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Bremsstrahlung in KIRAMS Electron Microbeam Cell-Irradiation System

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1. Introduction

The KIRAMS electron microbeam Cell-Irradiation System (KEMCI) provides a well-defined electron beam for single-cell irradiation [1]. The system has been devoted to the low-dose radiation effect studies for the cultured cells. Especially, the bystander effect, which is one of the main fruits of high-LET radiation microbeam study, is also the crucial issue in the electron microbeam study although its limitations such as large angle scattering and low linear energy transfer in the medium existing. The radiation dose due to the electrons and their secondary radiations like Bremsstrahlung should be estimated for the radiobiological interpretation. In this paper, the influence of the photons generated in the peripherals including the pinhole frame on the dose profile around the target cell is simulated using Monte Carlo method.

2. Simulation

Simulation was carried out with the geometry of a stack of cylindrical ring zones. Size of each ring zone is 2.5 μm both in height and in thickness. The 70 keV electron beam of 500 μm in radius was assumed to move toward the pinhole frame in parallel on front face. The stainless steal frame with a pinhole of 5 μm in diameter and 12.5 μm in thickness is covered with a 2 μm-thick Mylar foil, which plays a vacuum window of the beam transport chamber and a 2 μm-thick Mylar-bottomed cell dish is located on the vacuum window.

3. Results and Discussions

The energy loss to the pinhole frame leads to the generation of the secondary electrons and Bremsstrahlung. The secondary electrons forwardly generated in the pinhole frame have small kinetic energies below several tens eV and stop within the very narrow region near the surface, while the Bremsstrahlung photons generated in the entrance region of the pinhole frame undergo attenuation in the frame and very small portion of the photons is emitted into the cell-culture medium. Figure 1 shows the radial dose distribution at 2 μm above the dish bottom, which represents a single layer of the cells attached to the dish bottom. Dose attributed to the photons is negligible compared to the total dose.

The angular distribution of the photons generated by electrons is shown in Figure 2. Fluences at the forward and backward directions show similar tendency. As the emission angle increases, the fluence abruptly decreases.

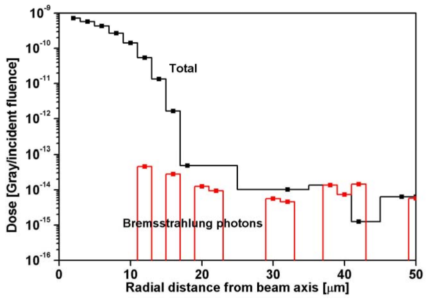

Figure 1. Radial dose distribution at the cell position.

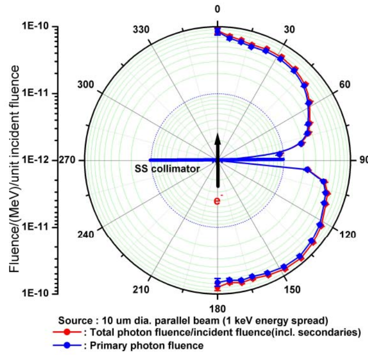

Figure 2. Angular distribution of the photons emitted from the pinhole frame.

Figure 3 is the dose contour around the target cell induced from the electrons incident on the cell through the pinhole and pinhole frame. At 2 μm from the dish bottom, the dose decreases to less than 1% of the maximum dose at 15 μm at radial direction. In conclusion, the Bremsstrahlung photons generated in the pinhole frame little influence the dose profile and this system is enough to be applied to the cellular bystander effect studies.

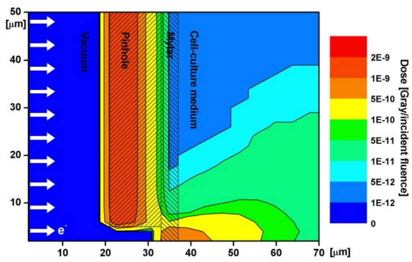

Figure. 3. Dose contour around the target cell.

REFERENCES

[1] G.M. Sun, E.H. Kim and K.B. Song, Characterization of the KIRAMS Electron Microbeam Cell-Irradiation System, submitted to Radiation Protection Dosimetrys.