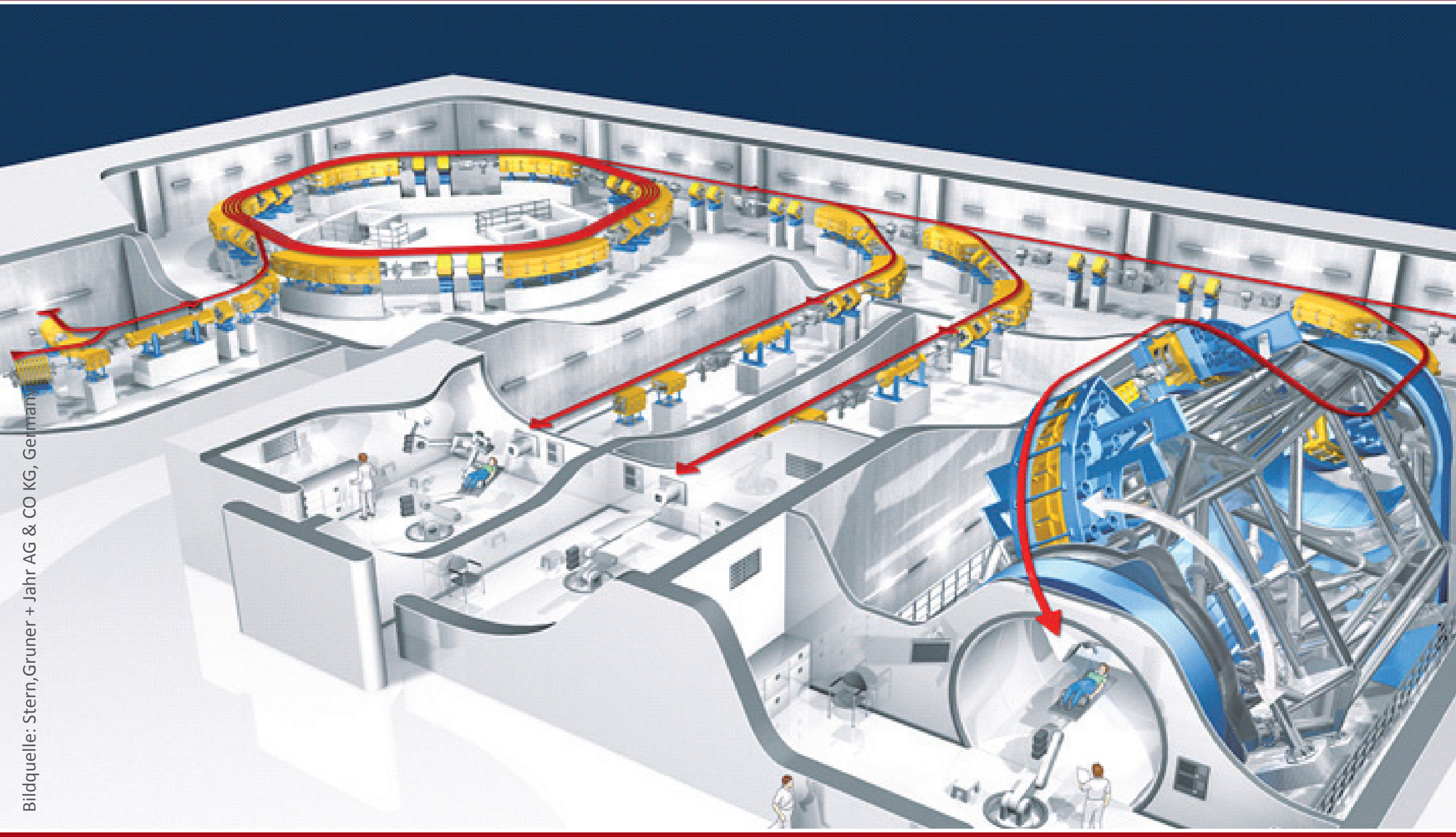
Medizinische Fakultät Heidelberg

MASTER ONLINE

ADVANCED PHYSICAL METHODS IN RADIOTHERAPY

Program Information Booklet

Distance learning MSc program in medical physics



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HIT Heidelberg Ion-Beam Therapy Centre

dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

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PROGRAM DESCRIPTION

INTRODUCTION

Thank you for your interest in the Master Online "Advanced Physical Methods in Radiotherapy" (MO APMR) program delivered by the prestigious University of Heidelberg in Germany. We are especially pleased to present the University's first postgraduate online distance learning opportunity on the next few pages and aspire to answer at least some of your questions about continuing your education with us.

The APMR program welcomes students of all cultural and ethnic backgrounds and is designed to accommodate the diverse needs of adult learners with at least 2 years professional experience from different areas of expertise in the interdisciplinary field of medical physics. Whether you are an undergraduate physics student, a practicing medical physicist or just completing your Bachelor's degree in biomedical technology, it's never too early to think longer term about your future career goals. This APMR program information booklet is for you – regardless of the current stage of your academic or professional career. If you plan on refining knowledge and skills while learning advanced cancer treatment techniques on a flexible, English-speaking curriculum in the company of likeminded colleagues, then read on. Let us demonstrate how the MO APMR program could be your springboard to exciting emergent career opportunities in the vibrant field of medical radiation therapy.

OVERVIEW

The MO APMR is a part-time, postgraduate program in medical physics delivered predominantly online (80%) with periodic practical attendance phases (20%) at flagship medical facilities in Heidelberg. Newly accredited (2011) by the German accreditation institute ACQUIN (Accreditation, Certification and Quality Assurance Institute), students are assured nothing less than expert instruction, high-quality learning materials and study support arrangements over a period of two years as set forth in the German quality assurance guidelines for Bachelor and Master programs of study.

This unique distance learning program is borne out of a fruitful, long-standing partnership between the successful German Cancer Research Center (DKFZ), the distinguished Heidelberg University Hospital and, more recently, the new state-of-the-art Heidelberg Ion-Beam Therapy Center (HIT). HIT is the world's prototype ion beam facility already widely acclaimed for its advanced beam scanning techniques and an isocentric gantry which provides beams of protons, carbon, helium and oxygen, while rotating up to 360° around the patient.

The advanced technology available at these cutting-edge, medical facilities plays an increasing role in the optimum care and treatment of cancer patients worldwide. Thanks to the ongoing collaborative activities between key stakeholders, and unlike any other program in advanced physical methods, APMR offers students advanced practical training at these facilities on location in Heidelberg. The practical training sessions are purposefully aligned to the continuous theoretical instruction from 60+ internationally based teaching staff and prominent experts, online, in the disciplines of radiology, radio oncology, radiation safety and medical physics.

OUTLOOK

Innovative research and developments in the field of medical physics continue to improve the quality of radiation treatment of cancer. Graduates of APMR will possess the specialized technical skills underpinned by a solid theoretical understanding of advanced cancer treatment techniques such as intensity modulated and image guided radiotherapy (IMRT, IGRT) and proton and heavy ion therapy. A shortage of specialists at the growing number of heavy ion beam facilities in Europe is already imminent and this is where APMR can contribute to filling a widening gap. With an MSc in APMR successful candidates hold a valuable and worthwhile terminal degree that can open doors to challenging new careers in teaching, research or care services in medical centers, national laboratories, academic institutions, governmental regulatory agencies, and in medical and nuclear industrial facilities.

MODE OF STUDY

APMR is a distance learning program tailored to fit the adult learner's busy schedule! Strictly speaking APMR takes a so-called blended learning approach. There is a growing consensus that the blended learning approach is the most effective at supporting student learning which on APMR entails a dominant online phase (80%) supplemented by periodic practical attendance phases at the HIT facility and further modern radiotherapy units (20%). By making effective use of online technology and educational multimedia students have access to a flexible and supportive virtual learning environment (VLE) hosted by the institutional Moodle platform. The VLE holds all relevant learning materials, assignments and activities. Web discussion boards and online seminars foster collegiate communication and collaboration with teaching experts and peers at times that suit students' individual needs.

APMR students are tasked with theoretical and practical coursework over a period of two years in five fully online modules and four scheduled short attendance phases plus one longer internship. The attendance phases are scheduled in between two subsequent online modules according to the table shown. The online-on-site sequences enable students to concentrate on acquiring a solid theoretical grounding and on refining knowledge in advanced cancer treatment "anytime and anywhere" supplemented by hands on, practical training sessions (i.e., the attendance phases) at fixed times that still allow for a reasonable work-life-study balance.

Semester 1						Semester 2						Semester 3						Semester 4					
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Module 1				Module 2		Module 3				Module 4		Module 5				Module P		Master's Thesis					
Start Attendance phase 1 (1.5 days)			Attendance phase 2 (1.5 days)						Attendance phase 3 (4 days)						Attendance phase 4 (4 days)		Attendance phase 5 (12 days)					Defense	
I1			W1			I3 online			W2			I5 online			W4		4 Internships						
			E1 (M1)						E2 (M2)						E4 (M4)								
			I2						W3						W5								
									E3 (M3)						E5 (M5)								
									I 4														
I: Introduction			W: Workshop			E: Exam			P: Internships														

STUDYING ONLINE

What is it like studying online? Studying online on the APMR program entails a range of carefully developed learning objects and activities that accommodate the different ways of learning as a working adult. APMR is a distance learning program that has been designed to balance the flexibility of stand-alone web-based materials, self-paced activities and study units with collaborative tasks and synchronous (live) online sessions. New topics are introduced within study units by the subject experts in prerecorded video lectures complemented by easily accessible text-based content. Self-tests feature after each sub-module to encourage self-monitoring of progress at regular intervals during the semester designed to signal to the student and tutor possible areas for improvement.

Sharing views, raising relevant issues and presenting selected homework assignments takes place in the themed asynchronous (time-delayed) discussions and synchronous (same time) online study sessions. These feature in selected sub modules in order to foster peer to peer support and tutor contact time. It's also an ideal way to beat the online blues!

Online guest lecture with Prof. Bortfeld, Boston, USA

State-of-the-art online conferencing, discussion and web 2.0 technology ensure reliable communication between all parties at a distance - from work, home or as in one instance on the program – even from a campsite in Italy! Online guest lectures delivered by experts from across the globe feature regularly and allow for international outreach not ever feasible in the traditional classroom.

WHAT'S THE CATCH?

It is no secret that online study requires more self-discipline and time management skills than in traditional modes of education where lessons are delivered in lecture halls and the instructor and fellow classmates are never far away. It can be difficult to stay motivated and on target between the ongoing demands that work and family bring from behind a glaring computer monitor. The APMR program developers are experts in technology-enhanced teaching and learning and have designed a program with all the potential online pitfalls in mind.

Dr. Christina Mainka
E-Learning Coordinator
APMR

Marcel Schäfer
Program Coordinator
APMR

First and foremost, APMR students are never alone as opportunities for communication and support are built into the curriculum in a number of ways. The program staff, Christina Mainka and Marcel Schäfer, can be reached via email, phone or telephony (skype) at anytime for personal 1:1 advice and support. The virtual learning environment (VLE) offers a dedicated synchronous online student meeting area and wiki working space for preparing assignments collaboratively or for simply sharing life's challenges with peers. A dedicated problems forum is available for raising any concerns or questions to the program team and regular synchronous online study sessions with the subject experts help foster a scholarly peer-tutor relationship. For students new to online study the very first attendance phase (M1 induction session) is of particular interest as it is also a hands-on opportunity to practice using the most common web-based tools that feature on the program under the guidance of an expert (in addition to the self-study online tutorials available via the VLE).

BENEFITS OF ONLINE STUDY

Still not sure if online study is right for you? Then consider the following benefits:

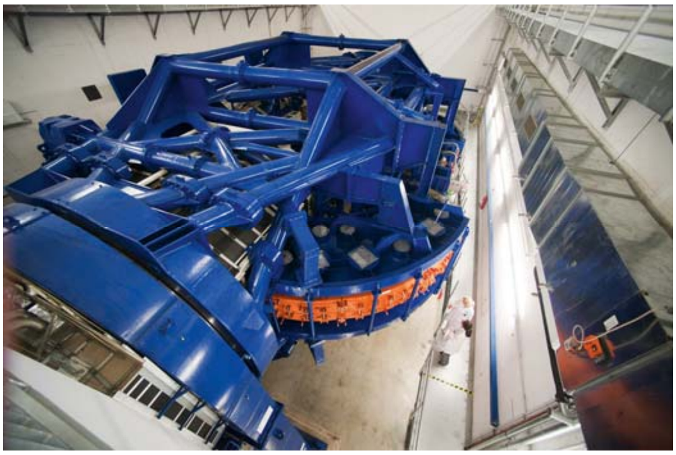
- Within limits students can study at a time and pace (and place) that suits them best.
- Online study is needs-based as material can be reviewed as many times as necessary to understand a topic.
- Geographic boundaries break down in synchronous online guest lecture sessions.
- Simulations and animations allow for better understanding of difficult processes.
- Internet communication tools (ICT) in the VLE facilitate more communication than might be possible in the traditional classroom.
- The global outreach of an online program allows for culturally and academically richer learning.
- The VLE is a one-stop-shop that holds all program resources to allow for more effective learning than if dispersed over time and place.
- It exposes students to emergent online communication technologies that are pivotal to collaborative research and technological developments in the global academic and professional communities.

ATTENDANCE PHASES

APMR adopts a blended learning approach and approximately 20% of your time will be spent on-site in Heidelberg carefully planned to keep travel and accommodation costs at a minimum. Inherently, medical physics is the application of physics to medicine and as such a program in medical physics would not be complete without opportunities for hands-on application of knowledge and new treatment techniques alongside the online instruction. On the APMR opportunity for guided practice takes place at radiotherapy centers including the DKFZ and the heavy ion-beam facility HIT in a total of five supplementary attendance phases as illustrated in the table above.

During the attendance phases APMR students will find themselves working side by side with pioneering experts with longstanding experience in IMRT, ion beam scanning and treatment planning as well as radiobiological modeling. The first two attendance phases (induction and M1) are the shortest at 1.5 days followed by two separate joint attendance phases of 4 days each for modules 2 & 3 and modules 4 & 5. The longest attendance phase offers time for at least 4 internships during the 3rd semester before the Master's thesis

The internships on APMR are a core element of the program and represent the longest compulsory attendance phase for its students as described previously. During the internships (M P) students will be present in Heidelberg for a block of 12 days during which they must take part in four out of five work-based training sessions. These are aligned closely to the lessons delivered in modules 2-5. Experts and teaching staff in medical physics and radiotherapy are on hand for guidance and support throughout.



Heidelberg Ion-Beam Therapy Center (HIT): the heavy ion gantry

The internship sessions take place at the Department of Medical Physics in Radiotherapy at the German Cancer Research Center (DKFZ), the Department of Radiation Oncology and Radiation Therapy at the University Hospital of Heidelberg and at the Heidelberg Ion-Beam Therapy Center, HIT. Besides providing authentic beam time experiences at the required radiotherapy units, these prestigious institutions also offer interns international networking opportunities that are sure to prove valuable not only in future job searches.

Clearly, for the MO APMR student being online does not stand in the way of hands-on, radiotherapy treatment time!

STUDENT SUPPORT

Help is never far away on the MO APMR where members of the program team offer individual online and on-site support in subject- or program-related questions.

The MO APMR program team supports you with the following:

- program handbook & website
- institutional virtual learning environment (Moodle) and technological support
- modern internet communication technology (ICT)
- email, phone and telephony contacts

- highly visible tutors online and on-site
- written and/or oral feedback to coursework
- alternative multi-media delivery formats
- administrative, pedagogical, and personal support from the program coordinating team

The University of Heidelberg offers you:

- a 625 year reputation of excellence in teaching and research
- state-of-the-art medical facilities and global interdisciplinary partnerships
- library support and study resources including e-resources in the form of e-books and e-journals
- student registry, admissions and advisory service

Last but not least – you will be residing in the superb city of Heidelberg during the attendance phases. As Goethe once said: “The beauty of the city and its environs can fairly be said to verge on the ideal.”

PROGRAM OBJECTIVES

In light of the rapid developments in the field of advanced cancer treatment the APMR program aims to best prepare its graduates for the versatile challenges that lay ahead.

During their studies APMR participants will:

- consolidate and refine their fundamental medical knowledge in the fields of anatomy, physiology and medical imaging.
- acquire a robust, basic, theoretical and practical understanding of IMRT/IGRT and particle therapy.
- demonstrate knowledge of recent developments in IMRT/IGRT and particle therapy and apply this knowledge in the treatment of patients.
- acquire an in-depth understanding of dosimetry and quality assurance tailored to include the most recent radiation therapy techniques.
- demonstrate the practical ability to carry out research and clinical tasks independently on modern radiotherapy units for IMRT, IGRT and particle therapy.
- develop and improve independent learning, organizational and team-working skills.
- become confident in the use of information communication technology (ICT) and recognize the role technology-enhanced teaching and learning plays in continuing personal professional development.

ECTS CREDITS

Semester	Modules		ECTS Credits
	Induction: Attendance phase (1.5 days)		
1	**M 1** **Anatomy and Imaging for Radiotherapy**	**M 2** **Intensity Modulated Radiotherapy (IMRT)**	15
	Attendance phase (1.5 days)		
2	**M 3** **Ion Therapy**	**M 4** **Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART)**	15
	Attendance phase M2, M3 (4 days)		
3	**M 5** **Advanced Dosimetry and Quality Assurance (QA)**	**M P** **4 Internships**	15
	Attendance phase M4, M5 (4 days)	Attendance phase (12 days)	
4	**M T** **Master's thesis**		30
			∑ 75
Pre-requisites	Degree of higher or further education institute (Bachelor, Diploma, Master)* Proof of at least two years of professional experience following the first degree* Competency in medical physics subject to scrutiny by submission panel*		**45**
			∑ 120

* For detailed information please see page 33

<u>Note:</u>

The workload of the program is defined by the European Credit Transfer and Accumulation System (ECTS, which can be found at http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm), where 1 ECTS-Credit corresponds to 30 hours of work. This results in a weekly workload of about 15 hours during online phases depending on the individual educational background.

ENTRY REQUIREMENTS

Prospective students are expected to demonstrate:

- fundamental knowledge of anatomy and physiology
- knowledge of biometry and statistics
- basic knowledge of the organizational and legal infrastructure of their national health care system
- fundamental knowledge of the methods of medical physics and engineering science (medical technology) and the application of this knowledge in medical procedures used in the treatment and care of patients
- knowledge of physics and engineering for radiotherapy and nuclear medicine
- knowledge of image generation and image processing (X-ray, CT, US, MRI)
- basic knowledge of dosimetry and radiation safety (basic course in radiation safety according to the German guideline on radiation safety in medicine, "*Strahlenschutz in der Medizin"* which can be found online at http://www.bmu.de/strahlenschutz/doc/5613.php)

It is at the discretion of the Admissions Committee (in German "Zulassungsausschuss") whether or not prior learning and qualifying academic degrees can be recognized. The recommendations of the Conference of German Cultural Ministers (in German "Kultusministerkonferenz") and the agreements reached within the partnerships of higher education institutions will be considered in the recognition of foreign degrees. Any ambiguous cases will be referred to the Central Office for Foreign Education (in German "Zentralstelle für ausländisches Bildungswesen, ZAB").

If the candidate has not met the prerequisites for admission by the application deadline, conditional admission can nonetheless be granted on the basis of provisional documentation, issued by the institutions concerned, which certify that the candidate is expected to meet the prerequisites for admission by the date the course commences in the semester for which admission is being sought.

MODULES OF STUDY

The APMR program is delivered in English in a total of six modules over a period of 1.5 years (3 semesters) including the internship module (M P), followed by one final semester dedicated to the completion of the Master's thesis. Each module is supported by the online program site in the institutional VLE (Moodle) which holds all study materials and online lessons. Scheduled attendance phases supplement the online study phases according to the table (see p. 4).

The modules M1-M5 are divided into a set of 4-6 themed sub-modules each with specific learning outcomes. Each sub-module is delivered slightly differently with variable emphasis on independent, self-paced activities and readings and collaborative assignments and scheduled online study sessions (as described earlier). Each sub-module terminates with a compulsory self-test designed to highlight learning deficits in a timely manner in order for student and tutor to address problems as early on in the program as possible. The self tests are formative and do not contribute to the overall final mark awarded upon successful completion of the program.

APMR modules are inherently interdisciplinary and include topics from medicine and physics. The individuals responsible for the module content and the tutors appointed in each case will be experts in the respective subject areas. This ensures highest quality instruction and study material optimally aligned to the work-based practical training sessions carried out in the module attendance phases and later on in the internships.

ASSESSMENT

Five cumulative, paper-based written module exams are administered for modules 1-5 during their respective attendance phases. For module M 3 one written report and for M P four written reports must be completed which together with the five final module exams contribute 60% to the final MSc award. The Master's thesis is marked for its written content and oral defense and counts 40% toward the final grade.

M 1 ANATOMY AND IMAGING FOR RADIOTHERAPY

Topics:

Introduction | Anatomy for Physicists | Imaging for Radiotherapy | Virtual Anatomy | Diagnostic Radiology | M1 Attendance Phase

We will refresh your anatomical knowledge and you will be exposed to the latest improvements in radiological imaging, including modern X-ray CT, dual energy CT, morphological and functional MRI and MR spectroscopy, as well as in modern techniques in molecular imaging. The knowledge gained will form the basis for the understanding and application of the new treatment techniques.

M 2 INTENSITY MODULATED RADIOTHERAPY (IMRT)

Topics:

Introduction IMRT | IMRT in Clinical Routine | Advanced Application Techniques | M2 Attendance Phase

After an overview of the basic features of IMRT, you will be introduced to the different technical implementations of modern IMRT and to applications in clinical practice. Building upon problem- and work-based scenarios you will have the unique opportunity to gain hands-on experience at our facilities and to discuss your activities on-site with the IMRT innovators.

M 3 ION THERAPY

Topics:

Introduction | Physical Principles | Beam Generation and Application | Radiation Biology| Treatment Planning | Clinical Application of Ion Therapy | M3 Attendance Phase

You will reinforce your knowledge about the basic physical interaction of protons and ions and discover how these can be harnessed to the benefit of the patient. An understanding of these interactions also forms the basis for the biological effects of high LET radiation, which you will study in detail. You will be introduced to vital technical features of accelerators, beam delivery systems and also to treatment planning and the implications for clinical practice.

M 4 IMAGE GUIDED RADIOTHERAPY AND ADAPTIVE RADIOTHERAPY

Topics:

Introduction | IGRT Techniques (physics) | Clinical Application IGRT (medicine) | Moving Target Volumes and Adaptive Radiotherapy | M4 Attendance Phase

More recently IGRT has become an important new paradigm. You will discover that applications of IGRT are not merely restricted to accurate patient positioning, but include further the resolution of inter- and intrafractional motion in order to arrive at a true 4D dose conformation. The basics of modern biological imaging techniques and their implication for radiotherapy will also be explored.

M 5 ADVANCED DOSIMETRY AND QUALITY ASSURANCE

Topics:

Introduction | Dosimetric Principles | Dosimetry for Advanced Radiotherapy Techniques | Quality Assurance | M5 Attendance Phase

The highly advanced techniques of IMRT, IGRT and ion beam therapy require complex solutions for dosimetry and quality assurance. You will scrutinize relevant guidelines for the design of dedicated QA procedures adapted to the unique requirements of these modern techniques. Dosimetric principles will be studied in-depth and then applied to special dosimetry techniques for small fields, ion dosimetry and dynamic fields. Finally, you will find yourself working side by side with world renowned experts during the practical training sessions at our flagship facilities.

M P INTERNSHIPS

Topics:

Treatment Planning | IMRT | ART | Ion Therapy | Dosimetry and QA

You will have the exclusive opportunity to visit the DKFZ, recognized as one of the birthplaces of IMRT in the 90'ies. Furthermore, you are given the rare opportunity to train at the world's first scanning beam ion facility, HIT. Here you will engage in discourse with the expert developers whilst experiencing state-of-the-art radiotherapy and its implementation in one of the largest radiotherapy centers in Europe.

M T MASTER'S THESIS

During their dissertation students will be supervised by a subject expert member of the program teaching team.

Topic to be selected from modules 1 - 5.

Module 1: Anatomy and Imaging for Radiotherapy

Module leader: Prof. Dr. Wolfgang Schlegel

M 1.1 **On-site**	**Introduction Module 1** ECTS points: 0.5
M 1.2 **Online**	**Anatomy for Physicists and Engineers** ECTS points: 1.5

Content:

1.) Fundamentals of anatomy:

- Topography

2.) Anatomy of the organ systems

- Cardiovascular system
- Respiratory system, mediastinum
- Digestive system, nasopharynx, oropharynx, larynx
- Urogenital tract, genital organs
- Central nervous system
- Sense organs
- Vascular system and lymph node system
- Spinal column and extremities

3.) Organ systems classified by function

Course objective:
Competence in selected anatomical regions which are important for radiotherapy.

M 1.3 **Online**	**Imaging for Radiotherapy** ECTS points: 1

Content:
An introduction to the fundamentals of physics and engineering underlying current advanced imaging techniques and the scientific application of this knowledge:

Computer Tomography (CT):

- Time-resolved/motion-compensated CT (4D CT)
- CT perfusion: fundamentals of mathematical modeling, maximum slope model as proposed by Miles, Patlak model, limitations of models in practice
- Dual-energy CT: basic concept in terms of mathematics and physics, technical implementation, potential applications
- CT for treatment planning: requirements, conversion of CT numbers into electron density for dose simulation and calculation, spatial and temporal constancy
- CT for stereotactic treatment planning

Cone-beam techniques:

- Cone-beam CT

- Cone-beam tomosynthesis

Magnetic resonance tomography (MR):
- Repetition of the fundamentals of MR imaging (MRI)
- Interventional MR
- Functional MR: diffusion and perfusion techniques, tractography (fiber tracking), BOLD imaging, dynamic contrast-enhanced MRI
- MR spectroscopy: fundamentals, detectable substances, sensitivity, spectral resolution, localization
- High-field MR above 3 Tesla

Ultrasound (US):
- Special methods in diagnostic ultrasound: sampling and excitation techniques, harmonic imaging and elastography
- Ultrasound ablation: high-intensity focused ultrasound (HIFU)

Positron emission tomography (PET/SPECT and PET/CT):
- Advanced analysis and further processing of dynamic PET-CT data and correlation of data to molecular biology
- Modern PET tracers and their use

Advanced image registration techniques for monomodal and multimodal applications:
- Rigid
- Affine
- Elastic

Course objective:
Knowledge of the fundamentals of physics and engineering underlying advanced imaging techniques.

M 1.4 **Online**	**Radiological and Virtual Anatomy** ECTS points: 2

Content:
- Fundamentals of anatomical structures in projection radiography, 2D and 3D
- Translation of anatomy into imaging techniques (US, CT, MRI, PET)
- Knowledge of the anatomical lead structures in the various organ sections (head/neck, thorax and abdomen, extremities)
- Distinguishing tissue types, specifically in the various imaging techniques (CT, MRI, US)
- Knowledge of the various examination techniques (native image acquisition, contrast image acquisition)
- Limitations of the individual diagnostic techniques (CT, MRI, US)

1.) Organ systems in CT, MRI and sonography
- Cardiovascular system
- Respiratory system
- Digestive system (liver, gall bladder, intestine, pancreas etc.)
- Urogenital tract (kidneys, urine bladder etc.)
- Central nervous system
- Sense organs
- Vascular system and lymph node system
- Spinal column and extremities

2.) Virtual anatomy (training software)

Course objective:
Competence in the radiological anatomy of healthy subjects and in normal morphology in imaging (CT, MRI, ultrasound and PET).

M 1.5 **Online**	**Diagnostic Radiology** ECTS points: 1

Content:
- Distinguishing anatomy and pathology in the individual imaging techniques (US, CT, MRI)
- Knowledge of pathological structures in the individual organ sections (head/neck, thorax, abdomen, and extremities)
- Knowledge of the most common pathological phenomena appearing in radiological images (projection radiology, CT, MRI and US)
- Distinguishing pathological phenomena from the major organ and lead structures
- Recognizing disorders in contrast and non-contrast images generated by the specific radiological image modalities

1.) Clinical application of CT
- Multi-phase CT, windowing and density distribution
- CT in treatment planning (e.g. stereotaxy)

2.) Clinical application of MRI
- Sequences
- MRI in treatment planning

3.) Clinical application of sonography:
- Sonography for therapy monitoring

Course objective:
Knowledge of imaging for the diagnosis and radiotherapy of the most common tumors, specifically for identifying tumor volume, clinical target volume and target volume in planning as well as risk organs. Potential applications of current imaging technology for more accurately determining target volumes and for individualized assessment of organ and tumor motion.

M 1.6 **On-site**	**Module 1 Attendance Phase**

Content:

- Presentation and discussion of clinical examples
- Seminars and practical courses for Module 1
- Discussion forum
- Practical application of the **course content** acquired online:
- Preparation for radiation treatment (techniques for positioning and fixation, exercises in defining target volume)
- Practical course in nuclear medicine (PET), practical course with current image generation software
- Tour of the equipment system in operation (Linacs, Artiste, 7 Tesla MR, HIT, tomotherapy)
- Ultrasound practical course

Course objective:
Mastery of the contents of Module 1, practical experience in the application of imaging techniques in radiotherapy.

K 1 **On-site**	**Exam Module 1** ECTS points: 0.5

MODULE 2: INTENSITY MODULATED RADIOTHERAPY

Module leader: Prof. Dr. Uwe Oelfke

M 2.1 **On-site**	**Introduction Module 2** ECTS points: 0.5
M 2.2 **Online**	**Introduction to IMRT** ECTS points: 1.5

Content:

- Treatment planning
  - Fundamentals
  - Inverse planning and optimization
- IMRT: dose application
  - Simple techniques
  - Multi-leaf collimators (MLCs)
  - Aids and techniques in positioning, stereotactic radiotherapy
- IMRT: basic clinical aspects
- Summary

Course objective:
Acquiring the fundamentals of physics and methodology for performing IMRT.

M 2.3 **Online**	**IMRT in Daily Clinical Work** ECTS points: 2

Content:

- Clinical indications and IMRT protocols (prostate, head/neck, abdomen, thorax)
- IMRT verification strategies (verification concepts, film dosimetry, ion chambers etc.)
- Clinical cases: step-and-shoot IMRT
- Clinical cases: tomotherapy
- Clinical cases: rotation therapy (RapidArc)
- Summary

Course objective:
Awareness and overview of current research and of the application of IMRT.

M 2.4 **Online**	**Advanced Application Techniques for IMRT** ECTS points: 2

Content:

- Inverse planning and optimization
  - Biologically motivated object functions
  - Hierarchical planning strategies
  - Multi-criteria optimization
  - Considering the physical properties of equipment (hardware constraints)
  - The method of direct aperture optimization
  - Optimization of rotation therapy

- IMRT: dose application and quality assurance
  o Tomotherapy
  o CyberKnife
  o Rotation therapy (VMAT, RapidArc)
- Clinical IMRT: Current status and challenges
  o Limitations of IMRT
  o Evidence for IMRT?
- Summary	

Course objective: Enhanced knowledge and competence in advanced IMRT applications.	
M 2.5 **On-site**	**Module 2 Attendance Phase** ECTS points: 0.5
Content: - Seminars and practical courses for Module 2 - Presentation of current clinical cases - Discussion forum	
Course objective: Verification and expansion of the skills acquired through online learning, strengthening competence in applying IMRT.	
K 2 **On-site**	**Exam Module 2** ECTS points: 1

MODULE 3: ION THERAPY

Module leader: Prof. Dr. Christian Karger

M 3.1 **Online**	**Introduction Module 3** ECTS points: 0.5
M 3.2 **Online**	**Fundamentals of Physics** ECTS points: 1

Content:

- Fundamental interaction mechanisms of protons and ion beams with matter
- Energy loss and energy loss distribution
- Fundamental physical parameters for dosimetry, stopping power ratio and W-value
- Multiple scattering, forward scattering
- Nuclear interaction and nuclear fragmentation
- Neutron generation and neutron interaction
- Radiation protection and shielding from primary and secondary beams

Course objective:
Understanding of the fundamental interaction mechanisms of the various types of ions and the differences among them for therapy; basic principles of modeling and of describing such interactions for application in therapy planning and dosimetry; appreciation of issues in the area of radiation protection.

M 3.3 **Online**	**Beam Generation and Application** ECTS points: 1

Content:

- Types of ion sources, function and where they are used
- Accelerator designs for therapeutic application (Zyklotron, Synchrotron, laser induction, other future developments)
- Beam transport and gantry design for protons and heavier ions (including designs under development such as superconducting gantries and fixed-field alternating gradient synchrotrons)
- Beam application systems (passive methods, scanning systems, combinations), commissioning of beam application systems
- Requirements for beam applications used in the therapy of moving organs (gating, rescanning, tracking and combinations)

Course objective:
Understanding of the most important parameters in beam generation and application and their influence on the quality of treatment; knowledge of the fundamental concepts of beam application as well as the potential and limitations when used on patients, including modeling these factors in therapy planning.

M 3.4 **Online**	**Radiobiology** ECTS points: 1

Content:

- Fundamentals of radiobiology, sensitivity to radiation, cell survival after radiation exposure, the linear-quadratic model and further developments, other factors influencing cell survival
- Reaction of cell systems to ion radiation, local effects of high LET radiation, biologically effective dose, relative biological effectiveness (RBE), dependency of RBE on particle type, dose, LET and biological parameters, oxygen enhancement ratio (OER)
- Track structure models for describing RBE, underlying assumptions and model parameters, application of track structure models to cell systems, principles for transferring the models to clinical application, model validation
- Reaction of in vivo systems to ion radiation, description using dose-effect curves, in vivo RBE, comparison with predictions from models, accuracy of model predictions, significance for clinical application

Course objective:

More detailed knowledge of the biological effects of ion radiation, specifically of the complex effects of physical and biological parameters on RBE.

M 3.5 **Online**	**Ion Treatment Planning** ECTS points: 1

Content:

- Physical radiation models, basic data, commissioning, range calculation using CT, optimization of dose distribution, validation of calculated dose distribution, monitoring range using PET
- Taking RBE into account in treatment planning, influence of fragments, fluence and dose distributions for a homogeneous biologically effective dose, biological dose optimization
- Techniques and strategies in clinical treatment planning, intensity modulated particle therapy (IMPT), parameters for radiation plans, uncertainties in treatment planning, dose verification techniques
- Treatment planning for moving target volumes, repainting, gating, tracking, patient monitoring, 4D treatment planning

Course objective:

Robust knowledge of treatment planning, specifically of calculating physical and biologically effective dose distribution and of clinical treatment planning including the uncertainties it entails.

M 3.6 **Online**	**Clinical Application** ECTS points: 1

Content:

- Clinical expectations placed on ion therapy, use of ion therapy for established clinical indications, procedures for establishing a particle therapy for new indications, design of clinical studies, evidence-based medicine
- Indication and treatment designs, use of particle therapy: 1.) tumors in the head/neck region; 2.) tumors in the thorax region; 3.) tumors in the abdomen/hip region; combination therapies
- Target volume concepts, definition of various target volumes in particle therapy, combination of particle therapy and IMRT while considering target volume concepts, target volume concepts with moving organs
- Dose prescription in ion therapy, clinical aspects of relative biological effectiveness (RBE) for the various ion types and taking into account biology in dose prescription for the target volume and for risk organs, tolerance doses of normal tissue and side-effects on normal tissue resulting from therapy, specific medical aspects of the surrounding dosimetric conditions resulting in ion beam therapy
- Presentation of the various methods for fixating and positioning patients, differences between ion and photon therapy with regard to patient positioning, options for monitoring positioning during treatment, adaptive ion therapy
- Medical aspects of the ion treatment of moving organs and limiting treatment, advantages and disadvantages of gating and tracking from a medical perspective
- Requirements for the clinical workflow, integration of ion therapy in the workflow at a clinic for radiation oncology
- Clinical dosimetry with ion beams
- Quality assurance for patient positioning, treatment planning and dosimetry

Course objective:

Fundamental and more detailed knowledge of the clinical use of particle therapy for treating various kinds of tumors. In addition, specialized medical knowledge of several tumors that are frequently treated using particle therapy as well as the specific treatment procedure for these disorders.

M 3.7 **On-site**	**Module 3 Attendance Phase** ECTS points: 1

Content:

- Study of publications and specialized articles dealing with a specific topic within the module (self-study)
- Preparation of a written paper at home
- Presentation of all papers at the seminar (attendance required)

Course objective:

More detailed knowledge of a specific topic within the module.

K 3 **On-site**	**Exam Module 3** ECTS points: 1

MODULE 4: IMAGE GUIDED RADIOTHERAPY AND ADAPTIVE RADIOTHERAPY

Module leader: Prof. Dr. Uwe Oelfke

M 4.1 **On-site**	**Introduction Module 4** ECTS points: 0.5
M 4.2 **Online**	**IGRT Techniques (Physics)** ECTS points: 2

Content:

- Introduction: patient and target structure setup
    - Imaging and procedures prior to treatment
    - Systematic and random error, margins
- Volumetric imaging techniques using X-rays for image guided radiotherapy (IGRT)
    - Reference data for imaging using X-rays
    - Fan-beam imaging for IGRT
    - Cone-beam imaging at kV energies
    - Cone-beam CT imaging at MV energies
- Other approaches to IGRT imaging
    - Volumetric MR imaging
    - 2D X-ray imaging, ultrasound, optical imaging
- Post-processing of IGRT information
    - Fast image registration
    - Dose reconstruction using EPIDs (electronic portal imaging devices)
- Summary / from IGRT to ART (adaptive radiotherapy)

Course objective:
Knowledge of the fundamentals of physics and techniques for performing IGRT.

M 4.3 **Online**	**Clinical Applications of IGRT (Medicine)** ECTS points: 1.5

Content:

- Target positioning of prostate patients
    - Clinical indications for IMRT / IGRT
    - Examples: tomotherapy, MV cone-beam CT, kV cone-beam CT
    - IGRT protocols
    - Examples for reducing margins
- IGRT for patients with head/neck disorders
    - Clinical indications for IGRT
    - Examples: tomotheraphy, mobile CT
    - IGRT protocols
    - Problem: tissue deformation and weight loss
    - Problem: dose accumulation

- IGRT for the hips / abdomen
    - Clinical indications for the pancreas / liver

- Organ motion
- Deformations and the problem of re-planning

- IGRT for lung tumors
    - Clinical indications for IGRT
    - Example: from the 4D CT to the treatment plan
    - IGRT protocols
    - Example: gating and tracking
- Summary

Course objective:
Knowledge of the clinical applications, areas of indication and of IGRT protocols.

M 4.4 **Online**	**Moving Targets and Adaptive Radiotherapy (Medicine/Physics)** ECTS points: 2

Content:

- Concepts of adaptive radiotherapy (ART)
    - The basic concept of ART
    - Margins and offline protocols
- Determination and monitoring of intrafractional organ motion
    - Diagnostic 4D CT/4D PET/4D IMRT
    - 4D cone-beam CT of patients in treatment position
    - Fluoroscopy
    - Other devices: Calypso, CyberKnife, VERO
- Surrogate monitoring of respiratory motion
    - Technologies: ANZAI belt, RPM etc.
    - Correlation of the surrogates with tumor motion
    - Predictive algorithms
- Real-time motion compensation techniques (gating, tracking)
    - Linac, multi-leaf collimators, sequencing
    - TrackBeam, CyberKnife, VERO
- Adaptive radiotherapy concepts II
    - Probabilistic treatment planning
    - Dose accumulation and re-planning strategies
    - Dose guided radiotherapy (DGRT)
    - 4D planning approaches
- From IGRT to BGRT
    - The problem of target delineation
    - Use of PET/CT imaging
    - Use of MRI/MR spectroscopy imaging
    - Dose painting
- Summary

Course objective:
Knowledge of the methods in physics and medicine for performing 4D therapy.

<table>
<tr><td>M 4.5
On-site</td><td>Module 4 Attendance Phase
ECTS points: 0.5</td></tr>
<tr><td colspan="2">Content:
- Seminars and practical courses for Module 4
- Presentation of current clinical cases
- Discussion forum</td></tr>
<tr><td colspan="2">Course objective:
Verification and expansion of the skills and competence in IGRT and ART acquired through online learning.</td></tr>
<tr><td>K 4
On-site</td><td>Exam Module 4
ECTS points: 1</td></tr>
</table>

MODULE 5: ADVANCED DOSIMETRY AND QUALITY ASSURANCE

Module leader: Prof. Dr. Günther Hartmann

M 5.1 **Online**	**Introduction Module 5** ECTS points: 0.5
M 5.2 **Online**	**Fundamentals of Dosimetry** ECTS points: 2

Content:

- Dosimetric variables and concepts
  - Variables for describing a radiation field
  - Useful applications of radiation field variables
  - Absorption of energy, energy dose
  - Additional dosimetric variables
  - Bragg-Gray conditions and probes
  - Spencer-Attix mass stopping power
- Measurement uncertainties
  - Terminological issues in accuracy and error
  - Definition of measurement uncertainty
  - Type A and B methods of determining measurement uncertainty
  - Uncertainty budget
- National and international dosimetry protocols
  - Similarities and differences
  - German DIN 6800-2 standard
  - International Code of Practice IAEA TRS 398
  - AAPM TG-51
- Dose calibration under reference conditions
  - Measuring instruments
  - Principle of calibration
  - Performing calibration
  - "Cross calibration"
- Methods of dose calculation
  - Parametric descriptions
  - Models
  - Monte Carlo methods

Course objective:

More detailed knowledge of the relevant fundamentals of physics and of the measurement methods, under reference conditions, for determining the water energy dose with high-energy electron and photon radiation as well as with ion radiation.

Superior competence in applying national and international dosimetry protocols.

Mastery of calculation methods in dosimetry.

M 5.3 **Online**	**Dosimetry for Current Radiotherapy Techniques** ECTS points: 2

Content:

- Ionization chamber dosimetry under non-reference conditions
  - Definition of non-reference conditions
  - Influence of field size, measurement depth, distance from the central beam and of phantom material on photon and secondary electron spectra
  - k_Q determination for non-reference conditions
  - Dosimetry using other detectors such as diodes, diamond, radiographic and radiochromic films, 2D arrays etc.
- Input data for treatment planning
  - General considerations
  - Total scattering factor $S_{c, p}$
  - Radiation head scattering factor S_c
  - Phantom scattering factor S_p
  - Dose profiles
  - PDD and TPR
  - Primary fluence
  - Dosimetry for small radiation fields
  - Definition of a small reference field
  - Validation of dose calculation algorithms
- Dosimetric verification of complex treatment techniques
  - Concept of dosimetric verification
  - Methods for comparing dose distributions
  - Single-beam fluence verification
  - Single-beam dose verification
  - Overall verification plan
  - Independent monitoring of calculated dose monitor units
  - Considerations in uncertainty
  - Definition of plan acceptance criteria
- Specialized QA for the linear accelerator
  - Recommendations in national and international standards and guidelines

Course objective:

More detailed knowledge of measurement methods under non-reference conditions, superior competence in applying measurement methods in dosimetric verification.
Mastery of special methods of quality assurance related to accelerators.

M 5.4 **Online**	**Quality Assurance** ECTS points: 1.5

Content:

- Quality management, e.g. DIN 6870-1
- 93/42/EEC and the German Act on Medical Products (MPG)
- Quality assurance: Acceptance test, commissioning, periodic checks

Course objective:

More detailed knowledge of quality management as related to the medical and physical aspects of radiotherapy in general and to current techniques in particular.

M 5.5 **On-site**	**Module 5 Attendance Phase** ECTS points: 0.5
Content: - Seminars and practical courses for Module 5 - Discussion forum	
Course objective: Verification and expansion of the skills and competence in dosimetry and quality assurance acquired through online learning.	
K 5 **On-site**	**Exam Module 5** ECTS points: 1

MODULE P: INTERNSHIPS

Module leader: Prof. Dr. Wolfgang Schlegel

The internships P1.1, P1.4 and P1.5 are compulsory. At least one of the elective internships P1.2 and P1.3 must be completed. If students complete more than one elective module, the higher individual grade can be applied in calculating the overall grade for the module.

P 1.1 **On-site**	**Internship in Treatment Planning** ECTS points: 2

Content:

- Instruction in common treatment planning programs
- Practical application of the ICRU target volume / risk organ definition to selected patient datasets
- Preparation of IMRT treatment plans involving various techniques (step-and-shoot IMRT, dynamic IMRT, rotational techniques, single-arc, tomotherapy) and particle therapy plans, including comparisons
- Documentation, evaluation and comparison of the treatment plans while taking into consideration the ICRU recommendation

Course objective:
Guided preparation and practical application of high-quality treatment plans.

P 1.2 **On-site**	**Internship in IMRT** ECTS points: 1.5

Content:

- Preparation of IMRT treatment plans and more detailed knowledge of the acquired treatment planning techniques within the various areas of application for special indications
- Analysis of the completed treatment plans while taking into account current issues in physics and medicine
- Examination of the influence of dose calculation accuracy on the applied 3D dose distribution
- Preparation of alternative treatment plans and application of current rotational techniques (tomotherapy, cone-beam therapy)

Course objective:
Guided preparation and practical application of high-quality IMRT plans.

P 1.3 **On-site**	**Internship in ART** ECTS points: 1.5

Content:

- Analysis of target volume motion using selected patient datasets
- Preparation of treatment plans by applying the acquired adaptation concepts
- Comparative treatment planning of the effective applied dose distribution
- Treatment of moving phantoms and evaluation of the resulting dose distribution while applying the various adaptation techniques (gating, tracking, probabilistic treatment planning)

Course objective:
More detailed and wider knowledge of ART, practical application under guidance.

P 1.4 **On-site**	**Internship in Ion Therapy** ECTS points: 2

Content:

- Performing quality assurance measures (dosimetric calibration of monitors, accuracy of the positioning equipment and X-ray imaging, dosimetric verification)
- Simulation of ion beam therapy in a phantom
- Definition of parameters for determining the accuracy of algorithms used in therapy planning
- Simulation of various treatment geometries using the Monte Carlo method
- (Alternative: equivalent practical experience at a partner institution)

Course objective:
Overview of the concepts underlying QA measures; ability to derive feasible definitions of relevant measures to achieve various aims; carry over the concepts to new radiotherapy methods.

P 1.5 **On-site**	**Internship in Dosimetry and QA** ECTS points: 2

Content:

- Dose calibration for high-energy photons and electrons
    - Virtual training using computer simulation software
    - Practical training on an accelerator
- Commissioning a treatment planning system
    - Virtual training using computer simulation software
    - Practical training using the CIRS lung phantom and a therapy planning system

Course objective:
Superior competence in applying dosimetry protocols and in commissioning a treatment planning system.

Module T: Master's Thesis	
M T	**Master's Thesis** ECTS points: 30
Content: Independent guided scientific research on a topic in the area of medical physics.	
Course objective: Extended competence and skill in a selected area of medical physics; independent scientific enquiry under guidance.	

FEES

Fee for regular 4-semester course:

€ 16,426 (from winter semester 2011)

Longer duration will cause higher costs.

New: Continuing professional development (CPD) opportunities are available for individual taught modules at a fee of € 2,700 per module.

MASTER ONLINE
ADVANCED PHYSICAL METHODS IN RADIOTHERAPY

As specified in the Admission Regulations (Zulassungsordnung; §§ 3, 4) for the Master course of advanced training in Advanced Physical Methods in Radiotherapy, applicants must submit the following documents:

- Tabular CV
- Passport photo (2 copies)
- 2 copies of your identity card or your passport (both sides)
- Certified copy of the higher education entrance qualification (in German: Hochschulzugangsberechtigung; e.g. GCE, baccalauréat, Lise Diplomasi, High School Diploma, Apolyterion, Maturität etc.).
- Certified copy of the university graduation certificate (terminal degree of higher or further education institute (Bachelor, Diploma, Master) in a subject related to physics or physical technology or biomedical technology or an equivalent course of engineering studies).
- Certified copy of your doctoral diploma (if applicable)
- Proof of at least two years of qualified professional work experience in medical physics following the first degree.
- Proof of specialized knowledge:
  - as specified in the Continuing Education Regulations (Weiterbildungsordnung) of the German Society of Medical Physics (DGMP) as a requirement for recognition as a specialist in medical physics in the field of medical radiation physics within the specialized area of radiation therapy
    or
  - complying with the requirements for a Qualified Medical Physicist (QMP) set forth in the Continuing Professional Development system of the European Federation of Organizations for Medical Physics (EFOMP) (EFOMP policy statements no. 9 and 10)
    or
  - corresponding to a comparable degree in the field of medical physics
    or
  - corresponding to an equivalent period of advanced training and qualification.
- Proof of English language proficiency at a level comparable to Level C1 of the Common European Framework of Reference (as demonstrated by school reports, the Cambridge Certificate in Advanced English (CAE) or comparable experience). This does not apply to applicants whose first language is English or who are able to provide evidence of having completed their previous studies predominantly in English.

Please send your application form and completed documentation to:

Heidelberg University
Postgraduate Scientific Studies

Bergheimer Str. 58, Buildung 4311
D – 69115 Heidelberg, Germany

MASTER ONLINE
ADVANCED PHYSICAL METHODS IN RADIOTHERAPY

Personal details

❑ Ms. ❑ Mr.

Academic degree(s)/title(s) | Surname | First name

Address (street, postcode, town)

Invoice address (if different)

Date of birth | Place of birth

Nationality

Telephone | E-mail

Telephone (business) | E-mail (business)

Prior knowledge

I have:

- ❑ knowledge as specified in the Continuing Education Regulations (Weiterbildungsordnung) of the German Society of Medical Physics (DGMP) as a requirement for recognition as a specialist in medical physics in the field of medical radiation physics within the specialised area of radiation therapy.
- ❑ knowledge complying with the requirements for a Qualified Medical Physicist (QMP) set forth in the Continuing Professional Development system of the European Federation of Organizations for Medical Physics (EFOMP) (EFOMP policy statements no. 9 and 10).
- ❑ a comparable degree in the field of medical physics.
- ❑ an equivalent period of advanced training and qualification.

Please include proof of your knowledge as specified.

Other requirements

- Regular access to a personal computer (PC or Mac), graphic and audio/video enabled, headset, webcam and high-speed internet access.
- Basic computing skills, OS (Windows or MacOSX or Linux) fundamentals, web competent at end user level

By signing below, I hereby apply with binding effect for a university place. I acknowledge that registration will incur a tuition fee of € 5,000 for each semester in addition to administration fees and student union fee (winter semester 2011/2012: € 40 + € 66.50 = € 106.50). In the examination semester, the tuition fee is € 1,000 in addition to administration fees and student union fee.

As specified in § 5 of the Admissions Regulations, the Vice-Chancellor of the University of Heidelberg will decide on admission based on a proposal by the Admissions Committee (*Zulassungsausschuss*). Applications will be considered on the basis of applicants' eligibility. Participation is limited to a maximum of 20.

Declaration of entitlement to examination

I hereby declare that I have not forfeited the entitlement to examination in the Masters course of study in Advanced Physical Methods in Radiotherapy or in courses of study having the same content for the most part. I furthermore declare not to be involved in current examination proceedings in these courses of study.

________________________ ________________________

Place, Date Signature

Professional experience

I hereby declare that I have at least two years of qualified professional work experience in Medical Physics following the first degree. I worked in the following positions during the periods specified:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Please include non-certified copies of documents giving proof of previous and current professional experience. Evidence of work experience beyond the minimum requirements specified above is not required.

______________________ ______________________

Place, Date Signature

PROGRAM LEADERS

Prof. Dr. Dr. Jürgen Debus

Professor for Radiation Oncology at the Medical Faculty Heidelberg, Heidelberg University
Medical Director of the Department of Radiation Oncology and Radiation Therapy, Heidelberg University Hospital and CEO of HIT GmbH, Heidelberg

Prof. Dr. Wolfgang Schlegel

Professor for Medical Physics at the Medical Faculty Heidelberg, Heidelberg University
Head of the Department of Medical Physics in Radiation Oncology, DKFZ, Heidelberg

Prof. Dr. Oliver Jäkel

Professor for Medical Physics at the Medical Faculty Heidelberg, Heidelberg University
Medical Physics Director of HIT GmbH, Heidelberg
Group Leader “Heavy Ion Therapy”, DKFZ, Heidelberg

top-ranking university | flexible online and on-site program | hands-on training at flagship facilities | renowned experts and teaching staff | promising career prospects

Application deadline:	July 15 (later applications may be accepted depending on numbers of participants)
Program start:	October of every academic year
Program duration:	4 semesters

CONTACT

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