IOP | Institute of Physics
Nuclear Industry Group

NEWSLETTER

October 2015

Issue no. 5

University of Birmingham's Cyclotron

Hinkley Point 'C' (artists impression)

New Horizons
(*Image courtesy of NASA*)

Contents

Notes from the Chair

Once again it is my pleasure as Chairman to introduce this, our 5th Newsletter, to all members of the Nuclear Industry Group (NIG). This newsletter is our main vehicle of communication with you and so we must again thank Heather Beaumont for her sterling work to produce it.

However, we have also set up LinkedIn and Facebook accounts and are looking at reinvigorating the webpage on MyIoP which has been rather neglected of late. I hope we will be able to post notes of the committee meetings, for example, on this page. Dale McQueen is running the Facebook account and Chris O'Leary is in monitoring LinkedIn. Claire Elliott has taken on the role of advertising and you may have already seen the format

that is being used for events. Hopefully these changes will keep members better informed of our activities.

We are an ever expanding group and now number over 600 members, from all parts of the nuclear industry. The breadth of our interests has been clear in our events over the past year. These have ranged from dealing with new approaches to the management of higher activity radioactive wastes, radiation sources as batteries in space craft, decommissioning the last civil research reactor in the UK, radiation damage in graphite, progress on Hinkley Point C and the difficulties of transporting a cyclotron from the US to the UK. We also supported a one-day seminar on nuclear data at the National Physical Laboratory in Teddington. I hope there was something there for everyone – reports on all the meetings are included in this newsletter.

As a committee we are very aware that as the industry is spread across the whole country; it is therefore difficult for our members to get to some events, and so we have looked into ways of making the events more accessible. At present we have not resolved the cost issues involved in filming or webinar, but in most cases we have been granted permission by the speakers to put their presentation on the web. We did get one film, of the space batteries talk, but this was kindly provided for free by our hosts at the University of Birmingham, which was also made available to members.

Later this year we are holding a half-day seminar at Wylfa to mark the end of Magnox generation, jointly with the IOP History of Physics Group and supported by the Wylfa NPP. The first Magnox reactor started generating energy in 1956 (the first nuclear power in the world to feed into a national grid) at the Calder Hall Power Station. Thereafter, in a series of reactors, the design was improved to get higher output and efficiency by increasing the pressure and outlet temperature. Initially steel pressure vessels were used, but the last two stations had concrete pressure vessels, foreshadowing the Advanced Gas Reactors. Wylfa was the last Magnox station and is the only one still generating. It is now reduced to operating only one of its two reactors and this will shut down by December. I hope many of you will attend this 'Farewell to Magnox' event. More details can be found later in the newsletter on page 21.

Other events we are planning will cover UK work on nuclear data, geological disposal of radioactive waste and some aspects of research in relation to Generation IV designs. If you have ideas of events or areas of the nuclear industry that you think we should cover (and, if possible, suggestions of names) please let us know. Or even better – volunteer to give a lecture!

We have two new members on the committee and their pen portraits are on page 7. Besides welcoming them, I would like to thank the retiring members, Michael Gifford and Steven Judge, for their efforts. This year we have to say farewell to Andy Quinn, as Honorary Secretary, as he has reached the maximum four years in an officer's post allowed by IoP rules. Andy has done a great job, in what is possibly the most onerous of the officer's roles, and his contribution has been significant to the success of the NIG. He will stand again for the committee, as will the other committee member who reaches the four year limit, but this should not stop others putting in nominations. Further information on the secretary's responsibilities, and the arrangements for the nominations and election to this post and the committee, are provided later in the Newsletter (see page 6).

Last year I commented that we were waiting for the EU to determine whether the state aid for Hinkley Point C was acceptable. This was found to be the case and we are now nearer

to a final decision on building this station. However, the Austrian Government and a group of German environmentalists are threatening to take legal actions based around the EU decision being flawed, although it seems unlikely they will be successful. Nuclear power never has had a smooth path politically and it seems that this will continue into the future. Let me finally wish you all well in your future endeavors and I hope I will meet more of you at NIG events in the coming year.

Geoff Vaughan
Chairman
IOP Nuclear Industry Group

Nuclear Industry Group Prizes 2015

The Nuclear Industry Group was pleased to award an Early Career Prize and a Career Contribution Prize this year at the AGM. Selecting the prize winners this year was again, a difficult decision as the calibre of the entrants was very high.

Early Career Prize
We are delighted to announce that this year's prize was awarded to David Hughes of EdF Energy.

Over the course of 18 months David has managed a group of nine contractors, who have developed a suitable decay heat methodology with associated validation and uncertainties associated with the proposed Sizewell B Dry Fuel Store. This involved development of a number of novel models, extensive code-to-code and code-to-experiment comparisons. He specified and managed the work throughout, taking responsibility for critical choices of project direction. He also liaised with a world expert in decay heating in order to obtain independent review and endorsement of the method.

The project provided considerable scope to interact with the wider EDF business through regular progress and interface meetings. It was been necessary to develop an appreciation of how this work interfaces with, and impact other technical disciplines. David had to argue the need for funding for contracts from the Dry Store management team; this has proved challenging. Interaction with station staff ensured that the project meets not only the theoretical requirements, but also the requirements of a real-world, nuclear safety orientated, and engineering environment.

Career Contribution Prize

The NIG Committee were delighted to award this year's career contribution prize to Professor David Weaver. David has dedicated over 40-years to research and training used by the nuclear industry and has made significant contributions to both.

In 1967, David emerged from Trinity College, Cambridge with a first-class degree and a Tripos

Prize, subsequently completing the Birmingham Reactor Physics MSc. – obtaining the top-student Liquier-Millward prize. His Ph.D study followed coupled with time in Canada as a Commonwealth Scholar. David obtained his doctorate in 1971.

Joining the Birmingham-Aston Radiation Centre, from this point onward, David played an ever increasing role in both the nuclear industry – through research – and in training the future generation of industry leaders. Made a Lecturer in 1976 and Senior Lecturer in 1992, David taught on the Reactor Physics MSc. and researched delayed neutron spectroscopy at the Dynamitron. Such was the relevance of this research to reactor behaviour, that a review article followed in Advances in Nuclear Science and Technology.

Following Aston's pull-out from the Radiation Centre in 1982, David became a formal member of the Department of Physics at Birmingham with stewardship of the Physics and Technology of Nuclear Reactors (PTNR) MSc. Course, and, critically, shepherded the course through the withdrawal of EPSRC student funding. It is indicative of both
David's standing with the nuclear industry and his enthusiasm for training (MSc. and Ph.D) that he was able to persuade a consortium of companies to sponsor the course; all at a time of low public and government support. Overcoming this challenge proved key, as the PTNR course was, for a time, the only university course supplying trained Masters students to the industry. From this point course numbers increased dramatically with industrial sponsors of the course currently numbering greater than 10. The PTNR course's reputation in the UK, is second to none, and many of today's leaders in the nuclear industry have graduated through its rigorous demands.

David's research brought not only industry and academic recognition, but further highlighted his aptitude for training; demonstrating patience and honed analytical skills in supervising many Ph.D students. This was alongside David's increasingly important role in nuclear data evaluation, for which his expertise was soon acknowledged internationally by membership of IAEA programmes and JEF working groups to name but two.

His reputation within industry and more widely can be most easily evidenced by his committee memberships and other commissions of trust. Two of his most notable are service on the UK Naval Nuclear Propulsion Programme committees (NNPP): the Physics Working Group and the Research Programme Group. The latter has oversight over all NNPP technical working groups and its recommendations feed directly into high-level government. Other wider roles are as Vice-President for Regional and Public affairs (IoP) and on the government's Radioactive Waste Management Advisory Committee.

Most recently, David has continued to disseminate his command of the whole nuclear picture through media and The Policy Commission on The Future of Nuclear Energy in the UK.

The calling notice for the 2016 Nuclear Industry Group prizes will be released later this year. The deadline for submissions will be 31 January 2016.

Committee Elections

As noted in the Chairman's remarks, we need a new secretary to be appointed this year as four years is the maximum in a specific officer's role. Also, one of the longstanding members of the committee must stand down as he has completed his four year's on the committee. In both cases, the incumbents can stand agin for the committee as memebers can serve in total for 12 years.

Chairman position

The basic requirement of the NIG Chairman is to ensure that the committee runs effectively and efficiently for the benefit of the group's members. As any chairman will tell you, the role is to some extent created by the post-holder who has to determine how he/she will carry them out.
The activities that need to be overseen by the chairman include:

- Interacting with IoP on group activities attending the Group Officers Forum (twice a year, but this can be shared with other officers),

- Ensuring an adequate and interesting programme of lectures, visits and other events is organised for group members,
- Ensuring advertising for the above,
- Ensuring that committee meetings are held as appropriate,
- Ensuring the Newsletter is produced,
- Ensuring nominations and elections for committee places are held in a timely manner and as appropriate,
- Interacting with other IoP groups on areas of common interest and organising joint meetings,
- Interacting with relevant groups and organisations outside the IoP such as the Nuclear Institute,
- Considering requests for funding from conference organisers etc, and
- Responding to requests from IoP to comment on various issues and consultations.

During my tenure of the post many of the above are in fact carried out by other members of the committee and generally discussed at committee before a decision is made, although there are times or situations where I do get involved directly or making decisons. Clearly a new Chairman may decide to do things differently.

Geoff Vaughan was elected into this role in October 2012 and so it becomes open for applications again for October 2016.

Group Secretary position

The Honorary Secretary Role is one of three roles required for running the NIG, along with the Honorary Treasurer and Chairman; with which a lot of close working is required. The main role of the Honorary Secretary is to organise the regular committee meeting for the NIG, take minutes at the meetings and formally record and distribute them to the committee members following a meeting.

In addition the Honorary Secretary acts as a liaison between the committee and the rest of the NIG membership, acting as a point of contact for members who wish to raise something to the committee to discuss at the next committee meeting.

The Honorary Secretary also has further responsibilities required by the IoP also. These involve providing a group activity report in the start of the new year detailing the list of committee meetings held during the year, and a list of all events the group has organised or been involved with any aspect of organising (eg sponsorship); along with the attendance at each event. The activity report also details any prizes given out by the group, and details relating to communication with the membership of the group. The Honorary Secretary is also required to inform the IoP Science Support Officer with the details of changes to the committee in a committee report each year also.

'Honorary Treasurer' Group Officer Position

The 'Honorary Treasurer' role is concerned primarily with ensuring the group complies with the IOP regulations on managing its allocated budget, specifically:

"Group committees are required to submit an annual budget request to the Institute each year to facilitate the allocation of funding for groups. The group committee should also monitor their budget and inform the Institute of any concerns."

Funds for each group are allocated on a yearly basis, in advance. A monthly update on group finances is provided by the finance team at the IOP. The Honorary Treasurer needs to ensure there is no overspend (or, at least, that any overspend is minimised), and that expense claims comply with the IOP rules as a registered charity. They should also aim to use the allocated funds effectively and in a manner consistent with the group's aims; other members of the group will seek guidance from the Honorary Treasurer on the requests for funding of talks, seminars, conferences and other activities.

Chris O'Leary was elected into this role in October 2013 and so it becomes open for applications again for October 2017.

Role of a Committee Member

Committee members can become involved in a variety of different activities. Some of the committee members take on specific roles such as, for example, being members of the prize committee, newsletter editor; others may do one-off tasks such as organising an event or lecture.

The committee organises the events and lectures that currently are held about four or five times a year. Possible joint events with other IOP groups, or sponsoring events outside IOP,

are discussed and promoted. One of the less publicised activities of the committee is commenting on IOP documents and responding to requests for views on government consultation documents to inform the IOP response. As the type of event and subject of lectures is determined by the committee, a strong, knowledgeable membership is necessary to maintain the successful start to the life of the NIG.

Requests for nominations for secretary and the committee will be sent out later in the year and elections, if necessary, will be held in January 2016.

Meet the new Committee members

Following elections last year the Nuclear Industry Committee welcomes some new members, Claire Elliot and Dale McQueen. Brief biographies for Claire and Dale can be found below. The committee also welcomes Alfie O'Neil who has been co-opted onto the committee to represent NNL. Michael Gifford and Steven Judge stepped down from the committee in the past year. The committee also wishes to thank Michael and Steven for their support and efforts which have helped to make this group a success.

Claire Elliot

Claire is a temperature measurement research scientist at the National Physical Laboratory (NPL), where she has been based since October 2010. In this time, she has worked in three main areas – calibrating temperature equipment, developing and testing novel sensors (including those designed to meet the unique challenges posed by the nuclear industries) and consulting on commercial measurement challenges; and is presently helping to set up a young professional/ early-career network at NPL. She completed her PhD (in semiconductor physics) and MPhys (in chemical physics) at the University of Sheffield and was elected to Chartered Physicist in January 2015.

Dale McQueen

Dale completed his BA and MSci in Natural Sciences at the University of Cambridge, specialising in Experimental and Theoretical Physics. He initially joined the nuclear industry as a summer placement student at Wylfa Nuclear Power Station, Magnox Ltd where he worked in the Fuel and Reactor Systems Team, before moving to join Sellafield Ltd. Whilst at Sellafield, he has worked across the company in a variety of technical and strategy roles and was awarded the Sellafield Ltd Graduate of the Year award. Dale is an associate member of the IOP and is currently working towards chartership with the institute. He is very keen on developing the voice of young people within the nuclear industry and has organised numerous events to that end, most recently facilitating a workshop to provide a collaborative submission to the NuGen public consultation from the Young Nuclear Professionals of West Cumbria.

Alfie O'Neil

Alfie is a graduate within the Criticality Safety and Assessment team in NNL based in Preston, having joined the company in September 2014. Prior to this he studied for an MPhys in Physics at the University of Manchester. He is currently also involved with the steering group in NNL, which is looking to raise the profile of the IOP within NNL.

IOP Group Officers Forum

The 'Group Officers Forum' meets twice per year, in June and November, at the IOP building in London. Officers (eg Chair, Secretary or Treasurer) from all groups are eligible to attend; typically around half of the groups are represented. The meeting allows senior officials in the IOP to communicate matters of significance, particularly those affecting groups, and receive direct feedback and questions. Occasionally, the forum divides into small groups to 'think tank' solutions to specific issues.

There is a standing agenda for the meeting, but the subtopics change. For example, at the June 2015 meeting, the topics discussed included: conference venue pricing and subsidy guidelines; expenses for committee members at AGMs; IUPAP (International Union of Pure and Applied Physics) commission representatives; 2016 funding requests; merger of the dielectrics and electrostatics groups; the group service level agreement; the new IOP building; and the new IOP five-year strategy goals.

Minutes from the forum are written by the IOP Science Support Officer, and issued to all IOP Group Officers prior to the next meeting.

IOP Groups Committee

The 'Groups Committee' (previously known as the Group Coordination Committee) meets twice a year, in March and October, at the IOP building in London. It is responsible for monitoring the activities of groups, and is very much a 'hands-on' committee, considering all matters associated with the groups, including finance, policies, portfolio, and new groups. Members help to support and shape the role of the groups within the IOP. They must already hold Honorary Officer roles with an IOP group, and their term of office lasts for four years.

We are pleased to say that our Honorary Treasurer, Chris O'Leary, was elected onto this committee last year, and will serve until October 2018.

Minutes from the meeting are written by the IOP Science Support Officer, and issued to all IOP Groups Committee members prior to the next meeting.

The Role of NNL in the Nuclear Industry

Alfie O'Neil

The National Nuclear Laboratory (or NNL as more commonly known) is a Government owned science and technology organisation working to provide support and innovation to the UK nuclear industry. That involves reducing the cost of clean-up and decommissioning, maintaining critical skills and attracting talented new people to the industry.

Succeeding Nexia Solutions Ltd and originally operated by BNFL, NNL was formed in 2009 as a Government Owned, Contractor Operated (GOCO) business with the SBM consortium (Serco, Battelle and the University of Manchester) as the Managing Contractor. In October 2013 NNL became a Government Owned, Government Operated (GOGO) business. Today, NNL provide independent and trusted advice to the UK Government, collaborate with other National Laboratories around the world, and deliver a full range of research and technology solutions to support customers across the nuclear fuel cycle.

There are three main areas NNL operate in are:

- Waste Management and Decommissioning – developing and applying techniques to decommission nuclear facilities. NNL have the breath to cover everything from waste management to environmental impact assessments, working with the Nuclear Decommissioning Authority (NDA) and other customers.

- Fuel Cycle Solutions – providing technical solutions to industry. This includes fuel cycle performance, spent fuel disposition and plant integrity assessments. NNL also handles nuclear security, safety management and engineering services, along with advanced modelling and simulation services.
- Reactor Operations Support – NNL offers support to reactor operations in the UK, including post irradiated examination and the performance of fuel components and graphite. Services also cover power station chemistry, endoscopy and metallography.

NNL have a variety of facilities, including Central Laboratory at Sellafield - the most modern nuclear technology research facility in the world. NNL also operate a non-active Rig Hall in Workington, Active labs in Preston and Offices in Warrington, Stonehouse and Culham. Part of NNL's remit from the Department of Energy and Climate Change (DECC) is to make its facilities available to the wider scientific community; this includes allowing access to 10 % of the NNL Central Laboratory to the University of Manchester and the University of Liverpool.

NNL has always worked closely with academia, and has close links with Leeds University, Imperial College London, the Dalton Cumbria Facility and the University of Manchester. NNL is a partner in the Research Centre for Non-Destructive Evaluation (RCNDE) and the National Nuclear User Facility (NNUF) initiative. The future goals of NNL include: expanding into a broad range of national and international markets, profitable deploying nuclear technologies, continuing to provide independent and authoritative advice on nuclear issues and to become the employer of choice for nuclear scientists and engineers.

For more information please visit www.nnl.co.uk

Alfie O'Neil is Alfie is a graduate within the Criticality Safety and Assessment team in NNL based in Preston. His a co-opted NIG committee member representing NNL.

Radiation metrology for the nuclear industries

Claire Elliot

The National Physical Laboratory (NPL) is the UK's national measurement institute –the laboratory is part of the UK government's system to ensure that all measurements made in the UK are done so accurately and are equivalent to those made in all other countries. The institute was founded in 1900 in Teddington, West London with the aim of providing the impartial underpinning confidence that fair trade requires. NPL's work in ionising radiation metrology started in June 1913, when the laboratory took delivery of a radium standard certificated by Rutherford, Curie and Meyer. These days, NPL holds the UK's primary standards for radioactivity, dosimetry and neutron metrology. The focus of the work in this field is safety – enabling industry and hospitals to use ionising radiation whilst minimising the impact on the environment, radiation workers and patients from the harmful effects.

NPL's work with the nuclear industry is not restricted to ionising radiation. Other groups are addressing challenges such as the development of radiation-hard temperature sensors using built-in measurement validation and novel techniques (www.npl.co.uk/temperature-humidity/research/contact-thermometry) and the measurement of the deformation of waste drums due to expansive corrosion www.npl.co.uk/news/innovation-and-the-uks-nuclear-legacy).

CARM 2015 CONFERENCE ON APPLIED RADIATION METROLOGY

NPL is hosting a new conference (10 – 12 November 2015) on the applications of radiation metrology in the nuclear industry. The intention is that this will be an annual conference and we hope that it will grow to become one of the key conferences to support scientists and engineers in the industry. If you are interested in attending the UK National Conference on Applied Radiation Metrology (CARM-2015) please see here for details: www.npl.co.uk/events/10-12-nov-2015-carm-2015

Relations with the Nuclear Institute

Neil Thomson

Discussions are taking place with the Nuclear Institute to improve collaboration in a number of areas. After the recent NIG AGM, the committee were able to discuss joint approaches to organised events with John Warden (the new CEO of the Nuclear Institute). An action was taken to improve the links between the two institutes.

John also indicated that the Nuclear Institute is hoping to discuss with the IOP Chief Executive, Paul Hardaker, the possibility of agreeing a Memorandum of Understanding (MoU) covering interactions between the institutes.

Close collaboration between the institutes is essential to ensuring that the growing need for professional physicists in the nuclear industry receives appropriate attention as the industry deals with life extension, new nuclear build and decommissioning.

Neil Thomson is presently a Senior Technical Advisor in EDF-Energy Generation and a member of the NIG committee. He is also Vice-President of the Trustees of the Nuclear Institue and was recently elected to the Council of the IOP.

NIRAB/NIRO

Neil Thomson

The NIRAB (Nuclear Innovation Research Advisory Board) annual report was published on 26th February and is available on the internet. The report was welcomed by Ministers, especially the skills and training aspects and how these contribute to a sustainable future for the nuclear sector.

Government has asked NIRAB to advise on the level and nature of publicly funded research and innovation necessary over the next five years to maintain a pathway to achieving Nuclear Industrial Strategy objectives. The development of the technical content of the five-year programme options has been coordinated over the last six months by NIRAB subgroups. These involved NIRAB members, and a wider range of specialists, and have been supported by NIRO (Nuclear Innovation Research Office) staff. A technical roadmap is in preparation and will be published in due course.

NIRO is working with Department for Business, Innovation and Skills (BIS) and the Department for Energy and Climate Change (DECC) to present NIRAB's recommendations to government as part of the forthcoming Comprehensive Spending Review process.

Nuclear data workshop at the National Physical Laboratory, Oct 2014

Steven Judge

'Nuclear data' is the multi-disciplinary science of mapping the nuclear properties of matter, information that is needed for safety cases, reactor operation, accident studies, fuel cycle calculations, site characterization, management and nuclear medicine. The National Physical Laboratory (NPL) & Surrey University organized a workshop on the topic in 2014, sponsored by the the IoP Nuclear Industry Group and the National Nuclear Laboratory. The workshop followed on from a review by the IoP of the role of nuclear physics research in the UK.

Robert Mills from the National Nuclear Laboratory set the scene, defining industrial nuclear data as “the parameters required to model the nuclear physics of an applied/industrial process to give engineering relevant quantities” – including cross sections, fission yields and decay data. Robert explained that there is a cyclic process of measuring nuclear data, evaluating the measurements, capturing and ‘freezing’ the evaluated data in international databases (such as ENDF and JEFF) and then identifying any further measurements that are needed. The Nuclear Data Section of the International Atomic Energy Agency is heavily involved in this work, and Robin Forrest (the section head) explained the role of nuclear data, the databases that are available, how they are structured and validated, and outlined current international projects. Robin

also emphasized that nuclear data had to be freely available internationally but was not cost-free to measure or evaluate.

Requirements for nuclear data for both fission and fusion reactors were raised by representatives from EdF Energy and JET. Speakers from NPL discussed the applications of nuclear data in nuclear medicine, and AWE highlighted the importance of the topic for the international network of laboratories that monitors compliance with the Comprehensive Test Ban Treaty. The 'state-of-the-art' in nuclear physics studies at CERN and other international laboratories was outlined by leading academics.

The workshop underlined the importance of this discipline for the nuclear industry and nuclear medicine, emphasizing that it is an international collaborative effort involving academia, the nuclear industry and national/international laboratories. Further details and copies of presentations are available on www.npl.co.uk/science-technology/radioactivity/collaboration/joint-npl-iop-nnl-workshop-on-nuclear-data

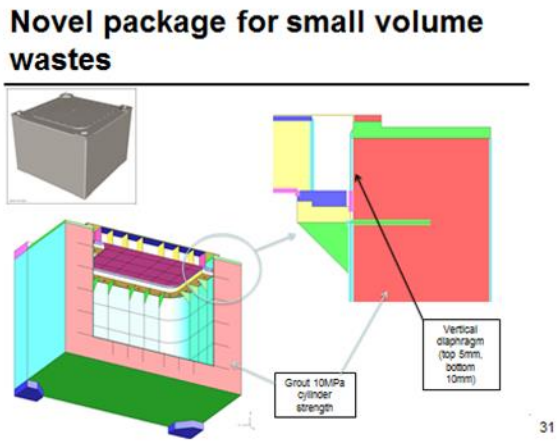
Steven Judge is a Radiation Metrologist at the National Physical Laboratory

Innovative Approaches to Optimise the Management of Higher Activity Radioactive Wastes

A report on the talk given by Dr Ciara Walsh, Radioactive Waste Management Limited, on 17 September 2014.

Lucy Bailey

At a lively and interactive seminar held in Barnwood, Gloucestershire, Dr Ciara Walsh, Upstream Optioneering Manager at Radioactive Waste Management Limited (RWM), explained the challenges of disposing of higher activity wastes and the work that she is leading at RWM to encourage waste producers to look for innovative solutions that increase safety and minimise cost.



Ciara began her talk by outlining the current siting process for a geological disposal facility for higher activity radioactive waste in the UK. This involves a national geological screening exercise, amendments to national land-use planning arrangements for projects such as a geological disposal facility and a more active role for RWM in engaging with communities as part of a volunteer process, providing upfront information on issues including geology, socio-economic impacts and community investment.

As there is currently no geological disposal facility available in the UK, wastes need to be retrieved and safely packaged for interim storage pending geological disposal. RWM supports this process by undertaking disposability assessments of waste packaging proposals, aimed at supporting hazard reduction and reducing the risk of the requirement for future re-work. Requirements are placed on the wasteform and waste container that take account of both normal conditions and all credible accident scenarios.

Ciara emphasised the important role of innovation in the treatment and packaging of radioactive wastes, stating that "small innovations can save millions of pounds". She explained how it can be particularly challenging to find cost effective, ALARP[1] solutions for small volume and problematic waste streams, for example mercury wastes, contaminated bulk oil, pyrophoric material and solvents, to name but a few. Ciara explained that RWM holds a lot of information on historic work for dealing with such materials and is actively promoting an

[1] Risks should be reduced As Low As Reasonably Practicable (ALARP) to meet the requiremnts of the Health and Safety at Work etc Act 1974

environment in which knowledge is shared across the UK's nuclear sites. For example, a novel package for small volume waste has been developed that has a grouted liner and sacrificial diaphragm, such that it has negligible releases in all credible accident conditions, meets RWM specifications for disposable packages, can be handled with no additional infrastructure and is affordable.

In summarising, Ciara encouraged all waste producers to engage with RWM for help in identifying cost-effective packaging solutions. She explained that innovation can be about asking simple questions, such as is a waste conditioning process needed, has it been done before, how else could the aim be achieved? Fundamental research and innovation have a big role to play in the management of higher activity radioactive wastes, which is just as well as these wastes will be generated for decades to come!

Anyone interested in the work of RWM can subscribe to receive the latest updates at www.nda.gov.uk/rwm.

A copy of the presentation from Ciara's talk is now available on the IOP NIG website: http://www.iop.org/activity/groups/subject/nig/recent-events/page_63207.html.

Lucy Bailey leads the Post-closure Safety Case Group of Radioactive Waste Management Limited (RWM), a subsidiary of the UK's Nuclear Decommissioning Authority (NDA) and is a member of the NIG committee..

Space Batteries

A report on the talk given by Tim Tinsley National Nuclear Laboratory (NNL) business leader.

Zahid Riaz

The NIG organised a presentation on "Space Application of Nuclear Technology", at the University of Birmingham last October. The speaker was National Nuclear Laboratory (NNL) business leader Tim Tinsley.

The presentation had three main parts:

a) the need for nuclear space technology
b) nuclear spacecraft systems/ history
c) current UK research & development

Of particular interest to NIG members was the work being performed by NNL with the European Space Agency (ESA) and other organisations on radioisotope systems as a source of heat and power for spacecraft. This article will provide an outline of Tim's presentation.

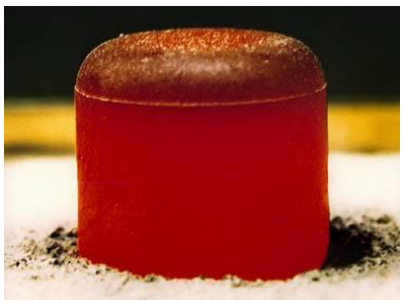
Outer space is vast, most near earth traditional space satellites and systems rely on solar power. However the solar flux weakens at a rate of $1/r^2$. Space missions to the outer solar system or a Mars/ moon lander/ rover that wish to survive and operate effectively require an alternative source of power. Three types of power source are available:

i. **Chemical**: These do not last very long and the fuel cells require fuel which is very expensive to launch into earth orbit.
ii. **Solar**: Although proven and cheap it is orbit dependant and becomes ineffective beyond Mars. Solar panels are also easily damaged if their deployment is large and complex.
iii. **Nuclear**: This power source is independent of orbit and location, proven and reliable. But very expensive due to the limited supply, of the required radioisotope and has launch safety concerns.

However if humanity wishes to explore the outer reaches of the solar system, a nuclear power source is the only option. Nuclear systems have been deployed in space via three key systems.

- Radioisotope Heater Unit (RHU): These provide direct production of heat by radioactive decay and are used to keep the electrical systems on a spacecraft at an operable temperature. They are small pellets of encapsulated radioactive material within a protective capsule. Notable examples of their use have been the US 1969 Apollo missions, USSR 1970 Lunokhod lunar rover and the US 1976 Mars Viking landers.

- Radioisotope Power Systems (RPS): These provide electrical power generation via radioactive decay heat. The two types of systems are:



Bare RHU pellet ($^{238}PuO_2$)
(Image *courtesy of US DOE*)

1. Radioisotope Thermoelectric Generator (RTG). These use thermoelectric systems to convert radioisotope decay heat into electrical power. They have been used to power many spacecraft. Voyager 1 (currently ~ 20 billion km from earth), Galileo which was the first spacecraft to orbit Jupiter and New Horizons which recently sent back detailed photos of Pluto.
2. Stirling Radioisotope Generator (SRG). This system works by converting the radioisotope decay heat into the kinetic energy of a piston which in turn oscillates back and forth through a coil of wire generating electrical current. These are being developed for a variety of missions e.g. deep space exploration spacecraft and for Mars orbiters/ landers.

- Nuclear reactor system, of which there are two types:

1. Nuclear Electrical Power/ Propulsion (NEP). The first and only US use of a nuclear reactor in space was the SNAP 10A reactor which was used to generate electrical propulsion. The USSR launched 33 reactors into space to be used as auxiliary electrical power sources. Both the US and USSR reactors were NaK cooled and used U235. Future exciting developments for this type of space reactor may include powering Mars/ moon bases and for electrical thrusters on interplanetary space-craft.
2. Thermal Propulsion (NTP). Essentially this is the nuclear rocket engine concept whereby the heat generated in a nuclear reactor core is used to expel high velocity exhaust gases to propel a spacecraft. Many designs have been tested but none have ever been flown. At the moment this reactor technology remains a future ambition.

Current spacecraft use RHU's and RPS's to provide heat and power. These use Pu238 which is not naturally occurring and is produced by neutron capture of Np237 in a high flux reactor.

$$^{237}_{93}Np + ^{1}_{0}n \rightarrow ^{238}_{93}Np \xrightarrow{\beta \quad 2.1d} ^{238}_{94}Pu$$

The production route for Pu238 is currently closed and world stocks are limited. Setting up a European based production route would cost €100M's so an alternative less costly radioisotope is required. This radioisotope is required to have the following requirements:

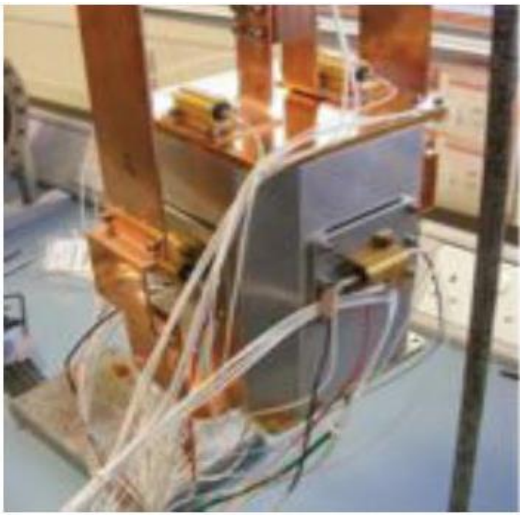
i. sufficient power density over a typical 15yr life
ii. manageable radiation dose
iii. high melting point
iv. chemically stable
v. readily available
vi. technically feasible
vii. acceptable production costs

Research has shown Am241 to be the radioisotope that meets these requirements best. The specific power density of Am241 is only one-quarter the power of Pu238, but it may be the more affordable to produce. Am241 is produced by the beta decay of Pu241 which is in turn produced in a civil nuclear power reactor. Pu241 is found as one of several Plutonium isotopes as a product of spent fuel reprocessing and separation and has a half-life of ~14 years. The UK's stored civil plutonium stockpile provides a source of Am241 that can be efficiently separated, with benefits to both the nuclear and space sectors.

To manufacture a unit containing Am241 that can be used in a RHU, RPS or SRG. It is first chemically separated from Plutonium isotopes and then converted into a suitable stable chemical form i.e. Americium Oxide (Am_2O_3). A pellet of Americium Oxide is then encased within a system of physical barriers to prevent fuel dispersal under accident conditions e.g. launcher explosion, re-entry, earth impact etc. Research in how to do this is being carried out under ESA contracts and UK academia and industry are major contributors. Some of the UK based organisations include NNL, SEA (Systems Engineering & Assessment Ltd),

University of Leicester, Astrium UK, Lockheed Martin, Rutherford Appleton Laboratory (RAL) and the University of Oxford.

The University of Leicester with its collaborators the Fraunhofer Institute and Astrium UK have succeeded in manufacturing and testing electrically heated RTG prototypes which will provide a few watts of electrical power. Whilst SEA Ltd, RAL and Oxford University have studied and derived the detailed system requirements for a European space SRG, which will potentially provide tens of watts of electrical power. In both cases NNL is contributing with its expertise in chemical separation of Am241 from Plutonium isotopes and conversion into Americium Oxide. NNL's Laboratory at Sellafield will house any future Am241 separation facility.

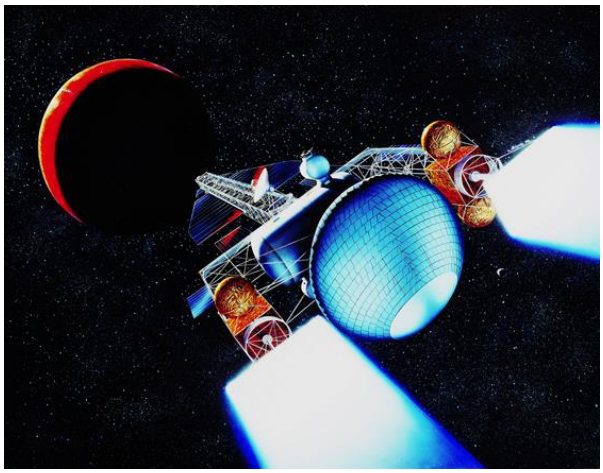


Prototype RTG (electrically heated) prepared for testing at the University of Leicester *(Image courtesy of ESA and University of Leicester*)

In addition to the work being funded by the ESA, the UK represented by the NNL was also part of the MEGAHIT consortium. This was composed of 6 partners and funded by the European Commission (EC), it ran from March 2013 to September 2014. MEGAHIT was an EC – Russia supporting action in preparation of the Horizon 2020 European Union (EU) research and innovation programme. This will be the biggest EU Research and Innovation programme ever, with nearly €80 billion of funding available over 7 years (2014 to 2020). The objectives of MEGAHIT were:

i. to construct a road-map for nuclear electric in-space propulsion activities within the EU Horizon 2020 programme
ii. to create a European community including Russian partners around nuclear space power systems
iii. to analyse the potential collaboration opportunities at international level

The future for nuclear research and development in space thus looks promising with the potential for considerable funding. In conclusion developing future nuclear space technology will be an exciting challenge; it has enabled science and discovery that would have been impossible without it and it will remain essential for future space discovery.



Artist's illustration of future nuclear spacecraft (*Image courtesy of ESA*)

Zahis Riaz is an inspector for the Office for Nuclear Regulation and a member of the NIG Committee

From Fission to Fuel Gone

A report on the talk given by Trevor Chambers, Head of the Reactor Centre at Imperial College, London,

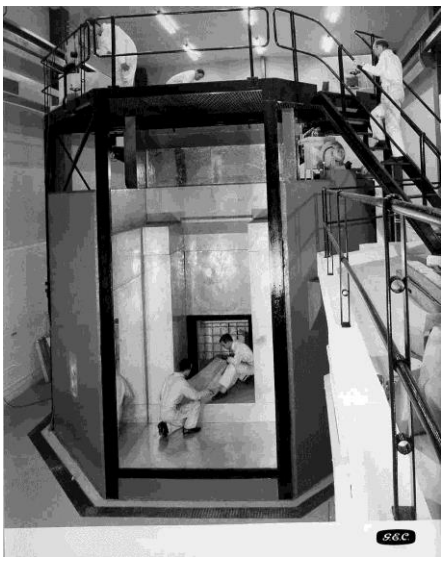
Geoff Vaughan

On November 20th 2014, Trevor Chambers, Head of the Reactor Centre at Imperial College (IC), London gave an interesting and lively talk on the CONSORT reactor covering its full life cycle from conception to decommissioning. This reactor was the last of the civil research reactors in the UK. It was operated by Imperial College from April 1965 to December 2012, which gave

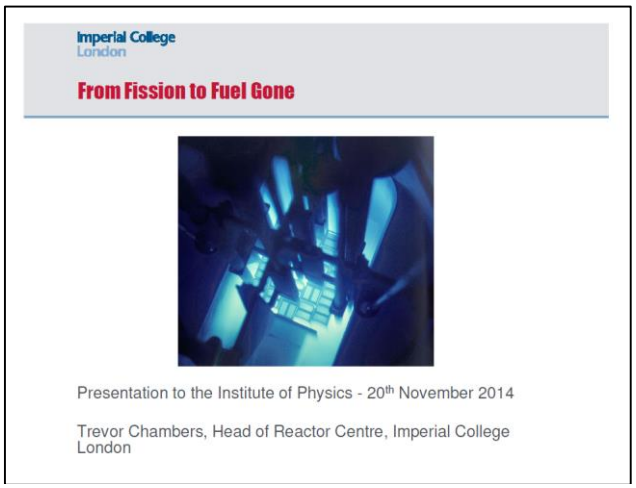
Trevor his alternative title of "The Secret Diary of the CONSORT Reactor Aged 49 $^{3}/_{4}$".

The decision to have three low power reactors available for the use of universities in the UK was taken in 1961 and these were built at Risley (for the Northern Universities), near Glasgow (for the Scottish Universities) and Imperial (for the Southern Universities). The Consort Reactor was designed jointly by Mechanical Engineering Department of IC and GEC Ltd and was a low flux LWR fuelled with HEU (~80%) in the form of U/Al alloy. After showing some photos of the reactor during construction and describing some of the work done during its operational life, Trevor then introduced the issues involved in decommissioning the reactor.

The major issue was how to defuel the reactor as it had not been designed to be refuelled during its lifetime. Hence there were substantial design, manufacture and installation issues involved in developing a defuelling system. Imperial College decided to retain the Nuclear Site Licence and carry out the work themselves with the aim of clearing the site completely. This required engagement with regulators (the existing safety case did not cover refuelling), DECC, other agencies and various contractors to supply equipment.



Designing the defuelling system posed several issues as the existing crane was over 50 years old, the height clearance above the reactor was quite small and the dose from the fuel was estimated to be 75 mSv/hour at 1 m, so a shielded facility would be needed. For security reasons it was decided that all the fuel (24 assemblies) should be transported in a single flask, but there were not many in the UK that were suitable and these were not easily available and they were heavy. To add to the problems there was a substantial amount of asbestos in the building, so modification of it would be difficult!



The solutions found were, firstly to use a modified AREVA flask, though a safety case for its use and for it to be tran,sported on UK roads was needed. The problem of whether to refit the old crane or install a new one was solved by doing neither and using an elevated flaskway with the transfer flask moved on a trolley. By using a specially designed low trolley the transport flask could be moved in and out of the building without changing the reactor hall doors and so avoiding the problem of asbestos. The fuel element was then transferred from the transfer flask to the transport flask using a water-filled tophat as shielding. The final link was a mobile crane to move the flask from the low trolley to the road transport vehicle. Design, manufacture and installation of the flaskway assembly were carried by Amec, the cask bogie assembly by Aquila.

Trevor then showed several pictures of the manufacture and installation of the defuelling equipment. However, during the installation more problems arose with the weather and flooding around Ascot, which is the presumed culprit for several electrical problems on the site! But in the end, clearance to defuel was given by all the regulators and other agencies involved and work began with active commissioning at the end of May/early June 2014. The Areva flask was approved and fuel removal began on 12th June. Then the weather struck again with the hottest day of the year making working on the flaskway uncomfortably hot!

Trevor showed a fascinating set of photographs of the actual defuelling operation, which was very successful – the highest operator dose was 20 μSv. The success was built on sound training and carrying out dummy runs. The fuel was transported to Sellafield on 18th July.

Trevor finished with a few lessons learnt: highly unlikely risks such as electrical failure can bite; having an enthusiastic, experienced team doesn't entirely compensate for age: good regulator interaction was important; and dummy runs were invaluable to provide confidence for team and regulators.

As mentioned there were many photographs and diagrams showing the defuelling and it is recommended that readers should peruse these on the website at:

http://www.iop.org/activity/groups/subject/nig/recent-events/page_63207.html

Geoff Vaughan is the Chariman of the IOP NIG committee.

Radiation Damage in Nuclear Graphite

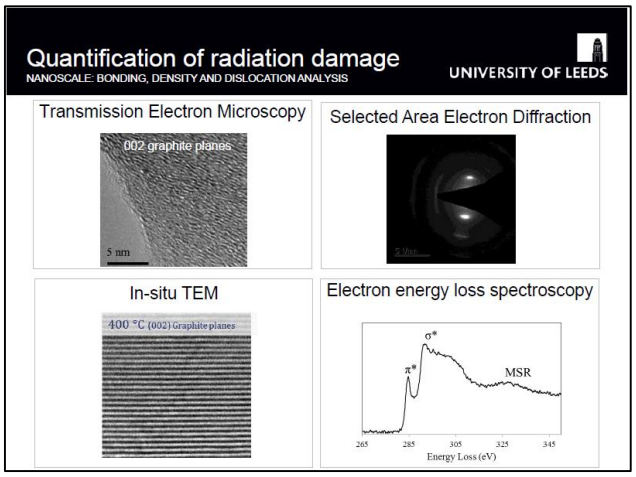
A report on the talk given by Helen Freeman of Leeds University

Geoff Vaughan

On 24th March, Helen Freeman gave a lecture on her PhD studies into the behaviour of graphite under irradiation. Given the long history of the use of graphite in nuclear reactors, for some 75 years, it is somewhat surprising that there is a still a need for fundamental research into how it behaves under irradiation.

Graphite has been fundamental to nuclear power since the days of Enrico Fermi's first pile in the squash court at Staggs Field in Chicago in 1942. Almost all UK reactors use graphite as the moderator and as part of the core structure; and modern developments of high temperature gas-cooled reactors will also use graphite. Hence the importance of understanding how the material changes under irradiation is a continuing issue as the lifetime of such reactors is primarily limited by the properties of the irreplaceable graphite. An accurate measure of its condition is necessary for determining economic performance and plant safety.

The research described used various techniques to investigate the atomic structure of graphite and on larger scales and how irradiation affected the material and influenced its chemical and physical properties. Graphite has a linear molecular structure with planes of six atoms in a hexagonal ring, held together by Van de Waals forces. Radiation damage disrupts this structure by either causing the hexagons to distort into rings of seven or five atoms or atoms to move into the space between the planes. These distortions affect properties such as dimensional expansion and contraction of the graphite, thermal conductivity, moderation and other physical properties that can affect the reactor core.



The manufacturing process was described as this introduced various features in the graphite that were important in understanding how irradiation affected the structure on both an

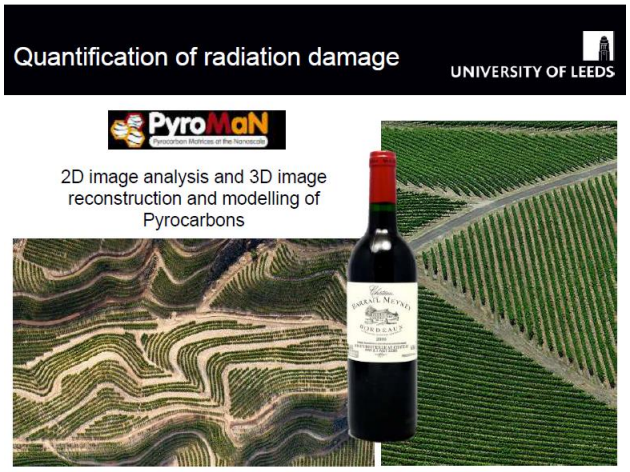
atomic scale and larger scales. In particular the introduction of dislocations and other defects was noted.

One of the techniques used was Transition Electron Microscopy. It was found that at the normal electron energies used in this technique, the samples were physically damaged so lower energies had to be used. However, as the damage from the lower energies was similar to that caused by irradiation, this provided a way of studying damage without needing irradiated samples which were difficult to obtain. An interesting sidelight was that a similar technique for analysing the results was used for improving the quality of French wine! It was found that there was no damage at temperatures up to 400°C, whereas previously it had been claimed that atomic mobility measurements implied that damage would occur at temperatures in the range of 100-200°C.

As well as damage due to irradiation, Helen also reported on measurements of the C-C bond length obtained from Electron Energy Loss Spectroscopy which disagreed with modelling predictions and indicated a possible breakup of the crystalline bonds

By using fluorescent material it had been possible to compare closed and open porosity and it had been found that there was more open porosity than closed. Voids affect graphite properties such as thermal conductivity, Young's Modulus, dimensional change, chemical reactivity and moderation coefficients. Investigations of cracks in graphite from BEPO (British Experimental Pile '0', which was commissioned in 1948 as the second UK nuclear reactor) had allowed a relationship between crack length and dpa (displacements per atom) to be determined. X-ray diffraction had shown the changes in length across and between the planes of atomic rings.

The results showed understanding had been gained on several aspects of graphite behaviour which could affect reactor operation such as: atomic displacements leading to expansion and contraction of graphite planes, increased tortuosity and length of graphite planes and changes in bonding; the breaking up of crystallites; and the formation of cracks and closure of cracks with swelling.



The talk had covered a wide range of measurements and properties of graphite under irradiation and the audience raised several questions and suggestions for further investigations such as the effect of temperature cycling.

Helen finished by acknowledging the various people in many countries who had helped her by supplying samples, software, time on their diagnostic facilities and that absolutely essential requirement – advice. The world-wide interest in graphite suggests that our knowledge will be less sparse over the next 75 years!

We wish Helen well with her PhD and future career.

The presentation from Helen's talk is available on the IOP NIG website: http://www.iop.org/activity/groups/subject/nig/recent-events/file_65390.pdf

Geoff Vaughan is the Chariman of the IOP NIG committee.

Hinkley Point C – Progress and Challenges

A report on the talk given by Dr Nigel Knee, EDF Energy

Geoff Vaughan

On 20 May, Dr Nigel Knee from EDF Energy gave an interesting and topical lecture on the progress with the nuclear station that EDF intends to build at Hinkley Point in Somerset. Hinkley is, of course, already the site of a Magnox reactor (decommissioned) and an AGR plant and was one of the sites the Government listed as available for new nuclear build. However, siting was only one of the issues that faced EDF in developing the project and Nigel gave some insights to these during his talk.

Nigel began by saying there were three reasons for developing nuclear power: to contribute to diverse electrical production; to keep the lights on by having a secure form of electrical production; to reduce carbon emissions. But this had to done in an affordable way. In 2013, nuclear contributed 18% to the UK electrical grid – twice as much as all renewables did. Around 4% came from interlinks with other countries and more of these were being developed. However by the mid-2020s there would be difficulties and Nigel showed a graph of predicted future requirements against existing plants and those under construction which indicated that the need for new construction. He commented that, without new nuclear, gas would fill the gap, but production of oil and gas from the North Sea has been falling for several years.

So the future need for nuclear power seems clear - but do the public agree? Nigel showed a series of surveys over the last 5 years which indicated between 60 and 70 percent of the UK population felt nuclear had to be part of the energy mix with only about 10-15% disagreeing. This was a fairly constant result with the dip after the accident at Fukushima-Daichii having only a small effect which soon disappeared. There was also strong political support, perhaps increased following the recent election.

Nigel then described some features of the Areva EPR design which is the design accepted for HPC. The site will consist of two reactors each of which will produce 1650 MWe (4500 MWth) which will account for ~7% of the UK power requirement. The design life is 60 years and all the spent fuel will be stored on the site. With some moving slides the way in which the heat produced by nuclear fission was turned into electricity was demonstrated. Photographs of the major components being fitted at the similar plant at Flamanville in France were shown and impressive figures on the scale of these components were given.

Safety is a key requirement of nuclear facilities and using the three basic Cs – control, cooling and containment – Nigel took the audience through the multiple safety features in the design. In each area there were three independent systems:

- Control: multiple rods; boric acid; and emergency boration.
- Cooling: Steam generators; safety injection; emergency feedwater
- Containment: fuel cladding; primary circuit; containment building.

A film showing the second function of the containment, prevention against external hazards was shown with an aircraft driven into a mock-up with little effect on its integrity.

Nigel also emphasised the scale of the project in terms of the number of jobs that will be created, the amount of concrete to be poured and fact that five million homes will receive power. However on a complex site there are many hazards to the workforce and having shown some photographs on the present state of work on the site, Nigel described some Values which EDF is promoting amongst its workforce. One issue on site was the uncovering of a Medieval burial site which had required archaeological investigation. There had also been a need to build a bat house and provide badger tunnels!

Recent issues had included defects in the forgings for major Flamanville forgings. These were still being investigated. EDF may not use the same company as was used for the Flamanville forgings but there are a limited number of companies worldwide that can produce major forgings.

Finally, Nigel spoke about the financial position and discussed the processes for agreeing the cost of electricity with Government and getting agreement with the EU in relation to State Aid. There was a challenge on this from Austria that should not hold-up developments. He also discussed the raising of finance from investors which included the Chinese Venture Company: this was complicated as the Chinese wished to be involved in Sizewell C (a sister station to HPC) and Bradwell (where they may suggest a Chinese design. He noted that the final decision on HPC had not yet been taken but expected this to be taken soon.

There was a lively question session after the talk ranging over a variety of technical, regulatory and financial issues. Eventually, the meeting closed after nearly 1½ hours - quite an effort from our speaker whom we take this opportunity to thank again for his presentation.

Geoff Vaughan is the Chariman of the IOP NIG committee.

Travels with a Cyclotron

A report on the talk given by Professor David Parker, University of Birmingham

David Tattam

The evening of the 9th of June saw a well-attended evening lecture on 'Travels with a Cyclotron' given by Professor David Parker. David has been at the University since 1989, and was awarded the IOP Joule Medal in 2008 for the development of Positron Emission Particle Tracking (PEPT).

David's talk focused on three areas, the history of the cyclotrons at Birmingham, some of the applications the cyclotrons, and then the tale of moving a cyclotron half way around the world.

There have been cyclotrons at Birmingham University since 1948, with the Nuffield cyclotron in operation up to 1999. The radial Ridge cyclotron was in operation between 1960 and 2002.

The MC40 cyclotron, which was purchase and shipped from Minneapolis, is currently in operation at Birmingham.

The cyclotron is the only one in the UK to manufacture ^{81}Rb – ^{81m}Kr generators in the UK which are used to image lungs by the use of a gamma camera. This production operation runs five evenings a week, 50 weeks a year, and runs with an amazing success rate of 97% - very

important when you are the only supplier of this imaging agent in the UK.

The cyclotron also plays a key part in Thin Layer Activation research, producing other radioisotopes for example ^{69}Ge for labelling oil, ^{62}Zn supplied to St Thomas' Hospital London and various exotic nuclides for NPL.

In addition the cyclotron is used for radiation effects studies of biological media, space electronics, and components for the ATLAS particle physics project.

The university has an active programme using the PEPT technology developed by David. This technology works by introducing a particle into a fluid system which has been labelled with a positron emitter (e.g. ^{18}F, made on the Birmingham cyclotron). When the positron annihilates with an electron, back-to-back 511 keV photons are emitted. By detecting the position and timing of when these photons arrive in the detector an accurate position can be calculated. This can be done multiple times a second, and so the particle can be tracked. This technique helps industry understand how powders and fluids mix, and even helps engineers understand how oil flows around an engine.

David then talked through the process of buying a cyclotron from the University of Minnesota and shipping it half way around the world to Birmingham. The process started with a sealed-bid auction; this way it was unknown how many other people were bidding, or how much they were offering!

Once the purchase was made, the hard part of the logistics began. To enable the lift of the cyclotron from below ground, through an exit hole in the roof, the hospital grounds were closed off and a large hole dug. The first problem quickly became apparent when it became clear that the hole was not large enough! This meant a bit of quick thinking, and the top part of the cyclotron was to be lifted at an angle which would just give enough clearance to remove it. When the crane moved into position it was noticed that the lifting hooks were the only item on the whole cyclotron not to be made in metric units! This meant that the whole lift would need to be cancelled unless the correct hook could be found; luckily one of the work men had the right size hook in his garage so the lift could proceed!

Once out of the hole, the cyclotron was packed into 40 boxes, which were shipped to the UK. The team at Birmingham put the cyclotron back together again in the radiation centre. From the first yoke being placed, to the first beam on target, took 12 months.

This was a highly enjoyable talk given by David covering the history of cyclotrons at Birmingham, giving a flavour of the research done, and the trial and tribulations of traveling with a cyclotron.

A copy of the slides in available on the Nuclear Industry Group web page: http://www.iop.org/activity/groups/subject/nig/recent-events/file_65955.pdf

David Tattam is the Head of Physics Group at GE Healthcare based on The Grove Centre site (at Amersham) and a member of the NIG committee.

Future Events

The NIG is pleased to announce the next few events in our calendar:

28 October 2015 - 'Farewell to MAGNOX' Wylfa Sports and Social Club, Anglesey

This year marks the end of an era — production of electricity by Magnox reactors will cease in the UK when Wylfa Reactor 1, the last of the UK's Magnox reactors, is shut down in December 2015.

In the 1950s, owing to the need for plutonium production for nuclear weapons, it was decided to build natural uranium, metal fuelled, gas cooled reactors. The fuel cladding was a magnesium non-oxidising alloy called Magnox and reactors of this type took this as the generic name. The first Magnox reactor, Calder Hall, was officially opened by the Queen in 1956 (*right*). As the reactor produced a lot of heat, it was decided this should be converted into electricity and fed into the grid – the **first time in the world** that a nuclear reactor was connected to a national grid.

Although the first reactors were devoted mainly for defence purposes, the use of this type of reactor for purely civil electrical production purposes soon followed and reactors were constructed at several sites in England, Scotland and Wales. The design was modified during the years, and the Wylfa reactors had the largest electrical output of the whole Magnox Programme.

The Seminar

In collaboration with Wylfa staff, the IOP Nuclear Industry Group together with the IOP History of Physics Group, have arranged this half-day seminar, to mark the closure of Wylfa. Presentations from a range of speakers cover the history and evolution of the design of Magnox reactors, their contributions to UK electricity generation, and the future of the Wylfa site.

Registration
This event is free to attend you can register online at:
https://www.iopconferences.org/iop/frontend/reg/tSelectBookingMode.csp?pageID=401006&eventID=812&tempPersonID=217286&eventID=812.

March 2015 (final date to be confirmed)– 'Nuclear Data' by Robert Mills of NNL Venue EDF HQ Barnwood.

Details of this evening event will be released closer to the event.

June 2015 (final date to be confirmed)– 'Geological Disposal' various speakers Venue Birchwood Conference Centre Warrington.

Details of this half day event will be released closer to the event.

19th - 24th June, 2016 COSIRES 13 (Note this this event is run by and hosted at Loughborough University, Loughborough, Leicestershire, UK with co-sponsorship from the IoP Nuclear Industry Group)

The 2016 Computer Simulation of Radiation Effects in Solids (COSIRES) is the 13th edition of this conference. The biennial conference is a major international forum to present and discuss the recent achievements in the advanced computer modelling of surface and bulk phenomena stimulated by all forms of irradiation.

The meeting concerns modelling radiation effect in many different materials but over recent years it has graduated towards nuclear reactor structural materials and has many participants from the French Nuclear Industry and National labs in the US such as LLNL and Los Alamos. There have been fewer participants from the UK Nuclear Industry in the past.

Further details of this even can be found on the event web site http://www.cosires2016.co.uk

September 2015 (final date to be confirmed)– 'Generation IV' by Richard Stainsby of NNL Venue Birchwood Conference Centre Warrington.

Details of this evening event will be released closer to the event

Items for the next newsletter – Submit an Article

We'd like to hear what you're doing, what you think of the Nuclear Industry Group, any ideas you may have for networking opportunities or anything else you think would be of interest to the rest of the group. We plan to publish our next Newsletter in early of 2014.

Please submit any articles and accompanying photographs or pictures to either Heather Beaumont (mailto:heather.beaumont@amecfw.com) or Geoff Vaughan (mailto:geoff.vaughan@physics.org) .

This newsletter is also available on the web and in larger print sizes.

The contents of this newsletter do not necessarily represent the views or policies of the Institute of Physics, except where explicitly stated. In addition the views and opinions stated in this Newsletter do not represent those of the organisations employing the article authors.

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