Heavy Ion Therapy – Medical Physics and Engineering

Course Overview

Title: Heavy Ion Therapy Specialised Course with a Focus on Medical Physics and Engineering

Level: Suitable for master students, Ph.D. Students, postdocs and early stage researchers in medical physics, medical engineering and medicine with an interest in medical accelerators, oncology and hadron therapy.

Knowledge Requirements: Undergraduate knowledge in physics, medicine, biology or engineering. Intended for students specifically interested in medical physics, radiotherapy, radiobiology, radiology, bioengineering, imaging and medical applications of particle accelerator technologies.

Duration: 35 hours

Mode of Study: Online

Language: English

Course Objectives

Educate a new generation of researchers, giving them the required skills and tools to access and engage with Europe's heavy ion therapy research infrastructures.

Provide multidisciplinary researchers from academia and industry with updated knowledge of both heavy ion therapy and the ongoing activities of the four major heavy ion therapy facilities in Europe.

Provide students and early stage researchers with opportunities to network with leading researchers in the field.

How to Apply

Course is readily available online on YouTube. Interested students are free to access the course at a click of a button from the HITRI*plus*.eu webpage (Select Tab – Training and Events)

Content
- Introduction to Heavy Ion Therapy
- Accelerators for Heavy Ion Therapy
- Introduction to current Heavy Ion Therapy Facilities
- Designs of Novel Heavy Ion Therapy Research Infrastructures
- Magnet Technology
- Biophysics
- Clinical Considerations for Heavy Ion Therapy
- Advances in Proton Therapy
- Radiobiology for Hadron Therapy
- Patient Selection, Costing, and Business Development in Heavy Ion Therapy
- Treatment Planning in Heavy Ion Therapy
- Monte Carlo Dose Calculations
- Gantry Design and Beam Dynamics
- Dosimetry
- Lineal and Linear energy
- Imaging
- Control Systems
- Moving targets and precision 4D-delivery
- External Beam Ablation Medical Devices

- Certification Aspects of Heavy Ion Therapy Machines
- EU Funding
- Science Communication
- Entrepreneurship
- Knowledge Transfer and Intellectual Property

Learning Outcomes

This course consists of a number of advanced lectures that provide a good foundation of the field. It also consists of a few hands-on treatment planning exercises that may be done through freely available simulation software.

The skills and learning outcomes include:

- scientific knowledge of the underpinning theory, techniques and methods that should form the foundation of a specialist's knowledge in heavy ion therapy that will allow the attainment of insight into real-world phenomena
- Specialised medical physics knowledge with specific focus on heavy ion therapy
- technical expertise in the fundamental building blocks of heavy ion therapy facilities
- analytical, critical and evaluation skills of various medical physics and engineering aspects of heavy ion therapy

Fees

This is a free online course

Career Prospects

Opportunities to work, study or conduct research in Heavy Ion Therapy facilities as part of scientific, engineering or medical teams.

Suggested Reference Books

Advances in Particle Therapy: A Multidisciplinary Approach (Series in Medical Physics and Biomedical Engineering by Manjit Dosanjh and Jacques Bernier, Taylor & Francis Ltd; 1st edition (1 Jun. 2018) ISBN-13:978-1138064416

Theory of Heavy Ion Collision Physics in Hadron Therapy (Volume 65) (Advances in Quantum Chemistry, Volume 65) by Dzevad Belkic, Academic Press (22 Feb. 2013), ISBN-13:978-0123964557

Particle Accelerators: From Big Bang Physics to Hadron Therapy, by Ugo Amaldi, Springer (10 Jan. 2015), ISBN-13: 978-3319088716

Hadron Therapy Physics and Simulations, by Marcos d'Ávila Nunes, Springer; 2014th edition (2 Oct. 2013), ISBN: 1461488982

Nanoscale Insights into Ion-Beam Cancer Therapy, by Andrey V. Solov'yov, Springer; 1st ed. 2017 edition, ISBN-13: 978-3319430287

Organisers and Sponsors

EU – European Union Horizon 2020 Research and Innovation Programme
HITRIplus – Heavy Ion Therapy Research Integration Plus
CERN – The European Organisation for Nuclear Research
CNAO – Centro Nazionale di Adroterapia Oncologica
MIT - Marburger Ionenstrahl-Therapiezentrum

SEEIIST - South-East European International Institute for Sustainable Technologies
LBNL – Lawrence Berkeley National Laboratory
National Cancer Institute
AVO–ADAM – Advanced Oncotherapy
EBAMed – External Beam Ablation Medical Devices
ENLIGHT – European Network for Light Ion Hadron Therapy
University of Pisa
University of Malta
GSI - Helmholtzzentrum fur Schwerionenforschung
PARTREC – Particle Therapy research Centre
MedAustron - EBG GmbH MedAustron
University of Manchester
ICL - Imperial College London
HIT – Heidelberger Ionenstrahl-Therapiezentrum
LMU - Ludwig-Maximilians Universitat Munchen
INFN - Instituto Nazionale di Fisica Nucleare
PSI – Paul Scherrer Institute
DKFZ – Deutsches Krebsforschungszentrum
Cosylab JSC
University of Melbourne
Vienna University of Technology

Programme Committee

M. Dosanjh (Chair)	University of Oxford/SEEIIST
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A. Facoetti	CNAO
M. Necchi	CNAO
J. Bateman	University of Oxford
P. Georgieva	SEEIIST/CERN
K. Palskis	Riga Technical University
C. Robertson	University of Oxford
R. Taylor	Imperial College

Lecturers

Ugo Amaldi	TERA Foundation
Giovanni Anelli	CERN
Kilian Baumann	Marburg Ion Beam Therapy Center
Elena Benedetto	SEEIIST
Maria Giuseppina Bisogni	University of Pisa and INFN Pisa
Eleanor Blakely, (retired)	LBNL
Jeff Buchsbaum	NCI
Alberto Degiovanni	Avo-ADAM
Manjit Dosanjh	University of Oxford / CERN/SEEIST

Adriano Garonna	EBAMed
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Mimoza Strikchani	CNAO

Technical Instructions – MatRad

Participants who wish to fully exploit matRad and take full advantage of the hands-on sessions are expected to have MATLAB licenses obtained via their academic institutions.

matRad is an open source software for radiation treatment planning of intensity-modulated photon, proton, and carbon ion therapy. matRad is developed for educational and research purposes. It is entirely written in MATLAB.

Software Installation

Minimum requirements

There are no hard minimum requirements to do dose calculation and optimization with matRad. Treatment planning tutorials can be done with systems with 2GB RAM but then cases you are looking at are somewhat small (low spatial resolution, few beams, rather no particles). If you want to do treatment planning at realistic resolutions, we recommend 8GB RAM or more. More information can be found on https://github.com/e0404/matRad/wiki/Minimum-System-Requirements.

matRad Installation step by step

There are two ways to install matRad. The first (and suggested) one is to use the Matlab source code from within the MATLAB programming environment. It requires a local MATLAB installation. The second way is to use a standalone that installs a runtime that allows usage of matRad without a valid MATLAB license. However, the functionality is limited to the user interface and thus one would not be able to take part in coding exercises.

- 1st way (recommended): Source Code to use with valid MATLAB installation

You can also work with the current source code when you have matlab installed (even with Octave, but only without a GUI), which you can get from GitHub here:

https://github.com/e0404/matRad/releases/tag/v2.10.1

There, just download the provided *.zip or *.tar.gz file and extract it to a folder on your hard drive that can be accessed from Matlab.

For completeness and for the ones interested to go deeper, there's also a detailed documentation, targeted at people who work with the software (Matlab source code). It can be found in https://github.com/e0404/matRad/wiki explaining a lot about the workflow and the underlying principles.

- 2nd way: matRad Installation as standalone

VIDEO: MatRad Installation Video (Installation_MatRad file)
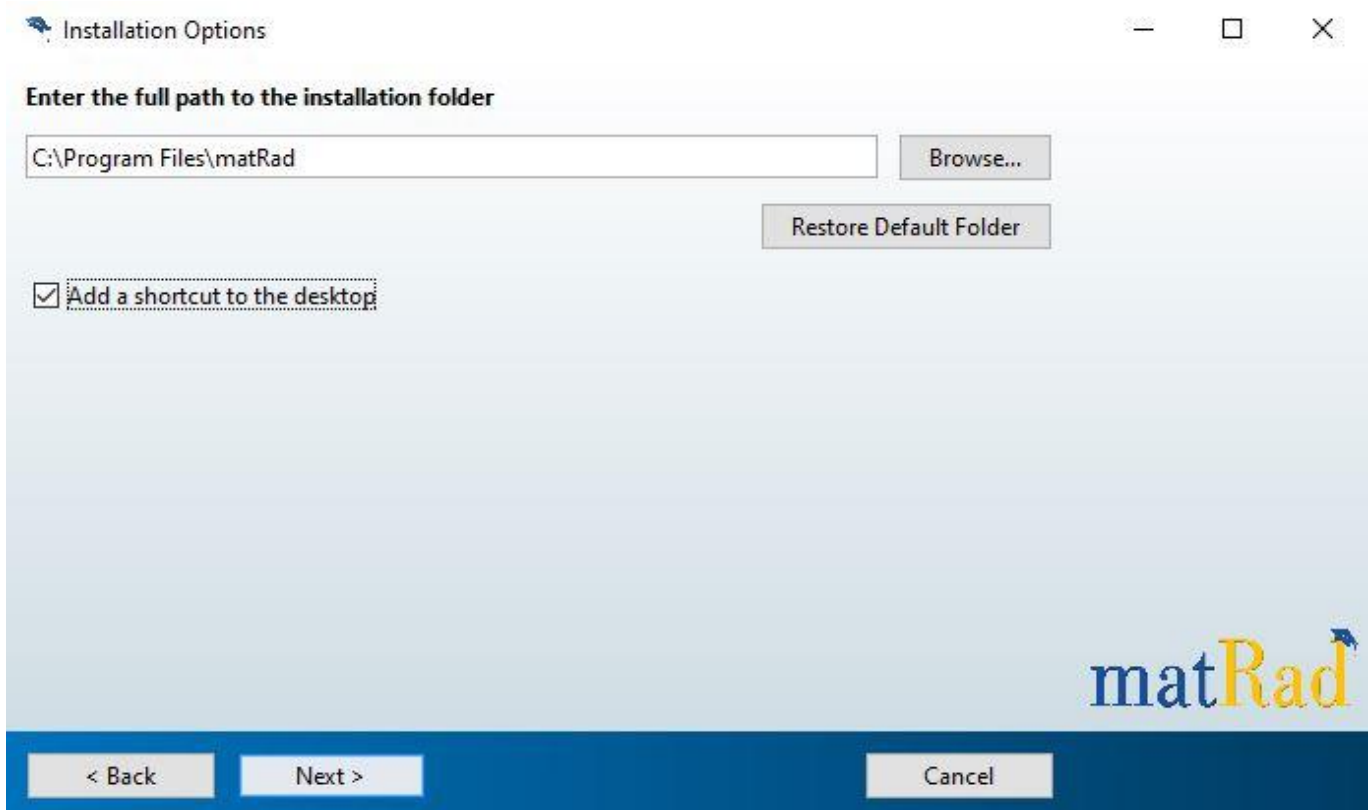
1. To download matRad, download the installer for your system from https://github.com/e0404/matRad/releases/tag/v2.10.1

2. Run the respective installer for your system

- Windows: Run the downloaded executable installer
- Linux: Run the executable install script. Make sure that the *.install file has executable permissions.
- Mac: Here we provide a dmg containint the installer (Since the installer is not apple-certified, you might explicitly launch it from the terminal or by right-click).

After that, you should be guided through the installation process:

Note that the installers will want to download the "Matlab Runtime" from Mathworks in the process. The runtime is quite large (~2GB) and is required to run compiled deployed applications written in Matlab.

3. Run matRad:

- Windows: Just like with every other progam, you should have a desktop icon.
- Linux & Mac: To start matRad, you can use the provided run_matRad.sh script from the terminal. It requries one argument which gives the path to the installed Matlab-Runtime. Refer to the readme_linux.txt and readme_mac.txt in your installation directory for more information.

Patient/Phantom files

The patient files should be included with the installer and will be installed into the desired location. For windows, for example, they can be found within the "application" folder ofr the chosen installation directory.

We also provide an extra link for the patient files: [Download here!]