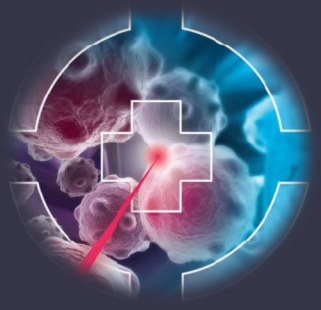


OMA Express
March 2021
Issue 15

Highlights

- Research News
- Fellows Activity
- Partner News
- Upcoming Events

COVID challenges, events and graduations

One year ago, the first national lockdowns were announced in countries around the world. The way we work, collaborate and live has since changed very fundamentally - in ways that few of us would have imagined possible before the start of this health crisis. Asynchronous teaching, video-conferencing and working-from-home (WFH) have become our "new normal". A lot of research has continued though and international collaborations, such as OMA, have identified creative ways of how to keep R&D active and use technology to overcome challenges posed by the pandemic.

Scientific events have worked around these restrictions and are currently mostly held online. Last week for example, the MSCA Cancer Cluster organized a 2-day conference on cancer research and innovation. This online event involved keynote talks by leading scientists and panel discussions about treatment options and policy principles. OMA was present as well through a poster contribution. All contributions are available online, so please have a look in case you were unable to attend the live event.

Also last week, the IOP invited me for a podcast on improving proton beam therapy for better cancer care. I gave examples of how our network has worked together to push the boundaries of technologies and treatment techniques. You can now register for a healthcare instrumentation workshop in April to which several OMA partners will contribute, you can meet us at a (virtual) booth at IPAC21, and you might wish to join us for the FLASH radiotherapy and particle therapy conference in December where OMA is a collaborator.

Finally, I would like to congratulate our OMA Fellows who have recently graduated to PhD! You will find details about their projects in this OMA Express.

Congratulations! I am very proud of your achievements!

Prof Dr Carsten P Welsch
OMA Coordinator

Research News

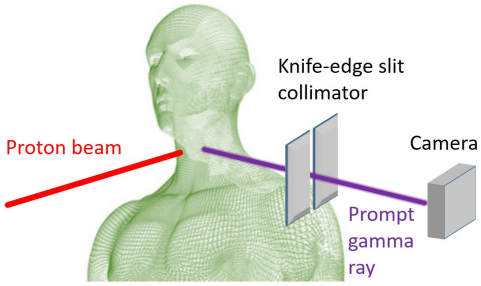
Accounting for prompt gamma emission and detection for range verification in proton therapy treatment planning

Prompt Gamma (PG) imaging is one of the most promising methods for proton range verification in proton therapy, but its performance is affected by several factors, like the number of protons in the pencil beam.

OMA Fellow Liheng Tian and co-workers from the Ludwig-Maximilians-Universität (LMU) in Munich have been investigating a new treatment planning concept. Their proposal boosts the number of protons of a few pencil beams for PG imaging, selected on the basis of two indicators which quantify the conformity between the dose and prompt gamma emission.

In a paper recently published in Physics in Medicine & Biology, Liheng Tian and colleagues from LMU and the company IBA further explore this method at the detection level. In this work they report the response of a knife-edge slit prompt gamma camera which had been deployed in the first clinical application of PG monitoring in proton therapy.

The authors investigate the camera-adapted pencil beam selection method using computed tomography scans at two different treatment time points of a head and neck, and a prostate cancer patient under different scenarios.



Knife-edge Prompt Gamma camera setup for head and neck cancer patient.

The results show that a precision of 0.8 mm for prompt gamma falloff identification can be achieved when a pencil beam has more than 2×10^8 primary protons. The PG signals of most of the pencil beams recommended by all the indicators are observed to be reliable for proton range verification, with much smaller deviations between the inter-fractional shift of proton range than the rejected pencil beams.

The indicators proposed are shown to be valuable for identifying and recommending reliable pencil beams to create new PG monitoring-friendly treatment plans.

'Accounting for prompt gamma emission and detection for range verification in proton therapy treatment planning'
Liheng Tian, Ze Huang, Guillaume Janssens, Guillaume Landry, George Dedes, Florian Kamp, Claus Belka, Marco Pinto, Katia Parodi, Phys Med Biol 66(5), 055005 (2021).
https://doi.org/10.1088/1361-6560/abc939

Fellows Activity

Mixed particle beam project among top 10 for Physics Breakthrough of the Year award

Every year since 2009, 'Physics World', a magazine published by the Institute of Physics (IoP), awards the 'Breakthrough of the Year' prize to outstanding research in physics. This year, a collaboration project between OMA Fellow Laurent Kelleter (UCL, London, UK, supervised by Simon Jolly) and Lennart Volz (DKFZ, Heidelberg, Germany, supervised by Joao Seco) has been selected among the 10 finalists for the award. The project was previously featured in an article in Physics World and the OMA newsletter.

The aim of the project is to simultaneously use a carbon-ion beam for treatment and a helium-ion beam for imaging (theranostics). This is done by exploiting the 3x longer range of helium ions compared to carbon ions when accelerated to the same energy per nucleon. The residual helium beam is measured in a detector behind the patient, enabling the online monitoring of intra-fractional movements. The employed detector, which is based on a segmented plastic scintillator read out by a large-scale CMOS sensor, was developed in the frame of Laurent's PhD thesis at UCL. Laurent and Lennart demonstrated in their study with sequentially irradiated ion beams the outstanding sensitivity of the method: beam range shifts of only 22% of the beam particles by just 1 mm could be detected. Moreover, using two anthropomorphic pelvis phantoms, they showed that prostate cancer patients could benefit from the technique.

In the future, it needs to be shown if the delivery of a mixed helium/carbon beam is technically feasible in a synchrotron. Challenges that need to be overcome before clinical implementation include the simultaneous pre-acceleration of the ions in the linac, the beam extraction from the synchrotron as well as the pencil beam scanning. The mixed-beam method could enjoy a boost with the potential future commercialisation of cyclotrons for carbon therapy.

Image: Physics World

PhD completed

Congratulations to OMA Fellows Anna Baratto Roldán, Sud Srinivasan, Jacinta Yap and Liheng Tian, who successfully defended their PhD theses!

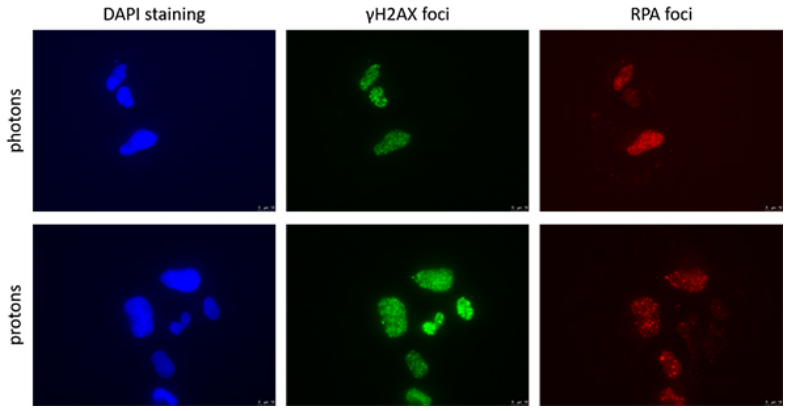
Anna Baratto Roldán

The 25th of November 2020, OMA Fellow Anna Baratto Roldán defended her PhD thesis entitled *"Development of an external beam line for radiobiology experiments and microdosimetry applications at the 18 MeV proton cyclotron facility at CNA"* at the University of Seville, receiving the special mark of honour "Cum laude".

The thesis was the result of Anna's work, as part of the OMA project, at the National Centre of Accelerators – CNA of Seville, and led to the construction of a radiobiology beam line at the cyclotron external beam line installed at the CNA, and to the conduction of the first experiments with cell samples in collaboration with the Centro Andaluz de Biología Molecular y Medicina Regenerativa – CABIMER.

Anna's thesis was centred around the problem of proton RBE variability in clinical proton therapy, and faced this issue from two different perspectives: (1) experimental, by the design and mounting of a low energy proton facility at the CNA for the experimental measurement of proton RBE in mono-layer cell cultures and (2) computational, by the development of a Monte Carlo application with Geant4-DNA to study the microscopic patterns of energy deposition in water for the computation of microdosimetric quantities, useful for the implementation of variable RBE/LET schemes in proton therapy treatment planning.

After the completion of her thesis, Anna is now continuing her scientific career as a Postdoctoral researcher at the CNA, where new measurements at the radiobiology beam line are foreseen to extend the applications of this facility. In particular, new collaborations have been established to move into the hot topic of flash proton therapy, where the collection of biological data at low proton energies, in correspondence of the Bragg peak region of clinical proton beams, would be extremely useful.



Representative pictures of the cells irradiated at the cyclotron radiobiology beam line and stained for immunofluorescence microscopy analysis.

Sud Srinivasan

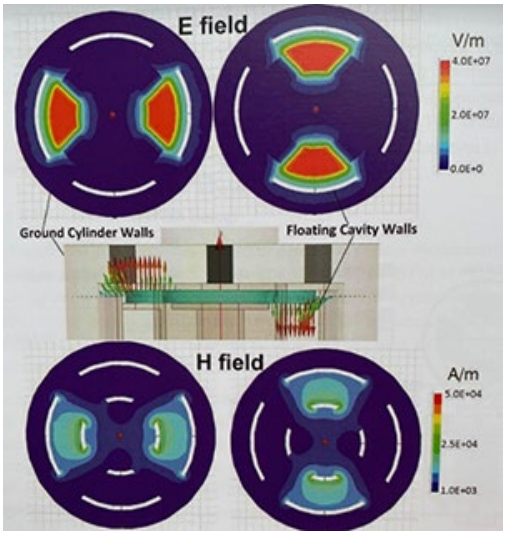
Proton and ion beam therapy is a very successful treatment method for some types of cancer. The reliable delivery of the treatment beam critically depends on beam diagnostics that is able to fully characterize the beam, ideally in a non-invasive way so that the diagnostics does not degrade the beam quality.

A non-invasive beam current monitor based on the principle of electromagnetic resonance was designed, built and tested by Sudharsan (Sud) Srinivasan, OMA Fellow at PSI and PhD student at the University of Groningen, working under the supervision of Dr Pierre-André Duperrex.

In his PhD thesis entitled "Non-interceptive beam current and position monitors for a cyclotron based proton therapy facility" Sud describes how this new monitor can open up interesting opportunities for potentially replacing some of the commonly used ionization chambers for beam current measurements at proton therapy facilities with cavity monitors.

In his project Sud has successfully designed, tested and characterized in detail a dielectric-filled re-entrant cavity resonator as beam current monitor for medical applications. The fundamental resonance frequency of the purpose-built cavity is 145.7MHz, i.e. the second harmonic of the pulse rate. In his project, he tested this novel monitor in both, lab measurements and experiments in the COMET beamline. It was successfully demonstrated that the monitor can measure proton beams with currents down to 0.15 nA for an integration time of 1 second. This makes the monitor a very interesting and important development for essentially any proton accelerator used for therapy purposes.

Sud has developed a very promising device that shows excellent prospects for future application at ion beam therapy facilities.



Electromagnetic field simulations of the cavity monitor.

Jacinta Yap

OMA Fellow Jacinta Yap has successfully passed her PhD viva in February 2021. Jacinta carried out research into „Characterisation Studies of Proton Beamlines for Medical Applications and Beam Diagnostics Integration“.

Jacinta's thesis describes several methods to characterize and model a particle beam for novel beam diagnostics development. Namely, the VELO beam halo monitor was adapted into a standalone system and optimised for implementation into the Clatterbridge Cancer Center's ocular proton therapy beamline. As the detector provides beam information based on non-destructive measurements of the halo, a comprehensive overview of the cyclotron, beam transport and treatment delivery system at the facility was performed.

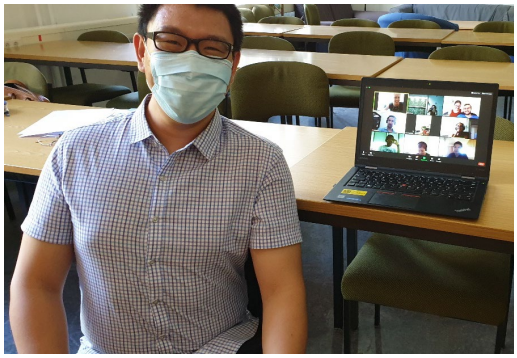
In order to fully exploit the beamline, the propagation and behaviour of the beam must be well understood. Therefore, simulation studies and experimental measurements were required to precisely model and completely characterise the facility. Jacinta developed several computational tools to accurately reproduce the current state of the facility and detailed properties of the treatment beam, which also supported the development of novel instruments such as the Medipix3 and MiniPIX-Timepix detector. Measurements were performed to explore their capabilities in a clinical proton environment and to determine the transverse beam profiles and LET. Her work could also be carried out at similar facilities to study aspects which are necessary for beamline upgrades, optimization and for the efficient integration of diagnostics.

Jacinta's work provides a versatile basis for a complete simulation framework to integrate realistic simulation models and advanced beam diagnostics for the enhancement of particle therapy treatments.

Jacinta was supervised by Dr Javier Resta-Lopez, Dr Jason Parsons and Professor Carsten P Welsch. She has already started a Postdoc position at the University of Melbourne and we look forward to collaborating with her!

Liheng Tian

OMA Fellow Liheng Tian passed successfully his PhD defense on 27th July at the Physics Faculty of Ludwig-Maximilians-Universität (LMU) in Munich, Germany. His project was funded by OMA and LMU and was carried out at the Department of Experimental Physics – Medical Physics at the host University LMU, benefiting from an internship and collaboration with IBA.



The title of his thesis was *'A new treatment planning concept accounting for prompt gamma imaging for proton range verification*'. The performance of proton therapy is highly affected by the proton range uncertainties caused by e.g. anatomical changes and patient positioning. The thesis focuses on the integration and optimal exploitation of the novel proton range verification technique of prompt gamma imaging in a Monte Carlo-based treatment planning platform for proton therapy. In this Monte Carlo simulation work, a method was proposed to identify the reliabilities of the pencil beams used in the treatment in terms of prompt gamma imaging at the stage of treatment planning. Pencil beams selected by this method were then boosted to create a more PG-monitoring friendly treatment plan, as verified both at the emission and the detection level with a realistic model of a prompt gamma knife edge slit camera.

With the results of Liheng's thesis, proton range verification method is taken into account in a Monte Carlo-based proton treatment plan for the first time, potentially contributing to a future reduction of proton range uncertainties.

The work has been published in three peer reviewed articles in Physics in Medicine and Biology (see below).

Published articles:

Accounting for prompt gamma emission and detection for range verification in proton therapy treatment planning.
Liheng Tian, Ze Huang, Guillaume Janssens, Guillaume Landry, George Dedes, Florian Kamp, Claus Belka, Marco Pinto, Katia Parodi, Phys Med Biol 66(5), 055005 (2021).
https://doi.org/10.1088/1361-6560/abc939

A new treatment planning approach accounting for prompt gamma range verification and interfractional anatomical changes.
L. Tian, G. Landry, G. Dedes, M. Pinto, F. Kamp, C. Belka, K. Parodi, Phys Med Biol 65(9), 095005 (2020)
https://doi.org/10.1088/1361-6560/ab7d15

Toward a new treatment planning approach accounting for in vivo proton range verification.
L. Tian, G. Landry, G. Dedes, F. Kamp, M. Pinto, K. Niepel, C. Belka, K. Parodi, Phys Med Biol 63(21), 215025 (2018).
https://doi.org/10.1088/1361-6560/aae749

Partner News

National particle accelerator open day

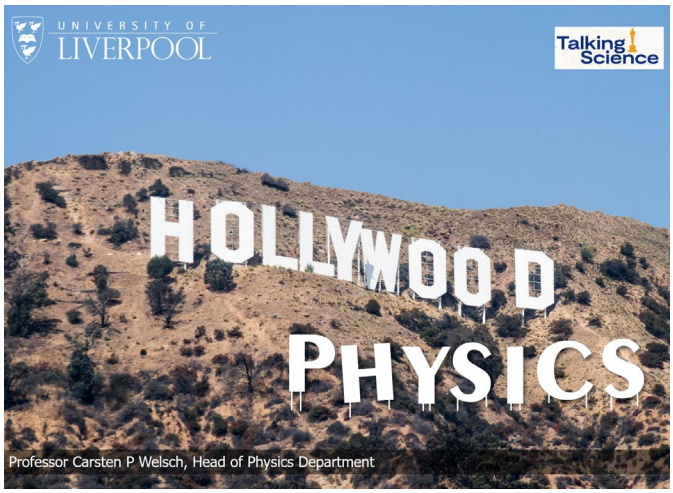
The Cockcroft Institute, which hosts several OMA Fellows through the Universities of Liverpool and Manchester, organised a virtual national particle accelerator open day on 3rd February 2021 for undergraduates studying engineering or physics at UK universities.

The national particle accelerator open day has been an annual feature where one of the UK facilities opens their doors to UK students, alongside talks on career opportunities and a recruitment event. This year two tours were done in a virtual environment, one of the Diamond light source, the UK's flagship synchrotron light source, and one of the Elekta factory, a world-leading producer of radiotherapy machines.

The open day covered an exciting programme of events including talks and virtual lab tours, as well as the opportunity to talk to UK universities, laboratories and industry about studentships and employment opportunities. The Open Day was supported by the IoP Particle Accelerators and Beams (PAB) Group and the IET Particle Accelerator Engineering Network.

Daresbury Laboratory

Talking Science - Hollywood Physics



Public Engagement with science, technology, engineering and mathematics (STEM) is a very important element in the QUASAR Group's activities. We love to talk about our research, together with the impact science has on the world around us.

On 27th January, QUASAR Group leader and OMA project coordinator Professor Carsten P Welsch contributed a presentation about "*Hollywood Physics*" to the monthly programme of fascinating public talks at Daresbury Laboratory called Talking Science. The aim of these seminars is to inspire and involve the public and in particular schools in STEM.

Professor Welsch took a look at a few of cinema's most mind-boggling moments of scientific inaccuracy. He talked about where Hollywood gets the physics wrong and how the correct science would impact on the films, as well as about how the actual experiments in his group often go beyond even the most exciting movie plots.

Given the current restrictions on meetings, the event was held online in Zoom. Professor Welsch was joined by several hundred people in the audience and covered movies such as Iron Man, Terminator and The Flash. All of these films feature particle accelerators, so this was an ideal basis to then talk about the exciting research in the in the OMA project. Professor Welsch explained the fundamental concept of proton and ion beam therapy and discussed the challenges related to beam control and diagnostics.

The meeting was hosted by Daresbury's public engagement team who did their magic behind the scenes and ensured everything run smoothly.

The talk received excellent feedback and many questions from a very engaged audience. STFC's public engagement officer Phill Day said: "*Wednesday's talk was a superb example of how to combine popular mainstream content with our science and technology. I thoroughly enjoyed it!*"

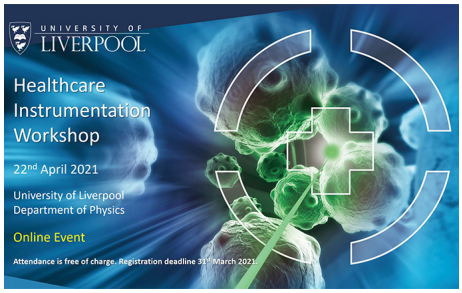
In case you missed Professor Welsch's talk, simply email dltalkingscience@stfc.ac.uk for a recording of the event.

Upcoming Events

Healthcare Instrumentation Workshop

22nd April 2021, Liverpool, Online Event

A Healthcare Instrumentation Workshop which was postponed last year due to the pandemic, will now be held online on Thursday 22 April 2021.
The workshop will bring together companies developing or manufacturing medical instrumentation, organisations which use such devices in healthcare, and academic researchers from the Physics Department of the University of Liverpool with the purpose of identifying the key research challenges in this area, and build partnerships to work together on future funding opportunities.



The event is open to industry, researchers, medical physicists and potential partners. The participants will have the opportunity to:

- Meet virtually potential collaborators to solve business challenges through collaborative research and development.
- Access specific research knowledge and support to enable you to prepare joint research proposals and develop new products.
- Hear about funding opportunities available from a range of funders, including STFC, EPSRC, the Industrial Strategy Challenge Fund, EU and CRUK.

Please register at: https://bit.ly/3po99mA

Email questions to:
c.astreos@liverpool.ac.uk

Attendance is free of charge.

12th International Particle Accelerator Conference (IPAC'21)

24th – 28th May 2021, Virtual Conference

The 12th International Particle Accelerator Conference - IPAC'21 will be held in virtual format from 24th - 28th May 2021, organized by the Brazilian Center for Research in Energy and Materials (CNPEM), located in Campinas, Brazil.

IPAC is the main international event to discuss the latest achievements in the science and technology of Particle Accelerators, promoting collaboration among scientists, engineers, technicians, students and industrial partners across the globe. This is a most exciting time in the field, with many new projects and challenges leading to innovation into the near future.

The University of Liverpool will be represented with a virtual booth, showcasing our research, projects such as OMA and upcoming events.

For registration and more information visit:
https://www.ipac21.org/

FLASH Radiotherapy and Particle Therapy Conference (FRPT 2021)

1st – 3rd December 2021, Vienna and Online

FRPT 2021 has grown out of FLASH workshops hosted by *Institut Curie* in Paris (1st FLASH Workshop in 2016) and CHUV in Lausanne (2nd FLASH Workshop in 2019). The conference will include the 3rd FLASH Workshop in this series, the workshops of the EMPIR project UHDpulse "Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates" and INSPIRE, the integrating activity for European research in proton beam therapy, and is also being developed together with GSI's International Biophysics Collaboration and MedAustron.

FRPT 2021 looks to build a worldwide organisation of scientists and professionals interested in FLASH Radiotherapy (RT) using protons, electrons, heavier charged ions and photons. The Conference will gather researchers and students (from academia and industry) with professionals working in clinical oncology, and provide a multidisciplinary forum to discuss the latest developments in FLASH RT.

FRPT 2021 goes from basic science, through preclinical research and combines these with translational applications and clinical trials and treatment. The ultimate goal of the Conference is to harness the potential for FLASH RT in a rigorous scientific and quality assured environment and to act as a forum for the very latest advancements in this rapidly developing field.

Many OMA partners, including the University of Manchester, PTB, The Christie (UK), GSI and MedAustron, are involved in this conference.

The OMA project is recognized as a formal collaborator in the event.

To learn more about the Conference: https://frpt-conference.org/

Abstract Deadline: 12 May 2021

Early Registration Deadline: 21 July 2021

This project 18HLT04 UHDpulse has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

Events

22nd April 2021	Healthcare Instrumentation Workshop, Liverpool, Online Event
24th - 28th May 2021	12th International Particle Accelerator Conference (IPAC'21), Virtual Conference
28th June – 2nd July 2021	International Conference on Radio Frequency Superconductivity (SRF 2021), Virtual Conference
1st – 3rd Dec 2021	FLASH Radiotherapy and Particle Therapy Conference (FRPT 2021) , Vienna and Online

NOTICE BOARD

DEADLINE FOR THE NEXT NEWSLETTER **15th June 2021**

The newsletter is published on a quarterly basis. Help us keep it interesting by providing your news and updates.

www.oma-project.eu

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