

Workshop report

Pathways to in-vivo 3D dosimetry measurements for adaptive radiation delivery

26 June 2019 - 27 June 2019, University of Surrey, UK

The aim of the workshop was to bring together established experts in dosimeter development and medical physics practitioners, as well as early career researchers working towards making routine 3D or even 4 D in-vivo dosimetry measurements a reality. The need to strengthen and bring together the expertise of researchers in this field had been highlighted during the discussions of collaborative work carried out in summer 2018 between the University of Surrey, Trueinvivo, and the Cancer Institute of Tehran (Iran). This work had been made possible through an IAS Fellowship award to Ramin Jaberi and Somayyeh Babaloui. The workshop proposal was developed following on from that work.

The local workshop organising committee was chaired jointly by Annika Lohstroh¹ and Shakardokht Jafari.^{1,2,3} and complemented by Silvia Pani,¹ Giuseppe Schettino,^{1,4} Lucia Florescu,⁵ and Phil Evans.^{4,5} The workshop aimed to provide an opportunity to form new collaborations. Overall, we had 34 participants from 20 different institutions situated in 9 different countries [although due to delays in visa processing, one participant could only join and present remotely]. They represented a range of institutions as illustrated in Table 1.

Institution type	Industry	Hospitals	University	Government funded research centre	Veterinary Practice specialised in Oncology
Number of Participants	7	10	14	2	1

Table 1: Summary of the Institutions the participants represented

The presentations were grouped into 5 sessions, which focused each on a different theme of the overall scope of the meeting. Each session started with a keynote speaker and the themes of the presentations and discussion are summarised below. More details can be found in the abstracts of the [workshop brochure](#).

A pre-workshop dinner was held on the evening of the 25th June 2019 that enabled participants who arrived the evening before the start of the workshop the following morning to meet and network. It was attended by 15 participants.

¹ Department of Physics, University of Surrey

² Queen Alexandra Hospital Portsmouth

³ Trueinvivo Ltd

⁴ National Physical Laboratory

⁵ Department of Electric and Electronic Engineering, University of Surrey

The workshop was opened by Annika Lohstroh with a brief outline of the purpose of the meeting and how it became a reality, followed by a short address of Nigel Biggs (CEO of Trueinvivo) outlining the company's interest in the work and motivation for supporting the workshop.

The first keynote speaker was Ramin Jaber, who was the recipient of an IAS Fellowship during summer 2018. Hence, it was particularly unfortunate that he was unable to join us in person due to delays in visa processing. Nevertheless, we did not want to deprive participants of the opportunity to learn about the research progress being made at the Cancer Institute in Tehran and it was decided to offer his presentation pre-recorded (in order to avoid distraction by glitches in the internet connection), as illustrated in Figure 1 (right), followed by a live question and answer session through skype. Despite this unusual procedure, participants engaged with the talk as evidence by their contributions of questions and answers to Ramin Jaber.

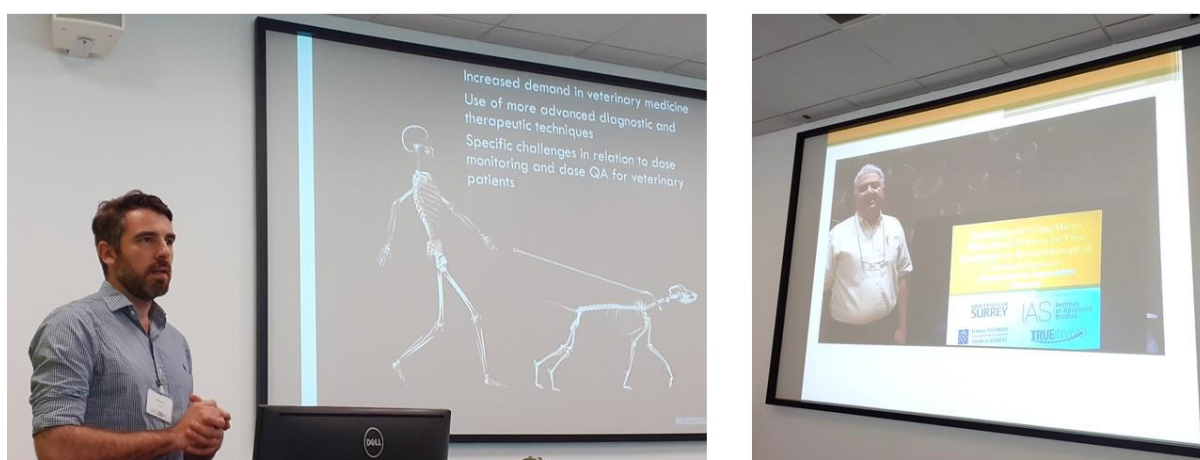


Figure 1: Introductions to (left) veterinary oncology by J. Benoit, (right) remote talk on using micro silica beads as in-vivo dosimeters in Brachytherapy of Cervical Cancers by R. Jaber (after the introduction, the slides filled the whole screen and the video image was removed).

Sessions

The first session focused on the development of phantoms suitable for quality assurance procedures in radiotherapy as well as operating as test-beds for future in-vivo measurements, which allows the testing of dosimeter placement and operation within a model reflecting the relevant aspects of the human body. All speakers highlighted the advantages of 3D printing and the potential step change this technology could introduce to personalising clinical practice. On the other hand, each speaker also highlighted the need to fine-tune the 3D printed material properties in order to accurately represent the relevant properties of the human structures.

The second session introduced different modalities of using silica based dosimeters, which offer high spatial resolution measurements, are made of non-toxic materials, water compatible and can be operated in “real time” in radioluminescence mode as well as in thermoluminescence mode, with off line read-out. The wide dynamic range of the devices is an additional advantage of the technology.

More than 20 participants used the opportunity to visit the local X-ray laboratories and the Ion Beam centre on campus before the afternoon sessions started with Jérôme Benoit (see Figure 1 (left)), who highlighted the increase in oncology in veterinary practice, and the

differences in regulatory framework for carrying out radiotherapy in veterinary practice. Similarities and differences between cancer occurrence frequency and treatment response between human and pet patients was presented and hence the potential progress that can be made using pets in research trials was highlighted.

Session 3 was introduced by Sonja Wegener, who gave a strong overview of the techniques available for in-vivo dosimetry of Head and Neck cancer patients, including MOSFETs that can be used for real time read-out, which led to the subsequent talks discussing real time monitoring of treatment delivery using a range of semiconductor based detector options.

Session 4 on Thursday morning continued with an emphasis on dose monitoring during treatment delivery. Ana Folgueras gave an excellent introduction to the issues faced. Some aspects of this reappeared in the subsequent discussions – if real time delivery can be monitored reliably – then criteria will be needed to decide whether a treatment should be aborted or not, which opens another set of unanswered questions.

Public Engagement



Figure 2: Left image: Joint Workshop Chair and Public Lecture speaker S. Jafari (left) and contributor C. Termsuk (right); Right image: Demo of the Truein vivo proto-type automated thermoluminescent silica bead read-out system.

The public engagement event in Wednesday evening was attended by approximately 20 participants of the workshop, as well as approximately 25 to 30 members of the public. The latter number was lower than average for public lectures organised by the department – however this may be due to the fact that the event was held outside term time and a significant proportion of the public lecture audiences are often UG students. Before the lecture, everyone had the opportunity to engage with each other over tea, coffee and biscuits (funded by the Physics department), with conference participants being recognisable through their badges. In addition, a new prototype automated TLD reader for silica micro bead dosimeters was on display (see Figure 2 (right)) – with the engineer responsible for its design ready to answer questions. The lecture was introduced by Annika Lohstroh, who gave an overview over the workshop, its history and purpose, followed by a brief summary of Ramin Jafari's work presented in the morning as he could not attend the event. The main speaker, Shakardokht Jafari presented an excellent overview of the potential, discovery,

development and commercialisation of micro silica bead dosimeters. This was brilliantly complemented by insights into her personal life's story that motivated and continues to drive progress in this field.

Next steps

The workshop concluded with a brief open discussion of the next steps. Overall, participants seem to have found the meeting and its format useful, which has also been expressed in the feedback free form comments that highlighted the opportunity to learn about new developments in the field and develop collaborations and networking. As summary of the Likert scale feedback form can be found in Table 2.

Poor =1, Fair =2, Average = 3, Good =4, Very good = 5	Average	Standard deviation
Advance Information	4.58	0.51
Conference Pack	4.42	0.84
Conference Venue	4.37	0.96
Programme Scheduling/Timing	4.58	0.51
Lunch & refreshments	4.37	0.68
Conference Dinner	4.27	0.79

Table 2: Average result of the tick boxes of the feedback questionnaires, which had been completed by 19 participants

There are varying expectations associated with the phrase “adaptive radiotherapy” which will be useful to clarify for future events. Participants requested that slides will be made available and these will be published on the IAS website before the end of July 2019 for those speakers that give us explicit permission to do so.⁶

A desire to possibly hold a similar themed workshop to discuss progress in one or two years' time, was expressed during the open discussion at the end of the workshop.

Acknowledgements

In addition to the IAS funding, the workshop was generously supported from the very first considerations of holding it by Trueinvivo Ltd. It would not have happened without Nigel Biggs encouragement and commitment.

Additional sponsorship (in return for small scale advertising) was received by Oncology Imaging Systems, Elekta and Imaging Equipment Ltd.

The workshop preparation and running strongly benefitted from the excellent practical support provided by Mirela Domic and Lisa Fletcher. During the event, the support of Hima Pitta Bindu and Chutima Termsuk was also greatly appreciated.

The Public Lecture event associated with the workshop was coordinated, and publicised by Heather Campbell on behalf of the Department of Physics at Surrey and also supported by a number of Physics Students.

⁶ On 12th July 2019, permission had been received for 11 presentations.



The workshop is also supported by:

