Foreword

Professor John Collier
Director, Central Laser Facility, STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot, UK
Email address: **john.collier@stfc.ac.uk** Website: **www.clf.stfc.ac.uk**

For over forty years, our team of Central Laser Facility (CLF) scientists, engineers and researchers have been developing laser technologies and techniques that have proven instrumental in opening up new areas of study and research. Based at the STFC Rutherford Appleton Laboratory in Oxfordshire, we operate several of the most advanced laser systems in the world, and have a rich history of innovation and development, empowering an international community of scientists in their efforts to solve major economic and societal challenges. Moreover, we continue to listen to our many collaborator organisations – in academia and in the commercial sector – and are constantly evolving to help meet their needs, as well as the ever growing and changing demands of science.

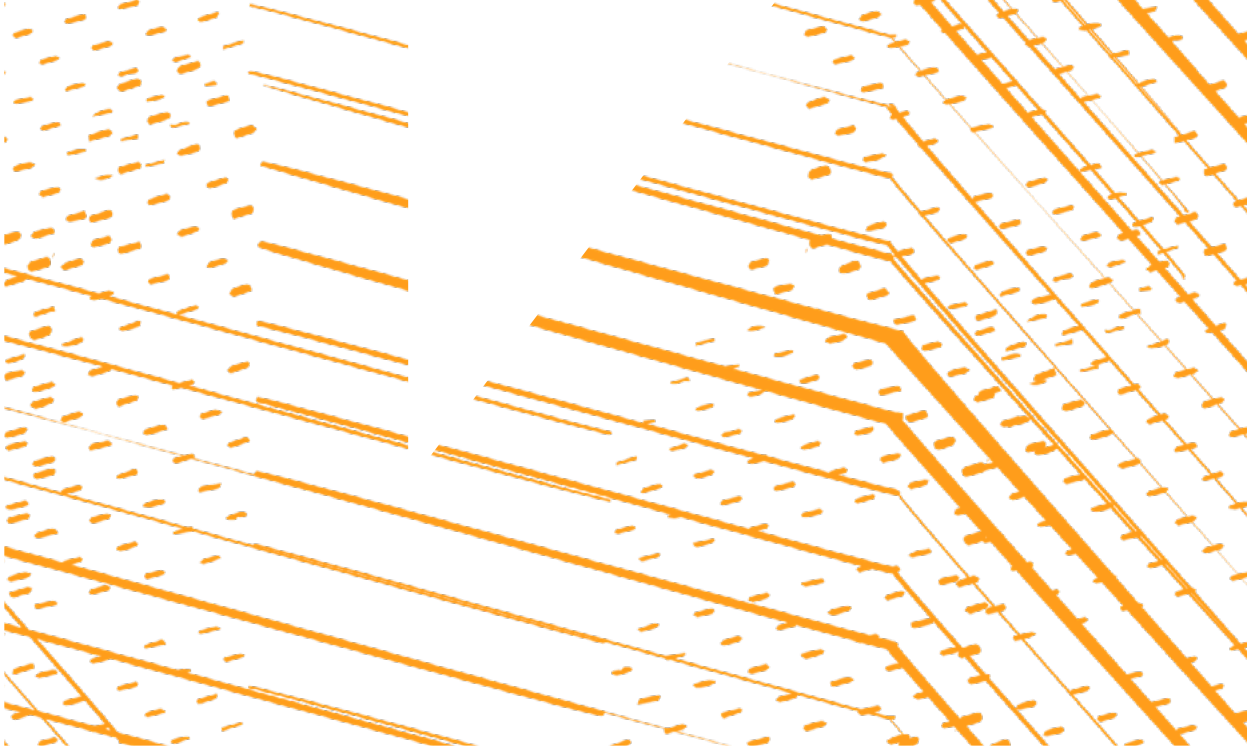
Our five major laser facilities enable scientists to investigate a broad range of science areas, spanning physics, chemistry and biology, and research topics ranging from the investigation of complex biological reactions within cells to new ideas for future energy production:

- The **Vulcan** facility, one of the most intense lasers in the world, has broken records on several occasions for producing the highest optical intensity ever on a target. It is based on versatile Nd:glass chirped-pulse-amplification technology delivering beams into two target areas, and is used in fusion energy, electron- and ion-acceleration research, laboratory astrophysics and plasma physics research. Work this year on a new short-pulse beamline for the Vulcan TAP area will deliver a PW level pulse (30 J in 30 fs and enable new areas of imaging and combined proton/ electron interactions to take place.

- The **Gemini** facility is a high-power laser based on titanium-sapphire chirped-pulse-amplification technology, with capabilities that balance and complement those of Vulcan. The energy contained in the pulses from the front end are delivered to a very small target extremely quickly, allowing experimenters to study the way matter behaves under extreme conditions of temperature and pressure. Recent experiments have demonstrated that Gemini's laser-driven x-ray sources are suitable for advanced imaging techniques suited to scientific studies and industrial inspection.

- **Artemis** is a high-repetition-rate titanium-sapphire laser system providing a unique combination of ultrafast and XUV pulses for studies of ultrafast dynamics in atomic, molecular, and condensed-matter systems. Artemis has just had a major upgrade, adding a new laser system and a third XUV beamline, making more energy available for XUV generation.

- **Ultra** is a world-class time-resolved (pump-probe) spectroscopy facility that combines laser, detector and sample manipulation technology to probe ultrafast molecular dynamics, facilitating innovative research in the physical and life sciences in academia and industry. Work carried out in Ultra provided fundamental insights into the mechanisms of charge transport, useful in guiding the design of better organic semiconductors and molecular wires and therefore improved devices in emerging applications, such as display devices in mobile phones and photovoltaic solar cells.



- **Octopus** is a unique user facility with a suite of advanced laser-based imaging and laser trapping capabilities. Advanced image processing algorithms are used to image real systems in real environments in real time, often well below the diffraction limit, with the modular nature of the facility allowing the development and exploitation of new advanced imaging techniques as they become available, to address grand challenges in the life sciences area. When the COVID-19 pandemic hit at the start of this reporting year, the Octopus facility remained open for CLF scientists to carry out collaborative work to increase understanding of the SARS-CoV-2 virus at the centre of the pandemic, and in particular how exactly it attacks cells.

Underpinning our laser facilities are enabling capabilities, from computational plasma physics to target micro-fabrication and engineering, which are helping our users to push the boundaries of science and research.

I remain tremendously proud of the CLF's expert staff, who are at the heart of our success, and who work hard to deliver scientific output and technical development of the highest order. When COVID-19 prevented most staff and users from coming to site, a huge amount of effort was put into enabling people to work from home, and providing remote access to our facilities. Staff were prepared to come to site to manufacture ventilators, demonstrating their willingness to apply their skills and expertise to help others. There is so much we can be proud of.

This annual report for the CLF provides a snapshot of some of the scientific and technical research that has been carried out by users of the CLF and its staff over the financial year 2019-20. I do hope that you enjoy reading this selection of abstracts, and feel inspired by the achievements of all those involved.

Professor John Collier FLSW
Director, Central Laser Facility