AbstractID: 6857 Title: Design and Dosimetry Validation for Micro-irradiator Using Monte Carlo Simulation

Purpose:
New tools are needed to improve the effectiveness of small specimen irradiation performed in radiobiology research. This work is focused to support the design and dosimetry of a new micro-irradiator, capable to deliver fields as small as 1 mm, using Monte Carlo simulation.

Method and Materials:
A miniature x-ray source was introduced into a brass collimator with 3.0 cm in diameter and 3.0 cm in length. A pinhole of 1.0 mm in diameter in the central axis of the collimator allowed a pencil photon beam. MCNP5 was used to characterize this collimated beam. Pulse height, flux and point detector were the tallies used to find dose rate at the surface of water, energy spectrum, PDD curves, penumbra, source position effect and radiation levels at 50 cm from the source at determined collimator-surface distance (CSD). Relative importance in cell sub-division, population control and angular distribution biasing were used to reduce computation time and keep the statistical fluctuation within 2%.

Results:
The designed micro-irradiator has the following characteristics: the photon energy fluence was proportional to the source area projected in the pinhole and the average energy was 26.6 keV. At CSD=6.0 mm, the dose rate may go up to 1 Gy/min and it decayed about 10% per millimeter depth in water. The penumbra in the beam increases about 40 μm per millimeter away from the collimator. A source displacement of 0.5 mm respect to the pinhole axis resulted in a dose rate reduction of 20%. Radiation level at 50 cm was 10^{-7} Sv/min.

Conclusion:
The characteristics of the photon beam produced by the miniature x-ray source and the pinhole collimator system are adequate to irradiate total and partial body of zebrafish embryos, cell cultures and other small specimens used in radiobiology research.