Improved Proton-Based Cancer Radiation Therapy System with Beam Intensity and Energy Modulation

INVENTORS • Jihad Al-Sadah, Thomas (Rock) Mackie

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an improved method and apparatus for intensity and energy modulation of ion beams used in proton-based radiation therapy.

OVERVIEW

External beam radiation therapy commonly is used to treat cancer patients by directing one or more beams of high energy radiation, such as X-rays, toward a tumor. Current photon-based radiation therapy methods use multiple X-ray fan beams directed at the patient over a 360° range with each beam’s intensity individually modulated. These existing techniques are able to define complex treatment areas to minimize radiation applied to healthy tissue. However, X-rays irradiate healthy cells along the entire path to the target tissue and through the other side of the patient. Protons and other ions are a promising alternative to X-ray radiation because they can be controlled to stop within the target tissue, reducing irradiation of healthy cells.

The main advantages of proton beams include the ability to control both beam intensity and energy, two parameters that determine the dose of radiation delivered to the tissue. Control of intensity allows for dose rate modulation; that is, the number of protons delivered to the target tissue per unit time. Proton beam energy modulation determines the depth at which the dose is concentrated because the majority of energy is released where the proton beam stops in the tissue.

UW-Madison researchers previously developed a method for intensity modulation of X-ray beams using a multi-leaf attenuator to accurately control the dose delivered to irregular shaped tumors. Attenuation based methods modify energy for ion beams but could not be used as such to control intensity. The time accumulation methods could control average beam intensity through duty cycle modulation; that is, changing the length of time tissue is exposed to radiation. Yet, such techniques require increased treatment time. Controlling the beam current from the ion source/accelerator could achieve intensity modulation, but requires sequential treatment, which lengthens the treatment time and requires that the source be able to dynamically modify current.
THE INVENTION

UW-Madison researchers have developed an improved method and system to modulate ion beam intensity and energy for proton-based radiation therapy. The modulator is mounted on a ring gantry, like a CT scanner, able to rotate around the patient. In general, the system transforms a pencil beam of ions into a fan beam modulated in intensity and energy through a series of steps.

The thin pencil beam is first passed through a scattering foil and collimated to form a rectangular area beam. The area beam then is occluded by a plane of ion-blocking shutters, resembling a series of interlocking fingers, independently actuated by computer to modulate the intensity of the area beam. The area beam subsequently is collapsed into a fan beam by a pair of quadrupole lenses, which use magnetic fields to longitudinally compress the rectangular area beam. The intensity of individual beamlets, one from each aperture of the ion-blocking shutters, is averaged by blurring and compression as the ions pass through the lenses. This achieves parallel time-independent intensity modulation of the proton beamlets. The fan beam then is passed through a plane of opposed, overlapping, ion-attenuating wedges to slow down the protons, thereby modulating the beam energy. Each pair of synchronized wedges is actuated by computer to provide control of each beamlet’s energy. Finally, the patient is treated with the resulting energy and intensity modulated fan beam.

This type of beam modulator provides real-time control of proton beams used in radiation therapy and, when multiple modulators are employed in a radiation treatment system, is able to precisely control the dose delivered to complex target tissue areas and also minimize irradiation of healthy cells. The new device will reform the practice of radiation therapy, improving the patient’s welfare, treatment efficiency and system precision.

APPLICATIONS

- Proton-based radiation therapy for cancer of the prostate, lung, brain, head and neck, etc.
- Reactive ion ablation in semiconductor manufacturing

KEY BENEFITS

- Provides precise, parallel control of an ion fan beam intensity and energy
- Reduces treatment time
- Improves patient comfort
- Increases patient turnover

ADDITIONAL INFORMATION

Publications

Tech Fields
Radiation Therapy - External beam therapy

CONTACT INFORMATION

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846.