OPERATIONAL STATUS OF THE UNIVERSITY OF WASHINGTON MEDICAL CYCLOTRON FACILITY

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Abstract

The University of Washington Medical Cyclotron Facility (UWMCF) is built around a Scanditronix MC50 compact cyclotron that was commissioned in 1984 and has been in continual use since. Its primary use is in the production of 50.5 MeV protons for fast neutron therapy. While this proton energy is too low for clinical proton therapy, it is ideal for proton therapy research in small animal models. In addition to the protons used for fast neutron therapy and proton therapy research, the MC50 is able to accelerate other particles at variable energies. This makes it useful for medical isotope research, including isotopes such as ^{211}At, ^{186}Re, and ^{117m}Sn that are being developed to target and treat metastatic disease at the cellular level.

The original accelerator and therapy control systems were run on a DEC PDP-11 with a custom centralized I/O system built around the Z80 processor and chipset. Over the last 10 years we have continually been upgrading the controls while remaining operational, moving to a distributed system developed with the open source Experimental Physics and Industrial Control System (EPICS) toolkit.

INTRODUCTION

In '78-'79 the National Cancer Institute (NCI) awarded contracts to 4 institutions to construct, develop, and operate state-of-the-art fast neutron therapy facilities: University of Washington (UW), Fox-Chase Cancer Center (FCCC), M.D. Anderson (MDA), and University of California, Los Angeles (UCLA). Of these four facilities, the UW fast neutron therapy program is the only one still in existence. The longevity of the UW facility can be ascribed to a commitment from physician and faculty leadership, an exceptional maintenance and upgrade program, and the fact that the facility was designed with the flexibility to support a variety of research programs. The UWMCF was built around a Scanditronix MC50 cyclotron that can produce 28-50.5 MeV protons, 13.6-23.8 MeV deuterons, and 27-47.3 MeV alphas and in addition to producing beam for fast neutron therapy, it also produces beam for medical isotope production, proton therapy research, and radiation effects testing.

OPERATIONS AND MAINTENANCE

The cyclotron facility was built inside the UW Medical Center (UWMC). At the end of construction and commissioning, ownership, operation, and all documentation was turned over to the UW. This model is quite different than most of the modern proton therapy facilities where operation and maintenance are done under service contracts by the accelerator manufacturers. This model has allowed the UW to develop in-house expertise and provided the freedom to modify and upgrade the facility to support changing research needs. The facility is maintained by an in-house engineering/physics group of 5.5 full time employees. The facility operates Tuesday-Friday 7:30 am - 4:30 pm, and is shut down for maintenance on Mondays. There are no planned maintenance shutdowns beyond the Mondays and facility downtime has averaged less than 1.5% over the last 20 years.

The Medical Cyclotron Facility is operated as a cost center within the UW and the service it sells is beam time. The facility is entirely reliant on the business it generates for income and is not allowed to operate with a surplus or deficit. If it does it must adjust its reimbursement rate based on projected usage and operating cost estimates. The primary customer is the UWMC. They pay for beam time required for patient treatments and account for roughly 90% of the income. The remaining income comes from grant based research (isotope and proton therapy research) and commercial users (isotope production and radiation effects testing).

RECENT UPGRADES

The original accelerator and therapy control systems were based on a centralized PDP11/23 control computer and Z80 based I/O devices. For the last 10 years there has been a concerted effort to upgrade the control system to a distributed PC system using the Experimental Physics and Industrial Control Systems (EPICS) toolkit. At this point the new therapy control system has been developed and commissioned, and the accelerator control system has been upgraded with the exception of the RF subsystem, which will be completed soon. One major change to the new therapy control system is the inclusion of a Digital Imaging and Communications in Medicine (DICOM) server to allow for the standardized transfer of treatment plans.

FAST NEUTRON THERAPY

The fast neutron therapy beam is generated by focusing protons (65-75 μA) on a 10.5 mm thick beryllium target housed in a rotating gantry. The neutron beam is flattened with a tungsten flattening filter downstream of the beryllium target, and can then be modified with one of three onboard tungsten wedge filters (30deg.-45deg.-60deg.) to create a wedged profile. The neutron beam is finally collimated with a 40-leaf steel/polyethylene multi-leaf collimator. The standard therapy dose rate is 60 cGy/min at d-max (1.7 cm) for a 10.3x10.0 cm field.

We have recently developed a Monte Carlo model of our neutron therapy beam using MCNPX. The model developed allows us to simulate percent depth dose, lateral dose profiles, and neutron fluence. Preliminary results are in good accordance with measured values. [1]

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The next steps are to use the model for treatment plan verification and to investigate microdosimetry and relative biological effectiveness (RBE). As our beam model evolves into a new treatment planning system we will investigate Neutron Intensity Modulated Radiation Therapy.

ISOTOPE RESEARCH

The multi-particle/variable energy capability of the Scanditronix MC50 cyclotron provides for unique research opportunities beyond radiation therapy. This functionality has helped sustain the facility in the face of declining neutron patient volumes. The UWMCF is now routinely producing 211-At for research in pretargeted radioimmunotherapy at the UWMC and the Fred Hutchinson Cancer Research Center, and 117m-Sn for clinical studies in treating arterial vulnerable plaque. [2-4].

PROTON THERAPY RESEARCH

The UWMCF was originally equipped with two fast neutron treatment vaults: one with a rotating gantry and multi-leaf collimator, and the other with a fixed horizontal port and square insert collimators. The fixed beam vault had only been used for physics and radiation biology research, never for routine patient treatment. Because of an increased interest in proton therapy we have removed the beryllium target station and neutron collimator from the fixed beam treatment head, extended the vacuum chamber, and installed a mechanical mounting system to allow for image guided proton therapy research. Current research includes proton activated PET scanning [5] and image guided proton beam research for preclinical in vivo studies.

RADIATION EFFECTS TESTING

The UWMCF has seen recent increase in requests for radiation effects from US aerospace companies. The ability to deliver proton, neutron, alpha, and deuteron beams at various energies along with in-house Monte Carlo modelling and high availability make the UW facility attractive for radiation effects testing.

CONCLUSION

After 32 years the UW Medical Cyclotron Facility is running well and is one of the few remaining centers worldwide treating with fast neutrons. The biggest threat to continued operations is declining patient treatments, which provide the bulk of funding for the facility. Beyond neutron therapy, the facility has an established isotope production and research program and is developing a proton therapy research program as well as a Monte Carlo based radiation effects testing program.

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