

EFT News from Theory

Eleni Vryonidou
University of Cyprus



University
of Cyprus



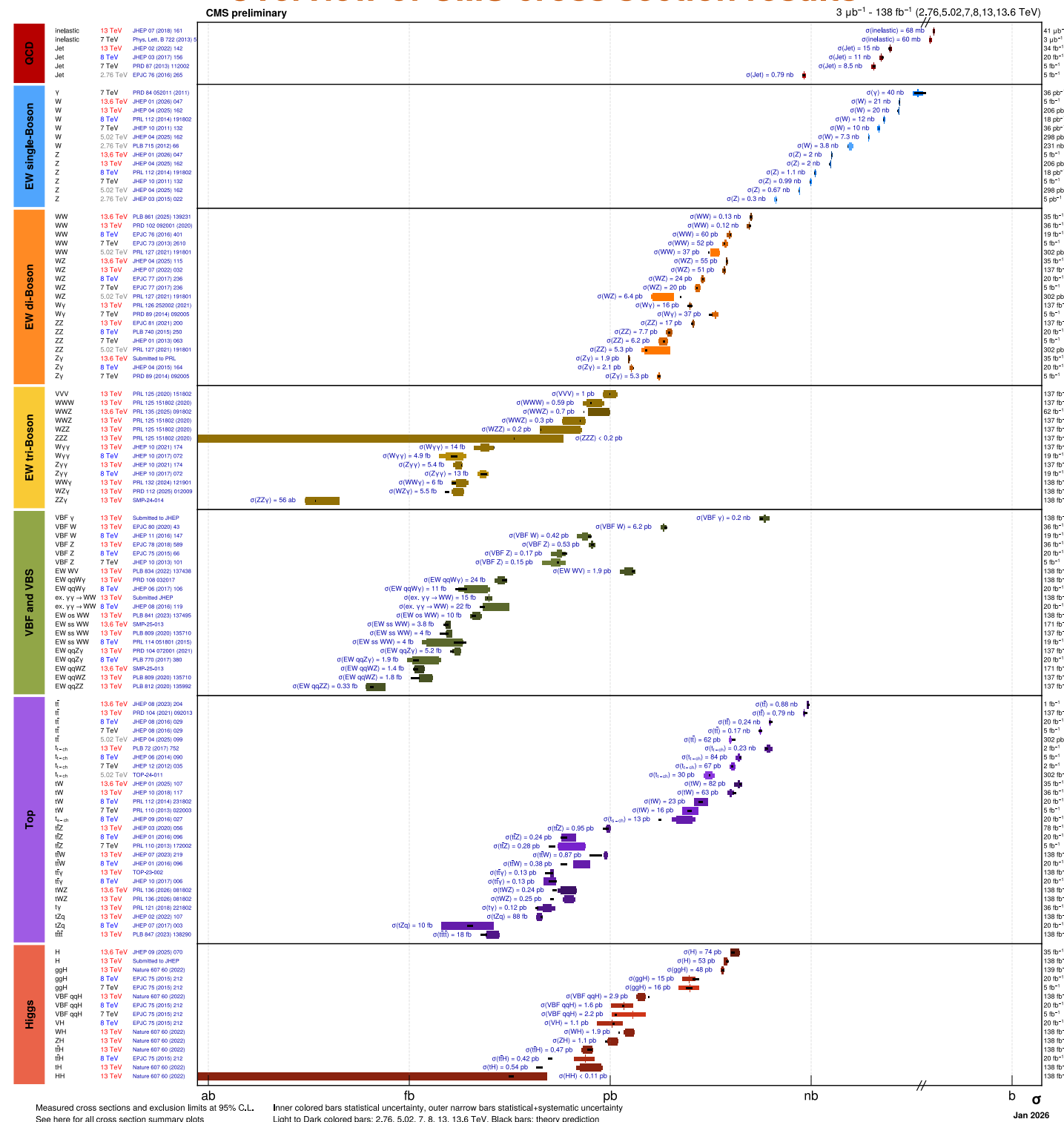
European Research Council
Established by the European Commission

Higgs Hunting
Paris, 17/9/2026

LHC: the story so far

Rediscovering the SM

Overview of CMS cross section results



Measured cross sections and exclusion limits at 95% CL.
See here for all cross section summary plots.

Inner colored bars statistical uncertainty, outer narrow bars statistical+systematic uncertainty
Light to Dark colored bars: 2,76, 5,02, 7, 8, 13, 13.6 TeV. Black bars: theory prediction

Jan 2026

Searching for the unknown

ATLAS Heavy Particle Searches* - 95% CL Upper Exclusion Limits

Status: Spring 2026

ATLAS Preliminary
 $\int \mathcal{L} dt = (3.6 - 195) \text{ fb}^{-1}$
 $\sqrt{s} = 13, 13.6 \text{ TeV}$

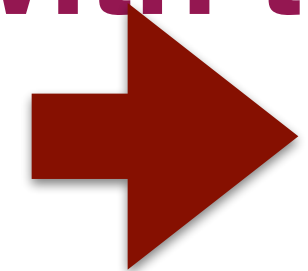
	Model	ℓ, γ	Jets [†]	E_{miss}^T	$E_{\text{miss}}^T [\text{fb}^{-1}]$	Limit	Reference
Extra dimen.	ADD $G_{KK} + g/q$	$0 e, \mu, \tau, \gamma$	$1 - 4 j$	Yes	139	M_D	2102.10874
	ADD non-resonant $\gamma\gamma$	2γ	—	—	36.7	M_{S}^2	1707.04147
	ADD OBH	$1 e, \mu$	$2 j$	—	139	M_{BH}	1910.08447
	ADD OBH	$1 e, \mu$	$1 j$	—	165	M_{BH}	2604.19495
Gauge bosons	ADD BH multijet	$1 e, \mu$	$\geq 3 j$	—	3.6	M_{BH}	1512.02586
	RS1 $G_{KK} \rightarrow \gamma\gamma$	2γ	—	—	139	$G_{KK} \text{ mass}$	2102.13405
	Bulk RS $G_{KK} \rightarrow WW/ZZ$	multi-channel	$1 e, \mu, \tau, \gamma, \geq 1 b, \geq 1 J/4 j$	Yes	36.1	$G_{KK} \text{ mass}$	1808.02380
	ZUED / RPP	$1 e, \mu$	$\geq 2 b, \geq 3 j$	Yes	36.1	$G_{KK} \text{ mass}$	2512.17856
CI	SSM $Z' \rightarrow \ell\ell$	$2 e, \mu$	—	—	139	$Z' \text{ mass}$	1903.06248
	SSM $Z' \rightarrow \tau\tau$	2τ	—	—	36.1	$Z' \text{ mass}$	1709.07242
	Leptophobic $Z' \rightarrow bb$	$0 e, \mu$	$\geq 1 b, \geq 2 J$	Yes	139	$Z' \text{ mass}$	1805.09299
	Leptophobic $Z' \rightarrow tt$	$1 e, \mu$	$\geq 1 b, \geq 2 J$	Yes	139	$Z' \text{ mass}$	2005.05138
DM	SSM $W' \rightarrow \ell\nu$	$1 e, \mu$	—	—	139	$W' \text{ mass}$	1906.05509
	SSM $W' \rightarrow \tau\nu$	1τ	—	—	139	$W' \text{ mass}$	2402.16576
	SSM $W' \rightarrow tb$	$0-1 e, \mu$	$0-1 b, \geq 1 J \text{ Yes}(1/)$	Yes	139	$W' \text{ mass}$	2308.08521
	HVT $W' \rightarrow WZ$ model B	$2 j/1 J$	—	—	139	$W' \text{ mass}$	2004.14636
LQ	HVT $W' \rightarrow WZ$ model C	$2 j/1 J$	—	—	139	$W' \text{ mass}$	2207.03025
	LQSM $W_R \rightarrow \mu N_R$	$1 e, \mu$	$2 j/1 J$	Yes	139	$Z' \text{ mass}$	2004.14636
	LQSM $W_R \rightarrow \mu N_R$	2μ	$1 J$	—	139	$W_R \text{ mass}$	2304.09553
	LQSM $W_R \rightarrow \mu N_R$	2μ	$1 J$	—	139	$W_R \text{ mass}$	2304.09553
Vector-like fermions	CI $q\bar{q}q\bar{q}$	—	$2 j$	—	37.0	A	1703.09127
	CI $\ell\ell q\bar{q}$	$2 e, \mu$	—	—	139	A	2006.12946
	CI $e\bar{e}b\bar{b}$	$2 e$	$1 b$	—	139	A	2105.13847
	CI $\mu\bar{\mu}b\bar{b}$	2μ	$1 b$	—	139	A	2105.13847
Excld. term.	CI $t\bar{t}t\bar{t}$	$\geq 1 e, \mu$	$\geq 1 b, \geq 1 j$	Yes	36.1	A	1811.02305
	Axial-vector med. (Dirac DM)	—	$2 j$	—	139	A	1703.09127
	Pseudo-scalar med. (Dirac DM)	$0 e, \mu, \tau, \gamma$	$1 - 4 j$	Yes	139	A	2006.12946
	Vector med. Z' -2HDM (Dirac DM)	$0 e, \mu$	$2 b$	Yes	139	A	2105.13847
Other	Pseudo-scalar med. 2HDM+a	multi-channel	—	—	139	A	2105.13847
	Scalar LQ 1 st gen	$1 e$	$\geq 1 j$	Yes	140.55	A	2105.13847
	Scalar LQ 2 nd gen	1μ	$\geq 1 j$	Yes	140.55	A	2105.13847
	Scalar LQ 3 rd gen	$0 e, \mu$	$\geq 2 j, \geq 2 b$	Yes	139	A	2105.13847
Higgs	Scalar LQ 3 rd gen	$\geq 2 e, \mu, \geq 1 \tau$	$\geq 1 j, \geq 1 b$	Yes	139	A	2105.13847
	Scalar LQ 3 rd gen	$0 e, \mu, \geq 1 \tau$	$0 - 2 j, 2 b$	Yes	139	A	2105.13847
	Scalar LQ 3 rd gen	$\geq 2 e, \mu, \tau$	—	—	140	A	2105.13847
	Scalar LQ mix gen	$1 e$	$\geq 1 j, \geq 1 j, \geq 1 b$	Yes	140.55	A	2105.13847
Higgs	Vector LQ mix gen	$1 e, \mu$	$\geq 1 j, \geq 1 b$	Yes	139	A	2105.13847
	Vector LQ 3 rd gen	multi-channel	Yes	Yes	139	A	2105.13847
	Vector LQ mix gen	1τ	$\geq 1 j, \geq 1 b$	Yes	140	A	2105.13847
	Vector LQ 3 rd gen	multi-channel	$\geq 1 j, \geq 1 b$	Yes	139	A	2105.13847
Higgs	VLL $\tau^+ \rightarrow Z\tau/H\tau$	$1 e, \mu$	$\geq 5 j, \geq 2 b$	Yes	139	A	2105.13847
	VLL $\mu^+ \rightarrow Z\mu/H\mu$	multi-channel	—	—	140	A	2105.13847
	VLL $e^+ \rightarrow Ze/H e$	multi-channel	—	—	140	A	2105.13847
	VLL $e^+ \rightarrow Ze/H e$	multi-channel	—	—	140	A	2105.13847
Higgs	Excited quark $q^* \rightarrow qg$	—	$2 j$	—	139	A	2105.13847
	Excited quark $q^* \rightarrow q\gamma$	1γ	$1 j$	—	36.7	A	2105.13847
	Excited quark $b^* \rightarrow bg$	—	$1 b, 1 j$	—	139	A	2105.13847
	Excited lepton $\tau^* \rightarrow \tau g$	2τ	$\geq 2 j$	—	139	A	2105.13847
Higgs	Type III Seesaw	$2,3,4 e, \mu$	$\geq 2 j$	Yes	139	A	2105.13847
	LRSM Majorana ν	2μ	$2 j/1 J$	Yes	139	A	2105.13847
	Higgs triplet $H^{\pm\pm} \rightarrow W^{\pm} W^{\pm}$	$2,3,4 e, \mu$ (SS)	various	Yes	139	A	2105.13847
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	$2,3,4 e, \mu$ (SS)	various	Yes	139	A	2105.13847
Higgs	Multi-charged particles	—	—	—	139	A	2105.13847
	Magnetic monopoles	—	—	—	138	A	2105.13847
	Magnetic monopoles	—	—	—	138	A	2105.13847
	Magnetic monopoles	—	—	—	138	A	2105.13847
Higgs	$\sqrt{s} = 13 \text{ TeV}$ partial data	$\sqrt{s} = 13 \text{ TeV}$ full data	$\sqrt{s} = 13.6 \text{ TeV}$ partial data	$\sqrt{s} = 13, 13.6 \text{ TeV}$ combined data	10 ⁻¹	1	10
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*Only a selection of the available mass limits on new states or phenomena is shown.

[†] Small-radius (large-radius) jets are denoted by the letter j (J).

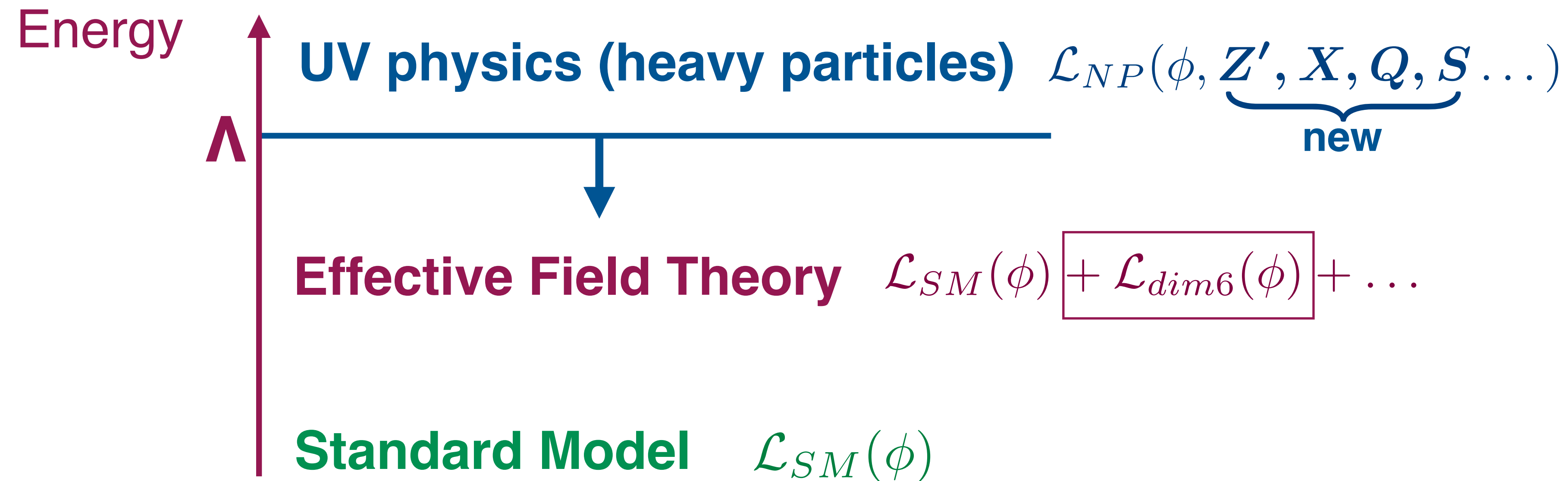
Good agreement with the SM predictions

No sign of new light particles



SMEFT opens new directions

Effective Field Theory

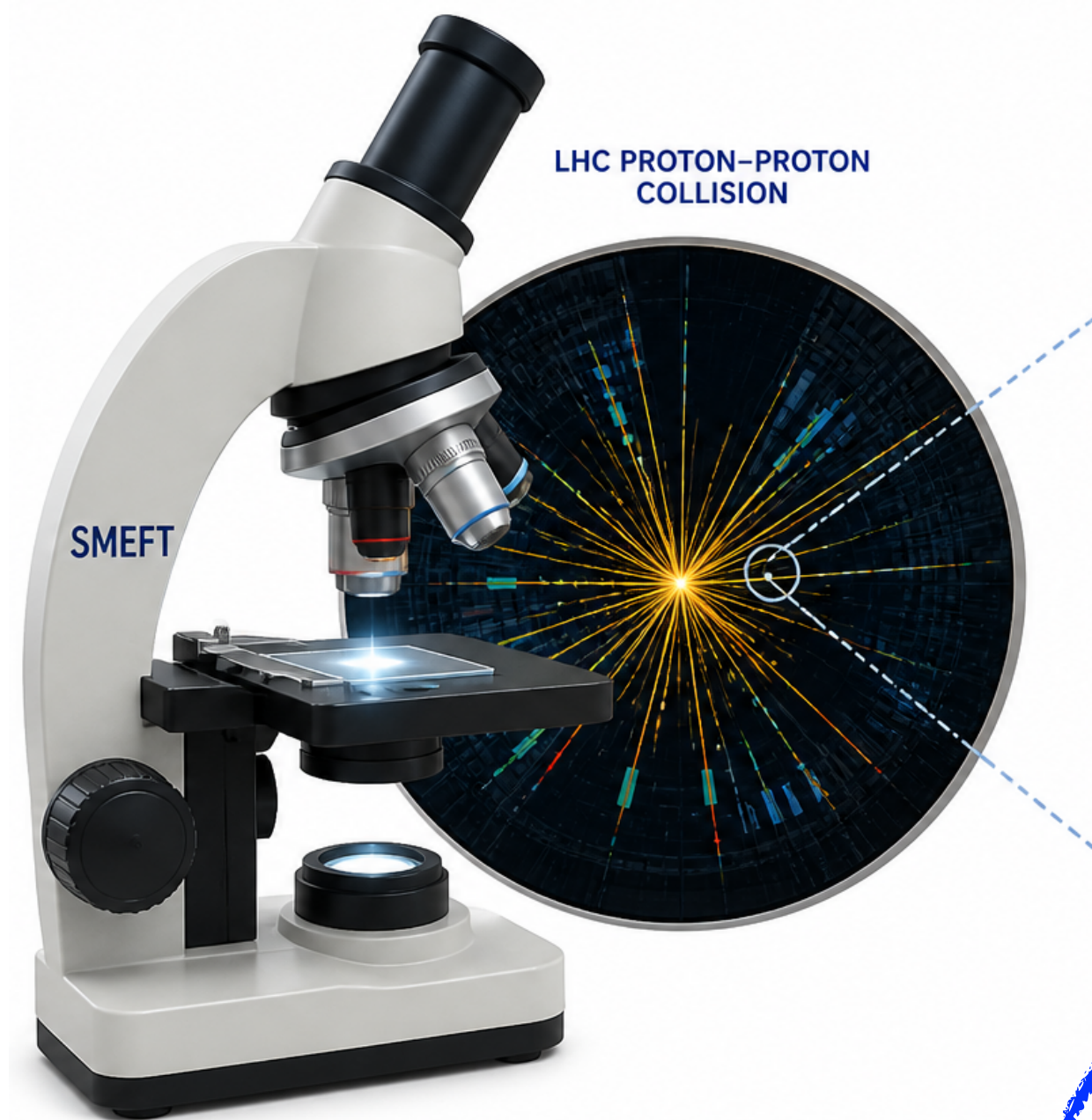


Effective Field Theory reveals **high energy** physics **through precise low-energy measurements**.

SMEFT assumptions: Heavy New Physics and Standard Model Symmetries

EFT pathway to New Physics

$$\Delta\text{Obs}_n = \text{Obs}_n^{\text{EXP}} - \text{Obs}_n^{\text{SM}} = \frac{1}{\Lambda^2} \sum_i c_i^6(\mu) a_{n,i}^6(\mu) + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$

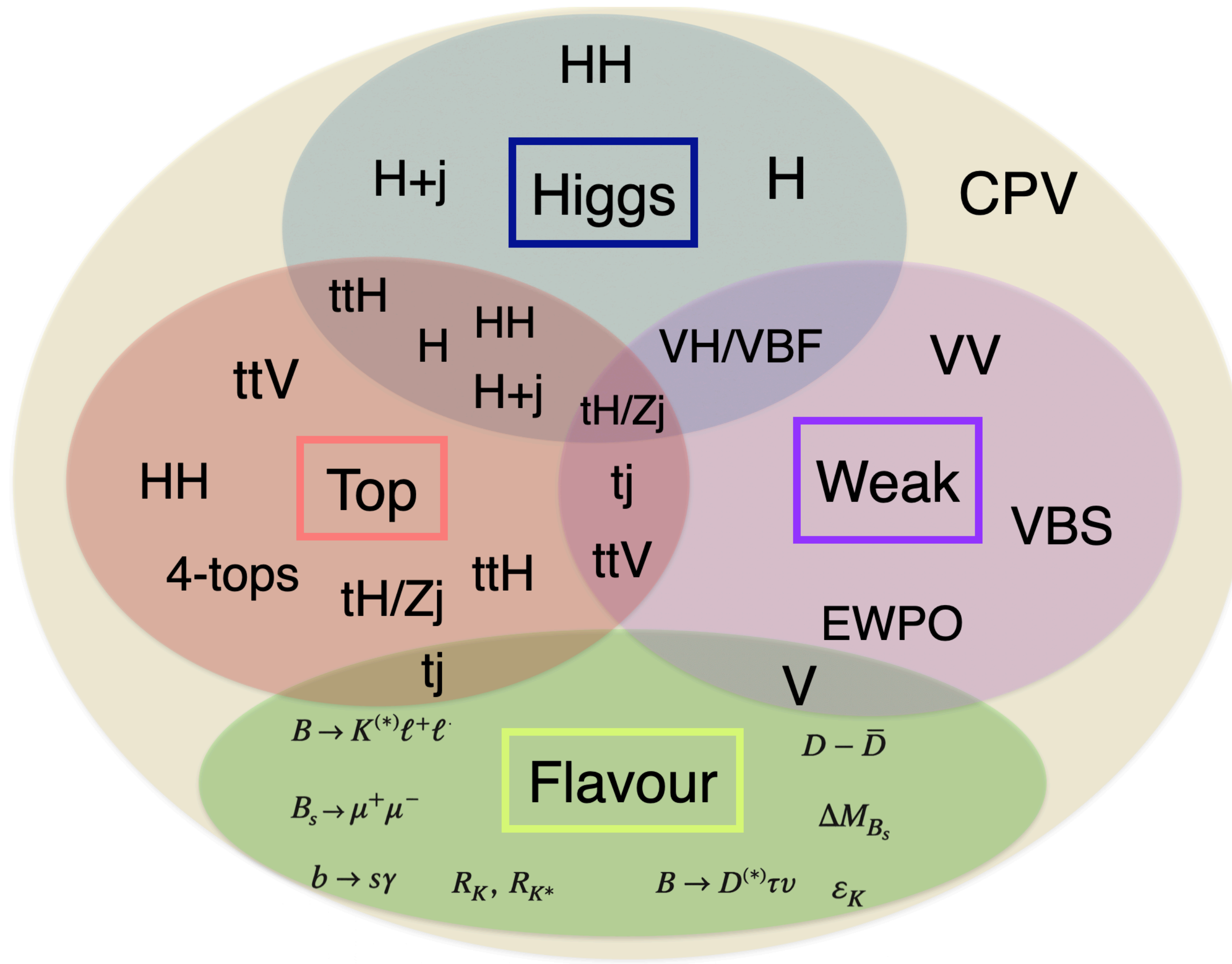


Precise SMEFT predictions

Precise SM predictions

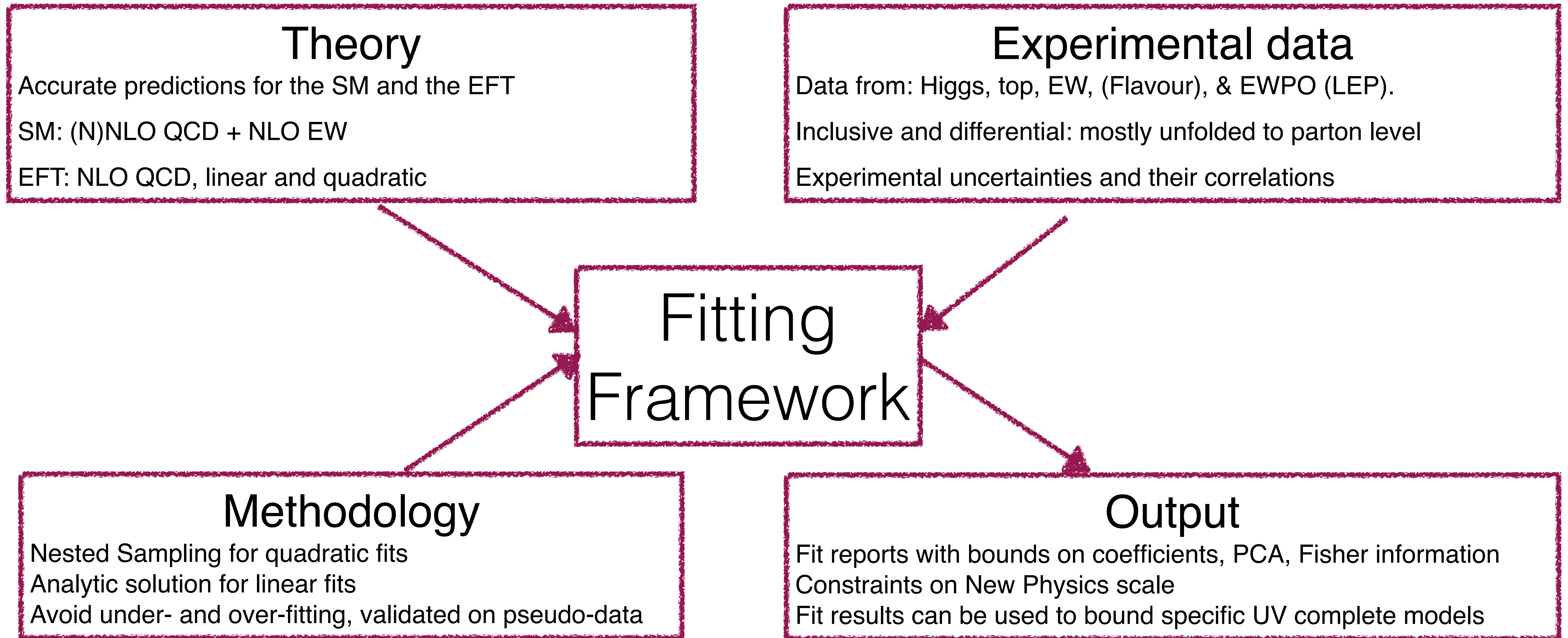
Precise experimental measurements

Global nature of EFT



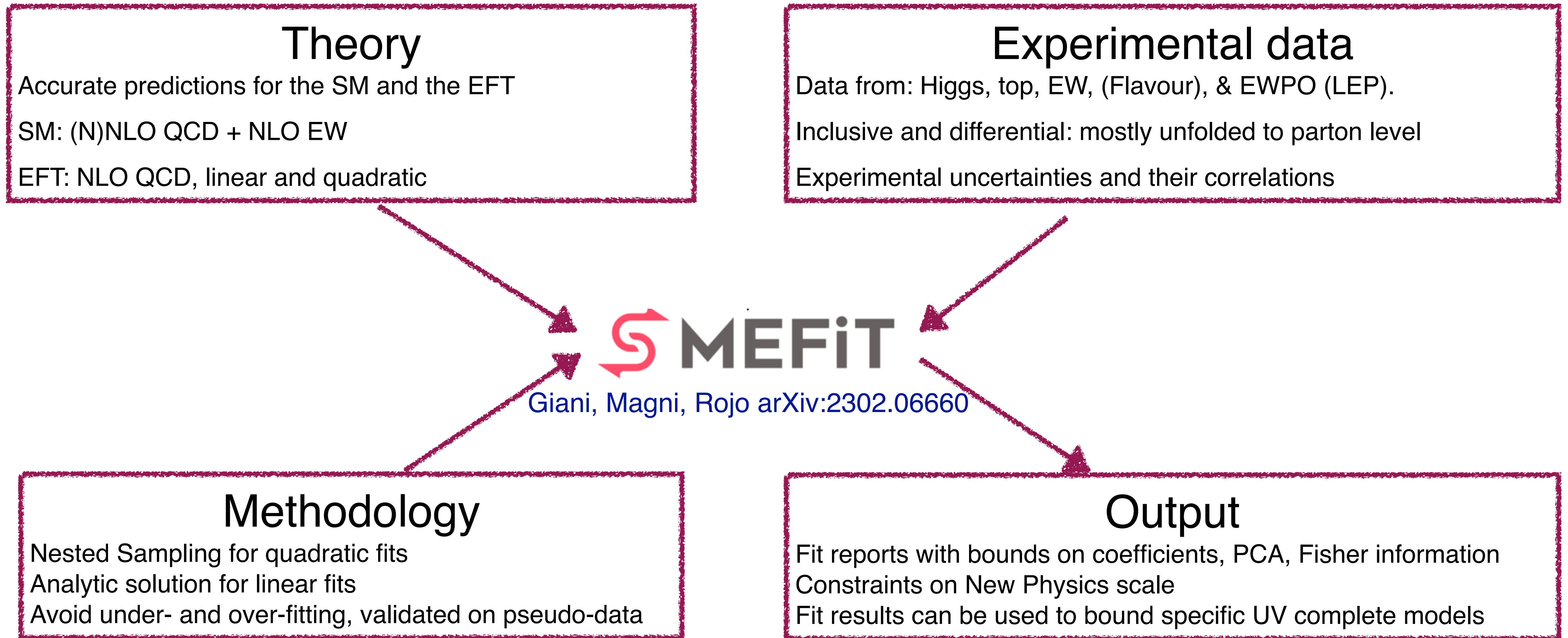
SMEFT correlates different sectors, and the patterns of correlations pinpoint to the type of New Physics

Global fit ingredients



See Marion's talk for more details

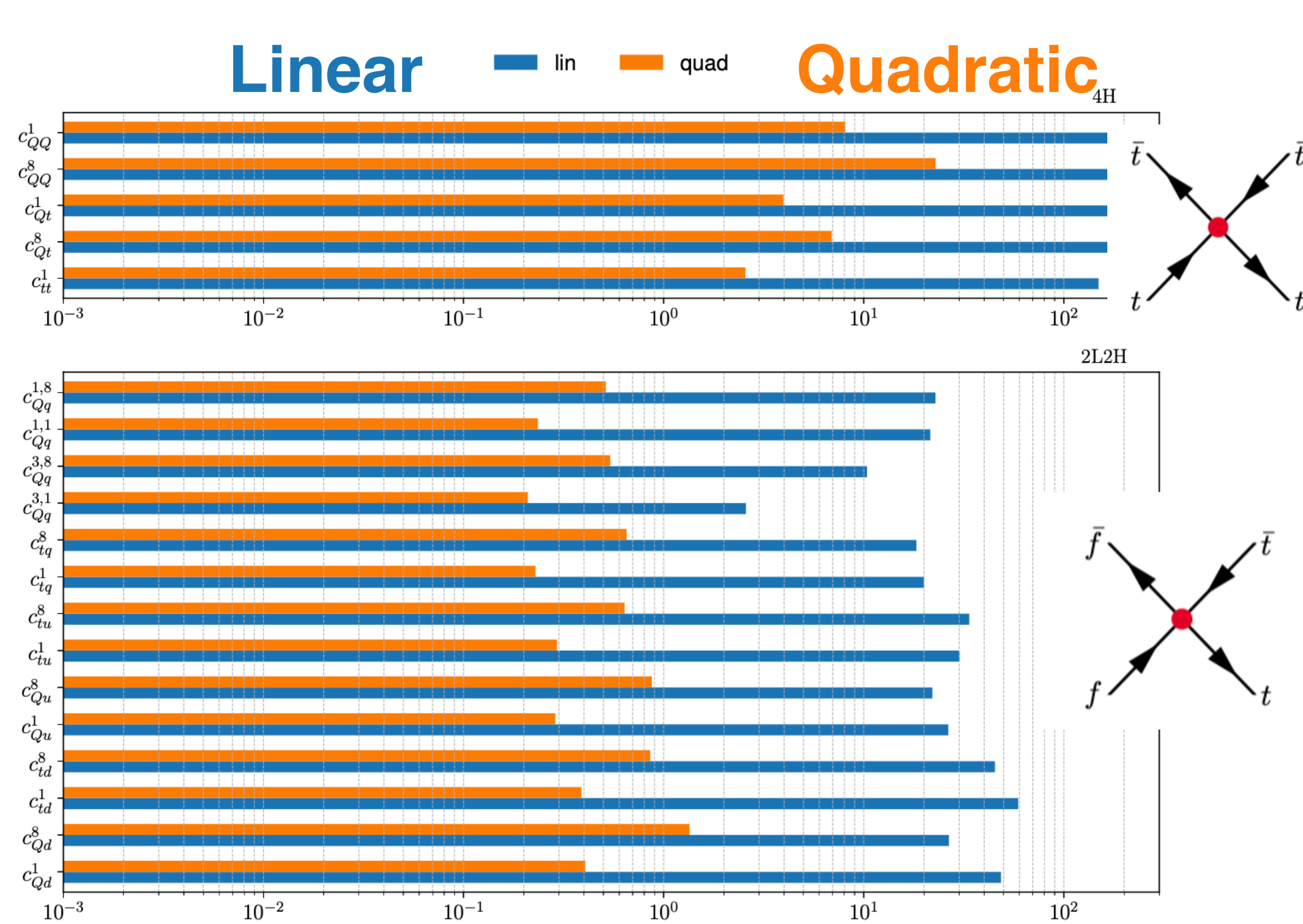
Global fit ingredients



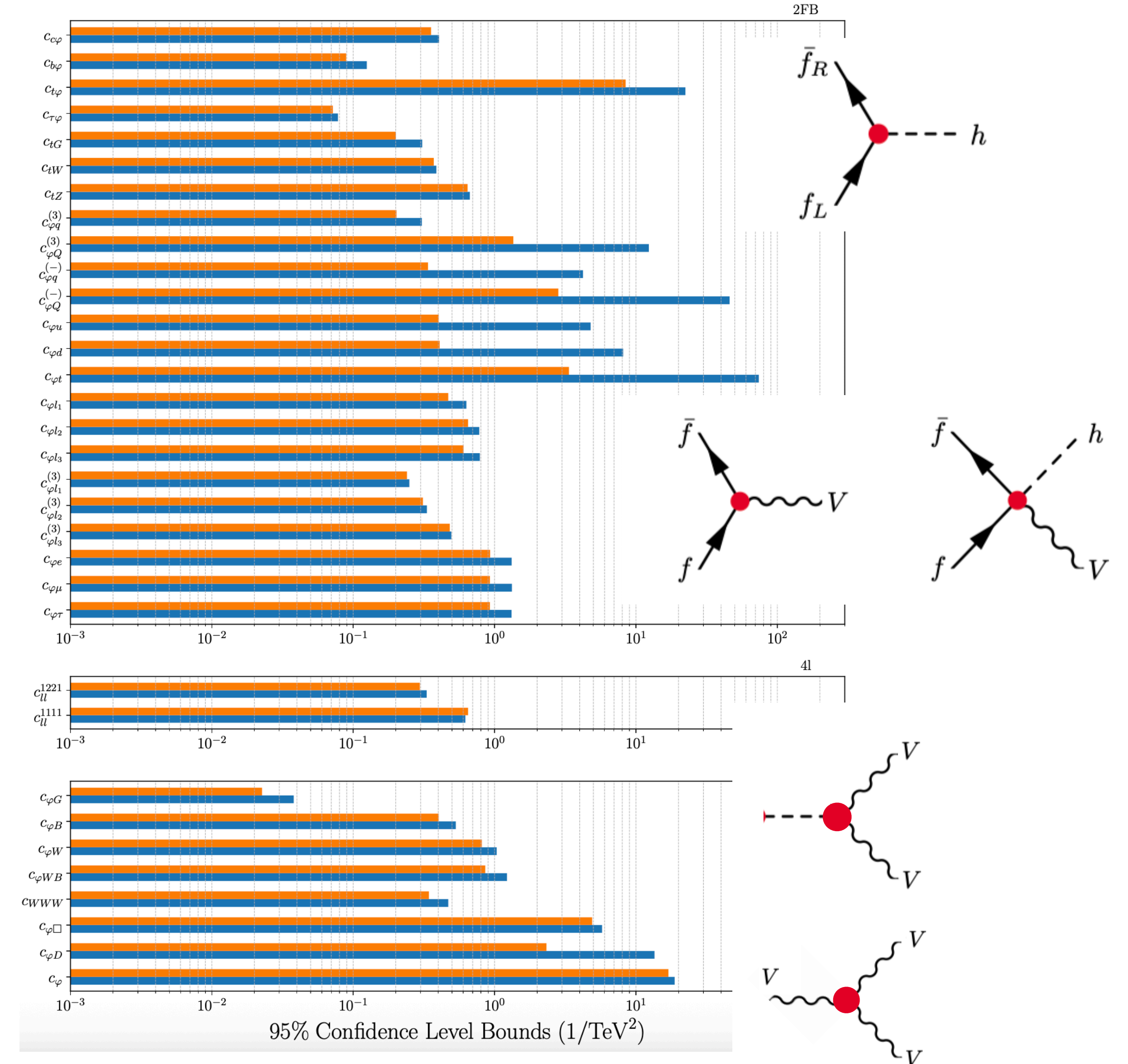
Other fitting frameworks: [HEPFit 2507.06191](#)

See Marion's talk for more details

LHC global fit results

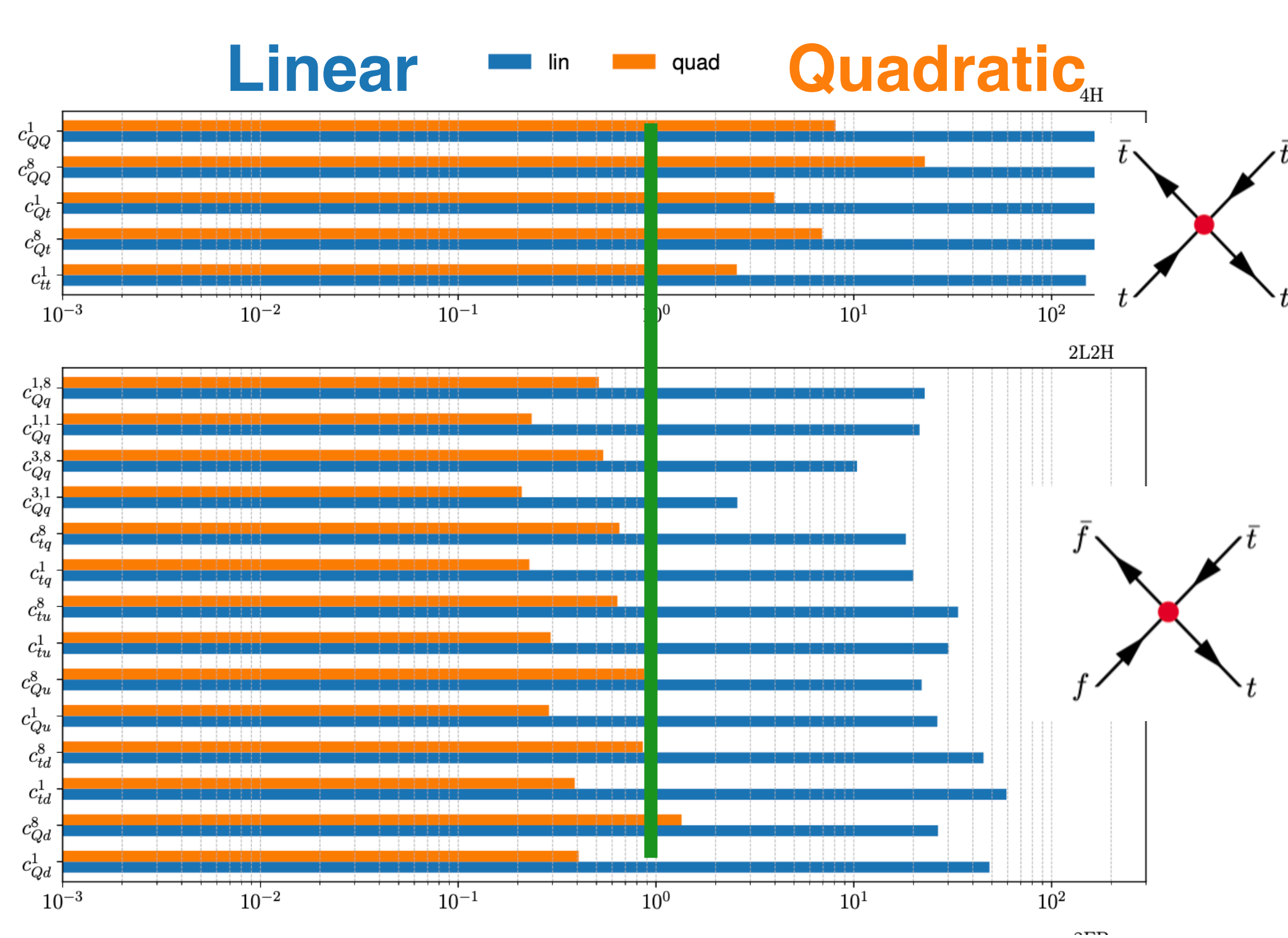


- Bounds varying between operators (~ 60 operators fitted)
- Most Wilson coefficient bounds **below 1 for $\Lambda=1$ TeV**
- Quadratic terms important (especially for 4-fermion operators)
- Least constrained coefficients are 4-top operators

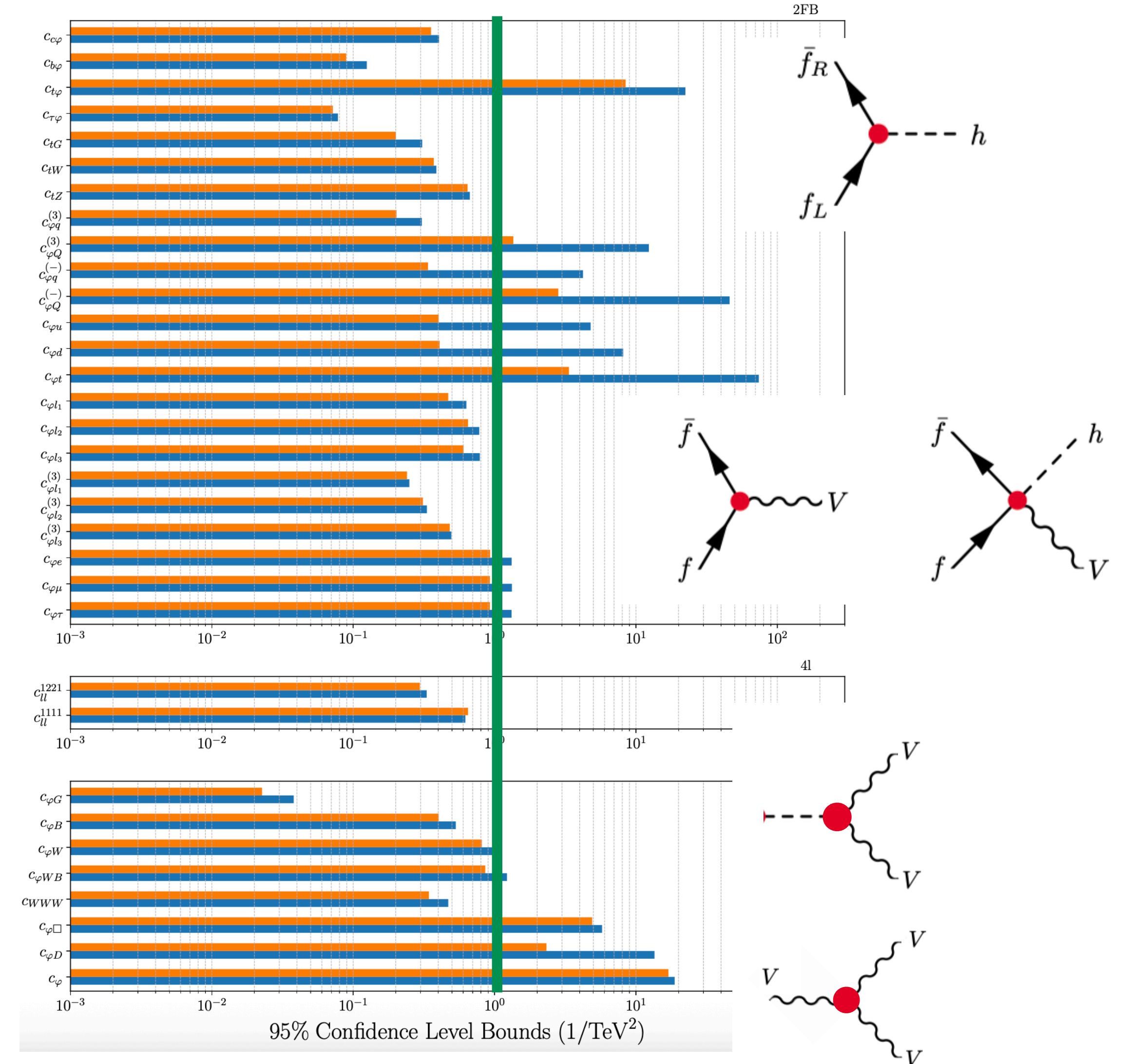


Armadillo, Celada, ter Hoeve, Maltoni, Mantani, Rojo, Rossia, Tentori, Thomas, EV arXiv:2604.16595

LHC global fit results



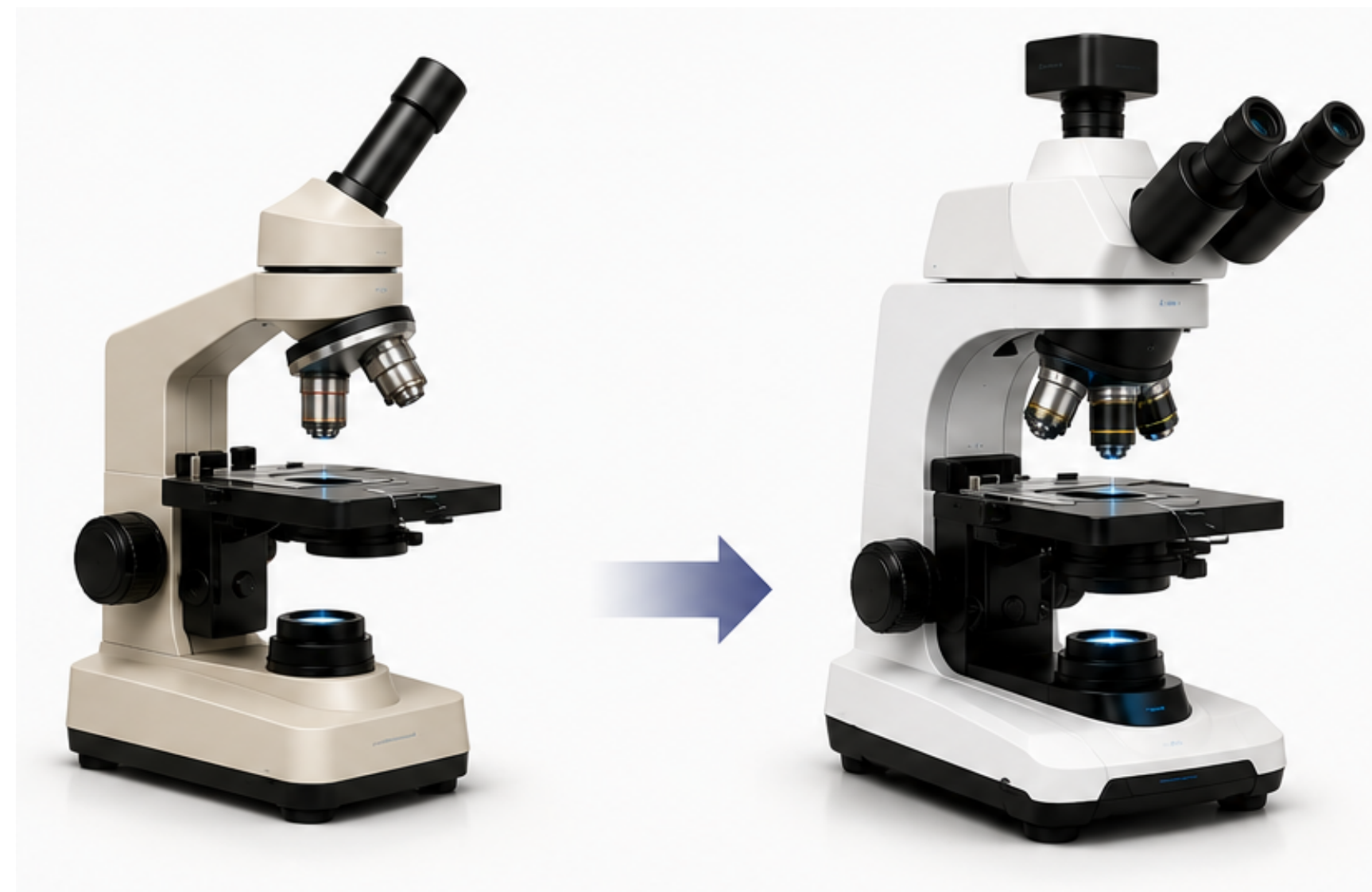
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Armadillo, Celada, ter Hoeve, Maltoni, Mantani, Rojo, Rossia, Tentori, Thomas, EV arXiv:2604.16595

Optimising EFT interpretations

Global fits are probing ~ 100 operators using hundreds of data points
How can we get the most out of EFT interpretations?



More Data, **Better predictions**

Aspects of EFT predictions

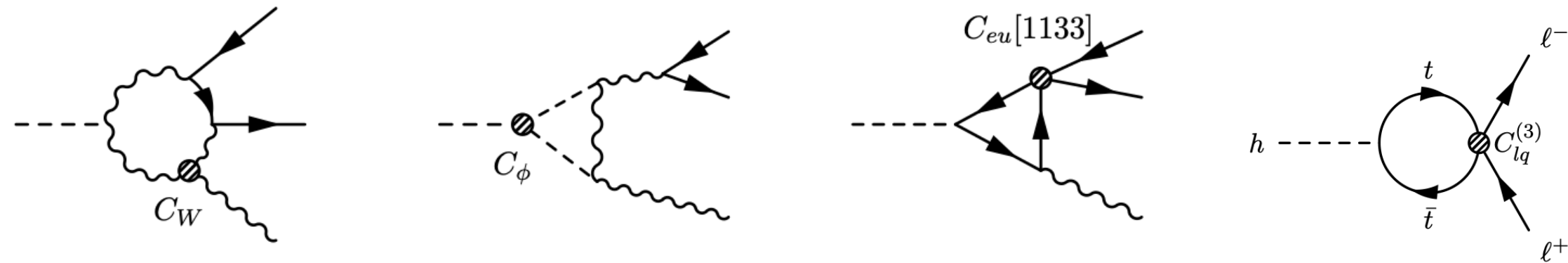
- Higher Orders in QCD/EW couplings and in the $1/\Lambda^2$ expansion
 - EFT is a QFT, renormalisable order-by-order in $1/\Lambda^2$

$$\mathcal{O}(\alpha_s, \alpha_{ew}) + \mathcal{O}\left(\frac{1}{\Lambda^2}\right) + \mathcal{O}\left(\frac{\alpha_s}{\Lambda^2}\right) + \mathcal{O}\left(\frac{\alpha_{ew}}{\Lambda^2}\right) \longrightarrow \text{Does this matter?}$$

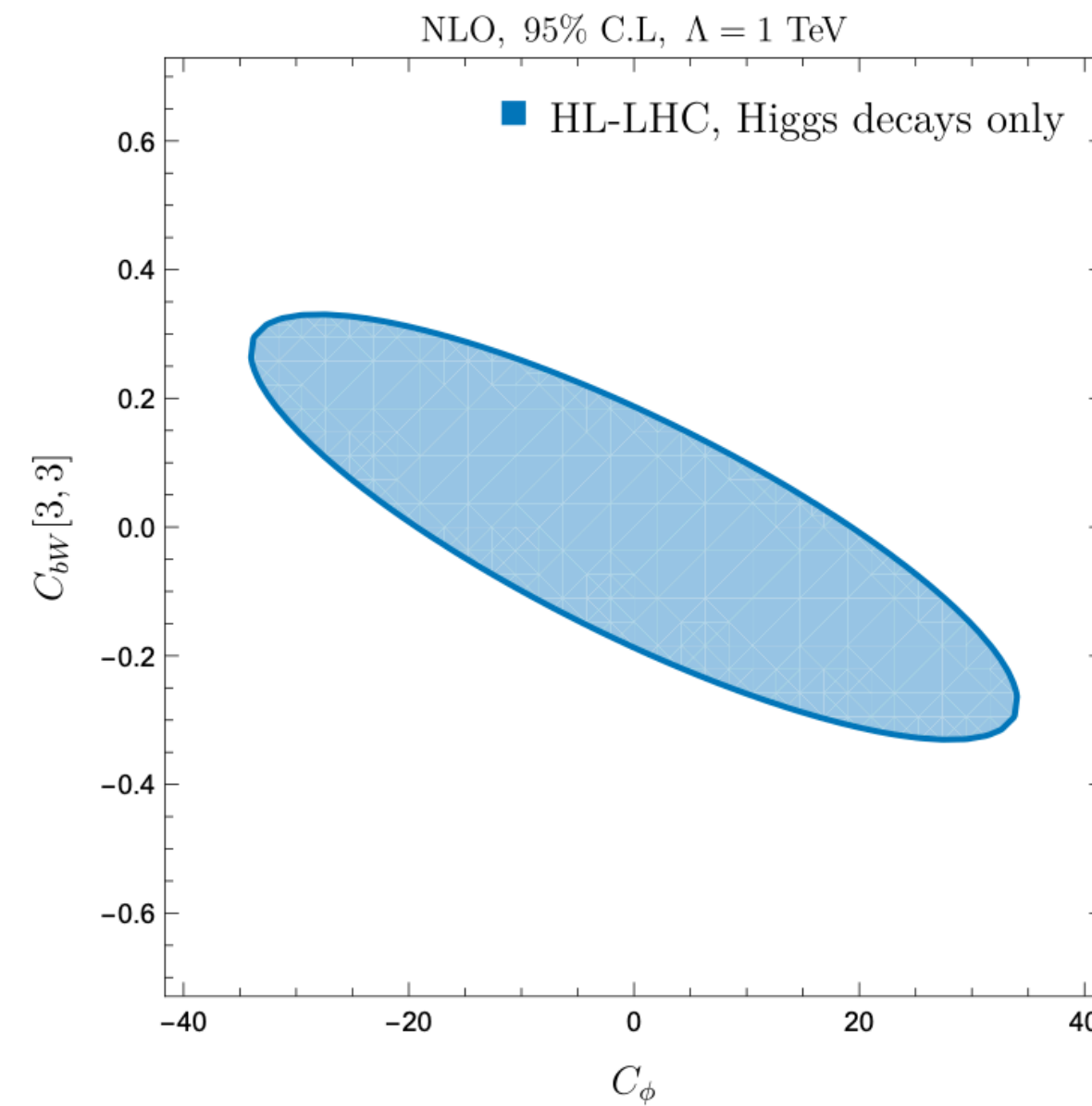
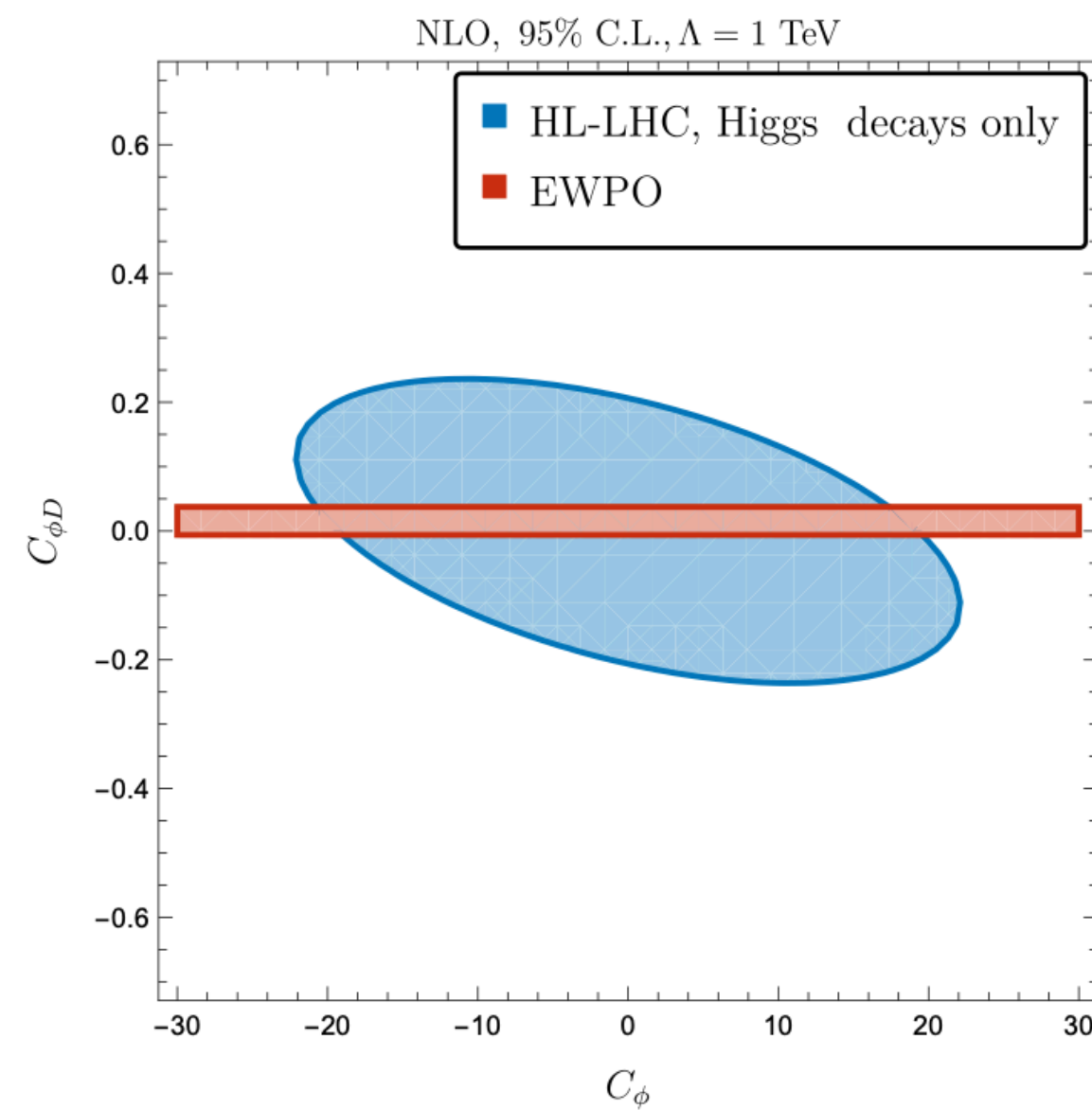
- Higher-order terms in the EFT expansion can also be added by considering higher-dimension operators
- Renormalisation Group Running and mixing
$$\Delta\text{Obs}_n = \text{Obs}_n^{\text{EXP}} - \text{Obs}_n^{\text{SM}} = \sum_i \frac{c_i^6(\mu)}{\Lambda^2} a_{n,i}^6(\mu) + \mathcal{O}\left(\frac{1}{\Lambda^4}\right) \quad \text{How about this } \mu?$$

1-loop: (Alonso) Jenkins et al arXiv:1308.2627, 1310.4838, 1312.2014,
2-loop: **Born, Fuentes-Martin, Thomsen 2601.19974**

Higgs processes at NLO in the SMEFT



New operators: new sensitivity



Bellafronte et al 2601.09599
Also implemented in public code

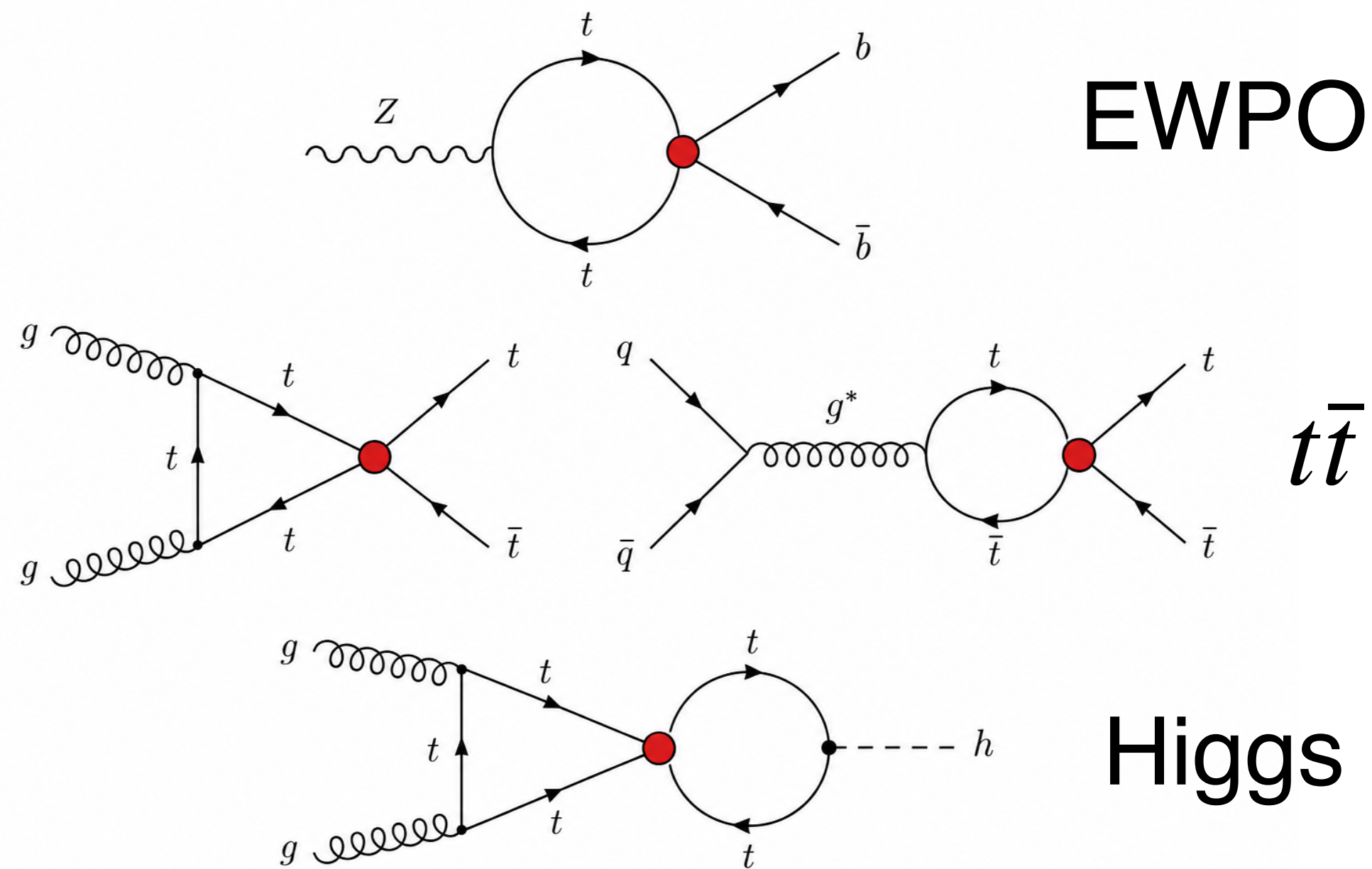
See also Maskos et al 2609.11681 for a Monte Carlo generator

Probes unconstrained interactions: e.g. 4-top interactions and the self-coupling

For loop-induced sensitivity see also: Di Noi et al 2310.18221, Bellafronte et al arXiv: 2304.00029, Freiheit, Haisch arXiv: 2512.05857, Haisch et al arXiv:2410.13304, Haisch and Niggetiedt 2507.20803, Haisch 2503.06249

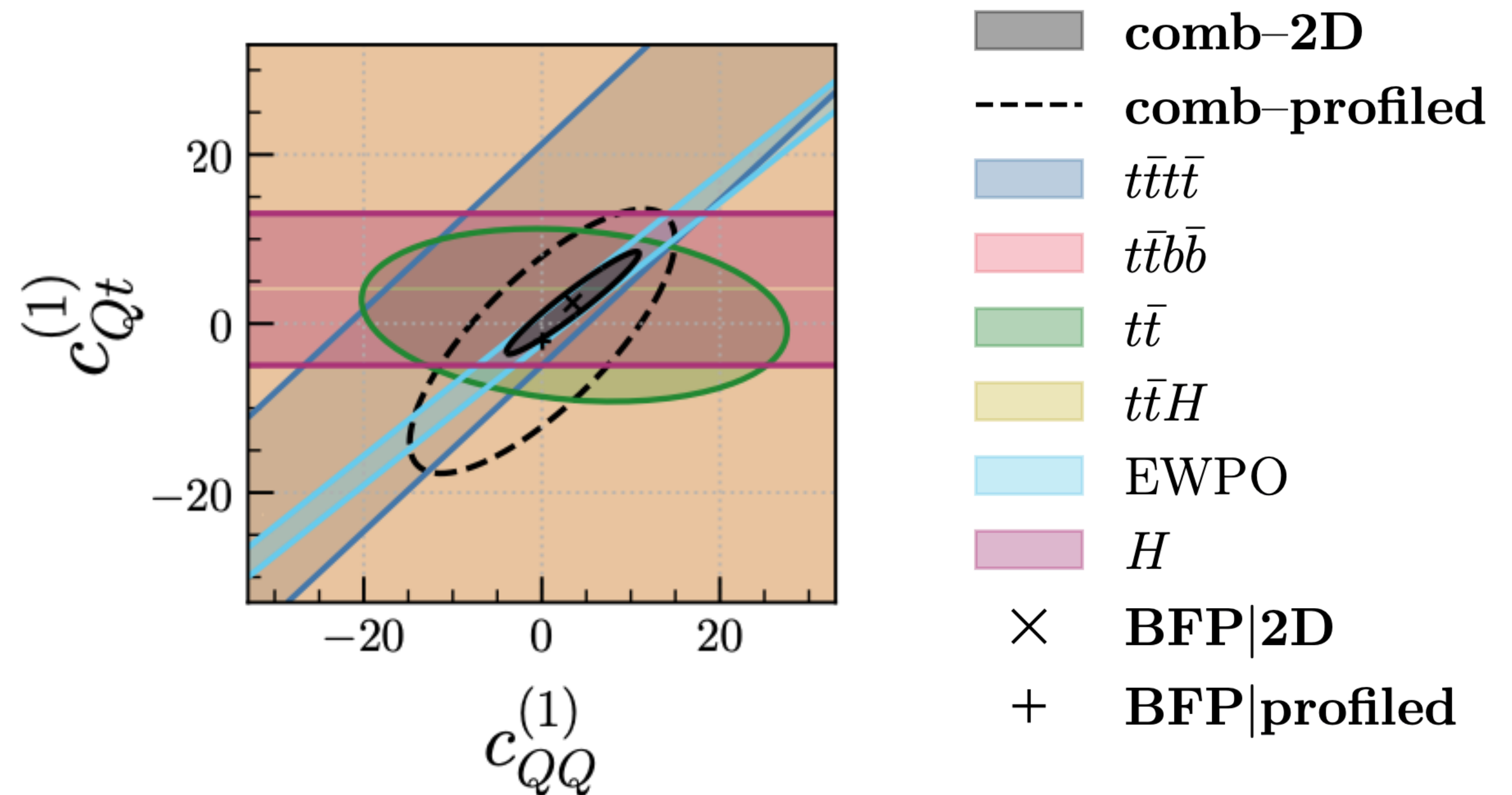
Improving sensitivity with EW loops

4-heavy operators: complementarity of different sectors



see also: Di Noi et al 2310.18221, Bellafronte et al arXiv: 2304.00029, Freiheit, Haisch arXiv: 2512.05857, Haisch et al arXiv:2410.13304

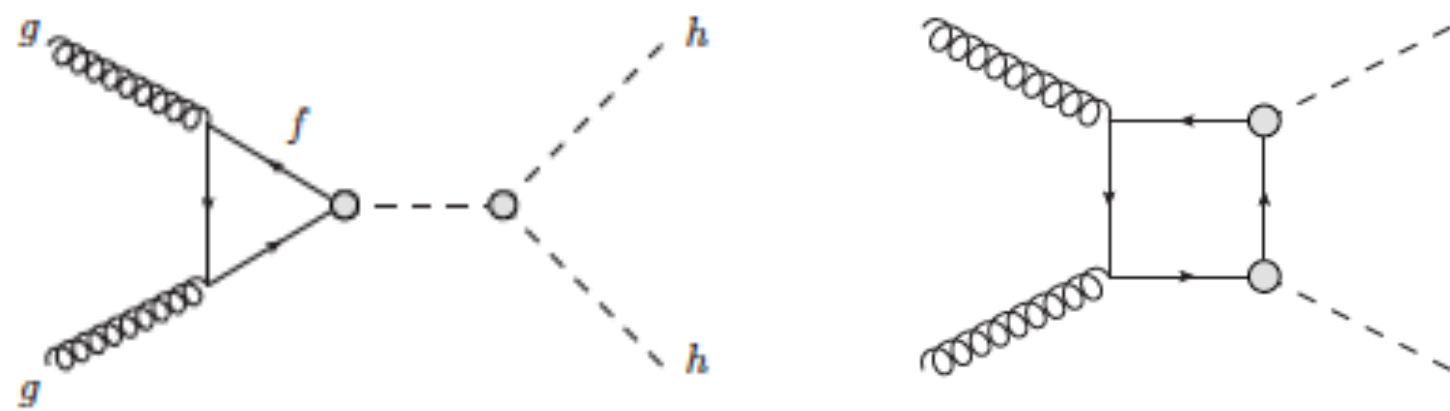
95% CL — two-parameter scan (others = 0) + profiled ellipse — $\mathcal{O}(\Lambda^{-4})$



Di Noi, El Faham, Grober, Vitti, EV arXiv: 2507.01137

Precision Higgs self-coupling probes

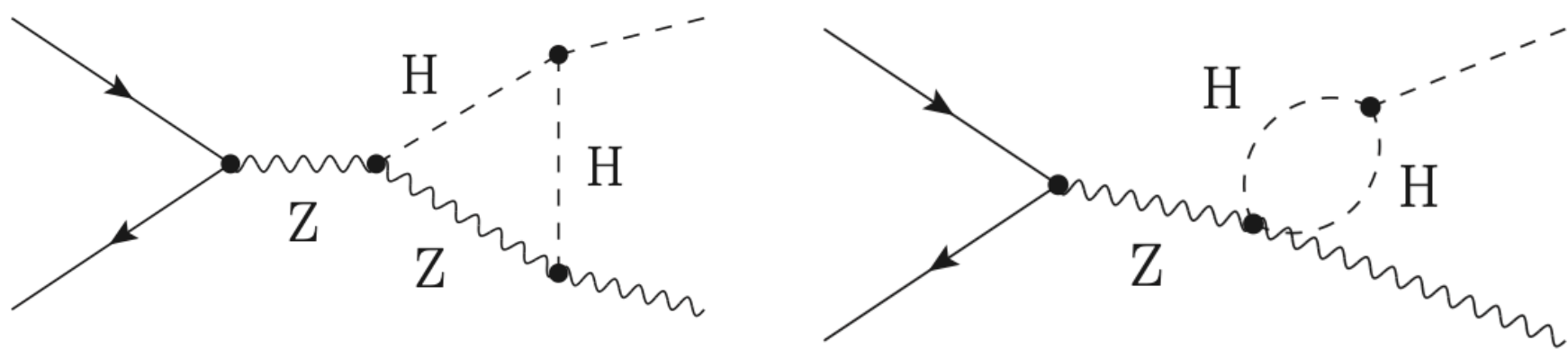
Hadron Collisions



Higgs pair production

ESPPU26 projections: 2504.00672

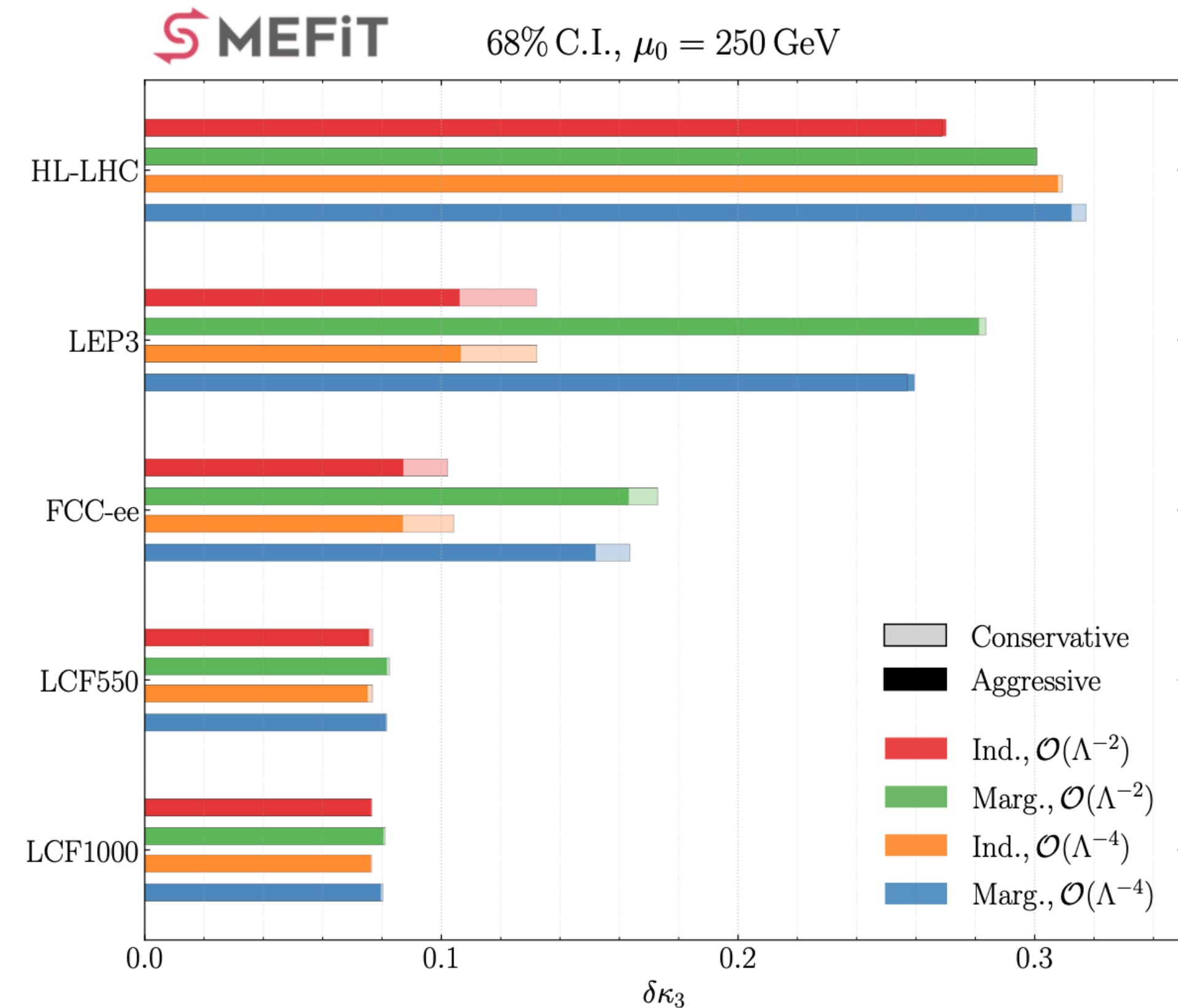
Lepton Collisions (<500 GeV)



Asteriadis, Dawson, Giardino, Szafron arXiv:2406.03557

ter Hoeve, Mantani, Rojo, Rossia EV arXiv: 2504.05974

See also : Maura, Stefanek, You arXiv: 2503.13719



$$\delta\kappa_3 = -\frac{2v^4}{m_h^2} \frac{c_\varphi}{\Lambda^2} + \frac{3v^2}{\Lambda^2} \left(c_\varphi \square - \frac{1}{4} c_\varphi D \right)$$

Armadillo et al arXiv:2604.16595, see also ESPPU BB

RGE effects in EFT analyses

Each observable entering the fit has a “natural” scale

Scales can be different by more than 2 orders of magnitude in an LHC global fit

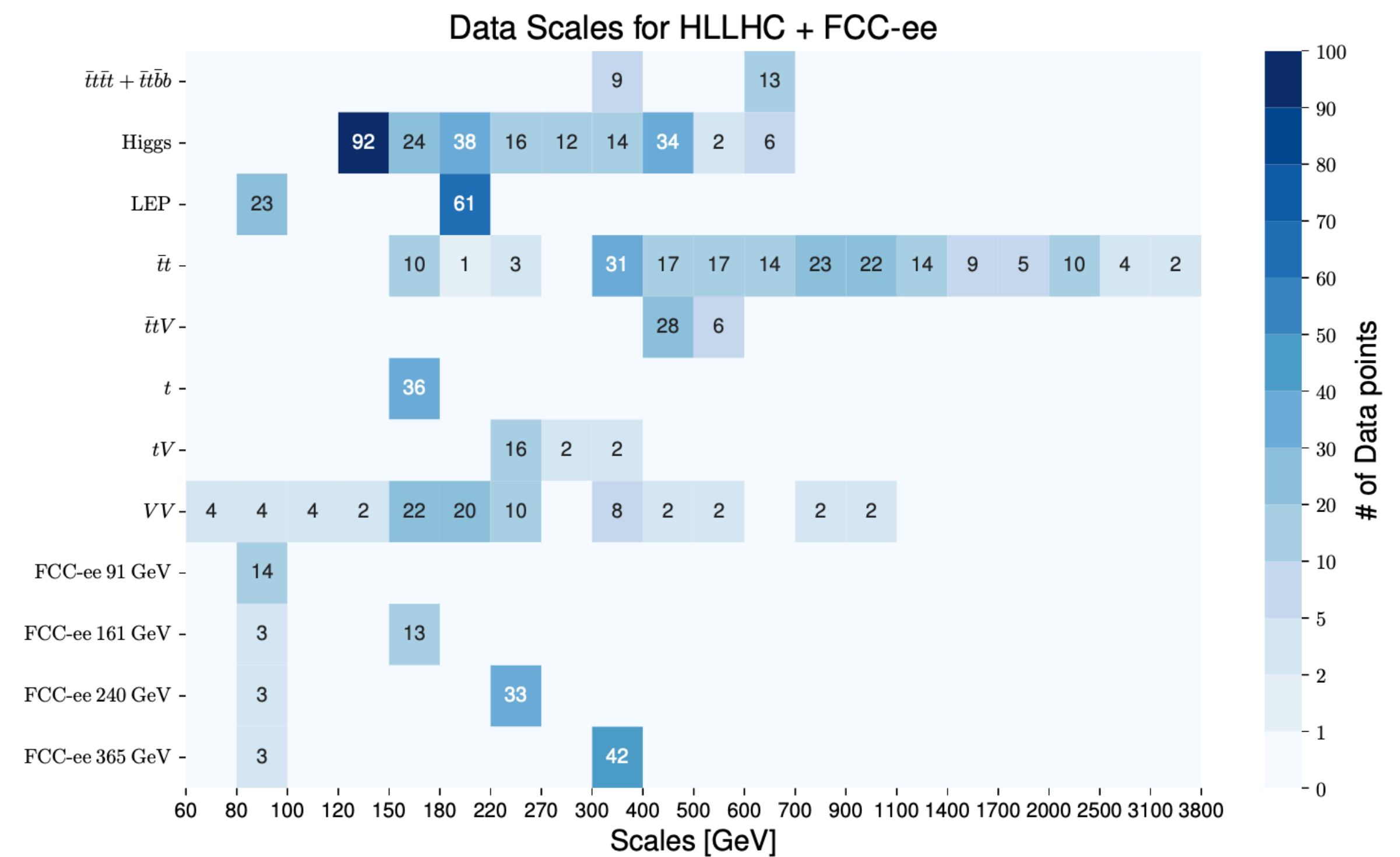
➔ RGE effects can be significant!

1-loop RGE

(Alonso) Jenkins et al arXiv:1308.2627, 1310.4838, 1312.2014

2-loop RGE

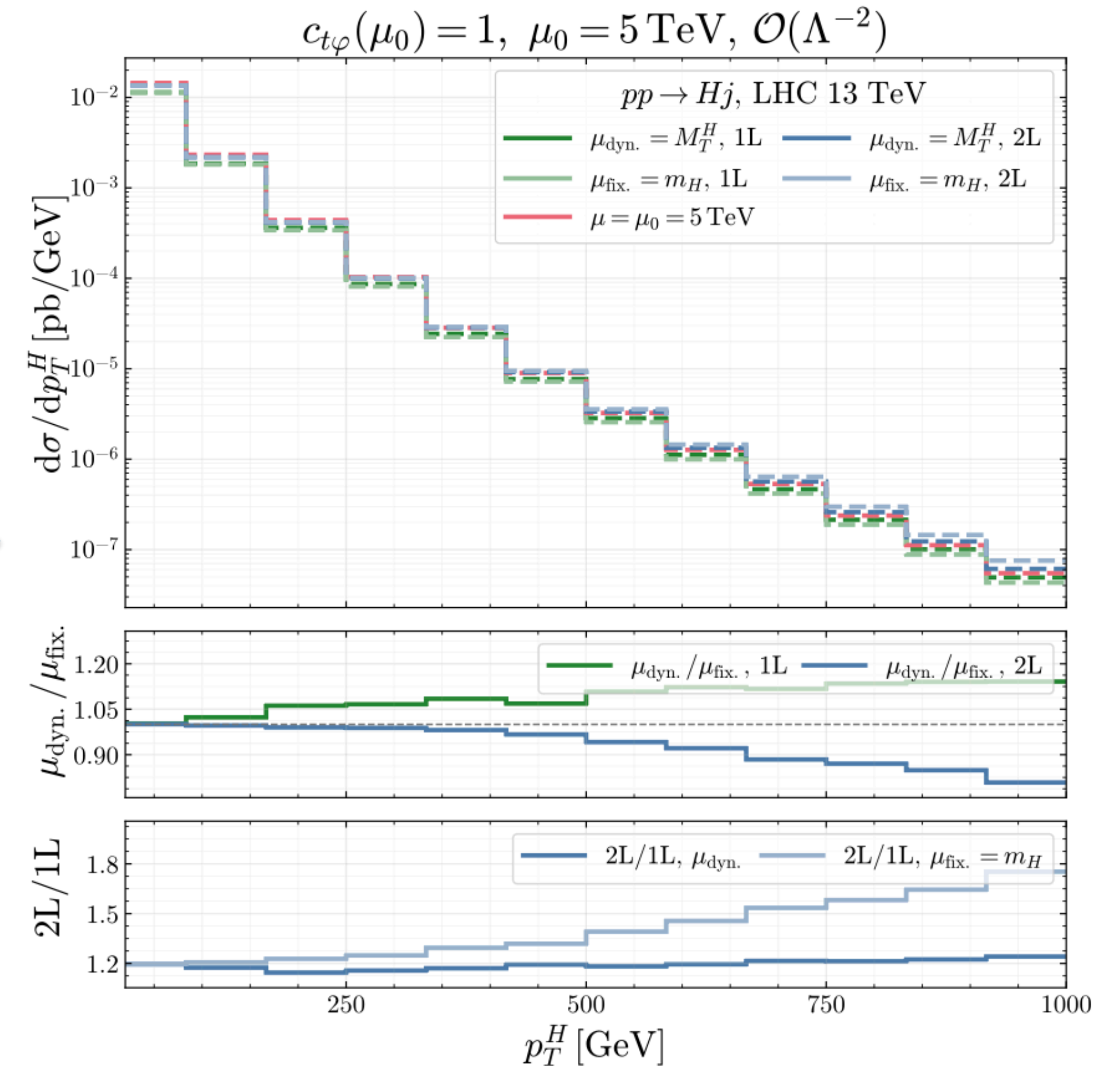
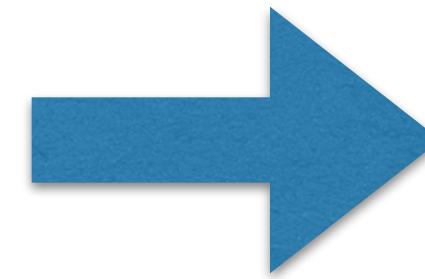
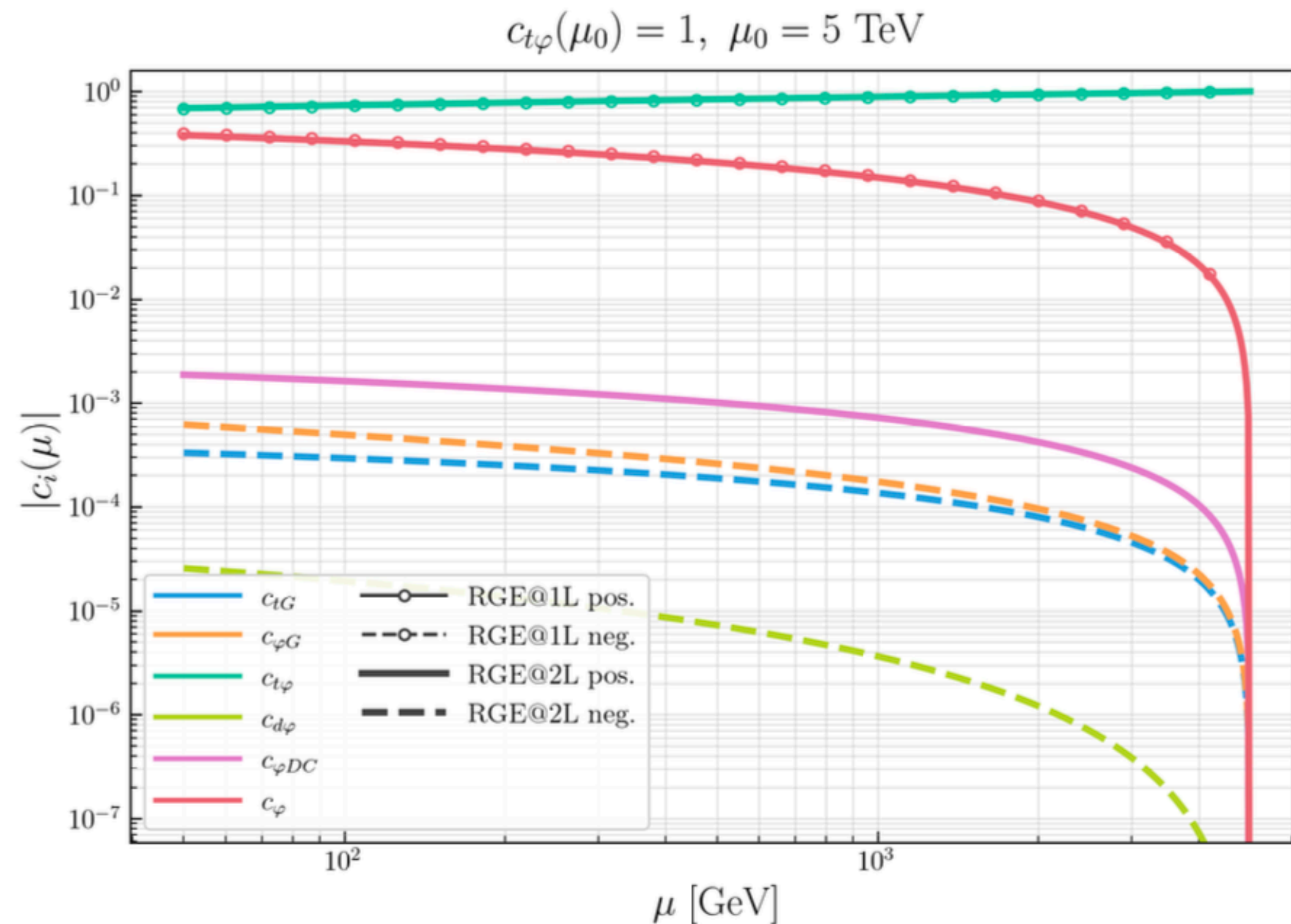
2-loop: Born, Fuentes-Martin, Thomsen 2601.19974



Dynamical scales are essential in global fits

Impact of two-loop RGE on Higgs observables

Running of the top-Yukawa operator

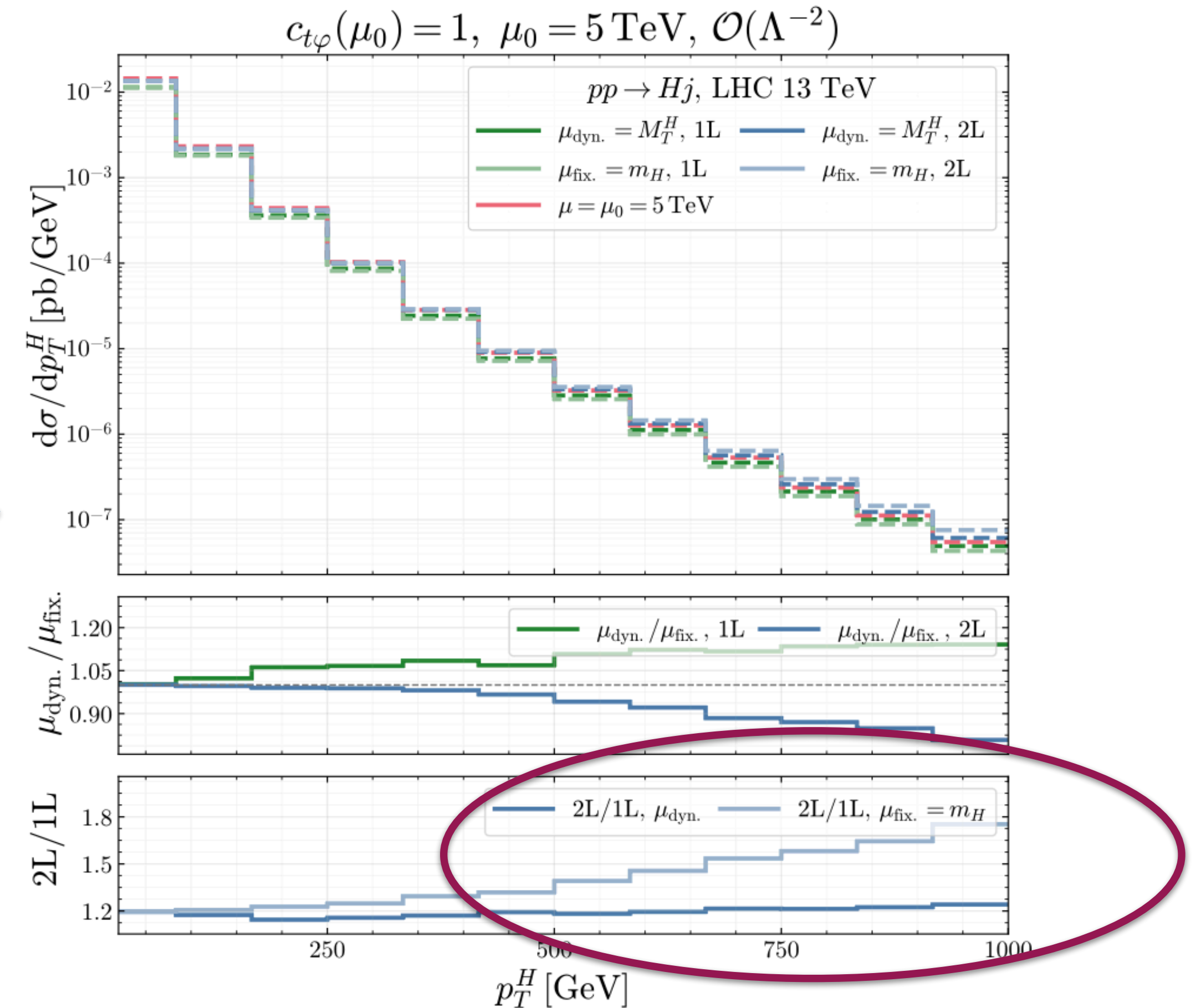
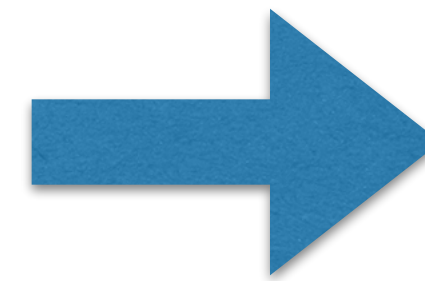
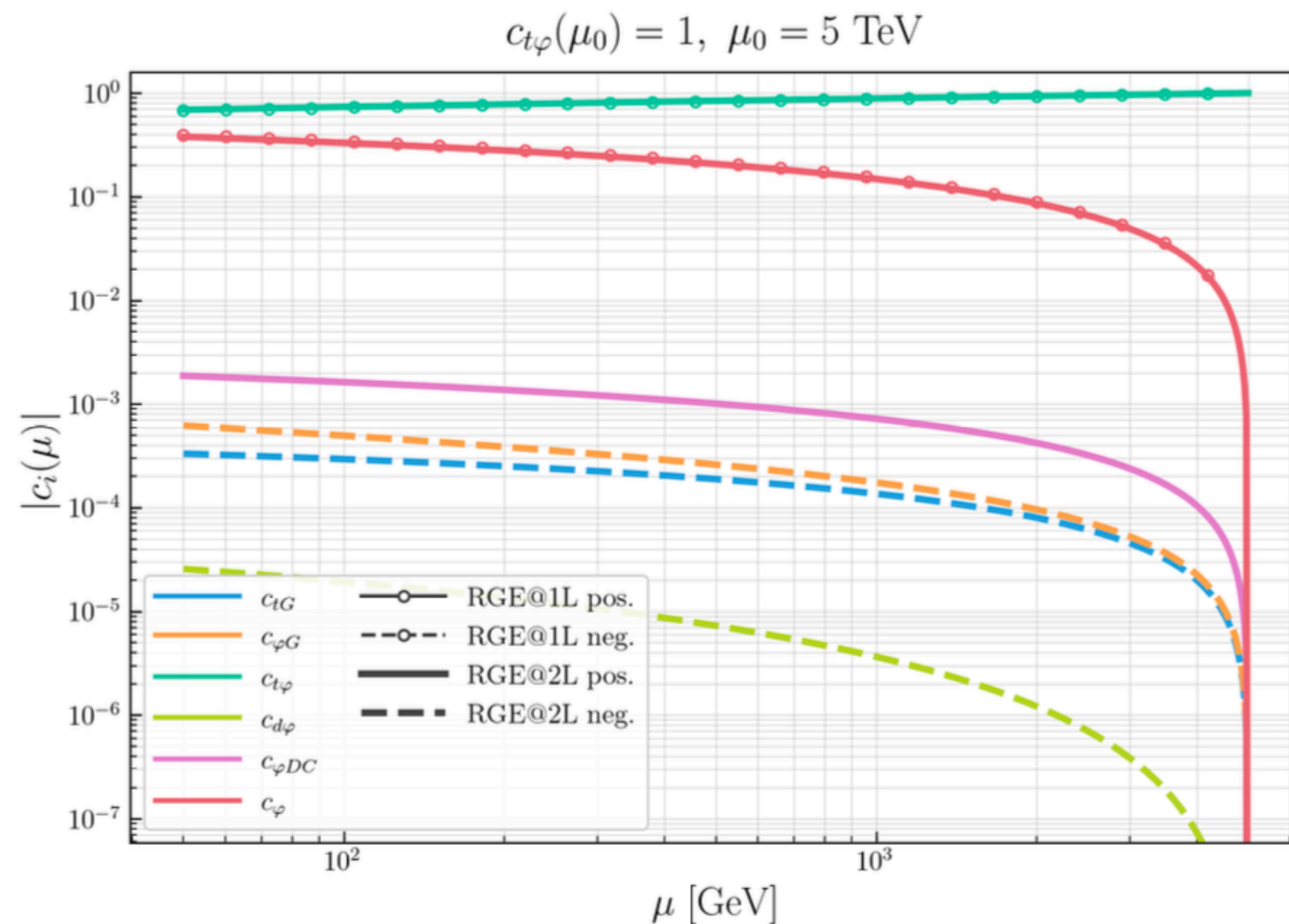


New operators generated at 2-loops

Thomas, Ventura, EV in preparation

Impact of two-loop RGE on Higgs observables

Running of the top-Yukawa operator

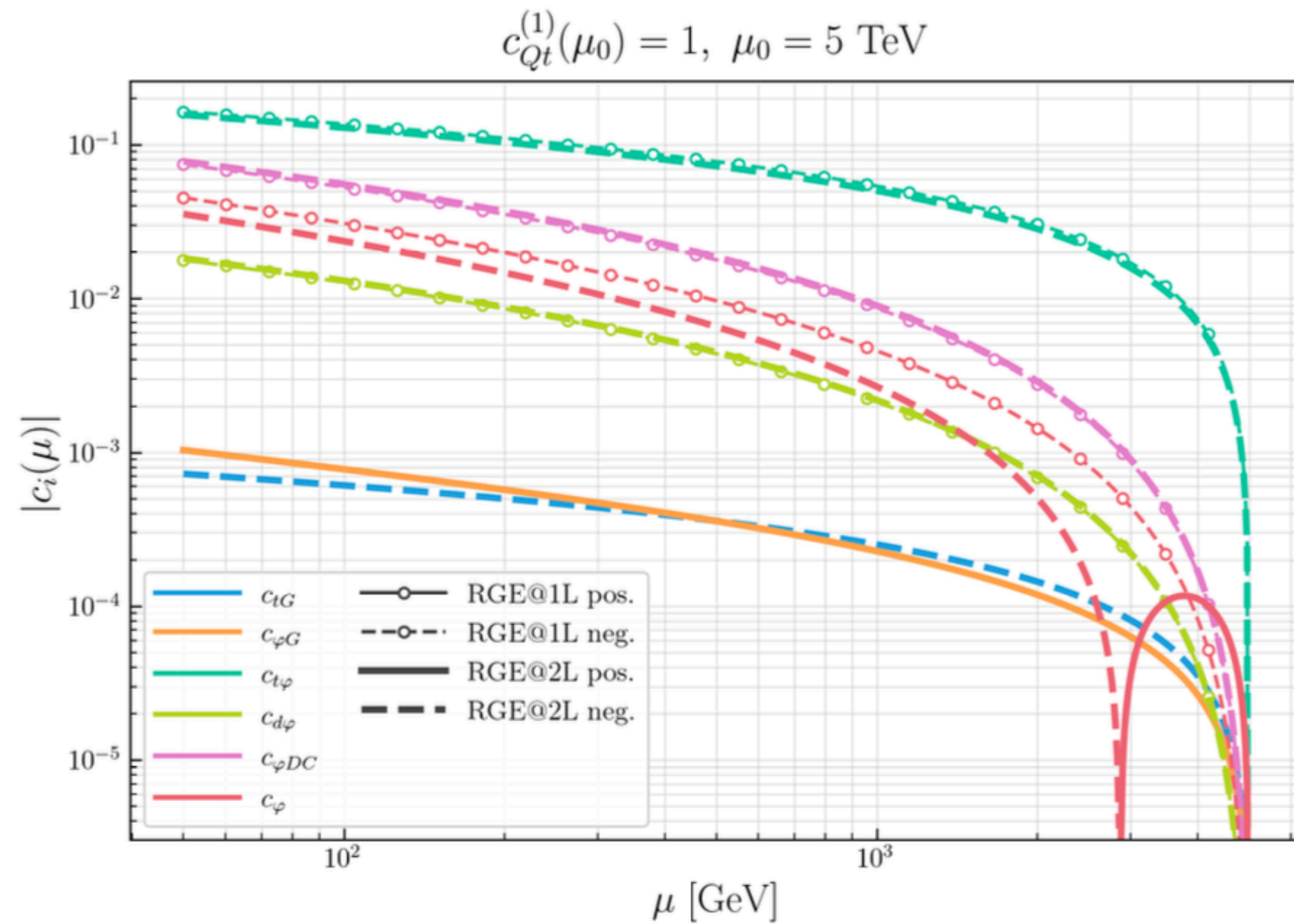


New operators generated at 2-loops

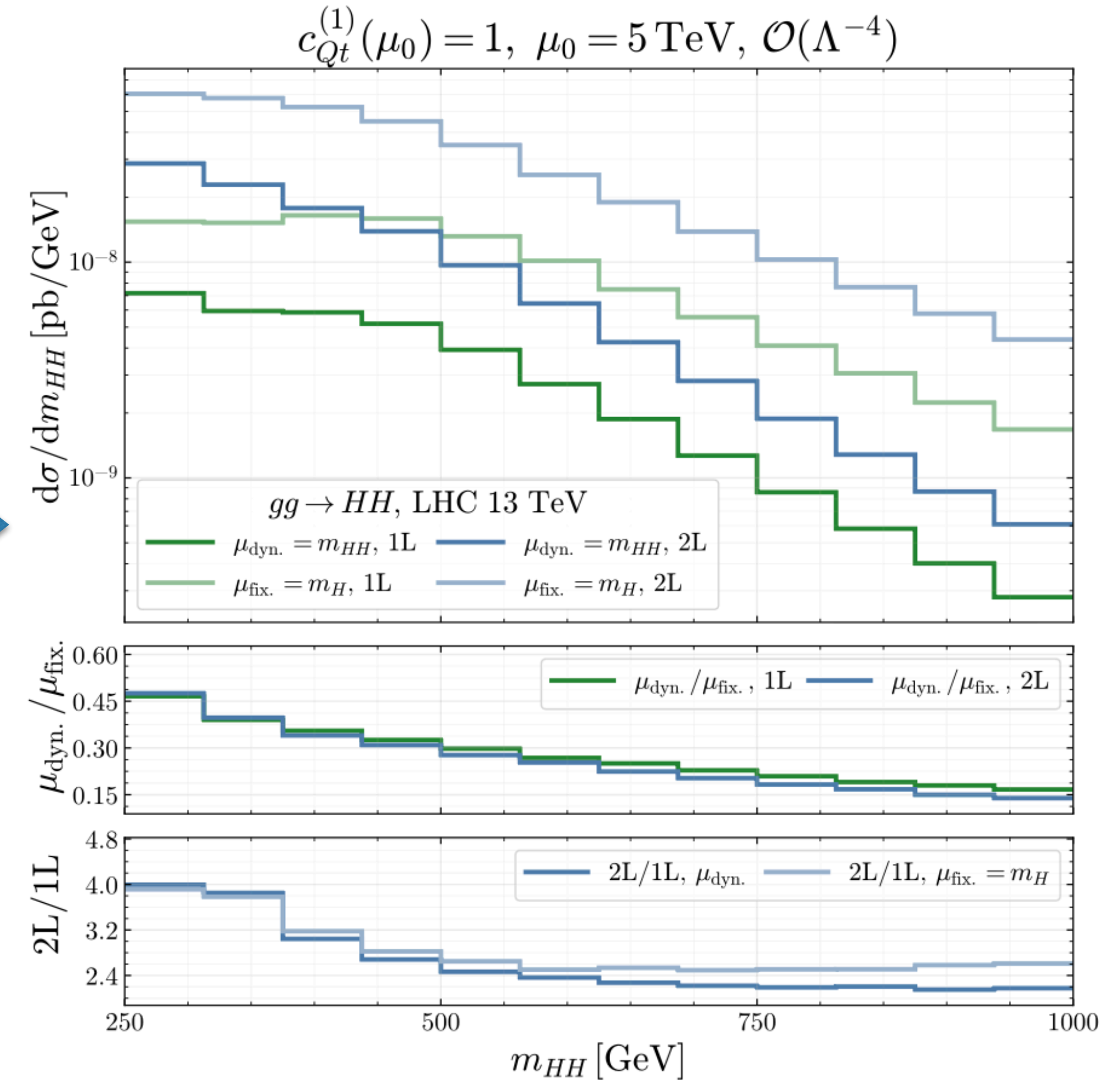
Thomas, Ventura, EV in preparation

Impact of two-loop RGE on Higgs observables

Running of the 4-heavy operators



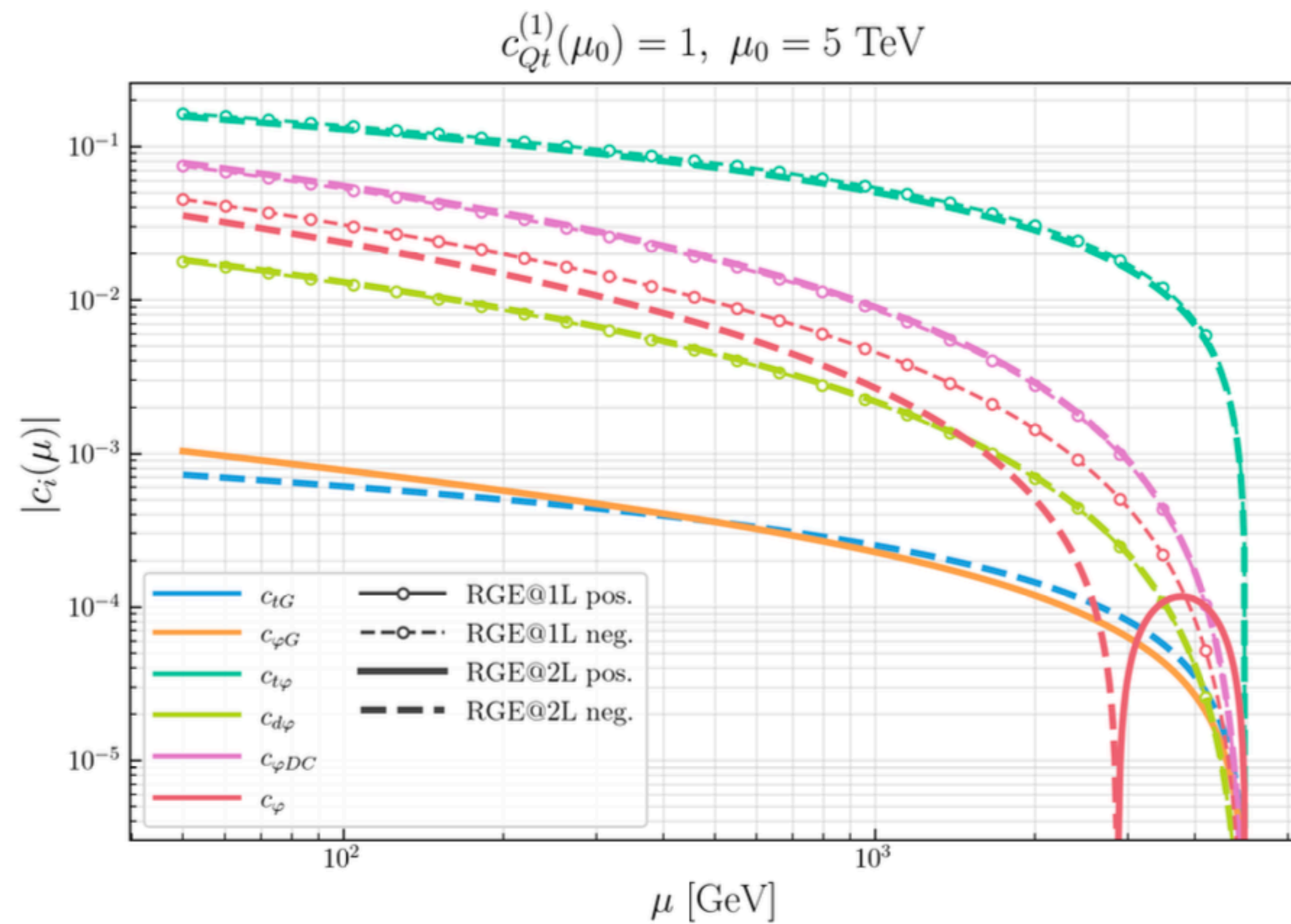
New operators generated at 2-loops



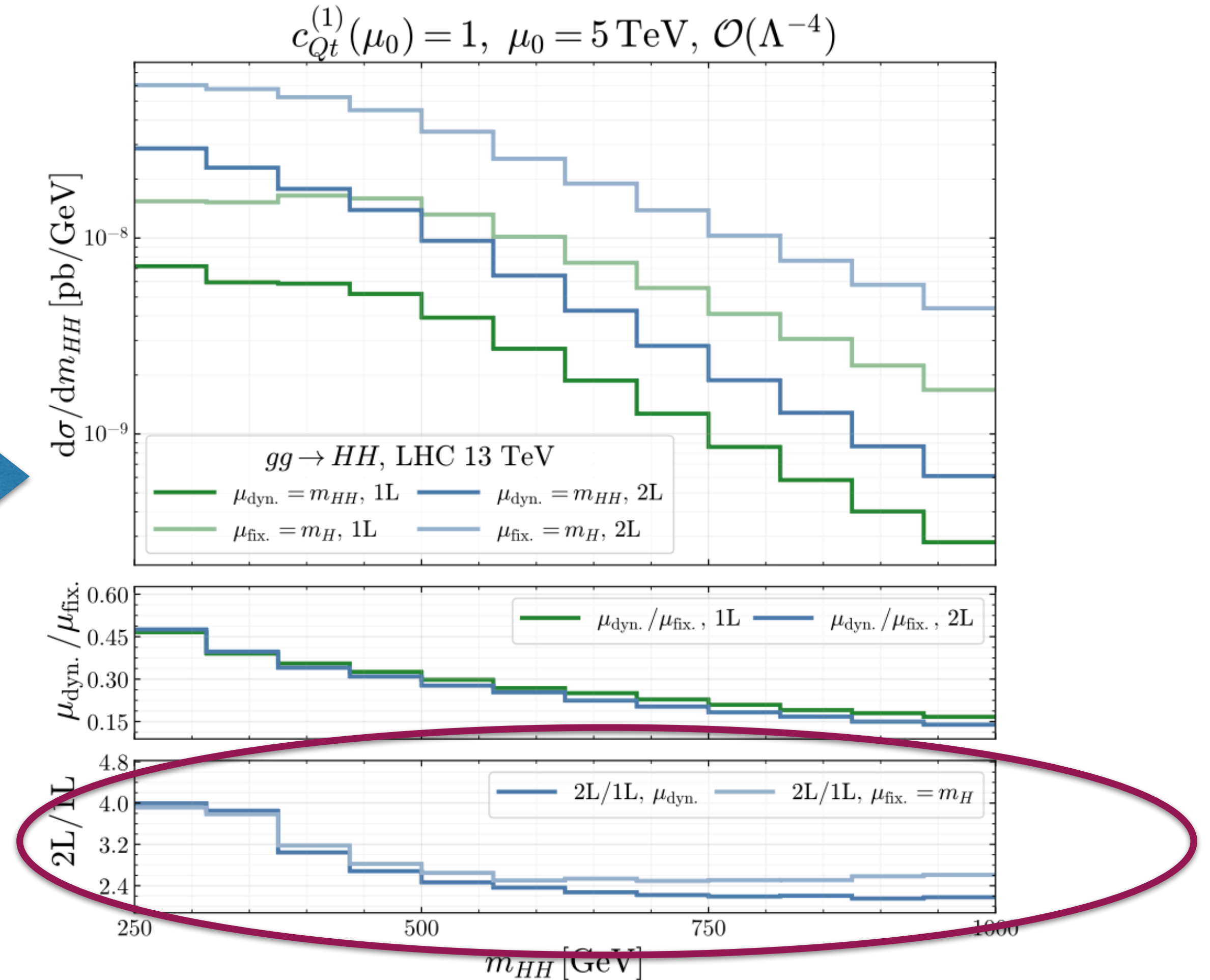
Thomas, Ventura, EV in preparation

Impact of two-loop RGE on Higgs observables

Running of the 4-heavy operators

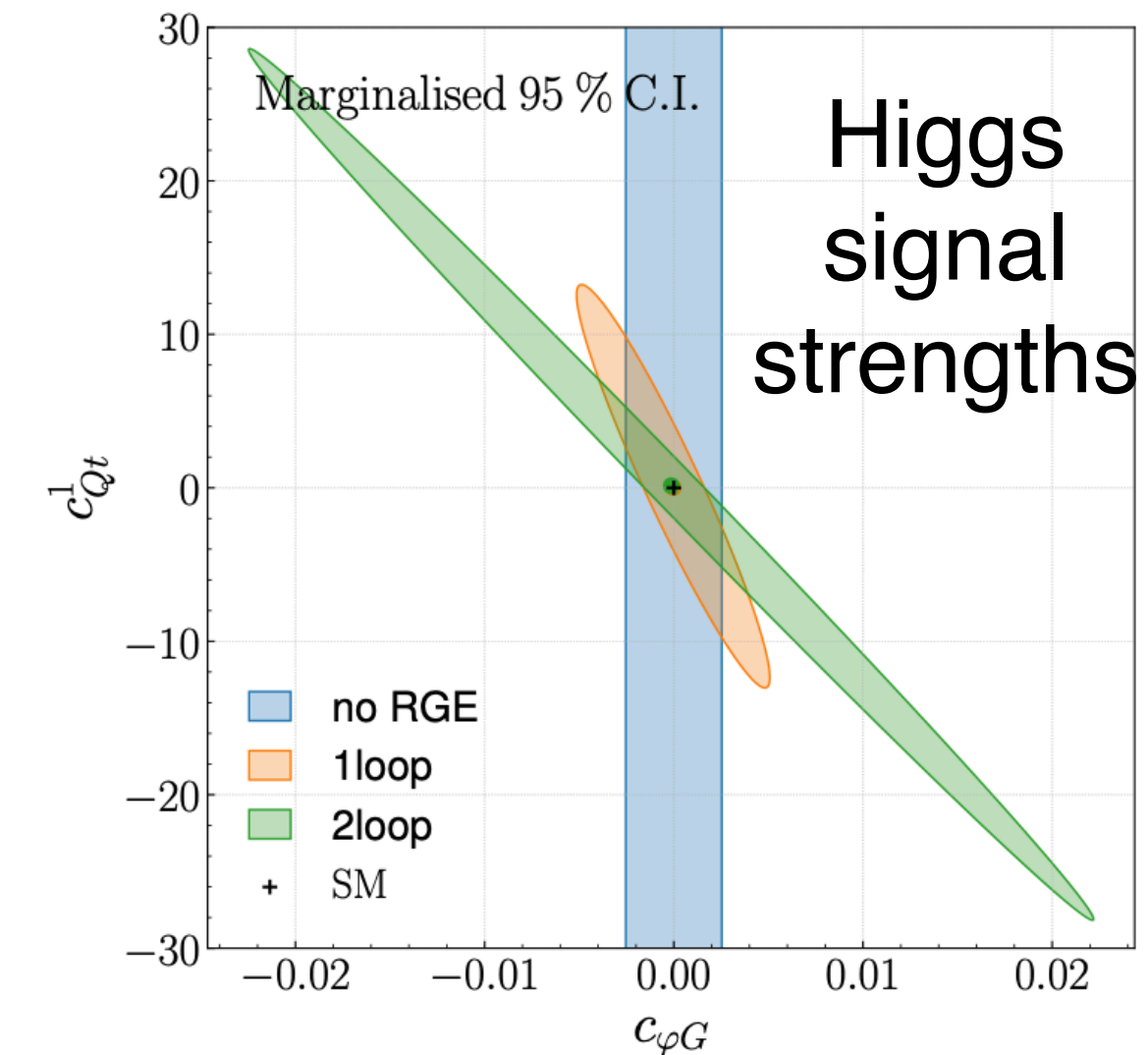
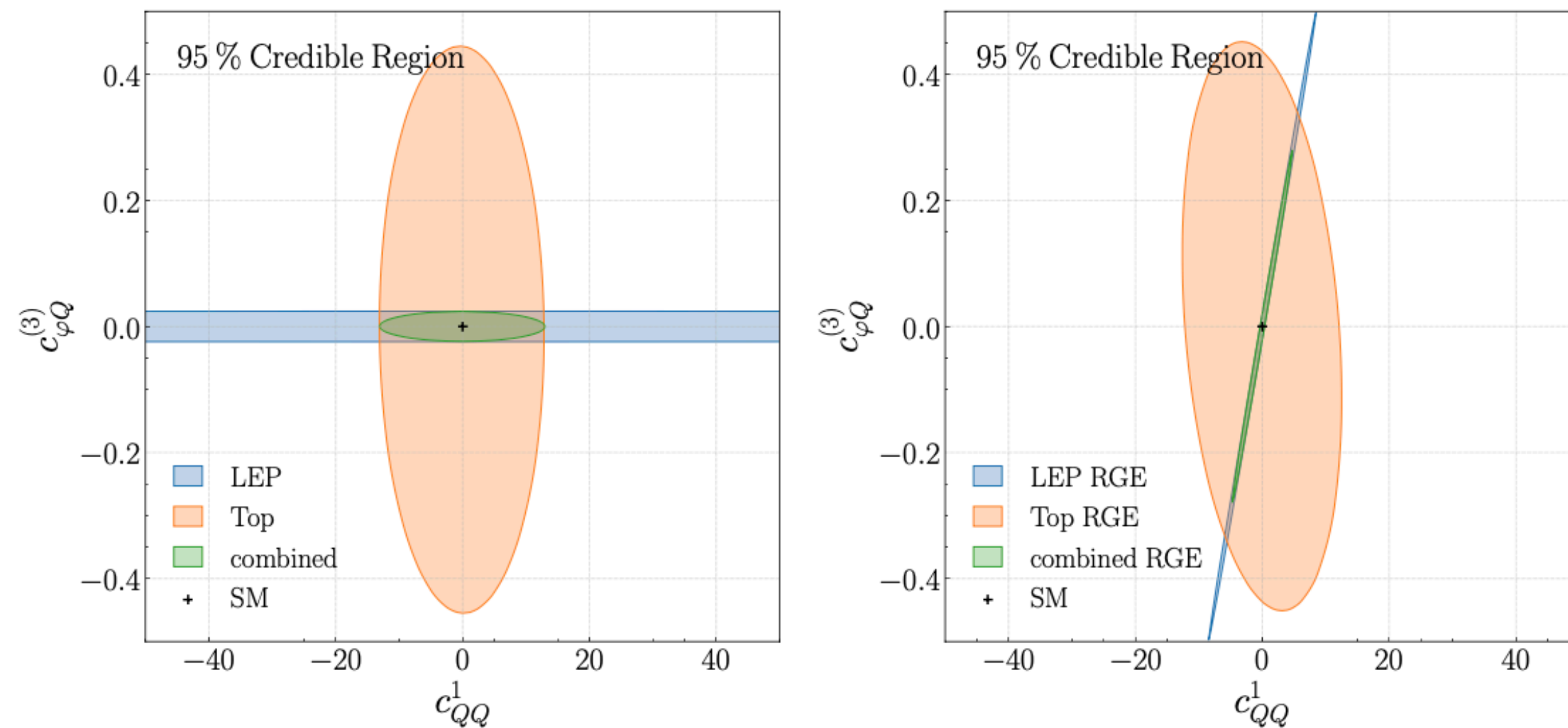


New operators generated at 2-loops



Thomas, Ventura, EV in preparation

Impact of RGE on the constraints



ter Hoeve, Mantani, Rojo, Rossia EV arXiv: 2502.20453

Mantani, Olgoso, Rossia arXiv:2604.16599

What do RGEs do?

- Change of linear combinations of coefficients probed (rotation of directions)
- Introduction of new dependences and hence correlations between coefficients
- RGE-improved constraints can be either more or less stringent

See Alejo's talk for more details

See also Bartocci, Biekotter, Hurth arXiv:2412.09674

When is dim-6 not enough?

How does introducing dim-8 operators change the bounds on dim-6 coefficient?

Example: Diboson production and c_W

Maximally growing dimension-8 operators:

$$\mathcal{O}_{10} = iW^{I\mu}{}_{\nu}W^{I\nu}{}_{\lambda}(\bar{q}\gamma^{\lambda}\overleftrightarrow{D}_{\mu}q)$$

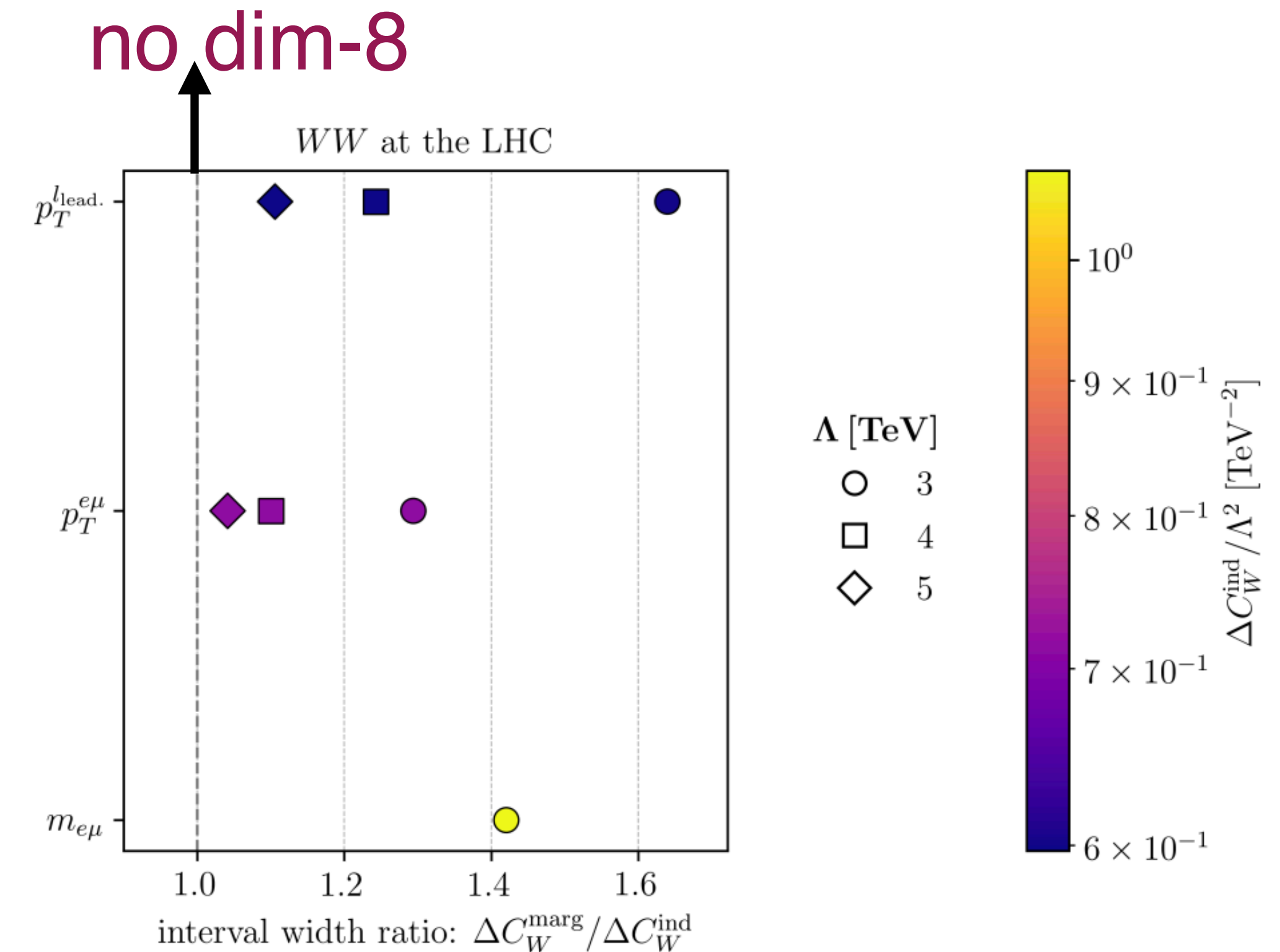
$$\mathcal{O}_{12} = i\epsilon^{IJK}\tilde{W}^{I\mu}{}_{\nu}W^{J\nu}{}_{\lambda}(\bar{q}^i\gamma^{\lambda}\tau_i^{Kj}\overleftrightarrow{D}_{\mu}q_j)$$

$$\mathcal{O}_{13} = i\epsilon^{IJK}W^{I\mu}{}_{\nu}\tilde{W}^{J\nu}{}_{\lambda}(\bar{q}^i\gamma^{\lambda}\tau_i^{Kj}\overleftrightarrow{D}_{\mu}q_j)$$

Degrande and Li 2303.10493

Positivity and unitarity can also play a role

Degrande et al 2511.15524, Chen et al 2309.15922



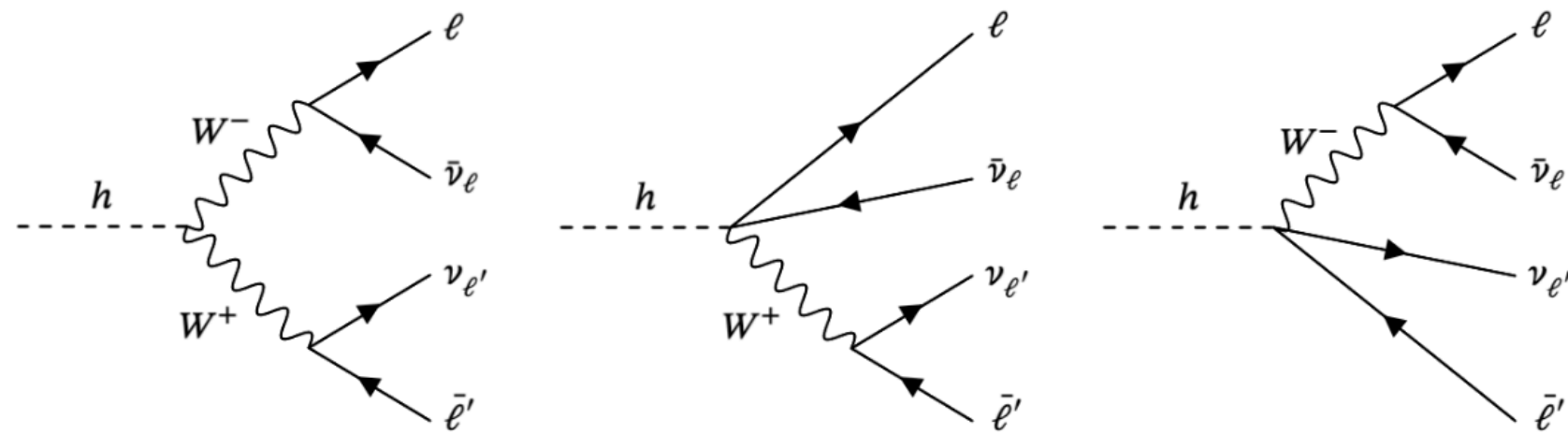
El Faham, Ventura, EV arXiv: 2511.04338

see also Gilles et al arXiv: 2412.16020, 2601.19495

Marginalisation over dim-8 coefficients can change the bounds on dim-6

Higher-order terms in the EFT expansion: $\mathcal{O}(1/\Lambda^4)$

$\mathcal{O}(1/\Lambda^4)$ description



$$Q_{HDHW}^{(8)} = i(H^\dagger H)(D^\mu H)^\dagger \sigma^I (D^\nu H) W_{\mu\nu}^I$$

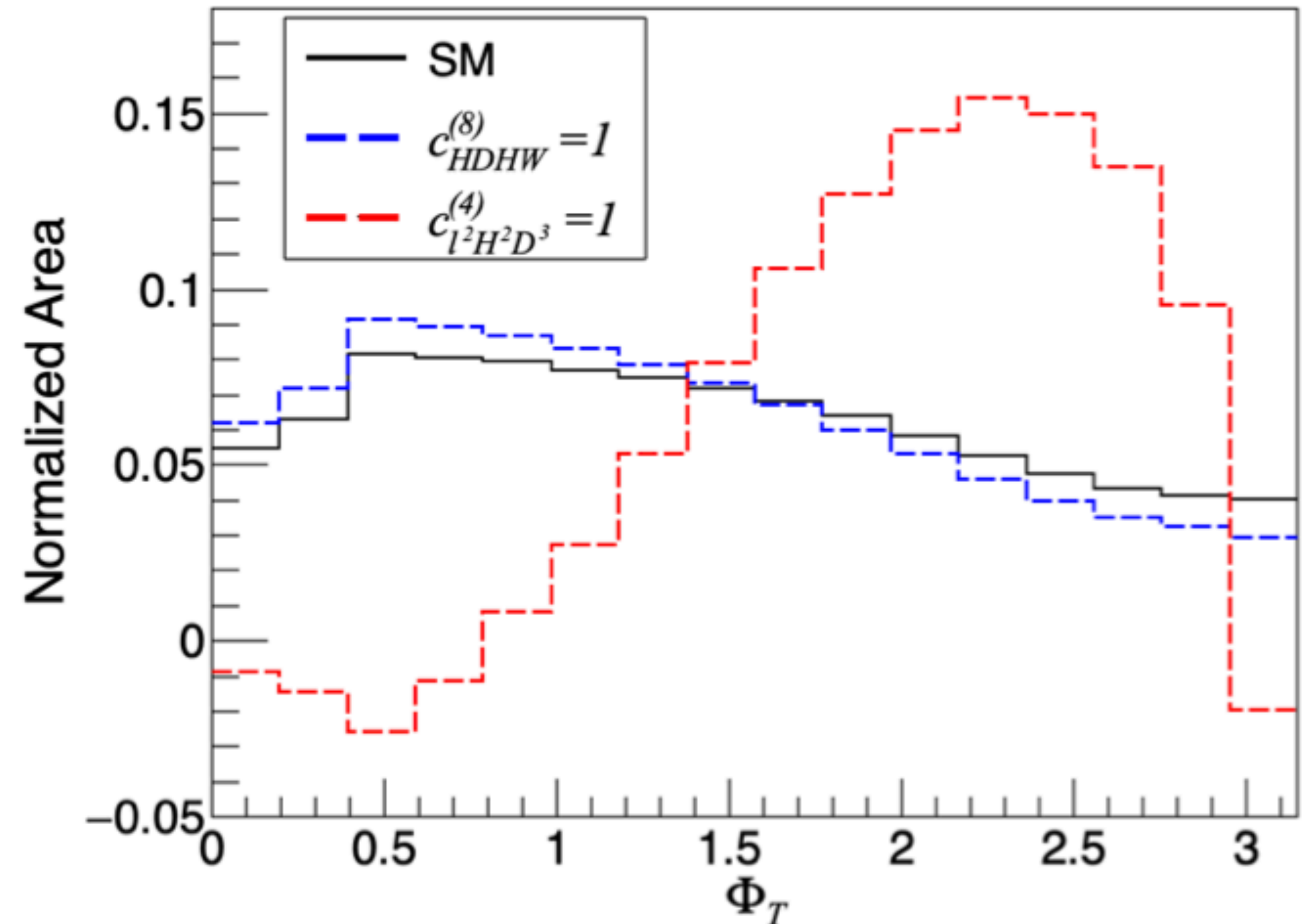
$$Q_{l^2 H^2 D^3}^{(4)} = i(\bar{l}_p \gamma^\mu \sigma^I \overleftrightarrow{D}^\nu l_r) [(D_\mu H)^\dagger \sigma^I (D_\nu H) + (D_\nu H)^\dagger \sigma^I (D_\mu H)]$$

GeoSMEFT: Flores-Hernandez and Martin 2602.12326

See also: Hays et al 1808.00442, Corbett et al 2107.07470, Corbett and Rasmussen 2110.03694, Corbett and Martin 2306.00053, Assi and Martin 2410.21563

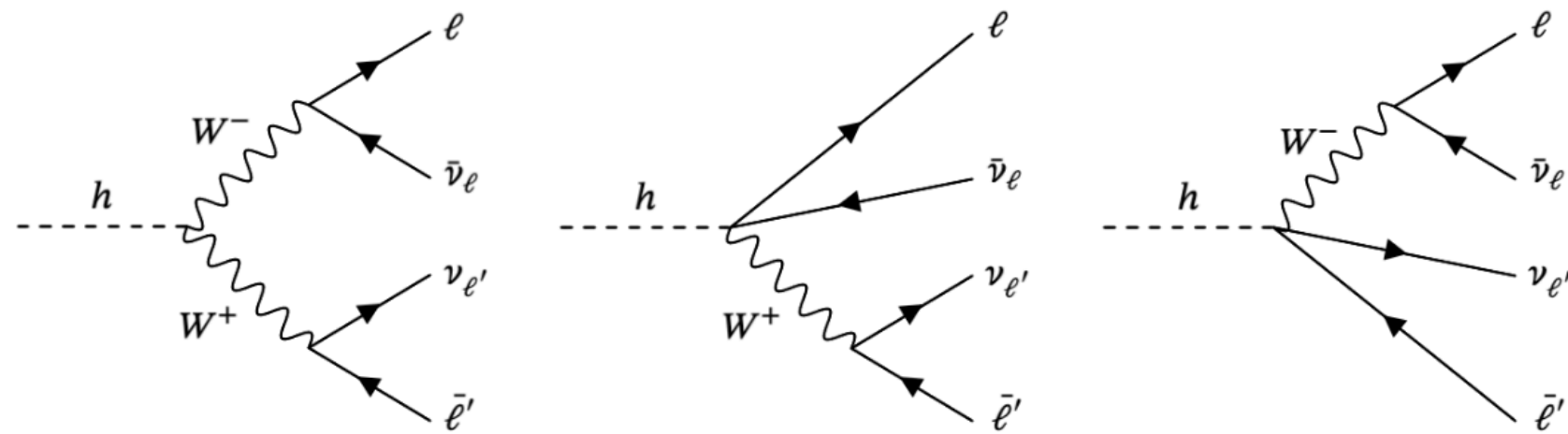
$$\cos \Phi_T = \frac{\vec{p}_{1,T} \cdot \vec{p}_{4,T}}{|\vec{p}_{1,T}| |\vec{p}_{4,T}|}$$

Potential new angular distributions but overall suppressed for $\mathcal{O}(1)$ coefficients



Higher-order terms in the EFT expansion: $\mathcal{O}(1/\Lambda^4)$

$\mathcal{O}(1/\Lambda^4)$ description



$$Q_{HDHW}^{(8)} = i(H^\dagger H)(D^\mu H)^\dagger \sigma^I (D^\nu H) W_{\mu\nu}^I$$

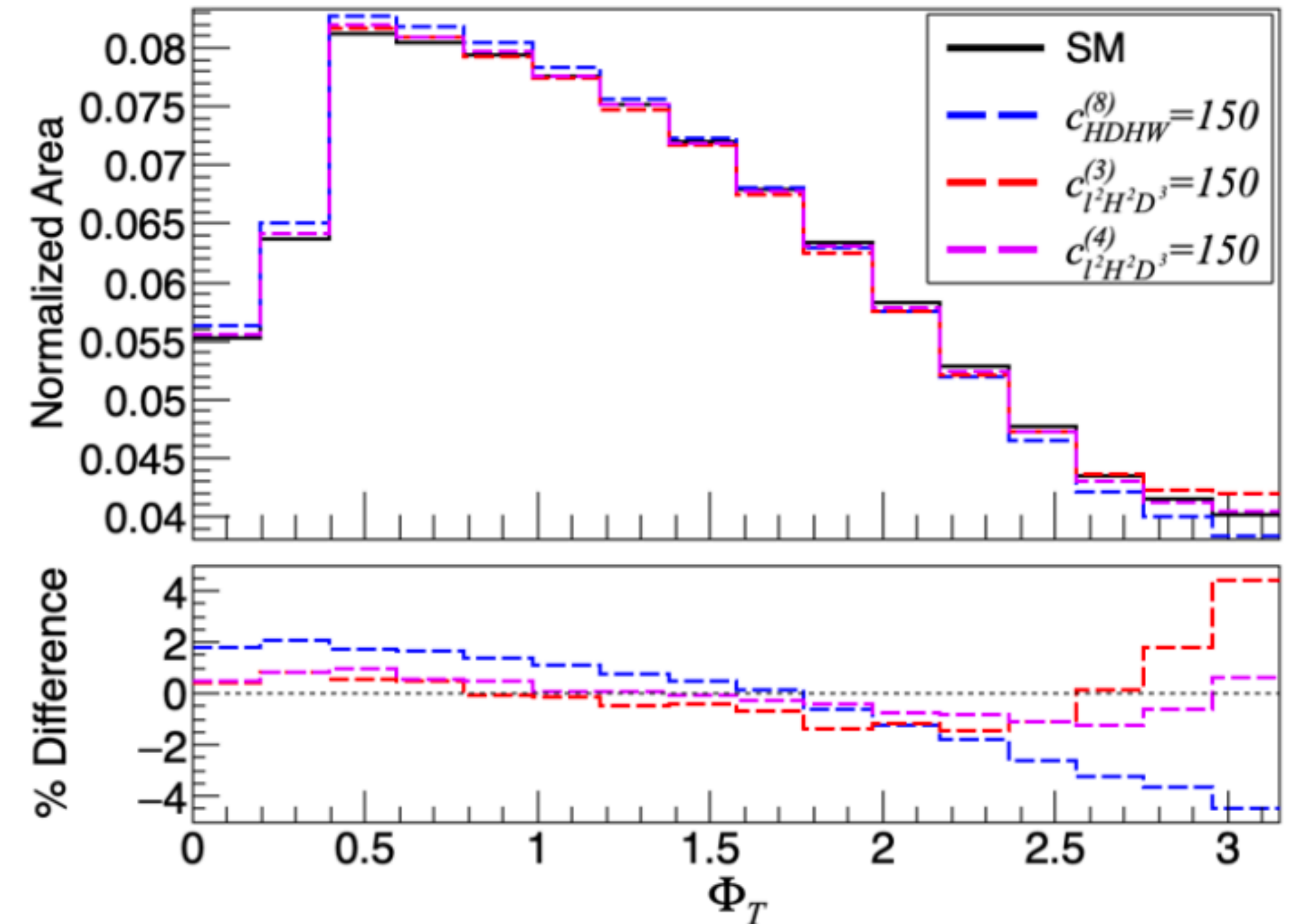
$$Q_{l^2 H^2 D^3}^{(4)} = i(\bar{l}_p \gamma^\mu \sigma^I \overleftrightarrow{D}^\nu l_r) [(D_\mu H)^\dagger \sigma^I (D_\nu H) + (D_\nu H)^\dagger \sigma^I (D_\mu H)]$$

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$$\cos \Phi_T = \frac{\vec{p}_{1,T} \cdot \vec{p}_{4,T}}{|\vec{p}_{1,T}| |\vec{p}_{4,T}|}$$

Potential new angular distributions but overall suppressed for $\mathcal{O}(1)$ coefficients



When SMEFT is not enough: HEFT vs SMEFT

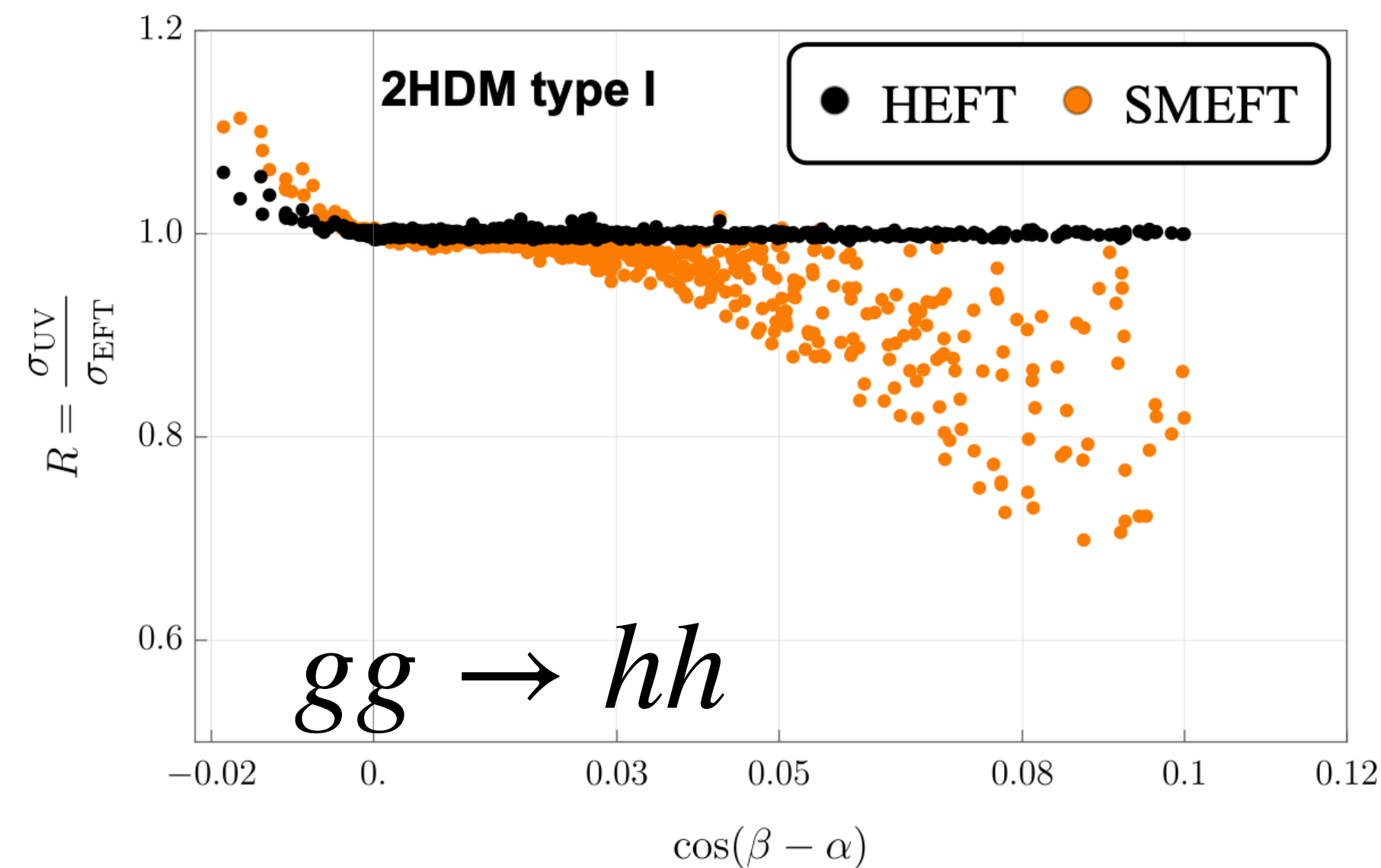
SMEFT assumes the SM symmetries leading to correlations
e.g. at dim-6 HVV and HHVV couplings, qqH and $qqHH$ are correlated

Motivations for going beyond SMEFT:

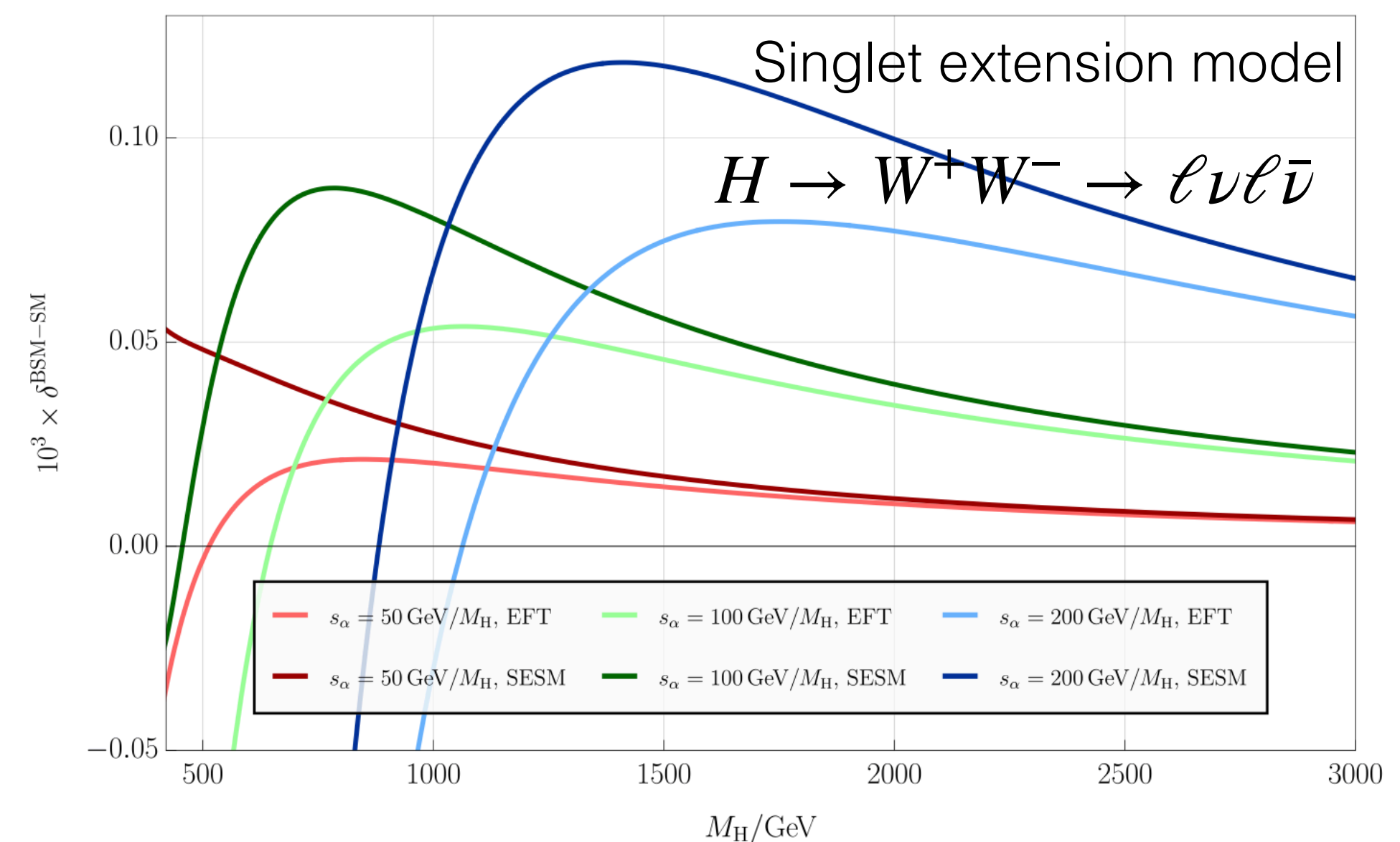
1) Confirm SMEFT is enough: e.g. HEFT (also at higher-orders) for HH

[Brivio, Grober, Schmid arXiv: 2511.23411](#)

2) UV models which cannot be described by SMEFT: e.g. Loryon models



[Asiain, Grober, Tiberi arXiv:2602.16288](#)



[Dittmaier, Schuhmacher, Stahlhofen arXiv:2604.01125](#)

Conclusions

- SMEFT is a consistent way to look for new interactions: a new standard for data interpretation
- Global fits results already available: important to combine as many processes as possible to extract maximal information
- Progress in precision computations in the SMEFT has an impact on probing new interactions
- Exploration of higher order terms in the EFT expansion and of HEFT are also underway

Thank you for your attention

SMEFT:

Standard Model
Effective Field Theory

