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Engineering & Technical
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MASTER

To be presented at the 1979 Nuclear Science Symposium,
San Francisco, CA, October 17-19, 1979

A MICROCHANNEL PLATE BASED DETECTOR FOR A HEAVY
ION BEAM SPECTROMETER

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October 1979

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

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Summary

The design parameters and operating characteristics of the detector used in the Brutus and Fannie heavy ion beam spectrometers at the SuperHILAC facility are described. The detector utilizes a 25 mm diameter microchannel plate array to obtain gains of 10^5 to 10^6 with a linear dynamic range of 10^3 . It has had over three years of almost maintenance-free service, detecting ion beams from carbon to xenon with energies between 1.2 and 8.5 MeV per nucleon.

Introduction

In 1975 we were asked to design and build a heavy ion beam spectrometer utilizing Brutus, an old C-type beam-line switching magnet, and existing beam lines for use in investigating operating parameters of the SuperHILAC accelerator and for making precision beam energy measurements (19,5%). The design incorporated a pair of 0.25 mm slits, separated by 2.73 m, which defined the trajectory of ions entering the magnet gap. A 0.5 mm slitted detector, 1.75 m down beam from the magnet, accepted particles that had been deflected by approximately 10^5 . The spectrometer was calibrated by the floating wire analog technique. This paper describes the design and operational characteristics of the slitted detector.

The Task

The SuperHILAC beam macrostructure consists of pulses from approximately 0.5 to 1- μ sec, duration with separations resulting from a 36 Hz time share schedule. Beam pulses with peak particle currents of 0.1 milli-ampere to below one nanampere needed to be analyzed. An attenuation of 10^5 to 10^6 of each pulse was expected due to the 0.25 mm entrance slits and the 0.5 mm detector slits. A system which would faithfully reproduce beam macrostructure was needed for currents which ranged from 10^{-15} to 10^{-8} amperes.

A further complication of the beam emitted by the SuperHILAC accelerator is that it very often consists of a multiplicity of charge states, energies and occasionally ion species. A system was needed which could quantitatively determine the relative amounts of the various species. An electron multiplier based detector followed by electronic amplification could meet these system requirements.

The design objectives of the detector included: variable gain from 10^2 to 10^6 ; a linear dynamic range of at least 10^3 ; low noise and long life; freedom from maintenance; operation in vacuums of 10^{-5} to 10^{-7} Torr; the ability to withstand continual exposure to the atmosphere and pneumatic insertion and withdrawal; simple vacuum feed-throughs; 55 mm length and under 90 mm diameter; an entrance slit of 0.5 mm; and low cost.

We were unsuccessful in meeting the latter design objective.

The Solution

The schematic of the detector is presented in Figure 1. The MCP (microchannel plate) array is used as an electron multiplier, satisfying the variable gain and dynamic range requirements. Since it is a very short and rugged device, and will operate in vacuums better than 10^{-5} Torr, it also satisfies several other requirements.

The direct impingement of high energy heavy ions upon the input face of the microchannel plate array would eventually degrade the performance of the multiplier. This problem was overcome by placing a 1.0 mm diameter tungsten rod 0.5 mm behind the 0.5 mm slit and 0.5 mm in front of the MCP input face.

The potential differences, and geometry between the slit, rod and MCP input, were designed to produce an electric field configuration that would take the secondary electrons produced on the rod to the beam ions and spread them over the input face of the MCP with sufficient energy to create further secondary electrons for amplification by the MCP electron multiplier.

Fig. 1. Detector schematic.

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Fig. 3. Voltage distribution schematic.

The enclosure for the detector has within it a voltage distribution network, resulting in only two electrical connections. The means by which the potential differences were generated is presented in Fig. 2. Resistors and capacitors in series/parallel combinations were used to accommodate the voltage, filtering, and power requirements of the distribution network. To eliminate arcing and sparking within the enclosure, sharp points on components and wiring were minimized. The high voltage connection is an unshielded spritz between the detector and an 5MΩ connector. The signal is passed through the 1/4-inch diameter actuating shaft to a hermetically sealed connector at the end of the shaft.

Results

Figure 3 is a photograph of the main components of the detector and Fig. 4 is a photograph of the assembled detector.

This detector has had over three years of almost maintenance-free service, detecting heavy ion beams from carbon to xenon with energies from 1.2 to 8.5 MeV/nucleon. The equivalent input noise with a gain of $>10^4$ is under one event p.a. second. The detector has been operated over six orders of magnitude of gain, and a linear dynamic range of better than three orders of magnitude has been verified.

Acknowledgments

The author is very indebted to Mr. Ted Lavitzten for his aid in putting so much in such a small package. This work has been supported by the Division of Nuclear Physics, Office of High Energy and Nuclear Physics of the U.S. Department of Energy, under contract W-7405-ENG-48.

Fig. 1. Photograph of components.

Fig. 4. Photograph of assembly.

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