# Foreword

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This annual report for the Central Laser Facility (CLF) at the STFC Rutherford Appleton Laboratory provides highlights of scientific and technical research that has been carried out by users of the Facility and its staff over the financial year 2016-17.

This year has seen an uplift in funding and consequently an uplift in the volume of user access we are able to offer, with the CLF's facilities remaining heavily oversubscribed. The CLF and its community have continued to deliver scientific output and technical development of the highest order.

**Vulcan** – One of the main highlights from this period was in the first imaging campaign for the x-ray radiography of nuclear waste. This feasibility study successfully demonstrated the ability to image a uranium penny encased in grout, and led to a successful grant and further experiments to continue this area of study. The successful imaging via electronic detectors on this experiment led to the further development of high-energy imaging cameras, and also underpins the concept for imaging at higher repetition rates.

**Gemini** continued to maintain its preeminent stature as a driver for secondary sources for applications as well as fundamental science, yielding several high-impact papers this year. These include two publications in Nature group journals (Nature Physics and Nature Communications) on the demonstration of relativistic-induced transparency that creates an instantaneous pinhole in an otherwise opaque plasma, providing a new way of controlling laser-driven proton beams. An experiment in Astra also demonstrated feedback control of high-energy electron beams employing genetic algorithms for the first time.

**Artemis** received funding for a laser upgrade – a mid-IR system running at 100 kHz – which is a joint purchase with Ultra. The laser will arrive in 2018. Artemis expanded the range of experiments it can offer with its first demonstration of XUV lensless imaging, using ptychography to image a biological sample (mouse neurons) with 100 nm resolution. The team also demonstrated UV-pump XUV-probe photoelectron spectroscopy from molecular gases for the first time.

**Target Fabrication** – Scitech Precision Ltd (the CLF spin-out specialising in microtargetry) continued to supply microtargets for use on an increasing number of international facilities including FELs.

The CLF's facilities in the Research Complex at Harwell, Ultra and Octopus, continue to serve a multidisciplinary community, with user programmes in areas ranging from fundamental chemistry and materials science, to biomedical and environmental research.

**Ultra** continued to deliver 60 weeks of access to the academic community. It also supported an increased volume of access by industrial users. Of note has been the application of a range of ultrafast techniques to catalysis research, including *in operando* Kerr-gate Raman studies of zeolites. The commissioning of an IR pulse shaper on the Ultra B station has enabled the first broadband 2DIR experiments on highly scattering zeolite samples. Two new programmes were awarded, both focusing on homogeneous solution phase catalysis.

**Octopus** is now running routinely with parallel operation for multiple user groups. As part of its programme of continuous development, two older microscopes were decommissioned to make way for new instruments. Development work has focused on cryo-super resolution and correlative microscopy, building on

technology patented by the CLF. As part of its drive to maximise the potential of multiple microscopy techniques available on the Harwell Campus, collaborations in correlative imaging have been established with both eBIC and the Rosalind Franklin Institute.

The CLF's **Centre for Advanced Laser Technology and Applications (CALTA**) demonstrated world leading performance from its "DiPOLE 100" laser in December 2016, with an output of 107 J at 10 Hz for an extended period. This is the first time that a system of this type has demonstrated kW-level average power operation and marks the successful completion of the £10M contract with the Institute of Physics in the Czech Republic. The laser is now fully commissioned in the HiLASE Centre, close to Prague.

Following this outstanding result, the CLF and HiLASE teams have been awarded €50M as part of a Horizon 2020 Widespread Teaming project to enhance the HiLASE Centre and to develop diode pumped solid state laser technology. As part of the project, the CALTA team will design and construct a 100 Hz version of the DiPOLE 10J laser. This system will be unique, extending STFC's lead at the forefront of DPSSL laser technology.

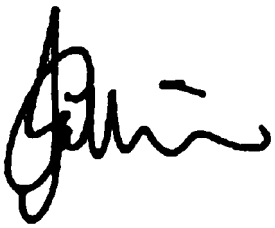
Construction of a second DiPOLE 100 laser (D-100X), a UK contribution to the HIBEF consortium at the European XFEL facility, is well advanced. The laser will be commissioned at RAL with delivery to Hamburg scheduled for December 2018. Funding is being provided jointly by STFC and EPSRC. When installed at the high energy density instrument, users will be able to access new states of matter, using the D-100X laser beam to shock-compress targets to high pressure followed by diagnosis using the XFEL beam. The 10 Hz repetition rate of D-100X will give users the ability to optimise the interactions in "real time" and to gather data at an unprecedented rate.

**Economic Impact** – CLF continues to build strong relationships with industry, resulting this year in five new commercial contracts with companies to gain access to our facilities (Ultra, Octopus and Gemini). Additionally two major contracts have been awarded: one with DSTL for the preparation of the PULSAR TDR; and a second through the H2020 Widespread and Teaming programme with the HiLASE facility in the Czech Republic, to develop DiPOLE technology further and to provide support for innovation activities.

We have continued to build on our Intellectual Property (IP) portfolio, with two new patent applications filed and two patents granted. CLF continues to take the lead in terms of invention disclosures and patent ideas submitted for review.

Work on developing Laser Driven Sources for industrial applications has progressed, and the CLF was awarded a grant through the STFC IPS scheme to work alongside Bristol University and Sellafield in developing laser driven x-rays and neutrons for inspection of nuclear waste containers. This is a big opportunity and further broadens the applications space for these rapidly developing sources.

Finally, at the CLF, the close partnership we have with our User Community has been central to our past success. As we look forward, it is imperative that we collectively draw on that partnership to promote our collective success that is, in part, represented in this publication. I hope that you enjoy reading it!



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