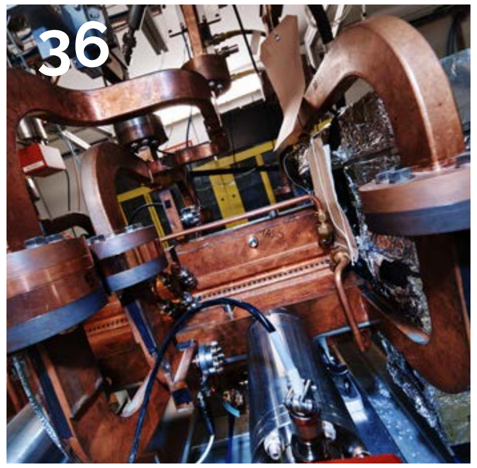
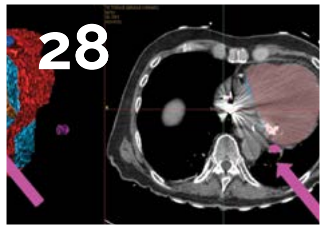
ENLIGHT

HIGHLIGHTS
December 2020

PAGE **INDEX**





HIGHLIGHTS EDITORIAL TEAM

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ENLIGHT COORDINATOR

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20 years of ENLIGHT at CERN

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20 Years of ENLIGHT: ready for adulthood

FROM THE ENLIGHT COORDINATOR

Manjit Dosanjh

2020 has been no ordinary year. We all had to slow down and even hadrontherapy centres have seen the number of treatments decrease because of the travel restrictions and challenges imposed on the hospital staff by the pandemic. The Coronavirus has impacted all of us, in one way or another. But it didn't stop our studies and even the development of new technologies, such as FLASH. It didn't stop our visionary projects for the diffusion of radiation therapy in developing countries. The online modality was a huge limitation for our social activities, which nurture the network. However, it allowed us to give voice also to people who are usually not able to travel and that can't easily be represented.

2020 was also our anniversary year. Our Network has gone through two decades, which sounds almost incredible to me and, I am sure, to all those who were at CERN in 2000 when the PIMMS study was presented and ENLIGHT started to take form. These twenty years at CERN have been for me an amazing journey, which has been exciting, stimulating, challenging but never dull. I entered another world when I joined CERN and found the joy of discovery of a new science discipline, people from all over the world, entirely-new international culture and new ways of working and collaborating for reaching the ultimate goal and the trials and tribulations of how to be patient for nearly 20 years for once in a life adventure of the world renowned "LHC". It has given me an amazing opportunity for my personal journey, which allowed me to discover the four corners of the world, closely following the tremendous progress that has been made in the field of cancer and the technologies that have emerged to combat this huge societal challenge.

We had dreams, we had hopes, we had a vision. Twenty years later, we can proudly say that we have achieved a lot. We are now ready for the next two decades and for adulthood. The challenges ahead of us are neither fewer nor less ambitious than those we faced twenty years ago but we are ready to take them on. Our network is strong and still unique, it has (and, it shares!) the expertise for supporting new projects, for training new experts and for developing new studies. Over the years, we have come closer to patients: our workshops, meetings and conferences have helped our members reduce that gap – "from the lab to bed" – that prevents people from benefiting from the latest, cutting-edge technologies to combat cancer.

2020 has been a challenging year for all people but, in particular, for the cancer patients. Their life was tough enough without the virus. In some cases, diagnoses have been postponed, treatments had to be delayed. Science and medicine, our pillars, have been under the spotlight over the last months and this will continue for many months ahead. However, we know that budget sustainability will be an issue for all of us.

The post-Corona era has started and ENLIGHT will be there to support our members and their dreams, hopes and visions. I send my warmest season's greetings to you and your loved ones! Have a great 2021!

Years of ENLIGHT

Figure 1: *Cancer and Global warming sharing the status of modern global challenges.*

Figure 2: *Aarhus Street Food Festival, June 2017 in Denmark – the diversity of the flavours matched the diversity of the ideas and cultures coming together.*

Perspective

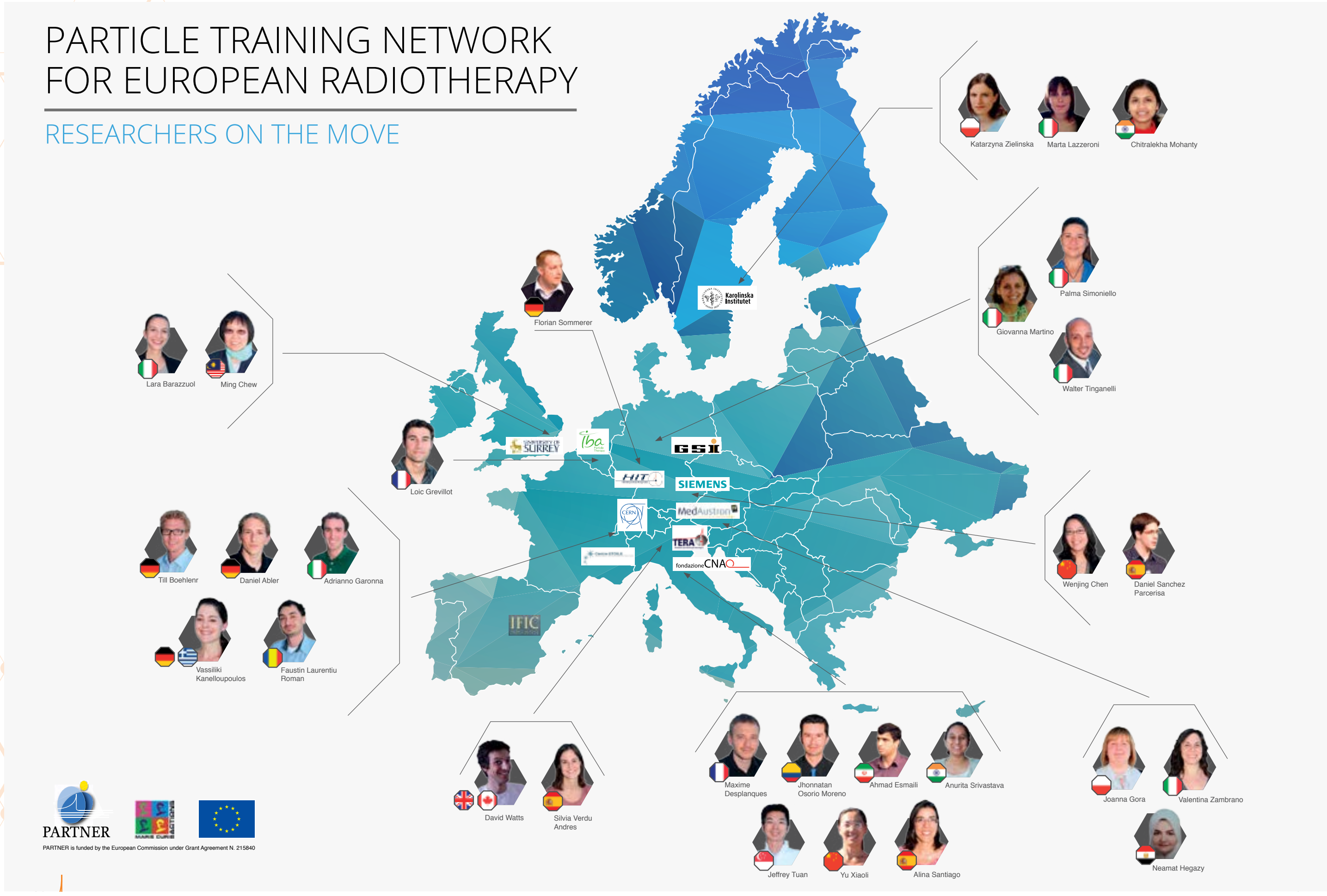


Figure 3: *ENLIGHT-ULICE meeting celebrating 60 years anniversary of CERN and 60 years of the first patient treated with protons at Berkeley.*

Perspective

Figure 4: *Launching of ENLIGHT, the first meeting in the CERN Council Chamber in February 2002.*

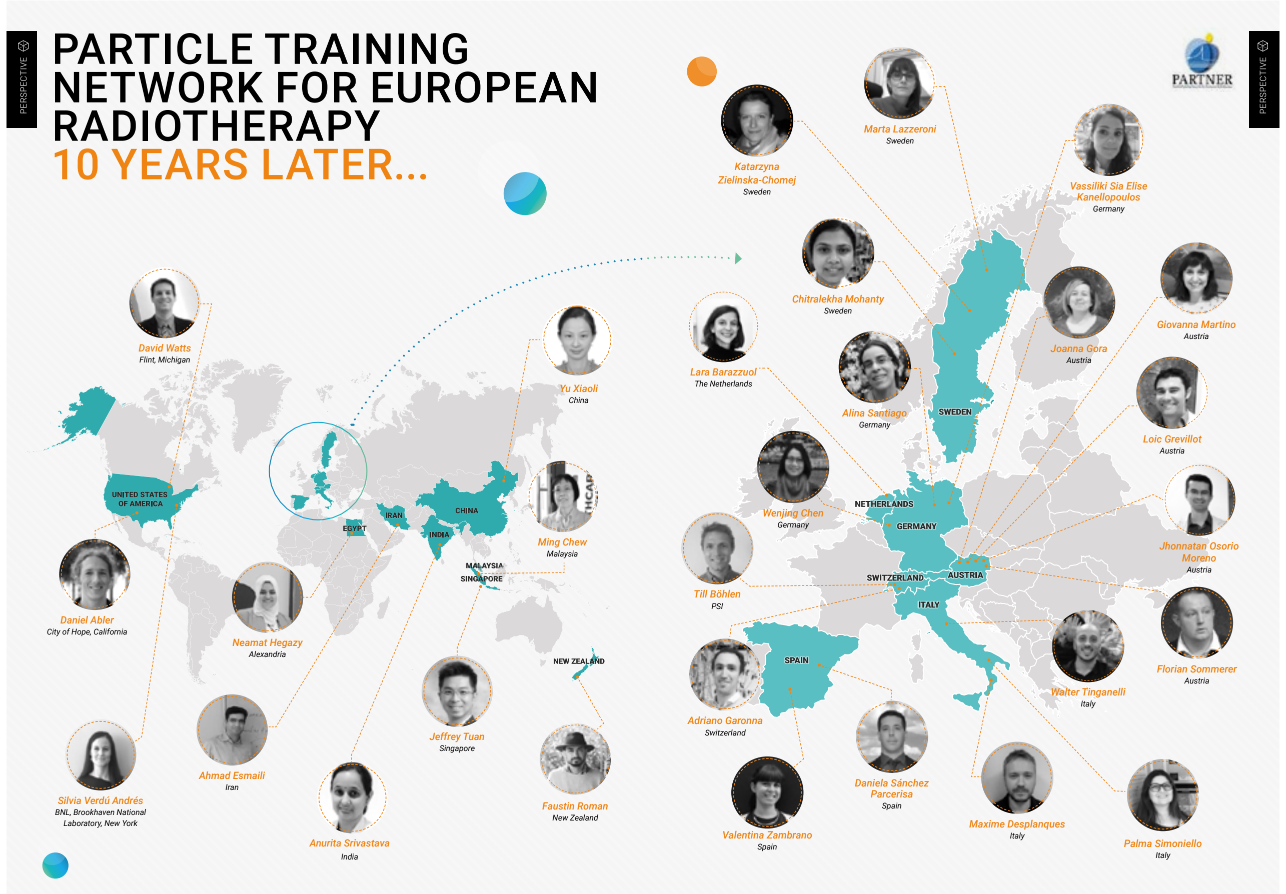


Figure 5: *Linacs for developing countries meeting in Botswana, 2019: Seeing first hand the clinical settings and hearing directly from front line staff on the challenges of providing cancer care in LMICs.*

Figure 6: *Participants of the ICTR-PHE 2016 meeting held in Geneva at CICG: conference to bridge gaps between disciplines for translational research from physics to medicine*

Figure 7: *Gemelli Clinic: Advanced Radiation Therapy and Art: Submarine bunker (painted by Silvio Irilli)*

Figure 8: *Members of ENLIGHT gathered in CNAO In Pavia in September 2012, to celebrate the 10th anniversary of the network*

Perspective

Figure 9: ENLIGHT network met at MedAustron in Wiener Neustadt, Austria to discuss the progress in particle therapy in 2013

Figure 10: Poster session at 2017 ENLIGHT Annual Meeting in Aarhus, Denmark

Figure 11: ENLIGHT Annual Meeting in Aarhus, Denmark, 2017

Perspective

The Skandion Clinic in Uppsala, Sweden

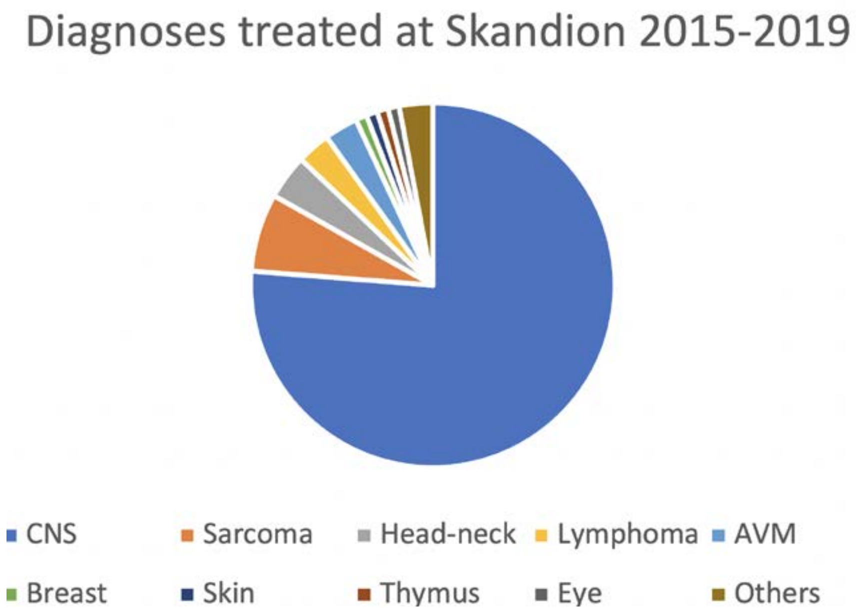
Particle therapy, the Scandinavian way

Cancer care in Sweden, Denmark and Norway is public and is covered through taxes. As such, all inhabitants have access to cancer therapies, including proton therapy whenever indicated. Despite the similarities, the principles are practiced differently among the countries. Here we will give a short review of how the use of particle therapy is implemented in the health systems in the Scandinavian countries. To get a view of which patients are offered particle therapy we will present current indications for treatment and actual data on patients treated with protons in the Scandinavian countries.

Sweden

The national proton centre, the Skandion Clinic, has been treating patients since August 2015. This unit has two gantries with scanning proton beams with a possibility for IMPT. Although the plan was to treat 1000 patients (15 000 fractions) per year, the ramping up process has been slower than expected, however the numbers are steadily increasing. Statistics from 2019 show that a total of 267 patients, including 29 patients referred from other countries (mainly Norway and Denmark), were treated. In Sweden, a decentralised solution was used to select patients for proton therapy. The construction of immobilization devices and treatment planning are done locally at the regional oncology units. The patients are then treated at Skandion in Uppsala. The Clinic building has an integrated hotel which provides a place for patients to stay while being treated. Doctors and physicists from the regional oncology clinics serve at Skandion on an exchange basis. Patient follow-up is also done locally. 70% of Skandion Clinic's financing is a fixed budget from the counties while the rest must be drawn from the regional radiation oncology departments' budgets. Because the cost of the proton treatment is covered by the counties, the need for the regional oncology clinics to cover 30% of the cost of proton therapy may influence their willingness to refer patients for proton therapy. This was not the intention from the start. It was also planned to recruit 80 % of the patients to be treated at Skandion for clinical trials. This part has proven more difficult and slower to be established as practically no money has been set aside for the research part of proton therapy in Sweden. So far only 35% of the patients have been included in clinical studies.

The expected indications for treatment at Skandion were initially described in a large report published in 2005, based on the experience from proton treatments so far both in Sweden (at The Svedberg laboratory) and internationally[1]. However, in re-



1 Glimelius B, AskA, BjelkengrenG, et al. Number of patients potentially eligible for proton therapy. Acta Oncol. 2005;44(8):836–849

The Danish Centre for Particle Therapy, Aarhus University Hospital

ality, the indications until now in Sweden have been quite limited with a focus on CNS tumours, both malignant and benign, and on pediatric tumours. All patients seen nationally are discussed at biweekly national videoconferences where the possible indications for proton therapy, including comparative photon treatment plans. This process has been a quality enhancement success for radiotherapy in general in Sweden.

Proton treatment techniques are quite challenging due to their sensitivity to set up and anatomical changes which require significantly more treatment planning capacity and adaptation than for photon therapy. One of the successes in the Swedish proton collaboration has also been the development of the logistics in the use of breath-hold techniques for treating thoracic tumours (e.g., lymphoma and thymoma) with protons. This includes preparing the breath-hold proton treatment plan at the patient's home clinic. Another important milestone is the pediatric radiotherapy treatments in Sweden which is now concentrated at Skandion. All Swedish children who are candidates for radiotherapy are discussed in a national videoconference and are offered proton therapy if appropriate.

A further explanation for the slow accrual of newly diagnosed patients for proton therapy are the evolving modern photon therapy techniques. This makes it more and more crucial to develop usable NTCP models for selection of the correct radiotherapy modality for the individual patient. In the very near future, the Skandion Clinic is planning to start proton treatments of patients with rectal cancer, anal cancer, lung cancer and breast cancer and to include as many patients as possible in clinical studies. Initiatives to strengthen the academic part of radiation oncology, and proton therapy in particular, are ongoing. The information is available in Swedish at the Skandion website:

https://skandionkliniken.se/en/.i

Denmark

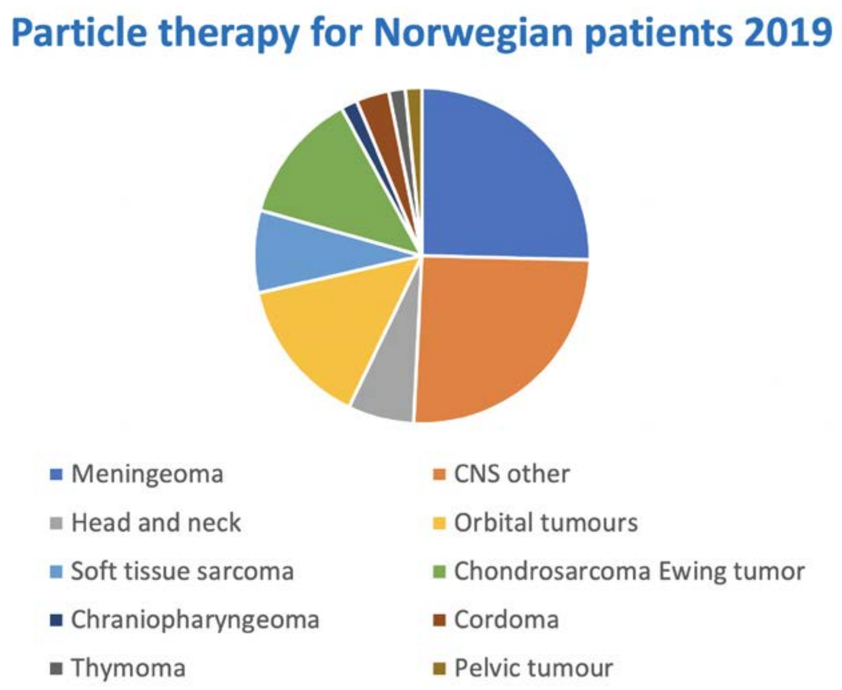
The Danish Centre for Particle Therapy (DCPT) is a national centre for proton therapy. It is hosted at Aarhus University Hospital and started clinical operation in January 2019. It is a multi-room facility with three gantry rooms with cone-beam CT for clinical treatment and a horizontal beam room for research, all with pencil beam scanning technology. The DCPT has dedicated CT- and MRI scanners.

From 2010 through 2018, selected Danish patients were sent to the US, Germany and Sweden for particle therapy, but since 2019 all relevant patients have received proton treatment at the DCPT. The first patients were treated for brain tumours. As today, we are treating children with cancer and adults with brain tumours, head and neck cancer, oesophageal cancer, breast cancer, sarcoma and rectal cancer. Future patient groups will be those with thymoma, lymphoma, liver cancer, anal cancer and high-risk prostate cancer. Most technologies were commissioned from day one. Anaesthesia for children was introduced in August 2019. We expect to treat the first patients with breath-hold technique in early 2021.

In 2019, 86 patients received proton therapy at the DCPT. With a reduced referral of patients because of the coronavirus, the number for 2020 will be lower than anticipated. Thus we expect to treat 200 patients in 2020 and to experience a gradual increase to our maximum capacity in 2024. DCPT is open for foreign patients and has so far treated a few foreign patients.

Almost all pediatric cases are referred directly and without photon-proton treatment plan comparison. In contrast, almost all adult patients are selected through a comparison of photon and proton treatment plans. The referring oncology centres are responsible for comparing the treatment plans and for selection of patients for proton therapy. The DCPT offers an educational program consisting of a teaching course with a number of workshops in proton therapy planning to ensure sufficient knowledge and skills in proton treatment planning. All patients are discussed at national virtual proton therapy conferences that are held all mornings and afternoons. If protons are preferred, the patient will be offered consultation, immobilisation and treatment plan scans the following day and will start proton therapy within a maximum of six workdays.

We are aiming for the inclusion of more than 80% of all patients in proton specific clinical trials. As of today, there are nine clinical trials open and four are in preparation. Three are phase III studies randomising patients between protons and photons: The DAHANCA 35 study randomising patients with head and neck cancer selected by a NTCP model, the DBCG-proton study randomising patients with breast cancer who will receive a high dose to the heart or ipsilateral lung with photons and the multicenter PROTECT study that will start randomising patients with oesophagal cancer for preoperative chemo-radiotherapy in early 2021. All clinical trials are initiated and led by the Danish Multidisciplinary Cancer Groups (DMCG) or international collaborator groups. Clinical trials on proton therapy are therefore sponsored by the DMCGs.



The establishment of DCPT was covered by a major grant from the AP Møller Foundation and the Danish State. This means that the price per treatment is equivalent to the running costs divided by the number of treatments. The DCPT received in the first years a fixed budget from the Danish Healthcare Regions, but after a ramp-up of 5 years, the DCPT will be financed solely by the reimbursement per treated patient.

For further information about DCPT, please see: https://www.en.auh.dk/departments/the-danish-centre-for-particle-therapy/

Norway

For Norway, one centre with 2 treatment rooms and one experimental room is planned in Oslo and one centre in Bergen with one treatment room and one experimental room. All rooms are equipped with gantries and scanned beams. The centres are based on an estimate that 12 % of all patients currently given radiation therapy will benefit from proton therapy. In practice, 80 – 85 % of the patients will be included in clinical studies. When the centres are operating, we plan to participate in randomised studies based on the Dutch NTCP selection model as pioneered by Langendijk. The centres are planned to open 2023 or 2024. The background for use of protons has recently been presented by Brandal et al. (Acta Oncol 2020). The ASTRO indications are mentioned in the text. The expenses for health care in Norway are covered by the Government except for a small symbolic fee (up to 250 euro). Proton therapy abroad is covered if the tumours are listed as approved indications (see **Table**). Carbon beam radiation is also covered for inoperable adenoid cystic carcinoma, mucosal malignant melanoma, chordoma, chondrosarcoma and selected radioresistant tumours.

In 2019, 56 patients were referred abroad for proton therapy and 7 for carbon ion radiation, see **Figure**. Half of them had CNS tumours and 21 % head and neck tumours. Unfortunately, the Covid-19 pandemic with travel restrictions has led to fewer referrals in 2020.

Petra Witt Nyström, The Skandion Clinic and DCPT

Morten Høyer, Århus

Olav Dahl, Bergen

The Norwegian list of indications for proton therapy is as follows:

Pediatric tumours:

- Chondrogenic sarcomas of the skull
- Spinal/paraspinal/pelvic sarcomas
- Rhabdomyosarcoma – orbital, parameningeal, head & neck, pelvis
- Ependymoma
- Ewings sarcoma
- Retinoblastoma
- Selected cases of low-grade gliomas
- Craniopharyngioma
- Pineal parenchymal tumours
- Esthesioneuroblastoma
- Medulloblastoma
- PNET
- Germinoma
- Locally aggressive semi malignant tumours of the skull/head (for instance giant cell tumours)
- Tumours in other locations where protons offer an advantage

Adult tumors:

- Chordoma
- Chondrosarcoma
- Spinal and paraspinal sarcomas
- Skull base meningiomas
- Pituitary adenoma
- Locally aggressive semi malignant tumours of the skull/head
- Selected cases of head and neck tumours (especially sinonasal).
- Reirradiation in selected sites - with dose-limiting previously performed photon treatment
- Low-grade glioma, centrally placed
- Medulloblastoma
- Ependymoma in need of spinal irradiation
- Tumours in pregnant women where the pelvic dose is a matter of concern

Eye tumours (mostly uveal melanomas)

The Norwegian list of indications for carbon ion therapy is as follows:

- Adenoid cystic carcinoma (inoperable)
- Mucosal malignant melanoma (inoperable)
- Chordoma and chondrosarcoma (inoperable)
- Selected cases of radioresistant tumours (inoperable)

Perspective

HITting the 10-YEAR mark

Introduction

In 1946 Robert Wilson concluded from the depth-dose characteristics of protons that charged particles could be used for treating localised cancers and not even ten years later the first patient was treated with protons in 1954 at the synchrocyclotron at the University of California, Berkeley. Since then, a number of research accelerators were adapted for treating cancer patients with charged particles. In Germany, a team of researchers of the GSI Helmholtz Center for Heavy Ion Research in Darmstadt, the German Cancer Research Center (DKFZ), the Helmholtz Center Dresden-Rossendorf (HZDR) and Heidelberg University Hospital initiated a pilot project for ion beam therapy in the 1990s and between 1997 and 2008, over 400 patients were successfully treated with carbon ion beams and the necessary experience was gathered for setting up a clinical facility in Heidelberg.

The planning and implementation of the Heidelberg Ion-Beam Therapy Center (HIT) were carried out under the general management of the GSI Helmholtz Center and in November 2001 the German Federal Scientific Council voted to fund the project. In 2009, the first patients underwent ion beam therapy at the horizontal beamline with protons and carbon ions.

Clinical Results and Clinical trials

Carbon ion irrCarbon ion irradiations (CIR) have a higher ionisation density compared to photons or protons and are therefore characterised by a high linear energy transfer and consequently by a high relative biological effectiveness (RBE). CIR exhibits its relative biological effectiveness (RBE) which is about 3- to 5-fold higher compared to photons and enables de-escalation of physical dose and thus sparing of critical structures like the optical nerve or the brain stem. Patients with skull base chordoma and chondrosarcoma were thus among the first patients treated at HIT. In a study within 155 patients, CIR was shown to be a safe and effective treatment for skull base chordoma that resulted in high local control and overall survival rates. For skull base chondrosarcoma, clinical results from 101 patients demonstrated safety and efficacy of CIR compared to proton beam radiotherapy at HIT. In 2012, HIT started operating the world's first heavy ion therapy facility with a 360° rotating-beam delivery system (gantry). The HIT gantry is 25 meters long and 13 meters in diameter with a total weight of 670 tons of which 600 tons can be rotated with submillimeter precision **(figure 1)**.

Being able to irradiate from different and multiple angles also greatly widened the treatment options for patients with tumours in locations otherwise difficult to treat, such as e.g. craniospinal irradiation of medulloblastoma.

Since 2009, more than 3000 patients were treated with protons and 3000 patients were treated with carbon ions at HIT, the vast majority within prospective trials. Currently, 14 clinical trials are recruiting and 9 trials are in follow-up or analysis phase. Six trials compare different radiation qualities or modalities and address the urgent need for randomised prospective trials studying particle beams. For example, patients with adenoid cystic carcinoma (ACC) of salivary glands benefit from Carbon ion irradiation (CIR) because of their high resistance to low-LET irradiation accompanied by a high radiosensitivity of the adjacent healthy salivary gland tissue. In the COSMIC trial, CIR was found to be superior to low-LET irradiation: Long-term- follow-up data up to 15 years, showed significantly higher local tumour control and also significantly higher overall survival in patients treated with IMRT and additional carbon ion boost. A dosimetric comparison of a photon beam radiotherapy plan and a corresponding carbon ion beam radiotherapy (CIR) plan for a patient with an ACC of the parotid gland is demonstrated in figure 5. In the currently recruiting successor trial ACCO, IMRT with carbon ion boost is being compared to carbon ion treatment alone.

> ***"Between 1997 and 2008, over 400 patients were successfully treated with carbon ion beams and the necessary experience was gathered for setting up a clinical facility in Heidelberg."***

Figure 1: *HIT rotable carbon ion gantry can be rotated with submillimiter precision.*

Perspective

Figure 2: Thermo-formed plastic face mask.

Figure 3: *Beam guidance and synchrotron at the Heidelberg Ion Beam Therapy Center (HIT). Ion sources generate ions that are accelerated to a tenth of their speed in high-frequency structures. In the synchrotron six 60° magnets keep the ion beams on a circular path where the speed of the ions is increased to up to 75% of the speed of light. The therapy beam is guided and bundled by magnets in vacuum tubes to one of the three treatment rooms where the patient is placed on a radiation table that is precisely adjusted by a computer-controlled robot, or to the experimental room. With a digital X-ray system or a mobile CT, anatomic positions are monitored. The gantry offers a rotatable radiation source with sub-millimeter precision for irradiation at an optimal angle. An additional beam guidance leads to the experimental area.*

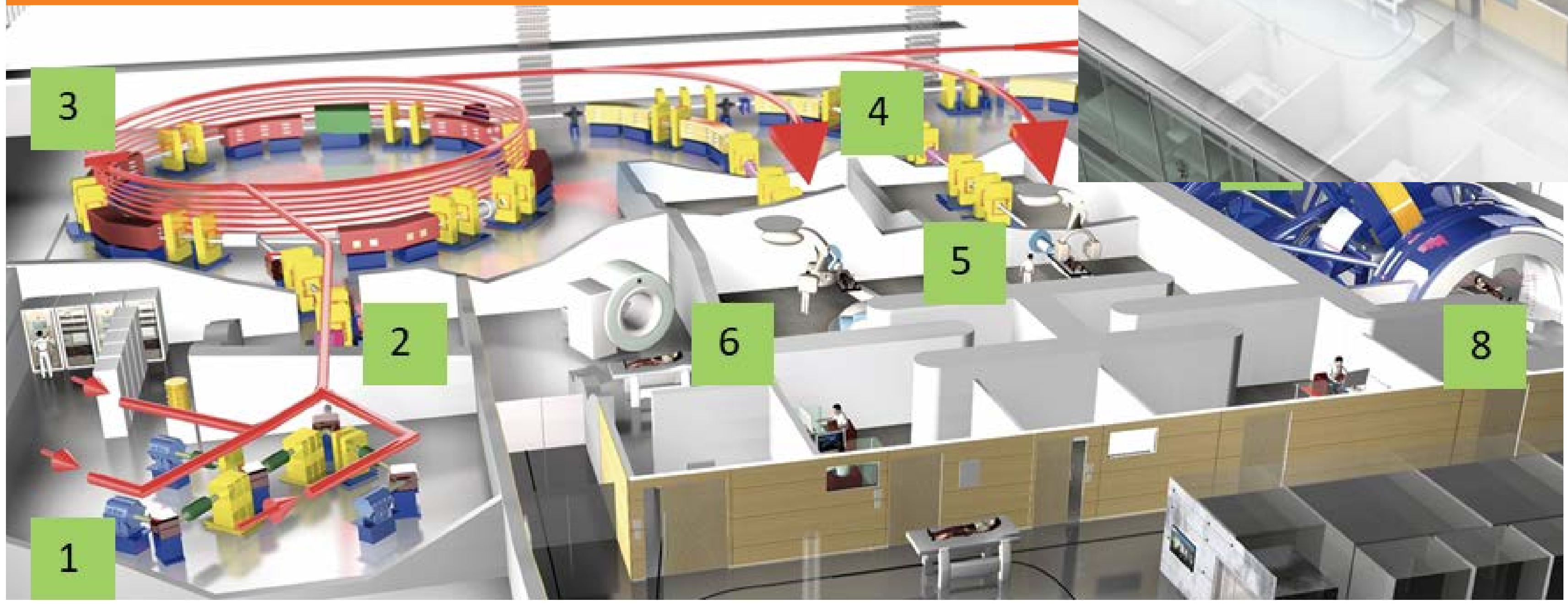


Figure 4: *The (1) ion sources: beams of positively charged ions are generated. Hydrogen gas is used to extract protons and carbon dioxide is used to extract carbon ions. Helium gas is used to extract helium ions. (2) Ions are accelerated in high-frequency structures to a tenth of the speed of light. (3) Synchrotron: Six 60 ° magnets keep the ion beams on a circular path. During around one million orbits, the speed of the ions is increased to up to 75% of the speed of light. (4) On the way to the treatment room: The therapy beam is guided and bundled by magnets in vacuum tubes. (5) The patient is placed on a radiation table that is precisely adjusted by a computer-controlled robot. (6) Position control: With a digital X-ray system and/ OR CT, images are generated before the irradiation. A computer program compares this with the treatment planning for the exact adjustment of the patient. (7) The gantry: With the rotatable radiation source, the therapy beam can be directed at the patient at the optimal angle. The gantry weighs 670 t, 600 t of which can be rotated with sub-millimeter precision. (8) Treatment in the gantry: Two rotating digital X-ray systems enable the position to be checked before the irradiation. (9) Beam guidance to the experimental area, e.g. for irradiation of tissue phantoms, cell cultures, mice and various other measurements.*

Most published data on particle beam radiotherapy are conducted with protons and evidence for proton beam radiotherapy is continuously rising for multiple indications. For example, patients with mediastinal lymphoma patients are at considerable risk for late effects because of their young age and excellent survival rates combined with the fact that lesions at mediastinum are in close proximity to important OAR, including the heart, breast, and lungs. Current research approaches focus on de-escalation on both chemotherapy and radiotherapy to reduce long-term treatment-related side effects. Studies at the HIT showed that proton beam radiotherapy was superior to IMRT because it significantly reduced the dose to the heart and breast without compromising target volume coverage and provided the basis to add mediastinal lymphoma on the list of indications for proton therapy in Germany in 2018.

Future aims and perspectives

While proton beam therapy becomes more and more available, carbon ion beam therapy requires

substantially more sophisticated equipment and techniques and are thus only available in few centres worldwide. Helium ion beams could offer an interesting alternative for radiotherapy treatments, owing to their physical and biological properties intermediate between protons and carbon ions. Investigations point to higher precision in dose distribution combined with an only mild increase of RBE, that make helium therapy to a preferred beam modality in treating delicate cases, such as pregnant women and children due to expected less long-term sequelae (like secondary malignancies) by reducing stochastic effects of irradiation as already demonstrated for protons. In 2014, the third ion source at HIT was set up for providing clinical helium beams. Biophysical research at HIT focuses on modelling and predicting biophysical processes elicited from particle beam interactions within the human body, including protons, helium-, carbon-, and oxygen –ions, both macroscopic and microscopic scales. To this end, both analytical and Monte Carlo tools for dose computation, as well as sophisticated models to describe biological effects in particle therapy are being developed, through either biophysical or phenomenological approaches. Currently, the clinical therapy planning system at HIT is being extended for helium ions. The first patient receiving helium ion RT at HIT is planned for 2021.

Another clinical focus within the next years will lie on image guidance. MR guided particle therapy is the next major milestone in the improvement of particle beam radiotherapy and is also a research focus at HIT. The implementation needs to address a variety of issues, ranging from effects from magnetic fields of an MRI on the particle beam and to beam monitoring system, MR- only treatment planning, to fast adaptation strategies.

Taken together, we expect that particle beam therapy at HIT will help up to 10% of cancer patients whose tumours cannot be controlled by conventional pho-

> ***"Taken together, we expect that particle beam therapy at HIT will help up to 10% of cancer patients whose tumors cannot be controlled by conventional photon radiotherapy***

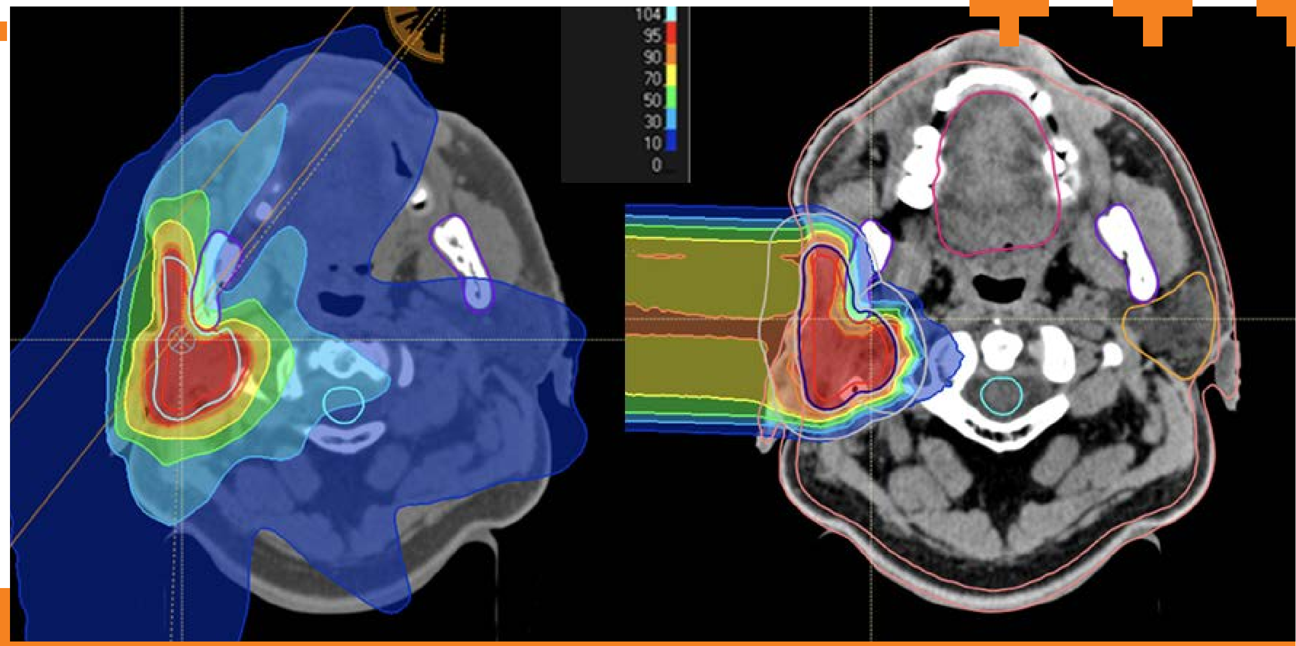


Figure 5: *Dosimetric comparison of a photon beam radiotherapy plan (left) and a carbon ion beam radiotherapy plan (right) in a patient with adenoid cystic carcinoma of the parotid gland. Both plans are calculated for 24 Gy or 24 Gy (RBE) on target volume, respectively.*

The Heidelberg Ion Beam Therapy Center (HIT)

2009
First patients treated at HIT with protons and carbon ions

2011
First patients treated at the gantry

2013
Installation of a third ion source for research purposes

2018
The 5.000th patient treated at HIT with particle beams

2019
Installation of a mobile in-room CT

2020
Installation of a 1.5 T MRI next to the treatment room

Perspectives
First patient for helium irradiation planned in 2021

Figure 6: *The Heidelberg Ion Beam Therapy Center (HIT) - More than a decade of Successes, Challenges and Perspectives for Particle Beam Radiotherapy*

Figure 7: Treatment room at the Heidelberg Ion Beam Therapy Center (HIT).

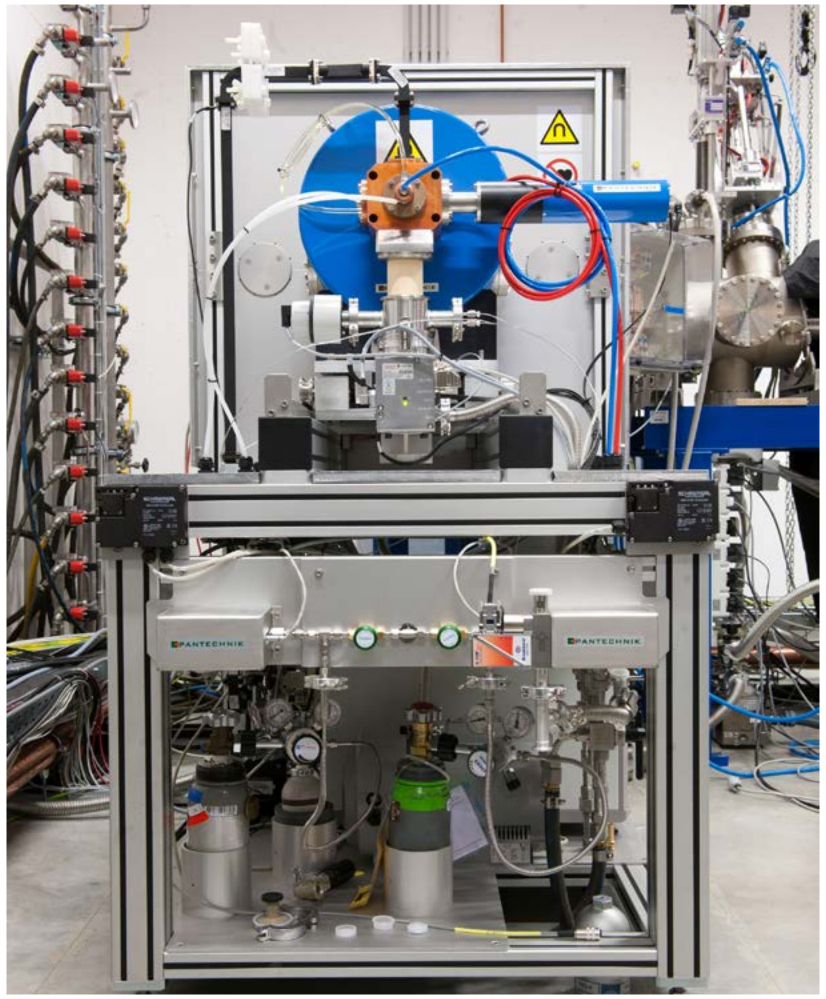


Figure 8: HIT Ion Source

ton radiotherapy because it is impossible to administer a sufficiently high dose without endangering the patient.

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Nicole Grau[1,2],
Jürgen Debus[1,2]

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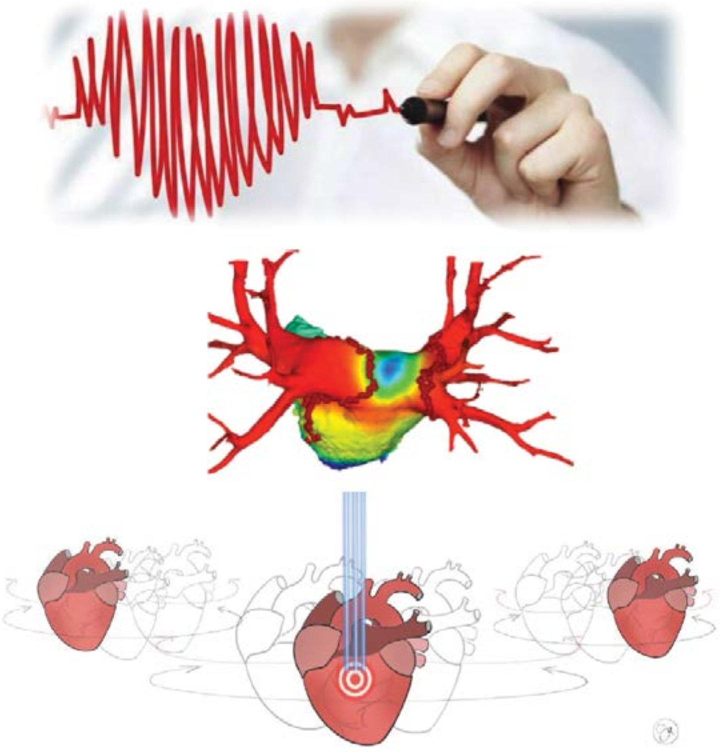
Figure 9: The rotable Gantry offers particle beam radiotherapy with sub-millimeter precision at the Heidelberg Ion Beam Therapy Center (HIT).

A remarkably steady beam at CNAO allows new treatment of **arrhythmia**



Non oncological application: ventricular arrhythmia

Ventricular tachycardia (VT) is a life-threatening condition, which usually implies the need for an implantable cardioverter-defibrillator in combination with antiarrhythmic drugs and catheter ablation. Unfortunately, recurrence of VT is relatively common due to failure of catheter ablation and/or drugs.

Stereotactic body radiotherapy radiation therapy (SBRT) a common form of therapy in oncology by photons, is recently emerging as a well-tolerated and promising alternative option for the treatment of refractory VT potentially overcoming some of the limitations of the conventional treatment strategies. It represents a noninvasive approach, in which the energy delivery technique is not related to cardiac catheterisation.

Particle radiotherapy using protons or carbon ions has a dosimetric advantage over photons due to local high dose delivery capability while minimising the off-target dose, which is particularly relevant at the cardiac level. So far only animal studies have been performed in this field with promising results.

On the 19th of December 2019, at the National Center of Oncological Hadrontherapy (CNAO), for the first time in humans , a 73 years old patient, with refractory ventricular tachycardia, not eligible for cardiac transplant due to advanced age, orother cardiological conventional treatment for the overall frailty, was referred to CNAO for proton therapy ablation, due to lack of immediate treatment alternatives.

After the approval by the Ethical Committee, a single fraction of 25 GyRBE was delivered to a total volume of 27.7 cc in the postero-lateral basal area of the left ventricle by an anteroposterior and a latero-lateral beams. Treatment target was defined based on invasive and non-invasive electrophysiological mapping data and reported bythe respiratory-gated CT scan. The procedure was developed in collaboration with the Cardiology Unit of the IRCCS Policlinico San Matteo of Pavia.

Regarding the effectiveness of the procedure, an almost immediate VT suppression was observed. One month after Stereo-

> *“Regarding the effectiveness of the procedure, an almost immediate VT suppression was observed.*

CNAO and Policlinico San Matteo staff involved in the treatment.

News

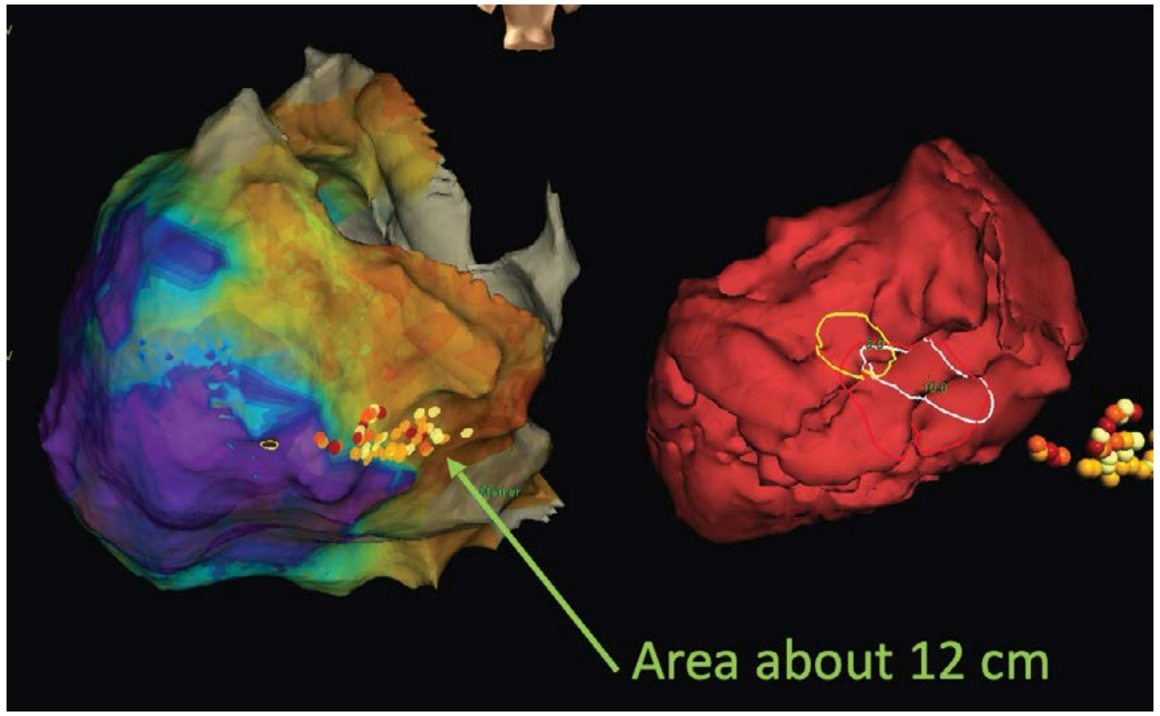
tactic arrhythmia radio ablation (STAR), reduced systolic strain peaks at the level of the treated and surrounding segments, together with the acute clinical ventricular tachycardia (VT) suppression, seem to suggest an effective targeting.

Overall, in the 77 days following STAR treatment we documented a dramatic reduction of VT episodes as compared to the 2 months before the procedure and both the clinical conditions and quality of life of the patient was greatly improved.

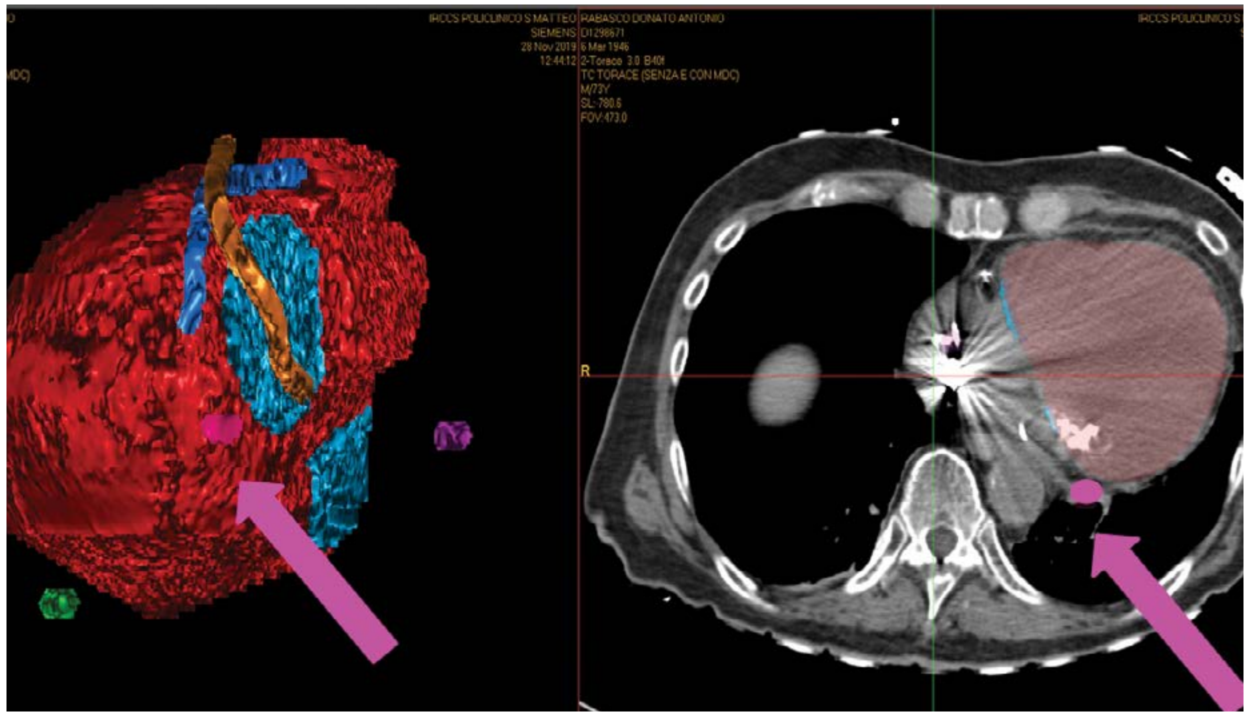
This clinical case suggests that STAR with protons for refractory ventricular arrhythmias is both feasible and safe. Compared with photons, protons have the potential to reduce cardiac and extracardiac off-target side-ffects.

More research is needed to optimise compensation/tracking for cardiorespiratory and target movements, to find the most appropriate dose and to unravel the mechanisms and the time kinetics for STAR antiarrhythmic effects onset and persistence.

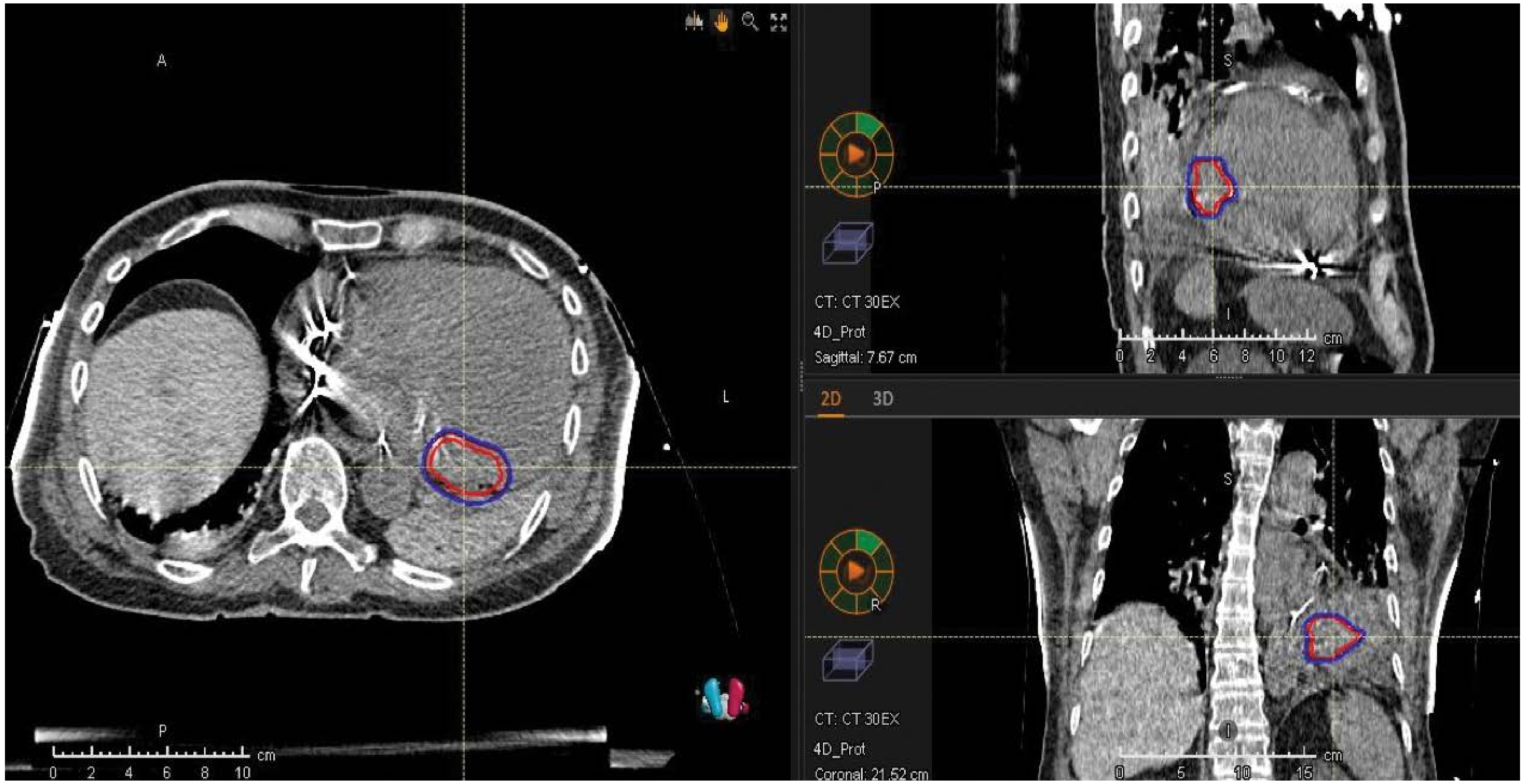
At CNAO definition of clinical protocols on this interesting field are ongoing.



CNAO patient: TARGET VOLUME DEFINITION - a)

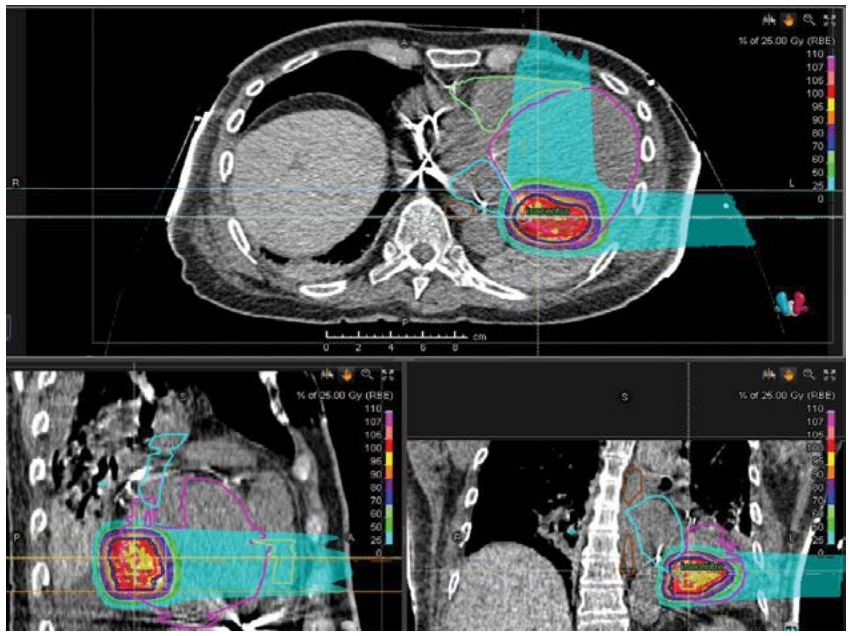


Target Volume definition - b)



Target Volume definition - c)

Silvia Meneghello



Target Volume definition - d)

A landmark year for SEEIIST

*Interview with **Sanja Damjanovic**, chairperson of the South East European International Institute for Sustainable Technologies (SEEIIST) Steering Committee*

1. In 2019, SEEIIST received a kick-off funding from the European Commission to start the Design Phase of the project, would you explain how that helped SEEIIST?

From the very beginning, SEEIIST had the mission to overcome the numerous challenges in the region of South-East Europe such as to advance European integration, reverse the brain drain and bridge the large gap to Western Europe. It has now grown to a pan-European dimension and is widely recognised. The dual dimension of SEEIIST, being both Cancer Therapy and a Cancer Research Centre, with many unique points such as multidisciplinary research, breakthrough advances in technology and Science Diplomacy were recognised by the European Commission (DG RTD), which granted SEEIIST the first financial support of 1M EUR to start the Design Phase. A special Service Contract was signed in July 2019, mediated by the DLR Agency in Germany. We are pleased that all the Deliverables defined in the contract have been fulfilled within the well-defined timeframe of one year, despite the special covid-19 situation which affected half of this funding period. The dedication of the team shows strong support for the SEEIIST Project in targeting one of the biggest long-term social challenges – fighting against cancer.

There are several highlights as the outcome of this 1st stage of the Design Phase. SEEIIST managed to establish a legal entity, becoming a Swiss Association with its seat in Geneva. High-level conceptual documents, the pre-TDR and the Business plan have been produced as key deliverables. This, together with building strong cooperation of 18 renowned research centres and clinics from 14 EU countries, was extremely important for the next steps of the development of SEEIIST, the HITRIplus application for the H2020-INFRAIA Call to complete the Design Phase and the application for the ESFRI Roadmap 2021 to assure the recognition of the pan-European dimension of the project and the Preparatory Phase. We are proud that the HITRIplus project has been formally approved with a budget of 5M EUR. We are also pleased that we managed in time to submit the SEEIIST@ESFRI application within the very short deadline of September 9, 2020. Since the start of the HITRIplus will be 1st of April 2021, we have received additional financial support from the EC DG-RTD of 0.5 MEUR as a bridge for this time period.

2. You mentioned the HITRIplus project, together with other institutes, SEEIIST will take part in an EU HORIZON 2020 funded project? Beyond the successful project proposal are there other ideas to boost research and cooperation in the region?

SEEIIST has shown itself to be a strategic partner, which federates eight countries in South East Europe, is the main ambition to prepare the construction of a Research Infrastructure in SEE?

HITRIplus will assure that the short-term future of the technical part of the project will be guaranteed along with the submission of the ESFRI application. We are also proud that, with the CERN activity of the Next Ion Medical Machine Study (NIMMS), the SEEIIST project is THE reference user for the Next Generation Ion Facility for Cancer Therapy. CERN is one of the 18 EU research centres and clinics which have joined forces to support SEEIIST, designing a compact accelerator project to be first realised in South East Europe. SEEIIST has built strong international cooperation, involving also many institutions and clinics from South East Europe. CNAO in Pavia is the coordinator of the HITRIplus Project. Building international cooperation and scientific capacity in South East Europe is a golden mission of SEEIIST.

3. The submission of an ESFRI proposal was earlier this year and SEEIIST is now waiting for the next steps but what exactly would this application mean for the project?

The SEEIIST@ESFRI application is highly emotive for our region. It is now more than 60 years that a large-scale competitive research infrastructure was built in the region of South East Europe, which is a large and integral part of Europe with more than 40 M inhabitants. However, in the past, our region had a strong tradition of technological development with several international institutes even older than CERN. Yugoslavia and Greece were actually founding members of CERN in 1954. The SEEIIST@ESFRI application is a great and important step for our region, as it will be the first time that our region would try to launch a project with a pan-European dimension on the European Roadmap.

We are also proud to have been able to submit a high-quality SEEIIST@ESFRI application with more than 350 pages in a timely manner. The team was highly motivated, and in spite of the difficult year marked with the Covid-19, we were able to come with a strong political and technical application. SEEIIST is proposed as a single-site New Research Infrastructure on Health with many satellite Hubs. We have received political support from 9 countries, including Switzerland and Hungary in addition to the SEE countries as well as of CERN and TIARA. For the technical part, we have presented a high-level pre-TDR document and a detailed Business plan. The SEEIIST Research infrastructure is aligned with the EC policy for the Green Deal and the Horizon Europe Cancer Missions. The outcome will be known in October 2021. We are convinced that our Project has a strong chance as it aims to become THE European Centre of Excellence for the fight against cancer. So far, Europe is missing a single-site Research Infrastructure for Cancer Research, and SEEIIST offers the possibility to integrate different cancer research activities beyond those with ion beams.

4. We heard that recently CERN and SEEIIST have signed a collaboration agreement, how will CERN be involved and why is having CERN as a partner of SEEIIST important?

News

CNAO, National Center for Oncological Hadrontherapy, will coordinate a European project called HITRIplus (Heavy Ion Therapy Research Integration) which brings together 22 institutes from 14 European countries and involves realities such as CERN in Geneva, GSI in Darmstadt, the other three European centers with carbon ion accelerators (HIT in Heidelberg, MIT in Marburg, and Medaustron in Austria), the National Institute of Nuclear Physics (INFN), the Commissariat for Atomic Energy and Alternative Energy (CEA) in France, the Investigaciones Energéticas, Medioambientales y Tecnologicas (CIEMAT) in Spain and other universities and SME's to promote the creation of a network of research and clinical collaboration centered on carbon ion beams.

Scientific support from CERN from the beginning to host the development of the design of the medical accelerator, part of the SEEIIST Design Study, was of utmost importance for the development of the Project. The recent signature of a Framework Cooperation Agreement between CERN and the SEEIIST Association formalises and thereby further strengthens the support to SEEIIST. This official cooperation gives the project special credibility and visibility, given that CERN is the World Center of Excellence.

5. Establishing a large research infrastructure in a region traditionally in conflict using the different conceptual frameworks about Science Diplomacy is challenging but SEEIIST has the official support of Switzerland? Are there any initiatives related to this important support?

Another important political milestone is the official support by the Swiss Government for the SEEIIST Project to develop a Science Diplomacy Roadmap. After CERN in Geneva and SESAME in Jordan, the SEEIIST is the third concrete example of Science Diplomacy. Switzerland offers a neutral platform for various discussions, like those which will be connected to the site selection. The Swiss Federal Department of Foreign Affairs (FDFA) will patronise and host a special SEEIIST High-level event which will be held in Bern, Switzerland, on 12-13 April 2021. The purpose of the event is the presentation of the Swiss plan on the diplomatic facilitation for the establishment of SEEIIST which also includes the establishment of a long-term legal entity framework. The Swiss Federal Councillor, Ignazio Cassis, will give an address in the frame of a High-Level Political Roundtable discussion. We expect the EU Commissioner Mariya Gabriel to be a key participant in this event.

We are happy that The Swiss State Secretariat for Education, Research and Innovation (SERI) provided us with a Letter of support for the SEEIIST@ ESFRI application. The Paul Scherrer Institute (PSI) is part of the HITRIplus consortium. We are planning to further strengthen the cooperation with the PSI via a Cooperation Agreement.

6. Is there a legal entity which represents SEEIIST? And where is it based?

The legal aspects related to SEEIIST consist of the creation of an Association as a temporary legal entity on one side and preparing the long-term establishment of the Institute as a final legal entity on the other. The Association was created in August 2019 under Swiss law with a seat in Geneva and entered in the Commercial register of Geneva in November 2019. A full management structure has been set up, consisting of a General Assembly, an Executive Board and a CEO. The 3rdnd General Assembly meeting was held on 11 December 2020 when the Budget for the year 2021 was approved.

As to the long-term legal status, the Swiss FDFA will moderate a special Working Group to help SEEIIST's development towards a full long-term legal entity. One of the options for that is the European Research Infrastructure Consortium (ERIC) model. A special technical meeting on the subject of the ERIC model for SEEIIST was held in November 2020 with representatives of the European Commission Research Infrastructure. The ERIC model seems very flexible. We need to explore further this possibility.

One of the most important and at the same time most difficult next steps is the site selection for the Institute. The Swiss FDFA will patronize the process of the final site selection which is expected by the end of 2021. An external expert committee has been set up to prepare the Criteria for the site-selection. A document with all the criteria is expected to be finalized by April next year when it will be distributed to all SEE Governments. In addition to this Document, an accompanying Brochure has been created and will also be delivered to the SEE Governments.

7. What do you see as the next steps for SEEIIST? Could you give us a 5-year perspective of where the project would be?

The most recent political support of the European Commission for the Western Balkans via the Innovation Agenda is of the utmost importance for the long term development of the SEEIIST Project. We are very grateful to Commissioner Gabriel who initiated this Agenda, which is now part of the Economic Investment plan for the Western Balkans. We are very proud that the SEEIIST Project is labelled to be one of the EU-WB Leading Projects in R&I and is the only Research Infrastructure part of the Economic Investment Plan for the WB. With such a clear sign of support from the European Commission, we very much hope that all activities defined in our Master Plan are going to be fulfilled. In five years from now, we hope to be already in the design and construction and the building infrastructure phase. Up to 240 MEUR is required for SEEIIST to guarantee competitiveness in Europe.

The breakthrough in technologies planned for SEEIIST will make Europe a world-wide leader in heavy ion medical facilities.

ACCELERATOR DEVELOPMENT

for high-energy physics opens new paths to treating cancer

Advancement in particle physics depends strongly on the steady improvements in the performance of the field's primary instrument, the particle accelerator. To carry out these improvements, the particle physics community invests significant resources at its laboratories and universities in accelerator technology development. One example is the CLIC project, an international collaboration led by CERN, the world's largest particle physics laboratory. The CLIC project has the ambitious goal of colliding electrons and positrons at TeV (that is 1,000,000,000,000 electron volts) energies to providing the particle physics community with a tool to improve our understanding of the enigmatic Higgs particle and to give insights into physics beyond our

"Using the CLIC high-performance linear electron accelerator technology, we designed a facility which is capable of treating large and deep-seated tumours in the very short timescales needed for FLASH therapy," explains Walter Wuensch, project leader at CERN.

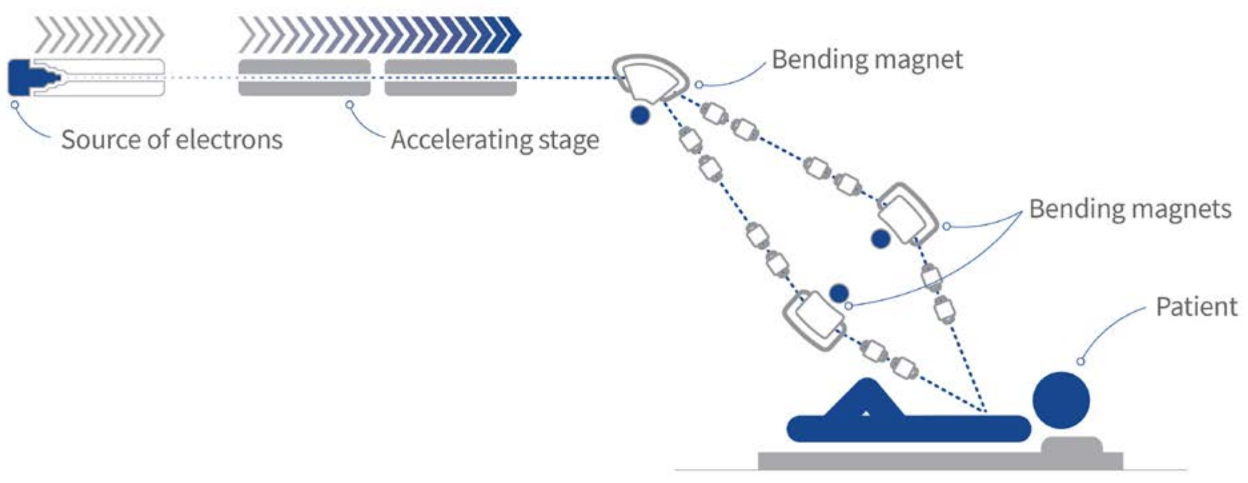


Figure 1: *A schematic layout of the CHUV/CERN FLASH treatment facility*

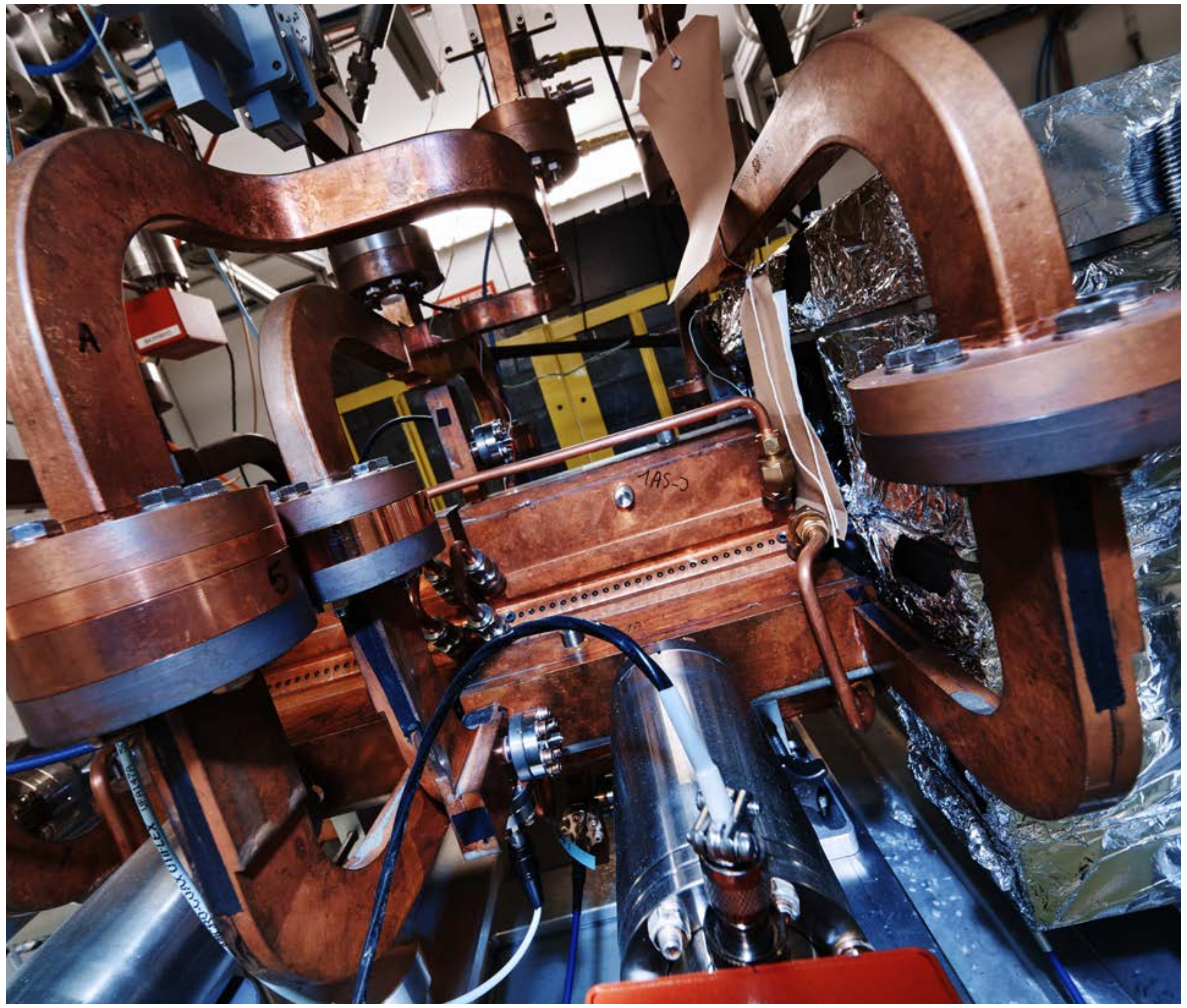


Figure 2: *A prototype accelerating structure for CLIC. An electron FLASH facility for large, deep seated tumors can use a structure that is very similar.*

current knowledge.

The technology developed for the CLIC accelerator is now making an important contribution to the advances in radiation therapy. This is occurring because important performance requirements for CLIC – having a high accelerating gradient for compactness, delivering intense beams efficiently and controlling them with extreme precision – turn out to have direct equivalents in a range of radiation therapy modalities. The areas where CLIC technology is applicable include X-ray linac systems, linac-based proton accelerators and electron-based FLASH therapy. Applying advances made in the CLIC study to these radiation modalities can give improvements in performance and in some cases entirely new capabilities.

The technology advances needed for CLIC have been under development for over two decades. These advances were needed because the performance requirements for CLIC are well beyond what was state-of-the-art at the time development started. For example, CLIC foresees acceleration with a gradient of 100 MV/m but the highest gradient in operating linacs is below 35 MV/m. Understanding the limitations in gradient, finding solutions, making designs optimised with other aspects of the accelerator, finding appropriate manufacturing recipes, making tests then finally building and validating prototypes were all part of the development process. The process did not, inevitably, actually play out smoothly and linearly as the previous sentence implies, rather, there were many failures and difficulties. However, the program has now achieved its goal of reliable 100 MV/m prototypes. All of this accumulated experience and expertise can now be applied to radiation therapy and is being done so to great effect.

Features

Figure 4: Walter Wuensch with a component in the high-accelerating gradient test area.

A recent, and very exciting, an example application of CLIC-developed technology is in electron-based FLASH therapy for large, deep-seated tumours. Many years after initial observations that radiation delivered in short, sub-second, timescales results in less damage to healthy tissue, new experiments have shown that the damage is in contrast not reduced in tumour tissue. This effect widens the therapeutic window and has rapidly become the scope of an intense research activity worldwide.

In a remarkable convergence of accelerator research for another purpose, CLIC technology reached maturity at roughly the same time as interest in FLASH grew exponentially. The initial realisation that CLIC technology can provide the 100 MeV-range electron beam energies of sufficient intensity and control to produce the FLASH effect in large, deep-seated tumours has quickly led to a facility design made in a collaboration between CHUV, a world leader in FLASH research, and CERN. A schematic of the basic layout of the facility is shown in **figure 1**. A CLIC accelerating structure, that provides an advanced starting point for an optimised structure for FLASH is shown in **figure 2**.

Other aspects of CLIC technology that have the potential to contribute to radiation therapy include high-efficiency klystrons. These are the radio frequency sources used to power accelerating structures. With their higher-efficiency, these klystrons are good alternatives to the magnetrons used in X-ray systems. Finally, the increase in practical accelerating gradient has been applied also to structures adapted for proton accelerators. An example of such a structure, with the construction funded by CERN's Knowledge Transfer internal funding scheme, under test at the University of Valencia is shown in **figure 3**.

Walter Wuensch, CERN

Steinar Stapnes, CERN

> ***In radiotherapy, the FLASH effect appears when a high dose of radiation is administered almost instantaneously - in milliseconds instead of minutes.***

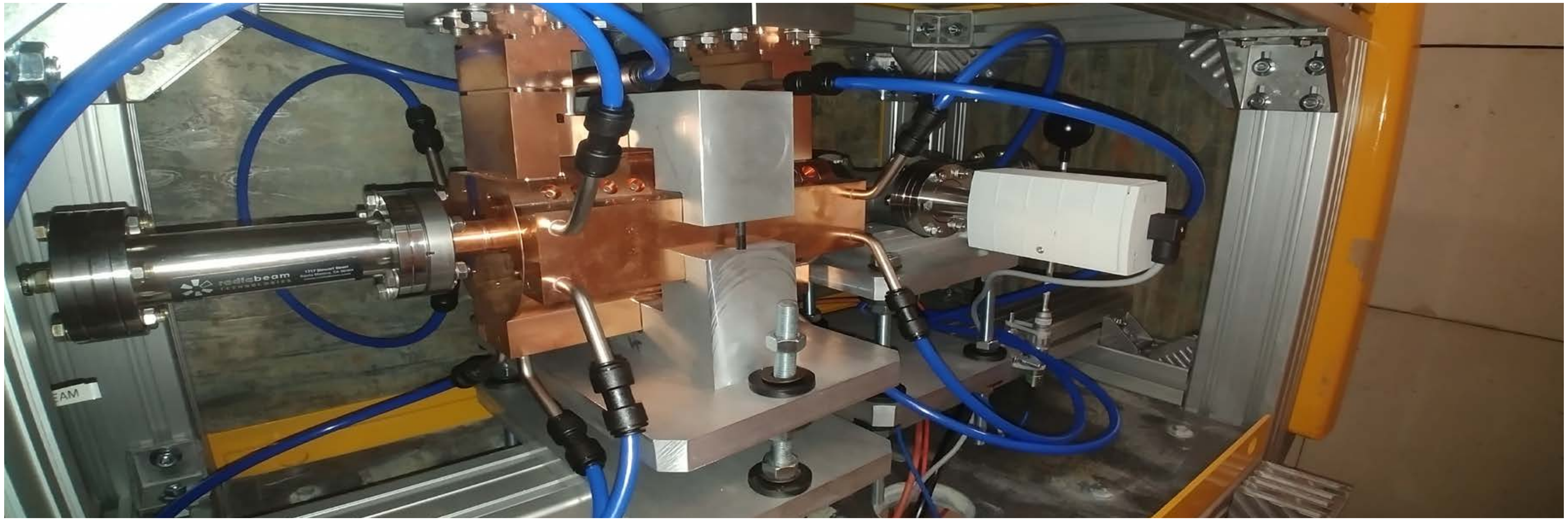


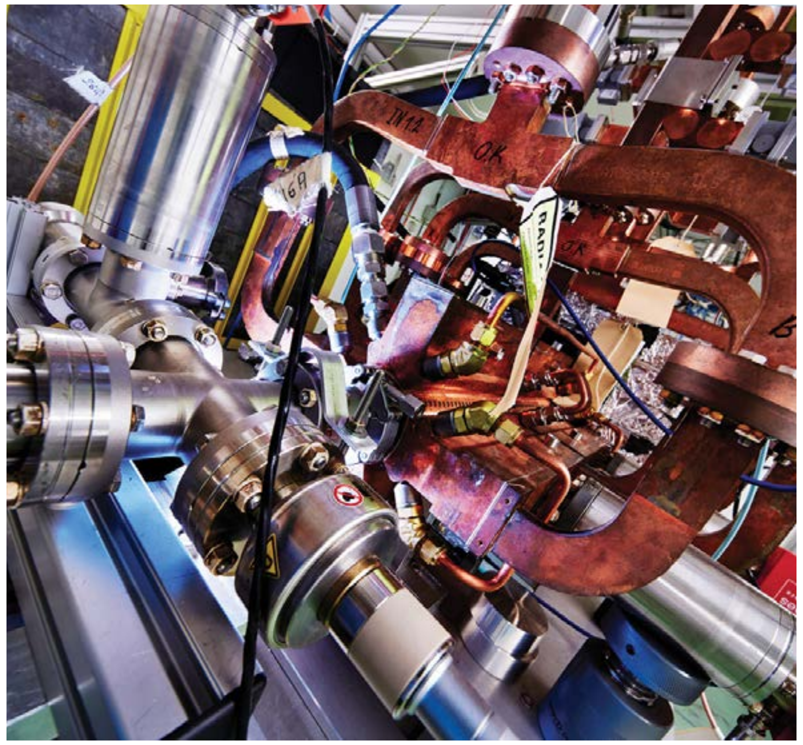
Figure 3: High-gradient proton accelerating structure under test at the University of Valencia. Such a structure could be used in a compact linac-on-gantry proton facility like the TULIP proposal made by the TERA foundations. The goal is a single-room facility proton facility with full beam scanning around the patient.

FLASH

clinical perspective and technology development

Technology developed for the proposed Compact Linear Collider (CLIC) at CERN is poised to make a novel cancer radio-therapy facility a reality. Building on recently revived research from the 1970s, oncologists believe that ultrafast bursts of electrons damage tumours more than healthy tissue. This "FLASH effect" could be realised by using high-gradient accelerator technology from CLIC to create a new facility at Switzerland's Lausanne University Hospital (CHUV).

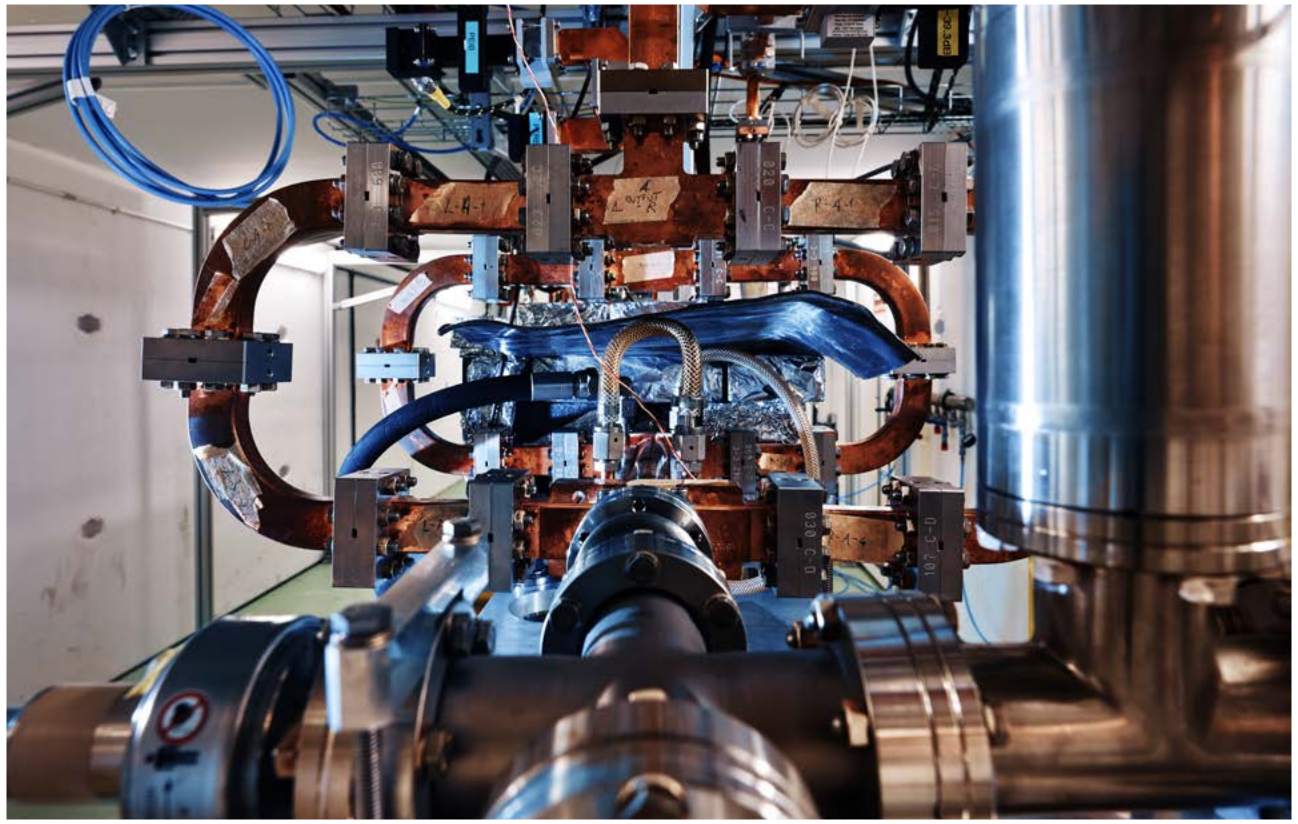
Traditional radiotherapy scans photon beams from multiple angles to focus a radiation dose on tumours inside the body. More recently, hadron therapy has offered a further treatment modality: by tuning the energy of a beam of protons or ions so that they stop in the tumour, the particles deposit most of the radiation dose there (the so-called Bragg peak), while sparing the surrounding healthy tissue by comparison. Both of these treatments deliver small doses of radiation to a patient over an extended period, whereas FLASH radiotherapy is thought to require a maximum of three doses, all lasting less than 100 ms.



X-band A high-gradient accelerating structure at CERN's CLEAR test facility, showing the waveguides that feed RF power in and out. Credit: CERN-PHOTO-202008-108-10

When the FLASH effect was first studied in the 1970s, it was assumed that all tissues suffer less damage when a dose is ultrafast, regardless of whether they are healthy or tumorous. In 2014, however, CHUV researchers published a study in which 200 mice were given a single dose of 4.5 MeV gamma rays at a conventional therapy dose-rate, while others were given an equivalent dose at the much faster FLASH-therapy rate. The results showed explicitly that while the normal tissue was damaged significantly less by the ultrafast bursts, the damage to the tumour stayed consistent for both therapies. In 2019, CHUV applied the first FLASH treatment to a cancer patient, finding similarly positive results: a 3.5 cm diameter skin tumour completely disappeared using electrons from a 5.6 MeV linear accelerator, "with nearly no side effects". The challenge was to reach deeper tumours.

Now, using high-gradient "X-band" radio-frequency cavity technology developed for CLIC, CHUV has teamed up with CERN to develop a facility that can produce electron beams with energies around 100 MeV, in order to reach tumour depths of up to 20 cm. The idea came about three years ago when it was realised that CLIC technology was almost a perfect match for what CHUV were looking for: a high-powered accelerator, which uses X-band technology to accelerate particles over a short distance, has a high luminosity, and utilises a high current that allows a higher volume of tumour to be targeted.



> ***"It really looks like it has the potential to be an important complement to existing radiation therapies.***

"CLIC has the ability to accelerate a large amount of charge to get enough luminosity for physics studies," explains Walter Wuensch of CERN, who heads the FLASH project at CERN. "People tend to focus on the accelerating gradient, but as important, or arguably more important, is the ability to control high-current, low-emittance beams."

The first phase of the collaboration is nearing completion, with a conceptual design report, funded by CHUV, being created together by CERN and CHUV. The development and construction of the first facility, which would be housed at CHUV, is predicted to cost around €25 million, and CHUV aims to complete the facility within three years.

"The intention of CERN and the team is to be heavily involved in the process of getting the facility built and operating," states Wuensch. "It really looks like it has the potential to be an important complement to existing radiation therapies."

Cancer therapies have taken advantage of particle accelerators for many decades, with proton radiotherapy entering the scene in the 1990s. The CERN-based Proton-Ion Medical Machine Study, spawned by the TERA Foundation, resulted in the National Centre for Cancer Hadron Therapy (CNAO) in Italy and MedAustron in Austria, which have made significant progress in the field of proton and ion therapy. FLASH radiotherapy would add electrons to the growing modality of particle therapy.

This article was originally published in the CERN Courier at the link: **https://cerncourier.com/a/clic-lights-the-way-for-flash-therapy/**

Features

At the African Organisation on Research and Training in Cancer (AORTIC) in Kigali, Rwanda in 2018

Simeon Chinedu Aruah

Head of Department of Radiation & Clinical Oncology, National Hospital Abuja, Nigeria

Background:

My name is Simeon Chinedu Aruah. I had my undergraduate Medical Education at the prestigious University of Nigeria Nsukka (UNN) where I obtained my MD in 2004 and MPH in 2013, respectively. I had my residency training in Radiation and Clinical Oncology in the National Hospital Abuja, Nigeria which is number one apex hospital in Nigeria in terms of cancer care and research. I obtained my Fellowship in Radiation and Clinical Oncology in 2014 and was inducted as a Fellow of West African College of Surgeons in March 2015.

Currently, I am Honorary Consultant Radiation and Clinical Oncologist and Head of Department Radiation and Clinical Oncology National Hospital Abuja, Nigeria. I am also a Lecturer in the University of Abuja College of Medicine in the Radiation Medicine Department where I teach undergraduate clinical medical students basic Radiation and Clinical Oncology. I am a member of several medical boards and international organisations such as the Central Bank of Nigeria Medical Board, Nigeria Immunisation Technical Advisory Group and International Cancer Expert Corps (ICEC).

I am involved in a number of research projects, both locally and internationally. My non-governmental organisation (NGO) "Pathfinder Healthcare Foundation" has been at the forefront of creating cancer awareness campaigns and screening tests, especially among formal and informal groups. I am married and live with my family in Abuja, Nigeria.

In Geneva, Switzerland to attend a workshop in CERN Facility and having a round table discussion with one of his mentors, Prof. David Pistenmaa, 2017.

WHICH WORK AND RESEARCH ARE YOU INVOLVED IN? WHERE? WHO ELSE IS INVOLVED?

My work is both clinical and teaching. As a Consultant Radiation and Clinical Oncologist, I am involved in cancer diagnosis and care in National Hospital Abuja. As a Lecturer at the University of Abuja College of Medicine, I teach medical students specifically the clinical classes. I am involved in both local and international research especially "Innovative Technologies towards building affordable and equitable global radiotherapy capacity (ITAR)". ITAR is a research collaboration in the UK involving many renowned scientists and researchers such as Prof Graeme Burt, Prof Manjit Dosanjh and Prof David Pistennma. I am also involved in a cancer awareness campaign through paper presentations as well as radio and TV programmes.

With RTT, Mrs Tosin in the treatment room

WHY AND WHEN DID YOU DECIDE TO INVEST TIME AND ENERGY IN RADIATION THERAPY FOR CANCER TREATMENT?

Cancer is the 2nd cause of mortality among non-communicable diseases globally. Although the cancer burden is low in LMICs, the mortality is quite high due to lack of access to modern diagnostic equipment, the late presentation of disease and, more importantly, the lack of trained health professionals in this area in Nigeria. Nigeria has less than 100 radiation and clinical oncologists with a population of 200 million people. Because of this obvious gap, I decided to pursue a career in this oncology in order to contribute my own effort to help solve these societal challenges.

WHICH ARE THE CHALLENGES LINKED TO YOUR WORK AND ADDITIONAL CHALLENGES

With Nina Wendling and Jennifer Dent at IAEA Conference in Vienna Austria, September, 2019.

Creating cancer awareness campaign among Anglican Church Women Fellowship in Abuja, 2019

YOU ARE FACING/TACKLING BY WORKING IN NIGERIA?

The major challenge I face working in Nigeria as radiation and clinical oncologist is lack of manpower. There are few radiation oncologists working in Nigeria which has fewer than 100 in a country with 200 million people. Apart from that, there is a lack of functional radiotherapy machines. Because the radiotherapy machines break down frequently and there is a high patient load, the patients waiting times can be very long. There are also challenges related to the lack of cancer awareness and screening tests especially among rural dwellers in Nigeria. Hence the majority of cancer patients present with advanced diseases making cure almost impossible. There are few functional radiotherapy centres in Nigeria making access to radiotherapy very challenging for most patients. Maintenance of radiotherapy equipment and lack of training opportunities are also big challenges.

WHAT DO YOU THINK IS NEEDED TO MEET THESE CHALLENGES FOR YOUR-SELF PERSONALLY AND FOR THE COUNTRY?

There is a need to expand radiotherapy centres in Nigeria to cater for the growing incidence of cancer in Nigeria which was estimated to be 112,000 cancer cases per year with about 70,000 mortality. Training and retaining of trained Radiation Oncologists is quite important as we continue to experience brain drain despite the few numbers of qualified cancer specialists we have. Expansion and equipping of additional radiotherapy centres coupled with the creation of cancer awareness campaigns as well as screening tests to encourage early detection will surely reduce cancer scourge in Nigeria. Also, oversea mentoring and training will equally equip our Radiation Oncologist to address global challenges of cancer by utilising modern technology and information systems.

At the 2 hours radio link programme at the Federal Radio Corporation of Nigeria in Abuja on Cancer Awareness Campaign, 7th November 2020.

> **“*It was this global exposure and mentoring by ICEC that lead to STELLA project in which I am deeply involved from the LMICs side of the world.*”**

HOW DID YOU GET INVOLVED IN ICEC AND STELLA?

I got involved in the International Cancer Expert Corps (ICEC) in 2017 following an invitation to attend a workshop and present a paper in Geneva, Switzerland in the CERN facility. It was a great opportunity as I was able to meet and discuss with Prof Dosanjh Manjit, David Pistennma, Dr Norman Coleman and many others who have shaped my career and destiny for good. Their mentoring and support lead to my increased international visibility in terms of paper publications and travelling to various parts of UK and Africa specifically Botswana to share discussion on increasing access to radiotherapy especially in low middle-income countries (LMICs) of the world.

It was this global exposure and mentoring by ICEC that lead to the STELLA project in which I am deeply involved from the LMICs side of the world. The STELLA means “Smart Technologies to Extend Lives with Linear Accelerators”. It is an ongoing project in which a number of eminent scientists, cancer advocacy groups, Medical Physicists, Particle Accelerator Physicists and Radiation oncologists are involved to ensure equitable access to radiotherapy in LMICs and underserved areas in (HICs) while providing access to education and training opportunities to support building a sustainable workforce.

WHICH PROJECT ARE YOU WORKING ON NOW?

I am currently working on a number of projects and, in particular, on ITAR which is gathering a lot of momentum because of the great positive impact, it will have in bridging the gap of lack of access to radiotherapy in LMICs and underserved areas in HICS. As a Researcher, I am working on “Prospective multicenter analysis on epidemiology and receptor status of breast cancer in Nigeria; A case for enhancing national cancer registry services”. Also, “A multicenter study on the current status of Radiotherapy in Nigeria: a case for strengthening manpower and infrastructural needs of various radiotherapy centres. All these projects are under the supervision of my overseas mentors who have contributed immensely to my academic and research progress. I owe them a huge debt of gratitude especially the ICEC team.

Supervising the RTT set up Breast Board for CT Simulation Image Acquisition for Radiotherapy planning at the NHA.

In Lagos, Nigeria at stakeholders meeting among other groups to discuss Urological malignancies, 2018.

WE KNOW THAT MONEY IS A CRUCIAL BARRIER, WHICH PREVENTS COUNTRIES LIKE NIGERIA FROM IMPROVING THEIR HEALTH SYSTEM AND, SPECIFICALLY, FROM MAKING RADIOTHERAPY AVAILABLE TO A LARGE FRACTION OF THEIR POPULATION. WHICH KIND OF SOLUTIONS CAN WE ENVISAGE TO OVERCOME THIS PROBLEM AND REDUCE THE CANCER DIVIDE BETWEEN COUNTRIES?

We can encourage private investors to invest in Radiotherapy or to donate generously to health projects. When they do, the government can give them tax waiver or other incentives that will grow their businesses. Increasing budgetary allocation to healthcare and ensuring that it is

implemented will go a long way in changing our narratives especially in LMICs where health and education hardly received recommended WHO budgetary allocations. Mentoring and oversea collaboration with an organisation such as ICEC will help in strengthening our radiotherapy centres and encourage staff retention through sustainable support programmes. With the expansion of more radiotherapy centres, increasing cancer awareness campaigns and screening test, I have no doubt that LMICs will experience a reduction in cancer mortality and morbidity thereby narrowing the gap between LMICs and HICs in terms of access to radiotherapy and appropriate cancer care.

WHAT ARE YOUR THOUGHTS FOR THE FUTURE, WHERE DO YOU SEE YOUR-SELF IN 10 YEARS FROM TODAY?

The future is bright in LMICs as they are emerging economies of the world especially countries that have ordered their priorities well in terms of increasing access to health and education. We have such countries like Rwanda, Ghana and others which can be showcased in Africa. Nigeria is equally making progress following the establishment of more radiotherapy centres. I have no doubt that the gap between LMICs and HICs in terms of access to equitable radiotherapy distribution will be bridged if we continue to collaborate with international bodies such as ICEC which is a leading light on global access to radiotherapy in LMICs and underserved areas in HICs.

I would like to see myself in 10 years from today as a renowned Professor of Radiation and Clinical Oncologist, a Philanthropist, a Researcher and a mentor to many generations of Nigerians and influential personalities globally. I want to be a great husband to my wife and big Daddy to my children. I also dream of becoming a Director-General in World Health Organisation (WHO)/International Atomic Energy Agency (IAEA) where I can influence policies that will increase access to cancer care in remote places of the world. All these are achievable for any determined mind. I am determined to achieve all.

Participating in cancer awareness among Cancer Advocacy Group in Abuja to mark challenges of accessing chemotherapeutic agents and targeted therapies, April 2020.

Focus On

Taofeeq Abdallah Ige

Dr. Taofeeq Abdallah IGE is a Chief Consultant Physicist at the National Hospital, Abuja (The Federal Capital of Nigeria) and the current Head of the Department (HoD) of Medical Physics in the Hospital

Background:

Dr. Taofeeq Abdallah IGE is a My name is Taofeeq Abdallah IGE and I am the Chief Consultant Physicist at the National Hospital, Abuja (The Federal Capital of Nigeria) and the current Head of the Department of Medical Physics in the Hospital – the only department of its type in the tertiary health facility in the country. I am also a visiting Senior Lecturer in Medical Physics in a couple of universities and has successfully co-supervised six PhD and five M.Sc. theses and I was recently appointed as an adjunct Senior Lecturer at the Physics Department of the University of Abuja.

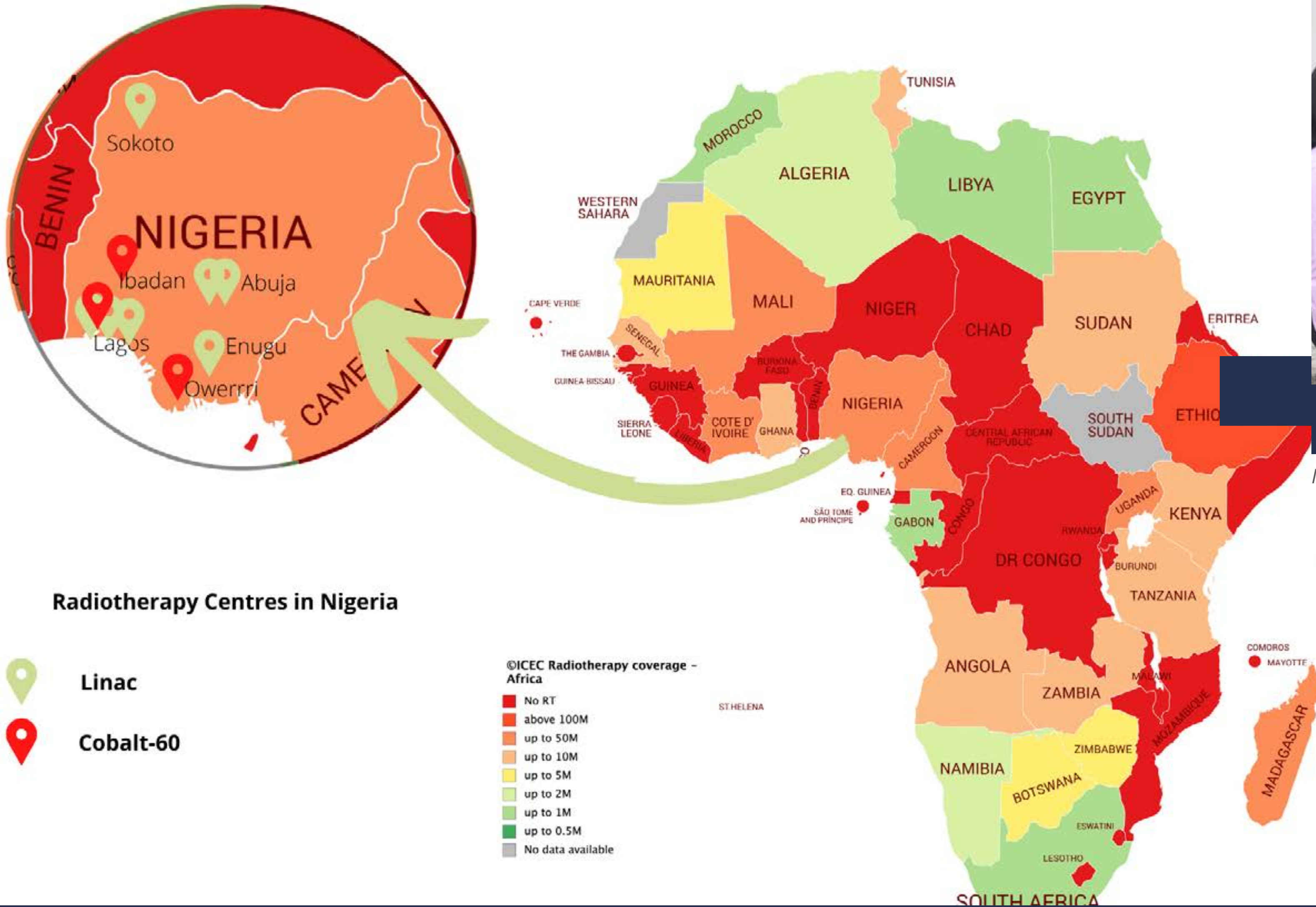
I represent Nigeria in the International Atomic Energy Agency (IAEA) projects on NIR6023 (National Project on the Development of Medical Physics Residency Programme – Developing the National Capacity to train Medical Physicists to support Radiotherapy Facilities in Tertiary Hospitals in Cancer Management), RAF6050 & RAF9057 (African Regional projects on Improving Access to Quality Cancer Management through Sustainable Capacity building and Strengthening National Capabilities in Occupational Radiation Protection in compliance with requirements of the New International Basic Safety Standards) and Regional Counterpart on the IAEA's Inter-Regional project on Strengthening Medical Physics in Radiation Medicine (INT6054). I have participated in a number of medical physics and radiation safety assignments as a World Health Organisation (WHO) consultant.

Part of my education and training has taken me to the "Demokritos" Nuclear Research Centre in Athens, Greece; the Hammersmith and Charing Cross NHS Trust hospitals / Brunel University in London; the Pretoria (now Steve Biko) Academic Hospital, Pretoria, Republic of South Africa and the Fukushima Medical University in Japan.

I have contributed to IAEA publications and several book chapters as well as a number of articles in international journals.

I am currently the Secretary-General of the Nigerian Association of Medical Physicists (NAMP) and the founding Secretary-General of the Federation of African Medical Physics Organisations (FAMPO) and cur-

Focus On



Nuclear Technology Centre (NTC),Abuja 2018

rently the President. I am a member of the IOMP (Awards and Honours Committee) and of the Health Technology Task Group of the International Union of Physical and Engineering Sciences in Medicine.

Which work and research are you involved in? Where? Who else is involved?

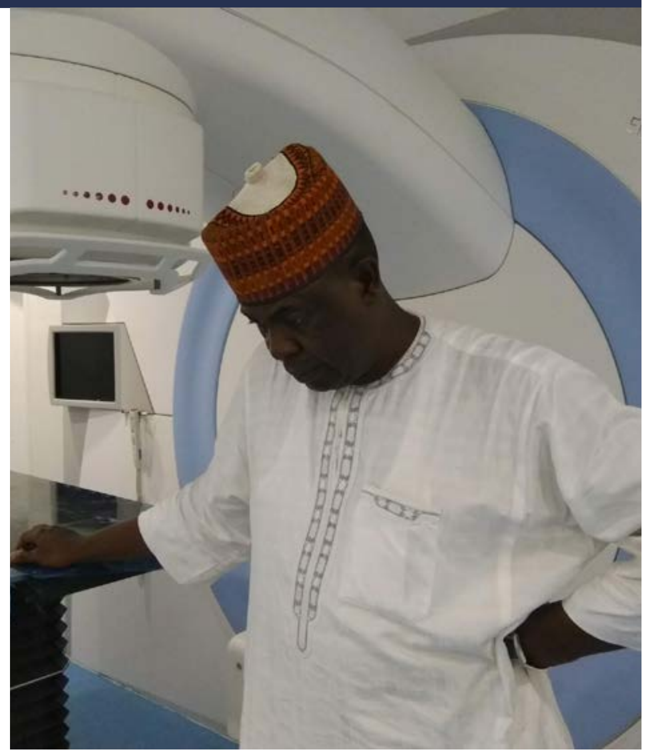
As an IAEA national and regional project counterpart, I am involved in a number of Medical Physics, Radiotherapy and Radiation Protection related research works. I am a contributor to the published Human Health Series (HHS) No. 25 -

I am involved in the International Research effort christened "ITAR – Innovative Technologies towards building affordable and equitable global radiotherapy capacity" which has Profs. Graeme Burt and Manjit Dosanjh as leads.

Currently, as the Head of the Medical Physics Department in the National Hospital, my work involves administrative, clinical, research and teaching duties.

Why and when did you decide to invest time and energy in RT for Cancer Treatment?

I started my career at the Nuclear Research Centre (Centre for Energy Research and Training) of the Ahmadu Bello University, Zaria as a Research Assistant in 1985 and rose through the ranks to a Senior Research Fellow in 1998 and was drafted in 1999 as the only Physicist in the 10 person project team to commission the National Hospital Abuja which then boasted of the First Linear Accelerator (LINAC) in the West African sub-region amongst other high-end radiation medicine facilities. Earlier in 1994, I was appointed as the Physicist to the IAEA supported Radiotherapy project at the Ahmadu Bello University Teaching Hospital, Zaria which since then has a donated Cs-137 brachytherapy machine from the Agency (IAEA) and subsequently followed by a "Cirrus" Co-60 External beam radiotherapy machine at the Shika permanent site of the infirmary.



Which are the challenges linked to your work and additional challenges you are facing/tackling by working in Nigeria?

Inadequate and sub-optimal working tools have been the bane of working in this part of the world. This presents some opportunities to proffer innovative solutions, more often than not – "the to-do spirit" are always hampered by the paucity of resources to bring this about.

The challenges are multi-dimensional and transcend institutional and national firmaments which include among others – inadequate and inefficient power infrastructure, encouragement, a deficit on the part of some managerial heads of institutions, unnecessary and unhealthy rivalry even among colleagues that ought to share the same vision etc.

What do you think is needed to meet these challenges for yourself personally and for the country?

Latching on to opportunities for global and international cooperation has assisted in no small measures to ameliorate the dire situation and prevent joining the statistics of the "brain-drain syndrome".

The pertinent and urgent need to increase access to radiotherapy by the multitudes of patients in the country through the expansion and equipping of more oncology centres with robust equipment and accentuating the human capacity development of the various cadres of staff involved in these onerous duties and responsibilities.

Taofeeq's family.

How did you get involved in ICEC and STELLA?

A kind invitation to attend the 2nd Workshop of the CERN/ICEC/STFC collaboration in Geneva in 2017 by Prof. Manjit Dosanjh brought me to the "world of ICEC and STELLA". The friendly disposition and the mentoring spirit by the erudite professor and her team and collaborators have greatly impacted my academic and clinical horizon.

Smart Technologies to Extend Lives with Linear Accelerators (STELLA) is one of the great thoughts that have emanated from several "talk-shops" and round-table discussions that characterised the 1st and 2nd workshops at CERN and my involvement and modest contributions have been quite significant by providing the access to several colleagues and organisations in and out of Africa to obtain real-time status report and data to facilitate the successful outcomes of this project.

Which projects are you working on now?

IAEA regional projects on (a) improving the quality of radiotherapy in the treatment of frequently occurring cancers in Africa (b) enhancing regional capabilities of African member states on occupational radiation protection in line with the new international safety standards and (c) establishing national dose reference levels for common diagnostic radiology facilities with the use of CT, Fluoroscopy and Mammography towards enhancing the capacity building of medical physicists to improve safety and effectiveness in medical imaging.

I am co-supervising some post-graduate students working on some diverse topics to improve radiotherapy and diagnostic radiology procedures including the analysis and quantification of patient set-up errors in the treatment of breast cancer patients undergoing external beam radiotherapy and in the determination of patient dose and evaluation of quality control parameters during computed tomography examinations.

I am driving the STELLA data gathering initiative in collaboration with Manjit for the ITAR project coordinated by Professor Burt and funded by STFC

We know that money is a crucial barrier, which prevents countries like Nigeria from improving their health system and, specifically, from making radiotherapy available to a large fraction of their population. Which kind of solutions can we envisage to overcome this problem and reduce the cancer divide between countries?

Budgetary allocations from the governmental bodies will need to be substantially improved and monitored. The public-private partnership (PPP) paradigm may also need to be pragmatically and wholesomely evaluated with a view to providing some "solution-mix" in the continental and national answers to the manpower and infrastructural deficits in the region and in

Nigeria. Perhaps leveraging on the camaraderie of sub-regional bodies like ECOWAS and within the continental association like the African Union of Health Ministers to facilitate cross-border fraternities in the implementation and setting-up of radiotherapy infrastructures and ancillary facilities to aid fast turn-around of the cancer epidemic.

Which are your thoughts for the future, where do you see yourself in 10 years from today?

I look forward to the world in the near and far future where there is improved and substantial access to radiation treatment machines in the LMIC's which is affordable and efficacious in reducing the cancer burden on the populace thereby extending the productivity and economic prosperity of the citizenry.

At a personal level, I fervently and sincerely wish to join the "mentors cohort" of ICEC to provide the requisite leadership ingredients to the upcoming generation and mentees so as to bequeath an enduring and lasting legacy to their world thus, assuring the sustainability of this illustrious, selfless and wonderful initiatives of the founding fathers and mothers.

AJMP - An Official Journal of the Federation of African Medical Physics Launching November 2018

Focus On

Walter Tinganelli

Group Leader for Clinical Radiobiology at GSI, Germany

Background: Tell us something about yourself, your education, career

Born in Naples, Italy, in December 1978, I have always had a strong passion for science and art.

Passionate astronomer, in 2001, I joined the Air Force as a pilot. My dream was to become an astronaut and fly among the stars.

In 2002 I heard about biotechnology, and I was dreaming about this new branch of biology. I decided to leave the air force and enrol at the University of Naples Federico II to graduate five years later. It was during my university years, that I discovered my second passion, the passion for theatre.

After a short experience in a company, in 2009, I decided that I wanted to get a PhD.

It was then that I started a fantastic experience at GSI working in the framework of the CERN PARTNER project. My experience at GSI gave me the possibility to better know Prof. Durante, an incredible guide for me. Over the years, he became and still is today, my mentor. These were three wonderful years that allowed me to meet many people, which today are big experts in the particle therapy field around Europe.

At GSI, I was working in the group of Clinical Radiobiology that was led by Wilma-Weyrather, which gave me excellent preparation about the particle therapy field.

After finishing my PhD, I worked for two years at the National Institute of Radiological Sciences in Chiba, Japan. At that time, I worked as the International Open Laboratory group director. In Japan, I had the fortune to work with bug experts in the particle therapy field, like Dr Furusawa, Dr Hirayama, and start fruitful collaborations with Dr Takashi Shimokawa, Dr Nickoloff, and Dr Allen from the Colorado State University.

Back in Europe, I worked at GSI again as a postdoc and then for the next three years, at the Trento Institute for Nuclear Physics and Applications in Trento, Italy, part of the National Institute of Nuclear Physics.

With his collaborators in Japan.

Walter during his flying course in the Italian air force.

> **“A part of me thought that contributing to the fight against cancer would have been a noble and useful thing.**

Since 2019, I am the Clinical Radiobiology Group Leader in the Biophysics Department at GSI. Moreover, since 2020 I also have some, for me, very important and prestigious, institutional responsibilities. I am part of the Life Science Working Group from the European Space Agency and Executive Board of the Italian Radiation Research Society.

Which research are you involved in? Where? Who else is involved?

I am involved in several lines of research with the common roots of hypoxia. Tumour hypoxia is a research line that I have been pursuing for years, even during my thesis. Moreover, I am interested in FLASH radiation and hibernation. Although this last research line, hibernation, sounds like science fiction, it could soon become a tool for future space missions and perhaps even in the future radiotherapy. In collaboration with the University of Bologna, the INFN, and the Gunma University, we performed irradiation of rats in synthetic hibernation for the first time. Synthetic hibernation, just like natural hibernation, increases the radioresistance of the inactive animal.

My work is done in collaboration with many different research centres. I have partnerships in South Africa with the iThemba institute, Japan with NIRS and Gunma University, Italy, etc.

Crucial for me is, of course, the collaboration with the other German institutes. HIT, DKFZ, and the University of Heidelberg are fundamental for the Clinical Radiobiology group research activities.

For me, it is important to say that the other groups of the Biophysics Department here at GSI are strongly involved in my collaborations. Dr Weber and his group are fundamental for the FLASH irradiation experiments.

Moreover, I have to say that everything would be impossible without my team. I could not do any research without them.

A team made up of extraordinary people with very diverse scientific and cultural backgrounds.

In my team, at the moment, there are two postdocs, Olga Sokol, Russian, and Anggraeini Puspitasari, Indonesian, one German technical assistant, Julius Opperman, and one Italian PhD student, Martina Quartieri. They are the people who do all the work. Special people who make working days less tiring.

“My passion for theatre brings me to the role of the hunchback of Notre Dame.”

Why and when did you decide to invest time and energy in radiation therapy for cancer?

My strong passion for science began in high school, thanks to my parents and outstanding teachers. However, when I was very young, I did not know where this passion of mine would take me. My dream has always been to become an astronaut. For this reason, in 2001, I decided to enter the academy as a military pilot. I won the competition for admission and started a great experience that I will never forget.

However, my passion for science and biotechnology was stronger, and I decided to enrol in the University Federico II of Naples.

Besides, unfortunately, like many others, I had lost important people in my life because of cancer. A part of me thought that contributing to the fight against cancer would have been a noble and useful thing.

After University, I decided that my career should continue with a PhD. It was at that point that I met Prof. Durante. He initiated me in this beautiful world that is radiobiology.

I then started a PhD at GSI, in the group of Clinical Radiobiology, directed by Wilma-Weyrather, an attentive supervisor, who transmitted and taught me so much about clinical radiobiology. It was here at GSI that my passion for radiobiology was born.

Current research: Which projects are you working on? Which are the challenges for you?

At the moment, my research is divided into four major topics.

I investigate the infamous circulating tumour cells in the hypoxic tumour regions, the high-dose-rate irradiation (FLASH effect), a new physiological process called synthetic hibernation for radioprotection, and the Peto's paradox. Working in radiobiology means having one eye on biology and one eye on physics. The challenge is staying current and prepared for the vast amount of information you need to know.

Can you give us some details on the type of research, how can it be extended to animal studies for preclinical and clinical studies?

Of course. As I said, there are several projects that I am following, but if I have to mention one for which I might see a clinical application soon, indeed, I have to talk about FLASH radiation.

This is an experiment that I am doing in collaboration with Dr Weber's group, Biophysics Department here at GSI, HIT in Heidelberg, the University of Heidelberg, and the DKFZ.

PARTNER PROJECT, a wonderful experience around Europe.

FLASH irradiation at the moment has been done only with electrons and protons. As far as I know, no studies of FLASH irradiation with carbon-ion beams have been done yet.

FLASH irradiation with carbon could give exciting results. We have already planned studies with animals approved by the GSI-FAIR BIOPAC program. Besides, we have already performed in vitro tests at HIT that demonstrates the efficiency of carbon ions in producing the carbon FLASH effect. We are now working on publishing the results.

What do you think are the key challenges facing the field of particle therapy?

I would say the FLASH irradiation, in which the very high-intensity beam is fundamental, and radioimmunotherapy in which the investigation of the dose, LET, dose/rate, and the drug interaction is essential. Those two topics are, for sure, challenging for the future of particle therapy.

PARTNER project on a visit at CNAO, Pavia, Italy.

Which is/are your dream(s) for future research and future career?

My dream is always to be able to do my job well.

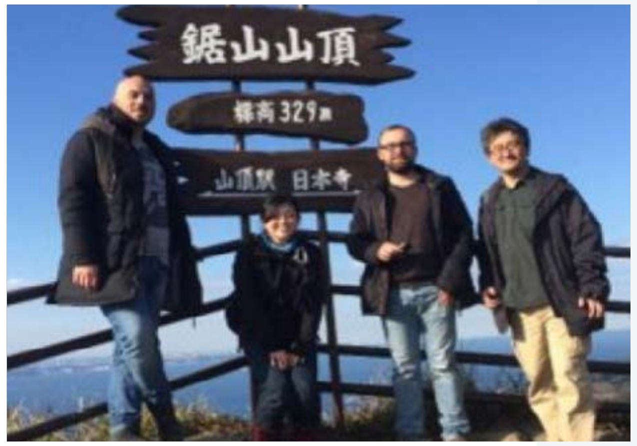
If one day, I will wake up knowing that I had contributed, even minimally, to improve therapies and improve the lives of those who previously had no hope, my dream would come true.

Where do you see yourself in 10 years from today?

As a motivated, full-of-energy researcher, I see myself trying to do my best for research in ten years from now. Moreover, I would also like to teach at the university. At the moment I have a contract as Group Leader. This allows me to do a lot of research, but it does not allow me to transmit my passion to new and young researchers. In my future, I also see myself teaching.

> ***It was here at GSI that my passion for radiobiology was born.***

With his PARTNER colleagues.



Group picture in Japan.

His first office at the GSI.

ENLIGHT and Nuclear Medicine at Nucleus 2020

The first part of the LXX International conference "NUCLEUS – 2020: Nuclear physics and elementary particle physics. Nuclear physics technologies" took place online from 12 to 17 October 2020 in Saint Petersburg State University (https://indico.cern.ch/event/839985/).

This conference is the oldest nuclear physics conference in Russia and one of the oldest in the world. The organizers of this event were Saint Petersburg State University, NRC "Kurchatov Institute", and JINR. The conference was opened with the warm greetings by the leaders of the largest Russian and international nuclear research centres: the Director of the NRC Kurchatov Institute A.E. Blagov, the Director of JINR Academician V.A. Matveev, the Director of GSI P. Giubellino (Germany) and the Vice-rector of Saint Petersburg State University S. Mikushev.

About 450 reports (oral and poster) were presented by the speakers from 38 countries, while the total number of registrants was over 550. The plenary conference talks were dedicated to most of the cutting-edge advances in nuclear and particle physics: neutrino physics problems (JUNO collaboration, GERDA collaboration), studies of ultrahigh-energy cosmic rays (Pierre Auger Collaboration), low-energy nuclear physics, nuclear fission studies and novel detector technologies. The section of relativistic nuclear physics had the highest interest and the highest number of reports. The major high-energy physics collaborations: ALICE, CMS, ATLAS, NA61/SHINE, PHENIX, STAR, FAIR, NICA presented their new physics and detector technology achievements.

The scientific conference program was notably rich and diverse. It covered a wide range of nuclear physics problems: experimental and theoretical studies of the atomic nuclei structure, investigations of the nuclear reactions, nuclear technologies, physics of elementary particles and high energies, neutrino physics and nuclear astrophysics. In addition to the traditional topics, several new ones were added to the conference program, such as synchrotron and neutron physics, nuclear physics methods for cultural heritage objects. An interesting report dedicated to the history of nuclear physics in Russia was presented by Dr S. Khlebnikov (V. G. Khlopin Radium Institute of State Atomic Energy Corporation ROSATOM). It referred to the historical milestones of Russian atomic science and to the 80th anniversary of the spontaneous nuclear fission discovery, which was made in Leningrad by young physicists G.N. Flerov and K.A. Peterzhak.

Special attention at this conference was paid to the problems of nuclear medicine. A really ENLIGHTful report was made by Professor Manjit Dosanjh (Senior Advisor for Medical Applications of CERN, CERN and University of Oxford, ENLIGHT Coordinator). The report highlighted the status and the main new directions of hadron therapy with the emphasis on international cooperation in the fight against oncological diseases. About 50% of cancer patients in the world are treated with Radiation therapy (RT) today. The efforts that are currently carried out worldwide to improve the ef-

The Peter and Paul Fortress in St. Petersburg, Russia

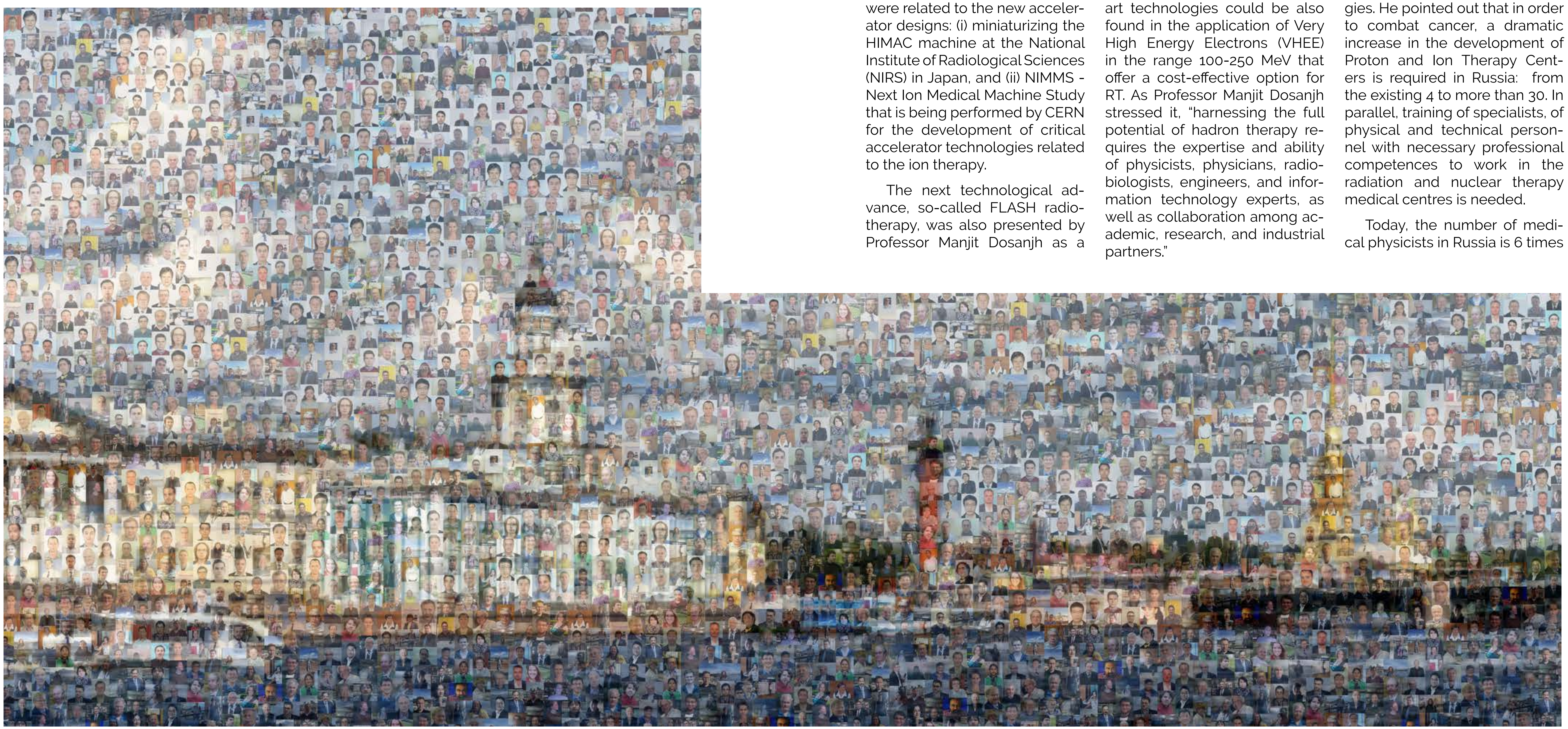
Past Events

fectiveness of RT have the potential to change the forecasts for the upcoming years. The main goal of today's Advanced Radiotherapy Treatment, as it was pointed out by Professor Manjit Dosanjh, is to maximize the damage of ionizing radiation to the tumour cells while minimizing exposure of the surrounding normal tissue and critical organs. To achieve this goal, RT has considerably progressed with the development of new technologies and methodologies that are able to increase the conformity of the dose delivered to deep-seated tumours. While the most frequently used modern RT modalities still rely on high-energy (MeV) X-rays, there is a rapidly growing interest and implementation of accelerated charged particles. Radiotherapy using charged hadrons (protons and light ions), with their unique physical and radiobiological properties, allows highly conformal treatment of various kinds of tumours while delivering minimal doses to large volumes of surrounding healthy tissues. But "much more still needs to be done", as Professor Manjit Dosanjh put it. This includes, in particular, imaging and dose delivery systems (to control and monitor an accurate dose delivered to the tumour), minimal radiation to nearby critical organs during treatment, development of smaller, simpler and cheaper accelerators, improvements in efficiency in patients throughput to increase the number of treated patients per year. As a nice example of new developments, the Laser-hybrid accelerator for radiobiological applications was shown. It is under the development by the LhARA consortium formed by a number of universities, industrial and clinical partners. Other examples were related to the new accelerator designs: (i) miniaturizing the HIMAC machine at the National Institute of Radiological Sciences (NIRS) in Japan, and (ii) NIMMS - Next Ion Medical Machine Study that is being performed by CERN for the development of critical accelerator technologies related to the ion therapy.

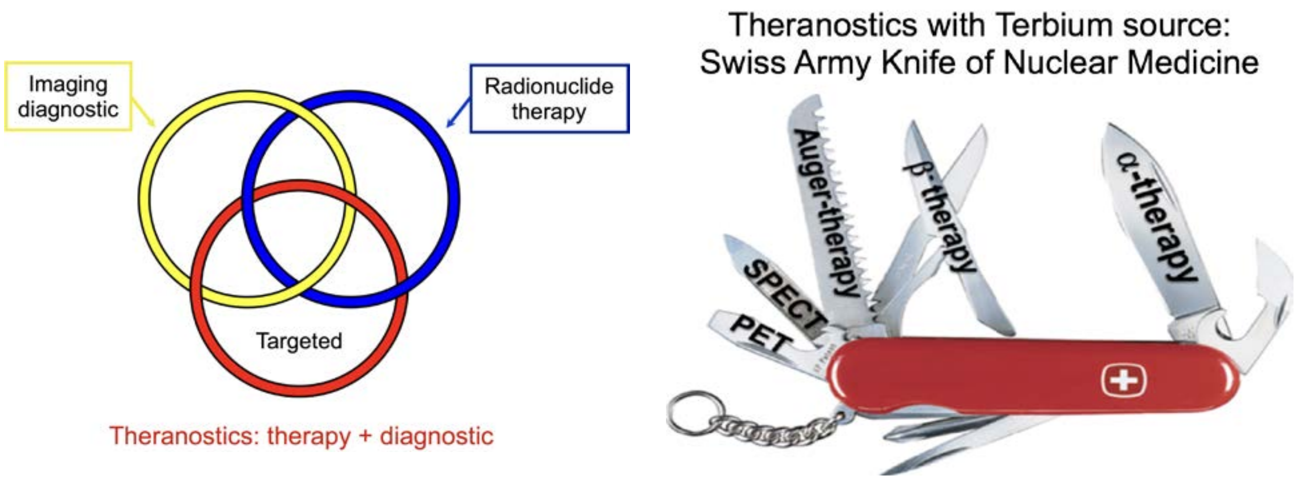
The next technological advance, so-called FLASH radiotherapy, was also presented by Professor Manjit Dosanjh as a promising method of modern nuclear medicine. The ultra-fast delivery of doses at the rates several orders of magnitude greater than those currently used in routine clinical practice opens completely new horizons in the treatment of oncological diseases. This ultra-fast (within a fraction of a second) high-dose radiation treatment was found, in a variety of tests with animals, to be efficient in tumour control with little or no damage to normal tissue. New state-of-the-art technologies could be also found in the application of Very High Energy Electrons (VHEE) in the range 100-250 MeV that offer a cost-effective option for RT. As Professor Manjit Dosanjh stressed it, "harnessing the full potential of hadron therapy requires the expertise and ability of physicists, physicians, radiobiologists, engineers, and information technology experts, as well as collaboration among academic, research, and industrial partners."

The experience of the expert training in nuclear medicine technologies was shared with the conference participants by Professor Alexander Chernyaev from the Moscow State University. In his report, he presented the history of proton therapy in Russia which started in three places: 1967 (JINR, Dubna), 1969 (ITEP, Moscow) and 1975 (PNPI, Gatchina). Professor Chernyaev also presented estimates for the current needs of the Russian Federation in radiation technologies. He pointed out that in order to combat cancer, a dramatic increase in the development of Proton and Ion Therapy Centers is required in Russia: from the existing 4 to more than 30. In parallel, training of specialists, of physical and technical personnel with necessary professional competences to work in the radiation and nuclear therapy medical centres is needed.

Today, the number of medical physicists in Russia is 6 times



Mosaics panorama of Saint-Petersburg prepared for the NUCLEUS 2020 conference by V.Kovalenko and A.Seryakov using the Machine Learning technique and portraits of participants.



«New radionuclides for personalized medicine (theranostics)»

> ***This conference is the oldest nuclear physics conference in Russia and one of the oldest in the world.***

less than in Europe and 14 times less than in the USA, but the situation should be improved. Currently, the Master's Degree Programs for Medical Physicists exist in several universities: Moscow State University, MEPhI, Tomsk Polytechnic University, Saint Petersburg Polytechnic University and Novosibirsk State University. Professional retraining program is going on in the Russian State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency (together with IAEA).

The other important theme of the nuclear medicine methods dedicated both to radionuclide therapy and diagnostic was raised by V.I. Zherebchevsky, Associate Professor, head of the Educational Laboratory for Nuclear Processes of Saint-Petersburg State University. He made a review report on the most modern methods of treating cancer by using radioactive isotopes of various elements. The vital role of new radionuclides for diagnosis (positron emission tomography and single-photon emission computed tomography) and therapy (target therapy) was discussed. The combination of radionuclide imaging with radioisotope therapy - "Theranostics" (a neologism resulting from therapy based on diagnostics) can give excellent results with minimal side effects in the fight with cancer illness. Some novel radionuclides (Auger-Electron emitters) for therapy and diagnostics were presented. The Auger electrons have micron and submicron energy deposition range, a discrete spectrum and higher linear energy transfer (LET) enhancing their ability to destroy cancer cells by means of double DNA strand breaking. Due to their short radii of action and high energies of transfer, Auger emitters are very promising for use in precision-targeted therapy with minimal side effects. In addition, such radionuclides can emit the gamma quanta with energy suited for single-photon emission computerized tomography (SPECT). New target system designed for radionuclide production at cyclotron beams was developed. Investigations of the nuclear reactions to produce Auger-Electron emitter antimony isotopes for diagnostic and therapy were discussed including new experimental data on excitation function of 117Sn(p,n)117Sb and 119Sn(p,n) 119Sb reactions. This work was done in collaboration with Saint-Petersburg State University, V.G. Khlopin Radium Institute of State Atomic Energy Corporation ROSATOM and Institute of Macromolecular Compounds of Russian Academy of Science.

In conclusion, one can note that despite thousands of kilometres and several time zones between participants, we all looked in October at the slides of the speakers, asked questions and commented on their reports. And, who knows, maybe some new hypotheses and investigations will emerge as a result? "From dreams to ideas and to discoveries"! And we hope that all quarantines will disappear soon, and we will be able to meet in person next year at the banks of the Neva River at the second stage of the NUCLEUS-2020 conference (planned at Saint-Petersburg State University in 2021 from the 28th June to the 03rd of July). And we will shake each other's hands without worrying about social distance! Welcome!

G. Feofilov,
T. Lazareva,
V. Zherebchevsky

Country	Population (millions of people)	Amount of accelerators (pieces)	Population per one accelerator (thousands of people)	Total amount of medical physicists
USA	308.7	3820	80	9550
China	1400	1113	1325	2782
Japan	128.1	833	140	2082
Germany	81	515	200	1288
France	70	458	168	1145
Italy	61.5	389	163	973
United Kingdom	59.5	313	200	783
Brazil	199	287	936	717
Canada	35.1	267	131	668
Spain	47.2	214	228	535
Indie	1140	198	2300	495
Turkey	76.2	172	540	430
Australia	23.3	136	170	340
Russia	140	218	1120	640
Netherlands	16.8	126	131	315
South Korea	48.7	122	402	305
Poland	38.2	142	341	355
Total		~9257		23308

«Nuclear physics in medicine: present and prospects»
«Cancer and European Network for Light Ion Hadron Therapy (ENLIGHT)»

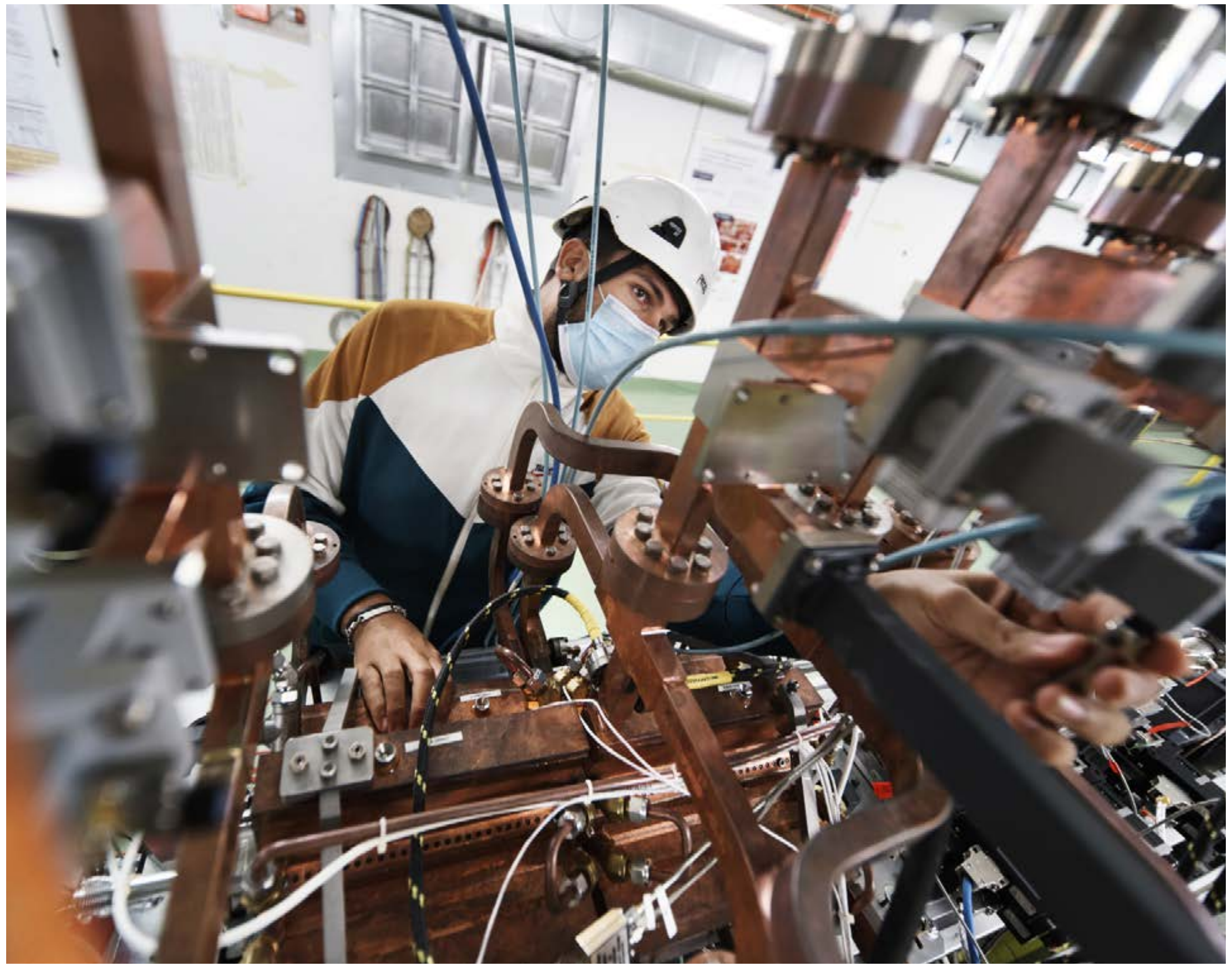
Future Events

NAME OF THE EVENT	DATE OF EVENT	PLACE OF EVENT
21-26 May 2021	PTCOG 59 Annual Meeting	Taipei, Taiwan
27-31 August 2021	ESTRO 40 Annual Meeting	Madrid, Spain
16 – 23 October 2021	2021 IEEE Nuclear Science Symposium and Medical Imaging Conference	Yokohama, Japan
24 -27 October 2021	ASTRO's 63rd Annual Meeting	San Diego, California
1-3 December 2021	FLASH and particle therapy - FRPT 2021	Vienna, Austria

Very High Energy Electron *RADIOTHERAPY WORKSHOP*

Establishing innovative treatment modalities for cancer is a major 21st-century health challenge. With the recent development of a High-Gradient Normal Conducting RF linac technology or even the novel accelerator techniques such as Laser-Plasma Accelerator (LPA), Very High Energy Electron (VHEE) in the range 50–200 MeV offer a very promising option for anticancer Radiation Therapy (RT). Theoretically, the ballistic and dosimetry properties of VHEE surpass those of photons, which are currently the most commonly used in standard RT. In particular, they show the following advantages:

- A significant decrease of integral dose to healthy tissues or sensitive organs compared to photons.
- High dose-rates and fast electromagnetic scanning provide a uniform dose distribution throughout the target and allow for unforeseen RT modalities in particular FLASH high-dose-rate.
- More compact and less expensive facilities than the one used in proton therapy.



CLEAR accelerator upgrade.

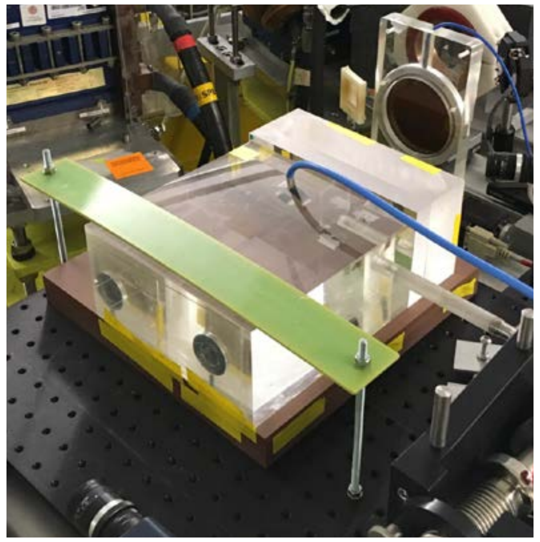
Past Events

For achieving these aims, a synergistic and multidisciplinary research effort based on accelerator technology as well as physical and radiobiological comparisons to see how well VHEE can meet the current assumptions and become a clinical reality is needed. All this asks in a first stage for a large beam test activity, in order to experimentally characterize VHEE beams and their ability to produce the FLASH effect, and provide a testbed for the associated technologies. It is also important to compare the properties of the electron beams depending on the way they are produced, (NC RF linac or LPA technologies). In the second stage, these results will guide the conceptual designs of new VHEE-RT facilities.

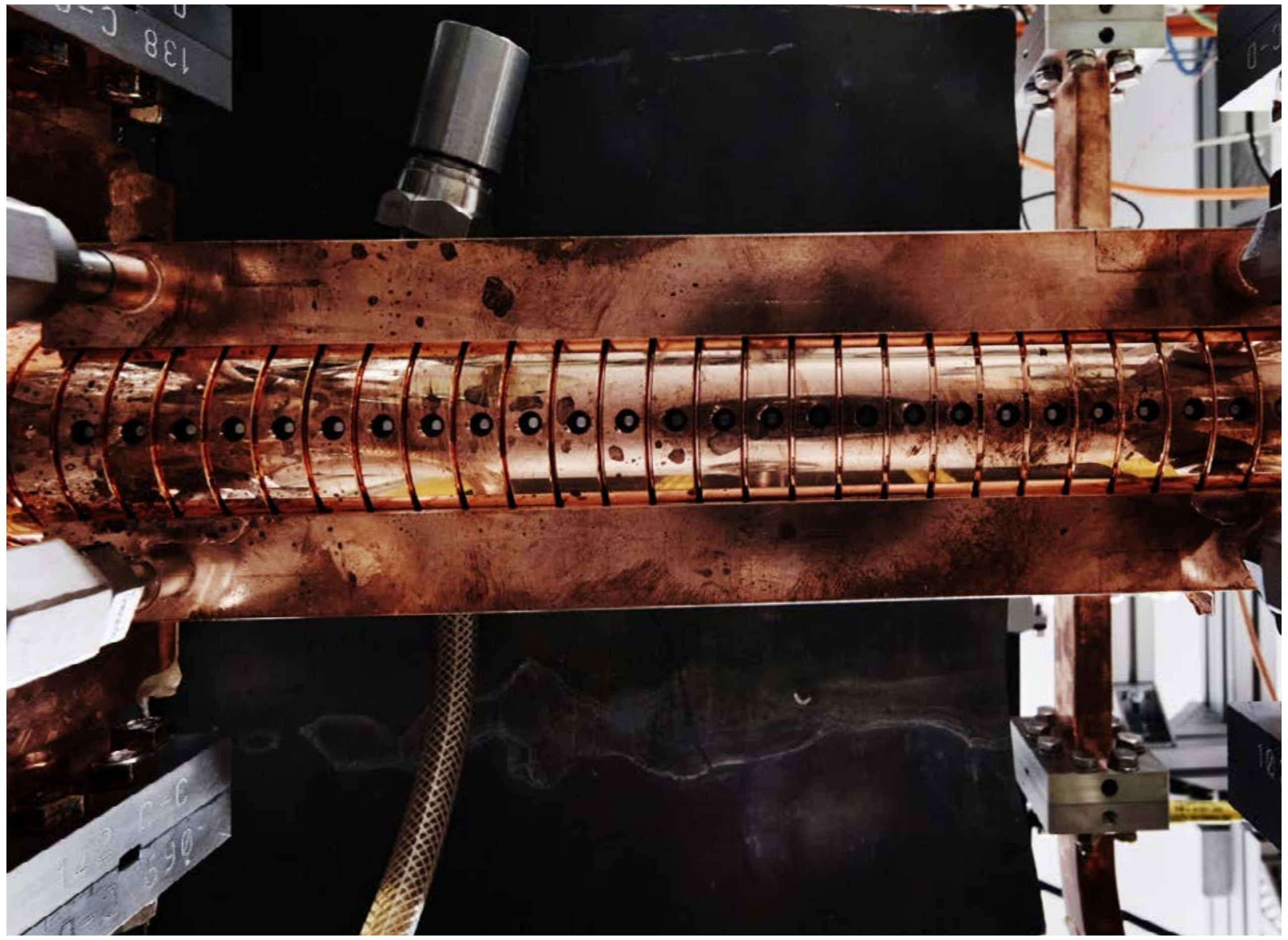
The VHEE 2020 International Workshop, which took place on the 5-7 October 2020, held in remote and organized by CERN **[https://indico.cern.ch/event/939012/]** provided the possibility to more than 400 scientists from the most diverse extractions, from clinicians to biologists, from accelerator physicists to dosimetry experts, to evaluate and discuss the perspectives of this novel technique. The workshop followed up a similar one organized in 2017 in Daresbury **[https://www.cockcroft.ac.uk/events/VHEE17/]** and the large increase in attendance shows the vitality and increasing interest in the field. The workshop also included a very lively session dedicated to industrial partners.

Angeles Faus-Golfe, IJClab–IN2P3

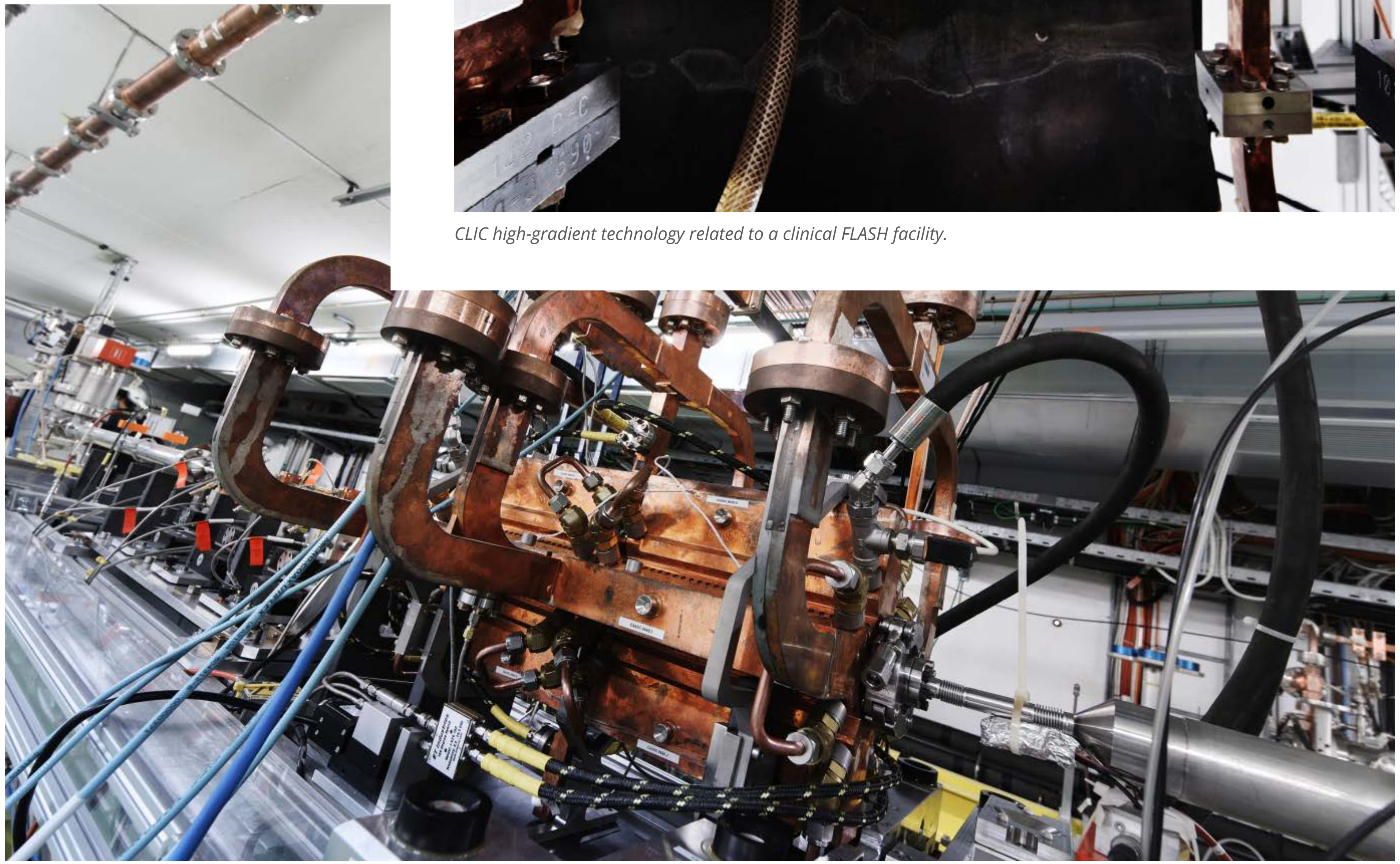
Roberto Corsini, CERN



High-tech A dosimetry experiment for VHEE studies in collaboration with NPL in CERN's CLEAR user facility. Credit: R Corsini/CERN



CLIC high-gradient technology related to a clinical FLASH facility.



Prototype CLIC accelerating structures.

ENLIGHT FOR SEEIIST

This summer, ENLIGHT hosted for the very first time an entirely online one-day event covering various topics dedicated to the Improvement of Cancer Control in Southeastern Europe and the role of the future SEEIIST (South East European International Institute for Sustainable Technologies) facility.

While the majority of Western Europe has access to Proton Therapy (26 centres 8 provide proton therapy), South-East Europe with a population of over 40 million inhabitants does not yet have a single Proton Therapy (PT) facility. Therefore, the role of the SEEIIST facility is challenging as it needs to incorporate both patient treatment and the associated cutting edge research programme, which should ultimately become an integral part of the European PT field.

This effort is very much supported by collaborating with the European Network for Light Ion Hadron Therapy (ENLIGHT), established 20 years ago to strengthen EU-PT in clinical research, in R&D for technology and in education and training, based on the principle of open collaboration and sharing of knowledge Thus, the ENLIGHT for SEEIIST conference resulted from the idea of building a community in South-East Europe (SEE) who will share, develop and lead to the successful implementation of hadron therapy in the region.

Key players from the particle therapy field and highlights of the event were presentations by Jurgen Debus (HIT), Ugo Amaldi (Tera Foundation), Sandro Rossi (CNAO), Piero Fossati (MedAust), Eleanor Blakely (Berkeley). The talks covered the multidisciplinary aspects of PT giving an overview of the current status and future perspectives in the development of Hadron Therapy.

In addition to the highly informative presentations by the world-leading speakers, an important point was made by Jurgen Debus, the Director of the Heidelberg Ion-Beam Therapy Center (HIT) for building a research infrastructure which would also be transnational for the area. His current research with helium beams has already proven successful and the first helium module is now ready and waiting for the formal adaptation of the European Union Medical law - "the vision of particle therapy that you have a multidisciplinary team, that you explore and utilise these novel beams such as Helium...but you may also explore and utilise the systemic effect of radiation therapy beyond the local tumour cell killing which leads in the end to multidimensional adaptive radiation therapy where you integrate also information about time, space, the biology, patient history..."

Some of the participants in the online conference.

Map of Europe showing the lack of facilities in South East Europe.

A further aspect of the talks given by SEE representatives such as Minister Sanja Damjanovic and prof. Vladimir Todorovic (Montenegro), Vesna Gershan and Mimoza Ristova (North Macedonia) placed the idea of SEEIIST into context and within the particle therapy map of Europe. "There is a need of having the scientific community behind us even if the political support is there", pointed Manjit Dosanjh while giving one of the reasons for organising this meeting, "to try to get the community in the region together, tell them which are the latest developments in the field and also point out the possibilities of how we can work together."

Behind this dedicated ENLIGHT meeting for the region was the underlying motivation to demonstrate that when working together we are stronger and we can move forward.

Most importantly, the call for having a centre which can educate, train, treat patients, bring people together and innovate which is really key for the future of SEE. There is an urgent need to have a multidisciplinary network in the region, build on existing networks and collaborate. But in order to have a centre first and getting the community to buy in, one has to raise the awareness of Hadron Therapy. Specifically, the conference and discussions showed that communication is key, scientific and political support is needed both, to have tools for open access, for knowledge sharing, training for the future and really getting public bodies, ministries, medical doctors as well as researchers on board with a common vision.

Petya Georgieva

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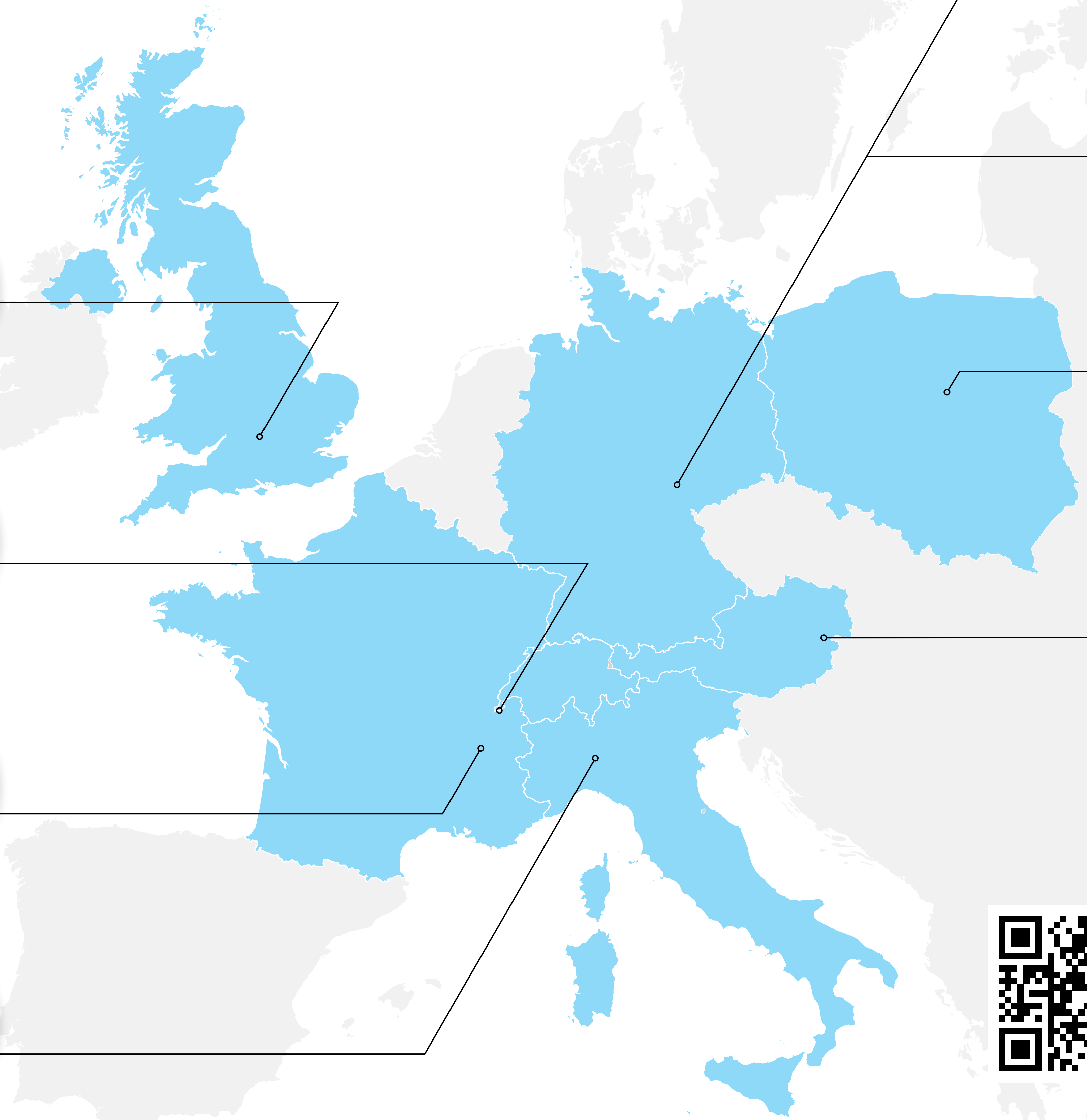

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Together, we can do even greater things!