Contribution ID: **36** Type: **talks**

DEVELOPMENT AND OPTIMIZATION OF TUNGSTEN MATRIX COLLIMATORS FOR SPATIALLY FRACTIONATED RADIATION THERAPY

Tuesday, January 21, 2025 4:30 PM (20 minutes)

This study investigates the effectiveness of tungsten matrix collimators for spatially fractionated radiation therapy (SFRT). The research combines experimental studies and Monte Carlo simulations to evaluate the fractionation of gamma-ray and electron beams. The results demonstrate the possibility of achieving high fractionation indicators (PVDR over 10) for irradiation of shallow tumors.
The experiments were conducted using a Varian Clinac iX medical accelerator with 6 MeV gamma-rays. Two types of collimators were tested: brass and lead. Monte Carlo simulations were performed using GEANT4 and CERN Fluka software packages, modeling a 10×10×10 cm plexiglass phantom and a tungsten collimator with a 5×5 matrix of 1 mm diameter holes.
The study examined the effects of collimator thickness and radiation energy on fractionation efficiency. For 25 MeV gamma-rays, the optimal tungsten collimator thickness was found to be 12 cm, achieving a PVDR of about 12 at the phantom entrance. For 18 MeV electrons, a 9 cm thick collimator provided a PVDR of about 20. However, the fractionation effect rapidly diminished with depth for both radiation types.
The role of secondary particles in dose distribution formation was also investigated. For gamma-rays, high-energy secondary electrons significantly contributed to the dose at depth. For electron beams, secondary gamma-rays from bremsstrahlung were less significant compared to primary electrons.
Based on these results, three versions of modular tungsten collimator designs were developed. These collimators consist of separate 3 mm thick plates, allowing flexible adjustment of parameters for different energies and beam types.
The study concludes that while SFRT shows promise for treating surface neoplasms, the rapid decay of the fractionation effect with depth limits its application for deep-seated tumors. The proposed modular collimator design offers flexibility for further research and potential clinical applications in adaptive irradiation systems.
This project has received funding through the EURIZON project, which is funded by the European Union under grant agreement No.871072. Grant \#3014.

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Session Classification: Session INVITED TALKS. "Ukraine for ESPP Update-2025"