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Nuclear Instruments and Methods in Physics Research A 461 (2001) 420–421

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

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Pixel segmented ionization chamber for therapeutical beams of photons and hadrons

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Abstract

A fast and precise detector to monitor on-line the dose delivered by an active scanning therapeutical beam has been built and tested. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Beam monitoring; Dosimetry; Hadrontherapy; Ionization chamber; Radiotherapy

1. Introduction

A fast and precise detector is essential for exploiting the therapeutical capabilities of radiotherapy with Intensity Modulated photon (IMRT) and hadron beams. We have developed a large area ionization chamber that allows 2D reconstruction in real time [1,2].

2. Design of the detector

The detector is a parallel plate ionization chamber with an extended sensitive volume that has to cope with the largest treatment field. A sketch of the detector is shown in Fig. 1. The anode, which is segmented in 1024 pixels to cover a total area of $(24 \times 24)\,\mathrm{cm}^2$, and the cathode planes are glued to vetronite frames. The front-end acquisition boards are mounted on the anode frames. The gas gap is defined by the thickness of a frame placed between the anode and the cathode. The anode has been obtained with the printed circuit board technology on a substrate of 100 μm thick vetronite foil. The cathode is made of aluminized 25 μm thick mylar foil. The equivalent water thickness is less than 1 mm.

3. Front-end electronics and data acquisition

The front-end electronics is based on Very Large Scale Integration (VLSI) chips that digitize the charge collected by the pixels [3,4]. Every chip serves 64 pixels. The data acquisition can handle up to 16 chips and read the counters with a frequency up to 10 MHz. A VME CPU controls the data acquisition using two PCI mezzanine cards (PMC) to generate the control signals and to acquire the data with a real-time operating system.

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PII: S0168-9002(00)01263-8

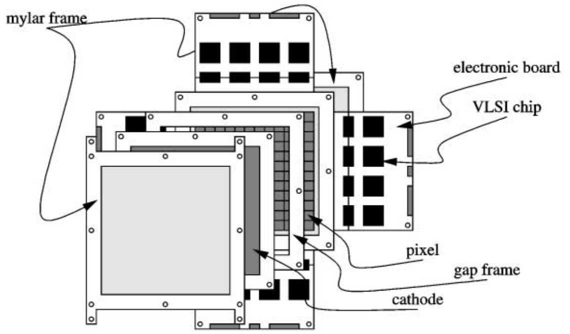

Fig. 1. Schematic view.

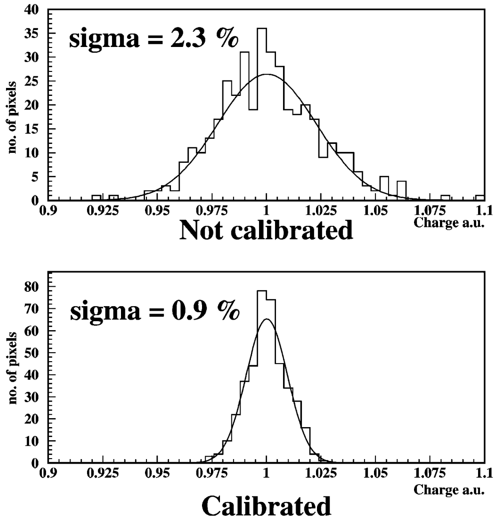

Fig. 2. Uniformity measurements.

4. Results

The chamber has been tested with photon, electron and hadron beams. To measure the uniformity of the chamber, it has been irradiated with a flat beam. We found that the uniformity is better than 3% before any calibration (see Fig. 2 top) which is improved to less than 1% after channel-to-channel calibration (see Fig. 2 bottom). The position resolution has been determined by comparing the center of gravity measurements to the known positions of the beam. With a C^{+6} beam 8.8 mm (FWHM) wide the resolution is better than 0.3 mm (see Fig. 3).

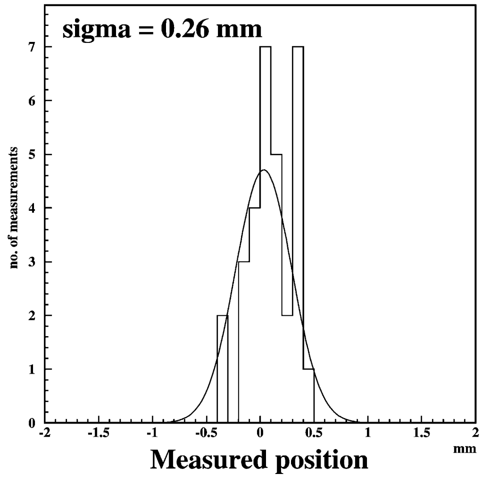

Fig. 3. Position resolution.

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