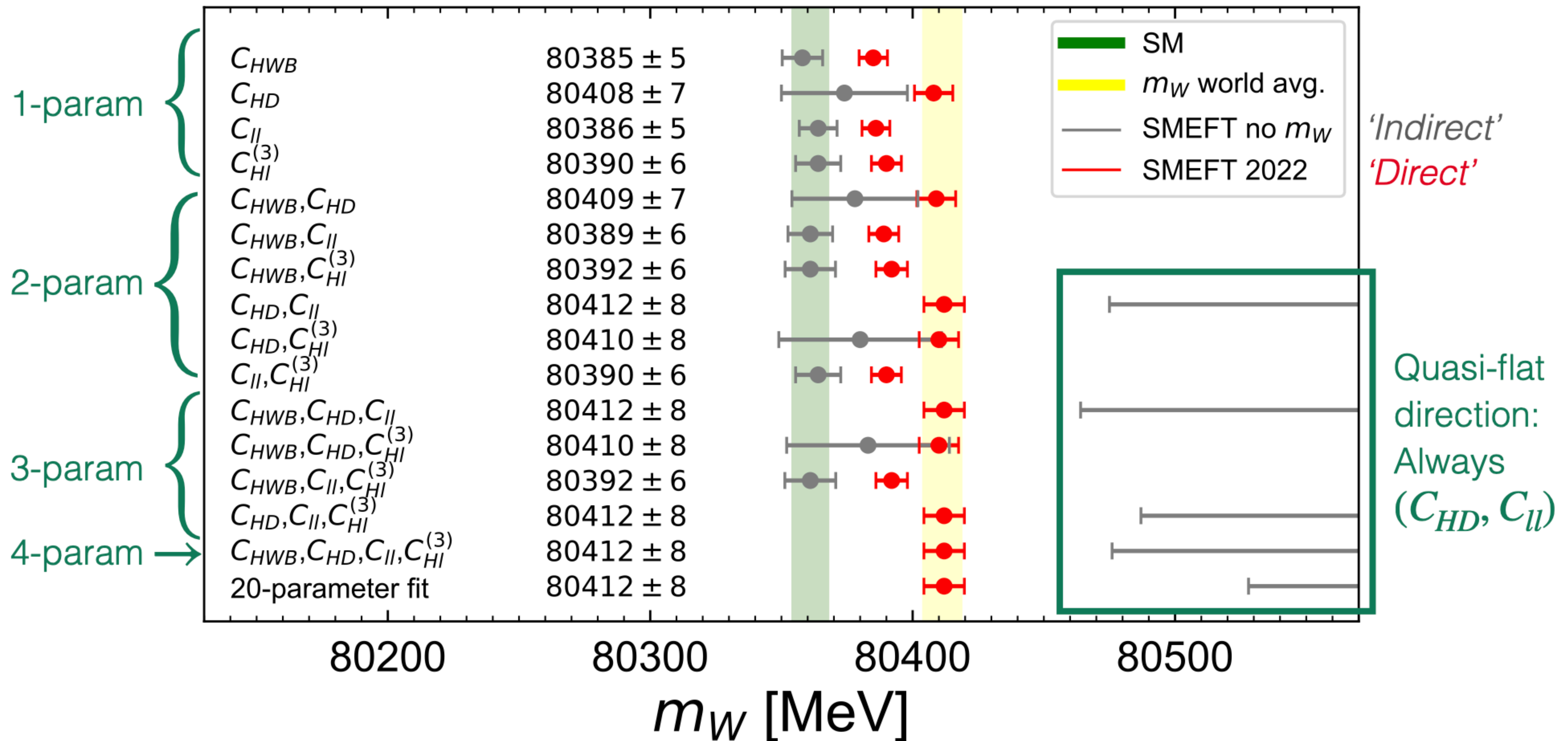
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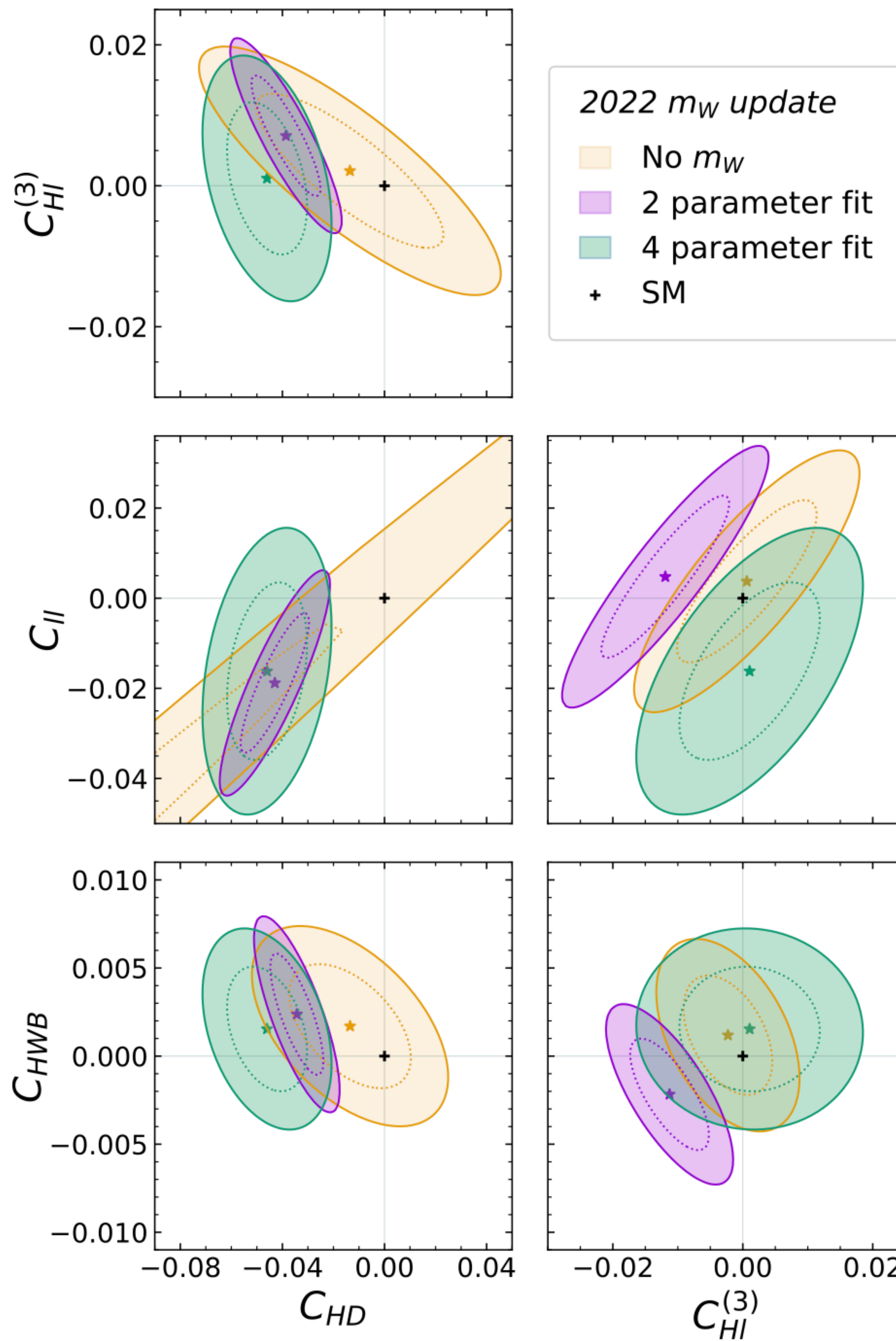
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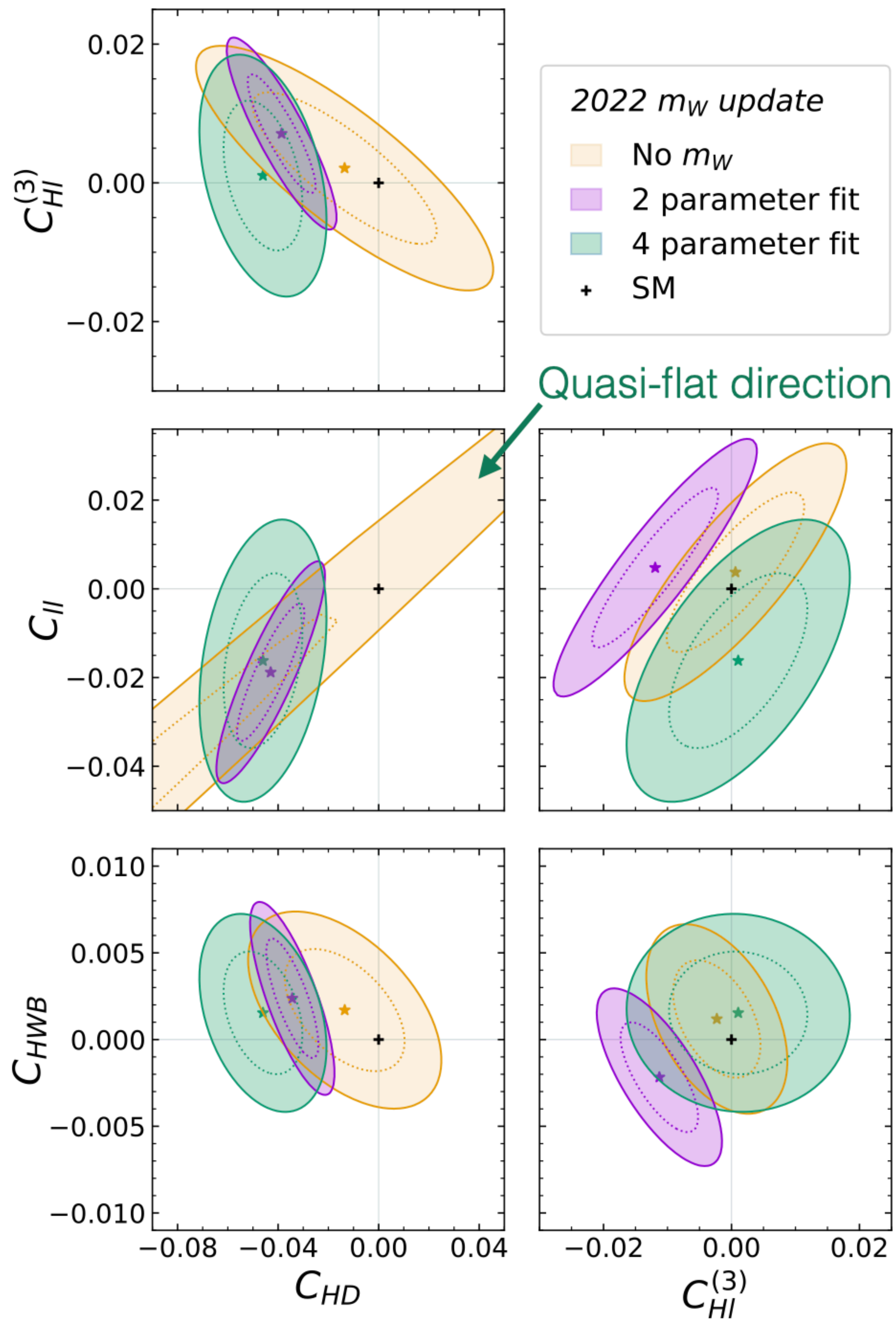
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$$\left(C_{HWB}, C_{HD}, C_{HI}^{(3)}, C_{II} \right)$$



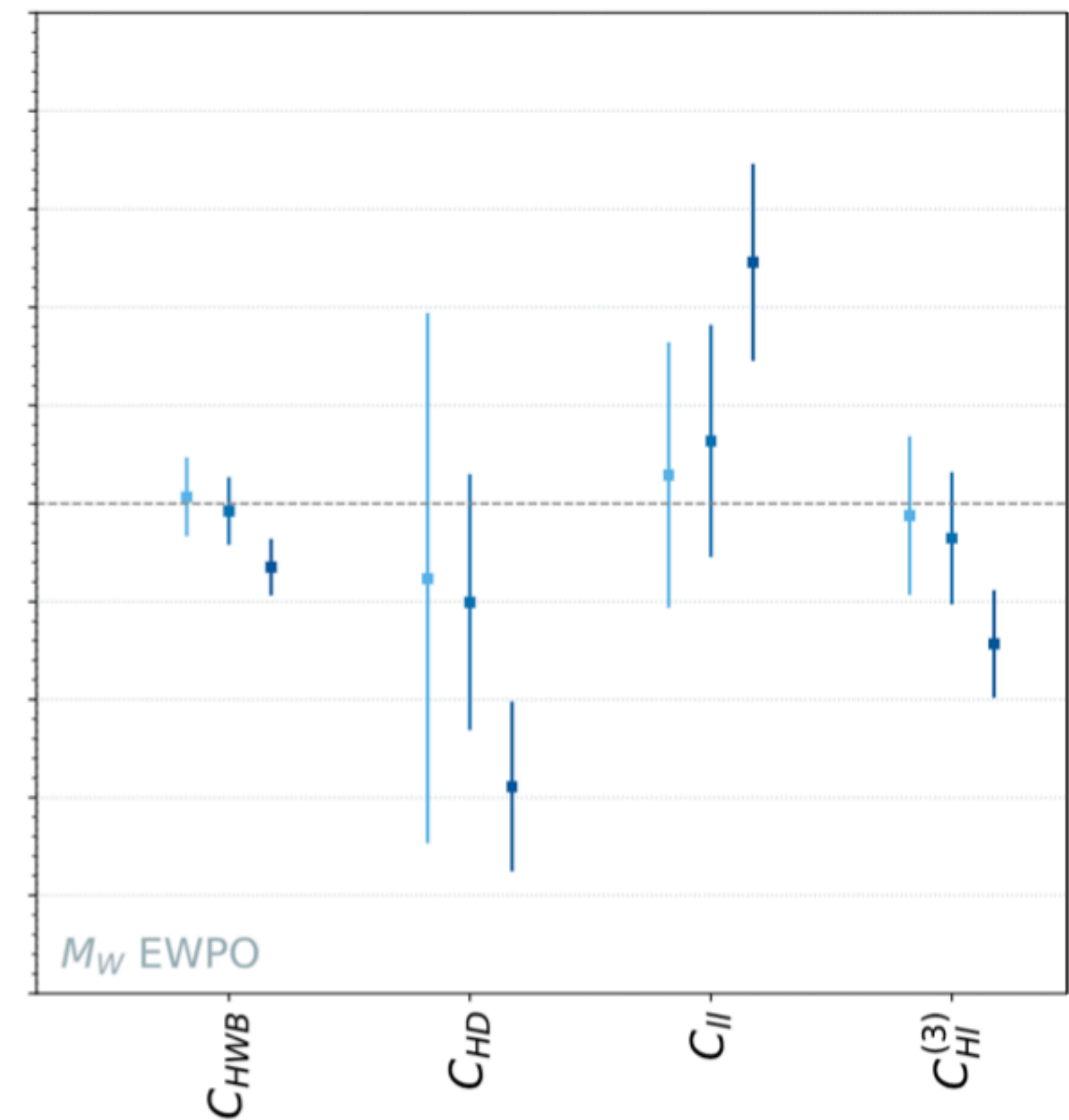
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Single-field SM extensions

What SM extensions can account for the anomaly at tree-level?

Fit preference:

- Negative C_{HWB} , C_{HD} , $C_{HI}^{(3)}$ & positive C_{ll}



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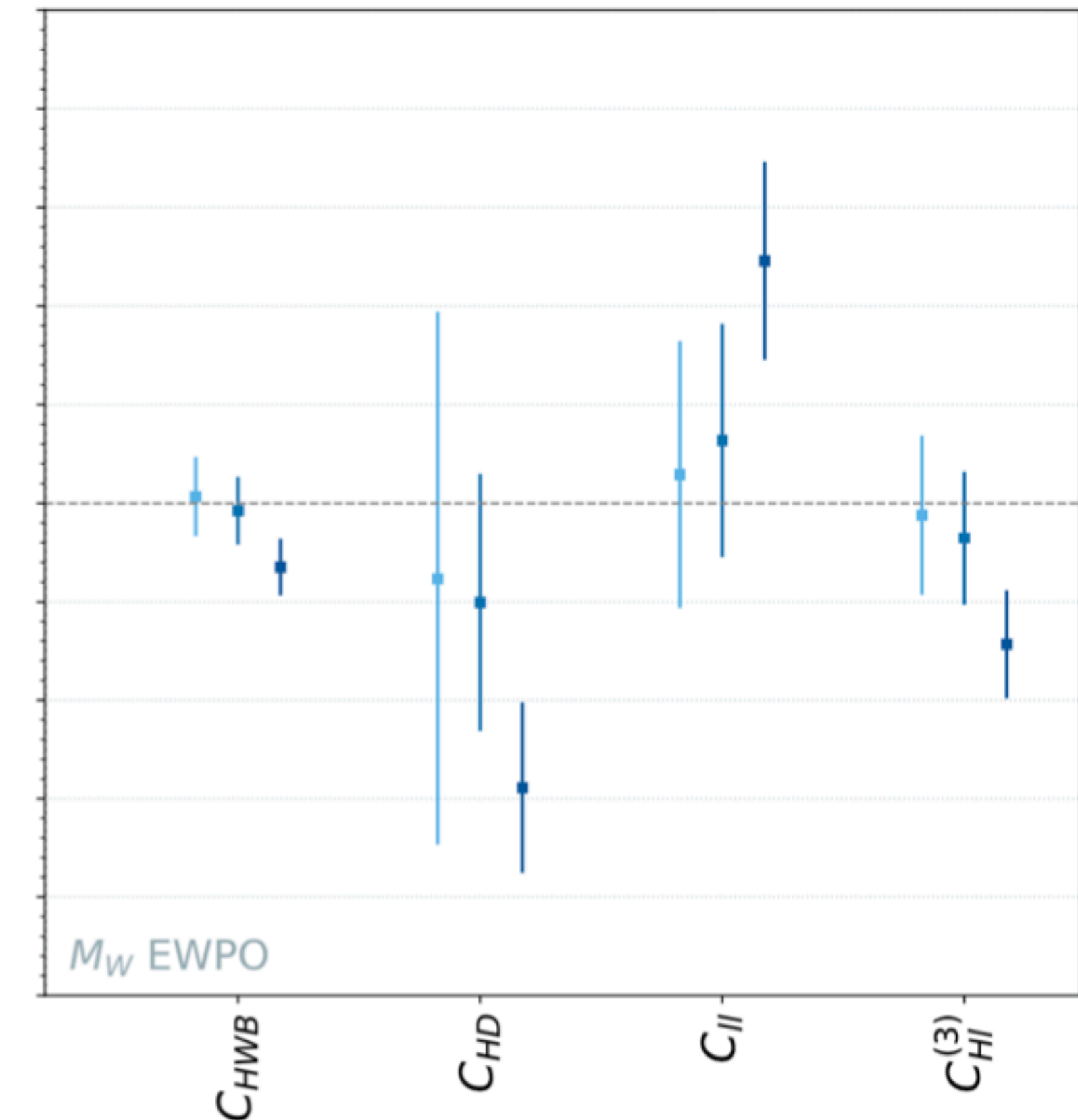
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Considered single field extensions

[de Blas et al.; JHEP 03 (2018) 109]

- Complete tree-level matching dictionary is known
- Interpret in terms of simplified 1 parameter versions of the models



Model	Spin	SU(3)	SU(2)	U(1)	Parameters
S_1	0	1	1	1	(M_S, κ_S)
Σ	$\frac{1}{2}$	1	3	0	$(M_\Sigma, \lambda_\Sigma)$
Σ_1	$\frac{1}{2}$	1	3	-1	$(M_{\Sigma_1}, \lambda_{\Sigma_1})$
N	$\frac{1}{2}$	1	1	0	(M_N, λ_N)
E	$\frac{1}{2}$	1	1	-1	(M_E, λ_E)

Model	Spin	SU(3)	SU(2)	U(1)	Parameters
B	1	1	1	0	(M_B, \hat{g}_H^B)
B_1	1	1	1	1	(M_{B_1}, λ_{B_1})
Ξ	0	1	3	0	(M_Ξ, κ_Ξ)
W_1	1	1	3	1	$(M_{W_1}, \hat{g}_{W_1}^\varphi)$
W	1	1	3	0	(M_W, \hat{g}_W^H)

Dimension-6 matching

$$\delta m_W$$

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		-1							
Σ			$\frac{1}{16}$	$\frac{3}{16}$			$\frac{y_\tau}{4}$		
Σ_1			$\frac{1}{16}$	$-\frac{3}{16}$			$\frac{y_\tau}{8}$		
N			$-\frac{1}{4}$	$\frac{1}{4}$					
E			$-\frac{1}{4}$	$-\frac{1}{4}$			$\frac{y_\tau}{2}$		
B_1	1					$-\frac{1}{2}$	$-\frac{y_\tau}{2}$	$-\frac{y_t}{2}$	$-\frac{y_b}{2}$
B	-2						$-y_\tau$	$-y_t$	$-y_b$
Ξ	$-2 \left(\frac{1}{M_\Xi}\right)^2$					$\frac{1}{2} \left(\frac{1}{M_\Xi}\right)^2$	$y_\tau \left(\frac{1}{M_\Xi}\right)^2$	$y_t \left(\frac{1}{M_\Xi}\right)^2$	$y_b \left(\frac{1}{M_\Xi}\right)^2$
W_1	$-\frac{1}{4}$					$-\frac{1}{8}$	$-\frac{y_\tau}{8}$	$-\frac{y_t}{8}$	$-\frac{y_b}{8}$
W	$\frac{1}{2}$					$-\frac{1}{2}$	$-y_\tau$	$-y_t$	$-y_b$

VLL

Z'

Spin-0,1
Triplets

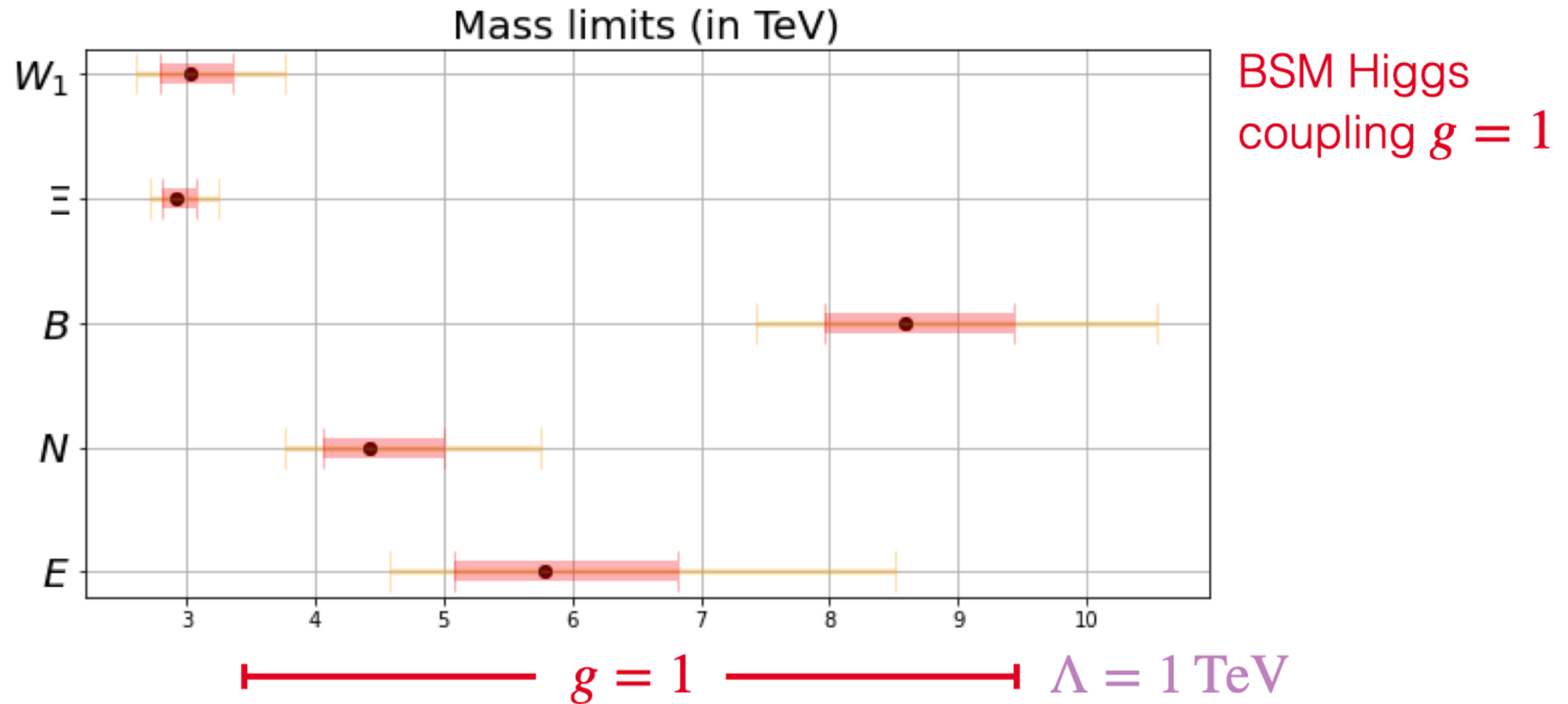
C_{HWB} is loop-generated by weakly coupled models 

[Arzt, Einhorn & Wudka; Nucl.Phys.B 433 (1995) 41-66]

All models can generate one of the required coefficients

*Only 5 predict them with the right sign

Masses and couplings



Model	Pull	Best-fit mass (TeV)	1- σ mass range (TeV)	2- σ mass range (TeV)	1- σ coupling ² range
W_1	6.4	3.0	[2.8, 3.6]	[2.6, 3.8]	[0.09, 0.13]
B	6.4	8.6	[8.0, 9.4]	[7.4, 10.6]	[0.011, 0.016]
Ξ	6.4	2.9	[2.8, 3.1]	[2.7, 3.2]	[0.011, 0.016]
N	5.1	4.4	[4.1, 5.0]	[3.8, 5.8]	[0.040, 0.060]
E	3.5	5.8	[5.1, 6.8]	[4.6, 8.5]	[0.022, 0.039]

CKM unitarity

β -decay + CKM unitarity imposes significant constraint on one combination of coefficients in $U(3)^5$

- Semi-leptonic analogue of muon decay:

$$\Delta_{CKM} \equiv |V_{ud}|^2 + |V_{us}|^2 - 1 = \frac{2\hat{v}^2}{\Lambda^2} \left(C_{Hq}^{(3)} - C_{Hl}^{(3)} + C_{ll} - C_{lq}^{(3)} \right)$$


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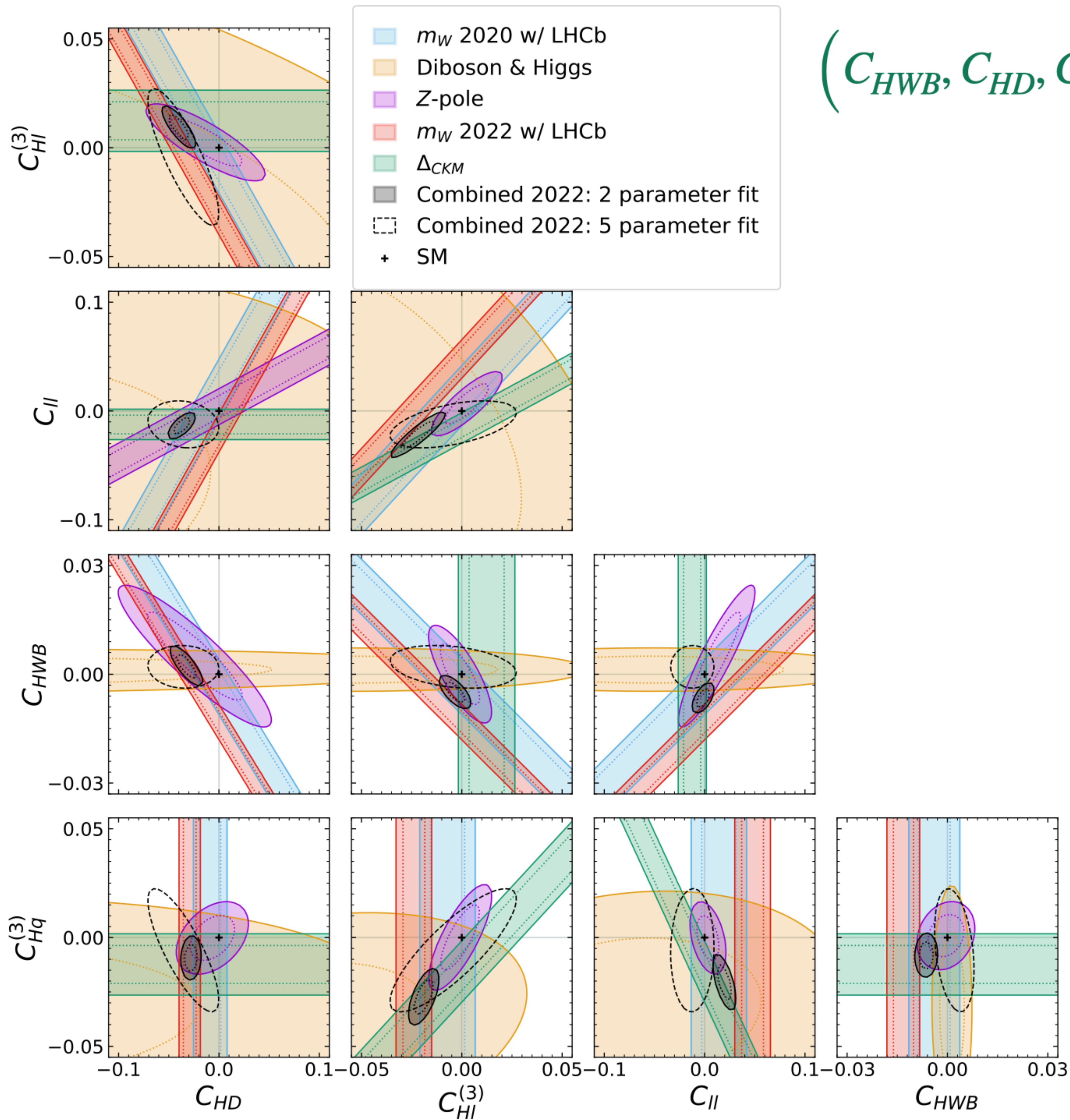
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$$\Delta_{CKM} = -0.0015 \pm 0.0007$$

Δ_{CKM} probes a direction that is correlated with δm_W^2

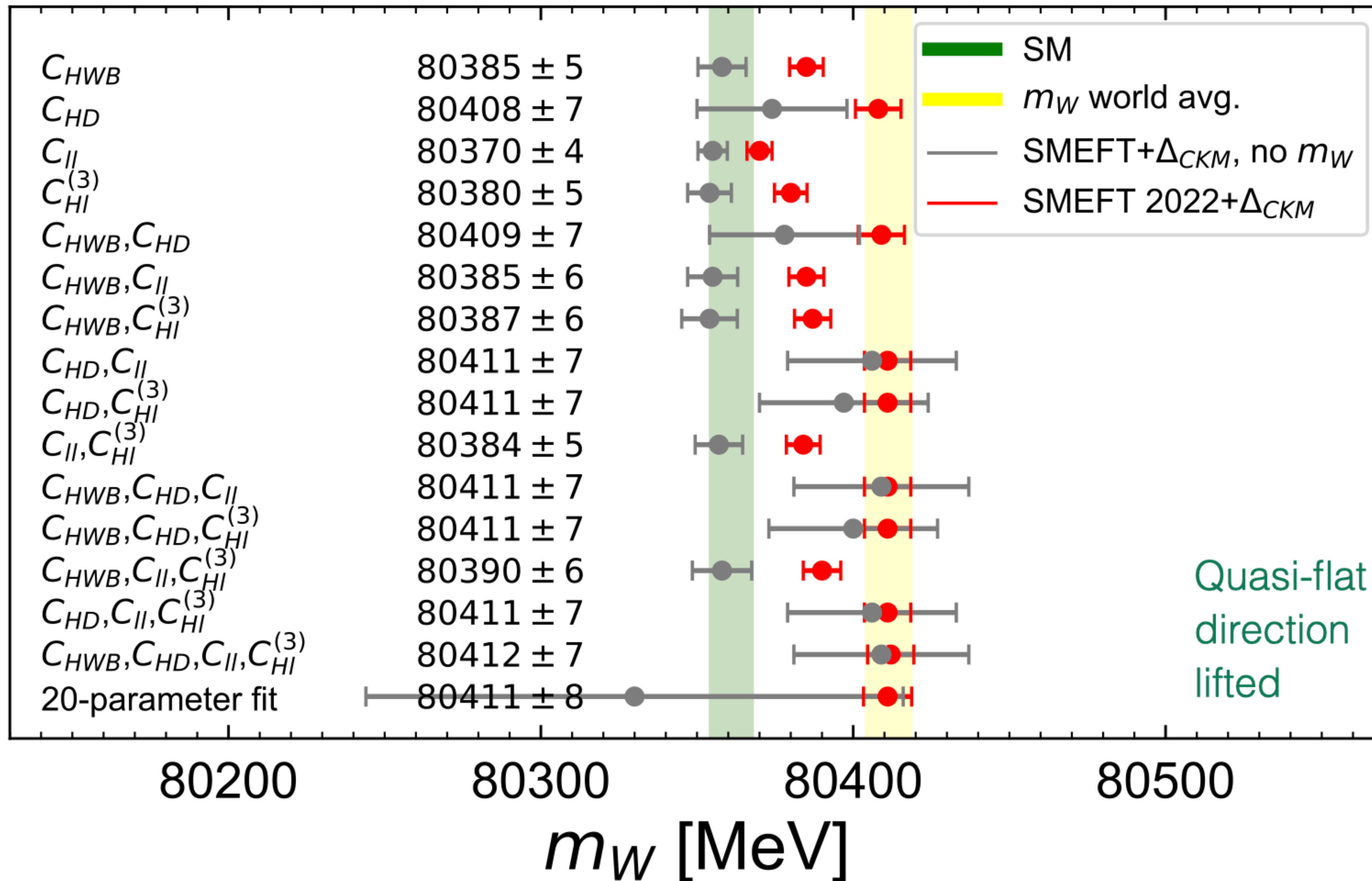
- Per-mille level constraint should compete with $m_W \Rightarrow$ new information
- Also sensitive to irrelevant parameters for m_W , bring correlations with, e.g., Drell Yan & other EWPO, Diboson rates...



$$\left(C_{HWB}, C_{HD}, C_{HI}^{(3)}, C_{II}, C_{Hq}^{(3)} \right)$$

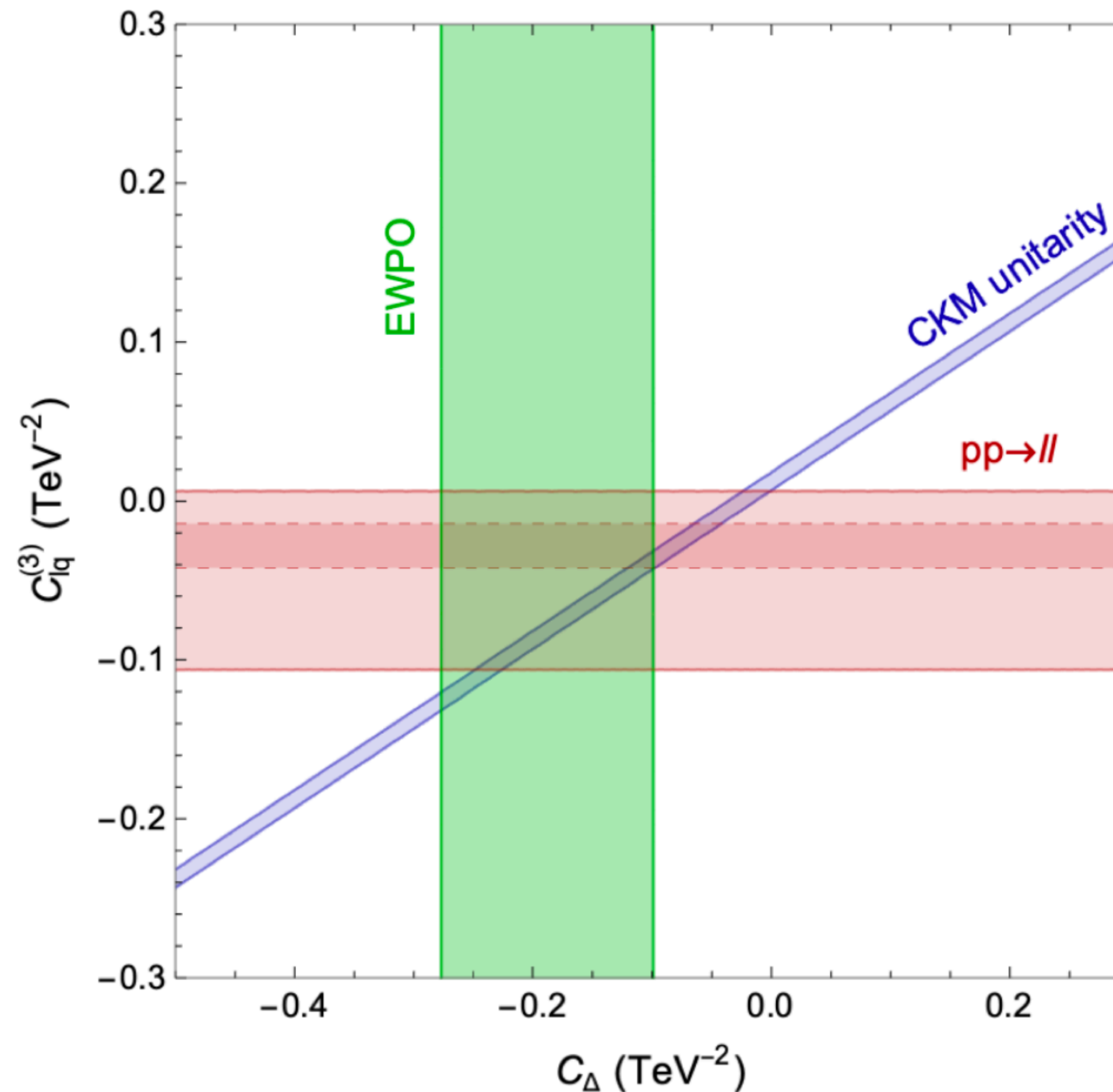
$$C_{ql}^{(3)} = 0$$

m_W after CKM unitarity



CKM unitarity & DY

[Cirigliano, Dekens, de Vries, Mereghetti & Tong; 2204.08440]



Beyond Dimension-6

Are dimension-8 effects important?

Precision?

EFT validity?

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Precision?

EFT validity?

- Explicit study of $Y=0$ triplet scalar, Ξ

$$\mathcal{L}_{\Xi} = \frac{1}{2}(D_{\mu}\Xi^a)(D^{\mu}\Xi^a) - \frac{1}{2}M_{\Xi}^2(\Xi^a\Xi^a) - \kappa_{\Xi}H^{\dagger}\Xi^a\sigma^a H - \lambda_{\Xi}(\Xi^a\Xi^a)(H^{\dagger}H) - \frac{1}{4}\eta_{\Xi}(\Xi^a\Xi^a)^2$$

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Dim-6: $\mathcal{O}_{HD} \equiv (H^\dagger D^\mu H)^\star (H^\dagger D_\mu H)$ **Dim-8:** $\mathcal{O}_{H^6}^{(2)} \equiv (H^\dagger H)(H^\dagger \sigma^I H)(D_\mu H^\dagger \sigma^I D^\mu H)$

$$\left. \frac{\delta m_W^2}{m_W^2} \right|_{D=6} = -\frac{\hat{c}_W}{\hat{c}_{2W}} \frac{C_{HD}}{2} \qquad \left. \frac{\delta m_W^2}{m_W^2} \right|_{D=8} = \frac{\hat{c}_W}{2\hat{c}_{2W}} \left(\frac{\hat{c}_W^2(\hat{c}_{2W} - \hat{s}_W^2)}{\hat{c}_{2W}^2} \frac{C_{HD}^2}{2} - C_{H^6}^{(2)} \right)$$

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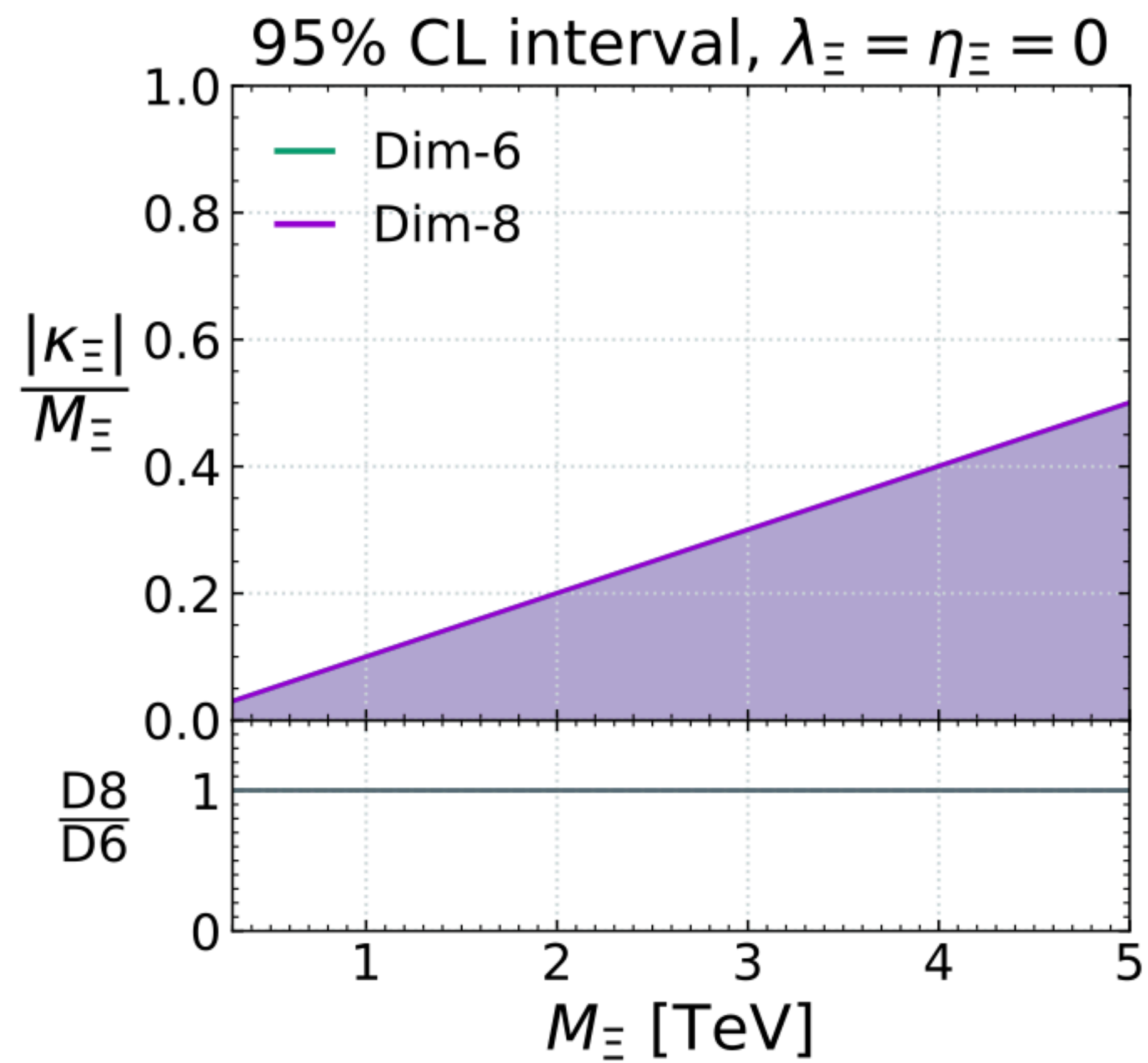
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Dim-6: $C_{HD} = -2 \frac{\kappa_\Xi^2}{M_\Xi^2}$ **Dim-8:** $C_{HD} = -2 \frac{\kappa_\Xi^2}{M_\Xi^2} \left(1 - \frac{4\mu^2}{M_\Xi^2} \right)$ $C_{H^6}^{(2)} = 4 \frac{\kappa_\Xi^2}{M_\Xi^2} \left(\lambda_\Xi - 2\lambda + \frac{\kappa_\Xi^2}{M_\Xi^2} \right)$

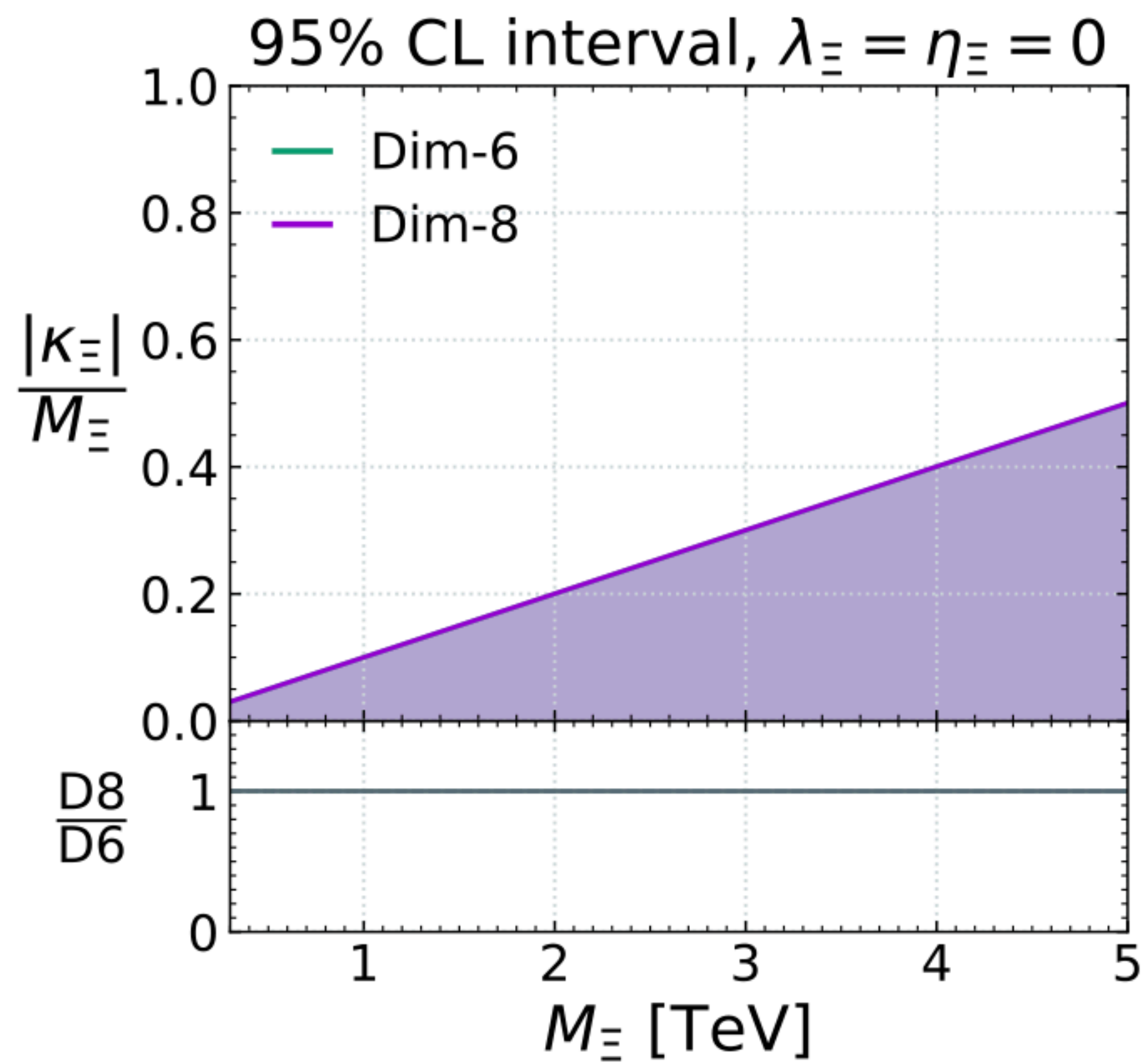
Pre-CDF

Single parameter: κ_{Ξ}

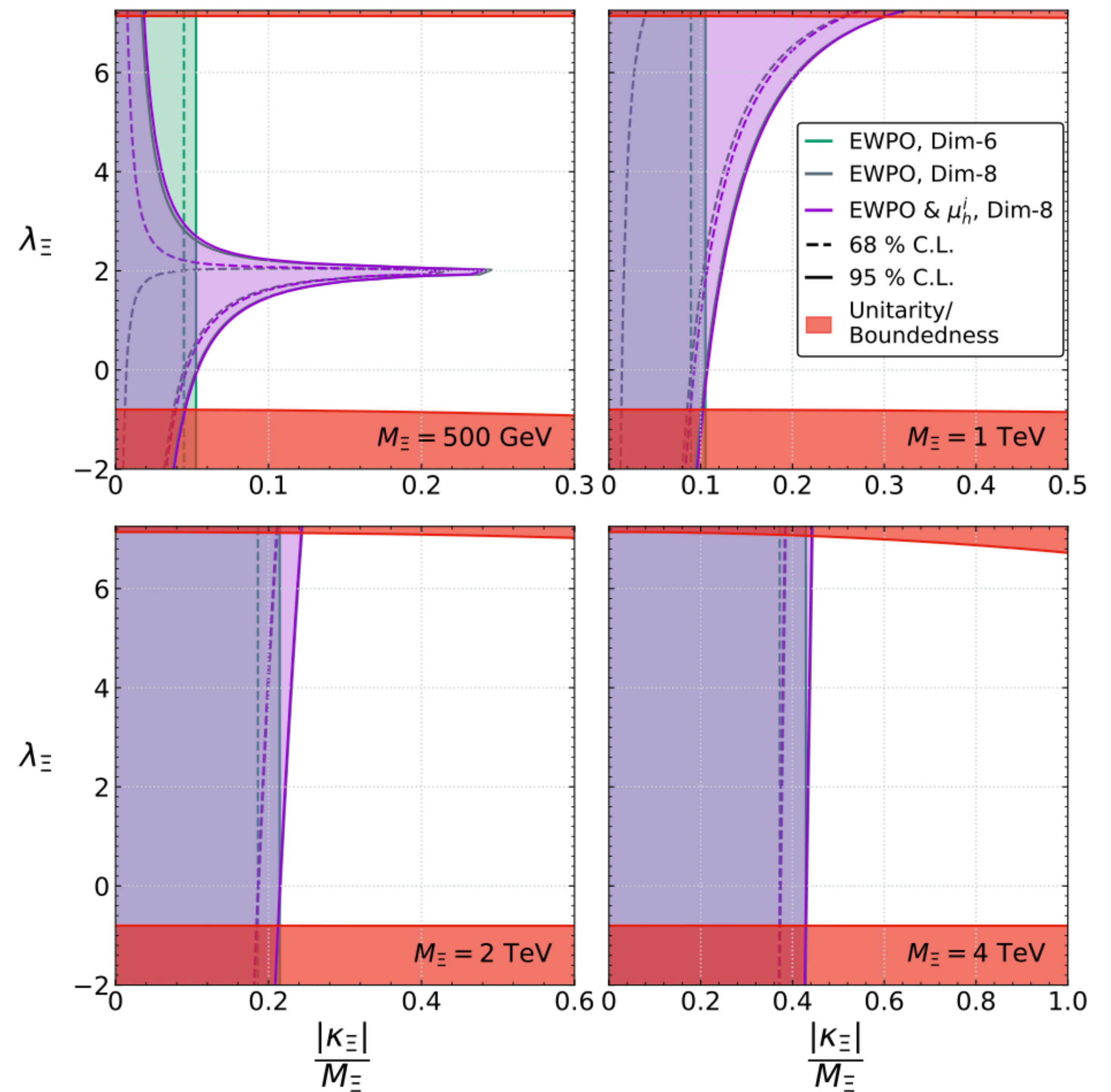


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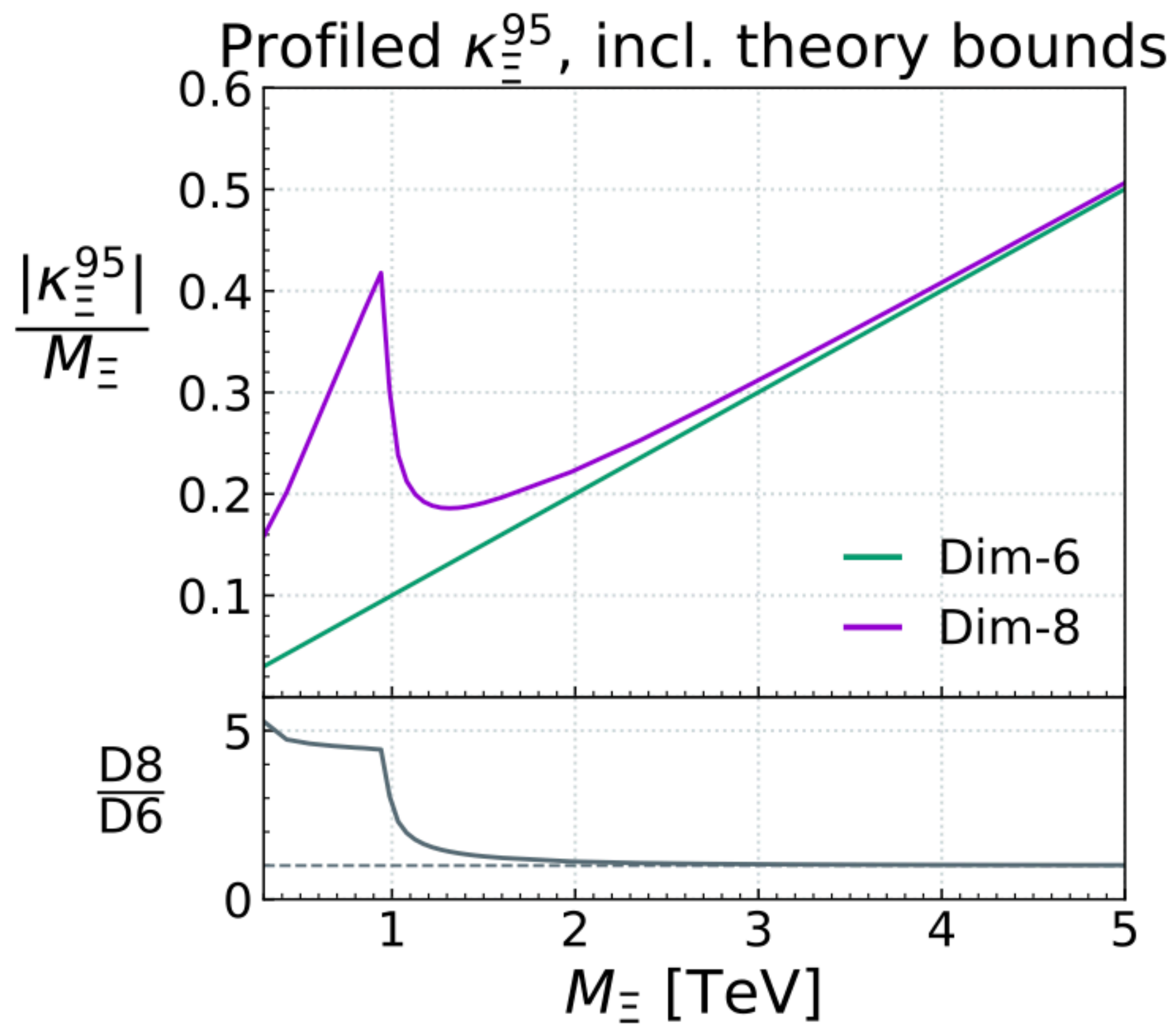


Two parameter: $\kappa_{\Xi}, \lambda_{\Xi}$

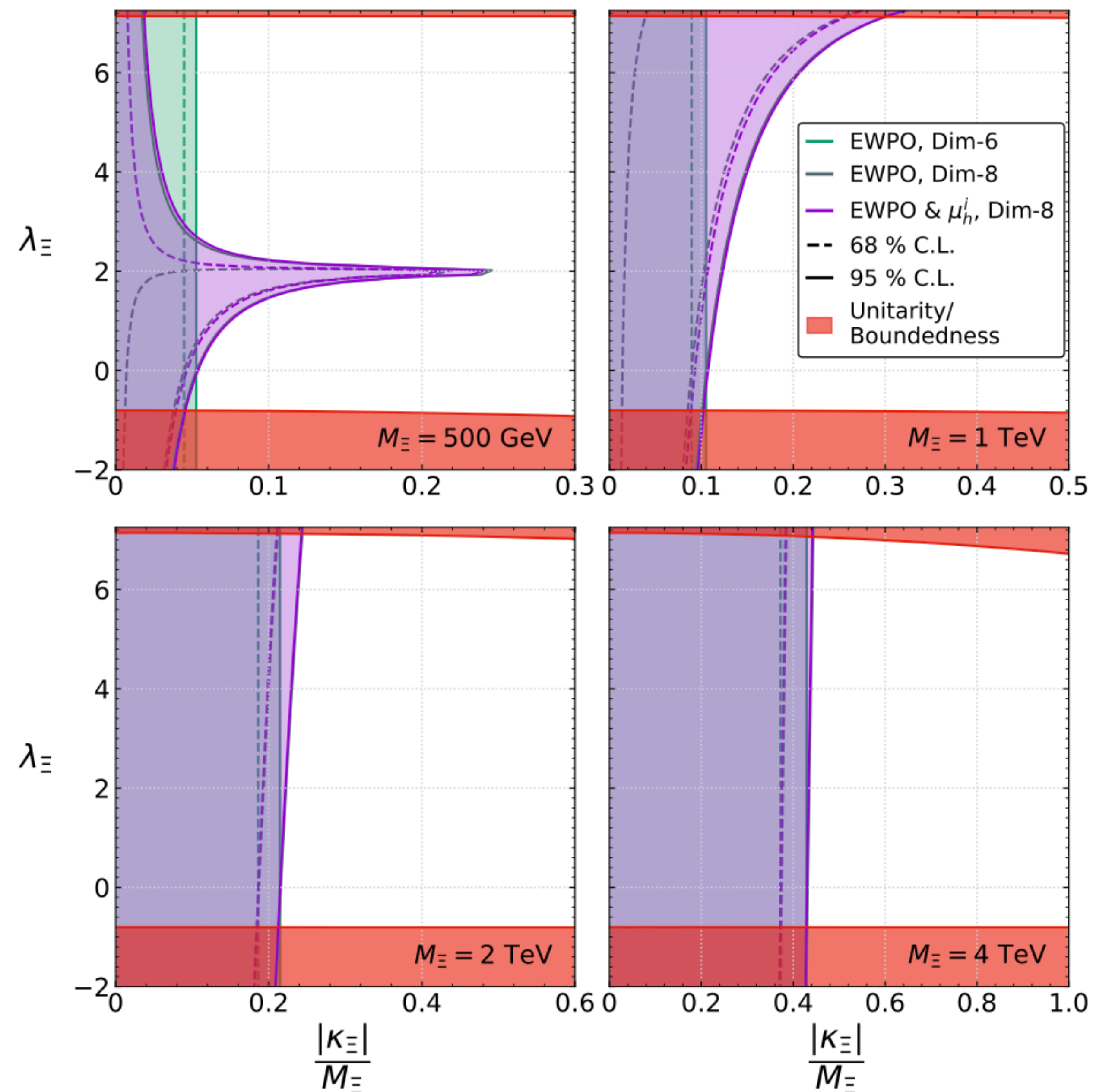


Profiled

Single parameter: κ_{Ξ}

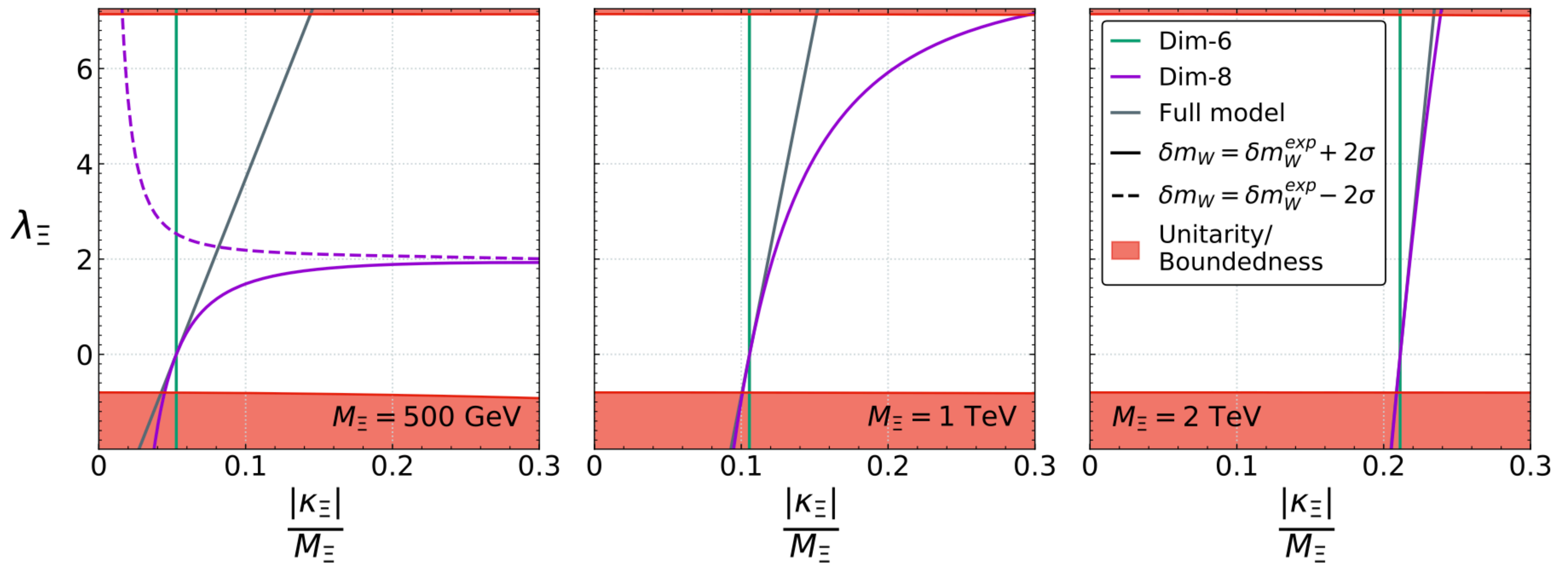


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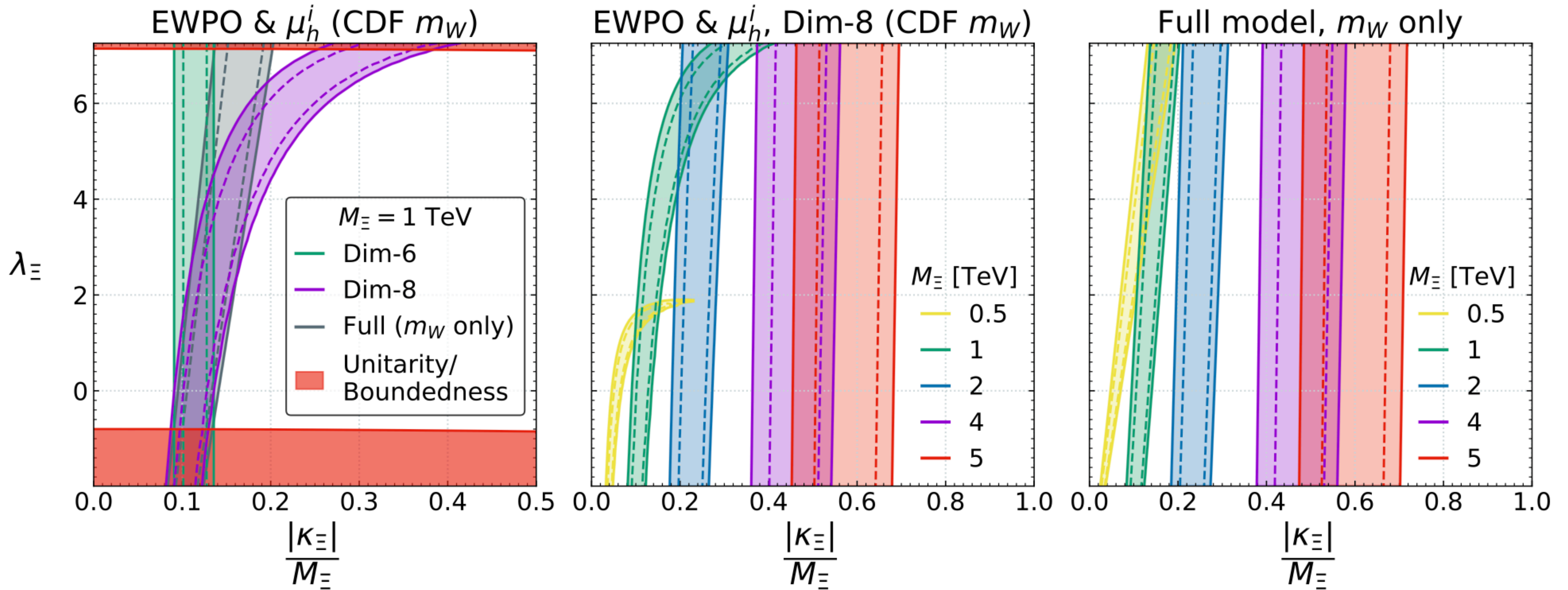


EFT Validity

Relative W -mass shift, δm_W ; $\eta_\Xi = 0$



Post-CDF



Conclusions

m_W is a precise probe of a direction in SMEFT space

- Crucial input to global fits, lifts a quasi-flat direction

SMEFT can globally accommodate m_W^{CDF}

- Higgs & Diboson data relatively less precise \Rightarrow Full 20-parameter fit remains consistent with SM
- SMEFT can help to pinpoint specific tree-level UV completions

- Beyond tree-level? *EWPO @ NLO* [Dawson & Giardino; PRD 101 (2020) 1, 013001]

RGE effects in interpreting CDF m_W
[Gupta; 2204.13690]

Interplay with CKM unitarity

Study of Dimension-8 effects in the scalar triplet model

- Dim-8 better reflects the constraints w.r.t full model
- Until the SMEFT expansion breaks down in strong coupling regions

Backup

+



SMEFT: SM v2.0

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \sum_{i,D} \frac{c_i^{(D)} \mathcal{O}_i^{(D)}}{\Lambda^{D-4}}$$

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BSM particle masses M



Generic new physics scale Λ

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Taylor expansion of \mathcal{A}_{BSM}



Tower of operators $\mathcal{O}_i^{(D)}$

$\mathcal{O}_i^{(D)} \supset$



*Low energy (SM)
fields & symmetries*

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Low energy (SM) fields & symmetries

Model parameters $\{g_{\text{BSM}}^i, M_k\}$



Wilson coefficients $\frac{c_j^{(D)}}{\Lambda^{D-4}} (g_{\text{BSM}}^i, M_k)$

measure g_i : new physics model parameters

“Matching”

measure c_i : coupling strengths of new BSM interactions

SMEFT: SM v2.0

$$\mathcal{L}_{\text{eff}} = \sum_i \frac{c_i \mathcal{O}_i^D}{\Lambda^{D-4}}$$

SM = low energy effective description

- New physics = tower of irrelevant ($D > 4$) operators
- Respecting low energy field content & symmetries

$$\text{SU}(3)_c \times \text{SU}(2)_L \times \text{U}(1)_Y$$

$$\varphi = \begin{pmatrix} G^+ \\ v + h + iG^0 \end{pmatrix} : \mathbf{2}_{\frac{1}{2}}$$

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aTGC

$$X^3 : \epsilon_{IJK} W_{\mu\nu}^I W^{J,\nu\rho} W_{\rho}^{K,\mu}$$

$$X^2 H^2 : (\varphi^\dagger \varphi)^2 G_{\mu\nu}^a G_a^{\mu\nu}$$

ggh(h)

λ_h

$$H^6 : (\varphi^\dagger \varphi)^3$$

$$H^4 D^2 : (\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D^\mu \varphi)$$

δM_Z

y_f

$$\psi^2 H^3 : (\varphi^\dagger \varphi)^2 (\bar{q}_i u_j \tilde{\varphi})$$

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ffV

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4F

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4F

More than 'just' a parametrisation of ignorance

- Unlike anomalous couplings
- Renormalisable QFT (order-by-order)
- Finite energy range ($\sim \Lambda$)
- Well defined matching procedure

SMEFT interpretation

$$\Delta o_n = o_n^{\text{EXP}} - o_n^{\text{SM}} = \sum_i \frac{a_{n,i}^{(6)}(\mu) c_i^{(6)}(\mu)}{\Lambda^2} + \mathcal{O}\left(\frac{1}{\Lambda^3}\right)$$

SMEFT interpretation

Improving sensitivity means improving...

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As many observables
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Identify patterns &
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Exploit energy-growth

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Best measurements & understanding of uncertainties and correlations

Theory:

Best available predictions for observables (NLO, NNLO, N3LO,...)

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Interpretation

Relies on accurate knowledge of the size & correlation among a_i

Determining $c_i^{(6)}$ requires most precise available SMEFT predictions

Theory

[Grzadkowski et al.; JHEP 10 (2010) 085]

X^3		H^6 and $H^4 D^2$		$\psi^2 H^3$	
\mathcal{O}_G	$f^{ABC} G_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	\mathcal{O}_H	$(H^\dagger H)^3$	\mathcal{O}_{eH}	$(H^\dagger H)(\bar{l}_p \gamma^\mu l_r)$
$\mathcal{O}_{\tilde{G}}$	$f^{ABC} \tilde{G}_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	\mathcal{O}_{uH}	$(H^\dagger H)(\bar{q}_p u_r \tilde{H})$
\mathcal{O}_W	$\varepsilon^{IJK} W_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$	\mathcal{O}_{HD}	$(H^\dagger D^\mu H)^\dagger (H^\dagger D_\mu H)$	\mathcal{O}_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$
$\mathcal{O}_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$				
$X^2 H^2$		$\psi^2 XH$		$\psi^2 H^2 D$	
\mathcal{O}_{HG}	$H^\dagger H G_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hi}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$
$\mathcal{O}_{H\tilde{G}}$	$H^\dagger H \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hi}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$
\mathcal{O}_{HW}	$H^\dagger H W_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{H} G_{\mu\nu}^A$	\mathcal{O}_{He}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$
$\mathcal{O}_{H\tilde{W}}$	$H^\dagger H \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{H} W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$
\mathcal{O}_{HB}	$H^\dagger H B_{\mu\nu} B^{\mu\nu}$	\mathcal{O}_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{H} B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$\mathcal{O}_{H\tilde{B}}$	$H^\dagger H \tilde{B}_{\mu\nu} B^{\mu\nu}$	\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}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$
$\mathcal{O}_{H\tilde{W}B}$	$H^\dagger \tau^I H \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	\mathcal{O}_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) H B_{\mu\nu}$	\mathcal{O}_{Hud}	$i(\tilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$

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

Theory

[Grzadkowski et al.; JHEP 10 (2010) 085]

X^3		H^6 and $H^4 D^2$		$\psi^2 H^3$		$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
\mathcal{O}_G	$f^{ABC} G_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	\mathcal{O}_H	$(H^\dagger H)^3$	\mathcal{O}_{eH}	$(H^\dagger H)(\bar{l}_p e_r H)$	\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}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{\tilde{G}}$	$f^{ABC} \tilde{G}_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	\mathcal{O}_{uH}	$(H^\dagger H)(\bar{q}_p u_r \tilde{H})$	$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	\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}_W	$\epsilon^{IJK} W_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$	\mathcal{O}_{HD}	$(H^\dagger D^\mu H)^* (H^\dagger D_\mu H)$	\mathcal{O}_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$	$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	\mathcal{O}_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	\mathcal{O}_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{\tilde{W}}$	$\epsilon^{IJK} \tilde{W}_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$					$\mathcal{O}_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	\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}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
$X^2 H^2$		$\psi^2 XH$		$\psi^2 H^2 D$		$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
\mathcal{O}_{HG}	$H^\dagger H G_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hi}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$	\mathcal{O}_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	\mathcal{O}_{duq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$		
$\mathcal{O}_{H\tilde{G}}$	$H^\dagger H \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hi}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$	$\mathcal{O}_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \epsilon_{jk} (\bar{q}_s^k d_t)$	\mathcal{O}_{qqu}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
\mathcal{O}_{HW}	$H^\dagger H W_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{H} G_{\mu\nu}^A$	\mathcal{O}_{He}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$	$\mathcal{O}_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \epsilon_{jk} (\bar{q}_s^k T^A d_t)$	\mathcal{O}_{qqq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jnm} \epsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$		
$\mathcal{O}_{H\tilde{W}}$	$H^\dagger H \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{H} W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$	$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \epsilon_{jk} (\bar{q}_s^k u_t)$	\mathcal{O}_{duu}	$\epsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
\mathcal{O}_{HB}	$H^\dagger H B_{\mu\nu} B^{\mu\nu}$	\mathcal{O}_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{H} B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{q}_p \tau^I \gamma^\mu q_r)$	\mathcal{O}_{Hu}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{u}_p \gamma^\mu u_r)$				
$\mathcal{O}_{H\tilde{B}}$	$H^\dagger H \tilde{B}_{\mu\nu} B^{\mu\nu}$	\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}_{Hd}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$				
\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}_{Hud}	$i(\tilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$				
$\mathcal{O}_{H\tilde{W}B}$	$H^\dagger \tau^I H \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	\mathcal{O}_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) H B_{\mu\nu}$								

Warsaw basis with CP & B conservation

- Full ‘bosonic’ sector: Higgs, triple-gauge & gauge-Higgs
- Scenario 1: Flavor-**universal** degrees of freedom

$$U(3)_L \times U(3)_e \times U(3)_Q \times U(3)_u \times U(3)_d$$

Theory

[Grzadkowski et al.; JHEP 10 (2010) 085]

X^3		H^6 and $H^4 D^2$		$\psi^2 H^3$		$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$			
\mathcal{O}_G	$f^{ABC} G_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	\mathcal{O}_H	$(H^\dagger H)^3$	\mathcal{O}_{eH}	$(H^\dagger H)(\bar{l}_p e_r H)$	\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}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$		
$\mathcal{O}_{\tilde{G}}$	$f^{ABC} \tilde{G}_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	\mathcal{O}_{uH}	$(H^\dagger H)(\bar{q}_p u_r \tilde{H})$	$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	\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}_W	$\epsilon^{IJK} W_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$	\mathcal{O}_{HD}	$(H^\dagger D^\mu H)^*(H^\dagger D_\mu H)$	\mathcal{O}_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$	$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	\mathcal{O}_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	\mathcal{O}_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$		
$\mathcal{O}_{\tilde{W}}$	$\epsilon^{IJK} \tilde{W}_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$					$\mathcal{O}_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	\mathcal{O}_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	\mathcal{O}_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$		
$X^2 H^2$		$\psi^2 XH$		$\psi^2 H^2 D$		$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating					
\mathcal{O}_{HG}	$H^\dagger H G_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hi}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$	\mathcal{O}_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	\mathcal{O}_{duq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$	$\mathcal{O}_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \epsilon_{jk} (\bar{q}_s^k d_t)$	\mathcal{O}_{qqu}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$
$\mathcal{O}_{H\tilde{G}}$	$H^\dagger H \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hi}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$	$\mathcal{O}_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \epsilon_{jk} (\bar{q}_s^k T^A d_t)$	\mathcal{O}_{qqq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jkn} \epsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$	$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \epsilon_{jk} (\bar{q}_s^k u_t)$	\mathcal{O}_{duu}	$\epsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
\mathcal{O}_{HW}	$H^\dagger H W_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{H} G_{\mu\nu}^A$	\mathcal{O}_{He}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$	\mathcal{O}_{Hu}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{u}_p \gamma^\mu u_r)$						
$\mathcal{O}_{H\tilde{W}}$	$H^\dagger H \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{H} W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$	\mathcal{O}_{Hd}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$						
\mathcal{O}_{HB}	$H^\dagger H B_{\mu\nu} B^{\mu\nu}$	\mathcal{O}_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{H} B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{q}_p \tau^I \gamma^\mu q_r)$	\mathcal{O}_{Hud}	$i(\tilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$						
$\mathcal{O}_{H\tilde{B}}$	$H^\dagger H \tilde{B}_{\mu\nu} B^{\mu\nu}$	\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}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$								
$\mathcal{O}_{H\tilde{W}B}$	$H^\dagger \tau^I H \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	\mathcal{O}_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) H B_{\mu\nu}$	\mathcal{O}_{Hud}	$i(\tilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$								

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- Full 'bosonic' sector: Higgs, triple-gauge & gauge-Higgs
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$$U(3)_L \times U(3)_e \times U(3)_Q \times U(3)_u \times U(3)_d \quad + \text{Yukawas: } \mathcal{O}_{tH}, \mathcal{O}_{bH}, \mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}$$

Theory

[Grzadkowski et al.; JHEP 10 (2010) 085]

X^3		H^6 and $H^4 D^2$		$\psi^2 H^3$		$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
\mathcal{O}_G	$f^{ABC} G_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	\mathcal{O}_H	$(H^\dagger H)^3$	\mathcal{O}_{eH}	$(H^\dagger H)(\bar{l}_p e_r H)$	\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}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$\mathcal{O}_{\bar{G}}$	$f^{ABC} \tilde{G}_{\mu\nu}^A G_{\nu\rho}^B G_{\rho\mu}^C$	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$	\mathcal{O}_{uH}	$(H^\dagger H)(\bar{q}_p u_r \tilde{H})$	$\mathcal{O}_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	\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}_W	$\epsilon^{IJK} W_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$	\mathcal{O}_{HD}	$(H^\dagger D^\mu H)^*(H^\dagger D_\mu H)$	\mathcal{O}_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$	$\mathcal{O}_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	\mathcal{O}_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	\mathcal{O}_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$\mathcal{O}_{\bar{W}}$	$\epsilon^{IJK} \tilde{W}_{\mu\nu}^I W_{\nu\rho}^J W_{\rho\mu}^K$					$\mathcal{O}_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	\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}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
$X^2 H^2$		$\psi^2 XH$		$\psi^2 H^2 D$		$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
\mathcal{O}_{HG}	$H^\dagger H G_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I H W_{\mu\nu}^I$	$\mathcal{O}_{Hi}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{l}_p \gamma^\mu l_r)$	\mathcal{O}_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	\mathcal{O}_{duq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$		
$\mathcal{O}_{H\bar{G}}$	$H^\dagger H \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	\mathcal{O}_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) H B_{\mu\nu}$	$\mathcal{O}_{Hi}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{l}_p \tau^I \gamma^\mu l_r)$	$\mathcal{O}_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \epsilon_{jk} (\bar{q}_s^k d_t)$	\mathcal{O}_{qqu}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
\mathcal{O}_{HW}	$H^\dagger H W_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{H} G_{\mu\nu}^A$	\mathcal{O}_{He}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{e}_p \gamma^\mu e_r)$	$\mathcal{O}_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \epsilon_{jk} (\bar{q}_s^k T^A d_t)$	\mathcal{O}_{qqq}	$\epsilon^{\alpha\beta\gamma} \epsilon_{jkn} \epsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$		
$\mathcal{O}_{H\bar{W}}$	$H^\dagger H \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	\mathcal{O}_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{H} W_{\mu\nu}^I$	$\mathcal{O}_{Hq}^{(1)}$	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{q}_p \gamma^\mu q_r)$	$\mathcal{O}_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \epsilon_{jk} (\bar{q}_s^k u_t)$	\mathcal{O}_{duu}	$\epsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
\mathcal{O}_{HB}	$H^\dagger H B_{\mu\nu} B^{\mu\nu}$	\mathcal{O}_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{H} B_{\mu\nu}$	$\mathcal{O}_{Hq}^{(3)}$	$(H^\dagger i \overleftrightarrow{D}_\mu^I H)(\bar{q}_p \tau^I \gamma^\mu q_r)$	\mathcal{O}_{Hud}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$				
$\mathcal{O}_{H\bar{B}}$	$H^\dagger H \tilde{B}_{\mu\nu} B^{\mu\nu}$	\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}	$(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_p \gamma^\mu d_r)$						
$\mathcal{O}_{H\bar{W}B}$	$H^\dagger \tau^I H \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	\mathcal{O}_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) H B_{\mu\nu}$	\mathcal{O}_{Hud}	$i(\tilde{H}^\dagger D_\mu H)(\bar{u}_p \gamma^\mu d_r)$						

Warsaw basis with CP & B conservation

- Full 'bosonic' sector: Higgs, triple-gauge & gauge-Higgs
- Scenario 1: Flavor-**universal** degrees of freedom

$$U(3)_L \times U(3)_e \times U(3)_Q \times U(3)_u \times U(3)_d \quad + \text{Yukawas: } \mathcal{O}_{tH}, \mathcal{O}_{bH}, \mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}$$

- Scenario 2: **top**-centric flavor symmetry

$$U(3)_L \times U(3)_e \times U(2)_Q \times U(2)_u \times U(3)_d \quad \begin{array}{l} \text{cf. Minimal flavor violation} \\ \text{[Buras et al.; PLB 500 (2001) 161]} \\ \text{[D'Ambrosio et al.; NPB 645 (2002) 155]} \\ \text{[Aguilar-Saavedra et al.; arXiv:1802.07237]} \end{array}$$

Degrees of freedom

Flavor scenario	EWPO: $\mathcal{O}_{HWB}, \mathcal{O}_{HD}, \mathcal{O}_U, \mathcal{O}_{Hl}^{(3)}, \mathcal{O}_{Hl}^{(1)}, \mathcal{O}_{He}, \mathcal{O}_{Hq}^{(3)}, \mathcal{O}_{Hq}^{(1)}, \mathcal{O}_{Hd}, \mathcal{O}_{Hu},$	
<i>Universal</i>	Bosonic: $\mathcal{O}_{H\Box}, \mathcal{O}_{HG}, \mathcal{O}_{HW}, \mathcal{O}_{HB}, \mathcal{O}_W, \mathcal{O}_G,$	
	Yukawa: $\mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}, \mathcal{O}_{bH}, \mathcal{O}_{tH},$	20
<i>'Top specific'</i>	Top 2F: $\mathcal{O}_{HQ}^{(3)}, \mathcal{O}_{HQ}^{(1)}, \mathcal{O}_{Ht}, \mathcal{O}_{tG}, \mathcal{O}_{tW}, \mathcal{O}_{tB},$	
	Top 4F: $\mathcal{O}_{Qq}^{3,1}, \mathcal{O}_{Qq}^{3,8}, \mathcal{O}_{Qq}^{1,8}, \mathcal{O}_{Qu}^8, \mathcal{O}_{Qd}^8, \mathcal{O}_{tQ}^8, \mathcal{O}_{tu}^8, \mathcal{O}_{td}^8.$	+14

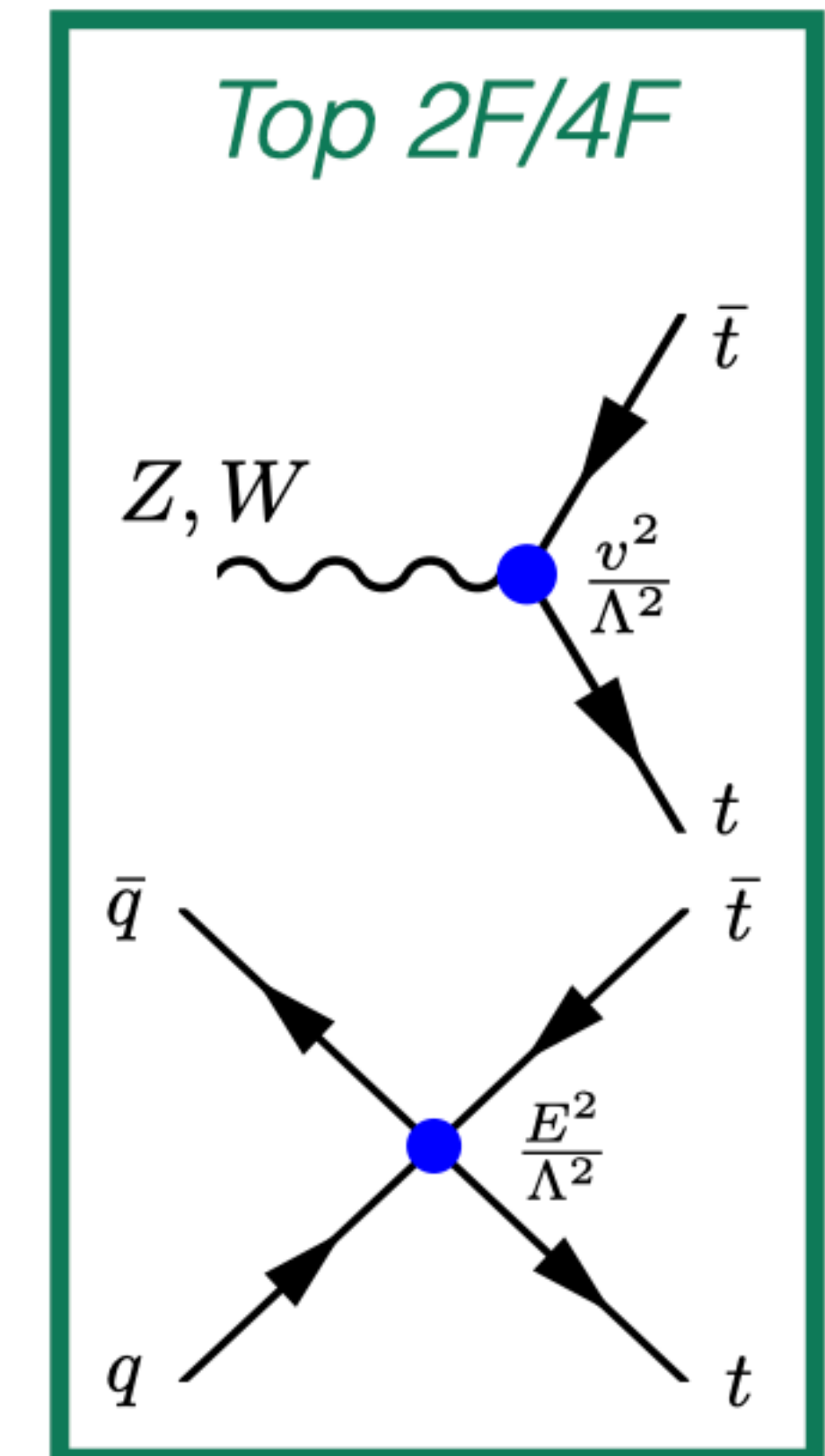
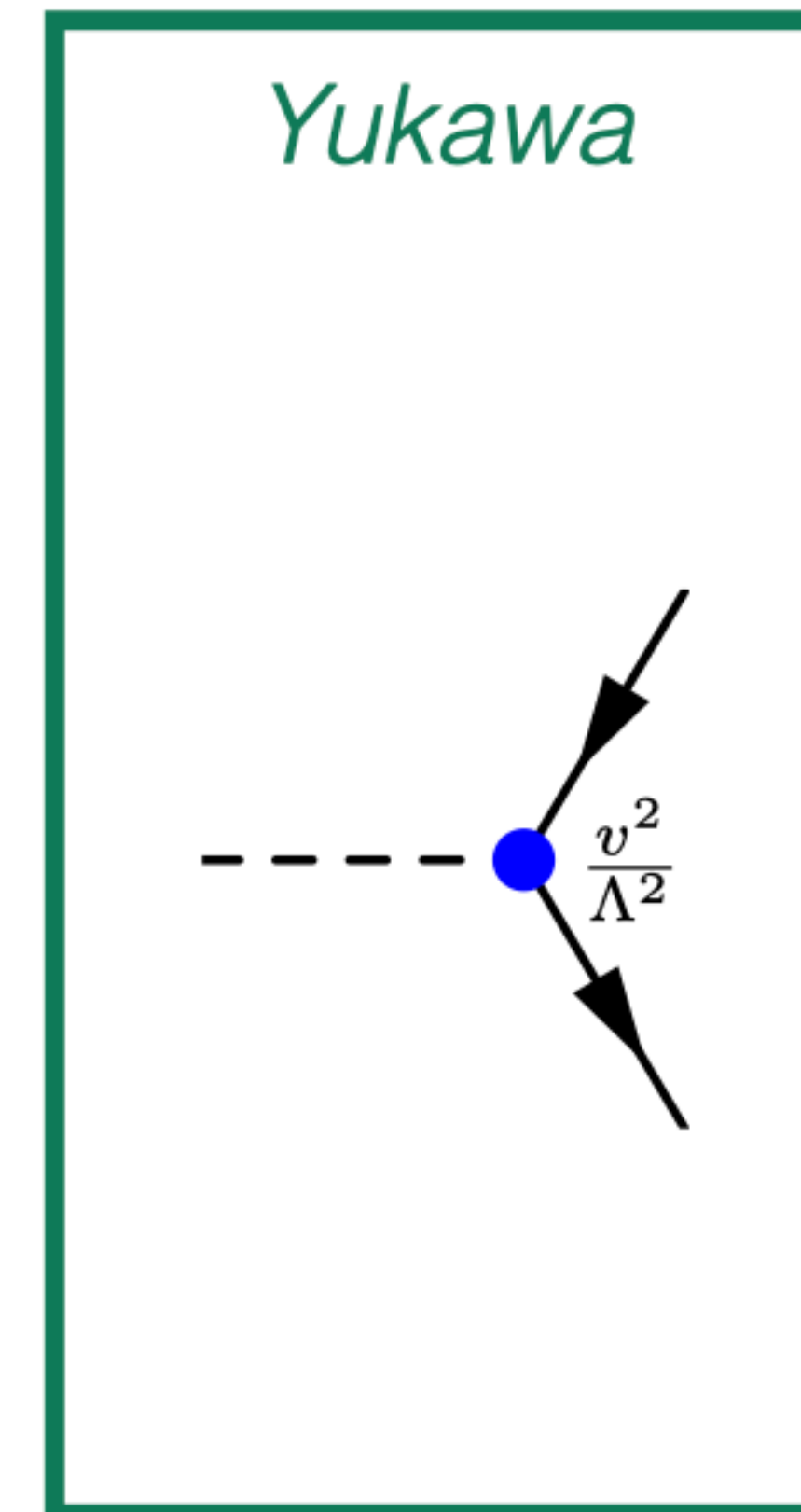
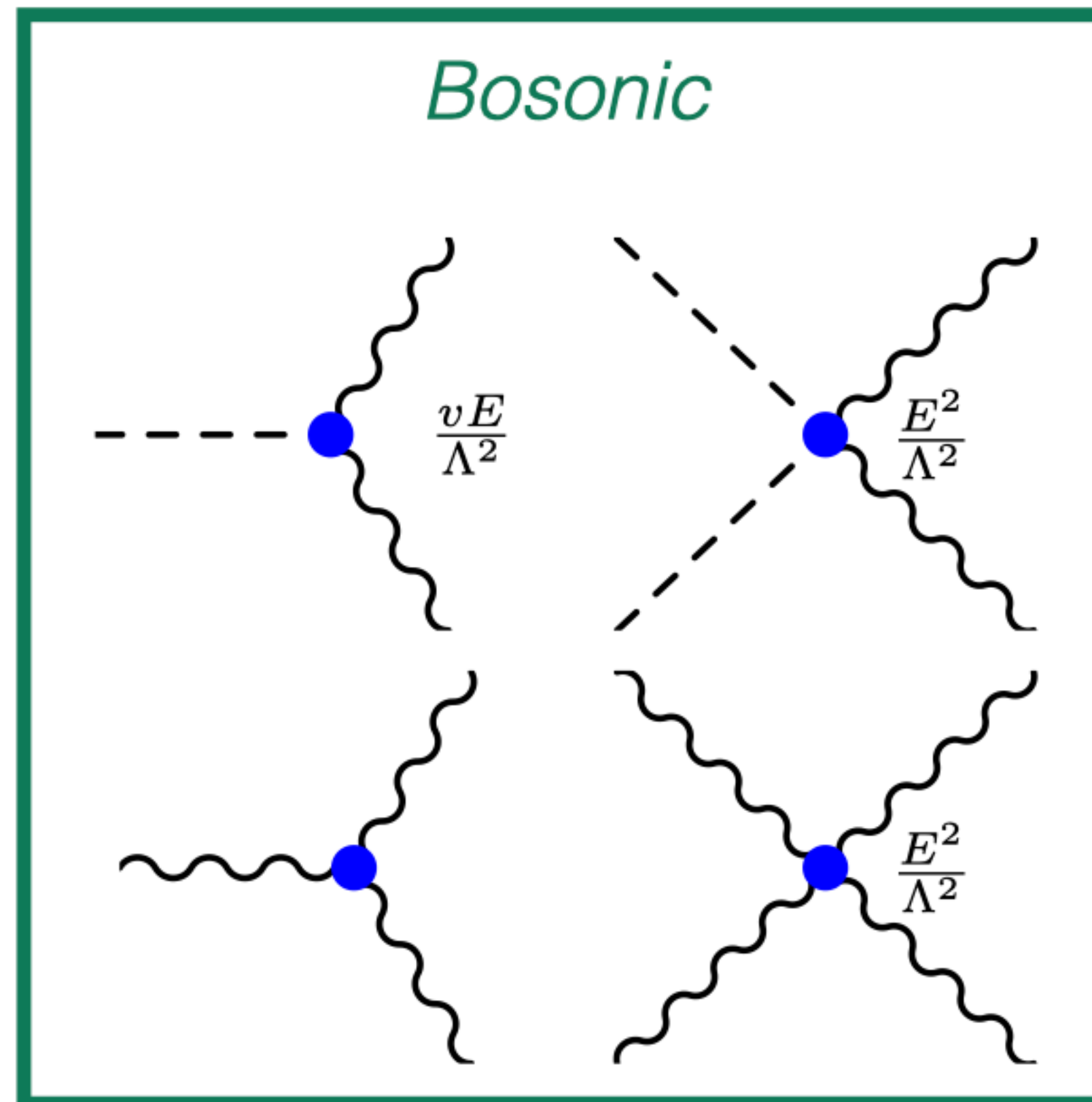
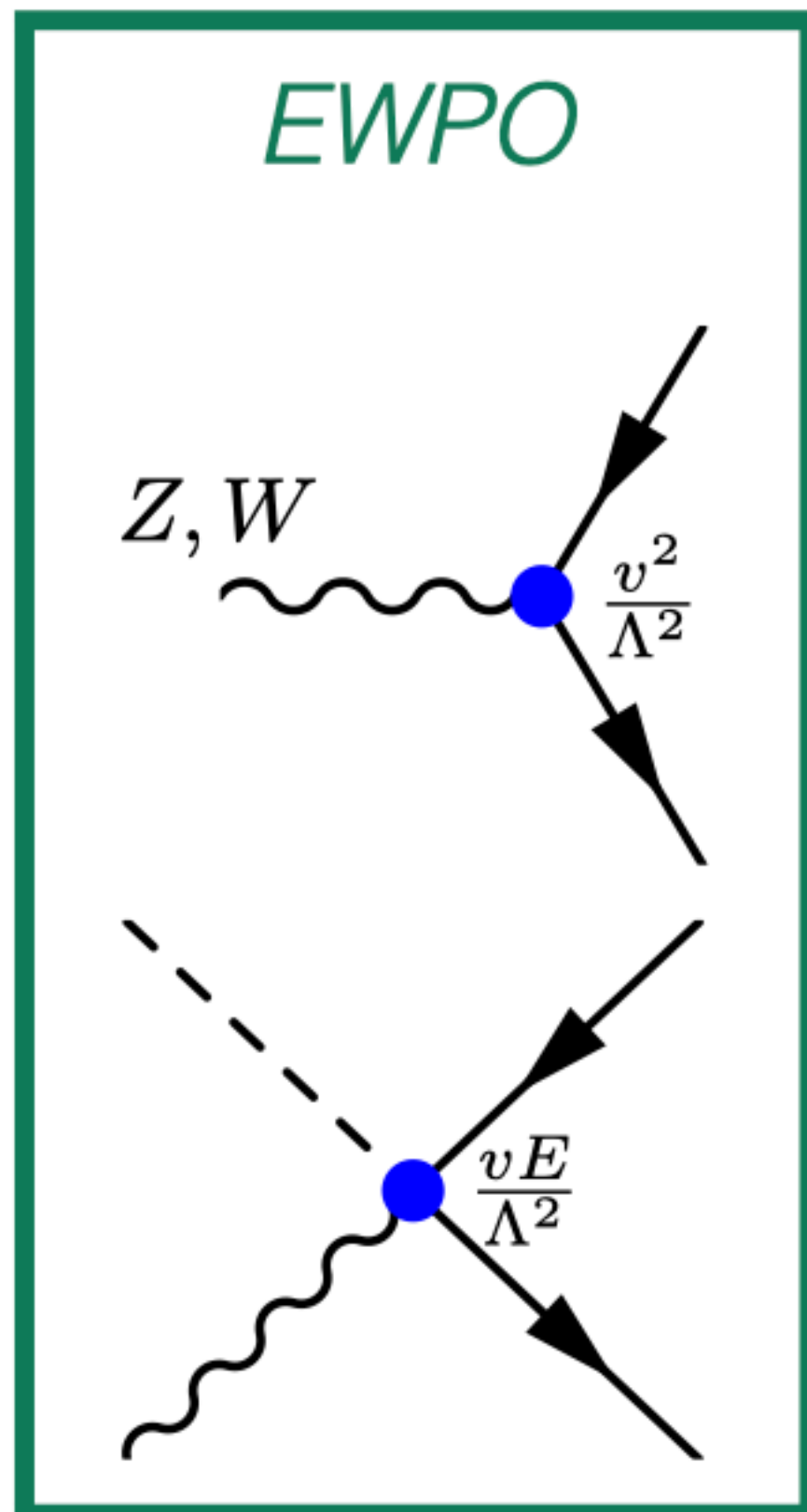
Degrees of freedom

Flavor scenario

Universal

'Top specific'

EWPO:	$\mathcal{O}_{HWB}, \mathcal{O}_{HD}, \mathcal{O}_U, \mathcal{O}_{Hl}^{(3)}, \mathcal{O}_{Hl}^{(1)}, \mathcal{O}_{He}, \mathcal{O}_{Hq}^{(3)}, \mathcal{O}_{Hq}^{(1)}, \mathcal{O}_{Hd}, \mathcal{O}_{Hu},$	
Bosonic:	$\mathcal{O}_{H\Box}, \mathcal{O}_{HG}, \mathcal{O}_{HW}, \mathcal{O}_{HB}, \mathcal{O}_W, \mathcal{O}_G,$	
Yukawa:	$\mathcal{O}_{\tau H}, \mathcal{O}_{\mu H}, \mathcal{O}_{bH}, \mathcal{O}_{tH},$	20
Top 2F:	$\mathcal{O}_{HQ}^{(3)}, \mathcal{O}_{HQ}^{(1)}, \mathcal{O}_{Ht}, \mathcal{O}_{tG}, \mathcal{O}_{tW}, \mathcal{O}_{tB},$	
Top 4F:	$\mathcal{O}_{Qq}^{3,1}, \mathcal{O}_{Qq}^{3,8}, \mathcal{O}_{Qq}^{1,8}, \mathcal{O}_{Qu}^8, \mathcal{O}_{Qd}^8, \mathcal{O}_{tQ}^8, \mathcal{O}_{tu}^8, \mathcal{O}_{td}^8.$	+14



SMEFT fit

SMEFT Coeff.	Individual			Marginalised		
	Best fit [$\Lambda = 1$ TeV]	95% CL range	Scale $\frac{\Lambda}{\sqrt{C}}$ [TeV]	Best fit [$\Lambda = 1$ TeV]	95% CL range	Scale $\frac{\Lambda}{\sqrt{C}}$ [TeV]
C_{HWB}	-0.01	[-0.009, -0.0034]	19.0	0.25	[-0.3, +0.81]	1.3
C_{HD}	-0.03	[-0.035, -0.019]	11.0	-0.6	[-1.8, +0.63]	0.9
C_{ll}	0.02	[+0.014, +0.034]	10.0	-0.05	[-0.099, +0.0043]	4.4
$C_{Hl}^{(3)}$	-0.01	[-0.019, -0.0083]	14.0	-0.01	[-0.11, +0.076]	3.3
$C_{Hl}^{(1)}$	0.00	[-0.0045, +0.013]	11.0	0.16	[-0.15, +0.47]	1.8
C_{He}	0.00	[-0.015, +0.0071]	9.6	0.28	[-0.34, +0.9]	1.3
$C_{Hq}^{(3)}$	0.00	[-0.013, +0.011]	9.1	-0.05	[-0.11, +0.012]	4.1
$C_{Hq}^{(1)}$	0.01	[-0.027, +0.043]	5.4	-0.07	[-0.2, +0.06]	2.8
C_{Hd}	-0.03	[-0.13, +0.072]	3.1	-0.44	[-0.96, +0.079]	1.4
C_{Hu}	0.00	[-0.075, +0.073]	3.7	-0.18	[-0.62, +0.26]	1.5
C_{HBox}	-0.27	[-1, +0.47]	1.2	-1.1	[-3.2, +1]	0.69
C_{HG}	0.00	[-0.0034, +0.0032]	17.0	-0.01	[-0.026, +0.013]	7.2
C_{HW}	0.00	[-0.012, +0.006]	11.0	0.18	[-0.33, +0.7]	1.4
C_{HB}	0.00	[-0.0034, +0.002]	19.0	0.09	[-0.074, +0.24]	2.5
C_W	0.18	[-0.072, +0.42]	2.0	0.15	[-0.1, +0.4]	2.0
C_G	-0.75	[-4, +2.5]	0.56	1.3	[-6.1, +8.7]	0.37
$C_{\tau H}$	0.01	[-0.015, +0.025]	7.1	0.00	[-0.017, +0.027]	6.7
$C_{\mu H}$	0.00	[-0.0057, +0.005]	14.0	0.00	[-0.0056, +0.0052]	14.0
C_{bH}	0.00	[-0.016, +0.024]	7.1	0.02	[-0.027, +0.058]	4.8
C_{tH}	-0.09	[-1, +0.84]	1.0	-2.7	[-8.8, +3.3]	0.41

Operators

Dim - 4	\mathcal{O}_{H4}	$(H^\dagger H)^2$
Dim - 6	H^6 and $H^4 D^2$	
	\mathcal{O}_H	$(H^\dagger H)^3$
	\mathcal{O}_{HD}	$(H^\dagger D^\mu H)^*(H^\dagger D^\mu H)$
	$\mathcal{O}_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$
	$\psi^2 H^3$	
	\mathcal{O}_{eH}	$(H^\dagger H)(\bar{l}_p e_r H)$
\mathcal{O}_{uH}	$(H^\dagger H)(\bar{q}_p u_r \tilde{H})$	
\mathcal{O}_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$	

Dim - 8	$H^8, H^6 D^2$ and $H^4 D^4$		$(\bar{L}R)(\bar{L}R)H^2 + \text{h.c.}$	
	\mathcal{O}_{H^8}	$(H^\dagger H)^4$	$\mathcal{O}_{lequH^2}^{(1)}$	$(\bar{l}_p^j e_r)\epsilon_{jk}(\bar{q}_s^k u_t)(H^\dagger H)$
	$\mathcal{O}_{H^6}^{(1)}$	$(H^\dagger H)^2(D_\mu H^\dagger D^\mu H)$	$\mathcal{O}_{lequH^2}^{(2)}$	$(\bar{l}_p^j e_r)(\sigma^I \epsilon)_{jk}(\bar{q}_s^k u_t)(H^\dagger \sigma^I H)$
	$\mathcal{O}_{H^6}^{(2)}$	$(H^\dagger H)(H^\dagger \sigma^I H)(D_\mu H^\dagger \sigma^I D^\mu H)$	$\mathcal{O}_{q^2 udH^2}^{(1)}$	$(\bar{q}_p^j u_r)\epsilon_{jk}(\bar{q}_s^k d_t)(H^\dagger H)$
	$\mathcal{O}_{H^4}^{(1)}$	$(D_\mu H^\dagger D_\nu H)(D^\nu H^\dagger D^\mu H)$	$\mathcal{O}_{q^2 udH^2}^{(2)}$	$(\bar{q}_p^j u_r)(\sigma^I \epsilon)_{jk}(\bar{q}_s^k d_t)(H^\dagger \sigma^I H)$
	$\mathcal{O}_{H^4}^{(3)}$	$(D_\mu H^\dagger D^\mu H)(D_\nu H^\dagger D^\nu H)$	$\mathcal{O}_{leqdH^2}^{(3)}$	$(\bar{l}_p e_r H)(\bar{q}_s d_t H)$
	$\psi^2 H^5$		$\mathcal{O}_{l^2 e^2 H^2}^{(3)}$	$(\bar{l}_p e_r H)(\bar{l}_s e_t H)$
	\mathcal{O}_{leH^5}	$(H^\dagger H)^2(\bar{l}_p e_r H)$	$\mathcal{O}_{q^2 u^2 H^2}^{(5)}$	$(\bar{q}_p u_r \tilde{H})(\bar{q}_s u_t \tilde{H})$
	\mathcal{O}_{quH^5}	$(H^\dagger H)^2(\bar{q}_p u_r \tilde{H})$	$\mathcal{O}_{q^2 d^2 H^2}^{(5)}$	$(\bar{q}_p d_r H)(\bar{q}_s u_t H)$
	\mathcal{O}_{qdH^5}	$(H^\dagger H)^2(\bar{q}_p d_r H)$	$(\bar{L}L)(\bar{R}R)H^2$	
	$\psi^2 H^3 D^2 + \text{h.c.}$		$\mathcal{O}_{l^2 e^2 H^2}^{(1)}$	$(\bar{l}_p \gamma^\mu l_r)(\bar{e}_s \gamma_\mu e_t)(H^\dagger H)$
	$\mathcal{O}_{leH^3 D^2}^{(1)}$	$(D_\mu H^\dagger D^\mu H)(\bar{l}_p e_r H)$	$\mathcal{O}_{l^2 e^2 H^2}^{(2)}$	$(\bar{l}_p \gamma^\mu \sigma^I l_r)(\bar{e}_s \gamma_\mu e_t)(H^\dagger \sigma^I H)$
	$\mathcal{O}_{leH^3 D^2}^{(2)}$	$(D_\mu H^\dagger \sigma^I D^\mu H)(\bar{l}_p e_r \sigma^I H)$	$\mathcal{O}_{q^2 u^2 H^2}^{(1)}$	$(\bar{q}_p \gamma^\mu q_r)(\bar{u}_s \gamma_\mu u_t)(H^\dagger H)$
	$\mathcal{O}_{quH^3 D^2}^{(1)}$	$(D_\mu H^\dagger D^\mu H)(\bar{q}_p u_r H)$	$\mathcal{O}_{q^2 u^2 H^2}^{(2)}$	$(\bar{q}_p \gamma^\mu \sigma^I q_r)(\bar{u}_s \gamma_\mu u_t)(H^\dagger \sigma^I H)$
$\mathcal{O}_{quH^3 D^2}^{(2)}$	$(D_\mu H^\dagger \sigma^I D^\mu H)(\bar{q}_p u_r \sigma^I H)$	$\mathcal{O}_{q^2 d^2 H^2}^{(1)}$	$(\bar{q}_p \gamma^\mu q_r)(\bar{d}_s \gamma_\mu d_t)(H^\dagger H)$	
$\mathcal{O}_{qdH^3 D^2}^{(1)}$	$(D_\mu H^\dagger D^\mu H)(\bar{q}_p d_r H)$	$\mathcal{O}_{q^2 d^2 H^2}^{(2)}$	$(\bar{q}_p \gamma^\mu \sigma^I q_r)(\bar{d}_s \gamma_\mu d_t)(H^\dagger \sigma^I H)$	
$\mathcal{O}_{qdH^3 D^2}^{(2)}$	$(D_\mu H^\dagger \sigma^I D^\mu H)(\bar{q}_p d_r \sigma^I H)$	$(\bar{L}R)(\bar{R}L)H^2 + \text{h.c.}$		
$\mathcal{O}_{leqdH^2}^{(1)}$	$(\bar{l}_p^j e_r)(\bar{d}_s q_{tj})(H^\dagger H)$	$\mathcal{O}_{lequH^2}^{(5)}$	$(\bar{l}_p e_r H)(\tilde{H}^\dagger \bar{u}_s q_t)$	
$\mathcal{O}_{leqdH^2}^{(2)}$	$(\bar{l}_p e_r)\sigma^I(\bar{d}_s q_t)(H^\dagger \sigma^I H)$	$\mathcal{O}_{q^2 u^2 H^2}^{(5)}$	$(\bar{q}_p d_r H)(\tilde{H}^\dagger \bar{u}_s q_t)$	

Triplet matching

Dim - 6	C_H	$\frac{\kappa_{\Xi}^2}{M_{\Xi}^2} \left((4\lambda - \lambda_{\Xi}) \left(1 - \frac{4\mu^2}{M_{\Xi}^2} \right) - \frac{5\mu^2 \kappa_{\Xi}^2}{M_{\Xi}^6} \right)$
	C_{HD}	$-\frac{2\kappa_{\Xi}^2}{M_{\Xi}^2} \left(1 - \frac{4\mu^2}{M_{\Xi}^2} \right)$
	$C_{H\Box}$	$\frac{\kappa_{\Xi}^2}{2M_{\Xi}^2} \left(1 - \frac{4\mu^2}{M_{\Xi}^2} \right)$
	$[C_{\psi H}]_{wx}$	$[y_{\psi}]_{wx} \frac{\kappa_{\Xi}^2}{M_{\Xi}^2} \left(1 - \frac{4\mu^2}{M_{\Xi}^2} \right); \psi = u, d, e$

Dim - 8	C_{H^8}	$\frac{2\kappa_{\Xi}^2}{M_{\Xi}^2} \left((2\lambda - \lambda_{\Xi})^2 + \frac{\kappa_{\Xi}^2}{M_{\Xi}^2} (3\lambda_{\Xi} - 5\lambda - \frac{\eta_{\Xi}}{8}) \right)$
	$C_{H^6}^{(1)}$	$-\frac{\kappa_{\Xi}^4}{M_{\Xi}^4}$
	$C_{H^6}^{(2)}$	$\frac{4\kappa_{\Xi}^2}{M_{\Xi}^2} \left(\lambda_{\Xi} - 2\lambda + \frac{\kappa_{\Xi}^2}{M_{\Xi}^2} \right)$
	$C_{H^4}^{(1)}$	$\frac{4\kappa_{\Xi}^2}{M_{\Xi}^2}$
	$C_{H^4}^{(3)}$	$-\frac{2\kappa_{\Xi}^2}{M_{\Xi}^2}$
	$[C_{l\psi H^5}/C_{q\psi H^5}]_{wx}$	$-[y_{\psi}]_{wx} \frac{2\kappa_{\Xi}^2}{M_{\Xi}^2} \left(\lambda_{\Xi} - 2\lambda + \frac{\kappa_{\Xi}^2}{2M_{\Xi}^2} \right); \psi = u, d, e$
	$[C_{l^2\psi^2 H^2}/C_{q^2\psi^2 H^2}]_{wxyz}$	$-[y_{\psi}]_{wz} [y_{\psi}^{\dagger}]_{yx} \frac{3\kappa_{\Xi}^2}{4M_{\Xi}^2}; \psi = u, d, e$
	$[C_{l^2 e^2 H^2}/C_{q^2 d^2 H^2}]_{wxyz}$	$[y_{\psi}]_{wz} [y_{\psi}^{\dagger}]_{yx} \frac{\kappa_{\Xi}^2}{4M_{\Xi}^2}; \psi = d, e$
	$[C_{q^2 u^2 H^2}]_{wxyz}$	$-[y_u]_{wz} [y_u^{\dagger}]_{yx} \frac{\kappa_{\Xi}^2}{4M_{\Xi}^2}$
	$[C_{l^2\psi^2 H^2}/C_{q^2\psi^2 H^2}]_{wxyz}^{(3)}$	$[y_{\psi}]_{wx} [y_{\psi}]_{yz} \frac{\kappa_{\Xi}^2}{2M_{\Xi}^2}; \psi = u, d, e$
	$[C_{lequH^2}^{(1)}]_{wxyz}$	$[y_e]_{wx} [y_u]_{yz} \frac{5\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{leqdH^2}^{(1)}]_{wxyz}$	$[y_e]_{wx} [y_d^{\dagger}]_{yz} \frac{5\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{q^2 udH^2}^{(1)}]_{wxyz}$	$-[y_u]_{wx} [y_d]_{yz} \frac{5\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{lequH^2}^{(2)}]_{wxyz}$	$[y_e]_{wx} [y_u]_{yz} \frac{\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{leqdH^2}^{(2)}]_{wxyz}$	$-[y_e]_{wx} [y_d^{\dagger}]_{yz} \frac{\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{q^2 udH^2}^{(2)}]_{wxyz}$	$[y_u]_{wx} [y_d]_{yz} \frac{\kappa_{\Xi}^2}{2M_{\Xi}^2}$
	$[C_{lequH^2}^{(5)}]_{wxyz}$	$[y_e]_{wx} [y_u^{\dagger}]_{yz} \frac{\kappa_{\Xi}^2}{M_{\Xi}^2}$
	$[C_{leqdH^2}^{(3)}]_{wxyz}$	$[y_e]_{wx} [y_d]_{yz} \frac{\kappa_{\Xi}^2}{M_{\Xi}^2}$
	$[C_{q^2 udH^2}^{(5)}]_{wxyz}$	$[y_d]_{wx} [y_u^{\dagger}]_{yz} \frac{\kappa_{\Xi}^2}{M_{\Xi}^2}$
	$[C_{l\psi H^3 D^2}/C_{q\psi H^3 D^2}]_{wx}$	$-[y_{\psi}]_{wx} \frac{4\kappa_{\Xi}^2}{M_{\Xi}^2}; \psi = u, d, e$