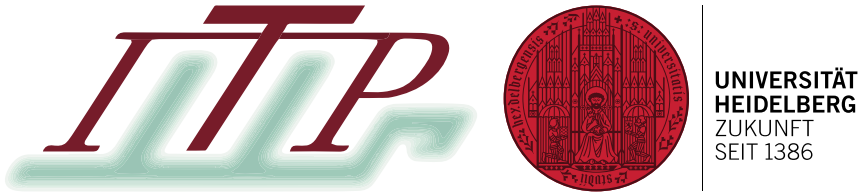
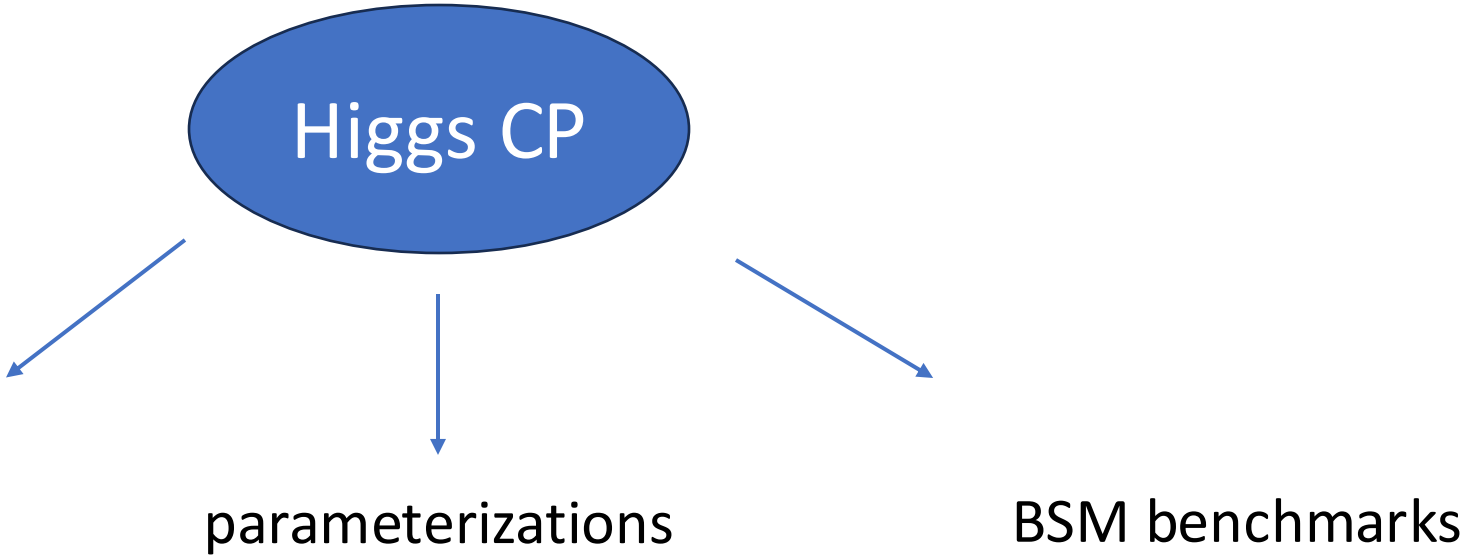
Parameterizations, STXS, and BSM benchmarks for Higgs CPV

Henning Bahl



The 21th Workshop of the LHC Higgs WG, CERN, 6.12.24

Higgs CP: on-going + new activities



STXS for Higgs CPV

- concept: extend STXS framework by CP-sensitive bins

  → easy combination across decay channels and experiments

  → straightforward reinterpretation in variety of CPV models

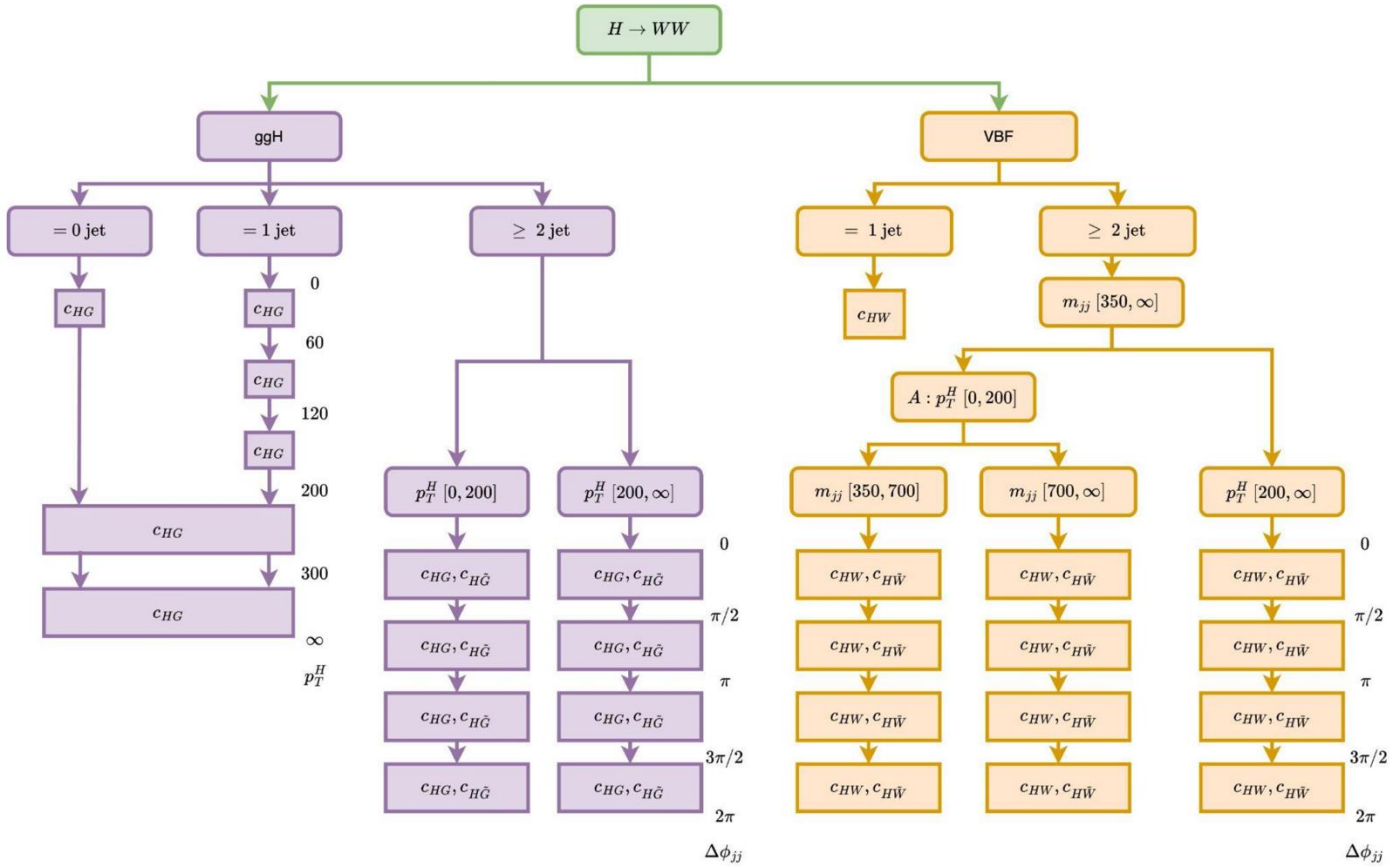
  → supplement dedicated CPV analyses

- relevant production modes:
  - VBF
  - ggF+2jets
  - ttH
  - (+ tH, ZH, …)

CP-sensitive STXS for VBF and ggF+2jets

→ See Matteo's talk in the morning!

- target: CPV HVV and Hgg couplings
- use CP-odd $\Delta\phi_{jj}$ observable
- strategy: divide ≥ 2 jet bins into four $\Delta\phi_{jj}$ bins
- aimed at STXS stage 1.3



[Marr & Basso, VBF workshop 2024]

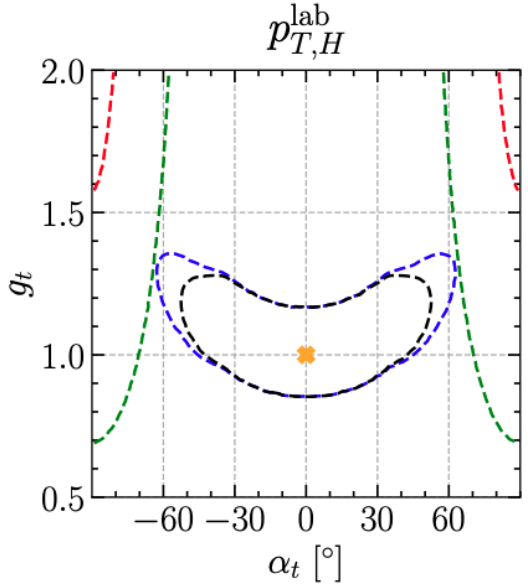
disentangle CP-even and CP-odd modifications of HVV and Hgg couplings

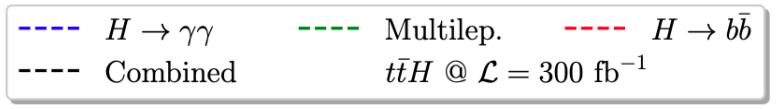
CP-sensitive STXS for $t\bar{t}H$

[HB et al., 2406.03950]

→ See Alberto's talk yesterday for more details!

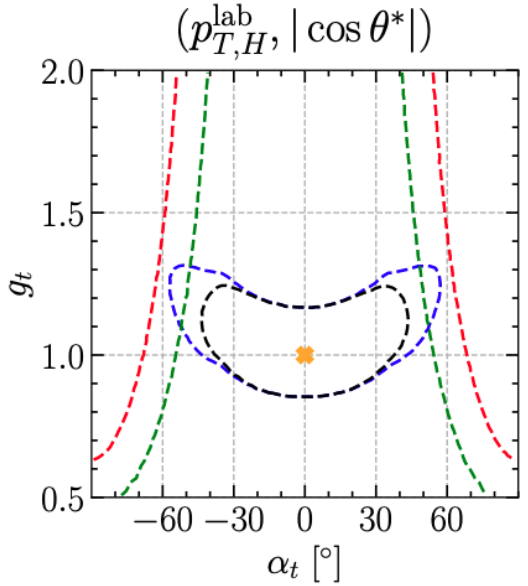
- target CPV top-Yukawa coupling
- check 2D combinations of 11 CP-sensitive (but CP-even) observables
- best combinations: $p_{T,H}$ + $b_2^{\text{lab}}, \Delta\eta_{t\bar{t}}, \ |\cos\theta^\star|$





2nd dim

$$\mathcal{L}_{\text{top-Yuk}} = \frac{y_t^{\text{SM}}}{\sqrt{2}} g_t h \bar{t}(\cos\alpha_t + i\gamma_5 \sin\alpha_t)t$$



→ 2nd observable provides additional information, performance close to BDT

Higgs CPV parameterizations

- various parameterizations are used in the literature

- consider e.g. top-Yukawa interaction:

  - SMEFT Warsaw basis: $\frac{c_{t\Phi}}{\Lambda^2}\Phi^\dagger\Phi(\bar{Q}_3 t\widetilde{\Phi})$
  - SMEFT Higgs basis: $\frac{h}{v}m_t\delta y_t\bar{t}t$
  - coupling modifiers: $\frac{y_t^{\rm SM}}{\sqrt{2}}h\bar{t}(c_t+i\gamma_5\tilde{c}_t)t$
  - angles: $\frac{y_t^{\rm SM}}{\sqrt{2}}g_t h\bar{t}(\cos\alpha_t+i\gamma_5\sin\alpha_t)t$
  - CP-odd fractions: $f_{\rm CP}^{h\bar{t}t}=\frac{\Gamma^{\text{CP-odd}}_{h\to t\bar{t}}}{\Gamma^{\text{CP-odd}}_{h\to t\bar{t}}+\Gamma^{\text{CP-even}}_{h\to t\bar{t}}}$

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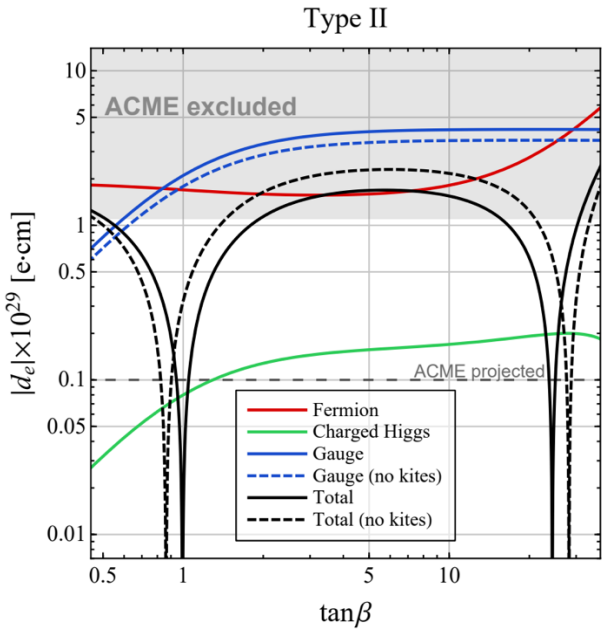
on-going work on note providing recommendations
+
translation between parameterizations

BSM benchmarks for Higgs CPV

CPV Higgs coupling

not too heavy BSM particle(s)

interplay with direct searches,
EDM cancellations, etc.

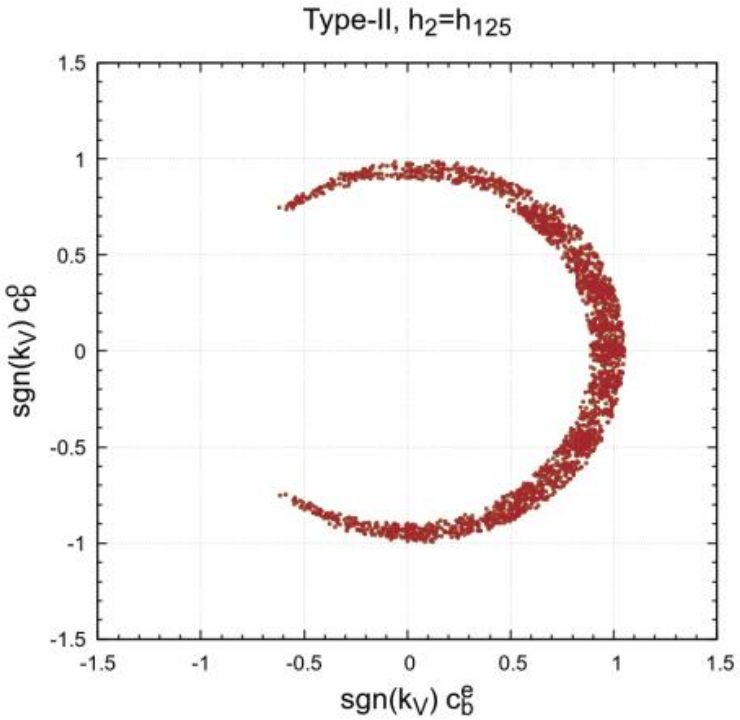


[Altmannshofer et al., 2009.01258]

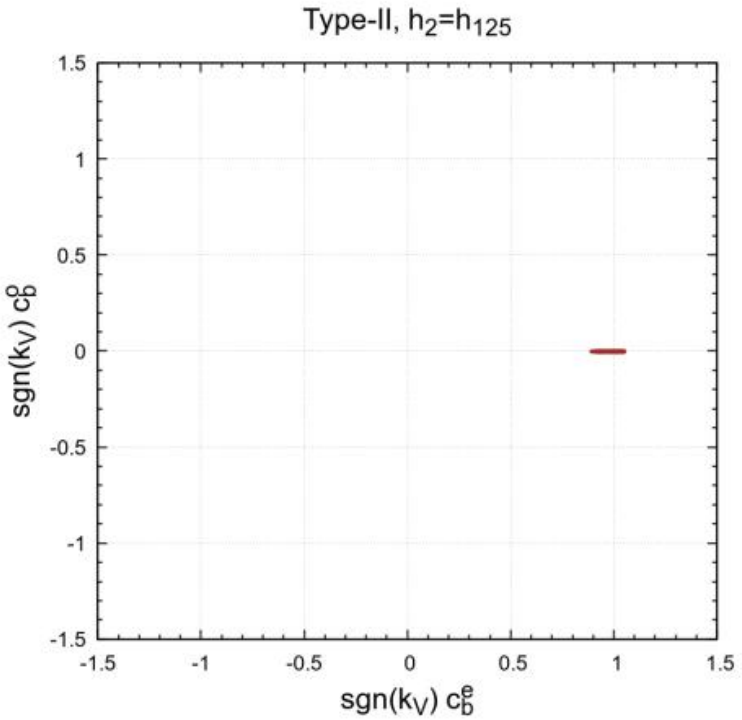
→ existing studies focus on complex 2HDM

BSM benchmarks for Higgs CPV —c2DHM

w/o limits from direct searches



w/ limits from direct searches

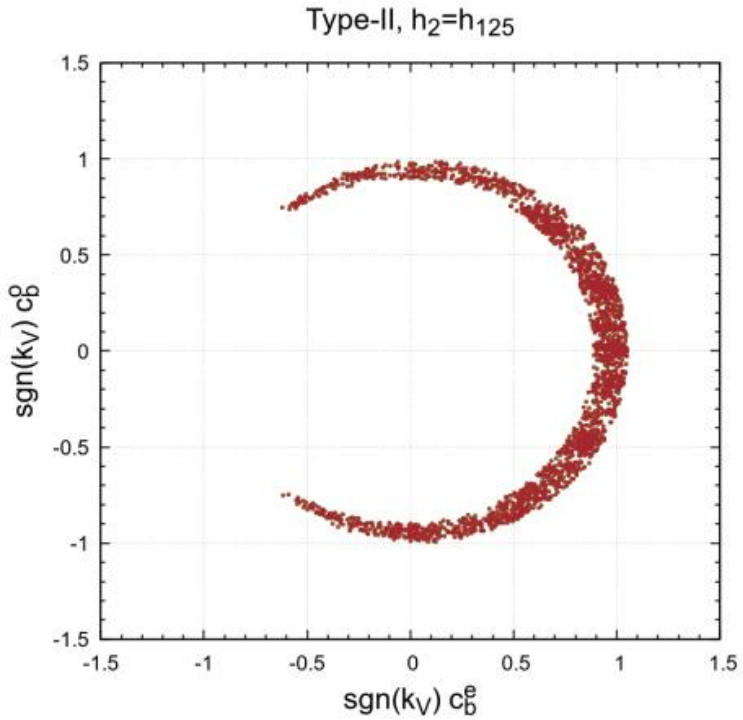


[Biekötter et al., 2403.02425]

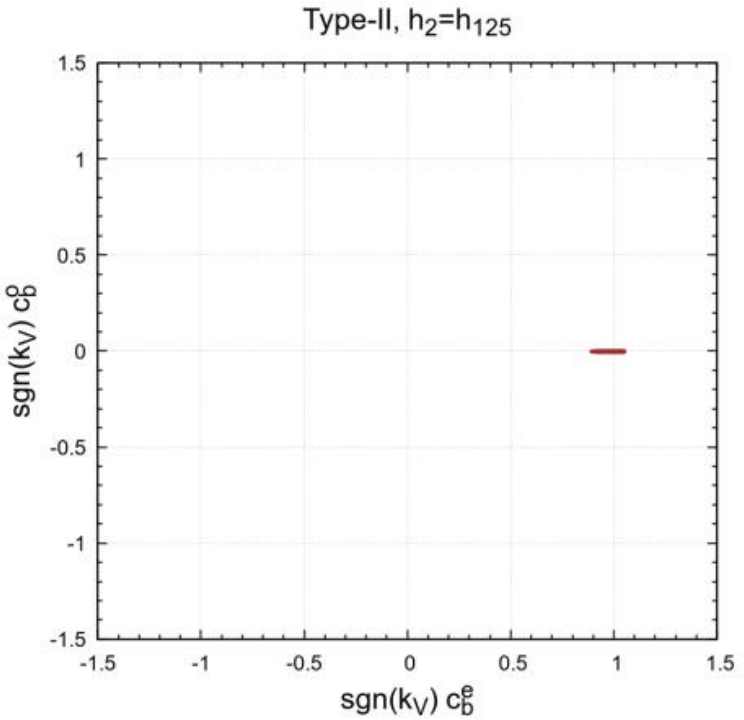
How does this look in other models?

BSM benchmarks for Higgs CPV —c2DHM

w/o limits from direct searches



w/ limits from direct searches



[Biekötter et al., 2403.02425]

How does this look in other models?

upcoming call for BSM benchmarks for Higgs CPV

Conclusions

- understanding the Higgs CP nature → important target for the (HL-)LHC

- on-going and planned WG2 activities:
  - STXS for Higgs CPV
  - note on Higgs CPV parameterizations
  - BSM benchmarks for Higgs CPV

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Thanks for your attention!