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Angle dependent focal spot size of a conical X-ray target

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HIGHLIGHTS

- Misaligned phantoms may severely affect the focal spot calculations.
- The aim of this research is to analyze systematically the angle dependent behavior of the focal spot size around a conical shaped X-ray target.
- A general purpose Monte Carlo (MCNP5) computer code is used to achieve a relatively small focal spot size.
- Angular distribution of the X-ray focal spot size mainly depends on the angular orientation of the phantom and its aligned FIR tally.
- This research will help in producing high quality X-ray images in multi-directions.

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ABSTRACT

Misaligned phantoms may severely affect the focal spot calculations. A method is proposed to determine the geometry of the X-ray target and the position of the image radiograph around the X-ray target to get a relatively smaller focal spot size. Results reveal that the focal spot size is not always isotropic around the target but it decreases as the point of observation shifts radially away from the center line of the conical X-ray target. This research will help in producing high quality X-ray images in multi-directions by properly aligning the phantoms and the radiograph tallies.

1. Introduction

The aim of this research is to analyze systematically the angle dependent behavior of the focal spot size around a conical shaped X-ray target. Several orientations for image radiograph were analyzed to achieve a relatively small focal spot size. The small sized focal spots are more useful for high-resolution X-ray radiography and tomography (Heo et al., 2007). In addition, the small sized focal spots are also useful in accurate measurement of X-ray dose profiles (Wang and Leszczynski, 2007) and to analyze the radiotherapy dose distributions in medical linear accelerators (Jaffray et al., 1993; Metcalfe et al., 1993). Fabrication of the X-ray tubes to obtain multi-directional X-ray images is one of the key aspects of our group (Kim et al., 2014). Several methods have already been devised to estimate the focal spot size (Sterpin et al., 2011). Such methods are based on measuring the blur caused by the phantom edges (Anai et al., 2011; Oliveira et al., 2009; Salamon et al., 2008). Changes in the effective focal spot size as a function of field location has been discussed in detail (Doi, 1977). It has been reported by researchers that the micro-focus X-ray tubes are widely used for obtaining good quality radiograph images (Ihsan et al., 2007). Micro-sized focal spots may be achieved by reducing the electron beam diameter. However, this reduction results in decreasing the intensity of the X-rays (Ihsan et al., 2007). Moreover, it is hard to measure the focal spot size accurately (Madsen, 1989). Factors such as beam diameter, target thickness, phantom geometry and image grid pixel size mainly affect the accuracy of focal spot calculations. It is worth noted that reflection type X-ray targets are less appropriate for measuring micro-sized focal spots. Heeling in the case of a reflection type X-ray target affects the size of the focal spots (Bushberg et al., 2002). Errors mainly come from the divergence of incident electrons inside the target block. Therefore, the use of X-ray targets having a thickness of a few microns is preferred to measure a focal spot size (Ihsan et al., 2009). European standard BS EN 12543-5 was followed to calculate the focal spot size (BS EN 12543-5, 1999). It specifies an indirect method to measure the focal spot size by measuring the

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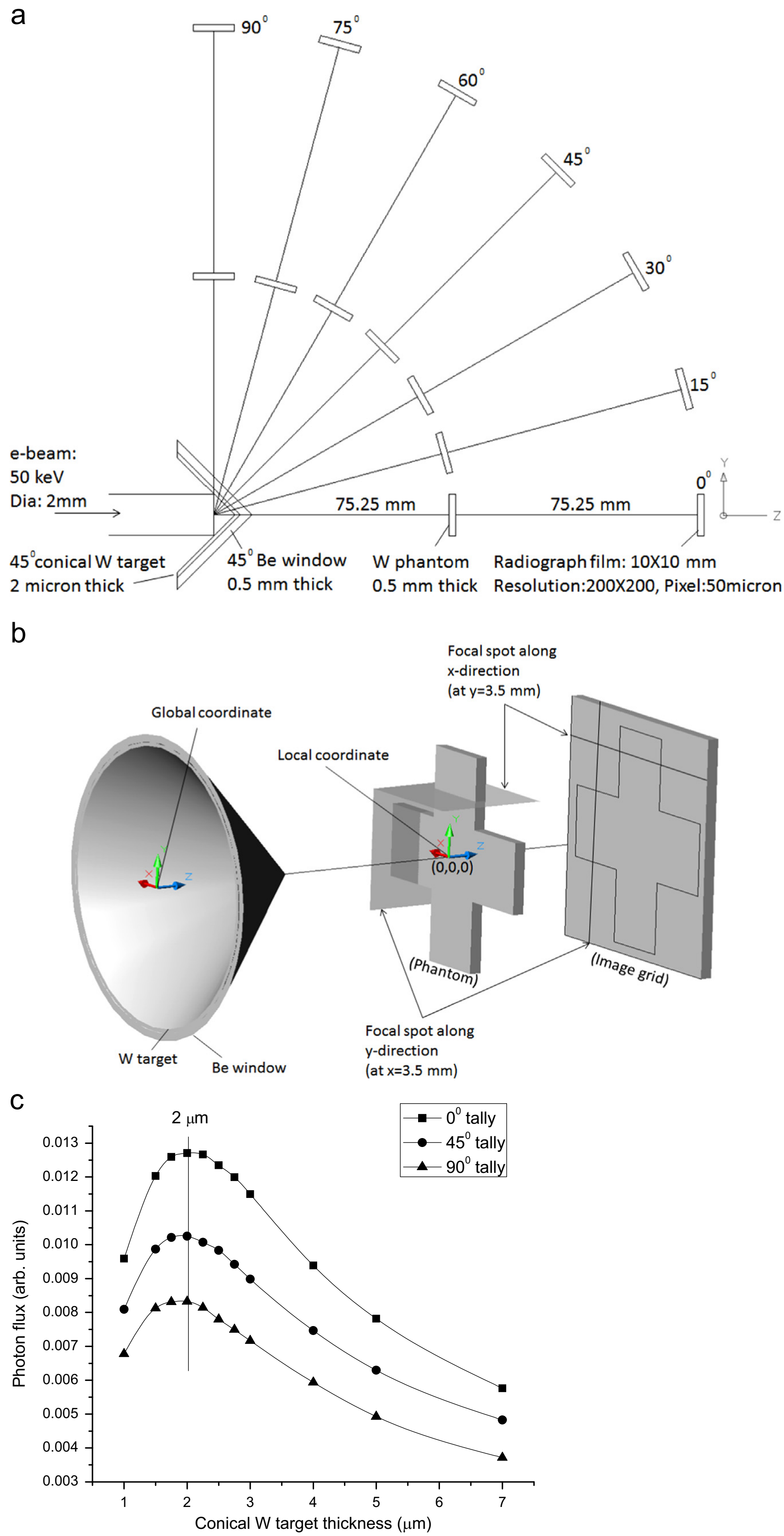

Fig. 1. Schematic diagram of (a) Tallies around the conical W target, (b) 0° tally, and (c) Photon flux as a function of the conical W target thickness.