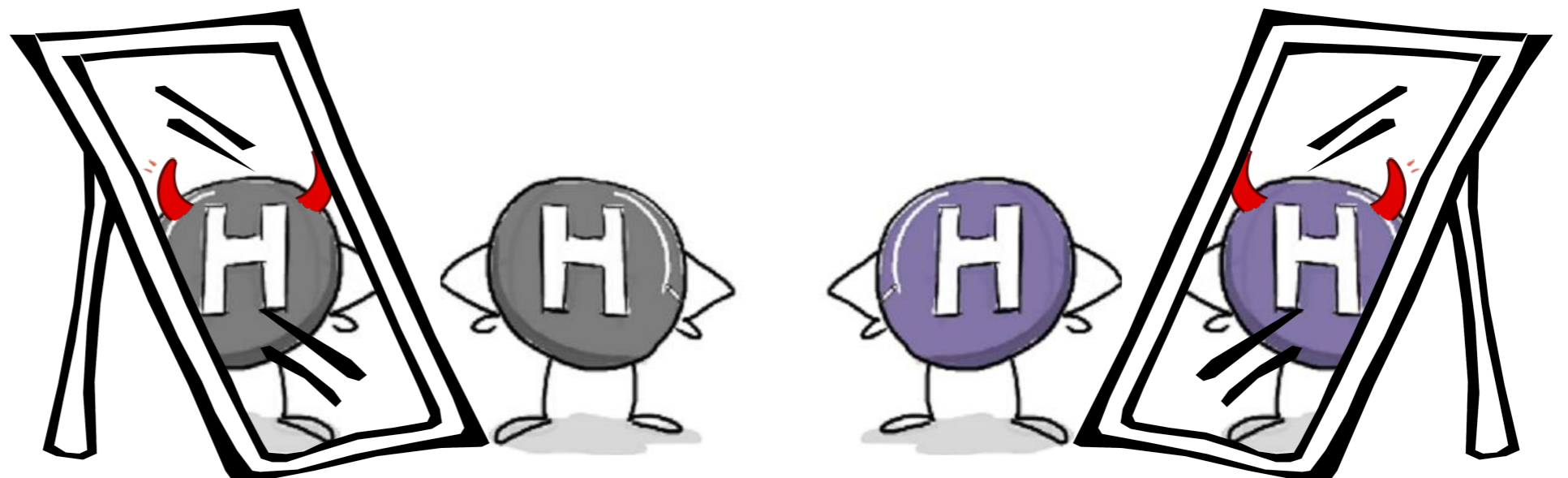# CPV in Higgs interactions: WG2/WG3 (extended Higgs) joint meeting

WG3: Mariarosaria d'Alfonso, Santeri Laurila, Tania Robens, Nikos Rompotis, Rui Santos, Shufang Su & Lidija Zivkovic

WG2: Nicolas Berger, Mauro Donega, Ken Mimasu & Daniele Barducci

23rd June 2022

General mission statement

Maximise our sensitivity to CPV in Higgs interactions

- Identify existing/new channels/observables sensitive to CPV

- Study how best to implement in global analyses, e.g. STXS

- Harmonise approach across experiments in view of future combinations

- Recommendations for common parametrisation & measurements to maximise CPV new physics reach at the LHC

'admixture' model $\quad \kappa \cos \alpha + \tilde{\kappa} \sin \alpha \quad \Longleftrightarrow \quad \begin{array}{ccccc} \tilde{C}_{HWB} & \tilde{C}_{HB} & \tilde{C}_W & \tilde{C}_{tW} & \tilde{C}_{tB} \\ \tilde{C}_{HW} & \tilde{C}_{HG} & \tilde{C}_G & \tilde{C}_{tG} & \tilde{C}_{tH} \end{array} \quad$ SMEFT

- Quantify LHC complementarity with other data (EDM, CP asymmetries in meson decays)

Deliverables: LHCHWG recommendations note $\Rightarrow$ Journal?
SciPost
CERN monograph
TWiki

Kick-off part 1

https://indico.cern.ch/event/1105813/, recording available

Experimental summary   🕐 20m

Speaker: Hualin Mei (Univ. of California Santa Barbara (US))

📄 CP_ violations_in_...

CP-odd flavor-invariants in the SMEFT   🕐 20m

Speaker: Quentin Bonnefoy (DESY)

📄 Bonnefoy_WG2.pdf

Matrix-Element Methods for EFT and CP measurements with the H boson   🕐 20m

Speaker: Andrei Gritsan (Johns Hopkins University (US))

📄 talk_LHCHiggsWG_...

Interplay with low Energy   🕐 20m

Speaker: Wouter DEKENS (university of california, San Diego)

📄 wdekens_WG2_Hig...

ttH phenomenology studies   🕐 20m

Speaker: Dorival Gonçalves (Oklahoma State University)

📄 Dorival_WG2.pdf

Discussion   🕐 20m

Kick-off part 2

https://indico.cern.ch/event/1116986/, recording available

New Physics in Yukawa Couplings with Flavour Symmetries   ⏱ 20m

Speaker: Luca Merlo (CERN)

📄 Merlo, NP in Yukaw…

Constraining the CP structure of Higgs-fermion couplings with a global LHC fit, EDM and baryogenesis   ⏱ 20m

Speaker: Marco Menen

📄 Marco Menen CPV.…

CP-violation, asymmetries and interferences in ttH   ⏱ 20m

Speaker: Rodrigo Capucha (Centro de Física Teórica e Computacional, FCUL)

Machine-enhanced CP-asymmetries in the Higgs sector   ⏱ 20m

Speaker: Andrew Pilkington (University Of Manchester)

📄 CPVusingNN.pdf

Discussion   ⏱ 30m

Round table meeting

Open google doc: link

- Organise various topics into interest groups

- "Les Houches" style sign up system

- Established "mailing lists" & identified contact people

- Next step: organise dedicated meetings/discussion

Joint WG2/WG3 activity

Todays meeting!

- Received several kick-off meeting contributions that overlapped with WG3 (extended Higgs sector) interests

- Many interesting signatures of spontaneous/explicit CPV in extended Higgs sectors

- From mixing of would-be CP-even/odd eigenstates

Discovery of BSM Higgs
in multiple decay channels
$\Rightarrow$ CPV

Classes	C_1	C_2	C_3	C_4	C_5
Decays	$h_3 \to h_2 Z$	$h_2 \to h_1 Z$	$h_3 \to h_1 Z$	$h_3 \to h_2 Z$	$h_3 \to ZZ$
	$h_2 \to h_1 Z$	$h_1 \to ZZ$	$h_1 \to ZZ$	$h_2 \to ZZ$	$h_2 \to ZZ$
	$h_3 \to h_1 Z$	$h_2 \to ZZ$	$h_3 \to ZZ$	$h_3 \to ZZ$	$h_1 \to ZZ$

WG3 Proposal for CP violating benchmarks in the C2HDM ~ 2015
[Fontes et al.; PRD 92 (2015) 055014]

h_{125}-style CP properties
study for BSM scalars
$\Rightarrow$ CPV

Decay angular distributions etc.

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Joint WG2/WG3 activity

Todays meeting!

- Undoubtedly complementarity with h_{125} CP properties

- Interesting to quantify for explicit BSM scenarios

- Establish some benchmark models & identify regions of parameter space where one or the other can provide complementary sensitivity

- Focus on **complementarity** between explicit BSM signatures and Higgs properties

- Likely interplay with low-energy e.g. EDMs:
  Are there gaps/blind-spots where we can increase parameter space coverage with BSM or h_{125} CPV searches?

Sign up!

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHWG

General WG2 CPV gdoc is public & freely editable

Hope that this initiative will lead to a concrete joint activity

- Outputs: LHCWG recommendation note(s), journal publication(s)

Sign up here by searching: https://e-groups.cern.ch/e-groups

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