



## 2025 Helmholtz – OCPC – Programme for the involvement of postdocs in bilateral collaboration projects

### PART A

**Title of the project:**

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Search for resonances decaying to a pair of Higgs bosons in the four b-jets final state at the CMS experiment

**DESY Division & Group:**

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FH-CMS

**Project leader/supervisor:**

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**Programme Coordinator** (Email, telephone and telefax)

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**Description of the project** (max. 1 page):

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The Higgs boson (H), the latest elementary particle discovered, is a powerful probe for physics beyond the standard model (SM) of particle physics. Several SM extensions addressing fundamental questions, such as the matter-antimatter asymmetry and the stability of the vacuum, predict the existence of a heavy Higgs-like boson, X, which decays into two bosons, either HH or YH, where Y is a new additional Higgs boson.

Hints of such Higgs-to-Higgs decays have emerged from LHC Run 2 (2015–2018) data. With the dataset from LHC Run 3 (2022–2026), amounting to an integrated luminosity of at least  $300 \text{ fb}^{-1}$ , it will be possible to scrutinize these indications further and potentially discover new Higgs bosons.

This project aims to look for the X→YH signature where both Y and H subsequently decay into a bottom quark-antiquark pair, which has the largest combined branching fraction in a wide range of models. The analysis will leverage the LHC Run 3 dataset collected by the CMS experiment, which benefits from newly introduced software-based triggers and an



optimized data storage strategy specifically to select events with the production of multiple bottom quarks, enabling access to the phase space region previously unavailable in Run 2.

The project will use state-of-the-art methods, based on open source tools, to identify the jets resulting from bottom quark fragmentation, and correctly associate them with to Higgs bosons candidates. Innovative background estimation techniques will be developed distinguishing new physics signals from the SM processes.

The DESY CMS Higgs group is composed of about 10 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. There is also significant expertise on double Higgs production.

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.

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

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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; 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; Nanjing Normal University; 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.

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**Required qualification of the postdoc:**

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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, preferably at one of the LHC experiments
- Excellent programming skills in python, C++
- Experience with statistical extraction methods
- Very good English (spoken, written)