HITRI plus
Heavy Ion Therapy Research Integration
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ARCHITECTURAL MODEL OF AN ACCELERATOR CONTROL SYSTEM FOR MULTI-ENERGY OPERATION

DECADES OF EXPERIENCE IN ACCELERATOR DESIGN, CONSTRUCTION AND OPERATION FOR MORE EFFICIENT ION BEAM DELIVERY

DESCRIPTION

Main objective: Design of an architectural model of an accelerator control system capable of multiple energy operation.

A survey has been conducted among the ion beam therapy facilities to assess the desired beam parameters (see table 1). Another key finding of this survey is that the treatment duty cycle is at or below 50% for all facilities, which is caused by the time required to change beam parameters between irradiations.

Multi-energy operation could address this challenge and improve the overall duty cycle of the facility. As left-over particles are not dumped after an extraction phase has ended. Instead, the particles are accelerated to the next energy.

To reaccelerate the beam to operate in this mode, the accelerator devices must be carefully tuned.

For this purpose, the data for the accelerator control system and its distribution must be defined and data volumes, reaction times and typical rates analyzed.

To enable multi-energy extraction in the synchrotron, a sophisticated accelerator control system and an extensive data supply model for standard components are crucial. This necessitates **a substantial upgrade to existing systems** to handle the calculation and storage of treatment settings on a large scale. The upgrade will allow adding ion species: CNAO plans helium, oxygen, lithium, and iron ions; MedAustron focuses on helium and oxygen ions. HIT plans to boost memory size for device controllers to handle more energy, intensity, and focus steps in the accelerator control system.

CNAO, MedAustron, and HIT aim to implement multi-energy operation, currently exclusive to HIMAC. HIT will implement this accelerator control model which streamlines the process by calculating control data online during the synchrotron cycle, eliminating the need for pre-calculating numerous energy step combinations.

Particles	Protons Ions: Helium, Oxygen, Carbon Options to add other elements
Energies	Ions: Beam energy corresponding to penetration depth of 3-30 cm, step sizes of 1-2 mm.
Focus	Protons: 10-30 mm Carbon-Ions: 3-15 mm
Intensities	Protons: 4 * 109 /s Carbon ions: 6 * 108 /s Further research is needed to achieve higher intensities as required for FLASH therapy

Table: Results of a survey on desired beam parameters at ion beam therapy facilities

CHALLENGE

When irradiating a tumor, the raster scanning dose delivery method is used to target slices of its volume. Such a slice is represented by a predefined beam energy, and for each such energy a new synchrotron cycle is started. The particles available in the synchrotron usually exceed the ones needed to irradiate a slice, and the ones that can't be used are dumped.

During the dumping and subsequent injection and acceleration of new ions, there is no beam available in the treatment room, prolonging the treatment time needed and contributing to higher costs.

SOLUTION

With multiple-energy extraction the ion beam can be accelerated or reaccelerated to the next energy instead of being dumped.

For this purpose, **an architectural model of an accelerator control system is designed**, capable of operating in multi-energy operation mode.

VALUE

- With multiple energy extraction mode, there is potential to reduce the time needed for an irradiation by up to 50%, offering significant time, energy and cost savings
- The patient experience will be benefited by a shorter treatment time
- The capability to move between different energies and extract will be unique to the architectural model. Previously, HIMAC has been the only center capable of multiple-energy extraction, starting at the highest energy and descending stepwise then extracting
- The multi-energy operating mode will be a key feature of the next generation accelerator control system at the heavy ion centres