Reviewer A:

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1. 'In conclusion, given that this proposal does not include any completely novel techniques I would not rate it as particularly innovative'

--> We have added references to the new BIT paper in Sec. 4 by including the following text

"The proposer’s group has recently developed an algorithm to design tree-based classifiers, which learn the likelihood ratio between SM-EFT and SM hypothesis exploiting the complete event information and optimally separate effects of SM-EFT operators from the SM background [37, 38]. It has already been shown that this novel technique provides a significant improvement in sensitivity to the SM-EFT operators under consideration with respect to traditional approaches of using a single kinematic distribution in regions optimized for the SM signal [38]."

It has also been stressed again at work package 10 in Sec. 8.

"Such kinds of methods have not been attempted in experimental measurements so far."

2. 'mixing & running of EFT operators have not been addressed ...'

--> We have added the following text to the work package 14 in Sec. 8.

"Mixing SM-EFT operators through renormalization group equations can change the sensitivity results. The matrix of anomalous dimensions is theoretically known [12, 13, 79] and the effects are expected to be at the percent level. These effects can be important if some poorly constrained operator leads to the running of a strongly constrained one. However, the existing constraints on the SM-EFT operators considered in this proposal are generally weak, so these effects are expected to be small [80]. Nevertheless, there are ongoing efforts in the theory community to check the RGE effects on the interpretation of LHC data in the context of global SM-EFT fits, and we leave it to theorists."

3. 'the usage of state-of-the-art SM predictions and what is the best way to obtain SMEFT predictions and extract the SMEFT coefficients (e.g. using ratios and/or higher-order calculations)

--> We have added the following text to the Sec. 6.2.

"We consider one operator insertion at a time for the VH production followed by the decay of H. In SMEFTsim model, the correction to the total Higgs decay width is computed using separate K factors for each decay channel following Ref. [66].

For the final measurement, both the SM VH signal and the backgrounds will be generated at next-to-leading order in QCD using Madgraph5 aMC@NLO or POWHEG [67–69] generators and will be normalized using cross sections calculated at the highest theoretical accuracy available (both in QCD and electroweak). These event samples are produced centrally in the CMS Collaboration. The next-to-leading-order (NLO) accurate electroweak corrections, important at high energy, and effects of finite bottom quark mass, known at next-to-next-to-leading order (NNLO) in QCD, will be applied to the SM VH signal. The SM-EFT effects for quark-initiated processes (WH and ZH) will be simulated at LO using the SMEFTsim model and at NLO with the SMEFT@NLO model [70] for the gluon-initiated process (ZH). The SMEFT@NLO model, so far, includes only the CP-even SM-EFT operators. Therefore, we can only test the CP nature of SM-EFT effects at LO in QCD. The SM-EFT effects for the ZH production with Z → l+l− and H → bb decays are now known at NNLO accuracy in QCD for six operators [71]."

4. 'There are some operators missing as soon as higher-order corrections are included (e.g. a point-like Higgs-gluon coupling in tree-level amplitudes with one radiated gluon, or a chromomagnetic dipole operator in the Higgs to bottom quark decay) ...'

--> We have added the following text to work package 2 in Sec. 8.

"All the SM-EFT effects parameterized as functions of Wilson coefficients will be applied as K factors on the VH production in the SM. At NLO and NNLO, additional operators beyond the list presented in Table 1 affect the VH production. Although some of those, e.g., gluon–top and Higgs–top contact terms, are expected to be probed with better sensitivity in other measurements (e.g., of tt, ttH productions), we still plan to consider those in case simulating SM-EFT effects for Z H production at NLO. At NNLO, the Higgs–bottom quark chromomagnetic dipole operator (∼ Q̄σ μν Ta HbGμνa with Ta as the generators of SU(3)\_C group) is expected to result in a significant change in the shape of important kinematic variables [71]. We plan to communicate with the authors of Ref. [71] to check if it is possible to simulate MC samples including these effects; otherwise, we will include an acceptance correction."

5. 'A minor criticism in the planning concerns the list of work packages, which all have the exact same timeframe, despite some of them, like it is explicitly written for number 13, require more effort than others. Similarly, there is no clear dependence among the different work packages indicated, if one of them turns out to be not feasible or delayed, will the other become not possible or delayed?

The proposal lacks some risk assessment and contingency plans.'

--> Timescales for some tasks have been changed, which, we believe, addresses the concern expressed by the referee. We would like to highlight that in the new version, each column in Table 4 corresponds to three months for 2022, 2023, and 2024, but to four months for 2025 and 2026. We have also added the following sentences at the end of Sec. 8.

"The timescales for the last two tasks, e.g., work packages 21 and 22, are conservative, so there is a contingency in case some previous tasks take more time than anticipated."

"It is worth mentioning that some of the tasks are correlated with others. For example, signal simulation and SMEFT parameterization have a strong interlink; the same is true for work packages 4

and 5. These kinds of tasks are put in similar time slots so that feedback of one of those immediately propagates to the others."

6. 'Very little information is given on how this process (even in the SM) is generated, apart from the fact that MG5\_aMC@NLO with additional SMEFT operators, in particular for ZH production, which also proceeds via gluon-gluon fusion with additional SMEFT operators. There are already more accurate tools to simulate the SM signal (and backgrounds), which will be crucial in order to achieve the level of precision the proposal envisages to achieve.'

--> We have added the following text to Sec. 6.2.

"For the final measurement, both the SM VH signal and the backgrounds will be generated at next-to-leading order in QCD using Madgraph5 aMC@NLO or POWHEG [67–69] generators and will be normalized using cross sections calculated at the highest theoretical accuracy available (both in QCD and electroweak). These event samples are produced centrally in the CMS Collaboration. The next-to-leading-order (NLO) accurate electroweak corrections, important at high energy, and effects of finite bottom quark mass, known at next-to-next-to-leading order (NNLO) in QCD, will be applied to the SM VH signal. The SM-EFT effects for quark-initiated processes (WH and ZH) will be simulated at LO using the SMEFTsim model and at NLO with the SMEFT@NLO model [70] for the gluon-initiated process (ZH). The SMEFT@NLO model, so far, includes only the CP-even SM-EFT operators, so we can test the CP nature of SM-EFT effects only at LO in QCD. The SM-EFT effects for the ZH production with Z → l+l− and H → bb decays are now known at NNLO accuracy in QCD for six operators [71]."

7. 'Theory developments are mentioned only under work package 16, but they should be considered already at the beginning of the project, ...'

--> The signal simulation for Run 2 is in work package 1. Work package 16 is the same thing for the Run 3.

8. 'No information is given how SMEFT effects will be included in the background.'

--> We have added the following text to the work package 13 in Sec. 8.

"Gauge coupling operators ${\cal O}\_{HW}$, ${\cal O}\_{HWB}$, ${\cal O}\_{HB}$ also affect the diboson production. We plan to take into the SM-EFT effects on backgrounds in the same manner as for the VH signal."

9. 'For the VH process, it is not discussed how production and decay are actually combined, since also the Higgs width receives SMEFT corrections, but again these are merely theoretical questions. '

--> We have added the following text to the Sec. 6.2.

"We consider one operator insertion at a time for the VH production followed by the decay of H. In SMEFTsim model, the correction to the total Higgs decay width is computed using separate K factors for each decay channel following Ref. [66]."

10. 'I don't see the PI to be completely independent in his work yet, which however is not to be expected at his scientific age ...'

--> I started to supervise a Master's student at HEPHY after submitting the first version of the proposal, so I added this reference to the section of supervision experience in my CV.

11. For the proposal to be excellent I miss some additional innovative ideas and a more complete/consistent theoretical treatment of the SMEFT operators. Indeed, the main weakness concerns only theoretical aspects of the SMEFT framework and theoretical predictions, because in precision analyses not only accurate measurements, but accurate theoretical predictions are crucial.

--> These concerns are now addressed.

Reviewer B:

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1. 'Since the detailed use of angular variables is new, it would have been interesting to have more details about the possible tuning of backgrounds Monte Carlo if needed, ..'

--> We have added the following text at the end of Sec. 6.2.

"It has been checked that the angular variables are modeled well by the simulations in control regions."

2. 'The authors clearly mention the possibility of inverting some cuts to get a background enriched sample, but don't discuss what should be done in case of discrepancies. '

--> We have added the following text in Sec. 6.2.

"In the final analysis, results will be extracted from a simultaneous maximum-likelihood fit of the signal-plus-background model to the data distributions in all SRs and CRs. The shape and normalization of all distributions for the signal and for the background components will be allowed to vary within the statistical and systematic uncertainties."

3. 'I would rather like to see a short discussion about the systematics on the MET determination, angular variable measurements as well and how they will influence the reach of the method.'

--> We have added the following text to the work package 11 in Sec. 8.

"Systematic uncertainties on jet and lepton energy calibration affect the determination of $\ptvecmiss$, thus the reconstructed neutrino momentum. Those also affect the measurement of angular variables. It is checked that those systematic uncertainties don’t change the shape of distributions of angular variables considerably and do not reduce the power of the measurement significantly."

4. 'Do authors want to use a data oriented approach if the MCs do not reproduce well enough the backgrounds? Or is there already confidence with present measurements that the description well be good enough?'

--> We have added the following text in Sec. 6.2.

"In the final analysis, results will be extracted from a simultaneous maximum-likelihood fit of the signal-plus-background model to the data distributions in all SRs and CRs. The shape and normalization of all distributions for the signal and for the background components will be allowed to vary within the statistical and systematic uncertainties."

5. 'Next items describe the determination of the final results and how they will be published.'

--> We have added the following text to the work package 15 in Sec. 8.

"We plan to release the measurement results in a format that the particle physics community can use to combine the results with other measurements. Since the expected number of \VH signal events is small in SM, we don't plan to perform the unfolding of detector effects. Also, the underlying theoretical assumptions used to create the response matrices needed for unfolding may change the sensitivity to the SM-EFT effects. Instead, we aim to publish the raw (unprofiled) likelihood information."

6. 'While it (person-power) seems a bit weak given the number of tasks to be accomplished ...' It would have been nice to have a few more people involved in this project (even as advisor) given the scope and importance of the project. '

--> Wolfgang Adam has kindly agreed to montior the progress and provide necessary advices. Thus, the following text is added in Sec. 11.

"Wolfgang Adam, a senior scientist at the HEPHY CMS group, will monitor the progress of the project and provide the necessary advice. He has vast experience in reviewing CMS publications as the former Physics coordinator of the CMS Collaboration. His role will be purely advisory, and he will not do any technical work."

7. 'My only worry is the effects of potential MC/data discrepancy for background and the effect of systematics on the final reach that could alter the performance on angular variables. ... It would have been nice to have a more "senior" person in the project to help the young post-doc as a PI but I am sure that this can be done unofficially at HEPHY.'

--> These concerns are now addressed.