Dedicated Operations and Scheduling

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CHESS is a dedicated x-ray source. That is the highlight of the past year's operations. For the first time in the history of Wilson Lab, the CESR storage ring is being run routinely with two particle beams for the sole purpose of generating x-rays for CHESS. Previously the only dedicated running time for CHESS operations was for short duration undulator runs or if the High Energy Physics (HEP) detector had a problem. As of April 2004, we have now had three dedicated running periods that have allowed some 466 users to experience the benefits of operating in a dedicated mode.

On January 3rd, 2003 CHESS entered a new phase of operation, with a short 3 week period of CHESS dedicated running. The purpose of this running period was to get an early indication of how the facility would be operated and to discover any unforeseen complications. A final month of parasitic operation took place shortly afterwards but by the fall of 2003 the transition to CHESS operating in a dedicated mode was complete. This shift is in large part due to the dramatic change in HEP investigations that are being conducted by the CLEO collaboration at LEPP. The high energy physicists in the CLEO group have begun studying the interactions of positrons and electrons at an energy of ~1.8GeV, which provides minimal usable beam to CHESS compared to the previous investigations around 5.3GeV. This change in the thrust of the high-energy physics operations required many major instrumentation changes to the ring.

The first and largest change was the fabrication and subsequent installation of 6 superconducting wigglers during the summer of 2003 in the eastern half of the storage ring. The symmetric complement of wigglers will be installed in the western half of the storage ring during the spring of 2004. These wigglers are needed to dampen, or reduce the amplitude of particle oscillations, which lead to loss of beam current and luminosity (colliding beam intensity) during low energy operation. This damping, or cooling, results from the strong synchrotron radiation from the wigglers. The wigglers also allow convenient control of the size of the core of the beam (beam emittance).

The lower energy operation for HEP (1.8 vs. 5.3GeV) requires synchrotron radiation beyond that created from the dipoles to ensure a stable beam orbit and maximize luminosity for the CLEO detector. This is why these wigglers are often referred to as damping wigglers. One's first thought may be that CHESS should be taking advantage of the installation of these wigglers to install more beamlines and make use of the additional wiggler beam generated. Unfortunately, these wigglers are located in areas unsuitable for the installation of synchrotron beam lines and have design characteristics inappropriate for new beam lines. In fact the wigglers that are used during CHESS operations for the generation of wiggler beam for A, F and G - lines must be effectively disabled during HEP operations by opening the gaps. This is done to prevent damage to equipment not designed to handle the increased beam fan these wigglers could produce if they were to remain closed during low energy running.

Installation of the new super-conducting wigglers is a large and complex job. Associated with their insertion into the storage ring is the large scale movement and modification of existing magnets along with the large scale addition of cryogenic infrastructure required to maintain the cooling of these wigglers.

During 2003, as the LEPP personnel were beginning the conversion of the laboratory to the current operating mode, individuals at CHESS were very busy with other projects, particularly associated with the new G-line. In the latter part of 2003, new vacuum chambers were constructed and installed to house the new multi-layer optics and mirrors to complete the G-line front end. Unfortunately, due to a water leak involving one of the new multi-layer optics, commissioning this past winter involved only the G2 and G3 stations. This will be ameliorated in the near future and we plan on starting up the summer of 2004 with all stations fully operational.

Dedicated running of the CESR storage ring for CHESS has meant a great number of changes to the day-to-day operation of the laboratory. While operating for CHESS, the facility is running in a standard four-week scheme that consists of six days of 24-hour user running and one day of maintenance down and machine studies. Prior to this we would often have two to three days of machine studies between running periods. Although this scheduling scheme is new, scheduling for users has already become much simpler as a result of better long-term predictability of the CHESS running schedule. The schedule for 2004 currently shows operations for CHESS for slightly more than 4 weeks out of every three months. Although this shows that CHESS will not have beam for about two months at a time, it is important to note that the annual amount of beam time for users will be about the same as during parasitic running conditions in the past.

CHESS USER SCHEDULE FOR 2004

July 21, 2004 - August 17, 2004

November 10, 2004 - December 7, 2004

Although dedicated running has just begun, we already see many improvements in running conditions. Particle lifetimes are improved, resulting in run lengths of 4 hours compared to 60 to 75 minutes during HEP, with similar losses in beam current (200mAmps reducing to ~150mAmps). We have also started to implement a “top-off mode” that entails boosting the particle currents without dumping either of the beams and improves stability due to reduced thermal cycling. Most important of all may be the fact that the machine startup does not entail weekly optimization of conditions for HEP luminosity; thus startups are quicker, more stable and more reproducible from week to week.

The overall improvements in beam stability and running conditions have had the added benefit of allowing CHESS and CESR to pinpoint and solve several problems that are more sporadic in nature. For instance, during the early 2004 running, it was found that the water temperature for the cooling of the storage ring magnets was out of regulation. Although there had been indications of these types of instability in prior years, it wasn’t until improved beamline position instrumentation in conjunction with dedicated running that we were able to definitively correlate water temperature fluctuations with beam motion. With each dedicated CHESS run we will continue to improve the stability of the particle beams, and likewise, the ability to discover the source of instabilities when they occur.

CHESS generally runs with some software feedback that uses localized magnetic bumps to attempt to restore beam conditions when stability problems occur. However, the current scheme (due mostly to lack of space for additional magnets and monitoring) is not ideal. In addition to further work in this area, CHESS operations staff are investigating with the LEPP personnel the possibility of incorporating a global feedback scheme that should be much more versatile.

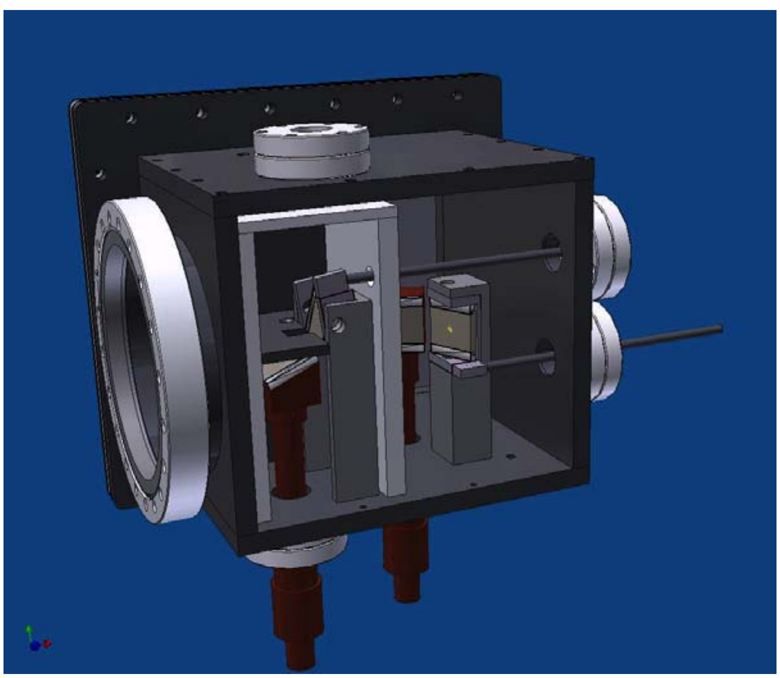

Fig 1: E-line Chamber cutout view - note two sets of optics for simultaneous horizontal and vertical source size measurements.

Although beam stability has long been first on the list, it isn't the only improvement that we are looking for. For the first time with dual recirculating particle beams, the storage ring has been operating with a lattice designed specifically for CHESS operations. This has meant a great deal of work on the part of many people to optimize running conditions. The first step was to do a minimal impact lattice design to try to reduce the beam sizes at the source. Over the past year the horizontal emittance (nm-radians) has gone from ~160 during HEP to ~120 for dedicated last year to ~90 during early 2004. If all else were equal this would imply a significant reduction in the horizontal beam sizes by almost a factor of two. Simultaneously, work has also been done to reduce the vertical beam source sizes. Although preliminary beam size measurements indicate that the horizontal beam sizes have changed for the better, there remain questions as to whether corresponding improvements have occurred at the experimental stations. To gather additional information, we are constructing a new analytical instrumentation beamline (E-line) dedicated to the measurement of these parameters.

The E-line will get its radiation from the hard-bend magnet that lies between the D and F3 hard-bend sources. To minimize the impact on nearby stations, the entire contents of the beamline, including experimental chamber (Figure 1), will be located in the tunnel. Prior to this, measurements of this type could only be made in one of the experimental stations, and thus competed with potential user time. The E-line will incorporate two sets of silicon crystal optics (horizontal as well as vertical) in a dispersive orientation to collimate the x-ray beam and project it onto fluorescent screens monitored by video cameras (Figure 2), allowing direct measurement of beamsize in the collimated direction. [1]

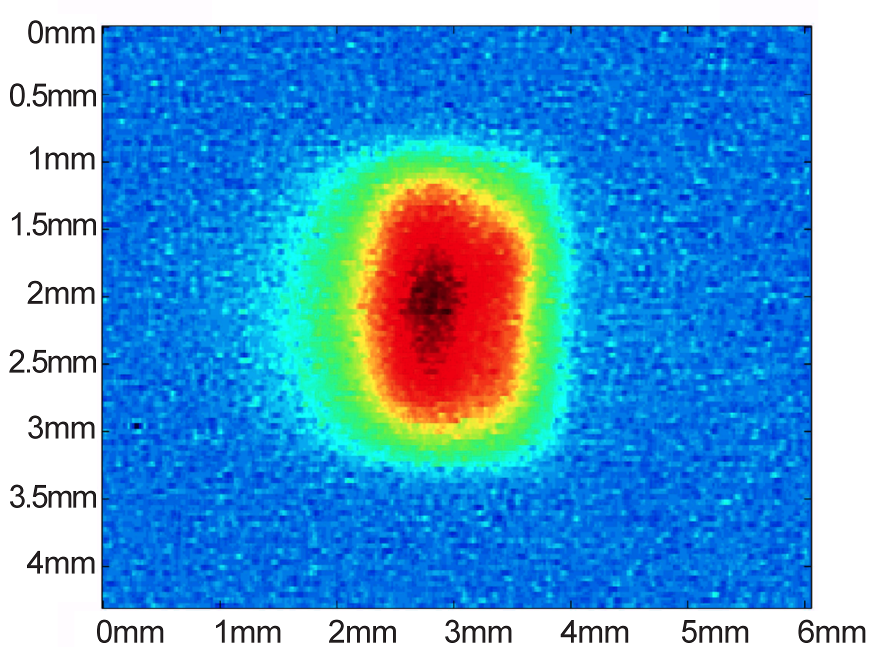

Fig 2: Image obtained at CHESS D1 station for horizontal source size measurements. Vertical size is not collimated.

The E-line measurement system will be available at all times of operation to verify theoretical lattice calculations. In addition to measuring source sizes, E-line will also be used in beam stabilization by analyzing the profile of the image and monitoring the location of the peak and Center of Mass (COM). Overall we look forward to improving running conditions and seek to better accommodate the users' needs for more demanding experiments.

References:

[1] Finkelstein, Bazarov, White, Revesz ; *"Crystal Collimator", "Measurement of CESR Source Size"*, AIP Conference Proceedings, Eighth International Conference on Synchrotron Radiation Instrumentation, The American Institute of Physics (2003)