# Effective Field Theories

3 slides of comparison
Thanks to Jay Sandesara and Angela Taliercio

Paolo Francavilla - University of Pisa - INFN Pisa
Higgs Hunting 2023  11-13/9/2023


# (Limited Sub)Set of publications

## CMS

Phys. Rev. D 104, 052004:
4lep &comb with ttHγγ - Anom. Coupling, SMEFT Warsaw

Nat. Phys. 18 (2022):
Offshell (and onshell)- Anom. Coupling,

CMS-PAS-HIG-22-008: HWW Anom. Coupling SMEFT Higgs

Phys. Rev. D 108, 032013:
Hττ & comb with 4lep and ttHγγ - Anom. Coupling

---

Phys. Rev. Lett. 125 (2020) 061801 :
ttHγγ - CP angle

JHEP 07 (2023) 092:
ttH/tH ML (&comb with ttH4l +ttHγγ) - CP angle

CMS-PAS-HIG-19-011:
ttHbb - CP angle

JHEP06(2022)012:
Hττ(Decay) - CP angle

---

CMS-PAS-HIG-19-005:
STXS combination - HEL

## ATLAS

JHEP 07 (2023) 088: γγ STXS - SMEFT Warsaw

JHEP 08 (2022) 027: γγ differential - SMEFT Warsaw

Phys. Rev. Lett. 131 (2023) 061802: Hγγ VBF CP - SMEFT Warsaw

EPJC 81 (2021) 29: 4lep STXS - SMEFT Warsaw

CERN-EP-2023-030: 4lep CP - SMEFT Warsaw

ATL-PHYS-PUB-2023-012: offshell (+onshell) - SMEFT Warsaw

CERN-EP-2023-025: WW - SMEFT Warsaw

Phys. Lett. B 816 (2021) 136204 & Eur. Phys. J. C 81 (2021) 178:
Hbb - SMEFT Warsaw

---

Phys. Rev. Lett. 125 (2020) 061802: ttHγγ - CP angle

CERN-EP-2022-208: ttH/tHb bb - CP angle

Eur. Phys. J. C 83 (2023) 563: Hττ(Decay) - CP angle

---

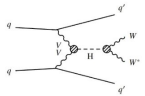
ATLAS-CONF-2023-052:
STXS comb. & Diff. comb - SMEFT Warsaw

# HVV

- HVV (CP-even/odd) coupling tested in different channels:
  - production
  - decays

## Jay

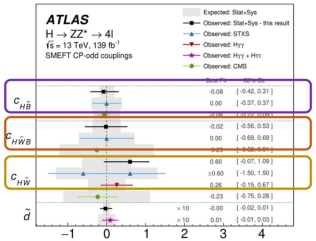
SMEFT $H \to WW^*$ measurements



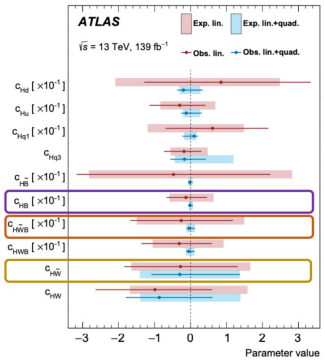
Fresh off the press!

The CP-odd analysis with its dedicated ME-based observables remains the most sensitive probe!

arXiv: 2304.09612




$H \to WW^* \to e\nu\mu\nu$




arXiv: 2304.03053

Jay Sandesara | Higgs Hunt

## Angela

**HVV coupling constraints in HWW**

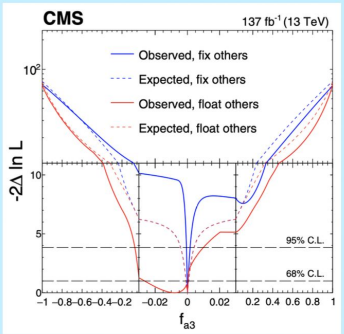
Phys. Rev. D 104, 052004

Final state: H → WW → μνev

H boson coupling studied: ggH, VBF, VH

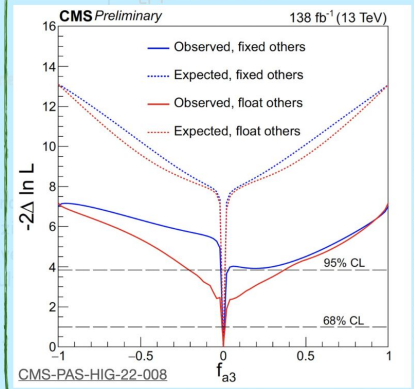
- MELA discriminator used to define the different categories
- reconstruction of boosted VH events

Main backgrounds: tt, DY, non-resonant WW and Wjets (estimated from data)




NEW!!!!

The same analysis can be performed in the HWW final state




$f_{a3}$ [-0.00083, 0.0035]

13

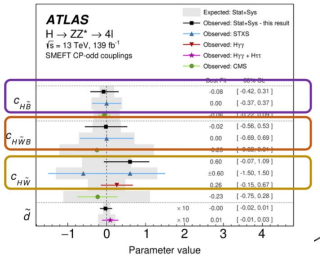
# HVV

- HVV (CP-even/oc
  - production
  - decays

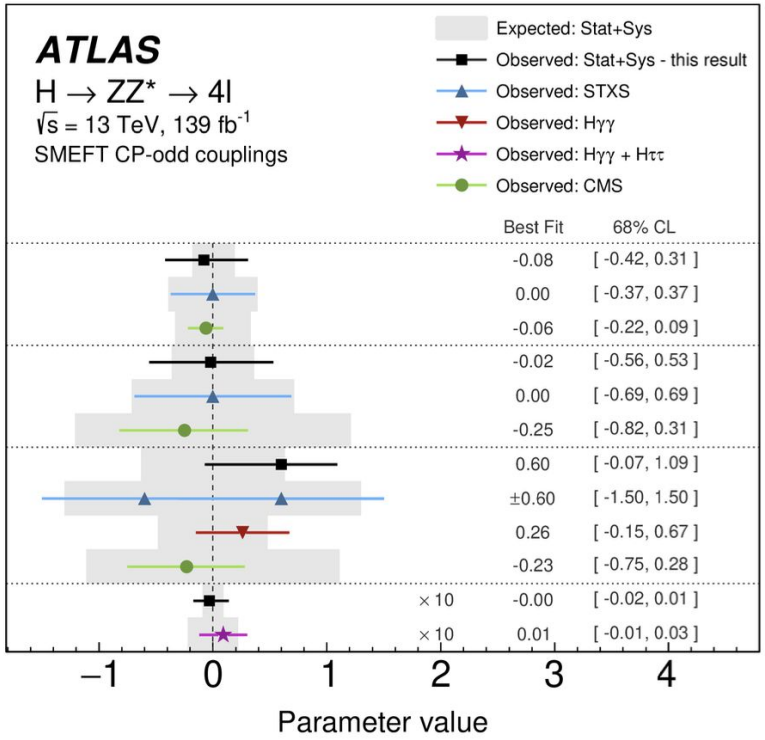
SMEFT $H \to WW^*$ measurements

The CP-odd analysis with its dedicated ME-based observables remains the most sensitive probe!

arXiv: 2304.09612




Jay



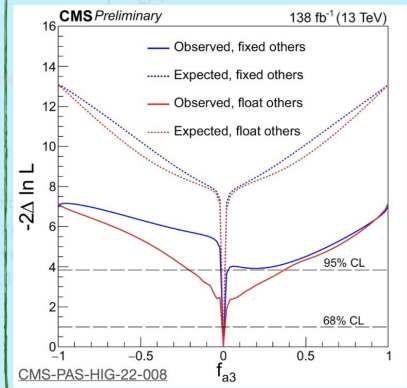

Phys. Rev. D 104, 052004

straints in HWW

Angela

NEW!!!!

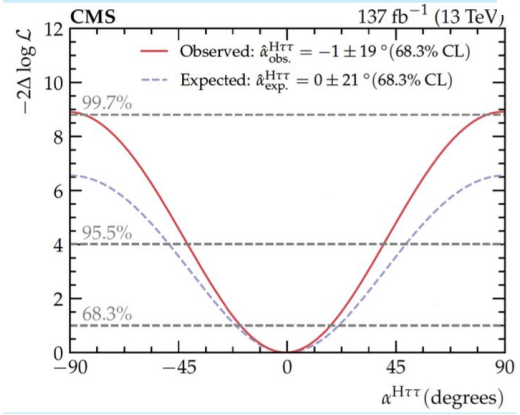
The same analysis can be performed in the HWW final state

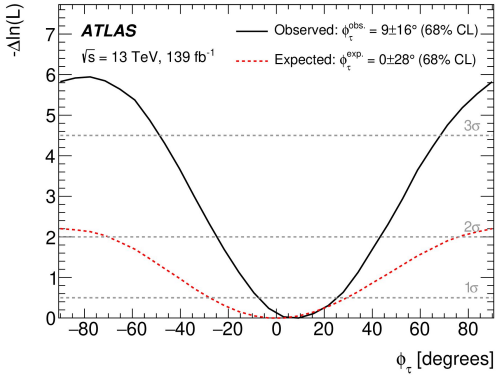


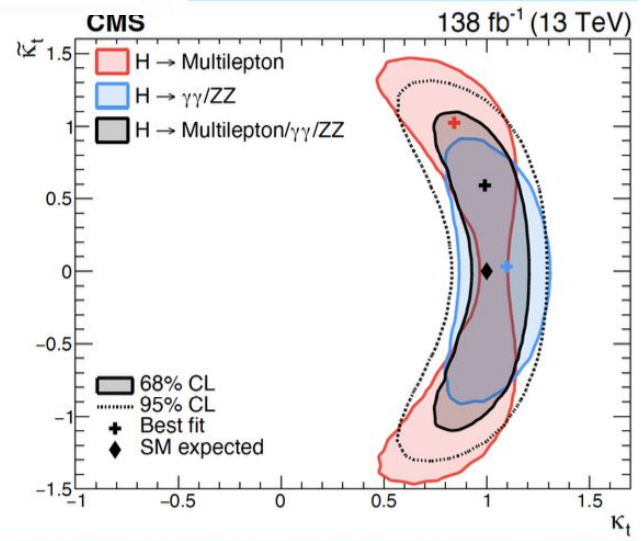

$f_{a3}$ [-0.00083, 0.0035]

# Hff

$$L_Y = -\frac{m_l \phi}{\nu}(\kappa_l \overline{\psi_l}\psi_l + \tilde{\kappa}_l \overline{\psi_l} i\gamma_5 \psi_l)$$



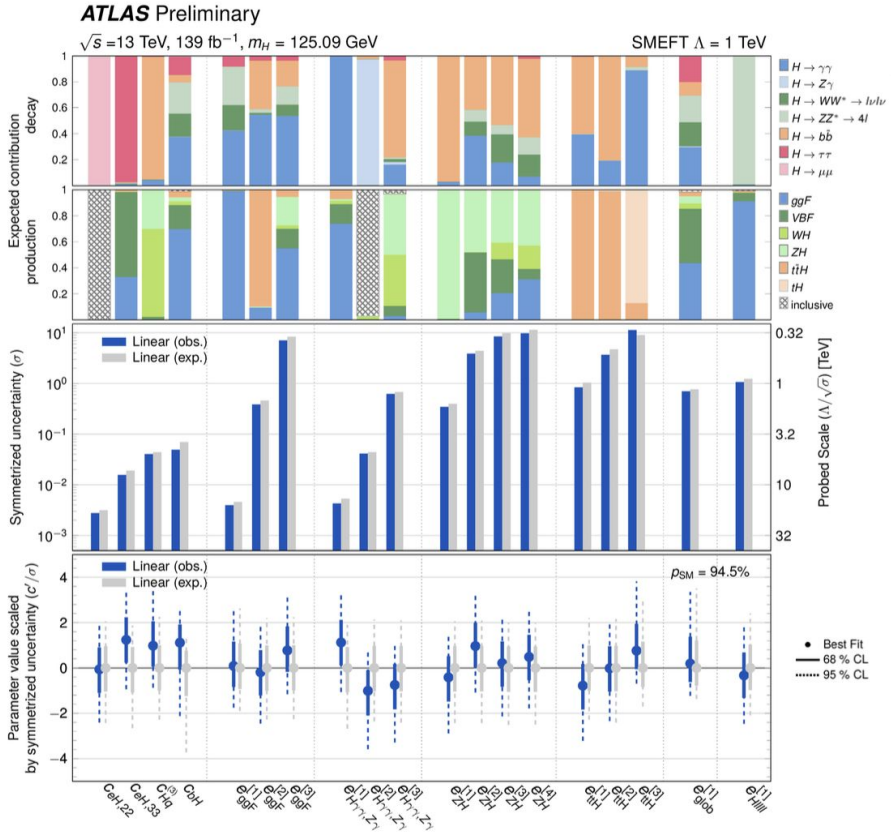

ATLAS → pure CP-odd hypothesis excl. at 3.4σ (EPJC 83 (2023) 563) → **α(Hττ) = 9 ± 16°**

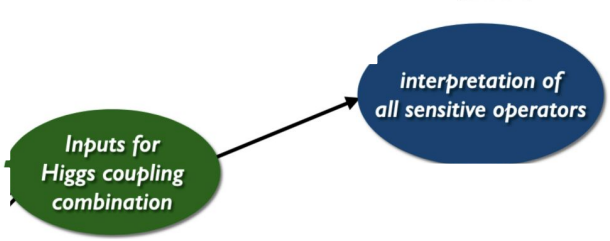
CMS → pure CP-odd hypothesis excl. at 3.0σ (JHEP 06 (2022) 012) → **φ(Hττ) = -1 ± 19°**

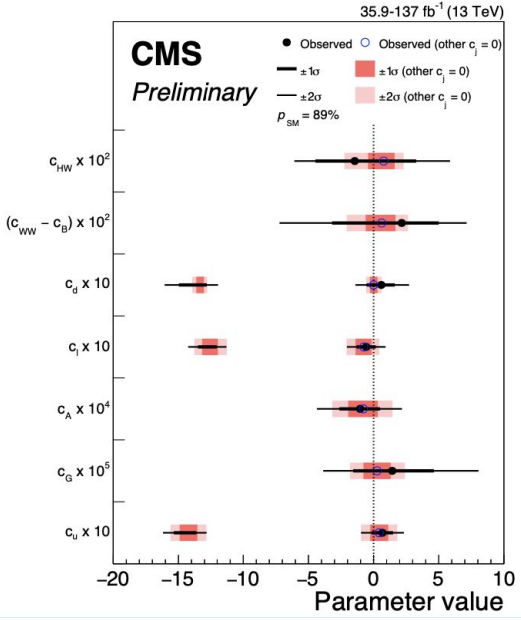
ATLAS → pure CP-odd hyp. excl. at 3.9σ (Hγγ) (PRL 125 (2020) 061802) **α(ttH)<43° @95%CL**

CMS → pure CP-odd hypothesis excl. at 3.7σ (JHEP 07 (2023) 092)
**kt = (−1.09, −0.74) or (0.77, 1.30)**
**k̃ t = (−1.4, 1.4)**

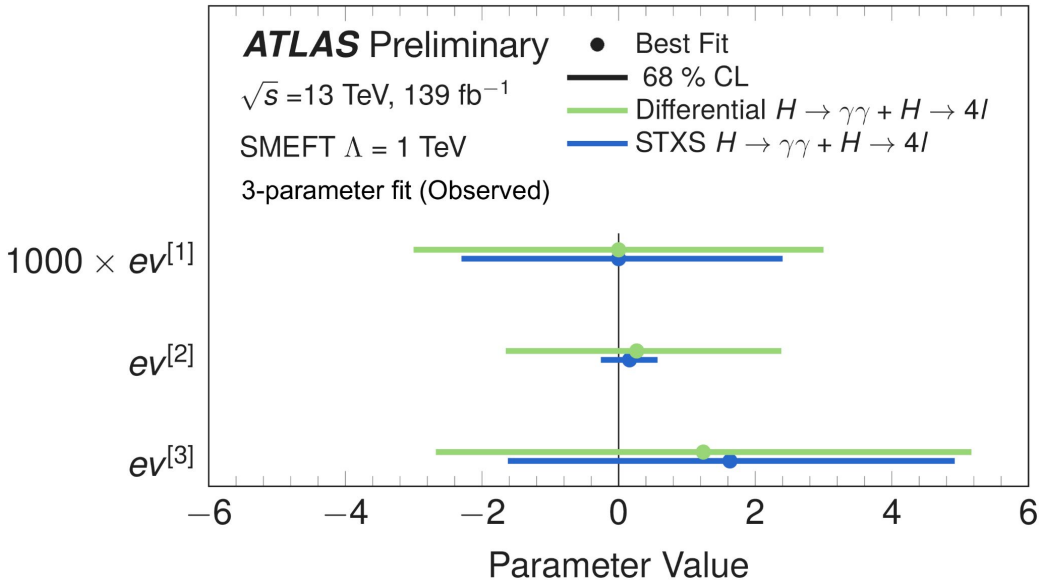
# Combinations

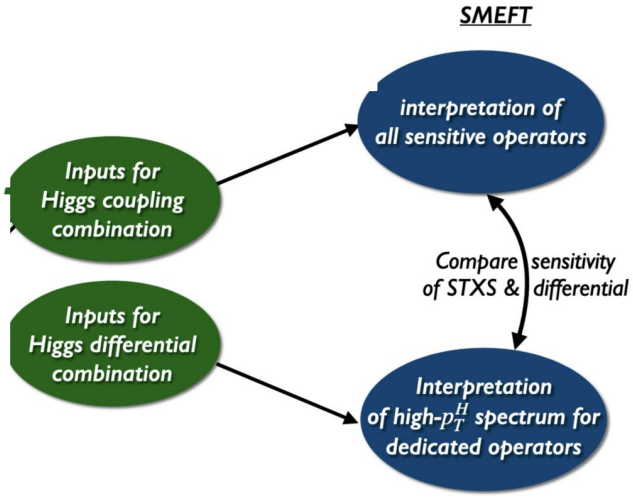


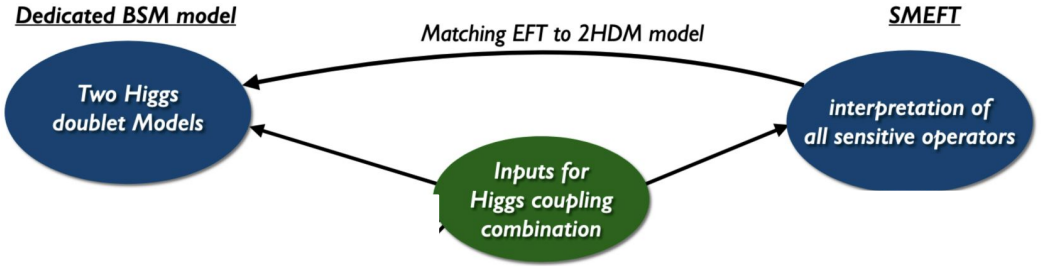



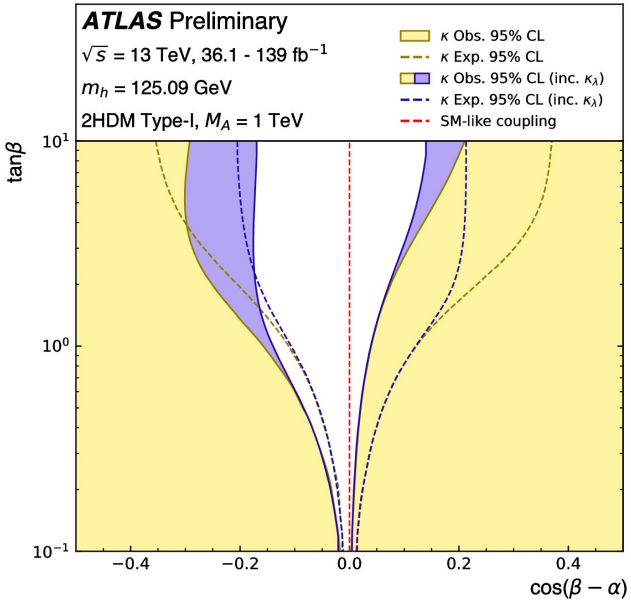
# Combinations



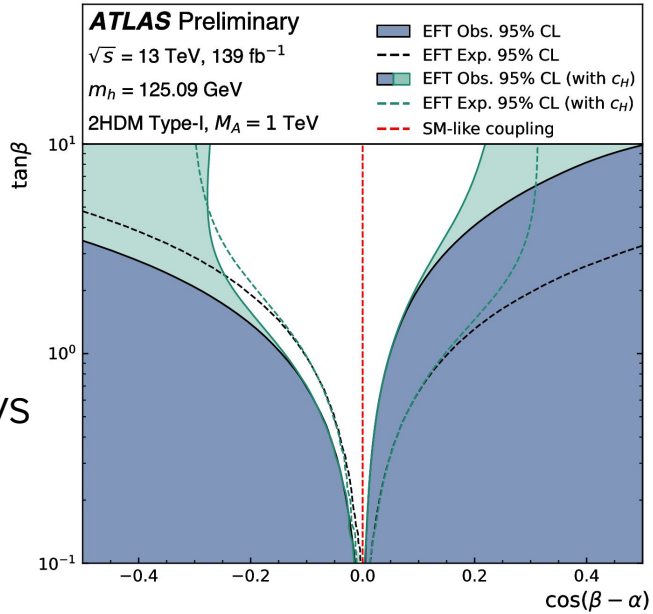



# Combinations

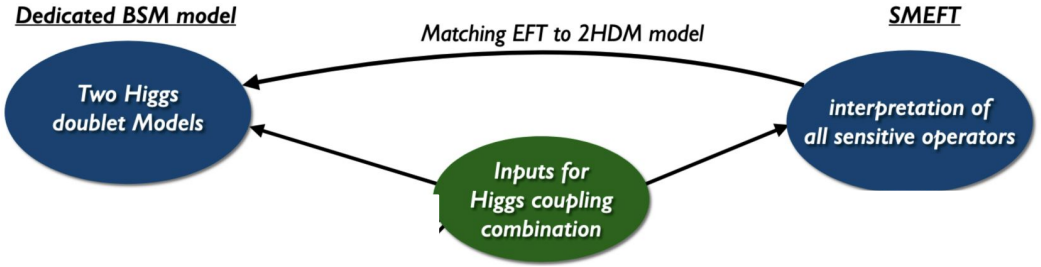


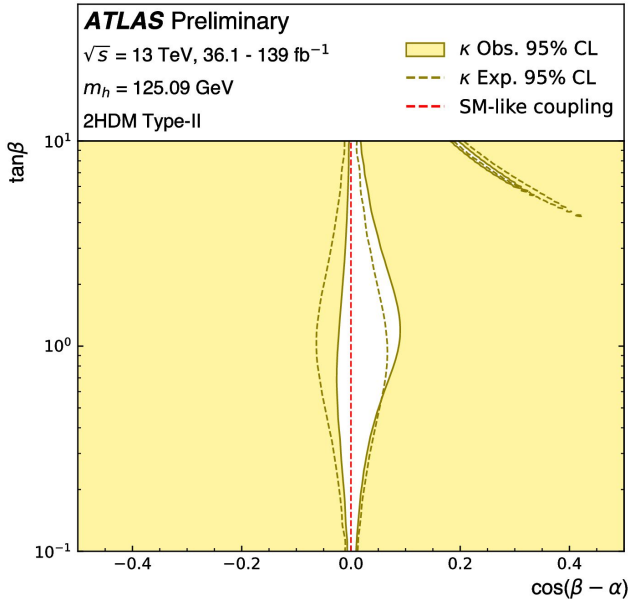




VS

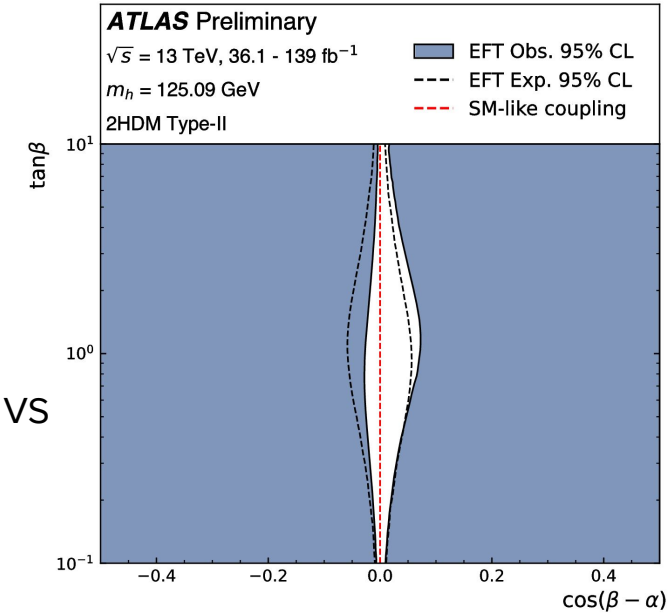


# Combinations




VS

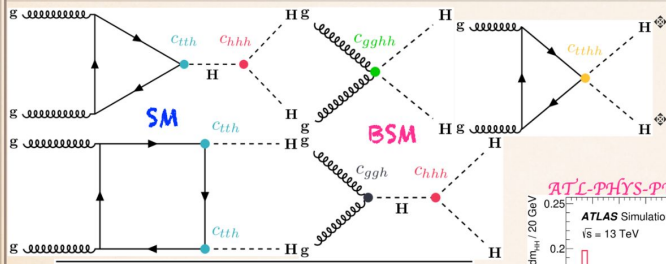


# EFT - HH searches

## EFFECTIVE FIELD THEORIES

*Jay Sandesara about other results from EFT

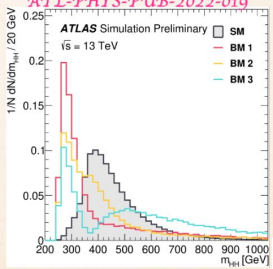
*Tom Ingebretsen Carlson about EFT in *bbγγ*

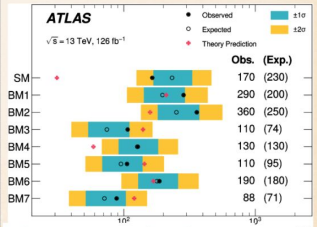



- Effective Field Theories (EFT) - indirect probe of new physics
  - H(iggs)EFT - physical Higgs boson
- BSM benchmarks based on impact on $m_{HH}$

| Benchmark Model | $c_{HHH}$ | $c_{ttH}$ | $c_{ggH}$ | $c_{ggHH}$ | $c_{ttHH}$ |
|---|---|---|---|---|---|
| SM | 1 | 1 | 0 | 0 | 0 |
| BM1 | 3.94 | 0.94 | 1/2 | 1/3 | −1/3 |
| BM2 | 6.84 | 0.61 | 0.0 | −1/3 | 1/3 |
| BM3 | 2.21 | 1.05 | 1/2 | 1/2 | −1/3 |
| BM4 | 2.79 | 0.61 | −1/2 | 1/6 | 1/3 |
| BM5 | 3.95 | 1.17 | 1/6 | −1/2 | −1/3 |
| BM6 | 5.68 | 0.83 | −1/2 | 1/3 | 1/3 |
| BM7 | −0.10 | 0.94 | 1/6 | −1/6 | 1 |

ATL-PHYS-PUB-2022-019



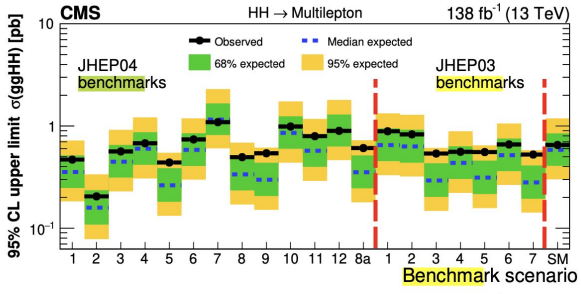




Phys. Rev. D 108 (2023) 052003

13

## CMS HH multilepton JHEP07(2023)095

| Benchmark | $\kappa_\lambda$ | $\kappa_t$ | $c_2$ | $c_g$ | $c_{2g}$ |
|---|---|---|---|---|---|
| JHEP04 BM1 | 7.5 | 1.0 | −1.0 | 0.0 | 0.0 |
| JHEP04 BM2 | 1.0 | 1.0 | 0.5 | −0.8 | 0.6 |
| JHEP04 BM3 | 1.0 | 1.0 | −1.5 | 0.0 | −0.8 |
| JHEP04 BM4 | −3.5 | 1.5 | −3.0 | 0.0 | 0.0 |
| JHEP04 BM5 | 1.0 | 1.0 | 0.0 | 0.8 | −1.0 |
| JHEP04 BM6 | 2.4 | 1.0 | 0.0 | 0.2 | −0.2 |
| JHEP04 BM7 | 5.0 | 1.0 | 0.0 | 0.2 | −0.2 |
| JHEP04 BM8 | 15.0 | 1.0 | 0.0 | −1.0 | 1.0 |
| JHEP04 BM8a | 1.0 | 1.0 | 0.5 | 4/15 | 0.0 |
| JHEP04 BM9 | 1.0 | 1.0 | 1.0 | −0.6 | 0.6 |
| JHEP04 BM10 | 10.0 | 1.5 | −1.0 | 0.0 | 0.0 |
| JHEP04 BM11 | 2.4 | 1.0 | 0.0 | 1.0 | −1.0 |
| JHEP04 BM12 | 15.0 | 1.0 | 1.0 | 0.0 | 0.0 |
| JHEP03 BM1 | 3.94 | 0.94 | −1/3 | 0.75 | −1 |
| JHEP03 BM2 | 6.84 | 0.61 | 1/3 | 0 | 1 |
| JHEP03 BM3 | 2.21 | 1.05 | −1/3 | 0.75 | −1.5 |
| JHEP03 BM4 | 2.79 | 0.61 | 1/3 | −0.75 | −0.5 |
| JHEP03 BM5 | 3.95 | 1.17 | −1/3 | 0.25 | 1.5 |
| JHEP03 BM6 | 5.68 | 0.83 | 1/3 | −0.75 | −1 |
| JHEP03 BM7 | −0.10 | 0.94 | 1 | 0.25 | 0.5 |
| SM | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |



# Backup

# Combinations

Full combination:

- choose a basis for the fit
-