Texas Regional Medical Technology Center

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Abstract: **A linear accelerator was partially completed as part of the SSC construction project. The related assets will be incorporated into a world-class medical center dedicated to providing proton-beam radiation therapy for cancer patients. The Texas National Research Laboratory Commission is collaborating with the University of Texas Southwestern Medical Center at Dallas on this project. The linac will be used to inject beam into a new proton synchrotron, which will provide protons at energies up to 350 MeV. A unique feature of this facility will be the capability to enhance the precision of the radiation therapy through the use of proton radiography. A Conceptual Design Report has been completed for this project. The Department of Energy has provided funds for this project subject to an environmental assessment.**

I. INTRODUCTION

When the Superconducting Super Collider (SSC) construction project was terminated in 1993, the U.S. Department of Energy (DOE) funded Project Definition Studies for the purpose of finding good uses for the existing SSC assets. One Project Definition Study described the Regional Medical Technology Center (RMTC). This proposed project will use the SSC linear accelerator assets, including the partially-completed linac and its building, for medical purposes. As part of the SSC Termination Settlement, the DOE placed $65 million in escrow with the Texas National Research Laboratory Commission (TNRLC), for the purpose of building the RMTC.

II. PROJECT DESCRIPTION

The first portion of the SSC linac, including the first tank of the drift-tube linac (DTL), will be completed for the purpose of providing a 13-MeV H^- beam. This injection linac will be placed in the SSC Linac Building, located on the West Campus, near Waxahachie, Texas. The H^- beam will be injected into a proton synchrotron located in a new RMTC building. The synchrotron will accelerate the protons to energies up to 350 MeV, in order to treat cancer patients and to provide a capability for proton radiography. The beam delivery system includes a high-energy beam transport line, two gantry treatment rooms, and two fixed-beam rooms. Double-scattering systems will provide beam spreading in the nozzles.

The system specifications for the RMTC are given in Table 1. They are based on the clinical requirements for the facility.

Table 1 **System Specifications**

Specification	Value
Injection	
Injection energy	13.4 MeV
Injection pulse current	17 mA
Injection pulse length	2.35 μs
Number of turns injected	4
Proton therapy	
Proton beam energy	70 - 270 MeV
Design extracted current	30 nA
Guaranteed extracted current	20 nA
Duty cycle	50%
Proton radiography capability	
Proton beam energy	70 - 350 MeV
Extracted beam current	1 nA
Repetition rate	1.5 Hz
Extraction system	Resonant (half integer)
Circumference	29.4m

The H^- beam is injected into the synchrotron using a stripper foil, and 4 turns of beam is injected in 2.35 μs. For proton therapy, the synchrotron accelerates the beam to energies up to 270 MeV. The machine design parameters are selected to provide 30 nA of average extracted beam current. This ensures that the guaranteed average extracted current of 20 nA will be achieved. A duty cycle of 50% is appropriate for many beam delivery systems, including raster scanning.

The capability for proton radiography is an important design goal for the RMTC. Proton radiography is the formation of images by the detection of low intensity proton beams which have passed entirely through the patient's body. This technique can be used to check the final alignment of the collimated proton beam relative to the treatment volume within the patient. It can also provide a check of the estimated proton-beam stopping power of body tissues. Higher energy beams (up to 350 MeV) are provided for radiography, but only very low beam currents are required.

A maximum repetition rate (i.e., synchrotron cycling frequency) of 1.5 Hz has been selected in order to provide a design beam current of 30 nA. A half-integer resonant extraction system will provide a slow beam spill from the synchrotron. Great care will be taken to assure a smooth beam spill, one that will be suitable for a raster-scan beam-delivery system. For example, the dipole-magnet power-supply specification includes a very stringent current-ripple requirement, in order to control the time structure of the beam spill.

Figure 1 shows the injector linac, and Figure 2 shows the new RMTC Building.

Table 2 gives some specifications for the RMTC subsystems.

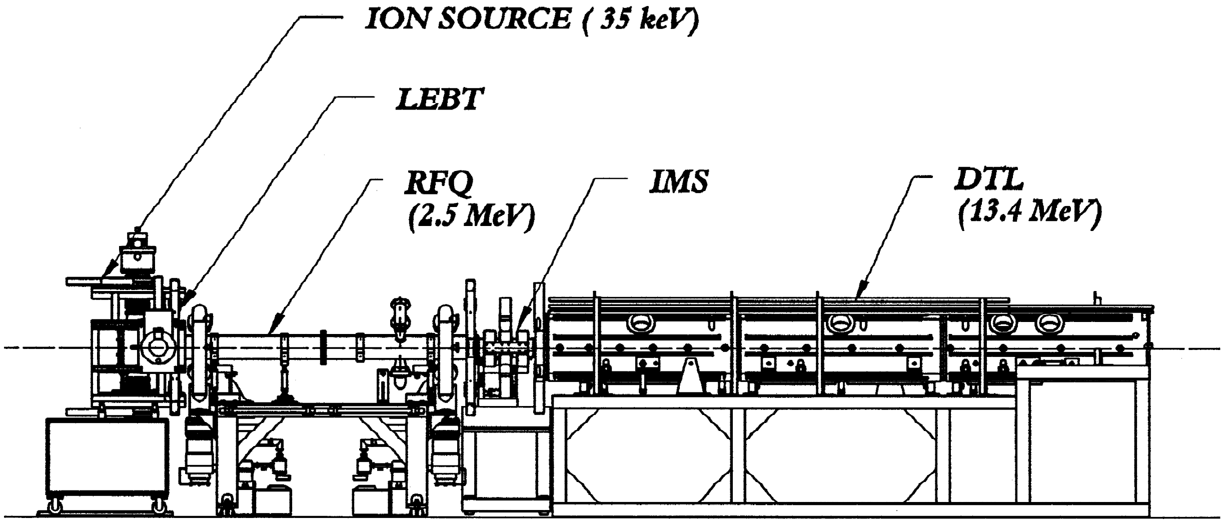

Figure 1 Injector linac

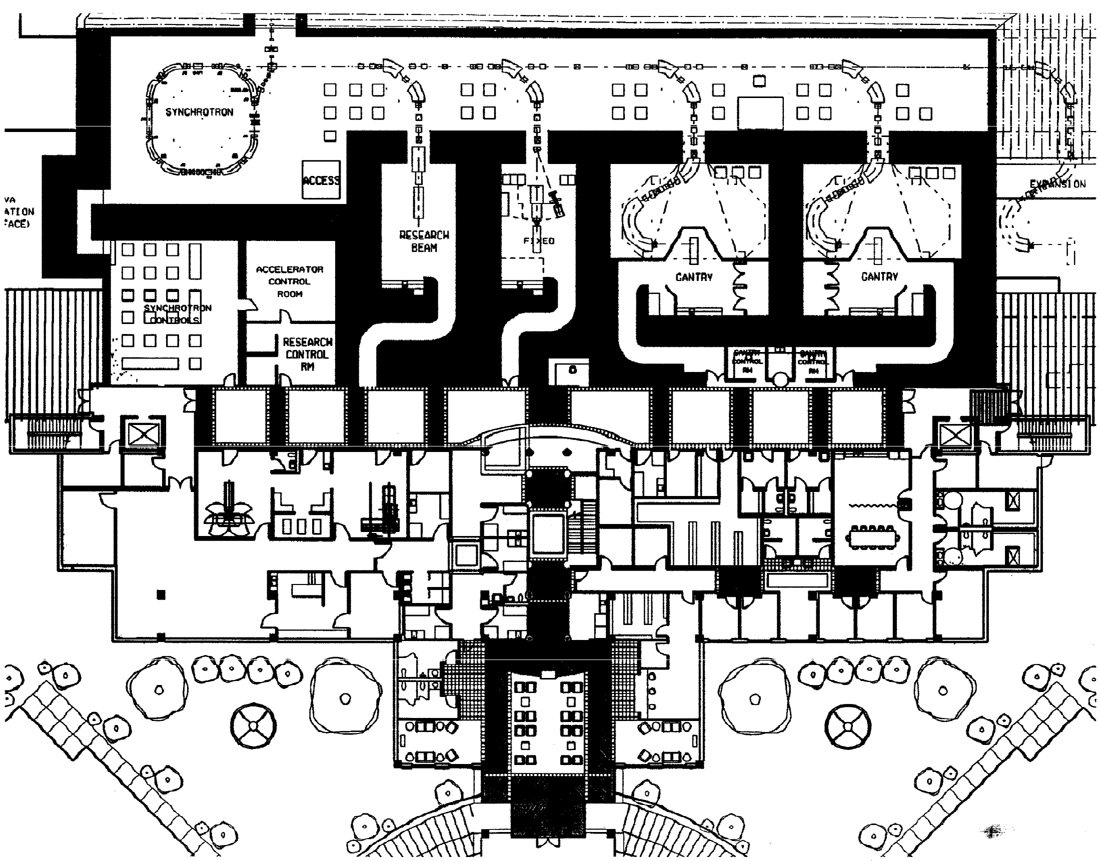

Figure 2 RMTC building

Table 2 **Subsystem Specifications**

Specification	Value
Injector	
Type	H^- linac
Energy	13.4 MeV
Design pulse current	25 mA
Guaranteed pulse current	17 mA
Design pulse length	10 µs
Guaranteed pulse length	2.35 µs
Synchrotron	
Horizontal betatron tune	1.56
Vertical betatron tune	1.58
Harmonic number	1
Radiofrequency	1.708 - 6.995 MHz
Dipole gap	60 mm
Good field region (FW)	80 mm x 50 mm (H x V)
Beam delivery systems	
Gantries	Conventional
Source to axis distance	3 m
Beam spreading system	Double scattering

The linac must provide a pulse current of 17 mA, in order to permit the synchrotron beam current to reach its design value of 30 nA. The design value for the linac pulse current is conservatively set at 25 mA. The design value for the linac-beam pulse length is set at 10 µs.

The harmonic number for the synchrotron has been selected to be 1. The radiofrequency must be swept over a rather wide frequency range, in order to capture beam at 13.4 MeV (injection) and to deliver beam at up to 350 MeV kinetic energy. The full gap of the synchrotron dipole magnets is 60 mm.

Two beam-treatment rooms will be outfitted with isocentric gantries of a “conventional” design, as opposed to a “corkscrew” design. These gantries feature a source-to-axis distance of 3 m. For the start of RMTC operations, a double-scattering system will provide beam spreading in the nozzles.

III. PROJECT STATUS

The technical staff at the TNRLC has completed a Conceptual Design Report that includes a technical design, a detailed cost estimate, a summary schedule, and a management plan. The U.S. Department of Energy has nearly completed an environmental assessment for the RMTC.