# EDUCATION AND TRAINING OF MEDICAL PHYSICISTS IN ESTONIA

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## 1. Introduction

In the early nineties after re-independence, Estonia got a challenge to develop the health care system - including the health care technology and its management - correspondingly to the best practice and accepted standards of the Western European countries. There are long traditions of medical education and health care in Estonia, but the education in medical physics and biomedical engineering was practically absent until that time. Only some groups at universities and research institutes have been involved into research activities in this field. The hospitals lacked of quality management system, including medical physicists' support.

The First European Conference on Post-graduate Education in Medical Radiation Physics, held in Budapest on 12-14 November 1994, was a milestone for the development of the profession of medical physicist in Central and Eastern Europe and also triggered various international activities in this particular field. Materials from 30 European countries and institutions were collected after the Conference and published in the book "Medical Radiation Physics - A European Perspective" [1], which included also information about the first initiatives at the University of Tartu and Tallinn Technical University in this field. In small countries, such as Estonia, it is probably unreasonable to differ education and professionals between the Medical Physics and Biomedical Engineering specialities, because possibilities of employment within so narrow field of qualification are quite limited. Therefore the educational activities began in the framework of joint specialisation in the both fields.

In 1997 the Medical Exposure Directive 97/43/Euratom (MED) [2] established the requirements to involvement of Medical Physics Expert in different procedures in Medicine. The Regulation of Social Ministry on the Use of Medical Exposure [3] included the requirements (adapted partly from MED) for radiological equipment, personnel and practice. The requirements for involvement of the medical physics and biomedical engineering (MP-BME) specialists in radiotherapy and nuclear medicine procedures came into force immediately, but the deadline in case of MP-BME specialists involved in diagnostic radiology procedures was set on 1 January 2002. In practice it seems that a prolonged "transition period" to follow the personnel requirements is still needed.

## 2. Healthcare system and medical technology

To give a short review the next numbers might help to illustrate the situation of health care system in Estonia in late 90ies. Being the smallest of three Baltic States Estonian population reached 1, 36 mln inhabitants ( 398 000 in Tallinn, 101 000 in Tartu), who were served by 79 independent hospitals, with 10 300 hospital beds (in 2000). These healthcare institutions had to be provided with different medical (incl radiological) equipment. The total annual expenditure of the new purchases reaches as average of 160 mln EEK. 50 % of the equipment is relatively up to date (purchased after 1995), covering 70 – 80 % of the need of the healthcare services.
**Estonian Healthcare Project** implementing process started in 1995 and was initially supported by the World Bank.
Under this project the Training Centre of medical Physic and Biomedical Engineering of the University of Tartu carried out over-Estonian Survey of Medical Equipment from 1997 to 1999.

The medical equipment infrastructure was audited in most of the hospitals in-site. It included also quality control tests of radiological equipment and the quality audit of the process. It also turned out that there are totally 36 full-time MP-BMEs employed in hospitals. In addition more than 50 vendor offices provide medical equipment support and maintenance services outside the hospitals.
Estonian Hospital Masterplan 2015 was drawn within the framework of Health Care Project 2015 by April 2002. Implementing Estonian Hospital Masterplan will consolidate special medical or health care treatment, thus increasing the general quality of health care services and developing their economical efficiency. According to the Masterplan the optimum number of in-patient hospitals for Estonia would be 13 in total in four separate healthcare regions (NE, NW, SE and SE Estonia), one central or one regional hospital for each region (with the exception of Tallinn where this number has to be bigger).
A complete quality control system should be established and developed at hospital level, taking into account the requirements for medical equipment that are fixed in EU directives.
The total number hospital beds will not decrease, yet their usage profile will change.
Implementation of Hospital Masterplan will produce an immense need for training of medical and MP-BME staff both via retraining and in-service training.

In Tallinn 23 different healthcare institutions were joined into 4 big hospitals: North-Estonian Regional Hospital, East Tallinn Hospital, West Tallinn Hospital and Children's Hospital
In 2001 the Estonian Hospitals Association carried out an inquiry about technical infrastructure and personnel in the hospitals. It was found that there are 0.58 full-time MP-BME positions per 100 hospital beds (if extrapolated to all hospitals it means 61 placements). The medical equipment maintenance structure is so that 32 % is done in-house, 38 % by vendors and 30 % by independent service organisations. 7 % of the specialists had qualification at the level equivalent to MSc, 7 % at BSc level, 28 % at vocational higher education level and 57 % at higher education level.

As a result of bilateral agreement between Estonian Ministry of Social Affairs and Estonian Society for Biomedical Engineering and Medical Physics a Strategic Plan for Development of Medical Technology until the year 2015 was developed [4]. This plan is a part of the Estonian Healthcare Project 2015. The main idea of this document is to enhance a quality of medical service using up-to-dated medical technology and quality assurance. Important part of this paper is a number and educational level of technical staff in related areas not only in hospitals but also in different institutional bodies connected with the health care system. Calculation of requirement of technical staff is based on recommendations of different international institutions, cost-effectiveness of medical technology, number of hospital beds, development plans of different physician specialities and opinions of leading physicians.
In the Medical Technology Development Plan 2001 the required amount of MP-BMEs (including technicians) was estimated as of 150-200 full-time positions for whole Estonia.

### 1) X-ray diagnostics and nuclear medicine

Amount of conventional X-ray units is about 140 (+ dental, CT and mammography). There are 68 new diagnostic X-ray units (purchased since 1995). The number of practising radiologists is currently about 160, and that of radiographers is 280. In smaller places about 10 X-ray examinations per day are made, in the X-ray rooms of big district hospitals (esp. emergency departments) there are 60-70 examinations at one unit per day.

New digital radiography (phosphor plate) technologies are implemented in North-Estonian Regional Hospital and Tartu University Clinics . There is also one practically working telemedicine link between Tartu University Clinics and Kohtla-Järve Hospital (for CT images).

At Tartu University Clinics (with about 700 hospital beds) radiological services are provided by the Department of Radiology. The Clinics have employed 2 MP-BMEs for diagnostic radiology support and a half-time MP-BME specialist for nuclear medicine support. The main tasks of the MP-BME are to provide IT management (incl. PACS) and radiological equipment (incl. MRI) maintenance support, consultation and quality assurance of the radiological equipment. The specialists have been graduated from the Physics Department of the University of Tartu and two of them are retrained RSTI (USA) for diagnostic radiological equipment maintenance.
The need for MP experts is estimated by the department as 1 specialist for nuclear medicine and 1 for diagnostic radiology with the working tasks in radiation protection and quality control.

North-Estonian Regional Hospital (with over 1300 hospital beds) has at least 2 MP-BMEs responsible for radiation protection and quality control.

### 2) Radiation therapy

There are two radiotherapy departments in Estonia:

- North-Estonia Regional Hospital, Cancer Centre, Tallinn
  (1100 patients treated annually)
- Tartu University Clinics, Clinic of Haematology-Oncology
  (600 patients treated annually)

Equipment available:

| Cancer Centre | Tartu University Clinics |
|---|---|
| One circular accelerator Microtron | One linear accelerator Siemens Mevatron |
| Two Co-60 units | One Co-60 unit |
| | One orthovoltage X-ray unit |
| One HDR brachytherapy Co-60 unit | One HDR brachytherapy Co-60 unit |
| CT-Sim “MHTI” simulator | Conventional simulator Siemens Simview |
| 2.5 D treatment planning system Theraplan | 3D treatment planning system Helax TMS |

- Both centres have a 3D beam analysers and the set of appropriate equipment for absolute dosimetry as well as the range of quality control tools.
- Both centres are routinely performing in vivo dosimetry with semiconductor diodes for high-energy photon beams and participating in the IAEA TLD dose intercomparison program.

Duties and Responsibilities of Radiotherapy physicist are established as follows:

- Radiation safety of patient and personal
- Training of the personal in the field of radiation protection
- Dosimetry
- Acceptance testing and commissioning of radiotherapy equipment
- Treatment planning (external beam and brachytherapy)
- Leading role in the development, implementation and maintenance of radiation protection and quality assurance programmes in the department
- Quality control of radiotherapy equipment

In therapy there are 3 positions of medical physicists in the Cancer Centre and 2 positions at Tartu University Clinics. By the recommendations of IAEA the corresponding staffing should be 6 and 3 medical physicists.

## 3. Educational schemes

The education on MP-BME was missing during the soviet period in Estonia when the entire education was led by the Soviet Union centralised specialisation's planning. The nearest institute for the equivalent specialisation was in Leningrad (present day St. Petersburg). The first institutional units to support biomedical engineering and medical physics education and study programs were organised during the last decade in two main public universities – the University of Tartu and Tallinn Technical University.

**The Biomedical Engineering Centre** (BMEC) has been established in Tallinn Technical University (TTU) in 1994. The Centre for Biomedical Engineering is a structural unit within Tallinn Technical University, incorporating departments and other research and medical institutions or units within these institutions, engaged in biomedical engineering and medical physics research and teaching. The BMEC has promoted research and development and teaching in biomedical engineering and medical physics. The BMEC comprises Chair of Radiophysics, Chair of Biomedical Engineering and associated structural units.

**The Training Centre of Medical Physics and Biomedical Engineering** (TÜ BMTK) of the University of Tartu (UT) has been established in 1996 to promote academic and continuing education in medical physics and biomedical engineering. The main objective of the centre is to provide support in hands-on training of clinical technologists (engineers, technicians) and medical personnel (medical doctors, nurses, radiographers using the medical equipment) in service, quality assurance or usage of modern medical equipment.
TÜ BMTK has participated in training of medical physics and biomedical engineering BSc and MSc students by giving lectures or practical lessons in medical physics, quality assurance methods and conformity assessment of medical devices. The centre carries out also quality control measurement in most of the X-ray departments of Estonia and maintains the corresponding database.
**Tartu University Clinics** has supported the Faculty in providing X-ray equipment for practical lessons.

**The study programs on MP-BME on Bachelor and Master degree level** started during last decade. The medical physics and biomedical engineering education was started both at UT and TTU in the academic year 1992-1993.

At **UT** the medical physics and biomedical engineering education was possible to select as a specialisation inside the applied physics sub-speciality at the Faculty of Physics and Chemistry. The students get basic education as physicists and after the fifth semester they may select special courses for the MP-BME specialisation. After receiving Bachelor's degree the students may continue in Master's degree and Doctor's degree program.
Up to now (since 1995) 26 BSc and 8 MSc students have been graduated in the speciality of medical physics and biomedical engineering from the University of Tartu.

At **TTU** the special subjects were available for students with different background: electrical, mechanic, computing, system engineering. A new study direction "Electronics and Biomedical Engineering" including bachelor, master and doctoral degree curriculum started in faculty of Systems Engineering in 1997.
Up to now (in the course of last 3 years) 23 BSc students have been graduated in speciality "Electronics and Biomedical Engineering".

For Master degree studies in both universities the nominal study periods were 4+2 years (by the old scheme) until the academic year 2002-2003.

The medical physics education in the Baltic countries was reviewed in the framework of **Joint European Project Tempus** S-Jep-12402-97 “Baltic Biomedical Engineering and Physics Master Courses” 1998-2000, with partners from the universities from Estonia, Latvia and Lithuania and from two EU countries (Linköping University, Prof. Åke Öberg and King's College London, Prof. Colin Roberts and Dr. Slavik Tabakov). Objectives of the project were development and introduction of the new Joint Baltic Biomedical Engineering and Physics Master courses on a base of reviewing, restructuring, adaptation and modularising of existing eligible courses delivered by Universities of Estonia, Latvia and Lithuania. Alongside this, Credit Transfer and Quality Assurance System harmonised with the European standards were developed and introduced in the BMEP education field of the Baltic States. The main outcome was the Joint Baltic Biomedical Engineering and Physics Master courses Curriculum recognised among the Partner Baltic Universities [5].

**The new scheme of higher education** (so-called “3+2” scheme) met the requirements and recommendations that follow from Bologna declaration was prepared and started at UT and TTU since the academic year 2002-03. It concerned also MP-BME curricula in both universities.

Bachelor degree (3 year study, 120 CP) includes mostly general, basic and core study and the MP-BME specialisation is not planned on this level at UT and TTU;
Master degree (2 year study, 80 CP) includes special subjects. BME specialisation in this level is planned at UT and TTU;
PhD degree programme (4 years study, 160 CP) is aimed to prepare researchers, University staff and high-level specialists. MP-BME specialisation in this level is planned at UT and TTU.

At **UT** the curriculum for Medical Physics and Biomedical Engineering studies was reviewed, modified and restructured, taking into account the new requirements. The speciality is renamed to Medical Technology (Appendix 1).

At **TTU** the new curricula for the speciality of Biomedical Engineering and Medical Physics at Master degree and Doctoral degree levels (see Appendix 2) were developed in 2001.
Parallel to the academic university study (5A) the high-school level education (5B) on BME is planned to prepare specialists for hospitals on the level of technicians.

## 4. National professional society and accreditation of engineers

The Estonian Society for Biomedical Engineering and Medical Physics was founded in 1994 as an independent non-profit organisation. The Estonian Society is affiliated to IFMBE, IOMP and EFOMP.
Since the beginning the Estonian Society for BME and MP has a purpose:
- To promote research and development activity in the field of biomedical engineering and medical physics;
- To provide healthcare system with technical specialists, give them the best possible education, based on modern theoretical knowledge and know-how;
- To establish the system of quality assurance and technical control of medical equipment and services in Estonia.

The Society has been involved in
- Organising conferences and seminars on biomedical engineering (national and international level) and actual problems of medical technology in country (national level);
- Accreditation of educational programmes and professional accreditation of engineers;
- Preparation of national legal regulations related to health care and health protection and their technical support,

Professional accreditation as Chartered Engineer and Euro-engineer in biomedical engineering in Estonia means that each applicant is required to hold a certificate of secondary education and his total period of formation must be at least 7 years (normally more because this is not a calendar but credit year) from that point. During this period at least 3 years must have been devoted to studies in a university (Bachelor degree) acknowledged by FEANI, 2 years to gaining professional experience and the 2 intermediate years, either to complementary University courses (Master degree), or to engineering training monitored by the approved engineering institutions, or to preliminary engineering professional experience.

In 2001 the Estonian Society for BME and MP had 55 members. Currently there are among them 8 Estonian Chartered Engineers and 2 EuroEngineers, accredited by the FEANI accreditation scheme for Engineers.

There are no accreditation schemes established for medical physicists (based on university physics education) in Estonia yet.

## 5. Training courses in medical physics

In 1999 a pilot training course in medical physics and biomedical engineering was organised by TÜ BMTK in Tartu. There were as average 12 participants from different health care institutions. The lectures and seminars took place in the course of one year on every Thursday by 3 hours. The training materials were based on materials from RSTI training centre (USA) and some other textbooks on Biomedical Equipment Technology. For such course in medical physics the EMERALD Training Course materials could be used also.
The organisation of such training courses has shown again a need for practical training facility and test equipment.

## 6. Future need for MP-BME specialists

As it was mentioned, the Medical Technology Development Plan – Estonian Healthcare Poject 2015 has set the whole number of required MP-BME specialists in the range of 150-200. In 2000 The Baltic healthcare technology cooperation initiative BaltMedTech suggested proposal 1:4:10 (Physicists-Engineers-Technicians), which could be taken as a ratio of the workload in different job tasks of MP-BME specialists.

## 7. References


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**Appendix 1**

**University of Tartu**
**MASTER DEGREE CURRICULUM IN**
**MEDICAL TECHNOLOGY**
**(Medical Physics and Biomedical Engineering)**

| | |
|---|---|
| **1 Fundamental study** | **12.0 CP** |
| Master course in theoretical physics | 4.0 |
| Master course in experimental physics | 4.0 |
| Micro-world physics II | 4.0 |
| **2 Special study** | **20.0 CP** |
| Methods and instrumentation for medical diagnostics and therapy | 3.0 |
| Human physiology and medicine | 3.0 |
| Basics of biomechanics and biomaterials | 3.0 |
| Medical imaging and image processing | 2.0 |
| Radiations in medicine | 2.0 |
| Signal processing I | 2.0 |
| Computer aided experiment | 2.0 |
| Basics of electrotechnics | 2.0 |
| Medical technology management | 1.0 |
| **3 Optional subjects** | **8.0 CP** |
| Medical biomechanics | 3.0 |
| Linear electric circuits | 3.0 |
| Systems for measurement and control | 3.0 |
| Interaction of radiation with matter | 2.0 |
| Signal processing II | 2.0 |
| Microprocessors | 4.0 |
| Myometry | 2.0 |
| Living systems | 1.0 |
| **4 Methodology of consulting** | **4.0 CP** |
| **6 Practical training** | **8.0 CP** |
| **5 Free study** | **4.0 CP** |
| **5 Master seminar** | **4.0 CP** |
| **7 Master theses** | **20.0 CP** |
| **Total** | **80.0 CP** |

**Appendix 2**

**Tallinn Technical University**
**MASTER DEGREE CURRICULUM IN**
**BIOMEDICAL ENGINEERING AND MEDICAL PHYSICS**

| | | |
|---|---|---|
| **1** | **General study** | **2.0 CP** |
| Foreign language for science | | 2.0 |
| | | |
| **2** | **Fundamental study** | **7.0** |
| Digital signal and image processing | | 3.5 |
| Electromagnetic fields and waves | | 3.5 |
| | | |
| **3** | **Core study** | **17.0 CP** |
| <u>Obligatory</u> | | |
| Mathematical modelling | | 3.0 |
| Microwave and optical engineering | | 3.5 |
| Anatomy and physiology | | 3.0 |
| <u>Optional</u> | | |
| Circuits, systems and signals | | 4.0 |
| Main course of programming | | 4.5 |
| System programming in C | | 3.5 |
| OS and network administrating | | 3.5 |
| Molecular and cell biology | | 6.0 |
| Gene technology | | 2.5 |
| Biophysics | | 1.5 |
| | | |
| **4** | **Special study** | **27.0 CP** |
| <u>Obligatory</u> | | |
| Biomedical instrumentation | | 4.0 |
| Physiological signal processing | | 4.0 |
| Physical principles of medical imaging | | 4.0 |
| Biological effects of radiation | | 4.0 |
| <u>Optional</u> | | |
| Neuroscience and information processing | | 2.5 |
| Physiological regulation and adaptation | | 2.0 |
| Bioelectromagnetism | | 4.5 |
| Quality in radiology | | 4.0 |
| Master Seminar | | 3.0 |
| Project | | 5.0 |
| | | |
| **5** | **Free study** | **4,0 CP** |
| **6** | **Practical training** | **3.0 CP** |
| **7** | **Master's theses** | **20.0 CP** |
| | **Total** | **80.0 CP** |

**Doctoral degree curriculum**

| | |
|---|---|
| **1 General and fundamental study** | **13.0 CP** |
| Obligatory | |
| Teaching methods and practical work on speciality | 8.0 |
| Optional | |
| Philosophy of Science | 2.5 |
| Psychology of personnel management and leadership | 2.5 |
| Didactics for Tertiary Education | 2.5 |
| Organisation of research and education | 2.5 |
| Ethical and Legal Aspects of Gene Technology | 2.0 |
| Project management | 3.0 |
| **2 Special study** | **25.0 CP** |
| Obligatory | |
| Seminar of the field of bio- and gene technology | 2.0 |
| Doctoral seminar of Biomedical Engineering | 4.0 |
| Doctoral seminar of Medical Physics | 4.0 |
| Optional | |
| Methods of laser diagnostics in medicine | 6.0 |
| Special course on bioelectromagnetism | 6.0 |
| Signal processing in biomedical engineering | 6.0 |
| Seminar of biomechanics | 5.0 |
| Special course of molecular medicine | 2.0 |
| Special course of biophysics | 2.0 |
| Special course of neurobiology | 2.0 |
| **3 Practice** | **2.0 CP** |
| **4 PhD theses** | **120.0 CP** |
| **Total** | **160.0 CP** |

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