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The Compact Muon Solenoid Experiment

Analysis Note

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Abstract

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Combination of tHq analyses with 2016 dataset

Benjamin Stieger[1], Pallabi Das[2], Jose Monroy[1], Kevin Flöh[3], and Nils Faltermann[3]

[1] University of Nebraska-Lincoln
[2] Tata Institute for Fundamental Research, Mumbai
[3] Karlsruhe Institute for Technology

Abstract

This note describes the combination of `HIG-17-005` (tHq in multilepton channels) and `HIG-17-016` (tHq in bb channels), as well as a reinterpretation of `HIG-16-040` ($H \to \gamma\gamma$ in 2016 data) for the `HIG-18-009` paper.

Contents

1 Introduction

This analysis note documents the steps taken to combine the two dedicated tHq analyses with 2016 data and a reinterpretation of the 2016 $\gamma\gamma$ result for a publication (`HIG-18-009`). The two analyses are described in more detail in their respective analysis notes[1, 2] and public summaries[3, 4]. The $\gamma\gamma$ reinterpretation is described in Ref. [5].

Both dedicated analyses attempt to exploit the sensitivity of the tHq production cross section to the relative sign of κ_t and κ_V (the modifiers of Higgs-top and Higgs-Vector boson couplings, respectively), due to interference of the two leading order diagrams. A similar interference is present for the tHW process, whereas the $t\bar{t}H$ production is independent of κ_V but scales as κ_t^2. Both channels exploit the kinematic distinctiveness of the tHq process—a light forward jet separated from a soft b jet with a large pseudorapidity gap, a central lepton and b jet from the top quark decay, and the central Higgs decay products—to discriminate the tHq signal from non-Higgs backgrounds, and from the other Higgs processes, including tHW, and $t\bar{t}H$.

The reinterpretation of the 2016 $\gamma\gamma$ result (`HIG-16-040`, Ref. [6]) consists in correcting the tHq and tHW contributions in those datacards with scale factors taking into account the changed efficiency and acceptance for different points of κ_t and κ_V from the changed kinematic properties.

Limits on the $tH + t\bar{t}H$ production cross section times the combined Higgs branching ratios ($H \to WW/ZZ/\tau\tau/b\bar{b}$) are then set for different points of the coupling modifiers. As the kinematics of the signal processes only depend on the ratio of the modifiers (κ_t/κ_V) the limits are displayed as a function of this ratio. Furthermore, it is assumed that the Higgs coupling to τ leptons is modified concurrently with κ_t, i.e. $\kappa_t =$. Thus the relative fractions of H to WW, ZZ, $\tau\tau$, $b\bar{b}$, and $\gamma\gamma$ decays are fixed at each κ_t/κ_V point.

The tHq and tHW signal samples contain weights encoded for 51 different points of κ_t and κ_V (17 κ_t values $\times$ 3 κ_V values), constituting 33 distinct values of the ratio κ_t/κ_V ranging from -6.0 to $+6.0$.

2 Inputs and Setup

Both analyses are based on the full 2016 13 TeV dataset of $35.9\,\mathrm{fb}^{-1}$. Data cards and input distributions for the three multilepton channels (, , and) are taken from the `HIG-17-005` analysis unchanged, except for an update of the luminosity uncertainty (from 2.6% to 2.5%), and for replacing the manually computed bin-by-bin statistical uncertainties by the `autoMCStats` feature of combine. Furthermore, b tagging related nuisances are renamed to match those of $\mathrm{b\bar{b}}$ cards to correlate the uncertainties. The original cards can be found on svn under `/cmshcg/trunk/cadi/HIG-17-005`.

Cards and inputs for the three $\mathrm{b\bar{b}}$ channels ($\mathrm{b\bar{b}}$3b, $\mathrm{b\bar{b}}$4b, and $\mathrm{b\bar{b}}$dilep) are taken from `HIG-17-016` unchanged.

Cards and input files from the six channels are combined using the `combineCards.py` script of the combine package, and are transformed into `RooWorkspace`s using `text2workspace.py` with the following options:

```
-P HiggsAnalysis.CombinedLimit.LHCHCGModels:K6 --PO BRU=0 -m 125.
```

Two models are compared, the `K6` and `K7` variants of the `KappaVKappaT` model, defined in `LHCHCGModels.py`. Note: there is a fix of the model implementation with respect to the central HiggsAnalysis-CombinedLimit repository, see here. The change is to assign a separate signal strength parameter to other (non $\mathrm{tH} + \mathrm{t\bar{t}H}$) production channel, i.e. it is only relevant for the $\gamma\gamma$ channel, where there are such contributions. The scalings of Higgs branching ratios with κ_t and κ_V for the two models are reported in Appendix A. (The cross sections do not depend on the model.)

The combined $\mathrm{b\bar{b}}$ and multilepton cards can be found on svn: `/cmshcg/trunk/cadi/HIG-18-009`.

The same procedure is repeated for each of the 51 κ_t and κ_V points.

3 Signal strength limits

From the workspaces, limits on the signal strength are obtained with the `AsymptoticLimits` method and by setting the κ_t parameter to the ratio $\kappa_\mathrm{t}/\kappa_\mathrm{V}$, while fixing the κ_V parameter at 1.0:

```
combine -M AsymptoticLimits -m 125 \
--setParameters kappa_t=<ct>/<cv>,kappa_V=1.0 \
--freezeParameters kappa_t,kappa_V,kappa_mu,kappa_b, \
kappa_c,kappa_g,kappa_gam,r_others \
--redefineSignalPOIs r
```

Note: most of this procedure is described in more detail, and including the code used to run it in sequence for each point in a `README` file on our GitHub repository: `TTHAnalysis/python/plotter/tHq-multilepton/signal_extraction`.

The resulting expected and observed signal strength limits are reported in Tab. 1 and 2.

Signal strength limits are then multiplied by the expected $\mathrm{tH} + \mathrm{t\bar{t}H}$ production cross section (for $\kappa_\mathrm{V} = 1.0$ as this was chosen for the input cross section during the limit setting) and the combined Higgs branching ratio to WW, ZZ, $\tau\tau$, and $\mathrm{b\bar{b}}$ (also for $\kappa_\mathrm{V} = 1.0$), see also Fig. 14 and Tables 5–7 in Appendix A. The resulting cross section limits for each point in $\kappa_\mathrm{t}/\kappa_\mathrm{V}$ are then independent of κ_V. They are to be compared with different predictions for $\mathrm{tH} + \mathrm{t\bar{t}H}$ cross sections at fixed values of κ_V.

κ_t/κ_V	$\kappa_V = 0.5$		$\kappa_V = 1.0$		$\kappa_V = 1.5$	
	exp.	obs.	exp.	obs.	exp.	obs.
-6.000	0.014	0.033				
-4.000	0.036	0.092				
-3.000	0.067	0.188	0.067	0.188		
-2.500	0.099	0.287				
-2.000	0.153	0.466	0.153	0.466	0.153	0.465
-1.500	0.257	0.819	0.257	0.818		
-1.333					0.314	1.014
-1.250			0.347	1.129		
-1.000	0.482	1.607	0.482	1.606	0.484	1.606
-0.833					0.621	2.074
-0.750			0.703	2.346		
-0.667					0.801	2.663
-0.500	1.070	3.491	1.070	3.486	1.070	3.483
-0.333					1.449	4.528
-0.250			1.680	5.110		
-0.167					1.930	5.737
0.000	2.578	7.405	2.578	7.401	2.578	7.398
0.167					3.297	9.940
0.250			3.500	1.139		
0.333					3.578	12.049
0.500	2.859	19.863	2.867	19.858	2.867	9.842
0.667					1.938	6.419
0.750			1.602	5.194		
0.833					1.324	4.277
1.000	0.922	2.927	0.922	2.912	0.922	2.925
1.250			0.582	1.819		
1.333					0.510	1.588
1.500	0.395	1.218	0.395	1.216		
2.000	0.210	0.629	0.210	0.631	0.210	0.632
2.500	0.126	0.367				
3.000	0.082	0.232	0.082	0.233		
4.000	0.042	0.109				
6.000	0.015	0.037				

Table 1: Expected and observed limits on the combined $tH + t\bar{t}H$ signal strength for the combination of all six channels for all 51 points, for the non-resolved model (K6).

κ_t/κ_V	$\kappa_V = 0.5$		$\kappa_V = 1.0$		$\kappa_V = 1.5$	
	exp.	obs.	exp.	obs.	exp.	obs.
-6.000	0.022	0.047				
-4.000	0.043	0.095				
-3.000	0.066	0.155	0.066	0.155		
-2.500	0.085	0.211				
-2.000	0.115	0.310	0.115	0.310	0.115	0.310
-1.500	0.171	0.505	0.171	0.505		
-1.333					0.202	0.618
-1.250			0.221	0.684		
-1.000	0.303	0.974	0.303	0.974	0.303	0.973
-0.833					0.393	1.277
-0.750			0.447	1.463		
-0.667					0.514	1.685
-0.500	0.713	2.317	0.713	2.311	0.713	2.312
-0.333					1.016	3.197
-0.250			1.203	3.724		
-0.167					1.426	4.314
0.000	1.992	5.847	1.992	5.845	1.992	5.843
0.167					2.578	7.887
0.250			2.734	8.809		
0.333					2.781	9.446
0.500	2.305	8.089	2.305	8.078	2.312	8.063
0.667					1.672	5.628
0.750			1.430	4.706		
0.833					1.230	3.998
1.000	0.922	2.927	0.922	2.912	0.922	2.925
1.250			0.644	1.997		
1.333					0.584	1.801
1.500	0.480	1.459	0.480	1.456		
2.000	0.293	0.846	0.293	0.848	0.293	0.850
2.500	0.192	0.508				
3.000	0.133	0.317	0.133	0.318		
4.000	0.073	0.151				
6.000	0.031	0.063				

Table 2: Expected and observed limits on the combined $tH + t\bar{t}H$ signal strength for the combination of all six channels for all 51 points, for the resolved model (K7).

4 Limits on tH production

To produce limits on pure SM-like tH (tHq +tHW) production, we freeze all processes including $t\bar{t}H$, and float a single signal strength parameter for the combined tH signal. This is done using the `LHCHCGModels:A1` model for signal strengths, and floating the `mu_XS_tH` parameter:

```
text2workspace.py card.txt -P HiggsAnalysis.CombinedLimit.LHCHCGModels:A1 -m 125
combine -M AsymptoticLimits --redefineSignalPOIs mu_XS_tH ws.root
```

This yields an observed limit of $r < 25.4$, with an expected limit of $r < 12.0$, which can be multiplied by the SM cross sections for tHq and tHW at 13 TeV (70.96 pb and 15.61 pb, respectively), and the sum of branching ratios to WW, ZZ, $\tau\tau$, $b\bar{b}$, and $\gamma\gamma$ (21.4%+2.6%+6.3%+58.3%+0.227%) to obtain limits on a SM-like tH signal of 1.96 pb (observed) and 0.92 pb (expected).

5 Cross Section × BR Limits

The resulting limits on cross section times branching ratio are shown in Fig. 1, compared to the background-only expected limits.

Expected limits in the presence of a Standard Model-like Higgs signal are produced using the `GenerateOnly` method of combine with the workspace for the SM point. The resulting toys are then processed with `AsymptoticLimits --run observed` for each of the 51 points, and the results gathered to calculate 68% and 95% bands around the median value. A set of 1000 toys is generated for the SM point and evaluated for each point. The resulting limits are shown in Fig. 2, compared to the same observed limits. A smoothing method (`scipy.interpolate.splrep`) is applied with a value of 0.001 for the 68% band and with a value of 0.050 for the 95% band. The central value of the expected limit is shown without smoothing applied.

The limits for each channel separately are given in Tab. 3

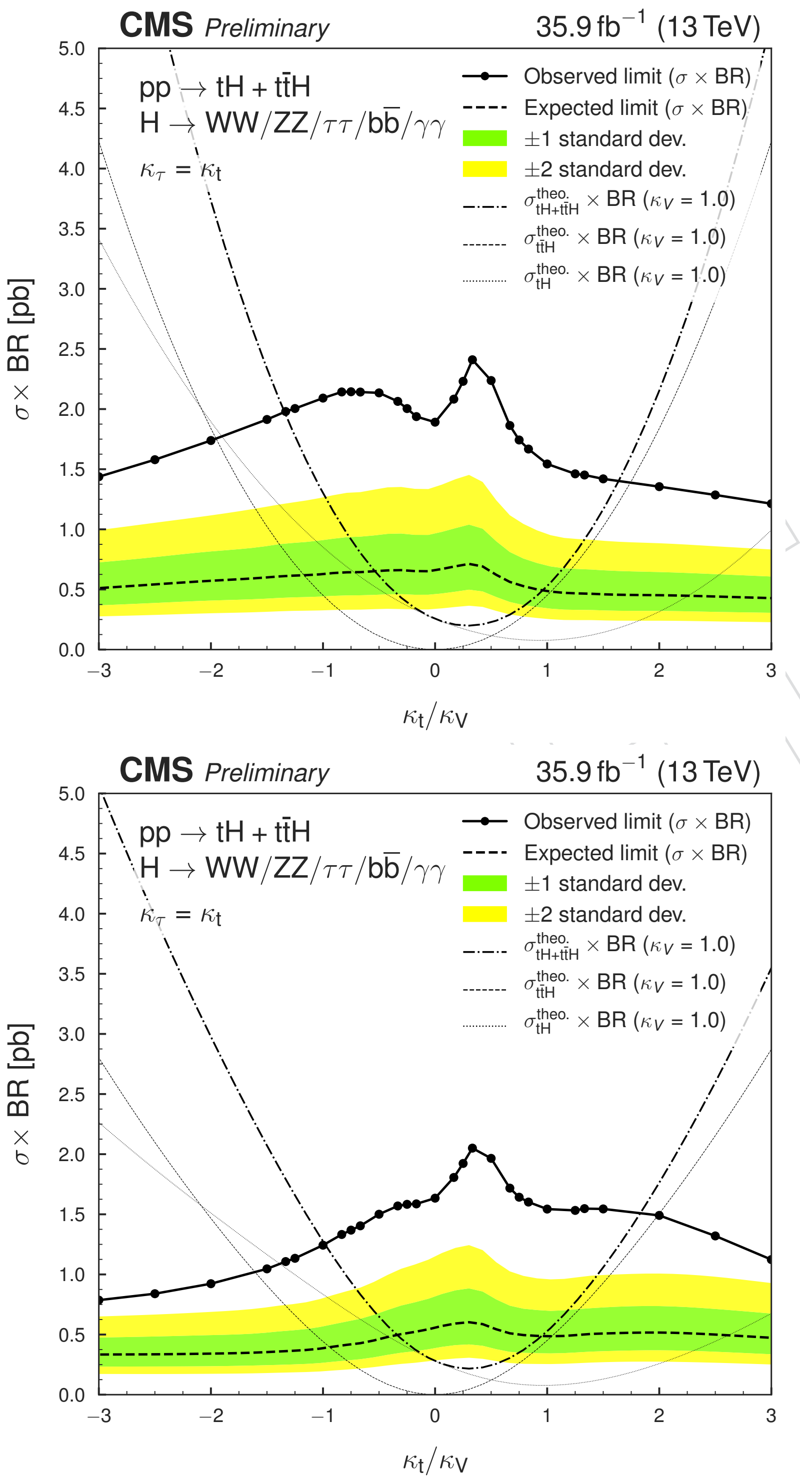

Figure 1: Observed and background-only expected cross section times branching ratio limits on combined tH + $t\bar{t}$H production, as a function of κ_t/κ_V. For reference, tHq, tHW, and $t\bar{t}$H cross sections for a κ_V value of 1.0 are displayed as well. Top panel shows the result with the non-resolved model, bottom panel with the resolved model.

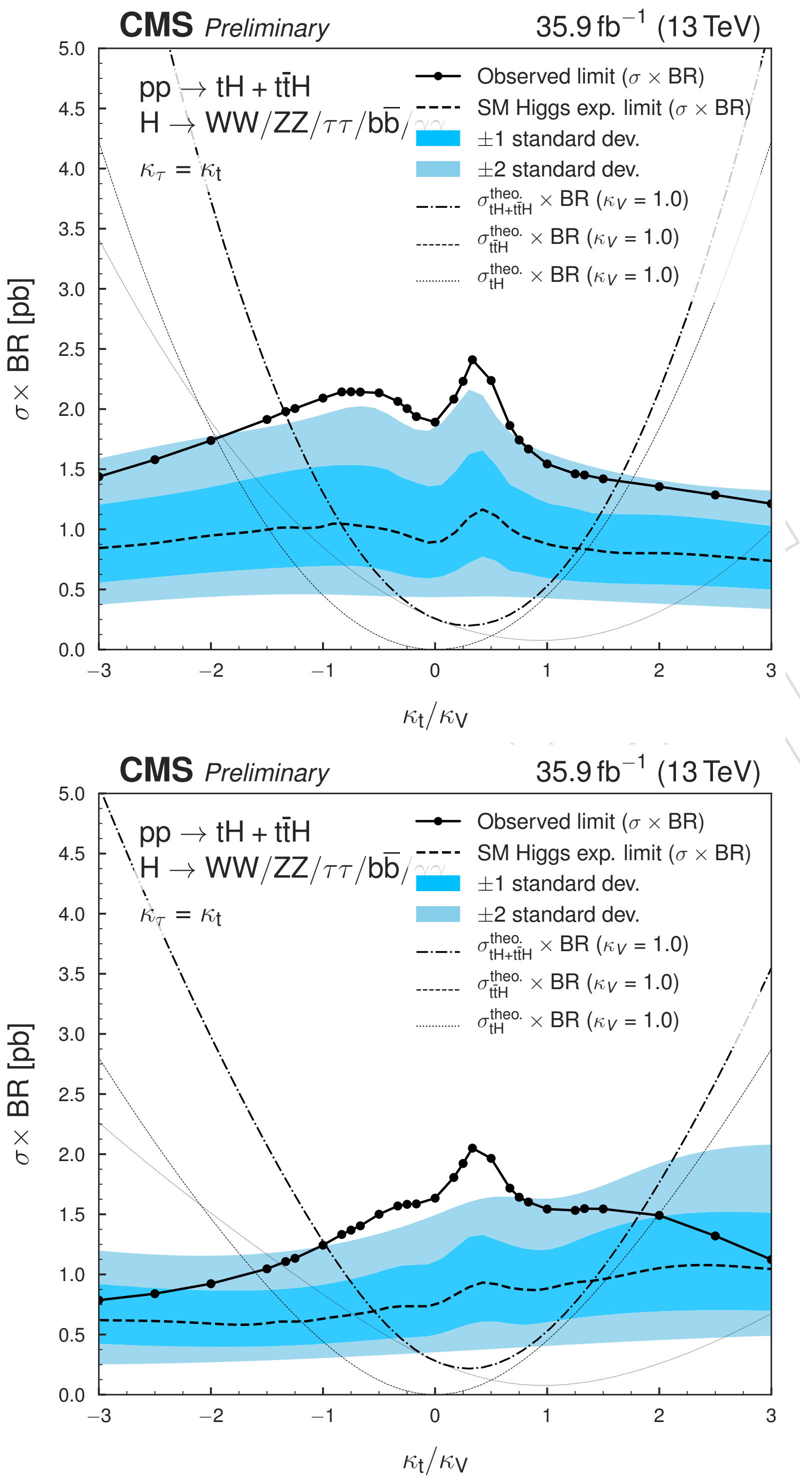

Figure 2: Observed and SM Higgs-like expected cross section times branching ratio limits on combined $tH + t\bar{t}H$ production, as a function of κ_t/κ_V. For reference, tHq, tHW, and $t\bar{t}H$ cross sections for a κ_V value of 1.0 are displayed as well. Top panel shows the result with the non-resolved model, bottom panel with the resolved model.

Scenario	Channel	Obs. Limit (pb)	Exp. Limit (pb)
$\kappa_t/\kappa_V = -1$ (K7)	$\mu\mu$	2.95	$1.72^{+0.75}_{-0.48}$
	$e\mu$	2.48	$1.59^{+0.65}_{-0.45}$
	$\ell\ell\ell$	2.05	$1.10^{+0.52}_{-0.34}$
	Multilep. comb.	1.87	$0.92^{+0.41}_{-0.27}$
	$b\bar{b}$3b	7.96	$5.22^{+2.69}_{-1.64}$
	$b\bar{b}$4b	6.57	$4.17^{+2.04}_{-1.27}$
	$b\bar{b}$ comb.	7.01	$3.51^{+1.72}_{-1.10}$
	$\gamma\gamma$	1.12	$0.45^{+0.22}_{-0.14}$
	Combined	**1.24**	$\mathbf{0.39^{+0.18}_{-0.12}}$
$\kappa_t/\kappa_V = -1$ (K6)	$\mu\mu$	2.94	$1.72^{+0.75}_{-0.48}$
	$e\mu$	2.48	$1.59^{+0.64}_{-0.45}$
	$\ell\ell\ell$	2.04	$1.09^{+0.52}_{-0.34}$
	Multilep. comb.	1.86	$0.92^{+0.41}_{-0.27}$
	$b\bar{b}$3b	7.93	$5.21^{+2.68}_{-1.65}$
	$b\bar{b}$4b	6.55	$4.17^{+2.03}_{-1.28}$
	$b\bar{b}$ comb.	6.98	$3.50^{+1.71}_{-1.09}$
	$\gamma\gamma$	2.69	$1.02^{+0.51}_{-0.33}$
	Combined	**2.09**	$\mathbf{0.63^{+0.28}_{-0.19}}$
$\kappa_t/\kappa_V = 1$ (SM-like)	$\mu\mu$	2.57	$1.19^{+0.51}_{-0.35}$
	$e\mu$	1.73	$1.10^{+0.47}_{-0.32}$
	$\ell\ell\ell$	1.60	$0.91^{+0.40}_{-0.27}$
	Multilep. comb.	1.65	$0.71^{+0.31}_{-0.21}$
	$b\bar{b}$3b	14.91	$12.00^{+4.45}_{-3.24}$
	$b\bar{b}$4b	6.29	$5.53^{+2.27}_{-1.53}$
	$b\bar{b}$ comb.	6.17	$4.63^{+1.68}_{-1.21}$
	$\gamma\gamma$	1.93	$0.73^{+0.36}_{-0.23}$
	Combined	**1.54**	$\mathbf{0.49^{+0.21}_{-0.14}}$

Table 3: Upper limits on the $tH + t\bar{t}H$ cross section times BR($H \to WW^* + \tau\tau + ZZ^* + b\bar{b} + \gamma\gamma$) for inverted couplings for the resolved (very top) and non-resolved (middle) models, and for the SM (bottom rows). Expected limit is calculated for background-only. Limits can be compared to expected $tH + t\bar{t}H$ cross sections × BR of 1.28 pb (K7), 1.30 pb (K6), and 0.53 pb for inverted top couplings and for the SM, respectively.

Scenario	Channel	Obs. Limit (pb)	Exp. Limit (pb)
$\kappa_t/\kappa_V = -1$	$\mu\mu$	1.22	$0.71\,^{+0.31}_{-0.20}$
	$e\mu$	1.03	$0.66\,^{+0.27}_{-0.19}$
	$\ell\ell\ell$	0.85	$0.45\,^{+0.21}_{-0.14}$
	$b\bar{b}$	2.90	$1.45\,^{+0.71}_{-0.45}$
	$\gamma\gamma$	0.46	$0.19\,^{+0.09}_{-0.06}$
	Combined	**0.51**	$\mathbf{0.16\,^{+0.08}_{-0.05}}$
$\kappa_t/\kappa_V = 1$ (SM-like)	$\mu\mu$	2.57	$1.19\,^{+0.51}_{-0.35}$
	$e\mu$	1.73	$1.10\,^{+0.47}_{-0.32}$
	$\ell\ell\ell$	1.60	$0.91\,^{+0.40}_{-0.27}$
	$b\bar{b}$	6.17	$4.63\,^{+1.68}_{-1.21}$
	$\gamma\gamma$	1.93	$0.73\,^{+0.36}_{-0.23}$
	Combined	**1.54**	$\mathbf{0.49\,^{+0.21}_{-0.14}}$

Table 4: Expected and observed 95% C.L. upper limits on the $tH + t\bar{t}H$ production cross section times $H \rightarrow WW^* + \tau\tau + ZZ^* + b\bar{b} + \gamma\gamma$ branching ratio for a scenario of inverted couplings ($\kappa_t/\kappa_V = -1.0$, top rows) and for a standard-model-like signal ($\kappa_t/\kappa_V = 1.0$, bottom rows), in pb. The expected limit is calculated on a background-only MC dataset. Limits can be compared to expected $tH + t\bar{t}H$ cross sections $\times$ BR of 1.28 pb and 0.53 pb for inverted top couplings and for the SM, respectively.

6 NLL Scans

To produce a likelihood scan, we can run combine with the `MultiDimFit` option and `--algo fixed --fixedPointPOIs`, once with $r = 1$ and once with $r = 0$. This first runs the nominal fit with floating signal strength, then repeats the fit with fixed signal strength, and reports the difference in log likelihood values. By always running one fit with $r = 0$ (which is identical in each point), we can use that likelihood value as the reference and subtract it from the $r = 1$ difference, to get comparable numbers for the likelihood outputs of the nominal fits.

The exact fit options are:

```
combine -M MultiDimFit --algo fixed --fixedPointPOIs r=1 \
 --rMin=0 --rMax=20 --X-rtd ADDNLL_RECURSIVE=0 \
 --cminDefaultMinimizerStrategy 0 \
 -m 125 --verbose 0 -n _nll_scan_r1_tag
 --setParameters kappa_t=<ct>/<cv>,kappa_V=1.0 \
 --freezeParameters kappa_t,kappa_V,kappa_mu,kappa_b, \
kappa_c,kappa_g,kappa_gam,r_others \
--redefineSignalPOIs r \
workspace.root
```

(and then repeated with `--fixedPointPOIs r=0`).

This produces the scan for the fit to observed data. To produce the expected likelihood scan, we repeat the procedure, but use toy data produced for the SM point. Generated with:

```
combine -M GenerateOnly -t -1 --expectSignal 1 \
--setParameters kappa_t=1.0,kappaV=1.0 \
--freezeParameters ... \
--saveToys \
workspace_SM.root
```

and passed to the scanning options above with `-t -1 --toysFile toy.root`.

The resulting series of likelihood values are adjusted such that the lowest value is at zero (by simply subtracting the lowest value from each point).

The scans are shown in Fig. 3.

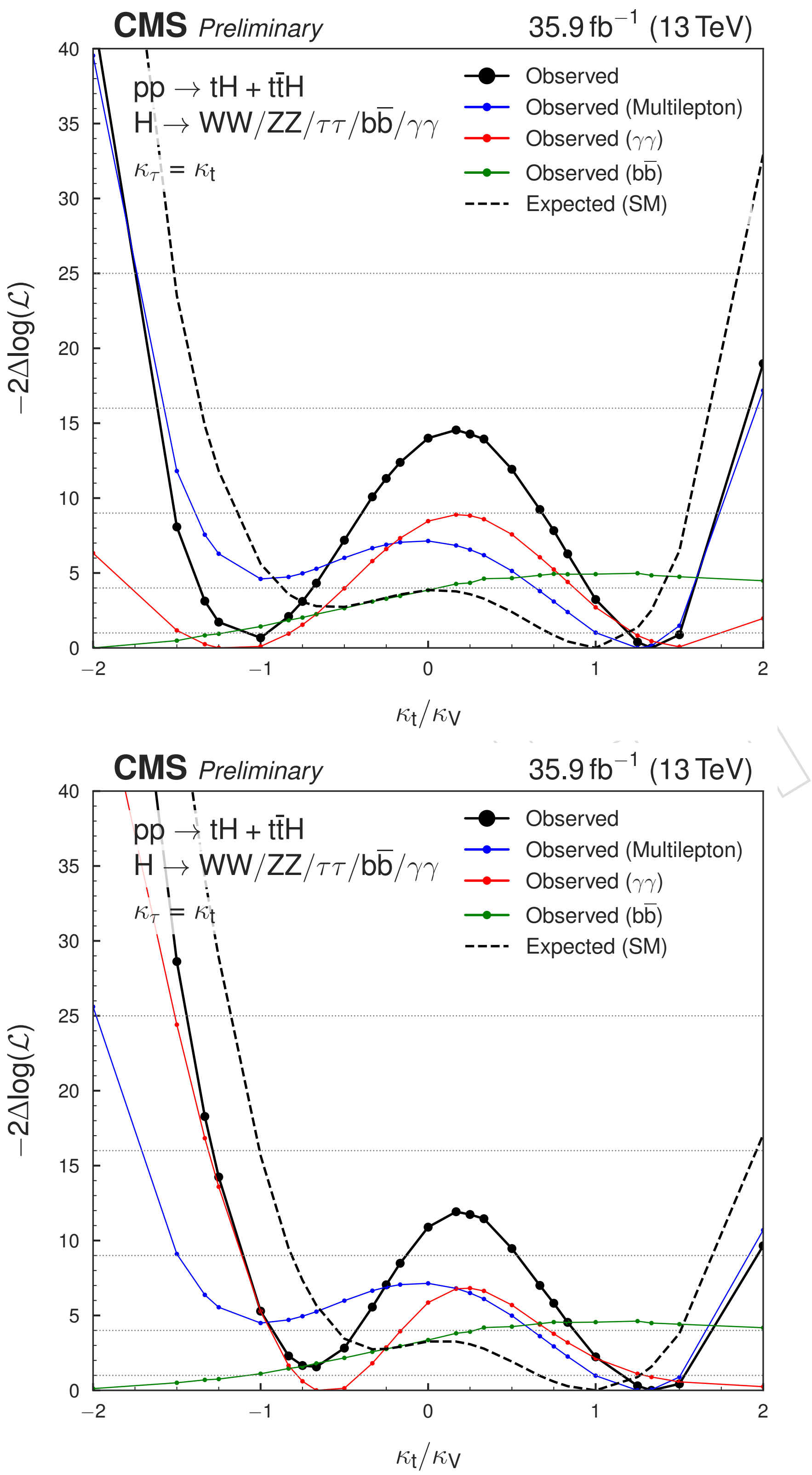

Figure 3: Negative log-likelihood scan for the non-resolved model (top) and the resolved model (bottom). Values are shown for each point in κ_t/κ_V, connected with a straight line. All values are corrected such that the lowest value is at zero.

7 Pull/Impacts

Pull and impact plots for the nuisance parameters in the combined fit are produced following the standard recipe, however with adjusting the fit options as follows:

```
--robustFit 1 --rMin=0 --rMax=20
--X-rtd ADDNLL_RECURSIVE=0
--setCrossingTolerance 1E-6
--cminDefaultMinimizerStrategy 0.
```

The resulting plots are shown in Fig. 4 to 10.

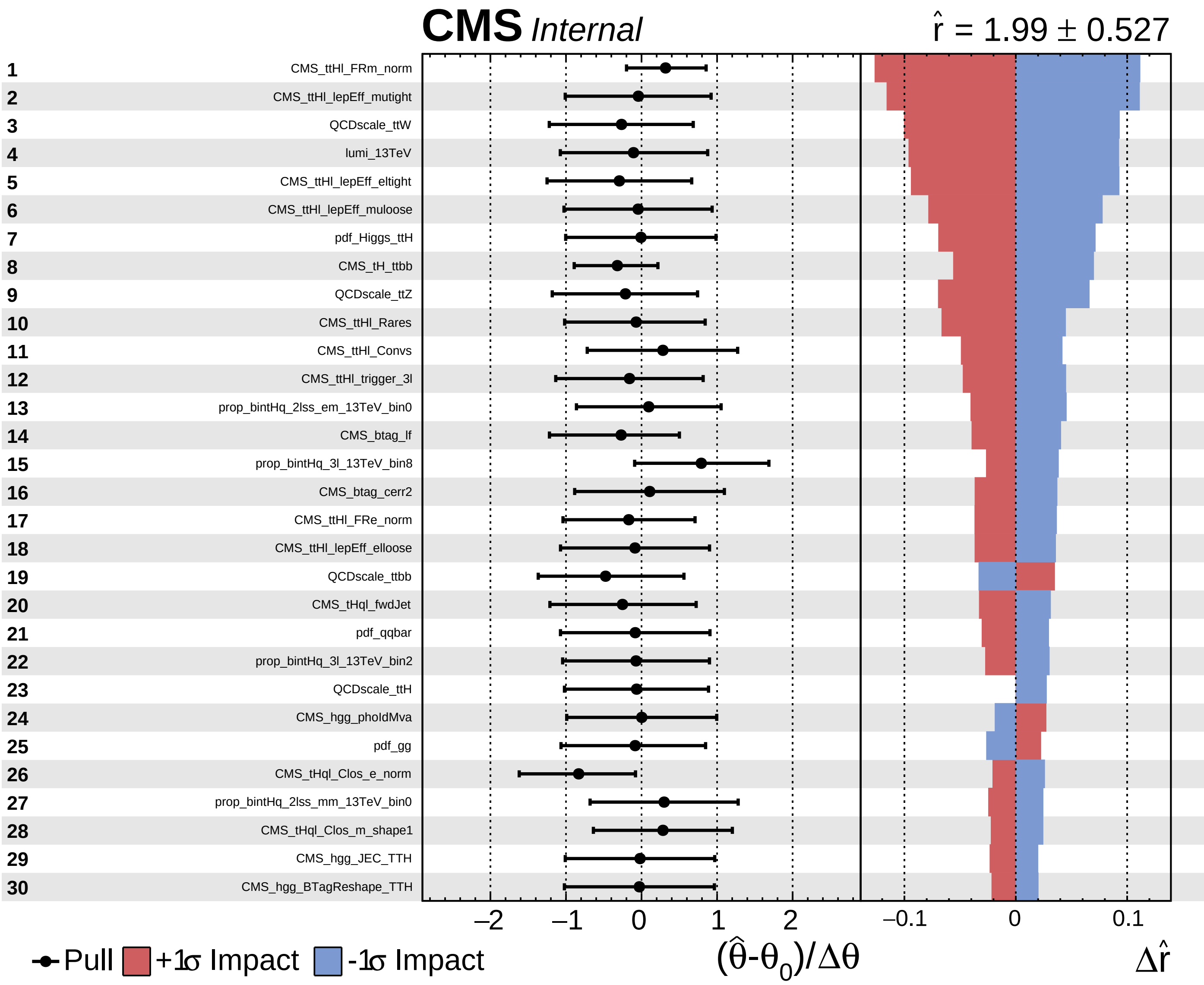

Figure 4: Pull and impact plots for all nuisances.

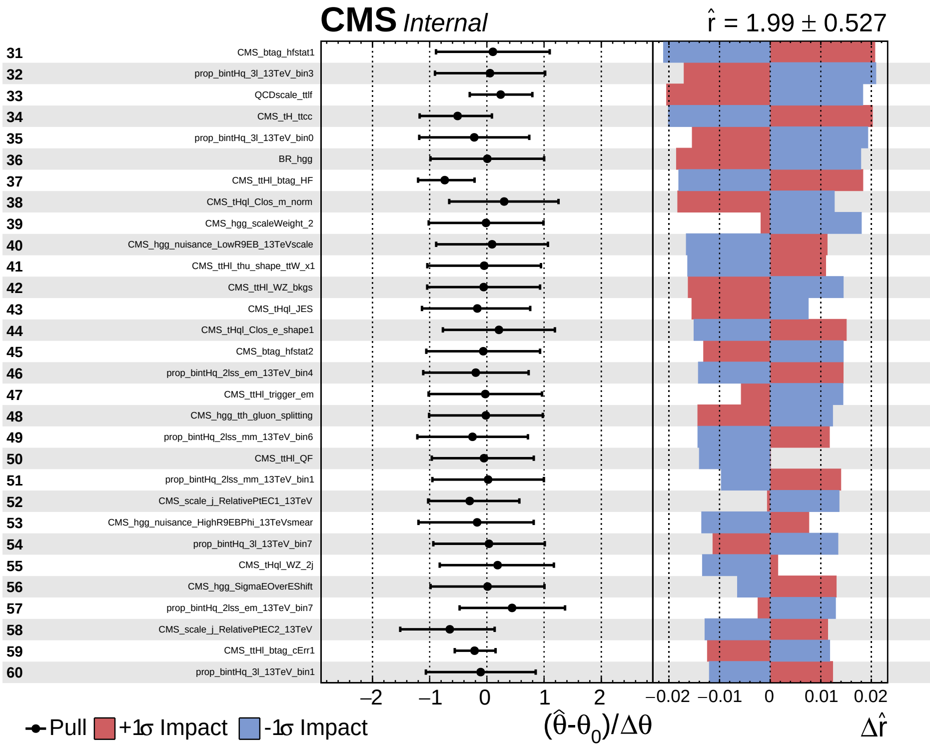

Figure 5: Pull and impact plots for all nuisances.

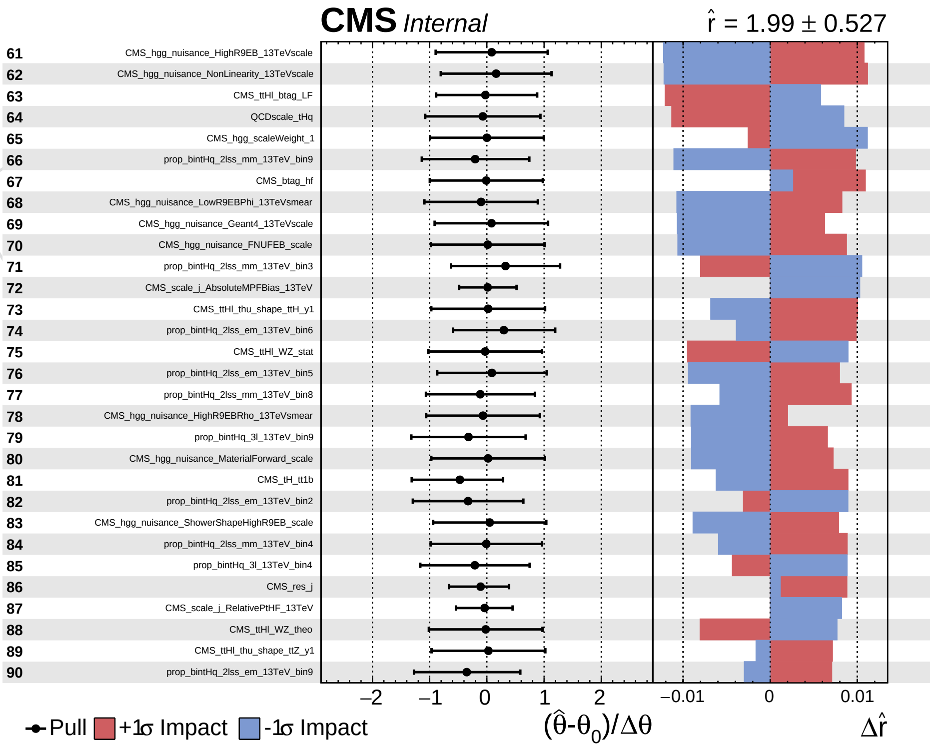

Figure 6: Pull and impact plots for all nuisances.

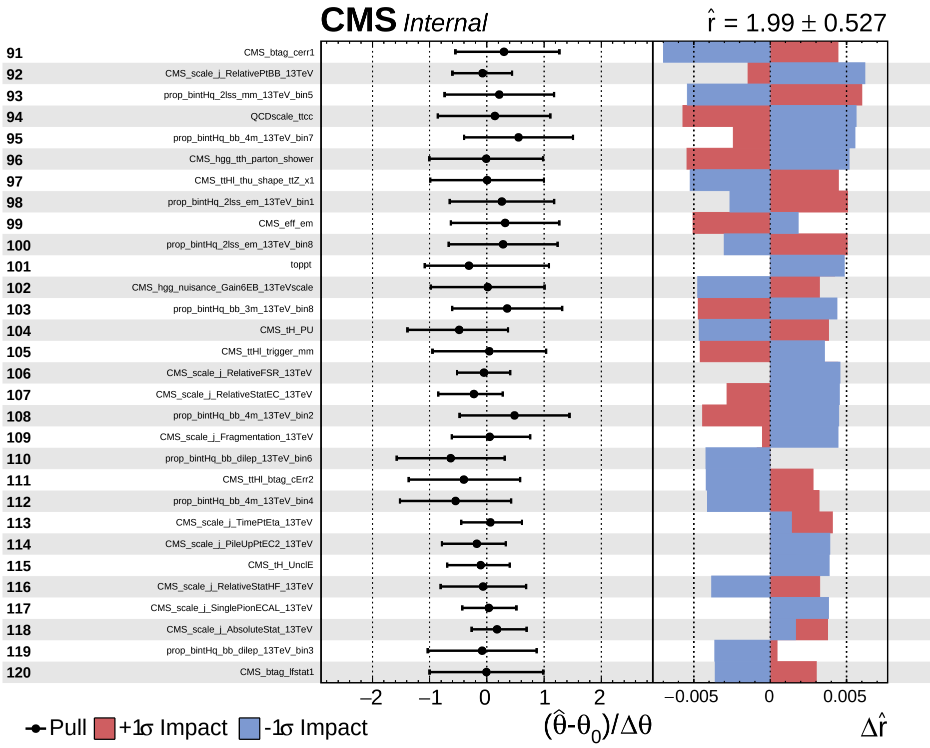

Figure 7: Pull and impact plots for all nuisances.

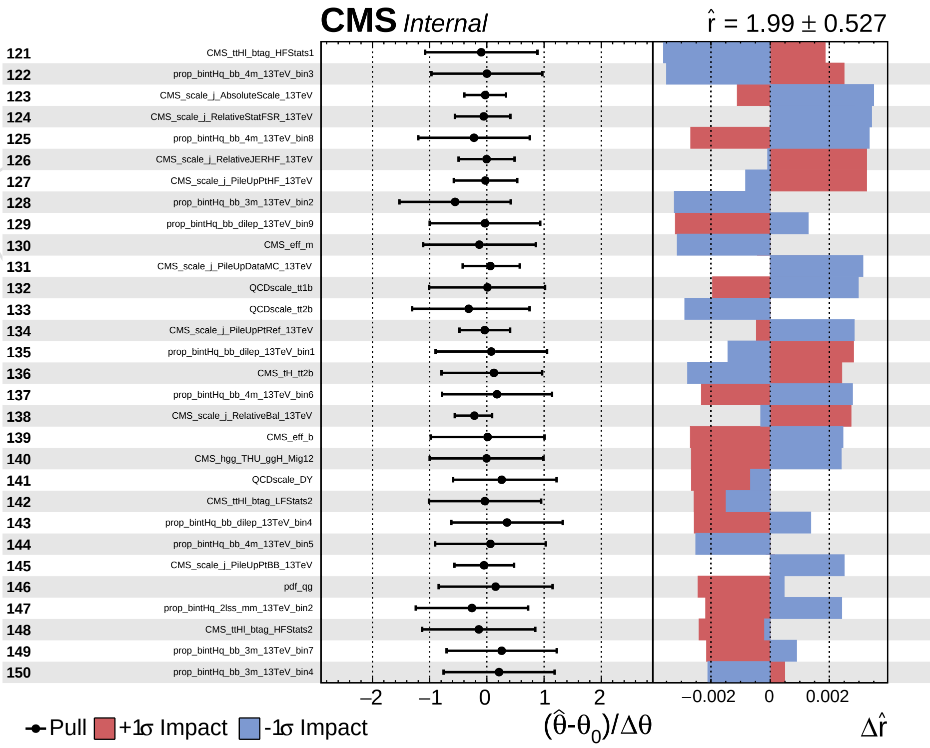

Figure 8: Pull and impact plots for all nuisances.

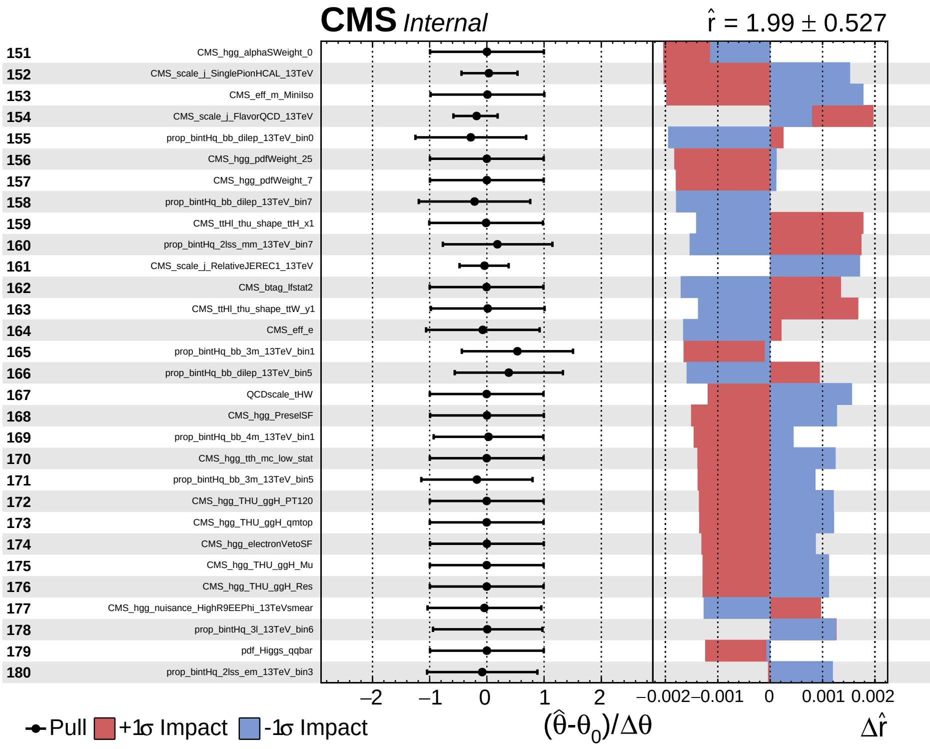

Figure 9: Pull and impact plots for all nuisances.

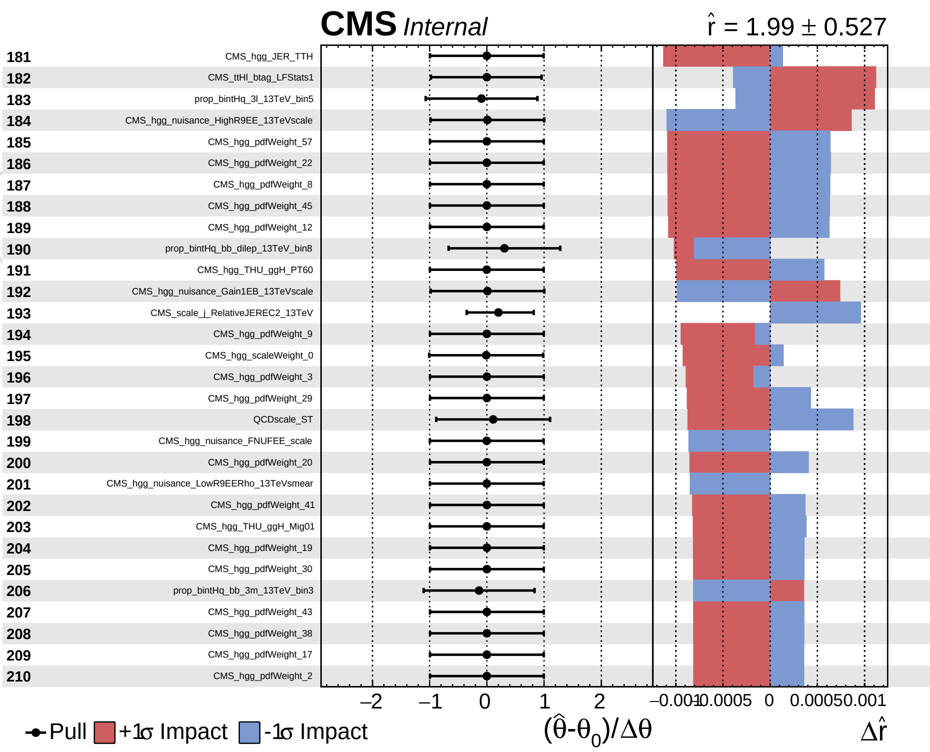

Figure 10: Pull and impact plots for all nuisances.

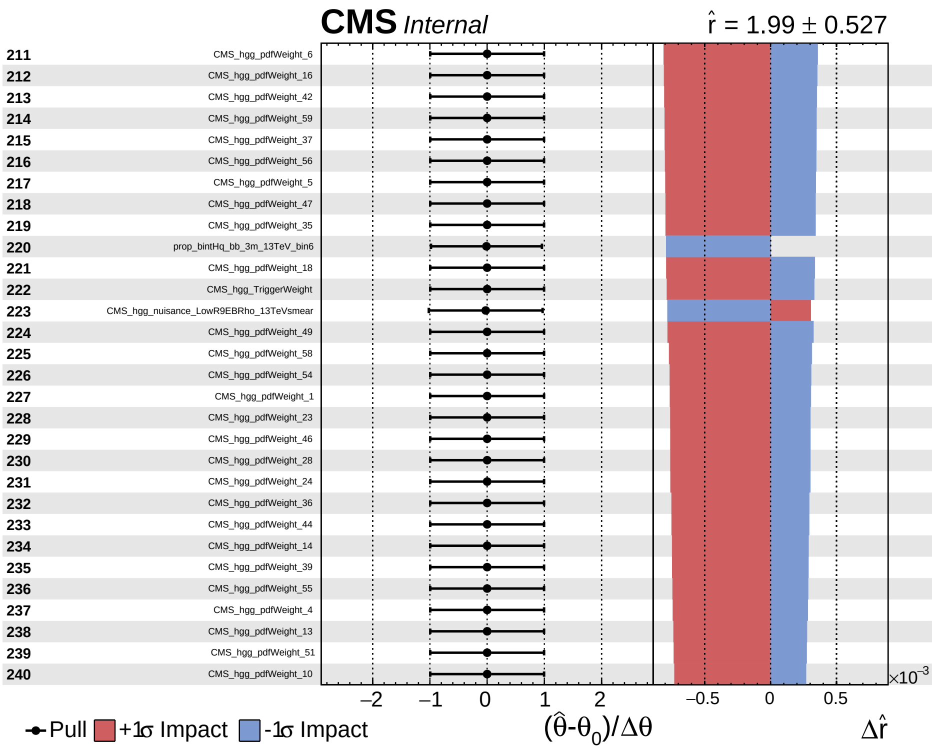

Figure 11: Pull and impact plots for all nuisances.

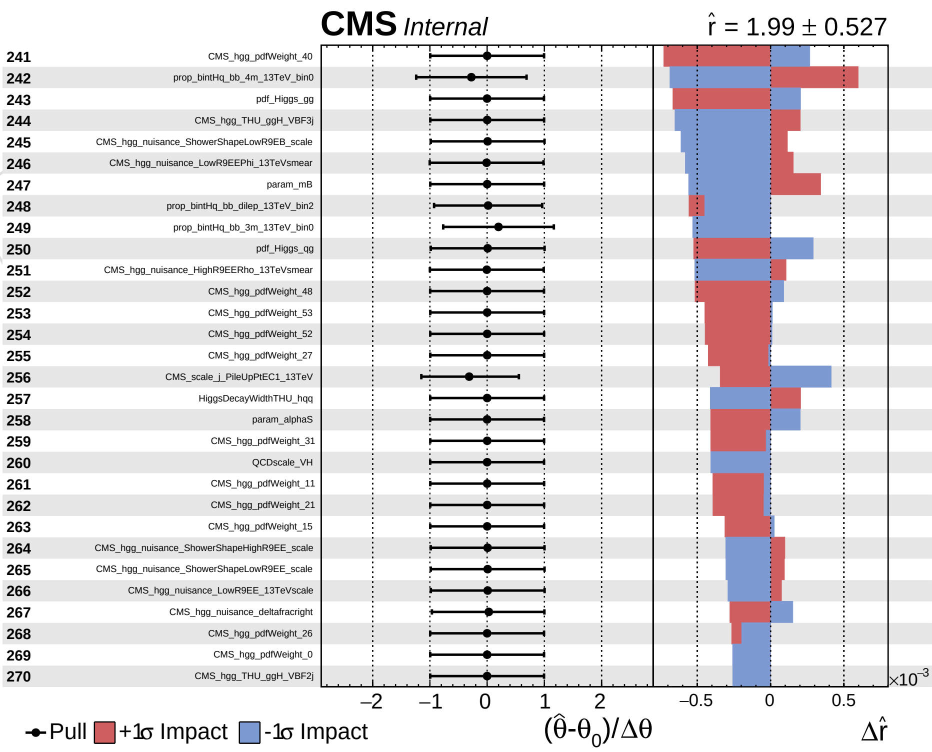

Figure 12: Pull and impact plots for all nuisances.

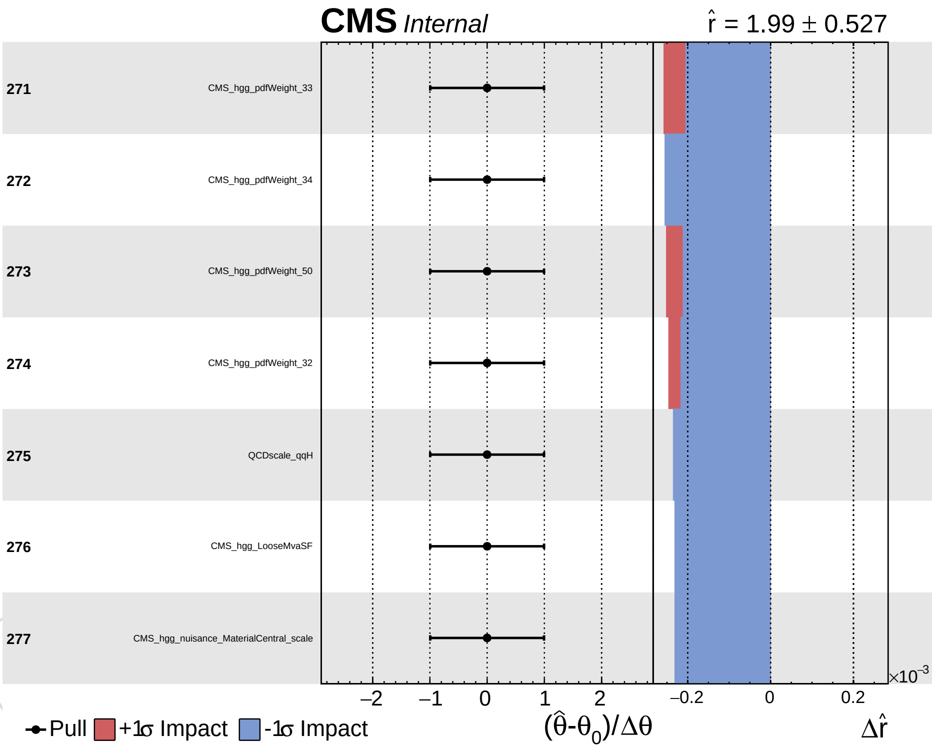

Figure 13: Pull and impact plots for all nuisances.

139 # A Cross section and BR scalings

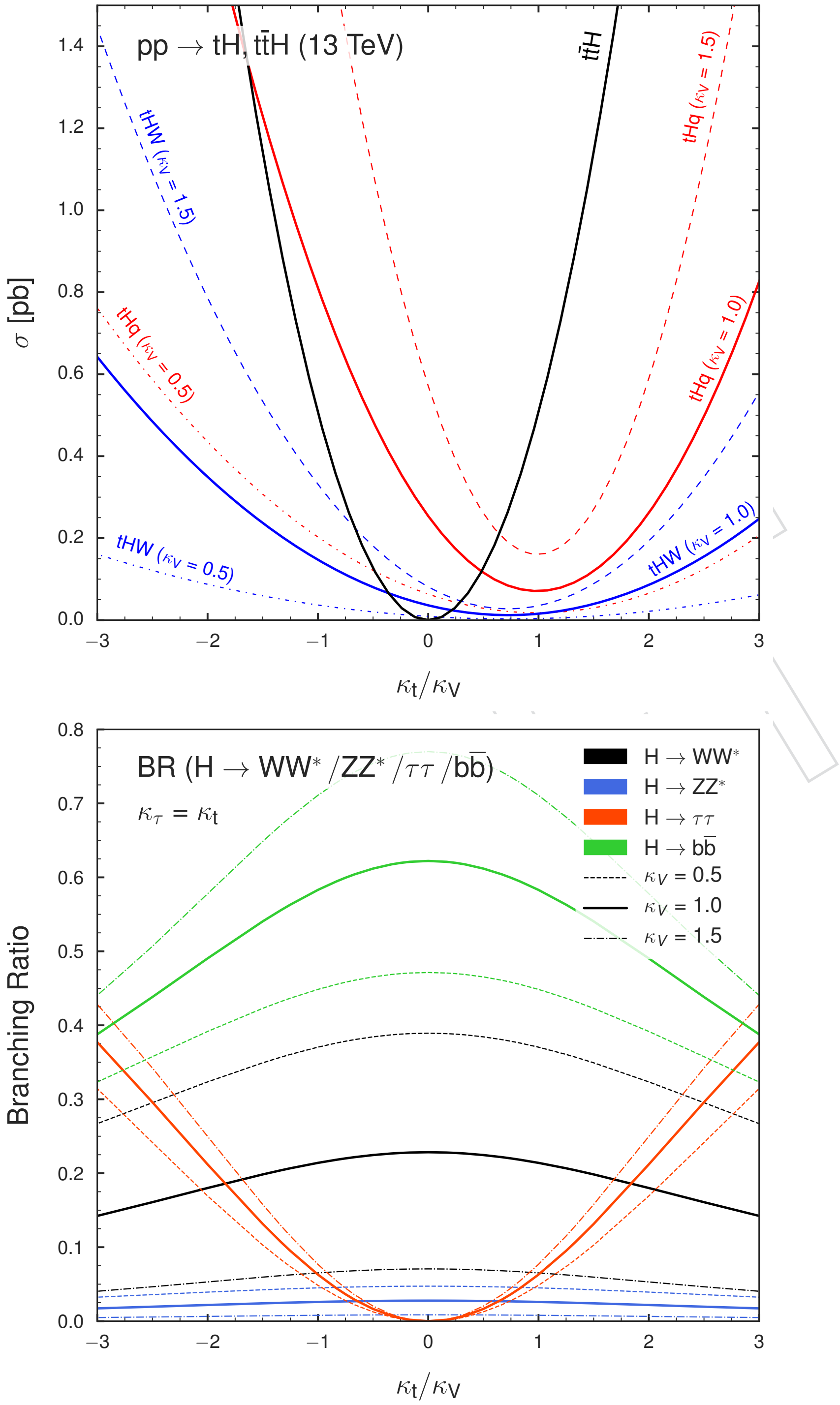

Figure 14: Scaling of the tHq, tHW, and $t\bar{t}H$ production cross sections (top) and of the $H \rightarrow WW^*$, $H \rightarrow \tau\tau$, $H \rightarrow ZZ^*$, and $H \rightarrow b\bar{b}$ branching ratios (bottom), as a function of κ_t/κ_V, for three different values of κ_V (for the non-resolved model).

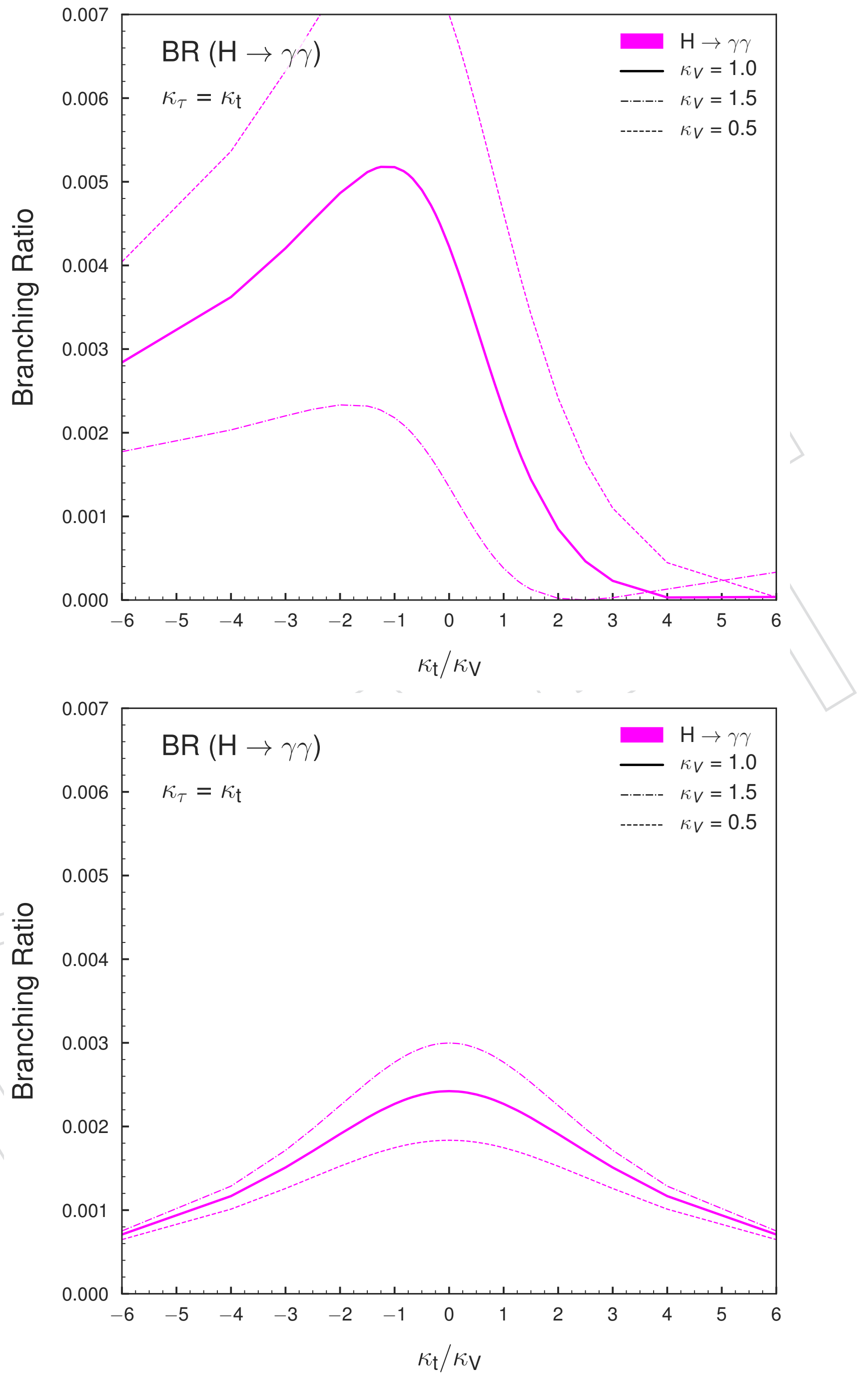

Figure 15: Scaling of the $H \to \gamma\gamma$ branching ratio, as a function of κ_t/κ_V and for $\kappa_V = 0.5, 1.0, 1.5$, for the resolved model (top), and the non-resolved model (bottom).

κ_V	κ_t	HWW	HZZ	$H\tau\tau$	$H\mu\mu$	Hbb	Hcc	$H\gamma\gamma$	$HZ\gamma$	Hgg
0.5	-6.0	0.0827	0.0827	11.9098	11.9098	0.3308	0.3308	0.3308	0.3308	0.3308
0.5	-4.0	0.1417	0.1417	9.0699	9.0699	0.5669	0.5669	0.5669	0.5669	0.5669
0.5	-3.0	0.1889	0.1889	6.7999	6.7999	0.7555	0.7555	0.7555	0.7555	0.7555
0.5	-2.5	0.2173	0.2173	5.4325	5.4325	0.8692	0.8692	0.8692	0.8692	0.8692
0.5	-2.0	0.2478	0.2478	3.9647	3.9647	0.9912	0.9912	0.9912	0.9912	0.9912
0.5	-1.5	0.2782	0.2782	2.5034	2.5034	1.1126	1.1126	1.1126	1.1126	1.1126
0.5	-1.333	0.2877	0.2877	2.0448	2.0448	1.1508	1.1508	1.1508	1.1508	1.1508
0.5	-1.25	0.2922	0.2922	1.8264	1.8264	1.1689	1.1689	1.1689	1.1689	1.1689
0.5	-1.0	0.3048	0.3048	1.2194	1.2194	1.2194	1.2194	1.2194	1.2194	1.2194
0.5	-0.833	0.3122	0.3122	0.8665	0.8665	1.2487	1.2487	1.2487	1.2487	1.2487
0.5	-0.75	0.3154	0.3154	0.7097	0.7097	1.2617	1.2617	1.2617	1.2617	1.2617
0.5	-0.667	0.3184	0.3184	0.5666	0.5666	1.2736	1.2736	1.2736	1.2736	1.2736
0.5	-0.5	0.3235	0.3235	0.3235	0.3235	1.2938	1.2938	1.2938	1.2938	1.2938
0.5	-0.333	0.3272	0.3272	0.1451	0.1451	1.3087	1.3087	1.3087	1.3087	1.3087
0.5	-0.25	0.3285	0.3285	0.0821	0.0821	1.3139	1.3139	1.3139	1.3139	1.3139
0.5	-0.167	0.3294	0.3294	0.0367	0.0367	1.3177	1.3177	1.3177	1.3177	1.3177
0.5	0.0	0.3302	0.3302	0.0000	0.0000	1.3207	1.3207	1.3207	1.3207	1.3207
0.5	0.167	0.3294	0.3294	0.0367	0.0367	1.3177	1.3177	1.3177	1.3177	1.3177
0.5	0.25	0.3285	0.3285	0.0821	0.0821	1.3139	1.3139	1.3139	1.3139	1.3139
0.5	0.333	0.3272	0.3272	0.1451	0.1451	1.3087	1.3087	1.3087	1.3087	1.3087
0.5	0.5	0.3235	0.3235	0.3235	0.3235	1.2938	1.2938	1.2938	1.2938	1.2938
0.5	0.667	0.3184	0.3184	0.5666	0.5666	1.2736	1.2736	1.2736	1.2736	1.2736
0.5	0.75	0.3154	0.3154	0.7097	0.7097	1.2617	1.2617	1.2617	1.2617	1.2617
0.5	0.833	0.3122	0.3122	0.8665	0.8665	1.2487	1.2487	1.2487	1.2487	1.2487
0.5	1.0	0.3048	0.3048	1.2194	1.2194	1.2194	1.2194	1.2194	1.2194	1.2194
0.5	1.25	0.2922	0.2922	1.8264	1.8264	1.1689	1.1689	1.1689	1.1689	1.1689
0.5	1.333	0.2877	0.2877	2.0448	2.0448	1.1508	1.1508	1.1508	1.1508	1.1508
0.5	1.5	0.2782	0.2782	2.5034	2.5034	1.1126	1.1126	1.1126	1.1126	1.1126
0.5	2.0	0.2478	0.2478	3.9647	3.9647	0.9912	0.9912	0.9912	0.9912	0.9912
0.5	2.5	0.2173	0.2173	5.4325	5.4325	0.8692	0.8692	0.8692	0.8692	0.8692
0.5	3.0	0.1889	0.1889	6.7999	6.7999	0.7555	0.7555	0.7555	0.7555	0.7555
0.5	4.0	0.1417	0.1417	9.0699	9.0699	0.5669	0.5669	0.5669	0.5669	0.5669
0.5	6.0	0.0827	0.0827	11.9098	11.9098	0.3308	0.3308	0.3308	0.3308	0.3308

Table 5: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 0.5$ for the `K6` model.

κ_V	κ_t	HWW	HZZ	H$\tau\tau$	H$\mu\mu$	Hbb	Hcc	H$\gamma\gamma$	HZγ	Hgg
1.0	-6.0	0.3122	0.3122	11.2408	11.2408	0.3122	0.3122	0.3122	0.3122	0.3122
1.0	-4.0	0.5144	0.5144	8.2305	8.2305	0.5144	0.5144	0.5144	0.5144	0.5144
1.0	-3.0	0.6651	0.6651	5.9862	5.9862	0.6651	0.6651	0.6651	0.6651	0.6651
1.0	-2.5	0.7517	0.7517	4.6979	4.6979	0.7517	0.7517	0.7517	0.7517	0.7517
1.0	-2.0	0.8412	0.8412	3.3647	3.3647	0.8412	0.8412	0.8412	0.8412	0.8412
1.0	-1.5	0.9271	0.9271	2.0859	2.0859	0.9271	0.9271	0.9271	0.9271	0.9271
1.0	-1.333	0.9534	0.9534	1.6941	1.6941	0.9534	0.9534	0.9534	0.9534	0.9534
1.0	-1.25	0.9658	0.9658	1.5091	1.5091	0.9658	0.9658	0.9658	0.9658	0.9658
1.0	-1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.0	-0.833	1.0196	1.0196	0.7075	0.7075	1.0196	1.0196	1.0196	1.0196	1.0196
1.0	-0.75	1.0283	1.0283	0.5784	0.5784	1.0283	1.0283	1.0283	1.0283	1.0283
1.0	-0.667	1.0362	1.0362	0.4610	0.4610	1.0362	1.0362	1.0362	1.0362	1.0362
1.0	-0.5	1.0495	1.0495	0.2624	0.2624	1.0495	1.0495	1.0495	1.0495	1.0495
1.0	-0.333	1.0593	1.0593	0.1175	0.1175	1.0593	1.0593	1.0593	1.0593	1.0593
1.0	-0.25	1.0627	1.0627	0.0664	0.0664	1.0627	1.0627	1.0627	1.0627	1.0627
1.0	-0.167	1.0652	1.0652	0.0297	0.0297	1.0652	1.0652	1.0652	1.0652	1.0652
1.0	0.0	1.0672	1.0672	0.0000	0.0000	1.0672	1.0672	1.0672	1.0672	1.0672
1.0	0.167	1.0652	1.0652	0.0297	0.0297	1.0652	1.0652	1.0652	1.0652	1.0652
1.0	0.25	1.0627	1.0627	0.0664	0.0664	1.0627	1.0627	1.0627	1.0627	1.0627
1.0	0.333	1.0593	1.0593	0.1175	0.1175	1.0593	1.0593	1.0593	1.0593	1.0593
1.0	0.5	1.0495	1.0495	0.2624	0.2624	1.0495	1.0495	1.0495	1.0495	1.0495
1.0	0.667	1.0362	1.0362	0.4610	0.4610	1.0362	1.0362	1.0362	1.0362	1.0362
1.0	0.75	1.0283	1.0283	0.5784	0.5784	1.0283	1.0283	1.0283	1.0283	1.0283
1.0	0.833	1.0196	1.0196	0.7075	0.7075	1.0196	1.0196	1.0196	1.0196	1.0196
1.0	1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.0	1.25	0.9658	0.9658	1.5091	1.5091	0.9658	0.9658	0.9658	0.9658	0.9658
1.0	1.333	0.9534	0.9534	1.6941	1.6941	0.9534	0.9534	0.9534	0.9534	0.9534
1.0	1.5	0.9271	0.9271	2.0859	2.0859	0.9271	0.9271	0.9271	0.9271	0.9271
1.0	2.0	0.8412	0.8412	3.3647	3.3647	0.8412	0.8412	0.8412	0.8412	0.8412
1.0	2.5	0.7517	0.7517	4.6979	4.6979	0.7517	0.7517	0.7517	0.7517	0.7517
1.0	3.0	0.6651	0.6651	5.9862	5.9862	0.6651	0.6651	0.6651	0.6651	0.6651
1.0	4.0	0.5144	0.5144	8.2305	8.2305	0.5144	0.5144	0.5144	0.5144	0.5144
1.0	6.0	0.3122	0.3122	11.2408	11.2408	0.3122	0.3122	0.3122	0.3122	0.3122

Table 6: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 1.0$ for the `K6` model.

κ_V	κ_t	HWW	HZZ	$H\tau\tau$	$H\mu\mu$	Hbb	Hcc	$H\gamma\gamma$	$HZ\gamma$	Hgg
1.5	-6.0	0.6424	0.6424	10.2785	10.2785	0.2855	0.2855	0.2855	0.2855	0.2855
1.5	-4.0	1.0028	1.0028	7.1307	7.1307	0.4457	0.4457	0.4457	0.4457	0.4457
1.5	-3.0	1.2477	1.2477	4.9909	4.9909	0.5545	0.5545	0.5545	0.5545	0.5545
1.5	-2.5	1.3802	1.3802	3.8338	3.8338	0.6134	0.6134	0.6134	0.6134	0.6134
1.5	-2.0	1.5115	1.5115	2.6870	2.6870	0.6718	0.6718	0.6718	0.6718	0.6718
1.5	-1.5	1.6322	1.6322	1.6322	1.6322	0.7254	0.7254	0.7254	0.7254	0.7254
1.5	-1.333	1.6682	1.6682	1.3175	1.3175	0.7414	0.7414	0.7414	0.7414	0.7414
1.5	-1.25	1.6851	1.6851	1.1702	1.1702	0.7489	0.7489	0.7489	0.7489	0.7489
1.5	-1.0	1.7310	1.7310	0.7693	0.7693	0.7693	0.7693	0.7693	0.7693	0.7693
1.5	-0.833	1.7570	1.7570	0.5419	0.5419	0.7809	0.7809	0.7809	0.7809	0.7809
1.5	-0.75	1.7684	1.7684	0.4421	0.4421	0.7860	0.7860	0.7860	0.7860	0.7860
1.5	-0.667	1.7788	1.7788	0.3517	0.3517	0.7906	0.7906	0.7906	0.7906	0.7906
1.5	-0.5	1.7962	1.7962	0.1996	0.1996	0.7983	0.7983	0.7983	0.7983	0.7983
1.5	-0.333	1.8089	1.8089	0.0891	0.0891	0.8039	0.8039	0.8039	0.8039	0.8039
1.5	-0.25	1.8133	1.8133	0.0504	0.0504	0.8059	0.8059	0.8059	0.8059	0.8059
1.5	-0.167	1.8165	1.8165	0.0225	0.0225	0.8073	0.8073	0.8073	0.8073	0.8073
1.5	0.0	1.8191	1.8191	0.0000	0.0000	0.8085	0.8085	0.8085	0.8085	0.8085
1.5	0.167	1.8165	1.8165	0.0225	0.0225	0.8073	0.8073	0.8073	0.8073	0.8073
1.5	0.25	1.8133	1.8133	0.0504	0.0504	0.8059	0.8059	0.8059	0.8059	0.8059
1.5	0.333	1.8089	1.8089	0.0891	0.0891	0.8039	0.8039	0.8039	0.8039	0.8039
1.5	0.5	1.7962	1.7962	0.1996	0.1996	0.7983	0.7983	0.7983	0.7983	0.7983
1.5	0.667	1.7788	1.7788	0.3517	0.3517	0.7906	0.7906	0.7906	0.7906	0.7906
1.5	0.75	1.7684	1.7684	0.4421	0.4421	0.7860	0.7860	0.7860	0.7860	0.7860
1.5	0.833	1.7570	1.7570	0.5419	0.5419	0.7809	0.7809	0.7809	0.7809	0.7809
1.5	1.0	1.7310	1.7310	0.7693	0.7693	0.7693	0.7693	0.7693	0.7693	0.7693
1.5	1.25	1.6851	1.6851	1.1702	1.1702	0.7489	0.7489	0.7489	0.7489	0.7489
1.5	1.333	1.6682	1.6682	1.3175	1.3175	0.7414	0.7414	0.7414	0.7414	0.7414
1.5	1.5	1.6322	1.6322	1.6322	1.6322	0.7254	0.7254	0.7254	0.7254	0.7254
1.5	2.0	1.5115	1.5115	2.6870	2.6870	0.6718	0.6718	0.6718	0.6718	0.6718
1.5	2.5	1.3802	1.3802	3.8338	3.8338	0.6134	0.6134	0.6134	0.6134	0.6134
1.5	3.0	1.2477	1.2477	4.9909	4.9909	0.5545	0.5545	0.5545	0.5545	0.5545
1.5	4.0	1.0028	1.0028	7.1307	7.1307	0.4457	0.4457	0.4457	0.4457	0.4457
1.5	6.0	0.6424	0.6424	10.2785	10.2785	0.2855	0.2855	0.2855	0.2855	0.2855

Table 7: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 1.5$ for the `K6` model.

κ_V	κ_t	HWW	HZZ	$H\tau\tau$	$H\mu\mu$	$Hb\bar{b}$	Hcc	$H\gamma\gamma$	$HZ\gamma$	Hgg
0.5	-6.0	0.0398	0.0398	5.7259	5.7259	0.1591	0.1591	0.7813	0.1241	6.4828
0.5	-4.0	0.0785	0.0785	5.0264	5.0264	0.3141	0.3141	0.8959	0.1841	5.7444
0.5	-3.0	0.1194	0.1194	4.2990	4.2990	0.4777	0.4777	0.9699	0.2386	4.9595
0.5	-2.5	0.1502	0.1502	3.7554	3.7554	0.6009	0.6009	1.0046	0.2756	4.3654
0.5	-2.0	0.1905	0.1905	3.0487	3.0487	0.7622	0.7622	1.0276	0.3199	3.5845
0.5	-1.5	0.2411	0.2411	2.1699	2.1699	0.9644	0.9644	1.0216	0.3689	2.6007
0.5	-1.333	0.2598	0.2598	1.8468	1.8468	1.0393	1.0393	1.0088	0.3850	2.2348
0.5	-1.25	0.2693	0.2693	1.6833	1.6833	1.0773	1.0773	0.9997	0.3927	2.0489
0.5	-1.0	0.2980	0.2980	1.1922	1.1922	1.1922	1.1922	0.9600	0.4136	1.4853
0.5	-0.833	0.3165	0.3165	0.8786	0.8786	1.2662	1.2662	0.9219	0.4248	1.1207
0.5	-0.75	0.3253	0.3253	0.7318	0.7318	1.3010	1.3010	0.8993	0.4291	0.9483
0.5	-0.667	0.3335	0.3335	0.5935	0.5935	1.3340	1.3340	0.8742	0.4326	0.7844
0.5	-0.5	0.3483	0.3483	0.3483	0.3483	1.3932	1.3932	0.8163	0.4363	0.4889
0.5	-0.333	0.3600	0.3600	0.1597	0.1597	1.4399	1.4399	0.7493	0.4352	0.2531
0.5	-0.25	0.3644	0.3644	0.0911	0.0911	1.4575	1.4575	0.7131	0.4327	0.1629
0.5	-0.167	0.3677	0.3677	0.0410	0.0410	1.4708	1.4708	0.6753	0.4289	0.0928
0.5	0.0	0.3711	0.3711	0.0000	0.0000	1.4842	1.4842	0.5957	0.4172	0.0172
0.5	0.167	0.3697	0.3697	0.0412	0.0412	1.4788	1.4788	0.5139	0.4004	0.0326
0.5	0.25	0.3673	0.3673	0.0918	0.0918	1.4692	1.4692	0.4733	0.3904	0.0739
0.5	0.333	0.3638	0.3638	0.1614	0.1614	1.4552	1.4552	0.4334	0.3793	0.1366
0.5	0.5	0.3537	0.3537	0.3537	0.3537	1.4148	1.4148	0.3561	0.3548	0.3225
0.5	0.667	0.3401	0.3401	0.6053	0.6053	1.3605	1.3605	0.2849	0.3279	0.5768
0.5	0.75	0.3323	0.3323	0.7478	0.7478	1.3293	1.3293	0.2524	0.3140	0.7238
0.5	0.833	0.3240	0.3240	0.8993	0.8993	1.2960	1.2960	0.2220	0.3000	0.8817
0.5	1.0	0.3060	0.3060	1.2241	1.2241	1.2241	1.2241	0.1674	0.2719	1.2241
0.5	1.25	0.2775	0.2775	1.7344	1.7344	1.1100	1.1100	0.1025	0.2314	1.7698
0.5	1.333	0.2679	0.2679	1.9044	1.9044	1.0718	1.0718	0.0852	0.2187	1.9533
0.5	1.5	0.2490	0.2490	2.2408	2.2408	0.9959	0.9959	0.0564	0.1945	2.3182
0.5	2.0	0.1971	0.1971	3.1537	3.1537	0.7884	0.7884	0.0089	0.1341	3.3202
0.5	2.5	0.1553	0.1553	3.8829	3.8829	0.6213	0.6213	0.0005	0.0912	4.1316
0.5	3.0	0.1233	0.1233	4.4379	4.4379	0.4931	0.4931	0.0124	0.0617	4.7561
0.5	4.0	0.0808	0.0808	5.1683	5.1683	0.3230	0.3230	0.0575	0.0281	5.5888
0.5	6.0	0.0406	0.0406	5.8478	5.8478	0.1624	0.1624	0.1465	0.0051	6.3812

Table 8: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 0.5$ for the `K7` model.

κ_V	κ_t	HWW	HZZ	$H\tau\tau$	$H\mu\mu$	Hbb	Hcc	$H\gamma\gamma$	$HZ\gamma$	Hgg
1.0	-6.0	0.1544	0.1544	5.5588	5.5588	0.1544	0.1544	1.2512	0.3078	6.2936
1.0	-4.0	0.2967	0.2967	4.7471	4.7471	0.2967	0.2967	1.5955	0.4970	5.4252
1.0	-3.0	0.4386	0.4386	3.9474	3.9474	0.4386	0.4386	1.8526	0.6694	4.5540
1.0	-2.5	0.5405	0.5405	3.3779	3.3779	0.5405	0.5405	1.9992	0.7860	3.9265
1.0	-2.0	0.6677	0.6677	2.6709	2.6709	0.6677	0.6677	2.1427	0.9243	3.1403
1.0	-1.5	0.8183	0.8183	1.8411	1.8411	0.8183	0.8183	2.2534	1.0768	2.2066
1.0	-1.333	0.8717	0.8717	1.5489	1.5489	0.8717	0.8717	2.2747	1.1275	1.8744
1.0	-1.25	0.8983	0.8983	1.4036	1.4036	0.8983	0.8983	2.2811	1.1520	1.7084
1.0	-1.0	0.9770	0.9770	0.9770	0.9770	0.9770	0.9770	2.2798	1.2205	1.2172
1.0	-0.833	1.0263	1.0263	0.7121	0.7121	1.0263	1.0263	2.2586	1.2596	0.9084
1.0	-0.75	1.0491	1.0491	0.5901	0.5901	1.0491	1.0491	2.2413	1.2763	0.7647
1.0	-0.667	1.0706	1.0706	0.4763	0.4763	1.0706	1.0706	2.2191	1.2909	0.6295
1.0	-0.5	1.1086	1.1086	0.2771	0.2771	1.1086	1.1086	2.1594	1.3129	0.3890
1.0	-0.333	1.1381	1.1381	0.1262	0.1262	1.1381	1.1381	2.0791	1.3236	0.2000
1.0	-0.25	1.1491	1.1491	0.0718	0.0718	1.1491	1.1491	2.0318	1.3244	0.1284
1.0	-0.167	1.1575	1.1575	0.0323	0.0323	1.1575	1.1575	1.9798	1.3220	0.0730
1.0	0.0	1.1660	1.1660	0.0000	0.0000	1.1660	1.1660	1.8622	1.3072	0.0135
1.0	0.167	1.1628	1.1628	0.0324	0.0324	1.1628	1.1628	1.7299	1.2796	0.0256
1.0	0.25	1.1569	1.1569	0.0723	0.0723	1.1569	1.1569	1.6600	1.2613	0.0582
1.0	0.333	1.1483	1.1483	0.1273	0.1273	1.1483	1.1483	1.5879	1.2402	0.1078
1.0	0.5	1.1232	1.1232	0.2808	0.2808	1.1232	1.1232	1.4390	1.1903	0.2560
1.0	0.667	1.0889	1.0889	0.4844	0.4844	1.0889	1.0889	1.2886	1.1320	0.4617
1.0	0.75	1.0689	1.0689	0.6013	0.6013	1.0689	1.0689	1.2145	1.1006	0.5820
1.0	0.833	1.0473	1.0473	0.7267	0.7267	1.0473	1.0473	1.1417	1.0680	0.7125
1.0	1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.0	1.25	0.9227	0.9227	1.4418	1.4418	0.9227	0.9227	0.8050	0.8958	1.4712
1.0	1.333	0.8962	0.8962	1.5925	1.5925	0.8962	0.8962	0.7457	0.8614	1.6333
1.0	1.5	0.8426	0.8426	1.8959	1.8959	0.8426	0.8426	0.6350	0.7938	1.9615
1.0	2.0	0.6894	0.6894	2.7576	2.7576	0.6894	0.6894	0.3737	0.6106	2.9032
1.0	2.5	0.5582	0.5582	3.4889	3.4889	0.5582	0.5582	0.2039	0.4640	3.7123
1.0	3.0	0.4526	0.4526	4.0736	4.0736	0.4526	0.4526	0.1011	0.3523	4.3657
1.0	4.0	0.3052	0.3052	4.8835	4.8835	0.3052	0.3052	0.0134	0.2070	5.2809
1.0	6.0	0.1579	0.1579	5.6827	5.6827	0.1579	0.1579	0.0162	0.0786	6.2011

Table 9: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 1.0$ for the `K7` model.

κ_V	κ_t	HWW	HZZ	H$\tau\tau$	H$\mu\mu$	Hbb	Hcc	H$\gamma\gamma$	HZγ	Hgg
1.5	-6.0	0.3315	0.3315	5.3036	5.3036	0.1473	0.1473	1.7809	0.5548	6.0047
1.5	-4.0	0.6113	0.6113	4.3473	4.3473	0.2717	0.2717	2.3633	0.9029	4.9683
1.5	-3.0	0.8691	0.8691	3.4762	3.4762	0.3862	0.3862	2.7854	1.2020	4.0104
1.5	-2.5	1.0422	1.0422	2.8950	2.8950	0.4632	0.4632	3.0202	1.3938	3.3652
1.5	-2.0	1.2460	1.2460	2.2150	2.2150	0.5538	0.5538	3.2473	1.6102	2.6043
1.5	-1.5	1.4707	1.4707	1.4707	1.4707	0.6537	0.6537	3.4270	1.8357	1.7627
1.5	-1.333	1.5466	1.5466	1.2214	1.2214	0.6874	0.6874	3.4664	1.9078	1.4780
1.5	-1.25	1.5837	1.5837	1.0998	1.0998	0.7039	0.7039	3.4806	1.9421	1.3386
1.5	-1.0	1.6906	1.6906	0.7514	0.7514	0.7514	0.7514	3.4985	2.0366	0.9361
1.5	-0.833	1.7556	1.7556	0.5414	0.5414	0.7803	0.7803	3.4862	2.0898	0.6907
1.5	-0.75	1.7853	1.7853	0.4463	0.4463	0.7935	0.7935	3.4720	2.1124	0.5784
1.5	-0.667	1.8128	1.8128	0.3585	0.3585	0.8057	0.8057	3.4523	2.1322	0.4738
1.5	-0.5	1.8610	1.8610	0.2068	0.2068	0.8271	0.8271	3.3948	2.1626	0.2902
1.5	-0.333	1.8980	1.8980	0.0935	0.0935	0.8436	0.8436	3.3133	2.1788	0.1483
1.5	-0.25	1.9117	1.9117	0.0531	0.0531	0.8497	0.8497	3.2639	2.1812	0.0950
1.5	-0.167	1.9221	1.9221	0.0238	0.0238	0.8543	0.8543	3.2088	2.1797	0.0539
1.5	0.0	1.9327	1.9327	0.0000	0.0000	0.8590	0.8590	3.0814	2.1649	0.0099
1.5	0.167	1.9291	1.9291	0.0239	0.0239	0.8574	0.8574	2.9342	2.1341	0.0189
1.5	0.25	1.9220	1.9220	0.0534	0.0534	0.8542	0.8542	2.8547	2.1132	0.0430
1.5	0.333	1.9116	1.9116	0.0942	0.0942	0.8496	0.8496	2.7715	2.0886	0.0797
1.5	0.5	1.8807	1.8807	0.2090	0.2090	0.8359	0.8359	2.5954	2.0292	0.1905
1.5	0.667	1.8378	1.8378	0.3634	0.3634	0.8168	0.8168	2.4110	1.9580	0.3463
1.5	0.75	1.8125	1.8125	0.4531	0.4531	0.8056	0.8056	2.3176	1.9189	0.4386
1.5	0.833	1.7849	1.7849	0.5505	0.5505	0.7933	0.7933	2.2237	1.8777	0.5397
1.5	1.0	1.7233	1.7233	0.7659	0.7659	0.7659	0.7659	2.0355	1.7898	0.7659
1.5	1.25	1.6197	1.6197	1.1248	1.1248	0.7198	0.7198	1.7614	1.6500	1.1477
1.5	1.333	1.5832	1.5832	1.2503	1.2503	0.7036	0.7036	1.6739	1.6024	1.2824
1.5	1.5	1.5081	1.5081	1.5081	1.5081	0.6703	0.6703	1.5047	1.5066	1.5602
1.5	2.0	1.2818	1.2818	2.2787	2.2787	0.5697	0.5697	1.0637	1.2307	2.3991
1.5	2.5	1.0736	1.0736	2.9822	2.9822	0.4771	0.4771	0.7273	0.9900	3.1732
1.5	3.0	0.8952	0.8952	3.5810	3.5810	0.3979	0.3979	0.4838	0.7921	3.8377
1.5	4.0	0.6286	0.6286	4.4700	4.4700	0.2794	0.2794	0.1967	0.5108	4.8337
1.5	6.0	0.3390	0.3390	5.4247	5.4247	0.1507	0.1507	0.0147	0.2296	5.9195

Table 10: Scalings of Higgs decay branching ratios vs. κ_t for $\kappa_V = 1.5$ for the K7 model.

B Multilepton + $b\overline{b}$ Combination

This section contains the results of the previous combination before including the $\gamma\gamma$ reinterpretation.

κ_t/κ_V	$\kappa_V = 0.5$		$\kappa_V = 1.0$		$\kappa_V = 1.5$	
	expected	observed	expected	observed	expected	observed
-6.000	0.014	0.026				
-4.000	0.037	0.070				
-3.000	0.075	0.145	0.075	0.145		
-2.500	0.115	0.228				
-2.000	0.190	0.388	0.190	0.388	0.190	0.388
-1.500	0.343	0.720	0.343	0.720		
-1.333					0.428	0.904
-1.250			0.478	1.012		
-1.000	0.680	0.680	0.680	1.437	0.682	1.438
-0.833					0.879	1.823
-0.750			0.992	2.034		
-0.667					1.125	2.251
-0.500	1.465	2.723	1.465	2.715	1.469	2.723
-0.333					1.914	3.148
-0.250			2.164	3.333		
-0.167					2.445	3.544
0.000	3.172	4.265	3.172	4.260	3.172	4.262
0.167					4.188	6.166
0.250			4.672	7.941		
0.333					5.109	10.280
0.500	4.516	10.482	4.516	10.480	4.531	10.565
0.667					3.039	7.186
0.750			2.469	5.805		
0.833					2.016	4.724
1.000	1.352	3.140	1.352	3.134	1.352	3.139
1.250			0.816	1.857		
1.333					0.705	1.600
1.500	0.529	1.189	0.529	1.189		
2.000	0.260	0.565	0.260	0.565	0.260	0.565
2.500	0.146	0.309				
3.000	0.091	0.188	0.091	0.188		
4.000	0.043	0.086				
6.000	0.016	0.030				

Table 11: Expected and observed limits on the combined $tH + t\bar{t}H$ signal strength for the combination of all six channels for all 51 points.

Pull and impact plots in Fig. 18 to 24 were produced with `--robustFit 1 --setRobustFitAlgo Minuit,migrad` options.

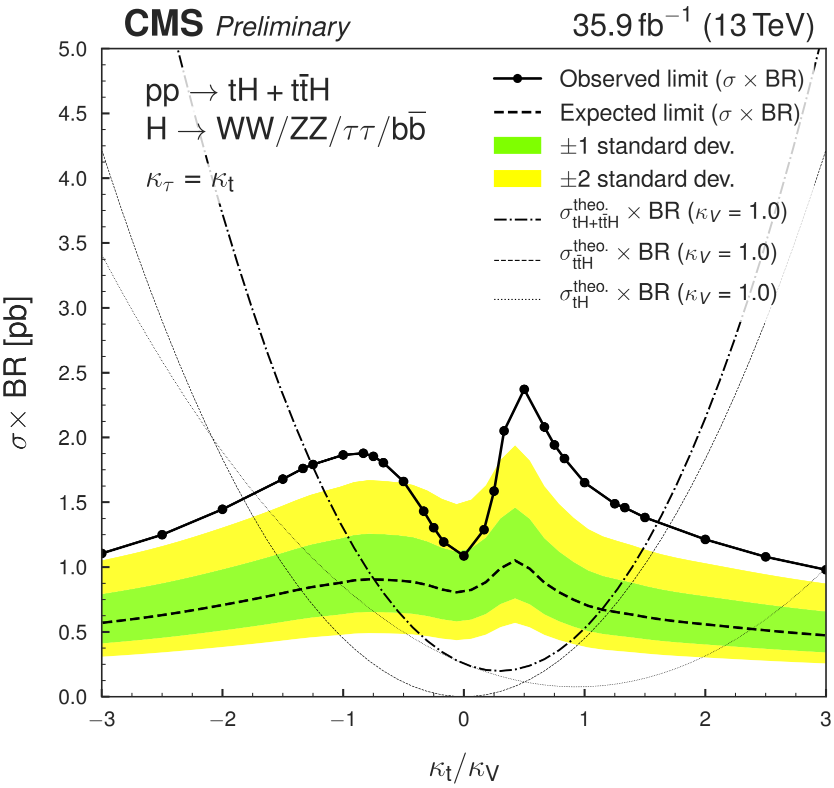

Figure 16: Observed and background-only expected cross section times branching ratio limits on combined tH + $t\bar{t}$H production, as a function of κ_t/κ_V. For reference, tHq, tHW, and $t\bar{t}$H cross sections for a κ_V value of 1.0 are displayed as well.

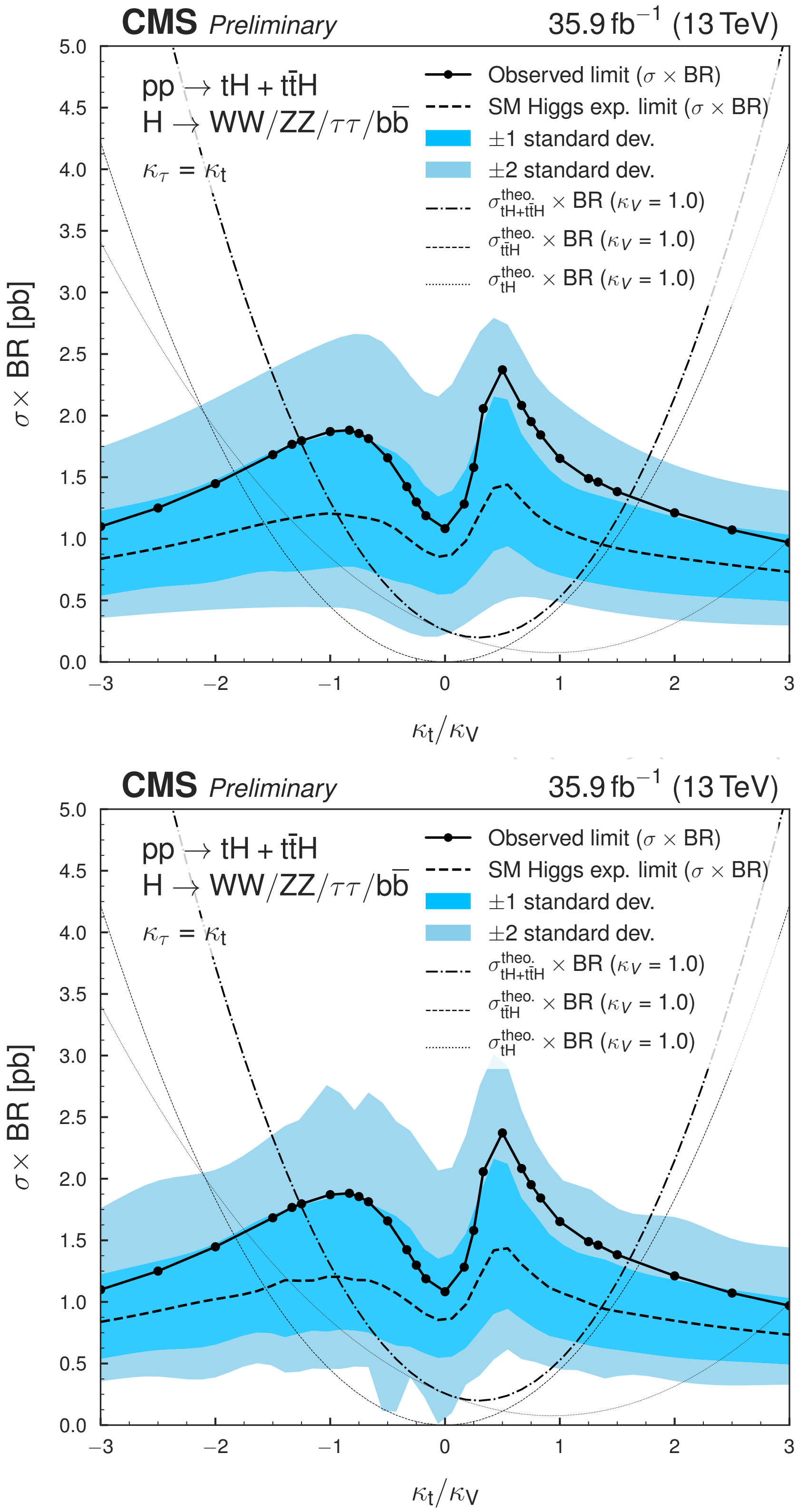

Figure 17: Observed and SM Higgs-like expected cross section times branching ratio limits on combined $tH + t\bar{t}H$ production, as a function of κ_t/κ_V. For reference, tHq, tHW, and $t\bar{t}H$ cross sections for a κ_V value of 1.0 are displayed as well. Top panel: smoothing function applied to expected limit, bottom panel: non-smoothed version.

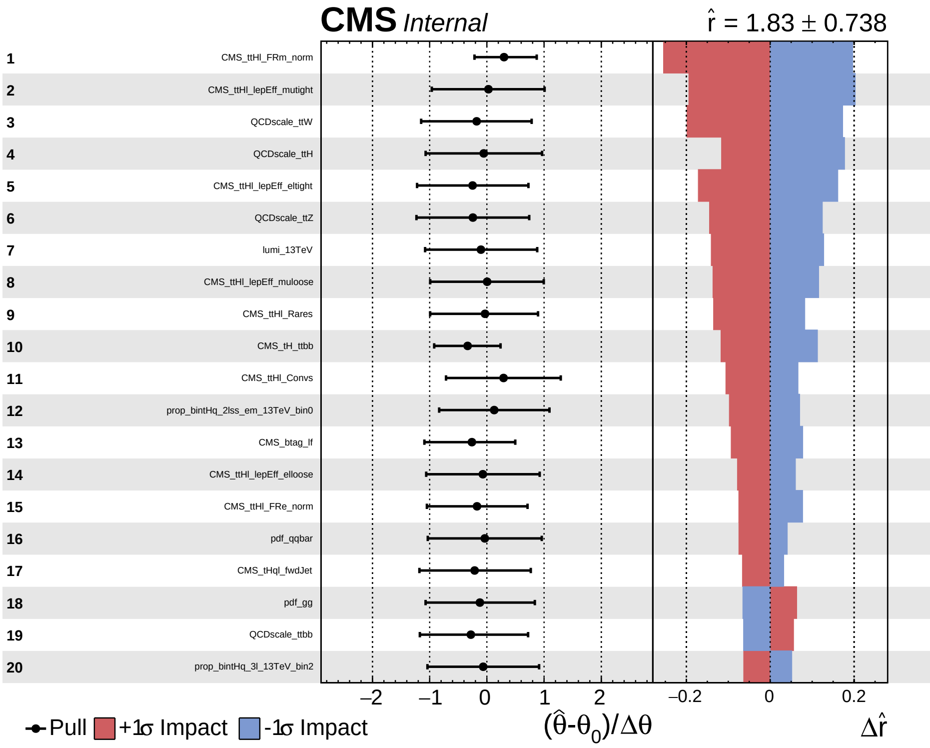

Figure 18: Pull and impact plots for all nuisances.

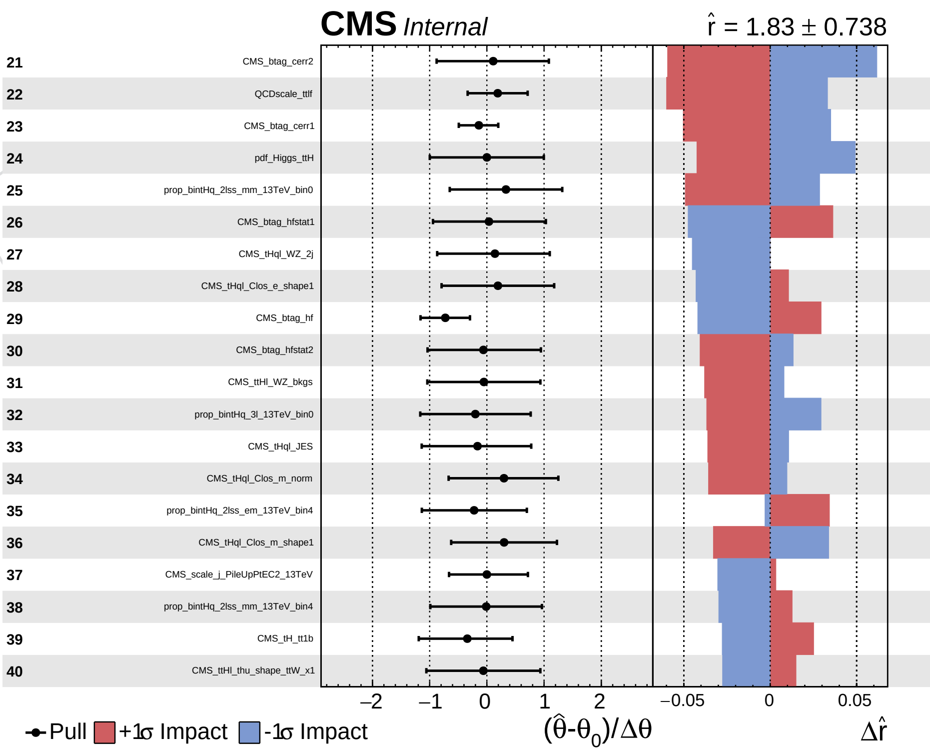

Figure 19: Pull and impact plots for all nuisances.

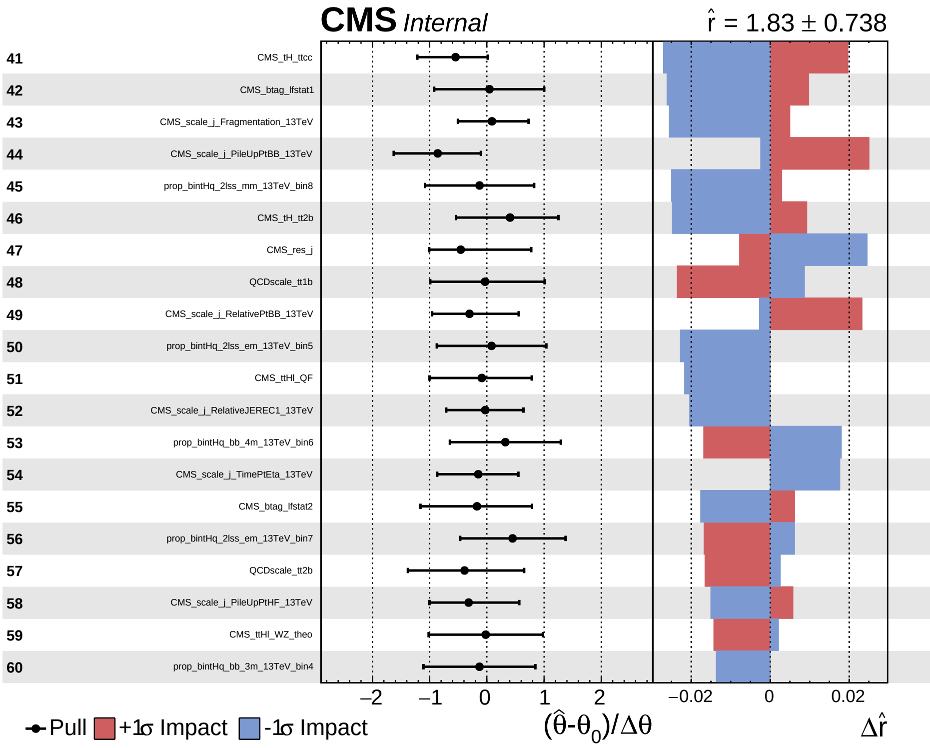

Figure 20: Pull and impact plots for all nuisances.

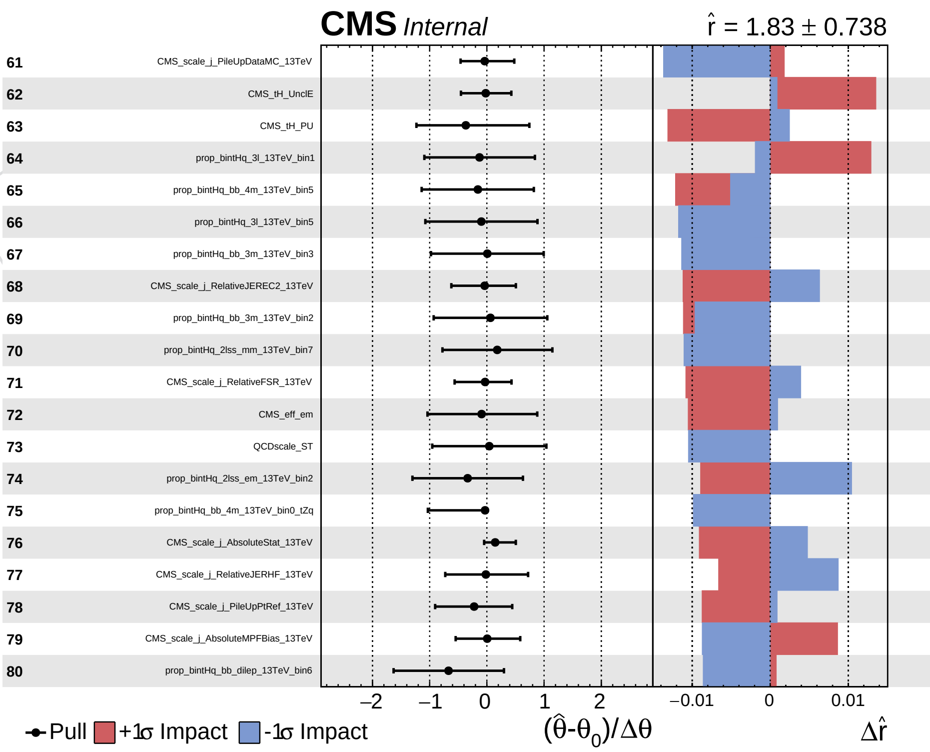

Figure 21: Pull and impact plots for all nuisances.

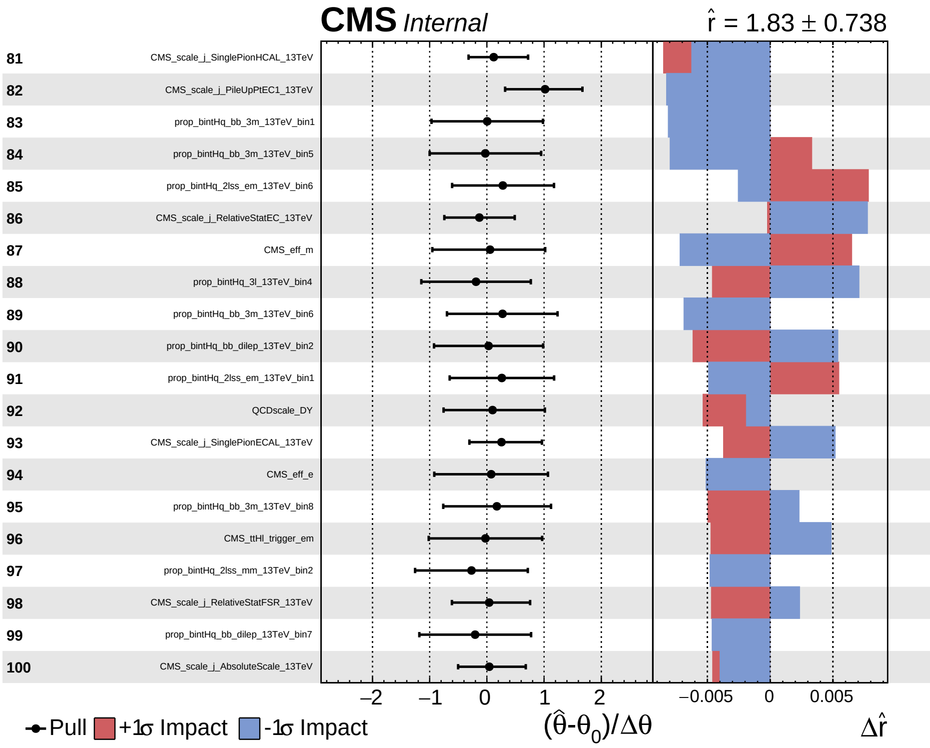

Figure 22: Pull and impact plots for all nuisances.

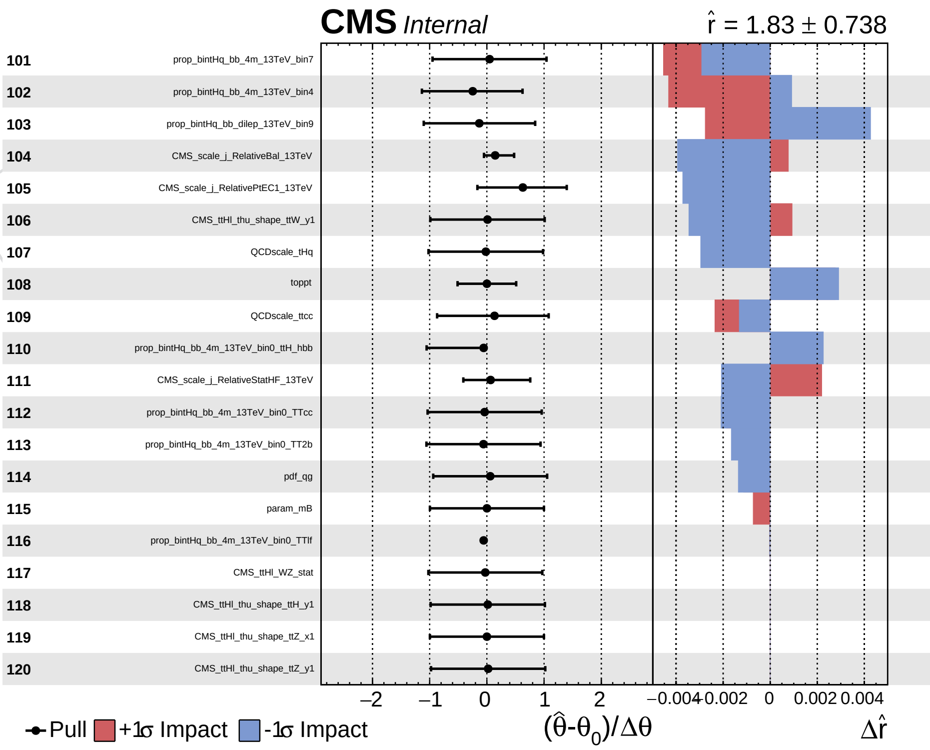

Figure 23: Pull and impact plots for all nuisances.

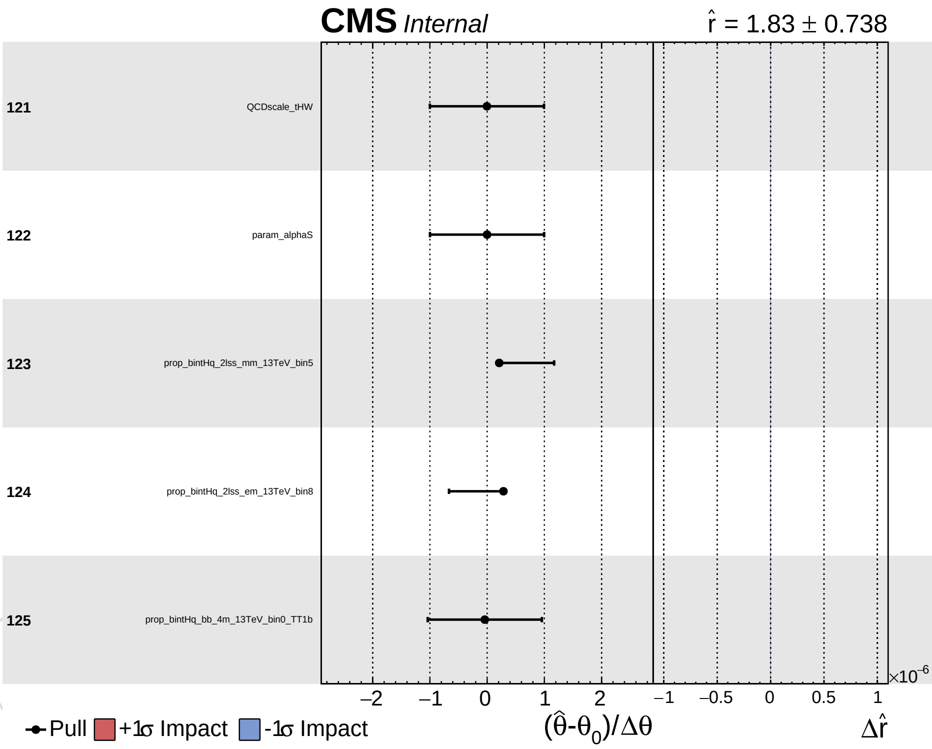

Figure 24: Pull and impact plots for all nuisances.

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