ELSEVIER

Medical Engineering & Physics 20 (1998) 149–151

Medical Engineering & Physics

The method of micro-displacement measurement to improve the space resolution of array detector

Yin Zejie [a,*], Wu Xiaoyi [a], Tang Yu [a], Huang Huan [b]

[a] *Department of Modern Physics, University of Science and Technology of China, Hefei 230027 PR China*
[b] *Center of Basic Physics, University of Science and Technology of China, Hefei 230027 PR China*

Received 28 May 1997; accepted 12 September 1997

Abstract

This paper introduces the method of micro-displacement measurement to improve the space resolution of limited size array detector. This method could also be applied in various research areas, especially in image measurement of nuclear detection.
© 1998 IPEM. Published by Elsevier Science Ltd. All rights reserved.

Keywords: Array detector; Micro-displacement measurement; Spatial resolution

1. Introduction

When measuring a space physical quantity using an array detector, the higher spatial resolution the better. Generally spatial resolution is mostly restricted by the size of array detector unit. For example, the highest spatial resolution that a detector with array units of 5 mm by 5 mm could provide is 5 mm. Although an array detector of smaller size can be used to achieve higher spatial resolution, the size of the array detector unit can not be reduced at will. To surmount this difficulty, we propose a new method called Micro-Displacement Measurement that can achieve higher spatial resolution by using an array detector of limited size.

2. Micro-displacement measurement

Suppose the spatial physical quantity is a one-dimension spatial distribution function $V(x)$, as shown in Fig. 1a. A one-dimension array detector is shown in Fig. 1b, in which D_i represents one unit of array detector. The width of D_i is Tg ($i = 1,2,\ldots,M$). Adjust the position of the array detector as shown in Fig. 1 and let the unit of D_1 be at origin. Thus, the spatial distribution of $V(x)$ can be acquired at one time. There are M units in this array detector, and M values of $V(x_i)$ ($x_i = \mathrm{Tg} \times i$, $i = 1,2,\ldots,M$) are obtained. Since the width of each unit is Tg, the spatial resolution is not better than Tg.

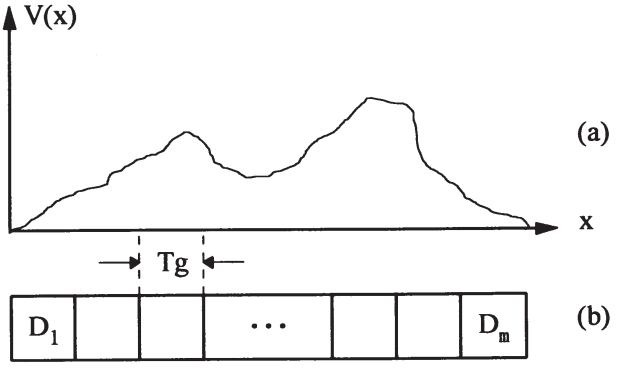

Fig. 1. Normal measurement.

To achieve higher spatial resolution under the same condition, the array detector is displaced one unit to the left. After one measurement, the array detector is shifted Δx ($\Delta x = \mathrm{Tg}/n$) to the right. Then, after the next measurement it is moved the same distance of Δx to the right. Then another measurement and another displacement, and so on. Finally, n measurements are taken. This means the one-dimension spatial to be measured is divided into $n \times m$ small units, and each value of $V(x_i)$ is

* Correspondence to: Dr. Y Zejie, Department of Modern Physics, University of Science and Technology, Hefei 230026, People's Republic of China.

1350-4533/98/$19.00 © 1998 IPEM. Published by Elsevier Science Ltd. All rights reserved.
PII: S1350-4533(97)00044-1

the integral value of n continuous small units with the width of Δx. Because D_1 is initially at $X = -$ Tg, each value of (x_k) ($x_k = (\mathrm{Tg}/n) \times k$, $k = 1,2,\ldots,n \times m$) can be inferred easily. The whole process of Micro-Displacement Measurement is shown in Fig. 2.

3. Method of data processing

After n measurements described above, all values of unit D_1 are given by

$$V_{D_1,1}(x) = 0$$

$$V_{D_1,2}(x) = V(x_1)$$

$$V_{D_1,3}(x) = V(x_1) + V(x_2)$$

$$V_{D_1,n}(x) = V(x_1) + V(x_2) + \ldots + V(x_{n-1})$$

The n values of unit D_i ($i = 2,3,\ldots,M$) are given by

$$V_{D_i,1}(x) = V(x_{(i-1)n+1}) + V(x_{(i-1)n+2}) + \ldots + V(x_{(i-l)n+n})$$

$$V_{D_i,k}(x) = V(x_{(i-1)n+k}) + V(x_{(i-1)n+k+1}) + \ldots + V(x_{(i-1)n+n+k-1})$$

$$V_{D_i,n}(x) = V(x_{(i-1)n+n}) + V(x_{(i-1)*n+n+1}) + \ldots + V(x_{(i-1)n+n+n-1})$$

where $x_i (x_i = i\Delta x)$ represents the distance from O (the Origin Point of the x-axis) to the ith point, $V(x_i)$ represents the integral value of function $V(x)$ from x_{i-1} to $x_i = \mathrm{Tg}/\Delta x$.

So after N times micro-displacement, all value of $V(x_i)(i = 1,2,\ldots,N)$ are given by

$$V(x_1) = V_{D_1,2}(x) - V_{D_1,1}(x)$$

$$V(x_2) = V_{D_1,3}(x) - V_{D_1,2}(x)$$

$$V(x_i) = V_{D_1,j+1}(x) - V_{D_1,j}(x)$$

$$V(x_n = V_{D_2,1}(x) - V_{D_1,n}(x))$$

$$V(x_{n+1}) = V_{D_2,2}(x) - [V(x_2) + V(x_3) + \ldots + V(x_n)]$$

Now, all values of $V(x_k)$ ($x_k = k\Delta x$, $k = 1,2,\ldots,m \times n$) are obtained. Because of the step $\Delta x = x_k - x_{k-1} = \mathrm{Tg}/n$, the spatial resolution is Tg/n, and the spatial resolution will be n times improved (Compared with the resolution of Tg).

4. Application

In a medical application of the measurement for the spatial distribution image of the dose rate of an γ-ray resource radiation field (^{60}Co, 5000 J), we built an array detector with N.S.0044-3-100 plastic scintillation fibers (ø = 1 mm) arranged parallel without intervals. The structure of the measurement system is shown in Fig. 3. With this system and the method of the micro-displacement measurement mentioned above, we measured the projection curve of the dose rate on the x-axis. In Fig. 3, M is the array detector formed by the scintillation fibers. Under the radiation of the γ-ray, scintillation light will generate in the fibers. The light will be coupled to the CCD photo-sensors through the fibers. The step motor controls the array detector to move along the x-

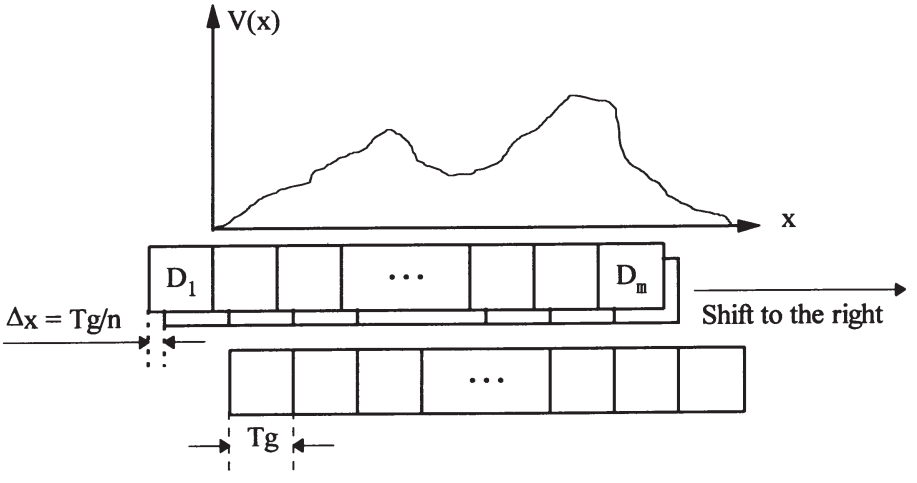

Fig. 2. Schematic of the micro-displacement measurement.

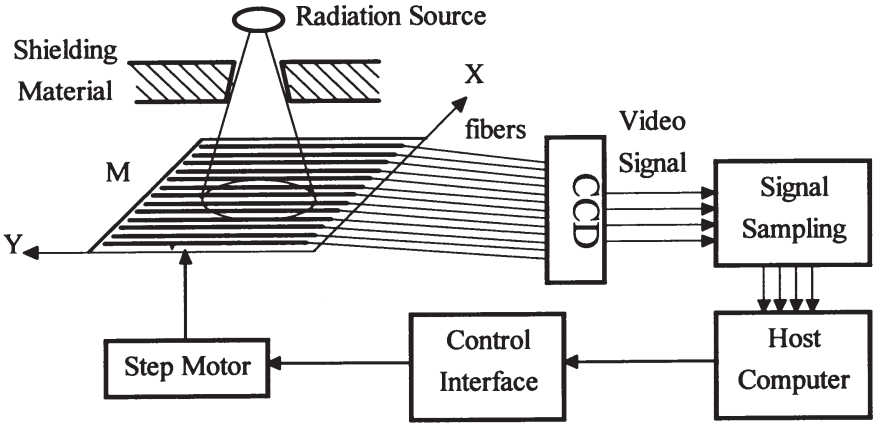

Fig. 3. Structure of the measurement system.

axis in the way of micro-displacement. In this system, Tg equals 1 mm which is the diameter of the scintillation fibre. We let $n = 5$, so we get

The host computer controls the step motor and the sampling of the CCD signal. By using the method mentioned above, with the data processed by the host computer, we obtained the projection curve of dose rate distribution on the *x*-axis with a 0.2 mm spatial resolution.

5. Conclusion

Micro-Displacement Measurement can be used not only to improve one dimensional spatial resolution, but also to improve two or three dimensional spatial resolution. This new method is universally applicable to the measurement system in many research fields. While using micro-displacement measurement to improve spatial resolution, the resolution of detecting and data processing system should be high enough.