OMA Express
February 2019
Issue 9

Highlights

- Several articles on OMA research published in *Instruments*
- 3rd OMA Topical Workshop held at GSI
- Christie treats first patients with high energy protons

2019 – a year filled with OMA Events

The OMA Steering Committee met in Brussels just before Christmas. The meeting was ideal to review research and training progress since project start and set the network's plans for an exciting year ahead.

Registration for our international Advanced School on Medical Accelerators and Particle Therapy has now opened and we would like to ask all OMA partners to spread the news about this event. The week-long school will discuss the state-of-the-art in proton beam therapy and is open to participants from within and outside the OMA network.

We will host an international Symposium on *Accelerators for Science and Society* on 28 June 2019 and this will include satellite events at OMA institutions across Europe – please save this date in your calendars!

Between 4-6 September we will then organize an International conference on the Optimization of Medical Accelerators in Seville, Spain with CNA as local host. This will be another highlight amongst our many events.

It was a meeting with apparently *heated* discussions about the detailed programmes as we had no less than two complete building evacuations because of fire alarms on the day. No Steering Committee members were harmed in the process and we now look forward to seeing you at one of our many events this year.

Prof Carsten P Welsch,
OMA Coordinator

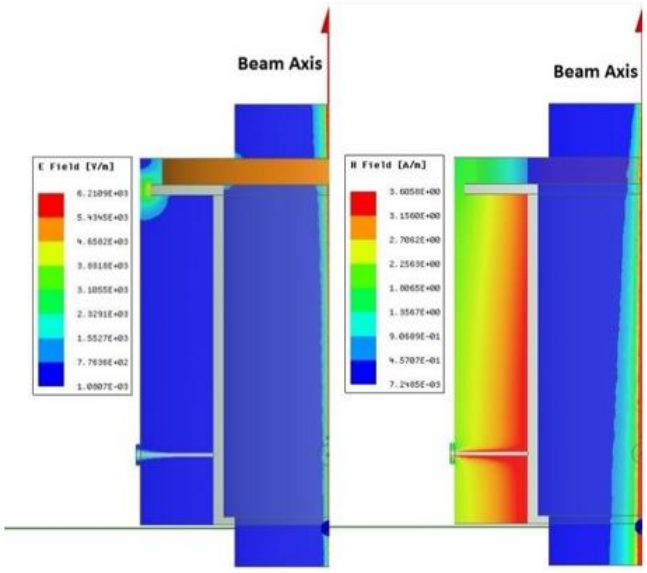
Research News

Article on non-interceptive monitor published in *Instruments*

Sudharsan Srinivasan and Pierre-André Duperrex, from Paul Scherrer Institut (PSI) have authored an article titled "Dielectric-Filled Re-entrant Cavity Resonator as a Low-Intensity Proton Beam Diagnostic" in *Instruments,* an Open Access Journal published by MDPI.

Measurement of the proton beam current (0.1–40 nA) at the medical treatment facility PROSCAN at the Paul Scherrer Institut (PSI) is performed with ionization chambers. To mitigate the scattering issues and to preserve the quality of the beam delivered to the patients, a non-interceptive monitor based on the principle of a re-entrant cavity resonator has been built.

The article shows good agreement between simulation and test-bench characterization. Number crunching from the test-bench measurement sympathizes the low-level signals that are expected and consequently a longer signal integration time to be able to read such low-level signals.

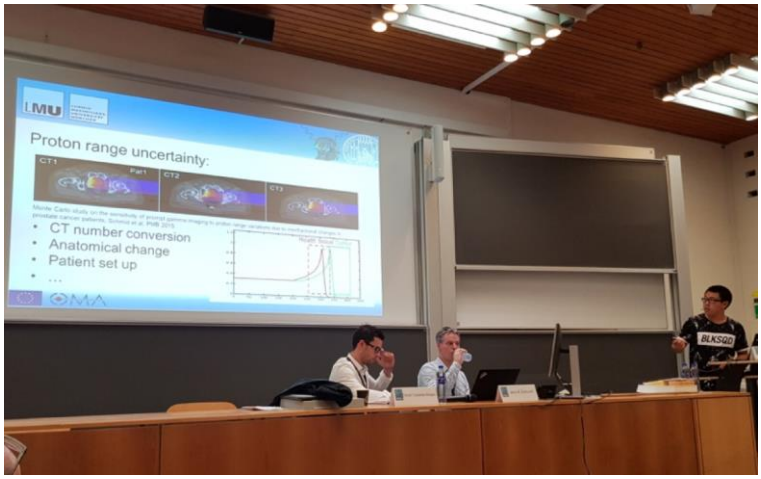


Induced E field and H field configuration focused separately in capacitive and inductive regions within the resonator

Further information:

S Srinivasan, P-A Duperrex, *'Dielectric-Filled Reentrant Cavity Resonator as a Low-Intensity Proton Beam Diagnostic'*, Instruments 2018, 2(4), 24; https://doi.org/10.3390/instruments2040024

Results on Proton Range verification via Prompt Gamma Imaging presented at European Congress of Medical Physics



Liheng presenting his research at ECMP2018, Copenhagen, August 2018

The latest results of Liheng Tian's research on prompt gamma (PG) imaging for proton beam monitoring have been presented at the European Congress of Medical Physics, in Copenhagen Denmark, August 2018.

Proton beams show considerable advantages in the field of radiation therapy for treating certain cancers due to the energy deposition peak at the end of their range. However, due to several factors, proton therapy exhibits uncertainties so it is vital that the beam is monitored during patient treatment. One of the most promising approaches, prompt gamma (PG) imaging, can enable in-vivo monitoring of the proton range.

The accuracy and precision of PG measurements are affected by both tissue heterogeneities and counting statistics. These effects are not considered in current treatment planning systems (TPS). To investigate the possibility of re-optimizing TPS accounting for in-vivo proton range monitoring, Monte Carlo treatment plans (initial plans) for 3 head and neck patients were firstly created using a research computational platform, combining Monte Carlo (Geant4) pre-calculated pencil beams with the analytical Matlab-based TPS engine CERR (a Computational Environment for Radiotherapy Research). Data analysis showed that the re-optimized plan is comparable to the initial plan in terms of dose distribution, dose averaged linear energy transfer (LET) distribution and plan robustness, while fulfilling the conditions for reliable PG monitoring. With the results of this project, the in-vivo PG range verification method is taken into account in the treatment planning process for the first time, potentially contributing to a future reduction of range uncertainties in proton therapy.

Further information:

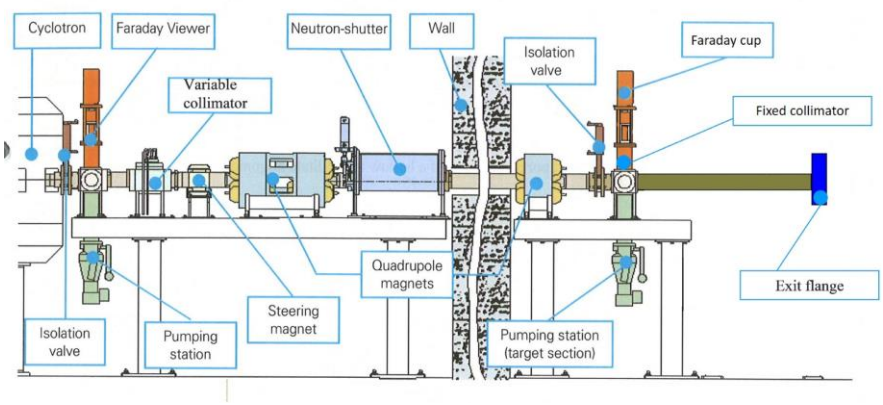
Liheng Tian, et al., '*Toward a new treatment planning approach accounting for in-vivo proton range verification*', October 2018, Physics in Medicine and Biology 63(21) DOI:10.1088/1361-6560/aae749

CNA Fellow publishes paper on new radiobiology beamline

Anna Baratto Roldán and co-authors from the University of Seville and the National Centre of Accelerators (CNA) in Seville, have recently published an Article entitled "Feasibility Study of a Proton Irradiation Facility for Radiobiological Measurements at an 18 MeV Cyclotron" in the special issue of *Instruments* on Diagnostics for Beam and Patient Monitoring.

In the article, the feasibility study of a radiobiology beam line at the CNA 18 MeV proton cyclotron facility is presented. Thanks to its characteristics, the cyclotron external beam line is suitable for the irradiation of mono-layer cultures for the measurement of proton Relative Biological Effectiveness (RBE) at low energies (below 18 MeV). This energy region is of interest for proton therapy, because it can be related to the Bragg peak region of clinical proton beams, where the variation of proton RBE, increasing with the particle Linear Energy Transfer (LET), may lead to unwanted side effects in proton therapy treatments.

In order to obtain the best irradiation conditions for radiobiology experiments, low beam intensities and homogeneous irradiation fields are required. At the cyclotron, these have been obtained by (1) defocusing the beam (2) intercepting the beam path with tungsten scattering foils and (3) varying the exit-window-to-sample distance. The procedures followed to optimize the beam properties are described in the article, together with the Monte Carlo simulations of the beam line and the experimental measurements performed with radiochromic EBT3 films. Meaningful dose rates of about 2-3Gy/min and homogeneous lateral dose profiles, with maximum deviations below 8%, have been achieved in the position of the samples.



Schematic representation of the CNA cyclotron external beam line.

Further information:

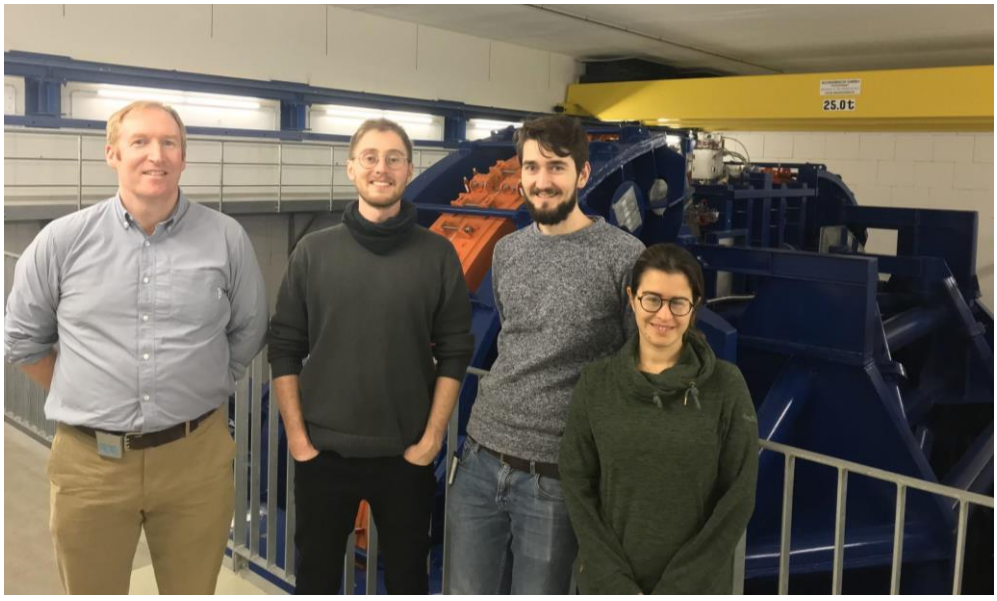
Anna Baratto-Roldán, et al., *'Feasibility Study of a Proton Irradiation Facility for Radiobiological Measurements at an 18 MeV Cyclotron'*, Instruments 2018, 2, 26. https://doi.org/10.3390/instruments2040026

Beam test at Heidelberger Ionenstrahl-Therapiezentrum and collaboration with DKFZ

The ion therapy centre in Heidelberg (Heidelberger Ionenstrahl-Therapiezentrum, HIT) is one of the world leading institutions for proton and ion therapy. It currently offers treatment with protons and Carbon ions. Furthermore, HIT is also one of only two centres in the world possessing a Carbon ion gantry.

On 15th November, a delegation from University College London consisting of OMA Fellow Laurent Kelleter, Dr Simon Jolly and Dr Raffaella Radogna travelled to Heidelberg in order to perform a joint experiment with Prof Joao Seco and Lennart Volz from DKFZ (Deutsches Krebsforschungszentrum). The aims of this collaboration are to test the range telescope for fast range quality assurance developed by UCL, to determine the energy resolution of a proposed Helium CT detector and to investigate the possibility of mixed Carbon-Helium beams at the HIT facility. The latter has recently attracted attention for the potential of simultaneous treatment and online range verification in carbon ion therapy (1). This technique is especially promising for the irradiation of lung tumours with carbon ion beams.

After a very successful beam test, the data analysis is running at full steam. The results will most likely be presented at the next OMA event.

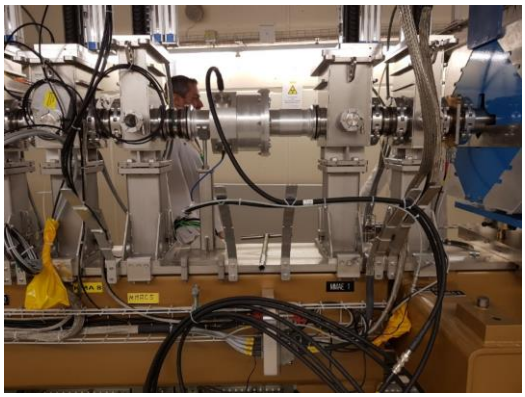


From left to right: Simon Jolly, Laurent Kelleter (both UCL), Lennart Volz (DKFZ) and Raffaella Radogna (UCL).

(1) Mazzucconi D, Agosteo S, Ferrarini M, Fontana L, Lante V, Pullia M, Savazzi S. *Mixed particle beam for simultaneous treatment and online range verification in carbon ion therapy: Proof-of-concept study.* Med Phys. 2018 Nov;45(11):5234-5243. https://doi.org/10.1002/mp.13219 Epub 2018 Oct 29.

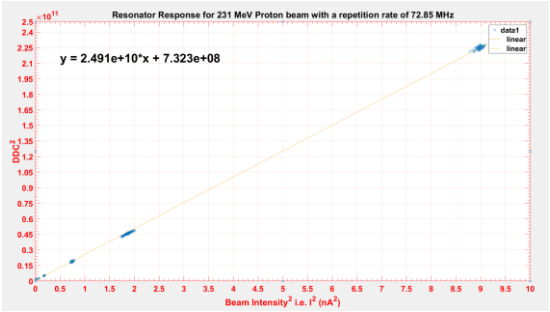
First results from Beam Line Characterization of Re-entrant Cavity Resonator as an Intensity Monitor

A macor filled re-entrant cavity resonator was installed in the PROSCAN beamline to characterize it as a beam intensity monitor by Sudarsan Srinivasan and colleagues. Proton beams of multiple energies (231 MeV, 201 MeV, 171 MeV and 141 MeV) were chosen for the study and the intensities were swept for the given energies to measure the resonator response. The resonator is placed behind the MMAC5 ionization chamber, an invasive monitor, as shown in the image below.



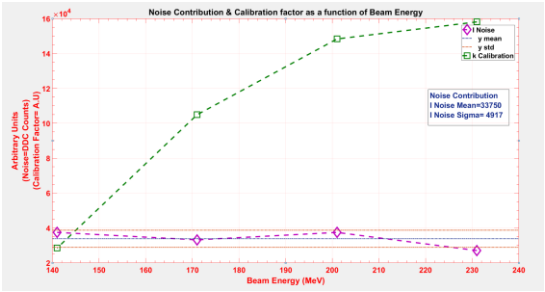
The Beam Intensity Monitor prototype installed in the PROSCAN beamline.

The resonator response is plotted against the MMAC5 as it is the intensity that passes through the resonator.



Resonator Response plotted as DDC2to beam intensity b2 for different intensities

The second image shows the resonator response vs beam intensity for 231 MeV proton beam. The resonator behavior could be modelled as $I_{DDC} = \sqrt{I_{noise}^2 + k^2 . I_{MMC5}^2}$. The noise factor is the square root of the intercept term and the calibration factor is the square root of the slope in the linear fit equation. Similarly, for other energies, the noise factor and the calibration factor is evaluated and their behavior is plotted in the image below.



Resonator Response plotted as DDC2to beam intensity b2 for different intensities

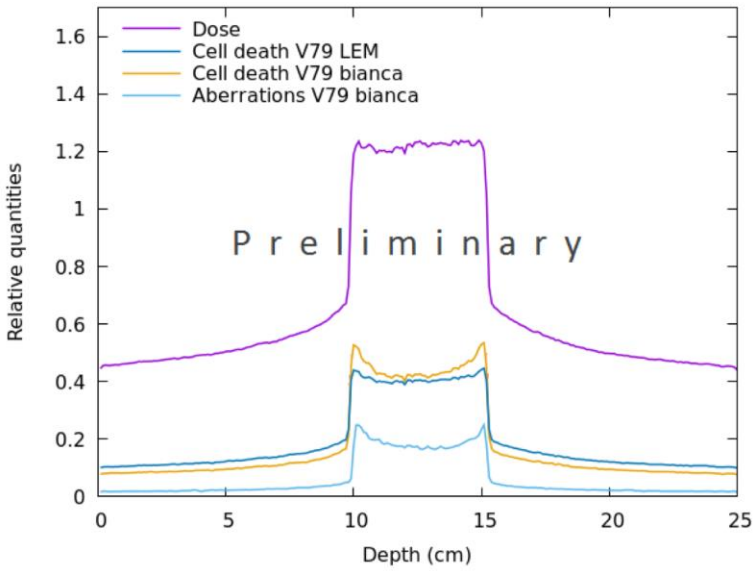
The calibration factor for the resonator increases as the beam energy is increased. The noise contribution for different energies is within 15% standard deviation.

From the first experiment, we could confirm the linear dependence of the resonator to beam intensity and the resonator calibration factor increases with increasing beam energy and reaches saturation at higher beam energies. The standard deviation in the noise floor is higher than expected, it could be due to not enough samples recorded during the measurement, and further study will be performed to understand the observed discrepancies.

Preliminary radiobiological studies for hadron therapy using FLUKA and BIANCA

In December 2018 OMA Fellow Giulia Aricò visited the research group led by Prof. Francesca Ballarini at the University of Pavia. Since some years, this group has been developing a new radiobiological model, called BIANCA (Biophysical ANalysis of Cell death and chromosome Aberrations). In comparison to other models, like the local effect model (LEM) used in clinics in Germany (HIT and MIT facilities) and Italy (CNAO), the main innovation of BIANCA is the possibility of linking the probability of cell death directly to the chromosome aberrations, which are also indicators of normal tissue damage.

During the 2 weeks visit in Pavia, Giulia Arico' together with her colleagues performed preliminary comparisons of the cell death probability predicted by BIANCA and LEM I. Irradiation of different cell lines, like Chinese hamster V79 and Chinese hamster ovary cells, have been simulated using the FLUKA code. The image shows an example of V79 cells irradiated with two opposite carbon ion fields, delivering a relative dose of ~0.45 Gy at the entrance channel, and producing a spread-out Bragg peak (SOBP) between 10 and 15 cm in water with a relative dose level of ~1.25 Gy. It was found that, with respect to LEM I, BIANCA predicts a lower cell death probability in the plateau area and a higher cell death probability at the SOBP, and in particular close to the SOBP edges. Furthermore, the probability of chromosome aberrations has been calculated with BIANCA. This research is promising in order to provide additional information to those achievable using the LEM I model and could contribute to the improvement of the accuracy of the treatment planning for cancer patients treated with hadron therapy.



Two opposite carbon ion fields are used to irradiate Chinese hamster V79 cells. The purple curve shows the delivered dose in Gy. The dark blue line shows the cell death probability predicted by the LEM I model. The yellow line and the light blue line show the cell death probability and the chromosome aberration probability predicted by the BIANCA model, respectively.

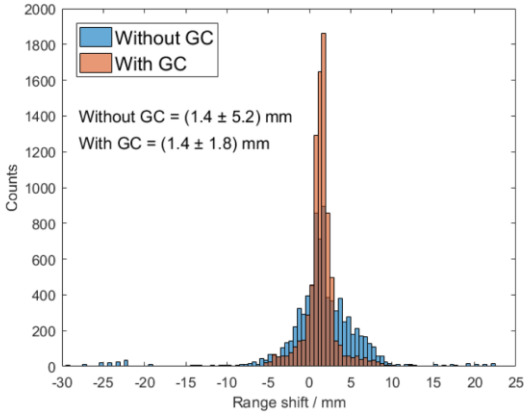
Geometrical Model to improve Accuracy of IBA Prompt Gamma Camera

Johannes Petzoldt with co-authors from OncoRay and IBA successfully published a study on a correction model that helps to improve accuracy and precision of a prompt gamma (PG) camera for range verification in proton therapy. The peer-reviewed paper is included in the special issue Diagnostics for Beam and Patient Monitoring of Instruments and is available online through open access.

While in theory with an infinite camera system, a Bragg peak shift directly translates into a shift of the PG profiles, small geometry depending variations of the profiles have been observed in measurements with the PG camera. Those variations are a result of the finite dimensions of the system and need to be corrected for in order to improve the comparison of the measurement with the fast analytical model which is used to determine the absolute range of a proton beam. In order to reduce those variations, the OMA Fellow at IBA developed a model that better resembles the geometrical response of the PG camera as some geometrical effects are not fully described in the analytical simulation. This geometrical correction is derived from Monte Carlo simulations in a water phantom using the MCNPX code. It was found that several parameters have an influence on the geometrical response: beam energy, shift along beam direction, and geometrical setup between camera, knife-edge slit collimator and isocenter. The effects are especially present at the edges of the recorded PG profiles and can differ by around 20 %.

In order to validate the model, Johannes performed a benchmark experiment together with researchers from OncoRay in Dresden, Germany.

Pencil beam scanning plans with energies between 100 and 190 MeV and very high doses were delivered by the IBA proton therapy system on a water phantom. The PG camera was aligned with an accuracy of 0.2 mm with the treatment room isocenter by using the in-room X-ray system resulting in very low measurement uncertainties. When applying the geometrical correction model to the experimental data, the measured PG profiles show very good agreement with the ones derived from analytical simulation. Furthermore, the corrected profiles show an improved precision for the range retrieval of 1.8 mm (2 sigma) in comparison to the non-corrected case with 5.2 mm (2 sigma). Furthermore, a small intrinsic offset between simulation and measurement of 1.4 mm could be observed in the water data. In summary, the developed model increases the range retrieval precision and the benchmark experiment could be used to fine-tune the analytical simulation in order to improve the absolute range accuracy of the PG camera.



Observed range shift in water measurement with and without applying geometrical correction.

Further information:

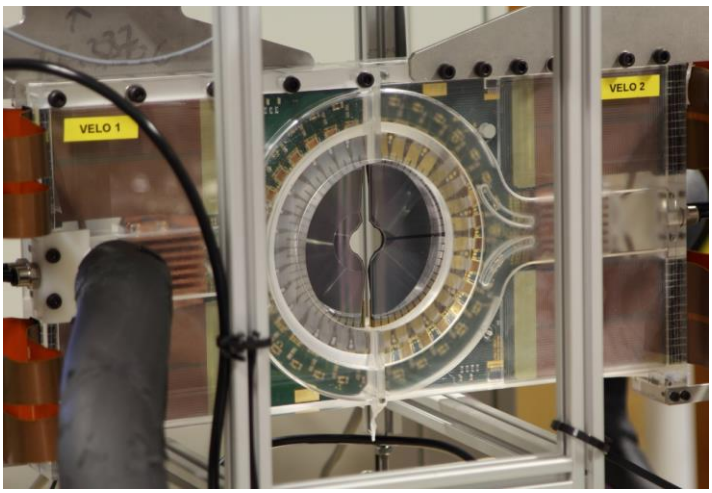
J Petzoldt, et al., *'Correction of Geometrical Effects of a Knife-Edge Slit Camera for Prompt Gamma-Based Range Verification in Proton Therapy'*, Instruments 2018, 2(4), 25 https://doi.org/10.3390/instruments2040025

Paper on the development of the VELO detector as a beam monitor for medical accelerators published

The first paper on the development of the LHCb VELO detector modules into a standalone, non-invasive online beam monitor for medical accelerators was published in the journal *Instruments*. This article is part of a special issue on "Beam and Patient Monitoring" based on the OMA topical workshop on “Diagnostics for Beam and Patient Monitoring” that was held at CERN in June 2018.

The paper summarises the extensive work and necessary changes on the VELO detector to operate it as a standalone system outside of the LHC environment performed by Roland Schnuerer. Build on the cooling, venting and positioning system designed by former QUASAR member Tomasz Cybulski, several hardware and software changes realised a synchronised readout with a locally constructed Faraday Cup and the RF frequency of a medical cyclotron with quasi-online monitoring. Further, co-author and OMA Fellow Jacinta Yap provided initial GEANT4 simulation to observe the beam behaviour in the integration zone.

The adapted VELO module is now ready to be used and plans are made to integrate the detector at the 40 MeV proton research beamline in Birmingham in March. These first tests will optimise the use of the detector for the 60 MeV proton therapy beamline at the Clatterbridge Cancer Centre (CCC), UK and the capability as a beam monitor will be assessed by measuring the beam current and by monitoring the beam profile along the beamline.



Further information:

R Schnuerer, J Yap, et al., *'Development of the LHCb VELO Detector Modules into a Standalone, Non-Invasive Online Beam Monitor for Medical Accelerators'*, Instruments 2019, 3(1), 1 https://doi.org/10.3390/instruments3010001

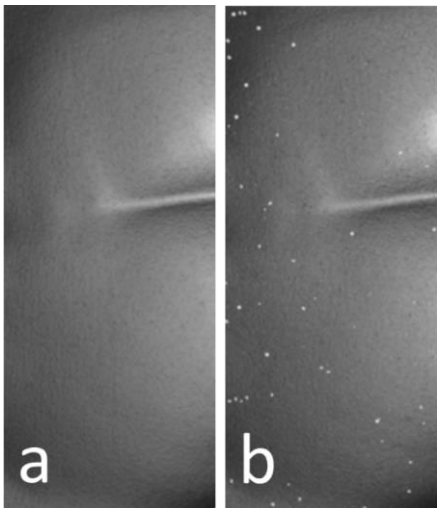
Studies in recognition performance reported by Vialux

Samuele Cotta, OMA Fellow based at ViALUX is studying the radiation hardness of the ViALUX 3D scanners to be used in radiotherapy. In a recent project report, he presented the results of a study about the recognition performance of a 3D scanner irradiated with neutrons.

Last September a test with thermal and fast neutrons was performed at the FRM II research reactor in Munich. Single electronic components and a whole 3D scanner were exposed to a high neutron flux in order to reproduce in a shorter time the effects that could be observed during months of operation in a treatment room. The devices under test worked without any big issues during the irradiation and only few interruptions of the device functionality were observed and suddenly recovered through a simple re-initialization. After the tests, the irradiated 3D scanner was object of further analysis to evaluate the possible damages caused by the radiation in the CMOS image sensor, which is a key component of the ViALUX 3D scanners.

Test setup at ViALUX GmbH

The most common effect caused by the radiation is the sensor performance degradation due to the increase of the number of bright pixels, which cause a sort of fix-pattern noise in the CMOS. Several 3D images of a plastic body model were acquired to evaluate if and how these bright pixels can affect the quality of the 3D scanning process.



Detail of a 3D image of the body model acquired with an exposure time of 50 ms (a) and 250 ms (b).

The acquired 3D images showed no issues at all when the typical exposure time values (5-25 ms) are used. Even with a higher exposure time (50 ms) no effect were observed (see a) and, only increasing it up to 250 ms, few missing 3D points were observed (see b).

Samuele is now considering possible solutions to further improve the radiation hardness of the device, even if the tests have already given a positive feedback about the reliability of the ViALUX devices.

Network News

OMA Steering Committee met in Brussels

The OMA Steering Committee met in Brussels just before Christmas. The day-long meeting took place in the Brussels office of the Helmholtz Association on Tuesday, 18 December 2018. Dr Christian Graeff and Michelle Lis (GSI, Germany), Johannes Petzoldt (IBA, Belgium), Dr Miguel Cortes Giraldo (CNA, Spain) all joined the meeting which was chaired by OMA Coordinator Professor Carsten Welsch (Liverpool, UK).

The OMA Steering Committee in front of the European Parliament in Brussels.

With the network now running at full speed, there were many exciting research results to discuss, along with reviewing the large number of Fellow trainings and outreach activities. The committee found the overall progress made in the network very impressive and commended the Fellows on their good work – in particular as more collaborative R&D activities are now emerging, directly benefiting from the OMA network.

The Steering Committee welcomed Dr Giraldo formally as new member after Professor Joaquin Gomez Camacho had announced that he would step down as university representative in the committee. Dr Giraldo brings along a wealth of expertise in R&D at accelerator facilities and has been involved in the OMA project since the start. The committee also approved the accession of two new adjunct partner institutions: The Centre for the Clinical Applications of Particles at Imperial College and the Spanish company Added Value Solutions were welcomed as formal partners in OMA. Both have agreed to contribute actively to the network's wide-ranging research and training program and will also offer additional secondment opportunities for the Fellows.

A focus of the discussion was on the planning of several international events that will be organized throughout 2019. This includes an Advanced School on Medical Accelerators and Particle Therapy that will be held in Vienna, Austria between 1st - 5th April 2019, an advanced researcher skills week that will be organized for all OMA Fellows and Fellows from the AVA network in June, an international Outreach Symposium on 28th June 2019 that will be held in Liverpool and which will be broadcasted around the world, and an international conference on medical accelerators that will be held in Seville, Spain between 4-6 September.

Exciting plans were drawn up and the committee was very optimistic about this final part of the OMA project. The next meeting was scheduled to take place on the Wednesday afternoon during the OMA School in Vienna.

3rd OMA Topical Workshop held at GSI

Participants at the OMA Workshop.

A workshop on *Accelerator Design and Diagnostics* was held at GSI in Darmstadt, Germany, on 10th - 12th December, 2018. Speakers discussed the latest developments in technology for accelerator beam monitoring. The scientific discussions were lead by invited plenary speakers, OMA Fellows and external participants and included over 30 delegates. The workshop linked OMA work package 2, *Beam Imaging and Diagnostics,* with work package 4, *Facility Design and Optimisation*. Talks included discussions across a wide range of medical facilities and applications and can be found on the event homepage.

The contributors from across Europe discussed challenges related to implementing accelerator diagnostics and how advances in beam monitoring can help design better particle therapy treatment facilities. Participants particularly enjoyed hearing from Dr. Christian Graeff on the challenges and trends in imaging technologies at medical accelerators and from Marco Schippers on future of technology for particle therapy treatments.

The visit included a trip to the construction site of the new major accelerator facility FAIR which is currently being built at GSI. Additionally, the participants visited the former particle therapy treatment facility at GSI which used scanned carbon ion beams clinically during a pilot project including 440 patients at GSI.

Information on previous workshops and all contributions can be found on the OMA website.

Special Issue of *Instruments* on Diagnostics for Beam and Patient Monitoring released

A special issue of the journal *Instruments* has been published, based on the research that was presented at the 2nd OMA Topical Workshop, "Diagnostics for Beam and Patient Monitoring".

This workshop took place at CERN in June 2018 and was attended by over 50 experts, from both within the OMA network as well as external participants, in charged particle beam diagnostics, control system development, and patient imaging. Technologies for non-invasive beam imaging were presented, as well as innovations based on prompt gamma imaging and 4D patient monitoring.

The journal has peer-reviewed all articles, following its normal review procedures and guaranteeing high quality of all published papers.

Outreach Update at UCL

The OMA network and the University College London (UCL) highly value the positive impact of scientific outreach events, which help to popularise science and raises awareness and interest in young people. Outreach events create links between the general public and scientists whose research is often publicly funded.

Dr Simon Jolly, OMA principal investigator at UCL, was invited to give a talk at the Royal Institute in October about *"How particle accelerators are used to cure cancer"*. In his talk, Simon began from the first principles to explain how cancer develops in a previously healthy human body. He then covers the basics of conventional radiotherapy using X-rays, highlighting the differences compared with proton radiotherapy. Simon also gave an update on the state of the proton therapy centre currently being built at UCL and scheduled to be operational in 2020. To conclude, he offered a unique insight into the impact of the treatment on the life of a young patient.

After receiving much positive feedback, OMA Fellow Laurent Kelleter went on to give a slightly shortened version of Simon's talk at JFS school in north London. Together with the groups Post-Doc Raffaella Radogna, Laurent talked about the physics and biology of proton therapy in front of about 25 interested students, which was Laurent's third outreach activity in a high school since the start of the OMA project.

Simon's talk at the Royal Institution is now available online:
https://www.youtube.com/watch?v=8YnQkUWTS64

New Fellow joins OMA

Charalampos Kalantzopoulos is the newest Fellow to join the OMA project. He obtained his 5-year diploma in Mechanical Engineering from Technical University of Crete, Greece. He followed a MSc in Biomedical Engineering, KU Leuven, Belgium. Through this study, he collaborated with other institutes and companies including Imec, KU Leuven, UZ Leuven, Qaelum NV and Icometrix. He completed his Master's thesis in collaboration with Icometrix, a Leuven-based company specializing on medical imaging processing and biomarkers. His topic was on 3D MRI processing on patients suffering from Multiple Sclerosis, to extract biomarkers for the disease located on the upper cervical spinal cord.
In November 2018 he began work as a scientific researcher in close collaboration with CNAO, Pavia and Polytechnico di Milano. The aim of his research is to provide motion modelling strategies for MRI data in order to quantify organ motion in abdominal area of the patients treated with particle therapy. This is done to quantify and correct for variations of the patients' respiratory motion.
The main goal of the project is to explore deformable registration methods such as Optical Flow Algorithm to track the movement of the region of interest (ROI) (e.g. tumour, organs at risk). This will allow to define treatment planning margins based on the motion quantified by cine-MRI data, which will be compared with conventional margins defined on the 4DCT dataset.Both geometrical and dosimetrical comparisons will be performed.
The proposed approach will be validated relying on phantom simulations or by exploiting treatment data provided by the experts. Motion modelling techniques will be also considered to explore the possibility of updating the planning CT with the motion provided by MRI data.

fondazione CNAO
Centro Nazionale di Adroterapia Oncologica

New OMA Steering Committee member appointed

Dr Miguel A. Cortés-Giraldo joined the OMA Steering Committee in December 2018. He brings his expertise in radiation therapy and biophysics to the committee.

He studied Physics at the University of Seville, graduating in 2006 and obtaining the First Prize for Excellence in Academic Performance in Spain of his year. His PhD focused on the development and application of Monte Carlo tools in radiation therapy physics. He contributed in the development of a patented detection system for radiotherapy treatment verification, obtaining his PhD in 2011.

Dr Cortés-Giraldo is now an Associate Professor at the Department of Atomic, Molecular and Nuclear Physics. His main research is related with the development and use of Monte Carlo codes for radiobiology with protons, but he has also worked in simulations applied to a wide variety of research topics, from neutron physics to radiation dosimetry in aircrafts. Furthermore, he has participated in the design of proton beam lines optimized for radiobiology experiments at the Centro Nacional de Aceleradores (CNA; Seville, Spain), and actively collaborates with the Roberts Proton Therapy Center / University of Pennsylvania (Philadelphia, PA, USA) and the Technological Institute of Aeronautics (São José dos Campos, SP, Brazil). He is also a member of Geant4 and n_TOF collaborations.

Dr Cortés-Giraldo has supervised one PhD thesis and is currently supervising three PhD projects. He has published over 40 papers in scientific journals and a book, for the general public, on Biophysics.

Upcoming OMA Events

Advanced School on Medical Accelerators and Particle Therapy

1st - 5th April 2019, TU Vienna & MedAustron, Austria

A scientific school will take place at TU Vienna from 1st - 5th April 2019 in partnership with MedAustron. The school will cover advanced topics in particle therapy including Radiobiology, Beam Diagnostics, 4D Imaging and treatment delivery over a 5-day school and is open to students and researchers with an interest in all aspects of Medical Physics and Accelerators.

The school will also feature an opportunity to learn from leaders in the field of Particle Therapy and a visit to the MedAustron site.

This advanced school is a core training element for all OMA Fellows.

More information and how to register can be found here.

OMA Advanced Researcher Skills Week

24th-27th June 2019, University of Liverpool, UK

An advanced research skills training week will take place at the University of Liverpool. This workshop will provide dedicated and practical training on the subjects of research communication, career development, industrial commercialization, networking and grant writing. The workshop is organised in conjunction with the AVA Network.

Accelerators for Science and Society Symposium

28th June 2019, ACC, Liverpool, UK

The University of Liverpool will host a public outreach symposium organised by the OMA and AVA networks, as well as the LIV.DAT Centre for Doctoral Training. This international Symposium will provide an opportunity for the research of these projects to be presented to the general public, including GSCE and A-level students.

All presentations will be live-streamed and partner organisations are encourage to host local seminars to take part in this unique event.

More information will soon be available via the project webpage.

Conference on Optimization of Medical Accelerators

4th - 6th September 2019, University of Seville, Spain

We are delighted to announce a 3-day International Conference on the Optimization of Medical Accelerators in Seville, Spain from 4th to 6th September 2019.

The conference will be hosted by OMA partner University of Seville/Centro Nacional de Aceleradores (CNA).

This international conference will be an ideal place to present and discuss research advances in beam and patient imaging, simulation studies into beam transport and treatment planning, as well as the facility and beam transport line optimization. The conference will feature several keynote talks and will also showcase the research outcomes from OMA by the project's Fellows and researchers from around the world. It will offer the opportunity for contributed talks and poster contributions, as well as ample of room to discuss future R&D activities in this multi-disciplinary field. Proceedings will be published in a refereed journal. Full details will be communicated via the OMA homepage and our usual social media channels.

Other Events

Symposium Particle Colliders - Accelerating Innovation

22nd March 2019, Liverpool, UK

The University of Liverpool and CERN, together with partners from the FCC/EuroCirCol projects, will host a symposium to showcase the science and technology challenges related to a potential Future Circular Collider (FCC).

The FCC study is a global collaboration, supported by the H2020 EuroCirCol project, to investigate options for a future higher energy particle collider.
This event will take place in the Liverpool Arena and Convention Centre on 22nd March 2019 and participation is free of charge. Its aim is to explore the opportunities opened by the FCC study for co-innovation in a variety of industries - not limited to particle colliders. Potential medical applications, imaging and data handling techniques – all important aspects in OMA – for example will be discussed. Thereby, the event offers companies and research groups an ideal opportunity to discuss and setup future joint developments of advanced technologies.

For more information and to register please visit https://indico.cern.ch/event/747618

10th International Particle Accelerator Conference

19th - 24th May 2019, Melbourne, Australia

IPAC is the main international event for the worldwide accelerator community and industry. Attendees will be presented with cutting-edge accelerator research and development results and gain the latest insights into accelerator facilities across the globe. With over 1000 delegates and 70 industry exhibits this is a unique opportunity to network with, learn from and meet a wide range of decision makers, opinion leaders, buyers and new kids on the block.
Fellows and partners from OMA will be at IPAC'19 presenting talks and posters and we look forward to meeting you all at **Booth D13** in the main exhibition hall.

Fellows Activity

European Researcher Night celebrated by Samuele Cotta

European Researchers' night 2018 took place on 28th - 29th September and was celebrated in many cities all around the Europe with the contribution of universities and research institutions. The aim of this event is to bring together researchers from different fields in order to promote science among children, young students and people usually not involved in science.

The Insubria University, an Italian university which is based in Como and Varese, organized outreach activities along all the week, from public conferences to hands-on experiments for everyone.

Samuele Cotta, the OMA Fellow based at ViALUX, took part in these activities as a former student of the Insubria University. On 28th September several physics experiments were prepared in a central square in Como, involving the classes coming from the schools of the city. Explaining experiments to students with different age and knowledge (from kindergarten to high school) was a challenging experience, but it showed how science is suitable for everyone and can raise enthusiasm in everyone. On the 29th September the activities were performed again in Varese, this time involving all the people who were enjoying the sunny Saturday afternoon in the city center, in particular families with children, but also teenagers and older people.

Samuele Cotta presented the Wimshurst machine, which, besides amusing the audience with amazing small lightning, offers a good starting point to explain what electricity is and what happens during a thunderstorm.

Jacinta Yap presents R&D results down under at EPSM

Jacinta Yap presenting a talk at EPSM, Australia.

The annual EPSM 'Engineering & Physical Sciences in Medicine' conference was held from 29th - 31st October in Adelaide, Australia. This national meeting is one of the major events for medical physicists, biomedical engineers, researchers, medical professionals and others in the field within Australasia. This year's theme was 'Science Fusion: Innovation through Diversity', touching upon the importance of interdisciplinary collaboration for progress in the industry. The scientific talks covered many areas; radiobiology, medical imaging, radiation protection, modelling, nuclear medicine, dosimetry, radiotherapy, hadron therapy nanoparticles, treatment planning as well as informational sessions such as publication writing and education. Both international and national speakers were invited to give keynote speeches, including Prof. Harald Paganetti from Massachusetts General Hospital & Harvard Medical School who presented on RBE of proton therapy. The highlight on particle therapy was especially welcomed as it was only recently announced that Australia is finally due to establish a proton therapy facility [1], the Australian Bragg Centre for Proton Therapy in Adelaide, just down the road from the conference venue. This will be the first in Australia and is due to start treatments in 2022.

OMA Fellow Jacinta Yap gave a talk during the hadron therapy session on *"Monte Carlo modelling of the Clatterbridge Eye Proton Therapy beam line"*. She presented recent modelling work and experimental results contributing to the development and optimisation of the VELO standalone beam monitor for the Clatterbridge beamline. This involved a study of the beam dynamics and validation measurements in order to improve upon and verify the current Clatterbridge Geant4 model. This is essential for simulations to benchmark the VELO module measurements of the proton beam halo and for correlation with the total dose delivered.

[1] Penfold, S. A positive move: proton therapy in Australia. Australas. Phys. Eng. Sci. Med. 2018, 41, 1–2, doi:10.1007/s13246-018-0621-3.

Michelle Lis delivers outreach talk on medical and health physics careers

Michelle Lis presenting an outreach talk at Loyola University Chicago.

In November, Michelle Lis, OMA Fellow at GSI and Medical Physics PhD student at Louisiana State University delivered an outreach presentation at her Alma Mater, Loyola University Chicago. Her presentation *"Careers in Health and Medical Physics"* was warmly received by the students and faculty of the physics department. The event was organised with several members of Loyola's physics faculty, including Dr. Rasinariu and Dr. McNees, as part of a physics seminars series held every Thursday.

Michelle Lis' talk was devoted to enlightening interested students on the educational and exam requirements for a variety of career paths within medical physics and health physics in the USA. She began by describing the roles and responsibilities of each profession, then broke down steps to becoming a practicing physicist. Finally, she described research opportunities, Fellowships, and her personal efforts to stand out. She also shared some information on ongoing research, including her own, and ended by providing a variety of resources on more information for these opportunities. The information presented at this talk will be influential to both the students and professors.

The audience was very interested in the information and eager to apply it in the future. Loyola University's Department of Physics is currently developing a 5 year BS – MSc combined program in medical physics, and valued the input and resources that Michelle provided. Michelle Lis will be continuing to collaborate with the department to help structure the program and share additional opportunities .

Anna Vnuchenko attends a course of Scientific writing

OMA Fellow Anna Vnuchenko, based at IFIC, attended a two days course on communicating research and scientific writing. The training course, organized by the well-known Institution, SISSA Medialab Srl (Trieste, Italy) was held on 5th - 6th December 2018 at CERN. Communicating research is an integral part of the work of a scientist and to do it well requires specific skills. The course provided the tools and techniques to set up a communication project. This included identifying the main research ideas and transferring the ideas to a specific audience. The workshop gave advice on how to prepare and structure clear, concise content for scientific presentations and how to develop visual aids which convey key messages. The course also addressed details including layout, font, bibliography format of writing scientific articles, reports and thesis. The training was very informative for our Fellow and helped improve her communication skills.

Navrit Bal attends BND Particle Physics School and makes progress with Medipix3

As is tradition at Nikhef, Navrit Bal attended the annual BND (Belgium Netherlands Germany) graduate school in particle physics, based in the outskirts of Berlin this year. Topics included in-depth QCD and QFT. The most relevant lecture for him was *"Biology with Accelerators (Petra, LCLS, XFEL)"* by Dr Dominik Oberthuer where the Medipix3 chips were mentioned.

At the end of August 2018, Navrit uncovered some very low level problems with the driver used for control and readout of the Medipix3 detector. That driver was never tested for high frame rate readout until then. The problems found included: Chips lost synchronisation between each other at any frame rate immediately; The driver claims packets were lost when they were not, it just could not take them from the kernel fast enough; When saving to disk, frames would not update after some time. It seems this is due to a circular buffer filling and not being processed quickly enough to correct itself.

For these reasons, a new Medipix3 driver is under development. Initially, the work started out as a quick test to try to debug the current driver, however, after improved results (0 ns overhead) on the first part of the new driver, it has continued development with a colleague at ASI. Having been rewritten, integrated into the software and tested, this is being deployed to customers.

Anna Barratto Roldán realizes her first secondment at GSI

Anna Baratto Roldán, OMA Fellow based at the CNA in Seville, visited GSI from the 4th of November to the 15th of December for her first secondment. During this fruitful period, she joined the Biophysics group under the supervision of Dr. Michael Scholz and learned about basic radiobiology techniques, receiving training on the methods for the preparation and irradiation of cell samples, the measurement of growth curves and cell survival curves, and subsequent analysis of samples.

The aim of this training period was to learn about the biology-specific language and methods, and to understand in deeper detail the needs of a facility for radiobiology experiments, in view of a future collaboration with biologist groups in Seville for the irradiation of cell samples at the CNA cyclotron facility. Anna carried out her first radiobiology experiments irradiating CHO cell samples with X-rays. Another secondment is foreseen in the next months, during a GSI beam time period, so that irradiations with carbon and other ions will also be possible.

Anna also took the opportunity to visit the UNILAC experimental cave for radiobiology experiments at the GSI, talking with different experts about the setup for the irradiation of cell samples, and discussing possible improvements of the setup currently installed at the CNA cyclotron facility.

These conversations were very helpful and provoked many questions, giving rise to new ideas and solutions for future work.

Partner News

The Christie treats first patients with high energy protons

The Christie NHS
NHS Foundation Trust

New proton-beam therapy centre at the Christie hospital, in Manchester (Source: BBC)

The first patients have been treated at the newly opened proton therapy centre at the Christie hospital in Manchester, UK. It has been reported by the BBC that fifteen-year-old Mason Kettley, who has a rare brain cancer, will be amongst the first treated.

This facility is the first of its kind to treat cancer patients with high energy protons in the UK. Previously, patients needing this type of treatment had to go abroad. Proton therapy targets cancer cells without damaging the healthy tissue around the tumour. This is particularly important when treating children. The type of tumour Mason has cannot be operated on because of a risk of blindness and other complications.

The Christie hospital centre which opened in autumn 2018 is one of two new high energy NHS proton beam therapy (PBT) centres which will be operated in the UK, the other centre being at the University College London Hospitals. In addition, several private treatment facilities are expected to open over the next few years.

Research within our OMA project aims to improve PBT facilities through research carried out in close collaboration between partner institutions across Europe, including the Christie Hospital. OMA covers research on Beam Imaging and Diagnostics, Treatment Optimization, as well as Facility Design and Optimization as its main work packages, all aimed at enhancing cancer treatment using ion beams.

The new UK-based facilities will improve the healthcare for cancer patients requiring proton beam therapy. Of Mason's experiences as a patient, he remarked that they have influenced his future career plans, saying *"I'm so grateful to all the doctors involved in my care and I'd love to do what they do one day - it will be my way of giving something back."*

OMA project welcomes new adjunct partners

The OMA consortium has been joined by two adjunct partners: The Centre for the Clinical Application of Particles Imperial College and Added Value Solutions, approved at the last OMA Steering Committee meeting.

The Centre for the Clinical Application of Particles (CCAP) is an interdisciplinary collaboration of staff from the Faculty of Medicine, the Imperial Academic Health Science Centre, the Department of Physics, the Imperial CRUK Cancer Centre, the Institute of Cancer Research, the John Adams Institute and the Oxford Institute for Radiation Oncology. The principal objectives of the CCAP are to deliver a broad programme of measurement of the radiobiological effect of particle beams and systematic studies of radiobiological mechanisms; develop novel, compact, laser-driven accelerator systems for clinical applications; and develop novel diagnostic, imaging, data-processing, and machine-learning techniques.

Added Value Industrial Engineering Solutions S.L.U. is an international company which provides technology-based services to innovative and challenging projects, mainly for Big Science projects in the field of Nuclear Fusion, Accelerators, High power LASERs, Space, Neutron Sources and Astrophysics. Strongly focused on the development of outstanding devices, instruments, mechanisms and structures, their expertise covers design, manufacturing, assembly, tests and supply under ISO 9001 EN 9100, providing to our customers all the way up from the conceptual design to the turnkey solution.

Both complement the expertise in OMA and offer additional research and secondment opportunities to the network's Fellows.

Dr Miguel Cortés-Giraldo presents proton therapy to the general public

On 21st January OMA Steering Committee Member Dr. Miguel A. Cortés-Giraldo gave a talk at the Faculty of Physics of the University of Seville entitled *"Use of Monte Carlo techniques to model radiobiological effects in proton therapy treatments"*. His talk was organized by the Royal Academy of Science of Seville and was open for the general public.

During the talk, Dr. Cortes-Giraldo showed some of his R&D in this area, including the research carried out by OMA Fellow Anna Baratto-Roldán. He showed the physical and radiobiological advantages of proton therapy with respect to traditional radiotherapy techniques using photon or electron beams, and also explained the essentials of how Monte Carlo codes are used to model radiation transport in matter.

OMA Events

April 1st – 5th 2019	Advanced School on Medical Accelerators and Particle Therapy, Vienna, Austria
June 24th – 27th 2019	Advanced Researcher Skills and Technology Transfer Workshops, Liverpool, UK
June 28th 2019	Symposium: Accelerators for Science and Society, ACC Liverpool, UK
September 4th – 6th 2019	International Conference on Optimization of Medical Accelerators, Seville, Spain

Other Events

March 22nd 2019	Symposium: Particle Colliders – Accelerating Innovation, ACC Liverpool, UK
May 19th – 24th 2019	IPAC'19, Melbourne Convention & Exhibition Centre, Australia
June 10th - 15th 2019	PTCOG58, Manchester, UK
July 1st - 3rd 2019	ENLIGHT Annual Meeting and Training, Caen, France

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

DEADLINE FOR THE NEXT NEWSLETTER **24th March 2019**

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