Higgs Pairs Workshop 2025

Report of Contributions

https://indico.cern.ch/e/1399335

Contribution ID: **4** Type: **not specified**

A Future Higgs Factory - The Circular Electron Positron Collider (CEPC)

Friday 16 May 2025 10:15 (15 minutes)

The Circular Electron Positron Collider (CEPC) was proposed shortly after the discovery of the Higgs boson at the LHC, as a Higgs factory, with the possibility of being upgraded to a proton-proton collider in the future. The CEPC Study Group has been continuously working on the design of the accelerator, the R&D of critical technologies and components for both the collider and the instrumentation for the experiments. The group recently published the Technical Design Report of the e+e- collider and is in the process of completing a reference design of the detector system. The CEPC will be proposed to the Chinese government for approval for beginning the construction in the 2027-8 period. The CEPC is intended to be an early Higgs factory for the particle physics community. The author will report on the status, recent progress and the plan of the CEPC project.

Author: CHEN, Mingshui (Chinese Academy of Sciences (CN))

Co-authors: LOU, Xinchou (Chinese Academy of Sciences (CN)); Prof. LOU, Xinchou (IHEP,CAS)

Presenter: CHEN, Mingshui (Chinese Academy of Sciences (CN))

Session Classification: Parallel

Track Classification: Self coupling at future colliders

Contribution ID: **5** Type: **Poster**

Probing exotic Higgs decays to 4τ in single and di-Higgs production at the HL-LHC and FCC-hh

We study the prospects for observing exotic decays of the Standard Model (SM) Higgs boson h into light beyond the Standard Model (BSM) scalars a with mass m_a
$lesssim m_h/2$ in the single Higgs and Higgs pair production channels at the High Luminosity run of the Large Hadron Collider (HL-LHC). Discovery prospects for single Higgs production in the gluon-gluon fusion and vector boson fusion modes with the Higgs boson decaying via the exotic mode $h \to aa \to 4\tau$ are analyzed at the HL-LHC. The projected sensitivity for exotic Higgs decays in the non-resonant Higgs pair production channel $pp \to hh \to (h \to b\bar{b})(h \to aa \to 4\tau)$ at the HL-LHC and a future $\sqrt{s} = 100$ TeV hadron collider (FCC-hh) are also estimated. Furthermore, we study HL-LHC's potential reach for the Higgs-strahlung process in the $2b4\tau$ channel, taking into account the contamination from non-resonant Higgs pair production.
Finally, the potential reach for resonant Higgs pair production in the $2b4\tau$ channel: $pp \to H \to hh \to (h \to b\bar{b})(h \to aa \to 4\tau)$ at the HL-LHC is also explored for several choices of $\{m_H, m_a\}$. Our studies suggest that significant improvements over existing bounds are achievable in several production channels, motivating new dedicated searches for $h \to aa \to 4\tau$ at the HL-LHC and future colliders.

Authors: ADHIKARY, Amit (CPT Marseille, France); BHATTACHERJEE, BIPLOB (Indian Institute of Science); BATELL, Brian Thomas; BOSE, Camellia (Indian Institute of Science); BARMAN, Rahool Kumar (Kavli IPMU); BANERJEE, Shankha (IMSc, Chennai); QIAN, Zhuoni (Hangzhou Normal University, Hangzhou, Zhejiang 311121, China)

Presenter: BOSE, Camellia (Indian Institute of Science)

Session Classification: Poster

Track Classification: Poster

Contribution ID: **6** Type: **not specified**

Two-loop running effects in Higgs physics in Standard Model Effective Field Theory

Friday 16 May 2025 11:20 (12 minutes)

We consider the renormalization group equations within the Standard Model Effective Field Theory and compute two-loop contributions proportional to the top quark Yukawa coupling for the operator generating an effective Higgs-gluon coupling, focusing on the Yukawa-like operator.
These two-loop running effects
are relevant for processes where the effective Higgs-gluon coupling contributes ata lower loop order compared to the Standard Model contribution and where a dynamical scale choice is adopted. Such a situation arises, for instance, in the invariant mass distributin in Higgs pair production. We investigate the phenomenological impact of our computations, observing a large impact close to the threshold.
We also comment on the differences arising from using a fixed renormalization scale in comparison with a dynamical renormalization scale.

Authors: MANDAL, Manoj Kumar; GROEBER, Ramona (Università di Padova and INFN, Sezione di Padova); Dr DI NOI, Stefano (K.I.T.)

Presenter: Dr DI NOI, Stefano (K.I.T.)

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **7** Type: **not specified**

Trilogy of event reconstruction at electron positron Higgs factory

Friday 16 May 2025 11:40 (15 minutes)

The electron positron Higgs factory is regarded as the highest priority future collider facility, as it could bring decisive data from the Higgs portal to address the long standing Known Unknowns such as the origin of matter, the nature of Dark matter, the naturalness problem, etc. Meanwhile, these facilities, especially the circular ones like CEPC or FCC, could produce huge statistic of Massive Standard Model particles that enables the exploration at EW, Flavor, QCD, and direct New Physics signal search, which greatly enhances their physics merits.

Hadronic events are the bulk part of physics events at future electron positron Higgs factory. For instance, 97% of ZH signal decays into final state with jets, while the majority are actually full hadronic events. Therefore, an efficient reconstruction of those hadronic events is critical for the physics exploration at future Higgs factory, and, actually the entire high energy frontier.
To address this requirements, we propose and realize a trilogy for the event reconstruction at future Higgs factory using Artificial Intelligence and state of art detector design.
First, one-one correspondence reconstruction that aims at efficiently reconstruct and identify all the visible particles, or, to some extend, could be regarded as the confusion free Particle Flow reconstruction with Perfect particle identification;
secondly, jet origin identification that distinguish jets originated from 11 different kinds of colored particles; and thirdly, color singlet identification that aims at distinguish the color singlet origin of each reconstructed particles, for example, in a full hadronic ZH event or vvHH events, to identify from which boson a final state particle is generated.
We will present the current status of relevant performance studies, and discuss its impact on the physics exploration at future collider experiment.

Author: RUAN, Manqi (Chinese Academy of Sciences (CN))

Presenter: RUAN, Manqi (Chinese Academy of Sciences (CN))

Session Classification: Parallel

Track Classification: Self coupling at future colliders

Contribution ID: **8** Type: **not specified**

Resonant HH production: interference effects and higher order loop corrections

Friday 16 May 2025 09:20 (15 minutes)

In my talk, I will show that potentially large higher-order corrections to the trilinear Higgs coupling in Beyond the Standard Model (BSM) scenarios could enhance the interference effects between the non-resonant contribution to Higgs pair production and a resonantly produced heavy scalar. These interference effects have a significant impact on the expected shape of the differential cross section and the value of the total cross section, altering the predictions in the regions currently accessible to experiments. I will demonstrate that neglecting the interference between the contributions from heavy Higgs resonances and non-resonant (background) diagrams, as done by experimental collaborations, can lead to unreliable exclusion limits.

Authors: WEIGLEIN, Georg Ralf (Deutsches Elektronen-Synchrotron (DE)); RADCHENKO SERDULA, Kateryna (DESY); MÜHLLEITNER, Milada Margarete; HEINEMEYER, Sven (CSIC (Madrid, ES))

Presenter: RADCHENKO SERDULA, Kateryna (DESY)

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **9** Type: **not specified**

Higgs pair production with higher power dependencies of the self-couplings

Thursday 15 May 2025 17:45 (15 minutes)

The precise determination of the Higgs boson self-couplings is essential for understanding the mechanism behind electroweak symmetry breaking. However, due to the limited number of Higgs boson pair events at the LHC, only loose constraints have been established so far. Current constraints are based on the assumption that the cross section is a quadratic function of the trilinear Higgs self-coupling within the κ framework. Incorporating higher-order quantum corrections from virtual Higgs bosons would significantly alter this function form, introducing new quartic and cubic power dependencies on the trilinear Higgs self-coupling. To derive this new function form, we propose a specialized renormalization procedure that tracks all Higgs self-couplings at each calculation step. Additionally, we introduce renormalization constants for the coupling modifiers within the κ framework to ensure the cancellation of all ultraviolet divergences. With the new function forms of the cross sections in both the gluon-gluon fusion and vector boson fusion channels, the upper limit of κλ3H = λ3H/λSM3H by the ATLAS (CMS) collaboration is reduced from 6.6 (6.49) to 5.4 (5.37). However, extracting a meaningful constraint on the quartic Higgs self-coupling λ4H from Higgs boson pair production data remains challenging. We also present the invariant mass distributions of the Higgs boson pair at different values of κλ, which could aid in setting optimal cuts for experimental analysis.

Author: Prof. WANG, Jian (Shandong University)

Co-authors: LI, Hai Tao (Shandong University); SI, Zong-Guo (Shandong University); ZHANG, Xiao (Shandong University); ZHAO, Dan (Shandong University)

Presenter: Prof. WANG, Jian (Shandong University)

Session Classification: Plenary

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **12** Type: **not specified**

Theory challenges for Higgs self coupling measurements at future hadron colliders

Friday 16 May 2025 18:30 (25 minutes)

Higgs-boson pairs are dominantly produced via gluon fusion at hadron colliders, i.e. via a loop-induced process. This process will constitute the first direct access to the trilinear Higgs self-interaction. In recent years the NLO QCD corrections involving the full top-mass dependence became available by means of numerical integrations, since analytical methods available so far are not capable to solve the two-loop integrals with up to five energy scales. I'll summarize the methods that have been adopted to achieve the results with a discussion of the outcome, i.e. with the particular emphasis on the scheme and scale dependence of the virtual top mass that induces the dominant theoretical uncertainties at present. Finally, I'll provide a summary and outlook on the extension of the efforts to the full electroweak corrections to the same process.

Author: SPIRA, Michael (Paul Scherrer Institute (CH))

Co-authors: Mrs BHATTACHARYA, Arunima (University of Valencia); CAMPANARIO, Francisco (University of Valencia-University of Karlsurhe); Mr CHANG, Jamie (Paul Scherrer Institut); MAZZITELLI, Javier (Paul Scherrer Institut (CH)); Dr RONCA, Jonathan (INFN, Padua); MÜHLLEITNER, Milada Margarete; CARLOTTI, Sauro

Presenter: SPIRA, Michael (Paul Scherrer Institute (CH))

Session Classification: Plenary

Track Classification: Self coupling at future colliders

Contribution ID: **13** Type: **not specified**

Threshold enhanced corrections to $q\bar{q} \to VH$ production at the LHC

Friday 16 May 2025 12:10 (15 minutes)

We study the threshold effects for the associated production of a Higgs boson with a massive vector boson (V = Z, W) in the $q\bar{q}\to V^*\to VH$ process at the LHC. By leveraging the universality of threshold logarithms and employing soft-virtual (SV) and next-to-soft virtual (NSV) resummation techniques, we compute threshold corrections to next-to-next-to-leading logarithmic accuracy. After matching the resummed predictions to the Next-to-Next-to-Leading order (NNLO) fixed order results, we present the invariant mass distribution to $NNLO + \overline{NNLL}$ accuracy in QCD for the current LHC energies and the total production cross-sections.

The VH production channel is crucial for studying the couplings of the Higgs boson to the vector bosons (W, Z) and understanding the mechanism of electroweak symmetry breaking. Precision measurements of this process help test the validity of the SM and can reveal potential deviations indicating new physics.

Authors: Dr BHATTACHARYA, Arunima (Instituto de Física Corpuscular (University of Valencia)); Mr DEY, Chinmoy (IIT Guwahati); Dr MEDURI CHAKRAVARTULA, Kumar (IIT Guwahati); PANDEY, vaibhav

Presenter: Dr BHATTACHARYA, Arunima (Instituto de Física Corpuscular (University of Valencia))

Session Classification: Parallel

Track Classification: Rare production mode (VHHH, HHH, ⋯) and quartic-coupling

Contribution ID: **14** Type: **not specified**

Double Higgs production and the Higgs self coupling in Global SMEFT fits

Friday 16 May 2025 11:50 (12 minutes)

The ongoing Standard Model Effective Field Theory (EFT) program at the LHC and elsewhere aims at charting the parameter space allowed for deviations from the SM coming from heavy Beyond Standard Model (BSM) physics. Possible hints of New Physics could appear as subtle correlated deviations in several observables but parameterized by a single parameter. Hence, the community has invested great effort in producing global fits of the SMEFT that consider hundreds of experimental data points from LHC experiments and others.

The SMEFiT collaboration, which I am part of, has produced the most ambitious global fit yet with more than 400 experimental data points, mostly from LHC Run 2, cutting-edge Bayesian statistical techniques, inclusion of NLO corrections and quadratic dependence on the WCs, automated support for future colliders and for UV models matched onto SMEFT (see 2404.12809 and 2309.04523).

Here, I will present one of our latest updates: the inclusion of double Higgs measurements from LHC Run 2 and its HL-LHC projections. This allowed us to fit the dimension-6 operator c_H that modifies the Higgs potential for the first time and claim that double Higgs production is enough to constrain this operator in a large global fit. I will discuss possible correlations with other operators, RGE running effects, how FCC-ee could improve on double Higgs via 1-loop corrections, and the impact of this measurement on exploring concrete BSM models. Overall, we can assess the global impact of double Higgs measurements in the SMEFT framework now and in the future.
These results will be part of an upcoming paper (to be published before the workshop).

Author: ROSSIA, Alejo Nahuel (University of Padua and INFN Sezione di Padova)

Presenter: ROSSIA, Alejo Nahuel (University of Padua and INFN Sezione di Padova)

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **15** Type: **not specified**

Boosted HH to 4B at CMS

Friday 16 May 2025 09:40 (15 minutes)

We present the search for nonresonant Higgs boson (H) pair production performed in the four-bottom-quark final state with the CMS experiment at the LHC. The analysis targets Lorentz-boosted H pairs identified using novel machine learning techniques and constrains the strengths relative to the standard model of the H self-coupling and the quartic VVHH couplings. We report on the latest results from the LHC Run3 dataset.

Author: KANSAL, Raghav (California Institute of Technology)

Presenter: KANSAL, Raghav (California Institute of Technology)

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **16** Type: **not specified**

CMS Level-1 Trigger improvements for HH at the HL-LHC

Friday 16 May 2025 09:30 (12 minutes)

The CMS Level-1 Trigger will be upgraded for the HL-LHC in order to cope with the increased pileup and upgraded detectors. In particular, the inclusion of the tracker will enable offline-like Particle Flow reconstruction at L1, which will allow preserving and even potentially extending the trigger acceptance. This talk will give a brief overview of the upgraded L1 Trigger, the expected performance and focus on improvements that will improve sensitivity to HH final states.

Author: LOBANOV, Artur (University of Hamburg (DE))

Presenter: LOBANOV, Artur (University of Hamburg (DE))

Session Classification: Parallel

Track Classification: Performance: trigger, object reconstruction, calibration, and identification

Contribution ID: **17** Type: **not specified**

Triple Higgs boson production in EFTs from on-shell amplitude techniques

Wednesday 14 May 2025 10:30 (15 minutes)

With the measurement of double Higgs production within reach, it is justified to expand our interest to more exotic processes, such as three Higgs boson production. This rare process is crucial for advancing our understanding of the Higgs boson, its interactions (including self-coupling), the Higgs potential, and the mechanism of electroweak symmetry breaking (EWSB). This talk explores the application of on-shell amplitude techniques to study triple Higgs production via gluon fusion and vector boson fusion in EFTs. We construct the relevant kinematic structures, match our results to both HEFT and SMEFT, and analyze the implications. The comparison provides valuable insights into Higgs dynamics and the interplay between EFT frameworks. The talk based on ongoing work.

Authors: ROSSIA, Alejo Nahuel (University of Padua and INFN Sezione di Padova); RYCZKOWSKI, Michal; GROEBER, Ramona (Università di Padova and INFN, Sezione di Padova)

Presenter: RYCZKOWSKI, Michal

Session Classification: Plenary

Track Classification: Rare production mode (VHHH, HHH, ⋯) and quartic-coupling

Contribution ID: **18** Type: **not specified**

VBF-HH at NLO QCD in non-linear Higgs Effective Field Theory

Friday 16 May 2025 11:35 (12 minutes)

We present a calculation of the NLO QCD corrections to Higgs boson pair production in vector boson fusion including anomalous couplings. Those couplings are generated by the relevant leading operators of the non-linear Higgs Effective Field Theory (HEFT). We use the Monte Carlo program Whizard interfaced with the amplitude provider GoSam to investigate EFT effects at the level of the total cross section and in various kinematic distributions.

Author: HÖFER, Marius (KIT)

Co-authors: HEINRICH, Gudrun (KIT); BRAUN, Jens (KIT); BREDT, Pia (Universität Siegen)

Presenter: HÖFER, Marius (KIT)

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **20** Type: **not specified**

CMS results with EFT and UV completion

Friday 16 May 2025 09:00 (15 minutes)

Over the course of the LHC Run 2 the number and precision of Di-higgs results have greatly increased and while the CMS and ATLAS experiments are inching towards SM sensitivity, the interest in BSM interpretations remains unbroken with the improving sensitivity unlocking more sophisticated interpretations of the experimental results. One useful tool in this effort are EFT frameworks such as SMEFT and HEFT which allow us to search for new physics without strong model dependencies. On the theory side, constraints of the relevant Wilson coefficients can then be used to check the viability of more sophisticated and UV-complete models, where different correlation patterns between EFT parameters arise. Such correlation is not trivial to take into account in recasts from one or two dimensions EFT parameter scans. In the presented CMS results, we use mappings of parameters such as mixing angles in extended Higgs sectors scenarios to EFT operators to re-express our experimental likelihood directly in the parameters of a full model. We also compare the constraints obtained with this method with the ones obtained by direct resonance searches for Higgs pairs in the singlet model and with a similar approach used on single Higgs searches.

Author: LANGE, Torben (National Institute of Chemical Physics and Biophysics (EE))

Presenter: LANGE, Torben (National Institute of Chemical Physics and Biophysics (EE))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **21** Type: **not specified**

General CP-violating 2HDM in light of the excesses in di-photon searches at the LHC

Thursday 15 May 2025 16:35 (12 minutes)

The most general CP-violating two-Higgs-doublet model (2HDM) in the Yukawa alignment limit can produce significant di-photon branching ratios for the neutral scalars of the model. In the Higgs basis, where the two scalar doublets are identified as H_1 and H_2, the lagrangian term $Z_7 H_1^\dagger H_2 H_2^\dagger H_2 + \text{h.c.}$ enters the branching ratios to di-photon of the new physics (mostly) CP-even scalar H and the (mostly) CP-odd scalar A. While the $\Re[Z_7]$ contributes to $H \to \gamma\gamma$, the $\Im[Z_7]$ affects $A \to \gamma\gamma$ and can also be correlated to CP violating observables, such as non nonzero electric dipole moments.

In this framework, we derive bounds on electroweak scale scalars, using the recently observed statistically significant excesses at $95\,\text{GeV}$ and $152\,\text{GeV}$ as indicative benchmarks. In particular, the $152\,\text{GeV}$ scenario requires associated production of new physics scalars via Drell-Yan.

Based on: https://arxiv.org/abs/2412.00523

Author: COLORETTI, Guglielmo (University of Zurich (UZH) / Paul Scherrer Institute (PSI))

Presenter: COLORETTI, Guglielmo (University of Zurich (UZH) / Paul Scherrer Institute (PSI))

Session Classification: Plenary

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **22** Type: **not specified**

Top-Yukawa-induced corrections to Higgs pair production

Friday 16 May 2025 10:00 (12 minutes)

After the discovery of the Higgs boson in 2012, the measurements of the Higgs self coupling is still a challenge for current and future experiments in particle physics.
Higgs-boson pair production via gluon fusion is a loop-induced process. In order to increase the accuracy of the theoretical predictions for this process, higher-order corrections are necessary to reduce theoretical uncertainties and to describe differential distributions reliably. The next-to-leading order (NLO) corrections involve the evaluation of two-loop Feynman diagrams. In particular, for electroweak (EW) corrections, many different mass scales appear in the calculation, such as the gauge boson, bottom, top quark, and Higgs boson masses. Further complications include numerical instabilities due to virtual thresholds which require careful treatment. In my talk, I will present results for the EW corrections induced by the top Yukawa coupling with contributions from light-quark loops without using any reduction techniques to master integrals. The calculations is done by keeping the masses as fully symbolic parameters, allowing, in the future, for a study of parametric and mass scheme/scale uncertainties.

Authors: Dr BHATTACHARYA, Arunima (Instituto de Física Corpuscular (University of Valencia), Spain); CAMPANARIO, Francisco (University of Valencia-University of Karlsurhe); CHANG, Jamie (Paul Scherrer Institut); MAZZITELLI, Javier (Paul Scherrer Institut (CH)); RONCA, Jonathan (INFN, Padua); SPIRA, Michael (Paul Scherrer Institute (CH)); MÜHLLEITNER, Milada Margarete; CARLOTTI, Sauro

Presenter: CARLOTTI, Sauro

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **23** Type: **not specified**

Looking for a SFOEWPT in the RxSM at the HL-LHC and LISA

Friday 16 May 2025 10:00 (12 minutes)

We explore the real-singlet extension of the Standard Model without a Z2 symmetry (RxSM) as a framework to address the baryon asymmetry of the Universe and investigate modifications to the Higgs potential. First, we identify regions of parameter space that allow a Strong First-Order Electroweak Phase Transition (SFOEWPT) using the public tools BSMPT, CosmoTransitions, and TransitionListener, while incorporating relevant theoretical constraints as well as experimental bounds through HiggsTools. Additionally, we calculate the stochastic gravitational wave background and assess its potential observability at LISA. Next, we determine the one-loop corrections to the trilinear Higgs couplings involved in di-Higgs production (λ_{hhh} and λ_{hhH}) using the public code anyH3. Finally, we evaluate the di-Higgs production cross section at the (HL-)LHC within the regions of the RxSM parameter space that permit an SFOEWPT, taking into account the one-loop corrections to the trilinear Higgs couplings. This result is compared with those obtained in the SM and in the RxSM at tree level, highlighting the significant impact of loop corrections on the trilinear couplings.

Authors: VERDURAS SCHAEIDT, Alain (DESY); BRAATHEN, Johannes Alf (DESY); HEINEMEYER, Sven (CSIC (Madrid, ES))

Presenter: VERDURAS SCHAEIDT, Alain (DESY)

Session Classification: Parallel

Track Classification: Self coupling at future colliders

Contribution ID: **24** Type: **not specified**

Connecting Multi-Higgs production and the Electroweak Phase Transition

Friday 16 May 2025 11:50 (15 minutes)

Exploring the Higgs sector via multi-Higgs production searches is a main goal for run-3 and high-lumi LHC. Can these searches inform us about the electroweak phase transition and matter-antimatter asymmetry?
We address this question in the context of the TRSM (Two-Real-Singlet Model), which has known benchmark points enhancing multi-Higgs production.
We update the triple-Higgs production benchmark points to include refined perturbativity bounds and explore the type of electroweak phase transition that occurs in the early universe; whether continuous or the first-order discontinuous phase transition desired for matter-antimatter asymmetry.
After presenting our work, I outline lessons on correlating the type of electroweak phase transition and the enhancement of di-Higgs or triple Higgs production, highlighting the importance of the theory's vacuum expectation value of today and the symmetries of the model.

Author: KARKOUT, Osama (Nikhef National institute for subatomic physics (NL))

Presenter: KARKOUT, Osama (Nikhef National institute for subatomic physics (NL))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **25** Type: **not specified**

A novel implementation of the Matrix Element Method at next-to-leading-order (NLO) for the measurement of the Higgs tri-linear coupling in di-Higgs production at the LHC

Friday 16 May 2025 09:00 (15 minutes)

One of the LHC's priorities, following the discovery of the Higgs boson, is to observe the production of Higgs pairs and to measure the Higgs tri-linear coupling λ_{3H}.
Due to the rarity of di-Higgs production, measuring λ_{3H} has proven to be highly challenging. Exclusion limits have been observed using a variety of approaches, including cut-based methods and boosted decision trees (BDTs).
To address this difficulty from a new perspective, our work explores the application of the Matrix Element Method (MEM), a technique that has demonstrated its effectiveness in multiple analyses in which measurements were performed in processes that were rare (at the time). One can mention the primordial role of the MEM in measuring the top-quark mass at Tevatron, or its role in the first evidence for single top production in the s-channel at the LHC for example.
The MEM is a statistically optimal multivariate method that maximizes the utilization of both the experimental and theoretical information available to an analysis, making it inherently well-suited to rare process searches and Standard Model measurements at particle accelerators like the LHC.
The MEM avoids the application of strict selection requirements to the data. It accounts for the entire dataset (with minimal preselection), which is very important when dealing with such rare processes.
Most MEM studies have been limited to leading-order (LO) accuracy, with extensions to next-to-leading-order (NLO) explored only in specific cases due to the additional complexities introduced by virtual and real contributions. Building a MEM at LO is already a highly challenging task, and incorporating NLO formalism substantially amplifies this difficulty due to the increased computational demands and complex theoretical requirements.
To contribute to the measurement of λ_{3H} from LHC data in the $gg \to HH \to b\bar{b}\gamma\gamma$ channel, we developed a MEM framework by working on a new NLO implementation (which can be applied in many more analyses).
This MEM framework utilizes state-of-the-art Matrix Elements at NLO from the POWHEG-BOX-V2 and MG5_@NLO software packages. The framework is implemented within a modified version of MoMEMta, a software designed for managing multi-variable phase-space integration, which has been extended to incorporate this new NLO implementation.
To our knowledge, this work marks the first application of the MEM at NLO accuracy to the search for HH and the measurement of λ_{3H}. This also represents the first application of the MEM using this new NLO formalism.
We have demonstrated that this NLO framework is functional and effective.
We also applied this framework to Monte Carlo (MC) simulated samples in a search for λ_{3H}, achieving promising results. This study aims to introduce this new approach to the community and position the MEM (at NLO) as a competitive alternative to other established methods to determine the Higgs self-coupling λ_{3H}.

Authors: STARK, Jan (Laboratoire des 2 Infinis - Toulouse, CNRS / Univ. Paul Sabatier (FR)); TARTARIN, Matthias Jean (Laboratoire des 2 Infinis - Toulouse, CNRS / Univ. Paul Sabatier (FR))

Presenter: TARTARIN, Matthias Jean (Laboratoire des 2 Infinis - Toulouse, CNRS / Univ. Paul Sabatier (FR))

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **26** Type: **not specified**

Light-Quark Electroweak Contributions to Double Higgs Production at Hadron Colliders

Friday 16 May 2025 10:15 (12 minutes)

A precise determination of the Higgs boson self-coupling is a central objective in high-energy physics, offering critical insight into the structure of the Higgs potential and electroweak symmetry breaking. As the Hi-Lumi phase at the LHC aims to tighten constraints on this coupling, next-to-leading order (NLO) electroweak corrections to double Higgs production become a critical component of theoretical predictions.
In this talk, I will present the analytic evaluation of the light-quark electroweak contributions to double Higgs production at hadron colliders. I will discuss the computational challenges associated with these calculations and examine how these contributions compare to the full electroweak corrections.

Author: Mr BONETTI, Marco (IAP Karlsruher Institut für Technologie)

Co-authors: Mr RENDLER, Philipp (KIT); TORRES BOBADILLA, William (University of Liverpool)

Presenter: Mr BONETTI, Marco (IAP Karlsruher Institut für Technologie)

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **27** Type: **Poster**

Towards full EW corrections to Higgs pair production

With the upcoming HL-LHC and the increased experimental precision, the calculation of electroweak corrections to Higgs boson pair production in gluon fusion is important for sufficiently precise theory predictions. This talk will present recent results regarding Yukawa and Higgs self-coupling induced corrections and discuss the status of our calculation including gauge bosons.

Authors: VESTNER, Augustin; HEINRICH, Gudrun (KIT); Mr BONETTI, Marco (IAP Karlsruher Institut für Technologie); KERNER, Matthias (KIT); RENDLER, Philipp (Institute for Theoretical Physics, KIT); JONES, STEPHEN; STONE, Tom (IPPP @ Durham University)

Presenter: VESTNER, Augustin

Session Classification: Poster

Track Classification: Poster

Contribution ID: **28** Type: **not specified**

Analysis improvements for the Higgs self-coupling measurement at ILD

Friday 16 May 2025 12:00 (12 minutes)

A precise determination of the Higgs self-coupling represents a cornerstone of the physics program of future colliders because it gives important insights into the shape of the Higgs potential and thus into the evolution of the early universe. This contribution will present an update of the analysis of di-Higgs production in e^+e^- collisions at \mbox{500 GeV} using detailed simulations of the ILD detector concept, incorporating advancements through state-of-the-art particle ID, flavor tagging and ML-driven event selection. In particular, we will apply these tools to the $HH \to b\bar{b}b\bar{b}$ and $Z \to q\bar{q}/e^+e^-/\mu^+\mu^-/\bar{\nu}\nu$ channels. Based on the experience of previous analyzes, we extrapolate these to cover the contributions of other decay modes and from the W^+W^- fusion production mode. We study the dependency of the results on the center-of-mass energy as well as on the value of the trilinear coupling realized in nature.

Authors: BLIEWERT, Bryan (Deutsches Elektronen-Synchrotron (DE)); VERNIERI, Caterina (SLAC National Accelerator Laboratory (US)); NTOUNIS, Dimitris (SLAC National Accelerator Laboratory (US)); LIST, Jenny (Deutsches Elektronen-Synchrotron (DE)); TORNDAL, Julie Munch (Deutsches Elektronen-Synchrotron (DE)); Dr TIAN, Junping (The University of Tokyo)

Presenter: BLIEWERT, Bryan (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Parallel

Track Classification: Self coupling at future colliders

Contribution ID: **29** Type: **not specified**

One Loop BSM Triple Higgs Couplings at future electron-positron colliders via double Higgs production

Friday 16 May 2025 12:15 (12 minutes)

We analyze the impact of one-loop corrections to triple Higgs bosons on the di-Higgs production cross section at e^+e^- colliders within the two Higgs doublet model (2HDM). In particular, we study the production cross section of two SM-like Higgs bosons together with a boson, also known as double Higgs-strahlung. The one-loop triple Higgs couplings are calculated using the one-loop effective potential, and in the case of the SM-like Higgs boson self-coupling λ_{hhh}, a full one-loop diagrammatic calculation is also considered. We show that one-loop corrections to the Higgs self-coupling can enhance the di-Higgs production cross section by up to a factor of about five with respect to the SM prediction for a center-of-mass energy of 500 GeV and 1 TeV. These large corrections, originating in the one-loop corrections to λ_{hhh}, arise from the large couplings of the SM-like Higgs boson with other heavy BSM Higgs bosons, while being in agreement with the main theoretical and current experimental constraints. In addition, we discuss the momentum effects from the full one-loop self-coupling prediction, and we show that they are small compared to the results obtained with the effective potential. We also analyze some scenarios where the one-loop corrections to the triple Higgs couplings can affect the resonant production of a heavy neutral Higgs boson, and discuss the implications for the structure of the resonance peak, as well as the accessibility of the BSM triple Higgs coupling λ_{hhH} at e^+e^- colliders.

Authors: ARCO, Francisco; MÜHLLEITNER, Milada Margarete; HEINEMEYER, Sven (CSIC (Madrid, ES))

Presenter: ARCO, Francisco

Session Classification: Parallel

Contribution ID: **30** Type: **not specified**

Advanced identification techniques for Boosted $H \to \tau\tau$

Friday 16 May 2025 09:15 (12 minutes)

The identification of Lorentz-boosted Higgs boson is a critical challenge in advancing Higgs pair production studies. This talk provides a comprehensive overview of recent developments on techniques to identify boosted Higgs bosons decaying into tau lepton pairs ($H \to \tau\tau$), on offline reconstruction. Both hadronic ($H \to \tau_{\mathrm{had}}\tau_{\mathrm{had}}$) and leptonic ($H \to \tau_{\mathrm{had}}\tau_{\mu}$) decay channels are considered. The presentation explores the progress on several approaches, using machine learning-based algorithms adapted to the decay properties of tau leptons in the boosted regime. The presentation highlights the importance of the tagging strategy in the boosted regime to enhance the sensitivity of the Higgs pair production analyses.

Author: NINIO, Gadi (Tel Aviv University (IL))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: NINIO, Gadi (Tel Aviv University (IL))

Session Classification: Parallel

Track Classification: Performance: trigger, object reconstruction, calibration, and identification

Contribution ID: **31** Type: **Poster**

Search for Higgs boson pairs with multi-lepton final states in pp collisions at √s = 13 TeV with the ATLAS detector

A search is presented for non-resonant Higgs boson pair production decaying to multi-lepton final states using 140 fb-1 of proton-proton collision data at centre-of-mass energy 13 TeV, recorded with the ATLAS detector during Run 2 of the LHC. Nine search channels with varying multiplicities of electrons, muons, taus, and photons are combined to determine the observed (expected) limit on the signal strength, found to be 17 (11) times the Standard Model prediction. The observed (expected) 95% confidence interval constraints on the HHH coupling modifier, kappa lambda, are -6.2 < kappa lambda < 11.6 (-4.5 < kappa lambda < 9.6). A projection of the sensitivity of this analysis to non-resonant Higgs boson pair production to the High Luminosity LHC (LH-LHC) is also presented, assuming a centre-of-mass energy 14 TeV and integrated luminosities up to 3000 fb-1.

Author: THORNBERRY, Rea (Southern Methodist University (US))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: THORNBERRY, Rea (Southern Methodist University (US))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **32** Type: **not specified**

Search for Higgs Pair Production Decaying into 2 Photons and 2 b Quarks at the High-Luminosity LHC

Friday 16 May 2025 09:20 (15 minutes)

The Standard Model (SM) is currently the most predictive framework for describing interactions among the fundamental constituents of matter. It includes 19 free parameters, which are measured experimentally, notably with the ATLAS detector at the Large Hadron Collider (LHC) at CERN. These parameters encompass particle masses, phases, and coupling values. One of these couplings, the Higgs boson self-coupling, stands out due to its unique nature: Only a scalar can possess a self-coupling, and it is a key parameter in shaping the Higgs potential, explaining the origin of particle masses. Hence, precisely knowing the value of this coupling is crucial, either to strengthen the predictive power of the SM and constrain the shape of the Higgs potential, which has a direct impact on the stability of our universe, or to open the door to new physics. This coupling is involved in the simultaneous production of two Higgs bosons via a virtual Higgs boson, a rare process with a cross-section 1,000 times smaller than that of single Higgs boson production. This process presents a detection challenge, as the two Higgs bosons decay into various types of particles with different probabilities. A particularly sensitive signature for this measurement is the decay of a pair of Higgs bosons into two b-quarks and two photons ($HH \to b\bar{b}\gamma\gamma$). Although currently limited by the amount of data collected, this analysis has provided the best existing constraint on this value. An upgrade to the LHC, called the High Luminosity LHC (HL-LHC), aims to increase the data produced by a factor of 20 compared to the current measurement. A sensitivity projection study for this coupling measurement allows us to determine the expected constraint at the end of the HL-LHC program, based on the latest Run 2 legacy results provided by ATLAS (JHEP 01 (2024) 066). Moreover, this channel will play a major role in the combination with other channels as well as the one with CMS, providing the most precise measurement of the self-coupling and paving the way for the discovery of Higgs pair production.

Author: LAFARGE, Arthur (Université Clermont Auvergne (FR))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: LAFARGE, Arthur (Université Clermont Auvergne (FR))

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **33** Type: **not specified**

Advances in Trigger Strategies for the Run 3 HH->bbtautau search in the ATLAS experiment

Friday 16 May 2025 09:45 (12 minutes)

The HH searches are fundamentally constrained by statistical limitations. Enhancing the sensitivity to the HH → bbττ decay channel, the most sensitive process for Higgs pair production in ATLAS, necessitates innovative trigger strategies. Conventional trigger approaches adopted for the HH → bbττ channel in Run 2, focusing solely on di-τ triggers have faced challenges in capturing the full spectrum of events. The ATLAS collaboration is considering for the Run 3 analysis the usage of di-b-jet triggers in addition to improved di-τ triggers and implemented also a new b+tau trigger at the start of 2024 for increasing the trigger selection efficiency for the HH → bbττ signal. By this point, the ATLAS experiment has already recorded a remarkable integrated luminosity of 180 fb^{-1} of Run 3 data, larger than the total Run 2 luminosity, with an additional 1.5 years of data collection remaining. This advancement is a crucial step toward overcoming current limitations and improving the efficiency of the HH → bbττ analysis.

Author: FIACCO, Davide (Sapienza Universita e INFN, Roma I (IT))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: FIACCO, Davide (Sapienza Universita e INFN, Roma I (IT))

Session Classification: Parallel

Track Classification: Performance: trigger, object reconstruction, calibration, and identification

Contribution ID: **34** Type: **Poster**

Search for a resonance decaying to a scalar particle and a Higgs boson in the final state with two bottom quarks and two photons in proton-proton collisions with the ATLAS detector

A search for the resonant production of a heavy scalar 𝑋 decaying into a Higgs boson and a new lighter scalar 𝑌, through the process 𝑋 → 𝑌(𝑏𝑏)𝐻(𝛾𝛾), where the two photons are consistent with the Higgs boson decay, is performed. The search is conducted combining an integrated luminosity of 140 fb−1 of proton-proton collision data at a centre-of-mass energy of 13 TeV, and 58.6 fb-1 of proton-proton collision data at a centre-of-mass energy of 13.6 TeV, recorded with the ATLAS detector at the LHC from 2015-2018, and 2022-2023 respectively. Similarly to the previous iteration of this search, it is performed for 170 ≤ 𝑚𝑋 ≤ 1000 GeV and 15 ≤ 𝑚𝑌 ≤ 500 GeV and parameterised neural networks are used to enhance the signal purity and to achieve continuous sensitivity in a domain of the (m_X, m_Y) plane.

Author: VANDE VOORDE, Magdalena (KTH Royal Institute of Technology (SE))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: VANDE VOORDE, Magdalena (KTH Royal Institute of Technology (SE))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **35** Type: **not specified**

A FreSH set of data: First ATLAS Run 2 + partial Run 3 SH search in the two b-quark, two photon final state

Friday 16 May 2025 09:40 (15 minutes)

Many BSM models predict the existence of additional Higgs-like scalar bosons, including the two-Higgs-doublet model, the Next-to-Minimal Supersymmetric Standard Model, and the Two-Real-Singlet-Model, among others. The existence of these particles would be consistent with a first order phase transition during the early universe, which could explain the matter-antimatter asymmetry we observe in the universe. Searches for these particles via the X to SH process, where X and S are BSM Higgs-like scalar bosons, have been performed by the ATLAS and CMS experiments in multiple final states using the Run 2 dataset. Excesses of this process were observed in the two photon, two b-quark final state by both the ATLAS and CMS experiments using their Run 2 datasets in different regions of the two dimensional mass plane, strongly motivating the extension of these analyses with the newly collected Run 3 data. This talk will present the first Run 3 ATLAS search for X to SH in the two b-quark, two photon final state, where a combination of the Run 2 and partial Run 3 dataset is performed.

Author: TISHELMAN-CHARNY, Abraham (Brookhaven National Laboratory (US))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: TISHELMAN-CHARNY, Abraham (Brookhaven National Laboratory (US))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **37** Type: **not specified**

Calibration of the GN2 b-tagging algorithm with ttbar and Z+jets events using 140 fbˆ-1 of ATLAS proton-proton collsion data at sqrt(s)=13 TeV

Friday 16 May 2025 09:00 (12 minutes)

Jet flavour-tagging algorithms to identify hadronic jets containing b-hadrons are crucial tools for searches of Higgs boson pair production in the ATLAS experiment at the LHC, due to the large branching ratio of the H−>bb process. GN2, the state-of-the-art jet flavour-tagging algorithm developed by ATLAS, delivers a performance that significantly surpasses its predecessors and is expected to significantly enhance the sensitivity of Higgs pair production searches featuring b-quarks in their final states. This talk presents the calibration of GN2's performance on b, c, and light-flavour jets on real data, using ttbar and Z+jets candidate events selected from 140 fbˆ-1 of proton-proton collision data collected at a center of mass energy of sqrt(s)= 13 TeV between 2015 and 2018.

Author: TANASINI, Martino (Stony Brook University (US))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: TANASINI, Martino (Stony Brook University (US))

Session Classification: Parallel

Contribution ID: **38** Type: **not specified**

Taming a leading theoretical uncertainty in HH measurements via accurate simulation for bbH production

Friday 16 May 2025 11:00 (15 minutes)

We present a new simulation for Higgs boson production in association with bottom quarks (bbH) at next-to-leading order (NLO) matched to parton showers. The contributions proportional to the bottom-quark Yukawa coupling and top-quark Yukawa coupling (from gluon fusion) are both taken into account in a scheme with massive bottom quarks. The bbH process constitutes a crucial background to measurements of Higgs-boson pair (HH) production at the LHC when at least one of the Higgs bosons decays to bottom quarks. So far, the modeling of bbH induced one of the dominant theoretical uncertainties to HH measurements, as the gluon-fusion component was described only at the leading order with uncertainties of O(100%). Including NLO corrections allows to reduce the scale dependence to O(50%). We provide an in-depth analysis of the bbH background to HH measurements and we propagate the effect of the new bbH simulation to HH searches in the $2b2\gamma$ and $2b2\tau$ final states.

Author: MAZZEO, Elena (Università degli Studi e INFN Milano (IT))

Co-authors: MAZZITELLI, Javier (Paul Scherrer Institut (CH)); ZARO, Marco (Università degli Studi e INFN Milano (IT)); WIESEMANN, Marius (Max Planck Institute for Physics); MANZONI, Stefano (CERN)

Presenter: MAZZEO, Elena (Università degli Studi e INFN Milano (IT))

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **41** Type: **not specified**

Impact of renormalisation group equation on Higgs production in the SMEFT

Friday 16 May 2025 12:05 (12 minutes)

We study the impact of RGE running and mixing of SMEFT operators on differential observables in Hj,$t\bar{t}H$ and HH production at the LHC. We focus on a subset of operators closed under the QCD-induced anomalous dimension matrix and explore the impact of employing a fixed or dynamical scale on the EFT predictions for the Higgs transverse momentum and Higgs pair invariant mass spectra. We then explore the impact of taking into account RGE effects on the constraints obtained on the Wilson coefficients through fits to current data, as well as projections for the HL-LHC.

Authors: VRYONIDOU, Eleni (The University of Manchester (GB)); Prof. MALTONI, Fabio (Universite Catholique de Louvain (UCL) (BE) and Università di Bologna); VENTURA, Giuseppe

Presenter: VENTURA, Giuseppe

Session Classification: Parallel

Track Classification: Non-resonant HH and self-coupling

Contribution ID: **43** Type: **not specified**

A calibratable jet-free HH(4b) search framework at the LHC

Friday 16 May 2025 10:00 (15 minutes)

A calibratable experimental strategy is proposed to enhance the $HH(4b)$ search sensitivity via full-particle classification. Inspired by the competitive performance from the boosted-topology HH analysis, which uses state-of-the-art jet neural networks to analyze $o(100)$ particles within large-R jets, this approach aims to extend its strong signal-to-background discrimination power beyond the boosted regime to a broader phase space accessible through conventional $HH(4b)$ triggers.

The approach involves training a universal classifier to distinguish $X \to Y_1Y_2 \to b\bar{b}b\bar{b}$ signals from QCD and $t\bar{t}$ multijet backgrounds across a wide range of X and $Y_{1,2}$ mass values, and simultaneously estimating the $Y_{1,2}$ masses via a multiclass classification technique. Results demonstrate that the background suppression capability matches that of identifying two boosted $X \to b\bar{b}$ jets, revealing a scaling law governing signal and background yields in both cases. The framework is complemented by a robust signal calibration and validation procedure: event-level classier calibration is performed using an orthogonal dimuon-triggered phase space and an "event hemisphere mixing"technique to construct fake $ZZ(4b)$ events; validation is then conducted using genuine $ZZ(4b)$ data passing the analysis trigger. With combined Run 2 and 3 datasets, the proposed strategy can achieve the first observation of the $ZZ(4b)$ process and deliver a search sensitivity for $HH(4b)$ comparable to HL-LHC projection. This approach holds a great premise to accelerate the pace of HH search at the LHC and advance our understanding of the Higgs self-coupling.

Authors: LI, Congqiao (Peking University (CN)); YANG, Tianyi (Peking University (CN))

Presenter: LI, Congqiao (Peking University (CN))

Session Classification: Parallel

Track Classification: Performance: trigger, object reconstruction, calibration, and identification

Contribution ID: **44** Type: **not specified**

CMS HH/SH resonant search with anomaly detection algorithm

Friday 16 May 2025 11:30 (12 minutes)

A search for a new massive particle X decaying into a Higgs boson H and a second particle, Y using an anomaly detection algorithm is presented. The dataset collected by the CMS experiment in proton-proton collisions at 13 TeV center-of-mass energy is analyzed. The final states with Higgs bosons decaying to a bb quark pair and reconstructed a single large-radius jets are considered. This search focuses on the final states with the Y decay products reconstructed as a large-radius jets. The identification of the Y particle is enhanced by computing the anomaly score of its candidate jet using a variational autoencoder, allowing the simultaneous search for multiple Y decay modes with a single analysis.

Author: ROGULJIC, Matej (Johns Hopkins University (JHU))

Co-author: COLLABORATION, CMS

Presenter: ROGULJIC, Matej (Johns Hopkins University (JHU))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **45** Type: **not specified**

CMS HH/SH resonant searches in bbVV channels

Friday 16 May 2025 11:15 (12 minutes)

The HH/SH resonant searches in the bbWW and bbZZ decay channels are presented in this talk. This channel is particularly important for beyond standard model searches because for certain values of the S mass, i.e. below the HH threshold and above the ZZ (or WW) threshold, this could be the SH decay channel with the largest branching ratio. Dedicated searches are carried out at the CMS experiment to cover multiple WW/ZZ decay channels with different reconstruction techniques depending on the Lorentz-boost of the resonances.

Author: MITRA, Amitav (Johns Hopkins University (US))

Co-author: COLLABORATION, CMS

Presenter: MITRA, Amitav (Johns Hopkins University (US))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **46** Type: **not specified**

CMS ZH resonant searches

Friday 16 May 2025 11:00 (12 minutes)

This presentation will cover the searches for BSM resonances decaying to a scalar particle H and a standard model (SM) Z boson at the CMS experiment. These searches are one the most powerful probes of the two-Higgs-doublet models at the LHC, and are complementary to the searches for scalars decaying to SM Higgs bosons (h). One of the major differences with respect to the resonant hh/Sh searches is that the H scalar could be sufficiently heavy to open the decay channel to a top-antitop quark pair. Searches in the most sensitive Z and H decay channels are probed at the CMS experiment and presented in this talk.

Author: MALARA, Andrea (Universite Libre de Bruxelles (BE))

Co-author: COLLABORATION, CMS

Presenter: MALARA, Andrea (Universite Libre de Bruxelles (BE))

Session Classification: Parallel

Track Classification: Resonant HH/SH and BSM models

Contribution ID: **47** Type: **Poster**

Studies of boosted topology for the non-resonant HH search in bbττ and bbγγ final states

The study of boosted Higgs boson pair (HH) production enables the development of advanced reconstruction and identification techniques crucial for probing the Higgs self-coupling and potential new physics beyond the Standard Model. In this work, we focus on methodologies for analyzing the boosted topology, where one Higgs boson is produced with high transverse momentum, leading to collimated decay products. We investigate jet substructure techniques, large-radius jet identification, and machine learning-based classification methods to enhance signal selection. Using Monte Carlo simulations and CMS data, we evaluate the effectiveness of these approaches and their impact on signal discrimination. Our preliminary studies demonstrate the potential for improved event reconstruction in the HH→bbγγ and HH→bbττ channels.

Author: ZHONG, Yibo (Purdue University (US))

Presenter: ZHONG, Yibo (Purdue University (US))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **48** Type: **not specified**

Welcome

Monday 12 May 2025 09:00 (10 minutes)

Presenters: CIOCCI, Agnese (Universita & INFN Pisa (IT)); ANNOVI, Alberto (INFN Sezione di Pisa)

Session Classification: Plenary

Contribution ID: **49** Type: **not specified**

Theory status for non resonant HH

Monday 12 May 2025 09:15 (25 minutes)

Presenter: DAVIES, Joshua (University of Liverpool)

Session Classification: Plenary

Contribution ID: **50** Type: **not specified**

Overview of CMS HH non-resonant results

Monday 12 May 2025 09:45 (20 minutes)

Presenter: BETHANI, Agni (Universite Catholique de Louvain (UCL) (BE))

Session Classification: Plenary

Contribution ID: **51** Type: **not specified**

Overview of ATLAS HH non-resonant results

Monday 12 May 2025 10:10 (20 minutes)

Presenter: LENEY, Katharine (Southern Methodist University (US))

Session Classification: Plenary

Contribution ID: **52** Type: **not specified**

Theory status for resonant HH and Scalar+H

Monday 12 May 2025 11:05 (25 minutes)

Presenter: ROBENS, Tania (Rudjer Boskovic Institute (HR))

Session Classification: Plenary

Contribution ID: **53** Type: **not specified**

Overview of ATLAS HH and Scalar+H resonant searches

Monday 12 May 2025 11:35 (20 minutes)

Presenter: FUJIMOTO, Minori (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR))

Session Classification: Plenary

Contribution ID: **54** Type: **not specified**

Overview of CMS HH and Scalar+H resonant searches

Monday 12 May 2025 12:00 (20 minutes)

Presenter: GOUSKOS, Loukas (Brown University (US))

Session Classification: Plenary

Contribution ID: **56** Type: **not specified**

Trigger performance for HH at ATLAS and CMS

Monday 12 May 2025 15:30 (20 minutes)

Presenters: SHI, Liaoshan (UCL (GB)); DONATO, Silvio (Universita & INFN Pisa (IT))

Session Classification: Plenary

Contribution ID: **57** Type: **not specified**

Jet and missing transverse momentum performance at ATLAS and CMS

Monday 12 May 2025 16:00 (20 minutes)

Presenters: LEWIS, Charles (University of Washington (US)); IEMMI, Fabio (Chinese Academy of Sciences (CN))

Session Classification: Plenary

Contribution ID: **58** Type: **not specified**

Performance in tracking and flavour tagging at ATLAS and CMS

Monday 12 May 2025 16:30 (20 minutes)

Presenters: BURGER, Angela Maria (Centre National de la Recherche Scientifique (FR)); ZAZA, Angela (Universita e INFN, Bari (IT))

Session Classification: Plenary

Contribution ID: **59** Type: **not specified**

Tau performance at ATLAS and CMS

Monday 12 May 2025 17:30 (20 minutes)

Presenters: ANDROSOV, Konstantin (Texas A & M University (US)); FARRINGTON, Sinead (University of Edinburgh)

Session Classification: Plenary

Contribution ID: **60** Type: **not specified**

Photons and leptons performance at ATLAS and CMS

Monday 12 May 2025 18:00 (20 minutes)

Presenters: ERRICO, Filippo (Sapienza Universita e INFN, Roma I (IT)); NIKOLAIDOU, Rosy (Université Paris-Saclay (FR))

Session Classification: Plenary

Contribution ID: **61** Type: **not specified**

ATLAS object performance at HL-LHC

Monday 12 May 2025 18:30 (15 minutes)

Presenter: SANTI, Lorenzo (CERN)

Session Classification: Plenary

Contribution ID: **62** Type: **not specified**

CMS object performance at HL-LHC

Monday 12 May 2025 18:50 (15 minutes)

Presenter: AMAPANE, Nicola (Universita e INFN Torino (IT))

Session Classification: Plenary

Contribution ID: **63** Type: **not specified**

ATLAS and CMS non-resonant HH searches in the 4b final state

Tuesday 13 May 2025 09:00 (20 minutes)

Presenters: KOLOSOVA, Marina (University of Florida (US)); CAI, Yizhou (Nanjing University (CN))

Session Classification: Plenary

Contribution ID: **64** Type: **not specified**

ATLAS and CMS non-resonant HH searches in the 2b2γ final state

Tuesday 13 May 2025 09:30 (20 minutes)

Presenters: D'ONOFRIO, Adelina (INFN Napoli (IT)); DUTTA, Irene (Fermi National Accelerator Lab. (US))

Session Classification: Plenary

Contribution ID: **65** Type: **not specified**

ATLAS and CMS non-resonant HH searches in the 2b2τ final state

Tuesday 13 May 2025 10:00 (20 minutes)

Presenters: SCHIAVI, Carlo (INFN e Universita Genova (IT)); GOY LOPEZ, Silvia (CIEMAT - Centro de Investigaciones Energéticas Medioambientales y Tec. (ES))

Session Classification: Plenary

Contribution ID: **66** Type: **not specified**

ATLAS and CMS non-resonant HH searches in the 2b2l/2b2V final states

Tuesday 13 May 2025 15:30 (20 minutes)

Presenters: DATTA, Abhisek (University of California Los Angeles (US)); TAFFARD, Anyes (University of California Irvine (US))

Session Classification: Plenary

Contribution ID: **67** Type: **not specified**

ATLAS and CMS non-resonant HH search in multi-leptons final states

Tuesday 13 May 2025 16:00 (20 minutes)

Presenters: SCULAC, Ana (University of Split. Fac.of Elect. Eng., Mech. Eng. and Nav.Architect. (HR)); AGGARWAL, Anamika (Johannes Gutenberg Universitaet Mainz (DE))

Session Classification: Plenary

Contribution ID: **68** Type: **not specified**

Di-Higgs combination, single-Higgs constraint and EFT interpretation in ATLAS and CMS

Tuesday 13 May 2025 16:30 (20 minutes)

Presenter: DELMASTRO, Marco (CNRS/IN2P3 LAPP)

Session Classification: Plenary

Contribution ID: **69** Type: **not specified**

HL-LHC projections for di-Higgs non-resonant searches at ATLAS and CMS

Tuesday 13 May 2025 17:00 (20 minutes)

Presenter: ZUOLO, Davide (University of Colorado - Boulder (US))

Session Classification: Plenary

Contribution ID: **70** Type: **not specified**

News on precision computations of HH: EW corrections

Tuesday 13 May 2025 11:00 (20 minutes)

Presenter: YU, Huai-Min (Peking Univeristy)

Session Classification: Plenary

Contribution ID: **71** Type: **not specified**

MC generators for HH in gluon fusion and VBF

Tuesday 13 May 2025 11:25 (20 minutes)

Presenter: HEINRICH, Gudrun (KIT)

Session Classification: Plenary

Contribution ID: **72** Type: **not specified**

EFTs for HH

Tuesday 13 May 2025 11:50 (25 minutes)

Presenter: ENGLERT, Christoph

Session Classification: Plenary

Contribution ID: **73** Type: **not specified**

Theory models that modify trilinear

Session Classification: Plenary

Contribution ID: **74** Type: **not specified**

Triple-Higgs searches in CMS

Wednesday 14 May 2025 09:00 (15 minutes)

Presenter: Mr THACHAYATH SUGUNAN, Aravind (Tata Institute of Fundamental Research)

Session Classification: Plenary

Contribution ID: **75** Type: **not specified**

Triple-Higgs searches in ATLAS

Wednesday 14 May 2025 09:20 (15 minutes)

Presenter: BETTI, Alessandra (Sapienza Università e INFN, Roma I (IT))

Session Classification: Plenary

Contribution ID: **76** Type: **not specified**

Resonant BSM for HHH

Wednesday 14 May 2025 09:40 (20 minutes)

Presenter: Dr PAPAEFSTATHIOU, Andreas (Kennesaw State University, GA, USA)

Session Classification: Plenary

Contribution ID: **77** Type: **not specified**

Search for HH in rare production modes (VHH, ttHH) at ATLAS and CMS

Wednesday 14 May 2025 10:05 (15 minutes)

Presenter: DANIEL, Jessy (Centre National de la Recherche Scientifique (FR))

Session Classification: Plenary

Contribution ID: **78** Type: **not specified**

Overview of BSM models not yet excluded

Thursday 15 May 2025 09:00 (25 minutes)

REMOTE PRESENTATION

Presenter: WEIGLEIN, Georg Ralf (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Plenary

Contribution ID: **79** Type: **not specified**

ATLAS and CMS HH/SH resonant searches in the 4b final state

Thursday 15 May 2025 09:30 (20 minutes)

Presenters: ZIVKOVIC, Lidija (Institute of physics Belgrade (RS)); LAURILA, Santeri (CERN & Helsinki Institute of Physics (FI))

Session Classification: Plenary

Contribution ID: **80** Type: **not specified**

ATLAS and CMS HH/SH resonant searches in the 2b2γ final state

Thursday 15 May 2025 10:00 (20 minutes)

Presenters: JOURD'HUY, Elise Anne Marie (Centre National de la Recherche Scientifique (FR)); TOLKACHEV, Grigorii (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR))

Session Classification: Plenary

Contribution ID: **81** Type: **not specified**

ATLAS an CMS HH/SH resonant searches in the 2b2τ final state

Thursday 15 May 2025 11:30 (20 minutes)

Presenters: DEIANA, Allison Mccarn (Southern Methodist University (US)); D'AMANTE, Valeria (Universita & INFN Pisa (IT))

Session Classification: Plenary

Contribution ID: **82** Type: **not specified**

ATLAS and CMS HH/SH resonant searches in other final states

Thursday 15 May 2025 12:00 (20 minutes)

Presenters: AEBI, Devin Michael (Texas A & M University (US)); Mr GOSWAMI, Soumyananda (Oklahoma State University (US))

Session Classification: Plenary

Contribution ID: **83** Type: **not specified**

Combination of HH and Scalar+H resonant searches at ATLAS and CMS

Thursday 15 May 2025 15:00 (20 minutes)

Presenter: CARVALHO ANTUNES DE OLIVEIRA, Alexandra (Peking University (CN))

Session Classification: Plenary

Contribution ID: **84** Type: **not specified**

Interference/NLO effects in resonant Higgs pair production

Thursday 15 May 2025 11:00 (20 minutes)

Presenter: BRAATHEN, Johannes Alf (DESY)

Session Classification: Plenary

Contribution ID: **85** Type: **not specified**

Summary of statistical excesses in di-Higgs and multi-boson searches

Thursday 15 May 2025 16:15 (15 minutes)

Presenter: LES, Robert (Michigan State University (US))

Session Classification: Plenary

Contribution ID: **86** Type: **not specified**

Theory interplay between HH and diboson resonances

Thursday 15 May 2025 15:25 (20 minutes)

Presenter: TESI, Andrea (INFN)

Session Classification: Plenary

Contribution ID: **87** Type: **not specified**

BSM Composite Higgs Models

Thursday 15 May 2025 15:50 (20 minutes)

Presenter: DE CURTIS, Stefania (U)

Session Classification: Plenary

Contribution ID: **88** Type: **not specified**

The FCC project

Friday 16 May 2025 11:00 (15 minutes)

Presenter: COBAL, Marina (Universita degli Studi di Udine (IT))

Session Classification: Parallel

Contribution ID: **89** Type: **not specified**

The LCF project

Friday 16 May 2025 11:20 (15 minutes)

Presenter: LIST, Jenny (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Parallel

Contribution ID: **90** Type: **not specified**

the Higgs potential and gravitational waves

Friday 16 May 2025 15:00 (25 minutes)

REMOTE PRESENTATION

Presenter: CAPRINI, Chiara (CERN)

Session Classification: Plenary

Contribution ID: **91** Type: **not specified**

Higgs self-couplings at FCCee and CEPC

Friday 16 May 2025 15:30 (25 minutes)

Presenters: TISHELMAN-CHARNY, Abraham (Brookhaven National Laboratory (US)); LIU, Jia (Peking University)

Session Classification: Plenary

Contribution ID: **92** Type: **not specified**

Higgs self-couplings at ILC and CLIC

Friday 16 May 2025 16:00 (25 minutes)

Presenter: LIST, Jenny (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Plenary

Contribution ID: **93** Type: **not specified**

Higgs self-couplings at a future muon collider

Friday 16 May 2025 16:30 (25 minutes)

Co-author: FRANCESCHINI, Roberto (Rome 3 U.)

Presenter: WANG, Xing

Session Classification: Plenary

Contribution ID: **94** Type: **not specified**

Higgs self-couplings at FCC-hh

Friday 16 May 2025 17:30 (25 minutes)

Presenter: TALIERCIO, Angela (Northwestern University (US))

Session Classification: Plenary

Contribution ID: **95** Type: **not specified**

Theory challenges for Higgs self coupling measurements at future lepton colliders

Friday 16 May 2025 18:00 (25 minutes)

REMOTE PRESENTATION

Presenter: GROJEAN, Christophe (DESY (Hamburg) and Humboldt University (Berlin))

Session Classification: Plenary

Contribution ID: **96** Type: **not specified**

EPS poster prize

Friday 16 May 2025 19:00 (10 minutes)

Session Classification: Plenary

Contribution ID: **97** Type: **not specified**

The LHCHWG YR5

Thursday 15 May 2025 17:30 (15 minutes)

Presenter: BROST, Liza (Brookhaven National Laboratory (US))

Session Classification: Plenary

Contribution ID: **98** Type: **Poster**

Triple-Higgs searches in CMS

The shape of the Higgs potential is yet to be studied experimentally by the determination of the Higgs boson self-interaction couplings. While the trilinear coupling has already been constrained by measuring the inclusive di-Higgs production, the quartic coupling has only been constrained recently by direct experimental measurements. Quartic higgs self coupling can be accessed directly in triple Higgs production mode at LHC. This work reports one of the first searches at the LHC for simultaneous production of three Higgs bosons using Run 2 data of CMS. We also highlight the scope for HHH measurements going into the Run-3 and HL-LHC period.

Author: Mr THACHAYATH SUGUNAN, Aravind (Tata Institute of Fundamental Research)

Presenter: Mr THACHAYATH SUGUNAN, Aravind (Tata Institute of Fundamental Research)

Session Classification: Poster

Track Classification: Poster

Contribution ID: **99** Type: **not specified**

top quark mass renormalisation scheme uncertainty

Thursday 15 May 2025 18:00 (25 minutes)

Presenter: JASKIEWICZ, Sebastian

Session Classification: Plenary

Contribution ID: **101** Type: **Poster**

Using Boosted Decision Trees based event categorization to target SM and BSM HH->2b2y at ATLAS

In this poster, we present a study of di-Higgs production in the HH→bbγγ decay channel using data from the ATLAS experiment. This channel is considered one of the "golden channels" for constraining the Higgs self-coupling, benefiting from the high branching ratio of the H→bb decay and the excellent ATLAS photon triggers. The analysis employs Boosted Decision Trees (BDTs) to define event categories with varying purities, ensuring that each category contains at least 11 γγ+ jets events within the diphoton mass range of 110–160 GeV. In this poster, we highlight the benefits and challenges of this strategy, along with its impact on limits, significances, and the trilinear Higgs boson self-coupling modifier under different scenarios.

Author: SHARMA, Punit (Brookhaven National Laboratory (US))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: SHARMA, Punit (Brookhaven National Laboratory (US))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **102** Type: **Poster**

Updated measurement prospects for di-Higgs production in the HH->2b2y channel with the ATLAS experiment at the HL-LHC

We present an updated prospect study on di-Higgs production in the HH⟶bbɣɣ decay channel with the ATLAS experiment at the High Luminosity LHC (HL-LHC). The latest projections are based on extrapolating the recent legacy Run 2 ATLAS search and therefore improve over the previous results shown

Author: WANG, Alex Zeng (University of California,Santa Cruz (US))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: WANG, Alex Zeng (University of California,Santa Cruz (US))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **103** Type: **Poster**

ATLAS electron and photon energy calibration with Run 3 data

This poster presents the latest result on ATLAS Run 3 electron and photon in situ energy scale and resolution calibration

Author: HSU, Tao (Université Paris-Saclay (FR))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: HSU, Tao (Université Paris-Saclay (FR))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **104** Type: **Poster**

HL-LHC prospects for the search of boosted Higgs boson pair production via vector-boson fusion in the 4b final state at the ATLAS experiment

Projection studies for non-resonant Higgs boson pair production via vector-boson fusion in the 4b final state with the luminosity-upgraded ATLAS detector at the High Luminosity LHC (HL-LHC) are presented. These studies are the first HL-LHC prospects on the boosted di-Higgs topology, where each Higgs boson is constructed as a single large-radius jet. The latest Run 2 analysis results using 140 fb−1 of proton–proton collision data at √ = 13 TeV recorded by the ATLAS detector at the Large Hadron Collider are considered as a baseline point. Sensitivities are projected assuming a center-of-mass energy of √ = 14 TeV for a variety of integrated luminosities ranging from 1000 fb−1 to 3000 fb−1. Various systematic uncertainty scenarios are explored. With (without) systematic uncertainties, the allowed 68% confidence interval for the modifier 2 is expected to be [0.84, 1.19] ([0.86, 1.17]), while the 95% confidence interval is expected to be [0.75, 1.27] ([0.79, 1.23]), for a 3000 fb−1 data sample.

Author: PORTILLO QUINTERO, Dilia Maria (TRIUMF (CA))

Co-author: TANAKA, Reisaburo (IJCLab, Université Paris-Saclay (FR))

Presenter: PORTILLO QUINTERO, Dilia Maria (TRIUMF (CA))

Session Classification: Poster

Track Classification: Poster

Contribution ID: **105** Type: **not specified**

Workshop conclusion

Friday 16 May 2025 19:15 (10 minutes)

Presenter: MANZONI, Stefano (CERN)

Session Classification: Plenary