Radiation Protection in a PET/CT Installation
The Design Change to Optimize Radiation Protection

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1 Introduction

- FDG is the most widely used radio-pharmaceutical in the medical imaging modality positron emission tomography and produces 511 KeV gamma rays in the positron annihilation reaction.
- This physical feature makes radiation doses very important.
- The process of the optimization of protection is implemented by means of detailed assessment of all the jobs, to reduce the doses as much as reasonably achievable, taking into account social and economic factors

2 Scope

Optimization of radiation protection during planning, design, construction, commissioning and operation phases for the nuclear medicine laboratory.

3 Material and Method

- A PET/CT station was installed in the nuclear medicine department at the Regional Oncology Treatment Centre.
- Prior to the planning process, a global radiation protection assessment was performed in order to achieve the necessary overall picture regarding the compliance to the individual dose constraints, as well as to the collective dose constraints.
- The outcome of this assessment allows us to apply radiation protection distinctly, with measures according to the system.
- For diagnosis, flourodeoxyglucose FDG is used with the following characteristics:
  - Maximum activity of the applied dose is 10 mCi.
  - Waiting time in the injection room is 30-60 minutes.
  - Examination time is 60 minutes.
  - Average value for the dose rate coefficient is 1 m per patient, immediately after administration of the radio-pharmaceutical is Γ=3 μGy x m^2/hour x mCi
  - Work load for the station(installation load): 8 patients/day.
- For the calculation of the actual dose rate and of the protection screen thickness, the specifications of DIN 6844-3/2006 have been used.

4 Results

1. The radiation protection screens have been improved for a reduction of the radiation dose rate for both the patients and the staff, and at the same time the available space is more efficiently used and the execution costs reduced.

	Improvement solutions	Radiation protection screens	Screen thickness	Results
Before optimization	The waiting room for the patients was next to the FDG injection room	The door between the injection room and the waiting room	30 mm Pb	High costs Strenuous handling
After optimization	The waiting room is farther from the patients FDG injection room by the insertion of a shield room (where standing is prohibited) between the waiting and the injection rooms	The door between the injection room and the shield room	10 mm Pb	Lower costs Easier handling Reduction of the radiation dose on the patient
		The door between the shield room and the waiting room	2.5 mm Pb	

Table 1 Optimising the protection screens, reduces the patient's and operator's in-taken doses and also the costs

2. Functional route have been amended so that supplemental exposure of staff is avoided.

	Entrance route		Exit route		Results
	Patient	*Worker*	*Patient*	*Worker*	
Before optimisation	The patients wait in the waiting room to be invited for investigation and then pass into the injection room	The worker enters and exits the source room through the waiting room	The examined patients exit the department without waiting for the radiation dose reduction	The worker walks the radiant patient on the exiting hallway	High radiation level for both the worker and the patient
After optimisation	The patients wait in the waiting room to be invited for investigation. In order to enter the injection room, they pass through the shield zone where standing is prohibited.	The worker enters and exits the source room through the shield zone, **only** after the patients working hours	The examined patients wait in the post-examination room for the radiation dose to lower down normal limits established for the common population members.	The worker walks on the hallway next to the post-examination waiting room	Lower radiation level for both the worker and the patient

Table 2 Modifying the functional circuits lead to a decrease of the radiation dose level in-taken by patients and medical staff

3. ***A ventilation system was commissioned*** in the nuclear medicine laboratory that was

- completely separeted from the one for the other rooms in which no open radiation sources are handled
- designed for three levels of pressure, the area controlled from the PET/CT laboratory having the lower pressure, so that possible contamination dispersion is prevented
- provided with complex filtering systems for the absorbtion of emissions and for the reduction of internal exposure to aerosol, dust, etc.

4. ***The radiation source handling time was decreased*** by the use of HOT Cell for the preparation of the injection solution.

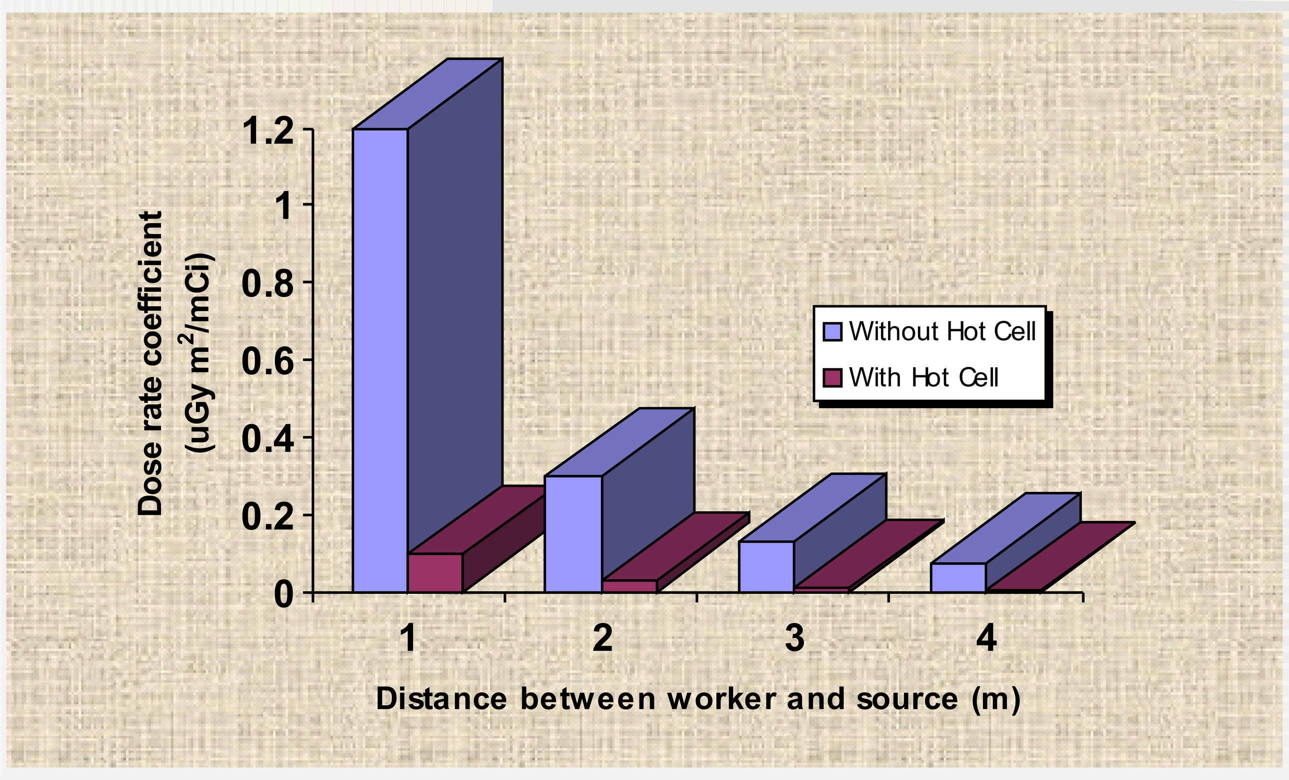

Fig.1. The decrease of the handling time of the FDG source using the Hot Cell to a decrease of the in-taken radiation dose by the operator

5. ***Initial and continuous training*** of the staff exposed to the ionised radiation environment aiming for the reduction of the number of hours spent in the radiation area.

6. ***The optimum staffing was established.***

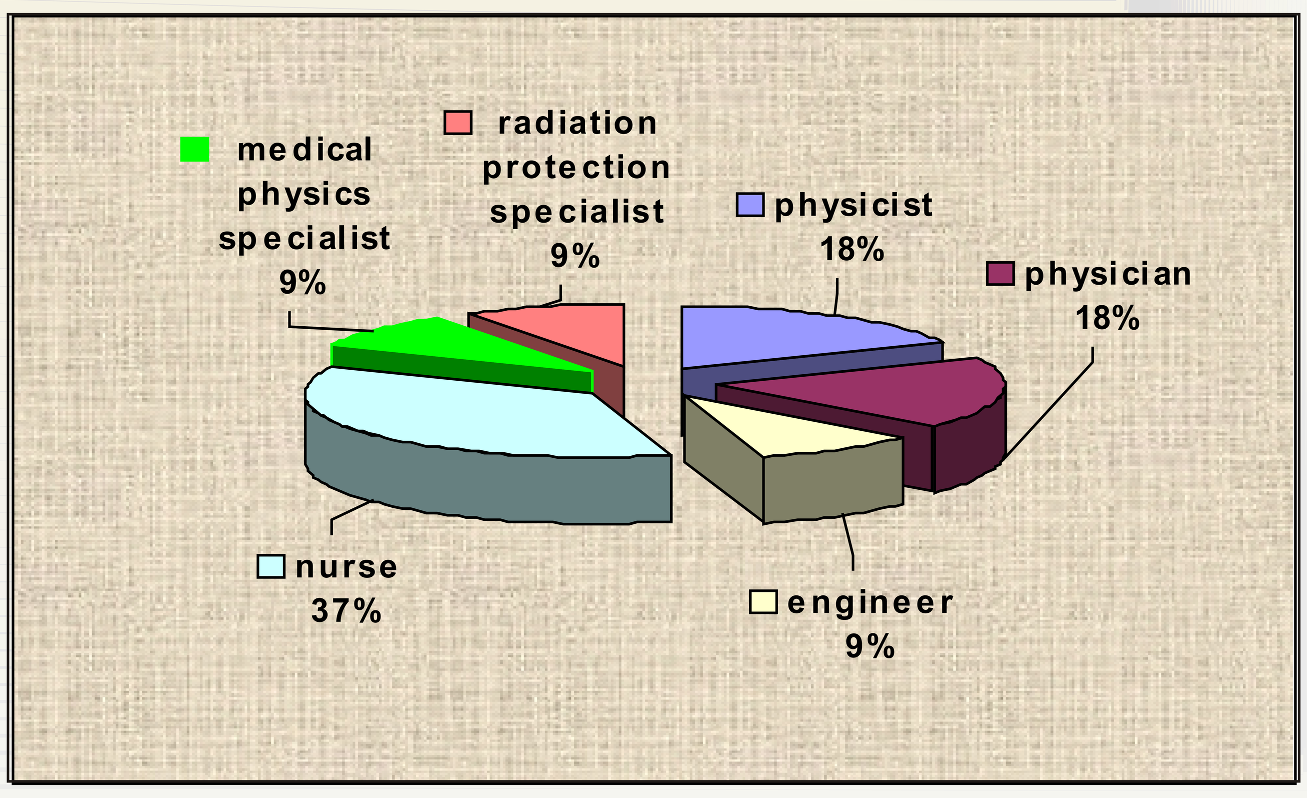

Fig.2 Using an optimum number of operators leads to a decrease of the in-taken doseper person and better results

7. ***Measures have been taken for construction supervision*** as well as for the commissioning.

8. ***A medical physics specialist*** was employed to supervise the drafting of work procedures, of quality assurance and control procedures, the measurement and control equipment.

5 Conclusions

- **The following aspects were observed during planning a PET/CT station:layout in the available space, floor load, room sizing, route establishing within the building, heating and cooling systems protection, water system protection, etc.**
- **Radiation protection is continuously optimised during operation.**
- **Reduction of workforce-related costs, due to more efficient work.**