Higgs boson physics
Items for discussion/attention

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Thanks to the organizers for this very interesting conference and for the choice of the format and thanks to the speakers for keeping that into account in their very inspiring talks:
we found this extremely useful the interaction between experimentalists and theorists!
In the following NOT a summary but a few items for discussion and future work

Items for discussion

- (Precision) measurements of Higgs properties are important by themselves, in particular in the Yukawa sector (fundamental parameters)
- Amazing progresses in SM Higgs theory predictions and tools:
  - With increasing statistics experimental precision is now challenging theory predictions, crucial to treat correctly theory uncertainties: guidelines form LHCHXSWG are crucial for the LHC experiments
  - Important that experiments use state-of-the-art signal modeling and prediction to compute theory uncertainties and to test SM: experimental analyses are a long process so sometimes there is a gap between most recent developments and their use in the publications but the goal is to do that for full Run2 publications
  - Public results in format that can be used to test models/SM also from physicists outside the experiments:
    - Publish on Hepdata and make all information available: measurements, covariance matrixes, fiducial cuts
    - Difficult to go beyond that (full PL?)
    - In general experiments are moving in this direction

Items for discussion

- Best way to perform measurement and to present results:
  - General agreement on fiducial cross-sections as best way to present results but not suitable for all channels, but with more statistics it can be extended to all production modes (now mainly ggF)
  - SXTS is an intermediate step focused on production mode kinematics that tries to:
    - Disentangle prediction errors from theory errors that affect measurements
    - Test SM on the production kinematic: regions optimized to minimize theory uncertainties and be sensitive to BSM physics
    - It works optimally if measurement sensitivity/categories match signal templates: already one iteration in LHCHXSWG after 1st round of Run2 results
    - Harmonize treatment of signal theory uncertainties: is current scheme optimal? Consider other approaches beyond ST? Need discussion in/with LHCXSWG/Theorists

Items for discussion

- Use of theory errors in "Profiled Likelihood" fit
  - Several analysis are able to "strongly constrain" (reduce by fit to data) input theory background uncertainties:
    - Major examples: VH->bb and ttH->bb
    - Crucial to agree on the way that theory systematics are modeled in the fit: "shape systematic modeling":
      - this has to be done at the analysis design stage: chose on purpose observables and region splits
    - Parametrization of the modeling uncertainties: associated shape uncertainties vs observables crucial input from theory community
    - Important to get MC tools with more precision and agreed guidance on systematic variations
    - Will become a FUNDAMENTAL issue for HL-LHC (all channels but H->$\gamma\gamma$, 4l)
- Sensitivity of tt/ttV/4top processes to Y_t:
  - Large impact of Higgs induced contribution due to large Y_t: complementary sensitivity to ttH measurements of Higgs-top coupling

Items for discussion

- Higgs couplings to second generation Fermions:
  - Next challenges for LHC experiments:
    - Muon accessible at HL-LHC (>2σ sensitivity with Full run2 + combination ATLAS+CMS)
    - Novel ideas to access charm-Higgs interaction via Low PtH spectrum, can give comparable sensitivity to direct measurements in charm-Higgs couplings, critically dependent PtH theory predictions
- Higgs self couplings:
  - Direct measurement from HH process challenging: HL-LHC projection shows we can have 4σ evidence for HH production but errors on λ_{HHH} still ~50%
  - Complementary approach: study EW corrections to single-Higgs production: need coherent treatment of rates and kinematics predictions vs λ_{HHH} for all production modes (now missing ggF parametrization)

Backup

Items for discussion

- Theoretical uncertainties on Higgs plays already an important role on xs measurements: need close interaction between theorists and experiments

Uncertainty source	$\frac{\Delta\sigma_{\mathrm{ggF}}}{\sigma_{\mathrm{ggF}}}$ [%]	$\frac{\Delta\sigma_{\mathrm{VBF}}}{\sigma_{\mathrm{VBF}}}$ [%]	$\frac{\Delta\sigma_{WH}}{\sigma_{WH}}$ [%]	$\frac{\Delta\sigma_{ZH}}{\sigma_{ZH}}$ [%]	$\frac{\Delta\sigma_{t\bar{t}H+tH}}{\sigma_{t\bar{t}H+tH}}$ [%]
Statistical uncertainties	6.4	15	21	23	14
Systematic uncertainties	6.2	12	22	17	15
Theory uncertainties	3.4	9.2	14	14	12
Signal	2.0	8.7	5.8	6.7	6.3
Background	2.7	3.0	13	12	10
Experimental uncertainties (excl. MC stat.)	5.0	6.5	9.9	9.6	9.2
Luminosity	2.1	1.8	1.8	1.8	3.1
Background modeling	2.5	2.2	4.7	2.9	5.7
Jets, $E_{\mathrm{T}}^{\mathrm{miss}}$	0.9	5.4	3.0	3.3	4.0
Flavour tagging	0.9	1.3	7.9	8.0	1.8
Electrons, photons	2.5	1.7	1.8	1.5	3.8
Muons	0.4	0.3	0.1	0.2	0.5
τ-lepton	0.2	1.3	0.3	0.1	2.4
Other	2.5	1.2	0.3	1.1	0.8
MC statistical uncertainties	1.6	4.8	8.8	7.9	4.4
Total uncertainties	8.9	19	30	29	21

Combination up to 80fb^{-1}

Items for discussion

- Use of EFT to "interpret" measurements:
  - Difficult if agnostic approach is taken (include all possible D>4 operators): easier to test "more restricted sets" based on some models?
  - These operators are often degenerate on measurements and affect not only signal but also bkgs. (e.g., H->WW analysis) so need to include them in the analysis at early stage (need to parametrize bkg. and signals in our fits as a function of EFT)
  - Best solution would be to disentangle the measurement from the interpretations:
    - Possible in channels where bkg. can be measured simultaneously (H->$\gamma\gamma$, 4l)
- Need guidance on restricted consistence set of interactions to be tested: be more quantitative on most relevant measurements for constraints on new physics