

# **VBF Workshop: Collaborative Advances in Theory and Experiment**

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CERN

## **Book of Abstracts**



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## Welcome

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State of the art / 19

## State of the art at fixed order and parton shower of VBF Higgs

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## Experimental review of ATLAS and CMS

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## Gluon-Fusion & Contamination in VBF

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## STXS and new STXS

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## Experimental bottleneck

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## Electroweak Hjj production in the POWHEG-BOX

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We present an implementation of the full electroweak Higgs plus two jets production process at hadron colliders. Our implementation, including vector-boson fusion and Higgsstrahlung contributions, is built in the framework of the resonance-aware version of the POWHEG BOX, which allows to match next-to-leading order QCD and EW corrections with shower Monte Carlo programs like PYTHIA8.

We provide phenomenological results for setups typical for VBF- and Higgsstrahlung analyses. For both cases we investigate the impact of NLO-QCD and EW corrections and their matching with parton showers.

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

**Authors:** Arnd Behring<sup>1</sup>; Ivan Novikov<sup>None</sup>; Kirill Melnikov<sup>2</sup>; Konstantin Asteriadis<sup>3</sup>; Raoul Röntsch<sup>4</sup>

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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.

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## Higgs + photon and triboson production as probes of Higgs Yukawa couplings

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The measurement of Yukawa couplings of the 125 GeV Higgs boson to light SM fermions (weakly constrained at present, particularly for first-generation fermions) is very challenging experimentally, yet key to unravel the details of the mass generation mechanism for the first two generations of matter and establish the role of the SM Higgs in such a mechanism. We discuss two recently proposed ways to constrain these Yukawa couplings at the LHC and future hadron colliders: Higgs production in association with a photon, and the production of three massive SM gauge bosons. We explore the sensitivity reach of both of them, and for the latter we briefly discuss the pros and cons of off-shell Higgs probes of SM Higgs couplings.

**Selected topics on VBF and related / 29**

## VBF simulations in CMS and theory limiting factors in CMS analyses

**Author:** CMS speaker<sup>None</sup>

This talk focuses on an in-depth review of the Higgs production through Vector Boson Fusion simulation programs used in CMS analyses. A review of both fixed order accuracy programs and Parton Shower uncertainties depending on the final states and the analysis scope will be given. Additionally, the talk intends to go into the details of the hadronization and underlying event modelling currently used in CMS. Details on the limiting factors of parton shower uncertainties will be given as function of the different phase-spaces of the various analyses. The talk will also review the usage and will cover the problems related to the integration of two-point systematic in profile likelihood fits that are widely used in Higgs physics.

**Selected topics on VBF and related / 30**

## Treatment of ggF contamination in VBF phase-spaces across CMS analyses

**Author:** Atul Jaiswal<sup>1</sup>

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An in-depth discussion of the gluon gluon fusion contamination in the VBF phase-space for both simplified template cross section and fiducial measurements in CMS will be given. In particular, the talk will cover different mitigation techniques for several analyses and into the different mitigation treatments the different analyses use and will touch upon the experimental challenges this contamination poses.

#### Selected topics on VBF and related / 31

### Precise prediction for Higgs plus two jets production

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In this talk, I will present the NLO QCD prediction for loop-induced Higgs-plus-two-jets production ( $pp \rightarrow H + 2 \text{ jets}$ ) at the LHC in [2110.06953]. The top-quark mass effects in Born and real corrections are computed exactly, and the effects in the two-loop virtual corrections are taken into account through the so-called full-theory approximation. I will discuss the technical challenges for this calculation, and present inclusive and fiducial total cross sections as well as differential distributions.

#### Selected topics on VBF and related / 32

### Exploring the CP-sensitive STXS staging in the HWW decay channel by the ATLAS experiment

**Co-authors:** Matthew Basso<sup>1</sup>; Metea Castilleja Marr<sup>2</sup>

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The current STXS stage 1.2 binning is not sensitive to the charge-parity property of the Higgs boson. While there is an on-going effort to finalize the STXS stage 1.3 bins, the ATLAS experiment is making a first attempt at measuring CP-sensitive STXS-like bins in the  $H \rightarrow WW$  decay channel. This is done by measuring cross-sections split by the signed azimuthal angle difference between the two leading jets. This STXS measurement considers both ggF and VBF production modes in order to explore the ggF and VBF CP-odd anomalous coupling simultaneously. The CP-odd effect is characterized by SMEFT operators in the Warsaw basis and the analysis aims to constrain the corresponding CP-odd Wilson coefficients, considering only the linear term from SM-BSM interference. The talk focuses on the motivation of the binning and gives an overview of the CPV test strategy.