Hunting for new interactions of Higgs boson: Effective Field Theory results from the CMS experiment

Suman Chatterjee
for the CMS Collaboration

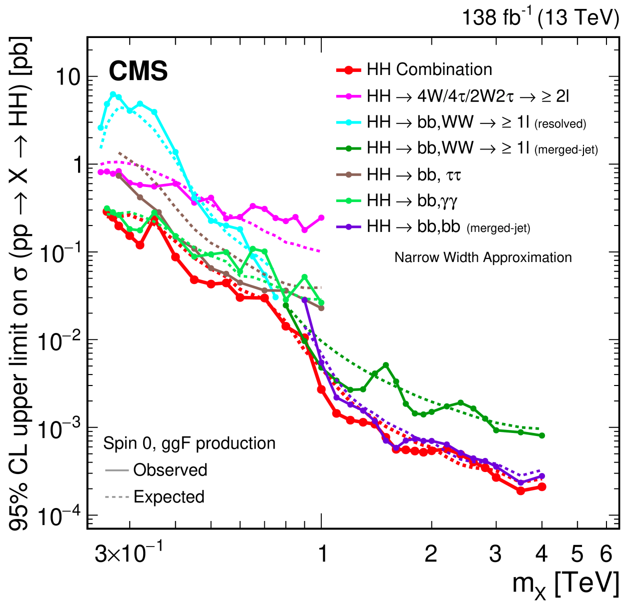
Deutsches Elektronen-Synchrotron (DESY)

Higgs Hunting **2025**

16/07/2025

Introduction

New probe for discovery of new physics



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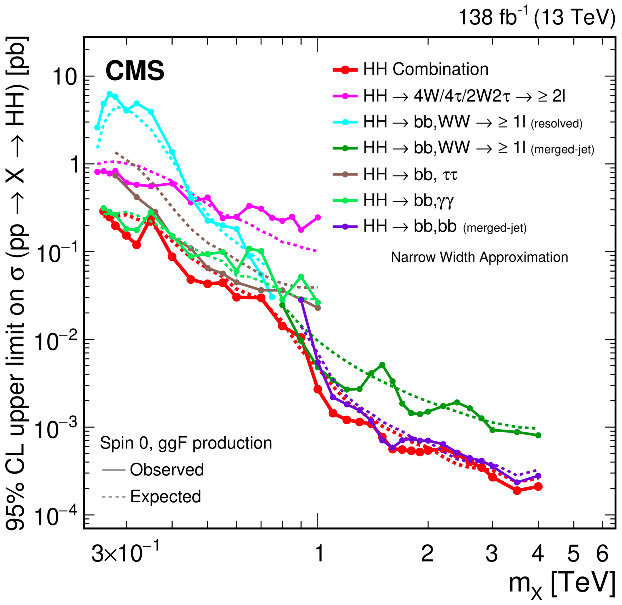

Hint for a separation of new physics scale & electroweak scale?

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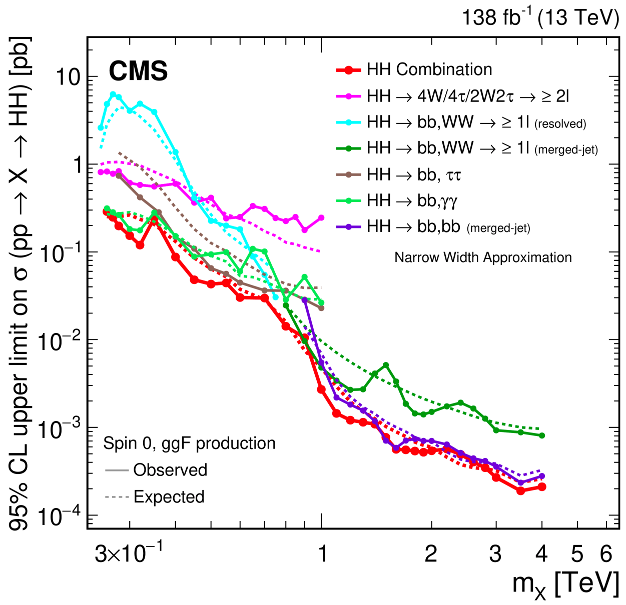
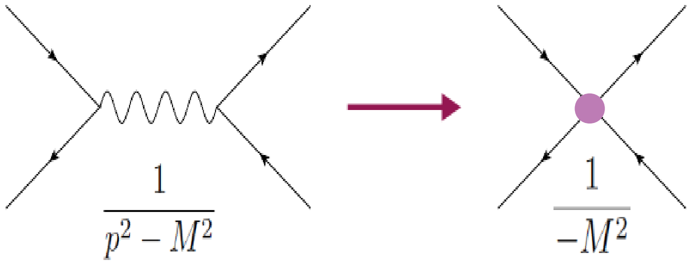
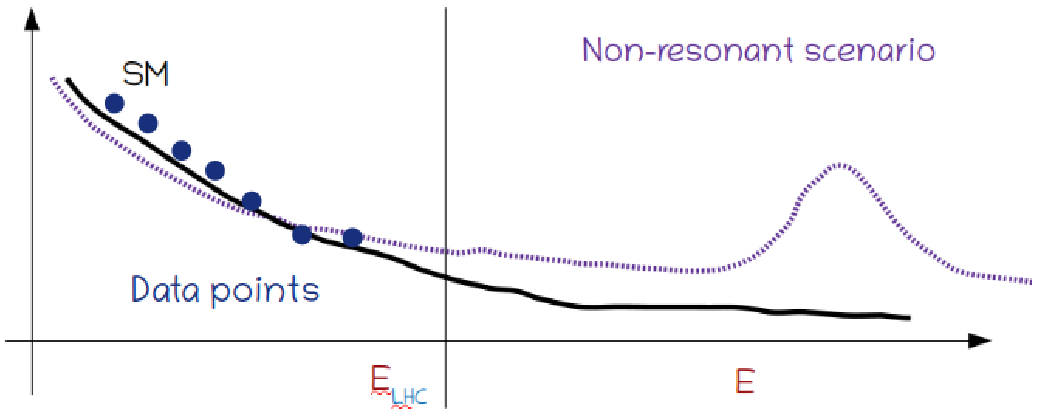




Discovery through precision measurements



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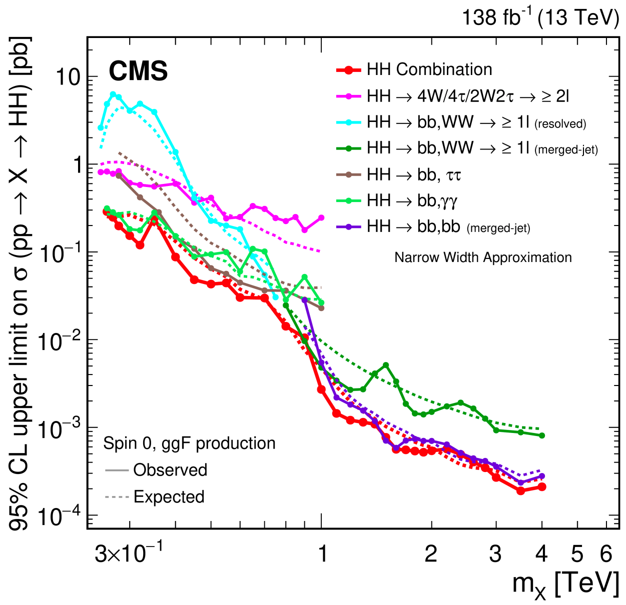

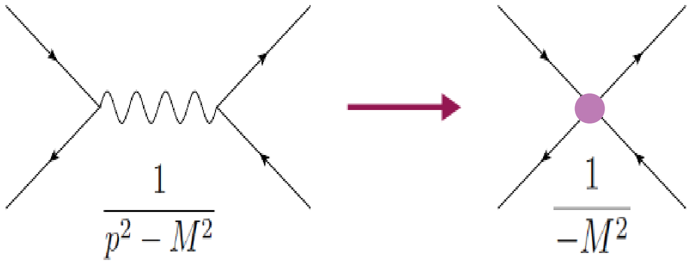

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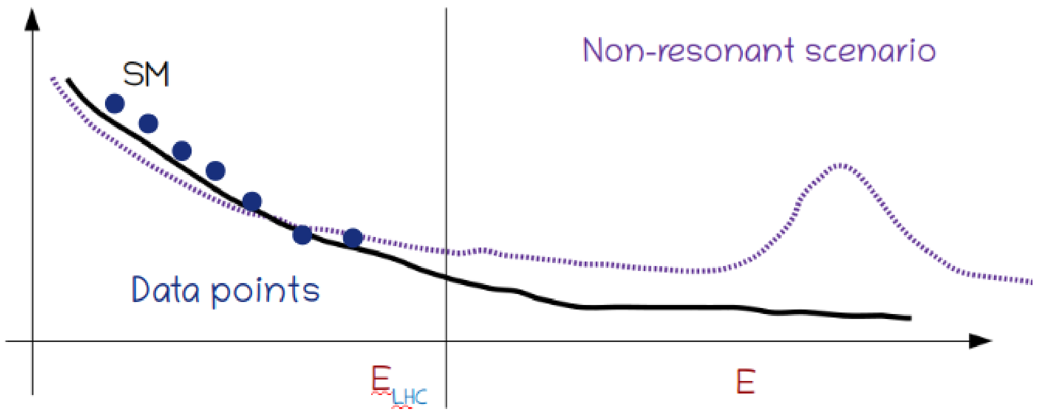

Hint for a separation of new physics scale & electroweak scale?

Deviations parameterized in terms of effective field theory (EFT) operators

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_i \frac{c_i^{(5)}}{\Lambda}\mathcal{O}_{5,i} + \sum_i \frac{c_i^{(6)}}{\Lambda^2}\mathcal{O}_{6,i} + \sum_i \frac{c_i^{(7)}}{\Lambda^3}\mathcal{O}_{7,i} + \sum_i \frac{c_i^{(8)}}{\Lambda^4}\mathcal{O}_{8,i} + \dots\,.$$

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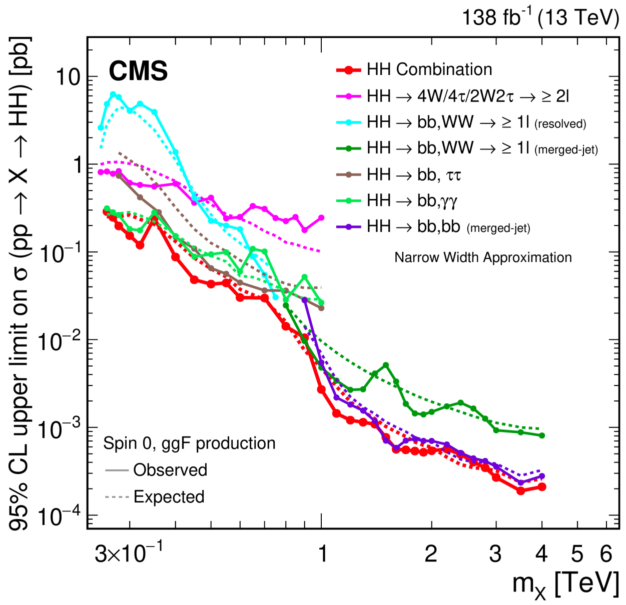

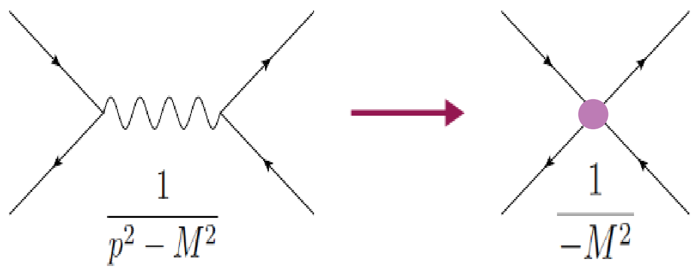

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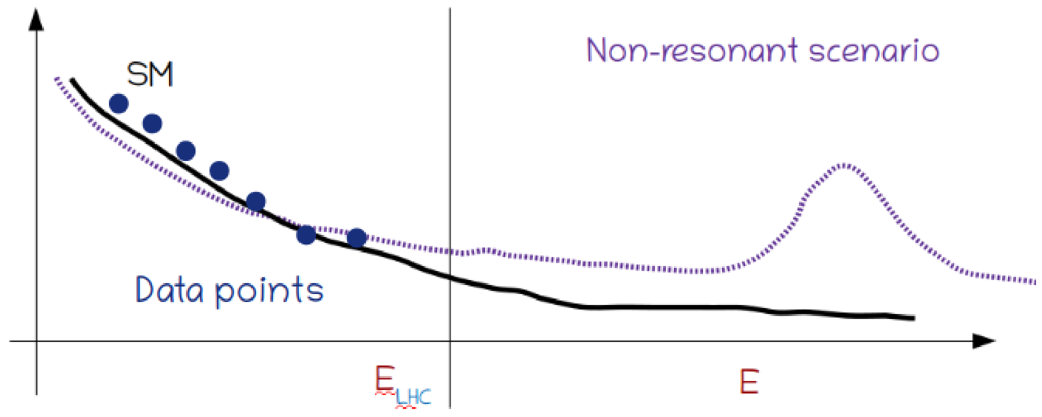

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Lepton number violation

59 (SM)EFT operators @ dimension=6

Lepton & Baryon number violation

Grzadkowski, Iskrzyński, Misiak, Rosiek (2010)

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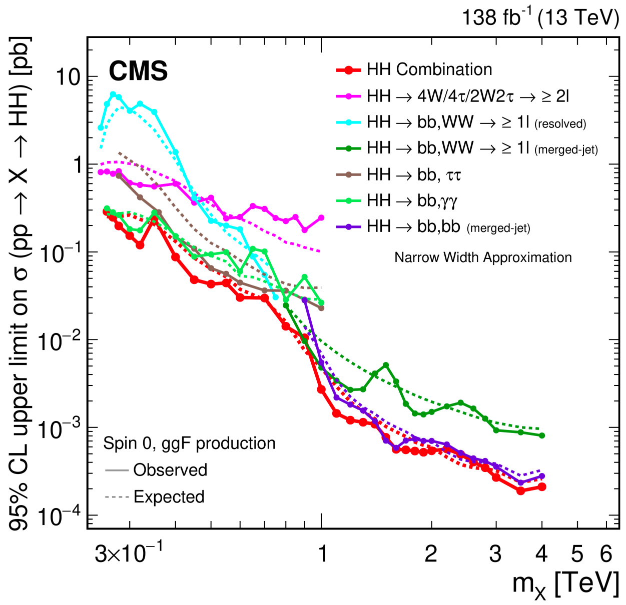

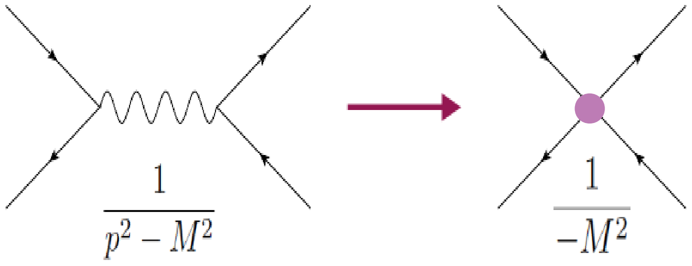

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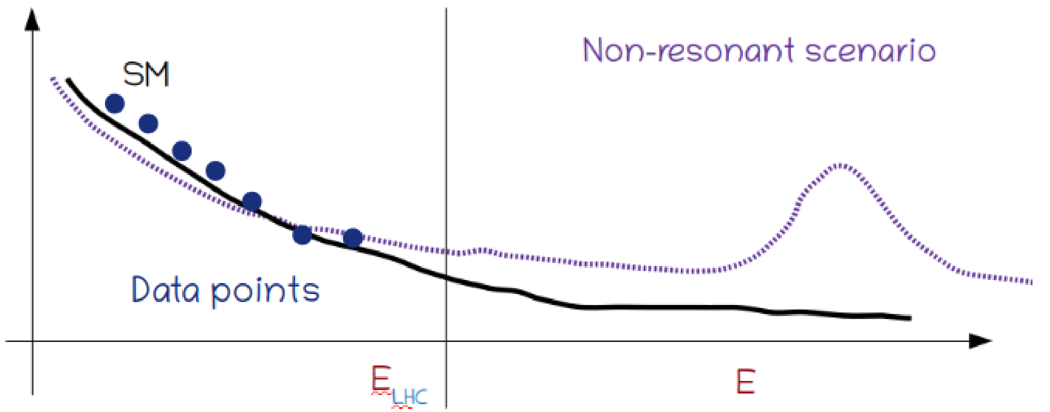

Hint for a separation of new physics scale & electroweak scale?

Deviations parameterized in terms of effective field theory (EFT) operators

Use measurements to probe size of EFT operator coefficients

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \cancel{\sum_i \frac{c_i^{(5)}}{\Lambda} \mathcal{O}_{5,i}} + \boxed{\sum_i \frac{c_i^{(6)}}{\Lambda^2} \mathcal{O}_{6,i}} + \cancel{\sum_i \frac{c_i^{(7)}}{\Lambda^3} \mathcal{O}_{7,i}} + \sum_i \frac{c_i^{(8)}}{\Lambda^4} \mathcal{O}_{8,i} + \dots .$$

$c \leftarrow$ Wilson coefficients (WCs)

Lepton number violation

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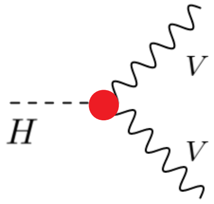
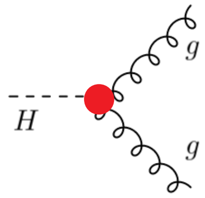
Anomalous gauge couplings of Higgs boson

Higgs coupling to Gauge bosons

$$\mathcal{A}(\mathrm{HVV}) \sim \left[\boxed{a_1^{\mathrm{VV}}} + \boxed{\frac{\kappa_1^{\mathrm{VV}} q_1^2 + \kappa_2^{\mathrm{VV}} q_2^2}{\left(\Lambda_1^{\mathrm{VV}}\right)^2}}\right] m_{\mathrm{V1}}^2 \epsilon_{\mathrm{V1}}^* \epsilon_{\mathrm{V2}}^* + \boxed{a_2^{\mathrm{VV}} f_{\mu\nu}^{*(1)} f^{*(2)\mu\nu}} + \boxed{a_3^{\mathrm{VV}} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2)\mu\nu}}$$

SM | Couplings due to High-scale new physics | New CP-even coupling/ loop-induced (for Hgg) | New CP-odd coupling



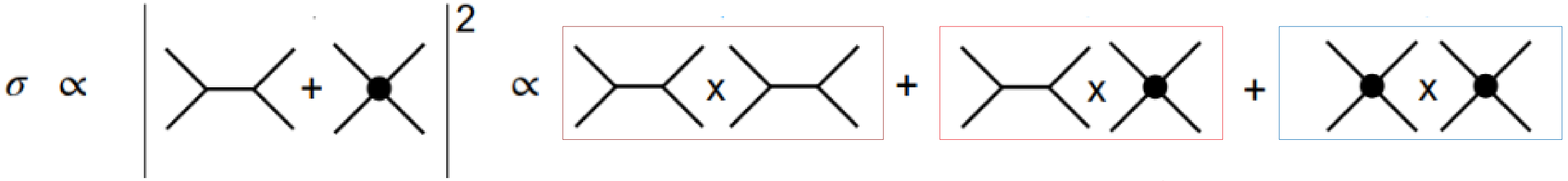


Constraints on anomalous couplings (ACs) → bounds on EFT operator coefficients

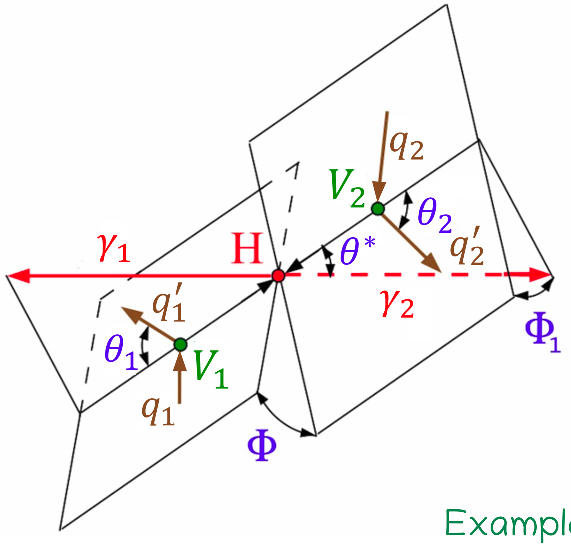
Also see talk by A. Krishna

Matrix element likelihood approach (MELA)

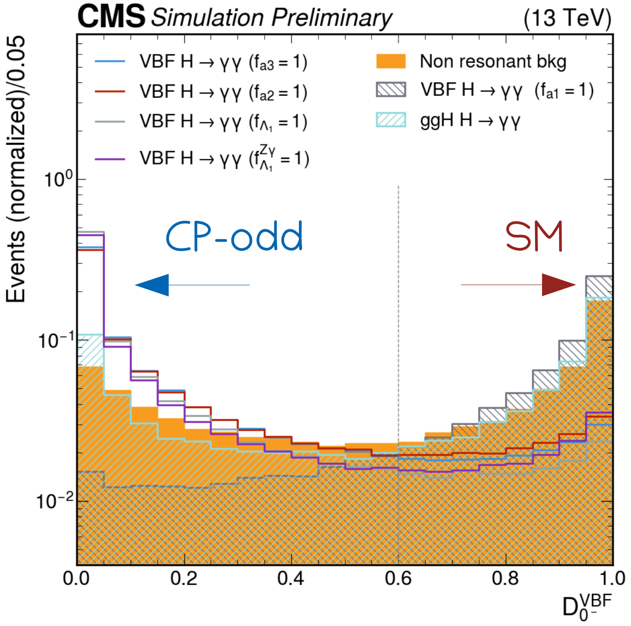
Construct discriminants sensitive to individual ACs



SM | SM-BSM interference | Pure BSM



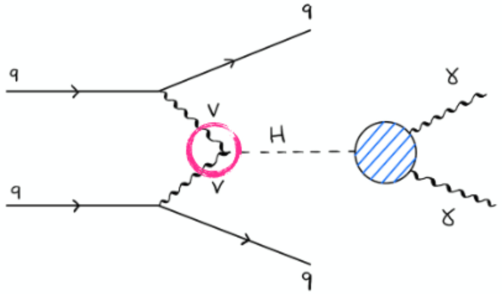
Example topology:
VBF H production + H→ γγ decay



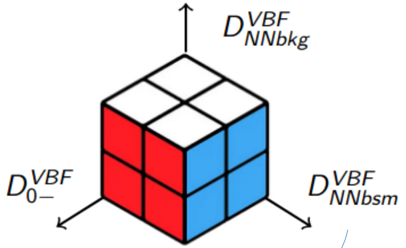
$$\mathcal{D}_{\mathrm{BSM}} = \frac{\mathcal{P}_{\mathrm{SM}}(\vec{\Omega})}{\mathcal{P}_{\mathrm{SM}}(\vec{\Omega}) + \mathcal{P}_{\mathrm{BSM}}(\vec{\Omega})}$$

Anomalous H-V couplings in H→ γγ final states

CMS-PAS-HIG-24-006

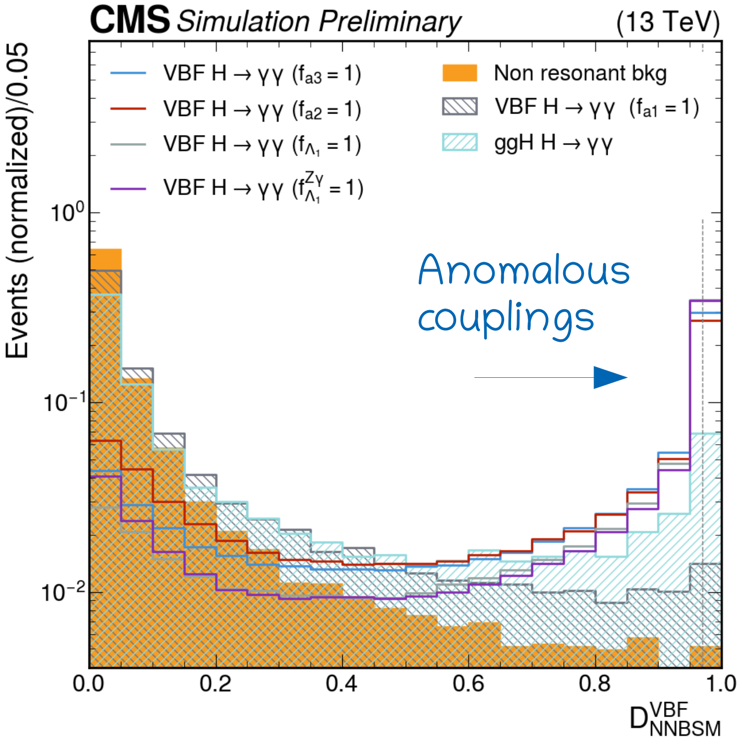


Categorization in 3D space



5 categories for analysis of H-V coupling

Similar 2D categorization for VH production



$$f_{ai} = \frac{|a_i|^2\sigma_i}{\sum_j |a_j|^2\sigma_j} sign(a_i/a_1)$$

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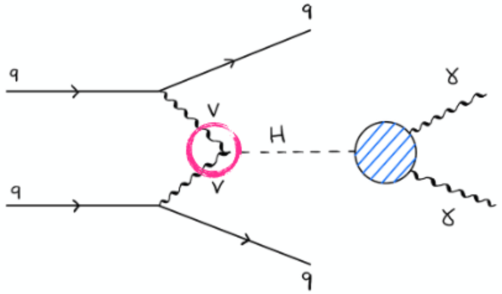

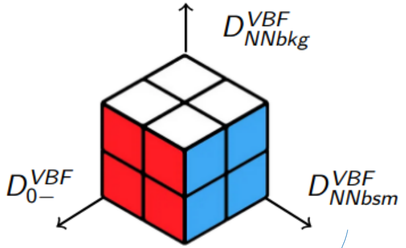

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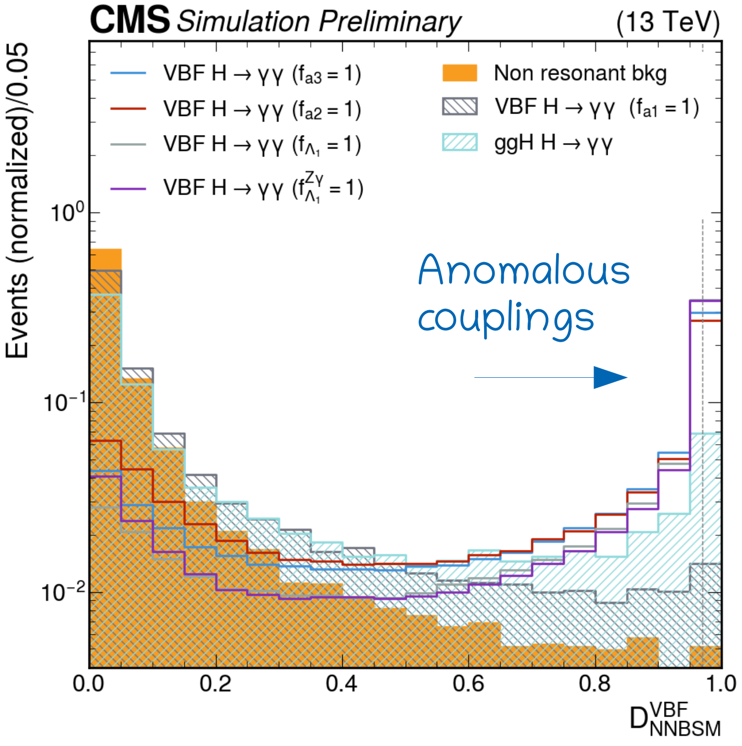

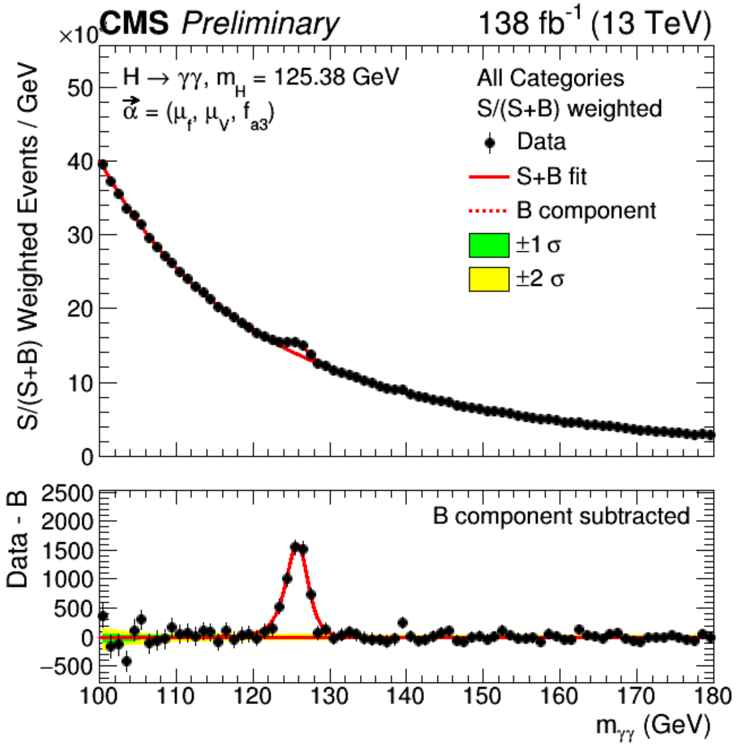

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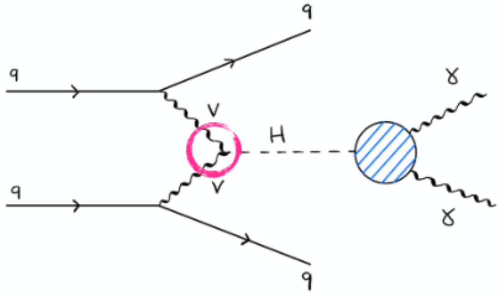

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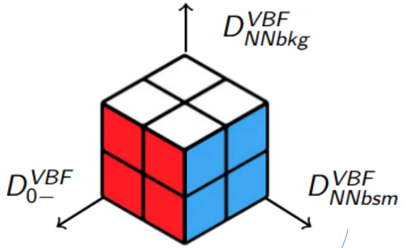

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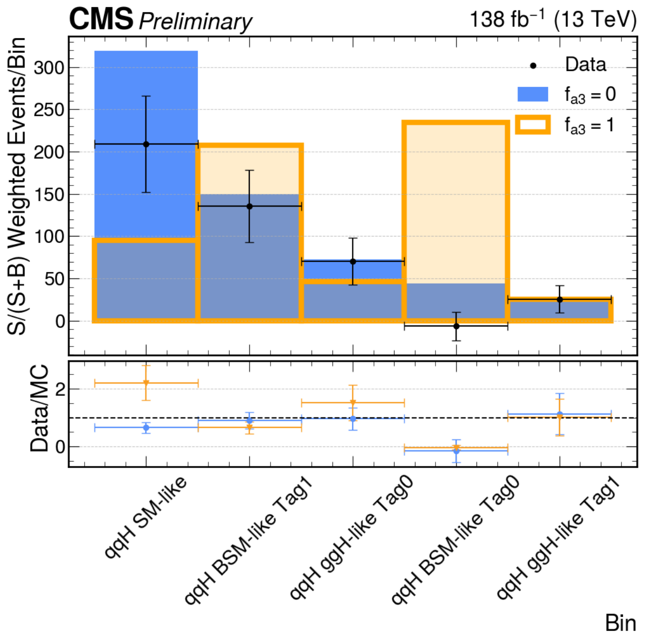

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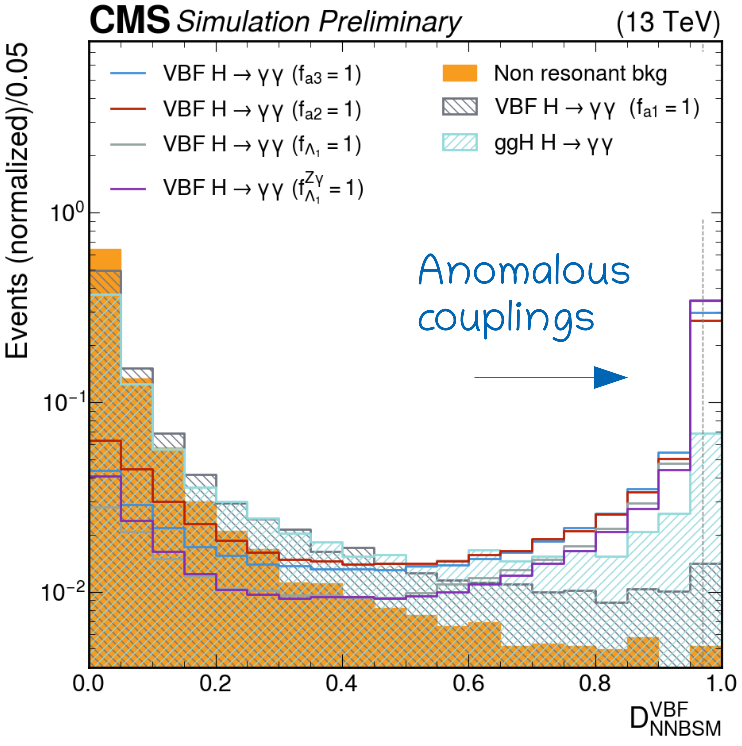

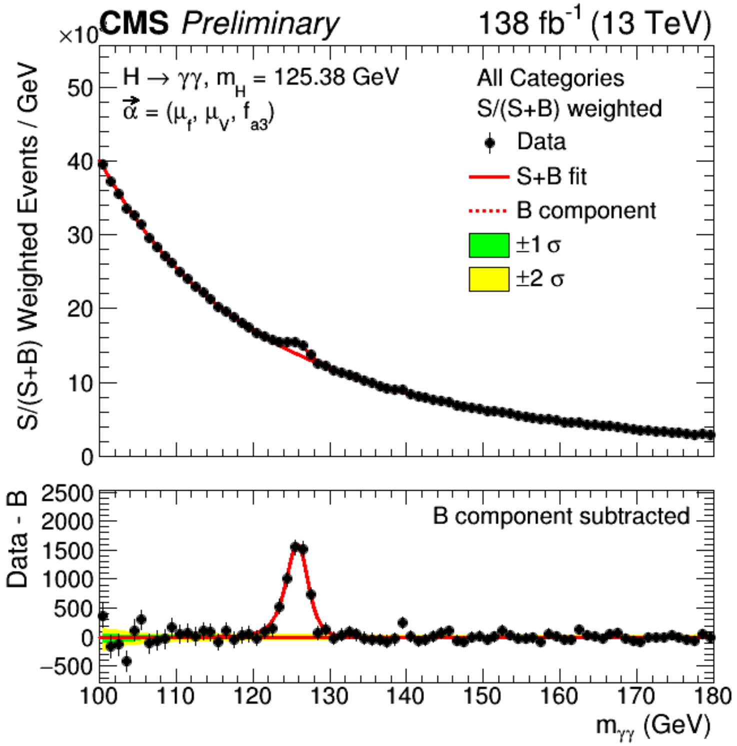

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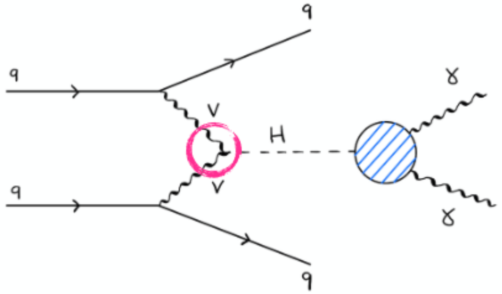

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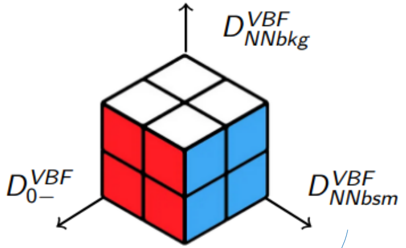

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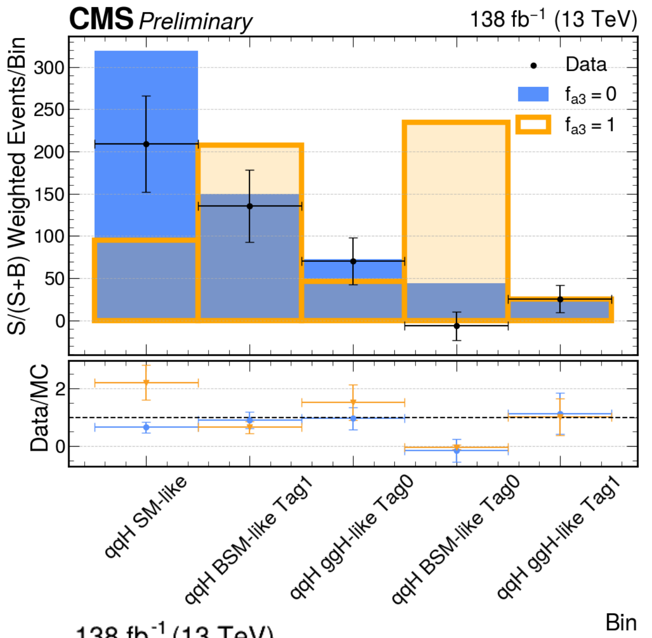

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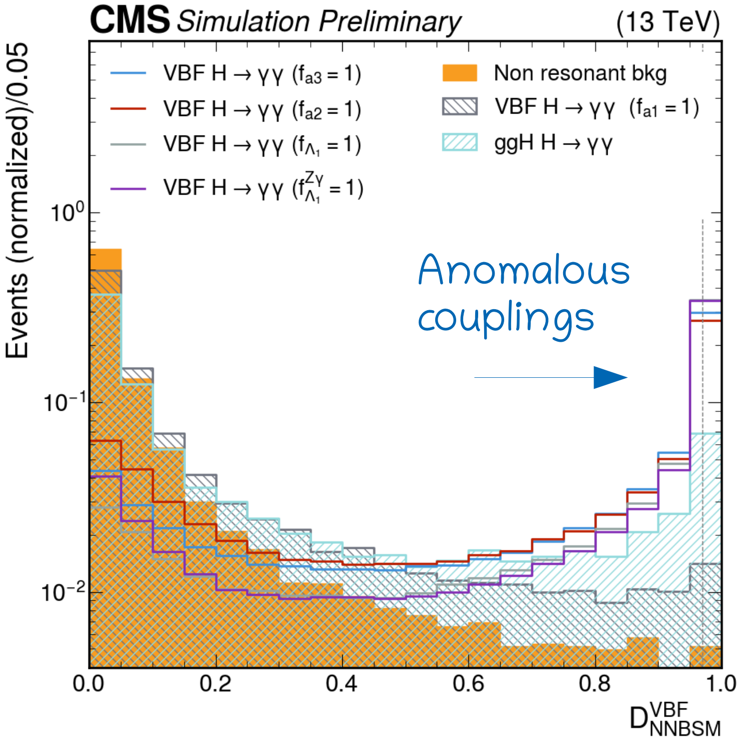

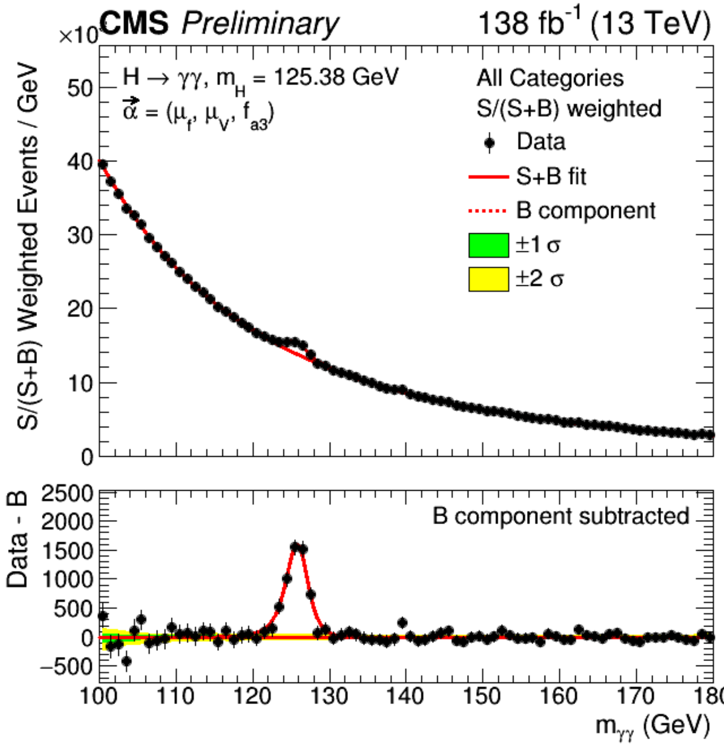

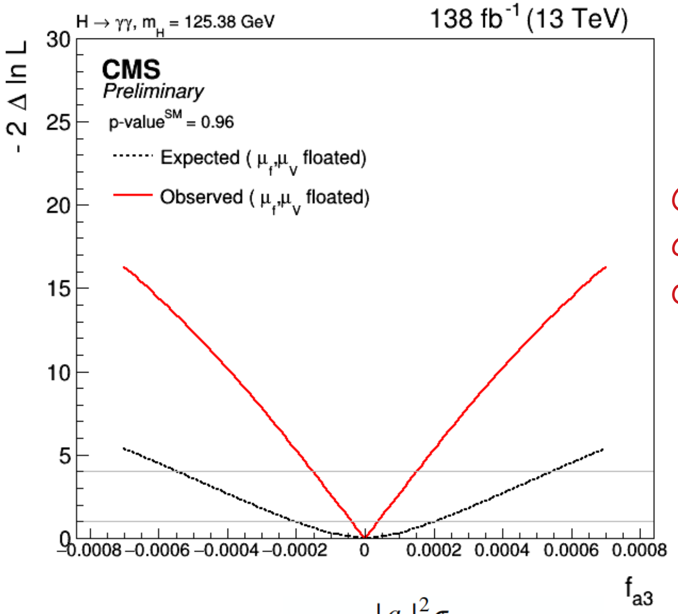

Constraint on cross section fraction due to AC ~ 10^{-4}

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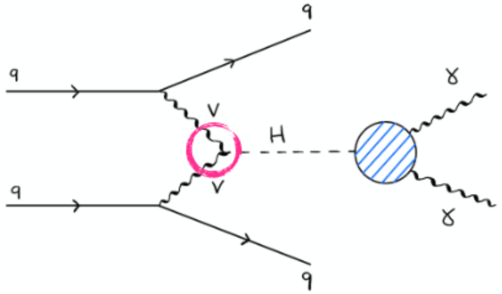

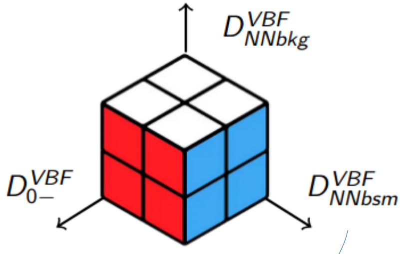

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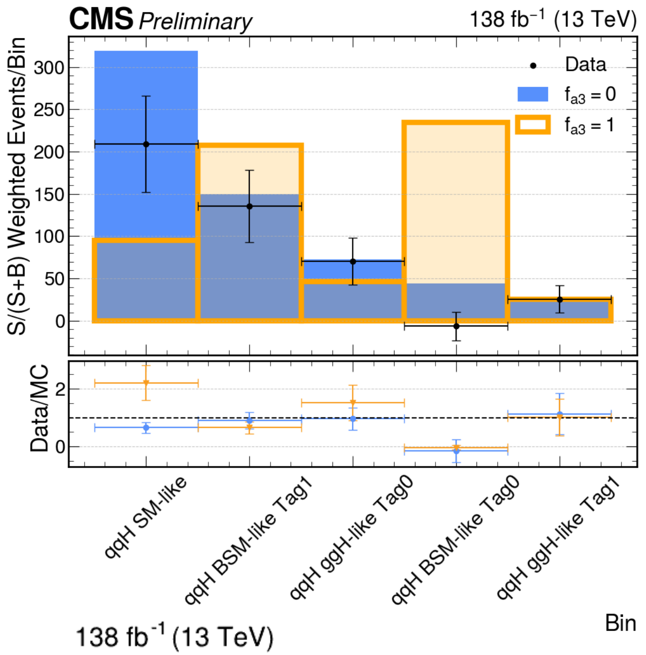

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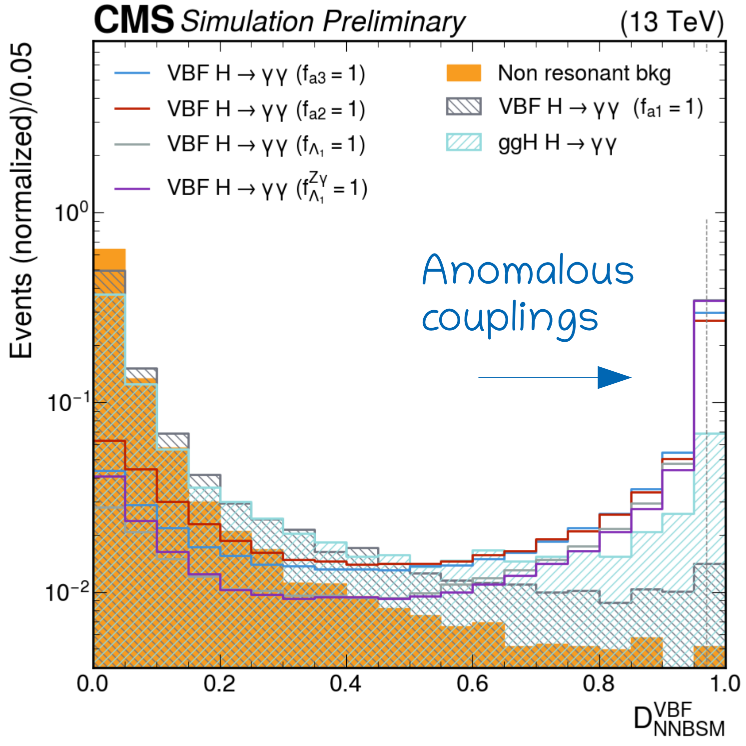

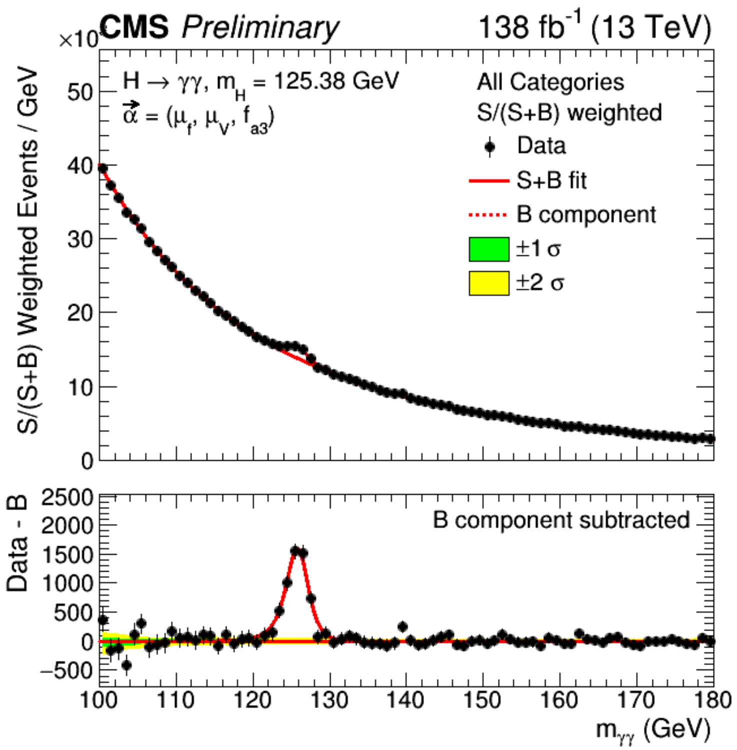

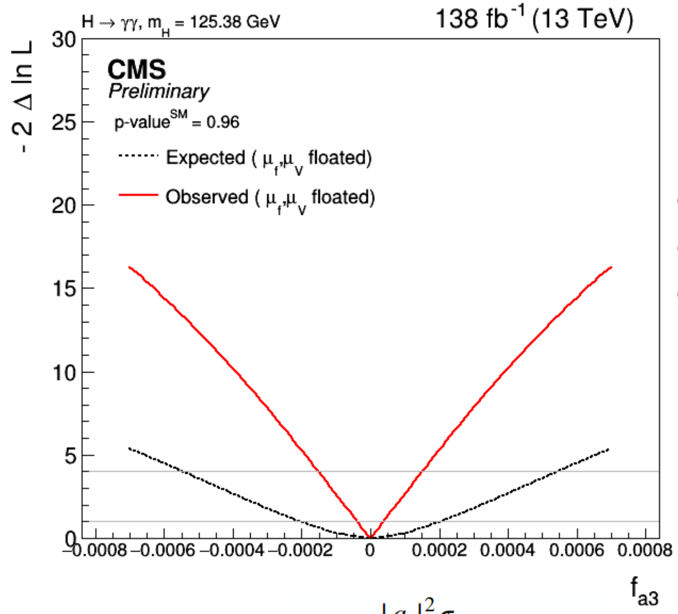

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More details in talk by F. D. Riggi

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SMEFT analysis in V($\rightarrow$leptons) H($\rightarrow b\bar{b}$)

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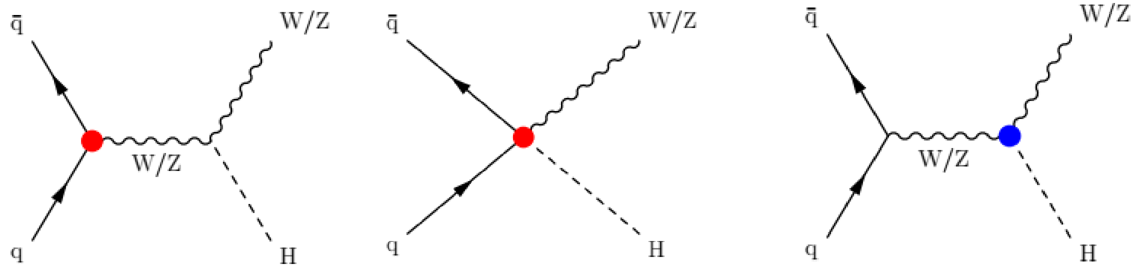

Current operators

Gauge coupling operators

Likelihood-free inference approach to construct optimal observables

Brehmer, Cranmer, Louppe, Pavez (2018)

Implementation using boosted decision trees: boosted information tree (BIT)

SC, N. Frohner, L. Lechner, R. Schoefbeck, D. Schwarz (2021)

Details in talk by M. Mazza

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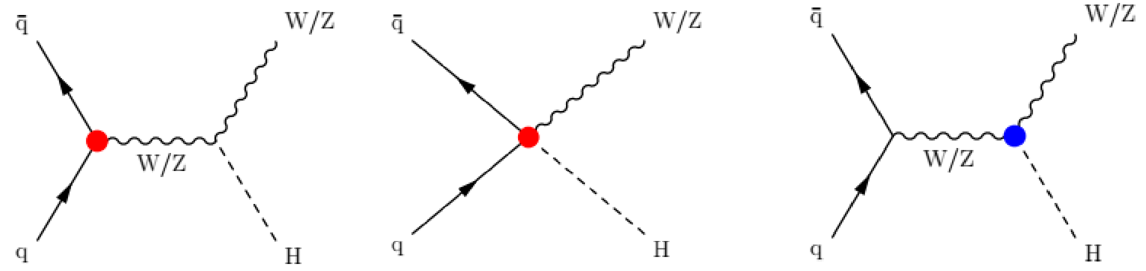

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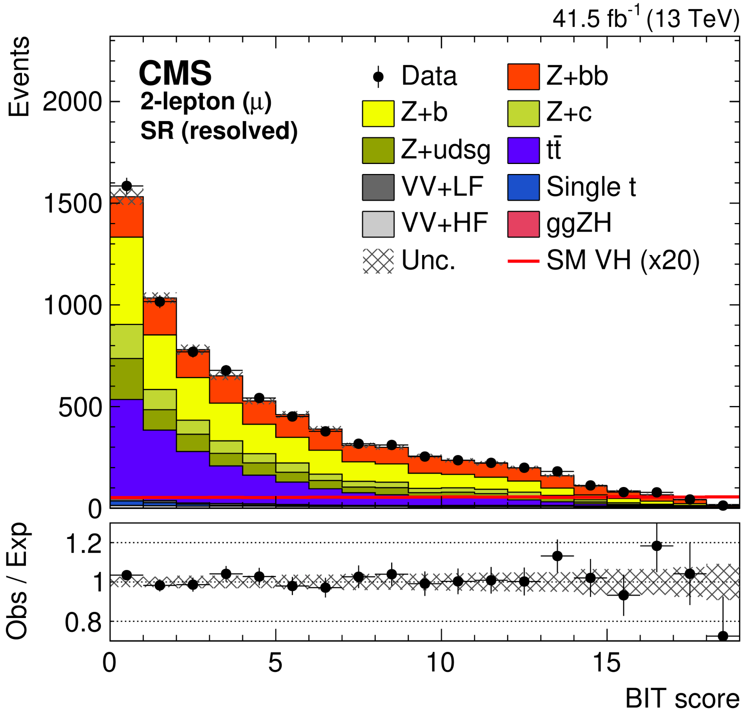

Binned template used for signal extraction

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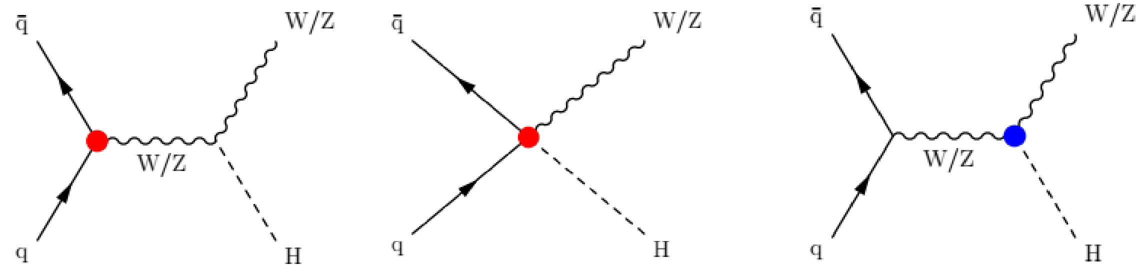

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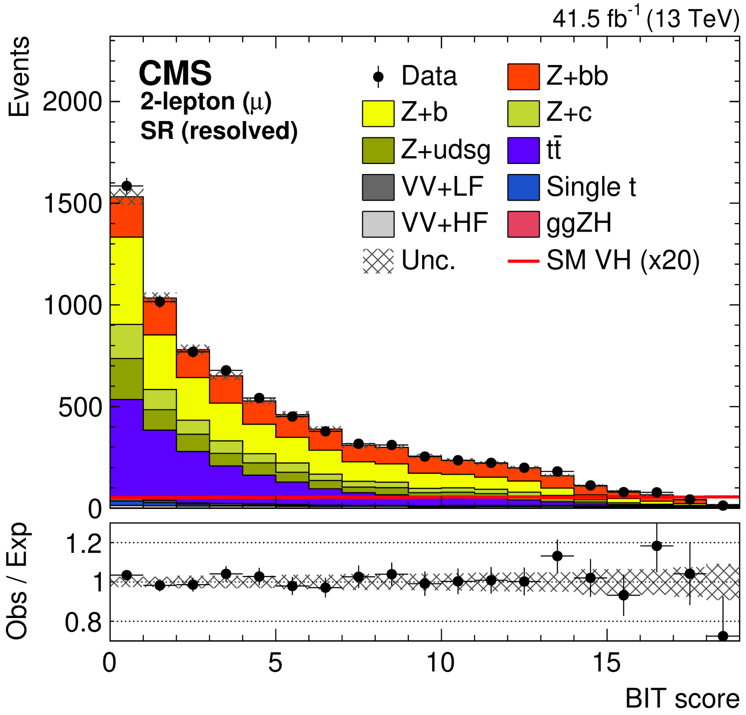

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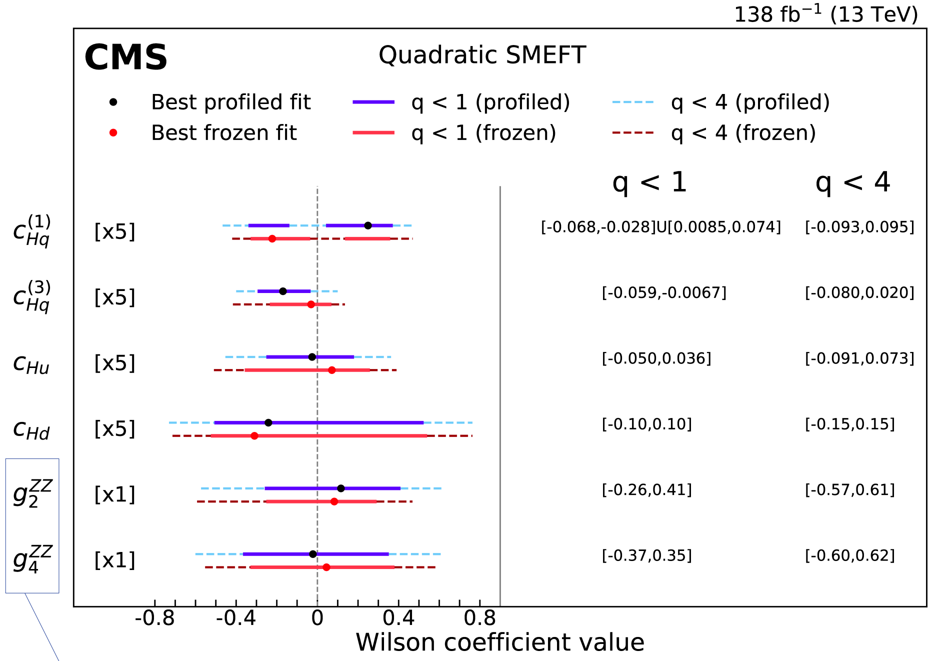

Rotation to mass-eigenstate basis

$$g_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{HB} + c_w^2 c_{HW} + s_w c_w c_{HWB}\right) \quad g_4^{ZZ} = \tilde{g}_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{H\tilde{B}} + c_w^2 c_{H\widetilde{W}} + s_w c_w c_{H\widetilde{W}B}\right)$$

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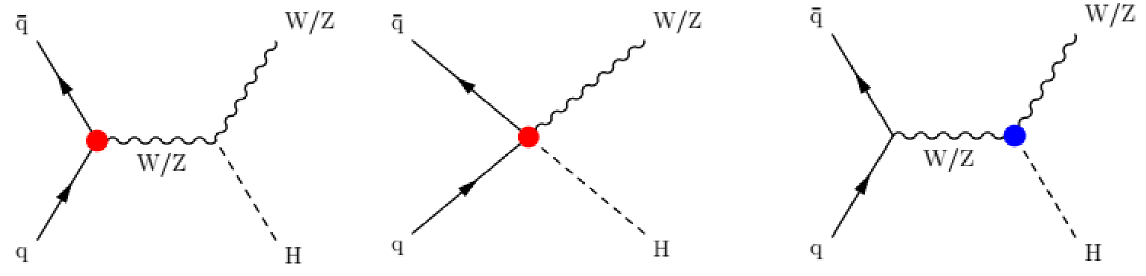

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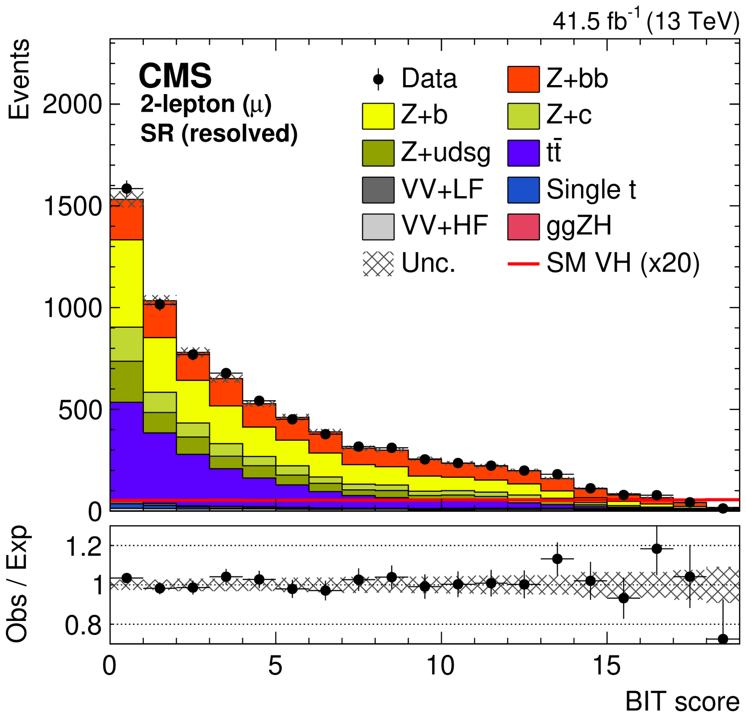
Consistency with SM: p-value = 84% *(w/ varying all Wilson coefficients)*



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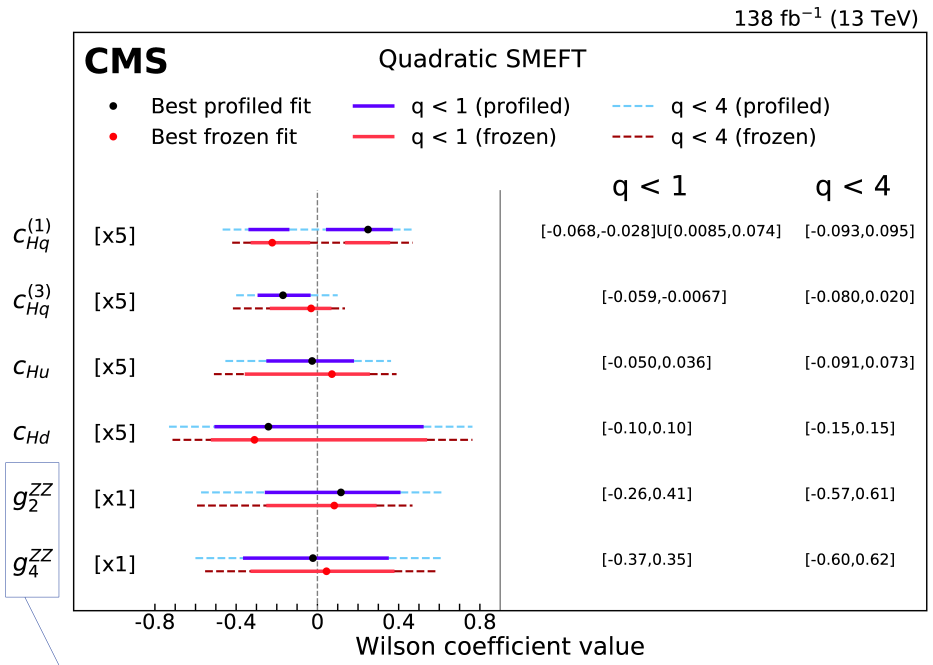
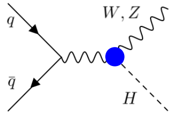
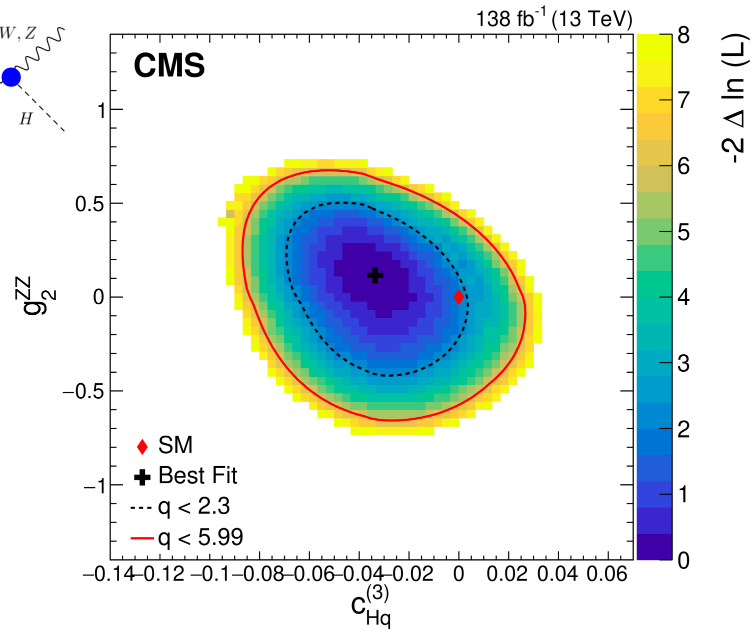
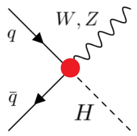




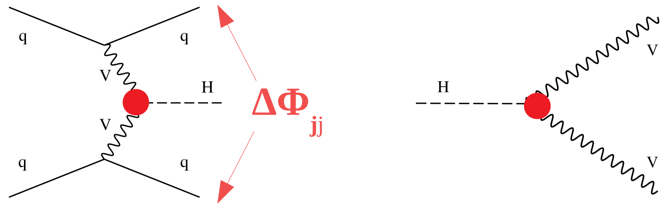




Rotation to mass-eigenstate basis

$$g_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{\mathrm{HB}} + c_w^2 c_{\mathrm{HW}} + s_w c_w c_{\mathrm{HWB}}\right) \quad g_4^{ZZ} = \tilde{g}_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{\mathrm{H\widetilde{B}}} + c_w^2 c_{\mathrm{H\widetilde{W}}} + s_w c_w c_{\mathrm{H\widetilde{W}B}}\right)$$

Differential measurements in H→WW* + 2 jets: H-V coupling



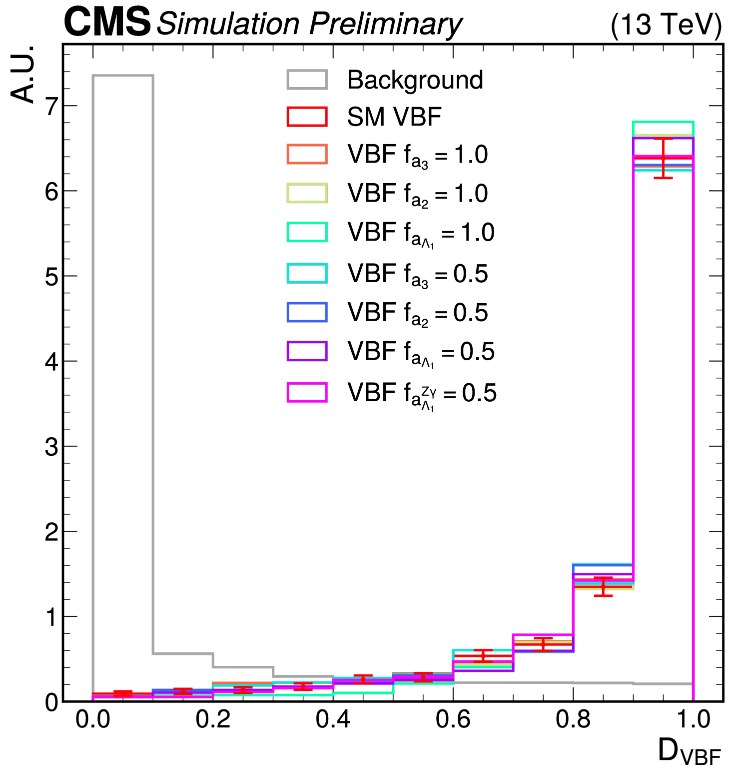
Event topology: H + 2 forward jets targeting H production via VBF & ggF

CMS-PAS-HIG-24-004

Differential measurement of $\Delta\Phi_{jj}$ to probe anomalous H-V coupling

Signal extraction with adverserial deep neural network

→ separating signal from background
→ agnostic to physics model for signal



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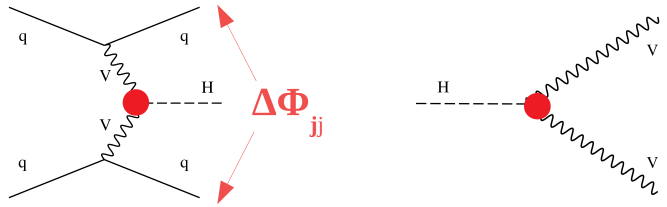

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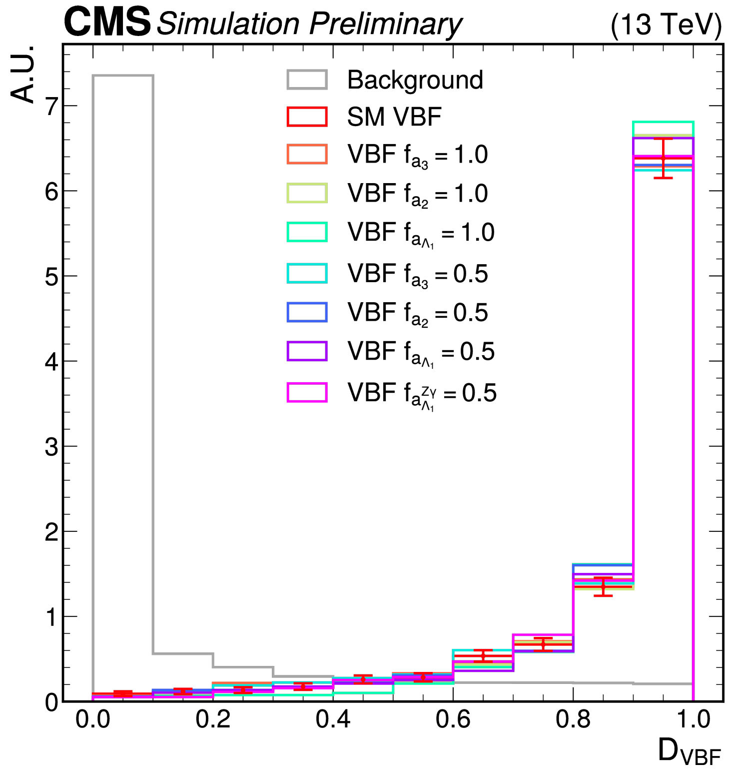

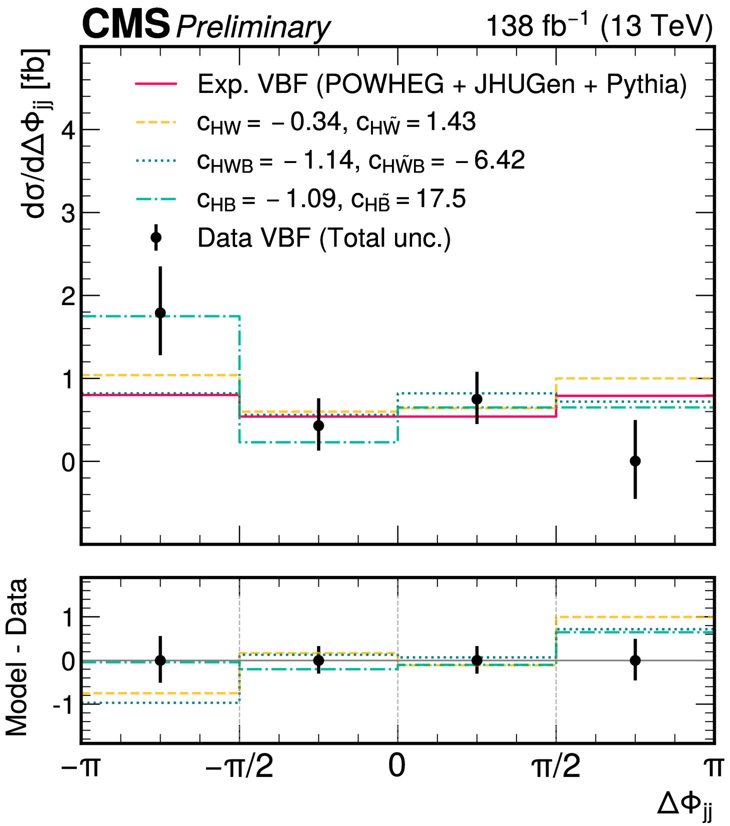

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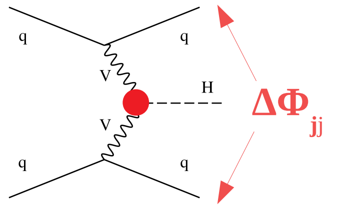

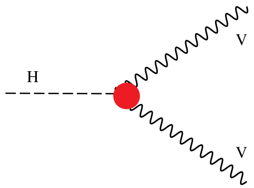

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CMS-PAS-HIG-24-004

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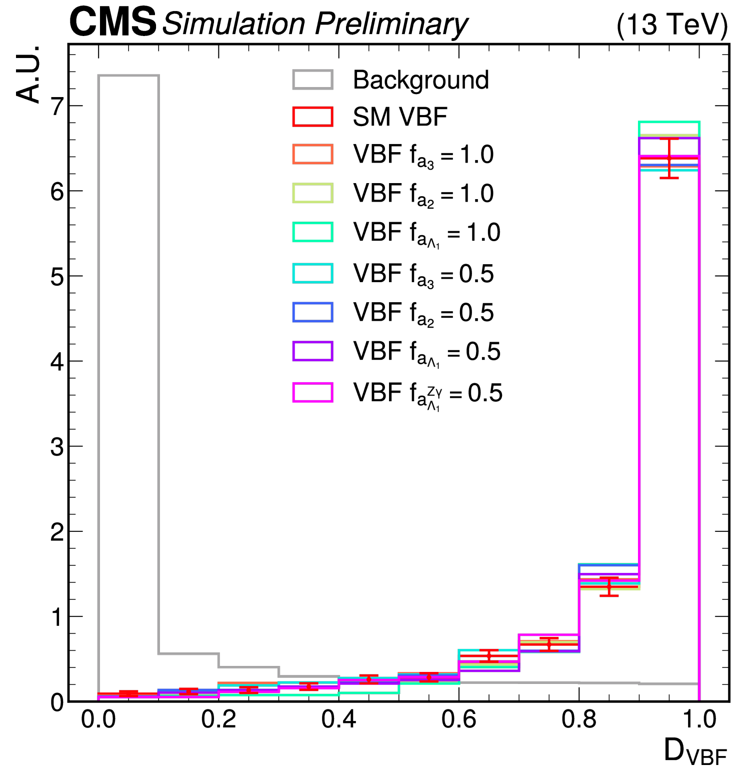
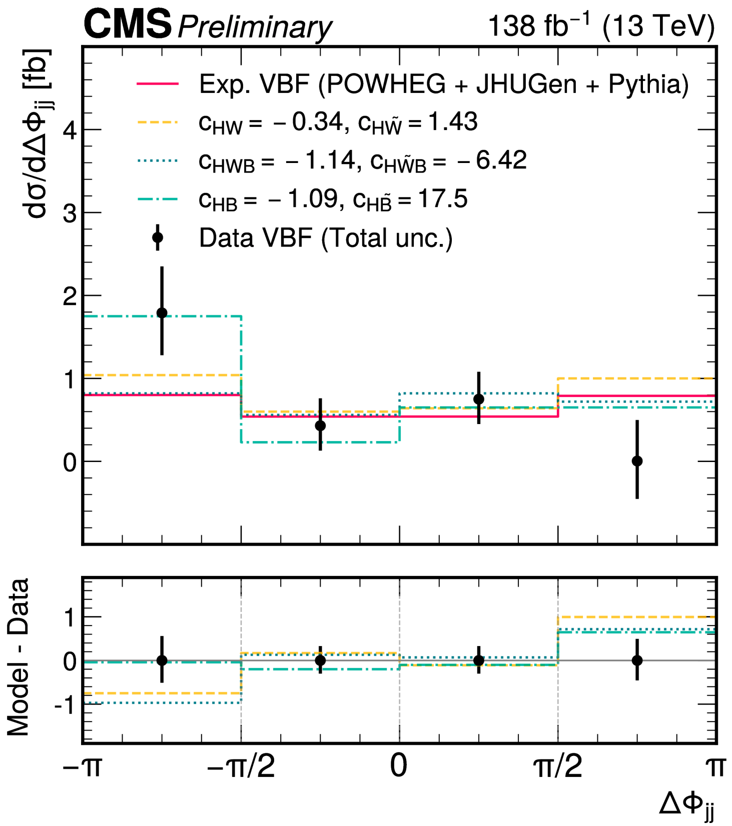
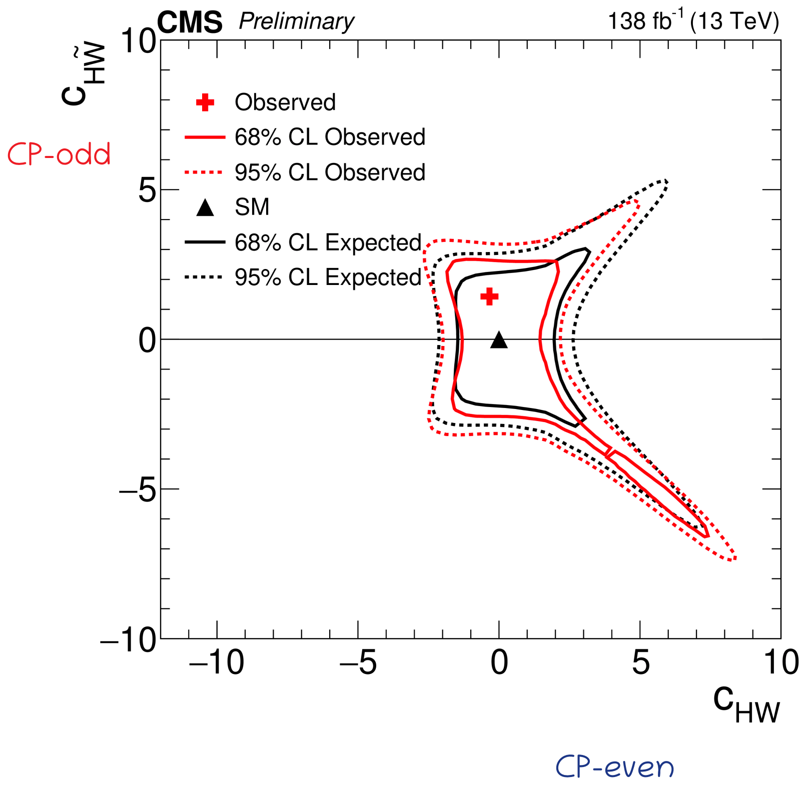
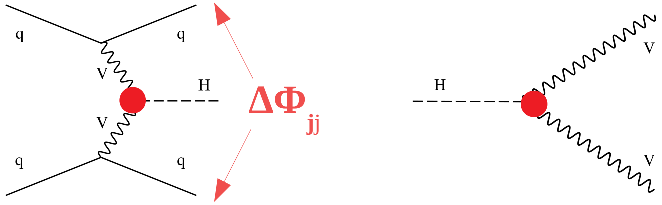
EFT operators modifying H-V coupling probed using D_{VBF} in 4 bins of $\Delta\Phi_{jj}$







Differential measurements in H→WW* + 2 jets: H-V coupling



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CMS-PAS-HIG-24-004

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More details in
talk by B. Camaiani

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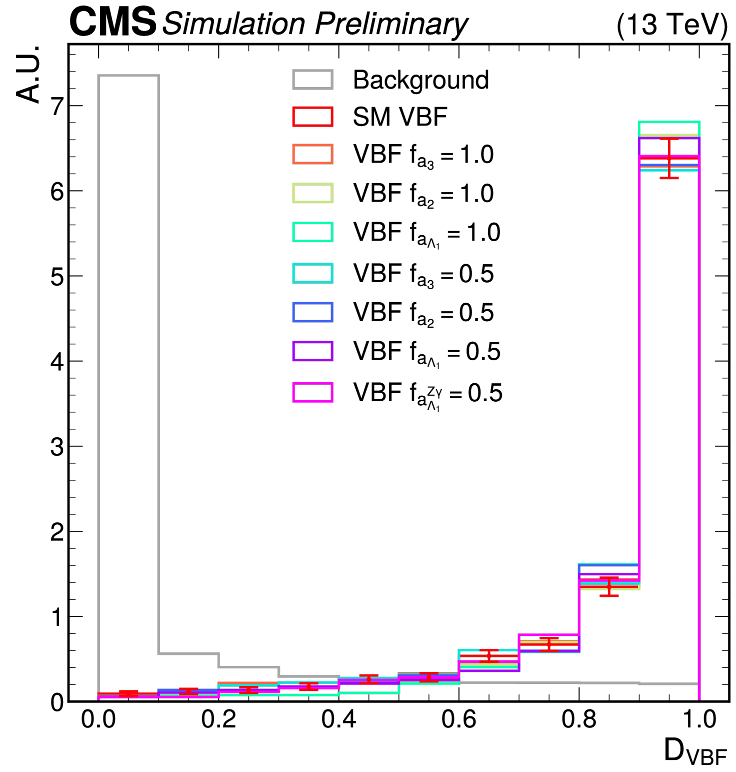
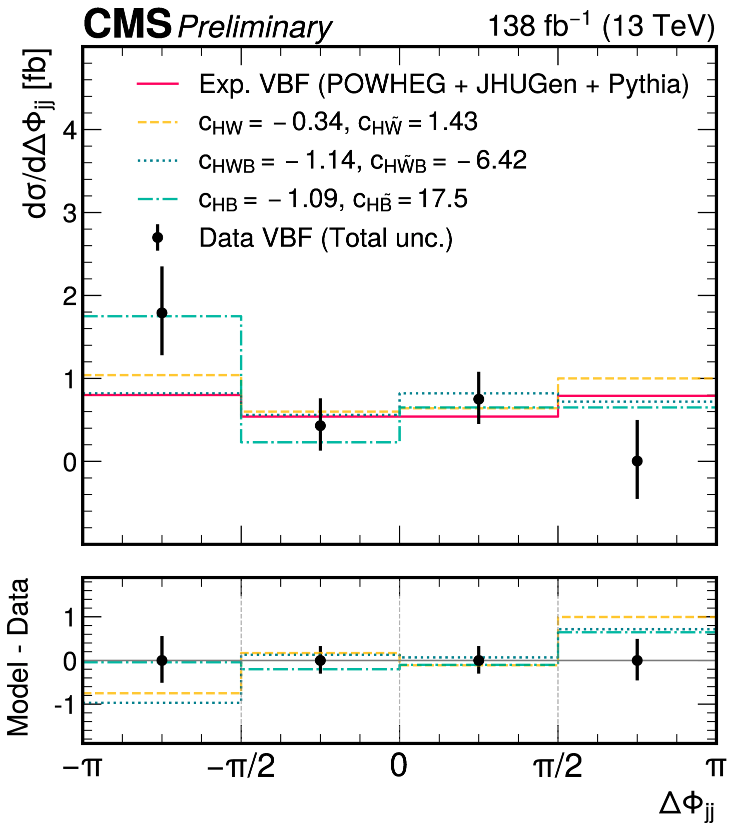
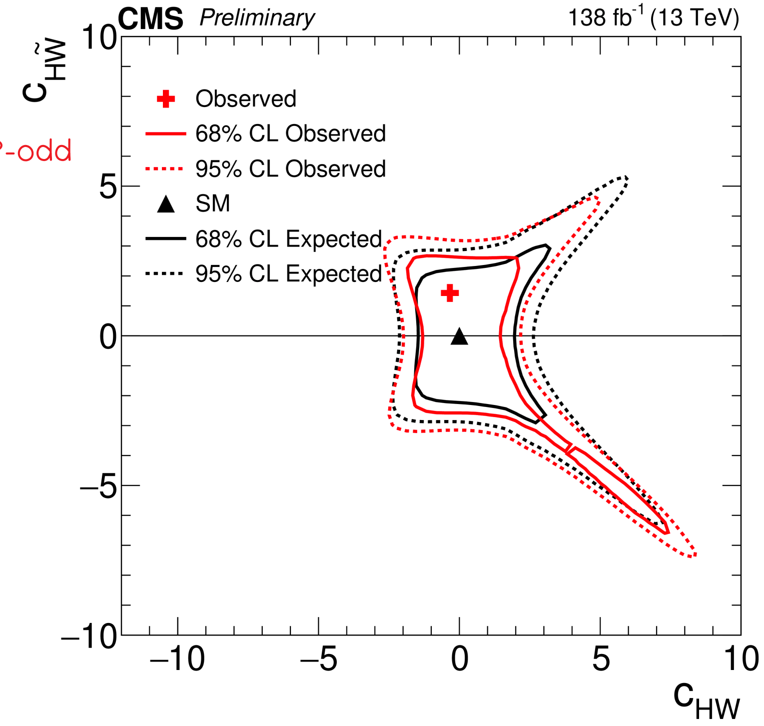


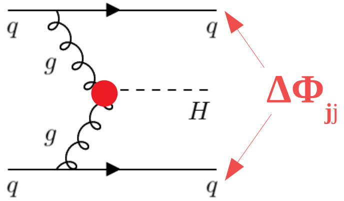


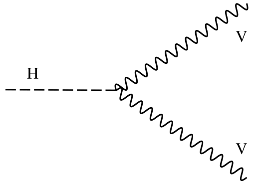


CP-odd

CP-even

Differential measurements in H→WW* + 2 jets: H-g coupling





Event topology: H + 2 forward jets targeting H production via VBF & ggF

CMS-PAS-HIG-24-004

Differential measurement of $\Delta\Phi_{jj}$ to probe anomalous H-g coupling

More details in talk by B. Camaiani

Signal extraction with adverserial deep neural network

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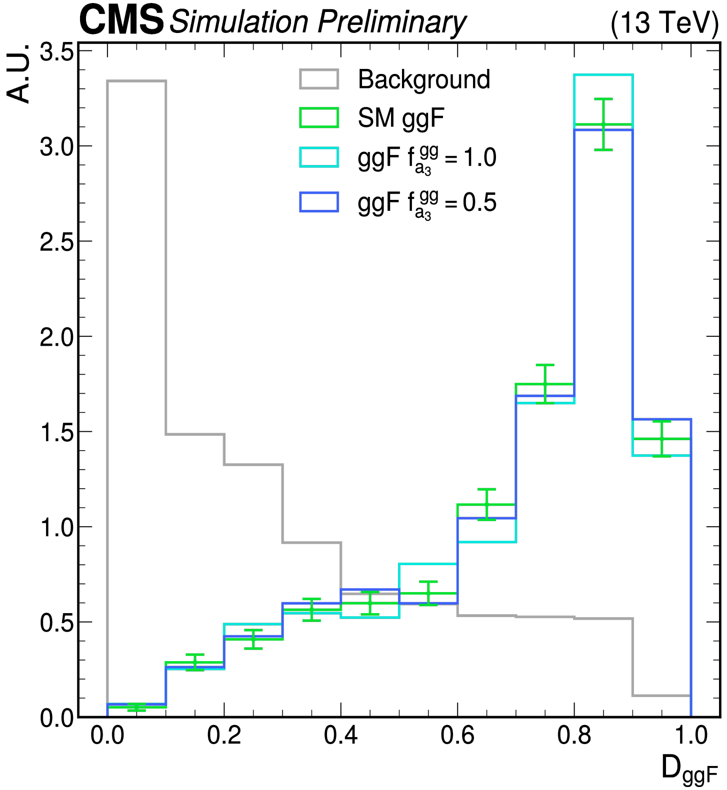
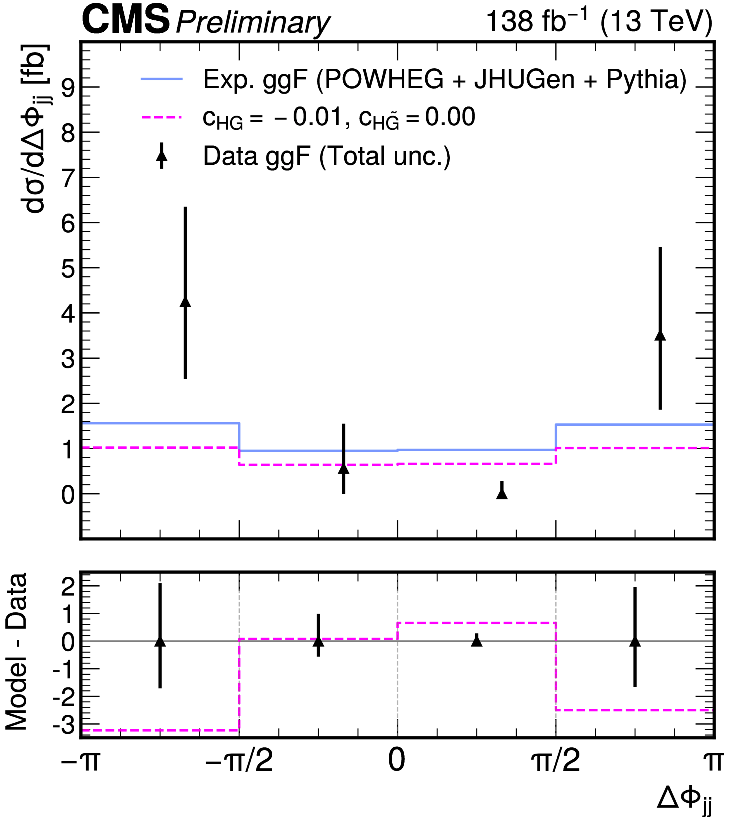
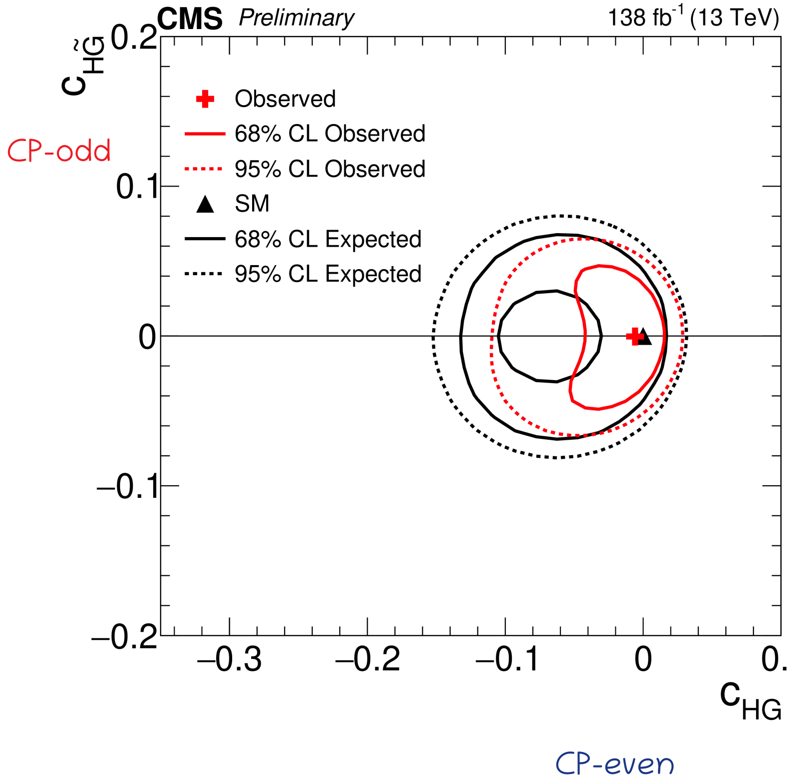
→ agnostic to physics model for signal

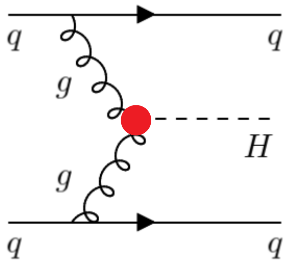
EFT operators modifying H-g coupling probed using 2D distribution of D_{ggF} and D_{VBF} in 4 bins of $\Delta\Phi_{jj}$







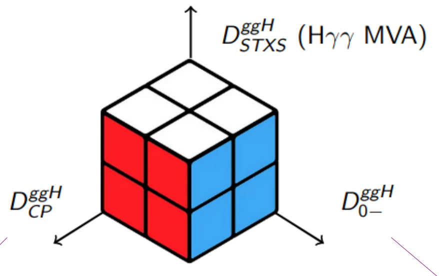
Anomalous Higgs to gluon couplings in H→ γγ final states



Higgs-to-gluon coupling in production is probed in H+2 jets events

CMS-PAS-HIG-24-006

Physics Briefing



Categorization in 3D space

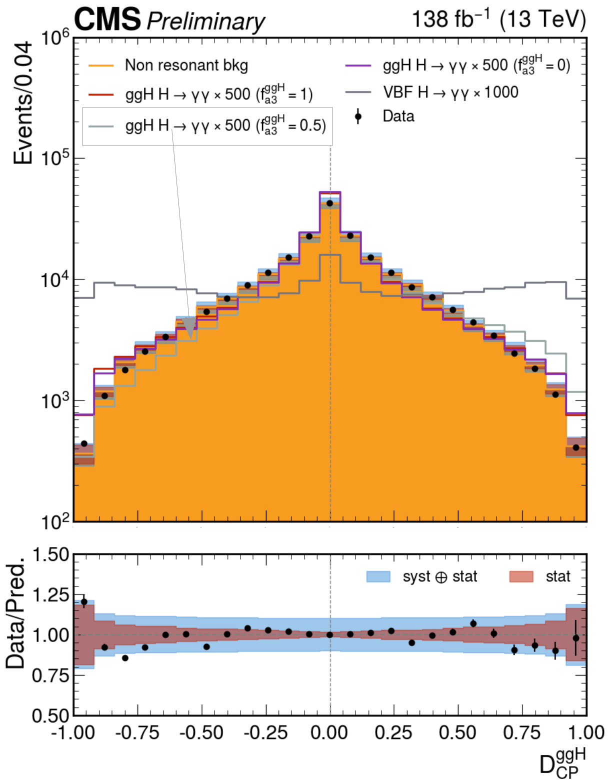
30 categories for analysis of H-g coupling

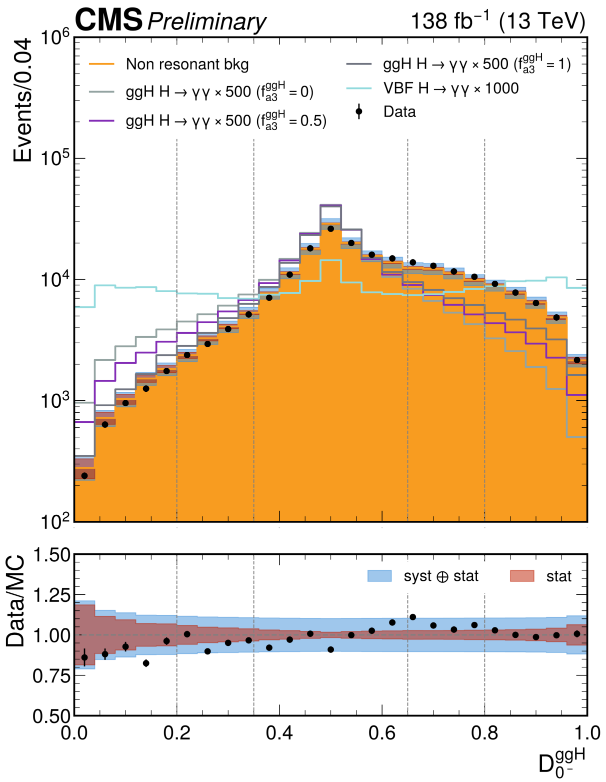
New

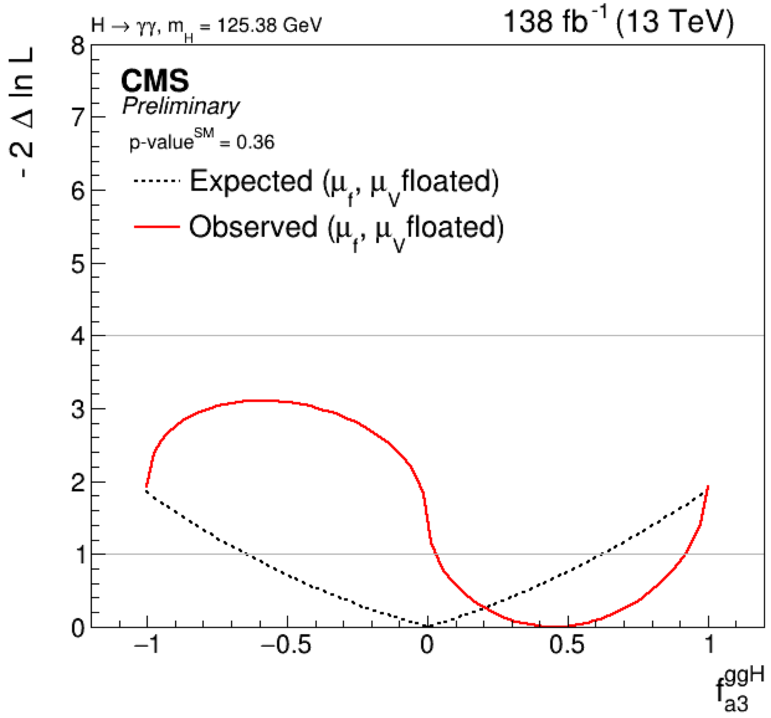
More details in talk by F. D. Riggi

SM-BSM interference

Pure BSM







$$f_{a3}^{ggH} = \frac{|a_3^{gg}|^2}{|a_2^{gg}|^2 + |a_3^{gg}|^2} \operatorname{sgn}\left(\frac{a_3^{gg}}{a_2^{gg}}\right)$$

Anomalous Higgs to top coupling

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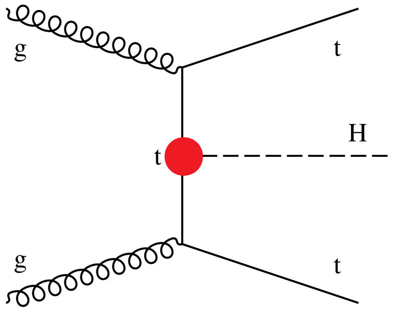
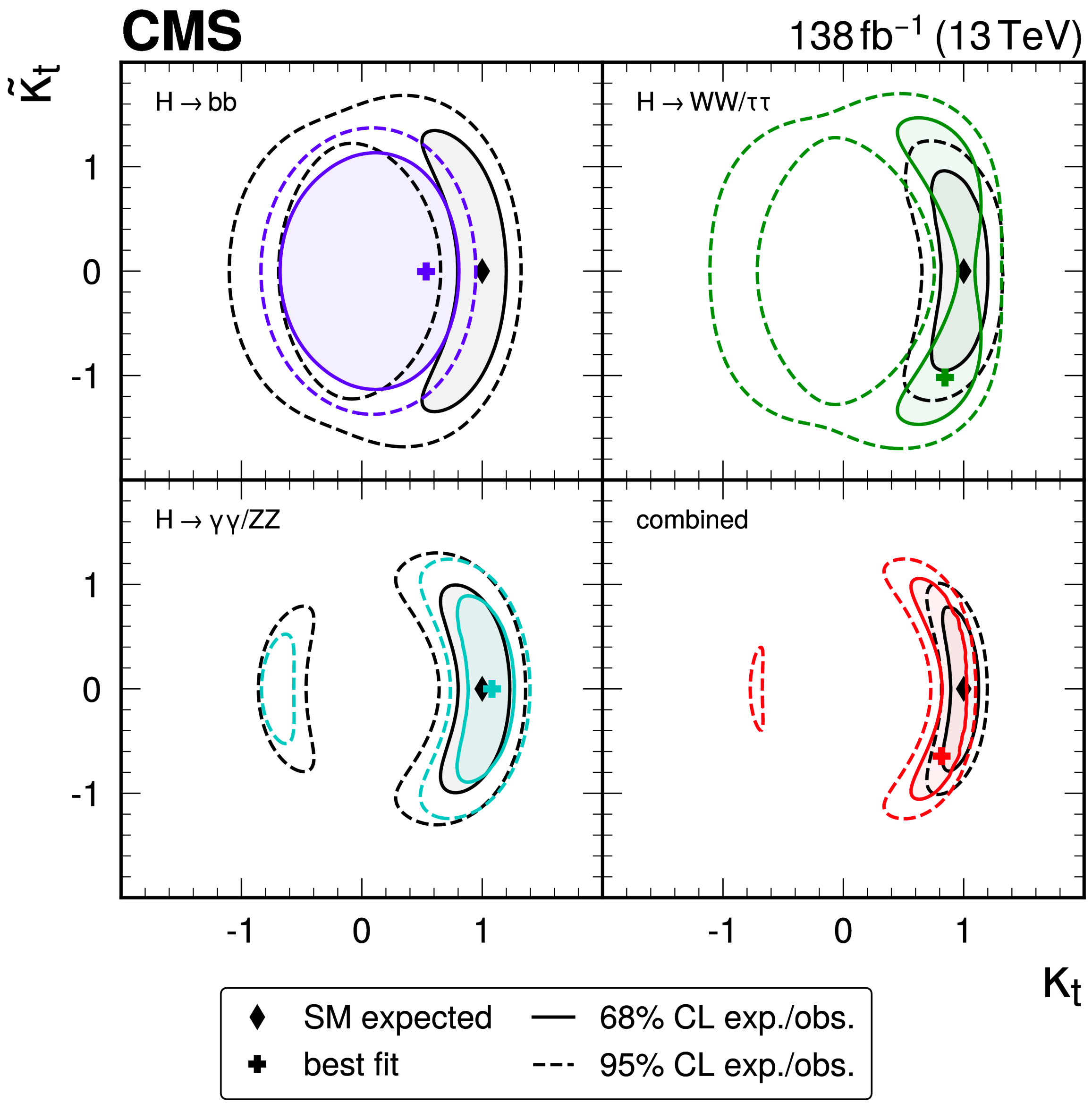
Higgs coupling to fermions

$$\mathcal{A}(\mathrm{Hff}) = -\frac{m_f}{v}\bar{\psi}_\mathrm{f}\left(\boxed{\kappa_\mathrm{f}} + \mathrm{i}\boxed{\tilde{\kappa}_\mathrm{f}\gamma_5}\right)\psi_\mathrm{f}$$

CP-even CP-odd





CP structure of t-H coupling is probed using ttH & tH measurements

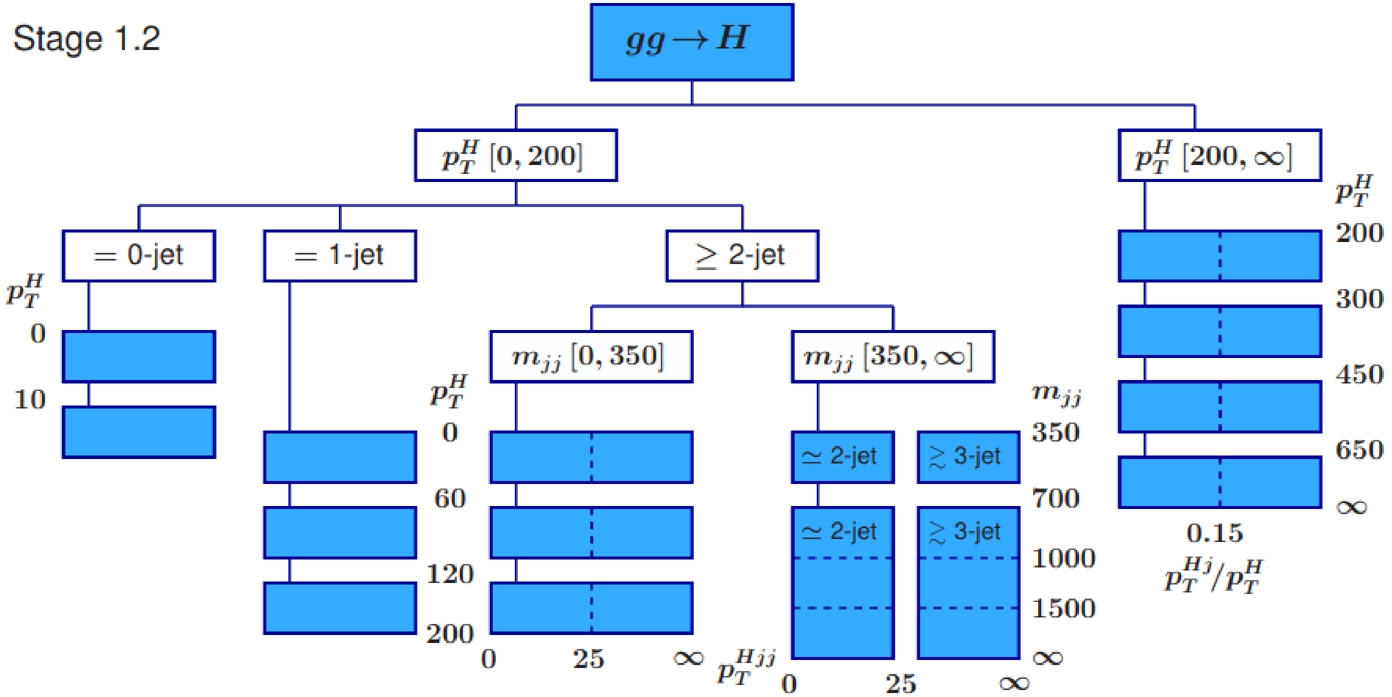
- Combination performed across multiple analyses:
  $H \to b\bar{b}$ / $H \to WW^*/\tau\tau$ (multilepton) / $H \to \gamma\gamma$ / $H \to ZZ^* \to 4$ lepton
- Pure CP-odd hypothesis excluded at ~3σ by combined results (5σ expected)

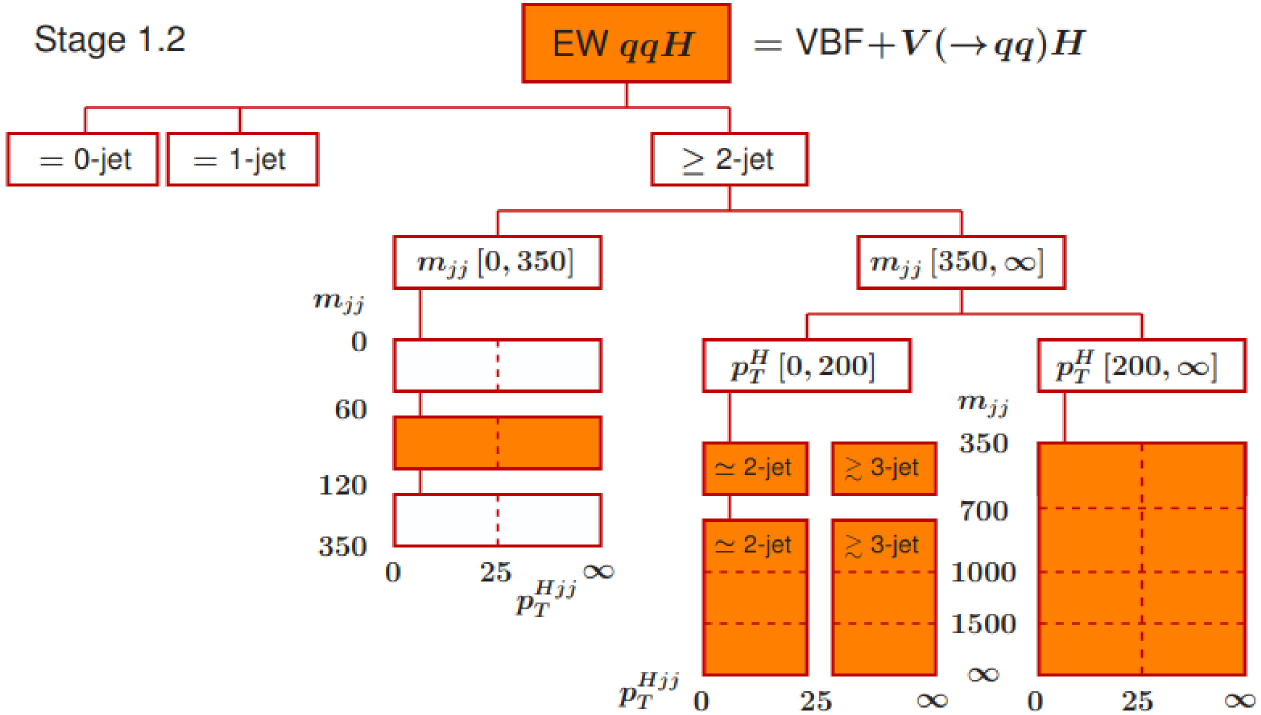
STXS combination

CMS-PAS-HIG-21-018

Combination of measurements in simplified template cross section (STXS) framework → interpreted in terms of SMEFT operators

Also see talk by W. Elmetenawee





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Constraints on 43 coefficients *fitted individually (others set to SM values)*

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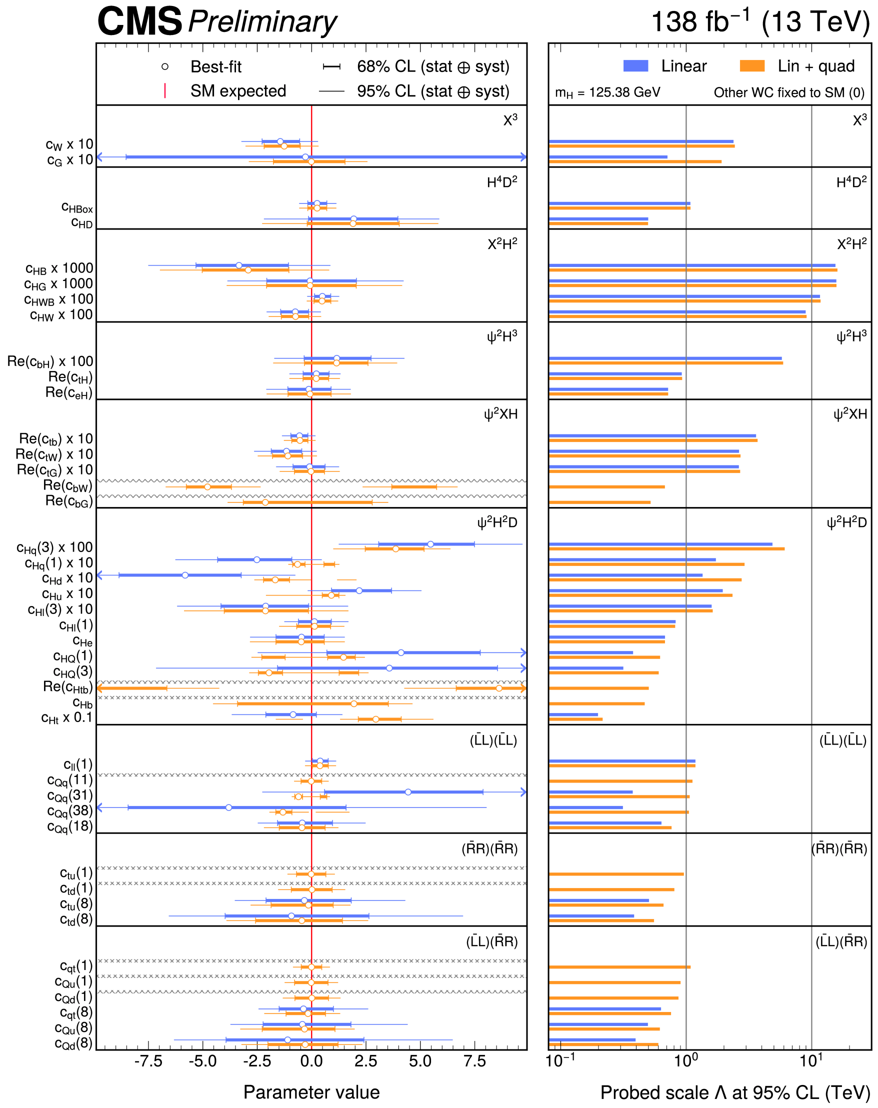

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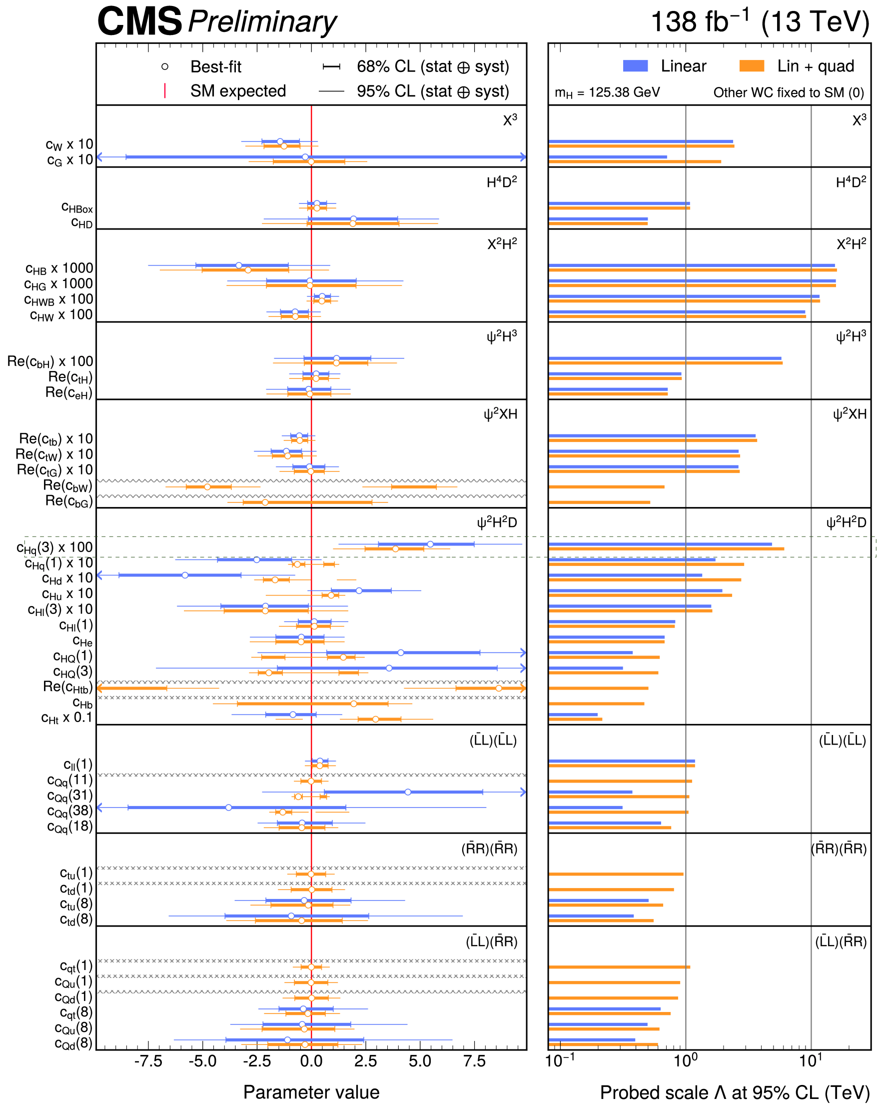

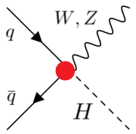

Largest discrepancy p_{SM}: 1%

STXS combination

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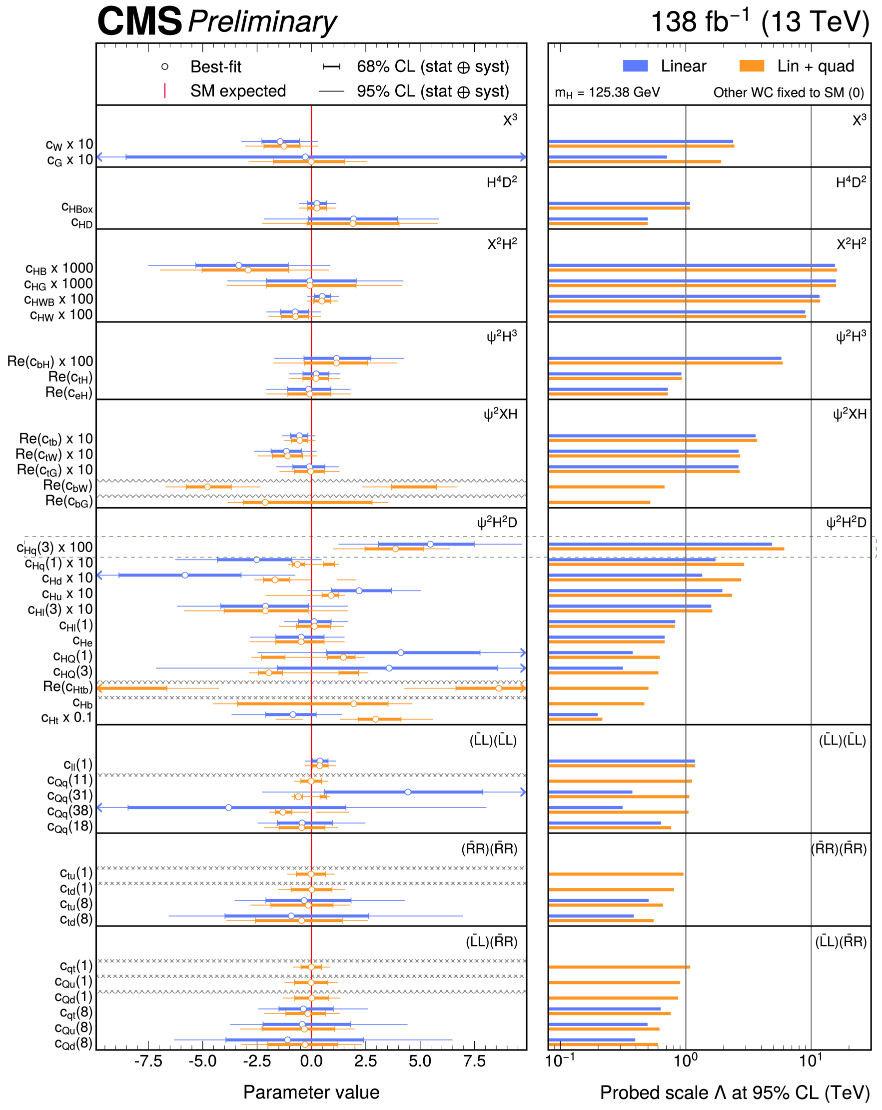
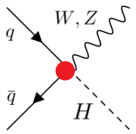
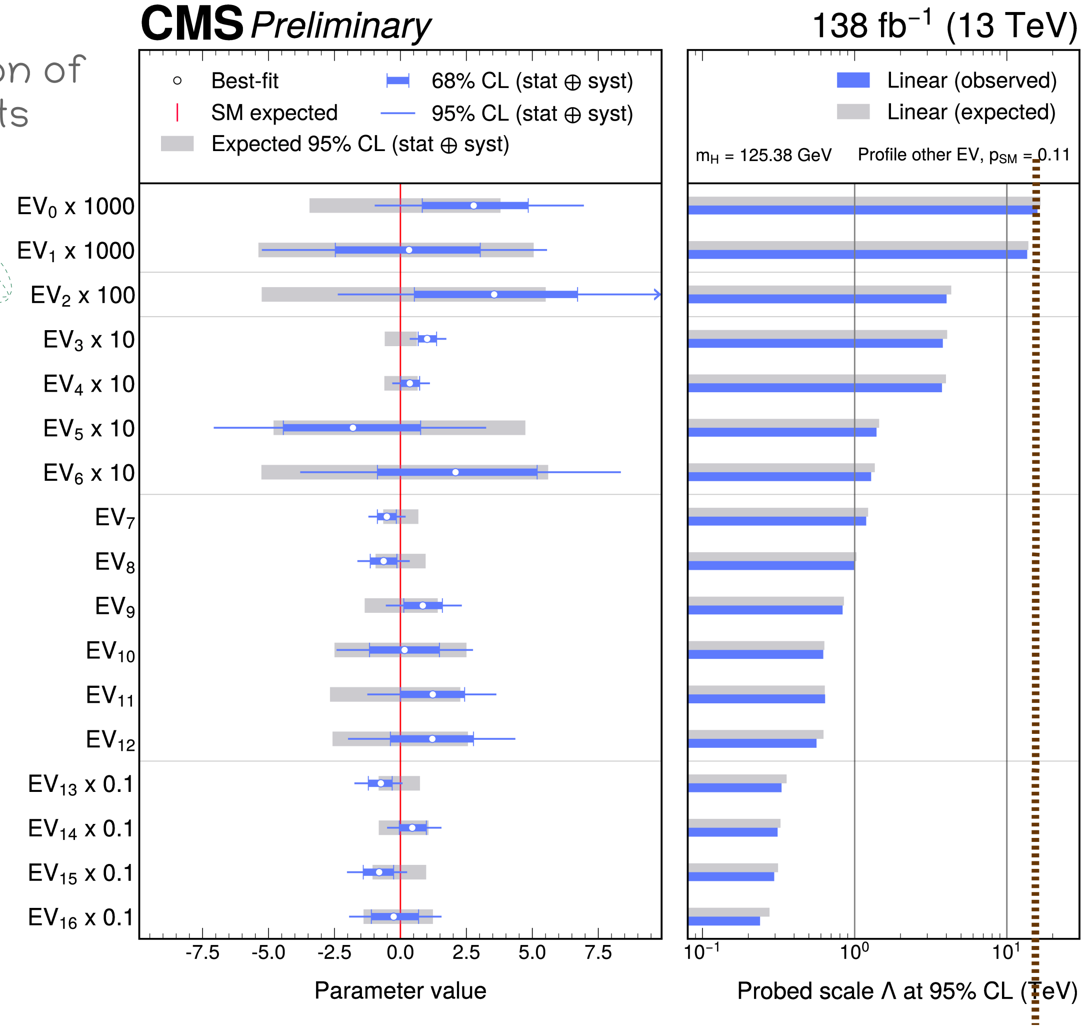




Largest discrepancy p_{SM}: 1%

Principle component analysis (PCA) to probe multiple operators

Linear combination of Wilson coefficients



~20 TeV

STXS combination

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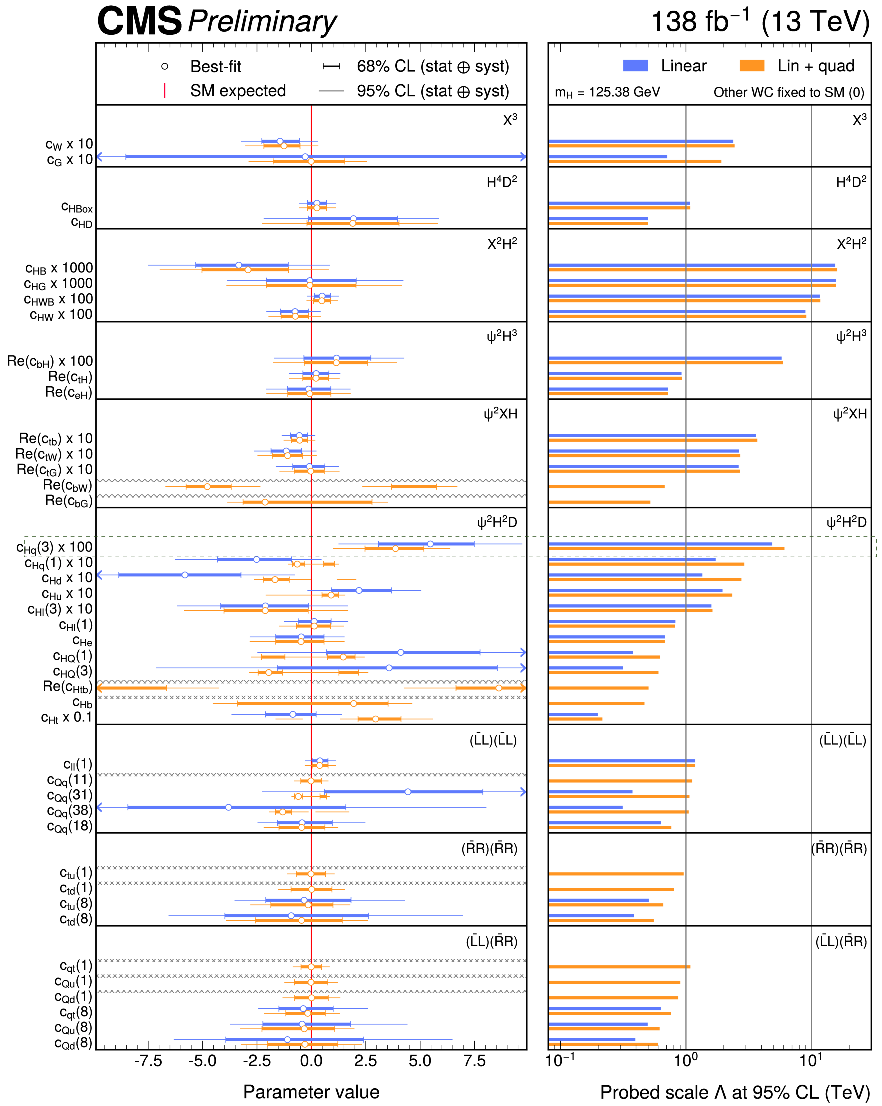
Constraints on 43 coefficients *fitted individually (others set to SM values)*



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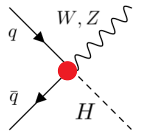

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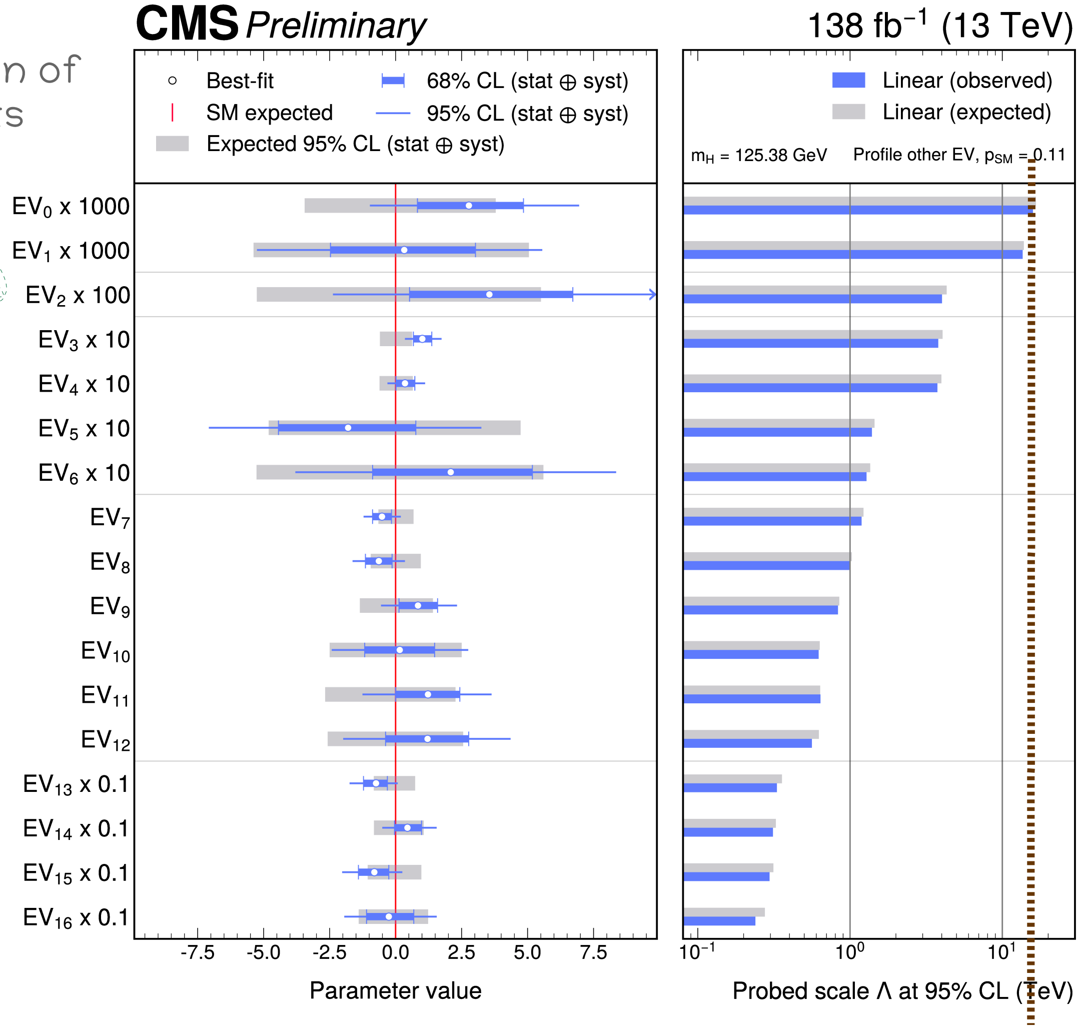

~20 TeV

Compatibility with SM:
p-value ~ 11%
varying all eigen vectors together

Higgs+Top+EWK+Multijet combination

arXiv: 2504.02958

Combination of performed across CMS measurements
→ spanning a variety of processes

Measurements provide complementary sensitivity to EFT operators

Analysis	Type of measurement	Observables used	Experimental likelihood
$H \to \gamma\gamma$	Differential cross sections	STXS bins [54]	✓
$W\gamma$	Fiducial differential cross sections	$p_T^\gamma \times \lvert\phi_f\rvert$ [33]	✓
$Z \to \nu\nu$	Fiducial differential cross sections	p_T^Z	✓
WW	Fiducial differential cross sections	$m_{\ell\ell}$	✓
$t\bar{t}$	Fiducial differential cross sections	$m_{t\bar{t}}$	×
$t(\bar{t})X$	Direct EFT	Yields in regions of interest	✓
Inclusive jet	Fiducial differential cross sections	$p_T^{jet} \times \lvert y^{jet}\rvert$	×
EWPO	Pseudo-observables	Γ_Z, σ^0_{had}, R_ℓ, R_c, R_b, $A_{FB}^{0,\ell}$, $A_{FB}^{0,c}$, $A_{FB}^{0,b}$ [36]	×

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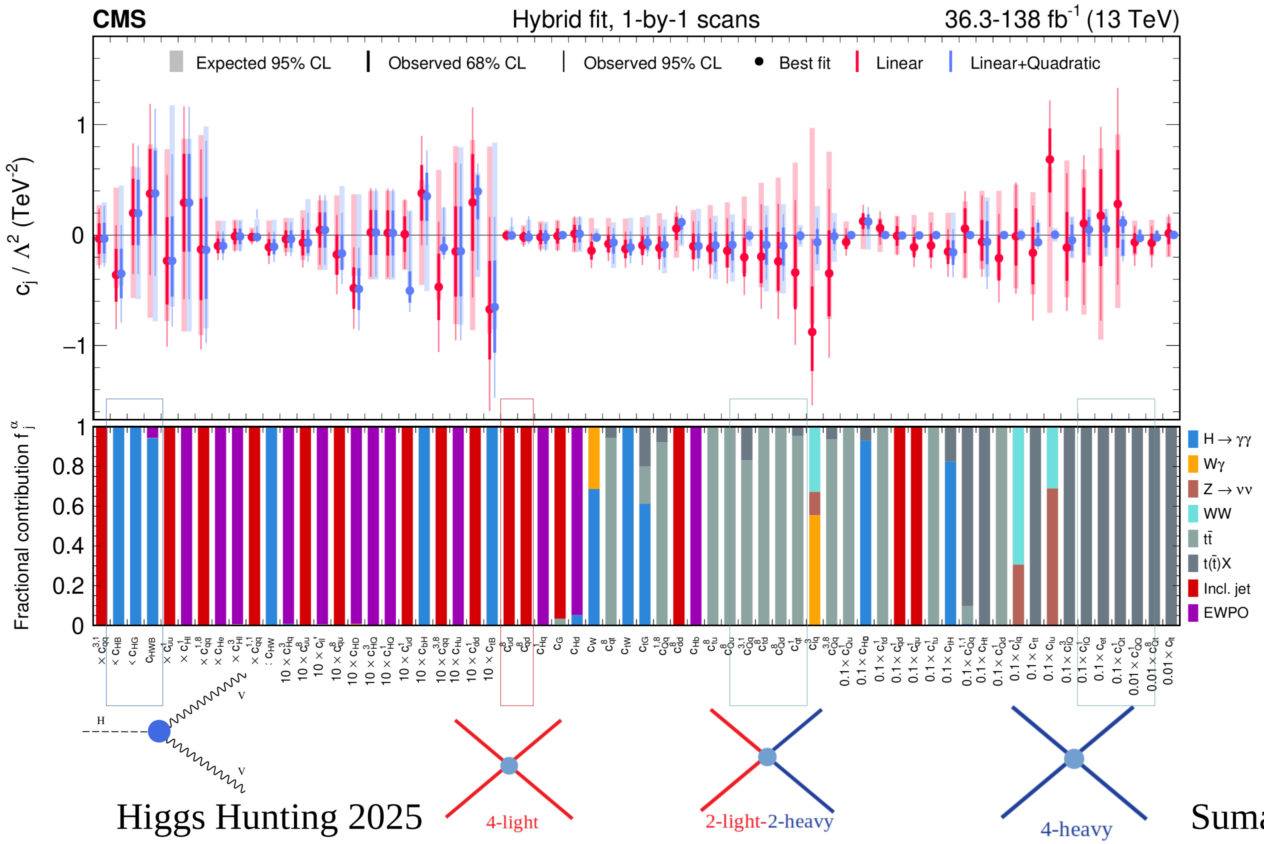
Constraints on 64 coefficients *fitted individually*



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arXiv: 2504.02958

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Measurements provide complementary sensitivity to EFT operators

PCA to construct 43 eigen-vectors (EVs)
→ Constraint on each EV reported while varying others

Constraints on 64 coefficients *fitted individually*

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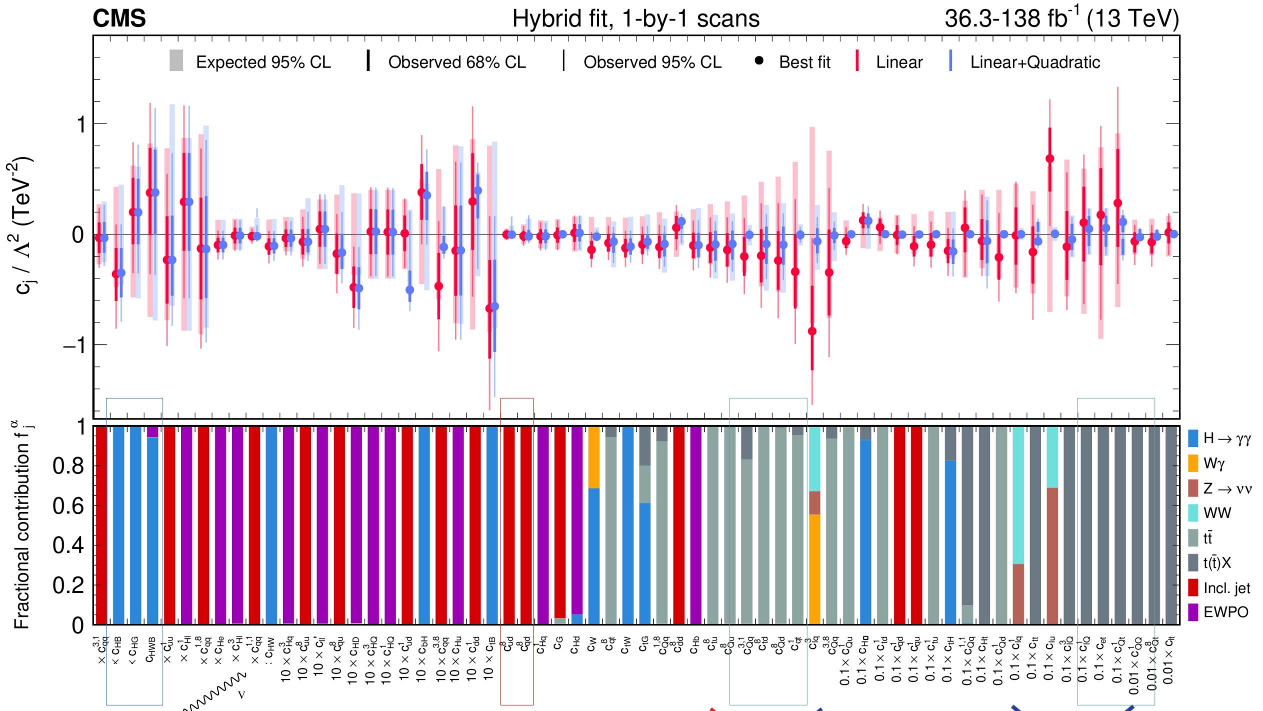
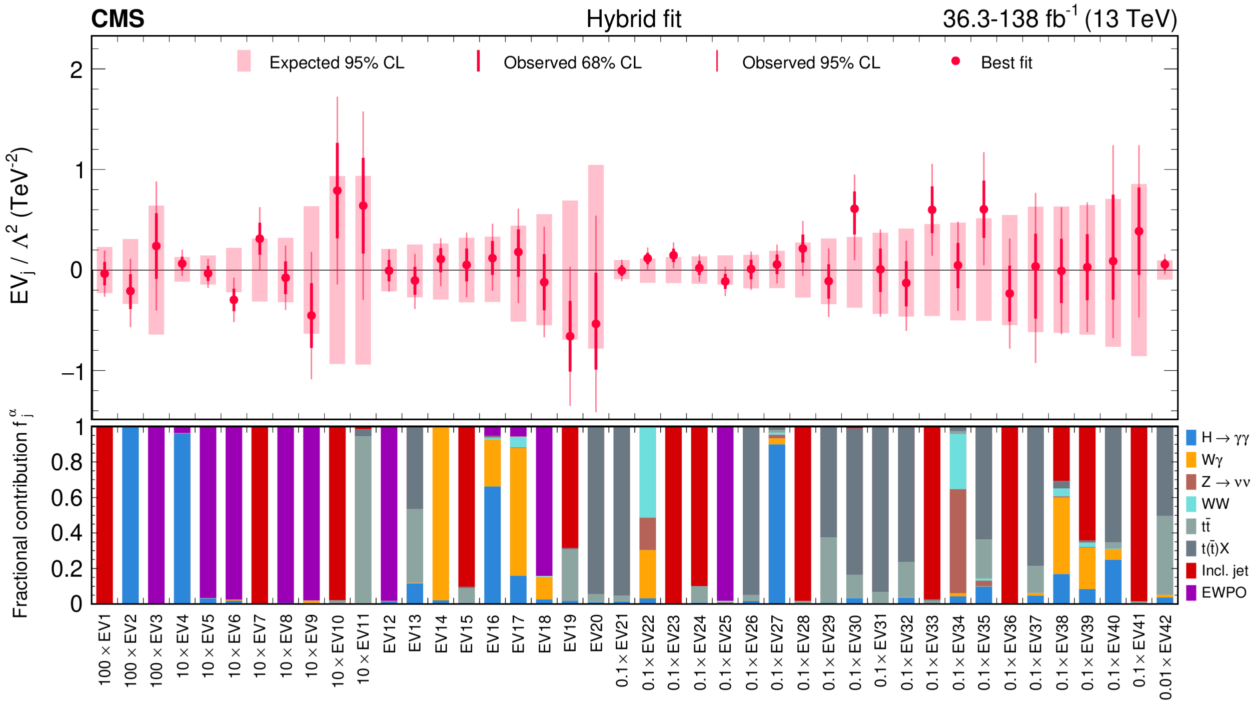




Compatibility with SM: p-value ~ 1.7% *varying all EVs together*

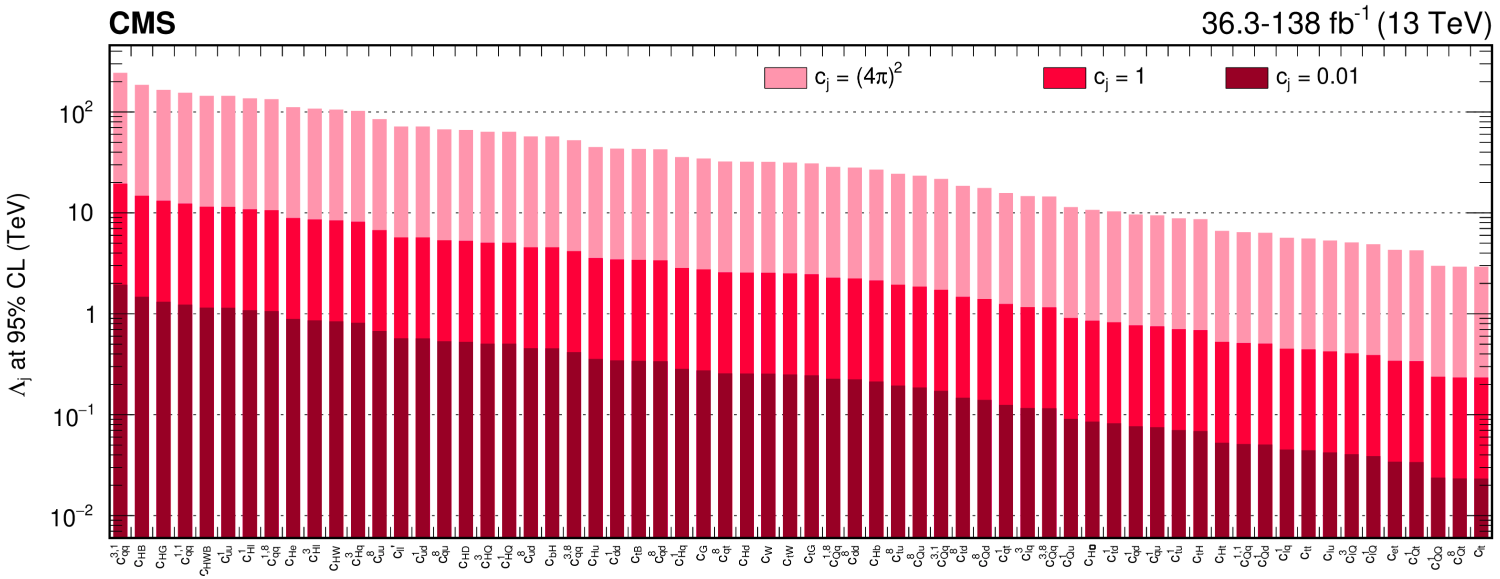
26% w/o inclusive jet measurements

Summary & Outlook

- Complementary approaches to probe effective field theory effects in Higgs sector:
  direct measurement targeting new operators/interactions and reinterpretation of cross section measurements

- Combination performed between cross section measurements targeting several H production & decay with Run-2 data
  → Power to probe a large number of EFT operators

- Combination between Higgs, top, diboson, multijet measurements have already started arXiv: 2504.02958



Looking forward to new results from Run-3!

Summary & Outlook

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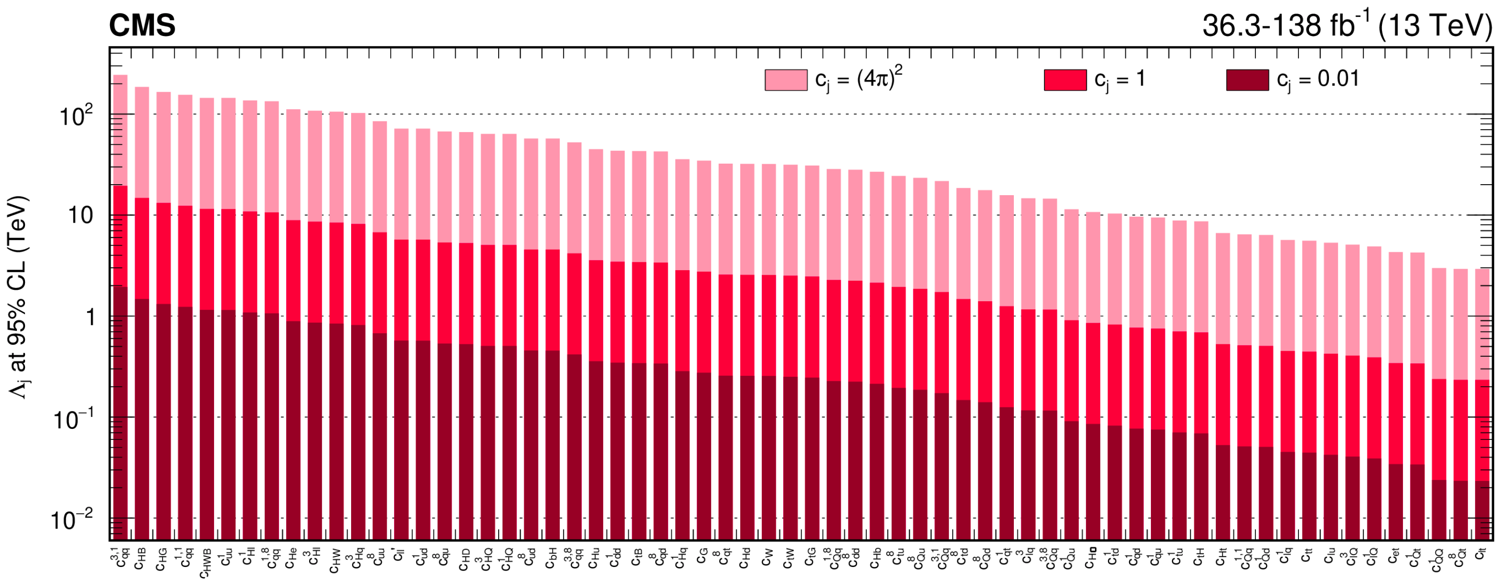


Looking forward to new results from Run-3!

Extra Material

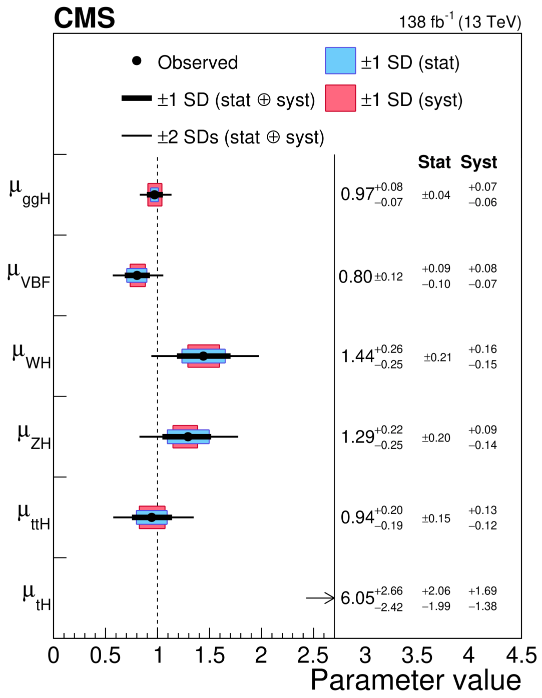
Precision era

LHC Run 1: Higgs boson discovery era

Run (1+)2, 3: Precision measurements of Higgs boson

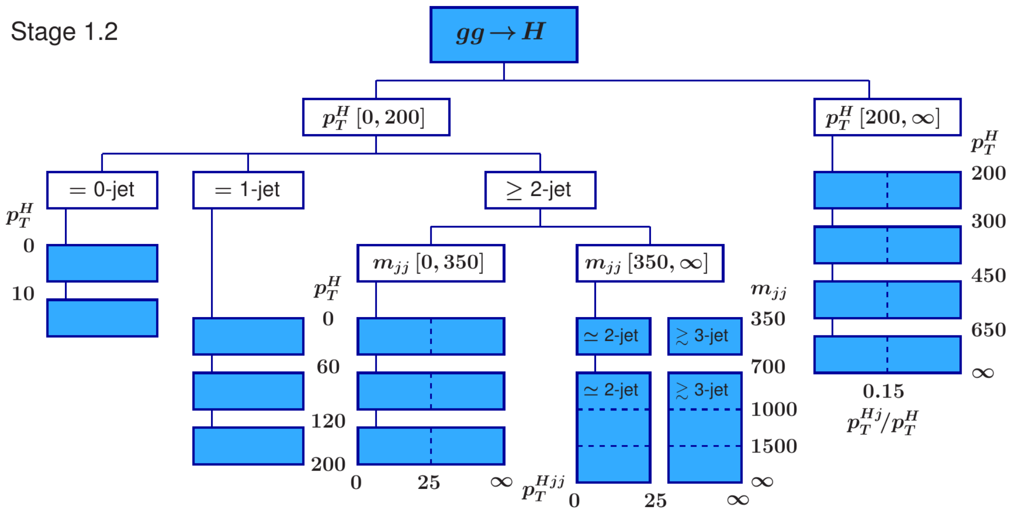
Inclusive measurements

Nature 607 (2022) 7917, 60-68

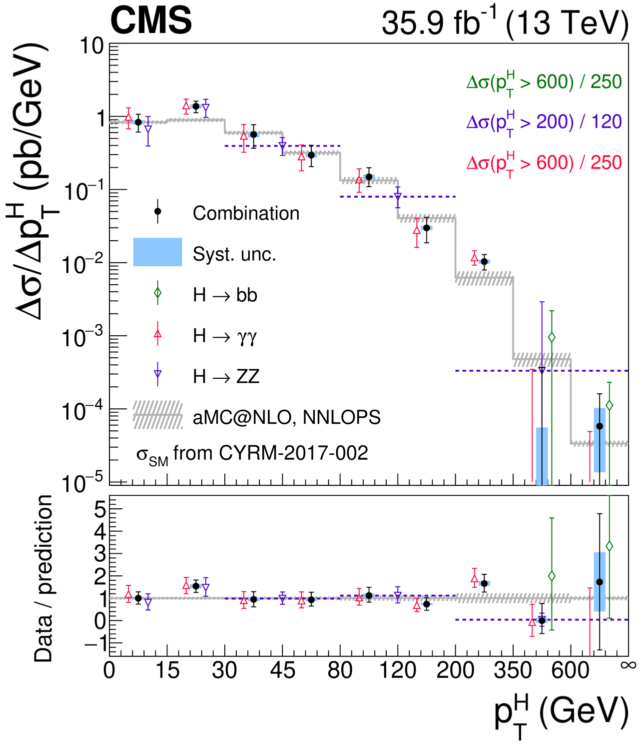


Simplified template cross section (STXS)

LHCHWGFiducialAndSTXS twiki



Differential distributions (fiducial phase space)



Phys.Lett.B 792 (2019) 369-396

Model independence

Granular measurements improve sensitivity to new physics effects away from bulk

SMEFT analysis in V($\rightarrow$leptons) H($\rightarrow b\bar{b}$)

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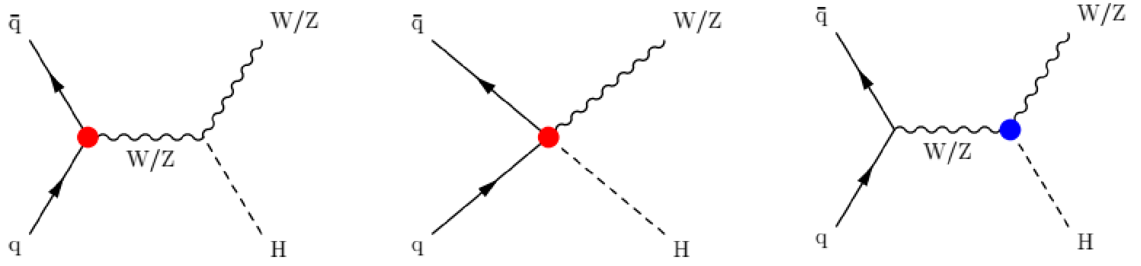
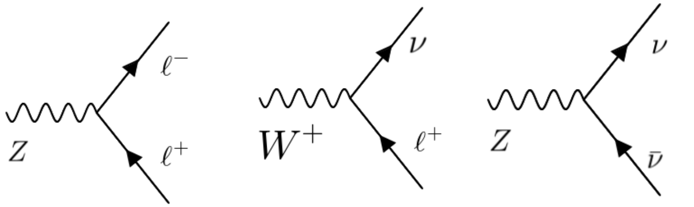


Current operators

Gauge coupling operators

3 final states



2 topologies

- Likelihood-free inference approach to construct optimal observables

  Brehmer, Cranmer, Louppe, Pavez (2018)

  Likelihood ratio between two EFT hypotheses $\rightarrow$ learned by regressing on joint likelihood ratio

$$\boxed{R(\boldsymbol{x}|\boldsymbol{\theta}_1,\boldsymbol{\theta}_0) = \frac{p(\boldsymbol{x}|\boldsymbol{\theta}_1)}{p(\boldsymbol{x}|\boldsymbol{\theta}_0)}} \qquad \boxed{R(\boldsymbol{x},\boldsymbol{z}|\boldsymbol{\theta}_1,\boldsymbol{\theta}_0) = \frac{p(\boldsymbol{x},\boldsymbol{z}|\boldsymbol{\theta}_1)}{p(\boldsymbol{x},\boldsymbol{z}|\boldsymbol{\theta}_0)} = \frac{p(\boldsymbol{x}|\boldsymbol{z})p(\boldsymbol{z}|\boldsymbol{\theta}_1)}{p(\boldsymbol{x}|\boldsymbol{z})p(\boldsymbol{z}|\boldsymbol{\theta}_0)} = \frac{p(\boldsymbol{z}|\boldsymbol{\theta}_1)}{p(\boldsymbol{z}|\boldsymbol{\theta}_0)}}$$

$$p(\boldsymbol{x}|\boldsymbol{\theta}) = \int p(\boldsymbol{x}|\boldsymbol{z})p(\boldsymbol{z}|\boldsymbol{\theta})d\boldsymbol{z}$$

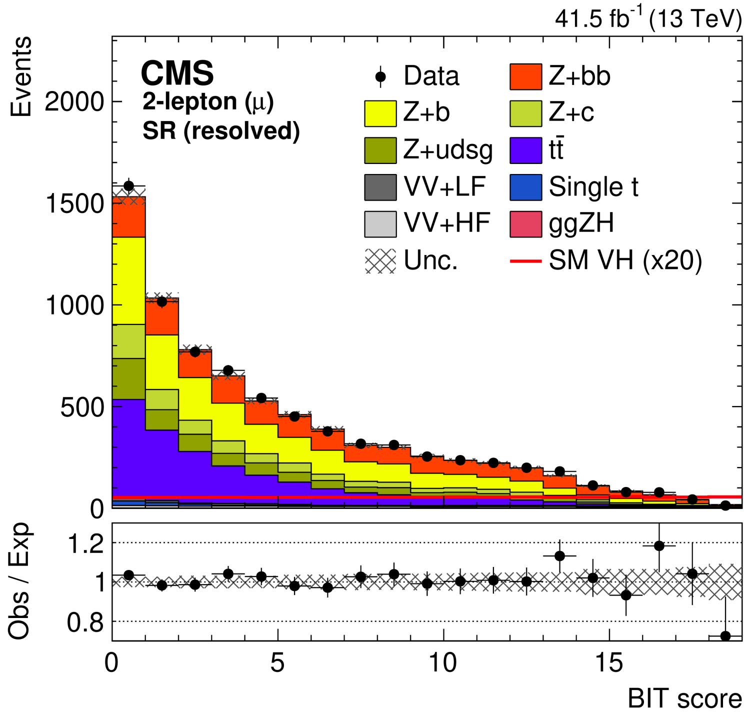
$\boldsymbol{x} \leftarrow$ observable @detector level $\qquad \boldsymbol{z} \leftarrow$ observable @parton level

- Boosted information tree (BIT)

  SC, N. Frohner, L. Lechner, R. Schoefbeck, D. Schwarz (2021)

  Using decision trees to regress on learn likelihood ratio terms

$$R(\boldsymbol{x}|\boldsymbol{\theta}_1,\boldsymbol{\theta}_0) = 1 + (\theta_1-\theta_0)_a \boxed{R_a(\boldsymbol{x})} + \frac{1}{2}(\theta_1-\theta_0)_a(\theta_1-\theta_0)_b \boxed{R_{a,b}(\boldsymbol{x})}$$



Binned template used for signal extraction

$\rightarrow$ optimized to extract 6 Wilson coefficients simultaneously

SMEFT analysis in V($\rightarrow$leptons) H($\rightarrow b\bar{b}$): Results

- 1- & 2-dimensional constraints reported on Wilson coefficients in Warsaw basis

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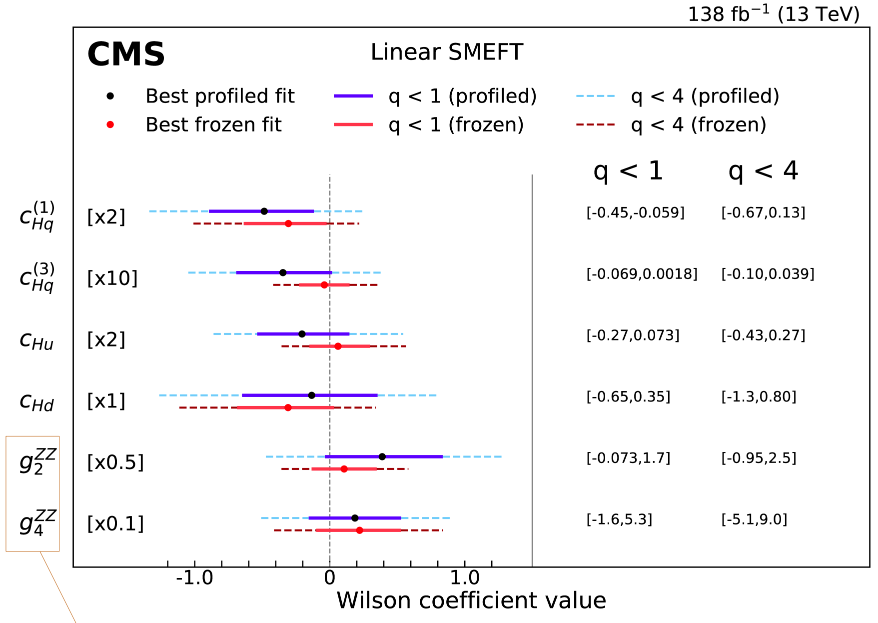
$$\sigma \sim |\mathcal{M}_{\mathrm{SMEFT}}|^2$$

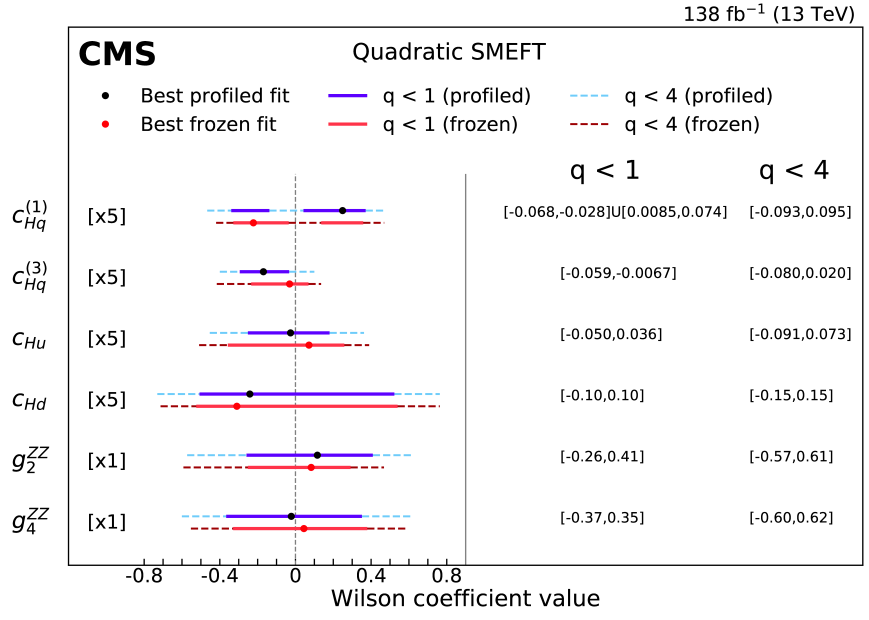
$$\sim |\mathcal{M}_{\mathrm{SM}}|^2 + \sum_i \frac{c_i}{\Lambda^2} 2\mathrm{Re}(\mathcal{M}^{\dagger}_{\mathrm{SM}}\mathcal{M}_{6,i}) + \sum_i \frac{c_i^2}{\Lambda^4}|\mathcal{M}_{6,i}|^2 + \sum_i \sum_{j,j>i} \frac{c_i c_j}{\Lambda^4}\mathcal{M}_{6,i}\mathcal{M}_{6,j}$$

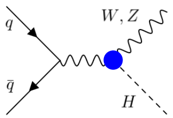
Λ = 1 TeV

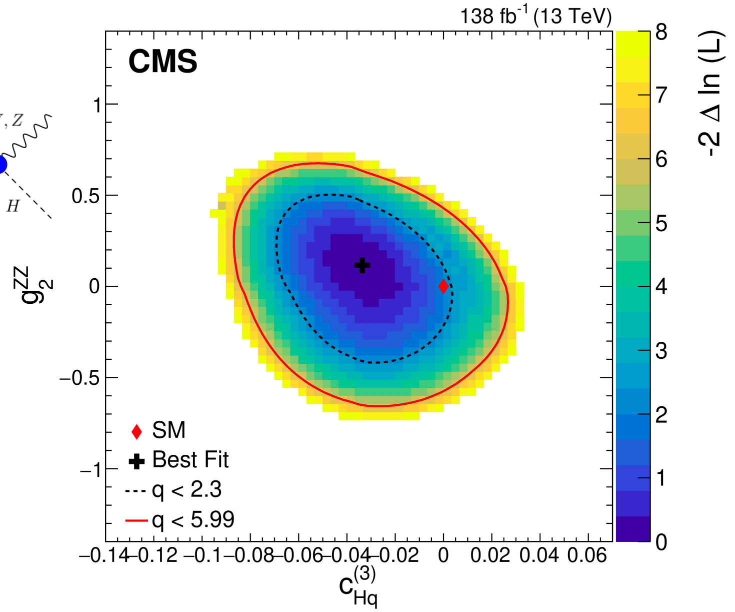
p-value = 73%

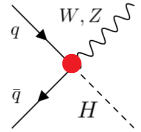
p-value = 84%











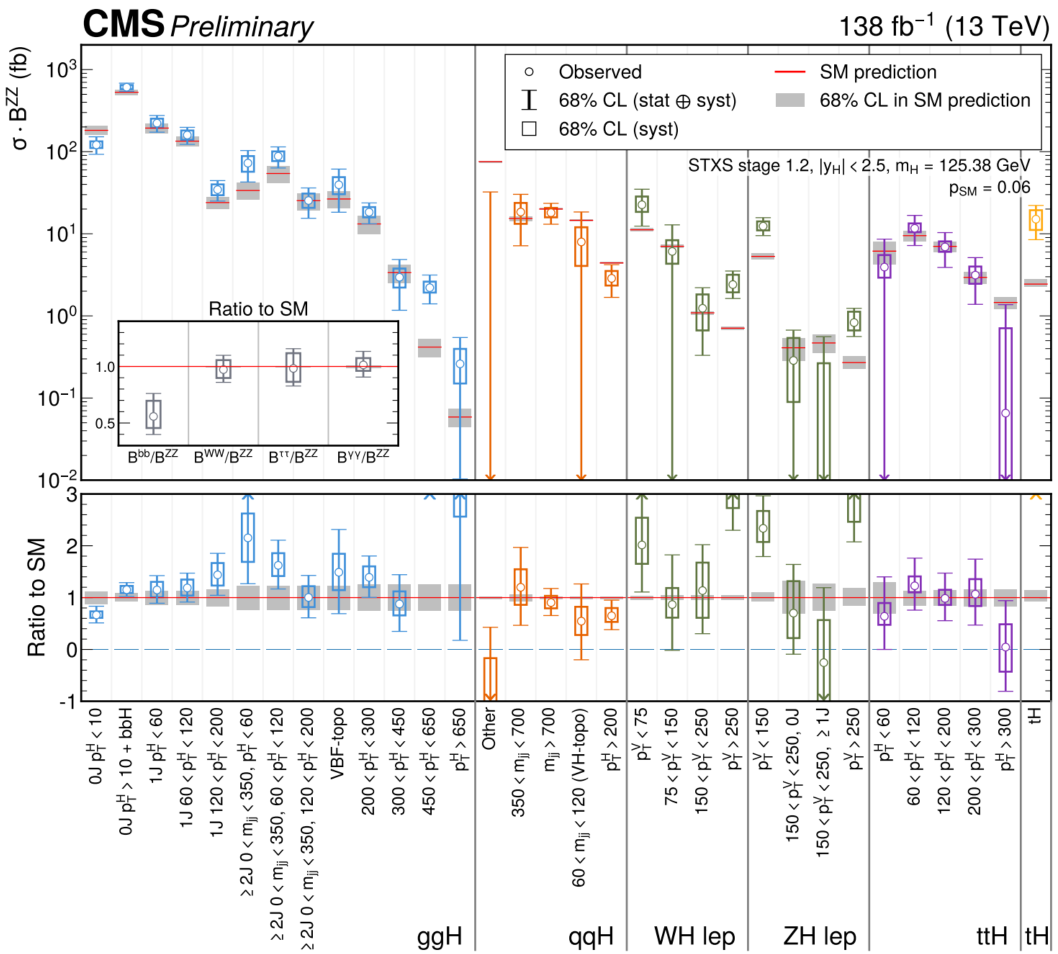
Rotation to mass-eigenstate basis

$$g_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{\mathrm{HB}} + c_w^2 c_{\mathrm{HW}} + s_w c_w c_{\mathrm{HWB}}\right) \quad g_4^{ZZ} = \tilde{g}_2^{ZZ} = -2\frac{v^2}{\Lambda^2}\left(s_w^2 c_{\mathrm{H\widetilde{B}}} + c_w^2 c_{\mathrm{H\widetilde{W}}} + s_w c_w c_{\mathrm{H\widetilde{W}B}}\right)$$

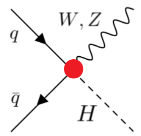
STXS combination

CMS-PAS-HIG-21-018

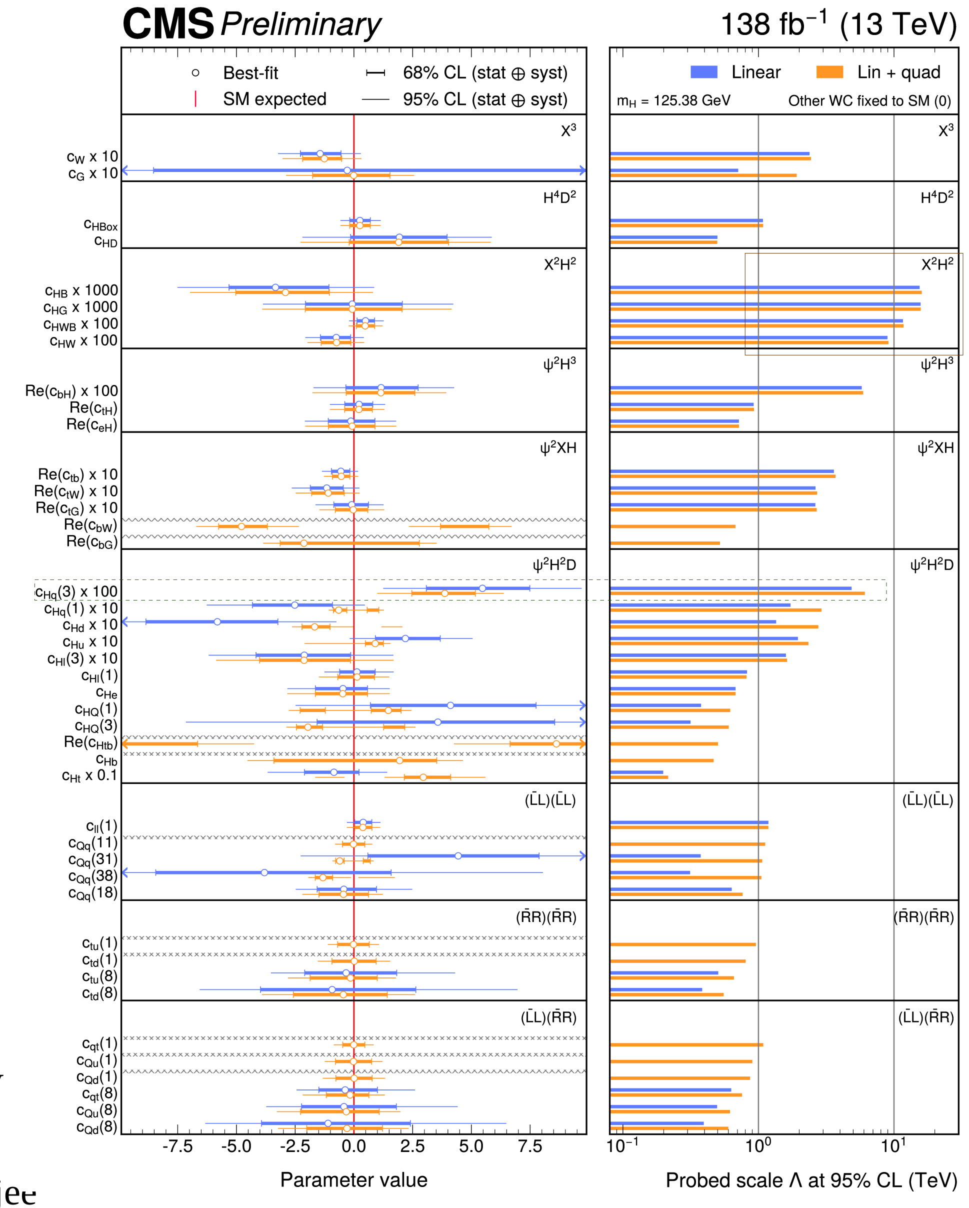
Combination of measurements in simplified template cross section (STXS) framework
→ interpreted in terms of SMEFT operator coefficients



Largest discrepancy
p_{SM}: 1%



Constraints on 43 coefficients *fitted individually*



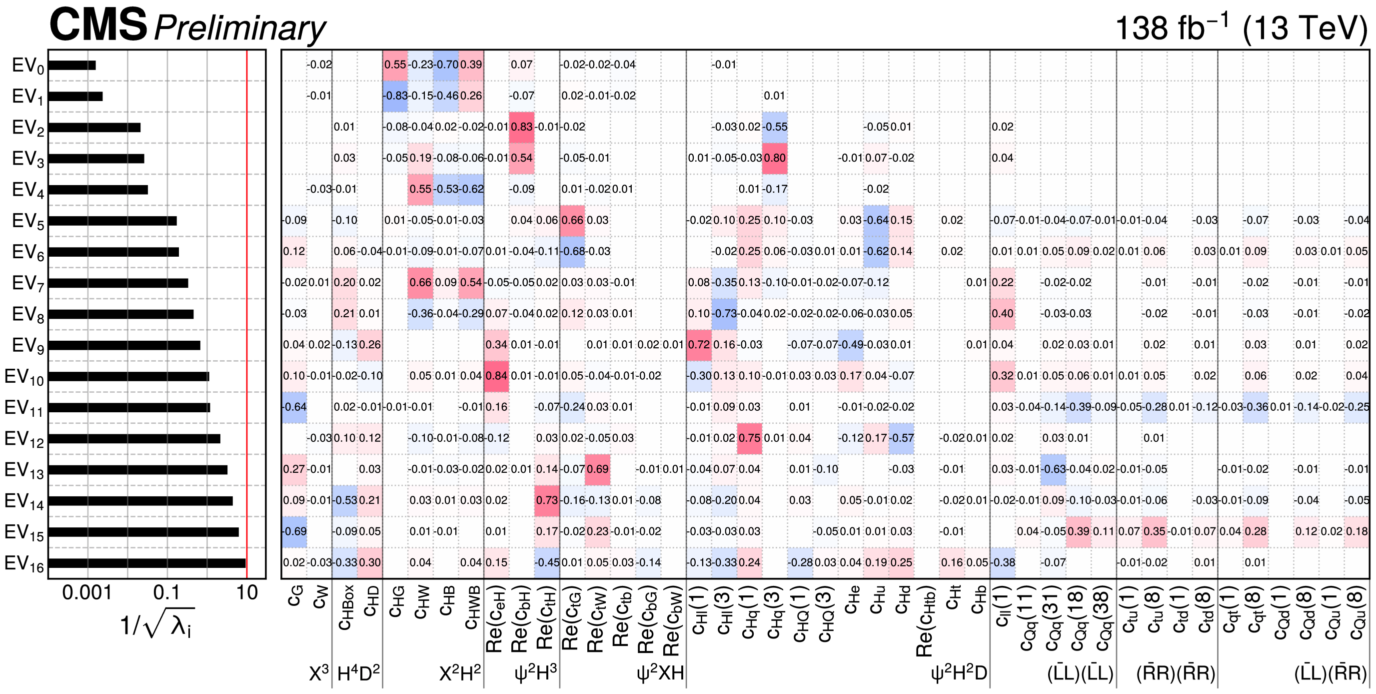
Sensitivity up to ~20 TeV energy scale

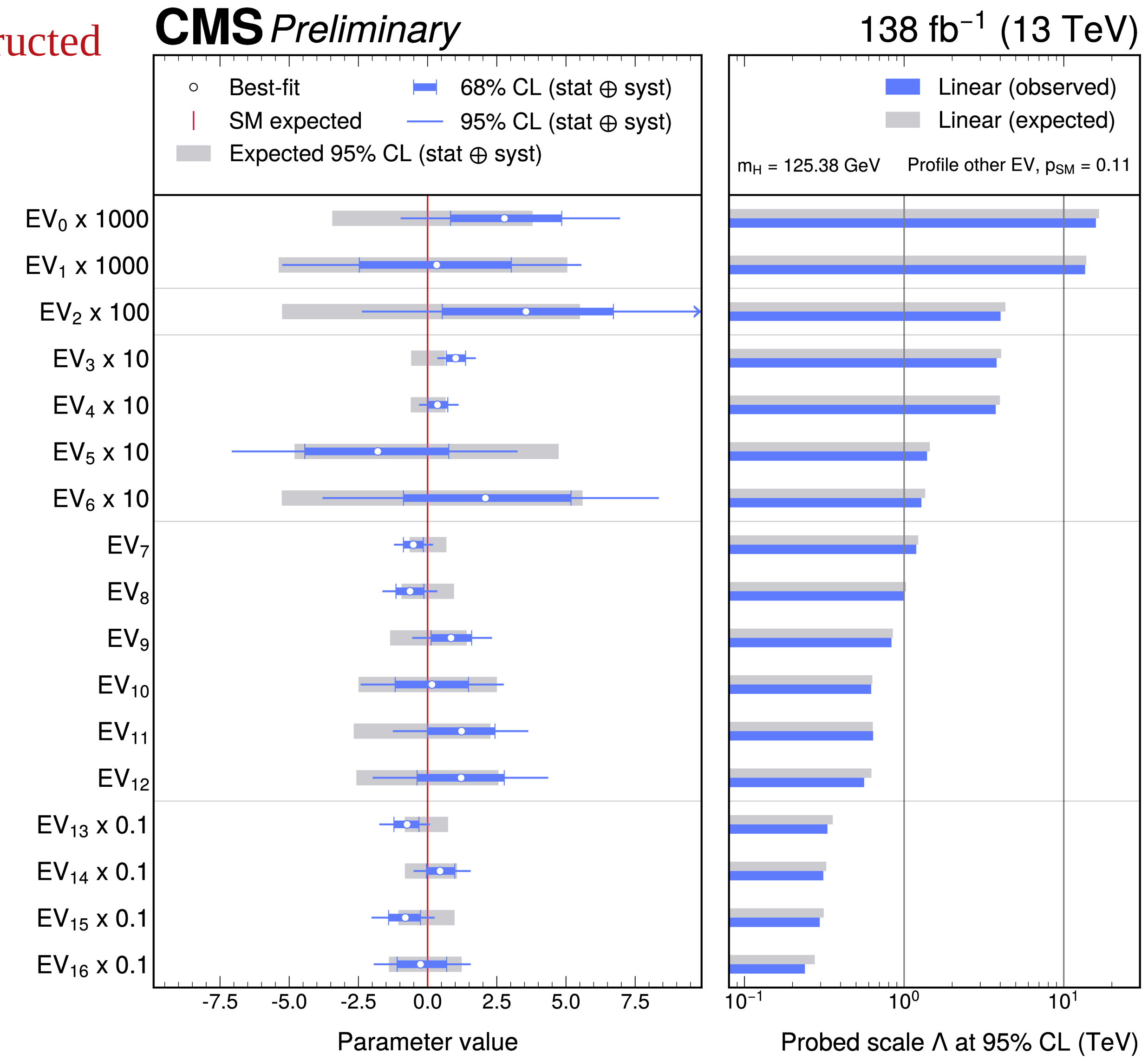
SMEFT parameterization in STXS bins for both H production & decay

STXS combination: EFT interpretation (2) CMS-PAS-HIG-21-018

Principle component analysis (PCA) performed
for probing multiple operators together → 17 eigen-vectors (EVs) constructed

EVs → linear combinations of Wilson coefficients



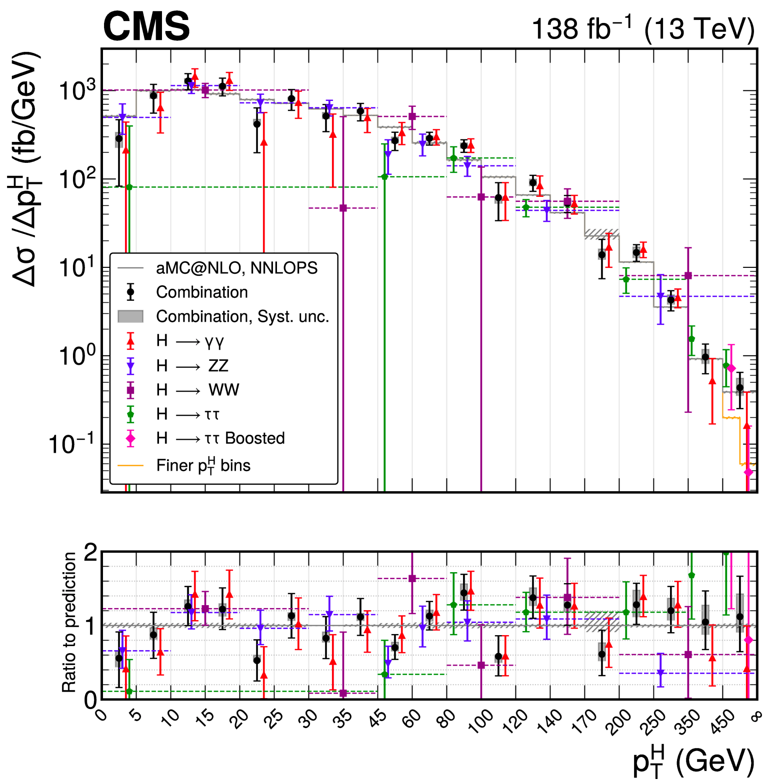


Good compatibility with SM: p-value ~ 11% *varying all EVs together*

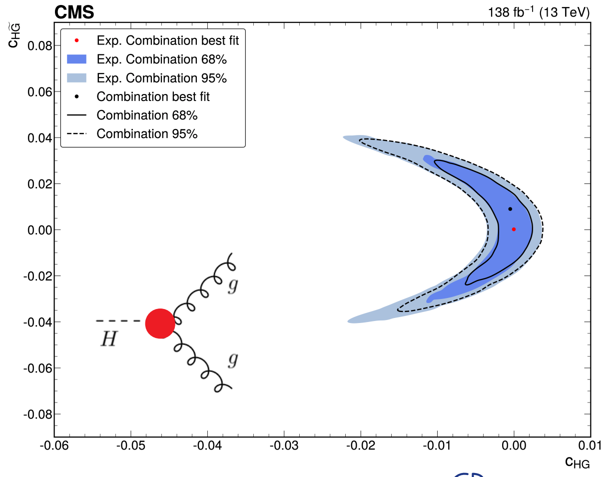
Differential combination: EFT interpretation

Differential distributions in fiducial phase space combined across H decay modes

→ Reinterpreted in SMEFT framework



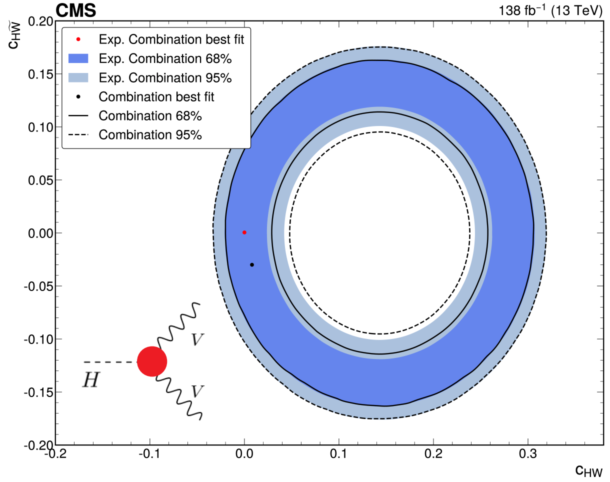
CP-odd



CP-even

Only two coefficients varied in each case

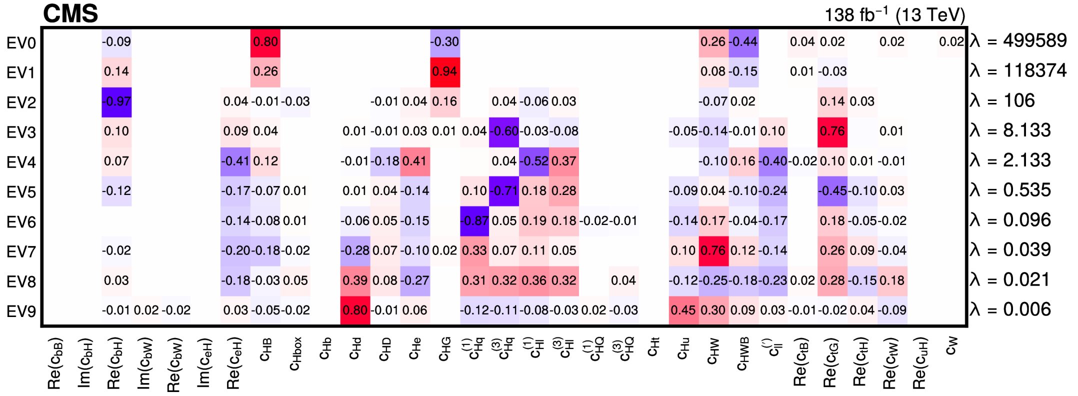
CP-odd

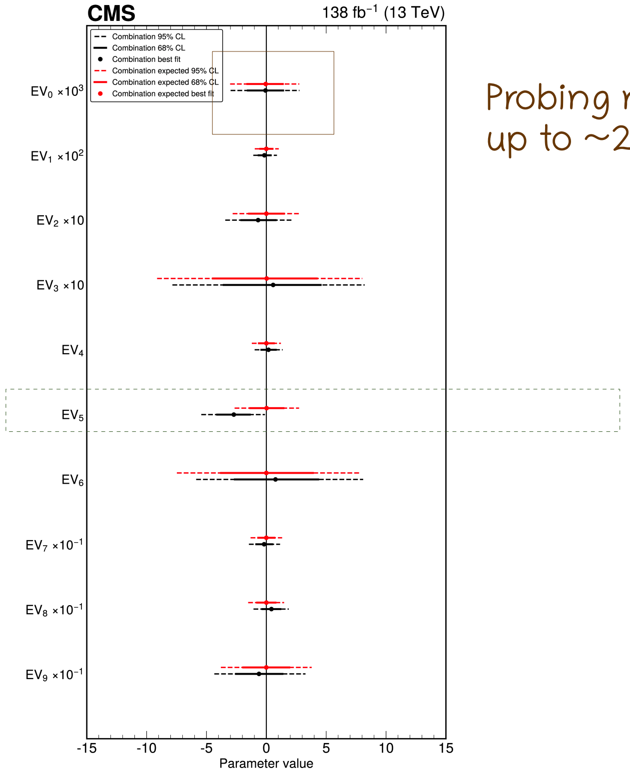


CP-even

Principle component analysis

→ 10 eigen-vectors (EVs) from 31 Wilson coefficients





Probing new physics scale up to ~20 TeV

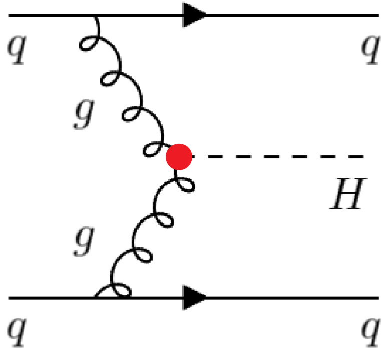
Largest discrepancy p_{SM}: 3.6%

Anomalous Higgs to gluon couplings

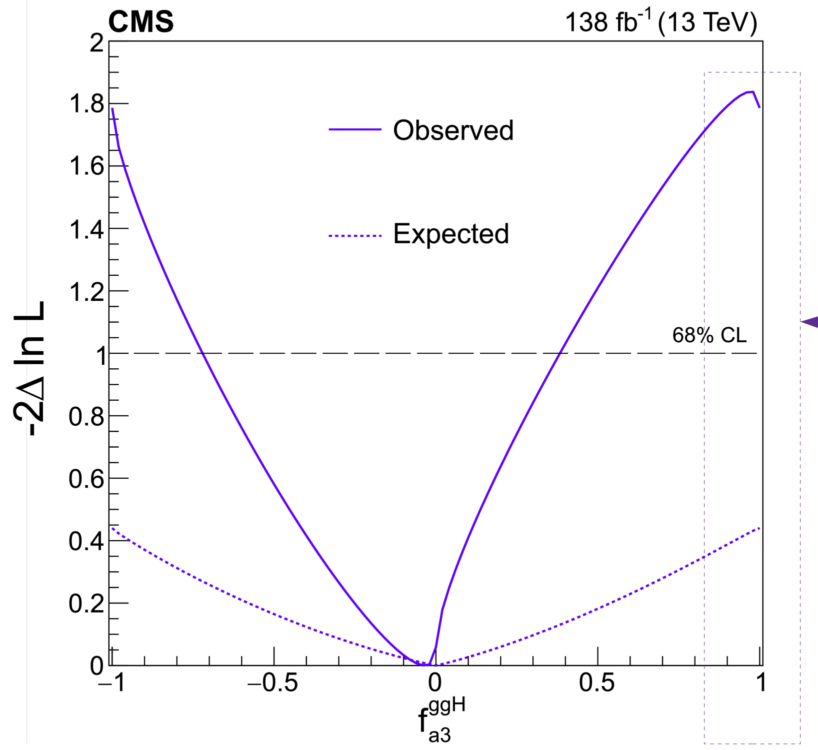
Eur.Phys.J.C 84 (2024) 8, 779

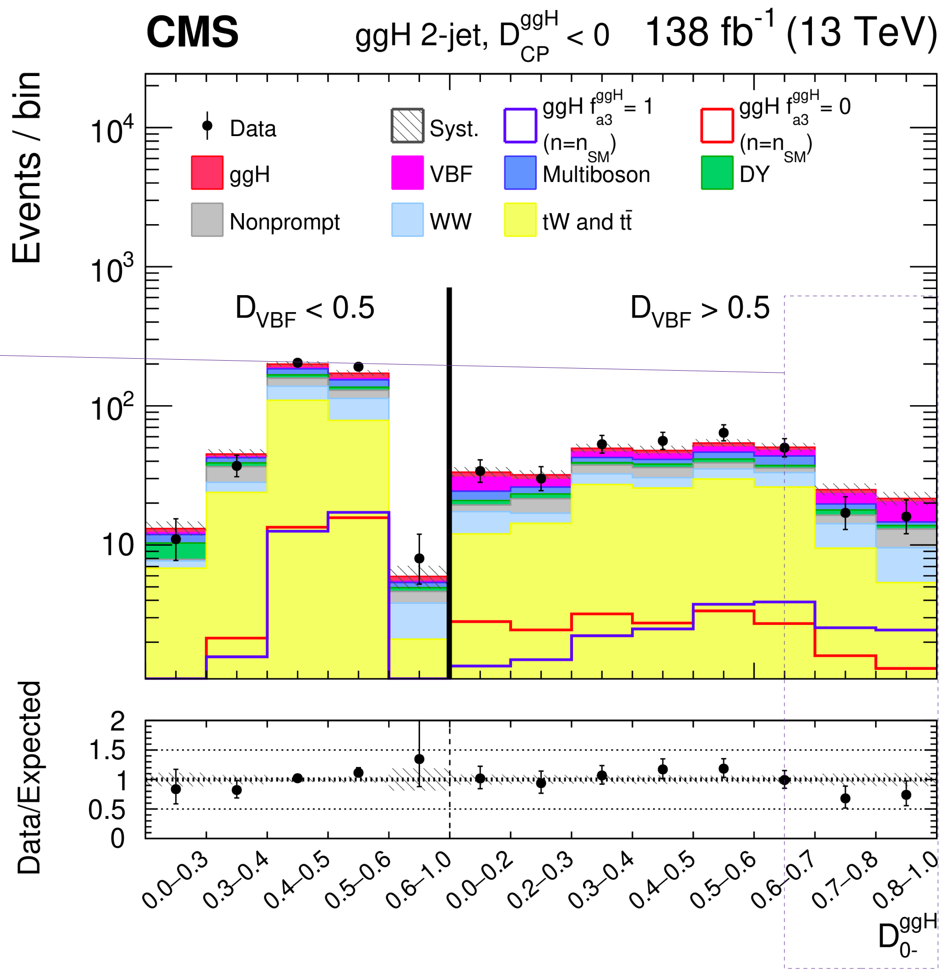
Higgs-to-gluon coupling is probed in H+2jets events

H→ WW*



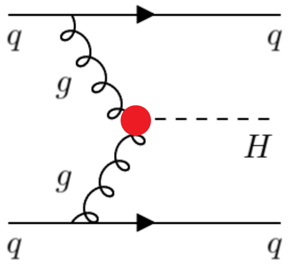
$$f_{a3}^{ggH} = \frac{|a_3^{gg}|^2}{|a_2^{gg}|^2 + |a_3^{gg}|^2} \operatorname{sgn}\left(\frac{a_3^{gg}}{a_2^{gg}}\right)$$





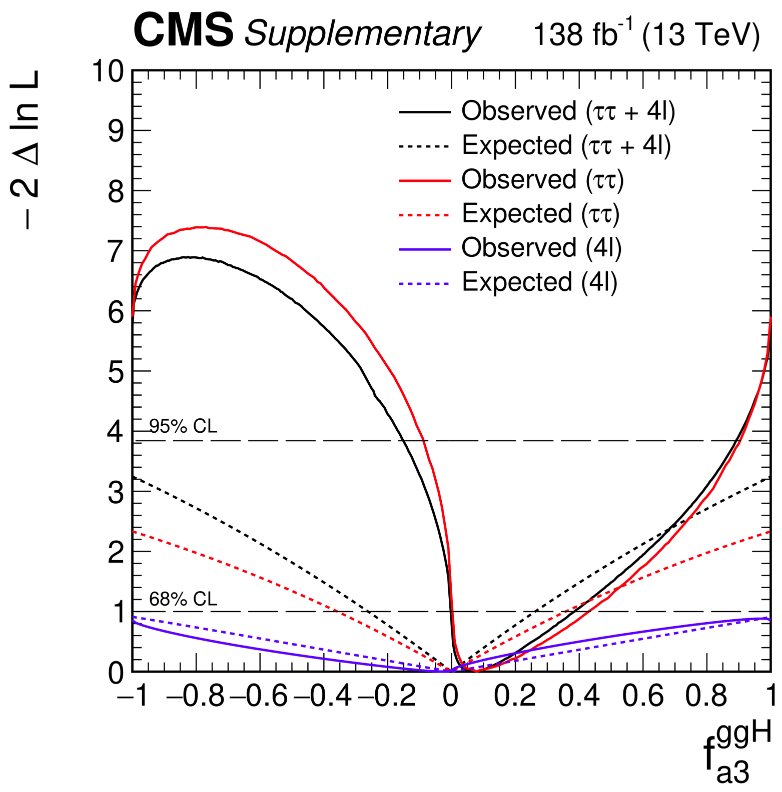
CP-odd cross section fraction: = -0.034 [+ 0.38 – 0.72 @ 68% CL]

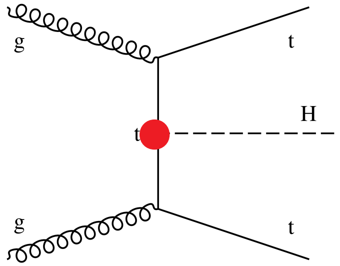
Anomalous Higgs to gluon & top couplings



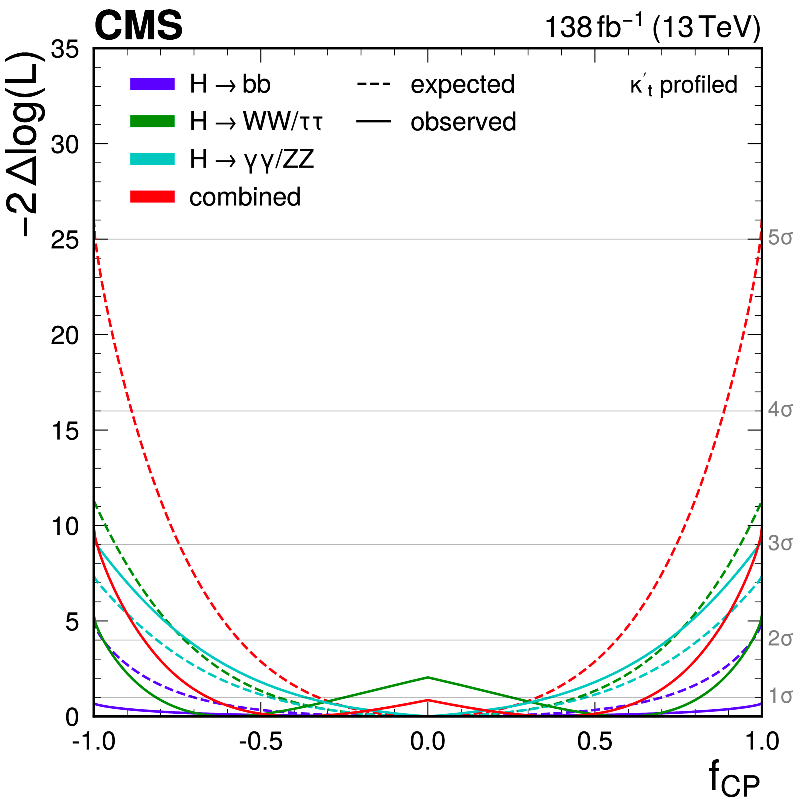
H→ ττ + H→ ZZ*→ 4l

Phys.Rev.D 108 (2023) 3, 032013





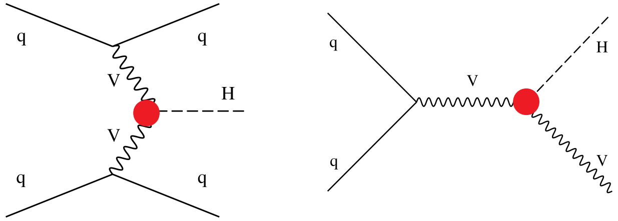
JHEP 02 (2025) 097



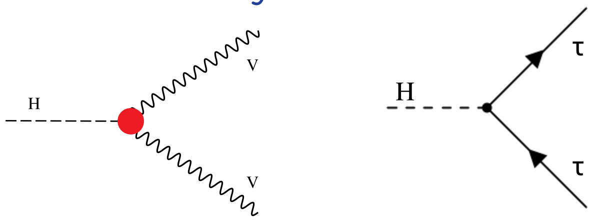
$f_{a3}^{ggH} = 0.07$ [+ 0.32 – 0.07 @ 68% CL]

Anomalous H-V couplings: CP-even

AC in production

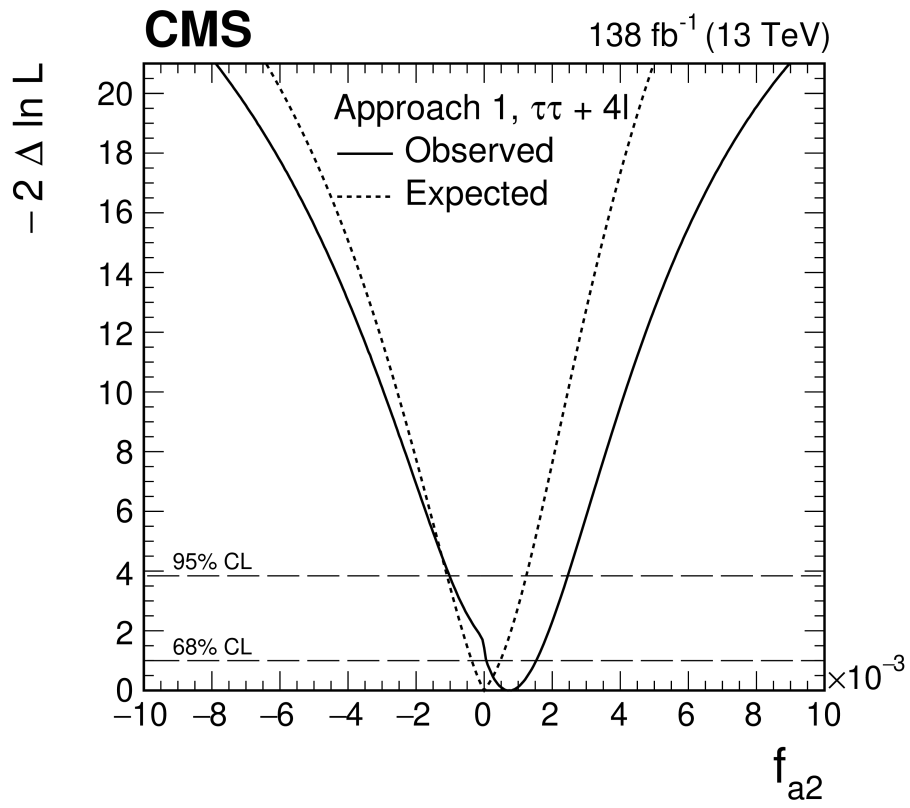


AC in decay



$$\mathcal{A}(\mathrm{HVV}) \sim \left[a_1^{\mathrm{VV}} + \frac{\kappa_1^{\mathrm{VV}} q_1^2 + \kappa_2^{\mathrm{VV}} q_2^2}{\left(\Lambda_1^{\mathrm{VV}}\right)^2} \right] m_{\mathrm{V}1}^2 \epsilon_{\mathrm{V}1}^* \epsilon_{\mathrm{V}2}^* + \boxed{a_2^{\mathrm{VV}}} f_{\mu\nu}^{*(1)} f^{*(2)\mu\nu} + a_3^{\mathrm{VV}} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2)\mu\nu}$$

Phys.Rev.D 108 (2023) 3, 032013



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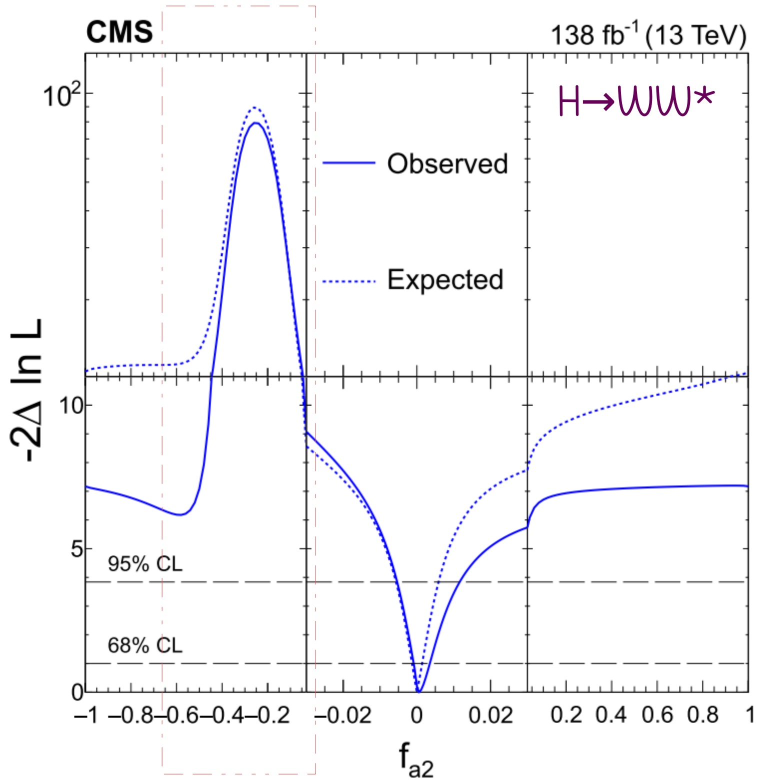


Approach 1:

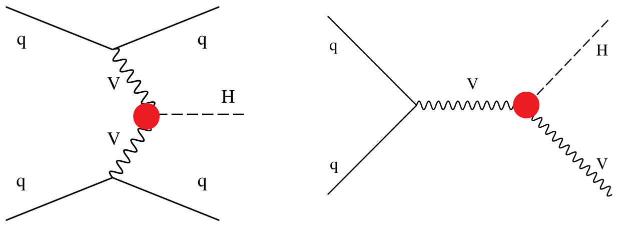
Equal ZZ & WW couplings $a_i^{WW}=a_i^{ZZ}$

Interference effects are significant for a_2

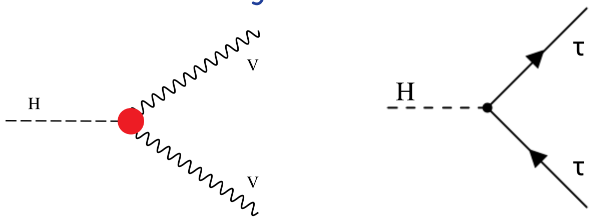
- Strong constraints on CP-even anomalous Higgs to electroweak vector boson couplings

Anomalous H-V couplings: CP-odd

AC in production



AC in decay



$$\mathcal{A}(\mathrm{HVV}) \sim \left[a_1^{\mathrm{VV}} + \frac{\kappa_1^{\mathrm{VV}} q_1^2 + \kappa_2^{\mathrm{VV}} q_2^2}{\left(\Lambda_1^{\mathrm{VV}}\right)^2} \right] m_{\mathrm{V1}}^2 \epsilon_{\mathrm{V1}}^* \epsilon_{\mathrm{V2}}^* + a_2^{\mathrm{VV}} f_{\mu\nu}^{*(1)} f^{*(2)\mu\nu} + \boxed{a_3^{\mathrm{VV}}} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2)\mu\nu}$$

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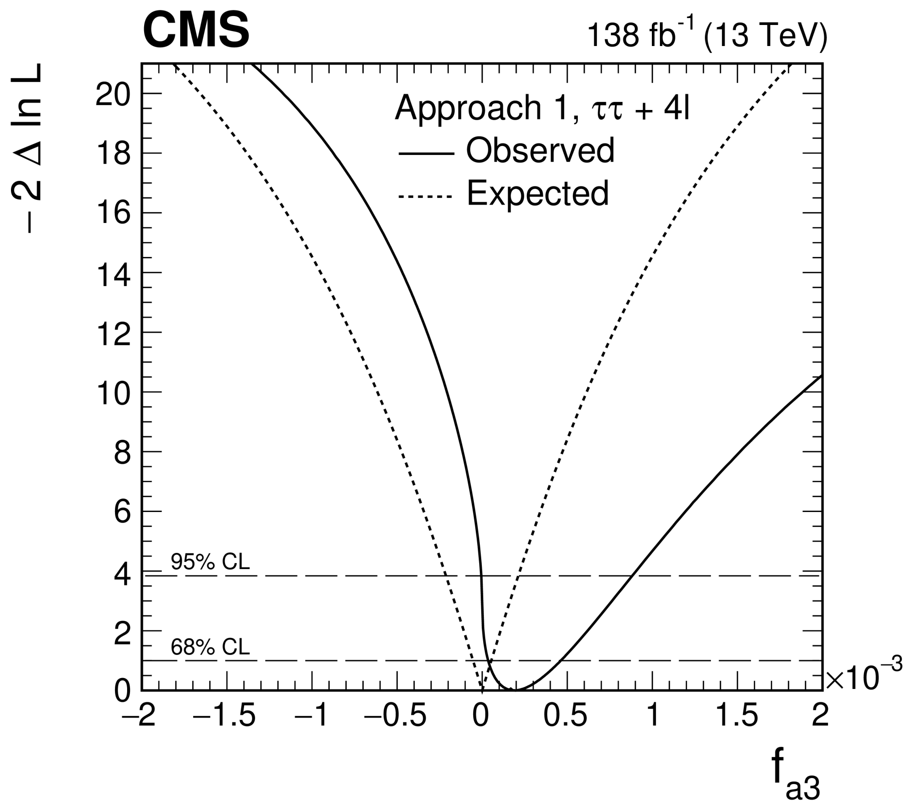

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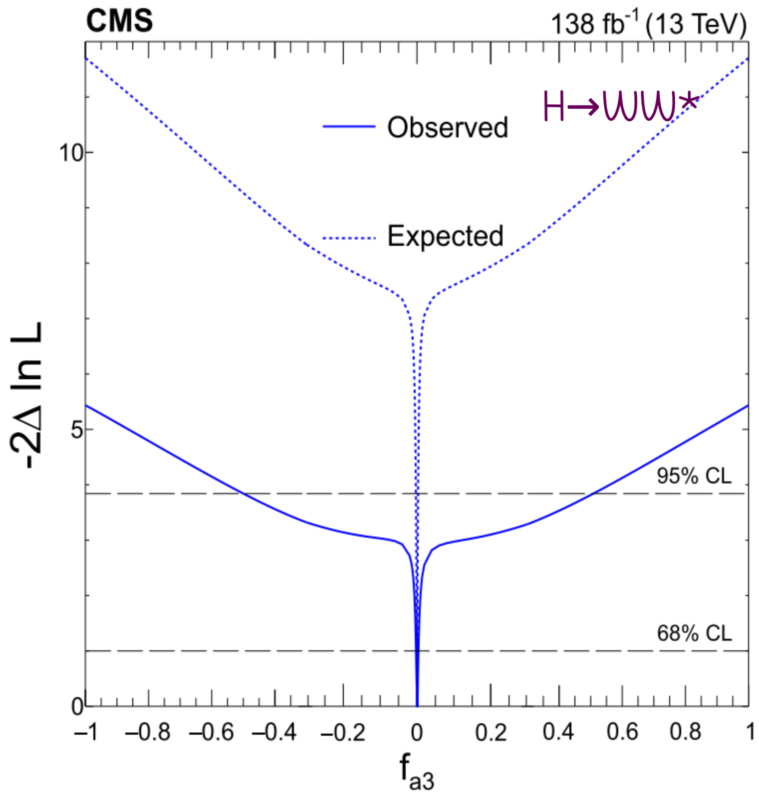


Approach 1:

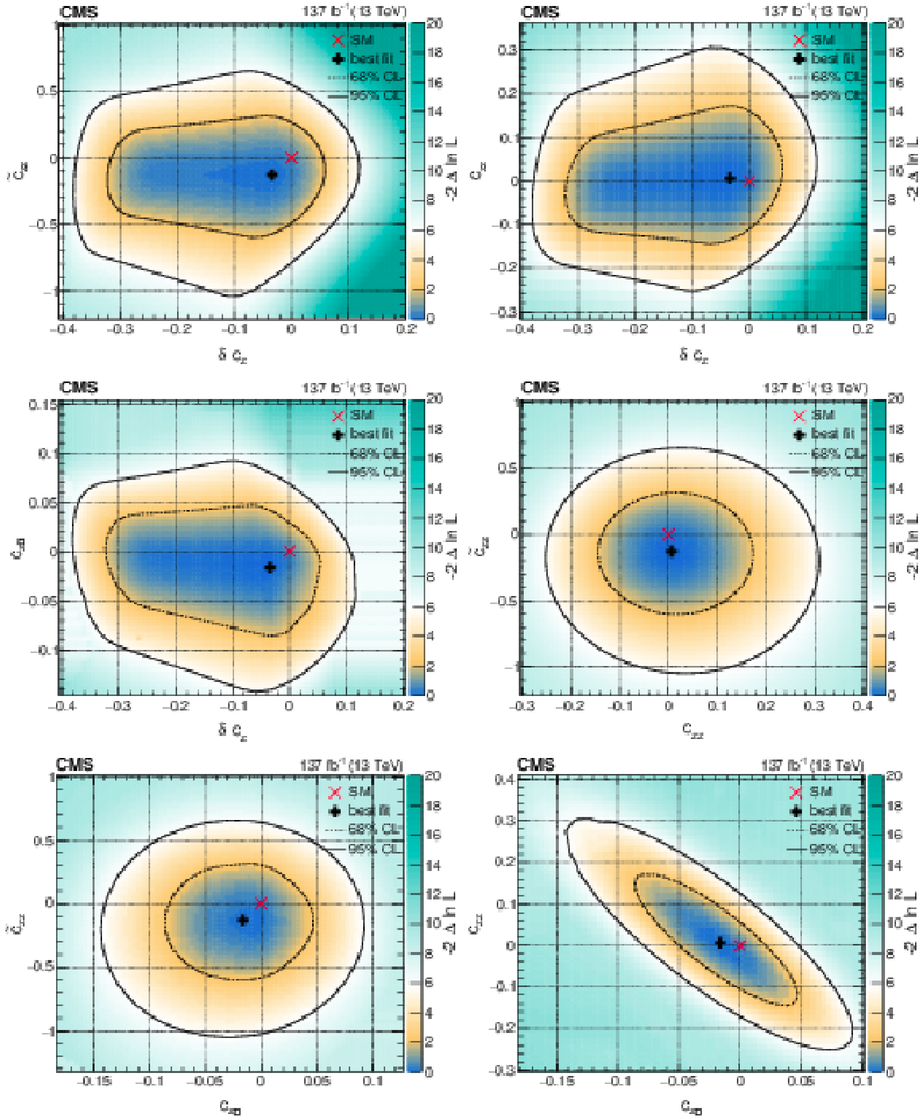
Equal ZZ & WW couplings $a_i^{WW}=a_i^{ZZ}$

- Strong constraints on CP-odd anomalous Higgs to electroweak vector boson couplings

Anomalous H-V couplings with H→ZZ* decay mode

Higgs basis

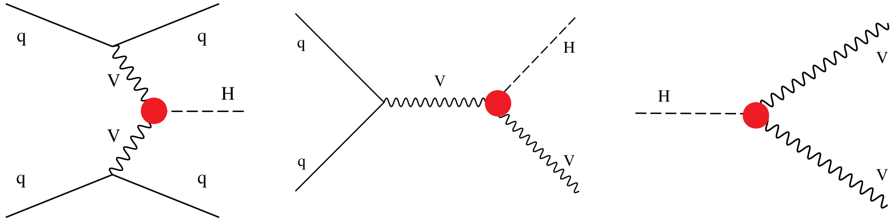
Phys.Rev.D 104 (2021) 5, 052004



Warsaw basis

Channels	Coupling	Observed	Expected
VBF & VH & H $\to 4\ell$	$c_{\mathrm{H}\square}$	$0.04^{+0.43}_{-0.45}$	$0.00^{+0.75}_{-0.93}$
	c_{HD}	$-0.73^{+0.97}_{-4.21}$	$0.00^{+1.06}_{-4.60}$
	c_{HW}	$0.01^{+0.18}_{-0.17}$	$0.00^{+0.39}_{-0.28}$
	c_{HWB}	$0.01^{+0.20}_{-0.18}$	$0.00^{+0.42}_{-0.31}$
	c_{HB}	$0.00^{+0.05}_{-0.05}$	$0.00^{+0.03}_{-0.08}$
	$c_{\mathrm{H\tilde{W}}}$	$-0.23^{+0.51}_{-0.52}$	$0.00^{+1.11}_{-1.11}$
	$c_{\mathrm{H\tilde{W}B}}$	$-0.25^{+0.56}_{-0.57}$	$0.00^{+1.21}_{-1.21}$
	$c_{\mathrm{H\tilde{B}}}$	$-0.06^{+0.15}_{-0.16}$	$0.00^{+0.33}_{-0.33}$

Anomalous H-V couplings with H→WW* decay mode



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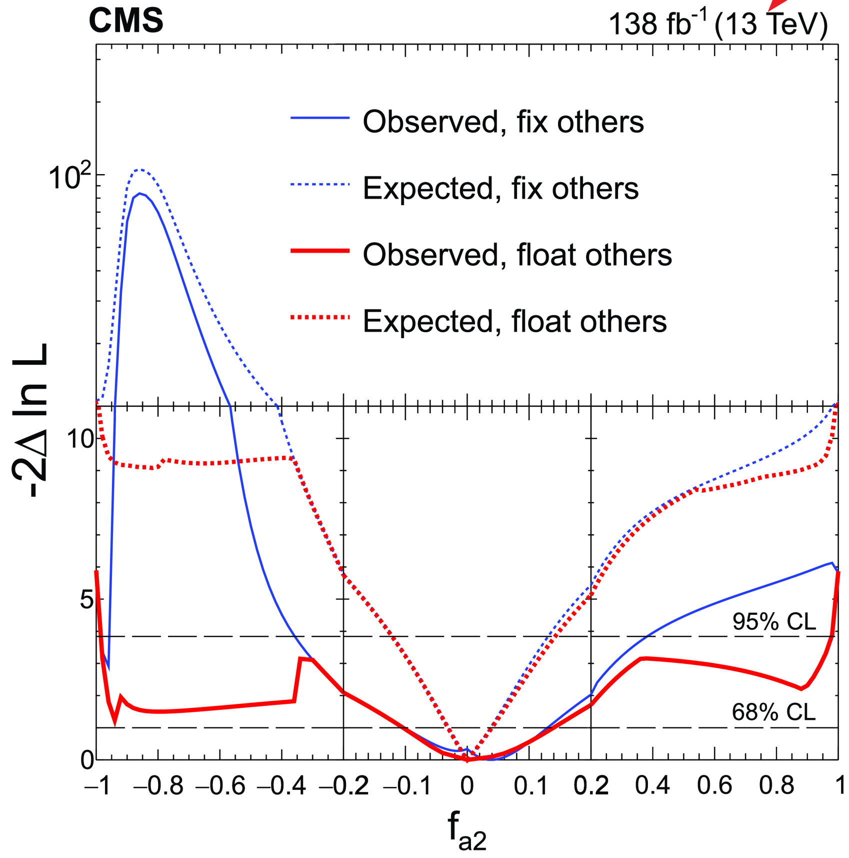
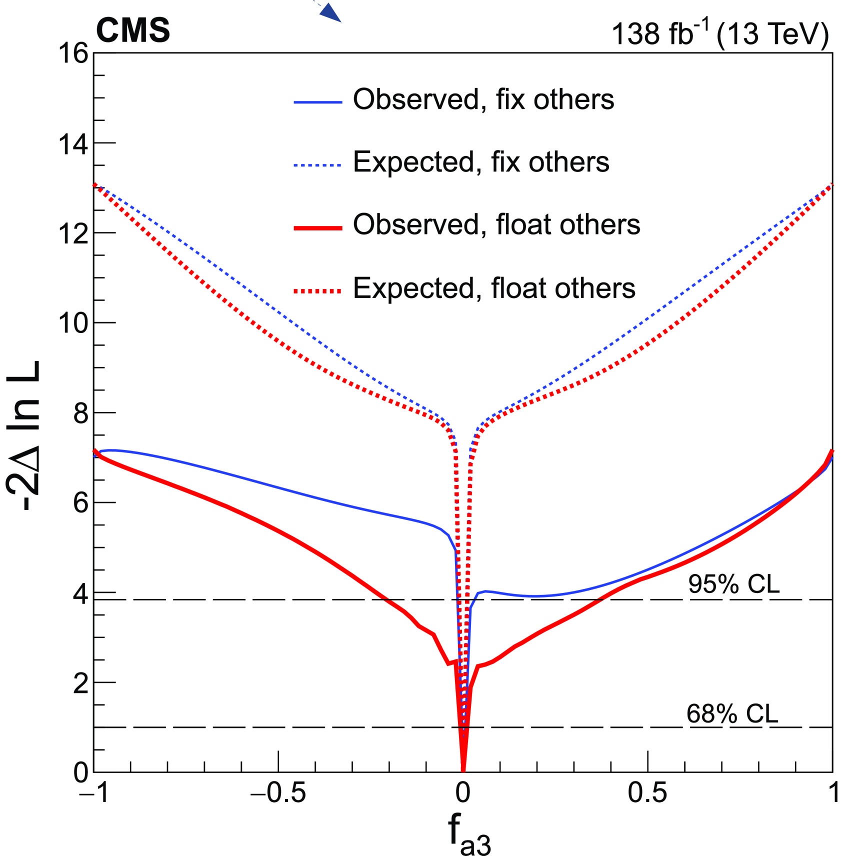
$$\mathcal{A}(\mathrm{HVV}) \sim \left[a_1^{\mathrm{VV}} + \frac{\kappa_1^{\mathrm{VV}} q_1^2 + \kappa_2^{\mathrm{VV}} q_2^2}{\left(\Lambda_1^{\mathrm{VV}}\right)^2}\right] m_{\mathrm{V1}}^2 \epsilon_{\mathrm{V1}}^* \epsilon_{\mathrm{V2}}^* + \boxed{a_2^{\mathrm{VV}}} f_{\mu\nu}^{*(1)} f^{*(2)\mu\nu} + \boxed{a_3^{\mathrm{VV}}} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2)\mu\nu}$$

<u>Approach 2:</u>

Use SU(2)xU(1) symmetry

$$a_1^{\mathrm{WW}} = a_1^{\mathrm{ZZ}},$$
$$a_2^{\mathrm{WW}} = c_{\mathrm{w}}^2 a_2^{\mathrm{ZZ}},$$
$$a_3^{\mathrm{WW}} = c_{\mathrm{w}}^2 a_3^{\mathrm{ZZ}},$$
$$\frac{\kappa_1^{\mathrm{WW}}}{(\Lambda_1^{\mathrm{WW}})^2} = \frac{1}{c_{\mathrm{w}}^2 - s_{\mathrm{w}}^2}\left(\frac{\kappa_1^{\mathrm{ZZ}}}{(\Lambda_1^{\mathrm{ZZ}})^2} - 2s_{\mathrm{w}}^2 \frac{a_2^{\mathrm{ZZ}}}{m_{\mathrm{Z}}^2}\right)$$
$$\frac{\kappa_2^{\mathrm{Z}\gamma}}{(\Lambda_1^{\mathrm{Z}\gamma})^2} = \frac{2s_{\mathrm{w}}c_{\mathrm{w}}}{c_{\mathrm{w}}^2 - s_{\mathrm{w}}^2}\left(\frac{\kappa_1^{\mathrm{ZZ}}}{(\Lambda_1^{\mathrm{ZZ}})^2} - \frac{a_2^{\mathrm{ZZ}}}{m_{\mathrm{Z}}^2}\right),$$





Compatibility with SM: p-value ~ 91% (while floating all anomalous couplings together)

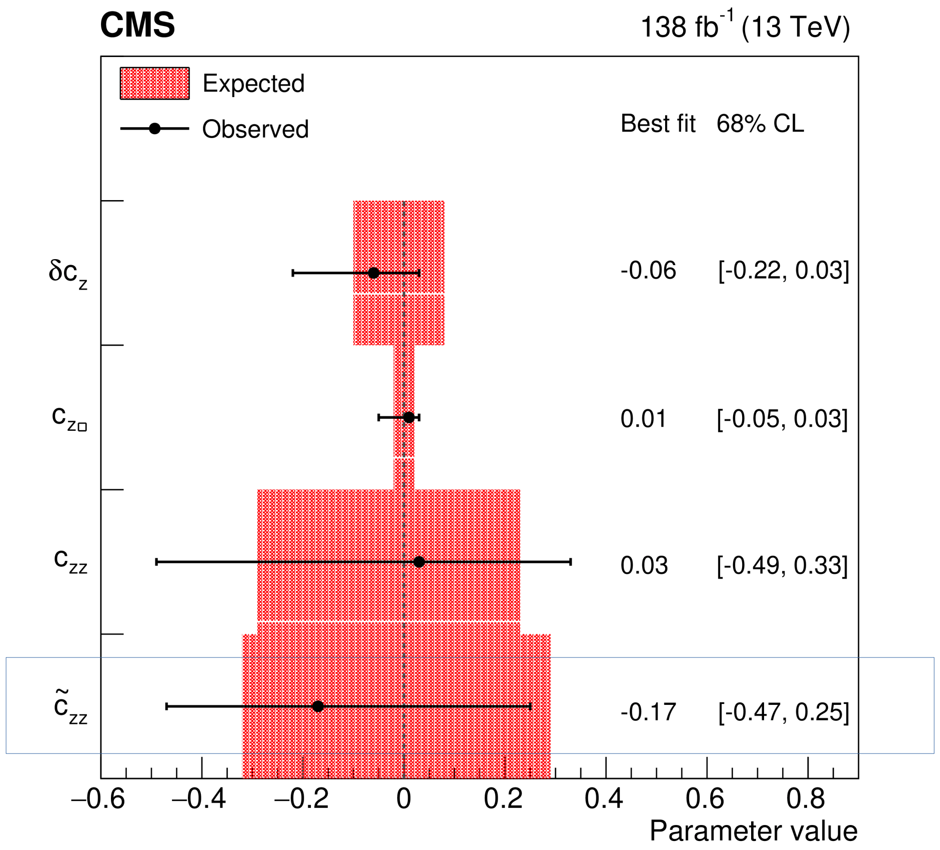
Constraints translated to SMEFT operator coefficients (including CP-odd operators) in Higgs & Warsaw bases

Anomalous H-V couplings with H→WW* decay mode

arXiv: 2403.00657
(accepted in EPJC)

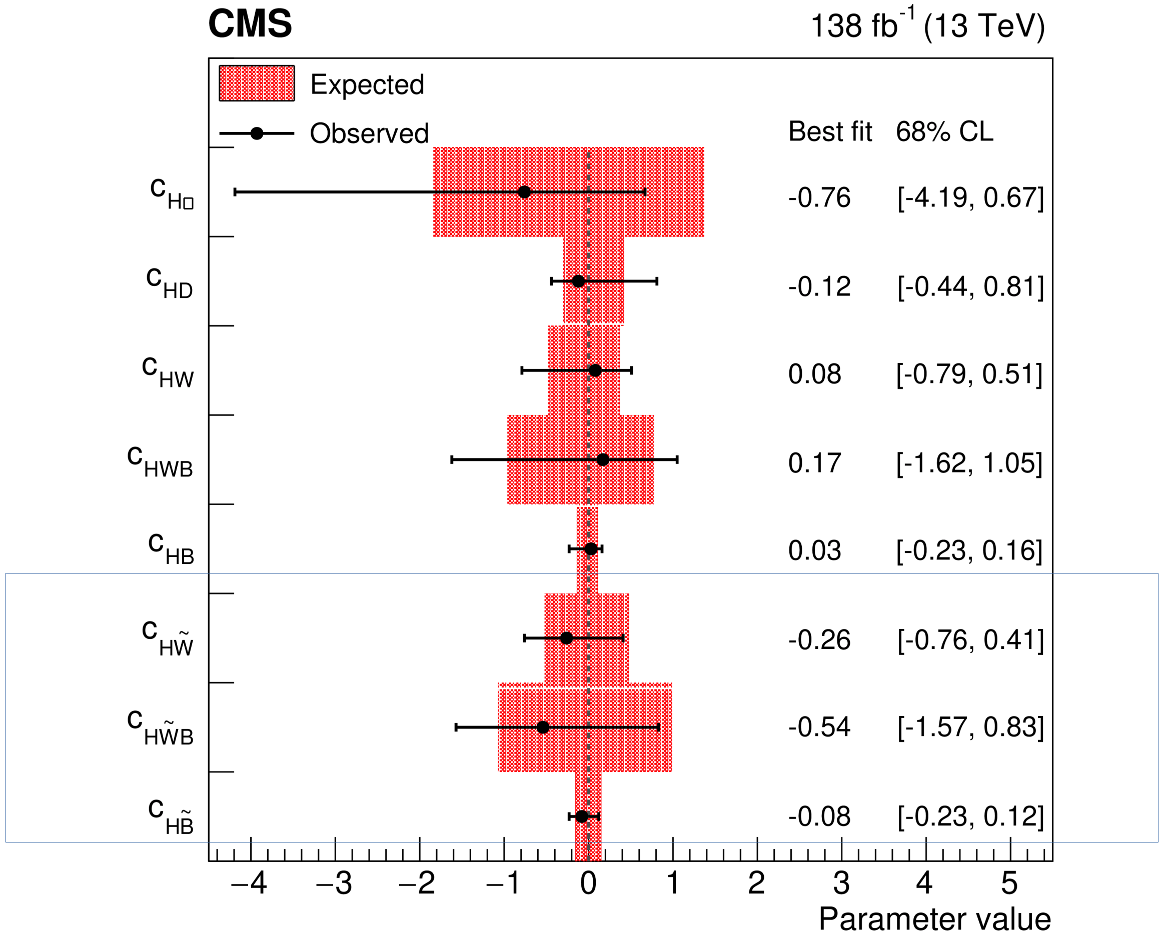
Constraints translated to SMEFT operator coefficients

Higgs basis



CP-odd

Warsaw basis



Inclusive jets in combination