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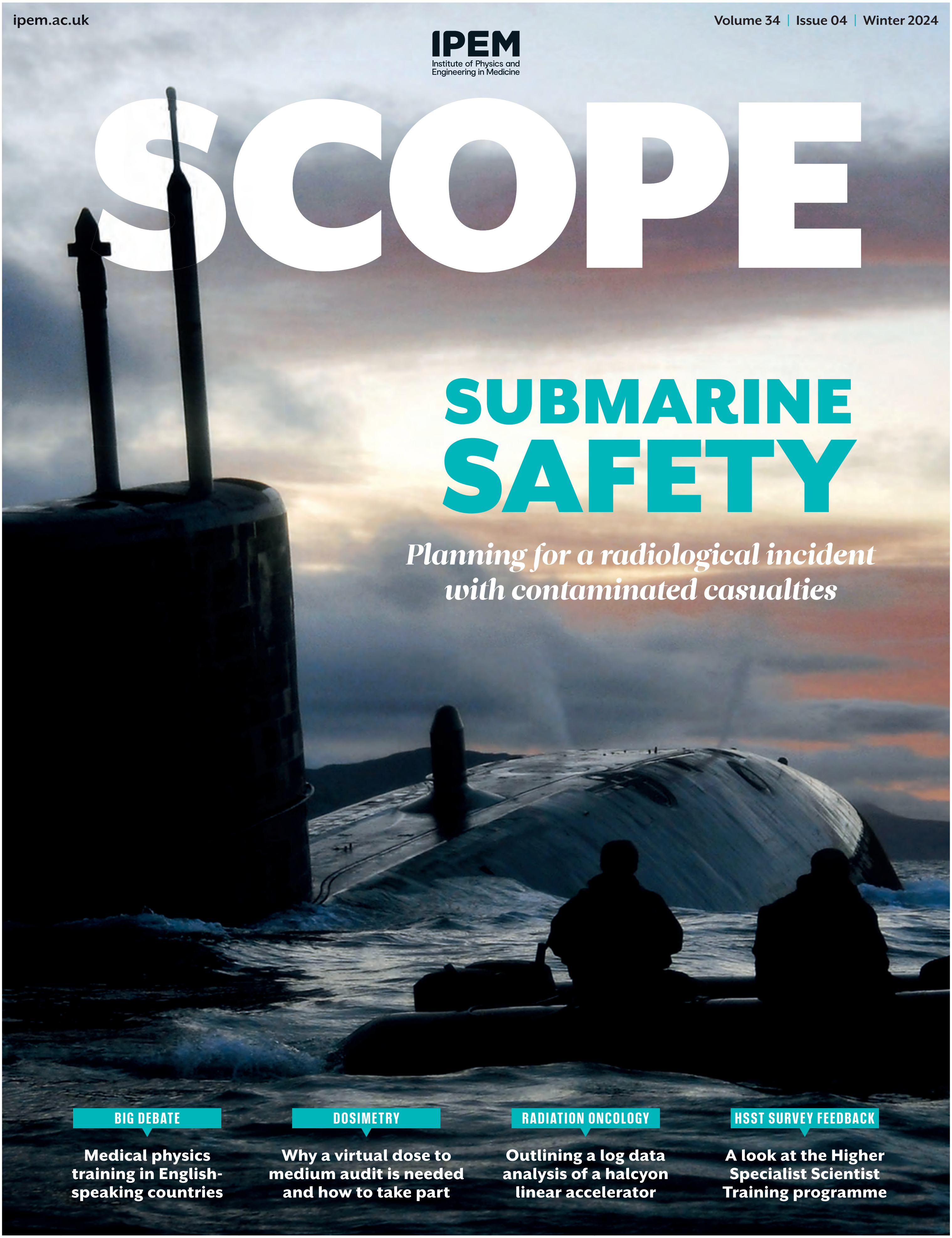
Volume 34 | Issue 04 | Winter 2024

IPEM
Institute of Physics and Engineering in Medicine

SCOPE



SUBMARINE SAFETY

Planning for a radiological incident with contaminated casualties

BIG DEBATE
Medical physics training in English-speaking countries

DOSIMETRY
Why a virtual dose to medium audit is needed and how to take part

RADIATION ONCOLOGY
Outlining a log data analysis of a halcyon linear accelerator

HSST SURVEY FEEDBACK
A look at the Higher Specialist Scientist Training programme

CHAIR OF IPEM SCOPE EDITORIAL ADVISORY BOARD

Developments and challenges

Usman Lula outlines the content in the latest issue, from planning for radiological incidents, to the future of MRI services and clinical audits.

Welcome to the Winter 2024 edition of *Scope*. As we wrap up the year, we're thrilled to present an issue filled with inspiring features, thought-provoking discussions and the latest advancements in medical physics and engineering. A heartfelt thank you goes out to our authors and the dedicated Editorial Advisory Board (EAB) who have worked tirelessly to bring this final issue of 2024 to life.

This issue is packed with diverse features that capture the ongoing developments, challenges and opportunities in our field. First up, we have a Professional Profile with Claire Sharpe, Interim CEO of IPEM. Claire shares insights into her career, discussing her passion for leadership, the challenges she faces, and her vision for the profession. She also gives a glimpse into her personal interests, making this a must-read for those curious about her journey.

In a unique piece on emergency preparedness, Katharine Thomson and Corey Lyth dive into "Submarine Safety – Planning for a Radiological Incident." They reflect on their observations from naval radiological incident rehearsals, showcasing a fascinating aspect of radiological readiness.

Our Member Profile highlights Xavier Golay, CEO of Gold Standard Phantoms, who answers questions about his multifaceted role and contributions.

Led by Natasa Solomou, the special Big Debate tackles international medical physics training. With contributions from English-speaking countries. Sadly, Natasa steps down from her role on the EAB at the end of this year. We wish her the very best and thank her for all her fantastic contributions!

"Shaping the Future of MRI Services in UK Healthcare" sees Rebecca Quest and colleagues outline the evolving landscape of MR services. They discuss upcoming advancements, infrastructure adaptability and strategies for workforce expansion – a crucial read for anyone invested in MRI's future.

> We hope this issue informs, inspires and engages you. Here's to more innovation, collaboration and professional growth

For those keen on clinical audits, Joe Whitbourn updates us on the "Dose to Medium Virtual Audit." He explains the audit's purpose, its connection to dose-to-medium planning and how to get involved.

There are many more fascinating contributions in this issue of *Scope*, including a British Standards Institute call for experts, which we hope informs, inspires and engages you. Here's to more innovation, collaboration and professional growth in 2025. Happy reading.

Usman Lula

Usman Lula
Chair of IPEM Scope EAB

DIVERSE CONTENT

A roadmap for professional growth

In "Advancing Clinical Technologist Careers", IPEM proposes a roadmap for professional growth, focusing on registration, career frameworks and advanced practice roles.

This roadmap offers a promising vision for expanding recognition and career opportunities within the field.

We feature a summary of the 2023 HSST survey, exploring whether the training programme meets the profession's evolving needs. IPEM's recent census on the UK's radiotherapy workforce is also included, recommending increased trainee output and support for career development to relieve workforce pressures. We're hoping we can work with the providers and the national school of healthcare science to facilitate this further.

IPEM
Institute of Physics and Engineering in Medicine

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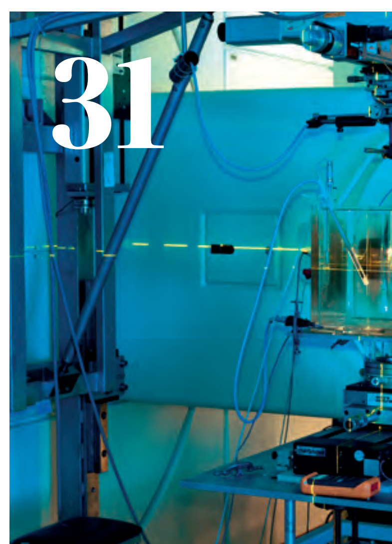
THE BIG DEBATE

In our semi-regular Big Debate feature we take a look at training and education across the globe. We ask a panel of experts from English-speaking countries and subregions about medical physics training, from MScs and PhDs to curriculums and starting salaries for newly qualified medical physicists, and much more.

> A match process was established approximately 10 years ago, and based on the 2021–2022 match results 127 of 250 candidates were matched to residency positions (50.8%.)

Professor Joann I Prisciandaro
Director of Clinical Physics, Michigan Medicine/University of Michigant **page 26**

UPFRONT



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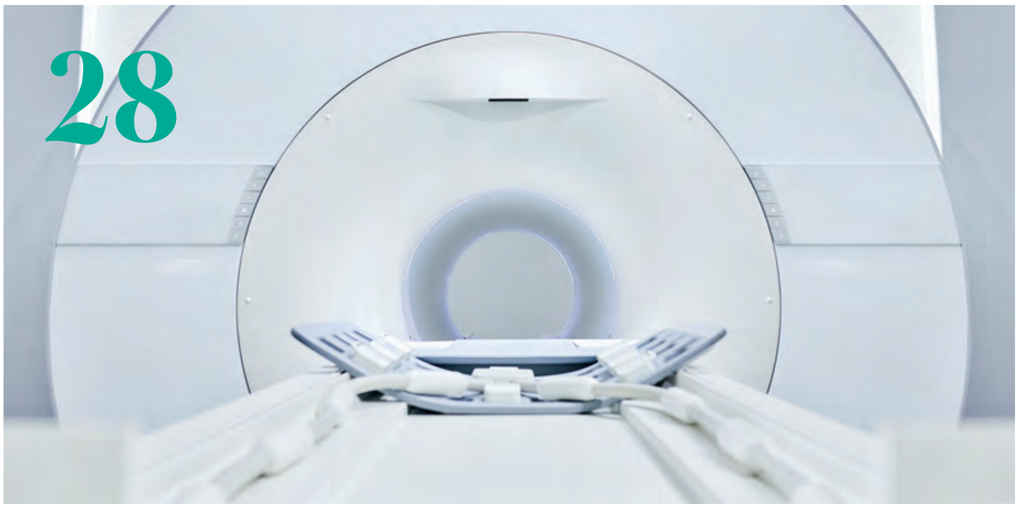

ENDNOTES

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UPFRONT

ARTIFICIAL INTELLIGENCE

Flagship AI-ready dataset released in type 2 diabetes study

Researchers have released the flagship dataset from an ambitious study of biomarkers and environmental factors that may influence the development of type 2 diabetes. Because the study participants include people with no diabetes and others with various stages of the condition, the early findings hint at a tapestry of information distinct from previous research.

For instance, data from a customised environmental sensor in participants' homes show a clear association between disease state and exposure to tiny particulates of pollution.

The collected data also include survey responses, depression scales, eye-imaging scans and traditional measures of glucose and other biologic variables.

All of these data are intended to be mined by artificial intelligence for novel insights about risks, preventive measures and pathways between disease and health.

"We see data supporting heterogeneity among type 2 diabetes patients – that people aren't all dealing with the same thing. And because we're getting such large, granular datasets, researchers will be able to explore this deeply," said Dr Cecilia Lee, a Professor of Ophthalmology at the University of Washington School of Medicine.

She expressed excitement at the quality of the collected data, which represent 1067 people – just 25% of the study's total expected enrollees.

"This process of discovery has been invigorating," said Dr Aaron Lee, also a UW Medicine Professor of Ophthalmology and the project's principal investigator. "We're a consortium of institutions and multidisciplinary teams that had not worked together before. But we have shared goals of drawing on unbiased data and protecting the security of that data as we make it accessible to colleagues everywhere."

At study sites in Seattle, San Diego and Birmingham, Alabama, recruiters are collectively enrolling 4000 participants, with inclusion criteria promoting balance:

- Race/ethnicity (1000 each – white, Black, Hispanic and Asian)
- Disease severity (1000 each – no diabetes, prediabetes, medication/non-insulin-controlled and insulin-controlled type 2 diabetes)
- Sex (equal male/female split).

"Conventionally scientists are examining pathogenesis and risk factors," Lee said. "We want our datasets to also be studied for salutogenesis, or factors that contribute to health. So if your diabetes gets better, what factors might be contributing to that? We expect that the flagship dataset will lead to novel discoveries about type 2 diabetes in both of these ways."

b.link/lprsuhu4

FAST FACTS

4000
The total number of participants that are expected to take part in the project

15+
The number of data types that are being collected, for example vitals and electrocardiogram

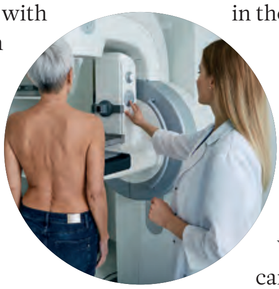
8
There are eight research institutions that are collaborating on this project

IMAGES: ISTOCK, NOUN PROJECT

RADIOTHERAPY

Overcoming breast cancer drug resistance

The most common type of breast cancer, estrogen receptor positive, has been effectively treated with hormone therapy combined with drugs that block cell division called CDK4/6 inhibitors.



However, it has been impossible to predict how long people will respond to this drug combination. In some patients, the disease is controlled for years, but in others, it starts progressing again after months.

This presents a dilemma for those trying to decide whether to scale up or down this treatment regimen.

A research team led by Physician-Scientist Sarat Chandarlapaty from the Memorial Sloan Kettering Cancer Centre has analysed samples from thousands of breast cancer patients receiving the combined therapy. They found that tumours with a short-lived response to treatment had a mutation in the p53 gene.

The researchers discovered that an enzyme called CDK2 plays a key role in allowing the p53-mutated tumours to begin growing again. Working with breast cancer models in the lab, they found that blocking CDK2 and CDK4/6 together could put these p53-mutated tumours into a deep, arrested state.

Researchers are now beginning to test CDK2 inhibitors in combination with CDK4/6 inhibitors in clinical trials.

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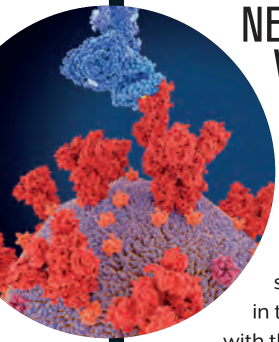
GENETIC TECHNOLOGY



NEW SARS-COV-2 VARIANT DETECTION METHOD

Researchers from Japan claim to have made a significant breakthrough in the fight against COVID-19 with the development of Intelli-OVI, a cutting-edge diagnostic tool capable of rapidly identifying emerging variants of SARS-CoV-2.

The system combines advanced DNA detection technology with computational algorithms to offer a quick and cost-effective method of monitoring viral mutations.

The IntelliPlex technology uses a microdisc, printed with a unique pictorial pattern (πCode), to capture and analyse specific genetic mutations of the virus.

This allows the system to process multiple viral mutations simultaneously, significantly speeding up the detection process.

The OVI algorithm then interprets the data, identifying known and new variants by analysing the unique mutation patterns.

"Our system can be easily updated to track new viral mutations," said Professor Yorifumi Satou, from Kumamoto University.

b.link/tjpyjf0w

NEWS IN BRIEF

AI to measure prostate lesions

US researchers have trained and validated an AI model based on MRI scans from more than 700 prostate cancer patients. The model was able to identify and demarcate the edges of 85% of the most radiologically aggressive prostate lesions. Tumours with a larger volume, as estimated by the AI model, were associated with a higher risk of treatment failure and metastasis, independent of other factors that are normally used to estimate this risk. Furthermore, for patients who received radiation therapy, the tumour volume performed better than traditional risk stratification for predicting metastasis.

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UK health data

An independent review, *Uniting the UK's Health Data: A Huge Opportunity for Society*, has found that complexities and inefficiencies are impeding the use of the UK's health data to improve people's health and lives. Researchers and analysts frequently have to wait months or years to securely access health data to improve care and for vital research into diseases. The review calls on policymakers and healthcare leaders to recognise that health data should be treated as critical national infrastructure. It provides five recommendations to remove barriers, simplify processes and enable safe and secure data use across the UK.

b.link/n9rczasx

Bubble printing

Scientists have developed a bubble printing method that enables high-precision patterning of liquid metal wiring for flexible electronics. It offers new options for creating bendable, stretchable, and highly conductive circuits, ideal for devices such as wearable sensors and medical implants. The team from Yokohama National University employed a femtosecond laser beam to heat the EGaIn particles, generating microbubbles that guide them into lines on a flexible-glass surface.

b.link/5vhumjmn

NANOTECHNOLOGY

Flexible biosensor with modular design

A modular strategy has been developed for designing sensors that can be adapted to various target molecules and concentration ranges.

The modular sensor has the potential to accelerate the development of new diagnostic tools for research.

The sensor uses a DNA origami scaffold, which consists of two arms connected by a molecular "hinge." Each arm is tagged with a fluorescent dye and the distance between the tags is recorded by means of fluorescence resonance energy transfer (FRET). In a closed state, the two arms are parallel; when the structure opens, the arms fold out to form an angle of up to 90°.

"As a result of this large conformational change, the fluorescence signal also changes substantially," said Viktorija Glembockyte, senior author. "This allows signals to be measured with greater clarity and precision than in systems with small conformational changes."

The origami scaffold can be equipped with docking sites for various biomolecular targets, such as nucleic acids or proteins. Whether the sensor is open or closed depends on the binding of the respective target molecule to the origami scaffold.

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UP CLOSE

CUPROPTOSIS

WHAT IS CUPROPTOSIS?

It is a form of cell death driven by copper. Copper-based treatment exerts an inhibiting role in tumour growth and could lead to treatment of chemotherapy-insensitive tumours.

WHAT IS THE LATEST NEWS?

A team of scientists from China has found, for the first time, that cuproptosis-related proteins in tumour tissues were highly expressed under X-ray irradiation. The research also revealed a novel cell death mechanism induced by copper ions – cuproptosis – which could serve as a new target for radiosensitisation.

WHAT DID THEY DO?

Based on this finding, researchers designed and synthesised a copper-containing polyoxometalate, PWCu, to act as a targeted radiosensitiser for re-irradiation. PWCu nanocapsules can enter tumour cells, where they release copper ions during radiotherapy to trigger cuproptosis. In this way, the tumours' acquired radiation resistance is overcome. In addition, the nanocapsules can activate an abscopal effect, inducing immunogenic cell death and stimulating an antitumor immune response.

WHAT DOES THIS MEAN?

These findings suggest that PWCu nanocapsules not only enhance the local anti-tumour effects of radiotherapy but can also activate systemic anti-tumour immunity. It demonstrates the potential of using PWCu nanocapsules to improve patient outcomes, especially in the context of recurrent and metastatic disease.

WHERE CAN I READ MORE?

Their paper in *Nature Nanotechnology*, which you can read here: b.link/fbh6pxnz

NEUROIMAGING

IMAGING TECHNIQUE TO IMPROVE HEAD AND NECK CANCER SURGERY

A team of US researchers from has developed a new imaging technique that enhances the visibility of both tumours and nerves during head and neck cancer surgery.

Their study focused on using fluorescence-guided surgery (FGS) with two different near-infrared (NIR) fluorophores – one specific to tumours and another to facial nerves.

They successfully demonstrated that the two types of fluorophores could be used together to clearly differentiate between cancerous tissues and nerves. The nerve-specific fluorophore showed no significant interference from surrounding tumour tissues, ensuring accurate nerve visualisation even in the presence of cancer.

The development offers a promising tool for surgeons, potentially improving their ability to perform cancer resections while minimising nerve damage.

b.link/s4skmda6

IMAGE: SCIENCE PHOTO LIBRARY, GETTY IMAGES

PROFESSIONAL ROLES

TWO NEW IPEM APPOINTMENTS

IPEM has congratulated Professor Chris Hopkins and Claire Hardiman for winning the recent internal elections.

They have been appointed to the roles of Deputy Director for STERIC and Vice President for Medical Physics, respectively.

Professor Chris Hopkins is a Consultant Clinical Scientist and an Honorary Professor, among many other accomplishments and roles. Claire Hardiman is the Head of Radiation Physics at Imperial College Healthcare NHS Trust. She is also an IPEM Fellow and has held multiple voluntary IPEM roles in the past.

EVENT NOTICE

ICRU CENTENNIAL

The International Commission on Radiation Units and Measurements (ICRU) is hosting a centennial meeting in partnership with IPEM and King's College London.

The ICRU was founded in 1925 in London and its centennial will be held at the London Institute for Healthcare Engineering, King's College London.

The free symposium will take place on 19 March at 9am–5pm and includes coffee breaks, lunch and a reception.

There will be talks on the history of the ICRU and IPEM; radioisotopes for radiation medicine; interventional and image-guided radiation medicine; and balancing benefit and risk for radiation medicine.

icru.org

FINANCES

IPEM responds to the 2024 budget

IPEM has welcomed the increased investment for significant pieces of equipment, such as scanners and radiotherapy machines, in the government's budget.

However, it has warned that there is still an urgent need to invest in the highly trained and specialised staff to operate the machines safely, efficiently and in the best interests of patients.

Claire Sharpe, Interim Chief Executive of IPEM, said: "In our manifesto for the future of medical physics and clinical engineering, published before the election, IPEM specifically called for investment in vital life-saving equipment like scanners and linear accelerators and it is great to see the government heeding that call. Investing for the long term now is not only good for patients in terms of reducing waiting times for diagnosis and treatment, but will also provide the NHS with the latest, cutting edge technology.

"However, these machines need highly trained experts in medical physics and clinical engineering to operate and maintain them safely, effectively and efficiently.

"It's vital therefore, that the government addresses the workforce crisis in medical physics and clinical engineering by investing in more trained MPCE staff and more training places, including wider access to apprenticeships and improving the provision of education in STEM subjects. This includes recruiting more physics teachers in schools."

A key point from the budget is £20bn of funding for government investments in research and development in engineering, biotechnology and medical science.

It also includes the following for the NHS:

- £22.6bn increase in the day-to-day health budget
- £3.1bn increase in capital budget
- £70m funding for radiotherapy machines to improve cancer treatment
- £520m for a new initiative, The Life Sciences Innovation Manufacturing Fund which invites applications for medical technology including MedTech and diagnostics
- New ministers have already received a copy of IPEM's manifesto and we will continue to press them to address the challenges faced by the medical physics and clinical engineering community.

EDUCATION

MRSE AND MRSO EXAMS ARE NOW AVAILABLE IN THE UK

IPEM is pleased to note that the international versions of the American Board of Magnetic Resonance Safety (ABMRS) MRSE and MRSO exams are now available in the UK.

For information on the exams and how to register please go to the ABMRS website: abmrs.org

IMAGES: ALAMY, GETTY IMAGES, SHUTTERSTOCK

DARZI INVESTIGATION

IPEM welcomes report into the state of the NHS

IPEM has welcomed the Darzi Investigation into the state of the NHS and the government's promise to act on its findings.

IPEM's Manifesto for the Future of Medical Physics and Clinical Engineering offers tangible actions that the government can take to address the challenges faced by this vital part of the NHS.

Phil Morgan, former Chief Executive of IPEM, said: "Lord Darzi has recognised the importance of investing in new technology and IPEM welcomes the government's commitment to increase scanner capacity, but the government must also invest in the workforce to operate and maintain them safely and efficiently. Despite the overall narrative around this report that staff levels have increased in the NHS, in medical physics and clinical engineering there is an overall vacancy rate of 10% in existing posts, which are themselves below the recommended staffing levels, which has serious implications for patient safety.

"AI and new technology can also offer significant benefits for patients and staff and IPEM is calling on ministers to bring together the professionals with the expertise necessary to create a framework for its ethical and effective use for the benefit of the NHS. Medical physicists and clinical engineers are a vital part of that conversation."

IPEM is ready to work with the government to deliver its ambitions for the NHS, in which medical physics and clinical engineering plays an essential part."

b.link/fkzx49ur

PROFESSIONAL RECOGNITION

NHS WALES WORKFORCE TRENDS REPORT

The *NHS Wales Workforce Trends* report from Health Education and Improvement Wales has been released.

IPEM was pleased to see that healthcare scientists were one of the professional groups represented in this report: it was informative to see how workforce trends among this group compared with trends across NHS Wales as a whole.

While healthcare scientists were represented in the report, there was no information presented specifically on medical physicists and clinical engineers.

These professions represent a significant portion of the healthcare scientist workforce and any specific information on workforce trends in medical physics and clinical engineering would be welcome.

b.link/4dayv3y6

POLITICS

Minister thanks IPEM for insights

The new Minister of State for Health, Karin Smyth MP, has responded positively to IPEM, after President Dr Anna Barnes wrote to her and the Secretary of State with a copy of *IPEM's Manifesto for the Future of Medical Physics and Clinical Engineering*.

The minister thanked IPEM for "the valuable insights you provided regarding the critical role that medical physicists, technologists and clinical and biomedical engineers play in diagnosing and treating illnesses, as well as your comprehensive overview of the challenges facing the field of medical physics and clinical engineering",

She went on to say that the government was committed to providing enough staff in the NHS "to be there for all of us, whenever we need it".

Commenting on IPEM's calls for the statutory regulation of clinical technologists and more investment in the life-saving equipment that our members are responsible for every day, the minister said these were "areas for consideration". The government has already committed to significant investment in scanner capacity and IPEM will continue to press ministers on this.

IPEM's Head of Communications and Public Affairs, Chris Watt, said: "The minister's positive tone is very welcome and we will be taking her up on her offer to engage with stakeholders such as IPEM to tackle the challenges faced by medical physics and clinical engineering in the interests of the professionals we represent and their patients."

Professional profile: Claire Sharpe

My role has recently changed from Deputy CEO to Interim CEO, before I was a member of the senior leadership team, now I report directly to the Board of Trustees. My job is to lead the development and implementation of strategic plans, build and maintain strong relationships with key stakeholders, such as trustees, volunteers, members, partners and staff. No two days are the same, I have to be adaptable and use various skills to lead IPEM

Which elements of your job do you like the most?
I really enjoy promoting IPEM's mission to our stakeholders and ensuring it continues to be a leading force in physics and engineering in medicine. This takes various forms, from ensuring that we have a clear strategy that we can share with stakeholders, to attending events, fostering strategic partnerships to enable collaboration and increase our reach and supporting our active volunteers working in special interest groups (SIGs) and committees to achieve the best impact for medical physics and clinical engineering (MPCE) and for IPEM.

What are the biggest challenges you see – either for yourself or the sector?
Currently we are one year into a new long-term financial plan to diversify our income and reduce the risk of reliance on a single source of income. In the past, IPEM has derived 60–70% of its income from our journals, but there are big changes in the scientific publishing world due to the drive for open access. On one hand, open access is very aligned to our charitable objective to further sharing of scientific knowledge for the public benefit, but the potential impact to our income could be significant. We don't expect this to impact for a few years, so we have made a great start in changing the overall proportions of our different income streams.

For me personally I am looking forward to the exciting challenge of becoming interim CEO. I have a great team around me and I hope to continue the great work started with Phil Morgan.

If you could change one thing about the profession, or your area of specialty, what would it be and why?
I am a huge advocate of social mobility and would love to make MPCE careers more accessible (and visible) to all, so that we have increased staffing numbers and increased diversity in the workforce.

What skillsets do you think are required to be successful in your role, and is there a particular career path or training option you would recommend??
Over the past few years, I have made the move from subject matter expert (in my case, charity finance) to senior leader. This has involved developing lots of new skills and really refining my leadership skills, such as influencing and strategic thinking. I have also ensured I have developed resilience and a strong support network to provide extra support as a senior leader.

What accomplishment have you been most proud of in your career?
I have been lucky enough to work for some fantastic charities, but I think the thing I am most proud of is the team culture here at IPEM. Across both staff and volunteers we achieve some really amazing things together I am really proud to be a part of that.

IPEM's Science Leadership Strategy is all about identifying and anticipating what

IMAGES: ISTCOK, NOUN PROJECT

might impact the working environment of our members now and in the near future. What are your predictions about the future of your profession and your area of specialty?
My predictions for the future of MPCE are largely aligned to grand challenges and emerging trends in the science leadership strategy. In particular I think AI will have a huge positive impact and we need to be ready to support members as this area develops.

What do you do in your free time?
I am a cyclist and triathlete, I regularly enter swim, bike, run events and prefer the longer distances, as I'm not very fast but better at endurance.

I have a collection of bikes for different purposes at home, ranging from a Brompton to a TT bike and I have a fully functioning bike repair workshop in which I enjoy fixing my bikes and those of the people in my village. I can often be found covered in bike dirt in my workshop, where I recently upgraded my groupset to a new electronic shifting setup.

"I THINK AI WILL HAVE A HUGE POSITIVE IMPACT AND WE NEED TO BE READY TO SUPPORT MEMBERS AS THIS DEVELOPS

Why did you join IPEM?
I joined in July 2022 as Head of Finance and Operations. I joined because I am passionate about science and engineering and I enjoy working for organisations that make a difference.

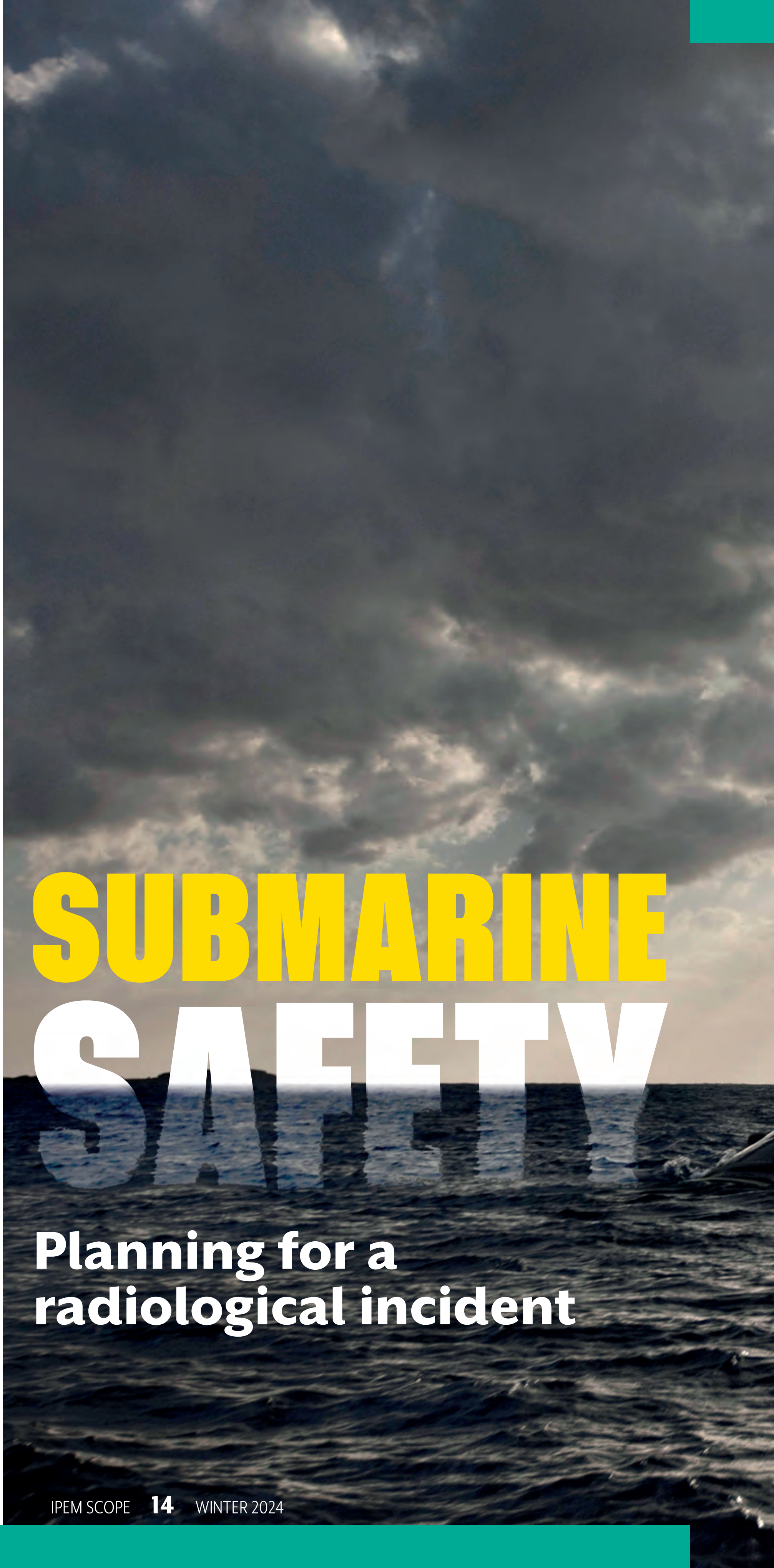


IMAGE: ALAMY

SUBMARINE SAFETY

Planning for a radiological incident

Katharine Thomson and **Corey Lyth** from University Hospital Plymouth NHS Trust discuss a unique project to deal with contaminated casualties.

The life of a nuclear medicine physicist is a varied one. One minute you are risk assessing an infusion method for a radionuclide therapy; the next you're heading into the gents' loos to monitor a puddle that you suspect the last bone scan patient might have left.

Recently, though, there has been an extra element to my job that I hadn't foreseen when I was setting out as a medical physicist. Over the last year, my colleagues and I from Derriford Hospital in Plymouth have descended into the belly of a nuclear submarine – we have observed naval radiological incident contingency rehearsals and we have hosted a health physicist at the hospital on secondment. Most bizarre of all, from my point of view, was the moment I found myself on stage at two IPEM conferences explaining the difference between various submarine classes – an area on which I had zero prior knowledge until working in Plymouth.

The reason?

About five miles away from Derriford Hospital, where the River Tamar meets the sea, sits His Majesty's Naval Base (HMNB) Devonport (see box, overleaf). This is the largest naval base in Western Europe, comprising a Military of Defence (MoD)-

authorised site and a licensed site (Devonport Royal Dockyard) operated by Babcock International Group, a defence contractor. Devonport covers more than 650 acres and four miles of waterfront, with dry docks, berths and basins for a range of vessels.

The vessels most relevant to us are nuclear-powered submarines. Some are undergoing maintenance or repairs, and others, such as the T Class submarines, are in the process of being decommissioned. This is a three-stage project, the first being the removal of the reactor core (as low-level waste), the second the removal of the reactor pressure vessel (intermediate waste) and the third the conventional disposal and recycling of non-radioactive components.

The Radiation (Emergency Preparedness and Public Information) Regulations 2019 (REPPIR) establish a framework to protect the public from radiation accidents. REPPIR requires the MoD and Babcock, as Devonport's on-site operators, to plan for any reasonably foreseeable radiation emergency resulting from the presence of nuclear-powered submarines. They also need to liaise with the local authority and receiving hospital for any contaminated casualties. That receiving hospital is Derriford Hospital.

According to Devonport's Off-Site Emergency Plan, held by the local authority, any casualties from an incident that are contaminated with radioactivity and have life-threatening injuries will be brought to us at Derriford Hospital, where a limited monitoring and casualty decontamination facility will be set up in the courtyard of our emergency department. Casualties who don't fall into this category, i.e. with more minor injuries, should be decontaminated as far as possible at Devonport before being brought to Derriford for medical treatment.

HMNB DEVONPORT FACTFILE

Devonport is the biggest naval base in Western Europe and has been a vital support for the Royal Navy since 1691.

Spread across a vast area of more than 650 acres, it features 15 dry docks, four miles of waterfront, 25 tidal berths, and five basins.

It is home to several Royal Navy ships and units based in the Westcountry. This includes Britain's largest amphibious ships, research and survey vessels and the majority of the Royal Navy's frigates.

It also serves as the central training hub for the frontline and the FOST (Fleet Operational Standards and Training) organisation, who are responsible for ensuring Royal Navy and Royal Fleet Auxiliary vessels are fit to join the operational fleet.

With a workforce of 2500 service people and civilians, Devonport also contributes to the local economy by supporting approximately 400 local businesses and generating around 10% of Plymouth's income.

The priorities

So, if the worst happened and gravely injured, potentially contaminated casualties were brought from the naval base to the hospital, what would we do? The basis of our plan is the following priorities:

1. Resuscitation/life-saving treatment/urgent medical or surgical care
2. Containment: preventing spread of contamination on individuals (e.g. from skin contamination to ingestion or absorption via wound), to other people or the surroundings
3. Decontamination
4. Other clinical treatment and follow up

The first hospital staff involved are likely to be emergency department staff, who receive regular training in monitoring (using the RAM GENE combined dose rate/contamination meters) and in decontamination procedures for all types of contamination (e.g. chemical or caustic). Nuclear medicine/medical physics staff, including radiation protection advisers (RPAs) and radioactive waste advisers (RWAs), will be called for further support and advice – a radiation emergency call out list is held by the switchboard out of hours. Our role is to assist and advise on:

1. Identifying radioactive contamination and assessing its levels
2. Minimising its spread
3. Handling radioactive waste generated by the decontamination process, using segregation, containment and safe disposal where possible
4. Communication with non-specialist staff, external bodies, the public and patients.

Depending on staff availability, some of this support will be provided on the ground in the emergency department, some from a lead physicist embedded in the incident control centre, and, in a worst-case out-of-hours scenario where we can't reach site quickly enough, advice can also be given remotely.

Our plan focuses on two scenarios: a contaminated casualty with very significant injuries requiring immediate life-saving treatment, and an alternative where less-injured but potentially contaminated people arrive at the emergency department.

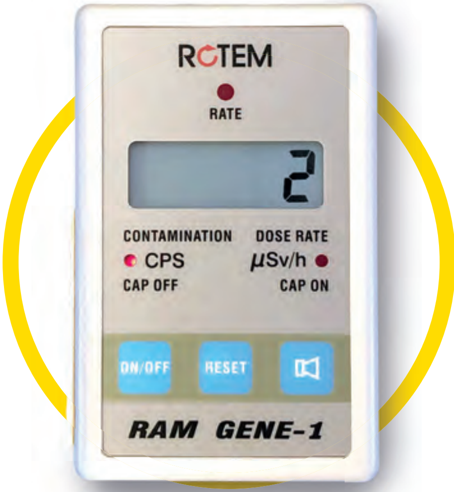
The scenarios

In the first scenario, we have made provision for transfer straight to a dedicated surgical theatre. This was chosen, with help from the trust's Emergency Planning and Liaison Officer, for its location with easy but controllable access, allowing other nearby theatres to continue normal clinical work. Contamination of staff must still be prevented, and access to the area controlled. Decontamination of the theatre, route and equipment must follow immediately.

In the second scenario, "hot/cold" zones would be enforced outside the emergency department, with casualties monitored at barriers before proceeding into the "cold", non-contaminated area, or for decontamination. Access would again be controlled and in "hot" areas PPE would be required.

The decontamination process depends on the nature of the scenario. Removal of outer clothing may be sufficient; at the other end of the spectrum, a dedicated decontamination tent could be deployed. The casualty's dignity must be considered. Official guidance from Public Health England and NHS England describes dry and wet decontamination methods, with wet decontamination preferred for caustic substances or radioactivity. It recommends using water plus a washing aid (e.g. sponge plus detergent) and a rinse-wipe-rinse system, taking care to avoid splashing (and containing waste water if possible). Damp wipes may also be effective at removing contamination.

The same principles of radiation protection apply as in more familiar scenarios. Time, distance and shielding are as relevant as ever, a dynamic risk assessment of likely doses from measured dose rates should be performed, and



Above. Radiation dosimeter. Personal dose meter (dosimeter). This device is used to measure exposure to ionizing radiation.

personal dosimetry worn (e.g. electronic personal dosimeters (EPDs), if possible). Internal contamination must be prevented as in a normal nuclear medicine department: no eating, drinking or smoking.

After the immediate phase of monitoring, decontamination and treatment, comes the follow up. All areas, equipment and staff need to be carefully monitored, and any accumulated waste stored or disposed of safely (following RWA and EA advice). Staff and patients must be followed up and radiation doses calculated where possible. Specialist advice can be obtained, and an investigation completed.

Serve as a link

Part of our role as hospital physicists in an emergency of this kind would be to serve as a link between Devonport health physicists and our clinical colleagues, helping to explain risks and precautions. Casualties arriving from Devonport should be accompanied by MoD/Babcock staff including a health physics monitor, who will be trained in monitoring and able to describe the contamination type and location. One of our key aims in our latest plan review was to strengthen links and communication with our counterparts at Devonport. We have got to know the Devonport RPAs, RWAs, health physicists and emergency planners, many of whom have similar experience and training to ourselves.

Familiarisation visits

As part of this collaboration, we hosted our Devonport counterparts on familiarisation visits to the hospital and vice versa. On our day at Devonport we were lucky enough to visit HMS Talent, a T Class nuclear-powered submarine operational from the 1980s until 2022. I won't forget the astonishing sight of thirteen decommissioned submarines laid up together in a basin, nor the fascinatingly complex but cramped interior where the crew lived submerged for months at a time. Back at Derriford, we set up a secondment placement for a Babcock Trainee Health Physicist to help us with our review of emergency plans and to get a better idea of how we work.

Differences exist, though, between our team at Derriford Hospital and our Devonport colleagues, not least that, for us, this work has inevitably been fitted around our normal clinical work. On our visit to Devonport we were hugely impressed by the resources, in staffing, facilities and equipment, that are (rightly!) dedicated to emergency planning.

Another key difference is that in an incident of this type we may not know what isotope or activity we are dealing with; this is an interesting challenge for a Nuclear Medicine RPA like me, used to dealing with, for example, up to several GBq of Tc-99m.

Key priorities

The more time we have spent on our plan,

"I WON'T FORGET THE ASTONISHING SIGHT OF THIRTEEN DECOMMISSIONED SUBMARINES LAID UP IN A BASIN

IMAGE: LA(PHOT) HAMISH BURKE

the more conscious we are of its limitations. In any emergency, even the most detailed plan will probably fail to account for something unexpected, and people will have to think on their feet. We have tried to focus on the key priorities – enabling life-saving treatment and preventing spread of contamination – and beyond that to make best endeavours with the advice that we give.

A few other things we've learned:

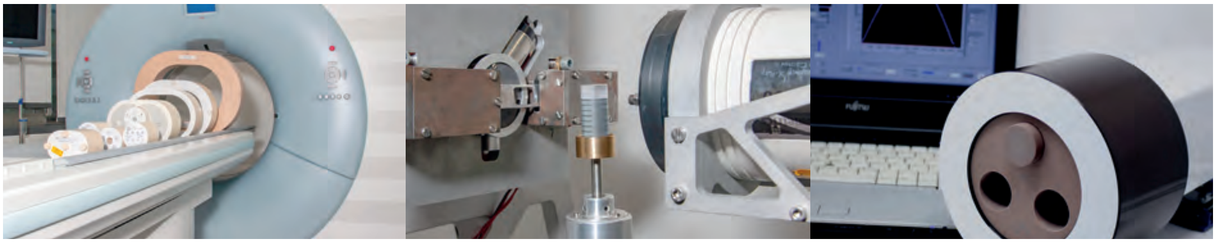
- **PPE:** The UK Health Security Agency (UKHSA) provides guidance recommending more extensive personal protective equipment (PPE) for suspected biological or chemical contamination than for radiological alone. Clearly, staff must be trained in whatever PPE they use (e.g. if you require FFP3 respiratory masks, you must have an in-date fit test).
- **Monitors:** The best monitor for a job is the one appropriate to the contamination type, and that you are trained and familiar with. Emergency department staff may have access to and training with RAM GENEs, whereas medical physics and nuclear medicine staff may use other monitors. UKHSA guidance suggests a contamination threshold of three times background level, or a locally agreed action level may be adopted. Guidance gives action levels for monitoring internal contamination.
- **Record keeping:** It is vital to keep records throughout the incident, e.g. a timed log of actions and advice given, monitoring data or dose rates, and details of people involved.
- **Communication:** What are the communication pathways? Will all radiation protection advice go through one person, e.g. an on-site lead RPA? Does that go to an emergency department lead? The incident control centre? What about external organisations, such as the Police or Fire and Rescue?
- **Call Out Lists:** Many hospitals have some kind of call-out list for emergencies needing medical physics input. They're difficult to keep up to date and often don't work very well. We have overhauled ours to be scenario-specific: i.e. the list of people to be contacted in the event of a chemical, biological, radiological or nuclear (CBRN) incident is different from those called to advise for a radionuclide therapy inpatient.

Although Devonport's proximity to Derriford Hospital gives us a particular focus, these considerations are applicable to anyone planning for a CBRN event, when a contaminated person – or someone who thinks they are – arrives at hospital. Although unlikely, it is worth being prepared as far as possible.

*The authors would like to thank colleagues at University Hospitals Plymouth and HMNB Devonport, especially **Miriam Smith** from UHP, **Hannah Gill**, **Barry Philips** and **Scott Tucker** from Babcock International Group and **Andrew Turner** from the MoD.*

PTW THE DOSIMETRY COMPANY

QRM Phantoms



A comprehensive range of phantoms for all situations

Phantoms are specially designed objects that are scanned or imaged to analyse the accuracy and efficiency of a wide range of processes in medical imaging. PTW have teamed-up with QRM to provide a huge range of phantoms for all your needs. Here are a few examples:

The Spectral CT Phantom

The Spectral CT Phantom is used to test different types of CT modalities with dual-energy, multi-energy or photon-counting setups and is available in 4 (QRM-10139) and 8 (QRM-10147) hole versions. The 20 mm inserts are available in a wide range of tissue types and Iodine/CaHA concentrations

The Comprehensive Electron Density Phantom

The Comprehensive Electron Density Phantom (QRM-90114) is used to calibrate the HU/electron density conversion for CT datasets used for radiotherapy treatment planning. 16 rods mimic a variety of tissue densities and conform to ICRU recommendations. Suitable for photon, electron and proton planning processes

The Cone-Beam Phantom

The Cone-Beam Phantom, Expert (QRM-10103), for testing the imaging performance in diagnostic and cone-beam CT, has low contrast sections providing contrasts between 3 and 200 HUs. Spatial resolution line patterns from 4 to 30 lp/cm and an additional edge insert determine the system MTF in different orientations.

In addition to our standard range, we can design bespoke phantoms for medical, industrial and research purposes. For more information on our range of QRM phantoms and to see what PTW can do for you visit https://www.qrm.de/en/, or contact us at PTW-UK: sales2.uk@ptwdosimetry.com

BEYOND BOUNDARIES

The IPEM Science, Technology and Engineering Forum

The second IPEM Science, Technology and Engineering Forum (STEF) took place in London in October. We take a look at the two-day event.

IPEM's Interim Chief Executive Officer Claire Sharpe

Over 150 people travelled to London to attend STEF, which this year had the theme "Beyond Boundaries: Collaborating for Tomorrow's Innovative Solutions". True to the theme, many of the sessions touched on the breaking down of barriers and silos, with a strong focus on what can be achieved by pulling together as a sector and working closely with other disciplines.

Dr Anna Barnes, IPEM's President, said that in an age where communication is often carried out via online platforms, it was incredibly valuable to have everyone coming together in person for an exchange of ideas and to work together to help shape the future of medical physics and clinical engineering. "I'm loving how everyone is in agreement – there's not a single dissenting voice in the room in terms of why we are doing this," she said. "I think it's wonderful that we are able come together after being so remote for such a long time. I miss the mingling and the networking and it's great to have a professional gathering – it has helped to give me some messages that I can take with me as President."

Collaboration

Many of the session directly addressed the theme, such as the keynote lecture delivered by Professor Wendy Tindale OBE of Sheffield Teaching Hospitals NHS Foundation Trust. Her talk was entitled "Multidisciplinary Collaboration in Technology Development and Evaluation – Opportunities, Challenges and Reflections".

The wide-ranging talk started with some disparate examples of great collaborations – from the double helix and Large Hadron Collider through to the Beatles and Ben and Jerry's ice cream – before moving on to some examples closer to home – integrated care systems, pathology networks and virtual wards, among others.

Dr Anna Barnes, IPEM's President and Mark Knight, IPEM's President Elect

She went on to discuss some of the projects she's been involved with where collaboration with other disciplines and the public were vital, from early work on artificial heart valves, to the Dignity Commode, a portable self-contained bidet commode; a toilet seat with a controlled warm water jet spray to clean, and warm air to dry afterwards, for those who need help going to the toilet.

"It's absolutely vital to take different viewpoints into account," she said. "That can be the difference between success and failure." She stressed the importance of involving people from different specialism and working closely with the public and end-users, where possible.

She added: "I'd encourage you to think big and if there's something that you don't know, someone in a different area might know, so reach out."


The IPEM President's Symposium

Sustainability and AI

Among the other key themes to emerge from the event were two major subjects that are having a big impact, not just in medical physics and clinical engineering, but that are touching almost every aspect of modern life – artificial intelligence and sustainability. There was an industry Q&A panel on AI in healthcare featuring Dr Anna Barnes and Dr Richard Meades of the Royal Free London NHS Foundation Trust and a session by Dr Paul Doolan, General Co-ordinator of Medical Physics at German Oncology Centre on whether AI is a "foe, friend or frenemy".

In one discussion on AI and machine learning, Dr James Harkin, Principal Clinical Scientist at the Christie, talked about increasing patient throughput for magnetic resonance imaging (MRI) by using AI to generate images, which increased speed by 60% while maintaining image quality. This allowed the team to increase the number of 30-minute slots for patients by 18.8% (in excess of the 10% target they had been given to try to reduce backlogs).

"If you are going to buy a new scanner, I certainly wouldn't get one without these AI technologies," he said.

Sustainability was well represented at STEF, with a couple of breakout session on the topic across the two days and a keynote lecture by Fanny Burrows from the Greener NHS Programme entitled "Environmental Sustainability in Healthcare – a Greener NHS Overview".

She said: "The NHS produces 4.6% of all UK emissions, that's why we need to become part of the solution and this gives us a great opportunity to provide better air quality and there are lots of co-benefits", including better diets and more active lifestyles, she added.

She discussed a number of areas where action is needed including transport, supply chains, data, the workforce and clinical transformation, among others.

Fanny outlined some of the areas where progress is already being made, such as reducing carbon emissions from inhalers and anaesthetic gasses, while, from an NHS estates perspective, solar panel are being installed and the switch to electric heating is underway.

Alongside the sessions on collaboration, artificial intelligence and sustainability, a wide range of other topics was covered, ranging from ethical healthcare and the art of grant-writing, to the John Mallard Lecture: "New Prospects in Precision Image-Guided Particle Therapy", delivered by Professor Katia Parodi, among others.

Collaborate in real time

While at many conferences and congresses, the attendees are lined up in rows of seats to watch the sessions, IPEM's forum format meant that attendees were all seated at round tables while watching the presentations – a format that encourages collaboration and pre- and post-presentation discussions among colleagues.

The sessions also allowed attendees to submit questions to the speakers via Slido – a platform in which submitted questions are projected on a screen behind the speakers and the audience has the ability to "like" questions and push them up the pecking order to be asked first.

Speaking at the end of the event, Mark Knight, IPEM's President Elect, who is Chief Healthcare Scientist at NHS Kent and Medway, said: "We had some great sessions and I really enjoyed the panel sessions – they demonstrated what it's like to collaborate in real time. It creates a hive mind when you get people together in one place. I think we've seen lots of opportunity for people to work together."

IPEM's Interim Chief Executive Officer Claire Sharpe added: "It's been a brilliant opportunity for collaboration. It's been really lovely to see everyone from different areas interacting and I think that some new connections have been forged."

The next STEF is due to take place on 13–14 October 2025.

IMAGE: ISTOCK

MEDICAL DEVICES & AI, SOFTWARE AND SYSTEMS

A call for experts

The British Standards Institute is seeking experts to give their invaluable insights into standard development for the following committees.

Committee: CH/62 "Medical equipment, software and systems"

***PWI 62-5** - Establishing the credibility of computational modelling in the field of medical devices through verification, validation, and uncertainty quantification*

This project intends to prepare a new work item proposal for a standard that specifies requirements and recommendations for establishing the credibility of computational models used in the field of medical devices.

***PNW PAS 62-531 ED1** - Data management and data quality assessment for medical devices*

This document provides a framework for the data life cycle processes for management of data used to train, test or validate an AI model that is part of a medical device.

***IEC 63450 ED1** - Testing of Artificial Intelligence / Machine Learning-enabled Medical Devices*

This document establishes methods for medical device manufacturers to verify and validate artificial intelligence / machine learning-enabled medical devices (AI/ML-MD) i.e. medical devices that use artificial intelligence, in part or in whole, to achieve their intended medical purpose.

***IEC 63521 ED1** - Machine Learning-enabled Medical Device - Performance Evaluation Process*

This document defines a standardised performance evaluation process for machine learning-enabled medical devices (MLMD).

Committee: CH/62/1 "Common aspects of medical equipment, software, and systems

***PNW 62A-1609 ED1** Health software and health IT systems safety, effectiveness and security - Part 5-2: Security Risk Management for Manufacturers*

This document provides requirements and guidance when addressing design, production and post-production security risk management across the lifecycle within the risk management framework defined by ISO 14971.

***IEC TS 81001-2-2 ED1** Health software and health IT systems safety, effectiveness and security - Part 2-2: Guidance for the implementation, disclosure and communication of security needs, risks and controls*

This document presents aset of common, high-level security-related capabilities and additional considerations to be used across the entire life cycle of health software.

Committee: CH/62/2 "Medical imaging equipment, software and systems"

***IEC 63524 ED1** Artificial Intelligence enabled Medical Devices — Computer assisted analysis software for pulmonary images - Algorithm performance test methods*

This document specifies algorithm performance test methods of computer assisted analysis software for pulmonary images based on AI technology.

Committee: CH/210/4 "Risk Analysis for Medical Devices"

***ISO/TS 24971**-2 Medical devices — Guidance on the application of ISO **14971** — Part 2: Machine learning in artificial intelligence*

This document provides guidance for applying an ISO 14971 risk management process when evaluating medical technology utilising machine learning).

Would you like to influence how your area is shaped? Would you like to feed into the global standardisation frameworks? Getting involved gives you invaluable insights into standards development and a chance to be the voice of the UK in shaping international standards.

If you are interested in contributing to any projects here, please send an email to: **lindsey.ferrari@bsigroup.com** by 30 January 2025.

***Usman Lula** is the Deputy Chair of the BSI Committee CH/62/3*

IMAGE: ISTOCK

Member profile: Xavier Golay

I serve as the CEO of Gold Standard Phantoms and hold an honorary professorship at University College London, alongside my role as Director of Quantitative Imaging at Bioxydyn in Manchester. I'm also the incoming IPEM Vice President for Industry.

IMAGE: ISTOCK

Which elements of your job do you like the most?
It is very varied, from the writing of grant applications to the sale of our products to universities, hospitals and clinics around the world. What I like the most is steering the development of novel tools to improve magnetic resonance imaging (MRI) quality assurance (QA) and calibration, leading a team of exceptional software, biomedical and mechanical engineers, MRI scientists and chemists to solve extremely complex problems.

What are the biggest challenges you see for your role?
Being relatively new to IPEM, and coming first from academia, while now representing the industry at large, I need to make sure to provide a fair and balance view of all industry representatives, being very aware that MRI QA and calibration represents only a small fraction of the industry connected to IPEM.

What accomplishment have you been most proud of in your career?
My efforts to transform the use of arterial spin labelling (ASL), a non-invasive magnetic MRI technique for measuring cerebral blood flow, into a widely accepted clinical practice.

While at UCL, I led a research programme aimed at harmonising ASL protocols and enhancing its clinical utility. This has led to a significant increase in the global uptake of ASL in clinical practice, improving patient outcomes and making it a valuable tool in trials for neurological diseases, such as dementia, brain tumours and strokes.

What one thing would you change about the profession or your area of specialty?
It is rather shocking that, currently, there are no requirements in the UK to have clinical scientists appointed to ensure proper use of MRI within the NHS. The current number of clinical scientists per MRI scanner within the NHS is barely enough for them to provide the most basic QA and safety support, with barely any option to improve the services, cut the imaging time and improve patient experience.

What skillsets do you think are required to be successful in your role?
Persistence and hard work. There is no denying either that for most academic careers, chance plays a great role, but the most important aspect for reaching such a position is to never hesitate to take positions to serve on learned society boards, committees and leadership positions.

IPEM's *Science Leadership Strategy* is about identifying and anticipating what might impact the working environment of our members. What are your predictions?
One of the most important challenges is the advance of AI. Before accepting its presence as a fact, IPEM should be at the heart of assessing what makes sense and what doesn't. As the incoming IPEM Vice President for Industry, this will be one of my priorities.

What do you do in your free time?
I recently moved to Sheffield, and in my free time, I love spending long hours walking through the Peak District with my wife and our dog.

Why should people join IPEM?
For anyone serious about their job as a physicist or engineer working within a hospital, it seems like the best association to join to get help with any issue arising in our professions.

Which IPEM member benefits do you think is the most valuable?
Meetings and conferences.

What does, or should, IPEM do to help career development?
Provide enough training on the up-and-coming new technologies to hit hospitals, such as AI.

THE BIG DEBATE

Medical physics training

We ask a panel of experts from English-speaking countries and subregions about medical physics training, from MScs and PhDs to curriculums and starting salaries for newly qualified medical physicists, and much more.

Q ***Do the residents and trainees complete an MSc during their residency, or is this expected to be held beforehand? How many years is the duration of the programme?***

SOUTH AFRICA

The trainees must first complete the academic training at a university, which is a BSc (Hons) degree in medical physics as a minimum requirement. It is not allowed that interns register for an MSc or other postgraduate degree during their clinical training, but existing university registrations do not have to be cancelled. The residency is two years and covers radiotherapy, diagnostic radiology, as well as nuclear medicine.

CANADA

In Canada, the Canadian College of Physicists in Medicine (CCPM) is the organisation that certifies individuals with proven competence as certified medical physicists through the membership examination. This certification of competence is offered in four sub-specialties: radiation oncology physics, diagnostic imaging, magnetic resonance imaging and nuclear medicine. For all four sub-specialties, a two-year "patient-related" experience is mandatory after completion of a graduate degree. For the radiation oncology physics sub-specialty, the applicants have to complete a two-year residency or a one-year bridging programme at an institution having a Commission on Accreditation of Medical Physics Education Programs (CAMPEP)-accredited residency programme.

Currently, no formal training through a CAMPEP-accredited residency is mandatory for the imaging sub-specialties. However, they must meet the minimum requirement of two years for patient-related work experience. On completion of this requirement, the trainees can apply for the membership examination and those who qualify through the credentialing process must complete a written exam and an oral exam to become certified. The CCPM membership certification is recognised in North America. To maintain this competency certification, members of CCPM are required to recertify every five years through a credential review of evidence of their clinical practice and continuing education.

AUSTRALASIA

Trainees can complete an MSc in medical physics during the programme, however, for the past several years most have completed one prior to entry. The training programme duration is three years, if entry is with an MSc, and five years, if an MSc is completed during the programme. The Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) accredits university MSc courses as meeting ACPSEM requirements for entry into their training programme. Most trainees undertake an ACPSEM-accredited MSc, however trainees can apply to have post-graduate degrees from other institutions evaluated for equivalence.

UNITED STATES

In North America, for an individual to sit for their medical physics board exams, they need to complete an accredited medical physics residency programme. The accrediting body for graduate and residency programme in medical physics is the Commission on Accreditation of Medical Physics Education Programs

IMAGES: ISTOCK

(CAMPEP). The most streamlined pathway into a medical physics residency programme is for the candidate to complete a CAMPEP-accredited graduate programme. An alternative route for candidates with a PhD in a related discipline is for them to join programmes that have an associated graduate or certificate programme that would allow them to complete their remedial education in medical physics.

The length of these training programmes are extended to allow the trainee to complete their clinical and didactic training. This latter route is completely at the discretion of the programme – this option is typically limited to outstanding students that programmes are trying to recruit. Residency programmes in the US are at least two years in length, however, they are extended for programmes that include a research component, and can run for three to four years.

Q *Are the programmes competitive? Is a PhD a pre-requisite?*

SOUTH AFRICA

A PhD is not required beforehand; many students pursue entry into the programme after completing their undergraduate honours degree. Currently, competition is intense due to limited paid positions. Government posts have mostly been frozen, so many students must complete their internships without pay. Some are fortunate enough to receive a stipend from the private sector for the two years.

CANADA

Admission to the residency programmes is competitive with the limited number of accredited residency

MEET THE PANEL

SOUTH AFRICA

Professor Chris Trauernicht, Medical Physics Department Head
Tygerberg Hospital

CANADA

Professor Geetha Menon, Senior Medical Physicist, Cross Cancer Institute and Clinical Professor, Department of Oncology
University of Alberta

AUSTRALASIA

Dr Andrew Campbell, General Manager, Education
ACPSEM

UNITED STATES

Professor Joann I Prisciandaro, Director of Clinical Physics, Michigan Medicine/ University of Michigan
Department of Radiation Oncology

programmes in Canada. The educational prerequisite for admission to these programmes is a graduate degree i.e. MSc and/or PhD. The graduate degree must be from an accredited university or college in medical physics, physics, science with physics as a major option, engineering or applied mathematics. Recently, with several CAMPEP-accredited graduate programmes in the country, most applicants for residency come from these programmes. In addition, to meet the didactic requirements for admission to a CAMPEP-accredited residency, aspirants with a PhD in physics, or allied field, can complete a CAMPEP-accredited certificate programme.

AUSTRALASIA

To be accepted into a training programme applicants must be employed by a clinical institution accredited by ACPSEM for training. It is not possible to apply for programme entry without such a position. Any applicant who meets this requirement and other programme entry requirements would be admitted into the training programme. There is no requirement to have a PhD to complete training, but a recognised MSc is mandatory.

UNITED STATES

Yes, entry into North American residency programmes is very competitive. A match process was established approximately 10 years ago, and based on the 2021–2022 match results 127 of 250 candidates were matched to residency positions (50.8%) Resident applicants must hold either a Masters or PhD to be eligible for residency training.

Q What does the training curriculum involve? Do the residents and trainees have to undertake hospital placements or placements in other areas?

SOUTH AFRICA

Students are required to undergo clinical training across three areas at an accredited teaching hospital. Accreditation of the residency programmes is done by the Health Professions Council of South Africa (HPCSA).

- Nuclear medicine – 6 months
- Diagnostic radiology - 6 months
- Radiation therapy – 12 months

Throughout their training, they must prepare reports, maintain work logs, and pass an exit examination with external examiners.

A portfolio of evidence must be submitted to the HPCSA, which is assessed and moderated by appointed medical physicists.

CANADA

The residency programmes are normally structured as per institutional plans, with guidance from the CAMPEP residency. The comprehensive curriculum includes training in clinical environment, safety and ethics. The radiation oncology physics residencies are mostly conducted in association with academic cancer hospitals, with the additional possibility of visiting other institutions to receive training on procedures that are unavailable locally. Trainees in accredited residency programmes receive funding for the period of their training.

AUSTRALASIA

Trainees have to be employed in a clinical institution accredited for training by ACPSEM. These are almost entirely hospital departments.

UNITED STATES

The minimum training requirements are outlined in CAMPEP's Residency Standards and additional recommendations are provided in the American Association of Physicists in Medicine (AAPM) Report No. 249. Residency programmes are not required to be hospital-based, they can reside in private practice groups, medical physics consulting groups, or other organisational structures, as long as senior management of the entity demonstrates they support the programme (e.g. letter of support).

Q Is the training scheme paid or is it self-funded? What is the starting salary for a newly qualified medical physicist?

SOUTH AFRICA

While we do offer some paid positions, this remains a significant challenge at present. Many students are currently completing their internships without pay. Additionally, some support is provided by the private sector in the form of stipends for the two-year training period. The average starting salary for a medical physicist in South Africa varies R564,000–R751,523 (£24,500–£32,900) per year.

CANADA

Yes, the residents do get paid. They might make $30K-40K (£16,700–£22,300) – less than a starting certified physicist. A certified medical physicist with <5 years experience made about a median of $125,000 (£69,675), according to our 2023 survey. Note that the salaries vary quite a lot amongst the provinces.

AUSTRALASIA

Trainees pay an annual fee to ACPSEM for programme participation. Starting salaries for newly qualified medical physicists varies between Australian states and New Zealand. ACPSEM does not routinely track such information

UNITED STATES

Financial support of residents is not guaranteed. CAMPEP requires that at a minimum, financial support (i.e. salary, benefits) be clearly described to prospective students. That said, most programmes provide a stipend to residents. One potential exception may be Doctor of Medical Physics (DMP) programmes. These programmes are a combination of a graduate and residency programme (where didactics should be equivalent or more than an Master of Science (MS). In these, candidates are required to pay a tuition during the didactic component of their training, but often times they will receive a salary during their clinical training. Based on the 2022 AAPM salary survey, the average salary for medical physics resident salaries recorded was US $62900 (£48,454). The total tuition for the entire programme is reported as US $92000 (£70,900) for in-state students and US $139000 (£107,077), respectively.

Q *Is the medical physics qualification recognised internationally?*

SOUTH AFRICA

Yes, the South African medical physics qualification is generally recognised internationally. However, specific recognition can vary by country and institution. It's advisable for individuals seeking international recognition to verify the specific requirements and equivalencies with the relevant regulatory bodies or professional associations in the country of interest.

CANADA

The CCPM membership certification is valid in North America. Similarly, the ABR certification (from US) is valid in Canada. I am aware of physicists working in other countries like Australia, Ireland with MCCPM (Canadian College of Physicist in Medicine). But you may want to confirm, as I am not sure about other countries.

AUSTRALASIA

ACPSEM pursued mutual recognition with several international bodies around a decade ago, but no agreements were reached. An individuals seeking international recognition would need to verify the specific requirements and equivalencies with the relevant regulatory bodies or professional associations in the country of interest.

Q *Is there a Medical Physics Expert equivalent training? If so, what does the curriculum involve and is it recognised internationally?*

SOUTH AFRICA

No, once a medical physicist registers with the HPCSA they can work in any field. No further specialisation, such as medical physics expert training, is required.

However, this also means that a medical physics expert with training in one field only cannot register in South Africa, because they would first have to undergo clinical training in the other fields.

CANADA

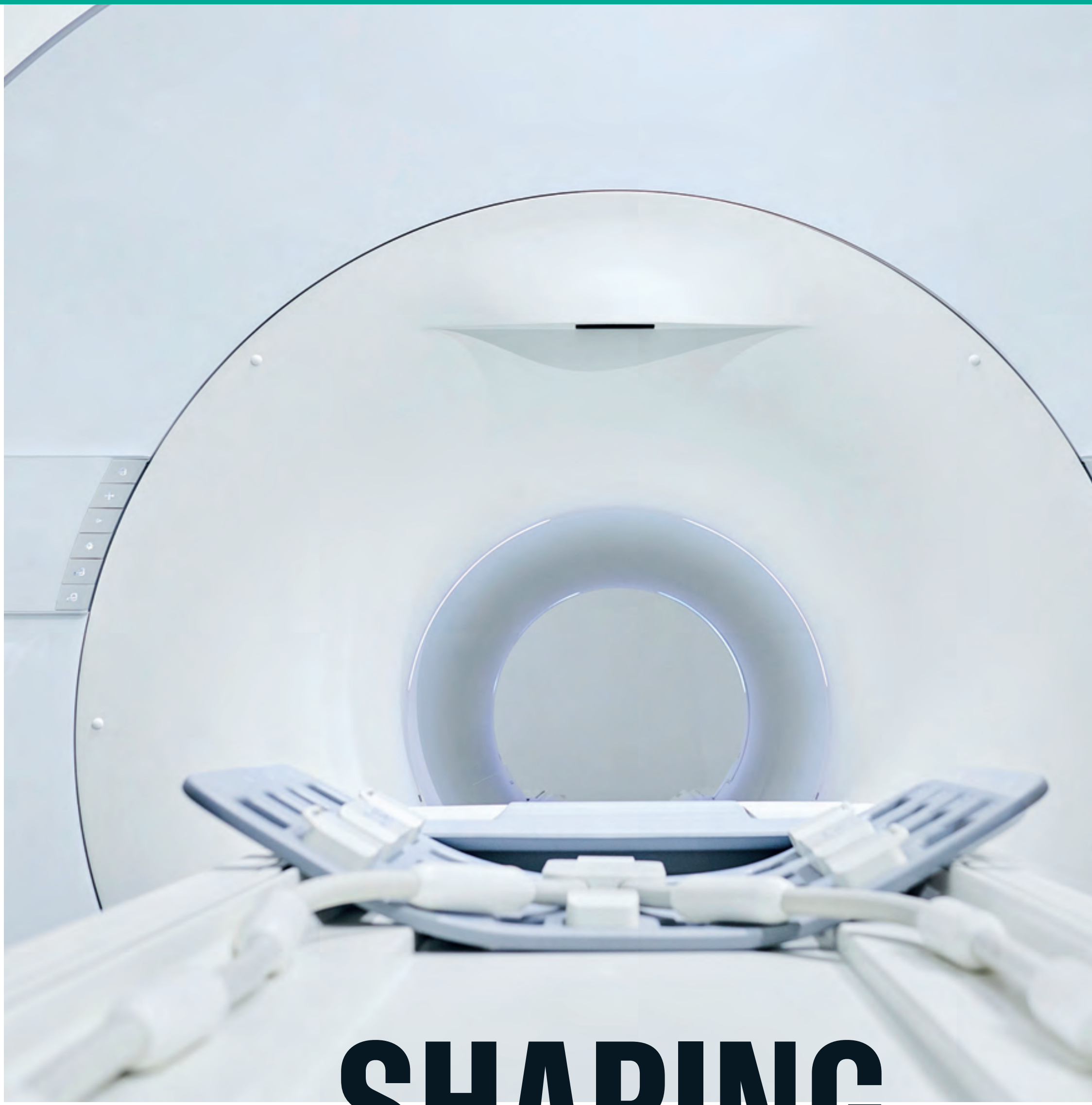
We don't have a category called "Medical Physics Experts" in Canada. To be eligible to take the membership examination of the CCPM and become a certified medical physicist, a two-year training/residency or a one-year bridging programme is a requirement. For the radiation oncology physics specialty, the training has to be done at a CAMPEP-accredited institution.

AUSTRALASIA

There are training programmes in three medical physics areas: radiation oncology, nuclear medicine and radiology medical physics. Looking at the (RPA 2000) Medical Physic Expert curriculum, I believe that our specialisations would be equivalent. Completion leads to registration with the ACPSEM and continuing registration is subject to mandatory CPD requirements. In Australia and New Zealand medical physicist is not a protected title (unfortunately) however. While ACPSEM registration is frequently asked for my employers, it is not mandatory.

UNITED STATES

Residency training is required before a candidate can sit for the American Board of Radiology (US) or the Canadian College of Physicists in Medicine board certification exams. The designation "Medical Physics Expert" does not exist in the North America. In radiation oncology, additional training and special authorisation is required for those medical physicists interested in practicing high dose rate brachytherapy, teletherapy, or gamma stereotactic radiosurgery.



SHAPING THE FUTURE

Scientific Support to MRI Services in UK Healthcare

Rebecca Quest, **Angela Darekar** and **John McLean** on a roundtable discussion about the future of magnetic resonance imaging.

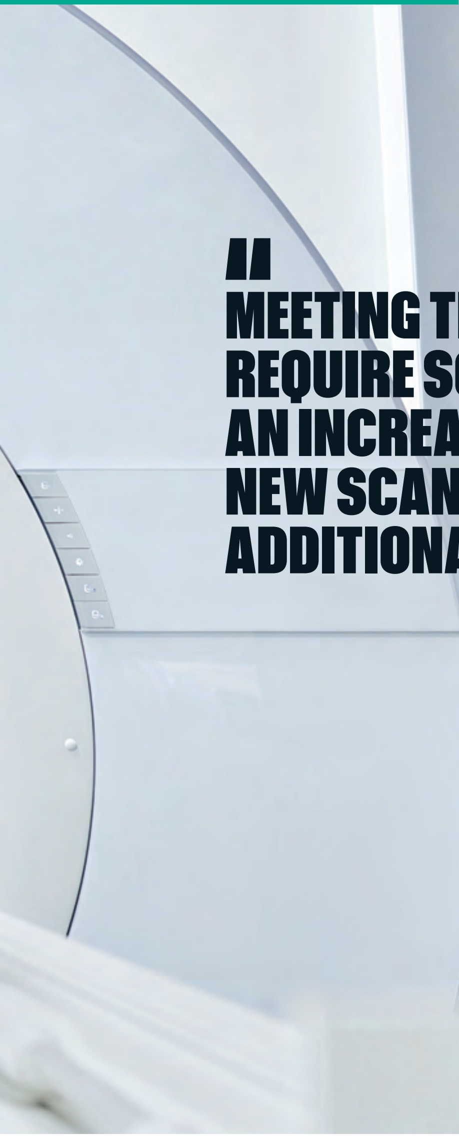
The future of scientific support for magnetic resonance imaging (MRI) services is poised for significant growth and evolution, and the MR physics community needs to be ready and prepared. The approaching challenges and opportunities include changes in how these MRI services are delivered, greater networking, increased complexity of services and patient cohorts, MRI backlogs and increasing numbers of referrals, staffing challenges across the imaging workforce, and rapid deployment of technical advances. Around 40 delegates joined a horizon-scanning workshop to discuss the important themes of MR physics strategy and workforce at the "Everything MRI All At Once" 2024 meeting, organised by the IPEM MR-SIG.

The survey and vision

Angela Darekar began the session by recapping the results of the 2022 MR Workforce Survey and summarising the 2024/25 National Vision for Healthcare Science from NHS England, introducing the key themes that include scientific leadership, championing research and innovation, data analytics, quality and sustainability improvements and transformation of services. Six discussion points were then proposed with the aim of creating a set of actions to develop a robust futures strategy for the specialism: current value; future changes; infrastructure and workforce needs; scientific workforce evolution; leadership and influence; and collaboration and strategy implementation. Responses from the workshop are outlined below.

Q Where do MR physicists add value to imaging departments? How is it demonstrated in practice?

MR physicists play a crucial role in improving both image quality and efficiency within imaging departments, which ultimately leads to better and faster patient care. Efficiency can be relatively straightforward to quantify, however an increase



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MEETING THE DEMAND WILL REQUIRE SCOPE TO MANAGE AN INCREASE IN REFERRALS, NEW SCANNERS AND ADDITIONAL STAFF

in image quality can come without any time saving or indeed accompanied by an increase in protocol time, and thus is a more problematic measure. Enhanced image quality undoubtedly contributes to improved patient outcomes, but linking the value of these improvements back to the contribution from MR physicists can be challenging.

MR physicists add value by widening access to MRI services increasing equity of care, for example by facilitating off-label scanning of patients with implants. They also reduce the decision-making burden of radiographers, as well as contributing to the development of new clinical services that can then be handed over, with confidence, to radiographers to implement. MR physicists also contribute significantly to value-for-money decisions in equipment procurement and provide essential support for research initiatives and clinical trials. Their involvement in troubleshooting and reducing scanner downtime is crucial for maintaining efficient operations. A health economics approach to determine the impact on patient outcomes of the service development, innovation and research input would highlight the value added by MR physicists.

Q How will the work of an MR physics department change in the next 5-10 years?

Anticipated future changes include regional expansion of services, diverse growth variants and increased involvement in software and medical device regulations (MDR). Research, innovation and clinical work will likely be driven by advancements in AI that in turn will require an evolving role from MR physics.

An increased demand on imaging services suggests the need for comprehensive MR safety support around the clock, which highlights the importance of safety framework contributions by MR physicists, such as generic implant safety procedures and other considerations of how to deal with out-of-hours queries. With an increase in MR physics workforce levels, groups will have better capacity to support staff training and implement processes that result in a less reactive safety management culture, thereby fostering the sustainable growth of MR services. There is also a role for MR physics to play in research to evaluate new treatments and diagnostics, to evidence value and efficacy, which may increase demand for their services.

Q Is the current infrastructure in place to achieve transformation at scale? If not, what other stakeholders need to be involved?

Meeting the growing demand for MR services will require scope to manage an increase in referrals, new scanners and additional staff. The development and dissemination of a published document specifying the recommended number of whole-time equivalents (WTE) staff members per scanner, on a scale dependent on complexity of work and working hours of the scanner, will provide a benchmark for departments to aim for. Increasing the MR physics workforce in line with the IPEM recommendations from the workforce survey and calculator and incorporating this workforce within multidisciplinary teams (MDTs) are essential steps. MR physicists often feel underrepresented compared to other healthcare professionals, underscoring the need for better visibility and advocacy. With published workforce requirements, vendors could assist in pushing for sites procuring new MR scanners to be equipped with dedicated MR physicists. This integration would significantly enhance the operational efficiency and quality of MR services.

Q What changes to the scientific workforces supporting MR units are envisaged in the next five to 10 years?

The evolution of the scientific workforce supporting MR units will result in the need for more advanced computing skills to support MDR. Upskilling in clinical scientific computing and MDR support will further enhance the capabilities and recognition of MR physicists. Clearly defining and advertising the roles of MR physicists will help increase numbers and influence. Public opinion and government strategies should be influenced to increase visibility and recognise the value of MR physicists. The required expansion of the workforce is likely to pose a problem for recruitment in a profession where there is already a known shortage of both personnel and training capacity. It could be necessary to think beyond the more traditional STP and Route 2 streams and may require recruitment from additional pathways, such as associate physicists and other progression roles. Additionally, pathways for training, career development and upskilling should be established to ensure continuous professional growth, including research skills and clinical academic opportunities.

Q Where does MR physics leadership need to be exerting influence to agree and achieve the strategy?

MR physics, and medical physics, sits within differing hierarchical structures in different organisations. In some cases, leadership in MR physics would benefit from being more closely aligned with radiology. Leaders themselves should receive more structured training in NHS management, business and strategy development and effective ways of working to positively influence and to advocate for MR physicists and their value in delivering transformation to services. National standards for staffing and early involvement in the design of MRI units and scanner procurement are critical to ensure that MR physicists have a say in essential decisions. Pushing for MR physicist recognition in the form of an MR physics expert, extending beyond that of the MR safety expert and encompassing broader roles, is seen as essential for regulatory progress and improved service delivery. The contribution of NHS MR physicists to research and innovation delivery, and academic developments, should be recognised and valued.

To continue the discussion or take forward an action point, start or join a thread on the IPEM COI Magnetic Resonance Community and tag with *#ShapingTheFuture*. Help us evolve and drive forward the clinical MR physics community so that it can respond to the changing needs of stakeholders and patients, and improve MRI services in the UK.

Q How can the MR physics community collaborate to achieve the strategic aims?

Collaboration is key to achieving the strategic aims of MR physics. Utilising an online collaborative community database for standard operating procedures (SOPs), tips, and reports may be one way to streamline practices across departments. Increasing the visibility of MR physicists and marketing their full range of skills is crucial. Effective visualisation of the impact of MR physics, not just at a project level but across departments, will help showcase achievements and identify other areas for improvement. Enhanced communication through webinars and more interactive forums will foster a more connected and supportive community.

Summary

Some clear themes came out from the brainstorming session. The following action points are deemed necessary for advancing the role and impact of MR physicists in imaging departments.

Define and showcase value:
- Demonstrate the contribution of MR physics to improved patient outcomes and value-for-money decisions. Explore effective key performance indicators and how they can drive the business intelligence process.
- Showcase research support and the value of research led and enabled by MR physicists.
- Implement mechanisms to track impact.
- Increase visibility and market the full range of skills of MR physicists.

Prepare for future growth:
- Plan for regional service expansion and cover and increased MR safety services.
- Create educational frameworks to upskill MR physicists in scientific computing and MDR support.

Enhance infrastructure:
- Lobby for increased MR physics staffing level per scanner, as per IPEM recommendations.
- Build a stronger community among MR physicists and more widely across other related specialisms, for resource sharing.
- Ensure vendor support strongly recommends MR physics input with new scanner installations.

Transformation of the scientific workforce:
- Advocate for inclusion in government strategy and funding.
- Support training for associate physicists.
- Publish and promote a defined MR physics staffing level per scanner weighted by complexity and use.

Strengthen leadership:
- Ensure MR physicists are involved in regulatory discussions.
- Advocate for the MR physics expert role and the specialist expertise it assures.
- Build stronger connections with management.
- Train leaders in NHS leadership and management, and ensure high level representation.

Facilitate collaboration:
- Develop collaborative community resources.
- Encourage stronger communication within the MR physics community.

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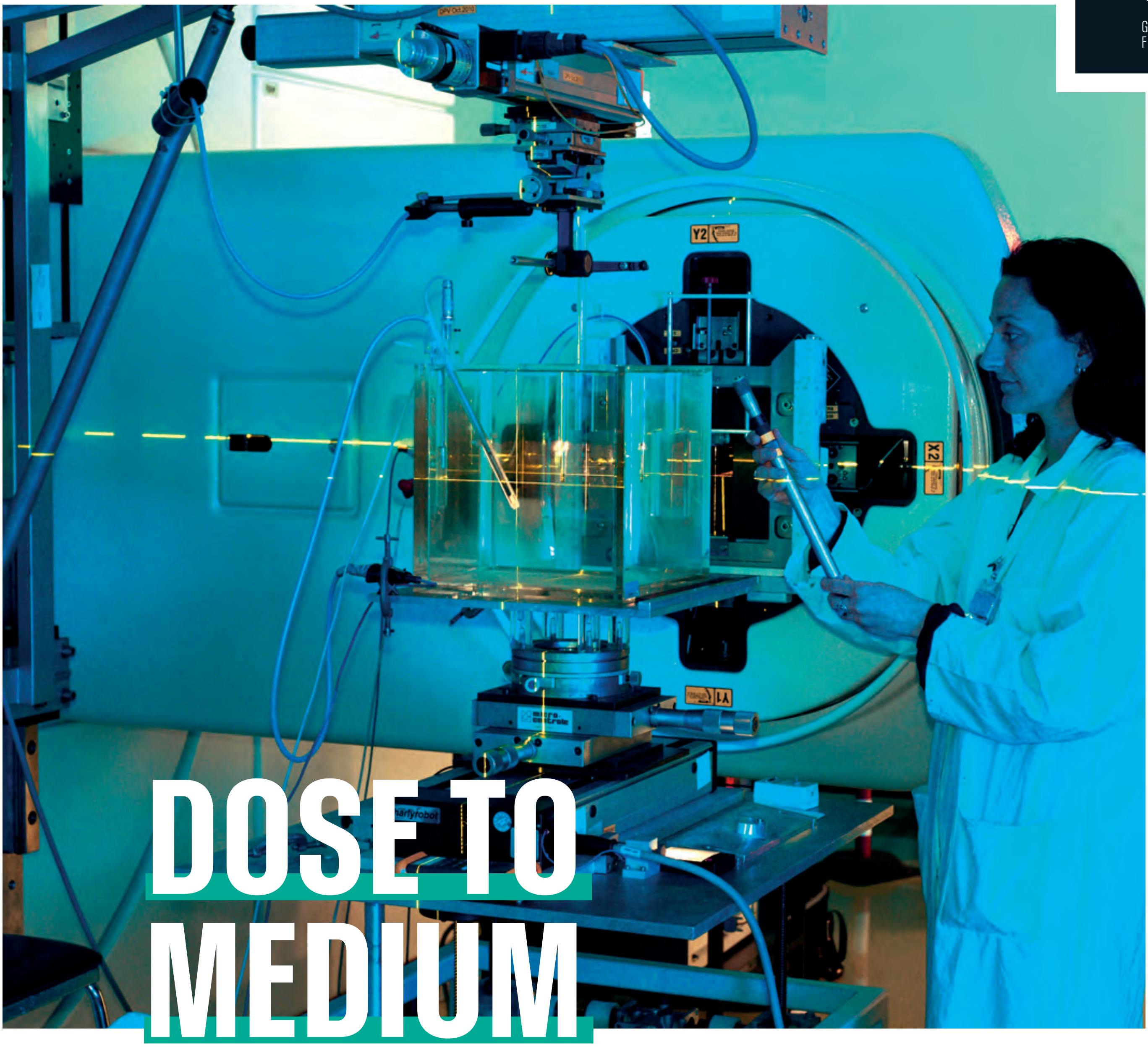


IMAGE: PATRICE LATRON/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY

DOSE TO MEDIUM VIRTUAL AUDIT

Why is a virtual audit needed and how can you take part? Clinical Scientist in Radiotherapy **Joe Whitbourn** looks at the issues.

What is best practice when it comes to commissioning dose to medium (Dm) treatment planning systems (TPS)? Do we need dose to medium correction factors for Gy/MU in our TPS? How can we audit the planning and delivery of Dm across a wide variety of materials?

All these questions are of increasing importance to the provision of precise and standardised radiotherapy in the UK but remain unresolved.

IPEM has a working party investigating verification of Dm TPS algorithms in

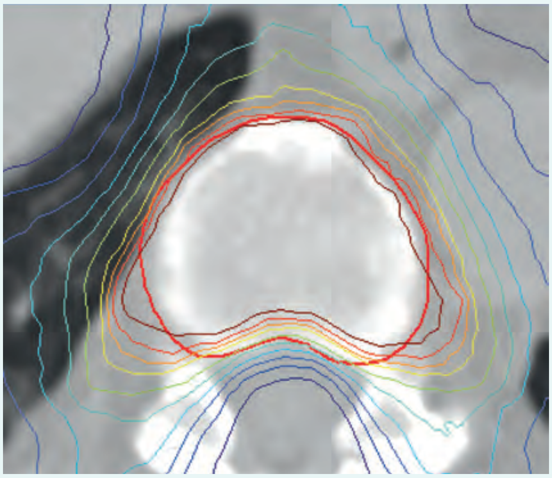


Fig ❶ An example CT slice showing a bony PTV in a clinical spine SABR plan.

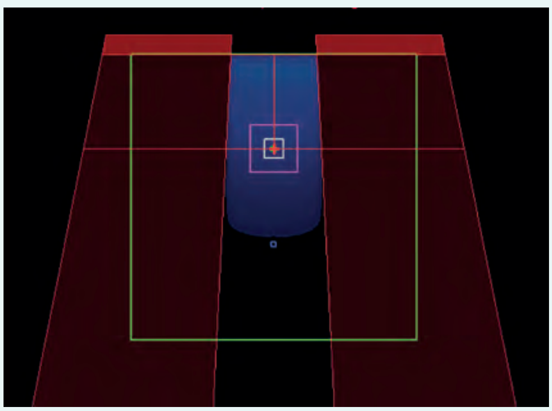


Fig ❷ A visualisation of the synthetic phantom setup in this virtual audit.

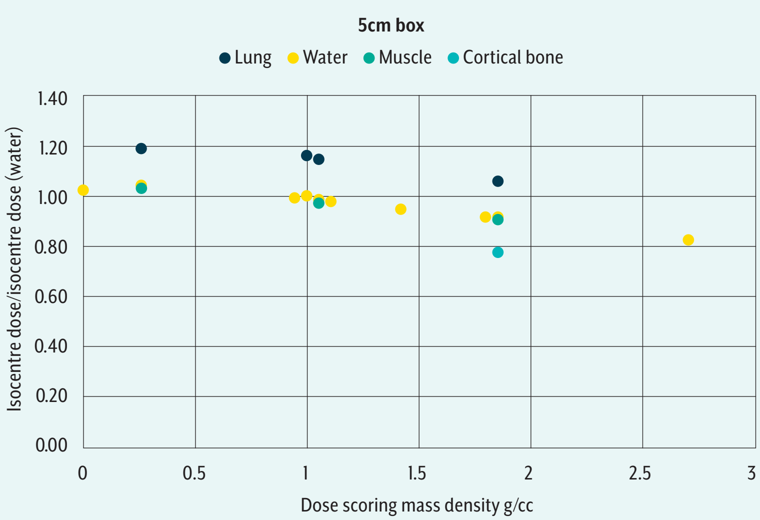


Fig ❸ An example of a set of results from the audit which shows how the relative isocentre dose changes for different material inserts (plotted as a function of the mass density of the material insert).

radiotherapy that is looking to answer these questions. To progress this work, we need your help in completing a virtual TPS audit. In this article we describe why this virtual audit is needed, where it fits in with clinical Dm planning, and what it involves. If you are interested in this, we invite you to take part – please see the end for details on how to contribute.

Why this audit is needed

Dm algorithms are seeing substantial use in clinical practice, as shown in a 2023 survey of UK radiotherapy centres, which reported that 41% of UK centres use Dm clinically and 46% were planning to commission a Dm algorithm in the next 1–2 years (see the Spring issue of *Scope*, 2023).

One of the issues this raises for the standardisation of radiotherapy is that Dm will be systematically offset from dose to water, which forms the basis of the UK dosimetry system and is reported by many other TPS algorithms.

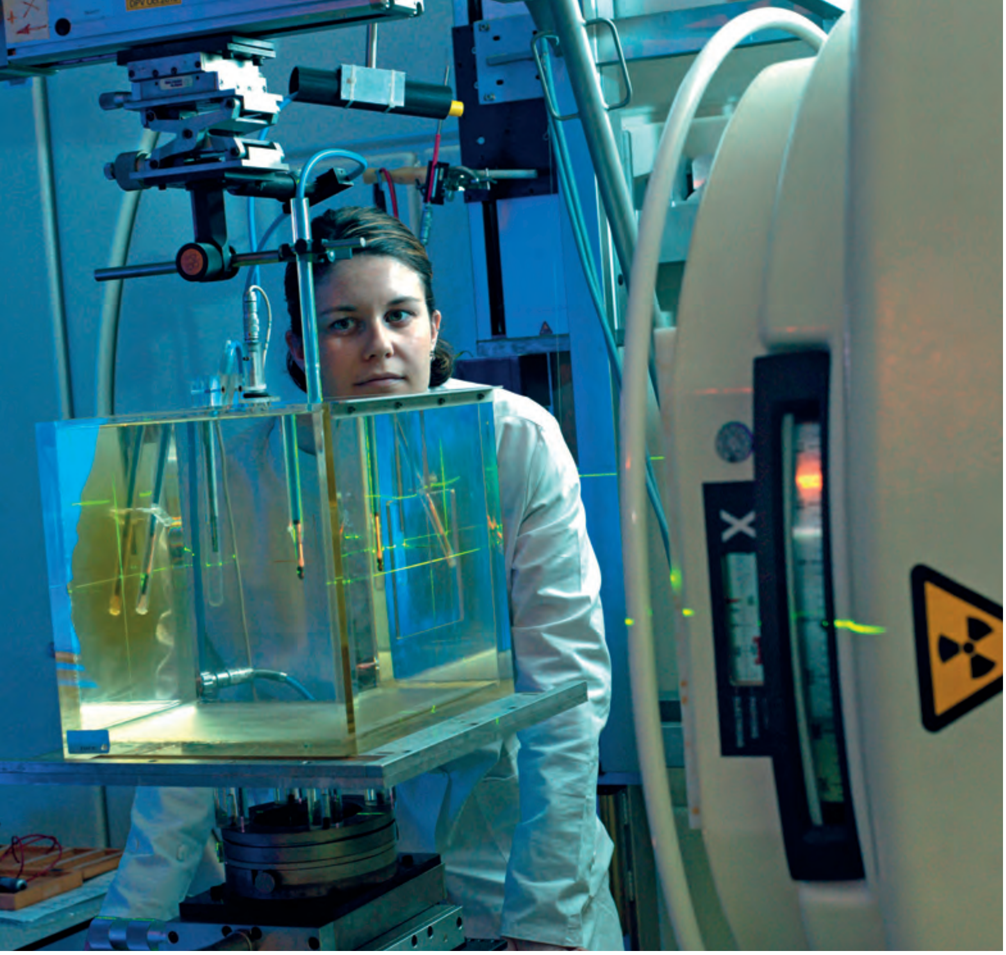
To address the potential for differences the Global Harmonisation Group (GHG) has issued guidance recommending the use of dose to medium for clinical trial reporting. Similarly, the American Association of Medical Physicists have issued *Report 329*, which recommends using absorbed "dose-to-muscle" for dose specification instead of dose to water. To implement dose-to-muscle into the dosimetry system AAPM *Report 329* provides a TPS-specific correction factor to be applied to the Gy/MU – with the correction being either nothing (if the TPS is classified as reporting a dose to tissue) or 1%.

However, the UK dosimetry system does not currently incorporate any correction factors such as this. This audit will investigate the need for these correction factors by establishing the range of variation seen in clinical practice. We will then be able to compare the range of results to Monte-Carlo calculations conducted at NPL.

Finally, this virtual audit will feed into and help guide a follow-up physical audit that is currently being designed at NPL.

Together these audits will be part of a wider programme of work that improves the consistency and accuracy of UK radiotherapy patient treatments by

IMAGE: PATRICE LATRON/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY



The audit will investigate the dose to: air, lung, adipose, water, muscle, cartilage, vertebral bone and bone. We will additionally look at the dose to graphite and aluminium to feed into potential calorimetry studies in a physical phantom.

Material overrides are recommended as the most convenient and consistent approach to material definition. This will not require users to create a new HU-density curve and is more compatible with MR specific approaches to radiotherapy. A downside to this is that different TPS implement density overrides in different ways. A study was made of a variety of TPSs, and the findings were incorporated into the audit guidance.

Each centre's results may also be of ongoing value beyond reporting in this audit – for instance, when performing TPS QA or validating updates to the TPS – see Fig ❸ for an example data set.

answering those initial questions on how Dm TPS algorithms should be commissioned, calibrated and audited.

Where this audit fits in with clinical Dm planning

The final stage of generating every clinical plan is the normalisation of the dose in the target structure to the prescribed dose. Dependent on the voxels in the target structure this may require conversion of non-tissue like material such as bone (for instance in spine SABR ,as shown in Fig ❶). A full and accurate conversion is highly non-trivial and requires modelling of the impact of the tissue on the fluence, according to section 4.6 of a 2015 paper by P Andreo.

That is why with this audit we want to establish how wide the variation in clinical practice is over a range of biological materials for as many Dm TPS algorithms as possible.

What does the audit involve?

We are asking every UK radiotherapy centre to import a provided virtual phantom dataset into their TPS.

Users will set a variety of material overrides to phantom inserts and report the dose to the material from a single static beam (see Fig ❷ for a depiction).

> **"WE WANT TO ESTABLISH THE VARIATION IN CLINICAL PRACTICE OVER A RANGE OF MATERIALS**

A workbook has been provided for reporting the results in a standardised way.

This audit focuses on reference type dosimetry so we have chosen a 10x10cm field with an isocentric setup at a depth of 10cm. This aligns with the IPEM 2020 [option 2 for machine calibration] code of practice, as well as TRS-398 and TG-51.

How to take part

We are interested in entries from any and all UK radiotherapy centres. Those using dose to water are welcome to report their results, which will be valuable. However, our priority is to investigate the Dm results and compare these to Monte-Carlo simulations.

If you would like to contribute, in the first instance, please send us an email at *RTaudit@npl.co.uk* to see if someone at your centre has already filled in the audit.

We have made the data available for distribution both through an NPL Sharepoint location and ProKnow. We will then send you the details for how to access the data via either method.

In terms of the staff who can complete the audit, they will not necessarily need to be registered. In fact, this may be a good learning opportunity for trainees as it provides experience of virtual dose audits which can be complementary to that of external dose audits which is required as part of STP competency S-RP-S1:19.

Thank you in advance for any work you and your centre can do for this. ◘

__Joe Whitbourn__ is a Clinical Scientist in Radiotherapy at The James Cook University Hospital, Middlesborough. He wrote this article on behalf of the IPEM Verification of Dose to Medium Treatment Planning System Algorithms Working Party – TPS subgroup (Nick Harding, Mo Hussein, Usman Lula, Chris South, Vanya Staykova, Joe Whitbourn).

REFLECTIONS ON THE TECHNOLOGISTS TRAINING SCHEME

We hear from two IPEM members who have undertaken the scheme and **Robin McDade**, the training scheme lead.

The last decade has witnessed technological advancements in nuclear medicine (NM) that outstripped a co-ordinated response in guidance, standards and the provision of adequate education to skill the clinical technologist workforce. Hybrid imaging techniques rapidly redefined workforce practice and, looking forward, molecular radiotherapy promises to revolutionise the management of certain cancers as well as the skill and knowledge base to deliver these new services.

IPEM, as the UK's largest trainer of clinical technologists, updated its NM curriculum in 2021. Coupled with new standardised national plans and pro forma portfolios (2023), we document the knowledge, skills and practice required in modern NM departments. Masters-level modules, particularly in cross-sectional anatomy for NM, are embedded in our training plans. Our scheme aims to meet single photon emission computed tomography/computed tomography (SPECT/CT) and positron emission tomography (PET/CT), national occupational standards (NOS) and all

IMAGE: GETTY IMAGES

relevant education career frameworks (ECF). We have risen to satisfy the needs of the workforce and have expanded the IPEM national office team to meet rising demand. Yet our greatest achievement is always the confident, competent, graduates of our Diploma in Technology, to which we now turn for their reflections on the scheme.

Allan Laird, Nuclear Cardiology, Glasgow Royal Infirmary

The Technologists Training Scheme (TTS) provides a fantastic foundation for trainees entering the field of NM. With a combination of peer-reviewed training, along with external moderation and assessment – covering all aspects of general NM, through to more specialised aspects: nuclear cardiology, theranostics and PET-CT. Our scheme provides an excellent pathway to becoming a well-rounded and knowledgeable clinical technologist.

The landscape of NM is rapidly evolving, for example, improved technology cadmium zinc telluride (CZT) detectors and hybrid imaging – specifically CT. The skillset and knowledge base of staff therefore needs to evolve. The TTS continues to move with the landscape, identifying the advancements in the profession and providing trainees with the opportunity to fulfil their scope of practice.

At the beginning of my training many of my colleagues and fellow trainees, particularly those not from a diagnostic radiography background, had no formal qualifications in CT, particularly in cross-sectional anatomy.

Concerned by my lack of knowledge and understanding in cross-sectional anatomy, as I was involved in SPECT-CT daily, additional training requirements were placed within my training plan. Through discussion with my supervisor, a formal national-level qualification was sought to bridge that gap. This was achieved through enrolment on the MSc NM course at University of the West of England (UWE). The cross-sectional anatomy for NM module was exactly what I needed to aid my understanding. Confidence in my work, my understanding of the patient images and understanding of both general and cross-sectional anatomy and pathologies improved. The course was invaluable to my knowledge and development.

As I sought to continue my studies, UWE acknowledged that the level of work involved in the production of the TTS portfolio more than met the standard for additional MSc level credits. Struan and I have become the first trainees to be awarded Post Graduate Certificates in NM, obtained through accredited learning. This was extremely rewarding and showed a great appreciation for the level of work trainees produce whilst on the training scheme. I'm delighted to see that the opportunity and requirement to embark on further education at MSc level has been made standard to all new trainees.

"THE CROSS-SECTIONAL ANATOMY FOR NM MODULE WAS EXACTLY WHAT I NEEDED TO AID MY UNDERSTANDING

Without a doubt, the TTS has been instrumental in my career. It has not only enabled me to reach the highest standards and levels of competency, but the experience has also enabled me to give back, as I am involved in the continuing improvement of the scheme. I have achieved this through the role of External Moderator; assessing and supporting current trainees. I also created the portfolio template to aid all new trainees, giving clear direction on the structure, layout and essential content. To meet the ever-changing requirements and standards, I also contribute to the regular review and update of the viva papers. These opportunities, post-training, highlight how the scheme continues to play a pivotal role in raising the standards of the next generation of technologists.

Struan Robertson, NM and PET/CT, Ninewells Hospital

The TTS has given me an in-depth knowledge of both NM and PET/CT, allowing a solid start to my career in an ever-evolving sector. The intense two-year training, along with my BSc in Biomedical Science (Hons), has equipped me with the skills to work in a modern NM department. Performing radiopharmaceutical injections for a range of scans, along with more specialised tests, such as cardiac stressing and sentinel node scintigraphy ensured my skills developed. Rotation to PET/CT allowed

"OUR SCHEME HAS AND WILL CONTINUE TO ADAPT TO NEW TECHNOLOGIES AND REFERRAL TRENDS

me to be part of newer services e.g. prostate-specific membrane antigen (PSMA) and DOTATOC scans. The scheme enabled me to be confident in performing a wide range of tests while understanding the underpinning theory. It gave a robust training framework and allowed access to the Register of Clinical Technologists. Completing an in-depth portfolio, along with a viva and examination in my workplace, allowed me to gain the IPEM Diploma in Technology with distinction. In addition, UWE had deemed the work done on the portfolio as equivalent to their module Fundamental Skills in Nuclear Medicine, worth 30 credits. This is a great step going forward, meaning future trainees can also gain a PG Certificate by completing two 15 credit modules e.g. cross-sectional anatomy or instrumentation for NM.

As part of my training plan, I completed M level modules, which allowed me to build on my knowledge of the science behind NM, relating this to our imaging facilities, both SPECT/CT and PET/CT. It was a good introduction to concepts in NM physics particularly between radioactive substances and matter. The module gave an advanced understanding of the current design of gamma cameras and an appreciation of the pros and cons of future camera designs. Related directly to clinical practice with experiments performed including the practical effects of scatter, collimator type, distance and counts on the system resolution. Solidifying my understanding of the intricate process from injection to the image formation. From detail to big picture, my training plan enabled me to work in a modern NM department.

The TTS has given me both the clinical skills and a solid grounding in the theory behind general NM and PET/CT. I can work confidently while always having the patient at the centre of my practice. The scheme ensured my understanding of radiation physics, clinical skills, diagnostic imaging, therapies, hybrid imaging and more. I enjoy learning and I am currently completing the second year of the Master's programme in NM to further enhance my knowledge.

I advocate for clinical technologist as a career pathway by attending local school events as well as giving guest lectures at local universities. I hope to become an External Moderator for the IPEM scheme in the near future to help and guide future trainees. General NM and PET/CT continue to fascinate me every day, the emerging opportunities that exist, particularly in PET/CT imaging and theranostics, are really inspiring.

Robin McDade, TTS Lead

Allan and Struan are exemplary examples of the capable, competent patient-centred practitioners our Diploma in Technology aims to develop. Our scheme has and will continue to adapt to new technologies and referral trends, growing to meet the needs of a modern workforce. Our graduates have an excellent grounding; a certified skill base, externally reviewed knowledge and understanding and qualifications to build upon to take them forward into enhanced practice. IPEM has recently added to its offering a framework for competence using IV contrast in NM. Its Future Skills Commission looks to identify where further training and certification can support Clinical Technologists from pre-registration through to enhanced, advanced and consultant levels of practice.

The future looks bright, as we build such excellent graduates into our future examiners, supervisors and senior officers of the scheme.

IMAGE: GETTY IMAGES

TROUBLESHOOTING IN RADIATION ONCOLOGY

A team of Senior Radiation Engineers from **Kent Oncology Centre** outline log data analysis of a halcyon linear accelerator.

IMAGES: ISTOCK

Linear accelerators, such as the Varian Halcyon Linac, are indispensable in radiation oncology, as any fault or malfunction in this equipment may lead to treatment interruptions. These machines are crucial in delivering radiation therapy and, thus, require continuous monitoring and maintenance to assure treatment accuracy and patient safety. Data analysis is an major task due to the volume and complexity of data generated by log files from these class machines.

The combined log files generated by the Varian Linacs operating in the Kent Oncology Centre are very time consuming, labour intensive and often inefficient for troubleshooting manually to extract valuable insights.

To solve these problems, we developed the Halcyon Log Data Plotter. This custom-specific programme, written in Python and using some of the most powerful Python libraries, simplifies the analysis of Halcyon machine log data. Improved data visualisation and automation of anomaly detection make for effective monitoring of the key operational metrics and provide a more straightforward integration of log data over several days.

This article describes the Halcyon Log Data Plotter's design and functionalities, emphasising how it significantly fosters better machine maintenance and reliability within radiation oncology. With the ease that this software handles volumes of operational data, the optimal performance of machines is ensured, and it has developed into a very useful tool that helps to maintain the precision developed in modern cancer equipment.

Methodologies for data extraction and analysis

The Halcyon Log Data Plotter is an application that addresses significant concerns for machine maintenance by developing a comprehensive approach for automatic extraction, analysis, and visualisation from the log file output generated by any Halcyon machine. This tool processes log files to provide an integrated view of the performance trend of the equipment used to aid engineers in machine health monitoring and required preventive measures. Below is a list of significant features and methodologies adopted by the software:

Automated data extraction using python libraries

The Halcyon Log Data Plotter uses Python libraries, notably Pandas, to extract structured data from combined log files. Log files host copious amounts of unstructured data, including, but not limited to, water pump pressure, cooling system temperature, SF6 gas pressure and multi-leaf collimator performance.

It uses regular expressions and data filtering techniques to segregate the critical parameters. It looks for patterns related to pressure readings to extract water pump pressure values. Automating this would save the hassle of manually going through extracted data and speed up this job for retrieving the critical machine performance measures.

Time-series data visualisation with Matplotlib

It visualises the extracted data as time-series graphs that are easy to interpret using a python library called Matplotlib. Time series visualisation helps engineers monitor the variation in each important operational parameter, such as pressure, temperature, and SF6 gas levels, over time. This makes identifying gradual deviations or anomalies easier and signals when machines malfunction.

It enables the engineers to overlay months of data to give a comprehensive long-term view of the machine's performance, which is not achievable with log files in one day. This is great for predicting possible equipment failures before they occur and showing trends over extended periods.

Anomaly detection and trend analysis

Core functionality of the Halcyon Log Data Plotter includes real-time detection of anomalies. The software compares existing operational data to baseline data in order to identify deviations that indicate faulty equipment. For instance, it monitors SF6 gas pressure for slow declines that could point toward a slow leak or cooling system temperature for spikes that may denote system malfunction.

Trend analysis enables the software to continuously issue early warnings to the engineers, who are able to take on the problem of machine performance with an advantage in terms of proactivity. Thus, machine downtime and the inevitable consequences of interruption to treatment are reduced to a minimum.

Fault extraction and recurrence analysis

The software also excels at fault extraction, categorising and counting occurrences of specific fault codes – such as hardware errors or communication failures. This information is displayed in a tabular format for easy review. Engineers can search for specific faults and access a detailed history of when each fault occurred, allowing them to prioritise maintenance based on the frequency and severity of recurring issues.

This feature optimises troubleshooting by helping engineers focus on the most impactful faults, which results in enhancing machine reliability and reducing operational downtime.

Key features

❶ Water pump pressure analysis

The Halcyon Log Data Plotter keeps track over time of the pressure pull of the water pump to cool consistently – an important feature to avoid machine

Figure ❶ Cooling pump pressure over time

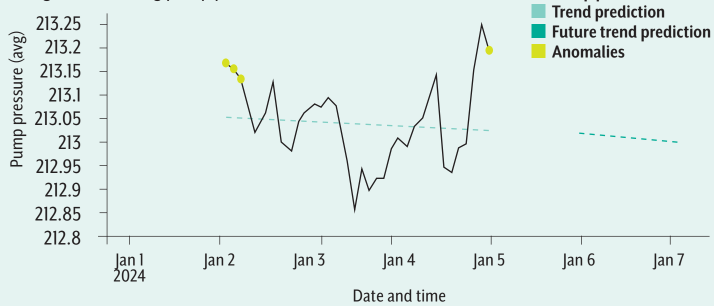


Figure ❷ Cooling water tank average temperature over time

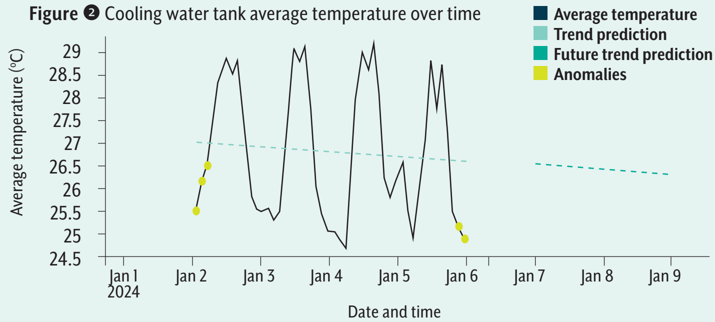


Figure ❸ Average MLC backlash values for all leaves across log files

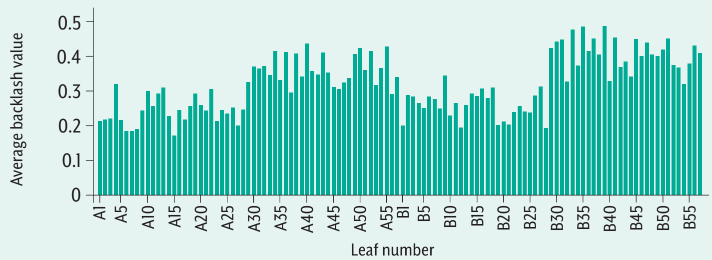


Figure ❹ SF6 gas pressure over time

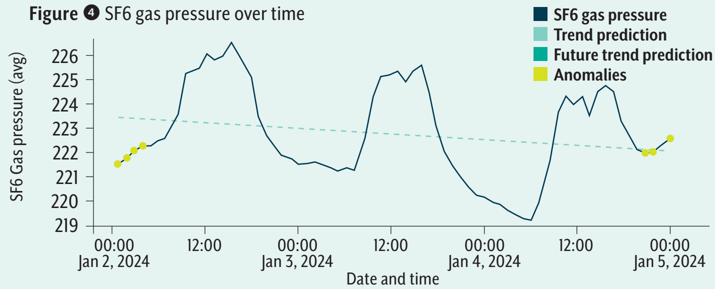


Figure ❺ Fault Codes extraction and analysis

overheating. This software will be able to monitor such pressure levels and flag anomalies, such as those caused by clogged filters or malfunctioning pumps, through the real-time data comparison to expected performance ranges. It will, therefore, be easier for the engineering team to realise a forthcoming problem with the visualisation of the pressure trends and act earlier to prevent more extensive system failures.

❷ Temperature data analysis

Monitoring the cooling water tank temperature is critical for maintaining safe machine operation. The Halcyon Log Data Plotter extracts average temperature data and visualises it over time. In this way, any deviation from a safe operating temperature is easily detected. Using temperature trends allows an engineer to take timely action on potential cooling system issues before they develop into major ones.

❸ MLC backlash leaf analysis

There are 57 leaves in each halcyon MLC bank A and bank B in the multi-leaf collimator (MLC), which is responsible for shaping the radiation beam to target specific areas during treatment. Backlash in these leaves can result in inaccuracies, affecting treatment outcomes. Log Data Plotter helps engineers study the performance of each MLC leaf over time and identify which leaves are developing too much backlash and plan service work in advance. In this manner, proactive surveillance ensures that the machine can perform precise and accurate beam delivery.

❹ SF6 gas pressure monitoring

Sulphur hexafluoride gas, or SF6, provides the insulating medium in the Halcyon machine to prevent arcing in waveguide. Correct pressure of SF6 is critical to the machine operation. SF6 pressure data is logged and plotted over time with the Halcyon Log Data Plotter to observe trends that assist engineers in detecting a potential leak or insulation problem early. By identifying gradual decreases or sudden pressure change, software identifies situations where the machine might be outside the safety limits of pressure to ensure there are no possible insulation failures.

❺ Fault codes extraction and analysis

One of the more powerful features of the Halcyon Log Data Plotter is fault analysis. It counts and then categorises specific fault codes, such as hardware or communication failures, in an easy-to-read way. This allows engineers to see which faults pop up over and over again, thus enabling them to focus their attention on solving those problems that are most critical. Also, by providing a search function and a detailed fault history, this utility optimises maintenance efforts through the targeting of the root causes of frequent problems. This feature helps to capture all of the faults during treatment and service mode, without relying on radiotherapy staff who generally reports fault during treatment.

Technical impact

The Halcyon Log Data Plotter significantly improves machine monitoring and maintenance in radiation oncology by automating complex data analysis, extraction and visualisation tasks. Its ability to track trends, detect anomalies, and prioritise faults ensures optimal machine performance and helps engineers address issues before they affect patient care.

Conclusion

The Halcyon Log Data Plotter is a huge leap forward that has been specifically designed to meet the challenges faced by the Radiation Engineering Department at Kent Oncology Centre in its maintenance work related to Varian Halcyon linear accelerators. This software analyses complex log files for information, thus bridging the critical gap in functionality left by the traditional tools that have been generally labour-intensive and without integrated multi-day analytical capabilities.

It visualises key operational parameters over time and allows for the detection and tracking of recurring faults. The Halcyon Log Data Plotter enables engineers to service machines with greater accuracy and speed, increasing the reliability of the Halcyon machines and ensuring radiation therapy treatments are delivered with a high degree of accuracy, thereby improving patient outcomes.

With the constant growth of radiation oncology, the solution becomes the vital one-of advanced approaches of data analysis and visualisation, helping to plan machine maintenance in order to improve the quality of the radiotherapy service at Kent Oncology Centre.

***Mohamed Madani**, **Ahmed Ramadan** and **Krunal Nakrani** are Senior Radiation Engineers from Kent Oncology Centre, Maidstone and Tunbridge Wells NHS Trust.*

ADVANCING CLINICAL TECHNOLOGIST CAREERS

Technologists deliver services that meet the regulatory, ethical and legal requirements of their profession. They possess a unique body of scientific knowledge related to patient care and the use of technology, to deliver safe and effective healthcare. This is blended with personal and interpersonal skills and attributes that enable practitioners to deliver high-quality patient-centred care in complex, demanding and changing healthcare environments. They are competent to practise to a high standard and may work in a wide variety of health and care settings, delivering services from before birth to after death.

Clinical technologists working in medical physics and clinical engineering are registered by the Register of Clinical Technologists (RCT) or Academy for Healthcare Science (AHCS) in defined scopes of practice:

- Medical engineering
- Nuclear medicine
- Radiation engineering
- Radiation physics
- Radiotherapy physics
- Rehabilitation engineering
- Bone densitometry.

Clinical Technologists are key members of the healthcare workforce, contributing to a diverse range of services that are fundamental in delivering high quality care.

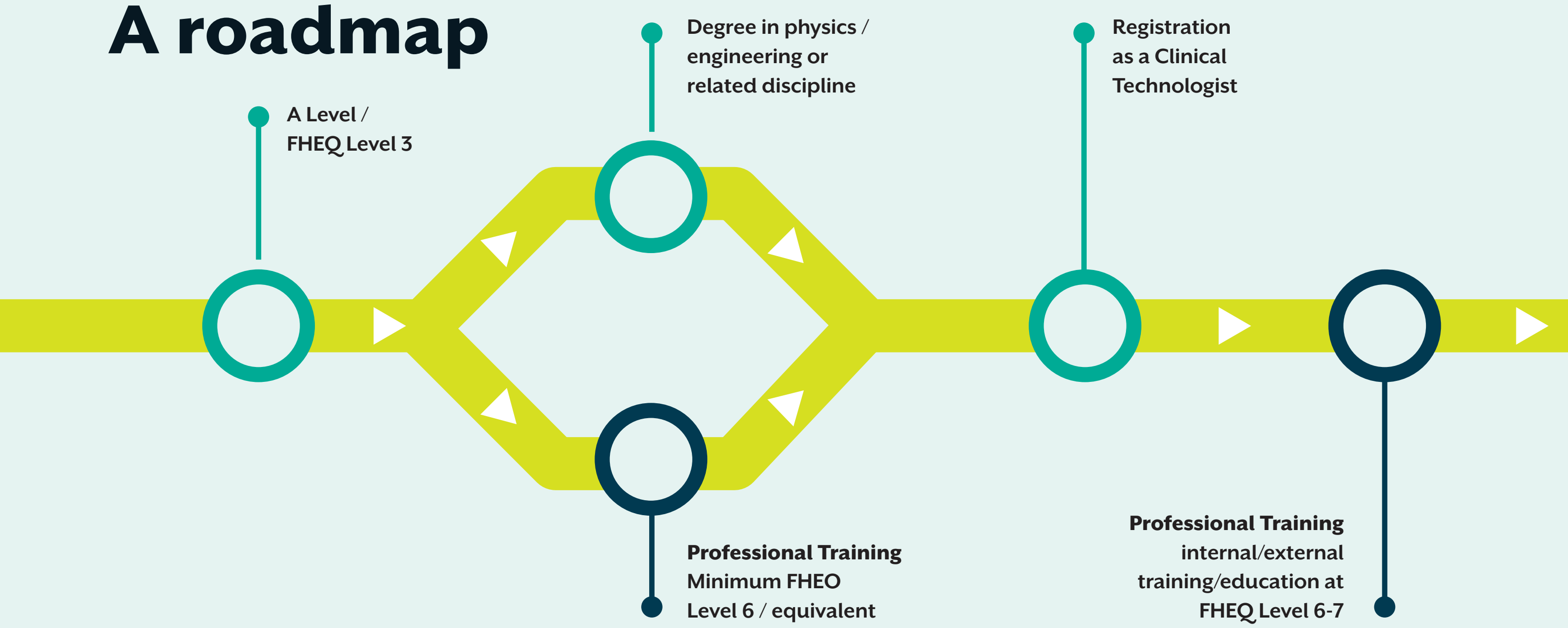
IPEM believes...

1. Technologists are a separate professional group to clinical scientists
2. Technologists deserve and require professional recognition
3. Enhanced, advanced and consultant level technical practice can, and should, exist
4. Usage of advanced practice technologists would enable greater flexibility within a stretched workforce

In order to support this IPEM is:

- Making our position on professional recognition clear
- Making our position on advanced practice clear

A roadmap



- Pushing for statutory regulation
- Expanding IPEM's Technologist Training Scheme
- Developing a career and education framework
- Making example job roles and descriptions available
- Submitting requests to the Jobs Evaluation Group to evaluate example role description so that appropriate national job profiles are created
- Creating a network to support advancing practice and advanced practitioners
- Supporting clinical technologist career progression to become advanced technologists through CPD and volunteering opportunities.

A separate entity

It is IPEM's view that the profession of clinical technologist is a separate entity, with defined skills that are complementary to those of a clinical scientist. The technologist role is not merely an alternative starting point on the pathway to clinical scientist, but the starting point of a career in clinical technology, transitioning across enhanced, advanced and consultant practice.

IPEM has noted with concern that there is not universal recognition of advancing practice for technologists, with employers not recognising the skills and benefits that an advanced practitioner can bring. There is concern that this lack of career opportunity and development is creating a barrier to both retention and recruitment.

This has the potential to cause individual professionals and employers to miss out on opportunities to develop their professional practice and, through that, the service that is offer to patients and colleagues.

As the delivery model of healthcare changes with practice development, influenced and led by technological advances, the technologist workforce must evolve too. It is timely to introduce a formally recognised framework, providing an education and training pathway to advance careers.

Promoting registration

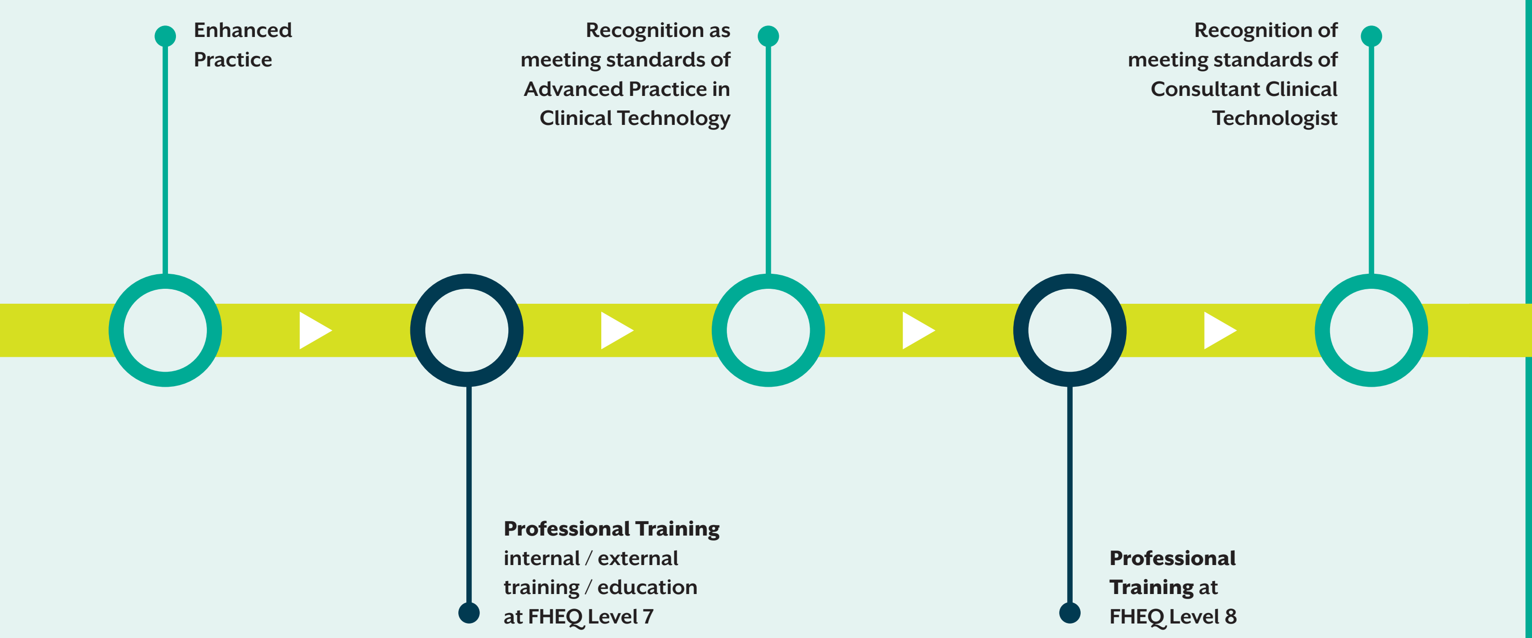
At present, registration is not statutory. However, as a professional body, IPEM strongly promotes registration and continuing professional development as a highly desirable recognition of professionalism, public and patient protection, and demonstration of commitment to lifelong learning.

IPEM also believes that statutory registration of clinical technologists is essential to safeguard the professional standing of these highly skilled practitioners and underpin public confidence in patient safety.

Across the UK, practice and roles vary significantly, and aspects of clinical practice that are considered advanced in one location may not be in others. This document sets out IPEM's intentions to create a universal description and create a career and education framework to support technologist careers.

There is currently no formal recognition or designation indicating practice at any level above initial registration in clinical technology. This is in contrast to other related professionals, such as clinical scientists or radiographers. This independent recognition of advanced practice would enable service managers to create roles to optimally mix skills within their unique workplace and effectively use the advanced skills of experienced technologists.

In many locations, technologists have developed their roles working at an advanced practice level organically as the service has required. A standardised and quality assured training route and framework is therefore required. IPEM proposes the road map below.



HIGHER SPECIALIST SCIENTIST TRAINING

A survey

In 2023, IPEM's Workforce Intelligence Unit ran a survey to determine whether Higher Specialist Scientist Training (HSST) is meeting the needs of the medical physics profession. Here we look at the feedback.

IPEM believes that HSST delivers the necessary skills to support a consultant clinical scientist (CCS) workforce of the future. However, medical physics staff have suggested that the content of the programme should be reviewed. Concerns were also raised regarding the positioning of HSST, and the time commitment required for the programme.

The survey

A consultant clinical scientist is a medical physicist with the same level of professional competency as a medical consultant. They are responsible for quality improvement, innovation and research to modernise and improve healthcare. The Higher Specialist Scientist Register (HSSR) is a means of formally recognising that an individual has the necessary skills to act as a consultant clinical scientist. One achieves HSSR registration through HSST, or via an equivalence route (Higher Specialist Scientist Equivalence).

All heads of department across different medical physics disciplines – which included radiotherapy, nuclear medicine, diagnostic radiology and radiation protection, and magnetic resonance – were contacted to take part in the survey. The survey gathered information on the current CCS workforce, including the number of individuals enrolled on HSST, and asked respondents to discuss their views on HSST.

The CCS establishment

Current CCS staffing levels fall short of service requirements in every specialism. Recruitment to CCS posts is infrequent, and often difficult for employers. The number of individuals working toward HSST reflects appropriate succession planning for future CCS roles, particularly in radiotherapy. However, this varies with specialism: diagnostic radiology and radiation protection have fewer staff working towards HSST, possibly due to discipline-specific staffing shortages and the diversity of expert qualifications sought by staff.

Respondent views on HSST

Survey respondents commented positively on the skills delivered by HSST. The programme provides training in management and research skills that are required to act as a CCS. Respondents who had experience recruiting for CCS roles stated that HSST is useful in demonstrating the required skills for the role. HSST can help the profession work towards ensuring conformity of skillset of staff at higher levels of the medical physics profession.

However, these respondents added that the presence of HSST alone does not immediately qualify an individual for a CCS role. Plentiful experience in the profession is highly valuable and continues to be seen as a role requirement. It is recommended that this be made clear to prospective applicants, to avoid any misconceptions about the position of the programme.

Respondents also expressed concerns related to inclusivity of the future CCS workforce. The HSST programme incurs a heavy time commitment for a period of no less than five years. Concern has been expressed previously, as well as in the present survey, over whether this unfairly disadvantages prospective applicants with caring responsibilities. While the time burden cannot be entirely mitigated, there currently exist provisions for part-time learning and longer timeframes of completion. For the programme to be seen as flexible and inclusive, departments who are considering enrolling staff on HSST must be aware of the provisions available to them.

IMAGE: GETTY IMAGES

RECOMMENDATIONS OF THE REPORT

IPEM proposes the following recommendations:

- **Communicate the position of registration on the HSSR: this is evidence of the skillset needed to become a CCS, not a guarantee of a CCS position.**
- **Promote the existing flexibility in delivery of HSST and increase this further where possible. Increase awareness of existing part-time modalities, and longer time frames for completion. To increase further the flexibility of the programme, support for modular or remote learning is suggested.**
- **Suggest that the current HSST physics curriculum is reviewed, with particular focus on the Imaging track and alignment with MPE requirements.**
- **Support HSSE as an alternative route to registration, through workshops, peer support and alternative learning opportunities.**
- **Encourage MRI staff who are interested in HSST to enrol on the programme's Imaging track, without Part C if they hold a relevant PhD.**

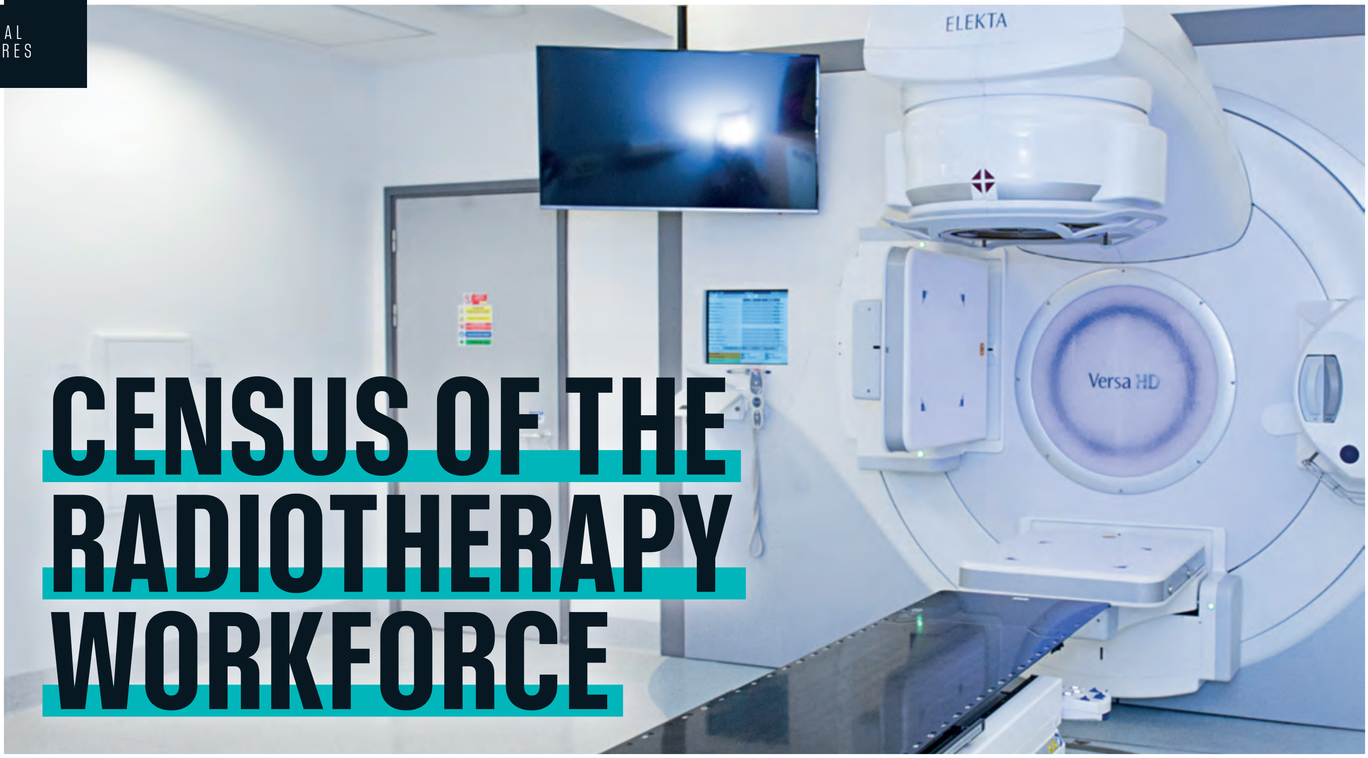
HSST programme content

A desire for programme content to be reviewed was expressed. In 2019, volunteers from IPEM released a policy statement comparing HSST curriculum content to the competencies required to gain certification as a Medical Physics Expert (MPE). This showed that the competencies of HSST and MPE certification were designed to be complementary. Specifically, detailed understanding in topics on dosimetry, equipment management, and medical exposure optimisation are fully covered by HSST.

However, analysis undertaken for the present survey indicated that this alignment is unlikely to be taken advantage of, as prospective MPEs are unlikely to use evidence submitted for HSST in their portfolios. The reasons for this are twofold. While HSST is considered a higher qualification, many professionals undertake MPE certification at the "mid-career" stage. Staff may therefore be more likely to undertake HSST after they have already submitted their MPE portfolio.

Additionally, IPEM's policy statement on curriculum content was released in 2019. The medical physics profession – and knowledge requirements for consultant-level practice – have evolved since this time. Some of the present survey respondents felt that the current curriculum content did not match their expectations of "consultant-level" physics knowledge, and that the curriculum is due for review. These comments were particularly prevalent among those in specialties covered by the "imaging" track (i.e. diagnostic radiology and radiation protection, nuclear medicine, and magnetic resonance).

*Survey results are presented in full in the IPEM report **HSST and the Consultant Clinical Scientist Workforce**, which can be accessed by visiting **b.link/7650zwsp***



CENSUS OF THE RADIOTHERAPY WORKFORCE

In November 2023, IPEM undertook a census of the UK's Radiotherapy workforce. We cover the results and the Institute recommendations.

All radiotherapy centres across the UK were invited to take part in the census and 93% responded. The work showed that 8% of radiotherapy posts are vacant, and that there are not enough established posts to support safe and effective services across the UK.

The number of established posts has increased by around 5% since 2021. However, vacancy rates remain high for clinical scientists, and clinical technologists in physics and engineering. Comparisons with IPEM's Radiotherapy Staffing Calculator show that the number of staff in post must increase overall by 20% in order for safe and effective services to be delivered.

Most respondents feel that they have insufficient staff. Around 40% report insufficient clinical scientists and around 70% report insufficient clinical technologists. This limits capacity for future planning, service development and training. Between 50% and 60% of centres have too few staff with expert qualifications (e.g. MPE and RPA). The complexity of the certification process is likely to be deterring prospective applicants.

The group requiring the biggest increase is clinical technologists in engineering, who have a 9% vacancy rate. Furthermore, this workforce is ageing: around a third of clinical technologists in engineering are aged 55 or older. Succession planning is a pressing concern, as NHS staff are eligible to receive their pension at age 55. With very few centres able to train new clinical technologists in engineering, urgent action will be needed to ensure that this workforce does not decrease further.

Respondents commented that senior staff are difficult to recruit. This is largely because there are few staff with the required background. Many centres solve this by recruiting staff at junior levels, and training them in-house until they are at the level of experience that the centre needs. This can be costly and time-consuming.

IPEM developed a predictive model of future workforce growth. It showed that the number of clinical scientists entering the workforce annually is 11 fewer than is required to fill vacancies and maintain establishment growth. In order to do this, and to meet IPEM's recommendations for safe staffing, an estimated 75 new clinical scientists must enter the workforce each year until 2026.

Regarding radiotherapy equipment, 22% of all linacs, and 11% of all computed tomography simulators are older than 10 years. This is typically the age at which equipment must be replaced. Respondents suggest that this is because many clinical scientists lack capacity to decommission and procure new equipment. Funding may also play a role. The prevalence of old radiotherapy equipment is very likely to have implications for patient safety.

BASED ON THESE FINDINGS, IPEM RECOMMENDS:

1. **Increase trainee output:** this can be achieved with higher funding for training programmes and trainee posts, improved outreach about the career and improved support for regional training solutions.
2. **Increase support for career progression.**
3. **Increase non-clinical scientist/clinical technologist posts** that can strategically ease pressures on these staff groups.

IMAGE: ISTOCK

METROLOGY FOR MEDICAL PHYSICS

Delivering measurement science

A team from the The National Physical Laboratory outlines the work that it is undertaking across six areas of medical physics for healthcare.

The National Physical Laboratory (NPL) is part of a network of National Measurement Institute (NMI) laboratories, which is responsible for delivering measurement science, as well as traceable and increasingly accurate standards of measurement. We develop and maintain the national primary measurement standards, as well as collaborating with other NMIs to maintain the international system of measurement. Formed in 1900 when the development of uses for radiation was in its infancy, NPL received the UK's first radium standard in 1913 and has offered testing and audits of X-ray equipment since the 1920s. There is documented evidence of standardisation and traceability with the first primary standard free air ionisation chambers since the 1930s.

The current driver for a focus on medical physics is that the government recognised the need to speed up the adoption of innovative new diagnostic tools, treatments and medical technologies to make the UK home to world-class healthcare. Hence, we aim to support rapid acceleration of the development and implementation of these technologies, share expertise to help enhance healthcare and improve quality of life for patients in the UK, and develop a focussed programme of research and innovation to support metrology in medical physics (see figure ❶, overleaf).

There are now staff across NPL working in numerous areas to support medical physics. These include joint posts, healthcare scientists and research scientists who collaborate with academia, healthcare and industry. The main themes are radiotherapy, radiation biology, nuclear medicine, magnetic resonance imaging (MRI), ultrasound and data science, as described below.

Radiotherapy

The radiation dosimetry and radiotherapy team at NPL has existed in various forms for almost as long as ionising radiation has been used in healthcare. During this time the group has been at the cutting edge of the development of primary standards and the definition of relevant quantities, such as air

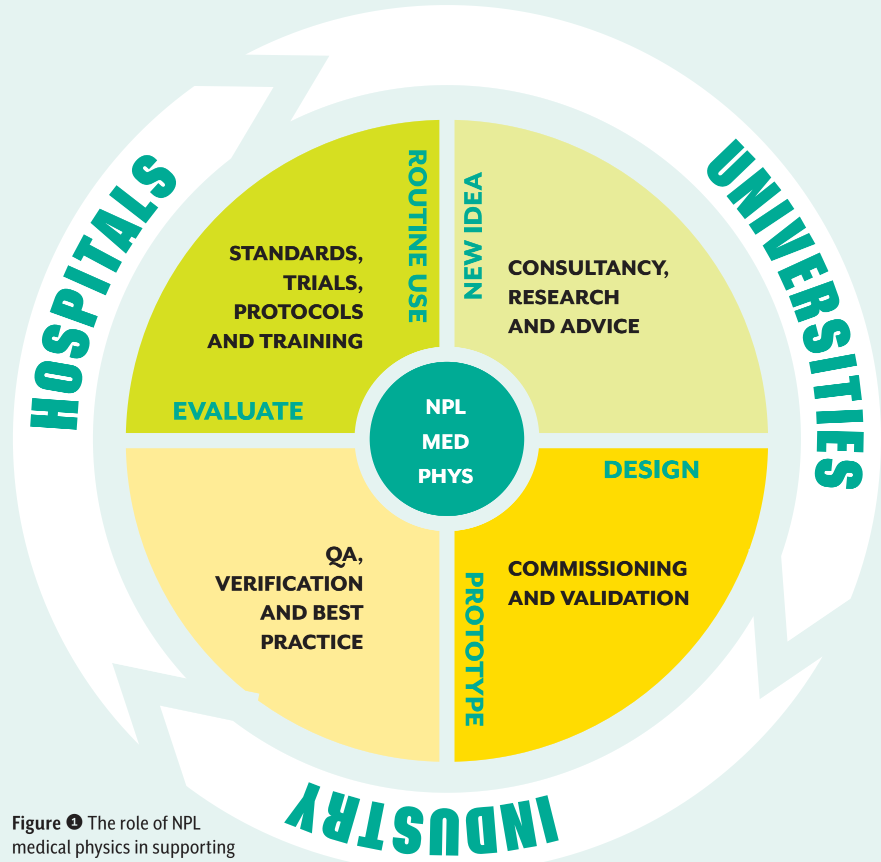


Figure 1 The role of NPL medical physics in supporting healthcare developments in hospitals, industry and academia.

kerma and absorbed dose, striving to make them more obtainable and relevant to the developing field of radiotherapy. NPL works closely with clinical colleagues to ensure the dose defined from these primary standards is disseminated to the clinics, always with an eye to continued improvement and reduction in uncertainty. This is facilitated by the measurement services and consultancy that NPL offer, which align with the relevant codes of practice produced by IPEM working groups.

A necessary part of any rigorous traceability chain is audit of the implementation by the end user. To this end NPL offers a range of audits, from reference dosimetry through to end-to-end audits across numerous delivery modalities and also in collaboration with IPEM's interdepartmental audit group and the Radiotherapy Trials Quality Assurance (RTTQA) group. We also work to develop dosimetry for upcoming modalities, such as ultra-high dose rate and spatially fractionated radiotherapy to be ready to support the future clinical implementation. In order to facilitate both the research and service provision, NPL holds primary standards, free air chambers and calorimeters that are operated in various facilities including linacs, X-ray sets, cobalt 60 units and brachytherapy units, as well as a treatment planning system, all of which enable us to continually develop and improve our support of the clinical users.

Radiobiology

NPL's radiation biology programme focuses on developing metrology-based tools that underpin precision medicine in radiotherapy, driving the transition from "evidence-based" to "outcome-based" treatment strategies. Our research aims to support patient stratification in radiotherapy, allowing for more personalised treatments by accurately measuring and predicting biological responses to radiation.

This is achieved through the development of traceable metrological techniques, including quantum-based approaches for microdosimetry to assess radiation effects at the cellular and subcellular levels. These efforts identify key dosimetric parameters underpinning radiobiological responses across a wide range of new radiotherapy modalities. Our scope also extends to creating standard systems that mimic the complexity of human tissues, leveraging microfluidic technology in organ-on-a-chip models to closely replicate physiological conditions. Additionally, we plan to exploit AI and machine learning to identify novel radiation biomarkers.

Our activities directly address the growing need for biologically optimised radiotherapy, ensuring that the right dose is delivered to the right patient, at the right time while minimising adverse side effects. The programme actively collaborates with UK and international radiobiology centres, establishing standardised measurement protocols that enable harmonisation across clinical and research settings.

Nuclear medicine

All clinical administrations of radiopharmaceuticals are underpinned by primary radiation standards – a critical component in ensuring their safe and effective clinical use in nuclear medicine (NM) diagnostics and therapies. NPL plays a key role in helping clinical centres to establish measurement traceability for radioactivity measurements, giving confidence in results for clinical users, harmonisation of measurements across sites and fulfilling regulatory requirements. The increased use of quantitative NM imaging, both as a diagnostic tool and as input to absorbed dose calculation for molecular radiotherapy (MRT), means that there is now a need to extend this traceability and associated understanding for the measurement to both single-photon emission computed tomography (SPECT)/computed tomography (CT) and positron emission tomography (PET)/CT imaging. This need is further increased by the requirements of MPACE accreditation for nuclear medicine departments.

NPL has been developing the metrology for clinical NM, expanding our existing support for radioactivity measurements. We have established the first dedicated SPECT and PET imaging laboratory at a national metrology institute, providing a unique facility to support clinical and academic research. To support the therapeutic use of radiopharmaceuticals we have contributed to guidance documents on uncertainties in MRT dosimetry, open-access resources for MRT dosimetry and provided freely available datasets for the validation of dosimetry calculations. Currently NPL is taking part in the AlphaMet project addressing the unique and unmet metrological challenges of targeted alpha therapies, contributing to their safe and optimised implementation into routine clinical practice.

"NPL HAS AN EXPANDING GROUP WORKING ON THE METROLOGY UNDERPINNING MEDICAL PHYSICS

Magnetic resonance imaging (MRI)

NPL has been actively developing MRI metrology since 2018. A lot of the work focusses on traceable MRI test objects, or phantoms, along with recommendations on image acquisition and processing to provide reference metrology for quantitative methods. Working with a network of partners across the UK and Europe, including NHS trusts, universities, manufacturers and other NMIs, we have developed reference metrology for MRI-based measurement of relaxivities (T1, T2, T2*), apparent diffusion coefficient (ADC), and proton density fat fraction (PDFF) imaging.

NPL is currently in the process of building a primary standard facility for MRI, consisting of a variable field NMR spectrometer calibrated to the SI second, meter and Kelvin, to provide measurement services in these measures and conduct further development. The team is also developing uncertainty quantification for MRI-based measurement approaches and working with the NHS and IPEM to develop new QA approaches for AI in MRI, to allow clinical physics teams to have confidence in the performance of their new AI products.

Ultrasound

Diagnostic ultrasound imaging is the second most frequently used imaging modality worldwide, after conventional radiography. Though ultrasound is non-ionising, there is potential for tissue damage during imaging and, consequently, there are limits imposed on the output levels of diagnostic ultrasound by regulatory agencies. The accurate quantification of ultrasound (pressure, intensity and power) outputted by medical devices to a traceable calibration standard is crucial to ensuring patient safety and treatment efficacy in different applications. NPL has been a forerunner in researching improved measurement and calibration methods able to address new measurement challenges created by emerging medical ultrasound equipment.

NPL's research helps manufacturers develop new products and provides the healthcare user community with the confidence that diagnostic and therapeutic systems are safe and effective. We have supported NHS via contributing to Scientist Training Programme ultrasound workshop, lent metrology experience to assess existing image quality assurance procedures and held joint appointments to develop instrumented phantoms for performance assessment of MR-guided ultrasound therapy systems. We have worked with the British Medical Ultrasound Society and wider NHS medical physics community in publishing physics and safety statements to assist healthcare professionals in the safe use of ultrasound.

Data science

Data quality and confidence is critical for trustworthy decision making and underpins good outcomes. This extends to the complete data processing pipeline from raw data (e.g. from a medical device) to a trusted measurement result (e.g. biomarker) and ultimately principled and confident decision making (e.g. a diagnosis). The data science department at NPL focuses on these areas, with particular attention paid to quality assurance of data and trustworthy artificial intelligence. Quality and trustworthiness are built on the foundations of metrology, such as traceability (provenance of data, metadata and transparency of data processing pipelines), quantification and propagation of uncertainties (in data and models) and standards and evaluation (metrics and ground truths).

Applying these metrology concepts can improve patient outcomes through standardised and repeatable measurements (e.g. radiotherapy) and build trust in black box models by understanding certainty and the basis of output. We have supported the NHS and health sector through optimisation of cancer pathways, analysis and standardisation of radiotherapy audits, uncertainty quantification in AI for medical imaging and data from wearables, patient subtyping and trajectory modelling, and the development of a FAIR (findable, accessible, interoperable, reuseable) and traceable data curation framework for data storage and meta-analysis.

Conclusions and future

NPL has an expanding group working on the metrology underpinning medical physics for healthcare. Across the six themes described, there is activity from research, through implementation to services for routine clinical work.

However, these do not cover all areas of medical physics, nor clinical engineering, so if you want to discuss what we are already doing, or what we could do in the future, please do get in touch. For more information, visit **npl.co.uk**

Catharine Clark, ***Matt Hall***, ***Srinath Rajagopal***, ***Andrew Robinson***, ***Giuseppe Schettino***, ***Russell Thomas*** *and* ***Spencer Thomas*** *all work at the National Physical Laboratory.*
This work was funded by the UK Government's Department for Science, Innovation and Technology through the UK's National Measurement System programmes.

IMAGES: NOUN PROJECT

GENERAL FEATURES

IPEM ESSAY PRIZE 2024

Dr Anna Wang, a second-year STP trainee specialising in radiation protection and diagnostic radiology at The Royal Marsden in London, is the winner of the Early Career Essay Prize 2024. Following is her response to the question: ***"How can the integration of AI into clinical practice improve diagnosis and patient outcomes, and what impact will this have on workforce training?"***

It's Monday and Sarah, a chest radiologist, logs on to her computer to start the first task of the day – reviewing chest images. Scrolling through the worklist, she clicks the AI button on the sidebar to see if there are cases requiring her immediate attention. The AI hasn't flagged anything critical so Sarah clicks on the oldest one on the list, a CT scan of a patient with lung cancer. The patient recently underwent treatment and had this follow-up CT scan to assess the tumour response. The AI algorithm matched the lung nodules found in this CT to ones found in a scan made before treatment, and generated a report. In addition to finding no new lesions, the AI analysis shows that the target tumour responded to treatment and its size has decreased by 32%. Looking through the images to check that the AI has outlined the tumour correctly and hasn't overlooked any nodules gives Sarah confidence in the results. A positive story to start the day, great! Sarah knows that AI isn't always perfect but when paired with her clinical expertise, she can now review many more cases and help get patients their results faster.

Going back to the worklist, Sarah finds that the AI software has flagged up a routine chest x-ray performed on an inpatient only ten minutes ago. The AI spotted a potential collapsed lung and prioritised it for review. Opening the image, Sarah sees that indeed, the patient has a serious case of a collapsed left lung and immediately alerts the patient's clinical team for treatment. Phew. Without AI that image might have only been reviewed much later in the day and delayed the patient's treatment. The rest of the morning continued without incidence, and after lunch it's time for a meeting with specialists across the hospital – surgeons, oncologists, pathologists and nurses – to plan treatments. For one lung cancer patient, the option of post-surgery radiotherapy is discussed. Whilst radiotherapy could decrease the chances of cancer recurrence, it might also harm healthy parts of the patient's heart and lungs. To help them make these types of decisions, the team recently introduced an AI tool designed to predict if individuals might benefit from radiotherapy based on their chest images.

Sarah has been involved in the extensive testing required before the software's clinical use and is pleased to see it now playing a part in delivering personalised patient care. Sarah's final job of the day is to prepare some teaching materials for lectures she's

"

THE HIGH DEMAND AND PRESSURE CURRENTLY FACED BY HEALTHCARE SERVICES MAKES AI IMPOSSIBLE TO IGNORE

giving to trainees. With a click, Sarah opens up the AI-powered chatbot on her computer and types "make PowerPoint slides based on the first specialty training exam curriculum in clinical radiology". After some simple edits, Sarah has time to add a few interesting case studies from her own work that she thinks the trainees would benefit from. Before logging off, she quickly checks tomorrow's schedule for any last-minute changes and with that, it's time to head home.

The scenario presented here is fictional and definitely different from the healthcare we are all used to but I hope it shows a snapshot into the potential applications of AI to improve patient care. As with all new technologies, the integration of AI into the current healthcare system also poses many questions. For example, in this scenario, AI prioritised the scans for review based on their urgency but how do we know it's suggesting the "right" cases? How well does AI work in fringe cases where underlying medical conditions may not be so obvious? How can we ensure that the underlying training data provides a fair representation of the patient population? And can it keep up with new advances in medical knowledge? When used for CT scans, there are indications that AI could lower radiation doses to patients without adversely affecting clinical judgements. But how do we know what AI is showing us is real? In short, how do we ensure that

AI has a positive effect on the patient pathway? These questions are partly why there has been a call from many professional bodies such as IPEM and the Royal College of Radiologists for more guidelines into quality control and auditing of AI algorithms before widespread clinical use.

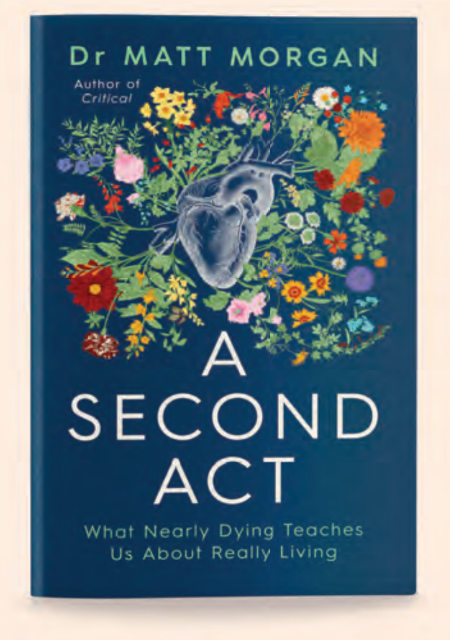
Work in this area has already started. For example, the LungIMPACT trial is assessing whether a real-world AI algorithm similar to one Sarah used in the scenario can improve patient waiting times for diagnosis by flagging time-critical cases. Trials such as this help build a body of evidence for cost-benefit analysis to ensure safe implementation. As part of this drive, workforce training in AI is also key. The likely widespread use of AI across healthcare means that foundational knowledge in AI will play a crucial role in establishing staff confidence in the care that they are giving to patients and its general involvement to make clinical decisions. The depth and type of knowledge required will also depend on the workforce group. Whilst a radiologist might require familiarity with the capability and limitations of specific AI software, clinical scientists involved in auditing and monitoring of AI might require both broader and more technical knowledge about the algorithms and potential biases. Training for staff in patient facing roles will also allow for better interactions with patients whether when communicating results involving the use of AI or addressing AI related concerns patients might have. These varying workforce needs should be reflected in training, ranging from foundational courses to specialist hands on education for specific clinical scenarios. In all cases, AI education will need to be established as part of the curriculum in training programs. The high demand and pressure currently faced by healthcare services makes AI impossible to ignore. Though not without its challenges, safely incorporating AI into our healthcare system with appropriate staff training has the potential to help build towards a solution.

BOOK PITCH

A Second Act:

What Nearly Dying Teaches Us About Really Living

Matt Morgan outlines the idea behind and the content within his new book.



There is nothing better than bringing someone back from the dead. After twenty years working as a doctor, it still amazing to seeing a flat line on a heart monitor dance back to life after resuscitating a patient. Although CPR (cardiopulmonary resuscitation) is not always the right thing to do, this simple physical act can lead to another chance at life – a Life 2.0 or, the title of my next book suggests, "A Second Act".

Countless books have been written on how to live a better life. People from many walks of life, from scientists to spiritual leaders, have shared their expertise. But what they all have in common is being written only from the perspective of the living. But what if we could instead hear from these people I've cared for who have already died once, only to be given a second chance at life?

My work as an intensive care doctor forces me to peer through the window between life and death. In my first book, *Critical*, I explained how people can survive a cardiac arrest thanks to advanced healthcare. Yet, only a few out of every one hundred will live to tell their story, and restarting a patient's heart is just the first page of their new chapter. The days, months and years that follow give these patients a unique perspective on life through the prism of death. Although many are left with ongoing struggles, those I have met also step back into their lives with insights we can all benefit from.

> **" I RETURN TO MEET PEOPLE I HAVE CARED FOR, WHO ALL DIED IN DIFFERENT WAYS**

In my new book, I return to meet these people I have cared for, who all died in different ways, from being struck by lightning, to drowning, heart attacks to allergies to poisoning. After learning the science of how their lives were reignited, we discover that each has an important lesson to teach us. Whether it is connecting with lost friends, rediscovering the beauty in nature or finding meaning through work, each message can be applied to our own lives, and hopefully long before we find ourselves at death's door.

Like 29-years-old Roberto, an Italian climber who survived the world's longest cardiac arrest, nearly nine hours where his heart didn't beat. The extreme cold of the Dolomites helped to keep his brain safe and his story reminds us of the incredible neurodevelopment power of the thousands of images that lay dormant on your phone right now. Look at your old photos. Look now. Don't wait until someone has died to look back. Don't print them out just for their funeral – make it a habit to look back every day.

The book ends with the conclusion that everyone should have a funeral before they die. It was my own living funeral that allowed me to put the lessons from these patients into practice. I hope the book will make you realise that we have two lives – the second begins when you realise you have one. Just like my work in the intensive care unit, life too is an emergency. But this book is not about death but about life. Your life. And new ways to live it.

***A Second Act: What Nearly Dying Teaches Us About Really Living** is published by Simon and Schuster. Matt Morgan is a Consultant in Intensive Care Medicine, Honorary Professor at Cardiff University and Curtin University in Australia and regular BMJ columnist.*

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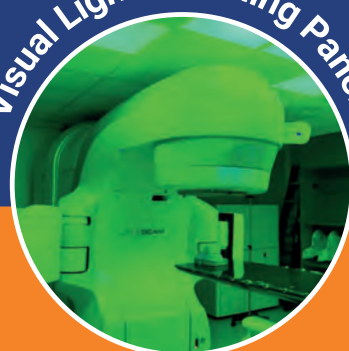
Quick patient focused set ups with minimal manual handling.

Camera Set-up

Consistent camera configurations with open and closed gantry systems allowing for future proofing with Linac replacement programmes.

Visual Light Coaching Panels



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