Sandra Kortner on behalf of the ATLAS Collaboration







Effective Field Theory interpretations of Higgs boson measurements by the ATLAS experiment









Introduction

Without any direct evidence of new physics beyond the SM so far, the SM may be viewed as a low-energy approximation to a more fundamental theory.

Linearly realized SM Effective Field Theory (SMEFT):

$$\mathscr{L} = \mathscr{L}_{SM} + \sum_{i} \frac{C_{i}^{(d)}}{\Lambda^{d-4}} \mathcal{O}_{i}^{(d)}$$

dimension-6 terms dominate.

Deviations from the SM: higher-dimension operators $\mathcal{O}_{i}^{(d)}$, suppressed by powers of Λ . Wilson coefficients $C_i^{(d)}$ are free parameters, correlated to each other

 Non-linearly realized Higgs Effective Field Theory (HEFT): More general (encompassing SMEFT): Higgs and EW Goldstone bosons are treated independently. Free parameters of the theory are not correlated.

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HEFT interpretation of Higgs boson pair searches



- Upper limits at 95% CL on $gg \rightarrow HH$ production cross section for seven HEFT benchmark scenarios (with different m_{HH} spectra): 50.4 fb (46.0 fb expected) to 135.1 fb (135.1 expected).
- Allowed range for $C_{hhh} (\equiv \kappa_{\lambda})$ from ATLAS-CONF-2021-052 (-1.0, 6.6) observed, (-1.2, 7.2) expected.
- Constraints on HEFT coupling parameters c_{gghh} and c_{tthh}:

Simultaneous constraints needed for more model-independence.



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Interpreting searches for the Higgs pair production in $bb\tau\tau$ and $bb\gamma\gamma$ final states, and their combination.







SMEFT interpretations of single-Higgs measurements





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Wilson coefficient	Operator	Wilson coefficient	Operator
$\mathcal{C}_{H\square}$	$(H^{\dagger}H)\Box(H^{\dagger}H)$	c_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \widetilde{H} G_p$
C _{HDD}	$\left(H^{\dagger}D^{\mu}H ight)^{*}\left(H^{\dagger}D_{\mu}H ight)$	c_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \widetilde{H} W_p$
c_{HG}	$H^{\dagger}HG^{A}_{\mu u}G^{A\mu u}$	C_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \widetilde{H} B_{\mu\nu}$
C_{HB}	$H^{\dagger}H\dot{B}_{\mu u}B^{\mu u}$	c'_{ll}	$(\bar{l}_p \gamma_\mu l_t) (\bar{l}_r \gamma^\mu l_s)$
c_{HW}	$H^{\dagger}H W^{I}_{\mu u}W^{I\mu u}$	$C_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_t) (\bar{q}_r \gamma^\mu q_s)$
C_{HWB}	$H^{\dagger} au^{I} H^{I} W^{I}_{\mu u} B^{\mu u}$	$c_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r) (\bar{q}_s \gamma^\mu \tau^I$
C_{eH}	$(H^{\dagger}H)(\bar{l}_{p}e_{r}H)$	c_{qq}	$(\bar{q}_p \gamma_\mu q_t) (\bar{q}_r \gamma^\mu q_s)$
C_{uH}	$(H^{\dagger}H)(\bar{q}_{p}u_{r}\widetilde{H})$	$c_{qq}^{(31)}$	$(\bar{q}_p \gamma_\mu \tau^I q_t) (\bar{q}_r \gamma^\mu \tau^I$
C_{dH}	$(H^{\dagger}H)(\bar{q}_p d_r \widetilde{H})$	C _{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$
$c_{Hl}^{\scriptscriptstyle (1)}$	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}H)(\bar{l}_{p}\gamma^{\mu}l_{r})$	$c_{uu}^{(1)}$	$(\bar{u}_p \gamma_\mu u_t) (\bar{u}_r \gamma^\mu u_s)$
$c_{Hl}^{\scriptscriptstyle{(3)}}$	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}^{I}H)(\bar{l}_{p}\tau^{I}\gamma^{\mu}l_{r})$	$c^{(1)}_{oldsymbol{q}oldsymbol{u}}$	$(\bar{q}_p \gamma_\mu q_t) (\bar{u}_r \gamma^\mu u_s)$
c_{He}	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}H)(\bar{e}_{p}\gamma^{\mu}e_{r})$	$c_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r) (\bar{d}_s \gamma^\mu T^A u_r)$
$c_{Hq}^{\scriptscriptstyle (1)}$	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}H)(\bar{q}_{p}\gamma^{\mu}q_{r})$	$c_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r) (\bar{u}_s \gamma^\mu T^A q_r)$
$c_{Hq}^{\scriptscriptstyle (3)}$	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}^{I}H)(\bar{q}_{p}\tau^{I}\gamma^{\mu}q_{r})$	$c_{qd}^{\scriptscriptstyle (8)}$	$(\bar{q}_p \gamma_\mu T^A q_r) (\bar{d}_s \gamma^\mu T^A q_r)$
C_{Hu}	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}H)(\bar{u}_{p}\gamma^{\mu}u_{r})$	c_W	$\epsilon^{IJK} W^{I u}_{\mu} W^{J ho}_{ u} W^{K}_{ ho}$
c_{Hd}	$(H^{\dagger}i\overleftrightarrow{D}_{\mu}H)(\bar{d}_{p}\gamma^{\mu}d_{r})$	c_G	$f^{ABC}G^{A\nu}_{\mu}G^{B\rho}_{\nu}G^{C}_{\rho}$

Assuming $U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_l \times U(3)_e$ flavour symmetry.





$H \rightarrow \gamma \gamma$ differential and fiducial cross sections in SMEFT

assuming there is no BSM impact on higher-order corrections.



arXiv:2202.00487





$H \rightarrow \gamma \gamma$ differential and fiducial cross sections in SMEFT

Using state-of-the-art SM predictions, assuming there is no BSM impact on higher-order corrections.



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arXiv:2202.00487









 Simplified Template Cross Sections **(STXS)**:

Differential measurements with a coarser binning in p_T^H , N_{jets} and m_{jj} , but with additional information from different production vertices.

 Considering 34 Wilson coefficients with a visible impact.



arXiv:2207.00348

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- Parameters affecting the high-pT bins (e.g. c_G , $c_{H_q}^{(1)}$ etc.) constrained predominantly by the quadratic terms, indicating non-negligible contributions from higher-order terms in the SMEFT expansion.
- Simultaneous fit of 12 mutually orthogonal linear combinations of Wilson coefficients also performed.

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• 1D fits are a good measure of sensitivity, but don't account for possible correlations between the Wilson coefficients.





 \triangleleft

∆(o×B)(c_i)/SM

-0.5

0.5

-0.5 F

O.jet

			ATLAS √s = 13 T€
Decay channel	Targeted prod. modes	Ref.	0.8
$H o \gamma \gamma$	ggF, VBF, WH, ZH, ttH,tH	[1]	0.0 0.4 0.2 ₹ 1
$H \to ZZ^* \to 4\ell$	ggF, VBF, WH+ZH, ttH+tH	[2]	S/(c)/(c)/(c)/(c)/(c)/(c)/(c)/(c)/(c)/(c)
$H \to WW^* \to \ell \nu \ell \nu$	ggF, VBF	[<u>3]</u>	
$H \rightarrow bb$	VBF, WH, ZH, <mark>ttH+tH</mark>	[4],[5],[6],[7]	
$H \to \tau \tau$	ggF, VBF, WH, ZH, ttH+tH	[8]	$ \begin{array}{c} \overline{(S)} \\ (\overline{(S)}) \\ (\overline{(R)}) \\ ((R$
Update of the previous co	mbination using $\gamma\gamma$, 4 ℓ and V	H(bb) inputs.	$\begin{array}{c} \overset{\circ}{\triangleleft} \\ \overrightarrow{\neg} \end{array} = \begin{array}{c} \phantom$
₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩	ĸĸſĊĸſŢŴĬĊĊġſĸĨĸĬĬĬĬĬŢĸġĊĸſĊĸĬĊĊġŔĸĬĬĬĬĬĬŢŢĸġĊĸĬĬĬĬĬĬŢŢĸġĊĸſĬŎĸŔĊĸĬŢŢġĊĸĬĊĬĬĬĬĬĬĬŢŢŢĊĸſŎĸĬŔĊĸĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬ	<u> </u>	$-0.5 \begin{bmatrix} -0.5 \\ C_{Hl}^{(1)} \end{bmatrix}$
			$C_{Hl}^{(3)} = 0.5$

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–0.5 🗗

0.5

-0.5

-0.5

Δ(σ×B)(c_i)/SM

∆(م×B)(c_i)/SM

Decay channel	Targeted prod. modes	Ref.	ATL √s=
$H o \gamma \gamma$	ggF, VBF, WH, ZH, ttH,tH	[1]	0.0 0.4 0.2 ≥ 1
$H \to ZZ^* \to 4\ell$	ggF, VBF, WH+ZH, ttH+tH	[2]	S/(c)/
$H \to WW^* \to \ell \nu \ell \nu$	ggF, VBF	<u>[3]</u>	
$H \rightarrow bb$	VBF, WH, ZH, <mark>ttH+tH</mark>	[4],[5],[6],[7]	
$H \to \tau \tau$	ggF, VBF, WH, ZH, ttH+tH	[8]	US/(')(g) 0.5
Update of the previous co	mbination using $\gamma\gamma$, 4 ℓ and V	VH(bb) inputs.	$\stackrel{(b)}{\nabla} 0 \stackrel{[c]}{\Box} \stackrel{(c)}{\Box}$

 Linear combinations of Wilson coefficients along sensitive directions of parameter space:
 eigenvectors from principal component analysis of the Fischer information matrix

$$C_{SMEFT}^{-1} = P^T \ C_{STXS}^{-1} \ P.$$

C⁻¹_{STXS} : STXS information matrix (Gaussian approx.)
 P : SMEFT parametrization matrix (linear-only)

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Global SMEFT fit of Higgs+EW+EWPO data

First global EFT interpretation in ATLAS: (using U(2)_q x U(2)_u x U(2)_d x U(3)_l x U(3)_e) flavour symmetry)

- **Higgs STXS measurements**
- **EW differential distributions:** <u>WW</u> $(p_T^{\ell'}), \underline{WZ} (m_{WZ}), \underline{4} (m_{Z2})$ and <u>VBF Z</u> $(\Delta \phi_{ij})$
- **LEP/SLD EWPO:** $\Gamma_{Z}, R^{0}_{\ell}, R^{0}_{c}, R^{0}_{b}, A^{0,\ell}_{FB}, A^{0,c}_{FB}, A^{0,b}_{FB}, \sigma^{0}_{had}$

Constraining 6 individual and 22 linear combinations of Wilson coeff.

Five tightest constraints come mainly from a single observable: $gg \to H, \sigma_{had}^0, H \to \gamma\gamma, \Gamma_Z, A_{FB}$. Several constraints driven both by ATLAS and LEP/SLD.

Simplified likelihood model available for re-interpretations, provides results that are very similar to the full model.

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For more details, see the talk by U. Blumenschein (Top and EW parallel session)

Summary

 significantly increased number of sensitive directions straightforward implementation into a more global EFT fit

First global ATLAS EFT interpretation of Higgs, EW and EWPO data now available, providing also the corresponding simplified likelihood model.

addition of additional measurements to the combination, etc.

All results consistent with the SM predictions so far.

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Increasing number of Higgs measurements interpreted in terms of Effective Field Theories.

- Combined interpretation of simplified template cross section measurements well advanced.
- Still a lot to do (on a global scale): treatment of truncation and higher-order uncertainties,





Backup Slides

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Effective Field Theory: Motivation

Without any direct evidence of new physics beyond the SM so far, the SM can be viewed as a low-energy approximation to a more fundamental theory.

• Linearly realized SM Effective Field Theory (SMEFT):

Assumes that the Higgs particle is part of a Higgs doublet.

$$\mathscr{L} = \mathscr{L}_{SM} + \sum_{i} \frac{C_{i}^{(d)}}{\Lambda^{d-4}} \mathcal{O}_{i}^{(d)}$$

Assuming first-order deviations come in general from dimension-6 terms.

Deviations from the SM: higher-dimension operators $\mathcal{O}_{i}^{(d)}$, suppressed by powers of Λ (mass scale of new physics). Wilson coefficients $C_i^{(d)}$ are free parameters of the theory, correlated to each other.

 Non-linearly realized Higgs Effective Field Theory (HEFT): More general framework, encompassing SMEFT. Free parameters of the theory are not correlated.

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Higgs and EW Goldstone bosons are treated independently, Higgs is assigned to a singlet representation.

HEFT interpretation of Higgs pair search



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$H \rightarrow \gamma \gamma$ differential and fiducial cross sections in SMEFT

ATLAS

Observed statistical correlations, evaluated with bootstrapping technique, between $p_T^{\gamma\gamma}, N_{jets}, m_{jj}, \Delta \Phi_{jj}, p_T^{j1}$.

																																		-
p ^{γγ} [GeV]:0-5	100 -2	5 4	0	0	-1	1	-1	0	-1	0	0	0	-1	0	0	0	0	-1	22	-2	0	-1	-2	-1	-2	0	-3	-2	-1	-2	-1	0	0	11
p _τ ^{γγ} [GeV]:5-10	-25 10	0 –2	2 3	-1	0	1	0	-1	0	1	0	0	0	0	0	0	-1	1	29	-2	1	1	-1	-1	-1	0	-2	-1	0	-2	1	1	0	
p _τ ^{γγ} [GeV]:10-15	4 -2	2 10	0 –22	2 3	0	0	0	-1	1	0	0	0	0	2	0	-1	0	1	29	-1	2	-1	I –2	0	-1	0	-1	-2	1	0	0	0	1	
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p _∓ ^{י∕γ} [GeV]:20-25	0 -	1 3	-23	3 100) –22	3	-1	0	0	1	1	0	0	1	1	0	1	0	22	2	2	2	11	2	-1	12	-1	-1	2	13	1	1	1	
p _∓ ^{†γ} [GeV]:25-30	<u> </u>	0	4	-22	2 100	-24	3	0	-1	0	0	0	-1	0	-2	0	0	0	18	5	2	1	1	2	0	3	0	-2	3	8	0	1	0	
p ₇ ^{∤γ} [GeV]:30-35	1 1	0	0	3	-24	100	-17	1	2	0	0	0	0	0	0	0	0	1	14	8	2	1	i 1	4	0	I 3	-1	0	3	10	1	1	0	 a
p ^{†γ} [GeV]:35-45	<u> </u>	0	0	-1	3	-17	100	-10	0	0	1	0	0	0	0	1	1	0	13	17	3	4	3	6	0	6	1	0	5	19	1	2	2	0
p ^{∲γ} [GeV]:45-60	0 -	1 -	1 1	0	0	1	-10	100	-6	0	1	0	-1	0	1	-1	0	0	6	25	6	5	6	10	3	8	2	2	9	26	7	4	2	
p ^{∤γ} [GeV]:60-80	-1 0	1	0	0	-1	2	0	-6	100	-6	0	1	-1	1	-1	0	0	0	1	23	9	6	10	12	4	10	6	7	9	17	18	5	5	Ι.
p ^{γγ} [GeV]:80-100	0 1	0	–1	1	0	0	0	0	-6	100	-7	0	0	0	0	1	0	1	-1	15	10	8	9	12	5	9	8	8	8	6	17	12	9	 4
p_γ ^{γγ} [GeV]:100-120	0 0	0	0	1	0	0	1	1	0	-7	100	-8	1	0	0	0	0	0	0	9	9	10	8	13	5	18	8	10	7	2	8	14	13	
p ^{†γ} _− [GeV]:120-140	0 0	0	0	0	0	0	0	0	1	0	-8	100	-8	0	-1	0	1	0	-1	5	8	6	7	8	5	5	9	8	4	0	4	11	16	
p_ ^{/γ} [GeV]:140-170	-1 0	0	–1	0	-1	0	0	-1	-1	0	1	-8	100	-6	0	-1	0	0	I_2	5	4	10	I 5	9	6	I 4	9	9	4	0	3	6	22	 2
p ^{†γ} ₋ [GeV]:170-200	0 0	2	. 0	1	0	0	0	0	1	0	0	0	-6	100	-5	1	0	2	0	2	4	8	4	6	6	2	8	7	4	0	2	2	20	2
p ^{1/γ} [GeV]:200-250	0 0	0	0	1	-2	0	0	1	-1	0	0	-1	0	5	100	-4	0	-1	0	1	4	6	I 2	6	7	I 3	7	7	2	-1	1	-2	23	
p ¹ / ₇ [GeV]:250-300	0 0	_	1 0	0	0	0	1	-1	0	1	0	0	-1	1	-4	100	-4	0	0	-1	3	7	3	5	3	3	5	5	2	-1	0	-1	14	
p_{-}^{\dot{\gamma}\gamma}[GeV]:300-450	0 -	1 0	0	1	0	0	1	0	0	0	0	1	0	0	0	-4	100	-2	11	0	1	7	11	4	5	12	7	3	1	0	0	-1	10	 10
p_ ¹ / ₇ [GeV]:450-650	-1 1	1	1	0	0	1	0	0	0	1	0	0	0	2	-1	0	-2	100	1	0	1	3	1	2	4	3	2	3	0	0	0	1	1	
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m"[GeV]:0-120	-2 -	i -2	2 0	- 1	- 1	- -	3	6	10	-9-	8	7	5	4	2	3	1	1	-8	-10	47	6	100	-16	-2	19	33	33	18	22	10	1	0	
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m _{ii} [GeV]:450-3000	-2 -	1 -	1 –1	-1	0	0	0	3	4	5	5	5	6	6	7	3	5	4	-6	-5	16	17	2	-11	100	17	10	7	16	4	2	3	20	
″ _∆φ _{ii} : (-π,-π/2)	0 0	₀	2	2	- 3	3	6	8	10	9	8	5	4	2	3	3	2	3		-8	39	20	19	43	17	100	-5	-5	-8	10	12	10	21	
∆φ ["] : (-π/2,0)	-3 -2	2 –	1 –2	-1	0	-1	1	2	6	8	8	9	9	8	7	5	7	2	-6	-8	27	11	33	11	10	-5	100	-4	-5	9	7	4	6	 -
∆φ _" : (0,π/2)	-2 -	1 -2	2 –2	-1	-2	0	0	2	7	8	10	8	9	7	7	5	3	3	I_6	-7	26	10	I 33	12	7	I_5	-4	100	-6	9	7	4	5	
∆φ _" : (π/2,π)	-1 0	1	1	2	3	3	5	9	9	8	7	4	4	4	2	2	1	0	-5	-7	40	18	18	44	16	-8	-5	-6	100	12	11	10	19	
p ^{j1} [Ge ^V]:30-60	-2 -2	2 0	3	- 3	8	10	19	26	17	6	2	0	0	ō	-1	-1	0	_0_	-30	69	6	1	22	7	4	10	-9	9	12	100	-31	8	-2	 _
p ^H [GeV]:60-90	-1 1	0	0	1	0	1	1	7	18	17	8	4	3	2	1	0	0	0	1	7	13	9	10	17	2	12	7	7	11	-31	100	-37	7	
p ^{j1} [GeV]:90-120	0 1	0	1	1	1	1	2	4	5	12	14	11	6	2	-2	-1	-1	1	i_1	7	9	9	11	18	3	10	4	4	10	8	-37	100 -	-27	
p ^{j1} [GeV]:120-350	0 0	1	0	1	0	0	2	2	5	9	13	16	22	20	23	14	10	1	_1	4	12	25	0	28	20	21	6	5	19	-2	7	-27 1	00	
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$H \rightarrow \gamma \gamma, \sqrt{s} = 13 \text{TeV}, 139 \text{ fb}^{-1}$





$H \rightarrow \gamma \gamma$ differential and fiducial cross sections in SMEFT

2D constraints on Wilson coefficients:



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ATLAS \sqrt{s} =13 TeV 139fb⁻¹; H $\rightarrow \gamma\gamma$

EV12	-0.00	-0.01	-0.15	0.01	-0.20	-0.36	-0.00	0.02	-0.01	-0.13	-0.16	-0.06	0.00	-0.00	0.37	-0.30	0.69	0.10	0.14	0.14	0.00	-0.02	-0.05	-0.01	0.00	-0.02	0.00	0.00	-0.01	-0.00	-0.00	0.00	0.00	λ =0.0067
EV11	0.00	-0.01	0.04	0.01	-0.03	-0.05	-0.00	-0.02	0.00	-0.10	0.03	-0.00	0.00	0.00	0.06	-0.05	0.11	0.01	0.02	-0.95	-0.00	0.15	0.05	0.11	-0.01	0.13	-0.01	-0.01	0.09	-0.00	0.00	-0.00	0.00	λ =0.0108
EV10	-0.00	-0.00	0.06	0.02	-0.09	-0.13	-0.00	0.37	-0.00	0.05	-0.02	-0.00	0.00	-0.00	0.01	0.02	-0.14	0.02	0.03	-0.05	0.00	0.04	-0.89	0.06	0.00	0.03	0.00	-0.00	0.02	0.00	0.00	0.00	0.00	λ =0.027
EV9	-0.00	0.01	0.03	0.09	-0.38	-0.65	-0.00	-0.08	-0.01	-0.17	0.03	-0.08	0.00	-0.02	0.13	0.04	-0.56	0.09	0.12	0.02	-0.00	-0.01	0.18	-0.02	-0.00	-0.01	-0.00	-0.00	-0.01	-0.00	-0.00	-0.00	0.00	λ =0.038
EV8	-0.00	0.27	0.38	0.02	0.06	0.10	0.00	0.02	0.00	-0.78	0.37	0.07	-0.00	0.01	-0.04	0.00	0.09	0.00	0.00	0.09	-0.00	-0.03	-0.06	-0.04	0.00	-0.03	0.00	0.00	-0.02	-0.00	-0.00	-0.00	-0.00	λ =0.075
EV7	-0.00	0.03	0.03	0.09	0.15	0.32	0.00	0.00	0.00	0.02	0.01	0.05	0.00	-0.10	0.83	-0.25	-0.31	-0.04	-0.05	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	λ =0.89
EV6	0.01	-0.24	0.01	-0.90	0.21	-0.14	0.01	0.01	0.01	-0.11	0.01	0.01	-0.00	0.15	0.10	-0.03	-0.08	0.00	0.01	0.03	0.00	0.05	0.00	0.08	0.00	0.05	0.00	0.00	0.03	0.00	-0.00	-0.00	-0.00	λ =1.78
EV5	-0.02	0.64	-0.09	-0.24	0.04	-0.06	0.00	0.00	0.00	0.15	-0.09	-0.01	-0.00	0.05	0.02	-0.01	-0.02	0.00	0.00	-0.19	-0.02	-0.28	-0.04	-0.52	-0.01	-0.27	-0.03	-0.01	-0.16	-0.03	0.00	-0.00	-0.00	λ =2.87
EV4	-0.01	0.68	-0.06	-0.08	0.01	-0.04	0.00	-0.01	-0.00	0.13	-0.07	-0.01	0.00	0.08	0.00	-0.00	-0.01	0.00	0.00	0.14	0.01	0.27	0.06	0.56	0.02	0.26	0.04	0.01	0.17	0.04	-0.00	-0.00	0.00	λ =20.2
EV3	-0.01	0.05	-0.01	-0.17	0.03	-0.04	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.00	-0.98	-0.07	0.02	0.03	0.00	0.00	0.01	0.00	0.01	0.00	0.03	0.00	0.01	0.00	0.00	0.01	0.00	-0.00	0.00	-0.00	λ =106
EV2	-0.85	-0.02	0.00	-0.14	-0.44	0.25	-0.01	-0.01	-0.02	-0.01	0.00	-0.00	0.00	0.01	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	λ =34473
EV1	-0.53	-0.02	0.00	0.23	0.71	-0.40	0.02	0.02	0.04	0.01	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	λ =34682
	С _{НG}	С _{иG}	с _{иН}	с _{нw}	С _{НВ}	с _{нwв}	cw	\mathbf{c}_{uW}	с _{иВ}	c ⁽³⁾	C,	c _{HDD}	C _{Hbox}	$c_{Hq}^{(3)}$	с _{ни}	с _{нd}	$c_{Hq}^{(1)}$	с _{Не}	$c_{\rm HI}^{(1)}$	c _G	c ⁽¹⁾	$c_{qq}^{(1)}$	$c_{qq}^{(3)}$	c ^{(3)'}	C _{uu}	C [,] uu	c ⁽⁸⁾	$c_{qu}^{(1)}$	$c_{qu}^{(8)}$	$c_{qd}^{(8)}$	$c_{ud}^{(1)}$	С _{еН}	с _{dн}	

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arXiv:2207.00348

)67 08

88

73 827



Non-zero values outside the diagonal: information matrix used in the Larger correlations observed due to the effect of the quadratic terms, which are not considered in the PCA. PCA is not an exact representation of the measurement.

Differences not considered in PCA:

non-Gaussian effects due to low event counts in some categories and the non-linear impact of some systematic uncertainties.

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EV1: broad shape in the expected linear+quadratic scan, partially due to the presence of two degenerate minima from the quadratic dependence.

Degeneracy partially lifted in the observed scans, since observed data don't exactly correspond to the SM expectation.

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$VH, H \rightarrow bb$ simplified template cross sections in SMEFT

- (setting the others to 0).

SM

BR w.r.t.

х b



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ATLAS-CONF-2021-051

$VH, H \rightarrow bb$ simplified template cross sections in SMEFT



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Examples of improvements achieved by including the measurements of high- p_T^V bins using the boosted topology.

Significant improvement achieved despite of the statistically limited measurement precision.





Decay channel	Targeted prod. modes	Ref.	[1]
$H o \gamma \gamma$	ggF, VBF, WH, ZH, ttH,tH	[1]	[2]
$H \to ZZ^* \to 4\ell$	ggF, VBF, WH+ZH, ttH+tH	[2]	
$H \to WW^* \to \ell \nu \ell \nu$	ggF, VBF	[3]	[3]
$H \rightarrow bb$	VBF, WH, ZH, ttH+tH	[4],[5],[6],[7]	[4]
H o au au	ggF, VBF, WH,ZH, ttH+tH	[8]	

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- ATLAS-CONF-2020-026
- Eur. Phys. J. C 80 (2020) 957
- ATLAS-CONF-2021-014
- Eur. Phys. J. C 81 (2021) 178
- [5] Phys. Lett. B 816 (2021) 136204
- [6] Eur. Phys. J. C. 81 (2021) 537
- [7] arXiv:2111.06712
- [8] ATLAS-CONF-2021-044









Previous result:

ATLAS-CONF-2020-053

ATLAS Preliminary $\sqrt{s} = 13$ TeV, 139 fb⁻¹ $m_H = 125.09 \text{ GeV}, |y_{\mu}| < 2.5$

$m{c}_{Hq}^{(3)}$	1	-0.74	0.28	0.75	-0.38	0.24	0.07	0.12	0.64	0.70		
С ^[1] _{НІ⁽¹⁾,Не}	-0.74	1	-0.19	-0.91	0.19	-0.05	0.05	0.00	-0.44	-0.95		0.0
$c_{HI^{(3)},II'}^{[1]}$	0.28	-0.19	1	0.25	-0.54	0.47	0.05	0.95	-0.40	0.44		0.6
$C_{Hd Ha^{(1)} Hu}^{[1]}$	0.75	-0.91	0.25	1	-0.24	0.12	0.06	0.09	0.30	0.90	_	0.4
$C_{HG}^{[1]}$	-0.38	0.19	-0.54	-0.24	1	-0.69	-0.20	-0.66	-0.09	-0.33	_	0.2
$\boldsymbol{c}^{[2]}_{\mu \rho \nu \rho $	0.24	-0.05	0.47	0.12	-0.69	1	0.19	0.58	0.00	0.18	_	0
АG,UG,UH,top С [3]	0.07	0.05	0.05	0.06	-0.20	0.19	1	0.11	0.09	-0.03	_	-0.2
\sim HG,uG,uH,top $C^{[1]}$	0.12	0.00	0.95	0.09	-0.66	0.58	0 11	1	_0 49	0.27	-	-0.4
\sim HW,HB,HWB,HDD,uB,uW $\sim^{[2]}$	0.12	0.44	0.40	0.20	0.00	0.00	0.00	0.40	4	0.21	_	-0.6
HW,HB,HWB,HDD,uB,uW [3]	0.04	-0.44	-0.40	0.30	-0.09	0.00	0.09	-0.49		0.21		-0.8
C _{HW,HB,} HWB,HDD,uB,uW	0.70	-0.95	0.44	0.90	-0.33	0.18	-0.03	0.27	0.21	1		-1
	$c_{Hq}^{(3)}$	1),He] (⁽³⁾ , II'	1),Hu	H,top	1,top	H, top	3,uW	3,uW	3,uW		
		C ^[1]	C C] d,Hq ⁽	uG,uł	uG,ul	uG,uł	DD, uE	DD, uE	DD, uE		
				C H H	[1] HG,	[2] HG,	[3] HG,	VB,HL	VB,HL	VB,HL		
					Ŭ	Ŭ	Ŭ	IB, HV	IB,HV	IB,HV		
								[1] HW,H	[2] HW,H	[3] HW, H		
								C)	Ċ	C C		

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New result: ATLAS-CONF-2021-053 **ATLAS** Preliminary $M_H = 125.09 \text{ GeV}, |y_H| < 2.5$ 0.12 <u>-0.09</u> -0.08 -0.14 -0.43 -0.03 -0.25 -0.66 0.28 -0.11 -0.02 -0.03 -0.30 -0.73 -0.05 0.02 -0.10 0.06 0.15 -0.52 -0.10 -0.09 C_{dH} 0.50 C_{eH} ' -0.39 -0.37 0.01 0.02 -0.20 0.17 0.05 0.02 0.16 0.09 -0.09 0.50 $C^{[1]}_{Hl^{(1)},He}$ 0.09 0.45 -0.43 0.69 0.30 -0.49 -0.20 -0.12 -0.03 –0.08 <mark>–0.30 –0.39</mark> $c^{[1]}_{_{HI^{^{(3)}},I}}$ -0.14 -0.73 -0.37 0.09 -0.31 0.10 -0.04 0.03 0.17 -0.11 **с**^[1] _{Нd,Нq⁽¹⁾,Ни} <u>-0.91 -0.24 -0.07</u> 0.03 <mark>-0.43</mark>-0.05 0.01 0.45 0.17 <mark>-0.72</mark> 0.62 0.74 <mark>-</mark> С^[2] На,На⁽¹⁾,Ни -0.03 0.02 0.02 <mark>-0.43 -0.11 -0.72</mark> 0.27 0.08 0.00 C^[1] HW,HB,HWB,HDD,uB,uW,W -0.25 -0.10 -0.20 0.69 -0.13 0.62 -0.52 0.59 -0.64 -0.19 -0.15 -0.03 C^[2] HW,HB,HWB,HDD,uB,uW,W 0.66 0.06 0.17 0.30 0.03 0.74 -0.44 0.59 <mark>-0.76 -0.12 -0.07</mark> 0.00 С^[3] _{HW,HB,HWB,HDD,uB,uW,W} 0.28 0.15 0.05 -0.49 -0.31 -0.91 0.80 0.24 0.14 0.02 0.64 -0.76 $c^{[1]}_{HG, uG, uH}$ 0.23 0.09 -0.11 -0.52 0.02 -0.20 0.10 -0.24 0.27 С^[2] НG,иG,иН <u>-0.15</u> -0.07 0.14 0.23 1 0.86 0.16 -0.12 -0.04 -0.07 0.08 0.02 0.09 0.86 -0.03 0.03 0.03 0.00 -0.03 0.00 $c_{HG,UG,UH}^{[1]}$ $c_{HG,UG,UH}^{[2]}$ $c_{HG,UG,UH}^{[1]}$ $c_{Hq}^{(3)}$ с_{dH} $c_{_{eH}}$ $c_{H_{l}^{(l)},H_{l}}^{[l]}$ С^[1] Нd,Нq^{(1,} С^[2] Нd,Нq⁽ $c_{HW,H}^{[1]}$ $c_{HW,H}^{[2]}$ $c_{HW,H}^{[3]}$



Global SMEFT fit of Higgs+EW+EWPO data



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					1	1	1								1	1	1		1											
-0.01																														
	0.95	-0.2	0.22	0.11																										
	0.27	0.89	-0.23	-0.2	-0.2	-0.1	-0.08	-0.03	-0.02 -0	0.02	0.01	0.01																		
														0.8	-0.45		0.02		0.01	-0.23	0.3	0.01	0.02	-0.02	-0.04	-0.06	0.01	-0.06		
															-0.01	0.84	-0.47	0.27		-0.01	0.01	-0.01								C
														0.29	-0.2	0.09	0.15	0.03		0.61	-0.55	0.35	-0.05	0.05	0.11	0.12	-0.02	0.12		
														0.23	0.51	0.24	0.47	0.08	0.59	0.11	0.21	-0.05	-0.01		0.01	0.03	0.02	0.03		C
														-0.02	-0.02	-0.06	-0.09	0.01	-0.03	0.56	0.24	-0.17	-0.03	0.03	0.05	-0.54	0.09	-0.54		
														-0.32	-0.24	0.17	0.32	0.04	0.01	-0.13	0.3	0.75		0.01		-0.14	0.04	-0.14		C
														-0.11	-0.13	-0.08	-0.08	0.09	-0.1	0.48	0.59	-0.04	0.09	-0.16	-0.15	0.39	-0.06	0.39		
														-0.01	-0.01			0.01	-0.03	0.03	0.07	-0.03	-0.02	0.94	-0.31	0.05		0.05	0.01	
														0.06	0.12	-0.06	-0.08	0.06	-0.14	-0.03	0.21	0.05	-0.18	0.26	0.88	0.1	0.12	0.1	-0.03	_
														-0.2	-0.4	0.03	0.43	0.65	-0.01	-0.06	-0.1	-0.41	-0.05	0.02	0.1	-0.01	-0.05	-0.01	-0.02	
														0.17	0.34	-0.38	-0.29	0.7	-0.01	-0.05	-0.02	0.33	0.06	-0.03	-0.15	-0.05	0.03	-0.05		_
														-0.01	-0.03	0.03	0.06	0.01	-0.05		-0.05	-0.05	0.34	-0.02	-0.05	0.06	0.93	0.06	0.05	C
														0.11	0.23	0.14	0.24	0.01	-0.47			-0.01	0.72	0.04	0.11	-0.05	-0.3	-0.05	0.1	
														-0.15	-0.29	-0.16	-0.28	-0.01	0.63		-0.05	0.02	0.55	0.11	0.23		-0.14		-0.02	C
c.0 ^{d⁽¹⁾-}	20 ³¹	20, e	20, e	d'i (due c		SUUT C	out a	Ude Cul	ک ۲	dan c	udth c.ddth	C dd	CHIL	CHe	CHB	HWB	CHIN C	.HDD	chi ^{l®} (C∥	CHd (;Hi th	CHU ~	HOM	CHIDO ~	103)	CHI	C
u∽ ci	u Ci	u Ci	U Ci	u V	- · · · ·	, -· ·	J · · · · ·	- · · · ·		U	·· 、		v -	-			<u>,</u> 、	· · · ·	. ·	- `	-			-	U	`	- ()	~		



