

Overview of the Central Laser Facility

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The Central Laser Facility (CLF) is a world leading centre for research using lasers. This section provides a brief overview of the capabilities available to our international user community.

This is a time of growth for the CLF – with the inclusion of single molecule imaging techniques from the Daresbury Laboratory, major developments underway on each of our three principal facilities (Astra, Vulcan and the LSF), the potential offered by the start of the HiPER and ELI European projects, and the initiation of the New Light Source project in the UK.

The CLF continues to offer its leading capabilities free at the point of access to our UK academic and industrial community, with significant scope for European and wider international involvement.

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. Short pulse (<500 fs), high irradiance (up to 10^{21} Wcm⁻²) chirped pulse amplification (CPA) capability is available on the Petawatt and 100 TW beams.

The Petawatt Target Area (TAP) is our highest intensity area, and now offers the capability for beam splitting, combination with a ~100 J long pulse beamline, and various probe beam options.

This year has seen a complete overhaul of **Target Area West (TAW)**. In addition to the existing 80-100 J / 1 ps (10^{20} W/cm²) beam and the long-pulse beamlines, we have added a second CPA beam that can either operate at 80-100 J/1 ps, or at 500 J/10 ps. A new compressor vessel and a significant extension to the interaction chamber have been introduced.

There has also been significant progress with the development of the front-end of the proposed **10 Petawatt upgrade** (300J in 30fs), and in the design of the envisaged facility. Following user consultation in the summer of 2008 we will submit a full case to STFC in October 2008 with the aim of realising this major upgrade in the early part of the next decade.

Astra

Gemini has been designed to offer two beams with a power of 0.5 PW every 20 seconds, enabling interaction studies at 10^{22} Wcm⁻². F/20 and F/2 beam focusing options are available, and a solid target insertion system currently under development. This facility fired its first user shots in January 2008 to a successful series of electron acceleration experiments. The second beam will be commissioned during 2008, along with the supporting diagnostics and targetry. The system is planned to come up to its full specification in early 2009.

Artemis marks a major development to the existing TA1 facility, combining <10fs high energy IR and XUV beams with a tunable probe source and end-stations offering optimised time resolution or energy resolution.

A new laser has been installed to generate carrier envelope phase stabilised high power, <30 fs, 780 nm pulses with 14 mJ/pulse at 1 kHz or 3.5 mJ/pulse at 3 kHz. The output energy can be split into the following beam-lines:

- i. 1mJ can be further compressed to <10 fs, 0.5mJ/pulse;
- ii. 8mJ can be used to pump an IR OPA system providing tuneable ~40 fs pulses in the spectral range of 1.18µm - 15µm with an output of up to 1.5 mJ/pulse.
- iii. The remaining energy can be used as synchronized pump/probe pulses.

Over the course of the next year, the synchronized Artemis beamlines will be focused into either a visiting end-station or one of our new end-stations:

- i. A high harmonic generation chamber with kHz gas-jet and XUV flat-field spectrometer (10-40 nm spectral region) will be available, together with a monochromator to select a single XUV harmonic in the spectral range 10eV-100eV.
- ii. Materials science end-station with hemispherical photoelectron analyser and 20K five-axis cryo-manipulator (to be commissioned early 2009, and extended to 10K in due course).
- iii. Gas-phase science end-station with a velocity-map imaging detector (to be commissioned summer 2009).

TA2. In addition to the existing 500 mJ, 40 fs pulse, this area is being fitted with a pair of new probe beams. The first will deliver 10 fs, 800 nm beam at 500 µJ, whilst the second is a tunable (450-1200nm) TOPAS at 30 fs, 20 µJ. Both beams can be independently delayed up to 60 ns. There are highly flexible target irradiance options up to 10^{19} Wcm⁻², at contrast levels up to 10^{10} :1.

Lasers for Science Facility (LSF)

The LSF operates a suite of state-of-the-art table top laser systems, giving users access to highly tunable (VUV to IR) and variable pulse width (ns to fs) laser radiation. The extremely versatile lasers are applied to a wide range of scientific and industrial applications across chemistry, physics, biology, medical and material sciences.

The **Ultrafast Spectroscopy Laboratory** houses a state-of-the-art high power kHz fs/ps regenerative amplifier system combined with OPAs to generate pulses for a range of unique pump and probe spectroscopy techniques. These are used in the investigations of fast photodynamic processes in solids, solutions and gases. Its time resolved resonance Raman (TR³) capability enables highly fluorescent samples to be studied using a 4 ps optical Kerr shutter in combination with a fully tunable kHz femtosecond synchronised pump-probe capability. The same laser source also drives the high brightness **PIRATE** facility (Picosecond InfraRed Absorption and Transient Excitation) giving two independently tunable beams across the mid infrared region of the spectrum for pump / probe experiments.

Good progress is being made with the **Ultra upgrade project**, which will significantly enhance our Raman and IR spectroscopy. Operating at 10 kHz with spectral coverage from 200-16000 nm and temporal resolution down to 50 fs, this will provide unsurpassed sensitivity, with 60 fold faster data acquisition than the current state of the art. This laser system comes online in 2008.

The **Laser Microscope Laboratory** is actively developing the use of lasers for imaging and spectroscopic characterisation of biological materials at the cellular level. Alongside this, a '**Laser Tweezers**' laboratory is used to study Raman spectra and pico-Newton forces between particles in solution (such as living cells and aerosol droplets) for bioscience and environmental research.

These capabilities will be pulled together within the Research Complex at Harwell, currently under construction with completion anticipated in late 2009. This will provide a combined capability for their exploitation alongside the Diamond Light Source.

Laser Loan Pool

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

Engineering

Mechanical, electrical and computing support are 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. Access to mechanical and electrical CAD tools and workshop facilities enable a rapid response to be provided to users.

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 resources.

Target Preparation

A high quality target fabrication facility is operated within the CLF. This area has been significantly extended in the past year, now 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. A rapid turnaround service responds quickly to the developing demands for targets, essential for maintaining the scientific productivity of the programme.

Access to Facilities

Calls for access are made twice annually, with applications peer reviewed by external Facility Access Panels. For information please visit www.clf.rl.ac.uk/Access/Index.htm or contact me at the above email address.

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 entire CLF suite for significant fractions of the available time.

Dedicated access to CLF facilities is awarded to European researchers under the auspices of the LaserLab-Europe initiative (www.laserlab-europe.net).

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 see our website for more details on all aspects of the CLF (www.clf.rl.ac.uk).