Editorial

Dear Reader,

With this issue, we close an important chapter: 54 months of the EU-MSCA-RAPTOR project— 54 months of shared effort across institutes, disciplines, countries, and sectors, all driven by a common goal: making online adaptive particle therapy a realistic and sustainable clinical option.

I would like to sincerely thank all ESRs, supervisors, beneficiaries, partner organisations, and collaborators for the energy, commitment, and teamwork that made RAPTOR such a success. The project has delivered outstanding science, strong clinical translation, and a uniquely interdisciplinary training programme — but also something equally valuable: a cohesive and vibrant community.

The successful launch of the EU-MSCA-RAPTORplus project is a strong testament to this cohesion, to the scientific quality achieved, and to the mature project development that RAPTOR fostered over the past four years. It marks a natural transition from RAPTOR's foundations to the next phase of innovation in adaptive particle therapy.

With this transition, I would like to sincerely thank Kristin Stützer for taking over the lead of RAPTORplus. Building on RAPTOR's scientific and collaborative legacy, RAPTORplus will drive the field further over the coming years, and I very much look forward to seeing how the consortium's ideas, energy, and momentum will translate into new clinical and scientific advances. I wish you all the very best — and many rewarding and fun moments with the project.

Inside this issue

As we move into a new year, the field of adaptive therapy continues to progress rapidly. RAPTORplus will build directly on the tools, concepts, and expertise developed in RAPTOR — pushing further towards efficient, broadly deployable, and biologically informed adaptive strategies.

I wish you a Happy New Year and hope you enjoy this overview of RAPTOR's achievements — from scientific progress and clinical milestones to PhD defences and awards.

Happy reading!

Francesca Albertini (RAPTOR coordinator)

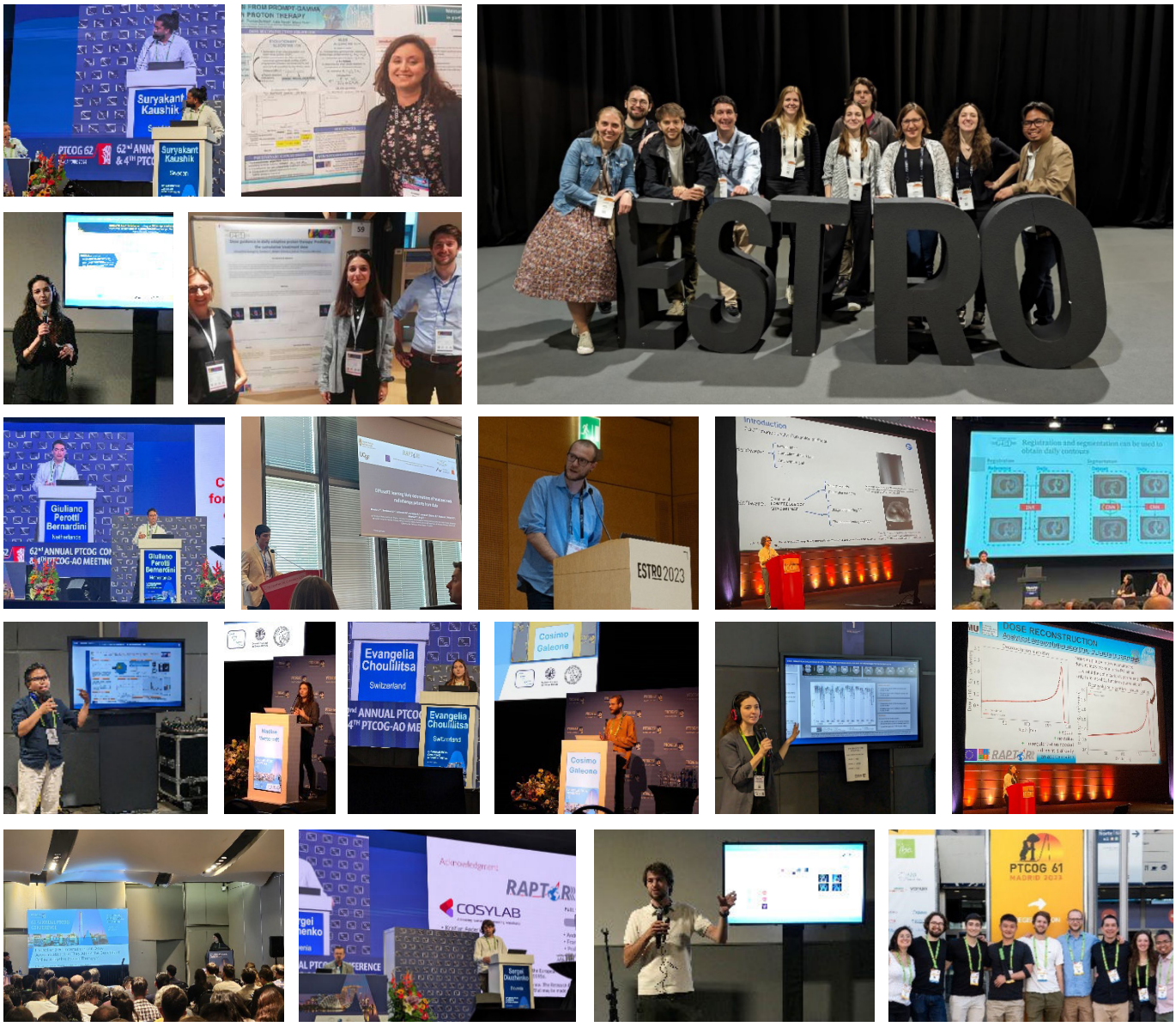
RAPTOR: Four Years Shaping Online Adaptive Particle Therapy

The Marie Skłodowska-Curie Innovative Training Network RAPTOR (Real-Time Adaptive Particle Therapy Of Cancer) was launched with an ambitious goal: to lay the scientific, technological, and human foundations required to make online adaptive particle therapy (OAPT) a realistic and sustainable clinical option.

Over 54 months, RAPTOR successfully combined cutting-edge research, clinical translation, and advanced doctoral training, delivering both tangible scientific outputs and a new generation of experts ready to shape the future of adaptive particle therapy.

RAPTOR in numbers (2021–2025)

- 15 Early Stage Researchers (ESRs) trained
- 20+ partner organisations involved
- 45 secondments and research visits across academia, clinic, and industry
- 45+ peer-reviewed scientific publications
- 80+ conference contributions (>50% oral contributions)
- 51 deliverables and 17 milestones successfully completed
- 3 international RAPTOR Schools, multiple workshops, and a final conference
- 150+ dissemination outputs (newsletters, social media posts, videos)



Scientific progress across the adaptive therapy loop

RAPTOR addressed the entire adaptive therapy loop, from imaging and decision-making to intervention and verification, through a tightly integrated and interdisciplinary research programme.

Imaging and anatomical modelling

RAPTOR developed advanced AI-based solutions for image segmentation, contour propagation, synthetic CT generation, and dose accumulation, supporting both static and dynamic anatomies. Novel pipelines enabled CBCT- and MRI-based dose calculation without repeated planning CTs, while uncertainty quantification methods explicitly addressed the reliability of deformable image registration and accumulated dose estimates.

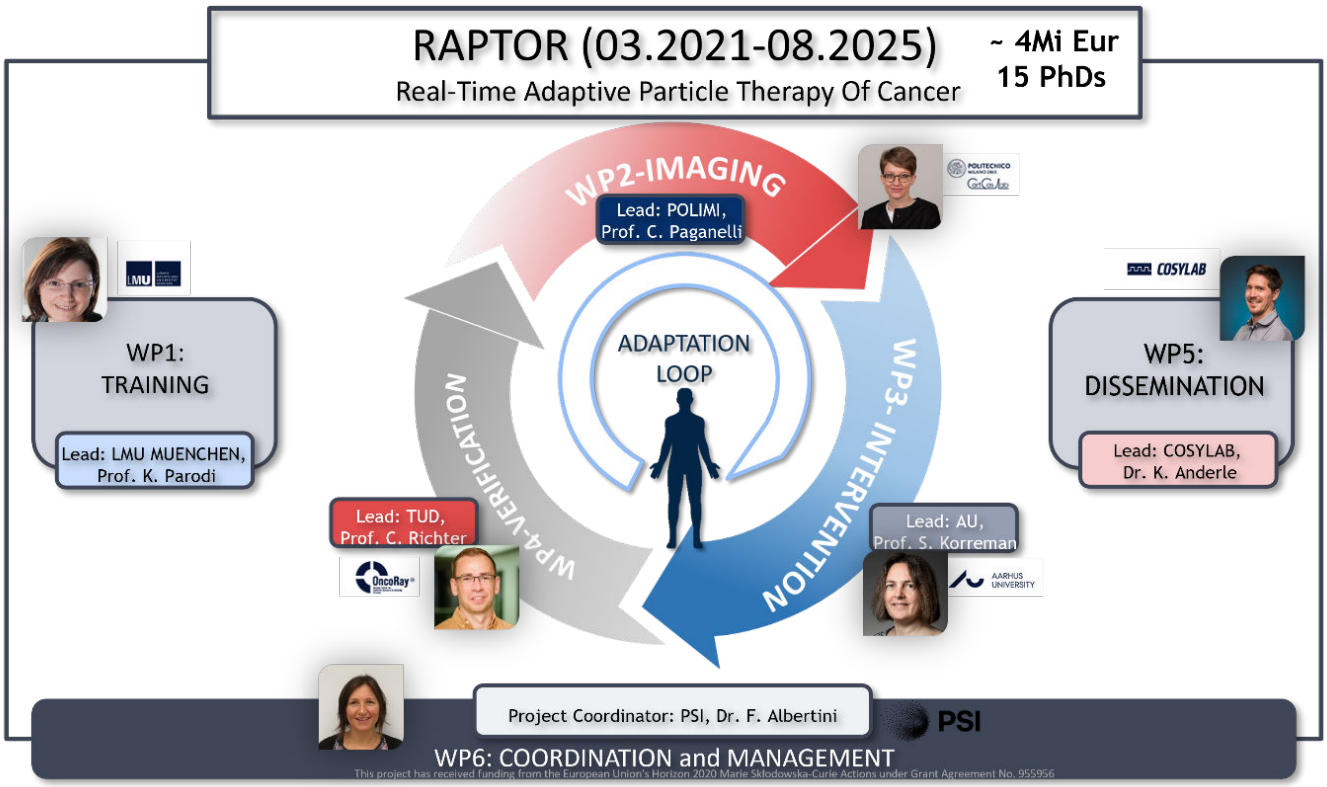
Fast intervention and adaptive planning

To enable real-time plan adaptation, RAPTOR delivered ultra-fast optimisation engines capable of re-planning on daily images both on-line and in real-time, alongside visualisation tools and classification systems to support clinical decision-making. These developments allowed automated plan adaptation while maintaining robustness and treatment quality, even in the presence of anatomical change and motion.

Verification and safety

Verification was a core pillar of RAPTOR. The project advanced prompt-gamma imaging, range probing, and AI-based dose reconstruction, enabling near real-time verification of adapted treatments. A modular 3D-printed phantom, designed within RAPTOR, supported a comprehensive end-to-end test campaign, validating the full adaptive workflow from imaging to delivery.

Together, these developments delivered integrated, uncertainty-aware solutions that go beyond isolated algorithms, providing a coherent basis for safe adaptive particle therapy.



From research to patient treatments

A defining achievement of the RAPTOR project was its direct clinical translation. The project culminated in the successful clinical implementation of online adaptive proton therapy at PSI (Switzerland), demonstrating the feasibility of RAPTOR-developed workflows in real patient treatments.

In parallel, all components of daily adaptive particle therapy were evaluated in a structured end-to-end validation campaign, ensuring clinical robustness and reproducibility.

Rather than promoting adaptation as a universal solution, RAPTOR also demonstrated when adaptation is beneficial and when it can be safely omitted, addressing efficiency, treatment time, and healthcare resource constraints — a crucial aspect for sustainable clinical adoption.

Training a new generation of experts

At its core, RAPTOR was a training network. All 15 ESRs were enrolled in PhD programmes aligned with national requirements and completed structured training combining scientific excellence, clinical exposure, industrial experience, and transferable skills development.

Three fully accredited RAPTOR Schools formed the backbone of the programme:

1. Loop Basic (2021, virtual): fundamentals of imaging, planning, and scripting
2. Loop Requirements (2022, Ljubljana): real-time implementation and system integration
3. Loop Engagement (2023, Ascona): clinical translation and stakeholder communication

These were complemented by workshops, Science Check-Ins, and a final international conference in Dresden (2024).

Secondments and mobility

All ESRs completed at least one secondment, with 45 secondments and research visits overall. These intersectoral experiences — spanning academia, clinics, and industry — strengthened collaborations between institutes, accelerated knowledge transfer, and directly enabled multi-institute scientific publications. Equally important, they created lasting professional connections and many memorable moments across the consortium.









Transferable skills and outreach

RAPTOR also placed strong emphasis on communication and career development. Throughout the project, ESRs benefited from targeted training in grant writing (contributing to successful MSCA-PF and national funding applications), science communication through public-facing videos and explainers, social media engagement, and leadership opportunities such as chairing and moderating internal meetings and scientific check-ins.

In addition, an open-access e-learning platform was launched and will remain available beyond RAPTOR, serving as a long-term training resource and a lasting legacy for the community.

Dissemination, visibility, and community building

RAPTOR placed strong emphasis on dissemination and outreach. Scientific results were widely shared through 40+ peer-reviewed publications and 80+ conference contributions, including a high proportion of oral and invited presentations.

Beyond the scientific community, RAPTOR actively engaged broader audiences through newsletters, social media, and its public website, producing 150+ dissemination items. These efforts raised awareness of adaptive particle therapy and positioned RAPTOR as a visible and recognised initiative in the field.

https://youtu.be/PFst2VjR6yg?si=387ieYg2776OFLq4

https://youtu.be/HJxOJPFLcFU?si=PxiPE8pPimLBHyoX

PhD defences and awards

PhD defences

RAPTOR has already celebrated several successful PhD defences, with more to follow

Andreas Smolders (CPT, PSI / ETH Zürich)

"Towards online adaptive particle therapy in deforming anatomies" (Defence: 26 Aug 2024)

Andreas was the first RAPTOR ESR to defend, marking an important milestone for online adaptive proton therapy in deforming anatomy. His work spans contouring and DIR uncertainty handling, including patient-specific neural networks for improved daily contours, strategies to account for contour uncertainties in robust optimisation, and modelling DIR-related uncertainties for dose accumulation.

Evangelia Choulilitsa (CPT, PSI / ETH Zürich)

"Beam On, Game On: Advancing Online Adaptive Proton Therapy for Clinical Use" (Defence: 28 May 2025)

Eva's PhD bridged technical development and clinical translation of daily adaptive proton therapy. Her work combined simulation, experimental validation, and a clinical perspective, including multi-institutional comparisons of online optimisation approaches (with MGH), evaluation of adaptive workflows under DIR uncertainty, and investigations of plan efficiency by reducing the number of treatment fields while maintaining benefit.

Anestis Nakas (Politecnico di Milano)

"4DMRI and Motion Management in Adaptive Particle Therapy of Cancer" (Defence: 19 June 2025)

Anestis carried out his PhD at Politecnico di Milano in close collaboration with CNAO and the Biophysics Department at GSI. His research focused on motion management in adaptive particle therapy, including deep-learning methods to generate synthetic 4DCT from abdominal 4DMRI for carbon-ion therapy, evaluation of network architectures, and motion mitigation studies using non-periodic cine-MRI data. He also contributed to frameworks integrating motion modelling and dose reconstruction in clinic-like setups and to platforms for motion-compensated real-time 4D delivery using optical monitoring.

Stefanie Bertschi (OncoRay / TU Dresden)

"Towards the application of prompt-gamma imaging in online adaptive proton therapy" (Defence: 29 Aug 2025)

Stefanie's work advanced prompt-gamma–based verification toward clinical use in online adaptive proton therapy. She improved practicality and speed, demonstrated feasibility for CBCT-based adapted plans, and quantified margin-reduction potential — supporting translation toward an interventional clinical study.

Nadine Vatterodt (DCPT / Aarhus University)

"Practical insights into anatomical robust optimization and evaluation in head and neck cancer proton therapy" (Defence: 29 Oct 2025)

Nadine's PhD advanced clinically feasible robust planning and adaptation strategies for head & neck proton therapy, with strong focus on applicability for centres with limited resources. Highlights include population PCA models to generate plausible anatomical change scenarios and triggered robust adaptation approaches incorporating CBCT and planning CT with robust objectives for key OARs.

Cosimo Galeone (GSI)

"Let's get moving: Real-time 4D-dose calculation to assess the efficacy of motion mitigation strategies" (Defence: 26 Nov 2025)

Cosimo's PhD focused on real-time delivered dose reconstruction and motion management in particle therapy. Building on the RIDOS framework, his work evolved from static dose reconstruction to 4D (regular motion) and 5D (irregular motion) approaches, integrating real-time internal–external motion modelling. Extensive validation demonstrated accuracy and real-time performance, supporting future clinical integration and potential intrafraction adaptation.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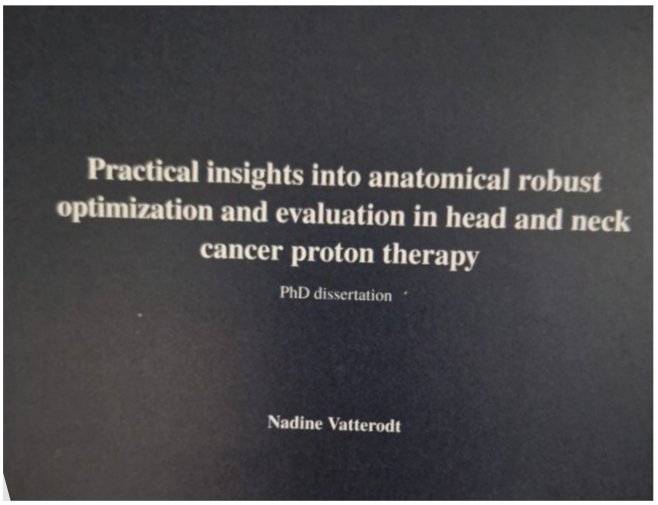
RAPTOR


Treatment Planning
Patient-specific model based on respiratory-correlated 4D imaging
4DCT → current clinical standard
Limitations → motion artifacts, low contrast, additional dose
4DMRI → radiation-free, soft tissue contrast, dynamic modality
Limitations → no electron density
Synthetic CT
Deformation vector field via Deformable Image Registration (DIR)
Deep Learning solutions
Most studies on static anatomies
Limited applications to dynamic anatomies (abdomen)
Particle Therapy
Robust treatment planning
Application


Practical insights into anatomical robust optimization and evaluation in head and neck cancer proton therapy
PhD dissertation
Nadine Vatterodt

Awards and recognitions

RAPTOR ESRs have received multiple awards and recognitions at international conferences and institutions, reflecting both scientific excellence and strong visibility within the radiation oncology and medical physics communities.

Nadine Vatterodt (Aarhus)

- BiGART 2023 (June 20–21, 2023) – Best Poster Award

Andreas Smolders (PSI)

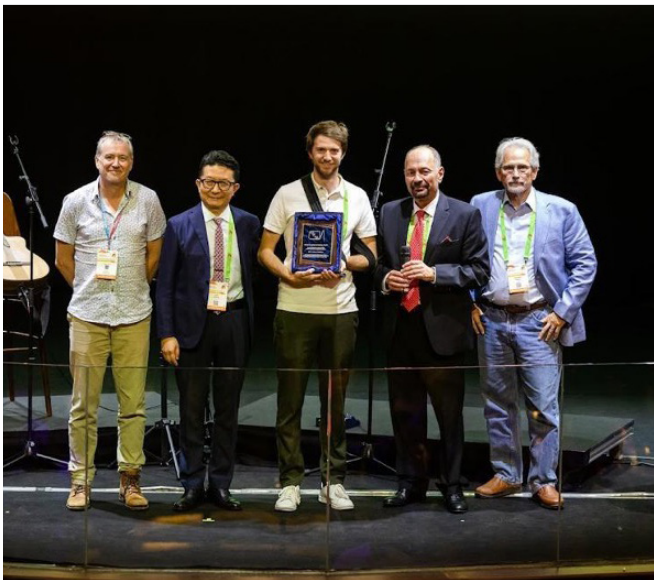
- Varian Recognition Award, SSRMP 2024, Lausanne
- Nominated for the Rising Star Competition, ICCR 2024, Lyon
- Best Presentation Award, SASRO 2023, Bern
- Young Investigator Award, PTCOG 2023, Madrid
- Best Presentation Award, WBIR 2022, Munich

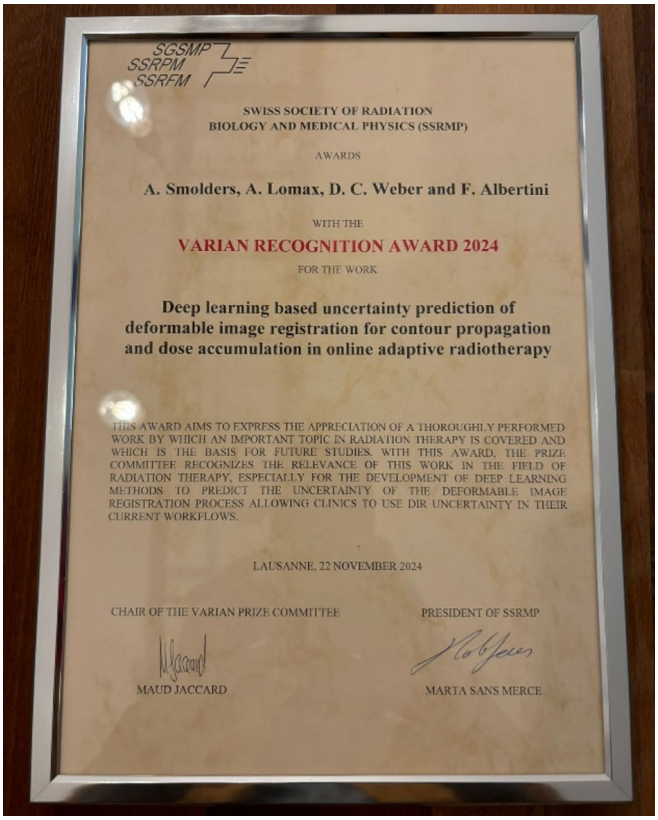
Eva Choulilitsa (PSI)

- Best Presentation Award, SASRO 2025, Davos

Stefanie Bertschi (OncoRay)

- Christoph Schmelzer Preis for PhD thesis, 2025, Darmstadt





SGSMP
SSRPM
SSRFM

SWISS SOCIETY OF RADIATION
BIOLOGY AND MEDICAL PHYSICS (SSRMP)

AWARDS

A. Smolders, A. Lomax, D. C. Weber and F. Albertini

WITH THE

VARIAN RECOGNITION AWARD 2024

FOR THE WORK

Deep learning based uncertainty prediction of deformable image registration for contour propagation and dose accumulation in online adaptive radiotherapy

THIS AWARD AIMS TO EXPRESS THE APPRECIATION OF A THOROUGHLY PERFORMED WORK BY WHICH AN IMPORTANT TOPIC IN RADIATION THERAPY IS COVERED AND WHICH IS THE BASIS FOR FUTURE STUDIES. WITH THIS AWARD, THE PRIZE COMMITTEE RECOGNIZES THE RELEVANCE OF THIS WORK IN THE FIELD OF RADIATION THERAPY, ESPECIALLY FOR THE DEVELOPMENT OF DEEP LEARNING METHODS TO PREDICT THE UNCERTAINTY OF THE DEFORMABLE IMAGE REGISTRATION PROCESS ALLOWING CLINICS TO USE DIR UNCERTAINTY IN THEIR CURRENT WORKFLOWS.

LAUSANNE, 22 NOVEMBER 2024

CHAIR OF THE VARIAN PRIZE COMMITTEE — MAUD JACCARD

PRESIDENT OF SSRMP — MARTA SANS MERCE

RAPTORplus – Continuing the RAPTOR Legacy

Building on RAPTOR: What is new in RAPTORplus?

RAPTOR was funded under Horizon 2020 as an Innovative Training Network and established the foundations of online adaptive particle therapy, demonstrating feasibility, developing key tools, and training experts across imaging, planning, and verification.

RAPTORplus is the next step.

It moves beyond feasibility and isolated solutions toward sustainable, efficient, and personalised clinical implementation of OAPT. Making OAPT a routine treatment option requires more than advanced hardware and algorithms — it requires cohesive integration, economic efficiency, and evidence-based decision-making in increasingly strained healthcare systems.

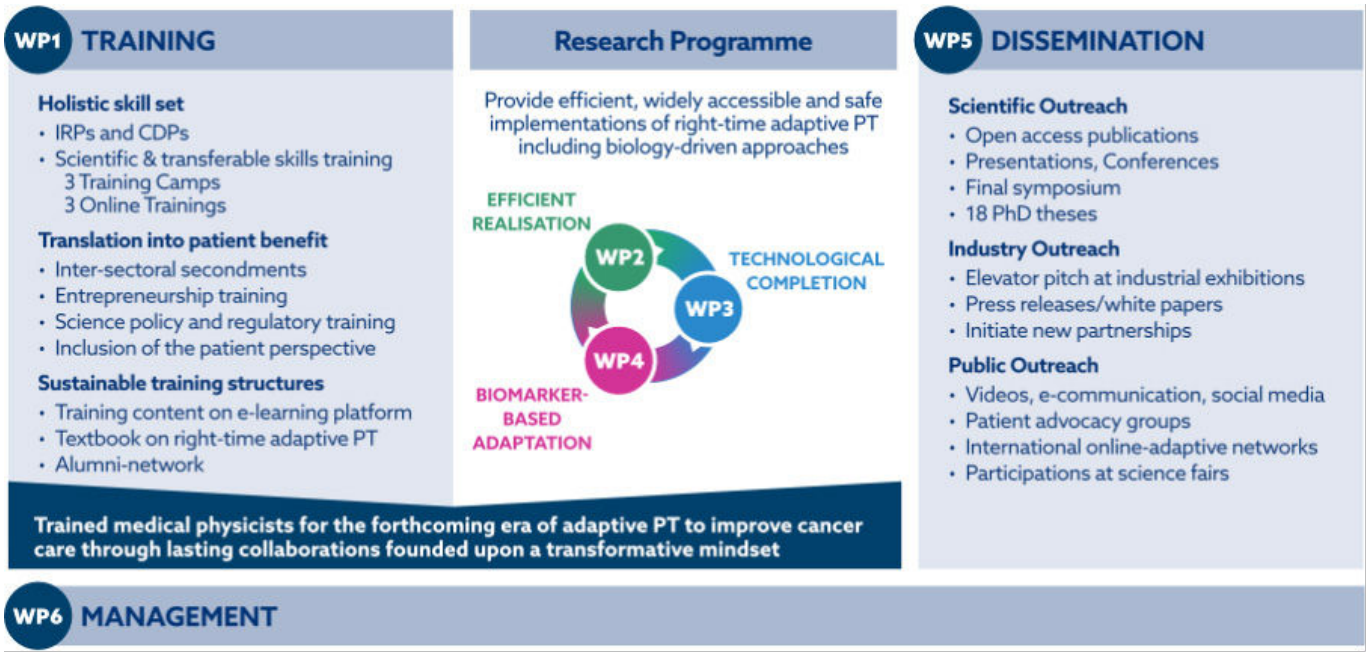
RAPTORplus addresses three fundamental challenges:

- Efficient realisation of OAPT with minimal treatment prolongation and imaging dose,

- Technological completion to ensure safety, robustness, and broad clinical applicability,
- Biomarker-based adaptation, Integrating functional imaging and biological models to guide right-time adaptation and optimise healthcare resource allocation.

Training and research vision

RAPTORplus will educate 18 doctoral candidates through a fully integrated, interdisciplinary, and intersectoral programme. Given the limited number of particle therapy facilities per country, sustainable training in adaptive PT can only succeed at an international level, combining academia, clinics, and industry.



Recruitment now open

RAPTORplus has been launched and is now recruiting doctoral candidates.

More information: https://raptor-consortium.com/

*Listed in alphabetical order.

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