Monte Carlo optimization of the target configuration for bremsstrahlung x-ray production in flash radiotherapy

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Background: Flash radiotherapy (FR) relies on high dose rates > 40 Gy/s. To implement x-ray FR with conventional sources based on bremsstrahlung processes, high electron currents impinging on the anode target are needed. Such a target should withstand an enormous thermal load. This work investigates via Monte Carlo (MC) simulations several anode configurations to be embodied on the BriXSino beamline featuring electron currents up to 5 mA accelerated up to 10 MeV [1].

Material and Methods: In the Geant4 MC simulations, a Gaussian 10-MeV electron beam was directed on the anode modelled as W layer of variable thickness followed by a Cu layer of 1 mm. The energy deposit map was scored within the anode along with the produced spectra and dose rate at 100 cm beyond the anode. The anode temperature was monitored over time using Ansys simulations.

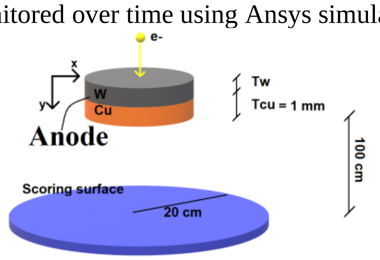

Figure 1: Scheme of the simulated irradiation geometry.

Preliminary results: Figure 2a shows the air-kerma fluence at the scoring surface for 5 mA and 1 s. The energy-integrated air-kerma rate was 38.4 Gy/s. The temperature of the anode over the time is reported in fig. 2b. The anode temperature for 10^9 electrons per pulses repeated at 100 Hz tends to the maximum value of 1250° C. Several configurations for keeping the anode temperature well below 2000° C, are under evaluation for this methodology.

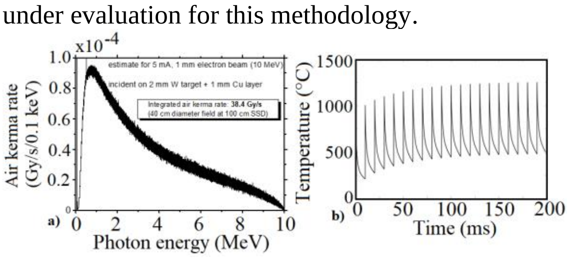

Figure 2: a) Air kerma rate spectrum and b) Anode temperature evolution for current pulses each of 10^9 electrons, repeated at 100 Hz.

[1] C. Koral et al., Frontiers in Physics (2022): 127.