1. Introduction

We have recently installed two improved ionisation beam scanners (IBS) in the SPS. These devices embody modifications to the coil configuration which, together with careful alignment of the crossed magnetic and electric fields, give a much improved spatial resolution. The IBS's are of the PS Booster design and have been recently removed from the PS, whose beam current has risen to the point that space charge forces affect their resolution. In the SPS, beam currents are smaller by virtue of the larger circumference, and one expects optimum resolution.

We are able to report, following initial beam tests, that the improved IBS's give horizontal and vertical beam profiles with a resolution of better than 1 mm. The availability of a continuous non-destructive display of beam dimensions should provide the control room with valuable diagnostic information. Transverse instabilities may be readily identified and measurements of beam dilation during storage tests will now be possible.

2. Results of Tests

Figure 1 shows a mountain range display of the development of a horizontal beam profile from injection, at the top, to 350 GeV, at the
bottom. Figure 2 shows a snapshot of the trace at high energy. Both pictures are consistent with the adiabatic damping of a beam of \(10^\pi\) mm\(\text{mrad}\) invariant emittance from a Gaussian with \(\sigma = 5\) mm at 10 GeV to a \(\sigma\) of only 0.8 mm at 350 GeV.

Figure 3(a) at 200 GeV, and 3(b), at 350 GeV taken with an expanded horizontal scale show how the beam shrinks from a \(\sigma\) of 1.1 mm to 0.8 mm as expected from adiabatic theory. We conclude that the \(\sigma\) of the resolution curve of the device must be smaller than 0.5 mm.

3. Principle of Operation

Figure 4, taken from Reference 1 shows a cross sectional diagram of an IBS which measures a horizontal profile. A d.c. potential is symmetrically applied to two parallel plates, \(e_1\) and \(e_2\) from a floating power supply. Electrons, produced in interactions between the beam and residual gas, travel along the equipotential lines between the plates making a series of small cusps in the solenoidal axial magnetic field. Those following the zero equipotential pass between two plates which define a resolution window of \(\pm 50\) V and enter an electron multiplier whose signal reflects the local beam density at the point where the zero equipotential samples the beam. By applying a 3 kV peak to peak sine wave to both plates the zero equipotential can be made to scan from plate to plate. To avoid the collection of spurious electrons from the earthed vacuum tank, the centre points of both the floating power supply and the resolution plates are biased by 100 V.

Signal strength depends on gas pressure and one needs a local pressure of 1 or \(2 \times 10^{-6}\) Torr if clean profiles are to be obtained without unduly widening the resolution window to the detriment of precision. The electron multiplier output is applied to the \(y\) deflection of an oscilloscope whose time base is triggered by the scan signal to cover the full screen in the time of one half of the scan wave.
A special circuit which detects when the earth equipotential just touches the plates can be used to calibrate the device so that one half of the scan wave corresponds to the physical distance between the plates. The scan amplitude may then be reduced by a known amount to expand the horizontal scale and examine profiles of a millimeter or so width. Because the scan is sinusoidal the horizontal scale at the centre of the display is \(\sqrt{2}\) times that calculated from the plate separation and peak to peak amplitude.

4. Hardware

The two IBS's are installed in LSS3. One, measuring the horizontal profile, is close to an F quadrupole, the other, measuring vertical distributions, near a D. The plate separation horizontally is 130 mm and that of the vertical IBS is 65 mm. Both are equipped with adjustable vacuum leaks.

The scan is transformed up to high voltage in a rack of radiation resistant electronics in the tunnel. All other circuits originate in a control rack in BA3, from where signals may be cabled to the control room.

Typical operating settings are:

- Magnet field excitation: 3.6 A
- Plates: 3.0 kV
- Bias: 100 V
- Resolution: 100 V
- Electron Multiplier: 4.2 kV
- Scan frequency: 2.2 kHz

Subsequent adjustment of these parameters for optimum performance proves to be a rather simple procedure.
5. **Acknowledgement**

We would like to thank B. Flockhart, G. Kouba, B. Sagnell and H. Wahl for their assistance in adapting and installing the devices in the SPS.

The SPS would also like to thank the PS for the loan of this equipment.

Reference:

1. C.D. Johnson, L. Thorndahl  MPS/Int.CO 68-13
Fig. 1 1 cm/division horizontal profile mountain range display with injection at the top, 350 GeV at the bottom.

Fig. 2 1 cm/division horizontal profile at 350 GeV
Fig. 3  Expanded horizontal profiles