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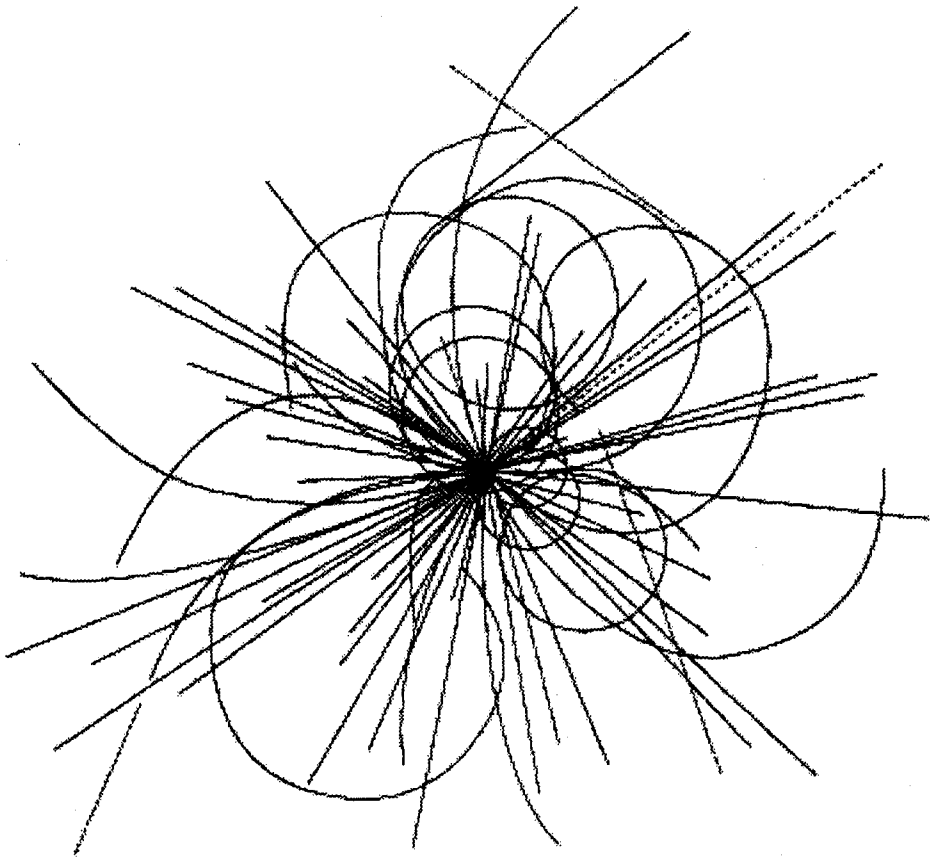

Superconducting Super Collider Laboratory

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Limitations of a Residual Gas Ionization Beam Profile Monitor for the SSC Collider

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Limitations of a Residual Gas Ionization Beam Profile Monitor for the SSC Collider

R. Meinke, W. Nexsen, E. Tsyganov, A. Zinchenko

Abstract

A residual gas ionization beam profile monitor for the Superconducting Super Collider is considered in detail using the Monte Carlo simulation code. It is shown that a good spatial resolution could be obtained using a combination of strong electrical and magnetic fields.

A system of beam profile monitors that can control the beam emittance is a very important factor in the commissioning and reliable operation of the Superconducting Super Collider (SSC). The Conceptual Design of the SSC[1] proposes flying-wire scanners and synchrotron-radiation light monitors for this purpose. Both methods have their own shortcomings, and some alternatives would be desirable. A residual gas ionization monitor to measure the collider beam profile is discussed below.

The characteristic parameters for the warm section and cold section of the collider are shown in Table 1.

TABLE 1. PARAMETERS FOR WARM AND COLD SECTIONS OF COLLIDER.

Warm Section	
Pressure (nitrogen)	10^{-9} Torr (1.65×10^{-15} g/cm^3)[1]
Ionization losses of MIP in nitrogen	1.82 MeV/g/cm^2[2]
Average energy loss of MIP to produce one primary electron-ion pair in nitrogen	196 eV[3]
Beam intensity	75 mA (0.45×10^{18} p/s)
Number of ionization electrons	0.7×10^7/cm-s
Cold Section	
Hydrogen density	3×10^8 H_2/cm^3 (1.0×10^{-15} g/cm^3)[1]
Ionization losses of MIP in hydrogen	4.12 MeV/g/cm^2[2]
Average energy loss of MIP to produce one primary electron-ion pair in hydrogen	65 eV[3]
Beam intensity	75 mA (0.45×10^{18} p/s)
Number of ionization electrons	2.8×10^7/cm-s

Calculations indicate that the statistics are high enough to expect good spatial resolution for a residual gas ionization monitor. However, systematic effects could smear the resolution for the SSC beam. Electrons produced with velocity close to zero are affected by beam charge, and so the space information could be essentially lost. One can expect a better performance of such a monitor if strong external electrical and magnetic fields are applied.

A diagram of the residual gas ionization monitor using a dipole magnetic field is presented in Figure 1. Two compensating magnets are used to compensate for the influence of the magnetic field on beam dynamics. Electrons are accelerated up to the energy of about 30 KeV and are detected either by silicon microstrip detectors or by microchannel electron multipliers with a multicathode readout. A similar detection system was proposed in Reference 4. One can achieve some magnification of the beam profile image using shaped magnetic and electrical fields.

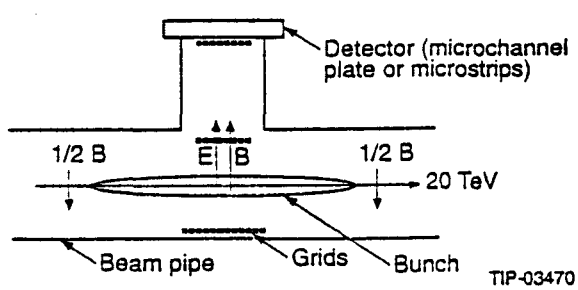

Figure 1. Residual Gas Ionization Beam Profile Monitor for the SSC.

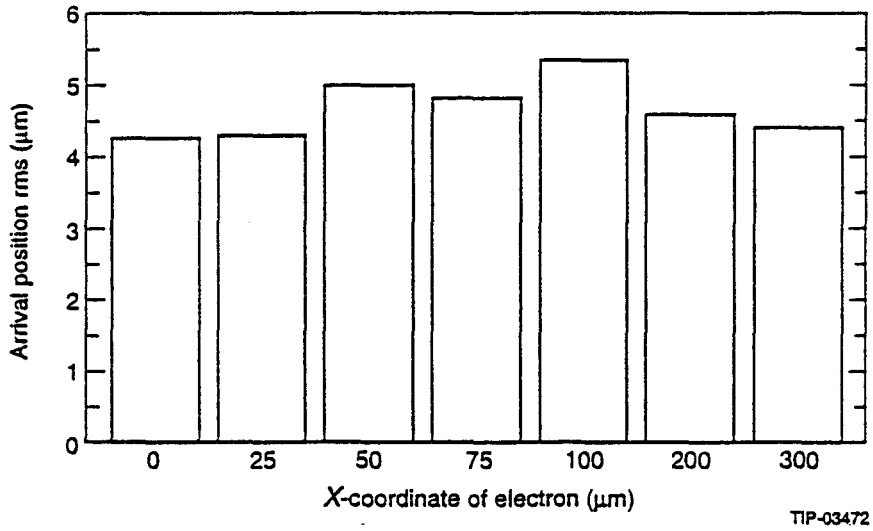

Figure 3. Space Resolution of the Device vs. Position of an Ionization Electron.

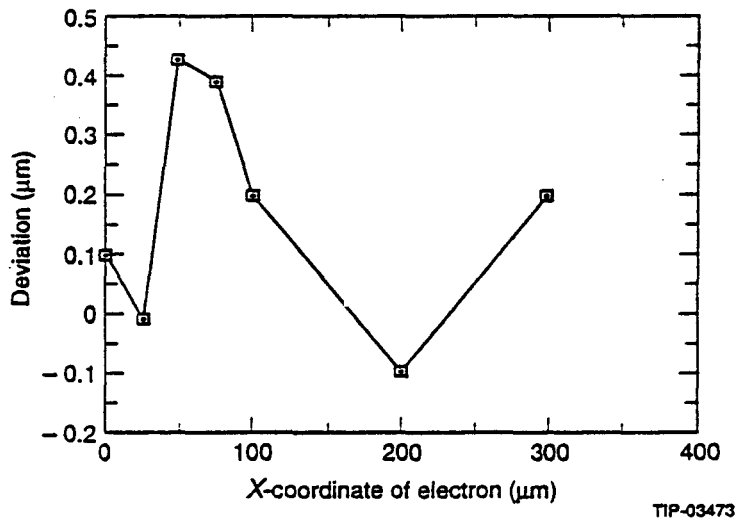

Figure 4. Deviation of the Average Positions of the Arriving Electrons for Different Starting Positions. Statistical accuracy is about 0.3 μm.

REFERENCES

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2. "Review of Particle Properties," *Phys. Rev. D*, 45 (1992).
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4. A. G. Chilingarov *et al.*, "The Non-Destructive Ionization LEB Beam Profile Monitor," 1992.
5. E. Tsyganov and A. Zinchenko, "ZBEAM, charge tracing code for the SSC environment," in publication.

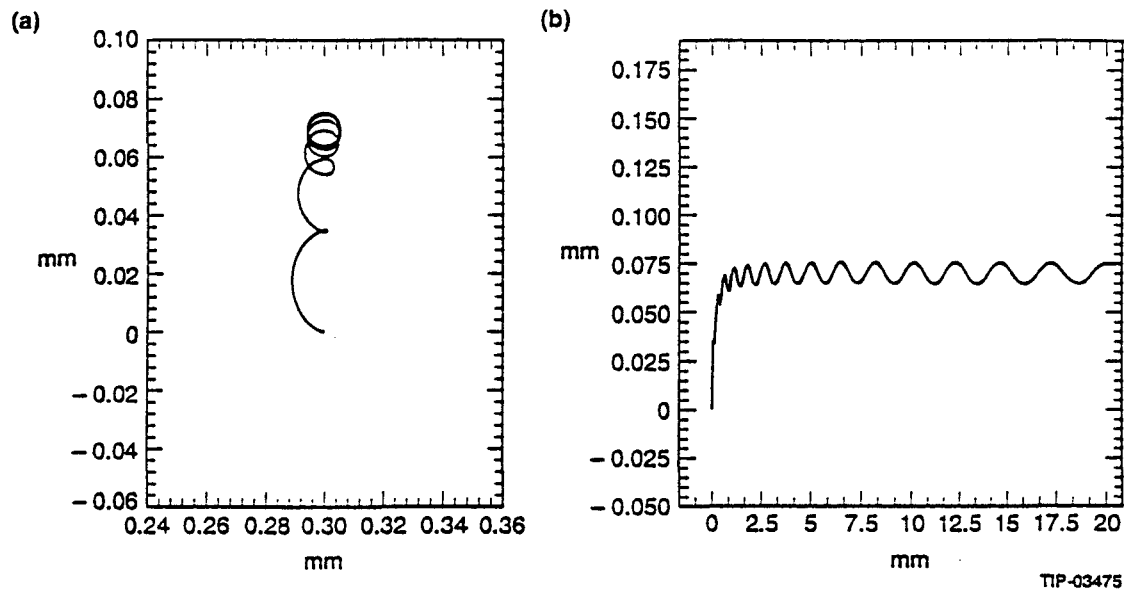

Figure 6. The same as in Figure 5, except the initial electron position is 300 μm. There are no oscillations.

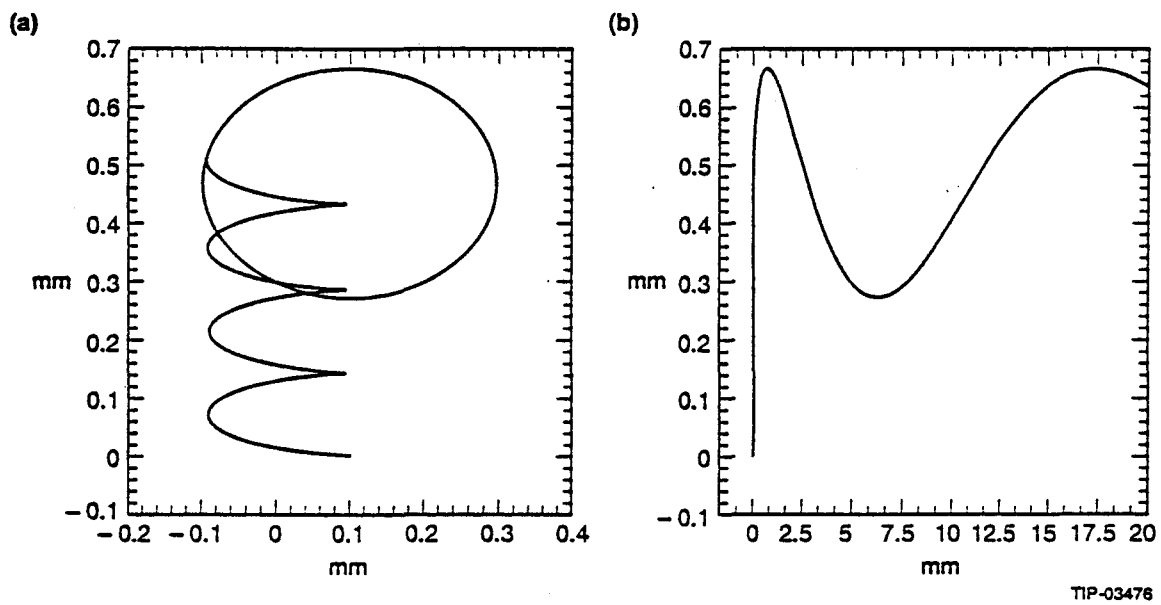

Figure 7. The same as in Figure 5, except $B = 0.1$ T.