HISTORY OF MEDICAL PHYSICS EDUCATION AND TRAINING IN CENTRAL AND EASTERN EUROPE – FIRST CONFERENCES, PROJECTS AND MSC COURSES

Slavik Tabakov, FIPEM, FHEA, FIOMP

IUPESM Vice-President (2018-2021), IOMP President (2015-2018), King's College London, UK

Content

This history paper traces the first conference, projects and courses, associated with the development of medical physics education and training in Central and Eastern Europe (mainly the countries which before the end of the "Cold War" were with limited opportunity for communication with the rest of the world). The fall of the Berlin Wall, and the start of the democratic changes in Central and Eastern Europe since 1989, are undoubtedly some of the historic milestones of the 20th century. In this period of time colleagues from East and West Europe renewed collaboration, which had been dormant for many years.

One of the fields of cooperation was related to harmonisation of education and training in all professions, leading to the future expansion of the European Union. Part of this overall trend were the activities related to development of specific education and training in medical physics in Central and Eastern Europe. The author has initiated and has been actively involved in most of the initial steps of this development.

This brief history addresses specifically the development and introduction of new educational/training programs.

1. The Education and Training Network and the Conference on Medical Physics Education and Training, Budapest 1994

Medical Physics education was one of the main topics to be discussed at the Report of a Joint IAEA-WHO Expert Committee in 1968 [1]. The person representing Central/Eastern European countries at this Committee was O.

Chomicki from Poland (IOMP President 2000-2003). His involvement in this activity, as well as the big number of specialists in the Radium Institute in Poland (founded by Maria Sklodowska Curie as early as in 1932) were the main reason for development of specialised University courses on medical physics in Poland during the 1970s. These are among the first such courses in the world [2]. Before 1989 the rest of the countries in Central/Eastern Europe did not have specific courses in medical physics, but had well established activities and courses in medical engineering and nuclear engineering, which included significant element of the traditional medical physics curriculum.

The necessity for a pan-European forum in the field of Medical Physics & Engineering education and training was discussed on various occasions. The author presented his views on the subject at the 5th Conference of the Bulgarian Society for Biomedical Physics and Engineering held in Sofia, Bulgaria (1988), the 5th Mediterranean Conference on Medical and Biological Engineering held in Patras Greece (1989) [3] and the Weimar Clinical Engineering Workshop in the former GDR (1990). During the Intra-European Workshop held in Szentendre, Hungary in May 1991 (organised by N Richter) [4], it was agreed that there is considerable interest in and need for future collaboration between Central/Eastern and Western European countries in the area of professional education and training, and activities for joint ventures were initiated.

The next steps included formation of Network of active specialists in the field of education and training. Traditionally Medical Engineering education was well developed in Central/Eastern Europe [5] and the Network included many medical engineers. The Network was created by S Tabakov in 1993 and a Bulletin (Fig.3) was made to disseminate information between its members (see the Logo of the Network on Fig.3 – on the banner to the right of the Polish Conference Logo).

In parallel to the Network other inter-university activities took place, notably through the EC projects TEMPUS (a Trans-European Cooperation Scheme for Higher Education). The first such projects were organised by the University of Patras, Greece with Universities from Bulgaria and Romania [6]. These activities triggered the creation of new MSc courses (mainly medical engineering with elements of medical physics).

In 1992 two new MSc programmes were initiated in Bulgaria – an MSc on Medical Physics at the Shumen University and an MSc on Medical Engineering at the Technical University Sofia – branch Plovdiv, while in 1995 a similar University programme was founded in Iasi, Romania.

Following the Network creation a submission was made to the European Commission (EC) for supporting of a Conference on the subject. The proposal was successful [7] what triggered the organisation of the First European Conference on Education in Medical Radiation Physics.

The venue of the Conference was agreed to be in Budapest – a central meeting point for colleagues from Central/Eastern and Western Europe. The objectives of the Conference were:

- To increase the East/West European co-operation in the field of Medical Physics;

- To establish the status and needs of education and training in Medical Radiation Physics in Central/Eastern European countries;

- To formulate proposals for the advancement of post-graduate education in Medical Radiation Physics and identify resource sharing initiatives;

- To consider the need for a Training Authority and a professional network in the field of Medical Physics & Engineering in Central/Eastern Europe.

The Organising Committee was set up in London with members: C Roberts, S Tabakov, C Lewis, assisted by V Tabakova and D Smith. The Local Organising Committee was set up in Budapest with members: P Zarand, N Richter, I Polgar. Emails were rare at that time, hence most of the organisation was handled through facsimile exchanges.

The European Federation of the Organisations for Medical Physics (EFOMP) was also involved in the Conference, the concept of which was accepted enthusiastically in almost all countries invited to participate. The delegates to the conference were senior medical physicists, each being a nominee of their European professional society and/or their University. In total 37 Institutions, Societies and Universities from 23 European countries were represented at the Conference. This Conference was very important for EFOMP, as it allowed the leadership of the Federation to meet their senior colleagues from Central/Eastern Europe.

The European Conference on Post-graduate Education in Medical Radiation Physics was held in Budapest from 12-14 November 1994. It included presentations about the current status of medical physics education and training in each of the present countries and organisations. Two general discussions (round tables) followed which focused on two major themes:
- education and accreditation of centres for education & training;
- training and continuing professional development.

The Delegates to the Budapest Conference (Fig.1) represented EFOMP and the Societies of most European countries. Papers about the status quo were collected from: Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Rep, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Turkey, Ukraine, UK (13 Central/Eastern European countries were presented). Additionally information was presented from EFOMP, IFMBE (International Federation of Medical and Biological Engineering) and IAEA (International Atomic Energy Agency).

All presentations from the Conference were later included in the book "Medical Radiation Physics – A European Perspective", editors C Roberts, S Tabakov, C Lewis, King's College London, 1995 (Fig.2). The book [8] was also published as an electronic PDF book (on a floppy disk) and distributed in most Medical Physics Societies in Europe and the world (more than 1000 copies of the book and the diskette were distributed). The diskette with the electronic book was one of the first e-books in the world.

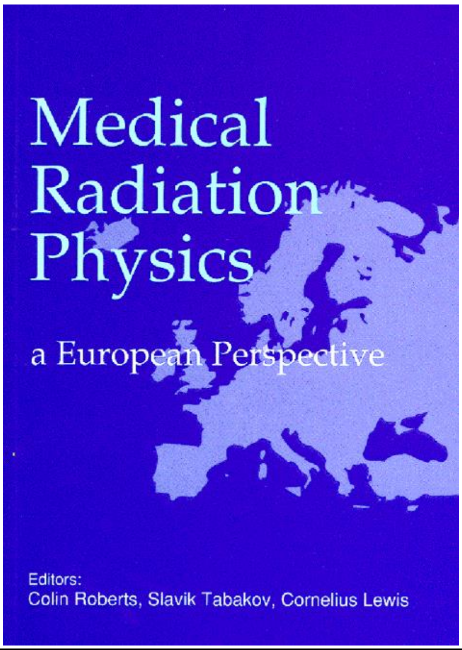


Fig.1 Some of the delegates to the European Conference on Post-graduate Education in Medical Radiation Physics was held 12-14 November 1994, Budapest. The Delegates to the Conference included: C Roberts, S Tabakov, C Lewis, P Zarand, N Richter, I Polgar, M Radwanska, F Milano, M Ribas-Morales, J Gomes da Silva, V Orel, V Laginova, S Kovacova, L Musilek, W Selentag, S Aid, M Gershkevich, S Sheriff, M Vrtar, Y Lemoigne, P Frangopol, N Sheahan, A Vaitkus, C Milu, H Zackova, I Stamboliev, B Proimos, A Karadjov, I-L Lamm, P Trindev, M Morawska-Kaczinska, I Tarutin, S Spyrou, A Benini, G Pawlicki, Y Dekhtyar, D Gubatova, V Tabakova, D Smith, G Kemikler, I Ozbay, T Ratner, A Noel, B Aubert.

Fig.2 - Book following the Conference (distributed all over Europe).

This book triggered many new MSc-level medical physics courses in Eastern Europe. The author later used the model of this Conference to support the development of medical physics courses in some South-East Asian countries (see further in the paper).

A number of activities between countries were initiated immediately after this Conference, including the projects EMERALD and ERM, as well as the projects with the Baltic countries (these will be described further in the paper). In Budapest was also the first presentation of the European Scientific Institute (ESI) in Archamps, which later became one of the main Schools of the EFOMP [9]. The Conference also stimulated the Societies from Eastern Europe to join EFOMP. As a result the number of national members societies of EFOMP increased significantly after the Budapest Conference.

The Conference delegates made a review of the current situation, revealing main areas of improvement in most of the existing MSc programmes curricula, such as inclusion of specific specialist topics. A weakness associated with the practical training was lack of structure and uniform method for training delivery. Specific strengths were noted as the traditionally good education in maths and physics in Central/Eastern Europe, the good computer literacy and radiation protection activities [10]. The Conference emphasized that the best way forward is creating new MSc programmes, specific for medical physics, and also the need of professional translation of medical physics terminology (this was realised later through the projects EMIT and EMITEL, developed and coordinated by the author [47]). The need of specific curricula for development of new MSc courses and Training schemes was emphasized. This was addressed through the projects ERM and EMERALD (described further in the paper).

It was agreed that collaboration between the East/West European countries is essential for the advancement of the profession and a Declaration of Intent was signed by all delegates (see Fig. 10). The Network was further expanded and its first meeting was agreed to be associated with the Conference of Medical Physics in Krakow, Poland (September 1995), organised by M Radwanska (Fig.3). The Network had its own Bulletin (edited by the author at King’s College London). The Network members were instrumental in starting new educational activities.

Fig. 3 The first workshop of the European Network on Medical Physics Education and Training at the 10th Congress of the Polish Society of Medical Physics (1995, Krakow, Poland, part of the delegates).
The logo of the Network Bulletin is added to the lower left corner.

2. Project ERM – the Inter-University Centre for Education in Medical Physics and its Curriculum

Immediately after the Budapest 1994 Conference the author initiated an EU project in Bulgaria (the project ERM - acronym for Education for Radiation in Medicine) [11] in parallel with the project EMERALD. This was a natural continuation of the Conference objectives for strengthening East/West European relations. The project was submitted to the newly established EU programme TEMPUS (a Trans-European Cooperation Scheme for Higher Education), one of its objectives was to support the synchronisation of Eastern European University education with this at the European Union (EU).

The selection of Bulgaria for this project was underpinned by the fact the before 1990 the author had worked in the Medical University Plovdiv Bulgaria and had the necessary local support there. Additionally during 1988-89 the author developed and presented at the MEDICON Conference in Patras, Greece (September 1989) an effective educational model for small countries starting their new education in medical engineering and medical physics, using International Education/Training Centres [3]. These ideas and expertise were applied in the project ERM.

The project included partners from the Budapest Conference: King's College London, UK (led by C Roberts and S Tabakov), University of Florence, Italy (led by F Milano), Trinity College Dublin, Ireland (led by N Sheahan). The Bulgarian counter-parts were: Medical University Plovdiv (led by A Djurdjev and I Delov, later K Velkova), the Technical University (TU) – branch Plovdiv (led by L Genov and G Stoilov) and later the University of Plovdiv (PU) Chair Atomic Physics (led by N Balabanov). Contractor was C Roberts and Coordinator S Tabakov.

The project ERM objective was to introduce MSc/Diploma degree course in Medical Radiation Physics plus short CPD courses in the field of radiation applied to medicine. The project was supported by SIEMENS, IAEA, EFOMP, The Bulgarian Academy of Sciences, The Bulgarian Ministry of Health and The Parliament of Bulgaria - this being one of the first projects to introduce the widely used in Europe two-tier university degree system of Batchelor - Master into the education in Bulgaria (the system previously used in Bulgaria was 'Diploma-degree', equivalent to Master, and based on 5 years University education). The project was also supported by the Bulgarian Scientific Societies of Biomedical Physics and Engineering and of Roentgenology, Radiology and Radiobiology, as well as the UK Institute of Physical Sciences in Medicine (IPSM, currently IPEM) [12].

The project ERM was initiated during October 1995. Its first year included founding and equipping a new Educational Centre (space was provided by Medical University - MU Plovdiv) and at the same time organising all lecturers in the international team to exchange information and begin the preparations of the syllabi of the modules and related books with lecture notes. The project plan was to develop for every module of the MSc programme its own textbook with lectures in English. This was important as such books were not yet available in Eastern Europe or were too expensive. These books (in total 20 textbooks with lecture notes) were used in many other countries (see further). The curricula and modules syllabi (see Annex 1) developed in ERM project were later shared with colleagues planning to develop similar MSc programmes in other countries.

The course was developed as one academic year fully modularised course, consisting of 12 modules, divided in three parts – here below is the structure of the MSc curriculum:

- Part 1 - Basis of Medical Physics (including modules in the field of Human Anatomy, Radiation Physics, Radiation Detection and Measurements, Radiobiology);

- Part 2 - Special subjects of Medical Physics (including education on the principles and equipment of Radiotherapy, Diagnostic Radiology, Nuclear Medicine, and other Imaging modalities);

- Part 3 - Continuing Professional Development CPD (this part includes subjects on Radiation Protection, Hospital Safety, Medical Informatics and European Integration, which were developed for the MSc students, but were additionally open to external medical specialists applying radiation (as CPD courses).

TERM 1 (MSc Curriculum Part 1: September - December)

1. Basis of Human Anatomy and Physiology (approx. 90 acad. hours; test assessment)
2. Radiation Physics (approx. 90 acad. hours; exam)
3. Radiation Detection and Measurements (approx. 90 acad. hours ; exam)
4. Radiobiology (approx. 60 acad. hours, test assessment)
5. Physics and Equip. of Ultrasound, Lasers, MRI (approx. 90 acad. hours, exam)

TERM 2 - 1st part (MSc Curriculum Part 2: January - March)
6. Physics and Equipment of Diagnostic Radiology (approx. 80 acad. hours, exam)
7. Physics and Equipment of Nuclear Medicine (approx. 80 acad. hours, exam)
8. Physics and Equipment of Radiotherapy (approx. 80 acad. hours, exam)
9. Image and Signal Processing in Medicine (approx. 60 acad. hours, test assessment)

TERM 2 – 2nd part (MSc Curriculum Part 3: April - May)
10. Radiation Protection and Hospital Safety (approx. 80 acad. hours, tests, Certif.)
11. Medical Informatics (approx. 30 acad. hours, test)
12. European Integration (approx. 30 acad. hours, test)
Awarding Post-graduate Diploma in Medical Physics

MSc Research Thesis development (approximately 5 months, April to September)

All education was planned to be conducted in English and this was one of the entry requirements for the students. A specific feature of the Curriculum was that it included both physics and engineering aspects of the specialist modules, thus allowing students to work, if necessary, also as service engineers – a useful activity for a small country. Each module was based on condensed delivery (1 to 3 weeks) to allow external lecturers to visit the Centre. Each module had its Bulgarian module Organiser and European module Adviser. Each Bulgarian lecturer visited his/her counterpart to adapt their model of lecturing and several Workshops were made to synchronise all modules. The names of all lecturers to the Inter-University Centre are listed in ANNEX 1.

The Bulgarian Universities in the project signed declarations allowing mutual recognition of the MSc in Medical Physics degrees, and the MSc Diplomas were signed by the Rectors of all participating Bulgarian Universities. This way all three Universities (each having specific speciality – medicine, engineering, physics) made their first Inter-University Centre. The Universities were sharing their Laboratories for the needs of the Centre (MU allowed use of its medical equipment in the late afternoons). All lecturers received honorary status to the Centre – either as visiting lecturers or visiting professors to MU and PU. All these activities were approved by the Academic Councils of the three Bulgarian Universities and during the spring of 1997 the Centre was officially established.

The official opening of the ERM Inter-University Centre and the start of its first academic year was at the beginning of September 1997. It included all lecturers, students and project supporters. The ceremony attracted dignitaries from the Government, the Parliament, the City Council and many Institutions and Societies, including the Rectors of the three Bulgarian Universities (Fig. 4).

Fig. 4 Opening of the Inter-University Centre for Medical Radiation Physics ERM, 1997, Plovdiv Bulgaria

The achievements of the Centre and its MSc programme were reported at the World Congress in Nice (WC2007). The lecture notes, structure of curriculum, modules syllabi (see ANNEX 1) and experience of this Centre were later used in the forthcoming Tempus projects with the Baltic States and in a number of other countries.

At that stage the author repeated an experiment made during 1990 (also in Plovdiv) – a test to evaluate the difference between alphanumerical memory and image memory of the students. We used tasks explained verbally and explained mainly through images, and were asking the students to perform the tasks and evaluate how they had understood these. In both cases the students were showing 80% better understanding when using images - something all lecturers had experienced from practice. The results from these tests underpinned the need to use Educational Image Databases in the teaching process (this being one of the main tasks in the EMERALD project).

The first applications of our EMERALD e-learning materials were in this Centre and in the ICTP College on Medical Physics 1996-1997 [13].

In order to be able to publish the ERM Lecture Notes (Fig. 5) a legal body associated with the Centre was established – the Foundation "Physics Engineering Medicine XXI" FIM XXI (Физика, Инженерство, Медицина XXI, ФИМ XXI). The Foundation was led by S Tabakov and N Balabanov.

During 1999 the ERM MSc course received UK accreditation through the UK IPEM – this being the first non-UK based MSc course in Medical Physics with such accreditation. The MSc course continued its delivery in English at the Inter-University Centre in the Medical University until 2003. Later it was delivered and examined in Bulgarian (however using the English text books, hence knowledge of the language was an entry requirement). Later the MSc course was transferred to the University of Plovdiv and continues successfully until now.

The graduates from this MSc course work in various hospitals in Bulgaria and abroad. The ERM MSc programmes provided a model, which was useful for other countries, as discussed later. The original syllabi of its modules are presented in ANNEX 1 to this paper.

3. The Project for development of medical physics education in the Baltic countries

Soon after the start of the ERM project the author worked with colleagues from Riga Technical University and University of Linköping (Y Dekhtyar and A Oberg) to develop a similar educational project for the three Baltic states - Latvia, Estonia and Lithuania.

Fig. 5 The set with MSc lecture notes of ERM project, Published in Plovdiv, Bulgaria

Fig. 6 Book with Baltic Curricula and Syllabi, Published in Riga, Latvia

The Objective of the project was: development of a new Joint Baltic Medical Engineering and Physics Master course (JBMEP) on the basis of developing new educational modules and restructuring of some existing modules on Medical/Biomedical Engineering and Physics (including their teaching materials) delivered as part of various MSc programmes in the universities of Latvia, Lithuania and Estonia [14].

The project partners were: Linköping University, Sweden (represented by A Oberg, Contractor and P Ask); Riga Technical University, Latvia (represented by Y Dekhtyar, Co-ordinator and I Knets); Kaunas Technical University, Lithuania (represented by A Lukosevicius and D Adliene); Tallinn Technical University, Estonia (represented by H Hinrikus and K Meigas); University of Tartu, Estonia (represented by A. Soosaar and P-H. Kingisep); University of Latvia (represented by J Spigulis and M Auzinsh); King's College London (represented by C Roberts, J Lee and S Tabakov).

This project started in mid-1998 and developed quite quickly by using the significant experience from the ERM project, and many teaching materials (from ERM and EMERALD projects). Additionally, the Universities in Kaunas and Tallinn already had medical engineering courses.

In 1999 Estonia hosted the Nordic Baltic Conference on Biomedical Engineering in Tallinn, where a joint Workshop [15, 16] was made on the Education in medical physics and medical engineering (Fig.7). This International Conference was supported both by the IFMBE and the International Organization for Medical Physics (IOMP was represented by O Chomicki and S Tabakov). The Conference was attended not only by colleagues from the European Nordic countries, but from representatives of more than 30 countries (Conference organisers were H Hinricus and K Mejgas). The development of the profession in the Baltic countries continued with steady progress and in 2008 Latvia hosted the Nordic Baltic Conference on Biomedical Engineering in Riga, where a similar Workshop took place (Organiser Y Dekhtyar).

The structure of the joint Baltic MSc course was different from the ERM MSc course – in the Baltic project the students had to travel (for some of the modules) between the countries, but this was facilitated by the fact that the distances were small and there were no border problems.

The Coordinator Y Dekhtyar was also helped by A Katashevs and they set up a Teaching Centre in Riga. The Centre had its own laboratories. These laboratories included old decommissioned medical equipment, which was revived and maintained for training purposes only. This was an excellent asset for the students. These activities in Latvia led to quick development of medical physics in the country.

Fig.7 The International Advisory Committee of the 11th Nordic Baltic Conference on Biomedical Engineering, 1999, Tallinn, Estonia

The Baltic project received all ERM Lecture Notes and EMERALD Training Tasks and Image databases. A number of EMIT project training tasks (another training project, discussed further in the paper) were tested through the students there. Some colleagues from this project took part later in the EMITEL project [47] – they were the main translators of the Dictionary terms in Latvian, Estonian and Lithuanian, as well as taking part in writing some entries for the Encyclopaedia of Medical Physics.

The Baltic project revealed significant need for specialists in medical physics and engineering in the three countries. While EFOMP minimal requirements at the time were for about 20-30 medical physicists per country of this size, the rapid healthcare development in the Baltic countries predicted figures of c. 200 medical physicists and engineers per country. These figures are yet to be achieved, however ten years later the overall number of medical physicists and engineers in these three countries was around 200. Without doubt this Tempus project contributed significantly to this rapidly increased number of such professionals in the Baltic region. The members of the Baltic project Consortium (Fig.8) continued actively in further educational, professional and research activities in their countries.

The Curriculum development in the Baltic project included development of new modules and restructuring of existing modules in the Baltic Universities. This created a number of specific specialist modules. The number of modules and their syllabi formed a considerable list of options (24 modules in biomedical engineering and 17 modules in medical physics). These were published in the book Baltic Biomedical Engineering and Physics MSc Courses [17] - Fig.6.

The Baltic MSc-level Curriculum was designed to be delivered over 2 years. Each country had the freedom to include various combinations of the optional modules, thus creating a flexible workforce. The structure of this Curriculum was based on credits (one credit being equal to one full week of education).

During the whole project lecturers from the Baltic countries were visiting partners in Sweden and UK, in order to synchronise their educational practices with those in the EU Universities. The project (1998-2001) paved the path for further medical physics and engineering international projects and conferences and proved a boost for the professional development in the Baltic countries.

Later the MSc programmes created in this project continued with the active involvement of Prof F Milano (Florence University), who took part in the lecturing, examination and placements (in Italy) of many Baltic students. Further F Milano transferred his experience from Bulgaria and Latvia in the development of similar medical physics courses in Ukraine (Zhytomyr University).

Fig. 8 The Baltic project Consortium meeting, 2000, Kaunas, Lithuania

4.Assessment of educational courses

The abovementioned MSc programmes developed real examples for establishing of medical physics University courses. Professional evaluation of the quality of these courses was an activity which at that time was performed only by the two largest medical physics societies – the IPEM in UK and the AAPM in the USA.

An attempt to achieve this at international level was made through the EU project TEMPERE (Thematic Network for Training and Education in Medical Physics and Biomedical Engineering). The project (1996-1999) was Coordinated by the University of Patras (Coordinator B Proimos) and included about 40 European Universities and Organisations. The main documents used were policy statements and publications of EFOMP, IPEM, AAPM, HPA, IFMBE, and others, including the Book from Budapest Conference.

The TEMPERE project did not include many Central/Eastern European Universities, but its Conference (satellite to the MEDICON Conference in Patras 1999) had considerable number of participants from this part of the world. The results from the TEMPERE project were published in 2001 (Editor Z Kolitsi) [18]. The recommendations were useful, but it was difficult to be implemented in practice on international level due to the significant variety of national/local regulations.

On a national level the first medical physics MSc programme accreditations were made almost simultaneously by the IPEM (IPSM) in 1994 [19] in the UK and in 1995 in the USA [20]. The accreditation in USA was handled by CAMPEP (Commission on Accreditation of Medical Physics Educational Programs) – this was a collaborative activity of several organisations. CAMPEP was formed in 1994 and initially was supported by AAPM (American Association of Physicists in Medicine), ACR (American College of Radiology (ACR), ACMP (American College of Medical Physics). In 2001 CCPM (Canadian College of Physicists in Medicine) also joined CAMPEP and in 2010 was replaced by COMP (Canadian Organization of Medical Physics).

IOMP made an attempt to initiate accreditation activities in 2005 by forming a Validation and Accreditation Panel (Chaired by S Tabakov and later A Krisanachinda) to its Education and Training Committee (ETC). The first activity of this Panel was to create an IOMP Model Curriculum, which to be used as background for the accreditation [21]. This was developed (using experience from the UK, USA and the ERM project), but was not applied in practice as the accreditation activity required legal obligations, which IOMP could offer only in connection with its legal status (what was achieved in 2017). However the IOMP Model Curriculum was used, together with the ERM and EMERALD materials, as one of the founding blocks of the IAEA Training Course Series No. 56 (IAEA-TCS-56) - Postgraduate Medical Physics Academic Programmes [22]. This TCS 56 is currently the main quality criteria for international medical physics accreditation.

In 2015 the IOMP President (S Tabakov) and the IOMP ETC Chair (J Damilakis) renewed the IOMP accreditation activities in connection with the expected legal status of IOMP (achieved in 2017) [23]. The Accreditation Manual of IOMP was prepared as a guide to future applicants [24]. The first IOMP international accreditation was made by S Tabakov and J Damilakis (issued to the ICTP MSc programme in Trieste) – Fig.9. In the following IOMP office the ETC (Chair A Chougule) continued successfully these activities.

Fig.9 First IOMP accredited alumni of MSc Advanced Studies in Medical Physics with supporting colleagues from AIFM

The IOMP Regional Organisation for Europe EFOMP arranged its legal status before IOMP and in 2016 it established the European Board for Accreditation in Medical Physics (EBAMP) as an independent organisation that accredits medical physics education and training courses and events [25].

International accreditation for Training Centres exists on paper but has not been realised as a regular activity at the moment. However another activity – Certification for medical physicists was realised on international level. This activity was initiated in 2008 by R Wu and KY Cheung and was discussed at several IOMP meetings. An independent International Medical Physics Certification Board (IMPCB) was formed, which made a number of certifications – initially for National Certification Boards (as in Hong Kong and South Korea), later for individuals (specifically from the ICTP Master programme in Advanced Medical Physics Studies). IMPCB has Memorandum of Understanding with IOMP, which is one of its main sponsoring organisations [26].

Although these activities are not directly related with Central and Eastern Europe, some colleagues from this part of the world benefitted from the international accreditation and certification. An important moment is that these activities triggered various national activities related to assessment the quality of education and training.

5.Medical Physics Training development in Eastern Europe

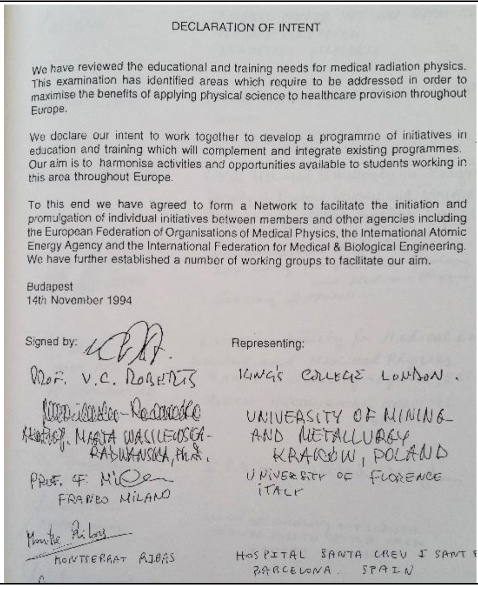
The work on medical physics training in Eastern Europe was going in parallel with the development of MSc courses. This activity was associated with the project EMERALD (1995-1998), developed by the author in collaboration with colleagues from several EU countries [47]. The training of the project EMERALD (acronym of European Medical Radiation Learning Development) was made as a structured training, following industry training examples. The training was associated with purpose-built training tasks, each building specific competencies (as per the IPEM Training scheme competencies at the time). The Curriculum of the training (Training Timetables – see ANNEX 2 to this paper) was made in a way to allow progressive building of competencies, covering the important at the time elements of the main fields of medical physics. The Curriculum was made this way in order to allow easy introduction in countries where previous training in medical physics did not exist. As such it was very useful for the first steps of medical physics training in Central/Easter Europe and other LMI countries. The structure of the Curriculum was made as a compendium of semi-independent tasks, thus allowing easy replacement of old tasks with new training tasks. This provided a continuous frame for the training. EMERALD was later continued with the project EMIT (developed by almost the same team) [47]. EMERALD was addressing training in Diagnostic Radiology (X-ray), Nuclear Medicine and Radiotherapy, while EMIT was addressing training in MRI and Ultrasound Imaging.

EMERALD and EMIT Consortia developed 5 Training modules, each including specific Workbook with Training tasks and Image Database with educational images. Each module was developed with a length of 4 months (80 days). During this time the trainee is expected to acquire most necessary professional skills (as per the IPEM

Training scheme). This part of the training was called “condensed” and can be performed in most countries, where training conditions are set up. Further the trainees can spend several months in their own country/state where they can additionally study the local Regulations and professional requirements.

Each of the modules is based on Training tasks. Each task was given a notional completion time (in days). Achieving completion of 3 modules for 1 year would require very intensive work. However the design of the EMERALD scheme allows the individual modules to be taken separately with intervals between each.

The First International Conference on Medical Physics Training, was organised by S Tabakov under the project EMERALD in ICTP Trieste (24-26 September 1998). It included EFOMP officers and senior delegates from 28 European countries (of these 10 from Central and Eastern Europe, as per the Declaration from Budapest – Fig.10): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Netherland, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, UK, Yugoslavia [27]. Additionally there were 8 trainees from 3 countries to give feedback on the usability of the EMERALD e-learning materials. Each delegate to this Conference received the full set of EMERALD Training materials (Fig.11).



DECLARATION OF INTENT

We have reviewed the educational and training needs for medical radiation physics. This examination has identified areas which require to be addressed in order to maximise the benefits of applying physical science to healthcare provision throughout Europe.

We declare our intent to work together to develop a programme of initiatives in education and training which will complement and integrate existing programmes. Our aim is to harmonise activities and opportunities available to students working in this area throughout Europe.

To this end we have agreed to form a Network to facilitate the initiation and promulgation of individual initiatives between members and other agencies including the European Federation of Organisations of Medical Physics, the International Atomic Energy Agency and the International Federation for Medical & Biological Engineering. We have further established a number of working groups to facilitate our aim.

Budapest
14th November 1994

Signed by: Representing:

Prof. V.C. Roberts — King's College London
Marta Wasilewska-Radwanska, PhD — University of Mining and Metallurgy, Krakow, Poland
Prof. F. Milano, Franco Milano — University of Florence, Italy
Montserrat Ribas — Hospital Santa Creu i Sant P..., Barcelona, Spain

Fig. 10 Declaration of Intent to all Delegates to the Budapest Conference 1994

Fig.11 EMERALD Training materials (given to all delegates of Conference at ICTP, 1998 and Prague, 2000)
The delegates of the First International Conference on Medical Physics Training (Emerald, ICTP, 1998) included: R Nowotny, W Schmidt, P Trindev, V Todorov, M Vrtar, S Spyrou, L Musilek, C-A Jessen, H Hinrikus, K Mejgas, H Escola, A Noel, S Naudy, I Gardin, F Nuesslin, Z Kolitsi, P Zarand, N Sheahan, U Bottigli, V Punys, M Radwanska, U Zdesar, P Smith, S Sheriff, A Rogers, M Tooley, D Saunders, P Andreo, S Andric, S Faermann, C Roberts, S Tabakov, C Lewis, D Smith, V Tabakova, S-E Strand, B-A Johnson, M Ljungberg, F Milano, L Riccardi, A Benini, J Gomes da Silva, N Teixeira, A Pascoal, L Bertocchi.

The discussions at this Conference revealed what type of Training Centres are necessary and how to establish these. The already functioning Training Scheme of IPEM UK was used as a model for organising training activities and the timetable of EMERALD was used as a sample scheme. It was agreed that a specific Seminar is necessary to be made for the colleagues in Central and Eastern Europe.

This additional activity (Euro Seminar on Medical Radiation Physics Training) was organised by S Tabakov and L Musilek in Prague, 3-5 September 2000 (Fig.12, Fig.13). It was attended by senior specialists from EFOMP and from 15 Eastern European Countries: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Ukraine, Ukraine.

Each delegate was given a full set of all EMERALD e-learning materials – timetables, 4 textbooks with Guide and Training Tasks (in Diagnostic Radiology, Nuclear Medicine and Radiotherapy), 3 CD-ROMs with full image databased in these three fields and Sample Documents for organising the Training Centres and related activities.

The seminar not only introduced the concepts of quality training, but also discussed the development of Medical Physics in this part of the world. It was stated that during the 5 years after the Budapest Conference (1994), almost all Eastern European countries have developed their own Medical Physics University courses (at Master level).

Additional Seminars for the development of Medical Physics Training were made in France, Sweden and Ireland. It was evident that the EMERALD Training materials were used In different degree) in 30 European countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Rep., Slovenia, Spain, Sweden, UK, Ukraine.

After 2000 all EMERALD materials (and later all EMIT) training materials (training tasks and associated over 3000 images) were included at the first medical physics educational web site, made as part of the project EMERALD II [47]. In 2005 this web site (www.emerald2.eu) was made as open access and continues to serve the profession.

Fig. 12 - Euro Seminar on Medical Physics Training, 2000, Prague, Czechia -part of delegates.
The delegates from Central/Eastern Europe to the Euro Seminar (Prague, 2000) included: E Milieva, P Trindev, M Vrtar, A Santic, H Hinrikus, K Mejgas, P Zarand, N Richter, y Dekhtyar, V Atkocius, D Adliene, N Golnik, G Pawlicki, G Matache, N Loutova, T Ratner, L Zamecnik, Kozlikova, G Kemikler, Lysitsia, Yabloshanska, Z Bozovic, S Andric.

Fig. 13 - Working discussions in the Prague Seminar (with all Emerald materials in blue boxes).

It was natural the next Conference on e-Learning in Medical Physics, organised by S Tabakov in ICTP Trieste, 9-12 October 2003, to include delegates from Central and Eastern Europe (Fig.15). The delegates to this Conference included senior specialists from 26 countries (of those 10 from Eastern Europe and 3 from outside Europe): Austria, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Cuba, Lithuania, Macedonia, Netherland, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Turkey, Thailand, UK, USA. EFOMP, AAPM, IFMBE and IOMP were also represented at this Conference.

The delegates to this Conference received the EMIT project materials – all as digital publications – 2 CDs with e-books with Training tasks and Image databases related to MRI and Ultrasound Imaging, plus the mini CD with the first edition of the Scientific Dictionary of Medical Physics (Fig. 14). All EMIT materials plus the previous EMERALD materials were also available to the delegates through the web site www.emerald2.eu. The Conference took decisions for the collaborative development of the profession in Europe, what was subject to the special Declaration signed [47]. Project EMIT included EFOMP as a project partner (the first EU project of EFOMP) and was natural the Declaration to be synced with EFOMP officers. The Conference discussed the new EMIT training materials and the use of e-learning in the profession. The successful implementation of e-learning in the profession attracted in 2004 the inaugural EU Award for education – the Leonardo da Vince Award [47].

Approximately at the same period of time the International Atomic Energy Agency (IAEA) increased its series of projects specifically addressing education and training [28, 29]. For an extensive list of projects see [29]. As part of these the author worked on development of new courses and training with specialists from Czech Republic, Hungary, Belarus, Macedonia, Armenia and Georgia (I Horakova, L Judas, M Yermalitsky, S Tramptova, R Stamenov, K Stepanjan, G Archuadze). Additionally the author took active part in other such educational IAEA projects with Malaysia, Thailand, Jamaica and later Zimbabwe (S Salikin, A Krisanachinda, A Tajuddin, W Kirdpon, M Vouckov, G Azangwe). Further part of the expertise from these activities were transferred to the large IAEA Regional project with Africa. These and other projects led to the sharing our educational curriculum (from Project ERM) and training materials (from projects EMERALD and EMIT) to: Armenia, Belarus, Brazil, Costa Rica, Czech Republic, Estonia, Egypt, France, Georgia, Jamaica, Latvia, Lithuania, Macedonia, Malaysia, Thailand, Zimbabwe. These materials were used in setting and updating MSc programmes and training schemes.

Fig. 14 EMIT Training materials (given to all delegates of Conference at ICTP, 2003) and web site front page

Fig.15 Delegates at the EMIT EuroConference on e-Learning in Medical Physics, ICTP, Trieste, 2003
The delegates to the First Conference on e-Learning in Medical Physics (ICTP, 2003) included: C Lewis, C Deane, A Cvetkov, C Oates, T Jansson, D Goss, G Helms, S Keevil, M Buchgeister, M Stoeva, C vaan Pul, G Clarke, K Nagyova, A Krisanachinda, P Sprawls, Dr Nick Fernando Poutanen, J Young, Y Ider, A Milan, A Rosenfeld, A Simons, R Wirestam, I Hernando, V Gersanovska, P Zarand, P Caplanis, F Stahlberg, C Etard, N Fernando, R Stollberger, P Smith, F Milano, A Lukoshevicius, V Aitken, E Perrin, A Evans, A Briquet, C Bigini, A Paats, M Almqvist, G Boyle, F Fidecaro; in Front: C Roberts, J-Y Giraud, Mr L Torres, S Riches, S Tabakov, I-L Lamm, M Radwanska, S Naudy, R Magjarevic, L Musilek, T Wehrle

In 1998-99, as soon as EMERALD Training and associated e-Learning materials were ready, the author with F Milano and M Radwanska prepared an EC project (alongside EMERALD II) aiming to develop a dedicated Internet server for Medical Physics e-Learning (an "e-Broadcast for education") to support all countries in Central/Eastern Europe, and later to be expanded for the other LMI countries at the time. The project would be led by our Italian partner F Milano and the main counterpart was in Poland (M Radwanska and a Polish Internet company), where we intended to host the dedicated e-learning server. The project was not accepted for funding as being "well ahead of its time". This way the idea was not further developed. However the project EMERALD II (EMERALD – Internet Issue) developed in 1999 the first educational web site in the profession (www.emerald2.net, later www.emerald2.eu) which was directed toward training. It was opened free in 2003 to all colleagues from Central/Eastern Europe and the students at ICTP and later was made an open resource to everyone in the profession, as it continues until now, supported by the author.

6. Transferring the experience from Central/Eastern Europe to other Regions

A number of colleagues from the projects described above took part in supporting the development of the profession in other countries. Additionally in this period EFOMP and the IOMP Education and Training Committees supported many activities, with increasing number of these for the countries from Central/Eastern Europe [30, 31, 32], while AAPM organised courses in some of these countries.

One of these activities was organised by the colleagues from the Baltic project – an IAEA supported Seminar and Workshop in 2010 in Kaunas, Lithuania. The book with the materials from this Workshop included information about the current MSc courses in Central and Eastern Europe, which showed the progress of medical physics education in these courses during the 15 years after the Budapest Conference (similar information was included for European, Asian, African and Latin American courses in the book on Education in training from 2011 – to be discussed later). This Seminar and Workshop was led by D Adliene, Y Dekhtyar and M Laurikaitis. The book from Kaunas included also some countries which had not been covered in the other books: Albania, Georgia, Macedonia [33].

The most important disseminator of the activities related to medical physics education and training was the ICTP College on Medical Physics. This international activity was running since 1988. ICTP as institution was a member of the EMERALD Consortium and during 1996 and 1999 tested the EMERALD training programmes. In 2002 the College Co-Directors P Sprawls and S Tabakov changed its curriculum and included special Workshop and sessions focussed on exchange of experience and knowledge related to establishing and running educational programmes. These additional activities were successful and collected significant amount of information about the professional status of medical physics in many countries.

The development of medical physics professional activities, the pioneering of e-learning in the profession and the activities of the ICTP College were part of the presentation of medical physics as part of the applied physics sub-specialities at the UNESCO Conference Physics and Sustainable Development, 2005, Durban, South Africa (co-organised by ICTP). The presentation "Physics and Health" at this High-level Conference was led by P Sprawls and D van der Merwe, with the support of S Tabakov and A Niroomand Rad. The very successful presentation resulted in selecting the field Physics and Health as one of the 4 major fields of applied physics for the 21 century [34]. This activity was essential for the increase of funding for projects related to medical physics in the following years.

Until 2020 the ICTP College on Medical Physics educated over 1000 young colleagues from Low-and-Middle-Income (LMI) countries. These were from: Albania, Algeria, Armenia, Argentina, Bangladesh, Belarus, Bosna, Brazil, Brunei, Bulgaria, Cameroon, P.R. China, Chili, Croatia, Congo, Costa Rica, Columbia, Cuba, Czech Rep., Ecuador, Estonia, Ethiopia, Egypt, Eritrea, Ghana, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenia, Kuwait, Latvia, Lebanon, Lesotho, Lithuania, Libya, North Macedonia, Malaysia, Malawi, Moldova, Mongolia, Mexico, Morocco, Montenegro, Namibia, Nepal, Nigeria, Oman, Peru, Philippines, Papua New Guinee, Panama, Pakistan, Poland, Romania, Russia, Serbia, Senegal, Slovenia, Slovakia, Sudan, Syria, Sri Lanka, South Africa, Tanzania, Trinidad and Tobago, Thailand, Turkey, Uganda, Ukraine, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe. More than 1/4 of these from Central and Eastern Europe. Over the years many of the Central/Eastern European countries became members of the European Union and some of them moved out of the LMI category [35].

Each participant to the ICTP College on Medical Physics received a free set of EMERALD and EMIT training materials, Curriculum for MSc programme, full access to the established Sprawls Resources, and full set of lectures notes and Power Point slides. Using these materials and experience many of the colleagues organised spin-off courses in their countries, while some organised MSc courses or re-structured and enriched existing University courses.

The success of the College on Medical Physics led to opening and supporting of other medical physics activities in ICTP – notably various IAEA Courses. In 2015 ICTP started a regular activity - School of Medical Physics for Radiation Therapy (in alternating years with the College). This School is headed by R Padovani, with the support of L Bertocchi. In 2014 ICTP formed an alliance with the University of Trieste, resulting in the first international MSc programme in Medical Physics, headed by R Padovani and R Longo. This MSc on Advanced Studies in

Medical Physics, with IAEA support, has already produced several alumni (including graduates from Central/Eastern Europe) and has the strong support of the Italian Association of Medical Physics (AIFM) [35].

In 2003 the author discussed with N Suchowerska from Australia that the experience from education/training progress in one whole region (Central/Eastern Europe) could be very useful for Asia (and in particular South-East Assia). In this connection a full day Education and Training Workshop was organised by N Suchowerska, K Inamura and S Tabakov, as a satellite event to the World Congress WC2003 in Sydney. The success of this event led to a further similar Workshop (with more countries) as a satellite event to the World Congress WC2006 in Seoul (organised by A Krisanachinda, Kwan Ng and S Tabakov).

The materials from these activities, and from the Workshops of the ICTP College, were gathered and published by ICTP in a new book: Medical Physics and Engineering Education and Training, 2011 [36]. The book included a number of various MSc curricula and was distributed to senior colleagues from almost all LMI countries. It presented an overview of the global progress of medical physics education and training.

Workshop on Education and Training was made also in Moscow, 2010 (Fig.16), satellite to the 3rd Euro-Asian Congress on Medical Physics, supported by the Russian Association of Medical Physics (AMFR). This activity (organised by V Kostiliev, B Allen, F Nuesslin, S Tabakov) identified possibilities for opening of new medical physics educational courses in the regions of Siberia and in the former Soviet republics.

To transfer this experience in Latin America such Workshop on Medical Physics Education/Training was made successfully as satellite to the ICMP2011, Porto Alegre, Brazil (organised by S Tabakov, R Wu, M do Carmo Lopes, P Costa, R Terini, M Freitas). This activity also assessed the possibility for CAMPEP accrediting MSc courses in this part of the world. In 2014 King's College London and the University of Sao Paulo formed a joint project for translation the EMERALD Diagnostic Radiology Training Curriculum and associated Training tasks in Portuguese for use in Brazil [37]. The project included a Workshop Medical Physics Training in Sao Paulo, 2014 with many senior specialists from the country (Fig.17).

Fig.16 Organisers of Workshop on Medical Physics Education and Training, 2010 Moscow

Fig. 17 Participants of the Workshop for dissemination of the Emerald-BR project in São Paulo, 2014, Brazil.

To transfer this experience for developing of MSc courses in Africa, Workshops on Education and Training were held as satellite to the ICMP2013, Brighton, UK (Fig.18), and also as satellite to the WC2015, Toronto (both organised by S Tabakov and F Nuesslin). These Workshops were financially supported by IUPAP and included also specialists from IAEA and WHO. These IOMP-IUPAP Workshops became a traditional collaboration between the two organisations for the support of LMI countries. During ICMP2016 similar Workshop was made satellite to the ICMP2016, Bangkok (organised by S Tabakov, Y Pipman, A Krisanachinda, Kwan Ng, S Pawiro) Fig.19. Another Workshop was held as satellite to the WC2018, Prague (organised by S Tabakov, Y Pipman, L Judas, F Nuesslin), Fig.20.

Fig.18 IOMP-IUPAP-IAEA-WHO Workshop Medical Physics Development in Africa ICMP2013, Brighton, UK

During the ICMP2016 IOMP expanded its activities on the subject to set its own IOMP School, which was repeated at the AOCMP2017, Jaipur (organised by J Damilakis, S Tabakov, M Stoeva, A Krisanachinda and A Chougule). The IOMP School is now a regular activity organised also as a Virtual event with Web-Seminars in 2020 (organised by J Damilakis, M Rehani, A Chougule, M Stoeva).

In the period 2005-2015 the author worked with colleagues from Central/Eastern Europe for the inclusion of their languages in the Multilingual Scientific Dictionary of Medical Physics Terms. This was important as many countries allowed education only in the national language, while most textbooks were on English (and some of the other most popular languages). To further promote the growth of the Dictionary a special Workshop was held with colleagues from Central and Eastern Europe (organised by S Tabakov and V Tabakova, as part of project EMITEL [47]), satellite to the WC2009, Munich, Germany. As a result 13 out of the 32 languages in the Dictionary (40%) are from Central and Eastern Europe: Bulgarian, Czech, Hungarian, Lithuanian, Polish; Estonian, Romanian, Latvian, Russian, Slovenian, Croatian, Georgian, Ukrainian (the teams of translators are listed at the Dictionary and Encyclopaedia web site www.emitel2.eu) [38].

These many activities resulted in significant increase of medical physicists in Central/Eastern Europe. The increased confidence in the professional status of these countries led to selecting Sofia, Bulgaria to host the European Conference in Medical Physics in 2012, and the same year Czech Republic was selected to host the World Congress 2018 in Prague.

Fig.19 IOMP-IUPAP Workshop Education and Training with IAEA participation, Bangkok, ICMP2016

Fig.20 IOMP-IUPAP Workshop on Education and Training with IAEA participation, Prague, WC2018

This brief history addresses specifically activities related to the organisation of new educational courses and associated training. The next step – introducing in the education novel methods and equipment – is an ongoing process, which has always been led by the largest societies and organisations of the profession. We have to specifically mention here the Summer Courses on AAPM, which in the past 10 years were made available free to colleagues from LMI countries through the Virtual Library [39]. Similarly the regular Summer School which EFOMP organised, has a special role in the updating of the course content.

The EU projects which EFOMP led in the past decade were similarly pivotal for updating the knowledge of all colleagues in Europe. Specific projects were presented in the MPI Journal, together with statistics of their implementation. Some of these projects included activities organised in Central/Eastern European countries [40, 41]. The current free Webinars add further dimension to the update of educational courses (of course, plus disseminating new knowledge to the colleagues). These activities continue and the colleagues are constantly informed of new short courses or certified activities.

Conclusion

It was obvious from the books in 2010-211 [33, 36] that the profession in Central/Eastern Europe has developed with fast pace for just 15 years. While the book from the Budapest Conference [8] showed only several curricula, the further publications presented confidently their progress in education and training. To make another point-check, we commissioned from EFOMP a paper on the development of education and training in 2018 [42]. This paper was presented at the Workshop at WC2018, Prague (Fig. 20). The author H Hrsak from Croatia had used specific Questionnaire and has analysed the current status of medical physics education and training in several countries from Central/Eastern Europe. The results show significant increase of medical physicists in this part of the world. It is also shown that the need of such professionals in healthcare would require further boost of education and training.

This brief history of the development of medical physics education and training in Central/Eastern Europe is part of the celebrations of the development of medical physics in Europe, related to the 40th Anniversary of EFOMP in 2020. The history presents the fast progress in the region, starting from two educational courses (and no training), and reaching level similar to this of other countries with traditions in this field.

Most projects briefly described in the paper are covered in the book "The Pioneering of e-Learning in Medical Physics" [44], which the authors dedicated to all colleagues who took part in these projects and volunteered their contribution for the global development of medical physics.

The paper showed how important is to have models for development and to exchange expertise on international level (the two Annexes to the paper present two of the important models used for establishing educational courses and training activities). This is also well shown in the Summative papers from the IOMP Regional Organisations from Middle East, Latin America, Africa and South – East Asia (presented in the History – related Special Issues of this Journal Medical Physics International – see www.mpijournal.org).

The need to boost the profession through education and training was one of the main reasons for the initiation of the Journal Medical Physics International [43], which serves the profession since 2013 and provides open access information to all colleagues. These activities were, are and will be fundamental for the global growth of the profession and the quality of the services which medical physicists deliver to healthcare [45, 46, 47].

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Being personally involved in the initiation, development and dissemination of many of the activities presented in this short description of the education and training development in the countries from Central/Eastern Europe, the author would like to thank most heartily to all colleagues who took part in the above-described projects, Workshops/Seminars and other activities.

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47. Tabakov S (2018), History of Medical Physics E-Learning Introduction and First Activities, Journal Medical Physics International, Special Issue No.1 2018, p 82-109 (available free from www.mpijournal.org)

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ANNEX 1

Inter-University Education Centre ERM, Plovdiv: MSc in Medical Physics - MSc Modules Syllabi

This Annex 1 presents the outlines of the project ERM MSc modules syllabi. The development of the ERM project Curriculum and Modules syllabi was coordinated by S Tabakov. The Syllabi are presented here as an indication of the quality of the teaching programme developed in the MSc course ERM in Medical University Plovdiv during the period 1996-1997, as well as the quality of the many others courses, which used elements of this curriculum as part of their development.

The main lecturers of the respective modules are listed at the end together with the Lecture Notes. Many of these lecturers are now professors and senior specialists, some changed their affiliation, others retired and some are no longer with us. Naturally over these 20+ years the syllabi have developed to include new methods and equipment (and excluding the outdated ones). In a similar manner the teaching materials have been updated.

Module 1. Basis of Human Anatomy and Physiology

Aims:

The aim of this 3-weeks module is to present the theoretical knowledge on the structure of the human body and the basic mechanisms of its function.

Objectives:

Having successfully completed the module, the student should have the basic knowledge on the structure of each principal functional system of the body and to understand how do the organs work separately and as integrated units into the body. The student should obtain scientific information on the principal instrumental methods for studying human structure and for investigating the function of human organs and functional systems, their physical basis and clinical importance, the possible sources of error and artefacts which depend mainly on the human organism.

Learning Program:

The module ‘Basis of Human Anatomy and Physiology’ consists of 9 submodules. Each of them concerns one of the basic structural and functional systems of the human being: structure and function of the cell (in health & disease); nervous system; muscle and skeletal tissues; heart and circulation; blood and lymph; respiratory system; gastrointestinal system; urinary system; and endocrine system. A detailed syllabus for the course is attached.

<u>Syllabus Outline</u>

* The cell - physical structure and functional systems of the cell. Genetic control of the cell function and cell reproduction. Genetic diseases.

* Cellular injury, apoptosis, cellular death, neoplasia.

* Functional systems of the human body, biocybernetics; homeostasis. Human and cell metabolism.

* Extracellular transport of fluids and nutrients - diffusion and active transport.

* The control systems of the body (basic principles of control systems; control mechanisms and automaticity of the body).

* The nerve cell - structure and basic functions. Electrical phenomena in the nerve cell. Ionic basis of excitation and conduction. Basic physics of membrane potentials (resting membrane potential, the nerve action potential and after potentials).

* The nerve trunks; velocity of conduction in nerve fibres; inhibition of excitability (local anesthetics); recording membrane potentials and action potentials; electroneurograme; glia.

* The synapses - structure of synapses; electrical events at synapses.

* Anatomy of the central and peripheral nervous system. Anatomy of autonomic nervous system.

* Physiology of processing information in the central nervous system. reflexes (integrative function of the nervous system).

* Anatomy and physiology of the organs of sensations (cutaneus, deep and visceral sensation, pain, vision, hearing and equilibrium, smell and taste).

* Motor functions of the nervous system. Higher functions of the nervous system (leaning and memory). Behavioural and emotional functions of the nervous system. Electroencephalography.

* Skeletal muscle - physiological anatomy of skeletal muscle and skeletal muscle fibre.

* Molecular mechanism of muscle contraction. Muscle hypertrophy; muscle atrophy and electrical stimulation of skeletal muscle. Electromyography.

* The smooth muscle (physiological anatomy). Contractile process in the smooth muscle (membrane potentials in smooth muscle and excitation contraction coupling; automaticity).

* Skeletal tissues: Macroscopic and microscopic structure of the bone, tendons and ligaments.

* Skeletal tissues: Mechanism of calcification and development of the bone.

* Skeletal tissues: Diseases of the bone (osteoporosis, Paget’s disease, rickets, osteomalacia, osteomyelitis, sarcoma).

* Anatomy of the heart muscle. Action potentials in cardiac muscle. Contraction of cardiac muscle. Rhythmic excitation of the heart - the especial excitatory and conductive system. Structure and function of heart valves. The cardiac cycle. Normal heart sounds. Phonocardiography.

* Regulation of the heart function. cardiac insufficiency.

* Electrocardiography. Echocardiography. Other methods for studying the structure and the function of the heart.

* Anatomy of the system circulation. Hemodynamics. Arterial pressure and its control. Arterial pulses and pressure pulses in the veins. Sphigmography and phlebography. Cardiac output and venous return.

* Physiologic anatomy of the pulmonary circulation. Pressure of the pulmonary system. Circulation trough special regions.

* Methods for studying the circulation plethismography, capillaroscopy, oscillography. The circulatory insufficiency - shock.

* Red blood cells - anatomy of the red blood cell. Normal values for the number of the red blood cells and methods for counting. Haemoglobin. White blood cells - general characteristics and morphology; properties and function. Normal values for the number of white blood cells. Immunity and allergy. Blood groups. Transfusion.

* Thrombocytes. Hemostasis and blood coagulation. Blood coagulation tests. The lymph.

* Blood disease.

* Functional anatomy of the respiration system and structure of the airways. Pulmonary ventilation and alveolar ventilation.

* Gaseous exchange - physical principles. transport of oxygen and carbon dioxide in the blood. Respiratory exchange ratio. regulation of respiration.

* The pulmonary volumes. and capacities-spirometry; methods for measuring the gaseous exchange and blood gases in humans. respiratory insufficiency.

* Anatomy of the gastrointestinal system.

* Movement of food through the alimentary tract. Secretory function of the alimentary tract. Digestion and absorption. The liver. Methods for studying the function of gastrointestinal tract.

* Nutrition and dietary basis.

* Anatomy of the kidney and the urinary tract and basic theory of nephron function. Renal blood flow through the kidneys. Glomerular filtration. Reabsorption and secretion in the tubules. Micturition.

* Methods for studying the function of the urinary system. Renal insufficiency.

* Anatomy of the endocrine glands. Nature of hormone. measurement of hormone concentrations in the blood.

* The hypothalamus as a gland. The pituitary hormones, the thyroid hormones and parathyroid hormone, the adrenocortical hormones, the pancreatic hormones.

* Reproductive and hormonal functions of the male. The female hormones. Pregnancy and lactation.

* Fetal and neonatal physiology. Methods for studying glandular function and structure.

Additional Teaching Materials to the Course Lecture Notes:

Ganong, W. F. Review of Medical Physiology., Lange Medical Publ., Los Altos, 18th ed., 1995

Greenspan, K.700 Multiple-choice Questions with Explanatory Answers (Physiology)., Prentice-Hall Int., 1990.

Guyton, A. C. Textbook of Medical Physiology., WB Saunders Co., Philadelphia, 9th ed., 1995.

McMinn’s Interactive Clinical Anatomy, Mosby, London, 1997.

Tortora, G. Introduction to the Human Body., Biol. Sci. Textbooks Inc., 4th ed., 1997.

Vander, A. J., J. H. Sherman, D. S. Luciano. Human Physiology - The mechanisms of body function., Mcgraw-Hill Inc., New York, 1994.

Laboratory equipment:

Myograph, EEG and ECG equipment, HP - multifucntional patient equipment, equipment for studying the function of the respiratory system, equipment for studying the blood.

Hours:

The module consist of 90 hours teaching of which there are 72 hours lectures, 6 hours seminars, and 6 hours of practical work. In addition 6 hours tests are included.

Links with Other Modules:

Provides basic information for Modules 4, 5, 6, 7, 8, and 9.

Student Assessment: Three tests during module delivery.

Module 2. Radiation Physics

Aims:

The course aims to present the theoretical and practical foundations for a new physics and/or engineering recruit to the basics of radiation physics.

Objectives:

Having completed the module, the student should have all necessary knowledge about ionizing radiation, its sources, its characteristics and also about the ways in which this radiation interacts with the matter and the effect it causes. He will gain some practical experience on the work with radioactive sources and on the measurements of their basic characteristics.

Learning Program:

The course is divided into six sub-modules. The first covers the radiation from atoms and molecules. X-ray radiation and its physical features are thoroughly explained. Sub-module two describes the phenomena radioactivity. Emphasis is placed on different radioactive decays, on gamma-radiation and on physical laws governing them. Sub-module 3 covers the sources of nuclear radiation and their practical applications while sub-module 4 deals with different nuclear reaction and the techniques for production of radionuclides. The last two sub-modules explain the interaction of the ionizing radiation with the matter and the effects which appear in it as a result of the interaction.

Syllabus Outline

* Atomic spectra. Bohr’s model of the atom.

* Quantum model of the atom and the molecule.

* Quantum theory of the atomic radiation

* X-ray radiation - general physical features

* Radioactive decay - general features. Radioactive theory. Radioactive series.

* Alpha and Beta radioactivity. Gamma radiation.

* Gamma radiation.

* Isotope sources.

* Nuclear reactors

* Accelerators

* General information on nuclear reactions

* Reactions with charged particles

* Photonuclear reactions.

* Neutron reactions.

* Production of radionuclides.

* Interaction of charged particles with matter.

* Interaction of X-rays and γ-rays with the matter.

* Interactions of neutrons with the matter.

* Effect of the radiation on the structure of the matter.

* Chemical effects.

* Biological effects.

* Dosimetry and radiation protection - fundamentals, definitions, parameters.

Additional Teaching Materials to the Course Lecture Notes:

K. S. Krane, Introductory Nuclear Physics, John Wiley&Sons, New York, 1988

R. Chandra, , Introductory Physics of Nuclear Medicine, Lea&Febidger, Philadelphia

F. J. Blatt, Modern Physics, Mc-GRAW HILL, Inc., 1992

Glenn F. Knoll, "Radiation Detection and Measurement", 2nd edition, John Willey & Sons - New York

D. G. Giancoli, Physics, principles with applications, Prentice Hall, Inc. 1980

Laboratory Equipment:

All the equipment in the laboratories of the Chair "Atomic Physics" at Plovdiv University will be accessible for the students.

Hours:

The module consists of 37 hours lectures, 33 hours practical work and 10 hours seminars. 10 hours of tests are also included, so that the course requires 90 hours to complete.

Links with other Modules:

Provides information for modules: 3, 4, 7 and 8.

Student Assessment: Five tests during module delivery and unseen written exam after the module.

Module 3. Radiation Measurement

Aims:

The aim of this three-weeks module is to present the theoretical and practical foundations for a new physics and/or engineering recruit to the field of radiation measurements.

Objectives:

Having completed the course, the student should have the knowledge and the practical skills required to plan radiation measurement experiment and to assemble apparatus for such experiment. The student should know the sources of possible errors, and on this base should be able to estimate the physical and technical limitations to the accuracy in a given measurement.

Learning Program:

The module is divided into three sub-modules. The first gives introduction to the field, common things for all the detectors and measurements procedures are covered there. Sub-module 2 describes a wide range of detectors. The underlying physics for each detector is explained The applications to which each detector can be put are discussed. The last sub-module covers the electronic devices, which are most commonly used with radiation detectors.

Syllabus Outline

* Detectors. General features. Classification. Modes of operation.

* Influence of the statistical processes on the radiation measurements. Basic characteristics of the detectors. Requirements for the bias supply.

* Gas-filled detectors. General description. Typical voltage dependence of a gas-filled detector.

* Ionization chambers. DC chambers. Pulse ionization chambers. Pulse shapes in ionization chambers. Applications.

* Proportional counters. Gas multiplication. Proportional counter gases. Energy dependence of the proportional counter efficiency. Multi-wire proportional chambers. Applications.

* Geiger counters. Mechanism of pulse formation. Geiger counter plateau. Count rate limitations with Geiger counters. Efficiency. Applications.

* Semiconductor detectors. Basic principles of semiconductor physics. PN junction. Principles of action of semiconductor detectors. Characteristics and parameters. Classification. Applications.

* Radio-fluorescent detectors. principles of operation. Inorganic and organic scintillators. The photomultiplier device. Construction of a scintillation counter. Thermoluminiscent detectors. Applications.

* Miscellaneous detectors. Cherenkov detectors. Special detectors using noble gases. Detectors with event storage properties. calorimetric detectors.

* Amplification principles for radiation detectors. Pre-amplifiers- voltage-, charge- and current-sensitive.

* Main amplifiers - functions, resistance-capacitance shaping, pole-zero cancellation, baseline restoration.

* Single channel analyser (SCA) and discriminator. Scalars and rate-meters. Energy spectra processing.

* Multi-channel analysers. Analogue-to-digital converters. Spectrum storage and analysis.

* Timing systems. Cables and impedance matching. Fast amplifiers. Timing windows. Time to amplitude converters. Pulse shape discriminators.

* Coincidence units. Housing of electronic units. High-voltage power supply. Complete system.

* High voltage high power rectifier.

Additional Teaching Materials to the Course Lecture Notes:

Radiation Detection and Measurement, Glenn F. Knoll, 2nd edition, John Willey & Sons - New York

Radiation Detectors, C. F. G. Delaney and E. C. Finch, 1992; Caldron Press -Oxford

EG&G ORTEC, Instruments and Systems for Nuclear Spectroscopy, Handbook, 1993/94

CANBERA NUCLEAR, Edition Nine, Instruments Catalog

Laboratory Equipment:

Different gas filed detectors, scintillation probes, semiconductor detectors, SCA, MCA, counters, spectrum analysers, computers, oscilloscopes, coincidence units, base line restorers, high voltage power supplies etc.

Hours:

The module consists of 84 hours lectures, 26 hours practical work and 7 hours seminars. 6 hours of tests are also included.

Links with other modules:

a) Requires core information: Module 2

b) Provides information for modules: 7,.8, 10.

Student Assessment: Three tests during module delivery and unseen written exam after the module.

Module 4. Radiobiology

Aims:

The aim of this two-weeks module is to provide basic knowledge in radiobiology in respect to radiobiological basis of radiotherapy with special emphasis on the aspects which are of particular importance for medical physicists.

Objectives:

Having successfully completed the module, the student should:

- Be familiar with the basic radiochemical changes in biomatter and their importance for the biological effects of ionising radiation

- Understand how variations in proliferation kinetics parameters of cell populations may affect tumour and normal tissue response to irradiation

- Be able to interpret cell survival curves and major mathematical models with respect to radiotherapy of tumours

- Be able to discuss the main types of radiation cell damage and repair and their dependence on LET, 02 tension, dose, dose rate and fractionation pattern

- Be familiar with the man pathological changes in acutely and late-responding tissues, the concept of Therapeutic ratio and Tolerance doses

- Be able to discuss the impact of dose rate and fractionation on the Therapeutic ratio

- Have a general knowledge of the principal methods of radiosensitivity modification

Learning Programme:

The module covers the following general areas in Radiobiology:

1. Introduction; 2. Radiation Chemistry; 3. Proliferation Kinetics of Cell Populations; 4. Radiation Effects on Cel; 5. Radiation Response of Tumours; 6. Radiation Effects in Man; 7. Radiobiological problems in radiation therapy; 8. Developments in Radiotherapy

Syllabus Outline

* Introduction: History and definitions.

* Radiation Chemistry.

* Proliferation Kinetics of Cell Populations.

* Radiation Effects on Cell.

* Radiation Response of Tumours: Proliferation kinetics of tumours, Post-irradiation kinetics, The four R's of radiobiology and their implication in radiotherapy.

* Radiation Effects in Man.

* Radiobiological problems in radiation therapy: Acute and late responding tissues, Therapeutic ratio, Toleranse doses, The concept of NSD, Fractionated radiotherapy, Protracted radiotherapy, Whole body irradiation.

* Developments in Radiotherapy: Radiobiological problems of high-LET radiation, Radiosensitizers and radioprotectors, Hyperthermia.

Additional Teaching Materials to the Course Lecture Notes:

Principles and Practise of Radiation Oncology, Perec C, 1992

Radiobiology for the Radiologists, Hall, E, 1988

Elements of Radiobiology, Selman J, 1983

Biological Effects of Radiation, Coggle J E, 1983

Hours:

The module consists of 40 lectures, 14 hours practical work and seminars and 6 hours tests.

Links with other Modules:

Radiobiology is the biological basis of radiotherapy - Module 8.

Student Assessment: Three tests during module delivery.

Module 5. Non-ionization Medical Imaging - Physics and Equipment

Aims:

The aim of this 3-weeks module is to present to the students the theoretical and practical bases of ultrasonic, laser and nuclear magnetic resonance instrumentation and their medical applications.

Objectives:

Having completed the module the students should gain knowledge on the basic physical and engineering principles of operation of the corresponding instruments and systems. They will be able to operate ultrasonic and laser equipment and understand the main functional control organs of magnetic resonance imaging systems.

They will also be aware of the corresponding safety requirements and rules of adequate and safe operation. The basic principles for quality monitoring and testing will be mastered including basics on servicing.

Learning Program:

The module is divided into three main submodules. The first is dedicated to ultrasonic diagnostic instruments and systems. It covers physical, engineering and medical fundamentals and practical bases in this field. The second module is structured in a similar way for laser radiation generation and medical applications. The third is centred predominantly on the basic principles. as the nuclear magnetic resonance imaging systems presently in use are of various design and operational controls with different computers.

Syllabus Outline

Ultrasonic Medical Diagnostic Instrumentation

* Ultrasound (US) - basic physical principles.

* Generation and detection of ultrasound.

* Amplitude scanning and visualisation: A-scan.

* B-mode and M-mode scanning and visualisation.

* Electronic linear and phased array scanning. Formation of a beam from a group of crystals. Basics of phase control in scanning.

* Transducers for different scanning systems.

* Computerized ultrasonic instrumentation.

* Ultrasonic image processing.

* Ultrasonic image recording on different carriers.

* Instrumentation performance testing, quality control.

* Artefacts in medical ultra-sonography.

* Doppler effect - basic notions.

* Method of pulsed (gated) Doppler for blood flow detection and measurement.

* Duplex (simultaneous) B-scan and Doppler visualisation.

* Method and instrumentation for colour flow mapping.

* New developments in medical ultrasonics.

* Basics on biological safety of ultrasound.

Lasers, Medical Applications

I. Laser radiation. Major characteristics and techniques and apparatus for measurement.

* Description of laser radiation as electromagnetic wave: polarisation, coherence - temporal and spatial structure of the laser beam. Divergence.

* Intensity and power of light, pulse energy and pulse power, average energy and average power, power density. Spectral characteristics of monochromatic laser radiation.

* Measurement of power and energy of radiation. Measurement of temporal parameters of radiation. Investigation of polarisation and spectral characteristics.

II. Absorption and emission of light. Generation of laser emission.

* Energy levels in quantum systems. Spontaneous and induced transitions between levels. Emission and absorption of light. Non-emission transitions. Stimulated emission.

* Possibilities for light amplification. Inverse population. Methods for creating of inverse population. Active media for lasers.

* Optical resonators. Losses in optical resonators. Stable and unstable optical resonators. Inverse population medium in an optical resonator. Gain, feedback, laser generation and threshold.

* Principle construction of laser. Review of laser sources.

III. Lasers for biomedical application. Action, construction, problems.

A. Lasers with optical pumping.

* Neodimium-YAG lasers.

* Q-switched Neodimium-YAG lasers

* Frequency conversion of the Neodimium-YAG laser light.

* Continuous-wave, flashlamp-pumped and pulsed-laser-pumped dye lasers. Titanium-sapphire lasers. Operation, construction and tuning.

B. Gas discharge lasers

* He-Ne lasers - construction, operation. Argon-ion lasers and crypton-ion lasers - operation, construction.

* Carbon dioxide lasers. Continuous wave CO2 lasers - construction, operation. Pulsed CO2 lasers.

* Eximer lasers - construction, operation. Nitrogen lasers. Copper vapour lasers - construction, operation. Golden laser. He-Cd lasers.

* Semiconductor-diode lasers. Types, operation, construction, spectral range and tuning. Free-electron lasers.

* The laser as a research tool in biology.

* The laser as a clinical tool.

* Sources of ultraviolet radiation. Medical applications of ultraviolet radiation. Evaluation of ultraviolet radiation in hospitals.

* Principles of fibre optics. Optical fibres in medicine. Laser safety in hospitals and research establishments.

Nuclear Magnetic Resonance Instrumentation

* Basic Physics of Nuclear Magnetic Resonance

* Basis of NMR Image formation

* Pulse sequencing in NMR Imaging

* Relaxation processes and their measurement

* NMR Image acquisition and reconstruction

* Brightness and Contrast in NMR imaging

* Instrumentation for NMR Imaging

* Biological effects and hazards of NMR

* NMR Spectroscopy

* NMR Flow imaging

Additional Teaching Materials to the Course Lecture Notes:

- Wells P. N. T. Biomedical Ultrasonics. Academic Press, 1977.

- Kissle J., Adams D. B. and Belkin R. N. Doppler Color Flow Imaging. Churchill Livingstone, 1988.

- Evans D. H., McDicken W. N. Skidmore R. and Woodcock J. P. Doppler Ultrasound: Physics, Instrumentation and Clinical Applications. Wiley Books, 1989.

- Kremkau F. W. Diagnostic Ultrasound - Principles, Instruments and Exercises. W. B. Saunders, 3rd ed., 1989.

- Fish P. Physics and Instrumentation of Diagnostic Medical Ultrasound. John Wiley & Sons, 1990.

- Hedrick W. R., Hykes D. LK. and Starchman D. E. Ultrasound Physics and Instrumentation. Mosby, 3rd ed., 1994.

Nenchev M. and Saltiel S. Laser Technique. Ed. Sofia University and Nauka i Izkustvo, 1994 (in bulgarian).

- Yariv A. Quantum Electronics. John Wiley & Sons, New York, 3rd ed. 1988.

- Milonni P. W. and Eberly J. H. Lasers. John Wiley & Sons, New York, 1988

- Arecchi F. T. and Shulz-Dubois E. O. (Eds). Laser Handbook, Vol. 1 and 2. North-Holland, Amsterdam, 1988.

- Wilson J. and Hawkes J. F. B. Lasers. Principles and Applications. Prentice Hall. New York, 1987.

- Demtroder W. Laser Spectroscopy. Springer, 2nd enlarged ed., 1995

- Law J. and Haggith J. W. (Eds). Practical Aspects of Non-Ionising Radiation Protection. Proc. Joint Meeting Hosp. Phys. Assoc., Leeds, June 1981.

- Diffey B. L. and Langley F. C. Evaluation of Ultraviolet Radiation Hazards in Hospitals. The Institute of Physical Science in Medicine, Report No. 49, 1986.

- Serafenitides A. A. Short Pulse Beam Interaction with Polymers Biocompatible Materials and Tissue. Invited Lecture. To be published in Proceedings of SPIE, 9th Internat. School on Quantum Electronics, Varna, 16-22 Sept. 1996.

- Sliney D. H. and Trokel S. L. Medical Lasers and Their Safe Use. Springer, New York, 1993.

- Carruth J. S. and McKenzie A. L. Medical Lasers (Science and Clinical Practice). (Series Editor K. Mould) Adam Hilger, London, 1994.

- Webb S. Physics of Medical Imaging, IOP Publishing, 1988

- Krestel E. Medical Imaging Systems, SIEMENS Publishing, 1988

Laboratory instruments for practical training in ultrasonics and lasers:

Modern ultrasonic scanners and nuclear magnetic resonance imaging systems will be available for demo practical on site - in the corresponding medical diagnostic departments.

Hours:

The module consist of 50 hours lectures, 34 hours seminars and practical work. In addition 6 hours tests are included.

Student Assessment: Three tests during module delivery and unseen written exam after the test.

Module 6. Diagnostic Radiology - Physics and Equipment

Aims:

The aim of this 3 weeks module is to present to the students the basic physical principles of Diagnostic Radiology. X-ray physics and principles of radiography are considered together with the aspects of X-ray engineering and maintenance. Special attention is given to the Quality Control in Diagnostic Radiology. The most important medical applications are reviewed in brief.

Objectives:

With completion of this course the students will have gained knowledge on the basic physical and engineering principles of operation of the Equipment for Diagnostic Radiology (DR). They will be able to operate DR equipment and perform DR Quality Control tests. They will also understand the basic principles of X-ray radiography and digital principles corresponding safety requirements and rules of adequate and safe operation. The basic principles for quality monitoring and testing will be mastered including basics on servicing.

Learning Program:

The course is divided into two submodules - X-ray tubes and generators (including radiography X-ray films and laboratory); X-ray Image Intensifiers and Digital X-ray systems (including X-ray TV components, Computed Tomography, Image quality assessment and patient dosimetry). All questions include elements of practical use in medicine and Quality Control.

<u>Syllabus Outline:</u>

* Introduction. Historical development. Basic methods of Diagnostic Radiology (DR). Types of DR Equipment.

* Formation of the X-ray image. Contrast, Brightness and Resolution in DR imaging. Contrast media. Characteristic features of the "Ray-image".

* X-ray tube - Elements. Anode, Cathode, Grids, Glass envelope, Housing.

* General Types X-ray tubes. Fundamentals of X-ray tubes assessment.

* X-ray tube Basic Characteristics, Parameters and standards.

* Classical High voltage X-ray generator. Elements, Construction and Basic Types. Safety issues.

* Basic electric circuitries of the classical HV generator. Medium frequency HV generators.

* HV - working regimes and generator parameters. Fundamentals of HV generator assessment.

* Radiographic film - Basic types, Characteristics. Radiographic screens - Basic types, Characteristics.

* General types and Basic elements of the Radiographic Equipment. Systems for Automatic Exposure Control in DR.

* Mammographic X-ray equipment. Tomographic X-ray equipment.

* X-ray Laboratory - parameters and standards of X-ray film processing.

* X-ray Image Intensifier - Components, Construction.

* Image Intensifier - Basic types and Characteristics. TV cameras and systems used in DR - basic types and characteristics.

* General types and basic elements of the Fluoroscopic DR equipment. Systems for Automatic Brightness Control in DR.

* Digitisation of fluoroscopic X-ray image. Basic types of ADC in DR. Basic parameters of the digital X-ray image. Window technique.

* Digital fluoroscopic X-ray equipment - basic types and characteristics. Digital Subtraction Angiography Equipment.

* Fundamentals of image reconstruction from projections

* CT scanners - construction and basic types.

* CT scanners - basic scanning and imaging parameters.

* Spatial resolution in DR imaging - comparison in different modes, assessment. The MTF concept. Test Objects.

* Noise in DR imaging-sources, influence, comparison in different modes, assessment. Anti-scatter grids.

* Contrast in DR imaging - comparison in different modes, assessment. Test objects.

* Post-processing of radiographs. 3D imaging in DR. Artefacts in DR imaging. Image archiving in DR and PACS architecture.

* Basic methods of Radiographic/Fluoroscopic/Digital DR practice.

* Concepts of Quality Control in DR. Patient doses comparison.

Additional Teaching Materials to the Course Lecture Notes:

Webb S. Physics of Medical Imaging, IOP Publishing, 1988

Krestel E. Medical Imaging Systems, SIEMENS Publishing, 1988

Forster E. Equipment for Diagnostic Radiology, MTP Press, 1993

Tortoricci M, Medical Radiographic Imaging, W.Saunders Co, 1992

Weir. J., P. Abrahams Imaging Atlas, MOSBY Multimedia, 1997

Simulations with PC and Multimedia are included in the module as well.

Laboratory instruments for practical training in Diagnostic Radiology:

Modern X-ray equipment, CT scanner and DSA systems will be available for demonstrations on site - in the corresponding medical diagnostic departments.

Hours:

The module consists of 78 academic hours, including 52 hours of lectures, 22 hours of seminars and practical exercises and 4 hours for tests.

Links with other Modules:

This module provides information for modules 2, 9, 10 and 11.

Student Assessment: Two tests during module delivery and unseen written exam after the module.

Module 7: Nuclear Medicine - Physics and Equipment

Aims:

The aim of this three-weeks module is to present the theoretical and practical foundation for a new physics/engineering recruit to the field of nuclear medicine.

Objectives:

Having successfully completed the course, the student should have the knowledge and skills required to provide scientific and technical support for scintillation probe systems, well counters, dose calibrators, radioimmunoassay (RIA) instrumentation, gamma cameras and associated computing equipment, including their Quality Control. The student should also understand the clinical foundation for common Nuclear Medicine studies as well as their implementation in clinical practice, such studies include in-vitro and in-vivo measurements of body function, RIA, two and three dimensional imaging. The student should know the common sources of error and artefact in all of these applications, the physical limitations to the accuracy of measurement, and the specifications required for state-of-the-art equipment.

Learning Program:

The course is divided into six sub-modules. The first gives a broad based introduction to the field while the following two address in-vitro counting systems sub-module 2 stresses physical measurements while sub module 3 focuses on clinical and laboratory measurements. The remaining sub modules address in vivo studies: sub module 4 covers scintillation probe studies while the last two focus on two dimensional and three dimensional imaging respectively. A detailed syllabus for the course is attached.

<u>Syllabus Outline</u>

* Contribution of Nuclear Medicine to Clinical Practice: history: current status.

* Radioisotopes used in Nuclear Medicine Production: Physical Characteristics & Implications for patient dose and image quality/assay accuracy.

* Radiopharmaceuticals: In-vivo Distribution & Kinetics: Quality Assurance Radiation Protection in Nuclear Medicine. Design of Facilities: Good Practice: Dose Optimisation

* Single probe scintillation Counting Systems: Technology and Functional Characterisation.

* Sample Assay using Well Counters and Dose Calibrators: Techniques: Sources of Error, Quality Assurance.

* Body Composition and Tissue Volume measurements

* Radioimmuno Assay (RIA): General Principles & Instrumentation

* Liquid Scintillation Counter (LSC): Principles & Technical Factors

* Data Processing in RIA

* In-Vivo Measurements with 1, 2 or 3 probe systems: General Principles and Clinical Applications.

* Linear Scanning systems: Technology and Functional Performance

* Gamma camera (a): General Principles & Construction

* Gamma Camera (b): Collimators: Design and Performance

* Gamma Camera (c): Sources of error: Functional Specification: Q.A

* Gamma Camera (d): Data Acquisition & Image Quality Measurements.

* Gamma Camera (e) Data Processing for static Images: Techniques: Clinical Implementation.

* Gamma Camera (f) Dynamic Studies: Data Processing: Clinical Implementation.

* Gamma Camera (g) Functional Imaging: Techniques: Clinical Implementation.

* SPECT (a): Basic Principles: Clinical Rationale & Technical Implementation.

* SPECT (b): Data Acquisition and Reconstruction; Sources of Error.

* SPECT (c): Image Quality: Technical Specifications for SPECT systems; QC & Acceptance Testing.

* PET: Basic Principles: Technical Implementation and Image Quality.

Additional Teaching Materials to the Course Lecture Notes:

Physics in Nuclear Medicine, J. A Sorenson & M.E Phelps 2nd Edition, 1987, W.B Saunders Company Philadelphia.

Principles and Practice of Nuclear Medicine, P.J Early & D.B Sodee 2nd Edition 1995, Mosby, St Louis

Quality Standards in Nuclear Medicine G.C Hart and A.H Smith (Editors) 1992 The Institute of Physical Sciences in Medicine. York

Laboratory Equipment:

Scintillation probes, well counter & spectrum analyser: radionucleid dose calibrator & area dose monitoring equipment: multiple sample counter; gamma camera and computer; Tc99m generator. Associated QA equipment for these instruments..

Hours:

The module consists of 72 hours teaching of which there are 42 hours lectures, 28 hours of practical work and seminars. In addition 8 hours of tests are included.

Links with other Modules:

(a) Required core information: Modules 1,2,3,4

(b) Provides information for Modules 9,10

Student Assessment:

Three tests during module delivery and unseen written exam after the end of the module.

Module 8. Radiotherapy - Physics and Equipment

Aims:

The aim of this three-weeks module is to present the physical rationale for the clinical radiotherapy, the main features and characteristics of the radiotherapy equipment and to provide dosimetric methods and physical procedures of quality assurance.

Objectives:

Having completed the module the student should gain knowledge and practical skills required to routine calibration of the treatment units, to carry out simple treatment planning, to calculate treatment time or monitor units in simple plan, to perform Quality Assurance Procedures for treatment units.

Learning Program:

The module is divided to three submodules: the description of radiotherapy equipment and sources, the electron and photon beams characteristics, the methods of ionizing radiation dosimetry, the treatment planning in radiotherapy.

Syllabus Outline

* Kilovoltage units: Operating characteristics, Grenz-Ray and contact therapy units, Superficial Therapy units, Orthovoltage Therapy units, Surface output, Beam quality, Depth dose data, Factors influencing percentage depth dose values, Isodose curves.

* Cobalt 60 units: Source and source housing, Beam collimation and penumbra, Timer.

* Linear accelerator: Principles of operation, Beam transport system, Target/flattening filter, Scattering foil, Scanning electron beam, Beam monitor, Collimation, Gantry.

* Treatment simulation and verification: Simulators, Port films, Electronic portal imaging.

* Quality of X-ray beams: Half-value layer, Filters, Measurement of Beam Quality Parameters, Factors influencing quality.

* Electron Beam Characteristics: Most Probable Energy, Mean Energy, Energy at Depth.

* Measurements of absorbed dose: Absorbed Dose, Kerma, Exposure, Relationship between Kerma, Exposure and Absorbed Dose, Calculation of Absorbed Dose from Exposure, The Bragg-Gray Cavity Theory, Calibration Protocols for Megavoltage Photon and Electron Beams, Measurements of Absorbed Dose, In vivo dosimetry.

Lect. 7h

* Dose Distribution and Scatter Analysis: Phantoms, Back scatter , Percent Depth Dose, Tissue Air Ratio (TAR), Relatioship between Tissue Air Ratio and Percent Depth Dose, Tissue phantom ratio (TPR), Tissue maximum ratio (TMR), Relationship between Percent Depth Dose and TAR, TPR, TMR, Scatter Air Ratio, Scatter Phantom Ratio.

* External Beam Dosimetric Calculations: Dose Calculation Parameters, SSD Technique, Isocentric Technique, Co60 Calculations, Irregular Fields, Asymmetric Fields, Practical Calculations

* Treatment Planning: Measurements of Isodose Curves, Parameters of Isodose Curves, Wedge Filters, Combination of Radiation Fields, Isocentric Techniques, Wedge Field Techniques, Tumor Dose Specification for External Photon Beams.

* Patient Data and Setup: Acquisition of Patient Data, Corrections for Contour Irregularities, Correction for Tissue Inhomogeneities, Field Block and Shaping

* Electron Beam Therapy: Central Axis Depth Dose Curves, Isodose Curves, Field Flatness and Symmetry, Electron Beam Treatment Planning.

* Brachytherapy: Radioactive Sources, Calibration of Radioactive Sources, Calculation of Dose Distributions, Systems of Implant Dosimetry, Computer Dosimetry, Dose Specification.

* Quality Assurance: Equipment Specification, Acceptance Testing, External Beam Units, Brachytherapy Sources, Simulator, Periodic Quality Assurance

Additional Teaching Materials to the Course Lecture Notes:

.The Physics of Radiology, H.E. Johns, J. R. Cunningham, 4th edition, Charles C. Thomas

The Physics of Radiation Therapy, F. M. Khan, 2nd edition William & Wilkins

Radiation Therapy Physics, W.R. Hendee, G. S. Ibbott, 2nd edition, Mosby

Radiotherapy Physics in Practice, J.R. William, D. I. Thwaites, Oxford Press Univ.

Hours:

The module consists of 52 hours lectures, 20 hours practical work. 6 hours of tests are also included, so that the course requires 78 hours to complete.

Links with other modules:

a) Requires core information: Module 2, 3, 4.

b) Provides information for module 10.

Student Assessment:

Three tests during module delivery and unseen written exam after the end of the module.

Module 9. Signal and Image Processing in Medicine

Aims:

The aim of this two-weeks module is to present the theoretical background and application-oriented algorithms for Signal and Image Analysis.

Objectives:

Having completed the module the students should gain knowledge and practical skills required to process X-ray, nuclear and ultrasound pictures.

Learning Program:

The module is divided in two parts. Each of them consists of 2 sub-modules.The first part gives introduction to the field, which is necessary as preliminary knowledge before the education in modules 5 through 8. The submodule 9i.1, delivered after module 4, deals with some anatomical and physiological basics of the human eye, medical image media, image parameters, storing, recording and transmitting of images. The submodule 9I.2 (below), delivered during the second term, offers basic characteristics of ECG, EEG and EMG signals and methods for their acquisition, distortion suppression and recording. The second part representing the basic course consists of 2 submodules. The first submodule deals with some problems of the signal analysis. The second submodule 9.2 is devoted to the digital image processing.

<u>Syllabus Outline</u>

* Time domain measure of signal properties. Estimation. Correlation and covariance. Cross-correlation function.

* Fourier transform. Discrete Fourier transform. Parseval’s theorem. Time and frequency domain equivalence. Power spectrum.

* Point operations. Automatic graylevel mapping. Binarization. Varying greylevel mapping. Arithmetic operations in two images.

* Local operations. Graylevel smoothing. Emphasizing graylevel differences. Sharpening graylevel steps.

* Global operations. Two dimensional case. Spectral experiments.

* Region-oriented segmentation. Thresholding. Connectivity analysis. Feature extraction.

* Contour-oriented segmentation. Detection of contour points. contour enhancement. Linking contour points. Contour approximation.

* Hough transform. foundations.

* Morphological image processing. Binary morphological procedures. Morphological processing of greylevel images.

* Texture analysis. Foundations.

* Pattern recognition. Foundations.

* Image sequence analysis. Foundations.

Additional Teaching Materials to the Course Lecture Notes:

Bessman H. and Ph. W. Besslich (1995) 'Ad Oculos Digital Image Processing. Student Version 2.0'. Intern. Thomson Publish.

Baxes G. A. (1994) 'Digital Image Processing. Principles and applications'. John Wiley & Sons, Inc.

Challis R. E. and R. I. Kitney (1991) 'Biomedical signal processing (in four parts). Part 1 Time-domain methods'. Med. Biol. Eng. Comput., Vol. 28, 509-524.

Challis R. E. and R. I. Kitney (1991) 'Biomedical signal processing (in four parts). Part 2 The frequency transforms and their interrelationships'. Med. Biol. Eng. Comput., Vol. 29, 1-17.

Challis R. E. and R. I. Kitney (1991) 'Biomedical signal processing (in four parts). Part 3 The power spectrum and coherence function'. Med. Biol. Eng. Comput., Vol. 29, 225-241.

Dotsinsky I. A. (1996) 'Notes on ECG Preprocessing', University of Patras, Greece.

Pavlidis Th. (1982) 'Algorithms for Graphics and Image Processing'. Comp. Sci. Press, Inc.

Hours:

The module consists of 48 academic hours including

32 hours lectures, 12 hours practice and 4 hours tests.

Links with other Modules:

Provides information for modules 5 through 8.

Students Assessment:

Three test during module delivery (one for M9I and two for M9).

Module 10. Radiation Protection and Hospital Safety

Aims:

The aim of this three-weeks module is to provide basic information on hospital safety and radiation protection. It provides an understanding of and respect of recommendation relating to the safe use of ionizing and non-ionizing radiation. Specific principles concerning the protection of individuals are presented.

Objectives:

Having completed the module the student should gain knowledge and practical skills required to use safely ionizing radiation, adopting the proper methods for protection, understanding the basic principles of safety in hospitals.

Learning Program:

The module consists of two submodules. The first one deals with hospital safety, electrical safety and other aspects of hospital safety.

The second submodule reviews basic concepts in radiation protection, presents radiation units, discusses the significance of various radiation levels. Some simple calculations in radiation protection are presented. Practical aspects for users are included, in particular a review of detectors is included.

<u>Syllabus Outline</u>

Safety in Healthcare

* Introduction

* General healthcare and safety problems

* Manual handling

* Seating

* Display screen equipment

* Control of substances hazardous to health

* Electrical safety

Radiation Protection

* Introduction. A brief history of the human knowledge about biological effects of ionising radiation. Early development of the radiation protection recommendations. Tasks of radiation protection, basic definitions, quantities and units.

* Biological basis of radiation protection - deterministic and stochastic effects. Sources of information about effects to humans after radiation exposure - epidemiological studies and risk models.

* Philosophy of Radiation Protection. Radiation risk - a comparison to other risks. Radiation exposure from natural sources. The conceptual framework and the system of radiation protection - ALARA principle. Dose limitation system, recommended by the ICRP. International basic safety standards and other relevant publications of IAEA, CEC etc. National legislation in the field of radiation protection. National dose limitation system and radiation protection standards. Codes of practice and guidance notes.

* Radiation protection instrumentation used for radiation surveys of photon beams. Methods and instrumentation for measuring the dose from neutrons. Dose measurements in mixed radiation fields. Dosimetry of electrons. Radiation protection instrumentation used for survey of radioactive contamination of surfaces, skin, clothing. Calibration and quality assurance.

* Personnel dosimetry. Personnel dosimeters - film badges and TLD cassettes. Dose to the trunk and to the extremities - ICRU recommendations. Calibration and quality assurance. Assessment of the activity incorporated in the organism by bio-assay methods and in vivo by whole body counting systems.

* Environmental radioactivity measurements. Sampling techniques. Low-background counting systems. Gross-counting and spectrometry measurements. Gamma spectrometry by high purity germanium detectors. Measurements of radon and radon progeny in the human environment.

* Factors affecting dose to patients, staff and public. Designation of supervised and controlled radiation areas and controlling access. Patient doses in diagnostic radiology. Dose optimisation

* Protection from external radiation. Time, distance, shielding. Workload, use and occupancy factors. Shielding design for primary, scattered and leakage radiation. Barrier calculations.

* Internal radiation protection. Routes of entry, body burden and critical organs. Determination of dose from internally deposited radio-nuclides - bio-kinetic models and committed effective dose calculation. Control of contamination. Protective clothing and respiratory protection. Treatment of contaminated personnel. Estimation of internally deposited radioactivity. Accident procedures. Design of areas for work with radioactive materials. Departmental design and related subjects. Patient dose in Nuclear Medicine - dose optimisation.

* Radioactive waste and transport. Storage of radioactive waste, disposal of liquid and solid wastes. Shipping and transporting radioactive materials. Practical aspects of the use of radio-nuclides - authorisation and training.

Additional Teaching Materials to the Course Lecture Notes:

Cember H. Introduction to Health Physics, McGraw Hill, 1996

Noz M.,Maguire G., Radiation Protection in the Health Sciences, World Sc. 1995

Hours:

The course consists of 52 hours lectures, 20 hours practical work and seminars and 6 hours tests.

Links with other Modules:

Requires core information: Module 2, 3, 4, 6,7,8

Student Assessment: Three tests during module delivery.

Module 11. Information Technologies in Medicine

Aims:

The aim of this one-week module is to provide the students with information about contemporary PC technologies and their application in medical practice.

Objectives:

Having completed the module the student gain the knowledge and practical skills of using information systems (IS), based on information received from computerised patient records (CPR) - clinical status, medicines for treatment, finances envisaged for medical care, also picture archiving and communication systems (PACS). The student should understand also some approaches for integration of modern diagnostic equipment to the IS's.

Learning Program:

The module reviews the computer networks, archiving systems and storage of patient records.

<u>Syllabus Outline</u>

* Introduction to information systems (IS). The main building components of IS.

* Information technologies (IT). The main components of IT.

* The general medical problems, which can be solved with the application of IT.

* Computerised patient records (CPR) - basic component of IT in medicine. Information sources for the patient.

* Centralised and distributed model of CPR.

* Integrated information systems in medicine - virtual CPR.

* Integration of diagnostic equipment to the IS. Hardware and software problems, interfaces and protocols.

* An example architecture of IS in medical department, clinical laboratory, hospital. Computerised hospital.

* X-ray department - archive of the visual information.

* Highpertext in medical IS.

Additional Teaching Materials to the Course Lecture Notes:

James A. O'Brien. Management Information Systems. Second edition. International ed. 1993.

Comuterised Medical Imaging and Graphics. Vol.15, Number 2, March-April 1991.

Scott Wallece. The Computerised Patient Records. BYTE. May 1994.

Laboratory Equipment: LAN with PC , OS Windows NT and Windows 95

Hours:

The module consists of 20 hours lectures, 8 hours of practical work and 2 hours test.

Student Assessment: One test at the end of module delivery.

Module 12. European Integration

Aims:

This one-week optional module aims to convey to students essential information about the European Union, its background, institutions and ways of functioning. The module is requirement of the EU at the moment.

Objectives:

To provide students with knowledge about the development of the EU; the way its institutions such as the European Parliament and the European Commission operate; the key policy issues (internal and external) of the Union and the importance of these issues for member countries and citizens of the EU.

Syllabus Outline:

* The European Community - aims, size, structure, historical development.

* Institutions and consultative bodies of the EC.

* EC legislation. Community law and procedures. The subsidiarity principle.

* Economic policy of the EU: The common market; European monetary system; EMU

* Other elements of the EU's internal policy: agriculture; health, education, transport and communications, environment.

* EC and the wider world. Relations EC- the rest of Europe; EC-USA, EC-Japan

* Intellectual property and the EU.

* Budget and funding within the EU. Framework programmes.

Additional Teaching Materials to the Course Lecture Notes:

Roney, Alex. EC/EU Fact Book. Fourth edition. Kogan Page, 1995.

Woods, Tony et al. European Studies. Hodder & Stoughton, 1996.

Hours:

The module consists of 30 academic hours including

20 hours lectures, 8 hours seminars/practice and 2 hours test

Student Assessment: One test at the end of module delivery.

Lecture Notes, associated with the above modules

The Lecture Notes associated with the above educational modules were published by Foundation FIM XXI, Plovdiv, Bulgaria during 1999. The authors to the Lecture Notes are the main lecturers of the respective modules:

1. Basis of Human Anatomy and Physiology (part 1), N Boyadjiev, ISBN 954 9807 12 6

2. Basis of Human Anatomy and Physiology (part 2), S Kostianev, ISBN 954 9807 13 4

3. Radiation Physics, N Balabanov, M Mitrikov, ISBN 954 9807 05 3

4. Laboratory Manual on Radiation Physics, N Balabanov, M Mitrikov, ISBN 954 9807 06 1

5. Radiation Measurements (part1) - Counting Statistics. Gas filled Detectors, A Antonov, G Belev, ISBN 954 9807 02 9

6. Radiation Measurements (part2) - Scintillation Counting. Semiconductor Detectors,

A Antonov, G Belev, ISBN 954 9807 02 9

7. Radiation Measurements (part3) - Electronics for Radiation Detection, G Stoilov, ISBN 954 9807 03 7

8. Radiobiology, M Yaneva, L Michova, ISBN 954 9807 11 8

9. Non-ionising Medical Imaging - Ultrasonic Medical Instrumentation, I Daskalov, ISBN 954 9807 08 8

10. Non-ionising Medical Imaging - Lasers for Medicine, M Nentchev, E Stoykova, ISBN 954 9807 07 X

11. Non-ionising Medical Imaging - Magnetic Resonance Imaging, G Spassov, ISBN 954 9807 09 6

12. Diagnostic Radiology - Physics and Equipment, S Tabakov, A Litchev, ISBN 954 9807 17 7

13. Nuclear Medicine - Physics and Equipment, N Sheahan, P Trindev, ISBN 954 9807 01 0

14. Radiotherapy - Physics and Equipment, F Milano, E Milieva, ISBN 954 9807 10 X

15. Introduction to Signal and Image Processing, A Litchev, G Petrova, ISBN 954 9807 19 3

16. Image Processing in Medicine, I Dotsinsky, ISBN 954 9807 20 7

17. Radiation Protection and Hospital Safety (part 1), D Pressianov, P Pavlova, ISBN 954 9807 15 0

18. Protection and Hospital Safety (part 2), C Roberts, ISBN 954 9807 16 9

19. Information Technology in Medicine, G Spassov, ISBN 954 9807 18 5

20. Introduction to European Integration, V Tabakova, ISBN 954 9807 14 2

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ANNEX 2

EMERALD Training Module on Diagnostic Radiology (X-Ray) Physics/Equipment

This ANNEX 2 presents one of the EMERALD Training Curricula. The development of this Curriculum for Training in X-Ray Diagnostic Radiology (plus associated Training tasks and Image Database) was led by S Tabakov as part of the project EMERALD. This Curriculum for structured training in medical physics was made in 1997-98 (it was updated only once in 2003). Thus some tasks are now obsolete (specifically those addressing film/screen and classical tomography). However some tasks (e.g. related to of X-ray tube/Generator assessment) are still relevant and used in many countries. Some MSc courses used part of the Training tasks as laboratories.

The EMERALD Training Curriculum is given here as an example of the breadth and depth of its coverage, and as an example of structured training (all tasks were assessed by the Consortium and external IPEM experts). If this Curriculum frame is renewed (excluding old tasks and including new ones), its concept could continue to be very useful. The concept of this training and many of its training tasks are used in many LMI countries.

Each subject of the Training curriculum has an associated DR (X-ray) Task – accessible through the hyperlinks in the left window of this address: http://www.emerald2.eu/cd/Emerald2/dr_mod/index.htm

N.B. The other Curricula and Training Tasks (with associated images) for the modules:

*Nuclear Medicine (1998),

*Radiotherapy (1998),

*MRI (2003),

*Ultrasound imaging (2003),

plus the EMERALD and EMIT project teams who developed these, can be assessed through:
http://www.emerald2.eu/cd/Emerald2/index.htm

Details follow in next pages, associating the Curriculum/Timetable with specific Training Tasks.

TRAINING MODULE ON DIAGNOSTIC RADIOLOGY (X-RAY) PHYSICS/EQUIPMENT

TRAINING TIMETABLE - TRAINING CURRICULUM (1998, update 2003)

No.	**Sub-module**	**Competencies (*)** Aligned with the IPEM Training Scheme – see at the end	**Days**
i	Introduction. Programme. Using the training materials and multimedia.		**1**
1	General principles of Radiation Protection in DR	General	**3**
2	General principles of DR Quality Control organisation and equipment	General	**3**
3	X-ray dosimetry and Patient dosimetry	**3,5,9,10,12,13**	**11**
4	Radiological image	**3,7,10,11,14**	**4**
5	X-ray tube and generator	**2,3,4,5,14,15,22**	**7**
6	Radiographic Equipment	**1,2,3,4,5,6,8,10,14,16**	**11**
7	~~X-ray screens/films and Laboratory~~ (removed in 2003)	**1,7,8,16**	**5**
8	Fluoroscopic Equipment	**1,2,3,7,8,10,11,14,15,16**	**10**
9	Digital Imaging and CT Equipment	**1,2,6,7,8,10,14,16**	**10**
10	Basis of shielding in Diagnostic Radiology	**16,17,18**	**5**
11	Digital Radiography and Spiral CT (Update added in 2003)		**5**
ii	Organising of the portfolio, training assessment, etc.		**4**
	Total for 4 months: 16 weeks x 5 days = 80 days ***Total****:*		***80***

No.	**Sub-module and Subject**	**Necessary materilas/arrangements**	**Competencies acquired**	Days	Comments
i	**Introduction. Programme. Using the training materials and multimedia**	PC, General acquaintances	**Introductory**	**1**	
1.x	**General principles of Radiation Protection in DR**		**Basic concepts of RP in DR**	**3**	
1.1	Core of Knowledge Course	Core of knowledge course Multimedia, Video	General RP in DR	2	The module is a DR-RP refresher
1.2	Observing a Radiation Protection audit	Rad.Prot. visit	General RP in DR	1	
2.x	**General Principles of DR Quality Control**		**Basic concepts of QC in DR**	**3**	
2.1	Observing a QC organisation and visit	QC visit	Genral QC in DR	1	
2.2	Acquainting with the use of various QC equipment	Various QC equipment Multimedia, Video	Using QC equipment	2	

<u>**No**</u>	<u>**Sub-Module and Subject**</u>	<u>**Necessary Materials / Arrangements**</u>	<u>**Competencies Acquired**</u>	<u>**Da ys**</u>	<u>**Comments**</u>
<u>**3.x**</u>	**X-ray dosimetry and patient dosimetry**		**X-ray dosimetry** ***(3, 5, 9, 10, 12 13)**	<u>**11**</u>	
3.1	Cross calibrate an ionisation chamber	Calibrated Dosimeter with Ion.ch. and one other	Calibrate ion.ch.	1	
3.2	Prepare and calibrate TLD chips	TLD reader and chips, X-ray equipment	Calibrate TLD ch.	2	
3.3	Visit a Personnel Monitoring Service	Arrange visit to PMS	Organisation of PMS	1	
3.4	Examine the characteristics of a DAP meter and calibrate	DAP meter, X-ray eq.	Using DAP meter	1	
3.5	Interaction of X-rays with matter Using tables with various attenuation coefficients	X-ray attenuat coef. tables Multimedia	Using tables with attn. coef. data	2	
3.6	Use software to estimate patient doses in a variety of cases; general x-ray paediatric exposures CT exposures exposures in pregnancy	Software	Using software with patient dos. data	2	
3.7	Undertake a brief patient dose survey using TLD Undertake a brief patient dose survey using a DAP meter	TLD , DAP	Practical use of TLD and DAP for patient dosimetry	2 (8)	The data will be collected for ~8 days

No.	Sub-module and Subject	Necessary materilas/arrangements	Competencies acquired	Days	Comments
4.x	**Radiological Image parameters**		**Understand/assess image param. in DR** ***(3,7,10,11,14)**	**4**	
4.1	Image formation in Radiography and Fluoroscopy. Inverse square law. Different magnification. Brightness and Contrast parameters. Contrast in Diagnostic Radiology. Contrast agents in DR. Contrast Scales.	General acquaintances (Radio/fluo room) Observing X-ray images (films/fluoro/MM)	Understand Contrast and Brightness in DR image	1	All practical use of X-ray rooms from No.5 can be in one day
4.2	Image Resolution and Unsharpness. Different unsharpnesses. Combined unsharpness. Quantitative assessment of image resolution. MTF. Practical assessment of MTF. Typical phantoms.	X-ray radio/fluo room; Sp.Resol. Test Objects; PC with image proc.soft.; Observing X-ray images (films/fluoro/MM)	Understand/assess spatial resolution in DR	1	Repeated in No.7&9 as part of a whole QC test
4.3	Image noise and SNR in DR. Noise assessment. Wiener spectrum. Contrast resolution. Typical phantoms.	X-ray radio/fluo room; Contr.Res. Test Objects; PC with image proc.soft.; Observing X-ray images (films/fluoro/MM)	Understand/assess cont.res. and noise in DR	1	same
4.4	Scatter Radiation and Contrast. Techniques for decreasing of Scatter radiation influence. Anti-scatter grids (construction and grid ratio). Stationary grids. Moving grids. Using of Anti-scatter grids. Errors in Using of Anti-scatter grids.	X-ray radiogr. room; Different Anti-scat. grids; Test objects; Films/cassettes	Understand/assess/use anti-scatter grids	1	More practical use of grids

No.	**Sub-module and Subject**	**Necessary materilas/arrangements**	**Competencies acquired**	Days	Comments
5.x	**X-ray tube and generator**		**Understand/measure/ compare separate X-ray tube/gen. parameters** ***(2,3,4,5,14,15,22)**	**7** tot	
5.1	X-ray tube Components. X-ray tube Characteristics. Loading diagramm of a X-ray tube. Some typical X-ray tube characteristics. Special X-ray tube types.	X-ray tube diagrams; Different company broshures; Several types tube inserts	Understand/compare X-ray tube paramet.	2	
5.2	Tube housing - construction. X-ray beam filtration. Light beam diaphragm. HVL measurement.Estimating the total filtration from the HVL. Shielding, leakage radiation.	Tube housing; X-ray radigr. room; Dosemeter; Al plates HVL/Filt. diagramms; ~6 X-ray film/cassetes	Understand/measure X-ray tube filtration	1	Repeated in No.7 as part of a whole QC test
5.3	X-ray tube output parameters (consistency, output variation, linearity). Typical parameters. Factors affecting tube output. X-ray tube output spectrum and distribution. Measuring of the focal spot . Assesing the beam alignement. Seasoning of a new X-ray tube . X-ray tube failure.	X-ray radiogr. room; Dosemeter; calculator, Foc. spot meas. tool; LBD align.tool	Understand/measure/calculate tube otput param., focal spot size and LBD. Learn to season the tube	2	same
5.4	Block diagramm of the X-ray Generator. Basic electrical circuitries of the HV generator. HV rectification. Electrical safety. kVp assessment with non-ivasive kVp meter. kVp waveform and ripple. kVp consistency, accuracy and variation with mA. Typical values. Other ways of kVp assessment. Timer and mA assessment. Typical values.	X-ray gen. diagrams; X-ray radiogr. room; kVp divider; kVp non-inv. meter; oscilloscope; kVp cassette; mA and Timer meters.	Understand/measure kVp with different tools. Assess ripple. Measure mA.time of the exposure	2	same

No.	**Sub-module and Subject**	**Necessary materilas/arrangements**	**Competencies acquired**	Days	Comments
6.x	**Radiographic Equipment**		**Using and QC of radiographic equip.** *** (1,2,3,4,5,6,8,10, 14,16)**	**12** tot	
6.1	General Radiography Equipment. Main features of the Control panel of a typical Radiography equipment. Practical use of Radiographic equipment. Selecting the X-ray exposure parameters (2 and 3 point systems).	General acquaintances with practice (patients) in the Radiographic room Observing radiagraphic procedures in DR	Using DR equipment; Practical selecting X-ray parameters; Patient care.	2	Observing radiographic procedures & different X-ray param. settings
6.2	Quality Control of a typical Radiography equipment. Typical QC protocol. Excel spreadsheet with QC programme. Interpretation of QC results. Additional checks in Accepting testing.	X-ray radiogr. room; Dose, kVp, etc. meters; QC protocols, PC.	Perform QC tests and QC protocols; Accept DR radiogr.eq. Interpret the QC result	2	Full QC survey (linked with experience from No.4,5,6
6.3	Specificities in QC of Mobile Radiography equipment. QC protocol for capacity discharge equipment.	Mobile X-ray radiogr. eq.; QC equipment; QC protocols, PC	Perform specific QC tests for mobile radiogr. eq. Interpret the QC result	1	same
6.4	Quality Control of Dental Radiography Equipment. Typical QC protocol. Ortho-pan Tomography Equipment - basic principles and CD tests.	Dental X-ray radiogr. eq.; QC equipment; QC protocols, PC	Perform specific QC tests and write QC protocols for Dental equipment; Interpret the QC result	2	same

6.5	Quality Control of Mammography Equipment. Typical QC protocol. Excel spreadsheet with QC programme. Interpretation of QC results.	Mammo X-ray radiogr. eq.; Special Mammo QC equip. and test objects; QC protocols, PC	Perform specific QC tests and write QC protocols for Mammo-graphic equipment; Interpret the QC result	2	same
6.6	Special Radiography equipment. Conventional Tomography Equipment - Specific QC checks and phantoms. Task 6.6 was removed in 2003	Tomogr. X-ray radiogr. eq.; QC equipment and test objects; QC protocols, PC	Perform specific QC tests and write QC protocols for Tomo-graphic equipment; Interpret the QC result	1	same
6.7	AEC systems in Radiography. Practical using of AEC. Basic AEC parameters. Quality Control of AEC.	X-ray AEC radiogr. eq.; QC equipment, test objects; QC protocols, PC.	Use of different AEC. Perform specific QC tests and write QC protocols for AEC; Interpret the QC result	2	Observing using AEC plus full QC survey.

No	Sub Module and Subject	Necessary Materials / Arrangements	Competencies Acquired *(1,7,8,16)	Da ys	Comments
7.x	**X-ray films/screens and Laboratory**		**Assess X-ray films/ screens, QC in X-ray Laboratory**	5	
7.1	Change developer/fixer in a film processor	X-ray film processor, arrange visit during change of dev/frx	Acquaint with X-ray film processing	1	
7.2	Run a routine sensitometry strip and read the results	Sensitometer, densitometer	QC in X-ray lab.	1	
7.3	Expose films of various types/speeds and measure various parameters including characteristic curve, contrast, latitude and gradient	Different films, film character., X-ray equip., densitometer	Assessing X-ray films	2	In assoc. with 7.4
7.4	Examine response of films to various types of film screens	Different screens and films, X-ray equip., densitometer	Assessing X-ray screens	1	In assoc. with 7.3

These tasks were removed in 2003 and replaced with 3 new tasks on CD and DDR and 2 new tasks on Spiral CT

(see below - 11.x New Tasks)

No.	**Sub-module and Subject**	**Necessary materilas/arrangements**	**Competencies acquired**	Days	Comments
8.x	**Fluoroscopic Equipment**		**Using and QC of fluoroscopic equip.** **Image quality assess.** *** (1,2,3,7,8,10,11,14, 15,16)**	**10** tot	
8.1	Block diagramms of II-TV sytem and contemporary Image Intensifier. Basic components and characteristics of II. Basic TV camera types and characteristics. Assessment of the image noise. Assessment of the Spatial resolution and Contrast resolution. Video signal assessment. Typical values. Typical Contrast/Detail diagramms.	II , TV and camera diagrams; Different broshures; Oscilloscope; TV line selector; Test objects; PC	Understand/compare X-ray fluoroscopic equipment; Image quality and video signal assessment	2	Linked with experience from No.5
8.2	Typical Fluoroscopy equipment. Layout of the equipment in the room. Scatter radiation considerations. Typical control panel. Typical modes of operation of fluoroscopic equipment. Practical use of fluoroscopic equipment.	Fluoroscopic room; Dosimeter	Using fluoroscopic equipment; Practical selecting of X-ray fluoroscopic param.; (Patient care).	2	As above plus more practical use of equip.
8.3	Assessment the fluoroscopic image quality. QC equipment and phantoms. Typical QC protocol. Excel spreadsheet with QC programme. Interpretation of QC results. Additional tests in Acceptance testing. Assessment of mobile Fluoroscopic equipment.	Fluoroscopic room; mobile Fluoroscopic eq.; Test objects; QC equipment; QC protocols, PC	Perform specific QC tests and write QC protocols for Fluo-roscopic equipment; Interpret the QC result	2	As No.9.1
8.4	ABS systems in Fluoroscopy. Basic types ABS systems and parameters. Dose output/II Format dependence. Patient skin entrance dose. Quality Control of ABS. Excel spreadsheet with QC programme. Interpretation of QC results. Typical parameters.	Fluoroscopic room with ABS; Dosimeter; range of attenuators QC protocols, PC	Perform specific QC tests and write QC protocols for ABS fluorosc. equipment; Assess patient skin dose in fluoroscopy Interpret the QC result	2	

8.5	Quality Control of Angiographs. Electrical requirements for Angio rooms. Angio-acessories (Film changer and 100mm camera, Synchronisator and Cine camera). Assessing the additional imaging devices and fluoroscopic modes.	Angio-room, Test objects; Oscilloscope; QC equipment and test objects; QC protocols, PC	Perform specific QC tests and write QC protocols for Tomo-graphic equipment; Interpret the QC result	2	Experienc e with several equip. types can be of need. Linked with No.10

No.	Sub-module and Subject	Necessary materilas/arrangements	Competencies acquired	Days	Comments
9.x	**Digital Imaging and CT Equipment**		**Using and QC of radiographic equip.** *** (1,2,6,7,8,10,14,16)**	**10** tot	
9.1	Postprocessing of digital images. Filtering, Harmonization, Subtraction. Histogramm manipulation. Reconstruction principles. Digital image formats and compressions. Digital image parameters. Contrast and Brightness. Typical "Window techniques".	PC. Image processing software Digital X-ray equip. (or CT console).	Image processing; Using the window technique and other built-in functions in Dig. X-ray eq./CT	2	
9.2	Formation of the digital image in DR. Typical Block Diagram of the equipment. System types. Adjusting the TV camera Gain. CCD camera.	Digital X-ray II-TV (DSA) equip. plus respective diagrams	Understand typical working modes. Adjusting camera gain	1	
9.3	DSA equipment. Practical use of DSA. Subtraction techniques. Functional imaging. Densitometry and Quantitative Cardio measurements. QC of Digital X-ray equipment. Image quality assessment. Specific test objects. Typical image quality parameters. Spatial resolution. Influence of the matrix and "processing algorithms". Contrast resolution. Noise manipulations.	DSA eq., test objects, QC equipment, pre-recorded cardio images	Using quantitative DSA measurements. QC of DSA	2	Assoc. with 9.5
9.4	Archiving of digital images. Picture Archiving and Communication Systems.	Visiting PACS Centre	Acquaint with PACS administration	1	
9.5	CT equipment. General block diagram. CT scanner generations. Basic CT equipment componentes. Practical use of CT. Typical CT scanner installation. Room and environment requirements. General CT scan and topogramm - scanning parameters. Scanning radiation dose.	CT equipment plus respect. diagr.	Understand typical CT working modes and practice	2	
9.6	QC in Computed Tomography - typical parameters. QC protocol. Figure of merit. Interpretation of results.	CT scanner, test objects, QC equipment, prerecorded images	Using quantitative CT measurements. Perform QC of CT scanner	2	

No	**Sub-Module and Subject**	**Necessary Materials / Arrangements**	**Competencies Acquired** ***(16,17,18)**	**Da** **ys**	**Comments**
10.x	**Basis of shielding in Diagnostic Radiology**			**5**	
10.1	Perform shielding measurements using a variety of materials (*eg* lead, lead glass, barium plaster, ordinary plaster, x-ray tables, concrete *etc*)	Shielding materilas, dosimeter, attn.tables	Perform basic DR shielding measur.	2	
10.2	Comment on a pre-existing room plan	Room plan	Assess DR room shielding	1	
10.3	National, EU and International regulations and standards in Diagnostic Radiology	Standards, Regulations	Acquaint. with the basic rag/std docum. in the field of DR	2	The subject is taken in detail in the Rad.Prot. module

No.	**Submodule and Subject – UPDATE 2003**	Necessary Materials/Arrangements	Competencies acquired	Days	Comments
11.x	**Digital Radiography and Spiral CT**				
11.1	Testing DDR and CR Systems – Introduction and Routine Testing (Non-Image Quality)	General acquaintance CD/DDR Equipment Test objects		1	
11.2	Testing DDR and CR Systems – Qualitative Image Quality	CD/DDR Equipment		1	
11.3	Testing DDR and CR Systems – Quantitative Digital Analysis	CD/DDR Equipment		1	
11.4	Basic Principles of SPIRAL CT	General acquaintance Spiral CT equipment		1	
11.5	Quality Control of SPIRAL CT	General acquaintance Spiral CT equipment Test objects		1	

Diagnostic Radiology Competencies (as per IPEM Training Scheme)

A. Use of Equipment The trainee shall be able to:

1.
B operate most types of X-ray unit for the purpose of equipment testing (complex X-ray units, CT scanners, etc may require the assistance of an experienced operator);
2.
B perform measurements and test procedures appropriate to the commissioning and periodic performance testing of various types of diagnostic X-ray equipment;
3.
B select and operate appropriate measuring equipment for radiation quantity in the primary beam, attenuated beam and scattered beam. (These should include ionisation chambers, geiger counters, scintillation counters and solid state devices);
4.
B operate non-invasive tube voltage measuring devices;
5.
B perform other basic tests such as measurement of radiographic exposure time, half value layer filtration, beam collimation, tube leakage, etc.;
6.
B perform specific performance tests on specialised equipment e.g. mammography units, conventional tomography systems and CT scanners;
7.
B check the imaging performance of various types of X-ray equipment, including measurement of contrast, resolution, unsharpness, noise, distortion etc. and use of appropriate test objects and test phantoms;
8.
B prepare reports and draw conclusions resulting from tests and measurements on various types of diagnostic X-ray equipment.
9.
C calibrate or arrange calibration of various types of test equipment for diagnostic radiology equipment.

B. Quality Assurance and Quality Control The trainee shall:

10. B be aware of factors affecting dose to patients, staff and public;
11. B be aware of consequences, hazards and control of scattered radiation;
12. B be familiar with methods for measurement of patient, staff and environmental dose (including the use of TLD);
13. B be able to calculate the dose to organs and the effective dose;
14. B have an appreciation of the magnitude and range of dose for various X-ray procedures;
15. B be familiar with the use of protective clothing and equipment for patients and staff,
16. B be familiar with the designation of supervised and controlled radiation areas, appropriate systems of work and means of controlling access;
17. B be able to calculate the required thickness of protective barriers and shields and choose appropriate types of shielding materials;
18. B be able to measure the attenuation of protective barriers and shields;
19. B take appropriate action in case of accidents and incidents;
20. C supervise and perform test procedures appropriate to the commissioning and periodic performance testing of various types of diagnostic X-ray unit;
21. C review data and reports of equipment surveys and discuss with others the findings, implications and action required;
22. C assess equipment in terms of its safety and suitability for use;
23. C provide guidance on routine quality control quality assurance procedures for various types of diagnostic X-ray equipment.

Legislation Guidance The trainee shall:

24.
B be able to discuss the scope and requirements of relevant national legislation.;

25.
C be able to interpret and apply existing legislation, codes of practice, guidance notes and related documents appropriate to diagnostic radiology;

26.
C be able to interpret and apply appropriate standards documents, in particular British and European standards;

27.
C be able to overview the procedures involved in the design and commissioning of new diagnostic radiology facilities;

28.
C have knowledge of alternative diagnostic techniques and modalities (such as ultrasound and MRI) for obtaining diagnostic information with particular reference to reduced radiation dose;

29.
C be thoroughly familiar with methods of dose assessment, calculation of dose and use of protective measures and be able to take appropriate action in case of incidents or accidents.