



2023 Helmholtz – OCPC – Programme for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Double-Higgs production in the final state with 4 b-jets at CMS

Helmholtz Centre, division:

DESY-FH

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Description of the project (max. 1 page):

The Run 3 has just started at the Large Hadron Collider and one of the main topics in Higgs physics will be the constraint on the trilinear coupling, which is governing the Higgs potential. Such coupling can be determined looking for double Higgs production and many decay channels have been exploited up to now. The channel in which the two Higgs bosons both decay into b-quarks is the one with largest branching ratio, however the large QCD background due to multi b-jets production makes the search particularly challenging.

The project aims to analyse the CMS data collected during Run 3 to extract constraints on the trilinear coupling from this channel, $HH \rightarrow 4 \text{ b-jets}$. The CMS Collaboration is planning to have a special trigger and dataset dedicated to this search, making this channel particularly attractive. We foresee that double Higgs production will be one of the main topics at the LHC in Run 3.

The DESY CMS Higgs group is composed of about 20 people among staff, postdocs and PhD students and has acquired since Run 1 extensive experience in Higgs physics and in particular in single Higgs or heavy Higgs bosons decaying into b-jets. It is natural then to move to double Higgs production and a lot of expertise is on site.



The project will have to first concentrate on the trigger or trigger efficiency for the channel $HH \rightarrow 4 \text{ b-jets}$ and then design an analysis workflow. The signal extraction and data-driven methods for the background will have to be studied. Machine learning will be needed to be able to disentangle the signal above the background. A CMS publication at the end of the two years of postdoc is foreseen.

The analysis can be used with few changes also for a search of a resonant heavy state decaying into two standard model Higgs bosons, in the same final state with 4 b-jets. Also here the DESY CMS Higgs group has extensive expertise, and we will align with the CMS needs and interest from the candidate postdoc to define better this part of the project.

The Higgs group in DESY CMS is also involved in Tracker alignment and in the developments of statistical and analysis tools at CMS, so that possibilities for services for the Collaboration on site can be fully supported.

Description of existing or sought Chinese collaboration partner institute (max. half page):

The CMS Collaboration has several Institutes in China as full members, covering a wide range of analysis topics and detector activities. A partner Institute from one of these Institutes would be beneficial for both DESY and the China partner. The following institutes are in CMS: Beihang University; Institute of High Energy Physics Beijing; Department of Physics, Tsinghua University; Guangdong Provincial Key Laboratory of Nuclear Science and Guangdong-Hong Kong Joint Laboratory of Quantum Matter; South China Normal University; Sun Yat-Sen University; University of Science and Technology of China; State Key Laboratory of Nuclear Physics and Technology, Peking University; Institute of Frontier and Interdisciplinary Science, Shandong University; Institute of Modern Physics and Key Laboratory of Nuclear Physics and Ion-beam Application (MOE) - Fudan University; Zhejiang University - Department of Physics. In addition, Nanjing Normal University is applying to CMS as full member.

Required qualification of the postdoc:

A candidate with already experience in analysis of data in experimental particle physics is preferred. The required qualification is:

- PhD in Physics
- Experience with data analysis in experimental particle physics and preferably in analysis of data at the LHC
- Excellent programming skills in python, C++
- Experience with machine learning
- Very good English (spoken, written)