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Development of Simulator for Depth Encoding Multicrystal Detector for PET

S. Nishiya[1], H. Haneishi[1], Y. Miyake[1], H. Murayama[2], T. Omura[3] and H. Ishibashi[4]

1 Chiba University, Chiba-shi, Chiba, Japan
2 National Institute of Radiological Sciences, Chiba-shi, Chiba, Japan
3 Hamamatsu Photonics K. K., Hamamatsu-shi, Shizuoka, Japan
4 Hitachi Chemical Co. Ltd., Tsukuba-shi, Ibaraki, Japan

INTRODUCTION

A variety of detectors have been proposed for detecting the depth-of-interaction(DOI) in PET. Requirements in DOI detector design accounting for easiness and cost in fabrication are that the crystal is made of a uniform material and that the detector unit yields optical output to only one side so as to be detected by an array of photomultiplier tubes (PMT). A detector proposed by Murayama et al.[1] consists of three-dimensionally arranged crystal blocks with proper optical reflectors and is coupled to an array of PMTs. This detector satisfies the above requirements.

In designing such a detector, computer simulation based on Monte Carlo technique is very effective because it allows us to examine the combination of various parameters of detector unit before making detectors actually. This paper introduces the simulator that we are constructing for this purpose[2].

DEPTH ENCODING MULTICRYSTAL DETECTOR

As an example of detector unit, 2x2x3 GSO crystal blocks coupled to four PMTs are schematically shown in Fig. 1. For discrimination of crystal block where the interaction takes place, two positioning variables, X and Y, are calculated from four PMT output signals, A, B, C and D as follows:

$$X=\{(A+B)-(C+D)\}/(A+B+C+D)$$
$$Y=\{(A+C)-(B+D)\}/(A+B+C+D).$$

If a flood source is used for gamma ray irradiation, the histogram of two positioning variables is generated as shown in Fig. 2. Each clustered distribution corresponds to a crystal block of interaction. The degree of separation between clusters determines the discrimination precision and therefore may be used as a criterion in designing a detector.

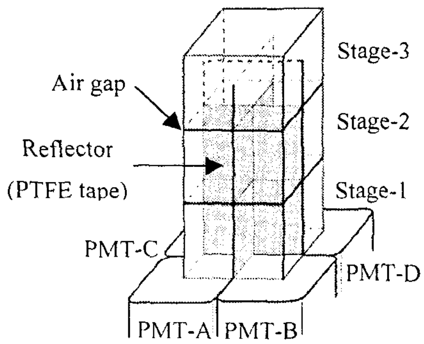

Fig. 1 Schematic illustration of depth encoding multicrystal detectors.

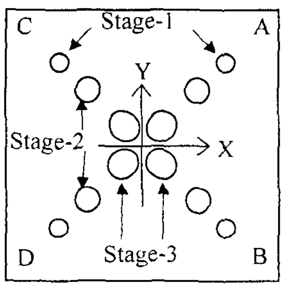

Fig. 2 Schematic illustration of the histogram of positioning variables.

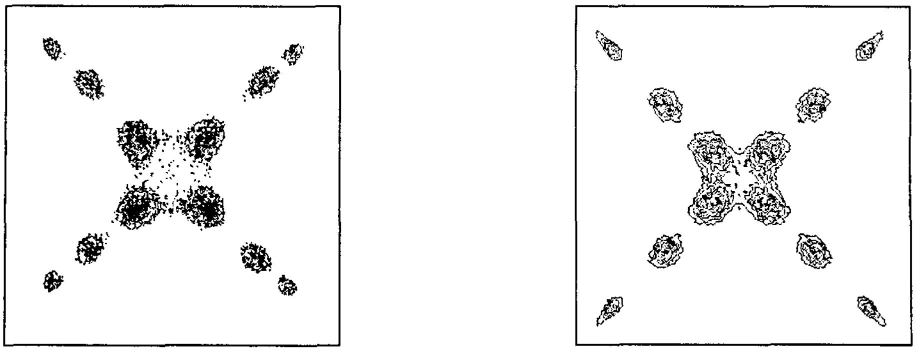

Fig. 3 Comparison of histograms. Left: experiment, right: Monte Carlo simulation.

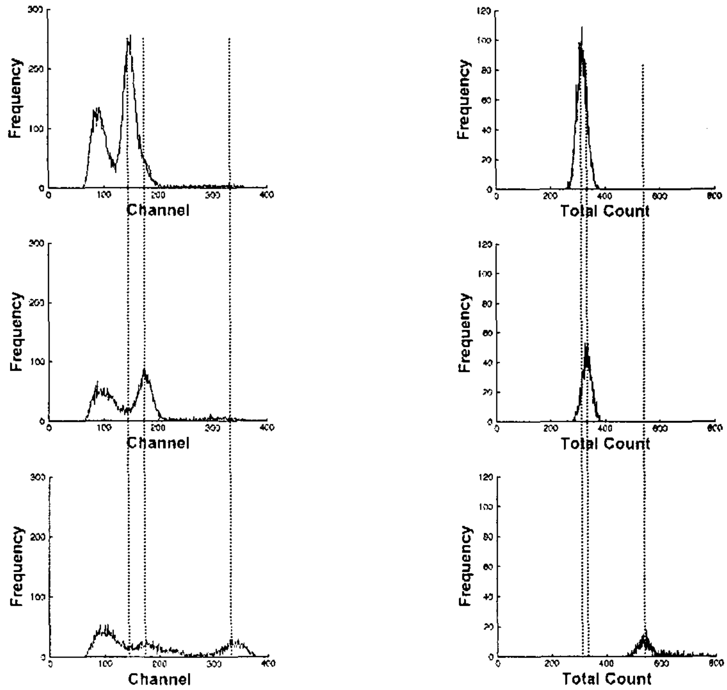

Fig. 4 Comparison of energy spectra. Left column: experiment, right column: Monte Carlo simulation. Top row:stage-3, middle row:stage-2, bottom row:stage-1.

Table 1. Numerical evaluation of similarity between experiment and simulation results.

		Experiment			Simulation		
		Stage-1	Stage-2	Stage-3	Stage-1	Stage-2	Stage-3
X-Y histogram	(i)Distance	0.96	0.70	0.27	1.11	0.62	0.21
	(ii)Spread	0.050	0.080	0.103	0.068	0.072	0.096
Energy spectrum	(iii)Peak position	1.0	: 0.55	: 0.45	1.0	: 0.61	: 0.55
	(iv)Frequency	0.23	: 0.36	: 1.0	0.18	: 0.45	: 1.0