Planning a New Life for the IUCF Cyclotrons

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Plans for conversion of existing accelerators at Indiana University for use in proton radiation therapy are presented. The project concept, including some information on the business plan and the new facility, is included. The present status of the project is reviewed.

INTRODUCTION

The Indiana University Cyclotron Facility ("IUCF"), in conjunction with the Advanced Research Technology Institute ("ARTI") at Indiana University, is developing the Midwest Proton Radiation Institute ("MPRI"). MPRI will offer proton radiation therapy treatments for cancers and other diseases afflicting the citizens of the Midwestern United States.

Proton therapy, an external beam radiation treatment that offers specific advantages over conventional radiation therapy, has been proven as an effective treatment technique for a specific set of cancer cases, including tumors of the head, neck and pelvis, cancers of the eye, and prostate cancer. Although sufficient data is not available, proton therapy has the potential to be an effective treatment for macular degeneration, a disease that affects over 25% of senior citizens between the ages of 75-85.

Much continuing clinical and basic research is needed to quantify the advantages of proton therapy over conventional therapies for the many different cancers that arise. The MPRI will provide an excellent facility to pursue this cancer treatment modality. We also expect the MPRI to benefit from the close proximity of accelerator and subatomic research physicists whose expertise can help solve new challenges and should lead to new commercially exploitable technology.

PROJECT CONCEPT

The project concept specifies that the MPRI will be an independent radiation therapy center. It will run as a regional center in association with a consortium of radiation oncology departments from hospitals in Indiana and other Midwest states. This requires that MPRI contain all of the oncology, medical physics, and nursing space found in conventional centers, in addition to the unique proton treatment facilities. In the business being developed, MPRI will be operated by one or more existing organizations which already operate medical clinics.

In 1996, a consortium of physicians and scientists throughout the Midwest collaborated to form the MPRI consortium. This consortium will allow increased accessibility for both patients and physicians interested in proton therapy. Patients from the service area who are receiving treatment can remain under the supervision of doctors with whom they are familiar. The members of the consortium will provide the best possible care by developing an increasing pool of knowledge and expertise on the applications of protons as a tool in the arsenal of the oncology community. Associate physicians and scientists of MPRI are affiliated with institutions in a number of large radiation oncology practices within a 300-mile radius of the institute.

IUCF already has two operational accelerators suitable for proton therapy--a 210 MeV cyclotron similar to MGH's facility, and a 240 MeV synchrotron similar to the LLUMC facility. At these high energies the IUCF accelerators are capable of delivering protons 27 cm into soft tissue. The cyclotron is currently available and the synchrotron could be available for expansion.

IUCF has been in operation for more than 20 years, and has the trained and experienced physicists necessary for managing the beam line, developing beam delivery systems, and supporting the research necessary to further develop the clinical application of proton therapy technologies. It operates as a national facility and is familiar with the demands of servicing a diverse group of users from many institutions.

FINANCES AND MANAGEMENT

Traditional research regarding referral patterns has shown travel distance from a conventional radiation treatment facility has been a key factor in referral patterns. A review of the available literature reports that most NCI designated

comprehensive cancer centers indicated that 80 percent of their patients come from within a 100-mile radius of their facility. While these facilities are located within large population centers, and are not representative of large geographic areas, the study showed that 20 percent do seek care outside of their local area. The most common reason cited was the reputation of the center, followed by the availability of unique services. Twenty-five percent of the U.S. population resides within 300 miles of the proposed MPRI clinic.

Based upon the above information, MRPI believes it will draw referrals from, and serve three distinct markets:

Primary Services Area - is expected to be within 100 miles of IUCF. This geography includes much of Indiana, the greater Indianapolis area, Cincinnati, OH, and Louisville, KY. This area's population is approximately 4 million.

Secondary Service Area - is expected to be from 100 to within 225 miles of IUCF. This geography includes the balance of Indiana, Ohio and Kentucky, as well as the states of Illinois, Missouri and Michigan. This area's population is approximately 41 million.

Tertiary Service Area - is defined to compose the balance of the area reaching at least 300 miles from IUCF. This addition includes the remaining Midwestern states. This area's population is approximately 17 million.

Starting with this demographic distribution, we proceeded to determine potential proton patients using figures for incidence of various cancers from National Cancer Institute figures. Next we selected those cancers where protons have already been shown to have an advantage or are now an option. Finally, in order to get potential referral numbers, we used the referral versus distance information from MGH. This already resulted in a considerably larger number of treatment fractions than the approximately 16,000 which we would expect to be able to deliver in our phase 1 facility which will have four treatment rooms. Currently the Health Care Financing Administration (HCFA) has not developed CPT-4 billing codes which specifically address proton beam therapy. Thus, in initial financial projections we have used conventional X-ray treatment billing rates.

As previously mentioned, we expect the MPRI to be operated by an organization external to Indiana University. Contracts would be enacted between MPRI and ARTI, which was established in 1996 at IU to develop emerging technologies, for the present IUCF personnel to provide the required proton beam for the clinical program.

DESCRIPTION OF THE FACILITY

In planning the conversion of the existing 210 MeV cyclotron into a proton therapy facility, we adopted the following rationale. In addition to the cyclotrons, other existing major assets have to be incorporated wherever possible in order to reduce cost. This includes such items as an existing building with some 12,000 GSF, concrete radiation shielding, beam lines, and associated services. A

building addition will be added to contain offices for MPRI personnel and most patient reception and evaluation rooms.

In addition to the treatment rooms, the Midwest Proton Radiation Institute proposed will have a nursing control station and facilities for patient care evaluation and administration. Treatment planning and medical physics support areas will include an X-ray computer tomography scanner for planning the treatment of tumors that present complicated spacial configurations.

The existing beam line of the IUCF cyclotron was designed to transport 210 MeV protons to several experimental areas. It was used in a long and successful history for nuclear physics research. For the planned dedicated proton therapy facility, a new beam line design is needed to meet the new medical performance parameters.

The function of the new beam line is to match the beam from the cyclotron and deliver an achromatic beam to several treatment areas. A non-linear expansion (NLD) section at the beginning of the trunk beam line allows the production of a homogeneous beam intensity distribution using magnetic elements. The beam is distributed to several treatment areas using a fast beam splitting system. Local energy selection systems (ESS) allow the preparation of the desired beam energy and distribution

The length of the building for which the 30 ton crane is available sets constraints in which the planned treatment and radiation effect areas have to be accommodated. It is possible to extend the building in the future for additional areas beyond the present walls. Most of the 55 inch thick concrete shielding will consist of large standard blocks which can be moved and reconfigured with the existing crane, but several cement walls are poured and are part of the building structure, and these impact the new design.

These constraints had several implications for the beam line concept like energy selection system, bend angles, and locations of treatment areas.

The full cyclotron beam of maximum of about 1.5 micro Amp and 210 MeV is transported down the achromatic trunk beam line into the main Faraday cup at the end of the system. Distribution of fractions of the beam into the planned treatment areas is accomplished using beam splitting systems at the entrance of each area.

Beam splitting systems will be installed in drift spaces in the trunk line at the entrance of each area. A splitting system consists of a fast splitter dipole and a Lambertson septum magnet. When no beam is requested from any treatment area, the full beam is transported down the trunk line into the main Faraday cup.

The four proton treatment rooms will have quite different functions. The isocentric gantry rooms will be utilized for the more complex multiport treatments and arc therapies. One of the fixed horizontal beam lines will be devoted to eye therapy and the other to head, neck, and brain treatments. Stereotactic

radiosurgery also may be performed on the fixed beam line.

STATUS OF THE PROJECT

The current plans call for completion of the new facility over a four year period starting in 1999. This past year has been occupied in finalizing the clinical specifications and in the design of the facility to these specifications. This stage is now essentially complete. The resulting layout derived is shown in Fig. 1. In it there are five rooms --four for MPRI clinical use and a fifth for radiobiology and other radiation effects studies.

In addition to major changes in the physical plan, we have also analyzed carefully the information on breakdowns in the cyclotron accelerator complex over the last decade. This has allowed us to identify a small number of items which together were responsible for most of the average of 7% of beam unavailable time. We also will have a program to remove these from the system. Major changes to improve the reliability, however, will come at the expense of some of the present flexibility of the accelerators. The changes include such items as installation of a motor generator set to overcome stoppages due to small power glitches in our feed line (mostly resulting from thunderstorms), replacement of the Cockcroft-Walton preinjector with a radiofrequency quadrupole accelerator, improvements in trim coil power supplies, and simplification of the beam inflector and deflector system. After these changes reliability should be at the 98% level.

The first horizontal beam room was completed by mid-1998. It is presently configured for eye treatments. A clinical trial is now underway to study efficacy of protons in the treatment of macular degeneration. This study is being carried out in collaboration with the Department of Ophthalmology at the IU Medical School, the IU Department of Optometry, and radiation oncologists from Methodist and IU Hospitals. This room can also be modified relatively easily to treat ocular melanoma.

The last nuclear physics utilization of the cyclotrons will be in November 1998. Following this we will begin the decommissioning and removal of the equipment currently in use. The renovation of the cyclotron will then start early in 1999. While much of the shielding and beam components are already in place, we will be designing and manufacturing some laminated dipole magnets to allow for rapid energy variation in the treatment rooms as required for planned rastor scanning of the beam.

Finally, we have not yet settled on a design for the two gantry systems. This is the last major design task remaining.

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FIGURE 1. The layout of beam transport system, treatment rooms, and new clinical sciences wing for the Midwest Proton Radiation Institute.

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