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# THE SPEAR INJECTION MONITOR

The horizontal injection phase-space admittance for SPEAR, seen at the end of the septum, is an erect phase ellipse ± 1 mm x ± 1.5 mrad.[1] The vertical admittance is far less critical, since it is the horizontal size which must clear the septum for successful injection. This phase space matches the SPEAR transport-system admittance and is approximately twice the accelerator emittance.[2] The beam has a very poor depth of field, focusing errors of 0.5% in some lenses will cause catastrophic changes in the spot at injection.

The septum has a 0.77-meter effective length and bends 7 degrees. The beam at the entrance to the septum is spread so much due to angular divergence and momentum spread that a proper focus at the injection point cannot be observed at this point. The only place to properly "see" the focusing of the beam is at the injection point.

A piece of tungsten one or two radiation lengths deep struck by a high-energy electron beam develops a useful voltage signal due to electromagnetic cascade shower emission.[3] A tungsten foil or arrangement of foils makes a useful high-resolution beam monitor. We are installing a vertical tungsten foil 0.25 mm thick and 9.5 mm long at the end of the septum magnet, about 5 cm beyond the edge of the septum lip and 10 cm beyond the end of the magnetic field (Fig. 1). The foil is mounted on a standard electrical feedthrough which is attached to a flange on top of the septum magnet vacuum chamber.

The beam does not strike the foil when it is steered and deflected for injection. The beam must be deflected outward with the septum magnet by 4.2% of the magnet nominal strength to center the beam on the foil. To obtain the horizontal profile of the beam out to ±2 mm, the septum bend must be scanned ± 4.2% of its nominal $7^{\circ}$ bend value. If the suitably processed output of the foil is connected to the vertical amplifier of an oscilloscope while a voltage corresponding to the septum scan position drives the horizontal amplifier (Fig. 2), the profile of the beam can be monitored.

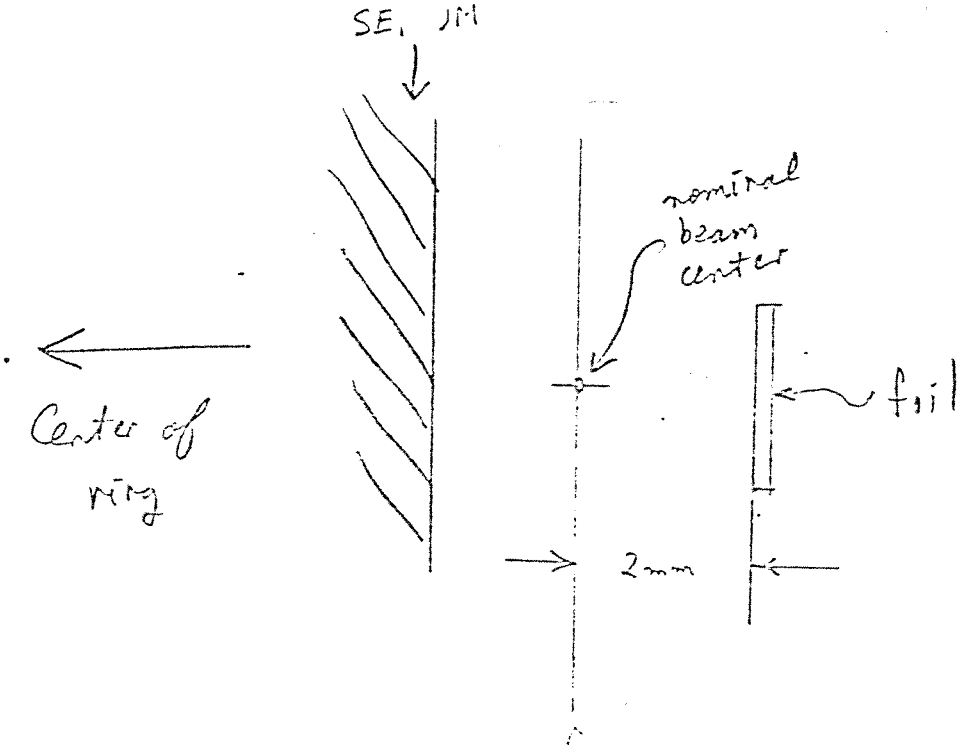
SE, JM
nominal beam center
foil
Center of ring
2mm

FIG. 1

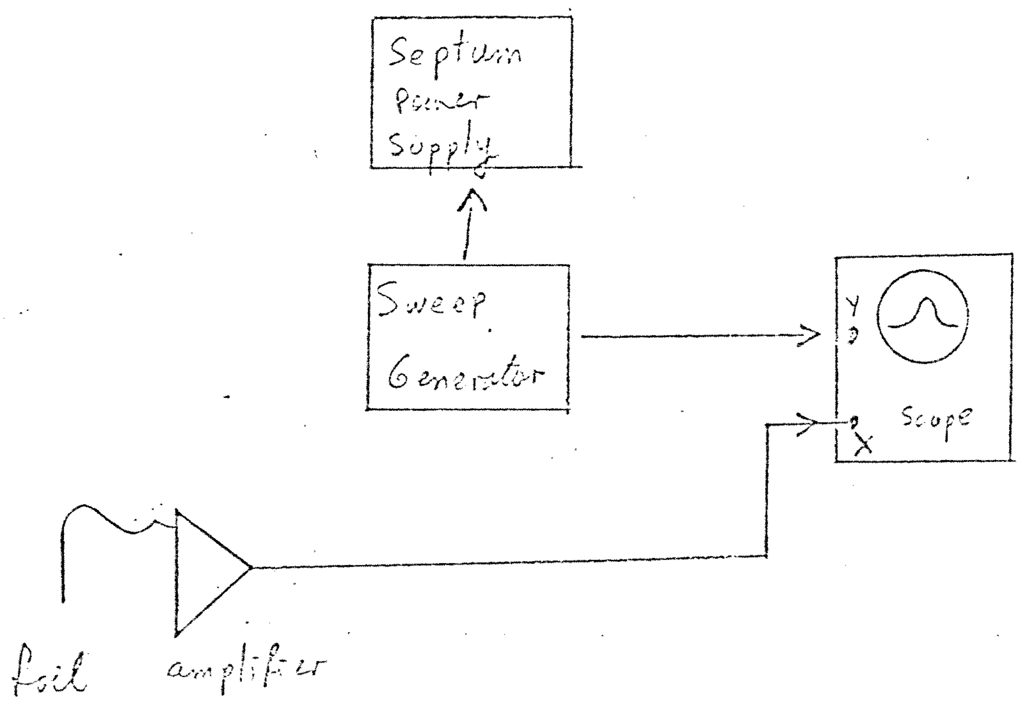
Septum Power Supply
Sweep Generator
Y
X
Scope
foil
amplifier

FIG. 2

From an extrapolation of Seppi's[3] results, I estimate the charge efficiency of the monitor to be 1. (Charge efficiency is Q scattered out of foil/Q through foil.) The nominal injection beam is a pulse of 3 mA, 7 nsec long, charge/pulse of $21 \times 10^{-12}$ coul. The foil intercepts 0.125 of the nominal $\pm 1$ mm beam, giving $2.6 \times 10^{-12}$ coul/pulse, an average current of $5.25 \times 10^{-11}$ amp at 20 pps.

The foil is struck by the synchrotron radiation from the opposite-sign stored beam: This radiation causes photoemission from the surface of the tungsten foil. Synchrotron radiation-produced-photoemission has been studied.[4] Applying a sufficient positive-bias voltage to the tungsten foil should suppress the photoemission, which produces relatively low-energy electrons, in favor of the electrons produced by shower emission. An estimate based on Fischer and Mack's[4] data and assuming a bias voltage of 5 kV on the foil gives a photoemitted current of $\simeq 2 \times 10^{-11}$ amp with a stored beam of 250 mA at 1.5 GeV. Thus, the photoemitted current can be ignored if the injection current is high enough, and since the counter-rotating beam has no time variation on the scale of 1-10 Hz, the photocurrent will be only a dc bias on the useful signal, which is ac.

References

1. SPEAR Design Report, August 1969.
2. SPEAR-3, January, 1970.
3. SLAC-PUB-882, D. R. Walz and E. J. Seppi.
4. CEAL-1017, G. E. Fischer and R. A. Mack, February, 1965.