

HE/HL-LHC YR Preparation WG2

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June 18-20, 2018 Workshop @ CERN

HL/HE-LHC YR

- **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.
- Harmonise results between LHC experiments and projections from the TH community.
- Synthesis of projections for HE-LHC.
- 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.

- **Goal of the workshop:**

- Review the progress in each section (in particular survey the HE projections).
- Collect and discuss all areas where choices are needed.
- Organise integration of experimental results.
- Liaise between all participants to ensure a good communication between authors.

Subscriptions

hllhc-wg2@cern.ch

- 178 Subscribers.
- If you have not done it yet, please subscribe!
- e-groups for each main section will be assigned shortly (see discussion of writing of the manuscript).
- This will constitute our draft author list. Please do not hesitate to check the list at:

Timeline and Milestones

- October CERN workshop
- April 4-6: HL/HE-LHC Workshop at Fermilab (w/ BSM-WG3 and Flavor-WG4)
- May-June 18: Restricted WG2 meetings (Exp and HH).
- June 18, HL/HE-LHC Workshop: YR Protodraft ready.
- July-October: Exp. input and preparation of combinations (ATLAS and ATLAS-CMS).
- October: Exp notes ready.
- December 18, documents submission to European Strategy.
- Early 2019: Completion of YR.

Submission



Contact:
EPPSU-Strategy-Secretariat@cern.ch

Guidelines for submitting input for the 2020 update of the European Strategy for Particle Physics

Cover page (1 page)

Each document submitted should carry a single cover page containing no more than the title, the contact person(s) and an abstract.

Comprehensive overview (maximum 10 pages)

This core part of the document must be no more than 10 pages long (excluding the cover page) and must provide a comprehensive and self-contained overview of the proposed input. It should address:

- scientific context,
- objectives,
- methodology,
- readiness and expected challenges.

Addendum

A separate addendum is to be provided addressing the following topics (where relevant):

- interested community,
- timeline,
- construction and operational costs (if applicable),
- computing requirements.

Format and deadline for submission

The cover page and the comprehensive overview are to be submitted as a single file, the "main document", in portable document format (pdf) by 18 December 2018. The addendum is to be submitted as a separate file by the same deadline. A dedicated submission portal will be available on the EPPSU website as of October 2018, once the Strategy update has been formally launched by the Council at its September 2018 Session. The link to the EPPSU website will appear on the CERN Council's web pages - <https://council.web.cern.ch/en> - and be widely communicated through the appropriate channels.

Cover page: Title, Abstract and Authors,

Executive summary (10 pages)

December 18, 2018

Full YR will not be formally submitted to
the European Strategy

This means that conclusions of the YR
effort should be finalised by then.

TH Signal Model Scenarios: Collaboration with LHC Higgs XS Working Group

- First meeting with LHC Higgs XS WG Steering this week. Foresee common meetings in the near future.
- Provide cross sections (14 TeV and 27 TeV)
- Decide on TH systematics scenarios for HL/HE-LHC (taking into account, as accurately as possible future TH developments)
- Give scenarios for TH uncertainties, including scale variations, PDFs and strong coupling constant.
- At most: one baseline scenario (current uncertainties) and one optimistic (with an imaginable reduction of the uncertainties).

Experimental Systematic Uncertainties Scenarios

- Two WG2 meetings devoted to discussions on experimental systematic uncertainties and background modelling scenarios. Conclusions will be discussed during the meeting and in dedicated talk in Plenary.
- General modus operandi agreed upon (goal is to be accurate not reach necessarily extreme precision), based as much as possible on the knowledge gathered from most recent analyses.
 - Extrapolation of latest Run 2 analyses in luminosity.
 - Extrapolation at higher energies (14, 15 and 27 TeV).
 - Making generic assumptions on performance (accounted for in form factors, e.g. efficiency or rejection corrections), folding in the different detectors and the higher PU (tricky exercise!)
 - Making assumptions on evolution of systematic uncertainties on similar basis.

Specific HE Matters

- HE running scenario given (27 TeV and 15 ab⁻¹) - however detector not specified.
- Experiments will attempt very basic extrapolations (in energy and luminosity - without fancy corrections for high foreseen PU of ~800 and different detector performance) for very few analyses (e.g. HH).
- Projections will rely mostly on TH community.
- This has to be organised within sections, please ensure to survey the status of HE projections.

YR Outline

- Outline available at the following location:

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHEWG2>

Draft Table of Contents of report:

Preliminary Outline (05/June/2018)

1. **Introduction: Main goals and timeline**
2. **Precision Higgs physics** (CMS: Predrag Milenovic, ATLAS: Michael Duehrssen-Deblin, Theo: Simone Alioli)
 - a. Channels reach in diboson decays, including fiducial and differential measurements.
 - b. Channels reach in main Yukawa couplings, including fiducial and differential measurements.
 - c. Special focus on direct and indirect probe of top Yukawa coupling
 - d. Progress on TH uncertainties: what to expect?
 - e. Impact from PDFs and alphaS on Higgs measurements.
 - f. Progress on Higgs specific MC. (Prestel,Hoeche,Maltoni,Alioli)
 - g. HE Cross-sections. (Grazzini et al.)
 - h. Higgs couplings precision overview.
 - i. Probes using differential distributions of CP sensitive observables. (Yu, Piccinini et al.)
 - j. Interpretation in terms of Composite Higgs models. (Vecchi)
 - k. Interpretation in terms of [SUSY](#) models. (Wagner, Shah)
 - l. Kappa-formalism and the nonlinear EFT. (Krause, Cata)
3. **Di-Higgs production and Higgs self couplings** (CMS: Luca Cadamuro, ATLAS: David Wardrope, Theo: Riembaun)
 - a. SM Calculation. (Dawson, Heinrich et al.)
 - b. Double Higgs measurements and trilinear coupling.
 - c. Indirect probes of the trilinear coupling through differential distributions measurements.
 - d. Indirect probes through single Higgs boson production. (Maltoni,Pagani,Zanderighi et al, Englert)
 - e. HE prospects (Goncalves & Plehn, Homiller & Meade)
 - f. Theory Implications (including a critical view of the validity of direct and indirect trilinear couplings measurements. (di Vita, Riembaun, Vantholon)
4. **Other high energy probes** (CMS: , ATLAS: , Theo: Francesco Riva)
 - a. Measuring Offshell couplings
 - b. ttH differential measurements (Maltoni, Vryonodou)
 - c. WH/ZH at high energy/luminosity (Spannovski, Mcccoulough)
 - d. WW WZ at high energy/luminosity (Elias-Miro, Panico, Azatov)
 - e. VBF
 - f. longitudinal VBS and di-Higgs (Rojo,Bishara,Contino)
 - g. Same-sign WW scattering (Kalinowski, Kozow, Pokorski, Rosiek, Szleper, Tkaczyk)

5. **The higgs boson mass and width** (CMS: Meng Xiao , ATLAS: , Theo:)
 - a. Theory review (Melnikov,Caola)
 - b. Measurement of the Higgs boson mass.
 - c. Mass shift from the diphoton interference: constraints on the width. (Dixon)
 - d. Direct constraints from the Higgs boson lineshape.
 - e. Direct constraints from the Higgs boson lifetime measurements.
 - f. Width from Off-Shell higgs boson couplings.
 - g. Width from the diphoton interference rate. (Z.Liu)
6. **Invisible decays of the Higgs boson** (CMS: [AnneMarie](#) Magnan, ATLAS: Benjamin Nachman)
 - a. Main channels for direct searches.
 - b. Interpretation and combination with precision Higgs boson measurements.(Stefaniak, Robens)
 - c. Higgs portal interpretations.(Stefaniak, Robens)
7. **Higgs flavor and rare decays** (common with WG4) (LHCb: Lorenzo Sestini, CMS: Alexander Schmidt, ATLAS: Kostas Nikopoulos, Theo: Yotam Soreq)
 - a. Flavor aspects Yukawa modifications in flavor models. (Bishara)
 - b. Exclusive Higgs decays. (Soreq)
 - c. Flavor tagging (charm and strange) (Schlaffer)
 - d. LFV decays of the Higgs
 - e. Yukawa constraints from Higgs distributions (Soreq)
 - f. CP violation in Higgs couplings (tau, ttH) (Harnik)
8. **Global view of Higgs couplings at the HL/HE-LHC** (CMS: Andrew Gilbert, ATLAS: Roberto Di Nardo and Hongtao Yang, Theo: Chris Murphy)
9. **BSM Higgs** (CMS: Martin Flechl, ATLAS: Lei Zhang, LHCb: Martino Borsato, Theo: Stefania Gori)
 - a. Searches for additional Higgs bosons in fermionic final states (taus, b's, muons and tops)
 - b. Searches for additional Higgs bosons in diboson final states.
 - c. Searches for intermediate mass Higgs bosons (60 GeV - 120 GeV). (Heinemeyer)
 - d. Searches for low mass Higgs bosons (up to 60 GeV).
 - e. Covering the MSSM and 2HDMs (J.M.No)
 - f. Covering Twin Higgs models (Redigolo)
 - g. Interference effects in heavy Higgs searches. (M. Carena, Z.Liu)
 - h. New techniques for reconstructing highly boosted heavy Higgs bosons (Klimek)
 - i. Exotic decays of the Higgs boson (D. Curtin, Z.Liu, L.T.Wang)

10. Conclusions and outlook

- Overall YR will be centralised using Overleaf.
- We will send shortly individual templates for each section.
- E-groups will be created for each section.

- YR editing organised: with editors for specific sections and sub sections.
- E-groups created for each section.

YR Editing

2. Precision Higgs physics

Editors - CMS: Predrag Milenovic, ATLAS: Michael Duehrssen-Deblin, Theo: Simone Alioli

3. Di-Higgs production and Higgs self couplings

Editors - CMS: Luca Cadamuro, ATLAS: David Wardrope , Theo: Marc Riembau

4. Other high energy probes

Editors - Theo: Francesco Riva

5. The higgs boson mass and width

Editors - CMS: Meng Xiao

6. Invisible decays of the Higgs boson

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7. Higgs flavor and rare decays (common with WG4)

Editors - LHCb: Lorenzo Sestini , CMS: Alexander Schmidt, ATLAS: Kostas Nikopoulos , Theo: Yotam Soreq

8. Global view of Higgs couplings at the HL/HE-LHC

Editors - CMS: Andrew Gilbert, ATLAS: Roberto Di Nardo and Hongtao Yang , Theo: Chris Murphy

9. BSM Higgs

Editors - CMS: Martin Flechl, ATLAS: Lei Zhang, LHCb: Martino Borsato, Theo: Stefania Gori

Workshop Organisation

- Sessions of the workshop are organised following the structure of the outline (session per section).
- Ensure that discussions are focussed on the points needing consensus.
- Goal have a progress report and a synthesis for each session.
- Speakers, please keep allocated times and stimulate discussion!