The Chair of Medical Physics of the *Ludwig-Maximilians-Universität München* offers:

1 PhD position (m,f,d)

(TVL-E13 at 65% position, 3 years)

Combined X-ray and ion image guidance in particle therapy

Particle therapy with protons and light ion beams is an emerging form of external beam radiotherapy, which takes advantage of the favorable interaction properties of swift ions in matter, particularly their enhanced energy deposition at the end of their range. This results in a characteristic maximum in the depth dose deposition, so called Bragg Peak, which can be optimally placed inside the tumor, with better sparing of surrounding normal tissue and organs at risk with respect to conventional photon therapy. However, full clinical exploitation of this advantage requires accurate knowledge of the Bragg Peak position within the patient.

Treatment planning of ion beam therapy is typically performed on X-ray Computed Tomography (CT) images, which are empirically calibrated to ion stopping power ratio relative to water, with a remaining uncertainties of approximately 1-3%, limiting the precision of Bragg Peak placement within the tumor. Moreover, in-room volumetric imaging aiming to verify patient position and anatomy, and to trigger adaptive corrections in case of significant changes from the treatment panning, is typically performed on X-ray cone-beam CT images of even lower quality than planning CT images.

Several studies have shown that imaging with the ion beam itself has the potential of directly measuring the tissue stopping power properties to overcome inaccuracies in (CB)CT-based treatment planning and adaptation.

To this end, this project **aims at investigating the optimal combination of X-ray imaging with ion radiographies to minimize inaccuracies in the CT calibration for treatment (re)planning**. Conventionally, this minimization relies on optimization algorithms that are limited by intrinsic inconsistencies of the forward-projection model of the ion radiographies. Moreover, these optimization algorithms have been investigated so far only for application to the treatment planning CT image. In this project, also the in-room X-ray CBCT images typically acquired for treatment planning adaptation (being anatomically correspondent to the ion radiographies) are adopted for such a minimization. To overcome the limitation of the model-based approach, unconventional data-driven machine learning (including deep learning) algorithms and architectures will be considered. **The project will thus devise new solutions for combined X-ray and ion imaging, for application at all clinically viable ion species and different concepts of so-called list-mode and integration-mode detectors**.

The PhD position is financed by the *Deutsche Forschungsgemeinschaft* (DFG) within the project Hybrid ImaGing framework in Hadrontherapy for Adaptive Radiation Therapy (HIGH-ART, https://gepris.dfg.de/gepris/projekt/372393016?language=en). The project, led by Dr. Chiara Gianoli and Prof. Katia Parodi, will be carried out at the LMU Chair of Medical Physics (www.med.physik.uni-muenchen.de), which offers a multi-disciplinary environment and works on various core-topics of ion beam therapy. The working place is at the *Forschungszentrum Garching*, which is well-connected with public transportation to the city center of Munich and the collaborating Department for Radiation Oncology of the *Klinikum der Universität München*.

Requirements

- MSc in physics or engineering, ideally with a background in medical physics or biomedical engineering
- Good understanding of the physics of medical imaging
- Experience and interest in artificial intelligence and machine learning
- Proficiency in coding and documentation standards, Monte Carlo simulations and programming languages, preferably C/C++, Python, MATLAB and related imaging libraries and machine learning tools, along with Linux and Windows OS
- High level of creativity and motivation to pursue interdisciplinary research
- Fluent English knowledge (spoken and written)

How to apply

If you are interested in the position, please send us your application (letter of motivation, curriculum vitae, last school certificate, university degree including grades, publication list [if applicable], other qualification certificates like TOEFL) until the **20th of December 2021** via email to

Katia.Parodi@physik.uni-muenchen.de

Chiara.Gianoli@physik.uni-muenchen.de

indicating the earliest possible entry date, ideally early 2022. Disabled candidates are preferentially considered in case of equal qualification. Applications from women and minorities are strongly encouraged.