# TIME CHARACTERISTICS OF PHOTON FIELDS AT A NUCLEAR MEDICINE CLINIC

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## 1. Introduction

The Nuclear Medicine Clinic, situated at the Faculty Hospital in Prague - Motol, has been specializing in diagnosis and treatment of thyroid gland diseases, particularly in thyroid related carcinomas. The old ward of the clinic had 30 beds, where cancerous thyroid patients were treated using solely orally administered $^{131}$I-NaI, with weekly totals going up to about 40 GBq. In addition to radiotherapeutic use of $^{131}$I, standard diagnostic procedures using mainly $^{99m}$Tc-labelled radiopharmaceuticals were also employed. Recently, the clinic has moved to a new complex, where its activities continue in much spacious and better conditions, including possible improvements in the radiation protection situation.

The penetrating gamma photons emitted by $^{131}$I from patients seem to be the principal contributor to the radiation fields at the most places within the Nuclear Medicine Clinic. This paper addresses the time variations of these fields in terms of dose equivalent rate, which has been monitored in order to evaluate the relevant exposures incurred in the practice of nuclear medicine at the clinic, where some similar measurements were carried out some time ago [1]. From the data presented, it is possible to assess the magnitude of personal doses to those directly associated with the use of radioactive materials, those who provide nursing care to the patients containing radiopharmaceuticals, as well as the members of the public, be they waiting patients, other (nonradiation) health care personnel, accompanying persons or visitors.

## 2. Radiation protection considerations

Essentially, there are two kinds of sources contributing to radiation fields at a nuclear medicine workplaces: the radioactive materials themselves and the administered patients who can be considered as moving radiation sources irradiating nearby persons.

The first type of source can affect only some specially designed places and contribute to doses of a relatively limited number of professionals, whose exposures can be adequately limited by suitable radiation protection procedures related to the receipt and delivery of radioactive materials, and their *in-house* handling, transportation as well as radiopharmaceuticals preparation, calibration and administration.

While the location and movement of the first type of sources can be fully controlled and its contribution to the radiation fields predicted, the second type of source always represents a unique group of several individual sources containing various radionuclides with generally different activities. Although the movements and whereabouts of the nuclear medicine patients can also be restricted to a certain extent, at wards with many patients and at busy nuclear medicine departments it is practically impossible to foresee their actual minute by minute activities and the resulting radiation levels at some particular places within the facilities. This is why it is desirable to have time profiles of radiation fields at selected points in order to obtain a realistic picture about the potential exposures to persons who may spend some time at these locations. The dose equivalent rate will obviously depend on the time after the administration and the distance from a patient.

In order to obtain the relevant information needed for assessing the actual levels of external gamma radiation at the ward, the photon dose equivalent rate was continuously monitored at regular 1 or 10 min intervals for several days. The time profiles of the mapped radiation fields revealed useful data, which can be of great help in optimizing and reducing the exposures received by the involved personnel and also by other persons coming in contact with cancer patients.

The patients who received radiopharmaceuticals for diagnostic purposes present minimal potential for exposure to persons nearby since the administered activities are relatively low (typically up to 740 MBq of $^{99m}$Tc-based radiopharmaceuticals). While the total effective dose to these patients may be in the order of several mSv, the dose equivalent rate at 1 m from such patients is usually about 10 μSv/h [2,3]. However, the dose equivalent rate at the same distance from a patient to whom a therapeutic quantity of $^{131}$I was administered may reach values in the range of 0.1-0.5 mSv/h. In close contacts with the patient, and this cannot be excluded in some emergency or intensive health care situations, the accumulated dose to the personnel handling the patient may easily reach levels close to the relevant occupational dose limits. One has to realize that at a distance of 10 cm from the surface of the patient body, the dose rate can amount to more than 10 mSv/h [4].

## 3. Instrumentation

Time profiles of the photon dose equivalent rate were obtained using a sophisticated monitor Gamma-TRACER [5], which can measure radiation levels in the range of 10 nSv/h to 10 Sv/h. The results of the measurement are stored in the memory and can be later transferred into a PC for further evaluation and presentation. The measuring interval can be selected from one minute to two hours. The monitor is based on two energy compensated GM counters. The final results are used to illustrate the changes in the radiation fields at some selected places. This information gives a more comprehensive picture of the existing situation as to real and potential exposure at nuclear medicine workplaces.

## 4. Results

The present work was concentrated on such places as patients' rooms, adjacent corridors as well as the gamma camera rooms. The measurements were carried out in both old and new buildings of the Nuclear Medicine Clinic. The maximum dose equivalent rate reached 3 to 100 μSv $h^{-1}$ depending on the number of patients treated, activities applied and the occupancy or movement of patients in the vicinity of the measuring point.

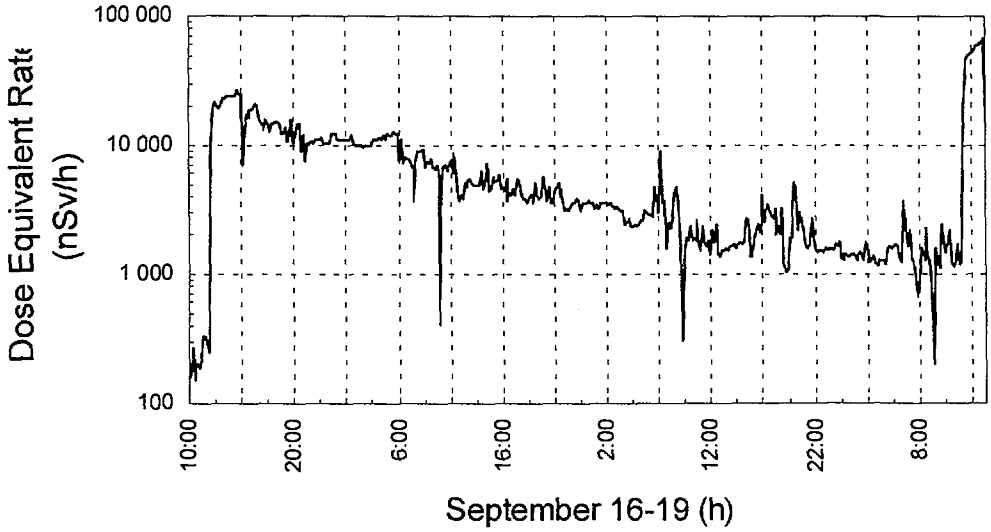
Some results of the time profile of the dose equivalent rate in the room (at about 2 m distance from the adult patient) and in the corridor are shown in Fig. 1 and Fig. 2, respectively. The radiation field in the room of a child patient during and following the application of 5.5 GBq of $^{131}$I-based radiopharmaceutical is illustrated in Fig. 3.

In order to assess the potential exposure which a technician can receive in the camera room during a typical skeleton scanning (after the administration of $^{99m}$Tc), the radiation level was monitored at a 2 m distance from the patient (Fig. 4). The actual dose equivalent rate of a person at the control desk during the examination of several patients is shown in Fig. 5. These measurements were carried out in the new building of the clinic and the results indicate the levels lower by about 20% comparing to the doses from the same examinations in old premises.

## 5. Discussion and conclusions

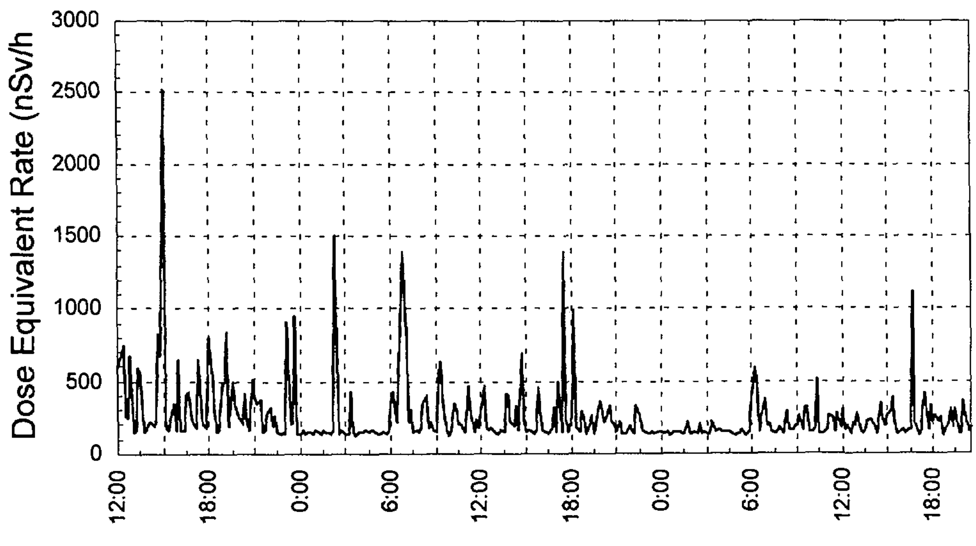
The results presented show a potential use of a field environmental photon monitor, which continuously measures external radiation levels indicating dose equivalent rate and total exposure incurred by a patient following the administration of radioactive materials. Such information can form a useful basis for implementing the ALARA principle, which is aimed at the further reduction of unnecessary exposures to nuclear medicine personnel, especially from radiotherapy applications of $^{131}$I-based radiopharmaceuticals. Since the dose rate at short distance to the therapy patients - being in some cases even over 20 mSv/h - may result in cumulated doses to the health care personnel which can exceed the relevant annual limits for professional exposures.

**Fig.1. The dose equivalent rate as a function of time showing decrease of exposure following the administration of NaI. The activity of $^{131}$I applied was 3.7 GBq to one patient on September 16 shortly before 12.00 PM and a total of 12.56 GBq administered on September 20 to three patients occupying the same room. The sudden decreases are always appearing when the patient leaves the room. It is very important to avoid any unnecessarily close contacts with those patients unless emergency or other urgent procedures occur**




It is very important to avoid any unnecessary close contacts with those patients unless emergency or other urgent procedures are required. Administration of high activities to several patients sharing a room in the ward should also be taken into account when handling the patients including food service, housekeeping, changing linen etc. Under normal circumstances, the radiation level in the corridors and other places accessible to cancer patients within the clinic are usually below 5 μSv/h averaged for 1 min intervals.

**Fig. 2. The dose equivalent rate in the corridor adjacent to the patients' room. It can be seen that during the nights the radiation level is steadily lower, in contrast to the daily dose equivalent rate, where spikes from the nearby patients are clearly visible**




The records of the time profiles of radiation fields may also be very helpful in investigating the cause of therapeutic misadministration and, retrospectively, in assessing exposures of persons without individual dosimeters, including visitors.

**Fig. 3. Dose equivalent rate in the ward room 2 m from a child patient after administration $^{131}$I-MIBG with the total activity 5.5 GBq. The intravenous application from a shielded source took about 6 hours, which resulted in the increase of radiation field during this time. After reaching the maximum corresponding to 40 μSv/h, it was falling down with the effective half-life. The local maxims and minima were caused by movement of the patient in the room and outside**

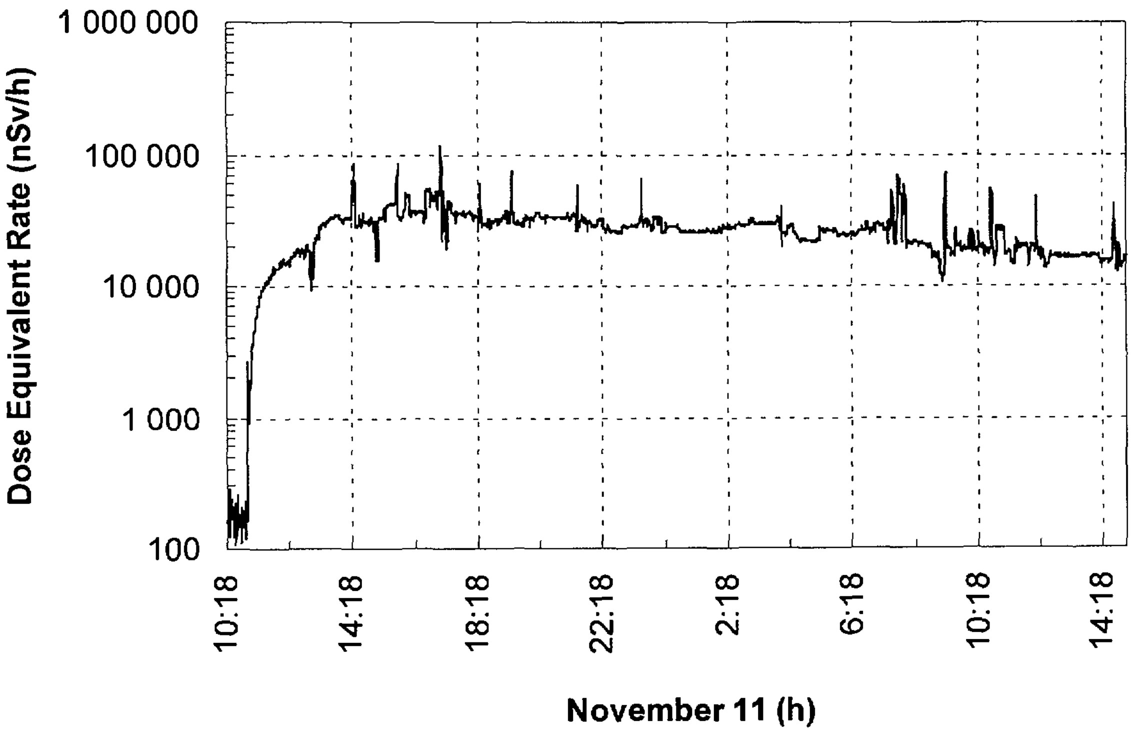



**Fig. 4. The dose equivalent rate in the two-head camera room during the SPECT skelet scanning of 14 patients with the administration of $^{99m}$Tc-radiopharmaceuticals (700 MBq). The monitor was positioned at 2 m distance from 2 m from an examined patient**

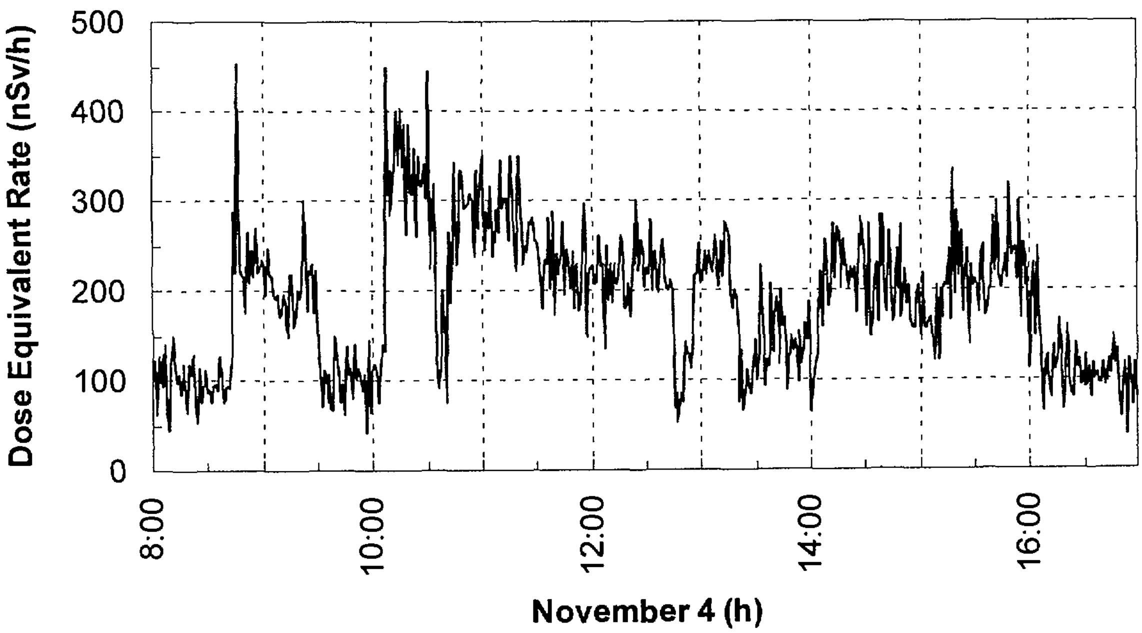
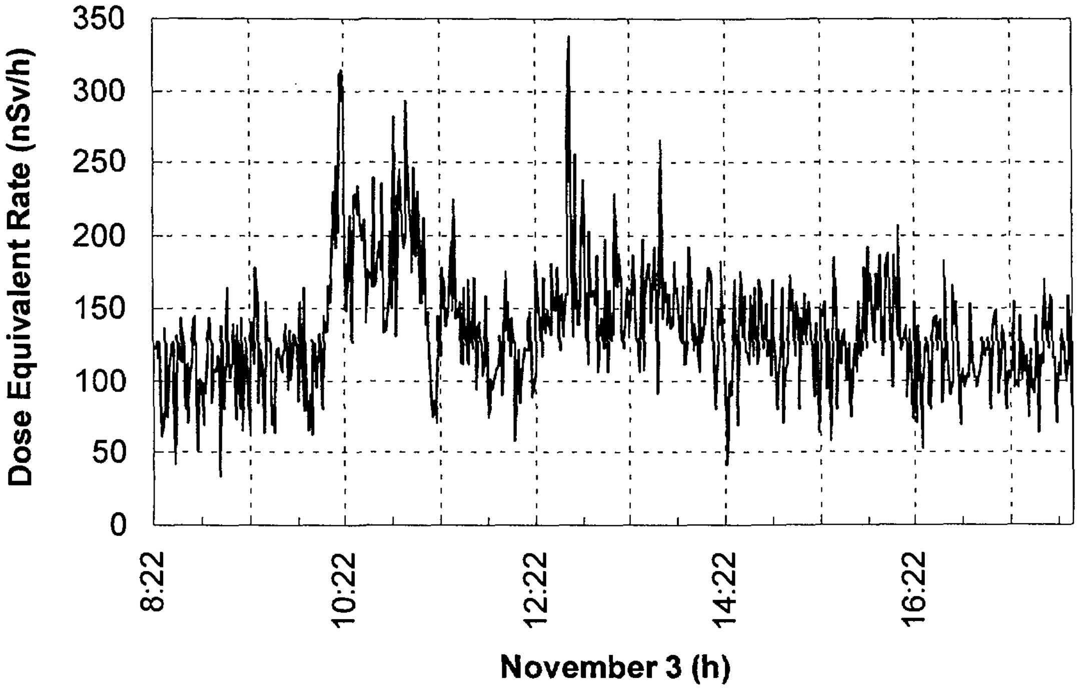


**Fig. 5. Time profile of the radiation field at the control desk of the two-head gamma camera. The monitor was at the control desk situated behind the viewing window in a shielding wall separating the camera room from the control enclosure**




## 6. Acknowledgement

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## 7. References

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# *SESSION 4*

# ENVIRONMENTAL ASPECTS OF RADIATION PROTECTION