DAΦNE TECHNICAL NOTE

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EVALUATION OF RADIATION SKYSHINE FROM THE DAMPING RING OF THE DAΦNE PROJECT

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ABSTRACT

To safely dimension the top shielding for the Damping Ring of the DAΦNE Project, the neutron dose equivalents due to the skyshine effect as a function of distance from the machine building and of the altitude have been evaluated.

The calculations were performed in two steps: source definition and radiation transport. For the first step the code used was FLUKA. The transport of the emitted particles was simulated using the CERN version of the MORSE code.

From the results obtained, it can be concluded that a 40 cm thick concrete roof makes the skyshine contribution to dose in the environment negligible, in normal operating conditions.

1. INTRODUCTION

The doses due to the skyshine effect during the injection in the Main Rings of the DAΦNE Project was already evaluated and the results presented in a previous paper (Fa92). In this note the problem is considered in the case of the Damping Ring.

This machine will be placed in a pre-existent building of the LNF, the Gamma Hall of Leale Laboratory, suitably shielded to house the new machine.

The Damping Ring will operate receiving $1.04 \cdot 10^{11}$ e^-/s from the Linac. Under normal operating conditions 5% of the beam injected is expected to be lost in the injection septa. Equal fraction of the beam could be lost uniformly in the rest of the machine. In exceptional conditions, for example during commissioning, the beam losses in the septa could be higher even by one order of magnitude than those in normal conditions, but in this case the operation will be carried out at low intensity.

The skyshine calculations were performed in two steps: source definition and radiation transport. For the first step the program used was FLUKA (Aa86, Aa93a, Aa93b), a hadron transport code which has been recently provided with an improved module for electron-photon transport (Fe92) replacing to a large extent the original EGS4 interface (Ne85). The transport of the emitted particles was simulated using the CERN version of the MORSE code (Em75, Fa87). The details of the simulations can be found in (Fa92).

The simple geometry of the building housing the Damping Ring has been represented as a parallelepiped with 14x11 m^2 base and 3 m height. The electron beam was assumed to hit a lead target of 10 cm diameter and 10 cm length. The target position was assumed to be in the middle of the building at the same height of the beam (1.8 m).

Since the photon doses resulting from the previous Main Rings calculations were rather low compared to those of neutrons, we have considered only the neutron component. The gamma dose can be easily reduced anyway adding lead over the beam loss points.

We have considered three possibilities:
- machine without roof;
- machine with 40 cm ordinary concrete roof;
- machine with 50 cm ordinary concrete roof.

2. RESULTS

The results of the calculations are shown in Figs. 1, 2, 3, 4 and 5 normalized to 10^{11} e^-/s incident on the lead target described before.

In Figs. 1, 2, 3 the neutron ambient dose equivalent rates as a function of height at various distances from the machine are shown for the three cases under consideration.

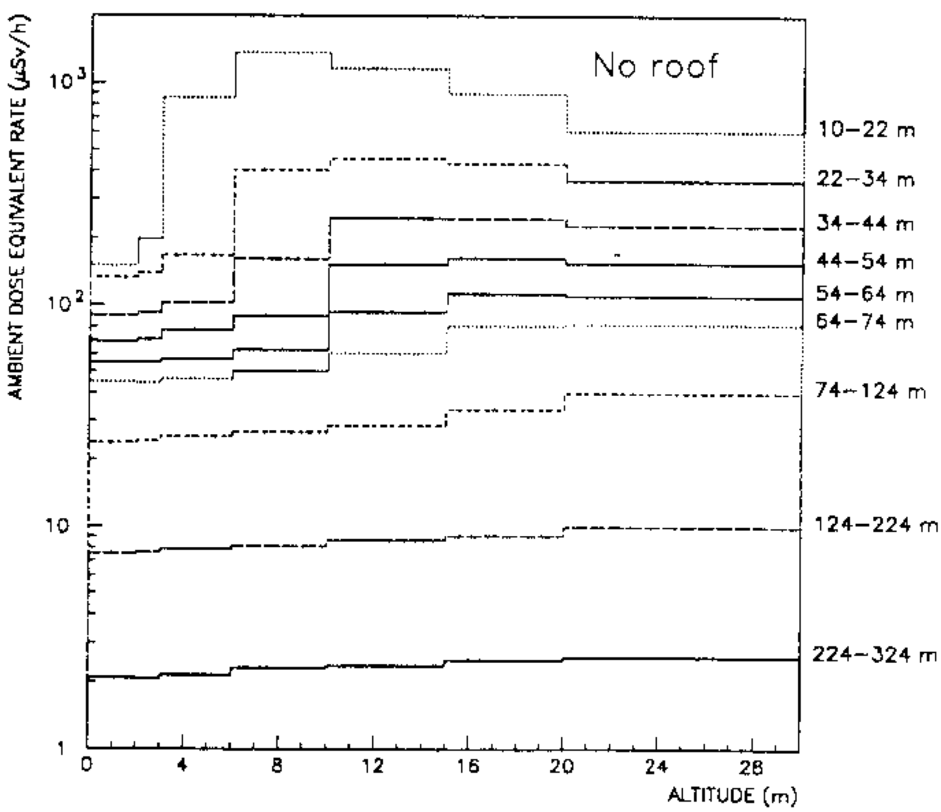

Fig. 1 - Neutron ambient dose equivalent rates as a function of height at various distances from the machine without roof.

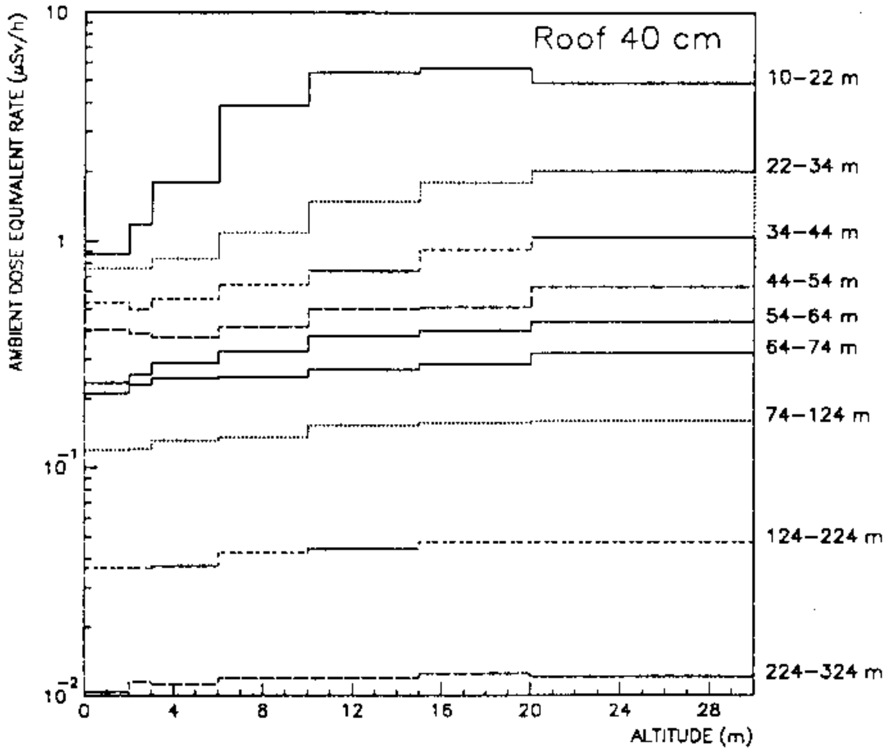

Fig. 2 - Neutron ambient dose equivalent rates as a function of height at various distances from the machine covered with a 40 cm thick concrete roof.

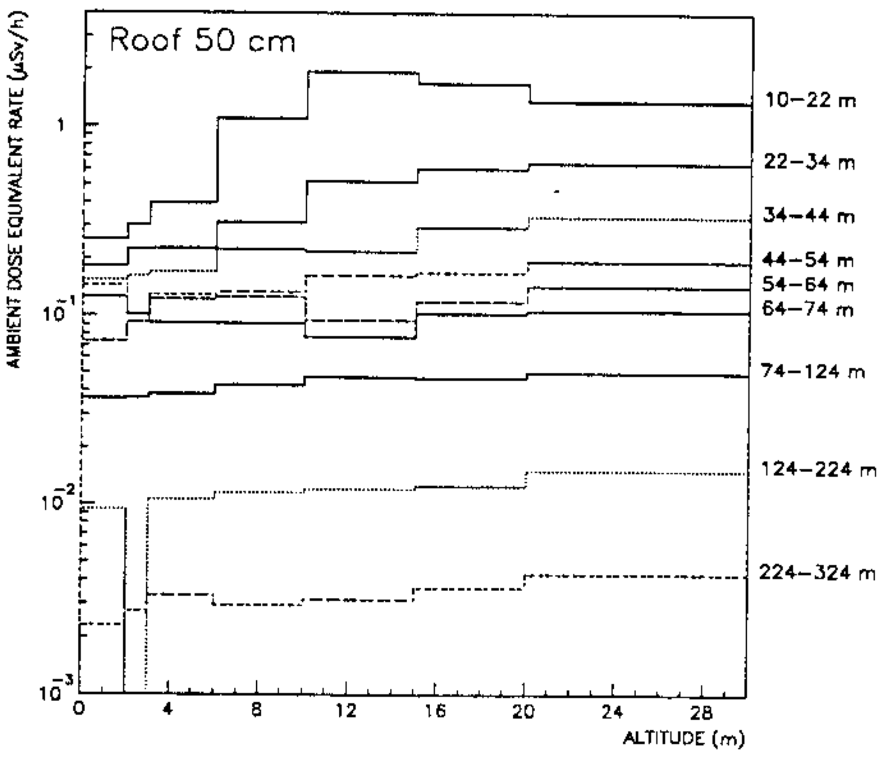

Fig. 3 - Neutron ambient dose equivalent rates as a function of height at various distances from the machine covered with a 50 cm thick concrete roof.

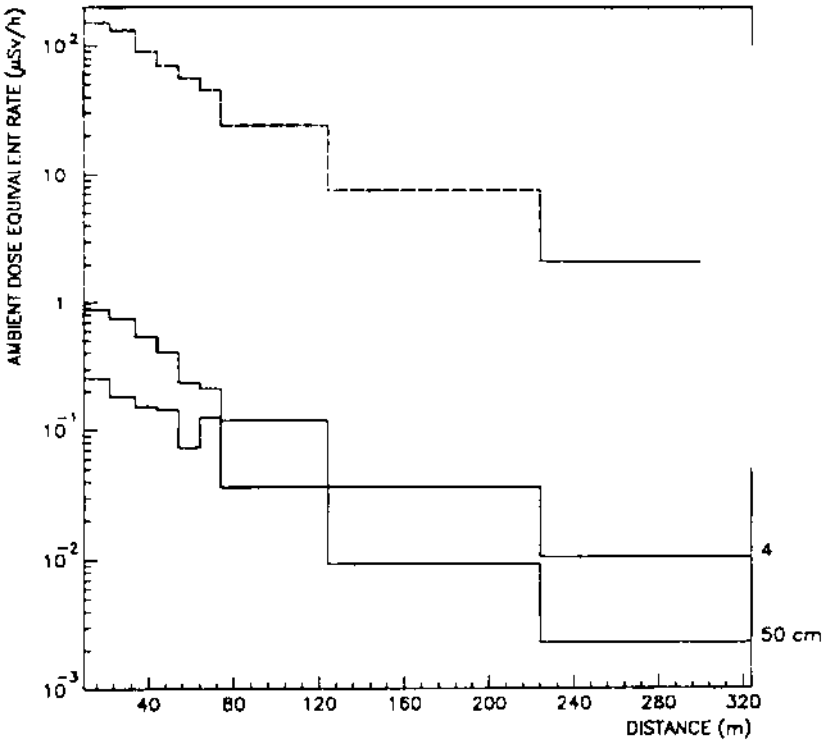

Fig. 4 - Neutron ambient dose equivalent rates as a function of distance from the machine at height between 0 and 2 m from ground.

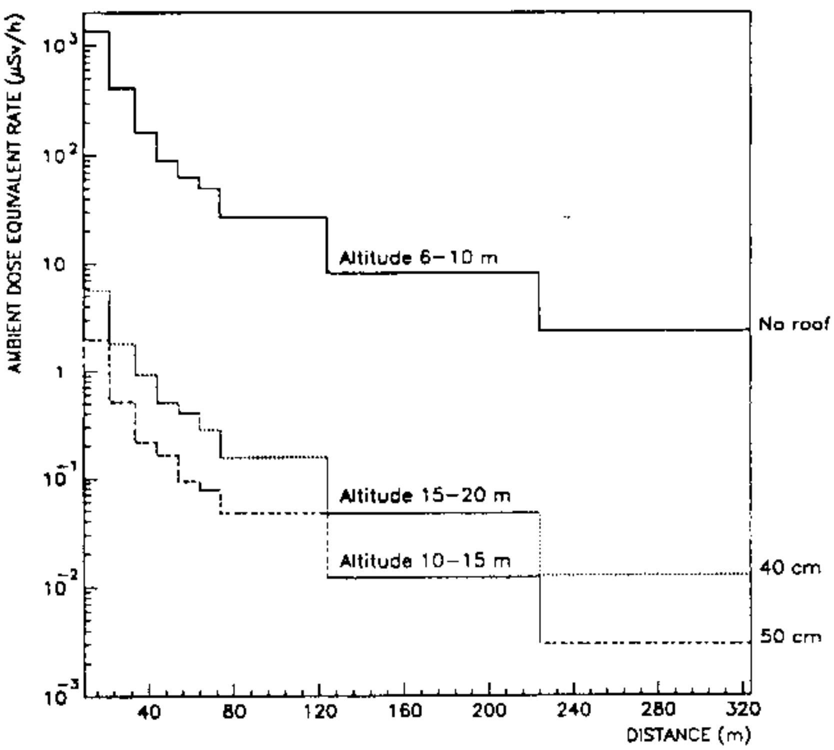

Fig. 5 Neutron ambient dose equivalent rates as a function of distance from the machine at the height where they reach the maximum value.

In Fig. 4, the average neutron ambient dose equivalent rates between 0 and 2 m from ground are shown as a function of distance from the machine. Doses at this height are relevant for potentially exposed workers around the machine.

In Fig. 5, for the three situations considered, the neutron ambient dose equivalent rates are shown as a function of distance from the machine at the height where they reach the maximum value. These data could be of interest for the radiation protection point of view of the surrounding buildings.

3. RADIATION PROTECTION CONSIDERATIONS

The dose rates shown in the figures of the previous paragraph are those expected in the case of catastrophic beam losses.

The mean neutron ambient dose equivalent rate in the area between 10 and 22 m from the machine, at a height of 2 m, has a value of about 150 μSv/h in the case of no roof. The dose level decreases slowly with distance. By applying the empirical formula suggested by Nakamura et al. (Na81a, Na81b), we get a value higher by a factor about 2.5. This difference, not particularly important, could probably depend on the uncertainties linked to the use of a rather general formula.

With a concrete roof 40 cm thick the dose between 10 and 22 m from the target reduces to 0.85 μSv/h, while with 50 cm we would have 0.25 μSv/h. In both cases the doses are negligible at distances of 100 meters or more. At some height, the doses can be higher by a factor 10.

It has been decided to cover the machine with a concrete roof of 40 cm thickness. Therefore in the case of beam losses in normal operating conditions, the doses due to the skyshine effect would be completely negligible.

REFERENCES

(Aa86) P.A. Aarnio, A. Fassò, J.H. Moehring, J. Ranft, G.R. Stevenson, *FLUKA86 user's guide*, CERN Divisional Report TIS-RP/168 (1986);
P.A. Aarnio, J. Lindgren, J. Ranft, A. Fassò, G.R. Stevenson, *Enhancements to the FLUKA86 program (FLUKA87),* CERN Divisional Report TIS-RP/190, 1987.

(Aa93a) P.A. Aarnio, A. Fassò, A. Ferrari, J.H. Moehring, J. Ranft, P.R. Sala, G.R. Stevenson and J. Zazula, FLUKA User Guide, (to be published).

(Aa93b) P.A. Aarnio, A. Fassò, A. Ferrari, J.H. Moehring, J. Ranft, P.R. Sala, G.R. Stevenson and J. Zazula, Electron-photon transport: always so good as we think? Experience with FLUKA, to be presented at the MC93 International Conference on Monte Carlo Simulation in High Energy and Nuclear Physics, Tallahassee, Feb. 22nd-26th 1993.

(Em 75) M. B. Emmett, *The MORSE Monte Carlo Radiation Trasport Code System*, ORNL-4972, 1975.

(Fa 87) A. Fassò, *The CERN version of MORSE and its application to strong-attenuation shielding problem*, Proceedings of the Topical Conference on Theory and Practices in Radiation Protection and Shielding, Knoxville, Tennessee, April 22-24, pag. 462, 1987.

(Fa 92) A. Fassò and M. Pelliccioni, *Evaluation of radiation skyshine from the Main Rings of the DAΦNE Project*, DAΦNE Technical Note DI-8, 1992.

(Fe 92) A. Ferrari, P. Sala, G. Guaraldi e F. Padoani, *An improved multiple scattering model for charged particle transport*, Nuclear Instruments and Methods B71, 412, 1992.

(Na81a) T. Nakamura and T. Kosako, *A systematic study on the neutron skyshine from nuclear facilities. Part I. Monte Carlo analysis of neutron propagation in air over ground environment from a monoenergetic source*, Nucl. Sci. Eng. 77, 168, 1981.

(Na81b) T. Nakamura and T. Kosako, *A systematic study on the neutron skyshine from nuclear facilities. Part II. Experimental approach to the behavior of environmental neutrons around an electron synchrotron,* Nucl. Sci. Eng. 77, 182, 1981.

(Ne85) W.R. Nelson, H. Hirayama, D.W.O. Rogers, *The EGS4 code system,* Stanford Linear Accelerator Report SLAC-265, 1985.