A Guide to the
The Morris and Beverly Baker Foundation Laboratory for
Medical Physics Education

Background

In the summer of 2012, the Baker Lab did not exist. In fact, the room you are now seeing was completely empty awaiting the infusion of funding and effort to turn it into the premier undergraduate lab in the Department of Physics. This new teaching space has been funded through a generous $125,000 donation from the Morris and Beverly Baker Foundation, a $40,000 contribution from the University of Windsor’s Strategic Priority Fund, and significant support from the Faculty of Science. Although labs have been underway in this space since January of 2013, this event marks the official opening of the facility.

Motivation

This funding was used to develop an undergraduate teaching laboratory which will be utilized by upper-year students in the Department of Physics Medical Physics program. Two fourth-year medical physics laboratory courses will be taught in this space. Students graduating from the medical physics program with access to these laboratory facilities will be uniquely prepared for a career in medical physics, either working clinically with patients or working for medical high-technology companies.

Medical physicists are health care professionals with specialized training in the medical applications of physics, particularly in cancer diagnosis and treatment. Their work often involves medical imaging such as x-rays, CT scans, MRI, ultrasound, and nuclear medicine scans as well as radiotherapy which involves the treatment of tumors with high-energy x-rays, radiation, and radioactive seeds. Students graduating from this program will eventually go on to work in hospital diagnostic imaging departments, cancer treatment facilities, or hospital-based research establishments.

Achievements

To date funding has been used to:

✓ provide this space with all new furnishings
✓ acquire the Epson “smart” teaching console for lectures and demonstrations
✓ acquire and construct all the experiments summarized in this document and displayed on the tables in the lab.
Medical Imaging Labs

- Convolution and Aliasing Algorithms in Matlab®
  The field of medical imaging is not just concerned with acquiring high-quality images or pictures of anatomy. A large amount of computational effort is expanded in image analysis and data handling. In this lab students learn about the critical mathematical operation of “convolution” which is required for all filtering and processing of medical image data. As well, students will learn about one of the most important aberrations that can be introduced into medical images, called “aliasing.” Using software, students will graphically investigate the convolution of mathematical functions and explore the aliasing phenomenon.

- MRI “K-Space Tutorial” for Matlab®
  Magnetic resonance imaging “MRI” is one of the most important imaging modalities available to the medical physicist. Because MRI machines cost millions of dollars and clinical units are used almost around the clock, the best way to learn about MRI is via computer simulation. In this lab, students will utilize software to investigate how data is acquired during MRI and how this data is mathematically transformed into a medical image.

- Virtual Magnetic Resonance Imaging (VMRI) for Java®
  In this lab, students learn more about the actual data acquisition process which occurs during an MRI scan. Utilizing open-source software written in Java®, students will simulate all the important MRI sequences currently in use clinically and examine the effects that the variation of many important experimental parameters have on the quality of the MRI image.

- Ultrasound Imaging
  Ultrasound is one of the most common and safest medical imaging technologies. Using an ultrasound apparatus designed and built by UWindsor medical physics students, in this lab students will investigate the operation of a common ultrasound source/receiver, examine the resolution of such an instrument, and measure the attenuation of water and tissue-like phantoms that they construct themselves.

- Medical Image Visualization Techniques for MATLAB®
  A variety of common mathematical algorithms are used to convert generic medical image data (MRI or CT) to the “pictures” most of us are familiar with. In this lab, students will use the Matlab® software and investigate how three dimensional “virtual” medical images are constructed from various slices of two-dimensional data.

- CT Simulator
  X-ray computed tomography “CT” is probably the most common medical imaging modality available to a medical physicist. It is commonly used to assess tumor growth and control, as well as to plan x-ray therapy. Because an x-ray machine emits harmful ionizing radiation, the best and safest way to learn about CT is by utilizing the DeskCAT™ CT simulator (Modus Medical® Inc.). This simulator uses a completely safe light source and transmission phantoms to allow the student to learn how CT images are mathematically created from x-ray data and to investigate what determines CT image resolution, noise, and quality.
Radiological Physics Labs

- **High Resolution Gamma-Ray Spectroscopy**
  Students will learn about nuclear isotopes and nuclear radioactivity which are used both in cancer treatment (by placing radioactive sources in or near tumors) and in nuclear medicine imaging (in which patients are injected with radioactive isotopes which are then imaged from outside the body.) This instrument allows students to “see” and measure the types of radiation emitted by specific isotopes.

- **Gafchromic Film Dosimetry (WRCC)**
  Students will investigate a new method of “dosimetry” which is the measurement of radioactive dose administered to a patient for tumor control. Using relatively inexpensive flexible single-use film, the students will measure the dose administered by a cancer treatment machine at the WRCC. Students will expose these films at the WRCC and then using a commercial high-resolution scanner in the Baker lab determine the dose that was delivered.

- **High Dose Rate Brachytherapy Source Activity (WRCC)**
  Students will start to prepare for careers in medical physics by learning one of the QA (quality assurance) techniques routinely performed. The radioactivity of high dose rate radioactive seeds used, for example, for treating prostate cancers, will be measured at the WRCC and compared to the theoretically calculated values.

- **Water-tank Electron/Photon Beam PDD Profiles (WRCC)**
  Students will learn another important medical physics QA (quality assurance) technique by measuring the distribution of dose from a clinical treatment machine (a linear accelerator or “LINAC”) at the WRCC. Students will compare the experimentally determined behavior of dose in a water phantom with the theoretically predicted behavior of both x-rays and electrons used for therapy.

- **Thermoluminescent Dosimetry (TLD reader)**
  Students will be introduced to another technique common in dosimetry, which is the measurement of dose measured by small thermoluminescent crystal chips. Such chips are common in radiation monitoring “badges” that hospital staff and radiation workers are required to wear at all times. Chips will be exposed at WRCC to known doses and then analyzed in the Baker Lab to measure this dose.

- **X-ray Photon Interactions in Matter (WRCC)**
  Students will learn the different physics involved in how x-rays interact with tissues depending on whether they are of relatively low energy (used in x-ray imaging machines) or high energy (used in controlling tumors in treatment machines). This experiment utilizes the LINAC and low-energy x-ray units at the WRCC.

- **On-line Wireless mobileMOSFET Dosimetry (WRCC)**
  Students will prepare for a career in medical physics by learning another important emerging technique in dosimetry, the use of very small inexpensive MOSFET devices to measure the dose delivered by a clinical LINAC machine. Utilizing the wireless mobileMOSFET system (Best® Medical Canada), MOSFETs will be exposed to a variety of x-ray doses at the WRCC and the data accumulated there. Returning to the Baker lab, students will analyze this data to learn about important calibration routines, experimental apparatus design, and x-ray field geometry.