HE/HL-LHC WG2 Experimental Discussion Meeting

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HL/HE-LHC YR

- Motivations:
  - Prepare a synthesis of current status of the HL-LHC physics program. Reappraise projections made for ECFA 2014, perform new analyses, complete partial analyses and combine to provide the most complete picture.
  - Harmonize results between LHC experiments and projections from the TH community.
  - Gather and discuss new ideas from the community and reappraise prospects in the light of increased precision in SM measurements with the much larger data sample.
  - Produce a YR for the European Strategy group by EOY 2018.
- Methodology: Basic idea is to use extrapolations from Run 2 analyses to give more realistic projections (rather than partial analyses with fully parametrised realistic detector performance).
- HE-LHC: Only selected analyses will be performed with an emphasised disclaimer that these are only extrapolations with no account taken for effects such as a different detector and PU conditions (possibly in excess of 800).

Concrete Example

Recent report from LCC working group

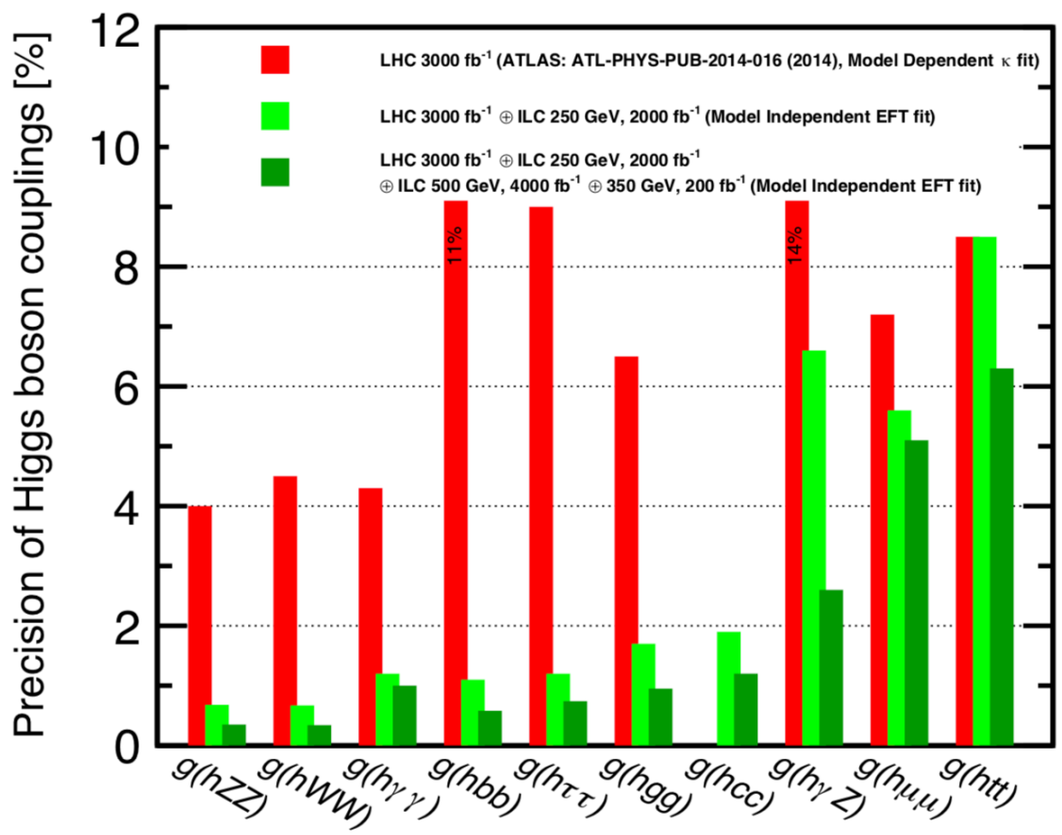

Figure 5: Illustration of the Higgs boson coupling uncertainties from fits in the EFT formalism, as presented in Table 1, and comparison of these projections to the results of model-dependent estimates for HL-LHC uncertainties presented by the ATLAS collaboration [24]. Earlier projections for HL-LHC are summarized in [29].

Important to fully clarify the extent of model dependence

Run 2 analyses sensitivities are already close to these projections:

- These results were based on analysis projections with as realistic as possible resolutions taken into account (parametrised) but only partial or non optimised analyses.
- Huge improvement in TH uncertainties.

Format

Two volumes YR: first volume (budget of approximately 150 pages for WG2) devoted to review of the Higgs at HE/HL-LHC, second volume collection of experimental public notes on analyses.

Subscriptions

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- 137 Subscribers (currently making a campaign for potential contributors who have not subscribed yet).

- If you have not done it yet, please subscribe!

- Currently assigning subjects to contributors through common google document.

https://goo.gl/VQ45yy

Timeline

- Nano status: Gathered a group of TH and EXP, prepared an outline, and made a **wishlist** of results from EXP.
- Workshop in October at CERN: https://indico.cern.ch/event/647676/
- April 4-6: HL/HE-LHC Workshop at Fermilab (w/ SM-WG1, BSM-WG3 and Flavor-WG4)
- May: Readiness of first projections.
  - We would like to be able to discuss among experiments early the projections to harmonize and combine in order to give a coherent message.
- June: Start Combinations discussions.
- June 18, HL/HE-LHC Workshop: https://indico.cern.ch/event/686494/
- June: YR Protodraft ready.
- Towards completion:
  - July/August: First batch of public notes.
  - September Plenary HE/HL-LHC workshop and complete draft YR.
  - October: Completion of publica notes and YR Volume I.
- December YRs submission

Outline

1. **Introduction: Main goals and timeline**

2. **Precision Higgs physics (WG1 does cross sections for the HE?)**
    1. Channels reach in diboson decays, including fiducial and differential measurements.
    2. Channels reach in main Yukawa couplings, including fiducial and differential measurements.
    3. Special focus on direct and indirect probe of top Yukawa coupling
    4. Progress on TH uncertainties: what to expect?
    5. Impact from PDFs and alphaS on Higgs measurements.
    6. Progress on Higgs specific MC.
    7. Higgs couplings precision overview.
    8. Probes using differential distributions of CP sensitive observables (and other dimension -6).
    9. Interpretation in terms of Composite Higgs and the MSSM.

3. **Di-Higgs production and Higgs self couplings**
    1. SM calculation
    2. Double Higgs measurements and trilinear coupling.
    3. Indirect probes of the trilinear coupling through differential distributions measurements.
    4. Indirect probes through single Higgs boson production.
    5. Theory Implications (including a critical view of the validity of direct and indirect trilinear couplings measurements.

4. **Other high energy probes**
    1. Measuring Offshell couplings
    2. tth differential measurements
    3. WH/ZH at high energy/luminosity
    4. WW WZ at high energy/luminosity
    5. VBF
    6. longitudinal VBS and di-higgs

5. **The higgs boson mass and width**
    1. Theory review
    2. Measurement of the Higgs boson mass.
    3. Mass shift from the diphoton interference: constraints on the width.
    4. Direct constraints from the Higgs boson lineshape.
    5. Direct constraints from the Higgs boson lifetime measurements.
    6. Width from Off-Shell higgs boson coupling.
    7. Width from the diphoton interference rate.

6. **Invisible decays of the Higgs boson (DM WG?)**

    1. Main channels for direct searches.
    2. Interpretation and combination with precision Higgs boson measurements.
    3. Higgs portal interpretations.

7. **Higgs flavor and rare decays**

    1. Flavor aspects Yukawa modifications in flavor models
    2. Exclusive Higgs decays
    3. Flavor tagging (charm and strange) exp mostly
    4. LFV decays of the Higgs exp mostly (CMS can try to cover this)
    5. Yukawa constraints from Higgs distributions
    6. CP violation in Higgs couplings (tau, ttH) exp mostly.

8. **BSM Higgs**
    1. Searches for additional Higgs bosons in fermionic final states (taus, b's, muons and tops)
    2. Searches for additional Higgs bosons in diboson final states.
    3. Searches for intermediate mass Higgs bosons (60 GeV - 120 GeV)
    4. Searches for low mass Higgs bosons (up to 60 GeV).
    5. Covering the MSSM, 2HDMs and the NMSSM, composite Higgs.
    6. Searches for unconventional signatures of additional Higgs bosons
    7. Searches for exotic decays of the Higgs boson

9. **Conclusions and outlook**

Collaboration with LHC Higgs XS Working Group

- First meeting with LHC Higgs XS WG Steering in January. Foresee common meetings in the near future.

- Provide cross sections (14 TeV and 27 TeV)

- Decide on TH systematics scenarii for HL/HE-LHC (taking into account, as accurately as possible future TH developments)

  - Give 2 or at most 3 scenarios for TH uncertainties, including scale variations, PDFs and strong coupling constant.

  - One baseline scenario (current uncertainties) and one optimistic (with an imaginable reduction of the uncertainties mentioned above).

  - These uncertainties should include also a foreseen optimistic scenario for jet bin uncertainties.

Today’s meeting

- Discuss internal list of plans from ATLAS, CMS and LHCb

- Start discussion to identify principal correlated systematic uncertainties in order to define projection scenarios (already done for main TH systematics with LHC Higgs XS WG).

- Ensure coverage of main analyses projections: lists have been made with priorities and we want to ensure that at least one experiment covers the important subjects.

- Highlight subjects of highest priority: worth mentioning in particular a complete and combined projection for HH and trilinear coupling constraints and on ttH.

Confidentiality

- Today's meeting is in preparation of the common LHC experiment's projections for the YR. For efficiency we need to coordinate our efforts.

- We therefore want to openly discuss our plans and possibly share unpublished projections of published results.

- Please keep these plans confidential within this working group.