Introduction

Wilson Laboratory was built in the 1960's and housed an accelerator in the late 60's early 70's. It is 0.8 kilometers (0.5 miles) in circumference and can carry a beam at an energy of 5 GeV (billion electron volts).

Experiments done at the laboratory have focused largely upon the collision of electron and positrons and studying the by-products of those collisions. For the first 20+ years Wilson Lab was known largely for the studies conducted on the b (bottom) quark and more recently (past five years) the c (charm) quark.

The future of the laboratory lies in the direction of x-ray physics where research first started on campus in the 1950's at Newman Laboratory and continued in the late 1970's at Wilson Laboratory.

When a charged particle passes through a dipole magnetic field, it gives off energy in the form of a photon, mostly x-rays, and we are able to use these x-rays to do various experiments (at CHESS).

High-energy physics at Cornell will now be conducted at the Large Hadron Collider (LHC) at the CERN particle physics lab in Geneva, Switzerland. Our physicists are part of a collaboration of thousands of scientists building one of two large detectors at the LHC called the Compact Muon Solenoid (CMS). Physicists are involved in the following areas of the CMS experiment: pixel calibration, core software, tracking, and the EM calorimeter.

At Cornell, physicists plan on building a new, large accelerator to produce x-rays and will continue to operate the existing accelerator, CESR.

CESR Control Room

In this control room there is a mixture of late 1960's, early 1970's and modern computer controlled instrumentation.
The new controls are based on GUI interfaces with commonly available PCs.

CLEO Catwalk/Mezzanine

What you are looking at is the CLEO detector that was used up until March of 2008 for electron/positron collisions. We have recently removed the center portion of the detector and are now installing components of a newly configured accelerator that is going to pass through the center of CLEO. The outside remnants of CLEO remain (iron muon chamber) because it was too large/heavy to remove.

We are now using this area to test components and ideas for a new accelerator called the International Linear Collider (ILC). Right now visitors can see the wiggler magnets, which alternate north/south as the beam passes through them, sticking out of the center of

CLEO. We will be installing six of these wiggler units. It is planned that this part of the project will be completed by the middle of October. All of the work done of these wiggler magnets has been conducted here at Wilson or Newman laboratory; fabrication and winding of the magnet coils, circuit boards and vacuum chambers.

All sorts of people working together is what makes this project possible; scientist, technicians, machinists and students all provide the skills and expertise to make a project of this magnitude possible. The majority of the parts/components of the exiting structure and future structure are manufacture here on campus.

CESR Tunnel

CESR is located 40 feet under ground and has been in operation since the 1970's. Electrons and positrons are stored in the beam pipe and can be stored for several hours. This allows scientists to continually conduct experiments (used to collide the particles) but now we run CESR for accelerator purposes (x-ray production).

The orange devices are dipole magnets, simple electromagnets with uniform magnetic fields down it's length, that alternated between focusing magnets such as the blue quadrapole magnets. As the electrons are accelerated through the beam pipe, they repel one another and the bunches grow larger. Every other magnet is oriented in such a way and is used to focus the bunches all the way around the tunnel.

SRF Cavity

As the electrons and positrons circulate, they give off energy as x-rays. We must continually plumb in energy or the beams will slowly start spiraling inwardly until the particles strike the inside of the vacuum chambers until the energy is entirely lost.

In the SRF cavities, each time the beam passes through the particle are provided with a boost of energy (analogous to a child being pushed on a swing).

The RF cavity is designed where an electromagnetic wave passes through the inside of a niobium cell. The electromagnetic wave gives a push to the particle as it passes through the cavity. The particles must be very carefully timed so they arrive in phase with the RF waves to receive the acceleration.

There is a lot of technology in the RF cavity. The cavity must be cooled down to a temperature where the niobium becomes superconducting because the amount of power we have to put into it would heat up any copper we would use and would cause problems with electric power. Niobium superconducting cavities do not cause these problems. This type of technology requires that we make our own cryogenic fluid (liquid helium) to keep these cavities at 4 degrees Kelvin (-269 Celsius). It has taken a lot of work to develop this technology; we were able to license this technology to a company (ACCEL) that produces these cavities commercially around the world (four or five other synchrotrons).

New Accelerator

We are currently building a new machine called the Energy Recovery Linac (ERL), which is not based on circulating beam technology as seen in CESR, but on a linear accelerator. The idea is to accelerate electrons to 5 GeV through a long series of RF cavities just like the one you saw in CESR. This series will consist of approximately 300 RF cavities in a row – which is a huge structure with a large price tag and many associated difficulties!

The 5GeV accelerator will consist of a series of magnetic devices that will send electrons around a loop, and have the electrons pass back around 180 degrees out of phase with each electromagnetic wave. When it passes through the RF cavity the second time, the beam will be decelerated and will impart its energy to an electromagnetic field where the energy will be ‘recovered’.

Think about this: A beam of electrons at 5 GeV, and a current of 0.1 amps (100 milliamp) has a power of 500 megawatts of electrical power. This amount of power is equivalent to the average power produced by an electrical power plant that we will not be able to build! Therefore, the recovery of this energy by passing the beam back through the linear accelerator out of phase is the only way that we will be able to build this kind of machine.

When a beam circulates thousands of times a second in an accelerator, the size of the electron beam increases and we cannot make the beam the size that we want it. But, in a linear accelerator, we can make x-rays, extract the energy out of it, and do this continually. We are generating electrons every time they pass through the machine and therefore we can create very ideal beams of electrons that produce x-rays orders of magnitude smaller and more intense than what exists today. X-ray physicists are very interested in this new source of x-rays and it will bring all sorts of new x-ray experiments to them that they cannot currently perform. (13:10:13)