A BEAM PROFILE MONITORING SYSTEM FOR THE BIO-MEDICAL IRRADIATION

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ABSTRACT

A multi-wire ionization chamber system for monitoring the charged particle beam profiles was designed and constructed to meet the requirements for the bio-medical applications. The system is composed of the dual 16 channel multi-wire ionization chambers, electrometer amplifiers, control logic, CRT display and the interface to the computer through the CAMAC modules. The orthogonal beam profiles both in horizontal and in vertical can be monitored, simultaneously with irradiating the bio-medical samples.

Introduction

The high energy charged particle beams are recently used for the study of radiation biology and medical applications. However, the charged particle beam from the accelerator has, in general, inhomogeneous spatial distributions of intensity. So, the spatial distribution of the beam must be monitored and controlled to give the uniform dose distribution on the irradiated area. For most of the biological and medical irradiations, the required beam intensity ranges somewhere around 1 Gy/min (about 10^7 protons/cm sec or 3 pA/cm^2). This intensity level is far beyond the capability of the multi-wire proportional counter system, but it is still too weak for most of the scintillation devices and for the secondary emission scanner or the scanning wire technique. So, it is quite important to develop the beam profile monitor system for this intensity range.(1)

Multi-wire chamber beam profile monitoring system

Fig. 1 shows the block diagram of the charged particle beam profile monitoring system using the multi-wire ionization chamber. The system is composed of the dual 16 channel multi-wire chamber, electrometer amplifiers, local control logic and CRT display or the CAMAC interface for the computer control. The multi-wire chamber for both vertical and horizontal has only the thickness of 2 cm, so that it is easy to house it at any place in the beam line. The central electrodes are made of gold covered tungsten wires of 30 μm diameter. The 16 collecting electrodes and two guard electrodes were wired with 5 mm spacing, providing the 8 x 8 cm^2 sensitive area. The chamber is designed to integrate the charge collected in the central electrode rather than to count the pulse from the individual particle. It is operated either as an ionization chamber filled with air or as a proportional chamber flowing the PR gas. The charge from each wire is integrated in the feedback capacitance by a low offset current (0.1 pA) IC operational amplifier. The integration time interval is remotely controlled. The output voltage from each current integrator is then fed to the sample and hold IC. The 16 channel output signals are multi-plexed continuously, generating the stable beam profiles on the CRT display in the control area. These procedures can also be controlled by the CAMAC modules under computer program.

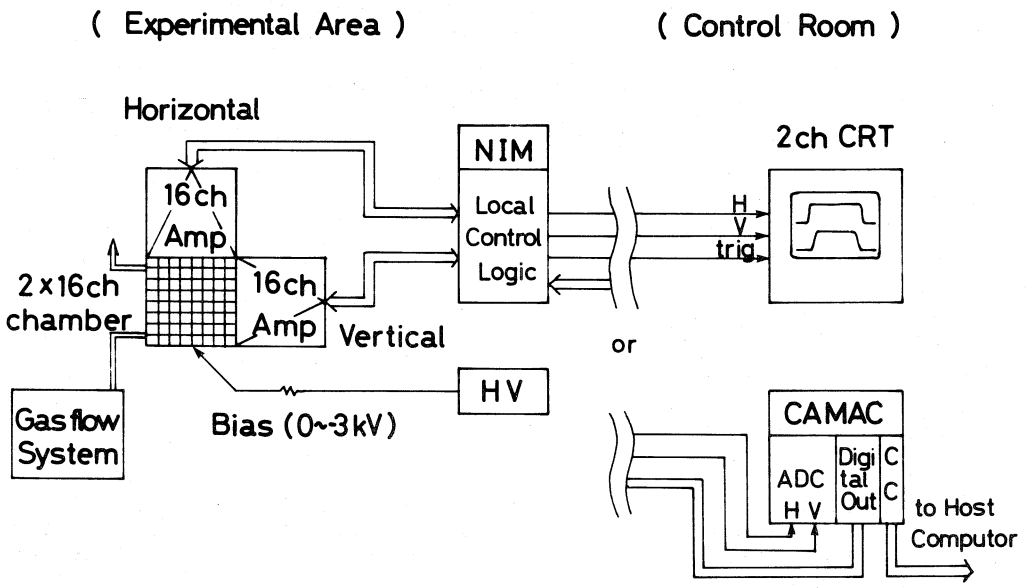

Fig.1 Block diagram of the beam profile monitoring system

Beam profiles for the bio-medical irradiation

The performance of the system was first tested with the Co-60 gamma ray field to check the uniformity of the individual chamber cell. Then, the system was tested with the 52 MeV proton beam from the INS FM cyclotron. The proton beam was extracted in air after shaping the beam spot to 2.5 x 2.5 cm^2 by a slit system. Fig. 2 shows an example of the proton beam profile. The upper curve shows the vertical profile and the lower represents the horizontal one. In this case, the chamber was operated as an ionization chamber filled with air. Fig. 3 shows an example of the vertical beam profile of the pion beam (150 MeV/c) at the π-μ channel of KEK. The beam intensity was so weak (about 10 pions/burst) ,that the chamber was operated as a proportional chamber.

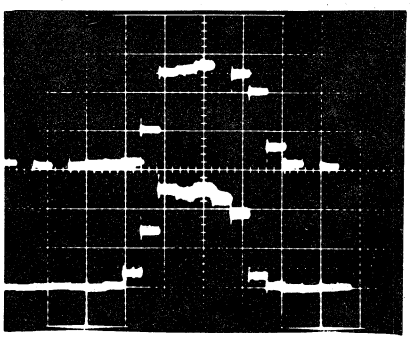

Fig.2 Profiles of 52 MeV proton

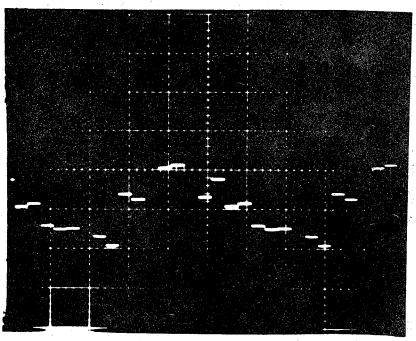

Fig.3 Vertical profile of π-beam

Reference

(1) Cuperus,J and Morgado,R., A MULTI-WIRE CHAMBER SYSTEM FOR HEAVY ION BEAM MONITORING AT THE BEVALAC, IEEE Trans. on Nucl. Sci., Vol.NS-22, No.3, pp.1561-1563, 1975.