Conceptual Design of Treatment Control System for a Proton Therapy Facility at HUST

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Abstract

A proton facility based on a superconducting cyclotron for cancer treatment is to be built by Huagong Tech Company Limeted, Wuhan, China. This facility is aimed at providing proton beams with continuously tuneable energy from 70 MeV to 250 MeV, for kinds of cancer treatments. Our team is responsible for the development of the treatment control system, which consists a number of functional modules and connects to many subsystems. In this paper, we will report our conceptual design of the treatment control system.

Treatment Control System

The treatment control system is internally divided into a number of independent modules for specific functionali-ties, including the interface modules to subsystems. All the modules are designed to be standalone applications, each of them runs as a separate process, so that one will not affect another.
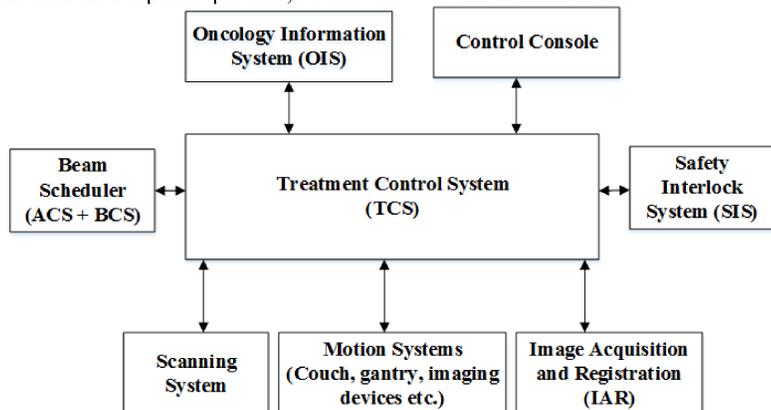
Figure 1: Overview of the treatment control system

Functionalities

➢ Allow the users to verify the patient information and prepare specific equipment;
➢ Allow the users to position the movable devices, e.g. couch;
➢ Allow image guidance, i.e. the image acquisition of X-ray or CBCT, thus allow automatic correction of the patient position using the registration information;
➢ Guide the users to perform required steps for a treatment session, inform the users about problems and safety issues when needed;
➢ Allow the users to execute the irradiation and monitor the progress, record the status of a stopped treatment;
➢ Display the relevant status information of all con-nected systems (e.g. accelerator system, safety interlock system, etc.).

Treatment Workflow

The treatment procedure is controlled and directed by the WEM of TCS. As it's shown in Figure 2, the conventional process of treatment can be roughly separated into three stages: treatment preparation (1 to 5), beam delivery (6) and ending treatment (7 to 9).
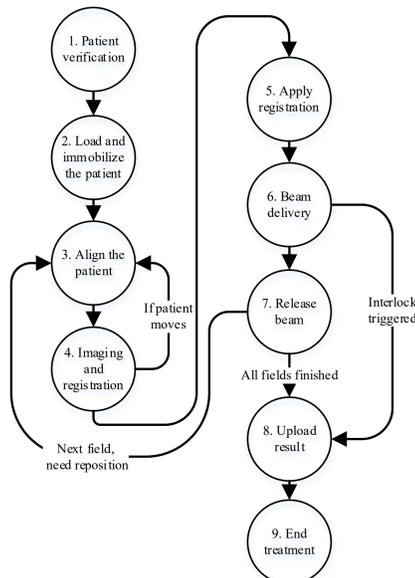
Figure 2: Conventional process of a treatment.

Main Modules

➢ Workflow Execute Module: responsible for actually controlling and directing the flow of the entire TCS operations;
➢ Graphical Interface Module: provides graphic interface to users, and serves as the main entry point into the TCS;
➢ Motion Management Module: operate the movable devices of the system, including the gantry, nozzle and couch;
➢ Resource Management Module: manages the access to the beam resources, and allows the requesting modules to gain exclusive right to access the beam resource in a mutually exclusive way;
➢ Logger Module: offers the capability to monitor and store all messages internally exchanged between modules;
➢ Treatment File interface: connected to the OIS, receive the treatment plan in Dicom-RT format, interpret and distribute the data to the corresponding modules during preparation. This module is also responsible for receiving the treatment data from subsystems and uploading the result to the OIS;

Other Systems

➢ Accelerator and Beamline Control System: serves as a beam production unit for the connected treatment rooms, it is also connected to the scanning system to generate proton beam with specific parameters for delivery.
➢ Scanning System: uses the cyclotron and beamline to produce a beam with appropriate parameters (energy, size, intensity etc.) and the scanning magnets to transversely scan the beam over a layer of the tumor according to the treatment plan.

Safety Interlock System

The Safety Interlock System is aimed at protecting the patient from radiation hazards by minimizing the risk from an uncontrolled irradiation. Thus this system is designed with redundant sensors and final elements.
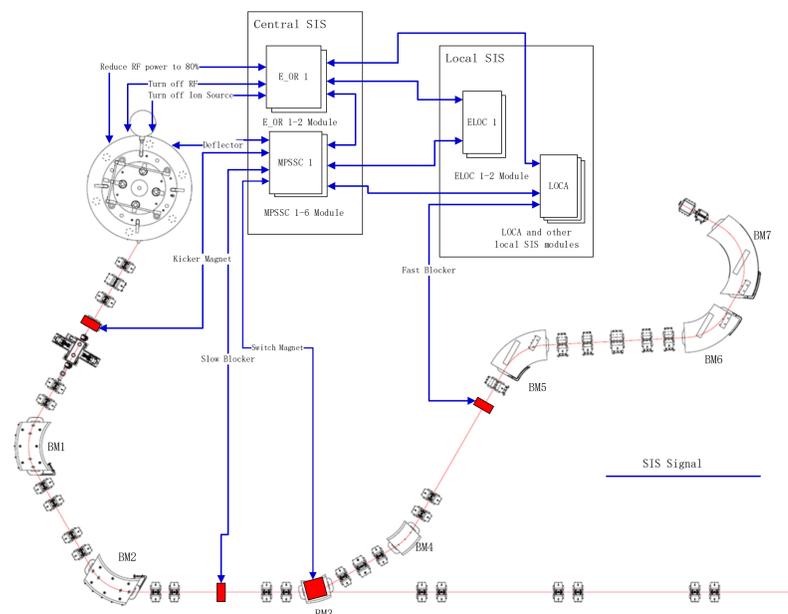
Figure 3. Layout of final elements of HUST-PTF SIS
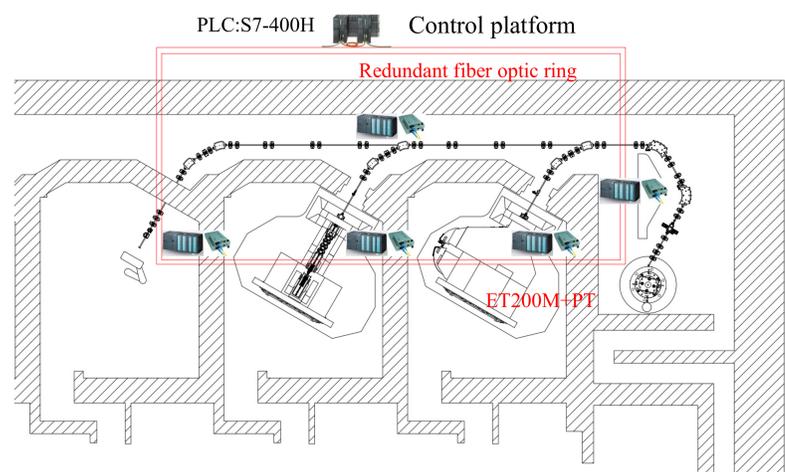
Figure 4. Redundant fiber optic ring for SIS

Conclusion

In our PTF project, the primary design of treatment control system consists of separated modules running as standalone applications, DDS is chosen for the communication among internal modules. Since the TCS is basically a medical software, its development should follow the procedures of international standards, such as IEC-62304, and this will take much of the development efforts.
In this paper, we also described several main modules, their functionalities and main treatment workflow. The accelerator and beamline control system, scanning system and a primarily design of safety interlock system is introduced.