Design of the Beam Profile Monitor for Phase 1 of the 5 MeV Electron Cooling Test Beam Facility

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In phase 1 of the 5 MeV Electron Cooling Test Beam Facility 12.351 keV kinetic energy protons are propagated in order to understand the space charge dominated optics, Because these low energy protons are not ionizing and the beam current is extremely low (< 1 μA), only charge sensitive intercepting monitors can be used. Since both beam current and beam profile information is required as a function of position along the beamline, a cart which moves up and down the 6" O.D. beam pipe is needed. In this paper the design of such a cart is described.

The first quantity which is to be measured with this cart is the total current. This is accomplished by measuring the current of a intercepting plate. The maximum current envisioned for initial operations is 1 μA. The minimum current is approximately 10 nA. The operational amplifier AD549L has a maximum input bias current of 60 fA and an input impedance of 10^{13} Ω. With a load resistance of 10 kΩ and a feeback resistance of 1 MΩ, a current of 1 μA yields an output voltage of 1 V. A 1 kΩ output resistance is used to limit the output current to the maximum range of the amplifier.

The second purpose of this instrumentation cart is to measure the beam profile. This is accomplished in each plane through the use one horizontal and one vertical wire which is capable of slowly moving back and forth across the beam distribution. By measuring the wire current as a function of position, the beam transverse density distribution can be determined. Assuming a wire of diameter 0.032", near the gun the wires can intercept most of the beam. At a point where the beam is at a maximum radius of approximately 1", the wire intercepts at most 1/100th of the beam current. To determine the beam profile, at least a factor of 10 smaller current than the peak possible current must be measureable. At the beam current of 10 nA, a minimum wire current of 10 pA must be resolved. If a load resistor of 1 MΩ and feedback resistor of 10 MΩ is used, this minimum wire current is translated into 100 μV. The maximum wire current of 1 μA yields and output voltage of 10 V. At the minimum output voltage, the 1 kΩ output impedance of the circuit means that a current of 100 nA will be delivered. In this situation another AD549L circuit is required to further boost the signal.

The maximum wire motion is 3". The resolution of this motion should be approximately 30 μm, which is to compared with the wire radius of 300 μm. The maximum distance the cart should be able to travel is 20'. The resolution of this motion can be as poor as 1".

To read out the wires and the current monitors, 3 coaxial signal cables must be sent through vacuum feedthroughs. To measure the position of the cart and the two wires, 3 position readback cables are required. Finally, 3 sets of control wires are needed to actually cause the 3 motions.

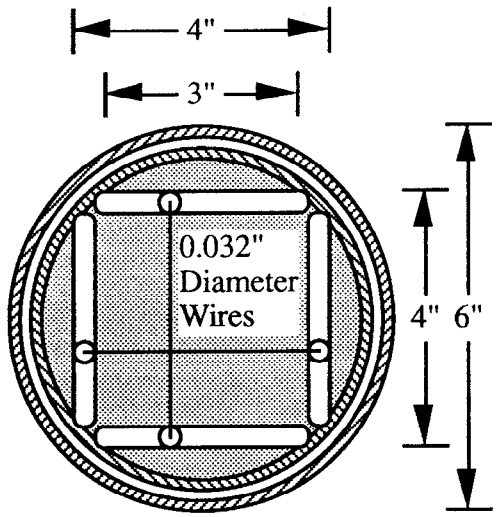

Figure 1: Beam's eye view of the beam profile and current monitor.

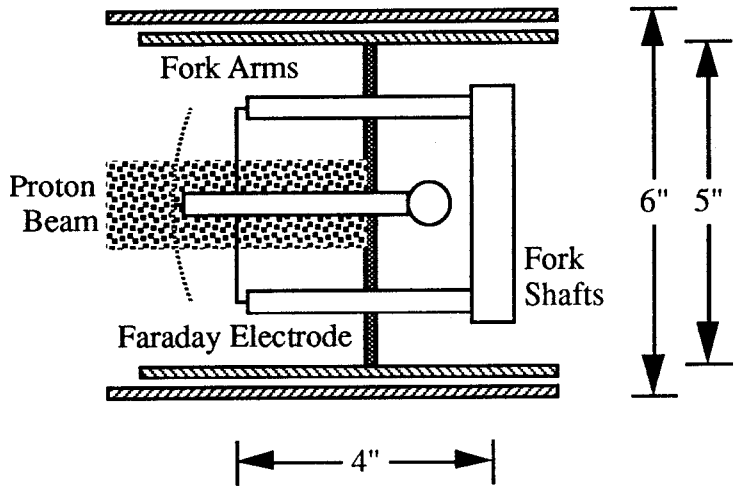

Figure 1: Side eye view of the beam profile and current monitor.