Past, present, and future of VBF

Wednesday, 19 October 2022 - Friday, 21 October 2022

CERN

Book of Abstracts

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Deep-learning techniques for VBF Higgs searches: a case study in the invisible decay channel

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Vector boson fusion production of the Higgs boson provides a relatively clean channel of investigation compared to the more abundant but rather chaotic gluon fusion production. It has been known for decades that the lack of QCD radiation in the central areas of the detector between the two tagging forward jets is a recognising feature of VBF processes. In this presentation, we discuss the possibility of Convolutional Neural Networks (CNNs) utilising this difference by looking at the inclusive event information in the form of the tower image. Taking the invisible decay of the Higgs boson as a proxy for a difficult signature due to the lack of knowledge of the Higg's decay products, we compare the performance of CNNs with univariate shape analysis of the dijet invariant mass and pseudorapidity separation, as well as with Artificial Neural Networks that take physics-motivated variables, and find that the CNN can put the most stringent bounds on the invisible branching ratio of the Higgs.

The use of inclusive event information, on the other hand, brings in the possibility of CNNs picking up artefacts of the simulation, which generally concentrate more on reproducing the physics of the reconstructed objects. We also study the dependence of the CNN on the parton shower recoil scheme (global and dipole) and the perturbative accuracy (LO and NLO) of the VBF Higgs production. Although there is a large difference in the training accuracies, we find that the validation accuracy of the dipole-NLO generated samples is very mildly affected by the type of signal data used during the training process, with a variation of 1.6% in the AUC. This points toward CNNs being able to learn the underlying physical differences regardless of the sub-par simulation used during training.

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Theory overview of VBF

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Future of VBF and open issues

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State of the art review of current VBF Higgs experimental results from ATLAS

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State of the art review of VBF Higgs results from CMS

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Limiting components of theoretical uncertainties in current VBF Higgs ATLAS measurements

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Experimental falsification of SMEFT

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Vector Boson Scattering is central to our understanding of the Electroweak Symmetry Breaking Mechanism. Corrections to the Standard Model are conventionally studied in Standard Model Effective Field Theory (SMEFT). However, SMEFT can be cast in the form of the more general Higgs Effective Field Theory (HEFT). We expose the SMEFT-induced correlations on the coefficients of HEFT that, if found to generate tension with future data, would lead to the experimental falsification of the SMEFT framework. These correlations in VBF couplings are derived from the necessary symmetric point and analyticity of the SMEFT Lagrangian that allows the construction of the SMEFT expansion (as laid out by other groups), and properties at that point of the Higgs-flare function $\mathcal{F}(h)$ coupling Goldstone and Higgs bosons. We present amplitudes for VBF ($W_LW_L \to n \times h$) at the TeV scale, and show how SMEFT produces a theory prediction on cross-section ratios that does not depend on the specific value of the relevant Wilson coefficient (allowing direct experimental falsification of SMEFT).

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Looking at VBF processes from a polarization perspective

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Studying the polarization of weak bosons provides crucial information to better understand the electroweak-symmetry-breaking mechanism that is realized in nature. We will report on the status of Standard-Model calculations of polarized di-boson production in the VBF channel at the LHC, with a focus on vector-boson-scattering and VBF Higgs-boson production. We will show a number of phenomenological results and address the extension of the currently available results to higher orders in perturbation theory.

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Towards WBF with realistic final states and anomalous couplings at NNLO

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I present fully differential studies of WBF at NNLO QCD that go beyond stable Higgs boson production. For the first time at this order, decays of the Higgs boson at leading order and anomalous weak couplings of the Higgs boson are included. I will show that for the H -> bbar decay channel currently employed implicit fiducial cuts on stable Higgs boson transverse momentum are crucial and might need to be adapted when radiative corrections to the decay process are taken into account.

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High Energy Jets (HEJ) applied to inclusive Higgs + jets production

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In order to further study the properties of the Higgs boson at the LHC, both gluon fusion (GF) and vector boson fusion (VBF) production modes have to be investigated. Within VBF cuts of large rapidity separation between jets, high energy effects are numerically significant and have to be taken care of appropriately. The High Energy Jets (HEJ) framework resums these large log(s/t) effects to all orders in the strong coupling, resulting in a suppression of the cross-section compared to fixed-order at large Δy_{12} or m_{jj}. In the case of Higgs production plus two jets, this suggests that the GF contribution within VBF cuts is further suppressed compared to fixed-order predictions. More recently, inclusive Higgs production plus one jet predictions have been made available within HEJ, thus extending the resummation range of the phase space containing at least two jets from previous predictions and providing the first HEJ results for processes involving only one jet.

In this talk, I will summarise the impact of high-energy resummation in $H+ \geq 1$j and $H+ \geq 2$j, including new comparisons to experimental data.

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Limiting components of theoretical uncertainties in current VBF Higgs CMS measurements

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Experimental prospects of VBF measurements

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Electroweak corrections and shower effects to Higgs production in association with two jets at the LHC

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A sensitivity study of VBF-V to dimension-6 EFT operators at the LHC

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Vector Boson Fusion (VBF) is a purely electroweak process and a fundamental tool to test the electroweak sector of the standard model (SM). Leptonic decay modes of the vector bosons are used to measure SM processes and search for physics beyond the SM, since they feature a clean signature and hence, a lower level of background.
We present a parton-level study in two VBF channels at the Large Hadron Collider that establishes the VBF sensitivity to a set of dimension-six operators in the Standard Model Effective Field Theory (SMEFT). Two different final state are studied, namely VBF-Z and the VBF-W.
The template analysis performed to define the optimal observables for each operator and process considered is shown.
Constraints are put on dimension-6 operators and compared to current limits extracted in VBS and diboson channels.
An outlook on the possible combination of different final states toward a global SMEFT fit is also given.

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Parton shower and VBF, an overview

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Experimental potential on CP sensitive SXTS splitting.

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Welcome

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Discussion