China Institute of Atomic Energy

THE DESIGN OF SCANNING CONTROL SYSTEM FOR PROTON THERAPY AT CIAE

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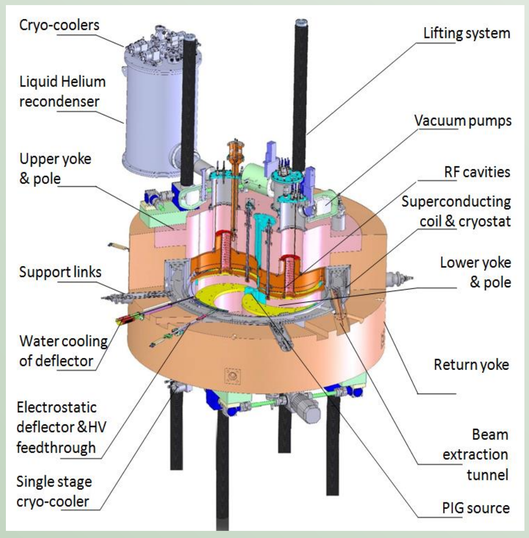
ABSTRACT

A novel proton therapy facility is designed and constructed at China Institute of Atomic Energy (CIAE) in Beijing, which includes a superconducting cyclotron CYCIAE-230 to provide 230 MeV proton beams for cancer therapy. As a part of therapy control system, the scanning control system is designed to scan the beam for the access of required tumour volume field. Two set of dipole magnet is driven for changing the beam path. Meanwhile, interfaces between scanning system and other systems will be built for beam control and safe considering. In order to acquire high precise feedback control, the beam position and dose monitor ionization chambers will be constructed in the nozzle. Detailed description will be presented.

Introduction

Proton therapy has proven to be an effective cancer treatment with minimal side effects. Due to the progress of superconducting devices, very compact cyclotrons, suitable for hospital installations, can be manufactured with lower cost. In order to promote the development of proton therapy in China, CIAE (China Institute of Atomic Energy) has designed a superconducting cyclotron, which would produce a 230 MeV, 300 nA proton beam .

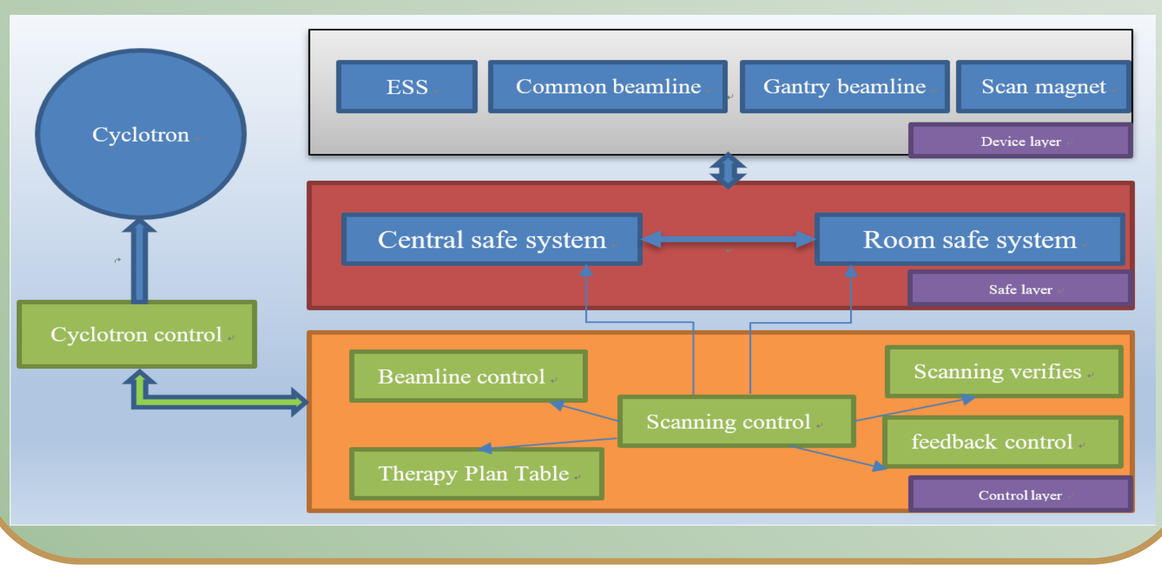
Parameter	Value
Extraction energy	>230MeV
Extraction current	>500nA
Injection/Extraction field	2.35 T / 2.95 T
RF frequency	~71.3 MHz
RF voltage	70 kV/110 kV



As the essential Part of Proton therapy, CYCIAE230 are in commissioning phase. Scanning control system belongs to the treatment control system and is the core part to do the main process which is designed for the proton therapy facility.

Scanning Control System

Scanning control system require the therapy data table to direct the scanning to target volume and the field feedback data to verify the scan process. The device layer is mainly comprises of needed hardware for conventional process, which accept the control of relatively target front end. The lower layer is safe related function that protects the patient against over dose radiation. The central interlock system will act as a protector for treatment. The last layer is control layer. In this layer, scanning control system is the coordinator to arrange other subsystem to work together smoothly under the defined process.



Hardware Design

The scanning system is composed of three different parts. The digital compute board is the master component. Another part is ADC/DAC part, which in charge of signal convert rapidly to magnet controller or from field sensors. Through the therapy plan data achieved from treatment control system, master compute gives the final output signal instantly according the designed algorithm. The final part is the ionization chamber for beam position and dose value feedback.

Connections between main compute board and ions chamber are via fiber optics to ensure stable and robust transmission against radiation damage and single event upset to electronics.

Software Design

The scanning control software is comprised of four modules, and the modules interfaced internally with fast bus. These main modules are as following corresponding the hardware. Core compute module (CCM): This module is mainly responsible for actually current value output and directing the feedback flow. User Interface Module (UIM): It provides device screens to operators which display live scanning information. Covert Management Module (CMM): This module is designed to produce the interpolation values result from the delivery table. Safe Interlock Module(SIM) : This is the import module because the beam safe operation is depended on the fast respond to cut off. With the safe policy, a proper action should be carried out as soon as possible.

Safe Interlock

The scanning control system is directly connected to safety interlock system that consists of a fast interlock system that cuts off RF sources switch to the RF amplifier. It is built on the cyclone series FPGA platform. It supports 32 fast digital inputs (100 ns response time), 32 slower (response within 10μs) and 16 analogue channels (100 kHz).
In addition, there is a slow interlock system based on a Siemens S7-400 PLC system. The current system support about 1000 i/o channels but enough memory space is ready for expansion if safety needed. The data is collect-ed by a server which broadcast the readout over Ethernet to be easily picked up by the EPICS channel access client. The radiation protection area is protected by a door interlock. A unique procedure is required before closing the door.

Conclusion

CIAE has designed a scanning control system for proton therapy that integrates all the different subsystems necessary for treatment process. The fast feedback sys-tem is based on FPGA technology with state-of-art algo-rithm. The use of EPICS simplifies the extensible feature for coming requirement of other subsystems.

Due to the open loop control of magnet power supply, over-shot will occur. The delay feedback of ionization chamber also have a side effect for high accuracy dose delivery. A new method for fast dose feedback need to be developed for high accuracy radiation.