

Project title: Laser-driven high-repetition rate particle and photon sources for non-destructive applications

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Helpful existing knowledge: 1st or 2:1 BSc or MSci degree in physics or related subjects

Funding status: Funding to be officially confirmed

Closing date: TBD

Project description: Laser-driven particle accelerators can drive a wide range of secondary radiation and particle beams with spatiotemporal properties (typically in the micron and femtosecond scales) that are effectively unmatched by any other technology. Their extreme versatility not only enables a precise control and fine-tuning of the beam parameters but also permits to select, by simply varying the interaction conditions, the type of particle or radiation (i.e., x-rays, gamma-rays, electrons, positrons, ions, and neutrons). This unique feature can thus also enable multi-modal imaging, a unique feature of laser-driven systems.

These sources have the potential to provide a paradigm shift in a wide range of industrial and applied domains. For example, they can deliver high-resolution radiography and tomography of electronic components and sensitive materials, enable precision manipulation of advanced materials, and provide a platform for testing the resilience of instruments and detectors under extreme environments, including space-weather conditions. To unlock these applications, however, one must achieve high average fluxes and thus have access to high repetition rate and high-power laser systems.

Current high power (multi-TW to PW) laser systems in the UK can only operate at limited repetition rates of the order of 1 Hz. To fill this gap in technological capability, we are building at Queen's University Belfast a user facility that will host the first high-power (10TW) and high repetition rate (100 Hz) laser in the UK, which will offer a host of high-flux particle and photon sources for applications. The facility is co-funded by the EPSRC and is planned to be operational in January 2027.

The successful candidate will join a multi-disciplinary team at QUB under the supervision of Prof. Gianluca Sarri to develop, optimise, and apply laser-driven particle and photon sources at 100 Hz repetition rates. The student will develop specific frameworks for the self-optimisation of these sources for specific applications, including resilience testing of instruments and detectors under extreme environments and high-resolution radiography of electronic components and high-Z materials. The main aim of the project is to establish and utilise specific operational models of laser-

driven sources (e.g., x-rays, gamma-rays, electrons, and positrons) for specific applications of direct interest to DSTL.