Teaching Nuclear and Radiation Physics at the Czech Technical University in Prague

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SUMMARY

The Czech Technical University in Prague, founded on the basis of a decree of the Emperor issued in 1707, is the oldest and largest technical university in the country. Nowadays, it is the only technical university dealing with all aspects of nuclear and radiation sciences and their applications. Since the 1950s, the Faculty of Nuclear Sciences and Physical Engineering (FNSPE) has been a faculty of the Czech Technical University. Though it does not deal only with nuclear topics, and nuclear engineers now form only about one third of its graduates, the Faculty represents a powerful teaching and research capacity, more or less unique in the contemporary world, where confidence in nuclear power is still influenced by the Chernobyl accident, and nuclear power plants have become popular targets for various environmentalist movements. The structure of courses and study programmes on nuclear issues has been adapted to this social atmosphere. First of all, a wide variety of orientations in applied nuclear physics and chemistry are offered: not only nuclear power, but also medical and other applications, environmental aspects, radiation physics and chemistry, etc. Courses dealing with many other topics, e.g., applied mathematics and information sciences, are also offered. Some other faculties of the University are also engaged in the nuclear and radiation “business”, e.g., the radon group at the Faculty of Civil Engineering, and the Department of Fluid Dynamics and Power Engineering at the Faculty of Mechanical Engineering. The Institute of Experimental and Applied Physics, dealing with nuclear and subnuclear physics and radiation detection, as well as the Centre for Radiochemistry and Radiation Chemistry, were founded a few years ago as a part of the University.

1. CTU AND FNSPE FROM THE BEGINNINGS TO THE PRESENT TIME

CTU Prague is a typical technical university, with no study programmes in humanities and a relatively low proportion of humanities courses in the technical studies programmes (which can be understood as a weak point). The university consists of 6 faculties

- Civil Engineering,
- Mechanical Engineering,
- Electrical Engineering,
- Nuclear Sciences and Physical Engineering,
- Architecture,
• Transportation Sciences,

and 3 university institutes

• Klokner Institute of Building Materials,
• Masaryk Institute of Advanced Studies,
• Institute of Biomedical Engineering.

This structure means that CTU does not deal comprehensively with chemistry (except nuclear chemistry at the Faculty of Nuclear Sciences and Physical Engineering and at the Centre for Radiochemistry and Radiation Chemistry), with economics (except in specialized departments at the first three faculties, in the MBA programme at the Masaryk Institute, and in some programmes at the Faculty of Transportation Sciences), or with agriculture, which form basic parts of most technical universities. These fields of study were separated off by the communist government in the 1950s, and specialized universities in these study areas still exist in Prague.

The history of CTU dates back to 1707, when Emperor Joseph I published a decree allowing the former military officer Ch. J. Willenberg to establish an engineering school in Prague for sons of the Czech Estates. Willenberg started only 10 years later, with 12 students, 3 of whom completed the courses. The present-day CTU has slightly more than 22,000 students and about 3,000 staff members, of whom about one half are academic staff. Unfortunately, the failure rate has improved only moderately from Willenberg’s times.

The Faculty of Nuclear Sciences and Physical Engineering, as the key faculty of the CTU Prague in nuclear sciences, was founded under the name Faculty of Technical and Nuclear Physics in 1955, as a part of the very ambitious plans to set up and develop a nuclear programme in former communist Czechoslovakia. The best nuclear scientists in the country were at the birth of this new institution. At the same time, the Institute of Nuclear Physics was founded in Řež, near Prague, which was intended as the main research centre for the developing (and economically and politically important) science. For the first four years, the Faculty formed part of Charles University in Prague, but in 1959 it was transferred to the Czech Technical University in Prague. Practically all its study programmes in the 1950s and in the first half of the 1960s dealt with nuclear sciences (both physics and chemistry, and their applications), as well as related topics needed for the development of the nuclear industry, e.g., material sciences, solid state engineering, and electronics.

Unfortunately, the Czechoslovak nuclear programme made much slower progress than had been anticipated. It therefore became necessary to extend the topics covered in the teaching and research activities of the Faculty. More fields of applied physics were added. In 1969, the Faculty was given its present name. From the 1970s onwards, specialisations in applied mathematics, mathematical modelling, software engineering and information sciences were introduced. Nowadays the Faculty offers a wide spectrum of courses at all three stages, in accordance with the recommendations of the Bologna Declaration. MSc and PhD level graduates still represent the main “product”.

Basic and applied nuclear sciences represent a significant part of the Faculty’s programme. Roughly speaking, one third of the Faculty is nowadays “nuclear”, one third deals with non-nuclear branches of physics and, last but not least, one third covers various topics and applications of mathematical and information sciences (see, e.g., [1]).

Dealing specifically with nuclear sciences, we can conclude that, in the Faculty’s first decade, the nuclear studies were divided in a classic way into nuclear physics, nuclear chemistry, and nuclear reactor theory and technology. In the mid 1960s, advanced MSc programmes in dosimetry and application of ionising radiation were set up. This still did not satisfy the
requirements of society and of the potential students. In the early 1990s, the spectrum of nuclear studies was extended to some rather attractive fields, such as medicine and environmental sciences.

2. SOCIETY AND NUCLEAR ISSUES IN THE CZECH REPUBLIC

There are two nuclear power plants in the Czech Republic: Dukovany and Temelín. The older plant, Dukovany, has 4 units of 440 MW_{el} power. Construction started in 1974 according to the Russian project of VVER units, and the plant entered operation between 1985 (1st unit) and 1987 (4th unit). The newer plant, Temelín, is possibly the politically most controversial building in Europe. It has two units of 1000 MW_{el} power, and construction began in 1987. After the fall of the communist regime in 1989, the decision was taken to replace the Russian control system and fuel by a system and fuel provided by Westinghouse. This prolonged the building period and increased the cost, but on the other hand it also increased the technical and safety level. The first unit reached criticality in 2001, and the second unit started trial operation in 2002. Nowadays both units are in full commercial operation.

Both NPPs are in the southern part of the country, Dukovany about 40 km and Temelín more than 60 km from the Austrian border. Temelín, in particular, has become a target of attacks by the Austrian ”greens”, by Czech organisations related to them, e.g., the so-called “South Bohemian Mothers”, and sometimes also by the Austrian political authorities. We must take them into account as a factor influencing the atmosphere in the country in relation to the nuclear industry and nuclear sciences.

Scientists are aware that there are advantages as well as disadvantages in the applications of nuclear science. The points in favour of the nuclear sciences (see, e.g., [2]) can be summarised as follows:

- reliable and safe operation of NPP Dukovany, which is remarkable because it is based on a relatively old Russian design,
- lack of alternative sources of energy and the strong impacts of mining coal and burning it for power generation, which has environmentally destroyed large areas of land in Northwest Bohemia and North Moravia (the main production areas), and elsewhere.
- good experience and wide application of nuclear methods in medicine,
- a well elaborated system of laws regulating nuclear activities and a good system of control,
- the need to deal with the impact of natural radioactivity, as a large part of the Czech Republic lies in a region with a high concentration of natural radionuclides, and as uranium mining was a very important branch of Czech industry in past decades,
- a long tradition in nuclear sciences and technologies and a relatively strong scientific and production basis,
- at least a part of the public now sees environmental influences in a broader perspective. The dangers connected with emissions of CO₂ have become a part of the perception, and nuclear power is beginning to be perceived in Czech conditions as the best solution in an imperfect world of available energy sources,
- some new concepts of inherently safe reactors have appeared and large programmes working on accelerator-driven reactor systems have been started, in which Czech research institutions (and also the FNSPE) are taking part,
paradoxically, the principle of action and reaction, which is valid not only in physics but also in society, has increased pro-nuclear attitudes in the public as a reaction against the pressure from environmentalists and from Austria.

On the other hand, there are also some factors acting against the applications of nuclear sciences, namely:

- the protracted and extremely costly construction of NPP Temelín,
- as yet, no clear concept and no specified location for a final depository for the nuclear wastes,
- considerable import of various anti-nuclear activities from neighbouring Austria, sometimes with political backing from the Austrian authorities, which forms an unstable environment for Czech decision makers and can be influential on the political level,
- nuclear sciences and technologies usually require great initial investments, which are sometimes beyond the financial possibilities of Czech universities, research laboratories and industrial companies.

As a result of these contrasting influences, in recent years a more realistic view has emerged of the nuclear industries, together with a slight revival of interest in nuclear sciences and applications in comparison with the period immediately after 1989 [3].

This description of the situation cannot be taken as a deep analysis, but it may provide an idea about the social context in which we educate our specialists in nuclear sciences. More detailed information about the situation in the first half of the 1990s can be found in [4].

3. TEACHING NUCLEAR SCIENCES AT FNSPE CTU PRAGUE

The BSc level degree programmes at the FNSPE are now divided into two main branches, one of which has six sub-branches:

a) Nuclear engineering:
- Nuclear reactor theory and engineering,
- Dosimetry and application of ionising radiation,
- Radiological techniques in medicine,
- Experimental nuclear physics,
- Radiation protection and the environment,
- Nuclear facilities.

b) Nuclear chemical engineering

The MSc level degree programme, as the second step according to the Bologna declaration, is now divided into two main branches and seven sub-branches:

a) Nuclear engineering:
- Nuclear reactor theory and engineering,
- Nuclear energy and the environment,
- Dosimetry and application of ionising radiation,
- Radiological physics in medicine,
- Experimental nuclear physics,

b) Nuclear chemical engineering
- Applied nuclear chemistry,
- Chemistry of the environment.
Doctoral programmes cover similar topics as the BSc and MSc programmes, and extend and deepen the knowledge gained at the lower levels in the direction toward science and research.

As has been shown, the Faculty covers practically the whole spectrum of the nuclear sciences, from basic experiments, microcosm theory and high energy particle physics (some of the departments are involved in CERN programmes), through applications of nuclear and radiation physics and chemistry in medicine, research and industry, to practical issues connected with nuclear reactors, the fuel cycle and nuclear legislation. Wide-ranging collaboration with other universities (e.g., the Faculty of Mathematics and Physics of Charles University in Prague), with research institutes and with industrial research laboratories at home and abroad forms an integral part of this programme.

The Faculty has a small VR-1 nuclear reactor (a swimming-pool type light water reactor, maximum power 5 kW), which serves as a good tool for training students specialising in nuclear science. Unfortunately, it was necessary for financial reasons to stop operating the microtron, which was another useful tool for both teaching and research work at the Faculty. Further very useful equipment includes the electron microscope for material research, the X-ray and neutron diffractography laboratories, the ion beam from the Van de Graaff accelerator (owned by the Faculty of Mathematics and Physics of Charles University in Prague, with which we collaborate closely), power laser systems, etc. All this equipment is also available for students to use in their project work and for working on PhD dissertations. It is also used to give students some practical experience of performing experiments and processing the results.

All the study programmes at the FNSPE have a profound general basis of mathematics, physics, information and computer sciences. English and one optional foreign language (German, French, Russian and Spanish are offered) and social sciences are also included. Students usually begin to specialise in the second or third year of their studies (the credit system makes the boundary between years of study a bit fuzzy). The very exacting character of the core courses has always made our graduates very attractive to employers.

Students in advanced courses are assigned a high proportion of research tasks and specialised topics. Great emphasis is placed on student projects (see, e.g., [5]). All students spend a significant part of their time at a computer, and a significant part of the Faculty budget is spent on setting up and updating the computer laboratories. The negative consequence of this approach is that some students are satisfied with producing a nice computer model of some process, and it can be very difficult to convince them that they must verify the model experimentally.

4. NUCLEAR ISSUES AT THE OTHER FACULTIES AND INSTITUTES OF CTU PRAGUE

Nuclear and radiation sciences are also included to some extent in the study and research programmes of other parts of CTU Prague.

The Czech Republic is a country with regions where there are relatively high levels of natural radioactivity, and radon needs to be monitored. The Department of Building Structures at the Faculty of Civil Engineering deals with environmental aspects of the building industry, including radon.

Nuclear power forms nearly 40% of the Czech electrical energy mix. The Department of Fluid Dynamics and Power Engineering of the Faculty of Mechanical Engineering teaches courses dealing with the design and operation of machines for energy conversion, including nuclear
reactors and other nuclear power plant equipment. Great emphasis is also placed on optimal energy utilisation in industrial power supply, including waste heat, which is a problem of both “classical” and nuclear power plants.

Two research centres related to nuclear and radiation problems have recently been founded at CTU. The Institute of Experimental and Applied Physics, despite its name, is engaged exclusively in nuclear sciences, namely in experiments at CERN, especially with ATLAS at LHC, but also deals with the structure of atomic nuclei and double beta decay, with the development of radiation detectors and applied radiation spectroscopy. The Centre for Radiochemistry and Radiation Chemistry deals mostly with radionuclides in the environment and in wastes, decontamination of soils from radionuclides and heavy metals, and radiation technologies in chemistry. Both of these centres are also engaged in teaching, mainly at PhD level.

CONCLUSIONS

The large demand for graduates from technical universities in the Czech Republic has enabled the universities to attract considerable numbers of talented young people. This is an important issue also in nuclear sciences.

The nuclear sciences, however, are in a special position, because they have not been well understood by the public, and moreover they have been felt by many people to pose a threat. This feeling is sometimes, and for various reasons, artificially fuelled both by environmentalists and by some politicians. Nevertheless, there has been some progress in the perception of the need to continue teaching and research in nuclear physics and related branches. A gradual increase in the number of students wishing to enrol in nuclear specialisations is a positive sign, and brings hope that we will be able to “produce” a sufficient number of high-quality graduates for the needs of our nuclear industry, medicine and research. This slowly but continuously changing atmosphere provides good prospects for both teaching and research in nuclear and radiation sciences at CTU Prague.

REFERENCES


