Dim-6 and dim-8 EFT studies with VBS at CMS

Costanza Carrivale[1], Andrea Piccinelli[2]
(Università degli Studi di Perugia [1], INFN Perugia [1],
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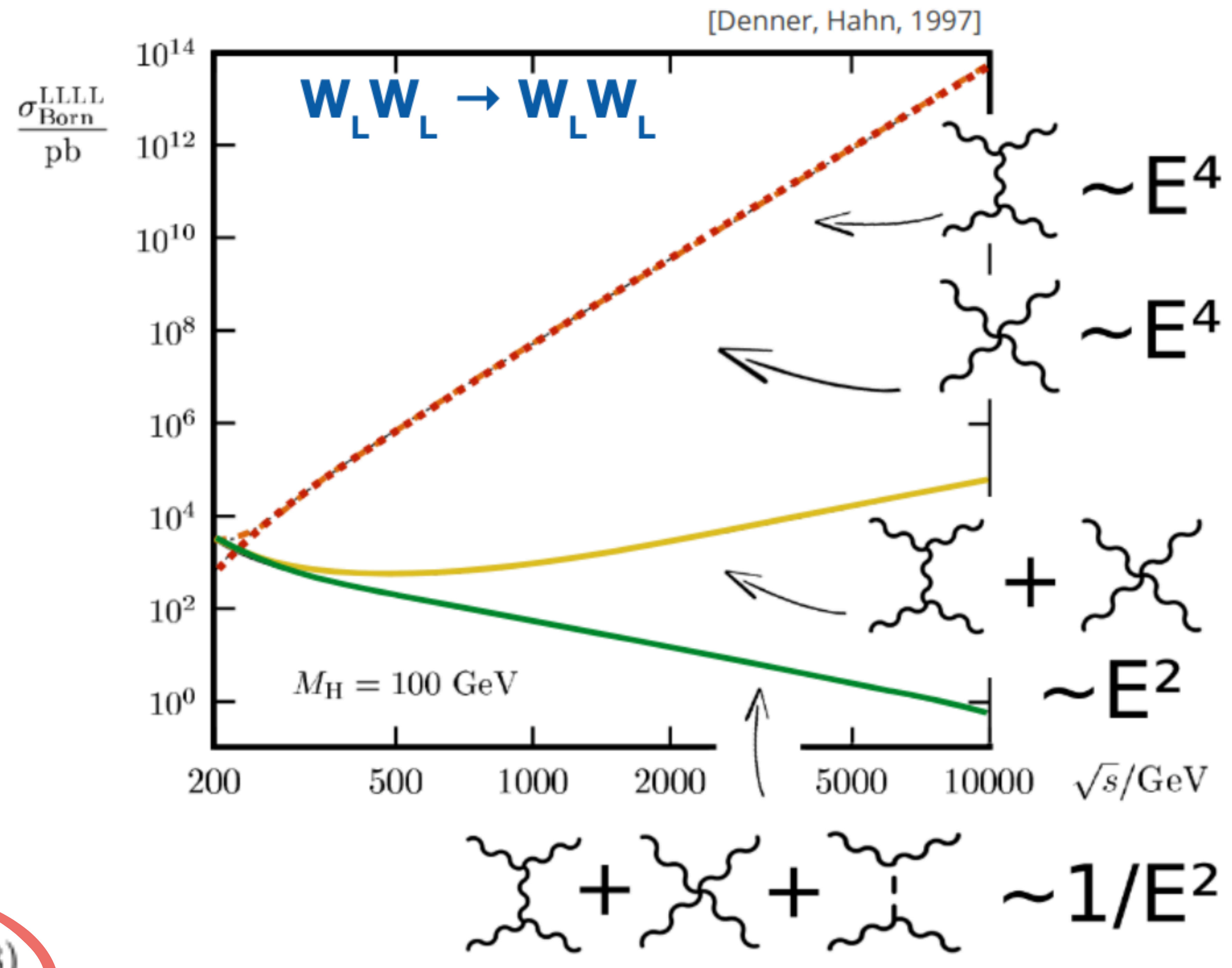
on behalf of the CMS Collaboration

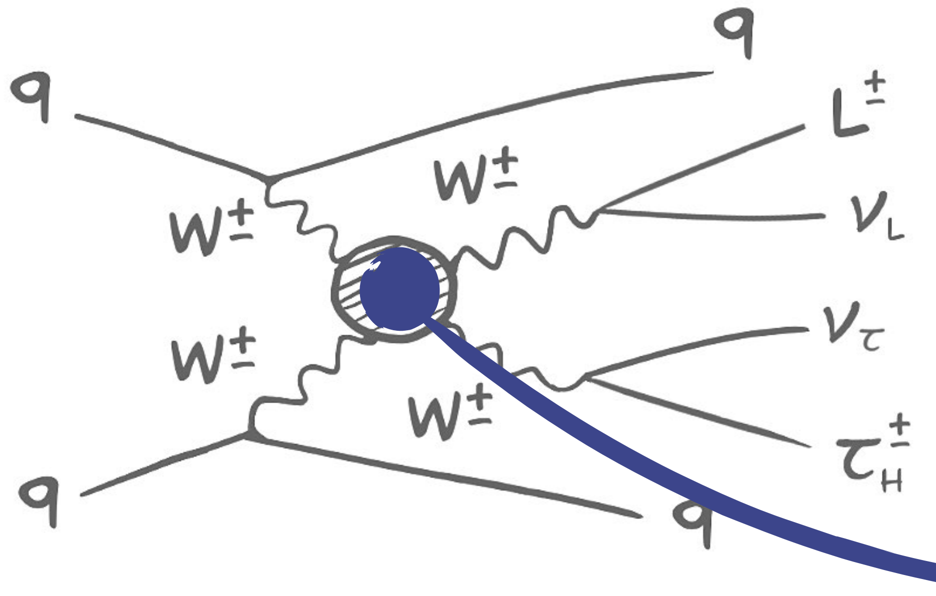
LHC EFT WG General Meeting - CERN, 3rd December 2024

Why is VBS so charming?

- **Investigation of both SM and (possible) BSM effects**
  VBS processes are strictly related to **unitarity preservation** in SM and precise measurements can probe the nature of the Higgs sector and EWSB mechanism

- **Anomalies modeling with EFT approach**
  VBS processes exhibit both QGC and TGC vertices and can be sensitive to deviations from the SM, parameterizable via model-independent approaches like EFT.





$$\mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{c_i^{(6)}}{\Lambda^2}^{*}\mathcal{O}_i^{(6)} + \sum_i \frac{f_i^{(8)}}{\Lambda^4}^{*}\mathcal{O}_i^{(8)} + \ldots$$

*c_i and f_i are EFT couplings, i.e. Wilson coefficients

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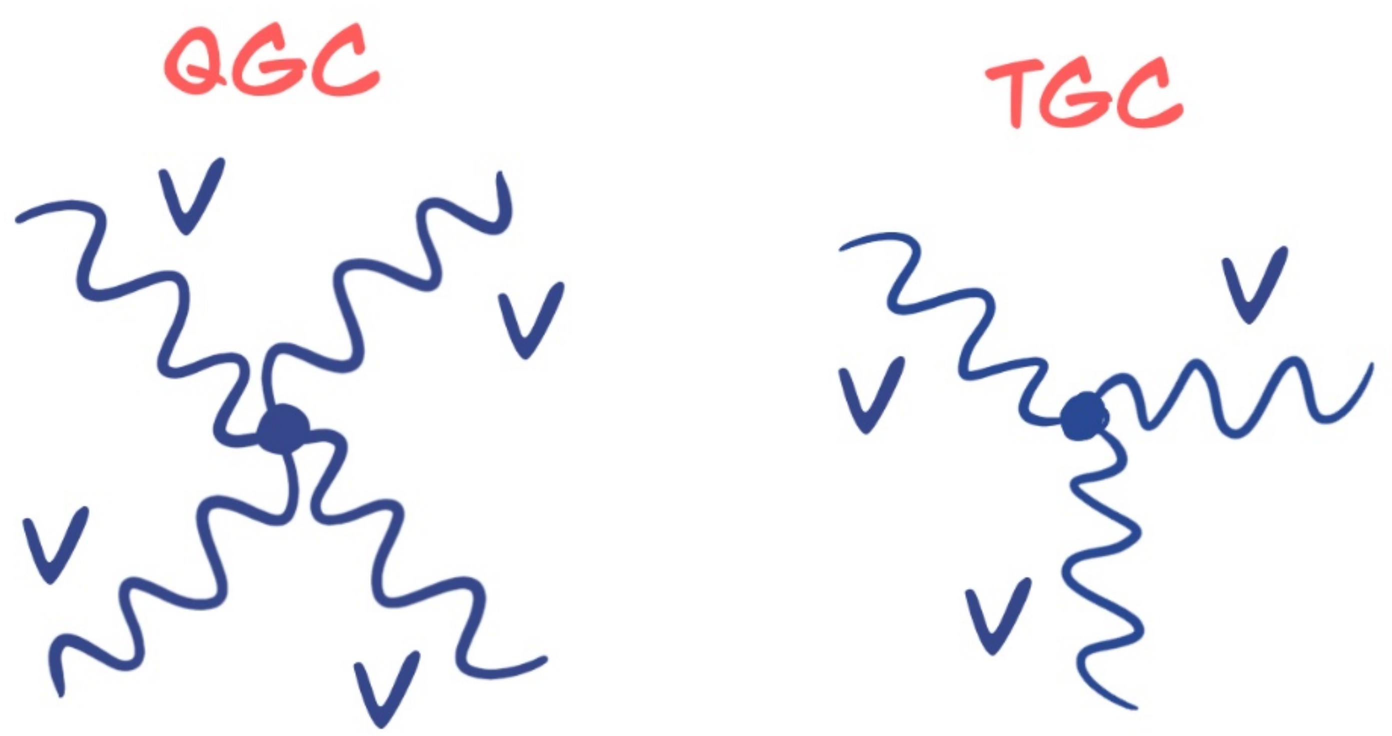

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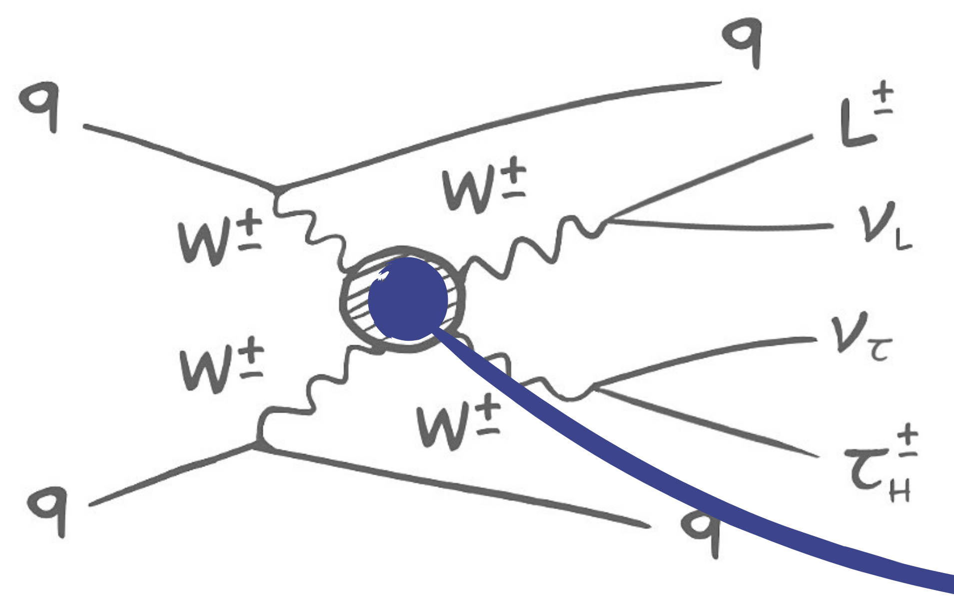

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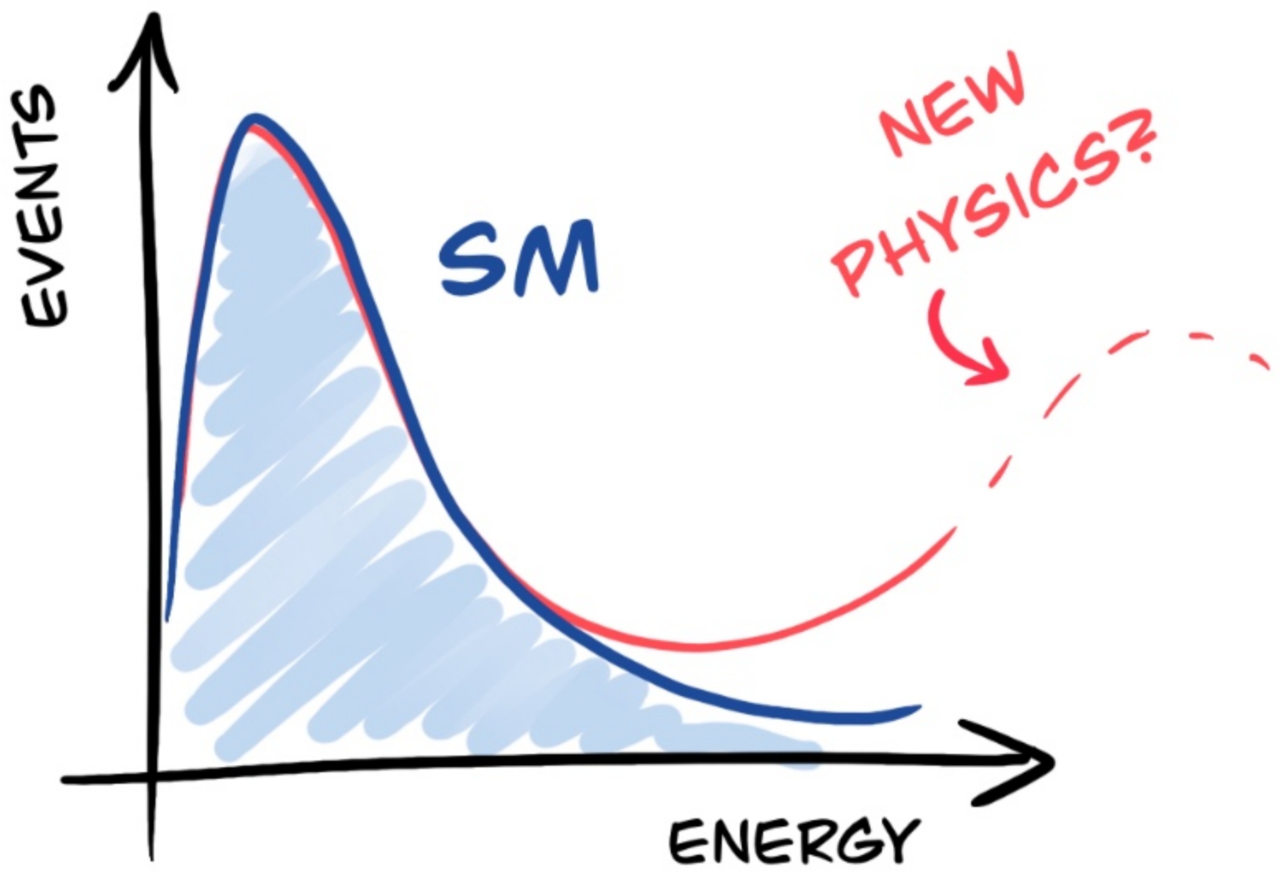

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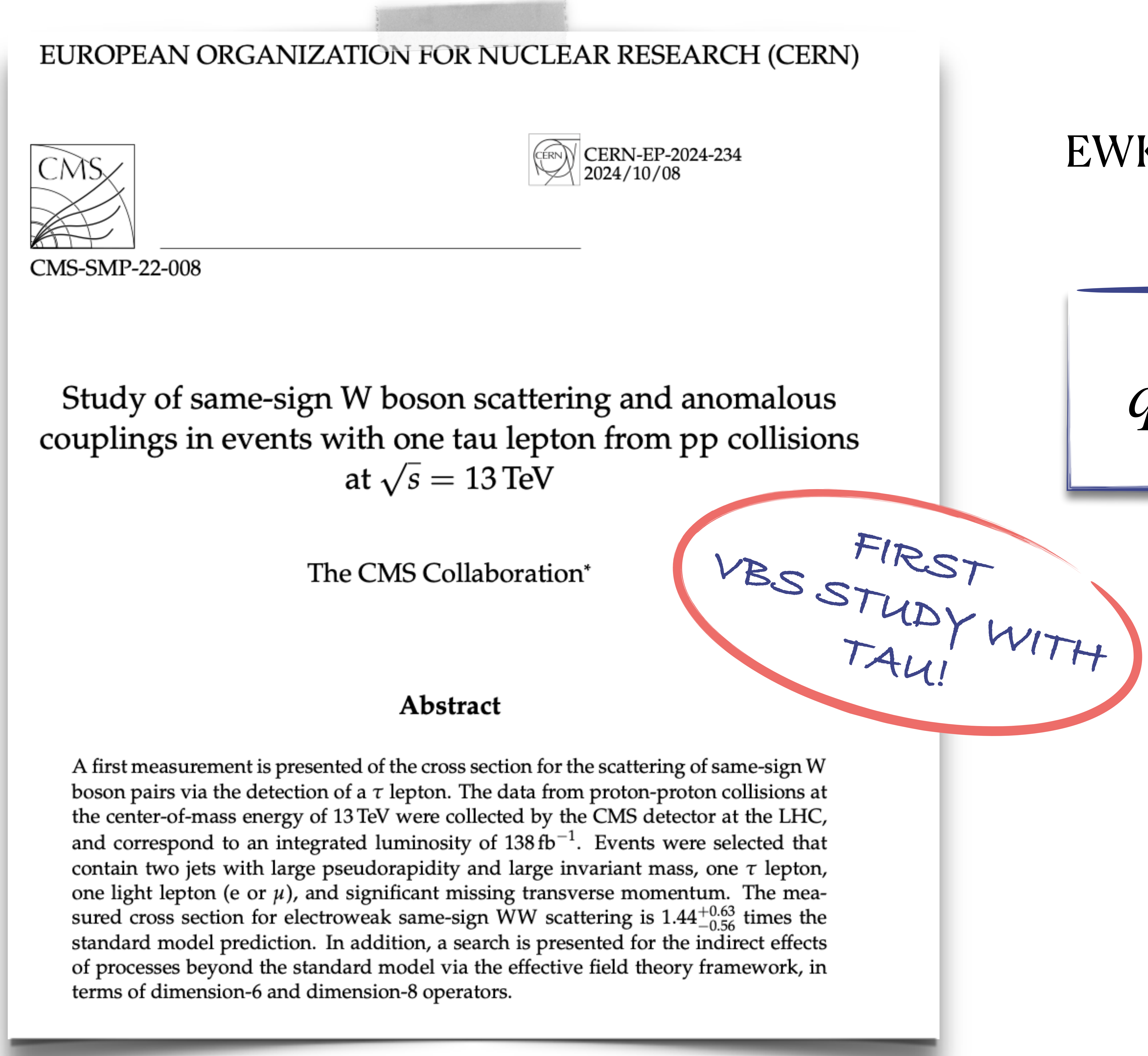
Overview of VBS same-sign W with one hadronic tau study

arXiv:2410.04210 - submitted to the Journal of High Energy Physics


EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CMS-SMP-22-008

CERN-EP-2024-234
2024/10/08

Study of same-sign W boson scattering and anomalous couplings in events with one tau lepton from pp collisions at $\sqrt{s} = 13\,\text{TeV}$

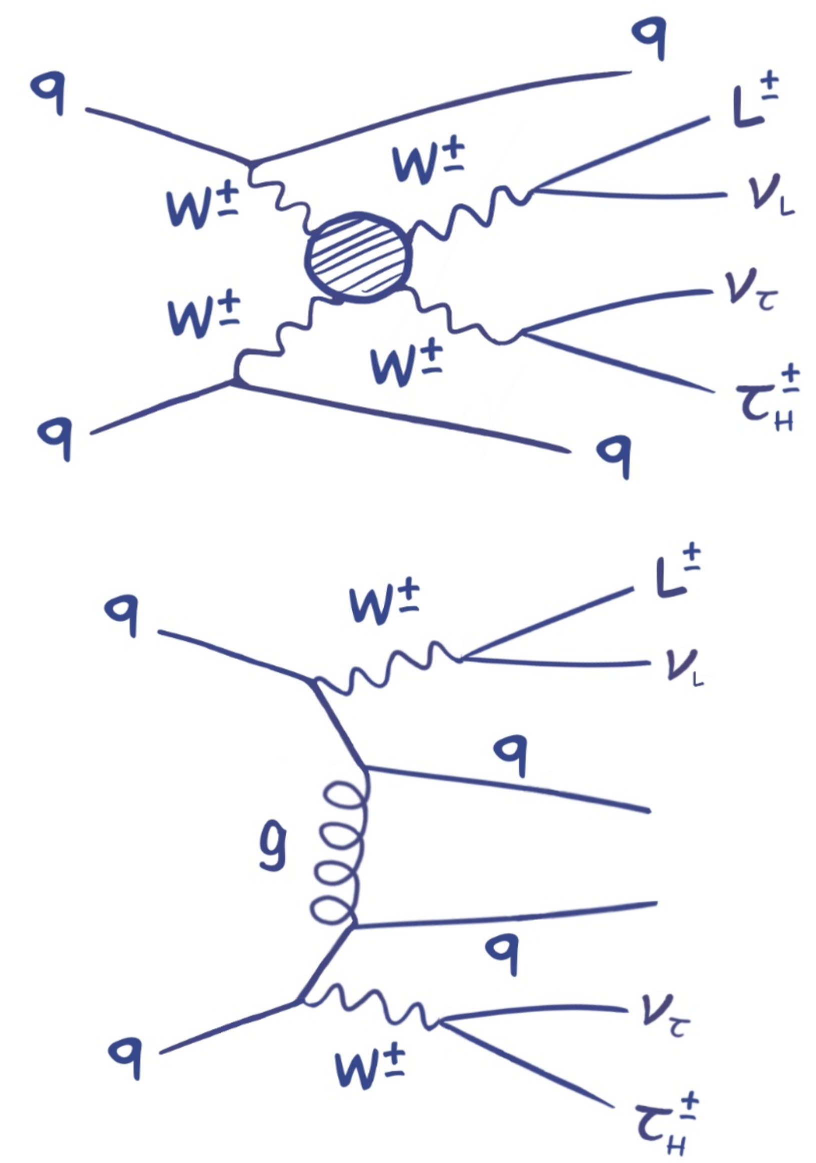
The CMS Collaboration*

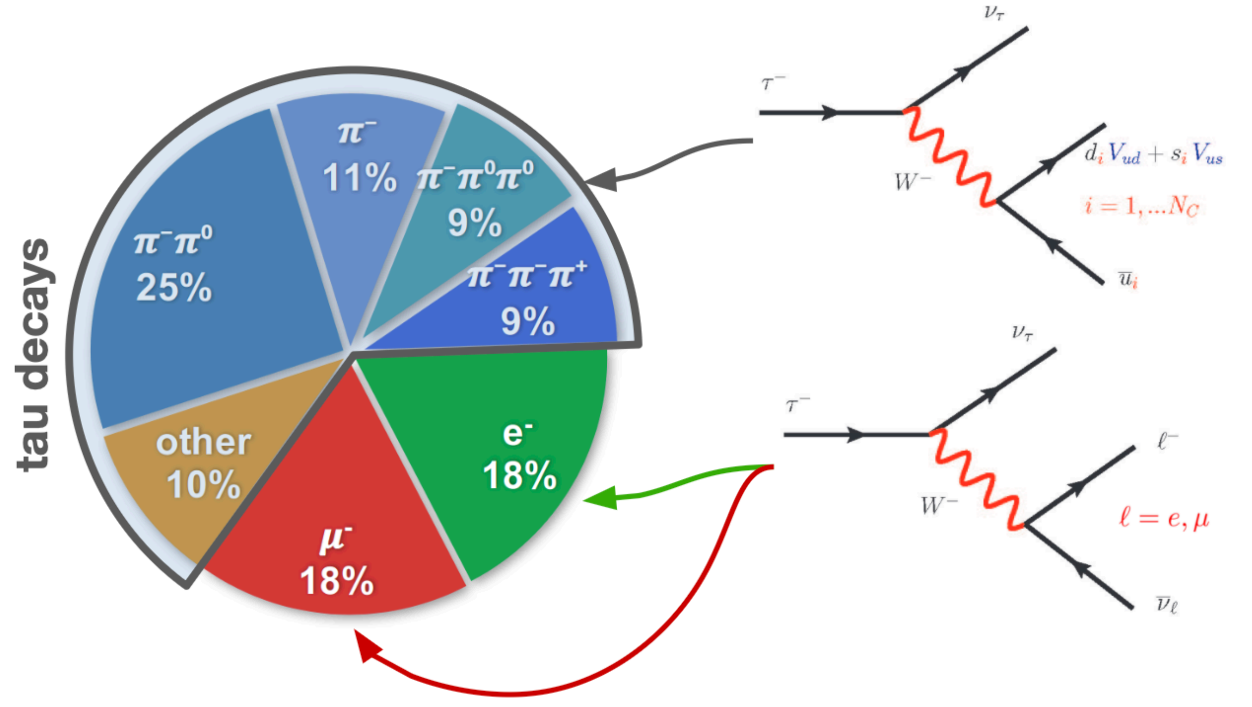
Abstract

A first measurement is presented of the cross section for the scattering of same-sign W boson pairs via the detection of a τ lepton. The data from proton-proton collisions at the center-of-mass energy of 13 TeV were collected by the CMS detector at the LHC, and correspond to an integrated luminosity of $138\,\text{fb}^{-1}$. Events were selected that contain two jets with large pseudorapidity and large invariant mass, one τ lepton, one light lepton (e or μ), and significant missing transverse momentum. The measured cross section for electroweak same-sign WW scattering is $1.44^{+0.63}_{-0.56}$ times the standard model prediction. In addition, a search is presented for the indirect effects of processes beyond the standard model via the effective field theory framework, in terms of dimension-6 and dimension-8 operators.

EWK production of same-sign W boson pairs with a hadronically decaying τ in the final state (@13 TeV, full RunII data):

$$qq' \rightarrow W^{\pm}W^{\pm}q''q''' \rightarrow l^{\pm}\tau_h j j \nu_l \nu_\tau \quad (l = e, \mu)$$





Overview of VBS same-sign W with one hadronic tau study

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FIRST VBS STUDY WITH TAU!

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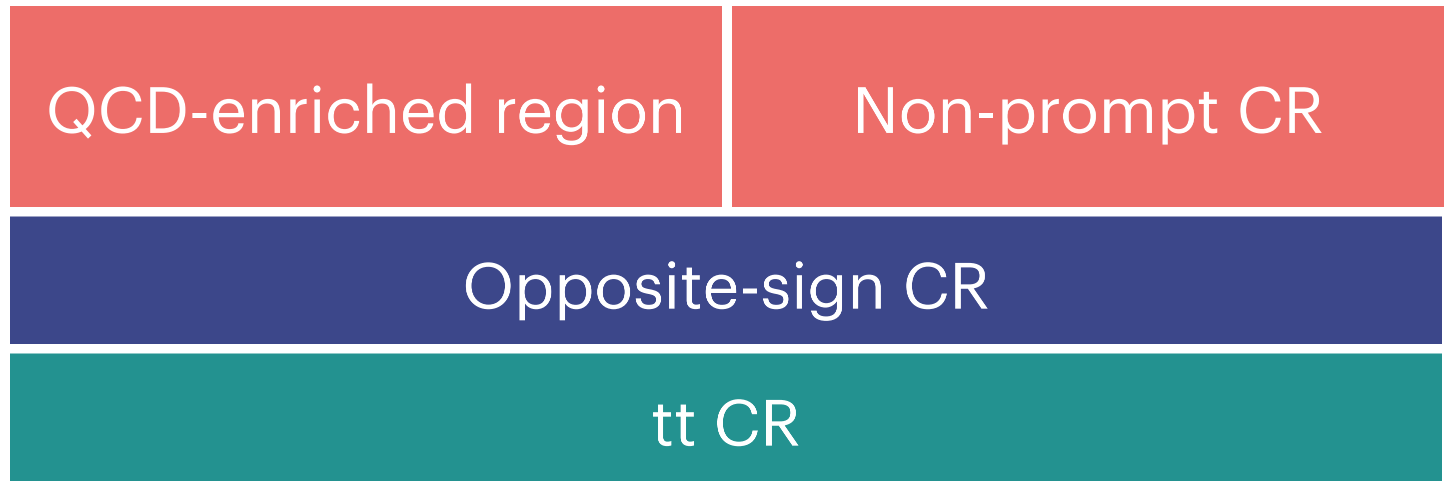
Main backgrounds sources in SR are:

- events containing nonprompt leptons from QCD-mediated multijet, W+jets, hadr. and semi-leptonic tt (**95%**)
- Z/γ^* + jets (2%)
- Dileptonic tt production (1%)



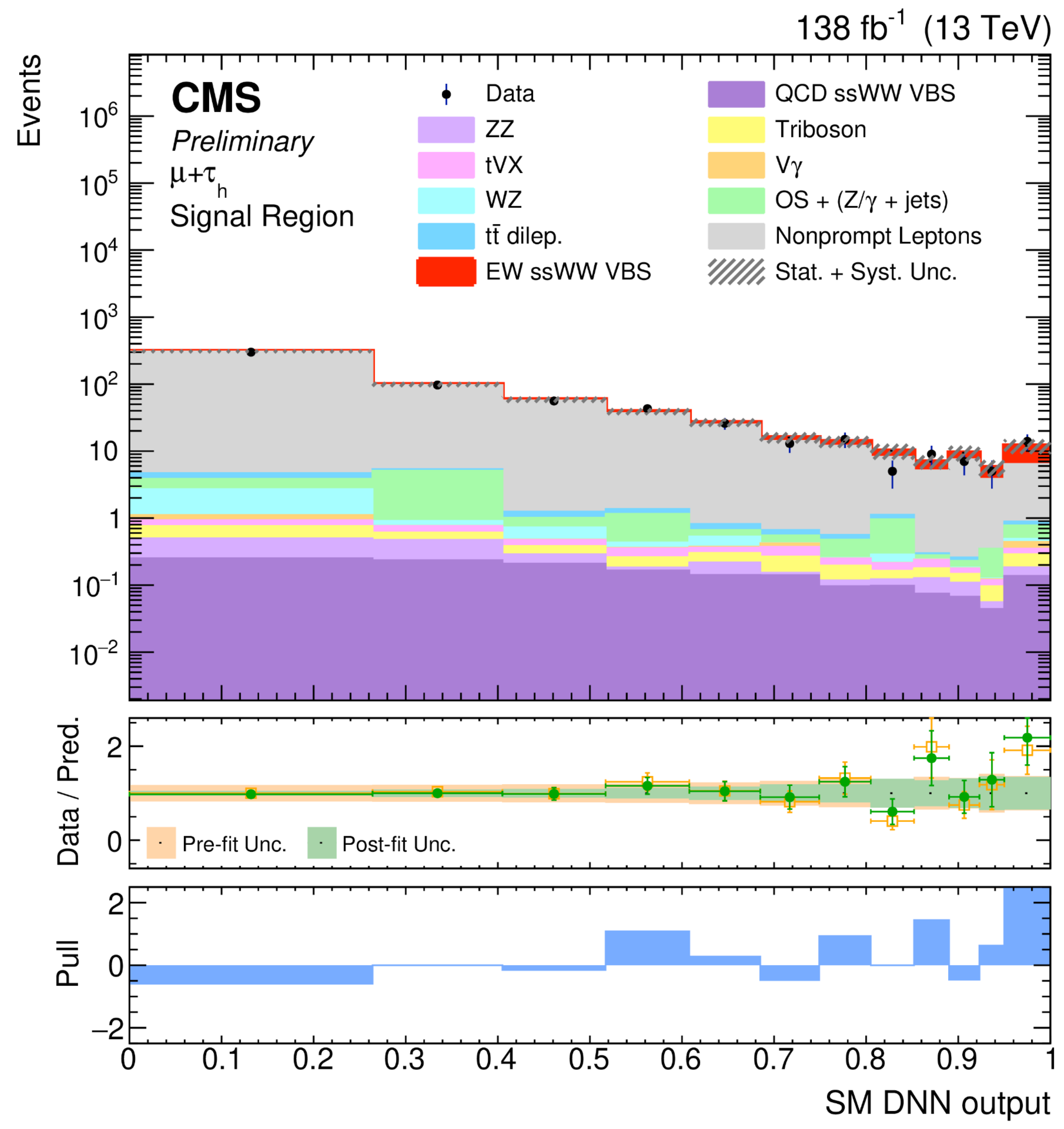
Both signal and background events are fully processed through detector reconstruction —> Full simulation analysis

Deliverables from the analysis

SM measurements

Measurement of purely EW ssWW signal strength and EWK+QCD ssWW signal strength:

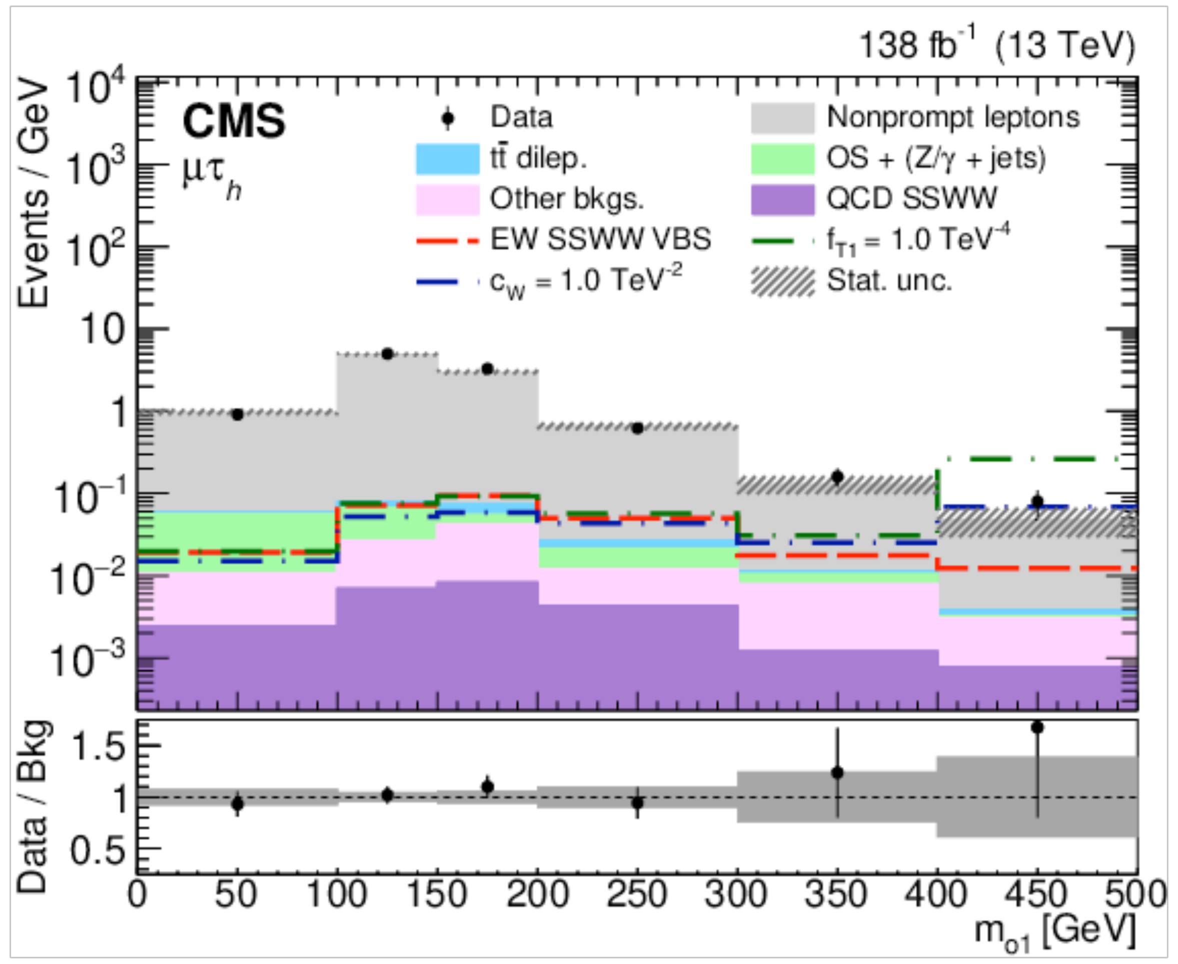
Signal	$\mu = \sigma_{OBS}/\sigma_{SM}$	Significance [σ]	Cross Section [fb]
EWK ssWW	$1.44^{+0.63}_{-0.56}$	2.7 (1.9 exp)	28.7
EWK+QCD ssWW	$1.43^{+0.60}_{-0.54}$	2.9 (2.0 exp)	51.0



EFT sensitivity study

Likelihood scan performed using a dedicated transverse mass as the discriminating variable.

- 1D scans, both for dim-6 and dim-8 operators (first time in VBS)
- 2D simultaneous scans of relevant operator pairs, first time ever with different dimension.



Focus of today: dim-6 vs dim-8 fits.

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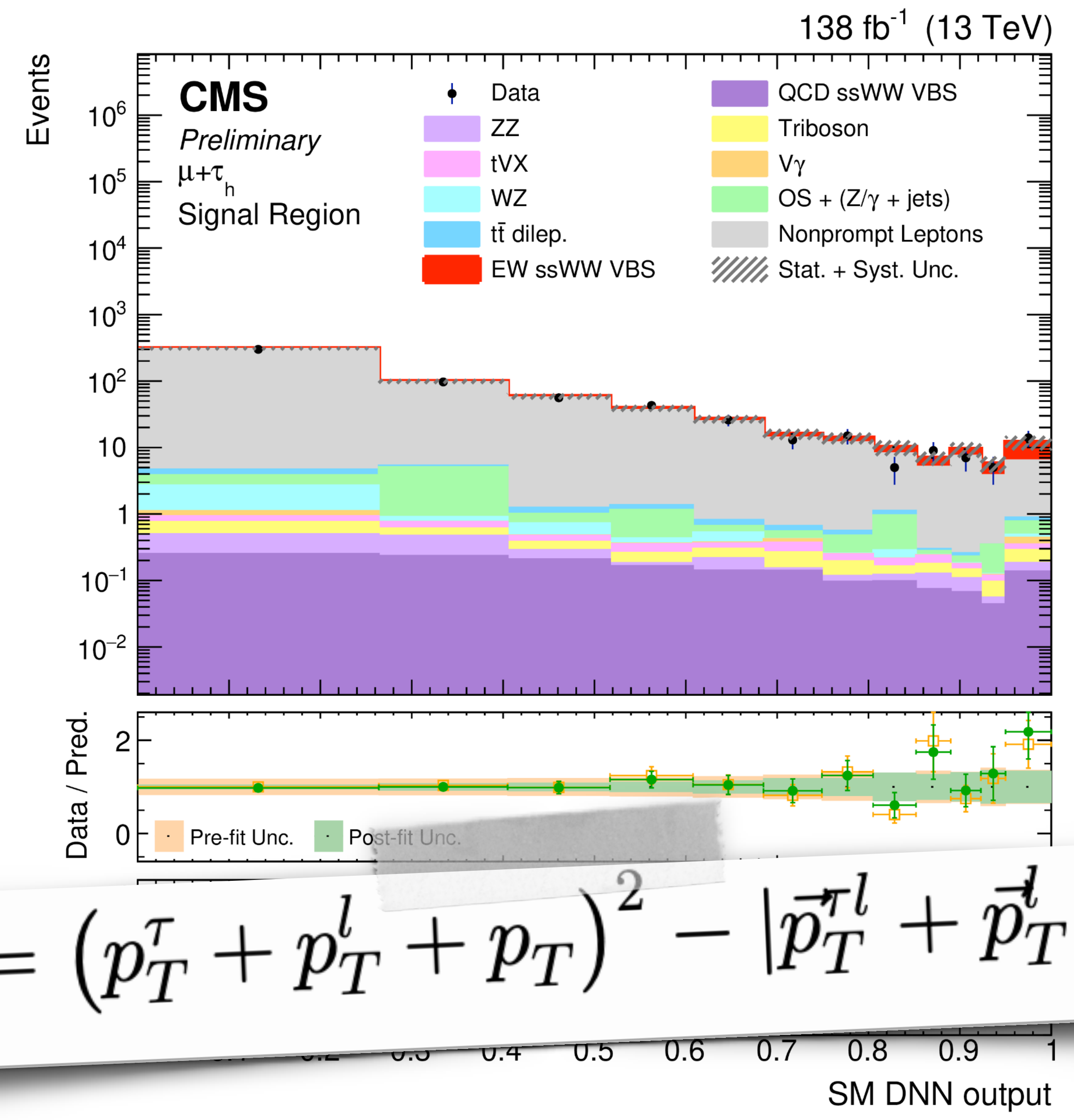

$$M_{o1}^2 = (p_T^\tau + p_T^l + p_T)^2 - |\vec{p}_T^{\tau} + \vec{p}_T^{l} + \vec{p}_T|^2$$

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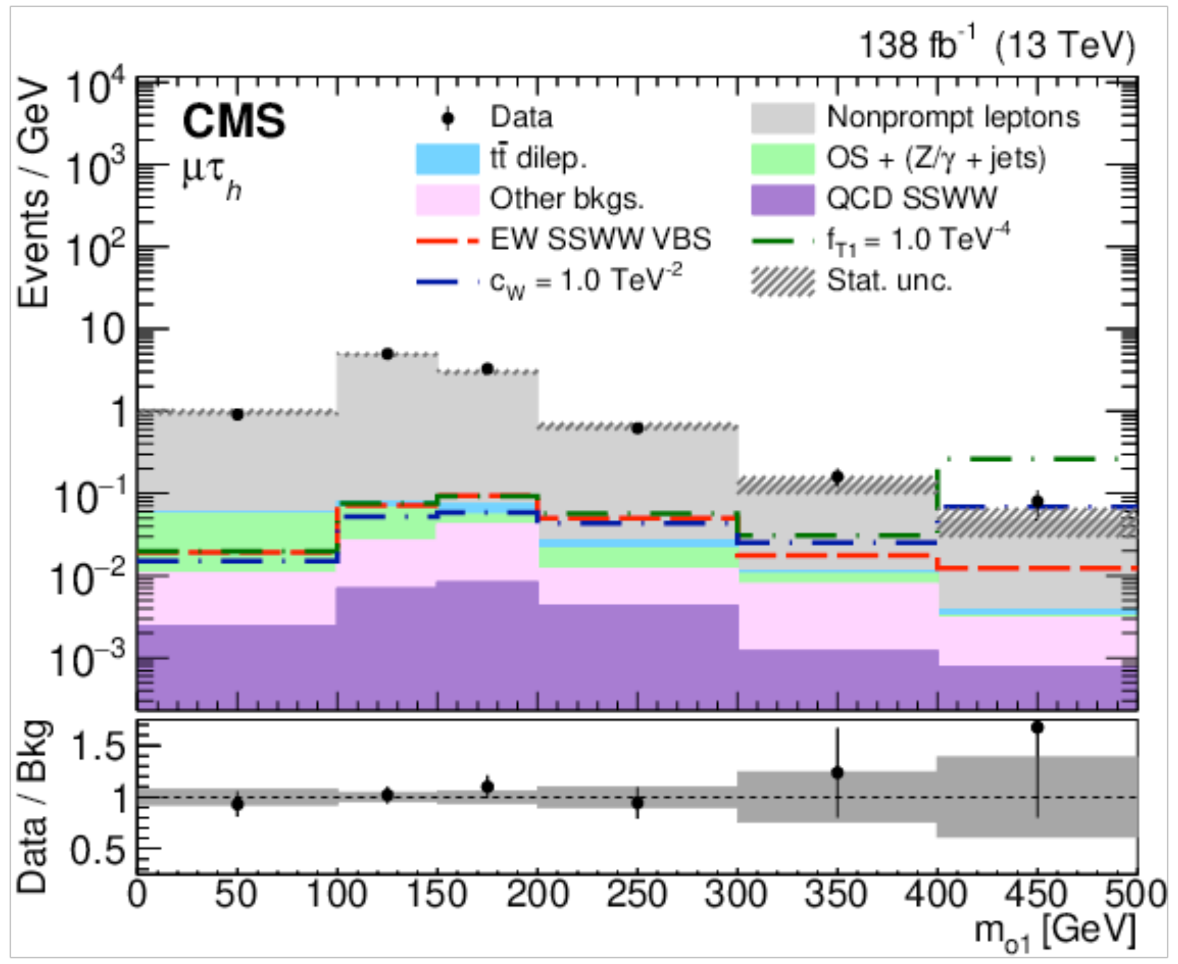


List of operators included

$$\mathcal{L}_{\text{EFT}} = \mathcal{L}_{\text{SM}} + \sum_i \frac{c_i^{(6)}}{\Lambda^2}\mathcal{O}_i^{(6)} + \sum_i \frac{f_i^{(8)}}{\Lambda^4}\mathcal{O}_i^{(8)} + \dots$$

Dim-6 operators

$$\mathcal{O}_{ll} = \delta_{pr}\delta_{st}(\bar{l}_p\gamma_\mu l_r)(\bar{l}_s\gamma^\mu l_t)$$
$$\mathcal{O}'_{ll} = \delta_{pt}\delta_{sr}(\bar{l}_p\gamma_\mu l_r)(\bar{l}_s\gamma^\mu l_t)$$
$$\mathcal{O}^{(1)}_{qq} = \delta_{pr}\delta_{st}(\bar{q}_p\gamma_\mu q_r)(\bar{q}_s\gamma^\mu q_t)$$
$$\mathcal{O}^{(1)'}_{qq} = \delta_{pt}\delta_{sr}(\bar{q}_p\gamma_\mu q_r)(\bar{q}_s\gamma^\mu q_t)$$
$$\mathcal{O}^{(3)}_{qq} = \delta_{pr}\delta_{st}(\bar{q}_p\gamma_\mu\tau^i q_r)(\bar{q}_s\gamma^\mu\tau^i q_t)$$
$$\mathcal{O}^{(3)'}_{qq} = \delta_{pt}\delta_{sr}(\bar{q}_p\gamma_\mu\tau^i q_r)(\bar{q}_s\gamma^\mu\tau^i q_t)$$

$$\mathcal{O}^{(1)}_{\varphi l} = (\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar{l}_p\gamma^\mu l_r)$$
$$\mathcal{O}^{(3)}_{\varphi l} = (\varphi^\dagger i\overleftrightarrow{D}^i{}_\mu\varphi)(\bar{l}_p\tau^i\gamma^\mu l_r)$$
$$\mathcal{O}^{(1)}_{\varphi q} = (\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar{q}_p\gamma^\mu q_r)$$
$$\mathcal{O}^{(3)}_{\varphi q} = (\varphi^\dagger i\overleftrightarrow{D}^i{}_\mu\varphi)(\bar{q}_p\tau^i\gamma^\mu q_r)$$

$$\mathcal{O}_W = \epsilon^{ijk}W_\mu^{\nu i}W_\nu^{\rho j}W_\rho^{\mu k}$$
$$\mathcal{O}_{\varphi\Box} = (\varphi^\dagger\varphi)\Box(\varphi^\dagger\varphi)$$
$$\mathcal{O}_{\varphi D} = (\varphi^\dagger D^\mu\varphi)*(\varphi^\dagger D_\mu\varphi)$$
$$\mathcal{O}_{\varphi W} = \varphi^\dagger\varphi W^i_{\mu\nu}W^{\mu\nu i}$$
$$\mathcal{O}_{\varphi WB} = \varphi^\dagger\tau^i\varphi W^i_{\mu\nu}B^{\mu\nu}$$

Warsaw basis

arXiv:1008.4884

SMEFTsim@LO

CP conservation

U(3)5 flavor symmetry

Eboli basis

arXiv:1604.03555v1

generating genuine **anomalous-Quartic-Couplings**

dedicated UFO model

U(3)5 flavor symmetry

Dim-8 operators

$$\mathcal{O}_{S,0} = [(D_\mu\Phi)^\dagger D_\nu\Phi]\times[(D^\mu\Phi)^\dagger D^\nu\Phi]$$
$$\mathcal{O}_{S,1} = [(D_\mu\Phi)^\dagger D^\mu\Phi]\times[(D_\nu\Phi)^\dagger D^\nu\Phi]$$
$$\mathcal{O}_{S,2} = [(D_\mu\Phi)^\dagger D_\nu\Phi]\times[(D^\nu\Phi)^\dagger D^\mu\Phi]$$

$$\mathcal{O}_{M,0} = \text{Tr}[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}]\times[(D_\beta\Phi)^\dagger D^\beta\Phi]$$
$$\mathcal{O}_{M,1} = \text{Tr}[\hat{W}_{\mu\nu}\hat{W}^{\nu\beta}]\times[(D_\beta\Phi)^\dagger D^\mu\Phi]$$
$$\mathcal{O}_{M,7} = [(D_\mu\Phi)^\dagger\hat{W}_{\beta\nu}D^\nu\Phi]$$

$$\mathcal{O}_{T,0} = \text{Tr}[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}]\times\text{Tr}[\hat{W}_{\alpha\beta}\hat{W}^{\alpha\beta}]$$
$$\mathcal{O}_{T,1} = \text{Tr}[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}]\times\text{Tr}[\hat{W}_{\mu\beta}\hat{W}^{\alpha\nu}]$$
$$\mathcal{O}_{T,2} = \text{Tr}[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}]\times\text{Tr}[\hat{W}_{\beta\nu}\hat{W}^{\nu\alpha}]$$

Simulation @LO with MADGRAPH5 aMC@NLO v2.6.5

Combined EFT operators study

The number of expected events is proportional to square module of scattering amplitude.

Two dim-6 operators at the time

$$|\mathcal{A}_{\mathrm{TOT}}|^2 = |\mathcal{A}_{SM}|^2 + \sum_{i}^{N_{dim6}} \left[\frac{c_i}{\Lambda^2} 2\Re\left(\mathcal{A}_{\mathcal{O}_i^{(6)}} \mathcal{A}_{SM}^*\right) + \frac{c_i^2}{\Lambda^4} |\mathcal{A}_{\mathcal{O}_i^{(6)}}|^2 \right] + \sum_{j \neq m}^{N_{dim6}} \left[\frac{c_j c_m}{\Lambda^4} 2\Re\left(\mathcal{A}_{\mathcal{O}_j^{(6)}} \mathcal{A}_{\mathcal{O}_m^{(6)}}^*\right) \right]$$

$$+ \sum_{k}^{N_{dim8}} \left[\frac{f_k}{\Lambda^4} 2\Re\left(\mathcal{A}_{\mathcal{O}_k^{(8)}} \mathcal{A}_{SM}^*\right) + \frac{f_k^2}{\Lambda^8} |\mathcal{A}_{\mathcal{O}_k^{(8)}}|^2 \right]$$

One operator dim-6 and one operator dim-8 at the time

- EFT operator contributions up to Λ^4 are considered;
- CMS analysis framework breaks down in presence of negative histograms (coming from EFT linear terms). Since SM·dim8 interference can give negative contributions, $\mathrm{dim8}^2$ term is included.

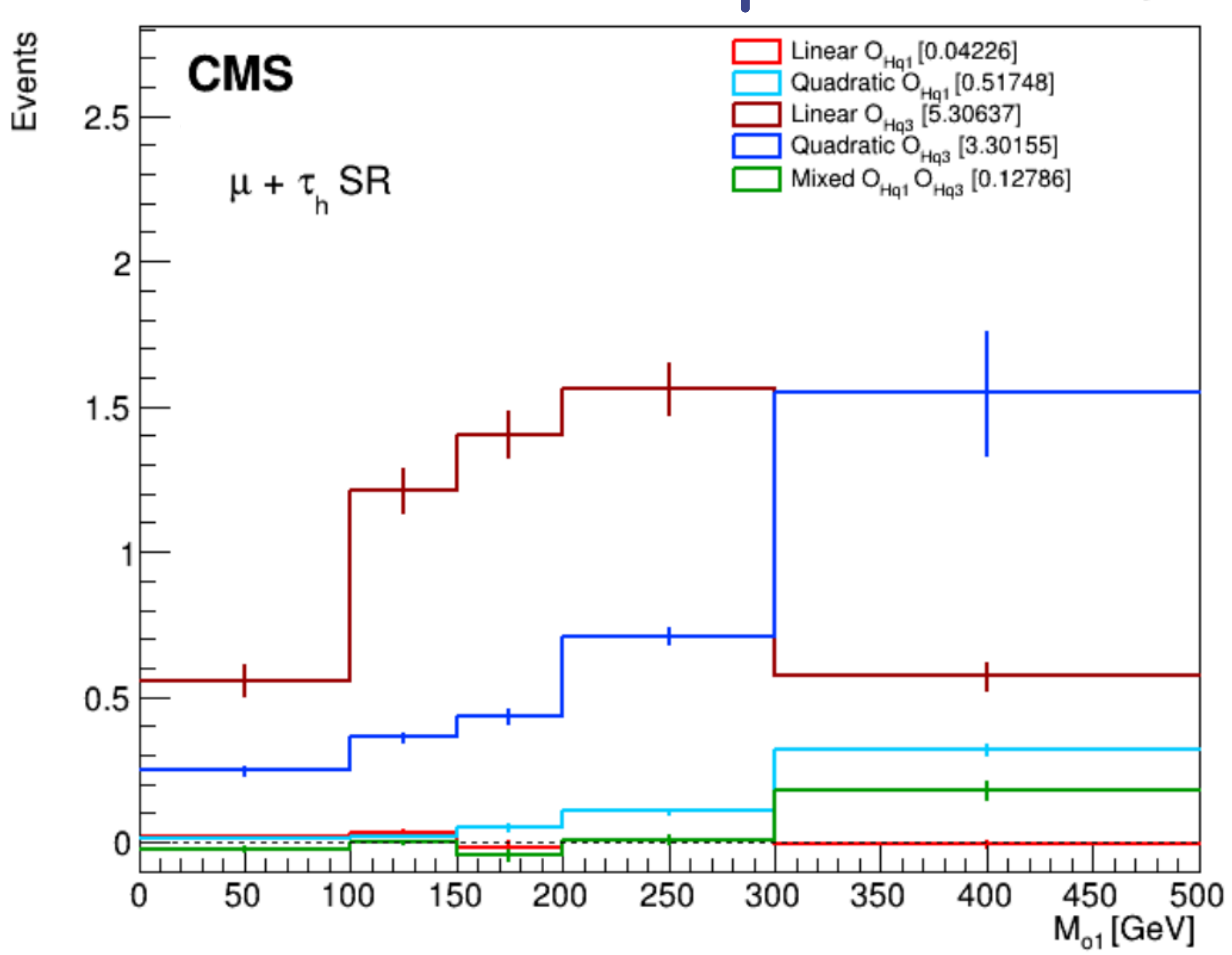
Which pairs are we considering?

We want to avoid looking at the statistical effects coming with multiple EFT contributions.
The coupling criteria are the following:

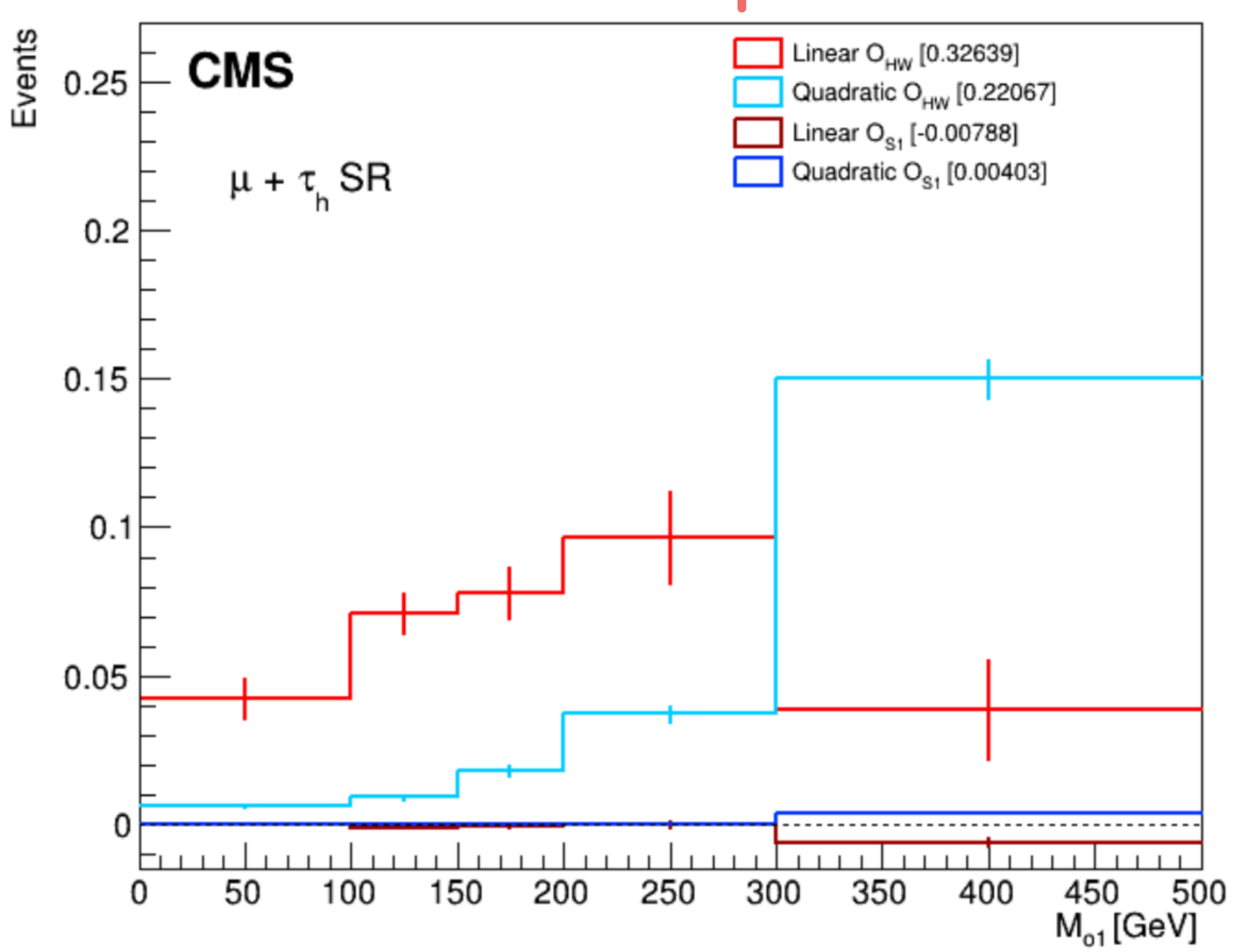
- Operators acting on the same vertex ($W^{\pm}W^{\pm} \rightarrow W^{\pm}W^{\pm}$ scattering vertex);
- Operators giving similar contributions to the process (ratio between linear and quadratic terms).

Any effect arising from such a combination can be interpreted in terms of physics effects.

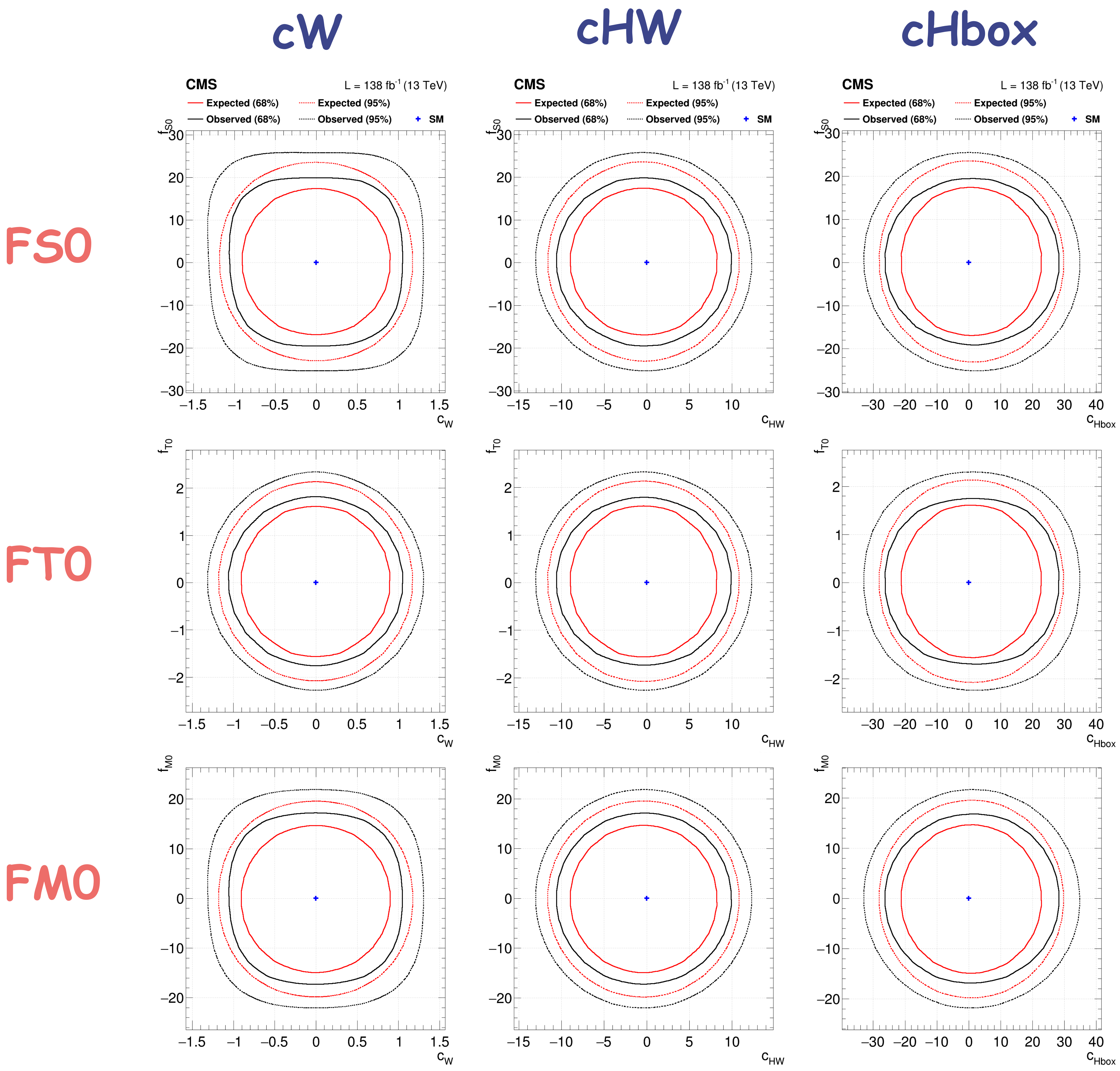
dim6-dim6 pair



dim6-dim8 pair



2D scans: dim6 VS dim8 pairs



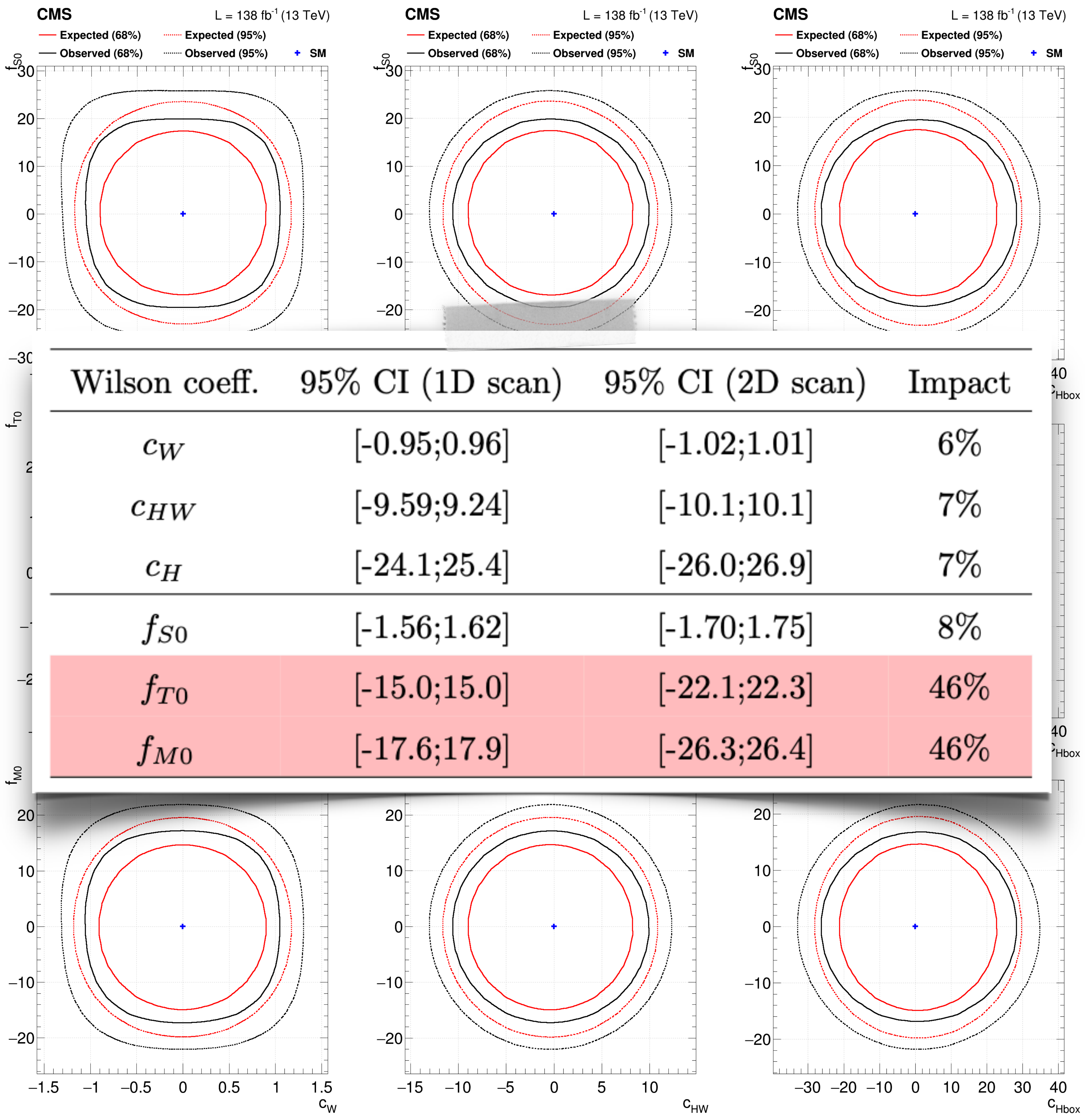
2D scans: dim6 VS dim8 pairs

cW | cHW | cHbox

FS0

FT0

FM0



Wilson coeff.	95% CI (1D scan)	95% CI (2D scan)	Impact
c_W	[-0.95;0.96]	[-1.02;1.01]	6%
c_{HW}	[-9.59;9.24]	[-10.1;10.1]	7%
c_H	[-24.1;25.4]	[-26.0;26.9]	7%
f_{S0}	[-1.56;1.62]	[-1.70;1.75]	8%
f_{T0}	[-15.0;15.0]	[-22.1;22.3]	46%
f_{M0}	[-17.6;17.9]	[-26.3;26.4]	46%

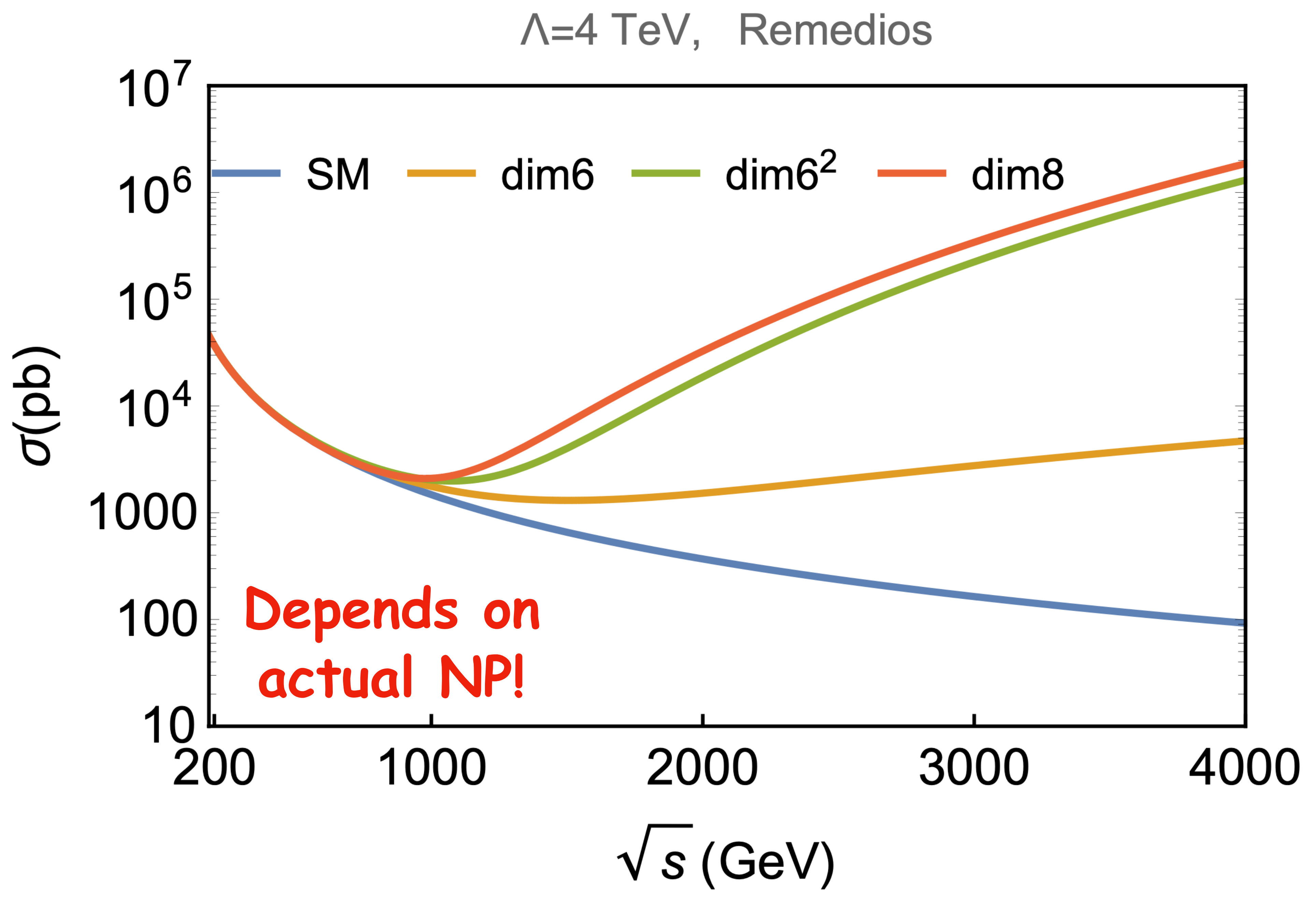
Conclusions

In EFT, we cannot always assume that dim-6 operators are negligible compared to dimension-8 ones.

- Overestimation of **dim-8 experimental sensitivity** occurs if **dim-6 operators** are not included in the analysis.

- The interplay between dimension-6 and dimension-8 effects cannot be determined a priori without explicit consideration in the analysis -> potential bias on NP

VBS $W_T W_T \longrightarrow W_T W_T$



Common model for dim-6 and dim-8 operators: SmeftFR model

SmeftFR v3 – Feynman rules generator for the Standard Model Effective Field Theory

A. Dedes[a], J. Rosiek[b,*], M. Ryczkowski[b], K. Suxho[a], L. Trifyllis[a]

[a]*Department of Physics, University of Ioannina, GR 45110, Ioannina, Greece*
[b]*Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*

Abstract

We present version 3 of SmeftFR, a Mathematica package designed to generate the Feynman rules for the Standard Model Effective Field Theory (SMEFT) including the complete set of gauge invariant operators up to dimension-6 and the complete set of bosonic operators of dimension-8. Feynman rules are generated with the use of FeynRules package, directly in the physical (mass eigenstates) basis for all fields. The complete set of interaction vertices can be derived, including all or any chosen subset of SMEFT operators. As an option, the user can also choose preferred gauge fixing, generating Feynman rules in unitary or R_ξ-gauges. The novel feature in version-3 of SmeftFR is its ability to calculate SMEFT interactions consistently up to dimension-8 in EFT expansion (including quadratic dimension-6 terms) and express the vertices directly in terms of user-defined set of input-parameters. The derived Lagrangian in the mass basis can be exported in various formats supported by FeynRules, such as UFO, FeynArts, *etc.* Initialisation of numerical values of Wilson coefficients of higher dimension operators is interfaced to WCxf format. The package also includes a dedicated Latex generator allowing to print the result in clear human-readable form. The SmeftFR v3 is publicly available at www.fuw.edu.pl/smeft.

Keywords: Standard Model Effective Field Theory, Feynman rules, unitary and R_ξ-gauges

SmeftFR model (arXiv:2302.01353) includes operators of both dimensions:

- Warsaw basis for dim-6;
- **Murphy's basis*** for dim-8 bosonic operators.

Possibility to perform dim-6+dim-8 simulations including effects of dim8 on TGCs.

* In Eboli we have dim8 operators affecting QGCs only and with a limited number of derivatives. Murphy's one is a full basis of dim8 operators.
It's possible to map operators from one basis to another.

Basis of [5]	Basis of [6]	SmeftFR	AGC	Δ
w+ w- > h h				
SM		0.0218	0.0218	0.00%
$C^{(2)}_{\varphi D^4}$	$C^{(0)}_S$	0.2191	0.2191	0.00%
$C^{(3)}_{\varphi D^4}$	$C^{(1)}_S$	1.5868	1.5868	0.00%
$C^{(1)}_{\varphi D^4}$	$C^{(2)}_S$	0.2191	0.2191	0.00%
$\frac{1}{2}C^{(2)}_{W^2\varphi^2 D^2}$	$C^{(0)}_M$	2.5622	2.5622	0.00%
$-\frac{1}{2}C^{(1)}_{W^2\varphi^2 D^2}$	$C^{(1)}_M$	0.2307	0.2307	0.00%
$\frac{1}{4}\left(C^{(1)}_{W^2\varphi^2 D^2} - C^{(4)}_{W^2\varphi^2 D^2}\right)$	$C^{(7)}_M$	0.0576	0.0576	0.00%

Common model for dim-6 and dim-8 operators: SmeftFR model

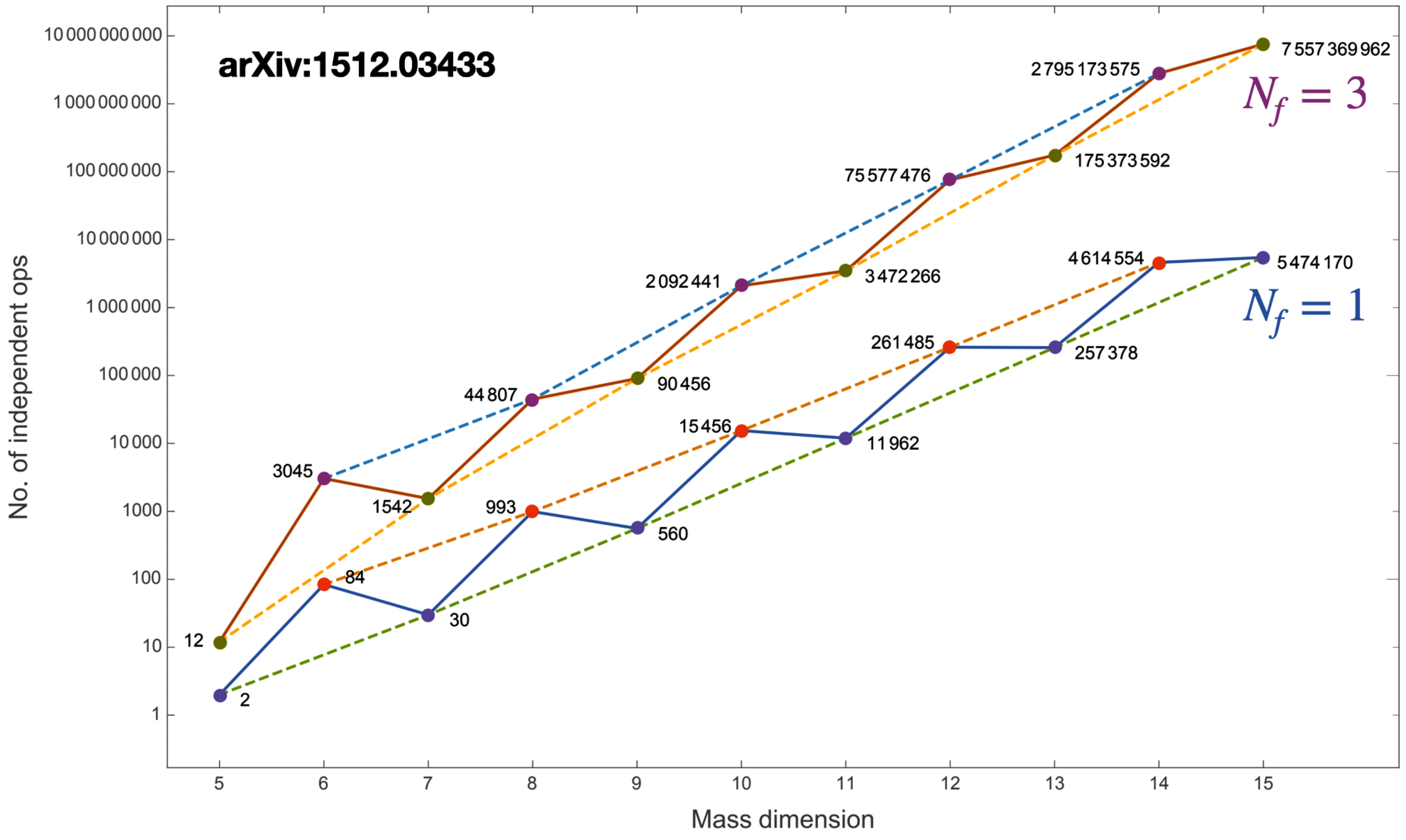
HIGH NUMBER OF OPERATORS!

PROS:

Effects of interplay between operators of different dimensions on TGCs

CONS:

High number of operators —> increase of degrees of freedom in the fits (leads to instability of fits due to limited statistics)



Summary

In this analysis we demonstrated that there is an interplay between different dimensions (even though we are not considering the dim6-dim8 interference term!)

- There is technical complexity in considering both dimensions, but it's a more correct approach to preserve model independence in NP searches;
- A validated model that allows us to perform a complete dim6+dim8 study on TGCs is available.

We may need a full model including dim6-dim8 interference terms to see correlations between two different dimensions.

Backup

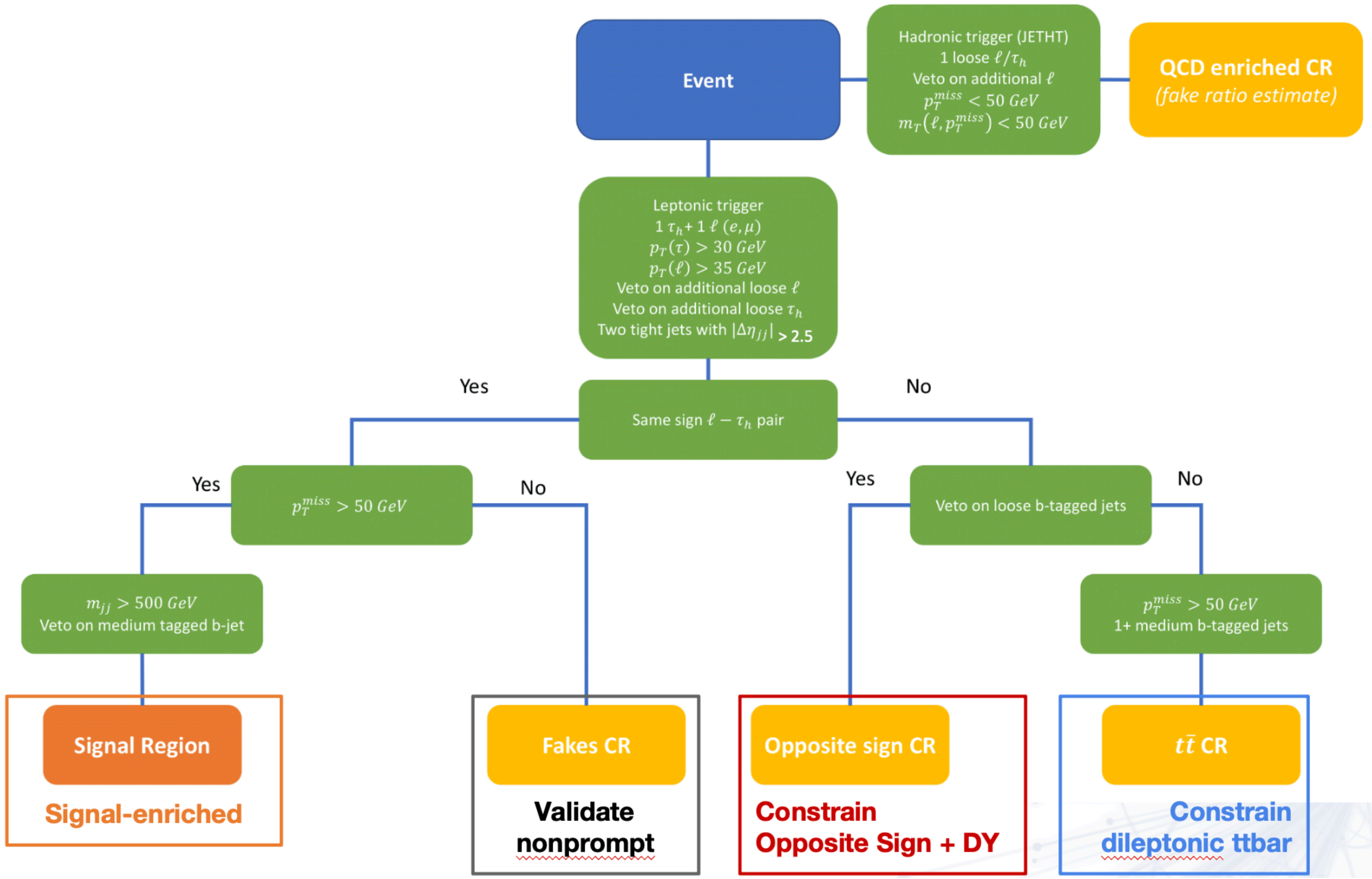
1D results

Wilson coefficient		68% CL interval(s) Observed	68% CL interval(s) Expected	95% CL interval Observed	95% CL interval Expected
dim-6	$c_{ll}^{(1)}/\Lambda^2$	$[-11.6, 0.045]$	$[-12.9, -8.03] \cup [-2.95, 1.91]$	$[-13.5, 2.11]$	$[-14.6, 3.53]$
	$c_{qq}^{(1)}/\Lambda^2$	$[-0.341, 0.416]$	$[-0.501, 0.576]$	$[-0.605, 0.681]$	$[-0.742, 0.818]$
	c_W/Λ^2	$[-0.513, 0.481]$	$[-0.681, 0.669]$	$[-0.842, 0.818]$	$[-0.987, 0.974]$
	c_{HW}/Λ^2	$[-5.48, 4.31]$	$[-7.00, 6.09]$	$[-8.68, 7.60]$	$[-9.99, 9.05]$
	c_{HWB}/Λ^2	$[-30.7, 89.2]$	$[-41.7, 69.6]$	$[-49.7, 110]$	$[-66.6, 96.4]$
	$c_{H\Box}/\Lambda^2$	$[-12.0, 14.0]$	$[-16.6, 18.1]$	$[-20.9, 22.7]$	$[-24.7, 26.3]$
	c_{HD}/Λ^2	$[-15.3, 31.5]$	$[-24.6, 34.7]$	$[-31.4, 45.5]$	$[-38.2, 48.8]$
	$c_{Hl}^{(1)}/\Lambda^2$	$[-38.2, 39.5]$	$[-28.8, 29.9]$	$[-69.3, 68.3]$	$[-49.4, 49.7]$
	$c_{Hl}^{(3)}/\Lambda^2$	$[-0.045, 8.58]$	$[-1.43, 2.23] \cup [5.88, 9.54]$	$[-1.59, 9.94]$	$[-2.64, 10.8]$
	$c_{Hq}^{(1)}/\Lambda^2$	$[-3.27, 3.44]$	$[-4.53, 4.42]$	$[-5.55, 5.60]$	$[-6.56, 6.44]$
	$c_{Hq}^{(3)}/\Lambda^2$	$[-1.88, 0.705]$	$[-2.39, 1.37]$	$[-2.82, 1.61]$	$[-3.24, 2.16]$
dim-8	f_{T0}/Λ^4	$[-0.774, 0.842]$	$[-1.02, 1.08]$	$[-1.32, 1.38]$	$[-1.52, 1.58]$
	f_{T1}/Λ^4	$[-0.319, 0.381]$	$[-0.426, 0.480]$	$[-0.552, 0.613]$	$[-0.640, 0.695]$
	f_{T2}/Λ^4	$[-0.851, 1.12]$	$[-1.15, 1.37]$	$[-1.51, 1.76]$	$[-1.75, 1.98]$
	f_{M0}/Λ^4	$[-8.07, 7.70]$	$[-9.89, 9.74]$	$[-13.1, 12.8]$	$[-14.6, 14.5]$
	f_{M1}/Λ^4	$[-9.54, 11.15]$	$[-12.5, 13.3]$	$[-16.4, 17.7]$	$[-18.7, 19.6]$
	f_{M7}/Λ^4	$[-17.6, 15.3]$	$[-20.3, 19.2]$	$[-27.6, 25.8]$	$[-29.9, 28.8]$
	f_{S0}/Λ^4	$[-9.60, 9.82]$	$[-11.6, 12.0]$	$[-15.9, 16.1]$	$[-17.4, 17.9]$
	f_{S1}/Λ^4	$[-40.9, 41.3]$	$[-37.4, 38.8]$	$[-60.9, 61.8]$	$[-57.2, 58.6]$
	f_{S2}/Λ^4	$[-40.9, 41.3]$	$[-37.4, 38.8]$	$[-60.9, 61.8]$	$[-57.2, 58.6]$

Uncertainties

Uncertainty source	$+\Delta\mu$	$-\Delta\mu$
Theory (PDF, scales, ISR, FSR)	+0.16	−0.10
Nonprompt background estimation	+0.13	−0.12
$t\bar{t}$ normalization	+0.051	−0.023
Trigger mistiming	+0.105	−0.059
Luminosity	+0.079	−0.092
b tagging and mistagging	+0.007	−0.004
Jet energy scale, resolution, and identification	+0.079	−0.097
Pileup	+0.15	−0.16
LO-to-NLO VBS corrections	+0.043	−0.025
Unclustered energy	+0.003	−0.010
τ_h energy scale and identification	+0.15	−0.15
Charge misidentification	+0.005	−0.010
Lepton reconstruction, identification, and isolation	+0.005	−0.024
Background statistical	+0.32	−0.32
Total systematic	+0.34	−0.30
Data statistical	+0.52	−0.48
Total	+0.62	−0.56

Details on Control and Signal Regions



Generation details

Reweighting

```
set param_card SMEFT 2 1
set param_card SMEFT 4 1
set param_card SMEFT 5 1
set param_card SMEFT 7 1
set param_card SMEFT 9 1
set param_card SMEFT 21 1
set param_card SMEFT 22 1
set param_card SMEFT 24 1
set param_card SMEFT 25 1
set param_card SMEFT 29 1
set param_card SMEFT 30 1
set param_card SMEFT 31 1
set param_card SMEFT 32 1
set param_card SMEFT 33 1
set param_card SMEFT 34 1
```

```
import model SMEFTsim_U35_MwScheme_UFO-cW_cHWB_cHDD_cHbox_cHW_cHl1_cHl3_cHq1_cHq3_cqq1_cqq11_cqq31_cqq3_cll_cll1_massless
define p = g u c d s b u~ c~ d~ s~ b~
define j = p
define l+ = e+ mu+ ta+
define l- = e- mu- ta-
define vl = ve vm vt
define vl~ = ve~ vm~ vt~
generate p p > l+ vl l+ vl j j SMHLOOP=0 QCD=0 NP=1
add process p p > l- vl~ l- vl~ j j SMHLOOP=0 QCD=0 NP=1
output WWjjTolnulnu_SS_ewk_dim6
```

```
import model QCKM_5_Aug21v2
define p = g u c d s b u~ c~ d~ s~ b~
define j = p
define l+ = e+ mu+ ta+
define l- = e- mu- ta-
define vl = ve vm vt
define vl~ = ve~ vm~ vt~
generate p p > w+ w+ j j QED=4 QCD=0 NP=1, w+ > l+ vl @ 1
add process p p > w- w- j j QED=4 QCD=0 NP=1, w- > l- vl~ @ 2
output WWjj_SS_dim8_ewk
```

Combine formula for negative histograms

Combine can handle only non-negative defined histograms, then the simple model has to be re-written, such that only non-negative defined inputs are provided.

$$A = A_{SM} + k * Op$$

$$N = SM + k * Lin + k^2 * Quad$$

Can be negative

$$\begin{aligned} N &= SM + k \cdot Lin + k^2 \cdot Quad \\ &= SM + k \cdot (SM + Lin + Quad) - k \cdot SM - k \cdot Quad + k^2 \cdot Quad \\ &= SM \cdot (1 - k) + k \cdot (SM + Lin + Quad) + (k^2 - k) \cdot Quad \end{aligned}$$

SmeftFR - dim8

Dim-5 + dim6 operators from Warsaw basis
Dim8 bosonic operators from Murphy's basis
Doesn't consider dim8 fermionic opertors, nor dim7.

Same input schemes of SMEFTsim (AEM and GF)

$X^3\varphi^2$	
$Q^{(1)}_{G^3\varphi^2}$	$f^{ABC}(\varphi^\dagger\varphi)G^{A\nu}_{\mu}G^{B\rho}_{\nu}G^{C\mu}_{\rho}$
$Q^{(2)}_{G^3\varphi^2}$	$f^{ABC}(\varphi^\dagger\varphi)G^{A\nu}_{\mu}G^{B\rho}_{\nu}\widetilde{G}^{C\mu}_{\rho}$
$Q^{(1)}_{W^3\varphi^2}$	$\epsilon^{IJK}(\varphi^\dagger\varphi)W^{I\nu}_{\mu}W^{J\rho}_{\nu}W^{K\mu}_{\rho}$
$Q^{(2)}_{W^3\varphi^2}$	$\epsilon^{IJK}(\varphi^\dagger\varphi)W^{I\nu}_{\mu}W^{J\rho}_{\nu}\widetilde{W}^{K\mu}_{\rho}$
$Q^{(1)}_{W^2B\varphi^2}$	$\epsilon^{IJK}(\varphi^\dagger\tau^I\varphi)B^{\nu}_{\mu}W^{J\rho}_{\nu}W^{K\mu}_{\rho}$
$Q^{(2)}_{W^2B\varphi^2}$	$\epsilon^{IJK}(\varphi^\dagger\tau^I\varphi)(\widetilde{B}^{\mu\nu}W^{J}_{\nu\rho}W^{K\rho}_{\mu}+B^{\mu\nu}W^{J}_{\nu\rho}\widetilde{W}^{K\rho}_{\mu})$

$X^2\varphi^4$	
$Q^{(1)}_{G^2\varphi^4}$	$(\varphi^\dagger\varphi)^2G^{A}_{\mu\nu}G^{A\mu\nu}$
$Q^{(2)}_{G^2\varphi^4}$	$(\varphi^\dagger\varphi)^2\widetilde{G}^{A}_{\mu\nu}G^{A\mu\nu}$
$Q^{(1)}_{W^2\varphi^4}$	$(\varphi^\dagger\varphi)^2W^{I}_{\mu\nu}W^{I\mu\nu}$
$Q^{(2)}_{W^2\varphi^4}$	$(\varphi^\dagger\varphi)^2\widetilde{W}^{I}_{\mu\nu}W^{I\mu\nu}$
$Q^{(3)}_{W^2\varphi^4}$	$(\varphi^\dagger\tau^I\varphi)(\varphi^\dagger\tau^J\varphi)W^{I}_{\mu\nu}W^{J\mu\nu}$
$Q^{(4)}_{W^2\varphi^4}$	$(\varphi^\dagger\tau^I\varphi)(\varphi^\dagger\tau^J\varphi)\widetilde{W}^{I}_{\mu\nu}W^{J\mu\nu}$
$Q^{(1)}_{WB\varphi^4}$	$(\varphi^\dagger\varphi)(\varphi^\dagger\tau^I\varphi)W^{I}_{\mu\nu}B^{\mu\nu}$
$Q^{(2)}_{WB\varphi^4}$	$(\varphi^\dagger\varphi)(\varphi^\dagger\tau^I\varphi)\widetilde{W}^{I}_{\mu\nu}B^{\mu\nu}$
$Q^{(1)}_{B^2\varphi^4}$	$(\varphi^\dagger\varphi)^2B_{\mu\nu}B^{\mu\nu}$
$Q^{(2)}_{B^2\varphi^4}$	$(\varphi^\dagger\varphi)^2\widetilde{B}_{\mu\nu}B^{\mu\nu}$

$X^2\varphi^2D^2$	
$Q^{(1)}_{G^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D^\nu\varphi)G^{A}_{\mu\rho}G^{A\rho}_{\nu}$
$Q^{(2)}_{G^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)G^{A}_{\nu\rho}G^{A\nu\rho}$
$Q^{(3)}_{G^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)G^{A}_{\nu\rho}\widetilde{G}^{A\nu\rho}$
$Q^{(1)}_{W^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D^\nu\varphi)W^{I}_{\mu\rho}W^{I\rho}_{\nu}$
$Q^{(2)}_{W^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)W^{I}_{\nu\rho}W^{I\nu\rho}$
$Q^{(3)}_{W^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)W^{I}_{\nu\rho}\widetilde{W}^{I\nu\rho}$
$Q^{(4)}_{W^2\varphi^2D^2}$	$i\epsilon^{IJK}(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)W^{J}_{\mu\rho}W^{K\rho}_{\nu}$
$Q^{(5)}_{W^2\varphi^2D^2}$	$\epsilon^{IJK}(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(W^{J}_{\mu\rho}\widetilde{W}^{K\rho}_{\nu}-\widetilde{W}^{J}_{\mu\rho}W^{K\rho}_{\nu})$
$Q^{(6)}_{W^2\varphi^2D^2}$	$i\epsilon^{IJK}(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(W^{J}_{\mu\rho}\widetilde{W}^{K\rho}_{\nu}+\widetilde{W}^{J}_{\mu\rho}W^{K\rho}_{\nu})$
$Q^{(1)}_{WB\varphi^2D^2}$	$(D^\mu\varphi^\dagger\tau^I D_\mu\varphi)B_{\nu\rho}W^{I\nu\rho}$
$Q^{(2)}_{WB\varphi^2D^2}$	$(D^\mu\varphi^\dagger\tau^I D_\mu\varphi)B_{\nu\rho}\widetilde{W}^{I\nu\rho}$
$Q^{(3)}_{WB\varphi^2D^2}$	$i(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(B_{\mu\rho}W^{I\rho}_{\nu}-B_{\nu\rho}W^{I\rho}_{\mu})$
$Q^{(4)}_{WB\varphi^2D^2}$	$(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(B_{\mu\rho}W^{I\rho}_{\nu}+B_{\nu\rho}W^{I\rho}_{\mu})$
$Q^{(5)}_{WB\varphi^2D^2}$	$i(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(B_{\mu\rho}\widetilde{W}^{I\ \rho}_{\nu}-B_{\nu\rho}\widetilde{W}^{I\ \rho}_{\mu})$
$Q^{(6)}_{WB\varphi^2D^2}$	$(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)(B_{\mu\rho}\widetilde{W}^{I\ \rho}_{\nu}+B_{\nu\rho}\widetilde{W}^{I\ \rho}_{\mu})$
$Q^{(1)}_{B^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D^\nu\varphi)B_{\mu\rho}B_{\nu}^{\ \rho}$
$Q^{(2)}_{B^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)B_{\nu\rho}B^{\nu\rho}$
$Q^{(3)}_{B^2\varphi^2D^2}$	$(D^\mu\varphi^\dagger D_\mu\varphi)B_{\nu\rho}\widetilde{B}^{\nu\rho}$

$X\varphi^4D^2$	
$Q^{(1)}_{W\varphi^4D^2}$	$(\varphi^\dagger\varphi)(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)W^{I}_{\mu\nu}$
$Q^{(2)}_{W\varphi^4D^2}$	$(\varphi^\dagger\varphi)(D^\mu\varphi^\dagger\tau^I D^\nu\varphi)\widetilde{W}^{I}_{\mu\nu}$
$Q^{(3)}_{W\varphi^4D^2}$	$\epsilon^{IJK}(\varphi^\dagger\tau^I\varphi)(D^\mu\varphi^\dagger\tau^J D^\nu\varphi)W^{K}_{\mu\nu}$
$Q^{(4)}_{W\varphi^4D^2}$	$\epsilon^{IJK}(\varphi^\dagger\tau^I\varphi)(D^\mu\varphi^\dagger\tau^J D^\nu\varphi)\widetilde{W}^{K}_{\mu\nu}$
$Q^{(1)}_{B\varphi^4D^2}$	$(\varphi^\dagger\varphi)(D^\mu\varphi^\dagger D^\nu\varphi)B_{\mu\nu}$
$Q^{(2)}_{B\varphi^4D^2}$	$(\varphi^\dagger\varphi)(D^\mu\varphi^\dagger D^\nu\varphi)\widetilde{B}_{\mu\nu}$

φ^8		φ^6D^2		φ^4D^4	
Q_{φ^8}	$(\varphi^\dagger\varphi)^4$	$Q_{\varphi^6\Box}$	$(\varphi^\dagger\varphi)^2\Box(\varphi^\dagger\varphi)$	$Q^{(1)}_{\varphi^4D^4}$	$(D_\mu\varphi^\dagger D_\nu\varphi)(D^\nu\varphi^\dagger D^\mu\varphi)$
		$Q_{\varphi^6D^2}$	$(\varphi^\dagger\varphi)(\varphi^\dagger D_\mu\varphi)^*(\varphi^\dagger D^\mu\varphi)$	$Q^{(2)}_{\varphi^4D^4}$	$(D_\mu\varphi^\dagger D_\nu\varphi)(D^\mu\varphi^\dagger D^\nu\varphi)$
				$Q^{(3)}_{\varphi^4D^4}$	$(D_\mu\varphi^\dagger D^\mu\varphi)(D_\nu\varphi^\dagger D^\nu\varphi)$

$X^4,\ X^3X'$	
$Q^{(1)}_{G^4}$	$(G^{A}_{\mu\nu}G^{A\mu\nu})(G^{B}_{\rho\sigma}G^{B\rho\sigma})$
$Q^{(2)}_{G^4}$	$(G^{A}_{\mu\nu}\widetilde{G}^{A\mu\nu})(G^{B}_{\rho\sigma}\widetilde{G}^{B\rho\sigma})$
$Q^{(3)}_{G^4}$	$(G^{A}_{\mu\nu}G^{B\mu\nu})(G^{A}_{\rho\sigma}G^{B\rho\sigma})$
$Q^{(4)}_{G^4}$	$(G^{A}_{\mu\nu}\widetilde{G}^{B\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{B\rho\sigma})$
$Q^{(5)}_{G^4}$	$(G^{A}_{\mu\nu}G^{A\mu\nu})(G^{B}_{\rho\sigma}\widetilde{G}^{B\rho\sigma})$
$Q^{(6)}_{G^4}$	$(G^{A}_{\mu\nu}G^{B\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{B\rho\sigma})$
$Q^{(7)}_{G^4}$	$d^{ABE}d^{CDE}(G^{A}_{\mu\nu}G^{B\mu\nu})(G^{C}_{\rho\sigma}G^{D\rho\sigma})$
$Q^{(8)}_{G^4}$	$d^{ABE}d^{CDE}(G^{A}_{\mu\nu}\widetilde{G}^{B\mu\nu})(G^{C}_{\rho\sigma}\widetilde{G}^{D\rho\sigma})$
$Q^{(9)}_{G^4}$	$d^{ABE}d^{CDE}(G^{A}_{\mu\nu}G^{B\mu\nu})(G^{C}_{\rho\sigma}\widetilde{G}^{D\rho\sigma})$
$Q^{(1)}_{W^4}$	$(W^{I}_{\mu\nu}W^{I\mu\nu})(W^{J}_{\rho\sigma}W^{J\rho\sigma})$
$Q^{(2)}_{W^4}$	$(W^{I}_{\mu\nu}\widetilde{W}^{I\mu\nu})(W^{J}_{\rho\sigma}\widetilde{W}^{J\rho\sigma})$
$Q^{(3)}_{W^4}$	$(W^{I}_{\mu\nu}W^{J\mu\nu})(W^{I}_{\rho\sigma}W^{J\rho\sigma})$
$Q^{(4)}_{W^4}$	$(W^{I}_{\mu\nu}\widetilde{W}^{J\mu\nu})(W^{I}_{\rho\sigma}\widetilde{W}^{J\rho\sigma})$
$Q^{(5)}_{W^4}$	$(W^{I}_{\mu\nu}W^{I\mu\nu})(W^{J}_{\rho\sigma}\widetilde{W}^{J\rho\sigma})$
$Q^{(6)}_{W^4}$	$(W^{I}_{\mu\nu}W^{J\mu\nu})(W^{I}_{\rho\sigma}\widetilde{W}^{J\rho\sigma})$
$Q^{(1)}_{B^4}$	$(B_{\mu\nu}B^{\mu\nu})(B_{\rho\sigma}B^{\rho\sigma})$
$Q^{(2)}_{B^4}$	$(B_{\mu\nu}\widetilde{B}^{\mu\nu})(B_{\rho\sigma}\widetilde{B}^{\rho\sigma})$
$Q^{(3)}_{B^4}$	$(B_{\mu\nu}B^{\mu\nu})(B_{\rho\sigma}\widetilde{B}^{\rho\sigma})$
$Q^{(1)}_{G^3B}$	$d^{ABC}(B_{\mu\nu}G^{A\mu\nu})(G^{B}_{\rho\sigma}G^{C\rho\sigma})$
$Q^{(2)}_{G^3B}$	$d^{ABC}(B_{\mu\nu}\widetilde{G}^{A\mu\nu})(G^{B}_{\rho\sigma}\widetilde{G}^{C\rho\sigma})$
$Q^{(3)}_{G^3B}$	$d^{ABC}(B_{\mu\nu}\widetilde{G}^{A\mu\nu})(G^{B}_{\rho\sigma}G^{C\rho\sigma})$
$Q^{(4)}_{G^3B}$	$d^{ABC}(B_{\mu\nu}G^{A\mu\nu})(G^{B}_{\rho\sigma}\widetilde{G}^{C\rho\sigma})$

$X^2X'^2$	
$Q^{(1)}_{G^2W^2}$	$(W^{I}_{\mu\nu}W^{I\mu\nu})(G^{A}_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(2)}_{G^2W^2}$	$(W^{I}_{\mu\nu}\widetilde{W}^{I\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(3)}_{G^2W^2}$	$(W^{I}_{\mu\nu}G^{A\mu\nu})(W^{I}_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(4)}_{G^2W^2}$	$(W^{I}_{\mu\nu}\widetilde{G}^{A\mu\nu})(W^{I}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(5)}_{G^2W^2}$	$(W^{I}_{\mu\nu}\widetilde{W}^{I\mu\nu})(G^{A}_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(6)}_{G^2W^2}$	$(W^{I}_{\mu\nu}W^{I\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(7)}_{G^2W^2}$	$(W^{I}_{\mu\nu}G^{A\mu\nu})(W^{I}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(1)}_{G^2B^2}$	$(B_{\mu\nu}B^{\mu\nu})(G^{A}_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(2)}_{G^2B^2}$	$(B_{\mu\nu}\widetilde{B}^{\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(3)}_{G^2B^2}$	$(B_{\mu\nu}G^{A\mu\nu})(B_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(4)}_{G^2B^2}$	$(B_{\mu\nu}\widetilde{G}^{A\mu\nu})(B_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(5)}_{G^2B^2}$	$(B_{\mu\nu}\widetilde{B}^{\mu\nu})(G^{A}_{\rho\sigma}G^{A\rho\sigma})$
$Q^{(6)}_{G^2B^2}$	$(B_{\mu\nu}B^{\mu\nu})(G^{A}_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(7)}_{G^2B^2}$	$(B_{\mu\nu}G^{A\mu\nu})(B_{\rho\sigma}\widetilde{G}^{A\rho\sigma})$
$Q^{(1)}_{W^2B^2}$	$(B_{\mu\nu}B^{\mu\nu})(W^{I}_{\rho\sigma}W^{I\rho\sigma})$
$Q^{(2)}_{W^2B^2}$	$(B_{\mu\nu}\widetilde{B}^{\mu\nu})(W^{I}_{\rho\sigma}\widetilde{W}^{I\rho\sigma})$
$Q^{(3)}_{W^2B^2}$	$(B_{\mu\nu}W^{I\mu\nu})(B_{\rho\sigma}W^{I\rho\sigma})$
$Q^{(4)}_{W^2B^2}$	$(B_{\mu\nu}\widetilde{W}^{I\mu\nu})(B_{\rho\sigma}\widetilde{W}^{I\rho\sigma})$
$Q^{(5)}_{W^2B^2}$	$(B_{\mu\nu}\widetilde{B}^{\mu\nu})(W^{I}_{\rho\sigma}W^{I\rho\sigma})$
$Q^{(6)}_{W^2B^2}$	$(B_{\mu\nu}B^{\mu\nu})(W^{I}_{\rho\sigma}\widetilde{W}^{I\rho\sigma})$
$Q^{(7)}_{W^2B^2}$	$(B_{\mu\nu}W^{I\mu\nu})(B_{\rho\sigma}\widetilde{W}^{I\rho\sigma})$

SmeftFR - validation

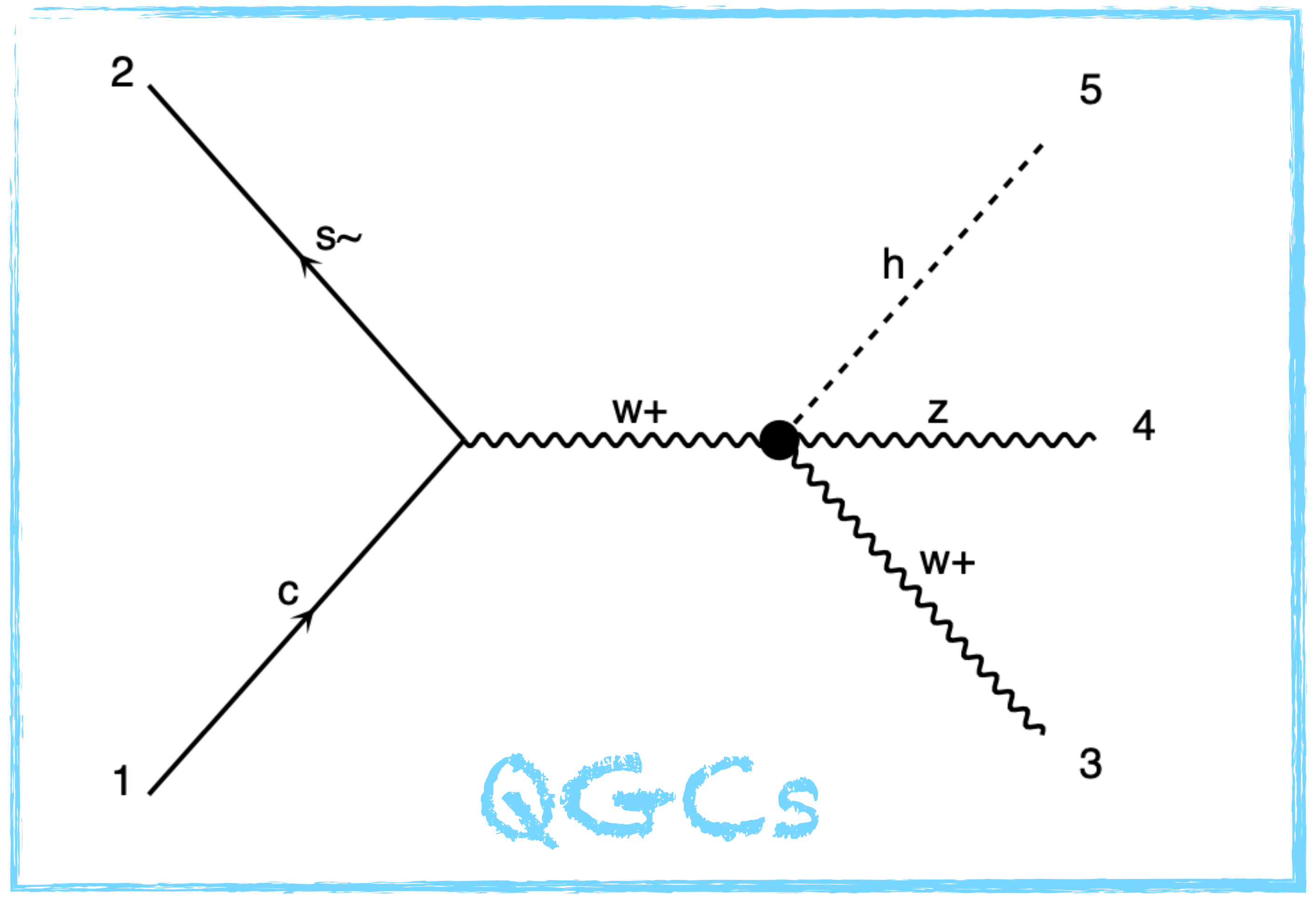
Basis of [5]	Basis of [6]	SmeftFR	AGC	Δ
w+ w- > h h				
SM		0.0218	0.0218	0.00%
$C^{(2)}_{\varphi D^4}$	$C^{(0)}_{S}$	0.2191	0.2191	0.00%
$C^{(3)}_{\varphi D^4}$	$C^{(1)}_{S}$	1.5868	1.5868	0.00%
$C^{(1)}_{\varphi D^4}$	$C^{(2)}_{S}$	0.2191	0.2191	0.00%
$\frac{1}{2}C^{(2)}_{W^2\varphi^2 D^2}$	$C^{(0)}_{M}$	2.5622	2.5622	0.00%
$-\frac{1}{2}C^{(1)}_{W^2\varphi^2 D^2}$	$C^{(1)}_{M}$	0.2307	0.2307	0.00%
$\frac{1}{4}\left(C^{(1)}_{W^2\varphi^2 D^2} - C^{(4)}_{W^2\varphi^2 D^2}\right)$	$C^{(7)}_{M}$	0.0576	0.0576	0.00%
z z > h h				
SM		0.0416	0.0416	0.00%
$C^{(2)}_{\varphi D^4}$	$C^{(0)}_{S}$	0.0916	0.0916	0.00%
$C^{(3)}_{\varphi D^4}$	$C^{(1)}_{S}$	1.7156	1.7156	0.00%
$C^{(1)}_{\varphi D^4}$	$C^{(2)}_{S}$	1.7156	1.7156	0.00%
$\frac{1}{2}C^{(2)}_{W^2\varphi^2 D^2}$	$C^{(0)}_{M}$	1.5589	1.5589	0.00%
$-\frac{1}{2}C^{(1)}_{W^2\varphi^2 D^2}$	$C^{(1)}_{M}$	0.1773	0.1773	0.00%
$C^{(1)}_{B^2\varphi^2 D^2}$	$C^{(2)}_{M}$	0.5406	0.5406	0.00%
$-C^{(4)}_{B^2\varphi^2 D^2}$	$C^{(3)}_{M}$	0.0920	0.0920	0.00%
$\frac{1}{2}C^{(1)}_{WB\varphi^2 D^2}$	$C^{(4)}_{M}$	0.4761	0.4761	0.00%
$-\frac{1}{2}C^{(4)}_{WB\varphi^2 D^2}$	$C^{(5)}_{M}$	0.1456	0.1456	0.00%
$\frac{1}{4}\left(C^{(1)}_{W^2\varphi^2 D^2} - C^{(4)}_{W^2\varphi^2 D^2}\right)$	$C^{(7)}_{M}$	0.0580	0.0580	0.00%

Basis of [5]	Basis of [6]	SmeftFR	AGC	Δ
w+ w+ > w+ w+				
SM		2.9395	2.9395	0.00%
$C^{(2)}_{\varphi D^4}$	$C^{(0)}_{S}$	6.5868	6.5868	0.00%
$C^{(3)}_{\varphi D^4}$	$C^{(1)}_{S}$	2.9307	2.9307	0.00%
$C^{(1)}_{\varphi D^4}$	$C^{(2)}_{S}$	2.9307	2.9307	0.00%
$\frac{1}{2}C^{(2)}_{W^2\varphi^2 D^2}$	$C^{(0)}_{M}$	4.2146	4.2146	0.00%
$-\frac{1}{2}C^{(1)}_{W^2\varphi^2 D^2}$	$C^{(1)}_{M}$	2.6295	2.6295	0.00%
$\frac{1}{4}\left(C^{(1)}_{W^2\varphi^2 D^2} - C^{(4)}_{W^2\varphi^2 D^2}\right)$	$C^{(7)}_{M}$	3.9113	3.9113	0.00%
$\frac{1}{4}C^{(1)}_{W^4}$	$C^{(0)}_{T}$	23.541	23.541	0.00%
$\frac{1}{4}C^{(3)}_{W^4}$	$C^{(1)}_{T}$	98.636	98.636	0.00%
$\frac{1}{16}\left(C^{(1)}_{W^4} + C^{(3)}_{W^4} + C^{(4)}_{W^4}\right)$	$C^{(2)}_{T}$	6.2602	6.2602	0.00%
z z > z z				
SM		0.0820	0.0820	0.00%
$C^{(2)}_{\varphi D^4}$	$C^{(0)}_{S}$	2.6660	2.6660	0.00%
$C^{(3)}_{\varphi D^4}$	$C^{(1)}_{S}$	2.6660	2.6660	0.00%
$C^{(1)}_{\varphi D^4}$	$C^{(2)}_{S}$	2.6660	2.6660	0.00%
$\frac{1}{2}C^{(2)}_{W^2\varphi^2 D^2}$	$C^{(0)}_{M}$	3.9388	3.9388	0.00%
$-\frac{1}{2}C^{(1)}_{W^2\varphi^2 D^2}$	$C^{(1)}_{M}$	0.6317	0.6317	0.00%
$C^{(1)}_{B^2\varphi^2 D^2}$	$C^{(2)}_{M}$	1.3635	1.3635	0.00%
$-C^{(4)}_{B^2\varphi^2 D^2}$	$C^{(3)}_{M}$	0.2214	0.2214	0.00%
$\frac{1}{2}C^{(1)}_{WB\varphi^2 D^2}$	$C^{(4)}_{M}$	1.1997	1.1997	0.00%
$-\frac{1}{2}C^{(4)}_{WB\varphi^2 D^2}$	$C^{(5)}_{M}$	1.0921	1.0921	0.00%
$\frac{1}{4}\left(C^{(1)}_{W^2\varphi^2 D^2} - C^{(4)}_{W^2\varphi^2 D^2}\right)$	$C^{(7)}_{M}$	0.3474	0.3474	0.00%
$\frac{1}{4}C^{(1)}_{W^4}$	$C^{(0)}_{T}$	57.045	57.045	0.00%
$\frac{1}{4}C^{(3)}_{W^4}$	$C^{(1)}_{T}$	57.045	57.045	0.00%
$\frac{1}{16}\left(C^{(1)}_{W^4} + C^{(3)}_{W^4} + C^{(4)}_{W^4}\right)$	$C^{(2)}_{T}$	13.2092	13.2092	0.00%
$\frac{1}{2}C^{(1)}_{W^2B^2}$	$C^{(5)}_{T}$	18.870	18.870	0.00%
$\frac{1}{2}C^{(3)}_{W^2B^2}$	$C^{(6)}_{T}$	18.870	18.870	0.00%
$\frac{1}{16}\left(C^{(1)}_{W^2B^2} + C^{(3)}_{W^2B^2} + C^{(4)}_{W^2B^2}\right)$	$C^{(7)}_{T}$	4.4206	4.4206	0.00%
$C^{(1)}_{B^4}$	$C^{(8)}_{T}$	6.2832	6.2832	0.00%
$\frac{1}{4}\left(2C^{(1)}_{B^4} + C^{(2)}_{B^4}\right)$	$C^{(9)}_{T}$	1.5190	1.5190	0.00%

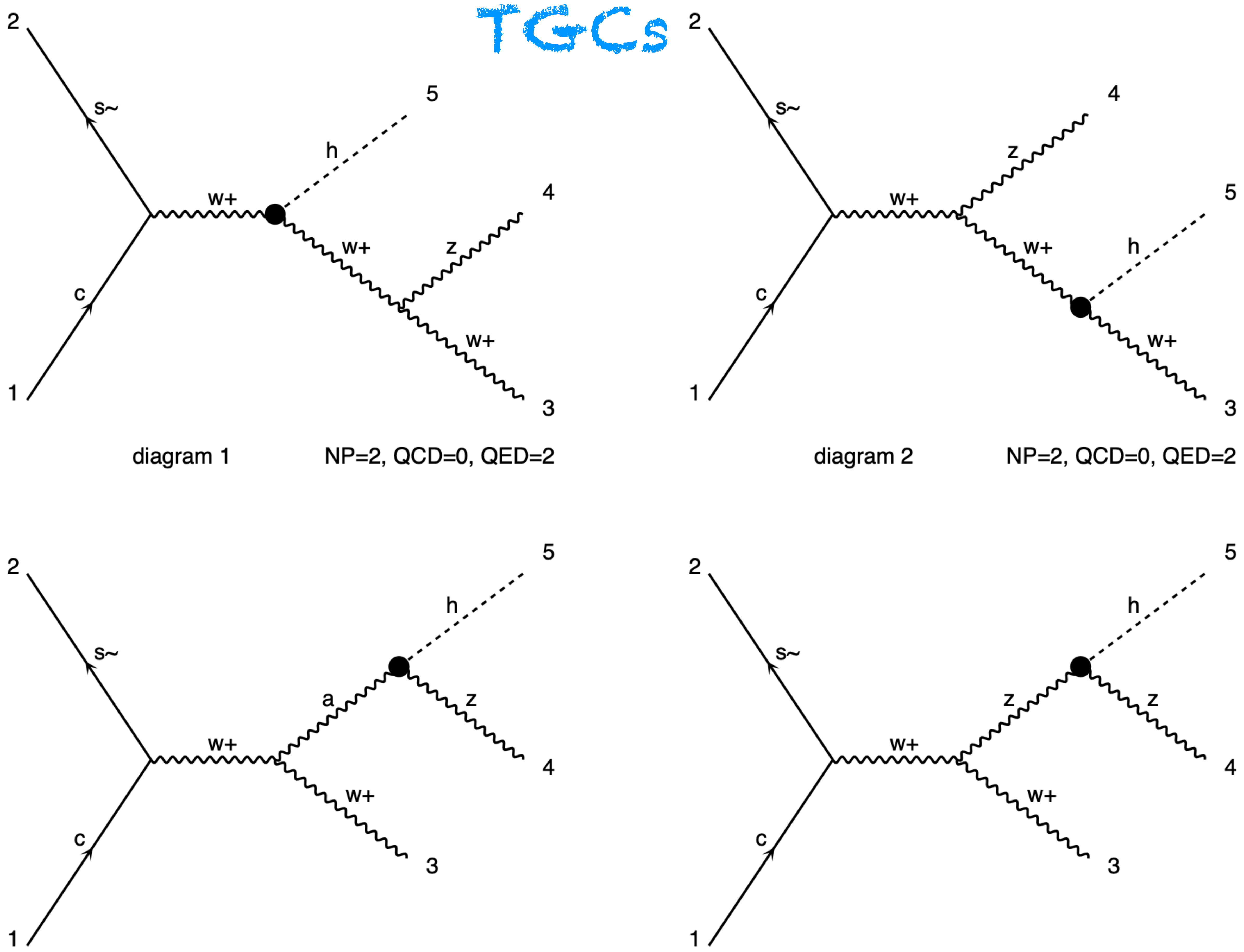
EFT insertions in Murphy

Murphy Cphi6Box, Cphi6D2, CW2phi4n*, CW3phi2n*, CWphi4D2n*, CB2phi4n*, CBphi4D2n*, CW2Bphi2n*, CWBphi4n*

Eboli S-type, M-type
Murphy Cphi4D4n*, WBphi2D2n*, W2phi2D2n*



+



Effects on UV matching

Benefits from including dimensions consistently with power counting:

- More consistent results in terms of experimental findings
- Preserving model independence in EFT approach
- Unlock reliable matching with BSM models (better hints on where NP hides)

Example with Z2RSE model

arXiv:2311.16897

$$\phi = \begin{pmatrix} G^+ \\ \frac{1}{\sqrt{2}}(v + h_1 + iG_0) \end{pmatrix}, \quad S = \frac{v_s + h_2}{\sqrt{2}}$$

$$\begin{pmatrix} h \\ H \end{pmatrix} = \begin{pmatrix} c_\chi & -s_\chi \\ s_\chi & c_\chi \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \end{pmatrix}$$