Prostate brachytherapy
Survey of practice in the UK and Ireland

MEDICAL PHYSICS
Learning from non-ionising radiation – an ultrasound tutorial

CLINICAL ENGINEERING
Identify design flaws using equipment fault reporting...

SPECIAL REPORTS
Visiting Chernobyl – site of the catastrophic reactor explosion
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Welcome to the final Scope issue of 2017! I would like to start by thanking all who have contributed to IPEM Scope magazine this year. Please do keep your contributions coming – we need these to ensure our readers are kept abreast of activities of other members, the National Office and also of any changes to national policies, regulations or new guidelines that affect our profession.

In this issue we have a special focus theme on public engagement. One of the IPEM projects that has been making a huge mark across the globe is the ‘Science for Patient Benefit’ campaign, which started out as a simple idea to engage with the UK’s medical physics and engineering profession. Sean Edmunds kindly highlights this important piece of work. The Public Engagement Panel (PEP) was set up 3 years ago with the aim of involving lay people in a proactive way in a wide range of the Institute’s activities. Sean provides background to the vital work whilst John Turner (Chair of the PEP) provides an insight to three new PEF members and their desire to join.

Our main feature article is on brachytherapy services – surveying the practices in the UK and Ireland. Thanks to Geraldine Workman for supplying the material. There is currently a general shift in practice away from the conventional methods to other methods, an important indication of how technology and new techniques are driving such changes in healthcare. For those centres planning to move in other directions, this work will provide a great reference.

Although progress has been made in developing ultrasound dosimetry, Professor Francis Duck emphasises in his excellent article that there is still more to learn from advances in other specialisms. Ultrasound has come a long way as a non-invasive technique and, in the last decade or so, there has been a lot of talk about ultrasound dosimetry. This article is a must-read for those wanting to push the boundaries of this specialty or who are interested in the historical aspects of ultrasound dosimetry. Centres looking to set up a clinical molecular radiotherapy dosimetry service may want to read the article supplied by the IPEM Working Party on this topic to advise centres in resourcing the service.

Are you interested in any of the NIHR training schemes? Are you planning to write the NIHR research application? In our Applied Academics section, Dr Ellen Donovan (the NIHR Research Training Advocate for Healthcare Scientists) provides the third much-needed instalment in the NIHR series, discussing the research training award application.

A few months back, at University Hospitals Birmingham, we introduced RayStation and we are now working on our second phase of project RayStation – automating our breast planning service. For those commissioning RayStation, I would like to refer you to an excellent users meeting earlier this year (see below).

We now have a new IPEM President, Professor Mark Tooley. Sean Edmunds has talked to our President about his career, his vision for the Institute and also his hobbies! Finally, if you do have any ideas for articles, tutorials, profiles, special reports or any new content, or even general feedback, please drop me an email.

Until next year, and enjoy!

Usman I. Lula (Editor-In-Chief) would like to acknowledge everyone who has contributed to Scope this year, and hopes to keep receiving more submissions in the future.
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TRUSTEE UPDATE

PUBLIC ENGAGEMENT PANEL

Engagement with the public

John Turner [Independent Trustee of IPEM and Chair of the Public Engagement Panel] hopes that all members are proud of their contributions towards public engagement.

Welcome to the December issue of Scope. I am one of the non-member Independent Trustees of IPEM and Chair of the Public Engagement Panel (PEP). It is in this latter capacity that I have the privilege of writing a few lines to introduce ‘public engagement’ as the theme of this quarter’s edition. I hope that once you have seen the articles on the following pages you will agree with me that IPEM has much to be proud of in this area. IPEM’s activities in this field have also attracted favourable comments from other professional institutions.

Reconnecting with the scientific community

Many years ago I completed a degree in physics before taking a completely different career path into chartered accountancy and, subsequently, investment banking. I retired from the City just over a year ago and now have a small portfolio of non-executive and consultancy positions in the charity and not-for-profit sector, including two professional membership organisations. I was invited to join the Board of IPEM in September 2016 in succession to Danielle Ross, who stepped down after the completion of her 3-year term of office. She was also the first Chair of the PEP and thus imparted it with its momentum and future direction of travel.

I have really enjoyed reconnecting with science, even if many of the technical matters that members and fellow Trustees write and talk about go over my head! For me, the PEP is an excellent way of gaining a better understanding of your profession and the hugely diverse range of activities and research that it covers. Over the course of the last few months it has been a privilege to meet and work with first-class professionals, both on the Board and in the Executive Office, who have had the patience to bring me up to speed on various matters and help me wade my way through the baffling alphabet soup of acronyms.

IPEM currently has two designated non-member Trustees and the current Honorary Treasurer is also not a member. The Board acts collectively; that is, all members of the Board have joint responsibility and all Trustees (who in law are directors) have the same rights and obligations. The Independent Trustees’ role is to provide an external, objective and independent viewpoint in Board meetings by drawing on the relevant experience we have gathered from our own working lives in commerce, finance, higher education and general management. Our contributions therefore tend to be on matters of strategy, performance and governance – and, in my case, public engagement – as opposed to matters in which we have insufficient relevant knowledge, such as science and technology.

The PEP is an excellent way of gaining a better understanding of your profession and the hugely diverse range of activities

All professionally active members of IPEM engage with the public to some degree by (a) explaining to the public in general, and patients in particular, what medical physicists and clinical engineers do on a daily basis, and (b) stimulating interest in STEM subjects in general with the hope that talented young people will be encouraged to join the profession.

As a collective body representative of the profession, one of IPEM’s strategic objectives is to strengthen public engagement and influence decision makers. At this level the engagement needs to be two-way; for example, collate the public perspective on, say, policy matters or communications material produced by IPEM. Beyond the common sense view that such engagement can only be good for the profession in the long term, it also helps deliver IPEM’s charitable aim (“To promote for the public benefit the advancement of physics and engineering applied to medicine and biology, and to advance public education in the field”).

The PEP is a relatively recent initiative of IPEM, being set up almost 3 years ago. It was designed as an additional resource to supplement previously established means of engagement carried out by the organisation and consists of a dozen or so non-IPEM members (like me, they are independent) recruited directly through public advertisement (you will meet three of our new members on page 14). The number of PEP members is thought to be a reasonable compromise of being as representative as possible without making it too difficult to co-ordinate. We meet formally twice a year but many of the activities are undertaken between meetings. We report directly to the Board and are independent of the Executive Office but we do work closely with them and in particular with the External Relations Manager, Sean Edmunds.

Sean’s article on page 12 describes in more detail the panel’s aims and some of its wide range of activities to date. In further articles you will read about the 2017 Roy Ellis Patient Benefit Award and IPEM’s involvement in the Sense About Science campaign.

If you have any thoughts or comments on the subject, please engage with me!

Email any comments on this article to Johnturner@hotmail.com
YES, IT’S SMALL AND NON-MAGNETIC

The launch of the new non-magnetic design allows the 3880 to operate safely in a 30,000 gauss magnetic field without the need for a heavy roll cart used by traditional MRI monitors.
IPEM NATIONAL OFFICE UPDATE

EXTERNAL SERVICES

External relations

Sean Edmunds [External Relations Manager] gives an overview of his area involving member communications, policy activity, media liaison and other external engagement.

If you read the monthly IPEM newsletter, glance at the Policy Update page in Scope, have a Science for Patient Benefit poster proudly on display in your department or have ever been approached by the National Office to give a quote on a story running in the media, then that gives you a flavour of the External Relations Manager’s role.

Communicating with you, our members, is an essential part of the job. As the life-blood of the organisation, it is vital that IPEM keeps you informed about key decisions, major announcements and provides pertinent information about the wider science and engineering community.

Such communications take a variety of forms and involve careful thought and planning on the right channel to use. If something is really important and is felt to be crucial for you to know about, then an all-member email is the best way to reach all 4,500 of you in one go.

Communicating the news

A common cry heard everywhere nowadays is that people receive too many emails. To help reduce the number of emails you receive from IPEM, part of my role is to carefully plan with colleagues in the National Office about when we send out all-member emails so that you are not swamped by us.

The monthly e-newsletter is a crucial channel in helping to disseminate information. I write the newsletter from a variety of sources to provide a balance of how the Institute is working for you and to also share news from across a broad range of organisations.

The IPEM website, Twitter feed and LinkedIn pages are also key ways of communicating with you. Along with my colleague Eva McLean, the Institute’s Communications and Development Manager, we keep the website and our social media outlets fed with stories regularly, so please do remember to look at them whenever you can.

The second biggest strand of my role is that of policy activity, as it is vital that you are involved in what we do. As the Institute’s strategic objectives state, we want to influence and engage with national and international bodies and key decision makers, and one way we can achieve this is by responding to consultations.

I try and ‘horizon scan’ for those which I think are of particular relevance for IPEM to respond to and liaise with various Special Interest Groups to draft suitable responses from the Institute. This can encompass responding to Select Committee inquiries of the UK Parliament and also to consultations from the Scottish Government and the Welsh and Northern Ireland Assemblies, plus other public bodies such as NHS England.

I’m always on the lookout for new speakers, so if you want to volunteer to give a talk to a mixed audience then please do get in touch!

Liaising with the media

I also write the Policy Update for Scope, which not only involves recording the consultations that have been responded to but also informing you about the influential meetings and workshops that have been attended as well.

Policy work also involves liaising closely with partner organisations and other charities that IPEM supports, such as the Campaign for Science and Engineering (CaSE) who actively lobby on behalf of the whole science and engineering community.

Media liaison falls within my remit and I work with the Science Media Centre on major reactive stories where we can add value or clarify a point. When we have a member who has done something newsworthy, then as well as writing about it for the website and the newsletter, I liaise with the communications department at their NHS employer, university or company to share that news with them so that hopefully they will use it too.

Promoting the work of the Institute externally also involves raising its profile and the Science for Patient Benefit campaign was an excellent way of doing this. The fact that the campaign has gone global and is being adopted and adapted to cover many other aspects of healthcare science is testament to the fantastic support it received from you.

The Public Engagement Panel is a valuable resource, which I try and involve as often as I can as a sounding-board and ‘sense check’ when producing, for example, the popular ‘The Science & The Scientists’ leaflet series.

I also manage the public lecture programme, which is a great way to showcase the work of members. I’m always on the lookout for new speakers, so if you want to volunteer to give a talk to a mixed audience then please do get in touch!

As you can see, the External Relations Manager’s role is wide-ranging, varied and never dull, something I’ve come to learn and appreciate in the 18 months since I joined IPEM.

Email any comments to Sean@ipem.ac.uk

Scope welcomes your feedback! #IPEMScope, @IPEMScope
Sean Edmunds, the Institute’s External Relations Manager, summarises members’ involvement in influencing policy across the UK on behalf of IPEM

The implications and ramifications of the Brexit vote continue to dominate not only the news headlines but also much of the recent consultation and policy work undertaken by the Institute.

A special Brexit page has been created on the IPEM website, under the News and External Affairs section, to pull together much of the work that members have been involved in with regards to this.

IPEM Fellow Sarah Allen, Head of Nuclear Medicine at Guy’s and St Thomas’ NHS Foundation Trust, joined a working group set up by the Institute of Physics earlier this year to ensure the best outcomes for physics when the UK leaves the EU and Euratom. She will share her knowledge and expertise with regards to the issue of medical radioisotopes and the working group is expected to span the period of the Brexit negotiations.

The Institute, along with 11 other scientific member organisations, funded a new policy officer for the Campaign for Science and Engineering (CaSE), of which IPEM is a member. The 2-year role will see James Tooze involved in all aspects of policy analysis and development concerning the science and engineering community and Brexit.

Members of the Radiotherapy, Radiation Protection, Diagnostic Radiology and Nuclear Medicine Special Interest Groups, together with the Radiotherapy Professional Standards Group, produced an extremely comprehensive and detailed response to a Department of Health consultation on the regulations for the transposition and implementation of the medical exposures aspects of the European Council Directive 2013/59/Euratom.

Staying with Euratom, IPEM’s Radiation Protection Expert/Medical Physics Expert task group provided a briefing, in the members’ area of the IPEM website, on the requirement for all EU member states to recognise RPEs and MPEs under the Basic Safety Standards Directive by February 2018.

In the summer, the Government commissioned the Migration Advisory Committee (MAC) to advise on the economic and social impacts of the UK’s exit from the European Union and also on how the UK’s immigration system should be aligned with a modern industrial strategy. The MAC launched a call for evidence to identify the sort of information it would find most helpful to receive during the initial phase of its consideration of the Government’s commission.

In response to this call for evidence, IPEM’s Workforce Intelligence Unit produced a survey which was sent to Heads of Departments in the NHS, seeking tangible data on the percentage of EU and non-EU overseas workers in their departments to identify how great an impact the potential loss of these workers would be. At the same time, the survey was also sent to members working in academia and in industry to seek their views on the added value that overseas workers in all three sectors – healthcare, academia and industry – bring in terms of their experience and skills to the UK market.

Away from matters concerning Brexit, a working party of the Radiotherapy SIG, comprising of David Eaton (Chair of the RT SIG), Leila Shelley, John Byrne, Katie Hutchinson and Rosemary Hakes, produced a new policy statement on the roles of the scientist and technologist in radiotherapy physics.

David Eaton also attended a radiotherapy event at the House of Commons on behalf of IPEM, which brought together stakeholders from the NHS, patient and professional groups, the Department of Health, MPs and peers to consider the benefits of radiotherapy and the next steps to take across the UK.

Rosemary Cook, IPEM’s Chief Executive Officer, spoke at the launch of the Royal Academy of Engineering’s report on ‘Creating cultures where all engineers thrive’, which aims to create a more inclusive culture to attract and embrace a more diverse workforce.

Earlier this year, NHS England commissioned the development of an ‘Improving Clinical Engineering and Physical Science Services Accreditation Scheme’ (ICEPS), which is now simply known as Medical Physics and Clinical Engineering (MPACE). IPEM is working with the UK Accreditation Service (UKAS) on the standardisation of the accreditation of healthcare science services. A Technical Advisory Committee has been established by UKAS and it is chaired by former IPEM President, Dr Peter Jarrett.

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At the time of writing, IPEM was working on responses to a number of other consultations, including the Department for Business, Energy & Industrial Strategy consultation on the Building our Industrial Strategy Green Paper, a Scottish Government consultation on the National Health and Social Care Workforce Plan, and the Higher Education Funding Council for England consultation on the second Research Excellence Framework. A full list of all consultations and IPEM’s responses can be found on IPEM’s website under News & External Affairs.

THE INSTITUTE’S EXTERNAL RELATIONS MANAGER SEAN EDMUNDS

Email any comments on this article to Sean@ipem.ac.uk
Sean Edmunds [IPEM’s External Relations Manager] explains how the Science for Patient Benefit campaign has spread across the world – and how it is spreading to embrace other areas of healthcare science.

What started out as a simple idea to invigorate the UK’s medical physics and engineering profession and gain staff the recognition they deserve amongst their hospital peers has grown into a campaign which is slowly spreading across the world – and to the rest of healthcare science.

‘Science for Patient Benefit’ was something Professor David Brettle, former President of IPEM, thought would resonate with both staff and patients alike.

As Head of Medical Physics and Engineering at Leeds Teaching Hospitals NHS Trust, Europe’s largest teaching hospital, Professor Brettle said it was almost as though medical physicists and engineers were an invisible army of workers.

The launch of the campaign

‘Before the Science for Patient Benefit campaign began, I would walk around a hospital and have no idea who the medical physicists and engineers were. I thought we needed something to rally round, almost a flag to follow, and that was really where the idea for the campaign came from,’ said Professor Brettle.

The germ of Professor Brettle’s idea, conceived at the beginning of his Presidency in September 2015, slowly became a reality over several months as IPEM strived to ensure all aspects of its members’ areas of work were incorporated into a vibrant, eye-catching campaign with one simple message – that without physics and engineering there would be no modern healthcare.

IPEM’s Trainee Network and the Institute’s Communications Committee came up with designs for a poster. An illustrator was brought on board to produce simple, yet effective artwork to demonstrate the crucial role that medical physics and clinical engineering plays in delivering a safe, effective and modern healthcare service to patients.

Backing for the campaign was also given by both the Chief Scientific Officer for NHS England, Professor Sue Hill, and the President of the Academy for Healthcare Science, Dr Brendan Cooper. Professor Hill said: ‘The Science for Patient Benefit campaign highlights the amazing contribution scientists, medical physicists, engineers and technologists make to patient care daily through the diagnostic, therapeutic, rehabilitative and innovative services they provide. This inspiring initiative will demonstrate their critical role in delivering a modern healthcare service.’

Dr Cooper also added: ‘This excellent initiative from IPEM highlights the essential role of the healthcare scientist as a vital part of the healthcare team. British healthcare is the envy of the world because we have a heritage of high-quality scientists supporting all aspects of clinical work – diagnosis, treatment and monitoring. Behind every good doctor and nurse there is a great scientific team – and medical physicists, engineers and technologists are the epitome of this teamwork.’

Finally, in June 2016, the campaign was ready to launch, with the Science for Patient Benefit posters, pens bearing the campaign name, lanyards for hospital staff and pop-up banners for use at open days and events being produced.

The actual launch itself demonstrated why the campaign was sorely needed. While patients and members of the public took an
interest in the Science for Patient Benefit stand at the hospital, it was the staff themselves who were genuinely the most intrigued to realise that they had colleagues working alongside them carrying out this vital role.

IPEM members right across the UK, from Aberdeen to Exeter and Londonderry to Swansea, responded to the call to get involved. Initially, some 70 members came forward, volunteering to be the Science for Patient Benefit ‘champion’ at their hospital, and today members still continue to get in touch to request the campaign materials for use.

A social media campaign has spread the message further, with lots of activity on Twitter, and a special campaign webpage set up on the IPEM website has been visited by more than 1,000 people since its launch.

‘I visited a hospital recently and suddenly I could spot all the medical physicists and engineers because they were all proudly wearing the Science for Patient Benefit lanyard,’ commented Professor Brettle.

**Spreading the word across the globe**

It was at the first European Congress of Medical Physics (ECMP) held in Athens in September 2016 that the campaign began to spread overseas. Delegates at the Congress snapped up the limited number of campaign posters which were on the IPEM stand and Professor Brettle talked about it during his address to the European Federation of Organisations for Medical Physics (EFOMP) Council at the ECMP, where it was hailed as a ‘brilliant idea’.

To build on the momentum following the ECMP, Professor Brettle wrote to Professor John Damlakis, President of EFOMP, and Professor Slavik Tabakov, President of the International Organization for Medical Physics (IOMP), to seek their support to help spread the campaign internationally.

Their response was a resounding ‘yes!’ EFOMP wrote to its National Member Organisations across Europe to let them know that they could request the poster artwork from IPEM to translate into their own language. To date, the posters have appeared and been translated in many European countries, including Belgium, the Czech Republic, Croatia, Greece and Malta.

The campaign has gone even further afield than the UK and Europe. An IPEM member in South Africa, based in the Medical Radiation Department of iThemba Labs in Cape Town, requested the poster. To help celebrate the International Day of Medical Physics last year, delegates attending the Conference on Radiation in Healthcare in Jaipur, India, carried the Science for Patient Benefit posters in a rally through the streets of the city after the organisers contacted IPEM requesting the artwork. Campaign posters, and other IPEM posters, were printed locally and used in the rally.

**Raising the profile of the profession**

The campaign is also making in-roads in Malaysia, thanks to contacts between IPEM and colleagues in hospitals working there, where the number of medical physicists is very low. Raising the profile of the profession helps to highlight the need for more of these scientists to improve patient services.

The Academy for Healthcare Science has also adopted and adapted the Science for Patient Benefit campaign to embrace other areas of healthcare science under its ‘One Voice’ banner.

It is hard to believe that in just 18 months, Science for Patient Benefit has gone from being launched in a hospital in Leeds to now being recognised around the world – and bringing recognition to the crucial role that medical physics and engineering play in delivering modern healthcare.
INCE THE PUBLIC ENGAGEMENT PANEL (PEP) was set up almost 3 years ago, its members have been involved in a variety of activities, from judging awards and commenting on IPEM publications to visiting hospital radiotherapy departments.

The initial idea of IPEM’s Trustees for the PEP was for it to involve ‘lay’ people – those from outside of the membership professions – in a proactive way in a wide range of the Institute’s activities. By involving lay people in IPEM it also helps to deliver on the Institute’s charitable objective to advance public education about physics and engineering applied to medicine.

The Panel has four main aims:

- To help ensure that IPEM’s strategy and activities are focused on achievement of its charitable objectives.
- To improve IPEM’s engagement and communication with public audiences.
- To bring a public perspective to inform IPEM’s policy responses, regulatory activities, contribution to education programmes and policy debates, and so on.
- To link with other public engagement bodies in the fields of healthcare and science, as appropriate.

The Panel reports directly to the Board of Trustees via the Independent Trustee who chairs it, and the current incumbent is John Turner (see page 6).

Member and Panel involvement
Several IPEM members have given talks and presentations to the Panel on a variety of topics. Kevin Alty, who at the time was a Trainee Medical Physicist at Castle Hill Hospital in Hull, talked about his route from being a teacher to becoming a medical physicist. Also from the Hull and East Yorkshire Hospitals NHS Trust, Jenny Marsden, Higher Principal Physicist, talked to the Panel about women in STEM careers.

Two other notable members to address the Panel have been Professor Peter Sharp, former IPEM President, who talked about the European Federation of Organisations for Medical Physics (EFOMP), of which he was the immediate past President, and Professor Paul White, former Vice President Industry and the current Healthcare Scientist of the Year, who talked about his

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Public Engagement Panel

IPEM’s Public Engagement Panel is almost 3 years old. Sean Edmunds (IPEM’s External Relations Manager) takes a look at what they have been involved in
pioneering work on the clinical engineering aspects of non-beating heart donors.

Earlier this year, several members of the Panel went on a visit to the radiotherapy department at St James’s Hospital in Leeds to see for themselves the work of the medical physicists and clinical engineers there.

Panel members have also become directly involved by sitting on a number of other panels. Two members joined the management panel of the Register of Clinical Technologists (RCT) and several other members are part of IPEM’s Internal Audit Panel, having undertaken appropriate training courses. One member also recently joined the IPEM/UK Accreditation Service Medical Physics and Clinical Engineering (MPACE) Technical Advisory Committee.

Providing expertise to publications and awards

A major area that PEP members have been involved in is providing comments and views on various IPEM publications and the Science for Patient Benefit campaign.

Valuable and insightful comments have been made on ‘The Science & The Scientists’ leaflet series, especially with regards to the ultrasound and the rehabilitation engineering on special wheelchair seating leaflets. Members also provided comments on the RCT leaflet and on the Science for Patient Benefit campaign poster, as shown below.

There was also a very lively and wide-ranging discussion amongst Panel members when it came to commenting on the IPEM strategy and their comments were taken into account by the Board of Trustees when the strategy was agreed last year.

PEP members have also been involved in judging entries for some of IPEM’s own awards, as well as for external awards. Three Panel members helped with judging for the Roy Ellis Patient Benefit Award, which this year was awarded to IPEM members Dr Jonathan Ashmore and Dr Cormac McGrath for an app they developed for Android and iOS to prepare paediatric patients at King’s College Hospital and the Royal Belfast Hospital for Sick Children for their upcoming MRI scan. They also helped to judge the Spier’s Award for Outreach, which was this year presented to Elizabeth Kapasa.

In 2016, two members of the Panel helped in judging the entries for the Advancing Healthcare Award for the IPEM-sponsored ‘Patients as Partners in Science’ category, which was won by Trainee Cardiac Physiologist Stephanie Smith and her colleague, Principal Cardiac Physiologist Stuart Allen, of the Manchester Heart Centre.

As you can see, the Public Engagement Panel has a wide-ranging role and its members provide extremely valuable contributions and insight on many areas of IPEM’s work.

THE INSTITUTE’S EXTERNAL RELATIONS MANAGER
SEAN EDMUNDS

Sean promotes the work of the Institute internally and externally

Email any comments on this article to sean@ipem.ac.uk

Science for Patient Benefit

DID YOU KNOW?

A team of at least two physicists is involved in planning for your radiotherapy treatment.

The three-dimensional images made by sending pulses of high-frequency soundwaves into the body – ultrasound – help doctors determine how far the tumour has spread. The sound bounces off the tissues and different tissues reflect varying degrees of sound and these echoes are turned into a picture of a ‘slice’ of the body. It works like radar, only using sound instead of radio waves.

Almost every hospital department has its own ultrasound machine. As well as the most commonly known usage for checking the health of babies in the womb ultrasound is also used for breast screening, monitoring blood flow to the heart by echo, and looking deep within the body. Ultrasound is also becoming a useful tool in treatment, such as for removing gallstones. Ultrasound is also regularly used in conjunction with other imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI).

Without physics and engineering there would be no modern healthcare

DO YOU KNOW?

Medical physicists, clinical scientists and technologists provide scientific, safety, quality control and technical expertise on the use of ultrasound. They ensure the best quality images are obtained.

Seeing inside the body with ultrasound

Almost every hospital department has its own ultrasound machine. As well as the most commonly known usage for checking the health of babies in the womb ultrasound is also used for breast screening, monitoring blood flow to the heart by echo, and looking deep within the body. Ultrasound is also becoming a useful tool in treatment, such as for removing gallstones. Ultrasound is also regularly used in conjunction with other imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI).
Meet the new PEP members

John Turner [Chair of the Public Engagement Panel] welcomes some of the latest additions to the Panel, who are already involved in many areas of IPEM’s work.

IPEM’S PUBLIC ENGAGEMENT PANEL (PEP) is a new network of volunteers who are not part of the health-related physics, engineering or technologist professions, and not members of IPEM. We look to this network to bring a wider perspective to the work of the Institute. Here, three new members explain why they applied for the positions and wanted to get involved.

**Griselda Goldsbrough**
As Arts Development Manager at York Teaching Hospital NHS Foundation Trust, I guide a team where our main aim is to provide a varied, ongoing programme of artistic enhancements to improve the environment of our hospitals for patients, visitors and staff. I believe the arts have the ability to enhance the convalescence process, both supporting and promoting mental wellbeing.

I also work part-time as an education consultant, advising, devising and creating participative projects for the arts, museums and heritage sectors, in engaging new audiences and communities. I am a freelance visual artist where my artistic practice is primarily concerned with the relationship between, and in the engagement of, the arts, health and sciences.

I wanted to become involved with IPEM as I have a keen interest in scientific research and the presentation of it, new technologies and methods that improve current medical treatments and also to gain a clearer picture of the work that is currently undertaken. I hope to offer experience, advice and understanding in a variety of audience and public engagement programmes and activities.

I am an enthusiastic advocate for enabling science to be better understood and I have already attended an IPEM engagement meeting, reviewed content for ‘The Science & The Scientists’ leaflets and judged on two of IPEM’s prizes and awards.

**Helen King**
I am currently combining work as a freelance writer and education consultant with finishing my MA in technical communication and e-learning.

I have worked in education and training roles for more than 20 years, developing and writing about everything from short day courses for florists to new trailblazer apprenticeship programmes for maintenance engineers. Although most of my work is in education, I write and edit for other organisations too.

The IPEM PEP member recruitment advert really caught my eye as it asked for experience of education, outreach work and communication, and invited applications from current students. I met all of the criteria and am interested in healthcare so I applied! I was pleased to be invited to join the panel and attended my first meeting back in April.

Since then, it was a privilege to be one of the judges for the Spiers’ Prize for Outreach and the Roy Ellis Award for benefiting patients. The standard of entries was incredibly high and it was great to see so many innovative uses of technology for both categories.

I have also contributed to editing a new leaflet about designing customised seating for wheelchair users for ‘The Science & The Scientists’ leaflet series. I also joined IPEM staff and other PEP members for a behind-the-scenes visit to the radiotherapy and nuclear medicine department at St James’s University Hospital in Leeds.

It is fascinating to have an insight into IPEM’s communication and education work and I’m looking forward to contributing to more projects in the future.

**Howard Widdall**
Since graduating with a BSc (Hons) in Environmental Sciences in 1980, I have spent my whole career working in the medical devices and healthcare industry sector in sales, marketing and general management roles. I have occupied senior executive positions in a multinational organisation and in a UK SME.

Before retiring at the end of March 2016, I spent the previous 7 years as Sales and Marketing Director of a Sheffield-based company which manufactures and supplies joint replacement implants. My entire career has been involved with products and technologies which bring benefits to patients and I have, as a result, developed and still maintain a strong interest in science, innovation and research aimed at improving medical technology and patient treatment outcomes.

Post retirement I have been keen to continue this involvement and interest through voluntary work, and participating as a member of the IPEM PEP is one way that I have been able to do this.

Since joining I have attended PEP meetings, undertaken audit training and conducted an internal audit of one of IPEM’s policies and its associated procedures, provided feedback on the wording of IPEM’s entry to the Third Sector Awards for the Communications Campaign of the Year and on the format and content of the latest leaflet in ‘The Science & The Scientists’ series. I have also joined the UK Accreditation Service/IPEM Technical Advisory Committee (TAC) as a lay member. The TAC is tasked with developing an accreditation scheme for clinical engineering and physical sciences services.

Email any comments on this article to Johnturner@hotmail.com
Evidence-based policymaking

Anastasia Skamarauskas (Communications Officer, Sense about Science) works to ensure that public interest in sound science is taken into account when making policy decisions.

**Evidence matters**
The idea of a ‘post-truth’ public has been thrown around increasingly over the past 18 months; a sense that the public at large don’t care about evidence and don’t want to hear from experts especially when it comes to policy. At Sense about Science, our day-to-day experience with everyone from patients to teachers and parents challenges that idea. Late last year, we sought to show politicians that the public does care about evidence-based policymaking and expects it from their government. Over 100 people from across the UK and all walks of life came to parliament; 15 of them stood up and told their story of why evidence matters to them. They also stated three expectations:

- We expect the government to use evidence when making policy.
- We expect ministers to explain their reasoning.
- We expect parliament to seek and to scrutinise reasoning behind policies.

We took this powerful message to Brussels in June, when citizens from across Europe came to the European parliament to stand in front of MEPs and commissioners. A Dutch dairy farmer, a Romanian teacher and a Bulgarian surfer were just some of those who told their representatives why evidence matters. They were supported by many more citizens, including members of our Voice of Young Science network (VoYS), one of whom spoke about why evidence matters in her work to engage school children in Ghana with science. These events are just the start of conversations between members of the public, ministers, parliamentarians and officials about the importance of evidence in policymaking.

**Transparency of evidence**
In order for the public to fully engage with policy proposals it needs to be clear what the government is trying to do, and why. We need to see the thinking behind policy, what we’ve been calling the government’s ‘chain of reasoning’. Before we can assess the merits of policy or the quality of evidence it may (or may not) be based on, we need to see what evidence has been considered at all – we need transparency of evidence. This is important if researchers are to evaluate and improve the evidence that policy is based on.

Last year, we assessed 12 months of government proposals. Our report, ‘Transparency of Evidence’, highlighted good and bad practice across departments and showed clear, often simple ways to improve. This year we are scoring departments on how transparent they are about the evidence behind policy proposals.

**Ask for Evidence**
The Ask for Evidence campaign empowers and encourages people to ask for evidence behind advertising claims, newspaper articles or policy proposals. This is a key campaign for Sense about Science across Europe. To show how it’s done, when our EU Director Sofie Vanthournout heard about a debate on a digital ‘age of consent’ in the Flemish parliament, she asked on Twitter her MEP and the MEP behind the proposal about the evidence. They talked about the trade-offs when making decisions about age restrictions and it was illustrated that the
The responsibility of researchers

By engaging people in policy, we see it as the responsibility of researchers and the evidence movement to empower the public to ask the right questions; those that give more reliable answers. The nuance of decisions, trade-offs between policy approaches, risks put into context, should not be hidden from the public or debated only in closed committees. By helping people ask scientific questions and take a critical approach, we can enshrine the value of evidence-based decision making at every level.

Proposal was about a general commitment to tackle the dangers for children on the Internet, rather than an imposed ban based on age. A simple question resulted in an engaged discussion about the evidence and explored the reasoning behind the policy.

Whilst getting to the evidence isn’t always so easy, the more we all ask about the evidence behind policy, the more people with power will expect to be asked and held to account. During the recent parliamentary General Election, VoYS member and Sense about Science intern Emily Parr asked the Conservative, Labour and Liberal Democrat parties about the evidence behind claims in their manifestos. It wasn’t easy to get to the evidence and Emily had to do some investigating on her own.

The evidence wasn’t always conclusive but Emily was encouraged to see lively debates with evidence being discussed. In her words, ‘Political parties will only feel the responsibility to make their evidence public if voters start asking them for it’. It’s essential to encourage and foster that questioning attitude in the next generation and our recent update of the Ask for Evidence lesson plan brings the principles of the campaign (asking for and evaluating evidence) to 13–16-year-olds.

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THE WINNERS OF THE Roy Ellis Patient Benefit Award for 2017 were Dr Jonathan Ashmore and Dr Cormac McGrath for an application they developed for Android and iOS to prepare paediatric patients for their upcoming MRI scan.

How the app came about

We developed a free app to help children who are scared and anxious about having an MRI scan. A team from King’s College Hospital and the Royal Belfast Hospital for Sick Children used their experience to develop this resource, which is now attracting interest from around the world.

It started in early 2016 when the Neuroradiology Department at King’s College Hospital was approached by the Trust’s play specialist team who were looking to obtain photos of the scanner for use in preparing paediatric patients. Coincidently, at the same time I had been ‘playing’ with a newly acquired Christmas present, a 360° camera, and trying to capture footage from within the scanner bore the idea of using it for patient preparation. The play specialist team jumped at the chance of having this resource and so the project of using the 360° video to create a full virtual reality MRI experience began.

The benefits of preparing children for an MRI is well known and studies have shown that around 47 per cent of children between 5 and 6 require a general anaesthetic for their scan, a figure that is reduced to 27 per cent if appropriate preparation is used. In response to this, there have been numerous resources developed to prepare children for MRI, ranging from simple picture books to life-sized inflatable and complete replica scanners. However, it seemed that a virtual reality solution could be extremely cost effective (Google cardboard-style virtual reality headsets can now be purchased for under £5) and could be used anywhere in the hospital or even at home by both a child and their parents.

In April 2016, initial results were presented at the IPEM Fetal, Neonatal and Paediatric MRI conference in Leeds. The team from Belfast attending the meeting thought that the idea could help children at their site as well, and so the collaboration grew, a great testament to how IPEM meetings can help bring people together.

The app with a VR headset in action, demonstrating the equipment and what the child sees
Eventually, a team of physicists, play specialists and radiographers from Belfast and London and an app programmer from King’s College London came together to develop an app which, when used with a virtual reality headset and a standard mobile phone, allowed children to feel as though they were inside an MRI scanner and experience what it would be like. To accompany the app, we also developed an MRI preparation book showing the full journey with clickable links to load the 360° videos from YouTube, which can also be displayed on a virtual reality headset.

The app has been extremely well received. The effectiveness of the app was rated via feedback questionnaires from 23 patients (aged 4–12) and 10 members of staff. Unanimously, it was thought to have had a positive impact, and children seemed to find it enjoyable, informative and genuinely helpful in relieving their anxieties. One child even exclaimed, ‘I can’t wait for my MRI scan!’ Even though the app is targeted at children, an unexpected outcome was the impact on parents, who said that the app made them feel much less anxious about their child’s scan. It has also been used to avoid the need for patients to be anaesthetised during the scanning.

Since the app’s release, there have been queries from around the world from sites wanting to recreate the experience. The most commonly asked question asked is, ‘How did you film inside the scanner?’ Besides some minor projectile effects (overcome by fixing a Samsung Gear360 camera to a phantom), we were able to capture footage whilst the scanner was on.

Future development
Apps are currently available for the King’s College Hospital and the Royal Belfast Hospital for Sick Children MRI units and are soon to be released for Raigmore Hospital in Inverness. There is continued interest from other NHS Trusts and for other patient journeys. The filming for one such journey, a patient going to theatre for surgery, is already underway.

Costs for the project included the 360° camera and a number of headsets and in total amounted to under £400, which was initially funded by hospital charities and research budgets.

The app is available for free download from the Google Play Store or Apple App Store under the names ‘My MRI at King’s’ or ‘Virtual Reality MRI’ for the King’s and Belfast versions.

MRI PHYSICIST
DR JONATHAN ASHMORE
Winner of the Roy Ellis Patient Benefit Award 2017, along with Dr Cormac McGrath

Email any comments on this article to jonathan.ashmore@nhs.net

> AFFILIATION
Dr Jonathan Ashmore is an MRI Physicist at King’s College Hospital NHS Foundation Trust in London

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GOLD MEDAL AWARDS have been presented to IPEM members who have made outstanding contributions in their fields of work.

The IPEM prizes and awards programme, which was fully updated 2 years ago, introduced Gold Medal awards for IPEM members who have made outstanding contributions in academia, innovation and healthcare, as well as recognition for the achievements of early career members.

Academic Gold Medal
Professor David Lurie, School of Medicine, Medical Sciences & Nutrition at the University of Aberdeen, was presented with the Academic Gold Medal.

An IPEM Fellow, Professor Lurie has devoted his research to the development of magnetic resonance imaging (MRI) technology and its applications, primarily in biomedicine. The early work by Professor Lurie and his team included, in 1988, the first use of dynamic nuclear polarisation in MRI, in a method called proton-electron double-resonance imaging (PEDRI), for imaging the distribution of free radicals in biological samples. His PEDRI paper has been cited 151 times.

He has continued to innovate in the field of MRI, including ‘continuous-wave’ MRI of solid materials. During the last decade Professor Lurie has developed fast field-cycling MRI (FFC-MRI); by measuring relaxation as a function of field strength, extra information can be obtained which is invisible to standard MRI. His team have built two human-scale scanners and FFC-MRI is showing significant promise for enhanced, early diagnosis.

After graduating in Natural Philosophy (Physics) at the University of Aberdeen in 1979, he then went to St Bartholomew’s Medical College, University of London, where he completed an MSc in radiation physics and a PhD in medical physics. He joined the staff of the University of Aberdeen in 1983 as a research assistant, working with Jim Hutchison on low-field MRI, and 2 years later was appointed as lecturer, followed by senior lecturer in 1992 and to Personal Chair in Medical Physics in 2002.

He has been Visiting Scientist at the Johns Hopkins University School of Medicine and Visiting International Scholar at Ohio State University. Professor Lurie is the author of 72 peer-reviewed publications, seven book chapters, five patents and more than 250 conference abstracts. He has given 81 invited, keynote and plenary lectures at conferences and workshops around the world, as well as many invited seminars.

He was External Examiner for medical physics MScs in Dublin and Kuala Lumpur and sits on IPEM’s Course Accreditation Committee. This year he was appointed as an assessor on the European Organisations for Medical Physics (EFOMP) Examination Board, examining candidates for the European Diploma of Medical Physics.

Professor Lurie was a member of the Physics in Radiology subcommittee of the European Congress of Radiology (ECR) for 2 years, and chaired it for this year’s ECR meeting. EFOMP appointed him as their representative on the overall Programme Planning Committee of ECR for the 2018 and 2019 conferences. He is on the Scientific Committee of the 2018 European Congress of Medical Physics, to be held in Copenhagen.

He led a consortium which obtained a prestigious EU Horizon 2020 grant for a project called IDentIFY (Improving diagnosis by fast field-cycling MRI), a 4-year, €6.6m project which began in 2016 and which has nine partners in six countries. As well as coordinating IDentIFY, Professor Lurie was elected Vice Chair of the EURELAX EU COST Action scientific network, which is made up of 27 member countries.

Healthcare Gold Medal
Dr Neil Lewis has been awarded with the Healthcare Gold Medal after a lifetime spent in medical physics.

Prior to retirement in 2016, Dr Lewis was Director of Medical Engineering and Physics at King’s College Hospital in London for more than 12 years, the culmination of a 40-year career.

An IPEM Fellow, his interest in medical physics as a career stemmed from his undergraduate course in the subject and a subsequent visit to the Medical Physics Department at Queen Elizabeth Hospital in Birmingham.

He was awarded his PhD in Medical Physics in 1979 from the University of Leeds, where he worked under the supervision of Professor David L. Lurie.
of Professor Roy Ellis in the Department of Medical Physics at Leeds General Infirmary. His research topic was negative pion meson dosimetry, which was part of a wider programme to determine the potential for using such particles in radiotherapy. After completing his doctorate he undertook a further study on negative pion dosimetry, based at the University of Surrey. The practical work for this study took him to Vancouver for 12 months to use the TRIUMF meson facility at the University of British Columbia.

Dr Lewis joined the NHS in 1981 as a Senior Physicist in Radiation Protection at Mount Vernon Hospital, Northwood, where he gained valuable training and experience in radiation protection, nuclear medicine and radiotherapy. This led to a post as Senior Physicist in Nuclear Medicine at University College Hospital in London, with responsibility for the physics support to nuclear medicine at the National Heart and Chest Hospitals, London. He was then appointed as Principal Physicist to the St Peter’s Hospitals and the Institute of Urology in London, where he was responsible for the provision of services in nuclear medicine, urodyneimetry and radiation protection.

In 1991, Dr Lewis moved to King’s College Hospital as Consultant Physicist in Radiation Protection and Radiation Protection Adviser. Six years later, he was also appointed Centre Supervisor to the King’s Centre for the Assessment Radiological Protection Adviser. Six years later, he was also appointed Centre Supervisor to the King’s Centre for the Assessment Radiological Equipment (K CARE), an evaluation centre funded by the Medical Devices Agency.

Dr Lewis was appointed Head of Medical Engineering and Physics at KCH in 2004. He played a leading role in the development the King’s MSc in Medical Engineering and Physics. More recently, Dr Lewis has led, in collaboration with IPEM Fellow Jo Young, the development of an apprenticeship scheme to encourage young people who are not academically inclined in the traditional sense to find career opportunities across healthcare science.

Innovation Gold Medal

Dr David Gow CBE, the inventor of the i-Limb® prosthetic hand, has been awarded the Innovation Gold Medal.

An IPEM Fellow, Dr Gow graduated from the University of Edinburgh in 1979 with a BSc (Honours) in Engineering Science and after a brief spell working for Ferranti he became a research associate at the Bioengineering Centre at the University of Edinburgh.

It was here that he took part in clinics and saw first hand a range of children and adults born without or having lost part of a hand being offered something of little functional use to them. He resolved to use his engineering skills and clinical experience to design something to address this problem. By combining his engineering skills and clinical experience, he developed a self-contained powered digit for partial hands which could be configured as multiple units to give a complete hand for people with total absence.

As Director of Rehabilitation Engineering Services and Bioengineering and then as Head of SMART Services for NHS Lothian, Dr Gow managed a research team of bioengineers and technicians to work on prosthesis development. In 1993, he designed and patented the first ProDigits™ module consisting of a powered digit. He continued to work on the design of finger articulation and a passively adjustable thumb to give a selection of gripping postures.

This work was conducted as part of a larger project to produce a complete arm system, which became the basis for the Edinburgh Modular Arm System (EMAS), the results of which became known to the world in August 1998 when it was fitted to the world’s first ‘bionic man’.

He founded a spin-off company, Touch EMAS Bionics, from NHS Scotland in 2002 and 5 years later, the company launched the most advanced hand prosthesis, the i-Limb®. In 2008, the i-Limb® was named one of the top 50 innovations of the year by Time Magazine and, in the same year, Dr Gow and his team won the MacRobert Award from the Royal Academy of Engineering.

In 2014, he was appointed Commander of the Order of the British Empire (CBE) for services to upper limb prosthetics and, a year later, the i-Limb® was selected as one of eight great inventions to feature on a set of Royal Mail special stamps celebrating Inventive Britain.

Academic Early Career award

A research fellow in radiation therapy at University College London has been awarded the Academic Early Career award.

Dr Tracy Underwood graduated from the University of Oxford with a Bachelor in Physics and then completed an MSc in Medical Engineering and Physics at King’s College London. She then joined the Oxford Institute for Radiation Oncology to start a DPhil on the dosimetry of small photon beams.

The key paper from her DPhil research has now been downloaded more than 12,000 times and her work prompted leading commercial dosimeter manufacturer PTW to prototype a new detector, the ‘DiodeAir’.

She then received a MRC Centenary Early Career Award and was the 2015 winner of the IET/IMechE prize for the Best Medical Engineering PhD.

A personal award from the Leverhulme Trust enabled Dr Underwood to pursue postdoctoral research on small-field dosimetry in Toulouse, before she won a prestigious Marie Curie Research Fellowship from the European Commission, taking her to Massachusetts General Hospital and Harvard Medical School. There, she spent more than 2 years gaining clinical experience in proton therapy and performing proton physics research.

She has given two presentations at ASTRO and two at ESTRO, has been invited to present at national meetings and has chaired a session at ESTRO.

Dr Underwood lectures on undergraduate and MSc courses on medical physics at both University College London and King’s College.
London. She is a keen mentor of students at all levels and for 2 consecutive years she planned, developed and directed a week-long summer school for 16-18-year-olds interested in pursuing a career in engineering/the physical sciences.

**Innovation Early Career award**

The developer of a model to predict the properties of novel pharmaceuticals has won the Innovation Early Career award.

Dr Mohammed Atari received his BSc in Biomedical Engineering from Jordan University of Science and Technology and then moved to the UK to pursue his postgraduate studies, obtaining a first class MSc in Advanced Biomedical Engineering from the University of Warwick. He was awarded the university’s Vice Chancellor’s Scholarship to work towards his PhD in biomedical systems modelling, which he was awarded in 2010.

He then joined Cyprotex (acquired by Evotec in 2016) as a mathematical modeller, a research organisation specialising in *in silico* and *in vitro* ADME-Tox services, where he developed novel mechanistic *in silico* (*in vitro* processes and physiologically based pharmacokinetic) models for drug pharmacokinetics and pharmacodynamics. Dr Atari was promoted to Senior Mathematical Modeller at the organisation in 2016.

The model that Dr Atari has now developed represents an important step in the model-based prediction of the properties of novel pharmaceuticals. It enables researchers in the earliest stages of drug discovery to estimate the rate at which their compounds, or metabolites of their compounds, will be eliminated via the kidneys, providing important information for drug researchers.

Crucially, the model that Dr Atari has developed predicts the renal elimination rate using just the structure of the compound, reducing the cost of the information produced compared to models requiring experimental data as inputs.

As part of a suite of models, Dr Atari’s model supports researchers in determining the likely properties of many ‘virtual’ compounds with low cost and high throughput, significantly speeding up the search for new drugs.
Our first question concerns the modification of medical devices. ‘If you add a coating to a medical device to improve its cleaning and sterilisation, is this considered re-manufacture or modification? Would the device need to have a technical file (but not fully CE marked at it is for in-house use for now)?

I have my views, the MHRA seem to have another and I would really like to hear the views of my peers (I was going to say ‘and elders’ but I am now fairly elderly myself, hence…)’

Question supplied by Patrick Carena, Physicist, Ninewells Hospital

‘Modification of a medical device (including by coating the device), assuming that it is not designed to be modified in this way, constitutes using the device off-label. This means that the CE mark of the device is no longer valid, and you use it at your own risk, taking on legal responsibilities that would normally reside with the manufacturer.

Use of a medical device off-label is only advisable in exceptional circumstances where there is no medical device available for a procedure. Individual NHS Trusts may have a policy on the use of non-conforming medical devices.

If there is no option other than to use a device off-label, then a risk-based approach should be taken to justify its use. This would include a carrying out and documenting a risk assessment (which may well stipulate the generation of a technical file), considering the legal and ethical implications, implementing any necessary precautions and periodic reviews of the risk assessment.

Note that the Medical Device Regulations (obligatory from 26th May 2020) are prescriptive on the requirements for the use of devices manufactured in-house (article 5, paragraph 5).


Dr Thomas Beale, Chair of IPEM Clinical Engineering Special Interest Group

Our next question concerns the situation regarding registration of Assistant Practitioners. ‘Is/when is the RCT/IPEM going to develop a register for Assistant Practitioners (AP)? There are quite a few now working in nuclear medicine...’

Q & A
but they have no professional body that seeks to represent them, or a formal route for training and registration.

The Society and College of Radiography developed formal training and a register some time ago for APs working in imaging. It would be good for the RCT/IPEM to look at this.’

Question supplied by Dudley Ibbett, Consultant Healthcare Scientist, Derby Teaching Hospitals

‘The RCT is not looking to develop a register for Assistant Practitioners in the near future; however, the registration landscape is ever-changing and this may be something we revisit at a later date. The question about formal training routes for Assistant Practitioners is something that may be addressed by the newly developed Healthcare Science apprenticeships. There are now apprenticeships for Healthcare Science Assistants, Associates and Practitioners, and I would encourage anyone interested to contact their education department to find out how they can implement this locally. These apprenticeships also qualify for funding from the apprentice levy.

The question of not having a professional body is different, and IPEM would welcome Assistant Practitioners as Associate Members as they are working in a relevant field. If they joined, they would have discounted access to the meetings, conferences, journals, networks and other CPD opportunities that would help them to move on in their careers. If they go on to progress and qualify as clinical technologists, they would then be eligible to register with the RCT. Associate membership is also free to apprentices so anyone on one of the Healthcare Science apprenticeship programmes should be actively encouraged to join IPEM.’

Mr Iain Threlkeld, RCT Registrar

‘What are IPEM members, and IPEM itself, doing to increase retention of staff, particularly in the NHS, which spends considerable sums of money training clinical scientists? We are always being told about a skills shortfall and the need to recruit more staff, yet there seems to be little focus on keeping the staff who have already been trained. It often seems that promotions are based on time served or right place, right time, rather than on demonstrated ability. With promotion being unlikely for many of us (unless we want to move families to new towns or cities) and other companies offering recognition for good work, it is easy to see why trainee and qualified clinical scientists and technologists leave the NHS.

Is IPEM doing anything to actively encourage the NHS to keep the staff that it has invested so heavily in training?’

Question supplied by Robert Ross

‘As a professional body, IPEM does not have responsibility or remit for addressing recruitment or retention issues for staff in the NHS or elsewhere; that is a role for employers themselves. However, IPEM has created the Workforce Intelligence Unit in order to provide robust accurate data regarding retention, shortages and training. This data is mostly collected via workforce surveys, in which respondents are also invited to comment on general concerns regarding recruitment, training and workforce shortages. Such comments we have received to date do not suggest that this is an NHS-wide problem, but possibly it is a difficulty which varies by geography. Where we have received comments regarding retention difficulty this is often in relation to the independent sector or industry offering higher salaries. Specific workforce vacancy rates, available from IPEM, have successfully been used in a number of cases to argue for recruitment and retention premia to make NHS posts more appealing in an economically challenging environment.

There have been concerns noted regarding the impedance of career progression owing to a shortage of posts in niche professions, most notably in rehabilitation engineering. In this instance, this is in conjunction with a shortage of positions for the workload. IPEM has addressed this through Statements on the Role of Clinical Scientists and Technologists in Rehabilitation Engineering. We would encourage all members to complete the Workforce Unit surveys when they come round, as the better our data, the more helpful we can be to members who need this robust evidence of workforce numbers and shortages to argue for support, such as recruitment and retention premia, to avoid losing colleagues to better paid jobs in other industries. For more information on the Unit and data available, see the website.’

Dr Jemimah Eve, IPEM Workforce Intelligence Unit Manager

Many thanks to Patrick, Dudley and Robert for their questions and of course to our experts. If you are seeking clarity on issues of registration, training, professional standards or just horizon scanning – you know what to do!
A clinical molecular radiotherapy dosimetry service

Rebecca A. Gregory, Bruno Rojas, Andrew Fenwick, Jill Wevrett, Elaine Hamer and Allison J. Craig are part of the IPEM Working Party on Implementing a Clinical Molecular Radiotherapy Dosimetry Service to advise centres on resource implications.

Establishing standards of practice and further guidelines

Dosimetry data needs to be collected using standardised robust methods in order to collect data to form the evidence base for guidelines and to prove clinical benefit. Whole-body dosimetry is the simplest and most accessible form of dosimetry. Current guidelines aid the reproducibility of these methods between centres.

Standardised methods for internal radiation dosimetry are being developed for use in clinical multicentre trials, including the UK-based SEL-I-METRY trial. Once established, these standardised methods can then be moved from research into the clinic and used to produce guidelines. A list of currently available guidelines that offer any advice on MRT dosimetry is being collated (see table 1), and will be included in the final working party report.

Course attendance needs to be built upon through further in-house training by experienced staff

Measuring MRT absorbed radiation doses

A broad overview of dosimetry methods is given in IPEM Report 104. The principles underlying MRT absorbed dose calculation apply to all forms of dosimetry. The cumulated activity $A$ is measured and multiplied by a dose factor of $S$ (see figure 2). The dose factors describe the energy per unit of mass delivered to a target per cumulated activity (Bq.hour) measured in the source. These factors are available in the literature from MIRD pamphlets (http://www.snmni.org) and the RADAR website (http://www.doseinfo-radart.com). Dosimetry packages are available to assist with these calculations, although in-house spreadsheets can be set up to perform many of the calculations.

The cumulated activity needs to be measured and the methods and facilities required for this depend on the radiopharmaceutical and target absorbed dose to be measured (see table 1). Therefore, to set up a dosimetry service, centres require:

1. Dose calibrators with a calibration traceable to a primary standard.
2. Activity or dose rate measurement hardware.
3. Hardware to be calibrated and a system of routine quality control to be in place.
4. Activity or dose rate measurements to be made. The measurement schedule will depend on the radiopharmaceutical and required information.
5. Measurements to be converted to cumulated activity in a robust way:
   a. Whole-body counting self-calibrated against first measurement for the known administered activity.
   b. Trained staff to define volumes of interest (VOI) for internal organs and lesions on scans for internal dosimetry in a reproducible way. Calibration factors will be required to convert counts to activity.

6. The correct dose factors to be applied by trained staff taking into account target organ/lesion mass.
7. Dose calculations checked by a second trained staff member, following established practice in external beam radiotherapy.

Human resources

On completion of the current NHS Scientist Training Programme (STP) (imaging with ionising radiation specialism), newly trained physicists should be able to implement the principles of internal radiation dosimetry, patient-specific dosimetry protocols and their requirements for data acquisition and analysis. There are practical courses available to teach the fundamentals of dosimetry, such as those provided by the European Association of Nuclear Medicine, the Internal Dosimetry Users Group (IDUG) and the Royal Marsden Hospital/Institute of Cancer Research. Course attendance needs to be built upon through further in-house training by experienced staff.

The length of time that each patient’s dosimetry calculations take can vary from less than an hour to calculate a whole-body dose to up to half a working day for a...
FIGURE 1. A Coxcomb graph of the reasons given by centres for not being able to provide a dosimetry service (averaged over answers to questions about each therapy), in response to the MRT dosimetry working party survey. The lengths of the arcs are proportional to the number of centres indicating each reason that is relevant to their site. The inner etched arcs are for whole-body dosimetry, the outer clear arcs are for internal (lesion/normal organ) dosimetry. *Other reasons given were often that the site does not provide that MRT service.

FIGURE 2. MRT absorbed dose calculation, with an example of a whole-body time activity curve for a paediatric mIBG treatment, to demonstrate calculation of the cumulated activity and calculation of the target dose using MIRD S-factors calculated for instance from a standard man (http://www.doseinfo-radar.com).

TABLE 1. Types of dosimetry, hardware, measurement schedules and examples of existing guidelines

<table>
<thead>
<tr>
<th>Target</th>
<th>Hardware</th>
<th>Calibration</th>
<th>Measurement schedule</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body</td>
<td>Dose monitor (hand held or ceiling mounted) or gamma camera</td>
<td>Dose vs activity linearity</td>
<td>Pre-void whole-body count followed by 2-hourly monitoring when possible</td>
<td>4, 9, 10</td>
</tr>
<tr>
<td>Bone and blood</td>
<td>Dose monitor or gamma camera and blood sampling</td>
<td>Well counter calibration</td>
<td>All cases – regardless of dose</td>
<td>10</td>
</tr>
<tr>
<td>Internal dosimetry for other organ at risk (e.g. kidneys and tumours)</td>
<td>For intra-arterial/cyst delivery (e.g. microspheres)</td>
<td>Dead time characterisation for high count scans, e.g. radioiodine therapies</td>
<td>One scan and assume only physical decay</td>
<td>Manufacturer’s guidance</td>
</tr>
<tr>
<td></td>
<td>For systemic delivery (e.g. radiiodine (RAI), Ra-223, PRRT, mIBG etc.)</td>
<td>Volume-specific calibration, through measurement of sensitivity factors for different volumes</td>
<td>Ideal scanning frequency depends on effective half-life of radiopharmaceutical emissions</td>
<td>Lu-177 DOTATATE: 11 Radioiodine: 12, 13, 14 Alpha-emitters: 15</td>
</tr>
<tr>
<td>Voxel dosimetry to assess dose distribution (e.g. to produce DVHs to assess dose uniformity)</td>
<td>Gamma camera, SPECT/CT or PET/CT system (modality depends on radiopharmaceutical emissions)</td>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>
full set of organ and lesion absorbed dose calculations by an experienced physicist. Therefore, the human resources to provide a dosimetry service will depend on the complexity of the dosimetry methods used and staff experience.

Additional consideration will need to be given to the radiation doses received by staff performing complex calibrations and additional dosimetry scans.

The future
The working party hopes that the report advising centres on the resources necessary to set up an MRT dosimetry service, along with further work by other interested parties, such as IDUG, and future planned clinical trials, will support more centres to take the step towards setting up their own dosimetry service.

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Bruno Rojas The Royal Marsden National Physical Laboratory, London
Julia Veerrott National Physical Laboratory, London/Royal Surrey County Hospital NHS Foundation Trust, Guildford/University of Surrey, Guildford
Elaine Hamer Royal Stoke University Hospital, Stoke-on-Trent
Allison J. Craig The Royal Marsden Foundation Trust and Institute of Cancer Research, Sutton

Required accuracy in radiotherapy dose delivery
Professor David Thwaites (Institute of Medical Physics, School of Physics, University of Sydney, Sydney, Australia) and Paul Whittard (The Beacon Centre, Musgrove Park Hospital, Taunton) provide an extract from the second edition of IPEM Report 81

There is a considerable amount of clinical evidence which indicates that a high degree of accuracy in dose delivery and geometric positioning is essential for successful outcomes of radiotherapy. The clinical requirements on accuracy are based on this evidence, obtained from dose response (dose effect) curves for tumour control probability (TCP) and for normal tissue complication probability (NTCP). These typically have sigmoidal shapes, with a threshold dose, relatively steep rises and saturation (100 per cent effect) at high enough doses.

Generally, in practical clinical situations the two relevant curves overlap along the dose axis (figure 1) such that the dose to the tumour is limited by the levels that can be tolerated by the most at-risk normal tissues. It may be noted that the ‘absorbed dose’ in figure 1 is the dose to the tumour for both curves. Normal tissues are not necessarily less radiosensitive than tumours; the relative positions of the curves are influenced by various factors which generate a therapeutic ratio, such as the treatment planning process reducing the dose to organs at risk compared to that received by the tumour. Uncertainties in any radiotherapy process parameter that affects dose delivered to the patient will change TCP and/or NTCP and hence the balance and optimisation of tumour response vs normal tissue effects.

Improving the balance
Radiotherapy optimisation and many advances in technology and techniques are aimed at improving this balance, i.e. maximising tumour control whilst maintaining tissue complications at an acceptable level. The steepness of the given TCP or NTCP curve vs dose defines the change in response expected for a given change in delivered dose. Thus, uncertainties in delivered dose translate into either reductions in TCP from the optimised expected value, or increases in NTCP from the optimised expected value, both of which worsen the clinical outcome. The accuracy requirements are defined by the most critical (steepest) curves, observed for normal tissues or sharply responding tumours. The dose gradient data of clinically derived TCP and NTCP curves are summarised and reviewed in a number of previous publications.1,2 These
IN-HUMAN MRI-LINAC DATA
A research team at the University Medical Center Utrecht performed the first patient treatment using Elekta’s Unity, an MRI-guided radiotherapy system that integrates a diagnostic quality 1.5T MR scanner with an advanced linear accelerator. The team has published details of the first four patient treatments, demonstrating the feasibility and clinical utility of the Unity MRI-linac. (Phys Med Biol 2017; 62: L41)

FOCUSSED ULTRASOUND
A non-invasive treatment that delivers ultrasonic energy to targets deep within tissue is being investigated for a large variety of medical conditions, with clinical applications at various stages of research, development and commercialisation. A pilot study at the University of Virginia School of Medicine has shown that focussed ultrasound shows promise as a treatment for Parkinson’s tremor. (doi:10.1001/jamaneurol.2017.3098)

MRI-GUIDED DOSIMETRY
Verifying dose delivery in an MRI-guided radiotherapy environment is complicated by the deflection of secondary electrons in the MRI scanner’s magnetic field. Traditional dosimeters such as ionisation chambers exhibit magnetic field dependence and are unable to make detailed 3D measurements of dose distributions. Researchers in the US have shown that three chemical dosimeters can measure dose in strong magnetic fields without a correction factor. (doi:10.1016/j.radonc.2017.08.027)

MACHINE LEARNING
A machine learning tool can help identify which high-risk breast lesions are likely to become cancerous, reports a study from Massachusetts General Hospital/Harvard Medical School. The approach has the potential to reduce unnecessary breast surgeries by nearly a third. (doi:10.1148/radiol.2017170549)

The steepness of the given TCP or NTCP curve vs dose defines the change in response expected for a given change in delivered dose

Improving accuracy
Historically, ICRU Report 24 reviewed the more limited information available up to that time and considered that +/-5 per cent accuracy was required in the delivery of absorbed dose to the target volume, but that in critical situations, +/-+10 per cent accuracy would be required. The steepest clinical curves are for normal tissue effects, with γ50 values of up to 6 or 7 and as a general requirement, it is necessary to base accuracy recommendations on the steeper dose–effect relationships encountered in routine clinical situations, as overall process accuracy must be established to meet these more demanding situations. It may be noted that whilst there have been new clinical data and many other studies of such information over recent years, including reviews such as the QUANTEC reports for normal tissue effects (quantitative analysis of normal tissue effects in the clinic), these general values are still applicable.

In Brief

INBRIEF

FIGURE 1. Schematic dose effect curves for tumour control probability (TCP) and normal tissue complication probability (NTCP). The curves are sigmoid and are assumed here for simplicity to have the same shape and steepness. The ‘absorbed dose’ here is the dose to the tumour [see text]
situations +/-2 per cent may be required. However, it was recognised that the latter figure was not generally realisable in current practice then. It was not made clear what uncertain value the figures represented. Mijnheer et al. obtained a figure for required accuracy by considering normal tissue complications. They considered the steepness of dose–effect curves in terms of the percentage increase in absorbed dose to produce a change in the probability of normal tissue complications from 25 per cent to 50 per cent. A representative value of 7 per cent was taken for this relative gradient and it was concluded that any transfer of clinical information from one centre to another will involve unacceptable risks of complications if overall uncertainty in absorbed dose is larger than this value. This was then assigned to the 2 s.d. (standard deviation) level, resulting in a value of 3.5 per cent, as one relative s.d. level, resulting in a value. This was then assigned to the 2 in absorbed dose is larger than this value the figures represented. Mijnheer et al. obtained a figure for required accuracy by considering normal tissue complications. They considered the steepness of dose–effect curves in terms of the percentage increase in absorbed dose to produce a change in the probability of normal tissue complications from 25 per cent to 50 per cent. A representative value of 7 per cent was taken for this relative gradient and it was concluded that any transfer of clinical information from one centre to another will involve unacceptable risks of complications if overall uncertainty in absorbed dose is larger than this value. This was then assigned to the 2 s.d. (standard deviation) level, resulting in a value of 3.5 per cent, as one relative s.d., as the general accuracy requirement on absorbed dose delivery.

Brahme et al. considered the effects of variations in dose on tumour control for typical values, showing that the most critical loss in tumour control introduced by dosimetric inaccuracy is found at the highest level of tumour control probability. A general figure of 3 per cent (relative s.d.) on the delivered absorbed dose to the patient was recommended as the tolerance level on accuracy in dose delivery, in order to keep variations in the probability of tumour control within acceptable limits. These values are still generally applicable. Thus, overall a figure of 3 per cent s.d. can be taken as a currently recommended general accuracy requirement, being considered as one relative s.d., on the value of the dose delivered to the patient at the dose specification point. This implies there is a 95 per cent probability that changes will be clinically observable for dose changes at twice this level, in situations described by the steeper dose–effect relationships. This is also consistent with more anecdotal evidence on clinical observations of normal tissue reaction following inadvertent dose changes due to dosimetric errors, where an increase in dose of 7–10 per cent resulted in clinically detectable reactions. Hence, from clinical observation there is good evidence that a difference in target absorbed dose of 10 per cent is readily detectable for a number of tumours and that a difference in absorbed dose of 7 per cent can be observed for normal tissue reactions. These fits well with reporting criteria of adverse events in radiation protection systems.

### It may also be noted that uncertainties in some parameters may have a systematic impact for an individual patient

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### Summary

Considering the different effects of systematic and random dose uncertainties on TCP and NTCP gives a further perspective. Overall, systematic uncertainties in the dose delivered will translate directly into changes in TCP and NTCP for the population of patients involved (and also as expected for an individual patient, but likely to be complicated by the effect of individual radiosensitivity). For random uncertainties, the effect is much more variable and depends on the steepness of the curve, the point of interest on the curve (effects will now be greatest where the curvature of the curves is greatest), the level of uncertainty, etc. Generally, random uncertainties will smear effects and will reduce TCP and increase NTCP but in a less direct way. It may also be noted that uncertainties in some parameters, which may be randomly distributed between patients in their impact on a patient group-based dose–effect curve, may have a systematic impact for an individual patient. These considerations might indicate that tighter requirements are necessary on systematic uncertainties, of say better than 1 or 2 per cent, with requirements still of around 3 per cent on random uncertainty, to keep the changes in TCP and NTCP within acceptable tolerances (e.g. also within approximately 3–5 per cent). Together these also imply that the overall required accuracy in absorbed dose distributions should be in the region of 3–5 per cent. This may change for high-dose per fraction hypofractionated treatments, which would be significantly less forgiving of random uncertainties.

### References

What ultrasound can learn from non-ionising radiation

Professor Francis Duck (University of Bath) has made progress in developing ultrasound dosimetry but there is still more to learn from advances in other specialisms

Ultrasound dosimetry is still evolving. This was impressed on me when, a few years ago, I helped to prepare a document for the Advisory Group for Non-Ionising Radiation (AGNIR) of the, then, Health Protection Agency, on the health effects of exposure to ultrasound and infrasound. I was pressed by others on the AGNIR committee to explain how the ultrasound community measured ‘dose’. They had become not a little confused by the plethora of ultrasound exposure quantities and indexes, wanting simplification and clarity.

I recounted the establishment of FDA controls on the sale of ultrasound equipment in the USA in the 1980s, and the imposition of limits on three acoustic exposure quantities. These were: (1) the peak time-averaged intensity \( I_{spta} \) (mW cm\(^{-2}\)), loosely related to heating, (2) the now redundant ‘peak intensity’ and (3) the peak pulse-averaged intensity \( I_{spqa} \) (W cm\(^{-2}\)). These exposure quantities were calculated from measurements using a hydrophone in water. A ‘derating’ factor of 0.3 dB MHz\(^{-1}\) cm\(^{-1}\) was applied to compensate for the average attenuation of tissue. I referred them to a review article in which I had explained the difficulties in making further progress in developing ultrasonic dosimetry. 1

‘Yes,’ they said, ‘but this offers no more than an estimate of in-situ exposure, and is not “ultrasound dose”. We want to know how you quantify the bioeffects once ultrasound is absorbed in tissue.’

I explained that this was exactly what was requested by the users (and manufacturers) of ultrasound equipment, for whom the estimated in-situ exposures meant little. The outcome was the development by the American Institute of Ultrasound in Medicine (AIUM) of the Output Display Standard (ODS). This approached dosimetry from the other end, by asking the biophysical questions, ‘how much will the tissue heat?’ and ‘what is the likelihood of cavitation?’ The two safety indices, thermal index (TI) and mechanical index (MI), have become universally implemented on ultrasound scanners to encourage users to use the highest output only when it can be clinically justified. The MI, a unitless MHz-weighted derived index from peak-rarefaction pressure, \( p \), [MPa], \( MI = p/\sqrt{f} \), was underpinned by the theory of inertial cavitation, in which a microbubble is caused to collapse in an ultrasonic field, resulting in severe local damage to cells and tissues. (It has since been added to the list of FDA controlled quantities and has found a clinical use in managing microbubble contrast agents). The TI has the simple definition \( \Delta T/\Delta T_{\text{deg}} \), in which \( \Delta T \) is the greatest estimated temperature rise in the beam and \( \Delta T_{\text{deg}} \) is the acoustic power causing a greatest estimated temperature rise of 1°C. Seductively simple in concept, a surrogate for temperature rise, but challenging to measure, TI remains a quantity that cannot be fully evaluated in the absence of a fully equipped acoustic laboratory.

‘That’s all very well,’ they said, ‘but MI and TI are not quantitative dosimetric quantities as we understand them. They are only advisory indicators. Even the ODS admitted that thermal index should not be taken as an estimate of temperature rise. What about dose?’

Feeling backed into a corner, I reached for the only quantity that was being used for ultrasonic dosimetry, thermal dose. It is the ‘dosimetric’ quantity that was being used to underpin ultrasound surgery, quantifying the intended threshold to cause tissue ablation. This would satisfy them. At least here I could present a defined quantity that, moreover, used the ‘dose’ word that was constantly sought. Sadly for my argument, thermal dose was a chimera. Familiar dosimetry units were absent: thermal dose is the time required, at a specified temperature to achieve a
specified change in a specified fraction of a specified target cell culture or tissue. It is a dedicated practical tool for use in thermobiology, but has no place to play in the familiar physics of radiation dosimetry.

‘Ultrasound has an unresolved problem,’ I admitted. ‘But it is surely not so far from the challenges met by non-ionising radiation, with E and M fields, and the ultimate need to estimate, for example, temperature rise to assess safety for mobile phones and other devices. How is dose handled for e-m fields?’

**Acoustic dose rate**

The answer, of course, is implemented on all MR scanners. It is the specific absorption rate (SAR). Here is an appropriate dosimetric quantity, defined as the rate of energy absorption per unit mass, fully embedded in a clinical environment. Might there be an equivalent acoustic quantity, the acoustic power absorbed per unit mass? The answer revealed the underlying problem for ultrasound. Acoustic waves are mechanical, and the theory that underpins acoustics is built on spatial quantities. Mass dependence is never considered. The simple change of perspective from the acoustic space or volume into which energy is deposited to the substance or mass that is absorbing the energy, a slight but significant change, places acoustic dosimetry in an equivalent place as electromagnetic dosimetry. Not only that, but it turns out that the quantity that could support acoustic dosimetry is embedded in the calculations predicting temperature rise and volume force resulting from exposure to ultrasound.

The rate of acoustic energy absorption per unit mass \( Q_m \) is given by:

\[
Q_m = \frac{2\alpha_0 I}{\rho_0}
\]

where \( I \) is the acoustic intensity, \( \alpha_0 \) is the amplitude absorption coefficient in nepers per unit length and \( \rho_0 \) is the density.\(^2\) This quantity may be given any name, but may be conveniently called the acoustic dose rate. It is measured in practical units of mW g\(^{-1}\). In any real situation, \( Q_m \) has spatial dependence because \( \alpha_0 \) and \( \rho_0 \) are properties of tissue, so the local values depend on the tissue structure, and also because intensity varies according to the acoustic structure of the beam in vivo. \( Q_m \) also has temporal dependence, both because of beam pulsing and scanning, and also from any time-dependent alteration to the tissue properties, caused by heating, for example. The acoustic dose is the integral of \( Q_m \) over time: for steady-state conditions \( Q_m t \).

Acoustic dose rate is embedded in two bioeffects formulae. The first concerns heating, where the initial rate of heating \( \frac{dT}{dt} = \frac{Q_m}{C} \), where \( C \) is the heat capacity of the target tissue. The second concerns the radiation force exerted on the tissue. In an idealised case the force per unit mass \( F_r = \frac{Q_m}{c_s} \), where \( c_s \) is the sound speed. This formalism demonstrates the intimate relationship between heating and radiation force exerted on the target tissue exposed to ultrasound.

Strong inhomogeneities such as cavitation bubbles and bubble nuclei certainly present a problem with this approach to dosimetry, but not perhaps an insuperable one. It is possible to determine the energy deposited from individual bubbles, and knowledge of the bubble density and size distribution could in principle lead to a calculation of the total energy deposited per unit mass. Nevertheless, whilst bubbly conditions occasionally arise, for example during HIFU and contrast studies, these need not invalidate the general approach to acoustic dosimetry that emerged from the perspective of other non-ionising radiations.

**Frequency banding**

The re-evaluation of acoustic dosimetry is not the only area where developments in electromagnetic non-ionising radiation have informed discussions in ultrasound. The International Commission on Non-Ionising Radiation ([ICNIRP]) includes ultrasonic exposure within its remit. A newly formed committee, under the chairmanship of Dr Zenon Sienkiewicz of Public Health England, has been given the task of reconsidering the health effects of ultrasound. Within this debate, again disciplined by committee members bringing different expertise, a discussion emerged about unifying statements for human responses to ultrasound over its whole frequency range, from about 20 kHz, through the low MHz range familiar in medical applications, to the highest frequencies above 100 MHz. Was the current division of the acoustic spectrum into only three bands, based upon the response of the human ear, sufficient? More particularly, should the health effects of ultrasound remain bundled together in one group without further subdivision?

It soon became clear that it would not be possible to formulate conclusions and recommendations that would be general enough usefully to encompass the whole ultrasonic spectrum. High amplitude noise at around 20 kHz may cause a hearing deficit, but causes an infinitesimally small temperature rise if absorbed in tissue. Limitations to exposure for foetal scanning have no implications for exposure at 50 kHz. Indeed, the misuse of the term ‘ultrasound’ has led to genuine misrepresentations about safety issues. The manufacturer of a proposed ultrasonic battery charger, operating in the tens of kHz, justifies its safety by citing FDA regulations for medical ultrasonic exposures above 1 MHz. A scientific study into DNA breakage caused by 30 kHz ultrasound was partially justified by specific reference to medical applications of ultrasound in the MHz frequency range. These are just two examples of the confusion arising from the broad meaning of the term ‘ultrasound’.

Faced with this dilemma, it is being proposed that the ultrasonic spectrum should be divided into three bands, for the purpose of evaluating health effects and safety.\(^3\) These could be referred to as ‘low-frequency ultrasound’, ‘high-frequency ultrasound’ and ‘very high-frequency ultrasound’, or more succinctly US(A), US(B) and US(C). Such a division is familiar in non-ionising radiation in which the ultraviolet part of the spectrum has been separated into UVA (230–400 nm), UVB (290–320 nm) and UVC (200–290 nm), based on the tissue responses in each of these frequency bands.

Broadly, the three ultrasound bands may be described as follows:

- **US(A):** 17.8 to 500 kHz, for which most biological effects result from local forces at interfaces, including cavitation effects.
- **US(B):** 500 kHz to 100 MHz, for which most biological effects result from a temperature rise from volume absorption.
- **US(C):** above 100 MHz, for which most biological effects...
result from volume forces.

Within the low-frequency ultrasound band, US(A), acoustic cavitation dominates other mechanisms in liquids and soft tissues. It is the only band of relevance to airborne ultrasound. Public and occupational exposures to airborne ultrasound can occur, with some humans able to hear at the lower end of this band. Practical in vivo medical applications associated with this band include thrombolysis, extracorporeal lithotripsy, dental scaling and ultrasonic cutting.

In the high-frequency ultrasonic band, US(B), temperature rise from absorbed energy dominates. Cavitation in this band retains biological importance only in association with high-power heating and in the presence of introduced microbubbles in the form of contrast agents, and even in these contexts it is of progressively decreasing importance towards the upper frequencies in the band. Conversely, radiation volume force emerges as a potential bioeffects mechanism towards the upper end of the band. Practical medical applications include diagnostic imaging, physiotherapy and focused ultrasonic surgery.

The very high-frequency band, US(C), allows applications at such frequencies to be appropriately separated from practical medical applications in the lower MHz range of frequencies.

The lowest frequency threshold, 17.8 kHz, has been chosen to replace the more widely used 20 kHz as the lower threshold for ultrasound. This is because all acoustic measurements are based on third octave bands and this is the lower end of the third octave band centred at 20 kHz. The selection of 500 kHz to be the threshold between US(A) and US(B) and of 100 MHz for that between US(B) and US(C) was based on the frequency dependencies of the biophysical mechanisms of heating, cavitation and radiation force. Thresholds for cavitation and similar gas-body effects have a weak inverse dependence on frequency, whilst tissue acoustic absorption coefficient, and hence acoustic dose rate and heating, exhibits a positive dependence on frequency. At some frequency that depends both on the type of ultrasonic exposure and on the tissue target, heating takes over from cavitation as the more important mechanism. The choice of 500 kHz was a convenient compromise. Similarly, as frequencies increase above 100 MHz, beam widths at these frequencies are sufficiently narrow to limit heating, whilst retaining local forces.

Banding is not about specific applications. Nevertheless, the test for a new framework for ultrasound health effects is its application to the assessment of possible new devices, and clarification of the applicability of existing regulations. We may consider how the existence of an accepted banding structure would impact on the problems noted above. The use of airborne ultrasound for remote battery charging lies clearly in band A. This is because the attenuation coefficient of air above 500 MHz places further limits on an already inefficient method of energy transfer. The FDA regulations were based on a review of exposure to US(B), with no considerations applied for frequencies below 500 kHz or above 100 MHz. It is entirely inappropriate to justify the safety of a means to propagate power in US(A) using a regulatory regime designed exclusively for exposure within US(B).

The second example alluded to above was that of a study into DNA breakage at 30 kHz. Here, the error of the authors was to imply an associative link between their results, observed at frequencies well within the US(A) band, and uses of ultrasound for medical applications that are almost exclusively carried out within the US(B) band.

There is nothing within the banding scheme to prevent the operation of a practical device at a frequency that lies close to a band boundary. In such a case, it would only be necessary to state, for example, ‘This device operates at the boundary of US(B) and US(C)’. In this case, the dominant bioeffects mechanism would depend as much on the pulsing regime as on the band or frequency.

Overview

Ultrasound specialists like to consider themselves in some way apart, independent, with scientific challenges and technical solutions unique to their speciality. Differences are emphasised. Ultrasound is not sound: indeed it is, literally, above sound. It is not part of ionising radiation and, within the non-ionising radiations it is not electromagnetic. And it is true that much of the physics specific to medical ultrasound is not much shared with the other radiations: the strong non-linearity, the ultra-short pulses, the coherent scattering of tissue, the unusual frequency-dependence of the absorption coefficient and the strong coupling between wave and material. But this does not mean that there is nothing to learn from the experience and scientific endeavours of other specialists. This brief review has identified two areas in which there is much to learn from developments in other non-ionising radiations. An acoustic quantity, the acoustic dose rate, equivalent to the electromagnetic specific absorption rate, is the missing dosimetric quantity that links acoustic exposure to temperature rise and radiation force. Regulatory control could, indeed perhaps should, be written in terms of acoustic dose rate, to bring ultrasound in line with the other radiations to which humans are exposed. Frequency bands for ultrasound, similar to those used in ultraviolet radiation, would assist in clarifying safety discussions and in preventing regulations being applied inappropriately. Such transfer of concepts will take root only to the extent that users find them valuable. It may be expected that other cross-disciplinary fertilisation will emerge in the future to benefit both medical ultrasound and other disciplines in medical physics. No man is an island entire of itself.

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\textbf{AFFILIATION}

Professor Francis Duck is a Visiting Professor in the Department of Physics at the University of Bath.

\textbf{REFERENCES}

3 Duck FA, Leighton T. Frequency bands for ultrasound, suitable for the consideration of its health effects. J Acoust Soc Am (accepted for publication).
Survey of prostate brachytherapy practices 2014–16
Ahamed Badusha Mohamed Yoosuf, Geraldine Workman, Monica Byrne, Gemma Corey, Darren Mitchell and Suneil Jain (Northern Ireland Cancer Centre, Belfast City Hospital) documented the development of prostate brachytherapy practice in the UK and Ireland.

Methods and materials
An online survey, using the Survey Monkey™ tool, was created and the hyperlink communicated to participants (n = 25) of the UK and Ireland Prostate Brachytherapy Conference (held in Belfast in 2017), inviting them to provide one response per department. An open invitation (survey hyperlink) was also placed on the medical physics mailbase and the Institute of Physics and Engineering in Medicine (IPEM) newsletter. Sixty-three questions were grouped into six themed sections which included: (1) centre experience and staffing, (2) number of implants by clinical oncologist, (3) number of cases treated in the preceding 3 years, (4) LDR pre-implant techniques, (5) LDR post-implant technique and (6) HDR implant technique. Responses were collated and descriptive statistical analysis performed.

Results
(1) Centre experience and staffing
Eighteen centres responded within the allocated timeframe, with a final response rate of 72 per cent. Seventeen centres perform LDR permanent seed implantation and seven centres carry out HDR source implantation. Six centres carry out both LDR and HDR implants and one centre performs HDR implantation only. Additionally, 13 out of 17 centres who perform LDR permanent prostate brachytherapy have more than 10 years of experience and five of the seven centres who carry out HDR implantation have more than 5 years of experience, as shown in table 1.

The Royal College of Radiologists (RCR) recommends that there should be a minimum of two radiation oncologists and two medical physicists on each brachytherapy team, to ‘ensure service resilience’.7 Thirteen centres have two or more oncologists and 15 centres have two or more medical physics experts (MPE). Sixteen centres have at least two clinical scientists and 11 centres have at least two therapy radiographers. Further, 15 centres facilitate physics trainees and six centres facilitate clinical trainees. Details of staffing levels are shown in table 2.

(2) Number of implants by clinical oncologist
RCR guidelines recommend a minimum workload of 25 cases per oncologist per year. Table 3 represents the number of cases (LDR and HDR) performed by each consultant during the year 2016. Seven of the 18 centres (39 per cent) responded with leading consultants performing less than 25 cases in the year 2016. Similarly, centres with a second (n = 13) and third consultant (n = 6) have confirmed that 38 per cent and 50 per cent of them performed under 25 cases, respectively, in 2016.

(3) Number of cases treated in the preceding 3 years
LDR monotherapy is performed in all centres except one. The banded survey options for case number per year were ≤15, >15 ≤35, >35 ≤50, >50 ≤70 and >70 per year. As seen in figure 1, eight centres reported the same band (green lines) for 2014–16 but eight centres reported a reduced number (red lines) in 2016. Only one centre reported an increase (orange line) in cases.

LDR boost combined with EBRT was performed in seven centres in 2014 and eight centres in 2015 and 2016, as shown in figure 2. Generally, case numbers are between 15 and 35 per year for most of the centres. Four centres showed constant patient numbers (green lines) within the questionnaire ranges, four centres showed reduced patient numbers (red lines) in 2016 and two centres increased cases in 2016 (orange lines).

One centre performed LDR focal brachytherapy during 2014 to 2016 with less than 15 cases per year, as shown in table 4. LDR salvage therapies have increased over the 3-year period, with two centres in 2014, four centres in 2015 and five centres in 2016. No centre performed more than 15 cases.

HDR boost treatments were carried out in five centres during 2014 and 2015, and six centres during 2016. Four out of five centres performed over 75 cases per year in 2014 and 2015, whilst one centre performed less than 15 cases per year. The number of centres performing HDR monotherapy has increased: four centres in 2014, five centres in 2015 and six centres in 2016. The majority of centres were performing less than 15 cases. HDR salvage therapy has increased from one centre in 2014 to three centres in 2015 and 2016, with all treating less than 15 cases a year. No centres reported performing HDR focal monotherapy.

(4) LDR pre-implant techniques:
(a) implant type and seed placement
Thirteen centres reported using a prescription dose of 145 Gy for LDR monotherapy, whilst the other four centres use a prescription dose of 160 Gy. When used in combination with EBRT, the prescription dose in eight centres is 110 Gy, two centres prescribe 106 Gy, two centres prescribe 107 Gy, one centre prescribes

<table>
<thead>
<tr>
<th>Years of Experience</th>
<th>Number of Centre</th>
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<tbody>
<tr>
<td>&lt; 1</td>
<td>LDR 0 HDR 1</td>
</tr>
<tr>
<td>1–5</td>
<td>LDR 1 HDR 1</td>
</tr>
<tr>
<td>5–10</td>
<td>LDR 2 HDR 2</td>
</tr>
<tr>
<td>10–15</td>
<td>LDR 8 HDR 1</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>LDR 5 HDR 2</td>
</tr>
</tbody>
</table>

TABLE 1. Years of experience in LDR and HDR prostate brachytherapy

Scope welcomes your feedback! #IPEMScopeMedPhys, #IPEMScopeDiscussions, @IPEMScope
RADIOTHERAPY MODEL
The ability to predict the radiosensitivity of a patient’s cancer could significantly impact treatment decisions, but direct measurement remains challenging and the lack of predictive models is a significant problem. To address this shortfall, a research team from Queen’s University Belfast and Massachusetts General Hospital has developed a mechanistic model of DNA damage repair to predict response to ionising radiation. ([Sci Rep 2017; 7: 10790])

GLOBAL DISPARITIES IN DOSE
The growing use of radiation dose tracking software has revealed an inconvenient truth: there are substantial differences around the world in the amount of radiation dose being used for CT scans, according to a Swiss study recently published. Researchers used radiation dose tracking software to study the dose used in CT scanning by radiology departments from select North American and European medical institutions. ([doi:10.2214/AJR.17.18087])

MRI FOR CARDIAC ARREST SURVIVORS
By taking MRI measurements of the brain’s functional network connectivity within 2 weeks after a patient experiences cardiac arrest, clinicians may be better able to predict their clinical outcomes, according to a recent study. Researchers from the US and Europe are hopeful that the degree of connectivity between brain networks could become a novel prognostic biomarker that could help clinicians make treatment decisions for these severely injured patients and allow families time to prepare for potentially less than favourable outcomes. ([doi:10.1148/radiol.2017162161])

PORTABLE BRAIN SCANNER
French researchers have developed a portable, non-invasive system for imaging babies’ brain activity in a clinical setting. They have used their new approach to monitor seizures with a higher resolution than achieved by existing functional brain imaging technologies. ([Sci Transl Med 2017; 9])
Fourteen of the 17 centres perform LDR brachytherapy as a ‘real-time’ implant; three centres perform a ‘two-step procedure’ with volume study performed separately to the implant. All 17 centres use 1425 seeds and one centre also uses Pd-103 and Cs-131.

(b) Imaging and contouring
Ultrasound is the most common imaging modality and is used by 11 out of 17 centres for the pretreatment volume study. Four centres use multiple modality imaging and one centre uses MRI. Pretreatment contouring is performed by the oncologists (38 per cent), radiologists (13 per cent), radiographers (13 per cent), urologists (19 per cent) and others (19 per cent) which includes physicists. Three centres use image registration/fusion. The Variseed treatment planning system (Varian Medical Systems, Palo Alto, CA) is the most commonly used (Variseed 8 (n = 9) or Variseed 9 (n = 7)) and one centre uses Oncentra Prostate planning system (Elekta, Crawley, UK).

(c) Treatment planning
Treatment planning is carried out by a physicist or dosimetrist in all the centres. Of the centres that replied (n = 16), source loading is carried out by a physicist (n = 7), dosimetrist (n = 5), both (n = 4) and others (n = 4), which includes trained nurses, technologists and trainees. During the implant, the ultrasound is operated most commonly by the oncologist (n = 9) or urologist (n = 9), in five centres by the radiologist and in one centre by the physicist. The majority of centres (n = 10) use stranded seed placement as shown in figure 3(a), and one centre uses a variation of all four placements including stranded, preloaded, loose and Mick applicators. Similarly, the majority of the centres use loose seeds for calibration (n = 5), five centres use strands, and one centre uses both loose seeds and strands. Most centres use a reference air kerma rate (RAKR) of 0.5–0.6 U (n = 12) or 0.4–0.5 U (n = 11) for LDR planning, as shown in figure 3(b). One centre uses a RAKR of 0.7 U. Of all centres that responded the mean number of needles is 23 (± 5) and mean number of seeds is 72 (± 9) per LDR monotherapy implant, as shown in figures 4(a) and 4(b), respectively, although this is RAKR dependent. Similarly, the average number of needles per unit volume (cc) is 0.85 (± 0.5) and seeds/cc is 1.9 (± 0.5).

(d) Planning objective
The planning objectives used by the respondents (n = 17) are represented in table 6.
5. Seven of the centres use an objective of V100%, greater than or equal to 99 per cent for prostate, two centres with 98 per cent and eight centres require greater than 95 per cent. Further, seven centres require a clinical target volume (CTV) V100, of greater than 95 per cent. A variety of constraints for prostate, CTV, urethra and rectum were applied during treatment planning, as shown in table 5.

(v) Post-implant dosimetry
All centres perform a post-implant computed tomography (CT) scan, with 88 per cent (n = 15) performing the scan 4–6 weeks later, one centre on day zero/day 1 and one centre 4–5 weeks later, respectively. Similar to the pre-implant contouring, the oncologist performs the majority (n = 10) of the post-implant contouring followed by radiographers (n = 4), and others (n = 3) which includes radiologists, physicists and dosimetrists. Thirteen out of the 17 responding centres perform routine calculation of the CT/ultrasound volume. The median CT/US volume ratios were >0.9 ±1.0 (n = 4), >1.0 ±1.1 (n = 7) and >1.1 (n = 2). Out of the 17 centres that responded, three centres routinely perform image registration or fusion in post-implant dosimetry.

Table 6 represents the average prostate D90 (Gy) achieved over the period 2014–16. Almost 70 per cent of the centres have achieved an average D90 of greater than 145 Gy in the years 2014–15, whereas 63 per cent of the centres have achieved greater than 145 Gy in the year 2016. Four centres report performing sector analysis, which entails subdividing the prostate into sectors to extract spatial dose-volume information. Following patient discharge, room monitoring for radiation protection purposes is usually performed by a nurse or physicist. The average seed loss based on implanted seed number compared with post-implant CT seed number is <3 per cent in one centre and 98–100 per cent in two centres. Independent dose calculation verification is carried out in all centres, by Microsoft Excel in three centres, commercial software in three centres and Matlab in one centre. Further, one centre performs in vivo dosimetry measurements using metal oxide semiconductor field effect transistor (MOSFET) detectors.

Summary
The use of brachytherapy either as monotherapy (LDR/HDR) or boost (LDR/HDR) combined with EBRT provides excellent biochemical outcomes for men with localised prostate cancer.1 With lower response rates than the previous 2012 RCR audit, this survey documents the ongoing role of prostate brachytherapy in the management of localised and locally advanced disease. The use of the three key RCR quality assurance markers in LDR of D90, CT:US volume ratio and V100 is universal across responding centres and the reported D90s suggest that high-quality implants are performed across the region.

One of the most interesting features of this survey is the number of centres reporting a reduction in the number of LDR cases being performed in 2016, both as monotherapy and as combination therapy. It can only be postulated that the competing options of robotic radical prostatectomy and EBRT have impacted the referral practice. In contrast to LDR, the use of HDR appears to be at least stable and more centres are reporting an increase in case numbers. The radiobiological advantage, improved planning software, reduced reliance on operator skill and potential consumable cost saving, although offset by procedure time, may in part explain the limited number of LDR boosts directed registration. In six centres, pretreatment contouring is performed by the oncologist and in one centre by the radiologist.

In five centres, the prescribed dose for HDR boost treatments is 15 Gy in one fraction to 100 per cent isodose volume, whereas in two centres 15 Gy is prescribed to 90 per cent of the prostate volume. Similarly, for HDR monotherapy treatments, five centres prescribe 19 Gy in one fraction to 100 per cent isodose volume, whereas one centre prescribes 19 Gy to 90 per cent of the prostate volume. Two centres aim for a salvage dose of 19 Gy and two for a salvage dose of 15 Gy. Most centres reported an average of 15–20 needles per implant. The average percentage of the target volume receiving 100 per cent of the dose (V100) is 95–8 per cent in four centres, less than 95 per cent in one centre and 98–100 per cent in two centres. Independent dose calculation verification is carried out in all centres, by Microsoft Excel in three centres, commercial software in three centres and Matlab in one centre. Further, one centre performs in vivo dosimetry measurements using metal oxide semiconductor field effect transistor (MOSFET) detectors.
towards HDR boost therapy.

The number of implants performed by individual consultants is noteworthy for two reasons; firstly, based on the RCR guidance, consultants are encouraged to perform 25 per year and our survey echoes the report by Stewart et al.10 showing a limited number of consultants performing fewer than this.

Secondly, the RCR guidelines suggest that in order to mentor a trainee in brachytherapy, the mentor should perform >100 implants over the preceding 3-year period. Our survey would suggest that the number of potential mentors is limited, so trainees may therefore have limited exposure to brachytherapy and with lower levels of exposure and experience the base of collegiate referral may be reducing. This may also explain the apparent fall in LDR cases reported by some centres in 2016.

Our survey shows that all brachytherapy teams are continually reviewing and assessing implant quality and as an adaptive process may identify and adjust parameters for their centre that may improve dosimetric, biochemical or toxicity outcomes.

**ACKNOWLEDGEMENTS**

We gratefully acknowledge the staff from 18 centres who responded to this survey. We also thank Right Angle Communications for assistance with survey dissemination and collection of results and to IPEM for inclusion of the survey website in the newsletter.

**REFERENCES**


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Within hospitals, a large proportion of medical device fault reports are a result of user error and usability related issues. However, these are often identified and reported as device failures. In such instances, investigation of the devices by medical equipment engineers commonly reaches the conclusion of ‘no fault found’ (NFF), doing nothing to address the underlying problem. A recent study identified instances of NFF reports and investigated their relationships with device usability.

**Study methodology**

The first part of the study involved the analysis of 8 years’ worth of data from the medical equipment maintenance databases of four healthcare organisations in Canada. Specifically, the authors were keen to identify medical device models associated with high levels of unscheduled repairs (where no fault was found by the medical equipment engineers). In total, six models of medical device were identified as having frequent instances of NFF reporting.

Concurrent with the database analysis, medical equipment engineers were interviewed. The interviews were recorded and retrospectively assessed to identify the opinions of the engineers towards the various medical device models. Eleven device models were identified by the engineers as being associated with high levels of NFF reporting; this correlated well with the findings from the database analysis. Additionally, the engineers were able to provide context for the high levels of occurrence of the NFF reports in these devices.

**Investigation of the devices by medical equipment engineers commonly reaches the conclusion of ‘no fault found’, doing nothing to address the underlying problem**

Next, usability evaluations of the six identified devices were performed by the investigators. The evaluations assessed the extent to which devices met various usability criteria. The combined heuristic violations for each device were additionally assessed for their severity. In total, 112 usability issues were identified across the six devices. For five of these devices, violations corresponded well with the results of the database analysis and engineer interviews. For one device, however, there was poor correspondence. This suggests that NFF reports in this instance may be due to intermittent faults or environmental factors.

Based on the findings of the database analysis, the engineer interviews and heuristic evaluations, three devices were selected for usability testing. This testing involved clinical users operating the devices in a simulated environment. The users, and a remote observer, were thus able to reveal usability related design flaws. Table 1 shows the design flaws revealed from the usability testing of a defibrillator.

The fact that a number of design flaws were revealed during usability testing validated the use of the initial database analysis which initially identified these three devices. Additionally, usability testing correlated well with both the engineer interviews and heuristic analysis.

**Recommendations from the study**

Based on the findings of this study, the authors made a number of recommendations. Since it is not usually feasible to investigate every NFF report, the use of database analysis is suggested as being an effective way of identifying devices that are of most interest for the further investigation of design flaws. The use of engineer interviews and heuristic evaluations are recommended as effective means of establishing the reasons for the high levels of NFF reporting in those devices and to confirm that these reports were indeed the direct result of design flaws. Whilst it is resource intensive, usability testing is suggested in order to validate the results of the previous stages.

From the implementation of the described methodology, there are a number of suggested outcomes. One of these is the identification of device features which staff experienced difficulty in using. The study found that features which cause the most

<table>
<thead>
<tr>
<th>Design flaw ID</th>
<th>Design flaw</th>
<th>Task(s) affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Location of accessory connection</td>
<td>Ensure pads/paddles are connected</td>
</tr>
<tr>
<td>D2</td>
<td>Inadequate pads disconnect error message</td>
<td>Ensure pads/paddles are connected</td>
</tr>
<tr>
<td>D3</td>
<td>Lack of error message explaining failed SYNC</td>
<td>Ensure sync mode disengaged when applicable</td>
</tr>
<tr>
<td>D4</td>
<td>Lack of error message explaining shock button inoperable</td>
<td>Ensure QRS gain is sufficient</td>
</tr>
<tr>
<td>D5</td>
<td>Lack of shock button alert</td>
<td>Ensure QRS gain is sufficient</td>
</tr>
<tr>
<td>D6</td>
<td>Inadequate lead placement diagram</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D7</td>
<td>Lack of a system state indicator for SYNC disengaged</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D8</td>
<td>QRS gain adjustment is not automatic</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D9</td>
<td>Device does not default to lead II</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D10</td>
<td>No alert indicating to depress shock button until shock has been delivered</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D11</td>
<td>Inadequate pacing mode</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D12</td>
<td>Location and labeling of pacing controls</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D13</td>
<td>Inadequate system state message indicating pacing mode</td>
<td>Fix inverted waveform</td>
</tr>
<tr>
<td>D14</td>
<td>Pacing status message is unclear</td>
<td>Fix inverted waveform</td>
</tr>
</tbody>
</table>

**TABLE 1. Design flaws revealed from the usability testing of a defibrillator**
problems were often those less commonly used. Thus, it should be ensured that these features were included as part of staff training. Results would also reveal device models that were perhaps less intuitive to use and thus, more often associated with NFF reporting. Identification of these devices would allow limited training resources to be directed towards them. Finally, whilst modifying staff behaviour through training may be effective in reducing the effects of device design flaws, it does not fundamentally address them. It is therefore deemed important to feed back the evidence gathered through the study to manufacturers and bodies such as the MHRA.

Section Editor’s Comments
Working in a medical equipment management service, I see many repair jobs conclude in there being no fault with the device, despite the clinical user reporting as such. This evidently consumes the valuable time of the engineer investigating the fault. The clinical user may also become frustrated that nothing has been done to resolve their reported issue. In addition, a conclusion of NFF, in isolation, does nothing to address what may be a training deficiency or an intrinsic usability design issue with the device. This study presents an easily repeatable methodology to utilise these NFF reports to identify devices and device features that may be responsible for such issues. Once these have been identified, the authors propose ways to confirm and expand upon the initial analysis as well as constructively implement the findings.

CLINICAL & BIOMEDICAL ENGINEERING

Dr Michael Ayers is the Engineering Editor of Scope

Email any comments on this article to m.ayers@nhs.net

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REFERENCES
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The NIHR research training award application

Dr Ellen Donovan (NIHR Research Training Advocate for Healthcare Scientists)

The second article in this series gave an overview of the preparation required prior to making a formal application to the National Institute for Health Research (NIHR) research training schemes. This article concentrates on suggestions for producing a high-quality, readable and engaging application which accurately showcases the research and the researcher. These suggestions are distilled from information from research funders, senior researchers and successful applicants to NIHR personal award schemes.

The schemes open around 2 months before the deadline. It is then possible to register on the online system and obtain access to the Standard Application Form (SAF). Ideally, all the preparatory work suggested in the previous article is well advanced by the date at which the call opens.

Realistically, applicants will be working on many aspects of the proposal concurrent with filling in the SAF. Build a timetable leading to completion which is achievable. Set target dates which allow others to carry out a review of the application in sufficient time so that changes can be made prior to the deadline.

Your local Research Design Service (RDS)1 may have a panel review process to which you can submit your application for feedback. Information about the members of the panel is available online.2 Look at this before writing. Panel members are experts in their fields and skilled in reviewing applications, but the majority of them will NOT be physicists or engineers. It is critical to understand this so that the application is written clearly and is intelligible to non-specialists. Remove subject-specific jargon or explain it clearly.

Be aware that panel members will have between 15 and 20 applications to review in a short time period (2 to 3 weeks). Consider how to make your application stand out. Some suggestions for style and format are given in the box below.

**Think before you write**

Before launching into completing the SAF, think about the audience and the assessment process. NIHR research training awards are funding an individual to support her/his development as a researcher whilst s/he completes a high-quality research project. Panel members will be considering, ‘Why this person? Why this project? Why this place?’. For these awards, you and your future potential as a research leader are a key component of the assessment.

**Your local Research Design Service (RDS) may have a panel review process to which you can submit your application for feedback**

**What are reviewers looking for?**

**Person**

Reviewers will assess each individual for their potential clinical research career trajectory and ability to become a future research leader. The review will be based on the CV information, the quality of past research output and its impact as well as the plans for both the research and the researcher’s career.

Do not neglect the training and development plan. This is an opportunity to prepare a bespoke programme to support...
your research and clinical and professional progression. Ensure it is linked clearly to the planned schedule for your research.

**Writing positively about yourself**
This is difficult for most people so use others to help you. Have a clear message about yourself and your commitment to research; your desire for a clinical academic or applied health research career, and your track record. Make the impact of your previous and planned research activity explicit. Use strong statements in the first person. Be ambitious, original and credible.

**Project**
The research needs to fit the NIHR remit. Explain clearly how it will have a positive benefit to patients and the NHS within 5 years of its completion.

Reviewers will look for a relevant and important research question with detailed and appropriate methodology which is described accurately. Provide a clear, logical plan to achieve challenging and exciting objectives. Be specific about what you aim to achieve, how you will do it and the project milestones (provide a Gantt chart or equivalent graphical representation).

Include pilot data to support your proposal and accept that risks are inevitable so demonstrate a plan to mitigate them.

**Place**
Reviewers will check whether the proposed host environment is suitable and can support your clinical academic career during and beyond the fellowship. The host environment includes the institutions, supervisors and/or mentors. Make clear their track record in fields relevant to your research and provide evidence; for example, Research Excellence Framework (REF) rating, publication records and number of successful PhDs supervised.

Statements of support must not be generic and should clearly describe how the institutions will support your clinical academic career beyond the fellowship.

**Plain English summary**
This has to be of the highest quality. Guidance notes provide a suggested structure which is recommended. Obtain critical comments from a wide range of readers to ensure it is clear and jargon-free.

**Patient and public involvement in research**
Patient and public involvement (PPI) in research is a pre-requisite for most research funding and has to be taken seriously. For NIHR, it is a critical component and funding applications will be severely criticised, and potentially rejected, if it is not engaged with appropriately. There will be patient/public/carer representatives on the fellowship interview panels who are skilled in assessing the commitment of researchers to PPI in research. Token PPI will jeopardise your application.

NIHR define PPI in research as ‘research being carried out “with” or “by” members of the public rather than “to”, “about” or “for” them’. Some examples of how PPI could benefit you are given in the box below.

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**How can patients/public/carers support your fellowship?**
- Work with you to refine the research question so it is relevant to patients and the NHS with impact within 5 years of completion.
- Aid you to write a high-quality plain English summary.
- Offer advice via a project steering group throughout the project lifecycle.
- Comment/develop materials with you, e.g. Participant Information Sheets (PIS).
- Give you mock interview practice.
- Support you in creating a dissemination plan to maximise the impact of the research beyond peer review journals. These are examples and not an exhaustive list; how PPI develops will depend on your research.

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**Support for your patient and public involvement (PPI)**
Kay Stephenson (left) is a PPI Adviser with the Research Design Service South East (RDS SE). She provides tailored advice on PPI and how it can be embedded into proposals for research funding. All the RDSs in England, and your NHS Trust, can assist you in making contact with patients/public/carers who can work with you to embed PPI within the research proposal and throughout the fellowship. Some RDSs may have grants/bursaries available to support PPI activity for a fellowship application. Note that these may be competitively funded.

Kay has some tips for those new to PPI:
- Start with an attitude of goodwill and collaboration – patients/public/carers are enthusiastic about research and want to support good research which has an impact on the NHS.
- Engage with your RDS early as it may not be immediately obvious how to incorporate PPI into your proposal.

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**Summary**
This article has discussed suggestions for producing an application in an engaging, readable style which is jargon free and makes a convincing, robust case for the researcher and the research. It included a focus on PPI which is now an essential component for most research funders, and essential for NIHR funding. The final article in this series will discuss the interview process, dealing with feedback and include the perspective of NIHR fellowship panel members on applications and interviewing fellowship candidates.

**REFERENCES AND RESOURCES**
3. https://www.nihr.ac.uk/patients-and-public/
4. NIHR Trainees Coordinating Centre (TCC). Email: tcc@nihr.ac.uk; telephone: 0113 346 6260.

**NIHR RESEARCH TRAINING ADVOCATE**
**DR ELLEN DONOVAN**
Ellen supports researchers with applications to NIHR funding competitions

Email any comments on this article to e.donovan@surrey.ac.uk

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**AFFILIATION**
Dr Ellen Donovan is an NIHR Research Training Advocate for Healthcare Scientists and a Visiting Senior Fellow at CVSSP, University of Surrey
**MCNEG group visit to the Chernobyl reactor**

Henry Lawrence (MCNEG, the UK Monte Carlo Radiation Transport Codes User Group) visited the site of the catastrophic nuclear reactor explosion in Kiev.

‘Where to hold the next meeting?’ This perennial question is asked by conference organisers the world over. MCNEG (the UK Monte Carlo Radiation Transport User Group) decided to eschew the shores of the UK for the Chernobyl nuclear reactor in Kiev, Ukraine.

In summer 2017, a group of 17 physicists headed east and stayed at the Dream Hostel in Kiev before piling onto coaches bound for Chernobyl. The reactor underwent a catastrophic explosion in 1986, and the accident and its clean-up were described in the film *The Battle for Chernobyl*.1

Tours to Chernobyl must be under the control of licensed tour companies.2 There are two exclusion zones, of 10 km and 30 km radii.

The 10 km zone covers the now-deserted town of Pripyat, a model Soviet town built to house power station workers and their families. Pripyat boasted concert halls, sports complexes, fairgrounds and parks, but it is now derelict and uninhabited.

The 30 km zone covers Chernobyl town, which has two hotels and accommodates many of the decontamination workers. The countryside is now the largest wildlife reserve in the Ukraine; we saw a raccoon and giant catfish, and there are reports of wolves. The exclusion zone is guarded by the Ukrainian army. Despite this, our guide Igor (who was born in the year of the accident) assured us that groups of Ukrainian techno music fans break through the barbed wire and hold illegal raves in an abandoned coach in the countryside.

In order to contain contamination, the world’s largest moveable structure was built to cover the stricken reactor.

**Monitoring contamination doses**

As a result of the contamination barrier, effective dose rates away from the reactor and severely contaminated areas have been reduced by a factor of 4, and wind-blown contamination has been greatly reduced. All visitors are monitored, and I received a dose of 3 microsieverts during the visit.

David Mouat (Clinical Engineering Group, Newcastle Freeman Hospital) was one of the delegates. He built a GPS-enabled contamination monitor that stored position and dose rate, and carried out tests on this device during the visit to Chernobyl.

At the time of the accident, Chernobyl was planned to become the world’s largest nuclear complex. After the accident, most of the construction projects were abandoned. However, the site now boasts some fine art installations; some from the time of the Soviet Union and some recent works, such as a piece in an abandoned cooling tower.

**Visit to Pripyat**

We visited Pripyat, the abandoned town next to the reactor site. It provides a fascinating glimpse into Soviet life. Schools, shops and concert halls are all deserted. Surrounding villages have been engulfed by forest, and Pripyat is succumbing to the same fate.

**Insight into Soviet life**

Finally, on the way back we visited the DUGA array. This was a RF receiver designed to detect changes in the ionosphere caused by a hostile ballistic missile attack. This secret military installation is based in the military town of Chernobyl 2. It is three-quarters of a kilometre long, 100 m high and is visible on the horizon when viewed from the roof in Pripyat.

An RF signal is bounced between Earth and the ionosphere and the signal detected in these arrays. Any change in signal...
would indicate a missile going through the ionosphere. Three such large arrays were built at the extremities of the Soviet Union. The visit gave us a poignant view of the aftermath of a major nuclear accident. It also gave a fascinating insight into cultural life in the Soviet Union.3

REFERENCES
The elective component of the STP (Scientist Training Programme) aims to broaden the horizons of trainees by enabling them to pursue scientific projects or training outside of their normal practice. I took this opportunity to seek project work at a proton beam therapy (PBT) centre and was fortunate enough to be accepted by the medical physics team at Massachusetts General Hospital (MGH).

MGH resides on the bank of the Charles River running through Boston and Cambridge. It is the original and largest teaching hospital of Harvard Medical School and, unsurprisingly, is a world leader, both in research and in the care it provides. As of the summer of 2016, the centre has topped national rankings of care, community, education and research. The MGH medical physics group have been at the forefront of many advances in radiotherapy, and PBT is no exception. The centre itself is one of the earliest practitioners of PBT and remains a highly regarded centre for its delivery.

The department can deliver both passive scanning, comparative to conformal photon therapy, and spot scanning, comparative to IMRT. The centre is currently expanding with a second proton machine soon to be installed. This complements the sizable group of Elekta and Varian linacs at the site.

My project
My research project at MGH was focused on spatially fractionated radiotherapy (SFRT) and whether the PBT modality could obtain a better dose distribution.

SFRT first emerged in the 1930s as a method of reducing the unacceptable skin toxicities faced by patients receiving treatment for deep tumours. The skin toxicities were caused by the use of kV energies, which were the highest available at the time. It was found, by spatially fractionating across the beam, that enough target dose was delivered to obtain a clinical response but with a lower skin toxicity. This technique disappeared from clinical use with the introduction of MV energies in the clinic.

However, the problems in treating large, bulky, radio-resistant tumours have not been resolved. The large treatment area limits the total dose due to the surrounding normal tissue tolerances and thus the rates of local tumour control are woeful. In the last 20 years or so, SFRT has been applied to improve rates of tumour response. It has particularly found success in the treatment of sarcomas.

This success has been linked to some very interesting (but poorly understood) radiobiological processes. There is substantial evidence that the bystander effect (where non-irradiated cells neighbouring irradiated cells are primed for cell death) is occurring in SFRT. This is combined with evidence that the abscopal effect (where distant metastases shrink upon irradiation of the primary tumour) could occur in SFRT treatments.

Recently, SFRT has seen further development with the publication of techniques applying IMRT and VMAT to produce a 3D SFRT dose distribution. Preliminary work on using PBT has been presented at AAPM conferences but to date no paper has been published.

Preliminary results showed PBT produces much better dose distribution in deep, large, bulky tumour cases

My time and work
The aims of the project were to identify possible techniques in the literature, create a method for delivering each of these techniques using the resources available at MGH and then to deliver these techniques to different treatment sites and compare the results obtained.

Much of my time at the centre was spent interpreting the techniques outlined in the literature and constructing a procedure for their application at MGH. The resources available were significantly different to those at my hospital – this obviously included the PBT but also the linacs and treatment planning software (TPS).
The photon-based techniques were planned using the RayStation TPS. This is one of the newest TPSs available and is produced by RaySearch. Its use of multicriteria optimisation (MCO) during inverse planning was fascinating and fundamentally changed how I view the treatment planning process. The software pregenerates what are known as ‘pareto-optimal’ plans, which act as a surface over which the planner can search to find the most acceptable trade-off between the objectives. A pareto-optimal plan is one where the improvement of one objective leads to deterioration in another. I found this to allow an easier understanding of the compromises at play and potentially a large reduction in treatment planning time.

The proton treatments were planned using ASTROIDS. This software was developed at MGH and applies MCO in delivering plans. At first I was concerned about usability but its GUI was more straightforward than other TPSs I have encountered.

By the end of the 9-week project, I had identified and created procedures for the application of the photon SFRT techniques, as well as developed workable solutions for SFRT PBT delivery. The last stage was to apply the three techniques to nine patients grouped in three different treatment sites. I did not manage to complete the 27 plans before my time at the centre was up but preliminary results showed PBT produces much better dose distributions in deep, large, bulky tumour cases. Further examination is required, but these results certainly attest to the advantages of PBT.

Reflections

I found the experience phenomenal in terms of building knowledge and developing my skills. Besides learning a great deal about PBT and photon therapy delivery, my research skills significantly progressed from the first day to the last. I would like to end this special report expressing my gratitude to everyone at MGH for the amazing hospitality and training I received during my stay. Whilst it is not possible to individually thank everyone (report word limits!), I wish to specifically thank my supervisor Kyung-Wook Jee PhD for his insight, training and patience, Herman Suit MD for his many fascinating stories and inspiring advice. I would also like to thank Edward Duck, Mark Knight and Mark Fleckney for allowing me to pursue this fantastic opportunity.

REFERENCES


Email any comments on this article to edwardsmith2@nhs.net
The beautiful market town of Darlington hosted this year’s 34th Annual Conference of the British Medical Laser Association (BMLA). Set in a picturesque location, the Blackwell Grange Hotel saw 160 delegates, eight sponsors, eight invited speakers, Leah Totton (winner of The Apprentice in 2013) and a Naked Scientist descend upon this seventeenth-century mansion. What do all these people have in common? Well, in some way they are all involved in the use of laser or light sources in medicine.

The BMLA’s remit is far reaching and delegates included clinicians, scientists, nurses, technologists and high-street practitioners. With such a diverse audience one would expect a varied programme and in this aspect the BMLA annual conference did not disappoint. Topics included regulation, training, insurance, medicolegal issues, home-use light devices, skin applications of lasers, laser surgery, photodynamic therapy (PDT), biophotonics, photodiagnostics and genital rejuvenation.

Whilst many delegates come for the acclaimed BMLA laser Core of Knowledge or the informative laser treatment courses, it was the scientific programme upon which I set my focus.

Going through my training and working towards Laser Protection Advisor (LPA) status, I was very interested in the presentation by Vincent Pelling (Brighton and Sussex University Hospitals NHS Trust) on “The trials and tribulations of a novice LPA”. Vincent’s tale of being thrown in at the deep end will probably be familiar to many and I appreciated his candid view on succession planning – only without the planning. His experiences gave me great ideas for laser awareness vs Core of Knowledge courses, and his emphasis on engaging the Laser Protection Supervisors (LPS) throughout the hospital struck a chord with me.

It was truly a lesson in how to communicate science and I would highly recommend the podcasts to everyone

**Highlights from the conference**

The first morning of the conference continued on the theme of training and qualification whilst the afternoon sessions were a mixture of laser applications and PDT. Following a stimulating first day we were whisked off to the 5-star Rockcliffe Hall for the conference dinner and drinks reception (figure 1). It is always a nightmare trying to park one’s helicopter and so I had left it at home, not appreciating that the evening venue could accommodate such a mode of transport. There were tears-a-plenty at the conference meal as Professor Harry Moseley (University of Dundee) stepped down as Honorary President of the BMLA after 16 years in the post! Those who have ever attended a BMLA conference will know that Harry’s after-dinner speeches are not to be missed and this year was no exception. Harry leaves the BMLA presidency in the very capable hands of Dr Vishal Madan (Salford Royal NHS Foundation Trust).

It was an early rise on the Friday but luckily the presentation by Dr Paul O’Mahoney (University of Dundee) made it a worthwhile start to the day (figure 2). Paul informed us all about how the results from easily available cheap lux meters could be converted into patient-specific dose for daylight PDT. He analysed thousands of measurements made by Public Health England, determining a correction equation between illuminance and Protoporphyrin-nine (PpIX) effective irradiance. As an increasingly popular treatment, daylight PDT would benefit from improved dosimetry to provide confidence in treatment efficacy and Paul...
is attempting to bridge this gap.

The high quality of scientific study continued throughout the morning with presentations of particular note from Gemma Bale (University College London) and Lewis McMillan (University of St Andrews). Lewis is using Monte Carlo simulations with genetic mutation algorithms to investigate cardiovascular disease biomarkers. Combining computer simulations with real in vitro clinical data of laser-induced fluorescence, Lewis hopes to identify markers which may indicate cardiovascular disease in the population not at risk through diet or smoking habit (figure 3). The highlight of the 2-day programme was surely The Vasant Oswal Oration & Plenary Session delivered by Dr Chris Smith (The Naked Scientists, Cambridge). Entitled ‘Stripping down science: The Naked Scientists’ (figure 4), Dr Smith took us on a journey from his bedroom hobby podcast to what is now an international hit with millions of listeners. This incredibly entertaining lecture broached topics such as ‘How hard would you need to fart to levitate?’; ‘How fast does a sneeze travel?’ and ‘How useless is a chocolate teapot?’.

Afterwards, strolling through the hotel gardens, he was kind enough to answer for us in detail why our eyes wouldn’t pop out of their sockets if we closed our mouths and noses whilst sneezing. It was truly a lesson in how to communicate science and I would highly recommend the podcasts to everyone (http://www.thenakedscientists.com). They have certainly gained a new listener in me!

After an intense 2-day conference and a 5-hour drive home, it is fair to say that I was exhausted. Exhausted but excited. Invigorated by what I had learned and the opportunities that had opened up. I would like to thank IPEM for the travel grant which allowed me to attend this conference and which has undoubtedly benefitted both myself and our department.

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> AFFILIATION
Ewan Eadie works for NHS National Services Scotland and NHS Tayside
IPEM SCOPE

Just Published!

Nuclear Medicine Physics: The Basics, 8th edition by Ramesh Chandra and Arman Rahimz (Lippincott Williams & Wilkins) helps build foundational knowledge of how and why things happen in the clinical environment. Ideal for board review and reference, the 8th edition provides a practical summary of this complex field, focusing on essential details as well as real-life examples taken from nuclear medicine.

Authors: Francis Hegarty, John Amoore, Paul Blackett, Justin McCarthy, Richard Scott
Publisher: CRC Press
ISBN-10: 1498703542
Year: 2017
Format: Hardback
Pages: 569

ARTICLES REQUIRED!

We seek to make Scope relevant and important reading material for people working in the field, as well as anyone with an interest in medical physics and bioengineering. To ensure that Scope is filled with interesting, informative and valuable material, we rely entirely on you to submit features, book reviews, news stories, or anything of interest to our readers. We need you to provide us with great material! Please do get in touch. The submission process is really simple and it will count towards your CPD.

Email any comments on this article to Usman.Lula@uhb.nhs.uk

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BOOK REVIEWS

Reviews of textbooks published on medical physics, along with recently published books

Healthcare Technology Management: A Systematic Approach

Medical equipment management is a large and diverse area. Therefore, it is perhaps not surprising that books comprehensively covering the topic are few and far between. I was pleased when I heard about the publication of Healthcare Technology Management: A Systematic Approach. Other books I have read which cover medical equipment management have taken a rather hands-off approach to the topic, leading the reader, in a structured manner, through the various aspects of the equipment management lifecycle. This book presents a loftier ambition, inviting the reader to apply a systematic approach to the management of healthcare technology. This approach is based upon the ISO 55000 asset management suite of standards and defines processes that derive value from medical equipment.

The book is divided into 10 chapters. The first chapters lay out the foundations for the rest of the book, describing the role of the clinical engineer within a healthcare organisation, the use of a systems engineering approach to the various aspects of equipment management, and describing applicable standards, regulations and guidelines. The next few chapters introduce the concept of the proposed healthcare technology management system, describing its application to a healthcare organisation, from high-level policy to its implementation by a clinical engineering department.

The final chapters take a more directed look at the roles of clinical engineers, including their involvement beyond the day-to-day management of the equipment and the department within which they work. Also covered towards the end of the book is medical device governance and a look at the various benefits in the use of the systems proposed.

At the end of each chapter are self-directed learning points and case studies. These help emphasise that the authors intended this book to be actively engaged with, not just read. In particular, I was impressed with the effort that has clearly gone into putting the case studies together. Evidently written based upon the authors’ personal experiences within clinical engineering, these painted a colourful picture of how the various topics discussed may apply to real-life situations.

By presenting to the reader a singular concept for medical equipment management, this book perhaps sacrifices a certain degree of accessibility. Whilst it is possible to dip into certain topics, the interdependence between many of the chapters means that a certain degree of commitment by the reader is required to fully appreciate the vision presented by the authors. The reader should be prepared for regular reviews of earlier chapters; however, in my electronic version of the book, in the Bookshelf app on an iPad, this is handled well. The standard of writing remains high throughout the book and, combined with a distinct lack of errors for a first edition, make the text a pleasure to read.

This book is described in the preface as being directed to anyone with responsibility towards medical equipment and its management. The focus however is clearly towards the clinical engineer. For anyone within this profession, I would not hesitate to recommend it. Whilst other books may provide a more accessible introduction to equipment management, this book is unique in the guidance it gives to the established clinical engineer to better utilise the medical equipment at their disposal.

Dr Michael Ayers is a Clinical Scientist at Kings College Hospital, London, UK.
practice. New full-colour illustrations, concise text, essential mathematical equations, key points, review questions and useful appendices help you quickly master challenging concepts in nuclear medicine physics.

Image-guided Focused Ultrasound Therapy – Series in Medical Physics and Biomedical Engineering by Fend Wu, Gail ter Haar and Ian Rivens (Springer) covers the basic physics, biomedical engineering and clinical applications of focused ultrasound therapy, the first book to do so. Focusing on applications in cancer treatment, it reviews the medical physics and bioeffects of focused ultrasound beams on living tissues, dosimetry methods and measurements, image guidance including MRI and ultrasound, treatment delivery systems and clinical applications. It also gives practical guidelines on patient setup, target localisation, treatment planning and image-guided procedures for the treatment of various tumours.

Medical and Biological Microwave Sensors and Systems – The Cambridge RF and Microwave and Engineering Series by Isar Mostafanezhad, Olga Boric-Lubecke and Jienhao Lin (Cambridge University Press) details recent advances in medical and biological microwave sensors and systems, with chapters on topics such as implantable sensors, wearable microwave tags and UWB technology. Each chapter explores the theory behind the technology, as well as its design and implementation. This is supported by practical examples and details of experimental results, along with discussions on system design, design trade-offs and possible constraints and manufacturing issues. Applications described include intracranial pressure monitoring, vital signs monitoring and non-invasive molecular and cellular investigations.

Linear Accelerators for Radiation Therapy, 2nd edition by David Greene (Taylor & Francis) focuses on the fundamentals of accelerator systems, explaining the underlying physics and the different features of these systems. This edition includes expanded sections on the treatment head, on x-ray production via multileaf and dynamic collimation for the production of wedged and other intensity-modulated beams, on electron scattering systems and on dosimetry. With high-quality illustrations and practical examples throughout, it contains a detailed description of electron beam optics and linear accelerator components. The final chapter explains how to use other equipment, such as scanners and simulators, in conjunction with linear accelerators for the optimum treatment of various cancers.

Physics for Anesthesiologists by Antonio Pisano (Springer) discusses, explains and provides detailed, up-to-date information on physics applied to clinical practice in anaesthesiology, with the aid of simple examples from daily life. Almost everything that happens around us, including in the operating room and intensive care units, can be explained by physical laws. An awareness and understanding of relatively simple laws such as Bernoulli’s theorem, the Hagen–Poiseuille equation and Pascal’s principle, to name just a few, offers anaesthesiologists and intensivists fascinating insights into why they do what they do. This book is intended for anaesthesiologists, intensivists, anaesthesia teachers, anaesthesia trainees and medical students.

Applied Fourier Analysis from Signal Processing to Medical Imaging by Tim Olson (Springer) is the first of its kind. This focused textbook serves as a self-contained resource for teaching from scratch the fundamental mathematics of Fourier analysis and illustrating some of its most current, interesting applications, including medical imaging and radar processing. Developed by the author from extensive classroom teaching experience, it provides a breadth of theory that allows students to appreciate the utility of the subject, but at as accessible a depth as possible.


Graphics Processing Unit-based High Performance Computing in Radiation Therapy – Series in Medical Physics and Biomedical Engineering by Xuan Jia and Steve Jiang (Taylor & Francis) offers an introduction to the GPU technology and its current applications in radiotherapy. Most of the chapters discuss a specific application of a GPU in a key radiotherapy problem. The book summarises recent advances and presents technical details and insightful discussions on the use of GPU in addressing the problems encountered. The book also examines two real systems developed with GPU as a core component to accomplish important clinical tasks in modern radiotherapy.

New Reports Supplement 2 for the 2004 update of the AAPM Task Group 43 Report: Joint Recommendations by the AAPM and GEC-ESTRO.


Can you write an article for Scope?

Please contact the Editor, Usman Lula

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I am sure you agree that Scope is a high-quality publication for IPEM members to read. We seek to make it relevant and important reading material for people working in the field, as well as anyone with an interest in medical physics and bioengineering. To ensure that Scope is filled with interesting, informative and valuable material, we rely entirely on you to submit articles.

Scope is published four times a year and ideally includes five or six feature articles. This is only possible if you continue to provide us with great material. The readership survey revealed that a number of people were willing to write articles. If you were one of the people who expressed interest in doing so (or even if you weren’t!), please give it serious consideration. Perhaps you have an idea that could be turned into a feature article but do not feel you are the right person to write it? Ask a friend! Alternatively, simply let us know about your idea and we will try to take it forward.

The submission process is simple and articles are normally published in the next issue. It will also count towards your CPD.
WHEN PROFESSOR MARK TOOLEY accepted the role as the new President of IPEM earlier this year, he said he was both honoured and excited about it, and admitted to being somewhat nervous about the challenge he had just taken on.

You have to ask yourself whether the role of President will really be as nerve-wracking as the fascinating fact that Mark revealed about himself as he gazed out over the majestic setting of Sandown Park racecourse at the MEIBioeng/MPEC conference.

‘I once played Debussy on a full-sized Steinway grand piano at a black-tie concert, to an audience of 00 people, at the first (and only) Institution of Electrical Engineers members’ concert, which was both terrifying and exciting at the same time,’ he laughed.

The beginnings of a science career
The eldest of five siblings, Mark grew up in Southampton before the family moved to Bristol when he was a teenager. Only his sister, a mental health professional, has followed Mark into healthcare with his brothers having extremely diverse careers, from one being the head of nuclear safety for EDF, another being a professor of education policy, to another owning a vineyard!

So what sparked Mark’s passion for medical physics and bioengineering? The answer is that it has literally been with him since birth.

‘I was a 1 kg premature baby, born at 27 weeks, and in 1956 was not meant to survive. I was in an incubator for the first 3 months of my life, so medical technology has always been very important to me. With dad an electrical engineer and mother a nurse, our home was full of books on electricity and medicine. Combine that with my teenage hobbies of electronics and amateur radio, it was almost natural that I would go down this route.’

Mark went to the University of Bath in 1975 to do his BSc in electronic engineering. It was a close university friend, who had a placement at Bristol General Hospital, which led Mark following him into the NHS.

‘I answered an advert in IEE News and started my first job as a basic grade physicist at Bath Hospital, and did my MSc on day release at St Barts in London. The technology in medical physics back then was basic to say the least – no computers, no Internet, not even a direct phone line! I then moved to become Senior Medical Physicist in the Medical Electronics Department at St Barts.’

Here, he was involved mainly in research and development, designing software and systems to analyse physiological signals, working with anaesthetists, cardiologists, neurophysiologists and psychologists.

It was at Barts that Mark did his PhD project on implantable defibrillators and pacemakers, inventing, with a cardiologist, a new method of detecting if heart rhythm was normal or pathological.

At the end of his PhD in 1990, Mark was faced with a choice – either to move to Sweden and continue to work on the invention or move back to the West of England. He chose the latter path and joined Bristol Royal Infirmary as Principal Medical Physicist, where he was based in the academic department of anaesthesia, leading a small team researching and lecturing on the physics of anaesthesia.

Mark’s role again saw him carrying out lots of research with anaesthetists on EEG, signal processing and analysis, and teaching them about signals and electricity.

Providing training around the world
In 1997, Mark was involved with setting up the Bristol Medical Simulation Centre (BMSC), the first centre of its kind in Europe, as the Scientific Director and trustee.

This led to him establishing Multimed, a European Space Agency initiative, which linked the BMSC by satellite to remote locations across the UK and one in Bosnia. This pioneering work is something that Mark hopes to continue, providing satellite medical training in southern Africa.

Also at this time, Mark was very involved with the training of scientists. He was the NHS tutor for the South West region, and

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training co-ordinator. He was well immersed with IPEM, as Chair for the Accreditation and Training Committee, and a member of the council.

In 2004, he rejoined Royal United Hospitals in Bath, now as Head of Department and Director of Research and Development, positions he held until his retirement in June of this year. He was involved with many projects in Bath, including studying premature babies in the Neonatal Intensive Care Unit, inventing a new blood pressure system and setting up a simulation centre.

Mark’s route to become the Institute’s President was unusual, but now, 3 months into his Presidency, how does he want the role to develop?

‘I would like the work already started by David [Brettle] and the Trustees to make the role leaner and more efficient to continue. I hope the role can then be very attractive for senior members to apply in the future. My wish is that we would have elections for all the positions of the board, including the President Elect, mirroring what other institutions do. I want to engage with as many other organisations as possible to promote our unique role.’

While Mark may have retired from his full-time job after 37 years in the NHS, it is more than just his interests of running in marathons, playing classical piano, attending music festivals (*lastonbury among them) and spending family time which will be keeping him busy.

Visions for the future of the Institute

Mark, who celebrated his silver wedding anniversary with his wife Stella in August, will be continuing with research projects, consulting on the satellite training project and being an active member on several committees with the Royal Academy of Engineering.

Now, he adds to that list as the new President of IPEM, for which he has a very clear vision of how he wants to see the Institute grow and develop.

‘I want to see our organisation as the body of choice that people working in physics and engineering in medicine and biology want to join and be very involved with. I want to see the membership grow and attract medical technologists and academics working in this field to be part of us. I want to see IPEM as a strong, nurturing community which supports its members, with a very strong and influential voice.

‘I want to encourage members to be proud of what they do, to tell the public about their work and for as many as possible to be involved with the research and innovation agenda.’

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**A day in the life of a member...**

**Professor Mark Tooley**
Roland Blackwell, who died aged 74, was a leading figure in medical physics and bioengineering from the 1970s until his retirement in 2003. He was one of the generation of scientists who came into medical physics during the 1960s and 1970s, and who drove the growth of the profession outside of its traditional base in radiotherapy. He is probably best known for his contributions to the development of diagnostic ultrasound, but his influence was much broader than this.

Roland was born in March 1943, the son of Bessie and Albert Blackwell, who was a Company Secretary by profession. Roland and his elder brother Malcolm grew up in South Norwood and, in 1962, Roland started a 4-year sandwich course in Applied Physics at Battersea College of Technology, which later became the University of Surrey. He spent his industrial year working for the Gas Council on acoustics. Roland met Jean Venner, a teacher from Devon who had moved to Croydon for work, through the local Baptist Church. Jean and Roland were married in 1968 and went on to have five children together.

Career achievements
Roland joined the Department of Medical Physics at University College Hospital (UCH) in 1966, as a Basic Grade Physicist, and trained in radiation physics applications. Roland’s final-year project for his degree course had been on the attenuation of ultrasound in gases; this background led to his being assigned the task of evaluating the Diasonograph, the first commercially available ultrasound scanner.

The immediate response of the radiologists on seeing the ultrasound images was that they were ‘totally hopeless’. But the Medical Physics Department’s established links with obstetrics brought Roland into contact with an obstetrician, Ernie Kohorn, who saw the potential for ultrasound in obstetrics. This led to a number of publications in 1968 and 1969. The obstetrician Stuart Campbell, who also worked at UCH, used the machine in the development of foetal growth charts based on the measurement of the foetal biparietal diameter, which are still widely used today.

By the early 1970s, ultrasound was becoming established as a routine tool in obstetrics. Roland continued to oversee the clinical service as it grew. Technical developments and improvements in image quality brought interest from gastroenterologists and radiologists, for imaging the liver and kidneys. The growing clinical demand meant that there was a need for training of clinicians and, in 1974, Roland established the first course of its kind in England to meet this need. The course ran successfully for 6 years, and spawned a textbook published by Pitman Medical.

In 1978, with the advent of small, portable ultrasound scanners, it became possible to take ultrasound into the neonatal unit. The successful development of ultrasound imaging for detecting and monitoring intracranial haemorrhage in premature babies was an important step forward. Roland led the physics side of the project, working closely with the neonatal intensive care unit at UCH. That early work led to an immensely valuable technique that rapidly became an essential tool in looking after those tiny babies. It also stimulated a huge amount of work aimed at understanding the mechanism of haemorrhage and its antecedents.

Committee and board member
Throughout his career, Roland was involved with IPEM and its forbears, the Hospital Physicists’s Association (HPA) and the Institute of Physical Sciences in Medicine (IPSM). He served on numerous committees and boards, including a term as Secretary of the Scientific Committee, and on the editorial boards of both PM&B and CPPM (now Physiological Measurement).

From 1988 to 1990, he was President of the HPA, in the time covering the separation of the learned society activities, which became IPSM, from the professional and trades union activities of the HPA. Roland’s calm leadership contributed immensely to the success of this major change. Roland also served as a Council Member of the Institute of Physics, as Chairman of the IoP’s Admissions Committee, and on the IoP Degree Accreditation Panel.

In 1992, Roland succeeded John Clifton as Head of Medical Physics & Bioengineering at UCH at a time when there was great pressure on the NHS. He was a powerful advocate for medical physics, locally.
At UCH, more generally in the NHS and in wider forums. He represented the profession at the meetings of the Parliamentary and Scientific Committee and of the Health Care Committee of the Council of Science and Technology Institutes.

He took the major role, on behalf of the HPA, in preparing the pay claims to Whitley Council for 1987–8 and 1988–89, which led to a restructuring of the entire profession, and submissions to the Social Services Select Committee on the functioning of Whitley Council and on the NHS Reforms. Roland served on the NHS's New and Emerging Applications of Technology committee, evaluating and sponsoring research principally into new medical devices. He was Vice Chair of the Professional Conduct Committee for the UK profession. From 1994–7 he was Chairman of the Department of Health Board of Assessors in Medical Physics and Bioengineering and a panel member from 1989 to 1998.

Roland addressed the Back Bench Committees of the Parliamentary Conservative and Labour Parties and met with the front bench spokesmen of the Labour and Liberal Democratic parties to discuss the problems of medical physicists in the NHS. His address to the All Party Parliamentary Committee on Health led to the inclusion of lasers and intense-pulsed lights into the Private Health Care Act.

A strong sense of ethics

I was fortunate to work for and with Roland for most of my career. I experienced at first hand his way of encouraging people to give their best, and to enjoy achievement. I came to know him, as all who worked with him did, as a good friend and a great mentor and supporter.

It is impossible to write about Roland without referring to his Christian faith. Whilst he did not preach or proselytise, it was obvious that his faith was deep, absolutely sincere and informed his whole outlook on the world. He drew from it his moral and ethical position, his respect for others and his commitment to the truth, all of which earned him the greatest respect of his peers and all who dealt with him.

Roland is survived by his wife of 49 years, Jean, and their five children, Joanne, Mark Anna, David and Jonathan, and 10 grandchildren.

This obituary is written by Geoff Cusick and John Clifton

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**OBITUARY**

18TH MARCH 1943 – 26TH APRIL 2017

**PROFESSOR ROLAND BLACKWELL**

BSc, MSc, FIET, CEng, FinstP, Cphys, FIPEM, ARCP, MRCR(Hon)

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