MEASUREMENT OF SPATIAL DOSE-RATE DISTRIBUTION USING A POSITION SENSITIVE DETECTOR

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1. INTRODUCTION

In recent years, radiation detectors using a plastic scintillation fiber (PSF) have been developed to measure positions exposed to radiation, such as neutron and high energy charged particles [1,2]. In particular, the time-of-flight (TOF) method for measuring the difference of time that two directional signals of the scintillation light reach both ends of the PSF is a rather simple method for the measurement of spatial distribution of fast neutron fluence rates [3]. It is possible to use the PSF in nuclear facility working areas because of its flexibility, small diameter and long length.

In order to apply the TOF method to measurements of spatial gamma dose-rate distribution, characteristic tests of a detector using PSFs were carried out. At first, the resolution of irradiated positions and the counting efficiency were measured with collimated gamma-rays. The sensitivity for unit dose rate was also obtained. Furthermore, measurements of spatial dose-rate distribution were carried out at a radiation field in a nuclear facility.

2. EXPERIMENTAL SETUP

The sensor is made of ten bundled PSFs (BCF-10, 5 m long, 1 mm diameter) supplied by BICRON Corp., and two BFO connectors.

The electronic schematic is shown in Fig. 1. The anode signals from the two PMTs, after passing through two corresponding ORTEC fast amps and ORTEC constant-fraction discriminators (CFD), are sent to the Start channel and the Stop channel of an ORTEC time-to-

amplitude converter (TAC). To correct the TAC's dead time, not only the signal but the dead time flag from the TAC is provided to the ADC.

3. EXPERIMENTS

The sensor was exposed to 662 keV of gamma-rays (^{137}Cs), collimated to 1.5 cm width by lead blocks. We examined how variations of both FWHM, regarded as an exposed position, and counting rate, regarded as relative efficiencies, depend on exposed position.

The sensor was uniformly exposed by standard irradiation equipment to obtain its sensitivity for unit dose rate. The sensor was made into a ring. Then it was put perpendicular to the radiation direction, the distances from the standard sources to all positions of the sensor being the same.

The practical measurements were accomplished using the sensor put on the surface of a filter unit that contains some HEPA-filters at intervals of about one meter. The surface of the filter unit is the most suitable place because the dose rate distribution varies in the range of the sensor's length (5 meters).

4. RESULTS

The basic characteristic result of the exposed position resolution was about 30 cm for the FWHM. The resolution was not effected by exposed position, although the shapes of the peaks varied depending on exposed positions. However, the efficiencies were slightly influenced by exposed positions. The efficiency of the middle of the PSF was the most sensitive, and each end of the PSF was 20% lower than the middle, as shown in Figs. 2 and 3.

The result of the sensitivity tests for unit dose rate was an efficiency of about 0.33 cps/μSv/h·cm on average. There was less counting loss below 100 μSv/h. There was more counting loss from 100 μSv/h to 10 mSv/h, but the linearity between the counting rate and the dose rate was evident by correcting the dead time of TAC (see Fig. 4). The counting loss couldn't be corrected, for the dose rate

above 10 mSv/h, and the detector didn't indicate true position exposed.

For the practical measurements, there were little differences between the dose rates measured by this detector and by a survey meter. A few seconds are enough for measurement of spatial dose-rate distribution using this detector to get the accuracy equal to measurements using a survey meter for several minutes (see Fig. 5).

5. CONCLUSIONS

It was found that the PSF detector has good enough performance to measure spatial gamma dose-rate distribution. This is due to its gamma-ray efficiency and its linearity between counting rate and dose rate.

The exposed position resolution of 30 cm for the FWHM could be regarded as enough to measure spatial radiation distribution in a nuclear facility. It could be mentioned that this detector is a suitable spatial dose-rate distribution meter. However, it is difficult to apply this detector where more accurate measurements are required at a location where the dose-rate is very different from that of the near position. For instance, the spatial variations of response decrease when the detector is exposed to local streaming of radiation. Also, the efficiency and the shapes of its peaks depend slightly on exposed position.

Furthermore, when exposed to more than 100 μSv/h, the counting loss increases, due to the increase in electrical dead time. So, speeding up the electric circuit is required for measurements with less counting loss in the dose range from 100 μSv/h to 10 mSv/h. However, 10 mSv/h is the dose rate limit for this detector because chance coincidences occur too often when measuring true dose rate over 10 mSv/h.

REFERENCES

[1] T.O. White, Nucl. Instr. and Meth., A273 (1988) 820
[2] J. Bisplinghoff et al., Nucl. Instr. and Meth., A329 (1993) 151
[3] S. Soramoto, KEK Proceedings, 93-8 (1993) 171

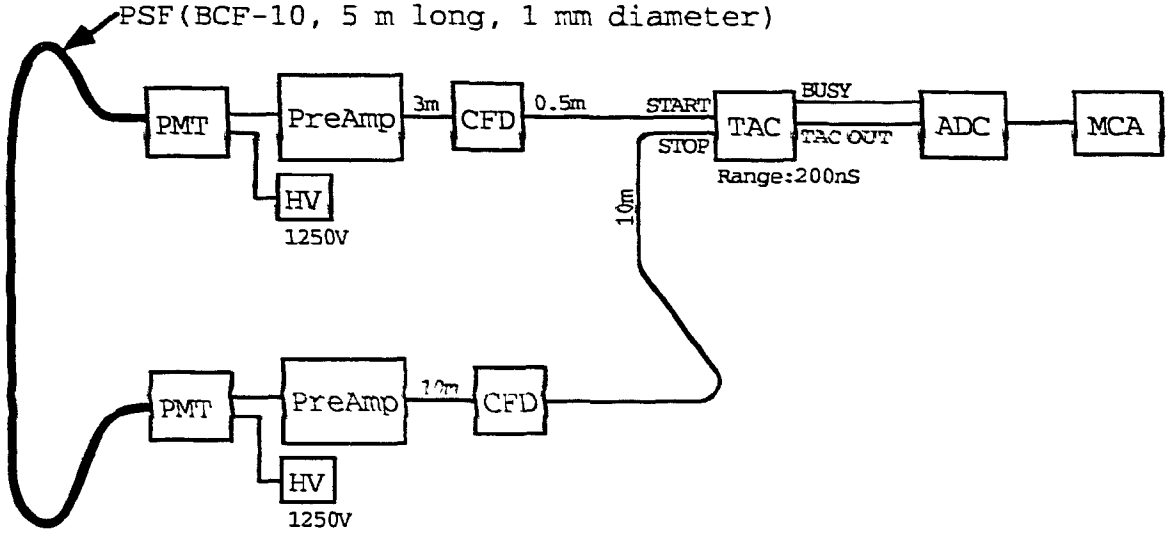

Fig. 1 Block Diagram of the Radiation Detector using PSF

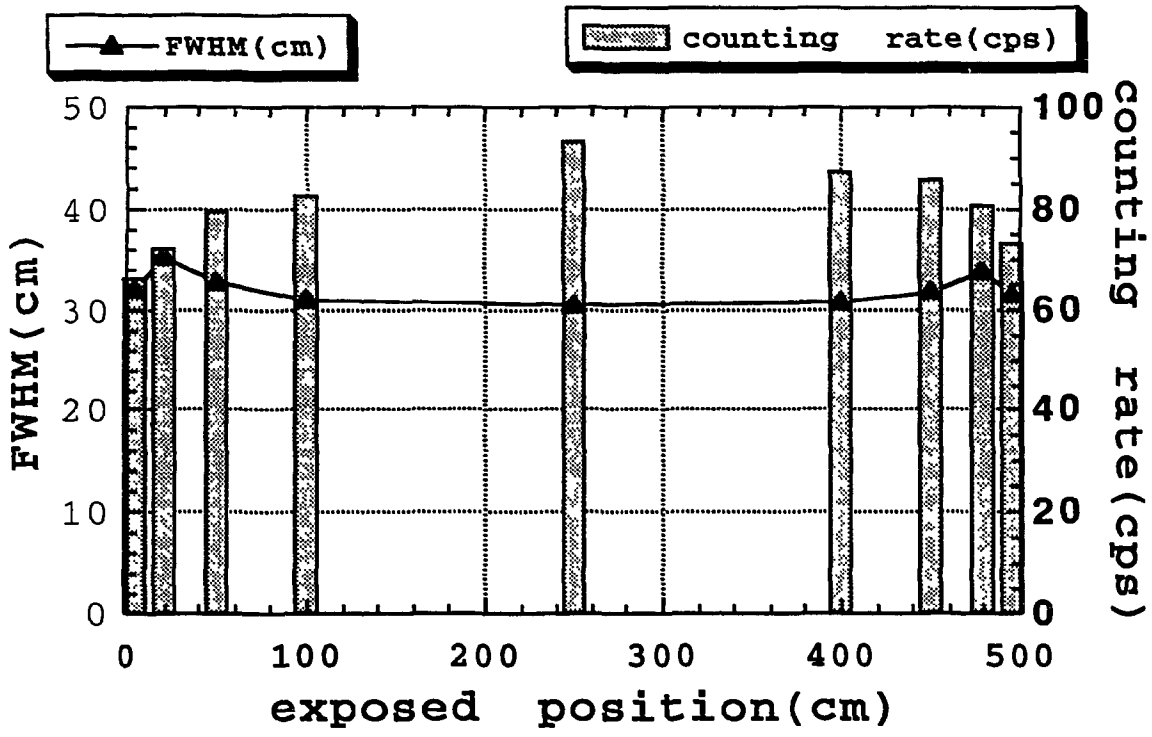

Fig. 2 FWHM and Counting Rate vs Exposed Position

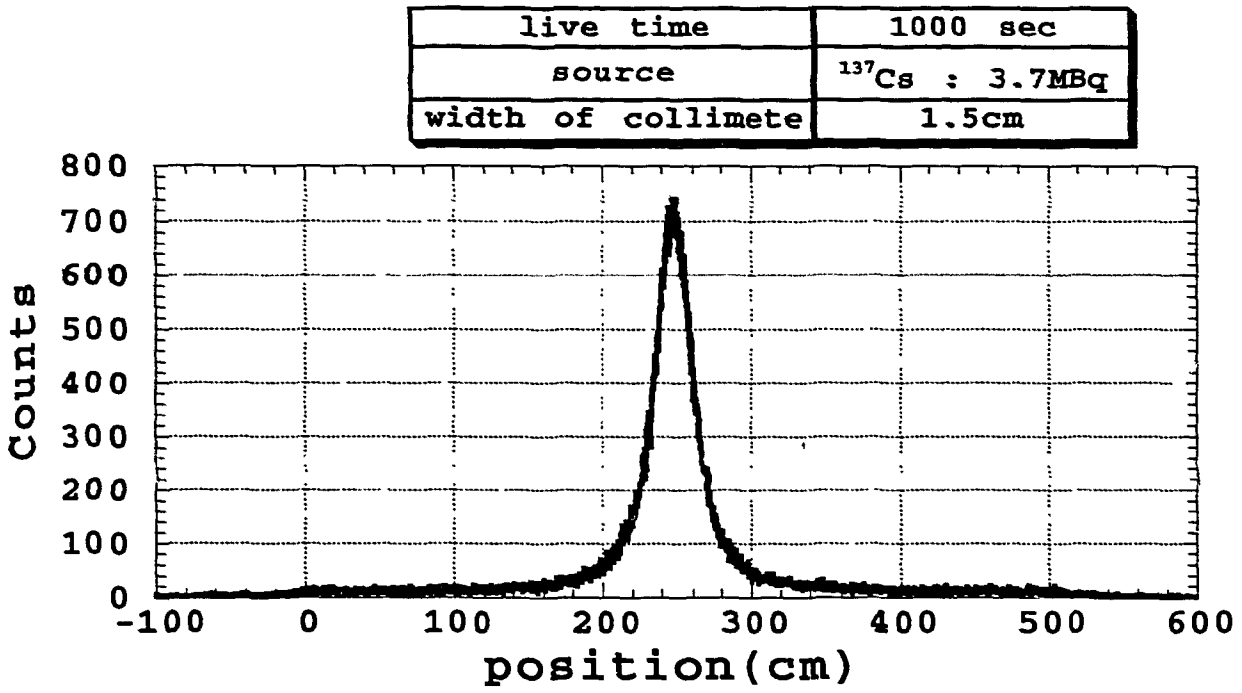

Fig.3(a) Response of the Detector Irradiated at the Middle of PSF

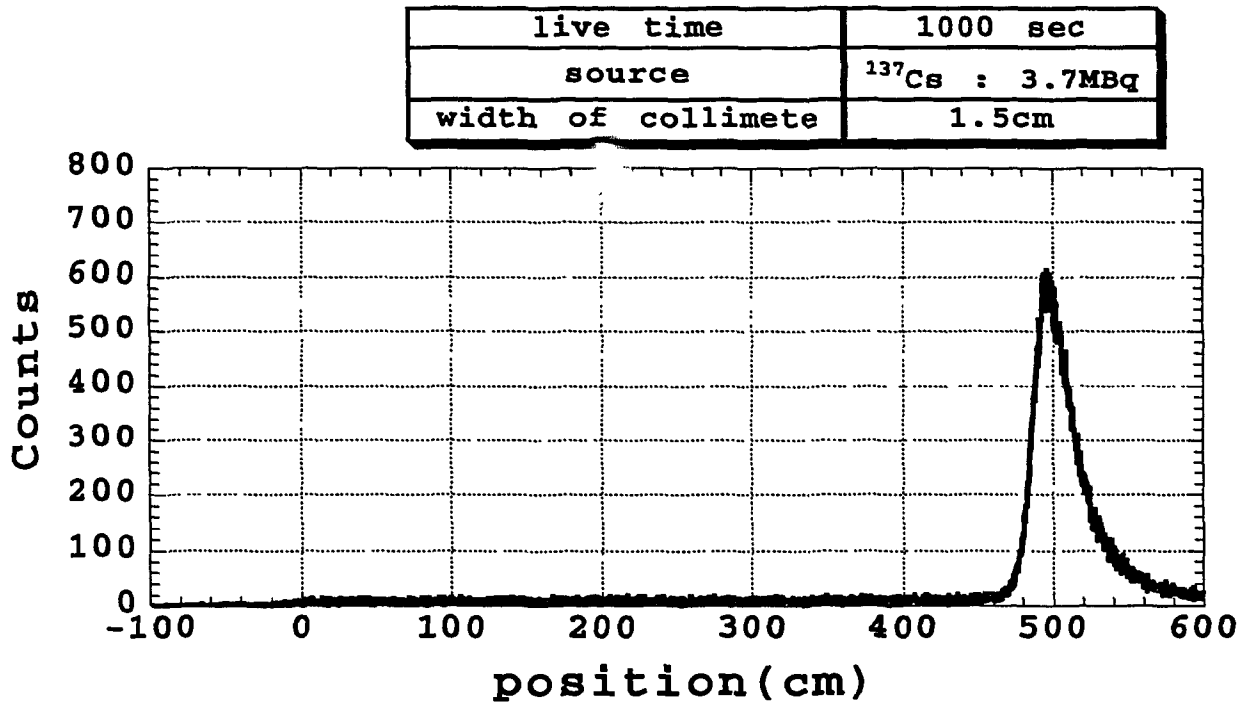

Fig.3(b) Response of the Detector Irradiated at the End of PSF

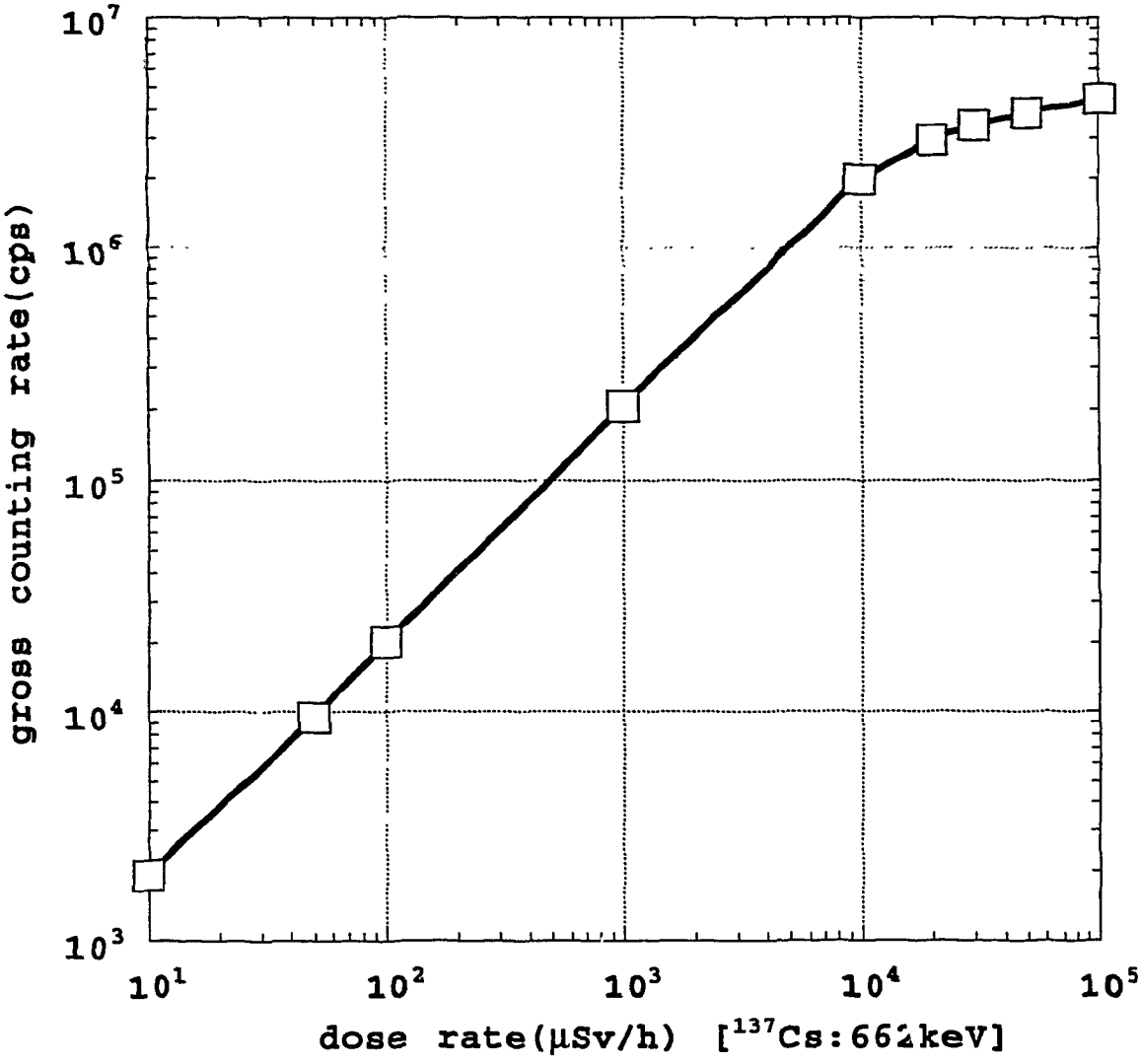

Fig.4 Linearity between Counting Rate and Dose-Rate

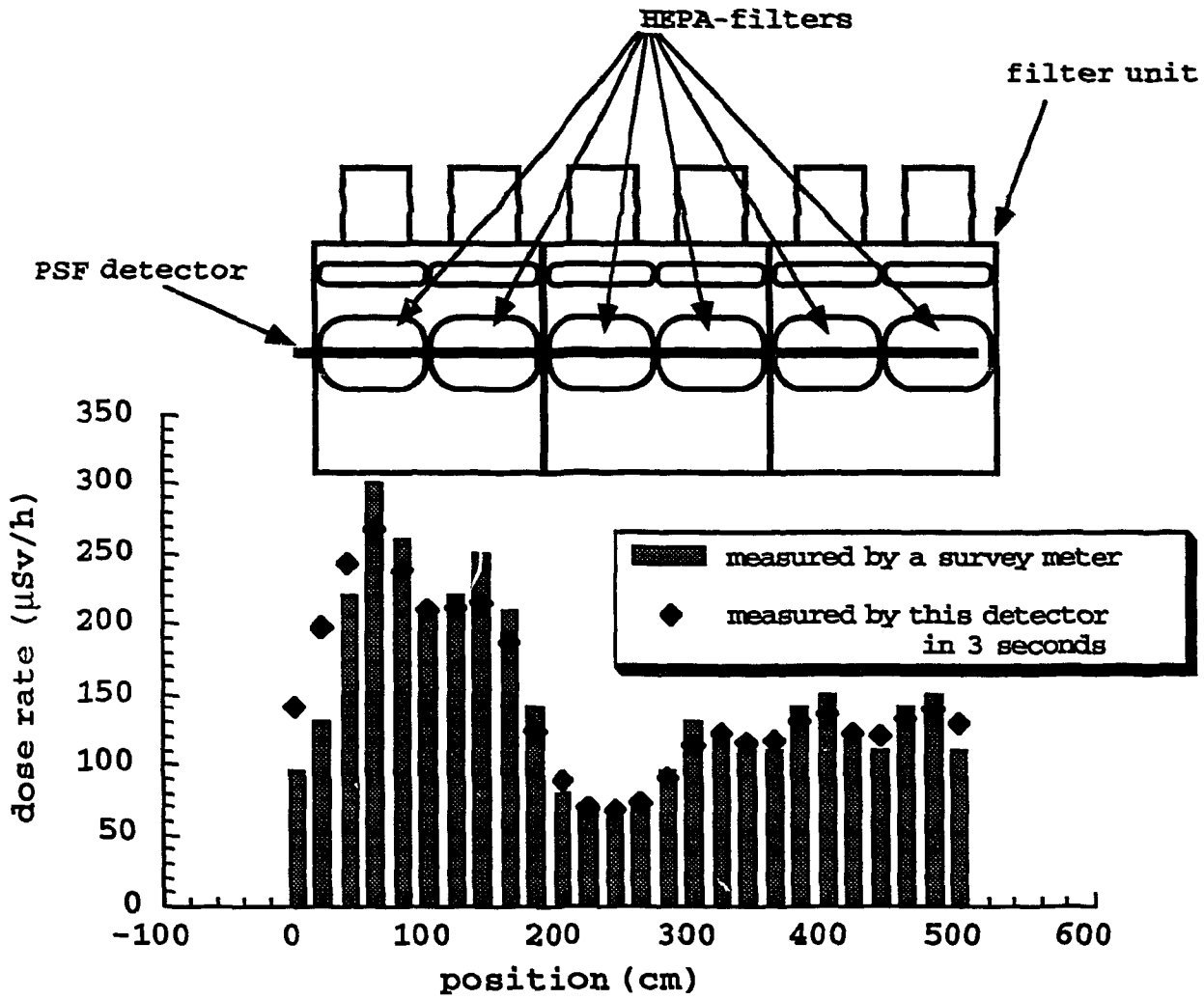

Fig. 5 Dose-Rate Distribution Measured along the Filter Unit