

Information from Yulin Li (1/6/09)

I. General Background Information

- CESR's electron-positron collisions for many years will help us with future studies to be done at Wilson for the International Linear Collider (ILC) Damping Ring
- The ILC will achieve an energy level of 1 TeV. The design cannot be circular and achieve this energy because too much energy would be lost to synchrotron radiation.

II. CEsrTA (CESR test accelerator)

- One-third of the running time of CESR will be devoted to CEsrTA studies
- Major accelerator reconfigurations (including vacuum systems and magnet systems) been done over past 1.5 years for CEsrTA
- A short-term project (3 years?) with several research areas being addressed:
 1. Electron cloud studies: the clouds that form destroy the positron beam. Investigations into how these clouds are formed and how they are distributed.
 - A. Many specialty instruments have been implemented in CESR to measure EC, to understand the EC growth and distributions in various magnetic fields, particularly in the wiggler magnets. These measurements will be also used to benchmarking various computer simulation models.
 - B. ECSuppressions – can electron clouds be prevented from forming?
Passive Techniques: TiN (Titanium-nitride) coating, Non-evaporable getter (NEG) coating, Grooved surfaces (collaboration with SLAC)
Active Techniques: Clearing Electrode (KEK collaboration).
 2. Ultra-small beam emittance: work being done to create a more collimated beam of electrons/positrons.
 - A. Arrangement of wiggler magnets into one place (CLEO area) where the beam pipe does not bend and no synchrotron radiation emitted. Called the Zero Dispersion area; wigglers “damping” or cool the beam by radiating energy. Must demonstrate and measure this phenomenon.
 - B. X-ray Beam Size Monitoring (x-BSM) being done in D-Line and will be done in C-Line soon. Optical devices used to measure the divergence and the size of the beam.

- C. Magnet Alignment: using modern laser tracking equipment and GPS to align the magnets in CESR to within 100 micron or better.

III. ERL (Energy Recovery Linac)

- There is a need by the scientific community to support a facility that can produce very high brilliance X-ray sources (hundreds of or even thousands of times higher than the currently storage ring based 3rd generation light sources).
- Generating electron beam with ultra-low emittance, that is round in beam shape with very low beam size and divergence, is essential to the very high brilliance X-ray sources
- In storage ring based accelerator, the beam will inevitably spread out as it takes millions of turns around the circle. With beam energy spread and ring dispersion, during these trips, the shape of the beam is ‘relaxed’ into a “ribbon-shaped” beam with measurements of approximately sub-millimeter in height by ~1 centimeter in width. The X-ray beam generated by this electron beam will have similar shape. This can be visualized and seen by looking at a “burn” image of a ribbon taken by CHESS.
- If a beam circles a ring only once, then this “ribbon” phenomenon does not occur because the electrons/positrons do not have time to spread out.
- There are two major practical obstacles about a ring-shaped accelerator producing low-emittance beams (and circulating those beams only one time around the ring):
 1. The energy bill: To accelerate this beam, you need 500 megawatts of power! No one can afford to pay such a high utility bill.
 2. Inability to dispose or “dump” the beam. A beam with this energy will drill a hole in any material that is put in front of it.
- An Energy Recovery LINAC (ERL) based accelerator provides the solutions:
 1. In an ERL machine, electron beam from an injector is accelerated to full energy (say, 5 GeV) in a superconducting linear accelerator (SC LINAC) in one pass. The electron beam will be used to generate high brilliant X-ray beams. The used electron beam will be decelerated in the same SC LINAC to extract the energy out of the electron beam back to the LINAC.
 2. With a goal of 99.99% energy recovery, the 500 Megawatts power bill can be reduced to ½- Megawatts!
 3. The low energy electron beam may be safely dumped with a properly designed beam dumper (that is possible with existing technology and available material)

- In an ERL-based light source, the electron beam current and emittance are determined by the electron source (the electron gun) and the injector. The electron gun and the injector required by the ERL are most challenging.
- The prototype that has been built downstairs (Phase 1a) has cost approximately \$20M. Why did it cost so much? Because we need to ‘feed’ 100 mA electron beam continuously to the ERL, therefore a powerful injector must be built to accomplish this.
- The injector consists of a photocathode gun, and a super-conducting RF (SRF) cavity cryomodule.
- A high power (20 W) laser with high frequency (1.3 gigahertz). The laser must be perfectly timed with the accelerator fields inside of the SRF cavities.
- The “submarine” (container which houses the injector) contains the photocathode gun and the high voltage power source. There is a very strong electric field generated within the submarine and it is filled with Sulfur Hexafluoride (SF₆) gas to prevent high voltage break-down.
- The electrons must be accelerated quickly inside of the gun (lots of voltage!). (Electrons tend to ‘blow’ themselves apart. Accelerating electrons close to the speed of light reduces this blow-up, thanks to Einstein’s relativity !!)
- Designers want to achieve 100 milliamps from the injector. They have achieved ~20 mA in a smaller scaled test, achieved ~2 mA in its present setup, only limited by high radiation problem.
- Components found in the different beam lines emerging from the cryomodule include: many beam viewers, a fly wheel (FW), a deflection cavity (dF cavity), the dispersion area (to bend and measure energy spread).
- Scientists are currently running tests and collecting data on beam size, dispersion and timing as well as the ability to merge and dump the beam