The University of Manchester
Dalton Nuclear Institute

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DALTON CUMBRIAN FACILITY NEWSLETTER

February 2023

WELCOME

Dear friends, colleagues, and collaborators,

As any Bob Dylan fan will recognise *"The Times they are a Changing."* – so too at DCF.

Perhaps our biggest change recently was Kevin Warren's retirement. As anyone concerned with DCF will know, as our long-standing Director of Operations he has been a lynch pin of DCF life. Thank you very much, Kevin, we will all miss you.

We have been delighted to welcome Adam, Mariam and Rob into our community – you can learn more about their backgrounds and activities in this edition of our newsletter. Change is also continuing a-pace for DCF's ion beams and the associated facilities we offer our users. New end-stations and new shielding are being put in place and we look forward to soon welcoming users to the upgraded facilities. New developments at RAICo are also described below as they commission a 'swimming pool' for robots to develop wireless communication between nuclear multi robot fleets.

A change about measuring change - Alex Baidak has started developing exciting plans for pulsed ion capability at DCF, something which will have a major impact on our ability to probe the dynamics of radiation chemistry. His article describes an initiative underway to make this possible.

Whilst there has been a hiatus of ion beam irradiations due to the ongoing upgrades, high energy photons have continued to affect their own changes on matter in our labs. Will Leising's radiation grafting for surface functionalise of 3D printed plastics and Jordan Elliot's RNA damage studies are two examples of this kind of research highlighted below. Photon irradiation also featured in our first post-covid open night when the local Girl Guide group came to visit us and enjoyed seeing us image a range of objects, including a 3D printed Pikachu - again we have a short article on this event.

It is interesting to reflect that ***radiation changes matter***, deliberate pun intended!

Fred Currell
Director of DCF

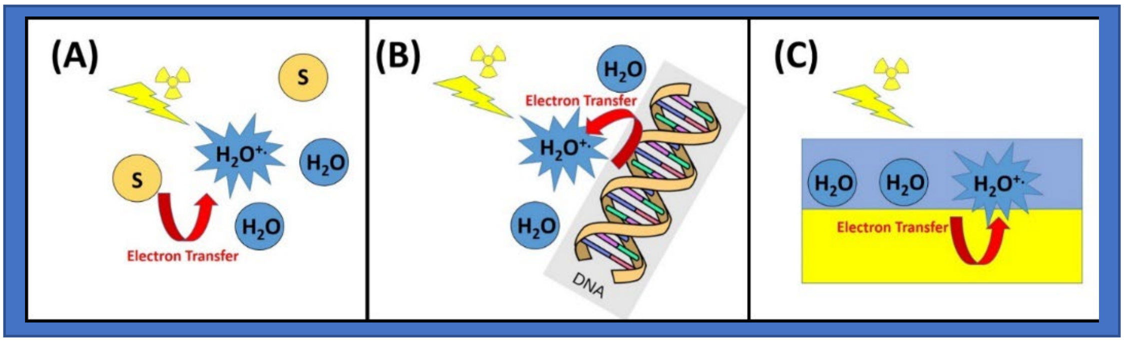
Lian Murdoch
Editor

NEW TECHNIQUE/CAPABILITY

Developing the UK's pulse radiolysis combined with ultrafast measurement capability

Dr. Aliaksandr Baidak

Although water radiolysis has been studied extensively in the past, fundamental ultrafast processes even for this system are not fully understood. The conventional wisdom in radiation chemistry has it that the radical cation, $H_2O^{\cdot+}$, is too short-lived to initiate any chemistry since it disappears within ~50 femtoseconds after its formation through the proton transfer reaction: $H_2O^{\cdot+} + H_2O \rightarrow \cdot OH + H_3O^+$. However, there is a number of relevant scenarios, in which the water radical cation can initiate reactions directly, outcompeting the proton transfer. For example, spent nuclear fuel is processed in highly concentrated (5-7 M) nitric acid aqueous solutions. In this case, the radical cation $H_2O^{\cdot+}$ is likely to react with nitrate ions directly, thus enabling new reaction mechanisms in the nitric acid solutions. Another scenario is of potential importance in cancer radiotherapy. Upon irradiation, part of the radiation energy is absorbed directly by DNA, leading to the bond breakage. However, some of the ionising radiation is also absorbed by the water adjacent to the DNA. In this case, the formed water radical cation $H_2O^{\cdot+}$ may induce a chemistry different from the hydroxyl radical $OH^{\cdot}$, resulting in new reaction pathways. Another important scenario is found in the treatment and storage of spent nuclear fuel. For example, when radioactive material is covered by cladding or waste form material, the interface contact area is extensive, and the oxidation reactions brought about by the radical cation $H_2O^{\cdot+}$ could be playing an important role. Hence, the investigation of the properties and behaviour of this ultra-short lived radical cation as well as its counterpart, the non-hydrated electron, is very important.



Under specific conditions, radiolysed water can form a water radical cation that engages in an electron transfer in competition with the proton transfer reaction: (A) highly concentrated solutions in which the water radical cation can oxidise solute molecules directly; (B) highly structured water layers formed in contact with biomolecules, such as DNA; and (C) water/solid interface.

DCF researchers are leading Manchester's initiative to establish a unique UK experimental capability in nanosecond time-resolved ion pulse radiolysis, which will be integrated into existing UK National Ion Beam Centre.

There would be strong synergy and complementarity with the capabilities of the proposed RUEDI and UK XFEL national facilities. Realisation of such important initiatives is driven by the user demand, so we invite our stakeholders to join the discussion concerning the development of pulse radiolysis capability in the UK; please contact Dr Aliaksandr Baidak if interested.

OUR PEOPLE

Dalton Cumbrian Facility welcomes some new starters into its family

Mariam Littler

I am a final year MChem student at the University of Manchester and will be joining DCF for my master's year. I have returned from my industrial placement year, having worked as a lab research scientist at Reckitt Benckiser in Heidelberg, Germany. My master's project aims to develop polydiacetylene-based materials and explore their applications as radiation and chemical sensors. After a year in industry, I am excited to undertake academic research and expand my knowledge in materials science and radiation chemistry.

Dr. Adam Fisher

Tell us about your career journey so far?
Since finishing my PhD at The University of Sheffield in 2020 studying UK HLW glass corrosion, I undertook a post-doctoral position investigating the corrosion behaviour of new post-operational-clean-out HLW glass formulations under conditions relevant to geological disposal. During my PhD, I undertook a six-month placement at the IAEA HQ in Vienna where I contributed to the Predisposal Waste Technology team. Here I worked on projects relating to Chernobyl decommissioning and the disposal of radioactive contaminated metals. I then ventured into consultancy as part of Eden Nuclear & Environment, where I worked on numerous technical and strategy development projects for the NDA, Dounreay, LLWR, DEFRA and NIRO.

What brought you to DCF?
I missed all aspects of laboratory work and the academic environment. DCF is the perfect place to bring my experimental experience, learn new laboratory skills and to use the state-of-the-art irradiator facilities to conduct further exciting studies. I enjoy teaching and assisting students in the laboratory and look forward to helping the DCF students achieve their goals.

What are your research interests?
I am interested in fundamental UK HLW glass corrosion, particularly related to supporting the safety case for geological disposal. I would like to explore the effects of radiation on the chemical durability of HLW glass. I am also interested in the thermal treatment of ILW and Pu disposition.

What do you enjoy doing when you aren't at work?
I enjoy hiking the many mountains in the Lake District with my wife and dog! I am an avid snooker fan and enjoy jogging and a good beach clean. I'm also a 20th century history buff and enjoy travelling to sites of significance!

Dr. Rob Jones – Head of Operations, Dalton Nuclear Institute

Tell us about your career journey so far.

I've worked in various roles and industries throughout my career, always in the safe management of activities with a strong technical component. I began as a Geotechnical Engineer in 2004, working on various interesting projects including dam grouting, to support the water level increase at Dinorwig pumped storage system, then onto design management in the rail industry for a large number of refurbishment projects. From 2013 to 2016 I took a career break to study as a Postgrad student at the Dalton Cumbrian Facility (DCF) where I achieved my PhD in mucky pipes. I then moved into the nuclear industry to work on various Post Irradiation examination projects and installation of capabilities funded by the Henry Royce institute at NNL working on various post irradiation, I was responsible for international projects and worked extensively with some of the US national labs and within the Decommissioning sector for JAEA. Prior to joining DCF I was a Programme Manager looking after the proposed treatment capability for the SIXEP plant at Sellafield Ltd.

What brought you to DCF?

I've been involved and aware of DCF since 2013. My time in the nuclear sector has been within industry but very much focused on research and development and I have had a significant involvement with UoM and Dalton during that time. When I heard that this post was available, I was very keen to apply as it felt a good fit using my operational experience and to help facilitate more fundamental research. I find great professional satisfaction in assisting others to develop their ideas and enjoy the more free-thinking approaches to problems and solutions that academia can achieve.

What are your aspirations for DCF?

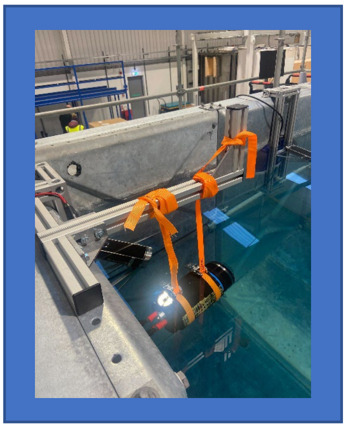
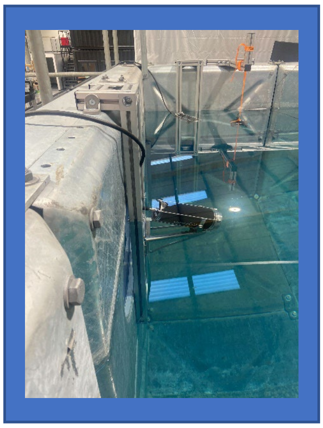
I hope DCF continues to provide and collaborate on highly impactful and influential work and continues to be a highly valued asset of the university and maintains its position as one of the preeminent research centres in radiation science within the UK. I want us to be a happy, safe place to work. Having been a student here in the past, I'm aware of the need for a strong community of practice for support and the wellbeing of everyone here. I would like to see us growing the academic community that is based at DCF and within Cumbria. On a more practical level I want to increase engagement within the local area and develop stronger links with other labs within the area. When DCF was first set up it was seen as a route to more active labs and I'd like to try and develop this route further. I'd also like to see more people coming the other way from industry to use our facilities that provide unique capabilities at a much easier route for access. Longer term I see some potential for new capabilities and facilities but these are many years away from even being at a concept stage and would form a longer-term strategy for growth.

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

Part of the reason for moving to Cumbria all those years ago was prime access to the Lake District. I'm a very keen cyclist, who has unfortunately taken a sabbatical due to a young family. My most extreme event was the London, Edinburgh to London ride that was 1400km completed in under 5 days non-stop. I like nothing more than putting my toddler on my back and going for a walk in the hills or around some of the local lakes with her and our two dogs. We bought a large old Victorian house a couple of years ago and we have been slowly improving the rooms as we get time. I enjoy doing a bit of wood working pottering around in my shed when I have the time as well.

RAICO

Post doc Melissa Sandison has been busy setting up a new underwater wireless optical communication system at the RAICo1 tank.
The water tank is used to test aquatic based robots. As Wi-Fi does not perform well underwater, the newly installed modems from Sonardyne (BlueComm 200UV) transmit data via LED lights at up to 10Mb/s allowing transmission of even live video streams.
This is part of a collaborative project with Sellafield Ltd and the aim is to use the system for wireless communication between nuclear multi robot fleets.

Setting up the Sonardyne kit in the RAICo1 tank'.

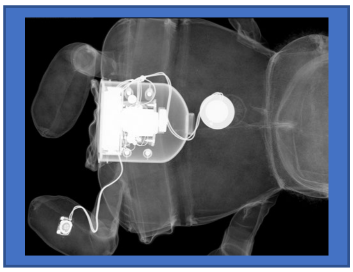
Photos supplied by Melissa Sandison

OUTREACH VISIT TO DCF

Our local Whitehaven Girl Guide Unit attended an outreach evening at DCF organised by staff and students.
The girls are all aged 10-14 and 18 girls attended with four leaders and a young leader.

The evening consisted of learning about photons, X-rays and γ-rays, as well as ions, which involved firework glasses, as well as some optical microscopy, scanning electron microscopy and X-ray imaging.

The evening ended with making and eating liquid nitrogen ice cream and the girls all thoroughly enjoyed themselves.



Xray Images of Santa Stuffed toy (left) and a 3D printed Pikachu (right)

Images provided by Dr. Ruth Edge

WILL LEISING – INTERNATIONAL IRADIATION ASSOCIATION (IIA) CONFERENCE - BANGKOK

I am a 3rd year PhD student based full time at Dalton Cumbrian facility. My work revolves around the use of radiation grafting for surface functionalise of 3D printed plastics.

I recently attended the IIA conference and workshop in Bangkok to present a poster in which I ranked 2nd within the student category. While out there I had the joy of collaborating with Prof. Wanvimol Pasanphan and her group based at Kasetsart university.

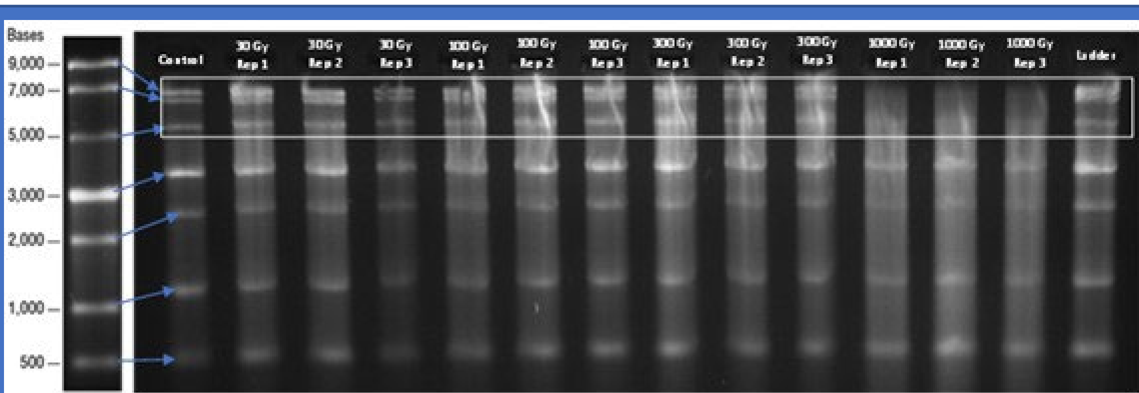
Using their electron beam facilities, I was able to develop novel surface functionalisation methods in conjunction with my work at Dalton Cumbrian Facility using gamma radiation.

I also recently lectured in the Institute of Materials (IoM3) young lectures competition where I placed 2nd in the local rounds.

JORDAN ELLIOT – PROJECT UPDATE

My project, "Probing RNA structure using Ion Beams," has progressed steadily over the last six months.

Experiments with irradiating RNA with X-rays have yielded some positive results, showing that we can induce RNA strand breakage with X-rays and that there is a correlation between strand length and occurrence of breakage.



Gel electrophoresis of the X-ray irradiated ssRNA ladder samples. The controls are in the first and last lanes. Moving from left to right, as the dose of X-rays increases, the longest lengths of RNA (the bands at the top of the columns) are being broken. In the 30Gy sample, the top two bands are clearly visible but in the 1000Gy sample those bands have significantly faded; this is the result of the X-rays breaking the RNA strands into smaller fragments.

Because of this progress, my supervisor and I felt this and any new revelations in the next few months warranted a presentation at the Miller conference. Along with several others at DCF, I have submitted an abstract in hopes of presenting my findings at the conference with a talk and poster, to gain invaluable experience and share my findings.

ACCELERATOR HALL

Shielding upgrade

The NNUF funded EMITS project to upgrade the shielding of the ion accelerator hall is progressing and reaching its final phase. As we go to press the main lead shielded walls are up and decorated, the final stage – due to happen imminently – is the installation of the steel work prior to the fitting of the shielded doors. This upgrade will enable us to safely accelerate higher current ion beams at higher energies in the tandem 5MV accelerator.

New end stations

In parallel with the accelerator hall shielding upgrade, we have been progressing with the installation of two new end stations: a versatile dual-beam end station which will take our existing radiation damage sample stages, and a new end station incorporating SIMS and EELS analysis tools. The dual-beam end station is expected to be available for users in the next round of proposals. Full commissioning of the much more complex SIMS/EELS end station is expected later in the year.

A high temperature target stage (up to 1200 ºC) for ion irradiations is currently undergoing testing and will be made available to users for ion irradiations in our Hotcell end station.

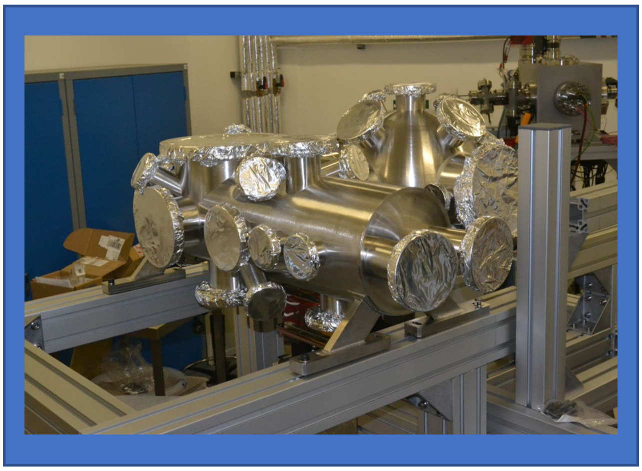
Following completion of the building works in the accelerator hall (see above) we will take some time for routine annual maintenance of our accelerator systems before we recommence normal user operations. We anticipate that the next proposal round will cover the May-June-July quarter and expect to be able to issue the next call for DCF ion beam proposals in late February – early March. If you are not already signed up to our Ion Beam Users email list, email your details to the DCF Experiments inbox and you will automatically receive notification when the proposal round opens.

Dual Beam

The new versatile dual beam end station in place on beamlines L5 and LA of the 5MV tandem and 2.5MV single accelerators, being ready for vacuum testing

Royce

The Henry Royce Institute funded SIMS/EELS end-station being assembled in the Near Target Room



EMITS

Lead walls being built in the accelerator hall to allow for higher ion beam currents and energies to be accelerated in the 5MV tandem accelerator

NNUF National Nuclear User Facility

UKNIBC UK NATIONAL ION BEAM CENTRE

HENRY ROYCE INSTITUTE