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Central Laser Facility Annual Report

50th Anniversary of the Laser

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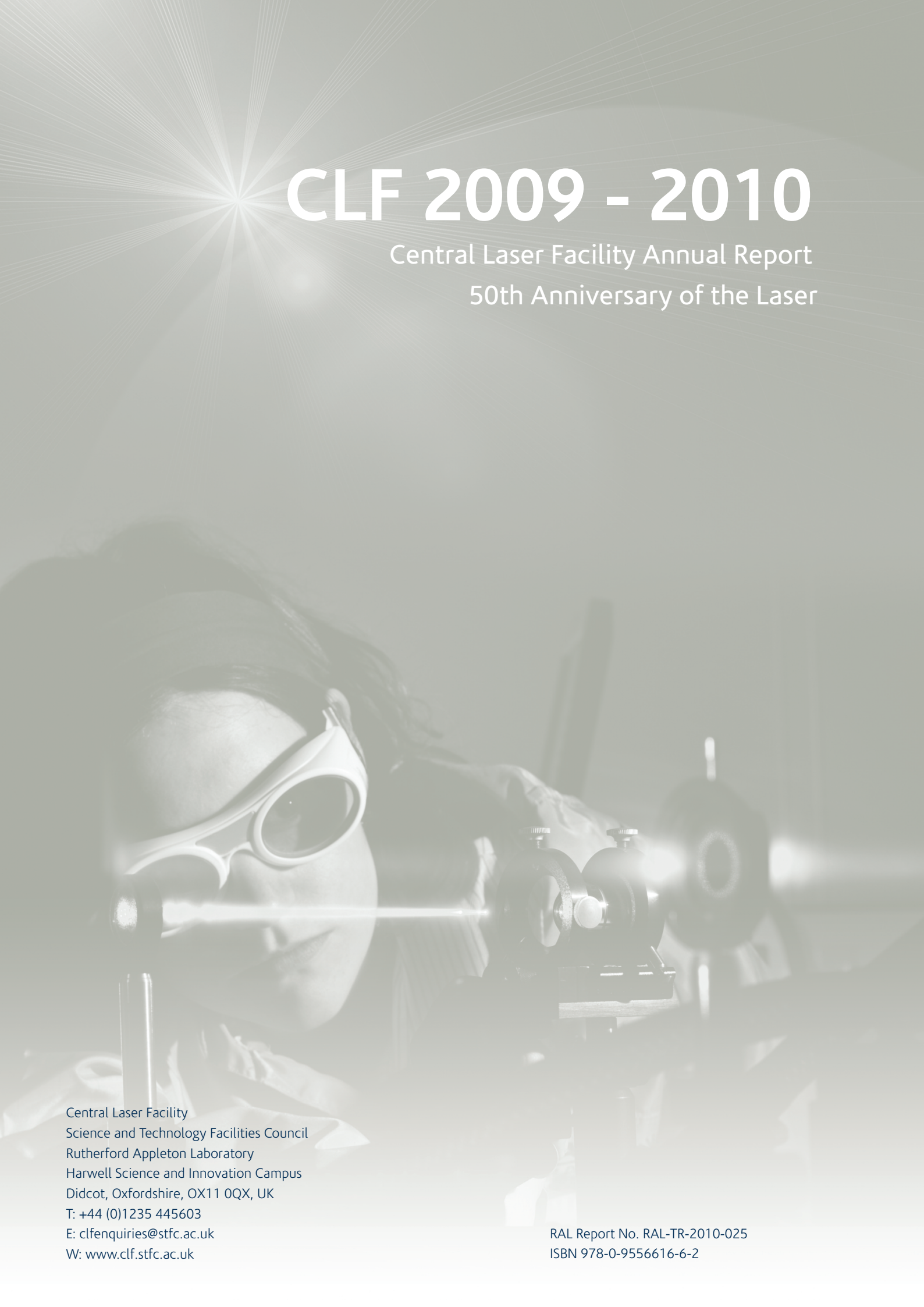

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Contents

Foreword

Mike Dunne
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This annual report for the Central Laser Facility (CLF) at the STFC Rutherford Appleton Laboratory provides highlights of the scientific research which has been carried out by users of the Facility and its staff over the financial year 2009-10.

The report records an ever widening scope of research, making use of the new Artemis and LSF facilities, data from the first arm of Astra-Gemini and continuing high level output from the constantly-evolving Vulcan laser facility. This breadth of research is key to the ongoing success of the CLF – allowing continuous innovation and cross-over between areas, whilst maintaining a leading capability and the flexibility to respond to emerging new concepts and opportunities.

I am sure you will be impressed by the scale and quality of the output reflected in these pages.

Sadly, this report marks the end of my tenure as Director of the Central Laser Facility. I move on to pursue the challenge of laser fusion energy in the USA, to help contribute to the delivery of abundant clean energy – as manifested in the HiPER and LIFE projects.

Looking back at the past 5 (hugely enjoyable) years in the CLF, there were three principal aspects of our operation which I felt needed development, building from the incredibly successful 30 years of prior research:

1. Securing a long-term future for the Lasers for Science Facility (LSF), with a clear role and fit within the research community. With the move to the new suite of laboratories in the "Research Complex at Harwell", and a well defined new mission, I believe the LSF is now an essential component for the future scientific and economic health of physical and bio-science research at RAL.

2. Ensuring a robust upgrade programme for the CLF's High Power Lasers. With the commissioning of Astra-Gemini and Artemis, and the decision to move forward with the construction phase of the Vulcan 10 Petawatt project, the CLF will continue for many years to provide truly world leading capability to its international user community.

3. Establishing a much stronger strategic context in which to grow and flourish. By working at the European level to build cohesion and coordination, a wholly new scale of laser research activity has been developed – manifested in the ELI and HiPER European projects. Underpinned by Laserlab-Europe and the strategic objectives of these projects, there is a robust, long-term platform to guide the CLF's future development and demonstrate the global impact of its research.

This has all been made possible by the dedication, expertise and creativity of the CLF's staff and our close-knit user community.

I would like to thank you all for your wonderful support, hard work and sheer brilliance over the past few years in developing and delivering ideas. The CLF can be proud to be the best in the world in its chosen fields. Long may this continue.

Professor Mike Dunne
Director, Central Laser Facility

Overview

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The CLF is a world leading centre for research using lasers. This section provides an overview of the capabilities offered to our international academic and industrial community.

Vulcan

Vulcan is a highly versatile Nd:glass laser with three independent target areas that couple long and short pulse beams in a variety of flexible geometries. A maximum of 2.5 kJ can be delivered in its eight beams. Long-pulse temporal shaping is possible, with pulse durations from 100 ps to 20 ns, and a selection of focusing, beam smoothing and harmonic conversion options. Intensities up to 10^{21} Wcm^{-2} are available.

TA-Petawatt is Vulcan's highest intensity area, with a ~500 J / 500 fs beam capable of being focused to 10^{21} W/cm^2. It offers the capability for beam splitting, combination with a ~100 J long pulse beamline, and various probe beam options.

TA-West offers dual CPA beams coupled to the long pulse beamlines. One beam operates at 80-100 J / 1 ps (10^{20} W/cm^2), and the second CPA beam operates either at 80-100 J / 1 ps, or at 500 J / 10 ps configurable in flexible geometries.

TA-East offers long pulse capability along with short pulse probe beams – in a variety of highly flexible configurations.

Work continues on a very major upgrade – to 10 Petawatt peak power (300 J / 30 fs) capable of being focused to 10^{23} W/cm^2 delivered to two target areas (TAP and one new one). Approval to proceed with the major build phase is expected in early 2011.

Astra Gemini

This Ti:Sapphire facility has been designed to offer 2 beams, each with a power of 0.5 PW and a repetition rate of one shot every 20 seconds. The facility will enable interaction studies up to 10^{22} Wcm^{-2}. F/20 and F/2 beam focusing options are available, along with a robotic solid target insertion system and a variety of 'plasma mirror' configurations for high contrast pulse delivery. The second beam has now been commissioned, as have further improvements to the beam contrast and stability.

Artemis

Artemis offers carrier stable ultra-short pulse capability from the Infrared through to XUV spectral regions, with a tunable probe source and end-stations offering optimised time resolution or energy resolution for atomic/molecular physics and condensed matter science. The end-stations are:

i. A high harmonic generation chamber with kHz gas-jet and XUV flat-field spectrometer (10-40 nm spectral region), together with a monochromator to select a single XUV harmonic in the spectral range 10eV-100 eV.

ii. Materials science end-station with 2D hemispherical photo-electron analyser and <14 K five-axis cryo-manipulator.

iii. Gas-phase end-station with a velocity-map imaging detector

iv. A fs time and electron spin resolved end-station.

Lasers for Science Facility (LSF)

The LSF, located in the Research Complex at Harwell, clusters into two areas: molecular structural dynamics (ULTRA), and functional bio-systems imaging (OCTOPUS).

In the dynamics area ULTRA offers a state-of-the-art high power 10 kHz fs / ps system combined with OPAs to generate pulses for a range of unique pump and probe spectroscopy techniques. It provides spectral coverage from 200-12000 nm and temporal resolution down to 50 fs. This is used in the investigations of fast photodynamic processes in solids, solutions and gases. Its time resolved resonance Raman (TR^3) capability enables highly fluorescent samples to be studied using a 4 ps optical Kerr shutter. The PIRATE facility (Picosecond InfraRed Absorption and Transient Excitation) gives two independently tunable beams across the mid infrared region of the spectrum for pump / probe experiments. A new development to link the two capabilities is underway (TRMPS).

In the imaging area, the Octopus cluster provides access to a broad range of capabilities from single-molecule imaging, confocal microscopy and spectroscopy, along with bio-preparation laboratories and associated tools. In addition, a 'laser tweezers' laboratory is available to study Raman spectra and pico-Newton forces between particles in solution for bioscience and environmental research.

Laser Loan Pool

Commercial laser systems are available from the EPSRC Laser Loan Pool for periods of up to 6 months at the user's home laboratory. A wide range of ancillary and diagnostic equipment is also available to support user experiments.

Engineering Services

Mechanical, electrical and computing support is provided for the operation of the laser facilities at the CLF, for the experimental programmes on these facilities and for the CLF's research and development activities. Mechanical and electrical CAD tools and workshop facilities enable a rapid response.

Theory and Modelling

The CLF will support any scheduled experiment throughout the design, analysis and interpretation phases. We offer multi-dimensional fluid, PIC, hybrid and Vlasov-Fokker-Planck modelling capabilities and access to large scale computing.

Target Preparation

A high quality target fabrication facility is operated within the CLF. This area has been significantly extended recently, offering separated characterisation, assembly, and coating areas, plus office space. It is equipped with a wide range of target production and characterisation equipment, including evaporation and sputter coating plants, interference microscopes, SEM, AFM, surface profiling and a plasma etch facility. Many targets are produced in collaboration with STFC micromachining and lithographic services. Commercial access to target preparation capabilities is available for supply to other laboratories via the spin-out company Scitech Precision Ltd.

Access to Facilities

Calls for access are made twice annually, with applications peer reviewed by external Facility Access Panels.
The CLF operates "free at the point of access", available to any UK academic or industrial group engaged in open scientific research, subject to external peer review.
European collaboration is fully open for the high power lasers, whilst European and International collaborations are also encouraged across the CLF suite for significant fractions of the time. Dedicated access to CLF facilities is awarded to European researchers via the LaserLab-Europe initiative (www.laserlab-europe.net) funded by the European Commission.

Hiring of the facilities and access to CLF expertise is also available on a commercial basis for proprietary or urgent industrial research and development.
Please visit www.clf.stfc.ac.uk for more details on all aspects of the CLF.