



2022 ESTRO Physics Workshop: Science in Development

Particle arc therapy: from concept to clinical reality

7 - 8 October 2022, Lisbon, Portugal

Chairs: Xuanfeng Leo Ding, Stewart Mac Mein

On behalf of the particle arc therapy (PAT) workshop, we give many thanks to the European Society for Radiotherapy and Oncology (ESTRO) physics committee for organising a successful workshop this year, the American Association of Physicists in Medicine for their endorsement and our arc industry partners for their participation and support.

The first international workshop dedicated to PAT (Figure 1) began with an online introductory session on September 16, 2022, before culminating in an in-person meeting on 7-8 October 2022 in Lisbon, Portugal. The event was attended by 42 participants from Europe, Asia and North America, and five vendors (Ion Beam Applications (IBA), IBA dosimetry, RaySearch, Elekta and LEO Cancer Care). The purpose of this workshop was as follows:

- to connect clinical scientists, researchers and industry members interested in the development and translation of PAT;
- to investigate and discuss the physics, radiobiology and clinical aspects of arc delivery that uses protons, carbon ions and other charged particle beams;
- to establish an international expert group to outline the status, challenges and future directions; and,
- to report findings and conclusions at a dedicated session for PAT at the ESTRO 2023 annual conference.

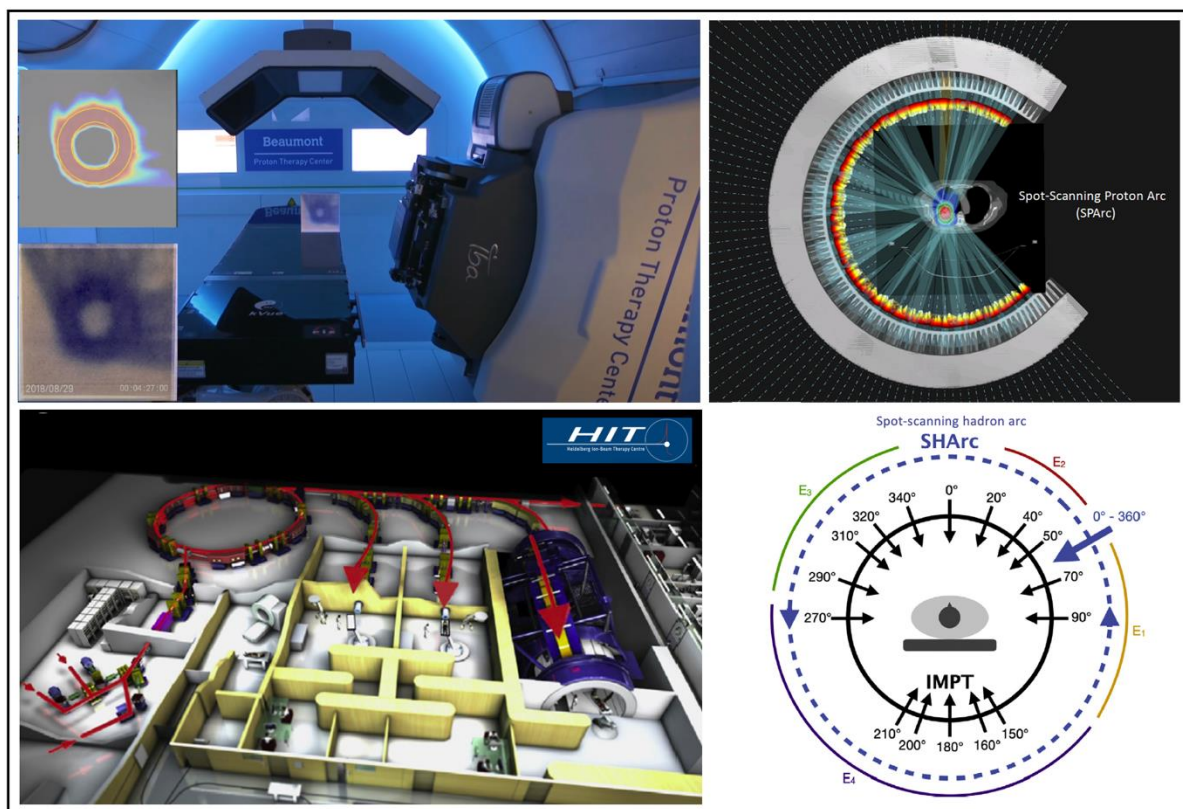


Figure 1. Facility and concept diagrams for potential particle arc treatment optimisation and delivery techniques that use protons, carbon and/or novel ion beams, e.g., spot-scanning proton arc (SPArc) therapy

(<https://doi.org/10.1016/j.ijrobp.2016.08.049>) and spot-scanning hadron arc (SHArc) therapy (<https://doi.org/10.1016/j.adro.2021.100661>)

It was planned that the workshop would cover five major aspects of PAT (Figure 2): treatment planning, delivery, dosimetry/quality assurance, radiobiology and clinical workflow/outlook. During the online pre-meeting, focus groups were formed to cover these topics independently before, during and after the in-person workshop. Drawing consensus from the workshop talks and discussion, the focus groups outlined each sub-topic by defining the current status, clinical objectives, challenges and potential solutions, technological demands to meet clinical needs and unknowns/open questions.



Figure 2: Different aspects of PAT that were covered during the workshop

Presentations were made during the first three workshop sessions: session I — treatment planning; session II — delivery; and session III — radiobiological and clinical considerations. During session IV, selected quick pitches were presented, after which focus groups met to discuss and outline sub-topics. The focus groups presented their findings and conclusions during session V. Several speakers were invited to present during the workshop sessions:

- Rock Mackie (University of Wisconsin, USA), who gave the keynote lecture for the in-person workshop on “proton arc therapy vs. rotation therapy”;
- Sophie Wuyckens (UCLouvain, Belgium), who presented “walking on the ridge line between harnessing new degrees of freedom and complying with stringent technical constraints in PAT treatment optimisation”;
- Lewei Zhao (Beaumont Proton Therapy Center, USA), who spoke on “an overview of proton machine-specific delivery sequence models and their clinical applications”;
- Xiaoqiang Li (Beaumont Proton Therapy Center, USA), who presented “proton arc therapy delivery, current status and future direction”;
- Konrad Nesteruk (Massachusetts General Hospital & Harvard Medical School, USA), presenting “a novel static beam delivery system for fast proton arc therapy”;
- Stefan Both (University Medical Center Groningen, The Netherlands), who talked on “towards proton arc in the model-based clinic”;
- Alejandro Carabe (Hampton University Proton Therapy Institute, USA), who presented “proton arc treatment planning: RBE [relative biological effectiveness] & LET [linear energy transfer] considerations”;
- Christan Graeff (GSI Helmholtz Center for Heavy Ion Research & the Technical University Darmstadt, Germany), who spoke on “upright carbon ion arc therapy”;
- Gang Liu (Union Hospital), who presented “redefine the role of spot-scanning proton arc therapy (SPArc) in the hypofractionated regimen”;
- Xiaoying Liang (Mayo Clinic Florida, USA), who presented “beam delivery sequence and beam delivery time for Hitachi proton pencil beam scanning system with novel scanning mode”;
- Taoran Li (University of Pennsylvania, USA), whose talk was called “single-isocentre multi-target SRS [stereotactic radiosurgery]: challenges with photon, and potentials for proton arc?”; and
- Yupeng Li (University of Texas MD Anderson Cancer Center, USA) presented “geometry-based energy selection for proton arc treatment planning for ependymoma”.



From our industry partners,

- Erik Engwall (RaySearch) presented “proton and ion arcs: from promising dream to clinical reality – a treatment planning perspective”;
- Martin Soukup (Elekta) presented “Monaco proton arc: from innovation to product”;
- Francois Sergent and Cedric Osterrieth (IBA/IBA-dosimetry) presented “Dynamic@ARC”;
- Niek Schreuder (LEO Cancer Care) presented “upright imaging and positioning – a comprehensive and cost-effective solution enabling rotation therapy for all radiation therapy treatment modalities”.

Prior to the in-person workshop, the online pre-meeting featured keynote talks by Professor Tony Lomax (Paul Scherrer Institute, Switzerland) and Prof. Harald Paganetti (Massachusetts General Hospital & Harvard Medical School, USA), who shared their visions of PAT. Their talks discussed “IMPT [intensity-modulated proton therapy], degeneracy and proton arcs” and “considerations for proton arc: integral dose and integral effect”, respectively. These talks were followed by a lively question-and-answer session with the audience and keynote speakers and personal introductions of the workshop participants. Selected quick-pitch research talks were presented by Samuel Burford-Eyre (University of Manchester, UK), Lennart Volz (GSI, Germany), Macarena Chocan (UCLouvain, Belgium) and Marek Maryanski (Gdansk University of Technology, Poland).

Over the next year, research collaborations between clinical scientists, researchers and industry will be fostered within the workshop collaboration and beyond (Figures 3 and 4). Subsequently, a review and outlook publication will detail the discussion and perspectives from the workshop. The workshop outcomes and next steps will be summarised and presented at a dedicated session during the next ESTRO annual congress. We look forward to seeing you all in Vienna, Austria, next year!



Xuanfeng Leo Ding, PhD
Beaumont Health System
Royal Oak, Michigan, USA
Xuanfeng.ding@beaumont.org



Stewart Mac Mein, PhD
Heidelberg Ion-beam Therapy Center
Germany Cancer Research Center
University Clinic Heidelberg
Heidelberg, Germany
s.mein@dkfz.de
&
University of Pennsylvania
Philadelphia, USA
stewart.mein@penmedicine.upenn.edu





Figure 3. Special thanks to the arc team for their great efforts to gather in Lisbon with talks, pitches and focus groups — we look forward to continuing the exciting collaborations and driving arc therapy forward



Figure 4. PAT social dinner (8 October, 2022) at Portugália Cervejaria

