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Angular Distribution of Bremsstrahlung Photons in Ta Target for 40 MeV Electron Beam

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Bremsstrahlung photons are created by electron beams de-accelerating in electric field (coupling with a thin radiator) and are used in a variety of different fields. In nuclear physics experiments it is important to transport and focus the created photon beam into the experimental cavity. Here angular distribution of the photon beam is one of the important parameters, which should be known. In this study a FLUKA simulation has been done to obtain angular distribution of photon beam created by interaction of 40 MeV electron beam with the tantalum (Ta) radiator of varied thickness, which is planned to be used in bremsstrahlung photon facility at TARLA (Turkish Accelerator and Radiation Laboratory in Ankara). TARLA will be the first facility of Turkish Accelerator Center project.

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1. Introduction

In many accelerator centers, bremsstrahlung facilities have been built to investigate nucleus structure and photo-nuclear reactions. In these facilities, various bremsstrahlung photons are produced depending on types of accelerators and beam parameters.

TAC (Turkish Accelerator Center), which includes IR-FEL (infrared free electron laser) and Bremsstrahlung photon facilities [1], is planned to be established in our country.

When an electron beam, accelerated in the electron gun, interacts with the radiator, it generates bremsstrahlung photons. The radiator which is used at the bremsstrahlung facility must be optimized to give maximum yield and also minimum angular spread of high energy bremsstrahlung photons [2]. The maximum yield optimization calculations were presented in the previous work [3]. In this work, the angular distribution of bremsstrahlung photons from the Ta radiator has been calculated using the FLUKA simulation code.

2. Materials and methods

2.1. Radiator

Radiator, which decelerates electrons and generates photons, is a rig positioned in the path of electron beam, and it is a significant part of bremsstrahlung photon facility equipment. In this simulations thin Ta metal foil was used as a radiator. It had a cylindrical geometry with a radius of 0.8 cm. The angular distribution of photons was investigated for varying thicknesses of the Ta radiator.

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2.2. FLUKA

FLUKA is a Monte Carlo simulation code used for calculations of particle transport and particle interactions with matter. There are many application fields for FLUKA, such as proton and electron accelerator shielding, target design, calorimetry, activation, dosimetry, detector design, accelerator driven systems, cosmic rays, neutrino physics and radiotherapy. Radiation source, beam parameters, geometry of the system and employed materials should be determined and the intended results should be described at the first stage of defining a problem for FLUKA. In this study FLUKA [4] was used for simulation of the scattering of photons from the radiator.

2.3. FLUKA Simulations

In the simulation, a pencil-shaped beam of electrons was used as a radiation source. 10^6 of primary electrons with the energy of 40 MeV were simulated using FLUKA code. Photon fluence was calculated for optimum thickness (6 μm) of Ta radiator, at different scattering angles and the results are presented in Fig. 1. The highest photon fluence was obtained at angle of 5 mrad. It can be seen that as the angle increases, the photon fluence decreases.

The angular distribution of the bremsstrahlung photons was calculated for varied radiator thicknesses. For this purpose, double differential photon yield, plotted in Fig. 2, was produced using the FLUKA code. Here θ is angle between the electron beam and the scattered photon. It can be observed, that with the increasing thickness of the radiator, the number of bremsstrahlung photons increases and at the same time angular spread of generated bremsstrahlung photons also increases.

Two dimensional plots of angular distributions of photons generated in Ta radiator with thicknesses of 6 μm and 100 μm are presented in Fig. 3a and Fig. 3b respectively.

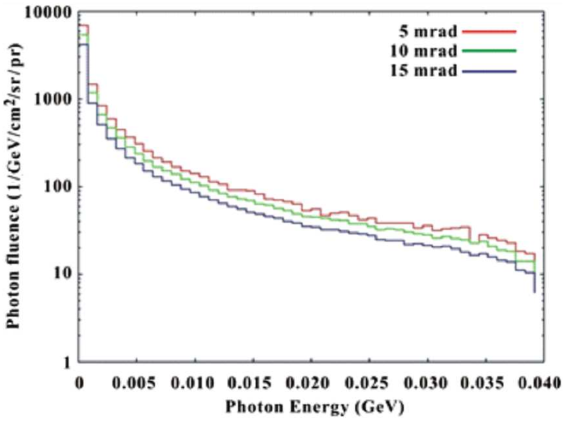

Fig. 1. Fluence of photons scattered at different angles (5 mrad, 10 mrad, 15 mrad) from Ta radiator with thickness of 6 μm, for electron energy of 40 MeV.

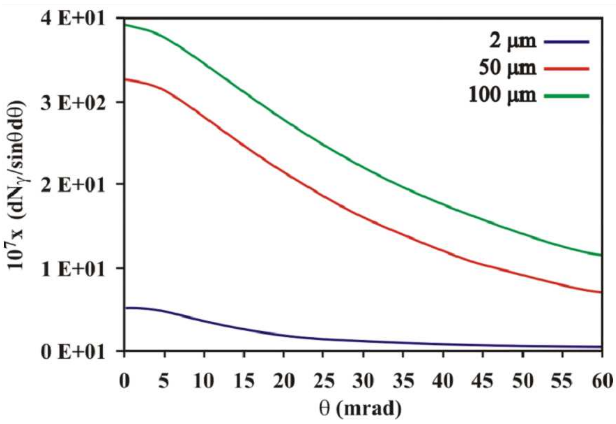

Fig. 2. Angular distribution of bremsstrahlung photons generated at Ta target with varying thickness, bombarded by 40 MeV electrons.

Figures 3a and 3b show that the maximum photon fluence is in the forward direction. It can be seen that a higher photon fluence is generated from Ta radiator with a thickness of 6 μm. It can be also seen that the angular spread and backscattering of photons increases with the increasing thickness of Ta radiator.

3. Conclusions

The angular distribution of bremsstrahlung photons from Ta radiator, bombarded by electrons with energy of 40 MeV, has been investigated using the Monte Carlo code FLUKA. Photon fluence was calculated for 6 μm thick Ta radiator at scattering angles of 5, 10 and 15 mrad. The scattered photon fluence at angle of 5 mrad was found to be higher than for the other angles. The angular spread of bremsstrahlung photons has been calculated as a function on radiator thickness. It was observed that the angular spread increases with the increasing radiator thickness and the backscattering of photons

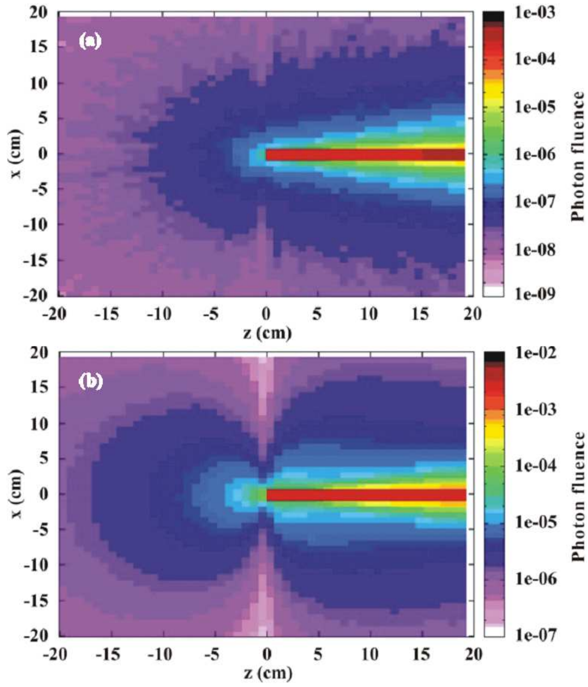

Fig. 3. Angular distribution of bremsstrahlung photons in XZ plane, for Ta radiator with a thickness of (a) 6 μm (b) 100 μm.

also increases. This causes a reduction in the intensity of the photons which are transferred into the experimental area. Consequently, there is no advantage in increasing the radiator thickness in such facility.

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