Recent developments of dim-8 effects in SMEFT

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- In order to describe heavy BSM physics, we can resort to the SMEFT (assuming lepton and baryon number conservation)

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \frac{1}{\Lambda^2}\sum_i c_i^{(6)}\mathcal{O}_i^{(6)} + \frac{1}{\Lambda^4}\sum_j c_j^{(8)}\mathcal{O}_j^{(8)} + \cdots$$

For $\mathcal{A} \propto a_0\, g_{\rm SM} + a_1 \frac{C^{(6)}}{\Lambda^2} + a_2 \frac{C^{(8)}}{\Lambda^4} + \ldots$, it follows:

$$\sigma \propto |a_0\, g_{\rm SM}|^2 + \frac{2}{\Lambda^2}{\rm Re}[a_0\, a_1\, g_{\rm SM}\, C^{(6)}] + \frac{1}{\Lambda^4}\Big\{|a_1\, C^{(6)}|^2 + 2\,{\rm Re}[a_0\, a_2\, g_{\rm SM}\, C^{(8)}]\Big\} + \ldots$$

- The first non-trivial order, $1/\Lambda^2$, has seen a spectacular development in the last ~10 years

- But what about beyond that?
  - Why would we care? Aren't those pieces supposed to be suppressed?
  - In general, yes. Yet, it is known that $\mathcal{O}(1/\Lambda^4)$ may not be enough in some cases [Contino et al, 1604.06444] (e.g., light-by-light, neutral gauge couplings)
  - Also, the increasing precision of LHC data is requiring $\mathcal{O}(1/\Lambda^4)$ [Alioli et al, 2203.06771]
  - Both Drell-Yan and low-energy phenomena can be significantly affected by $\mathcal{O}(1/\Lambda^4)$ [Boughezal et al, 2106.05337, 2207.01703] [Mereghetti et al, 1305.7049] [Boughezal et al, 2104.03979]
  - $\mathcal{O}(1/\Lambda^4)$ effects can be crucial in the matching to particular UV models [Dawson et al, 2205.01561]

- What, then, has been done beyond $\mathcal{O}(1/\Lambda^2)$? [Snowmass, 2203.06771]

SMEFT beyond $1/\Lambda^2$

(from a theoretical perspective)

Bases

[Corbett et al, 2404.03720]
[Harlander, Kempkens, Schaaf, 2305.06832]
[Ren, Yu, 2211.01420]
[Li et al, 2201.04639]
[Chala, Díaz-Carmona, Guedes, 2112.12724]
[Liao, Ma, 2007.08125]
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[Liao, Ma, Wang, 2005.08013]
[Murphy, 2005.00059]
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...

RGE's and positivity

[Hong, Wang, Zhou, 2404.04479]
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geoSMEFT

[Martin, 2312.09867]
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Computational tools

[Harlander, Schaaf, 2309.15783]
[Dedes et al, 2302.01353]
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[Allwicher et al, 2207.10756]
[Carmona et al, 2112.10787]
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Other theoretical analyses

[Banerjee et al, 2311.12757]
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Matching to UV models

[Dawson, Forslund, Schnubel, 2404.01375]
[Corbett, 2405.04570]
[Cepedello et al, 2402.04306]
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Specific processes

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[Jahedi, 2305.11266]
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[Ellis, He, Xiao, 2206.11676]
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- Two complete & non-redundant dim-8 bases showed up in 2020, involving 44807 operators [Li et al, 2005.00008] [Murphy, 2005.00059]

$4: H^4D^4$	
$Q_{H^4}^{(1)}$	$(D_\mu H^\dagger D_\nu H)\,(D^\nu H^\dagger D^\mu H)$
$Q_{H^4}^{(2)}$	$(D_\mu H^\dagger D_\nu H)\,(D^\mu H^\dagger D^\nu H)$
$Q_{H^4}^{(3)}$	$(D^\mu H^\dagger D_\mu H)\,(D^\nu H^\dagger D_\nu H)$

[Murphy, 2005.00059]

- In 2023, bases up to dim-12 (!) appeared [Harlander, Kempkens, Schaaf, 2305.06832]

[Check Zhe Ren's talk]

- These are on-shell bases — the kind of basis used in physical calculations

[Check Javier López Miras's talk]

- For matching and running, however, it is convenient to work with off-shell quantities.
  The price to pay is that operators related by field redefinitions must be kept.
  A complete set of all such operators is a Green's basis, which appeared in 2022 [Ren, Yu, 2211.01420]
  Examples:

$$
\begin{aligned}
&H_iH^{\dagger i}D_\nu D^\mu D_\mu H_j D^\nu H^{\dagger j}, \quad && H_iH^{\dagger j}D_\mu H_j D^\nu D_\nu D^\mu H^{\dagger i},\\
&H_iH^{\dagger i}D_\mu H_j D^\nu D_\nu D^\mu H^{\dagger j}, \quad && H_iH^{\dagger j}D^\mu D_\mu H_j D^\nu D_\nu H^{\dagger i},\\
&H_iH^{\dagger i}D^\mu D_\mu H_j D^\nu D_\nu H^{\dagger j}, \quad && H_iH_jD^\mu D_\mu H^{\dagger i}D^\nu D_\nu H^{\dagger j},
\end{aligned}
$$

[Check Zhe Ren's talk]

- To reduce the EFT parameters, one may assume *universality*: BSM couples dominantly to SM bosons. At dim-6, this reduces 2499 ops. to 16. At dim-8, it reduces 44807 to 175.
  Recently, the SMEFT basis and relations implied by universality appeared [Corbett et al, 2404.03720]

- The RGEs for dim-8 operators are still not completely known. Yet, significant advances have been made, in part using a geometric approach

[Chala et al, 2106.05291] [Das Bakshi et al, 2205.03301] [Helset, Jenkins, Manohar, 2212.03253]
[Huber, De Angelis, 2108.03669] [Das Bakshi, Díaz-Carmona, 2301.07151] [Assi et al, 2307.03187]

	d_5	d_5^2	d_6	d_5^3	$d_5 \times d_6$	d_7	d_5^4	$d_5^2 \times d_6$	d_6^2	$d_5 \times d_7$	d_8
$d_{\leq 4}$ (bosonic)			✓						✓		✓ (orange)
$d_{\leq 4}$ (fermionic)			✓						X		X
d_5	✓				✓	✓					
d_6 (bosonic)		✓	✓					✓	✓	✓	✓ (orange)
d_6 (fermionic)		✓	✓					X	X	X	X
d_7				✓	✓	✓					
d_8 (bosonic)							✓	✓	✓	✓	✓ (orange)
d_8 (fermionic)							X	X	X	X	✓ (orange)

[courtesy of Supratim Das Bakshi]

Rows show the renormalised operators, while columns show the operators contributing to RG running. Blank entries vanish. ✓ denotes that the complete contribution is available, ✓ (orange) implies that only partial results are present, and X indicates that nothing, or very little, is known

- Dim-8 RGE have consequences for positivity bounds — constraints on the sign of WCs

  [Check Chia-Hsien Shen's talk] (from analiticity and unitarity of the S-matrix)

  For even if a certain bound holds at tree-level, $c_{H^4}^{(2)} > 0$, it is not scale-invariant. If $c_{H^4}^{(2)}(\Lambda) = 0$,

$$c_{H^4}^{(2)}(\mu) = \frac{1}{96\pi^2}\left[28c_{H^4}^{(1)}(\Lambda) + 15c_{H^4}^{(3)}(\Lambda)\right] g_2^2 \log\frac{\mu}{\Lambda} + \mathcal{O}\left(g_1^2, \lambda\right)$$

[Chala, Santiago, 2110.01624]

- Positivity may be probed experimentally. If $a_L(a_R)$ represents the $\gamma\gamma\bar{e}_L e_L\,(\gamma\gamma\bar{e}_R e_R)$ dim-8 int., the positivity bounds read simply: $a_L \geq 0, \quad a_R \geq 0$

  This might be checked at both lepton colliders and hadron colliders

- Positivity has been object of several recent studies

  ... [Chala, 2301.09995] [Chen et al, 2309.15922] [Chala, Li, 2309.16611]
  [Davighi et al, 2308.06226] [Yang, Ren, Yu, 2312.04663]
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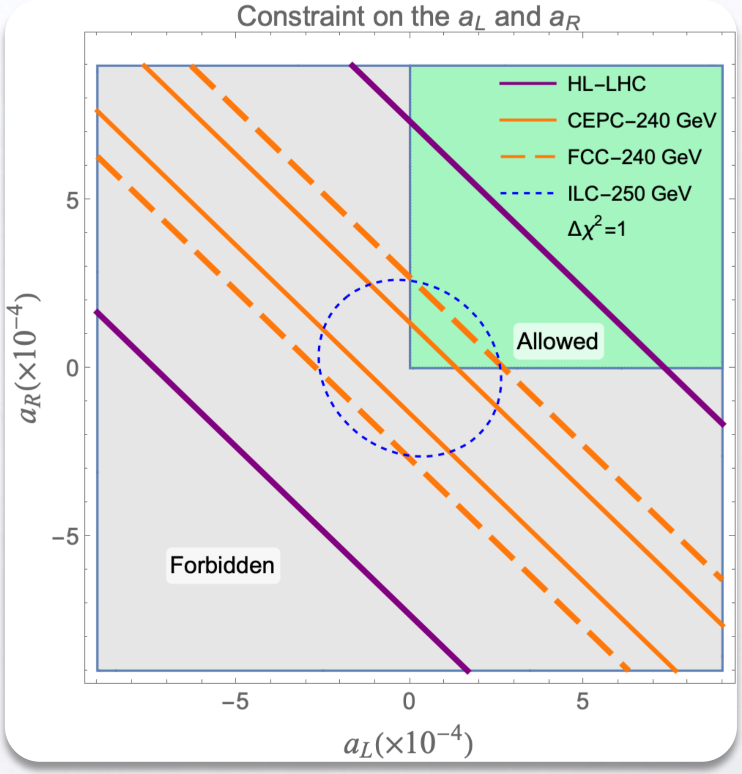


[Gu, Shu, 2311.07663]

- GeoSMEFT: SMEFT formulated to all orders in $\mathcal{O}(v/\Lambda)$ for 2- and 3-point functions
[Helset, Martin, Trott, 2001.01453]

- It exploits the fact that, for d>6, the # of ops. contributing to those Green's functions is small
E.g., for the kinetic term of the EW gauge bosons,

$$
\begin{aligned}
Q_{HB}^{(6+2n)} &= \left(H^\dagger H\right)^{n+1} B^{\mu\nu} B_{\mu\nu}, \\
Q_{HW}^{(6+2n)} &= \left(H^\dagger H\right)^{n+1} W_a^{\mu\nu} W_{\mu\nu}^a, \\
Q_{HWB}^{(6+2n)} &= \left(H^\dagger H\right)^{n} \left(H^\dagger \sigma^a H\right) W_a^{\mu\nu} B_{\mu\nu}, \\
Q_{HW,2}^{(8+2n)} &= \left(H^\dagger H\right)^{n} \left(H^\dagger \sigma^a H\right) \left(H^\dagger \sigma^b H\right) W_a^{\mu\nu} W_{b,\mu\nu},
\end{aligned}
$$

Then, all SMEFT effects can be lumped into a 'metric' $g_{AB}(\phi) W^A_{\mu\nu} W^{B,\mu\nu}$

- This leads to compact formulae, which simplify the study of $\mathcal{O}(1/\Lambda^4)$ effects

- GeoSMEFT has been applied to several Higgs production and decay modes at $\mathcal{O}(1/\Lambda^4)$:

$$gg \to h, \quad h \to gg, \quad h \to \gamma\gamma, \quad h \to \bar{\psi}\psi, \quad \ldots$$

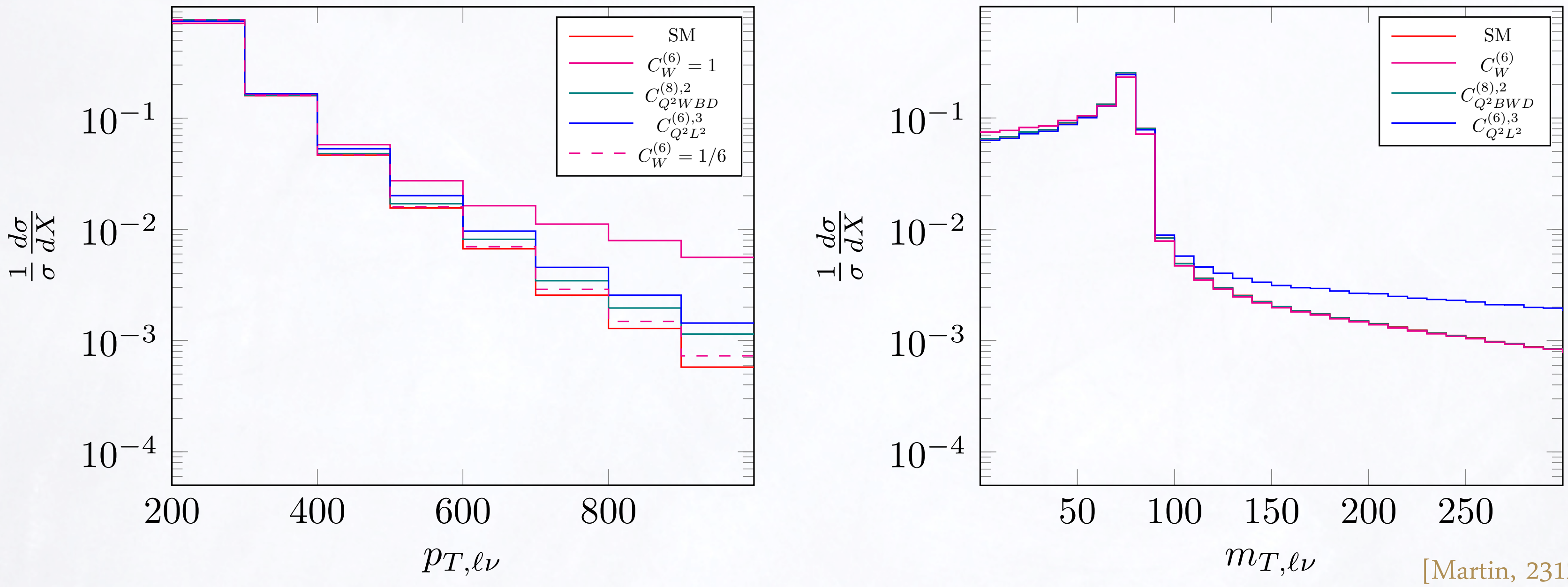
[Corbett, Martin, Trott, 2107.07470]
[Martin, Trott, 2305.05879]

- Other processes have also been investigated

  Example: $pp \to W^{\pm}\,(\ell^{\pm}\nu)\,\gamma$

$pp \to \ell^{\pm}\nu$ [Kim, Martin, 2203.11976]

$pp \to W^{\pm}\,(\ell^{\pm}\nu)\,\gamma$ [Martin, 2312.09867]



[Martin, 2312.09867]

Λ = 3 TeV with the displayed coefficient set to ±1 (unless otherwise specified), and all other Wilson coefficients set to zero. X on the vertical axis refers to the kinematic quantity on the horizontal axis

$$
\begin{aligned}
C_W^{(6)} &: \quad \epsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu} \\
C_{\psi^2 BWD}^{(8),2} &: \quad \epsilon_{IJK} \left(\psi^\dagger \bar{\sigma}^\mu \overleftrightarrow{D}^\nu \tau^I \psi\right) B_{\mu\rho}^J W_{\nu\rho}^K \\
C_{Q^2L^2}^{(6),3} &: \quad (Q^\dagger \bar{\sigma}^\mu \tau^I Q)\,(L^\dagger \bar{\sigma}_\mu \tau^I L)
\end{aligned}
$$

- Several computational tools have contributed to the study of dim-8 effects. Some examples:
(check [Aebischer et al, 2307.08745])

  - SmeftFR v3: generates (bosonic) Feynman rules up to dim-8 [Dedes et al, 2302.01353]

  - Matchete: allows the matching to UV models, using functional methods [Fuentes-Martin et al, 2212.04510]
    [Check Javier Fuentes-Martin's talk]

  - MatchMakerEFT: allows the matching to UV models, using a diagrammatic method
    [Carmona et al, 2112.10787]
    [Check Pablo Olgoso's talk]

  - ABC4EFT: provides a procedure to construct complete operator bases [Li et al, 2201.04639]
    [Check Zhe Ren's talk]

  - AutoEFT: builds an on-shell operator basis for general EFTs and arbitrary mass dimension
    [Harlander, Schaaf, 2309.15783]

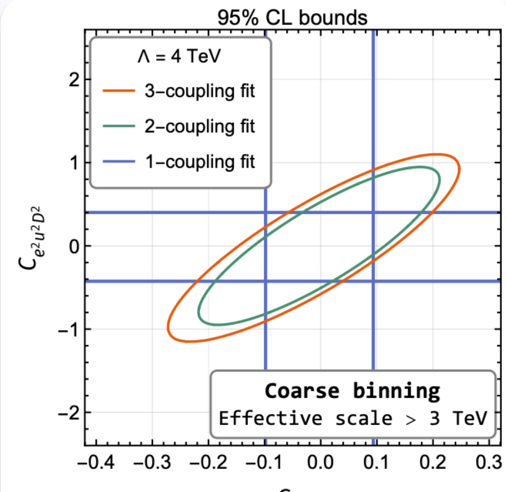
  - HighPT: allows to compute Drell-Yan cross sections with a consistent expansion up to $\mathcal{O}(1/\Lambda^4)$
    [Allwicher et al, 2207.10756]
    [Check also Chang-Yuan Yao's talk]

- Contribution of dim-8 effects to phenomenology have been explored in several specific processes, so as to constrain Wilson coefficients. Some examples:

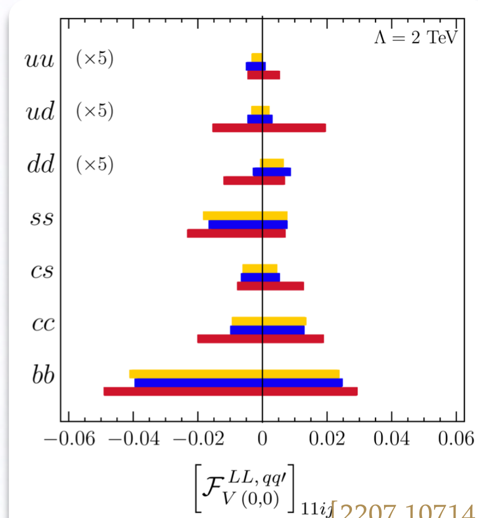
  - **Drell-Yan**

    [Alioli et al, 2003.11615] [Boughezal, Mereghetti, Petriello, 2106.05337] [Boughezal, Huang, Petriello, 2207.01703] [Allwicher et al, 2207.10714]

$$\mathcal{O}^{(1)}_{e^2u^2D^2} \;:\; D^{\nu}\left(\bar{e}\gamma^{\mu}e\right) D_{\nu}\left(\bar{u}\gamma_{\mu}u\right)$$
$$\mathcal{O}_{eu} \;:\; \left(\bar{e}\gamma^{\mu}e\right)\left(\bar{u}\gamma_{\mu}u\right)$$



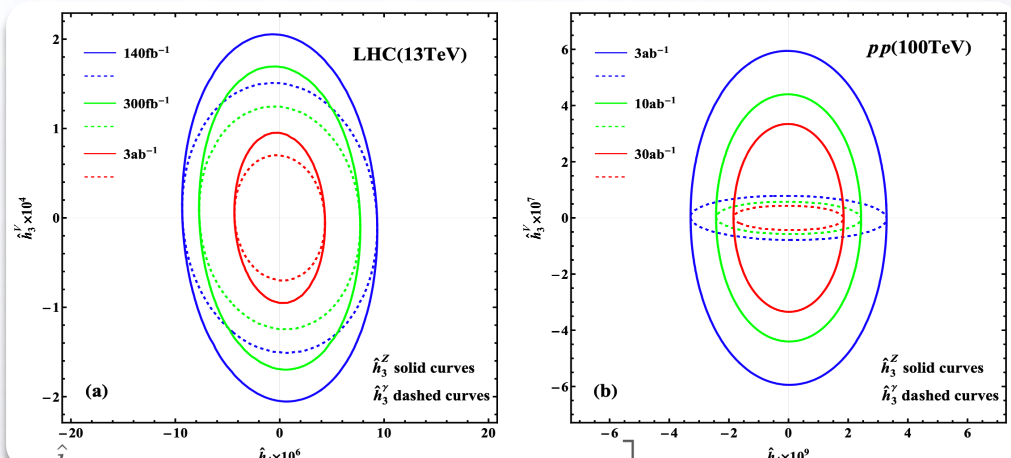
[2207.01703]



[2207.10714]

  - **Neutral triple gauge couplings**

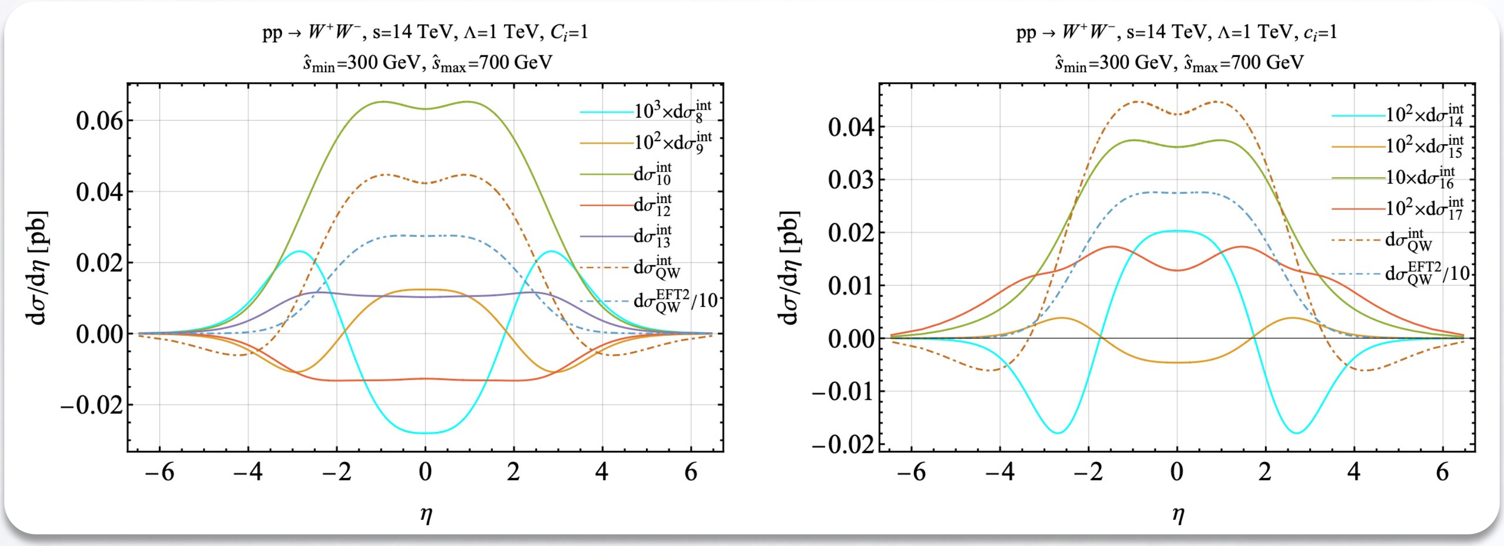
    [Ellis, He, Xiao, 2206.11676] [Corbett et al, 2304.03305] [Jahedi, 2305.11266] [Ellis, He, Xiao, 2308.16887] [Liu et al, 2404.15937]



$$\Gamma^{\alpha\beta\mu}_{Z^*\gamma Z^*}\left(q_1,q_2,q_3\right) = \frac{e\left(q_3^2-q_1^2\right)}{M_Z^2}\left[\hat{h}_3^Z q_{2\nu}\epsilon^{\alpha\beta\mu\nu} + \frac{\hat{h}_4}{2M_Z^2}\left(2q_2^{\alpha}q_{3\nu}q_{2\sigma}\epsilon^{\beta\mu\nu\sigma} + q_3^2 q_{2\nu}\epsilon^{\alpha\beta\mu\nu}\right)\right].$$

[2308.16887]

Diboson production



[Degrande, Li, 2303.10493]

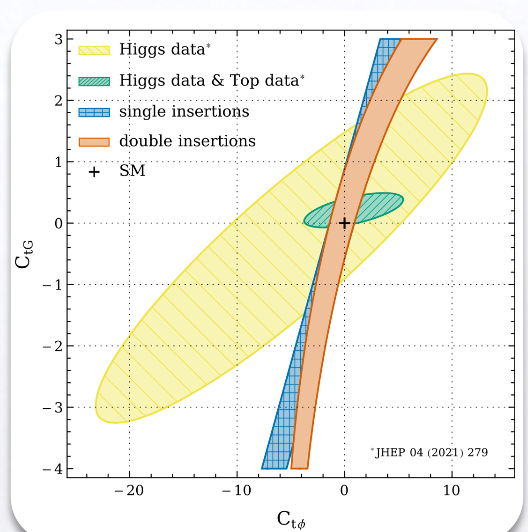
(following [Degrande, 1308.6323])

Higgs productions and decays

[Asteriadis, Dawson, DF, 2212.03258]

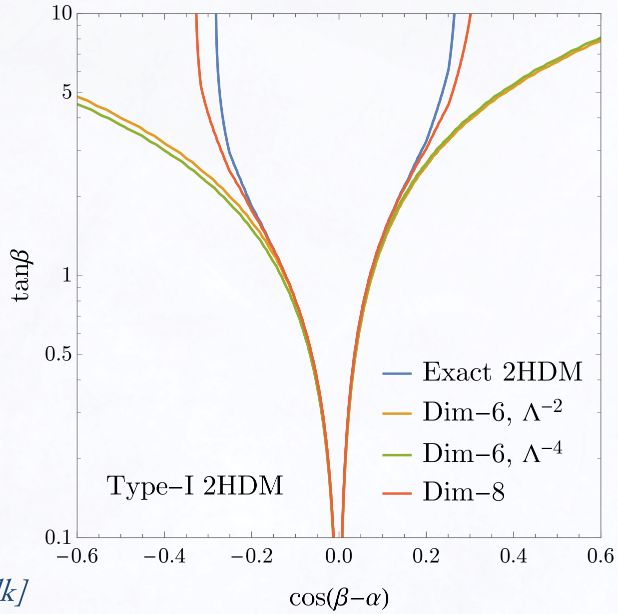
[Grojean et al, 2405.20371]

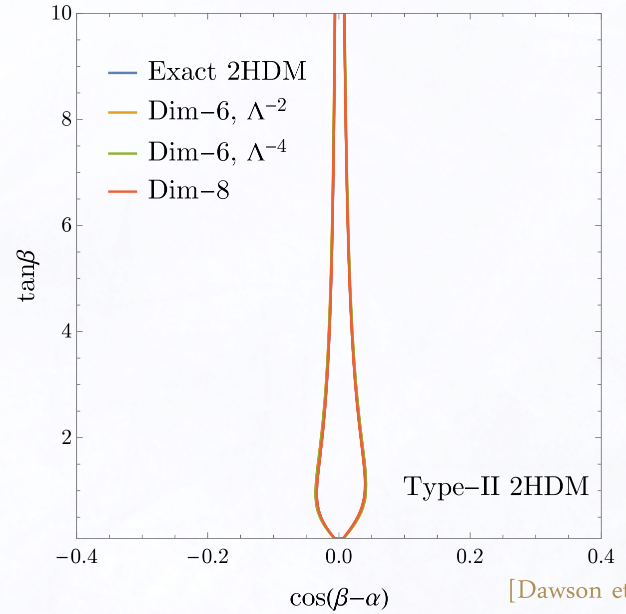
[Check Guilherme Guedes's talk]



[Asteriadis, Dawson, DF, 2212.03258]

- $\mathcal{O}(1/\Lambda^4)$ effects have been studied in the matching between the SMEFT and UV-models. Exs:
  - 2HDM:

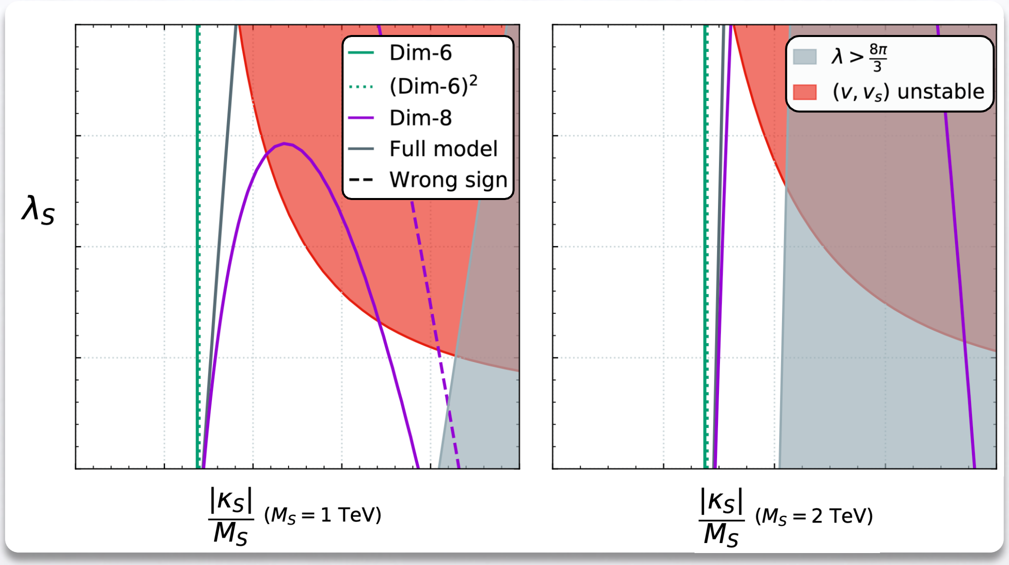




[Check Sally Dawson's talk]

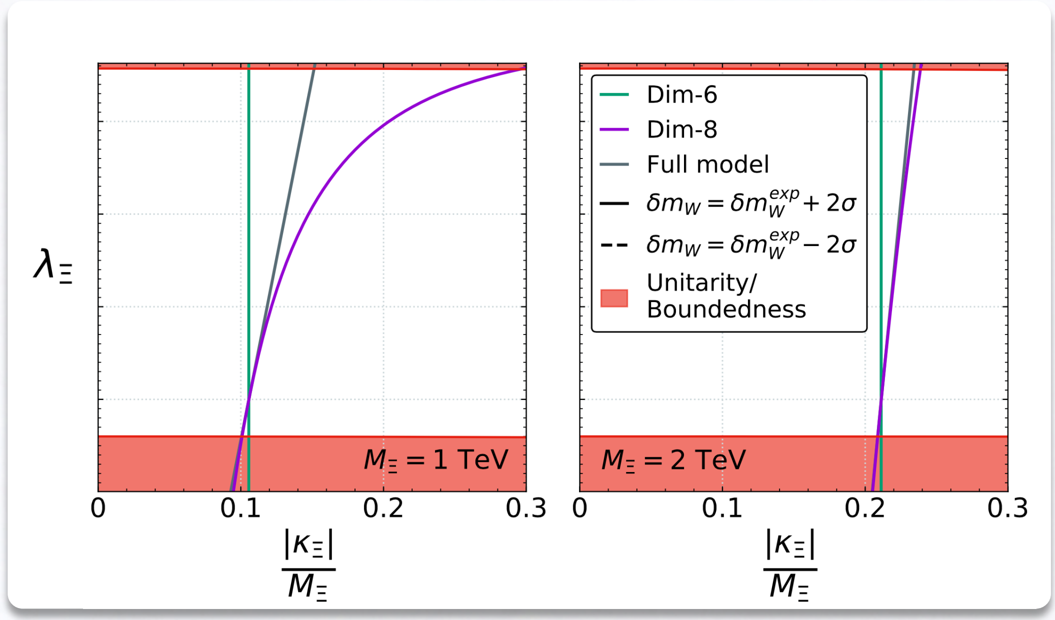
[Dawson et al, 2205.01561]

  - Real singlet extension:



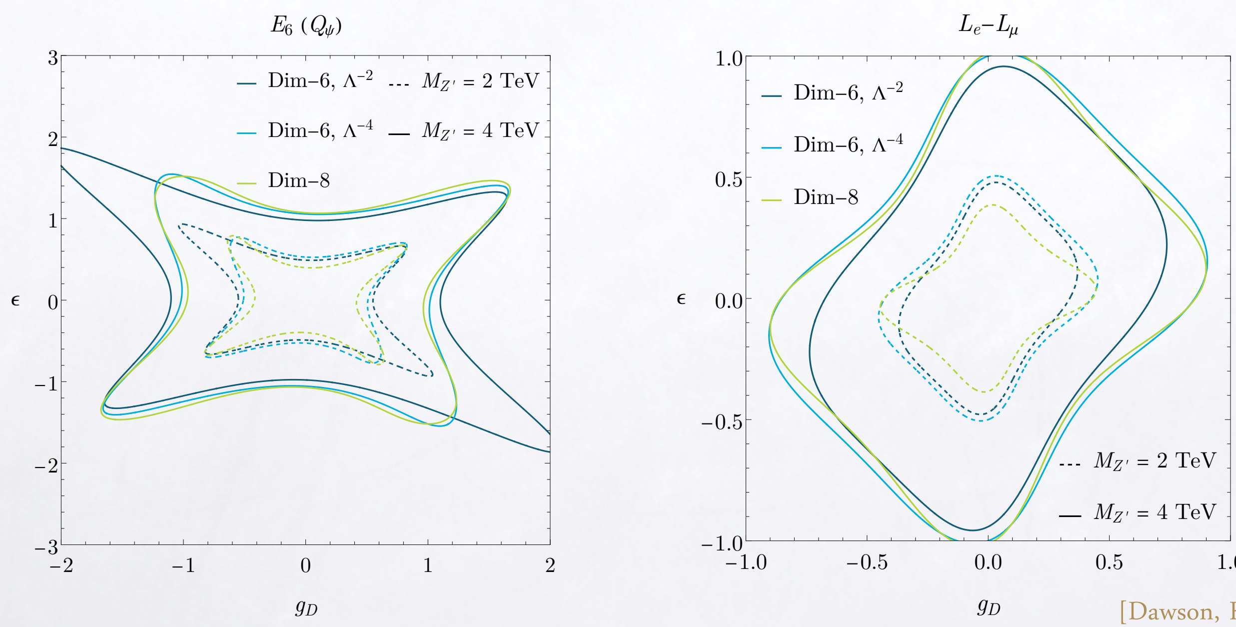
[Ellis, Mimasu, Zampedri, 2304.06663]

- Real triplet extension:



[Ellis, Mimasu, Zampedri, 2304.06663]

- Z':

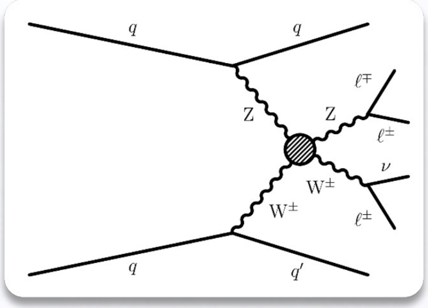


[Check Sally Dawson's talk]

[Dawson, Forslund, Schnubel, 2404.01375]

- Other directions have been explored in the context of dim-8 effects in the SMEFT. Exs:
  - Find all possible UV origins of dim-8 operators in a bottom-up approach, using J-basis of effective operators and Young tensor method [Li et al, 2204.03660, 2309.15933]
  - Study the universal one-loop effective action up to dim-8 using the Heat-Kernel method [Banerjee et al, 2311.12757] [Chakrabortty et al, 2308.03849] [Banerjee, 2306.09103]
  - Explore alternative power countings, whose lower order includes dim-8 effects of the decoupling power counting [Banta et al, 2304.09884]

- What about experiment?
  - Contraints on dim-8 WCs have been been made at the LHC since 2020
  - One avenue is to use vector boson scattering analyses, since dim-8 is the LO in which operators can modify quartic gauge couplings without modifying triple gauge couplings
  - They tend to resort to the following parametrization:



[Eboli, Gonzalez-Garcia, Mizukoshi, hep-ph/0606118]

$$\begin{aligned}
\mathcal{L}_{S,0} &= \left[(D_\mu\Phi)^\dagger D_\nu\Phi\right] \times \left[(D^\mu\Phi)^\dagger D^\nu\Phi\right] \\
\mathcal{L}_{S,1} &= \left[(D_\mu\Phi)^\dagger D^\mu\Phi\right] \times \left[(D_\nu\Phi)^\dagger D^\nu\Phi\right]
\end{aligned}$$

$$\begin{aligned}
\mathcal{L}_{M,0} &= \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right] \\
\mathcal{L}_{M,1} &= \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right] \\
\mathcal{L}_{M,2} &= \left[B_{\mu\nu}B^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right] \\
\mathcal{L}_{M,3} &= \left[B_{\mu\nu}B^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right] \\
\mathcal{L}_{M,4} &= \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu} D^\mu\Phi\right] \times B^{\beta\nu} \\
\mathcal{L}_{M,5} &= \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu} D^\nu\Phi\right] \times B^{\beta\mu} \\
\mathcal{L}_{M,6} &= \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\nu} D^\mu\Phi\right] \\
\mathcal{L}_{M,7} &= \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\mu} D^\nu\Phi\right]
\end{aligned}$$

$$\begin{aligned}
\mathcal{L}_{T,0} &= \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}\right] \times \mathrm{Tr}\left[\hat{W}_{\alpha\beta}\hat{W}^{\alpha\beta}\right] \\
\mathcal{L}_{T,1} &= \mathrm{Tr}\left[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}\right] \times \mathrm{Tr}\left[\hat{W}_{\mu\beta}\hat{W}^{\alpha\nu}\right] \\
\mathcal{L}_{T,2} &= \mathrm{Tr}\left[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}\right] \times \mathrm{Tr}\left[\hat{W}_{\beta\nu}\hat{W}^{\nu\alpha}\right] \\
\mathcal{L}_{T,3} &= \mathrm{Tr}\left[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}\hat{W}^{\nu\alpha}\right] \times B_{\beta\nu} \\
\mathcal{L}_{T,4} &= \mathrm{Tr}\left[\hat{W}_{\alpha\mu}\hat{W}^{\alpha\mu}\hat{W}^{\beta\nu}\right] \times B_{\beta\nu} \\
\mathcal{L}_{T,5} &= \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}\right] \times B_{\alpha\beta}B^{\alpha\beta} \\
\mathcal{L}_{T,6} &= \mathrm{Tr}\left[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}\right] \times B_{\mu\beta}B^{\alpha\nu} \\
\mathcal{L}_{T,7} &= \mathrm{Tr}\left[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}\right] \times B_{\beta\nu}B^{\nu\alpha} \\
\mathcal{L}_{T,8} &= B_{\mu\nu}B^{\mu\nu}B_{\alpha\beta}B^{\alpha\beta} \\
\mathcal{L}_{T,9} &= B_{\alpha\mu}B^{\mu\beta}B_{\beta\nu}B^{\nu\alpha}
\end{aligned}$$

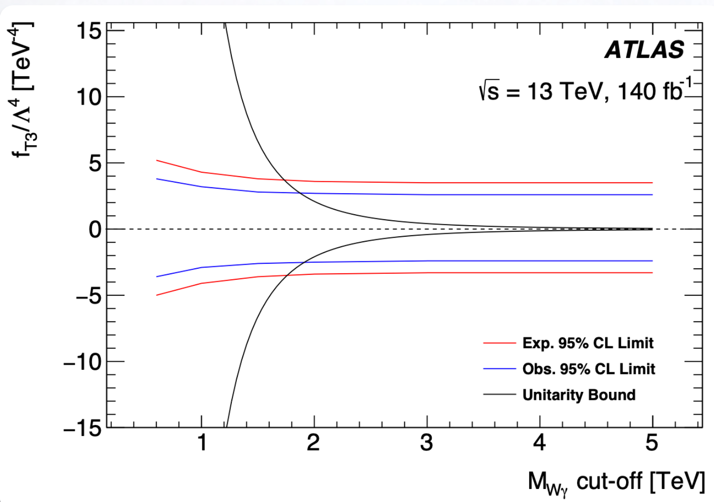
Expected limit	Observed limit	U_{bound}
$-5.1 < f_{M,0}/\Lambda^4 < 5.1$	$-5.6 < f_{M,0}/\Lambda^4 < 5.5$	1.7
$-7.1 < f_{M,1}/\Lambda^4 < 7.4$	$-7.8 < f_{M,1}/\Lambda^4 < 8.1$	2.1
$-1.8 < f_{M,2}/\Lambda^4 < 1.8$	$-1.9 < f_{M,2}/\Lambda^4 < 1.9$	2.0
$-2.5 < f_{M,3}/\Lambda^4 < 2.5$	$-2.7 < f_{M,3}/\Lambda^4 < 2.7$	2.7
$-3.3 < f_{M,4}/\Lambda^4 < 3.3$	$-3.7 < f_{M,4}/\Lambda^4 < 3.6$	2.3
$-3.4 < f_{M,5}/\Lambda^4 < 3.6$	$-3.9 < f_{M,5}/\Lambda^4 < 3.9$	2.7
$-13 < f_{M,7}/\Lambda^4 < 13$	$-14 < f_{M7}/\Lambda^4 < 14$	2.2
$-0.43 < f_{T,0}/\Lambda^4 < 0.51$	$-0.47 < f_{T,0}/\Lambda^4 < 0.51$	1.9
$-0.27 < f_{T,1}/\Lambda^4 < 0.31$	$-0.31 < f_{T,1}/\Lambda^4 < 0.34$	2.5
$-0.72 < f_{T,2}/\Lambda^4 < 0.92$	$-0.85 < f_{T,2}/\Lambda^4 < 1.0$	2.3
$-0.29 < f_{T,5}/\Lambda^4 < 0.31$	$-0.31 < f_{T,5}/\Lambda^4 < 0.33$	2.6
$-0.23 < f_{T,6}/\Lambda^4 < 0.25$	$-0.25 < f_{T,6}/\Lambda^4 < 0.27$	2.9
$-0.60 < f_{T,7}/\Lambda^4 < 0.68$	$-0.67 < f_{T,7}/\Lambda^4 < 0.73$	3.1

[CMS, 2212.12592]

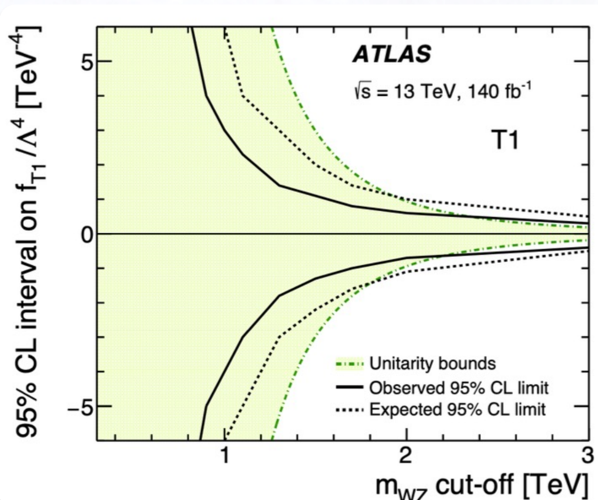
Coefficients [TeV^{-4}]	Observable	Expected [TeV^{-4}]	Observed [TeV^{-4}]
f_{T0}/Λ^4	p_T^{jj}	[-2.4, 2.4]	[-1.8, 1.8]
f_{T1}/Λ^4	p_T^{jj}	[-1.5, 1.6]	[-1.1, 1.2]
f_{T2}/Λ^4	p_T^{jj}	[-4.4, 4.7]	[-3.1, 3.5]
f_{T3}/Λ^4	p_T^{jj}	[-3.3, 3.5]	[-2.4, 2.6]
f_{T4}/Λ^4	p_T^{jj}	[-3.0, 3.0]	[-2.2, 2.2]
f_{T5}/Λ^4	p_T^{jj}	[-1.7, 1.7]	[-1.2, 1.3]
f_{T6}/Λ^4	p_T^{jj}	[-1.5, 1.5]	[-1.0, 1.1]
f_{T7}/Λ^4	p_T^{jj}	[-3.8, 3.9]	[-2.7, 2.8]
f_{M0}/Λ^4	p_T^{l}	[-28, 28]	[-24, 24]
f_{M1}/Λ^4	p_T^{l}	[-43, 44]	[-37, 38]
f_{M2}/Λ^4	p_T^{l}	[-10, 10]	[-8.6, 8.5]
f_{M3}/Λ^4	p_T^{l}	[-16, 16]	[-13, 14]
f_{M4}/Λ^4	p_T^{l}	[-18, 18]	[-15, 15]
f_{M5}/Λ^4	p_T^{l}	[-17, 14]	[-14, 12]
f_{M7}/Λ^4	p_T^{l}	[-78, 77]	[-66, 65]

New!

[ATLAS, 2403.02809]



[ATLAS, 2403.02809]



[ATLAS, 2403.15296]

- I discussed recent developments of dim-8 effects in the SMEFT
- On-shell bases are available up to dim-12 operators; off-shell bases up to dim-8
- The RGEs for dim-8 are still not completely known, but great progress has already been made
- Dim-8 RGE lead to positivity bounds, which have been studied and can be measured
- GeoSMEFT leads to compact formulae, and has been used for several processes
- Several computational tools have been published (and updated) to study dim-8 effects
- Specific processes have been used to constrain EFT coefficients. Dim-8 can be relevant!
- Matching to particular UV-models has been explored in several cases. Dim-8 can be relevant!
- Other theoretical analyses provide insights about dim-8
- The LHC has been constraining dim-8 WCs via quartic gauge couplings