WG2: summary & plans

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The 18th Workshop of the LHC Higgs Working Group

3rd December 2021

WG2: Higgs properties

Personnel changes since last general meeting

- **WG2 conveners:**
  N. Berger (ATLAS), M. Donega (CMS)
  K. Mimasu (TH), G. Panico (TH)

  - Recent change: J. de Blas ⇒ K. Mimasu - Thanks Jorge!

  https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHWG2

- **Fiducial, differential & template XS subgroup:**
  A. de Wit (CMS), F. Tackmann (TH), H. Yang (ATLAS)

  - Recent changes: L. Viliani ⇒ E. Scott ⇒ A. De Wit
    Thanks Lorenzo & Ed, welcome Adinda!

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

2021 Activities

Meetings https://indico.cern.ch/category/5848/

- **Higgs CP properties through EFT fits** https://indico.cern.ch/event/995686/
  - ATLAS, CMS & TH summaries of CPV EFT interpretations
  - Focus on $t\bar{t}H/tH$ where new measurements are out
- **STXS: ggH stage 1.2 uncertainties** https://indico.cern.ch/event/1035784/
  - Finalising exercise (see next slide)
- κ_λ **in single Higgs measurements STXS** https://indico.cern.ch/event/1077767/
  - Status of TH computations: ggH differentials out of reach
  - Interplay with EFT, other loop-induced contributions
  - Discussion of ATLAS+CMS common parametrisation exercise

2021 Activities

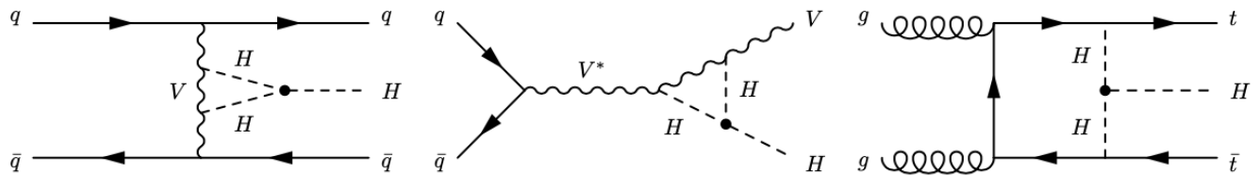
ggH STXS uncertainties

Talk by Haider

- Collaborative effort over ~1 year: ATLAS + CMS + theorists
- Revisited both nuisance parameter scheme (i.e. uncertainty correlations across bins) and their numerical values for stage 1.2 ggF STXS (low p_T (0, 1, 2 jets) and high p_T)
- "Long range ST method" to evaluate impacts across bin boundaries
  - Evaluate the yield variations inclusively over all bins
  - Distribute the migration systematics across all 'higher' bins, not only neighboring bins
  - Possible double counting on overlapping bins reduced by *ad hoc* scale factor
- General comment: parton shower uncertainties are the leading source of systematics in several cases
  - need a unified approach to parametrize them

LHCHWG note in preparation

2021 Activities



κ_λ in STXS: common parametrisation

Talks by Stefano and Jorge

- Relevant for combination of single- & double-Higgs

  single-H: $-3.2 < \kappa_\lambda < 11.9$ (ATLAS) and $-3.5 < \kappa_\lambda < 14.5$ (CMS)

  double-H: $-1.0 < \kappa_\lambda < 6.6$ (ATLAS bbγγ+bbττ)

- Within LHCXSWG2, ATLAS and CMS are working to provide a common κ_λ parametrization for STXS stage 1.2
  - Developed a common package: Gitlab link
  - Evaluated C_1 (interference between LO and virtual NLO EW) in each STXS stage 1.2 bin for Hjj, WH, ZH, ttH

    to be documented in a twiki and a note

- Issues to be clarified:
  - theory predictions/uncertainties (eg. predictions at LO vs NLO)
  - Interpretation (relation between κ_λ, full EFT) Talk by Jorge

Talk by Savvas

EFT tools comparison and sensitivity to Higgs couplings to virtual photons

- Extensive comparison of EFT tools (see also LHC EFT WG talk)
  - Discussion ongoing on the conventions to be taken into account
  - Differences between tools: motivates common parametrisation where possible!

- Phenomenological study of anomalous $H\gamma\gamma/HZ\gamma$ couplings
  - MELA discriminants using decay and (new) production information
  - Decay information constraints CP structure better than production

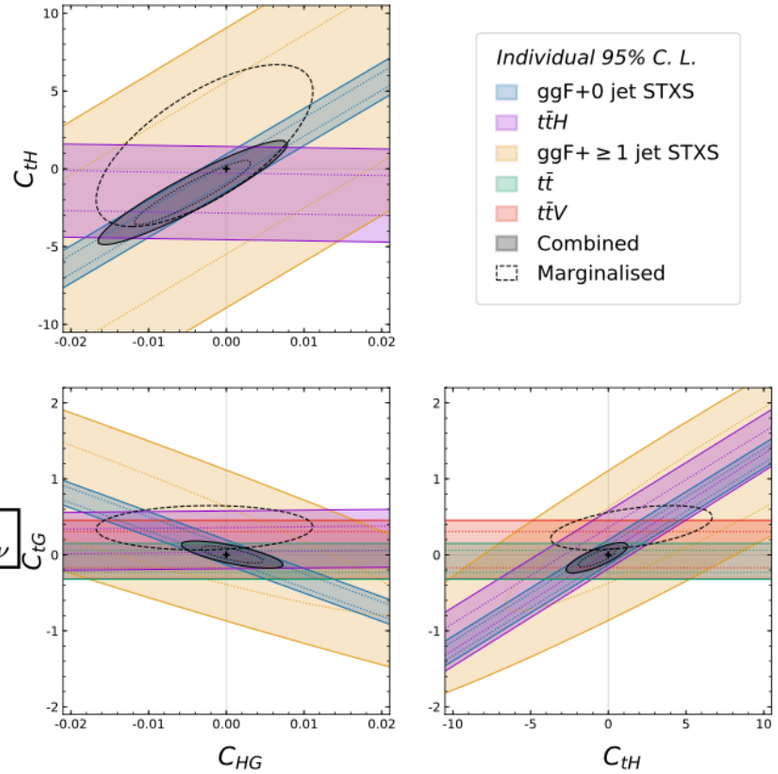
- Feasibility study showing the effect of AC in enhancing the $\gamma H(\rightarrow 4l)$ production at the LHC
  - Projections for 3ab^{-1} combining γH/VBF/VH/H$\rightarrow$4l & H $\rightarrow \gamma\gamma/Z\gamma$

The global picture

- Latest STXS/differential measurements are improving our understanding of Higgs interactions

- Fantastic Higgs properties programme is bearing fruit

$\left(\varphi^\dagger\varphi\right)\bar{Q}\,t\,\tilde{\varphi}$



$\left(\bar{Q}\tau^{\mu\nu}\,T_A\,t\right)\tilde{\varphi}\,G^A_{\mu\nu}$

Talk by Eleni

$\left(\varphi^\dagger\varphi\right)G^{\mu\nu}_A\,G^A_{\mu\nu}$

$\left(\varphi^\dagger\varphi\right)\bar{Q}\,t\,\tilde{\varphi}$

Ellis, Madigan, Mimasu, Sanz, You arXiv:2012.02779

- Interesting interplay between Higgs/Top is being quantified for the first time
  - Loop-induced EFT sensitivity is crucial
  - Higgs data can provide best constraints on *e.g.* top EW couplings
  - NLO corrections can be relevant & tools are available

- Continue to work closely with LHC EFT WG

WG2 contact: J. De Blas

Future plans

New activity on CP violation in Higgs interactions

Mission statement

- 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 $\kappa \cos\alpha + \tilde{\kappa} \sin\alpha$ $\Leftrightarrow$ $\tilde{C}_{HWB}\ \tilde{C}_{HB}\ \tilde{C}_{W}\ \tilde{C}_{tW}\ \tilde{C}_{tB}$ $\tilde{C}_{HW}\ \tilde{C}_{HG}\ \tilde{C}_{G}\ \tilde{C}_{tG}\ \tilde{C}_{tH}$ SMEFT

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

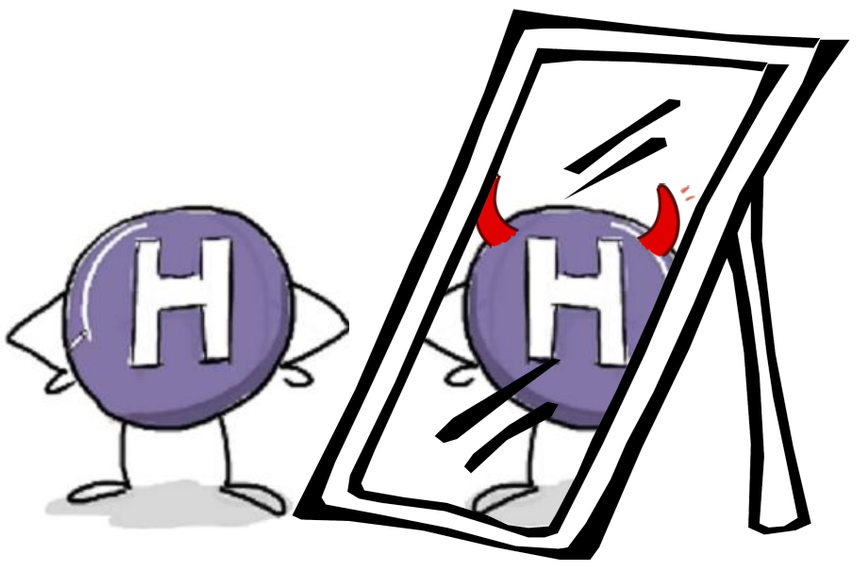
Future plans

New activity on CP violation in Higgs interactions

Kick-off meeting announcement on Wednesday

- Build on discussion in January topical meeting
- In the 2 weeks before winter break or just after
- Call for participants & short talk contributions
- Hopefully see you at the meeting!

Link to Doodle poll



Future plans

Talk by Mingshui

Fiducial Differential cross sections: combination and interpretation

- ATLAS / CMS already provided several measurements (see e.g. Higgs2021)
- Significant progress in aligning bins & converging on a common unfolding
- **Combinations:**
  - different channels via full phase space extrapolation (model dependence)
  - same channel to a common phase space (limits model dependence)
  - no combination and do a joint fit of the single measurements (next slide)
- Agree on common variables & plan for future *e.g.* more 2D distributions?
- EFT interpretation in close collaboration with the LHC EFT WG
  - provide a common tool for interpretation in the same spirit of the κ_λ parametrization ?

Joint fit of single measurements

Frank's point during the discussion session

"Traditional" combinations ⇔ Combine separate measurements + correlation info.

- May be interesting from the "optimal interpretation" perspective
- Requires some additional infrastructure
  - Separate covariances for different error sources
  - Non-Gaussian case: could be enabled by publishing likelihoods
- Applies to any measurements, e.g., STXS
- Interesting starting point for discussion at a future meeting
  - Possible toy exercise performed within WG2
  - See if other WG (e.g. top) have any relevant experience

similar to the treatment in the standard ATLAS/CMS κ combination

Future plans

Towards STXS 1.3…

- Finer & higher p_T binning (H→bb already probing the >1 TeV region)
- New, dedicated bins for BSM sensitivity
  - CPV Higgs couplings ($\Delta\phi_{jj}$, …)
  - Other angular information in e.g. VH (CPV, interference resurrection,…)?

Discussion points for CPV activity

- STXS for Higgs decays
  - Some discussion last year led by M. Dührssen, now dormant…
  - Call for interested contributors

Michael's Presentation and Draft note

- $H + \gamma$ channel?
- Any others?

Next steps

Possible topics/meetings for 2021-2022

- CP violation in Higgs interactions (coming weeks, stay tuned!)
- Towards STXS 1.3: theory & experimental input
- STXS for decays
- Differential measurements: combinations & evolution for run 3
- Exercise on joint fit of single measurements
- Suggestions welcome!

Thanks everyone for your efforts in 2021

We look forward to working together in 2022!

Sign up, get in touch.

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