



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

### PART A

**Title of the project:**

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Software and analysis tools development for LUXE experiment at DESY

**Helmholtz Centre, division:**

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DESY-FH

**Project leader:**

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Frank Gaede

**Contact Information of Project Supervisor: (Email, telephone)**

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**DESY Group:**

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FH group FTX

**DESY-OCPC Programme Coordinator (Email, telephone and telefax)**

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

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DESY is one of the world's leading research centers in high energy physics and in photon science. European X-ray Free Electron Laserfacility (EuXFEL) currently operated at DESY is a unique linear electron accelerator primarily designed as an X-ray light source for wide areas of scientific studies including applied materials research and fundamental physics.

At the same time the 16.5 GeV electron beam of the EuXFEL provides an excellent possibility to probe the properties of QED vacuum and in particular its instability in the vicinity of a strong electric field close to and above  $1.3 \times 10^{18}$  V/m, known as the Schwinger limit. The phenomenon has been predicted long ago and has been widely studied theoretically. Its experimental investigation was prevented by the technical limitations in reaching high fields in laboratories. The current state-of-the-art in laser technology makes it possible to plan an experiment where QED in the strong field regime can be studied. Such an experiment, called LUXE (Laser Und XFEL Experiment) is currently under development at DESY and aims for studying strong field QED in collisions of a high power laser and the XFEL electron beam.

At present stage the international team is working on the technical design of the experimental setup which includes the design of the beam delivery components, detector systems optimization, and the development of a common reconstruction and simulation software stack for LUXE. For the software it is currently planned to use standard tools which are being developed for future colliders, namely the Key4hep software stack. Currently discussions are ongoing on how to best adopt the Key4hep software stack for LUXE's needs. While several core components of Key4HEP match the LUXE requirements out of the box, e.g. DD4hep for detector description, or the general adaption of common workflows for building software via Spack, other components require more consideration.

Among these is the adaption of EDM4hep, which provides datatypes originally designed to meet the needs of collider experiments. While the detector measurements from the positron tracking device have a natural representation in EDM4hep, the high particle density environment in electron-laser collisions in LUXE requires different types of detectors than a standard collider experiment, for example high electron flux detectors such as a scintillator screen imaged by a camera, or a Cherenkov detector measuring the electron rates. A representation of such high-flux detector measurement data does not yet exist in EDM4hep and needs to be defined.

The first phase of the proposed project consists of the adaptation of Key4hep components for the LUXE-specific use case, which will pave the way for new ways to simulate and reconstruct information from high-rate detectors in Key4hep. The second phase of the project aims at leveraging the consolidated software landscape to optimize the LUXE physics reach. This part consists of optimizing existing and developing novel reconstruction and analysis algorithms, e.g. by employing Machine Learning approaches, as well as their integration into the software stack. These developments are crucial to unlock the full physics potential of the measurements that will be done at LUXE to study for the first time QED in an entirely new and uncharted experimental regime.

### Job description:

- Reuse, adapt and develop Key4HEP software in the context of LUXE;
- Study detector performance in Monte Carlo simulation;
- Design detector reconstruction algorithm using advanced machine learning techniques;



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

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The LUXE collaboration is looking for partner institutes that would be interested in studying physics at the QED frontier. Opportunities exist for the performance study and data reconstruction of the currently planned detectors (tracker, calorimeters, Cherenkov detectors, scintillating screens, etc.) expected to operate at LUXE. Innovative reconstruction techniques such as machine learning techniques are expected to prove successful where more traditional techniques are not viable given the very harsh environment detection expected at the experiment. The collaboration is planning to collect a large amount of physics and background data that will allow to use complete data-driven analysis techniques.

**Required qualification of the postdoc:**

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- PhD in physics (experimental physics);
- Awareness of data acquisition techniques;
- Awareness of simulation techniques;
- Experience in programming;
- Experience in machine learning techniques;
- Fluent English and good communication skills.