

HIGGS 2024

Monday 4 November 2024 - Friday 8 November 2024

Uppsala University Main Building

Book of Abstracts

Contents

Registration	1
Summary of precision Higgs calculations (20+10)	1
ATLAS Higgs highlights (20+10)	1
CMS Higgs highlights (20+10)	1
Extended Higgs sectors (20+10)	1
Composite Higgs (20+10)	1
ATLAS joker talk (12+3)	2
CMS joker talk (12+3)	2
Precision measurements at the LHC - cross-section in different production modes, STXS (20+10)	2
Precision measurements at the LHC - properties: mass and width, couplings, CP, off-shell (20+10)	2
Higgs Monte Carlo simulations (20+10)	2
Higgs fermion couplings and interplay with flavour (20+10)	3
H to bb/cc at LHCb (20+10)	3
Rare decays, including 2nd generation fermions, at the LHC (20+10)	3
Di-Higgs theory overview (20+10)	3
Beyond the pure Higgs self-couplings –HEFT, SMEFT (20+10)	3
Non-resonant HH searches and Higgs boson self-coupling at the LHC (20+10)	4
EFT results in and beyond Higgs physics at the LHC (20+10)	4
EFT interplay with top/multi-boson (20+10)	4
Probing CP-violation in the Higgs sector (20+10)	4
Low-mass new scalars and Higgs decays to BSM particles at the LHC (20+10)	4
High-mass new scalars at the LHC. without H in the final state (20+10)	5

High-mass new scalars at the LHC, with H in the final state (20+10)	5
Experimental methods: ML in Higgs, including jet substructure and taggers (20+10)	5
Monte Carlo: backgrounds and specific precision computations (20+10)	5
Higgs physics as a probe of entanglement (20+10)	5
Interplay with cosmology probes: baryogenesis, gravitational waves (20+10)	6
Higgs and ALPs (20+10)	6
Indirect probes of the Higgs sector (20+10)	6
Higgs physics at future colliders (20+10)	6
Future Higgs factories and experimental challenges (20+10)	7
Closing and Higgs2025	7
Welcome	7
Vacuum Stability in the Standard Model and Beyond	7
Quantum Gravity Effects on Dark Matter and Gravitational Waves	8
Recent results on SUSY searches in ATLAS	8
Higgs couplings and detector requirements at the FCC-ee	8
Higgs properties (mass/width/CP) and detector requirements at the FCC-ee	9
Higgs physics at the FCC-hh	9
Searching for additional neutral Higgs bosons at ATLAS	10
Probing the nature of electroweak symmetry breaking with Higgs boson pairs in ATLAS	10
Exotic Higgs decays ($H \rightarrow aZ$, $H \rightarrow aa \rightarrow 4 f$, etc) at ATLAS	11
Searches for singly- and doubly-charged Higgs bosons in ATLAS	11
Searches for axion-like-particles (ALPs) in Higgs boson decays in ATLAS	12
Prospects for single- and di-Higgs measurements at the HL-LHC with the ATLAS experiment	12
Measurements of Higgs boson production with top quarks with the ATLAS detector	12
Indirect measurements of the Higgs boson natural width with the ATLAS detector	13
Measurements of Higgs boson coupling properties to bottom and charm with the ATLAS detector	13
Measurements of Higgs boson coupling properties to leptons with the ATLAS detector	14
Measurements of Higgs boson coupling properties to vector bosons with the ATLAS detector	14

Combined Higgs boson measurements and their interpretations with the ATLAS experiment	14
STXS and differential cross section measurements at CMS, bosonic channels	15
STXS and differential cross section measurements at CMS, fermionic channels	15
Measurements of the Higgs boson mass and width at CMS	16
Anomalous couplings and CP properties at CMS	16
Searches for rare Higgs boson production processes with the CMS detector	16
EFT interpretations in the Higgs sector at CMS	17
Di-Higgs searches at CMS	17
Searches for Extended Higgs Sectors at CMS	18
Rare & BSM decays of the Higgs boson at CMS	18
Low-mass Higgs searches at CMS	18
Constraints on Higgs-charm couplings	19
Quark-Mass Effects in Higgs Production	19
Towards Higgs and Z boson plus jet at NLL+ matched to NLO	20
Revisiting the Higgs Boson Decay into a Dineutrino and Photon	20
Impact of interference effects on Higgs searches in the di-top final state at the LHC	21
Indications for New Higgs Bosons in Associated Di-Photon Production	21
Highlights of the Higgs physics at ILC	22
Higgs boson production in weak-boson fusion and $H \rightarrow b\bar{b}$ decay at NNLO with realistic event selection criteria	22
Examining the CP properties of the top-Yukawa and the ggH coupling	23
Status of triplet extended Higgs sector models in the light of NLO unitarity and the latest LHC data	24
Higher-order soft and virtual corrections to $H^+ H^-$ production	24
Higgs combined measurements at CMS	25
Resonant HH/SH searches at CMS	25
Single- and di-Higgs prospects for CMS at HL-LHC	25
General CP-violating 2HDM in light of the excesses in di-photon searches at the LHC	26
Effect of anomalous HHH and ZZHH couplings on the decay width of $H \rightarrow 4l$	26
Towards a numerical evaluation of $q\bar{q} \rightarrow t\bar{t}H$ at two loops	27

The Art of Counting: where to cut-off SMEFT and HEFT in Higgs Pair Production	27
Charm and bottom Yukawa couplings via quarkonia production at HL-LHC	28
Interference effects in resonant di-Higgs production at the LHC	28
Prospects for New Discoveries Through Precision Measurements at e+e- Colliders	29
The Higgs Self-coupling Strategy at Linear e+e- Colliders	29
Higgs-muon interactions at a multi-TeV muon collider	30
Single top plus Higgs at LHC with CP violating top Yukawa	31
Long-lived particles from exotic Higgs decays at the FCC-ee	31
Searches for resonances decaying to pairs of Higgs bosons in ATLAS	32
Towards HH at NNLO QCD: the n_h^2 contribution	32
Higgs decay to llZ at one loop in the SMEFT	32
Yukawa- and Higgs self-coupling corrections to di-Higgs production	33
Top-Yukawa coupling at future muon collider	33
Anomalous couplings in Higgs plus jet production	34
Probing CPV mixing in the Higgs sector in VBF at 1 TeV ILC	34
Jet Bundle Geometry of Scalar EFTs	35
Prospects for single Higgs couplings measurements at the multi-TeV muon collider	35
Higgs self-coupling possibilities at multi-TeV muon collider	36
Higgs portal long-lived particle searches at future colliders	36
Impact of renormalisation group equation on Higgs production in the SMEFT	37
How large can the light quark Yukawa couplings be?	37
The (first) LISA miracle	38
CP-violation in complex-singlet extension of 2HDM	38

1

Registration

Plenary session 1 - sal X / 2

Summary of precision Higgs calculations (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 3

ATLAS Higgs highlights (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 4

CMS Higgs highlights (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 5

Extended Higgs sectors (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 6

Composite Higgs (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 7

ATLAS joker talk (12+3)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 1 - sal X / 8

CMS joker talk (12+3)

Plenary session 2 - sal X / 9

Precision measurements at the LHC - cross-section in different production modes, STXS (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 2 - sal X / 10

Precision measurements at the LHC - properties: mass and width, couplings, CP, off-shell (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 2 - sal X / 11

Higgs Monte Carlo simulations (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 2 - sal X / 12

Higgs fermion couplings and interplay with flavour (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 2 - sal X / 13

H to bb/cc at LHCb (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 2 - sal X / 14

Rare decays, including 2nd generation fermions, at the LHC (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 15

Di-Higgs theory overview (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 16

Beyond the pure Higgs self-couplings –HEFT, SMEFT (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 17

Non-resonant HH searches and Higgs boson self-coupling at the LHC (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 18

EFT results in and beyond Higgs physics at the LHC (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 19

EFT interplay with top/multi-boson (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 3 - sal X / 20

Probing CP-violation in the Higgs sector (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 4 - sal X / 21

Low-mass new scalars and Higgs decays to BSM particles at the LHC (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 4 - sal X / 22

High-mass new scalars at the LHC. without H in the final state (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 4 - sal X / 23

High-mass new scalars at the LHC, with H in the final state (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 4 - sal X / 24

Experimental methods: ML in Higgs, including jet substructure and taggers (20+10)

Plenary session 4 - sal X / 25

Monte Carlo: backgrounds and specific precision computations (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 4 - sal X / 26

Higgs physics as a probe of entanglement (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 27

Interplay with cosmology probes: baryogenesis, gravitational waves (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 28

Higgs and ALPs (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 29

Indirect probes of the Higgs sector (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 30

Higgs physics at future colliders (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 31

Future Higgs factories and experimental challenges (20+10)

Is the speaker a PhD student or post-doc?:

Primary track:

Plenary session 5 - sal X / 32

Closing and Higgs2025

Plenary session 1 - sal X / 33

Welcome

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Higgs boson pairs and Higgs potential 1 - sal IX / 34

Vacuum Stability in the Standard Model and Beyond

Authors: Daniel Litim¹; Gudrun Hiller²; Tim Höhne^{None}; Tom Steudtner^{None}

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We revisit the stability of the Standard Model vacuum, and investigate its quantum effective potential using the highest available precision in theory tools and experimental input parameters to date. We observe that the stability of the electroweak vacuum centrally depends on the values of the top mass and the strong coupling constant and how their uncertainties impact SM vacuum stability. We further investigate vacuum stability for a variety of singlet scalar field extensions with and without flavor using the Higgs portal mechanism. We identify the BSM parameter spaces for stability and find sizable room for new physics. We further study the phenomenology of Planck-safe models at colliders, and determine the impact on the Higgs trilinear, the Higgs-to-electroweak-boson, and the Higgs quartic couplings which can be probed at current and future colliders.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Common session: HH & future colliders 2 - sal IV / 36

Quantum Gravity Effects on Dark Matter and Gravitational Waves

Author: Rishav Roshan¹

¹ *University of Southampton*

Corresponding Author: r.roshan@soton.ac.uk

We explore how quantum gravity effects, manifested through the breaking of discrete symmetry responsible for both Dark Matter and Domain Walls, can have observational effects through CMB observations and gravitational waves. To illustrate the idea we consider a simple model with two scalar fields and two Z_2 symmetries, one being responsible for Dark Matter stability, and the other spontaneously broken and responsible for Domain Walls, where both symmetries are assumed to be explicitly broken by quantum gravity effects. We show the recent gravitational wave spectrum observed by several pulsar timing array projects can help constrain such effects.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

BSM Higgs physics 2 - sal IX / 39

Recent results on SUSY searches in ATLAS

Supersymmetry (SUSY) provides elegant solutions to several problems in the Standard Model, and searches for SUSY particles are an important component of the LHC physics program. This talk will present the latest results from SUSY searches from ATLAS, where Higgs bosons are produced as part of the decay chain of supersymmetric particles. A variety of models and possible final states are considered, both in R-parity-conserving and R-parity-violating scenarios. Results going beyond simplified models will also be discussed.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

Higgs physics at future colliders 1 - sal IV / 40

Higgs couplings and detector requirements at the FCC-ee

Authors: David d'Enterria¹; FCC Higgs Conveners^{None}

¹ *CERN*

Corresponding Authors: fcc-ped-physicsgroup-higgs-admin@cern.ch, david.d'enterria@cern.ch

The Future Circular Collider stands at the forefront of the European Strategy for Particle Physics vision. A technical and financial feasibility study for the 100 km infrastructure is currently underway. A main objective of the FCC is to comprehensively explore the properties of the Higgs boson in e+e-collisions. The FCC-ee makes use of the well-known centre-of-mass energy by using Z tagging to perform a model-independent determination of the ZH cross-section at 240 GeV. This will allow for a measurement of the coupling to Z bosons and, in turn, the total width. In combination with branching ratio measurements, the absolute couplings to W, b, c, g (and, likely, strange) will be known at the FCC-ee. The measurements of top quark properties at FCC-ee will be instrumental in the measurement of the top Yukawa coupling. A combination of the measured cross sections at the two different centre-of-mass energies (240 and 365 GeV) further provides the first evidence for the trilinear Higgs self-coupling. Finally, the FCC-ee offers a unique opportunity to determine the electron Yukawa coupling by searching for the s-channel Higgs production at $\sqrt{s} = 125$ GeV. The detailed detector requirements imposed by such important measurements will be reviewed.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Higgs physics at future colliders 1 - sal IV / 41

Higgs properties (mass/width/CP) and detector requirements at the FCC-ee

Authors: David d'Enterria¹; FCC Higgs Conveners^{None}

¹ CERN

Corresponding Authors: david.d'enterria@cern.ch, fcc-ped-physicsgroup-higgs-admin@cern.ch

The FCC-ee offers powerful opportunities to determine the Higgs boson parameters, exploiting about $2 \cdot 10^6$ e+e \rightarrow ZH events and almost 10^5 WW \rightarrow H events at centre-of-mass energies around 240 and 365 GeV. The determination of the Higgs boson mass with a precision significantly better than the Higgs boson width (4.1 MeV in the Standard Model) is a prerequisite to either constrain or measure the electron Yukawa coupling via direct e+e \rightarrow H production at $\sqrt{s}=125$ GeV, as well as the being a limiting parametric uncertainty on the calculation of Higgs branching ratios. Approaching the statistical limit of 0.1% and O(1) MeV on the ZH cross section and the Higgs boson mass respectively, and of O(1%) on the Higgs total width, sets highly demanding requirements on accelerator operation (ZH threshold scan, centre-of-mass energy measurement), detector design (lepton momentum resolution, hadronic final state reconstruction performance), theoretical calculations, and analysis techniques (efficiency and purity optimization with modern tools, constrained kinematic fits, control of systematic uncertainties). Perspectives for the precise measurement of CP properties of the HVV couplings have been also performed with the matrix-element package MELA, that has been used to introduce event based-weights into the Standard Model simulation and to calculate optimal kinematic observables.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Higgs physics at future colliders 1 - sal IV / 42**Higgs physics at the FCC-hh****Authors:** David d'Enterria¹; FCC Higgs Conveners^{None}¹ *CERN***Corresponding Authors:** david.d'enterria@cern.ch, fcc-ped-physicsgroup-higgs-admin@cern.ch

The Future Circular Collider stands at the forefront of the European Strategy for Particle Physics vision. Currently, a technical and financial feasibility study for the 100 km infrastructure is underway. The physics programme is based on the sequence of a 90-365 GeV high luminosity and high precision e+e- collider, FCC-ee, followed by a 100 TeV hadron collider, FCC-hh. A main objective of the FCC-hh is to comprehensively explore the properties of the Higgs boson, in particular determine the Higgs selfcoupling with percent-level precision from HH production, as well as its rare decays to $\gamma\gamma$, $Z\gamma$, $\mu\mu$, and invisible final states. The measurement of the top Yukawa coupling at the FCC-hh will greatly benefit from the measurements of top quark properties at FCC-ee.

Primary track:**Is the speaker a PhD student or post-doc?:**

No

BSM Higgs physics 2 - sal IX / 43**Searching for additional neutral Higgs bosons at ATLAS**

The discovery of the Higgs boson with the mass of about 125 GeV completed the particle content predicted by the Standard Model. Even though this model is well established and consistent with many measurements, it is not capable to solely explain some observations. Many extensions of the Standard Model addressing such shortcomings introduce additional neutral Higgs-like bosons. The current status of searches for additional low- and high-mass Higgs bosons based on the full LHC Run 2 dataset of the ATLAS experiment at 13 TeV are presented.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

Higgs boson pairs and Higgs potential 1 - sal IX / 44**Probing the nature of electroweak symmetry breaking with Higgs boson pairs in ATLAS**

In the Standard Model, the ground state of the Higgs field is not found at zero but instead corresponds to one of the degenerate solutions minimising the Higgs potential. In turn, this spontaneous

electroweak symmetry breaking provides a mechanism for the mass generation of nearly all fundamental particles. The Standard Model makes a definite prediction for the Higgs boson self-coupling and thereby the shape of the Higgs potential. Experimentally, both can be probed through the production of Higgs boson pairs (HH), a rare process that presently receives a lot of attention at the LHC. In this talk, the latest HH searches by the ATLAS experiment are reported, with emphasis on the results obtained with the full LHC Run 2 dataset at 13 TeV. Non-resonant HH search results are interpreted both in terms of sensitivity to the Standard Model and as limits on the Higgs boson self-coupling and the quartic VVHH coupling. The Higgs boson self-coupling can be also constrained by exploiting higher-order electroweak corrections to single Higgs boson production. A combined measurement of both results yields the overall highest precision, and reduces model dependence by allowing for the simultaneous determination of the single Higgs boson couplings. Results for this combined measurement are also presented.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 1 - sal IX / 45

Exotic Higgs decays ($H \rightarrow aZ$, $H \rightarrow aa \rightarrow 4 f$, etc) at ATLAS

Precision studies of the properties of the Higgs and gauge bosons may provide a unique window for the discovery of new physics at the LHC. New phenomena can in particular be revealed in the search for lepton-flavor-violating or exotic decays of the Higgs bosons, as well as in their possible couplings to hidden-sector states that do not interact under Standard Model gauge transformations. This talk presents recent searches by the ATLAS experiment for decays of the Higgs bosons to new particles, using collision data at $\sqrt{s} = 13$ TeV collected during the LHC Run 2.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 2 - sal IX / 46

Searches for singly- and doubly-charged Higgs bosons in ATLAS

In the Standard Model, one doublet of complex scalar fields is the minimal content of the Higgs sector in order to achieve spontaneous electroweak symmetry breaking. However, several theories beyond the Standard Model predict a non-minimal Higgs sector and introduce charged scalar fields that do not exist in the Standard Model. As a result, singly- and doubly-charged Higgs bosons would be a unique signature of new physics with a non-minimal Higgs sector. As such, they have been extensively searched for in the ATLAS experiment, using proton-proton collision data at 13 TeV

during the LHC Run 2. In this presentation, a summary of the latest experimental results obtained in searches for both singly- and doubly-charged Higgs bosons are presented.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 1 - sal IX / 47

Searches for axion-like-particles (ALPs) in Higgs boson decays in ATLAS

Searches for axion-like-particles (ALPs) in Higgs boson decays, as well as searches for ALP production with two top quarks are presented, using LHC collision data at 13 TeV collected by the ATLAS experiment in Run 2. The searches cover a mass range of ALPs below the Z-boson mass. Novel reconstruction and identification techniques used in these searches are described.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

Common session: HH & future colliders 1 - sal IV / 48

Prospects for single- and di-Higgs measurements at the HL-LHC with the ATLAS experiment

The large dataset of about 3 ab^{-1} that will be collected at the High Luminosity LHC (HL-LHC) will be used to measure Higgs boson processes in detail. Studies based on current analyses have been carried out to understand the expected precision and limitations of these measurements. The large dataset will also allow for better sensitivity to di-Higgs processes and the Higgs boson self coupling. This talk will present the prospects for Higgs and di-Higgs results with the ATLAS detector at the HL-LHC.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 4 - sal IV / 49

Measurements of Higgs boson production with top quarks with the ATLAS detector

The study of Higgs boson production in association with one or two top quarks provides a key window into the properties of the two heaviest fundamental particles in the Standard Model, and in particular into their couplings. This talk presents property measurement of Higgs boson, in particular cross section and CP nature, with tH and ttH production in pp collisions collected at 13 TeV with the ATLAS detector using the full Run 2 dataset of the LHC.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 1 - sal IV / 50

Indirect measurements of the Higgs boson natural width with the ATLAS detector

The total width of the Higgs boson is an important parameter for Higgs sector phenomenology. It is too small to be measured directly at the LHC, but indirect measurements can be performed using the off-shell Higgs boson production process in the ZZ and WW final states, as well as through interference effects in the diphoton decay channel. This talk presents the most recent indirect width measurements by the ATLAS experiment in these channels, using the full Run 2 dataset of pp collisions at the LHC collected at 13 TeV.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 3 - sal IV / 52

Measurements of Higgs boson coupling properties to bottom and charm with the ATLAS detector

Testing the Yukawa couplings of the Higgs boson with fermions is essential to understanding the origin of fermion masses. Higgs boson decays to quark pairs are an important probe of these couplings, and of properties of the Higgs boson more generally. This talk presents various measurements of Higgs boson decays into two bottom quarks as well as searches for Higgs boson decays into two charm quarks by the ATLAS experiment, using the full Run 2 dataset of pp collisions collected at 13

TeV at the LHC, as well as their combination and interpretation. The results of the search for Higgs boson production associated with a charm quark is also reported.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 4 - sal IV / 53

Measurements of Higgs boson coupling properties to leptons with the ATLAS detector

Detailed measurements of Higgs boson properties can be performed using its decays into fermions, providing in particular a key window into the nature of the Yukawa interactions. This talk presents the latest measurements by the ATLAS experiment of Higgs boson properties in its decays into pairs of leptons, using the full Run 2 pp collision dataset collected at 13 TeV.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 1 - sal IV / 54

Measurements of Higgs boson coupling properties to vector bosons with the ATLAS detector

The Higgs boson decay to two vector bosons can be used to perform some of the most precise measurements of the Higgs boson production cross sections. This talk presents the more recent Higgs boson cross section measurements by the ATLAS experiment in the W boson decay channel. Interpretations of these results in the context of Standard Model effective field theories will be presented. The results are based on pp collision data collected at 13 TeV during Run 2 of the LHC.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 2 - sal IV / 55**Combined Higgs boson measurements and their interpretations with the ATLAS experiment**

Very detailed measurements of Higgs boson coupling and kinematical properties can be performed using the data collected with the ATLAS experiment, exploiting a variety of final states and production modes, and probing different regions of the phase space with increasing precision. These measurements can then be combined to exploit the specific strength of each channel, thus providing the most stringent global measurement of the Higgs properties. This talk presents the latest combination of Higgs boson measurements by the ATLAS experiment, with results presented in terms of production modes, branching fractions, Simplified Template Cross Sections and coupling modifiers. These combined measurements are interpreted in various ways: specific scenarios of physics beyond the Standard Model are tested, as well as a generic extension in the framework of the Standard Model Effective Field Theory. The results are based on pp collision data collected at 13 during Run 2 of the LHC.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 1 - sal IV / 56**STXS and differential cross section measurements at CMS, bosonic channels**

We will discuss the latest differential measurements of Higgs boson cross sections with the CMS detector in bosonic decay channels. Both fiducial differential cross section measurements and measurements in the simplified template cross section framework will be presented. The data collected during Run 2 of the LHC by the CMS experiment are used. We also present interpretations of these measurements as constraints on constraints of Wilson coefficients of beyond Standard Model operators in the framework of Effective Field Theories.

Primary track:**Is the speaker a PhD student or post-doc?:**

No

Precision Higgs measurements and calculations 3 - sal IV / 57**STXS and differential cross section measurements at CMS, fermionic channels**

e will discuss the latest differential measurements of Higgs boson cross sections with the CMS de-

tector in fermionic decay channels and ttH production. Both fiducial differential cross section measurements and measurements in the simplified template cross section framework will be presented. The data collected during Run 2 of the LHC by the CMS experiment are used. We also present interpretations of these measurements as constraints on constraints of Wilson coefficients of beyond Standard Model operators in the framework of Effective Field Theories.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 1 - sal IV / 58

Measurements of the Higgs boson mass and width at CMS

An important aspect of the Higgs boson physics programme at the LHC is to determine all the properties of this particle, including its mass, which is a free parameter in the SM, and its width. This presentation will discuss the latest developments in measurements of the Higgs boson mass and width, with data collected by the CMS experiment at a centre of mass energy of 13 TeV. Both direct and indirect constraints on the Higgs boson width will be shown.

Primary track:

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 4 - sal IX / 59

Anomalous couplings and CP properties at CMS

To fully characterize the Higgs boson, it is important to establish whether it presents coupling properties that are not expected in the Standard Model of particle physics. These can probe BSM effects, such as CP conserving or CP violating couplings to particles with masses not directly accessible at the LHC through virtual quantum loops. In this talk we will present the most recent searches from the CMS experiment for anomalous Higgs boson interactions with vector bosons (HVV) or in effective interactions via the gluon-fusion production.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 3 - sal IV / 60**Searches for rare Higgs boson production processes with the CMS detector**

The full set of data collected by CMS experiment at a centre of mass energy of 13 TeV allows searches for rare production modes of the Higgs boson, subdominant with respect the ones already observed at the LHC, by using a variety of decay modes profiting of the ones with largest expected branching fractions. They include associate production of the Higgs with two b-quarks, with a c-quark, or vector boson scattering production with two associated Ws. While the expected rate is still limited with the collected data, these modes become enhanced in several BSM theories and can be used to constrain such models.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 4 - sal IX / 61**EFT interpretations in the Higgs sector at CMS**

Effective Field Theories provide an interesting way to parameterize indirect BSM physics, when its characteristic scale is larger than the one directly accessible at the LHC, for a large class of models. Even if the Higgs boson is SM-like, BSM effects can manifest itself through higher-dimension effective interactions between SM fields, providing indirect sensitivity through distortions of kinematic distributions. Constraints on such effects derived by measurements of several production and decay modes of the Higgs boson and their combination on the data set collected by the CMS experiment a centre of mass energy of 13 TeV will be presented.

Primary track:**Is the speaker a PhD student or post-doc?:**

No

Higgs boson pairs and Higgs potential 1 - sal IX / 62**Di-Higgs searches at CMS**

The measurement of the production of Higgs boson pairs (HH) at the LHC allows the exploration of the Higgs boson interaction with itself and is thus a fundamental test of the Standard Model theory and has a key role in the determination of the Higgs boson nature. The most recent results from the CMS collaboration on measurements of non-resonant HH production using different final states and their combination using the data set collected by the CMS experiment at a centre of mass energy of 13 TeV will be presented

Primary track:

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 2 - sal IX / 63

Searches for Extended Higgs Sectors at CMS

We present searches for additional neutral and charged Higgs boson with the CMS detector using the full run 2 dataset. The presented searches also include decays of heavy Higgs bosons into other Higgs bosons (both the 125 GeV Higgs boson and other additional Higgs bosons).

Primary track:

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 1 - sal IX / 64

Rare & BSM decays of the Higgs boson at CMS

We present searches for rare and beyond-the-standard-model decays of the Higgs boson with the CMS detector using the full run 2 dataset. Amongst others, Higgs boson decays to two (pseudo-) scalars and to invisible particles are discussed.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 1 - sal IX / 65

Low-mass Higgs searches at CMS

We present searches for a resonance production in the diphoton final state with a mass lower than 125 GeV, predicted by several theoretical models beyond the standard one, as for example axion-like particles. Different possible production modes at the LHC are investigated.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 3 - sal IV / 66

Constraints on Higgs-charm couplings

The discovery of the Higgs boson ten years ago and successful measurement of the Higgs boson couplings to third generation fermions by ATLAS and CMS mark great milestones for HEP. The much weaker coupling to the second generation quarks predicted by the SM makes the measurement of the Higgs-charm coupling much more challenging. With the full run-2 data collected by the CMS experiment, a lot of progress has been made to constrain this coupling. In this talk, we present the latest results of direct and indirect measurements of the Higgs-charm coupling by the CMS experiment. Prospects for future improvements are also given.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 2 - sal IV / 68

Quark-Mass Effects in Higgs Production

Authors: Felix Eschment¹; Marco Niggetiedt²; Michal Wiktor Czakon³; Rene Poncelet⁴; Tom Schellenberger⁵

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We present results for the Higgs production cross section in the gluon-gluon-fusion channel at next-to-next-to-leading order with finite quark masses. While the impact of finite quark masses are power-suppressed, the precision of state-of-the-art theory predictions makes an exact determination of this effect indispensable. With this result, we address one of the leading theory uncertainties of the cross section.

Primary track:

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Precision Higgs measurements and calculations 2 - sal IV / 69

Towards Higgs and Z boson plus jet at NLL+ matched to NLO

Authors: Francesco Giovanni Celiberto¹; Luigi Delle Rose²; Gabriele Gatto^{None}; Alessandro Papa^{None}

¹ *UAH Madrid*

² *Università della Calabria*

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Recent analyses on high-energy inclusive Higgs-boson rates in proton collisions, matched with the state-of-the-art fixed-order N³LO accuracy, have shown that the impact of high-energy resummation corrections reaches 10% at the FCC nominal energies. This supports the statement that electroweak physics at 100 TeV is expected to receive relevant contributions from small- x physics. In this talk we will present novel predictions for rapidity and transverse-momentum distributions sensitive to the emission of a Higgs boson accompanied by a jet in proton collisions, calculated within the NLO fixed order in QCD and matched with the next-to leading energy-logarithmic accuracy and beyond (NLL/NLO⁺). We will also highlight first advancements in the extension of our analysis to the Z-boson case. According to our knowledge, this represent a first and novel implementation of a matching procedure in the context of the high-energy resummation for rapidity-separated two-particle final states. We come out with the message that the improvement of fixed-order calculations on Higgs- and Z-boson plus jet distributions is a core ingredient to reach the precision level of the description of observables relevant for Higgs and electroweak physics at current LHC energies as well as at nominal FCC ones.

Primary track:

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Precision Higgs measurements and calculations 1 - sal IV / 70

Revisiting the Higgs Boson Decay into a Dineutrino and Photon

Authors: Aliaksei Kachanovich¹; Ivan Nišandžić²

¹ *ULB*

² *Ruđer Bošković Institute*

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We present new calculations of the leading-order one-loop amplitude and the decay rate for $H \rightarrow \nu\bar{\nu}\gamma$ within the Standard Model. We present the full reduction of the Amplitude to a set of basic Passarino-Veltman functions resulting in more concise expressions compared to prior works. In this work we obtained the total decay rate as $\Gamma(H \rightarrow \nu\bar{\nu}\gamma) = 1.33 \text{ keV}$, that is in close agreement with the narrow width approximation (NWA) for the intermediate Z boson. A comparison with previous results available in the literature is also provided. We evaluate the differential decay rate with respect to the energy of the photon and find that the non-resonant contributions from box diagrams beyond the NWA notably affect the kinematic region associated with high-energy photons, where the intermediate Z boson is offshell. This suggests potential implications for searches of dark sector mediators, particularly in future lepton collider experiments.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

BSM Higgs physics 3 - sal IX / 71

Impact of interference effects on Higgs searches in the di-top final state at the LHC

Authors: Henning Bahl^{None}; Romal Kumar^{None}; Georg Ralf Weiglein¹

¹ *Deutsches Elektronen-Synchrotron (DE)*

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Various extensions of the Standard Model predict the existence of additional Higgs bosons. If these additional Higgs bosons are sufficiently heavy, an important search channel is the di-top final state. In this channel, interference contributions between the signal and the corresponding QCD background process are expected to be important. If more than one heavy scalar is present, besides the signal-background interference effects associated with each Higgs boson also important signal-signal interference effects are possible. We perform a comprehensive model-independent analysis of the various interference contributions within a simplified model framework considering two heavy scalars that can mix with each other, taking into account large resonance-type effects arising from loop-level mixing between the scalars. The interference effects are studied with Monte Carlo simulations for the di-top production process at the LHC. We demonstrate that signatures can emerge from these searches that may be unexpected or difficult to interpret.

Is the speaker a PhD student or post-doc?:

No

Primary track:

BSM Higgs physics

BSM Higgs physics 3 - sal IX / 72

Indications for New Higgs Bosons in Associated Di-Photon Production

Authors: Andreas Crivellin¹; Bruce Mellado Garcia²; Guglielmo Coloretti³; Saiyad Ashanujjaman⁴; Siddharth Prasad Maharathy⁵; Sumit Banik⁶

¹ *University of Zurich (CH)*

² *University of Wisconsin*

³ *University of Zurich (UZH) / Paul Scherrer Institute (PSI)*

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Statistically significant excesses exist at around 152 GeV in associated di-photon production contained in the sidebands of SM Higgs analyses. They are most pronounced in the $\gamma\gamma + \tau$, $\gamma\gamma + \text{MET}$, $\gamma\gamma + \geq 1\ell + \geq 1b$, $\gamma\gamma + 4j$ signal regions, and can be explained by the Drell-Yan production of new Higgs bosons, i.e. $pp \rightarrow W \rightarrow H^\pm$. In this context, we first examine the excesses in a simplified model approach, considering the decays of $H^\pm \rightarrow \tau\nu, tb, WZ$. We then specialize our analysis for the real Higgs triplet and two-Higgs doublet models, resulting in a combined significance of $\approx 4\sigma$ and $\approx 4.3\sigma$, respectively.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs physics at future colliders 1 - sal IV / 73

Highlights of the Higgs physics at ILC

Precise determination of Higgs parameters is crucial for validation of the Standard Model or any alternative BSM theory addressing open questions either in particle physics or cosmology. Clean environment, high precision of measurements dominated by the statistical uncertainty and a possibility of beam polarization can provide per mille level precision of the Higgs couplings measurements as well as the high sensitivity to BSM physics scale - $O(100 \text{ TeV})$ indirectly accessible already at 250 GeV ILC in EFT formalism. ILC operation at higher center-of-mass energies (500 GeV and above) offers unique prospects of Higgs self-coupling measurement to around 10% and CP violation measurement in vector boson fusion along with numerous BSM probes.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 3 - sal IV / 74

Higgs boson production in weak-boson fusion and $H \rightarrow b\bar{b}$ decay at NNLO with realistic event selection criteria

Authors: Arnd Behring¹; Ivan Novikov^{None}; Kirill Melnikov²; Konstantin Asteriadis³; Raoul Horst Rontsch^{None}

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² KIT

³ University of Regensburg

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The b-quark Yukawa coupling y_b can be measured in $H \rightarrow b\bar{b}$ decay. While $H \rightarrow b\bar{b}$ is the main decay mode of the Higgs boson, measuring it experimentally is challenging because of the large number of b-quarks from other QCD processes. However, Higgs boson production in weak-boson fusion (WBF) can be distinguished from those QCD backgrounds by the presence of two nearly back-to-back forward jets. In order to isolate such a signal it is important to have a good theoretical model of this process in the kinematic region defined by event selection criteria.

We present fully-differential results for Higgs boson production in weak-boson fusion followed by $H \rightarrow b\bar{b}$ Higgs decay in the narrow-width approximation, at NNLO in QCD. The nested soft-collinear subtraction scheme is used to cancel infrared divergences between real and virtual corrections and obtain finite predictions.

We find that the perturbative corrections to this process reduce the fiducial cross-section by about 40% in comparison to the leading-order predictions. Such large corrections can be attributed to a number of distinct sources, the strongest of which is the tendency of the QCD radiation in the $H \rightarrow b\bar{b}$ decay to reduce the transverse momentum of b-jets to the point where they no longer pass the b-jet selection criteria.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: precision & BSM 2 - sal IX / 75

Examining the CP properties of the top-Yukawa and the ggH coupling

Authors: Alberto Carnelli¹; Anastasia Kotsokechagia²; Elina Fuchs³; Frederic Deliot¹; Henning Bahl^{None}; Laurent Olivier Schoeffel¹; Marc Hannig⁴; Marco Menen⁴; Matthias Saimpert⁵; Tanguy Lucas Marsault¹

¹ *Université Paris-Saclay (FR)*

² *CERN*

³ *Leibniz Universitaet Hannover (DE)*

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The \mathcal{CP} structure of the Higgs couplings is a fundamental property which has not yet been constrained with high precision. The Higgs-top quark coupling is of particular interest due to its size and accessibility at the LHC via top-associated Higgs production and gluon fusion. To improve the sensitivity to the CP property of this coupling, we propose an extension to the STXS framework of the ttH process by extending the binning in the transverse momentum of the Higgs boson $p_{T,H}$ by either the pseudorapidity difference of the two top-quarks $\Delta\eta_{t\bar{t}}$, or a variable that is based on the top quark momenta, namely b_2 or the Collins-Soper angle $|\cos^*|$. Furthermore, we exploit the \mathcal{CP} sensitivity of a so far neglected phase space region for gluon fusion with a multivariate approach. Our results suggest that significant improvements in current experimental limits are possible.

Primary track:

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

BSM Higgs physics 3 - sal IX / 76**Status of triplet extended Higgs sector models in the light of NLO unitarity and the latest LHC data****Author:** Subrata Samanta¹**Co-authors:** Debtosh Chowdhury¹; POULAMI MONDAL²¹ *Indian Institute of Technology Kanpur*² *University of Calcutta***Corresponding Authors:** samantaphys@gmail.com, debtoshc@iitk.ac.in, poulami.mondal1994@gmail.com

Minimal triplet scalar extension of the Standard Model demanding custodial symmetry gives rise to a new model, the extended Georgi-Machacek (eGM) model, not the well-known Georgi-Machacek (GM) model. In this talk, I will discuss the theoretical bounds on the model parameter space, such as next-to-leading order unitarity and state-of-the-art bounded from below conditions on the potential parameters. I will present the results of a Bayesian fit with Markov Chain Monte Carlo simulations for both GM and eGM models to these theoretical bounds together with the Run 1 and Run 2 LHC data on Higgs signal strengths, incorporating the latest CMS and ATLAS di-photon excess data for a Higgs boson around 95 GeV. I will delineate the allowed ranges for the additional Higgs boson masses and their mass differences, and the limit on the triplet vacuum expectation value in the presence of the 95 GeV scalar. Finally, I will discuss the possibility of studying new decay modes in the eGM model and present the bounds on their branching ratios from the global fit, that could potentially be observed at the LHC and at the other future colliders.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

BSM Higgs physics 4 - sal IX / 77**Higher-order soft and virtual corrections to $H^+ H^-$ production****Author:** Nikolaos Kidonakis^{None}**Co-author:** Alberto Tonero¹¹ *Kennesaw State University***Corresponding Authors:** nkidonak@kennesaw.edu, alberto.tonero@gmail.com

We present calculations of higher-order corrections for the production of a heavy charged-Higgs pair ($H^+ H^-$) in the two-Higgs-doublet model at LHC energies. We calculate the NNLO soft-plus-virtual QCD corrections and the N³LO soft-gluon corrections to the total cross section and the charged-Higgs rapidity distribution.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Precision Higgs measurements and calculations 2 - sal IV / 78

Higgs combined measurements at CMS

The newest Higgs combined measurements at CMS are presented in this talk.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

No

Higgs boson pairs and Higgs potential 2 - sal IX / 79

Resonant HH/SH searches at CMS

The newest results of resonant HH/SH searches at CMS are presented in this talk.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

No

Common session: HH & future colliders 1 - sal IV / 80

Single- and di-Higgs prospects for CMS at HL-LHC

Single- and di-Higgs prospects for CMS at HL-LHC are presented in this talk.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

No

BSM Higgs physics 3 - sal IX / 81**General CP-violating 2HDM in light of the excesses in di-photon searches at the LHC****Author:** Guglielmo Coloretti¹¹ *University of Zurich (UZH) / Paul Scherrer Institute (PSI)***Corresponding Author:** guglielmo.coloretti@physik.uzh.ch

Recently, statistically significant excesses in inclusive and associated di-photon searches have been observed at the LHC, accumulating at around 95 GeV and 152 GeV, respectively. In this context, I will argue how the most general CP-violating 2HDM in the Yukawa alignment limit can account for these observations. 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) of the model. While $\Re[Z_7]$ contributes to $H \rightarrow \gamma\gamma$, $\Im[Z_7]$ affects $A \rightarrow \gamma\gamma$ and can be correlated with the observation of nonzero electric dipole moments.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Common session: precision & BSM 1 - sal IX / 82**Effect of anomalous HHH and ZZHH couplings on the decay width of $H \rightarrow 4l$.****Author:** BISWAJIT DAS¹**Co-author:** Pankaj Agrawal²¹ *The Institute of Mathematical Sciences, Chennai*² *Institute of Physics, Bhubaneswar, India***Corresponding Authors:** agrwal@iopb.res.in, bisubangla92@gmail.com

Despite the discovery of the Higgs boson, the Higgs sector of the standard model is still not fully established. In particular, the self-couplings of the Higgs boson, and its couplings with gauge bosons, are still to be fully determined. We consider electroweak corrections to the process $H \rightarrow 4l$. The corrections depend on the HHH and ZZHH couplings. We investigate this dependence in κ -framework. We find that the width depends on HHH coupling significantly. The dependence on ZZHH coupling is only marginal. We also discuss the dependence on ZZWW coupling.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Precision Higgs measurements and calculations 4 - sal IV / 83**Towards a numerical evaluation of $q\bar{q} \rightarrow t\bar{t}H$ at two loops**

Authors: Anton Olsson¹; Bakul Agarwal²; Gudrun Heinrich³; Jannis Lang^{None}; Matthias Kerner³; STEPHEN JONES^{None}; Vitaly Magerya^{None}; Víctor Bresó Pla⁴; Yannick Klein⁵

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We present progress on the calculation of the virtual NNLO corrections to $t\bar{t}H$ production in the $q\bar{q}$ -channel. We focus on the numerical evaluation of the amplitude, and the associated challenge of constructing a grid to interpolate the amplitude over a 5-dimensional phase space.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs boson pairs and Higgs potential 2 - sal IX / 84**The Art of Counting: where to cut-off SMEFT and HEFT in Higgs Pair Production**

Authors: Ilaria Brivio¹; Konstantin Schmid²; Ramona Groeber³

¹ University & INFN Bologna

² University and INFN Padova

³ Università di Padova and INFN, Sezione di Padova

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In searches for beyond the Standard Model (BSM) Physics, bottom-up effective field theories (EFTs) such as the Standard Model EFT (SMEFT) and Higgs EFT (HEFT) have become crucial theoretical tools. Besides specifying their particle content and the respective symmetries on which the higher-dimensional operators are built, the choice of a power counting in a small parameter is the third necessary ingredient. The latter dictates how the operators are organized and enables us to perform a truncation on Lagrangian and amplitude level, which is essential when computing physical observables. In this work, we discuss the power counting approaches to SMEFT and HEFT and study their application in the context of the Higgs pair production process.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Precision Higgs measurements and calculations 4 - sal IV / 85

Charm and bottom Yukawa couplings via quarkonia production at HL-LHC

Author: Yang Ma¹

Co-authors: Tao Han ; Xiaoze Tan ²

¹ *INFN Bologna*

² *HIT*

Corresponding Authors: mayangluon@pitt.edu, than@pitt.edu, xz.tan@hit.edu.cn

Since the discovery of the Higgs boson in 2012, Higgs physics has entered the precision era, with a key focus on measuring the Yukawa interactions between the Higgs boson and Standard Model fermions. The LHC serves as a crucial Higgs factory, and the High Luminosity LHC (HL-LHC) is expected to provide even more precise measurements due to its increased luminosity. However, effective charm and bottom quark tagging remains a significant challenge. We propose to analyze quarkonia production through Standard Model Higgs decay within the non-relativistic quantum chromodynamics (NRQCD) framework, discussing the potential of these processes to measure the charm and bottom quark Yukawa couplings at the HL-LHC, thereby advancing our understanding of Higgs physics.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Higgs boson pairs and Higgs potential 2 - sal IX / 86

Interference effects in resonant di-Higgs production at the LHC

Author: Daniel Winterbottom¹

Co-authors: Elina Fuchs ²; Finn Feuerstake ³; Tania Natalie Robens ⁴

¹ *Imperial College (GB)*

² *Leibniz Universitaet Hannover (DE)*

³ *Leibniz University Hannover*

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In this talk, I will present an investigation into finite width and interference effects in di-Higgs production at the LHC, with a particular focus on the real Higgs singlet extension of the Standard Model. This extension enhances di-Higgs production through the resonant decays of an additional heavy scalar into two SM-like Higgs bosons. The study examines the impact of interference between

non-resonant and resonant diagrams, revealing that this interference has a significant effect on the cross-sections and differential distributions at the LHC. Additionally, I will introduce a new tool that employs a matrix-element reweighting method, enabling the efficient modeling of interference effects in computational simulations.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs physics at future colliders 2 - sal IV / 87

Prospects for New Discoveries Through Precision Measurements at e^+e^- Colliders

Authors: Konstantin Asteriadis¹; Pier Paolo Giardino^{None}; Robert Szafron²; Sally Dawson³

¹ *Universität Regensburg*

² *Brookhaven National Laboratory*

³ *BNL*

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We systematically study potential effects of BSM physics in the $e^+ e^- \rightarrow Z H$ process. To this end, we include all relevant dimension-6 Standard Model Effective Field Theory operators and work to next-to-leading order (NLO) accuracy in the electro-weak coupling. We consider both polarized and unpolarized electron and positron beams and present results for $\sqrt{s}=240, 365$ and 500 GeV and emphasize observables where the NLO predictions differ significantly from the leading order (LO) results. At NLO, a sensitivity arises to operators that do not contribute at tree level, such as the Higgs trilinear coupling, CP violating operators, dimension-6 operators involving the top quark or anomalous Higgs-Z boson couplings, among many others. We compare the prospects of future e^+e^- colliders to explore these new physics effects with measurements from the LHC, electron EDMs (for CP violating operators), and Z pole measurements.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: HH & future colliders 1 - sal IV / 88

The Higgs Self-coupling Strategy at Linear e^+e^- Colliders

Authors: Bryan Bliewert¹; Caterina Vernieri²; Dimitris Ntounis²; Jenny List¹; Julie Munch Torndal¹; Junping Tian³

¹ *Deutsches Elektronen-Synchrotron (DE)*

² *SLAC National Accelerator Laboratory (US)*

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Measuring the Higgs self-coupling is a key target for future colliders, in particular through di-Higgs production at e+e- Linear Colliders with GeV, e.g. at ILC, C3 or CLIC. This contribution will discuss the roles and the interplay of di-Higgs production processes at various collider energies, including the case of non-SM values of the self-coupling. Previous studies, already based on Geant4-based detector simulation, established that the Higgs self-coupling can be extracted with 10-27% precision and provided a solid understanding of the limiting factors. This provides a robust starting point to explore the potential of more modern and sophisticated reconstruction and analysis techniques. We review the impact of advanced, often machine-learning-based algorithms, including e.g. jet clustering, kinematic fitting and matrix element-inferred likelihoods on the reconstruction of ZHH events, and offer an outlook on what can be expected for the self-coupling measurement.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: HH & future colliders 2 - sal IV / 89

Higgs-muon interactions at a multi-TeV muon collider

Author: Yang Ma¹

Co-authors: Davide Pagani²; Eugenia Celada ; Fabio Maltoni³; Juergen Reuter⁴; Keping Xie⁵; Nils Kreher⁶; Tao Han ; Tobias Striegl ; Wolfgang Kilian

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⁴ *DESY Hamburg, Germany*

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We study the capabilities of a muon collider, at 3 and 10 TeV center-of-mass energy, of probing the interactions of the Higgs boson with the muon. We consider all the possible processes involving the direct production of EW bosons (W , Z , and H) with up to five particles in the final state. We study these processes in the HEFT and SMEFT frameworks, assuming that the dominant BSM effects originate from the muon Yukawa sector. Our study shows that a Muon Collider has sensitivity beyond the high-luminosity LHC, especially as it does not rely on the Higgs-decay branching fraction to muons. A 10 TeV muon collider provides a unique sensitivity on muon and (multi-) Higgs interactions, significantly better than the 3 TeV option. In particular, we find searches based purely on multi-Higgs production to be particularly effective in probing these couplings.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: precision & BSM 2 - sal IX / 90

Single top plus Higgs at LHC with CP violating top Yukawa

Author: Ya-Juan Zheng^{None}

Corresponding Author: yjzheng218@gmail.com

We study the single top plus Higgs production process at the LHC with a CP violating Yukawa coupling from a dimension-6 operator. The amplitude of the subprocess $ub \rightarrow dtH$ is obtained both in the Unitary (U) and Feynman-Diagram (FD) gauges. Energy and angular distributions of the cross section and CP violating asymmetries are understood clearly from the interference among the FD gauge amplitudes.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Higgs physics at future colliders 2 - sal IV / 91

Long-lived particles from exotic Higgs decays at the FCC-ee

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The European Strategy for Particle Physics identifies an e^+e^- Higgs factory as its top priority and the first step towards an ultra-high energy future hadron collider. The Future Circular Collider (FCC) is being proposed at CERN to address these goals. The FCC includes an electron-positron collider (FCC-ee), which will be followed by an energy-frontier hadron collider (FCC-hh).

New long lived particles (LLPs) are connected to many new physics models and could be the key to new physics discoveries at FCC-ee.

This contribution presents an ongoing sensitivity analysis for exotic Higgs boson decays to LLPs at FCC-ee within the FCCAnalyses framework.

The study targets the production of a Higgs boson in association with a Z boson in e^+e^- collisions at 240 GeV, with the Higgs boson decaying into two long-lived scalars. This builds upon previous work with improved statistics and a refined analysis strategy.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Higgs boson pairs and Higgs potential 2 - sal IX / 92

Searches for resonances decaying to pairs of Higgs bosons in ATLAS

Several physics scenarios beyond the Standard Model predict the existence of new particles that can subsequently decay into a pair of Higgs bosons. This talk summarises ATLAS searches for resonant HH production with LHC Run 2 data. Several final states are considered, arising from various combinations of Higgs boson decays.

Primary track:

Is the speaker a PhD student or post-doc?:

No

Higgs boson pairs and Higgs potential 1 - sal IX / 93

Towards HH at NNLO QCD: the n_h^2 contribution

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The virtual corrections for $gg \rightarrow HH$ at NLO QCD have been efficiently approximated using a Taylor expansion in the limit of a forward kinematics. The same method has been recently applied to the calculation of a subset of the NNLO corrections, which are desirable given the significant impact, at NLO, of the uncertainty due to the choice of the top mass renormalization scheme. In this talk, I will report on the progress in the calculation of another contribution at NNLO, given by diagrams in which the two Higgs bosons couple to different top quark loops. For this contribution a naive Taylor expansion cannot be used, and I will instead discuss an approach based on asymptotic expansions in different kinematic limits.

Primary track:

Precision Higgs measurements and calculations

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Common session: precision & BSM 1 - sal IX / 94

Higgs decay to llZ at one loop in the SMEFT

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The Higgs decay into four leptons remains one of the best measured decay modes of the Higgs at the LHC, making precision calculations necessary for accurate predictions and constraints. We present the first calculation of the decay width for H to llZ at full one-loop in the Standard Model Effective Field Theory. At one-loop, a variety of new coefficients appear that modify the total rate and differential distributions, and coefficients appearing at tree-level experience sizable corrections. We show the impact of some select coefficients on the differential and inclusive partial decay width and discuss the reach for BSM physics at the LHC.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs boson pairs and Higgs potential 1 - sal IX / 95

Yukawa- and Higgs self-coupling corrections to di-Higgs production

Authors: Augustin Vestner¹; Gudrun Heinrich¹; Matthias Kerner¹; STEPHEN JONES^{None}; Tom Stone²

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Higgs pair production from gluon fusion is a process of high interest for the upcoming HL-LHC phase. In this talk we present our calculation of electro-weak NLO contributions comprising Yukawa-type and Higgs self-coupling corrections at two-loop level. Also, we show the effect of these corrections on the Higgs pair's invariant mass distribution.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs physics at future colliders 2 - sal IV / 96

Top-Yukawa coupling at future muon collider

Author: Ya-Juan Zheng^{None}

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We study a CP-violating top Yukawa coupling at muon collider through $\mu^- \mu^+ \rightarrow t\bar{t}h\nu\bar{\nu}$ process. The gauge invariant Lagrangian is obtained by a dimension-6 operator. Although the cross section and

distributions are gauge invariant, amplitudes calculated in the Feynman Diagram (FD) gauge allow us to understand the origin of the energy and angular dependence of CP violating asymmetries, and may help us preparing the future search strategy.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: precision & BSM 1 - sal IX / 97

Anomalous couplings in Higgs plus jet production

Authors: Benjamin Campillo Aveleira^{None}; Gudrun Heinrich¹; Lucas Kunz²; Matthias Kerner¹

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We present NLO QCD results for Higgs boson production in association with one jet, including anomalous Higgs-top and Higgs-gluon couplings and with full top quark mass dependence. We will compare the full theory with varied anomalous couplings to the Standard Model, based on our implementation into POWHEG-BOX-V2. Of special interest will be the $p_{T,H}$ distribution, since the high- p_T tail is sensitive to heavy new physics.

Primary track:

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs physics at future colliders 2 - sal IV / 98

Probing CPV mixing in the Higgs sector in VBF at 1 TeV ILC

Author: Natasa Vukasinovic¹

Co-authors: Ivanka Bozovic-Jelisavcic²; Ivan Smiljanic²; Goran Kacarevic²; Ivana Vidakovic²

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With the current precision of measurements by ATLAS and CMS experiments, it cannot be excluded that a SM-like Higgs boson is a CP violating mixture of CP-even and CP-odd states. We explore this possibility here, assuming Higgs boson production in ZZ-fusion, at 1 TeV ILC, with unpolarized beams. The full reconstruction of SM background and fast reconstruction of the signal is performed, simulating 8 ab⁻¹ of data collected with the ILD detector. We demonstrate that the CP mixing

angle Ψ_{CP} between scalar and pseudoscalar states can be measured with the statistical uncertainty of 3.8 mrad at 68% CL, corresponding to $1.44 \cdot 10^{-5}$ for the CP parameter f_{CP} . This is the first result on sensitivity of an e^+e^- collider to measure f_{CP} in vector boson fusion, recently published in Phys. Rev. D.

Primary track:

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: precision & BSM 2 - sal IX / 99

Jet Bundle Geometry of Scalar EFTs

Authors: Mohammad Alminawi¹; Iliaria Brivio²; Joseph Enea Davighi^{None}

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Geometric formulations of scalar EFTs formulate fields as coordinates on a field space manifold, which provides an alternative method of studying theories by relating physical quantities emerging from the two derivative term to geometric tensors which are invariant under field redefinitions.

Fibre bundles provide us with the tools to extend the formalism to both describe the potential via geometric quantities as well as extending to higher derivative orders via the construction of Jet bundles. As the full Lagrangian becomes possible to describe using a (pseudo-)Riemannian metric all physical quantities become related to geometric quantities.

The talk will introduce the mathematical formalism of fibre bundles showing how higher derivatives can be incorporated via Jet bundles as well as showing the computation of tree level and one loop amplitudes in the fibre bundle. The talk is based on arXiv: 2308.00017 as well as an upcoming work.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Higgs physics at future colliders 1 - sal IV / 100

Prospects for single Higgs couplings measurements at the multi-TeV muon collider

Muon collisions at multi-TeV center-of-mass energies provide an ideal environment for studying Higgs boson properties. At these energies, the high production rates and low background contributions allow for precise measurements of Higgs couplings to fermions and bosons. This contribution aims to provide an overview of the results obtained at a center-of-mass energy of 3 TeV, as well as

perspectives on the precision of cross-section measurements at 10 TeV center-of-mass energy, using detailed detector simulations and taking into account both physics and machine-induced background contributions.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

No

Common session: HH & future colliders 1 - sal IV / 101

Higgs self-coupling possibilities at multi-TeV muon collider

The determination of the double and triple Higgs production cross sections will allow probing the triple and quartic self-couplings of the Higgs boson, providing an opportunity to directly explore the nature of the scalar potential. The multi-TeV muon collider offers a unique opportunity to measure these couplings, thanks to the high production cross sections of multi-Higgs processes and the low physics background environment. This contribution will present the results obtained from detailed detector simulations, including both physics and machine-induced backgrounds, on double Higgs cross-section measurements and Higgs self-coupling extraction, and will discuss the prospects for triple Higgs studies.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

No

Higgs physics at future colliders 2 - sal IV / 104

Higgs portal long-lived particle searches at future colliders

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The Higgs portal to BSM is very well motivated both theoretically and experimentally. We study long-lived BSM particles in the Higgs portal model, produced either from the decay of a B-meson or the Higgs boson. We discuss the search for these particles at future colliders, like the 100 TeV future collider experiment. Given the need to optimise the designs of dedicated LLP detectors for future colliders, we propose dedicated LLP detector designs for the 100 TeV collider experiment, DELIGHT (Detector for long-lived particles at high energy of 100 TeV) and FOREHUNT (FORward Experiment for HUNDred TeV), and study their sensitivities for LLPs in the Higgs portal.

Primary track:

Higgs physics at future colliders

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

Common session: precision & BSM 1 - sal IX / 105

Impact of renormalisation group equation on Higgs production in the SMEFT

Author: Giuseppe Ventura^{None}

Co-authors: Eleni Vryonidou¹; Fabio Maltoni²

¹ *The University of Manchester (GB)*

² *Universite Catholique de Louvain (UCL) (BE) and Università di Bologna*

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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.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

BSM Higgs physics 4 - sal IX / 106

How large can the light quark Yukawa couplings be?

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While the third-generation couplings of the Higgs boson have been observed and studied, the first and second-generation fermion couplings to the Higgs (except the Higgs-muon coupling) remain elusive. This is due to two reasons mostly: light quark Yukawas smallness, and the difficulty of tagging light quarks efficiently. Therefore, even at the High Luminosity LHC (HL- LHC), the projections for the light quark Yukawa couplings, especially for the first generations, remain orders of magnitude away from the Standard Model prediction.

In this work, we try to address the question of how large the light quark Yukawa couplings can be by considering concrete UV scenarios using simplified models. Particularly, we explore various models

with vector-like quarks that generate EFT operators that modify the couplings of the light quarks to the Higgs boson. We examine the impact of constraints from electroweak precision observables, Higgs data, and flavor physics, and find that it is still possible to achieve significant deviations in the Yukawa couplings of the light generations, around $O(1000)$ for the first generation and around $O(50)$ for the second generation, even with vectorlike quarks with masses in the few TeV range. These maximized contributions to the light Yukawa couplings are achieved by allowing only one generation to couple to the new states, thereby suppressing the flavor constraints. Effectively, our analysis sets such models as a clear experimental target at the HL-LHC and partially motivates the continuation of light-quark Yukawa measurements at future facilities, as this is often the best way to access the vectorlike fermion states coupled to only one light generation.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024

Common session: HH & future colliders 2 - sal IV / 108

The (first) LISA miracle

Author: Carlo Tasillo¹

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The recent adoption of the LISA mission by the European Space Agency marks a significant milestone for gravitational wave cosmology, offering unprecedented sensitivity to gravitational wave backgrounds emitted at temperatures around a few hundred GeV. Intriguingly, this temperature range not only corresponds to the electroweak epoch but also coincides with the scale at which the freeze-out of WIMP dark matter is expected to happen. In this talk, I will present our recent work demonstrating how dark matter freeze-out triggered by a strong first-order phase transition in a dark sector can produce gravitational waves in the milli-Hertz range. Our findings suggest that a gravitational wave background detected by LISA could indicate such a phase transition, pointing to a specific dark matter candidate and opening new avenues for exploring the connection between Higgs physics, dark matter and gravitational waves.

Primary track:

Higgs boson pairs and Higgs potential (including electroweak phase transitions and connections to cosmology)

Is the speaker a PhD student or post-doc?:

Yes - My participation will be fully supported by my research group

BSM Higgs physics 3 - sal IX / 109

CP-violation in complex-singlet extension of 2HDM

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We explore the possibility of CP-violation in the complex-singlet extension of 2HDM. The addition of complex singlet paves the way for additional sources of CP-violation compared to 2HDM. If a Z_2 -symmetry is imposed on the complex-singlet, it can accommodate a dark matter candidate as well. We identify the regions of parameter space, that can fit DM observables and at the same time generate sufficient CP-violation. The amount of CP-violation gets severely constrained from electric-dipole moment experiments, which we take into account. Finally, we probe the CP-violation in this model at present and future collider experiments.

Primary track:

BSM Higgs physics

Is the speaker a PhD student or post-doc?:

Yes - I need some financial support (fee reduction) to attend Higgs 2024