Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Estimation of gamma radiation field by MCNP in Low dose rate irradiation facility

J.S. Shin, J.I. Kim, S.Y. Song, B.I. Lee, Y.K. Y, J.S. Kim
a Radiation Health Research Institute, KHNP, 388-1, SSangmoon-dong, Dobong-ku, Seoul, Korea
E-mail: shinjs@paran.com

1. Introduction

There are many researches giving proofs that the radiation exposure in high dose rate field causes various diseases and cancers through epidemiological study and experiments using animals. But there are few studies on the biological effects by the irradiation of low dose rate radiation. Therefore many countries have made efforts to study on effects by low dose radiation irradiation and these studies made by those countries are still in progress. In Korea RHRI(Radiation Health Research Institute) also has a plan to conduct the study on low dose rate irradiation and for this purpose RHRI installed γ -ray low dose rate irradiation facility.

Because low dose rate radiation should be irradiated with low dose rate and long term exposure time, we must know the exact distribution of dose rate in irradiation room. In particular effect of scattered radiation due to additional equipments can distort the distribution of dose rate. For this reason, we must have the accurate distribution information of given condition including additional equipments.

The purpose of this study is calculating the dose rate distribution of irradiation room.

2. Methods and Results

2.1 Low dose rate irradiation facility

The low dose rate irradiation facility is composed of cell irradiation room and animal irradiation room. The cell irradiation room has a 10Ci ^{137}Cs source. The animal irradiation room has a 5Ci and 50mCi source. This study was performed to evaluate the dose distribution in the animal irradiation room.

The animal irradiation room dimension were 7350mm × 4900mm ×3000mm. The source is enclosed in a cylindrical lead shield 700mm in diameter and 1230mm in height.

2.2 Ion chamber

The irradiation facility was calibrated by cylindrical ion chamber(Victoreen 550 series). The measurement were taken at 1m intervals between 2m to 6m to obtain the exposure rates. The exposure rate in mR/h was calculated from the integrated measurements and the exposure time at each location and then converted to Gy or mGy/h to make the comparison with the MCNP results easier. The exposure rates are plotted and used when calibrating instrument and as a reference in experiments.

2.3 Glass dosimetry

For animal dose analysis in experiment, glass dosimetry system(Asahi Techno, Dose Ace FGD-1000) be used. The glass chip was using GD-301 chip.

The measurement were taken at 1m intervals between 1m to 6m to obtain the air-absorption dose. The air-absorption dose in mGy/h was calculated from the integrated measurements and the exposure time at each location.

2.4 MCNP code

The MCNP simulation code was run with *F6 tally, and mesh tally types. *F6 tally output the energy deposition averaged over each cell in joule per gram. Mesh tallies are superimposed meshes that give the average flux of a cell in cm-2 (the same units that F4 tallies use). The output from MCNP was later converted to mGy/h for comparison with the experimental results.

The MCNP-X code was run using a 3.0 GHz CPU with 1GB RAM under the Windows XP operating system. The geometry of the source, source shielding, wall of the room were modeled in the input file.

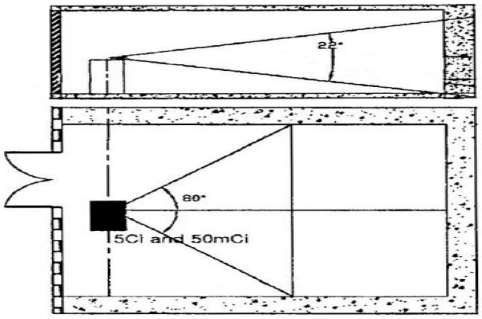

Figure 1. The plan of low dose rate irradiation facility

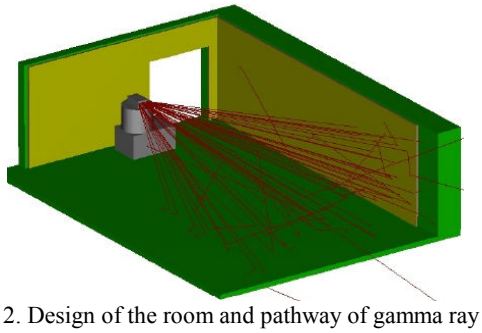

Figure 2. Design of the room and pathway of gamma ray

Table 1. Result of calculations and measurements.(mGy/hr)

Distance(m)	1	2	3	4	5	6
Ion chamber	-	3.91	1.80	1.07	0.70	0.51
Glass dosimetry	14.88	3.89	1.82	1.10	0.79	0.62
MCNP	16.22	4.04	1.84	0.97	0.68	0.55

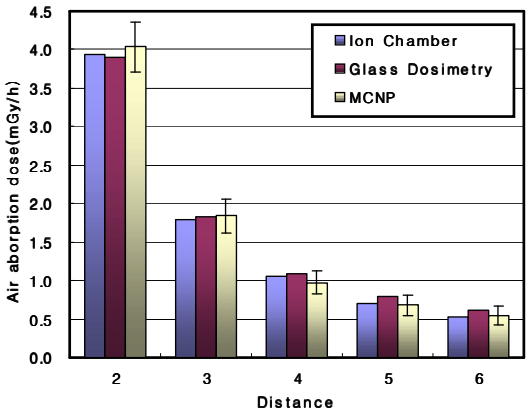

Figure 3. Comparison of MCNP calculated and measured data.

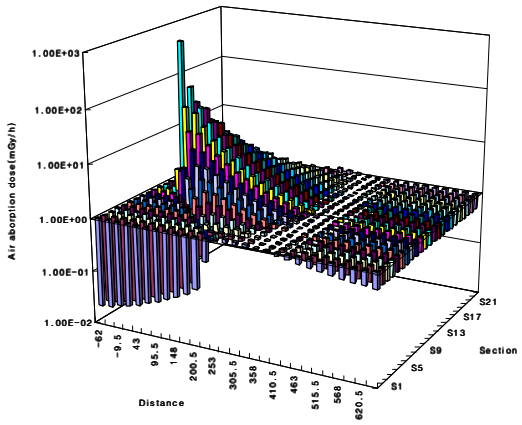

Figure 4. The dose rate map at the height of source

Two billion particle histories were run in MCNP-X to achieve an error of less than 1% for the on the center line and less than 10% for areas of the room with low dose rate. The PC took about 30h to perform the calculation.

2.5 Comparison of data

Table 1 compares the MCNP code calculated air-absorption dose rates with those obtained from the measurements at each location.

The measured exposure rates range from 3.9mGy/h at 2m to 0.5mGy/h at 6m. Our calculated results in MCNP range from 4mGy/h at 2m to 0.5mGy/h at 6m. The MCNP results agree with the measurements with in 5% for all the measured locations.

Considering the uncertainties in ion chamber measurements, the statistical error in MCNP, and assumptions made in MCNP simulation on source geometries, the MCNP-X code modeling was satisfactorily validated(Figure 3).

Distribution of Dose rate in irradiation room can be seen in the 3D plot in Figure 4.

3. Conclusion

In this study, we determined the activity of the 137Cs by the measurement (ion chamber, glass dosimetry). This activity was then used in the MCNP code calculations to predict the dose rates at the same location.

This study has demonstrated the usefulness of the MCNP code calculation for distribution of dose rate.

The result of this study can provide the informations which animal exposure study may need.

REFERENCES

[1] M. L. Rodriguez, Study of Radiation Field Characteristics of a 137Cs Irradiator by Monte Carlo Simulation, Health Physics, 85(4), 433-437(2003)

[2] C. Oliveira, J. Salgado, A. Freeo de Carvalho, Dose Rate Determination in the Portuguese Gamma Irradiation Facility: Monte Carlo Simulations and Measurements, Radiation Physics and Chemistry, 58, 279-285(2000)

[3] Jessica Leone, MarkFurler, Dose Mapping Using MCNP5 Mesh Tallies, Health Physics, Operational Radiation Safety, 88, S31-S33

[4] J. F. Briesmeister, MCNP-A General Monte Carlo N-Particle Transport Code, RSICC, Oak Ridge(1997)

[6] G. F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, New York, pp.612-613, 1999.