A TALE OF TWO SOURCES
Medical Physics at Maidstone Hospital recently took part in Major Incident Plan training exercises for radiation emergencies

THE PHYSICS BEHIND VOLUMETRIC MODULATED ARC THERAPY
The physics, concepts and technology behind VMAT, a method of radiation treatment delivery with advantages over IMRT

RADFET DEVICES
MOSFET radiation dose monitors (RADFETs) are chips originally designed to check space radiation, and they can now help to treat cancer

MOVING ON (LINE)
The birth of Scope Online (www.scopeonline.co.uk), an electronic version of this magazine, and its hopes for the future

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A tale of two sources

Mark Knight, Ben Medford and David Simpson (Medical Physics Department, Maidstone, and Tunbridge Wells NHS Trust) on their recent training exercises

t was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness’… for Medical Physics at Maidstone hospital, June was the month of the Trust’s emergency plan; July the month of NAIR.

The Health Physics and Imaging Group (HPIG) at Maidstone Hospital consists of a selection of medical physicists and technicians from the radiation protection and nuclear medicine departments. In addition to performing the regular day-to-day tasks of a medical physicist, we are also involved with the less regular task of handling radiation emergencies. These radiation emergencies come in two distinctly separate categories: NAIR-related emergencies (national arrangements for incidents involving radiation), and emergencies included in the Maidstone and Tunbridge Wells (MTW) Trust’s Major Incident Plan.

THE PREPARATION: NAIR
NAIR is co-ordinated by the Radiation Protection Division of the Health Protection Agency (HPA). It was set up to protect the public from hazards arising from the use and transport of radioactive materials and in situations where no formal contingency plans exist. There are two stages to the NAIR scheme: stage 1 response consists of a small group of radiation experts dispatched to determine if there is a hazard and advise on the action to take, and stage 2 involves a team of experts with more sophisticated resources for handling the incident. The HPIG are NAIR stage 1 responders. As such we have had to develop a streamlined approach to deal with a NAIR emergency; establishing our own contingency plans for such an incident. To allow a quick and easy dispatch of our NAIR team we have pre-assembled NAIR radiation incident kits (see figure 1).

These kits are dedicated solely for use in a NAIR incident; equipment is not removed for any non-NAIR related circumstances. The kits contain items listed in the NRPB NAIR Technical Handbook 2002 Edition, such as personal protective equipment, warning tape and signs, containment bags, notepad, pens, a hand torch and radiation monitoring equipment. All items in the kits are checked and the radiation detectors are tested at regular intervals. The radiation detectors included are:

- Thermo series 900 – a compensated Geiger used for the measurement of dose rates from gamma rays or beta-emitting isotopes;
- Thermo 44A – a sensitive NaI scintillation counter for measurement of gamma rays;
- Thermo AP2/4A ZnS – a scintillation detector for detection of alpha radiation;
- Thermo 1000 series mini-contamination monitor – an end-window Geiger for detection of gamma and some alpha and beta radiation;
- Berthold LB-124 – a sensitive scintillation contamination monitor for detection of gamma and some alpha and beta radiation, and
- Exploranium GR-135 – a NaI/Geiger tube-based instrument with isotope spectrometer and spectrum analyser.

A selection of detectors enables us to monitor a large range of radioactive materials. Which radiation meter to use depends on the type and energy of the emitted radiation and therefore the radioactive isotope present.

Advice on what instrument to use for each isotope is also given in the NAIR handbook.

In addition to the NAIR kits, we also have a cupboard containing equipment specifically for NAIR use, such as high-visibility waterproof NAIR jackets, gloves, boots and safety helmets (see figure 2). Having both this equipment and the NAIR kits available for use at any time really has proven to reduce the dispatch time of the NAIR response unit and decrease the likelihood of leaving critical equipment behind.

MTW’S EMERGENCY PLAN
MTW’s Major Incident Plan covers incidents, generally external to the hospital, that have the potential to produce significant numbers of casualties. The HPIG are only involved if there is any radiation.
Maidstone Hospital is prepared to receive radiation casualties and is the first point of call should there be a radiation incident at the local Dungeness nuclear power station.

Although Medical Physics do not have a specific action card for major incidents involving radiation within our Trust – something that is currently being addressed – it is our role in such an emergency to set up a Radiation Monitoring Unit, mentioned in the Planning for Major Incidents: NHS Guidance publication from the Department of Health, to reduce doses to patients, staff and general public to ALARP. More specifically it is the medical physicist’s duty to perform external and internal contamination monitoring of suspected radiation casualties, decontaminate patients and areas, and provide advice on matters relating to radiation.

The nurse ran over to me shouting, ‘This baby’s stopped breathing! We haven’t monitored it yet!’. I ran with it towards A&E shouting for the crash team. Ken could take charge of monitoring the decontaminated casualties so I could supervise the treatment of this baby and ensure the A&E department stayed open. The adrenaline had finally kicked in!

This was exercise ‘Saxon Shore’ arranged by the Health Protection Agency to test major incident plans of health and emergency services in Kent. The scenario was that a dirty bomb had exploded in Dover and hundreds of contaminated casualties were being brought to Maidstone Hospital, as well as William Harvey Hospital in Ashford. As part of the Health Physics and Imaging Group at Maidstone Hospital we had advance warning that we may be called upon, but no information about what sort of incident we might have to deal with.

Maidstone Hospital’s A&E department has a regularly rehearsed major incident plan which includes the use of a decontamination tent in cases of chemical biological or radiological contamination. Reading through the trusts major incident plan in advance we found that the instructions for several staff groups in the event of a radiological incident were to:

- Set up a Radiation Monitoring Unit to reduce doses to patients, staff and general public to ALARP.
- Perform external and internal contamination monitoring of suspected radiation casualties.
- Decontaminate patients and areas.
- Provide advice on matters relating to radiation.

### ADVICE

1. **Externally**
   - Give advice to the Environment Agency of the current situation in terms of waste accumulation and disposal.

2. **At Trust level**
   - Regular updates to management.

3. **On the ground**
   - a. Transporting contaminated corpse to mortuary.
   - b. Ad hoc containment arrangements for critically ill contaminated casualties.
   - c. Advice to theatre.
   - d. Advice to A&E staff dealing with contaminated casualty.
   - e. Supervising use of contamination monitors.

### INFORMATION, INFORMATION, INFORMATION

1. **Emergency services**
   - Details of dose rates and contamination levels from the site of the incident and to be told what the substance is as soon as the information becomes available. This allows decisions to be made, for example about time limits for staff contact with casualties or disposal of any onsite waste.

2. **Colleagues at other Trusts**
   - In the event of a genuine terrorist incident the mobile phone signal would be turned off. Contact with colleagues needs routing through the emergency services.

3. **Within the team**
   - Communication can become difficult when a team is split between contaminated and clean areas. Every zone with restricted access needs a ‘runner’ to relay messages.

### EQUIPMENT

1. **Monitors which produce an energy spectrum** would allow initial identification of the isotope and discrimination between contaminated casualty and a nuclear medicine patient.

2. **Areas bordering a restricted area** also need contamination monitoring equipment to ensure that they remain ‘clean’.

### MORE STAFF

A real incident could last for days. Another ‘shift’ of physics staff need to be available and kept in reserve. A large number of contaminated walking wounded would need a dedicated monitoring station which would also require more staff.

Radiotherapy physicists could be trained to provide this. Basic training would need to include operation of contamination monitors and ‘Dealing with difficult people’ communications training. Action limits on contamination/dose rate levels would need to be established.

Regional arrangements could be made with other departments to bring in other nuclear medicine/health physics staff.
proceed as if it had been a chemical spill until Medical Physics arrive and then do what they say. The plan stressed the role of the physics team in advising staff to ensure that radioactive contamination did not prevent the A&E department from functioning throughout the incident. It was thus with some trepidation that we turned up at the A&E department; three physicists, three technologists and two physics trainees were ‘instant experts’ in a completely novel situation.

After fending off the local news team (‘Is there anything you would like to say on live TV to reassure the whole of Kent?’), Mark Knight was needed to provide regular RPA briefings to Trust management. The rest of the group donned protective jumpsuits, overshoes, face masks and gloves and split into two groups. One team helped supervise the monitoring of the contaminated casualties before and the other after their trip through the decontamination tent.

Casualties arrived having been ‘monitored’ on the scene by the emergency services. Each volunteer had a series of cards with them which let us know what we should expect our monitors to read. This was useful as some of the paperwork from the emergency services had contamination figures reported as dose rates (2000 mSv/hour). We had no information whatsoever about which radionuclide was involved.

Practical difficulties soon became clear. Once everyone was suited up and in a designated contamination area there wasn’t anyone available to communicate between groups or run errands. Plastic overshoes designed for indoor wear don’t last long outside. Gloves are sweaty after an hour or so and large jumpsuits aren’t quite large enough. How were staff working in hot conditions (in both senses of the word) supposed to drink? It was clear that in a long extended incident we would need to call on colleagues from local trusts or other staff groups to relieve us.

All of this was an interesting academic exercise until I was handed the ‘baby’ (the plastic doll was doing a very convincing job of not breathing). We set up a side room in fracture clinic for those with life-threatening injuries who could not be decontaminated. After monitoring doctors and nurses in and out of the
side room I was given the news that the doll had died and I should give advice to the parents about contact with the body. We didn’t really cover this sort of material on my physics degree!

It was around this time, some hours into the exercise, that we were finally told the nuclide involved was “Co. Apparently the emergency service had known this for some time. We could finally be more certain about the sensitivity of monitors to contamination and the relative risks from inhalation and ingestion by referring to the Radiation Protection Dosimetry Radionuclide and Radiation Protection Data Handbook.

The incident finished with a bang rather than a whimper as a contaminated car careered into a tree with the driver shouting for attention for his dead (manikin) wife. The team had to make the car secure and give advice to the mortuary.

Comparing notes on Monday morning, everyone had spent the weekend going over the incident thinking about what lessons could be learned. The main thing I learned was that keeping an A&E department open in such a situation is not the same as a NAIR incident. It needs advanced thought in conjunction with the emergency planning team, and an ‘Action Card’ telling the team who to report to and what to do. The main thing I learned was that keeping an A&E department open in such a situation is not the same as a NAIR incident. It needs advanced thought in conjunction with the emergency planning team, and an ‘Action Card’ telling the team who to report to and what to do.

WHAT THE DICKENS IS THAT?
Just over a week later, we were called to the NAIR incident. At around 12.15pm on 7th July 2009 the Radiation Protection Adviser (RPA) at Maidstone Hospital received a phonecall from the Civil Nuclear Constabulary (CNC) concerning a suspected radioactive object, which was found at a residential address in Tunbridge Wells, Kent. The object was discovered whilst the householder’s son was digging in the back garden. After finding it he telephoned the Fire and Rescue Service (FRS) who were immediately dispatched to the location. The FRS report to CNC stated:

- that the canister was labelled with bio-hazard tape, and
- that the dose rate measured was 0.13 mSv/hour – corrected to 0.13 μSv/hour.

FRS advised the householder that the object was emitting low levels of radiation, and asked the CNC to invoke NAIR. NAIR stage 1 respondents were called from Maidstone Hospital.

The NAIR team telephoned the HPA for recommendations on action to take with bio-hazardous materials.

DISPATCH OF NAIR
Due to the small background dose rate observed by the FRS and the proximity of the source in a secure back garden, it was decided that there was no need for a police escort. Medical physicists from Maidstone Hospital made their own way to the scene with the pre-assembled NAIR radiation incident kit.

ARRIVAL AND INITIAL OBSERVATIONS
A police officer attended the scene with the NAIR respondents. This was invaluable in assisting with communications throughout the incident and with public relations with the residents of the property (who were not at all concerned) and with local residents (who became increasingly concerned throughout the day).

Wearing appropriate PPE, a member of the team approached the source. The suspected radioactive object was a 10 cm long, 3 cm diameter cylinder made of what looked like steel – it was slightly corroded (figure 3). All of the instruments gave background readings for alpha, beta and gamma radiation. The NAIR kit contains small sheets of lead, aluminium and paper which might help with analysis of radiation type/energy in situations where the isotope spectrometer could not be used.

Upon observation of the source it was noticed that the object did not contain a bio-hazard label but a ‘radioactive material’ label. Upon closer inspection there was writing on the top of the cylinder. Due to corrosion it was very hard to read.

The outer steel shell of the object may have attenuated radiation emitted inside the container for low energy betas/alphas, so there still was the possibility that radioactive material was present inside the container. It may be expected that some bremsstrahlung would be present if the pot contained a high-energy beta emitter. There was also the possibility that there was contamination present and the dose rate/contamination monitors employed were not able to detect it (e.g. H₂). The NAIR manual provides advice on the best instrument to detect various radioactive isotopes.

PROCEDURE
To give a more accurate assessment of whether any radioactive substances were present, the container needed to be opened. However, if the substance was a liquid/powder then opening the container could have lead to contamination problems. The medical physics team concluded that it was not safe to open the container on site.

Having demonstrated that there was no measurable contamination or external dose rate the problem became one of disposal. The Environment Agency were asked to arrange collection of the source and they, in turn, requested that the source was removed and stored at Maidstone Hospital. The hospital has no current authorisation or registration to hold such a source (although this will be on new certificates issued by the Environment Agency), so after some discussion NAIR stage 2 responders at Dungeness Power Station were asked to remove the source. The benefits of this approach were:

- that their existing authorisations and registrations would cover storage and disposal, and
- that they have facilities on site to safely open and assess the contents of the container.

A survey of the surrounding area where the source was found gave no indication of other sources being present. The owners of the property were asked to contact the appropriate authority if any more sources were found.

At some point in the afternoon a journalist from the local newspaper attended; she was given no information at the scene but contacted the Trust the following day. The local paper ran a front-page article on the story which was not a bad representation of what actually happened and the scale of public health risk (close to zero).

The NAIR respondents were in contact with the Police, Environment Agency, NAIR stage 2 at Dungeness Power Station and the Emergency...
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Restricted Area
Keep away from this area

DO NOT ENTER THE BUILDING THROUGH THIS DOOR!
If you have been involved in an incident near Dover Docks
Please use the Accident & Emergency Entrance
For all other access please use the Main Entrance.
Staff should follow lock down instructions.
Response Group at the Health Protection Agency during the incident, and their support and communication helped to ensure that the incident went smoothly. It is possible that the pot was a container for a source used for calibration of Geiger detectors which are owned by rock and mineral collectors. The presence of red radioactive labelling on yellow tape, and the raised lettering on the pot, indicates that the pot may be several tens of years old. A colleague identified the name of a mineral company on top of the pot, which was felt might be a good place for the relevant authorities to start investigations.

**LEARNING POINTS**

- Having more than one medical physicist at the scene was invaluable. There were a lot of simultaneous phone calls and advice being sought in the early stages that a lone physicist would have struggled to deal with effectively alongside assessment of the source. It was very useful to leave one member of the team at Maidstone to communicate with the Trust/agencies, etc.
- Having the NAIR kit fully stocked and ready to go meant response time could be fast if required.
- GPS made finding the house address very simple. Police escort could do this if the situation required urgent attendance and GPS was not available.
- The NAIR stage 2 responders do not have any more sophisticated radiation monitoring equipment to bring to the scene than was available in our own kit.
- Medical Physics did not have a Type A container with them or transport placards and will include something in the NAIR kit for the future.
- The mobile telephone battery ran out which meant that we were not contactable at the scene after a certain time. A battery charger or spare battery should be available.
- NAIR respondents should always go to the scene to corroborate information given to them over the telephone.
- It would have been helpful if NAIR respondents could be sent by email a photograph of the source from the scene from one of the initial responders.
- To facilitate rapid removal of the source, it would be helpful if NAIR respondents who chose to take the source to their own site had a prior guarantee from the Environment Agency that their only responsibility is to safely transport and store the source. NAIR respondents may be more likely to remove sources if they knew that they would have no responsibility for assessment, administration or disposal of the source following the incident.
- If there is media interest, ensure that press liaison officers from the Trust brief them before printing or broadcast. If journalists arrive at the scene ensure that they are briefed by somebody trained in talking to the media.

**MORE HARD TIMES**

Finally, we have had three further incidents which have taken our time in the past 6 months.

In the first, we were called under the NAIR scheme again to attend a house to investigate reports that the resident was being irradiated from the next door property. Although this seemed extremely unlikely, we knew from the recent NAIR experience that we should attend. In the event, we measured nothing and could find no evidence of ionising radiation sources. The symptoms described by the resident were not consistent with ionising radiation exposure. The Police could find no evidence of a large electrical power supply to the neighbouring property that would be needed for an electrical source of the required magnitude. The resident claimed that this was switched off whilst we were in attendance. Despite our reassurances the resident was, unfortunately, convinced that we were part of the conspiracy and so our visit had no net benefit. This took about 3 hours of Medical Physics’ time.

The second case involved a patient who developed a pustular rash on his hands after working in his garden in Kent. His acquaintance claimed to have measured a dose rate of 40 μSv/hour in the area and attributed the rash to radiation exposure as a result of a nuclear release in Berkshire several months earlier in the year. The Environment Agency wrote to the acquaintance explaining that the measurements may be attributable to Radon washout and would not give the symptoms described. The patient was similarly convinced that there is some kind of government cover-up. This case took about an hour of Medical Physics’ time calling the Environment Agency and writing a follow-up letter to the patient’s GP.

The third case involved a physicist in a telephone conversation with a patient who thought that she had been irradiated by taking some medicine given to her at an A&E department with the text ‘smil’ on the side. She thought that this could be somehow related to Sv, which may indicate that the medicine was radioactive. The patient was reassured after a 40-minute telephone conversation.

**CONCLUSIONS**

It has been a busy 6 months in Kent as far as radiation incidents are concerned (figure 4). We have recently devoted quite considerable resources to incidents which have arisen from public paranoia or misunderstanding. The authors wonder whether the heightened coverage of radiological or nuclear activities in the media are leading to the increase in incidents.
Andrew Holmes-Siedle (REM Oxford Ltd), Paul Menary, Phil Sharpe and John A. Mills (Radiotherapy Department, University Hospital Coventry and Warwick) explain how MOSFET radiation dose monitors (RADFETs) are chips originally designed to check space radiation and can now help to treat cancer.

The radiation-sensitive MOSFET (RADFET) is a silicon radiation-measuring device invented by REM. It is a field-effect transistor (FET), specially designed to be sensitive to ionisation, which it measures in the form of trapped, radiation-induced positive charge (holes). Several companies have launched clinical radiotherapy systems based on the RADFET. This article is an update on the MOSFET principle and also presents an experimental comparison of two clinical RADFET systems, one of which evolved from a collaboration between REM Oxford and Radiotherapy Physics at University Hospital Coventry and Warwick (UHCW).

INTRODUCTION AND HISTORY
In the late 1960s one of the authors discovered that the strong response of a silicon device to ionising radiation could be used in the measurement of integrated ionising dose – an idea first openly published in 1974. This discovery came about while Andrew Holmes-Siedle, now owner of REM Oxford, was working on space technology for RCA. The silicon device in question, the metal-oxide-semiconductor field effect transistor or MOSFET, had been developed by RCA for computer logic circuits. In the MOSFET, a dielectric film separates the control electrode (gate) from the input and output elements (source and drain diffusions) on the silicon surface. Earlier investigators had found that the response to radiation was due to the build-up and long-lived trapping of positive charges (holes) in this ‘gate oxide’ dielectric. Holmes-Siedle’s new concept was the use of this effect as a dosimetric principle. Pursuing this concept later, REM and the European Space Agency (ESA) launched the first RADFETs into space. In 1978, REM, in Oxford, began selling the radiation sensor commercially and the system was adopted quite widely by ESA for monitoring the radiation damage in operational, unmanned spacecraft such as communication satellites.

The target: cancer cells
In 1985, R. Hughes supplied the acronym ‘RADFET’, for ‘radiation-sensitive MOSFET’ and also demonstrated its use in a catheter as a part of breast cancer treatment. Next came several explorations of wider use; REM studied uses in personnel safety devices (for the military and emergency service personnel), tumour research (radio-immunotherapy), nuclear safety (ROBUG project) and high-energy physics (CERN, SLAC). In a competing effort, a Canadian company, Thomson Nielsen, drew on the UK ESA experiments and successfully marketed a clinical dosimetry system in the 1990s. The same group also supplied MOSFET dosimeters to the International Space Station. A French laboratory supplied RADFETs for homeland-defence instruments, and Japanese and Korean groups experimented with the RADFET for space and nuclear plants. Now, several companies are launching clinical radiotherapy systems. Known companies are Best Medical, Sicel and CMRP at the University of Wollongong. A bibliography covering the associated physics and development is to be found in Holmes-Siedle and Adams, and a survey of MOSFET responses in Holmes-Siedle et al.

In radiotherapy, the application of the RADFET ranges from dose verification for intensity modulated radiotherapy of the naso-pharynx to urethral dose measurements in prostate brachytherapy and implantation at many tumour sites. This article is an update on the MOSFET principle and also describes the comparison by the authors of a commercial radiotherapy unit with a new clinical prototype, evolved in a collaboration between REM and the University Hospital Cancer Centre in Coventry.

THE RADFET PRINCIPLE

Figure 1 shows the construction of a commercial RADFET sensor. It is similar to that of a conventional p-channel metal-oxide-silicon (MOS) transistor except that the gate oxide is much thicker and is often specially prepared. The gate oxide is indicated by a row of ‘+’ symbols because this is the ‘sensitive volume’, where radiation-induced oxide charge builds up with dose. Clearly, the RADFET is an integrating dosimeter – it measures total dose, and not dose rate.

The gate oxide of a RADFET may be as much as 100 times thicker than that of a submicron MOSFET integrated circuit. The thicker the oxide, the more sensitive the device. An individual RADFET, referred to as a die, is sawn from a single-crystal wafer. After processing it measures 0.65 × 1.25 × 0.5 mm, which is a volume of about 1 mm³. However, the sensitive volume is only about one millionth of this, consisting of an oxide film about 1 µm thick, within transistor structures on the surface of the die. Current is carried between two p-type junctions, the source and the drain, under control of the gate voltage. The raw dosimetric response of the sensor is the change in threshold voltage, ΔVT. The threshold voltage of a FET is the gate voltage value at which conduction begins between the source and drain junctions, visible in figure 1. We could also obtain a dosimetric response by measuring the gate capacitance in a manner which gives us the ‘change in flatband voltage, ΔVFB’. The value of responsivity, r, is proportional to the square of the thickness of the gate oxide layer, tox, and varies in a complex way with dose. The values of tox are manipulated by the sensor designer to get the right voltage shift. Values of irradiation bias may also be manipulated by the user to adjust the responsivity.

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**THEORY: ‘DOSEMISTRY BY OXIDE TRAPPING’ (DOT)**

For an understanding of the physical processes which occur when a MOSFET transistor is irradiated, we picture the energy bands of the metal gate, the oxide insulator (SiO$_2$) and the silicon (Si), as in figure 2. We also sketch the excitation, transport and trapping which occurs when the entering photon deposits sufficient energy ($E = h\nu$) to excite charge carriers into the conduction state. The forbidden energy gap $E_C$–$E_V$ in SiO$_2$ is 9 eV. Just as with an ionisation chamber or a diode, mobilised electrons move rapidly and escape. In the oxide, holes move much more slowly, to the right. On the way to the Si/SiO$_2$ interface, the latter encounter deep traps and are arrested for very long times which may be many years. We show this ‘oxide trapped charge’ (QOT) as large ‘+’ symbols in the centre of the oxide energy gap and to the right of the physical centre of the film.

References 3 and 15 give more precise models. Other effects generate ‘interface trapped charge’, shown by smaller ‘+’ symbols near the silicon. If this oxide is on the surface of a transistor, like figure 1, the overall effect is a net positive charge, causing the conduction band of the silicon to bend as shown, leading to a shift of the threshold voltage – the voltage at which current between the source and the drain starts to flow. An algorithm may be used to relate the measured electrical signal, $\Delta V_T$, and the energy absorbed by the oxide, i.e. the dose in cGy (SiO$_2$). The algorithm can also handle ‘side effects’ like the presence of the trapped charge (QIT), these being the small ‘+’ signs in figure 2.

In summary, the silicon layer acts as a ‘transducer’ for the oxide-trapped charge. Thus, the function of the system – RADFET and ‘read’ electronics – is ‘dosimetry by oxide trapping’, leading to our use of ‘DOT’ as a short name for the dosimeter system, briefly described later.

**QUANTITY OF CHARGE: GROWTH CURVES AND THE APPLIED FIELD**

In figure 3, a $V_T$ growth curve is shown. This is the means whereby a RADFET is calibrated. The growth of $\Delta V_T$ with total dose absorbed. The upper group of curves, the positive-bias responses (PBR), are 5–10 times larger than the zero-bias responses (ZBR). Both groups are non-linear but follow different functional forms. In each case, as the accumulated charge becomes significant, the internal field opposes the applied field so that the carriers do not separate as freely. As a result, the response shows a ‘roll-off’ with dose until, at a very high dose, the slope is zero. Normally, when the ‘roll-off’ reaches a certain point, the device is discarded. One of the special skills of RADFET dosimetry is in the choice of the correct bias mode and oxide thickness to suit the accuracy required over a given range of doses.

**RESPONSIVITY: THE RELATIONSHIP BETWEEN THRESHOLD SHIFT AND DOSE**

In clinical work, the responsivity, $r$, of a dosimeter is often measured by administering a series of 100 cGy shots of photons, as described in this report. The oxides are much thicker for RADFETS than for mass-produced MOSFETs so as to give high responsivity and stability. The responsivity varies strongly with the oxide field applied during exposure, often called ‘irradiation bias, $V_{IR}$’. The responsivity values for the devices used in the present study are approximately in the region of 1.25 mV/cGy, obtained by using a 0.30 micrometre oxide operating at $V_{IR} = +9$ V.

Table 1 shows responses of four devices with differing oxide thickness, $t_{OX}$. An increase from the standard 0.3 μm to 1.24 μm oxide thickness gives a large increase, of about 12 times, but thicker oxides have not proved useful so far in radiotherapy. Notes to the table point out that $r$ is not constant with increasing dose. The table presents the initial response values for a fresh sensor. The symbols QL and NL in the table recognise this non-linearity of MOSFET response.

In table 1, we describe ZBR as ‘non-linear’ because $r(0)$ changes much faster with dose than $r(+)$. This means that any value quoted for $r(0)$ holds for only one dose value. 10cGy is suitable as a standard. For calibration, a non-linear algorithm must be used.

PBR is by far the best mode for clinical use. This is because the electrical field exerted by positive gate bias improves linearity and increases $r$. Figure 1 helps us to see that the field does this by increasing the number of electrons drawn out of the oxide. Nevertheless, in many non-medical applications, such as space, nuclear power and military, users prefer the ZB mode despite the drawbacks mentioned.

**ADVANTAGES AND DISADVANTAGES**

The principle of charging and charge-storage has always been prevalent in radiation dosimetry, e.g. in the ionisation chamber and the thermoluminescent dosimeter (TLD). In the MOSFET, the charge, generated in the solid, induces its own DC electrical output signal. The transducing power of silicon supplies the miniature scale and the convenience of reading it. In the field of conformal radiotherapy, the RADFET has several advantages over other detectors:

- the sensor volume is a thin scrap of dielectric in the form of silicon dioxide – the smallest sensor volume of any common dosimeter;
- silicon dioxide is such a good insulator that it retains its radiation-induced charge for many years. The sensing region thus stores the dosimetric information without an electronic memory;
- no high voltages, no small currents – the dosimetric signal is a change in a low DC voltage (see figure 3), and
- the ‘fade’ effect is less of a problem than for other solid-state detectors.19

At present the lower dose limit for the RADFET is about 1 cGy. A lower dose limit would be desirable but the limitation derives from the micron-size dimensions of the ionisation-sensitive region. In the experimental section, we explore other aspects of dose resolution. The advantages of the RADFET in radiotherapy are expanded below. They should be seen against the general background that the majority of radiation monitors are expensive, sensitive to noise, use high voltages, are too large to be used inside the body and are difficult to integrate with a PC.

**Sensitive volume size**

The volume of the gate dielectric in a RADFET is typically 0.1 × 0.01 × 0.001 mm. As we like to say, the sensor element is ‘smaller than an ant’s eye’. In comparison, a thimble ionisation chamber seems very large. Even adding the necessary electrodes and wires, the RADFET structure still provides one of the smallest spatial dose resolutions currently known.

**Probe size**

The RADFET chip is mounted and wired to a small chip-carrier which is normally placed on the patient’s skin but can be placed in a cavity. With further engineering, it would be possible to produce thread-like probes for insertion into a
TABLE 1

<table>
<thead>
<tr>
<th>t_ox [µm]</th>
<th>+9V, X Lo mode *</th>
<th>+18V, X Hi mode *</th>
<th>0V, ZB mode **</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mV/cGy)</td>
<td>(mV/cGy)</td>
<td>(mV/cGy)</td>
</tr>
<tr>
<td>0.20</td>
<td>0.65</td>
<td>0.85</td>
<td>0.12</td>
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<tr>
<td>0.25</td>
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<td>0.16</td>
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<tr>
<td>0.30</td>
<td>1.25</td>
<td>1.75</td>
<td>0.20</td>
</tr>
<tr>
<td>1.24</td>
<td>15</td>
<td>20</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Notes: * In this ‘active’ or PB mode, the growth curve is quasi-linear; the threshold voltage shift is a saturating exponential function of dose. This function approximates linearity, a fixed slope (r+), when lifetime dose value is small. ** In this ‘passive’ or ZB mode, the growth curve is non-linear. The growth curve follows a power law, where ∆V_T is proportional to D^n, n being about 0.66. The slope of the curve, r(0), applies only to a lifetime dose value for the MOSFET of 10 rad (0.1 Gy).

TABLE 2

<table>
<thead>
<tr>
<th>Beam</th>
<th>Field size cm x cm</th>
<th>SSD cm</th>
<th>Depth cm</th>
<th>Wedge/ Open</th>
<th>MU</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>10 x 10</td>
<td>100</td>
<td>5</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>5 x 5</td>
<td>100</td>
<td>5</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>7 x 7</td>
<td>95</td>
<td>12</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>15 x 15</td>
<td>85</td>
<td>9</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>7 x 13</td>
<td>90</td>
<td>8</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>9 x 7</td>
<td>80</td>
<td>10</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>12 x 8</td>
<td>110</td>
<td>5</td>
<td>Open</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>9 x 20</td>
<td>120</td>
<td>13</td>
<td>Open</td>
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<td>6 x 8</td>
<td>90</td>
<td>5</td>
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<tr>
<td>10</td>
<td>9 x 5</td>
<td>95</td>
<td>7</td>
<td>Wedge</td>
<td>250</td>
</tr>
<tr>
<td>11</td>
<td>10 x 10</td>
<td>100</td>
<td>5</td>
<td>Open</td>
<td>100</td>
</tr>
</tbody>
</table>

A FIGURE 4. Dosimeter comparison. The three probes shown were compared under equal exposures. The probes are made from build-up material (Al and tissue-equivalent plastic, coloured brown), machined to fit exactly the cavity in the solid water phantom. On the left: the tip of the Farmer dosemeter. The next two items are halves of the ‘build-up’ structure – bright metal and brown ‘solid water’. The REM sensor element is a strip of green circuit board, fitted closely to this structure. On the right is the TN sensor, a strip of brown flexi-circuit, in a similar fitted probe. The MOSFETs reside under the small black globules at the lower end of the structures. The diameters of the brown half-cylinders surrounding the sensors are about 6 mm.

A TABLE 2. List of the beams and dose measurement points.

The read circuit is simple and consists of a current supply and a digital voltage measuring system. Some MOSFET users build the readers themselves. The two commercial clinical MOSFET readers, TN and Sicel, are light and contain conventional circuits which are little more than the interface between the sensor chip and a PC. By contrast, the TLD requires a complicated machine to convert trapped charge into a single, transient surge of light, while the signal is monitored by a photomultiplier. Like the TLD, the MOSFET method is ‘relative’, meaning that a calibration curve is required to convert a measured voltage into the value of radiation dose in units of rad or Gray.

THE MOSFET SYSTEM IN RADIOTHERAPY

MOSFETs began to be used in radiotherapy during the 1980s. At the University of New Mexico, an oncologist placed the small chip in a catheter within a breast cancer. The National Institute of Standards and Technology (NIST) declared that the space charge storing region resembled a ‘Bragg cavity’. At Harvard Medical School, RADFET sensors were inserted inside tumours in mice prior to radiation treatment, to record the dose received. At the same time, physicists were not satisfied with the level of control of charge retention in the oxide technology and so the diode at that time had the commercial lead in silicon devices giving real-time dose readout.

Several companies currently supply MOSFET systems for use in radiotherapy. Thomson Nielsen (TN) pioneered MOSFET Users’ Groups and initiated the clinical market, and is now incorporated in Best Medical. In the mobile MOSFET system, one MOSFET probe will measure a hundred or more fractions before it is discarded. A new system, the RADPOS, uses an RF position detection system to record dose and position simultaneously on or within the patient. Sicel offers a single-exposure dosimeter, the One-Dose, and also offers an implantable MOSFET, the Dose Verification System. The reader for the One-Dose is palm-top size; probably the first time a physicist could put an integrating dosimeter system – no cables – into their pocket and read an in vivo exposure before the patient leaves the treatment bunker. More firms will probably enter the market – a good situation since, at present, there is much less choice of RADFET product than there is in the other leading clinical dosimeter technologies.

POTENTIAL FOR FURTHER DEVELOPMENT

Although nearly 50 years old, the RADFET dosimeter is nowhere near the end of its development potential. There is great potential to exploit further modern semiconductor technology in ways not yet attempted. The intrinsic cheapness of the sensor is surprising. Large silicon wafers give rise to many tiny dosimeter chips – easily 10,000 chips from one 6-inch wafer. One can also fashion sensor arrays...

blood vessel or RADFET capsules carrying a micropower source, which can be left in the patient or swallowed and passed through the gut.

Long-term data storage

A film of silicon dioxide on silicon is such a good insulator that it retains charge for many years. If the sensor were stored, in a patient’s records, the legally important information would be readable for many years. Fading in 10 years is normally under 10 per cent.

Simplicity of the reader system

The read circuit is simple and consists of a current supply and a digital voltage measuring system. Some MOSFET users build the readers themselves. The two commercial clinical MOSFET readers, TN and Sicel, are light and contain conventional circuits which are little more than the interface between the sensor chip and a PC. By contrast, the TLD requires a complicated machine to convert trapped charge into a single, transient surge of light, while the signal is monitored by a photomultiplier. Like the TLD, the MOSFET method is ‘relative’, meaning that a calibration curve is required to convert a measured voltage into the value of radiation dose in units of rad or Gray.

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not unlike the imaging CCD. One can use the RADFET principle in more advanced structures to sense charge in very thick dielectrics, increasing sensitivity perhaps a hundredfold. Excellent work in electronic laboratories continues on the materials, refining the trapping power of dielectrics – silicon dioxide, silicon nitride and, in future perhaps, organics with perfect tissue equivalence. The use of the MOS capacitor as a dosimeter is also being explored.

EXPERIMENTAL COMPARISON OF TWO SYSTEMS

In this section we compare two MOSFET dosimeter systems: the commercial Thomson Nielsen system and the REM-UHCW ‘DOTw’ prototype clinical reader with a REM RADFET sensor. Both are designed for patient dose verification but employ different MOSFET devices, different electronics and different irradiation bias values.

Thomson Nielsen TN-20 patient dose verification system

This is a commercial clinical MOSFET dosimeter which first appeared in the mid 1990s. The system in use at UHCW was purchased in 2001. The TN-20 reader has digital control of the reading but the digitised reading is taken visually. The TN MOSFET sensor probe consists of several metres of multicore communications cable, terminating in about 250 mm kapton ‘flexi-circuit’ strip. The chip is mounted at the far end of this strip under a small epoxy encapsulation. This is visible in figure 4 and a longer view is given in figure 5.

REM DOT clinical MOSFET dosimeter system

The DOTw reader was jointly designed and tested by REM and UHCW. It is based on LabView software, a commercial A/D converter board and a microcontroller supervising optoelectronic switching of biases to and signals from the RADFETs. The MOSFET chip, chip-carrier and cable were designed by REM. The cable is a standard six-way flat flexible cable, which can be of any length up to a few metres. The chip carrier, visible in figures 4 and 5, is made of semi-rigid glass-epoxy material (0.3 mm FR4). These carriers were designed specially to suit the holder which simulates the shape of a Farmer dosimeter. The function of this holder is explained in the next section. The sensors are joined to the FCC cable by a six-way socket.

Method

Absolute dose measurements were made using a calibrated NE Farmer type 2571 graphite thimble air ionisation chamber along with an NE 2670 electrometer. In order to avoid any dosimetry artifacts which might arise due to using the dosimeters for surface dose measurements it was felt prudent to compare doses measured at depth and well away from the surface and the build-up region. Thus, a solid-water phantom with a hole drilled to fit a Farmer dosimeter was used for irradiation at depth. Holders for both the REM and the TN MOSFETS duplicated the geometry of the Farmer chamber and surrounded the MOSFET detectors with a close-fitting cylinder of solid water. Figure 4 shows the Farmer dosimeter, the REM sensor element and the TN sensor, both in their special closely fitted holder. With this arrangement, the MOSFET holder could be placed at the identical position of the Farmer air chamber and direct comparisons made of the dose measured. The dosimeters were irradiated on the 6 MV photon beam of an Elekta Precise treatment machine at the Arden Cancer Centre in the University Hospital in Coventry. In order to vary the conditions under which the doses were measured, a set of 6 MV beams with different field size, SSD and monitor units was devised, as shown in table 2. For each beam, the doses measured by the three dosimeter systems were recorded and the MOSFET result compared with that from the air ionisation chamber.

The measurements taken using beam 1 were used to determine a calibration factor for the MOSFET systems. Based on this, absolute dose measurements were made with the Farmer chamber and electrometer and then by substitution with the detectors. Three measurements were taken for each detector and the mean dose determined.

Results

The doses measured by each MOSFET detector system were compared to the absolute dose measured with the Farmer chamber and electrometer. Results were expressed as the percentage difference between the dose measured by the MOSFET and that measured with the Farmer chamber. Along with this, the reproducibility of the MOSFET readings was expressed as a percentage of the mean reading. The results for the two MOSFET sensors are presented in table 3. There are three columns because the REM sensor chip carries two identical MOSFETs, A and B, which are read separately. By contrast, the TN sensor chip carries two identical MOSFETs but the responses are combined by the electronics to yield a single visual reading. Table 3 includes an overall mean difference and a standard deviation across all the beam conditions.

The doses measured were in the approximate range of 40–100 cGy. The mean standard deviation of the Farmer chamber and electrometer measurements was 0.06 per cent, by comparison to the 2.53 per cent of the MOSFETs.

Summary and discussion of results

The standard deviation of the measurements was consistent for all the MOSFETs measured. The deviation values indicate that, at the magnitude of the dose measurements made (between 42 and 97 cGy), neither of the systems could detect dose variations less than 3 per cent with confidence. In addition to the magnitude of the standard deviation, devices exhibited a systematic variation of +2.14 per cent for the Thomson Nielsen MOSFET and −1.53 per cent for the REM MOSFET. The different figures probably derive from the fact that the two dosimeter systems employ different gate bias conditions during exposure.

The dose values administered were set in the range 50–100 cGy to ensure the delivery of accurate doses. It would be useful in future to study below 10 cGy because, if it worked well at this level, the device could prove useful for the verification of doses to critical structures such as the eye and pacemakers lying on the periphery of the main beam.

FUTURE POSSIBILITIES IN MOSFET DOSIMETRY

Radiation sensors based on the MOSFET have a future in medicine, civil and military defence, spaceflight and the nuclear and processing industries, plus a limited but important use in high-energy physics. The developments which are possible range from making the basic chip smaller and much more sophisticated to adapting the electronics and software to many individual, subtle applications of dose measurement. These are outlined below.

Chips

Smaller sensors will be necessary if MOSFETs are to work well in intracavitary uses such as catheters and implants.
The present REM chip has dimensions $0.65 \times 1.25 \times 0.5$ mm. This could easily be reduced by an order of magnitude (see the next section). Also, the technology can easily produce large device arrays, suitable for measuring dose profiles in microbeams or other penumbras. The chips can be better encapsulated and geometrically better arranged to give better charge equilibrium and spatial resolution (see the ‘edge-on’ method, successfully tested at ESRF and BNL\textsuperscript{3,4,5,6}). A re-usable or ‘erasable’ form of RADFET is possible.

**Smaller chip-carrying probes**

We need dosimeters which penetrate further into the body than at present. For this, RADFETs can either be mounted on thread-line cables inside catheters or can be implanted and accessed by an RF link.

**Smart electronics**

A RADFET reader capable of fitting into the clinician’s pocket is now available. The technology for smart medical electronics is already being developed for many medical sensors and the RADFET could easily go in tandem on some of these. Great reductions in reader size are being considered for environmental dosimeters; for example, defence designers are considering a RADFET reader the size of a grain of rice.

**Software**

The conversion of the electrical signal from the MOSFET to an accurate figure for dose can be done using the developing theory and understanding of the device. Correction factors may be applied for the side effects associated with charge trapping in oxides which interfere with linearity of response. Software programs will remove this mentally taxing job from the user. Algorithms will take into account response variation with temperature, dose and drift in the system itself. There may be applications where the software will go further and superimpose a radiation intensity contour map from a large array of sensors, on the image of a patient’s body and a planning target volume.

**Combination with new technology**

A minute silicon dosimeter such as the RADFET may well become more efficient and accurate when combined with other small devices. An obvious example is the inclusion of position-sensing by adding a position finder such as a radiopaque marker\textsuperscript{21} or RF device.\textsuperscript{22} Another technology likely to help is a micro-electromechanical system, supplying power without using a battery.

**CONCLUSIONS**

The RADFET is an exceptionally small, integrating dosimetric device which takes advantage of the transducing power of silicon to measure stored, radiation-induced charge in a microscopic layer of silica. The area of a typical silicon RADFET die is less than $1$ mm$^2$. Following its well-proven performance in space radiation monitoring, it has been demonstrated that the RADFET has a role in radiotherapy for patient dose verification and other quality control applications. This article provides an update on the MOSFET principle and the growing literature of medical applications and also describes a new experimental assessment of the relative accuracy of two MOSFET dosimeter systems employing different electronics and different MOSFET sensors. At a dose level near 50 cGy, dose resolution was in the region of 3 per cent for both dosimetric systems.\textsuperscript{14}

![FIGURE 5. Long view of the probes for dosimeter comparison, on the patient couch of the LINAC, along with a solid-water phantom, drilled for a Farmer dosimeter.](image)

**TABLE 3**

<table>
<thead>
<tr>
<th>Beam</th>
<th>Farmer Dose cGy</th>
<th>Thomson Nielsen MOSFET Diff %</th>
<th>SD %</th>
<th>REM RadFET A Diff %</th>
<th>SD %</th>
<th>REM RadFET B Diff %</th>
<th>SD %</th>
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<tbody>
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<td>1</td>
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<td>Mean</td>
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<td>-1.51</td>
<td>2.46</td>
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</table>

![TABLE 3. Difference compared with Farmer and standard deviations for each MOSFET.](image)
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MOVING ON (LINE)

Marc E. Miquel recently launched Scope Online with the help of Damian Farnell, an electronic version of this very magazine and here he presents his visions for its future.

LET’S GET THIS PARTY STARTED!
IPEM relies on its members to accomplish its objectives and when I joined the Institute I quickly looked for something I could do. I did not want to join a SIG as it seemed too related to work. As I always did a fair bit of editing for colleagues and friends, I decided to take the plunge when the Scope Editor position was advertised.

When I took over from Mark McJury, I naively arrived with a list of ideas I thought I could and would easily put in place; from popular book reviews to interviews and international news, my list was long and growing.

However, my first decision was not to end up in Mark’s position where I have to anxiously look for a replacement when I finally want to pass the reigns. Before starting anything, I decided to look for an Assistant Editor who could step in when I reach retirement age (or is that saturation point?). Gemma Whitelaw was happy to oblige and I am very grateful to her; she has been a tremendous source of help and invaluable advice, wise beyond her young age.

The hours spent on the different new ideas made me realise that I could easily end up having two full-time jobs and no family life; the need for more editors to materialise the new ideas was more and more obvious. I frantically went into recruitment mode with mixed success. The last time I saw previous Editor Mark McJury, he commented on the ever-growing number of editorial board members. Well a good editorial team is like a good party; you need the right mix of people and a few of them!

Time is behind any success, and thanks to the dedication of new editors, ‘international news’ and ‘popular science book reviews’ are now regular and successful sections. Unfortunately, ‘Interviews’ died quickly due to the lack of manpower. Some members are still underrepresented in Scope and my biggest disappointment so far still is my failure to recruit a new Technology Editor.

KILLING IN THE NAME OF
The strange thing for a new editor is that I did not like the title of the magazine I was taking over. In fact my mind was going hyperactive to develop a cunning plan to kill it. Don’t get me wrong, Scope is not a bad name, it is quite a good one, short and meaningful, but, like a lot of good ideas, it has been used and abused over the years (figure 1).

I could see that the members of the Publication Committee (PubCom) were fond of the name and not keen on dropping it. I finally I thought I had a ready-made solution by putting my next idea into practise: an online version of the magazine.

I always felt that we needed a stronger presence on the net. Two years ago you probably had to go through 20 pages to find our Scope...

FIGURE 1. The large scope of Scopes.
In the second phase, I am hoping that meeting reports can be published first on the website.

NEW KID IN TOWN
Scope Online was born, or at least everything seemed to be in place for its birth. I quickly went down to work on a simple design and started creating a few pages. However, the initial enthusiasm slowly phased out and once more came the realisation that my time could not stretch to cover this new endeavour. The hunt for yet another editor began. This safari was a slow one, unsuccessfully catching the glimpse of a few candidates until Damian Farnell took the plunge in the summer of 2009. Damian has since been hard at work regularly adding flesh to my original website skeleton.

Two is better than one, but as we were starting from zero we have decided to first focus on articles, tutorials, meeting reports and book reviews previously published in Scope. Although the online version might be seen to just double up with the magazine, this will allow a new audience to access some valuable material and will create an easily searchable archive. In the second phase, I am hoping that meeting reports can be published first on the website. This could be an opportunity to add videos or maybe a slideshow of presentation highlights.

HELP!
Despite not existing officially, the website has already succeeded in one of its objectives: increasing Scope’s visibility. Quite a few people have already found the website and both Damian and I have been contacted through it, indeed more and more of the phone calls I receive for Scope mention the website.

Consequently, we have decided that it is finally time to announce the birth of Scope Online. We both know that the site is far from perfect and must be riddled with little mistakes but with a little help from our members, I am sure they can be corrected very quickly. So please, visit the site and report any problems, broken links, missing figures or compatibility issues to Damian (admin@scopeonline.co.uk). Don’t hesitate to contact us if you want to comment on the work so far and make suggestions for future development and improvements.

By its flexible nature a website gives rise to opportunities print can never achieve and I am sure the online magazine will slowly grow and gradually become more and more independent of his printed sister publication.

MORE INFORMATION
Visit the Scope Online website at www.scopeonline.co.uk, or email admin@scopeonline.co.uk

in Google. The need for an online magazine was also real. Publishing online is quick whereas it takes months for our trimestrial print version. Most authors’ complaints rightly revolve around publication delay and this can be especially frustrating for meeting reports: who really wants to read a report on a conference that took place nearly a year ago?

Obviously, the first step if you want to be visible on the net is a good domain name and thankfully, for an editor on a killing spree, any Scope domain was already taken! The door was open, I was ready for the kill; just a small problem subsisted: a new name... And this is where I failed lamentably. I could not find any decent replacement and following the advice of the wiser PubCom members focused my energy on finding a Scope-ish domain name.

After some potential good names disappeared in front of my eyes (do they spy on people and buy names if you search for them a couple of times?), I settled for and quickly bought www.scopeonline.co.uk in December 2008. If The Times (visibly slower than its New York cousin) can live with www.timesonline.co.uk, I suppose Scope can too.
With an amazing 22,545 people in attendance, including over 15,000 children and young people and 4,188 teachers, parents and guardians, The Big Bang 2010 was the biggest single celebration of science and engineering of its kind and made a lasting impression on all who visited.

Staged in the Manchester Central Conference Centre, The Big Bang involved over 110 organisations from across the private, public and voluntary sectors. Reaching out to schools and students across the country, the Fair represented an unprecedented partnership of the UK science and engineering communities. It demonstrated a real desire to come together to celebrate and raise the profile of young people’s achievements in science and engineering.

IPEM’s interactive stand was constantly busy with students finding out about medical imaging techniques. IPEM created various handouts and career leaflets for the children and teachers to take home.

There was an ultrasound machine which the children could use for scanning various objects (figure 1). PET scans of cancer patients gave a good introduction to the use of radioisotopes and the benefits of

Eva McClean (Communications and Development Manager, IPEM) has recently attended The Big Bang 2010, a huge science and technology event, and explains how IPEM was involved to promote scientific careers to students.
nuclear medicine.

The most popular activity of the stand however was a quiz guessing MRI scans of chocolate bars (figure 2). The children had to match the MRI scans to some (taped down!) chocolate bars on the table which provided an excellent opportunity to tell them about the technology and benefits of MRI scans.

The stand was manned by a group of enthusiastic young IPEM members from Manchester who did a fantastic job explaining the activities and getting children interested in the profession.

For all the fun of The Fair, however, The Big Bang was an event with a serious aim: to promote STEM careers to young people and address related skills gaps across the UK. IPEM has played its role in achieving this objective by giving young people the opportunity to explore how physics and engineering can be applied to medicine.

IPEM President Dr Chris Gibson said: ‘Reaching out to young people and making them aware of the work of medical physicists, clinical engineers and technologists is an important role, and a key part of IPEM’s charitable objectives. The UK science community needs to enthuse school children about science in general and especially the benefits to patients, and the potential for satisfying and worthwhile careers’.

The Fair also included the National Science and Engineering Competition. The Rt Hon Lord Mandelson, First Secretary of State and Secretary of State for the Department of Business, Innovation and Skills, presented the ultimate awards of ‘UK Young Engineer of the Year’ and ‘UK Young Scientist of the Year’ to Shawn Brown, for a bamboo-framed electric trike using sustainable and reusable material, and Thomas Hearing, for mapping Monmouth beach and the eroding ammonite pavement (figure 3).

Some entries to the competition were covering medical physics and clinical engineering technologies, which was encouraging to see. Rebecca McVeigh (figure 4), for example, developed a user-friendly test for physiotherapy ultrasound equipment during her work experience with the Royal Berkshire Hospital.
Reference dosimetry for external beam radiotherapy is at present performed in broad beam reference conditions according to Codes of Practice like IAEA TRS-398, AAPM TG-51 and IPEM 1990. With the increased complexity of radiotherapy treatments, however, the reference conditions prescribed in those Codes of Practice are far away from the way such complex treatments are actually delivered. Think for example of intensity modulated radiotherapy (IMRT), tomotherapy, stereotactic radiosurgery and scanned proton beam therapy. Each of those modalities is characterised by a distinct way of delivering a dose distribution, different from broad beam deliveries and also very different from each other. For most of them there is at present a large step from the broad beam reference dosimetry to the dosimetry of a clinical delivery sequence involving large amounts of relative dose data and complex dose calculation algorithms. An additional issue is that numerous modalities are not able to create the broad beam reference conditions prescribed, either because the maximum field size is too small or because square field shapes cannot be set. Also dosimeters can be part of the problem since most are not the maximum field size is too small or because square field shapes cannot be set. Also dosimeters can be part of the problem since most are not suitable for the entire range of field sizes required.

While several particular solutions have been reported for absolute dosimetry or quality assurance (QA) of these complex clinical deliveries and non-standard field sizes, there is no comprehensive approach available to ensure the consistency of dosimetry across treatment modalities. This obviously raises the need for extending the scope of reference dosimetry towards reference conditions that are more closely related to the way these radiotherapy treatments are delivered to the patient as well as to smaller and intermediate reference fields.

An international working group was formed by the International Atomic Energy Agency (IAEA) in collaboration with the American Association of Physicists in Medicine (AAPM), with the aim of publishing an extension of existing Codes of Practice to provide recommendations on reference conditions and reference dosimetry procedures for small fields and composite fields. A first step in this direction was the publication of a proposed formalism allowing for such an extension.¹ The aim of this publication was to get the ideas of extended reference conditions out and to invite medical physicists and scientists worldwide to contribute to improved knowledge and understanding in this area by discussion and research. This has thus far lead to a number of papers and conference presentations being published by members of the working group.² while also other investigators have independently reported research in this area.³

There is a long way to go before the publication of a Code of Practice will be achieved. In particular on reference conditions for composite field dosimetry there is much to be investigated. Many groups are involved in this, among which, at present and to our knowledge, research groups from the University of Wisconsin (WI, USA), University of Pittsburgh (PA, USA), MD Anderson (TX, USA), McGill University (Montreal, Canada), Royal Marsden Hospital (London, UK), Stockholm University (Sweden), University of Vienna (Austria), University of Santiago de Compostela (Spain) and the University of Athens (Greece) are investigating ways to define relevant reference conditions for head-and-neck and prostate treatments with high-energy photons, as well as determining correction factors for the use of ion chambers in such composite reference fields by experiments and Monte Carlo simulations.

Some of these groups are in particular involved with reference dosimetry for GammaKnife and CyberKnife radiosurgery systems. Both are systems that cannot achieve 10 cm × 10 cm reference fields and in particular for the GammaKnife the maximum field size is way below that (18 mm for the classic type and 16 mm for the newer Perfexion type). Research groups who are performing research in this area or who feel that they can contribute to the research in this new area of reference dosimetry are welcome to contact members of the working group and if possible to establish a formal link with the IAEA working group.

In the coming year(s), there will be continued research activity by the working group members and the groups mentioned above to generate the necessary knowledge and data for developing a Code of Practice. The IAEA is organising an international dosimetry symposium from 9th to 12th November 2010.⁴ Provided a sufficient number of abstracts are received for this topic, a session on small and composite fields will be planned within this symposium as well as a round-table discussion. The working group also aims at producing a document by the end of 2010 that will present a comprehensive treatment of static small fields according to the formalism and that will highlight areas of missing data.
REFERENCES


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RADIOThERAPY HEADS AND TALES – HEADS OF RADIOTHERAPY PHYSICS MEETING

ALISON VINALL, Norfolk & Norwich University NHS Trust
STEVE BLAKE, Royal Devon & Exeter Foundation Trust

INSTITUTE OF CANCER RESEARCH, LONDON 14th October 2009

THE INAUGURAL MEETING OF the Heads of Radiotherapy Physics (HRTP) took place at the Institute of Cancer Research, London, in October 2009. The meeting offered a stimulating opportunity to meet colleagues, share fears and frustrations, benefit from each others’ experience and ideas, and discuss the current national radiotherapy issues from a physics perspective. The healthy exchange of views at the end of each session suggested that the choice of topics could not have been better selected, and fears that radiotherapy physics would grind to a halt throughout the country proved unfounded due to nearly every HRTP from all 53 centres in the country in attendance (figure 1), clearly confident that their colleagues were coping in their absence!

MORNING SESSION
In the first session we were privileged to have both Chris Gibson (IPEM President) and Tim Cooper (National Cancer Action Team, St Thomas’ Hospital, London) give presentations about IPEM’s current national profile and the current National Radiotherapy Implementation Group (NRIG) work strategy, respectively.

Tim’s talk covered the core issues of service delivery, governance, commissioning and the wider world but highlighted capacity and workforce as two issues with which we need to engage as critical to the implementation of the National Radiotherapy Advisory Group (NRAG) report (figure 2). Much work is going on in this area including connecting with and educating commissioners at a network level, the reconvening of the NRAG workforce subgroup and the formulation of a national purchasing framework and an appropriate tariff for radiotherapy. Tim emphasised the importance of getting the tariff right first time as even slight differences between actual cost and tariff could have a devastating effect on future ability to provide the service. Tim also stressed the need to not compromise on quality in the services that will be commissioned (figure 3). The Peer Review cancer standards are currently out to consultation and work is being done around what a good evidence folder should look like ready for inspection next year. Graham Chalmers (University Hospital Birmingham NHS Foundation Trust), the current Chair of RTSIG, also gave an excellent talk on the many areas SIG is involved with, ranging from committees and working parties to scientific meetings.
and publications. Current projects include a review of IPEM 75 and meetings on the Radiotherapy Workforce, Radiobiology and Electrons.

Following a welcome coffee break, the next session was devoted to two approaches to the capacity issue. **Mike Kirby** (Christie Hospital, Manchester) talked about the two satellite centres linked to the Christie Hospital – the first at Oldham opening in February 2010 and the Salford site by 2012. A number of networks are considering building satellite centres so this talk was of particular interest. Mike stressed the need for satellite centres to be fully in partnership with a local acute hospital trust. The processes of development, considering IT infrastructure, service design, staffing and equipment selection were considered. Using satellite centres can be a particularly good way to introduce changes and updates that can be more easily fed back into the host centre. Regarding staffing, early phased recruitment helps avoid the issues around depletion of staff from the host centre.

The next talk from **Viv Cosgrove** (Leeds Teaching Hospitals NHS Trust, Leeds) gave a contrasting approach regarding the opportunities and challenges of operating a very large centre. Advantages included the resilience and flexibility of the large staff team involved, with clear scope for in-house R&D and career progression. However, although purpose built with outstanding facilities, the design had resulted in communication issues between staff groups working in specialist areas. Viv speculated that the optimum size of a department could be as low as six linacs, which is even less than the eight linac limit proposed by NRAG. However, as the centre is still relatively new there is scope for fresh management approaches that will hopefully foster a greater sense of team working.

The next session concerned servicing and quality control arrangements.

The results of three surveys collected over the weeks prior to the meeting were presented, and provided some useful insight into the general working of departments across the country. **Geraint Lewis** (Velindre Cancer Centre, Cardiff) presented the results of the equipment management survey. His survey had elicited 33 replies with 52 per cent of centres servicing within normal hours, 18 per cent in the evenings and 30 per cent at weekends. A service efficiency machine was available to 45 per cent of the responding centres. When it came to QC the picture was slightly different, with 36 per cent doing QC within normal hours, 49 per cent in the evenings and 15 per cent at weekends. There did appear to be a trend in that more centres without spare capacity were doing servicing and QC out of hours. Spare capacity was defined as either a service efficiency machine or having greater than 5.5 linacs per million population.

**Jim Warrington** (Royal Marsden Hospital, Sutton) presented the results of the staffing levels survey to which 52 centres responded. Jim wins the prize for getting the most centres to respond to a survey, which must indicate how dear to our hearts the subject of staffing is! It appears that under the new IPEM staffing guidelines most centres are doing better, with clinical scientist levels at an average 89 per cent (range 61–137 per cent) of recommendations. For technologists the situation is worse, with average staffing levels at 64 per cent (range 20–99 per cent). Jim suggested that this probably reflects the urgent need for an effective training scheme for this group. Having more technologists in place would clearly help where skill mix efficiencies are possible.
**AMERICAN SESSION**

The first session of the afternoon concerned IMRT. Tom Jordan (Royal Surrey County Hospital, Guildford) had surveyed UK centres regarding barriers to the implementation of IMRT. Responses from 48 centres showed that the main obstacles are still staff time and funding. In all, 30 UK centres are undertaking IMRT but three of those are using tomotherapy, five are restricted to forward-planned IMRT and three centres are just starting up, leaving only 19 centres which are currently carrying out linac-based inverse-planned IMRT.

The other major IMRT issue concerned reducing the QA required on a per patient basis, which will come as a breath of fresh air to many. Carl Rowbottom (Christie Hospital, Manchester) reported an almost zero level of dosimetry issues at the patient QA stage, highlighting the history of reliability of the dose delivery system. It was argued that if we have checked the electronic transfer of data to the linac, and that the MLC can be tested separately on a routine basis, then we can have confidence in the main components of the IMRT delivery chain. Carl also encouraged the greater use of MU checking programs for IMRT. This was against the backdrop of a push for a 30 per cent increase in IMRT capacity.

Helen Mayles (Clatterbridge Centre for Oncology, Wirral) offered a different approach, which was that of sampling patient QA on a 1 in 5 basis. She highlighted the value of a number of QA devices including the Delta-4, which is particularly useful for checking volumetric arc delivery. She also reported moving to using electronic IMRT checking software more routinely.

While we wait for the publication of the evidence for these approaches there is clearly scope for greater cooperation between centres so that we do not have to reinvent the wheel every time a new technique is started up. For the future development of radiotherapy in the UK it is essential that we learn to harness the collective power of the physics community to facilitate fast implementation of new techniques.

The final talk of the day proved to be the most controversial. It was given by Alan Thompson (Freeman Hospital, Newcastle), standing in for Derek Pearson. Alan outlined the proposals for healthcare scientists under the Modernising Scientific Careers (MSC) framework. It was clear from the response that there were still major concerns regarding MSC with many questions raised around timescales for implementation. It is planned that new training courses will be in place by October 2010, which many felt to be over optimistic. Other concerns included the funding infrastructure, training of higher-level staff and the fact that the career grade for scientists is lower than for medics who are all aiming for consultant level. Many felt that we already have a perfectly good medical physics training scheme in place. This topic could possibly warrant further consideration at a future meeting!

**SUMMARY**

We are very grateful to Gill Lawrence (Newcastle General Hospital) for suggesting the meeting in the first place, and to Margaret Bidmead and Jim Warrington, Heads of RTP at the Royal Marsden Fulham Road and Sutton, respectively, who hosted the meeting and had to cope with a last minute change of venue. However, this did not seem to disrupt the success of the meeting, which was aided and abetted by a glass of wine for all at the end. There was strong support for another meeting and a call for volunteers to organise it!
BIENNIAL MR SAFETY UPDATE: CURRENT LEGISLATION AND INFORMATION

ANNA BARNES  University of Cambridge

75 DELEGATES ATTENDED THE MR Safety Update meeting last autumn, organised by the Magnetic Resonance Special Interest Group.

There were 13 invited and proffered papers presented at the meeting on a wide range of topics from NHS radiology services, research departments and manufacturers. The purpose of the meeting was to update relevant persons on current legislation and to inform with regard to latest research on electromagnetic exposure measurement and minimisation.

A summary of the keynote talks are described below.


Stephen Keevil (Guy’s and St Thomas’ NHS Foundation Trust and King’s College, London)

Dr Keevil provided an enthusiastic and concise presentation on the rather lengthy subject of MR safety regulation. The Physical Agents (EMF) Directive, adopted by the European Union (EU) in 2004, has the laudable aim of protecting workers from exposure that could possibly have detrimental effects of exposure to electromagnetic fields (EMF). However, it includes very conservative exposure limits in the low frequency range, routinely exceeded in MRI clinical practice and research.

Implementation, originally required by 30th April 2008, would make such activities illegal throughout the EU. As a result of lobbying by the MRI community, the European Commission announced late in 2007 that implementation of the Directive would be delayed by 4 years, allowing time for an amendment ‘…to ensure that limits will not have an adverse effect on the practice of MRI, whilst ensuring appropriate protection of personnel’. Several options for amendment of the Directive have emerged, and it is now possible to explore what MRI safety regulation might look like after 2012. In actual fact, the critical date may well not be 2012; it is entirely possible that a further postponement will be needed. The most optimistic view: adoption by April 2011, allowing for implementation by April 2012. However, discussions now focus on details of what the revised limits should be, and what form any ‘exemptions’ or ‘flexibility’ might take in the case of MRI. The International Commission on Non-ionising Radiation Protection (ICNIRP) (www.icnirp.org) has recently published new guidelines on static magnetic field exposure, with a higher limit of 8 T for ‘specific work applications’ (which could include MRI), and is consulting on new proposals for time-varying fields, but these proposals are still problematic for MRI. Alternative limits from the International Committee on Electromagnetic Safety (ICES) (www.ices-emfsafety.org) are more favourable in some regards, but less so in others. Recently, the German government has proposed yet a third set of possible limits (www.bmas.de/portal/36288/property=pdf/2009_10_05_bericht_elektromagnetische Felder.pdf), similar (but crucially not identical) to the approach taken in the International Electrotechnical Commission (IEC) standard for MRI equipment (IEC 60601-2-33), which also allow for higher exposures in a ‘controlled environment’. A crucial question in this debate is what physiological effects of EMF are to be regarded as ‘adverse health effects’, and what safety factors (if any) should be applied in setting exposure limits below the thresholds for these effects. Other stakeholders (notably the Netherlands government, http://docs.minszw.nl/pdf/92/2008/92_2008_1_22102.pdf) advocate exempting MRI from exposure limits altogether, if agreement can be reached on binding pan-European guidance on safe working practices. The latest news from Dr Keevil as this piece goes to publication is that a new Commission has just been appointed, which has had to go through ratification hearings at the European Parliament so things have pretty much ‘ground to a halt’ over the past few months. A new draft of the Directive is now not expected until about July, and consequently the 2012 deadline is looking less likely and a further delay will need to be built into this new Directive. Dr Keevil is due to attend a meeting at the end of March with officials in Brussels for the latest progress on this matter.

With a captive audience John Thornton (National Hospital for Neurology and Neurosurgery, London), current Chair of the MR-SIG, took the opportunity to discuss the issue of the provision of adequately qualified MR Safety Advisors (MRSA) in line with current MHRA guidelines. While this role is commonly, but not always, the responsibility of clinical scientists trained in medical physics, there is a need to clarify the qualifications and role of the MRSA, to determine if there is sufficient provision of MRSA within the UK MR workforce, and to establish a voluntary register of MRSA. The IPEM MR-SIG is actively working to establish a working party to move forward in this area.

INVITED SPEAKER – THE PHYSIOLOGICAL ORIGIN OF SENSORY EFFECTS IN THE MR ENVIRONMENT

Paul Glover (University of Nottingham)

Dr Glover provided a very comprehensive view on what the sensory effects experienced in the MR environment would be; a topical subject in view of Dr Keevil’s comments regarding lack of evidence for ‘adverse health effects’.

The presentation began with a summary of the main sensory effects associated with magnetic resonance imaging: peripheral nerve stimulation due to gradient switching; magnetic-field-induced-vertigo (MVIF) at ➤
high fields; metallic taste in the mouth due to movement in high fields, and magneto-phosphenes due to movement in high or switched fields. He then went on to explain how the spatial and temporal nature of a magnetic field induced electric field can excite or modulate particular sensory cells (nerve axon, hair and retinal cells). However, he was keen to point out that exact quantification and prediction of thresholds will depend on subject and scanner-dependent factors (for example the size of a person or their disposition to motion sickness), see figure 1. He also noted that the MFIV effect may (in addition to the electric field effect) also have a mechanical origin which is due to the relative magnetic susceptibility of the vestibular components. This presentation was a stark reminder that not only would establishing acceptable exposure limits be problematical but monitoring them would present a major undertaking.

INVITED SPEAKER – NEUROSURGERY IN THE MRI ENVIRONMENT: INITIAL EXPERIENCES IN DEVELOPING AND MAINTAINING SAFE WORKING PRACTICES
Mark White (National Hospital for Neurology and Neurosurgery, London)
Dr White provided us with a very interesting description of the preparations and initial experiences of providing an interventional MR clinical service. Again this is a topical subject since it will be these personnel who are highly likely to be experiencing some of the greatest exposures to EMF as described by the current EU directive. In brief, since entering clinical service in April 2009, the interventional MRI facility at the National Hospital for Neurology and Neurosurgery (figure 2) has been used for about one neurosurgical procedure each week, predominantly craniotomies lasting between 2 and 8 hours and including one to four MRI scans. The suite contains a 1.5 T Siemens Espree MRI scanner, a single-plane angiography scanner, a BrainLAB image guidance system with integrated microscope, and the full range of surgical and anaesthetic instrumentation (much of it ferromagnetic) used in a conventional theatre; surgery takes place in the scanner room, immediately outside the 5 gauss line. Maintaining safety in this environment, with large multi-disciplinary teams, presents a number of challenges.

All staff attend foundational MR safety training before first working in the suite. Clear, checklist-based workflows, overseen by a dedicated safety officer, govern equipment movement and transfers of the anaesthetised patient between the operating table and the scanner. Other associated issues and decisions included equipment placement and safety, surgical field sterility during scans, as well as the handling of intra-operative imaging data for surgical guidance. So far the service is a resounding success and looks to continue to be an expanding resource at the centre.

OTHER PRESENTATIONS
Other presentations during the day included a simple way of estimating the staff exposure limits of an everyday radiology service which were shown to be well within NRPB limits, presented by Sarah Whyte (University Hospital, Coventry). Changes in radiographer practices required with the increasing use of higher field MR units were highlighted by Julia Bigley (University of Sheffield). A very useful presentation from the manufacturer’s perspective was given by Matthew Clemence (Philips Medical, Guildford), where he explained that manufacturers are now increasingly...

![Summary of Effects](image)

**Summary of Effects**

- A summary of effects of induced currents showing integrated dB/dt (i.e. change in B against time of change). Data points show mild and severe experiences for our subjects. The likely area of operation for the MHD mechanism is also shown.
aware of the demands upon systems in newly emerging areas such as interventional MRI, how this puts additional requirements upon both manufacturers and system users to ensure safe use, and they are adjusting their focus accordingly. Simon Goodyear (Metrasens, Worcester) showcased a portable screening gate for patients entering the MR environment, which has already gained a foothold in some centres in the USA. More academically orientated presentations came from Jeff Hand (Imperial College, London) on using mathematical modelling to estimate SAR in the foetus, and from Ben Loader (National Physical Laboratory, Teddington) on using phantoms to better estimate SAR in a typical patient. For the final part of the day we had a ‘hot topic’ on incidental findings in neuroMR. As more normal control subjects are being imaged as part of psychiatry and neurology research studies so the question as to what should be done in the event of an abnormal finding becomes more likely to arise. This topic was covered comprehensively by Nigel Hoggard (University of Sheffield) and Zoe Morris (Western General Hospital, Edinburgh). We were told that currently there is huge variation in protocols to deal with incidental findings (IFs); from centres that ‘see no IFs, hear no IFs and certainly don’t want to talk about them’, to others that review all of their research imaging for IFs and some in the US that even provide a full diagnostic scan to all research volunteers. Dr Morris presented us with some hard facts from a meta analysis of MRI research studies of the brain: in 16 studies, 135 of 19,559 people had neoplastic incidental brain findings (prevalence 0.70 per cent, 95 per cent confidence interval 0.47 per cent to 0.98 per cent). In 15 studies, 375 of 15,559 people had non-neoplastic incidental brain findings (prevalence 2.0 per cent, 1.1 per cent to 3.1 per cent, excluding white matter hyperintensities, silent infarcts and microbleeds). The number of asymptomatic people needed to scan to detect any incidental brain finding was 37. The prevalence of incidental brain findings was higher in studies using high-resolution MRI sequences than in those using standard resolution sequences (4.3 per cent versus 1.7 per cent, P<0.001). The prevalence of neoplastic incidental brain findings increased with age (2 for linear trend, P=0.003). Dr Hoggard presented a more philosophical and ethical view, stressing the point that if a consensus emerged that included a clinical review of every research scan, how then should the incidental finding be managed? Who should do the review? What are the real implications of IFs for research participants? Who needs to be informed? What structures need to be in place to minimise the fallout from IFs once uncovered? What have the practical implications been for our research institution having had structures in place to deal with IFs for the last 10 years? Although there was no definitive protocol, plenty of food for thought had been provided on this controversial issue – watch this space.

Although the meeting was held on a dreary wet November day, the proceedings proved to be anything but. We had a good number of feedback response forms, more than 60 per cent. Overall the responses were fairly positive, with some interesting and constructive comments on possible content for future meetings: more emphasis on the practical aspects of running an MR service, a discussion forum for national safety guidelines and a specific request for more biscuits – I feel sure I can definitely organise the latter. The MRSIG would like to thank all attendees for their support and interest. The next meeting will be arranged for sometime during the second half of 2011.
ON 24TH NOVEMBER 2009, 48 delegates braved a windy Manchester to attend a one-day meeting on modern brachytherapy at the Manchester Dental Education Centre (MANDEC) organised by Chris Lee (Clatterbridge Centre for Oncology, Wirral) on behalf of the RTSIG. The theme of the meeting was chosen to present current advances in brachytherapy and how treatment techniques and equipment have increased in sophistication in recent years.

ADVANCES IN TECHNIQUES

One of the major driving forces behind these advances has been the increased use of imaging: CT, ultrasound and MRI. With this in mind, the opening invited speaker Daniel Berger (Medical University of Vienna, Austria) was well placed to give an excellent summary of the advances made at the Medical University of Vienna. Dr Berger’s group has already built up considerable experience utilising 3D image guided brachytherapy (IGBT) for treating gynaecological patients and he was able to share with us both their results and the lessons learned. The limitations of current auto-optimisation techniques were discussed, together with an important aside on the verification of actual physical source-dwell position within an applicator (figure 1).

Leading on from Dr Berger’s talk, both Peter Bownes (St James’s University Hospital, Leeds) and Diane Whitney (Addenbrooke’s Hospital, Cambridge) presented separate overviews on implementing IGBT at their respective centres. As the introduction of IGBT also coincided with the building of a new hospital in Leeds, the centre adopted a staged approach in moving from 2D x-ray imaging for treatment with the Joslin-Flynn applicator to full 3D imaging with CT-MRI fusion for treatments with a ring applicator. A dosimetric review of 22 patients receiving MRI-based planning, including 17 who had conformal plans for their second and third fractions, showed good agreement with the results achieved in Vienna. Diane Whitney’s talk concentrated on the important thought processes required when moving from LDR (low-dose rate) treatment with in-house planning software to HDR (high-dose rate) treatment with 3D planning on commercial software. The talk also highlighted the potential pitfalls of moving to MRI-based planning, notably geometric distortion in MR images.

Keeping with the 3D planning theme, Chris Lee gave a retrospective analysis of early 3D planning IGBT carried out at Clatterbridge between 2001 and 2005. The significant technical challenges inherent even as recently...
as 5 years ago were highlighted, which gave attendees a greater appreciation of recent developments in IGBT software systems!

Following a break for lunch, and a change in treatment site, the second invited speaker, Pete Hoskins (Mount Vernon Cancer Centre, London) gave a clinician’s view of image-guided prostate brachytherapy. The talk encompassed the use of imaging in all stages of prostate brachytherapy as well as the organs at risk and dose constraints. Results were also presented from a study looking into the effect of treatment catheter movement for fractionated HDR prostate brachytherapy; the data indicated a visible reduction in dose to 90 per cent of the prostate volume (V90) if corrective action is not taken.

EVALUATION OF STUDIES

Next, Alistair Pooler (Christie Hospital, Manchester) presented an evaluation of a year of prostate HDR treatments at the Christie Hospital. In a retrospective analysis of the first 70 patients treated, an average 12.2 per cent increase in prostate volume was found after insertion. One of the dose volume histogram (DVH) constraints used at the Christie is that 95 per cent of the prostate volume should receive at least 100 per cent of the prescribed dose (this is known as V100). In the analysis it was found that some patients did not achieve a V100 ≥ 95 per cent. Alistair attributed this to a number of possible factors, including incorrect needle positioning, rectal sparing and inadequate coverage of the base of the prostate.

The final invited speaker of the day A Sun Myint (Clatterbridge Centre for Oncology, Wirral) shared his centre’s experience with HDR brachytherapy for rectal carcinomas with the Onco-Smart flexible rectal applicator. The study included 29 patients who underwent chemo-radiotherapy, fractionated HDR post EBRT and surgery. The multi-modality treatment showed good results, with all patients having resection margins of either R0 (margin negative resection) or R1 (microscopically involved radial margin). Dr Myint also hypothesised that a combination of the above treatment techniques with contact radiotherapy using Papillon 50 kV x-rays may further increase the number of patients achieving complete sterilisation of the local tumour.

One of the last speakers of the day was Robert Price (City University, London) who gave a summary of some impressive work on an ultra-small diode detector with a 1.1 mm diameter (figure 2). The detector can be placed inside a HDR treatment catheter, internal diameter 1.5 mm, and be used to perform live measurement of delivered dose within an intracavitary applicator. The work, conducted under a NEAT (New and Emerging Applications of Technology) research grant from the Department of Health, and in collaboration with Clatterbridge, also includes a time resolved electrometer capable of dose interpretation at individual dwell points.

SUMMARY

All the talks presented over the course of the day were of a high standard and well received. Dedicating a one-day meeting solely to brachytherapy provided the opportunity to find out what other centres are currently doing, or planning to do. Particularly well received were those presentations that shared commissioning experience of different techniques and/or equipment. Having been through the process themselves, the speakers were keen to advise (and warn!) other centres about potential issues that can arise. The MANDEC is also worthy of mention as an excellent host to the event and is recommended for future conferences.
FIRST URODYNAMICS MEASUREMENT MEETING

JASON BRITTON Leeds Teaching Hospitals NHS Trust

FAIRMONT HOUSE, YORK 10th December 2009

THE FIRST URODYNAMICS MEASUREMENT meeting organised by the IPEM Physiological Measurement Special Interest Group and co-sponsored by the UK Continence Society took place at Fairmount House, York, on 10th December 2009. It was attended by 40 delegates in total from across the United Kingdom and this comprised of clinical scientists, clinical technologists, consultant physicians and surgeons. The meeting was also supported by three exhibitors, these being Lewis Medical, Digitimer and Laborie.

The stimulus for holding the meeting came from an email sent out on the Medical Physics mailbase by Mike Haddaway (Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry). Approximately 40 responses were received and it was judged at this point that there was sufficient interest in this topic nationwide to hold a one-day scientific meeting.

The programme for the day consisted of 11 proffered presentations and one invited talk, which was delivered by Paul Abrams (Bristol Urological Institute, Bristol).

THE SCIENCE UNDERPINNING URODYNAMICS

Professor Abrams provided an excellent talk to start the meeting, summarising the developments in the delivery of urodynamics services that had taken place in the last 30 years and identified some of the important collaborations between scientists and clinicians that have enabled ideas and research to be translated into everyday practice. Evidence was also presented on the benefits of urodynamics testing in the management of patients (see figure 1).

Scientists and clinicians in Bristol have demonstrated inconsistencies in NICE urology guidance, which advocates that women with stress urinary incontinence should not be referred for urodynamics prior to undertaking surgery. A retrospective study published by the Bristol group including over 200 patients showed that in only 5 per cent of the cases the outcome was pure stress urinary incontinence.

The second speaker of the morning was Andrew Gammie (Bristol Urological Institute, Bristol) who reported back on the International Continence Society 2009 workshop on the development of urodynamic equipment. The aims of the ICS workshop were to produce a consensus on:
- major shortcomings of currently available equipment;
- most important areas requiring development;
- issues facing proper application of ICS guidelines;
- mechanisms to encourage user/manufacturer dialogue;

![The Influence of Urodynamics on Treatment Outcome](image)
the feasibility of a standard for urodynamic equipment.

The team in Bristol has also been evaluating the urodynamic machines available from the eight different suppliers in the United Kingdom. The systems were tested using a simulator designed in Glasgow. The findings have been published as two evaluation guides by the centre for Evidenced Based Purchasing.

A number of next steps were suggested and these included repeating the workshop at a later date (although not this year) and updating the report by David Rowan from 1987 on the technical aspects of urodynamic machines. Other challenges were also identified, such as the common application of non-invasive urodynamic techniques.

UROFLOMETRY: NEWS FROM THE COALFACE

Continuing with the theme focusing on urodynamics technology, Michael Drinnan (Freeman Hospital, Newcastle) questioned the value of multiple free flow measurements made in the clinic and demonstrated that on occasions these added little value to the management of the patient. Newcastle are also investigating the use of the U-flow device and its diagnostic value, and demonstrated that measurements acquired using this device were similar to those recorded in clinics. The team in Newcastle are also developing a new device for recording frequency volume measurements made in the home prior to attending hospital and some example results were demonstrated from the use of this device. Although further review and evaluation is required, the data presented demonstrated that the device appeared to be both cost effective and provide a simpler, more reliable method for patients to acquire the information requested.

AMBULATORY URODYNAMICS

The Clinical Science team at University College, London have been developing ambulatory urodynamics services, and two presentations were made by Andrew Chu and Robert Heggie. The first of these demonstrated the use of a system to communicate wirelessly between the flow meter and the ambulatory recorder for patients who did not press the button on the device to record the flow or who were unable to undertake this task due to mental or physical disability. The system has been successfully installed and is now used routinely in all investigations. Robert Heggie showed evidence that fluid-filled catheters could be used as successfully in ambulatory urodynamics investigations as solid state systems, and artefacts did not mask the presence of events such as detrusor overactivity.

AIR-CHARGED CATHETER SYSTEMS

Philip Toozs Hobson (Birmingham Women’s Hospital) gave a talk on a pilot study comparing the use of T-DOC™ air-charged catheters sold in the United Kingdom by Laborie and concluded that there were major differences between the two measurement systems that would have an impact on clinical management of patients. It was concluded that further work to evaluate air-charged catheters is required and this may include a multi-centre trial.

Jonathon Whybrow (Royal Devon and Exeter Hospital, Exeter) discussed experiments undertaken with air-charged catheters developed in-house at the Royal Devon and Exeter Hospital. He reported that the entire ‘Exeter’ catheter system had a frequency response of approximately 6.5 Hz (−3 dB). The minimum acceptable frequency response for any catheter system for use in urodynamics is 5 Hz. The talk concluded with the
presentation of results on similar experiments conducted with the T-DOC™ catheters which had a whole system frequency response of 2.7 Hz (−3 dB) (figure 2). This latter point together with the presentation from Mr Toozs Hobson provoked a considerable degree of discussion amongst the delegates about the clinical use of air-charged catheters.

TRAINING AND MODERNISING SCIENTIFIC CAREERS

Gordon Hosker (St Mary’s Hospital, Manchester) initiated at the end of his presentation on development of urodynamics training programmes a wide-ranging discussion about the continued involvement of clinical scientists in delivering routine physiological measurement services as part of the Modernising Scientific Careers programme, which starts in October of this year. A number of concerns were raised about this development, as this may push clinical scientists working in this field of endeavour into the academic sector who may then lack the understanding of the day-to-day challenges faced in the delivery of urodynamics services.

SUMMARY

Overall the meeting was well attended, well received and a number of positive remarks and comments were made during the day and communicated afterwards. There was considerable interest in repeating the meeting in 1 to 2 years, possibly in conjunction with the annual UK Continence Society meeting in Bristol 2011. Lastly the organisers would like to take this opportunity to thank all those who presented and contributed.

INTERNATIONAL SCIENTIFIC MEETINGS

EUROPE

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<tr>
<th>Meeting</th>
<th>Venue and dates</th>
<th>More information</th>
</tr>
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<tr>
<td>11th International Workshop on Portal Imaging</td>
<td>Leuven, Belgium 7th–8th June</td>
<td><a href="http://www.epi2kx.org">http://www.epi2kx.org</a></td>
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<tr>
<td>International Workshop on Digital Mammography</td>
<td>Girona, Spain 16th–18th June</td>
<td><a href="http://www.iwdm2010.org">http://www.iwdm2010.org</a></td>
</tr>
<tr>
<td>International Conference on Radiation Protection in Medicine</td>
<td>Varna, Bulgaria 1st–3rd September</td>
<td><a href="mailto:office@cars-int.org">office@cars-int.org</a></td>
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<tr>
<td>ESTRO29</td>
<td>Barcelona, Spain 12th–16th September</td>
<td><a href="http://www.rpm2010.org">http://www.rpm2010.org</a></td>
</tr>
<tr>
<td>EANM '10 (Annual Congress of the European Association of Nuclear Medicine)</td>
<td>Vienna, Austria 9th–13th October</td>
<td><a href="http://www.estro-events.org">http://www.estro-events.org</a></td>
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<tr>
<td>International Symposium on Standards, Applications and Quality Assurance in Medical Radiation Dosimetry</td>
<td>Vienna, Austria 9th–12th November</td>
<td><a href="http://eanm10.eanm.org/">http://eanm10.eanm.org/</a></td>
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AMERICAS

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<tr>
<td>American Society for Photobiology</td>
<td>Providence, RI 12th–16th June</td>
<td><a href="http://www.pol-us.net/ASP_Home/asp_meet.html">http://www.pol-us.net/ASP_Home/asp_meet.html</a></td>
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</table>
ne unexpected outcome of being IPEM President is that I am finding myself slightly more sympathetic to journalists, at least with regard to timescales and copy deadlines. At the time of writing, the Prime Minister has just announced the date of the next General Election. However, because of the lead-in time for the production of Scope, the result will be old news by the time you receive this printed edition. Election time is traditionally a time for promises, and given the likely state of public finances over the next few years, I expect these will be treated with even closer scrutiny, and perhaps even greater scepticism. Nevertheless, all three of the major parties have made clear their commitment to funding for science and engineering, recognising at the very least the pragmatic argument that economic recovery will be strongly linked to investment in science and technology. We should, however, be ready to take the argument even further, and we have plenty of evidence to make the case. Economic cycles, rather like political ones, often have frequencies of the order of 0.1 to 0.3 per year. Understandably then, what appeals to politicians are investments which have predicted pay-back times of this order, leading to results within the lifetime of one or two Parliaments. At times of financial stringency it can be very difficult to argue for a longer term approach, and it would certainly be challenging to stand up in a public forum and defend ‘blue skies’ research funding against the countless urgent and sometimes distressing calls on public sector expenditure. Nevertheless, many of our current and essential technologies, especially in the medical area, have been developed from fundamental research activities which did not appear to have immediate economic or health benefits. Examples include magnetic resonance imaging, accelerators for photon and proton therapy, surgical and ophthalmic lasers, the photoelectric effect, and even the discovery of x-rays themselves. I suggest there are two things that IPEM and its members should do: we can express support for fundamental research in physics and engineering, recognising that although the timescale for benefits may be long, the potential for achieving fundamental improvement is great; and we can ensure that we keep abreast of developments in the wider field of physics and engineering, seeking opportunities to put novel technologies into use for the benefit of patients. Roentgen discovered x-rays in November 1895, and the medical applications were recognised so swiftly that by May of the following year the journal *Archives of Clinical Skiagraphy* was being published in London. Could we match that speed of implementation today, from fundamental discovery to medical application?

After a prolonged consultation period, proposals for the reform of training and career structures for healthcare scientists have been published by the four UK health departments. *Modernising Scientific Careers – The UK Way Forward* is a policy document which sets out the framework for education, training and career pathways for physicists and engineers working in the NHS. It will have a fundamental effect on IPEM activities, especially those relating to our Professional and Standards Board and all its sub-groups. The Institute has responded to the policy document, making clear our support for many aspects of this policy, in particular the key role played by the physics and engineering workforce in the delivery of safe and effective patient care, and the introduction of higher specialist training. We have strongly supported the commitment to the creation of a world-class scientific workforce, with a leading role in research, development and innovation. However, we have expressed concerns about the transition process, and about a number of specific issues relating to the recruitment and training of physics and engineering staff. The Institute will continue to engage with the health departments during the development and implementation of Action Plans, seeking to ensure that the high standards of existing training, accreditation and assessment schemes are preserved and where necessary enhanced, to the benefit of patient care.

I wrote part of this letter on a recent trip to India, my first visit to that country. As on every such occasion, I learned more from the visit than I expected, and have returned with a very different perspective on our local issues and problems. One of the things which struck me most forcibly was the very strong emphasis on higher education, and in particular degree courses in science and mathematics. Adverts on billboards, in newspapers and on the television, and significant new buildings at many university sites, all encourage participation and growth in the scientific and numerate workforce. University textbooks piled 2 m high outside bazaar stores may seem a little startling to western eyes, but the throngs of paying customers confirm that India is a country where physics and engineering are both exciting and popular. Perhaps it is no coincidence that manufacturing output in India is growing at over 10 per cent per year, and that the medical sector is expected to grow even faster. Our challenge is to ensure that all students, in the UK and elsewhere, are equally enthused about physics and engineering, and are aware of the direct benefits which can result from working in this area.
Two years in the making and still finding its feet, Scope Online is now officially out there.”
Mo-99 shortages

With two major production sites offline, nuclear medicine departments worldwide are again facing challenges due to a shortage of Molybdenum-99 (Mo-99). An informal poll by the Society of Nuclear Medicine found that 63 per cent of respondents replied with ‘strongly agree’ when asked whether the Mo-99 shortage will affect their ability to care for patients, 27 per cent ‘agree’ and 10 per cent either ‘disagree’, ‘strongly disagree’ or are ‘unsure’.

However, there is a positive side to the recent difficulties, as nuclear medicine departments have had to become more creative and efficient to ensure that the clinical service continues. Some departments have performed scans at the weekend when there is Mo-99 available which will have decayed by Monday. Other departments have converted almost all of their cardiac studies to thallium which allows this service to continue, whilst freeing up the remaining Mo-99 for other examinations such as cancer studies and lung scans for blood clots. Appointment cancellations have been minimal, and supply difficulties have not prevented emergency access to the nuclear medicine service.

Unexpected production issues last year forced Mo-99 production companies to use their resources more effectively to ensure some stability in supply, and other options such as Mo-99 produced from low-enriched uranium (LEU) targets in the new Open Pool Australian Lightwater (OPAL) reactor have now been tested and validated for use in a generator line. However, shortages are likely to be a long-term problem as reactors continue to age, and further creative ideas will be required to compensate for this.

PEM scanners may reduce unnecessary breast biopsies

In women with suspected breast cancer, breast MRI is often used to identify suspicious lesions. However, in many cases the lesions are subsequently found to be benign following biopsy, which means that many women are being subjected to unnecessary invasive procedures. An NIH-sponsored multi-site study, carried out in the USA, of 388 women with newly diagnosed breast cancer has been conducted to assess the sensitivity and specificity of positron emission mammography (PEM), and to determine whether this technique could reduce the number of unnecessary biopsies.

PEM scanners are high-resolution breast PET systems that can show the metabolic phase of a lesion in addition to its location, and this information is critical in determining whether a lesion is malignant or not. The PEM scanners used in the study were manufactured by Naviscan Inc. and are of a similar size to an ultrasound system which makes them convenient to use for breast imaging.

The results of the study showed a 6 per cent improvement in specificity at comparably high sensitivity and a 26 per cent higher positive predictive value (PPV) compared to breast MRI. This resulted in 31 fewer unnecessary biopsies. PEM has the potential to be a powerful tool in the fight against breast cancer, and is a particularly important development for women who are unable to tolerate an MRI examination for reasons such as claustrophobia, ferromagnetic implants or reactions to gadolinium contrast agents. There could also be financial savings involved as the costs associated with unnecessary procedures would be reduced.

MORE INFORMATION
This story was reported on Aunt Minnie on 12th March.
http://www.auntminnie.com/index.asp?Sec=sup&Sub=mol&Pag=dis&ItemID=89769
The effects of bubble-enhanced ultrasound on tissue temperature

High intensity focused ultrasound (HIFU) therapy involves the use of high-pressure acoustic radiation, which is focused within the body to heat tissue. The increase in temperature can be utilised for different purposes, e.g. tissue coagulation or to selectively release drugs from temperature-sensitive liposomes. Gas-filled bubbles within the blood stream will oscillate strongly when an external acoustic field is applied which increases the heating effect of the ultrasound beam, and makes it possible to achieve the same biological effects with less acoustic pressure, lowering the chance of damage to the surrounding normal tissues or giving shorter treatment times.

Previous studies have investigated the macroscopic tissue heating effect using invasive thermocouple probes or non-invasive MRI thermometry. In order to better understand the bio-effects of bubble-enhanced heating, researchers at Sunnybrook Health Sciences Centre and the University of Toronto have now simulated the microscopic temperature distribution in vivo induced by HIFU using invasive MRI thermometry. In order to investigate heating patterns on a microscopic scale, as non-uniformities may have a significant effect on the bio-effects of bubble-enhanced ultrasound therapies, and need to be taken into account when treatment effects are assessed.

Medical physicists at Imperial College and Hammersmith Hospital in London have developed a sophisticated model of thermal transport between mother and baby to assess how MRI can affect foetal temperature (Phys Med Biol 2010; 55: 913). The model takes into account two pieces of previously ignored information – the transport of heat through the blood vessels in the umbilical cord and the fact that the foetus is typically half a degree warmer than the mother.

The researchers considered a 26-week pregnant female model positioned within a type of birdcage coil commonly used in 1.5 T and 3 T MRI systems. Commercially available finite-difference software was used to predict the spatial distribution of SAR in the mother and foetus, and to calculate spatial and temporal temperature changes. The results showed that for a foetal MRI procedure carried out under ‘normal’ scanner operating conditions, the foetal SAR and average foetal temperature both fell within international safety limits, but when a less standard, but still clinically feasible, scanning protocol was used, the calculations suggested that the maximum local foetal temperature could exceed the recommended maximum value. However, this is unlikely to be a cause for concern, as the current model does not take foetal movement during imaging into account, which means that the predictions of local foetal temperature should be considered as a ‘worst case scenario’. Until the model can be adapted to account for foetal movement, average foetal temperature may be a better estimate of what happens in reality.

MORE INFORMATION
This story was reported on Medical Physics Web on 10th March.
http://medicalphysicsweb.org/cws/article/research/41668

Simulation of MRI foetal temperature change

MRI is increasingly being used to investigate problems with foetal development, such as evaluating malformations and visualisation of pathologies prior to surgical intervention. Although there is no indication that undergoing MRI procedures during pregnancy results in adverse effects, there is currently uncertainty about the true risks of such procedures. Existing guidelines contain limits for temperature changes and specific absorption rate (SAR) in pregnant women, but no such limits are defined for the foetus. A number of studies have been conducted previously to model SAR in pregnant women from RF exposure during an MRI scan, but few have looked at the temperature change caused by SAR, and the studies which did look at temperature change did not account for key differences between foetal and maternal temperature.

Medical physicists at Imperial College and Hammersmith Hospital in London have developed a sophisticated model of thermal transport between mother and baby to assess how MRI can affect foetal temperature (Phys Med Biol 2010; 55: 913). The researchers considered a 26-week pregnant female model, including the foetus (F), foetal brain (FB), placenta (P) and amniotic fluid (AF) the image shows the distribution of SAR in the 26-week pregnant female model, including the foetus (F), foetal brain (FB), placenta (P) and amniotic fluid (AF) and the fact that the foetus is typically half a degree warmer than the mother.

The researchers considered a 26-week pregnant female model positioned within a type of birdcage coil commonly used in 1.5 T and 3 T MRI systems. Commercially available finite-difference software was used to predict the spatial distribution of SAR in the mother and foetus, and to calculate spatial and temporal temperature changes. The results showed that for a foetal MRI procedure carried out under ‘normal’ scanner operating conditions, the foetal SAR and average foetal temperature both fell within international safety limits, but when a less standard, but still clinically feasible, scanning protocol was used, the calculations suggested that the maximum local foetal temperature could exceed the recommended maximum value. However, this is unlikely to be a cause for concern, as the current model does not take foetal movement during imaging into account, which means that the predictions of local foetal temperature should be considered as a ‘worst case scenario’. Until the model can be adapted to account for foetal movement, average foetal temperature may be a better estimate of what happens in reality.

MORE INFORMATION
This story was reported on Medical Physics Web on 10th February.
http://medicalphysicsweb.org/cws/article/research/41668
**DIARY OF MEETINGS 2010**

<table>
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<tr>
<th>Meeting</th>
<th>Dates</th>
<th>Venue</th>
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<tbody>
<tr>
<td>RPA Update 2010</td>
<td>22nd June</td>
<td>UCL Institute of Child Health, London WC1</td>
</tr>
<tr>
<td>Biennial Radiotherapy Meeting 2010</td>
<td>6th–7th July</td>
<td>Cardiff University</td>
</tr>
<tr>
<td>6th Annual IPEM Medical Engineering Technologists Study Day</td>
<td>20th July</td>
<td>York Racecourse</td>
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<tr>
<td>PER AORDUA AD ASTRA: Through Adversity to Enhancing the Science of Artificial Optical Radiation</td>
<td>27th–28th July</td>
<td>University of Reading</td>
</tr>
<tr>
<td>Advances in Special Seating and Wheelchair Product Design</td>
<td>29th September</td>
<td>Austin Court, Birmingham</td>
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**RPA Update 2010**
The RPA Update is IPEM’s main meeting of the year for healthcare-based radiation protection advisors and those seeking certification. It provides an invaluable opportunity for sharing the latest information from fellow RPAs, the Regulators and other relevant bodies.

**Registration deadline:** 9th June

**Biennial Radiotherapy Meeting 2010**
This biennial radiotherapy meeting offers the opportunity for presentations, sessions and posters covering ongoing developments in radiotherapy imaging, planning, delivery and verification.

**York Racecourse**
IPEM, in conjunction with Draeger Medical, invite you to the 6th Annual IPEM Medical Engineering Technologist Study Day.

**Registration deadline:** 2nd July

**6th Annual IPEM Medical Engineering Technologists Study Day**
IPEM, in conjunction with Draeger Medical, invite you to the 6th Annual IPEM Medical Engineering Technologist Study Day.

**Registration is free of charge.**

**Registration deadline:** 2nd July

**PER AORDUA AD ASTRA: Through Adversity to Enhancing the Science of Artificial Optical Radiation**
This meeting provides an opportunity for speakers to discuss current research and development activity, advances in measurement techniques and evolving practice in the safe management of laser and non-coherent sources.

**Austin Court, Birmingham**
This practical meeting is tailored to people working in rehabilitation engineering and seating, and is directly relevant to clinical technologists and clinical engineers.

**Call for papers deadline:** 4th June

**Advances in Special Seating and Wheelchair Product Design**

**Minimising the Risk of Falls in the Elderly: New Technological Advances**

**IPEM EXAM RESULTS CLINICAL TECHNOLOGISTS**

Congratulations to the following who have recently been successful in the IPEM Viva Voce examinations for the Clinical Technologist Certificate and Diploma of IPEM, DipIPEM(T).

**IPEM EXAM RESULTS**

**Name** | **Training centre** | **Result** | **Examination**
--- | --- | --- | ---
Catherine Nelson | Belfast City Hospital | Pass with Distinction | Diploma |
Joyjit Sarkar | West Midlands Rehabilitation Centre | Pass with Distinction | Diploma |
Laura Smith | Belfast City Hospital | Pass with Distinction | Diploma |
Lynne Adams | University Hospital of Hartlepool | Pass with Distinction | Diploma |
Jessica Marston | Queen Elizabeth Hospital | Pass | Certificate |
Stefanie Ollis | James Cook University Hospital | Borderline Pass | Certificate |
Timothy Powell | Royal Victoria Hospital | Pass with Merit | Certificate |
Claire Souter | Queen Elizabeth Hospital | Borderline Pass | Certificate |
Neil Turner | Freeman Hospital | Distinction | Certificate |
Anneliese Williamson | University Hospital of North Staffordshire | Pass | Certificate |
Congratulations to the following who have recently been successful in the IPEM Viva Voce examinations for the Clinical Scientist Diploma of IPEM, DipIPEM(S).

<table>
<thead>
<tr>
<th>Name</th>
<th>Training centre</th>
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<td>Lindsay Caisley</td>
<td>Christie Hospital NHS Foundation Trust</td>
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<td>Katherine Chester</td>
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<tr>
<td>Padraic Crean</td>
<td>Royal Liverpool University Hospital</td>
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<td>Andrew Edwards</td>
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<td>Felicity Horton</td>
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<td>Louise Hughes</td>
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<td>Leah Hunt</td>
<td>Kent Oncology Centre</td>
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<td>Gregory James</td>
<td>City Hospital</td>
<td>Pass with Merit</td>
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<td>Frances Lavender</td>
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<td>Lee Morris</td>
<td>Nuffield Orthopaedic Centre</td>
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<td>Frances Orrell</td>
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<td>Rushil Patel</td>
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<td>Benjamin Rowberry</td>
<td>Derriford Hospital</td>
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<tr>
<td>Kimberley Saint</td>
<td>University Hospitals Coventry &amp; Warwickshire NHS Trust</td>
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<tr>
<td>Catherine Scott</td>
<td>Southampton General Hospital</td>
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## NEW MEMBERS 2010

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<tr>
<td>David Geraint Lewis</td>
<td>Head of Medical Physics</td>
<td>Velindre Hospital</td>
<td>Cardiff</td>
</tr>
<tr>
<td>Aaron Bedder</td>
<td>Trainee Clinical Scientist</td>
<td>Leicester Royal Infirmary</td>
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<tr>
<td>Anna Morenc</td>
<td>Trainee Medical Physicist</td>
<td>Leicester Royal Infirmary</td>
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<tr>
<td>Bilal Tahir</td>
<td>Trainee Clinical Scientist</td>
<td>Royal Hallamshire Hospital</td>
<td>Sheffield</td>
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<td>Caroline Magrath</td>
<td>Trainee Clinical Scientist</td>
<td>Royal Free Hospital</td>
<td>London</td>
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<tr>
<td>Christopher Finch</td>
<td>Radiotherapy Physicist</td>
<td>Freeman Hospital</td>
<td>Newcastle upon Tyne</td>
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<tr>
<td>Claire McCabe</td>
<td>Physicist</td>
<td>Musgrove Park Hospital</td>
<td>Taunton</td>
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<td>Claire Tirim</td>
<td>Postdoctoral Researcher</td>
<td>University of Oxford</td>
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<td>Clare Madeleine Turnball</td>
<td>Trainee Clinical Scientist</td>
<td>Royal Victoria Infirmary</td>
<td>Newcastle upon Tyne</td>
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<td>David Duncan</td>
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<td>Royal Victoria Infirmary</td>
<td>Newcastle upon Tyne</td>
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<td>Elizabeth Wójcikiewski</td>
<td>Trainee Clinical Scientist</td>
<td>Salisbury District Hospital</td>
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<td>Hugh James Wallace</td>
<td>Trainee Clinical Physicist</td>
<td>Southern General Hospital</td>
<td>Glasgow</td>
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<tr>
<td>Ian Webster</td>
<td>Trainee</td>
<td>Nottingham University Hospitals NHS Trust</td>
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<tr>
<td>Ignacio Di Biase</td>
<td>Senior Radiotherapy Physicist</td>
<td>Royal Marsden Hospital</td>
<td>Sutton</td>
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<td>Jason Fazakerley</td>
<td>Technical Officer</td>
<td>Integrated Radiological Services Ltd</td>
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<td>Jessica Mary Winfield</td>
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<td>John Cronin</td>
<td>Trainee</td>
<td>Galway Clinic</td>
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<td>Katie Edmunds</td>
<td>Trainee Medical Physicist</td>
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<tr>
<td>Laura Jane Gold</td>
<td>Trainee Clinical Scientist</td>
<td>Leicester Royal Infirmary</td>
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<tr>
<td>Louisa Bumsbead</td>
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<td>Ipswich Hospital NHS Trust</td>
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<td>Maria Machado</td>
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<td>Michael Barlow</td>
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<td>Owen Mills</td>
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<td>Paul Chamock</td>
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<td>Integrated Radiological Services Ltd</td>
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<td>Paul James O’Dolan</td>
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<td>Richard Jenkins</td>
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<td>Siobhan Clare McIley</td>
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<td>Subir Humayun</td>
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<td>Stephan Hadley</td>
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<td>Victoria Kaums</td>
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<td>Yat-Ting Kwan</td>
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<td>Amy Comrie</td>
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<td>Andrew Matthew Dumbill</td>
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<td>Anna Bangiri</td>
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<td>Max Morris</td>
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<td>Samir Mahmoud Dawoud</td>
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<td>Reha’a Mohanraj</td>
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<td>David Russell</td>
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<td>Thomas Melloy</td>
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<td>Mehdi Siabet</td>
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<td>Amal Roche</td>
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<tr>
<td>Lora Ioannou</td>
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<td>Rakesh Kothakke Veetil</td>
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### Qualifications

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**Qualifications:**

- BSc (Hons) Physics, Birmingham / DPhil Nuclear Physics, Oxford
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- BSc Physics with Astrophysics, Bristol
- BEng Biomedical Engineering, Sheffield
- BSc (Hons) Physics, Newcastle upon Tyne / MSci Medical & Radiation Physics, Birmingham / PhD Solar Physics, Birmingham
- BSc (Hons) Physics, MSci Medical Physics, Surrey
- BPhys, Mic
- BSc Computer Science, Kent / BSc Physics, London
- MPhys Physics with Space Science Technology, Leicester
- BSci Physics, Madras / MSc Medical Physics, Chennai
- BSc (Hons) Physics, Strathclyde / PhD Physics, Strathclyde / MBChB Medicine, Liverpool
- BSc Physics, Birmingham / MSc Medical & Radiation Physics, Birmingham
- BSc (Hons) Physics, Manchester
- BSc Physics with Medical Physics, Nottingham
- BSc Physics, St Joseph’s College / Dip RP Radiological Physics, Mumbai
Joseph Rotblat: A Man of Conscience in the Nuclear Age

Martin Underwood worked with Joseph Rotblat in 1976 and this clearly made a lasting impression which has led him to publish short articles about the impact of his life. Rotblat held the chair of Medical Physics at St Bartholomew’s Hospital Medical School from 1950 to 1976. He has also made a significant contribution as its second editor to *Physics in Medicine and Biology*, establishing it as an important international journal. He died in 2005 at the age of 96. This short biography looks particularly at the political impact of Sir Joseph’s life and especially at his involvement with the anti-nuclear movement. There are some particularly interesting items in the many Appendices, which form about a third of the book, including proceedings of several of the Pugwash conferences, of which Sir Joseph was a founding member. Of particular interest are the articles that Rotblat himself wrote describing his reasons for leaving the Manhattan Project and his acceptance speech on receipt of the Nobel Peace Prize in 1995. Those looking for a full biography of Sir Joseph may be disappointed. The account of other aspects of Sir Joseph’s life is somewhat restricted, lacking the intimacy of someone who had known him over a longer timespan. The final chapter, ‘Thoughts on a creative life’, is not particularly insightful. As a fellow Nuclear Physicist it is perhaps surprising that Dr Underwood has not included more about Sir Joseph’s scientific work. However, Sir Joseph’s relationship with the nuclear bomb formed a very significant part of his personality and this book makes an interesting contribution on this aspect of his life and even includes his views on the Iraq war.

Philip Mayles, Clatterbridge Centre for Oncology NHS Foundation Trust

Archimedes to Hawking: Laws of Science and the Great Minds Behind Them

This book takes you chronologically through the laws of science as they were discovered and looks at the people who discovered them. For each law there is a brief description, information on events happening at the time of the law’s discovery, a more in-depth look at the law with examples, a short biography of the law discoverer, including a curiosity file of some of the more interesting aspects of the discoverer, and a section on conversation starters. The book has a final chapter listing the top physicist, equations etc., lists from various sources and a list of contenders that didn’t make it into the main text of the book.

This is a popular science book that is easy to read and sets out the laws well but with enough background information (some would call gossip) about the discoverer and time period to be very interesting and not at all textbook-like. The laws covered are those that you would find in many school and university textbooks, and it is useful as a very broad reference book. There are also many references in the book, so if any particular law or scientist piques your interest, further reading is easy to find.

Seemingly to have a law named after you it helps to be male, passionate (obsessed) with your scientific work and have a somewhat dysfunctional family life. The book describes the law givers in an interesting and detailed way, putting them in context of the time and place they lived and with the other scientists they worked/feuded with. Many of these men carried out their work to extremes – some even losing body parts – but without them the modern world would not exist and the book pays homage to them without being overly sentimental.

I really enjoyed this book and would recommend it for anyone interested in the history of science or a quick reminder of the fundamental laws of science. I especially like the many quotes in the book, from scientists and other public figures throughout history, and may well use one at the next work party.

Rachel Hollingdale, Guy’s and St Thomas’ NHS Foundation Trust

**JOSEPH ROTBLAT: A MAN OF CONSCIENCE IN THE NUCLEAR AGE**

**ARCHIMEDES TO HAWKING: LAWS OF SCIENCE AND THE GREAT MINDS BEHIND THEM**
Decoding Reality: The Universe as Quantum Information

Nowadays, it seems that you cannot switch on your television set or open your Sunday newspaper without discovering a new young (and looking even younger) professor preaching science to the masses. This new generation of media-savvy scientists won’t hesitate a second to abseil inside a volcano, dive in icy waters or blow up various objects in order to demonstrate their point, and all that without losing their devilishly telegenic smile. Specimens of this new breed are in fact so hip and cool that they could be confused with members of a pop-band (in some cases they are/were, remember D:Ream anyone?).

Gelled slick hair, shirt open revealing a large stone medallion, enters Professor Vlatko Vedral, specialist subject: quantum information science. Although a regular on TV, radio, newspapers and magazines, ‘Decoding Reality’ is his first foray in the popular science book market. From the prologue to the conclusion, it is easy to see that Vedral lives for information, his passion for the subject transpires on every page. In this short book, the author gives a nice overview of the importance and versatility of the information concept from biology to economics, sociology to computer sciences. Vedral rightly gives prominence to Shannon’s work and the close links between information and thermodynamics. His description of quantum information and its potential exciting applications is refreshingly accessible.

Finally, he eloquently argues the case of information as the most fundamental quantity above matter and energy.

Vedral’s style is entertaining but can sometimes feel too scholarly; the use of bullet point summaries at the end of each chapter feels out of place in a popular science book. The end-notes are a particularly useful source of further reading material on the subject but it is a shame he did not cross-reference them in the chapters.

Overall, if not a classic of the popular science genre, the book is a very good introduction to information and not a bad start for a first book. I am looking forward to his second opus.

Marc E. Miquel

The Scientific Revolution and Medicine 1450–1700 (The History of Medicine)

This book focuses on the people and events that were key to the advancement (or in some instances the hindrance) of medicine from 1450 to 1700. European sailors conquering the globe (whilst spreading disease), the wars and conflicts of the time, and the church’s opposition to the use of cadavers for dissection are some of the events discussed in connection with their link to medical advances. There are fascinating tit-bits of information that leave you staggered at the lack of anatomical understanding and the poor quality of medicine. It makes you thank your lucky stars that, should you ever have to have a limb amputated, it won’t involve being held down by your friends and family, gulping down some vodka, chomping down hard onto a wooden stick and staring wildly at the surgeon walking towards you with a hacksaw fresh with the last patient’s blood, saying ‘this might sting a little’. So the people mentioned in this book quickly become heroes, with Serveto, Descartes, Harvey and Fabricius leading discoveries in the circulation of blood, our own William Clowes writing ‘A Proved Practice for all young Chirurgeons, concerning burnings with gunpowder, and wounds made with Gunshot, Sword, Halbard, Pike, Launce or such other’, Paracelsus who found that by inhaling the powder from another’s smallpox scabs you could be immunised, and my personal favourite Ambrose Paré who stumbled on a clinical trial when those patients treated for war-wounds using burning oil favoured less well than those treated with his mixture of egg yolk, rose water and turpentine. Among the hinderances to medicine were Paré’s unfortunate advocacy of puppy oil (made by boiling newborn puppies with oil of lilies and earthworms), and the use of powder ground from unicorn horns (substituted for by rhino and narwhal horns).

Once I started this book I couldn’t put it down and found it terribly easy to read. In fact, at some points it may have been too easy to read. Some of the sections could have done with delving deeper into the subject matter, and instead leave you anchoring for more. This is the main feeling and purpose of the book though – a light-hearted look at the general events and characters of this period. The book is intended for those at secondary school and anyone upwards of that level, and it fulfils that objective well, though the older and more scientific you are the more you could have done with delving deeper into the series of six.

Christopher Thomas, Guy’s and St Thomas’ NHS Foundation Trust

THE SCIENTIFIC REVOLUTION AND MEDICINE 1450–1700 (THE HISTORY OF MEDICINE)

Kate Kelly
Publisher: Facts on File ISBN: 978-0816072071 Pages: 158
Biodesign: The Process of Innovative Medical Technologies

I found this a fascinating book, although it is very heavy going being a massive 742 pages long, and there are many case studies presented to highlight the themes of each chapter (the chapters are referred to as ‘stages’ in the book). It has clearly been put together by the three authors as a result of compiling and running a postgraduate-level course in the subject. In the Introduction they reasoned why this book evolved as a result of their experience in producing and developing book technologies presented to highlight the themes and case studies. It is very heavy going being a massive 742 pages long, and there are many case studies in the text, and not all the abbreviations used in the text are listed! I had to look at the references in the relevant stage/chapter to find out what HIC and FESS meant as they were not expanded on in the text. Typical sentences where this anomaly occurs are: ‘Codes set up by the AMA (e.g. CPT codes) or CMS (e.g. APC and DRG codes) are...’ (page 511); ‘RVUs are used by CM to calculate payment rates for CPT codes in the number of RVUs assigned by the RUC’ (page 509).

I would recommend this book strongly to SMEs (there I go using abbreviations!) in Europe who wish to penetrate the American market with medical device related products. It clearly describes how one can understand the methods of reimbursement that the US healthcare system uses and the regulatory issues that arise around clinical trials and pre-market evaluation which are very different to that outside the US. Also, if you get this book you also will not need to do the postgraduate programme in biodesign at Stanford University!

Julian Minns, Clinical Scientist Retired from Northern Regional Medical Physics Department


Just Published!

The Big Questions: Physics by Michael Brooks (Quercus Publishing Plc) is another publication from the Big Questions series. The series addresses 20 questions relating to science or philosophy with 3,000-word essays. The author attempts to examine fundamental questions, which have previously remained confusing to others. Examples of the questions include: ‘What is the point of physics?’, ‘Why is there no such thing as a free lunch?’, ‘Are solids really solid?’ and ‘Does chaos theory spell disaster?’.

Physics of the Human Body by Richard P McCall (Johns Hopkins University Press) is a text which explains how basic concepts of physics apply to the fundamental activities and responses of the human body, a veritable physics laboratory. An example includes blood pumping through our veins being a vital example of Poiseuille flow.

Modelling the Human Body Exposure to ELF Fields by C. Peratta and A. Peratta (WIT Press) takes a novel approach to investigate behaviour of currents induced in the human body by electric fields. It uses this methodology in three case studies, for which a sensitivity analysis has been carried out.

Tomographic Image Reconstruction and Quantification for PET/SPECT: Non-Uniform Resolution and Partial Volume Recovery Methods by Manir Ahmad (VDM Verlag Dr Muller Aktiengesellschaft & Co. KG) details information relating to the problems of partial volume effects, low resolution capabilities and non-uniform reconstructed resolution of tomographic imaging devices. This book would appeal to those interested in image reconstruction and finding methods of improving this process.

Radiation Physics for Nuclear Medicine by Marie Claire Cantone and Christoph Hoeschen (Springer-Verlag Berlin and Heidelberg GmbH & Co. KG) is a book in which acknowledged experts explain the basic principles of radiation physics in relation to nuclear medicine and examine important novel approaches in the field. New frontiers are then explored, including improved algorithms for image reconstruction, biokinetic models and voxel phantoms for internal dosimetry.

Physics for Diagnostic Radiology (Series in Medical Physics and Biomedical Engineering, 3rd edition) by Philip P. Denby, Brian Heathon, John G. Webster, Slawik Tabakov, E. Russell Ritenour and Kwan-Hoong Ng (CRC Press) is a revision text for FRCR Part 1 candidates, covering a range of topics including the fundamentals of radiation physics. The book deals with various areas of diagnostic imaging and also provides a multiple-choice question section for exam practice.

Radiation Hormesis and the Linear-No-Threshold Assumption by Charles L. Sanders (Springer-Verlag Berlin and Heidelberg GmbH & Co. KG) investigates the validity of applying the linear no-threshold assumption versus the radiation hormesis hypothesis to data obtained in epidemiological research.

Basic Radiation Oncology by M. Beyzadeoglu, Gokhan A-Zuygit and Cynexit Ebruli (Springer-Verlag Berlin and Heidelberg GmbH & Co. KG) is an all-in-one book, encompassing the essential aspects of radiation physics, radiobiology and clinical radiation oncology.