Bunch By Bunch Instrumentation Upgrades For CESR Based On Requirements For The CESR Test Accelerator Research Program

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Abstract

The research focus of the CESR Test Accelerator program requires new instrumentation hardware, software and techniques in order to accurately reevaluate beam dynamics in the presence of electron-cloud affects. These new instruments are also required to develop low-emittance beam conditions which are key to the success of the damping ring design for the International Linear Collider. This paper will detail some of the architecture and tools which have been developed and deployed on the CESR-Taggen beam line. Emphasis will be placed on the 4 ns bunch by bunch Beam Position Monitoring system as well as the 4 ns capable X-ray Beam Size Monitor.

CESR Instrumentation Support

- Baseline code:
  - Supports multiple instrument types
  - Supports multiple instrument types

- Data collection synchronization
  - Programmable trigger
  - Encoded plane elimination

XBSM Tools and Analysis

At this stage of the program, the electron instrument is now basically operational. Efforts have focused on amplifier and digitizer development. This instrument uses the new 4 ns digitizer and corresponding amplifiers. Software tools have been created using Matlab which allow for basic imaging and fitting operations.

At three optical elements have been imaged. Basic fitting has been applied to the pin hole data. The fits have been used to actively tune the beam conditions.

The basic characteristics of the electron optics are the same as the position instrument, with the exception of the dimensions of the Coded Aperture. The Coded Aperture used on the electron instrument is 155 µm x 500 µm.

Electrons

The electron instrument has been used to demonstrate the successful operation of the new digitizers and the clean separation of 4 ns spaced bunches.

XBSP Hardware

The FZP and CA are manufactured on a common silicon substrate. For the positron line, the patterns are cut into 0.7 µm Au and are supported by a 2.5 µm Si membrane. The FZP pattern has 120 transmitting pinholes. The CA is a combination of transmission and diffraction resulting from the 8 slits ranging in size from 10 to 40 µm (position line).

Advantages:
- As in the case of the vertically limiting slit, the imaging is relatively insensitive to variations in the wavelength. The resonant power of the CA has been compared to that of the FZP, both without the use of a monochromator. Data was collected in “slow scans” for the two imaging devices, for two beam sizes. For each imaging device, the RMS of the difference between images from different beam sizes is an indication of the resolving power. The RMS difference for the CA was 1.7x greater than that of the FZP (for the same change in beam size and normalised for incident photon flux), indicating that the beam size resolving power of the CA is superior.

Disadvantages:
- In the future, we will develop a template based fitting procedure necessary to exploit the improved resolution.

XBSP Observations

The detector is a vertical array of 32 InGaAs diodes with pitch 0.15µm and horizontal pitch 400µm. The InGaAs layer is 3.3 µm thick, which absorbs 73% of photons at 2.5keV. There is a 160nm SiN, absorption layer. The time response of the detector is sub-nanosecond.

Three optical elements are available for 20Gy/s stored beam operation: a vertically limiting slit, a Fresnel Zone Plate (FZP), and a Coded Aperture (CA). These elements reside in the storage ring vacuum and can be selected and aligned remotely to test the requirements of various measurements. At 20Gy/s, the typical power load on the optical elements is of order 1 mW/m². The optical elements are in contact with actively cooled copper supports to remove this heat.