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Informal Report

VERTICAL AND HORIZONTAL POSITION SENSING
OF UNBUNCHED BEAMS

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Abstract

One method of sensing the vertical and horizontal position at many azimuthal points of the unbunched proton beams that exist in storage rings is examined and found to be practical.

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When charged particle beams are unbunched, the vertical and horizontal position of their center of charge can easily be monitored by conventional pick-up electrodes. When these beams are unbunched this technique can no longer be employed. The ISR group at CERN have perfected techniques for monitoring momentum distributions using small empty rf buckets to produce coherent momentum voids in the beam which can be sensed by the pick-up electrode and by using frequency correlation to extract momentum distributions from the noise structure. Both of these techniques are very useful for their intended purpose but they give only momentum information from which only mean horizontal position can be inferred. No vertical position information is obtained and the horizontal position information does not sense coherent betatron motion which could exist under abnormal conditions.

The system suggested here is intended to provide both vertical and horizontal position information sensed at many points in azimuth thus providing the same complete continuous monitor on beam position for unbunched beams that pick-up electrodes provide for the bunched beam.

The principle is sketched in Fig. 1. Two magnetic field detectors located at positions H_1 and H_2 will be used to sense the magnetic fields at these points produced by the current in the beam. Ignoring the influence of the magnetic shield, the magnetic fields at H_1 and H_2 are

$$H_1 = \frac{2I}{r+x} \quad , \quad H_2 = \frac{2I}{r-x} \quad ,$$

where I is the current in the beam, from this the beam position, x , is given by

$$x = \frac{r(H_2 - H_1)}{H_2 + H_1} \quad .$$

This simple arithmetic operation can be performed in real time by an analog system, or if one insists in being in vogue, a digital computer will also work. In the same way the signals from the magnetic probe located at V_1 and V_2 can be processed to determine the vertical position.

A more detailed study or modeling of this system can determine the size and design of the magnetic shield so as to reduce its affect below desired levels. Similarly the nonlinearities associated with large vertical and horizontal displacement can be determined.

The magnetic field at the probes produced by the beam in the ISA is 600 milligauss, for $I = 12$ A and $r = 4$ cm. This field is large enough to be easily sensed with good accuracy. A 1 milligauss error in field measurement would result in a position error of about 0.1 mm. In the AGS where the circulating unbunched beam is only 0.3 A and an r of 8 cm is required, the magnetic field at the probe location is only 7.5 milligauss. This is too small to be attractive since small errors in measurement, 1 milligauss, would result in large position errors.

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Fig 1