Hall C Reference

Beam Quality Check and Monitor

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Abstract

This Howto outlines the basic methods and general Hall C beam line equipment to check and monitor the beam quality needed by experiments.

1 General equipment in Hall C beam line to verify quality

The general equipment in Hall C line that can be used to check or monitor the beam tune and beam quality include Superharps, Beam Position Monitors (BPMs), and Optical Transmission Radiation (OTR) monitor or Synchrotron Light Interferometer (SLI). In addition, fast feedback lock systems to lock beam energy and beam position on target are installed for the Hall C beam line using the readouts from specific BPMs and arc optics.

2 Superharps

Superharps are used to measure the beam size or profile at the specific locations alone the beam line where beam quality can be characterized. At each such location, there is a standard pair of superharps with known separation distance (1.817 meters), sandwiched a BPM in the middle. For example, at location C07, Superharp C07A is at upstream of the BPMC07 and Superharp C07B is at downstream of the BPMC07 with equal distance.

The four important locations are: (1) C07 (entrance of the arc), (2) C12 (middle of the arc), C17 (exit of the arc), and (4) H00 (2.5 meter before target).

For a normal archromatic tune (as most of the experiments use), the size of the beam at C07 and C17 should be around 100μm in both x and y directions. At the middle point of the arc, the momentum dispersion is maximized about 3-4 cm%, depending on the required beam energy. This means that the size of beam in x direction should be $< 300\mu$m, corresponding to an energy spread $< 10^{-4}$, while the size in y direction be around 100μm. Harp scan at the location of H00 will verify the beam size on target. Beam size at H00 can be specified to MCC based on the need of the experiment. MCC will tune the multipole magnets to meet the requirement. Around 100μm (FWHM) has been achieved in the past.

The centers of the beam profiles extracted from scanning the pair of superharps at the specfic location can provide the beam incident angles at that location.

The superharps cannot be used continuously. Harp scan should be done to verify the beam tune. The frequency of such scan depend on the need of experiments.

3 BPMs and fast feedback locks

The BPMs are used to measure the center position of the beam alone the line. The BPMs located at C07, C12, C17, and H00 are able to be read at a frequency of 1kHZ in order to install the fast feedback lock systems. They provide important information about stability of the central beam energy and position on target.

Under a specific tune of the arc, an optics for the given beam energy is defined. A position shift indicated by the BPM at C12 represents a central energy shift, if positions at C07 and C17 are relatively stable. For experiments that require high precision beam energy, monitoring the stability of these positions are important. The readout of these BPMs can also be added into data stream using a suitable readout frequency. Energy shift correction can be made offline using arc optics matrix.

With the same principle, energy fast feedback lock system reads these positions at a frequency of 1kHZ and calculates the needed energy correction. Then correction is added to the last cavity module in the south linac. Such system is installed on both Hall A and C arcs. Only one of these two can be used to control the beam stability. Practically, the hall with the lock on its arc has the best energy stability and $\sigma < 2x10^{-5}$ was achieved in the past. For other halls the energy shift is larger but less than 10^{-4}.

The BPMs, H00A and H00B, are in front of the target. They are 3.455 and 1.637 meters upstreams from the target, respectively, and are used to indicate the beam position on target and the incident angles. Checking and monitoring these positions allow experiments maintain their desired beam position on target and the stability.

A position fast feedback lock is also installed in order to stablize the beam position on target. This lock is independent for each hall. Since the position stability is coupled with the beam energy stability, whichever the hall having the enegry lock on will also have the best position on target stability ($< 200\mu$m.

4 OTR and SLI

OTR is a device which detects the emitted radiation from a thin (10μm) Carbon foil as beam passing through. It can measure both the center position and the size of the beam. Although its accuracy is less than superharp, it can be used continuously as a monitor.

An OTR system is installed at the C12 position, middle point of the Hall C arc. Thus, its continuously meausred beam size provides the intrinsic energy spread with respect the central value. Thus, it measures another important beam energy quality. Since this spread cannot be corrected as that of central drift that can be corrected by the fast feedback system, if the size measured at C12 exceeds the desired energy spread, MCC should be contacted.

Although OTR uses thin foil, it was seen that it did produce halo in the beam. Thus, a new device will be installed at the same location (C12) soon, replacing the existing OTR. The new device is SLI. This device does not have any material in beam but can measure the size of the beam as OTR does. By using it at the location of C12 to measure continuously the beam size, the intrinsic energy spread can be checked and monitered constantly.