



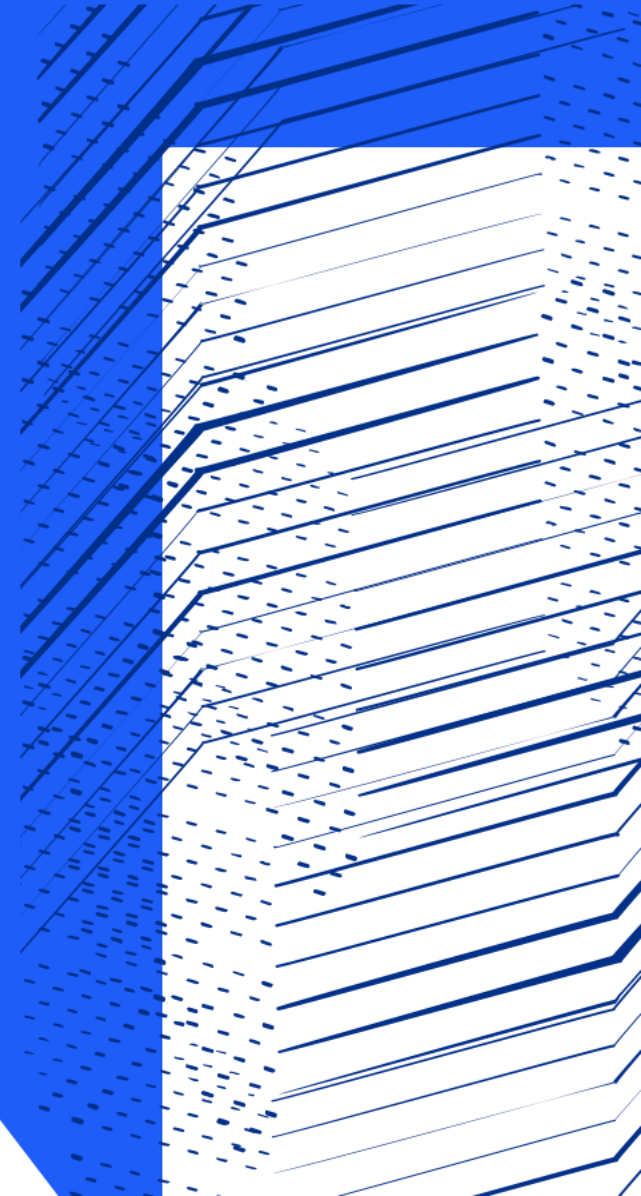
Science and
Technology
Facilities Council

SAQN STFC
AIR QUALITY
NETWORK

Laser Applications relevant to Clean Air Technologies

Central Laser Facility

Clean Air Network
5th July 2023

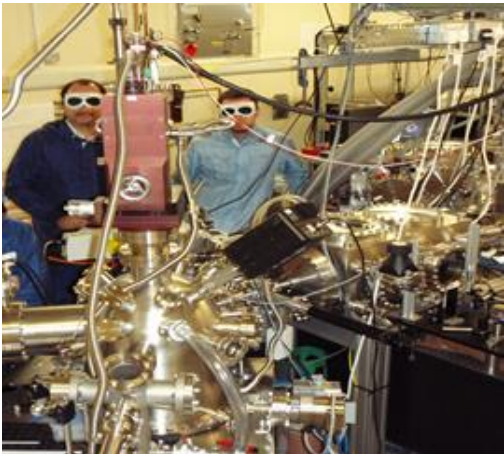


STFC Central Laser Facility

- CLF offers a broad combination of spectroscopy, imaging and high-power laser technologies.

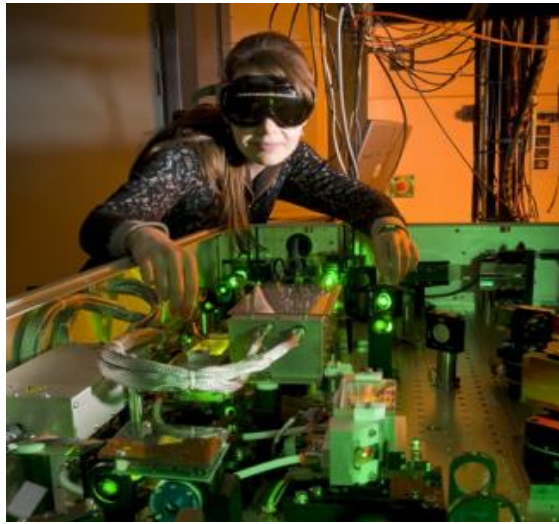
fs and as ultrafast spectroscopy, IR to soft x-ray

ARTEMIS



Ultrafast vibrational spectroscopy

ULTRA



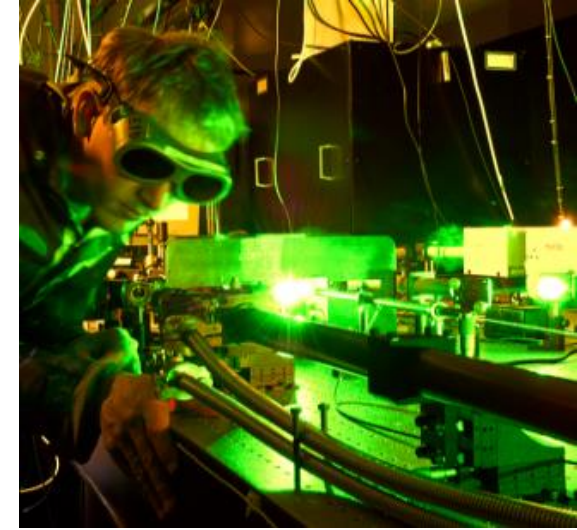
Imaging, laser tweezers and microscopy

OCTOPUS



GEMINI

High power, ultra-short pulse dual beams of 15 J, 30 fs pulses



Ultra high-power laser
Up to 1 PW peak power

VULCAN



Clean air technologies

- Following molecular processes in materials
 - Catalysis, photovoltaics, batteries



Watching charge flow in organic semiconductors

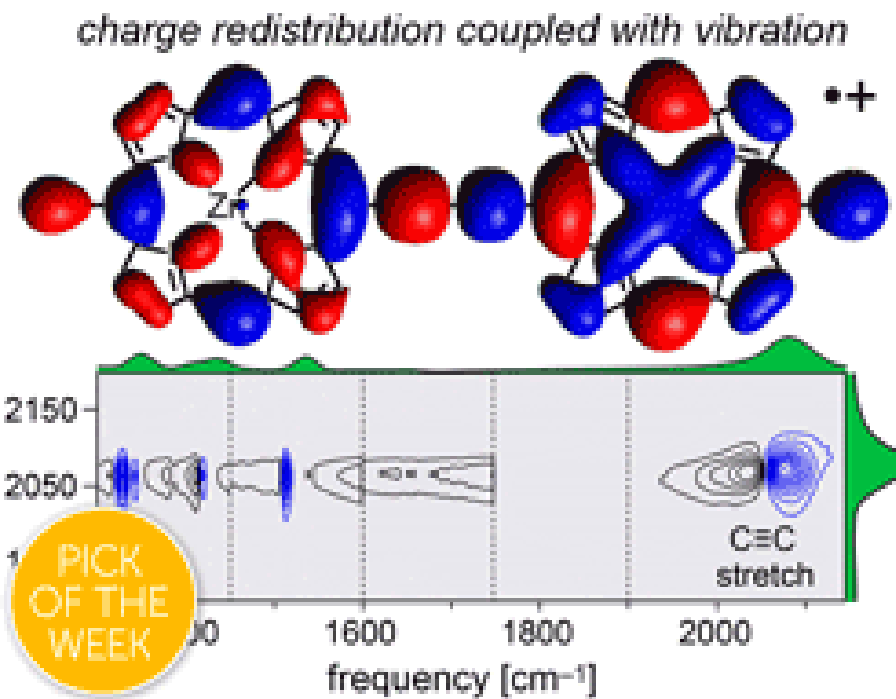
Organic semiconductors & molecular wires have many emerging applications, e.g. display devices in mobile phones and photovoltaic solar cells. Work published using the CLF's ULTRA facility provides fundamental insights into the mechanisms of charge transport.

Image Credit: Mechanisms of IR amplification in radical cation polarons

W. J. Kendrick, M. Jirásek, M. D. Peeks, G. M. Greetham, I. V. Sazanovich, P. M. Donaldson, M. Towrie, A.

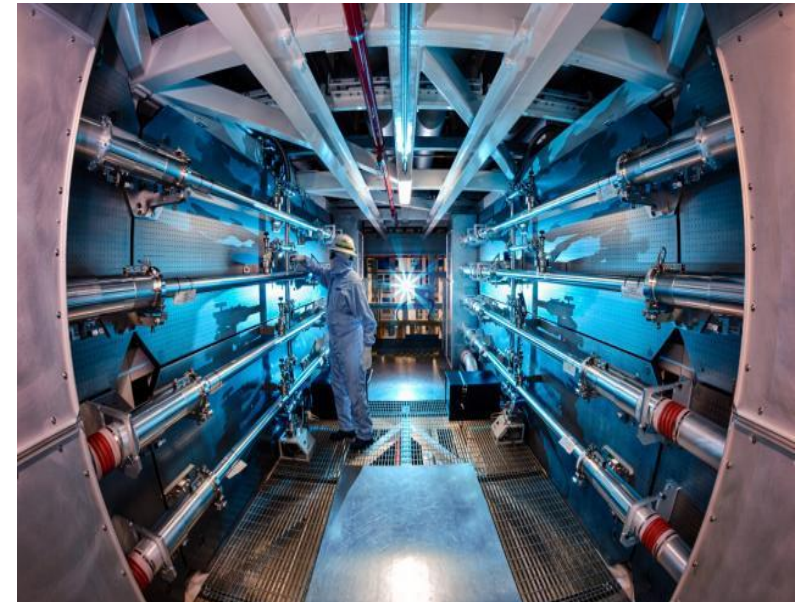
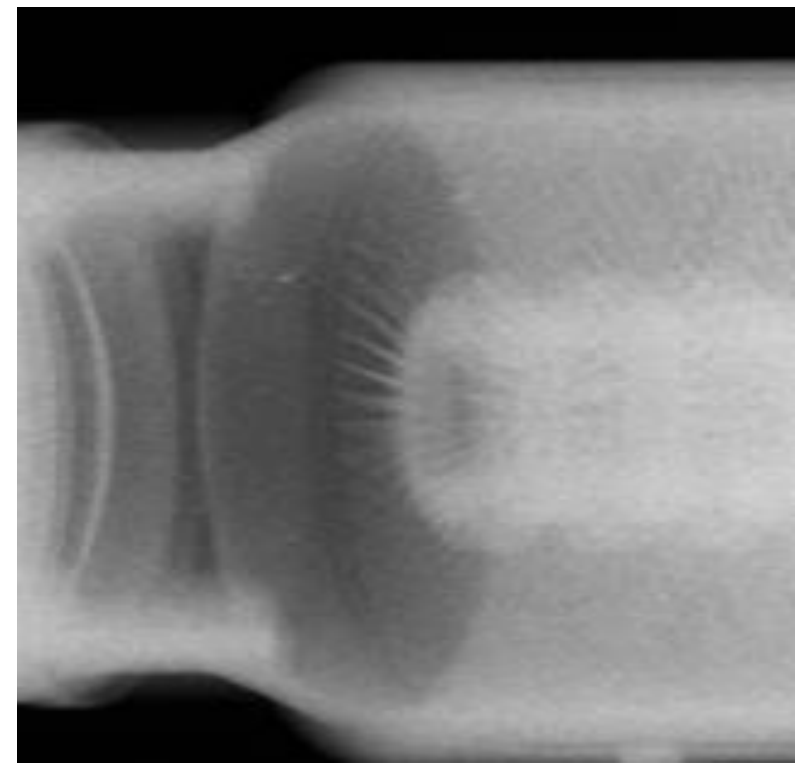
W. Parker and H. L. Anderson, *Chem. Sci.*, 2020, 11, 2112

DOI: 10.1039/C9SC05717J



Clean air technologies

- Improving engine efficiency
 - Fast X-ray imaging with pulsed lasers
- Inertial Confinement Fusion applications.
 - Potential carbon-free energy source
 - CLF staff research laser plasma instabilities in direct drive fusion – important in the ignition process



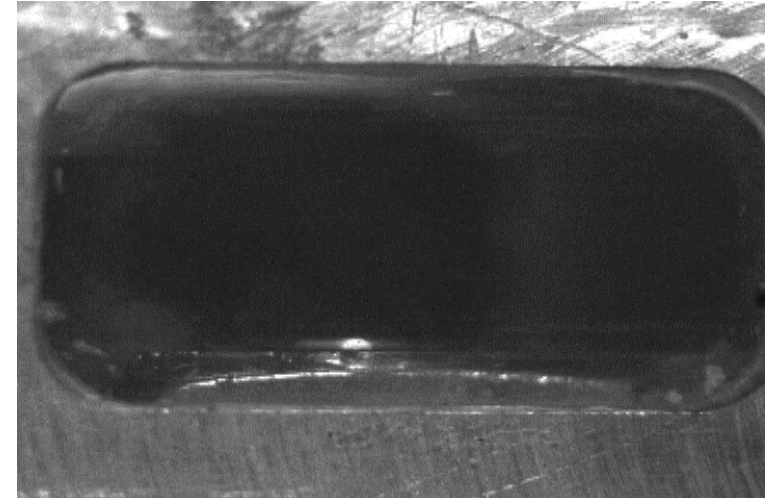
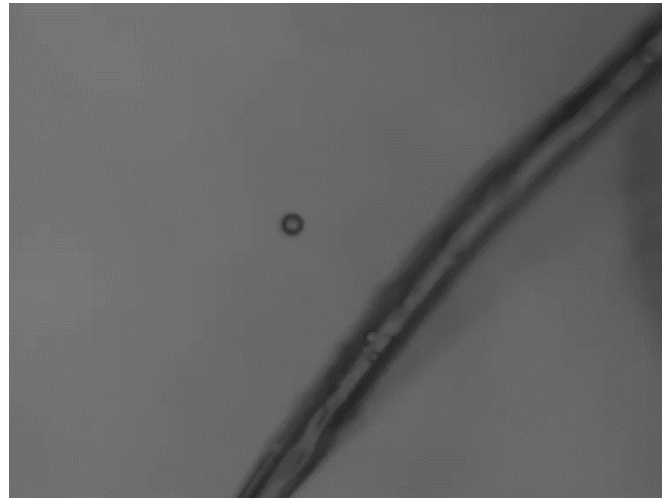
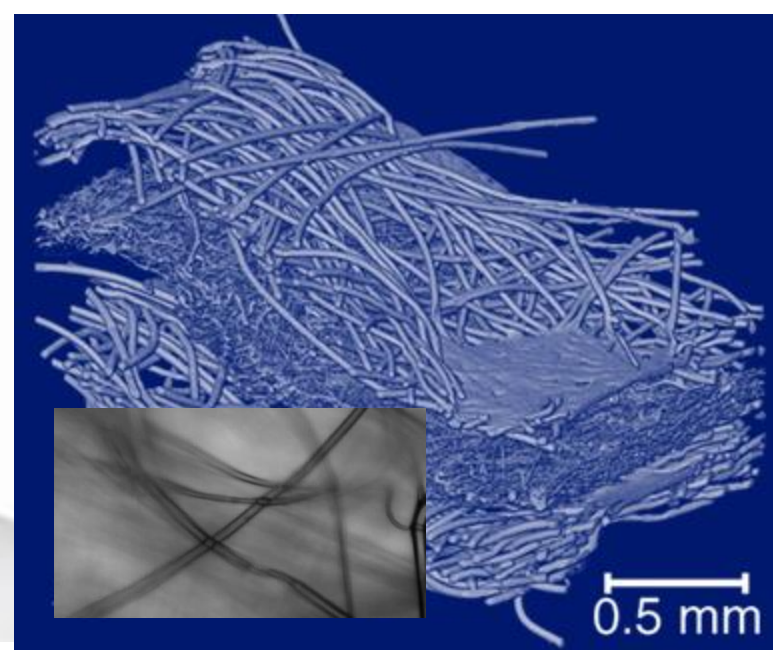
Aerosol studies

National Core Study: PROTECT



Central Laser Facility, Diamond Light Source and University of Manchester

Micro-droplets interacting with surgical facemasks. Levitating a respiration size droplet using laser trapping (lower left) to sense electrostatic attractions to the fibres.



Aerosol studies

- Collect and redisperse organic aerosols
 - Urban, marine, forest and pristine environments
- Reaction chemistry
 - Pollutants
 - Oxidation behaviour
 - Phase, core-shell



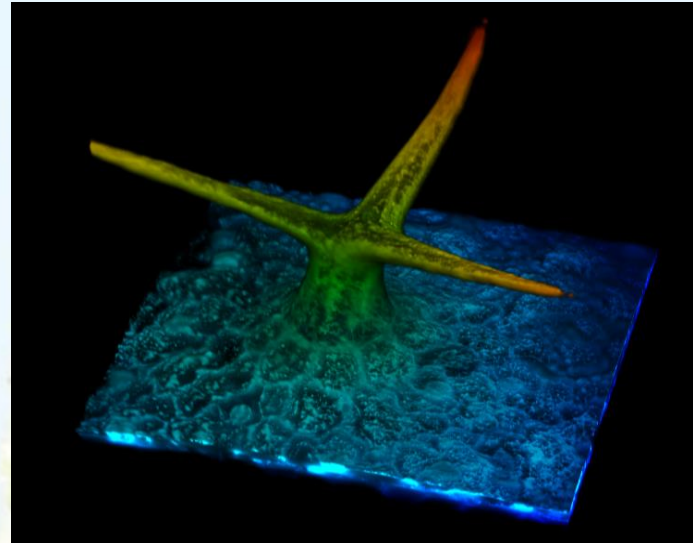
Alice Holt Forest,
Forest Research



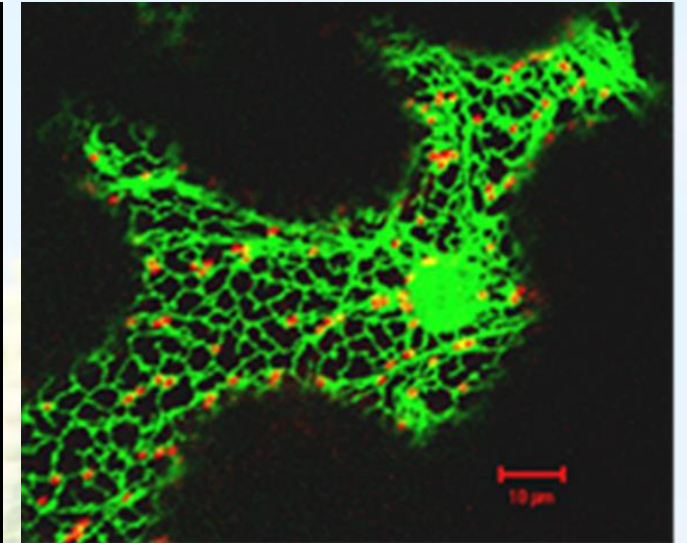
Microscopic Imaging of Plants

- Plant studies
 - Structure and function
 - Disease resistance
- Agrochemicals
 - How catalysts work for crop protection

syngenta



Plant Trichome: natural defence mechanism against insects...



Plant Cell: Endoplasmic Reticulum and Golgi Body transport network

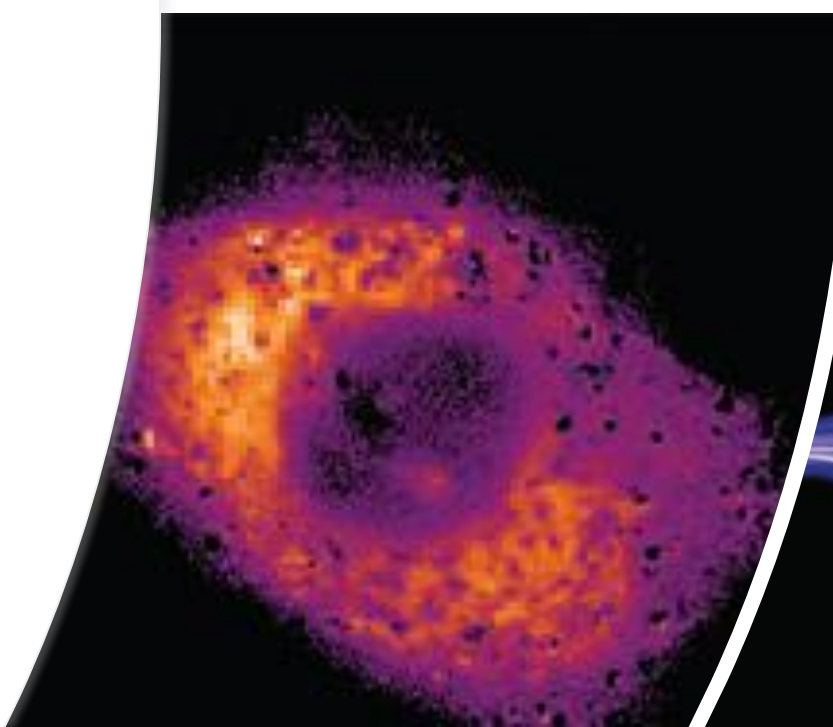
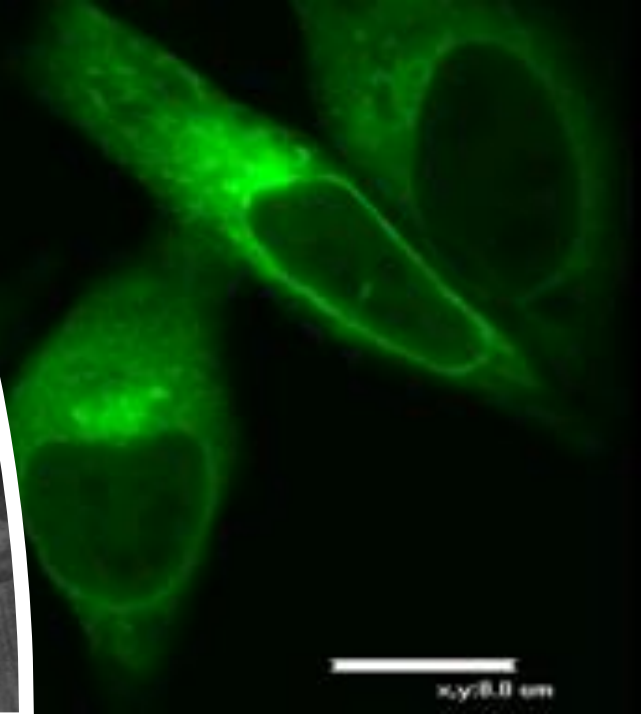
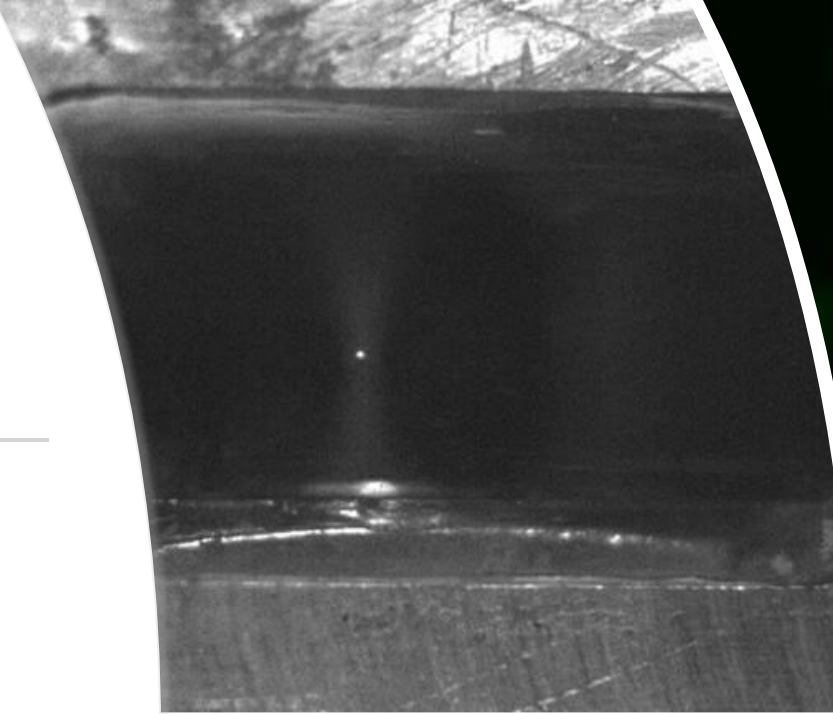


A study on the pathogen responsible for Potato Late Blight has imaged the attachment between chloroplast and the pathogen interface

Savage et al. The Plant Journal (2021) doi 10.1111/tpj.15416

Multi-modal imaging

- Combination of techniques
 - Cellular imaging with super-resolution microscopes
 - Delivery of airborne pollution
- Toxicology
 - in vitro



Biological solutions

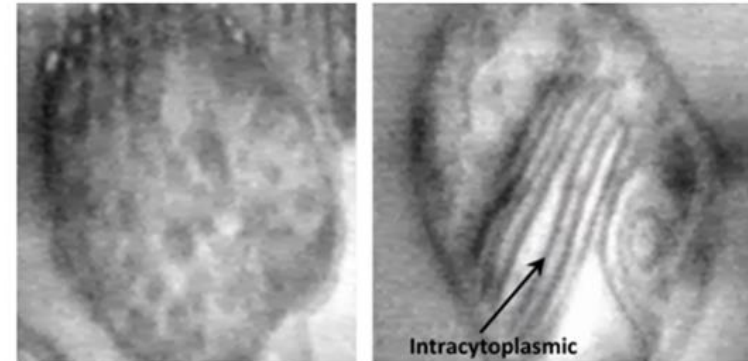
eBIC and Octopus Research on an Intriguing Bacteria Published in Nature Communications

19 Oct 2022 - Helen Towrie

The CLF's Octopus team recently worked in collaboration with eBIC to understand the inner workings of a type of bacteria called Methanotrophs.

These are extremely efficient at converting methane to methanol using special enzymes housed in internal membranes.

Research like this is important because, often, to be able to utilise potentially useful bacteria such as those which may help reduce unwanted gases in our atmosphere, it is important to create a full understanding of their fundamental characteristics - How do they look, work, and thrive?



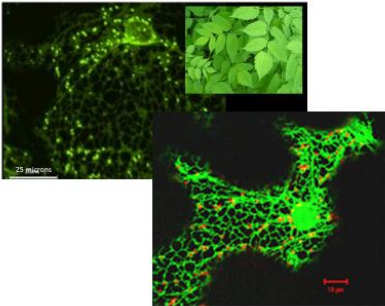
Nature Communications (Nat Commun) ISSN 2041-1723 (online)

Environmental Studies and Clean Energy

- ▶ Bacteria
- ▶ Atmospheric aerosol and cloud chemistry
- ▶ Plant cell function
- ▶ Clean Energy
- ▶ Catalysis

Science & Technology Facilities Council

Plant Cell imaging with TIRF-Tweezers



Combined with high resolution Total Internal Reflection Fluorescence (TIRF) microscopy to simultaneously image and measure forces on Golgi bodies inside living plant cells. Helping to understand the inner-workings of plants to help them grow faster and become disease resistant.

Science & Technology Facilities Council

Investigating 'ignition-scale' laser plasma instabilities, "an important result for laser fusion research"

06 Sep 2021 - Mathew Sims

An international team, led by the CLF's Robbie Scott, has developed a new experimental platform for investigating 'ignition-scale' laser plasma instabilities in direct-drive, inertial confinement fusion.

Their results, recently published in *Physical Review Letters*, indicate that in the 'shock ignition' approach to direct drive laser fusion, laser plasma instabilities should not degrade the implosion. Robbie said: "This is an important result for laser fusion research as shock ignition is one of the most promising approaches to generating energy from laser fusion".

Laser Fusion

Laser fusion works by taking a small (about 2 mm) hollow sphere of frozen hydrogen (deuterium and tritium isotopes) and illuminating the outside of it with extremely high-power lasers, exactly in unison. The energy from the laser light is enough to compress the sphere, or 'implosion shell', inwards, creating an implosion which kick-starts fusion reactions.




Science & Technology Facilities Council

Ultra Utilised to Improve our Understanding of Catalysts

24 Aug 2022 - Helen Towrie

This achievement was recently highlighted in a Chemistry World news piece which details the techniques the scientists used to collect their results.



Science & Technology Facilities Council

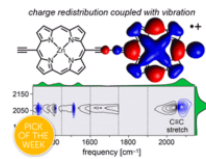
CLF News Bite: Watching charge flow in organic semiconductors

06 Aug 2020 - Helen Towrie

Organic semiconductors & molecular wires have many emerging applications, e.g. display devices in mobile phones, in photovoltaic solar cells, and potentially in restorative medicine. Work just published using the CLF's ULTRA facility provides fundamental insights into the mechanisms of charge transport, useful in guiding the design of better materials and therefore improved devices!

Read the paper [here](#).

Image Credit: Mechanisms of IR amplification in radical cation polarons
W. J. Kendrick, M. Jirásek, M. D. Peeks, G. M. Greetham, I. V. Sazanovich, P. M. Donaldson, M. Towrie, A. W. Parker and H. L. Anderson, *Chem. Sci.*, 2020, 11,



Science & Technology Facilities Council

CLF/ISIS collaborations in Environmental Science

CLF Scientists collaborate in environmental study: 'Real' atmospheric samples covering pollution particles analysed using neutrons for the first time

15 Jun 2022

A new approach of studying the behaviour of surface films covering particles taken directly from the atmosphere has been developed by scientists.

