A.14: Study of Scattered Synchrotron Radiation Dose at SR Beam Line Hutches of Indus-2

Scattered synchrotron radiation (SR) dose rate from different targets was measured at Indus-2 SR beam line BL-11. The measurement was carried out with thin window ion chamber detector at three different angles i.e. 90°, 120° and 150° with respect to the beam direction.

Aluminium, Copper and Tantalum disc targets of nearly 25 mm diameter and 5 mm thickness were fabricated and placed one by one in direct SR beam (white), extracted through a 200 micron thick Beryllium window. Scattered dose rate at 1m distance was measured using a thin window ion chamber based detector (Victoreen make, model-451P) in the integrated mode at three different angles simultaneously. The dose was integrated for 5 minutes and the dose rate was calculated. Three sets of data were taken and averaged. For all the set of experiments the electron beam energy in the storage ring was 2.4 GeV. Schematic diagram of the experimental setup is shown in Fig. A.14.1.

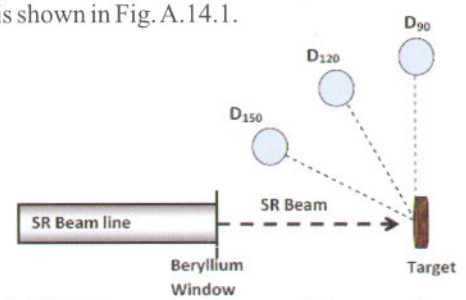

Fig. A.14.1 Schematic diagram of the experimental set-up

The above experiment was simulated using Monte Carlo code FLUKA. The SR spectrum in the energy range 4 keV to 100 keV (Fig. A.14.2) was generated using a FORTRAN program developed by Alberto Fasso, SLAC and was allowed to incident on target of 5 mm thickness and 25 mm diameter made of Al, Cu and Ta. The energy absorption in three spherical detectors (medium-water, radius-42mm) kept at 1m from the target at 90°, 120° and 150° was scored. Electron, positron and photon transport cut-off was set at 1 keV. The simulation was carried out for 5 x 10^8 histories in 3 cycles run.

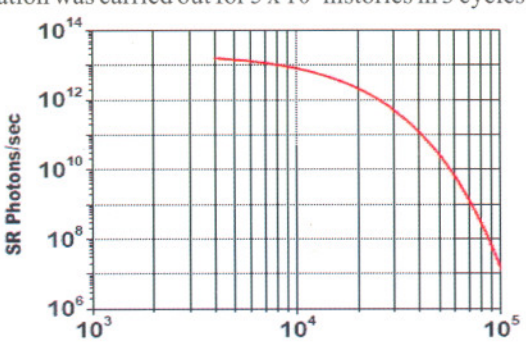

Fig. A.14.2: Synchrotron Radiation Spectrum in Indus-2 used for simulation

The angular distribution of scattered SR dose rates (both experimental and simulated data) is shown in the Fig. A.14.3. Though the pattern of angular distribution of dose rate normalized to electron beam current from all the targets shows an increasing trend as the scattering angle is increased, a consistent dependency with atomic number of the target materials is not observed. However the scattered dose rate from Cu is found to be the highest at all the angles studied, though the atomic number of Cu was lower than Ta.

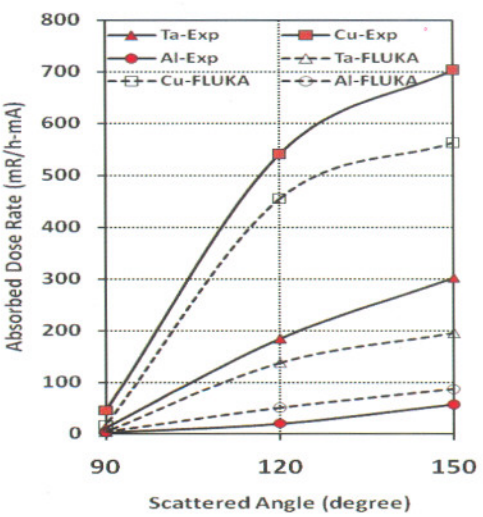

Fig. A.14.3: Scattered Dose distribution due to Ta, Cu and Al target at BL-11

The higher dose rate from copper at BL-11 than the high-Z Ta also can be explained based on the SR spectrum along with the K-absorption edge of these target elements. The K-absorption edge of Al, Cu and Ta are 1.56, 8.98, 67.42 keV respectively. Due to the abundance of K-edge photons for Cu at BL-11, the resonance absorption at the K-edge (8.98keV) and the subsequent de-excitation through characteristic fluorescent emission give rise to higher dose rate.

Scattered SR dose rate may vary in different beam lines depending up on the incident spectra and the experimental sample. The scattered SR dose rate from different target materials does not vary in proportion to the atomic number, but strongly depends on the incident SR spectrum, subsequent resonance absorption and fluorescence emission, if any from the irradiated target material. The maximum scattered dose rate extrapolated for the design stored electron beam current of 300 mA from the experimental data works out to be 210 R/h (~2.1 Sv/h) at 1m at 150°. This data is very useful in determining the sideward shielding requirement of the white SR beamline hutches of Indus-2 and similar machines.

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