Status of Multi-Ring High-Resolution Positron Emission Tomograph System PT931

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1. Introduction

Since September 1981, the studies for local organ function in human and animal bodies have been carried out with a positron emission tomograph (PET) ECAT II (EG&G ORTEC) in CYRIC.[1] The ECAT II has been a powerful system for quantitative measurement of the positron-emitting radioisotope concentration in the living tissue. However, the recent improvement of PET device provides higher spatial/axial resolutions, higher efficiency and accuracy of quantitation, and further capability of three dimentional imaging.[2,3] A new PET system PT931 (CTI Inc.) is designed with considering these benefits and has recently been introduced in our center. In this report, we describe the present status and results for the fundamental performance test of the PT931-PET system.

2. System Hardware

The block diagram of system is shown in Fig. 1, while design characteristics are summerized in Table 1. A uniquely feature of PT931 is detector block which consists of 32 small BGO crystal elements (8×4) with 4 photomultipliers. This design improves a high cost performance, spatial/axial resolution and axial field-of-view (FOV).[4] The gantry has a removable interplane septa to reduce the gamma-rays backgrounds from outside of image plane. Data aquisition system consists of ring receiver, image plane coincidence processor, real time sorter (RTS) based on the VME[5], and a host computer (Micro VAX II) which controles distributed processors for data aquisition, data storage and for mechanical motions. There are two data sampling modes; stational (low resolution) and wobbled (high resolution) modes. This system has a capacity for countings over 1 million per second.

3. Performance

The performance of the PT931 has been tested by scanning the phantom filled with appropriate activity of radioisotopes. The results have been compared with those of ECAT II.[1]

A. Spatial and axial resolution

Spatial and axial resolution were measured with a line source located at three points at 0.0, 10 and 20 cm from the center of FOV. The line source is a stainless steel needle filled with ^{68}Ge-^{68}Ga solution of 1.2 mm internal and 2 mm, outer diameter, and 12 cm long. The spatial and axial resolution with and without septa, and on data aquisition mode as well. (See Table 2.) As a result, both spatial and axial resolutions have been greatly improved comparing ECAT II, where spatial 10.9 mm was, while axial 18.1 mm, by a factor ranging 2 through 3.

B. Sensitivity

Sensitivity was measured by using the cylindrical phantom with 20 cm internal diameter and 20 cm long, and filled with ^{68}Ga solution. Row events were corrected for randam and multiple coincidences. Table 3 shows the results. Sensitivity of ECAT II is 10.8 kcps per μCi/ml with medium resolution shadow shield which is normally used for patient and animal studies, while sensitivity of PT931 is in the same order of magnitude (without septa) or half (with septa) of that of the ECAT II at direct plane. Since the slice width of ECAT II (3.8 cm) is wider than that of PT931 by the factor of 2.8, sensitivity of PT931 is higher than that of ECAT II by a factor of 1.5 through consequently.

C. Linearity

The relationship between concentration of radioiactivity and true coincidence rate was measured by using the same cylindrical phantom as described above but filled with ^{11}C-solution. Observed counting rates were corrected for dead-time loss. The correction was made by a conventional form $N_t = N_{ob}+1.58*N_m+0.101*N_m^{3/2}$ where N_t, N_{ob} and N_m are corrected true event rates, observed true event rates and multiple coincident rates respectively.[6] Fig. 2 shows a linear responce of corrected true counting rate up to 5.0 μCi/ml, while ECAT II indicated linear responce up to around 2.3 μCi/ml.

Conclusion

The present results indicates that the PT931 PET scanner is a system with high resolution, high efficiency and wide axial FOV. It provides furthermore high quality images with accurate quantitation.

References

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Table 1. PT931 system description.

Number of ring	4 rings
Number of image	7 images
Number of crystal	512 /ring
Detector crystal	BGO(5.6×13.5×30 mm)
Detector ring diameter	102 cm
Detector spacing	
Inplane	6.1 mm
Axial	14.3 mm
Field of view	
Planar	55 cm
Axial	5.4 cm
Minimum scan interval	1 second
Scanning modes	Wobble or Stational

Table 2. Resolution (mm FWHM).

A. Spatial

Sampling mode	Direction	Distance from center of FOV 0 cm	10 cm	20 cm
Wobbled	Tangential	5.4	5.4	5.9
	Radial	5.2	5.6	8.3
Stational	Tangential	6.0	6.4	7.1
	Radial	6.0	6.6	9.0

B. Axial

Septum	Image plane	Distance from center of FOV 0 cm	10 cm	20 cm
In	Direct	6.9	6.7	6.7
	Cross	6.4	5.1	5.8
Out	Direct	8.7	8.4	8.5
	Cross	8.9	9.0	8.9

Table 3. Sensitivity.

Septum	Sensitivity for the true coincidence (kcps per μCi/ml)	
	Direct	Cross
In	5.8	20.9
Out	9.8	22.1

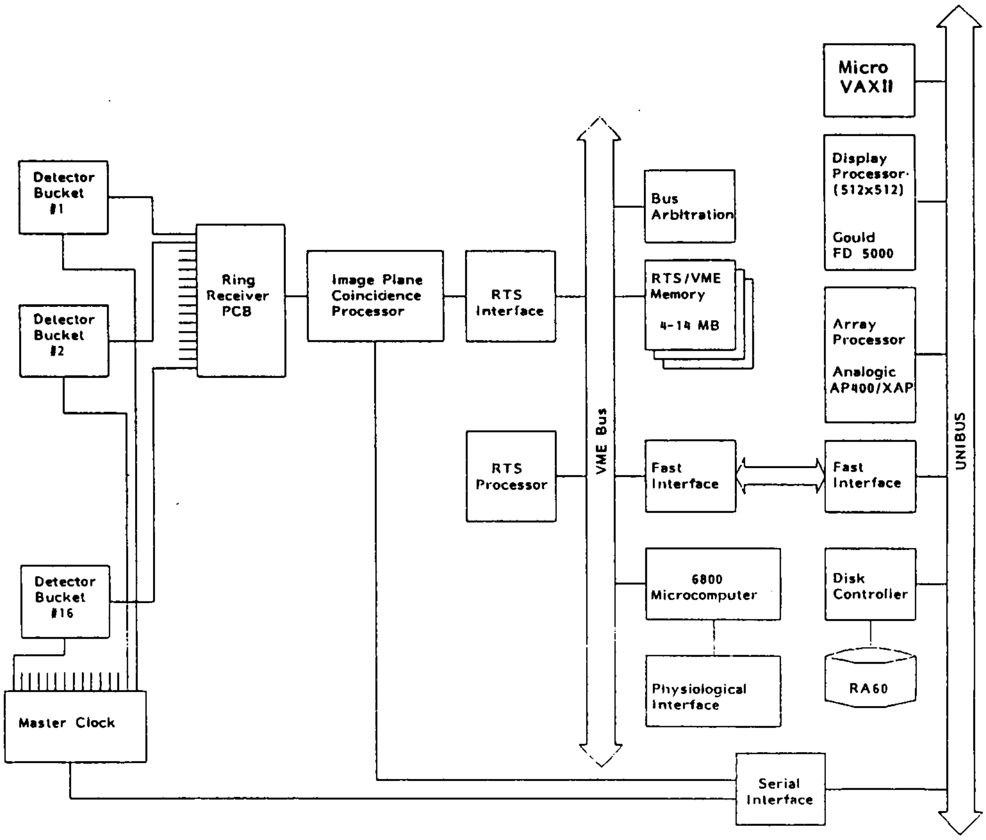

Fig. 1. Block diagram of PT931 system.

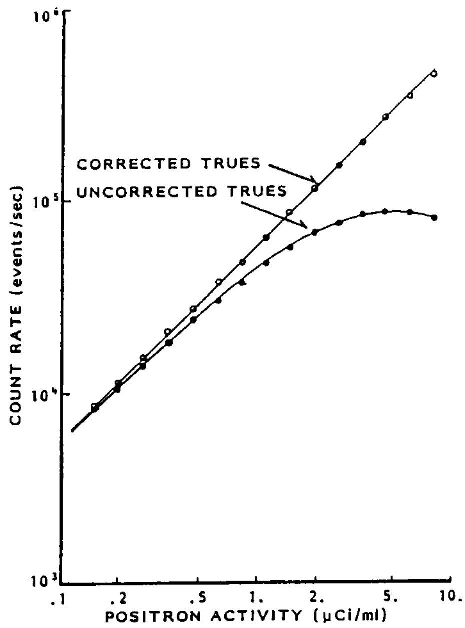

Fig. 2. Linearity of count rate.