



Editorial

Dear Reader,

Welcome to this edition of our bi-annual newsletter from the RAPTOR (Real Time Adaptive Particle of Cancer Therapy) project.

As we approach the end of 2023, a pivotal year for our project, we are delighted to share the remarkable progress that has been made to date. Now halfway through the project, which started in March 2021 and is scheduled to end in September 2025, RAPTOR has successfully met all planned deliverables and milestones. All 15 RAPTOR PhD students have made significant progress in their projects, contributed to national and international conferences and published 12 papers in peer-reviewed journals. Several collaborations have been initiated between the institutes involved in the consortium, facilitated by the secondments of the PhD students.

Three schools have been organised, not only for RAPTOR students but also for external participants.

This newsletter focuses on the 3rd RAPTOR School, a highlight of 2023. Held at the Paul Scherrer Institute (PSI) and in Ticino, Switzerland, the School was combined with the 4D Particle Therapy Workshop and a Photon Adaptive Radiotherapy Seminar. The event integrated a wide range of knowledge, including soft skills and scientific content. The atmosphere was charged with positive vibes, exemplifying a collaborative spirit and a solid commitment to advancing the development of online and real-time adaptive therapy.

As we close 2023, we look forward to an inspiring start to 2024.

For more information and future progress, please visit the official RAPTOR website ([RAPTOR Consortium](#)) and LinkedIn page ([RAPTOR LinkedIn](#)).

Enjoy reading!

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RAPTOR Loop Engagement *and the 4D workshop*

An integral part of RAPTOR's mission is providing specialized annual schools to train the new generation of scientists in proton therapy. The third and last school, Loop Engagement, took place from September 10-15, 2023 in Ascona, Switzerland.

4D workshop

The 14th edition of the 4D workshop for particle therapy took place from September 9-10, 2023, at the Paul Scherrer Institut (PSI) in Villigen, Switzerland. This marked a significant return to PSI, a decade after the 5th edition of the series. The event successfully brought together a distinguished gathering of senior scientists, clinicians, and emerging researchers in radiation therapy. Their collective focus was on exploring recent innovations, sharing clinical results, and addressing the evolving challenges in 4D particle therapy.

The workshop commenced with presentations by Dr. Christoph Bert and Dr. Dirk de Ruyscher, offering insights into the current status and challenges of 4D particle therapy, covering both physics and clinical aspects. This was followed by a new event in the 4D workshop: a case study comparing 4D clinical practices in the particle therapy community. Renowned particle therapy centers worldwide were asked to plan one common

This edition aimed to provide early-stage researchers not only with specialized scientific knowledge, but also with interdisciplinary skills to further develop their career. Our 15 early stage researchers (ESRs) participated, as well as multiple external students.

This year, the RAPTOR school was furthermore preceded with another important event in the particle therapy community: the 4D workshop for particle therapy. 4D treatments share many similarities and common difficulties with adaptive radiotherapy, such as fast image analysis, quality assurance, the need for automation,... Co-organizing both events in Switzerland allowed researchers from these different subdomains to interact and share knowledge. We summarize hereunder the highlights.



case before attendance, and a representative of each institute delivered a concise three-minute elevator pitch, outlining their institutional practices in 4D treatment planning and evaluation. Many



differences were found, especially in the estimation of the motion extent. The findings have been condensed into an abstract for the 2024 ESTRO conference, with plans for further detailed publication.

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In the afternoon session, Dr. Anthony Lomax provided a comprehensive overview of the development and milestones achieved in 4D therapy over the past decade. He also envisioned a future paradigm shift towards 5D therapy, acknowledging the irregularities in periodic organ motions. Following this inspiring talk, Dr. Marco Schwarz, Dr. Christian Graef, and Dr. Gabriel Guterres Marmit reported on the latest advances in treatment planning, delivery, and quality assurance in 4D therapy. The first day concluded with a vibrant poster session, where 20 young scientists presented their research on 4D therapy.



Day two of the workshop started with illuminating talks from Dr. Stephanie Tanadini-Lang and Dr. Olga Sokol. They shared insights into the clinical practice

and outcomes of online adaptive photon therapy and the biological effects of 4D dose painting. The experiences gleaned from 4D photon therapy provided the particle therapy community with a valuable reference, enhancing our understanding of current results in 4D particle therapy and guiding future developments.



In the final session, Dr. Martin Fast, Dr. Ye Zhang, and Dr. Aswin Hoffmann delved into the future applications of magnetic resonance imaging (MRI) and artificial intelligence (AI) in 4D particle therapy. The potential of MRI to enhance image quality and provide high-time resolution for tracking patients' anatomy was highlighted, contributing to improved 4D treatment accuracy. AI, with its diverse applications, was showcased, including synthetic CT creation. Dr. Ye Zhang presented a fascinating study on using AI to generate synthetic 4D MRI lung phantoms.

The 14th edition of the 4D workshop not only served as a dynamic platform for researchers to exchange ideas and share outcomes but also facilitated valuable networking opportunities. This event played a pivotal role in bringing the 4D therapy community closer together than ever before.



RAPTOR Loop Engagement



The 3rd Raptor School took place in the beautiful Swiss mountains alongside the Lake Maggiore. The venue was the Monte Verità, a settlement for pacifist, writers and artist in the early 20th century, later adapted as conference venue as part of the Congressi Stefano Franscini, support by ETH Zurich. The event seamlessly integrated a diverse range of knowledge, encompassing soft skills and scientific content. Dr. Barbara Bachtiry illuminated the financial challenges faced by cancer patients undergoing proton therapy, urging medical teams to address this crucial issue. Dr. Antje-Christin Knopf delved into project management intricacies, exploring styles and reflecting on teamwork dynamics within constraints like time, budget, and scope. Entrepreneurial prospects in the RT community were highlighted by Dr. Heinz Deutschman, and Dr. Marco Schwarz presented the art of engaging an audience for education. Scientific talks featured Dr. Simona Giordanengo unraveling beam delivery and instrumentation concepts, while Dr. Reinhard Schulte shared insights into recent advancements in detector technologies for adaptive radiation therapy. Collectively, these presentations painted a vivid picture of innovation, collaboration, and the ever-evolving landscape of advanced medical techniques shaping the future of treatment strategies. The program also delved into biological modeling and hot topics like proton mini-beams and FLASH irradiation.

In a captivating open-door seminar led by Prof. Bas Raaymakers from UMC Utrecht, we delved into the world of photon adaptive radiotherapy. The seminar proved highly informative, unraveling the innovative technology behind a hybrid MRI accelerator. This cutting-edge device enables precise image guidance based on soft tissue, ushering in a new era of improved radiotherapy with heightened dose escalation and reduced toxicity. Online MRI guidance has emerged as a crucial tool, effectively mitigating motion uncertainties and ensuring the safe and efficient administration of radiation.



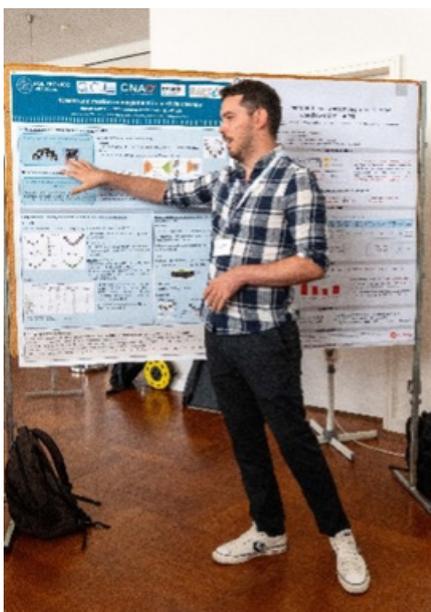


During a one-day event at the workshop, the young researchers participated in a writing workshop with the aim of improving their scientific writing skills for journal articles. The workshop was given by Scriptoria, in a way to empower participants to become more effective writers and enhance the quality of their research publications. The early-stage researchers gained valuable insights through cycles of learning, discussion, and critique, covering topics such as the manuscript review process, leading the writing process, addressing issues of authorship, integrity, and ethics, managing data and references, and crafting clear presentations of data through tables and figures. By the end of the workshop, participants were equipped with the knowledge and skills to draft concise manuscript abstracts and texts, as well as the ability to edit their own work for improved organization and style, ensuring a polished and professional final product.

At the same time, senior researchers involved in the current EU-MSCA-ITN RAPTOR grant organized a workshop open to external participants interested in potential future collaborations on adaptive therapy. During this session, which was attended by around 40 scientists, a consensus emerged on the need and desire to continue the collective effort to advance online and real-time adaptive particle therapy towards clinical implementation. As a result, a follow-up proposal is currently being drafted with the intention of submitting it in 2024.

Not only experienced researchers were allowed to showcase their work, also the young scientist had a dedicated session to present a poster. What followed were vivid and illuminating discussions, within and across different levels of seniority. The informal setting presented unique opportunities to improve the scientific work, to engage with the community and to expand everyone's network.

This recent gathering of young researchers was truly inspiring. What stood out was the harmonious atmosphere and a feeling of collective progress. Overall, the event was a showcase of vibrant intellect and collaborative spirit, and it left a lasting impression on all those who attended.



Scientific Contributions

Peer-reviewed journal publications

- Smolders A. et al. Deep learning based uncertainty prediction of deformable image registration for contour propagation and dose accumulation in online adaptive radiotherapy (2023), *Physics in Medicine and Biology* (ESR1)
- Galapon A. et al, Feasibility of Monte Carlo dropout-based uncertainty maps to evaluate deep learning-based synthetic CTs for adaptive proton therapy (2023), *Medical Physics* (ESR4)

Conference participations

During 2023, our ESRs have contributed to many national and international conferences: ESTRO, PTCOG, BigART, SASRO, SSRMP, ASTRO & AIFM. Here are some highlights:



At ESTRO 2023, Cosimo Galeone and Andreas Smolders gave presentations during the 'Adaptive radiotherapy' session. Cosimo discussed a new tool for real-time 4D carbon ion dose calculation, and Andreas talked about the impact of auto contouring on the dose distribution in adaptive proton therapy. Nadine Vatterodt and Jacob Brunner discussed their posters in the "Current challenges in proton therapy" session.



PTCOG 2023 was even more successful than ESTRO. So successful, that in one of the sessions 4 out of 5 speakers were RAPTOR ESRs. Luciano Rivetti and Andreas Smolders discussed uncertainty models for contour propagation and deformable registration respectively. Zihang Qui introduced a reference point method of daily treatment plan reoptimization, and Cosimo Galeone presented a method for real time DVH estimation for carbon ion therapy. Five other ESRs also travelled to Madrid to share their posters and learn about the latest work in particle therapy.



The cherry on the cake was during the PTCOG gala dinner, our ESR1 Andreas Smolders was awarded this year's PTCOG Young Investigator Award for his work on predicting the uncertainty of deformable image registration. An honor for him and the consortium, congratulations!

Secondment Reports



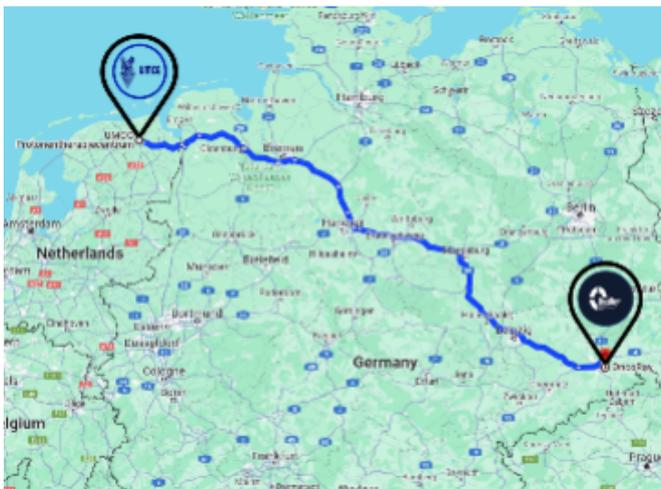
Giuliano Perotti Bernardini, CRCG (UMCG)

Who: Giuliano Perotti Bernardini, working with Stefanie Bertschi and Jonathan Berthold, under the supervision of Kristin Stützer and Christian Richter.

Where: OncoRay, Dresden, Germany

When: August - October 2023

Why: Compare two different and complementary approaches for treatment verification: prompt-gamma-imaging (PGI) and proton radiography (PR)



How would you describe your secondment in one word?

Second-home

What did you take home from your secondment?

My largest PR measurement dataset and new dance moves.

Which song describes your secondment best?

'En Douceur' – By Malcom Beatz ft. Kaysha

Dresden was super welcoming, not just because of the warm weather but also the friendly people. I hit the jackpot with the timing—had a blast barbecuing with the OncoRay team by the Elbe, cracked some city riddles in an escape room, and explored Saxon Switzerland National Park on hikes. Adventures kept rolling, like hitting a climbing park with PhD students and my brother. Nights were chill, learning Kizomba dance to unwind.

On the research front, the secondment was a real boost. Collaborating with Stefanie and Jonathan, we dove into experimental measurements, exploring the strengths of our imaging techniques and their synergy in spotting treatment deviations in proton therapy. Running the beam delivery system stole the show, leaving me with a load of proton radiography data to analyze. All in all, Dresden blended work and play seamlessly, making it a truly enriching experience.





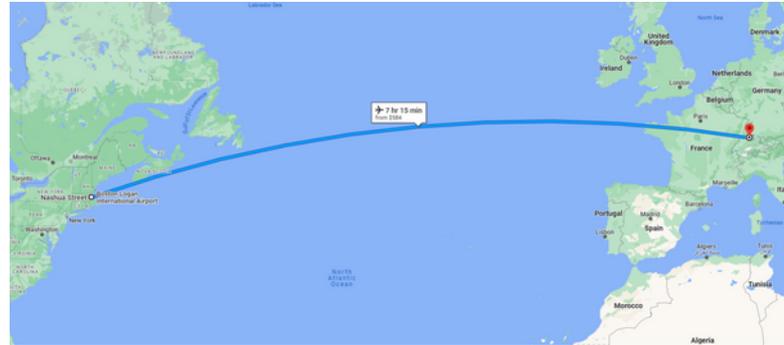
Evangelia Choulilitsa, PSI

Who: Evangelia Choulilitsa

Where: MGH, Boston, Massachusetts, United States of America

When: 18th September – 11th December 2023

Why: Investigation of different online adaptive workflows

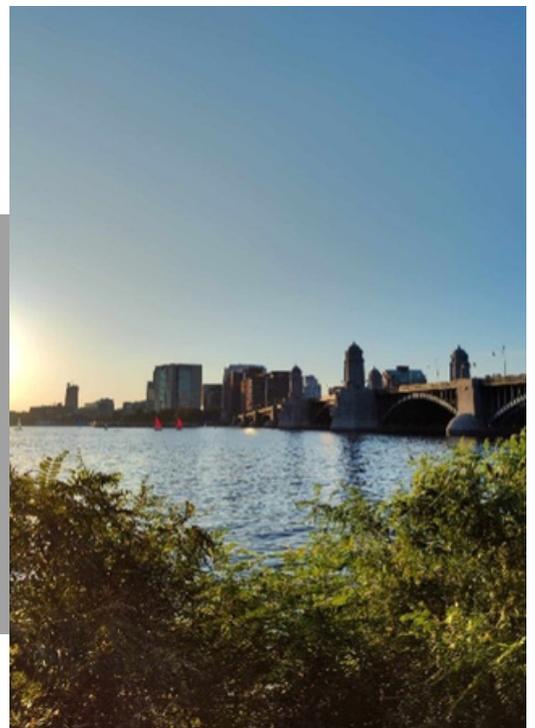


I spent three months at MGH as part of the ongoing collaboration between PSI's Department of Proton Therapy and MGH's Department of Radiation Oncology. During this secondment, a primary objective was to extend the analysis from our experiments at PSI in August 2023. Collaborating with the MGH team at our institute, we conducted a phantom study to compare two distinct daily adaptation approaches. Simultaneously, I initiated a retrospective study during my stay, exploring diverse daily adaptive strategies by incorporating insights from the unique perspectives of both institutes.

During these three months, I've not only been able to explore and expand my scholarly pursuits but also broaden my professional horizons. I had the pleasure of meeting new colleagues from whom I gained valuable insights and innovative techniques. Plus, I got to wander around Boston, soak in the awesome fall vibes as the weather changed, and do some cool traveling!



During this period of collaboration and exploration, I had the opportunity to work with some amazing people who helped me grow both professionally and personally. It was truly a noteworthy chapter in my life, and I'm grateful for the experience.



How would you describe your secondment in one word?

Stimulating

What did you take home from your secondment?

Results, memories, and new friends

Which song describes your secondment best?

Chaser – Mammal Hand



Cosimo Galeone, GSI, Darmstadt, Germany

Who: Cosimo Galeone
Where: National Institute of Nuclear Physics, Turin, Italy
When: 16th October – 15th December 2023
Why: Further development of the tool with experimental tests

I spent two more months in Turin, as part of my close collaboration with the medical physics team at the University of Torino and the Torino section of the Italian National Institute of Nuclear Physics.

I have been working on an extension of the algorithm, developed in the last two years. This is part of a project under development with another ESR, Anestis Nakas from the Polytechnic of Milan. The secondment has been very successful since I got to exploit the programming expertise of the group of Turin as well as the proximity to Milan for a better coordination of the project. We also managed to test experimentally the new system at CNAO.

Going back to Torino is always a pleasure for me. I lived there many years over there and I had the chance to meet some old friends and make new ones. It was also perfect timing since I managed to see my favorite tennis players for the ATP finals happening in Turin during that period.



How would you describe your secondment in one word?
Fruitful

What did you take home from your secondment?
A nice experiment

Which song describes your secondment best?
Menù – Patty Pravo



Beatrice Foglia, Ludwig Maximilian University of Munich

Who: Beatrice Foglia

Where: RaySearch Laboratories, Stockholm, Sweden

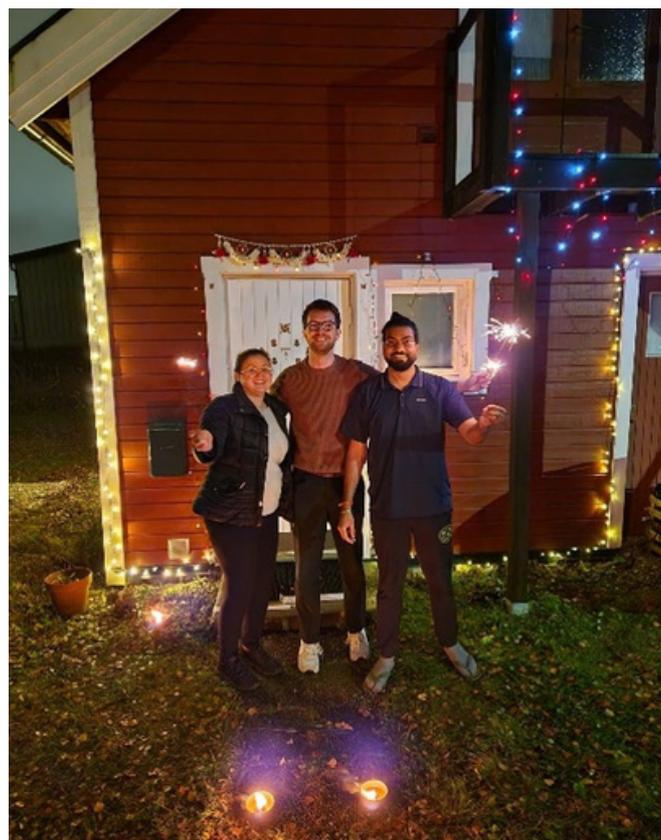
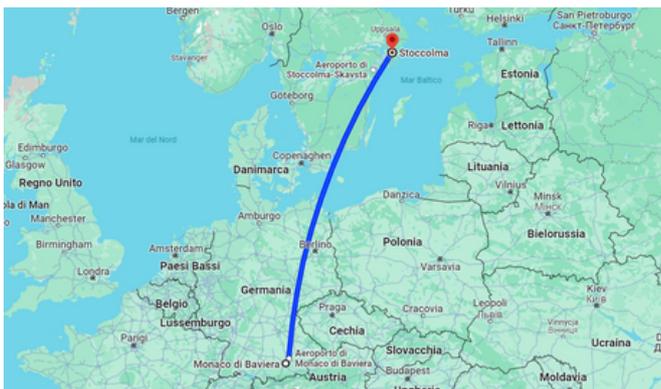
When: 25th October – 30th November 2023

Why: Spot boosting within RayStation

I had the pleasure of being hosted for one month of secondment at RaySearch Laboratories, a world leader company in software for radiation therapy (<https://www.raysearchlabs.com/>).

The purpose of the secondment was testing a new version of RayStation. This version allows to re-optimize proton plans where, for some selected spots, a high number of protons is delivered. This is of interest for my project, because boosting spots can improve range verification and monitoring with secondary particles, like prompt gammas. The question is: how much is it possible to boost a spot, and how many spots can be boosted, before degrading the plan? To answer to it, comparison of plans before and after re-optimization with different settings is ongoing.

Despite everyone I met told me that “November is the worst month to come to Stockholm”, it was not that bad. Stockholm offers a lot of art, science and nature, even in winter. I enjoyed a lot spending time with my RAPTOR ESRs colleagues Andreas and Suryakant.



How would you describe your secondment in one word?

Cold

What did you take home from your secondment?

Scientifically, I will probably get a new RayStation version (still to be defined). On a personal level, I increase my general culture knowledge, celebrating Diwali's festival.

Which song describes your secondment best?

Can't Get You Out Of My Head - Kylie Minogue



Suryakant Kaushik, *RaySearch*

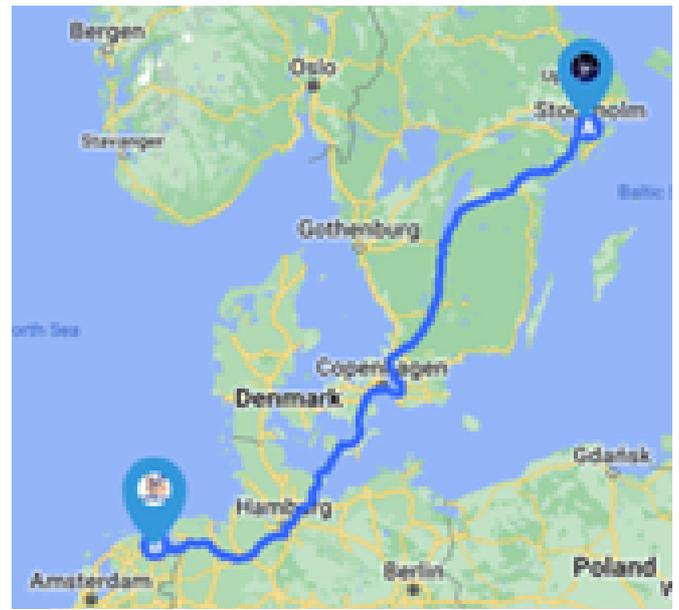
Who: Suryakant Kaushik in collaboration with Dr. Stefan Both.

Where: UMCG, Groningen, Netherland

When: 2nd October 2023 to 20th October 2023

Why: Variable RBE models uncertainty quantification.

A stunning city full of bike fanatics. I chose to bike as well and finally learned how to ride in a right sided driving country. The colleagues were kind, and we had a great time at several of the social events—the "Escape Room" perhaps the most memorable. I also admired a phenomenal panorama of the city from the Forum and the Martinitoren. I did not get the chance to explore the city much as it was raining most of the time during the secondment, I hope I get a second chance.



From a learning viewpoint, the secondment proved to be extremely beneficial. I had the chance to have a productive conversation with the Medical Physicists, which enabled me to better comprehend some of the challenges encountered while making clinical decisions based on different variable relative biological effectiveness (RBE) models. I conducted the study on various clinical sites, and some interesting and exciting findings came up. All things put together; this internship highlighted a work I should pursue further for my doctoral studies.



How would you describe your secondment in one word?
Friendly

What did you take home from your secondment?
Rolling stone tongue

Which song describes your secondment best?
'Chatte Batte' by Armaan Malik, Mohit Chauhan, Amit Trivedi



Sergei Diuzhenko, *Cosylab*

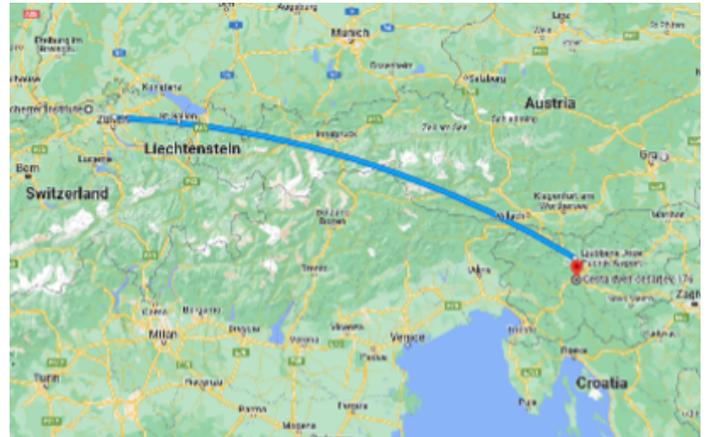
This summer I spent two months at PSI as part of a collaborative project between Cosylab and PSI's Proton Therapy Centre. We used patient dose delivery log files to investigate the uncertainties associated with the PSI Gantry 2 machine and their impact on treatment quality. The collaborative work we've done with other ESR Andreas Smolders gave a boost to the project and we are planning to continue our successful collaboration, and exploit obtained data to assist daily dose adaptation with machine specific information.

Who: Sergei Diuzhenko, collaborating with Andreas Smolders, under the supervision of Francesca Albertini

Where: Paul Scherrer Institute (PSI), Villigen, Switzerland

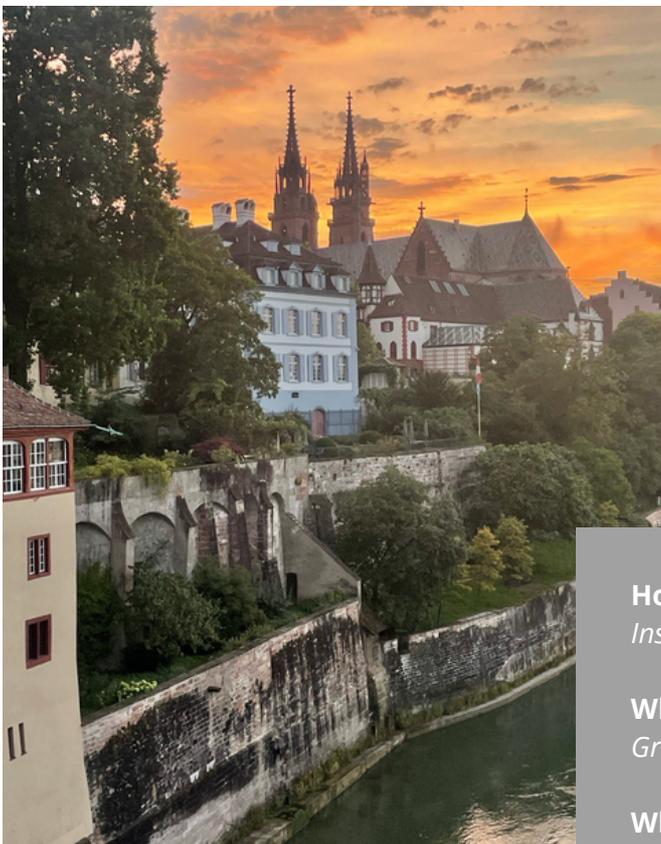
When: July-September 2023

Why: Validation and application of log-file based dose recalculation framework in clinical environment.



Majority of my PhD time I am working in an industrial environment and during the secondment with the help and guidance of Francesca Albertini I've gained a valuable experience of both academical and clinical side of particle therapy. It has been a pleasure to meet and work together with other PhD students from the PSI. Their enthusiasm, hard work and professionalism inspired me and helped me to overcome the challenges I faced.

During my stay in Switzerland, I decided to skip the famous hikes in the mountains and explore the urban side of the country, and a trip to Basel was a highlight. I was impressed by the quiet atmosphere of the city, the variety of museums, the mix of modern and medieval architecture and a special summer adventure - floating down the Rhine in the middle of Basel's old town.



How would you describe your secondment in one word?

Inspiring

What did you take home from your secondment?

Great basis for further work, and Basel Wickelfisch.

Which song describes your secondment best?

"Better than" by John Butler Trio



DEPARTMENT OF RADIATION ONCOLOGY



*Listed in alphabetical order.

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