SDAMPP Student Guide to a Medical Physics Career

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I. Introduction

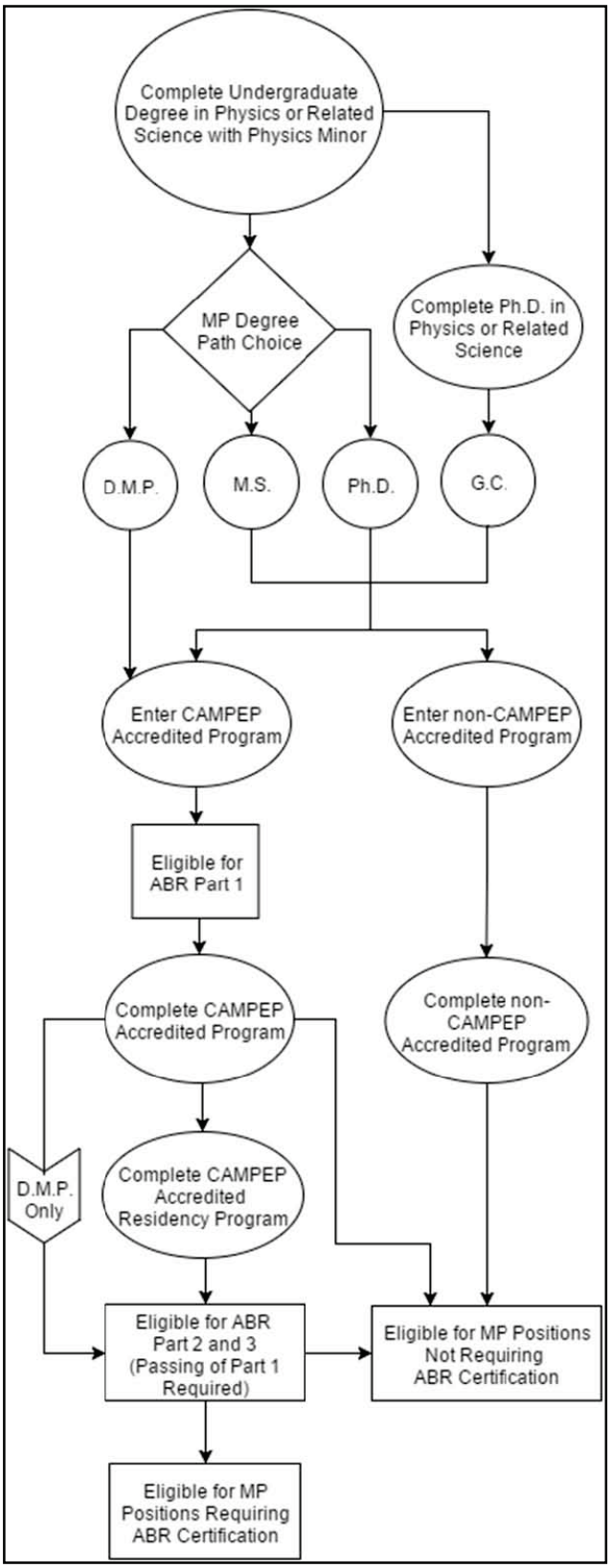
The *SDAMPP Student Guide* is provided to assist students navigating the growing complexity of medical physics educational options. The American Association of Physicists in Medicine (AAPM) provides a general explanation of the roles of a Medical Physicist divided into three areas of activity: clinical service and consultation, research and development, and teaching. In a broader sense, the Medical Physics field is roughly divided into four main career subfields: therapeutic medical physics, diagnostic medical physics, nuclear medicine physics, and medical health physics (see https://www.aapm.org/medical_physicist/fields.asp for information about the definition of a "Qualified Medical Physicist" in each of these subfields).

Medical Physicists specializing in **radiation therapy** will spend the majority of their time in a clinical setting interacting with oncologists, dosimetrists, and therapists on radiation treatments for patients with cancer or other diseases requiring radiotherapy. These treatments are generally performed using either external beam radiation, generated by linear accelerators (linacs), or brachytherapy, in which radioactive sources are placed inside the body. It is the job of the Medical Physicist to not only help create the treatment plans for patients, but also to administer the radiation safety program. Additionally, a Medical Physicist will oversee the technical aspects of the radiation oncology department including commissioning, calibration, and quality assurance (QA) for all radiation sources and delivery equipment in the department. The MP will work most closely with radiation oncologists who are physicians especially trained to treat disease with the application of radiation.

Medical Physicists work in **diagnostic imaging** to ensure safe, accurate, and reliable medical imaging used for diagnosis and treatment. They develop and maintain QA programs to ensure high quality imaging for radiography (x-ray) units, CT (computed tomography), and MRI (magnetic resonance imaging), all while minimizing patient dose and meeting regulatory standards. Additionally, they facilitate effective communication of scientific, technical, and safety-related information to the diverse members of the clinical staff. The MP works most closely in diagnostic radiology with radiologists who are highly trained physicians providing clinical interpretation of images.

Those Medical Physicists working in **nuclear medicine** focus on developing and maintaining PET (positron emission tomography) scanners, gamma cameras, and various radiopharmaceuticals (biological molecules with a radioactive marker) to obtain functional images of patients used to diagnose and treat a variety of diseases and medical conditions. Similar to radiation therapy and imaging, medical physicists working in nuclear medicine will be involved in technical aspects of quality assurance, patient safety, and advanced image analysis while working hand-in-hand with clinical staff. In nuclear medicine the MP works closely with physicians highly trained to interpret physiological function from the time course of nuclear radioactive pharmaceuticals injected into patients.

II. Educational paths to a successful MP career



Over the past century professional preparation for careers in medical physics has grown more demanding and specialized. The primary source of increased demands is growing complexity and increased range of physical phenomena encompassed by medical devices – most greatly impacted by refinements in computer augmented methods. The increasingly important role of medical physics devices in both patient well-being and possible death has led governments to regulate and carefully control training and qualification of medical physicists just as they do for physicians. The options in medical physics education and training have become more rigorous as shown in **Figure 1**.

Figure 1 *Educational path options for a successful medical physics career.*

The specific course and work experience requirements for medical physicists is determined by the **Commission on Accreditation of Medical Physics Education Programs (CAMPEP).** CAMPEP is a non-governmental commission sponsored by multiple scientific, educational and professional societies active in pertinent fields (*American Association of Physicists in Medicine, American College of Radiology , American Society for Radiation Oncology, Canadian Organization of Medical Physicists, Radiological Society of North America, Inc.*). CAMPEP sets educational standards and certifies that Medical Physics graduate and residency training programs have achieved and maintain those standards.

A typical pathway for becoming a clinical Medical Physicist involves bachelor degree graduation from an undergraduate physics program followed by graduate study within a CAMPEP-accredited Medical Physics program and subsequent completion of a CAMPEP-accredited residency program. However, there are many medical physics career opportunities in

academia, industry, and government that do not necessarily have a clinical component. There are several graduate degrees available in Medical Physics, including the MS, PhD, Professional Doctor of Medical Physics degree (often called a "DMP") or PhD in non-medical physics followed by a Graduate Certificate from a CAMPEP accredited program. The degree a student chooses will depend on the student's specific academic interests and career goals.

Students interested in a career in academia will pursue a PhD, as it is generally considered a prerequisite to establish an academic career in education or research. Students interested in a clinical career could earn any of these degrees. Most clinical medical physicists will seek board certification, such as by the American Board of Radiology (ABR), the Canadian College of Physicists in Medicine (CCPM), the American Board of Medical Physics (ABMP), the American Board of Science in Nuclear Medicine (ABSNM), or the American Board of Health Physics (ABHP). An MS degree from a CAMPEP accredited institution is the minimum necessary to enter the board certification process. The DMP is a professional doctorate degree (like the MD) which includes didactic education and clinical training. The Graduate Certificate is only for those who already hold a PhD in physics or a related scientific discipline, and provides the core elements of medical physics graduate education.

If a student chooses to pursue board certification, a 2 year CAMPEP accredited Medical Physics residency program will be required after the completion of the graduate degree (the DMP is an exception as the 2-year residency is built into the DMP program). After completion of the residency, the student will be eligible to take the board certification examination from the American Board of Radiology (ABR). Additional descriptions of the respective degrees are provided below. Those pursuing careers in academia, industry, or government may choose not to pursue board certification. There may be others who wish to pursue certification but not be able to obtain entry into the limited number of residency positions, yet can still pursue a clinical medical physics position. While board certification is desirable as a verification of the candidate's clinical competence, it is not required for clinical practice. However, for states that require licensure for clinical activities, it is accepted as a replacement for the state's own licensure examination. Board certification also makes it easier to become licensed to work with nuclear byproduct material, and in some cases is a requirement of the employing institution as part of clinical credentialing and/or promotion.

III. Undergraduate admission requirements for graduate study in Medical Physics

CAMPEP has established preparation standards for medical physics graduate students to assure sufficient preparation to encompass the range of topics in graduate medical physics curricula. Although specific requirements for each institution can vary, there are some basic undergraduate requirements that all graduate institutions expect from applicants. Typically, completion of 2-4 semesters of calculus and differential equations is required as well as at least 2 years of undergraduate physics courses, including at least 3 upper level physics courses. Typical candidates for graduate study will hold an undergraduate major in physics or a physical science, mathematics, or an engineering discipline. For many schools, a major in physics is not required for admission. However, physics minor or equivalent is typically required to fulfill the required number of undergraduate physics courses.

Specific undergraduate requirements for each graduate institution can be found on their individual websites. CAMPEP has a listing of all current institutions that have Medical Physics graduate programs and links to each specific programs website. The list can be found on the CAMPEP webpage.

IV. Choosing a Medical Physics graduate program to achieve career goals

In addition to factors similar to selecting an undergraduate program such as institution location, size, and cost, there are many important factors which should be considered when choosing a graduate program. Below is a brief list that may be helpful in making your decision:

a. **CAMPEP Accreditation**: One important factor in choosing an institution for graduate study in Medical Physics is whether or not the program is accredited by CAMPEP. As stated previously, CAMPEP is the governing body for graduate education and training in Medical Physics. Accreditation indicates that the program has been reviewed and found to meet the standards of CAMPEP. In order to meet these standards, a program must have high quality courses, instructors, facilities, research opportunities, and many other program aspects evaluated by CAMPEP. In addition, eligibility for ABR certification is contingent upon graduation from a CAMPEP-accredited residency program. Many residency programs only accept graduates from CAMPEP accredited graduate programs, and all entrants into CAMPEP accredited residency programs must have completed a minimum amount of graduate coursework from a CAMPEP accredited institution.

b. **Clinical Specialty:** As mentioned earlier, there are three primary clinical specialties within Medical Physics: radiation therapy, diagnostic imaging, and nuclear medicine. When evaluating Medical Physics programs, it may be helpful to investigate the didactic, clinical, and research options available to students within each specialty. Additionally, researching the faculty publications, professional standing and areas of expertise will allow you to determine whether your interests are appropriately represented at the institution. If you already have a particular specialty in mind, you should evaluate how many graduates this institution places in that specialty. Programs that offer tracks supporting all specialties are best for those who are undecided about the specialty they might wish to pursue as a career.

c. **Residency Placement Rate**: There currently are not enough medical physics residency positions to meet clinical demand. While the number of these positions continues to increase, so does the number of graduates from medical physics graduate programs, and the number of graduates currently far exceeds the number of residency positions. Thus, the competition for residency positions is fierce and becomes more competitive every year. For those interested in a clinical career, residency placement rates have never been a more important factor in choosing a graduate program. Each university is required to publish their residency placement rates every year on their website, making the information easily accessible to anyone. Statistics presented should mention the enrollment/graduation numbers for each degree granted by the institution as well as the number of students accepted into residency programs. CAMPEP has accumulated each institution's web link containing those statistics for 2014 into one file which can be accessed at this webpage

d. **Student to Faculty Ratio and Class Size:** The number of students admitted each year vs. the number of faculty available to you as a student can be an important factor in deciding which program to attend. Some students may work better in student groups and would enjoy having a larger class size, while others may find more one-on-one time with the instructor to be more valuable.

e. **Student Research:** Researching the faculty and their individual areas of expertise will allow you to determine whether your interests are appropriately aligned with opportunities at an institution. For students interested in academic careers, involvement in grant writing, manuscript preparation, and opportunities for multidisciplinary collaborations should be carefully considered. Students should also explore federally funded or institutionally funded training grants and fellowships that allow for full immersion into project-defining and grant writing processes.

f. **Multidisciplinary Education:** Students considering a non-clinical career path should evaluate each institution on their educational requirements and opportunities for coursework outside of clinical medical physics specialties. While all CAMPEP-accredited programs will provide students with a solid foundation in clinical medical physics education, experience and auxiliary coursework in related fields can be advantageous for non-clinical career path development and for bolstering a research profile. For students interested in industry careers, faculty and departments that have close and long-standing collaborations with companies are advantageous. Participating in a collaborative project with industry gives insight into the way such projects are conducted and can be of great value in the future career of the student.

g. **Ask around:** If you feel drawn to one institution and want to know more about it on a personal level, simply contact the program director and ask if there are any students that you could contact to get a little more information. They will be able to give you a better understanding of the day to day life as a student at that institution than you would find anywhere else.

V. Important study decisions to make while in graduate school

The two biggest decisions you will make while in graduate school (and one that you might make before you even attend) is which degree pathway you plan to take and whether or not you would like to become board certified by the ABR. A description of each degree is listed below along with a simple flowchart in **Figure 1** outlining the timeline involved for each.

There are currently four degree pathways available from CAMPEP-accredited programs for those interested in the field of Medical Physics and each varies slightly in the amount of didactic coursework, clinical experience, overall time to completion, and cost. The decision regarding which degree a student should apply to and complete depends on the relative experience, background, and overall goals of the student. Some information regarding each degree is listed below that may help in the decision process.

a. **Master of Science Degree (MS): ~2 years of didactic coursework culminating in a Master's project/thesis.** A physicist with an MS degree is typically employed to perform clinical work, or in industry or government. While a physicist with an MS degree will not have the same opportunities for faculty appointment at academic institutions, he/she is on the same level professionally as a physicist with any of the other degrees listed here. A non-academic hospital will rarely have a preference for the specific degree that the physicist holds, and the level of experience and certification status of the physicist will mean more in a clinical setting than the particular degree that the physicist holds.
b. **Doctor of Philosophy (PhD): ~2-3 years of didactic coursework and >2 years of research culminating in a Ph.D. dissertation.** A physicist with a PhD degree can serve in any of the same

clinical, industrial, or governmental roles as those with an MS but may also choose an academic career, performing research and/or teaching and mentoring trainees such as students, postdocs, or residents. While many physicists with an MS degree also perform research, teach and mentor students, and even hold an academic appointment, those without a PhD are often limited in terms of faculty appointment and application for research funding. The completion of a PhD serves to demonstrate the graduate's ability to perform independent research and create a research niche, in addition to being the terminal degree in the profession. These are commonly considered prerequisites for many academic and research roles.

c. **Professional Doctorate in Medical Physics (DMP): ~2 years of didactic course work combined with 2 years of tuition based, non-salaried clinical residency.** The DMP is a relatively new degree which incorporates both didactic and residency-level clinical training into the degree program. The didactic component is typically similar to that required for a PhD, however, the DMP student completes a 2 year clinical residency instead of a thesis research project. Since research is an important component of medical physics practice, DMP programs also require a significant research component (typically significantly larger than that required for the MS degree.) Graduates from CAMPEP accredited DMP programs are automatically eligible for ABR certification as the 2 year clinical residency program completed in years 3 and 4 of the DMP is equivalent to a CAMPEP accredited residency program. However, unlike typical residents who are paid a salary to complete their residency, a DMP student will pay tuition for this training. Some may consider the guarantee of ABR eligibility as sufficient to offset the additional cost of the program. Graduates from a DMP program can perform clinical, industrial, or governmental work similar to those with an MS. However, the DMP will likely appeal most to those pursing a clinical career since residency training and certification are most important for this career path. DMPs would be unlikely to be hired for the academic positions traditionally reserved for PhDs, particularly those requiring a significant research component, as the research training in the DMP is not equivalent to that in a Ph.D. program.
d. **Graduate Certificate (GC): ~1 year of didactic course work.** The Graduate Certificate program is designed for those students who already hold a PhD in physics, or other related field and who want to pursue a career in medical physics. The GC program is designed to provide the core essentials of medical physics didactic training, as described by AAPM Report #197S. This curriculum represents the required coursework to be eligible to enter a medical physics clinical residency program. A student would likely only complete a GC in order to be eligible to enter a CAMPEP accredited residency program, thus it is assumed that such a student is interested in a clinical career. However, since a GC student already has a PhD, an academic career is also a possibility.

For each of the 4 program options available, the ABR Part 1 exam can be taken during the first year of the degree (typically offered in July/August). In order to be eligible for ABR Part 2, a student completing an MS, PhD, or certificate program must also complete a CAMPEP accredited residency program which provides a minimum of 2 years of full time clinical training. The residency program must be completed by August 31 of the year in which the Part 2 exam is to be taken (it is assumed here that the candidate has already passed Part 1). A student in a DMP program is eligible for ABR Part 2 after completion of the degree (assuming the student passed Part 1 during the program).

VI. Importance of clinical training in a Medical Physics Residency

As the complexity of medical physics practice in clinical medicine grew, it became obvious that systematic on-site clinical training similar to physician residency training is necessary to reduce the risk

of patient lethal errors. A Medical Physics Residency is a 2 year clinical training program that trains a recent graduate to be proficient in critical clinical aspects of the Medical Physics profession. Some programs have a longer duration due to the incorporation of a research component. AAPM Report #249 describes the fundamental elements of such a training program. CAMPEP provides a set of standards that must be met in order for the program to be accredited. The purpose of these guidelines is to ensure that each resident receives a comprehensive training experience.

To be eligible for acceptance into a CAMPEP accredited residency, a student must have completed an MS, PhD, or GC degree from a CAMPEP accredited institution (or have completed all but 2 of the courses required for a GC since CAMPEP allows a resident to complete one graduate course per year while in a residency training program). Instituted for the first time for the 2014-2015 application cycle, the Medical Physics Matching Program (the "MedPhys Match") was created to ensure a fair application process for all candidates applying for a residency. The process opens in October and allows submission of applications to all Medical Physics residencies participating in the match program on one website within a common application process. The application is part of the AAPM website and is called the Medical Physics Residency Application Program (MP-RAP). After submission, selected applicants are invited to interviews throughout the following months. After all interviews have been completed, applicants rank their choice of institutions and institutions rank their choice of applicants. The match program then applies an algorithm to determine the best match for all applicants and programs.

VII. Medical Physics residencies and alternative medical physics career paths

For the 2014-2015 match application cycle, 112 residency positions were available, compared to 402 initial applicants. Based on these numbers alone, the chance of an individual obtaining a residency is approximately 25%. However, the chances of any specific student obtaining a residency are dependent on a number of factors including, but not limited to: quality/reputation of the graduate program, academic performance, clinical medical physics background, letters of recommendation, previous research, and interpersonal skills.

The company that facilitates the matching process (National Matching Services, Inc) has publically available statistics for the 2014-2015 match cycle and will continue to provide statistics for subsequent years. That information can be found here.

A large majority of the residencies available through the match program can be applied to with any of the medical physics degrees available. As of 2015, however, there were 25 institutions (out of 90) that require a PhD to apply. As you begin the application process, be sure to take note of any institution with these restrictions.

If you are not accepted into a residency during your first application, you will need to decide whether you would like to gain more clinical experience and apply again the following year, try to go directly into a clinical position, or investigate non-clinical career paths. If you feel that a clinical position is still your preferred career path and you intend to apply for a residency during the next cycle, the time spent between application cycles would be best spent obtaining experience which would make you a more attractive candidate. Talk to residency program directors to find out what they are looking for in a resident candidate, and compare this to any perceived deficiencies in your application. You could also

choose to apply for junior medical physics positions which do not require ABR eligibility. You can still apply for residency positions in the future, or may choose to continue to practice without ABR certification.

VIII. Significance of Board Certification for Clinical Medical Physicists

Board certification serves as recognition of proven competence in physics as applied to medicine. In North America, the two most widely recognized certification bodies are the American Board of Radiology (ABR) in the United States and the Canadian College of Physicists in Medicine (CCPM) in Canada. While there is reciprocity between the board certifications, generally speaking, residents tend to complete their board examinations on the same side of the border they have done their residency training and/or intend to work.

The American Board of Radiology is one of many specialty Boards certified by the American Board of Medical Specialties (ABMS) to certify physicians are qualified to practice many different medical specialties. The ABR certifies physicians in radiology and radiation oncology, and physicists in medical physics. Medical physicists are one of only two non-physician groups certified through the ABMS. Certification by the ABR is thus an important accomplishment indicating competence to care for patients in life-critical situations. It is important to note that while ABR certification is not required to practice medical physics, it is highly desirable in clinical settings. Applicants for a medical physics position that have ABR Certification or are eligible to eventually become ABR certified ("ABR eligible") are more sought-after than non-certified applicants. In fact, many positions (typically in the clinical setting) will state that only board-certified or board-eligible applicants need apply.

Certification by the American Board of Radiology (ABR) requires the candidate to pass three exams (2 written, 1 oral). Part 1 is typically taken after the first year of didactic course work in a CAMPEP-accredited graduate program, whereas Parts 2 and 3 are taken after completion of a CAMPEP-accredited residency. If a student has attended a non-CAMPEP-accredited graduate program or non-CAMPEP-accredited residency, that student is ineligible to take the ABR exams and cannot become board certified by the ABR.

The Canadian College of Physicists in Medicine is the certification body for medical physicists to practice in Canada. While CCPM certification is not required to practice medical physics in Canada, it is highly desirable and serves as a standard by which most applicants are judged in terms of employment eligibility. However, it is not uncommon for employers to hire uncertified applicants under the condition that they complete CCPM certification within the first two years of employment. Similar to the ABR certification process, the CCPM requires a candidate to pass three exams (2 written and 1 oral). Part 1 is a written examination on general medical physics and can be taken only after the candidate has completed two years of "patient related" experience within the last 5 years after completion of a graduate degree. Part 2 of the written examination is specific to radiation safety. Upon successful completion of the written examination, candidates must pass an oral examination that is scheduled later in the same calendar year. As of January 1, 2016, applicants for certification must have completed **either** a CAMPEP accredited graduate degree **or** a CAMPEP accredited residency program to be eligible for the CCPM examination.

IX. Job opportunities for residency graduates

The positions available in the medical physics profession are competitive and will require similar perseverance as that required to obtain a residency position. Estimates place the number of new medical physicists needed in the field every year to be between 150 and 200. Although these numbers are greater than the number of residency graduates in a given year, most of those residency graduates will complete their respective programs at roughly the same time (typically the end of June). Additionally, there are other medical physicists looking for positions at the same time who are not recent graduates of a residency thus increasing the size of the applicant pool. The large number of applicants for any one position makes the process difficult and competitive. Thus, the ability to obtain ABR certification becomes even more important and worthwhile.

Other career options for residency graduates include purely academic positions and careers in industry. In principle, a well-educated medical physicist can be successful in a faculty role in bioengineering or applied physics departments wishing to expand into biology and medicine. In industry, the possible spectrum of positions is even broader, from classical hardware R&D, to software development, clinical applications support, product sales, and on-site user training. Additionally, PhD graduates with strong quantitative and statistics skills may consider pursuing a position in the rapidly growing field of data science.

X. Rewards and value of medical physics education and training

The value of a position in the medical physics field is very dependent on the attitude and desires of the individual. Many physicists enter the field because they enjoy the possibility of helping patients, while others enjoy the technical challenges that come with developing new treatment techniques. Most medical physicists find their career a rewarding one (statistically, relatively few leave for another profession). We encourage you to evaluate medical physics journals, newsletters and other documents as well as talking with practicing medical physicists. Once you have done this and determined that medical physics is your career of choice, you'll need to answer these questions: "How much time and money am I willing to invest and how much risk am I prepared to bear to pursue the career I desire?" For many of us now in the profession, the answer was "whatever it takes."

Every year, the AAPM compiles salary information from medical physicists in order to obtain information on trends within the field and provide competitive salary data to those currently in the field. Those surveys can be found on the AAPM website. Each annual survey contains a plethora of information broken down by experience, employment sector, sex, and specialty. As a general overview, the following median incomes were given for the 2014 survey:

- MS degree with no ABR Certification: $120,000/year
- MS degree with ABR Certification: $175,000/year
- PhD degree with no ABR Certification:$132,000/year
- PhD degree with ABR Certification: $185,000/year

XI. Recommended sources of information from professional groups associated with Medical Physics

Below are descriptions and links to a number of professional groups within the medical physics field:

AAPM – American Association of Physicists in Medicine (aapm.org)
Primary professional organization for medical physicists practicing in the United States. Defines the scope of Medical Physics practice and recommends a standard educational path.

ABR – American Board of Radiology (theabr.org)
Certification board for the specialties of radiation oncology, diagnostic radiology, and medical physics.

ASTRO – American Society for Radiation Oncology (astro.org)
Primary professional organization for Radiation Oncology, providing medical education, health policy analysis, patient information resources, and advocacy for the profession.

CAMPEP – Commission on Accreditation of Medical Physics Education Programs (campep.org)
Accrediting body for educational and clinical training programs.

COMP – Canadian Organization of Medical Physics (comp-ocpm.org)
Primary professional organization for medical physicists practicing in the Canada.

CCPM – Canadian College of Physicists in Medicine (ccpm.ca)
Certification board for all medical physics sub-specialties (diagnostic imaging, mammography, nuclear medicine, MRI, radiation oncology) in Canada

IAEA – International Atomic Energy Agency (iaea.org)
Serves as the world's central intergovernmental forum for scientific and technical co-operation in the nuclear field.

IOMP – International Organization for Medical Physics (iomp.org)
Serves as the worldwide forum for scientific, educational and technical information supporting the operation of medical physics careers in more than 65 countries.

RSNA – Radiological Society of North America (rsna.org)
Primary professional organization for Radiology, providing medical education, professional leadership, software solutions, and research support for the profession.

SDAMPP – Society of Directors of Academic Medical Physics Programs (sdampp.org)
Provides a collaborative forum for improving medical physics education and training, interprogrammatic collaboration, and the development and distribution of best practices.