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Chapter 6

The Photon Beamline

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6.1 The Active Collimator

The primary photon beam collimator on the Hall D photon beam line has a circular aperture of diameter 3.4 mm, and is located 76 m downstream of the radiator. Effective collimation requires that the photon beam spot be centered on the collimator axis to a small fraction of its radius. The specification of the tolerance on this alignment during beam operation is a circle of radius 200 microns. The reason for this demanding requirement is illustrated in panel two of Fig. 6.1, which shows how the collimated flux of tagged photons varies as the beam spot centroid deviates from the center of the collimator. Parity violation experiments at CEBAF have shown that it is possible to obtain electron beam position stability at the level of 200 microns without employing active stabilization. However, the lever arm of 80 m from the last magnetic elements on the electron beam and the entrance to the photon collimator means that electron beam displacements less than 100 microns back at the source might potentially result in shifts of the photon beam spot by more than 200 microns at the collimator position. For this reason, the GlueX experiment has incorporated photon beam centroid monitoring and active stabilization into the source design. The device that performs this function is the active collimator.

The basic design for the Hall D active collimator was originally developed for electron beam lines at SLAC [1]. This device is very radiation hard, highly linear, and highly stable in its gain. It consists of a large tungsten plate divided azimuthally into four quadrants and radially into two rings. Attached

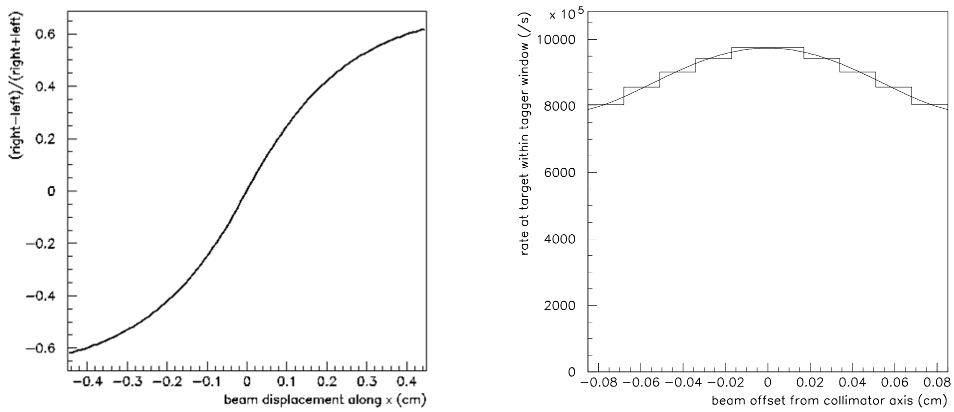

Figure 6.1: Results from Monte Carlo studies of the active collimator in the Hall D photon beam line. Panel one shows the current asymmetry (difference over sum) between two opposing inner sectors, as the beam position is shifted along the line between their centers. Panel two shows the systematic shift in the rate of tagged photons within the polarized peak that reach the GlueX target, as a function of the shift of the photon spot from the collimator axis.

to each sector is a large array of stout tungsten wires that rise out of the block along the direction of the beam. Beam photons interacting in the plates create showers that radiate into the pin arrays. The charge asymmetry of electrons over positrons in the showers due to high-energy delta rays called *knock-ons* generates a small net current in the plates. Currents in each of the plates measure the photon beam intensity integrated over the region of the pin arrays. Current differences between the azimuthal sectors in a ring are the signature of beam displacement from the central axis.

The first panel in Fig. 6.1 shows the current asymmetry between opposing inner sectors of the active collimator as a function of the offset between the beam centroid and the active collimator axis, derived from Monte Carlo simulation. The results show that the device achieves maximum sensitivity when the beam is nearly centered, and that 5% resolution in the current asymmetry is sufficient to measure the beam centroid offset with an error of 200 microns r.m.s. The second panel in Fig. 6.1 shows the collimated fraction of the photon beam in the coherent peak as a function of the offset of the beam centroid from the collimator axis. This variable reflects the sensitivity of the collimated spectrum to beam spot offsets at the collimator, and shows that 200 microns is about the right tolerance on the alignment if the collimated spectrum is to be stable at the 1% level.

Fig. 6.2 shows the measured response of the active collimator in a beam test conducted in the Hall B coherent bremsstrahlung beam line using a prototype of the final device. The two curves in the plot show the current in two opposing inner sectors as the collimator is moved across the beam. Even though the intensity of the Hall B beam was only a few percent of the full intensity of the photon beam in Hall D, it is clear from the smoothness and symmetry of the curves in the plot that the errors on the current measurement are less than 5%.

The current-sensitive amplifiers used to read out the active collimator have sufficient bandwidth to allow a beam centroid measurement many times per second, which allows a feedback signal to be derived from it that can be used to control micro-steering magnets on the electron beam to suppress drifts in beam position, and also beam motion at 60 Hz and its first few harmonics. A feedback system is being designed, in concert with the accelerator group, to enable a fast-feedback beam stabilization system. It is expected that such a system would only be usable at beam currents above 50-100 μA.

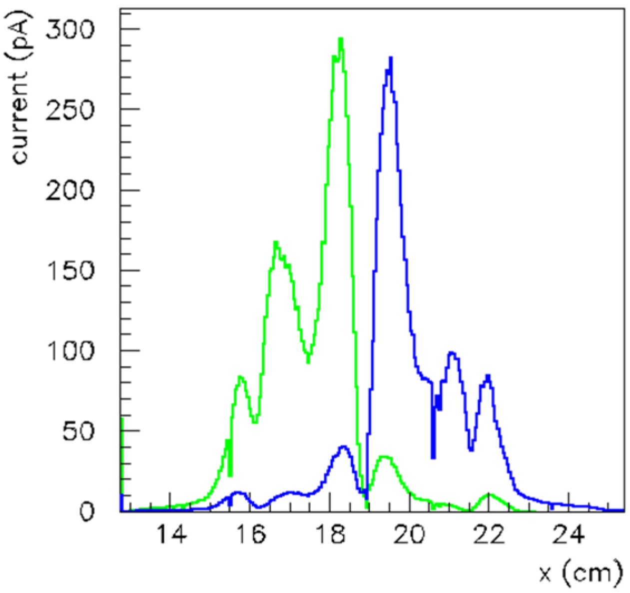

Figure 6.2: Results from a test of the prototype active collimator in the Hall B coherent photon beam during 2007. The two curves are the currents in inner opposing sectors, as the beam is moved across the collimator face along an axis passing through the centers of the two sectors. Only the two inner sectors were connected to amplifiers during this test.

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Bibliography

[1] G. Miller and D.R. Waltz. *Nucl. Instr. and Meth.*, **117:33, 1974.**