

To the WG conveners, could you please:

- Add items that might be missing or that might be new since the workshop.
- For each effort identify the editors, the team, the timeline, and the status.
- For the points that are still not decided, add “pending” or “not yet identified”.

LHC Higgs Working Group Report 5 (aka “Yellow Report 5”)

Note: updated policy for circulation and approval by the LHC HWG of Official Reports (required format for contributions to Report 5):

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHWGLibrary?redirectedfrom=LHCPhysics.LHCHXSWGLibrary>, point (b)

Links to published documents:

Offshell: <https://scipost.org/SciPostPhysCommRep.12>

ttH: <https://scipost.org/SciPostPhysCommRep.10>

Status summary:

<https://docs.google.com/spreadsheets/d/1IA3kSxvk-CztL7XyIF4WxEZZcUdathFU8gWvBrSBA9g/edit?usp=sharing>

High-priority topics proposed by the WGs:

WG1:

- **All:** Updated cross-section predictions for all Higgs boson production modes
 - ggF: Have all required input, need to write it up (started before LHCHWG meeting.)
 - VBF: Almost finished - need some numbers for aN3LO
 - VH:
 - ttH:
- **Editors:** WG1 conveners
- **ggF:**
 - The impact of N3LO pdfs on the ggF cross-section.
 - Editors/team: MSHT and NNPDF collaborations.

- Status: Document submitted to arXiv. Need to follow up to clarify the procedure they'll have to follow to get a contribution into YR5 (but want to understand the way we intend to use it in the 13.6 TeV xsec update first.)
 - Signal-background interference at NNLO in ggH diphoton.
 - Contacts: Buccioni, Tancredi
 - Status: they plan to submit.
 - 3-loop heavy flavour corrections
 - Contacts: Blumlein
 - Status: draft sent to ggF conveners
 - N4LO soft-virtual cross-sections
 - Contacts: Moch, Das
 - Status: draft sent to ggF conveners
- **VBF:**
 - Differential and parton shower study of VBF signal / harmonizing fiducial definitions.

Status: Submitted to arXiv:[2507.22574](https://arxiv.org/abs/2507.22574). (LHCHWG-2025-003)
 - ggF contribution in VBF phase-space (?)
- **VH:**
 - Differential NLO for ggZH, Include differential K-Factors in PowHeg
 - **Contributors:** Marco Vitti, Stephen Jones, Gudrun Heinrich, Ramona Groeber
 - **Status: Circulated as LHCHWG-2025-007, now on arXiv:**[2508.09905](https://arxiv.org/abs/2508.09905)
 - Resummed predictions for VH
 - **Contributors:** Goutam Das, Chinmoy Dey, M. C. Kumar, Kajal Samanta
 - **Status: In circulation (LHCHWG-2025-009)**
 1. Threshold resummation for DY-like VH process has been achieved to N3LO+N3LL accuracy.
 2. Results are available for both as a function of VH invariant mass as well as the total production rate for different center of mass energies.
 3. For the gluon-initiated ZH production, NLO+NLL resummation has been achieved for the total production as well as the ZH invariant mass in the Born-Improved theory.
 4. Combining both the DY-type and gluon fusion channels, a comprehensive study of the ZH production has been done.
- **ttH:**
 - NNLO cross-section update and comparisons among resummation schemes at NNLL: <http://cds.cern.ch/record/2924357>

Team: R. Balsach, A. Broggio, D. Devoto, A. Ferroglia, R. Frederix, M. Grazzini, S. Kallweit, A. Kulesza, J. Mazzitelli, L. Motyka, D. Pagani, B. Pecjak, C. Savoini, T. Stebel, M. Worek, M. Zaro

Status:

- Note has been circulated to LHC HWG1 list for comments on February 18
- Paper is already on arXiv: <https://arxiv.org/abs/2503.15043> (19 March 2025)
- Report number: LHCHWG-2025-001
- **Have already been submitted to SciPost (26 March 2025)**

- **Off-shell:**

- **Contents:** Comparison between LO 0+1jet (Sherpa and Madgraph) and NLO (POWHEG) cross section predictions. Parton shower and jet merging benchmarking study. Study of modeling uncertainties for off-shell predictions
- **Team:** M. Lazzeretti, M. Javurkova, R. Coelho Lopes de Sa, R. Röntsch
- **Status:** first draft in good shape, trying to include more results from Madgraph calculation.
- **Status:** posted to arXiv: [2506.17022](https://arxiv.org/abs/2506.17022), and submitted to SciPost LHCHWG-2025-002

- **BR:**

- Extend grids for quark-mass effects @ NLO for H $\rightarrow$ gg to 3 TeV in Hdecay
- Provide numbers for the Yukawa-induced contributions to H $\rightarrow$ ss with uncertainties
- For the future: proper implementation of Higgs Dalitz decays in Hdecay (not necessarily for YR5)
- **Status:** In circulation (LHCHWG-2025-008)

WG2:

- CP violation activities: dictionary note for parameterisation, kappa, SMEFT etc (presented by Henning Bahl at annual meeting)
 - Team: Daniele Barducci, Pier Paolo Giardino, Marta Fuentes Zamoro, Matthew Forslund
 - Editors: Daniele Barducci and Pier Paolo Giardino
 - Timeline: To start circulation by end of first week of July/beginning of second week
 - Status: Text being finalized
- EFT STXS toolbox parametrization has been split into two notes:
 - Team: K. Mimasu

- The EFT parametrization note is close to completion, expected to be done by the end of July
- The STXS part has been slower. Some progress has been made, but still quite far from a complete & validate set of STXS 1.2 predictions. Timeline unclear
- Recommendation for ATLAS + CMS full statistical model publication.
 - Team: G. Ortona and Hongtao Yang + others
 - Still discussing how this could be presented, e.g. some worked out examples for both ATLAS and CMS, for which the framework slightly differ. The timeline for this is unclear. Will not match the June deadline.
- Joint WG2+WG3 activity for a BSM benchmark call for Higgs CPV.
 - Team: WG2 and WG3 extended scalar sector conveners + interested person that replied to the benchmark call
 - Had a few meetings and found people that could lead the effort from both the th. and exp. side, but the activity hasn't started yet, due to people being busy. Will not match the June deadline.
- ~~STXS & CP violation for ttH~~

WG3:

- **Resonant HH/SH benchmarks in various models**
 - Authors: Thi Nhung Dao, Felix Egle, Martin Gabelmann, Margarete Mühleleitner
 - Started a discussion with the HH conveners. A common effort between WG3 and WG4. Overleaf: <https://www.overleaf.com/project/682371b7459d43c8f3440d6f>
 - Timescale: second half of July [email from Maggie]
- **bbH report: status of bbH. Theory and experiment.**
 - Authors: Christian Biello and Marius Wiesemann
 - Status on May 23: MC results are ready, including the comparison between different MC matching methods. HH ATLAS results still need to be approved.
 - Timescale~end of July
- **Exotic decays: “Exclusive hadronic decays”**

- Authors: David d'Enterria and Van Dung Le
 - Content discussed at the December workshop 2024
 - Status May 9: Content is ready, working on the text. Should be ready in time.
 - GB: Status as of 7/7/25 document ready with submission on CDS that was supposed to have happened last week, no news from the team yet.
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 - <https://scipost.org/submissions/2508.00466v1/>
- **CP violation and Extended scalars**
 - Authors: Rui Santos, Howie Haber, Venus Keus, Ken Mimasu and Thomas Biekötter
 - Status May 8: first meeting
 - Timescale: Tentative first draft 12/2025

WG4:

- Recommendations on HH cross sections at 13.6 and 14 TeV.
The document should include:
 - Cross sections recommendations for all main HH production modes for SM as well as for anomalous couplings, i.e. κ_λ and κ_{2V}
 - Higher order corrections to ggHH cross section
 - Recommendations for theory uncertainties on the ggHH cross section

Current status:

- (separate document) Introduction: **WG4 conveners**
- ~~Experimental summary and projections to HL-LHC: **WG4 conveners**~~
 - ~~Very short: where we stand, perspectives, limiting factors, ...~~
- ggF HH (suggestion to merge these into one document?):
 - Higher order corrections:
 - **Gudrun Heinrich, Michael Spira** → editors confirmed (results to be finalized in June and to be compared with Beijing group)
 - **Beijing group (Huan-Yu Bi, Li-Hong Huang, Rui-Jun Huang, Yan-Qing Ma, Huai-Min Yu)** → editors confirmed (results finalized in [Phys. Rev. Lett. 132 \(2024\) 231802](#))
 - Theory uncertainties at 13.6 and 14 TeV:
 - **Michael Spira group** → editor confirmed
 - **Sebastian Jaskiewicz** & co (top mass scheme uncertainties & log resummation), confirmed
 - Shape uncertainties (**Emanuele Angelo Bagnaschi**)
 - Dependence from k_3 and k_4 including NLO EW effects

- **Jian Wang (Shandong Univ.)** → editor confirmed (results public, https://indico.ihep.ac.cn/event/22941/contributions/171356/attachments/84646/108020/talk_in_CLHCP2024-20min.pdf)
 - **Davide Pagani, Luca** → confirmed and done
- VBF HH:
 - **Alexander Karlberg** → editor confirmed
 - **Gudrun Heinrich** → to be confirmed (powheg generator implemented)
- ttHH:
 - Nothing new to report since 2014 <https://arxiv.org/abs/1401.7340> => expect ~no changes with new PDF
 - Add a table with the reference, need to check if other groups are working on this and can produce new results
- VHH (could be included in the intro/summary? Or prepared as a standalone document):
 - Nothing new to report since 2014 <https://arxiv.org/pdf/1212.5581>
 - **Ramona** → working on this with a student, timeline of a few months, to follow up around the beginning of March 2025 (**confirmed**)
- Single-Higgs + heavy-flavour jets:

(to be done in collaboration with WG3 => organized by WG3)

 - Additional calculations for processes with b-quarks
 - **Stefano Manzoni** → confirmed
 - **Javier Mazzitelli** → to be confirmed (working together with Stefano)