RAPTORplus Recruitment

Sunday 21 December 2025 - Monday 9 February 2026

List of PhD Projects

IRP01 (Cosylab, Slovenia) - Data processing and transfer optimization for enabling OAPT

Adaptive particle therapy requires fast and reliable software systems that can support changes to treatment plans during therapy sessions. Current workflows in particle therapy are largely static and depend on pre-calculated plans, which limits flexibility when patient anatomy or machine parameters vary.

The challenge is to design and implement software that can handle real-time data exchange between planning and delivery systems while ensuring interoperability, security, and performance in clinical environments. This involves developing algorithms for adaptive workflows and creating intuitive user interfaces for clinical use, with potential use of machine learning, neural networks or similar approaches.

The PhD student will work on full-stack development, combining backend logic, database management, and frontend components, while exploring high-performance computing techniques for medical applications.

The student will be employed at Cosylab under the supervision of Dr. Kristjan Anderle and enrolled in the PhD program at the Faculty of Computer and Information Science, University of Ljubljana (UL). Cosylab is the global leader in control system integration for proton therapy and Big Physics machines: particle and nuclear accelerators and other large facilities such as tokamaks and radio telescopes. UL is the largest university of Slovenia and hosts multiple faculties dedicated to research and study areas.

IRP02 (OncoRay-HZDR, Germany) - Assessing and improving first OAPT workflows of a clinic-industry consortium

Proton therapy treatments of patients with lung cancer – the cancer type with the highest absolute mortality in Europe – are already today often adapted several times during the total treatment course. These and other patients with tumors in the thoracic-abdominal region could greatly benefit from an immediate adaptation, when it is (1) really indicated and (2) performed in efficient online-adaptive proton therapy (OAPT) workflows. The clinic-academia-industry consortium ProtOnART is currently working towards showcasing their first OAPT implementations for oesophageal and lung cancer patients in the proton therapy centres in Leuven (Belgium) and Dresden (Germany).

The project aims to assess and further develop the OAPT workflow efficiency in Dresden with a focus on time reduction at all key steps of the treatment pathway. The tasks include the establishment of automated treatment session documentations for the retrospective assessment of the workflow performance and the identification (plus solving) of critical obstacles during first clinical applications in Dresden also in comparison to experiences at the partner site in Leuven.

dIn addition, the doctoral candidate will specifically work towards an automated decision support

system for online adaptation with regard to economic factors and clinical measures, such as tumour-site-specific NTCP. They will also conduct research on novel, fast optimisation strategies. By gaining insight into and supporting the clinical implementation of the first ProtOnART OAPT workflow, the candidate will strengthen the connection between ProtOnART and RAPTORplus.

The selected secondments will support both the knowledge acquisition and the application of the gained expertise by the doctoral candidate: (1) Get to know industry solutions supporting precise radiotherapy of lung lesions at Brainlab SE, (2) Learn about metrics for the effectiveness assessment of adaptive proton therapy of lung lesions at Holland PTC, and (3) Apply OAPT efficacy assessment metrics/tool to other cancer site at KU Leuven.

The student will work at OncoRay – National Center for Radiation Reasearch in Oncology (Dresden), under the supervision of Dr. Kristin Stützer, and will graduate from the TUD Dresden University of Technology.

IRP03 (PSI, Switzerland) - Reducing the cost of OAPT: automation, workflow & health economics evaluation

As part of the online adaptive proton therapy (OAPT) process, daily adaptation requires substantial time and resources, which may affect clinical throughput and overall cost. While OAPT has the potential to improve treatment quality by accounting for anatomical changes, its widespread implementation is currently limited by the extra daily workload and the lack of clear evidence on its economic viability and acceptability for centres, insurers, and patients.

The central aim of this PhD project is to investigate how OAPT can be organized and automated so that the additional daily adaptation effort does not reduce treatment-room throughput and results in an acceptable cost per patient. The project will explore strategies to accelerate treatment delivery—such as reducing the number of beams or spots, optimizing dose rate, hypofractionation, and triggered adaptation—while maintaining plan quality and patient safety.

A second goal is to develop a time-driven activity-based costing model and apply health-economic methods to quantify the impact of workflow automation and different clinical strategies on treatment-room time, staff utilisation, cost per patient, and cost-effectiveness. Patient and public preferences (e.g., willingness to accept longer sessions versus fewer visits or lower toxicity), together with insurer and regulator perspectives, will be integrated into a multi-criteria decision-support tool to guide cost-effective use of OAPT.

This joint project between PSI (Switzerland) and ErasmusMC (NL) combines technical work (workflow analysis, scripting, planning) with quantitative health economics and preference modelling, in close collaboration with clinical, technical, and management teams at PSI and Erasmus.

The candidate will be enrolled in the Erasmus MC (NL) PhD program. The project is a 4-year funded PhD position: the candidate will be employed at PSI (Switzerland) for the first 3 years and employed at Erasmus MC for the 4th year.

IRP04 (Brainlab, Germany) - Multimodal early response assessment in radiotherapy

In addition to therapy guidance based on objective diagnostic assessment, patient reported outcome measures (PROMs) may also serve as reliable indicators for early response assessment and even an optimal stopping in radiotherapy. To conclude on this potential, the main objective of the project is to develop a framework for multimodal early response assessment in radiotherapy. This framework will build upon existing technology for cancer registries and will include imaging data such as MRI, CT and PET-CT, radiotherapy plans, dose distributions and other patient data including lab values from blood samples, molecular profiles, imaging-derived parameters, and PROMs. Data will be collected primarily with the LMU University Hospital as part of a specifically designed patient study conducted within the newly designed framework.

As a doctoral candidate (Dr. rer. nat./Dr. hum.biol) for Healthcare Data Modelling, you will fill our data ecosystem with life and create solutions together with our cross-functional teams and customers. Embedded within the multinational EU-funded RAPTOR+ consortium, your project will be part of an industry-academia collaboration between Brainlab and the LMU Hospital, Department of Radiation Oncology. At Brainlab, you will be part of a growing interdisciplinary team that creates a patient-privacy-centered ecosystem for data-driven healthcare and rethinks all aspects from data capture and visualization to analysis. You will play a central role in a project focusing on understanding client needs, the definition of data collection protocols, and the development of FHIR resources. Additionally, you will ensure compliance with regulatory standards and apply agile methodologies to drive project success. At LMU Radiation Oncology, as the academic partner, you will collaborate with a multidisciplinary team of medical doctors, physicists, and data scientists.

IRP05 (Univ. of Manchester, UK) - Assessing the benefits of adaptive proton therapy in paediatric patients

Proton therapy offers significant advantages to young patients by delivering highly conformal radiation while minimising dose to healthy tissues. This is crucial for preserving quality of life, reducing long-term side effects, and supporting normal growth and development. However, proton treatment plans are more sensitive to anatomical changes than conventional radiotherapy, making adaptive strategies essential to maintain safety and effectiveness throughout treatment. Young patients present additional challenges for adaptive radiotherapy, including diverse treatment indications of varying complexity, treatment under general anaesthesia and different risk profiles, where imaging dose and late effects must be carefully balanced. Since opening in 2018, The Christie Proton Beam Therapy Centre has treated over 840 paediatric patients (≤16 years) and >360 additional teenage and young adult patients (≤25 years). This rich dataset provides a valuable opportunity to investigate adaptive proton therapy in young patients and develop strategies tailored to their needs.

This project aims to address the research questions:
Can patterns of change observed in young patients be used to guide adaptive treatment strategies using short-term robust plans (plans designed to be robust to anticipated changes over a small number of upcoming fractions)?
How can young patients most benefit from adaptive treatment strategies and how should such strategies be adjusted for their different risk profiles?

This will be achieved through:
Quantifying anatomical uncertainties – analysing on-treatment imaging across a large patient cohort to identify phenotypes of change (e.g., weight variation, sinus filling, bowel changes) and their impact on treatment plans.
Developing strategies for evolving uncertainty evaluation in adaptive planning – building models to predict short-term anatomical changes using recent imaging and patient characteristics to guide robust treatment planning.
Evaluate the dosimetric benefit and risk trade-offs for paediatric patients – comparing daily adaptive approaches with short-term robust plans to determine which patient categories benefit most from adaptation.

The candidate will be embedded within the Radiotherapy Related Research team at the University of Manchester and the Proton Therapy Physics team at The Christie NHS Foundation Trust, gaining expertise in proton therapy physics, advanced image analysis using 3D imaging, and handling large, multidimensional datasets. The project will involve multidisciplinary clinical research with opportunities to work alongside experts from different fields.

IRP06 (PSI, Switzerland) - The benefit of OAPT for paediatric patients

Online adaptive proton therapy (OAPT) offers the potential to improve anatomical robustness and target coverage in paediatric patients, but the added imaging and adaptation steps may increase integral dose and secondary cancer risk. This PhD project will quantify the benefit–risk balance of daily or right-time adaptation for paediatric proton therapy and support evidence-based extension of OAPT to paediatric indications.

The project will evaluate the trade-off between imaging dose and therapeutic dose in children, assess how daily imaging and cumulative integral dose relate to long-term risks such as secondary malignancies and late effects, and develop a model-based patient selection strategy to identify paediatric patients who benefit most from OAPT compared to non-adaptive or robustly optimised treatments. The work will also support the integration of advanced imaging (e.g. CBCT, CT–MRI workflows) into paediatric OAPT.

Methods will include retrospective dose accumulation studies, Monte Carlo simulations, NTCP-based modelling, and scenario simulations of different imaging/adaptation schedules. The project will involve collaboration with international paediatric proton therapy cohorts and leading European centres.

The PhD will be carried out at PSI and ETH Zurich, with secondments to partner proton therapy centres across Europe to analyse complementary paediatric cohorts and harmonise selection models and benefit–risk assessments.

IRP07 (IBA, Belgium) - Novel CBCT designs for online imaging in proton therapy within a breath

hold

By carefully selecting the energy of a pencil beam of proton particles, most of its energy can be released at the desired depth within the tissues of a patient suffering from cancer, specifically at the depth of their target tumour volume. Accurate positioning of the patient before the delivery of each treatment fraction is consequently crucial to ensuring the sterilization of cancer cells while minimizing toxicity to surrounding healthy organs. This preparation may require adapting the treatment plan to account for any changes in the patient's anatomy.

As early as 2014, Ion Beam Applications SA (IBA) was first to integrate its proton therapy systems with the Cone-beam Computed Tomography (CBCT) technology, an X-ray on-board system used to acquire volumetric scans of the patient's anatomy. Beyond its use for patient positioning, the CBCT emerges as the cornerstone of the online adaptive proton therapy workflow, whose technological completion is pursued by Work Package #3 of the RAPTORplus project. Its image quality is benefiting from a continuous upgrade program at IBA to reach the highest standard of guidance, with both hardware and software improvements, and ultimately support the computation of adapted plans.

The CBCT reconstructs a single 3D image from hundreds of 2D projections acquired at all angles over a period of more than 1 minute. Unfortunately, even the finest algorithms won't prevent this reconstruction from exhibiting artefacts in the case of any respiratory motion within the captured field of view.

The doctoral candidate at IBA will therefore investigate and devise new candidate designs for a CBCT imager enabling high-quality images within an acquisition time below a breath-hold (<15s) to prevent motion artifacts, and benchmark their performance, versatility, and robustness by Monte-Carlo simulations in order to identify the most relevant trade-offs between requirements and constraints.

The successful candidate for this position will join the Clinical Research & Application group within the R&D department of IBA's Proton Therapy division at our Belgian headquarters in the vibrant university city of Louvain-la-Neuve and register for the PhD program at the prestigious University of Leuven (KUL). They will uniquely benefit from both industrial and academic resources to advance this project, with supervision by both Dr. Sébastien Brousmiche, Senior CBCT research expert at IBA, and Prof. Edmond Sterpin, Associate Professor of Medical Physics at KUL, and access to both the Imaging Lab at IBA and the flagship PARTICLE proton therapy center at KUL.

IRP08 (Univ. of Bern, Switzerland) - Longitudinal CBCT-Based Synthetic CT Assessment: Towards Robust, Quality-Assured and Biomarker-Driven Adaptation

This PhD project aims to advance adaptive proton therapy by establishing a clinically viable workflow for CBCT-based treatment adaptation. The research will contribute to designing an efficient and robust CBCT-based adaptation pipeline that enables daily treatment adjustments in proton therapy. A central component will be the development of reliable quality control tools for CBCT-to-synthetic CT conversion with particular emphasis on longitudinal quality assessment. The expected outcomes include clinically suitable CBCT-based synthetic CT generation, validated

quality assurance tools, and the clinical implementation of CBCT-driven adaptation. An additional aspect of this project is the exploration of longitudinal CBCT and synthetic CT trends to identify potential biomarkers. These biomarkers, extending beyond geometrical changes, may pave the way for biological and functional adaptation in proton therapy. Explorative work will investigate the potential of other imaging modalities such as PET and MRI to extract biomarkers, based on limited cases, thereby broadening the scope towards multimodal and functional adaptation. Ultimately, the project seeks to enhance precision and personalization in cancer treatment by integrating longitudinal imaging insights into adaptive workflows.

The successful candidate will be enrolled in the Graduate School for Cellular and Biomedical Sciences (GCB) of the University of Bern, under the supervision of Prof. Antje Knopf. The University of Bern is one of Switzerland's leading comprehensive universities, combining a strong medical faculty with internationally recognized research in oncology, digital medicine, and translational science. The project will be executed in close partnership with the clinical medical physics team of the Center for Proton Therapy (CPT) at the Paul Scherrer Institut (PSI).

The DC will be part of Prof. Knopf's research group, which is dedicated to advancing the integration of computational methods and clinical innovation in cancer care and beyond. Closely affiliated with the University Clinic for Radiation Oncology (UKRO) and embedded within the Center for Artificial Intelligence in Oncology (CAIRO), the group builds strong bridges between clinical practice, digital transformation, and cutting-edge research. Within the Department of Digital Medicine, it contributes actively to the digitization strategy of the Medical Faculty of the University of Bern, shaping the future of medical education and clinical decision-making through data-driven approaches.

IRP09 (UMC Groningen, Netherlands) - AI-Driven Robust Synthetic CT for Adaptive Proton Therapy

Adaptive radiotherapy relies on accurate daily volumetric imaging to ensure precise dose delivery. While cone-beam CT (CBCT) and MRI are routinely used to monitor anatomical changes, they do not directly support reliable dose calculation. Deep learning–based synthetic CT (sCT) generation offers a promising alternative but is highly sensitive to variations in image quality introduced by hardware or software upgrades.

This PhD project focuses on the development of robust, AI-driven sCT models for adaptive proton therapy. The core of the work will involve deep learning method development, including transfer learning, fine-tuning strategies, and uncertainty-aware modeling to enable rapid revalidation of sCT models following imaging system changes. In parallel, the project will address medical physics aspects, evaluating how variations in sCT quality influence dose calculation accuracy, proton range robustness, and adaptive treatment workflows.

The project is embedded in a clinically relevant environment and offers interdisciplinary training at the interface of artificial intelligence, medical imaging, and radiation physics.

IRP10 (HVL Bergen, Norway) - Pre-clinical evaluations of a novel, prompt gamma-ray and fast neutron-based treatment verification system

It is now a well-known fact that proton therapy (PT) suffers from range uncertainties that limit the full exploitation of the dosimetric advantages of PT as an effective cancer treatment modality. Range uncertainties might result from errors in the estimation of the proton stopping power in tissue, patient setup errors, anatomical changes and organ motion. To mitigate the undesired effects of range uncertainties, several online range and dose monitoring techniques are being investigated. The project at hand focuses on further developments of a novel concept being developed within the so-called NOVO (Next Generation Imaging for Real-Time Dose Verification Enabling Adaptive Proton Therapy) project.

In the NOVO project, a novel detector array, NOVCoDA (the NOVO Compact Detector Array) capable of simultaneous detection and imaging of secondary prompt gamma-rays and fast neutrons is being developed in an international effort funded by the EIC Pathfinder Open. In this project, within RAPTORplus, the candidate will further explore pre-clinical evaluations of NOVCoDA via in-silico models supplied with experimental data collected in clinically relevant proton beamlines. As part of these evaluations, the project will also explore use of advanced data analysis techniques based on Artificial Intelligence (e.g., deep learning techniques and multivariate regressions) to enhance the detection probability of range and dose deviations from the available detector data.

The main objective of the project is the confirmation of range shift detection capabilities of NOVCoDA under pre-clinical conditions as well as unravelling NOVCoDA's limitations in this regard. As an important part of the project, the clinical translation potential of NOVCoDA will be explored by comparison to the state-of-the-art systems that are based on the detection of secondary prompt gamma-rays, in particular, prompt gamma-ray imaging (PGI) and timing (PGT) systems. Through explorations of the capabilities of NOVCoDA as well as comparisons to PGI and PGT systems, the project will strengthen the ties between RAPTORplus and NOVO consortia.

The project is carried out at the HVL campus in Bergen at the Department of Computer science, Electrical engineering and Mathematical sciences under the supervision of Dr. Ilker Meric. The candidate will collaborate with the NOVO team at HVL and have access to HVL's radiation detection laboratory and the HVL high performance computing cluster. The candidate will perform extensive experiments with the current NOVCoDA prototype, located at Helmholtz-Zentrum Dresden Rossendorf (Germany) during an extended seconment.

IRP11 (LMU Munich, Germany) - Real-time online monitoring techniques for range and dose-guided adaptation in proton therapy

Range and dose□delivery uncertainties remain a major obstacle to fully exploiting the ballistic precision of proton beams. Several techniques for online monitoring are now being actively investigated to enable real-time range verification and, potentially, dose reconstruction in proton therapy. This project will focus in particular on prompt gamma and ionoacoustic monitoring, exploiting the online detection of secondary emissions of energetic photons and (for pulsed beams) thermoacoustic waves induced by proton irradiation, respectively.

The main objective is to compare the accuracy and precision of these methods in an in-silico study—complemented, when appropriate, by experimental data—across different anatomical sites, in order to identify the most suitable technique for specific tumour indications. Further goals include exploring adaptive treatment scenarios based on (i) range information alone and (ii) combined range and dose reconstruction for those portions of the treatment where secondary emissions can

be reliably detected. The project will also quantify the added value of range/dose-based adaptation relative to adaptation guided solely by anatomical changes.

Ultimately, the project aims to develop a strategy for online treatment adaptation that leverages the most effective monitoring approach identified, potentially enriched by biological information provided by other members of the consortium.

IRP12 (OncoRay-TU Dresden, Germany) - Benefit of prompt-gamma-based treatment verification to trigger online-adaptive interventions

Prompt gamma–based treatment verification (PGTV) is a key enabling technology for safe, fast, and clinically feasible online adaptive workflows in proton therapy. It provides an independent, in vivo verification of proton range during treatment delivery, enabling the detection of unexpected deviations without additional imaging dose or prolongation of the treatment session. In this way, PGTV serves both as a trigger for adaptive interventions and as an essential safety mechanism, ensuring that the adapted treatment is delivered with the planned proton ranges.

Using a prototype prompt gamma imaging (PGI) system, PGTV has been in clinical application at OncoRay since 2015, with more than 480 clinical treatment field deliveries monitored to date. Retrospective analyses have demonstrated the capability of PGTV to detect relevant anatomical changes, and the potential for treatment margin reduction has already been quantified for prostate cancer patients.

Building on this foundation, a prospective clinical study starting in 2026 will apply PGTV at every treatment fraction for prostate cancer patients treated with reduced margins. In cases where PGTV indicates a deviation, interventional in-room CT imaging will be triggered to confirm anatomical changes, followed by treatment adaptation for subsequent fractions. The doctoral candidate will play an active role in the execution, data analysis, and scientific evaluation of this clinical study.

In parallel, the doctoral candidate will contribute to the development of the next generation of prompt gamma–based treatment verification. A central task will be a design study investigating the integration of PGTV into both gantry-based and fixed-beamline proton therapy systems, with the goal of achieving a more compact, robust, and clinically integrated solution suitable for routine use (including a secondment at IBA). Different detector concepts will be assessed, including prompt gamma imaging and the OncoRay-pioneered multi-feature treatment verification approach.

Beyond prostate cancer, the project will explore the applicability of PGTV to other challenging clinical scenarios, such as moving targets and paediatric tumours (secondment in Leuven and Manchester). These investigations will primarily be conducted through simulation studies, providing a basis for future clinical translation.

The student will work at OncoRay – National Center for Radiation in Oncology (Dresden) and will be registered for the doctoral program at the TUD Dresden University of Technology under the supervision of Prof. Christian Richter. TUD is one of the leading and most dynamic universities in Germany. OncoRay represents a future-oriented research effort in the field of radiation oncology, building on the international reputation and extensive research infrastructure of the Dresden group.

IRP13 (INFN Torino, Italy) -Micrometrical assessment of biological response to particle therapy

Advanced experiments for assessing the biological effects of particle therapy (PT) are highly desirable to inform personalised adaptive proton or carbon ion therapy beyond anatomical changes.

Multi-scale image-based biological response models are essential to understand the differential radiosensitivity of normal and tumor cells as well as mechanisms of resistance, at a resolution which cannot be met by standard bulk analyses.

In this project, the student will merge different technologies and expertise from physics and biology integrating analysis of 2D delivered particles distribution with detailed exposure analysis, based on measurement of DNA damage foci abundance, morphology and clustering on 2D co-cultures of tumor and normal cells. These analyses will be complemented by spatial transcriptomics studies, aimed at assessing the local response of gene expression biomarkers.

The overall goal of the project is to develop and validate an integrated experimental and analytical framework to assess the biological effects of particle therapy beams using both 2D imaging of particle distributions and advanced spatial transcriptomics. The candidate will help design, simulate, and implement an optimized experimental setup that enables simultaneous acquisition of particle distribution maps during controlled irradiations of selected cell lines with pencil beams of different ion species and beam parameters. Afterwards, spatial transcriptomic profiling will be carried out on the irradiated 2D co-cultures of tumor and normal cells.

These activities will establish the basis for correlating high-resolution biological responses with the precise physical characteristics of therapeutic ion beams. Additionally, the research activity will indicate a methodology, transcriptomic-based, to detect micrometric biomarkers in a defined co-culture 2D cell model.

Secondments at leading international institutions will step-wise strengthen both technical and interdisciplinary expertise of the candidate:
Hands-on experience with radiobiological experiments in a clinical environment at Medical University of Vienna (Austria)
Detector tests across a wide range of carbon-beam intensities at GSI Helmholtz Centre for Heavy Ion Research (Germany)
Irradiation campaigns for correlating biological responses with measured particle distributions at CNAO – Italian National Center of Oncological Hadrontherapy (Pavia, Italy).

The student will be employed at the National Institute of Nuclear Physics (Italy) and will be registered for the doctoral program at the University of Torino (UNITO) under the supervision of Dott.ssa Simona Giordanengo. A collaboration with Prof. Ferdinando Di Cunto from Neuroscience “Rita Levi Montalcini” Department of UNITO will provide the candidate with a unique combination of skills in particle-beam physics, radiobiology, molecular analysis, and advanced imaging, contributing to the refinement of biologically informed treatment approaches in particle therapy.

IRP14 (Politecnico di Milano, Italy) - Multi-scale modelling from quantitative MRI in particle therapy

Advanced medical imaging in oncology is increasingly recognized for its value in radiotherapy guidance and treatment personalization. Multimodal imaging datasets acquired throughout the radiotherapy workflow can yield image-based biomarkers with strong predictive power. Yet, current clinical models for tailoring treatment dosimetry still exclude patient-specific imaging information, relying instead on parameters derived from in-vitro studies and thereby overlooking the in-vivo biological complexity of each patient. This limitation becomes even more pronounced in particle therapy, where the radiobiological advantages of this advanced modality remain largely underexploited on a patient-specific basis.

This project aims to advance PT treatments by integrating imaging biomarkers derived from quantitative Magnetic Resonance Imaging (MRI) into personalized PT, by implementing multi-scale models able to characterize tumour microstructure and its interactions with the radiation beam.

First, advanced computational models will be developed to extract macro- and micro-scale imaging biomarkers from quantitative MRI data, capturing tissue characteristics both at the voxel level and at sub-voxel resolution. These biomarkers will then be integrated into multi-scale modelling frameworks, including statistical methods, machine learning approaches, and Monte Carlo simulations. The capability of these models to characterize tumours and predict treatment outcomes in PT will be assessed using clinical parameters and biological analyses. Finally, the project will translate these findings into personalized treatment plans tailored to the biological profile of each individual tumour.

Expected achievements include the robust derivation of multi-scale MRI biomarkers, validated models for tumour characterization and outcome prediction, and the development of personalized PT strategies informed by patient-specific imaging biomarkers. The PhD will be carried out at the CartCasLab of the Department of Electronics, Information and Bioengineering of Politecnico di Milano. Secondments are planned at (i) the National Center for Oncological Hadrontherapy (Pavia, Italy) to access retrospective data for the analysis and collaborate with medical physicists with strong experience in treatment planning and optimization; (ii) Raysearch Laboratoties (Sweden) to develop personalized treatment plans in a research version of a treatment planning system; (iii) Stockholm University (Sweden) to collaborate on advanced microstructural and radiobiological modelling.

IRP15 (Univ. de Navarra, Spain) - Adaptive strategies considering image changes and RBE

There is growing evidence of unexpected imaging changes and toxicity related to proton therapy (PT) treatments. These data suggest a complex radiobiological behavior that could be better predicted using models for variable relative biological effectiveness (RBE). These models have not been incorporated yet to routine clinical practice. It is worth investigating the correlation between prediction and clinical outcomes, determine which RBE model should be preferred, and seek image biomarkers to anticipate such a response. Our hypothesis is that image changes and toxicity can be observed early in the patient response to the treatment, using MRI or CT depending on the treatment site. A strategy could be defined to adapt the plan during the last part of a typical PT treatment course of 3-5 weeks.

This project aims to assess the best variable RBE model to predict these image changes and toxicity. In central nervous system (CNS) tumors, several RBE models will be used to retrospectively calculate the biological dose distributions on a cohort of patients treated with PT where these changes have been observed in our Institution. We will propose for future patients to acquire a reference MRI scan before the treatment, one more during the treatment (week #4), and others during patient follow-up after treatment completion to identify image changes. Understanding the image formation processes will allow us to seek an MRI sequence and marker which could be related to the biological dose distribution.

In the case of lung tumors, changes in lung density will be observed using CT imaging and used as biomarkers which could identify a variable RBE response. We will use the planning CT, an intermediate during week #4, and the subsequent control CTs. Our aim is to relate these voxel density changes with retrospectively calculated biological dose values and define strategies for bio-adaptive PT in future patients. We will use deformable registration (DIR) to include the breathing cycle and accumulate the absorbed and biological proton doses.

The candidate will work at the Proton Therapy Unit of Clínica Universidad de Navarra (CUN), which is located in Madrid, and be part of the research group of Medical Physics and Biophysics in Pamplona.

IRP16 (Aarhus Univ., Denmark) - AI-driven anatomical and response adapted proton therapy

Adaptive radiotherapy currently focuses on anatomical variation, using daily imaging to restore planned dose distributions. However, many image changes during treatment reflect biological response – tumour regression or progression, and early normal-tissue effects – which may require genuine dose level adaptation rather than dose restoration.

This project will develop AI-based methods to distinguish between anatomical and biological components of daily image changes, as well as methods for subsequent corresponding dose optimization. The doctoral candidate will follow a structured progression of methodological tasks:
Synthetic image generation: develop and validate methods to produce anatomically and biologically plausible training images.
AI-based response characterization: build models that distinguish anatomy-driven from biology-driven image changes using multimodal features (population anatomy models, quantitative image biomarkers, radiomics, segmentation, accumulated dose, and uncertainty measures).
Dose-optimization strategies: design algorithms that execute dose restoration and/or dose adaptation according to the identified type of change, including combined scenarios.
In-silico integration: implement a proof-of-concept pipeline for response categorization and adaptive dose planning and evaluate it within a clinical treatment-planning system.

Three clinical datasets will be available for this (supporting different stages of the project: (1) daily CBCT from proton-treated head and neck cancer patients – central for modelling anatomical variation and testing daily-update strategies. (2) PET/MRI at baseline, mid-treatment, and follow-up from photon-treated patients – provides multimodal information on biological response patterns. (3) MRI and PET from proton-treated head and neck patients – supports cross-modality modelling and validation of combined anatomical and biological effects.

The project will take place in the research group AI and Big Data in Radiation Oncology of Professor Stine Korreman at Aarhus University. The medical physics research group is embedded in the joint oncology research environment at Aarhus University Hospital and housed at the Danish Center for Particle Therapy. The research environment is well-established and of the highest international standard, with research activities in radiation oncology bridging translational and clinical research. Aarhus University has a PhD program in clinical medicine at the Faculty of Health.

IRP17 (RaySearch, Sweden) - Robust optimization considering radiobiological models and tumour response assessed by functional image biomarkers

Radiotherapy is a fundamental modality in oncology treatment, typically delivered over multiple fractions across several weeks. Throughout the treatment course, patients may exhibit substantial anatomical modifications (such as tumour regression or weight loss) as well as biological and functional changes within both malignant and healthy tissues. These dynamic variations can compromise the precision and therapeutic efficacy of radiation delivery, making the initial treatment plan suboptimal and necessitating adaptive strategies to maintain clinical outcomes.

Current treatment planning and adaptation strategies in radiotherapy predominantly focus on the physical dose distribution delivered to the patient. While effective to some extent, these approaches offer limited personalization and frequently neglect individual biological variability, such as tumour response dynamics and normal tissue sensitivity.

This project seeks to enhance both the efficacy and personalization of radiotherapy by integrating biological modelling with conventional dose-based planning. Specifically, it will focus on developing methodologies that leverage biological information and imaging biomarkers for optimizing the initial treatment plan and guide adaptive strategies throughout the treatment course.

The project has three main components:
Robust radiobiological optimization – Improving initial treatment planning by considering not only dose but also radiobiological models that predicts how tumours and healthy tissues respond to radiation, while accounting for underlying uncertainties.
Functional imaging integration – Using advanced imaging (e.g., PET/fMRI combined with CT or other anatomical imaging) to monitor both anatomical changes and tissue responses, enabling adaptation of the radiotherapy treatment based on both anatomical and biological indicators.
Biologically guided adaptive planning – Combining these approaches into a research prototype of a commercial treatment planning system for individualised initial treatment planning and adaptive treatments, accounting for underlying geometrical and biological uncertainties.

By incorporating biological and imaging data, this project aims to enable more personalized and adaptive radiotherapy treatments, moving beyond traditional dose-based methods.

The successful candidate will be employed at RaySearch Laboratories under the supervision of Dr.

Jakob Ödén and Dr. Albin Fredriksson and will join the Research Department, which currently comprises 29 members. The candidate will also be enrolled in the Ph.D. program in Medical Radiation Physics at Stockholm University and become part of its research group under the academic supervision of Prof. Iuliana Toma-Dasu. This unique collaboration offers a diverse and stimulating research environment, with access to offices and resources at both institutions, located in Hagastaden, Stockholm's Life Science Hub, within walking distance of each other.

This project is a four-year PhD position in Sweden, with funding secured for all four years.

IRP18 (KU Leuven, Belgium) - 5D model-based treatment personalization for right-time adaptive proton therapy

RAPTORplus aims at adapting proton therapy treatment with multi-modality image information acquired at various time scales. Daily anatomical changes would be characterized by on-board X-ray based imaging systems (or eventually MRI), while longer term biological modifications would be detected with offline functional imaging (PET or MRI). The optimal timing of image acquisition and subsequent adaptations depend on the potential gains in outcome which must be balanced against practical considerations. For instance, it might be more productive to develop very fast treatment workflows without online adaptation to maximize patient throughput on an expensive proton therapy machine, instead of performing systematic online adaptation with minor gains in clinical outcome and a reduction in machine capacity due to the time required for the adaptation. The opensource treatment planning system (OpenTPS) will be extended to optimize and/or evaluate a treatment using multi-modality image information (3 first dimensions), timing considerations (4th dimension), and biological modeling (5th dimension). Variability in treatment outcome will be expressed using normal tissue complication and tumor control probabilities. Treatments with X-rays and protons will be both simulated.

We provide here a more detailed description of the workpackages (WP) associated to this project

WP1 – Development of a flexible clinical workflow simulator in OpenTPS: OpenTPS features an advanced robustness evaluation tool for proton therapy treatments (MCsquare), including LET computation. OpenTPS will also soon feature photon dose calculation. By introducing multi-modality imaging, treatment adaptations on various timescales, and, when necessary, biological functions (TCP and NTCP), it would be possible to provide a comprehensive and quantitative assessment of the treatment outcome for many adaptation, fractionation, and treatment prescription schemes.

WP2 – Optimization of the treatment workflow using various optimization techniques: We will first envisage optimization techniques that are not based on neural networks. We will first optimize the workflow against physical parameters (dose distribution related metrics) before integrating biological functions.

WP3 – Training of an AI-agent with reinforcement learning: In this case, an AI-agent, whose task will be to "discover" the best treatment strategy, will be trained with reinforcement learning. The reward can be formulated as the product of the TCP x (1 – NCTP). The AI-agent will then play with the meta-parameters in order to maximize that product.

The Doctoral candidate will work at the Laboratory of Experimental Radiotherapy in the Department of Oncology under the supervision of Prof. Edmond Sterpin.