Development of Microvolume LET Counter for Therapeutic Heavy Ion Beam

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ABSTRACT

We have been developing microvolume LET counter in order to measure the three-dimensional LET distribution of the therapeutic heavy ion radiation volumes in the water phantom. With help of the technique of cathode induced carhge readout, this detector has a rectangular (box-shape) sensitive volume of which size is about 1 mm^2 and 2mm (depth).

Keywords: heavy ion cancer therapy, LET measurement, proportional counter

1. INTRODUCTION

The heavy ion cancer therapy is one of the most advanced methods for cancer therapy because of its high dose-concentration. Recently, a clinical trial of the heavy ion cancer therapy has been performed in National Institute of Radiological Sciences, Japan, and obtained good therapeutic results[1] so that the detailed analysis of the heavy ion biological effect is of quite interest and necessity. As different from other radiotherapy, the heavy ion therapeutic volume is a quite complicated field because it consists of many kinds of secondary particles (nuclear fragments) due to the nuclear reactions in the beam delivery system and in the patient body. Therefore it is not easy to know the beam quality distribution in the therapeutic radiation volumes, like LET, fragments fluences or the biological effect distributions. As a part of effort to understand the beam quality distributions in the therapeutic heavy ion radiation volume, we have started the development of the LET counter. Our first goal is to create single-channel millimeter-volume proportional counter and to measure the three-dimensional LET distribution in a water phantom.

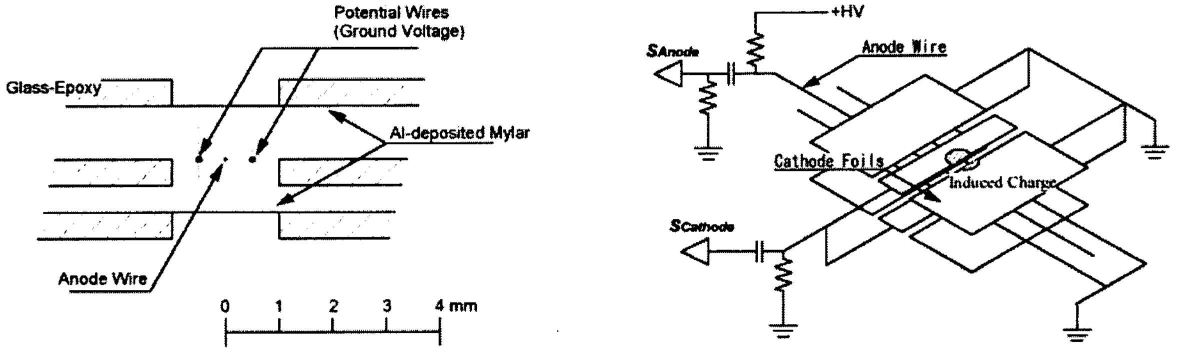

Fig. 1. (a) Cross sectional configuration of the Microvolue LET Counter. (b) Schematic View of electrodes in the LE T Counter.

2. MATERIALS AND METHODS

Considering that the heavy ions scarcely scatter in a large angles so that the both primary particles and fragments go almost along the beam direction, the rectangular (box-shape) sensitive volume is suitable for the heavy ion therapeutic field, rather than the usual spherical or cylindrical LET counter. The sensitive part of the counter consists of three glass-epoxy boards of 20mm times 70 mm with the 2 mm times 2mm square windows opened. One anode wire and two ground-level potential wires are on the center board while the other two boards have aluminum vapor-deposited 2 micron thick mylar foils, as seen in figure 1 (a). The anode wire is connected to a positive high voltage supply and a preamplifier (ORTEC 142PC) via capacitor. The sensitive volume was 1mm width (vertical to the wire direction) and 2mm (depth). In order to measure the avalanche position along the wire, we employed a technique that reading the induced charge on cathode foils[2,3]. The aluminum on the mylar foils was partially etched by laser to create a 1 mm width strip-shape pattern. These strips (in-front and behind the wire plane) are connected to another preamplifier in order to read out the induced charge (see figure 1 (b)). Both of the signals from the anode (S_{Anode}) and the cathode ($S_{Cathode}$) are proportional to the primary ionization, while the ratio of them, $S_{Cathode}/S_{Anode}$, corresponds to the along-the-wires distance between the avalanche position and the strips position. Figure 2 shows the schematic diagram of the along-the-wires distance and the $S_{Cathode}/S_{Anode}$. Once we obtain the relation between along-the-wire position and $S_{Cathode}/S_{Anode}$ by an alpha source measurement, we can know the along-the-wire position of avalanche in each event. These signals are processed by a simple NIM/CAMAC/PC DAQ system. The casing made of acrylic material is airtight and, of course, watertight. The wall thickness in-front and behind of the sensitive volume are 5.0 mm. Aluminum foils covered the counter partially in order to shield the external electromagnetic noise. The casing has three Swagelok ports in order to connect the gas flow. The first port (intake port) is connected to the regulator with a bubble-type gas-flow meter and the second port (exhaust port) is open to the atmosphere via a several meter Teflon tube. The third port can be connected to the capacitor-type pressure meter but usually the port is closed due to the electromagnetic noise from the pressure meter. In the development phase, we choose P-10 (Ar 90% and CH_4 10%) as a detector gas. Until the time of manuscript deadline, we have already observed both the anode and the cathode signal with a sufficient pulse height from an internal ^{241}Am source, but we still did not process the signals. The processed data will be shown in the presentation.

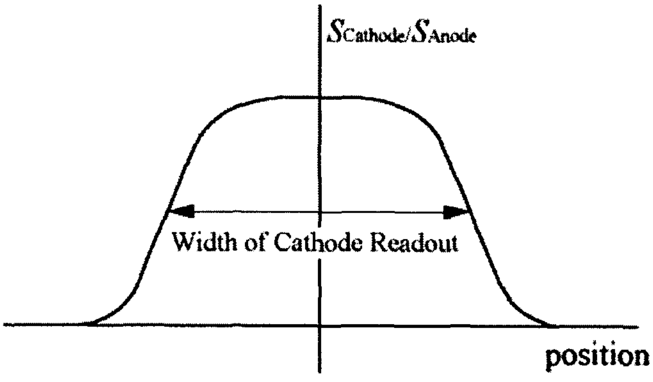

Fig. 2. Schematic position distribution of $S_{cathode}/S_{Anode}$.

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