Setup and Characterization of X-ray Reference Calibration Fields in a Dosimetry Laboratory

C. Hranitzky[1], H. Stadtmann[1], A. Steurer[2]

[1] Seibersdorf Labor GmbH, Dosimetry Laboratory, 2444 Seibersdorf, Austria
[2] BEV Bundesamt für Eich- und Vermessungswesen, Arltgasse 35, 1160 Vienna, Austria

Abstract: For testing and calibrating radiation detectors a new X-ray irradiation facility was installed in the dosimetry laboratory Seibersdorf. The X-ray assembly consists of a 160 kV X-ray high voltage generator, a calibrated voltage divider, and three x-ray tubes of tungsten, molybdenum and rhodium target material, respectively. The objective of this work was to establish geometrical irradiation conditions for the introduction of various photon reference radiation qualities according to international standards. The precise positioning and orientation of the x-ray tubes, diaphragms, filter holders, and transmission ionization monitor chamber along the central beam axis were carried out to finally provide accurate and traceable calibrations according to requirements of a primary and secondary standards dosimetry laboratory. The components of the X-ray irradiation facility were installed and adjusted in a stepwise procedure using a laser alignment system and a digital X-ray imaging detector. Setup and characterization of the X-ray field parameters such as field-size and field-homogeneity were based on measured 1024 x 1024 pixel intensity maps and derived relative intensity profiles at two different focus-detector-distances.

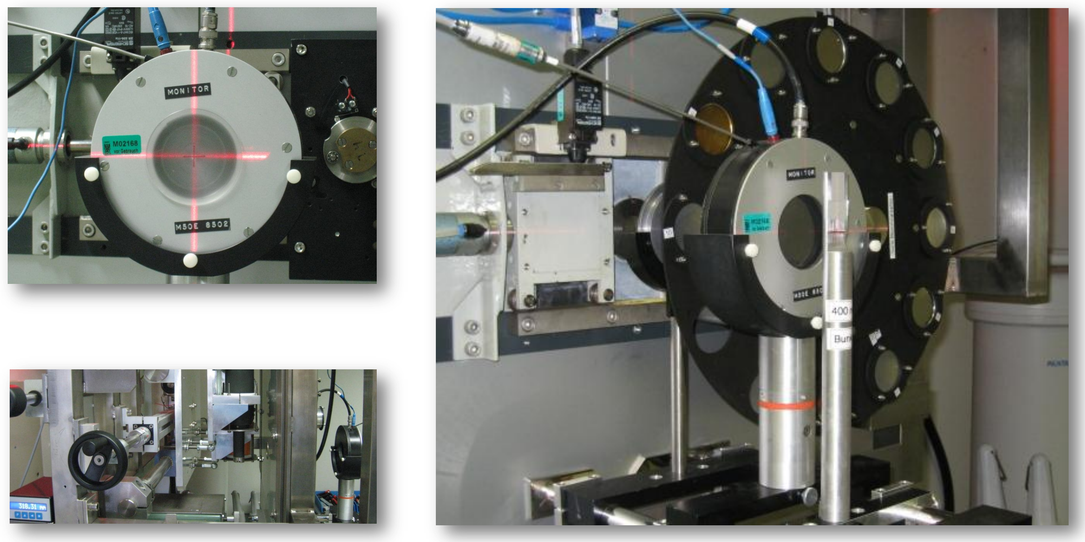

Figure 2: Photograph and sketch of the HS160 X-ray facility components: X-ray tubes, beam shutter, tungsten and lead diaphragms, filter wheel, monitor chamber, and reference distance 400 mm. Laser cross defining the main beam axis is visible.

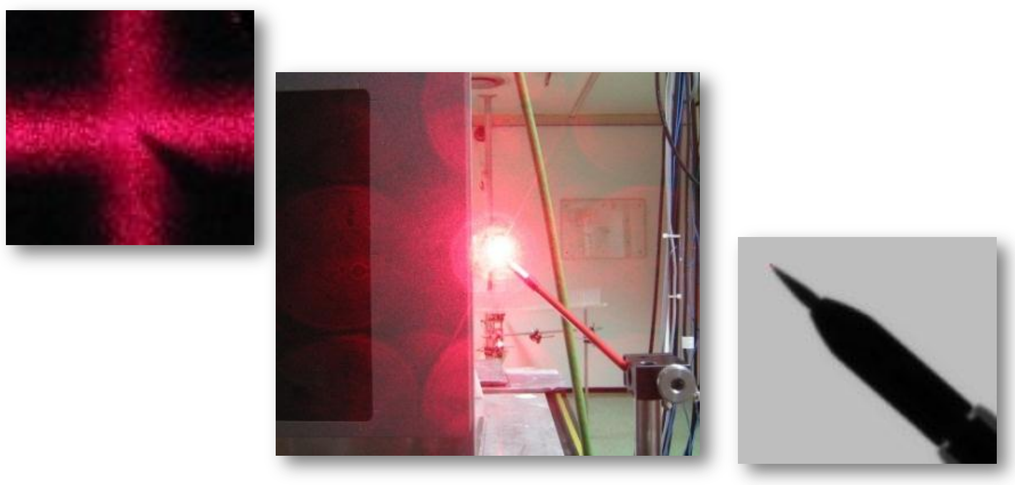

Figure 1: PerkinElmer XRD (digital aSi X-ray detector 1024 x 1024 pixel) imaging of a metal peak positioned at the center of the laser beam cross. Deviation of the peak is only about 1 pixel (0.2 mm) from to the actual image center.

Figure 3: W160 (tungsten X-ray tube) and Mo100 (molybdenum X-ray tube) measured focal spot sizes of about 3.4 mm x 4.3 mm and 12 mm x 5 mm, respectively. A pin-hole collimator was inserted resulting in an inverted and magnified image.

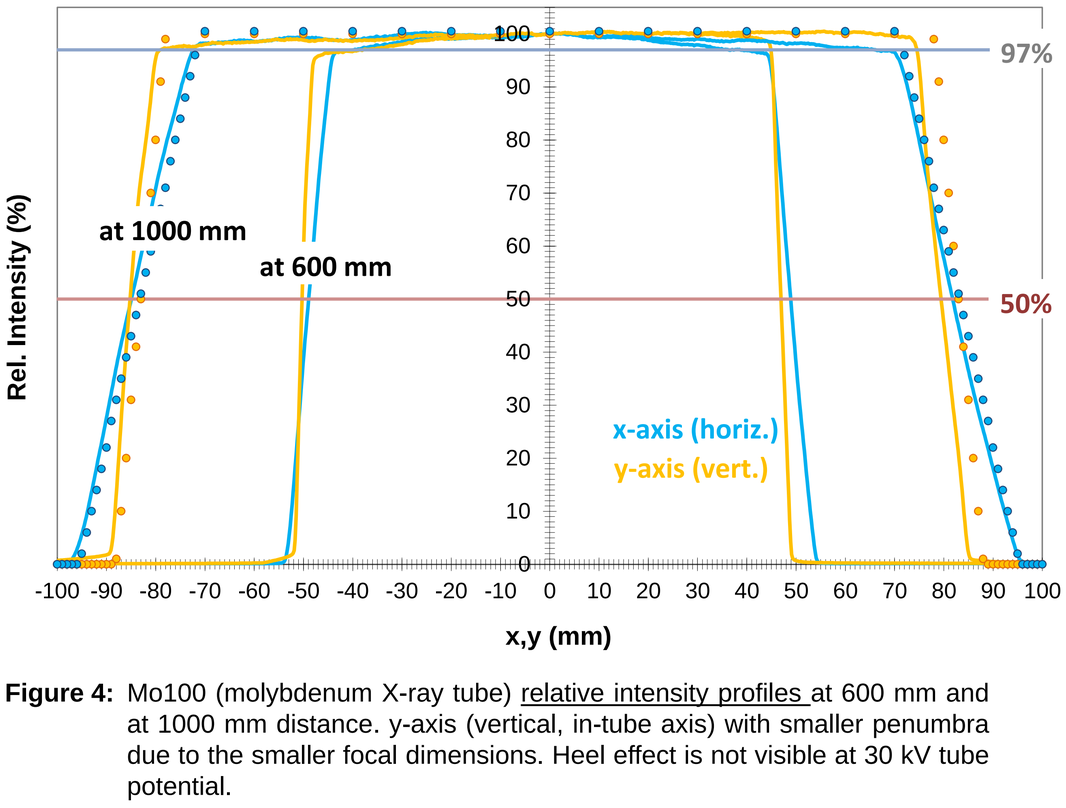

Figure 4: Mo100 (molybdenum X-ray tube) relative intensity profiles at 600 mm and at 1000 mm distance. y-axis (vertical, in-tube axis) with smaller penumbra due to the smaller focal dimensions. Heel effect is not visible at 30 kV tube potential.

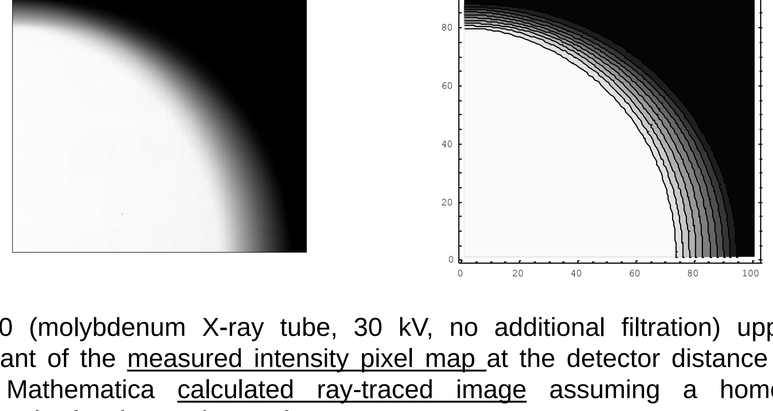

Figure 5: Mo100 (molybdenum X-ray tube, 30 kV, no additional filtration) upper right quadrant of the measured intensity pixel map at the detector distance of 1000 mm. Mathematica calculated ray-traced image assuming a homogenous rectangular focal spot shape of 12 mm x 5 mm.

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