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 2015-16.

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 still 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 this year was the publishing of the results from an experiment on the Petawatt facility, where a team from CLF / York used x-ray polarimetry diagnostics to measure the resistivity of a target heated to conditions similar to that found in brown dwarfs. The resistivity was found to be larger than existing models predicted, highlighting how current models are not adequate to explain the structure of such objects. The paper was published in Nature Communications.

Gemini continued to prove its unique capability as a driver for secondary sources for applications as well as fundamental science, yielding several high-impact papers this year in Nature-group journals and Physical Review Letters. These include the use of x-ray beams generated by Gemini for tomographic imaging of trabecular bone tissues and creating nearly charge-neutral electron-positron plasmas, recreating astrophysical phenomena observed in pulsars and quasars in the laboratory. Experiments in Gemini were also successful in accelerating electrons beyond 2GeV using the novel focusing geometry for the first time. The betatron x-rays generated in the process were used for high-resolution tomographic imaging of medical samples in this experiment.

Artemis continued to deliver experiments using XUV pulses to study electron dynamics, expanding the range of materials to include novel 2D materials and layered structures, with papers in the high-impact journals Physical Review Letters and Nano Letters. Artemis is building future capability by developing a few-cycle mid-IR source, which will enable generation of attosecond pulses at photon energies across the water window. The team showed that these few-cycle pulses can be further amplified, and are planning a power upgrade to the laser system, which will boost the flux of HHG available for experiments.

The CLF's facilities in the Research Complex at Harwell, Ultra and Octopus, were strengthened with the addition of new capabilities funded by the BBSRC in partnership with STFC.

Ultra – In 2015-16 access increased from 40 to 60 weeks per year through parallel operation of stations. The introduction of broadband infrared Surface Sum Frequency Generation (SSFG) has provided new facility capability. SSFG is a technique sensitive only to the vibrations of molecules at the monolayer level on surfaces and is being used to study the reactions during electro-catalysis.

Octopus biological imaging facility recruited two new scientists with expertise in super-resolution microscopy, to increase the amount of time delivered to users from 60 to 100 weeks per year. The new staff will allow parallel running of the Octopus stations, dealing with a serious oversubscription problem and making better use of the capital investment made in the facility by BBSRC, MRC, and STFC. A new single molecule localisation method suitable for mapping intermolecular separations was commissioned and made available for users.

The CLF's **Centre for Advanced Laser Technology and Applications (CALTA)** demonstrated world leading performance from its "DiPOLE 100" laser in October '15 with an output of 107J at 1Hz. This is the highest recorded pulse energy from a diode pumped laser of its type and a crucial milestone in the delivery of the £10M development contract for the HiLASE Facility in the Czech Republic. The system was dismantled and delivered to Prague in December and a joint STFC / HiLASE team has begun installing and commissioning the laser to its full 1kW specification in the new HiLASE facility building.

Design and component procurement of a second DiPOLE 100 laser (D-100X) is well advanced with assembly scheduled to commence in 2017. The system will be commissioned at CLF before delivery to Hamburg in mid-2018 as a joint EPSRC / STFC contribution to the European XFEL project as part of the international HiBEF consortium.

Economic Impact – This year CLF has continued to engage closely with industry and this has resulted in four companies gaining access to our facilities (Ultra, Gemini and Octopus). Additionally of particular note is the joint funding of a PDRA position with Johnson Matthey plc. This important step forward will enable much stronger links to be forged with both JM and wider industry.

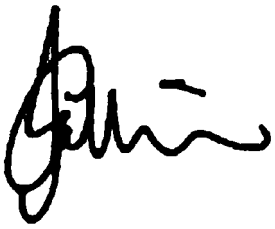
The year has been particularly productive in regards to Intellectual Property (IP) generation and protection, with a total of four patent applications filed. The IP reflects the broad range of sectors CLF covers and includes nuclear waste imaging, characterising ultra-short pulses, new laser alignment methods and novel biomarkers. CLF continues to take the lead in terms of invention disclosures and patent ideas submitted for review.

CLF's spin-out Scitech Precision Ltd. has grown this year and is now able to offer a laser micromachining service, having taken on two new members of staff and purchased laser processing equipment from a local company.

The communication of our work and its impact to non-scientific audiences is an increasing priority and the public profile of CLF continues to grow with a number of impact stories featuring in the mass media.

Finally, the close partnership the CLF has with its User Community has been central to our past success, and 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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