



# WG4 introduction

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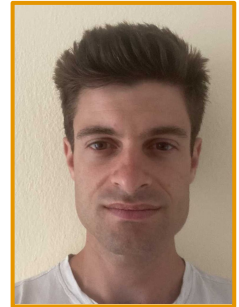


# WG4 leadership news

**Outgoing:** Javier (Theory), Margarete (Theory) and Stefano (ATLAS)



**Continuing/Incoming:** Arantxa (ATLAS), Ludovic (Theory) and Fabio (CMS)



Call for nominations for a new theory WG4 (HH and Multi-Higgs Production) convenor. Please send your nominations by email to [lhc-higgs-steering-committee@cern.ch](mailto:lhc-higgs-steering-committee@cern.ch) before 6th of December. Self-nominations are strongly encouraged.

# HHH WG4 subgroup

New starting sub-group to focus on HHH physics, both SM and BSM

Three incoming conveners: Benjamin Fuks (theory), Greg Landsberg (CMS) and William Balunas (ATLAS)



# Yellow report effort

Yellow report 5 will be as separated documents submitted by the LHCHWG on [SciPost](#)

- **June 2025: deadline for priority projects for SciPost submission**

- Priority document content (see also [Javier's talk on Friday](#))

-> **Call for our community to contribute on these topics**

- Experimental summary and projections to HL-LHC
- ggF HH production
  - Higher order corrections (QCD and EW)
  - Theory uncertainties:
    - Mtop shape uncertainties
    - Missing higher order EW uncertainty
  - Dependence from k3 and k4 including NLO EW effects
- VBF HH
- ttHH
- VHH
- single-Higgs + heavy-flavour jets background modelling

**Further submission deadlines after June 2025:**

- EFT, HHH and Resonant HH
- **open to other proposals (or adjustments) on the selected topics**

# HH 2025 workshop

[Workshop website](#)  
[Indico](#)

[Call for abstract already open,](#)  
deadline is January 20, 2025

The workshop is an in-person event and is limited to 280 participants. We encourage early registration.



# Agenda for the next days

## Today

09:30	12:00	<b>WG4 parallel session</b>	31/3-004 - IT Amphitheatre (CERN)	join	31/3-004	
Conveners: Arantxa Ruiz Martinez (IFIC Valencia), Milada Margarete Muehleitner (KIT)						
09:30		<b>Introduction</b>	10m			
Speaker: Stefano Manzoni (CERN)						
09:40		<b>Triple Higgs searches in ATLAS</b>	20m			
Speaker: William Balunas (University of Cambridge)						
10:00		<b>Overview of triple Higgs theory</b>	30m			
Speaker: Tania Natalie Robens (Rudjer Boskovic Institute)						
10:30		<b>Multi-Higgs Production and the Electroweak Phase Transition</b>	20m			
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.						
Speaker: Osama Karkout (Nikhef)						
10:50		<b>Effect of anomalous HHH and ZZHH couplings on the decay width of <math>H \rightarrow 4l</math> [remote]</b>	20m			
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 processes $H \rightarrow \nu e \bar{\nu} + \nu \mu \bar{\nu} + \nu \tau \bar{\nu}$ and $H \rightarrow e^+ e^- \mu^+ \mu^-$ . The corrections depend on the HHH coupling. We investigate this dependence in the kappa-framework without violating gauge invariance. We find that the width depends on coupling significantly.						
Speaker: Biswajit Das (The Institute of Mathematical Sciences, Chennai)						
<a href="#">h_to_4l_LHC_HWG...</a>						
11:30		<b>Double Higgs production in vector boson fusion at NLO QCD with anomalous couplings</b>	20m			
We present a calculation of the NLO QCD corrections to Higgs boson pair production in vector boson fusion, combined with the leading operators parametrisating anomalous interactions in non-linear Effective Field Theory (HEFT). Based on our Monte Carlo implementation using GoSam+Whizard, we investigate the effects of anomalous Higgs couplings on various observables.						
Speaker: Jens Braun (KIT)						
11:30		<b>Multi-Higgs production from VBS in HEFT (15+5)</b>	20m			
We computed some results for vector boson scattering in HEFT for the production of 2, 3 and 4 Higgs bosons. This results are updated after the latest results from both CMS and ATLAS for single and double Higgs production.						
Speaker: Javier Martínez Martín (Universidad Complutense de Madrid & IPARCOS)						

## Tomorrow

10:10		<b>Accessing the Electroweak Phase Transition through Top Quark and Higgs Boson Production (15+5)</b>	20m			
If a first-order electroweak phase transition is realized by an extended scalar sector, this impacts observables at (future) colliders. In this talk I will discuss multiple SM extensions that allow for strong first-order electroweak phase transitions: Two-Higgs Doublet Model (2HDM), Next-to-Minimal Two-Higgs Doublet Model (N2HDM), and two dimension-six effective field theory extensions of the 2HDM. For these I will illustrate how the strength of the phase transition impacts cross sections of double Higgs production, triple Higgs boson production, or top pair production.						
Speaker: Lisa Biermann (Paul Scherrer Institute)						
10:30	11:00	<b>Coffee break</b>	30m		500/1-201 - Mezzanine (CERN)	
11:00	12:30	<b>Plenary (WG4)</b>			4/3-006 - TH Conference Roo...	4/3-006
Conveners: Fabio Monti (CERN), Ludovic Michel Scyboz (Monash University), Stefano Manzoni (CERN)						
11:00		<b>Overview of HH searches at ATLAS</b>	15m			
Speaker: Arantxa Ruiz Martinez (IFIC Valencia)						
11:15		<b>Overview of HH searches at CMS</b>	15m			
Speaker: Torben Lange (National Institute of Chemical Physics and Biophysics, Tallinn)						
11:30		<b>VBF HH with Powheg</b>	20m			
Speaker: Simon Reinhardt (University of Tuebingen)						
11:50		<b>NLO EW corrections on <math>gg \rightarrow HH</math> cross section [remote]</b>	20m			
Speaker: Hualin Yu (Peking University)						
12:10		<b>Resonant HH production: interference effects and higher-order corrections</b>	20m			
Speaker: Kateryna Radchenko Serdula (DESY)						
15:10		<b>WG4: HH physics at 14 TeV (15+5) [remote]</b>	20m			
Speaker: Javier Mazzitelli (Paul Scherrer Institute)						