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SAQN STFC AIR QUALITY NETWORK

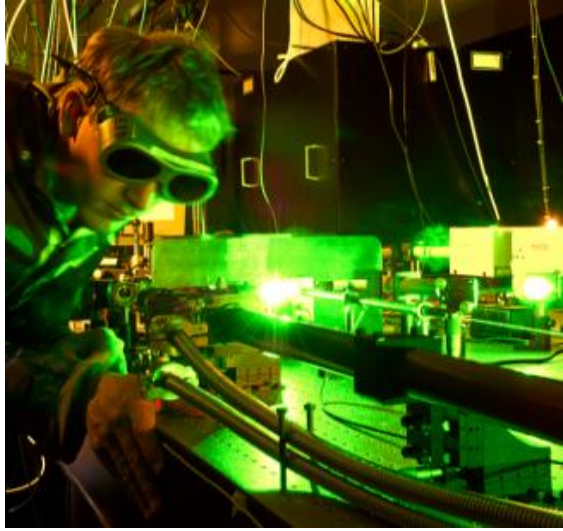
Laser Applications relevant to Clean Air Technologies

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.

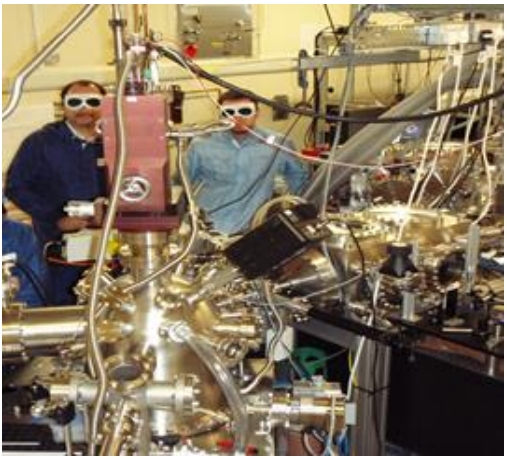


GEMINI

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

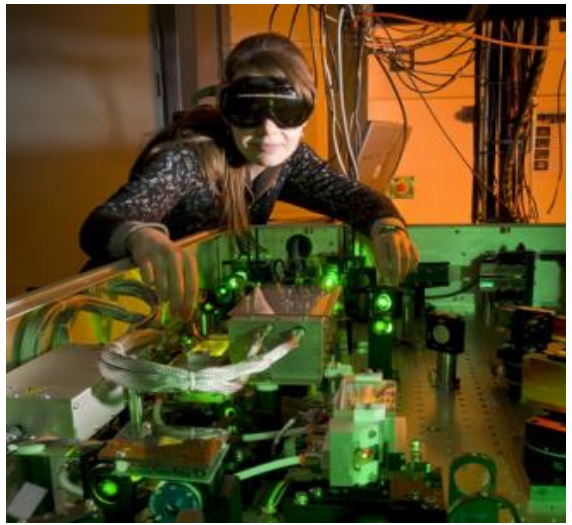
fs and as ultrafast spectroscopy, IR to soft x-ray

ARTEMIS



Ultrafast vibrational spectroscopy

ULTRA



Imaging, laser tweezers and microscopy

OCTOPUS

Ultra high-power laser

Up to 1 PW peak power

VULCAN

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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 ad photovoltaic solar cells. Work published using the CLF's ULTRA facility provides fundamental insights into the mechanisms of charge transport.

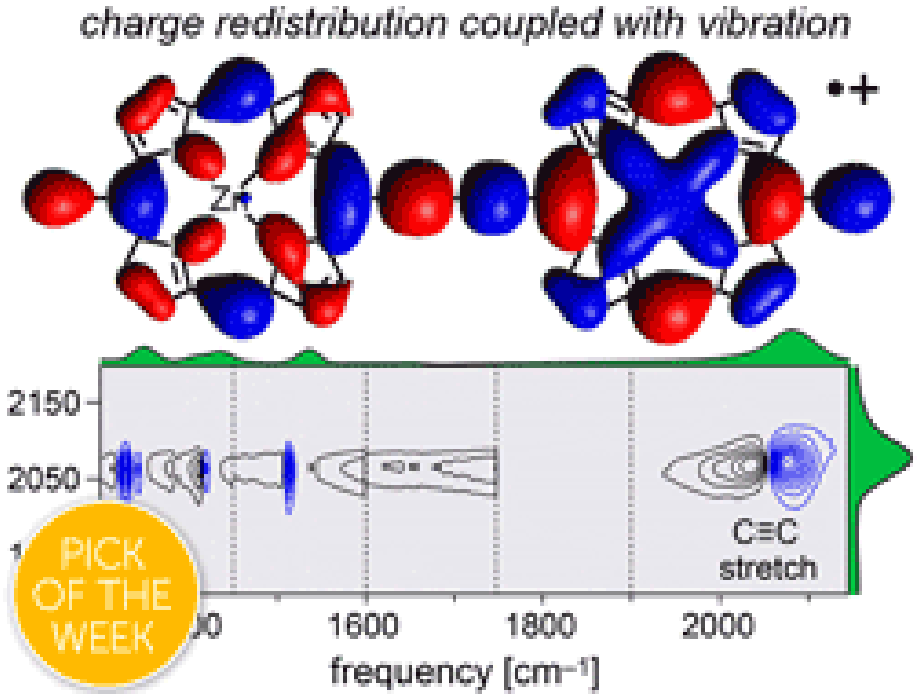

Image Credit: Mechanisms of IR amplification in radical cation polarons
W. J. Kendrick, M. Jirásek, M. D. Peeks, G. M. Greetham, I. V. Sazanovich, P. M. Donaldson, M. Towrie, A. W. Parker and H. L. Anderson, Chem. Sci., 2020, 11, 2112
DOI: 10.1039/C9SC05717J

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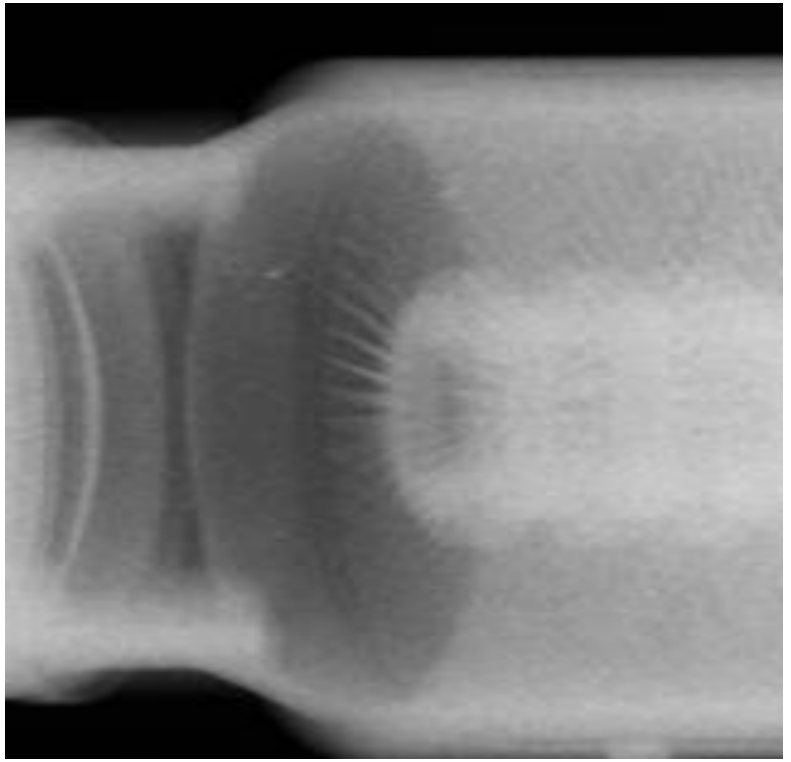
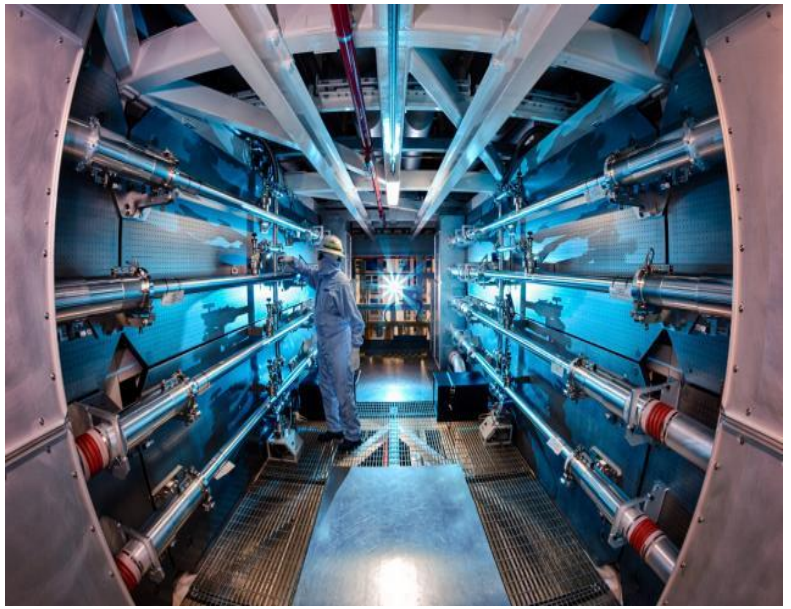
Clean air technologies

- 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





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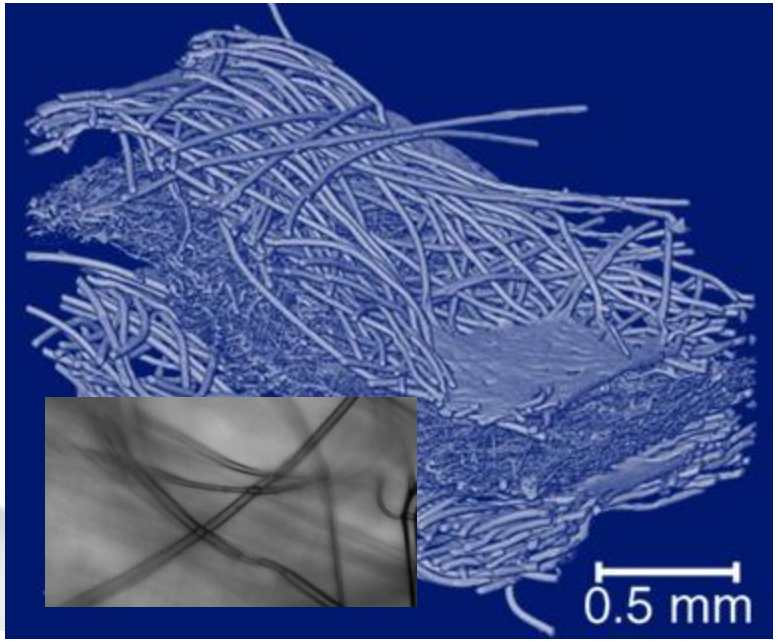
The National Ignition Facility (NIF) in California, USA

Aerosol studies

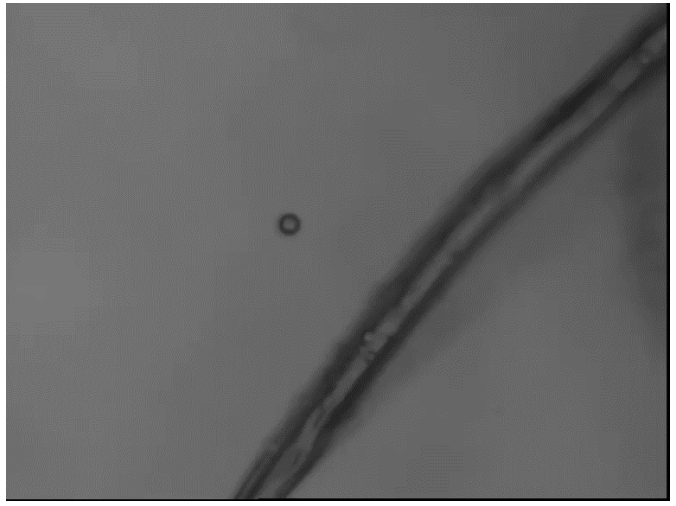
National Core Study: PROTECT

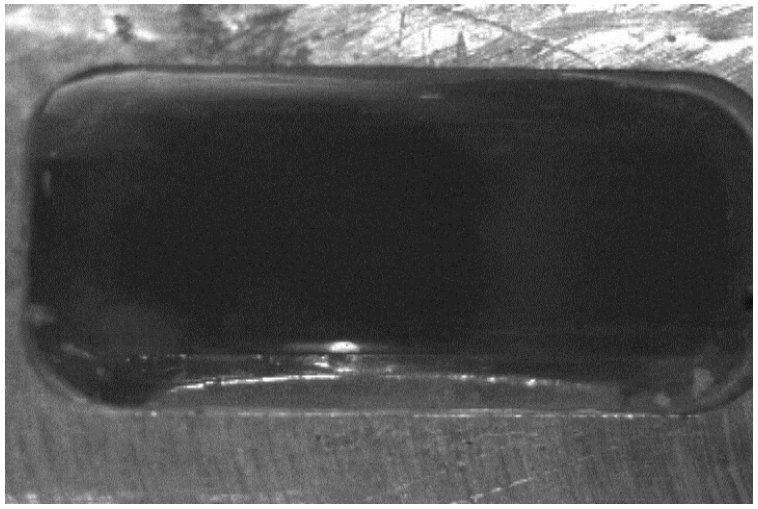
PROTECT
A COVID-19 National Core Study



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.





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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

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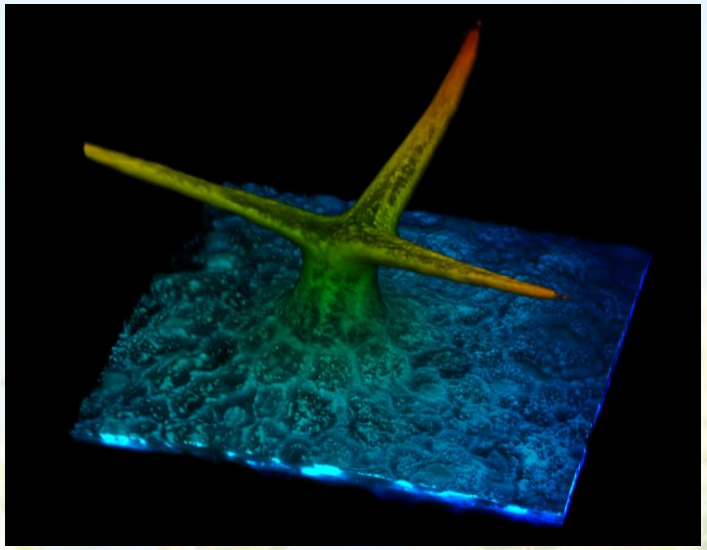
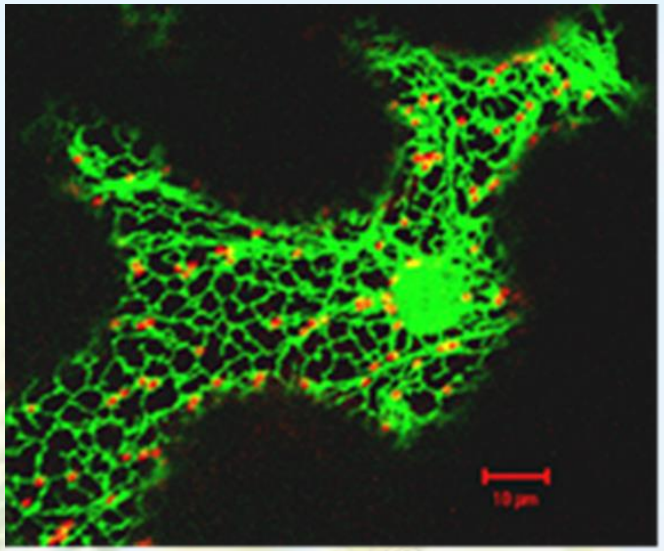
Microscopic Imaging of Plants

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



Plant Trichome: natural defence mechanism against insects…



Plant Cell: Endoplasmic Reticulum and Golgi Body transport network

syngenta

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

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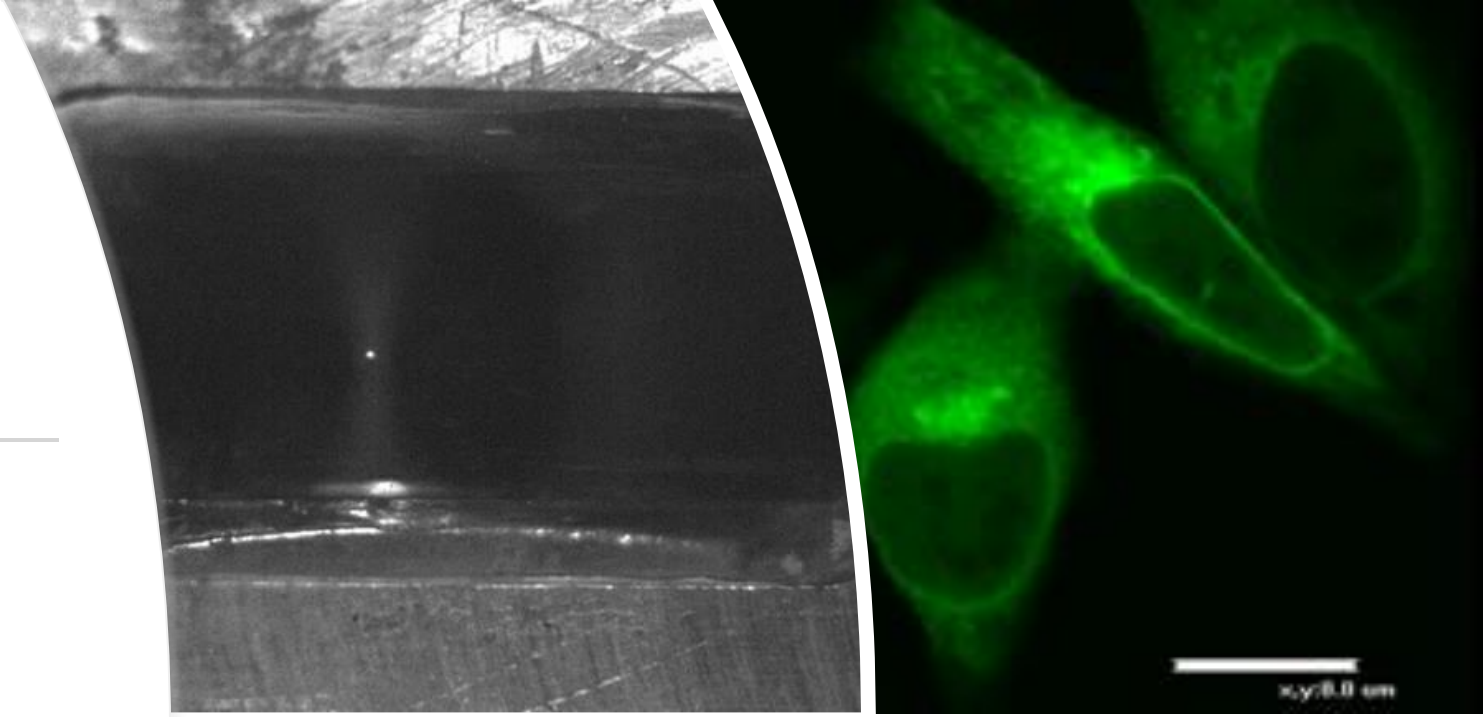
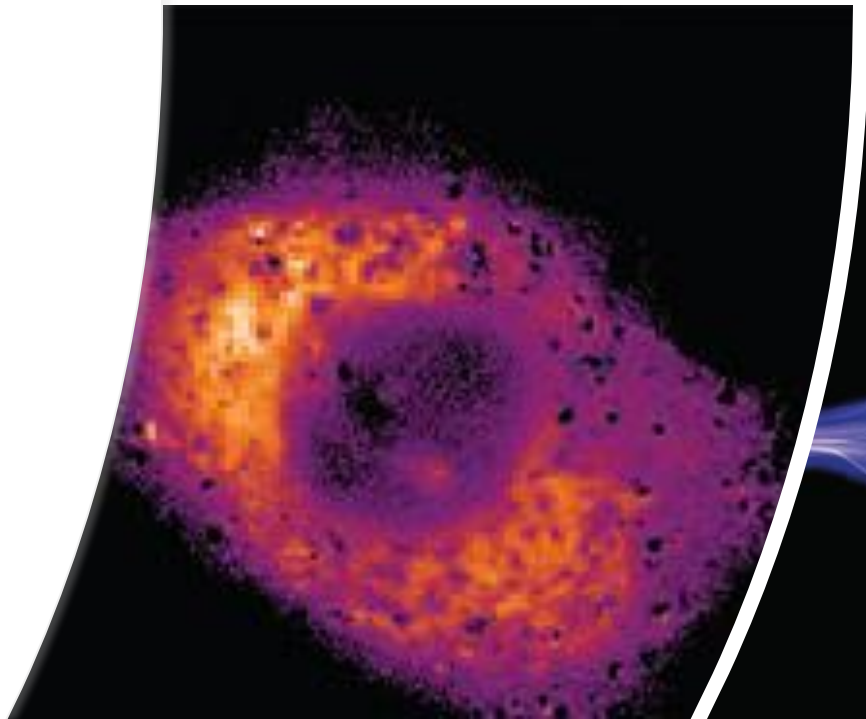
Multi-modal imaging

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





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Biological solutions

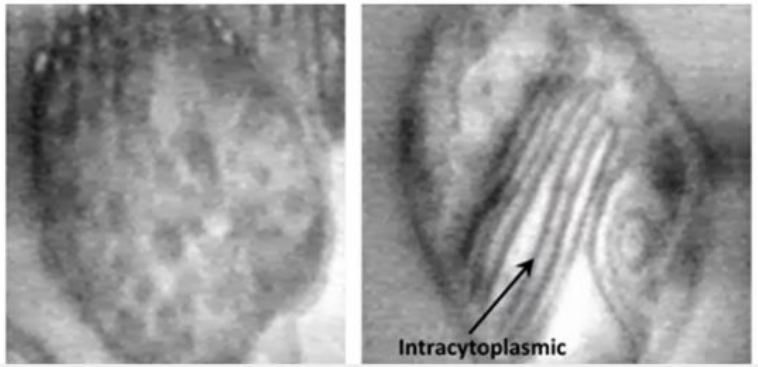
eBIC and Octopus Research on an Intriguing Bacteria Published in Nature Communications

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)

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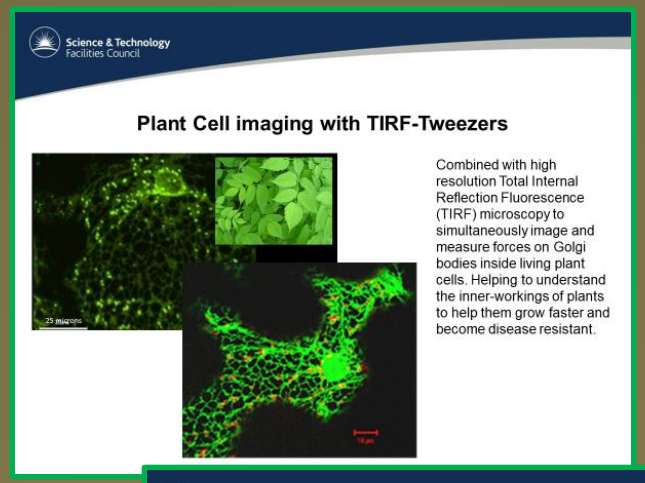
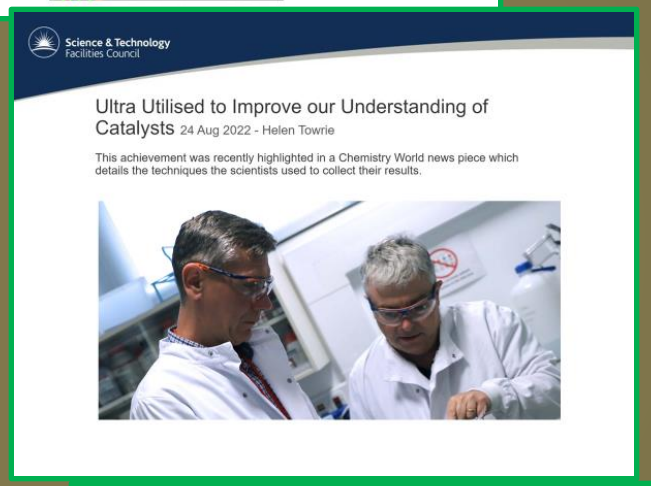
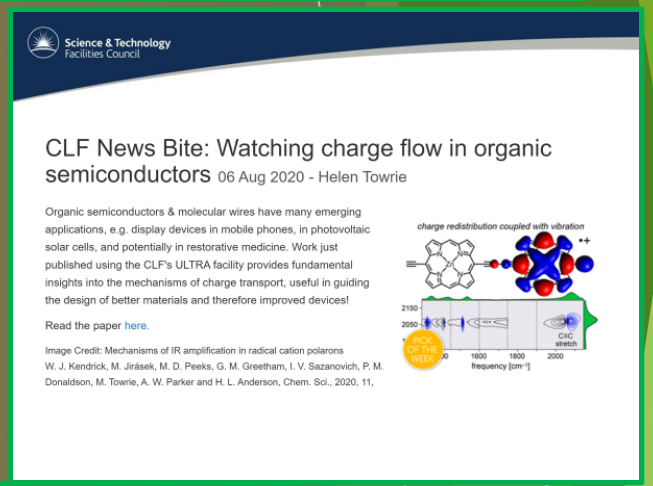
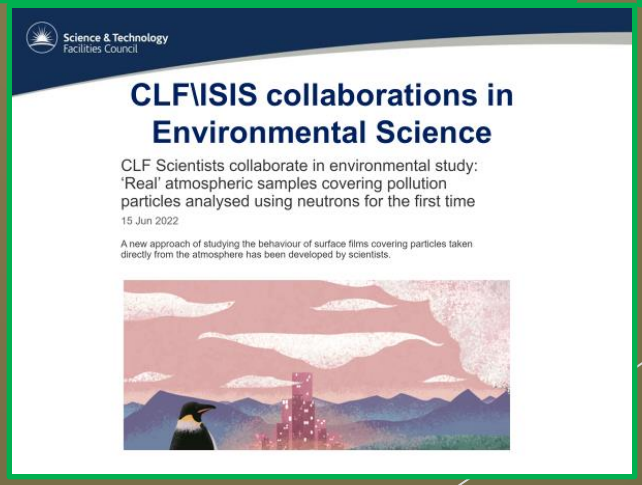
Environmental Studies and Clean Energy

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









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