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DALTON CUMBRIAN FACILITY
NEWSLETTER

October 2023

WELCOME

Dear friends, colleagues, and collaborators,

We recently celebrated DCF's 10th birthday, our official opening being on 6 September 2013.

DCF staff and students on the 10-year anniversary

Thank you to all of our researchers, staff, students and industry colleagues for helping us achieve so much in this time. DCF continues to grow and evolve - we are still witnessing super-linear growth in our number of users/stakeholders. This is largely driven by our great team (many of whom are pictured above on our 10th birthday) and their tireless enthusiasm for new developments which underpin cutting-edge research.

It is a good time to reflect on the journey. When DCF opened it had two radiation sources, the 5 MeV tandem ion accelerator and the ^{60}Co gamma irradiator. We have since doubled the number of radiation sources, adding a 2.5 MeV single-ended ion accelerator and an X-ray cabinet source. A hot cell for safe handling of activated samples, a relativistic ion beam analysis end station and a high specification flow loop to allow irradiation of water at high temperature and pressure have all been added to DCF's equipment fleet along the way.

Other pieces of equipment added to our fleet include:

- Setaram LabsysTM Evo for Thermogravimetric (TGA)/Calorimetric (DSC) analysis coupled with a Hidden EGA Mass Spectrometer.
- Niyro Ned Robotic Arm for flexible sample manipulation
- New model DC24000 CPS Disc Centrifuge for sizing nanoparticles
- Bruker EMX Nano EPR spectrometer

Fast-forward to this year – recent changes in the Accelerator Hall (covered in the last newsletter) include installation of two new end stations. One is a versatile dual-beam end station which will take our existing radiation damage sample stages, while the second is a new end station incorporating SIMS and EELS analysis tools. There has also been an upgrade to the shielding of the ion accelerator hall, which has enabled us to safely accelerate higher current ion beans at higher energies in the tandem 5MV accelerator.

As just one example of our ten-year evolutionary journey, it is interesting to look at one of our support laboratories. Laboratory G.009 has changed significantly over the ten years. It started off as a laser lab until it was converted into a surface science lab and finally a Bio Lab as it is currently as bio-related experiments are increasingly part of what DCF supports.

G.009 as a Laser Lab

G.009 currently as a Bio Lab

New people have joined us too – we were pleased to welcome Hayley and Christina to Team-DCF while Mel moved from being a fixed-term contract PDRA to a permanent member of the accelerator team. You can learn a little more about each of them on pages six and seven below. We also had four undergraduate scientists join us over the summer – George, Kacper, Charlie and Nathan; they have biopics on page five whilst a description of their project work is on page four. As you'll see capability development was a big part of their activity when with us – the take home message is that certain radiation chemistry measurements using the accelerator can now be done about 500 times faster than was previously possible! Thanks to everyone who has contributed to this amazing ten-year journey and let's hope the next ten years are just as fruitful for us all.

Fred Currell
Director of DCF

Hayley Austin
Editor

SUMMER PLACEMENTS

Dalton Cumbrian Facility Paid Summer Research Placements

Over the course of this summer DCF has hosted four undergraduate students who have taken part in projects focusing on the implementation of automation techniques and novel sample handling methods. The project work has focused on novel sample handling systems which have been brainstormed, designed and developed over the course of July, August and September. Alongside this, some work has also been begun in writing software to implement a webpage booking form to provide some automation in the booking process for irradiator facilities, with the aim to reduce the administrative workload for staff and streamline the process to allow external users to more easily book some facilities.

Two key sample handling setups have been developed – one for larger sample volumes on the order of millilitres with the capability for biological sample handling and one for much smaller samples on the order of ten of microlitres. Together these systems will allow for a wide range of possible sample volumes and irradiation techniques, adding to the in-house capabilities of DCF, particularly in the area of radiation chemistry studies. The main focus has been work on a new 'BioBox' setup – a system for allowing the safe irradiation of biological samples which, due to the intention to use the BioBox system to irradiate bacteriophages and viruses, will in the future require levels of containment that meet stringent biosafety requirements. This has been begun through the design and production of an initial version of an automated turntable setup that allows high throughput irradiation of samples on the 5MV tandem pelletron ion beam accelerator.

Compared to previous possible methods of irradiation which would only permit single samples to be irradiated, interspersed with lengthy changeover periods in between, the new BioBox system currently allows up to 16 liquid samples (held in vials, stirred with magnetic stirrer beads) to be irradiated in rapid sequence all with remote control of the setup. The work undertaken will feed into future projects including radiation chemistry dosimetry as well as the study of degradation of biological molecules (in particular RNA). Currently the turntable system is appropriate for large sample volumes (from 1mL up to 1.8mL with the current design). All the summer students have been involved in various aspects of the BioBox project and further work will continue, with later iterations of the design planned to be more compact and incorporate multiple layers of biologically secure confinement that will help continue the progress towards the final BioBox goals.

Recent work has focused on a new system for the irradiation of much smaller samples. This new system will allow the precise control of micro-litre samples and the principle ideas are currently being tested with preliminary irradiations. The present focus is liquid samples, which will also form part of the work to characterise the system. As we go to print the work on this newer microlitre system continues in earnest, with aims to potentially introduce transportation methods based on automated pumping of liquid samples, that would allow automated sample irradiation as well as handling.

The rapid progress of the projects is a testament to the excellent work and team effort of everyone involved, which includes not only the summer students and their direct supervisors, but the full team at DCF. For all the students involved the summer placements have been a brilliant experience.

George Tucker

I am an undergraduate physics student from Durham University and I undertook a six-week placement at DCF working on projects relating to the BioBox system as well as the micro-litre sample system. I have thoroughly enjoyed my time at DCF and the varied and hands-on nature of the work and hope that all our project work will inform future scientific work at DCF. After DCF I will return to Durham for my fourth year to finish my integrated masters with a project investigating metal-organic frameworks as novel battery electrode materials.

Kacper Burczyk

I am a physics student at Lancaster University specialising in condensed matter physics. Most of my work at DCF involves the 'BioBox' project in which I helped design a turntable and magnetic mixing system that allows biological samples to be irradiated efficiently, and I have also done some work with peristaltic pumps to optimise UV-Vis spectrometry. These projects have allowed me to learn a lot and develop my circuit design and 3D printing skills by using Arduino code and Fusion 360. After my internship at DCF I will be returning to Lancaster University to complete my integrated masters, and I will be working on developing thermophotovoltaic cells for my masters project.

Charlie Perkins

I'm Charlie, a theoretical physics student at UoM, hoping to study really small, tiny things. I'm from North Wales, but I spent the summer here at DCF in Cumbria contributing to the BioBox project from a software/firmware perspective. I'm astounded at the range of research going on here, and the amount of hands-on work I was able to be involved with.

Nathan Parry

Hi there! I'm Nathan, a Computer Science Student at the University of Manchester. I was extremely happy to be given the opportunity to help develop software for DCF and my team. It was an amazing experience.

OUR PEOPLE

Dalton Cumbrian Facility welcomes some new starters into its family

Mel O'Leary, Technical Specialist

Tell us about your career journey so far.
Currently a Technical Specialist (Accelerator Science). I was a Postdoctoral Research Associate at the Dalton Cumbrian Facility, investigating water radiolysis near oxide surfaces. I got a PhD from Queen's University, Belfast 2019.

What brought you to DCF?
Continuing my research from my PhD.

What are your research interests?
Water radiolysis near oxide surfaces.

What do you enjoy doing when you aren't at work?
Reading

Christina Pateras, Reception & Administrative Assistant

Tell us about your career journey so far?
I have a background of 18 years in the NHS as a Clinical Dietitian. Post maternity leave (during COVID) I found I was not enjoying my job as much as I used to and felt it was time to move onto administrative duties as I enjoyed those immensely.
I got a job in a holiday let company in Keswick, the work was great, different everyday but the Saturday rota wasn't helping my work-life balance.

What brought you to DCF?
I came across the advert for DCF and my partner encouraged me to apply as he works in the nuclear industry and felt I would fit in well.

What do you enjoy doing when you aren't at work?
When I'm not at work I'm usually out in a park or the garden with my 3-year-old, going off for camping trips to the lakes or if the weathers bad we all curl up with a good movie or a book.
I love making homemade gins and limoncello and cooking my Mums Greek recipes as a taste of home.

Hayley Austin, Executive Assistant

Tell us about your career journey so far?
I started out as a Graduate Trainee at Aberystwyth University after completing my degree there and have stayed in the Higher Education sector ever since. I worked at Nottingham Trent University for the past seven years.

What brought you to DCF?
We have always wanted to live close to the Lake District and my husband is lucky enough to be able to work anywhere so we decided to take a leap and relocate. When I saw the EA job at DCF advertised I had to apply as it seemed like a perfect fit for me and in a perfect location.

What do you enjoy doing when you aren't at work?
I like walking, running and generally trying to be active, I'll be making the most of having the Lake District on my doorstep! I have two cats and two tortoises so enjoy cuddles with them (not so much the tortoises).

AN UPDATE FROM WILL LEISING, PHD STUDENT

Will recently gave a presentation at the miller conference in June held in Corsica on the use of radiation for the synthesis of graft polymers and 3D printing and a presentation at the chemistry PGR conference in July held in Manchester where he won best materials talk. Will alongside Alex and Ruth is also part of an international collaboration between Dr Giovanna Buonocore (CNR Italy) and her group where one week was spent in Naples producing films alongside other experiments in relation to the sterilisation of foods using radiation. Will is looking forward to welcoming Dr Giovanna Buonocore and her group later this year when they visit DCF. Will has also been working closely with Charlie, George, Nathan and Kacper on the automation of DCF with the development of the remotely operated automated turntable with customisable magnetic stirring and the development of zero interface chemistry within DCF.

Will delivering a talk at The Miller Conference

PROJECT SPOTLIGHT

Developing a DIC (Digital Image Correlation) capability for measuring thermal and irradiation creep at multiple length scales on an ion beamline

Samir de Moraes Shubeita

D. Lunt[1,2a], B. Poole[1], C. Hardie[1], T. Hughes[2], J. Quinta da Fonseca[1], P. Frankel[2], E. Pickering[2,3], S. de Moraes Shubeita[4], M. Gorley[1], C. Hamelin[1], A. Harte[1]

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THE CHALLENGE

Understand the impact that harsh fusion environments will have on the structural integrity of candidate materials for such applications is of great importance. Research in the field of irradiation damage has, typically, focussed on materials performance under a single or dual aspect of these complex conditions: e.g., thermal-irradiation, thermal-mechanical or thermal-irradiation followed by thermal-mechanical testing. However, these effects are non-linear and examining them in isolation fails to predict the synergistic effect on material performance.

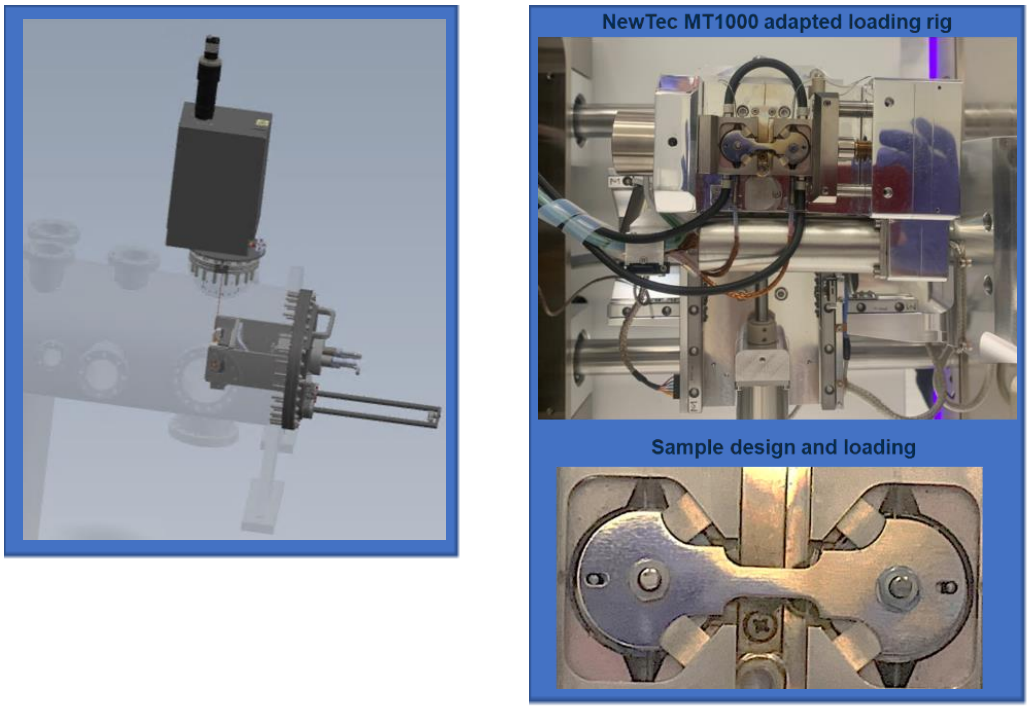
THE SOLUTION

The current development of an in-situ ion irradiation-thermal-mechanical materials testing capability, in conjunction with novel scientific experimental methodologies for quantifying the deformation and damage at multiple length scales, will enhance experimental capabilities for materials irradiation research. The goal of these experiments is to examine irradiation-enhanced creep, a long-term degradation phenomenon of which further understanding is required of for timely qualification of high temperature structural materials for fusion.

Commissioning of this new in-situ ion irradiation-thermal-mechanical materials testing target stage for use at the Dalton Cumbrian Facility will take place along autumn 2023.

THE BENEFITS

The application of these techniques will allow for significant improvements to our knowledge of deformation behaviour of structural materials under conditions relevant to the fusion operating environment.



CAD overview of tensile stage and optical measurement system mounted on one of DCF's end stations (left). Detailed view of the NewTec MT1000 tensile stage and sample design and positioning.

THE MILLER CONFERENCE

The Miller Conference on Radiation Chemistry was held Corsica Island, France in June. The conference gathers scientists at the forefront of research on radiation chemistry to share information on recent progress in the field. Fred Currell and Alex Baidak along with students Will Leising, Jordan Elliot, Arthur Purser, Cyrus Wyett and Georgia Bradshaw attended the conference and delivered talks. Between them they presented seven posters, five talks and achieved the award of best poster prize for 'Modelling the Spatially Anisotropic Kinestics of Water Radiolysis in Spherical Domains' by A. Purser, G Bradshaw, C. Wyett, M. Webb and F. Currell. DCF was by far the best represented lab at the meeting, further evidence of our world-leading position in this field.

Top: Jordan delivering his talk at The Miller Conference,
Bottom left: Georgia being presented a birthday cake
Bottom right: several of the DCF delegates relaxing outside the venue

PULSE RADIOLYSIS

Developing the UK's ultra-fast pulsed measurement capability in radiolysis

In May 2023, an academic team from DCF organised and hosted a UK XFEL (https://xfel.ac.uk/) workshop in Manchester, which was attended by about 25 people, including invited speakers (physicists, chemists, biologists, and clinicians) from the UK XFEL, STFC, Central Laser Facility, Manchester, Imperial, Belfast, Strathclyde, Birmingham, as well as Brookhaven and Argonne National Labs in USA. The workshop was a success; it served as a platform for fruitful discussions helping to further explore the science opportunities and conceptual design requirements of this world-leading facility. Representing DCF, Alex Baidak was invited to join the UK XFEL Science Team to lead and develop the radiolysis science case. In parallel to the UK XFEL activities, DCF's academic team prepared a grant application to EPSRC to develop nanosecond ion beam pulse radiolysis at DCF.

INTERNATIONAL COLLABORATION WITH CNR – NAPLES

RANDANOPACK: International Collaboration with the National Research Council of Italy (Naples)

A research team from DCF has been awarded a 24-month Royal Society International Exchanges grant, which enables DCF's collaboration with the Institute of Polymers, Composites and Biomaterials (Naples, Italy) in the area of intelligent food packaging. This activity further expands and internationalises DCF's collaboration network and adds very promising area of materials research to the DCF's portfolio. Researchers from DCF will learn about polymers for intelligent food packaging from the world-leading experts; the collaboration is expected to result in joint papers and future grant proposals. Furthermore, the Italian collaborator will provide project partner support to the DCF's Strategic Equipment bid (VeRITAS) to EPSRC.

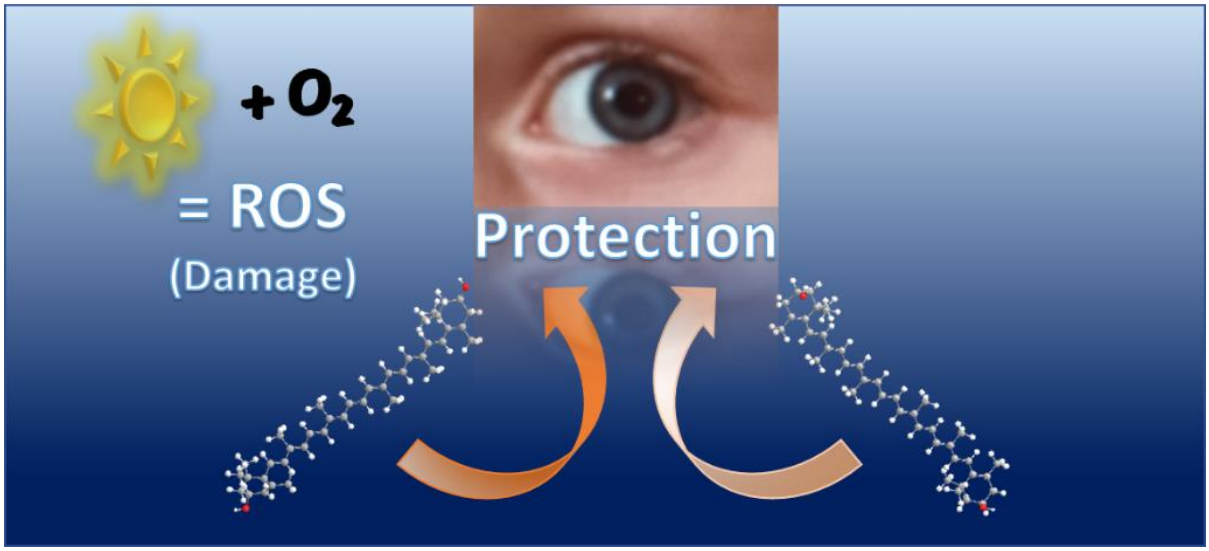
DCF researchers (Alex Baidak, William Leising, Ruth Edge), Bharat Bhusan (The Ohio State University, USA) with the lead Italian collaborator, Giovanna Buonocore, in Naples, Italy, June 2023

RECENT PUBLICATIONS

Gamma Radiation-Induced Degradation of Acetohydroxamic Acid (AHA)

DCF researchers (Dr. Alex Baidak and Dr. Liam Isherwood) contributed to the international study which looked at the radiolytic behaviour of acetohydroxamic acid. Results of this work have been recently published in ChemPhysChem. Working together with our colleagues from Idaho National Laboratory (USA), who led this study, and National Nuclear Laboratory (UK), we were able to uncover the fundamental reaction pathways for the radical-induced degradation of acetohydroxamic acid – an important candidate ligand proposed for the reduction and complexation of plutonium and neptunium ions in nuclear fuel reprocessing. Full article can be accessed here: https://doi.org/10.1002/cphc.202200749. This work is also featured on the ChemPhysChem cover page, which can be found here: https://chemistry-europe.onlinelibrary.wiley.com/doi/full/10.1002/cphc.202300083

Photochemical and photophysical properties of carotenoids and reactive oxygen species: Contradictions relating to skin and vision. F. Boehm, R. Edge, T.G. Truscott, *Oxygen*, **3**, 322-335 (2023). https://doi.org/10.3390/oxygen3030021



This is a review article which considers the molecular mechanisms of dietary carotenoids with reactive oxygen species, ROS, (including singlet oxygen and a range of free radicals), the carotenoid radicals themselves and the role of oxygen. These processes are used to suggest explanations of the poorly understood, and often contradictory, health-related outcomes of carotenoid supplementation. They offer possible explanations for the switch from beneficial to deleterious processes involving dietary carotenoids.

Modelling Inhomogeneous Radiation Chemistry by Linear Expansions (MIRaCLE)

In a more theoretical vein, the Modelling Inhomogeneous Radiation Chemistry by Linear Expansions (MIRaCLE) collaboration between DCF and Manchester's Maths department have just had their first paper published in Nature's Scientific Reports Journal. 'A new approach for simulating inhomogeneous chemical kinetics' [Sci Rep 13, 14010 (2023). https://doi.org/10.1038/s41598-023-39741-y, https://rdcu.be/dkyZN] models the concentrations of radiolytic species as continuous densities and uses spectral methods to rapidly solve the reaction-diffusion equation that governs the evolution of radiolytically created species. Several sets of functions used to describe the concentrations have been developed by the team, allowing users to conveniently describe radiolysis problems involving boundaries – the eventual aim is to have a publicly available software package able to describe all radiolysis systems through a friendly user interface.

To illustrate the capability, the team showed hundreds of separate calculations, each simulating radiolytic H_2-generation in thin layers of water on plutonium oxide under different conditions, performed using a single laptop. Other available codes would take several days of high-performance compute cluster time to simulate even one set of conditions. The team are currently preparing for a first release of the software early next year with a view to it eventually becoming widely available within the radiation chemistry community. The collaboration is interested in topical radiation chemistry problems readers might wish to solve using this software. Those with potential applications of the software are encouraged to contact Frederick.Currell@Manchester.ac.uk.

DCF OPEN DAY

We will be hosting open events 3-4 times a year to allow people the opportunity to take a tour of our facilities and learn more about what we do. The first event will take place on Tuesday 14th November. To book your place at the event, please visit: https://www.eventbrite.com/e/dalton-cumbrian-facility-open-event-tickets-728715647117?aff=oddtdtcreator or contact Hayley Austin Hayley.austin@manchester.ac.uk if you have any questions or would like more information.